‘Generalities’ about ALARO-0 => ALARO-1

J.-F. Geleyn
Météo-France (& CHMI)

(with acknowledgments to many others in ALADIN and HARMONIE)

‘ALARO-1 Working Days’
16-19/02/2010, Budapest

Content of the talk

- Justification on ‘why ALARO-1?’
- Some incentives coming from results and/or theoretical advances
- Synthesis about the challenges
- Analysis of the positioning of 3MT
- Some key input from work on ARPEGE and AROME
- The basic ideas for ALARO-1
- Recent news from elsewhere …

Why ALARO-1? (1/3)

- Short recall about the 'ALARO spirit':
  - Looking for simple concepts in the design:
    - Examples for ALARO-0: *Barycentric & conservative equations with prognostic precipitation species* (as 'cement'), *Net Exchange Rate formulation* (radiation), *RMC01 'unification' of L_K, L_ε and l_m* (p-TKE turbulence), *Chen-Bougeault's framework for prognostic M_c / Gerard's single microphysics concept / Piriou's M-T separation approach / PDF-based sedimentation* (3MT);
    - For ALARO-1 … be patient!
  - Caring for the details (algorithmics, IFMG rules, efficiency, consistency) in the actual implementation.
- Uncompleted aspects of ALARO-0:
  - Radiative gaseous transmission functions;
  - (Prognostic entrainment rates for updrafts);
  - Towards some consistency in the cloud description.

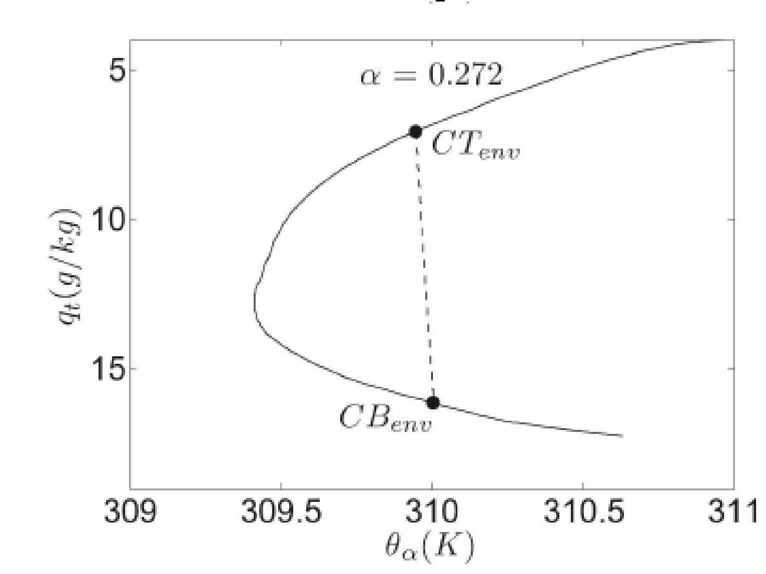
Why ALARO-1? (2/3)

- **A new definition of the environment following the ‘Convergence Days’ (September 2008):**
  - “The scale specificity which currently characterizes AROME and ALARO is going to be progressively replaced by a difference in the way of capitalizing on upstream research either rapidly for the process side or more slowly for the NWP specific side. This characterization allows to optimize the benefits from each other's developments.”
- **Weaknesses appearing when using ALARO-0:**
  - **Lack of convergence of 3MT with its ‘resolved’ equivalent at high resolution;**
  - **Compensating errors between radiative and PBL forcing terms;**
  - **Underuse of the TKE prognostic aspect of p-TKE.**

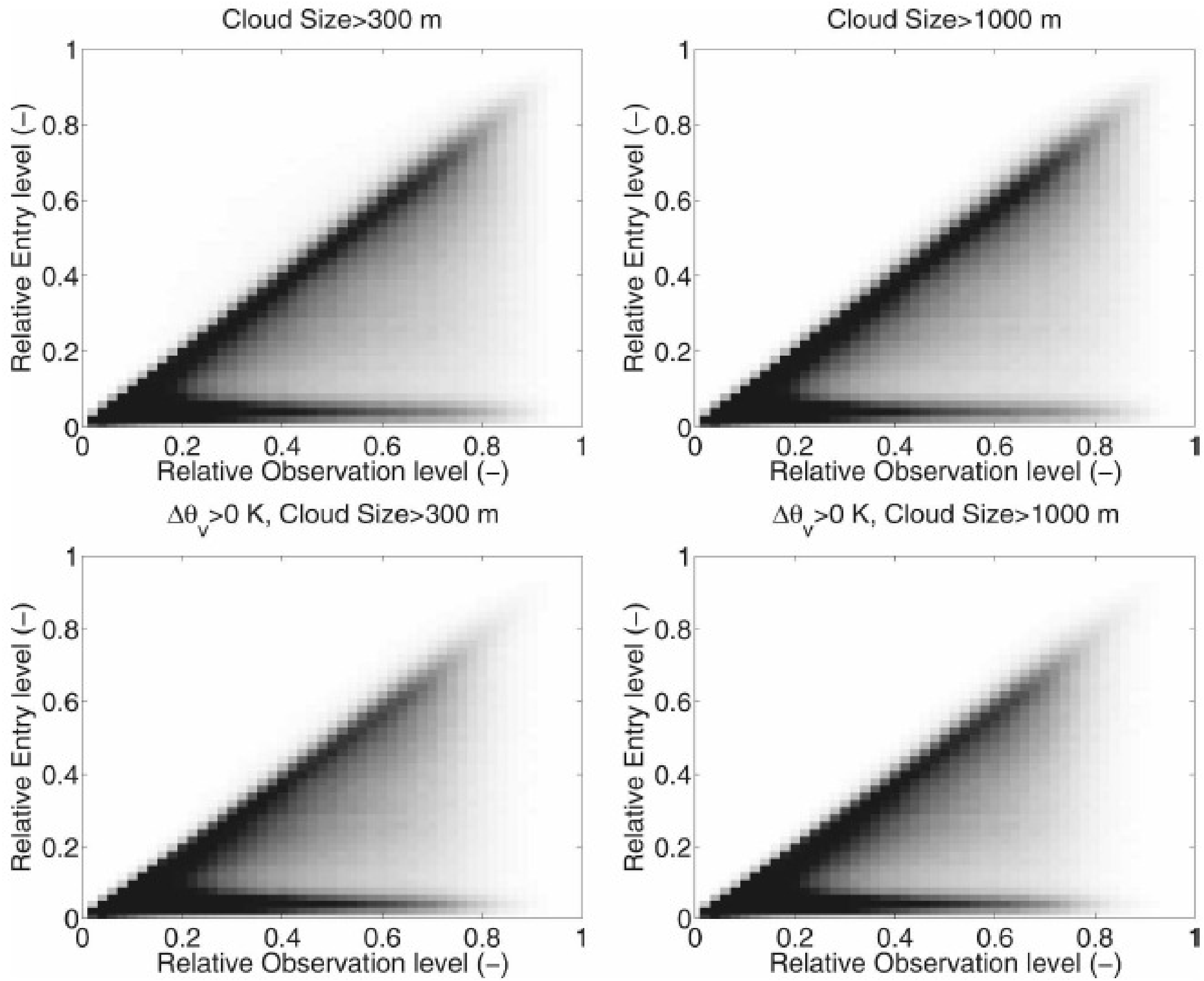
Why ALARO-1? (3/3)

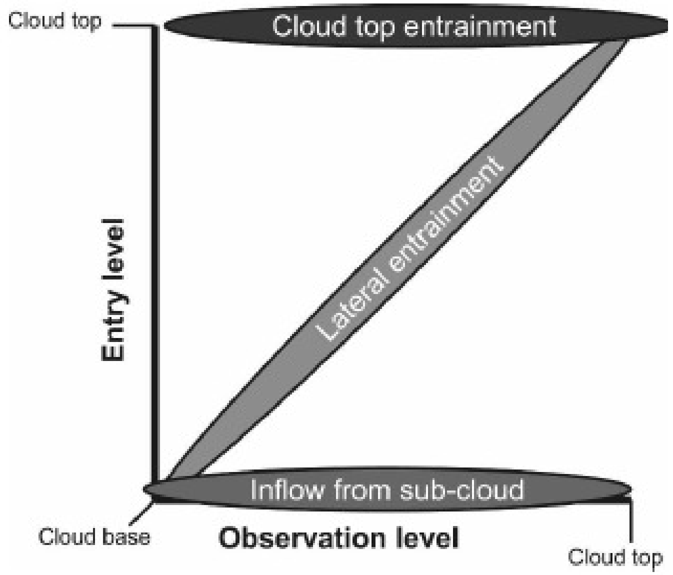
- A set of opportunities (scientific and others):
  - The SLHD concept reached maturity and starts to be a topic-generating issue by itself (see F. Vana's talk);
  - Decadal evolutions of the turbulence basic science:
    - Reynolds averaging Navier-Stokes is not any more the only conceptual framework (QNSE is the novelty);
    - The concept of a critical Richardson number will soon be 'as dead as a dodo';
    - The inclusion of higher statistical moments progressively loses its 'jungle' character.
  - The 'cloud top entrainment' concept seems to be a fake but convective clouds appear to be 'protected' by a subsiding shell => another angle of view on 3MT;
  - COST now supports an action on '*Basic concepts for convection parameterisation in Weather Forecast and Climate Models*' => 'change of paradigms' welcome?

Incentive N°1: Despite the 'mixing line' arrangement of cloud samples, the famous 'cloud top entrainment' seems to be a hoax

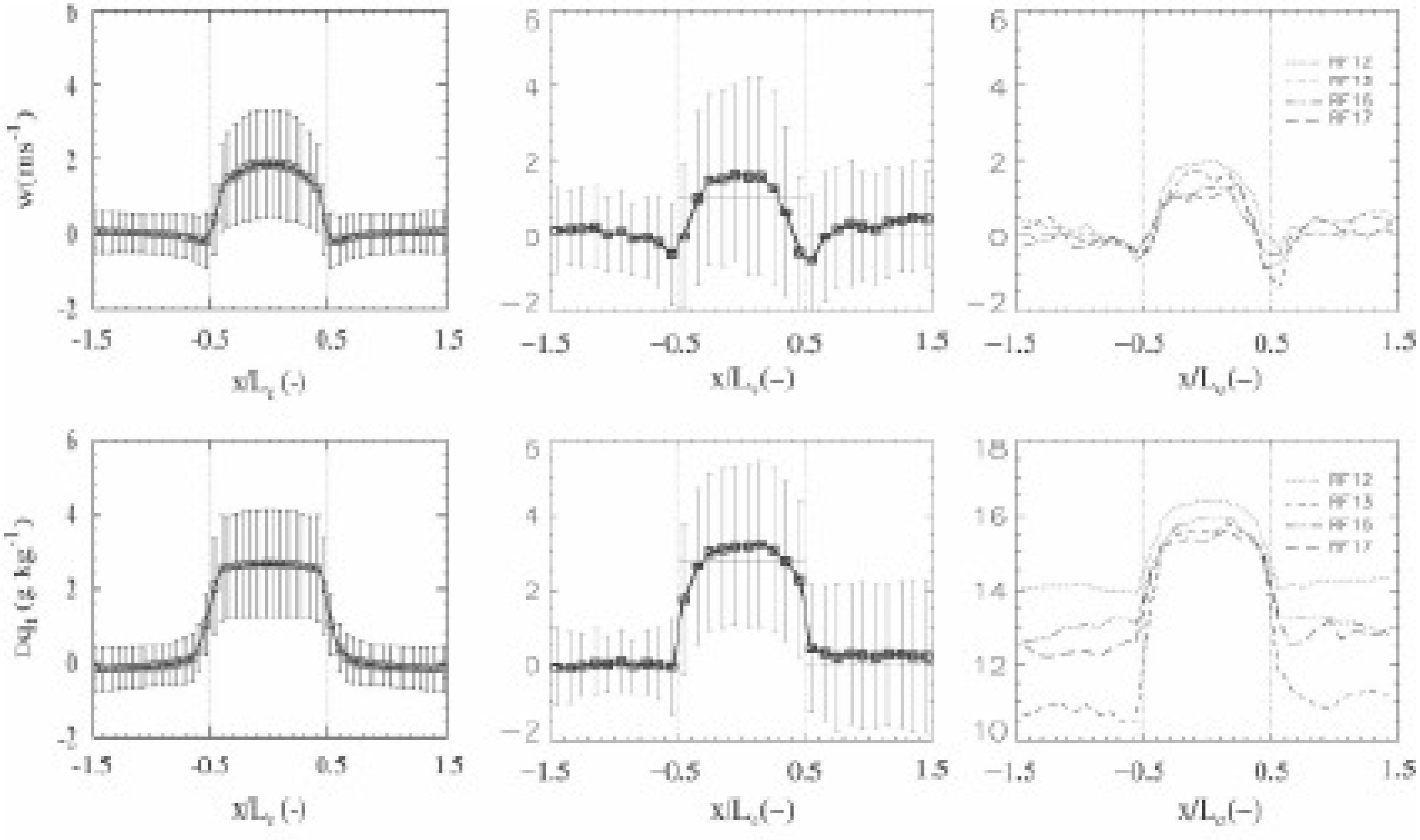


Heus et al., 2008



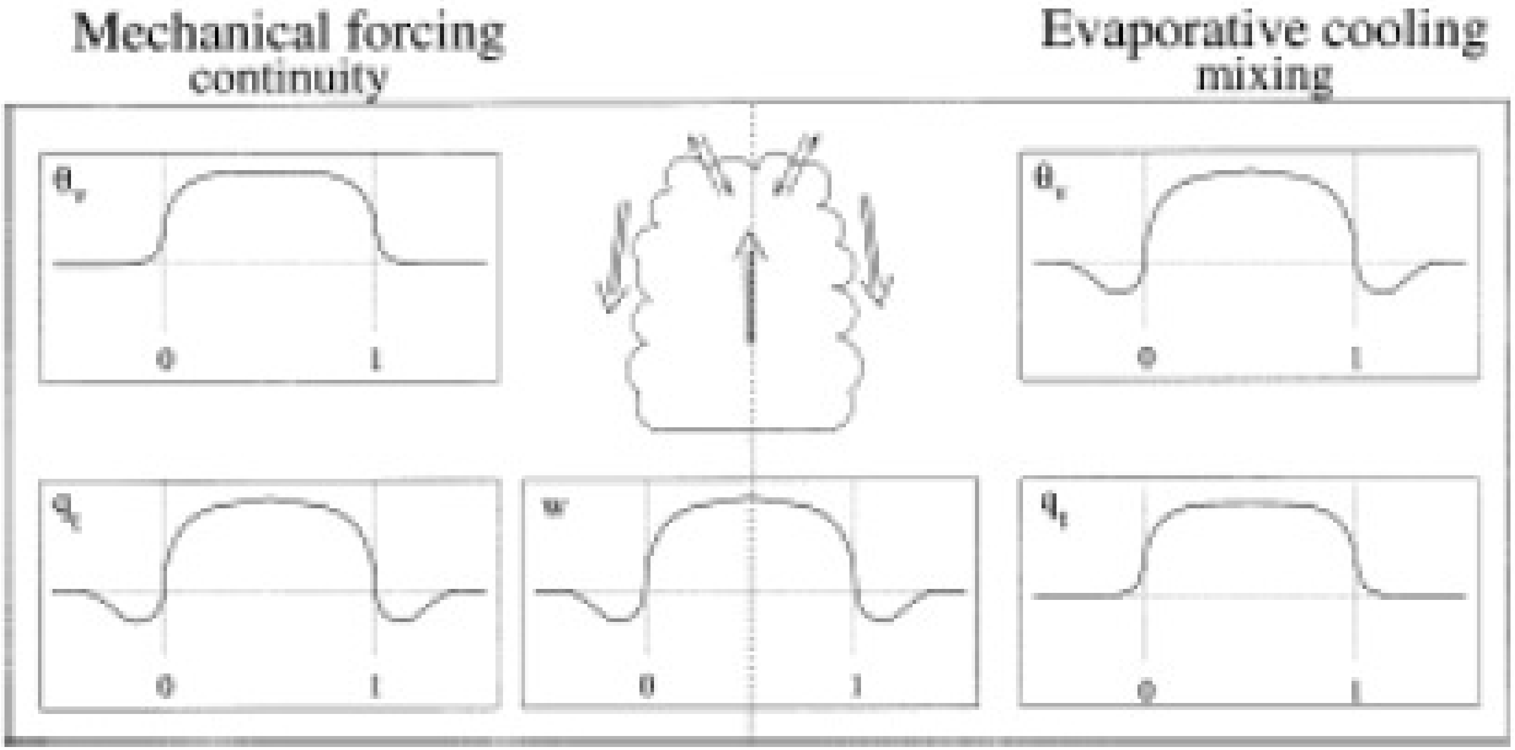


Incentive N°2: convective clouds have a ‘shell’ of subsident motions, driven by evaporation at the cloud edges



Heus and Jonkers, 2003

Incentive N°2: for small clouds (=shallow?) this leads to deconnection from the 'larger scales'



Rodts et al., 2003

Incentive N°3: Towards a Unified Description of Turbulence and Shallow Convection (D. Mirovov)

Quoting Arakawa (2004, The Cumulus Parameterization Problem: Past, Present, and Future. *J. Climate*, **17**, 2493-2525), where, among other things, "Major practical and conceptual problems in the conventional approach of cumulus parameterization, which include artificial separations of processes and scales, are discussed."

"It is rather obvious that for future climate models the scope of the problem must be drastically expanded from "cumulus parameterization" to "unified cloud parameterization" or even to "unified model physics". This is an extremely challenging task, both intellectually and computationally, and <u>the use of multiple approaches is crucial</u> even for a moderate success."

The tasks of developing a "unified cloud parameterization" and eventually a "unified model physics" seem to be too ambitious, at least at the moment.

However, a unified description of boundary-layer turbulence and shallow convection seems to be feasible. There are several ways to do so, but it is not a priory clear which way should be preferred.

Incentive N°3: Towards a Unified Description of Turb. and Sh. Conv. – Possible Alternatives

- ***Extended mass-flux schemes*** built around the top-hat updraught-downdraught representation of fluctuating quantities. Missing components, namely, parameterisations of the sub-plume scale fluxes, of the pressure terms, and, to some extent, of the dissipation terms, are borrowed from the ensemble-mean second-order modelling framework. (ADHOC, Lappen and Randall 2001)

- ***Hybrid schemes*** where the mass-flux closure ideas and the ensemble-mean second-order closure ideas have roughly equal standing. (EDMF, Soares et al. 2004, Siebesma and Teixeira 2000)

- ***Non-local second-order closure schemes*** with skewness-dependent parameterisations of the third-order transport moments in the second-moment equations. Such parameterisations are simply the mass-flux formulations recast in terms of the ensemble-mean quantities!

Incentive N°4: an interpretation of Luc Gerard for the problems encountered when trying to ‘cast in iron’ the upper resolution limit of the grey-zone

- ***The capacity of ‘resolved modeling’ to describe (at high resolution) convective situation may be (partly) limited for transition regimes: it works quite well for the steady phase but not for the onset and decay phases, which intrinsically require some ‘sub-grid’ approach …***
- This angle of view may be put in relation (work still pending) with the ‘dynamical’ theoretical considerations of Piotrowski et al. (JCP, 2009).

Synthesis of the challenges (individual aspects)

- **Allowing to push the 3MT concept until the kilometric scales** *(it is now more and more likely that, contrary to previous assessments, precipitating convection cannot be fully resolved with 2km to 3km mesh-sizes)***.**
- **Solving the most urgent moist boundary layer parameterisation problems, while staying at the complexity level of a single additional prognostic variable, i.e. the Turbulent Kinetic Energy (TKE).**
- **Avoiding the disappearance of turbulent friction at very high stability, a feature of old prognostic TKE schemes now contradicted by a wealth of measurements and theoretical arguments.**
- **Maintaining the acquired compatibility with the Rasch-Kristjansson scheme for ‘resolved condens.-evap.’.**

Synthesis of the challenges (catalysing aspects)

- **Sorting out cases where deep convection still needs to be parameterised at the kilometric scale from those where resolved clouds suffice.**
- **Reducing the compensating errors, through the acceptance of yet additional feed-back mechanisms, especially in the cloud descriptions.**
- **Obtaining a consistent picture between radiative, turbulent and microphysical forcings for clouds at the top of the PBL, without relying on artefacts like ‘top cloud entrainment’.**
- **Solving the problem of numerical compatibility between parameterising moist turbulence and accounting for the non flux-gradient part of vertical diffusive transport.**

Analysis of the 3MT positioning (1/2)

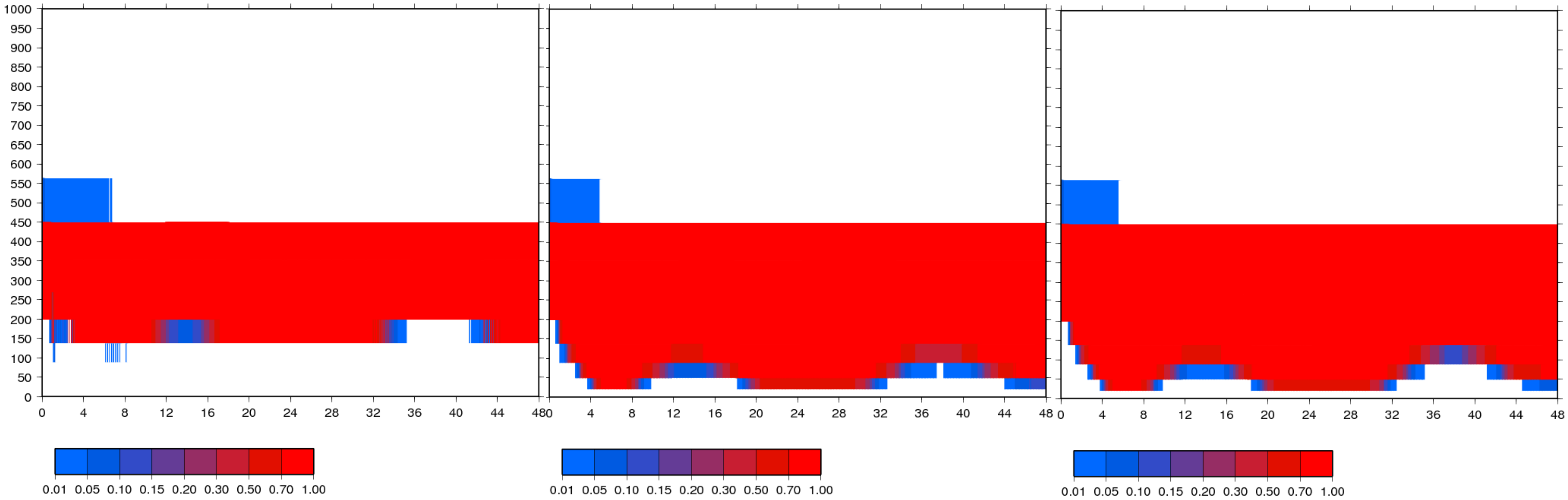
- The parameterisation schemes of organised convection are mostly just based on a 'statistical handling' of the grid-box population of 'plumes'. And it is indeed a complex issue!
- The shortcomings of this approach if the said population stops to be numerous enough for a true statistical sampling are well understood (so to say, ***1st 'grey-zone' syndrome*** **=>** ***single microphysics approach of 3MT***)
- But there is another problem: the 'invisible' return current of any plume with a 'net ascent' stretches horizontally on far larger scales. Said differently, the 'compensating subsidence' part of the local flow ALWAYS remains a statistical aggregate, EVEN when this is not any more true for the 'ascent part' of the grid-box where condensation happens.

Analysis of the 3MT positioning (2/2)

- And yet parameterisation schemes force us:
  - to treat both aspects in the same conceptual framework;
  - to close the mass-budget independently inside each grid-box.
- Forgetting both issues is the source of the what may be called ***2nd 'grey-zone' syndrome***, far more structural than the first one, especially in transition phases (when the 'grey-zone' may be said to extend to very small scales **=>** ***prognostic mass-flux approach of 3MT***).
- Additionally, it can be argued that the distinction deep/shallow (for convection) might better be linked with the notion of 'net-ascent or not' than with the one of 'precipitating or non-precipitating'. This would lead to try and push as much as possible of shallow-convection on the 'turbulent' side (**=>** ***leaving 3MT to treat 'only' deep convection***).

FIRE case: evolution of cloudiness on 48 hours (Jean-Francois Gueremy)

LDIFCEXP LDIFCONS LDIFCONS-LNODIFQC



K-law for each $q_{v/l/i}$

K-law for q_t

Reprojection on $q_{l/i}$

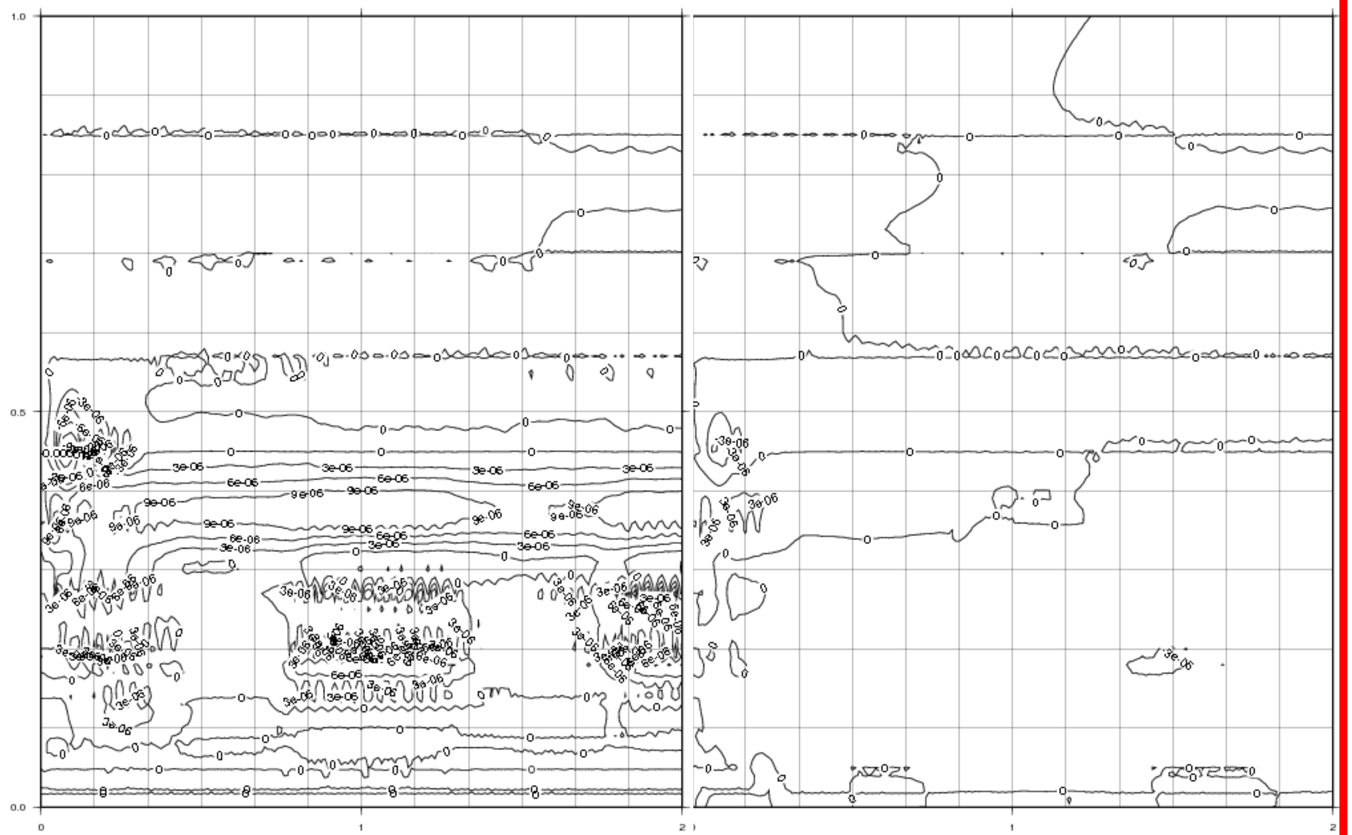
K-law for q_t

No reprojection on $q_{l/i}$

FIRE case: evolution of the diffusive flux of condensate on 48 hours

Exper = LDIFCEXP
PARAM = PDIFTQL

Exper = LDIFCONS
PARAM = PDIFTQL



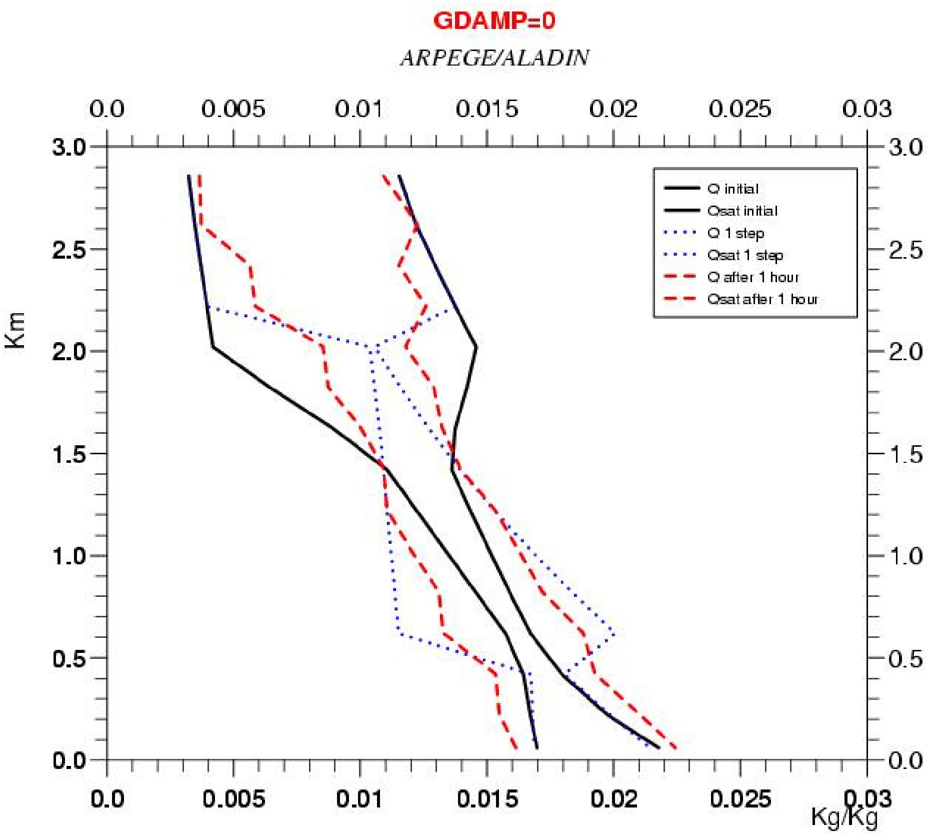
K-law for each $q_{v/l/i}$

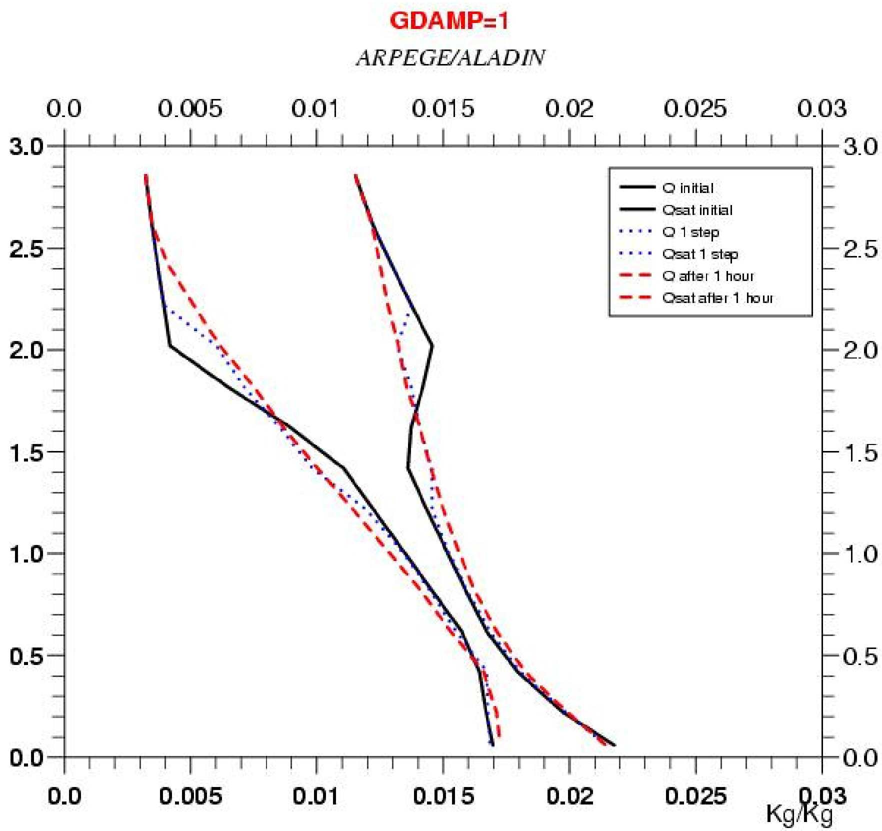
K-law for q_t

Reprojection on $q_{l/i}$

The 'reprojection option' was abandonned in ARPEGE in 2007, is going to be abandonned in AROME soon and was never used in ALARO-O => this cast some serious doubts on its potential to correctly describe a key part of the shallow convection process.

Impact of the 'Anti-fibrillation scheme for shallow convection' (Eric Bazile)





1D simulation on the BOMEX profile. 1 hour with 900s (4 time step). Only vertical diffusion !!

Blue dotted line after 1 time step. Red dashed line after 1 hour.

When the AF scheme is activated (right), the blue dotted line is obtained independently of the time step length and matches well the observations !!

Impact of the ‘Anti-fibrillation scheme for shallow convection’ => idea to use it as a core computation

- Given the success of this method (initially thought, in 2002, as a way to cure a numerical problem), one may dare to make it a technique for computing a ‘shallow convective cloudiness’ (SCC) from the sole information available at the beginning of the time step, in (nearly) stand-alone mode.
- One shall see that this is a key to indeed get rid of the ‘dubious’ link (‘re-projection option’) between thermodynamic adjustment and diffusive transport of cloud-condensates.
- In the longer term, we of course hope to do even better for the initial computation of the SCC.

The basic ideas for ALARO-1 (1/2)

- **Independent evolution of 3MT towards its ‘convergence with resolved solutions’**
  - **See justification in the previous viewgraphs (& refer to Luc Gerard’s talks).**
- **Rethinking of the RMT concept for moist physics**
  - **RMT (Radiation-Microphysics-Transport) is an extension of the M-T concept proposed by Jean-Marcel Piriou for convection. It states that the full moist physics can be spilt along the three entities.**
  - **But, based on the evidence shown above, another interpretation is possible: “what distinguishes convection from turbulence is that the distinction M-T applies in the former case and not in the latter”.**
  - **Keeping the idea of a single microphysics calculation in the 3MT spirit, one gets a full road-map.**

The basic ideas for ALARO-1 (2/2)

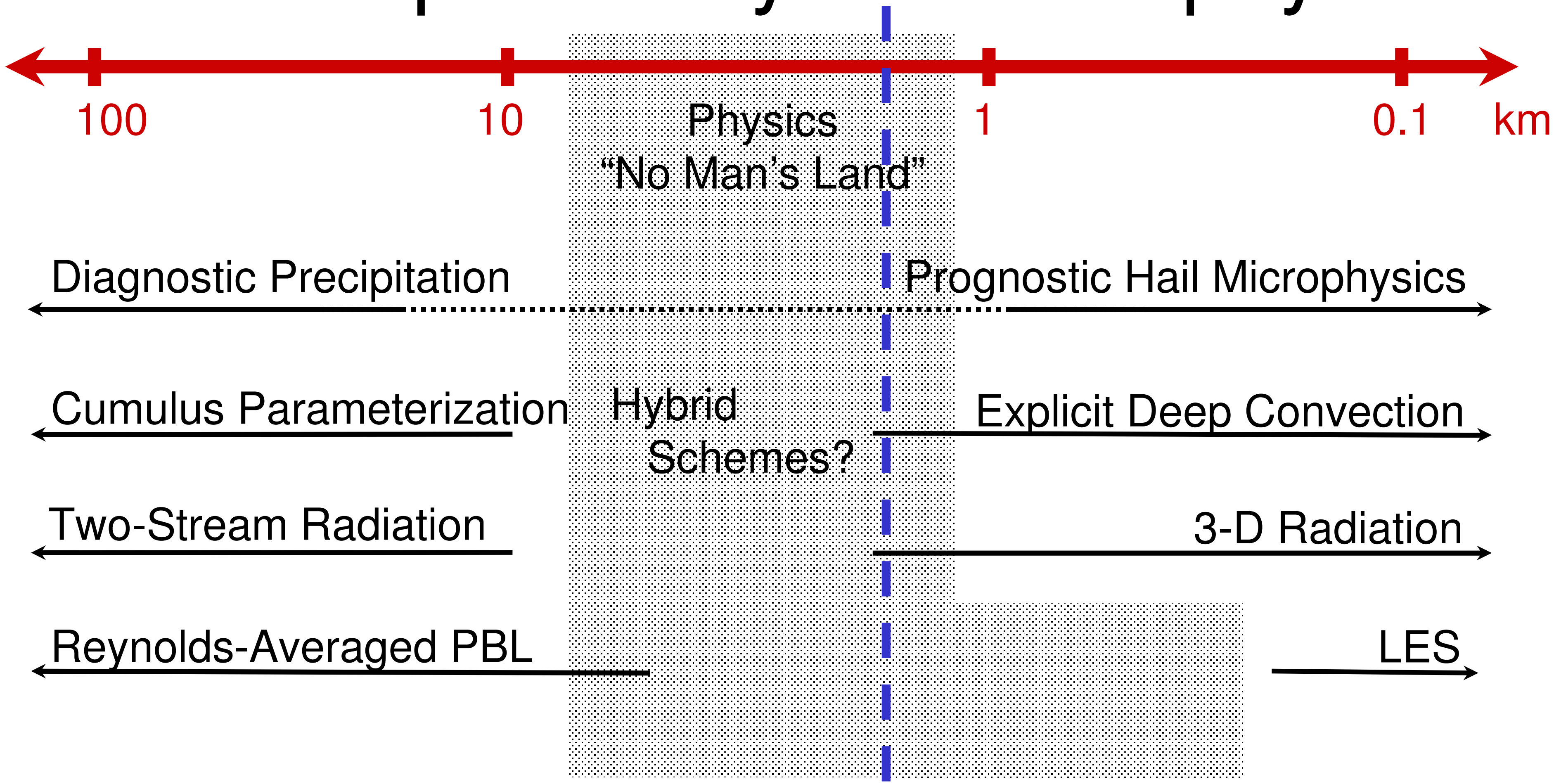
- **A guideline for the cloudiness unification topic:**
  - **In the case of convective clouds one puts cloudiness where the condensation mechanism has been detected, while in the case of stratiform clouds one computes condensation where clouds are diagnosed.**
  - **If one is able to have a stand-alone computation of a ‘shallow convective cloudiness’ at the start, this solves the ‘new RMT’ algorithmic problem.**
- **In depth rethinking for the ‘turbulence + diffusion’ part (1D aspects only here => see F. Vana’s talk for the ‘horizontal scale’ complement):**
  - **The ‘thermodynamic adjustment’ does not control anymore the rate of diffusion of cloud condensates.**
  - **All this leads to ‘TOUCANS’ (refer to talks about it).**

Some fresh news from Offenbach

or,

do we witness some ‘convergence of concepts’?

Scale dependency of model physics



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

"Extramuros Research Programme" of the German Weather Service (DWD) (1/2)

- Project: **Developement and test of a scale-independent parameterisation of convection for ICON**
- PIs, Institute: George Craig and Christian Keil, Ludwig Maximilian University, Munich
- Contact person at DWD: Dmitrii Mironov

- Project : **High-resolution LES of the atmospheric PBL – Contribution to the improvement of turbulence parameterisation schemes via a systematic study of higher moment terms and of their budgets**
- PIs, Institute: Rieke Heinze and Siegfried Raasch, Leibniz University of Hannover, Institut für Meteorologie und Klimatotologie
- Contact person at DWD: Dmitrii Mironov

"Extramuros Research Programme" of the German Weather Service (DWD) (2/2)

- Project: **Developement of a scale-independent parameterisation of cloud processes for the ICON model**
- PIs, Institute: Johannes Quaas, MPI Meteorologie Hamburg, Emmy-Noether Group for further education
- Contact person at DWD: Matthias Raschendorfer and Axel Seifert

---

- Total financing of the whole effort: 500 k€/year
- Here were presented 3 (COST ES0905 - related) out of the 10 projects selected from 31candidates
- Duration of the projects: 3 years
- Kick-off meeting: 1 December 2009

Outlook

- ALARO-1 does not exist yet as a complete entity (sorry to be so slow, but this is the fate of NWP people supposed not to understand the ‘processes’).
- But it has its structure, its components (nearly), some theoretical consistency and a corpus of supporting evidence for the key changes it wants to introduce.
- Does not this recall the situation of 3MT, three years ago?
- The novelty is perhaps that the belief in the need for the paradigm evolutions is less isolated than last time!
- Let us express and discuss all this in details in the three coming days in Budapest !!!