ORAL PRESENTATION

O-10. Anatoli Bogdan: Large moisture in the upper troposphere: a mystery or a lack of understanding of cirrus microphysics

Anatoli Bogdan

Division of Atmospheric Sciences, Department of Physical Sciences, University of Helsinki, P.O. Box FI-00014, Helsinki, Finland
(abogdan @ mappi.helsinki.fi)

Greenhouse effect is sensitive to the changes in the upper tropospheric (UT) moisture because water vapour is the dominant greenhouse gas and plays an essential role in radiative feedback mechanisms and cirrus cloud formation. In the UT, moisture is often expressed as relative humidity with respect to ice, RH_i, because liquid water does not exist below homogeneous freezing temperature, Th ≈ 233 K. Cold cirrus clouds (< 210 K) are believed to limit the accumulation of water in the UT because the growth and sedimentation of ice crystals redistribute moisture to lower levels. However, large RH_i is often observed in the upper troposphere where cirrus clouds are formed in situ i.e., not influenced by a deep convective water vapour source (*Jensen et al., 2008*). The large RH_i up to 230-250% are often observed both inside and outside cirrus (*Jensen et al., 2008*).

The existence of large clear-sky RH_i is not surprising, considering that cirrus form by homogeneous freezing of concentrated aqueous droplets. Using temperatures of homogeneous freezing of H_2SO4/H_2O, $(NH4)2SO4/H_2O$, and $(NH4)HSO_4/H_2O$ droplets, M. Molina with co-workers (*Koop,et al., 1998; Bertram et al., 2000*) reported that before cirrus start developing the clear-sky RH_i could reach ~170 %. More intriguing is how the large in-cloud RH_i can exist after the formation of ice crystals. Models of cirrus, which consider that cloud particles are pure ice only, do not permit in-cloud RH_i >100% because moisture is rapidly depleted by fast deposition of H_2O on the ice crystals. Several attempts, which were undertaken to explain large in-cloud RHi, included microphysical conceptions.

(i) Organic film on the surface of aqueous droplets could hinder the uptake of water vapour or/and suppress surface ice nucleation (*Jensen et al., 2008*). (ii) Small ice crystals may possess the deposition coefficient of H_2O molecules < 0.01. (iii) A new class of HNO_3-containing ice particles, so called Δ-ice, could be a reason of large in-cloud RH_i. By different reasons, these suggestions do not satisfactorily explain the large in-cloud RH_i. Our laboratory measurements show that other microphysical processes can be responsible for the build up and maintenance of the large RH_i. These involve the effects of ions on homogeneous ice crystal nucleation and growth in cold cirrus formed by freezing aqueous droplets.

References:

Jensen, E. J. et al. *Atmos. Chem. Phys*. 8, 1621 (2008).
Koop, T., Ng, H.P., Molina, L.T., Molina, M.J. *J. Phys. Chem*. A 102, 8924 (1998).
Bertram, A. K. et al., *J. Phys. Chem*.A 104, 588 (2000).