List of 3MT-related upgrades to the ALARO-0 code since early March 2007 (beware that the sequence is a mixing of chronology and of logical induction of further steps). Explanations about namelist use for 3MT in an ARPEGE framework, including indications about the already existing (and the yet missing) modularity/flexibility.

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<u>Foreword</u>: ***The present document comes at a precise time in the ALARO-0 history. Indeed there exists now a version of the code incorporating nearly all 3MT functionalities and that can compare favourably, in terms of objective and subjective quality, with the ALARO-0-minus-3MT LAM configuration (mesh-size = 9km) operational at CHMI for a bit more than one year. The only functionality planned two and a half years ago that has yet to be validated ab-initio is the one about 'historic entrainment'. One may add that the downdraft part of the computation has been scrutinised a bit less than the updraft part, owing to its lower impact; thus small residual bugs in this part are not excluded. There were six successive versions of the document. The (sixth) present one is the final one since the decision has been taken to 'freeze' for a while a version of the 3MT code, exactly at the time of going from to Cy33t1.***

The document is written with a very well defined purpose, i.e. to help people of CNRM/GMAP wanting to test 3MT in the environment of the global model ARPEGE (a use hardly considered in the above-mentioned validation). But, when producing it, it quickly became apparent that the document could also be a reasonably good 'user guide' for pre-operational testing of the full ALARO-0 LAM configuration at high resolution. In order to separate both uses, the parts of the document that serve exclusively the first purpose are put in italic.

The structure of the document is as follows: a first part reconstructing the code evolution since the basic documentation was produced for the TCA0 of March 2007, followed by a description of the important namelist parameters, some guidance on their use, guidance extended even to the 'hard coded' LL-type options still remaining in the code for its development phase. The combination of both types of options already gives to 3MT part of modularity-flexibility spirit required by its use in the ALARO-0 framework.

List of evolutions for the past year (approximatively)

1) An important error was found in the definition of the overall collection efficiency (March 07). As correction, ZRCOLL0 went from 0.2577 to 4.085. (JFG)

2) The LUDEN option was cleaned in the sense of a far simpler meaning (it now just helps rescaling the downdraft computations with an 'environment' [wide meaning of the term] that excludes the updraft ascent). This led (April 07) to an important recoding of the sequence ACCVUD, ACUPU, APLMPHYS, ACUPM, ACMODO, ACUPD. (LG & DB)

3) Conceptual bug discovered in APLMPHYS. The q_r and q_s species advected from the previous time step(s) were erroneously forgotten in the clear sky part not seeded by any precipitation generated above during the current time step. Hence they could neither evaporate nor melt/freeze. Consequently there was snow in summer at the ground and the

general error in the upper-air computations even led to a potentially unstable behaviour of the moist physics in ALARO-0. After correcting the bug (June 07), two other connected modifications were done to make the APLMPHYS results more consistent: (i) the fall-speed evaporation dependency was removed, following the general line of the Lopez parameterisation (if the particles fall with less speed they have more time to evaporate but they are less ventilated and the two effects should roughly compensate each other [the ACEVMEL code was streamlined on this occasion]); (ii) according to the basic PDF-based sedimentation hypothesis of a unique fall speed for each of the precipitating species, their local content was made proportional to the flux-intensity at the top of each 'section' (cloudy seeded, cloudy non-seeded, clear sky seeded and clear-sky non-seeded). (JFG & RB)

4) Still in the line of thoughts of tuning the evaporation/melting-freezing process within APLMPHYS and ACEVMEL, three modifications were introduced (between June and October 07). First there exist now the option ('LRCVOTT' not recommended because being contrary to the 3MT spirit, but left in the code) to distinguish a part of the microphysical computations of 'inhomogeneous origin' (i.e. convective if so defined in APLPAR) for which the evaporation is reduced (one assumes then that the air saturates very rapidly underneath convective towers) and for which the melting temperature is taken from the convective ascent rather than from the environment. Second the limitation of evaporation to re-saturation of the non-cloudy air and of melting-freezing to re-crossing of the treble point temperature was made asymptotic [X/(1+X) formulae]. Third the freezing process for liquid falling species can now happen at a different rate from the melting one (a ratio of 80 times less is currently hard-coded). (JFG, RB & DB)

5) An important issue, raised in the middle of the tests and evolutions of the evaporation of falling species (July 07) and still debated to-day, became the one of the evaporation of cloud condensed water. If the latter is of convective origin and does not auto-convert quickly enough it will be advected and this (alike for the falling species, see issue 3 above) in the whole of the grid-box. Hence, while in nature it might stay free of re-evaporation tendencies if 'protected' within a lasting convective cloud, in the model it will be quickly re-evaporated (convective clouds usually grow in rather dry environments). Perhaps with a bit of luck, a completely consistent cure was found for the case when the large-scale 'adjustment' is done following the Xu-Randall iterative approach, with the introduction of an estimate of the convective cloud fraction of the past time-step within the ACNEBCOND & ACCDEV computations. The use of the same input for a 'protection' in the Smith-Gerard case is more heuristic (rather than a modification of the internal parameters of the adjustment computation [alike in the previously mentioned case], it is an a-posteriori correction). The recommended choice is nevertheless to activate the option in all cases. (RB, JFG & LG)

6) It was found (September 07) that the loops dealing with the upstream-implicit algorithm for the transport parts of the M-T scheme were upside-down both for updrafts (ACCVUD) and downdrafts (ACMODO). The reason was a too hasty copy-paste of the ACCVIMP and ACCVIMPD algorithms. In the latter, the 'transport' part of the computation is driven by the so-called compensating subsidence (respectively ascendance) while in the M-T spirit it is the cloud that drives the same process, hence in the other direction. Similarly, a 'vertical staggering bug' was discovered in the treatment of the auto-advection terms for the mass-fluxes in ACCVUD and ACMODO. The latter terms were also erroneously divided by a factor two in the downdraft case. Finally the definition

of the vertical gradient of q_v to be multiplied by M_c in order to obtain the CCF (French acronym for 'buoyant convective condensation') term was modified in order to ensure a better consistency with the transport part of the M-T split and to obtain more logical conservation properties. (DB, JFG, RB, JMP & LG)

7) As a general bug for any version of the code, it was found (September 07) that the fact to recompute the ice fraction at all iterations of the Newton loops (both for ACTQSAT and for the four convective routines) is a detrimental choice leading to a deteriorated convergence. It was also discovered that there existed a contradiction between the 0/1 computation for the same ice fraction within ACTQSAT and the use of FONICE(T_c) in ACCVUD and ACMODO. In order to ensure compatibility with unmodified ACCVIMP and ACCVIMPD a routine ACTQSATS was created to correct both deficiencies within 3MT. (JFG, RB & DB). *It should be noted that this introduces a contradiction with the non-3MT part of the code. It was proposed to the ARPEGE team to test the impact of suppressing the iterative computation of 'ZDELTA' in ACTQSAT, ACCVIMP and ACCVIMPD in order to harmonise things at the occasion of a forthcoming phasing, but no return of information happened.*

8) Still in the same line of thoughts as in the previous paragraph, a bug was discovered within the Newton loop computations of the convective routines: the gradients computed without the derivation of the FONICE continuous dependency on T were not matching the discretised changes of the function to be 'solved'. The correction involved of course the same 'non-iterative choice' as above. Finally, it was discovered (January 08) that the fictitious 'double detrainment' syndrome had a lot (but not all) to do with the choice of FONICE(T_c) rather than a 0/1 transition at 0°C in the computation of the saturated adiabats. Correcting this brings the code far closer to the one of ACCVIMP/ACCVIMPD/ACTQSAT and makes some of the intermediate steps (of this paragraph and of the previous one) irrelevant or less relevant. Hence a common code solution might be sought for a modularisation of the ascent's computation. (RB, JFG, DB & LG)

9) There were minor bugs in the computation of an integral for the convective closure (September 07) and in the environmental latent heat formulation (January 08). (DB & RB)

10) Still in the range of minor improvements (January 08), the neglecting with respect to '1' of the logarithmic derivative of T upon p in the ACCVUD and ACMODO prognostic computations for updraft and downdraft vertical velocities was removed. (RB)

11) The computation of the condensate content of the convective ascent (controlled by ECMNP) was ill placed in the code (not immediately after the end of the Newton loop). There were no equivalents to the RCIN and LNOIAS computations of ACCVIMP/ACCVIMPD. All this was corrected (September 07) but the order between the computation of the buoyancy and the rectifications of the profile was judged to be better in 3MT after careful analysis. (LG & JFG). *A proposal to accordingly invert the relevant computations within ACCVIMP and ACCVIMPD was sent to the ARPEGE team (together with the above-mentioned proposal for the 'stationarisation' of the Newton loops). The non-answer to these proposals may delay further the much-needed efforts on modularisation.*

12) The properties of the convectively entrained air parcels in case of existing q_l and q_i were reviewed and improved (November 07) and the impact of this change on the

computation of the convective condensation rate was later added (February 08). This may also be of interest for a convergence of ascent computations but it is less pressing an issue than both above-mentioned ones. (LG & RB)

13) In order to fight the 'half' of the 'double detrainment syndrome' not caused by a 'wrong' latent heat release choice around 0°C (see issue 8 above) but rather linked to a feed-back effect forgotten in the definition of M-T, a modification of the updraft computation strategy was introduced (a kind of [M-T]' within 3MT, so to say). The basic problem is here that, while all other M-T-linked terms can be seen as controlled by the 'intrinsic' geometry of the cloud ascents and hence being 'in line' with CCF profiles, the ones about freezing and (especially) melting of falling precipitations have their positioning quasi-exclusively controlled by the altitude of the 0°C isotherm. Hence we do have a problem of three phases but not in a local sense at all. For instance the melting term depends on the integral of the precipitations generated above and not on the local situation in terms of condensation and evaporation. Said differently, in nature, convective precipitations will melt close to the cloud (if not within it) and the induced cooling will generate an additional amount of local condensation within the ascent (and oppositely for the freezing induced by the WBF process). If nothing is done, in 3MT (but it would be the same in any M-T version), the thermodynamical effects will be described through the call to the microphysics and will be spread to the whole gird box, thus with little chance to simulate the real physical process via their impact on the next time step(s). Short of iterating the whole 3MT computations (very expensive indeed), or even its 'ascent' or 'microphysics' parts, the proposed solution (January-February 08) is to make a simplified estimation of the convectively originating melting/freezing intensity. This estimation is obtained via the call to a stationary-type simplified micro-physical computation (similar in the spirit to the former ACPLUIE, but based on the APLMPHYS structure) and to iterate the computation of the CCF (and of the partly-linked detrained fraction area). For this double purpose, the new input is converted into a correction term (set to zero before the iterative loop), at unchanged moist adiabatic ascent characteristics and at unchanged integral of the convective condensation rate. One iteration is fortunately enough to catch the essential part of the impact, which indeed goes in the right direction and nicely complements the correction of the saturated adiabat in order to nearly eradicate the excess of detrainment around 0°C, when compared to ACCVIMP/ACCVIMPD (where there is also a slight 'kick' in the vertical profiles of E-D). (RB & JFG)

14) Four corrections were brought (January-February 08) to the logistics of the 3MT computation. A security is added to avoid the possibility of negative CCF values. The use of FONICE in ACMODO is replaced by a 'post-microphysics' diagnostic of the proportion of ice in the falling precipitations. The geometrical combination of 'convective' and 'stratiform' cloudiness prior to the use in the microphysics gets, at each level, weights computed from the local intensity of respective condensation terms and not (alike previously) from the integral of the latter aloft the current level. Finally, in the computation of the closure assumption for the determination of the area fraction of the updraft, Bougeault's formulation of the consumption term is replaced by the CCF one. (LG)

15) Concerning the detrained area fraction which is added to the prognostic updraft fraction (itself the result of the closure computation) in order to give the convective cloud-cover, one went (January 08) from a 'static' to a dynamic' logic. The budget computation done in ACCVUD is considered as an increment to a quantity otherwise decreasing with a

given (tunable) e-folding time. For the increment, two options remain, either with a budget of the detrained condensate (like in the old code, but then in a static way) or with a mass budget. The tuning constant ought to be bigger in the second case, for getting equivalent convective cloud cover outputs. It is however recommended (March 08) to use this 'historical' view of the detrained area only for the radiative and 'protection of cloudiness condensates' purposes (i.e. in short only at the next time step). One then considers only the instantaneous detrainment for the could-cover computation in input to the microphysical computations, both complete and simplified, through the use of the default values for local logical switches. (LG, RB & JFG)

Namelist (and 'internal' switches) considerations

<u>For an optimal familiarisation with 3MT, 5 different categories should be considered</u>:

I) The choices related to the ALARO-0 'envelope' of 3MT. In principle those could be treated independently of the 3MT choices, when still remaining in the ARPEGE-type framework (because of the common use of APLPAR and of CPTEND_new). This is surely true for really independent things like the radiation scheme, the tuning choices of vertical diffusion, etc.. However, when it comes to items like cloudiness, shallow convection and resolved thermodynamic adjustment, one should be extremely careful and verify that a change of options does not have a detrimental back influence on the behaviour of 3MT (the team preparing ALARO-0 obviously could not anticipate all consequences of 'strange' combinations). Ideally, a common strategy of switches' (and/or code pieces') handling should be established for such issues. Pending that, one should make a full 'diff' of the ARPEGE and ALARO-0 namelists, isolate the variables related to this part 'I' (by eliminating the other lists' ingredients) and start discussing all of them with the ALARO-0 team.

II) The choices relative to 3MT alone and having no counterpart in the ARPEGE world. For most of them, the recommended values are to be taken as such, at least before fine tuning starts. In a few cases, there are diverging opinions inside the ALARO-0 team about the best choices. A list of these issues will be presented below with additional comments.

III) The choices relative to 3MT (except microphysics), and which have an equivalent in the ACCVIMP/ACCVIMPD world. Here a change of namelist is necessary also in the ALARO-0 work when going from the LSTRAPRO switch to the L3MT switch or vice-versa. The relevant variables all have to do with the convective entrainment prescription of the updraft (with the change of closure from diagnostic to prognostic, one surely needs stronger entrainment rates in ACCVUD than in ACCVIMP):

- GCVNU=1.0E-05 (2.5 E-05 in ALARO-0-minus-3MT and 5.E-05 in ARPEGE => using 2.0E-05 for a global use of 3MT following a 'rule of three' is not recommended following preliminary tests made by JMP);
- GCVALFA=3.E-05 (4.5E-05 in both ALARO-0-minus-3MT and ARPEGE);
- TENTR=5.0E-06 (2.5E-06 in both ALARO-0-minus-3MT and ARPEGE);
- TENTRX=1.6E-04 (8.0E-05 in both ALARO-0-minus-3MT and ARPEGE).

IV) The choices for the variables related to microphysics and which have the same meaning in ARPEGE and ALARO-0 (of course there is here no distinction between the LSTRAPRO and L3MT options within ALARO-0, otherwise the spirit of the joint microphysics [resolved + convective] in the 3MT case would be lost). The only concerned variables are the ones concerning the auto-conversion. The values are:

- RAUTEFR=2.E-03 (1.E-03 in ARPEGE);
- RAUTEFS=2.E-03 (1.E-03 in ARPEGE);
- RQLCR=3.E-04 (2.E-04 in ARPEGE);
- RQICRMAX=5.E-05 (3.E-05 in ARPEGE);
- RQICRMIN=8.E-07 (2.E-07 in ARPEGE).

Two remarks are worth making here: (i) while the last three choices may without danger be brought back to the ARPEGE ones, the tuning of RAUTEFR/RAUTEFS was done specifically for 3MT (i.e. the original ALARO-0-minus-3MT values were identical to the ARPEGE ones and there was a need for change that appeared when going to the full ALARO-0); hence it might be dangerous for the 3MT behaviour to run with 1.E-03, even when activating the ARPEGE microphysics inside 3MT (see next paragraph); (ii) the parameterisation of the Wegener-Bergeron-Findeisen process in the ALARO-0 microphysics (and exclusively there) is done with a constant (RWBF1, recommended value 300.) that acts as a multiplier on RAUTEFR => putting it to zero switches off the parameterisation of the process; but, when changing RAUTEFR while still being with the ALARO-0 options in ACACON, keeping RWBF1 at the same value ensures the same ratio of intensities between the WBF process and the classical water auto-conversion.

V) The options ‘internal’ to APLMPHYS (and to its lower-level subroutines ACACON, ACCOLL and ACEVMEL) for allowing to activate the scientific options of the ARPEGE microphysical package:

In APLMPHYS:

- for the choice of the PDF-based sedimentation algorithm, LLSTASED activates the ‘statistical’ option (ALARO-0) and LLLAGSED the Lagrangian option (ARPEGE); both options are exclusive from each other but the code is not (yet) protected against double use;
- for the type of fall-speed spectrum, LLFSVAR activates the variable speed option (ALARO-0) and LLFSFIX the constant speed option (ARPEGE, with fall-speeds governed by the namelist under the same names as in the ARPEGE set-up); both options are exclusive from each other but the code is not (yet) protected against double use; it is highly recommended to use the combinations either ‘LLSTASED with LLFSVAR’ or ‘LLLAGSED with LLFSFIX’ and not the ‘crossed’ ones, this being the only restriction to any ‘panachage’ for the micro-physical issue;
- for the activation of a ‘diagnostic graupel’ option (present in ALARO-0 but not in ARPEGE) one must use LLPSGRP=.T.. The switch is however completely orthogonal to the other ones so that one could imagine activating this choice even while running all the other options of the ARPEGE microphysical package.

In ACACON, ACCOLL and ACEVMEL:

- totally independently from one another and from the APLMPHYS case, for each routine the switches have the same names and meanings, i.e. LLA0MPS activates the ALARO-0 code and LLARPSC the ARPEGE one; both options are exclusive from each other but the codes are not (yet) protected.

One last remark must be made concerning the internal switch to APLMPHYS named LLRNUMX. If .TRUE., the vertical geometry of clouds and precipitations is considered from the angle of 'maximum-random' overlap (alike for LRNUMX in radiative computations), if .FALSE. one goes to the random overlap choice. While the .FALSE. option might help emulating the current use of the ARPEGE microphysical package for stratiform clouds only, the use of LLRNUMX=.T. is mandatory once L3MT is activated (otherwise rain generated in convective towers will be distributed to the whole of the grid-box and will evaporate far too quickly).

<u>List of the yet open options for the use of 3MT (cf. section 'II' above)</u>:

NB: the initially provided namelist corresponds to all options 'a' below (i.e. after consideration of objective scores at 9km mesh size on the LACE domain and study of the corresponding cloud cover and surface precipitation maps); the options 'b and/or c' seem more oriented towards maximum scale-independence when going to higher resolutions on the smaller Belgium domain.

A) Concerning the 'resolved' precipitations (either in absolute for ALARO-0-minus-3MT or as a contribution in the case of the full ALARO-0 (*)), there are two options for computing the condensation-evaporation rates:

a. Either the so-called 'modified Xu-Randall' method (switch LXRCDEV=.T.), based on an initial proposal by Eric Bazile. In short it consists in assuming saturation at 1-Huc in the 1-Neb part of the mesh, full condensation in the other part and adjustment of Neb (via a Newton loop) in order to fulfil a slightly modified version of the Xu-Randall equation linking cloudiness with water vapour, saturating water vapour and condensed water contents. The tuning of the vertical profile of the critical relative humidity Huc depends on the tuning of the similar parameter Huc_n for the computation of 'radiative cloudiness' and on three coefficients. HUCRED, i.e. 'alfa' represents a scaling factor for a minimum value [1-min_Huc=alfa.(1-Nuc_n)] and there are two scale parameters for helping the critical relative humidity going from min_Huc to 'one' when the model's mesh size goes to zero. The length scale for the liquid water part of the vertical is called SCLESPR and the one for the pure ice water part is called SCLESPS. There is a transition between the two using FONICE(T). The tuning of the three above parameters benefitted quite substantially from the preliminary ARPEGE testing done by TK and JMP last fall. As already hinted at in paragraph '5' of the main text, the protection against re-evaporation in the convective cloudy area (of the past time step) is obtained (under the switch LNEBCV=.T.) just through the replacement of 'one' by 1-Neb_cv at one place in the central equation of the above-mentioned Newton algorithm.

b. Or the so-called 'Smith-Gerard' method (switch LSMGCDEV=.T.). The code is based on the same ideas than in the current ARPEGE application (independent set-up of the critical relative humidity vertical profile, assumed triangular statistical distribution of the ratio q_t/q_satur, computation of Neb and q_c from integrals along the corresponding PDFs, etc.). However, contrary to the current ARPEGE case, there is no 'filtering' of the input by a first computation of the auto-conversion's impact. Furthermore there are several refinements introduced by LG: optional use of surface temperature as input for computation at the lowest level, treble point smoothing, mixing of levels when there is dry convective instability, reduction of the cloud-cover for thick layers, smoothing out brutal jumps in the cloudiness vertical profile, maximum allowed rate of warming, preventing melting at negative temperatures. The switch LNEBCV=.T. also has a positive impact in this set-up.

B) Concerning the convective closure assumption (which, in 3MT, is used to determine the area fraction of the updraft) there exists a basic choice (the closest possible one to the ACCVIMP situation) and two ways (independent in the code but linked in their spirit) to depart from it (in fact the topic is surely still open in search of alternatives (**)):

a. The 'basic' choice (LCVGQD=.F.) is to incorporate the contribution of the vertical turbulent transport of water vapour in the so-called 'moisture convergence' (together with the dynamical part). Following the rule of 'no-double-counting' for the structure of the 3MT 'cascade', the contribution of the same term is not considered when incrementing prognostic variables between the calls to ACDIFUS and ACCVUD. There is no modulation of either part of the moisture convergence (since GCOMOD=0. is mandatory for L3MT=.T. and since LCVGQM=.F. [see below in 'c' for the latter's meaning]). Results are better at 9km resolution (less intense precipitation maxima) but obviously the auto-regulation of the closure towards kilometric resolutions cannot be compatible with LCVGQD=.F. and maybe with the absence of any 'scaling'.

b. If one wants to avoid the turbulent diffusive part of the moisture tendency to enter the convective closure via CVGQ but rather via the update of the input to ACCVUD, one should use the option LCVGQD=.T., both consequences being treated simultaneously under this switch.

c. Within ACCVUD and when LCVGQM=.T., the moisture convergence may be modulated for cases with low value of the updraft area fraction PUDAL. It is assumed that only a fraction RMULACVG*PUDAL (limited to 'one' of course) can be 'entrained' to feed the condensing ascent. The currently estimated value of the tuning constant RMULACVG is 30, which means updrafts influencing the flow within a distance up to five to six times their radius. Anyhow the option LCVGQM=.T. is currently non-recommended.

C) Concerning the computation of the detrained area fraction (see paragraph '15' of the main text for some more details), there are two options for the 'functional dependency' and the need to be careful when switching from one to the other because one tuning constant (despite keeping the same meaning) has to be modified in order to get a fair comparison:

a. One may choose the condensate detrainment budget (LLDEQC=.T. as a hard-coded local switch in ACCVUD); in this case the e-folding time for the disappearance (GCVTAUDE) must be of the order of 900s in order to get a 'reasonable' convective cloudiness in mid-latitudes (no global tuning was attempted here).

b. One may switch to a mass detrainment budget (LLDEQC=.F.); in this case the e-folding time for the disappearance (GCVTAUDE) must be about five times bigger (~4500s) in order to get the same convective cloudiness than in case 'a'. It should be noted that the vertical structure of the convective cloudiness is quite different from one case to the other, with less good scores and cloud structures (because of the longer life-time) in case 'b' but a better scale independence when going to high resolution.

Furthermore, there are two ways of using the result of the above computation (either 'a' or 'b', the two issues are independent):

c. The recommended solution (LLNEBINS=.T. in <u>both</u> ACCVUD and ACUPU) is indeed to use only the instantaneously detrained value in the APLMINI and APLMPHYS computations.

d. In the opposite case (LLNEBINS twice equal to .FALSE.) one has some more consistency for the use of cloud-cover properties from one time-step to the next, but one gets a rather wrong microphysical view of the convective condensate's vertical geometry.

It is absolutely not recommended to have diverging choices for LLNEBINS between ACCVUD (for APLMINI) and ACUPU (for APLMPHYS).

D) The role of the LRCVOTT switch has been mentioned in paragraph '4' of the main text. It should be used as .FALSE. (alike in the proposed namelist), but the code is maintained in order to offer a potentially useful degree of freedom.

E) Finally one word should be said about the vertical diffusive transport of q_l and q_i. In the proposed namelist it has been switched off (NDIFFNEB=0). Ideally one should use NDIFFNEB=3 in the 3MT logic. The impact of the change is small in convective situations (i.e. with relatively little cloud cover where there is condensate to be transported). However, in past experiences, there was a clear negative impact on the surface pressure scores in situations with dominant resolved type condensation and precipitation. The latter fact needs to be re-verified after all the changes that happened to the microphysics computations. If still true, it should be explained so that one can try and find a cure. Given the diversity of situations over the world, it is recommended to use NDIFFNEB=0 in global tests for the time being, this being by the way equivalent to the current ARPEGE choice.

(*) The way to treat the moist thermodynamic adjustment in ALARO-0 is quite special: separation of the computations between two routines (ACNEBCOND and ACCDEV) called on each side of the ACDIFUS computation; possibility to call APLMPHYS outside the L3MT case, optional protection of the convective condensate, etc.). In the spirit of the remarks made in section 'I' above, it is not recommended to try and bypass this algorithmic arrangement in order to get closer to the current ARPEGE practice. Ideally, concerned people should jointly work on creating a third option within ACNEBCOND and ACCDEV (alike what has been done within APLMPHYS and below) corresponding to the ARPEGE choices. In fact the ALARO-0 team made such an attempt (at having one new option besides LXRCDEV and LSMGCDEV) when creating the two concerned routines. But this attempt failed because of the obstacle created by the above-mentioned option of 'extra call to auto-conversion computations', at a time when those were not yet reproduced under APLMPHYS.

(**) It might be possible to reintroduce the meaning of GCOMOD=1 for the sole turbulent diffusive part of the basic moisture convergence (if the complement to what would be accounted for in CVGQ is indeed used to modify the water vapour profile in input to ACCVUD, the tuning of REFLKUO would allow to encompass both current extreme solutions under the LCVGQD logic).

Summing up for recommended options and/or tunings, especially for a LAM use of 3MT

<u>Recommended choices</u>:

GCOMOD=0.,
LRCVOTT=.F.
LCVGQM=.F.,
LNEBCV=.T.,
LLNEBINS(2x)=.T..

Possibilities of tuning, not to be considered without firm reasons:

Entrainment parameters (GCVNU, GCVALAFA, TENTR, TENTRX);

Auto-conversion inverse time scales (RAUTEFR, RAUTEFS).

Other (more open, but still needing some expertise) possibilities of tuning:

Other auto-conversion values (RQLCR, RQICRMAX, RQICRMIN, RWBF1 [the latter only if LLA0MPS=.T. in ACACON]);

Internal LL switches for microphysics (in APLMPHYS, ACACON, ACCOLL & ACEVMEL), see details higher up in the document;

Some overall tuning values for the microphysics:

In the case of the ALARO-0 options: FSPRAIN (parameter controlling the fall-speed of all hydrometeors), EFFCOLL (parameter controlling the efficiency of all four forms of collection), EVAP, FONT & ZGELSFON (local in ACEVMEL) for the evaporation, melting and relative freezing/melting efficiencies;

In the case of the ARPEGE microphysics options: TFVR, TFVS (fall-speed values), RACCEF, RAGGEF, RRIMEF (collection efficiency factors), RNINTR, RNINTS & ZEVASX (local in ACEVMEL) as coefficients controlling the evaporation/sublimation rates.

Quite open choices:

LCVGD;

LXRCDEV or LSMGCDEV (with more choices expected rather soon);

LLDEQC/GCVTAUDE (the two choices are coupled);

NDIFFNEB (preferably 0 or 3).

Further priority work on 3MT (beyond the above degrees of freedom):

Activation of the ‘historical entrainment’ concept;

Reducing the water vapour accumulation around 300 hPa.