Sequential data assimilation of canopy attributes from multispectral bidirectional reflectance

Adam Wolf, Joe Berry, Greg Asner

Carnegie Institution, Department of Global Ecology

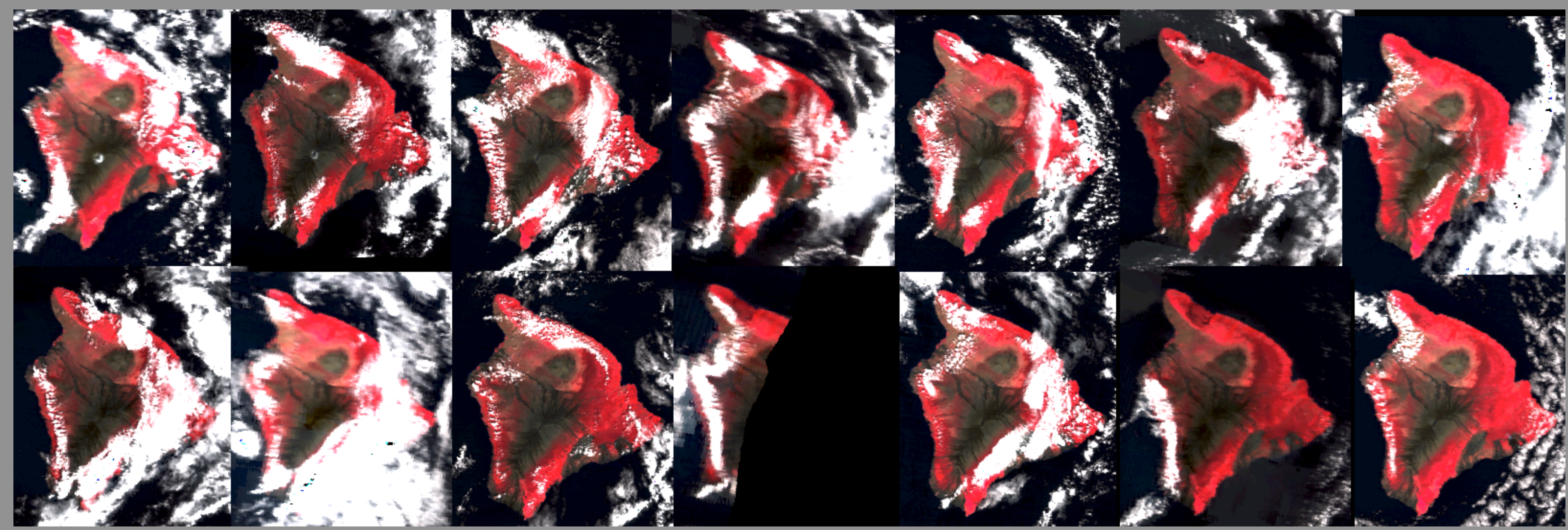
260 Panama St., Stanford CA 94305

adamwolf@stanford.edu

The Big Picture

Many vegetation characteristics change over synoptic, seasonal, and interannual time scales. Monitoring changes in canopy photosynthetic capacity using NDVI over the annual cycle has been a key component in observing and modeling the dynamics of the carbon cycle. However, many other facets to changing vegetation attributes remain unexploited. For instance, daily changes in plant physiological status are not assimilated into weather forecasts, despite the key role of water stress in modulating droughts. In addition, many dynamic plant characteristics are ignored in retrievals of multitemporal satellite imagery, such as stem silhouette area, tree height, ground cover, or leaf biochemistry among others, although all of these parameters have sensitivity in particular bands and particular sun/view angles and could be retrieved.

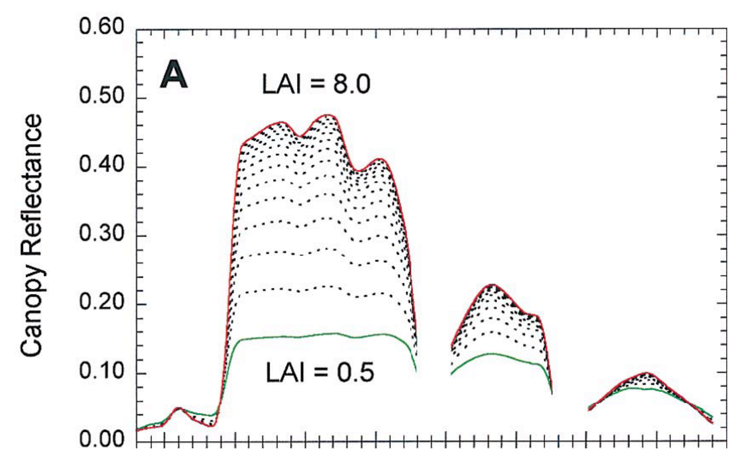
We present here an effort to assimilate a number of plant architectural parameters used to drive the numerical 3-D canopy radiative transfer model DISORD. The assimilation procedure is to use a Kalman Filter to sequentially assimilate multispectral satellite reflectances using a monte carlo technique that uses an ensemble of model realizations to define the covariance between model parameters and the observed reflectances in each spectral band at the actual sun/view geometry. Each new observation provides information that can update the model parameters that are correlated with it; for satellites such as Terra or Aqua, the parameters can be updated as often as twice-daily.

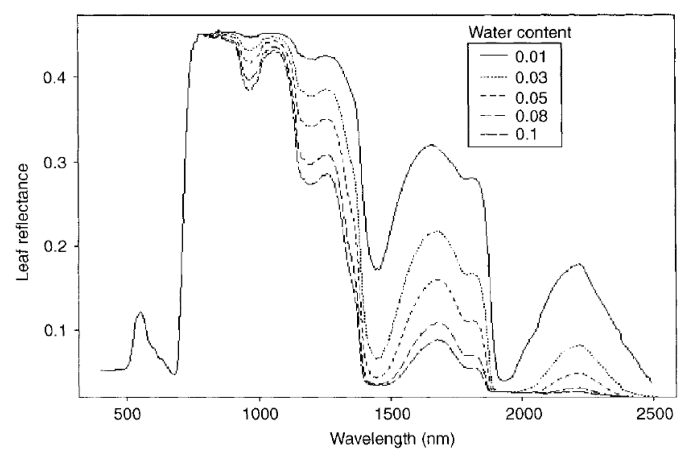


Daily Modis/Terra false-color IR images of Hawaii, Jan 12-26, 2007. Data is abundant in some places, but mostly cloudy in others. View angles and atmospheric composition have prominent effects.

The Nadir View

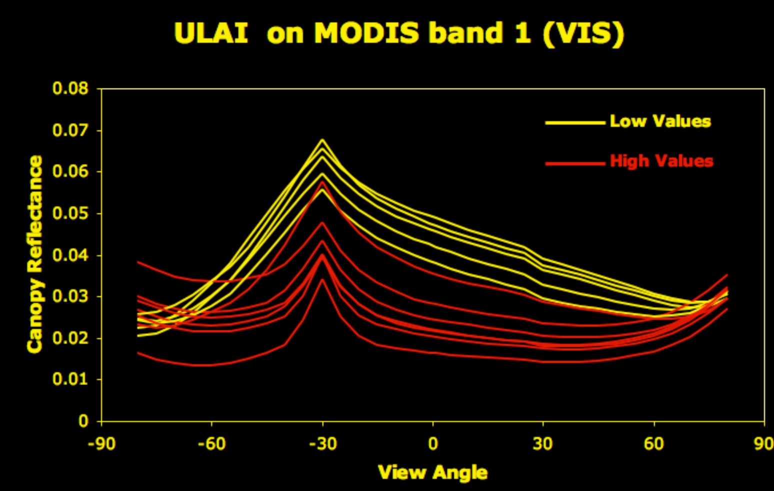
These show sensitivity of different spectral bands to leaf area and leaf water

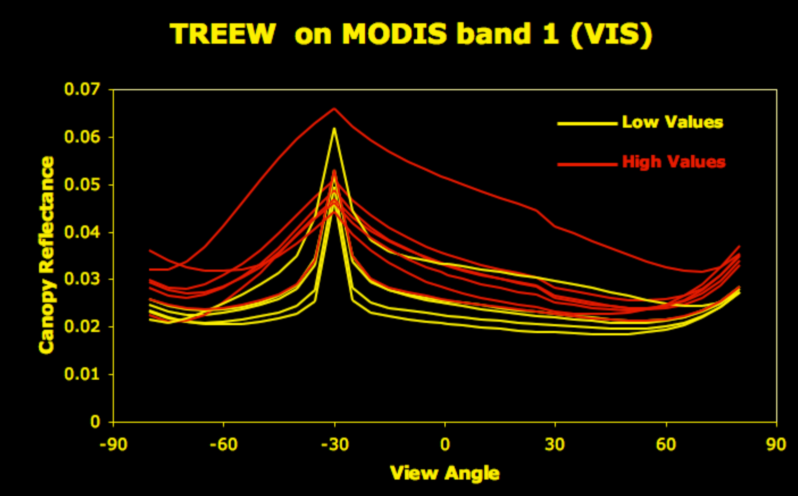




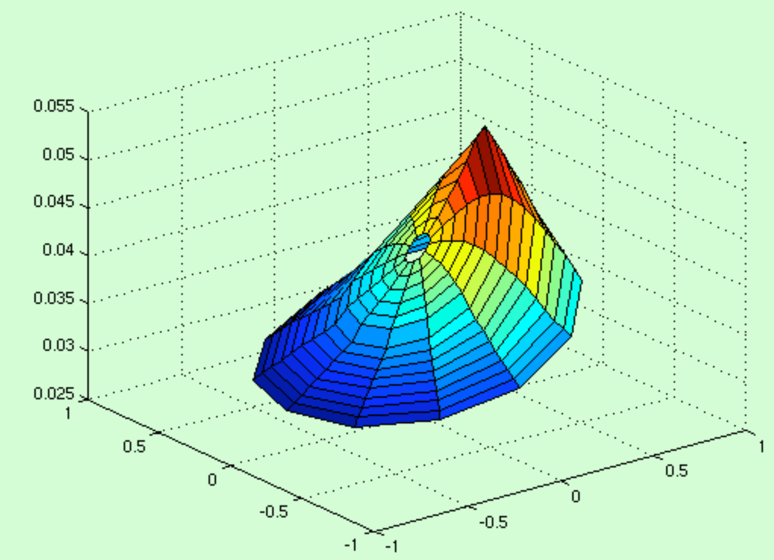
Multi-angle View

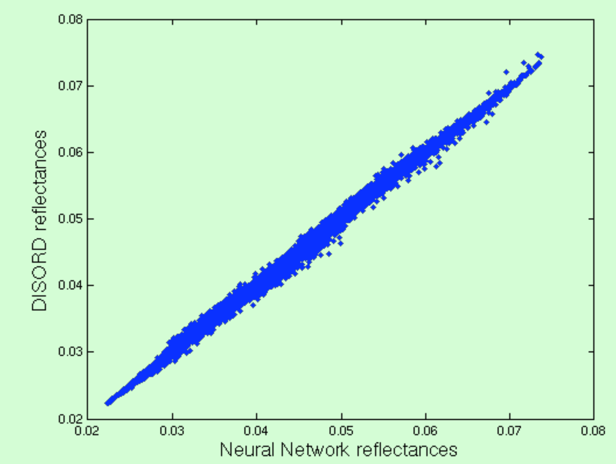
These show sensitivity of different view angles to under-story leaf area and crown width





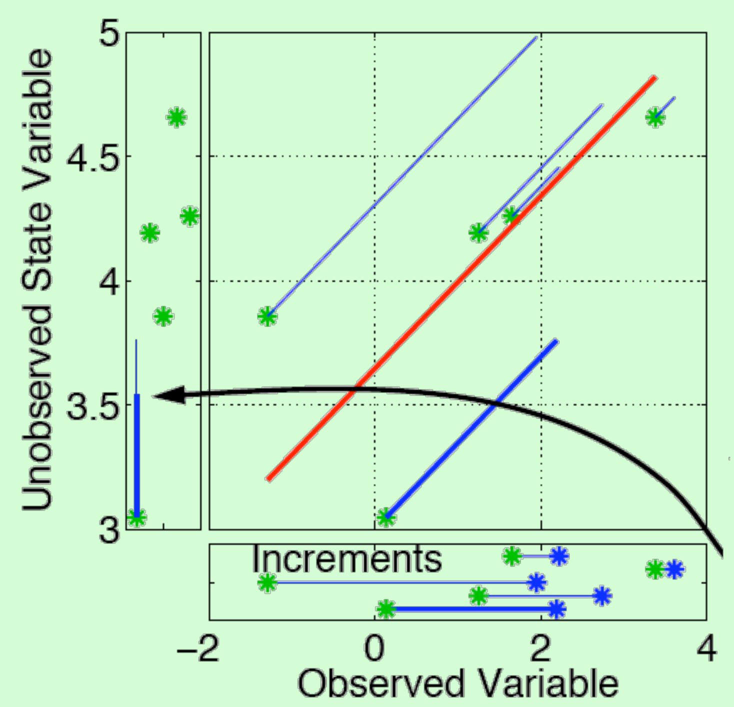
We started by running hundreds of canopy parameter realizations in different MODIS bands using different view/sun geometry. DISORD takes about 3 seconds per combination of geometry/canopy/spectral band. Below is one sun/canopy/band combination seen over all view angles. The peak shows the angle where the sun is behind the satellite and shadows are absent.





Next, we fit a neural network to the DISORD reflectances as a function of geometry and canopy parameters (above, right). The neural network speeds computation time by 1000x.

Finally, we incorporated this forward model of canopy reflectance into the ensemble data assimilation code DART. By comparing the satellite reflectance with the prior guess of reflectance, canopy parameters are updated, based on their covariance with reflectance in the given band/angle configuration.



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