Introduction

(scope, current status)

Piet Termonia

Scope (Friday)

- what is included into ALARO-1?
- the plan how to obtain ALARO-1 (short term)
- long term plan, LACE project
- validation of ALARO inside cycles
- ALARO with SURFEX
- continuation of 3MT-in-ARPEGE

This presentation is an attempt to put structure by paraphrasing some of the work you have done.

Please correct me whenever you think I am wrong!

Outline

- Scientific rationales and related scientific streams.
- Where to go with deep convection? A need for articulation.
- Validation: what?
- SURFEX: what to know about the (immediate) plans.
- Phasing/code validation and what we can learn from HIRLAM.
- **Scope of the meeting**: questions we want to address in the coming days.

A word about scientific evolutions: joining **4** streams of scientific research: ALARO-1, at the time of the EWGLAM meeting last year

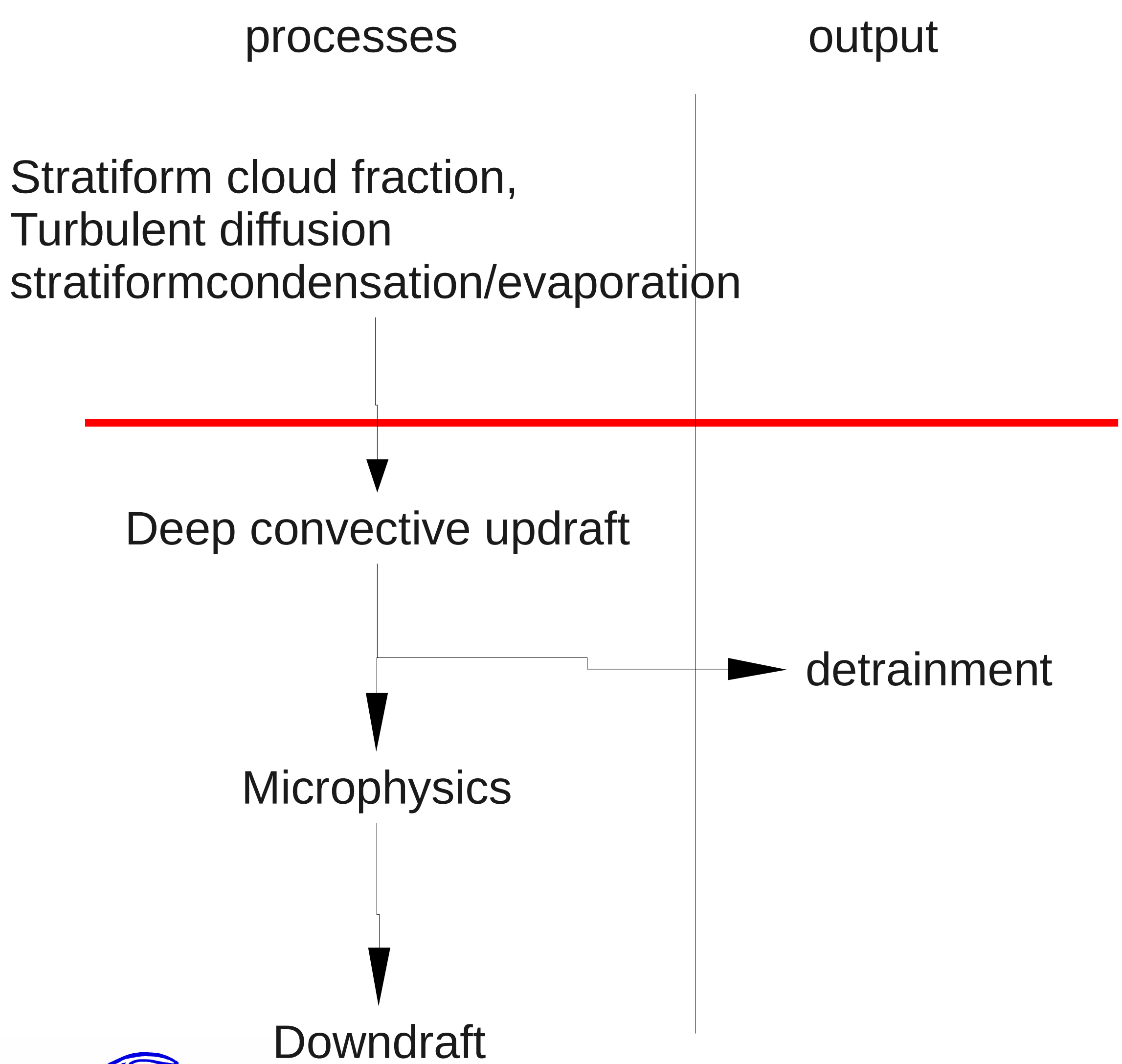
- MT (Piriou 2007) → 3MT (Gerard *et al.* 2007) → hydrostatic ALARO-0 → NH ALARO-1: **multiscale treatment of deep convection.** and PCMT (Piriou) [as a bifurcation, from the MT concept]

- CBR → The discovery of **non-zero turbulent diffusion in the stable regimes** concluded from Quasi-normal-mode-elimination techniques of Sukoriansky *et al.* (2005): TOUCANS. And further, 3D turbulence, TOMs.

- Lilly (1968) → Betts (1973)→ Marquet (2011)'s new moist thermodynamical variable theta_1s → Marquet, Geleyn (2011) -> treat **shallow convection as part of the vertical diffusion** → TOUCANS.

- Piotrowksi *et al.* (2009) → **physics-dynamics interaction (?)** → Work of Lisa (Bengsston) on cellular automata, currently coded with ALARO-0.

3MT: **Microphysics and Transport**



- Stands for Modular, Multi scale, Microphysics and Transport
- Key elements are:
  - It avoids **double counting** of (resolved and parametrized) precipitable water
  - There is no need to prescribe **detrainment, it is 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.
  - Sequential coupling (while still producing the output in parallel) facilitates **conservation** properties

3MT: Modularity

- At the code side: the M/T split, the cascade and the specific approach to the protection of the convective cloud fraction, makes it quite modular.
- For instance it has been demonstrated by the work of R. Brožková, that the code organization of 3MT can be realized in a general enough manner to make several cross combinations (this was done by making to code ready to use 3MT in ARPEGE):
  - Two radiation schemes (RRTM/FMR compared to the ACRANEB of the ALARO scheme)
  - different types of vertical diffusion (the old ARPEGE type ACDIFUS, CBR, and KFB)
  - Lopez microphysics
  - Mountain drag of ARPEGE (compared to the one in ALARO)

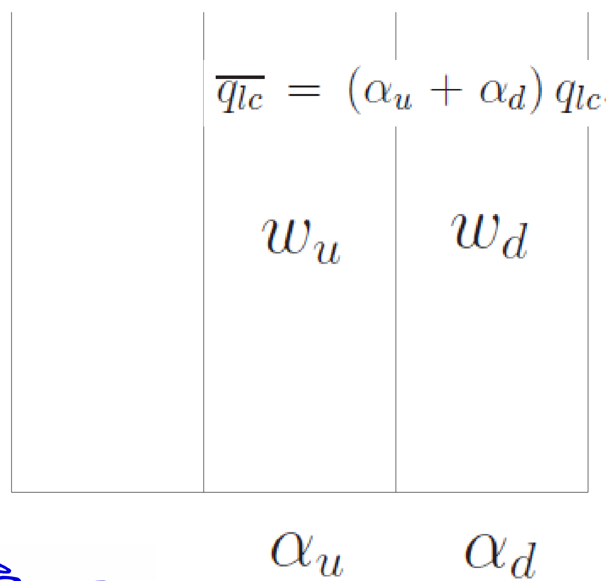
PCMT: a different approach

New structure to accommodate
Different types of research:
MT: Piriou (2007)
Microphysics: Lopez (2000)
Closure: Guérémy (2011)

TAB. 1 – Géométrie des 3 composantes sous-mailles du schéma PCMT.

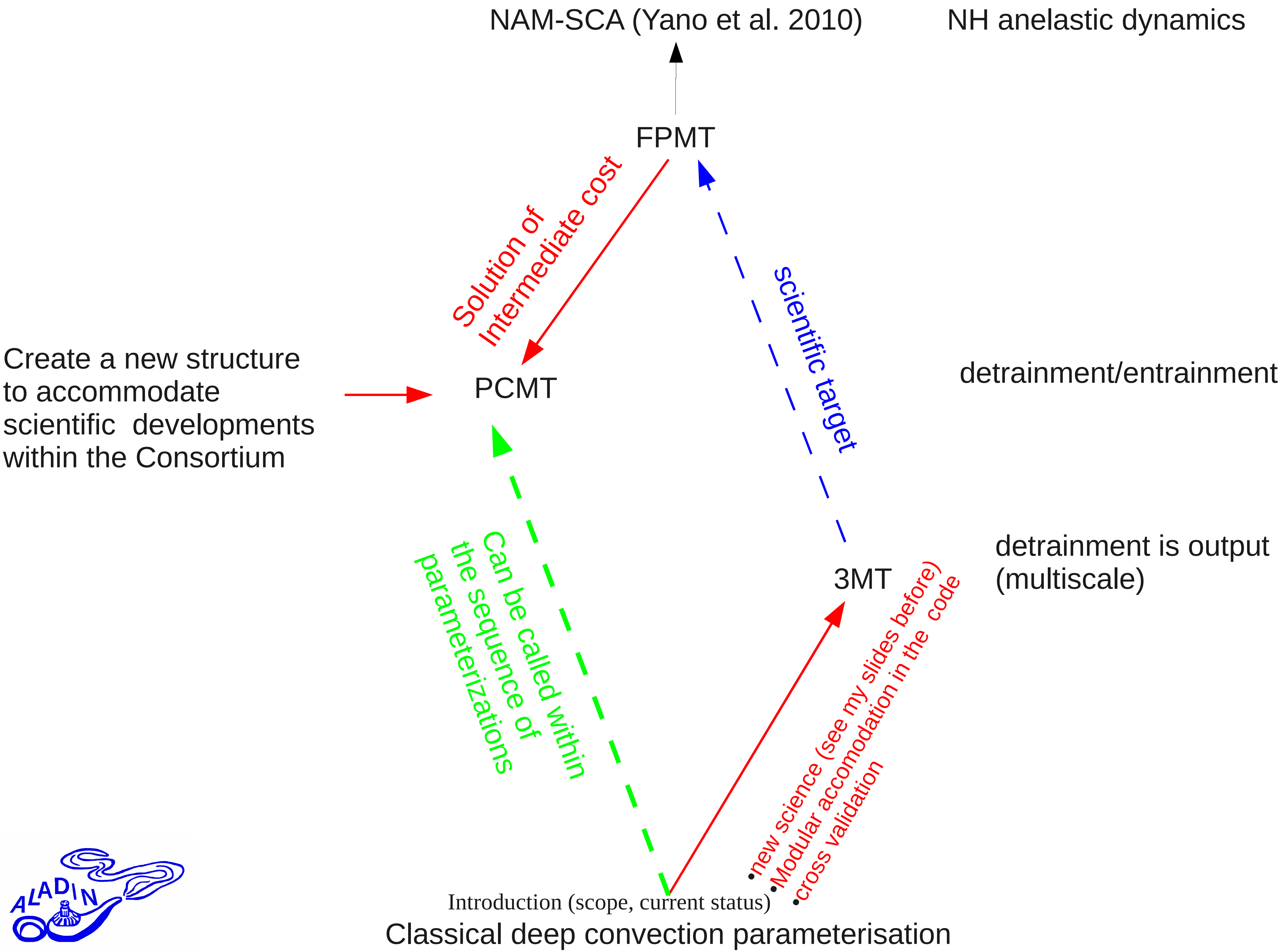
Composante	updraft	downdraft	environnement
Fraction de surface	α_u	α_d	$1 - \alpha_u - \alpha_d$
Vitesse verticale	w_u	w_d	$\frac{-\alpha_u w_u - \alpha_d w_d}{1-\alpha_u-\alpha_d}$
Eau liq. intensive	q_{lc}	q_{lc}	q_{lr}
Pluie intensive	q_{rc}	q_{rc}	q_{rr}

$$q_l,\ q_i,\ q_r,\ q_s$$



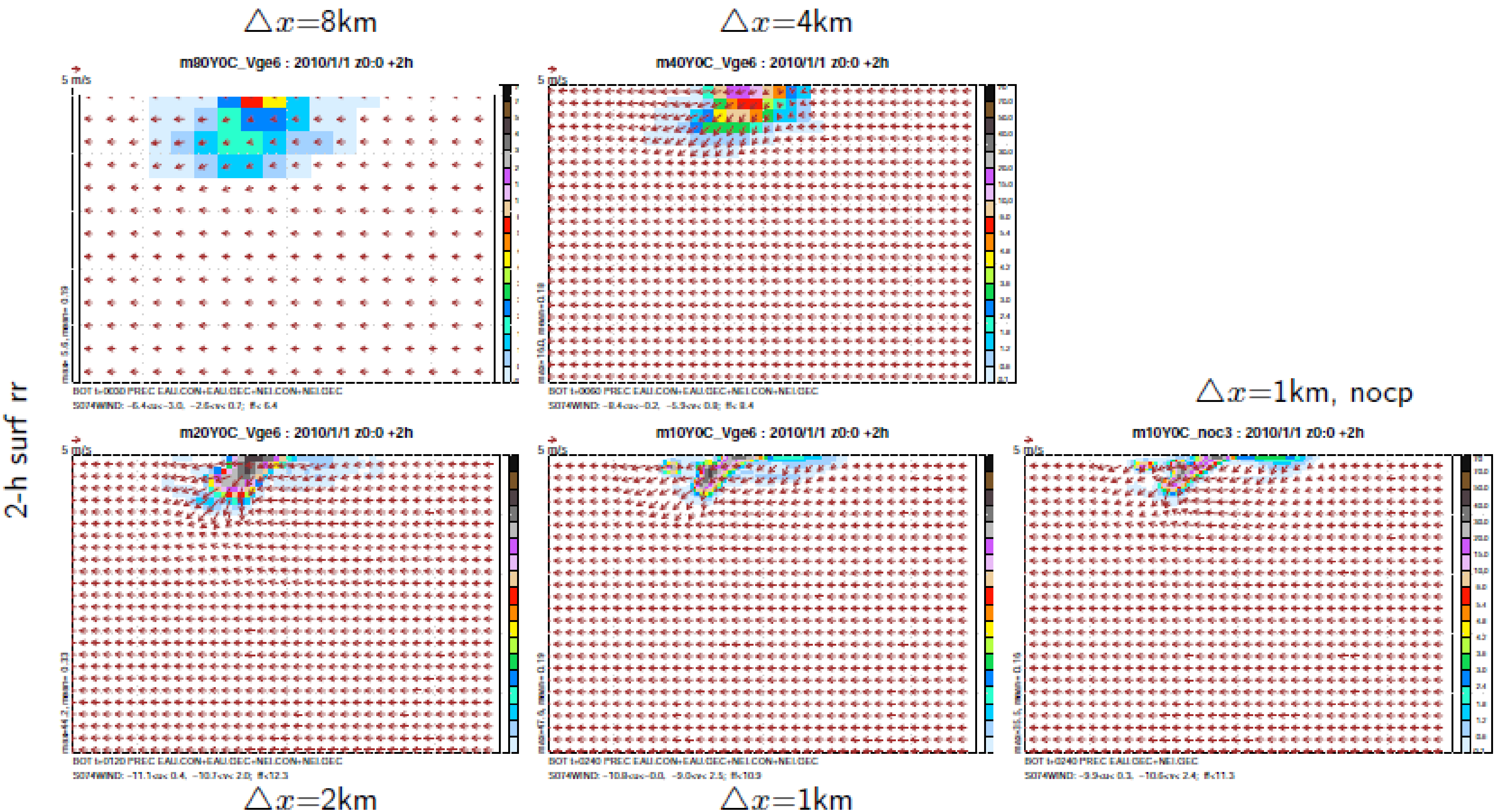
Horzontal exchange via entrainment/detrainment, e.g.:

$$\begin{aligned}\frac{\partial}{\partial t}\overline{q_{lc}} = & \ \mathrm{Advec}(\overline{q_{lc}}) \\ & -\frac{1}{\rho}\frac{\partial}{\partial z}\rho\left[\alpha_u w_u + \alpha_d w_d\right] q_{lc} \\ & +(E_u + E_d)\, q_{lr} - (D_u + D_d)\, q_{lc} \\ & +\mathrm{CondensEvap}_{q_{lc}} - \mathrm{AutoconvColl}_{q_{lc}} + \mathrm{MeltingIcing}_{q_{lc}}\end{aligned}$$

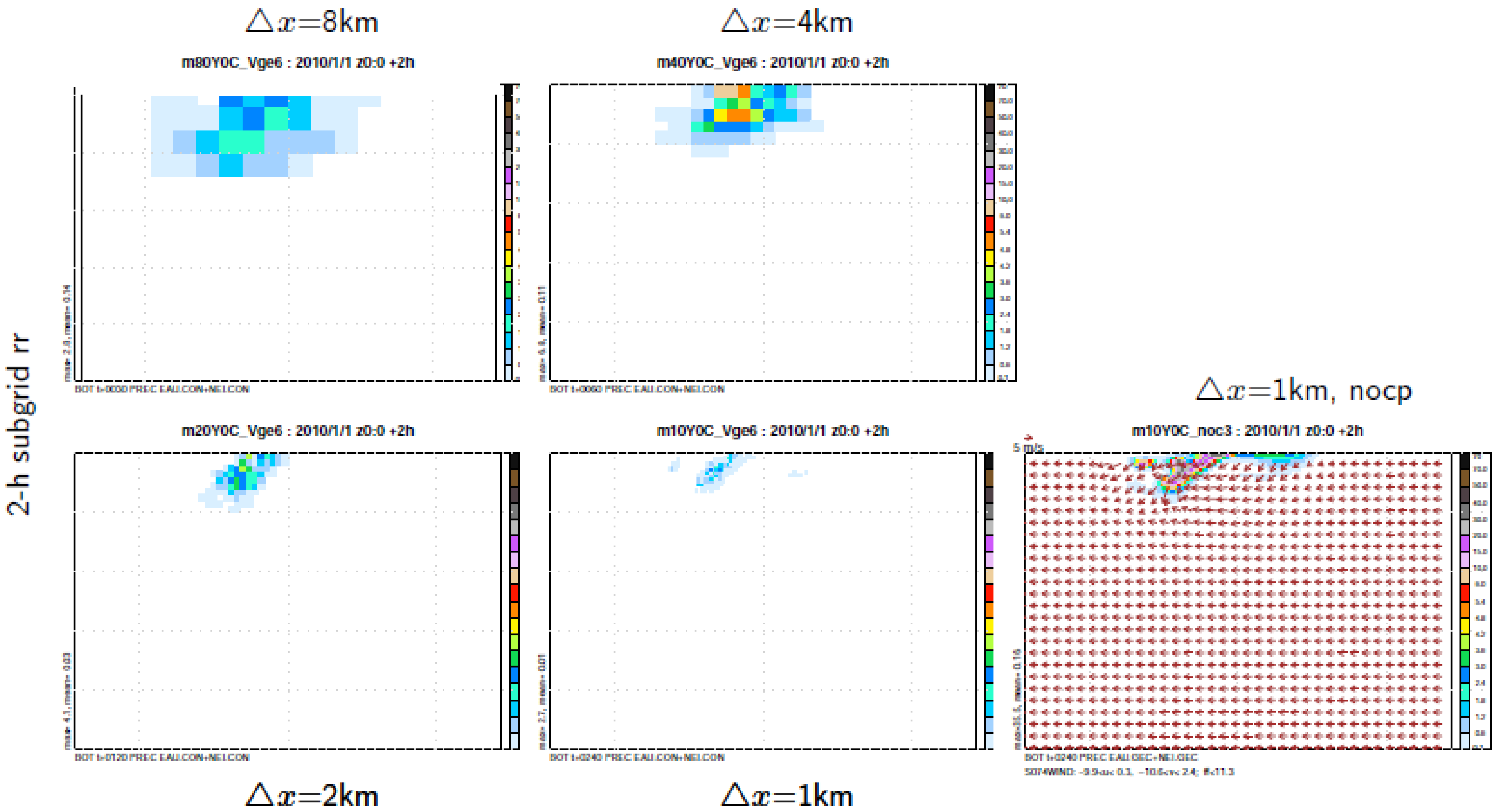


NAM-SCA (Yano et al. 2010)
NH anelastic dynamics
FPMT
Solution of
Intermediate cost
scientific target
Create a new structure
to accommodate
scientific developments
within the Consortium
PCMT
detrainment/entrainment
Can be called within
the sequence of
parameterizations
3MT
detrainment is output
(multiscale)
• new science (see my slides before)
• Modular accomodation in the code
• cross validation
Introduction (scope, current status)
Classical deep convection parameterisation

CSU scheme triggering



CSU scheme triggering



L. Gerard, Aladin Workshop, Marrakech, May 2012

Multiscale

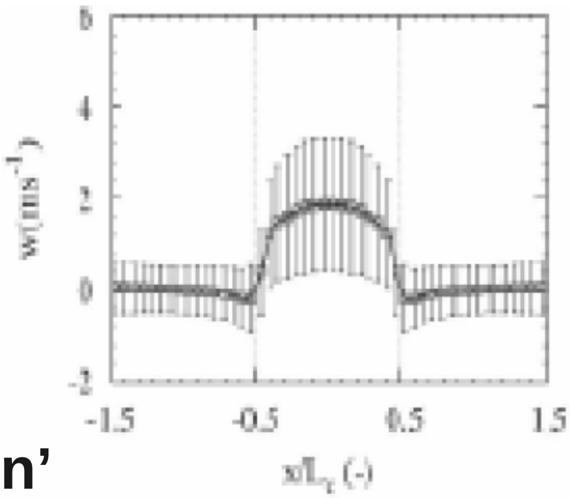
- Further evolution of Luc's work led to CSU
- Weissman-Klemp setups seem to be a handle to master the multiscale behavior. It determines a target resolution.
- However, there seems to be a consensus that the gray zone does not end at 1 km. **In some sense these Weissman-Klemp setups determine the gray zone.**
- Triggering (via Tv) turns out to be crucial for multiscale behavior.
- On the other hand, the triggering plays a major role in the stochastic behavior (Cfr. Discussion in COST0905, Savona).
- **Does this make CSU de facto the tool for a convection permitting EPS (e.g. Harmon EPS), i.e. consider the perturbing the triggering of deep convection?**

Deep convection is at the core of ALARO, but

- **Where to go with deep convection?** Are we going to hectometric scales? A few ways to consider:
  - Testing basic scientific hypotheses, e.g.
    - Bulk vs. spectral;
    - Projection on the dynamics (back scatter);
    - How far does the gray zone reach?
  - Global models: ECMWF, ARPEGE.
  - Ensemble systems:
    - One might argue that one needs a parameterization of deep convection to "perturb" the deep convection. Also the problem is the stochastic nature of the triggering (cfr. Talks in Savona) and the best candidate for perturbing would thus be the triggering mechanism in a convection-permitting EPS.
  - Climate applications, where the problem of the backscatter is crucial to get the feedbacks (cloud-albedo, radiation) right.
- All of this points rather in the direction of a seamless system. **Does this seem a realistic idea?**

3MT and shallow convection: a next logical sequential scientific stream

- 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)
- So shallow convection cannot enter the 3MT logic.
- **This lead to the decision to treat 'shallow convection' on the turbulent side .**



TOUCANS: the algorithmic part of it

$$\frac{de}{dt} = -\frac{\partial}{\partial z}\left(\overline{e'w'} + \frac{\overline{p'w'}}{\rho}\right) + I + II + III$$

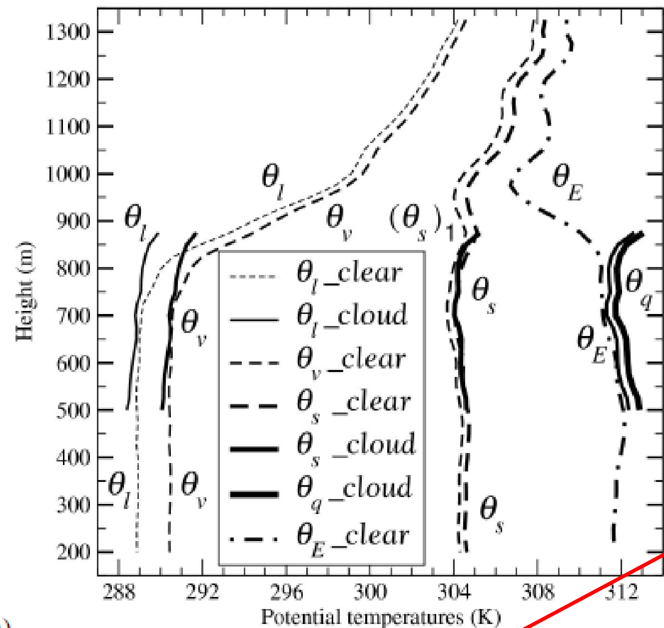
I (wind shear) and II (buoyancy) from
CBR (Cruxart, Bougeault, Redelsperger, 2000)

$$\frac{de}{dt} = -\frac{\partial}{\partial z}\left(\overline{-K_E \frac{\partial e}{\partial z}}\right) + \frac{1}{\tau_\epsilon}(\tilde{e} - e)$$

$$\tilde{e} = \frac{e}{\epsilon}(I + II)$$

- As an extension of the old Louis type formulation
- Allows to implement several ideas:
  - No critical Ri
    - Cheng et al. 2002, CCH02
    - Sukoriansky et al. 2006)
  - Anisotropy of turbulence
  - Prognostic TKE
  - Third-order moments
  - Shallow convection within turbulence

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



(a)

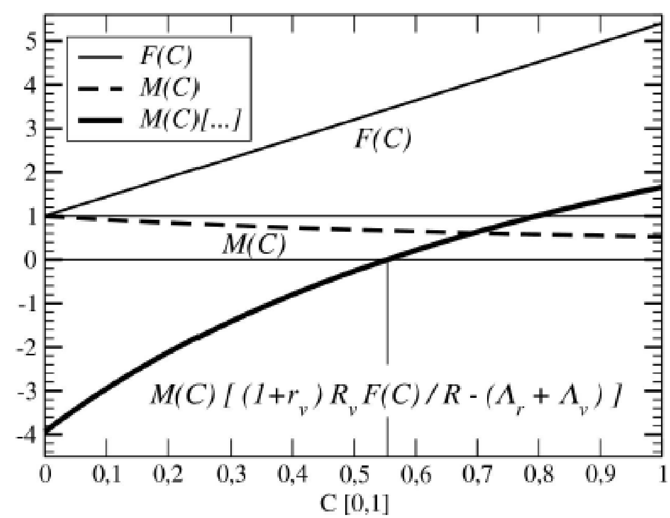
$$
\begin{aligned}
N^2(C) \;=\; & g\, M(C) \left(\frac{\partial \ln(\theta_s)}{\partial z} \right)_E + g \left(\frac{\partial \ln(q_d)}{\partial z} \right)_E \\
& + g\, M(C)\, F(C) \left[(1+r_v)\, \frac{R_v}{R} \right]_E \left(\frac{\partial q_t}{\partial z} \right)_E \\
& - g\, M(C) \, [\, \Lambda_r + \Lambda_v \,]_E \left(\frac{\partial q_t}{\partial z} \right)_E . \qquad \text{(F.4)}
\end{aligned}
$$

C=0

C=1

Unsaturated moist air

$$
N^2_{ns} = \Gamma_{ns} \frac{\partial s}{\partial z} + g \frac{\partial \ln(q_d)}{\partial z} + \Gamma_{ns} \left[(1+r_v) \frac{c_p\, R_v}{R} - c_{pd}\, (\Lambda_r + \Lambda_v) \right] \frac{\partial q_v}{\partial z} .
$$



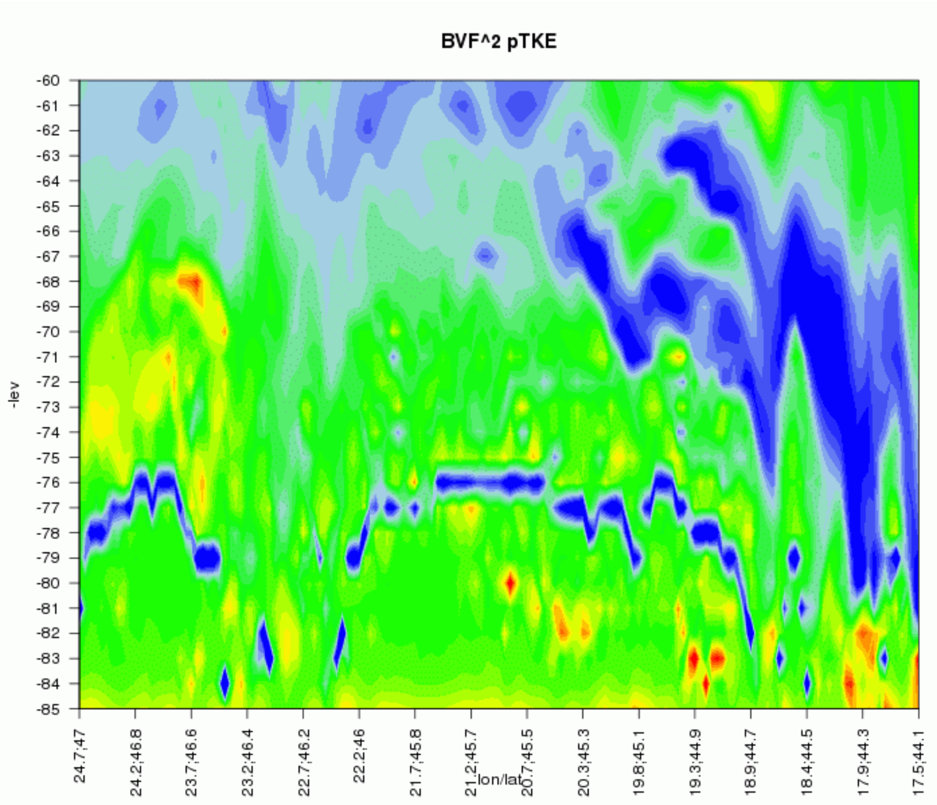
Introduction (scope, current status)

Saturated moist air

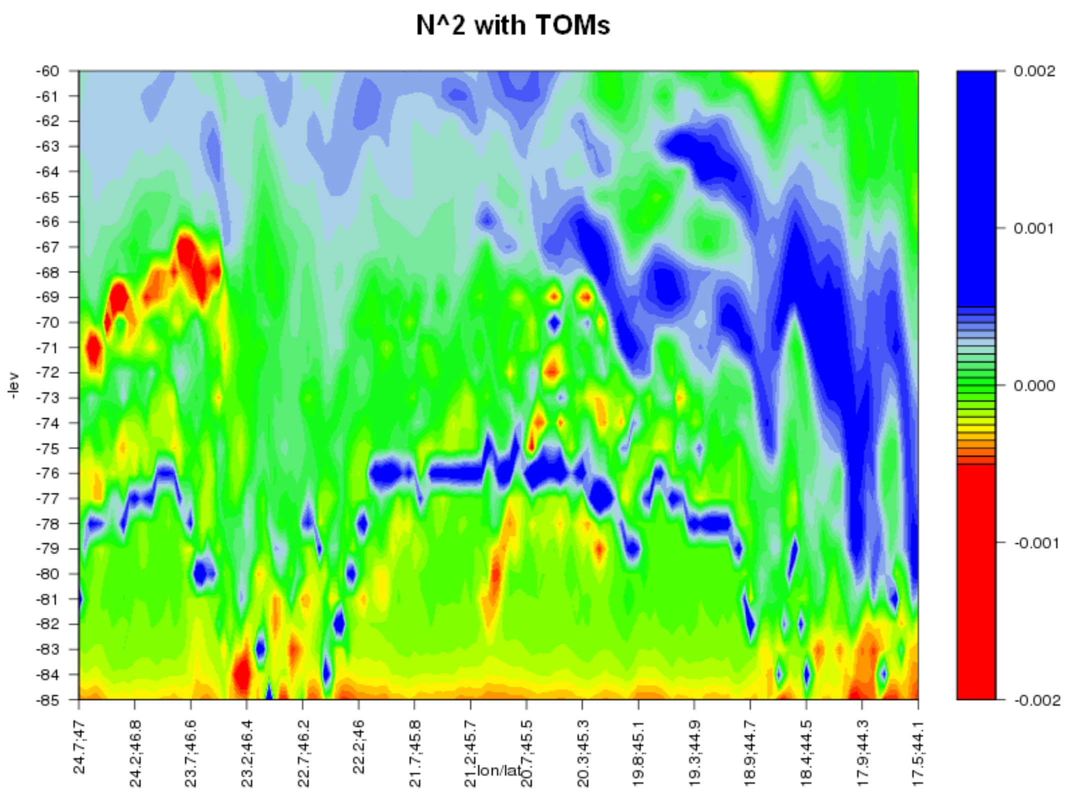
$$
N^2_{sw} = \Gamma_{sw} \frac{\partial s}{\partial z} + g \frac{\partial \ln(q_d)}{\partial z} + \Gamma_{sw} \left[(1+r_{sw}) \frac{L_{vap}}{T} - c_{pd}\, (\Lambda_r + \Lambda_{sw}) \right] \frac{\partial q_t}{\partial z}
$$

TOUCANS scheme: the effect of TOMS

PseudoTKE (current)

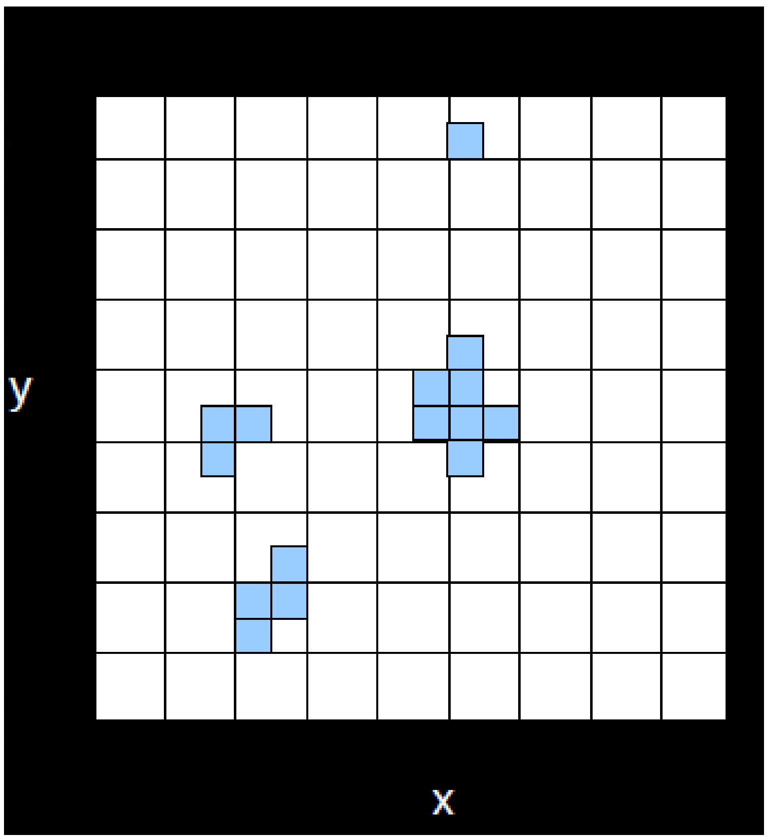


TOUCANS with Third Order Moments



Vertical cross section for Brunt Vaisalla frequency (BVF)
(30h of integration, start at 3.3.2011 6:00 am, operational CHMI horizontal and vertical resolution)

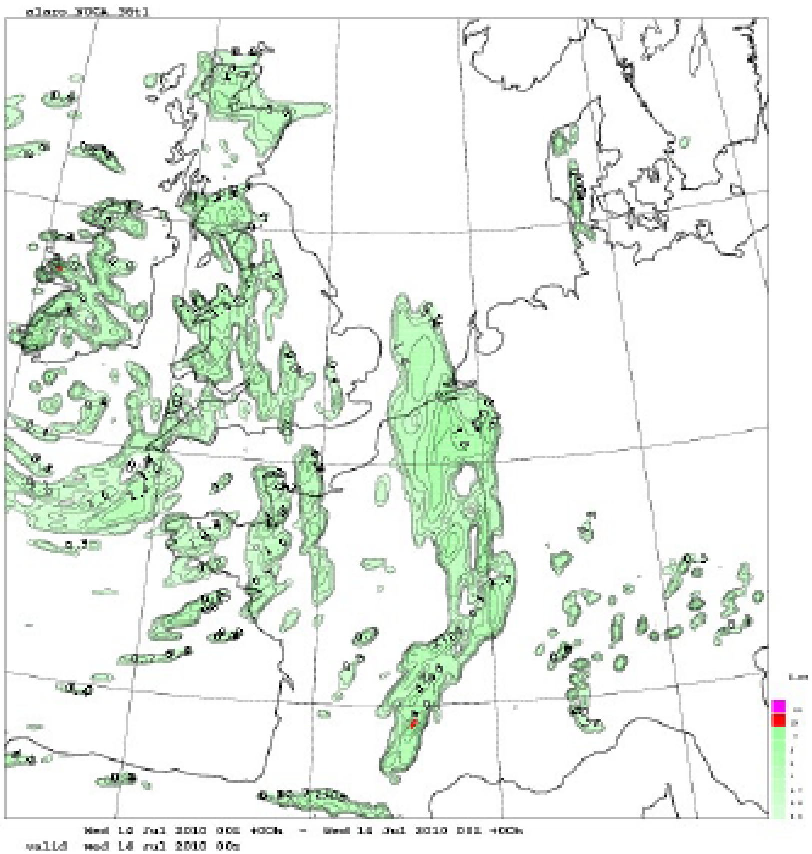
Stochasticity: Cellular automata Lisa Bengtsson



- Palmer (2001), Shutts (2005) and Berner (2008): use cellular automata to generate stochasticity.
- The aim is to add some stochasticity with sufficient back scattering
- In this work it is implemented in the deterministic model.
- It has *stochasticity*, *laterality* and *memory*

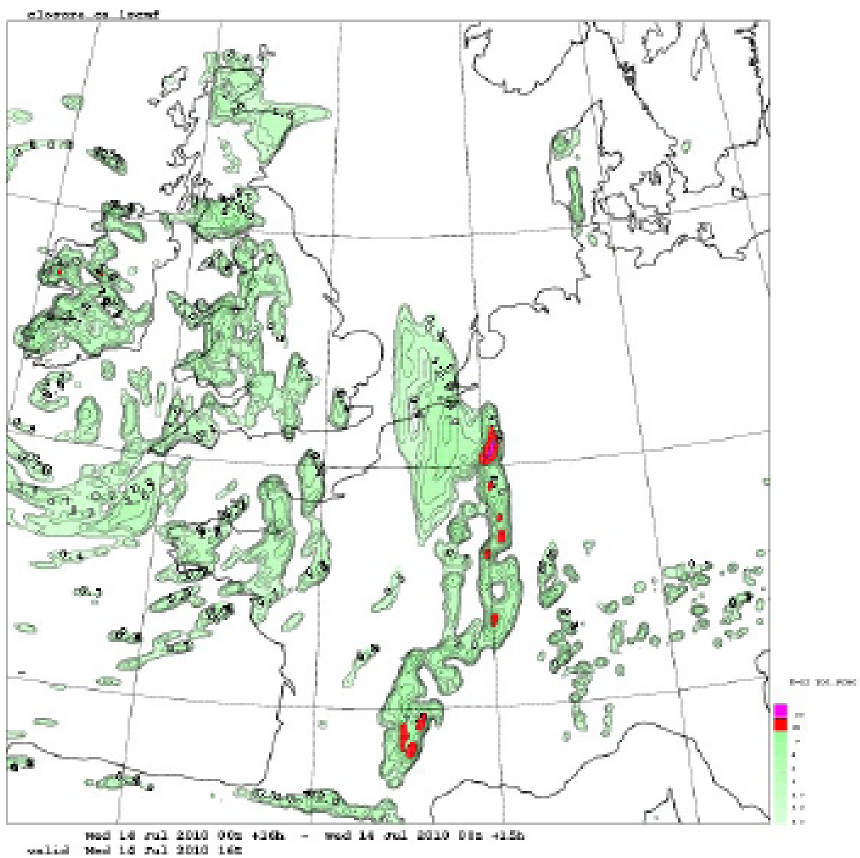
Total precipitation, 2010-07-14, 16 UTC

ALARO reference, 36h1.1



16 UTC

ALARO CA-CAPECONV, 36h1.1



16 UTC

Validation

- TOGA-COARE-type of validations and SCM tests (MUSC). I have the impression we do not put a lot of activities in this.
- LES (meso-NH) runs could allow to create a truth for us. Luc made some first steps in installing meso-NH.
- Case studies (e.g. Finnish case)
- Madden-Julian Oscillation (MJO): an example of where deep-convective activity projects on the dynamics.
- Climate runs: if the statistics become more realistic, it means our model behaves more like reality.
- Suggestions welcome...

We cannot do everything, but what is interesting?

Piotrowski, Smolarkiewicz, Malinowski, Wyszogrodski, 2009

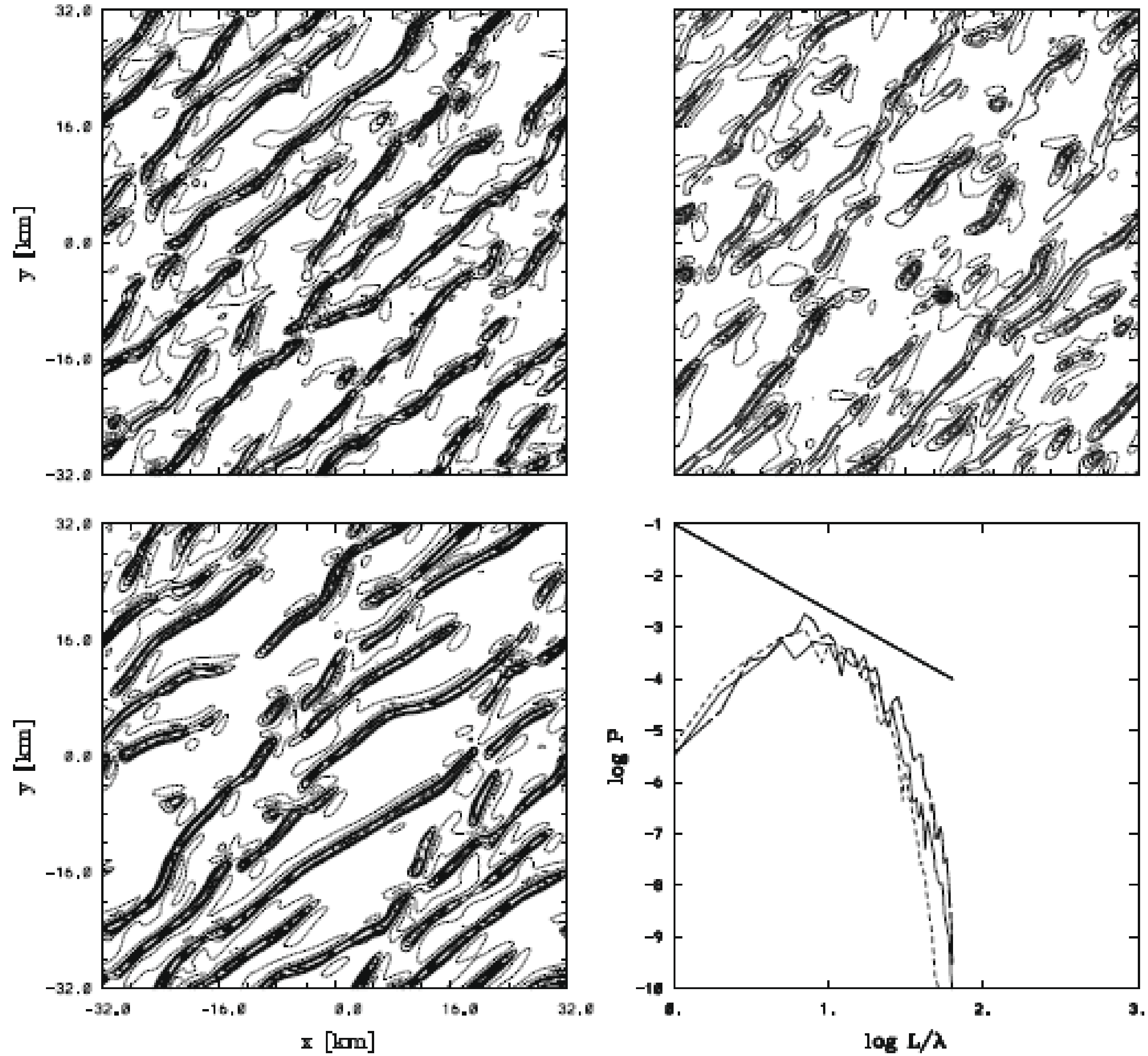


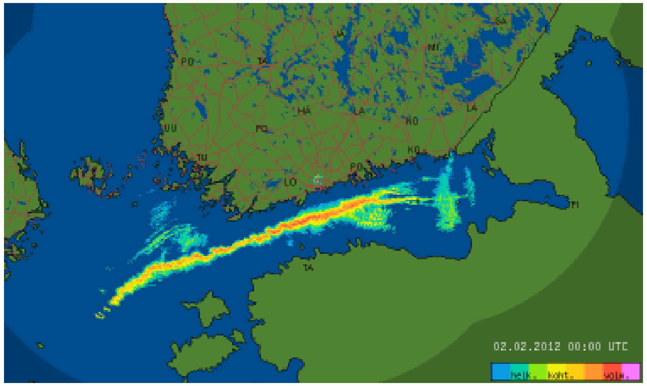
Fig. 17. Vertical velocity at 450 m as in Figs. 7 and 13, but for runs with various anisotropic filtering: composite schemes (upper left); a periodical 1–2–1 low-pass filter in the horizontal (upper right); constant anisotropic viscosity (lower left); and the corresponding diagonals of 2D spectra (lower right) shown with long dashes, short dashes and continuous line.

ALADIN

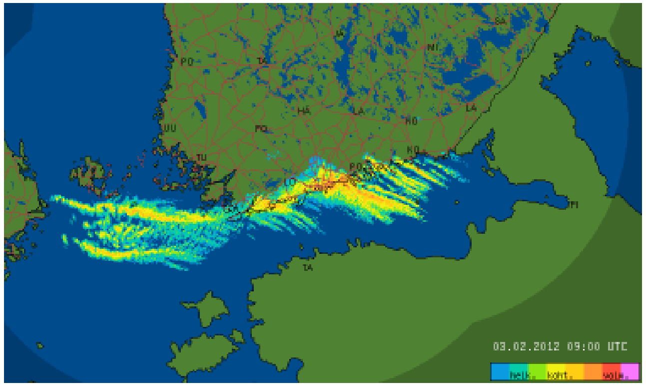
Finnish case (3 Feb 2012)

Radar data, 1 – 5 Feb 2012

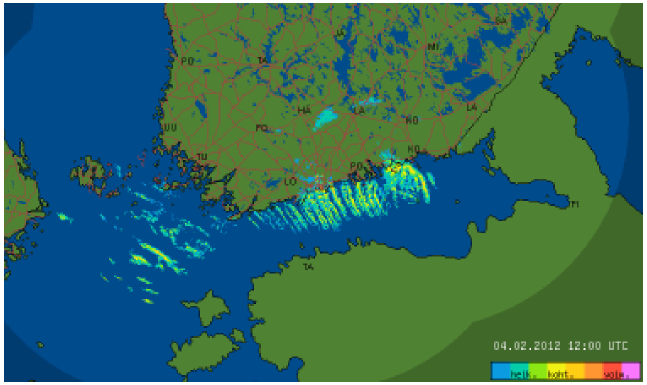
2 Feb, 00 UTC



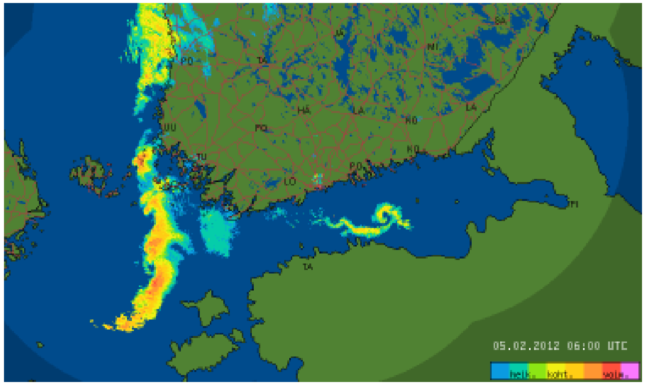
3 Feb, 09 UTC



4 Feb, 12 UTC



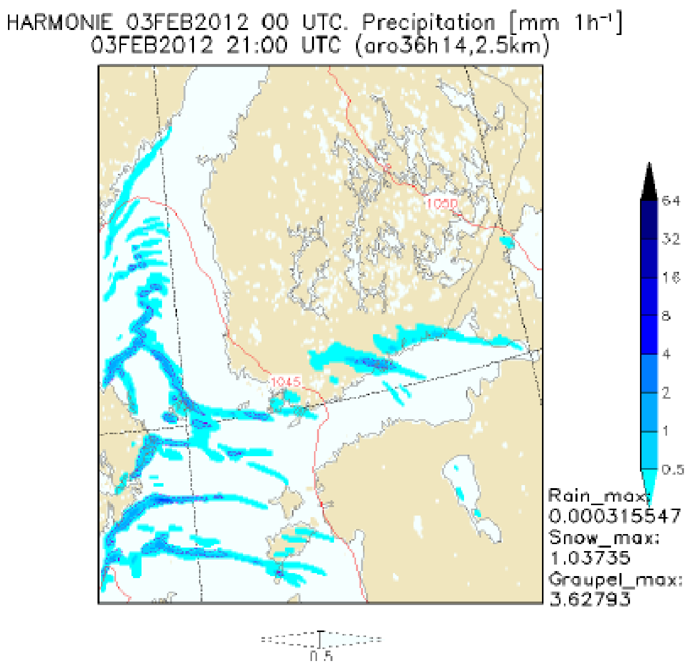
5 Feb, 06 UTC



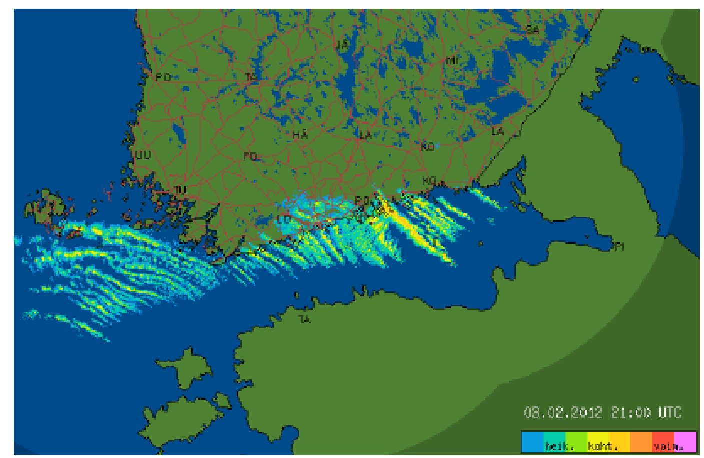
Simulation with AROME courtesy of S. Niemela workshop/ASM meeting in Marrakech

Harmonie vs. Radar

1h-prec [mm] , 00UTC +21h



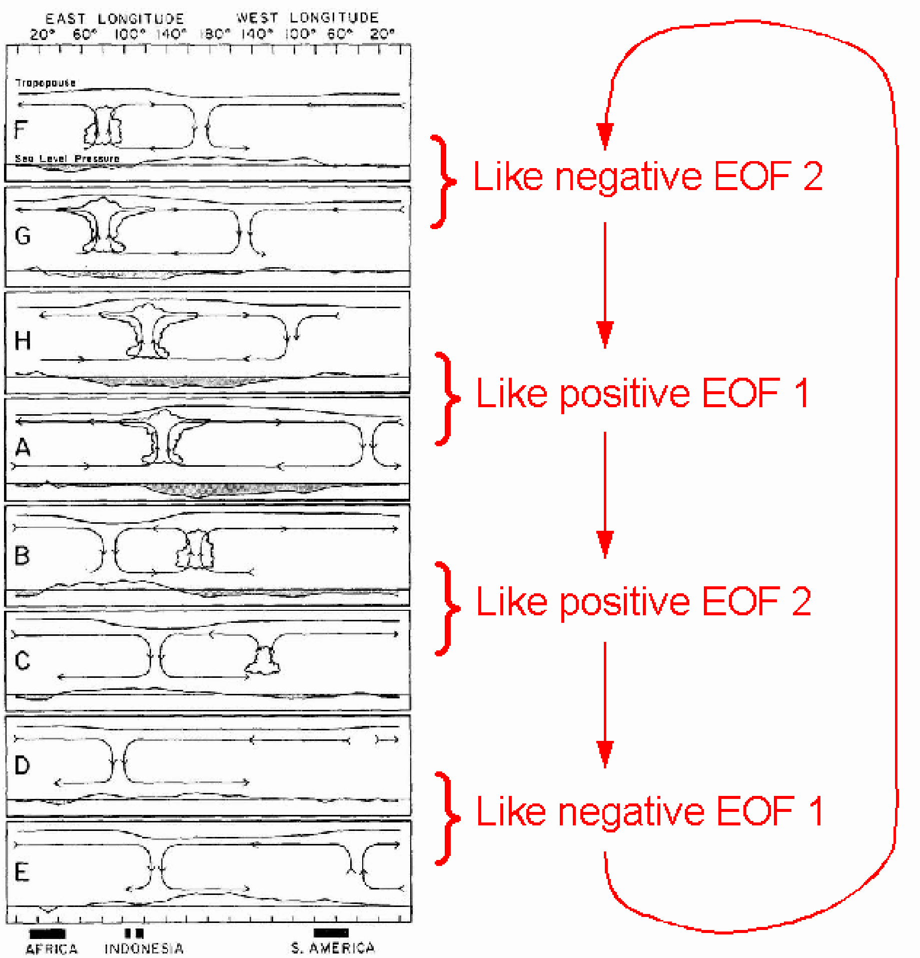
Reflectivity [dBZ], 3 Feb, 21 UTC

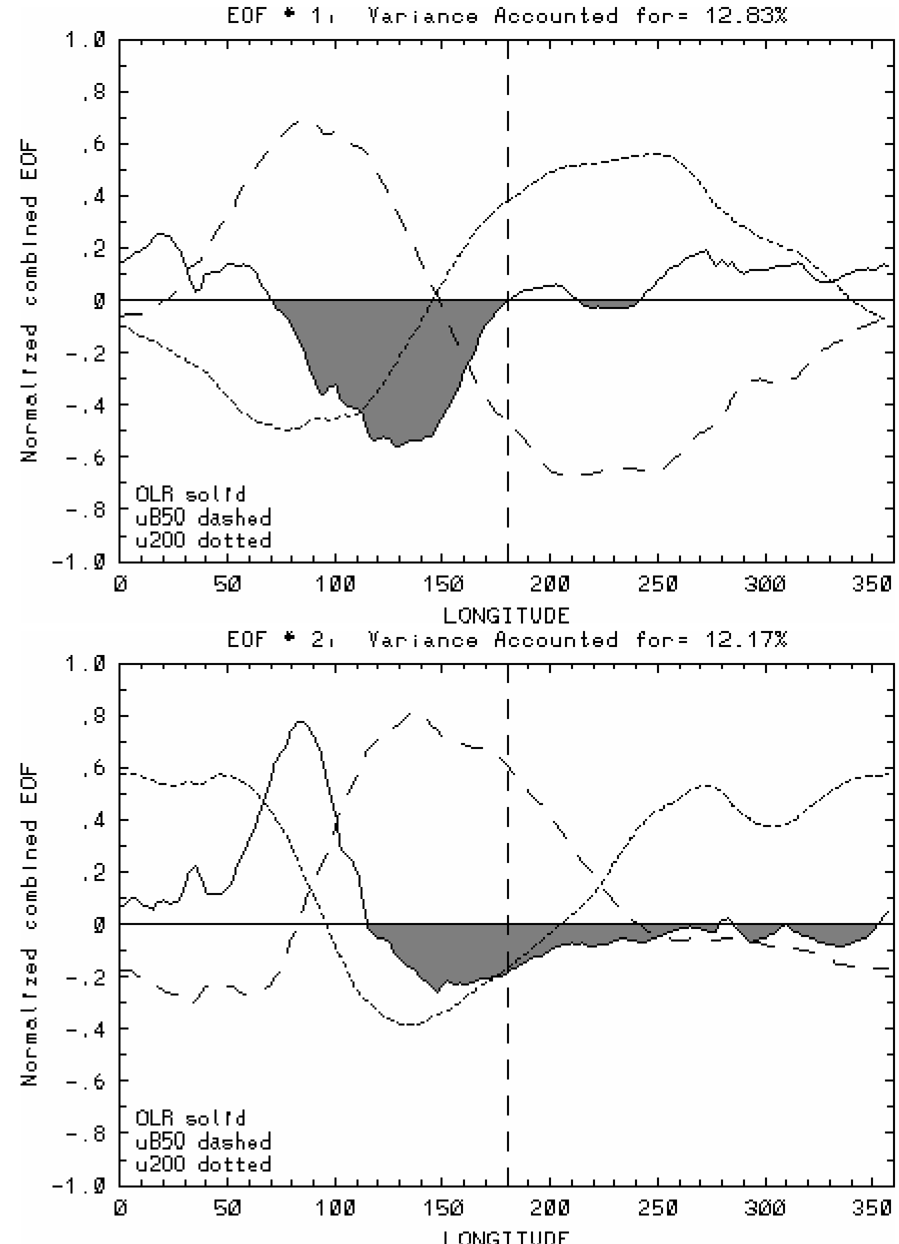


- During the COST0905 meeting in Savona it was mentioned that this is an illustrative case of the Piotrowski et al. paper.

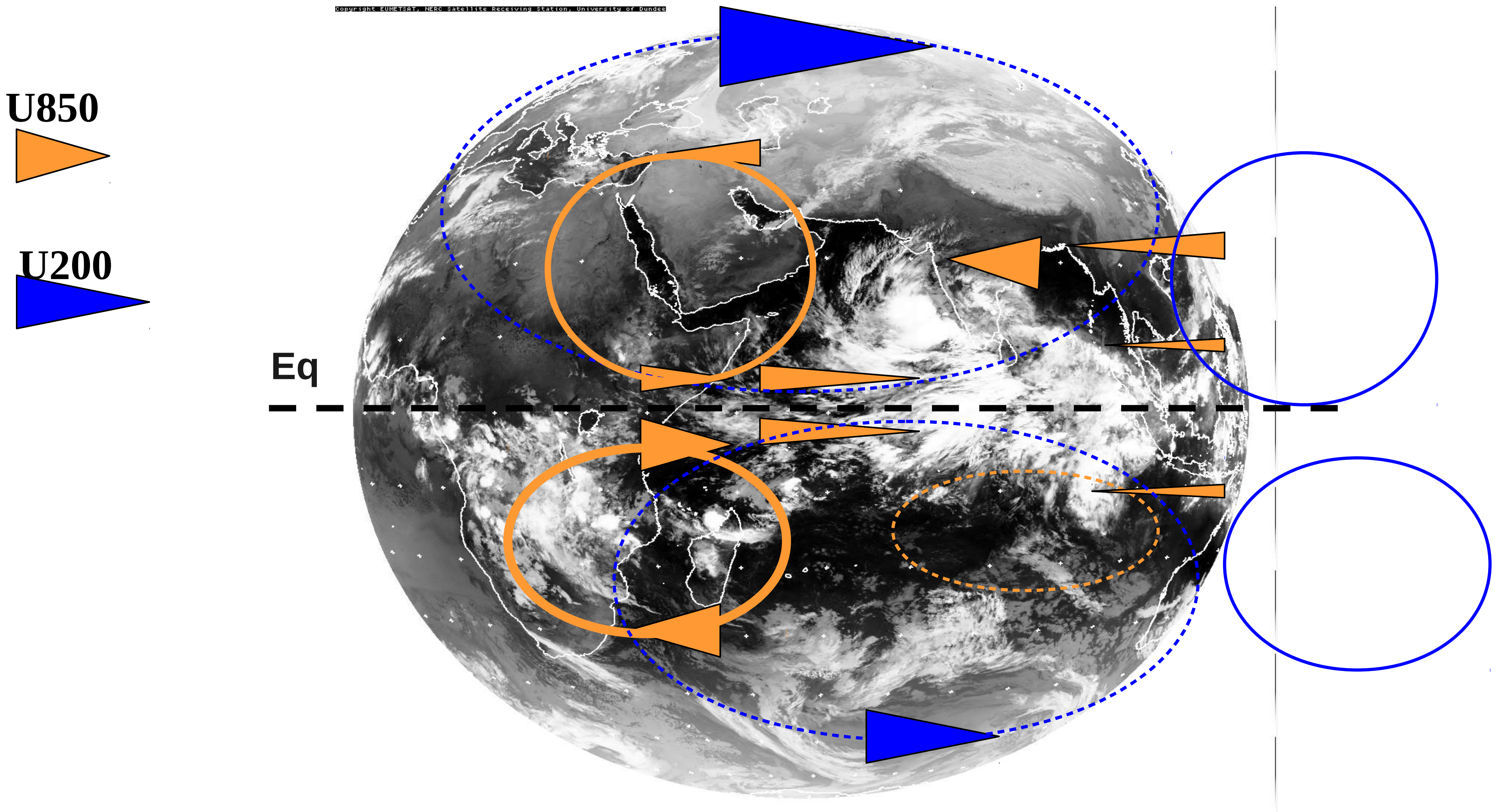
MJO: oscillation around two EOFS

Madden and Julian's (1972) schematic





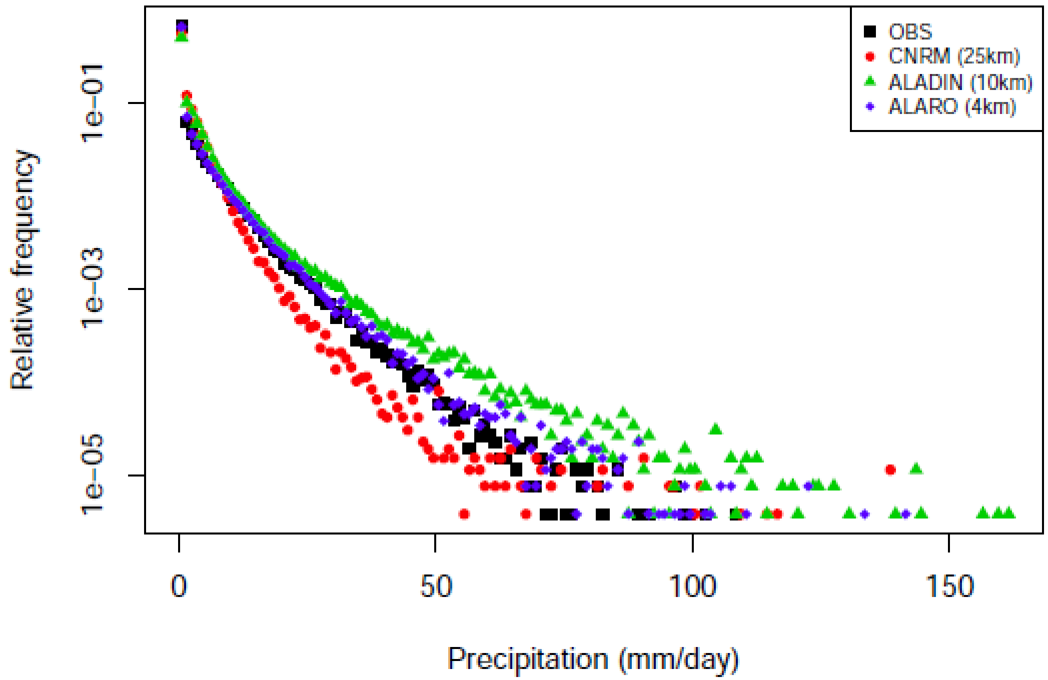
MJO: effect on Kelvin modes (source ECMWF)



Backscatter of deep convection?

- The equatorial Kelvin and Rossby waves are well understood theoretically through the Matsuno-Gill model of tropical dynamics (Matsuno, 1966; Gill, 1980). The condensation in the many **individual cumulonimbuses** releases latent heat into the atmosphere, and this heat source can then drive the tropical circulation. The equatorial Kelvin-Rossby wave responds to a heat source on the equator.
- MJO is considered as a phenomenon to validate the model. This has been done in ECMWF, after the Year of Tropical Convection (YOTC) 2008-2010 where they rerun daily forecasts with modified entrainment and adjustment time and check for forecast quality and projection on MJO.
- **QUESTION: does a sugrid super-parameterization add some extra handle to project on the large scale? Test 3MT vs. PCMT?**

Validation of our NWP model by climate study



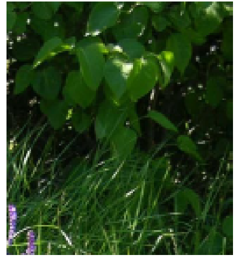
Courtesy of R. de Troch and R. Hamdi

- Relative frequency of precipitation events from downscaling of ERA-40 for the last 30 years compared to observations (black)
  - The CRNM (ALADIN) version of the EC ENSEMBLES project (red)
  - The older (operational) ALADIN version at 10-km resolution (green)
  - The current operational ALARO-0 at 4 km (blue)
- **Conclusion: the work to go to higher resolution payed off by a better climatology, including the one of extreme events (cfr. Floodings).**

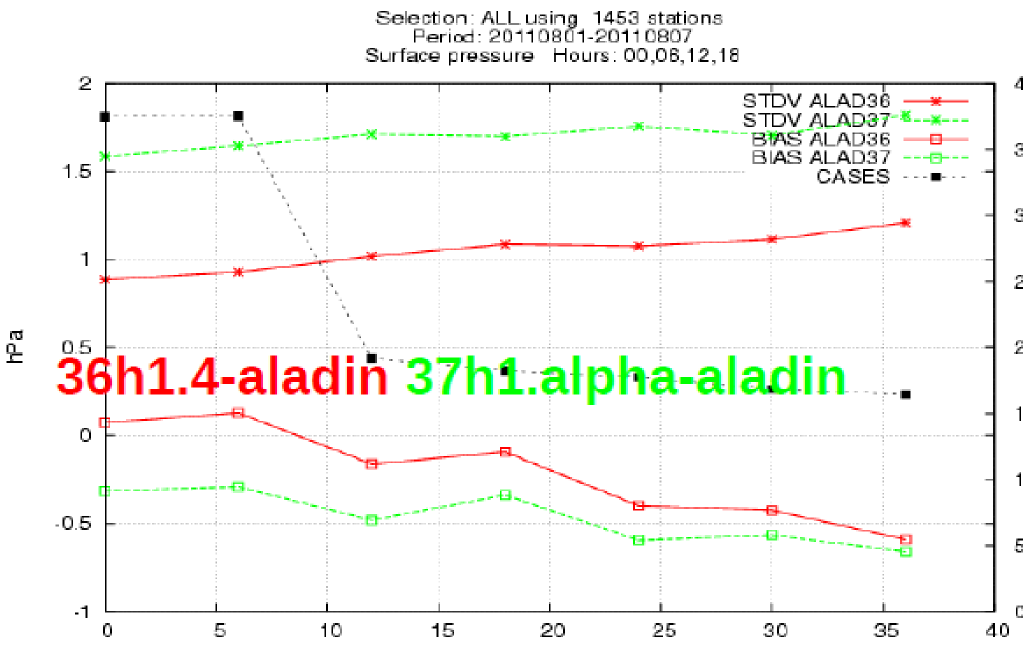
Validation

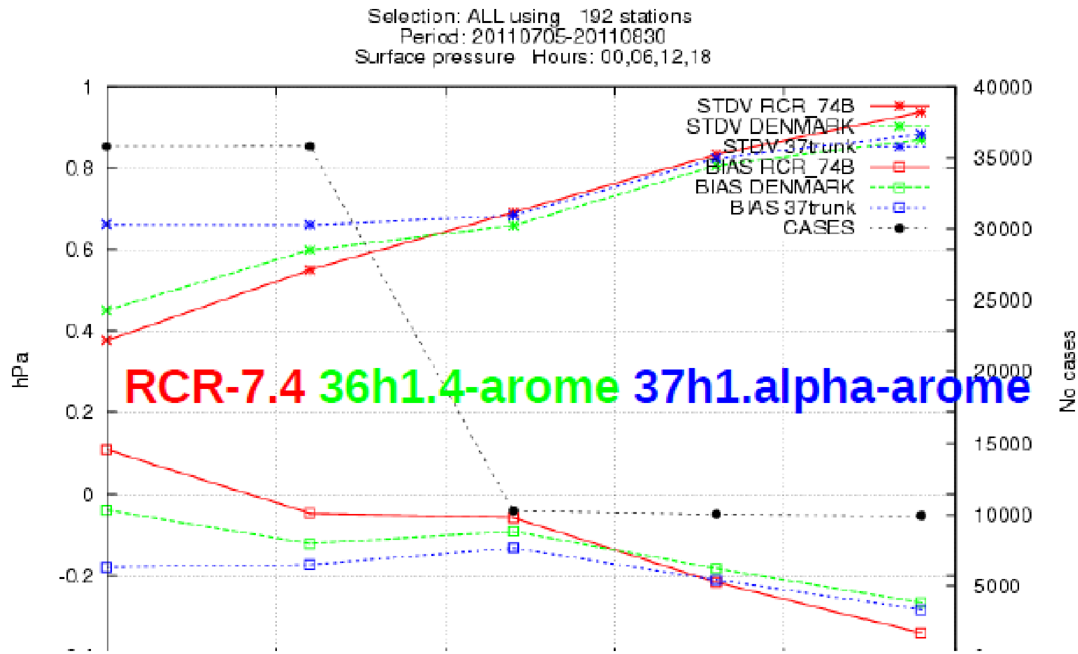
From Xiaohua's presentation
During the workshop/ASM in Marrakech

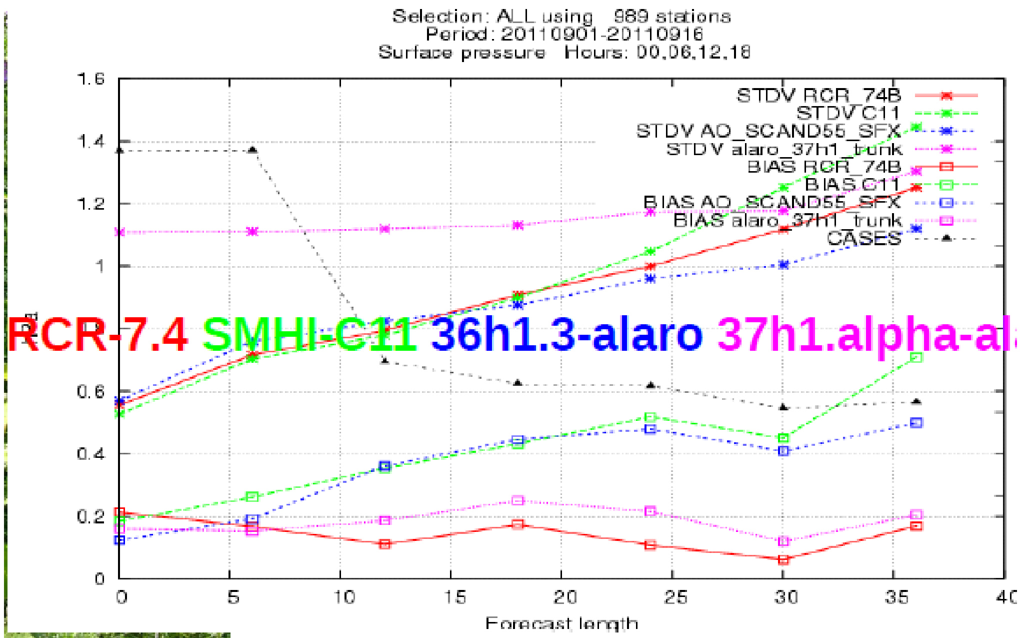
ALADIN can learn something from HIRLAM

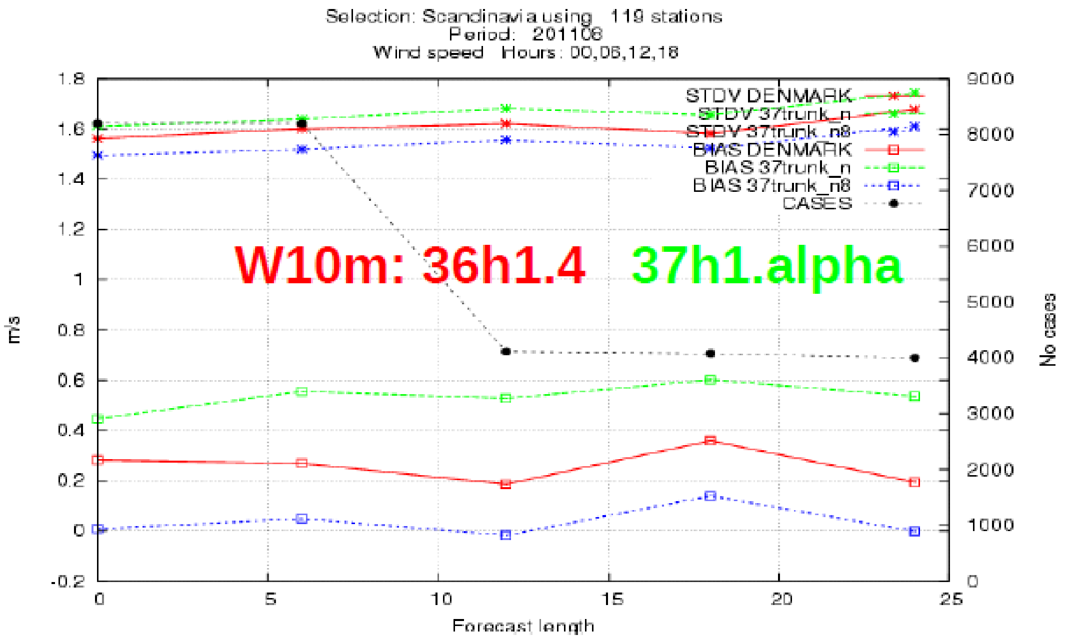


HIRLAM's initial encounter with 37h1









From 36h1 to 37h1

Issues seen & addressed

Scripts problems, namelist settings → many corrections & taggable now!

Lengthy soild spinup → swi conversion improved

Increased wind bias → improved with canopy_drag/sso tuning

Increased cloud bias → gone (bug correction or elsewhere?)

edmfm update chaos → adjusted and back to default

Parallelisation and reproducibility of AROME, edmfm → improved and assured

Stability of arome model

  Bugs in spectral nudging code... → corrected

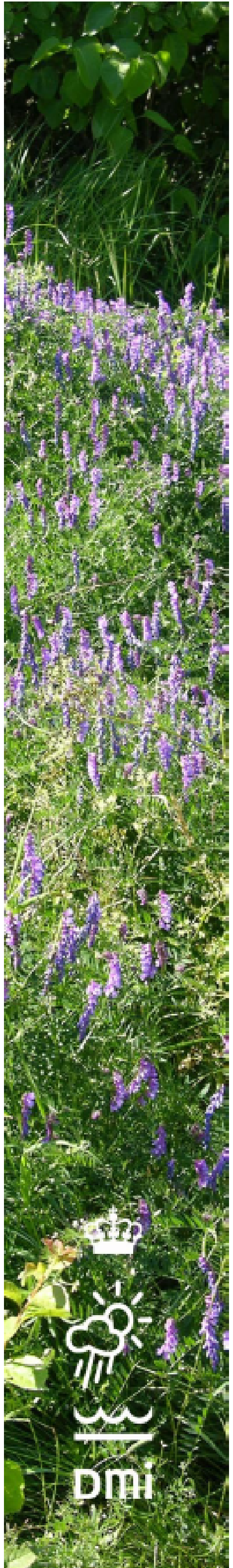
LSMIXBC → corrected and now default

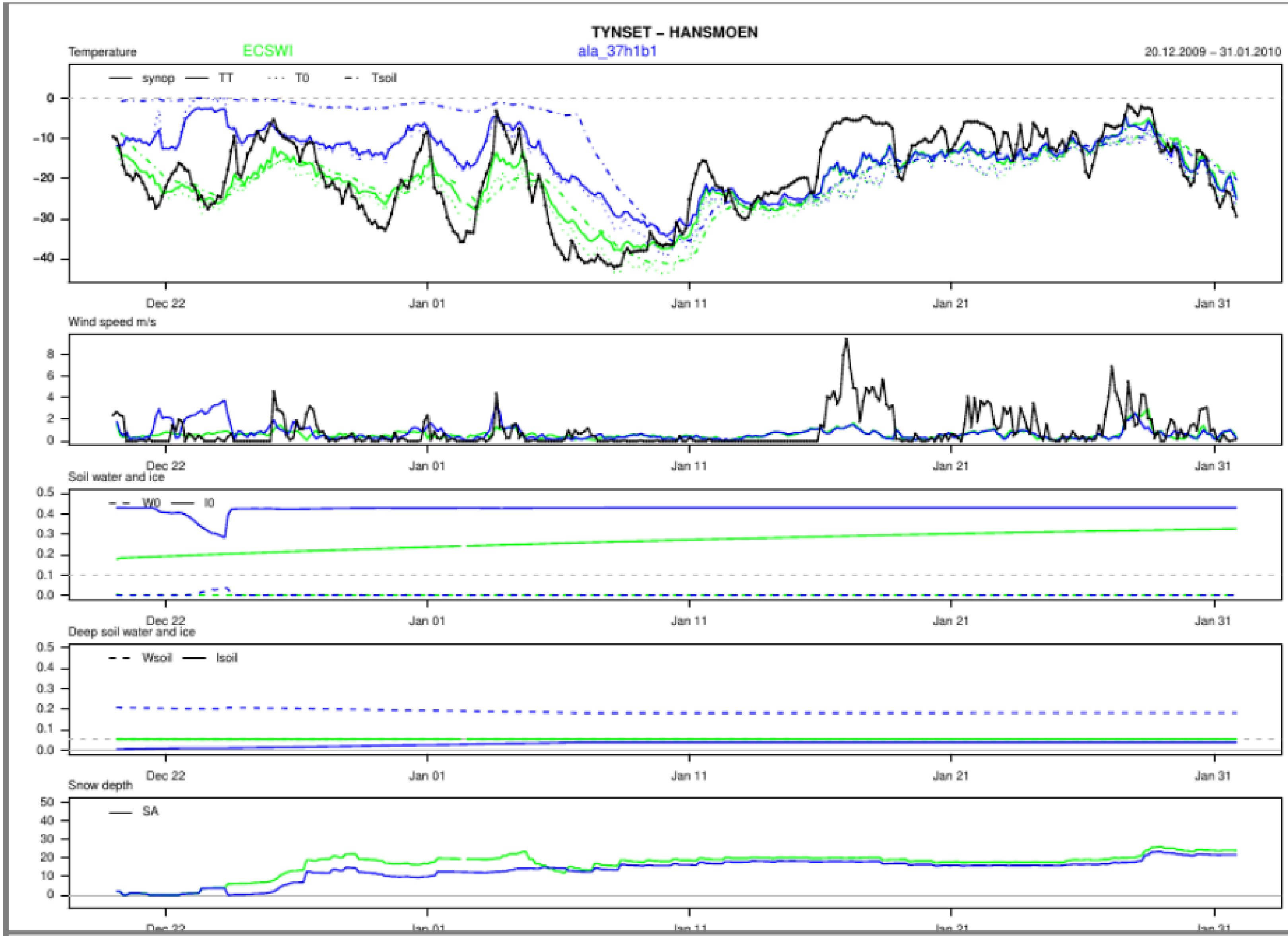
Shortcomings in utility, post-processing → improved but incomplete

From 37h1.alpha to 37h1.beta

Correction in swi conversion: alaro

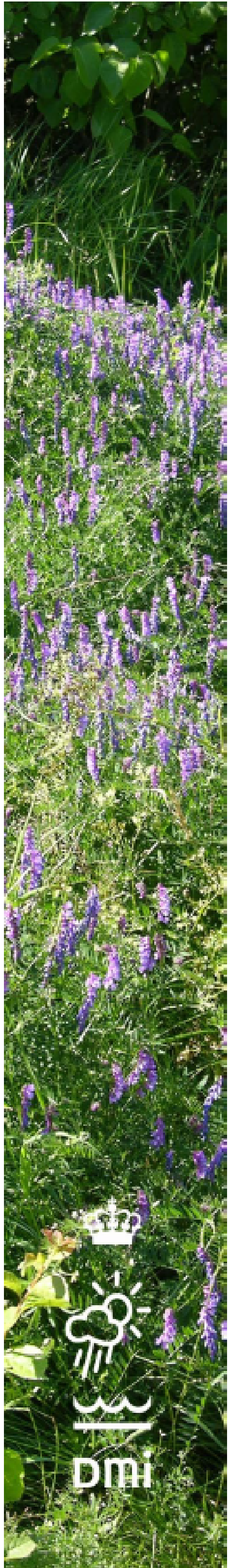
(by Sander Tijm)





Yang, ASM 2012

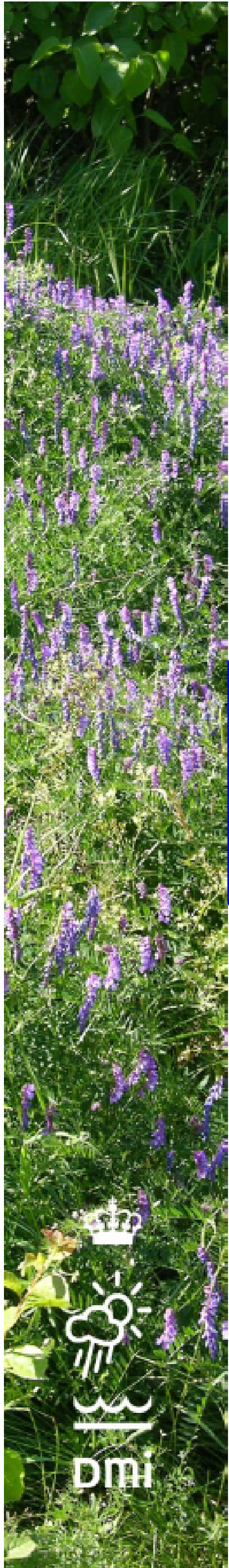
(Mariken Homleid)



Main conclusions/outcomes

- 37h1 (arome, alaro) at least no worse than 36h1.4
  - Swi conversion, improves greatly soil spin-up
  - Surface wind reduced, mostly better except for mountain area
  - Mslp and upper air scores improved with LSMIXBC
- Final tests with 37h1-arome indicates further improvement
  - Precipitation improved
  - No more degradation in cloud amount
- As such, 37h1 is now recommendable to HIRLAM operational services, but pre-launch evaluation and tuning still necessary

Yang, ASM 2012



Some Personal Reflections

(Xiaohua Yang)

Quite significant performance gain has been experienced throughout the evolution of 37h1

- **Cy36h1.4 → 37h1.alpha → 37h1.beta1 → 37h1.beta2 → 37h1**

Process of validation and evaluation benefited greatly from contribution of developers

Yet, in most cases, the evolution did not touch "core of science"

- Science has been pretty solid
- Technical adaptation has been pretty demanding

Can this community get more creative about the lengthy adaptation process??

Quite little tuning and innovative work on DA, PHYSICS, DYNAMICS during the porting

Reference HARMONIE has not become an effective development platform for the science team

Can HIRLAM and MF& ALADIN team make use of each other better?

Cycling (one year outlook with focus on code stuff)

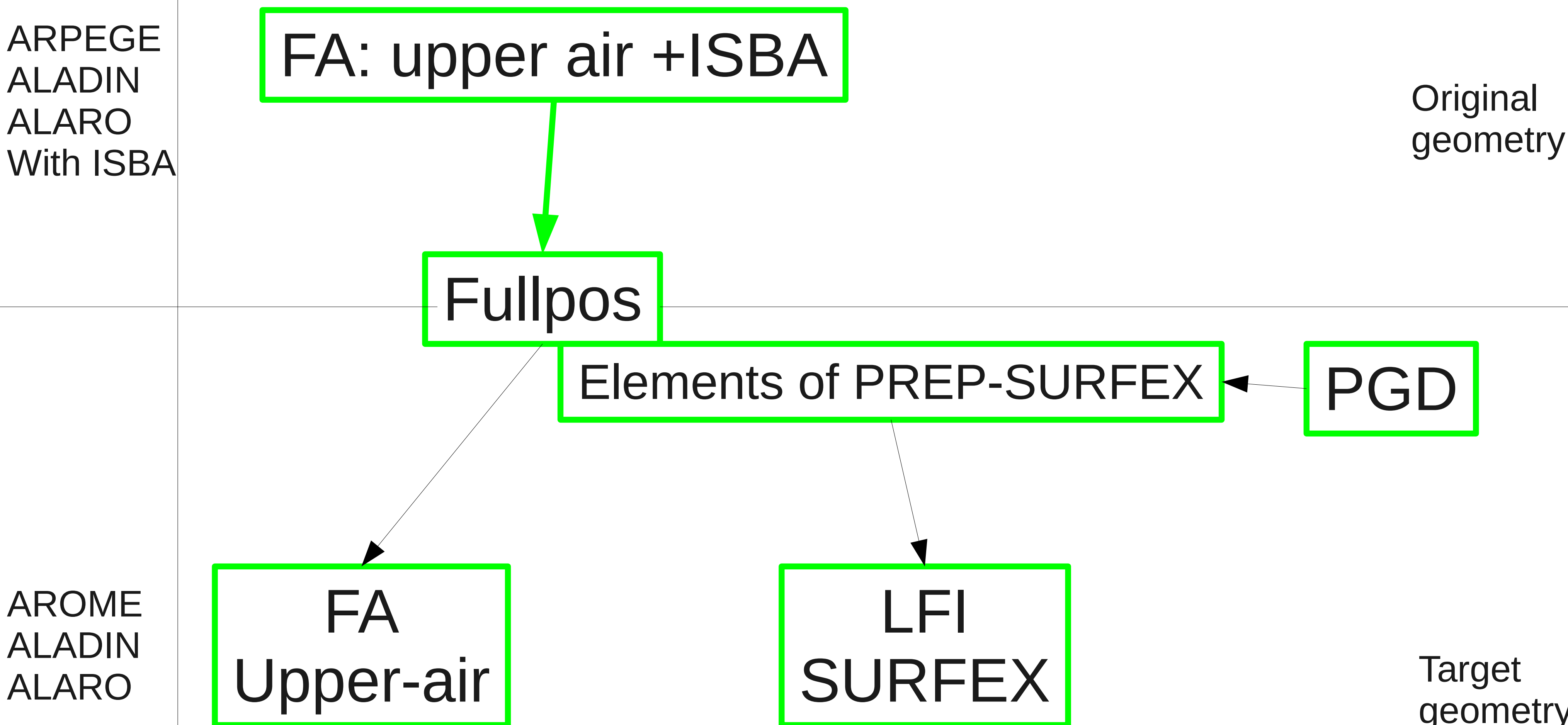
- **CY39: September/October 2012**
  - Contents of CY38R1-2 of IFS/ECMWF: new Fieldset Fortran code, some re-arranged Setup, horizontal SL interpolators made external from the IFS, Phase II of the overhaul of the code for observation operators, code adaptations to be able to run the OOPS 3D-VAR demonstrator on AMSUA-A radiances
  - Some extras (Full-POS algorithm, externalization of coupling)
  - **Participation of at least 6 Aladin phasers expected + Hirlam**
- **CY39T1: November/December or December/January 2012-2013**
- **CY40: March/April and April/May (leaving some back-up window in June). Release of CY40 must be completed in June 2013 the latest. The exact timing will be decided at the June 28 IFS/Arpège coordination meeting.**
  - Work on SL interpolators
  - Obs-interpolation restructuring, leftovers
  - Further break-up of setup routines (=> LAM)
  - Cleaning of CDCONF
  - Command line (part of it)
  - GFL/GMV cleaning
  - Enable more than one geometry
  - Call only GPHPRE
  - Optimization in the lateral coupling

Most of this is technical, especially in relation with OOPS.
Question: for ALARO-1, how much is already in cy38?
And for what is needed, we should consider phasing constraints.

SURFEX, short term plans

SURFEX WW

Fullpos changes the geometry of UA and ISBA surface fields then subcontracts to Surfex the elaboration of Surfex fields

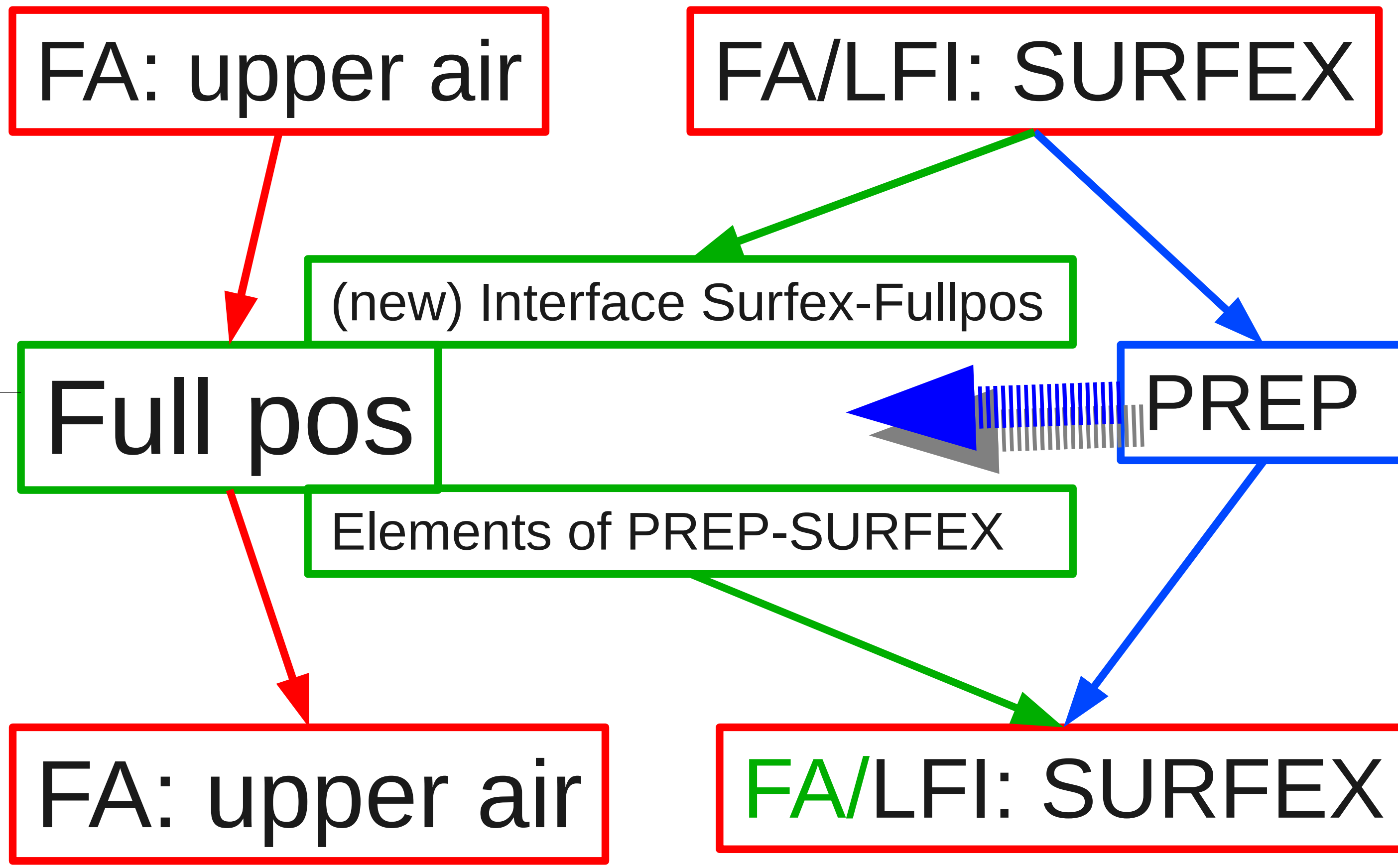


But Fullpos can't read Surfex data

PREP can change the geometry but it is inefficient

Fullpos could *inquire* Surfex data

ARPEGE
ALADIN
ALARO
With SURFEX



Original
geometry

Target
geometry

AROME
ALADIN
ALARO with
SURFEX

**CALL PREP science from Full pos
and write everything in FA files!**

Questions we might consider concerning code

- SC seen as turbulence vs. mass-flux? ACRANEB vs. FMR/RRTM? Different variation on the MT idea? **If we think in logical “stream” would this lead to blocks?**
- How much biodiversity is needed and how to organize the code? Some general remarks:
  - Codes developed by our community allow training of experts. Example: we do not have an influence on FMR nor on RRTM, so it is difficult to base a build a program on that that. But we need expertise on radiation!
- Everyone (that I spoke to) agrees we need to address the issue of APLPAR. This is related to the first bullet. We need an analysis, a plan and man power.... Question: reorganize it in blocks? Flexibility is good for clean scientific testing, but for some examples of distinct scientific streams the organization in blocks may be more useful (e.g. SC in turbulence vs. mass flux)?

TODO (in order of urgency which is not necessarily the same as priority)

- We need to test the physics-dynamics interface in AROME, see Daan's talk. **Who?**
- **Analysis of a rationalization of APLPAR/APL_AROME**
- Validation of the cycles. **Who? How to get organized, such that ALADIN and HIRLAM make use of each other better?**
- **Continuation of ICE3 in ALARO ...**