Short explanatory document on the 'cascade' and 'negative humidity corrections' aspects of ALARO-0

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The ALARO-0 code organisation is now phased into CY32. Apart from trying to tackle scientific and algorithmic efficiency challenges, two of its important signatures are:

(i) a complete set of step-by-step corrections of negative humidity (for any form of water);

(ii) a way to treat the interaction between the various parameterisations' impacts that is neither fully parallel nor fully sequential, named here 'cascade'.

Even if they are interlaced in the code, we shall treat here the two issues separately.

Negative humidity corrections

Some rules have been chosen inside the APLPAR routine for a consistent use of the water species initial values and parameterized fluxes (the latter will be used for the tendencies' computations in the CPTEND_NEW routine), when several parameterizations are used, which touch the water cycle.

1. The correction of the negative values of water species variables (PQ, PQI, PQL, PRR, PS) due to the advection part is done at the beginning of APLPAR, independently of the chosen parameterizations. All subsequent correction steps shall also happen in APLPAR (thus never in the routines it calls).

2. The initial correction is made through the negative value correction fluxes (i.e. PFCQVNG, PFCQING, PFCQLNG, PFCQRNG, PFCQSNG). They are computed such as pumping only water vapour from the layer below in the case when the specific humidity of vapour becomes negative either alone or after the local compensation for negative q_i, q_l, q_r, q_s. The procedure is repeated from top to bottom of the atmosphere such as to reach a minimum total correction at the surface.

3. All later computations in APLPAR have to use the corrected local values (i.e. ZQV, ZQI, ZQL, ZQR, ZQS).

4. Since there is no allowed update of water species variables inside the physical parameterization routines, when necessary the update has to be done outside the routines via output-parameterised fluxes coming from these routines, under specific switches. For a cascading parameterisation system (see below) this will involve the updating of the negative value correction fluxes PFCQxNG at each cascade-updating step.

5. It is assumed that the total changes of q_i, q_l, q_r, q_s due to the negative value correction fluxes (in CPTEND_NEW) will not affect the computation of the temperature through latent heat effects. This is in accordance with the situation in the advective processes when doing the initial correction, but may contradict later induced changes of the

hydrometeor contents. However it was thought that the two correction types should not be separated since it is thought that the parameterisation routines may be written such as not to generate any negative water quantity.

Cascading aspects

The basic rules for the ALARO-0 cascading sequence are the following:

1. The cascade touches only the water-cycle problems. Hence it does concern neither the radiative effects nor the momentum-related aspects.

2. The basic idea is (i) that the individual routines called by APLPAR continue to output only fluxes and may thus be called anywhere from APLPAR, while (ii) their input is the result of an updating of T, q_v, q_i, q_l, q_r, q_s after each relevant previous call of other routines, this leading finally to (iii) a set of fluxes which are influenced by the previously parameterised processes but will be added to each other in CPTEND_NEW as if the whole procedure would have been parallel.

3. This guarantees the total conservation of energy (following the equations described in Catry et al. (2006)) but for the case of negative hydrometeor species inadvertently created by one of the updating processes. But at the same time it allows to choose a sequential-like sequence of influence between the various parameterised processes.

4. In order to simplify the handling (and since the energy and total water conservation rules will anyhow be handled afterwards) the thermodynamic of the updates is simplified by neglecting the T-dependency of $L_{v/s}$ and the q_x-dependency of C_p. Both aspects are necessary in order to keep a good level of approximation with respect to what would have been given by a sequence of partial calls to CPTEND_NEW, i.e. what we tried to avoid here. The $L_{v/s}$ and C_p values chosen for that step are those of the input to APLPAR (after advection).

5. In order to avoid any double counting, the updating rule omits the contributions that will subsequently be used in the closure assumptions for the up- and down-drafts parameterisation of deep convection (respectively water vapour tendency due to vertical turbulent transport and cooling impact of evaporation/melting of falling precipitations in the micro-physics).