THE DIVINER LUNAR RADIOMETER COMPOSITIONAL DATA PRODUCTS: DESCRIPTION AND EXAMPLES. B. T. Greenhagen[1], P. G. Lucey[2], J. L. Bandfield[3], P. O. Hayne[4], J. P. Williams[5], and D. A. Paige[5], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA; [2]University of Hawaii, Honolulu, HI, USA; [3]University of Washington, Seattle, USA; [4]California Institute of Technology, Pasadena, CA, USA; [5]University of California, Los Angeles, CA, USA. Email: Benjamin.T.Greenhagen@jpl.nasa.gov

Introduction: The Diviner lunar radiometer has made the first direct global measurements of silicate mineralogy of the lunar surface using multispectral thermal emission mapping [1]. By mid-March, 2011, the first derived compositional data products (level 3) will be released into the Planetary Data System (PDS) Geosciences Node. These products describe the Diviner Science Team's best efforts to determine the position of the Christiansen feature (CF), which is directly related to silicate mineralogy of lunar soils [e.g. 2,3]. The initial release of these products include data from the mission's primary mapping phase between 9/17/09 and 9/16/10. This work describes at a high level the creation of Diviner's compositional data products.

Diviner Lunar Radiometer: Launched onboard the Lunar Reconnaissance Orbiter (LRO) in June 2009, Diviner is a nine channel pushbroom mapping radiometer designed to measure broadband reflected solar radiation (two channels) and emitted thermal infrared radiation (seven channels) between 0.3 and 400 µm [4]. The two solar reflectance channels both span 0.3 to 3 µm and are used to characterize the photometric properties of the lunar surface. The three shortest wavelength thermal infrared channels (ch 3: 7.55-8.05 µm; ch 4: 8.10-8.40 µm; ch 5: 8.38-8.68 µm – referred to herein as the "8 µm region channels") were specifically designed to characterize the CF [5]. Diviner's longer wavelength thermal infrared channels span the mid- to far-infrared between 13 and 400 µm and are used to characterize the lunar thermal environment, including thermophysical properties such as rock abundance and surface roughness.

Christiansen Feature: In the lunar environment (characterized by a fine particulate surface and vacuum resulting in high thermal gradients), the CF has significantly enhanced spectral contrast compared to other mid-infrared spectral features [e.g. 2,6]. The CF occurs when the refractive index (real part) of a material approaches the refractive index of the surrounding medium AND absorption is relatively low ($n \approx 1$, $k \approx 0$). The CF is tied to the fundamental vibrational band and shifts to shorter wavelengths with increasing polymerization of the SiO_4 tetrahedra (e.g. framework silicates exhibit CFs at shorter wavelengths than less polymerized pyroxene and olivine).

Level 3 Compositional Product: The primary compositional data product is a 128 pixel per degree gridded map of CF values. Ancillary gridded products include bin counts and a measure of data uncertainty. The Diviner team also intends to make lower resolution versions of the CF value map (Fig. 1A) available on the Diviner website (http://www.diviner.ucla.edu).

Coverage. The Diviner primary mapping phase included 14 complete and 2 partial mapping cycles. However, due to Diviner's relatively narrow swath width (~3.4 km at the equator) and ~1 degree orbit track spacing, Diviner does not obtain continuous longitudinal coverage with each mapping cycle. Additional longintudinal gores are caused by spacecraft rolls. Diviner in-flight calibrations and other spacecraft activities also cause latitudinal gores. Figure 1B shows the fraction of the surface covered by at least one data swath with good illumination (0800 – 1600 local time).

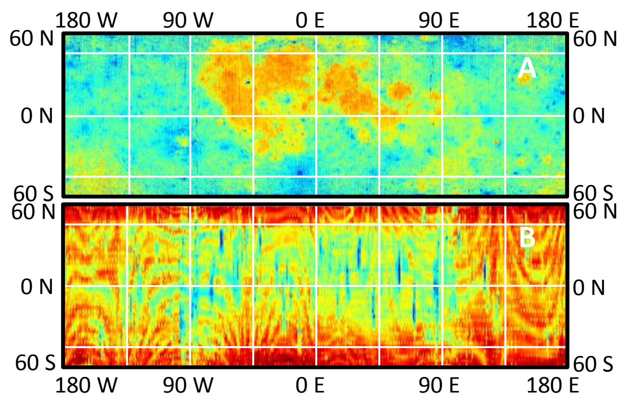

Figure 1: Diviner Preliminary CF Value and Factaional Coverage Maps. 1A: 8 pdd CF values scaled 7.8 (blue) to 8.55 (red). 1B: 1 ppd Fractional coverage scaled 0 (blue to 1 (red). Most coverage gores were caused by LRO rolls for targeted observations.

CF value calculation. Diviner's 8-µm channels span the CF of lunar soils measured in simulated lunar environment, 7.95 to 8.50 µm [e.g. 6]. A parabola closely approximates the shape of the CF when measured in the lunar environment [1]. Therefore, we solve the quadratic formula for the three 8 µm channels ($y = A x^2 + B x + C$). For most Diviner observations, the parabola is concave down ($A < 0$) and the CF value is defined as the wavelength of the parabola's maximum. It is important to note that the calculated CF value is similar to but distict from the CF position, which is the *actual* peak in emission [1]. Additionally, when the CF position is sufficiently far from the 8 µm region channels (e.g. quartz, albite, etc.), the parabola may be concave up ($A > 0$), reflecting the fact that the CF does not occur within Diviner's channel range. In this rare situation, the relative emissivities of ch 3 and ch 5 can be used to determine if the the CF position is shortward or longward of the 8 μm region channels and is given a CF value of 7.00 or 9.00 μm respectively.

Solar incidence correction. Diviner CF values show a strong dependence on solar incidence angle with CF values decreasing for both higher latitudes and local times away from noon [1]. This shift is likely caused by increased anisothermality at higher solar incidence due to the extreme roughness of the lunar surface [7]. First, we characterized the relationship between solar incidence and Diviner standard calibrated radiance (Fig. 2). Then, for each Diviner observation, we normalized radiance to 0º solar incidence. Finally, the CF value was calculated from the normalized radiances for the 8 μm region channels. We are currently investigating some terrain dependency (Fig. 2), which may result in either a terrain dependent correction analogous to a terrain dependent photometric correction, or an albedo dependent correction.

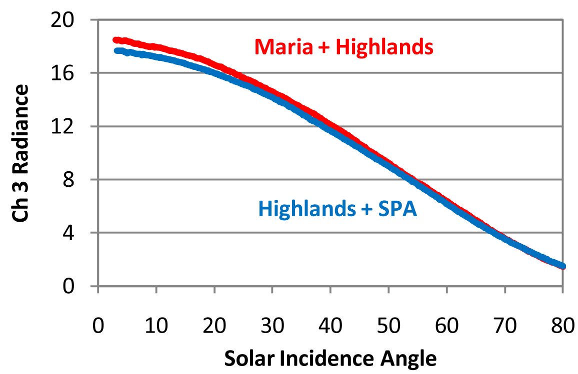

Figure 2: Radiance vs. Solar Incidence Angle. Highlands + SPA terrain is defined as mostly farside longitudes between 100E and 75W, while maria + highlands terrain is mostly nearside between 75W and 100E.

Example. The large Apollo Basin on the lunar farside has diverse lithologies and challenging topography and therefore is a good example of the CF value calculation and correction pipeline. Here we find temperature differences caused by observations at differenent local times and a latitude temperature gradient (Fig. 3A). The CF values calculated from the standard radiances display color striping and overestimate the CF value of illuminated crater rims (Fig. 3B). The CF values calculated from the highlands + SPA terrain normalized radiances are more uniform while areas with low and high CF values are preserved. This presentation will highlight the Diviner compositional data products by surveying a number of additional sites.

References: [1] Greenhagen B.T. *et al.* (2010) *Science*, *329*, 1510. [2] Logan L.M. *et al.* (1973) *JGR*, *78*, 4983. [3] Nash D.B. *et al.* (1993) *JGR., 98,* 23535. [4] Paige D.A. *et al.* (2009) *SSR*, *150*, 125. [5] Greenhagen B.T. (2009) Ph.D. Dissertation, UCLA. [6] Salisbury J.W. *et al.* (1973) *LPS IV,* 3191. [7] Bandfield J.L. *et al*. (2011) LPSC XLII.

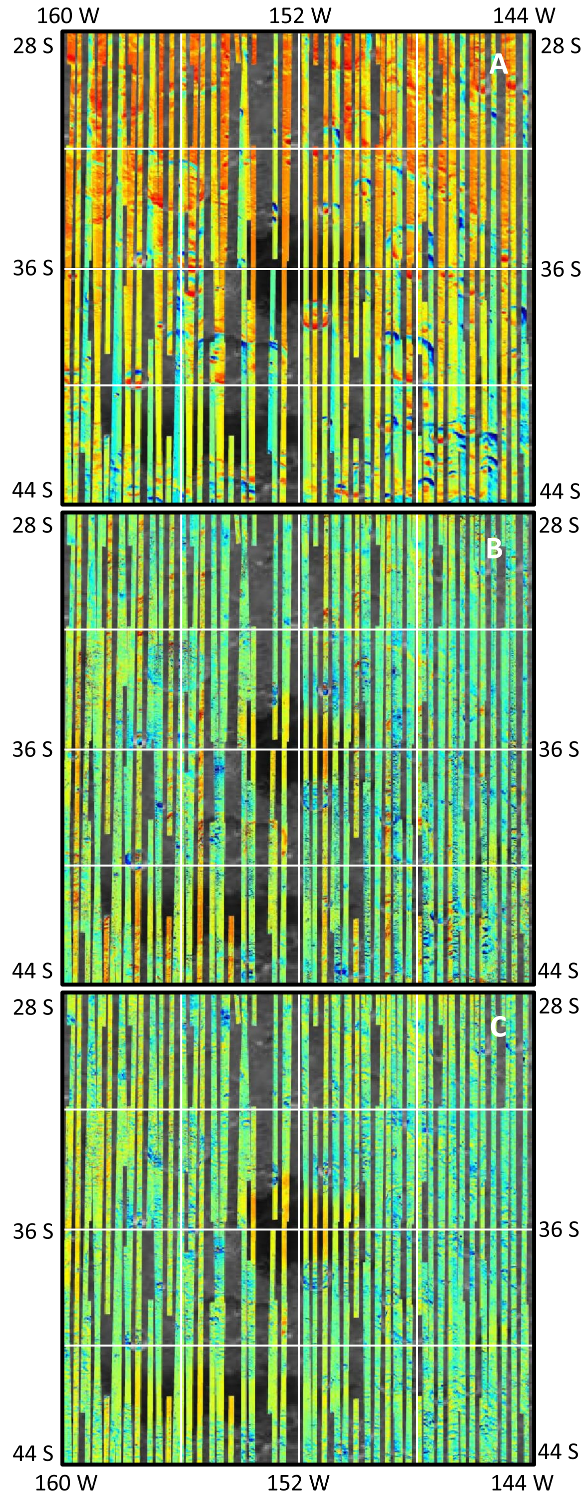

Figure 3: Apollo Basin Brightness Temperature and CF Value Maps. 3A: 8 μm brightness temperature, scaled 300 K (blue) to 400 K (red). 3B: CF values from standard radiance, scaled 7.8 (blue) to 8.55 μm (red). 3C: CF values from highlands + SPA normalized radiance. Diviner strips are 128 ppd. The basemap is Clementine 750 nm albedo.