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A Cirrus Cloud Case Study in Frontal Systems over Norway, observations and model calculations

S. Schlicht (1), P. Spichtinger (2), H. Vössing (3), R. Weigel (4)
C. Schiller (1), P. Konopka (1) and M. Krämer (1)

(1) ICG-I,FZ Jülich, Jülich, Germany (s.schlicht@fz-juelich.de)
(2) Institute for Atmospheric and Climate Science, ETH Zurich, 8092 Zurich, Switzerland
(3) IPA,University Mainz,Mainz, Germany
(4) Particle Chemistry,MPI Mainz, Mainz, Germany

During the aircraft campaign CIRRUS 2004 (Hohn, Northern Germany, November 2004), cirrus clouds in frontal systems over Norway were observed by means of the Lyman-α-hygrometer FISH (Fast Insitu Stratospheric Hygrometer), the water vapor tunable diode laser OJSTER (Open-path Jülich Stratospheric Tdl ExpeRiment) and an FSSP (Forward Scattering SPectrometer) mounted on board of a GFD-Learjet. Here, we present a case study of a cirrus embedded in a warm conveyor belt, detected during a flight on 24th of November 2004. Out of character of ice clouds formed on a synoptic scale, the ice particle concentrations inside the observed cloud reached high values up to 100cm^{-3}. However, backward trajectory calculations based on CLaMS and ECMWF-Data yield typical low synoptic vertical velocities of 1 to $3cm/s$.

To exclude the ice nucleation mechanism as the reason for the high concentration of ice particles, we performed several model simulations using the EULAG model with the recently developed ice microphysics scheme, including homogeneous and heterogeneous ice nucleation. We found that the effect of synoptic cooling indeed could not have produced such large ice particle concentrations, independent of the type of ice nucleation.

Having a closer look to satellite (infrared) pictures, clouds near Scotland (UK) and bands of clouds behind the Norwegian cost could often be found. This gave us a hint at orographic waves causing the formation of the observed cirrus cloud.

To simulate cirrus development due to orographic waves, we included mountains and performed some detailed simulations with stratified flow over the mountains. Whith this model setup the observed high crystal number concentrations could be reached in simulations.

As a matter of fact we needed not only one method to solve the problem of this special case of cirrus cloud formation. But using in situ measurements, satellite observations, trajectory calculations, and cloud resolving model simulations together the cirrus cloud formation and evolution in this special case could be explained.