Abstract Book of Posters

Joint Workshop on NASA Biodiversity, Terrestrial Ecology,
and Related Applied Sciences

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10.5-P **A Carbon Management Estimation System for US Agricultural Lands: Supporting Policy and Management Decisions** (*Stephen M Ogle*, Keith Paustian, Chris Potter, Steven Klooster, F Jay Breidt, Richard Conant)

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10.7-P **Decision Support for Forest Carbon Management** (*Randolph H. Wynne*, Chrisopher S. Potter, John R. Seiler, Thomas R. Fox, Ralph L. Amateis, David A. Sampson)

Biodiversity Posters

1.1-P: Remote Inventory for a Northern Temperate Forest: Integrating Waveform Lidar with Hyperspectral Remote Sensing Imagery

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We describe the integrated and individual capabilities of waveform lidar and hyperspectral data to estimate three common forest measurements - basal area (BA), above-ground biomass (AGBM) and quadratic mean stem diameter (QMSD) - in a northern temperate mixed conifer-deciduous forest. The use of this data to discriminate distribution and abundance patterns of several tree species was also explored. Waveform lidar imagery was acquired in July 2003 over the Bartlett Experimental Forest in New Hampshire using NASA's airborne Laser Vegetation Imaging Sensor (LVIS). Hyperspectral imagery was acquired in August 2003 using NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). Field data (2001-2003) from over 400 USDA Forest Service Northeastern Research Station plots were used to determine actual site conditions.

Results suggest that integrated data sets of hyperspectral and waveform lidar provide an advantage over the use of either data set alone in evaluating common forest metrics. Across all forest conditions, 8-9% more of the variation in AGBM, BA, and QMSD was explained by use of the integrated sensor data, with estimated error 5-8% lower for these variables. Notably, in an analysis using integrated data limited to unmanaged forest tracts, AGBM coefficients of determination improved by 25% or more, while corresponding error levels decreased by over 25%. AVIRIS data alone best predicted species-specific patterns of abundance. Nonetheless, use of LVIS and AVIRIS data - in tandem - produced complementary maps of estimated abundance and structure for individual tree species, providing a promising adjunct to traditional forest inventory.

1.2-P: Multi-Dimensional Vegetation Structure in Modeling Avian Habitat

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Amy Gilboy, Environmental Services Incorporated, agilboy@umich.edu
Daniel Brown, University of Michigan, danbrown@umich.edu

INTRODUCTION: The goal of this study was to evaluate the contributions of forest and landscape structure derived from remote sensing instruments to habitat mapping. Our empirical data focused at the landscape scale on a test site in northern Michigan, using radar and Landsat imagery and bird-presence data by species. We tested the contributions of multi-dimensional forest and landscape structure variables using GARP (Genetic Algorithm for Rule-Set Production), a modeling methodology used in biodiversity informatics. APPROACH: For our multi-dimensional variables, radar data were processed to derive forest biomass maps and these data were used with a Landsat-derived vegetation type classification and spatial neighborhood analyses. We collected field data on bird species presence and habitat for northern forest birds known to have a range of vegetation habitat requirements. We modeled and tested the relationships between bird presence and 1) vegetation type, 2) vegetation type and spatial neighborhood descriptions, 3) vegetation type and biomass, and 4) all variables together, using GARP, for three bird species. RESULTS: Modeled results showed that inclusion of biomass or neighborhoods improved the accuracy of bird habitat prediction over vegetation type alone, and that the inclusion of neighborhoods and biomass together generally produced the greatest improvement. The maps and model rules resulting from the multiple factor models were interpreted to be more precise depictions of a particular species habitat when compared with the models that used vegetation type only. We suggest that for bird species whose niche requirements include forest and landscape structure, inclusion of multi-dimensional information may be advantageous in habitat modeling at the landscape level. Further research should focus on testing additional variables and species, on further integration of newer radar and lidar remote sensing capabilities with multi-spectral sensors for quantifying forest and landscape multi-dimensional structure, and incorporating these in biodiversity informatics modeling.

1.3-P: Techniques for identifying and enumerating animals from high spatial resolution satellite imagery

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Eric Sanderson, Wildlife Conservation Society, esanderson@wcs.org

With the advent of commercially available high spatial resolution space based imagery, there have been several successes using this remotely sensed data for identifying and enumerating wildlife, Pacific walrus (Burn and Weber 2002), Orca and humpback whales (Alibeah pers comm), and African elephants (African Elephant Trust 2002). Other researchers have not had success with emperor penguins (Sanchez and Kooyman 2004). Our recent study has quantified the type of fauna able to be detected and identified within a range of habitat types (Bergen and Sanderson, in review).
Verifying mobile wildlife in wild condition for validating the use of high spatial resolution satellite imagery poses unique logistical challenges, since it is necessary to explicitly locate individual animals in space and time. Using data collected at the National Elk refuge in Jaskson, WY, we show how ground census procedures document the location of over 5,000 elk and bison occurring on the refuge on February 12th, 2006. These ground census procedures use digital photography that can cross-reference digital ground photography with individual elk in the satellite imagery. This has allowed us to examine different ground factors and there influence on reflectance spectra.
Animal's mobility can be an asset in identifying individual animals. In a study from Ruaha National Park, Tanzania, we show how change detection techniques can be used to identify animals. This method distinguishes individual animals from objects having similar size and reflectance spectra characteristics. These change detection algorithms performed between aerial digital photography and high spatial resolution satellite imagery have distinguished individual animals from cryptic background ground environments.

1.4-P: Application of Remote Sensing Data in Predictive Models of Species' Distribution

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Predicting geographical distribution of species requires data that can describe species' environmental requirements accurately. With the recent launch of a number of earth orbiting satellites, a vast array of direct physical measurements of ecological variables at high spatial and temporal resolution have become available. This study explores the relative merit of using these newly available remote sensing data in species distribution modelling. We applied a recently developed algorithm, based on the maximum entropy approach (Maxent), to model the distribution of two South American bird species, the wedge-billed woodcreeper and the speckled hummingbird, at 1 km spatial resolution. The models were developed separately for three scenarios of input data layers with bioclimatic and remote sensing layers in isolation and combined. Results from quantitative performance measures and visual inspections showed that Maxent scenarios with remote sensing and bioclimatic layers in isolation performed almost equally in predicting general patterns of species distributions, suggesting each of these data sets contain useful information. However, Maxent model runs with a combination of remote sensing and bioclimatic layers resulted in the best model fits and generally higher spatial accuracy including less overprediction, suggesting a more constrained characterization of the two bird's ecological niche. In Ecuador, the inclusion of high-resolution remote sensing data were critical in resolving known geographically isolated populations of these species. Further, due to their sensitivity to vegetation and landscape patterns, the remote sensing data were also essential in excluding areas in the Maxent predictions that had lost their natural forests, leading to much more detailed range maps. The findings suggest that remote sensing data can play a major role in modelling geographical ranges of species and in predicting and monitoring any changes due to human-induced fragmentation or climate-related stresses on their habitat.

1.5-P: Bio Bulletin: a Biodiversity Education and Public Outreach Medium Reaching 10 Million Annually

Ned Gardiner, American Museum of Natural History, ned@amnh.org (Presenting)

I will present examples of the American Museum of Natural History's Bio Bulletin, a current biodiversity science program broadcast in HDTV to 10 million informal science institution visitors annually. The Bio Bulletin web site, sciencebulletins.amnh.org/bio, archives frequently updated content, providing a media-rich resource for formal and informal education. The Bio Bulletin uses satellite imagery to portray important themes in Biodiversity Science, including: space-based biophysical measurements; unique ecosystems; rare and endangered species and their native ecosystems; biodiversity hotspots and ecoregions; and ecosystem processes. Workshop participants are encouraged to present their own research results for consideration as potential stories for the Bio Bulletin.

1.6-P: Application of Ecological Modeling and Remote Sensing Data Assimilation in Restoration and Conservation of the Brazilian Atlantic Forest

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Wolfgang Buermann, UCLA Center for Tropical Research, buermann@ucla.edu
Thomas Smith, UCLA Center for Tropical Research, tbsmith@ucla.edu

The Brazilian Atlantic Forest is considered a major global biodiversity hotspot and as one of the most endangered ecosystems in the world. Only 7% of the original forest is left intact and majority of the remaining patches are embedded in a mosaic of secondary regrowth, anthropogenic forests, tree plantations, pastures and agricultural crops. Majority of conservation activities in the region are concentrated in preserving forest patches while increasing the restoration efforts and developing larger *continuum* of forests to sustain the natural habitats and the high biodiversity. These efforts require detailed information on the location and size of forest fragments, their geographical distribution, the type and intensity of anthropogenic threats, and their values in terms of biodiversity and ecosystem services.

We use a combination of ecological niche modeling, a suite of remote sensing and climate data layers, and important endemic species to evaluate the importance of forest fragments in conservation efforts. We have selected occurrence data of two endemic bird species and the Maximum Entropy algorithm (MAXENT) to study their spatial distribution in the region. Remote sensing data from various optical and microwave sensors such as MODIS, QSCAT, SRTM are used to develop direct spectral metrics or derived products such as LAI and NDVI to represent the vegetation and landscape characteristics. Three scenarios are used: remote sensing, climate, and combined remote sensing and climate data to map the geographical range of the bird species. The modeling results indicate that remote sensing data alone can characterize the species range accurately and the combined remote sensing and climate improves the result. We discuss the implication of these results for conservation and restoration plans in the region.

1.7-P: Laser Remote Sensing of Canopy Habitat Heterogeneity as a Predictor of Bird Diversity in Maryland

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Habitat heterogeneity has long been recognized as a fundamental variable indicative of species diversity, in terms of both richness and abundance. Satellite remote sensing data sets can be useful for quantifying habitat heterogeneity across a range of spatial scales. Past remote sensing analyses of species diversity have been largely limited to correlative studies based on the use of vegetation indices or derived land cover maps. A relatively new form of laser remote sensing (Lidar) provides another means to acquire information on habitat heterogeneity. Here we examine the efficacy of Lidar metrics of canopy structural diversity as predictors of bird species richness and abundance in suburban forests of Maryland. Canopy height, topography and the vertical distribution of biomass were derived from Lidar imagery and compared to bird survey data collected at referenced grid locations. The vertical distribution of biomass was found to be the strongest predictor of both total richness and abundance. Species richness was predicted best when stratified by guilds dominated by forest, grassland, scrub, suburban and wetland species, with different variables selected as primary predictors across guilds. Generalized linear and additive models, as well as binary hierarchical regression trees produced essentially similar results. The Lidar metrics were consistently better predictors than traditional remotely sensed variables such as canopy cover, indicating that Lidar provides a valuable resource for biodiversity research

applications - particularly in complex and highly modified environments.

1.8-P: moved to 5.7-P

1.9-P: Response of birds to landscape matrix in fragmented forests in Jamaica

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We examined how resident bird communities and different foraging guilds are affected by vegetation structure, patch area, patch isolation, and landscape context (i.e., matrix) in the wet limestone forests in Jamaica. Over 400 point counts were conducted within the forest and matrix of three types of fragmented landscapes - agriculture, bauxite mining, and urban - as well as intact forest. We found that communities within forested landscapes were significantly different than agriculture, bauxite, and urban ($p<0.002$); and agricultural patches were significantly different than urban ($p<0.003$) and bauxite ($p<0.03$). The variance in community composition was not strongly correlated with patch-level variables or within-patch vegetation, but rather by species abundance within the matrix. Nectarivores, ominivores and frugivores were least sensitive to forest fragmentation and actually thrived, particularly in urban areas, where they were abundant within the matrix. Insectivores were the most sensitive to forest fragmentation, with significantly lower abundances in urban and bauxite than agricultural and forested landscapes ($p<0.01$), and were largely absent within the matrix. All three fragmented landscapes displayed a significant richness-area relationship. Agricultural landscapes had the strongest richness relationship with patch size (R2: 0.71), as compared to bauxite (R2: 0.58), and urban (R2: 0.18). Urban landscapes exhibited the weakest species-area relationship, with the least amount of variance explained by patch area, attributed to the fact that urban areas provide additional resources (i.e., gardens) surrounding forest fragments as compared to agricultural and bauxite landscapes. In contrast, only bauxite landscapes displayed a significant richness-isolation relationship ($p<0.01$), thus, supporting that corridors in agricultural landscapes and garden plots in urban landscapes are potentially aiding dispersal among forest remnants.

1.10-P: Forest Structure and Biodiversity on a Steep Geophysical Gradient: the Cloud Forest Lee Margin

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Tropical montane cloud forests are central elements of the complex of montane environments that lie at the core of most tropical biodiversity hotspots. Cloud forests, defined by frequent, prolonged and predictable immersion in cloud, are centers of endemism for many taxa. Although lowland rain forests are richer in species at spatial scales less than 0.1km2, cloud forests and associated formations are as species rich at scales of 10km2 and above. This contrast between the spatial organization of biodiversity in lowland and montane regions is poorly understood, but must be addressed in any theory explaining global gradients in biodiversity and ecosystem structure. This project is designed to address, in the well-known montane forests of Monteverde, Costa Rica, interrelationships among the critical components of this problem: (1) the geophysical gradient at the cloud forest margin, (2) the pattern of tree and bird species distribution, and (3) the physical structure of the forest. We will use GOES and MODIS imagery, combined with regional atmospheric modeling, to establish diurnal and seasonal patterns of cloud immersion. Data on tree and bird distributions will come from an extensive series of geolocated plots and census points. Data on forest structure will come from high resolution satellite data and plot-based ground measurements. The results will be of interest to ecologists, conservation biologists, land managers and decision makers involved in regional development in the montane tropics.

1.11-P: Predicting composition and structure of Hawaiian tropical dry forests

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Tropical dry forests in the Pacific are the most endangered forest type in the world. In the Hawaiian Islands, 17 native study sites, representing the largest and best-preserved fragments were identified. Belt transects totaling 1000 m2 were established at each site, then, species richness, density, and basal area were quantified. Three sites on the island of Lanai were used as preliminary sites to test the relationship between NDVI and species richness. The mean and standard deviation of NDVI values were collected at the forest stand level directly over the fifth and sixth transect belts of each site. Kanepuu 1 had the highest mean NDVI, the highest standard deviation of NDVI, the highest native species density, but also the lowest species richness. Kanepuu 2 had the highest species richness, but had the lowest mean NDVI, and the lowest standard deviation of NDVI. Kanepuu 3 had intermediate mean and standard deviation NDVI values and species richness similar to Kanepuu 1, but had the lowest native density of all sites. Compared to non-native monospecific sites, there does not appear to be a significant difference in mean NDVI or standard deviation, although species richness is much lower. These preliminary data suggest that mean NDVI may be a good predictor of basal area or density of forest fragments.

1.12-P: Giant Panda Habitat Distribution across its Entire Geographic Range: A Preliminary Assessment

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The world-famous endangered giant pandas (Ailuropoda melanoleuca) depend on forest overstory as shelter and understory bamboo as staple food. Although giant pandas had a wide geographic distribution in the past, they are currently restricted to five major mountainous regions in China. To understand the distribution of giant panda habitat across its entire geographic range, we have acquired relevant field and remotely sensed data. The spatial locations of panda evidences (feces, tracks, and eaten bamboo shoots) were recorded in the field using global positioning systems. They were utilized to develop presence/availability models by means of Ecological Niche Factor Analysis, using time series of different vegetation indices (obtained from MODIS) as predictor variables. We assessed the performance of the models created with each of the predictor data sets using two different validation procedures (Minimal Predicted Area and Prediction Success). In addition, a series of landscape metrics were calculated per mountain region in order to evaluate the degree of fragmentation of the habitat for the pandas. Preliminary analyses reveal that the habitat for the giant panda in its entire geographic range exhibits a high degree of fragmentation, particularly those located in the southern part of the geographic range. In addition, the temporal variability of vegetation indices exhibits a phenological characterization of the land surface that represents a suitable environmental predictor for giant panda habitat mapping. These results suggest that information contained in MODIS data has considerable potential for endangered wildlife species habitat mapping and management.

1.13-P: Will the proposed Mesoamerican Biological Corridor protect Biodiversity: Highlighting potential problems with biological corridors.

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The proposed Mesoamerican Biological Corridor (MBC) is an ambitious effort to stem the erosion of biodiversity in one of the world's biologically richest regions. The intent is to connect large existing parks and reserves with new protected areas by means of an extensive network of biological corridors within Mesoamerica/Central America to create an environment which provides better prospects for the long-term survival of native species while also addressing the region's socioeconomic needs.

Based upon climatological rainfall records at 266 stations in Guatemala and adjacent areas, dry season rainfall in March is markedly lower in deforested areas than in forested areas of the same life zone for each of the widespread life zones. In general, dry season deforested habitats have higher daytime temperatures, are less cloudy, have lower estimated soil moisture and lower values of Normalized Difference Vegetation Index (NDVI) than do forested habitats in the same life zone. The result is hotter and drier air over deforested regions, with lower values of cloud formation and precipitation. The data suggest that deforestation is locally intensifying the dry season, increasing the risk of fire, especially for the long corridor connecting regions. In addition, forest regeneration in some parts of the MBC may not result in second-growth forest that is characteristic of that life zone but rather in forest regeneration more typical of drier conditions. The extent to which this would influence the conservation utility of any given corridor depends upon the ecological requirements of the organisms concerned.

1.14-P: Remote Sensing in Support of Ecosystem Management Treaties

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John Mickelson, Socioeconomic Data and Applications Center (SEDAC), CIESIN, Columbia University, jmickelson@ciesin.columbia.edu

Concern for the impact of human activities on biodiversity helped launch the international environmental movement in the 1960s. This movement in turn helped to spawn a number of international agreements, including CITES (1968), the Ramsar Convention on Wetlands (1972), the Convention on Biological Diversity (1992), and the Convention to Combat Desertification (1992). It has also spawned a multi-million dollar research enterprise that has grown from early roots in taxonomic fieldwork to include a large array of sub-disciplines such as conservation biology, restoration ecology, and plant and animal genetics. As technology has advanced, so has the tool kit used by conservationists. The convergence of trends in the development of environmental agreements, biodiversity research, and advanced technologies has led quite naturally to the application of remote sensing to ecosystem management and, consciously or unconsciously, to the concerns raised and "legitimized" by environmental treaties. This poster examines the application of remote sensing to environmental treaties with particular reference to pilot applications in the Laguna Merín basin, a transboundary lake and wetland complex on the border of Brazil and Uruguay.

1.15-P: Global Socioeconomic Data for Understanding Human-Environment Interactions

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Robert S. Chen, Socioeconomic Data and Applications Center (SEDAC) of CIESIN, Columbia University, bchen@ciesin.columbia.edu

Despite the longstanding recognition of the human drivers of habitat loss and over-exploitation of biotic resources, as well as the impacts of biodiversity loss on society, the development of global socioeconomic and environmental datasets to support research on global-scale human-environment interactions has been slow. We report here on recent efforts to improve global spatial data on population distribution, urban extent, income distribution and poverty, natural hazards, the human influence on the environment, and environmental sustainability. We highlight selected applications of these data in the realm of biodiversity science. We also identify key gaps and areas for future development, e.g., with regard to development of consistent time series and projections and data on human infrastructure.

Invasive Species Posters

2.1-P: Assessing Resolution Tradeoffs of Remotely Sensed Data for Invasive Species Detection

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In order to aid federal agencies and private companies in mission planning and data analysis for invasive species detection applications, the authors have developed software for generating invasives detection accuracy-resolution-cubes (ARCs) for use in determining sensor resolution requirements. The three-dimensional ARC is the result of an invasives detection model, where spectral, spatial, and temporal resolutions are varied to determine acceptable system specifications. The software has three layers: (1) data ingest and resolution modification, (2) invasives detection model, (3) accuracy cube construction and assessment. The software is flexible, such that various data sources and detection models can be utilized. Two case studies are presented: (i) the detection of Cogongrass (*Imperata cylindrical*) in habitats containing other grasses, such as Johnsongrass (*Sorghum halepense*), and (ii) the detection of Water Hyacinth (*Eichhornia crassipes*) in habitats containing other floating vegetation, such as American Lotus (*Nelumbo lutea*). The ARCs resulting from the two case studies reveal the trade-offs of spectral, spatial, and temporal resolutions on various models to accurately predict and/or detect the invasives. For example, in the aquatic vegetation case study, overall detection accuracies of 90% or higher can be obtained during late summer, e.g. August, for spectral sensors with 80 - 1000nm FWHM when target abundances are 70 - 100% per pixel. In this fashion, ARCs can be readily used in remote sensing mission planning, sensor design/selection, and data analysis for invasive species applications.

2.2-P: Remote Sensing of Aquatic Invasives via Multi-Resolution Analysis of Time-Series Data: Fusing MODIS Vegetation Signatures and NOAA Buoy Signals

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Multi-resolution analysis, namely discrete wavelet transforms, are used to denoise and extract features from MODIS time-series data for the detection of aquatic invasive species. In addition, wavelet analysis is used to correlate the MODIS time series data to NOAA buoy signals in order to account for tidal fluctuations along the coastline which can significantly affect the reflectance properties of the target vegetation. Using the MODIS imagery, temporal vegetation signatures, i.e. vegetation indices as functions of time, are generated. Due to challenges with the MODIS quality assurance maps, a significant level of noise is present in the temporal signatures. Several methods for denoising the signatures are investigated, including simple moving average and median filters, as well as wavelet denoising techniques. The authors also have developed a wavelet-based feature extraction method for quantifying shape of the oscillations in the temporal signatures. This poster provides an explanation of how NOAA buoy time-series data was correlated to the MODIS time-series data to account for tidal effects on the vegetation signatures, as well as a comparative analysis of the denoising methods and wavelet-based versus Fourier-based feature extraction techniques.

2.3-P: Development and Implementation of Remote Sensing Techniques to Monitor Invasive Plant Species in the State of Idaho

Nancy Glenn, Idaho State University, glennanc@isu.edu (Presenting)
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Invasive plant species pose a serious economic and environmental hazard. The economic impact to the U.S. alone is billions per year and this amount is increasing annually. Invasive species are difficult to identify and eradicate in remote areas, especially in rugged terrain such as the Intermountain West. Remote sensing of invasive species has the potential to provide land management an efficient and effective means to identify previously unknown locations of weed infestations and to control the spread of these infestations. A collaborative project between weed managers (county, state, and federal) and university researchers are studying remote sensing techniques for the detection of leafy spurge, hoary cress, and rush skeletonweed (all noxious weeds) in southern Idaho. Using hyperspectral imagery we were able to identify small infestations (down to individual species) which were then treated by land managers. We also determined detection thresholds and accuracy limits for each of the noxious weeds using hyperspecral imagery. Finally, we studied the repeatability of using hyperspectral imagery for long-term implementation and cost effectiveness. We are extending these results to test detection thresholds (spatial extent and percent cover of infestations) in multispectral (ASTER, Landsat) imagery. These results will be used to determine the effectiveness of previous management measures (e.g. spraying, sheep/goat grazing). Weed managers in southern Idaho will use this information for ranking of management activities and long-term planning for re-surveying lands with remote sensing data.

2.4-P: N-fixation by kudzu (Pueraria montana): impacts on nitrogen cycling and soil microbial communities by an invasive vine.

Jonathan Hickman, SUNY-Stony Brook, hickman@life.bio.sunysb.edu
Manuel Lerdau, SUNY-Stony Brook, manuel.lerdau@sunysb.edu (Presenting)

Among invasive plants, those that fix nitrogen (N) present a clear threat to the integrity of native ecosystems. Kudzu (Pueraria montana) is a legume that has become highly invasive in the U.S., and is known to fix N in its native range. Kudzu's tendency to form dense stands and its extensive coverage in the southern U.S. may increase rates of N cycling and accumulation in soils, potentially leading to changes in community composition, soil acidification, and increased fluxes of trace N gases and leached nitrate to neighboring ecosystems. We present data on the effects of kudzu invasion on nutrient cycling and microbial communities for sites in the McKee-Beshers Wildlife Management Area in Montgomery County, Maryland. Two pairs of sites were selected for sampling; each pair consisted of invaded and uninvaded sites in close proximity, with similar slopes, aspects, and land-use histories. Soil samples were collected from each site and analyzed for extractable nitrate and ammonium, net N mineralization, net nitrification, denitrification enzyme activity, and microbial biomass. Preliminary results suggest striking effects of kudzu invasion on ecosystem processes, with large increases in N-cycling parameters occurring in the invaded sites.

2.5-P: Hyperspectral remote sensing and geospatial modeling for monitoring invasive plant species

Earle Raymond Hunt, USDA ARS, erhunt@hydrolab.arsusda.gov (Presenting)

Remote sensing is used to show the actual distribution of distinctive invasive weeds such as leafy spurge (Euphorbia esula L.), whereas landscape modeling can show the potential distribution over an area. Geographic information system data and hyperspectral imagery [NASA JPL's Airborne Visible Infrared Imaging Spectrometer (AVIRIS)] were collected for Devils Tower National Monument in northeastern Wyoming, USA. Leafy spurge was detected in the AVIRIS imagery using the Spectral Angle Mapper with a 74% overall accuracy. The areas of leafy spurge presence and absence were compared to the predictions of the Weed Invasion Susceptibility Prediction (WISP) model. Over the area of the AVIRIS imagery, about 8% of the landscape was covered by leafy spurge, whereas 23% of the landscape has the potential to be invaded. Using kappa analysis, the agreement between remote sensing and landscape modeling was 30%, which was significantly less than expected by chance, indicating model errors. Detailed analysis of individual data layers showed that only a few of the predictor variables were required. Elimination of non-significant predictor variables reduced the area predicted to be susceptible to 13%, and increased the accuracy of the predictions to 81%. Remote sensing was a powerful addition to landscape modeling because the entire landscape was used for the analysis, increasing its statistical power, whereas field data collection would be limited in scope and would be more costly.

2.6-P: Airborne Hyperspectral Research & Development for Invasive Species Detection and Mapping

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This project is testing the ability of airborne and space-borne hyperspectral remote sensing to map and monitor the distribution of specific noxious, non-native plants into rangeland, agricultural, and riparian landscapes of northern Nevada. The selected species include Lepidium latifolium (tall whitetop), Tamarix spp. (tamarisk), and Acroptilon repens (Russian knapweed). Research efforts are being coordinated with the University of Nevada Cooperative Extension (UNCE) office that works with agricultural and land management interests in the area. High spatial resolution (1.5 meter) hyperspectral imagery collected from airborne platforms present a promising way to address basic and applied research questions associated with invasive species, as well as providing a mechanism for better understanding how available methods scale up to satellite-based systems. Hyperspectral imagery is being collected by SpecTIR or Reno, Nevada using the AISA Dual hyperspectral system with the Eagle (VNIR) and Hawk (SWIR) sensors. Analysis methods will include multiple endmember spectral mixture analysis (MESMA) and stepwise discriminant functions. The developed monitoring techniques will complement ongoing control activities such as herbicide spraying and the use of biological control agents. The efforts described herein will feed into the efforts of the National Institute of Invasive Species Science (NISS) at the Fort Collins Science Center in Colorado.

2.7-P: Initial results using NASA's Invasive Species Forecasting System to support National Park Service decisions on fire management activities and invasive plant species control.

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NASA Goddard Space Flight Center has worked in conjunction with the US Geological Survey to develop invasive plant habitat models through the Invasive Species Forecasting System (ISFS). NASA, as part of the transferring ISFS to operational capability, is working with the National Park Service to explore the use and usefulness of ISFS and the predictive maps produced for three major park systems: Yellowstone/Tetons, Sequoia/Kings Canyon and throughout Alaska. The work with the National Park Service started in early 2006 and this poster describes our work to-date. The first step was to work with each park system to select two top-priority species. Once focal species were selected, numerous sources of presence/absence data were aggregated for these species in and around the Parks. During this process a Series of interviews were conducted with Park Service Personnel and volunteers to develop base-line "expert opinion" maps on areas likely to support the selected invasives. In parallel, we used logistic regression to couple the presence/absence points with environmental data layers, available through ISFS, to construct preliminary ISFS habitat maps. The ISFS habitat maps are more quantitative, less subjective, and built through a repeatable process. However, the expert opinion maps serve as a reality check against model results, reflect human knowledge gained through working experience and can inform model selection. Future work will involve compiling additional field data on the distribution of invasive species, building additional predictive environmental data layers from satellite data products and fire history records, and using ISFS with the expert opinion maps serving as a priori information, to generate more accurate and useful predictive habitat models with our agency collaborators.

2.8-P: Plant Invasions and Land Use in an Agricultural Frontier: The case of bracken fern invasion in southern Yucatan Peninsular region.

Laura Schneider, Department of Geography,, Rutgers University, SYPR., laschnei@rci.rutgers.edu (Presenting)

Plant invasions, affecting ecosystem recovery and household economics, are an important part of land-use change in the southern Yucatan peninsular region, Mexico, closely related to ecosystem function and homogenization of landscapes. Remote sensing analysis shows an increase of bracken fern from 60 km2 to almost 250 km2 in the region during the last 20 years (patch size up to 30 ha). The presence of bracken fern impedes regular succession of the vegetation and affects the amount of areas under forest opened for cultivation. The spatial distribution of bracken fern and its relation with land use suggests a complex process involving fire regimes, land management practices and environmental constraints. Biological strategies, such as a boom in bracken fern colonization just after fires and the increase in flammable biomass floor, show the dependency of bracken fern on continuous fires. In terms of land practices, results show low density of bracken in land-sparse areas characterized by intensive cultivation (swidden cultivation coupled with commercial chili production), and a high density in land-surplus areas characterized by less intensive cultivation (former large-scale agricultural and cattle projects). Large clearings of land promote the invasion, alternatively, where land is scarce and the household economy dependent largely on cultivation, the fern is attacked through labor. Finally, the invasion could have longer term ecological implications, analysis of soil nutrients show a decrease of Phosphorous in fields that have been invaded the longest. A nutrient that limits growth in the vegetation in the region is P, such decrease in P could make it more difficult for secondary

vegetation to compete successfully with bracken fern. This understanding of the invasion dynamics is facilitated by linking biophysical, socio-economic, and remote sensing/GIS analysis and would not necessarily follow from a more specialized study.

2.9-P: Detection of the Invasive Red Brome (Bromus rubens) in a Post-fire Landscape Using Landsat and MODIS Imagery

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Bromus rubens (Red brome), native to the arid deserts of Europe, Africa, and Asia, was first identified in the southwestern United States in the mid 1800s. Proliferation after fires has caused this annual to be regarded as a severe ecological threat. This plant suppresses the growth of native species by depleting the soil moisture and potentially degrades the habitat of the threatened Gopherus agassizii (desert tortoise). The purpose of this study was to assess the utility of using satellite imagery to detect B. rubens. During the summer of 2006, students from NASA's Ames Research Center DEVELOP Program worked with the Bureau of Land Management (BLM) and the National Park Service (NPS) to map the areal extent of red brome and predict its density within the region. The locations of B. rubens were visually identified and recorded using GPS in two study areas within the 2005 Goodsprings burn scar in southern Nevada. These positions acted as ground points for satellite imagery. MODIS Enhanced Vegetation Index (EVI) was used to identify optimal Landsat and ASTER scenes, which were then used to evaluate the density of B. rubens. Statistical analysis was used to determine the relationship between the percent cover of the plant and predictive variables. This information will be valuable to the BLM, the NPS and other land managers as they make decisions on how to control this invasive plant.

Ecosystem Function/Physiology Posters

3.1-P: Fire regime and woody cover changes in the Serengeti-Mara ecosystem

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This study investigates spatial variations of fire dynamics and woody cover changes in the Serengeti-Mara savanna ecosystem in East Africa. A previous analysis of remote sensing and field data for the first half of the 2000 decade has shown increasing woody cover in northern and central Serengeti National Park (SNP) and decreasing woody cover in the Masai Mara National Reserve, the northerly adjacent unprotected Mara pastoral areas (MPA), western SNP and corridor and in the Maswa Game Reserve. Fire frequency was determined from MODIS derived burned area maps. Fire intensity was estimated using an empirical model, as a function of fuel load, fuel moisture, air relative humidity, wind speed, and slope. Fuel load was calculated from grass production as a function of rainfall and grazing pressure. Fire frequency only yielded a weak relationship with woody cover changes. Fire intensity yielded a stronger linear relationship. This relationship was true within the protected areas, but did not hold up in MPA possibly due to the additional effects of high levels of elephant browsing. This study is limited by the briefness of the six-year time span but lays the ground work for long-term investigations as the data archives of high resolution satellite imagery expands. The results of this study underline the importance of fire events for controlling woody cover and generating woodland-grassland heterogeneity in African savannas.

3.2-P: The effect of warming on tropical forest gas exchange.

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Further research is required to understand the sensitivity of tropical forest to climate warming. Previous research has shown that tropical forest photosynthesis decreases and respiration increases at high leaf temperatures and that tree growth is reduced in years with higher average air temperatures (Clark et al 2003). Models indicate that the climate related destruction of the Amazon forest will amplify global warming by 1.5˚ C, resulting in a mean temperature increase of 5.5˚ C, as compared with 4˚ C without this carbon cycle feedback (Cox et al 2000). These studies demonstrate the importance of temperature on tropical forest gas exchange. At the LBA Tapajos km 83 site we determined what controls tropical leaf temperature and how temperature affects photosynthesis and respiration. Sunlit leaves were substantially warmer than air temperatures and this had a negative effect on photosynthesis and stomatal conductance. We used eddy flux data to compare intervals of 10 minute cloudy periods followed by 20 minute sunny periods to see if similar trends could be seen at both the leaf and canopy level. The longer the sunny interval the warmer the canopy became and canopy conductance and CO2 exchange declined correspondingly. As the canopy warmed u* increased which increased turbulence and kept the canopy temperature from rising more. Long light intervals can cause heat stress in tropical forests but due to the very cloudy nature of the tropics such intervals are rare. However, if the tropics become both warmer and less cloudy such heat stress will increase.

3.3-P: Trends in circumpolar photosynthetic activity from 1982-2003

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Temperature increases in the northern high latitudes over the past few decades have led to a wide variety of ecosystem changes, including modification of the productivity of plants as measured by ground cover (growth) and associated changes in global CO2 exchange. Well-known studies of "greening" trends between 1982 and 1991 in high latitude vegetation indicate an earlier onset of growing season and more active photosynthesis in the mid-summer months. Our recent work indicates that these trends do not continue uniformly in time or space but instead vary between vegetation types and different periods of the growing season. These results provide some of the first evidence that high latitude forests may be in decline following an initial growth spurt associated with CO2 and warming. Although the observational time scales of not as long as hoped, there is evidence that ecosystem response has been rapid, even accounted for lags in tree growth to recent past climate trends. The satellite observations are supported by a range of field observations, and indicate that natural ecosystems may be responding to climate change in unexpected ways that could have significant further effects on the biosphere.

3.4-P: Amazonian Dry Season: Controls of Evapotranspiration

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Previous observations at several individual sites over eastern and central Amazonia have shown that forest root uptake from deep soil provides enough water to maintain photosynthesis during the dry season. Consequently, the seasonal change in evapotranspiration (ET) appears to be largely controlled by surface radiation. However, it remains unclear as to whether this is true for dry season ET in general.
Radiative control of ET requires sufficient soil water supply. In the southern Amazonia, total dry season rainfall is less than 100 mm. To what capacity soil water storage can support a normal dry season ET is investigated using observations from the Jarú site for the period of 2000 to 2002. Soil moisture below 1 m depth is recharged by rainfall during the previous wet season: dry season rainfall rarely infiltrates to this depth. Our results suggest that, even near the southern edge of the Amazon forest, with substantially lower dry season rainfall than that in the interior Amazon, rainfall deficits such as during drought events can be easily mitigated by an increase in root uptake from deeper soil.
We also compared in situ observations from 10 sites from different areas of the Amazonia reported during the last two decades. Among these sites, the dry season length and total rainfall range from three to six months, and from 0 to 480 mm, respectively. However, we found that the average dry season ET varies less than 1 mm/day or 30% from the driest to nearly the wettest parts of the Amazonia. The change of surface net radiation averaged over the dry season is equivalent to 25% to 30% and is largely correlated with the changes of dry season ET between the 10 sites. Thus the geographic variation of the mean dry season ET, as represented by these 10 sites across large areas of the Amazon, appears to be mainly determined by the surface radiation.

3.5-P: North American Regional Ecosystem Dynamics Observed with Satellite Data

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Normalized difference vegetation index data from the NOAA series of Advanced Very High Resolution Radiometers (AVHRR) revealed regions in North America that experienced marked increases in annual photosynthetic capacity at various times from 1982 to 2005. Inspection of these anomalous areas with Landsat, Ikonos, aerial photography, and ancillary statistical datasets revealed a range of causes: climatic influences; drought and subsequent recovery; irrigated agriculture expansion; herbivores insect outbreaks followed by logging and subsequent regeneration; and forest fires with subsequent regeneration. We describe an efficient continental monitoring system that can identify major land use/land cover changes and climatic influences upon North America vegetation.

3.6-P: Multitemporal Assessment of Vegetation Disturbance in the Okavango Delta, Botswana

Amy L Neuenschwander, University of Texas at Austin, amy@csr.utexas.edu (Presenting)
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The Okavango Delta, located in northern Botswana, is RAMSAR-status wetland home to 650 bird species and over 1000 floral species. The Delta provides critical habitat and resources to wildlife (including large mammal populations) and humans. But it faces potentially ecologically damaging consequences due to natural and anthropogenic change. Changes in land use such as extraction of natural resources (water, fish, wood and reeds), increased burning, over-grazing of domestic livestock, and a growing tourism industry increasingly pressure the wetland-savanna ecosystem. The Delta experiences two remotely observable disturbance regimes, flooding and fire. Additionally, oscillations in precipitation cycles of 3, 8, 18, and 80 years have been reported for southern Africa. The impact of those oscillations on flooding (amount and distribution) across this alluvial fan is unclear.

This research utilizes 85 Landsat TM and ETM+ scenes from 1989 through 2002 covering the southeastern distal portion of the Delta. Extracted patterns of flooding and fire were tested against a 2000 Landsat-based vegetation structure classification created by local researchers at the University of Botswana's Harry Oppenheimer Okavango Research Center. Preliminary results suggest that 1) flooding and fire regimes manifest very different spatial and temporal patterns, 2) the co-occurrence of these disturbances occurs primarily in floodplain grasses, 3) fire regimes differ between management regimes (photography versus wildlife concessions), and 4) climatic trends reported in the literature are moderately correlated with Landsat-derived vegetation indices. These early findings suggest that seasonal, annual, and longer-term

anthropogenic and climatic impacts on ecologically critical disturbance regimes can be effectively assessed with seasonally rich optical time-series data.

3.7-P: Remote Sensing and GIS Approach Detects Key Resource Areas for Large Herbivores in Kenyan Rangelands

Moffatt Kangiri Ngugi, Colorado State University/NREL, ngugi@cnr.colostate.edu (Presenting)
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Rangelands are extensive low productivity areas interspersed with a few high productivity zones referred to as Key Resource Areas (KRAs). KRAs serve as fall back areas forming “oases” of forage reserves during dry seasons which enable fuller use of extensive rangelands by bridging resource supply between times of abundance and scarcity. We ascertained the presence and use of KRAs as dry season foraging zones for large herbivores during fieldwork in Kenya. Published descriptions and our hypothesized expectations of KRA characteristics were tested using MODIS satellite data. We examined spatial and temporal green-up dynamics during 2000-2005. KRAs had high NDVI mean and variance relative to outlying rangeland (nonKRA). The coefficient of variation of NDVI was lower at KRAs. KRAs can be isolated from nonKRAs due to higher base NDVI values during the start of seasons, higher maximum NDVI and larger NDVI integral values which represent total production in a season. Ground truth reports confirmed production from woody biomass and perennial herbaceous biomass contributes to the higher NDVI in KRAs. Application of remote sensing is an objective method to identify KRAs in dry tropical ecosystems. This approach will strengthen inventory and monitoring of rangelands and may be applied in other rangelands to support management and conservation.

3.8-P: Nutrient and light controls on grass productivity in an African woodland savanna

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Despite the ubiquity of sub-tropical savannas throughout the earth, limitations of savanna productivity are understudied relative to other terrestrial systems. The limitations of savanna productivity by precipitation have been documented but the role of nutrients and light is not as clear. In particular, there has been little attention on the role of phosphorus in savanna productivity and structure. This study examined the role of increased nitrogen and phosphorus in grass productivity in a woodland savanna in Botswana. We added aqueous forms of nitrogen and phosphorus to randomly selected 1-m2 plots inhabited primarily by grasses. During the following growing season we measured foliar nutrient concentrations and photosynthetic response at various light levels to estimate the productivity response. We observed an increase in foliar nutrient concentrations (mg P/g and mg N/g) for all grasses with increased levels of soil N and P. We also observed a significant increase in net carbon assimilation and Amax for these grasses with the largest increase in those grasses to which both N and P were added. These results suggest that the aboveground productivity of these woodland savanna grasses is limited by both nitrogen and phosphorus. Additionally, under constant C02 availability, photosynthesis is limited by nutrients for light levels greater than 1000 µmol m-2 s-1. These findings are helpful in addressing issues such as desertification and bush encroachment in the Kalahari region. Additionally, these data could be used in leaf- and canopy-scale modeling to predict changes in savanna productivity under a changing climate.

Remote Sensing Science Posters

4.1-P: Segmentation of Hyperspectral Imagery: Level Set Methods that Exploit Spectral Information

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When conducting automated segmentation of hyperspectral imagery, e.g. delineation of ground cover classes, it is clear that one should exploit the substantial spectral information that is available. Typical methods that are often used include parallelepiped or maximum-likelihood classification, both of which have their limitations. Parallelepiped methods often produce an overabundance of commission errors due to their relative sensitivity to within-class variances. Maximum-likelihood methods often encounter problems with hyperspectral imagery due to their requirement of large amounts of labeled training pixels. In this poster, the authors present level set segmentation as an alternative approach for ground cover mapping when using hyperspectral imagery. Advantages and disadvantages of level set segmentation are presented. A new method of supervised level set hyperspectral image segmentation is presented, where the spectral information is utilized to optimize the level set speed functions, i.e. the functions that control front propagation of the individual ground cover classes during the segmentation process. The new speed functions are composed of a spectral similarity term and a stopping term. The spectral similarity term is used to compare pixels to class training signatures and is based on best spectral band selection procedure developed previously by the authors. The stopping term is created from a new best spectral band selection algorithm, which uses a scaled spectral angle mapper. A case study is presented, and level set segmentation results are compared to those from maximum-likelihood classification.

4.2-P: Range Resolved Measurements of CO2 in the Lower Troposphere

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We describe the development of a differential absorption lidar (DIAL) at Goddard Space Flight Center designed to make range resolved measurements of CO2 within the planetary boundary layer (<3000 meters). The goal is to develop a compact, rugged, instrument capable of autonomous operation using commercial-off-the-shelf components and technology. The spatial and temporal variations in CO2 will permit fluxes to be derived and terrestrial sources and sinks to be identified. Simulations indicate that the system will make measurements at a precision of ppmv at 4000 meters with 10 minutes receiver integration time and a vertical resolution of 150 meters. Data will be

presented. The concurrent development of a small, compact optical parametric amplifier as a light source for this lidar will be discussed. Future directions for this research will be presented.

4.3-P: A Multi-Angle Approach to Mapping Forest and Shrub Canopy Structure in the Southwestern United States

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Red wavelength data from NASA's Multi-angle Imaging SpectroRadiometer (MISR) acquired at a nominal 275 m and in nine viewing directions were used to invert a simple geometric-optical (GO) model to retrieve canopy structure parameters over parts of S.E. Arizona and S. New Mexico (>159,556 km^2). This area encompasses desert grassland, often with woody shrub encroachment; riparian woodland; and upland forest. The combined soil and understory signal - represented by the Walthall model - was estimated a priori using regression relationships with MISR nadir data and the red band isotropic, geometric, and volume scattering kernel weights of the LiSparse-RossThin kernel-driven model, using measurements extracted from Ikonos panchromatic imagery over 19 locations in a grass-shrub transition zone with contrasting upper/lower canopy configurations. The GO model was adjusted using the Praxis minimization algorithm and the merit function min(|RSME|), with no constraints. Distributions of crown cover and mean canopy height for forested areas show good matches with maps from the USDA Forest Service developed from field survey as part of the Forest Inventory Analysis (FIA). Within upland forest, the mean canopy height map shows a better match with the corresponding FIA map than the cover map. Some areas with known shrub cover are predicted to have low or no woody plant cover, indicating a need to adjust the background calibration. Retrievals are very rapid - almost 3 million inversions were completed in < 15 minutes - allowing application of this method over very large areas.

4.4-P: Subsetting Tools for MODIS Land Products: Time-series data for field sites

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Satellite imagery provides a means of extending our understanding of vegetation dynamics from site-specific studies to larger regions. However, preparing time-series of remote sensing products for small areas is computationally challenging.

The ORNL Distributed Active Archive Center (DAAC) has developed two tools to facilitate the use of Moderate Resolution Imaging Spectroradiometer (MODIS) data to examine vegetation dynamics. The first tool provides subsets in ASCII (7 x 7 km) and GeoTIFF (31 x 11 km) formats of 20 MODIS products for 280 sites worldwide. The tool provides an ASCII file of the time series pixel values for the selected product along with quality information. The data can also be viewed in a time-series plot or as an individual composite period. In addition, the GeoTIFF files can be viewed in a WebGIS system, in Sinusoidal projection. For more information see http://daac.ornl.gov/MODIS/modis.html .

The second tool creates subsets in ASCII format for user-selected areas in North America from 1 x 1 km up to 201 x 201 km area and for a user-selected time period during the MODIS record. The tool takes up to 60 minutes to complete the processing for most products, and it will send an email message containing the URL where the output can be accessed. The tool provides time series plots of the measurement, an ASCII file of the time series pixel values for the selected product along with quality information, average and standard deviations for the area selected, and a file that can be imported directly into GIS software. In addition we provide a land cover grid (IGBP classification) of the area, along with an estimate of heterogeneity.For details, please see http://www.modis.ornl.gov/modis/NorthAmerica_Tool/index.cfm .

The ORNL DAAC will offer subsets of MODIS Collection 5 data using both tools, with the second tool expanding to global coverage.

4.5-P: Vertical Structure Complexity Assessment of Tropical Forests from a Portable LiDAR System

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Vertical structure is an important physical attribute of a forest, influencing the microclimate, biogeochemical cycling, and biodiversity. Tropical forests have a highly complex structure that is altered by both natural and anthropogenic disturbances. Such disturbances could permanently affect the abundance of diversity these forest support. Current field methods for quantifying vertical structure include field-based forest survey methods which utilize indicator values such as stem density and dbh (diameter at breast height) and labor intensive optical point quadrate methods that maybe inconsistently interpreted. LiDAR (Light Detection And Ranging) remote sensing provides a method for surveying forest structure that is repeatable and less exhaustive for researchers. Traditionally, LiDAR is collected via satellite (e.g. GLAS) or airborne (e.g. LVIS, EAARL) platforms. Satellite-based LiDAR is still lacking at moderate resolutions and airborne LiDAR has only been collected in a few broad-scale studies because of the costs of data collection. This research focuses on the use of a portable LiDAR system for tropical forest survey. Our system, SYCLPS (Structure Yielding Canopy LiDAR Portable System), utilizes a first return, upward facing LiDAR (Reigl LD90-3100VHS-FLP) to provide distributional information of the canopy components. Surveys at the La Selva Biological Station, Costa Rica in July 2005 demonstrate that SYCLPS is a useful tool for defining canopy vertical structure. SYCLPS data were able to highlight differences in canopy organization between primary and secondary forests at La Selva. Further work will use SYCLPS to develop pseudo-waveforms to mimic large-footprint sensors and extend the use of SYCLPS into forest management applications.

4.6-P: Towards multi-platform validation of active fire products from moderate resolution sensors in the Amazon

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Validation of active fire products from moderate resolution sensors, such as MODIS, AVHRR or GOES Imager, requires the mapping of burning, smoldering and unburnt areas within the pixel using independent information. This can be achieved by using coincident observations from higher resolution space borne sensors, even if their band configuration is typically suboptimal for active fire mapping. Thirty meter resolution ASTER data on board the Terra satellite provide an optimum sampling configuration for the validation of the 1km Terra/MODIS active fire products, but only for a narrow range of near-nadir scan angles. Sensors from alternative platforms provide the potential to sample a wider array of observing geometries of Terra/MODIS or other moderate resolution sensors, but at the expense of a time difference between the two observations. To estimate the temporal change in summary fire statistics at the scale of the MODIS pixels, used as input parameters for validation, we analyzed 10 pairs of fire masks from same-day imagery over the Amazon from ETM+ and ASTER, flown on Landsat-7 and Terra ~ 25 minutes apart. We found that, while the progression of the fire front was observable, in some biomes the change in summary statistics was small. The sensitivity of the validation results to the input fire masks was analyzed by comparing MODIS fire detection probabilities as a function of ASTER- and ETM+ -derived summary statistics. This work is part of a new LBA-ECO Phase III study, where multi-platform validation techniques will also be used to evaluate fire detections from the GOES Imager.

4.7-P: Exploring the role of global terrestrial ecosystem in the climate-carbon cycle interactions: An Integrated modeling and remote sensing approach

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Coupled climate-carbon system models constrained by remote sensing products provide important means to address how the terrestrial ecosystem affects and reacts to changing climate and global carbon cycle. However, our current capability is still limited because of inadequately developed modeling and remote sensing data approaches. Our current and past NASA projects have made critical progresses in improving satellite data representation of global terrestrial properties and developing new model schemes for the merge of satellite data and climate models. We propose to implement these progresses to explore various terrestrial biophysical coupling mechanisms that contribute to the trajectory of atmospheric carbon, and to develop a data assimilation system that allows direct inference of vegetation dynamical properties from remote sensed radiation fluxes in weather and climate prediction. The proposed work will be conducted using NASA MODIS products and the modeling framework of the Community Climate System Model (CCSM). Our scientific objectives are to substantially advance modeling of the carbon cycle and the climate and to enhance the utilization of satellite global measurements for understanding the role of global terrestrial ecosystem in climate-carbon cycle interactions.

4.8-P: Land cover classification of the Southern Yucatan & Improvement of secondary successional forest mapping

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This research explores land cover classification in the dry tropical forests of the Southern Yucatan Peninsular Region (SYPR), Mexico, with additional emphasis on secondary successional forests. Detailed land-cover characterizations facilitate analysis of both the human and ecological landscape, but classifications of medium spatial resolution remotely sensed data are challenging. The SYPR presents both typical and distinct challenges. Typical challenges include subtle vegetation transitions and within-class variability across ecological gradients making strict delineation between classes difficult, as well as frequent cloud cover and atmospheric disturbances. Tropical dry forests are defined by a distinct amount (250-2000 mm) and seasonality (received in 4-9 months) of precipitation, creating unique classification challenges related to variable annual deciduousness (0-100%) and the resulting spectral variability in land covers. A hybrid supervised and unsupervised methodology (IPCA: In Process Classification Approach) was used to both overcome the challenges of the landscape and to explore the level of information that could be uncovered from the imagery. This approach required an iterative process including extensive field and lab work to differentiate the maximum number of land cover classes which were both spectrally separable and ecologically meaningful. Despite high overall map accuracy of 87.6%, secondary successional forest classes remain difficult to distinguish. Further research on the properties of secondary forests in the region includes extensive field data collection on species composition and structural properties over a 15 year chronosequence. Analysis of the changing spectral properties through succession and methods which best differentiate multiple age classes and late secondary stands is ongoing.

4.10-P: Development of a prototype remote sensing data assimilation system for improving land products

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The NASA Earth Observing System (EOS) Program is routinely producing high-level land products from multiple sensors. However, there exist a series of generic issues: 1). multiple sensors have not been used effectively; 2). products are not continuous in both space and time; 3). most products are generated by one instrument algorithm regardless of many algorithms developed by the remote sensing community; and 4). most algorithms have not taken advantage of temporal signatures and incorporated a prior knowledge objectively. As a result, almost all products continue to have large uncertainties that have not been well characterized, and many products are not physically consistent.

To address these issues, we have been funded to reformulate the analysis of EOS data by developing a prototype remote sensing data assimilation system. After more than two years of work, significant progress has been made. Specifically, we have 1). developed methods for generating the spatially and temporally continuous land climatology as the first guesses; 2). conducted extensive validation for determining the accuracies of the existing products; 3). developed several new algorithms for producing different estimates of variables (e.g., aerosol optical depth, leaf area index, broadband albedo) that can be integrated through a data fusion algorithm, and 4). evaluated and developed different assimilation algorithms (e.g., ensemble Kalman filter, variational optimization with the adjoint method, neural networks).

4.11-P: Fitting a two-component scattering model to polarimetric SAR data from forests

Anthony Freeman, JPL, tony.freeman@jpl.nasa.gov (Presenting)

Two simple scattering mechanisms are fitted to polarimetric SAR observations of forests. The mechanisms are canopy scatter from a cloud of randomly oriented oblate spheroids, and a ground scatter term, which can represent double-bounce scatter from a pair of orthogonal surfaces with different dielectric constants or Bragg scatter from a moderately rough surface, seen through a layer of vertically oriented scatterers. The model is shown to describe the behavior of polarimetric backscatter from a tropical forest and two temperate forest sites, by applying it to data from NASA/JPL's AIRSAR system.
Scattering contributions from the two basic scattering mechanisms are estimated for clusters of pixels in polarimetric SAR images. The solution involves the estimation of four parameters from four separate equations. This model fit approach is justified as a simplification of more complicated scattering models, which require many inputs to solve the forward scattering problem. The model is used to develop an understanding of the ground-trunk, double-bounce scattering present in the data, which is seen to vary considerably as a function of incidence angle.
Results from the model fit for the ground scattering term are compared with estimates from a forward model and shown to be in good agreement. The behavior of the scattering from the ground-trunk interaction is consistent with the presence of a Brewster angle effect for the air-trunk scattering interface. If the Brewster angle is known, it is possible to directly estimate the real part of the dielectric constant of the trunks, a key variable in forward modeling of backscatter from forests. It is also shown how, with a priori knowledge of the forest height, an estimate for the attenuation coefficient of the canopy can be obtained directly from the multi-incidence angle, polarimetric observations. This attenuation coefficient is another key variable in forward models and is generally related to the canopy density.

4.12-P: Considerations on Validation of Space Based CO2 Measurement

William Stanley Heaps, NASA Goddard, William.S.Heaps@nasa.gov (Presenting)
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The precision requirements for total column CO2 measurement from space are more stringent than any ever attempted. Similarly the requirements on a validation system for a spaceborne CO2 column measurement are very demanding. We at Goddard have been developing a Fabry-Perot based instrument for remote sensing of CO2 column. This instrument holds high promise for offering a relatively inexpensive method for measuring CO2 column from the ground at very high precision--necessary for validating space borne instruments. We shall present some results obtained using our instrument and discuss some of the factors necessary for making a measurement of total column CO2 with precision less than 1%.

4.13-P: Water Column Radiative Transfer Compensations for Coral Reef Remote Sensing

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Deterministic remote sensing classification of coral reef bottom-types requires compensation for the combined effects of variable water depths and optical properties. One approach is implicit compensation, where a classifier is trained using sea surface remote sensing reflectance spectra, and imagery is classified directly without removing water column effects. Model results suggest that, for relatively clear water at least, coral, algae and sand are largely distinguishable from each other to depths of ~20 m using this approach. We are currently collecting field data to construct the spectral library necessary for further investigation and application. Another approach is to explicitly remove water column effects from remote sensing imagery, then apply a classifier built using known bottom-type reflectance spectra. We are developing an empirical technique based on simple decorrelation of visible wavebands from known water depth. Decorrelated wavebands are corrected to absolute reflectance, then the imagery is classified based on a library of reflectance spectra from coral reefs around the world. This investigation is ongoing.

4.14-P: Satellite Microwave Retrieval of Arctic and Boreal Soil Temperature and Moisture for Biophysical Monitoring

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Soil temperature and moisture are important drivers of plant and soil biophysical processes and are strongly coupled to a changing climate in the northern latitudes. Satellite passive microwave sensors such as AMSR-E on Aqua are sensitive to soil temperature, surface moisture and vegetation, and provide a potentially useful means for quantifying spatial patterns and regional monitoring of these variables in arctic and boreal regions where frequent cloud cover, low solar illumination and sparse surface station networks constrain regional monitoring from other means. We applied AMSR-E time-series multi-channel, dual-polarization brightness temperatures with surface biophsysical information from intensive monitoring sites across Alaska and Canada to develop and verify retrieval algorithms for soil temperature and surface moisture. Microwave V-polarization brightness temperatures were well correlated ($r > 0.70$; $p < 0.001$) with near surface (< 8 cm) soil and above and below forest canopy air temperatures. We applied a microwave polarization ratio to account for land cover heterogeneity effects on microwave emissivity, which also corresponded closely with vegetation seasonal phenology inferred from the MODIS LAI time series. We then applied multi-band regression and semi-empirical polarization ratio algorithms for near surface soil temperatures, which corresponded closely (RMSE < 3.8 K; R2 > 0.80) to soil temperature data from surface network sites. The AMSR-E data were also capable of extracting meaningful soil information at even greater (up to 0.5m) soil depths. The algorithms were found to be relatively robust for regional application, while retrieval accuracy may be improved using relatively simple approaches for mitigating snow cover and freeze-thaw effects. We found a generally low level of agreement between surface soil moisture and AMSR-E operational L3 and back-up algorithm soil moisture products for boreal-Arctic monitoring sites. Alternative approaches for improved soil moisture retrievals specific to boreal and arctic biomes are presented.
This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, and at the University of Montana under contract to the National Aeronautics and Space Administration.

4.15-P: Retrieving canopy structure from MISR data

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- A very strong correlation between multiangle spectral data and canopy height has recently been reported (Kimes et al, 2006). Multivariate linear regression and neural network models developed in this study achieved high accuracies in estimating the canopy height over study sites. Although this result demonstrates the ability of MISR data to predict the vertical structure of forest canopies, the physics behind the observed correlation remains unclear.

- The probability that a scattered photon will escape the vegetation canopy in a given direction, the directional escape probability, is a canopy structural parameter that can be derived from milti-angle spectral data. Our analysis of AirMISR and airborne LVIS data suggests that the escape probability and multi-angle spectral data convey the same amount of information about the canopy height. This finding indicates that the canopy spectral invariants explain physics behind the correlation documented in (Kimes et al., 2006). This result will be discussed in the poster.

- The MISR operational LAI/FPAR algorithm is parameterized in terms of structural variables that appear in the canopy spectral invariant relationships, i.e., the portion of ground shaded area, the recollision and escape probabilities. As part of LAI/FPAR retrieval, the algorithm estimates these parameters as well as background reflectance, ground cover, LAI and FPAR. Only LAI and FPAR are being archived. We will discuss the feasibility of reliable retrieving the full set of canopy parameters generated by the operational MISR LAI/FPAR algorithm. These parameters can further be used to obtain new information on the 3D canopy structure for use in the CLM, e.g., sunlit and shaded leaf area indices, and ecological models, e.g., the aspect ratio (the ratio of tree height to tree width) and ground cover.

- Reference:

  Kimes, D.S., Ranson, K.J., Sun, G., & Blair, J.B. (2006), Predicting lidar measured forest vertical structure from multi-angle spectral data, Remote Sensing of Environment, 100, 503-511.

4.16-P: NASA's Airborne Visible/Infrared Imaging Spectrometer (AVIRIS): Current Measurement Performance and Contributions to Biodiversity, Terrestrial Ecology, and Related Applied Sciences

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The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) measures the spectral range from 370 nm to 2510 nm with better than 10 nm sampling. AVIRIS is a whiskbroom imaging spectrometer with exceptional cross-track spectral uniformity. The Spectral-IFOV-Uniformity is also near 100%. The radiometric range of AVIRIS is from 0 to the maximum Lambertian reflected radiance. With F/1 optics and minimal obscuration, AVIRIS measures high precision spectra with signal-to-noise ratios in excess of 1500:1 in the visible (@ 600 nm) and 600:1 in the short-wavelength-infrared (@ 2200nm). The spatial swath of AVIRIS is 34 degrees with a 1 milliradian instantaneous-field-of-view (IFOV). AVIRIS operates on a range of airborne platforms offering spatial resolution from 2 to 20 meters. This poster presents details of the current measurement performance of AVIRIS as well as past, present, and expected future contributions to NASA's Biodiversity, Terrestrial Ecology, and Related Applied Sciences.

4.17-P: Land long-term data record from AVHRR, MODIS and VIIRS

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As a first step toward creating a land surface long-term data record from AVHRR, MODIS and VIIRS, we have reprocessed 20 years worth of AVHRR data (1981-2000) using algorithms based on improvements identified in the AVHRR Pathfinder 2 project and on the knowledge gained from the MODIS surface reflectance activity. In this presentation, we will describe the different steps in the processing chain and how to obtain the products and calibration coefficients from our first reprocessing of these data.

Coincident MODIS data starting in February 2000 offer an invaluable asset in evaluating and assessing the accuracy of the newly created AVHRR data set. We will present preliminary results derived from the comparison of AVHRR and MODIS coarse resolution surface reflectance. They include an assessment of the AVHRR vicarious calibration approach and the impact of limited atmospheric correction of on the accuracy of the AVHRR surface reflectance and NDVI products. We plan to use the coincident MODIS acquisitions to further refine the atmospheric correction of AVHRR data and reduce the inaccuracies due to this process.

4.18-P: Variability in seasonal freeze-thaw in the terrestrial high latitudes and relationships with land-atmosphere CO2 exchange: Characterization with spaceborne microwave remote sensing

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Landscape transitions between seasonally frozen and thawed conditions occur each year over roughly 50 million square kilometers of Earth's Northern Hemisphere. These relatively abrupt transitions represent the closest analog to a biospheric and hydrologic on/off switch existing in nature, affecting surface meteorological conditions, ecological trace gas dynamics, energy exchange and hydrologic activity profoundly. We utilize time series satellite-borne microwave remote sensing to examine spatial and temporal variability in seasonal freeze/thaw cycles for the pan-Arctic basin and Alaska. Regional measurements of spring thaw and autumn freeze timing are derived using daily brightness temperature measurements from the Special Sensor Microwave Imager (SSM/I), the Advanced Microwave Scanning Radiometer on EOS (AMSR-E), and the SeaWinds-on-QuikSCAT scatterometer. We examine relationships between freeze/thaw timing as related to sensor, satellite overpass time, and landcover, and in relation to regional biospheric activity indicated by atmospheric CO2 measurements. Spatial and temporal patterns in regional freeze/thaw dynamics show distinct differences between North America and Eurasia, and boreal forest and Arctic tundra biomes. Annual anomalies in the timing of thawing in spring also correspond closely to seasonal atmospheric CO2 concentration anomalies derived from NOAA CMDL arctic and subarctic monitoring stations. Classification differences between AM and PM overpass data average approximately 5 days for the region, though both appear to be effective surrogates for monitoring annual growing seasons at high latitudes. Timing of the primary spring thaw event determined from early evening acquisitions generally precedes that determined from early morning data acquisitions for arctic tundra and boreal forest landscapes. Grasslands in the southern margins of the pan-Arctic watershed show opposite patterns for active and passive sensors. This difference in day/night thaw timing observed by radars vs. radiometers may arise from differences in the influence of vegetation on the surface energy budget across biomes.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, and at the University of Montana, Missoula, under contract to the National Aeronautics and Space Administration.

4.19-P: NASA's Land Product Validation Infrastructure

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Over the past eight years, the MODIS Land Science Team has developed a validation infrastructure that supports key activities needed to determine the accuracy of its global land products. These include resource support of the "EOS Land Validation Core Sites", coordination of EOS, MODIS and other NASA-funded land validation activities, and international leadership of efforts to establish standardized validation protocols and global land product inter-comparisons associated with NASA's priority land products. This poster presents the main components of land product validation effort at NASA's Goddard Space Flight Center.

4.20-P: Analysis of LAI of FPAR Products from the Terra MODIS Sensor: 2000-2006

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The analysis of two years of Collection 3 and five years of Collection 4 Terra Moderate Resolution Imaging Spectroradiometer (MODIS) Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation (FPAR) data sets is presented in this poster with the goal of understanding product quality with respect to version (Collection 3 versus 4), algorithm (main versus backup), snow (snow-free versus snow on the ground), and cloud (cloud-free versus cloudy) conditions. Retrievals from the main radiative transfer algorithm increased from 55% in Collection 3 to 67% in Collection 4 due to algorithm refinements and improved inputs. Anomalously high LAI/FPAR values observed in Collection 3 product in some vegetation types were corrected in Collection 4. The problem of reflectance saturation and too few main algorithm retrievals in broadleaf forests persisted in Collection 4. The spurious seasonality in needleleaf LAI/FPAR fields was traced to fewer reliable input data and retrievals during the boreal winter period. About 97% of the snow covered pixels were processed by the backup NDVI-based algorithm. Similarly, a majority of retrievals under cloudy conditions were obtained from the backup algorithm. For these reasons, the users are advised to consult the quality flags accompanying the LAI and FPAR product. This poster also summarizes the experience of several collaborating investigators on validation of MODIS LAI products and demonstrates the close connection between product validation and algorithm refinement activities.

4.21-P: Amazonia Evapotranspiration calculated from remote sensing data

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The regional ET over the Brazilian Amazonia remains uncertain since in situ observational sites do not cover its entire domain and its fetch is ~1km. The present work used an empirical method to estimate ET over the Brazilian Legal Amazon (BLA) based on satellite measurements. Satellite data include the Enhanced Vegetation Index (EVI) from the Moderate Resolution Imagining Spectroradiometer (MODIS) and radiation budget at surface from the International Satellite Cloud Climatology Project (ISCCP) for the period (2000-2004). The underlying physical justification for this empirical formula is based on the understanding that ET is primarily controlled by surface radiation and vegetation conditions as indicated by most of the flux tower observations over the Amazon forest during last two decades. The empirical model was calibrated and validate from observational measurements at 4 different sites located in the States of Pará, Amazonas and Rondônia. Observed and calculated values had the same variance (F-test) and mean values (t-student). The influence of low quality of EVI images over calculated ET values are uncertain over the west site in the Amazons state since no observational data are available for validation. Main differences are related to the type of biome (cerrado and forest) and the season. Validation by independent flux tower data (not used in the development of the empirical formula) suggests that this ET index can qualitatively capture the seasonal and interannual variations of ET for the Amazon forested areas with monthly resolution.

4.22-P: Bioinformatic Mapping of Ocean Biogeochemical Provinces

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The concept of ocean biogeochemical provinces was introduced in 1995 by Alan Longhurst. This concept provided a framework to compare and contrast biogeochemical processes over broad regions of the ocean biome. Province designations have been used to understand many biogeochemical processes, including primary production and carbon fluxes. What has been difficult to assess is the spatial and temporal variability in these provinces, which are known to be important on short term (hurricanes and eddies) and long term (Pacific Decadal Oscillation [PDO], North Atlantic Oscillation [NAO]) time scales. The temporal variability of province distribution and interaction remains a vexing issue in discriminating between secular changes (i.e., anthropogenically induced trends) and decadal cycles in the ocean system (i.e., natural variability). While oceanic biogeochemical provinces oscillate seasonally, there appears to be secular changes in oceanic provinces, the underlying causes of which we know little about (e.g. increase in global chlorophyll over the last two decades). A clearer understanding of the processes that control the distribution of oceanic provinces requires an objective method to resolve these provinces in a time-dependent manner. In the work presented here, we develop and implement a biogeochemical classification scheme based on bioinformatic analysis of ocean color and sea surface temperature that overcomes the technical difficulties of fixed boundary province classification in order to objectively elucidate the time dependent distribution of provinces. We have successfully demonstrated this approach on regional scales, and propose to apply this approach to the historic global data to elucidate the dynamics of biogeochemical province distribution.

4.23-P: Examination of Canopy Disturbance in Logged Forests in the Brazilian Amazon using IKONOS Imagery

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Structural properties of forests are closely linked with ecosystem
functioning. Forest gaps are important in an ecological sense because they are involved with tree regeneration dynamics and species diversity and distribution (Schemske and Browkaw 1981, Denslow 1987, and Vitousek and Denslow 1986). The spatial patterning and distribution are of interest to ecologists. Gaps increase light levels in understory, release nutrients, and create structural habitat for some species of flora, fauna, and fungi(Schemske and Browkaw 1981, Denslow 1987, and Vitousek and Denslow 1986). Previously, we developed a crown detection algorithm that used high resolution satellite image data. We applied this algorithm in an undisturbed tropical forest with good results. In this work we have further developed the algorithm to examine logged forests and the disturbances of such forests. Patios and gaps created by

logging create a spectral signature that is different then local maxima associated with
tree tops. By using the multi-spectral image of IKONOS along with the
higher resolution panchromatic image, our refined algorithm estimated gap size and frequency and spatial patterning. Ability to estimate logging impacts in vast areas of the Brazilian Amazon using IKONOS imagery is vital in attempts to understand the regional carbon balance.

Examination of Tropical Forest Canopy Profiles Using High Res

4.24-P: Satellite Remote Sensing and Biological Impacts of Climate Change: A Case Study of the California Mussel

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Studies of intertidal organisms have contributed significantly to the understanding of complex biological responses to climate change. The intense thermal stresses characteristic of rocky coastal settings facilitate rapid population shifts, causing these habitats to be especially susceptible to deviations in weather patterns. Traditional in situ measurements are confined to specific areas and often span short time periods. This study proposes the use of satellite remote sensing techniques to expand these highly important climate studies into regional-scale monitoring over longer periods of time. To test this application, study sites were chosen along the Pacific coast of the U.S. within the rocky intertidal zones of California, Oregon, and Washington. Data from in situ sensors are used as ground references, and are the result of an on-going 10-year study of Mytilus californianus conducted at the Univ. of South Carolina. Satellite imagery includes a compilation of ASTER and MODIS land surface temperature (LST) data sets, with resolutions of 90 m and 1 km, respectively. Preliminary results indicate that the MODIS data set is more effective at representing logger observations compared to the ASTER imagery. Further comparisons include the difference between the morning and afternoon MODIS overpasses (via the Terra and Aqua satellites, respectively).

4.25-P: Testing a promising remote sensing of methane with in situ observations of emissions from a natural marine hydrocarbon seep

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The sources and sinks of methane, an important greenhouse gas, are poorly constrained. Remote sensing techniques can significantly improve our understanding of sources and sinks. Field and labortory studies used spectral and in-situ chemical measurements of methane emissions from natural marine seepage and radiative transfer calculations to test the feasibility of remote sensing from the AVIRIS platform on this marine source. Numerical MODTRAN simulations showed that although most of the spectral region between 2200 and 2340 nm is sensitive to CH4 it is only mildly sensitive to interference from H2O vapor.

Repeated transects of an intense marine seep area were conducted and flame ion detector (FID) measurements made of the methane plume. Based on a Gaussian plume model of observations, methane column abundances were calculated and showed values of 0.5 g/m2 to a downwind distance of 70 m. MODTRAN calculations showed that this was well above the noise equivalent detection level of AVIRIS.

During a separate field study, three FIDs at 2.2, 3.6, and 5 m above the sea surface recorded methane concentrations as high as 200 ppm while transecting an active seep area. Contemporaneously, spectra were obtained with a field spectrometer. Several plumes were identified from the FID data. A clear relationship was shown between the presence of methane plumes along the incident pathlength and the presence of methane absorption features in spectra, while methane absorption features above atmospheric background were not observed outside the plumes.

4.26-P: LIDAR Height Measures in Tropical and Coniferous Forests

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Combined LIDAR and hyperspectral measures have the potential of improving our ability to estimate carbon stocks, through biomass-height relations and carbon fluxes, through improved maps of forest species and physiology. While strong relationships have been observed between LIDAR-derived heights and above ground biomass, significant questions remain, such as whether these relationships are global or site specific depending on management, disturbance and climate. Furthermore, it is unclear the extent to which hyperspectral data complement LIDAR by providing measures of health, physiology and species. To address these questions, we have begun a program evaluating LIDAR and hyperspectral data at six highly variable sites ranging from tropical rainforest (La Selva), western coniferous forest (Wind River and Sierra Nevada), central United States (Yellowstone) to east-coast broadleaf deciduous forest (Harvard Forest, SERC). In this poster we report upon initial analysis of LIDAR data at La Selva, Wind River and Yellowstone.
Two approaches were employed to generate a Digital Terrain Model (DTM) and calculate a Digital Canopy Model (DCM) from LIDAR. Both relied upon the concept of identifying bare earth between crowns, but relied on different means for determining appropriate window sizes and interpolating a DTM. LIDAR heights were evaluated for individual trees at all three sites and plots for two sites. In general, all sites showed a high correlation between LIDAR heights and measured heights that improved at plot scales. LIDAR tended to underestimate tree height, with errors increasing for more dense stands and for shorter trees. The most accurate tree heights were estimated at La Selva for pasture trees and for open stands at Yellowstone. Common error sources included rugged terrain, the inability to estimate an accurate DTM for dense stands and sparse LIDAR point density. Biomass showed a near-linear relationship to LIDAR-height at La Selva, but appears non-linear at Wind River.

4.27-P: MODIS BRDF/Albedo Products and Applications

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The MODIS BRDF/Albedo products currently provide robust measures of the albedo and characteristic anisotropy of the global land surface. The algorithm depends on high-quality, multi-day, cloud-free, atmospherically-corrected surface reflectances and a linear kernel-driven model of the surface anisotropy. Products have been tailored to meet the needs of the global and regional modeling communities as well as those of users of direct broadcast and field instrumentation data. The newest reprocessing of the operational products (version 005) is now underway and represents several major enhancements including increased spatial resolution (500m), improved temporal resolution (every 8 days based on the last 16 days of directional observations) and simplified quality fields. The direct broadcast algorithm further enhances the operational products by providing a daily rolling product that is tailored to a specific region. Validation of both the daily and periodic values has begun and early results will be presented.

4.28-P: Putting the puzzle together: Connecting the HyperSAS with BreveBuster absorbance spectra, fluorometer, extracted chlorophyll and MODIS data.

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The absorbance characteristics of different phytoplankton classes vary due to specific photosynthetic accessory pigments. This phytoplankton class specificity has been used with HPLC and Chemtax for taxonomic purposes. Since hyperspectral sea surface reflectance is strongly affected by phytoplankton spectral absorbance, the extension of phytoplankton taxonomic discrimination to remote sensing applications appears feasible. Hyperspectral data was recorded with a Satlantic HyperSAS configured with 166-channel MiniSpec radiance and irradiance sensors during daylight travel. HyperSAS remote sensing reflectance was used to calculate chlorophyll *a*, which was compared to *in situ* fluorometric, extracted, and MODIS chlorophyll determinations. HyperSAS chlorophyll *a* calibrations against other methods gave a sigmodial response. Discrete phytoplankton absorption spectra were calculated from the HyperSAS data, Kishino filter method, and a BreveBuster using a liquid-waveguide capillary cell during day and night travel to measure absorbance spectra. The HyperSAS calculated absorption was in reasonable agreement with the other methods. The influence by several different water masses including the Equatorial Undercurrent, the Panama Current from the north, the Humboldt Current from the south, as well as the temporal variability seasonally contributed to changing phytoplankton absorption spectra over short distances based on temperature and salinity.

4.29-P: Quantifying the impact of cloud obscuration on remote sensing of active fires in the Brazilian Amazon

Wilfrid Schroeder, University of Maryland, schroeder@hermes.geog.umd.edu (Presenting)

Vegetation fires continue to play a significant role in land and atmospheric processes globally. Their occurrence is particularly important in tropical regions where human activity is still heavily based on the use of fires for land use management and land cover change. Correct quantification of fire events is needed primarily for understanding the dynamics of land use and land cover change, as well as for providing information for modeling of emission estimates from biomass combustion. A major factor influencing fire numbers derived from remotely sensed data is the effect caused by cloud obscuration. Current methods used to compensate satellite active fire detection numbers to account for fires missed due to cloud obscuration tend to rely on the assumption that fires occur with the same frequency under cloud covered areas as they do in the open. The simplicity of this assumption will often cause an overestimation of fire omission due to clouds, especially in areas where fires are unevenly distributed in space. Here I present an alternative approach that uses physical (precipitation) and social (fire use history) information to more precisely quantify the potential omission error associated with the cloud obscuration affecting satellite active fire detection products. The proposed approach is applied to a geostationary satellite fire data set in order to characterize the cloud effect on fire detection over the entire diurnal cycle. The analyses are focused on the Brazilian Amazon basin where intense fire activity and frequent cloud cover are prevalent.

4.30-P: Temporal Decorrelation Studies Relevant for a Vegetation InSAR Mission

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For mapping vegetation 3-dimensional structure, there are currently two principal methods. One method is to use full waveform lidar to map the canopy reflective properties as a function of range within the illuminated spot of the lidar. The second method is to use radar interferometry to collect the spatial frequencies which are used to estimate the 3-D structure of vegetation canopies over the radar swath. A realistic scenario for implementing a spaceborne 3-D structure mapping mission will likely include some combination of these two technologies, thus making best use of the high resolving power of the lidar measurements while benefiting from the all weather and wide swath

coverage of the SAR observations. Because of dimensional and orbital constraints, the InSAR portion of such a mission would likely use a repeat-pass observing strategy to measure the interferometric response of vegetation one spatial frequency at a time. In this observing scenario, the change of the target's geometry over time would be the principal error source in determining the vegetation 3-D structure. In this poster we discuss early results from existing airborne and satellite data for quantifying temporal decorrelation at L-band and P-band and present observing strategies which can be implemented in a spaceborne mission. By continuing this study of temporal decorrelation and quantifying its affect on 3-D structure estimation, we will provide critical information for designing a mission to make these measurements from a spaceborne platform.

4.31-P: Wind-Driven Upwelling in Lakes: Water Clarity and Fish Mortality

Todd Steissberg, University of California, Davis, tsteissberg@ucdavis.edu (Presenting)
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Thermal infrared images acquired by high- and moderate-resolution satellite instruments can be used to observe wind-driven upwelling in lakes and can provide a measure of their spatial variability and horizontal distribution, information that conventional field-based measurements cannot provide. The surface temperature maps derived from MODIS, ASTER, and Landsat ETM+ images enabled the characterization of wind-driven upwelling at Lake Tahoe, CA-NV and the Salton Sea, CA. At Lake Tahoe, the satellite images, paired with time series of in situ buoy-mounted surface thermistor and meteorological data, have shown that partial upwelling events occur at least twice monthly, on average, throughout the spring and summer stratified period, transporting water from intermediate depths to the surface. Partial upwelling events were found to generally decrease lake clarity, although deeper (full) upwelling events can increase clarity. At the Salton Sea, strong winds induced upwelling of hypolimnetic water, which due to their high concentrations of ammonium and hydrogen sulfide and low concentration of oxygen, are likely responsible for the massive fish kills reported there. Several fish-kill events at the Salton Sea were investigated using a combination of in situ wind data and MODIS thermal infrared images. Major fish kills occurred 1 - 5 days after strong sustained wind events in 12 of the 14 cases analyzed, suggesting that these fish kills are caused by wind-driven upwelling. Evaluation of satellite-derived surface temperature maps, available for five of these events verified that wind-driven upwellings did occur, confirming the relationship between wind-driven upwelling and fish-kill events in the Salton Sea.

4.32-P: Retrieval of Vegetation Structure and Carbon Balance Parameters Using Ground-Based Lidar and Scaling to Airborne and Spaceborne Lidar Sensors

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This research will use ground-based, upward-scanning hemispherical lidar to retrieve forest canopy structural information, including tree height, mean tree diameter, basal area, stem count density, crown diameter, woody biomass, and green biomass, and link this information to airborne and spaceborne lidars to provide large-area mapping of structural and biomass parameters. The terrestrial lidar instrument, Echidna(TM), developed by CSIRO Australia, allows rapid acquisition of vegetation structure data that can be readily integrated with downward-looking airborne lidar, such as LVIS (Laser Vegetation Imaging Sensor), and spaceborne lidar, such as GLAS (Geoscience Laser Altimeter System) on ICESat.
Lidar waveforms and vegetation structure will be linked for these three sensors through the hybrid geometric-optical radiative-transfer (GORT) model, which uses basic vegetation structure parameters and principles of geometric optics, coupled with radiative transfer theory, to model scattering and absorption of light by collections of individual plant crowns. Use of a common model for lidar waveforms at ground, airborne, and spaceborne levels will facilitate integration and scaling of the data to provide large-area maps and inventories of vegetation structure and carbon stocks.
Our research plan includes acquisition of Echidna(TM) under-canopy hemispherical lidar scans at North American test sites where LVIS and GLAS data have been or are being acquired; analysis and modeling of spatially coincident lidar waveforms acquired by the three sensor systems; linking of the three data sources using the GORT model; and mapping of vegetation structure and carbon-balance parameters at LVIS and GLAS resolutions based on Echidna(TM) measurements.

4.33-P: Test impacts of cloud and aerosols on methane retrievals using 3D CTM.

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We compared our model (MATCH driven by NCEP Reanalysis data) simulations of methane column burdens with remotely sensed data from SCIAMACHY for the year 2003. The model agrees very well with observations in terms of spatial distribution. The linear regression slope is 1.01 for yearly averages, and 0.96-1.05 for monthly averages. The model has 2.7E18 molecules/cm2 offset (~8% of the total CH4 column) compared with observations, when using effective cloud heights estimated by the retrieved CO2 column. In order to remove this offset, we further investigated the impact of cloud and aerosols on methane column estimates. The correlation of SCIAMACHY methane column with the cloud top height, estimated using the FRESCO scheme, increases with cloud fraction. When the sky is overcast, they are linearly correlated with an r2 of ~0.8. When the FRESCO cloud information, including cloud fraction and effective cloud height, is incorporated, we found that the model-satellite comparison splits into two branches: one is correlated with the cloud top height, while the other is not, especially when the cloud fraction is small. We then tested the impact of aerosols on the methane column, cloud fraction and cloud top height retrievals. We used MODIS aerosol optical thickness (AOT) at 550 nm, when it is overlapped with SCIAMACHY orbits. MODIS and SCIAMACHY footprints have about 30-60 min temporal differences. We assume the aerosol distribution does not vary during this time period.

4.34-P: Monitoring Vegetation State and Disturbance Using the MOD44 Product Suite

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Time series of MODIS surface reflectance data are utilized to characterize vegetation phenology and to derive products which depict land cover state (percent cover products from MODIS Vegetation Continuous Fields, MOD44B) and land cover change (disturbance products from MODIS Vegetative Cover Conversion, MOD44A).

Recent results are presented including global tree cover and leaf characteristics; forest fragmentation; tropical deforestation; persistent change due to burning; and innundation.

4.35-P: 3-Dimensional Tropical-Forest Structure from Interferometric SAR

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Global monitoring of the 3-dimensional (3-D) structure of vegetation bears on both the carbon cycle and the functioning and productivity of ecosystems. Beyond its relevance to fire susceptibility and habitat characterization, detailed 3-D information on the vertical distribution of vegetation seems to correlate strongly with forest biomass, perhaps more so than traditionally remotely sensed radar power, optical radiance, or tree height alone. Recent evidence suggests that the vertical profiles of vegetation needed to supply the third remotely sensed dimension can be estimated from multiple interferometric synthetic aperture radar (InSAR) observations—with multiple baselines, frequencies, or polarizations. Multialitude InSAR data taken with AirSAR over La Selva Biological Station in Costa Rica effectively provide a multibaseline InSAR data set from which to estimate vegetation density profiles. First InSAR profiles from La Selva primary and secondary forests as well as abandoned pastures demonstrate the current profile sensitivity and level of error. Comparisons to extensive field-measured profiles and lidar measurements show the potential of InSAR profiling and suggest spatial scales over which tropical-forest profiles change. Comparing InSAR, field, and lidar, each with their own errors, also helps to underscore the complexity of the characterization and use of the third dimension in forest remote sensing. The exact specifications of which quantities should or can be measured remotely, and which lateral and vertical resolutions would be most advantageous, are active areas of inquiry supported by this research.

Remote sensing measurements of forest properties are rarely direct. Biophysical estimates result from observations of electromagnetic power and phase. The means of connecting the electromagnetic signals to the underlying biophysics vary from statistical regression to physical models. The profiles in this study are derived from physical models, the approximations of which are quantifiable and beacons to the next observational and analytic steps. In addition to the 3-D profiles they produce, they provide a solid, quantitative paradigm for future NASA remote sensing.

4.36-P: Measuring Fisher Success, A Landscape Approach

Tracy Van Holt, University of Florida, tvanholt@ufl.edu (Presenting)

A mosaic of agriculture, cattle ranching, urban areas, forest plantations, and one of the world's few temperate rainforests is home to over 500 small-scale fishers in the Valdivian region of Chile. Land cover change over the past 20 years has impacted the fishers as health of the loco shellfish (Chilean Abalone) is associated with land cover/use and roads offer greater access to markets. The changing environment highlights the contrast between the success of fisher organizations and associated fishers in garnering high prices for their products which is both socially and ecologically dependent. This study builds on the theoretical anthropological framework of the "skipper effect," which addresses why some fishers catch more fish than others, given equal knowledge, experience, and equipment. In this study, we used profit or sale price rather than catch per unit effort as a measure for success. Ecosystem characteristics such as shellfish health, ecological integrity of the seascape, road connectivity, and landscape characteristics were included in addition to traditional skipper effect measures of knowledge, experience, and material factors. We surveyed over 300 fishers in 12 fishing cooperatives in southern Chile about their success and analyzed the trade offs between social and ecological factors. This work may give insights towards integrative research on resource management in linked social-ecological systems.

4.37-P: Impact of Pixel Size on Mapping Surface Water in Subsolar Imagery

Vern C Vanderbilt, NASA Ames Research Center, Vern.C.Vanderbilt@nasa.gov (Presenting)
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We observed surface water in a wetland, imaging in the subsolar or specular direction the exceptionally bright specular reflection of sunlight at a ground resolution of 0.3 m. We then simulated ground resolutions between 1.7 m and 1.2 km through aggregation of the 0.3 m pixels.

Contrary to expectations, for these data, the accuracy of spectral mixture analysis (SMA) estimates of surface water increases as pixel ground footprint size increases. Our results suggest that regional to global scale assessments of flooded landscapes and wetlands that do not involve issues requiring one meter resolution per se may be addressed with acceptable accuracy by applying SMA techniques to low resolution imagery.

Our results indicate within-pixel estimates of surface water area derived from data measured by subsolar viewing sensors with large ground pixel footprints, such as satellite POLarization and Directionality of Earth Radiance (POLDER) data, may be highly accurate under moderate surface wind conditions.

4.38-P: Improving access to Land and Atmosphere science products from Earth Observing Satellites: Helping NACP investigators better utilize MODIS data products.

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NACP ACCESS is a NASA-funded project supporting the upcoming North American Carbon Program (NACP), a component of the USGCRP Carbon Cycle Science Program. The purpose of this ACCESS project is to provide researchers with MODIS data products that are custom tailored for use in NACP model studies.

The NACP is designed to provide the scientific underpinning to inform future policy decisions involving the carbon cycle, such as managing carbon sources and sinks by efficient and effective options to reduce emission or enhance carbon sinks.

Our strategy is to offer a wide range of processing capabilities to be applied to any of the MODIS land and atmosphere products for a focus group of NACP investigators. During this first year we will develop the capacity to provide these investigators with very specific products that precisely match their needs. In year two we will expand the number of users to ~30 while assessing which requests/tools are most common among users. Year three would then develop an operational capacity for the most requested and/or critical tools.

This poster shows some results of our progress to date.

4.39-P: Coherent Radar Backscatter Modeling of Three-Dimensional Forest Canopies

Guoqing Sun, Department of Geography, University of Maryland, quoqing@ltpmail.gsfc.nasa.gov (Presenting)
Dawei Liu, Institute of Remote Sensing Applications, Chinese Academy of Sciences, david_liu863@163.com

A three-dimensional coherent radar backscattering model for forest canopies based on realistic three-dimensional scene is described in this paper. The realistic spatial structure of forest canopies is established through combined use of forest growth model and fractal tree model. A forest growth model parameterized using local environmental parameters provides information of forest stands structure composition in different growth phases. A fractal tree model (L-system) was used to simulate individual 3-D tree structure of different ages or heights. A forest stand is composed of trees with species and sizes simulated from tree growth model. Trees were randomly positioned in a stand resulting in a 3-D medium of discrete scatterers. The radar coherent backscatter model takes the 3-D forest scene as input and simulates the coherent radar backscattering signature. The scattering matrices of all scatterers within a pixel are coherently added to yield the total backscattering field. In this process, the phase information of backscattering is preserved, so the model can be used to simulate interferometric SAR data.
The simulation results of the coherent model were compared with the JERS-1 L-band SAR and ENVISAT ASAR C-band data from pure birch forests of Changqing test site in Daxinganling, Northern China. In sensitivity analysis of this model, the scattering phase center height simulation of birch forest stands shows that interferometric SAR response to forest canopies is influenced by its spatial structure intensively.

Agricultural Efficiency Posters

5.1-P: Near-Real Time Monitoring of Global Lakes and Reservoirs: Water Resources, Irrigation Potential and Agriculture.

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Brian Beckley, GST, brianb@nemo.gsfc.nasa.gov (Presenting)
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Satellite radar altimetry has the ability to monitor variations in surface water height (stage) for large lakes and reservoirs. A clear advantage is the provision of data where traditional gauges are lacking or where there is restricted access to ground-based measurements. As part of a USDA and NASA funded program, near-real time altimetric monitoring of the largest lakes and reservoirs in the world is currently underway. Data ingestion and manipulation follows the path of the NASA Ocean Altimeter Pathfinder Project. In Phase I African lakes were under scrutiny but Phase II allowed a more global outlook. Initial focus was on the historical Topex/Poseidon archive (1992-2002) with near-real time data from the Jason-1 mission (post 2002). The project has now progressed into Phase III, where data products from the US Navy's GFO mission are being brought on-line (post 200). Although global in outlook, the work focuses specifically on those reservoirs in prime agricultural areas particularly noting those regions that are susceptible to severe drought conditions. Reservoirs in Africa, Turkey, Afghanistan, Pakistan, India, Kyrgyzstan, Iran and Iraq are of particular interest.

The project utilizes satellite radar altimetry datasets and delivers graphic and text file products relating to elevation changes to a world-wide web site. Height accuracies are expected to be better than 10cm for the largest of the world's lakes, and product delivery time for the Jason-1 mission is ~2weeks after satellite overpass accounting for raw data availability, satellite orbit upgrades, and weekly product updates at NASA/GSFC. The lake products are primarily used by the Foreign Agricultural Service's, Precipitation Estimation and Crop Assessment Division (PECAD), for observation of flood/drought conditions and for analysis of reservoir volume and irrigation potential.

5.2-P: Improved Global Agricultural Assessment and Forecasting from AMSR-E Soil Moisture Estimates

John Bolten, USDA-ARS Hydrology and Remote Sensing Lab, jbolten@hydrolab.arsusda.gov (Presenting)
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The United States Department of Agriculture (USDA) Production Estimates and Crop Assessment Division (PECAD) monitors and predicts global food supplies through the combination of meteorological, remote sensing, crop model and soil moisture model data.
These assessments are provided by the PECAD Crop Assessment Data Retrieval and Evaluation (CADRE) Data Base Management System (DBMS). Of particular importance to the timely and accurate estimation of crop yield forecasts in high impact areas is the frequent regional characterization of near surface soil moisture. In the past, reliable soil moisture estimates used by CADRE have been calculated from daily precipitation and temperature extremes at point locations. For over four years, the NASA EOS Advanced Microwave Scanning Radiometer (AMSR-E) on the Aqua satellite has provided daily global soil moisture products. There are several alternative retrieval methods that are undergoing validation. The current research presents a methodology for integrating direct soil moisture observations from AMSR-E into the USDA CADRE to improve the predictive capability of PECAD crop forecasting capability. This presentation will give an overview of the current soil moisture model, the Ensemble Kalman Filter data assimilation algorithm, and expected results of the assimilated soil moisture data accuracy assessment. Comparisons of the AMSR-E and USDA calculated soil moisture datasets will also be presented.

5.3-P: Observing how carbon, energy, and water transports fluxes change with the introduction of intensive agriculture in the Amazon.

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This study presents direct turbulent flux measurements of carbon, heat, and moisture at an agricultural site near Santarém in the Eastern Brazilian Amazon. Since September 2000, agricultural practices in this region have changed rapidly from cattle grazing, to upland (non-irrigated) rice cultivation, and then to soybean cultivation. The pattern we witnessed in the sampled field is characteristic of the entire region along the BR-163 highway that runs south from the city of Santarém, Pará. At the LBA-ECO km77 site, global radiative fluxes turbulent heat, water vapor and CO2 fluxes, soil heat fluxes and surface layer, state variables are monitored.
We found that the eddy covariance (EC) technique fails to predict the fluxes accurately such is the case at the km77 site on nearly all nights. We estimated respiration fluxes by the boundary layer accumulation approach. during two field campaigns.
Seasonal changes in greenness and reflectivity measured in situ follow the patterns of daytime evaporation and carbon uptake. Lowest values of the Bowen ratio were observed during wet periods, principally during rice plantation. NEE in this field and it is larger than that in the adjacent undisturbed forest. After plowing and tilling there is a small efflux of CO2.
Continuing studies. We seek support to maintain the ongoing measurements. To our knowledge, the km77 agricultural site is unique in the Amazon for having continuous direct flux measurements for a long period of time. Continuing data analysis that is part of our ongoing LBA-ECO phase 3 concentrates on the linking remote sensing measurements (e.g., NDVI from MODIS and microwave band) with in situ measurements such as the radiometric and turbulent fluxes. Clear differences result in the turbulent fluxes (CO2, H2O, and heat,), radiative parameters (albedo and PAR-albedo) due to the landscape changing from pasture to crop field.

5.4-P: Integrating NASA Earth Science Data into Global Agricultural Decision Support Systems: Data Analysis and Visualization to Ensure Optimal Use

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Monitoring global agricultural crop conditions during the growing season and estimating potential seasonal production are critically important for market development of U.S. agricultural products and for global food security. Two major operational users of satellite remote sensing for global crop monitoring are the USDA Foreign Agricultural Service (FAS) and the U.N. World Food Program (WFP). The primary goal of FAS is to improve foreign market access for U.S. agricultural products. The WFP uses food to meet emergency needs and to support economic and social development. Both use global agricultural decision support systems that can integrate and synthesize a variety of data sources to provide accurate and timely information on global crop conditions. In addition, new products that further support agricultural decision support systems, using remote sensing data as inputs, are continuously being developed by USDA Agricultural Research Service (ARS). The integration of relevant NASA Earth Science data into the modeling and operational systems employed by these agencies will greatly enhance the accuracy and timely assessments of global agricultural crop conditions during the growing season.

This poster presentation describes the details and accomplishments of the NASA funded project that provides specific required NASA remote sensing data products that enhance decision support system accuracy. The project is comprised of 6 activities: Activities 1 and 2 are the development of operational, agriculture-oriented data products derived from MODIS and TRMM, based on extensions of previous NASA-sponsored work; Activity 3 is the generation of a MODIS 250-m, 10-day composite surface reflectance product, developed to be consistent with FASs 10-day boundary products; Activity 4 is the development of an Agricultural Information System (AIS), based on the existing Goddard Earth Sciences Data and Information Services Center (GES DISC) data analysis and visualization system, Giovanni; Activities 5 and 6 are the integration of ESE products into the existing decision support systems of FAS and WFP, respectively

Project accomplishments, including new products, data validation results, data access displays, new data management technologies employed, and real and potential impacts to agricultural decision support systems will be presented.

5.5-P: Quantifying impacts of water management on crop yield, net greenhouse gas emissions and water use efficiency for rice production in Asia with remote sensing and biogeochemical modeling approaches

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Driven by increasing demand for water resources due to urbanization and climate change, most of the rice-producing countries in Asia are developing alternative management practices to increase water use efficiency for rice production, a traditionally water-consuming industry, meanwhile to maintain optimum yields. Since rice paddies is an important source of atmospheric methane, predicting impacts of the changes in water management on methane emissions at large scale could be helpful to answer the question, i.e., in what degree human's activity in agriculture could alter atmospheric chemistry. An integrated approach constructed by combining remote sensing analysis with a biogeochemical model, DNDC, was applied for the 120 million hectare of rice fields in 18 major rice-producing countries in Asia to quantify methane emissions under three alternative water management conditions. The results indicated that converting the conventional management practice (i.e., continuous flooding or CF) to midseason drainage (MD), which is currently being spread in Asia, would reduce the total methane emission from the Asian rice fields by 40% (from 28 to 17 Tg CH4-C); and applying a new practice (i.e., shallow flooding or SF) reduced the emission by 75% (7 Tg CH4-C). The magnitude of the reductions is so large that could affect the trend of methane accumulation in the atmosphere. By the conversion of CF to MD or SF, nitrous oxide (N2O) emissions from the rice fields increased from 1.0 to 1.2 or 1.5 Tg N, respectively. The entire Asian rice land is a weak source of atmospheric carbon dioxide (CO2) with 140 Tg C annually released into the atmosphere. The changes in water management only slightly decreased the CO2 emissions. Converting CF to MD or SF elevated the total rice production of the 18 countries from 0.56 to 0.63 or 0.65 trillion tons, respectively, meanwhile reduced water use from 1.45 to 1.34 or 1.10 trillion cubic meters, respectively. It is the increase in yield and the decrease in water use that motivate the farmers to adopt the new water management practices, which unintentionally reduced net greenhouse gas emissions by 180- 360 Tg CO2 equivalent each year for the rice agriculture in Asia.

5.6-P: The Global Agriculture Monitoring (GLAM) Project: Enhancing Crop Production Forecasting and Agricultural Monitoring Capabilities of the Foreign Agriculture Service using Moderate Resolution Satellite Data

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The Global Agriculture Monitoring (GLAM) Project aims to enhance the agricultural monitoring and the crop-production estimation capabilities of the USDA Foreign Agricultural Service (FAS) using NASA's moderate resolution satellite data. The project is a collaboration between NASA/GSFC, USDA/FAS, and University of Maryland Department of Geography.

The primary mission of the FAS is to deliver objective, timely and regular assessments of global agricultural production and of the conditions which affect it. To help achieve this goal, the GLAM project provides the FAS with multiple remotely sensed data sets and derived products from moderate resolution sensors for target agricultural regions worldwide.

To monitor crop conditions and to locate and track the factors impairing agricultural productivity, a web-based information-analysis and data-delivery system has been developed. This system provides the FAS crop analysts with a suite of MODIS temporal composites of vegetation index (VI) data, false color imagery, and a dynamic, interactive crop likelihood mask. The system's web interface provides a range of analysis tools that allow crop analysts to interrogate these data and to drill down to the pixel level of detail. As a result, analysts can better characterize land surface conditions and monitor changes in the key agricultural areas. For near real time assessment and evaluation of disaster events, daily global data are provided from the MODIS Rapid Response system, which delivers data within 2-4 hours of satellite acquisition. These data and tools help FAS analysts track the evolution of the growing season, and inform decision makers of agricultural conditions and agricultural impediments to worldwide food-security.

5.7-P: An Observational and Modeling Study of Regional Impacts of Climate Variability at Agricultural Scales

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Cynthia Rosenzweig, NASA GISS, crosenzweig@giss.nasa.gov

Climate variability has large impacts on humans and their agricultural systems. Climate variability and its regional impacts are explored in NASA observations and NASA models for the current and future climate. The goals are to identify impacts of observed variability, assess model simulation of variability, and explore how climate variability and its impacts may change under enhanced greenhouse warming.

Multiple versions of NASA GISS Atmospheric General Circulation Models (AGCMs) are hindcast with observed sea surface temperatures (SST). Over a recent cycle of El Niño and La Niña, all versions produce appropriate local changes. SST forced model analysis is extended to multiple ENSO events and additional modes, with emphasis on key agricultural regions. Key findings are that the model can reproduce: 1) the spatial pattern associated with two additional related modes, the AO and NAO; and 2) rainfall features and dynamical features such as SLP gradients and wind in the study regions.
ENSO impacts are assessed in the region where the models show the most promise: Indonesia. Early rainy season precipitation and circulation, and same-season planting and harvesting dates, are shown to be sensitive to ENSO. The locus of ENSO convergence and rainfall anomalies is shown to be near the axis of rainy season establishment, defined as the 6-8 mm/day isohyet, an approximate threshold for irrigated rice cultivation. Circulation anomalies associated with ENSO are shown to be similar to those associated with rainfall anomalies, suggesting that long lead-time ENSO forecasts may allow more adaptation than 'wait and see' methods, with little loss of forecast skill. Under doubled CO2, the model able to capture ENSO dynamics - an atmospheric model coupled to the Cane-Zebiak ocean model ('C4' here) - generates more El Niño-like mean conditions in the tropical Pacific. These changes produce a 4x larger increase in maximum precipitation with warming in C4 than an atmospheric model with a slab ocean (Q4), dramatically enhancing the Pacific Hadley and Walker circulations, and through positive feedbacks, increasing the global temperature.

Science Support Posters

6.1-P: WaterNet: The NASA Water Cycle Solutions Network

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WaterNet will optimize the sustained ability of water cycle researchers, stakeholders, organizations and networks to interact, identify, harness, and extend NASA research results to augment decision support tools and meet national needs.

6.2-P: Addressing the unique safety and design concerns for operating towers in scientific field campaigns.

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Scientific field campaigns often require specialized technical infrastructure for data collection. NASA's LBA-ECO Science Team needed a network of towers, up to 65 meters in height, to be constructed in the Amazon forest to serve as platforms for instrumentation used to estimate carbon dioxide and trace gas fluxes between the forest and the atmosphere. The design, construction, and operation of these scientific towers represented unique challenges to the construction crews, the logistics support staff, and the scientists due to operational requirements beyond tower site norms. These included selection of safe sites at remote locations within a dense forest; building towers without damaging the natural environment; locating diesel generators so that exhaust would not contaminate the measurement area; performing maintenance on continuously energized towers so as not to interrupt data collection; training inexperienced climbers needing safe access to towers; and addressing unique safety concerns (e.g. venomous animal response, chainsaw safety, off road driving).

To meet the challenges of the complex field site, a comprehensive safety and site operation model was designed to ensure that NASA field safety standards were met, even under extreme conditions in the remote forests of the Amazon. The model includes all phases of field site safety and operation, including site design, construction, operational practices and policies, and personnel safety training. This operational model was employed over eight years, supporting a team of nearly 400 scientists, making several thousand site visits, without loss of life or major injury. The presentation will explore these concerns and present a model for comprehensive safety plans for NASA field missions.

6.3-P: Enhancing Linkages Between Projects and Datasets: Examples from LBA-ECO for NACP

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Peter C. Griffith, Science Systems & Applications, Inc. and the Carbon Cycle and Ecosystems Office, NASA Goddard Space Flight Center, peter.griffith@gsfc.nasa.gov

The Carbon Cycle and Ecosystems Office is developing ideas to build a warehouse of metadata resulting from the North American Carbon Program. The resulting warehouse and applications would be very similar to those developed for the LBA-ECO Project (www.lbaeco.org). The harvested metadata would be used to create dynamically generated reports, available at www.nacarbon.org, which would facilitate access to NACP datasets.

Our primary goal is to, as much as possible, associate harvested metadata with its corresponding project group profile. This also addresses high-priority goal #4 of the NACP Data System Task Force to "link the dataset metadata index with the project metadata index generated and maintained by the NACP Office"[1]. The benefit of achieving this goal will be the maximization of data discovery by association of each dataset with its corresponding NACP project group profile. This provides a greater understanding of the scientific and social context of each dataset. This will be challenging, because the datasets exist in many different formats, residing in many thematic data centers and

also distributed among hundreds of investigators. Among other things, this situation creates a lack of consistency in how associated metadata is composed, thereby limiting our ability to fully automate metadata harvesting as well as dynamic generation of a wide variety of associated reports.

Our presentation will give a brief technical overview of how we plan to harvest the metadata. We currently only harvest metadata that is in an XML format. However, not all NACP datasets have corresponding metadata in XML. Therefore, we will need to expand upon our current capabilities by creating harvest and ingest scripts that can extract metadata in other formats.

We will also demonstrate what we can do for NACP by looking at what we have already done for LBA-ECO. For example, the LBA-ECO website (www.lbaeco.org) provides a profile (e.g. participants, abstract(s), study sites, and publications) for each LBA-ECO investigation. These profiles are very similar to the NACP project profiles. Linked from each profile is a list of associated registered dataset titles, each of which link to a dataset profile that describes the metadata in a user-friendly way. Moreover, each dataset profile contains hyperlinks to each associated data file at its home data repository and to publications that have used the dataset.

We also use the harvested metadata from the LBA Project in administrative applications to assist quality assurance efforts. These include processes to check for broken hyperlinks to data files, automated emails that inform our administrators when critical metadata fields are updated, dynamically generated reports of metadata records that link to datasets with questionable file formats, and dynamically generated region/site coordinate quality assurance reports. These applications are as important as those that facilitate access to information because they help ensure a high standard of quality for the information. Where possible, we hope to create similar reports for NACP.

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[1] *Prioritized list of recommendations to CCIWG regarding NACP Data Central*, NACP Data System Task Force, July 24, 2006.

6.4-P: Towards Integrated Global Monitoring of Biodiversity

The nations of the world have determined the importance of monitoring change in global biodiversity (CBD, 2006). Initial steps have been taken in the design and implementation of a global biodiversity monitoring network (Pereira and Cooper, 2006). The Global Land Cover Facility (GLCF) is contributing in three areas essential to the success of these efforts: development of a long-term data record; access and outreach; impact monitoring.

The GLCF makes available a series of baseline satellite remote sensing data sets for use in biodiversity and ecosystem analysis. As a step toward monitoring areas of key importance to biodiversity, the GLCF is tasking the ASTER sensor to image the world's natural World Heritage Sites. Getting data into the hands of the public is another matter and the GLCF actively provides leadership in open access, participating in and abiding by the principles of the Conservation Commons. Finally, the GLCF and its partners are assessing areas of potential impact on biodiversity.

6.5-P: Ultra Fine Resolution Imagery Available at the Global Land Cover Facility

Paul Davis, The Global Land Cover Facility, University of Maryland, pdavis@umd.edu (Presenting)
Saurabh Channan, The Global Land Cover Facility, University of Maryland, schannan@umiacs.umd.edu

Ultra fine resolution imagery is essential for assessment and validation of local land cover, and is a great aid in verifying global or regional modeling. With ground resolutions ranging from below one to four meters, this primarily US commercial resource is an important asset for any Earth science research. The GLCF makes available the NASA Science Data Purchase archive of IKONOS and QuickBird imagery, including 2127 IKONOS scenes and 3061 QuickBird scenes. Access is restricted to NASA affiliated researchers, per the SDP agreement, but is otherwise available for free to users via FTP. Visit www.landcover.org for further information. This valuable archive is available now.

Ecosystem Modeling Posters

7.1-P: Changing Responses of Land Dynamics and Vulnerability to Flooding Under Policy and Environmental Change Near Poyang Lake China

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RESEARCH STATEMENT: Poyang Lake, in Jiangxi Province, is the largest freshwater lake in China and is connected to the Yangtze River, the World's third-longest river. The coupled system of land use and lake hydrology serves as an ideal case for studying issues of vulnerability and sustainability related to flooding and the land-use. The traditional land-use system in this region is adapted, but still vulnerable, to large seasonal and inter-annual fluctuations in lake levels. However, average high-water levels have increased every decade 1951-2000. In 1998, Poyang Lake reached the highest levels ever recorded. This event resulted in failure of over ninety-seven levees and widespread economic and human catastrophe. Subsequently, the Chinese national government began a policy called Returning the Land to the Lake in parts of the area. APPROACH: We are developing (a) spatial-temporal datasets on flooded areas, demographics, land cover/use (including development and agriculture), (b) agent-based models to examine the effects on vulnerability to flooding of internal alterations to the coupled human-natural system (e.g., levee construction/destruction and population resettlement), as well as external ones (e.g., relaxation of constraints to movement, land ownership, development, and climatic changes), and (c) habitat models to evaluate the effects on the ecological system. ESE Components to be engaged include: SRTM, Landsat 5, Landsat 7, Orbview-1 and -2. EXPECTED OUTCOMES: From this effort

we expect to be able to answer the following questions: How have human land-use responses and vulnerability to flooding the Poyang Lake area changed since before the 1998 flood? What are the possible roles of specific policy adjustments in those changes, including policies related directly to the LCLUC-flooding relationships and those external to the system and related to development? What is the impact on ecological services particularly waterfowl habitat? We expect that agent-based models, together with space-and ground-based observations, will be demonstrated useful in evaluating vulnerability.

7.2-P: Modeling the disturbance of vegetation by fire in the boreal forest

Cyril Crevoisier, AOS, Princeton University, ccrevois@princeton.edu (Presenting)
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Boreal regions are important for the global carbon cycle because it is the largest forested area on earth and there are large belowground carbon pools (~1000 PgC). It is also a region where largest warming trends on the globe over the last decades have been observed and changes of the land ecosystems have already started. A major factor that determines the structure and carbon dynamics of the boreal forest is fire. As fire frequency depends strongly on climate, increased fire occurrence and related losses to the atmosphere are likely, and have already been reported. In order to predict with more confidence the occurrence and effect of fire on forest ecosystems in the boreal region, we are developing a fire model that takes advantage of the large on-ground, remote sensing and climate data from Canada, Alaska and Siberia.
We have designed a prognostic model to estimate the monthly burned area in a grid cell of 2 by 2.5 degrees, from four climate (air temperature, air relative humidity, precipitation and soil water content) and one human-related (road density) variables. Parameters are estimated using a Markov Chain Monte Carlo method applied to a dataset of observed burned area for Canada.
The model is able to reproduce the seasonality of fire as well as the location of fire events, and to predict the large fire events that have occurred in the last two decades, for both Canada (on which data the model has been designed) and Siberia. The results also compare well with remote sensing observation. The fire model will be implemented in LM3, the new vegetation model of GFDL, in order to make prediction of future fire behavior in boreal regions, and the related disturbance of the vegetation and carbon emissions.

7.3-P: Towards Better Carbon Budget Estimates for North America

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A data fusion and analysis system in which aircraft, ground, and potentially satellite data are used to infer the magnitude of terrestrial carbon fluxes over North America on seasonal and inter-annual timescales is being developed. The system is based on a "receptor-oriented" analysis framework that links concentrations at measurement locations to surface fluxes in upwind regions. The framework incorporates three main components: 1. The Stochastic Time-Inverted Lagrangian Transport (STILT) model, 2. An observation-based lateral boundary condition for CO2, and 3. A parameterization for biosphere-atmosphere fluxes that uses observations from the AmeriFlux network. In the course of the research carried out so far, it has become apparent that transport uncertainties associated with the meteorological fields used to compute STILT trajectories are the dominant source of error in CO2 budget estimates for North America (this is also likely to be the case for other regions and globally). In order to reduce these uncertainties, we have developed customized runs with the Weather Research and Forecast (WRF) model to drive STILT. We have developed an interface for the WRF/STILT coupling, including a treatment of parameterized convective fluxes. Special care has been devoted to the mass conservation properties of the resulting trajectories. Initial results from the WRF/STILT runs to simulate measured CO2 concentrations at the Argyle tower have been promising. In particular, when coupled with the Vegetation Photosynthesis and Respiration Model (VPRM), the WRF/STILT-calculated footprints lead to a realistic simulation of nocturnal CO2 measurements. Ultimately, we hope that the employment of WRF/STILT/VPRM, especially when constrained with satellite data, will bring NWP-like realism into the resulting carbon budget estimates.

7.4-P: Reintroducing a large herbivore: a remote sensing and modeling approach to determine the mountain bongo's (Tragelaphus euryceros isaaci) past and present critical habitat

Lyndon Despard Estes, University of Virginia; Rare Species Conservatory Foundation, lde2c@virginia.edu (Presenting)
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The mountain bongo (Tragelaphus euryceros isaaci) is a rare, shy antelope confined to several isolated Kenyan montane forests. The bongo is the "flagship" species of these ecosystems, but has declined drastically in the last 40 years. An ambitious multi-lateral reintroduction effort aims to reverse this decline by re-establishing a viable wild population on the Mount Kenya World Heritage Site using captive bongo from North America. Success depends on learning the poorly-understood bongo's ecological requirements. Studying the elusive bongo in difficult mountain terrain presents two challenges: 1) collecting large and spatially comprehensive field datasets is difficult; 2) critical habitat variables may operate at different scales. To overcome these difficulties, a field dataset collected from the nearby Aberdares mountains' bongo population will be combined with ASTER, Spot, Landsat, and MODIS data to identify and map the past and present distribution of habitat variables. Spectral mixture and texture analyses will delineate forest structure. Vegetation types will be classified using an enhanced technique that incorporates prior probabilities derived from DEM-based models of vegetation distribution. The resulting maps will be used to generate statistical models that will identify: 1) ecological features important to the bongo and the scales at which they operate; 2) the current and historical distribution of the bongo's core habitat. Data collected from a remnant herd on Mount Kenya will enable independent model validation. A collaborative population genetics study using fecal DNA is expected to provide population and range size estimates that will greatly enhance this ecological

assessment.

7.5-P: Large-scale modeling shows little impact of 20th-century changes in temperature and fire on the central Canadian boreal forest

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Boreal forests are predicted to experience relatively large climate change, and recent increases in wildfire frequency suggest that fire dynamics of this region may not be in equilibrium with the changing climate. We used a distributed computing grid to model a 1,000 km x 1,000 km area of boreal forest, with each grid cell 1 km2, from 1948 to 2005. The modeled area stretched from eastern Manitoba, Canada, to eastern Alberta, and included both the Northern and Southern BOREAS study areas. Input data were assembled from regional ground-based and satellite records; compared to historical norms, temperatures in 1948-2005 were slightly warmer for this region, disturbance increased markedly, particularly in the northern half of the grid, and CO2 levels rose. As a result of these changes the growing season lengthened and the overall forest shifted to a younger and more deciduous state, but mean net ecosystem production (NEP, carbon balance) did not change significantly. This lack of ecosystem response to changing conditions may reveal inadequacies of the model used (Biome-BGC) or reflect a real stability in the boreal system under study.

7.6-P: Complete landscape characterization of tree density and its application to environmental gradient analysis

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We present a novel approach for performing environmental gradient analysis to address the question: is potential tree density in the eastern Lake Tahoe Basin, NV limited by water, temperature or photosynthetically active radiation (PAR)? To address this question we perform a multidimensional environmental gradient analysis based on a fusion of continuous tree density estimates derived from hyperspatial remote sensing imagery with continuous estimates of available water, annual mean temperature and annual PAR. Our analysis draws from a dataset of over 3 million individual trees and over 300,000 30m “plots”. We discuss how fusing accurate and ecologically relevant remote sensing outputs with continuous microclimate surfaces can provide a powerful tool for addressing major questions of tree distributions and life history parameters, and can provide parameterization of ecosystem models.

7.7-P: Understanding the Changing Carbon, Nitrogen, and Water Cycles in the Earth System

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Accurate predictions of the future climate and biogeochemistry of the Earth rely upon our ability to simulate the many complex interactions between ecosystems, the hydrosphere, and the atmosphere. These simulations must account for changes in forcing related to human activity and natural perturbations. Our research is focused on the development of a global-scale integrated mode of terrestrial and freshwater biogeochemical cycles (carbon, nitrogen, and water) in the context of changes in land-use, atmospheric chemistry, and climate. Remote sensing data from Terra/Aqua and other platforms is used for evaluation of predicted spatial and temporal patterns of key ecosystem characteristics and functioning.

7.8-P: Forest Inventory and Analysis and the North American Carbon Program: A Model for Collaboration

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The Forest Inventory and Analysis (FIA) program of the USDA Forest Service collects data annually on the status and trends in forested ecosystems nationwide. These inventory data have traditionally been used to support estimates of forest population totals over large geographic areas, and recent emphasis has been placed on producing broad-scale maps of numerous forest characteristics to make these extensive forest resource data more accessible and useful to a larger and more diverse audience. While spatial depictions of current forest attributes is a great improvement in reporting on the status of the nation’s forests, an important component of monitoring is gaining a clear understanding of what has happened in the past. Unfortunately, little work is being done by FIA in this arena. Reconstructing historical trends in forest disturbance is hampered by inconsistent sampling schemes and plot designs, varying definitions, gaps in plot distributions, irregular and sometimes non-existent temporal sampling, and the

list continues. FIA data alone cannot adequately tell the forest disturbance and recovery history. The Landsat-based change project characterizing historic forest disturbance and recovery is a successful joint venture between the North American Carbon Program and FIA. Work is well underway to involve the larger FIA community and develop standard tools for analyzing both historical and future trend that will have national application. Here, we describe the successful engagement of FIA scientists, analysts, managers, and clients by investigators in this project. We outline the local analyses currently being conducted in diverse ecosystems across the country, and identify the necessary ingredients for successful collaborations between NASA-funded scientists and FIA in the future.

7.9-P: Savannization of a tropical forest frontier: modeling changes in forest structure from anthropogenic fires and climate change

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Ruth S DeFries, University of Maryland, rdefries@geog.umd.edu

The magnitude of current and future carbon fluxes from Amazonia depends on the synergistic effects of climate change and anthropogenic land cover change on vegetation structure. Alone or in combination, these forcing mechanisms have the potential to convert forests into drought and fire-adapted grasslands, a process referred to as "savannization", with dramatic consequences for carbon storage. The main objective of this research is to evaluate the sensitivity of forests in the southern Brazilian Amazon to savannization through anthropogenic fires for land clearing and management and climate change with a modified version of Ecosystem Demography (ED), an ecosystem model. Initial work on SavannaED includes the development of an anthropogenic fire ignition and spread submodel. Here, we analyze the spatial patterns of historic fires in cerrado and forest cover using coarse and high-resolution satellite data products to identify specific features such as roads or rivers that permit or prevent fire spread on the landscape. We report typical fire sizes in different vegetation types and preliminary findings on the correlation among common landscape features and extent of burned area. Modeling current and future fire susceptibility depends on this understanding of landscape-level features that drive fire risk. Future work will incorporate these fire spread rules into SavannaED to improve the depiction of disturbance and vegetation competition at the forest/cerrado frontier in the southern Amazon. By focusing on the contribution of anthropogenic fires to changes in forest structure, model scenarios will generate insight into how different land use possibilities alter the long-term response of forests to climate change.

7.10-P: Canopy Radiative Transfer for Global Vegetation Dynamic Models: Characterization of Foliage Clumping

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Calculation of canopy radiative transfer for simulation modeling of coupled biosphere-atmosphere interactions, such as in dynamic global vegetation models (DGVMs) coupled to atmospheric general circulation models (AGCMs), must be able to provide:
albedo of the vegetated land surface for the atmospheric model's energy balance;2) incident radiation on foliage through the vegetation canopy for photosynthesis and stomatal conductance as controllers of land surface fluxes, and as determinant of vertical light competition amongplants;3) transmittance of radiation to the ground to predict soil temperature and snowmelt.

Clumping of foliage within plant canopies strongly influences the above three features, particularly as it affects the vertical profile of light in the canopy, which then strongly influences light competition within plant communities. For DGVMs, the level of clumping will change as vegetation structure changes due togrowth, senescence, and community dynamics. Acanopy radiative transfer algorithm for DGVMs mustbe able to quantify these structural changes andtranslate them to a measure of foliage clumping. Atthe same time, the algorithm must be computationally fast so as to be useful within a GCM.

We present new algorithms for quantifying foliage clumping and calculating canopy radiative transfer, developed for the Ent model, a new DGVM underdevelopment at NASA-GISS.

7.11-P: Integrating material and symbolic environments with remotely-sensed imagery: the case of US/Mexico borderlands

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Unsustainable development is acute on borders between comparatively affluent and poor nations, where long-time residents and immigrant populations are prone to differential treatment, access to political systems, and conceptions of the environment. This context has implications in a globalizing world with implementation of international policy. Trans-boundary environments represent some of the greatest opportunities and threats for humanity. The Lower Rio Grande Valley (LRGV; the southernmost 250 km on the Texas-Tamaulipas [Mexico] border) provides an excellent site to study the influence of coupled human-environment systems on sustainability of borderlands. Our project is evaluating the effects of NAFTA on primary productivity and land use in the LRGV, assessing public perceptions of threats to sustainability, identifing key attributes associated with public participation in land use planning, and will spatio-temporal dynamics of human-environment relationships under different policy scenarios. This poster presents preliminary results from our social survey and describes proposed methods for using a systems approach to integrate material environments, assessed via remote sensing, and symbolic environments, assessed via the social survey. Most (82.4%) respondents thought there were important environmental problems, but only 10% of our respondents had participated in political processes to address them. Hispanics and highly educated respondents were most likely to participate in those processes. Public concern about environmental problems was spatially linked to point sources for air and water pollution. Future findings should facilitate the identification of priority areas for land acquisition to protect endangered species, explicate linkages between social and environmental systems in trans-boundary contexts, and facilitate scaling up the project to support national and global decision making in similar trans-boundary contexts.

7.12-P: LBA-ECO Synthesis Studies of Intensive Agriculture Impacts in the Amazon/Cerrado: Field Data, Remote Sensing, Modeling Approaches

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The expansion of intensive agricultural practices into former Cerrado and seasonal forests of the eastern Amazon has increased markedly over the past several years. Over the last 30 years an estimated 37 percent of Cerrado natural vegetation has been transformed, with more than 12 million hectares planted to crops consisting mostly of soybeans, maize, and rice. We are synthesizing measurement data and MODIS remote sensing observations at locations that represent conversion of Cerrado types and Amazon forests to intensive agricultural land use. A principal objective is to improve calibration of the NASA-CASA model and subsequently evaluate and refine a series of regional model simulation runs for these transformed ecosystems.

7.13-P: The Dynamic Land Ecosystem Model (DLEM) and Its Applications in Carbon and Ecosystem Studies

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We have developed a highly integrated land ecosystem model called Dynamic Land Ecosystem Model (DLEM), which couples major biogeochemical cycles, hydrological cycle, and vegetation dynamics to make daily, spatially-explicit estimates of water, carbon (CO2, CH4) and nitrogen fluxes (N2O) and pool sizes (C and N) in terrestrial ecosystems. DLEM builds on the experience and heritage of the existing Terrestrial Ecosystem Model (Raich et al. 1991; Melillo et al. 1993; McGuire et al. 1992, 2001; Tian et al. 1998, 1999, 2000, 2003; 2005, Felzer et al. 2004, 2005) and Biome-BGC (Running and Hunt 1993; Thornton, P.E. 1998, 2002, Mu et al. 2006). DLEM includes five core components: 1) biophysics, 2) plant physiology, 3) soil biogeochemistry, 4) dynamic vegetation, and 5) land use and management. DLEM also integrates algorithms of N2O emission from DNDC (Li and Aber 2000) and CH4 emission from other previous studies (Huang et al. 1998,2005; Zhuang et al. 2004). The dynamic vegetation component in DLEM simulates two kinds of processes: the biogeography redistribution when climate change, and the plant competition and succession during vegetation recovery after disturbances. Like most DGVMs, DLEM builds on the concept of plant functional types (PFT) to describe vegetation distributions. The DLEM has also emphasized the modeling and simulation of managed ecosystems including agricultural ecosystems, plantation forests and pastures. We have used the DLEM to simulate the effects of climate variability and change, atmospheric CO2, tropospheric ozone, land-use change, nitrogen deposition, and disturbances (e.g., fire, harvest, hurricanes) on terrestrial carbon storage and fluxes in China and the United States. This model has been calibrated against various field data from the Chinese Ecological Research Network, LTER and AmeriFlux Network. The simulation results of the model have been compared with independent field data and satellite products. To assess the two-way response of terrestrial ecosystems to climate forcing and vice versa, DLEM is being coupled with regional climate model.

7.14-P: Estimation of Evaporative Fraction from a Combination of Day and Night Land Surface Temperatures and NDVI: A New Method to Determine the Priestly-Taylor Parameter

Kaicun Wang, Institute of Atmospheric Physics, Chinese Academy of Sciences, kcwang@umd.edu (Presenting)
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M. Cribb, Earth System Science Interdisciplinary Center (ESSIC) and Department of Atmospheric and Oceanic Science, University of Maryland, mcribb@essic.umd.edu

Satellite remote sensing is a promising technique to estimate global or regional evapotranspiration (ET) or evaporative fraction (EF) of the surface total net radiation budget. The current methods of estimating the ET (or EF) from the gradient between land surface temperature (LST) and near surface air temperature are very sensitive to the retrieval errors of LST and the interpolation errors of air temperature from the ground-based point measurements. Two types of methods have been proposed to reduce this sensitivity: the thermal inertia method and the LST- Normalized Difference Vegetation Index (NDVI) (LST-NDVI) spatial variation method. The former is based on the temporal difference between LST retrievals, and the latter uses the spatial information of LST. Another approach is proposed here that combines the advantages of the two types of methods and uses day-night LST difference- NDVI (delt LST-NDVI). Ground-based measurements collected by Energy Balance Bowen Ratio systems at the 11 enhanced facilities located at the Southern Great Plains of the United States from April 2001 to May 2005 were analyzed to identify parameterization of EF. delt LST-NDVI spatial variations from the Aqua and Terra MODerate-resolution Imaging Spectroradiometer (MODIS) global daily products, at 1 km resolution were used to estimate EF. Ground-based measurements taken during 16 days in 2004 were used to validate the MODIS EF retrievals. The EFs retrieved from the spatial variations of delt LST-NDVI show a distinct improvement over that retrieved from the LST-NDVI. The EF can be retrieved with a mean relative accuracy of about 17% with the proposed delt LST-NDVI spatial variations.

7.15-P: Interpretive visualization of the Yellowstone ecosystem

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An interactive kiosk will be demonstrated for use in Yellowstone National Park. The kiosk takes visitors on a 'Virtual Interpretive Trail' through the Yellowstone landscape. The media combines visualization and conventional video footage. The visualizations are 3D-realistic visualization flights - metaphors for the 'Trail' - travelling through a landscape described by remote sensing and ecosystem models, and containing important wildlife elements. The conventional video pieces are the 'Interpretive Stops' along the trail - explaining the landscape, wildlife, science, and management to the visitor.

7.16-P: Carbon Data Assimilation Using Maximum Likelihood Ensemble Filter (MLEF)

Dusanka Zupanski, Colorado State University, Zupanski@cira.colostate.edu (Presenting)
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Ensemble based data assimilation approaches are promising techniques for carbon science problems, especially because of the their capability to calculate realistic flow-dependent uncertainties of the estimated variables (e.g., carbon fluxes). We are developing a generalized framework for carbon flux estimation from multiple streams of carbon observations for the purposes of a NASA supported North American Carbon Program (NACP) research. For this research we employ Maximum Likelihood Ensemble Filter (MLEF), an ensemble-based data assimilation approach recently developed at Colorado State University. The MLEF approach is especially suitable for the carbon data assimilation problems because of its capability to address non-linear data assimilation problems, involving biased atmospheric and carbon transport models.
In this presentation, we address the carbon inversion problem using an offline Lagrangian Particle Dispersion Model (LPDM) forced by SiB-RAMS fluxes. Experimental results estimating biases in respiration and photosynthesis carbon fluxes using simulated tall tower CO2 observations will be presented and discussed.

7.17-P: Monitoring Sediment Resuspension in Coral Reefs and Seagrass Beds with MODIS and ASTER Sensors

Gerardo Toro-Farmer, University of Southern California, torofarm@usc.edu (Presenting)
Dale A. Kiefer, University of Southern California
Burton Jones, University of Southern California
Thaddeus Murdoch, Bermuda Zoological Society
Anne Glasspool, Bermuda Zoological Society

High concentrations of resuspended sediments reduce the survival of species inhabiting coral reefs and seagrass beds all around the world. We propose to demonstrate how MODIS moderate resolution and ASTER sensors can be applied to monitoring such threats in a case study of the Northern Lagoon of Bermuda Island. Specifically, with the support of NASA and the Bermuda Biodiversity Project, Bermuda Zoological Society, we propose to 1) use in-situ instruments for measuring inherent and apparent water column optical properties, as well as suspended sediment concentrations, at different distances from navigation channels and at different times of the year; and 2) to integrate remotely sensed measurements in order to develop an algorithm for mapping and investigating spatial-temporal variations in the amount of resuspended materials threatening coralline organisms. This work will facilitate and improve future monitoring and management of coralline ecosystems in the study area, as well as in other coastal ecosystems.

Ecological Forecasting Posters

8.1-P: Operational characterization of tropical forest change at high spatial resolution using a MODIS/Landsat data fusion approach in the Congo River Basin, Africa

Matthew Hansen, GISCE, South Dakota State University, Matthew.Hansen@sdstate.edu
Erik Lindquist, GISCE, South Dakota State University, Erik.Lindquist@sdstate.edu (Presenting)

Systematic, unbiased characterization of tropical forest change is a goal of multiple international initiatives and is critical for modeling Earth's biogeochemical cycles, monitoring habitat and biodiversity status and estimating anthropogenic effects on ecosystem services. The research proposed is a data fusion approach using moderate resolution MODIS imagery to normalize and train higher resolution, multi-temporal Landsat classifications across regional mosaics in the Congo Basin. The effects of sun-surface-sensor geometries on small field-of-view sensors will be addressed. Landsat SLC-off data will be included in the analysis to produce a mid-decadal estimate of tropical forest change. A suite of spatial statistics will be produced that provide a current baseline estimate of forest change characteristics and rates. The emphasis will be on minimal analyst input, building an automated and operational monitoring tool.

8.2-P: Assessing Fire Danger from Remotely Sensed Products within the Amur Tiger Habitat

Tatiana V. Loboda, University of Mryland, tloboda@hermes.geog.umd.edu (Presenting)

Forests of the Russian Far East present world's richest temperate forests and the main habitat of the critically endangered Amur Tiger (Panthera tigris altaica). The changes in the natural fire cycle prompted by decades of intensive economic development and the rising frequency of large fires are recognized as one of the gravest threats to this ecosystem. The Amur tiger's low population densities and reproductive potential even within high quality habitat make this species particularly vulnerable to fire induced habitat reduction, degradation and fragmentation. This project presents an approach to Fire Danger assessment within a broader framework of Fire Threat Modeling. The remotely sensed data driven Fire Threat Model (FTM) has been developed to provide spatially explicit and temporally dynamic quantitative assessment of fire threat to the Amur tiger. Coarse and moderate resolution remotely sensed data products from MODIS (Moderate Resolution Imaging Spectroradiometer), SPOT-VGT and Landsat/ETM+ were used to explore causes and distribution of fire within the Amur Tiger habitat, conditions leading to significant fire events, and fire impact severity for 2001 - 2005. The analysis shows large interannual and intra-annual variability in of fire danger levels within the tiger habitat. Fire regimes of the Russian Far East are primarily driven by the

presence of the summer monsoon which minimizes fire occurrence in the areas of high importance for tigers. The disruption of summer monsoons leads to a rapid increase in levels of fire threat. Additionally, fire occurrence is strongly influenced by anthropogenic activity.

8.3-P: Ecological Forecasting for Protected Area Management

Forrest Melton, California State University Monterey Bay, fmelton@arc.nasa.gov (Presenting)
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U.S. National Parks and other protected areas internationally are subject to increasing pressure from environmental change within and adjacent to park boundaries. Despite great interest in these areas and the fact that some U.S. parks receive as many as 3.5 million visitors per year, protected areas are often sparsely instrumented, making it difficult for resource managers to quickly identify trends and changes in park conditions. Remote sensing and ecosystem models offer protected area managers important tools for comprehensive monitoring of ecosystem conditions and scientifically based decision-making.

With support from the NASA Applied Sciences REASoN program, the Terrestrial Observation and Prediction System (TOPS) is currently being applied to automate the production, analysis, and delivery of a suite of data products from NASA satellites and ecosystem models to assist managers of U.S. and international protected areas. TOPS uses ecosystem models to combine satellite data with ground-based observations to produce nowcasts and forecasts of ecosystem conditions. Working with NPS personnel in the U.S. and with the SERVIR team in Mesoamerica, we are utilizing TOPS to deliver data products to resource managers in near-real-time for use in operational decision-making. Data products are designed to be integrated into existing decision support systems, such as the NPS Inventory & Monitoring System. Current products include estimates of vegetation condition, ecosystem productivity, soil moisture, snow cover, fire occurrence, and others. In addition, the use of TOPS to automate the identification of trends and anomalies in ecosystem condition enables protected area managers to track park-wide conditions daily, identify changes, focus monitoring efforts, and improve decision making through infusion of NASA data.

8.4-P: Towards an operational system to identify aggregations of foraging right whales using satellite data and models

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The northern right whale (*Eubalaena glacialis*) is the most endangered marine mammal currently being protected under United States environmental regulations. The primary cause of human-induced mortality in this species is through entanglement with fishing gear and collisions with ships. Management of this species is the responsibility of NOAA Fisheries (National Marine Fisheries Service), and their management plan depends on knowing where whales are likely to be encountered. We are developing an operational system to forecast likely right whale locations in the Gulf of Maine. Our system uses satellite-derived sea surface temperature and chlorophyll to drive the population dynamics of the right whale's main copepod prey. The copepod model uses operational circulation fields derived from a high-resolution assimilative atmosphere-ocean circulation model that has recently been developed for the Gulf of Maine. The suite of models will synthesize information from a variety of earth science observations to provide high resolution estimates of right whale feeding areas. The circulation, zooplankton, and right whale products will be validated by comparing them with available observations. The performance of the complete system and its potential impact on NOAA's right whale management will be assessed through a quantitative comparison of the high resolution right whale forecasts to the climatological right whale distributions that underlie the current management strategy.

8.5-P: Utilizing MODIS LAI to Identify Vegetative Anomalies in Yosemite National Park

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During Summer 2006, students from ARC's NASA DEVELOP program examined vegetation disturbances in Yosemite National Park using remotely sensed data. These disturbances can result in forest fragmentation and subsequent loss of wildlife habitat. The project utilized the MODIS Leaf Area Index (LAI) product in the analysis of vegetation in Yosemite. LAI provides a ratio of leaf area to total ground area. The LAI data for each month were averaged from 2001 to 2005. Data for the summer months of 2005 were compared with the monthly averages to produce a map of LAI anomalies. These maps were overlaid with known areas of insect infestation, snow cover or recent wild fire. Field work was conducted to verify the known causes disturbance and ascertain the causes of unexplained anomalies. Using MODIS LAI and ancillary data, locations of unknown anomalies for further investigation were developed for use by our research partners. Continuation of the project will result in the creation of an automated site selection and anomaly detecting utility which will allow park managers to quickly view files which provide locations that should be examined. This methodology is of interest to managers of national parks and forests because of the accessibility of MODIS data, its high temporal resolution and the speed with which large areas of land can be analyzed.

8.6-P: Heating it up in the intertidal: using remote sensing data in biophysical models to investigate climate-influenced species interactions

Lauren Szathmary, University of South Carolina, szathmary@biol.sc.edu (Presenting)
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Climate change has both direct effects on organism survival and physiological performance, and indirect ecological influences via impacts on rates of predation and competition. In this study we examine broad-scale geographic patterns of both indirect and direct effects of climate change using remote sensing data combined with computer simulations and physiological and ecological data. The upper zonation limits of many rocky intertidal species are set by physical stresses related to body temperature and desiccation. Lower limits are set by rates of predation, which in turn may be affected by the temperature of the predator's body. To investigate differential patterns in body temperature, and thus differential effects of climate on intertidal zonation heights of predator/prey species, we developed climate-based biophysical models for predatory seastars (*Pisaster ochraceus*) and prey (mussels *Mytilus californianus* and barnacles *Chthamalus stellatus*). Geostationary satellite data and surface observations in 32-km squares from the National Climatic Data Center North American Regional Reanalysis (NARR) dataset were used to generate predictions of body temperature along the west coast of North America from British Columbia to southern California. Preliminary results show greater body temperature variability during summer months than during winter months, and suggest that mussels are generally a few degrees warmer than their predators.

8.7-P: Forecasting Rangeland Condition with GIS in Southeastern Idaho

Jerome Theau, Idaho State University, theajero@isu.edu (Presenting)
Keith T Weber, Idaho State University, webekeit@isu.edu

Past research at Idaho State University's GIS Training and Research Center has found that changes to the rangelands of southeastern Idaho can be attributed to three principal agents: 1) fire, 2) invasive weeds, and 3) urbanization. However, Idaho has experienced severe to exceptional drought conditions since April 2001. The potential for drought to change rangelands is significant. Furthermore, without specific and purposeful monitoring of rangeland condition throughout this time period, observed changes could be misinterpreted. These changes to Idaho's rangeland landscape - regardless of the cause (drought, fire, invasive weeds, or urbanization) tend to degrade the health, productivity, and sustainability of rangelands and thereby pose problems for ranchers, range managers, and the economy of many western states. The purpose of this project is to use existing and new data (acquired both from the field and satellite remote sensing) to model rangeland sustainability relative to drought effects in southeastern Idaho at three study areas, the Big Desert (managed by the USDI BLM), the US Sheep Experiment Station (managed by the USDA ARS), and the O'Neal Ecological Reserve (managed by Idaho State University). This three-year project will 1) examine specific drought effects relative to livestock grazing, rest treatments and bare earth exposure, 2) model and monitor rangeland condition as a function of hydrologic cycling, 3) forecast rangeland condition using cellular-automata/ Markov chain analysis and artificial neural network techniques, and 4) continue and advance the GIS Training and Research Center's public outreach program. We are presenting here an overview of the project including the methodological approach and preliminary results.

8.8-P: Forecasting in the Yellowstone Ecosystem: Development of Remotely-Sensed Estimates of Vegetation 3-D Structure, and Disturbance Dynamics for Initializing, Constraining and Testing Terrestrial Biosphere Models

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Ecosystems worldwide face an uncertain future given recent and predicted trends in climate change. Biosphere models that are realistic, mechanistic, and accurate are thus needed to link with atmospheric models (GCMs) to provide future predictions of carbon, water and energy flux and community structure and composition. In order to achieve these goals, we have, and are developing, estimates of 3D vegetation structure and disturbance based on NASA data and data products for ingestion into biosphere models such the Ecosystem Demography (ED) and Carnegie-Ames-Stanford Approach (CASA) models. We demonstrate this for a variety of disturbance types and also develop functional cover types (FCTs), a hybrid of community composition, stand biomass, stand age, and land cover classes necessary for initializing, constraining, and testing biosphere models in forested communities. We are also developing techniques to map disturbances such as fire and pathogen mortality. We also evaluate estimates for fire fuels, soil moisture and NPP as products for ingestion into, and testing of, biosphere models. Initial model simulation outputs of the Yellowstone Ecosystem are provided. These products in turn can be used as inputs to other models such as RRSC (risk-reward spatial capacity) models used to predict changes in native and invasive species distributions and abundance.

8.9-P: SERVIR

Daniel Hardin, University of Alabama in Huntsville, DHardin@itsc.uah.edu (Presenting)

Mesoamerica - composed of the seven Central American countries and the five southernmost states of Mexico - is one of the richest biological regions in the world. The region is home to approximately eight percent of the planet's biodiversity. The rich biological, ecological and cultural diversity of this region is threatened by human influence and natural disasters alike. Illegal logging and slash and burn agriculture contribute to extensive deforestation. Earthquakes, volcanoes, drought, and severe storms regularly threaten the region.

An international effort is underway to preserve the remaining forested regions, and to promote sustainable development throughout the region. NASA has teamed with the World Bank, the United States Agency for International Development, the Central American Commission for Environment and Development, and the Water Center for the

Humid Tropics of Latin America and the Caribbean (CATHALAC) to develop an advanced monitoring and decision support system for Mesoamerica known as SERVIR. (SERVIR is a Spanish acronym meaning to serve.) SERVIR addresses the nine societal benefit areas of the Global Earth Observation System of Systems (GEOSS): disasters, ecosystems, biodiversity, weather, water, climate, oceans, health, agriculture, and energy.

SERVIR headquarters are located at CATHALAC in the Republic of Panama. A test bed SERVIR facility is managed by the NASA Marshall Space Flight Center at the National Space Science and Technology Center in Huntsville, Alabama. Local SERVIR partners--the University of Alabama Huntsville and Science Systems and Applications, Inc.--are creating data sets and developing information management techniques that will give policy makers, scientists, and educators, information based on solid science, that can be used to monitor and forecast ecological changes, respond to natural disasters, and better understand natural and human induced effects in the region.

Carbon/Biogeochemistry Posters

9.1-P: The influence of meridional transport on estimation of regional scale CO_2 fluxes in the temperate zone of the Northern Hemisphere.

Joseph A Berry, Carnegie Institution, joeberry@stanford.edu (Presenting)
Adam Wolf, Carnegie Institution, adamwolf@stanford.edu

A theoretical treatment by Betts et al., (2004) predicts that, (and empirical analyses of observational data by Bakwin et al., (2004) and Helliker et al., (2004) demonstrate that), exchange of CO_2 between the free troposphere (FT) and the atmospheric boundary layer (ABL) is on average, approximately in steady-state balance with CO_2 fluxes from the surface. For example, an analysis vertical advection (derived from analysis of the water budget of the ABL) and CO_2 concentration measurements over five years from the WLEF tall tower in Wisconsin match the seasonal cycle of net CO_2 exchange, measured by eddy correlation, of ecosystems in the region and capture interannual variation in the seasonal pattern of CO_2 exchange from year to year. To follow-up on this empirical work, we have used a global atmospheric transport model with forward simulations of atmospheric CO_2 concentration and other tracers (Kawa et al., 2004) to conduct a more detailed analysis of the influence of global atmospheric transport on these regional-scale correlations. The simulations show subtle mismatches between the local fluxes and CO_2 concentration gradients that appear to indicate meridional transport of CO_2 concentration anomalies that lead or lag the local fluxes. We have identified that these anomalies are associated with transport of air from the ABL over continental areas of the N. Hemisphere (>30N) into the polar region (>75N) and back. This flow drives the large seasonal changes in CO_2 concentration observed at arctic sampling stations - as there is little or no exchange of CO_2 in this zone. Studies of preferential transport of mid-latitude atmospheric pollution to the arctic (Stohl, 2006) also lend support to this analysis. The air flowing into the polar cell mixes over 10 -20 days before joining a return flow. Therefore, the CO_2 concentration of air coming back from the pole can differ from that flowing in at any given time. The total change in storage of CO_2 in the arctic atmosphere is similar to the putative carbon sinks in northern forests. Thus, regional scale atmospheric balance studies will need to take meridional transport of CO_2 associated with synoptic weather systems into account. This will require input from a global modeling framework.

9.2-P: Reducing Uncertainties of Carbon Emissions from Land Use-Related Fires with MODIS Data: From Local to Global Scale

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The atmospheric and carbon modeling communities are increasingly aware of the importance of fire as a major source of carbon to the atmosphere, and as a key driver of interannual variability of net carbon fluxes from the biosphere. Previous estimates of carbon emissions from fire are based on coarse-resolution satellite data and do not account for varying fire regimes associated with different land uses or for variations in biomass within the model's grid cell. Several groups have estimated fire emissions on global scales using coarse resolution approaches, and the outcomes vary by more than a factor two. We are applying MODIS data and a modified version of the CASA biogeochemical model (DECAF) at the MODIS 250m resolution in two test areas, each covering the extent of a MODIS tile (approximately 10 x 10 degrees). The test areas are the southern Amazon and Kalimantan, two regions of rapid land use change where fire is used extensively for land management. Model results provide a means of partitioning carbon emissions from different land use types, i.e. initial forest clearing vs. maintenance of previously cleared pasture or oil palm plantations. Initial results in the southern Amazon indicate that, in 2002, pasture clearing and maintenance fires were 78% and 14% of carbon emissions respectively, with clearing for cropland the remainder. Runs are currently in progress to extend analyses for the MODIS time series. Using the high-resolution model results, we are developing approaches to realistically scale up estimates of carbon emissions from land use-related fires to regional and global scales.

9.3-P: Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics

Robert B. Cook, Environmental Sciences Division, Oak Ridge National Laboratory, cookrb@ornl.gov (Presenting)
Robin L. Graham, Environmental Sciences Division, Oak Ridge National Laboratory, grahamrl@ornl.gov
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The ORNL DAAC archives and distributes biogeochemical dynamics data and information collected as part of the National Aeronautics and Space Administration's (NASA's) Earth Observing System (EOS) Program to study Earth systems. Data holdings are primarily from ground-based field investigations, and augmented by data collected through remote-sensing techniques. Archived products at the ORNL DAAC result from and support four core activities: (1) intensive field campaigns, (2) validation of remote sensing products, (3) regional and global data for terrestrial ecosystem modeling, and (4) numerical model archive.

Intensive field campaigns combine ground-, aircraft-, and satellite-based measurements of biogeochemical features in specific ecosystems over a one to six year period. These types of studies focus on a particular issue or set of issues and are crucial to providing an integrated understanding of biogeochemical dynamics that can be extended across spatial and temporal scales. The ORNL DAAC supports the validation of remotely sensed measurements by compiling data, such as leaf area index (LAI), net primary productivity (NPP), and Vegetation Indices Data from global test sites for comparison with satellite products. The ORNL DAAC offers two tools to subset MODIS Land Products at a scale and in a format useful for comparing with ground-based measurements. Realistic models that simulate ecosystem properties and processes are needed to improve our understanding of the structure and function of these ecosystems. Regional and global biogeochemical dynamics data, such as those available from the ORNL DAAC, can be used to parameterize and validate terrestrial ecosystem models at local, regional, and global scales. Archived numerical models provide the methodological detail of numerical modeling studies to recreate published modeling results, enabling the synthesis of results across modeling studies and the investigation of new hypotheses.

Although our efforts focus on NASA-funded data and data products, we also hold selected biogeochemical dynamics data collected by non-NASA researchers worldwide. Data at the ORNL DAAC are available to the global change research community, policy makers, educators, and the general public at no charge.

Web Site: www.daac.ornl.gov

9.4-P: Investigating Land-Atmosphere CO2 Exchange with a Coupled Biosphere-Atmospheric Model: SiB3-RAMS

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We coupled the Simple Biosphere (SiB3) Model to the Colorado State University Regional Atmospheric Modeling System (RAMS). The photosynthesis in SiB3-RAMS is driven by either leaf area index (LAI) and fraction of photosynthetically active radiation (FPAR) data from NASA's MODIS satellite or normalized difference vegetation index (NDVI) data from SPOT. The respiration factor and initial soil moisture fields are created for each grid cell from an offline SiB3 run. Evaluation of a 10-day North American simulation in August 2001 shows realistic CO2 fluxes and concentrations. Currently, we are implementing the capability to initialize CO2 concentrations and to nudge lateral boundaries to mixing ratios from Parameterized Chemical Transport Model (PCTM) global simulations, with 1o by 1.25ospatial resolution, 20 vertical levels, and a 3-hourly time-step. SiB3-RAMS will be used to evaluate high-resolution fossil fuel emissions estimates.

9.5-P: The Simple Biosphere Model, Version 3: Model Structure and Evaluation

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Modeled fluxes of energy, moisture, momentum between the atmosphere and terrestrial biosphere are critical to simulations of weather and climate. Simulated photosynthesis/CO2 flux can provide a further constraint on heat and moisture flux (as a result of stomatal resistance constaint on Bowen ratio) as well as provide essential information to chemical transport or mesoscale models.

We have modified the Simple Biosphere Model (SiB) to provide a higher level of biophysical realism; modeled surface fluxes, when confronted with eddy covariance tower observations of energy, moisture and CO2 have improved as well. Model upgrades have taken two predominant forms: 1) separation of the vegetative canopy into explicit sunlit and shaded fractions for radiative transfer and photosynthesis calculations, as opposed to a continuous representation of all vegetation, and 2) higher resolution of soil processes along with a modified calculation of soil water stress on photosynthesis.

We ran the modified SiB3 code at a variety of sites for comparison with eddy covariance observations, and results from 3 sites are presented: a midlatitude mixed forest (WLEF tall tower site, Wisconsin USA), midlatitude grassland (ARM Southern Great Plains site, Oklahoma, USA) and a tropical evergreen forest (Tapajos River, km 83 tower, Brazil). At all sites the model changes result in an improvement in the comparison of fluxes to observations, on both diurnal and annual scales.

9.6-P: Investigating the Synoptic Component in Atmospheric CO2 Variability Using An Atmospheric Transport Model

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A popular method for estimating the global distribution of terrestrial CO2 sources and sinks is to invert atmospheric CO2 measurements through the use of atmospheric transport models. In the past this approach has utilized monthly mean CO2 measurements in remote marine boundary layer environments. The global network of monitoring stations is growing, however, and continuous measurements are becoming more high frequency and continental. Inversions of continental data will help to improve the inversion results but taking advantage of the measurements requires an understanding of the processes driving the high-frequency variability.

This study focuses on synoptic scale variability, which is often regarded as noise. To simulate the transport of CO2 in the atmosphere, we use a global Parameterized Chemical Transport Model (PCTM) driven by surface CO2 fluxes and GEOS4 reanalysis. The results are compared to a network of well-calibrated continuous CO2 mixing ratio measurements in North America. Our results show that PCTM does a reasonable job capturing the various scales of variability at the measurement sites. The seasonal cycle is well represented by the model with some wintertime overestimation in the higher latitude sites. The diurnal cycle suffers from weak nocturnal buildup, especially in the higher latitude sites. Synoptic variability is captured surprisingly well throughout the year at all the stations. This study focuses on the roles of horizontal advection, vertical advection, and ecosystem response to synoptic weather in explaining CO2 signals during frontal passage events.

9.7-P: Mesoscale Carbon Data ASsimilation in SiB-RAMS

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In order to facilitate future decision making regarding regional carbon fluxes, it is essential to better quantify uncertainty in inverse carbon flux models. At Colorado State University, research is being performed in order to better quantify sources and sinks and associated uncertainties, on a mesoscale level, through a coupled atmospheric (RAMS and PCTM) and terrestrial carbon flux (Sib3) model. In particular, carbon-dioxide flux and mixing ratio data were collected from the numerous tall towers (30 meters or greater) during the summer of 2004. The fully coupled terrestrial-atmospheric model, SibRAMS, will be forced with 2004 reanalysis data to predict fine scale weather on a 40km grid for the continental United States for the summer of 2004. Relevant portions of this simulated weather, including wind fields and pertinent turbulence components, are extracted and used to create backward in time Lagrangian Particle Dispersion Modeled (LPDM) influence functions. Pseudo spatial carbon-dioxide mixing ratio and flux data created by SibRams is then used as input to estimation routines in order to try and predict pseudo tower data at different heights. Prior information as well as pseudo data will be combined in order to provide a somewhat well constrained problem. Attention will particularly be paid to hierarchical Bayesian regression schemes to measure influence at different factor levels (continental-level, biome-level, and model grid cell level).

9.8-P: The combined Simple Biosphere/Carnegie-Ames-Stanford Approach (SiBCASA) Model

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We combined the sophisticated photosynthesis and biophysical calculations in the Simple Biosphere model, Version 2.5 (SiB2.5) with the robust biogeochemistry from the Carnegie-Ames-Stanford Approach (CASA) model to create SiBCASA, a hybrid capable of estimating terrestrial carbon fluxes from diurnal to decadal time scales. SiBCASA includes dynamic allocation of Gross Primary Productivity to grow leaves, roots, and wood, explicit autotrophic respiration, and leaf biomass prescribed from Normalized Difference Vegetation Index. Simulated carbon fluxes and biomass compared well with observations at AmeriFlux eddy covariance flux towers and a paper fully describing SiBCASA is in peer review.

The detailed biophysical and biogeochemical processes, high time resolution, and short spinup time make SiBCASA well suited for use in a number of NASA funded research projects. SiBCASA will provide initial flux estimates for global and regional transport inversions of observed atmospheric CO2 concentration (Scott Denning PI, Randy Kawa PI). SiBCASA will be used in a NACP process study to link winter conditions to summer carbon fluxes for North America (Tingjun Zhang PI). We plan to eventually use SiBCASA in estimates of biomass burning carbon fluxes (Jim Collatz PI) and in the GMAO carbon cycle data assimilation project (Steve Pawson PI).

9.9-P: Monthly global emissions of anthropogenic CO2: Atmospheric CO2 transport calculations based on NASA data assimilation

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We present monthly estimates of the global emissions of anthropogenic CO2. We posit that high temporal estimates of anthropogenic CO2 fluxes will impact the seasonal cycle of atmospheric CO2 concentrations and will impact inversion calculations. Implementing a dual harmonic numerical treatment as a function of latitude the annual

fluxes are decomposed into monthly flux estimates. Using these monthly flux estimates we then use the NASA PCTM to transport the annual and monthly fluxes in the atmosphere. We find that the use of monthly fluxes makes a significant difference in the seasonal cycle of atmospheric CO2 in and near those regions where anthropogenic CO2 is released to the atmosphere. Local variations of 2-6 ppm CO2 in the seasonal cycle amplitude are simulated. We also find that in the mid latitudes near the sources synoptic scale atmospheric circulations are important in the winter and that boundary layer venting and rectifier effects are more important in the summer. There are clear transitions over the seasonal cycle between these two modes of boundary layer mixing. These findings have implications for inverse models that attempt to estimate surface source/sink regions especially when the surface sinks are co-located with regions of strong anthropogenic CO2 emissions.

9.10-P: Recent Trends in U.S. Forest Disturbance and Regrowth from Landsat and USFS FIA : A Contribution to the North America Carbon Program

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Understanding forest dynamics is critical to the goals of the NACP. Scaling local patterns of forest change to regional and continental areas will prove to be a significant challenge. As a result, mapping land-cover change and disturbance falls into the NACP's "First Tier" of land measurements - those measurements that must be made comprehensively at continental scales and, most likely, over a range of time periods, from remote sensing and allied comprehensive ground measurements such as the US Forest Service Forest Inventory and Analysis (FIA) data.
In this study, we are building upon our previous work with land remote sensing measurements in combination with the USFS FIA field measurements, to develop a 30+ year historical record of forest disturbance and regrowth dynamics for North America, This analysis will provide carbon modelers with critical information is needed to both parameterize and validate regional- to continental-scale process models applied across North America.

9.11-P: Africa and the global carbon cycle

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The African continent has a large and growing role in the global carbon cycle, with potentially important climate change implications. However, the sparse observation network in and around the African continent means that Africa is one of the weakest links in our understanding of the global carbon cycle. Here, we combine data from regional and global inventories as well as forward and inverse model analyses to appraise what is known about Africa's continental-scale carbon dynamics. With low fossil emissions and productivity that largely compensates respiration, land conversion is Africa's primary net carbon release, much of it through burning of forests. Savanna fire emissions, though large, represent a short-term source that is offset by ensuing regrowth. While current data suggest a near zero decadal-scale carbon balance, interannual climate fluctuations (especially drought) induce sizeable variability in net ecosystem productivity and savanna fire emissions such that Africa is a major source of interannual variability in global atmospheric CO2. Considering the continent's sizeable carbon stocks, their seemingly high vulnerability to anticipated climate and land use change, as well as growing populations and industrialization, Africa's carbon emissions and their interannual variability are likely to undergo substantial increases through the 21st century.

9.12-P: Using remotely sensed data to asses the burn severity of wildland fires in Alaska's interior boreal forest.

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The interior Alaskan boreal region has the potential for warm and dry summer conditions resulting in the increased possibility of fires, such as in 2004 when over six million acres of land burned. This complex system can have important implications for carbon sequestration and emissions - both on local and global scales. This study uses broad scale remote sensing mapping techniques to more accurately quantify the fraction of area burned and the burn severity of wildland fires in an effort to gain a better understanding of the carbon emissions of this region. First, the accuracy and feasibility of two Landsat TM and ETM+ remotely sensed indices are compared in the analysis - the differenced normalized burn ratio (dNBR) and the tasseled cap transformation. While the dNBR is traditionally used to map burn severity, it is believed that the tasseled cap transformation, based on information extending over a wider range of the electromagnetic spectrum than the dNBR, could be an alternative. The usefulness of these indices as methods to examine the fraction of area burned within each fire is then explored within the study. Additionally, MODIS Hotspot data is used to examine the progression of each fire event; this analysis is then used to better understand the results from the dNBR and tasseled cap in light of the time of year in which the fire occurred. These image analysis techniques, coupled with detailed vegetation maps of the interior boreal region, give greater insight into this region through accounting for and analyzing unburned islands within each fire scar and through quantifying variations within the perimeter of the burned area.

9.13-P: Reconstruct forest disturbance history using Landsat data: methodology development and preliminary results

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Forest disturbance and regrowth are significant forces moderating North American carbon balance. Quantifying the carbon fluxes of forest changes requires the changes be assessed with appropriate spatial and temporal details. The Landsat imagery archive accumulated since 1972 provides a unique data source for characterizing forest changes over the last 30+ years. Through the "North American Forest Disturbance and Regrowth since 1972" project, we have developed a highly automatic method for reconstructing the chronicle sequence of forest disturbance history using dense time series of Landsat observations. Specifically, the method was designed to analyze a stack of images consisting of one Landsat acquisition every one or two years. It produces products that reveal where and when each disturbance occurred, and provide indicators of the magnitude of each disturbance. Knowing when each disturbance occurred allows estimation of the stand age of post-disturbance recovering forest. This method has been tested in several areas in eastern and western U.S. The derived results were assessed by visually interpreting the input Landsat images and were found highly reliable. Field plot data collected through the Forest Inventory and Analysis (FIA) program were used to validate the age of post-disturbance forest estimated based on the derived disturbance products. The Landsat derived age of post-disturbance forest was found highly correlated with FIA field measurements.

9.14-P: Climatic variability, carbon exchange and vegetation vulnerability in Amazonia

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The stability of Amazonian equatorial forests, and the fate of their immense stores of organic carbon, depend on the ecosystem response to climate and weather. This study presents 4+ years of eddy covariance measurements of carbon and water fluxes and their response to environmental conditions in an Amazonian old-growth tropical forest. Contrary to expectations, this forest does not show signs of seasonal water limitation on growth despite a 5-month dry season. CO¬2 uptake responds primarily to light on hourly time scales, but photosynthesis overall maximizes in the middle of the dry season, responding to ecophysiological (flushing of new leaves) and atmospheric (high aerosol loading) changes. Annual carbon balance was very sensitive to weather anomalies, particularly the timing of the dry-to-wet seasonal transition, with mean net loss of 939 kg C ha-1 yr-1 (observed range of -221 (uptake) to 2677 (loss) kg C ha-1 yr-1). The climatic sensitivity has significant implications for Amazonian carbon balances on annual to decadal time scales.

We also assessed the vulnerability and resilience of Amazonian vegetation to climate change by analyzing observed climate-vegetation relationships using climate data, observed vegetation distributions, and evapotranspiration rates inferred from eddy flux data. We found that drought frequency is an excellent predictor of the forest-savanna boundary, indicating the key role of extreme climatic events for inducing vegetation change, and highlighting particularly vulnerable regions of Amazonia.

9.15-P: Progress in Modeling Global Atmospheric CO2 Fluxes and Transport

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Progress in better determining CO2 sources and sinks will almost certainly rely on utilization of more extensive and intensive CO2 and related observations including those from satellite remote sensing. Use of advanced data requires improved modeling and analysis capability. Here we seek to develop and integrate improved formulations for 1) atmospheric transport, 2) terrestrial uptake and release, 3) biomass and 4) fossil fuel burning, and 5) observational data analysis including inverse calculations. The transport modeling is based on meteorological data assimilation analysis from the Goddard Modeling and Assimilation Office. Use of assimilated met data enables model comparison to CO2 and other observations across wide range of scales of variability. In this presentation we focus on the short end of the temporal variability spectrum: hourly to synoptic to seasonal. Using CO2 fluxes at varying temporal resolution from the Transcom-C model intercomparison exercise, we examine the model's ability to simulate CO2 variability in comparison to observations at different times, locations, and altitudes. We find that the model can resolve much of the variability in the observations, although there are limits imposed by vertical resolution of boundary layer processes. The influence of key process representations is inferred. The high degree of fidelity in these simulations leads us to anticipate incorporation of real-time, highly resolved observations into a multidisciplinary carbon cycle data assimilation system that will reduce uncertainty in the terrestrial CO2 sink and lead toward credible, tested predictive models of climate and carbon needed for informed policy decisions.

9.16-P: The National Biomass and Carbon Dataset 2000 (NBCD 2000): A High Spatial Resolution Baseline to Reduce Uncertainty in Carbon Accounting and Flux Modeling

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A major goal of the North American Carbon Program (NACP) is to develop a quantitative scientific basis for regional to continental scale carbon accounting to reduce uncertainties about the carbon cycle component of the climate system. Given the highly complementary nature and quasi-synchronous data acquisition of the 2000 Shuttle Radar Topography Mission (SRTM) and the Landsat-based 2001 National Land Cover Database (NLCD 2001), an exceptional opportunity exists for exploiting data synergies afforded by the fusion of these high-resolution data sources. Whereas the thematic layers of the NLCD are suitable for characterizing horizontal structure (i.e., cover type, canopy density, etc.), SRTM provides information relating to the vertical structure, i.e., primarily vegetation height. In the NBCD2000 initiative, data are analyzed in 60 ecologically diverse regions, identical to the NLCD 2001 "mapping zones", which cover the entire conterminous United States. Within each mapping zone

data from the space shuttle are combined with topographic survey data from the NED to form a radar-measured vegetation height map. Subsequently, this map is converted to estimates of actual vegetation height, biomass, and carbon stock using survey data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program and derived biomass data, as well as ancillary data sets from the NLCD2001 project. In this poster first results from mapping zones in the interior west and eastern forests are presented.

9.17-P: A sample design for Landsat-based estimation of national trends in forest disturbance and regrowth

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Dense temporal stacks of Landsat images have great potential for describing the dynamics of forest disturbance and regrowth, particularly when spectral data are linked with forest inventory data, but require significant time and expense to process and analyze. Here we describe a stochastic, design-based sampling strategy used to identify 23 Landsat scenes in which we are characterizing detailed forest dynamics over the past three decades. The sample was required to meet several competing goals, including capture of diverse forest types and disturbance regimes, minimization of effort expended in low-forest-area scenes, flexibility for expansion of the sample size in the future, and preferential inclusion of scenes where significant prior research had been accomplished. Sample units were defined as the non-overlapping area of Landsat scenes on the WRS-2 grid, were divided into eastern and western sample frames, and were attributed with forest type and area from a recent national-level forest type map. For each frame, 100,000 randomized, ordered lists of scenes were chosen and scored according to the competing goals of the project using a target number of samples in the east and the west. The minimal set of these lists that best balanced all goals and that included each scene in the frame at least once was identified, and from this set a single ordered list was randomly chosen. Probabilities of inclusion for each scene were calculated from the proportion of lists from the final set that included that scene. This strategy allows use of unequal-probability estimators in a design-based estimation paradigm, while also ensuring that a full range of conditions can be used in a model-based estimation paradigm.

9.18-P: Automated characterization of disturbance year, intensity, and recovery rates in a two-decade stack of yearly Landsat Thematic Mapper imagery

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To relate landscape-level trends in forest disturbance and recovery to the environmental and economic factors that affect them, cross-ownership maps are needed of the timing and severity of forest disturbance as well as the rate of revegetation. The historical archive of Landsat imagery is a potentially rich source for developing such maps, but extraction of information from Landsat image stacks requires novel change detection approaches. Here, we describe results from a method for extracting continuous-variable estimates of forest disturbance and recovery properties from a stack of near-yearly Landsat images for a large (180 by 180km) region of western Oregon, U. S. A., from the year 1984 to 2004. The method utilizes a robust non-linear least-squares fitting algorithm to match idealized disturbance or recovery trajectories to temporal traces of normalized reflectance for every pixel in the image. Mapped disturbance parameters include year of disturbance, magnitude of reflectance change during disturbance (an estimate of intensity of disturbance), and the exponent of an exponential curve fit to the recovery trajectory of reflectance (an estimate of the recovery rate). This latter parameter is also used to describe recovery rate of areas disturbed prior to the change interval that are still recovering vegetative cover. Unlike other landscape disturbance maps, the approach requires no pre-stratification or classification, and determines thresholds for change from simple f-statistics describing the goodness of fit of the disturbance or recovery model.

9.19-P: Satellite observations of Pan-Arctic Terrestrial Net Primary Productivity from 1982-2005

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We applied the MOD17A2 production efficiency model (PEM) using AVHRR PAL and MODIS LAI/FPAR time series with NCEP reanalysis daily surface meteorology to assess terrestrial NPP for the pan-Arctic basin and Alaska from 1982 to 2005. We integrated the AVHRR and MODIS time series on a pixel by pixel basis by empirical adjustment of the AVHRR record using land cover specific regressions of overlapping NPP results for 2000. We then analyzed spatial patterns, temporal anomalies and trends in NPP over the 24 year record. Sensitivity analysis of the production efficiency model to uncertainties in surface meteorological inputs indicates that NCEP surface temperatures and solar radiation are the primary sources of PEM based NPP uncertainty for the region. Despite these uncertainties the reanalysis product captured the major annual anomalies and trends in surface meteorology for the domain. NPP for the domain showed generally widespread positive productivity trends from 1982 to 1997 followed by a significant productivity decline after 1997. The spatial pattern of 24-yr trends showed significant increases across southern Alaska and south-central Eurasia ($P<0.01$), and significant NPP declines across central Canada ($P<0.05$) and southeast Eurasia ($P<0.01$). Major NPP positive and negative annual anomalies are attributed to relatively warm and cool years, respectively, while NPP anomalies are also examined relative to regional droughts.

9.20-P: The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle

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The Carbon Cycle chapter of the Strategic Plan for the U.S. Climate Change Science Program (CCSP) describes a plan to produce "a series of increasingly comprehensive and informative reports about the status and trends of carbon emissions and sequestration," each to be called a State of the Carbon Cycle Report (SOCCR). The CCSP Carbon Cycle Interagency Working Group (CCIWG) envisions "a series of reports on the state of the carbon cycle designed to provide accurate, unbiased, and policy-relevant scientific information concerning the carbon cycle to a broad range of stakeholders." The first of these reports is underway and is being produced as CCSP Synthesis and Assessment Product (SAP) 2.2: *The First State of the Carbon Cycle Report (SOCCR): The North American Carbon Budget and Implications for the Global Carbon Cycle*. Currently in draft, and scheduled for final release in March 2007, SOCCR SAP 2.2 will provide a synthesis and integration of the current knowledge of the North American carbon budget and its role within the context of the global carbon cycle in a format useful to decision-makers. The report addresses carbon emissions, natural reservoirs and sequestration, rates of transfer, the consequences of changes in carbon cycling on land and the ocean, effects of purposeful carbon management, and the socio-economic drivers and consequences of changes in the carbon cycle. The content and the process of producing the report are both designed to summarize scientific information in a way most useable for decision support and policy formulation concerning carbon.

9.21-P: Use of a MODIS-Derived Photochemical Reflectance Index to Detect Interannual Variations in the Photosynthetic Light-Use Efficiency of a Boreal Deciduous Forest

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Hank Margolis, Laval University, hank.margolis@sbf.ulaval.ca (Presenting)

Biochemical changes in leaves during stress events have been shown to result in changes in spectral reflectance at 531 nm and the Photochemical Reflectance Index (PRI) was developed to measure this phenomenon. We calculated PRI from MODIS reflectance data for cloud-free days between 2001 and 2003 for the Fluxnet-Canada Old Aspen flux tower in Saskatchewan and the flux and meteorological data from the tower allowed us to calculate the photosynthetic light-use efficiency (LUE) at the time of MODIS overpasses. A linear relationship was found between the PRI and the LUE only when backscatter spectral data (minimal shadowing) was used. The relationship was stronger for top of the atmosphere reflectance data (R2=0,76) compared to data that had been atmospherically corrected with MODIS-derived aerosol optical depth values and the Six-S atmospheric correction model (R2=0.53). While our analysis of MODIS-derived PRI did not capture the seasonal variations in LUE, it did seem to detect interannual variations associated with drought versus non-drought years. An ability to reliably estimate LUE from satellites would significantly improve large-scale modelling of the carbon cycle.

9.22-P: Comparison of Carbon Fluxes Over Three Boreal Black Spruce Forests in Canada.

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Although mature black spruce forests are a dominant cover type in the boreal forest of North America, it is not clear how their carbon (C) budgets might vary across the continent. The installation in 2003 of an eddy covariance flux tower on an Old Black Spruce site in eastern Canada (EOBS, Quebec) provided a unique opportunity to compare and contrast its annual and seasonal carbon cycling dynamics with two other pre-existing Old Black Spruce flux sites located in Saskatchewan (SOBS) and Manitoba (NOBS). In 2004, SOBS and NOBS were weak C sinks of 30 and 27 g C m-2 y-1, respectively, while EOBS was C neutral (4 g C m-2 y-1). Total annual gross ecosystem productivity (GEP) and ecosystem respiration (R) were 690 and 660 g C m-2 y-1, respectively, at SOBS, 584 and 580 at EOBS, 565 and 538 at NOBS. EOBS had lower net ecosystem productivity (NEP) primarily because warmer soil under thicker snowpack appeared to increase winter C losses and low light suppressed NEP in June compared to the other two sites. All three sites showed a distinct response of half hour mean R to near surface temperature and light response parameters. At the daily and monthly time scales, temperature drove both total GEP and total R. All three sites showed similar response of relative daily GEP (total daily GEP / maximum total daily GEP) to air temperature. On the other hand, the responses of total daily R to soil temperature were clearly site specific. At the monthly scale, the responses of total R and total GEP to temperature were not different among sites. Soil water content had an influence on R at the daily time scale at SOBS and EOBS and appeared to be limiting at EOBS on a monthly time scale.

9.23-P: Ecosystem-Atmosphere Carbon Dioxide Fluxes for Canadian Forests and Peatlands.

Hank A Margolis, Fluxnet-Canada, Laval University, Hank.Margolis@sbf.ulaval.ca (Presenting)

The potential importance of the biosphere to climate change is highlighted by the fact that annual C fluxes from terrestrial ecosystems are an order of magnitude greater than fossil fuel emissions. Canada's vast land area encompasses more than 45% of the North American continent, indicating that Canada plays a significant role in the continental carbon cycle.

By March 2007 the Fluxnet-Canada Research Network will have been in operation for five years and conducted carbon flux measurements at a total of 36 network or associated sites along an east-west continental transect. Year-round measurements of the net exchange (flux) of C, water and energy between these sites and the atmosphere will have been made at 26 of these sites, while the other ten sites will have been measured periodically during the growing season. The network studies a) the relationship between the inter-annual variability of C fluxes and climate, b) the effect of disturbance on C fluxes, c) the relationship between ecosystem productivity and net C fluxes, and (d) ecosystem and climate models that allow extrapolation in space and time. The knowledge gained from these studies will allow us and others to provide better estimates of the potential for C uptake, emission and long-term sequestration by Canadian forests and peatlands. We will present key results from the network.

9.24-P: North American Disturbance Rates Assessed from LEDAPS Satellite Analysis

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Stand clearing disturbances (harvest, fire) are thought to play a major role in controlling land-atmosphere fluxes of carbon. Under the auspices of the North American Carbon Program, the LEDAPS (Landsat Ecosystem Disturbance Adaptive Processing System) has been analyzing the Landsat satellite record to assess rates of forest disturbance across North America. Wall-to-wall Landsat coverage for the period 1975-2000 has been converted to surface reflectance and analyzed for decadal losses (disturbance) or gains (regrowth) in biomass using a spectral “disturbance index”. Preliminary (unvalidated) results for the 1990’s indicate high rates of harvest within the southeastern US, Eastern Canada, and the Pacific Northwest, with spatially averaged (~50x50 km) turnover periods as low as 25-40 years. Lower rates of disturbance are found in the Rockies and Northeastern US. Validation of these results is occurring via visual analysis of image subsets and comparison with FIA data. This poster will give an overview of the LEDAPS processing and validation efforts, present recent results, and discuss lessons learned for large area analyses using high-resolution satellite data.

9.25-P: The Effect of Canopy Gaps on Subcanopy Ventilation and Scalar Fluxes above a Tropical Forest

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Forest gaps may provide conduits that preferentially vent moist, CO2 rich subcanopy air to the atmosphere. We measured the above-canopy fluxes of sensible heat, CO2, and water vapor, and vertical profiles of CO2 and water vapor, from two 67-m towers in a selectively-logged Brazilian rainforest as part of the Large-Scale Biosphere Atmosphere Experiment in Amazonia (LBA). One tower was in an intact patch of forest within the selectively logged area; the other was 400 m upwind in a large gap created by the logging. The logging removed ~3.5 trees ha-1, and increased the incidence of gaps by a factor of 3 over nearby undisturbed forest. The forest understory was drier and warmer during daytime after the logging, which would be expected to increase flammability. After the logging, the daytime subcanopy air in the intact patch of forest had more CO2, more water vapor, and was cooler than the air at comparable altitudes in the gap. Meanwhile, the daytime CO2 flux was less negative (reduced CO2 uptake) above the gap than above the intact forest, the daytime evapotranspiration was greater above the gap than the intact forest, and the daytime sensible heat flux was lower above the gap than the intact forest. These patterns cannot be explained fully by the local loss of canopy gas exchange in the gap, but are consistent with the horizontal transport into the gap, and subsequent vertical transport out of the gap, of high-CO2, humid, cool air from the forest understory. Estimates of the CO2 venting flux indicate the potential for high rates of subcanopy scalar emissions out the gap; however, these estimates were uncertain because the contribution of the gap to the flux footprint was not known. Further measurement and modeling efforts are needed to better understand the effect of canopy gaps on flux footprints.

9.26-P: Scaling and Evaluation of Ecosystem Carbon Uptake Through Integration of Multi-Scale Remote Sensing with AmeriFLUX Field Observations

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Spatial patterns of carbon assimilation in terrestrial ecosystems are influenced by two important classes of vegetation variables: those related to canopy structure (e.g. foliar biomass and leaf area index) and those related to photosynthetic capacity (e.g. leaf nitrogen and pigment concentrations). Although EOS-era remote sensing instruments have greatly improved assessment of vegetation productivity, focus has been concentrated on detection of LAI and related structural attributes that are used in models designed to be driven by these variables. Information on plant traits related to photosynthetic capacity has lagged far behind and is typically only available through use of biome-specific look-up tables that lack important sources of spatial variability

Here, we report on an investigation that examines the degree to which carbon assimilation in forest ecosystems can be related to both local and regional variation in canopy nitrogen. Field measurements collected at a diverse array of forested research sites within the AmeriFlux network have been combined with hyperspectral remote sensing data from the airborne AVIRIS and spaceborne Hyperion instruments. Resulting coverages of canopy nitrogen concentrations have been used to relate tower-based estimates of carbon assimilation capacity to canopy N for the local landscapes surrounding each tower. Results to date indicate a significant positive relationship between canopy N and GPPmax that cannot be attributed to co-variation with LAI. Because existing methods of canopy N detection are labor intensive and are restricted to small landscapes, a parallel investigation involves developing generalizeable canopy N detection methods that would enable more widespread application of these results. Results of this effort indicate that a single PLS regression equation can accurately predict canopy N concentrations at independent sites covering a wide range of site types. Further, we show that a substantial fraction of the variation in canopy N can be related to spectral features available from broad-band sensors.

9.27-P: Next-Generation SAR Amazon Mosaic: JERS and RADARSAT

Leland E Pierce, Univ of Michigan - EECS Dept., lep@umich.edu (Presenting)

We discuss the development of the next-generation
SAR Amazon mosaic using both L-band JERS and C-band
RADARSAT data.
Rather than using rubber-sheeting-based techniques,
this project uses custom orthorectification programs
to allow for precise positioning, geometric correction,
and radiometric correction made possible by the recent
90-meter-spacing digital elevation model provided by
the Shuttle Radar Topography Mission that flew on the Shuttle
in 2000. This topographic data allows for the correction
of many SAR-related image distortions. We rely on accurate
satellite orbital information as gathered by NORAD and
published on the web to correct for the usually quite
inaccurate orbital information that comes with each image.

Since we are building upon work done by JPL when they processed
the original Amazon mosaic using JERS (L-band) SAR data only,
we are using the same 34 tiles that they used to divide up the
Amazon into manageable pieces.
Each original JERS or RADARSAT image is then orthorectified
onto a tile, and subsequent images are then allowed to
overwrite this same tile until a complete tile is done.
At this point the SAR data is relatively seamless due to the
orthorectification process.
Geometric accuracy will be assessed using natural features
such as rivers and coastlines.
The resulting data will be made available to the public.

9.28-P: Evolution of the Latitudinal Gradient of Atmospheric CO2 and Its Relationship to Anthropogenic and Natural Sources and Sinks

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Ralph Keeling, UCSD/Scripps Institution of Oceanography, rkeeling@ucsd.edu

The annual mean atmospheric CO2 concentration currently is higher in the northern hemisphere than in the southern hemisphere because 90% of fossil fuel is burned in the northern hemisphere, and the interhemispheric mixing time of fossil fuel CO2 in the atmosphere is on the order of 1 year. This latitudinal gradient of atmospheric CO2 varies somewhat unpredictably from year to year on the El Nino time scale, but over the longer term, since the late 1950s, when direct CO2 measurements began to be measured, the north-south gradient has varied in close proportion to the magnitude of global annual fossil fuel emissions.

By regressing the difference of CO2 at each station in the Scripps network, supplemented by snapshot surveys in 1962, 1968 and 1980, from the CO2 at the South Pole against fossil fuel emissions, we can identify the latitudinal gradient attributable to anthropogenic emissions, and sources and sinks that vary in proportion to fossil fuel emissions. By extrapolating the regressions to zero fossil fuel emissions, we obtain a latitudinal gradient that is lower in the northern hemisphere than the southern by about 1 ppm, and a well-pronounced equatorial peak in CO2. The north-south gradient produced by a similar treatment of 13C/12C observations agrees somewhat well with a model prediction of temperature-dependent equilibrium fractionation suggesting that the equatorial peak in CO2 is produced by an oceanic source, or a very strong source of CO2 from C4 plants, and that any underlying terrestrial biospheric CO2 flux not correlated with fossil fuel emissions is small.

9.29-P: Terrestrial Carbon Sinks for the United States Predicted from MODIS Satellite Data and Ecosystem Modeling

Christopher Potter, NASA Ames Research Center, cpotter@mail.arc.nasa.gov (Presenting)
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A simulation model based on satellite observations of monthly vegetation cover from the Moderate Resolution Imaging Spectroradiometer (MODIS) was used to estimate monthly carbon fluxes in terrestrial ecosystems of the conterminous United States over the period 2001-2004. Predicted net ecosystem production (NEP) flux for atmospheric CO2 in the U.S. was estimated as annual net sink of about +0.2 Pg C in 2004. Regional climate patterns were reflected in the predicted annual NEP flux from

the model, which showed extensive carbon sinks in ecosystems of the southern and eastern regions in 2003-2004, and major carbon source fluxes from ecosystems in the Rocky Mountain and Pacific Northwest regions in 2003-2004. As demonstrated though tower site comparisons, NPP modeled with monthly MODIS Enhanced Vegetation Index (EVI) inputs closely resembles both the measured high- and low-season carbon fluxes. Areas of the country that show consistently high carbon sink fluxes in terrestrial ecosystems on a yearly basis are the southern Appalachian Mountains, the western Gulf Coast states, the northern Rocky Mountains, and Sierra Nevada Mountains. Because seasonal climate and atmospheric circulation patterns are likely to differ substantially between these widespread areas of the country, new intensive study campaigns for NACP must be specifically tailored to each of these four priority regions with careful attention to the measurement network requirements for continuous atmospheric CO2 monitoring.

9.30-P: Integration of Forest Inventory Data with Landsat Time Series Data for Characterization of Forest Disturbance and Regrowth: Joint Objectives of the North American Carbon Program (NACP) and Forest Inventory and Analysis (FIA)

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The objectives of both the North American Carbon Program (NACP) and Forest Inventory and Analysis (FIA) hinge on the integration of remotely sensed satellite observations with field measurements. To complement the Landsat satellite archive, we are compiling FIA data from over half of the states in the U.S. in support of the NACP and FIA goals to improve understanding of forest disturbance and regrowth dynamics. Tree-level FIA observations are aggregated to the plot-level, associated with corresponding Landsat spectral and ancillary data, and used to develop empirical models of aboveground biomass. These models are then applied to 20+ year stacks of normalized Landsat satellite images for each of 23 sample scenes across the U.S. The linkage between complementary FIA and Landsat datasets enables scaling of biomass estimates in both space and time, which in turn enables analysis of multidecadal trajectories of biomass dynamics associated with forest disturbance and regrowth. Additionally, FIA data are used to validate estimates of "time since disturbance" derived from spectral trajectories. Preliminary results from several test sites confirm that FIA data are a valuable and practical complement to the Landsat satellite archive, and that biomass trajectories associated with forest disturbance and regrowth can be captured across a wide range of forest conditions and disturbance types.

9.31-P: Effects of terrestrial carbon-nitrogen coupling on climate-carbon cycle feedbacks

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We demonstrate that the inclusion of coupling mechanisms between terrestrial carbon and nitrogen cycles has significant impacts on the major climate-carbon cycle feedback mechanisms that control the fraction of anthropogenic CO2 emissions taken up by the land biosphere. We use a series of offline simulations with a recently developed land model component of the NCAR Community Climate System Model to show that the land response to increasing CO2 is lower by approximately a factor of four when C-N coupling mechanisms are included. We also show that the sensitivities of land carbon exchange to variability in temperature and precipitation are reduced by inclusion of C-N coupling. Finally, we show that the change over time in the temperature and precipitation sensitivities under a scenraio of increasing atmospheric CO2 is opposite for the C-N vs. C-only model configurations, with decreasing sensitivities over time with C-N coupling, but increasing sensitivity over time for the C-only model. We are now performing fully coupled experiments with this model in the CCSM3 framework.

9.32-P: Interdisciplinary Research of Carbon and Water Cycles in the Terrestrial Ecosystems of China

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For millennia, Chinese people have altered the landscape in many ways in pursuit of food, fuel and fiber. China's expanding economy, which is the fastest growing in the world along with continued population growth, will lead to continued land transformations in the next decades, including dramatic urbanization. While we have a qualitative sense that land transformations across China have affected and will continue to affect the ability of China's ecosystems to provide people with essential goods and services, our challenge now is to quantify exactly how the provision of key goods and services has changed. Here we have developed a partnership between Chinese and US scientists to combine remote-sensing data and a set of ecosystem simulation models to quantify the consequences of land transformations on productivity, carbon sequestration and water yield in terrestrial ecosystems. We document the patterns of land-use change across China in the past 300 years. We also examine how ecosystem goods and services have changed as a result of multiple stresses and interactions among those stresses including land-use change, climate variability, atmospheric composition (carbon dioxide and tropospheric ozone), precipitation chemistry (nitrogen composition), and fire frequency using estimates of gross primary production, net primary production, carbon storage, evapotranspiration and water yield from factorial simulation experiments with three terrestrial ecosystem models (Biome-BGC, DLEM and TEM). Model results are compared to field-based estimates of carbon fluxes and pools, evapotranspiration and stream flow. Here we present the key results from a collaborative project, funded by NASA Interdisciplinary Science Program.

9.33-P: Scaling soil CO2 and CH4 fluxes in heterogeneous northern forest landscapes.

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In developing landscape-level carbon budgets, we measured fluxes of CO_2 and CH_4 from soils of forests and wetlands in the Marcell Experimental Forest (MEF) and the Chequamegon National Forest (CNF) during the 2005 growing season. At MEF, CO_2 efflux from peatland cover types (6.1 Mg ha^{-1}) was lower than that from forested and non-forested upland cover types (7.9 and 10.1 Mg ha^{-1}, respectively). MEF uplands were a slight sink for CH_4 (-0.005 kg C ha^{-1} d^{-1}), and peatlands were a substantial source (0.31 kg C ha^{-1} d^{-1}). As peatlands account for approximately 20% of the cover types at MEF, this site acted as a net source of CH_4 during the measurement period. At the CNF, we sampled 7 different field sites representative of vegetation cover classes and forest management regimes in the region. CO_2 efflux was lowest at an open bog site (2.9 Mg C ha^{-1}) and highest in a 5 year clearcut (7.8 Mg C ha^{-1}), with the flux from other wetland types, a mature forest, and a young clearcut ranging from 5.4-6.8 Mg C ha^{-1}). Net CH_4 flux also varied with site, with the mature hardwood site, the older clearcut, and the coniferous wetland acting as sinks for (-1.2, -1.3, and - 0.7 kg C ha^{-1} respectively), and the younger clearcut, the alder swamp, the bog, and the sedge fen acting as sources (3.7, 0.9, 2.7, and 19.8 kg C ha^{-1} respectively). Site differences appear to be directly related to differences in temperature, moisture and vegetation.

9.34-P: Estimating Regional Changes in Soil Carbon with High Spatial Resolution: Integrating Field Measurements, Inventory Data, and Remote Sensing Products

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To improve estimates of regional carbon dynamics, it is important to better represent landscape heterogeneity and local land management. We are currently developing a carbon accounting framework that can estimate carbon dynamics and net greenhouse gas emissions associated with changes in land management at a high spatial resolution. One component of this framework integrates field measurements, inventory data, and remote sensing products to monitor changes in soil carbon at a sub-county level (900m^2 resolution) caused by inter-annual changes in tillage and crop management. We applied this framework component to a mid-western region of the US that consists of 679 counties approximately centered around Iowa. We estimate the 1990 baseline soil carbon for this region to be 4,099,199,793 Mg to a 3m maximum depth. Soil carbon accumulation of 57,274,560 Mg is estimated to have occurred in this region between 1991-2000. Without accounting for soil carbon loss associated with changes to more intense tillage practices, our estimate increases to 66,338,751 Mg. This indicates that on-site permanence of soil carbon is approximately 86% with no additional economic incentives provided for soil carbon sequestration practices. This carbon accounting framework offers a method to integrate new inventory and remote sensing data on an annual basis, account for alternating annual trends in land management without the need for model equilibration, and provide a transparent means to monitor changes soil carbon. Our method of integration is capable of estimating regional or national changes in soil carbon while still representing heterogeneity at the sub-county level. Future research will include predictive changes in soil carbon based on socio-economic drivers, and a sensitivity analysis using high-resolution remote sensing products.

9.35-P: Characterization of seasonal variation of forest canopy in a temperate deciduous broadleaf forest, using daily MODIS data

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In this poster, we present an improved procedure for collecting no or little atmosphere- and snow-contaminated observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor. The resultant time series of daily MODIS data of a temperate deciduous broadleaf forest (the Bartlett Experimental Forest)in 2004 show strong seasonal dynamics of surface reflectance of green, near infrared and shortwave infrared bands, and clearly delineate leaf phenology and length of plant growing season. We also estimate the fractions of photosynthetically active radiation (PAR) absorbed by vegetation canopy (FAPARcanopy), leaf (FAPARleaf), and chlorophyll (FAPARchl), respectively, using a coupled leaf-canopy radiative transfer model (PROSAIL-2) and daily MODIS data. The Markov Chain Monte Carlo (MCMC) method (the Metropolis algorithm) is used for model inversion, which provides probability distributions of the retrieved variables. A two-step procedure is used to estimate the fractions of absorbed PAR: (1) to retrieve biophysical and biochemical variables from MODIS images using the PROSAIL-2 model; and (2) to calculate the fractions with the estimated model variables from the first step. Inversion and forward simulations of the PROSAIL-2 model are carried out for the temperate deciduous broadleaf forest in the northeastern USA during day of year (DOY) 184 to 201 in 2005. The reproduced reflectance values from the PROSAIL-2 model agree well with the observed MODIS reflectance for the five spectral bands (green, red, NIR1, NIR2, and SWIR1). The estimated leaf area index, leaf dry matter, leaf chlorophyll content and FAPARcanopy values are close to field measurements at the site. The results also showed significant differences between FAPARcanopy and FAPARchl at the site. Our results show that MODIS imagery provides important information on biophysical and biochemical variables at both leaf and canopy levels.

9.36-P: Mapping high-resolution incident Photosynthetically Active Radiation over land from satellite observations

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Incident Photosynthetically Active Radiation (PAR) is a key variable required by almost all ecosystem models some of which calculate biomass accumulation linearly proportional to incident PAR. Current PAR products that are generated either from satellite observations or GCM reanalysis have coarse spatial resolutions and inconsistent accuracy. Because the high-resolution incident PAR over land is not a standard EOS product, the MODIS team has to disaggregate the NASA DAO PAR product of 1° by 1.5° spatial resolution to produce 1km net primary productivity and net photosynthesis products. There is a critical need for mapping incident PAR at a high resolution for modeling hydrological and carbon cycles.

We have developed a series of algorithms for mapping incident PAR from MODIS, AVHRR and GOES. The basic procedure is composed of two steps, including 1) determination of the surface reflectance from the "clearest" observations during a temporal window, and 2) calculation of incident radiation from the determined surface reflectance and TOA radiance using the table look-up approach. The outputs include direct and diffuse PAR, insolation and other intermediate variables. The algorithms have been extensively validated using FLUXNET observations.

In support of North American Carbon Program, our efforts have been mainly on mapping PAR over North America. One-year (2003) PAR product (both instantaneous and daily) from MODIS at 1km resolution is ready and being distributed to the user. We are also generating the PAR products from GOES, AVHRR and SeaWiFS data. Intercomparison and integration of these products are under way.

9.37-P: Optimization of Global CO2 Fluxes at High Resolution using the Coupled MLEF-PCTM Model

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Increasing CO2 concentrations in the atmosphere believed to be a significant factor of the global warming. About half of the CO2 emitted by anthropogenic activities is taken up by the sink processes on land and ocean. There is a missing sink, which is hard to locate among the land and ocean processes. Hence the study of spatial and temporal variability of CO2 sources and sinks on the surface is important.

Inverse modeling is widely used to optimize surface CO2 fluxes using the observed concentrations in the atmosphere. Traditionally used Batch Mode inversions solve the problem by dividing the globe into several large regions. However this technique is lack of understanding the smaller scale variations of the fluxes and considering larger regions may leads to aggregation errors. In this study, we attempt to solve the fluxes in much finer scale compared to the batch mode inversions.

We introduced Maximum Likelihood Ensemble Filter (MLEF), coupled with Parameterized Chemistry Transport Model (PCTM) as an observation operator to optimize the surface CO2 fluxes. We conducted two experiments using synthetic data: (1) a very large problem, with observations defined in every grid cell, and (2) a more realistic problem with a network of 85 weekly observations. Our results show coupled MLEF-PCTM model can efficiently process very large observation vectors, and is thus suited for flux estimation using continuous-sampling towers and global satellite retrievals. Severely under constrained nature of the flux estimation problem with current observing system requires aggressive covariance localization and smoothing to obtain reasonable results.

Carbon Management Posters

10.1-P: Linking Landscape-Scale Carbon Monitoring with Forest Management

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We are integrating intensive ground-based measurements, remote sensing, and modeling at seven landscape-scale research sites across the U.S. to estimate carbon stocks and fluxes for forest carbon pools. As part of the North American Carbon Program, this study is intended to tie the spatially extensive, but coarsely resolved, measurements made through remote sensing and forest inventory to the spatially intensive and highly resolved measurements made at intensive monitoring sites such as the AmeriFlux network. Each study site consists of a diverse landscape that reflects the effects of natural disturbances and/or forest management activities on carbon stocks and productivity. To demonstrate the relevance of this work to land managers, we are evaluating how this information can improve decision support tools for estimating and reporting carbon stocks and changes in carbon stocks. The main products of this research include precise statistical estimates and maps of carbon stocks and productivity for a variety of forest landscape conditions; improved process models at ecoregion and stand scales; and decision-support tools for land managers interested in carbon management. We will estimate NPP and NEP for managed or disturbed tree stands in various stages of development, which will improve the ability of land managers to update or project stand-level inventories of carbon stocks for project evaluation and reporting to greenhouse gas registries. Reference data from these sites can be used by the scientific, policy, and land management communities. If successful, this project may evolve into a larger network of landscape-scale monitoring sites.

10.2-P: Remote Sensing Crop residue Cover and Soil Tillage Intensity

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Current methods of quantifying crop residue cover are inadequate for characterizing the spatial variability of residue cover within fields or across large regions. Our objectives were to evaluate several spectral indices for measuring crop residue cover using satellite hyperspectral data and to categorize soil tillage intensity in agricultural fields. Hyperion imaging spectrometer data were acquired over agricultural fields in central Iowa in May 2004 and 2005. Crop residue cover was measured in corn and soybean fields using line-point transects. Crop residue cover was linearly related to the cellulose absorption index (CAI) with coefficients of determination (r2) of 0.85 in 2004 and 0.69 in 2005. Three tillage intensity classes, corresponding to intensive (<15% residue cover), reduced (15-30% cover), and conservation (>30% cover) tillage, were correctly identified in 63-68% of fields. Classification accuracy increased to 68-82% for two classes, corresponding to conventional (intensive + reduced) and conservation tillage. Inventories of soil tillage intensity by previous crop type were generated for the whole Hyperion scene in each year. Regional surveys of soil management practices that affect soil conservation and soil C dynamics are possible using advanced multispectral or hyperspectral imaging systems.

10.3-P: Using temporal filters to deduce the cause of forest disturbances detected with time series of Landsat data

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The Forest Inventory and Analysis (FIA) unit of the Forest Service monitors the status and trends of the nation's forests. In collaboration with NASA and the North American Carbon Program, FIA is investigating the potential use of biennial Landsat imagery to support monitoring of forest disturbance. Digital change detection methods are being coupled with FIA plot data to map the year and magnitude of forest disturbances using time series of Landsat imagery from 30 scenes across the country. Complicating change detection efforts is the fact that defoliation events (insects, wind) can create spectral signals similar to those from disturbances that permanently alter forest structure. Differentiating these disturbance types is important with respect to FIA reporting; harvests, for example, are viewed quite differently than insect activity by the forest managers and policy-makers who rely upon FIA data. Likewise, the carbon flux involved with defoliation is significantly different than the flux associated with removal of woody material. In a pilot study in western Pennsylvania, we used a post-disturbance temporal filter to discriminate between gypsy moth defoliation and harvest activity. Though these types of disturbance are typically similar both spatially and spectrally immediately following disturbance, defoliated stands (as identified with independent management records) returned to near pre-disturbance spectral values within two years while harvested stands took much longer. Post-disturbance temporal filtering was found to be an accurate and, given this project's acquisition of relatively dense time series of imagery, expedient way to refine the change detection process.

10.4-P: A Global Forest Height and Biomass Product from ICESat

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Lidar sensors generally have been deployed on airborne platforms for short observational campaigns, limiting the scale of scientific questions that could be approached. With the data already collected by the Geoscience Laser Altimeter System (GLAS), we have the ability to move lidar remote sensing from the proof-of-concept stage to regional and global applications in forest ecology, forest management and carbon cycle science. Nevertheless, the translation of GLAS data from the realm of specialists, to part of the toolbox regularly used by remote sensing and carbon cycle scientists is impeded by two barriers: the technical difficulty of working with the data, and the lack of work scaling up existing approaches to regional and global scales.

Where substantial ground slope is present, GLAS waveforms over-estimate canopy height due to the broadened distribution of returns from the ground surface. A robust method for removing these effects has been developed that uses both metrics derived from the GLAS waveforms themselves, as well as ancillary data from Shuttle Radar Topographic mission. The results of this analysis, as well as the overall objectives and plans for data distribution will be discussed.

10.5-P: A Carbon Management Estimation System for US Agricultural Lands: Supporting Policy and Management Decisions

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Carbon management estimation systems are needed to support policy initiatives associated with greenhouse gas mitigation, such as C sequestration in agricultural soils. Moreover, farmers and ranchers need information about the potential to sequester C before making decisions that involve an investment of capital. Thus, a model-based assessment system has been developed to quantify land use and management effects on the soil C budget across a range of scales from the entire nation to individual farms

The system integrates model simulations with spatial data on environmental conditions, land use patterns and management information. The Century Ecosystem Model forms the foundation of the system, and environmental conditions are derived from weather records and soil survey data. Anthropogenic activity data on land use and management is derived from national surveys for broader-scale applications, while users enter the activity data for farm-scale assessments. Currently MODIS-derived products are being incorporated into this estimation system to improve the simulation of crop and forage production, which represents the carbon supply for sequestration. NPP in previous versions of the system was based solely on site edaphic characteristics, management information, and weather data. In the current version, an EVI "greenness" measure derived from MODIS is used to estimate NPP according to the framework of the NASA-CASA model. This estimation system has been applied to report changes in agricultural soil C to the UN Framework Convention on Climate Change as part of the US greenhouse gas inventory. A web-based version of the system, called COMET-VR, has also been developed that allows farmers and ranchers to evaluate on-farm decisions, and will be made available in the near future to register C credits through the US Federal Government 1605b voluntary reporting process.

10.6-P: Projections of Land-Use Change and the Carbon-Cycle

Steven Smith, JGCRI (UMd & PNNL), ssmith@pnl.gov (Presenting)

The terrestrial carbon cycle has been substantially altered by human activities and this alteration is continuing globally. Projecting the future behavior of the carbon-cycle, therefore, requires a coupled analysis of the carbon-cycle and the socio-economic forces driving land-use changes. Such an analysis is also required in order to consistently produce projections of land-use related emissions of carbon-dioxide and other compounds. Finally, analysis of carbon management options requires that the close coupling between the carbon- and socio-economic systems be explicitly considered.

This proposal will address these issues by using remote sensing information to improve long-term projections of land-use emissions, particularly CO2, CO, and CH4, and to provide for the analysis of the implications of land-use changes for atmospheric greenhouse gas concentrations, atmospheric chemistry, and carbon management. This will be accomplished within the -MiniCAM framework, the state of the art integrated assessment modeling framework developed at the Joint Global Change Research Institute (JGCRI - Umd and PNNL). Remote sensing data products and the results of models driven by remote sensing data will be used to improve the representation of the carbon-cycle and the Earth's land-surface characteristics. Critical to this project is the use of spatially resolved data products and earth system model outputs which will allow analysis of different regions and sub-regions as needed. This will enable global and regional analysis of carbon dynamics, carbon sequestration potential, and coupled dynamics of the carbon-cycle and the socio-economic systems that are driving land-use and climate changes. Both parametric uncertainty and uncertainty due to different model spatial definitions will be quantified. A particular focus will be analysis of the coupled carbon-cycle and socio-economic system as represented in the JGCRI integrated assessment framework. The result will be long-term emissions projections that are substantially improved over available data in terms of spatial and temporal detail, consistency with remote sensing data, and integration with socio-economic drivers. The capabilities developed through this proposal will be integrated into the JGCRI integrated assessment frameworks that will be used on a routine basis in future work for government agencies.

10.7-P: Decision Support for Forest Carbon Management

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The goal of this Integrated System Solutions project is to evaluate, verify and validate, and benchmark solutions that integrate Earth science observations (MODIS, ASTER, Landsat) and predictions (NASA-CASA) resulting from NASA research into existing forest management decision support tools. This will enable landowners to make informed decisions about forest management with full understanding of the resulting implications for carbon sequestration and productivity. The target applications of national priority are carbon management and agricultural productivity. Two extant and internationally-used DSTs are being supported. The first enables forest landowners to understand the effects of silvicultural prescriptions, particularly thinning and fertilization, on growth and yield - but currently has no output that would allow carbon to be managed concomitantly. It was developed by forest industry under the aegis of the Forest Nutrition Cooperative and Loblolly Pine Growth and Yield Research Cooperative, and is owned by the companies and organizations that comprise these two cooperatives. The second, the NASA-developed Carbon Query and Evaluation Support Tools (CQUEST), is a complete set of internet-based carbon management DSTs that deliver the results of both Carnegie-Ames-Stanford Approach (CASA) model simulations and other products generated from the fusion of carbon inventory data sets with new NASA remote sensing data (primarily from MODIS). Even though both models and data show the pine plantations of the southeastern United States to be important carbon sink, forest landowners currently have no ability within the framework of the existing DSTs to manage for carbon. Once robust DSTs allowing carbon management are available, however, the public relations value of carbon sequestration, coupled with the existence of functioning carbon markets (EU Emissions Trading Scheme and Chicago Climate Exchange Carbon Market), will lead many landowners to manage their forests for increased carbon sequestration.