# Technical report on stay at ZAMG

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# Setting up new ALADIN-LAEF domain and retuning of blending ratio accordingly

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## Foreword:

Demand for bigger ALADIN-LAEF domain with better topography representation arose mostly out of two reasons. One of them is inclusion of the whole Black sea (requested by Romania) and coverage of Turkey (as a new ALADIN partner) in the computational ALADIN-LAEF domain. The second reason is the request for the cooperation with GLAMEPS (Grand Limited Area Model Ensemble Prediction System). Hence the key factors for setting up new ALADIN-LAEF domain were as follows:

a) To cover up whole Turkey and the Black sea (unconditionally).
b) To enlarge the domain as much as possible towards the north and west taking into consideration the pre-operational GLAMEPS domain.
c) Increase horizontal resolution to approximately 10-12km (as much as we can afford).
d) To cover whole Mediterranean Sea.
e) …and at the same time not exceed serviceable CPU time limit at ECMWF's HPC which is available for Austria (upper limit would be something like $16x10^6$ SBUs instead of current $2x10^6$ SUBs spent by operational ALADIN-LAEF suite with actual smaller domain and 18km horizontal resolution).

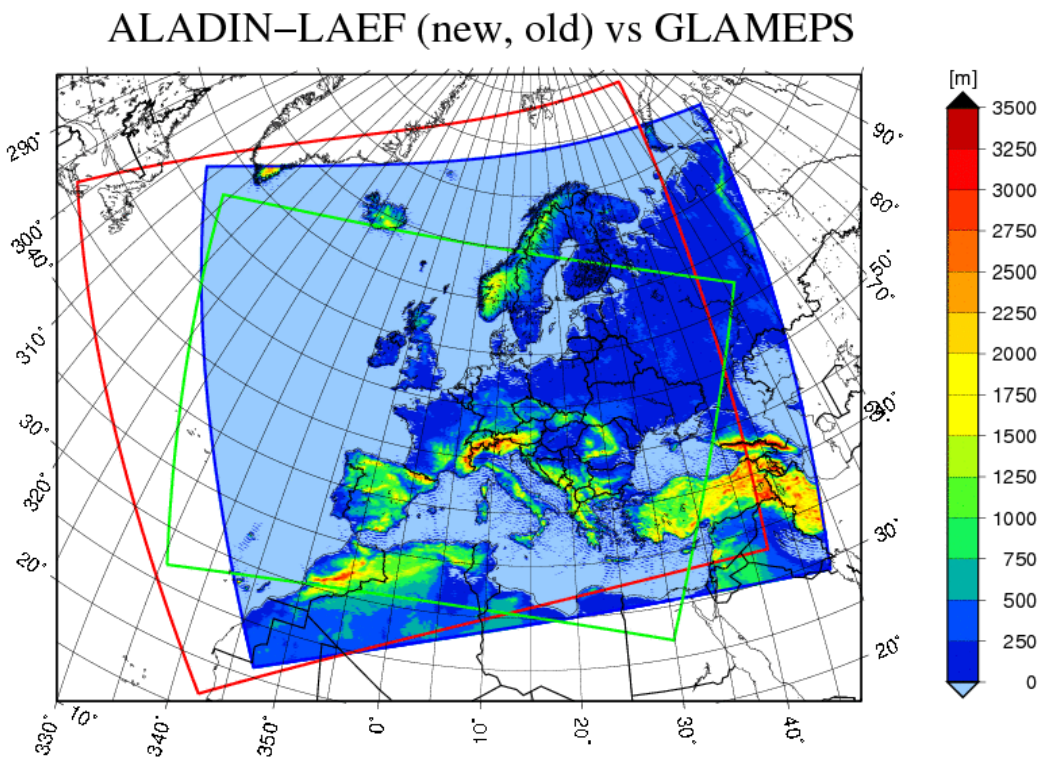
Afterwards some research is planned to answer the question, whether more profit would be gained from such high resolution ensemble or rather from increased number of ensemble members at the new domain but necessarily with coarser horizontal resolution (currently we have 16 members at $\Delta x$ = 18km).

New blending ratio must be re-computed (and corresponding low spectral resolution CLIM files prepared) regarding new ALADIN-LAEF domain.

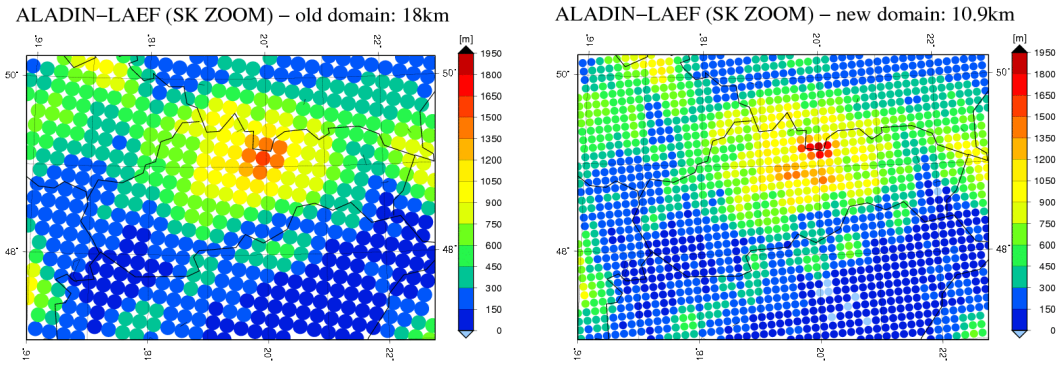
Eventually, all this effort should come into operations just by the end of 2010, mostly because of only limited number of SBUs which are now available for Austria and also because some precise parallel testing of the whole LAEF suite must be done at first.

## Setting up new domain:

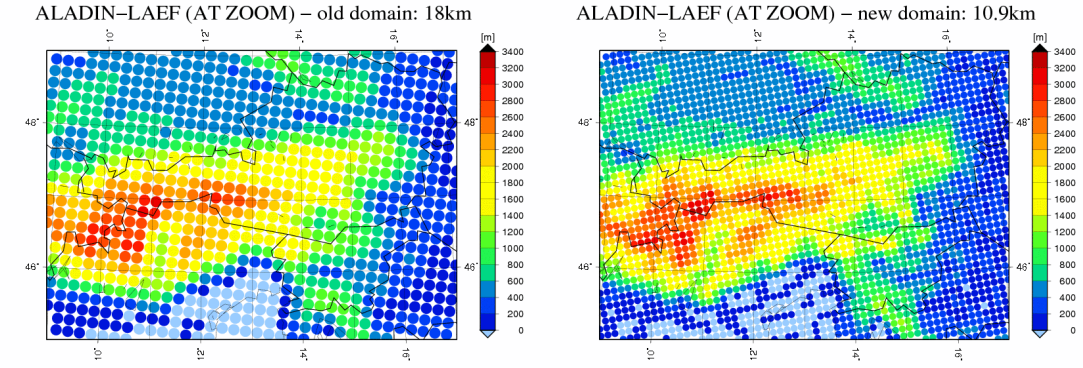
On the following picture (**Fig.1**) you can see the comparison of the old operational ALADIN-LAEF domain (green rectangle) with the new one (blue rectangle, topography map) and also with the GLAMEPS/ALADIN domain (red rectangle). Next maps (**Fig.2**-**4**) are shoving the effect of increased horizontal resolution on local topography, for instance the presence of valley between High and Low Tatras (zoom over Slovakia) which was not resolved by 18km grid (see **Fig.2**). Significantly better representation of Alpine ridges and valleys can be observed on domain zoom over Austria as well (**Fig.3**).



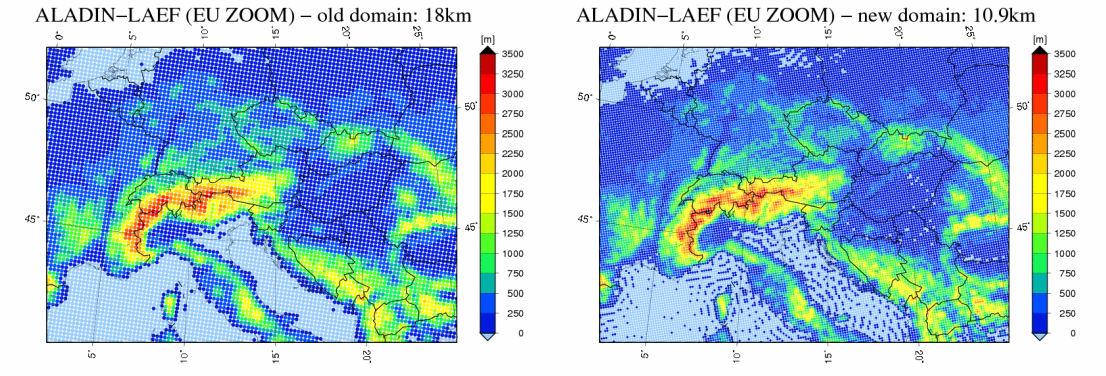

**::Fig.1** New ALADIN-LAEF domain




**::Fig.2** Zoom over Slovakia for Δx 18km (left) and 10.9km (right)




**::Fig.3** Zoom over Austria for Δx 18km (left) and 10.9km (right)




**::Fig.4** Zoom over Central Europe for Δx 18km (left) and 10.9km (right)

New ALADIN-LAEF domain definition:

```
&NAML
 NROTEQ      =  -1 ,
 REF%LON     =  30. ,
 REF%LAT     =  40. ,
 CENTER%LON  =  10. ,
 CENTER%LAT  =  52.50000000000001 ,
 SW%LON      =  -12.73220178248988 ,
 SW%LAT      =  20.982321720515007 ,
 NE%LON      =  71.89119737467462 ,
 NE%LAT      =  71.6421428436294 ,
 ERPK        =  0.6427876096865393 ,
 PDL%ONX     =  10900. ,
 PDL%ONY     =  10900. ,
 KGIVO       =  0 ,
 KSOTRP      =  0 ,
 NDLUN       =  1 ,
 NDLUX       =  573 ,
 NDGUN       =  1 ,
 NDGUX       =  480 ,
 NDLON       =  600 ,
 NDGL        =  500 ,
 NMSMAX      =  199 ,
 NSMAX       =  166 ,
/
```

In comparison with the old domain we have increased number of points in X-direction by factor 1.85 (324→600) and in Y-direction by factor 2.22 (225→500) and also due to increased horizontal resolution from 18 to 10.9km we had to shorten integration TSTEP circa 1.7-times. Number of vertical levels was not changed, so all together an approximate increase of CPU requirements would be about 7 (still acceptable).

## Re-computing blending ratio:

Due to changes in ALADIN-LAEF target domain horizontal resolution (18km →10.9km) blending ratio must have been re-computed accordingly (see following computation).

1 $T^{fa}{}_{ECM} = T^{f}{}_{ECM} * m = 399 * 1 = 399$

2 $T^{a}{}_{ECM} = \sqrt{T^{fa}{}_{ECM} * T^{m}{}_{ECM}} = \sqrt{399 * 42} \cong 129$

3 $T^{f}{}_{ALD} = L/(3 * dx) = 40000/(3 * 10.9) \cong 1223$

4 $T^{c}{}_{ALD} = \sqrt[3]{T^{a^2}{}_{ECM} * T^{f}{}_{ALD}} = \sqrt[3]{129^2 * 1223} \cong 273$

5 $r_b = T^{f}{}_{ALD} / T^{c}{}_{ALD} \cong 4.5$

6 $r_c = T^{f}{}_{ALD} / T^{fa}{}_{ECM} \cong 3.6$

7 $\sqrt{N_L{}^2 + M_L{}^2} * r_b \cong \sqrt{N_H{}^2 + M_H{}^2}$ *and* $\frac{N_L}{M_L} \cong \frac{N_H}{M_H} \cong \frac{NDGL}{NDLON}$

$\Rightarrow N_L = 37$

$\Rightarrow M_L = 45$

New spectral truncations for low spectral resolution (grid point resolution is kept unchanged) used during digital filtering in blending procedure will be now 37 and 45 (while full spectral resolution is 166 and 199).

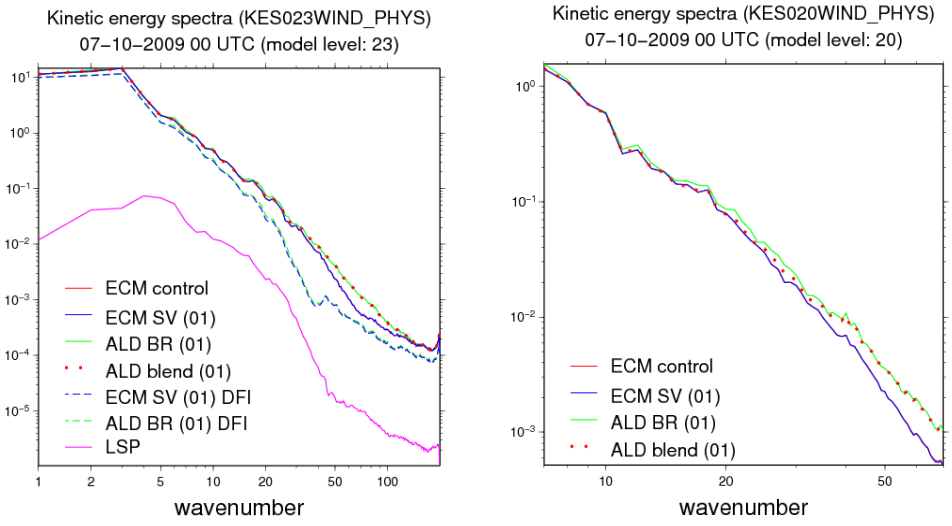
$$NSTDFI \geq \frac{0.69 * TAUS}{2 * RTDFI}$$

$NSTDFI \geq 4.3$ (and it must be even number)

$\Rightarrow NSTDFI = 6$

This means, that we will integrate digital filter for 12 steps (less then 5 hours) each direction (with constant coupling). Horizontal diffusion should be also rescaled by the blending factor (i.e. RRDXTAU = 123/$r_b$ = 27 in NAMDYN). For more details about the meaning of the equations 1-7 please see *Martin Belluš, 2008: Combination of large scale initial conditions uncertainty with small scale initial perturbations obtained by breeding cycling using blending technique in LAEF experiments - Report on stay at ZAMG 11/02 - 21/03/2008, Vienna, Austria*.

Pictures of kinetic energy spectra are showing the small scale information in new initial state (represented by red dotted line) which was inherited from breeding-blending cycle (**Fig.5**).




**::Fig.5** Kinetic energy spectra examples (zoom for selected wave numbers right)

## Preparing new climatology files:

Climatology files for the new target domain as well as for low spectral resolution necessary for digital filtering in blending procedure have been created on Meteo-France HPC yuki. The scripts for configuration e923 and the corresponding CLIM files can be found here:

yuki: ~mrpe733/e923/… scripts
cougar: /home/m/mrpe/mrpe733/LAEF/CLIM/… climatology files

or

zaanfe: ~laef/bellus/CLIM/LAEF_11km/laef_higres_q_m<MM> high resolution
laef_lowres_q_m<MM> low resolution

## Testing new ALADIN-LAEF domain:

First technical tests of new ALADIN-LAEF domain with the full breeding-blending cycle were performed on NEC SX8R at ZAMG/Vienna and at ECMWF's HPC (c1a cluster) as well.

Time consumption statistics from running blending jobs on NEC SX8R at ZAMG using 4 CPUs (**old domain / new domain**):

| **Blending step** | **Wall clock time** | **ratio** |
|---|---|---|
| [1] Convert ECMWF file to low spectral resolution (via ee927) | **12 / 28 sec** | 2.33 |
| [2] Convert ALADIN file to low spectral resolution (via ee927) | **13 / 30 sec** | 2.31 |
| [3] Run DFI on ECMWF file with low spectral resolution (via e001) | **18 / 96 sec** | 5.33 |
| [4] Run DFI on ALADIN file with low spectral resolution (via e001) | **19 / 96 sec** | 5.05 |
| [5] Convert filtered ECMWF file to high spectral resolution (via ee927) | **8 / 30 sec** | 3.75 |
| [6] Convert filtered ALADIN file to high spectral resolution (via ee927) | **8 / 30 sec** | 3.75 |
| [7] ECMWF filtered minus ALADIN filtered at high spectral resolution (via blend) | **1 / 2 sec** | - |
| [8] Add ECMWF long wave spectra to the ALADIN short wave spectra (via blend) | **1 / 3 sec** | - |

Time consumption statistics from running breeding jobs on NEC SX8R at ZAMG using 8 CPUs (**old domain / new domain**):

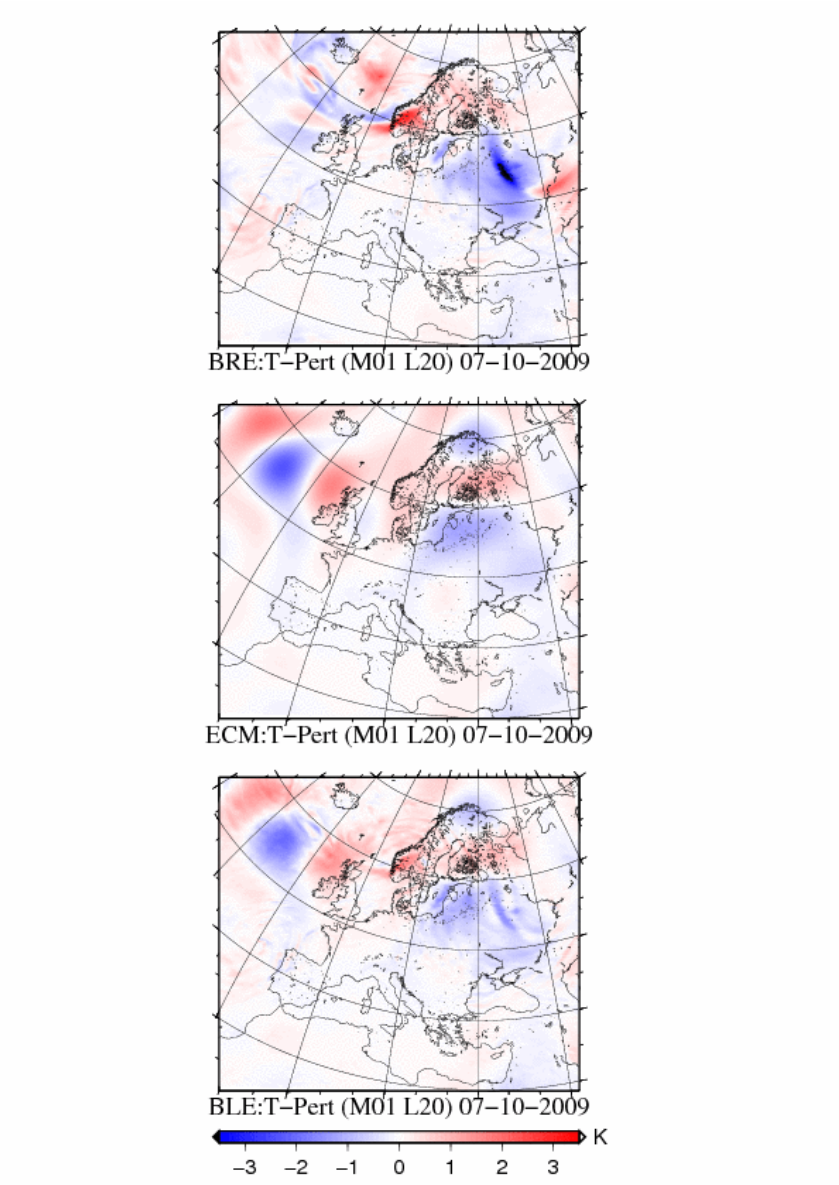
| **Breeding step** | **Wall clock time** | **ratio** |
|---|---|---|
| [1] 'P' member: 12 hours integration (via e001) | **41 / 172 sec** | 4.20 |
| [2] 'N' member: 12 hours integration (via e001) | **42 / 171 sec** | 4.07 |
| [3] 'P' perturbation and scaling (via Pptbini, ptbPSini) | **5 / 15 sec** | 3.00 |
| [4] 'N' perturbation and scaling (via Nptbini, ptbPSini) | **4 / 15 sec** | 3.75 |

It is obvious, that the procedure steps running integration (e001) are most affected by the enlarged domain and higher resolution, while the steps running fullpos (ee927) are affected

only by enlarged domain. However, the ratio is still a bit smaller than what was expected (which is good ;-).

On c1a cluster at ECMWF just the part of ALADIN-LAEF cycle was tested up to now. The observed increase of SBUs consumed by the surface perturbations computation (which consists of 12h integration at full resolution) was by factor 8. These preliminary results are still acceptable considering that the other resources (now used for parallel computation of ALADIN-EUROPE with $\Delta x$ = 6.5km) will be enabled for ALADIN-LAEF suite in the near future.

The following picture (**Fig.6**) show initial Temperature perturbation generated by breeding-blending cycle running already on the new ALADIN-LAEF domain (Temperature perturbation at model level 20 for ensemble member 01 is shown). It is for technical demonstration purpose only, since the results come from the first loop after cold start, but nevertheless perfectly proving the mixing mechanics of the large scale uncertainties with LAM generated high frequency perturbation.




**::Fig.6** Initial Temperature perturbation from LAM breeding (up), from ECMWF singular vectors (middle) and the resultant LAEF perturbation (bottom)

## Some technical notes:

- Breeding

There was a problem with the mixing of new and old FA file headers. Fortran programs for creating the breeding perturbations of 3D atmospheric fields, worked originally only with the old EGGX headers. New aladin blend utility from cy32t1 to the contrary worked only with the new file headers. Hence, the best solution was to upgrade the Pptbini.F90, Nptbini.F90 and ptbPSini.F90 source codes to be able to read both old and new FA file headers.

**Debugging:**
Problem was in: → esetup_trans → suemp_trans_prelog_mod
(setup distributed environment for the transform package)

input FA with the old eggx header:

```
 R_ZGEOM:          0.000000000000000D+00          0.000000000000000D+00
0.000000000000000D+00         6.060966465046848         0.3662105987357089
1.254738097389176           1.250391275805426         0.5235987755982988
0.6981317007977318         0.6427876096865393        0.000000000000000D+00
0.000000000000000D+00          6539999.999999995         5450000.000000002
10899.99999999999          10900.00000000000         9.607316983455032D-07
1.152878038014602D-06      0.000000000000000D+00     0.000000000000000D+00
0.000000000000000D+00   0.000000000000000D+00

 Z_EXWN:  9.607316983455032D-07 (index 17)
 Z_EYWN:  1.152878038014602D-06 (index 18)
```

input FA with the new eggx header:

```
 R_ZGEOM:   -1.000000000000000   0.6427876096865393   0.5235987755982988
0.6981317007977318          0.1745329251994335          0.9162978572970232
10899.99999999999           10900.00000000000           6539999.999999995
5450000.000000002        9.607316983455032D-07       1.152878038014602D-06
6.060966465046848           0.3662105987357089          1.254738097389176
1.250391275805426        0.000000000000000D+00       0.000000000000000D+00
0.000000000000000D+00      0.000000000000000D+00     0.000000000000000D+00
0.000000000000000D+00   0.000000000000000D+00

 Z_EXWN:  0.000000000000000D+00 (wrong) ...changed to index 11
 Z_EYWN:  0.000000000000000D+00 (wrong) ...changed to index 12
```

**Bugfix:**

```
if ( R_ZGEOM(1) == 0.0 ) then
  ! old eggx headers
  Z_EXWN=R_ZGEOM(17)
  Z_EYWN=R_ZGEOM(18)
endif

if ( R_ZGEOM(1) == -1.0 ) then
  ! new eggx headers
  Z_EXWN=R_ZGEOM(11)
  Z_EYWN=R_ZGEOM(12)
endif
```

+ enlarged some array dimensions regarding bigger domain

Modified source codes and the compilation scripts can be found on zaanfe1.zamg.ac.at in */home/bellus/src_breeding*.

Warning: The output from perturbation procedure will have the same file header as the third input file (the control analysis), since the final perturbed and rescaled 3D fields are just replacing the original 3D fields in that input-output file. After the conversion of ECMWF GRIB files (taken from MARS database) into FA files via configuration 901, the parameter NCADFORM=-1 must be set in the namelist of configuration e927 to obtain files with EGGX new style format headers. Initially the default value (NCADFORM=0) was used in our former experiments with ALADIN-LAEF on original domain (there is two-month experimental data set from 2007 of ECMWF's EPS SV boundary conditions and the same "strategy" for BC is still used in the operational ALADIN-LAEF suite too).

- Blending

ALADIN blending tool (ald/programs/blend.F90) must have been recompiled with increased dimensions for JPMXGPTOT (and also JPMXSPEC2) which is equivalent to the number of all grid points (new domain size already exceeded prescribed values). Some minor changes to the blend namelist were done as well.

```
&NAMBLEND
  CL_FNAME1='__FNAME1__',
  CL_FNAME2='__FNAME2__',
  CL_FNAME3='__FNAME3__',
  Z_NSIGN=__NSIGN__,
  L_SPEC_HYDRO=.TRUE.,
&END
```