Cirrus clouds triggered by radiative cooling and small eddies - a multiscale problem

Fabian Fusina

ETH Zurich
Institute for Atmospheric and Climate Science
CHN P 14, Universitaetsstr. 16
8092 Zurich, Switzerland

In this study, the influence of radiative cooling and small eddies on cirrus formation is investigated. For this propose the nonhydrostatic, anelastic model EULAG is used with a recently developed and validated ice microphysic scheme (Spichtinger and Gierens, 2008). Additionally, we implemented a fast radiation transfer code (Fu, 1998).

Using idealized profiles with high supersaturations up to 144% and weak stable stratifications with vertical gradients of the potential temperature down to 0.4 K/km within a layer of about 1km thickness in a height of approx. 10 km, the influence of radiation on the formation of cirrus clouds is remarkable. Due to the radiative cooling at the top of the ISSR with cooling rates down to 2 K/d and heating rates at the bottom of the ISSR up to 0.2 K/d, the stability of the ISSR stratification decreases with time. At a critical point, Gaussian temperature fluctuations turn the layer to an unstable regime and convection starts. The effects of increasing the local relative humidity by cooling due to radiation, convective lifting and small eddies lead to the formation of a cirrus cloud with IWC up to 20mg/m3 and optical depths up to 0.7. In all simulations, only homogeneous nucleation is considered. Our simulations could show that, if one of the two effects (either the radiation or the Gaussian temperature fluctuations) is disabled, no nucleation occurs within the simulation time of 6 h. Only the interaction of a small scale (fluctuations) and a large scale (radiation) effect leads to the formation of a cirrus in these particular cases, i.e. the cirrus only can be formed by a superposition of processes on different scales.

The main goal of this study is to obtain deeper insights in the different environmental conditions (temperature, relative humidity, stratification, strength of temperature fluctuations, insolation), which allow the formation of this type of cirrus clouds. Additionally the radiative properties of theses clouds are investigated.