

CRISM LIMB OBSERVATIONS OF MARS MESOSPHERIC ICE CLOUDS: TWO NEW RESULTS

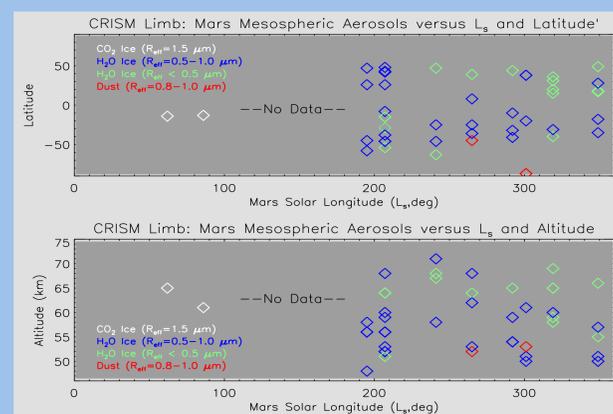
R. T. Clancy¹, M. D. Smith², M. J. Wolff¹, S. L. Murchie³, H. Nair³, A. D. Toigo³, K. D. Seelos³, and B. A. Cantor⁴, ¹Space Science Institute (clancy@spacescience.org), ²NASA/GSFC, ³JHU/APL, ⁴MSSS.

1) Mesospheric Water Ice Clouds: Particles Sizes and Distributions

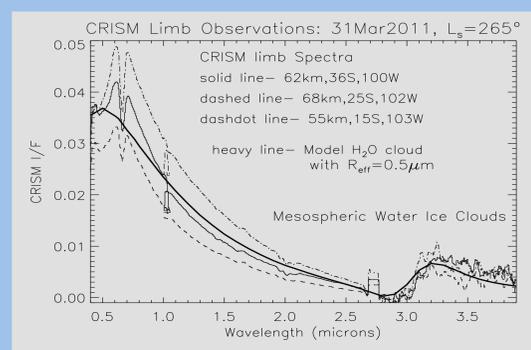
Mesospheric aerosols have been identified as most prominent outside of the aphelion season, associated with global perihelion dust storms [1,2,3], perihelion cloud trails [4], and widespread detached hazes [1,5,2,6,7,8]. The detached hazes are most prominent at mid-S (rising Hadley branch) and mid-N (polar hood) latitudes over $L_s=150-340^\circ$. Composition and particle size definitions for mesospheric aerosols [2,3,4,6,7,8,9,10,11,12,13] remain limited by restricted spectral coverage/specificity, particularly in vis/nearIR.

CRISM spectral ($\lambda=0.4-4 \mu\text{m}$) limb scans have been obtained over $L_s=190-360^\circ$ and 2009-2013. They indicate consistency with the L_s /global distribution of detached limb hazes returned by extensive, contemporaneous MCS limb scans in solar and $12 \mu\text{m}$ band photometry [8]. The CRISM spectra clearly identify these limb hazes as fine water ice particles with a range of R_{eff} from $0.8 \mu\text{m}$ to $< 0.3 \mu\text{m}$, the smaller particle sizes predominant at altitudes above 60 km. Mesospheric dust aerosols are uncommon for the non-global dust storm conditions observed by CRISM limb scans.

One set of CRISM limb scans coincides with MARCI imaging of an outbreak of perihelion cloud trails (PCT). PCT are local ($\sim 100\text{km}$), early afternoon, sub-solar plumes of fine (R_{eff} of $1 \mu\text{m}$ to $< 0.3 \mu\text{m}$) water ice clouds ($\tau=0.05-0.3$) at 40-55km that become entrained in westward mesospheric zonal winds [4]. The CRISM limb spectra indicate that similarly fine water ice hazes are present above the PCT at 55-65km. These correspondences reflect general conditions of water vapor saturation and water ice microphysics in the southern summer mesosphere.



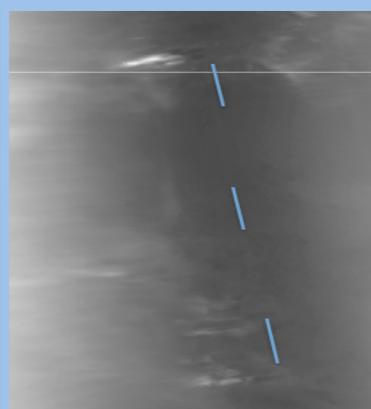
The lat/ L_s (upper) and alt/ L_s (lower) distributions of dust (red), H_2O ice (blue/green) and CO_2 ice (white) mesospheric aerosols as discriminated in CRISM limb vis/nearIR spectral scans.



CRISM vis/nearIR limb spectra of fine (model for $R_{\text{eff}}=0.5 \mu\text{m}$) water ice hazes at 55-65km, $L_s=265^\circ$, and 10-40S. A 10-40S set of corresponding PCT were observed at 40-50km altitudes (below), $\sim 200 \text{ km}$ to the west (earlier LT) of CRISM limb scans.



MARCI images of perihelion cloud trails (left, right) reflect 40-55km plumes of fine H_2O ice clouds associated with peak heating (perihelion, sub-solar, early afternoon). Mar2011 ($L_s=265^\circ$) MARCI PCT observations (right) and CRISM limb spectra (blue lines, upper right spectra) indicate the 40-70 km extent of water ice clouds at this time.

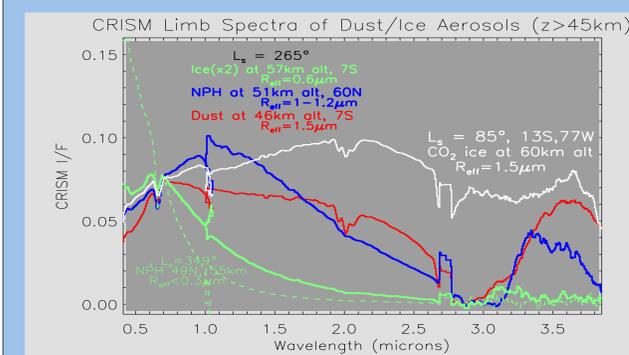


2) Observations of Mesospheric CO_2 clouds in CRISM Limb Spectra

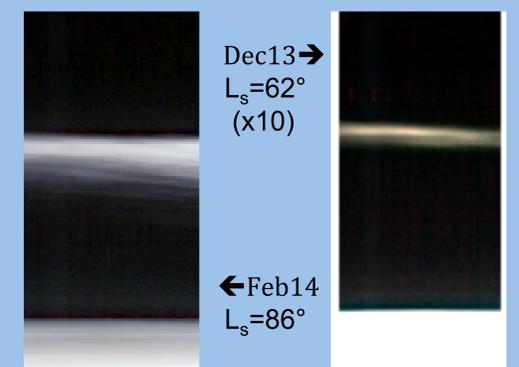
Low latitude mesospheric CO_2 clouds around the aphelion season have been measured in a wide variety of techniques [9,10,11,12,6,13] to characterize their spatial (lat=20S-20N; long=60-120W,30E-30W; alt=55-75km; horizontal scales $< 200\text{km}$) and temporal ($L_s=0-80^\circ, 100-140^\circ$; AM and PM) extents and physical properties (CO_2 , $R_{\text{eff}} \sim 1-4 \mu\text{m}$). Such clouds correspond to very cold mesospheric temperatures associated with seasonal and spatial forcing (orbital, non-migrating tides, gravity waves [14]).

Two recent CRISM limb observations present mesospheric CO_2 clouds (MY32: 13Dec13, $L_s=62^\circ$; 5Feb14, $L_s=86^\circ$). In both cases, the limb tangent was centered near 63km, 14S, 76W (this longitude has only recently been sampled by CRISM limb viewing). The Dec13 cloud brightness was 10x lower than observed for the Feb14 cloud (ave I/F of 0.01 vs 0.1), which was also observed as projected at a 19S limb view at 50km.

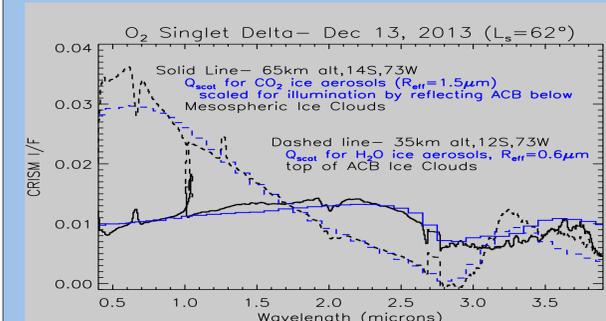
These CRISM limb measurements provide the first limb image of a mesospheric CO_2 cloud and the most direct identification of its visible and near IR ($0.4-4 \mu\text{m}$) reflectance spectrum. Limb RT spectral modeling indicates that these clouds contain $< 10\%$ H_2O ice, and present particle sizes with R_{eff} of $1.5 \pm 0.2 \mu\text{m}$. Despite the 10x difference in observed cloud brightnesses (which may reflect different cloud latitudinal extent as well as optical depth), they exhibit very similar particle sizes.



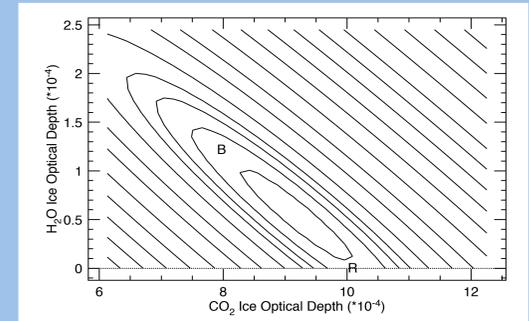
CRISM limb spectra of distinct mesospheric aerosols observed at $L_s=265, 349^\circ$. Compositional and particle size discriminations are well constrained by vis/nearIR scattering signatures.



Two CRISM color (RGB) limb images of mesospheric (60-65km) CO_2 clouds above aphelion H_2O ice clouds. Weaker Dec13 cloud stretched, both present $R_{\text{eff}}=1.5 \mu\text{m}$.



Comparison of observed (black) and model (blue) vis/nearIR spectra for fine ($R_{\text{eff}} \sim 0.6 \mu\text{m}$) H_2O (dashed) underlying larger ($R_{\text{eff}} \sim 1.5 \mu\text{m}$) CO_2 ice aerosols at 13S, 73W ($L_s=62^\circ$, early aphelion).



Limb RT multiple scattering retrievals [15], including lower atm H_2O clouds, indicate Dec13 mesospheric CO_2 clouds contain less than 10% H_2O component.