NASA Biodiversity, Terrestrial Ecology, and Applied Sciences
Joint Science Workshop
Summary of Workshop Findings by NASA HQ Organizers

The NASA Biodiversity, Terrestrial Ecology, and Applied Sciences Joint Science Workshop (JSW) was highly successful in meeting NASA's goals for the workshop of encouraging information exchange, exposing funded researchers to NASA's program activities and future plans, receiving input from workshop participants on program content and future plans, and fostering interactions among researchers – and, especially, between the research and applied sciences elements of the program.

The first 4 days of the workshop were composed of a half day of overview presentations in plenary venue, an early afternoon poster session, and late afternoon breakout sessions for discussions of research and applied science themes and cross-cutting topics. Each day was dedicated to a combined research-applied science theme (i.e., Day 1: biodiversity-invasive species; Day 2: ecosystem function/physiology-remote sensing science-agricultural efficiency; Day 3: ecosystem modeling-ecological forecasting; and Day 4: carbon cycle science-carbon management). The final 5th day (1/2 day) was devoted to plenary presentations and discussions of the future of the program.

Below are a series of findings, recommendations, and "main messages" gleaned from the workshop by the organizers. These are not intended to be a comprehensive summary of the workshop or even a complete list of all recommendations from the individual breakout groups. Links to the complete agenda and the discussion forum with breakout reports and recommendations are available on the welcome page after you log into your website account (http://cceo.gsfc.nasa.gov). The points below represent take-away messages from the workshop that the organizers: 1) believe to reflect the most important concerns of the workshop participants and 2) found to be most compelling in light of current program issues and needs. In addition, proposed actions that could be taken by Program Managers and Scientists at NASA HQ are offered to address the most important of these concerns.

The major findings, recommendations, and messages were:

1) **Data Access and Transparency Need Improvement**. Workshop participants expressed strong desires for improved access to data and data products and for greater understanding of the nature/history of the data and data products that are available. Capabilities desired included:

- an easy way to identify available data sets (i.e., a "Google Earth-like" ability to search for data) with user-friendly interfaces;
- an ability to zoom from fine resolution to coarse resolution products anywhere on the Earth
- active archive and distribution of higher level (levels 2-4) data products that are produced in on-going NASA research projects (e.g., products developed from airborne sensors, ICESat, field observations) – not just the standard products from

the more facility-class satellites [note: this desire was expressed by both the research and applied sciences researchers at the workshop, and their specific needs are different]

- "transparency" and traceability concerning the processing of the data, with algorithms, models, source code, and information about all adjustments and corrections being made available and accessible to researchers and other end users [Note: It was recommended that Earth System Data Records should be re-defined to include algorithms and field data]
- data set attributes that facilitate ease of use (e.g., common format standards for radar data)
- continued purchase of complementary data sets (e.g., commercial, foreign) that can then be made available to NASA researchers with relative ease and at reduced or no cost
- continuity of science-quality systematic observations (see also item #4 below).

Possible actions: NASA HQ Program Managers/Scientists need to work with their colleagues managing data and information systems and the providers of these services to articulate the above desires/requirements and find ways to make improvements. The relevant science programs may need to invest additional resources into the production of high-level data products. They also should raise questions about current NASA data policies under the ESSP and other PI-led missions and projects. One thing that may be necessary to ensure delivery of well documented products and source codes is changing research awards from grants to contracts. It is also worth noting that many of the applied sciences projects are investing in creating new, customized level 3 or 4 products to meet their specific needs. It may be possible, if these needs are understood sooner, to produce these products along with research products and/or agree upon common standards that would minimize the need for further customization.

Figuring out how to appropriately respond to this set of recommendations is going to take some careful thought and planning – as well as continuing interactions with the community. A working group to consider ways to follow up on this might be in order. This is something NASA managers will ask to discuss with the Carbon Cycle and Ecosystems (CC&E) Management Operations Working Group (MOWG) as well.

2) Ecological/Biogeochemical Modeling. Workshop participants recommended a re-evaluation of modeling priorities and new directions for NASA research in ecological and biogeochemical cycling modeling. Participants felt it was time to put ecosystem modeling at the center of what NASA does in the Carbon Cycle and Ecosystems Focus Area. Much of the modeling effort to date has been more in the service of climate models – and, while this is still important, a focus on whole ecosystem models offers the potential for greater advances toward an understanding of integrated Earth system function. Large advances in understanding and our collective ability to model the Earth system appear to be achievable by focusing on incorporating all of the drivers, especially the human system drivers, into current ecological models. The incorporation of socioeconomic information will be essential for that progress. Workshop participants

suggested that additional attention be directed toward the development of such advanced ecosystem models.

Workshop participants expressed strong desires for more modeling research at longer time scales and models that operate across spatial scales. We need new models that integrate across scales, rather than a suite of models that operate at different scales with no connections or only weak coupling among them. In the area of biological diversity, the use of mesoscale models in combination with local scale ecosystems models is proving to be a productive research direction.

It was recommended that a framework for NASA ecological modeling should be developed, starting with an inventory of ongoing projects and an analysis of progress, gaps, and any overlapping efforts. A working group to do this work and report back was suggested.

Applied sciences participants suggested that NASA support additional work to couple its geophysical models (developed by other Earth science focus areas) with the ecological models of NASA's applied sciences partner agencies to advance capability for national applications.

It was felt that process parameterizations are still a major factor limiting the utility and ultimate successful application of ecological and biogeochemical models.

It was recommended that models be developed so that their components are more "plug and play," perhaps implementing a "model web" consisting of separately developed, but interoperable models. [Note: The Earth System Modeling Framework (ESMF) should be explored to learn if it would be a suitable framework for ecological models, however, workshop participants did not have enough information to assess this option.]

Possible actions: A modeling cluster (of funded investigators) or a working group that could analyze the state of our modeling efforts; identify needed data products, tools, and support; and prioritize needs may be able to develop more specific recommendations on how NASA could best implement changes to its CC&E modeling research.

3) Measurements of Atmospheric Carbon Dioxide: At present, a majority of scientists within the terrestrial component of the CC&E Focus Area research does not see itself as "owning" the OCO mission or its requirements, and some do not feel that they are the best advocates for a future carbon dioxide profiling mission. However, an explicitly-stated science objective of OCO and of the proposed future mission is to advance the understanding of the terrestrial carbon cycle. Most scientists in the Focus Area recognize they will have a strong role to play in helping to explain and understand the measurements (i.e., explain "why the fluxes are what they are"). In this regard, they do not feel ready for the OCO mission or the challenges that will follow in interpreting the data and quantifying carbon sources and sinks. The workshop participants expressed a desire for some sample data sets so that they could begin exploring what could be done with OCO data. There was a recommendation to make sure the OCO data flow to the

broad research community sooner than 3-4 years post launch. They also suggested that NASA consider offering short courses on how to use this type of data.

Possible actions: NASA HQ program managers/scientists believe that is a situation that is probably not terribly unusual when a new tool or technique becomes available to a research community and/or when research questions become increasingly interdisciplinary. However, it does appear to require some increased program management/development attention, community development, and, probably, a fresh consideration of our partnership with the Atmospheric Composition Focus Area. CC&E Focus Area program managers will review what types of expertise and investigations will be called for on a future OCO team as well as what other types of preparatory work could be initiated as soon as possible to better prepare the research community.

4) Continuity of Systematic Observations. The continuity of systematic observations (i.e., vegetation, land surface, ocean color, and land cover from MODIS → VIIRS and Landsat → Landsat Data Continuity Mission) is of paramount importance to this community. The CC&E Focus Area managers/scientists have put those observations at the bottom of the legacy roadmap for CC&E as the foundation upon which all other scientific progress rests. Workshop participants expressed concerns about the course of action that the U.S. Government is currently implementing to provide for the long-term continuity of these measurements.

Possible actions: NASA does have a responsibility to assist in the transition of new observations to Government agencies with operational mandates, and will work to keep the requirements for science-quality time series data records, transparent data processing and algorithms, and rigorous calibration and validation in transition plans. We suggest it may be possible for all of us to focus on the applied uses that do require science-quality measurements as a means of reinforcing measurement system requirements that also assure a high-quality data stream for science. We believe that the NRC Decadal Survey and U.S. government studies that have followed the Nunn-McCurdy certification of NPOESS may yield recommendations that will address at least some of the workshop participant's concerns.

5) Priority Mission Concepts. Workshop participants expressed strong support for the advanced mission concepts for Vegetation 3-D Structure, Biomass, and Disturbance and Physiology and Functional Types that are represented both on the legacy roadmap for CC&E and in the update report of the NRC Decadal Survey's Panel on Land-Use, Ecosystem Dynamics, and Biodiversity. (NOTE: the aquatic mission concepts were not commented upon because the Ocean Biology and Biogeochemistry research community was not fully represented at this workshop) There was strong consensus that there is a potential for great synergy between these two missions and encouraged NASA to consider them for contemporaneous flight.

Other significant messages, findings and recommendations were:

- Close the "gaps" between research and applied sciences. Participants noted some "disconnects" or gaps between what is being done in the research and applied sciences components of the NASA program and saw real opportunities to build better linkages and close some of the gaps. (Examples of gaps: research activities of NACP and information needs of decision makers involved in carbon management in the U.S.; the global-continental scale of ecosystem modeling versus the local-regional scale of ecological forecasting and invasive species research; emphasis on water in agricultural efficiency research versus emphasis on light, carbon, and nutrients in physiology and remote sensing science research.) It was recognized that both research and applications may need to adjust their approaches and move from both sides to close the gaps.
- People are part of the system. Future research simply must include human-affected systems and bring the key drivers of change associated with human activities (e.g., management, disturbance, population pressures, etc.) into our analyses. This was noted in major finding #2 above, but also applies to non-modeling research.
- Interdisciplinary linkages. Our research is becoming increasingly interdisciplinary, and we have a clear need to strengthen our interactions across the Earth science community, especially with the hydrology and biological oceanography communities. We also need to work more closely with these communities in support of our common measurement needs (e.g., soil moisture; coastal ecosystems, land-water interfaces).
- International coordination. Several discussions at the workshop pointed out the need for increased involvement with international programs and coordination activities. Work toward international constellations of satellites, common data formats, and calibration/validation requirements and protocols should be pursued under GEOSS, CEOS, and other international groups.
- NACP coordination must be addressed. It was recommended that an NACP Science Team be formed and that an inventory/database of their research be prepared. The NACP research and researchers could be integrated by forming groups focused on cross-cutting themes or subject areas. This could be planned as part of the January 2007 workshop for NACP. NACP also needs a "synthesis task force." It was suggested that NACP should involve decision makers and other stakeholders in their science meetings (e.g., the January 2007 workshop). Workshop participants suggested that the idea of intensive campaigns might need to be revisited.
- Physiology and functional type research needs to advance beyond indices. There is an urgent need and sense of readiness to get away from the development and use of indices and move to direct measurement of physical and biological quantities. It was suggested that regional applications and management may be more important uses of physiological information than global change applications.
- Land cover products needed. The community needs annual land cover data sets!

Other findings and recommendations:

- Understanding ecosystem heterogeneity at small spatial scales is important for addressing a number of ecosystem and biodiversity questions (e.g., invasive species).
- NASA should promote within its funded group of researchers a practice of formally citing data sets used in research publications.
- NASA should require sponsored researchers to make all of their data available either through the DAACs or other reliable providers.
- The Carbon Cycle and Ecosystems Focus Area should consider the following sensors of primary importance: ICESat/GLAS, OCO, ALOS/PALSAR, and Hyperion, and should take steps to ensure these data are available for researchers conducting research under the focus area.
- There was a recommendation to pursue acquisition of a N. Hemisphere summer GLAS data acquisition.
- It was recommended that NASA explore cooperation with NSF's NEON program; researchers believe there are great opportunities.
- The biggest unanswered question from LBA concerns the controls on the forest – savanna transition.
- LBA needs a unified vegetation/land cover data product.
- The Earth System Data Record (ESDR) White Papers should be peer reviewed.
- Consider investment in *in situ* measurement technology.
- The ESTIPS database needs to be updated. It was suggested to do this as a discussion blog . . . the current workshops are not a good way to establish this content.
- Calibration needs more emphasis – especially for lidar and radar measurements and in correcting for aerosols.
- It was suggested that NASA should consider offering small grants for exploratory research and spread this sort of investment around more.
- Funded researchers should be provided current information on Education and Outreach programs and resources. They should be required in their progress reporting (and proposals) to include a 5-6 sentence explanation of their project in lay language that could then be used for education and outreach, as well as internal NASA reporting purposes.
- In light of the new emphasis on mission studies and in anticipation of the report of the NRC Decadal Survey, NASA's CC&E Focus Area should fully engage the scientific community and seek their inputs throughout the process. Inputs would include defining clear and compelling science questions and measurement requirements, articulating the societal relevance, supporting mission design and cost studies, evaluating cross-discipline/focus area joint missions, and prioritizing measurements, missions, and options. For mission concepts that are more mature, the community inputs should be sought as soon as possible, and the work should be completed within the next year.
- Future biodiversity investigations should seek to model the abundance, as well as the distribution, of taxa of concern.

Workshop participants recommended that the Joint Science Workshop be continued, with traceability (i.e., with findings documented, recommendations captured, and progress in addressing reported). Participants thought expanding to include the entire focus area (to add Land Cover and Land Use Change and Ocean Biology and Biogeochemistry) should be considered. The interactions across program elements were thought to be extremely valuable. Future workshops might consider adding a ½ day training option for Education and Outreach or use of particular data sets.

The NASA HQ organizers noted that the workshop format did not overcome a social dynamic regarding which break-out sessions are attended by what types of researchers. Scientists who best understand the research issues of the day and play key roles in deciding future research directions rarely go to the break-out sessions that consider tools, techniques, and supporting infrastructure. Thus, in many break-out sessions at the workshop, the technical specialists ended up primarily talking to each other. They had productive conversations and raised important issues, but were not guided by the lead scientists and therefore could not address certain questions posed for their session.

The HQ organizers also realized that overlapping the related science and applied science theme break-out sessions was a really bad idea – these two groups should have been at each other's sessions.