Airborne Lidars to Measure Stratospheric Winds and Temperatures over Deep Convection during the CGWaveS Campaign

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The Convective Gravity Waves in the Stratosphere (CGWaveS) aircraft campaign will take place in the midwestern US in early summer 2023 using the NSF/NCAR High-performance Instrumented Airborne Platform for Environmental Research (HIAPER) aircraft. The field campaign and associated modeling effort will increase understanding of convective gravity wave dynamics and their role in atmospheric circulation, structure, and variability from Earth's surface to the stratopause and above. HIAPER will overfly thunderstorms and other sources of deep convection at 12-14km altitude at night to make in situ measurements of vertical transport and mixing and remote sensing measurements of radial winds from 15-30 km and temperature and density perturbations from 25-60 km via two upward pointing lidar systems.

The lidars are based on the Rayleigh lidar and sodium wind/temperature lidar that flew on the the Deep Propagating Gravity Wave Experiment (DEEPWAVE) campaign in 2014 which focused on waves in the upper stratosphere, mesosphere, and lower thermosphere. This presentation will focus on the development of the lidar systems for better stratospheric wind and temperature measurements.

The high-spectral-resolution sodium lidar transmitter is being upgraded to transmit two 0.2W beams with 10MHz linewidth at 589nm. One beam is pointed at zenith using a 40cm telescope (shared with Rayleigh lidar) and one is pointed 20° off zenith forward of the aircraft. The output beam is locked to 3 different frequencies in succession using an acousto-optic modulated sodium vapor saturation spectroscopy system. The return signal from the forward beam is collected by the 40cm telescope and fed into a double-edge magneto-optic filter (DEMOF). The DEMOF uses a sodium vapor in a magnetic field to make two partially split Zeeman absorption lines coded by polarization. The two edges combined with the 3 laser frequencies allow us to measure the backscatter ratio, Doppler shift, and Doppler broadening of the stratospheric Rayleigh/Mie spectrum. This will give us radial wind along the forward beam and temperatures starting several km above the aircraft up to about 30km. The second beam at zenith will measure the temperature and vertical wind from 80-105km using a standard sodium lidar receiver.

The Rayleigh lidar transmitter (5W tripled ND:YLF at 351nm) worked well during DEEPWAVE worked well during DEEPWAVE and is largely unchanged. The Rayleigh receiver is being upgraded from a 30cm to a 40cm diameter zenith telescope to gain a factor of 1.8 in signal for better time/horizontal resolution. This lidar will measure the density and infer the temperature profile from 25-60km.