Research and developments by the Belgian team July – December 2004

KMI-IRM, University of Gent

1. Stability and accuracy of the physics-dynamics interface

(Piet Termonia)

The aim of this is the generalization of the work in a paper by Staniforth et al. (2002). As shown during my lectures in the TCWGPDI in Prague, extending this to include algorithmic issues imposed by the time-step organization rapidly leads to algebraic complications that are too tedious to be treated analytically. I proposed a way out of this by determining the stability of the scheme by means of a numerical maximization of the amplification factor. In the near future this method will be applied to perform a comparative study between the time-step organization of ARPEGE/ ALADIN (physics before dynamics, parallel physics) vs the ECMWF model (physics after dynamics, sequential physics).

2. Monitoring the coupling-update frequency

(Piet Termonia)

1. I have implemented the findings of my paper *Mon. Wea. Rev.*, **132**, 2130-2141, in cycle 28T2. This allows to operationally compute a warning index for information loss of the coupling data due to a too long coupling update interval.

2. I have started writing a paper presenting a method to objectively determine the coupling-update interval, with the aim to tune coupling strategies in case of detected information loss.

3. 2 m temperature forecasts

(Piet Termonia)

I also carried out some research on a proposed model output statistics to improve some bad 2 m temperature forecasts of the Belgian operational ALADIN runs during winter. Since the largest errors occur during stable conditions, I propose a correction of the 2 m temperature based on a time integration of the tendency computed by using the exchange coefficient for the temperature. The result can be physically interpreted as a temperature difference and is thus well suited to be compared with temperature errors. A quasi-linear relation can be identified between them. Tests during last winter showed that, by exhibiting this linearity, the RMSE for the 24 h forecast range 2 m midnight temperatures for ALADIN-Belgium could be reduced by about 1.3 degrees.

4. "Wavelet Jb"

(Alex Deckmyn)

Research was continued on the use of complex wavelets for the representation of background error covariances. Such wavelets not only represent location and scale of features, but also have a directional component (even though it is limited to a resolution of about 15°). The wavelets no longer form an orthogonal basis like Fourier components, but instead a so-called "tight frame". This non-orthogonal redundant transform increases the number of parameters but improves considerably the representation of anisotropies and reduces the occurrence of artefacts in the local variance.

Work has been initiated on an experimental 3D-Var implementation using wavelets in the control variable.

5. Adaptations to ALADIN of the Lopez micro-physical package

(Luc Gerard)

See the dedicated paper.

6. Gravity wave drag

(Bart Catry)

In 2004 I continued the work on the validation/tuning of the new mountain-wave-drag parameterization scheme in ARPEGE/ALADIN. This validation took place on three prediction scales: (1) semi-academical tests performed by ALADIN on an idealised flow over a complex orography (ALPIA) enables one to calculate momentum budgets which prove to be a good diagnostic tool; (2) regional scale tests using the Czech ALADIN-version produce verification

scores over Central Europe; (3) global tests using NWP ARPEGE render statistically significant scores over the different continents. Using these three scales one is able to cross-check the validity of the new parameterization scheme or parts of it.

We finally found values for the two new tuning constants ($\alpha=1.0$ and $\beta=0.5$). The already available constants were retuned using the above-mentioned method to find $\kappa=0.020$, $L_t=1.0$ and $C_d=5.4$. The new scheme was found to be resolution independent and usable down to horizontal mesh-sizes of 5 km. Below 5 km the scheme appears to have an incoherent behaviour suggesting that no mountain-wave-drag parameterization should be used at such scales. We were also able to show the clear improvement of the new lift scheme where the additional rotation is now in the correct direction. All these improvements give one the opportunity to remove the envelope orography and use (even operationally) a mean orography, which has been tested for the operational versions of ALADIN-CE and NWP ARPEGE.

At the end of 2004 I also started research on a multi-directional version of the current gravity-wave-drag scheme where the main goal is to have a better representation of the transport of momentum with height. This research should be finished by the end of 2005.

7. Physics-Dynamics Interface

(Bart Catry)

Due to the decision that one should go from ALADIN to AROME through ALARO, with a possible cooperation of HIRLAM, the need of a new physics-dynamics interface became a necessity. Not only should this new interface be able to be implemented in these different models, it should also be as flexible as possible to allow further developments concerning physical parameterizations in the near future without having to make big changes to the interface.

My work on these issues has been limited for 2004 to the analysis part, i.e. the full declination of the un-parameterized discretized equations with respect to the following problems : (1) account taken of the multi-phasic and baroclinic choices; (2) enthalpy conservation; (3) choice between $\delta m=0$ and $\delta m=1$; (4) optional projection of the heat source on temperature and pressure in the compressible case. These so-called "governing equations" should be obeyed by all low-level routines (i.e. all parameterizations routines).

In order to close the above-mentioned set of equations, some routines will need to add so-called "diagnostic-equivalent" variables to their local input/output stream. We could conclude that this means that one should find an expression for the following pseudo-fluxes : condensation, freezing, evaporation, sublimation and two fluxes related to the auto-conversion for the liquid and solid phases.

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