Diviner Level 2 Data Products

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Level 2: Gridded Data Records (GDR)

- Gridded products derived directly from the RDR (level 1) data product (nadir observations only)
- Data are binned and averaged according to the ~27-day LRO map cycle
- Current release:
  - July 2009 – Sept 2010 (ESMD)
  - Sept 2010 – Sept 2012 (SMD)
- Mimics format of the LOLA GDR data product for maximum compatibility with LOLA and other products
- The master resolution of 128 pix per degree
  - Lower res products: 64 ppd, 16 ppd, 4 ppd, 1 ppd
  - Polar maps: 240 m/pix
- LOLA uses interpolation to create continuous global grids
- Diviner GDR data products are not interpolated (NaN values in maps)
- Split into daytime (06:00 to 18:00) and nighttime (18:00 to 06:00)
- Sub-spacecraft longitude cycles between -180° and 180° every ~27 days
- Sub-spacecraft local time cycles between 0 and 24 hours once every Earth year
- Daytime and nighttime observations on alternate hemispheres in a single orbit
  - Two different local times separated by 180° longitude.
- Ascending and descending nodes alternating between daytime and nighttime every time the sub-spacecraft ground track crosses the terminator.

Orbit plane inclined ~90° relative to the lunar equator
• Sub-spacecraft longitude cycles between -180° and 180° every ~27 days
• Sub-spacecraft local time cycles between 0 and 24 hours once every Earth year
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  • two different local times separated by 180° longitude.
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Example: TB7, 128 ppd (daytime)
Map Cycles

- Map cycle start times are defined by the Julian Date when the sub-spacecraft ground track crosses ±180° longitude at the equator.
- Daytime orbit leg will cross ±180° longitude when the nighttime leg crosses 0° longitude and vice versa.
- Day and night map cycle start time are staggered in time ~13.5 days.
- Visible “seems” in at the start/end of the map cycles.
- The location of “seems” purposely chosen to occur at ±180° longitude to facilitate their placement at the edges of maps.
LRO Orbit
- Mapping cycles defined by Julian date LRO crosses +/-180° Longitude at equator (jdate1, jdate2).
- Problem: ground tracks at angle relative to N
Binning Data at High Latitudes

- Diviner GDR data products are not interpolated
- Resolution aliasing problems at higher latitudes
- High latitudes bin size is smaller than footprint

Two swaths of Diviner data from two consecutive orbits
Field-Of-View (FOV)

- Each channel is comprised of 21 detectors.
- Nominally pointed in the nadir direction operating as a multi-spectral pushbroom mapper.
- Observations are acquired continuously with a 0.128 s signal integration period.
- Swath width of 3.4 km and IFOV of 320×160 m for each detector at an orbital altitude of 50 km.
Effective FOV

• Spacecraft motion during the 128 ms sample integration time
• ~110 ms exponential detector thermal response time
• No broadening occurs in the cross-track direction
• 2-D EFOV is elliptical with elongation along the in-track direction
Geometric Correction & Binning

- The EFOV is populated with points using the Monte Carlo method ($n = 100$).
- Swarm of points projected onto the surface of the Moon (DEM).
- Modeled points are assigned the same radiance value as the original observation and are used as input to a binning routine.

Level 1 referenced to sphere $R = 1737.4$ km
What Does this Accomplish?

1) Assuming a sufficiently high point density, all bins within the EFOV will be populated with a value. This eliminates the occurrence of empty bins.

2) Where adjacent detectors have overlapping EFOVs, points from different observations may reside in the same bins. The resulting radiance value of each bin is therefore the weighted mean of the observations that fall within it.

3) Diviner channels also become better aligned reducing noise in multi-channel data products.
(A – B) Aliasing accounted for by populating bins with an additional 100 points. (C) Sparsely populated bins at swath edges eliminated by filtering the results with a bin count cutoff ensuring the swath width is preserved. (D - E) The normalized bin counts.
Figure 3. (a) Brightness temperatures of the lunar south pole derived from Diviner channel 8 radiance acquired between September 20, 2009 and October 17, 2009 and binned in polar stereo projection at a resolution of 120 m pix$^{-1}$. (b) The same data binned with the addition of the modeled EFOV processing step applied. (c) Subframe of (a) and (d) subframe of (b) showing 28 km diameter crater Idel'son L at 84.2°S, 115.8°E.
LRO orbit 1479 acquired at an altitude of 57.33 km and binned at 1/128° pix⁻¹. Local time is 10.6 (late morning).
LRO orbit 303 acquired at an altitude of 161.73 km. binned at 1/128° pix\(^{-1}\). Local time is 4.9 (nighttime).
Uncertainty (ERR maps)

• The uncertainty determined for each bin
• Account two sources of uncertainty
  (1) Formal pre-flight calibrated error of the instrument
  (2) Actual spatial variability in visible reflectance or thermal emission within a spatial bin.
Polar Stereo Maps

DGDR_TB7_AVG_POLN_20091017D_240  DGDR_TB7_ERR_POLN_20091017D_240
Bolometric Brightness Temperature (TBOL)

- Measure of spectrally integrated flux of infrared radiation from the surface
- TBOL more directly related to heat balance of the surface
- Individual Diviner channels can exhibit anisothermality

In radiative equilibrium, the surface heat balance can be expressed as:

\[ \sigma T_{BOL}^4 = \pi \int_0^\infty c(\lambda) B(\lambda, T_s) - S_0 (1 - A) \]

\[ \sigma T_{BOL}^4 = \sum_{i=3}^9 \sigma T_i^4 f(T_i, \lambda_1, \lambda_2) \]

\[ f(T_i, \lambda_1, \lambda_2) = \frac{\int_0^\infty B(\lambda, T)d\lambda}{\int_0^\infty B(\lambda, T)d\lambda} \]

For detailed description see:
# Level2 GDR data products

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## File Name Convention

DGDR_VB1_AVG_CYL_20090705D_128_IMG.IMG

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Where to get the data?

http://diviner.ucla.edu
Diviner Global Bolometric Temperatures
Bolometric Temperature
Temperatures

Maximum Temperatures

Minimum Temperatures

- Aristarchus
- Copernicus
- Mare Humorum
- Tycho
- Giordano Bruno
- Tsiolkovsky
Local time: 21 hr

Bolometric Nighttime Temperatures
Bolometric Nighttime Temperatures

Local time: 24 hr
Bolometric Nighttime Temperatures
Bolometric Nighttime Temperatures

Local time: 3 hr
Bolometric Nighttime Temperatures

Local time: 4 hr
Nighttime $T_{bol}$ – Nighttime Averaged $T_{bol}$