A NEW METHANE SPECTRAL INDEX FROM NASA'S NEW HORIZONS RALPH/MVIC INSTRUMENT. A. Emran[1], V. F. Chevrier[1], and C. J. Ahrens[2], [1]AR Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR 72701. [2]NASA Goddard Space Flight Center, Maryland, MD 20771. (alemran@uark.edu).

Introduction: NASA's New Horizons probe onboard Ralph/ Multispectral Visible Imaging Camera (MVIC) and Linear Etalon Imaging Spectral Array (LEISA) instruments have revealed spatial distribution of volatile methane (CH_4) ice on the surfaces of the dwarf planet Pluto and its largest moon Charon [1]. MVIC instrument comprises seven independent Charged-Coupled Device detectors (CCDs) array to produce both panchromatic and colored images of different filters. The color filters consist of a blue channel (400 – 550 nm), red channel (540 – 700 nm), near-infrared/NIR channel (780 – 975 nm), and a narrow band methane absorption channel (860 – 910 nm) [2].

Previous studies used different MVIC color bands to produce a planetary scale methane distribution from high-resolution methane "equivalent width" and spectral slope maps of Pluto's surface [3]. The study [3] used red, NIR, and the narrow methane bands to quantitatively analyze the relationships between methane distribution, redness, and other parameters such as altitude and latitude. In this study, we propose a new methane spectral index from MVIC instrument data. The new index uses only two bands (red and the narrow methane absorption channels) to produce a global methane distribution on the surface of Pluto.

Observations and Method: We use MVIC 4-color image cube 0299178092_0x536 to produce a methane distribution map on Pluto by implementing our proposed spectral index. Refer to [4] for the detail of the calibration of the MVIC image cube. We also applied the index to the MVIC global color mosaic produced by Southwest Research Institute (SwRI). The mosaic is composed of all MVIC color scans between MET (Mission Elapsed Time) 0298652198 and 0299178098 [5]. We propose the new methane spectral index (*MSI*) as:

$$MSI\ (CH_4) = \frac{\lambda_{\mathrm{red}} - \lambda_{\mathrm{CH_4}}}{\lambda_{\mathrm{red}} + \lambda_{\mathrm{CH_4}}}$$

where λ_{red} and $\lambda_{\mathrm{CH_4}}$ are the I/F of MVIC red and the narrow CH_4 absorption channels, respectively. The index values range from -1 to +1, where negative indicates little or no methane ice absorption and positive values represent greater absorption by methane ice grains in the surface volatile mixtures. Since we use a CH_4 band of around 890 nm, a weak methane band, the positive values may be indicative of pure and coarse-grain-sized methane ice. However, the index can be affected by the methane dilution sates and ice texture like the methane "equivalent width" does [3 and the references therein].

Results and Discussion: We produce a methane ice distribution map from the MVIC 4-color scene (Fig. 1) and MVIC global color mosaic (Fig. 2; where "high" and "low" represent positive and negative index values, respectively) on the surface of Pluto. The spatial distribution of methane ice using the new spectral index is visually consistent/ comparable to the existing methane distribution map using Ralph/ LEISA instrument by the existing study [1]. Around the equator at Cthulhu shows negative values in the index corresponding to the lack of absorption by methane ice and the dominance of redder materials or tholin deposits (Fig. 2). Eastern Sputnik Planitia (SP) at Tartarus Dorsa shows higher (positive) values in the index – suggesting the presence, perhaps, of pure and coarse-grain-sized methane ice.

The index can be used to see if this output is consistent with methane distribution in local areas of interest: for instance, methane-capped mountains e.g., Pigafetta and Elcano Montes at Cthulhu Macula, and eastern Tartarus Dorsa; Al-Idrisi Mons; glacier flow on the eastern SP (methane ice has a lower density (0.52 g cm^{-3}) than other surface volatiles e.g., nitrogen (1.0 g cm^{-3}) and carbon monoxide (1.0 g cm^{-3}) ices so pure methane signature can be seen on glacial flow); and Virgil Fossae and Elliot crater, etc. The potential advantages of this index are it is a quick method (using only two bands instead of using three bands in "equivalent width" and spectral slope maps by the previous study [1]) and the proposed index readily renders a (qualitative) impression of the pure methane ice distribution or abundance.

Conclusion and Future work: We propose a new spectral index for mapping the global-scale volatile methane ice distribution on the surface of Pluto. We plan to expand this project to see if our prosed index result is consistent with the local scale geology and associated methane ice abundance on the dwarf planet as mapped by the previous studies [1,3].

Acknowledgments: We use MVIC instrument data downloaded from NASA Planetary Data System (PDS): Small Bodies Node (SBN). All image data can be found at https://pds-smallbodies.astro.umd.edu/.

References: [1] Grundy W. M. et al. (2015) *Science*, 351. [2] Reuter D. C. et al. (2008) *Space Sci Rev., 140,* 129-154. [3] Earle A. M. et al. (2018) *Icarus 314,* 195–209. [4] Howett C. A. et al. (2017) *Icarus 287,* 140–151. [5] Stern A. J. (2018) *NASA PDS*.

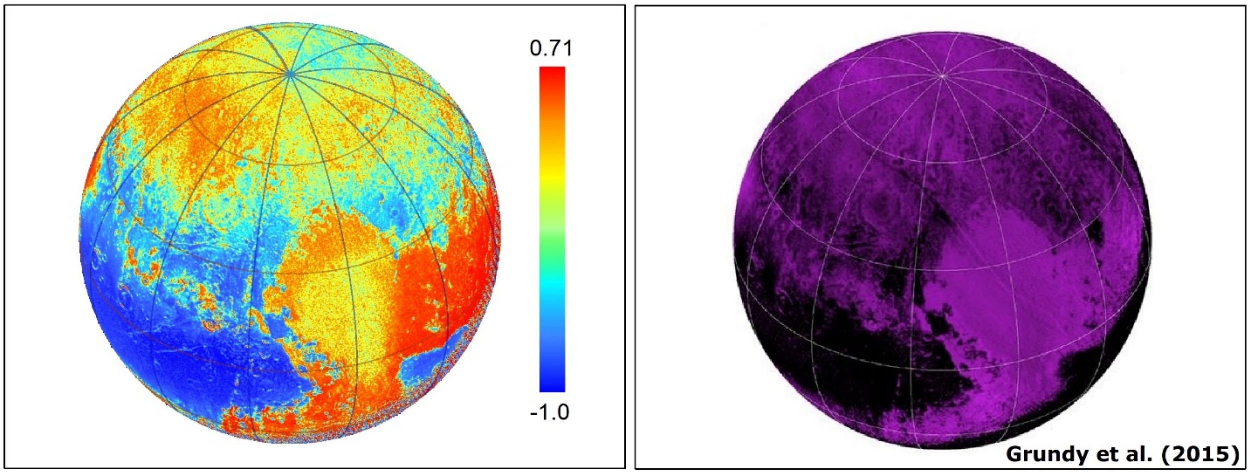

Fig 1: (on the left) Methane ice distribution map (histogram equalized stretch) as derived using the proposed spectral index from MVIC red and the narrow methane channels. Negative values indicate little or no absorption by methane volatile ice whereas positive values represent a greater absorption by coarse-grain-sized (pure) methane ice in surface volatile mixtures. (on the right) Absorption of methane ice (distribution) as mapped using LEISA instrument data by the study of Grundy et al. (2015), where the brighter colors corresponding to higher methane absorption. The two maps (left and right panels) show a similar spatial distribution of methane volatile ice.

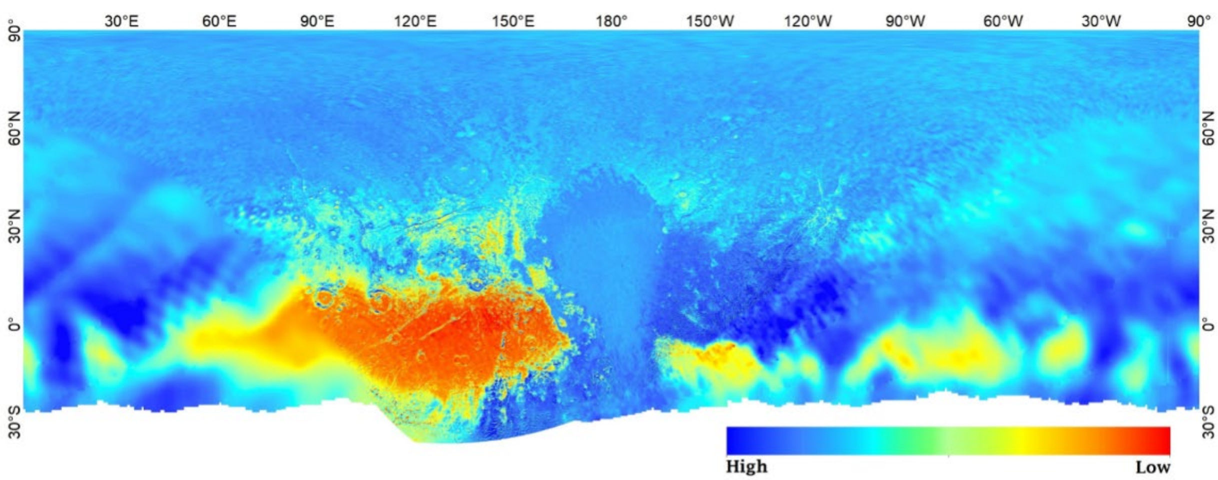

Fig 2: Global-scale methane ice distribution as derived by using the proposed spectral index using red and methane channels from the MVIC global color mosaic. The blue color indicates a higher concentration of coarse-grained/ pure methane ice whereas the red color represents an absence of methane ice (or presence of redder/ non-volatile materials/ tholin deposits).