Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

LACE - PROBLEMS IN DYNAMICS & COUPLING AND SOME SOLUTIONS

Petra Smolíková (CHMI)
with contribution from many colleagues

Summary

Dynamics:

- Finite element method in vertical discretization of NH model
- ENO technique for SL interpolations
- SL trajectory

Coupling:

- Fixing quadratic coupling in CY40T1
- Objective scores of ARPEGE new coupling files with SURFEX

VFE in NH

- designed by Jozef Vivoda based on hydrostatic version of FE used in vertical (being developped by A.Untch, M.Hortal)
- cooperation with HIRLAM colleagues (J.Simarro, A.Subias)

Current status: there is a working implementation of the VFE method in the NH model since cycle CY40T1

Recent development:

- revised definition of boundary conditions
- fully FE vertical Laplacian
- FE transformations d <-> w
- vertical operators satisfying the constraint C1

VFE in NH

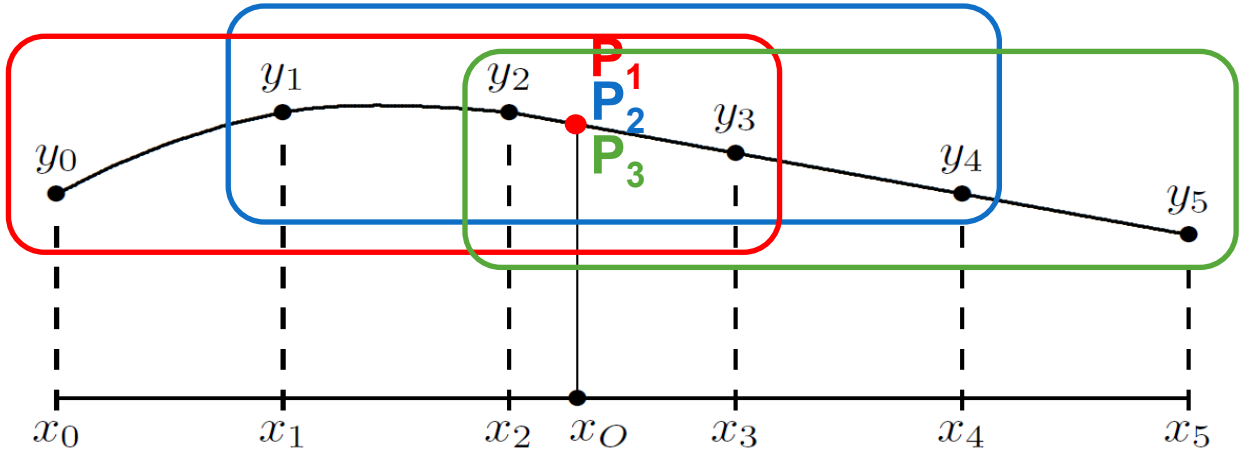
Recent development:

- clean merge of several developments
- revised definition of vertical integral
- revised definition of m, A, B for vertical levels definition
- revised formulation of pressure gradient term in horizontal and vertical momentum equation
- design of an interface routine for the integration and derivation => application of vertical derivative and integral operators should be easy and without long decision trees

=> a progress in the quality of operators which will be demonstrated on better stability, robustness of the scheme and more accurate, noise-free results

ENO/WENO in SL interpolations

Cubic interpolation needs values to be known in 4 points. With 6 points available, we can find the interpolated value on three different stencils and choose the “best” solution from them (ENO) or calculate a weighted average from them (WENO):



Stencil 1 => interpolated value P_1

Stencil 2 => interpolated value P_2

Stencil 3 => interpolated value p_3

ENO: choose “the best” from P_1, P_2 ,P_3 / WENO: $P = w_1P_1 + w_2P_2 + w_3P_3$

ENO/WENO in SL interpolations

Advantages:

- we may avoid to use stencils close to discontinuities or sharp gradients in the interpolated field producing spurious oscillations
- in smooth regions certain optimal weights are used to achieve higher order of accuracy

WENO completely removes the logical statements that appear in ENO => faster performance

Disadvantages: computationally demanding

1 eno ≈ 3 cubic interpolations + some calculations

1 3D interpolation ≈ 14 linear + 21 eno interpolations instead of 10 linear + 7 cubic interpolations in standard 32 point solution

ENO/WENO in SL interpolations

Previous work:

- 1D experiments with a rectangular pulse in a periodic domain
- Fast implementation of quadratic ENO (using 4 points for 1D interpolation), experiments in 2D and 3D model
- Complete implementation of cubic ENO using NSTENCIL_WIDE=3 (technically demanding, the stencil for SL 1D interpolation has to be extended from 4 to 6 points), experiments in 2D model

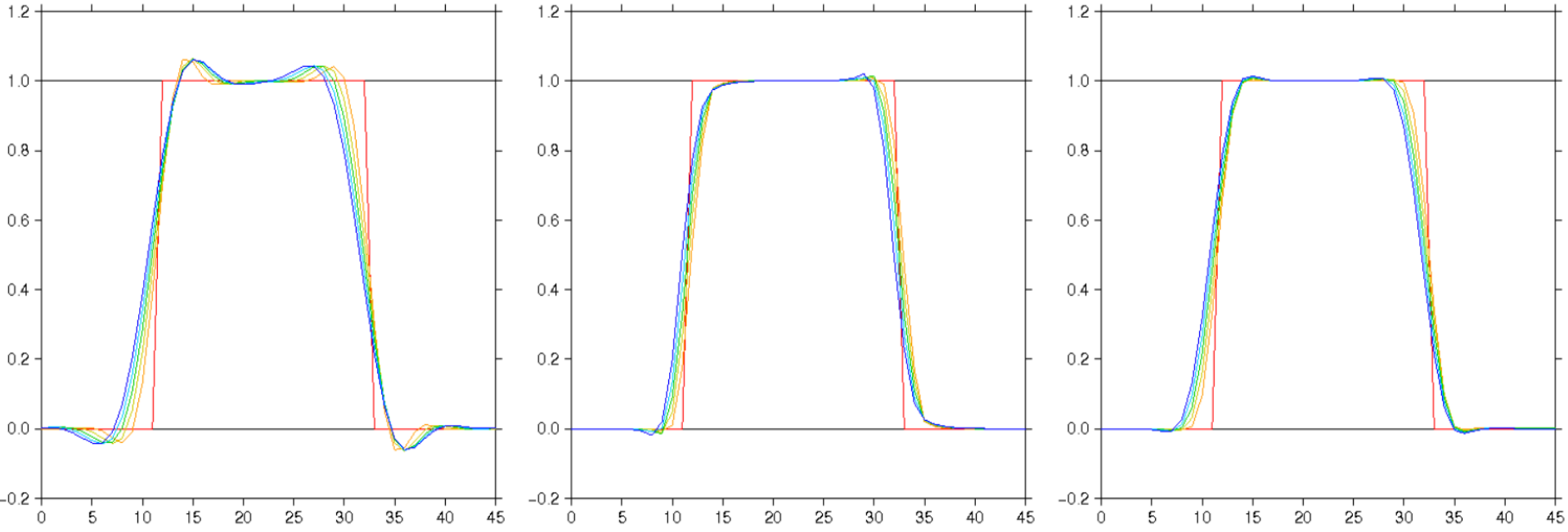
Current work:

- Complete implementation of cubic WENO using several possible smoothness definitions, experiments in 2D

ENO/WENO in SL interpolations

Summary of results:

1D experiments with a rectangular pulse in a periodic domain: we get rid of over/undershooting almost completely



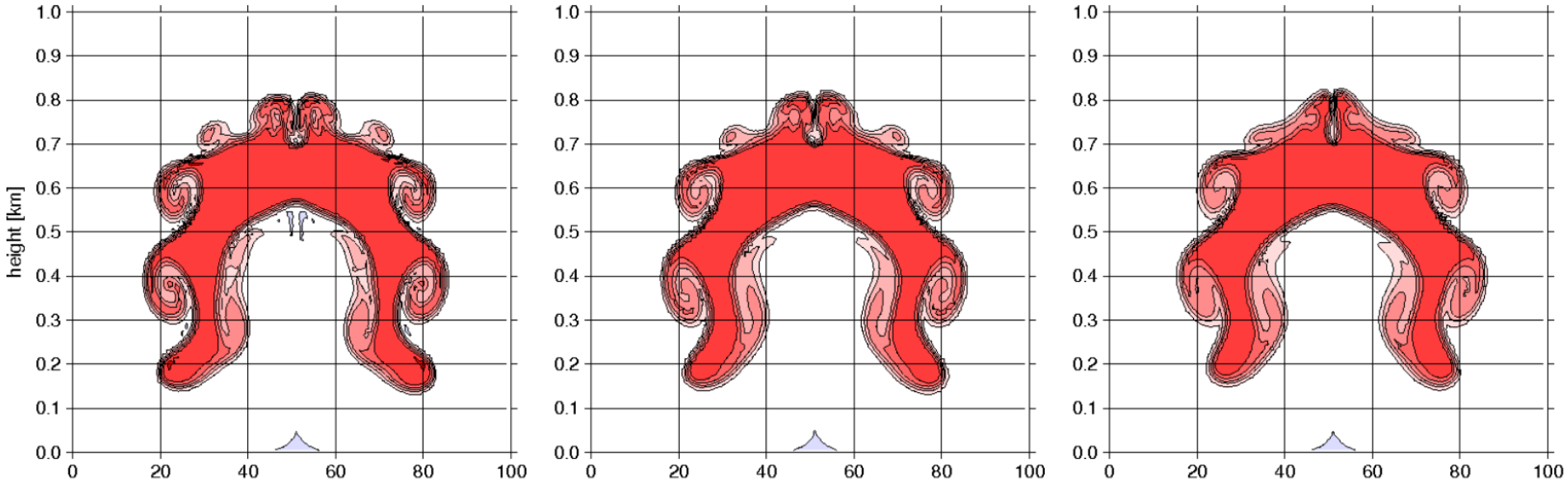
Cubic Lagrange **ENO** **WENO**

 Courtessy of Ján Mašek

ENO/WENO in SL interpolations

Summary of results:

2D experiments with a warm bubble in a homogenous potential temperature field: nice shape with less details, depends on the definition of smoothing indicators



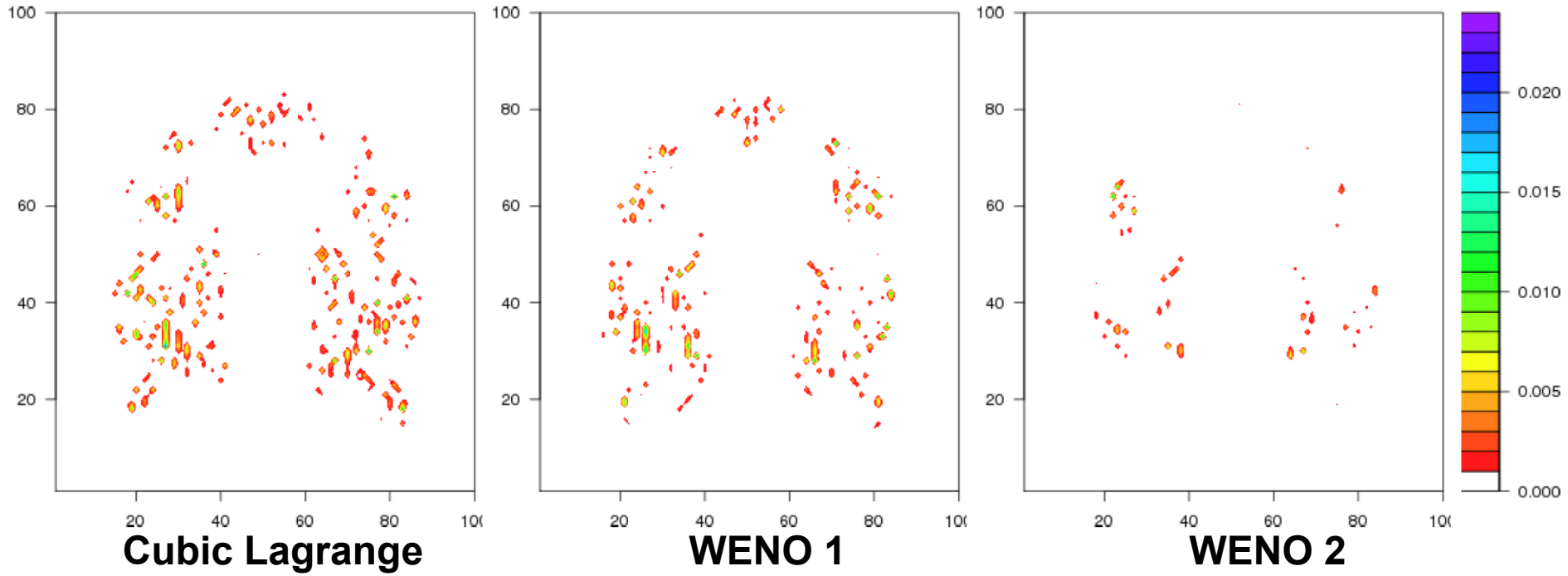
Cubic Lagrange **WENO 1** **WENO 2**

 Courtessy of Alexandra Craciun

ENO/WENO in SL interpolations

Summary of results:

2D experiments with a warm bubble in a homogenous potential temperature field: over/undershooting reduced depending on the smoothing indicators definition



 Courtessy of Alexandra Craciun

ENO/WENO in SL interpolations

Summary of results:

- The WENO technique implemented in CY40t1, branch available in the CVS versioning system of CHMI
- Over/undershooting not completely eliminated according to 2D bubble test, even if they are present with various intensity depending on the definition of smoothing indicators
- Only slight improvement in the production of over/under-shooting does not compensate the increase in the computational cost of the WENO scheme compared to the classical cubic Lagrange solution

Reported in the ALADIN-HIRLAM Newsletter N°8 : *Alexandra Craciun, Petra Smolíková , Application of ENO technique to semi-Lagrangian interpolations*

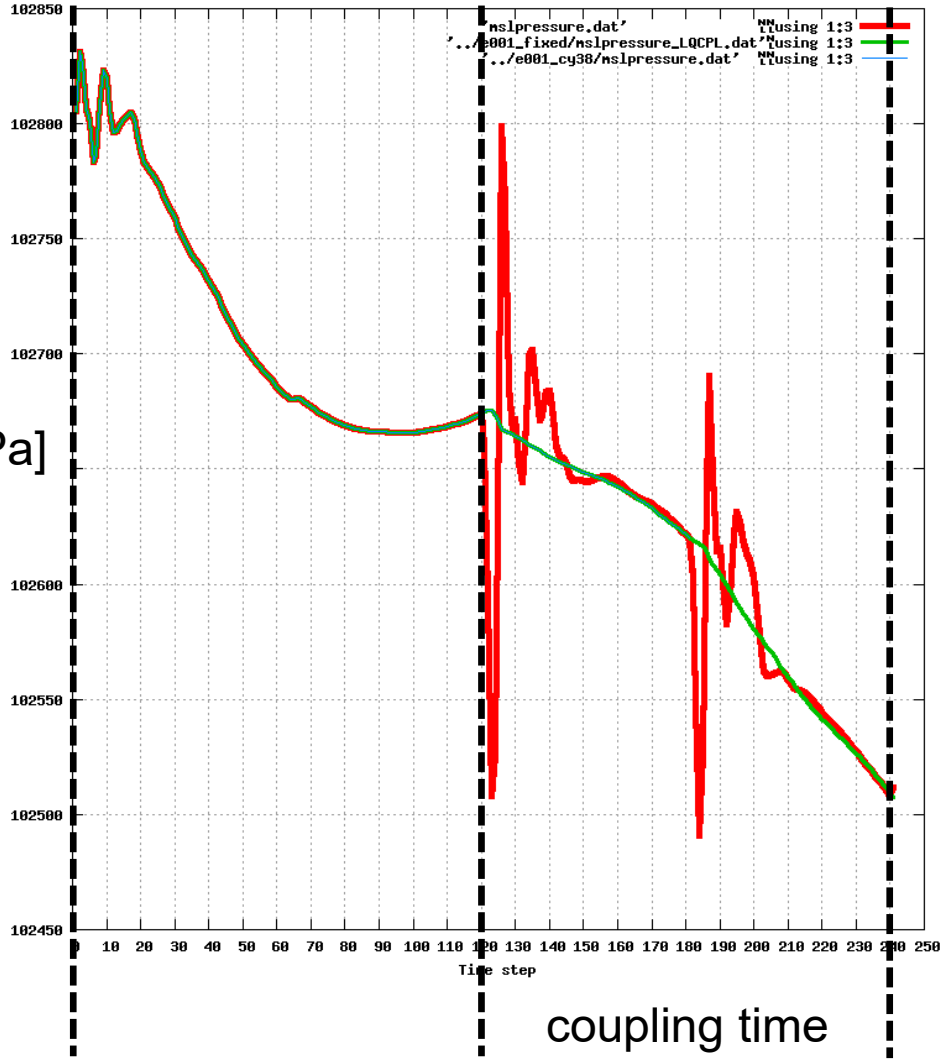
Quadratic coupling in CY40T1

Fixing bug in CY40T1 export version:
Only for LQCPL=.TRUE. (quadratic time interpolation of coupling files). The configurations with linear coupling are not affected.

Problem description: interpolation weights EWB computed in module elbc0b_mod.F90 are not consistent with treatment of GMV fields that holds coupling fields. This influences all prognostic quantities of HYD and NH dynamics. It propagates over whole domain. It spoils fields globally in sufficiently long time interval.

Fix: modified routine **elbc0b_mod.F90**
Information sent to alabobo maillist.

Quadratic coupling in CY40T1



MSL[Pa]

coupling time

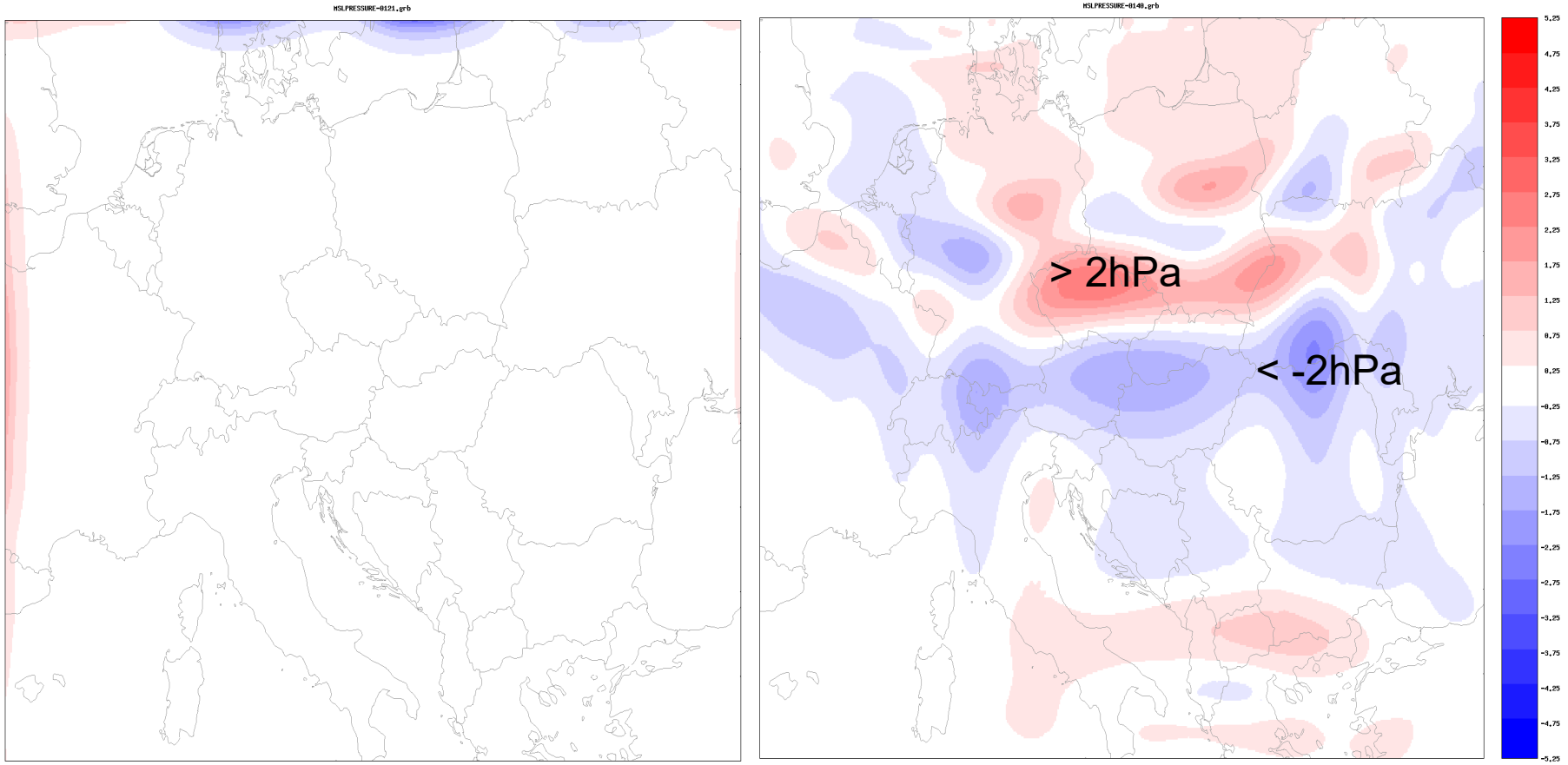
Time evolution of MSL pressure in a GP close to boundary

- CY38T1
- CY40T1 with bug
- CY40T1 fixed

Time step

Courtessy of Martin Belluš

Quadratic coupling in CY40T1



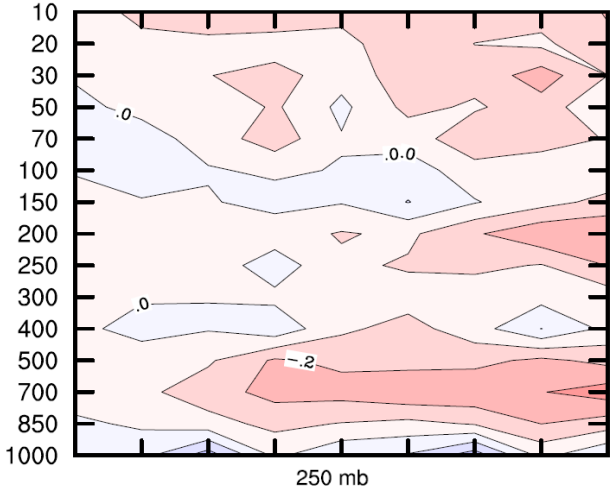
difference in MSL pressure between CY40t1 and CY38t1
after 121 steps (just after coupling at +03) and after 140 steps (+03:30)

Courtessy of Martin Belluš

New LBC from ARPEGE CY42 with SURFEX

Summer test case 06-31/08/2016, BIAS: NEW - REF

temperature



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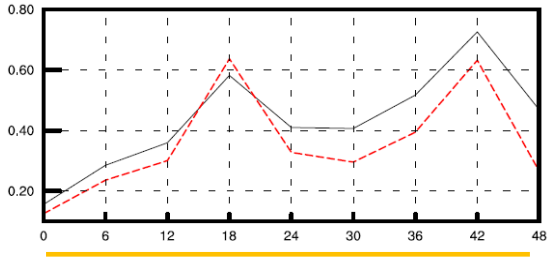

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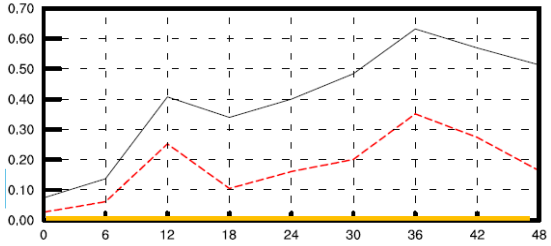
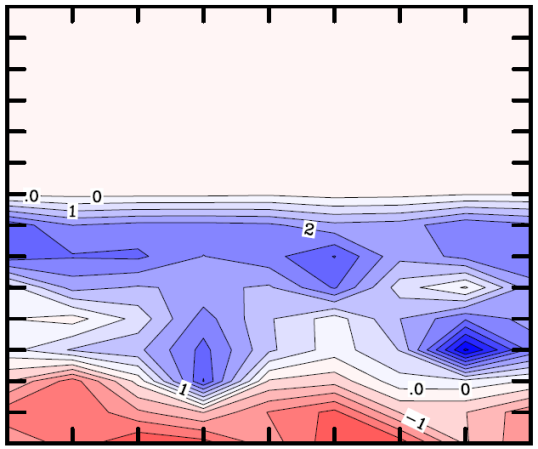


relative humidity



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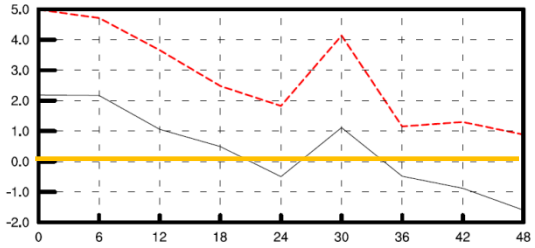

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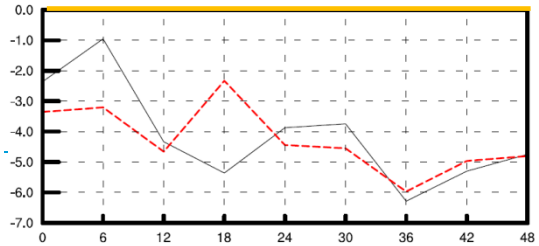
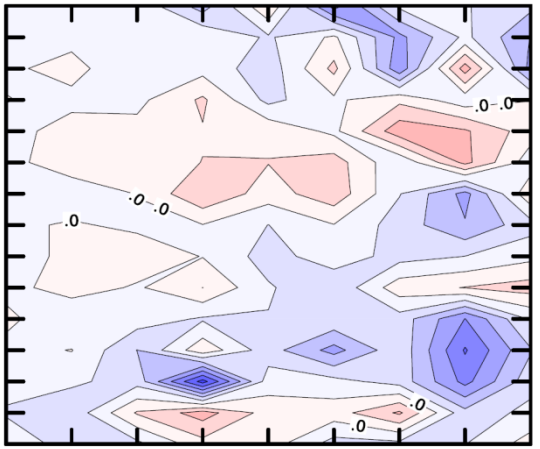


wind speed



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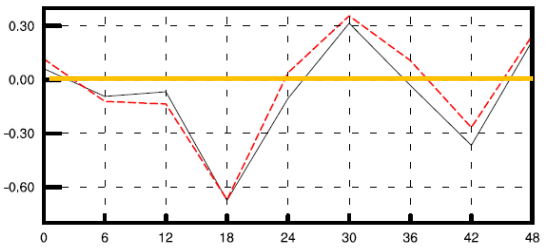

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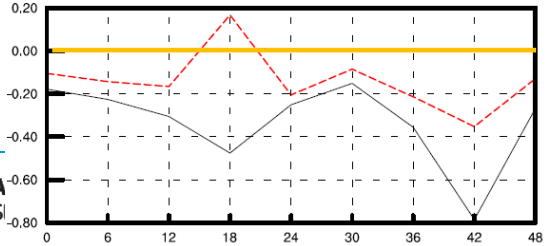
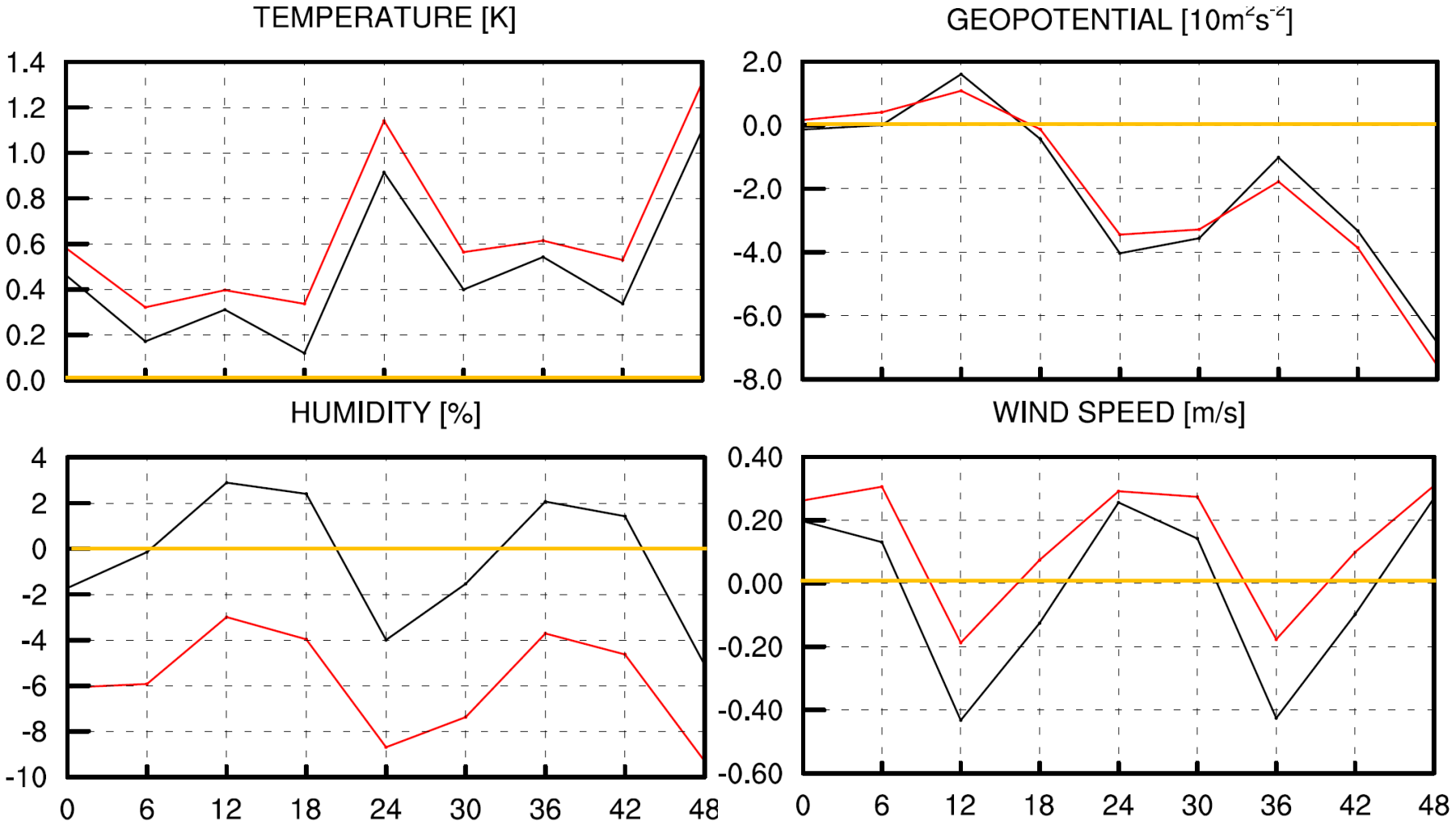


New LBC from ARPEGE CY42 with SURFEX

Summer test case 06-31/08/2016, surface BIAS: NEW - REF

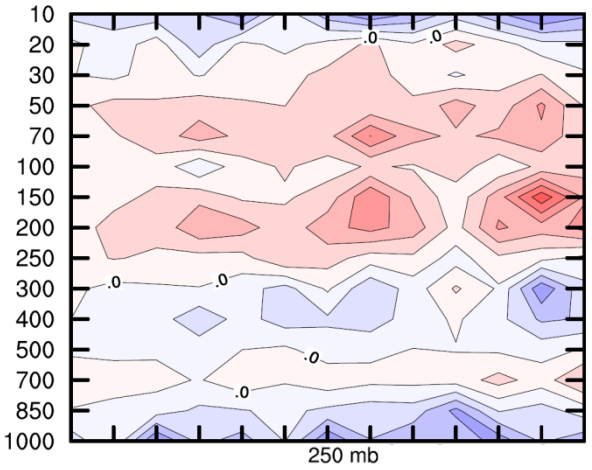


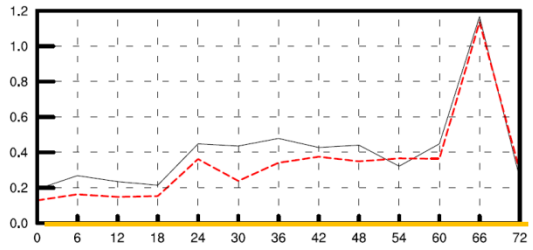
Courtesy of Radmila Brožková

New LBC from ARPEGE CY42 with SURFEX

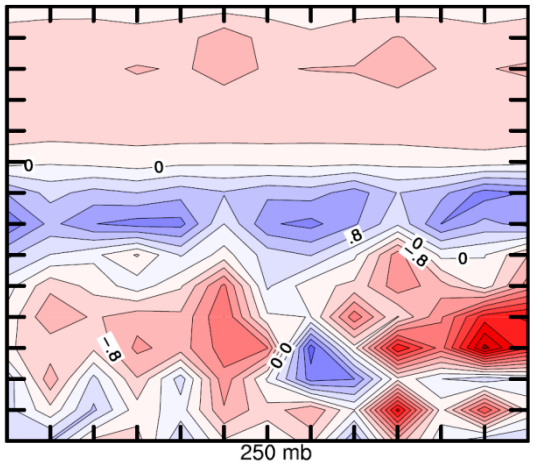
Parallel suite 07-20/02/2017, BIAS: NEW - REF

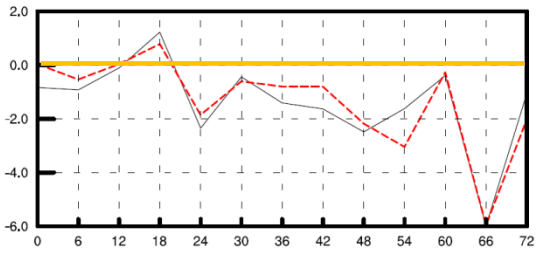
temperature



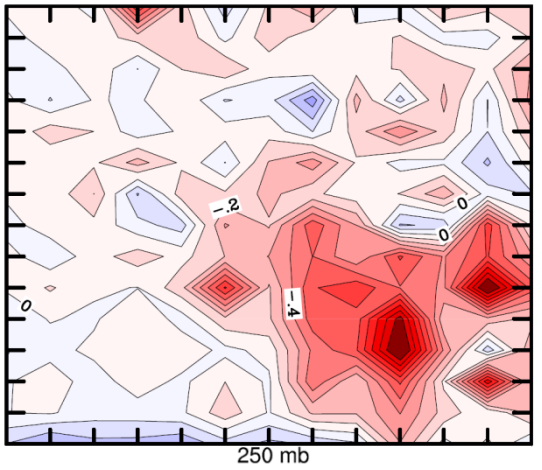


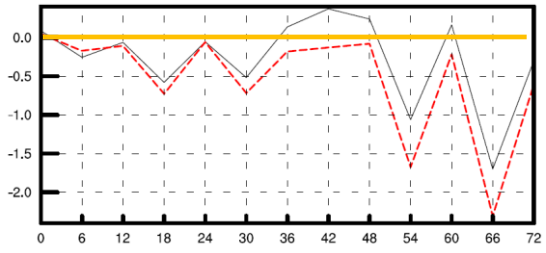
relative humidity





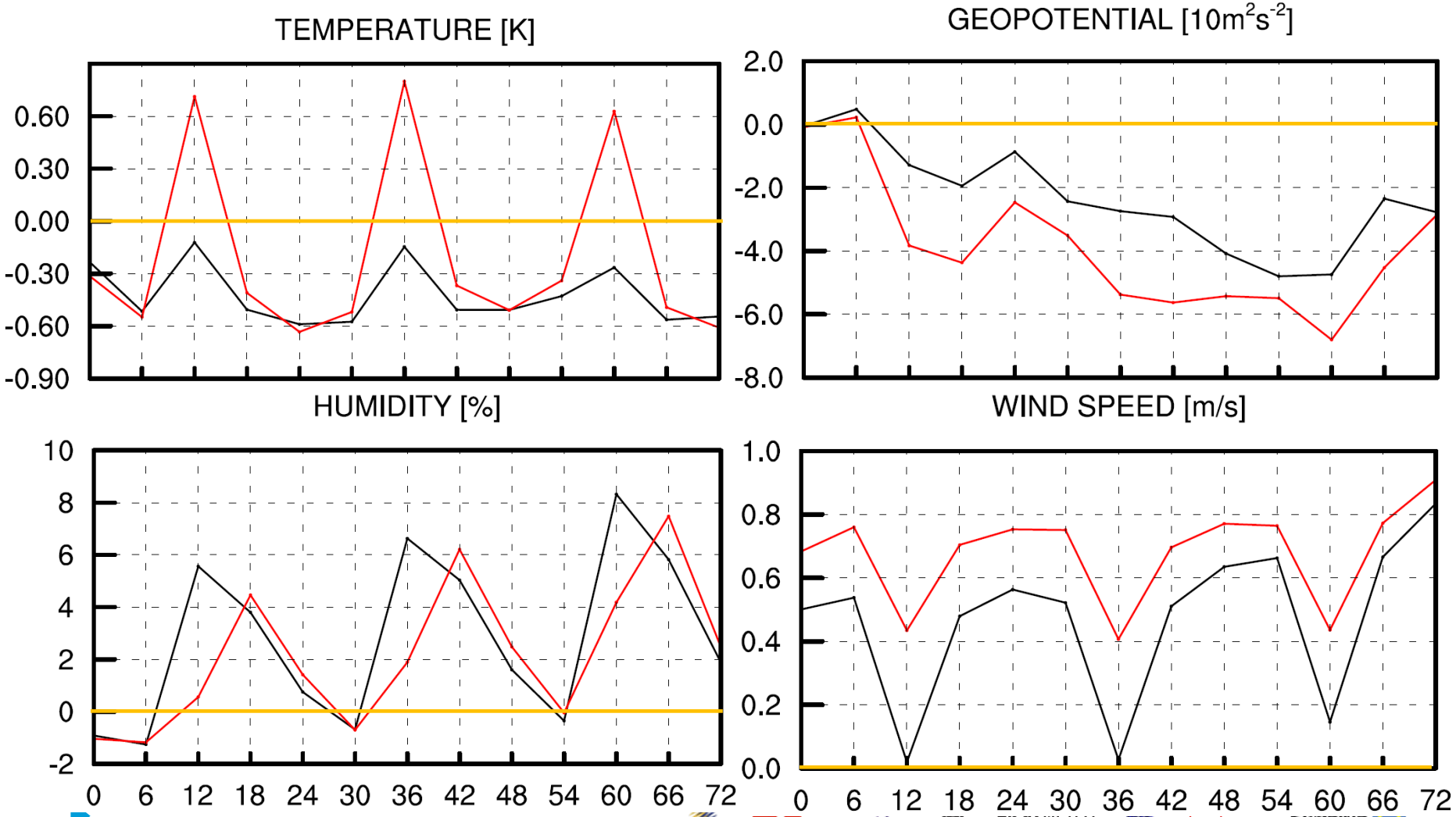
wind speed





New LBC from ARPEGE CY42 with SURFEX

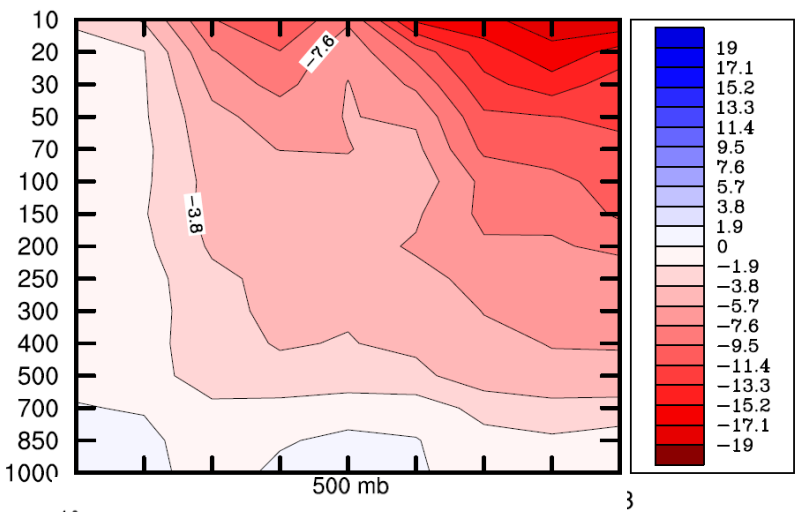
Parallel suite 07-20/02/2017, surface BIAS: NEW - REF



Courtessy of Radmila Brožková

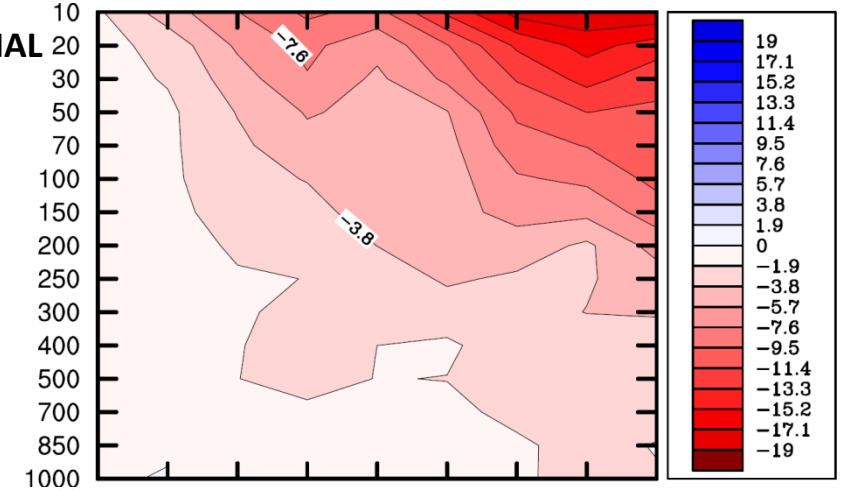
New LBC from ARPEGE CY42 with SURFEX

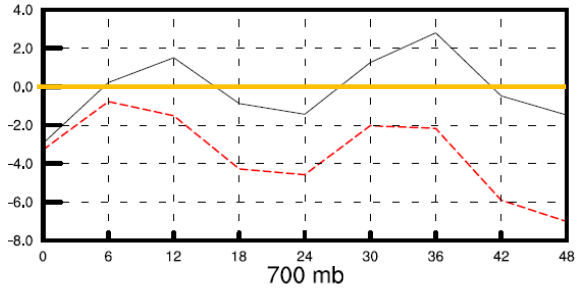
ALARO CZ run 06-15/08/2016 coupled with ARPEGE LBC: NEW-REF



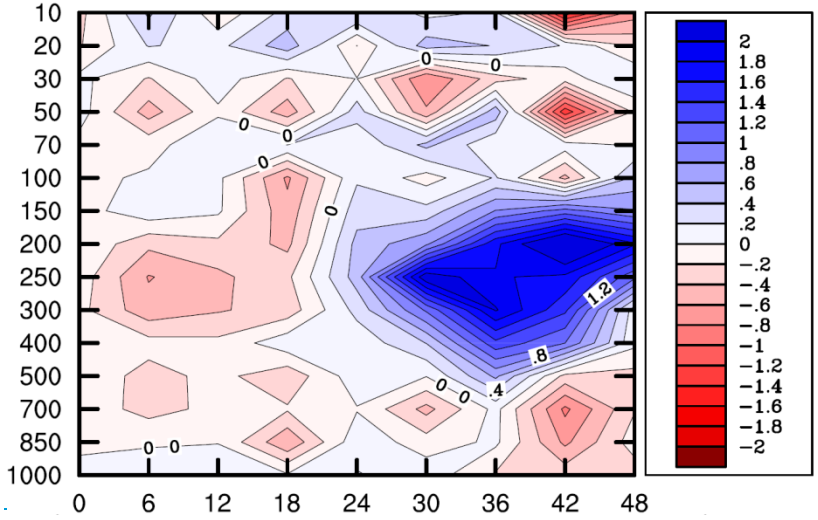
GEOPOTENTIAL
[$10m^2.s^{-2}$]

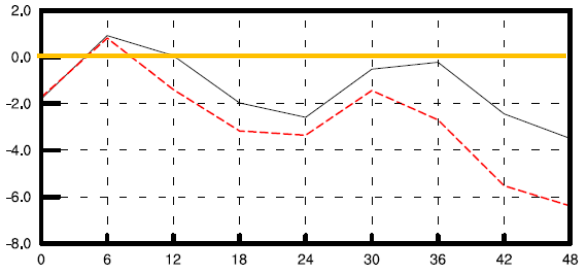
BIAS



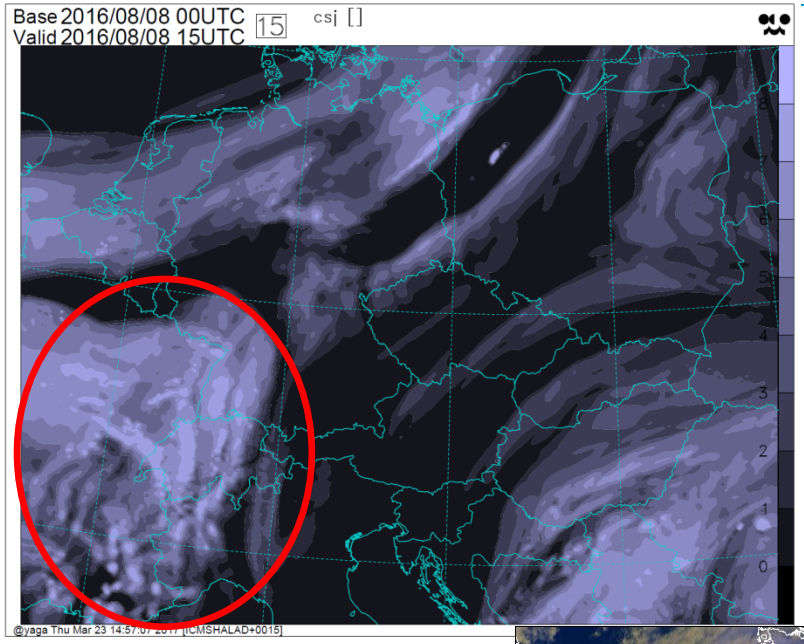


STDE





New LBC from ARPEGE CY42 with SURFEX



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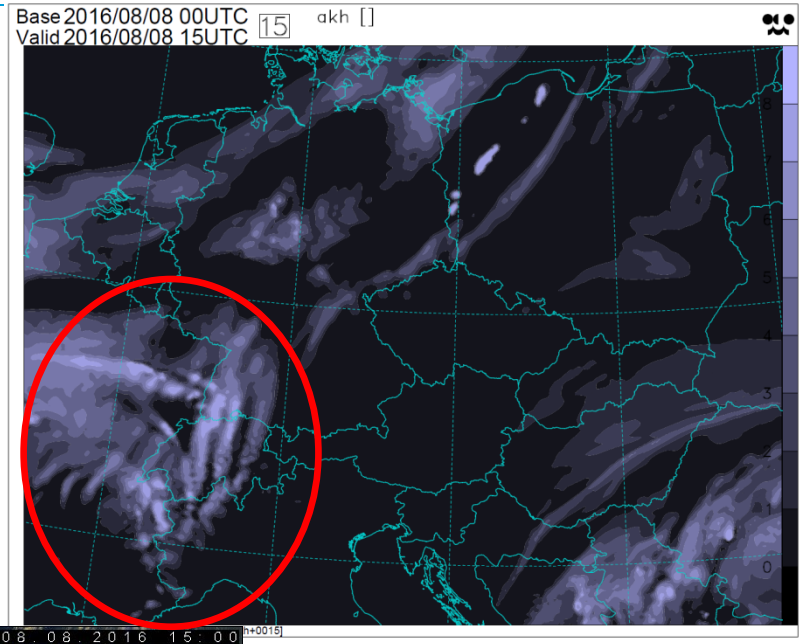
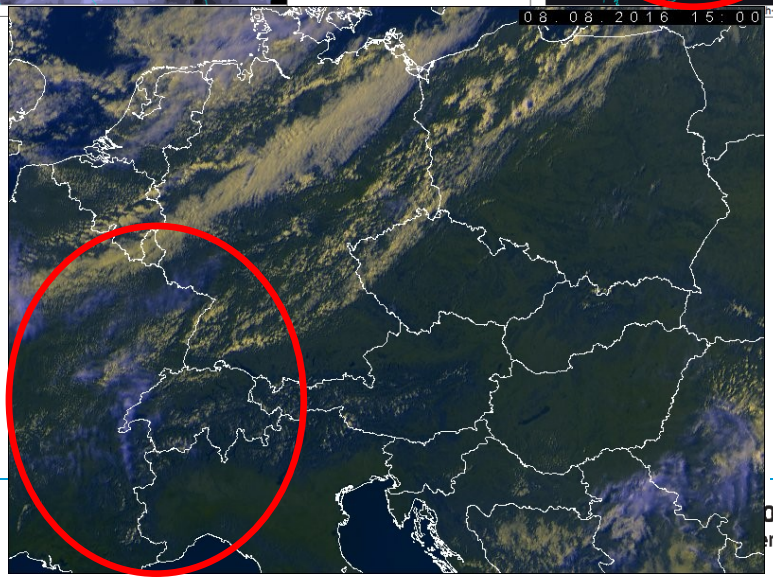


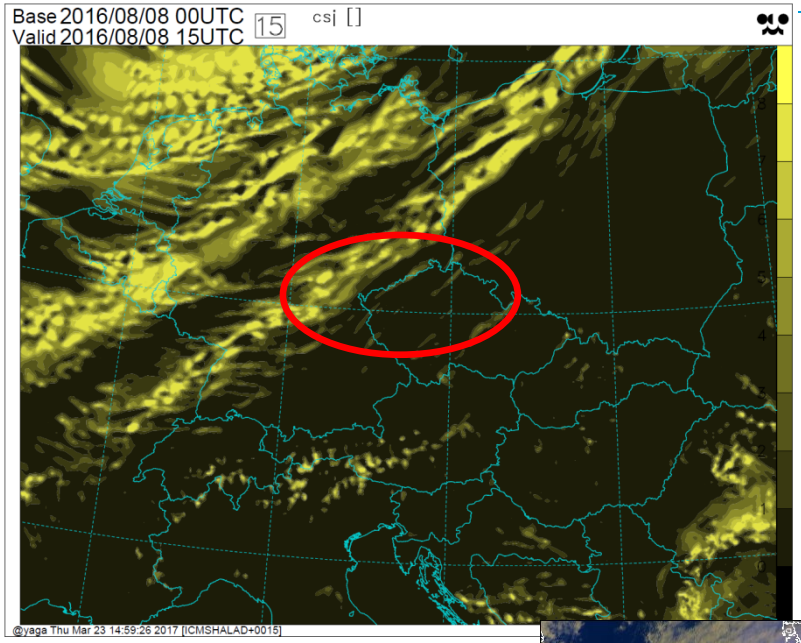
ALARO CZ
high cloudiness



SATELLITE
VISR

Courtesy of Radmila

New LBC from ARPEGE CY42 with SURFEX



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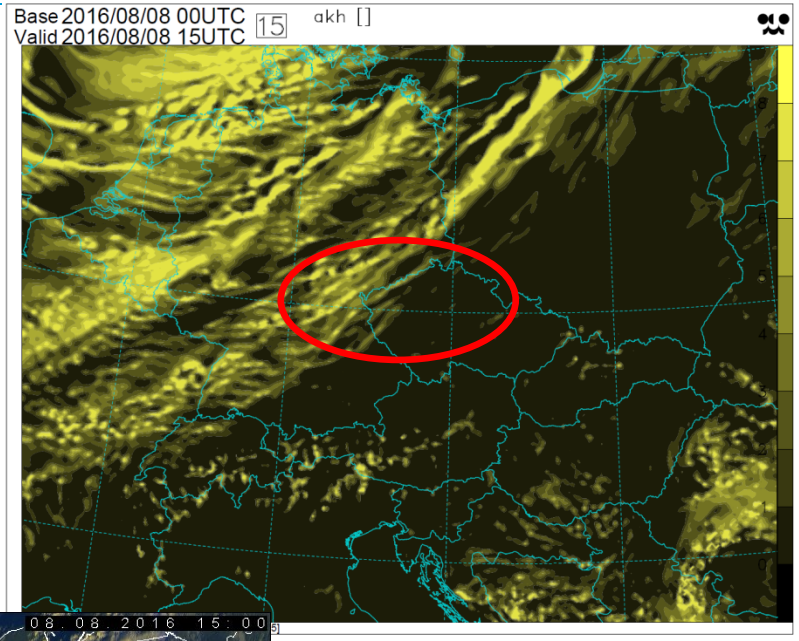
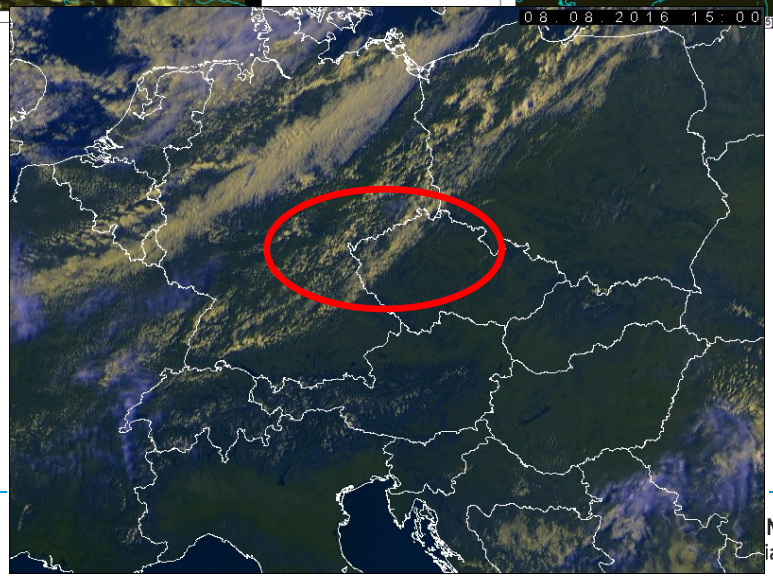


ALARO CZ
low cloudiness



SATELLITE
VISR

Courtesy of Radmila

Dynamics of Helsinki