**IIRS (IMAGING INFRARED SPECTROMETER ONBOARD CHANDRYAAN-2 ORBITER) ONBOARD SPECTRAL CALIBRATION AND VALIDATION OPERATIONS.** Vijayasree P[1*], Ankush Kumar[2], Satadru Bhattacharya[2], Minal Sampat[2], Arup Banerjee[2], Aditya Dagar[2], Gomathi Sarata[1], Naga Manjushaa[1], M Srikanta[1], Ritu Karidhala[1], [1]URSC-ISRO, Bengalore, India 560017; [2]SAC-ISRO, Ahmedabad 380015 ([*]vijaya@ursc.gov.in).

**Introduction:** The payloads were switched ON during the Earth bound and Lunar bound orbits before reaching the intended 100km circular orbit. As there were restrictions on the manoeuvring of the composite module, the payloads were switched ON at that portion of orbit so as to look at Earth. These exercises were performed for calibration and validation purpose ( i.e. onboard calibration and validation (cal-val) activity w.r.t. spectral performance of Imaging Infrared Spectrometer (IIRS) instrument onboard Chandrayaan-2 orbiter). For this Earth observations were carried out in order to capture the spectral signature of Earth's atmosphere due to various gases like water and carbon-dioxide. The onboard spectral cal-val activity shows that the spectral performance (i.e. band definitions) are intact as per pre-launch lab spectral calibration.

**Earth observation by IIRS:** Earth observation by IIRS carried out in natural / inertial orientation of the spacecraft (Fig. 1A). It was cloud condition at imaging location (Fig. 1B). In Earth observation data, portion of the Earth and Deepspace was covered across the swath of IIRS. About 20% of the swath contains Earth and 80% Deepspace (Fig. 1C). Spectral radiance profile corresponding to two location were plotted (Fig. 1D), showing the radiometric variation and spectral similarity in terms of the absorption bands. Spectral radiance profile along with reference or standard spectra (with atmospheric absorption) plotted (Fig. 1E) for comparison of spectral absorption band locations. We observed typical spectral signature of absorption due to water vapour (predominant absorption at ~0.9 µm, ~1.1 µm, ~1.4 µm and ~1.9 µm) and carbon-dioxide (weak absorption signature at ~1.6 µm and 2 µm) in the atmosphere.

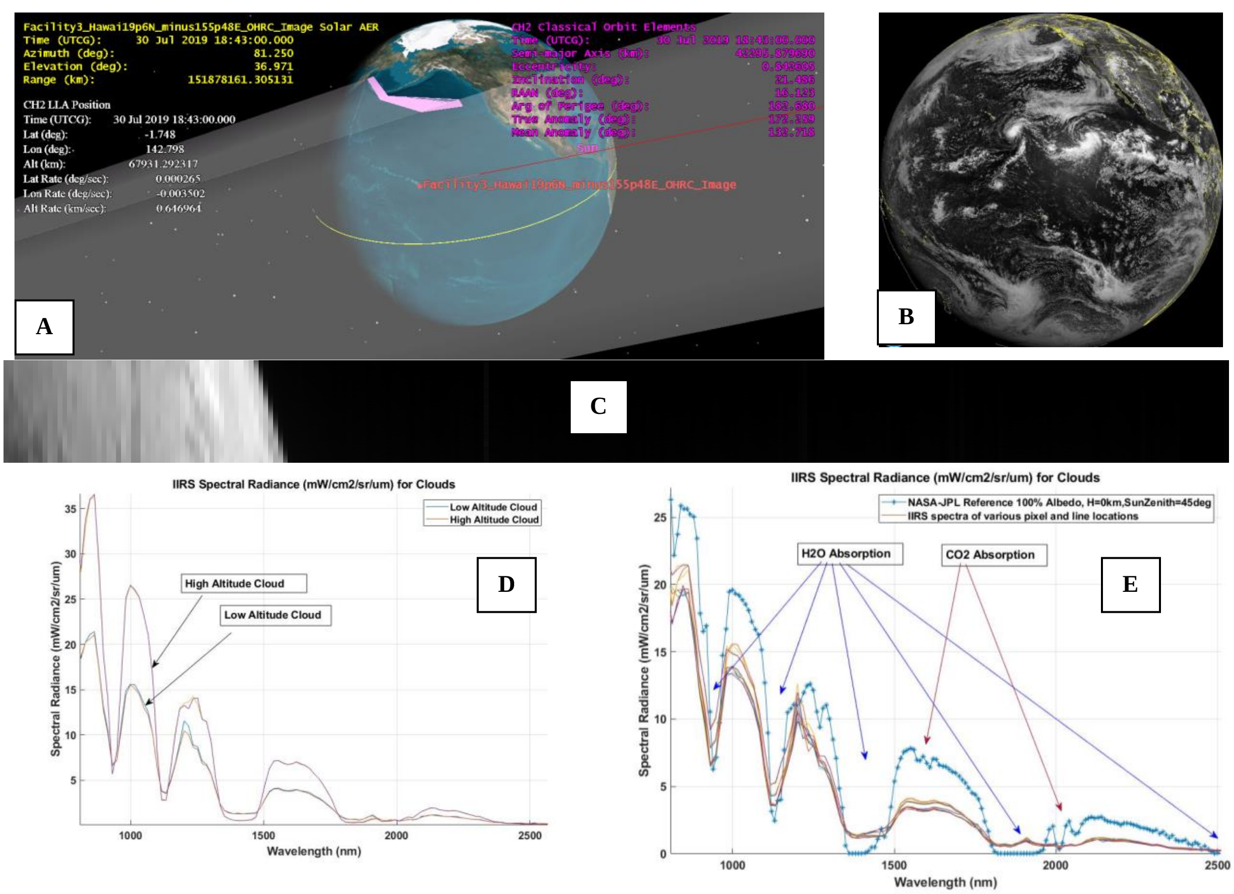


**Figure 1:** A**)** STK simulation for IIRS swath footprint on Earth (near North Pole) and in Deepspace, B) Earth's optical image of the same time frame showing cloud conditions, C) IIRS image of ~1030nm spectral band showing Earth and Deepspace coverage, D) Spectral radiance corresponding to two locations (over clouds) and E) Spectral radiance signature plotted along with reference or standard spectra for comparison of spectral absorption band locations.

There are radiometric differences due to the fact that atmospheric and imaging conditions for reference spectra and IIRS data were different. So, radiometric differences as expected. Spectrally IIRS spectra matches very closely with reference spectra as evident by observing the locations of strong $H_2O$ absorption bands.

**Additional Results from IIRS data of Earth observation:** IIRS spectral radiance data is utilized for studying some Earth atmospheric properties like clouds and $CO_2$.

False color composite (FCC) image is generated using IIRS near infrared (NIR) band 14, band 17 and band 19 (assigned to Blue, Green and Red respectively) (Fig. 2A).

As we know ice absorb more signal than water (liquid form) at 1.6 µm. So the reflectance at 1.6 µm is lesser for ice clouds as compared to clouds of water droplets. Reflectance at 1.0 µm are similar for both type of clouds. So, IIRS data of 1.0 µm band is used for normalization of signal corresponding to different pixels / locations. A map is generated showing ice clouds (in Yellow, Fig. 2B). Also, ice clouds are expected at higher altitudes (as compared water clouds).

$CO_2$ have weak absorptions at 1.6 µm. Illumination signal level was good at this wavelength, so IIRS is able to qualitatively capture the signature of the $CO_2$ absorption. Relative $CO_2$ abundance map is generated using IIRS data of spectral band ~1.6 µm (Fig. 2C). Other nearby bands are used for radiometric normalization of different pixels / locations.

Deepspace observation data is used for dark calibration for dark-offset removal or correction. Onboard data found to be as expected and comparable with pre-flight lab calibration.

**Summary and Conclusion**: Earth observation operation of IIRS was very useful for calibration and validation of IIRS for spectral performance and dark data. Spectrally IIRS data closely matches with reference, indicating that pre-flight lab spectral calibration is intact post launch or in-flight also. Additionally, we have generated FCC image showing dense clouds, which found to be made up of ice. Above these ice clouds, less $CO_2$ abundance is observed indicating their high altitude which is as expected.

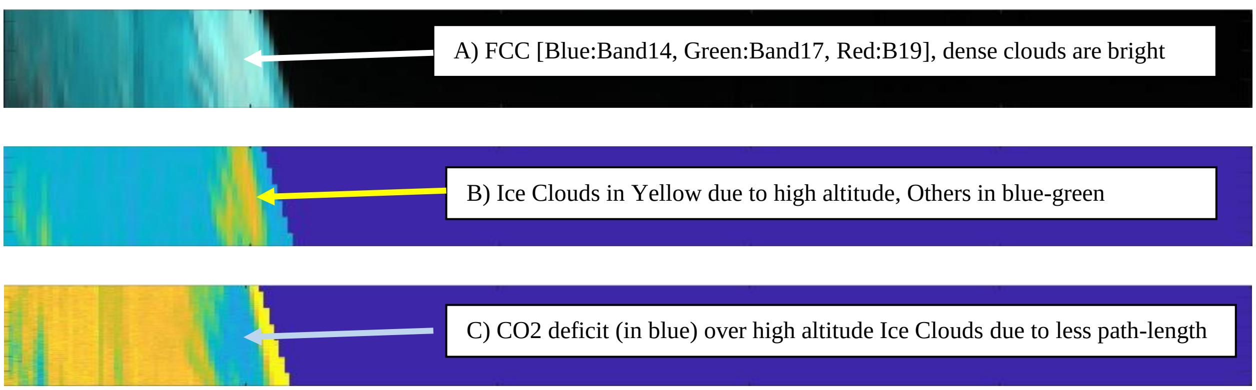


Figure 2: A) IIRS false color composite (FCC) image using band 14, 17, 19 in near infrared (NIR) range, B) High altitude, ice clouds (in yellow color) detected from data of ~1.6 µm (SWIR) band and 1.0 µm (NIR) band and C) Relative $CO_2$ abundance map, generated using IIRS data of spectral band ~1.6 µm (weak $CO_2$ absorption band), showing deficit over high altitude ice clouds due to less path length for absorption.

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**References:**

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