NUMERICAL SIMULATIONS OF MESOSCALE CIRCULATIONS AND RESULTING WATER VAPOUR TRANSPORT IN THE SPRINGTIME NORTHERN POLAR CAP EDGE REGION. T. Siili[1], D. S. Bass[2] and H. Savijärvi[3], [1]Finnish Meteorological Institute, Geophysical Research Division, PO Box 503, FIN-00101 Helsinki, Finland, Tero.Siili@fmi.fi, [2]Southwest Research Institute, PO Drawer 28510, San Antonio, TX 78228-0510, USA, dsb@grouse.space.swri.edu, [3]Department of Meteorology, PO Box 4, FIN-00014 University of Helsinki, Finland, Hannu.Savijarvi@helsinki.fi.

Introduction: Mariner 9 and Viking Orbiter observations of the polar cap and the atmosphere above it showed the residual/permanent Northern polar cap to be composed predominantly of water ice. Consequently, it is likely that during the spring and summer the exposing northern polar water ice is the major water vapour source. Indeed, the highest seasonal water vapour column abundances occur in the northern hemisphere [1].

Visual and infrared Mariner 9 and Viking Orbiter observations have shown brightening of the northern cap interior after the retreat of the seasonal carbon dioxide cap at $L_s = 93°$ that can not be attributed to the accumulation of CO_2 ice. The brightening was previously attributed to *interannual* variation of the water sublimation-condensation cycle [2-4]. However, recent analysis by [5-6] supports an alternate interpretation of the brightening, implying that the late summer brightening is a *seasonal* phenomenon associated with water being transported towards the cap interior and subsequently recondensed onto the residual water ice cap.

Our motivation for this work is to investigate the plausibility of the [5-6] scenario by simulating the water transport due to regional/mesoscale circulations driven by the surface thermal contrasts generated by the regolith/water ice/CO_2 ice edges. Terrestrial observational and modelling experience as well as Martian simulation work [7-9] show that such thermal contrasts on level or negligibly sloped terrain drive circulation patterns characterised by formation of daytime circulation cells rotating in the thermally direct sense (Fig. 1).

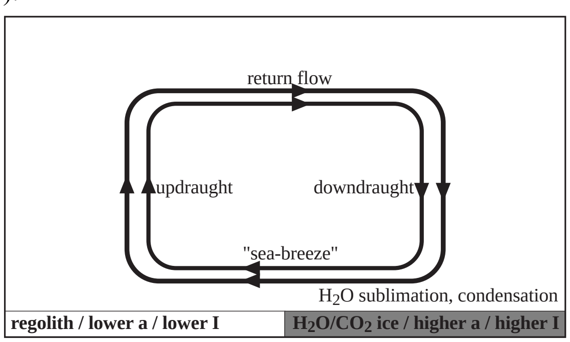

Fig. 1 Schematic of a surface thermal contrast circulation and the plausible H_2O sublimation (over water ice) and condensation (over CO_2 ice) regions over the cap edge region.

This circulation pattern can potentially pick up sublimating water wapour in the near-surface layers, transport it across the ice edge and onwards to higher levels and there towards the interior of the cap – especially, since proximity of the regolith/water ice and the water ice/CO_2 ice contrasts gives rise to two adjacent or merged circulation cells, which extend to over the CO_2 ice. The nocturnal – potentially reverse – circulation is weak in comparison.

The model(s) used: The primary model used in this study is the Department of Meteology/University of Helsinki 2-D Mars Mesoscale Circulation Model (MMCM). This model is based on a terrestrial 2-D mesoscale model, initially described in [10]. The model represents a slice of the atmosphere of horizontal and vertical extents of up to 2000 km and 30 km, respectively. The model has already been used to study a variety of Martian terrain-induced circulation phenomena, *e.g.*, slope winds [11], circulations driven by thermal contrasts caused by variations in surface albedo, soil thermal inertia [7], surface CO_2 [8] and H_2O [9] ice coverage as well as combinations thereof [12]. A companion one-dimensional (vertical) Boundary Layer Model (BLM) has been used in algorithm development [13-14] and independently to study, *e.g.*, the diurnal water vapour cycle at the Viking Lander 1 site [15] as well as the diurnal temperature cycle at the Mars Pathfinder site [16]. Thanks to the terrestrial heritage the schemes for water vapour transport are in place also in the 2-D model, but have been disregarded in most of the Mars related work so far.

The simulations: The regolith – water ice edge is described using albedo a and thermal inertia I differences. According to [4] the water ice thermal inertia is in the range of 600…1200 SI units and $a = 0.4…0.5$, whereas the corresponding typical values for ice-free regolith are $I \approx 300$ SI units and $a = 0.25$. For CO_2 ice we have used $a = 0.7$; due to the thermodynamic equilibrium between the solid surface CO_2 and the atmospheric CO_2, the CO_2 ice temperature is determined by the atmospheric surface pressure and is diurnally approximately constant.

We have investigated two different major scenarios of horizontal ice coverage: 1) an ice-free regolith bordering water ice, which in turn borders the CO_2 covered interior, and 2) regolith/water ice edge in the same location but no CO_2 ice in the cap interior. Comparison between the two scenarios provides insight into the significance of the water vapour recondensation onto the CO_2 cold trap. The effect of the CO_2 sublimation flow from the cap interior has also been investigated by use of a temporally constant inflow lateral boundary condition.

Although the permanent cap does slope upwards towards the interior [17], we have for the sake of simpler interpretation of the results omitted any topographical slope effects. Experience from Antarctic and from simulations of fully CO_2 ice-covered slopes [12] point to strong, predominantly downslope and diurnally fairly constant near-surface flows, which may during the seasonal cap retreat enhance the effect of the sublimation flow. Since the 2-D MMCM does permit inclusion of the slope, we expect to investigate the slope effect in the future.

References:

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