Moist physics developments and tunings in ALARO

Content of e-suite, CHMI, April 2012

This description is done to follow code changes made on top of CY36T1 export version in moist physics.

Adjustment – large scale condensation and cloud scheme

Dependency of the critical relative humidity on resolution

Critical relative humidity (RHc) is one of essential parameters of the adjustment. It reflects sub-grid scale variability of moisture in a grid box, deciding on balance between condensed and gas phases of water. In most schemes it is stationary, hence based on some statistical distribution of condensates and associated clouds. By construction, it is resolution dependent – the finer mesh, critical relative humidity gets closer to unity (or in other words to 100%), but one has to still parameterize how fast.

In ALARO, several options of adjustment are coded: Xu-Randall scheme (LXRCDEV), Smith scheme modified by Luc Gerard (LSMGCDEV) and Rash-Kristjansson scheme of HIRLAM (LRKCDEV).

Here we modified the horizontal resolution dependency of RHc for Xu-Randall scheme only, since this one is used in CHMI and testing required a non-negligible time.

While the vertical dependency of RHc was taken from the existing Xu-Randall cloudiness diagnostics scheme, which was already tuned in the past to follow observations (work of Thomas Haiden couple of years ago), its horizontal dependency was taken from what was used in ARPEGE for variable mesh. This was elaborated later with introduction of more tuning parameters: HUCRED (enabling further reduction of RHc) and characteristic lengths for water (SCLESPR) and ice (SCLESPS).

With increase of horizontal resolution from 9km to 4.7km, we noticed that the “automatic” change moved RHc a bit too much toward unity – by consequence scores of humidity showed moister bias in upper troposphere. There were feedbacks as well – more vapor meant more thermal radiation effect (warm T2m bias) and more diagnosed cloudiness, atmosphere was less washed out, especially when convection was not active, etc. Adjustment is therefore quite essential for balances in the model.

First, new tuning of HUCRED, SCLESPR and SCLEPS was found for resolution of 4.7km (HUCRED=1., SCLESPR=15400., SCLESPS=6700.). However, it would be unpractical to have to re-compute these length scales for each resolution, and thus a length-scale formula was modified in ACNEBCOND.

Exponent ZEXPLDX is introduced into **ACNEBCOND**, applied to lengths SCLESPR, SCLESPR and ZMESH (delta x). When ZEXPLDX=1., old results are recovered. New value of **ZEXPLDX=0.6**, with the namelist values:

HUCRED=1.

SCLESPR=8500.

SCLESPS=34000.

The parameter ZEXPLDX is set locally in ACNEBCOND; it could be moved into namelist for easier retuning if still needed. The setup with ZEXPLDX=0.6, HUCRED=1., SCLESPR=8500., and SCLESPS=34000., was tested both at 4.7km and 9km and it gave satisfactory result.

Phase of condensates

There is a small modification in the routine **ACCDEV**, concerning the phase of condensed water. In pure large scale condensation case, freshly computed condensates are split between solid and liquid phases by the FONICE function – there is no consideration of what were Q_L and Q_I values before the adjustment step.

In case of 3MT, we need to treat sub-grid-scale condensates of convective origin from the previous time-step, where part of them is protected against re-evaporation. Here we have to be more careful about their phase. For sure, the sum of condensates from previous time-step, when multiplied by FONICE, would not give exactly its components of Q_L and Q_I; especially due to recent introduction of cloud water sedimentation with different falling speed for each phase (see below). The existing difference needs to be adjusted in new result. Under LXRCDEV option the phase of the convective protected condensate is adjusted with the e-folding time-weight proportional to the length of the time-step (TSPHY) divided by the characteristic time decay of convective cloud (GCVTAUDE). In case of Smith (or Smith-Gerard), partition to liquid and solid phase is done at the end of computation, so no modification is required; for Rash-Kristjansson case we need to see this point with specialists.

Microphysics

There are four kinds of modifications in the **APLMPHYS**.

Correction of falling speed computation

This is an older modification, entering in December 2010. It is about better numerical treatment of the falling process, removing spurious vertical wave of the length four-delta-eta. For ascending compatibility, there was a local switch LLASC: when .TRUE., old (noisy) results were found (for validation reasons only), when .FALSE., new computation took place. In the current version, the old code and LLASC are removed.

Sedimentation of cloud water and ice

Even if cloud water and ice are considered as suspended, thus not falling, we may parameterize by their slow sedimentation what happens in nature (for example cirrus clouds appear like slowly falling but the process is much more complex). Sedimentation of cloud water and ice may use the same mechanism like falling precipitation but with their specific falling speeds. The option was first developed in ARPEGE microphysics, where from we have taken speeds ZFVL=0.02 (for liquid water) and ZFVI=0.08 (for ice); in higher cycles than CY36T1 we may find TFVL and TFVI constants in namelist (NAMPHY0). There are dedicated fluxes to this process, added to transport fluxes of cloud water. At surface, they should be added to precipitation flux entering soil, but for this purpose only; this treatment is not present yet in current version, but was properly coded in harmonization with ARPEGE in CY38T1.

Sedimentation of cloud water and ice has positive impact on humidity scores (less moist bias). It is activated by the local switch LLSED=.TRUE. In CY38T1 this switch, together with other useful switches, is moved to namelist.

Specific falling speed for graupel

It is a very recent fix, when even for pseudo-graupel (in current version of APLMPHYS we have not yet genuine prognostic graupel), it appeared necessary to introduce properly its falling speed and sedimentation probabilities. Till now, graupel was sediment like rain while influencing the fall speed of the mixed case of snow plus graupel; surprisingly this small contradiction was shown to be truly erroneous from the point of view of its consequences, via a quite devilish feed-back.

Integral of graupel

This is pure diagnostics, which may be used as possible indication of hail.

Autoconversion

There was a problem of rain, which existed also at quite low temperatures. This was caused by too low intensity of Wegener Bergeron Findeisen process, which auto-converts super cooled cloud water to snow. We increased the coefficient to:

RWBF1=1600.

Moist Deep Convection

Updraft

There are several small corrections with respect to CY36T1 basis in **ACCVUD**. Older ones are:

- Setting LLDIVENT to .TRUE. (treatment of entrainment);
- Correction in computation of latent heat for environment;
- Small corrections of computations of wet bulb and CIN;
- Correction by the factor of (1.-sigma_u) in computation of condensate.

Recent modification does not allow creating condensates below cloud bottom.

One of key parameters in entrainment computation is GCVALFA. This parameter is now set back to:

GCVALFA=3.E-05

Downdraft

There are older corrections of several bugs in **ACMODO**, reported by Luc Gerard. The most severe one was in computation of downdraft mesh-fraction sigma_d, which caused very small downdraft activity (compensated by too strong coefficient GDDEVF). Once corrections are applied, tuning of downdraft efficiency is:

GDDEVF=0.12

Also routine **ACUPD** (update after downdraft) was corrected; there is older modification of precipitation and evaporation fluxes updates.

Convective cloudiness

Tuning of convective cloud decay is set back to:

GCVTAUDE=900.

Other code modifications and tunings

There is **APLPAR** routine modified: an older bug is removed (subtracting downdraft evaporation fluxes from precipitation once too much). The rest of changes are due to modifications in dummy arguments of microphysics and introduction of cloud water sedimentation fluxes.

We have also retuned the overlap weight (introduced by Christoph Wittmann) for cloudiness diagnostics; we set it back to:

WMXOV=0.8

Nevertheless this tuning depends on vertical resolution, so it is not some universal value.