CHRISTIANSEN FEATURE MAP OF THE LUNAR POLES. Nandita Kumari¹, J.-P Williams², Henal Bhatt¹, T. D. Glotch¹, Elisha Jhoti² and Tyler Powell³, ¹Department of Geosciences, Stony Brook University, NY (Nandita.kumari@stonybrook.edu), ²Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles. CA, ³Johns Hopkins University Applied Physics Laboratory, Laurel, MD

Introduction: The presence of permanently shadowed regions (PSRs) and areas that experience extended periods of illumination has made the lunar south polar region a sought-after destination for exploration by different space agencies [1]. NASA’s plans for in-situ exploration and sample return from a south polar region during the Artemis III mission [2] requires well-determined and quantified composition of the lunar surface. We use data from the Lunar Reconnaissance Orbiter – Diviner Lunar Radiometer Experiment [3] to create a Christiansen Feature (CF) [4] map of the lunar polar regions to understand the bulk composition of the sites of interest selected by NASA and to aid in answering the scientific questions outlined in LEAG ASM-SAT 2017 [5].

Dataset and Methods: The Diviner instrument is comprised of two solar channels and seven infrared channels. Channels 3, 4, and 5 are narrowband filters used to study the lunar composition corresponding to 7.55 - 8.05 μm, 8.1 - 8.4 μm, and 8.38 - 8.68 μm respectively, while Channel 1 is used to measure the broadband visible/near-IR reflectance (0.35–2.8 μm). We have separated the Diviner Reduced Data Records (RDR’s) into 1-hour local time bins at 32ppd (Fig. 1) and the estimated brightness temperatures for Channel 3, 4 and 5.

Thresholding the brightness temperatures of the three channels to be above the noise floor of Diviner is a crucial step in creating the CF map. We have used the binned data of Channel 1 to estimate the reflectance for each hour followed by the average of data concatenated for 24 1-hr local time bins. We thresholded these data at a reflectance of 0.05 and the values below this were replaced by NaN. In the case of Channels 3, 4 and 5, we collected 10-years of summer polar data using subsolar latitudes < −0.5° N for south polar summer and >0.5° N for north polar summer. After the data extraction, we computed the brightness temperature of each channel and thresholded the temperatures at 250 K and 300 K for Channel 3 and 110 K for Channels 4 and 5 (Fig. 2). Channel 3 thresholds were kept at higher temperatures to prevent any noisy or dark pixels, while Channels 4 and 5 threshold temperatures were chosen at 110 K as an additional barrier to prevent noisy data.

We created two different data products (Fig. 3), using these datasets – 1) we calculated the CF, as described in [4], of each hour using this data, additionally thresholded it by albedo on top of brightness temperature and then removed the values below 7 μm and above 9 μm. We refer to this product as the “pre-concat CF”. Then we concatenated the 24-hr CF values and estimated the mean and median of the data; 2) we thresholded the brightness temperature of each channel using Channel 1 values, concatenated the brightness temperatures, estimated the mean and median of each channel, and then estimated the CF from the mean and median set of the data. We refer to this product as the “post-concat CF”. In both the methods, only the pixels with more than 8 values were used to estimate the mean and median, those below this threshold were dropped.

Fig. 1a) Brightness temperature of Channel 3 at each hour at the lunar south pole. The red line represents a temperature of 250 K.

Fig. 2 Histograms displaying the brightness temperature distribution of Channels 3, 4 and 5 of a) the lunar south pole and b) the lunar north pole.

Fig. 3 Flowchart of the method used to create the data products.
Results: The two sets of products explained in the methods section are illustrated in Fig. 4. We observe that the albedo, additional brightness temperature and 8-hour thresholding reduces the number of pixels in pre-concat thresholding by a significant amount for 250 K and they are almost non-existent for 300 K both for the south and north poles (Fig. 4a-b). The post-concat CF product has values ranging from \(<7.6 \mu m\) to \(>8.4 \mu m\) (Fig. 4c-d). We observe that the missing pixels correspond to the PSRs or poorly lit regions in the post-concat method without losing out on a lot of data, unlike the pre-concat method, and thus plan on using the post-concat method in future works.

The histograms of both products align well indicating that the results from both the methods are in agreement (Fig. 5).

Future Work: In the future we plan on applying this method to individual orbits to eliminate miscalibrated orbits from the analysis and apply the correction proposed by [6] to account for emission angle effects on brightness temperatures.

References: