Advanced NASA Earth Science Mission Concept for Vegetation 3D Structure, Biomass and Disturbance

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Carbon in forest canopies represents about 85% of the total carbon in the Earth's aboveground biomass (Olson et al., 1983). A major source of uncertainty in global carbon budgets derives from large errors in the current estimates of these carbon stocks (IPCC, 2001). The magnitudes and distributions of terrestrial carbon storage along with changes in sources and sinks for atmospheric CO_2 due to land use change remain the most significant uncertainties in Earth's carbon budget. These uncertainties severely limit accurate terrestrial carbon accounting; our ability to evaluate terrestrial carbon management schemes; and the veracity of atmospheric CO_2 projections in response to further fossil fuel combustion and other human activities.

Measurements of vegetation three-dimensional (3D) structural characteristics over the Earth's land surface are needed to estimate biomass and carbon stocks and to quantify biomass recovery following disturbance. These measurements include vegetation height, the vertical profile of canopy elements (i.e., leaves, stems, branches), and/or the volume scattering of canopy elements. They are critical for reducing uncertainties in the global carbon budget. Disturbance by natural phenomena, such as fire or wind, as well as by human activities, such as forest harvest, and subsequent recovery, complicate the quantification of carbon storage and release. The resulting spatial and temporal heterogeneity of terrestrial biomass and carbon in vegetation make it very difficult to estimate terrestrial carbon stocks and quantify their dynamics.

Vegetation height profiles and disturbance recovery patterns are also required to assess ecosystem health and characterize habitat. The three-dimensional structure of vegetation provides habitats for many species and is a control on biodiversity. Canopy height and structure influence habitat use and specialization, two fundamental processes that modify species richness and abundance across ecosystems. Accurate and consistent 3D measurements of forest structure at the landscape scale are needed for assessing impacts to animal habitats and biodiversity following disturbance.

This mission will acquire unique measurements with unprecedented scope and accuracy to quantify carbon in vegetation globally, how it is changing, and the implications for life on Earth. The science objectives are:

1. Develop globally consistent and spatially resolved estimates of aboveground biomass and carbon stocks.
2. Make globally consistent and spatially resolved measurements of vegetation vertical structure to understand changes and trends in terrestrial ecosystems and their functioning as carbon sources and sinks.
3. Characterize and quantify the three-dimensional structural response to disturbance.
4. Quantify changes in terrestrial carbon sources and sinks resulting from disturbance and recovery.
5. Characterize habitat structure for biodiversity assessments.

A new mission combining lidar and radar approaches will provide the information needed to meet the objectives and measurement requirements for vegetation 3D structure. A P-band SAR will provide contiguous measurements with seasonal, global coverage unaffected by clouds. A Multi-Beam Lidar point-sampling instrument will provide high-resolution, high-accuracy measurements over a statistically rigorous sample of the Earth's vegetated surface. In combination, they will provide accurate, high-resolution measurements of vegetation 3D structural properties and disturbance that can be used to greatly reduce uncertainties in estimates of global biomass and carbon stocks as well as to evaluate habitat and biodiversity.

References

Earth Science Enterprise Strategy, NASA Headquarters, October 2003
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Olson et al. 1983 http://cdiac.ornl.gov/epubs/ndp/ndp017/ndp017.html