LRO DIVINER LUNAR RADIOMETER GLOBAL DATA PRODUCTS. J.-P. Williams[1], D. A. Paige[1], M. T. Sullivan[1], B. T. Greenhagen[2], J. L. Bandfield[3], and E. Sefton-Nash[4], [1]Earth, Planetary, and Space Sciences, University of California, Los Angeles (jpierre@mars.ucla.edu), [2]Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, [3]Space Sciences Institute, Boulder CO, [4]European Space Agency, ESTEC, Noordwijk, The Netherlands.

Introduction: The Diviner Lunar Radiometer Experiment onboard the Lunar Reconnaissance Orbiter (LRO) [1] has been acquiring solar reflectance and mid-infrared radiance measurements of the lunar surface nearly continuously since July of 2009 [2],[3]. The instrument has nine spectral channels spanning the wavelength range 0.3 to 400 microns, providing a global perspective of the surface energy balance of the Moon revealing the complex and extreme nature of the lunar surface thermal environment. We have developed several higher level gridded data products to make the extensive dataset more accessible and user friendly for the community [3],[4],[5],[6]. Existing data products have been updated, and new global map products have been added to the NASA Planetary Data System (PDS) Geosciences node in 2017. We review these products and demonstrate examples of how they can be applied to address lunar science goals.

Reduced Data Records: The Diviner Reduced Data Records (RDR) are archived with NASA PDS within 3-months of acquisition. Diviner acquires 21 measurements in each spectral channel every 0.128 seconds. Each of these measurements generates an RDR record. This includes calibrated radiances and associated ephemeris and geometry information. The data are organized into files containing 10-minutes of time sequenced data and can be downloaded directly from the PDS, or accessed via the web-based PDS Lunar Orbital Data Explorer.

Gridded Data Records: We use the RDR data to generate Gridded Data Records (GDR). Approximately each month, the longitudes of the ascending and descending legs of the LRO orbit cycle between 0° and 360° separated by approximately 12 hours lunar local time. Each of the ~monthly cycles is gridded into our Level 2 mapped products using a spatial averaging scheme that projects the Diviner field of views onto a realistic three-dimensional model of the Moon based on LOLA topographic grids [2],[7]. Diviner acquires 24 monthly maps this way each year, with each map covering roughly 2 hours of local time.

Level 3 data. From the Level 2 data sets, we generate Level 3 data products that involve some aspect of modeling. These include the bolometric temperatures, the rock abundance, the regolith fines temperatures, and the Christiansen feature (CF).

Bolometric temperature is a measure of the spectrally integrated flux of infrared radiation emerging from the surface and is determined from the brightness temperatures of the individual infrared spectral channels. The bolometric temperature is the most fundamental and interpretable measurable quantity for the purposes of quantifying the overall heat balance of the surface and comparing with available models [8].

The rock abundance and regolith fines temperatures are derived from modeling the anisothermailty observed in the Diviner IR channels [6]. Anisothermality results when the instrument's field of view contains a mixture of surfaces radiating at different temperatures, such as large rocks (meter-scale and larger) that remain warmer then surrounding fine-grain regloth during the long, ~13 earth day, lunar night. Maps of rock abundance and regolith temperatures normalized for local time, latitude, and slope, are available covering latitudes ±80°.

Three of Diviner's channels are centered around 8 μm to characterize a compositional indicator of silicate mineralogy called the Christansen feature (CF) [5]. Common lunar minerals exhibit variations in the wavelength at which the spectral feature peaks and maps of the CF position are available covering latitudes ±70°.

Level 4 data. All nadir-pointing data acquired over the first 5.5 years of the LRO mission, approximately a quarter trillion calibrated radiance measurements, have been compiled into a 0.5° resolution global dataset with a 0.25 hour local time resolution. This provides a course diurnal temperature cycle for each map pixel location and has been released in the Spring of 2017 as a new Level 4 data set.

This data set significantly lowers the level of effort for data users to incorporate Diviner results into their research or presentations. Maps generated with this dataset provide a global perspective of the Moon's surface energy balance. Example applications and analysis of this data set are described in Williams et al. [3] and Figures 1 and 2 provide examples of how the data can be utilized to create map products and characterize radiative and thermophysical properties of the lunar surface.

References: [1] Paige D. A. et al. (2009) *Space Sci. Rev.*, DOI:10.1007/s11214-009-9529-2. [2] Williams J.-P. et al. (2016) *Icarus*, 273, 205–213. [3] Williams J.-P. (2017) *Icarus*, 283, 300–325. [4] Paige D. A. et al. (2011) *LPSC 42nd*, Abstract #2544. [5] Greenhagen B. T. et al. (2010) *Science*, 329, 1507–1509. [6] Bandfield J. L. et al. (2011) *J. Geophys. Res.*, 116, E00H02, doi:10.1029/2011JE003866. [7] Smith D. E. et al. (2010) *Geophys. Res. Lett.*, 37, L18204. [8] Paige D. A. et al. (2010) *Science*, 330, 479–482.

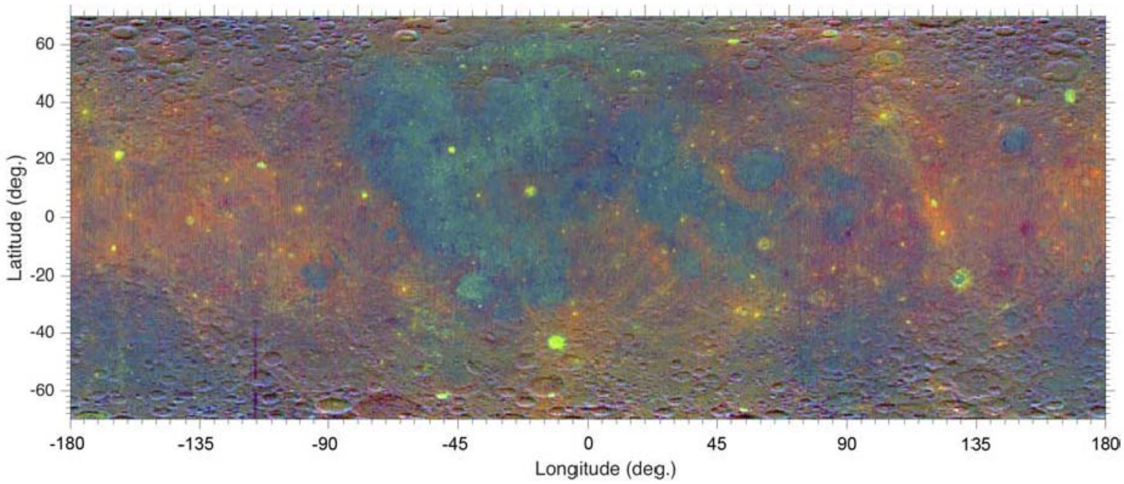

Figure 1. Broad characterization of terrains based on minimum and maximum temperatures (normalized by zonal mean temperatures). Maximum temperatures are sensitive to the radiative properties of the surface and minimum temperatures are sensitive to the thermophysical properties of the regolith. This characterization is highlighted in an RGB composite map (±70° latitude) where the red channel is visual brightness derived from Diviner's visible channel (channel 1), the green channel is the minimum temperaures, and the blue channel is the maximum temperatures. Terrains can be characterized as low/high reflectance and low/high thermal inertia (TI). Young craters and rays (yellow/orange) are bright and high TI. Cold spots and radar dark halos (magenta) are bright and low TI, mare (cyan/blue) are dark and high TI, pyroclastic deposits (blue) are dark and low TI [3].

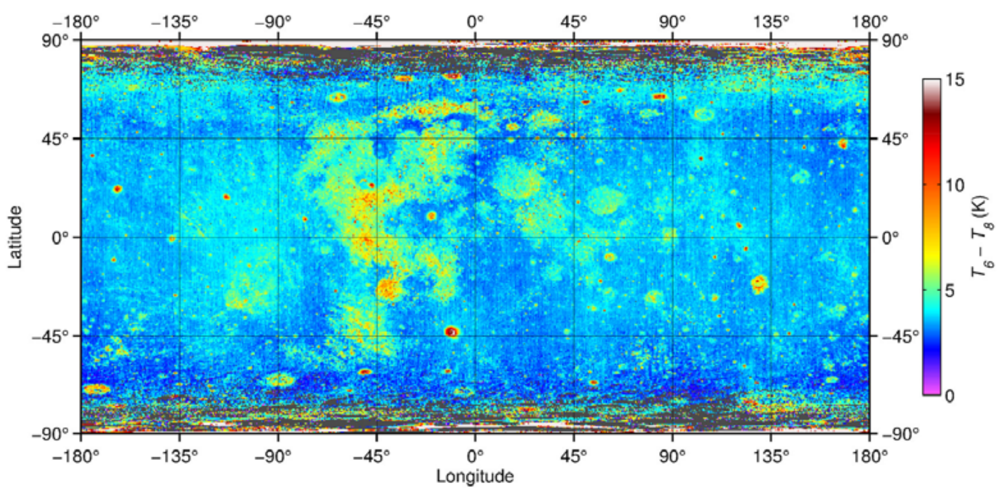

Figure 2. Mean nighttime (local time hours 20–4) brightness temperature difference between Diviner channels 6 and 8 highlighting anisothermality in Diviner observations. Areas of higher anisothermality have greater mixtures of surfaces radiating at different temperatures. Grey areas near the poles are where channel 6 loses sensitivity below ~95 K [3].