Basic user-guide for the introduction of the code and namelist modifications leading to '3MT in ARPEGE'

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Introduction

We start with a definition: what is called here in short "3MT in ARPEGE" is a modification of the code (and of namelist choices when appropriate) for APLPAR and for some subroutines below. It allows running the ALARO-0 3MT code in association with the following ingredients of physics currently used in the ARPEGE operational set-up in Toulouse:

- RRTM-thermal + FM-solar-6bands radiation code (*);
- A cloud/radiation interface based directly, for the non-deep-convective clouds, on the prognostic variables $q_{l/i}$ (q_c in short below for their sum), once upgraded by the thermodynamic adjustment and the shallow convection computation, and on the cloud-cover produced by the same parts of the algorithm;
- The vertical diffusion part, based on ACDIFUS, CBR and KFB, the latter in shallow convection mode (*);
- The above mentioned Smith-type thermodynamic adjustment, as specific input for the vertical diffusion and stratiform condensation/evaporation parts;
- The "Lopez-type" basic microphysical processes (sedimentation driving parameters, auto-conversion, collection, evaporation + melting/freezing);
- The mountain impact on the momentum budget (*).

Parts marked with (*) are those where the original ARPEGE code is used directly; the other ones are those where the ARPEGE algorithms were reincorporated (earlier or now), under an appropriate shape, within the ALARO-0-type subroutines and/or where the APLPAR code was modified to get the correct communication between parts of code of differing origins. Those are in principle the items which will mostly need further description below.

Concerning the organisation of APLPAR computations, in order to best obey the 3MT logic, the choice is the one of the so-called "cascade" (i.e. quasi-sequential call of subroutines, but parallel use of the fluxes' output of their computations). Another general remark is that the horizontal diffusion set-up remains of course the ARPEGE-type one, even if this could be considered as a completely independent issue at the time of the forthcoming joint tuning effort for the new configuration.

The following parts of the ALARO-0 algorithms were judged non-dissociable from 3MT (if the latter is considered in its most restrictive sense, i.e. the rather long code sequence "*computation of a non-modulated humidity convergence for the convective closure; call to the updraft part of sub-grid deep-convective motions [in doubly prognostic mode]; merge of the condensation/evaporation inputs of non-deep-convective and of deep-convective origins; call to the microphysical processes on the basis of this mixed input; computation of the driving force for downdrafts from the microphysical output in terms of evaporation and melting; call to the downdraft part of sub-grid deep-convective motions [in doubly prognostic mode]; correction of the sedimentation microphysical results to avoid accounting for previously evaporated precipitations within downdrafts*"):

- the use of the 3MT output for the diagnostic of convective cloudiness (1);
- the "protection against re-evaporation" of non-auto-converted cloud water of unambiguous convective origin (2);
- the geometrical interpretation of the microphysical computations (in the intermediate APLMPHYS subroutine) both for the horizontal (splitting of the mesh in four distinct parts) and in the vertical (use of the maximum-random overlap assumption for communicating the information about precipitation fluxes from any layer to the one just below) (3).

Implementation characteristics varied from one case to the next:

- (1): 3MT convective cloudiness was used (instead of a diagnostic quantity based on convective precipitation fluxes, which are anyhow not any more clearly defined in the 3MT solution) as input for the "protection against re-evaporation" and for the cloud-radiation interface computations, in a manner adapted to the main characteristics of the Smith-scheme and of the native ARPEGE solution, respectively;
- (2): owing to the fact that the ALARO-type method (based on the ideas of Xu and Randall) could not be directly applied to the Smith scheme, three of the solutions chosen in the Smith-Gerard scheme (including for the protection against re-evaporation of course) had to be adapted to the ARPEGE-type Smith-scheme;
- (3): the maintenance of the scientific compatibility of the process description (within deep level ALARO-0 subroutines ACACON, ACCOLL and ACEVMEL) with the equivalent of ADVPRCS computations was further assured. The logical switches corresponding to the ARPEGE choices for the sedimentation probability distribution functions, for the absence of any graupel component and of any WBF-process were of course activated. Conversely the 3MT choices remained valid whenever necessary (i) for the geometrical aspects (see above), (ii) for the treatment of sinks as negative sources and (iii) for the sequential arrangement between direct computations and securities needed for avoiding negative hydrometeor amounts in the final output of APLMPHYS.

Encountered difficulties

Apart from the normal trial and error aspects inherent to the detailed choices within such an effort, there were two main encountered difficulties, connected in their code position, but nearly independent in their roots.

A) Contrary to the too optimistic initial expectations, it was not possible to extend to the Smith case the strategy employed in the Xu-Randall case (of ALARO-0) in order to compute the "protection against re-evaporation", based on the use of the convective cloud-cover value advected from the previous time-step and on the hypothesis of equality between the intensive values of q_c between the "convective" and "stratiform" cloudy parts. The intrinsic set of equations trying to solve this problem does not have solutions for all possible situations in the Smith case, while it nicely simplifies to just a rescaling of the total moisture input for the stratiform part of the mesh in the Xu-Randall case. Trying to overcome this by limitations of the conditions of application (like first suggested by Joris Van den Bergh) leads to even bigger contradictions, at the level of the results this time.

B) Still concerning the issue of the thermodynamic adjustment (considered here equally with or without protection against re-evaporation) it rapidly appeared that the combination of the native ARPEGE solution for the Smith-type algorithm and of the core part of 3MT is a strong potential source of so-called "grid-point-storms". Since the identification of this syndrome is partly subjective (but some graphical proofs below are nevertheless quite telling) and since the only possible cure found after many tests is rather heuristic, it is difficult to profess a definitive judgment on the reasons leading to this crucial obstacle. The empirical study which we conducted nevertheless appears to point in one direction: the Xu-Randall algorithm apparently behaves better because it creates a causal hierarchy between the presence of condensate (the trigger) and the one of cloudiness (the product) while the Smith algorithm (like for any other Sommeria-Deardorff-type PDF-scheme) solves for obtaining both values at a parallel level. The nuance is small but perhaps important in its consequences in our case (some further investigation might be useful, but it was out of scope within the mandate given by the ALADIN governing bodies).

Remarks:

- (I) When facing these two issues, we were lucky that our colleague Luc Gerard developed (as the first vehicle for tests of the 3MT concept, back in 2006) a "Smith-Gerard" version of the protected thermodynamic adjustment. Despite some shortcomings, this version provided us with several deviations from the classical Smith scheme, out of which three gave positive inspiration for curing the (A) and (B) problems to a maximum extent.
- (II) The coincidence of the two problems in their code localisation might (or not) indicate that there exists some (unknown up to now) synergy between the core part of 3MT and the choice of the Xu-Randall-type algorithm for the thermodynamic adjustment. A trial of the shift of this issue from the ARPEGE side to the 3MT one (in the above classification) might become rather instructive, even if only for basic investigations. But since it did not belong to the mandate of the "3MT in ARPEGE" exercise, we left it aside.
- (III) Given the encountered difficulties, the choice of the strategy of coding for the present exercise (copying first a scientifically fully compatible version of the ARPEGE algorithm within the ALARO-0 subroutines ACNEBCOND and ACCDEV and then testing variants inspired by the Smith-Gerard scheme) was much beneficial. The issue is now whether (a) one should stay with the resulting code, (b) one should try a direct back-phasing of the found solutions in the ACNEBSM and APLPAR subroutines or (c) one should jointly develop an additional intermediate buffer-like routine (in the spirit of APLMPHYS, i.e. for isolating at the lower level only the real differences between the various solutions).

Solutions for the (A) and (B) problems as well as for other less difficult issues

- Problem (A): The chosen solution (implemented in ACCDEV) is inspired by the one of the Smith-Gerard version. Under activation of the logical switch LNEBCV, the ZUNEBH convective cloudiness of APLPAR is passed to the subroutine under the name PNCV (and otherwise the latter is set to zero). Combining PNCV and the just obtained "stratiform adjusted" cloud amount (obtained without any change of the related computations, unlike for the Xu-Randall case) one gets a proportion of convective cloudiness ZFRACON. The protected value of q_c, denoted as q_{c*}, is then obtained from the stratiform adjustment result for q_c (let us call it here X) and from the initially advected value of q_c multiplied by ZFRACON (let us call this Y), and this via the expression $q_{c*}=(X^2+Y^2)/(X+Y)$. It should be noted that Luc Gerard chose the less smooth function $q_{c*}=Max(X,Y)$. One verifies that the above proposal gives back the correct asymptotic results for both extreme cases (either the untouched result of the adjustment computation in case of zero convective activity [or of no activation of the switch] and nearly [if ZEPS2 is sufficiently small, see next item] neither condensation nor evaporation in presence of dominating convective cloud amounts). In-between, the transition formula is arguably fully empirical and does not make use of the idea (chosen as basis for the Xu-Randall case) of equalling the two intensive amounts of q_c.

- Problem (B): The grid-point-storms have been eliminated (as far as one can be sure of this kind of "success" within a necessary limited number of tests) by correcting twice (at the end of the computation in ACNEBCOND) the stratiform adjusted cloud amount PNEBCOND. First, if there was initially some advected condensate in at least a non-negligible quantity (1.E-10), PNEBCOND cannot be smaller than the value of ZEPS2 (a new tuning parameter, since Luc Gerard considered it rather as a numerical security, see below). Subsequently, PNEBCOND is reduced through multiplication by a factor $1/(1+\delta\varphi/\varphi^*)$ where the layer's geopotential thickness is scaled by the tuning parameter RDPHIC. The idea is here that too thick model layers cannot sustain extremely large values of horizontal cloud coverage. This double treatment avoids both extreme cases where the feed-back loops with the core part of 3MT are indeed most likely to generate auto-contradicting numerical behaviours.

- Cloud/radiation interfacing: In the case of LLSMITH=.T. (and only then; later to be perhaps extended to other cases in order to allow some cross-checking) a part of the ACCDEV computations is duplicated within ACNEBCOND in order to produce a stratiform adjusted value of q_c (without yet any protection against re-evaporation). Note that the same computation would anyhow need to be redone later (in the spirit of the cascade) when calling ACCDEV, even in the case LNEBCV=.F., since the input to the thermodynamic adjustment will have been modified in between by the impact of the various vertical diffusion fluxes. For lack of any available better solution and in order to stay close to what is done in ARPEGE, the cloudiness input variables are respectively the doubly (or simply, if the originally advected q_c was smaller than 1.E-10) bounded PNEBCOND stratiform cloud amount and the ZUNEBH advected convective cloudiness diagnosed at the previous time-step (whatever the choice for LNEBCV this time). In order to avoid the risk of quasi-transparent convective clouds in the radiative computation, the q_c amount needs a more special treatment. Prior to the call to ACNEBN the adjusted stratiform value of q_c is linearly combined (in APLPAR) with the originally advected value of q_c, with respective weights equivalent to 1-ZFRACON and ZFRACON (see above for the definition of this quantity). Note that, at least for the time being, only the random combination of the two types of cloud-cover is used in the operation described just above as well as in ACNEBN under activation of the LLSMITH switch, this in order to be compatible with the way the core part of 3MT acts on the same variables.

- Interaction with the shallow convection computation: The combination made in ARPEGE for stratiform and shallow convective quantities (i.e. summing the amounts of condensate and taking the maximum of both cloud-cover values) is done identically in "3MT in ARPEGE". However care must now be taken, for the cloud-cover, not to modify the stratiform output of ACNEBCOND that must absolutely stay the input to ACCDEV. Hence the above-mentioned operation is performed twice: first in APLPAR for the input quantities to ACNEBN (after the preparatory computation for q_c explained in the previous item); second in ACCDEV itself for the adjustment (and not anymore in APLPAR like for the nominal ARPEGE solution), after the "protection against re-evaporation" part of the calculations.

- Sedimentation of cloud liquid and ice water: The ARPEGE algorithm of ADVPRCS is implemented in identical shape within APLMPHYS (acting just after auto-conversion, using constant sedimentation speeds within the Lagrangian transcription of the PDF-based sedimentation, providing upgrades to the vertical diffusion fluxes for q_l and q_i respectively). The unicity of the cloud sedimentation speeds indeed allows inserting this computation without having to take into account the sub-geometrical aspects of APLMPHYS and this in turn helps preserving the ARPEGE algorithmic choices.

Tunings

We shall treat now only the issues where the choice was not obviously either the usual ARPEGE one or the 3MT-related one of ALARO-0. A separate technical documentation will give the full list of choices, together with hints of the main code novelties.

As first item, the same change was made to the auto-conversion coefficients RAUTEFR and RAUTEFS as when ALARO-0 went from its provisional "without 3MT" status to its "with 3MT" one. Both values remained equal between themselves but were doubled (the auto-conversion time-scale then goes down from 1000s to 500s in order to account for the increased intensity of the relevant processes in convective towers, which are now part of the microphysically handled clouds).

Owing to the above-mentioned difficulties linked to the thermodynamic adjustment and to a meaningful protection against re-evaporation of condensate of convective origin, it was decided that the rather ad-hoc choice of RFACNSM=1.2 wasn't appropriate and it was set to a more logical value of "one" in namelist.

Since the latter step led to a too small amount of clouds, it was empirically found that the easiest compensation was to also move the other parameters controlling the auto-conversion processes (RQLCR, RQICRMIN and RQICRMAX) from their ARPEGE values to the ones used in ALARO-0 [(2.E-04; 2.E-07; 3.E-05) => (3.E-04; 8.E-07; 5.E-05)].

Concerning the 'novelties' in the Smith-part of the new code (in ACNEBCOND to be more precise) there were two 'limiting constants' of the Smith-Gerard scheme that became true tuning parameters in order to cure the grid-point-storms syndrome. The first one kept for the time being its ZEPS-type name (security constant) but should become a global tuning parameter at the next phasing occasion. Their best tuning up to now was found to be ZEPS2=0.08 and RDPHIC=1.E+05 (i.e. 10 times more than in the nominal Smith-Gerard set-up but still significantly differing in its impact from the infinite value implicit in the native ARPEGE-Smith code).

Finally the too most important tuning parameters (together with GCVTAUDE, which was left unchanged at 900s in its control role of the amount of convective cloudiness) of the core 3MT part, namely GCVALFA (the higher, the less entrainment) and GDDEVF (the maximum proportion of precipitation that may evaporate in downdrafts) were retuned (in an ALADIN geometry, on the quasi-tropical Central-European situations of the second half of June 2009). The best combination seems to be obtained when giving to GCVALFA its ARPEGE value (in ACCVIMP), i.e. 4.5E-05 (vs. 5.E-05 in ALARO-0) and putting GDDEVF to 0.5 (vs. 0.25 in ALARO-0, the same value as for the rough equivalent GDDEVA in ARPEGE [again ACCVIMP]). These tunings are likely to be improved when tried in true tropical conditions within a global configuration. Owing to previously accumulated experience in ALARO-0 it was decided not to retune GCVNU, TENTR and TENTRX away from their '3MT in ALARO-0' values.

Among the several tunings, the only surprising one was the doubling (with respect to ALARO-0 3MT) of GDDEVF. We recently looked more in detail at this point. In fact one may keep GDDEVF=0.25 provided the equivalent of the ARPEGE-physics namelist parameter LEVAPX is set to false. In that case both scores and precipitation maps are very close to what was described in the ensuing figures (not updated). The LEVAPX switch controls an absolute limitation of the rate of evaporation. One may propose the following explanation: in the ARPEGE set-up the limitation is there because of the geometry choice that allows evaporation across the whole sub-cloud meshes even for partial cloudiness above. With the maximum-random overlap choice of 3MT this extra limitation is not any more necessary and the usual tuning of the downdraft activity may be chosen without problem. We do not know if this can be considered or not inside the "3MT in ARPEGE" mandate. This is the reason why we did not update the graphics below, but decided nevertheless to signal in this second version the possibility to have this new tuning, that we would personally recommend ***(paragraph added as the only modification from the v1 to the v2 version, plus some mistyping's corrections)***.

Outlook

The ALARO-0 party considers that it fulfilled the part of the 'Convergence-related' task (set-up by the ALADIN General Assembly and ALADIN Policy Advisory Committee), which it could perform in isolation. The next steps, if carried through, should be a joint effort with GMAP/PROC both for phasing the new code in a more permanent mode and for improving the provisional tunings in global conditions. Both steps would indeed require a combination of the know-how of both parties. As already mentioned, an effort for finding the best horizontal diffusion set-up for the case of grey-zone scales being reached in the highest resolution area of ARPEGE (and not elsewhere on the globe) could also be part of this second venture.

Some retuning/debugging steps at high resolution and the start of experimentation in the global T224/c=1 configuration

(new Section added, from the v3 version of the documentation onwards, without any related update of the now frozen versions v1+v2 part of the documentation, Figures 1 to 4 included)

During the winter-spring 2012 seasons, the ALARO-0 configuration underwent several improving modifications. Those linked to 3MT were ported to 3MT-in-ARPEGE; they are:

- Forbidding the presence of convective condensation below the diagnosed lifting condensation level;
- Retuning the coupled GCVALFA/GDDEVF values to 3.E-05/0.12;

- Updating ARPEGE-type microphysical basic processes in ACACON and ACEVMEL (below APLMPHYS thus), in order to follow the recent introduction of rain refreezing in layers with temperature below 0°C and of an instantaneous Wegener-Bergeron-Findeisen-type adjustment. These two updates were taken from the basic ARPEGE set-up. (Remark: this brings closer to one another the ARPEGE-type and ALARO-type algorithms; ALARO has already got the description of both processes for a long time, however in smoother, less yes/no shape.);
- Correcting a coding bug in the downdraft related updates of falling liquid and ice water sedimentation. These updates are necessary because the computation of downdraft precipitation-evaporation happens after the microphysical part (APLMPHYS) of the cascade. (Remark: 3MT-in-ARPEGE tests surprisingly showed a rather strong impact of this bugfix in the tropics, in contrast to the tests made at mid-latitudes even in the extreme convective conditions of June-July 2009.).

In addition, following a suggestion from GMAP/PROC, the new baseline 3MT-in-ARPEGE set-up went back (*temporarily, see below why*) to the ARPEGE choice for the auto-conversion threshold values (2.E-04; 2.E-07; 3.E-05).

Tests in the unstretched T224 (90km) 96h configuration realised with the support of François Bouyssel were extremely helpful (also for understanding some aspects of the ALARO-0 behaviour, something not reported here). The intermediate above described 3MT-in-ARPEGE baseline showed the following deficiencies (regarding the global average) when compared to the ARPEGE reference and also to the global “zero-tendency” target for temperature and water vapour:

- Cold free-tropospheric bias of about 0.2 K/day;
- Dry upper-tropospheric bias;
- Some lack of mid- and upper-tropospheric radiative cloud-cover;
- Systematically too small amounts of prognostic as well as of radiative cloud water.

After numerous tests it was found that three steps (described below) were necessary and mostly sufficient to alleviate a great part of the mentioned deficiencies (see for instance Figures 5 to 11). It should also be said, that despite an intensive search, no other mean of improvement was found, which would not also substantially degrade the results at the 4.7 km resolution of LACE domain that was quite systematically used for cross-validation. The steps are as follows:

- Returning to the earlier proposal of the auto-conversion thresholds RQLCR, RQICRMIN and RQICRMAX, kept from ALARO set-up (3.E-04; 8.E-07; 5.E-05). => *It seems that the application of microphysics indifferently to convective- and/or stratiform-origin clouds requires to choose shorter auto-conversion time-scales (see also above in v1+v2 part the remark about RAUTEFR and RAUTEFS) as well as higher thresholds than when computing only for stratiform clouds (tests around the ALARO tuning choices did not show any clear prospective ground for further improvement). This happens also when using the ARPEGE Kessler-type computation (Remark: the ALARO algorithm for auto-conversion differs from ARPEGE one only by using a smoother transition around threshold values, as proposed by Sundquist; so the tuning constants have the same meaning on both sides).*
- Increasing along the vertical the values of the minimum critical relative humidity, used in Smith adjustment scheme, by about 15%. The maximum value RHCRIT2 of critical relative humidity near the surface is unchanged at 0.91 (it was of course also validated by tests).

=> The best compromise configuration (for increasing sufficiently the global cloud cover and keeping at the same time good scores in mid-latitude high-resolution tests) seems to be the following one: increasing GRHCMOD from 0.3 to 0.4 and simultaneously RHCRIT1 from 0.5 to 0.58.

- Increasing GCVNU value from 1.E-05 to 2.E-05, i.e. the parameter in the entrainment formulation that controls the height of the final detrainment of convective clouds.
  => This choice is a result of the "rule of three" compromise: the move to 3MT in ALARO-0 required a reduction of this parameter from 2.5 E-05 to 1.E-05, while ARPEGE (with the same ACCVIMP diagnostic convection scheme as ALARO-without-3MT) had evolved roughly at the same time towards 5.E-05. It should be noted that the impact of this change (a similar doubling in fact) was clearly positive in the global configuration, which was of course the aim, i.e. to make tropical convection reach a higher and more appropriate top-cloud-level. However it led to a clear deterioration of the scores in the June-July 2009 high-resolution mid-latitude tests, where model clouds appear reaching too high altitudes then. The reasons for this discrepancy will be investigated later; for the time being priority was given to the ARPEGE configuration with a recommended value of 2.E-05.

In the new proposed baseline configuration (i.e. with the three above retunings on top of the ALARO-0 2012 library upgrade) the only really remaining discrepancies (in terms of global mean T224/c=1 4 day tendencies) are:

- The free-tropospheric cold bias, about halved but not completely suppressed. It was checked that a similar shift to a colder equilibrium position also appears when moving to 3MT in ALARO. Therefore it seems to be the consequence of compensating errors in the basic tunings, independently for both packages. Likely it is linked to the case where separately computed convective and stratiform condensation processes create some double counting. Removing the source of such kind of compensating errors might take some time!
- A remaining lack of prognostic water content of low-level-clouds. Since this is not reflected in the (more important) radiative equivalent, the reasons for this difference with the ARPEGE results, which are the only available, and quite indirect, reference, were not investigated further.

Some specific graphical results

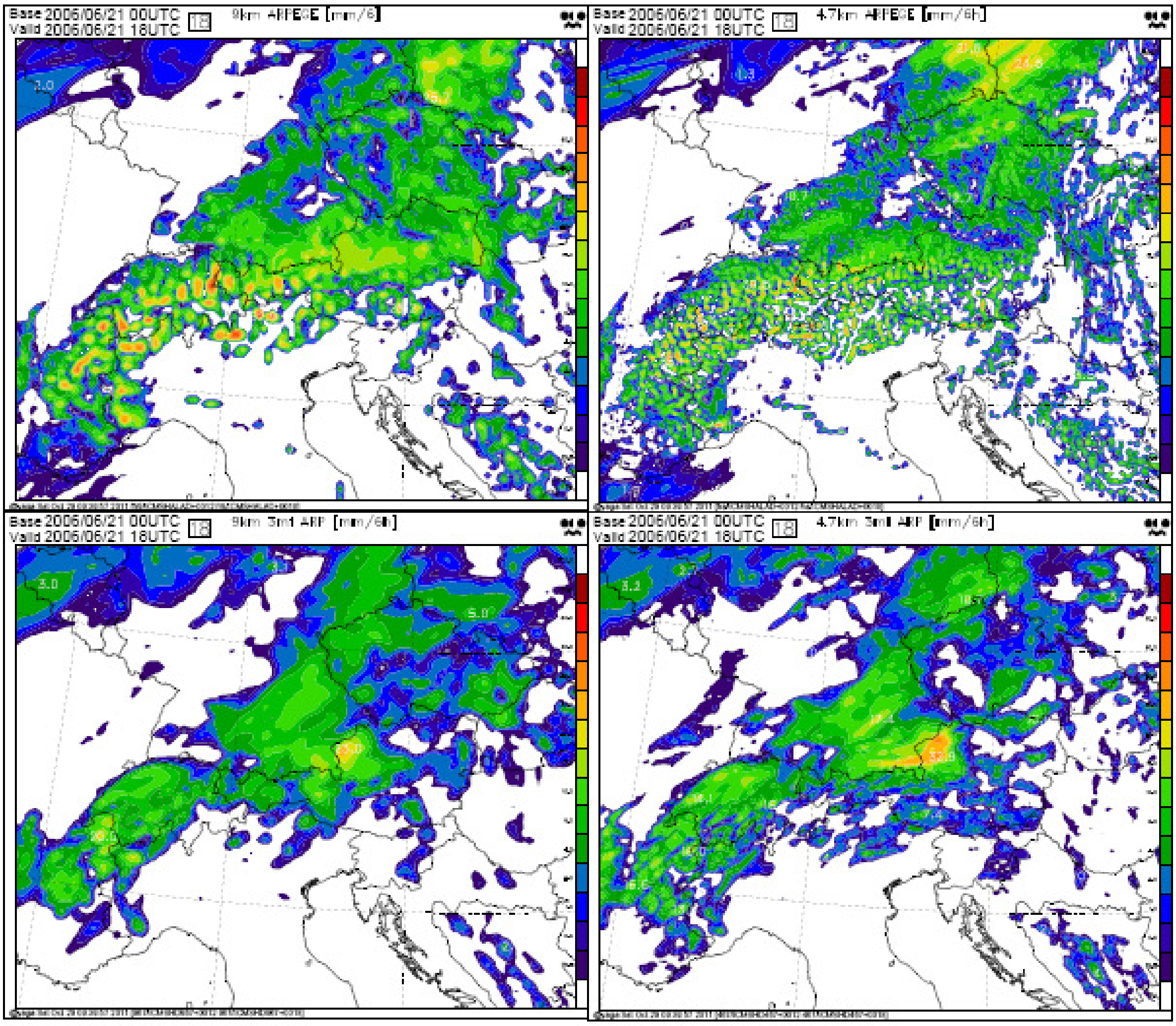


Figure 1: **Adequation of the "3MT in ARPEGE" configuration to the objective of avoiding problems in the horizontal structure of precipitations in the so-called grey-zone range of resolutions.** Six hour accumulated precipitation amounts for the period 12UTC to 18UTC on four runs with ALADIN-CZ domains (43 vertical levels), all starting on 21/06/2006 00UTC. ***Top-left picture***: 9.0km mesh-size and ALADIN transcription of the *native ARPEGE set-up*. ***Top-right picture***: the same *but* with a 4.7km mesh-size. ***Bottom-left picture***: 9.0km mesh-size and the above described *"3MT in ARPEGE" basic set-up*. ***Bottom-right picture***: the same *but* with a 4.7km mesh-size.

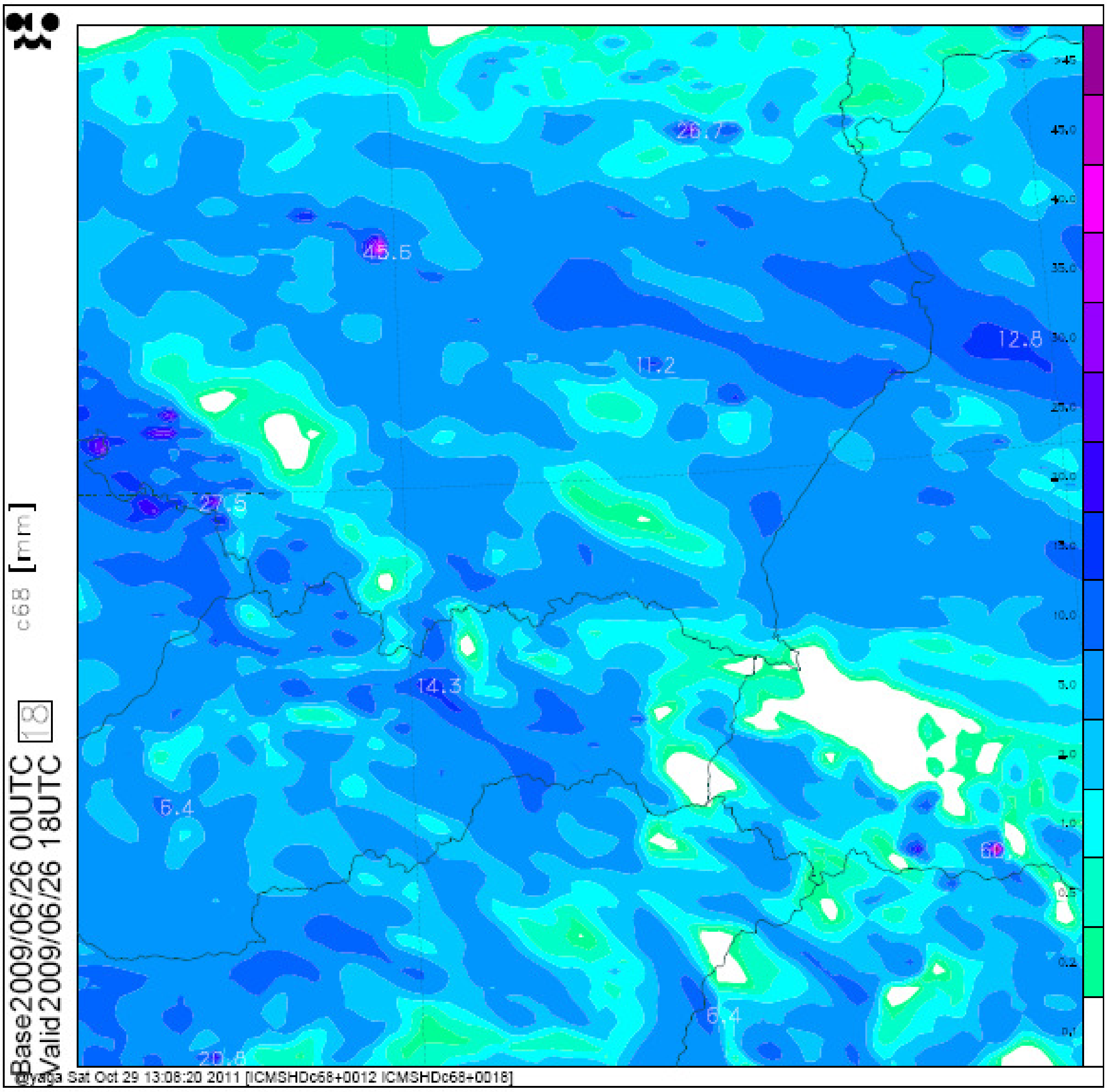


Figure 2a: **Proof of the existence of the "grid-point-storms" syndrome when the native ARPEGE solution is chosen for the thermodynamic adjustment in connection to 3MT.** Six hour accumulated precipitation amounts for the period 12UTC to 18UTC on two runs with the ALADIN-CE domain operational at CHMI, all starting on 26/6/2009 00UTC. ***Top picture of Figure 2***: 4.7km mesh-size, 87 levels and the above described "3MT in ARPEGE" set-up *but* without the two "imports" from Smith-Gerard (infinite RDPHIC and vanishing ZEPS2 in ACNEBCOND). There are two grid-point-storms in this particular part of the whole domain (and more elsewhere): the first one in the area of Kielce in Poland and the second one in the area of Rachiv in Ukraine.

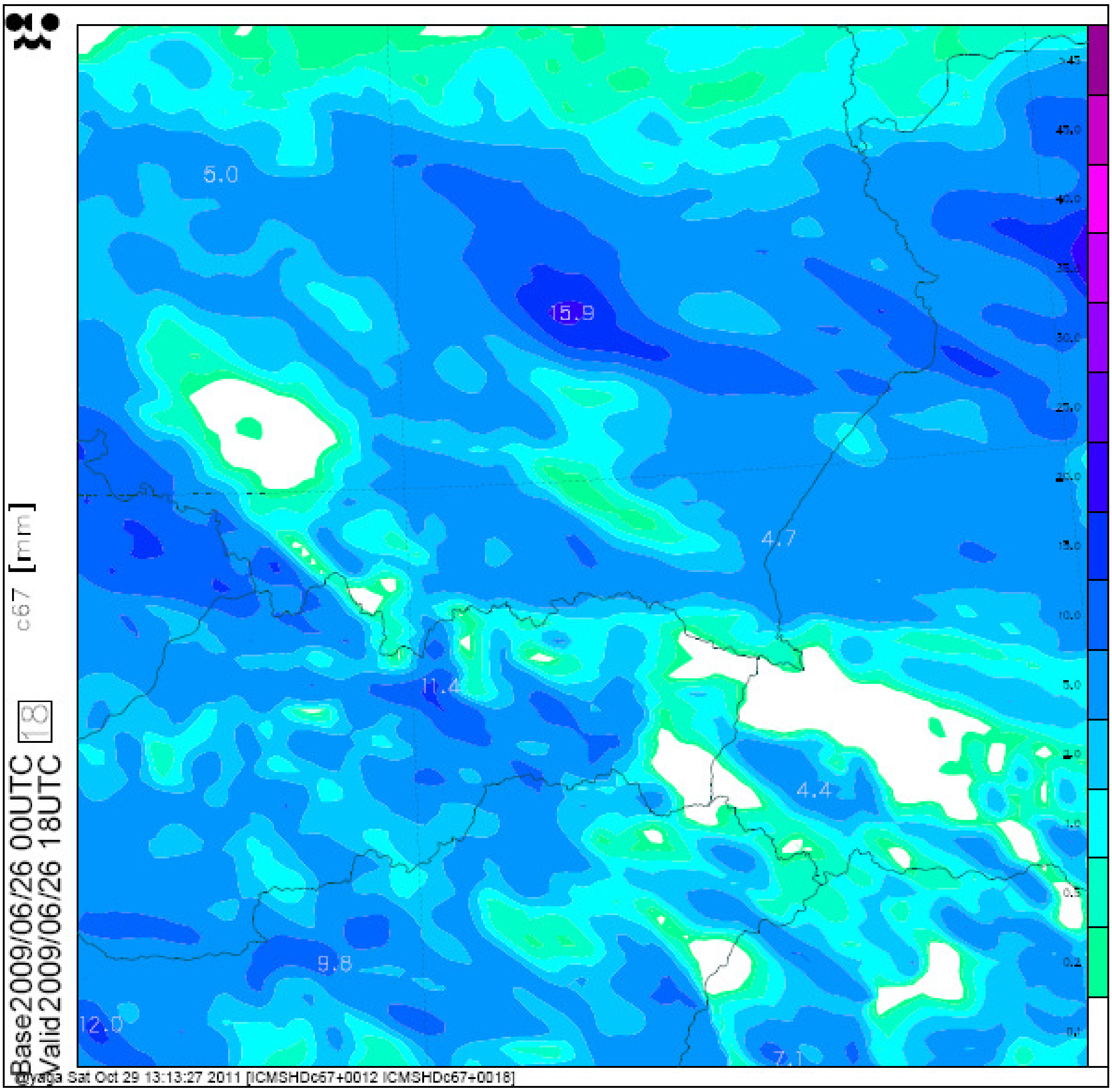


Figure 2b: **Validation of the above-proposed cure.** Six hour accumulated precipitation amounts for the period 12UTC to 18UTC on two runs with the ALADIN-CE domain operational at CHMI, all starting on 26/6/2009 00UTC. ***Bottom picture of Figure 2***: 4.7 km mesh-size, 87 levels and the above described "3MT in ARPEGE" basic set-up. The grid point storms have indeed disappeared.

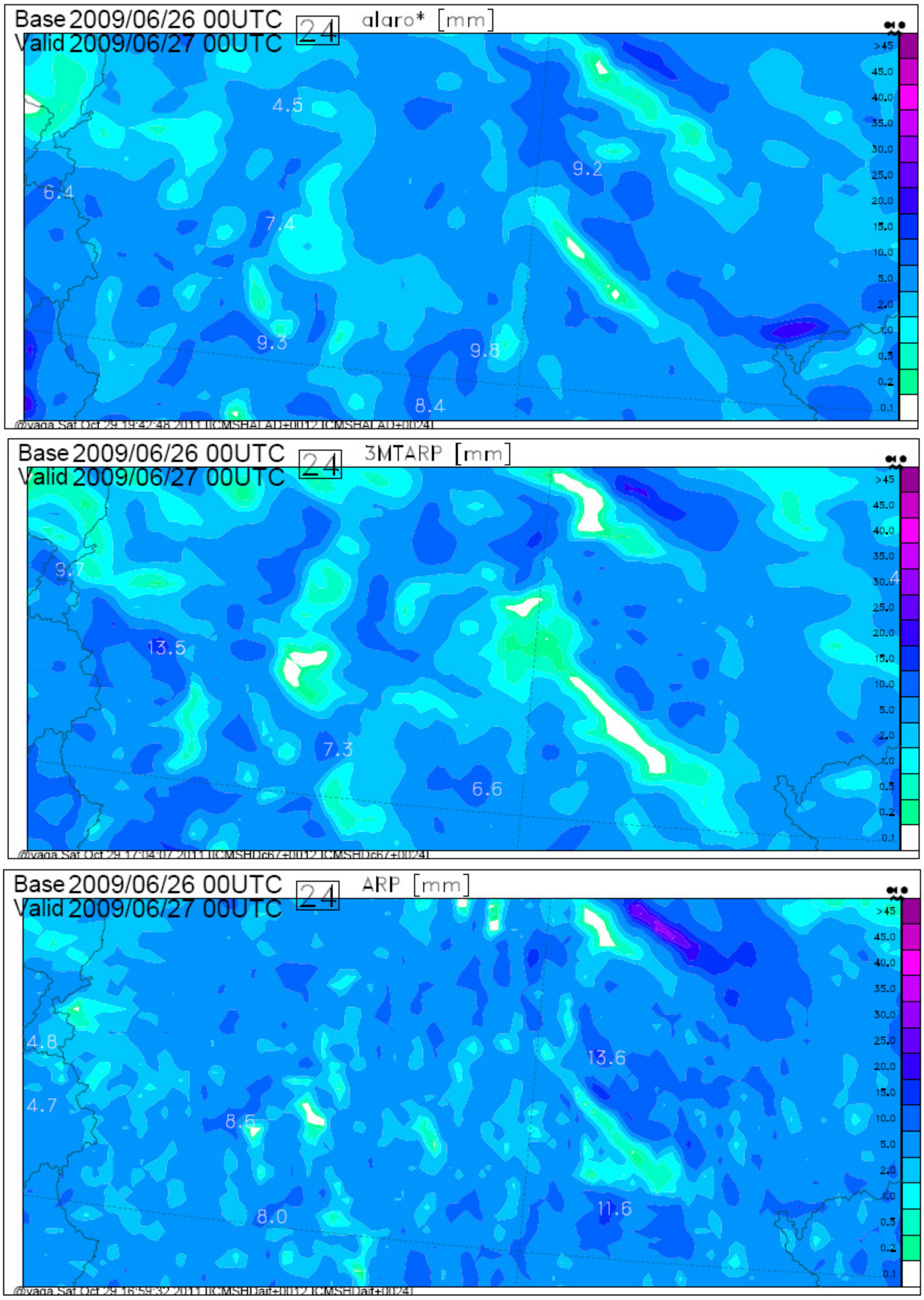
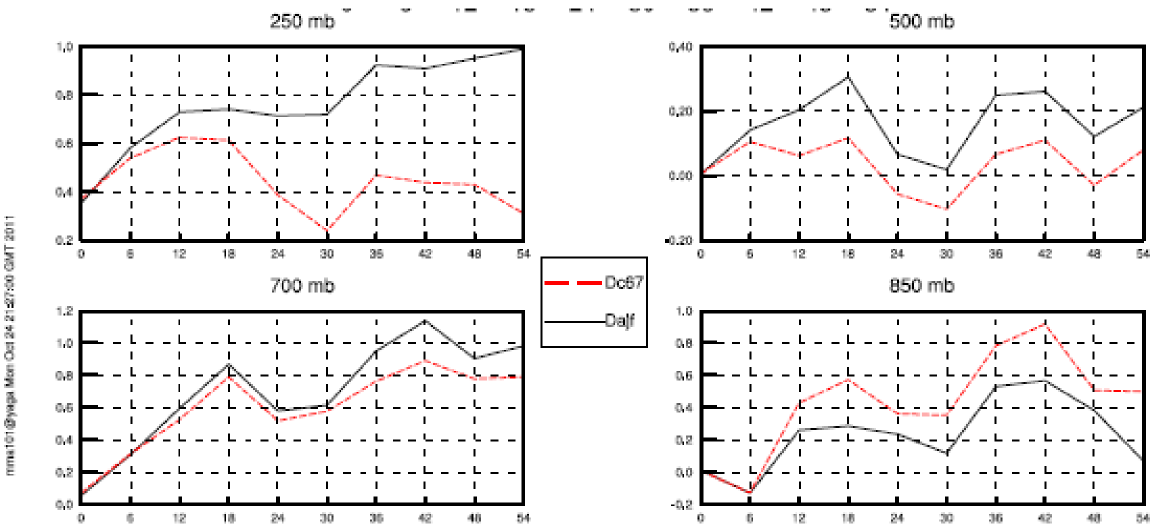
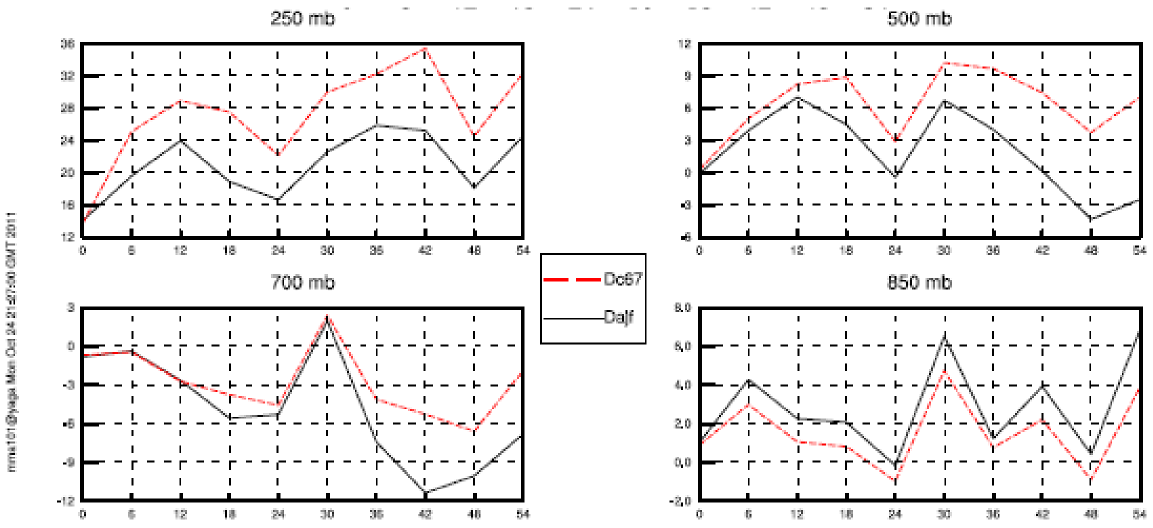


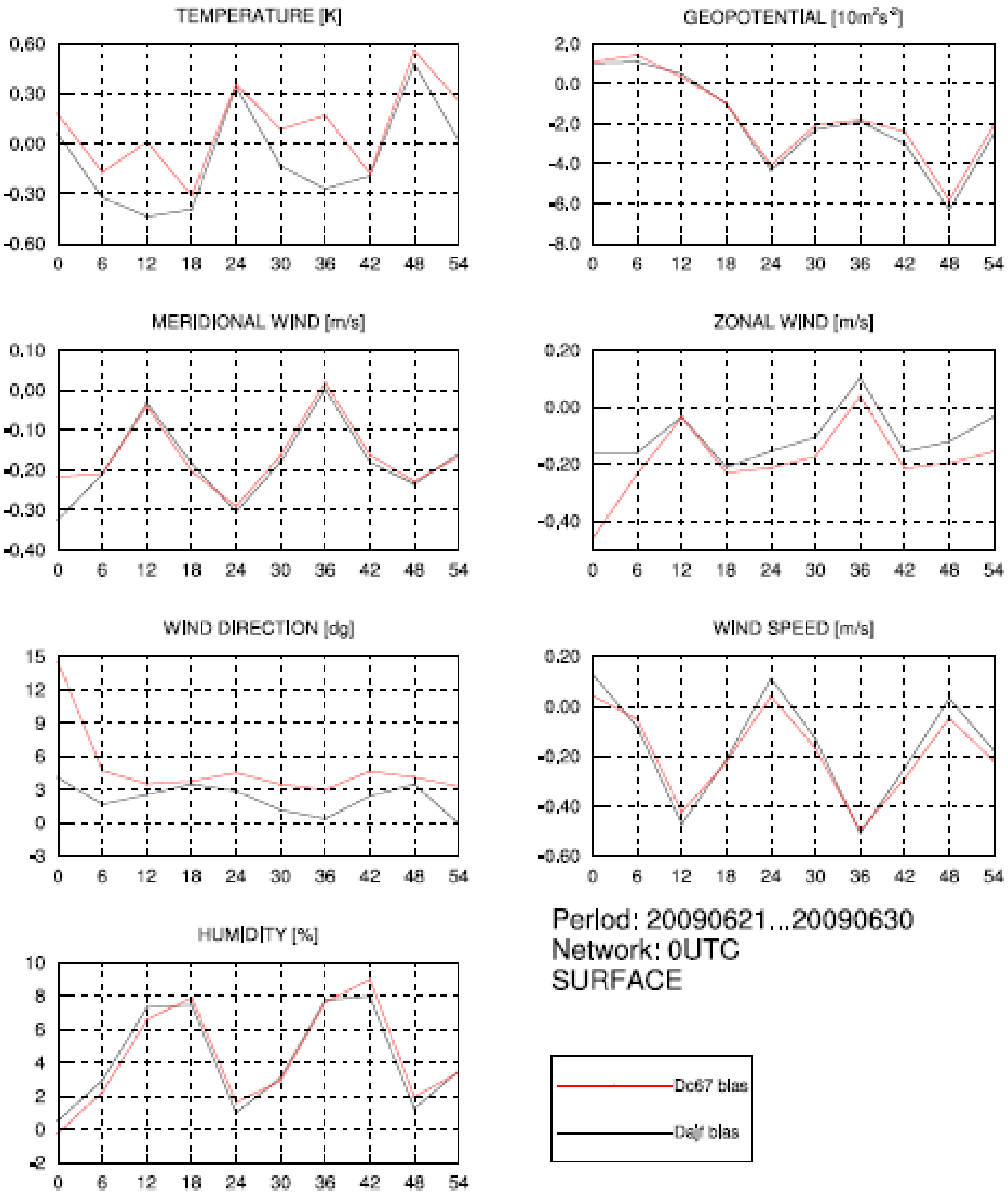
Figure 3: **Grey-zone-type results in a non-mountainous area (as complement to the alpine results of Figure 1).** Twelve hour accumulated precipitation amounts for the period 12UTC to 24UTC on three runs within the ALADIN-CE domain (4.7km mesh-size and 87 levels), all starting on 26/6/2009 00UTC. ***Top picture***: *ALARO-0 configuration* (but with the ARPEGE advection and horizontal diffusion set-ups). ***Middle picture***: proposed *"3MT in ARPEGE" basic set-up*. ***Bottom picture***: ALADIN transcription of the *native ARPEGE set-up*. Even if the noise issue is less clear (owing to the longer time window, intentionally chosen for that) a better structuring of precipitation areas clearly appears in both cases with 3MT, and even a bit more for "3MT in ARPEGE"!



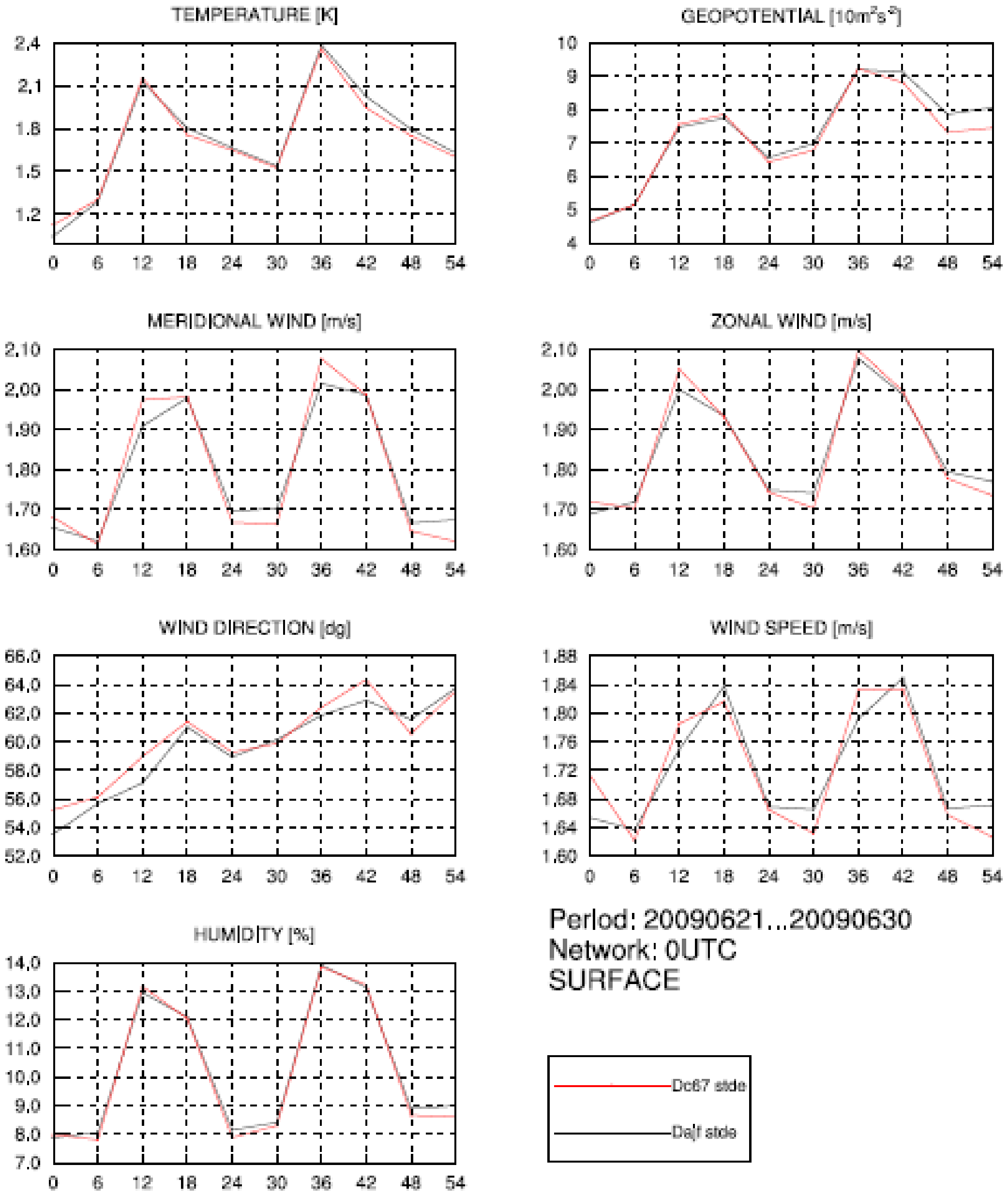
Bias in the temperature forecast at various pressure values



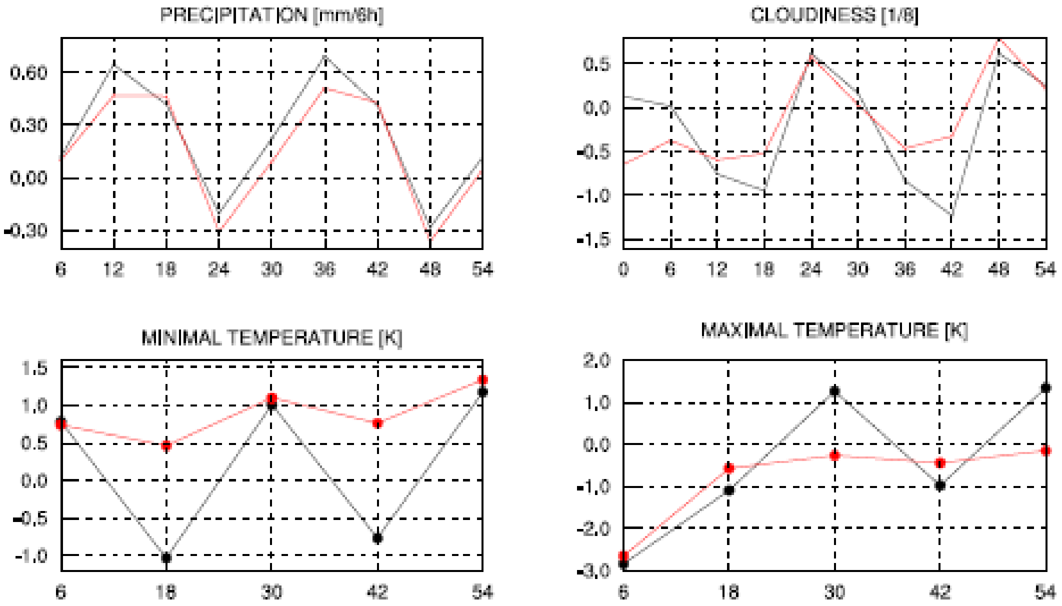
Bias in the relative humidity forecast at various pressure values



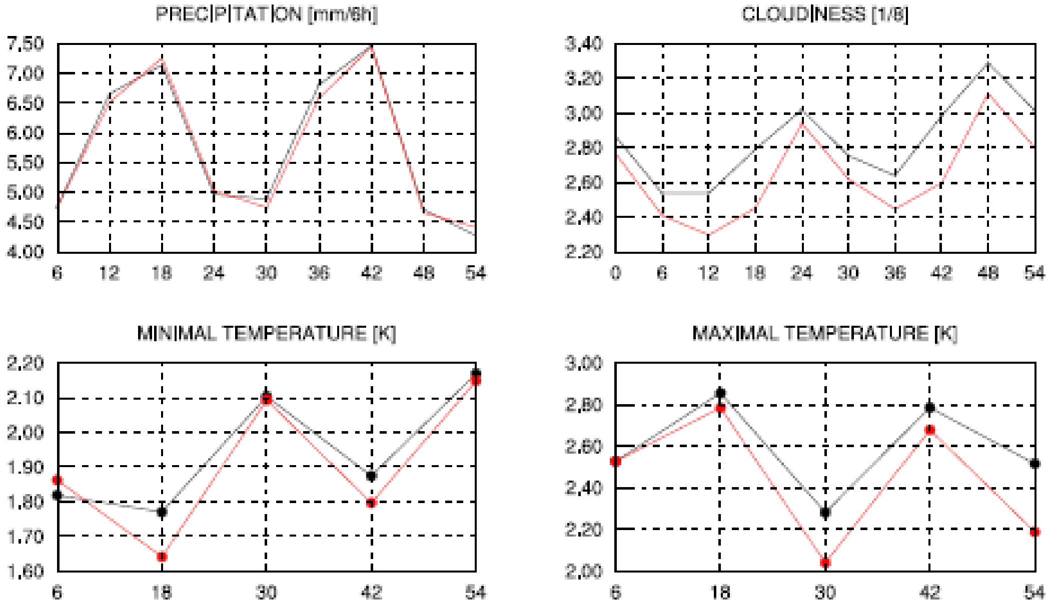
Bias in the surface parameters forecast (first part)



Standard deviation in the surface parameters forecast (first part)



Bias in the surface parameters forecast (second part)



Standard deviation in the surface parameters forecast (second part)

Figure 4: **Most significant differences in terms of scores (with respect to TEMPs and SYNOPs) for a ten day period (21 to 30/06/2009) on the ALADIN-CE geographical setting (4.7 km mesh-size and 87 vertical levels).** ***Dajf*** is the result of a run with the *ARPEGE native configuration*, in full cycling mode. ***Dc67*** is the result of 10 independent forecasts in *"basic 3MT in ARPEGE"* mode, starting from the results of an ALARO-0 cycling (in order to have as balanced as possible initial values of the prognostic variables for the convective mass-fluxes). The discrepancy between the cycling modes explains the rather big differences at the start of the verification (00 range) for the surface part of the results, but the scores were chosen to be probably robust to this problem at other ranges. The colour code is the same for all above diagrams of Figure 4.

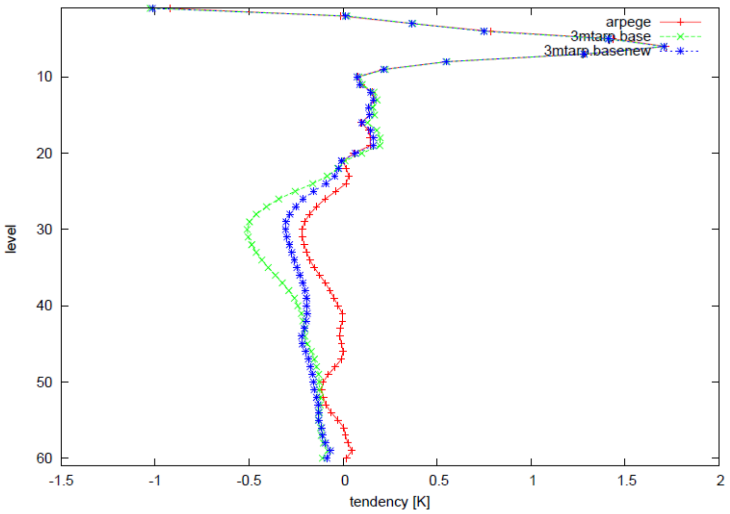


Figure 5: **Temperature tendency in terms of global norms after 96h forecast at T224, c=1.** ARPEGE set-up is red, 3MT in ARPEGE with corrected bug in downdraft update and old tuning is green, 3MT in ARPEGE with corrected bug in downdraft update and newly proposed tuning is blue.

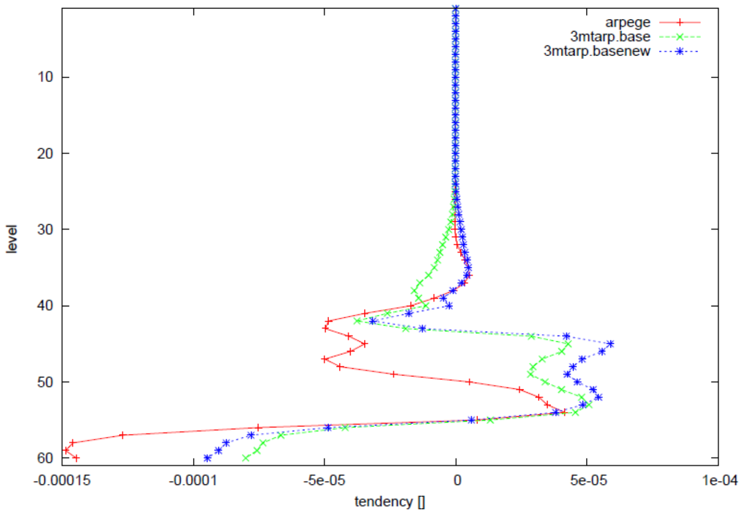


Figure 6: **Water vapour tendency in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.

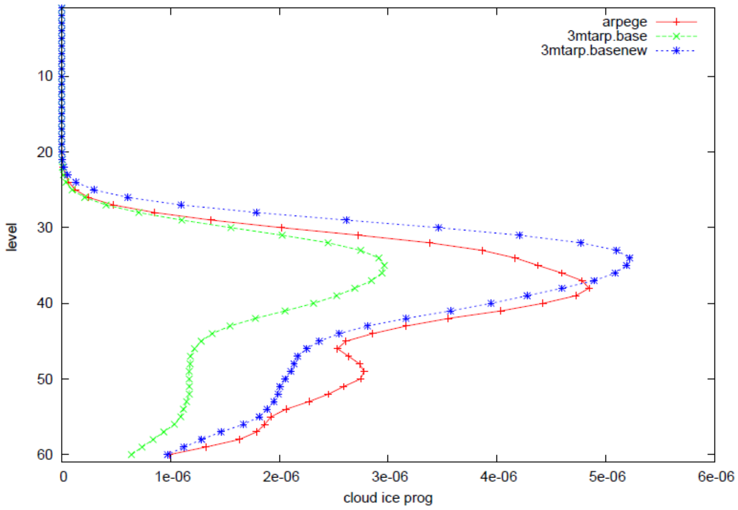


Figure 7: **Prognostic cloud ice values in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.

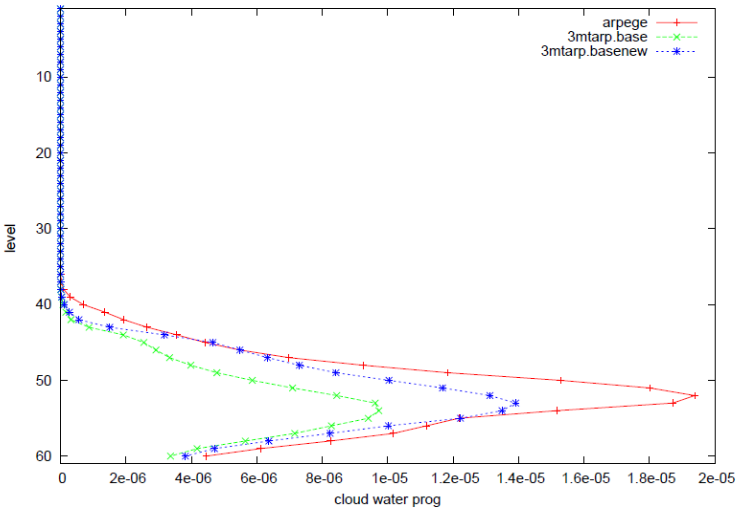


Figure 8: **Prognostic cloud liquid water values in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.

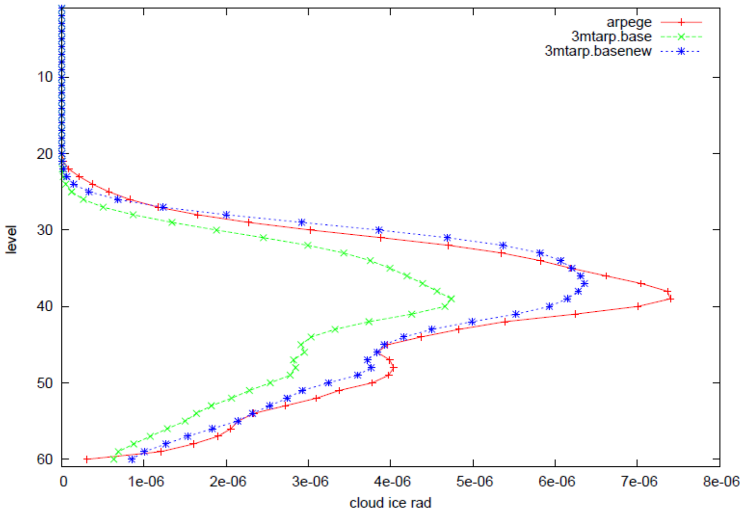


Figure 9: **Radiative cloud ice values in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.

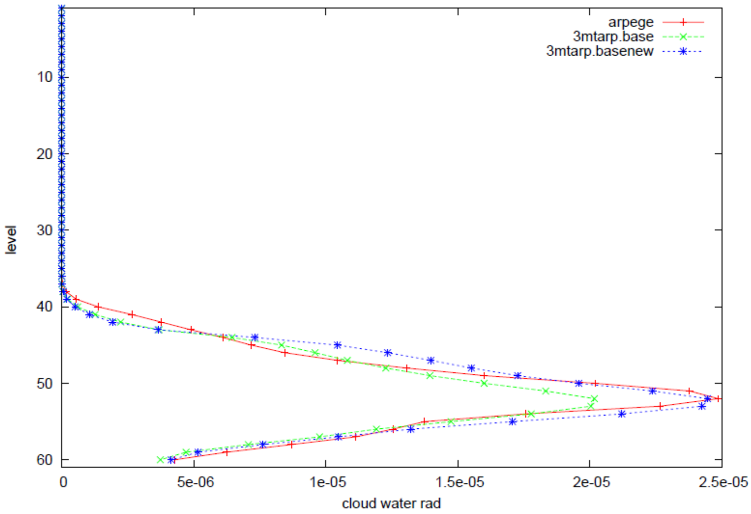


Figure 10: **Radiative cloud liquid water values in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.

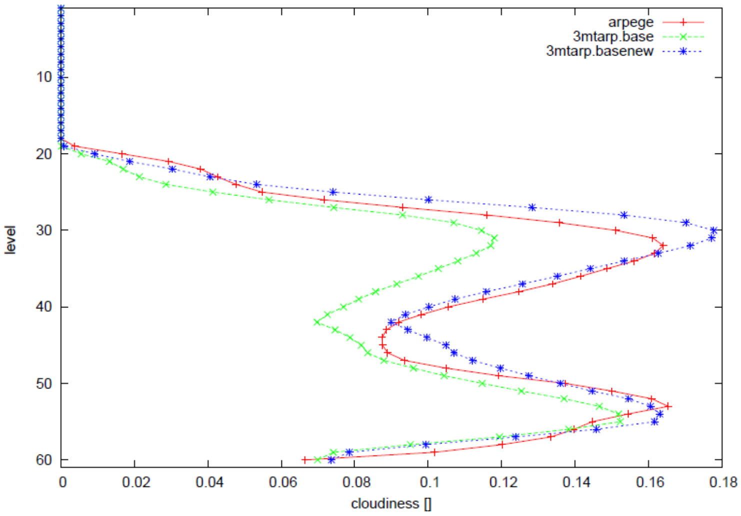


Figure 11: **Cloudiness values in terms of global norms after 96h forecast at T224, c=1.** Labels are like for Figure 5.