Development and Airborne Demonstration of the Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System: Advancing Lidar Capabilities for the STV Observing System

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We report on the design, build and planned airborne demonstration of a spaceflight-prototype Concurrent Artificially-intelligent Spectrometry and Adaptive Lidar System (CASALS). The CASALS lidar is an Adaptive Wavelength Scanning Lidar (AWSL) operating in push broom mode. The demonstration has three major goals: advance the Technical Readiness Level of the AWSL hardware, validate its measurement performance and mature algorithms and methods needed for the Surface Topography and Vegetation (STV) observing system. AWSL acquires parallel tracks of surface heights by rapidly steering a laser beam across a swath. A 1040nm-centered laser is tuned across 30nm and carved into 2-ns pulses, the pulse energy is fiber amplified and the pulses are dispersed cross-track using a non-mechanical wavelength-to-angle grating. For the spaceflight system the beam will be pointable to 1200 10m footprints across a 7km swath. For the airborne demonstration there will be 256 0.7m footprints across a 110m swath. In both cases the footprints overlap across- and along-track for uniform target illumination. For the airborne demonstration a steering mirror will increase the accessible swath width to 4km. At the receiver, solar radiation is filtered with a narrow-slit grating-spectrometer and the footprints are imaged onto a linear-mode, photon-sensitive HgCdTe APD-array. The received pulses are time-division-multiplexed to a few high-speed analog-to-digital converters to record waveforms. Spaceflight and airborne CASALS are designed to nominally detect 20 photons per pulse and, by averaging 27 overlapping footprints, achieve 2cm flat target range precision and high-quality vegetation structure waveforms The AWSL will be flown in the summer of 2024, along with a Headwall VNIR-SWIR hyperspectral sensor imaging a 4km wide swath, at NEON eddy covariance flux towers in the U.S. mid-Atlantic where high resolution hyperspectral and lidar data, acquired annually, are available for validation.