CNRM modelling strategy for MF NWP models

F. Bouttier and collaborators
(CNRM/GMAP, CNRM/GMME, CNRM/GMGEC)
Sept 2008

- **Aims and high-level constraints: scope for synergies**
- **MF's strategy for NWP models**
- **Examples in physical parametrisations**
- **Opportunities for ALADIN cooperation in this field**

Aims and constraints on MF NWP models

- **Objectives (cf. MF strategic plan, *contrat d'objectif*, GAME workplan, institutional commitments)**
  - to improve global (ARPEGE) forecasts, regional forecasts (wide-area and kilometric-scale LAMs), ensemble forecasts, nowcasting, seasonal, climate simulations
  - based on progress in modelling, data assimilation and supercomputing resources
  - as measured by objective scores, value to the forecaster (routinely and on high-impact weather), forecast skill on specific events (e.g. fog, flash floods) and scientific production (as both research modelling tools, and application of CNRM research)
- **Main constraint: to use human resources efficiently**
  - the variety of applications and issues (e.g. city weather, hydrology) grows faster than staffing: MF modelling must be strongly integrated:
    - *MF's NWP ARPEGEs and ALADINs must share identical physics*
    - *NWP and climate ARPEGEs physics shall converge*
    - *AROME physics must be shared with (i.e. part of) Méso-NH*
  - modelling needs of French research community : constrains evolution of ARPEGE and AROME
  - synergies with several NWP cooperations (mostly ECMWF, ALADIN, HIRLAM)
  - *the effort on assimilation & global NWP limits available staff for mesoscale modelling - particularly for atmospheric physical parametrisations*

Scope for synergies between models

- **There is not (yet ?) a magic recipe for unifying all NWP models:**
  - *physical issues are intrinsically diverse: synoptics ≠mesoscale ≠ LES ≠ 4DVar physics*
  - need to capitalise on historical assets, and to leave room for scientific innovation (avoid a "modelling bureaucracy")
  - a forced unification would freeze shorter-term developments: is it worth it ?
  - *model convergence may be unreachable because it is a moving target: scientific ideas and institutional priorities keep evolving...*
- **But, we could mutualize resources on appropriate issues:**
  - *to compare different approaches, in the evaluation framework of various applications*
  - *to share the best ideas: those with a clear value/investment benefit, and underpinned by a strong scientific community*
  - *to exchange corresponding codes if desirable: it shall be a pragmatic choice*
  - to standardize software ? Only to the extent that the benefits are clear.
  - Excessive software integration may harm its openness, and complicate the work.
- **This kind of pragmatic mutualisation has grown in CNRM models and with the ALADIN consortium in recent years.**

Already existing synergies

- Ongoing convergence of physical equations, sometimes (but not always) implying common software
- The modularisation of parametrisations is useful when it is done at the appropriate level (not to high or too low), in order to preserve openness to future imports.
- Table of parametrisations in various models: existing synergies shown in **green**

	HIRLAM	AROME	ALD-DBL		ALARO-0
vertical diffusion(K)	CBR (HL)	CBR full levels	CBR 1/2 levels		Louis +pTKE
mixing length	Lenderink-Holtslag.	BL 89	BL89+ Lshal option		Cedilnik-Tudor
shallow convection	Straco, KF or EDMF	KFB or EDKF	KFB puis EDKF 2009		Geleyn 87
clouds	Sundqvist ou Rasch-Kristjianson	f0f1f2 Bougeault	f0f1f2 Bougeault or Smith		Xu-Randall
Micro-Physcs	Sundqvist 2 var (4var)	Pinty 5 var « ICE3 »	PCS 4var « Lopez »		PCS Geleyn
Deep convection	Straco or KF	No	Bougeault limited		3MT
Radiation	Savijarvi	ECMWF	ECMWF		Geleyn

A strategy for improving MF NWP models

- **Balance the workload between**
  - different models: global, méso 10km, méso 2.5km, TL/AD, others
  - *short vs long term improvements*
  - *diversification of ideas* vs *unification of efforts*
  - in-house developments vs imports from the outside
  - *capitalising on proven ideas* vs *restarting on a fresh basis*
- **Be rigorous on task selection:**
  - only tackle problems that are (1) measurable, (2) priorities for MF, (3) with a known path to a solution
  - concentrate resources, do not scatter them (*importance of "staff critical mass"*)
  - delegate non-treatable issues to cooperations (e.g. grey zone convection)
- **Priority developments for MF NWP models (2008-2010):**
  - reduce *deep convection* weaknesses in ARPEGE/ALADIN-NWP and -climate
  - improve *radiation* in all MF models: try SRTM+McICA
  - try *EDKF* and *SURFEX* in ARPEGE/ALADIN-NWP and -climate
  - improve *strong precips in AROME* (involves phys+dyn+assim interaction)
  - improve AROME/MésoNH cloud realism (*subgrid ICE3*, add other microphys schemes)
  - improve slope & valley modelling in AROME (dyn+phys interaction)
  - improve fog & low clouds in AROME (resolution+assim interaction)

Methodological choices
of the CNRM modelling strategy

- **Very strong AROME/Méso-NH physics compatibility (=shared library):**
  - useful for comparing dynamics with same physics
  - Méso-NH provides high-resolution benchmark simulations
  - assess likely impact in AROME of more sophisticated parametrisations: 3D turbulence, C2R2 microphysics...
  - more detailed diagnostic tools in Méso-NH help problem-solving in Arome
- **Importance of multimodel cross-validation:**
  - using various validation frameworks: global NWP, LAM NWP, climate, 1D scientific community cases (GCSS)
- **Forecast improvement is a holistic process:**
  - increase resolution
  - improve data assimilation (algorithms and variety of observations)
  - *validation criteria encompass a wide variety of parameters, seasons, regions, levels*... it is a resource-intensive but essential work
  - surface analysis and physics
  - ...and atmospheric physics, but it is just one of many factors (with only ~15% NWP RD resources at MF)

The importance of data assimilation

- Physics development cannot be separated from data assimilation
- Physics consistency with the coupling model is important, too
- One physical problem may easily be mistaken for another...

Aro 2007072600+1500 T2m(C) & V10m
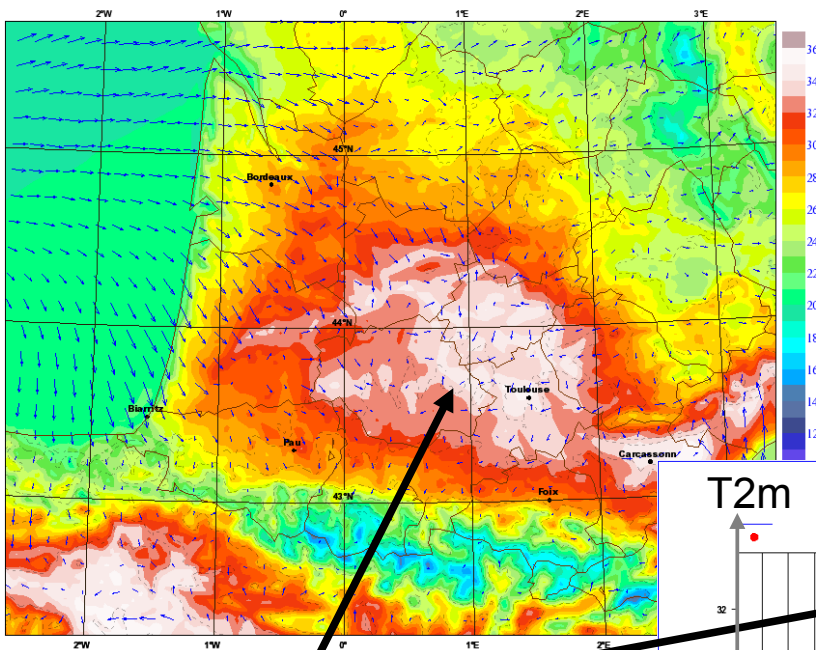
Aladin 2007072600+1500 T2m(C) & V10m
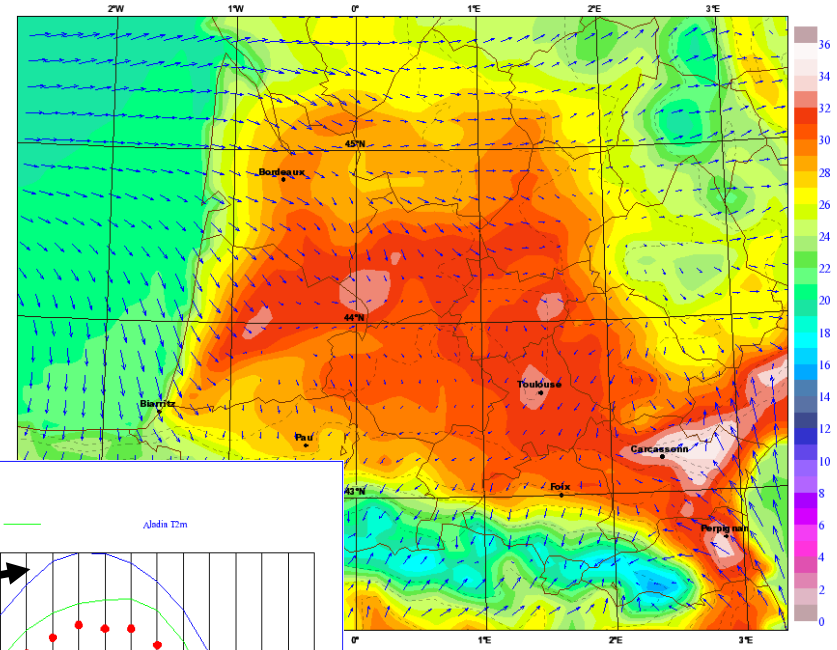
AROME too warm here - because of inconsistency with ARPEGE physics.

T2m
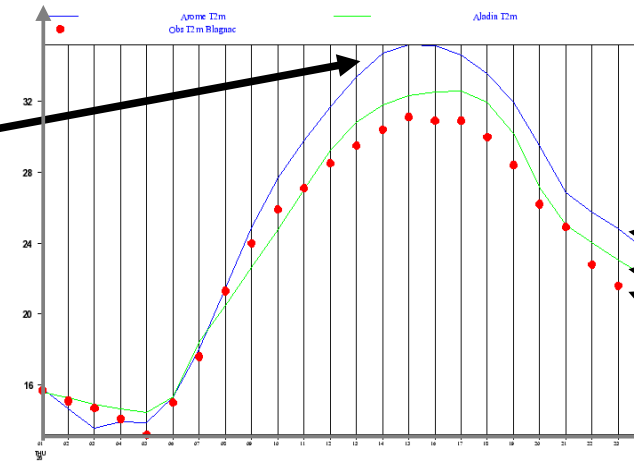
AROME
ALADIN
obs

time of day (hours)
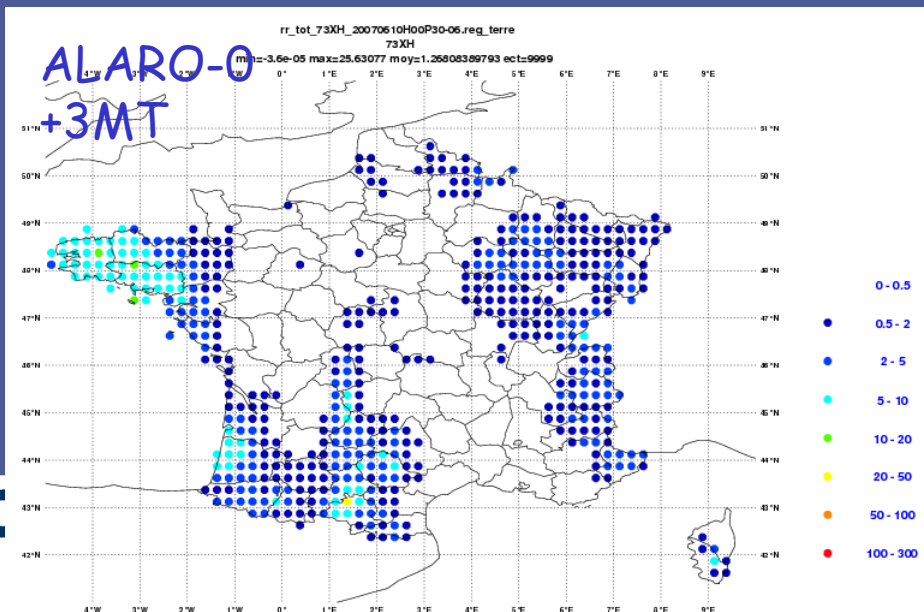
Model cross-validation: example on 10th JUNE 2007 (resolution 2.5km)

Obs from raingauge
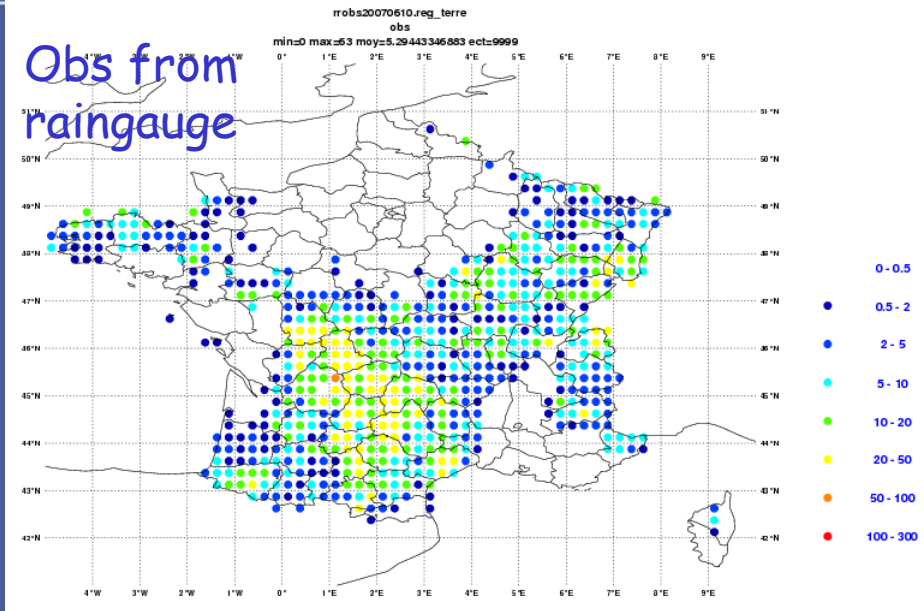
AROME
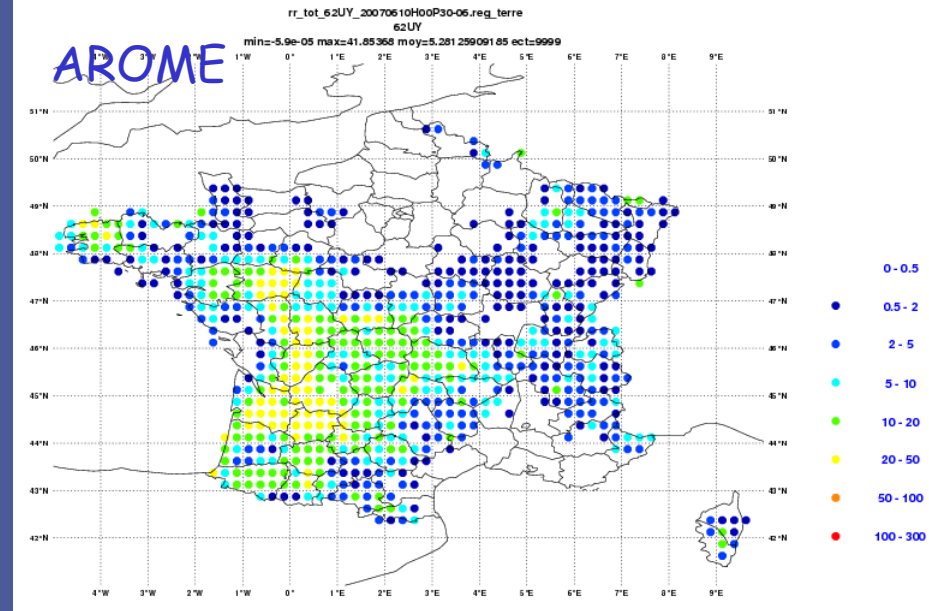
ALARO-0 +3MT

ALADIN with new-physics
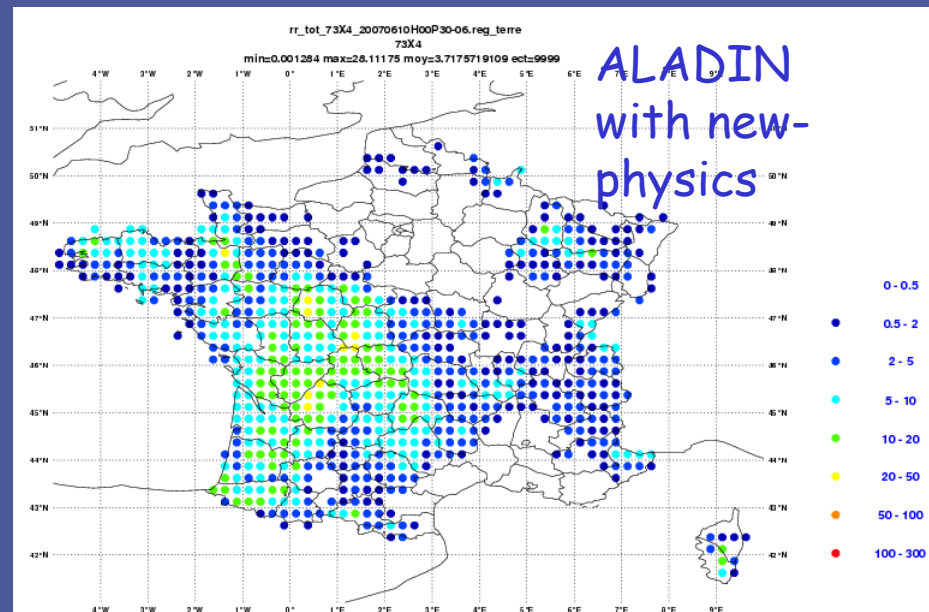
Scores of 24h-precip over France on 1 month: (E. Bazile, resolution 2.5km)
3MT improves the HSS score for strong rain, but at the expense of the histogram (underprediction of strong rains)

Precipitation histogram (Grid 1°x1°) June 2007

POD (Grid 1°x1°)

12.7%

3.6%

7.3%

1.8%

classe: 0.2 ; 1 ; 3 ; 7 ; 15
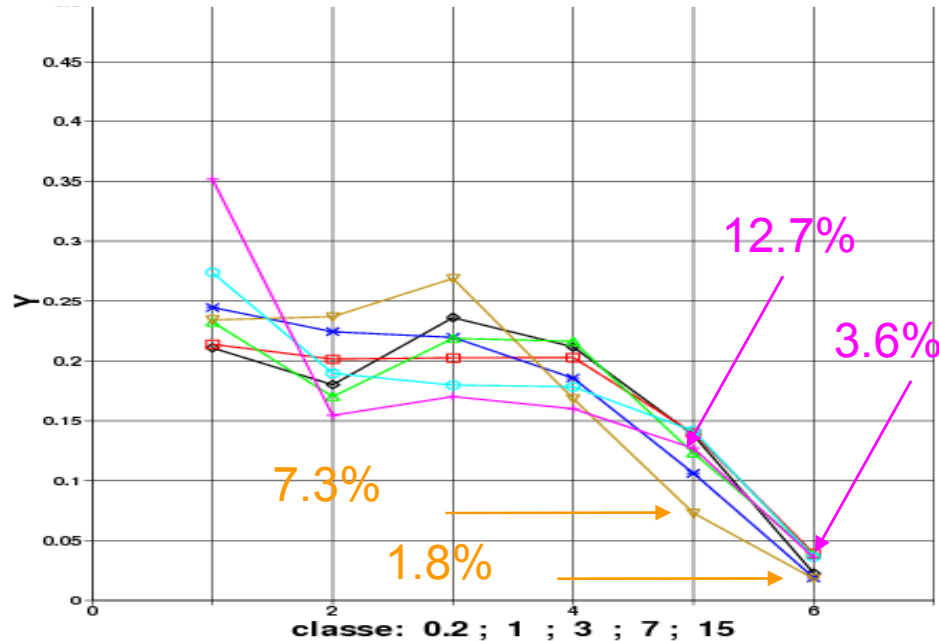
FAR (Grid 1°x1°)

HSS (Grid 1°x1°)
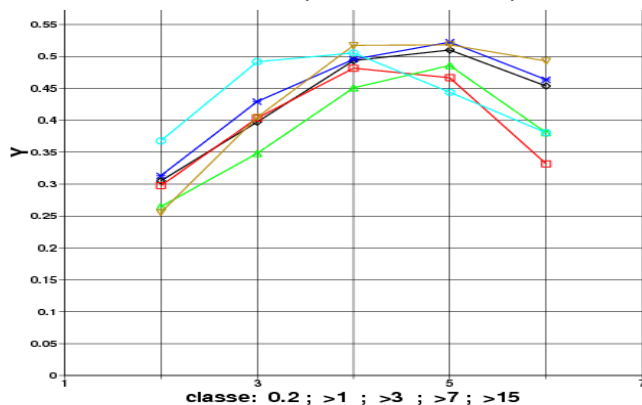
—+—	OBS
—○—	AROME_SLHD_EDKF
—▽—	ALARO0+3MT(73XH)
—△—	ALARO0-3MT(73WY)
—✕—	ANODIN_SLHD(73X4)
—□—	ANODIN(73WK)
—◇—	ALADIN(73WT)

classe: 0.2 ; >1 ; >3 ; >7 ; >15

classe: 0.2 ; >1 ; >3 ; >7 ; >15
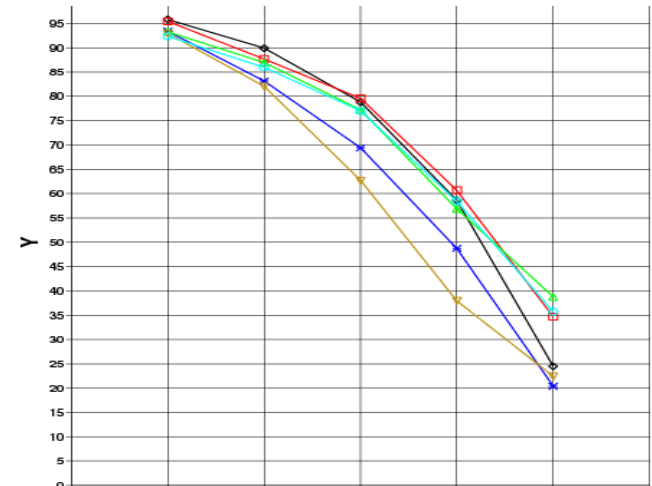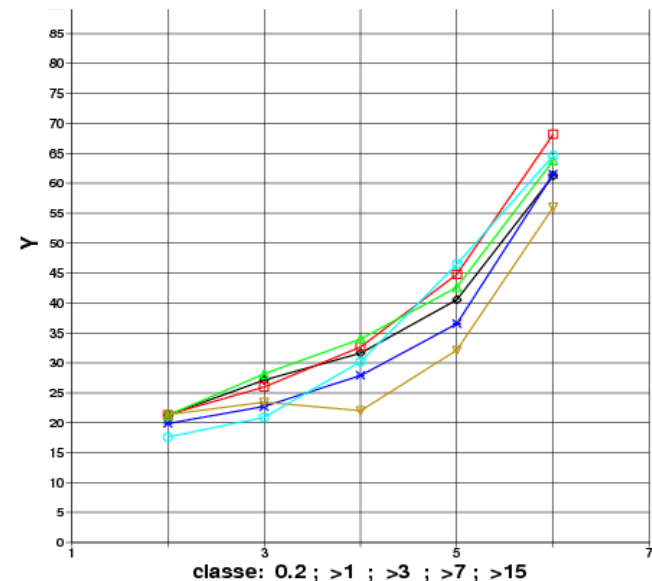
Multimodel study of subgrid convection vs other schemes (F Bouyssel)

Tests so far do not confirm the need for a parameterisation of deep convection at 2.5km. Differences between "ALARO without deep convection" and "new ALADIN-MF without deep convection" need further investigation.
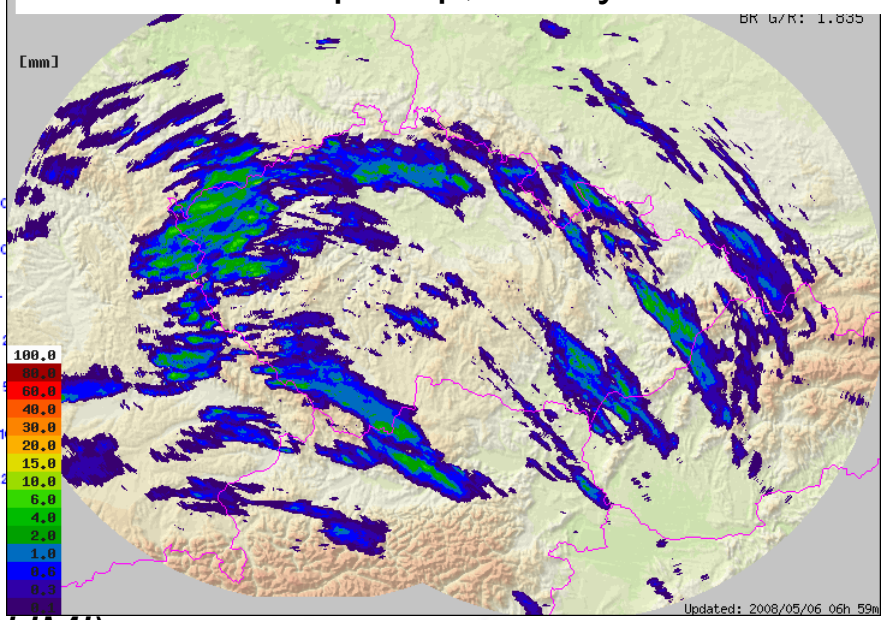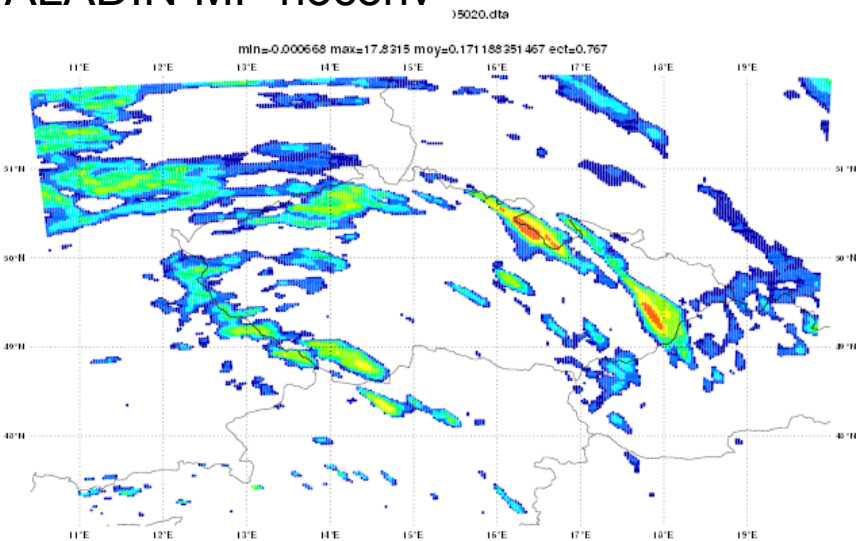
ALARO-noconv
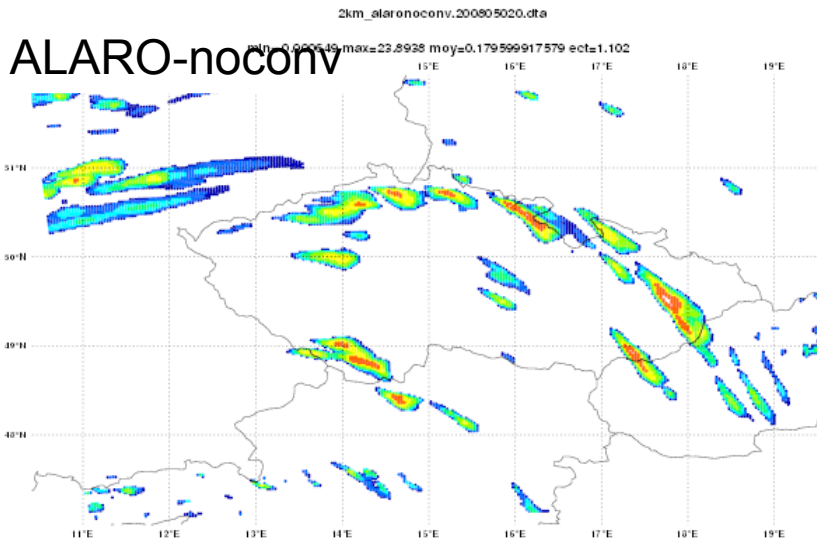
ALARO with 3MT
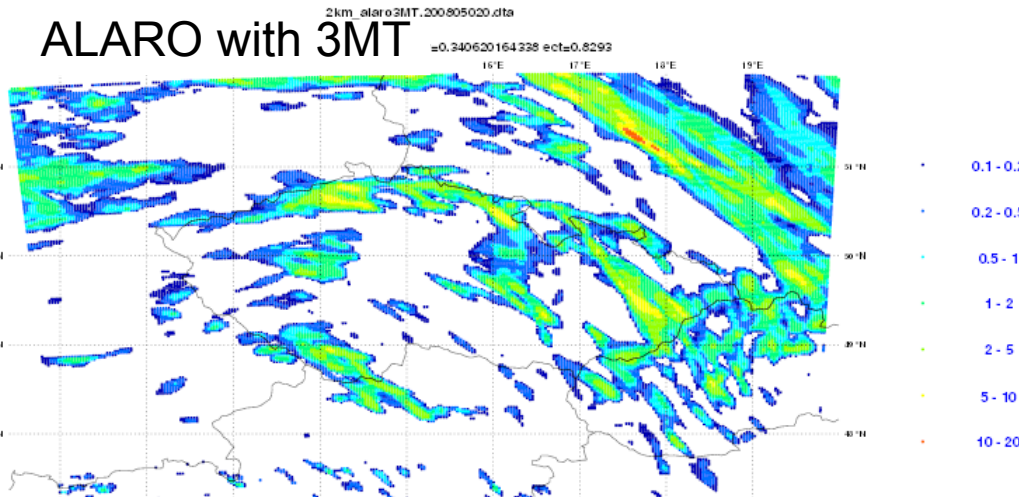
ALADIN-MF-noconv

radar obs: 6h-precip, 2 May 2008

(BCs and obs courtesy of CHMI)

CENTRE NATIONAL
DE LA RECHERCHE
SCIENTIFIQUE

Multimodel studies at dx=9.5km over ALADIN-France domain
Results so far:

- ALARO-3MT and ALADIN-oper have similar precipitation scores

- 3MT improves precipitation scores in ALARO

- CBR+KFB improve precipitation scores in a similar way in ALADIN-MF

- **We may expect that the combination of CBR+KFB+3MT will be even better !**

CENTRE NATIONAL
DE LA RECHERCHE
SCIENTIFIQUE

Justification of MF strategy: examples of recent NWP improvements

- **'Lopez' microphysics in ARPEGE/ALADIN-NWP and -climate**
- **RRTM in all MF models**
- **CBR & KFB in ARPEGE/ALADIN-NWP and -climate** : improves biases in boundary layer, cloudiness, alleviates cyclogenesis issues
- **EDKF in AROME and Méso-NH:** solved unrealistic boundary layer eddies at 2.5km resolution

All have been validated through
- *extensive scoring*
- *independent forecaster assessment*
- *specific case e.g. historic storms*

An MF NWP improvement: the summer 2008 ARP/ALD physics
ALDMF oper = Red   ALDMF-new=blue

Scores of 24-h precipitation over 1 month
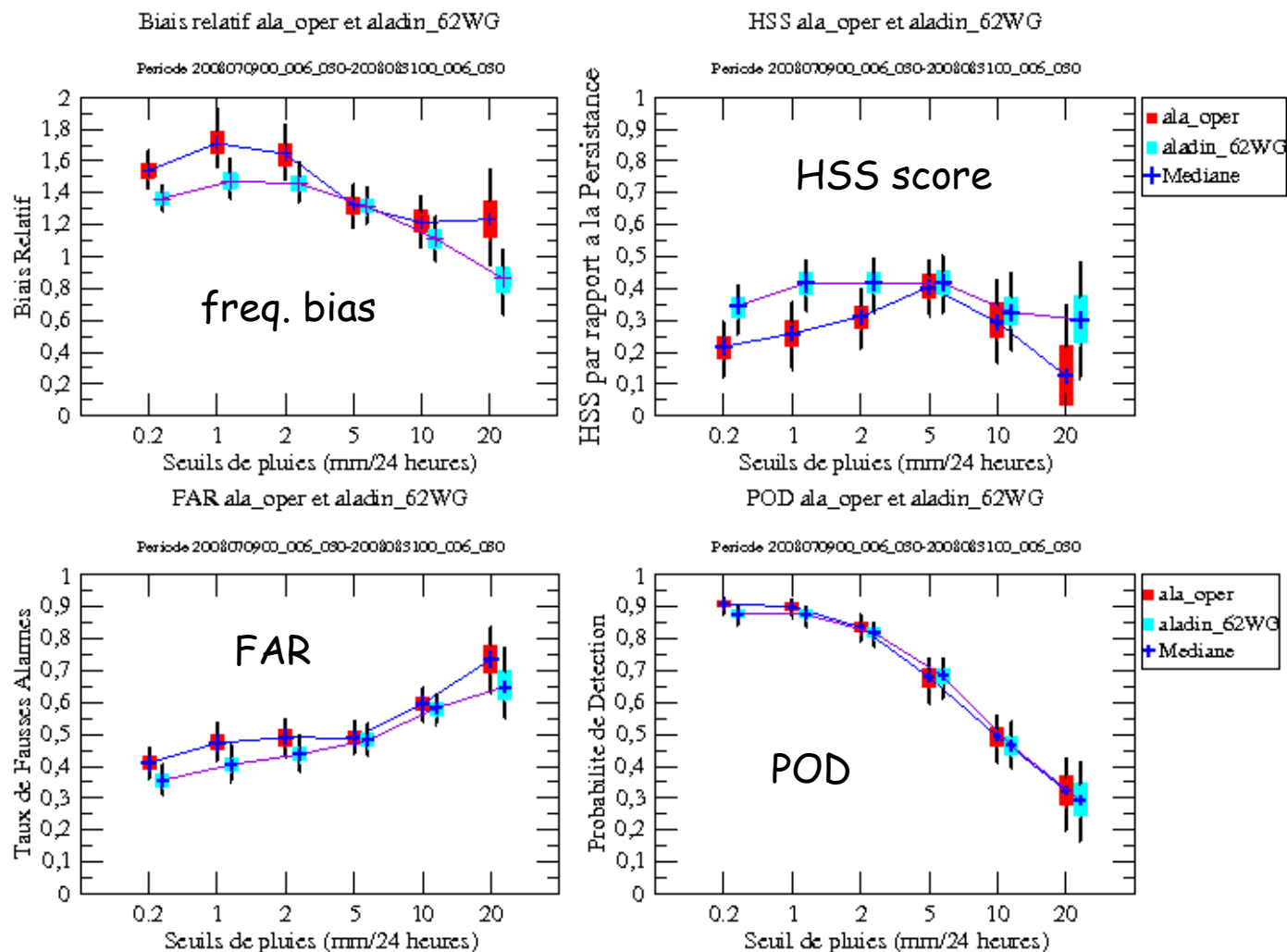
Not only precipitation: T/Hu score improvement thanks to the new CBR+KFB in ARPEGE/ALADIN-MF...

TEMPERATURE:PA.r 00/AC−PAD.r 00/AC

(0.05 K) Chaine 2008_02, Version V1, Chaine Physique 3G+

75 simulations de 102 h du 20080702 au 20080918
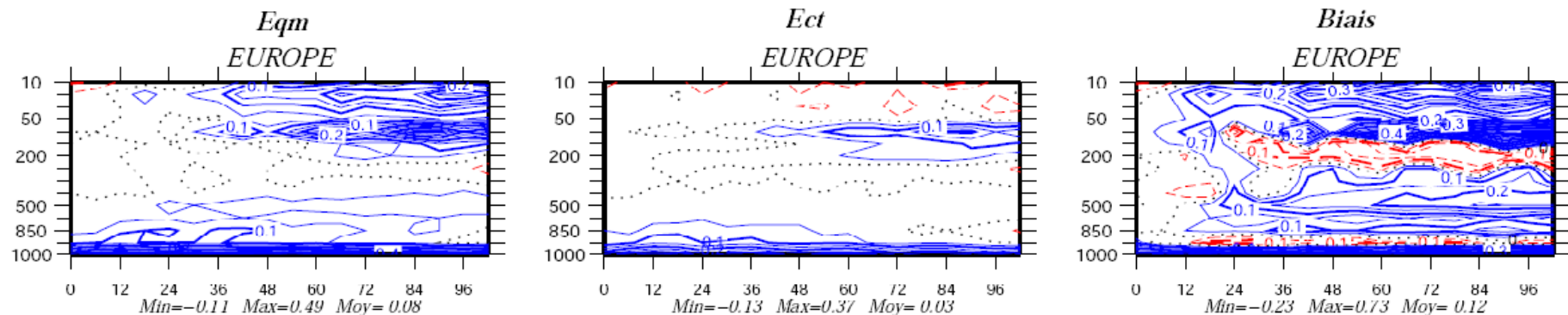
HUMIDITE:PA.r 00/AC−PAD.r 00/AC

(1. %) Chaine 2008_02, Version V1, Chaine Physique 3G+

75 simulations de 102 h du 20080702 au 20080918

Better and more coherent lateral conditions for AROME

ALADIN convergence workshop, Toulouse, Sept 2008
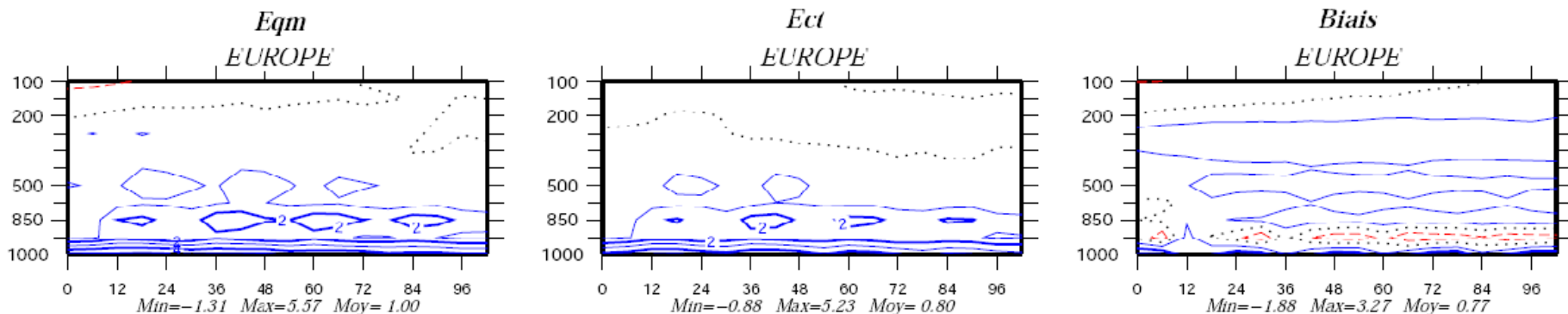
... and the very important global cloud climate is improved, too.

Mean error for total cloudiness (compared with ISCCP satellite climatology (for DJF))
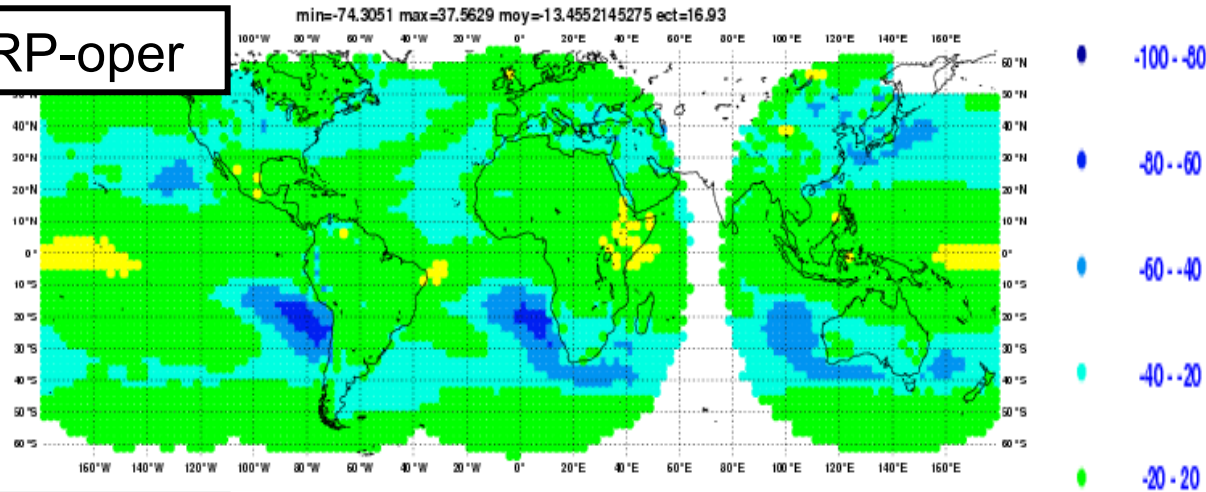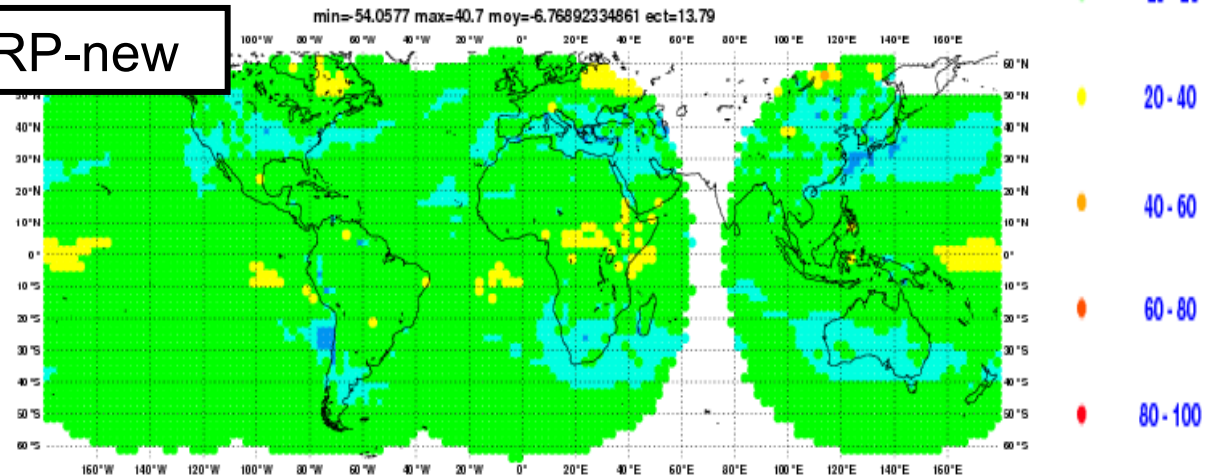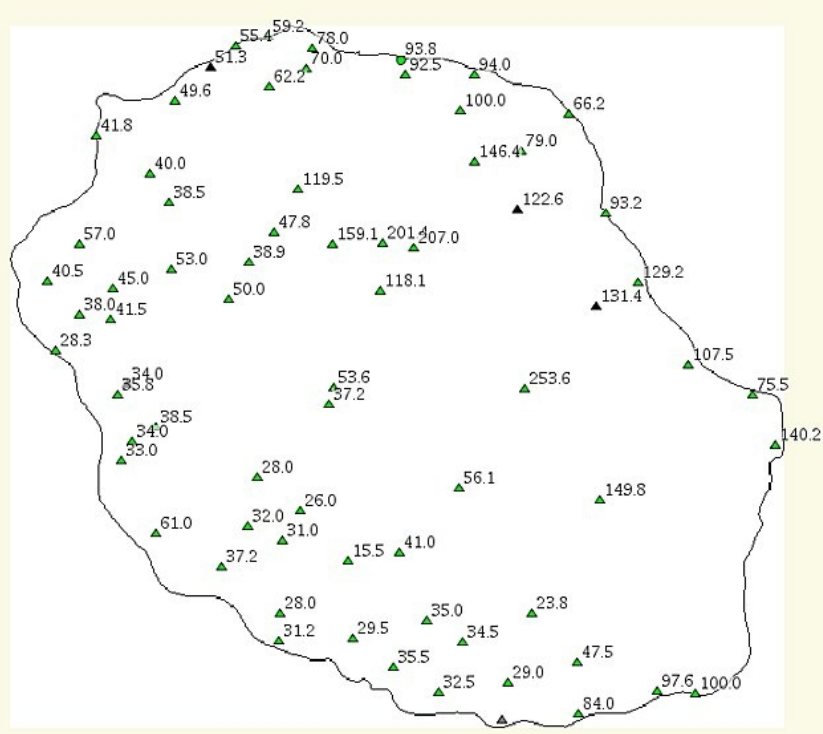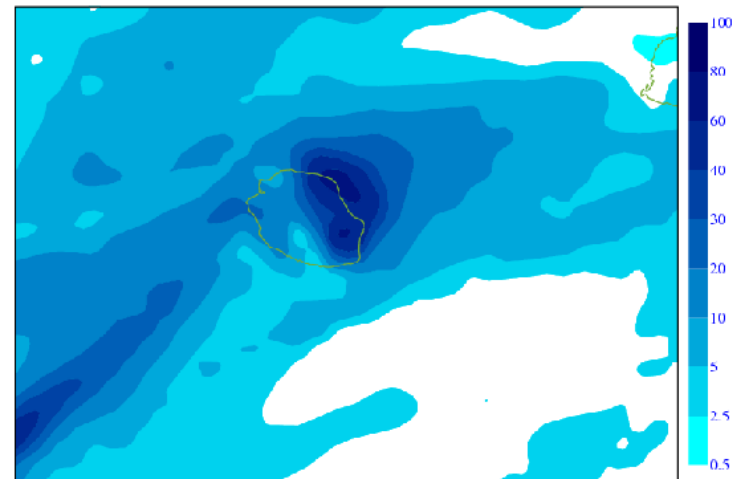
REFERENCE

CBR-KFE

New physics improve significantly precipitation forecasts over « la Réunion » (presently not enough precipitation over the island)
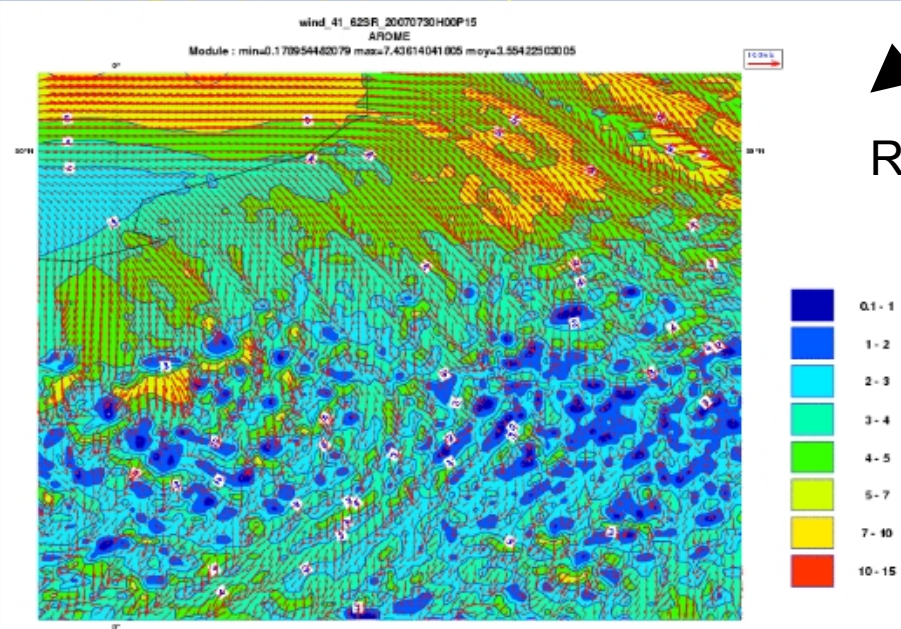
(G. Faure, CRC)

CENTRE NATIONAL
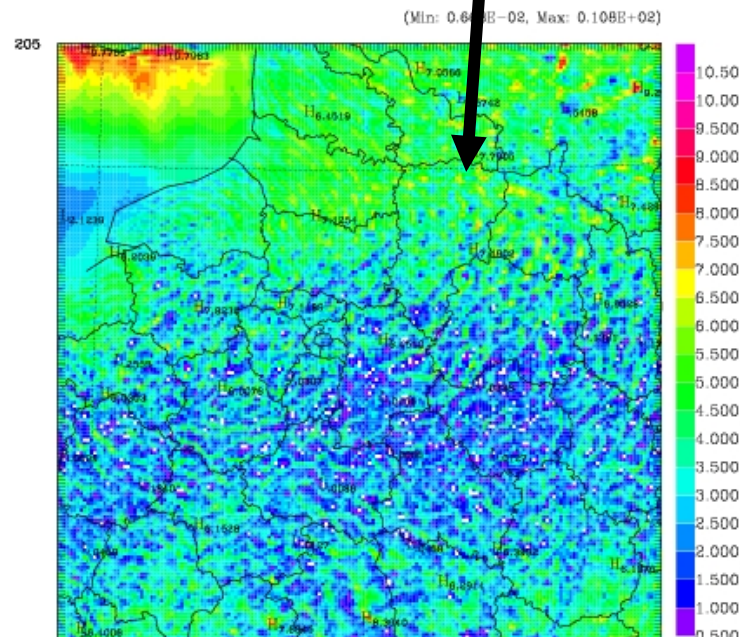DE LA RECHERCHE
SCIENTIFIQUE

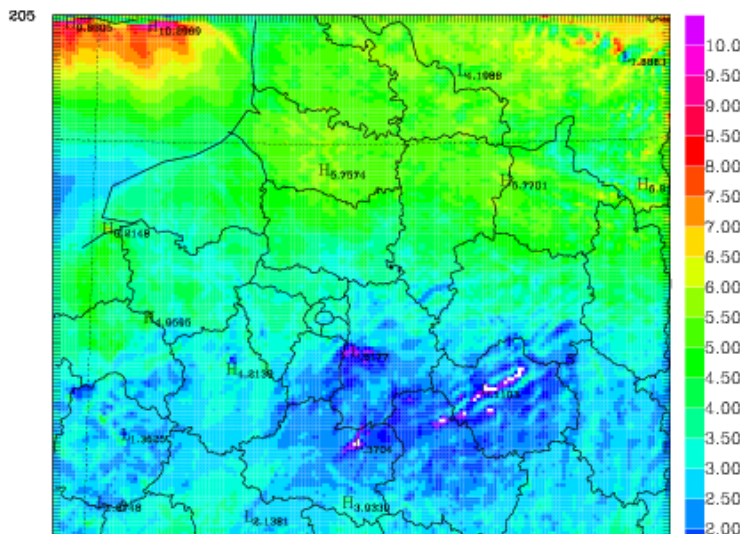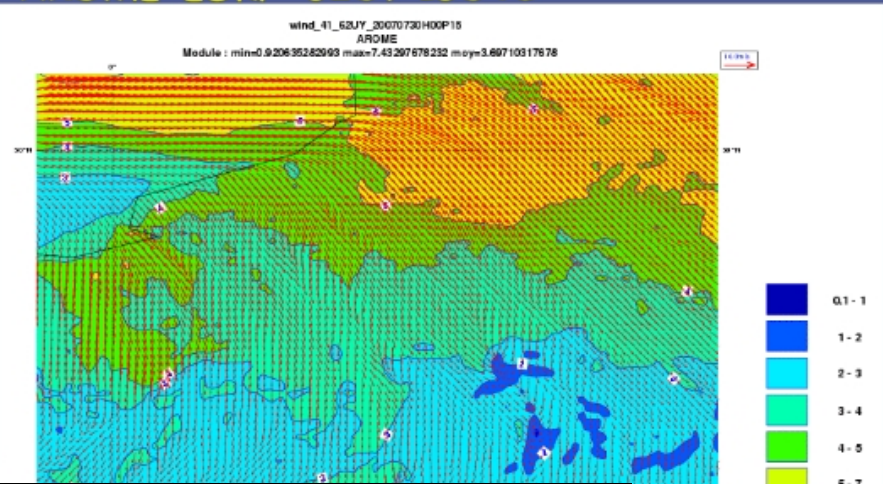# Another example, in AROME:
Impact of developing EDKF in AROME and Méso-NH

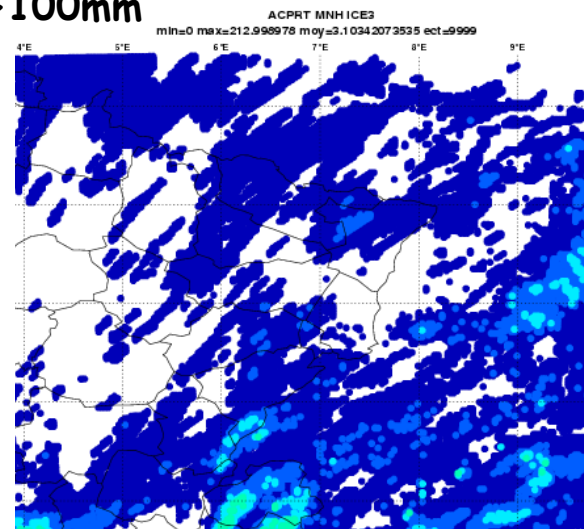AROME 62SR 15 UTC Ref
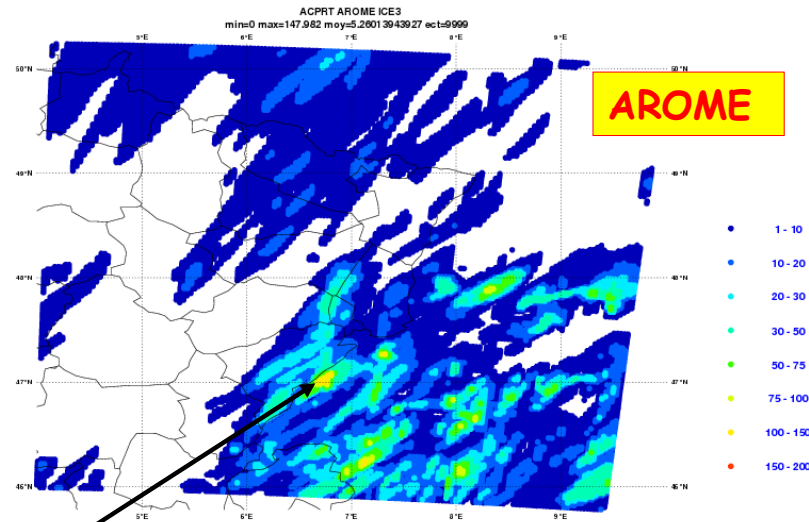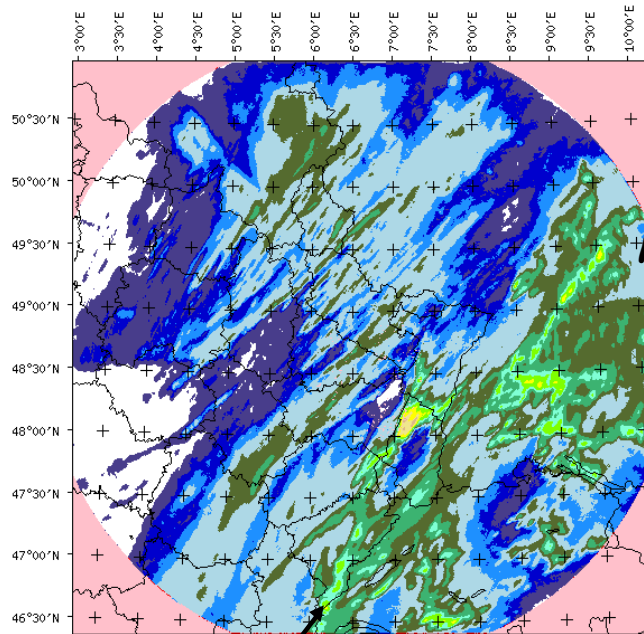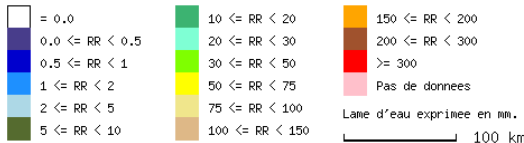
REF

AROME+EDKF 62UY 15UTC

Justification of the AROME-MesoNH physics strategy: using cross-validation for a precipitation forecast problem

It shows the problem lies in the interaction with the dynamics (currently being fixed using SLHD)

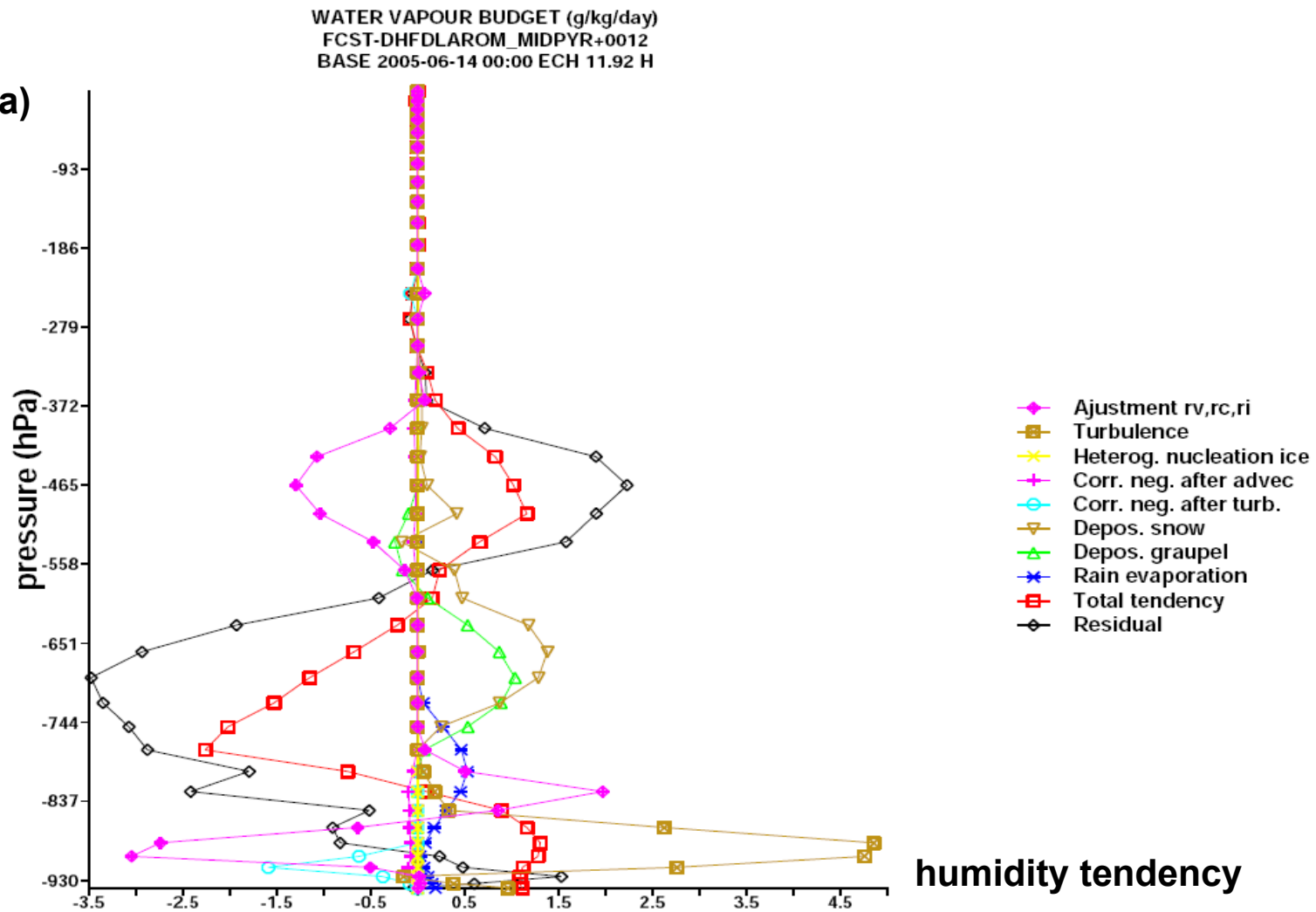# Opportunities for MF-ALADIN consortium cooperation in atmospheric physics

NB. This is just one of the consortium's activities, and it is difficult to unify

- **The physics/dynamics interface shall be modernised and cleaned**
  - see talk by F. Bouyssel
- Including the consortium's models in intercomparisons is useful for CNRM's research (*but using them operationally would be much more demanding*)
- **It would be helpful to improve the diagnostic tools:**
  - multimodel DDH with dynamical terms
  - diagnostic output of 3D fields
  - 1D model with GCSS cases
  - more elaborate tools needed (e.g. cloud simulators)
- **Study 3MT and transfer appropriate parts to ARPEGE/ALADIN-F:**
  - some work already done (aquaplanet, ALARO scores and case studies)
  - *need to adapt 3MT components* in order to plug them into ARPEGE/ALADIN-MF
  - *an MF priority in 2009*
  - (interfacing 3MT with AROME looks much more difficult, current tests suggest a subgrid convection scheme in AROME is not a priority)
- Suggestions for algorithmic changes (e.g. MAPFI) are welcome if they can be used in MF's models with reasonable effort e.g. subgrid precip should be optional in APLMPHYS.

example : CNRM development for common diagnostic tools

AROME column water vapour budget, DDH-style (J.-M. Piriou, O. Rivière)
see presentation by O. Rivière.

WATER VAPOUR BUDGET (g/kg/day)
FCST-DHFDLAROM_MIDPYR+0012
BASE 2005-06-14 00:00 ECH 11.92 H

Altitude (hPa)

humidity tendency

Conclusion

*We need to distribute the effort over many scientific questions
that affect our NWP performance.*

SYNTHESE

|	Arpege Aladin PNT Standard	Arpege / Aladin Climat Standard	Arpege / Aladin PNT + Climat
Coeff K diffusion	Louis 79	TKE-2.0 / Mellor -Yamada 82	CBR-2000 (1/2 niveaux …2008) (avec CCH02) + *PBL-entrain.*
Longueur de Mélange	Int. HCLA Troen & Mahrt	Profil cubique Troen & Mahrt	BL89 (1/2 niveaux)
Shallow Convection	Modified Ri Geleyn 87	via the moist TKE-2.0 + PDF's	*Meso NH* : KF-Bechtold (2001)
Nuages	Smith (90) PDF triangulaires	PDF / F_0, F_1, F_2 Bougeault (82)	PDF' : Gauss/Exp. (F_0,F_1,F_2) Bougeault (1982)
Micro-Phys + Précip.	Lopez / modifié (q_l,q_i,q_r,q_s) (02)	Kessler + Smith (90)	Bulk Lopez / modifié (q_l,q_i,q_r,q_s) (2002 … 2008)
Deep Convection	Bougeault (85) / Gerard (… 99)	Bougeault 85 (figé V3=cycle-18)	Bougeault/Gerard (1985/1999) + bridée Bazile (2008)
Rayonnement	ECMWF-RRTM	ECMWF – FMR15	*ECMWF* : SW(2/6) + RRTM

Suggestion for a new validation tool: satellite cloudiness

- an objective scoring method
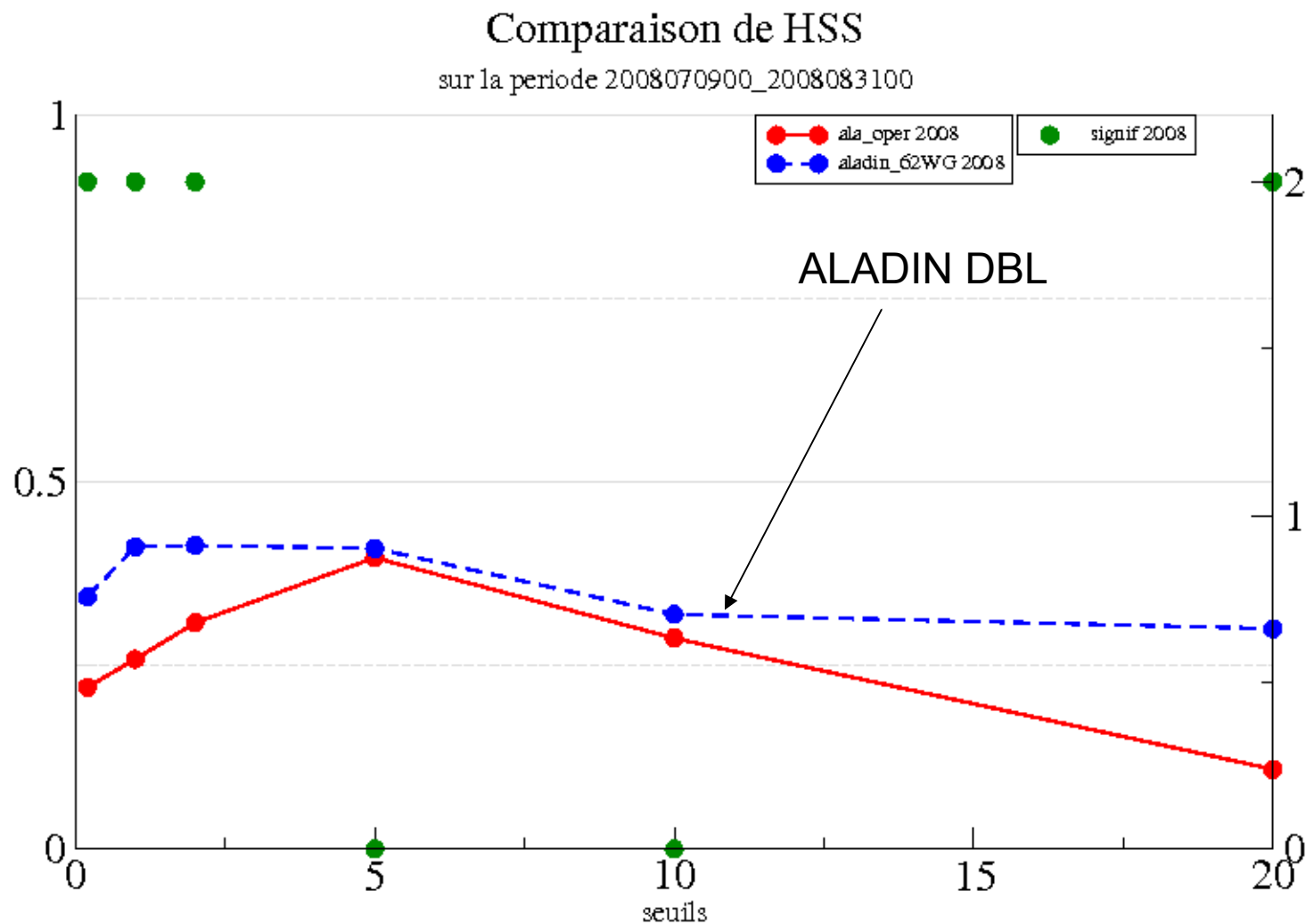- scale- and threshold- dependencies need to be taken into account

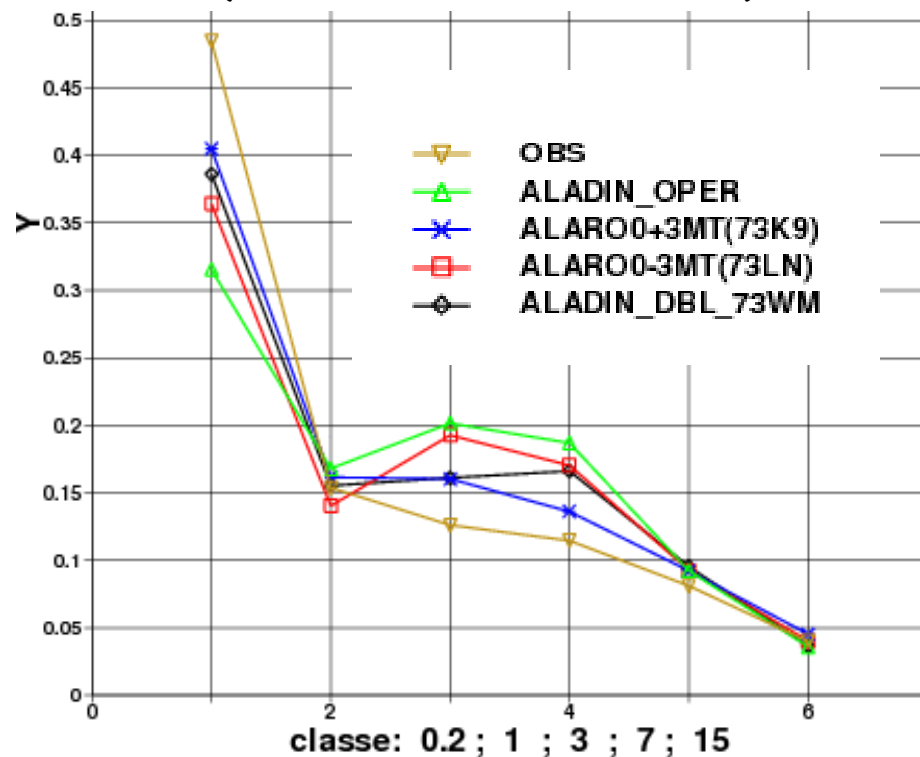## Arome IR10.8 forecast

MSG IR10.8 image

ALADIN convergence workshop, Toulouse, Sept 2008
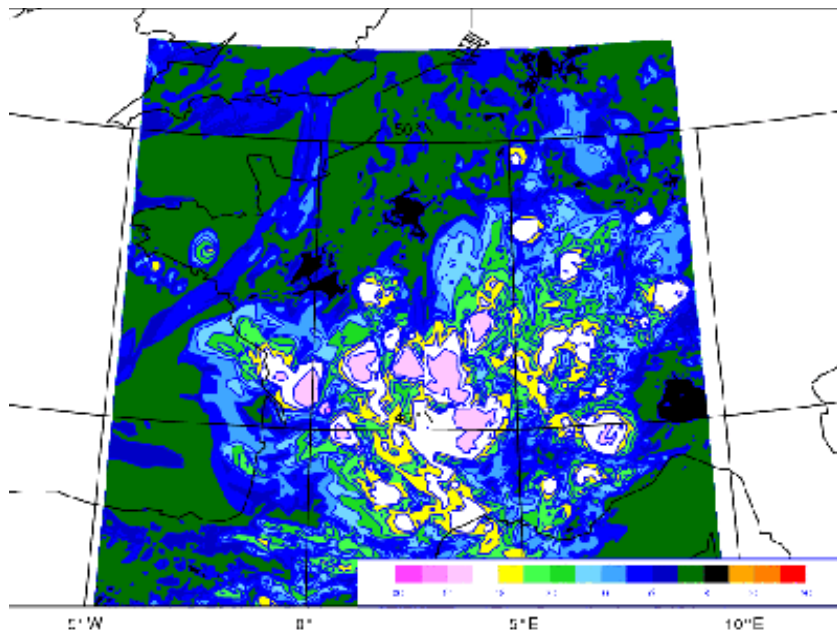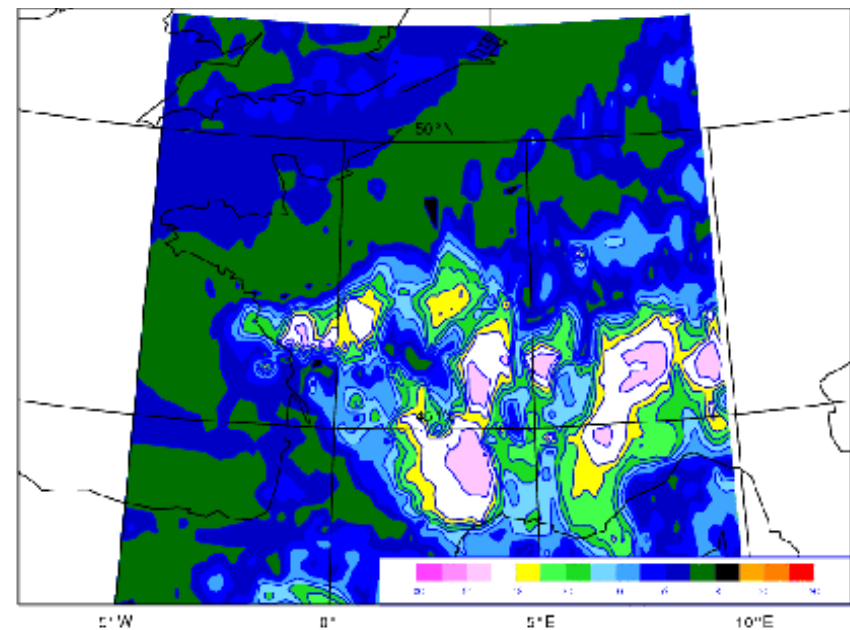
Examples of recent MF NWP improvements

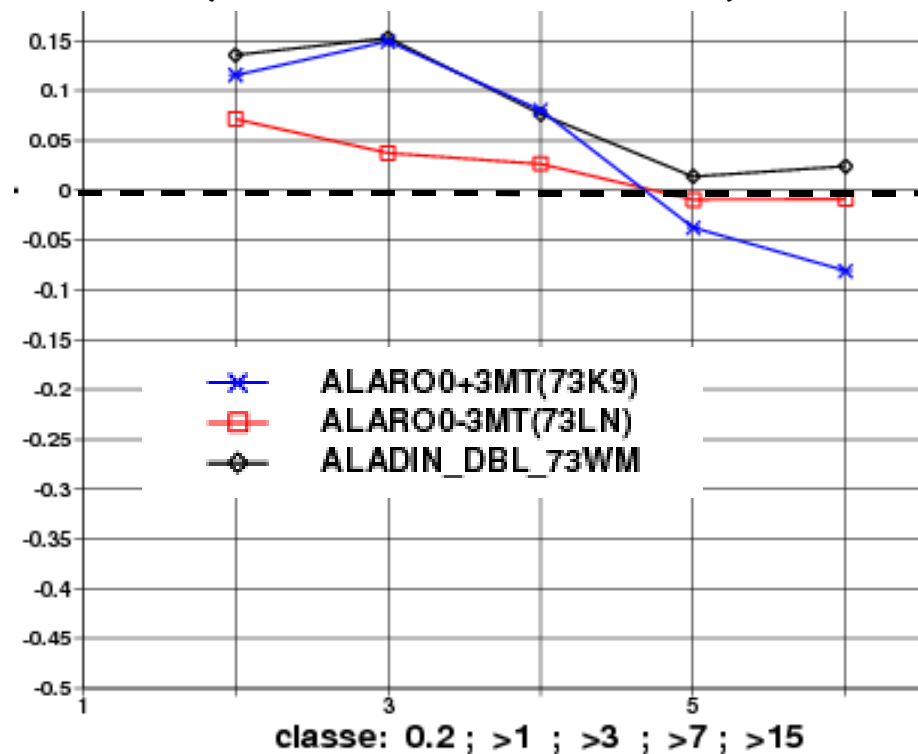ALADIN convergence workshop, Toulouse, Sept 2008

Cumulated precipitation on 24h (06TU-30TU) over France from the climatological observation network

Runs at 9.5km resolution over ALADIN-France domain

Histogramm computed on a 0.25° grid (June and November 2007)

Legend:
- OBS
- ALADIN_OPER
- ALARO0+3MT(73K9)
- ALARO0-3MT(73LN)
- ALADIN_DBL_73WM

classe: 0.2 ; 1 ; 3 ; 7; 15

HSS computed on a 0.25° grid (June and November 2007)

Legend:
- ALARO0+3MT(73K9)
- ALARO0-3MT(73LN)
- ALADIN_DBL_73WM

classe: 0.2 ; >1 ; >3 ; >7 ; >15

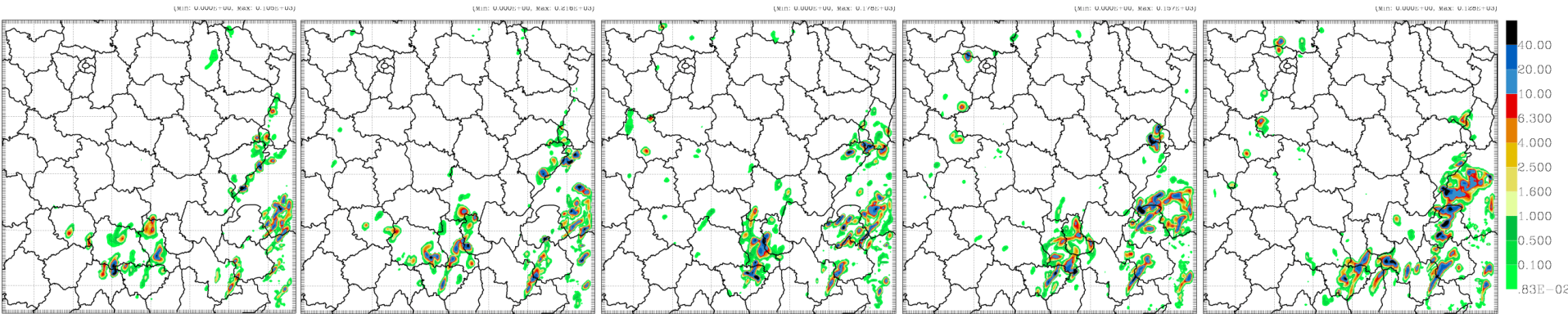ALARO-3MT and ALADIN-oper have similar precipitation scores
« 3MT » improves precipitation scores in ALARO
« CBR » + « KFB » improve precipitation scores in a similar way in ALADIN_dbl
We may expect that the combination of « CBR » + « KFB » + « 3MT » will be better

CENTRE NATIONAL
DE LA RECHERCHE
SCIENTIFIQUE

Case of 20-06-2007 (RR Inst. (INPRR))

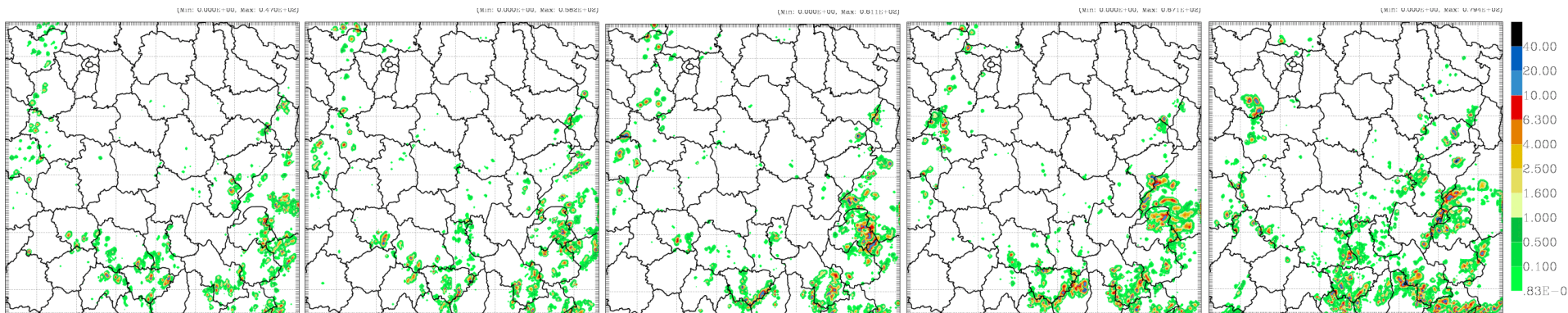## AROME-NH (dt=60s)

15 TU　　　**16 TU**　　　**17 TU**　　　**18 TU**　　　**19 TU**

Meso-NH

The cells are more intense & give more rain in Arome. Why ? still under investigation as Some medecine is applied in between (slhd on qcrigs)