AROME-ALADIN special workshop

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1 - Recent Progress in the ALADIN Non-Hydrostatic Dynamics

The development of the first version of the non-hydrostatic dynamics in ALADIN dates back to 1993. At that time most of the non-hydrostatic models were cast in height-type vertical coordinates and were used for research purposes. Contrary to this, in Numerical Weather Prediction (NWP) models, pressure-type coordinates are widely used thanks to their practical advantages. Therefore it was very attractive to base ALADIN's non-hydrostatic dynamical core on the newly proposed idea of employing a hydrostatic pressure coordinate (called also Laprise coordinate or mass coordinate) for developing the set of the fully elastic Euler equations.

It should be mentioned, that this strategy in ALADIN was at that time quite unique, since the development was based on the traditionally proven NWP choices: spectral, semi-implicit, semi-Lagrangian methods for seeking of the best trade-off of between efficiency and quality. Yet it was not sure whether the extension to a more complex equation set would hold.

The first prototype of ALADIN NH was ready in 1995 with the Eulerian advection scheme and temporal semi-implicit filter. At that time the first PhD network financing in ALADIN was over and further development mostly relied on the embassy supports. In 1996 the most important development was the extension to the semi-Lagrangian advection scheme. About at that time the team became aware about limitations in the robustness of the scheme, for example the two-time-level semi-Lagrangian scheme was violently unstable. It was clear that the iterated schemes must be worked out but that was not quite possible to manage within short visits to Toulouse. The decisive revival came thanks to the EU ALATNET financing when two scientific positions were opened in Prague, which enabled to efficiently team up all further colleagues (experienced and newcomers) working on the non-hydrostatic dynamics, still with the necessary implication of GMAP.

The progress between the fall of 2000 till the end of 2002 was then spectacular. The iterated time scheme was worked out, known also as the predictor-corrector scheme. To reach the robustness, the predictor step, which is the classical semi-implicit step, has to provide the best pre-conditioning for further convergence. Thanks to the numerical analysis tool, it was possible to verify the clever choice of prognostic variables enhancing the stability of the predictor. The different conditions for successful numerical control applying to the gravity waves and to the acoustic waves were understood. The general results, valid not only for the hydrostatic pressure coordinate but for the height coordinate, are going to be published. Besides, a lot of work was done on the revision of the spatial discretisation, namely on the correct treatment of the bottom and top boundary conditions, on the pressure gradient term, and so on. Here a substantial improvement was reached in the quality of the semi-Lagrangian scheme simulations.

As a result, ALADIN NH provides both high-quality and cost-effective results, as it was proved by the academic simulations of trapped lee waves. The robustness is quite excellent; for illustration, the time-step for the PYREX case experiments at 2,5 km horizontal resolution may be pushed up to 200s without blowing the model, hence the dynamics does not put any severe cost-constraint to the model. This was verified also regarding the Lipschitz stability criteria in an ALPIA-type study.