MASS BALANCE OF MARS' SOUTH POLAR RESIDUAL CAP FROM SPACECRAFT IMAGING DATA. P. C. Thomas[1], W. Calvin[2], R. Haberle[3] P. B. James[4], S. W. Lee[4] [1]Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853, [2]Department of Geological Sciences, University of Nevada, Reno NV 89577, [3]Space Science Division, NASA Ames Research Center, Moffet Field CA 94035, [4]Space Science Institute, 4750 Walnut Street, Suite 205, Boulder CO 80301

Introduction: Mars' south polar residual cap (SPRC) is essentially made of CO_2 ice, its occurrence is difficult to predict from basic physics, it is visually complex, and it is expected to be a sensitive indicator of climate variations. During the seven Mars year span of high-resolution imaging it has shown contradictory behavior: steady erosional expansion of pits while the area covered by ice at the end of summer sublimation has both expanded and contracted, a pattern observed over a longer time at lower resolution [1]. Mass balance estimates from surface pressure data are observationally difficult, and at present do not clearly support net gain or loss over the period since Viking lander measurements [2,3]. Imaging-based estimates based on a few selected locales [4,5] have suggested loss rates of $2x10^{10}$ m^3/♂y (scarp retreat) to $3.4x10^{10}$ m^3/♂y (downward erosion). These values are roughly 0.13 - 0.24% atmospheric mass/♂y. These estimates have been used to suggest a limited lifespan for the current cap, which has been observed at least since the late 19th Century. Modeling of parts of the cap behavior suggest regional mass balance might change due to feedback effects of surface characteristics [6].

Approach: Here we make a broader and more detailed approach to using imaging data for mass balance estimates. We first have updated the unit map of the SPRC [7], using the full 6 m/pixel late summer mosaic of Context Camera (CTX) images in Mars Year (MY) 31 (2013) as a base. Low resolution data from Mariner 9 and Viking (MY 9 and 12), MOC wide and narrow angle data from MY 24-27, and CTX and HiRISE data in MY 28-31 provide data for mapping and change measurements. The older, thicker mapped units are little different from earlier presentations, but the younger, thinner units are now subdivided on the basis of erosional state and probable condition before and after Mariner 9 observations. The rates of scarp retreat for the different units have been updated with MY 31 data; these show that pit erosion continues at different rates in different units (significanty dependent upon scarp height), and likely has continued at roughly the current rates since MY 9 (Mariner 9 observations; 1972). CTX mosaics from 4 Mars years allow mapping of changing areas of cover. As noted by [1], these area on the periphery of the SPRC are very small fractions of the total cap area. CTX also provides sampling of areas to directly measure the total eroding scarp lengths in the different units for estimation of the mass loss from pit erosion. HiRISE data, in concert with MOC data, show areas that sustain almost no surface changes over several Mars years, as well as some locales that have recently accumulated materials on older CO_2 deposits. The amounts of such deposition can be approximately constrained by the size of forms that survive or are buried.

Results and context: This work has produced a table of unit areas, scarp lengths/area, scarp heights, scarp retreat rates, areas subject to possible additional deposition over 7 Mars years, inferences of areas with no vertical change over 3-7 Mars years, areas of little net change that suffer both erosion and deposition (chiefly "fingerprint" terrain), and (small) areas subject to vertical collapse over periods from 3 to 22 Mars years.

This matrix of areas and rates has resulted in an estimate of average Mars-year volume changes on the SPRC of -7 to +4 km^3 over the last seven Mars years, and more likely a net gain in the years immediately following MY 9. These results are smaller values than those of [4,5] (-20 to -34 km^3/♂y). The total volume of the RSPC deposits is estimated at less than 400 km^3 [7]. Morphologic features such as pits and moats that mark post-Mariner 9 (MY 9) deposits that show relief (even in 6 m pixel CTX data) in widespread areas, provide for much of the possible positive mass balance. Some years of loss (such as MY 28) are usually followed by notable deposition. Such year-to-year variations are small parts of a longer term budget for a feature that has existed for at least an Earth century and likely will persist for at least that span in the future.

The estimated volume changes are not the major lesson of this work. Rather, the complexity of the units in the SPRC, their different responses to current environments, and obvious year-to-year differences especially involving large dust events emphasize that on a few year time scale, no single morphologic result will give an unambiguous "mass balance." Continued monitoring is the key to determining the role and signficance of both the short- and long-term variations of the RSPC in its overall history.

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