ALADIN: (some) highlights, (some) science and (some) plans

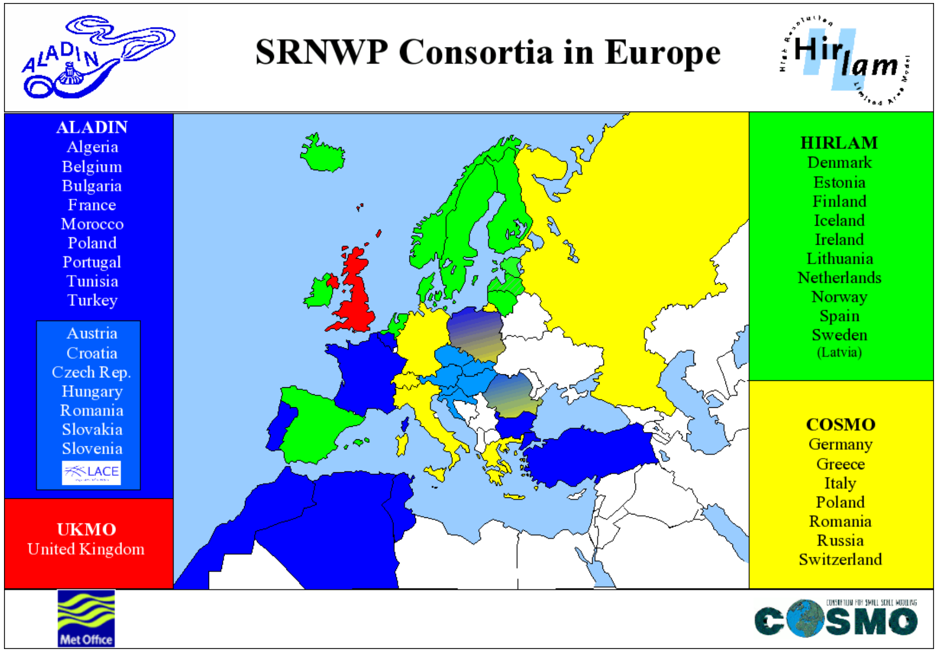
Piet Termonia, ALADIN Program Manager

With contributions of many ALADIN and HIRLAM colleagues

Outline (I don't pretend to give an exhaustive overview in this talk)

- Organization: HARMONIE
- Few highlights
- Research (i.e. open issues ...)
  - Convection permitting scales: status.
  - Dynamics: plans for the medium to long term
  - EPS: verification and :use of multi model EPS?
- More “straightforward” stuff to do (in the sense that we know we have to do it):
  - The surface scheme: SURFEX
  - DA radar

Merging HIRLAM and ALADIN

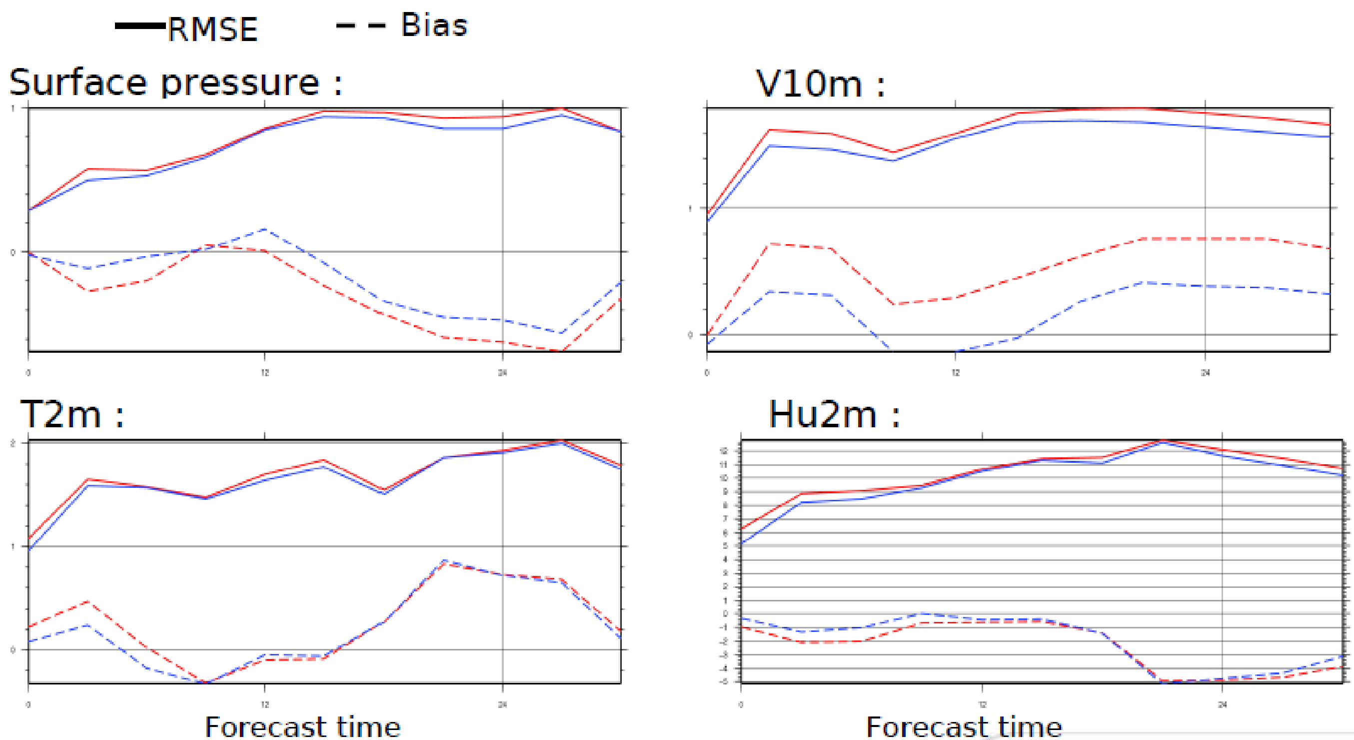


- The barriers between the scientists are mostly removed. We are now writing **common work plans** and we have **joint All Staff meetings (ASMs) and worshops**.
- We are investigating how to proceed with a possible merger: we will have a strategy meeting in a few weeks (27-29/9) in order to "synchronize" or strategies better.
- The same code, shared with IFS, called HARMONIE. The HARMONIE system consists of two model configurations:
  - **AROME**:based on MF meso-NH physics
  - **ALARO**: an extension of the ALADIN physics to be run in the gray zone (see later)

After 2008, AROME became a state of the art model (after some child deseases)

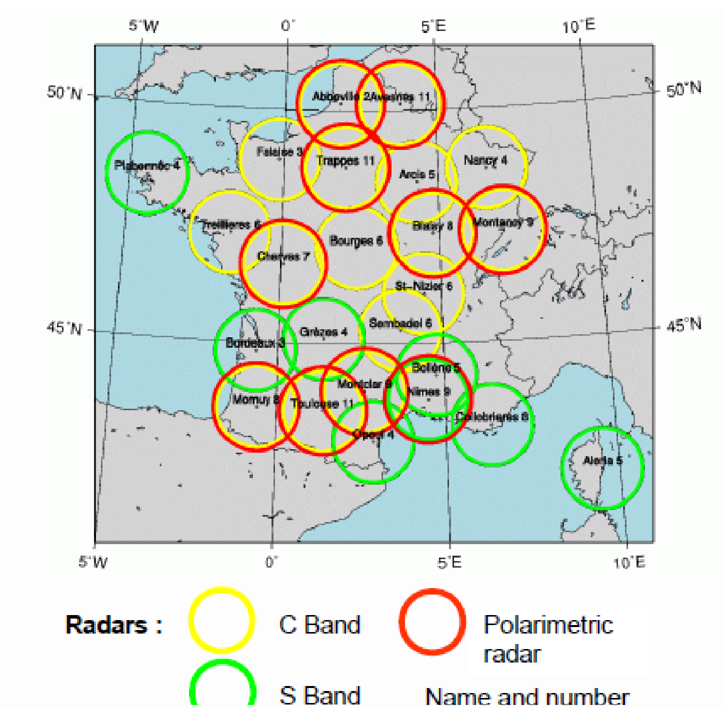
AROME-France scores

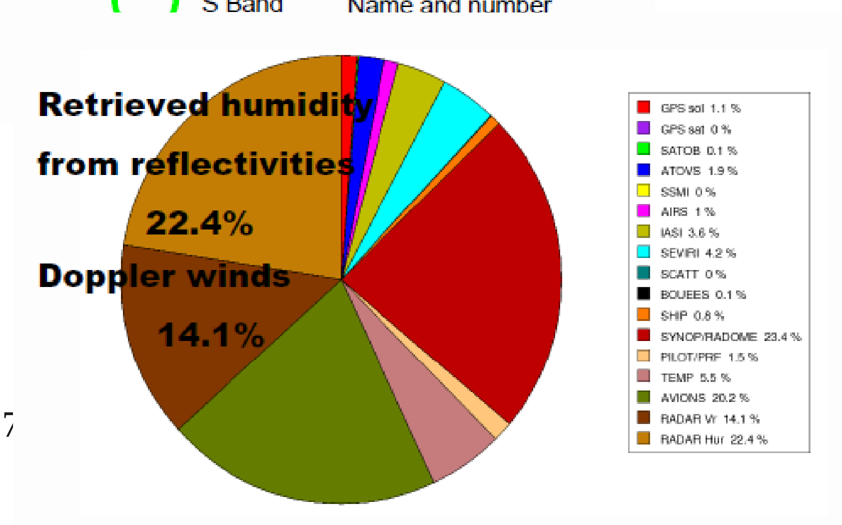
Surface scores (from 20 August to 13 September 2010) : AROME_35t2_op1, AROME_36t1_op1



METEO FRANCE
Toujours un temps d'avance

Morever, operational AROME radar assimilation in MF has provided improvements and shows potential for all ALADIN (and HIRLAM) partners





7 N: high

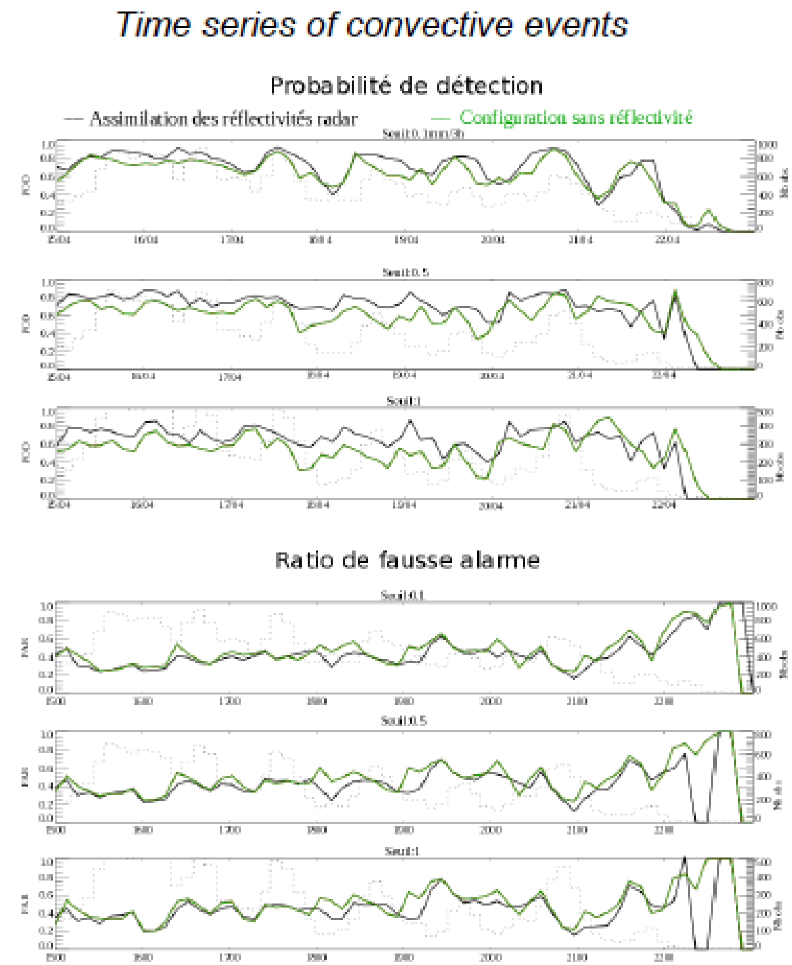


Fig. 2: Séries temporelles de scores probabilistes de cumuls de précipitations pendant les 3 premières heures d'échéance de prévisions pour les seuils 0.1mm, 0,5mm et 1 mm. Sur la période du 15 au 23 avril avril 2009, pour l'expérience sans assimilation des réflectivités radar (vert), avec l'assimilation des réflectivités radar (noir). En haut pour la probabilité de détection, et en bas, pour le ratio de fausses alarmes.

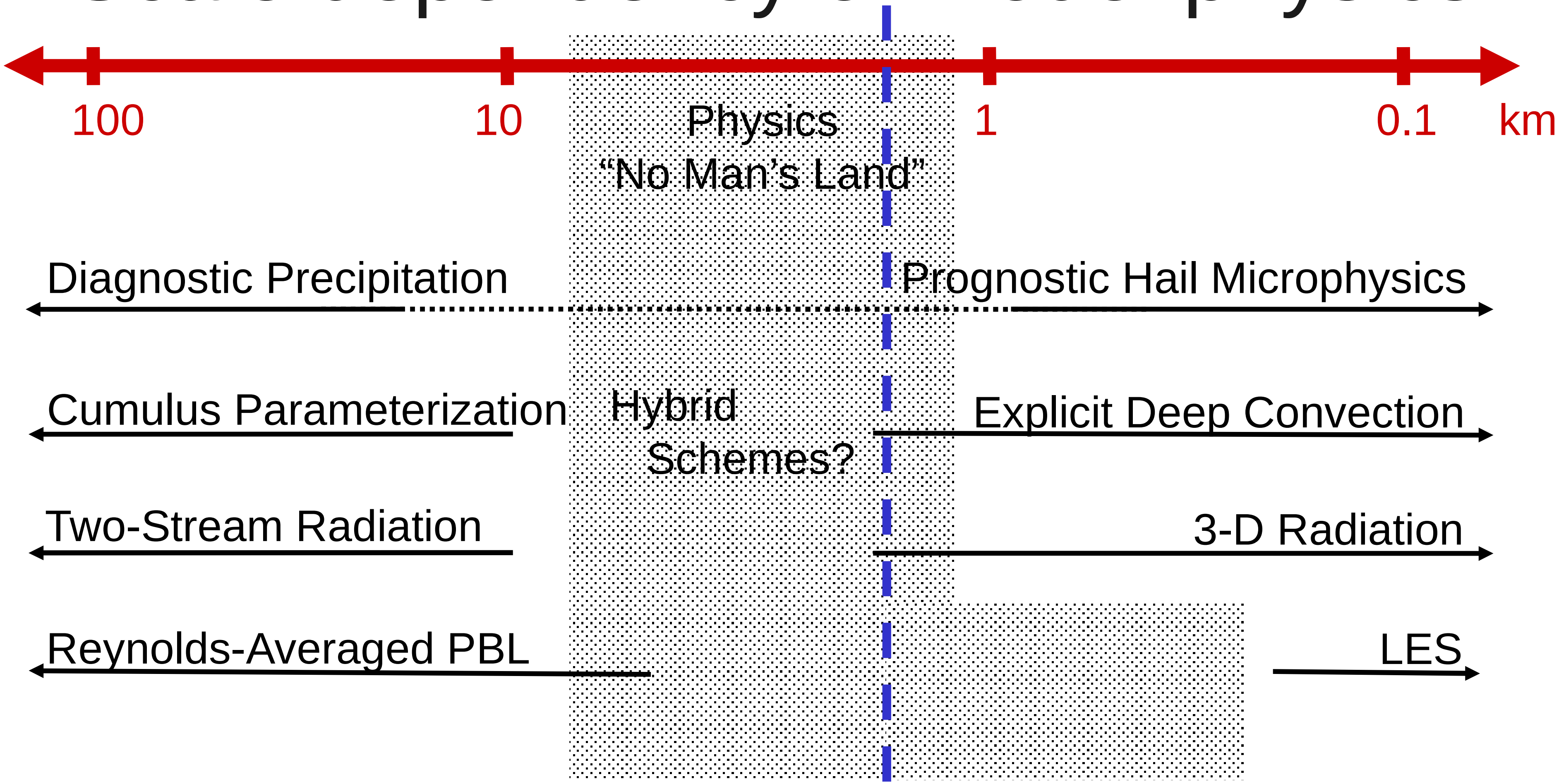
AROME

- The AROME project was finalized in 2008.
- After a number of child deseases, it has now become a state of the art NWP model
- The major step forward was the start of radar DA (reflectivities since last year).

Research

About Gray zone(s) and Dynamics, Since the talk of J.-F. Geleyn in 2009 in Offenbach

Scale dependency of model physics

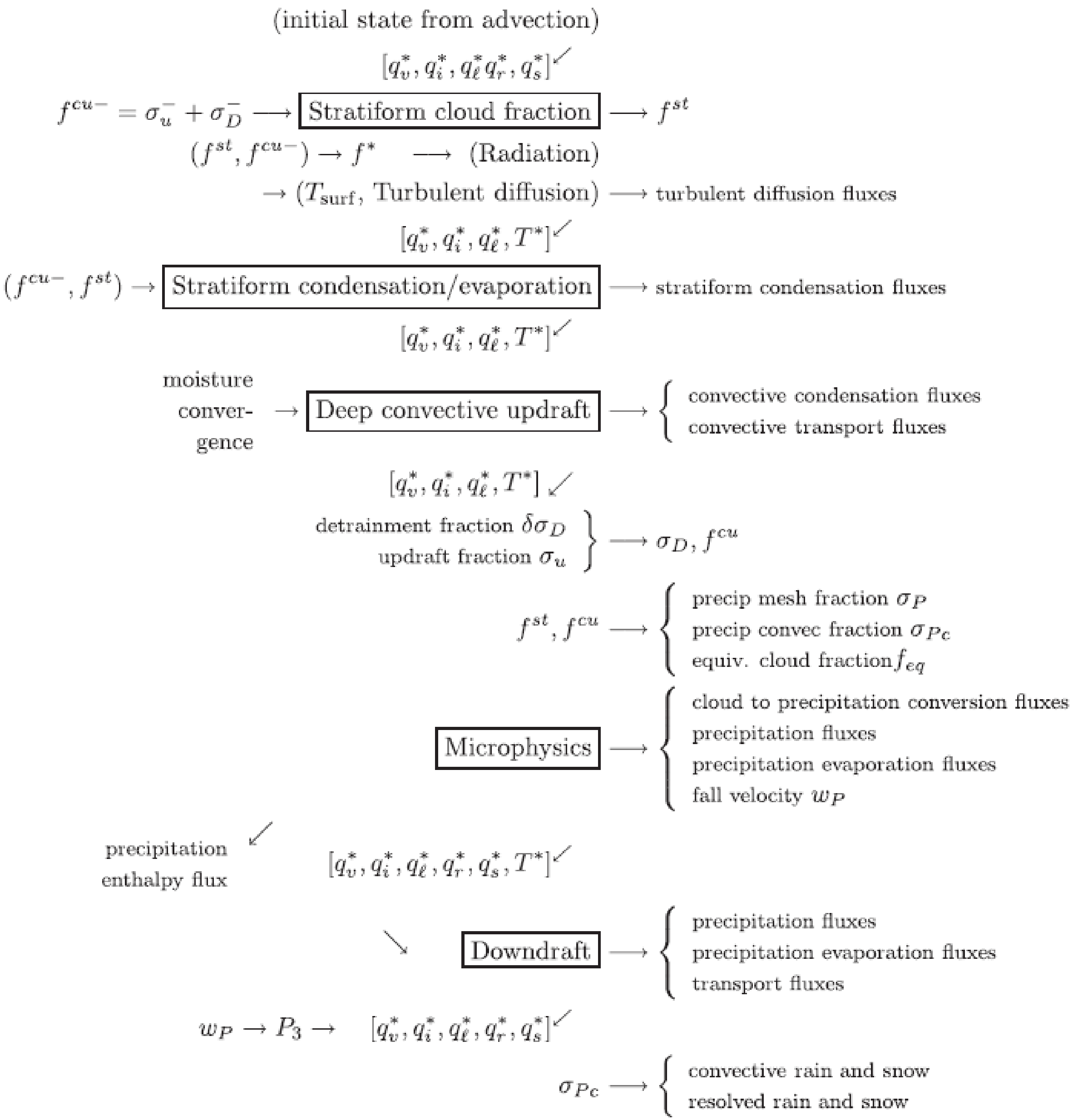


(adapted from Klemp 2007, by A. Seifert [GCSS, Toulouse, June 2008])

Convection-permitting scales?

- We can run at 2 km in a convection permitting mode without parameterization of deep convection. With proper tuning the models behave “correctly” at these resolutions, and moreover it has been shown that radar DA improves the forecasts at these scales. So taking a pragmatic attitude has proven to pay off..., at least within HARMONIE.
- The limits of grey zone are not settled, it depends on the processes. This is **scientifically an attractive problem** and also a quite desirable one to solve for practical reasons => ALARO 5km project of RC LACE with strong contribution of Belgium.
- I give two examples of the research on the next slides
    - The **3MT scheme**, originating in the ALADIN consortium, which originally formed the backbone of ALARO.
    - Lisa Bengtsson-Sedlar: **cellular automata (CA)**, based on idea's coming from ECMWF and then worked out within the HIRLAM-ALADIN collaboration

3MT



Stands for Modular, Multi scale, Microphysics and Transport

Key elements are:

- Its avoids **double counting** of (resolved and parametrized) precipitable water
- There is no need to prescribe **detrainment, it computed and it is given back to the dynamics** by relying on the MT concept of Piriou (2007).
- It has a convective **memory** by prognostic mass fluxes.

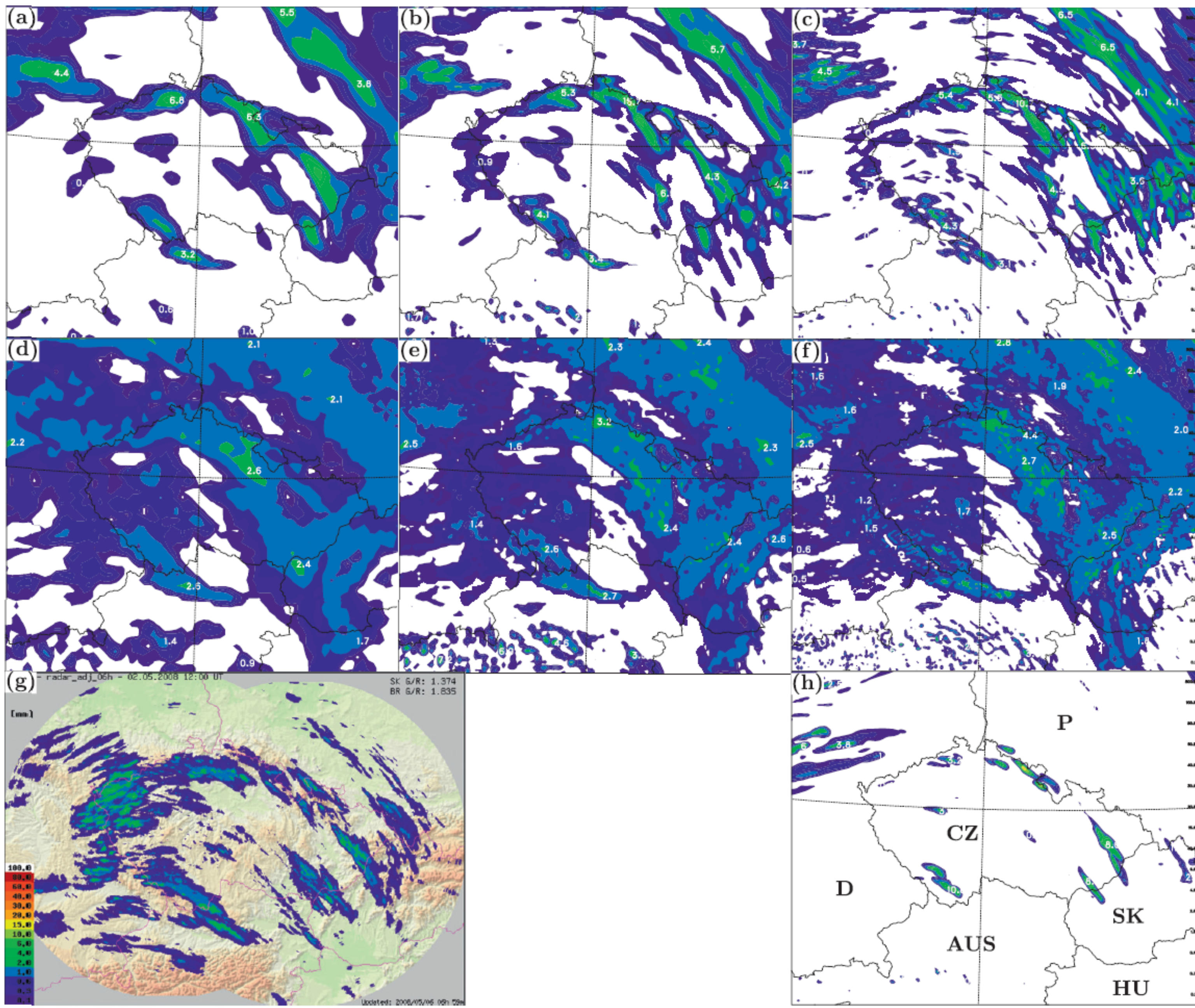
ans

Illustration of the multiscale aspect

With 3MT

Without 3MT

radar



Gerard et al. (2009)

No convection scheme

7 September 2011

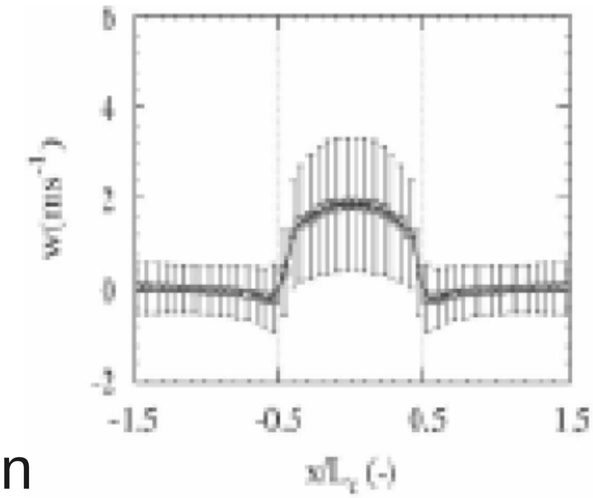
Status and operational applications of ALARO-0

- For operational applications ALARO-0 scales nice to the „middle“ of the gray zone, i.e. roughly 4 km.
- But we still have problems to go to 2 km.
- Nevertheless. This model configurations runs operationally in many ALADIN countries and two HIRLAM countries are testing it (w.r.t. To the old HIRLAM model)

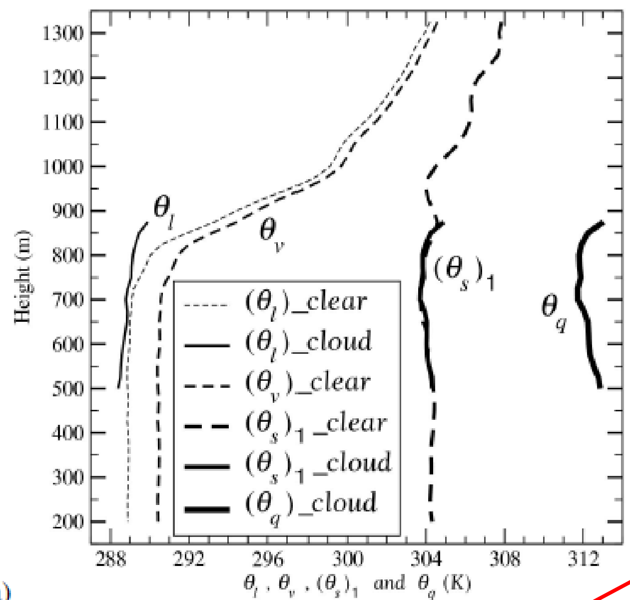
	ALARO-0 minus-3MT	Full ALARO-0
Cz	30/1/07	4/6/08
At	13/9/07	7/4/09
Sk	19/2/08	19/8/08
Hr	25/2/08	test
Si	X	16/6/08
Be	X	15/1/09
Ro	X	pre-oper 1/10

3MT and shallow convection:
(what J-F Geleyn told you in 2009)

- The spirit of 3MT should in principle allow to treat any kind of convection (precipitating [like up to now], non-precipitating, dry).
- But the link with the 'resolved' condensation requires that the convective part connects the 'thermal' with the environment (Transport = return current outside).
- Convective clouds have a 'shell' of subsident motions, (Heus and Jonkers 2003)
- Hence shallow convection cannot enter the 3MT logic.
- This leads to rather try and treat 'shallow convection' on the turbulent side (the 3rd of Mironov's alternatives: non-local second-order closure).



J.-F. Geleyn and P. Marquet: SC by a turbulence description, a step forward based on Marquet's moist entropy potential temperature (?)



(a)

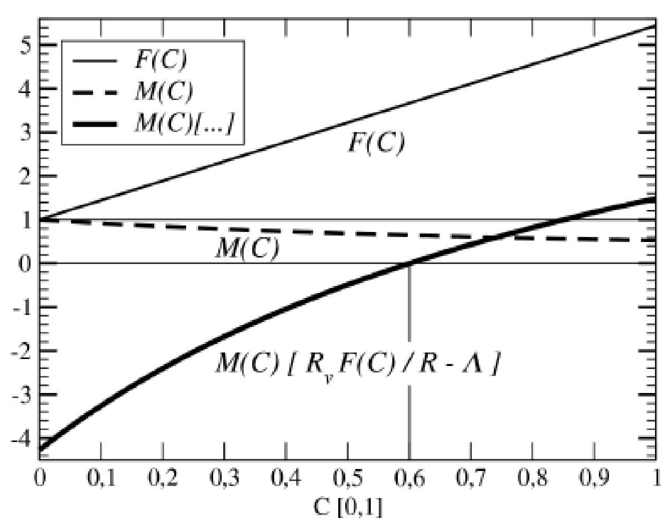
$$N^2(C) = g\,M(C)\left(\frac{\partial \ln(\theta_s)_1}{\partial z}\right)_e - g\left(\frac{T}{T_v}\right)_E\left(\frac{\partial q_t}{\partial z}\right)_e + g\,M(C)\left(\frac{R_v}{R}\,F(C) - \Lambda\right)_E\left(\frac{\partial q_t}{\partial z}\right)_e . \qquad (52)$$

C=0

C=1

Unsaturated moist air

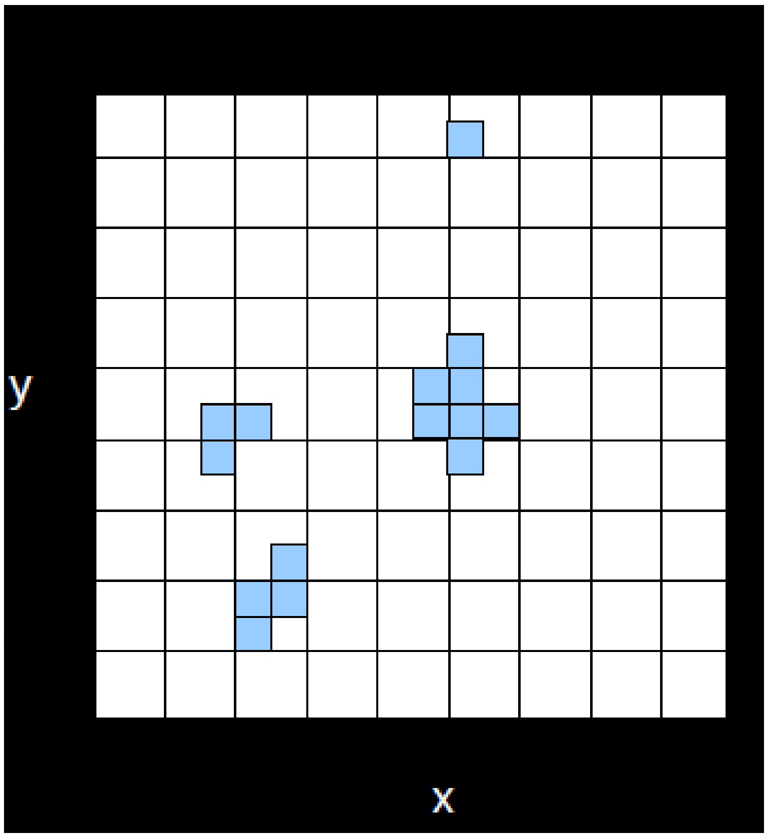
$$N^2_{ns} = g\left(\frac{\partial \ln(\theta_s)_1}{\partial z}\right)_e - g\left(\frac{T}{T_v}\right)_E\left(\frac{\partial q_v}{\partial z}\right)_e + g\left(\frac{R_v}{R} - \Lambda\right)_E\left(\frac{\partial q_v}{\partial z}\right)_e . \qquad (48)$$



Saturated moist air

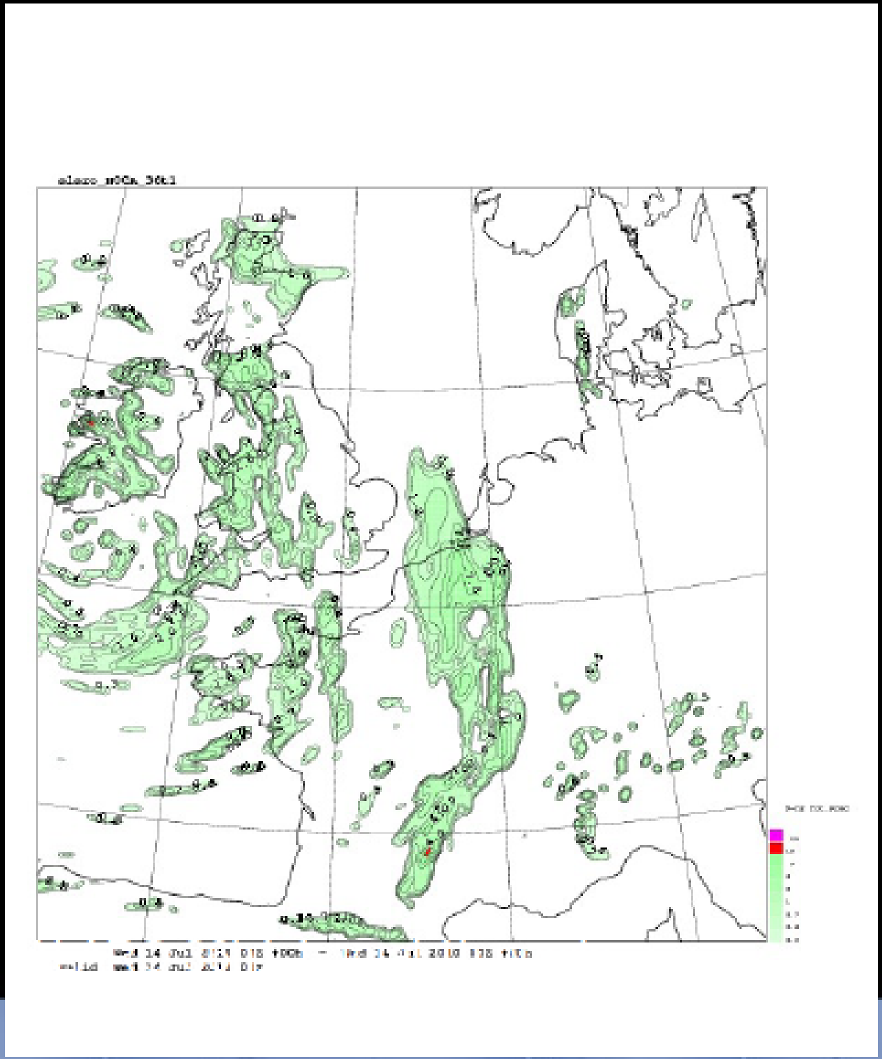
$$N^2_m = g\,\frac{D_{1v}}{D_2}\left(\frac{\partial \ln(\theta_s)_1}{\partial z}\right)_e - g\left(\frac{T}{T_v}\right)_E\left(\frac{\partial q_t}{\partial z}\right)_e + g\,\frac{D_{1v}}{D_2}\left(\frac{L_v}{c_{pd}\,T} - \Lambda\right)_E\left(\frac{\partial q_t}{\partial z}\right)_e , \qquad (39)$$

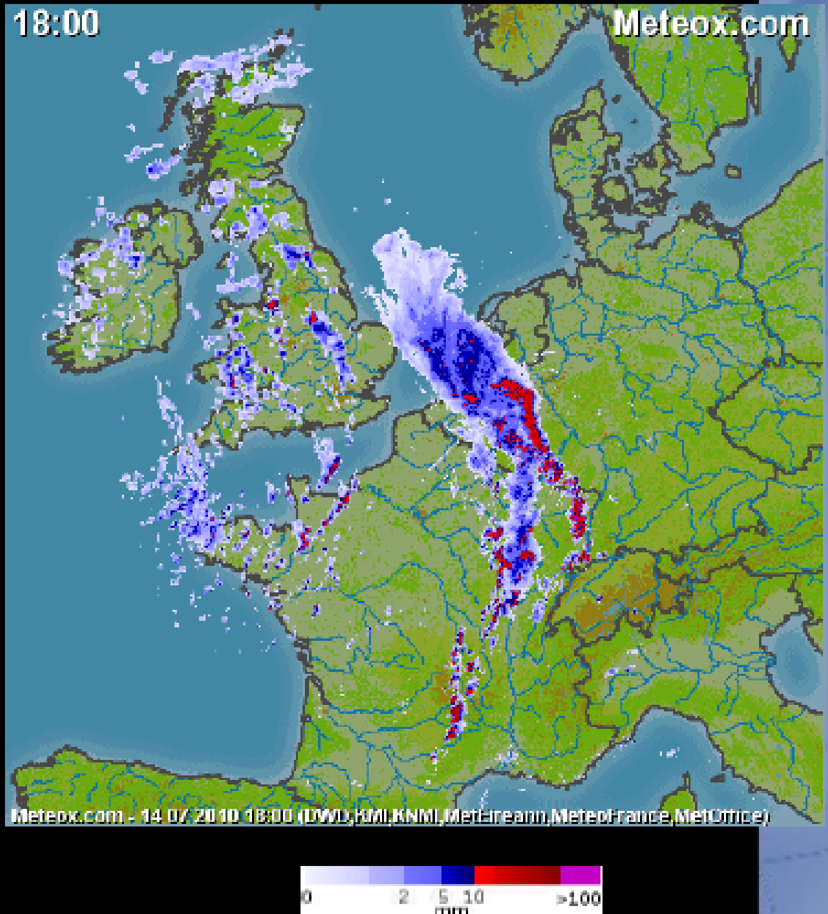
Cellular automata: work of Lisa Bengtsson-Sedlar



- Palmer (2001), Shutts (2005) and Berner (2008): use cellular automata to generate stochasticity.
- Should the stochasticity be added in the EPS or in the deterministic model? Lin and Neelin (2002, 2003), Shutts (2005), Teixeira and Reynolds (2008), Plant and Craig (2008)
- The aim is to add some stoachasticity with sufficient back scattering
- In this work it is implemented in the deterministic model.
- It has stochasticity, laterality and memory

Radar image, squalline 14/7-10
16 UTC (or 18 CET)

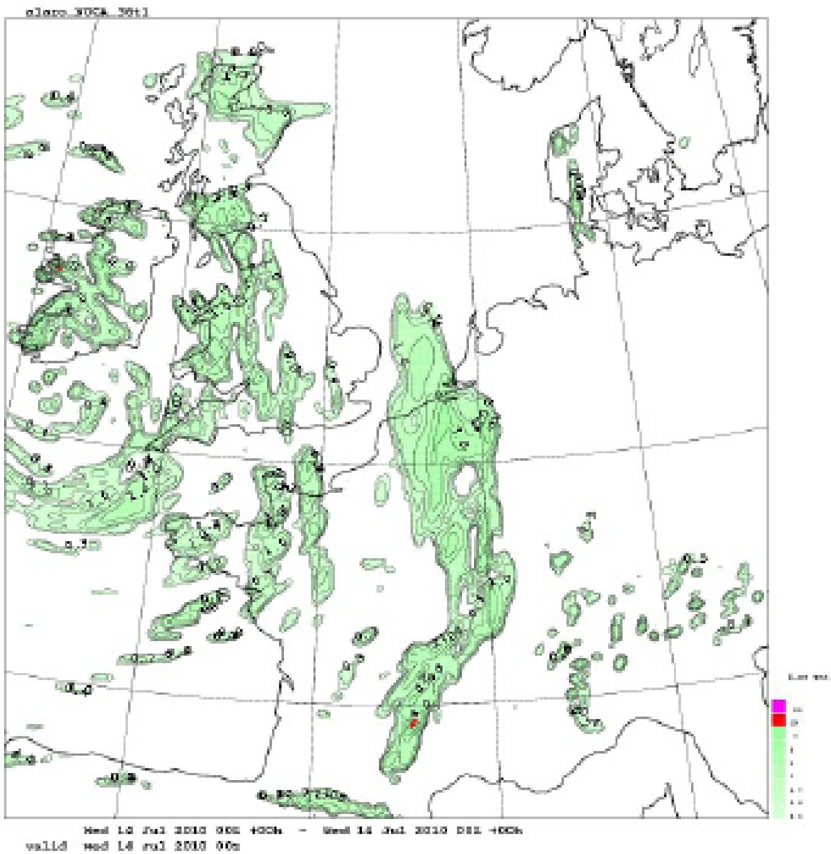




1 hour precip from radar image.

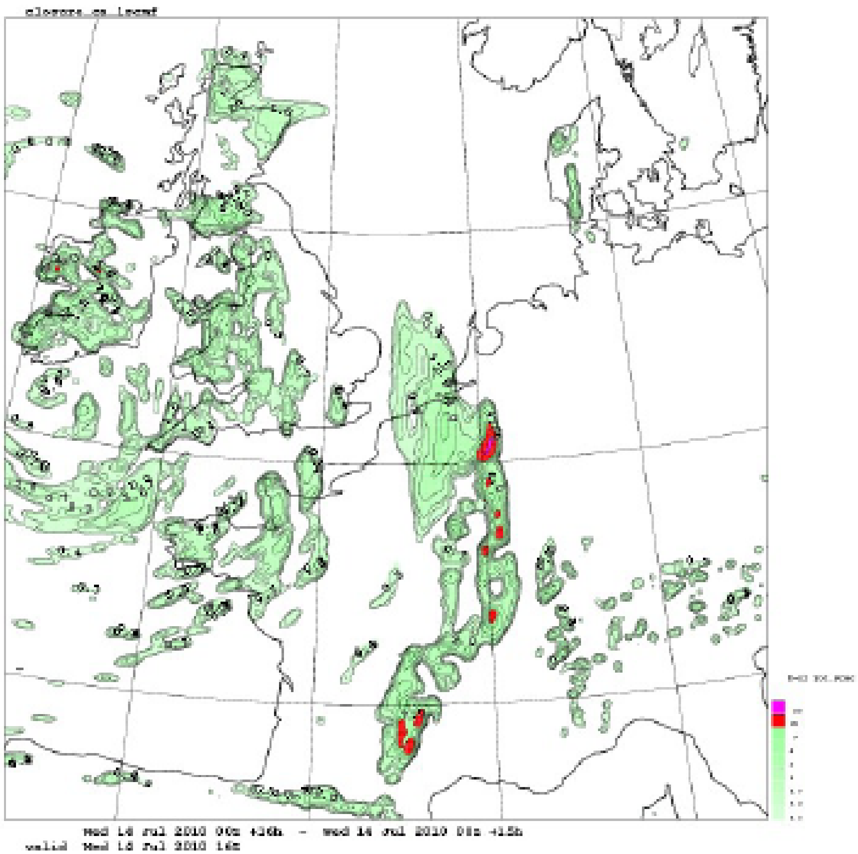
Total precipitation, 2010-07-14, 16 UTC

ALARO reference, 36h1.1



16 UTC

ALARO CA-CAPECONV, 36h1.1

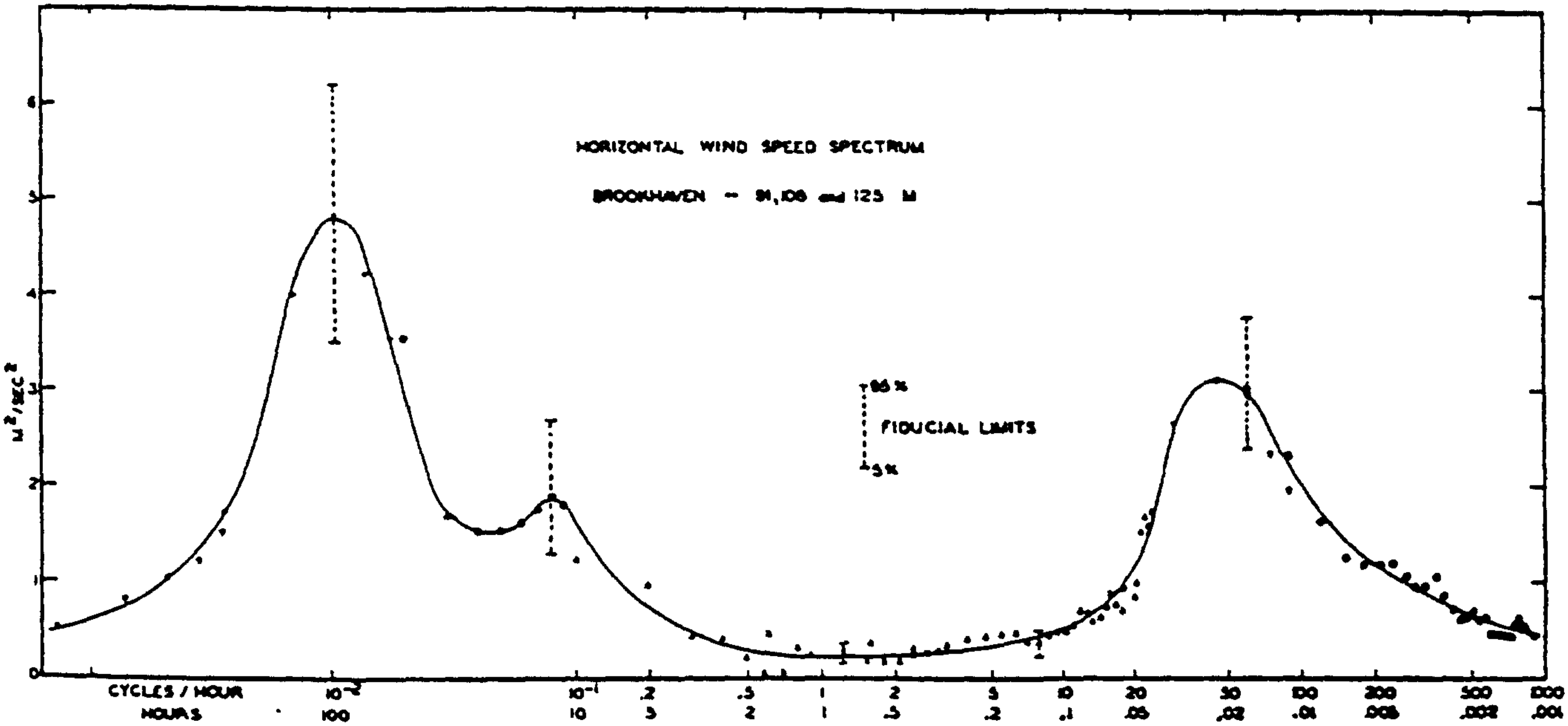


16 UTC

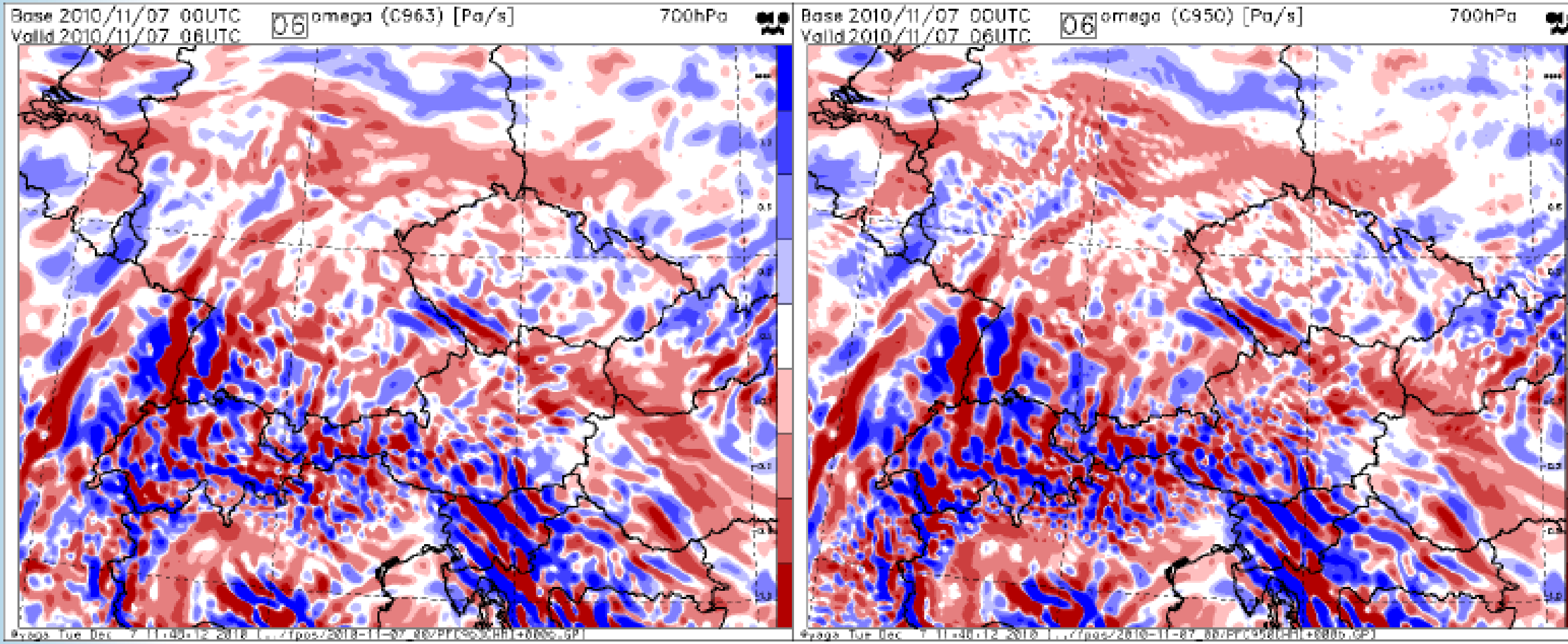
By the way, this is a nice example of the HIRLAM->ALADIN->ECMWF collaboration

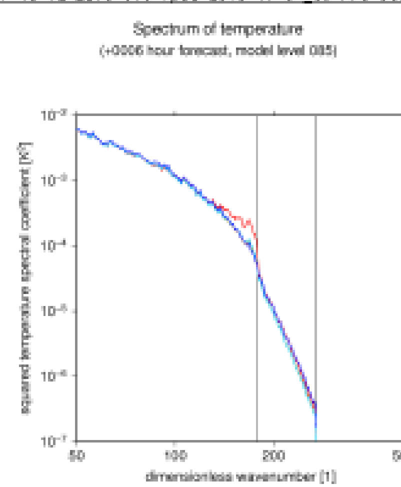
- The idea originated in ECMWF
- It became the PhD subject of a HIRLAM scientist
- It was coded by an ALADIN scientist with the code of ALADIN/ALARO/ARPEGE/IFS
- It may be again available for ECMWF

The turbulence gray zone?



Example of phys-dyn interaction



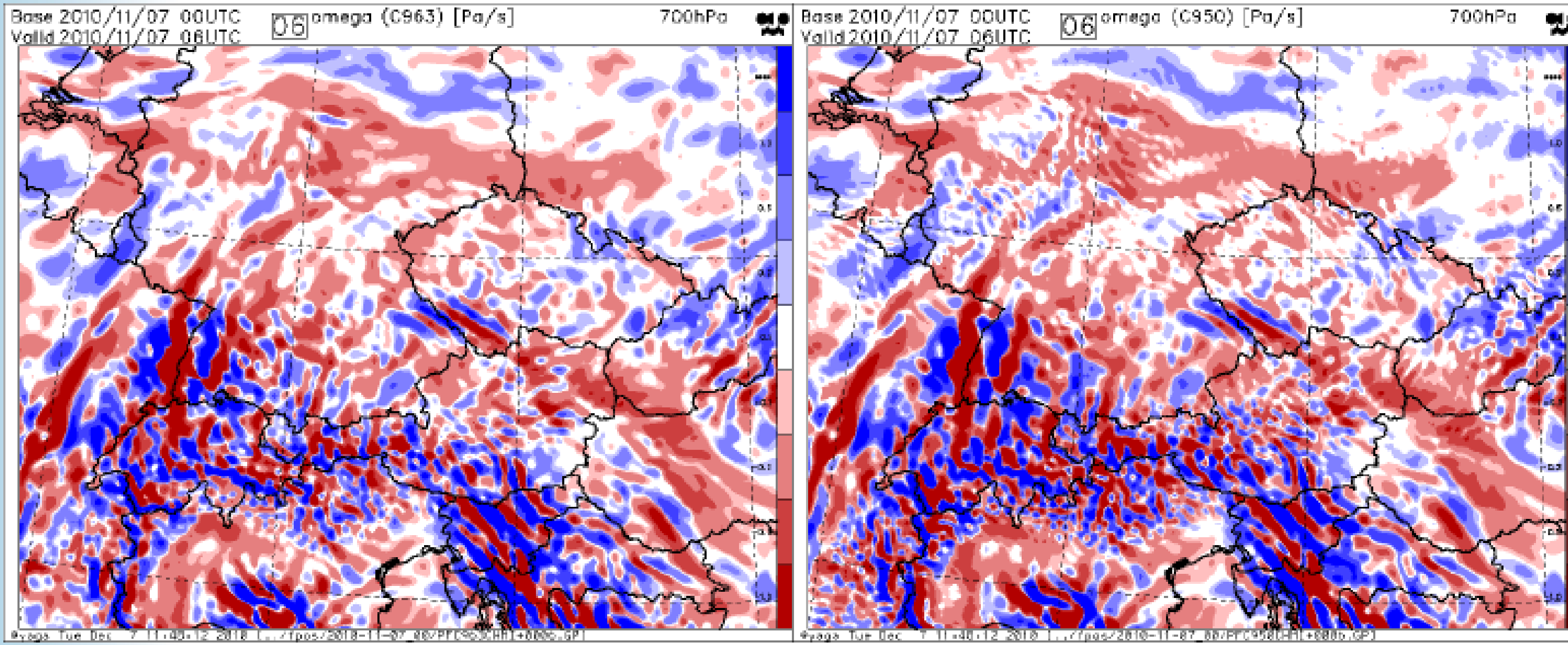


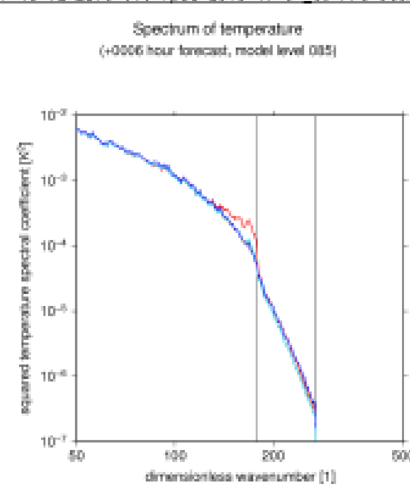
Vertical velocity as measure of noise: effect of diffusion and stationary forcing

ČHMÚ

spectral linear diffusion reduced by factor 10 for T,q and VOR and by factor 50 for DIV (left)

vertical velocities from adiabatic run obtained with the original diffusion tuning (right)





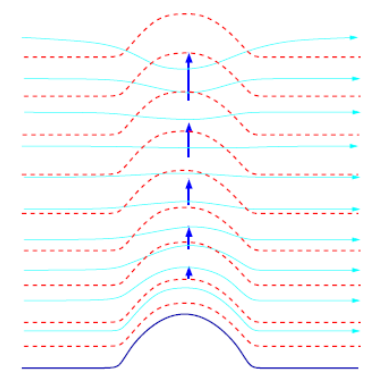
Vertical velocity as measure of noise: effect of diffusion and stationary forcing

We should not Be too dogmatic About "spectral" resolution!

Conclusion about a numerical diffusion

- The model behaves quite counter-intuitively
- But in this case it can be physically understood.
- This does not look very promising for the turbulence gray zone lying ahead of use. If already we see this kind of behavior in numerical diffusion. Then what will happen if we enter the turbulence gray zone (which is going to add a lot of small-scale diffusivity).
- If you can't master the numerical diffusion, ow do you expect to master 3D turburbulence?

Origin of this phenomena has been traced back to linear diffusion on divergence:

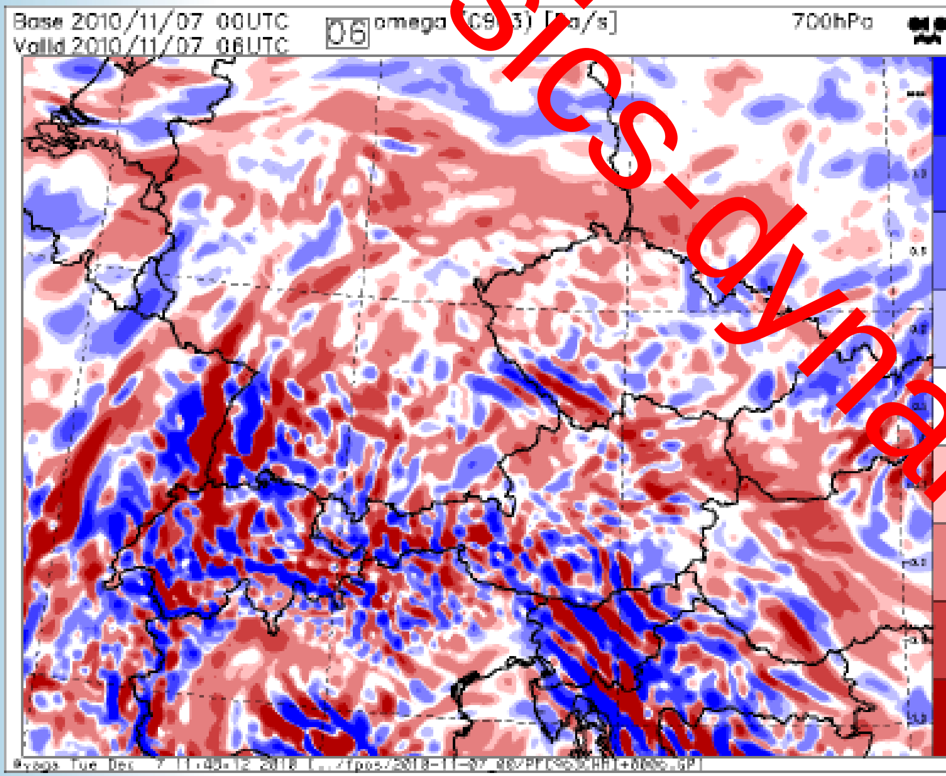


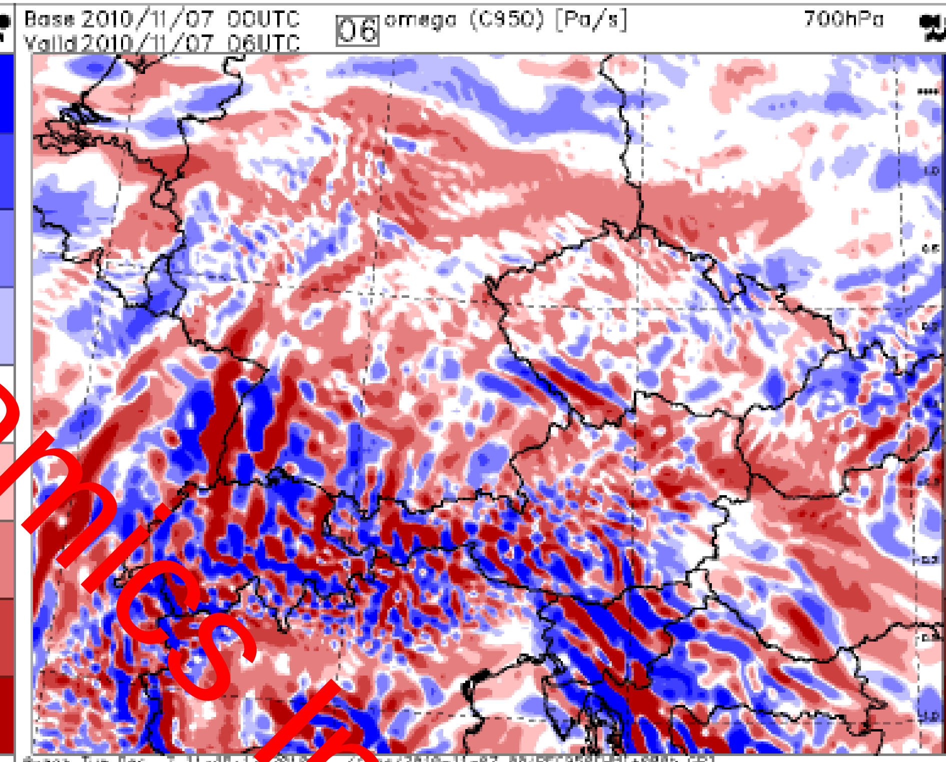
The difference between physical and non-divergent flows leads to noise in vertical velocity

LACE

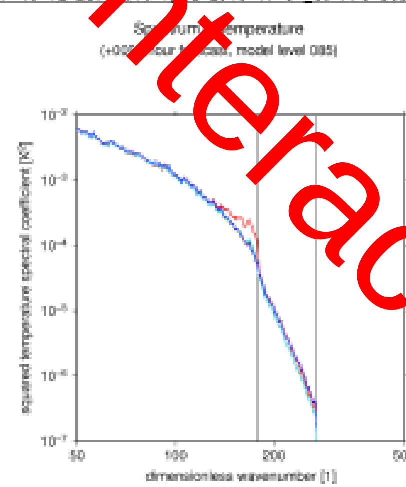
spectral linear diffusion reduced by factor 10 for T,q and VOR and by factor 50 for DIV (left)

vertical velocities from adiabatic run obtained with the original diffusion tuning (right)





Vertical velocity as measure of noise: effect of diffusion and stationary forcing



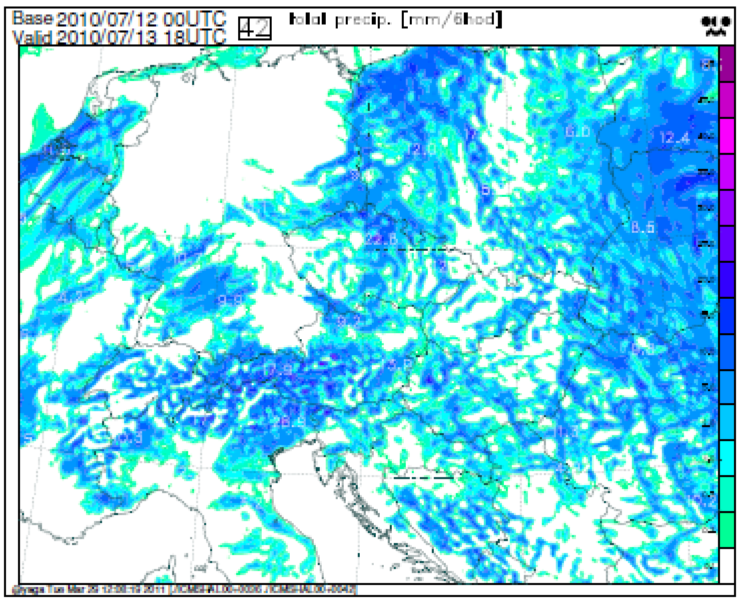
We should not Be too dogmatic About “spectral” resolution!

A few words about dynamics ...

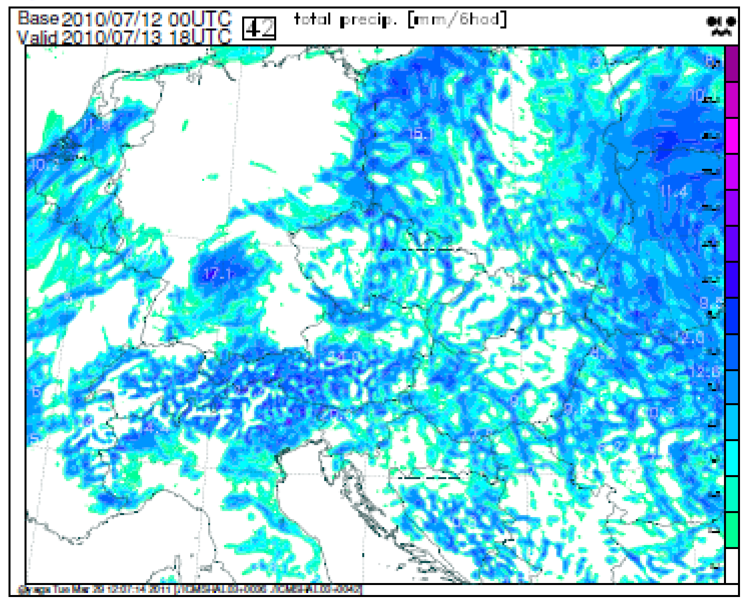
4th order treatment of the advection of water vapor (Cz)

$$u_i \frac{\partial q}{\partial x_i} = \frac{1}{4}\left[(u_l + u_{l-1})\frac{(27(q_l - q_{l-1}) - (q_{l+1} - q_{l-2}))}{24\Delta x_i} + (u_l + u_{l+1})\frac{(27(q_{l+1} - q_l) - (q_{l+2} - q_{l-1}))}{}\right], \quad i = 1, 2$$

Aladin/CE, Δx = 4.7 km



NCOMP_CVGQ=0

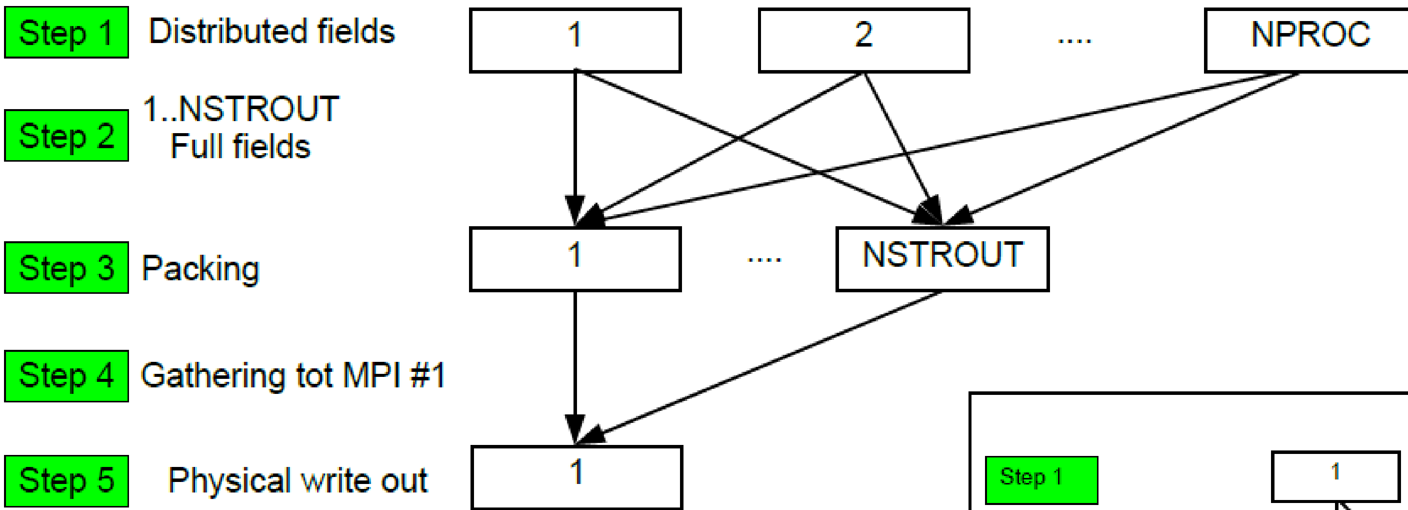


NCOMP_CVGQ=3

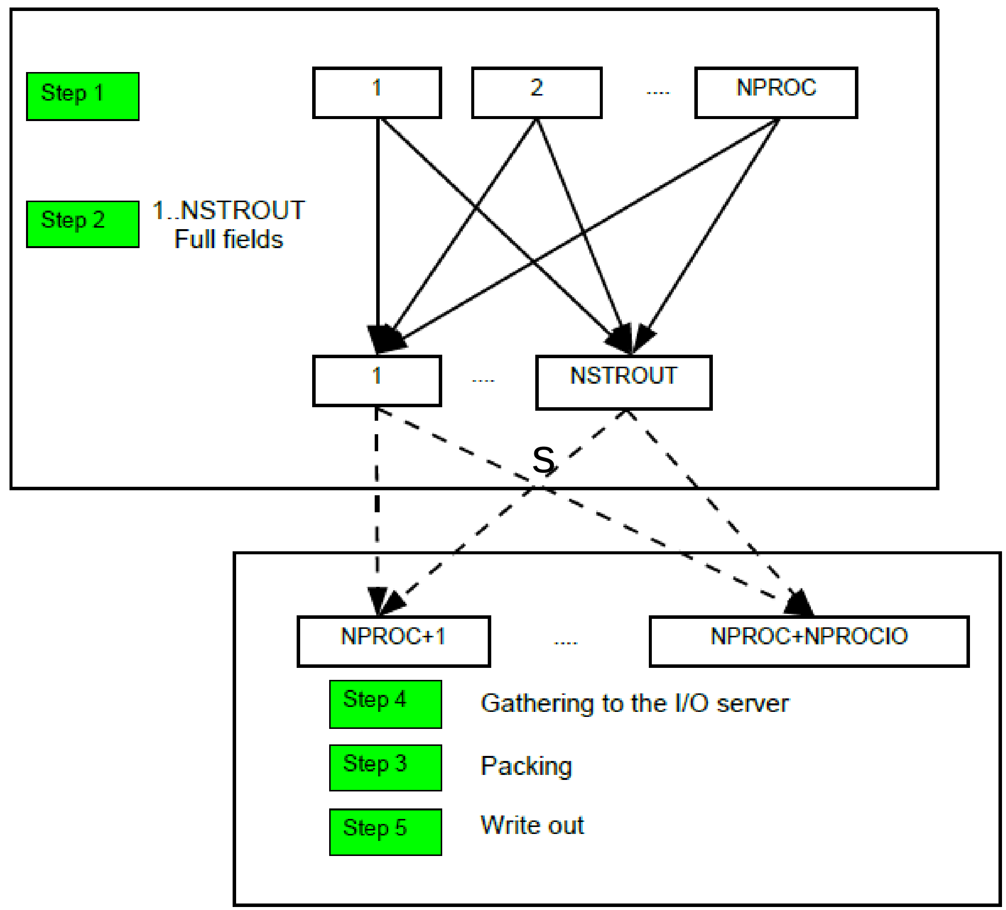
- No significant difference in terms of structure
- GP slightly worse in terms of scores
- Worse consistence between 4.7 km and 9 km runs
- GP more expensive (comms, memory conflicts) or memory consuming (multiplied 5*5 points stencil)

- There is no indication to gain anything at scales from 9 to 4.5 km.
- No improvement in accuracy from a grid point discretization
- The main obstacle is in the scalability of the FFT algorithm.

The problem of the IO



The IO seems, as of today, still to be the main bottleneck for scalability on HPC machines.



Work plan for dynamics (long term)

- (a) Separately explore the switch to grid-point methods for limited parts of the dynamical core (computation of derivatives, SI solver). **Remaining in the current staggering (A-grid) an horizontal finite volume (or elements) method** should be implemented and tested as an alternative to the bi-Fourier spectral method for LAM derivatives. In order to remove only the "spectral" option while keeping the SI option, this requires **the implementation of a 3D grid-point solver** and test of the results/performances all the rest being kept identical. These studies should be led from the **scientific** as well as from the computer points of view (scalability...)

Tests of dynamical cores on HPC infrastructures (An additional note of our post-Brac-HR work plan)

- Besides, in order to begin to examine the aspects linked to the global strategy, this task should also **contain actions to encourage comparisons with other dynamical cores built on different strategies (<u>COSMO</u>**, UM, WRF,...). These models would be compared on the same machines, and mainly in adiabatic mode, in order to compare the efficiency of dynamical cores only, but for other strategies (explicit, Eulerian, ...). Indeed, due to a non-uniform fields decomposition in different models any such comparison will be necessary in a way not contaminated by differing progranming strategies. **This task requires help from the consortium management.**

EPS systems within the ALADIN consortium

- The **ALADIN-LAEF** system (Wang et al. 2011), here denoted LAEF for short, is an operational limited area EPS based on the ALADIN NWP model. It has a control and 16 perturbed members.
- **GLAMEPS is a multi-model LAM EPS**. It combines members from
  - the ALADIN model and
  - 2 versions of the HIRLAM model with
  - members interpolated from ECEPS.
- The ALADIN and HIRLAM components of the system each run 12 perturbed members and a control. Combined with the ECEPS members themselves (which are interpolated to the common grid), this gives a total of 52 members (including the control members in the enemble).
- A test version of this system was described in Iversen et al. (2011). Since March 2011 a pre-operational version has been running twice daily. Compared to the test version described in Iversen et al. (2011), there are a few notable differences. The initial and boundary conditions are taken directly from ECEPS, not from the targetted global EPS system EuroTEPS.
- No calibration is applied to the member forecasts.
- Besides these EPS systems there is also the Hungarian HUNEPS the French global PEARP.

Economic value of EPS systems

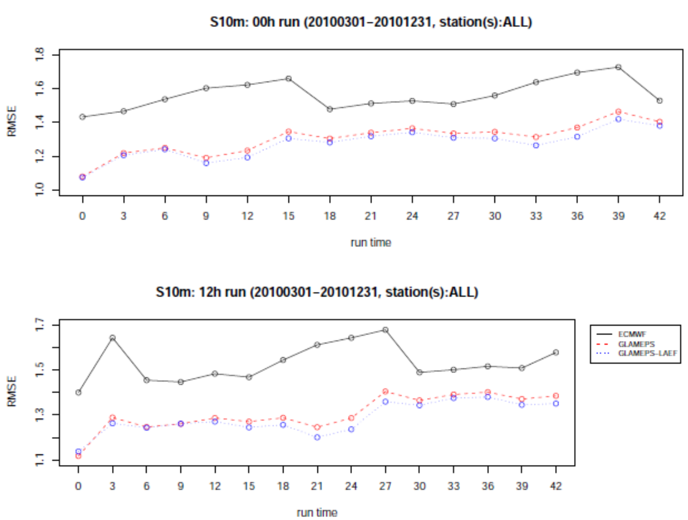


Figure: RMSE of ensemble means for S_{10m}.

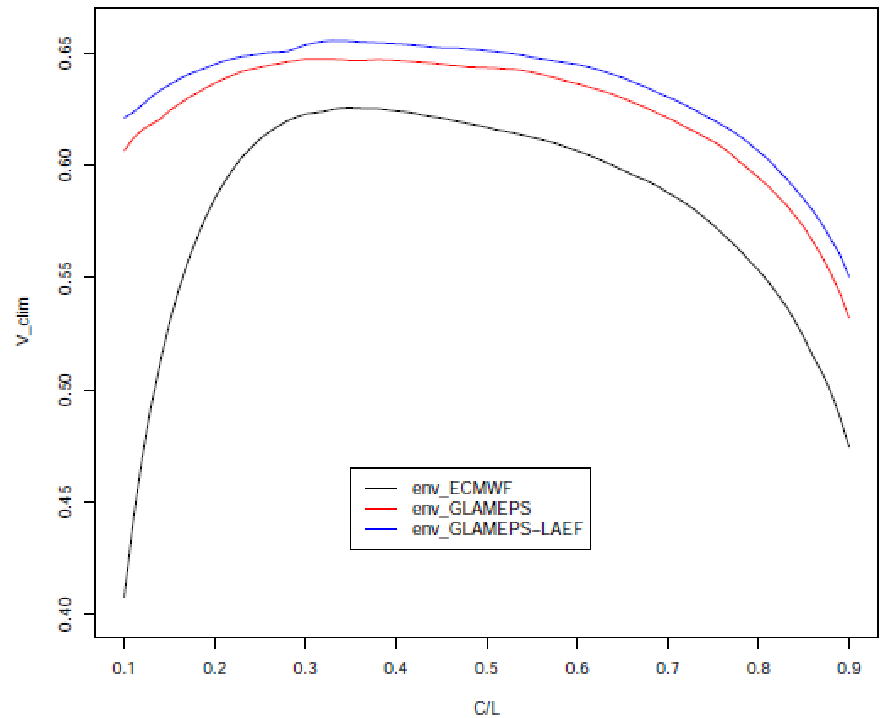


Figure: Relative economic value with respect to (sample) climatology for T_{2m} (run = 00h, lead time = 30h).

Robustness

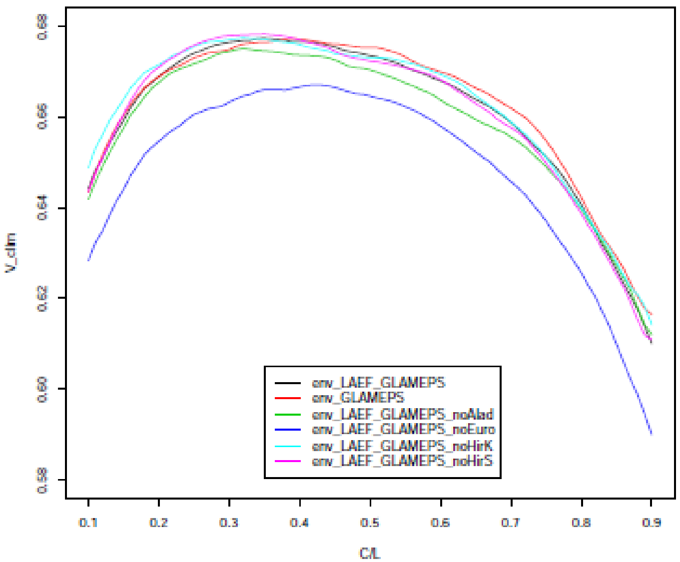
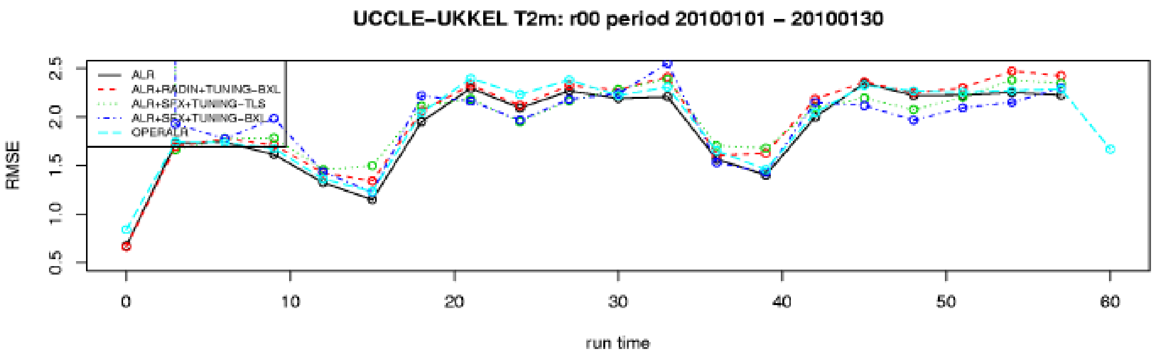
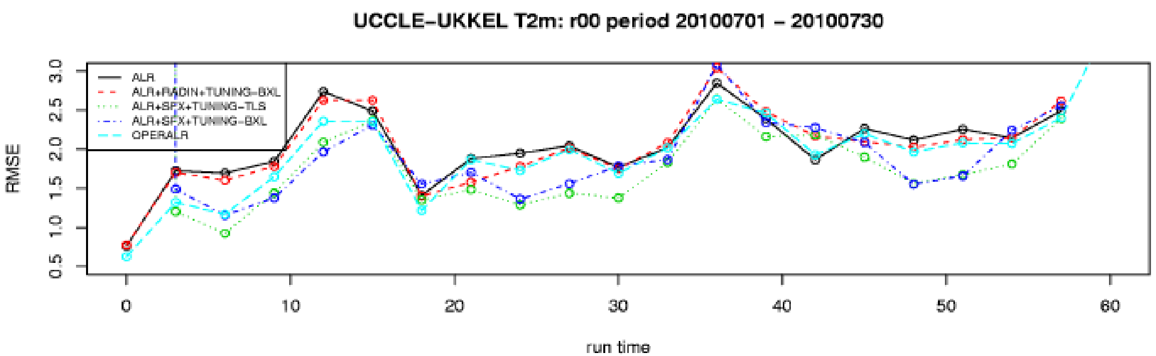


Figure 22. Potential economic value relative to (sample) climatology of GLAMEPS-LAEF (black full line), and GLAMEPS-LAEF with one of its components removed (coloured lines) for bias corrected T2m (run = 0h, lead time = 42h).

- There are now many mesoscale EPS systems.
- From the point of a user in the ALADIN consortium, one might consider using a limited amount of all the available EPS data (restricting the data transfer) to calibrate a local application.
- We take the case of GLAMEPS (including EuroTEPS, the HIRLAM versions and the ALADIN version) and LEAF.
- What is the effect if one drops out?

Running ALARO with SURFEX





- We are currently replacing the old ISBA scheme in the models with the SURFEX scheme, which contains als TEB (urban) and CANOPY.
- ISBA is part of SURFEX, so we are carrying out tests to replace it it all countries that still run either ALADIN or ALARO.
- By the way it is naturally part of AROME.
- We have quite some freedom in using different radiation schemes, switching on TEB and CANOPY, and different interpoation schemes.

Main plans for the coming year

- Replace the old ISBA scheme by SURFEX in all applications
- Make an effort to run all ALADIN applications with 3Dvar and then later with radar DA (i.e. extend the work in Meteo France to the other 15 ALADIN countries).
- We will have a strategy meeting (27-29 September):
  - Analyze both HIRLAM and ALADIN strategies and find room for convergence
  - Intermediate check whether we are on track