Geophysical Research Abstracts
Vol. 17, EGU2015-10073-1, 2015
EGU General Assembly 2015

Effect of gravity wave temperature variations on homogeneous ice nucleation

Tra Dinh (1), Aurélien Podglajen (2), Albert Hertzog (2), Bernard Legras (3), and Riwal Plougonven (2)

(1) Program in Atmospheric and Oceanic Sciences, Princeton University, USA, (2) Ecole Polytechnique, Laboratoire de météorologie dynamique, Palaiseau, France (apodgla@lmd.ens.fr), (3) Ecole Normale Supérieure, Laboratoire de météorologie dynamique, Paris, France

Observations of cirrus clouds in the tropical tropopause layer (TTL) have shown various ice number concentrations (INC) (e.g., Jensen et al. 2013), which has lead to a puzzle regarding their formation. In particular, the frequently observed low numbers of ice crystals seemed hard to reconcile with homogeneous nucleation knowing the ubuquity of gravity waves with vertical velocity of the order of 0.1 m/s. Using artificial time series, Spichtinger and Krämer (2013) have illustrated that the variation of vertical velocity during a nucleation event could terminate it and limit the INC. However, their study was limited to constructed temperature time series.

Here, we carry out numerical simulations of homogeneous ice nucleation forced by temperature time series data collected by isopycnic balloon flights near the tropical tropopause. The balloons collected data at high frequency (30 s), so gravity wave signals are well resolved in the temperature time series. With the observed temperature time series, the numerical simulations with homogeneous freezing show a full range of ice number concentrations (INC) as previously observed in the tropical upper troposphere.

The simulations confirm that the dynamical time scale of temperature variations (as seen from observations) can be shorter than the nucleation time scale. They show the existence of two regimes for homogeneous ice nucleation : one limited by the depletion of water vapor by the nucleated ice crystals (those we name vapor events) and one limited by the reincrease of temperature after its initial decrease (temperature events). Low INC may thus be obtained for temperature events when the gravity wave perturbations produce a non-persistent cooling rate (even with large magnitude) such that the absolute change in temperature remains small during nucleation. This result for temperature events is explained analytically by a dependence of the INC on the absolute drop in temperature (and not on the cooling rate). This work supports the hypothesis that even acting alone homogeneous ice nucleation is not necessarily inconsistent with observations of low INC.

Spichtinger, P. and Krämer, M.: Tropical tropopause ice clouds: a dynamic approach to the mystery of low crystal numbers, Atmos. Chem. Phys., 13, 9801–9818, doi:10.5194/acp-13-9801-2013, 2013.

Jensen, E. J., Diskin, G., Lawson, R. P., Lance, S., Bui, T. P., Hlavka, D., McGill, M., Pfister, L., Toon, O. B., and Gao, R.: Ice nucleation and dehydration in the Tropical Tropopause Layer, Proc. Nat. Acad. Sci., 110, 2041–2046, doi:10.1073/pnas.1217104110, 2013.