MLS-related Scientific Publication

Scientific Theme: Atmospheric Chemistry

A Lagrangian approach to studying Arctic polar stratospheric clouds using UARS MLS HNO_3 and POAM II aerosol extinction measurements, M. L. Santee, A. Tabazadeh, G. L. Manney, M. D. Fromm, R. M. Bevilacqua, J. W. Waters, and E. J. Jensen, *J. Geophys. Res.*, **107**, 10.1029/2000JD000227, May 2002.

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Summary

This paper assesses the viability of diagnosing polar stratospheric cloud (PSC) composition and denitrification using existing satellite measurements. A Lagrangian approach is used to track PSC evolution from formation through dissipation. Upper Atmosphere Research Satellite (UARS) Microwave Limb Sounder (MLS) observations of gas-phase HNO_3 and Polar Ozone and Aerosol Measurement (POAM) II observations of aerosol extinction from the Arctic late winter of 1995/1996 are correlated and compared to results from PSC composition models along air parcel trajectories. This approach is successful in capturing the broad patterns of PSC development. That is, a strong correlation is found between low-temperature, low-HNO_3, and high-extinction points. In most cases the observed behavior along the Lagrangian paths falls within the range predicted by equilibrium liquid ternary aerosol (LTA) and nitric acid trihydrate (NAT) composition models. Extracting detailed quantitative information about the composition of individual PSCs by combining these satellite HNO_3 and aerosol data sets is very difficult, however. In general there is a large degree of overlap in the comparisons between the models and the data. Although some examples are consistent with specific PSC formation mechanisms, no single set of model assumptions allows a majority of the cases to be explained. Large uncertainties in both measurements (including the meteorological analyses) and model calculations, together with other factors such as lack of colocated HNO_3, aerosol extinction, H_2O, and temperature measurements and low horizontal and (for MLS) vertical resolution of the data, preclude conclusive determination of PSC composition in most cases. The occurrence of denitrification is also investigated. In the majority of PSC events studied, gas-phase HNO_3 fully recovers to pre-PSC abundances following cloud evaporation. We conclude that, while severe denitrification (50% or greater) may have occurred in highly localized regions in the Arctic in 1996, it did not occur over spatial scales comparable to or larger than the MLS field of view (∼400 km×200 km×6 km), even though it was a relatively cold winter. Improved measurements from upcoming satellite missions, such as Earth Observing System Aura, will ameliorate many of the difficulties in diagnosing PSC composition and denitrification encountered in this study.

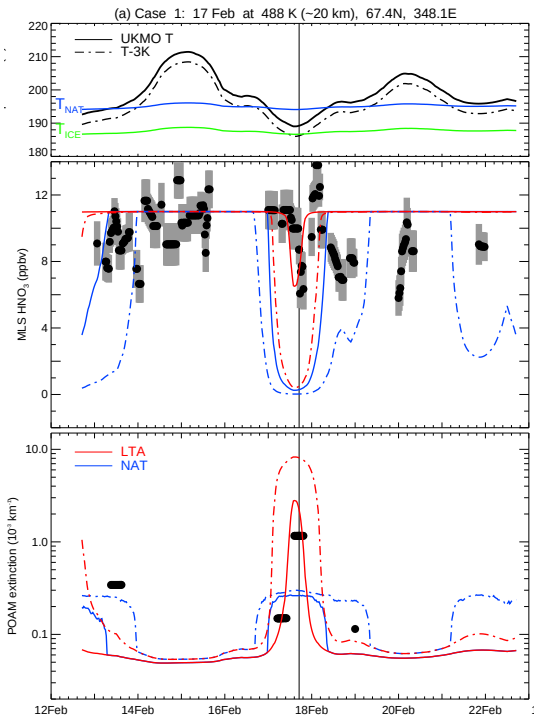

Figure 3. Measurements and model results along the trajectories. The date, location, potential temperature, and corresponding approximate altitude at which both the backward and forward trajectories are initialized are specified. The thin vertical line bisecting the plots indicates the time of the initialization point. The top panel shows the temperature evolution, with the solid black line representing the temperatures from the UKMO analyses and the dash-dot black line representing values 3 K lower than the reported ones at each timestep. Also shown are the NAT (blue line) and water ice (green line) formation thresholds. The other two panels compare measured and modelled gas-phase HNO_3 (middle) and aerosol extinction (bottom). Standard model runs (solid lines) are based on the reported UKMO temperatures; tests are also run with the temperature reduced by 3 K everywhere along the trajectory (dash-dot lines). Results from equilibrium LTA (red lines) and NAT (blue lines) composition models are shown. A gridding procedure is applied to obtain estimates of MLS HNO_3 (middle panel) and POAM aerosol extinction (bottom panel) at each timestep (black dots, with the estimated error bars shaded in grey). In this example, both the MLS and the POAM data are in good agreement with the LTA model, indicating the presence of liquid clouds.