Report of the Working Group Discussion on "Development of Microphysics for the fine scale"

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The classical species in a complete scheme of micro-physics and precipitations are: Water vapour, cloud ice crystals, cloud droplets, rain, snow, graupel and hail. A long discussion took place about the degree of sophistication that a micro-physical scheme should have for high resolution NWP models. The discussion concentrates primarily on hail and graupel.

As hail can only form in cumulo-nimbus, the working group considered that it does not belong to the classical micro-physics as it is used today, that is for the grid-scale (or stratiform) precipitations only. This simple fact already shows how more meaningful it would be to have an integrated precipitation scheme combining stratiform and convective precipitations, along the line presented by Luc Gérard during the Workshop.

Concerning the graupel, the discussion revealed two aspects: on one side it has been claimed that graupel is much more abundant in clouds than non-specialists generally believe. Consequently, it should be explicitly represented. On the other side, graupel is connected to snow as it is produced by accretion (the freezing of super-cooled water droplets on ice crystals). The discussion led nevertheless to the conclusion that, because of the steadily increasing complexity of our models (we want to mirror the atmosphere as precisely as we can), graupel should today be part of a micro-physical scheme of a very high resolution NWP model.

An important point was the discussion on super-cooled cloud droplets because these latter not only play a very important role in cloud micro-physics, but also because of their importance in aviation: they are the cause of air-plane icing. It has been confirmed by Paul Schultz that - after definition of thresholds - forecast maps showing the amount of cloud water where the temperature is below zero degree can be of great importance for the aviation. It is by temperatures of -2/-3 degrees that icing is the most dangerous, when glazed, transparent ice forms. At -6/-7 degrees, rimed, opaque ice forms, which is less dangerous as it remains on the edges of the wings and does not spread on the wings as the glazed ice.

Considering that many coefficients used today in the micro-physical schemes are very empirical, the question of whether our cloud physics is realistic has been asked. Paul Schultz and Jean-Pierre Pinty answered that large improvements coming on one side from the measurements made by research airplanes and on the other side from laboratory experiments with cloud chambers - they are still in use! - have been made during the last 15 years.

Micro-physics versus Dynamics

- It has been accepted that the micro-physics (without sedimentation) of our models can accept large time-steps, time-steps of several minutes without damage. But we have to be careful that mixing-rates do not become negative (particularly true for Eulerian schemes).
- Micro-physics and Semi-lagrangian advection: The answer to that question is that - as long as sedimentation is not considered - there is no specific problem with the semi-lagrangian advection: the micro-physics can be treated at the arrival points as in an Eulerian scheme.

Advected precipitations

- The experience made by COSMO - where precipitations are advected operationally - is that it is computationally expensive, at least in an Eulerian frame (see below). Paul Schultz has communicated the fall speeds that we should use: for drizzle: 3-4 m/s; for rain: 5-6 m/s. These values have been measured by wind profilers in the United States.

Advected precipitations and Semi-lagrangian advection

Little has been done in this field until today. There anyway exists a radical solution: the precipitations can be advected in the vertical (the fall of the precipitations) in an Eulerian way, with an implicit scheme in order to keep reasonable time steps in view of the thinness of the model layers in the boundary layer). But, as it has rightly been remarked, this solution would very expensive.

Fractional cloudiness

Due to lack of time, only one point has been discussed:

Do very high resolution models still need a parameterization of the fractional cloudiness?

The answer of the working group is a clear yes. Even with a grid point distance of one km, we need a parameterization of the partial cloudiness. Example: the small cumuli capping the boundary layer in summer by fair weather. But the parameterization can no longer be only a function of height and relative humidity as it is often the case in today's operational models: moist eddy diffusivity has also to be considered, maybe integrated in a shallow convection scheme.