Characterization of OH emission in the Mesosphere with the Atmospheric Multi-Spectral Explorer (AMSE)

Conference Paper · March 2020
DOI: 10.1029/2006GL026910.)

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Characterization of OH emission in the Mesosphere with the Atmospheric Multi-Spectral Explorer (AMSE)

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Payload Motivation:
Blue Origin's reusable suborbital rocket system, New Shepard, provides an innovative platform for the characterization of atmospheric absorption and emission profiles within the Earth's mesosphere at altitudes of up to 300,000 feet. With considerable existing data on the infrared background at stratospheric altitudes, the need to characterize absorption and emission features in the mesosphere becomes apparent.

The Atmospheric Multi-Spectral Explorer (AMSE) is a compact infrared spectrometer for measuring atmospheric absorption and emission profiles on a routine basis at near- and mid-infrared wavelengths with moderate spectral resolutions (R < 10,000). The instrument consists of COTS optical components with a flight computer separate from the sub-orbital vehicle and mission support through NASA's Flight Opportunity program (FOP).

The measurements envisioned are designed to guide astronomers in the selection of required altitudes for infrared observations at altitudes above those of airborne or balloon-based experiments. Although sub-orbital flights are currently limited in duration, some astronomical observations are transient in nature and may benefit from the unique capabilities offered by the latest suborbital vehicles.

Compelling Educational Experience for Undergraduate and Graduate Level Students

Figure 1 : Undergraduate and graduate students from the department of Aerospace Engineering at San Jose State University close out remaining hardware and software items prior to flight.

The AMSE payload introduces students to spectroscopy and hands-on flight experiments while leveraging an on-going development program in hyper-spectral imaging systems at the Silicon Valley Space Center.

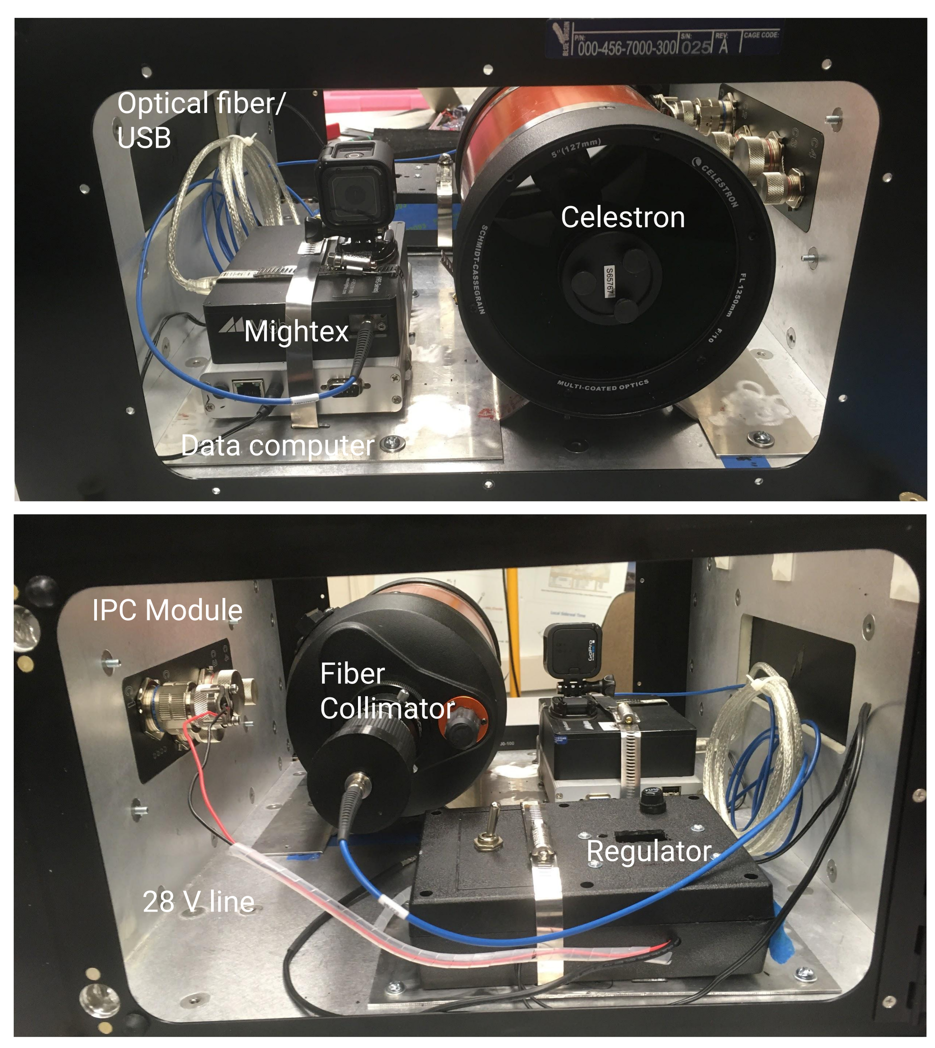


Figure 2 : Forward (a) and aft (b) views of the AMSE payload. a) A Celestron NexStar 5SE 125 mm f/10 Schmidt-Cassegrain telescope is coupled to a Mightex HRS-NIR-050 High-Resolution High-Stability CCD Spectrometer (with a 50-micron slit) with a wavelength coverage of 600 - 1000 nm. A customer data computer stores data from the Mightex spectrometer at 1 - 5 sec intervals. b) A step-down regulator conditions the 28 +/- 7 volt IPC voltage to a stable 15 volts required by the data computer. The Mightex spectrometer is powered by a single USB cable over which flight data is transferred.

Residual OH Emission at the South Pole

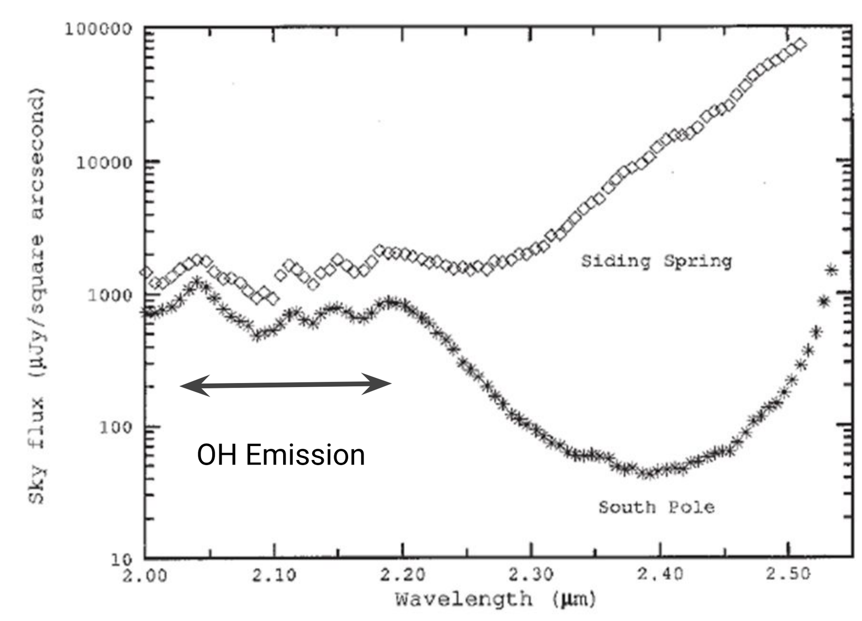


Figure 3 : Residual OH background from ground based observatories is present at sites where the thermal IR has decreased substantially. (Ref: Ashley et al. 1996, PASP, 108, 721.)

Scale height of OH Emission in the Mesosphere

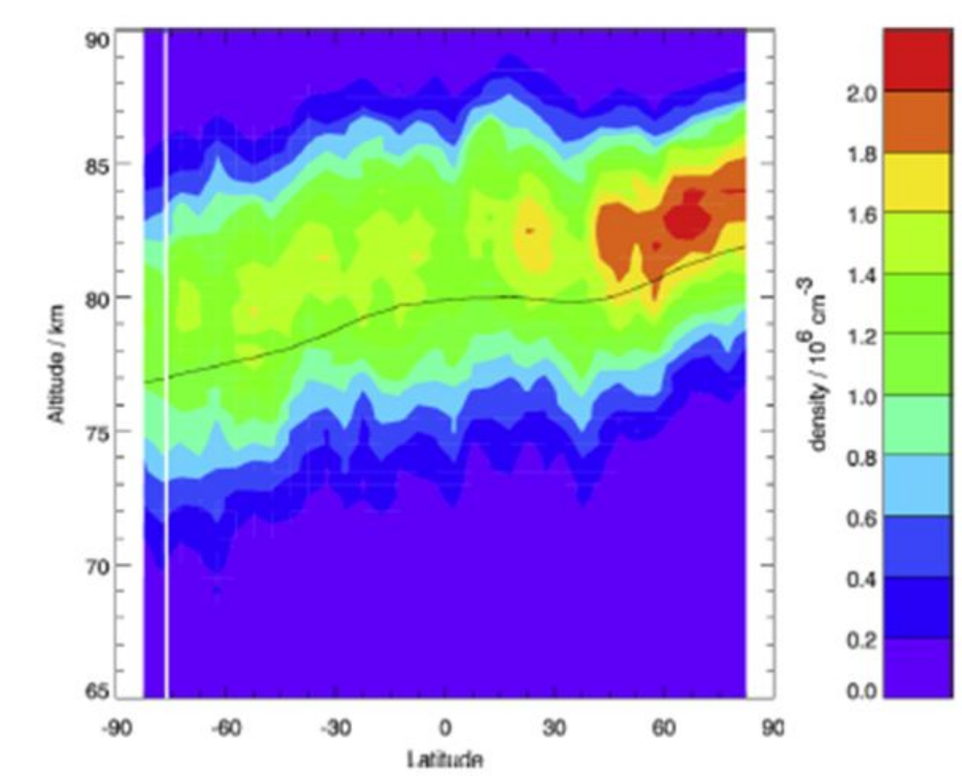


Figure 4 : Sub-orbital flights into the Mesosphere (> 300,000 ft = 91.44 km) should see both a rise and decrease in OH emission during the ascent and descent phase of the flight. (Ref: PICKETT ET AL.: "OBSERVATION OF NIGHT OH IN THE MESOSPHERE", Geophys. Res. Lett., 33, L19808, doi:10.1029/2006GL026910.)

Astronomical Sky Brightness

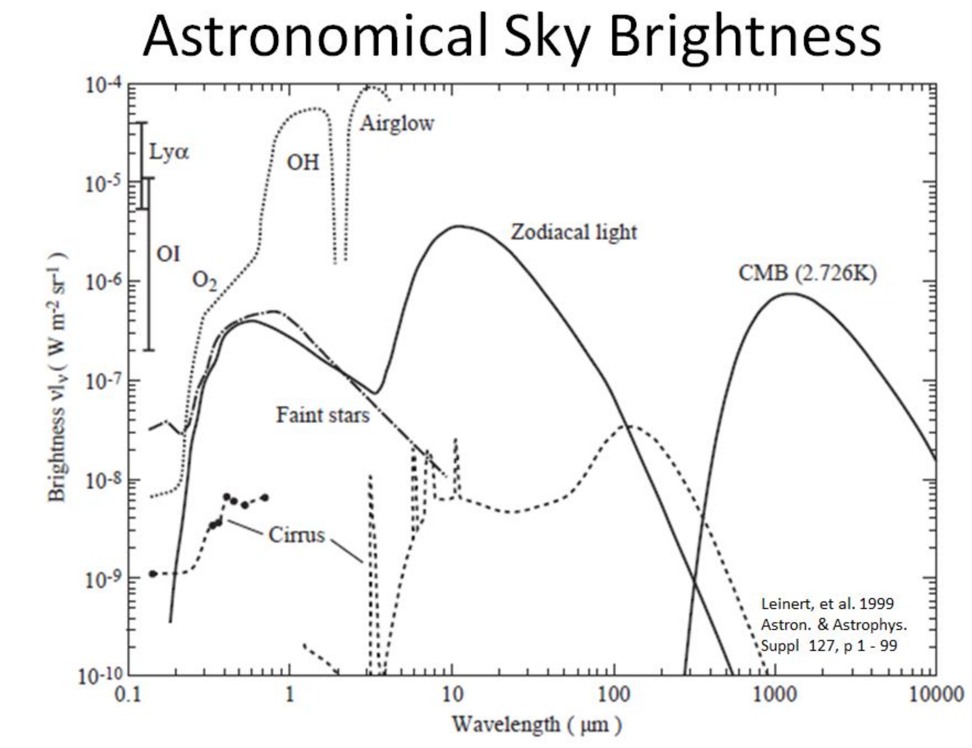
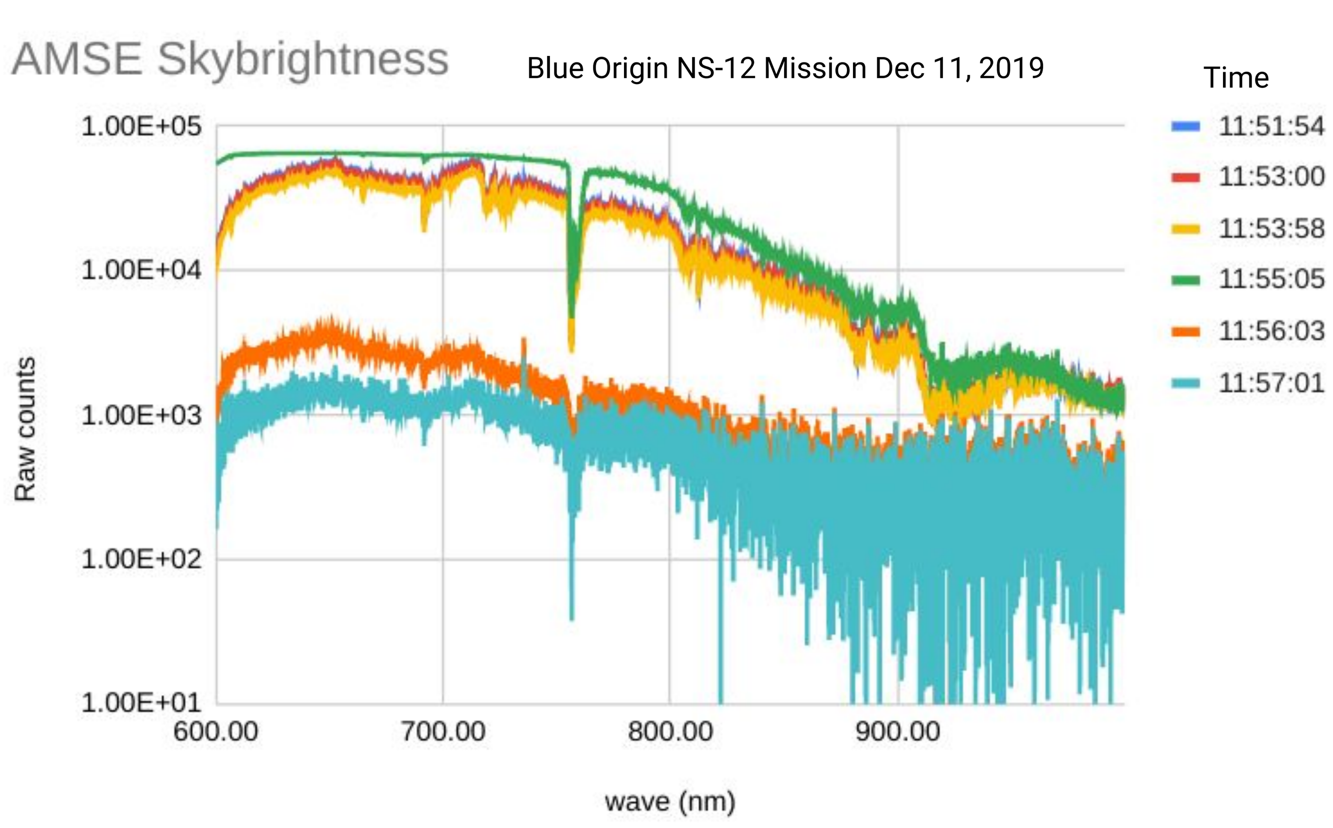


Figure 5 : At sub-orbital altitudes (above OH and airglow emission), the near-infrared background limit is expected to arise from faint stars in the Galaxy. Beyond 3 microns, the near-infrared background is set by the zodiacal light limit of the Solar System.

Preliminary Flight Results



Time (12/11/19 MST)	Altitude (est)	Plot legend
11:51:54	0.000 K ft	blue
11:53:00	Lift off	red
11:53:58	22,000 ft	yellow
11:55:05	110,000 ft	green
11:56:03	276,000 ft	orange
11:57:01	342,000 ft	azure

Solar Spectrum

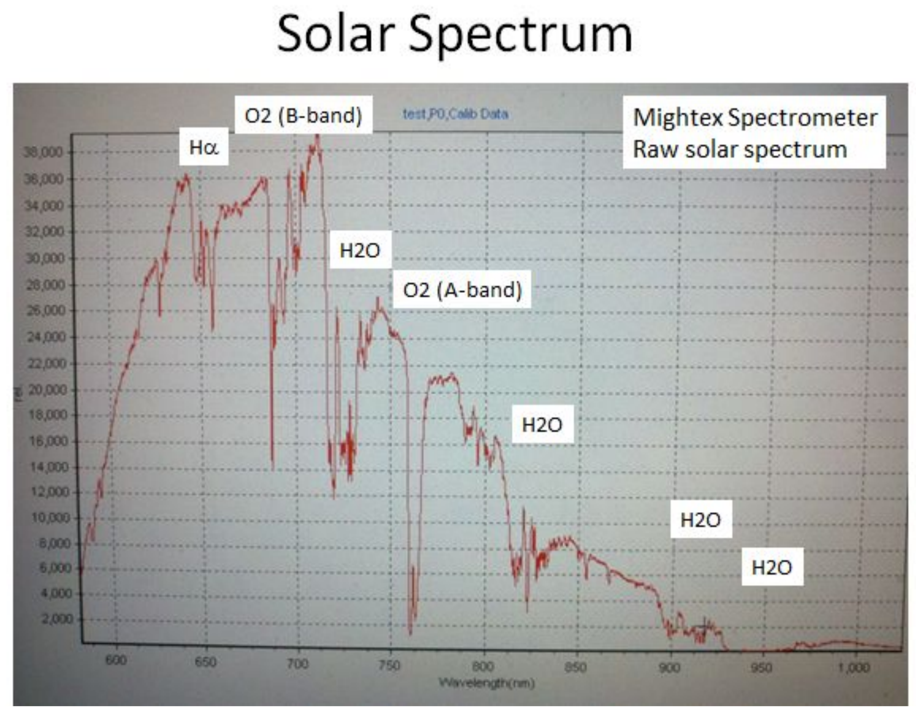


Figure 6: Solar spectrum using the Mightex spectrometer and fiber collimator. Various solar and terrestrial line absorption features are identified.

Preliminary flight results show the strong O2 & H2O absorption features prior to liftoff. Whereas the H2O feature is no longer apparent by 110K, the O2 feature is still strong and remains so for the duration of the mission.

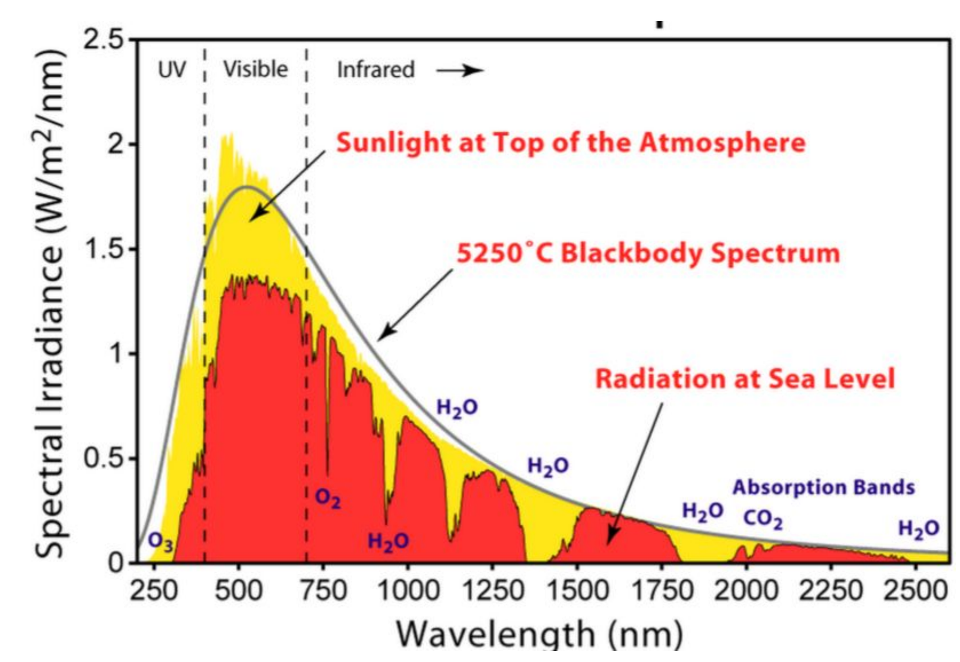


Figure 7: Solar reference spectra for comparison with figure 6. Note strong O2 and H2O features in the ground based and flight data.

Preliminary Conclusions: The Mightex spectrometer functioned during the ascent and descent portions of the flight. The figure above shows the pre-launch sky brightness at 11:51:54 (MST - blue). Lift-off is clocked at 11:53:00 (red). Strong H2O absorption features are evident (as noted in Figure 6). The O2 (ozone A-band @ 750 nm) is also strong. By 11:55:05 (green - 110K ft), the sky brightness signal saturates the spectrometer with a fixed (1000 msec) integration time. By 11:56:03 (orange - 276K ft), the sky brightness has dropped appreciably. The O2 feature is still present.

The AMSE payload functioned as designed and demonstrated the successful observations of the decrease / increase in sky brightness during the ascent and descent portions of the Blue Origin NS-12 mission.

Further analysis is required to co-add the spectra taken at successive intervals of 8.6-seconds to determine the low background limit of the experiment. Operating with a fixed integration time to avoid saturation was an issue.

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