Testing of a modified shallow convection parametrization with AROME at 500 m horizontal resolution

LACE stay report
Toulouse – Météo-France/CNRS,
02. Oct. 2017 – 27. Oct. 2017

Scientific supervisor: Rachel Honnert (CNRM UMR 3589, Météo-France/CNRS)

Report made by: Dávid Lancz (HMS – Hungarian Meteorological Service)

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1) Introduction

Based on the works of the previous LACE stays in Toulouse we proposed a new closure for the shallow convection parametrization. The aim of this improvement was to compute the turbulence parametrization scale-adaptively at those resolutions, where the dynamical core of the model resolves partly the shallow convection eddies, i.e. in the gray zone. At these high resolutions (100 – 1000 m) the subgrid turbulent flux has to be moderated, because the resolved turbulent flux increase with higher horizontal resolution (shown in Honnert et al. 2011).

The turbulence in the AROME (Application of Research to Operations at MesoscalE) model is treated by the EDMF (Eddy Diffusion – Mass Flux) scheme. In the EDMF the ED part represents the local mixing, while the MF part the non-local mixing of the shallow convection and it presumes a subgrid thermal in the grid-box. The initialization of the mass-flux at the surface of this thermal is given by this equation (Pergaud et al. 2009):

$$M_u(z_{grd}) = C_M \left(\frac{g}{\overline{\theta_{vref}}} \overline{w'\theta'_{vs}} L_{up} \right)^{1/3} , \qquad (1)$$

where g is the gravity acceleration [m/s^2], $\overline{\theta_{vref}}$ is the mean virtual temperature [K], $\overline{w'\theta'_{vs}}$ is the surface buoyancy flux [Km/s] and L_{up} is the Bougeault and Lacarrère upward mixing length [m]. The C_M coefficients value is 0.065 and it was estimated from LES (Large-Eddy Simulation) results using the conditional sampling method.

Our modification is also based on LES results which were transformed into fields with lower resolution by the coarse-graining method (Honnert et al. 2011). The resolved mass-flux values at the surface were estimated with the conditional sampling method too. The resolved mass-flux from the LES was considered as the total mass-flux, so the difference of the total and resolved was taken as the estimation of the subgrid mass-flux. The subgrid mass-fluxes of the different resolutions were normalized by the vertical velocity scale and plotted as the function of the horizontal grid-size normalized by the PBL (Planetary Boundary-Layer) height (Fig. 1).

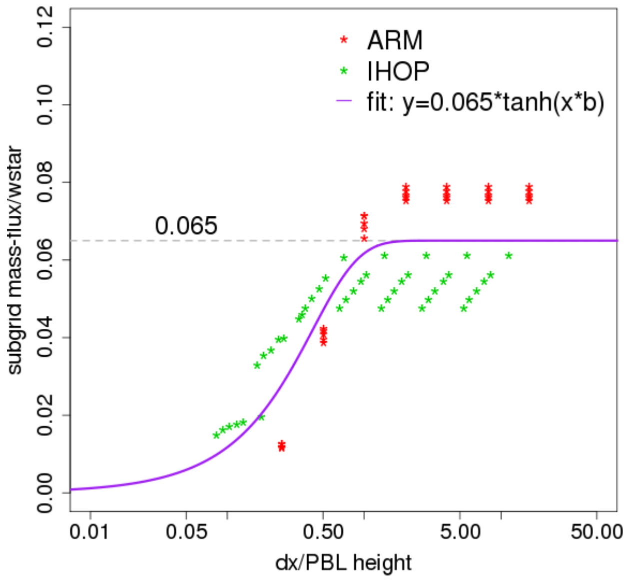
Based on the fitted tangent hyperbolic function on this plot, the equation (1) was modified:

$$M_u(z_{grd}) = 0.065 * \tanh\left(\frac{\sqrt{dx * dy}}{h} * b \right) \left(\frac{g}{\overline{\theta_{vref}}} \overline{w'\theta'_{vs}} L_{up} \right)^{1/3} , \qquad (2)$$

where dx and dy are the horizontal extents of the grid-box, h is the normalization factor of the horizontal resolution (which can be the PBL height or the Bougeault and Lacarrère upward mixing length) and b is the tuning parameter with 1.86 default value coming from the fitting.

By the tests with the idealized AROME was shown, that the new closure, even if it has a small effect, modifies the subgrid and resolved buoyancy fluxes in the right way, i.e. the subgrid part is decreased and the resolved part is increased in the gray zone. Then verifications were made on real cases: bias and RMSE scores from a 15-day-long summer period and a case study from a stormy weather situation.

The described new closure and the results from its testing were summarized in a submitted article: *Modification of shallow convection parametrization in the gray zone in a mesoscale model, Dávid Lancz, Balázs Szintai, Rachel Honnert (Boundary-Layer Meteorology)*. The revision of this article was also made during my LACE stay.



1) The ratio of subgrid mass-flux and the vertical velocity as a function of the ratio of the horizontal grid-size and the Planetary Boundary-Layer height. The gray dashed line shows the currently used C_M = 0.065 value. The purple line shows the fitted tangent hyperbolic function.

The reference and modified high resolution experiments described in this article were made without any tuning on the parametrization coefficients, and while they were used for the comparison of them, we wanted to test the new closure on a better known testbed. For this reason, new experiments were made in Toulouse during my stay, which were based on Karim Yessad's high resolution AROME simulations.

2) Modification

The experiments were made with AROME cy41t1. The implementation of the equation (2) was made in the compute_updraft.F90 routine. On the contrary to the previous implementations, for the sake of simplicity, this time it was not made possible to normalize the horizontal grid-size with the PBL height, only with the mixing length:

From line 315 in compute_updraft.F90:

```
IF (LREDEL_IN_METRES) THEN
   MODIF(:)=tanh(1.83*sqrt(EDELX*EDELY)/ZLUP)
  WHERE (ZWTHVSURF(:)>0.)
    PEMF(:,KKB) = XCMF * MODIF(:) * ZRHO_F(:,KKB) *&
    ((ZG_O_THVREF(:,KKB))*ZWTHVSURF*ZLUP)**(1./3.)
    PFRAC_UP(:,KKB)=MIN(PEMF(:,KKB)/(SQRT(ZW_UP2(:,KKB))*ZRHO_F(:,KKB)),XFRAC_UP_MAX)
    ZW_UP2(:,KKB)=(PEMF(:,KKB)/(PFRAC_UP(:,KKB)*ZRHO_F(:,KKB)))**2
    GTEST(:)=.TRUE.
  ELSEWHERE
    PEMF(:,KKB) =0.
    GTEST(:)=.FALSE.
  ENDWHERE
ELSE
WRITE(0,*)'ERROR IN COMPUTE UPDRAFT: EDELX and EDELY are not in the right unit, expected metres'
  !original
  WHERE (ZWTHVSURF(:)>0.)
    PEMF(:,KKB) = XCMF * ZRHO_F(:,KKB) * ((ZG_O_THVREF(:,KKB))*ZWTHVSURF*ZLUP)**(1./3.)
```

```
      PFRAC_UP(:,KKB)=MIN(PEMF(:,KKB)/(SQRT(ZW_UP2(:,KKB))*ZRHO_F(:,KKB)),XFRAC_UP_MAX)
      ZW_UP2(:,KKB)=(PEMF(:,KKB)/(PFRAC_UP(:,KKB)*ZRHO_F(:,KKB)))**2
      GTEST(:)=.TRUE.
    ELSEWHERE
      PEMF(:,KKB) =0.
      GTEST(:)=.FALSE.
    ENDWHERE
  ENDIF
```

3) Experiments

The setup of the high resolution experiments came from Karim Yessad. The domain of the experiments was in Southern France (fig. 2). It had 500 m horizontal resolution. The time step of the simulations was 15 s. The horizontal resolution of the orography was 90 m. The simulated days are 1-15. July 2015, a very hot and dry summer period. 15 forecast were made for every day, from 00 UTC, 24 h long, without data assimilation. The setup can be found in the Attachment.

2) The domain of the high resolution experiments (gray), four DDH diagnostic point (blue) and one radiosonde measurement point (red).

DDH diagnostics were made in four points:

1) Flat terrain (near Toulouse)	lon = 2.00°, lat = 43.60°
2) Coast	lon = 4.50°, lat = 43.63°
3) Sea	lon = 4.50°, lat = 42.60°
4) Mountain	lon = 6.20°, lat = 45.00°
*) Radio sounding data	lon = 4.40°, lat = 43.85°

(For comparison radio sounding data were downloaded from the webpage of University of Wyoming: *http://weather.uwyo.edu/upperair/sounding.html)*

The DDH diagnostics were made to check the effect of the new closure on the turbulence fluxes from the local turbulence and shallow convection part of the parametrization. Unfortunately, the DDH cannot distinguish the Eddy Diffusion and Mass Flux part of the vertical turbulence, thus only their sum could have been examined.

Beside the reference, two modified versions of the model were tested. In the first one, the parameter of the modification was set to the default 1.83 value. As the preliminary control of the results showed, the differences were quite small, so in the second version, the parameter of the modification was set to 1.33 to increase its effect.

4) Results

In the following figures can be seen the results from the experiments. In the figures 3-10 are the 24 hour budgets of temperature and water vapor on 15. 07. 2015 (the biggest differences between the reference and the modified versions of the temperature and water vapor profiles were on this day in the “flat terrain” point – not shown). The shown differences are between the reference and the modified experiments with the default parameter value. With the enhanced modification the differences are similar just bigger.

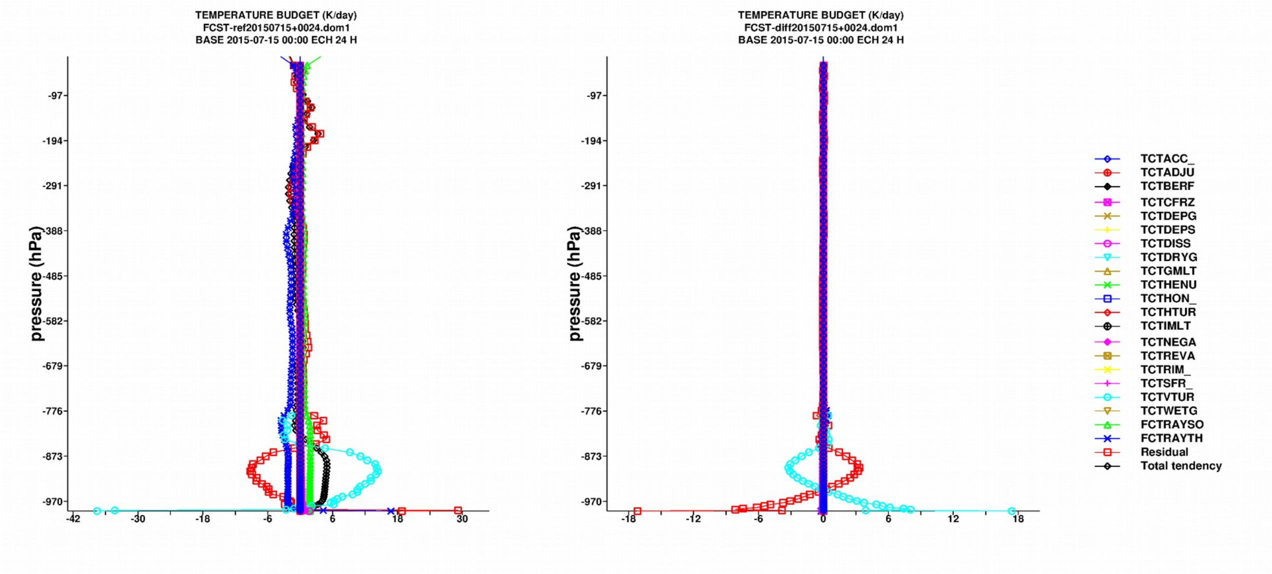
In the figure 3 are the temperature flux budget profiles from the “flat terrain” point. The main difference between the reference and the modified is in the vertical turbulent flux, which is bigger in the levels just above the surface and lower in the middle of the PBL. This is probably caused by that the weaker initialization of the mass flux, which means decreased number of parametrized thermals reaching the mixing layer. In long term it means more parametrized thermals with lower height. It is also notable that the total tendency profile is not changed very much so the residual has similar profile just with opposite sign. This means, that the advection (the vertical advection, as the boundary conditions of the horizontal wind were unchanged) compensates the change in the parametrization, which is expected.

In the figure 4 are the water vapor flux budget profiles from the “flat terrain” point. While figure 3 represents quite well the other days from the examined period, the flux budgets of the water vapor are irregular through the simulated days. The reason of this is not clear, but maybe it is connected to the fact that the source of the heat is more regular in time than the source of the water vapor at the surface. The turbulent flux is decreased in the downer part of the PBL and increased in the upper part by the modification in the figure 4, but as mentioned, it is not true for every day during the examined period. Also the total tendency profiles have more often magnitudes fore these budgets.

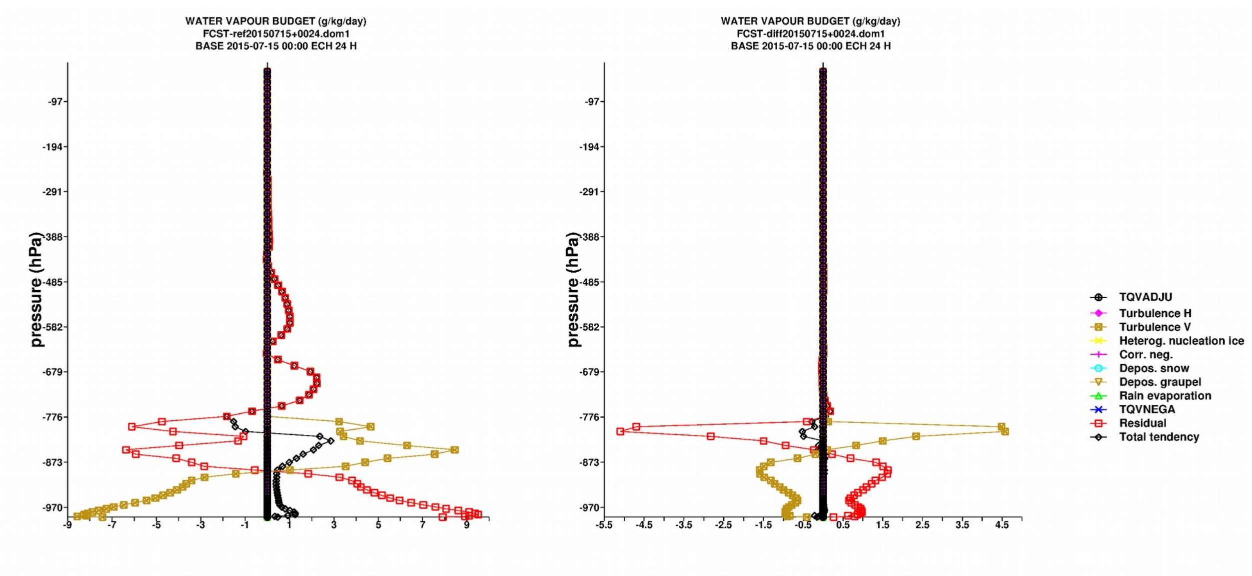
For figures 5 and 6 of the “coast” point are also true that the budget profile differences are irregular during the examined period and they are not very representative. Most often they are similar to the figure 3 where the differences are positive in the lower part of the PBL and negative in the upper mainly when the differences are higher between the reference and the modified runs. The total tendency profiles have also more often higher magnitudes.

About figures 7 and 8 of the “sea” point can be said that they are representative for the period in the magnitude of differences, which are quite low compared to the “flat terrain” and “coast” points. For the these point the modification has low effect, which is understandable as the shallow convection is more characteristic for the land area than for the sea.

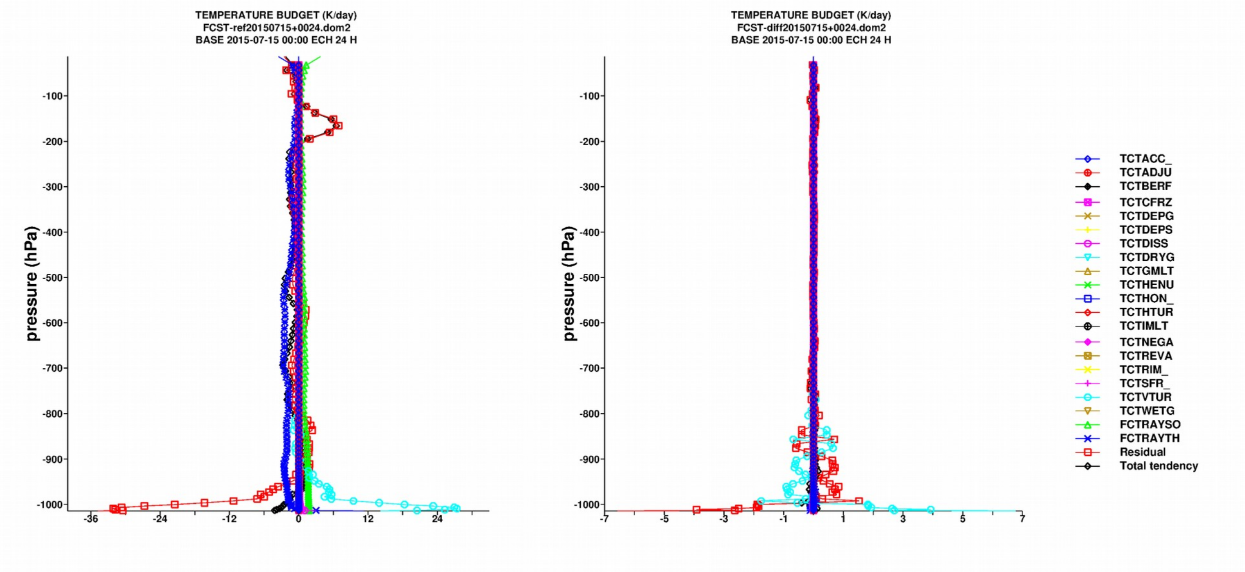
Figures 9 and 10 show the budgets from the “mountain” point. It has to be said, that the shallow convection parametrization is not expected to work properly in the mountain area. This point was examined just out of curiosity. In the figures can be seen that differences usually appear only at the bottom of the profile near the surface.



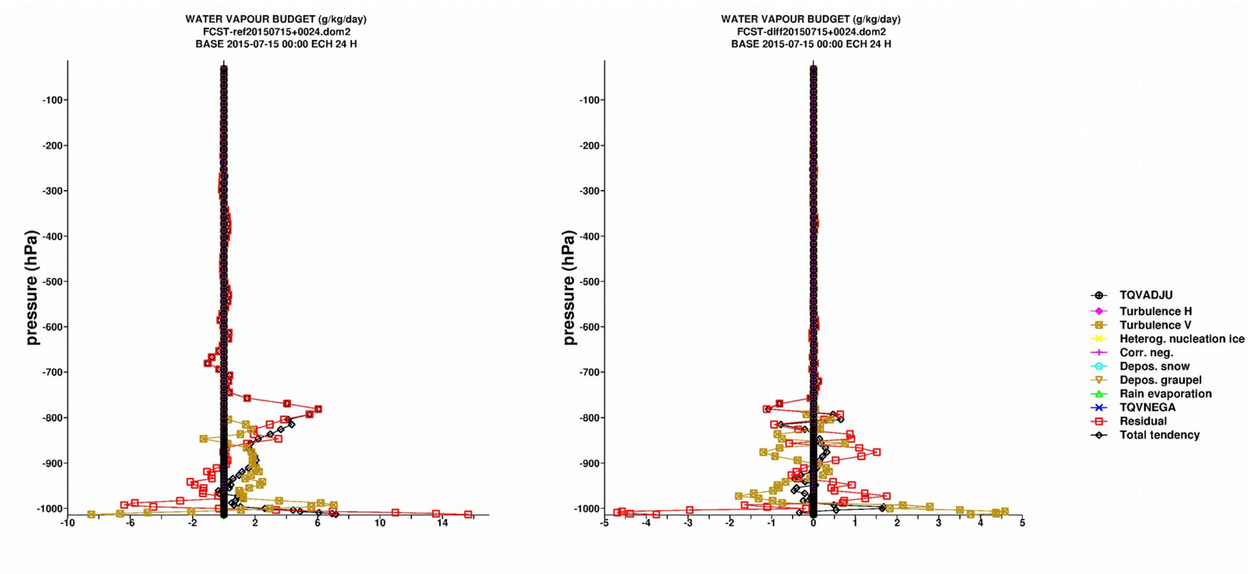
3) The 24 h temperature budget of the reference (left) and the difference from it caused by the modification (right) in the “flat terrain” point.



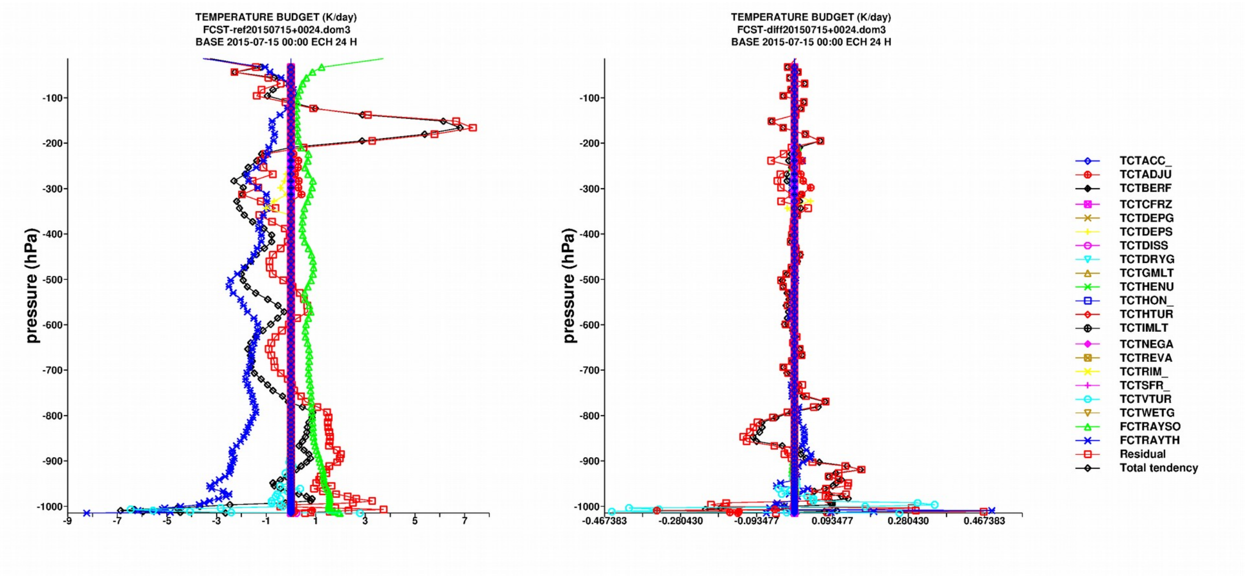
4) The 24 h water vapour budget of the reference (left) and the difference from it caused by the modification (right) in the “flat terrain” point.



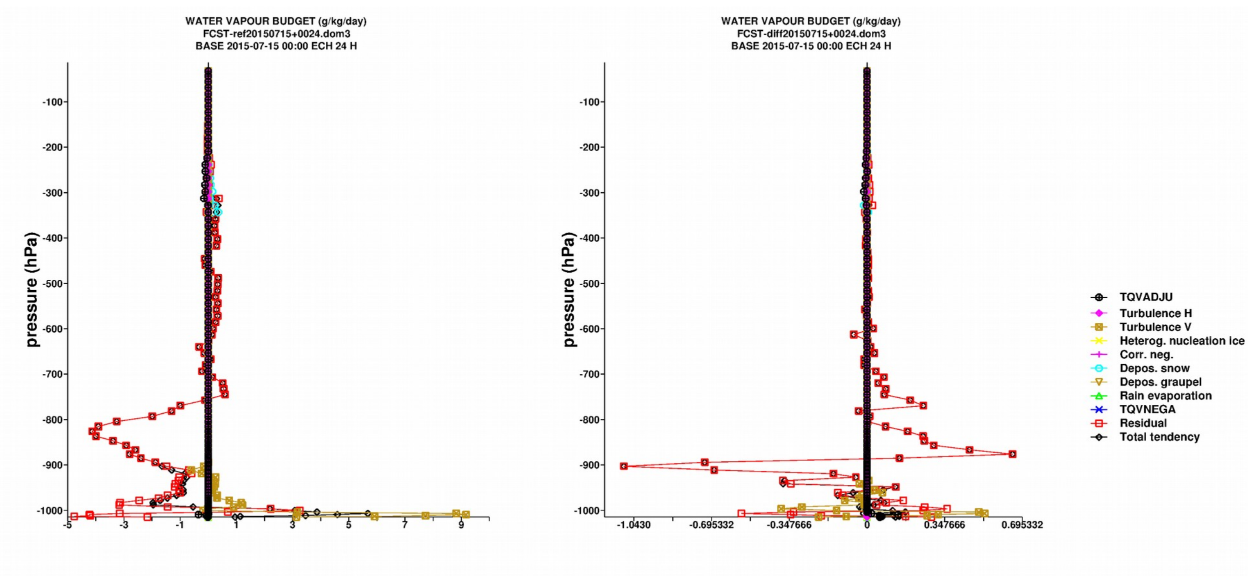
5) The 24 h temperature budget of the reference (left) and the difference from it caused by the modification (right) in the "coast" point.



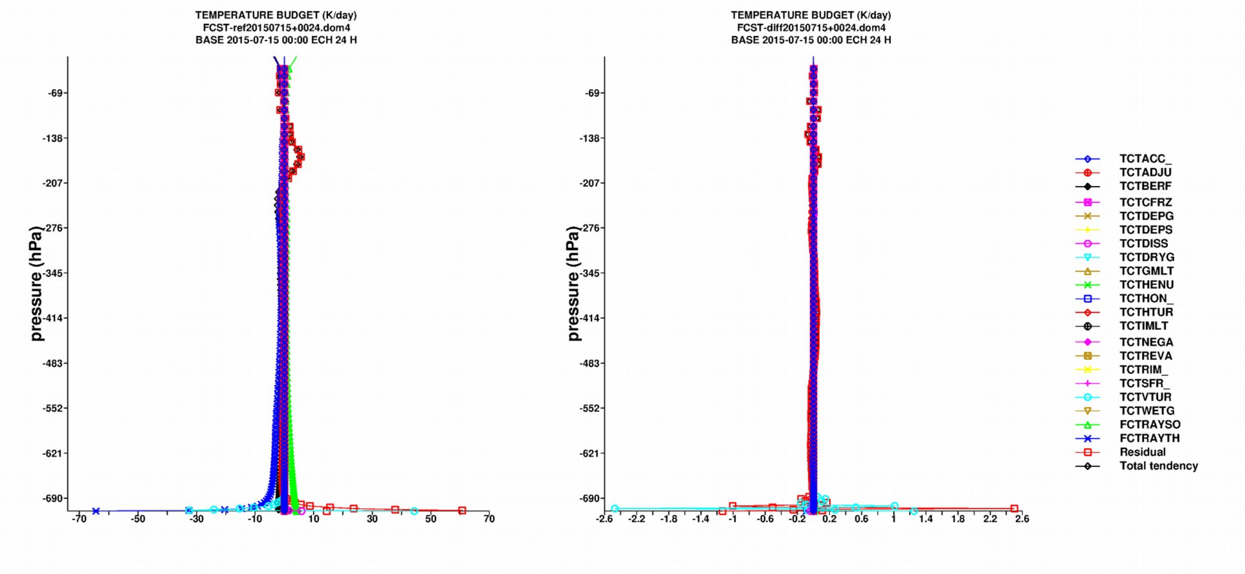
6) The 24 h water vapour budget of the reference (left) and the difference from it caused by the modification (right) in the "coast" point.



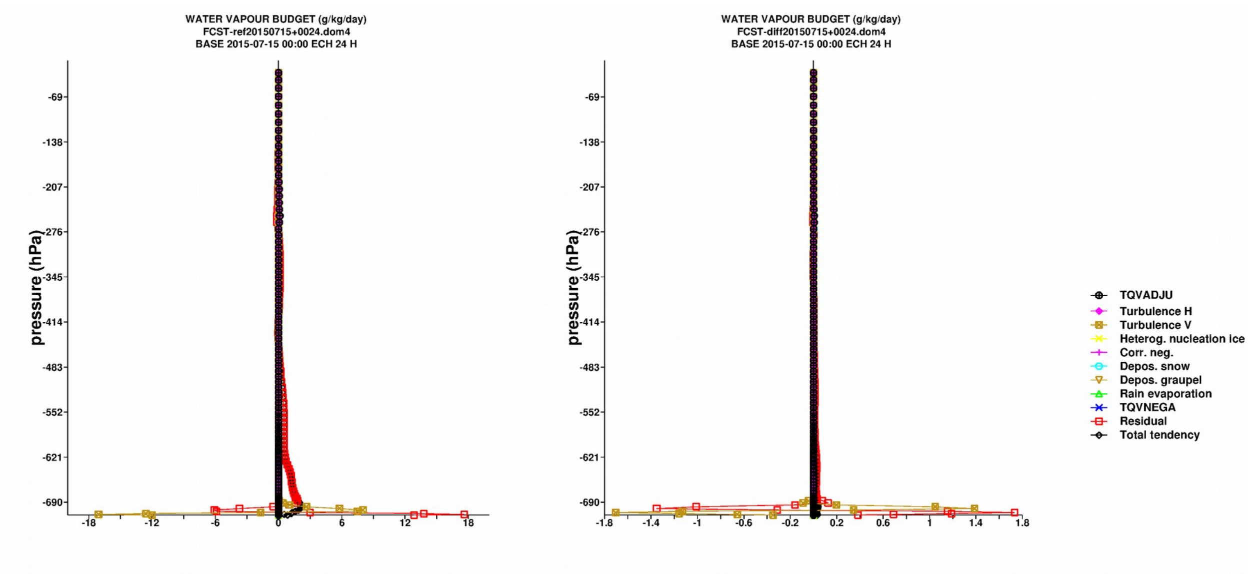
7) The 24 h temperature budget of the reference (left) and the difference from it caused by the modification (right) in the "sea" point.



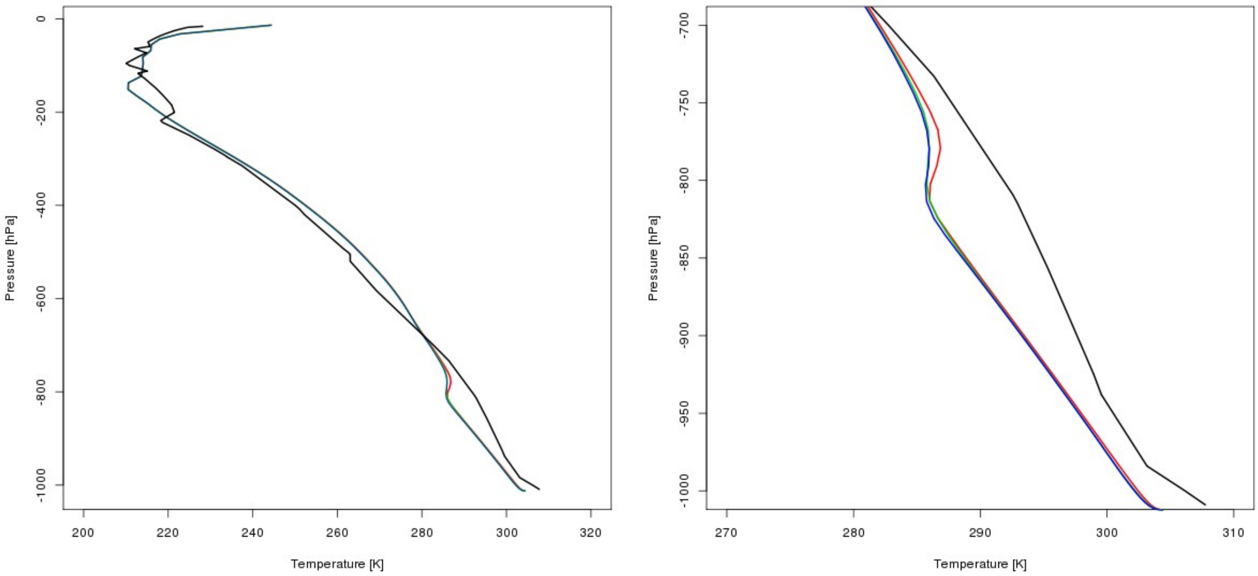
8) The 24 h water vapour budget of the reference (left) and the difference from it caused by the modification (right) in the "sea" point.



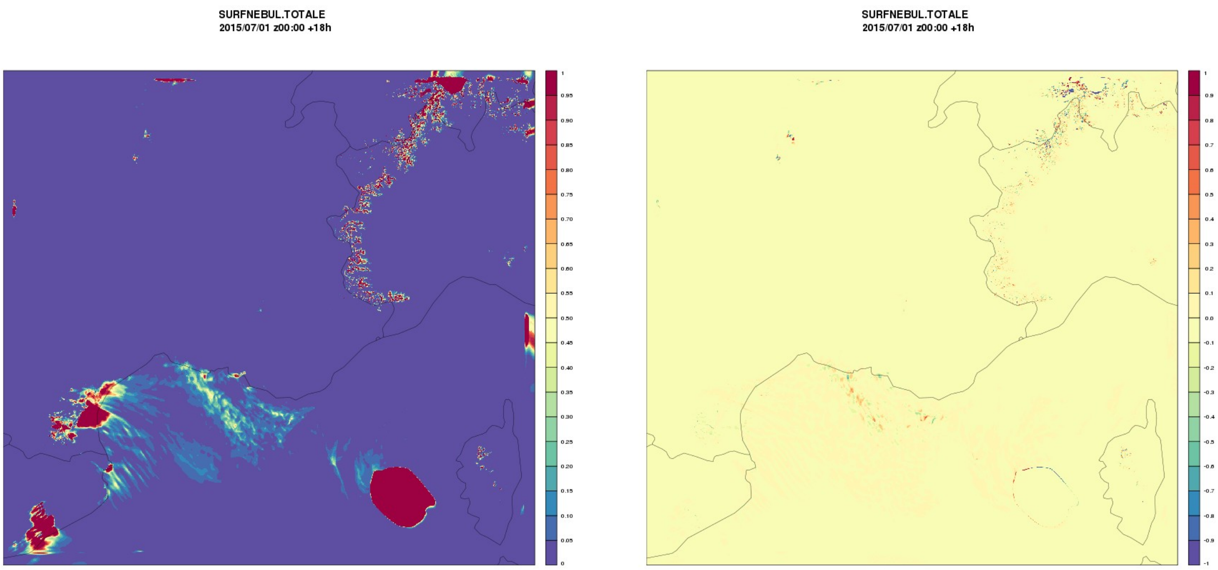
9) The 24 h temperature budget of the reference (left) and the difference from it caused by the modification (right) in the “mountain” point.



10) The 24 h water vapour budget of the reference (left) and the difference from it caused by the modification (right) in the “mountain” point.



11) Comparison of temperature profiles from radiosonde measurements (black), and simulations: reference (red), modified (green), modified with increased effect (blue) at 12 UTC 08. 07. 2015 (on the right is the zoom in the PBL).



12) Cloudiness of the reference (left) and the difference from it caused by the modification (right)

Figure 11 shows the temperature profiles of the reference and the modified runs as well as a radiosonde measurement from a nearby station at 12 UTC 08. 07. 2015. The most important information shown in this figure is that there is no big difference in the profiles, not even with the enhanced modification.

The difference caused in the cloudiness by the modification is shown in figure 12 at 18 UTC 01. 07. 2015. This difference is also not big, mainly just the location of the clouds is slightly affected.

5) Summary

A series of high resolution experiments were made to examine the effect of the modification of the shallow convection parametrization, which scale-adaptively moderate it in the turbulence gray zone. These experiments were made with 500 m horizontal resolution on a dry hot summer period. The DDH diagnostic tool was used to get a closer look at the turbulent budgets and the differences caused by the modification. Unfortunately the DDH is not able to distinguish the Eddy Diffusion and Mass Flux part of the vertical turbulence, so only their sum was examined. For four points were used the DDH: a “flat terrain”, a “coast”, a “sea” and a “mountain” point. The biggest interest was in the “flat terrain” point, as this represents the idealized situation for the shallow convection the best.

The effect of the modification is visible in the 24 h vertical turbulence budgets. It it also visible, that this effect is mostly compensated by the resolved turbulence (the vertical advection in this case), which is expected. When this compensation differs from the effect, the difference of the total tendencies has a bigger magnitude, but in overall, the summarized effect of the modification is low.

The more detailed description of the modification can be found in the submitted article: *Modification of shallow convection parametrization in the gray zone in a mesoscale model, Dávid Lancz, Balázs Szintai, Rachel Honnert (Boundary-Layer Meteorology)*. The revision of this article was also made during this LACE stay.

The final conclusion about the tested modification is that though its effect is low, it changes the turbulent fluxes in the expected way. It is clearly not enough alone to treat the shallow convection gray zone problem (true, its effect can be forced to be stronger through a parameter), but it can be a part of a final solution, which includes further developments like 3D turbulence and a more suitable set of mass flux equations for high resolution.

6) Acknowledgments

Many thanks to Rachel Honnert, Karim Yessad, Louis-Francois Meunier and Yann Seity for their help during my stay.

7) Attachment – parameter setup

```
 --- Set up control common 0 -------------------------------------------
  SUCT0 : LIFSTRAJ=(NCONF==1)  T
 COMMON YOMCT0
 LECMWF =  F LSCMEC =  F
 LNF    =  T LFDBOP =  F LGRBOP =  F LFBDAP =  T LGRIB_API =  F
 NCONF  =      1 NTASKS =      1 NCYCLE =      0 NOPT_MEMORY =  1
 CNMEXP = FCST
 CFPATH  = ./
 CSCRIPT_LAMRTC  = atcp CSCRIPT_PPSERVER = cnt3_wait
 LSLAG =  T LSLPHY =  F
 LRUBC =  F
 LSPRT =  T LNHDYN =  T LTRAJNH =  F LTWOTL =  T LRFRIC =  F
 LSLADREP =  F
 LVECADIN =  F
 LSFORC =  F
 NQUAD  =      1 N2DINI =      1 NSPPR  =      0
 NINTERPTRAJ =  1 NINTERPINCR =  1
 NSTART =      0 NSTOP  =   5760 NFRPOS =      1 NFRISP =      2 NFRSFXHIS =      1 NFRHIS =      1
NFRGDI =      1 NFRSDI =      1
 NFRDHFG =      4 NFRDHFZ =      4 NFRDHFD =      1 NFRDHP =     48 N6BINS =      0
 NFRCO =      0
 NFRCORM =      0
 NUNDEFLD = ******
  NPOSTS =          -25           0          -1          -2          -3
          -4          -5          -6          -7          -8          -9
         -10         -11         -12         -13         -14         -15
         -16         -17         -18         -19         -20         -21
         -22         -23         -24
  NPOSTSMIN =             0
  NPISPS =            0
  NHISTS =           -5           0          -6         -12         -18
         -24
  NHISTSMIN =             0
  NSFXHISTS =          -1          -3
  NSFXHISTSMIN =             0
  NGDITS =            0
  NSDITS =          -25           0          -1          -2          -3
          -4          -5          -6          -7          -8          -9
         -10         -11         -12         -13         -14         -15
         -16         -17         -18         -19         -20         -21
         -22         -23         -24
  NDHPTS =            0
  NDHFGTS =            0
  NDHFZTS =            0
  NDHFDTS =          -24          -1          -2          -3          -4
          -5          -6          -7          -8          -9         -10
         -11         -12         -13         -14         -15         -16
         -17         -18         -19         -20         -21         -22
         -23         -24
  NMASSCONS =            0
 LCANARI=  F LCASIG=  F LGUESS =  T LOBSC1 =  F LOBSREF=  F LOBS =  F LSIMOB =  T
 LIOLEVG =  T
 LSCREEN =  F L_SCREEN_CALL =  T L_SPLIT_SCREEN =  F LBACKG =  F LMINIM =  F
 NPRINTLEV  =  0 LALLOPR =  F
 LELAM  =  T LRPLANE  =  T
 LREGETA =  F
 LVFE_REGETA =  F
 LARPEGEF =  T
 LARPEGEF_TRAJHR =  T
 LARPEGEF_TRAJBG =  T
 LARPEGEF_RDGP_INIT =  F
 LARPEGEF_RDGP_TRAJHR =  F
 LARPEGEF_RDGP_TRAJBG =  F
 NFPOS =   1 LECFPOS =  F
 CFPNCF = ECHFP
 LOLDPP = F
 LAROME = T
```

```
LCALLSFX = T LSFXLSM = F
LSFORC = F LSFORCS = F
LIFSTRAJ, LIFSMIN= T F
LRETCFOU =  F ; LWRTCFOU =  F
LRFOUTCNORM(1) =  F
LRFOUTCNORM(2) =  F
LRFOUTCNORM(3) =  F
LRFOUTCNORM(4) =  F
LRGPTCNORM(1) =  F
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LVERCOR =  F
LCOUPLO4 =  F
LPC_FULL =  T
LPC_CHEAP =  F
LPC_NESCT =  T
LPC_NESCV =  T
LPC_NESC =  T
LOPT_SCALAR =  T LOPT_RS6K =  F
MODULE YEMCT0
LEQLIMSAT =  F
LSMIXBC =  F
L_GPQ_BDIFF =  F
--- Set up ENKF options -------------------------------------------
&NAMENKF
LENKF   = F,
NSIZE_ENSEMBLE  =           0,
MYMEMBER        =           0,
NOFFSET_OBS     =           0
/
--- Set up MASS VF Option -------------------------------------------
MODULE YOMJFH
  N_VMASS =-1
--- Set up dynamics part A -------------------------------------------
LDYNCORE    =  F
RPLRADI     = 0.1000000E+01
RCORIOI     = 0.1000000E+01
LAQUA       =  F
LHELDSUAREZ =  F
Printings of YOMDYNA/NAMDYNA variables
LGWADV =  T
NGWADVSI =  1
LRDBBC =  F
NPDVAR =  2
NVDVAR =  4
LNH_PDVD =  T
LNH_GEOGW =  F
LSLHD_W       =  F
LSLHD_T       =  F
LSLHD_SPD     =  F
LSLHD_SVD     =  F
LSLHD_GFL     =  T
LSLHD         =  T
LSLHDQUAD     =  T
LSLHD_OLD     =  F
LSLHD_STATIC  =  F
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SLHDKMAX      = 0.6000E+01
SLHDEPSH      = 0.8000E-01
SLHDEPSV      = 0.0000E+00
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LCOMADV       =  F
LCOMAD_W      =  T
LCOMAD_T      =  T
LCOMAD_SPD    =  T
LCOMAD_SVD    =  T
LCOMAD_SP     =  T
LCOMAD_GFL    =  T
ND4SYS = 2
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LRWSDLG =  F
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LSLDIA =  F
LGRADSP =  F
L3DTURB =  F
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LRPRSLTRJ =  F
LCURVW =  F
Rayleigh friction: LRFRICISOTR =  F

Printings of YOMCVER/NAMCVER variables
LVERTFE=  F NVSCH=  0
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LVFE_LAPL_BC =  F
LVFE_X_TERM =  F
LVFE_GW =  F
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LVFE_GWMPA =  F
LVFE_DERIB =  F
LVFE_DBCS =  F
LVFE_DBCT =  F
LVFE_CENTRI =  F
RVFE_CENTRI=     0.50000000000000
LVFE_APPROX =  F
LVFE_VDA =  F
LVFE_INT_ECMWF=  T
LVFE_INTB =  F
NVFE_ORDER=  4
LVFE_LAPL_HALF =  F
--- Set up forcing by coarser model part A ---------
----------------------------------
 --- PRINTINGS IN SUELBC0A ---
 LTENC =  F  LALLTC =  F
 LSPTENC =  F
 NBICOU =            2  NBICOT =            2  NBICOP =            2
 NBICPD =            2  NBICVD =            2  NBICNHX =            2  LQCPL =
F  LCCPL =  F
NECRIPL =  1
 NECOAD =            0  NECOTL =            0  LE0COTA =  F
NFRLSG =  1 N1LSG =  0
 NLSGTS =            0
LRDLSG =  F
LESPCPL =  T

--- Set up message passing interface ----------------------------------
 NDISTIO(1) =           0

----- PRINTINGS IN SUMP0:
NDISTIO =  0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
NDISTIO =  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
NCOMBFLEN =      1800000
LSYNC_SLCOM =  T
LSYNC_TRANS =  T
YRSL%LSLONDEM =  T
YRAD%LSLONDEM =  T
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NOUTTYPE =  1
NFLDIN =    0
LSPLITOUT =  F
 NWRTOUT =          416
```

```
 M_BARRINC_DIWRGIRD =            3
L_GATHERV_WRGP =  F
LUSEWRGRIDALL =  F
LEQ_REGIONS =  F
LSPLIT =  T
LSLDEBUG =  F
---- Set up variational assimilation ----------------------------------

--- PRINTINGS IN SUVAR:
MODULE YOMJQ
 LSTATMERR=  F
MODULE YOMMODERR
 N_COUPLED_WINDOWS =      0
MODULE TRAJECTORY_MOD
 LTRAJHR=  F
 LTRAJGP=  F
 LTRAJHR_ALTI=  F
 LTRAJHR_SURF=  F
 LREADGPTRAJ=  F
MODULE YOMVCGL
 NSAVEEV =      5
 NSAVEPC =      3
MODULE YOMSENS
 LGRVOL =  F NJROPT =      1
 LBSENS =  F
MODULE YOMVRTL
 L131TL= F  LOBSTL= F
 LDRYTL= F
 LTLINT= F
 LIDMODEL= F
MODULE YOMCOSJB
 LJBZERO =  F
 LJPZERO =  F
 LJTZERO =  F
 LJLZERO =  F
MODULE YOMVAR: variables linked to minimisation
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 RXMIN = 0.1490116E-07
 LN1CG1 =  F
 ZEPSNEG = 0.1000000E-07
 N1IMP =      5
 NSELECT =      1
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 LCONGRAD =  T
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 N_DIAGS_EIGENVECS =      1
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 RTOL_CHECK_GRADIENT = 0.1000000E-01
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 EVBCGL = 0.1000000E+00
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 NSIMU =     60
 NINFRA =     10
 RCVGE = 0.1000000E-01
 R_NORM_REDUCTION_ABORT_LEVEL = 0.1000000E-01
 L_ABS_CONVERGENCE =  F
 L_INFO_CONVERGENCE =  F
 L_CHECK_CONVERGENCE =  T
 L_INFO_CONTENT =  F
 N_INFO_CONTENT_METHOD =      1
 N_INFO_CONTENT_SEED =      0
MODULE YOMVAR: other variables
```

```
  LTWANA =  F
  LTWGRA =  F
  LTWINC =  F
  R_MAX_CNUM_PC = 0.1000000E+02
  NFGFCLEN =      6
  NHEVECS =      0
  NSSBGV_COUNT =      0
  NSSHEV_COUNT =      0
  LGCV =  F
  LGCVJO =  F
  NITERGCV =     40
  CFNSIGB = sigma_b
  CFNSIGA = sigma_a
  CFNSIGF = sigma_f
  CFNPCV = precon
  L3DFGAT =  F
  L_GUESS_RUNTIME =  T
  NITER_GUESS_RUNTIME =     10
  NFREQ_GUESS_RUNTIME =      5
  NMEM_GUESS_RUNTIME =     10
  LAMV_REASSIGN_PASSIVE =  F
  LREO3_BCOR =  F
  LCH4_BCOR =  F
  LCLDSINK =  T
  CTOPBGE = 0.3000000E+01
  CAMTBGE = 0.1000000E-01
  LTWLCZ =  F
  LTOY42 =  F
  LSUSPQLIM =  F
  LFDBERR =  F
  LENDA =  F
  LTEST =  F LTRREF =  F LZOWA =  T LWREINI =  F
  LJC =  F LJCDFI =  F LUSEJCDFI =  F LJCIMPACT =  F LJBIMPACT =  F ALPHAG = 0.1000000E+07 ALPHAV =
0.1000000E+01
  LGRASCAL =  F
  LWRISIGB=  F LWRISIGA=  F LWRISIGF=  F LWRISB_VPROF=  F LWRIBVEC=  F LWRIBVEC_FULL=  F LREABVEC=
F
  NSIM4D =      0 NDIAG =      1 NSIM4DL =    999
  RDX  = 0.1000000E-11
  NFRREF =      1 NFRANA =      1 NFRGRA =      1
  NREFTS =           0
  NANATS =           0
  NGRATS =           0
  NUPTRA =  99999 MUPTRA =      0 NBGVECS=      0 LBGTRUNC=  F NBGTRUNC=   1000 LBGOBS=  F LBGM=  F
LANOBS=  F
  NUPTRA_RANGE =      0
  LTOVSCV =  F LTSCV =  F
  FILTERFACTOR = 0.1000000E+01
  FILTEREXPO = 0.2000000E+01
  FILTERRESOL = 0.2550000E+03
  LINITCV=  T LMODERR=  F
  LVARBC=  F
  LAEOLUSAMD=  F
  LREPRO4DVAR=  F LTOVSREP=  F
  LSKIPMIN=  F
  LFCOBS=  F LFCOBSTEST=  F
  LREFINC=  F
  LSPINT =  F
  LPROPTL =  F
  LBACKGE =  F
  LBACKGECV =  F
  LDIAG_LCT =  F
  LFEMARSF =  F
  LFEMARSF_RAW =  F
  LFEMARSD =  F
  LFEMARSD_WRITERAW =  F
  DATE AND TIME OF 4DVAR WINDOW END=           0
  LMONITOR_OBSTATFC= F
```

8) References

HONNERT, R., V. MASSON and F. COUVREUX, 2011: *A Diagnostic for Evaluating the Representation of Turbulence in Atmospheric Models at the Kilometric Scale.* J. Atmos. Sci., **68**, 3112-3131

PERGAUD, J., V. MASSON, S. MALARDEL and F. COUVREUX, 2009: *A Parameterization of Dry Thermals and Shallow Cumuli for Mesoscale Weather Prediction.* Bound.-Layer Meteor., **132**, 83-106