Information about the ARPEGE physics and its relevance for ALADIN

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We are now at the junction between two ARPEGE parallel suites dedicated to physics changes. The first one was made operational on 11/02/03, following big improvements in objective scores, mainly but not only in terms of biases. The second one, starting 20/02/03, should also bring an improvement in objective scores, but its main target is to diminish the frequency and intensity of spurious small-scale cyclogeneses without destroying the model's capacity to simulate big storms like the ones of Christmas 98 and 99. Part of these changes were fostered by the comparison between the "NWP" and "climate" physical packages in ARPEGE, performed by Yves Bouteloup with the help of Pascal Marquet. We shall now see the content of the two packages, one by one.

FIRST PACKAGE

First ingredient: New option for the radiative computations

Following his comparison work with expensive radiation computations (done together with Helga Toth on FMR-15, GRAALS and Roger Randriamampianina's "reference code"), Yves Bouteloup decided to retest the option of adding a more sophisticated treatment of the "exchange with surface" (EWS) term of the thermal radiation overall budget. This development had been prepared back in 1996 by Neva Pristov but unfortunately deemed as too expensive for its "low impact". The problem is that the impact is indeed low in stand-alone three days forecasts but that its cumulative character starts to tell beyond five days and dramatically changes not only the PBL thermal structure but also, indirectly, the whole of the model's upperair circulation. And this change is for the best, whatever parameter one looks at, as showed by the multiple tests performed by Eric Bazile and Jean-Marcel Piriou. Once a few days of data assimilation have benefited from the activation of the EWS more exact computation, any compatible ARPEGE or ALADIN forecast is likely to be further improved by this new feature.

Second ingredient: Stabilization (yet again) of the deep convection computations

Jean-François Guérémy discovered a small bug in the partition of convective tendencies between diffusive transport (that was wrongly also treating the detrained condensates) and precipitations. This was corrected.

Martina Tudor and Jean-François Geleyn discovered another bug with only small consequences in *ACCVIMP* (respectively *ACCVIMPD*) : the securities against nonlinear instability of the pseudo-advection by compensating subsidence (respectively ascendance) were written in the wrong direction with respect to the mass flux (downstream instead of upstream). This was corrected. The combination of these two changes does not improve any of the forecast fields but it leads to slightly smoother vertical profiles of all prognostic variables.

Third ingredient: Reduction and reorganisation of the vertical turbulent transport in stable conditions

Thanks to the improvements in the steady state structure of the PBL brought in by the change of the radiation code, it became possible to relax some of the changes done in CYCORA, CYCORA-bis and CYCORA-ter in order to have a good capacity of simulation for the storms of December 98 and 99. The new tuning, while keeping untouched this "storm" quality, involves a strong reduction of the overall friction in stable cases (`USURIC:` 1.→ 0.25) and also a retuning of the ratio between the coefficients for heat and momentum (`USURIDE:` 1.→ 0.25 & `USURID:` 0.042 → 0.1). The mixing-length structure of CYCORA-ter is kept untouched in this tuning mainly made by François Bouyssel and Jean-François Geleyn. This change leads to a far better thermal structure of the PBL in case of low-level inversions and to even less large-scale geopotential biases than with the sole EWS improvement. See Figs 1 and 2a-b hereafter.

Fourth ingredient: New formulation and tuning of the horizontal diffusion

Following the work of Pierre Bénard to reproduce the behaviour of the Fourier space horizontal diffusion within the current framework of the "unified diffusion" (specific to stretched ARPEGE), François Bouyssel did some retuning of the absolute amount of diffusion (which was found to be about six times higher in ARPEGE than in ALADIN once the two could be compared owing to the new possibility). A multiplication by two of the current ALADIN level (i.e. a reduction by ~3 in ARPEGE together with a better latitudinal dependency) was found to be the best new tuning. This corresponds, for vorticity and temperature, to something closer to what other models (IFS, Meso-NH) have. Filip Vana did a parallel test in ALADIN-LACE that showed neutrality of dividing the coefficients `HDIR*` by 2. Hence the idea is to harmonise things around this new compromise for ARPEGE and also for ALADIN, setting in this case : `HDIRDIV=EDEL*`/123. for a "linear" grid, `HDIRDIV=EDEL*`/44.635 for a "quadratic" grid, and `HDIRVOR=HDIRT=HDIRQ`=5.×`HDIRDIV`). It would probably be good if all ALADIN partners would follow the same trend.

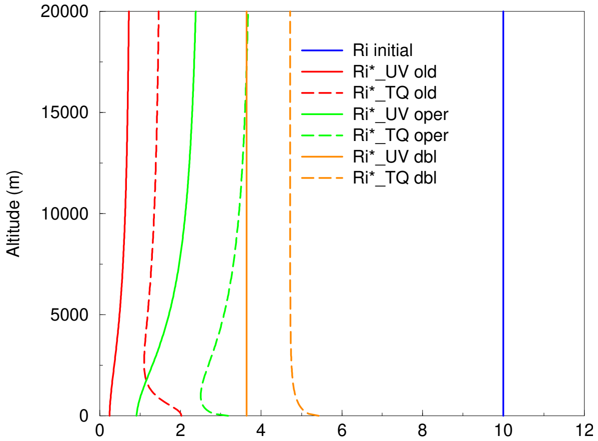

Figure 1 : Impact of the successive sets of modifications (1:3, 2:4) on the vertical profile of the modified Richardson number (Ri*), for the computation of turbulent momentum (UV) and heat (TQ) fluxes. First package : from "old" to "oper". Second package : from "oper" to "dbl"

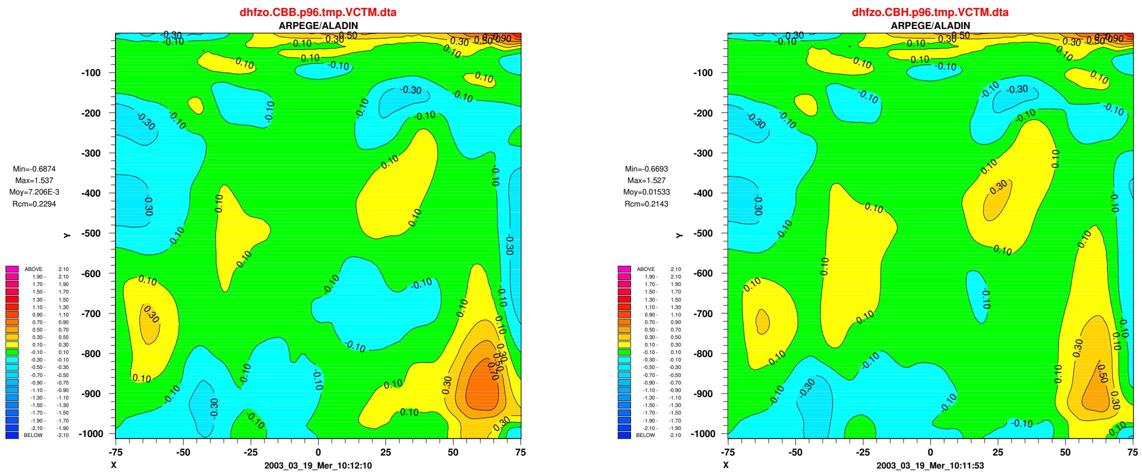

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Figure 2 : Impact of changes in vertical diffusion (1:3, 2:4) on the mean zonal tendency of temperature for a set of 8 96-h forecasts (in January 2002) : a) old, b) modified runs. The systematic warm trend in the lowest layers for the Winter hemisphere is less now.

SECOND PACKAGE

First ingredient: Rewriting of the diagnostic cloudiness scheme (for radiation computations)

This work follows the one done on an in-depth rewriting of the diagnostic cloudiness scheme (especially for missing low-level cloudiness) by Jean-Marcel Piriou with the help of several ALADIN colleagues. François Bouyssel finally found a better tuning for a selective cyclogenetic activity, mainly inspired by the comparison with the «statistical cloud scheme» of ARPEGE-Climat. One keeps the spirit of the current operational scheme (diagnostic of the condensate amount first, taking empirically into account three types of clouds - stratiform, cumuliform, below inversion - and cloudiness computation afterwards according mainly to the first result) but (i) one now combines the various water contents before a single diagnostic of cloudiness and (ii) the used formula is more realistic (following the work of Xu and Randall on observed cases). The obtained cloudiness is more realistic in its main features (especially more low-level clouds and better latitudinal contrasts, see Figs 3a-c), even if sometimes much more «0/1» locally. These features help maintaining a very reasonable capacity to simulate the intense storms of Christmas 98 and 99, and this even when the other ingredients (see below) lead to a strong reduction of fictitious small-scale cyclogenetic developments. Diagnosed cloud structures for various applications should be significantly modified (probably more than the radiative forcing itself) and everyone intending to use this new tuning ought to pay attention to these downstream aspects.

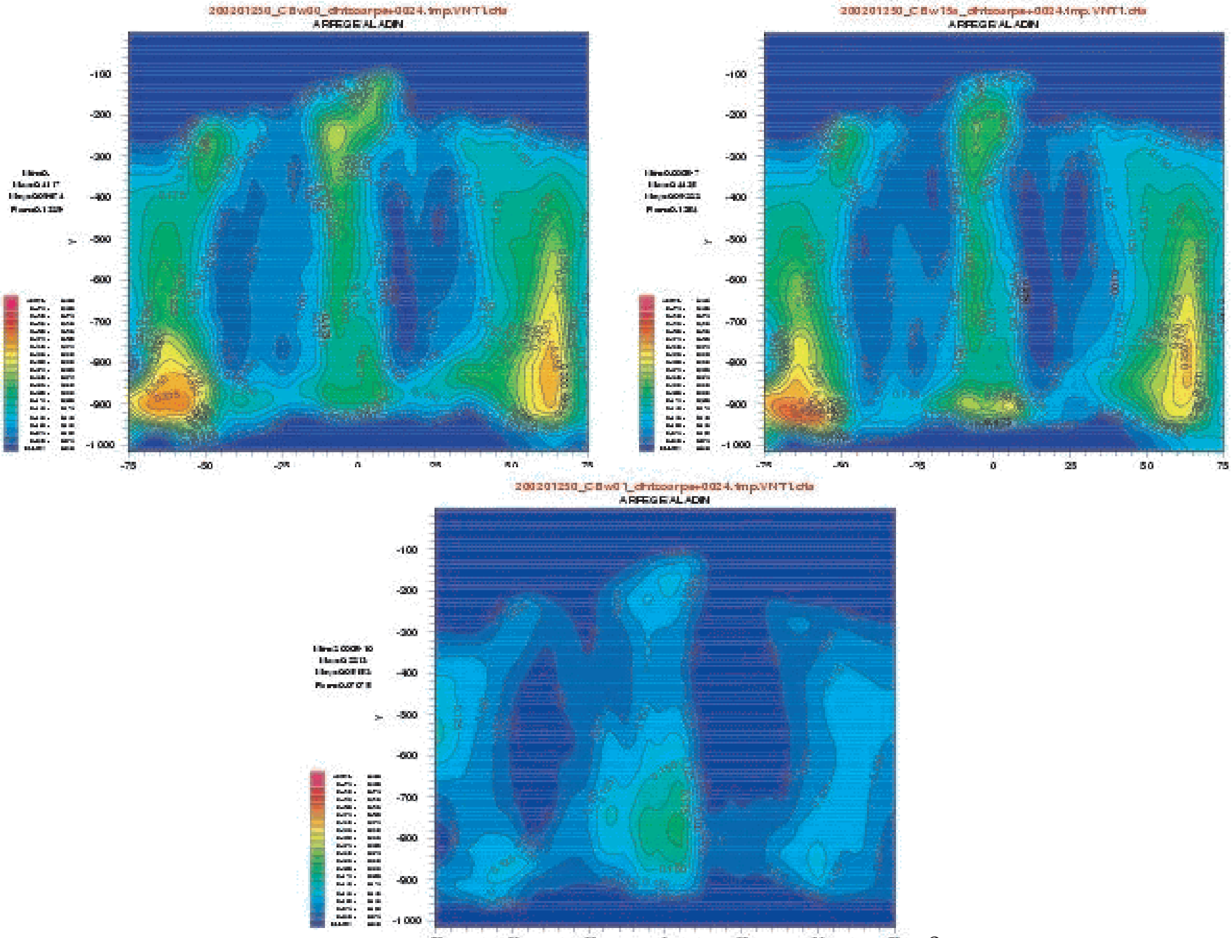

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Figure 3 : Zonal mean cloudiness, as resulting from a 24-h ARPEGE forecast with : a) the operational physics (including the first package of modifications); b) the operational physics and the modified cloudiness scheme; c) the "climate" physics

Second ingredient: Modification of the closure conditions for deep convection

One comes back, for the humidity convergence's calculation, to the situation before October 99: only the dynamical and turbulent parts are taken into account and the former is modulated according to the mesh-size, but about 3 times less than previously, in order not to diverge exceedingly from the current operational tuning. In short (and for experts) : "`LSRCON=LSRCONT=.F.` ; `GCOMOD=1.` ; `REFLKUO=5000.`"

In a similar line of thoughts, one chooses a completely local compensation (and not any more a partially "smoothed" one) of turbulent fluxes by convective fluxes. In short : "`GCVPSI=1.`" plus an additional security in order to inhibit moist convection in case of absolute dry instability. All these modifications, following scores of experiments performed by François Bouyssel, Eric Bazile, Siham Sbii and Jean-François Geleyn, are the essential damping ones for the reduction of cyclogenetic tendencies (frequency and intensity) at various scales.

Third ingredient: Less "noisy" numerical schemes

Making it proportional, at unchanged total amount, to the quantity of sustended condensate, and not any more to the vertical divergence of the convective precipitation flux, modifies the vertical profile of the convective contribution to the diagnostic cloudiness. There is no significant impact on the forecasts of this change, developed by Eric Bazile, but the vertical cloud-cover profiles are more realistic and one gets a smoother radiative forcing.

A far more stable numerical algorithm is now implemented (for an unchanged analytical formulation) in the shallow-convection parameterisation. Resulting from various remarks, it was developed, tested and optimized by Doina Banciu. The impact is quite important: disappearance of spurious oscillations of shallow convection (of course) but also of deep convection (i.e. elimination of the scintillation syndrome on pseudo-satellite animations); markedly less noisy vertical profiles of temperature and humidity in the planetary boundary layer; reduction of the moist bias in the free atmosphere and of the dry bias underneath; contribution to the reduction of cyclogenetic tendencies. This ingredient makes completely unnecessary the time-smoothing option of the shallow-convection intensity developed earlier by Martin Bellus and used in at least one of the operational ALADIN applications.

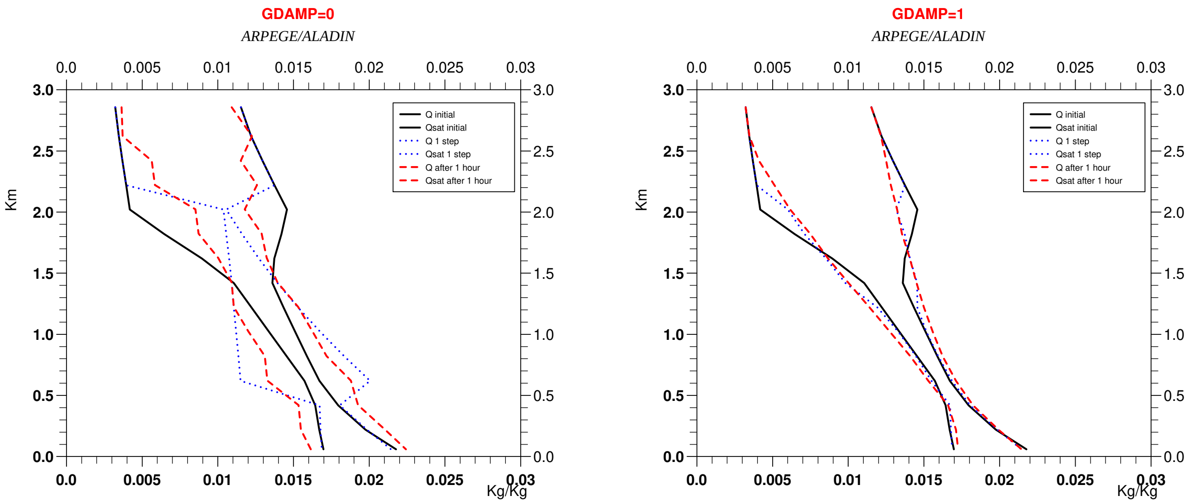

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Figure 4 : Vertical profiles of q and qsat , on a BOMEX case, at initial time (full lines), after 1 time-step (dotted lines) and after 1 hour, i.e. ~ 4 time-steps (dashed lines).

a) Operational shallow-convection scheme : the model tends to quickly and strongly modify the initial profile

b) Modified shallow-convection scheme : changes are far less, and the low levels keep close to saturation

Fourth ingredient: Further reduction of the vertical turbulent transport in stable conditions

Following the improvement diagnosed within the parallel suite for the first package, concerning the reduction of friction in stable condition (in terms of less geopotential biases and of strength of low level inversions), the work was pursued in the same direction by François Bouyssel. This time only the overall effect is reduced without any further change in the ratio of the momentum and heat parts (`USURIC:` 0.25 → 0.175 & `USURICL:` 4. → 1.). There is also a small consequence in terms of reduced cyclogenetic tendencies, which makes the "cloud" ingredient even more paramount in this package.

Fifth ingredient: Addition of a prognostic albedo for snow

Following the work of Eric Bazile with several Bulgarian and Moroccan colleagues, one adds (in full ascending compatibility for those not yet able to use this refinement) to the operational algorithm an "historical" treatment of the snow albedo with a "fresh" value of 0.85 and a diminishing trend with age until 0.65. Furthermore, in order to obtain the total albedo, one introduces a specific computation in order to better take into account the vegetation's albedo (to consider snow-free canopy). All this leads to a reduction of cold and warm biases for surface and lower boundary-layer in snow-covered areas. Diagnostic variables for snow density and "historical" (i.e. modified according to snow and sea-ice covers) albedo were also introduced. See the previous Newsletters for more details.

ADDITIONAL INFORMATION

The so-called "shear-wind linked convection" parameterisation is still under investigation. However, (i) its previously advocated version was partly bugged and (ii) results concerning the capacity to forecast big storms are still disappointing, even with all the above-mentioned progress behind us.

The bug, found by André Simon, is linked to what happens when one goes towards the equator (a classical «0/0» situation). The initial idea was to eliminate the Coriolis parameter f from both upper and lower case of the equations. But a simple geometrical analysis shows that there is no tilting any more of the slanted ascent in such a case (the upper case f takes priority) and that the correct behaviour should come from a multiplication by the ratio of the Coriolis parameter to the absolute vorticity. For mid-latitude applications the problem is probably minor, but a bug is a bug in any case. The "official" code should soon be corrected but a "patch" is already available.

It remains to be seen if all the ingredients of the two new packages can give back the advantages that the shear-linked convection brought in some specific circumstances (Adriatic or Balearic spurious cyclogeneses, some grid-point-storm-type situations, ...).

CONCLUDING REMARKS

Even if the second package has still to be carefully evaluated in ARPEGE and ALADIN-France, its already known benefits are likely to lead to an operational implementation somewhere in March this year. At that stage there should be a huge contradiction between differing physics at the edge of ALADIN applications that would not follow a parallel evolution (it is already "half the case" since 11/02 and some of you may have already noticed it, but the second set of changes ought to be of even bigger impact). The ALADIN performances per-se should also be dramatically improved for everyone adopting the above-described set of changes. All this calls for a rapid re-harmonisation of our parameterisation environment. Tunings (mixing lengths, shear-linked convection, amount of every type of cloud, level of friction, closure for convection, ...) might of course differ from place to place, but we believe that the advances in radiation, shallow convection and cloudiness diagnostic as well as all the bug fixes ought to be taken into account everywhere.

Since this double package is built on top of the serial of corrections that were necessary in order to cope with the "black spell" of late 2001 and early 2002, it seems difficult to itemise the upgrades and it would be preferable if everyone interested would undertake an overall back-phasing of the final outcome (~13 routines). Like previously advocated, this is only possible if you are already at the AL12 level (in other words, let us say that we are convinced that the present target is as good a basis as CYCORA-bis used to be). Toulouse people are ready to help you in such an exercise but it will surely not be a completely transparent one on your side. If you do not feel in a hurry despite all the advocated advantages of moving, there should be (in the spring) an export package on cycle 25T1 containing all the above-mentioned, but its implementation will involve a lot of other aspects than physics, especially for those partners late in terms of general phasing level.

In any case, an harmonisation of horizontal diffusion settings is easy and likely to help us continuing to speak a common language when it comes to the signal/noise ratio in our applications.