Some details about ALADIN physics in cycle 28T1

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1. Introduction

This document is a kind of users guide for the CY28T1 physics, in the spirit of the forthcoming ALADIN-2 evolutions that will lead to a more and more pronounced separation from the ARPEGE physics.

2. Convection

Together with a protection for the case $T_w > T$ in *ACCVIMP* and *ACCVIMPD*, a new tuning parameter was introduced in order to prevent any convective cloud lower down to trigger another one higher up in a non physical manner across some rather deep stable and/or dry layer (and the same upside down in *ACCVIMPD*). It is called RCIN. The (non-active) default is RCIN=0 and it indeed corresponds only to the small modifications of the results for the above-mentioned "protection" against a stupid situation. With RCIN=1, some slight improvement was found at CHMI on the "Black-Sea case" with the MFSTEP early set-up. Higher values of RCIN would probably be non physical. Anything between 0 and 1 may be tried but the sensitivity is of course small. All this was first detected by Jean-Marcel Piriou.

3. Stability

In the work of Martina Tudor on stiffness and/or non-linear instability, it was found that the default value of REVGSL (ratio of the fall speeds of rain and snow) at 80 was indeed favouring fibrillations around 0 °C (something detected years ago by George Ganev and never explained since). The new recommended compromise value is REVGSL=15. It does not completely suppresses the syndrome but values reaching that other goal (around 4) are indeed physically too small.

4. Orographic forcing

The 28T1 export version contains a new version of the *ACDRAG* code (with revised dependencies of the drag on the Froude number -to be activated by LNEWD in *NAMPHY*- and a lift orthogonal to the geostrophic wind and not any more to the real wind -to be activated by LGLT in *NAMPHY*-, see the presentation of Bart Catry in the proceedings of the 14th ALADIN workshop, http://www.zamg.ac.at/workshop2004/). The default namelist values indeed give back the present operational situation but the team working on the topic (François Bouyssel, Radmila Brozkova, Bart Catry, Maria Derkova, Dunja Drvar, Richard Mladek and Jean-François Geleyn) believes that there is now an occasion of getting rid of the envelope orography. When doing so, the following namelist values in *NAMPHY* and *NAMPHY0* are the highly recommended ones :

LNEWD=.TRUE., LGLT=.TRUE.,
GWDSE=0.02, GWDCD=5.4, GWDLT=1., GWDPROF=1., GWDVALI=0.5
(GWDAMP, GWDBC and HOBST remain unchanged).

Several advantages of this envelope disappearance and drag/lift improvement have been diagnosed (more realistic flow around the mountain ranges, better wind scores at 850 hPa and around, less upwind exaggerated precipitations on mountain flanks unfortunately without any shift in position, increased compatibility with the theory of sub-grid mountainous forcing, ...) but there are also some disadvantages (too weak 10 m winds near mountains, decreased foehn effect that was apparently well tuned before, slightly negative upper-air geopotential scores, ...). Everybody ought to make up its mind on the balance of its own experiments, but, in the preparation of the ALARO future work, it is clear that envelope orography has to disappear someday from our recommended version. AROME will indeed have neither envelope nor any need of a drag/lift parametrisation because of its sufficient horizontal resolution; so compatibility requires that the parametrisation at scales where we still need it -down to about 5km according to tests of Bart Catry- be a version tuned without envelope.

5. Radiation

Radiation is surely the most complex issue with respect to the 28T1 export version.

Using LREWS=.TRUE. is absolutely necessary for any version of *ACRANEB*.

The operational code in ARPEGE and ALADIN-France is not any more *ACRANEB* but FMR15 (a former version used at ECMWF and maintained since in Toulouse by the ARPEGE-Climat team of GMGEC). Since the FMR15 code is far more expensive than *ACRANEB_oper* (but more exact of course) it has to be called with a reduced frequency and some time extrapolation is then used in between for "classical" time-steps. Scores indicate a strong improvement with respect to the previous operational situation in the upper part of the atmosphere (from 400 hPa onwards) and some small induced benefits below. Partners wanting to use this option should contact Yves Bouteloup. Planned enhancements are now the use of ozone and aerosols 2d fields with monthly climatologies (already in parallel suite).

There exist now a version of *ACRANEB* (more expensive than the old one but still in reasonable proportions) that completely modifies the thermal computations and that improves the scores roughly like FMR15with respect to the *old ACRANEB*. This version can in principle be used in two modes :
(i) the so-called “statistical” one for which one continues to have a “basic” call at each time-step;
(ii) the “self-learning” one (LRAUTOEV=.TRUE.) where some chosen time-steps are far more expensive but help to better tune the “classical” ones used in-between (which also become a bit cheaper).
This development was undertaken with AROME and ALARO in mind and the current guess is that solution (i) will be appropriate for ALARO-10, solution (ii) for AROME, and that we do not yet know the transition scale. Note however that the mechanism for storage/re-use of information between expensive and half-cheap time-steps in option (ii) has not yet been coded so that this choice is far from pre-operational status (it can be used at all time-steps but is then very expensive). All related developments were discussed, prepared and tested by Pierre Bénard, Yves Bouteloup, Radmila Brozkova, Maria Derkova, Richard Fournier, Gwenaëlle Hello, Neva Pristov, Mikhail Tolstykh and Jean-François Geleyn.

Concerning the availability of this *ACRANEB_new* code, an intermediate version is already present in the export version 28T1. It is sufficient to set LRMIX=.TRUE., LRPROX=.TRUE. and LRSTAB=.TRUE. in *NAMPHY* for activating it (the first of the three switches carries nearly all the CPU overhead with itself, but it is also the one that makes the results most alike those of FMR15). This set-up has most but not all advantages of the new solution. People wanting to have the full version can contact Jean-François Geleyn and they will get a “transparent to use” ASCII file for that purpose. Note that the additional switches LRTDL=.TRUE. and LRTPP=.TRUE. are also to be activated, with a little further extra expense for the first of these two new switches, that are still hard-coded in CY28T2, the intermediate cycle corresponding to the present parallel suite in Toulouse. The above-mentioned enhancements in FMR15 will be phased with this “new-new” version but not any more with the old ones of *ACRANEB*, which results can anyhow be retrieved when all above-mentioned switches are let to .FALSE., except LREWS of course.

A few experiments made by Maria Derkova and Radmila Brozkova seem to indicate that the compatibility in the radiative forcing between ARPEGE and ALADIN has some positive impact on scores (LRMIX=.TRUE. only improves the ALADIN scores after the end of May when the operational switch to FMR15 for ARPEGE happened in Toulouse). It is therefore strongly recommended to switch as soon as possible either to the FMR15 or to the *ACRANEB_new* options. For those wanting to do the latter even before going to 28T1, there exists a tested version of the *ACRANEB_new_new* code phased with CY25T1 (and compatible with CY26) that Jean-François Geleyn can distribute to people ready to do a bit of interfacing.

For the comparison between FMR15 and the full new version of *ACRANEB* (in its "statistical" full version) the results were first rather neutral (and contradictory between geopotential and

temperature). It then turned out that FMR15 was implicitly using an option of random-maximum-overlap of clouds rather than the random-overlap version presently used in all *ACRANEB* applications. A test in ARPEGE then showed that (probably especially with the recent cloudiness tuning of *ACNEBN* and *ACNEBXRS*) using the same option in *ACRANEB* (i.e. activating the ever-sleeping switch LRNUMX=.TRUE.; beware, the "MX" indeed means "random-maximum" and not "maximum-only") was improving all aspects of the radiative forcing (surface and upper-air). With this, the results of *ACRANEB* in its full new version are now slightly but consistently better than those of FMR15. Therefore, even for people wanting to stick to the current *ACRANEB* options (for reasons of CPU cost) the use of LRNUMX=.TRUE. is rather mandatory if one wishes to benefit from the cloudiness structure improvement coming from COCONUT and from the recent retuning made in Toulouse (so-called Xu-Randall cloud schemes). This activation of the random-maximum option (also automatically present in the cloudiness diagnostic and obligatory with FMR15 for the sole diagnostic part) is more expensive for the cost of *ACRANEB* but the benefits are here unambiguous.

Neither of the two solutions (FMR15 and *ACRANEB_new_new*) is definitive. The former is frozen by construction so that a replacement by RRTM (the current ECMWF operational solution) is envisaged, if one sticks to the strategy of two completely different types of time-steps. *ACRANEB_new_new* should for itself be improved in two directions: first the incorporation of a Voigt parametrisation for upper stratospheric and mesospheric levels (little interest for ALADIN though); second a better tuning of the gaseous transmission functions to get them closer to the RRTM ones. The latter step is supposed to even further increase the benefits of the 'statistical' mode at equal costs. After that, two ALARO-bound developments should take place: (A) separating the code into three parts ((a) gaseous transmission functions, with a hierarchy of expense-versus-accuracy solutions; (b) model for "grey" properties, i.e. clouds, aerosols, etc.; (c) the "solver" like in *ACRANEB_new_new* but with both its "modes" then at an equal level of maintenance) and (B) refining the strategy of use of the "self-learning" mode.

6. Cloudiness

The cloudiness issue has already been mentioned in the part about radiation. Seen from the climatological point of view, the zonal mean distributions of cloudiness and cloud content are far better than the ones previous to the change linked with COCONUT. But the problem is the too much zero-one character of the cloudiness "seen from above". The recent changes (available in the 28T1 export version) do improve the situation as well as the use of LRNUMX=.TRUE. .

Recently Thomas Haiden proposed to strongly modify the vertical profile of critical relative humidity in order to get medium and high clouds starting to appear at lower relative humidity values. This change taken alone would create far too much cloudiness. The proposal of Thomas in order to counteract this effect is to strongly reduce both the relative humidity ceiling QXRHX in input to the Xu-Randall computations and the QXRAL constant linking cloud content and cloud cover. While the former seems acceptable, the latter of these tunings surely goes against observations and may lead to problems in radiative computations (too optically thick clouds while we already have too much solar optical depth, an independent problem). François Bouyssel, Radmila Brozkova, Ales Farda and Jean-François Geleyn are currently investigating whether one can take the "published" Xu-Randall values and a critical humidity curve close to Thomas' results as a basic "truth" and tune a smooth formulation replacing the relative humidity ceiling QXRHX as well as the constant QSSUSV (that already replaced the QSSHUS of COCONUT). Current problems are too thick mid-level clouds in the tropics and rather too little amounts of low level high latitude clouds (again, alas).

The following changes were also introduced in *ACNEBN*. First the definition of the PQLI and PQICE variables changed. They now correspond to values averaged over the whole grid-size, no longer to the cloud fraction. Warning : *APLPAR* was modified accordingly (Yves Bouteloup and

Jean-Marcel Piriou). Second there is a distinction between convective and stratiform maximum condensed (liquid + ice) water contents at the grid-point scale : QSUSX is replaced by QSUSXC (convective part) and QSUSXS (stratiform part), with no impact when "QSUSXC=QSUSXS with the value of QSUSX"(François Bouyssel).

7. Changes in vertical diffusion

The computation of the mixing lengths for momentum and heat (previously performed inside *ACCOEFK*) is now done in a dedicated routine (*ACMIXLENZ*), to allow an easy implementation of new formulations, like interactive mixing-lengths based on Tron and Mahrt or "Ayotte" PBL heights. No scientific change by default. (Eric Bazile)

The minimum value of the wind-shear (*ACHMT* and *ACCOEFK*) now depends on the depth of the layer (not any more a constant), in order to remove a dependency on vertical resolution. (ZEPS1=1.E-4 replaced by GCISMIN*PDPHIV/RG with GCSMIN=6.7E-05). There is no reproducibility, but since the tuning of GCISMIN has been done according to the previous situation, the impact is very small. (Jean-Marcel Piriou)

A new namelist parameter (EDK) has been introduced in the Louis functions F_m and F_h in stable conditions in order to reduce turbulent mixing (*ACHMT* and *ACCOEFK*). The default value (EDK=1) reproduces exactly the previous version. Be careful, some corrections of the anti-fibrillation scheme for EDK≠1 and/or for USURID=0 are necessary that are available only in CY28T2. (Eric Bazile)

The correction of a "required bug" (for reason of computer time-saving see the "History of the operational PBL", ECMWF seminar by Jean-François Geleyn) was done in the Louis' function F_h in unstable case (*ACCOEFK*). The impact is very small. (Eric Bazile and Andre Simon)

The thermal and dynamical roughness lengths are computed at each time-step over sea, but what was saved in historical files was th historical value for the dynamical roughness-length and the climatological value for the thermal roughness-length. The same treatment is now performed for both, the historical values are saved (*ACDIFUS*). (François Bouyssel)

A modification of the deep soil heat transfer in presence of snow was introduced. The default value (NCHSP=0) reproduces the previous situation (*ACDIFUS*). (Eric Bazile)

8. MFSTEP set-up

It is mentioned here because it has been the basis of many of the above-mentioned trials. Furthermore it contains some other choices that will be listed below, for completeness:

- activation of the 'moist gustiness option' developed by Martin Bellus (LRGUST=.TRUE. with RRSCALE=1.15E-04, RRGAMMA=0.8 and UTILGUST=0.125);
- computation, over sea, of a roughness length for heat and moisture that, while remaining close to the one for momentum at small surface wind values, saturates far earlier for strong winds (like suggested by observations); this did not enter CY28T1 for reasons of interaction with the data assimilation (10 m winds); for pure forecasting purposes a version of the code exists on CY25T1_op4 but probably needs a lot of attention to be merged with any other cycle; a "diff" in the same spirit will soon be prepared with respect to the export 28T1 version and interested people can contact me, but handling this piece of code will still require a lot of care, given the planned evolutions of *ACHMT* and *ACDIFUS* (mixing lengths, anti-fibrillation, EDK, etc., see Eric's documentation);
- some specific tunings: RCIN=1., GCSMIN=5.5E-04, REVGSL=15.;
- activation of the SLHD option for the horizontal diffusion processes. This is at the limit between physics and dynamics and interested people should contact Filip Vana for details.

The "frozen" MFSTEP set-up to be delivered for 1/9/04 (start of the so-called TOP period)

will contain the four above elements, the removal of the envelope and its replacement by the new drag/lift tuning, the *new_new ACRABEB* (except LRMIX, since it has little impact on surface fluxes and in the lower troposphere) with LRNUMX=.T. and a preliminary version of the cloudiness computations inspired by the HUC proposal of Thomas (no tuning of QSSUSV yet, since it is mostly a tropical problem). This version will very probably be alike the operational one of ALADIN-CE in Prague (apart from mesh-size and LRMIX) at the said date, but the latter will not be frozen, of course, especially concerning low-level cloudiness.

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