Radar and Lidar Remote Sensing of Forest Structure & Biomass

The DESDynI mission, as recommended by the Decadal Survey, will provide previously unavailable information about terrestrial ecosystems, worldwide. That information will help answer key scientific questions for understanding and managing ecosystems (and the global carbon cycle) and will, thus, be of considerable benefit to society.

In particular, the DESDynI mission will enable much-improved estimates of terrestrial sources and sinks of carbon by providing the data required for two kinds of information: (1) the distribution of aboveground woody carbon stocks over the world's forests, and (2) the distribution of terrestrial carbon sinks and sources resulting from forest disturbance and recovery.

The mission consists of orbital platform(s) with two active remote sensing sensors: an imaging Synthetic Aperture Radar (RAdio Detecting And Ranging), SAR, operating at L-band frequency (1.25 GHZ, 26 cm wavelength) in fully polarimetric and interferometric (INSAR) capability, and a multi-beam Lidar operating at 1064 nanometer. The sensors provide complementary information on the forest structure and biomass. The polarimetric InSAR measurements provide all-time imaging capability to measure forest height and biomass and to quantify the area and intensity of vegetation disturbance and the rate of recovery. The multi-beam lidar sensor is capable of sampling the vegetation height and vertical structure with high vertical and horizontal resolution and precision.

Synergism of these active sensors to achieve the required science measurements and accuracy is an important element of the DESDynl mission concept. With, other sensors such as the P-band polarimetric and InSAR from ESA (European Space Agency) BIOMASS concept, we will have, for the first time, a series of measurements and monitoring capabilities to quantify the global terrestrial carbon cycle and to model ecological processes at various scales.

However, there are areas of concern about the required measurements and sensor capabilities that will impact the design and the implementation of the mission concepts. The following questions will address these issues, will help to direct the discussions during the workshop, and will provide a series of reasonable compromises and/or recommendations to meet the science requirements.

DESDynl Sensors:

1. What are the L-band InSAR Measurements of Forest Structure?

L-band InSAR, as described in NRC decadal survey and discussed in Florida workshop is supposed to provide global measurement of forest/vegetation height and biomass, calibrated and corrected by the lidar samples and ground measurements. However, the following questions about the L-band InSAR applications need to be addressed by the community:

- What is L-band repeat pass interferometry height accuracy?

- What is the ideal repeat cycle for reducing the temporal decorrelation over different forest types?
- What are in situe requirements to transform L-band InSAR measurement to mean or maximum vegetation height?
- What is the ideal season (period) to measure the vegetation height from L-band InSAR?
- At what spatial resolution the optimum height accuracy is acheived? 6. What is the effect of surface slope on height measurement accuracy?
- Can InSAR coherence over time provide information about vegetation height change?
- To what extent polarimetric measurements are required to resolve the vegetation height?
- To what extent bald earth surface elevation is important to estimate vegetation height?
- What is the sensitivity of polarimetric measurements to aboveground biomass (saturation level)?

2. What are the Multi-beam Lidar Measurements of Forest Structure?

- What is the definition of vegetation 3D structure observed by full-wave lidar sensors?
- What is the height accuracy measured by lidar at pixel level over various forests?
- How many lidar samples are required to achieve the height accuracy?
- To what extent lidar measured structure papramters (e.g., maximum or average height of vegetation) are representative of forest biomass?
- To what extent energy measured by lidar return is important for biomass estimation?
- What is the best sampling strategy to capture both the vegetation heterogeneity and biomass?
- What is the biomass accuracy derived from lidar measurements? Is there a saturation limit for biomass estimation from lidar measurement?
- What is the impact of phenology on lidar measurements?
- What is the reasonable grid cell for lidar products of global vegetation biomass?
- Are there reasonable allometry or algorithms to transform lidar measurements to above ground biomass?
- Can lidar provide changes of vegetation height due to recovery and to what accuracy?
- What lidar profile information is required for biodiversity studies?

3. Can lidar and radar Data Fusion improve measurement of Forest Structure?

Based on our knowledge of forest structure measurements using lidar, polarimetric SAR and InSAR, the following questions address potential use of data fusion and synergistic algorithm:

- How many lidar samples are required within or near radar pixel to calibrate the radar measurements of heights or biomass?
- What is the maximum useful time difference between the lidar and radar measurements over the same vegetation area?
- What type of geospatial approach can combine the lidar samples with radar height or other structure measurements?
- To what extent the annual radar products can be degraded with the lack of lidar samples?

BIOMASS Sensor: P-band Pol-InSAR

Similar questions are valid for the ESA P-band Pol-InSAR sensor and its synergism with Lidar. However, there are some specific science and strategic questions about P-band and L-band sensors.

1. To what extent biomass estimation from P-band polarimetric data improves upon L-band polarimetric data?
2. What are the pros and cons of using a P-band InSAR over L-band?
3. Does any sensor have a major technological advantage over the other?
4. To what extent data fusion scenarios with P-band sensor differ from L-band?
5. Is there any advantage in sampling density by deploying the Lidar Sensor on BIOMASS platform?