Coupling of physics to the dynamics in ALADIN

Martina Tudor

Croatian Meteorological and Hydrological Service

Abstract

Physics at different positions on SL trajectory

The physics tendency with the current set-up is computed using state of the atmosphere at the beginning of the time-step $t^i$. Output from the physics package gives the increment of the model state due to parametrized processes $\Delta \rho_p X$. The new option is to couple the computed physics tendency in the origin point of the trajectory, final point or somewhere in between $O$ and $F$ is coded in such a way that now the physics tendency is used like this:

$$\Delta P^i_M = (1 - RSLPHY) \Delta P^i_O + RSLPHY \Delta P^i_F$$  (1)

Physics tendencies extrapolation

Using similar steps as were used for the LSETTLLS scheme, we may approximate the physics tendency in the middle point on trajectory (in space and time) as:

$$\Delta P^i_M = \frac{1}{2} \left[ 2 \Delta P^i_O - \Delta P^i_O - \Delta P^i_F \right]$$  (2)

Experiments

ALARO0 version of physics package was used and run on the domain with 9km horizontal resolution, linear grid and 43 levels in the vertical (low resolution allows longer time-steps). The time-step dependence of different schemes was tested in a way that there were two forecasts run for each scheme: one with an operational time-step of 360 seconds and another with 30 seconds time-step. Since the time needed for integration with the short time step is very long, only forecasts up to 21 hours were used. The accuracy of each scheme was measured with the deviation of the long time-step forecast from the short time-step forecast using:

$$dev = \sqrt{\left(F^j - F_M\right)^2}$$  (3)

the root of the areal average of the square of the forecast difference as a measure of the differences in forecasts produced using different time-steps. It is assumed that the better scheme has smaller difference between forecasts computed with different time steps.

Description of experiments

exp1: the reference using physics tendency interpolated to the origin point $O$.
exp2: half of the physics tendency $P^i$ is interpolated to the origin point and half used at the arrival point (equivalent of coupling physics tendency to dynamics in $M_1$ on Figure 1).
exp3: the whole physics tendency is used in the final point (equivalent of coupling physics tendency to dynamics in $F_2$ on Figure 1).
exp4: as exp1 but with using updated winds in trajectory research in place of stable extrapolation (No SETTLLS).
exp5: as exp2 but with using updated winds in trajectory research in place of stable extrapolation (No SETTLLS).
exp6: as exp3 but with using updated winds in trajectory research in place of stable extrapolation (No SETTLLS).
exp11 as exp1 but the wind field used for trajectory research is upgraded with the physics tendency.
exp12 as exp2 but the wind field used for trajectory research is upgraded with the physics tendency.

Experiments exp5 and exp6 were unstable with 360 seconds time step and are not shown in the figures below. Experiments exp11 and exp12 have values so close to their corresponding references (exp1 and exp2) that the lines are sometimes impossible to distinguish.

Averaging the physics tendency between origin and final points (equivalent of coupling physics tendency to dynamics in $M_2$ on Figure 1.)

Conclusions

Since physics of the ALARO package of the ALADIN System is called before the dynamics, averaging of the tendency along trajectory in both space and time is difficult to achieve. At this stage, it may be seen that averaging the physics contribution along the trajectory, even if done only in space and not in time, can bring potential benefits, especially for the wind field higher in the atmosphere. The problems of the temperature and moisture in the lowest model level, and it also decreases for pressure between 3 and 15 hour forecasts on all model levels. This indicates possible problem that occurs during the first steps of the model forecast. Looking at the pressure, we can see that the error grows only during the first 3 hours, and afterwards changes only slightly. Also, although the results for pressure show deterioration, geopotential shows improvement, except on the top of the atmosphere.

Including the tendency in the wind field used for trajectory research (exp11) did not bring significant change when compared to the reference (exp1), except a slight improvement later during the forecast for several variables. Perhaps full benefit of this scheme may be noticed only for much longer model run.