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Measurements of the Earth from lunar orbit in the Visible to the Far-IR by the Lunar Reconnaissance Orbiter Lunar Diviner Radiometer Experiment.

N. E Bowles (1), P Marsden (1), I R Thomas (1), J Hurley (1), B. T. Greenhagen (2), D A Paige (3) and the LRO Diviner team.
(1) Department of Physics, University of Oxford, Oxford, UK, (2) Jet Propulsion Laboratory, Pasadena, CA, USA, (3) University of California, Los Angeles, CA, USA (bowles@atm.ox.ac.uk).

Abstract

The Diviner Lunar Radiometer Experiment (Diviner), currently in orbit around the Moon as part of NASA's Lunar Reconnaissance Orbiter mission, is a nine-channel radiometer covering the visible to the far (≈400μm) infrared. As observation opportunities have arisen, Diviner has made more than nineteen measurements of the Earth (between July 2009 and January 2011). This paper describes some of the outputs from this unique dataset and discusses some of the basic physical parameters that can be determined for the Earth when viewed over broad spectral bands and relatively low (≈1300km) spatial resolution, with a view for application of studying the Earth as an extra-Solar planet.

1. Introduction

Diviner is primarily designed to investigate the surface temperature and mineralogy [4,6]. Diviner's spectral band passes (Table 1) are designed to measure temperatures over the full range expected at the lunar surface (e.g. <50K at the poles and >400K at local noon around the equator) along with three channels around 8μm (1250 cm^{-1}) to map variations in silicate mineralogy. Every four weeks, the LRO/Earth/Moon geometry aligns such that the Earth is essentially fixed in angular space relative to Diviner, which allows measurements to be made of the Earth (termed 'Earth scans' during Diviner command table planning). Diviner images the Earth by slewing the instrument away from the lunar nadir and scanning across the Earth's disc using Diviner's azimuth and elevation actuators. Low-resolution spatial scans of the Earth are then acquired using all 21 (240x480μm) detectors in each of the instruments nine channels.

Table 1. Diviner Radiometer Channel Definitions (from [4]).

Chanel number	Channel Passband (cm^{-1})	Lunar Measurement Function
1	3600-28600	Reflected solar radiation, high sensitivity.
2	3600-28600	Reflected solar radiation reduced sensitivity.
3	1242-1324	Christiansen feature
4	1190-1235	Christiansen feature
5	1152-1193	Christiansen feature
6	435-769	Surface temperature (>178K)
7	244-400	Surface temperature (69-178K)
8	100-200	Surface temperature (43-69K)
9	25-100	Surface temperature (<43K)

2. Using Diviner for Earth Observation.

Using the RADTRAN radiative transfer model [3] and spectroscopic data from the HITRAN database [5] we computed the nadir clear atmosphere transmission using a standard Earth atmosphere temperature and composition profile [1], along with the associated weighting functions for each of the Diviner channels (Figure 1). As expected, the surface is visible in channels 1,2,4 and 5 with channel 3 and 6 sounding to between 3 and 5km altitude. The remaining longer wave channels are located in regions of the spectrum dominated by the water vapour rotational spectrum so sound to approximately 10km altitude for this standard profile. Thus, even though the Diviner instrument was not designed for Earth

observation, it should be possible to derive some basic physical parameters such as low-resolution cloud cover and basic seasonal variations.

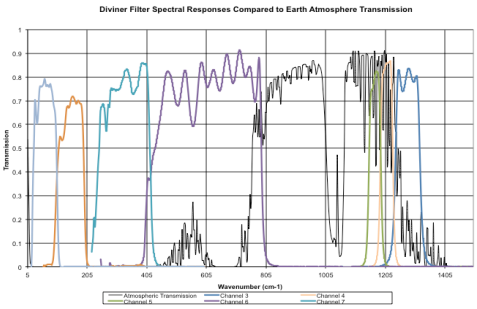

Figure 1. Diviner filter bandpass compared with the Earth's atmospheric transmission to space.

2.1 Example Diviner Earth Scan results

Figure 2 shows a typical raw Diviner Earth scan without correction for spatial over-sampling. Using the actuator position data contained in the level 1a Diviner data product these measurements have been combined and re-gridded to provide a data set suitable for comparison with results from (e.g.) operational weather satellites such as Meteosat Second Generation. Typical results for all nine Diviner channels are shown in Figure 3. The radiances were converted to brightness temperatures using a look-up table provided by the Diviner instrument team [2].

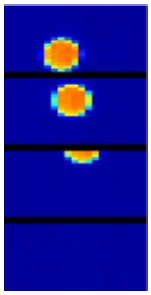

Figure 2. Example of a raw, un-calibrated Earth scan image.

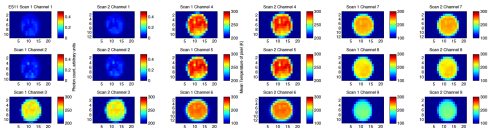

Figure 3. Example Diviner Earth Scan data from UTC 14:10, 13/6/2010.

3.0 Summary and Discussion

Figure 4 shows, that as expected the Diviner radiometer is able to see surface radiance in channels 1,2,4 and 5, with little variation in brightness temperature in channels 7,8 and 9. The data for all the Earth scans measured to date are currently being incorporated into a time series, and derivation of cloud cover and a search for seasonal variations is underway.

Acknowledgements

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References.

[1] Anderson et al. 1986 AFGL-TR-86-0110
[2] Greenhagen 2011, private communication
[3] Irwin et al 1997, Adv. Space Res Vol 19 No 8 p. 1149-1158
[4] Paige et al 2010 Space Sci Rev 150: p 125-160
[5] Rothmann et al 2009, JQSRT 110 p533-572
[6] Vondrak et al 2010 Space Sci Rev 150: p7-22