Visible Spectroscopy of the Atmosphere above West Texas from Ground Level to 350,000 ft via a Commercial Suborbital Rocket

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Abstract
The JHUAPL iSTART instrument successfully collected visible–near infrared spectra of the Earth's atmosphere from within the cabin of the payload module during the Blue Origin NS-10 flight of the New Shepard using a commercial spectrometer.

Results
The iSTART experiment launched on-board the Blue Origin New Shepard suborbital vehicle on October 13, 2020 at 13:36:58 UTC from the West Texas launch complex situated approximated 55 feet MSL. Apogee was achieved 3 min 59 sec after launch at an altitude of 346,977 feet. Descent was less dramatic with touch down occurring at 13:47:05 UTC. The objective of the flight of iSTART was to characterize the intensity and spectral structure of the visible to near IR portion of the electromagnetic spectrum that reaches the sensor during flight. This was the first time a Visible – NIR spectrometer has flown on a commercial suborbital spacecraft; thus understanding the spectral characteristics of the background illumination would inform on the nature of the observing conditions along the altitude profile, including the effects of spacecraft orientation with respect to the Sun during flight were primary objectives.

Measurements from commercial suborbital flights, such as the Blue Origin New Shepard vehicle, offer the potential to cover a gap in access to Earth's atmosphere between that which can be accessed by high altitude balloons (~ 40km, or 130,000') and sounding rockets measurements that typically occur between ~ 140 km and an apogee of over 300 km. At these altitudes, commercial suborbital flights are still immersed in the Earth's atmosphere and thus measuring the observing conditions is warranted.

To collect our data, we placed a vis/nearIR Ocean Optics OceanHDX Miniature Spectrometer on-board the JHU APL Integrated Universal Suborbital Integration Platform (JANUS) which mounted to the inside of our research payload box flying on Blue Origins mission NS-11. The flight reached an apogee of 350615 feet above sea level, and data was recorded starting at 3692 feet above sea level, the altitude at the Blue Origins launch pad in West Texas.

Spectral data was recorded for the wavelength range 195nm to 808nm at 2 different integration times: 10ms and 100ms. This allowed us to collect high signal data under bright conditions (low altitude with lots of scattered light) and at higher altitude. High signal was not obtained near apogee due to extremely low atmospheric scattering at these wavelengths. Data below 400nm was not useful for deriving atmospheric information because the Plexiglas window of the crew capsule blocks transmission of light at those wavelengths. Spectral data was recorded in bursts of three captures, one for each integration time, with each burst being acquired at 10 second intervals through-out the flight.

Each spectrum was recorded with its file name marked with the time the spectrum was taken and the integration time, which was used to derive the altitude at which it was taken from the flight log using the file's timestamp as an index. The most obvious trend we observed is that peak signal intensity decreases as altitude increases. This was expected, as the density of air is lower at higher altitudes and so the intensity of light being observed as a result of Rayleigh scattering decreases. While signal intensity decreases with altitude, so does the depth of multiple absorption features including O_2 (Figure 1).

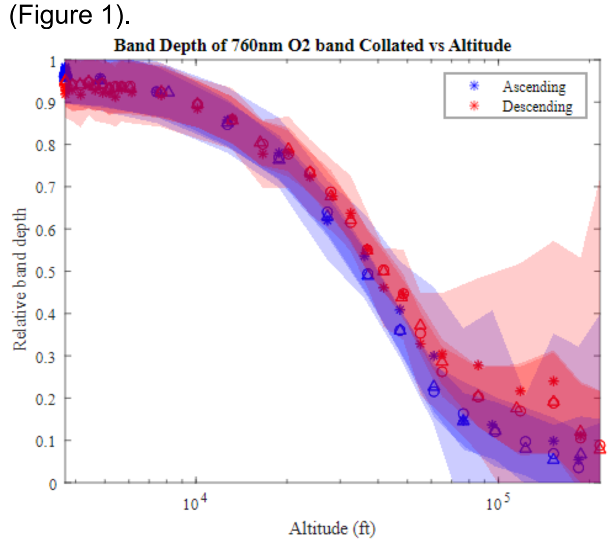

Figure 1. O_2 band depths are accurately measured to attitudes >100K ft