

TECHNOLOGY ADVANCEMENT FOR ACTIVE REMOTE SENSING OF CARBON DIOXIDE FROM SPACE USING THE ASCENDS CARBONHAWK EXPERIMENT SIMULATOR: FIRST RESULTS

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The ASCENDS CarbonHawk Experiment Simulator (ACES) is a newly developed lidar developed at NASA Langley Research Center and funded by NASA's Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP) that seeks to advance technologies critical to measuring atmospheric column carbon dioxide (CO₂) mixing ratios in support of the NASA Active Sensing of CO₂ Emissions over Nights, Days, and Seasons (ASCENDS) mission. The technology advancements targeted include: (1) increasing the power-aperture product to approach ASCENDS mission requirements by implementing multi-aperture telescopes and multiple co-aligned laser transmitters; (2) incorporating high-efficiency, high-power Erbium-Doped Fiber Amplifiers (EDFAs); (3) developing and incorporating a high-bandwidth, low-noise HgCdTe detector and transimpedance amplifier (TIA) subsystem capable of long-duration autonomous operation on Global Hawk aircraft, and (4) advancing algorithms for cloud and aerosol discrimination. The ACES instrument architecture is being developed for operation on high-altitude aircraft and will be directly scalable to meet the ASCENDS mission requirements. These technologies are

critical towards developing not only spaceborne instruments but also their airborne simulators, with lower platform requirements for size, mass, and power, and with improved instrument performance for the ASCENDS mission.

ACES transmits five laser beams: three from commercial EDFAs operating near 1.57 microns, and two from the Exelis oxygen (O₂) Raman fiber laser amplifier system operating near 1.26 microns. The three EDFAs are capable of transmitting up to 10 watts average optical output power each and are seeded by compact, low noise, stable, narrow-linewidth laser sources stabilized with respect to a CO₂ absorption line using a multi-pass gas absorption cell. The Integrated-Path Differential Absorption (IPDA) lidar approach is used at both wavelengths to independently measure the CO₂ and O₂ column number densities and retrieve the average column CO₂ mixing ratio.

The ACES receiver uses three fiber-coupled 17.8-cm diameter athermal telescopes. The transmitter assembly consists of five fiber-coupled laser collimators and an associated Risley prism pair for each laser to co-align the outgoing laser beams and to align them with the telescope field of view. The backscattered return signals collected by the three telescopes are combined in a fiber bundle and sent to a single low noise detector.

The detector/TIA development has improved the existing detector subsystem by increasing its bandwidth to 4.7 MHz from 500 kHz and increasing the duration of autonomous, service-free operation periods from 4 hours to >24 hours. The new detector subsystem enables the utilization of higher laser modulation rates, which provides greater flexibility for implementing advanced thin-cloud discrimination algorithms as well as improving range-determination resolution and error reduction.

The cloud/aerosol discrimination algorithm development by Langley and Exelis features a new suite of algorithms for the minimization/elimination of bias errors in the return signal induced by the presence of intervening thin clouds. Multiple laser modulation schemes are being tested in an effort to significantly mitigate the effects of thin clouds on the retrieved CO₂ column amounts.

Full instrument development concluded in the spring of 2014. After ground range tests of the instrument, ACES successfully completed six test flights on the Langley Hu-25 aircraft in July, 2014, and recorded data at multiple altitudes over land and ocean surfaces with and without intervening clouds. Preliminary results from these test flights will be presented in this paper.