

EFFECTS OF ATMOSPHERIC DUST ON RESIDUAL SOUTH POLAR CAP STABILITY. B.P. Bonev¹, J.E. Bjorkman¹, G.B. Hansen², P.B. James¹, M.J. Wolff³. ¹ Dept. Physics and Astronomy, U. Toledo, Toledo, OH, 43606 USA (bbonev@physics.utoledo.edu), ² Pacific Northwest Division, Planetary Science Institute, Dept. Earth and Space Science, U. Washington, Seattle, Washington, USA, ³ Space Science Institute, Boulder, CO, USA

The Martian polar caps have been studied from the time of Herschel. Neither polar cap normally disappears in summer. The Residual North Polar Cap (portion that remains through summer) is composed of a mixture of water ice and dust, and its interannual stability is due to its low sublimation rate at the summer temperatures in the North Polar Region. The Residual South Polar Cap (RSPC) is more enigmatic, surviving the relatively hot perihelic summer season despite being composed of much more volatile CO₂. It is able to do so because of its unusually high albedo, which is larger than that of other bright regions in the seasonal cap (e.g. Mountains of Mitchel).

The proximity of the albedo of the RSPC to the critical albedo for stability raises the question of whether the RSPC exists in every Martian year. The ground based record is somewhat ambivalent. Douglass and Lowell reported that RSPC suddenly vanished at Ls=297° in 1894 and did not reappear until Ls=0° [1], and Kuiper reported that it disappeared in 1956 [2]; but both observations were questioned by contemporaries, who tended to attribute them to obscuring dust. Barker [3] reported a large amount of water vapor over the south polar cap in 1969 that could be attributed to exposure of near surface water ice during partial removal of the CO₂ in the RSPC in 1969.

High resolution MOC images revealed unique “Swiss cheese” surface features in the RSPC region that change substantially from year to year [4,5]. The morphology of these features suggests that there has been episodic deposition and erosion of surface units over relatively short (~100 year) time scales [6]. The strongest evidence for changes in the RSPC on a time scale of a few Martian years is the striking difference between the cap seen in Mariner 9 images acquired in 1972 and that in subsequent Viking and MGS views. Both the large scale (~1 km) and small scale (Swiss cheese) features changed between 1972 and the MGS mission [6].

One possible mechanism for producing interannual variability in the RSPC is the interannual variability in the optical depth of atmospheric dust as a function of time. Atmospheric dust has the effect of reducing the incident energy at visible and near infrared wavelengths, but some portion of this energy is shifted to thermal infrared wavelengths via dust emission and is absorbed by the surface. The net effect on CO₂ sublimation depends sensitively on the physical nature of the CO₂ frost – the nature and effective grain size as well as the fractional contamination with dust and water ice. These in turn determine the albedo of the CO₂ frost as a function of wavelength [7]. Regions within the

seasonal south polar cap that have the highest visible albedo correspond to relatively fine grained, uncontaminated CO₂ deposits; and for these regions, such as the Mountains of Mitchel, the effect of atmospheric dust is to enhance sublimation, thus causing the features to disappear early in dusty years. This was demonstrated by comparing the Mountains of Mitchel in the first, relatively dust free year of MGS observations to the second year, in which there was a large, early spring dust storm [8].

Although one might anticipate that the accelerated sublimation would have affected the RSPC particularly because of its unusually large albedo, detailed comparisons of the RSPC in the two years showed little difference. One possible explanation is that the dust in 2001 was concentrated near the edge of the seasonal cap, which was located around -60° latitude during the storm; images suggest that dust penetrated to the central regions of the cap only briefly. Another, related explanation is that the incidence angles near the RSPC for the near equinox 2001 storm were close to 90° compared to 70° at the Mountains of Mitchel; thus the impact of the early dust storm on the energy budget of the RSPC is expected to be small. By contrast, the large 1971 dust storm observed by Mariner 9 occurred near solstice when the seasonal cap was very small and the RSPC incidence angle was near maximum.

In this paper we apply the model described in [8] to the RSPC responding to a relatively late dust storm such as that in 1971 in order to estimate the effects of the atmospheric dust on the sublimation rate. An important part of

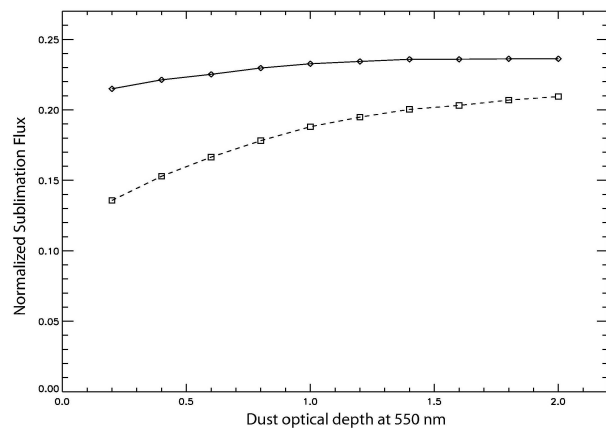


Fig 1: CO₂ sublimation flux as a function of dust optical depth. Models differ in the weight percentage of water ice: .01% (dashed) and .001% (solid).

this exercise is using a recent HST determination of the wavelength dependence of the visible albedo of the RSPC [9] to constrain models for the surface frost. Of the models run to this point, the best albedo fit is for 10mm grain size, .005% dust, and .01% water; the albedo in the visible is still somewhat too low for these parameters, though. The sublimation flux with solar incidence angle of 65° , equivalent to the RSPC at $L_S = 270^\circ$, for this frost model is shown by the dashed line in the figure. On the other hand, a model with .001% water, which results in a poorer albedo fit, leads to the sublimation flux shown by the solid line. Clearly, the result is very sensitive to the CO_2 ice parameters; a more complete sequence of models will be examined to achieve the best fit to the albedo data.

This work was supported by grants from the Mars Data Analysis Program.

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