**The Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System (CASALS):**

**A New Capability for Monitoring Forest Structure and Function from Space**

The CASALS team at NASA’s Goddard Space Flight Center and its partners are developing new lidar technologies and measurement methods that will significantly advance spaceflight lidar remote sensing capabilities. These advances will serve four of the observing challenges put forward in the United States National Academy of Sciences 2017 Earth Science Decadal Survey. CASALS will be able to conduct the first lidar swath mapping of topography, forest structure and snow depth from space, providing crucial information for a wide range of studies such as those of forest productivity, habitat quality, snow-melt water availability and the impact of natural hazards. The swath mapping along with concurrent narrow-band multispectral imaging will enable deeper understanding, modeling and prediction of complex forest processes, such as how the 3D interception of sunlight by varied foliage types affects function and productivity. An airborne CASALS is being developed to demonstrate the technologies and capabilities, in preparation for spaceflight mission opportunities later this decade. Lidar components that are, or can be, space qualified are used along with commercial hyperspectral imagers. Airborne CASALS is scheduled for flights in August 2024 at an altitude of 8.5m. Flights will target NEON eddy covariance flux tower sites in the United States mid-Atlantic region. NEON conducts growing season 1m resolution airborne laser swath mapping and hyperspectral imaging at each flux tower site which will serve as validation for the CASALS data.

The CASALS swath mapping is accomplished using a first-of-its kind, non-mechanical, beam scanning method and dramatic advances in lidar measurement efficiency. The transmitter combines a wavelength-tuning seed laser, centered at 1040nm, pulse carving electronics producing 2ns FWHM pulses, a high peak-power fiber amplifier and transmission through a wavelength-to-angle diffraction grating. From a 500km orbit, the transmitter can create 1,200 laser footprints scanned cross-track over an angular range of 0.825deg, corresponding to a 7.2km swath. Any subset of the 1,200 footprints can be adaptively selected by rapidly tuning to specific wavelengths. The receiver also uses breakthrough technologies, combining a grating spectrometer for solar background filtering, a linear-mode, single-photon sensitive, HgCdTe APD detector array to image the footprints, and time-multiplexed analog-to-digital waveform digitizing. In our near-term mission concept, deploying CASALS in low Earth orbit on a SmallSat, our performance modeling predicts we can operate the laser at 140Khz to map three 130m wide swaths, distributed across 7km, with overlapping 10m footprints spaced apart by 6m cross track and 3m along track. The expected density of detected photons for green foliage is ~1/m2, which is ~10x greater than along ICESat-2 profiles, while using a 2x smaller receiver telescope so a lower cost SmallSat can be used. That density is sufficient to produce waveforms with signal-to-noise ratio similar to those of GEDI for 20m x 20m areas. In the near-term, the swath width is limited by the size of the detector array qualified for spaceflight use. In the longer term, we are working with our detector partner to have a larger array that could image footprints everywhere across the 7km wide scan width.