Study of the Impact of the Natural Production, in the Mediterranean Sea, of Coastal Marine Aerosols on the Dynamics and Microphysical Behavior of a Convective Cloud

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The coastal marine area represents a specific zone for cloud formation. Aerosols caught in updrafts in these areas may have a mixed origin: sea spray aerosols punctually generated at the sea surface are added to a continental contribution issued from natural and/or anthropogenic sources.

The aerosol mixture in coastal zones is strongly related to the changes in the wind direction that could be in turn accompanied by variations in meteorological parameters.

To study the impact of marine aerosols, especially those generated in coastal areas, on the dynamics and microphysical behavior of the clouds, two numerical models were coupled. The first, calculates the coastal marine aerosol spectrum that could be generated under a given weather condition at the sea surface. The predicted spectrum is then introduced, as initial aerosol spectra, to a cloud model with a detailed microphysics.

Design of Numerical Experiments

The cloud model ExMix (External Mixture) has been developed to study mixed-phase clouds by integrating a detailed microphysics of the whole process of formation, growth and precipitation (Monier et al, 2006). EXMIX is dedicated to the different mechanisms behind the cloud formation and decay. The microphysics processes governing the growth of the water droplets inside the cloud depend on both the initial size spectrum and the chemical composition of aerosols caught in the updrafts feeding the cloud.

To include coastal effects in the aerosol model for the prediction of aerosol concentrations, Piazzola et al, (2003) proposed the coastal Mediterranean aerosol model (MEDEX) based on an extensive series of measurements on the island of Porquerolles (off the French Mediterranean coast, located at about 5 km from the coastline). The main inputs of the coastal Mediterranean aerosol model are both the wind speed and the fetch. The Mediterranean coastal aerosol model is a modification of the Navy Aerosol Model (NAM) developed by Gathman (1983) and it is formulated analogously to the model Medex on the basis of an aerosol data set acquired on the island Inisheer.

The simulations performed have focused on a convective cloud (mixed phase) using three distinct initial aerosols spectra of different origins: the first concern an unpolluted continental aerosol spectrum observed in Puy de Dome-France. The second one is for marine aerosol spectra developed by Jaenicke (1988) and the last one is produced by the MEDEX model.

Results:

The transition from a continental aerosol spectrum to a marine aerosol spectrum is synonymous to the introduction of aerosol particles of large size. The impact of such change in the initial spectrum of aerosol is much felt in terms of dynamic and microphysical responses of the cloud. The results obtained show that in presence of marine aerosols, some microphysical properties of the cloud evolution as well as the conditions for triggering rainfall are affected, and hence, the collected quantities on the ground. In particular, results indicate that precipitations are formed earlier, at lower altitudes and induce a larger rain accumulation at the surface. Moreover, simulations also showed pronounced changes when taking into account the natural production of coastal marine aerosols with more pronounced changes inducing greater amounts of water contents within the cloud, and hence, more important rain accumulation on the ground (Figure 1).

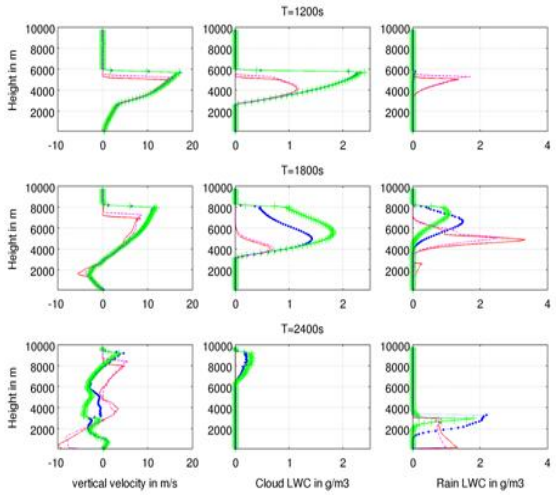

Figure 1. Comparison of vertical profiles obtained using the different aerosol spectrum.

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