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A re-analysis of airborne measurements in the upper level of a cumulonimbus during CRYSTAL-FACE by means of a high resolved 3D cloud model with detailed (bin) microphysics

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A 3D cloud model with detailed microphysics for ice, water and aerosol particles is used to simulate aircraft observations of microphysics and dynamics in order to understand the origin of the air masses, the evolution of hydrometeors and aerosol particles that were sampled at an altitude of 10 km. The simulated deep convective cloud for the case of 18 July 2002 develops a large anvil between 10 and 14 km. This case is of interest as numerous measurements of the liquid and ice phase, temperature and vertical winds are available (Heymsfield et al., 2005). The updraft core of the thunderstorm can be divided into two regions with very different characteristics: the first one with strong vertical velocities is entirely glaciated but surprisingly has a rather high temperature as compared to the environment. The second part of the updraft contains liquid water but the vertical winds are moderate and the temperature is colder than the glaciated portion of the core.

The model couples the dynamics of the NCAR *Clark-Hall cloud scale model* (Clark et al., 1996) with the detailed scavenging model (*DESCAM*) of Flossmann and Pruppacher (1988) and the ice phase module of Leroy et al. (2007). The microphysics follows the evolution of aerosol particle, drop, and ice crystal spectra each with 39 bins. Aerosol mass in drops and ice crystals is predicted by two distribution functions each with 39 bins in order to close the aerosol budget. Using a 3D grid resolution of 250 m this model, called *DESCAM-3D*, is able to simulate a Cb with anvil in very good agreement with the observed anomalies of temperature and vertical wind at 10 km and with the microphysical observations. The detailed analysis of the simulation

shows that the probed updraft core seems to be in fact a mixture of several ascending areas existing at different altitudes and with different microphysical and dynamical histories. The modeled ice crystals are continuous spectra from 30 μm up to 4 mm in agreement with the shape and the number of the 2DC observations.

Concerning the role of aerosol particles on the cloud evolution and structure our findings significantly differ from those of Fridlind et al. (2004) who investigated the same case of CRYSTAL-FACE. They estimate that aerosols between 6 and 10 km account for about two-third of the anvil nuclei. The same work with *DESCAM-3D* leads to quite different conclusions. The reasons will be discussed, as well as the dependency of the nucleation of drops on the presence of ice crystals and other questions which were raised in Heymsfield et al. (2005).