CHARACTERIZING LUNAR POLAR VOLATILES AT THE WORKING SCALE: GONG FROM ISRU GOALS TO MISSION REQUIREMENTS. A. Colaprete[1], R. C. Elphic[1], M. Shirley[1], [1]NASA Ames Research Center, Moffett Field, CA, anthony.colaprete-1@nasa.gov

Introduction: The economic evaluation of natural resources depends on the accuracy of resource distribution estimates. A frequently discussed lunar resource is water ice, however, we currently do not have a sufficient understanding of the distribution of water or its forms at the scales it would be extracted and processed. This paper provides an analysis of the number and distribution of observations needed to guide the next steps in lunar water ISRU. We use a combination of Monte Carlo studies and geostatistical approaches to go from the exploration goal of "understand the distribution of water" to a quantification of specific mission sampling requirements.

The Need for Mobility and Subsurface Access: A number of existing data sets suggest that water ice is heterogeneous at scales down to meters. For example, to reconcile the LCROSS observed water concentrations of ~5% [1] with the observations of neutron counts the water would need to be either buried under a desiccated layer of regolith 20cm to 50cm deep and/or mixed laterally with an areal density of 20-40% [2]. These ranges of values for the lateral and vertical distributions are consistent with what one would expect due to the constant excavation/burial by impacts [3]. The distance between 10 m wide craters (~1 m deep) is ~50-150 m, consequently the top ~meter is likely to be patchy at scales of 10s-100s of meters. Modeling and geostatistical analysis can be used to better quantify the scales needed to be measured and the minimum number of measurements required to adequately characterize an area.

Geostatistics and Monte Carlo Modeling: The application of geostatistics in resource characterization dates back to the late 1970s and are useful for site assessment where data is collected spatially [4]. These same techniques can be applied to lunar spatial data sets and / or model predictions to evaluate the geospatial distribution of key physical parameters, including for example, surface and subsurface temperatures.

Variograms: One way to look at the lengths scales associated with the distribution of water is to generate variograms of the subsurface water ice stability depth (the depth at which subsurface temperatures are cold enough to retain water ice for extended periods). A variogram provides a measure of the spatial correlation of a given parameter. Figure 1 shows several variograms (each with the same origin but differing directions) calculated for an ice stability map near the north pole crater Hermite-A. The points at which the curves flatten represents a loss in autocorrelation between the parameter and distance (or lag), and are indicative of critical physical scales.

Monte Carlo Modeling: In addition to geostatistical analysis, Monte Carlo modeling of surface traverses has been carried out. The model generates maps of randomized water distributions with variable burial depth and concentration. For each model run "samples" are taken along a prescribed traverse path. These samples are used to estimate the overall average water concentration and variability and compared to the actual average concentration and variability calculated for each run. The difference between the estimates from just the samples and the actual values represents the error in the traverse sampling. These estimates can be used to derive mission requirements for the necessary rover traverse distances and sampling density. These estimates were made for a binary water presence (either the water was sensed or it was not). The next set of calculations applies instrument models for how they would actually sense the water (or hydrogen) along the traverse. Finally, simulated subsurface sampling can be added to better understand how the number of subsurface "tie-points" reduce the overall uncertainty in the estimates.

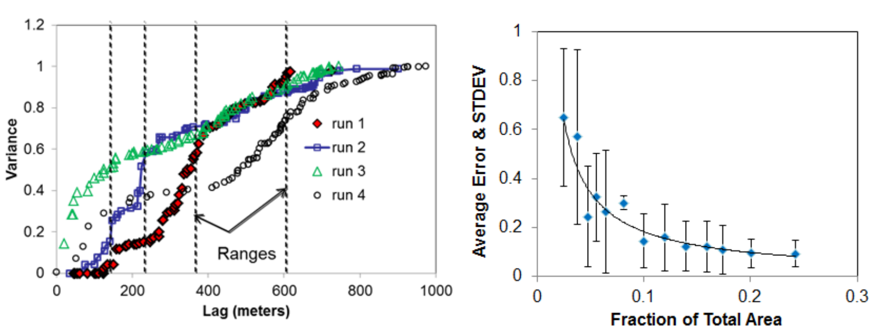

Figure 1 Calculated variograms of water ice stability depth for four transects with the same origin but different directions and Monte Carlo modeling derived error in the estimated mean water concentration as function of rover traverse density across the model domain

References: [1] Colaprete et al., (2010), Science, pp. 463. [2] Elphic, R. C. et al. (2012) *LPS XLII Abstract# 2751* [3] Yunsel, T. Y., (2012), The Journal of The Southern African Institute of Mining and Metallurgy, 112, pp. 239.