Recent progress and plans in ARPEGE and AROME Météo-France physics

Y. Seity (Météo-France CNRM/GMAP)
And many colleagues from GMAP/GMME

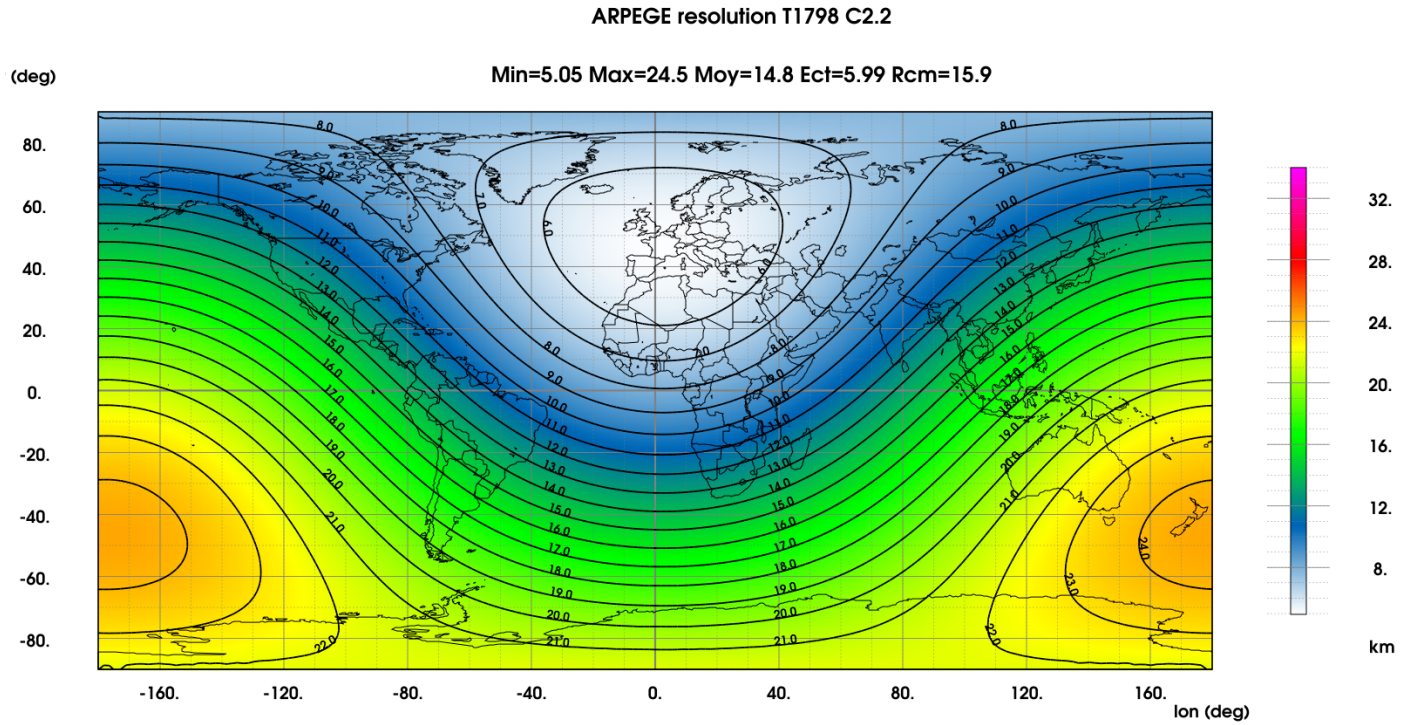
EWGLAM/SRNWP Meeting, October 2018, Salzbourg

Outline

1. ARPEGE e-suite
2. AROME e-suite
3. Ongoing work in ARPEGE
4. Ongoing work in AROME
5. Outlooks

METEO FRANCE

Improvement of ARPEGE resolution : Min 5 km – Mean 11 km – Max 24 km

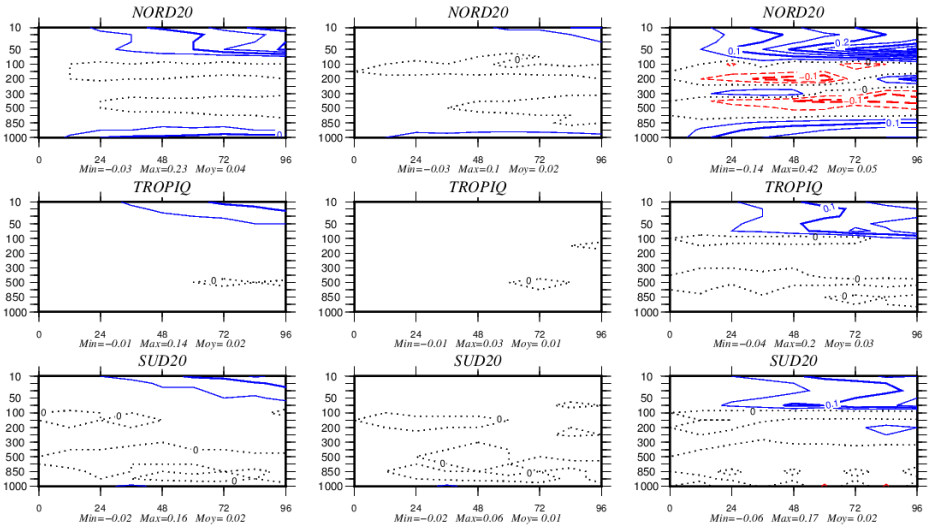


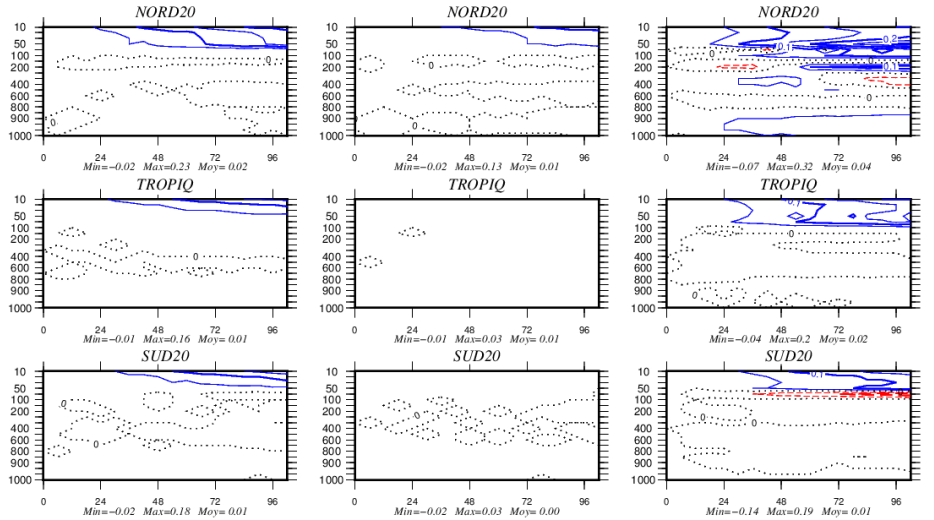
- To be oper in the beginning of 2019 containing :
  → surfex v8
  → tunings in the dynamics
  → tunings of anti- Gridpoint Storms scheme (in the convection scheme)
  → new diagnostics

Dynamics tunings

- Increase numerical diffusion on wind in the stratosphere
- Remove numerical duffusion on T and qv
- 3 → 4 iterations in Semi Lagrangian origin point calculations.

Temerature Scores (T1798c2.2L105)
(01/01/17 → 28/02/17)



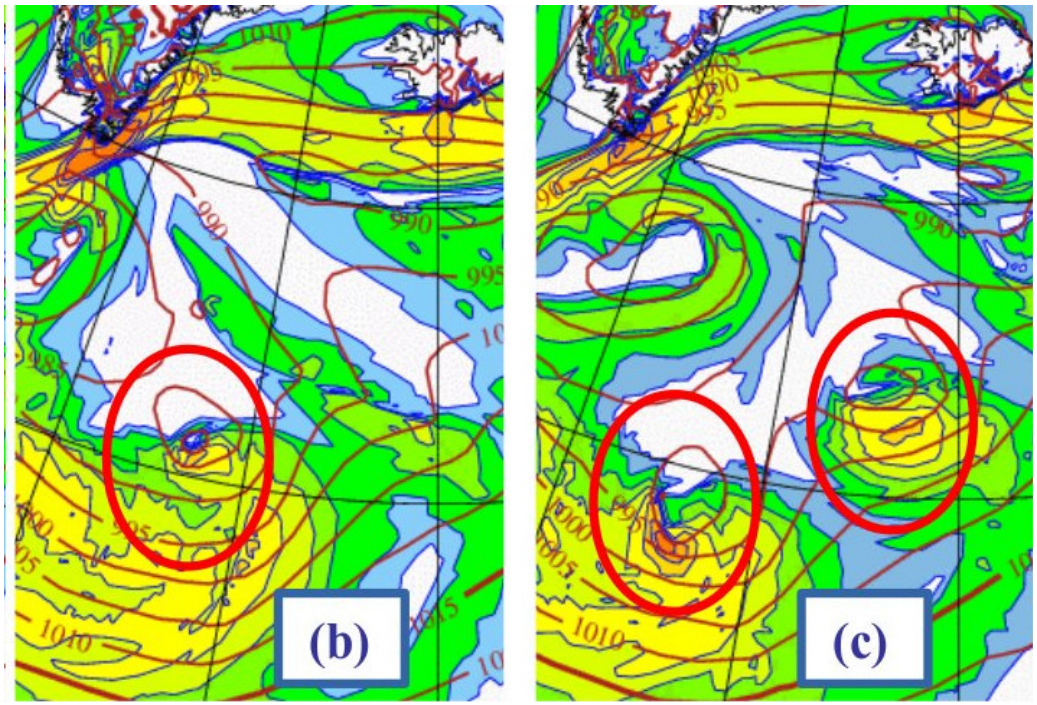


Anti- gridpoint storms tuning

MSLP and V10m :

Oper T1200 :

T1800 :



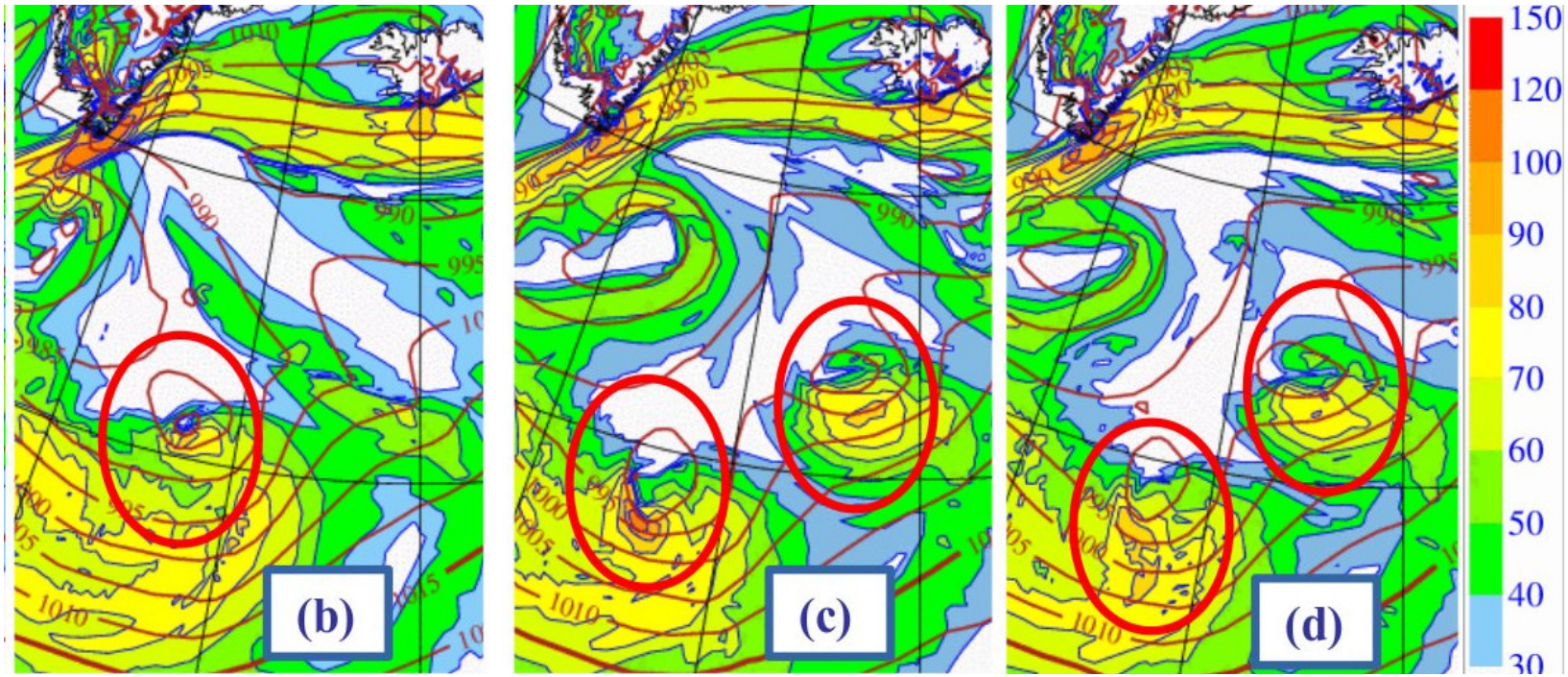
- Mandatory in order to reduce gridpoint storms intensity and number

From Pascal Marquet

Anti- gridpoint storms tuning

MSLP and V10m :

Oper T1200 : | T1800 : | reTuned T1800 :



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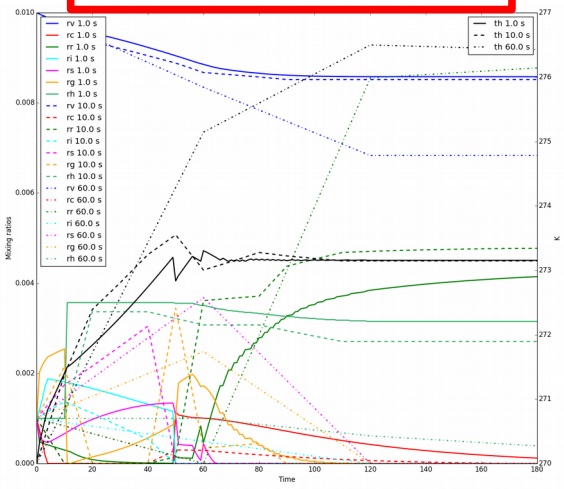
Modified ICE3

Oper dt=1,10.,60s



From Sébastien Riette

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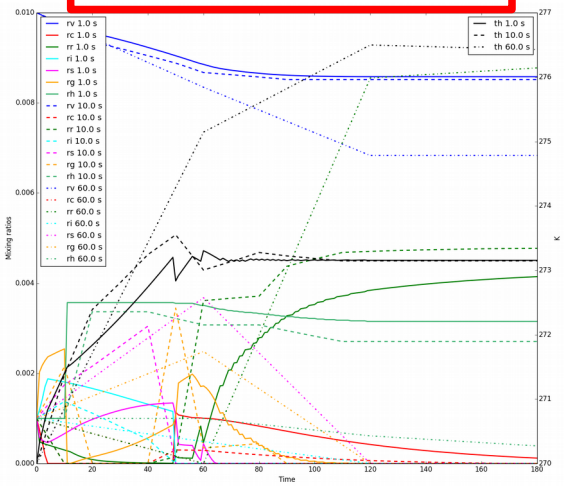
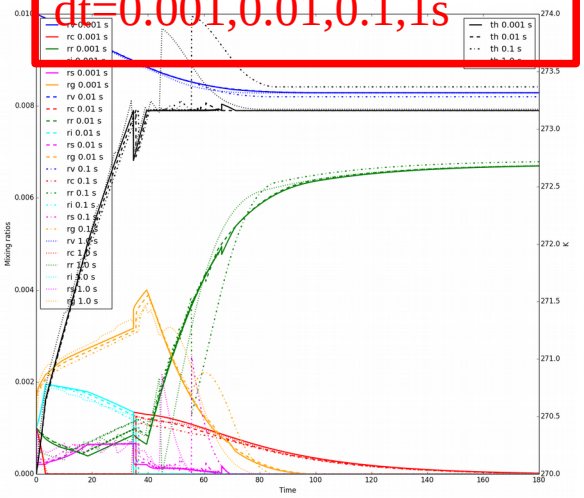


Oper dt=0.001,0.01,0.1,1s



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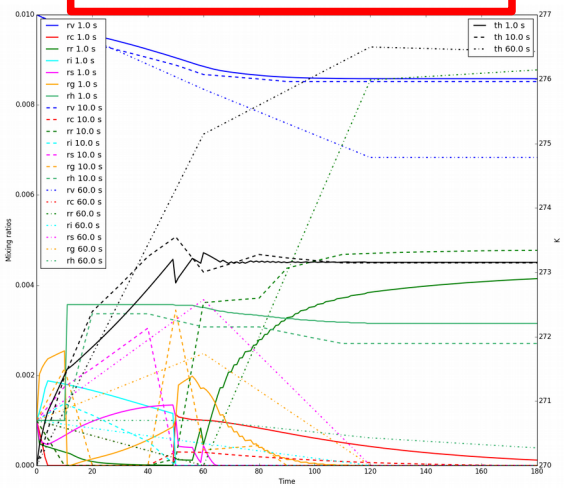
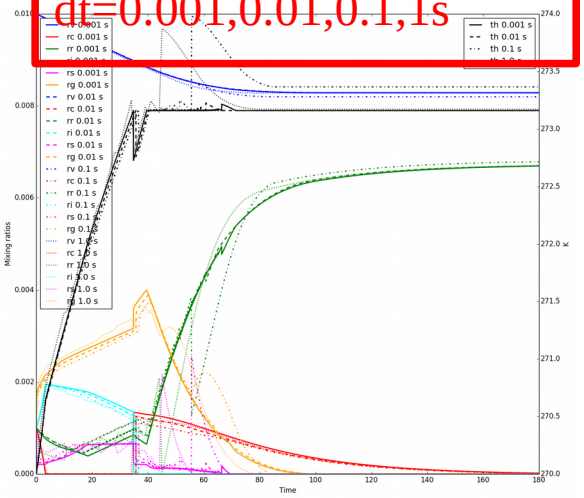
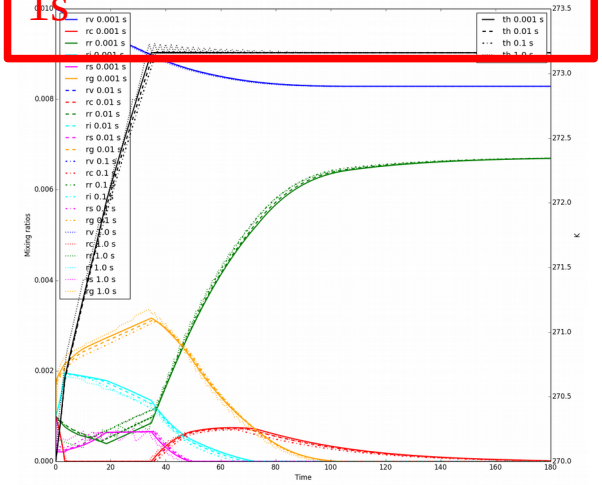


- Heat budget in order to stop processes when impact on T should stop it.
- Example : melting when latent heat release → T < 0°C
- ~ 10 processes concerned
- Revised graupel growth mode
- On read 3D cases → less graupel and more snow

Oper dt=0.001,0.01,0.1,1s



43t2_op :dt=0.001,0.01,0.1,1s



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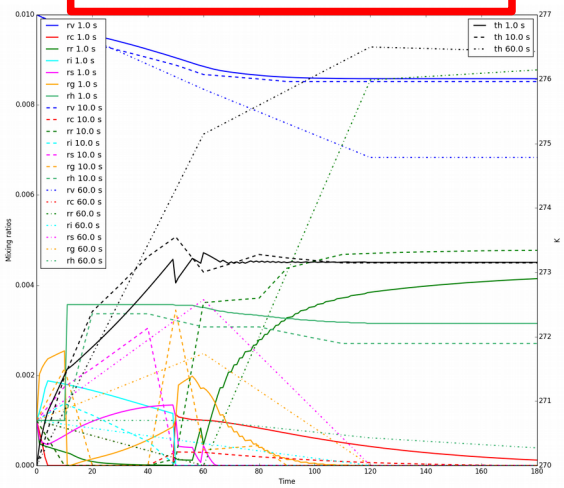

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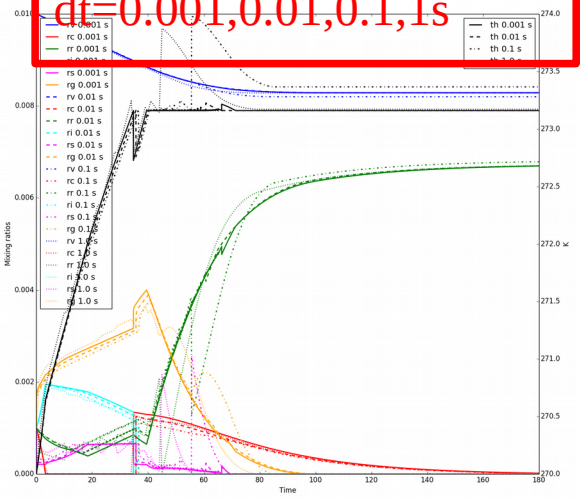

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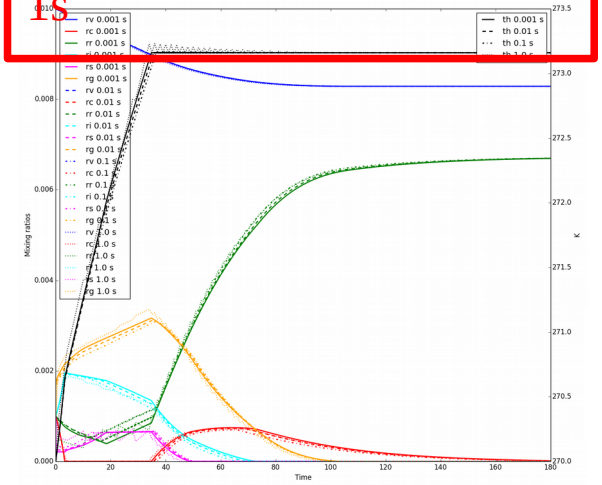
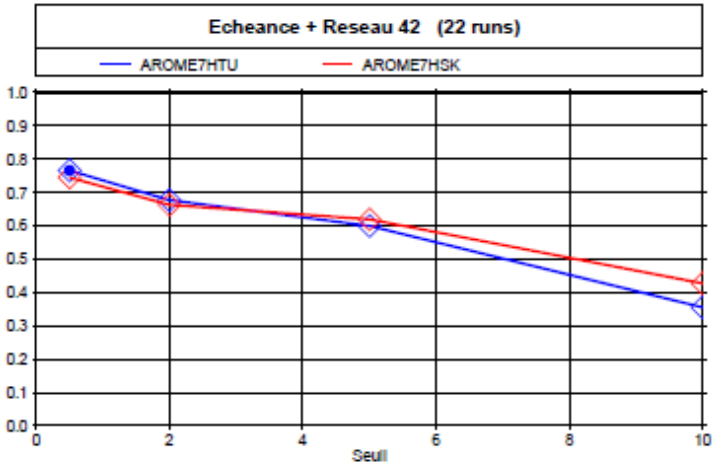


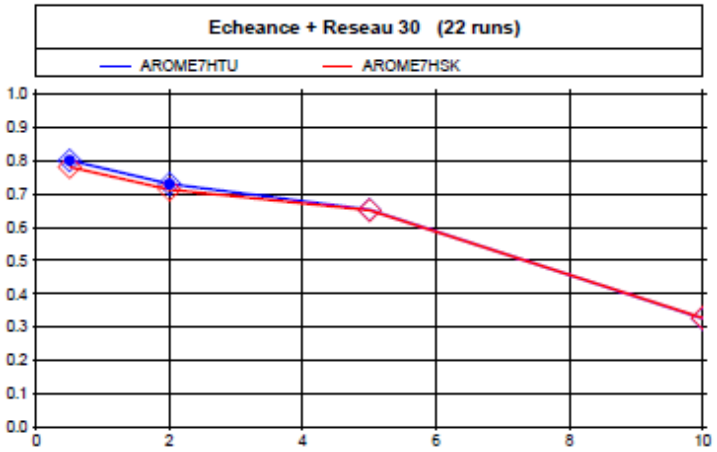
From Sébastien Riette

Evaluation ICE3-new (BSS scores RR6):

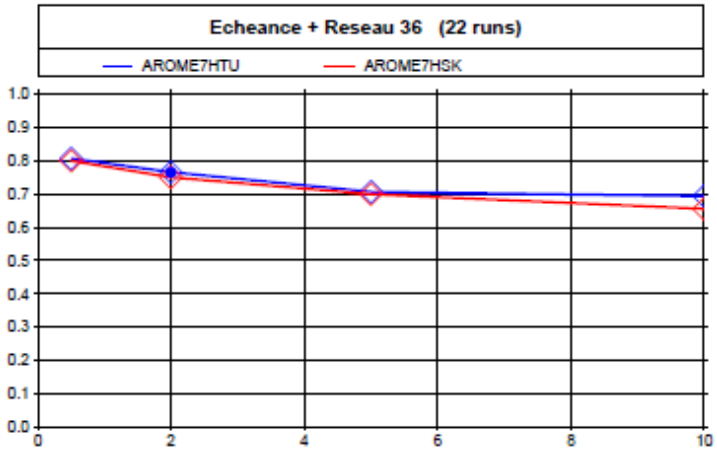


ICE3MOD OPER

- 3DVAR experiments February 2018
- Improvements for small rain tresholds



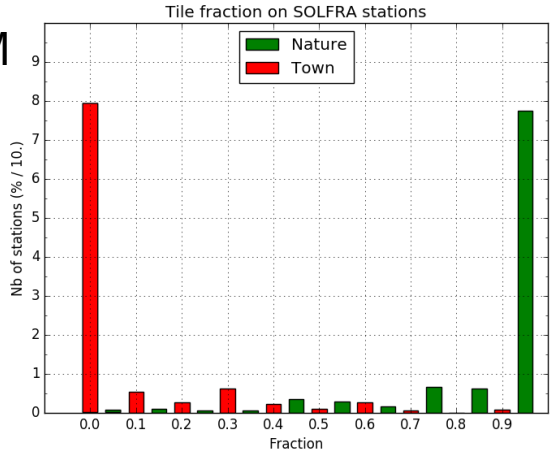
mm/6h



mm/6h

Surface :

- Tunings of some parameters + T2M_Nature instead of T2M
- → warmer and dryer soil after 3 weeks of 3DVAR
- → reduces Latent/Sensible heat flux bias



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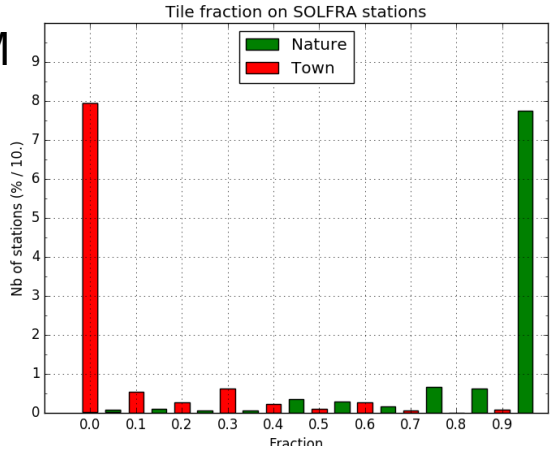
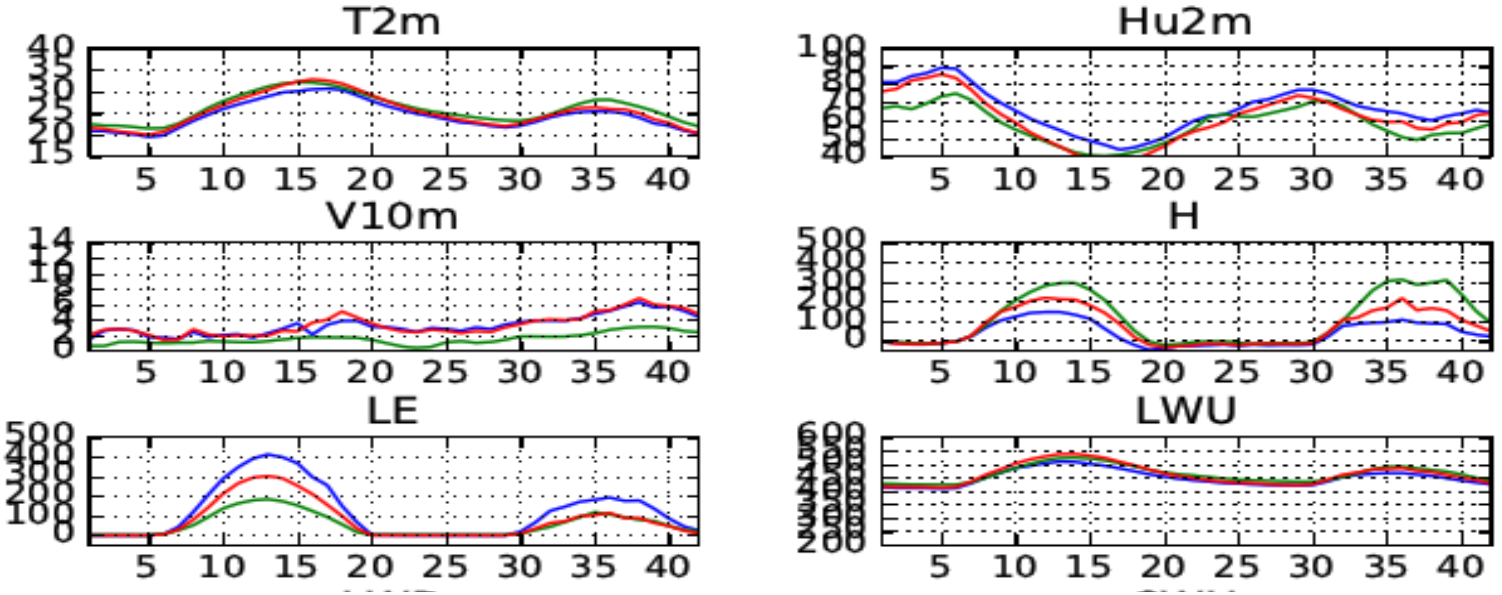
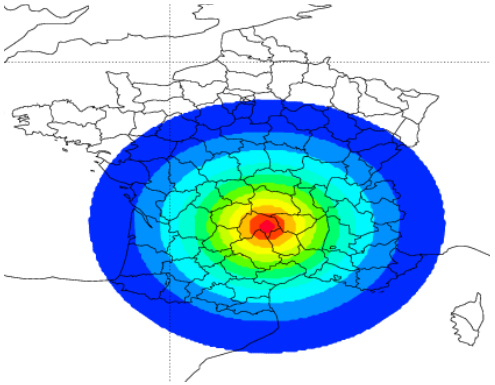


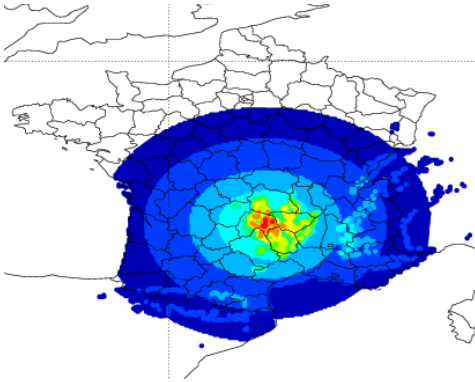


After 51 days of 3DVAR, clear sky day over Toulouse (August 4th 2017)
ARPEGE / AROME-OPER / EXP

Surface :

- Modification of structure functions in surface analyses (MESCAN)
- More realistic over orography





(Images from A. Mary)

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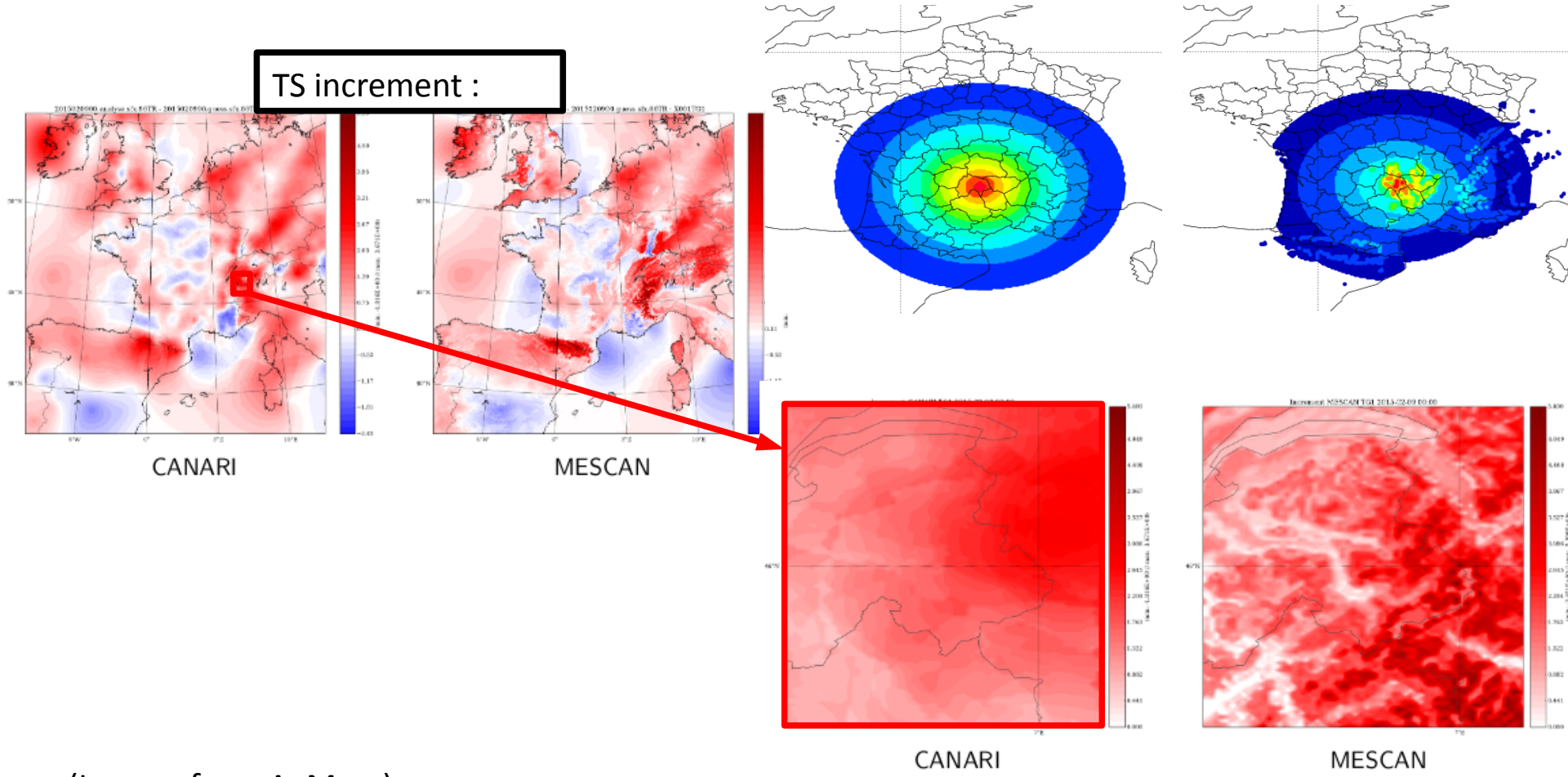
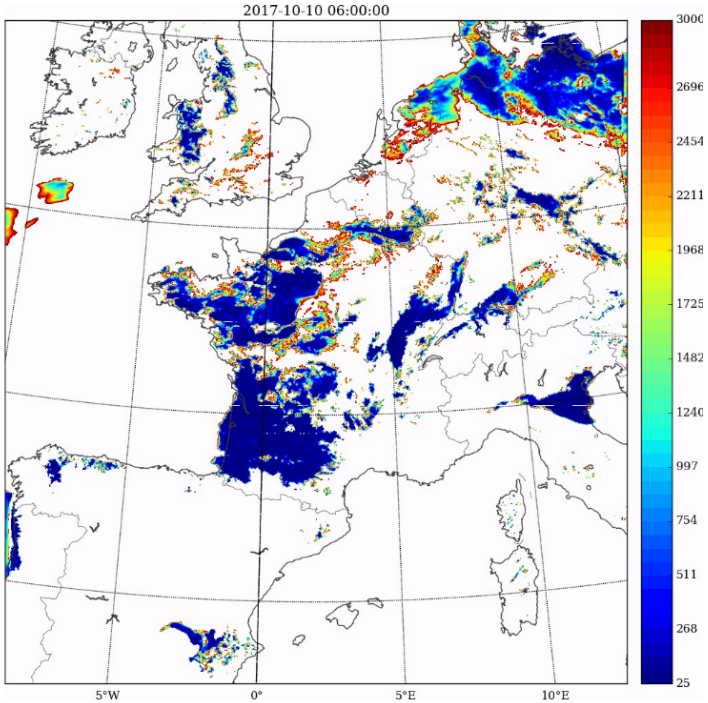


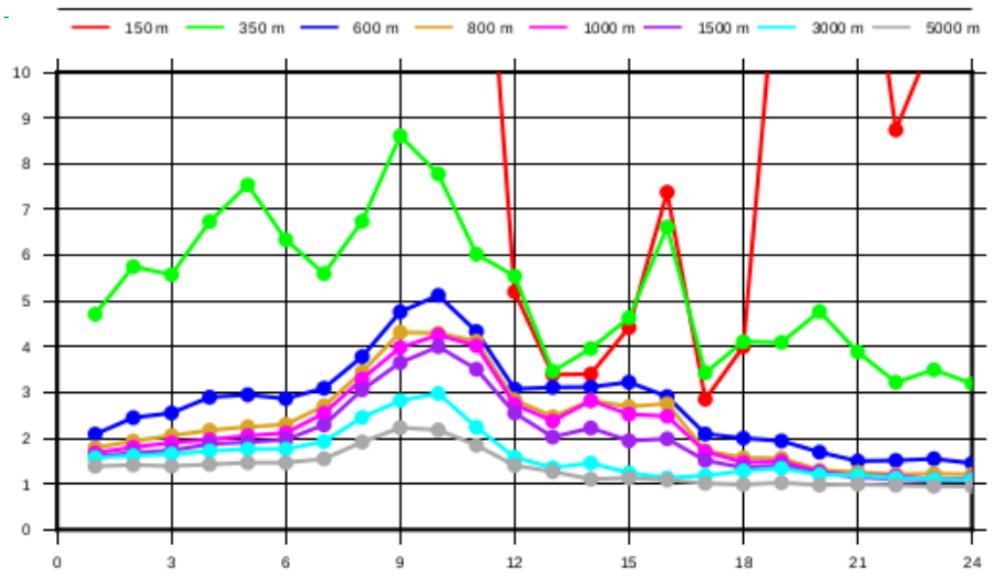
(Images from A. Mary)

Visibility

- Kunkel type formulations with separate Clouds and precipitations (as in Niemelä 2014)
- Calculated every dt → in output files : min over a period
- Ongoing calibration/tuning

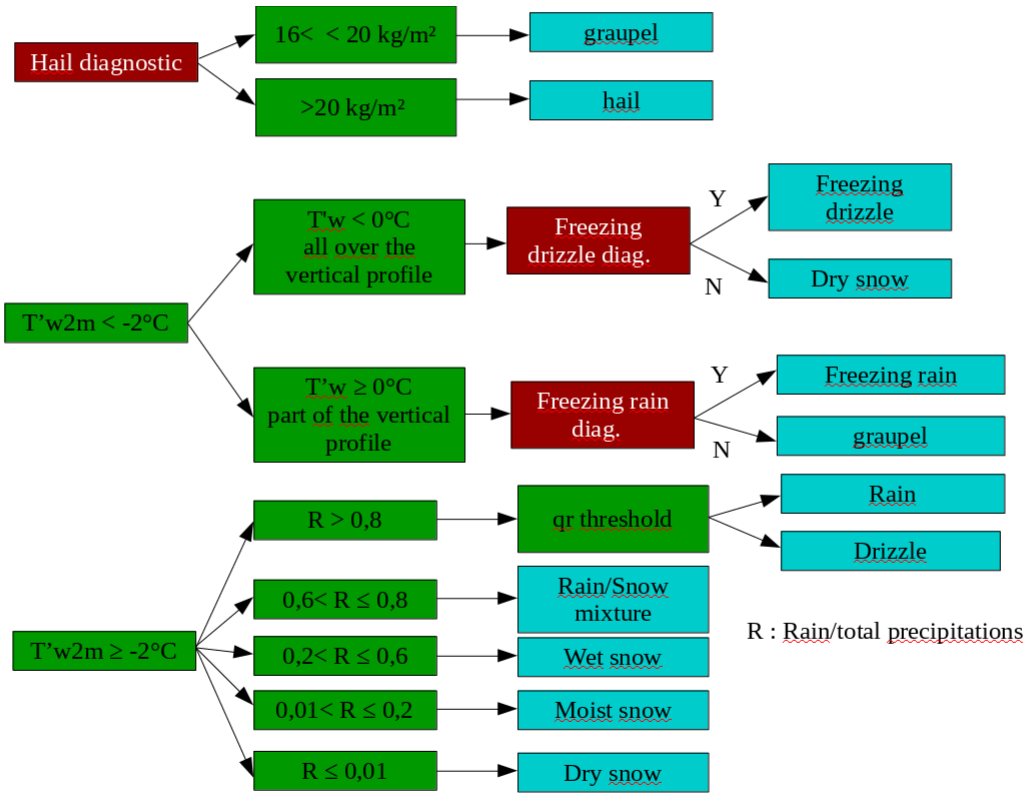


Sept. to Nov. 2017 Bias compared with 138 obs over France :



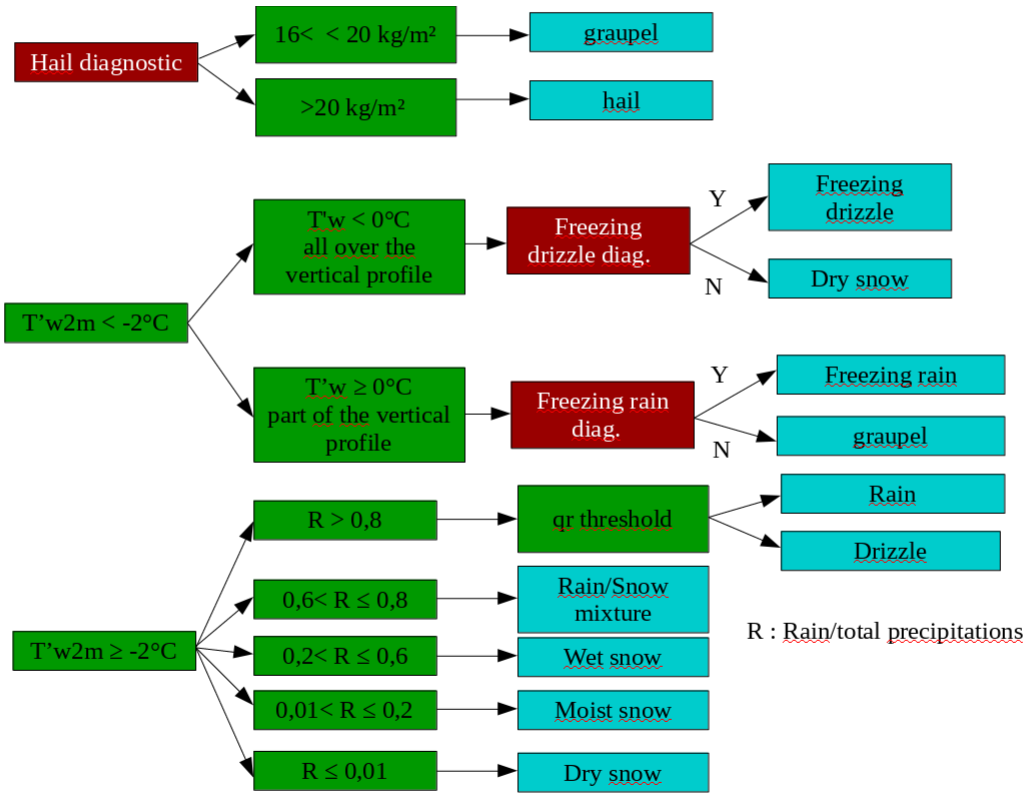
From I. Sanchez

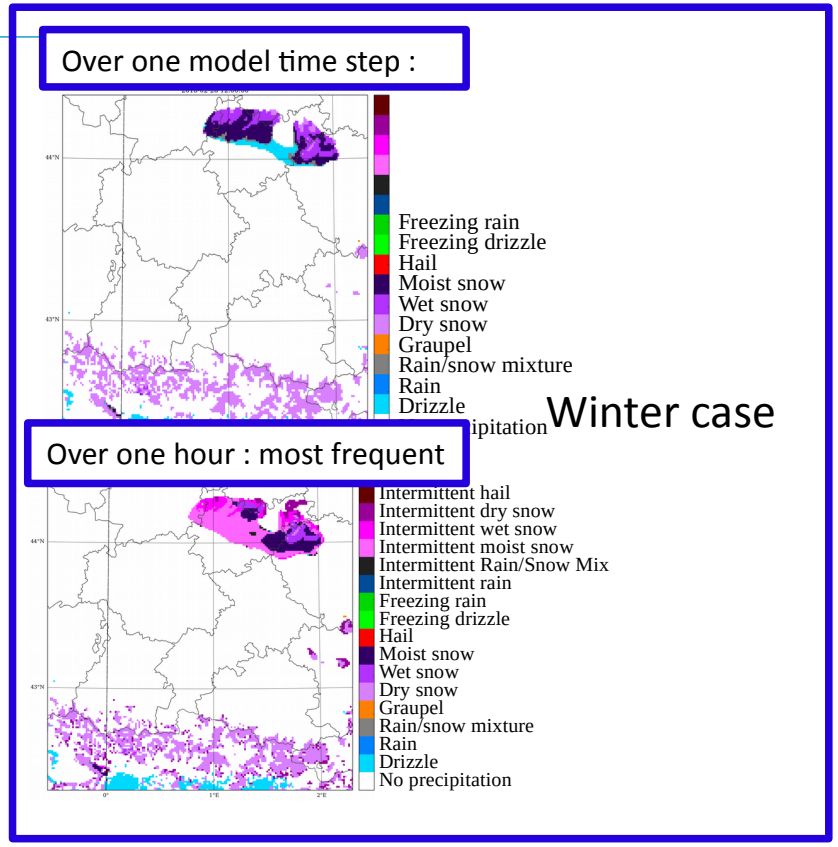
Surface precipitation type diagnostic :



- Adapted from IFS and Radar diagnostics
- Computed each model time step
- Most frequent and most dangerous types in output

Surface precipitation type diagnostic :





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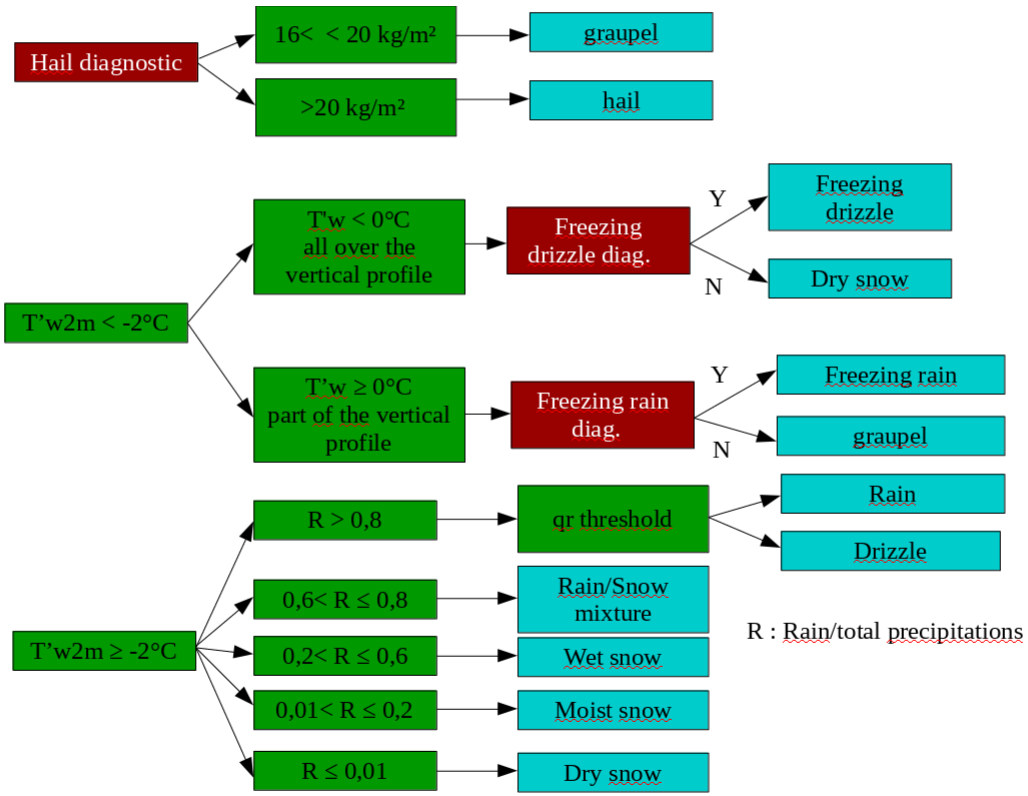

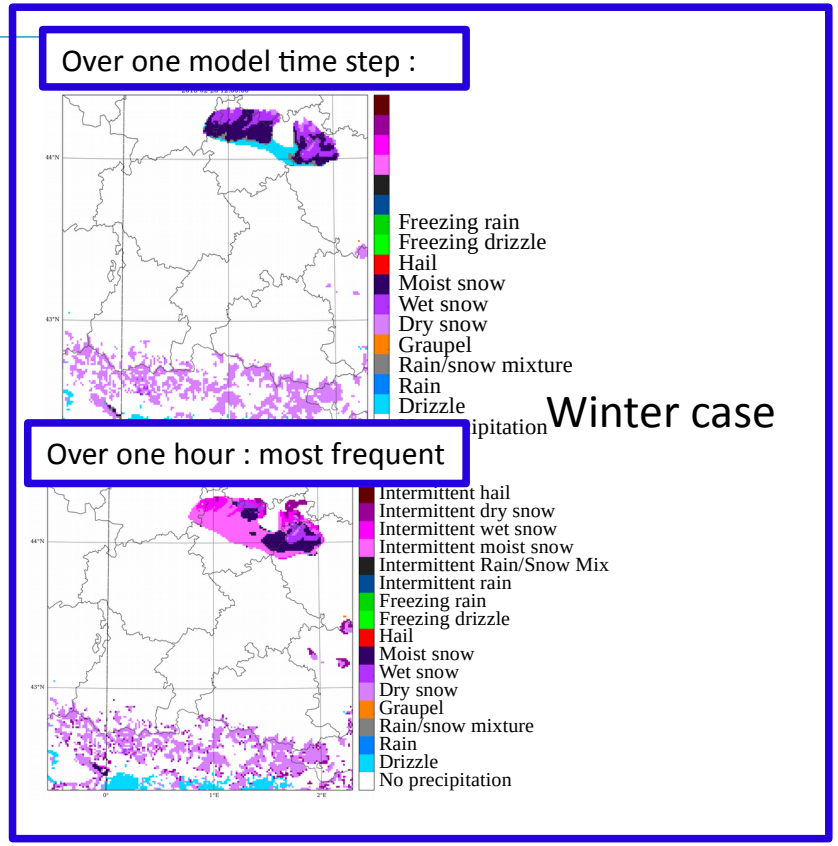

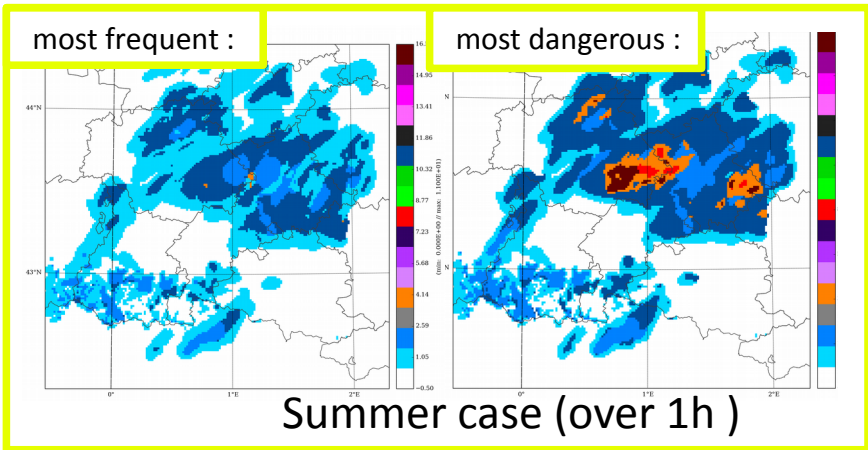

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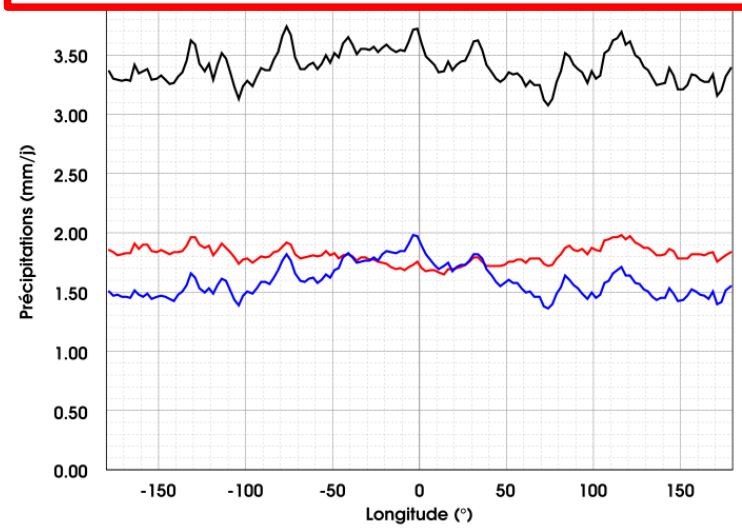
Ongoing work in ARPEGE physics :

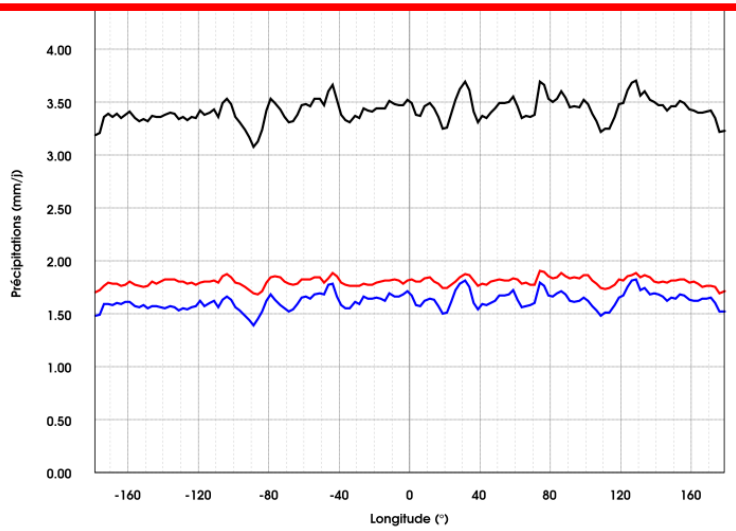
→ tests of convection parametrisation on idealized water planet

Intertropical rainfalls (mm/day) with ARPEGE-oper convection max resolution at

0°LAT



45°LAT



TOTAL
RESOLVED
PARAMETRIZED

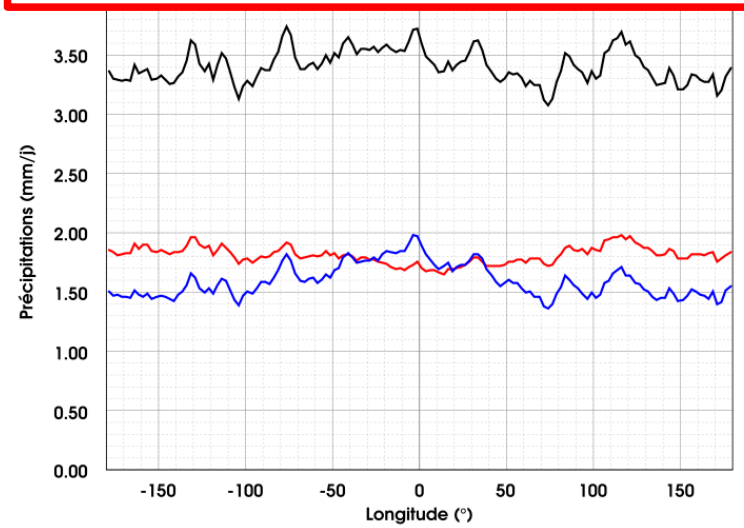
From Antoine Hubans

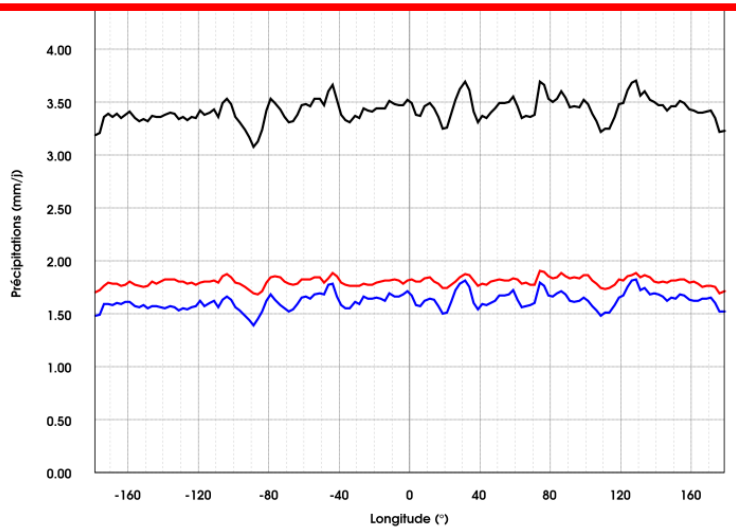
Ongoing work in ARPEGE physics :

→ tests of convection parametrisation on idealized water planet

Intertropical rainfalls (mm/day) with ARPEGE-oper convection max resolution at

0°LAT 45°LAT





TOTAL
RESOLVED
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→ tests of IFS convection scheme in ARPEGE

From Antoine Hubans

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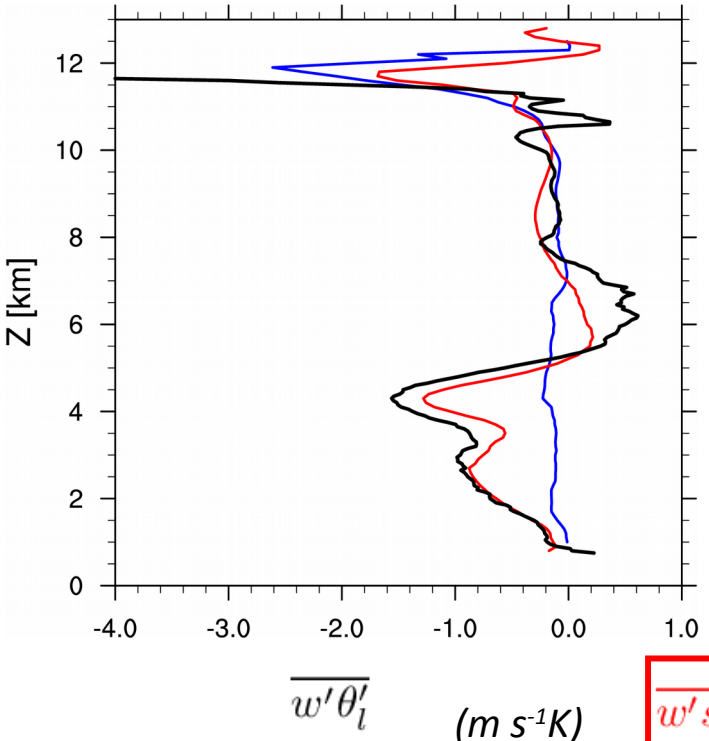
Turbulence parameterization: impact on deep convection

Evaluation on idealized simulations : LES ($\Delta x = 50$m) and 1-km grid spacing runs

Vertical profiles inside convective system t= 180 min



$\overline{w'\theta'_l}$ (m s^{-1}K)

REF (coarse-grained LES)

Kgrad (1km run)

(Cuxart et al 2000)

$$\overline{w's'} = -K\frac{\partial \overline{s}}{\partial z}$$

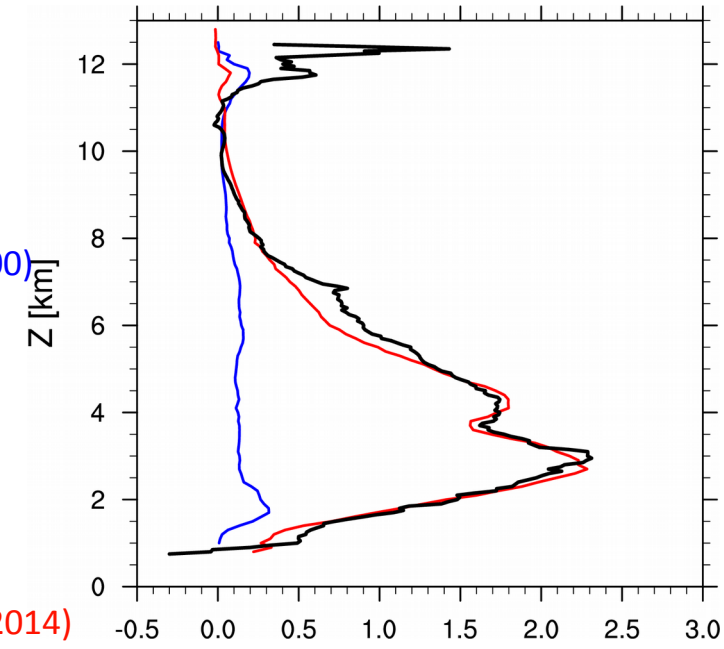
$$s = r_{np}, \theta_l$$

Hgrad (1km run)

(Moeng et al 2014)

$$\overline{w's'} = C\left(\frac{\partial \overline{w}}{\partial x}\frac{\partial \overline{s}}{\partial x} + \frac{\partial \overline{w}}{\partial y}\frac{\partial \overline{s}}{\partial y}\right)$$

$(C = 3\Delta x^2/12)$ $\quad s = r_{np}, \theta_l$



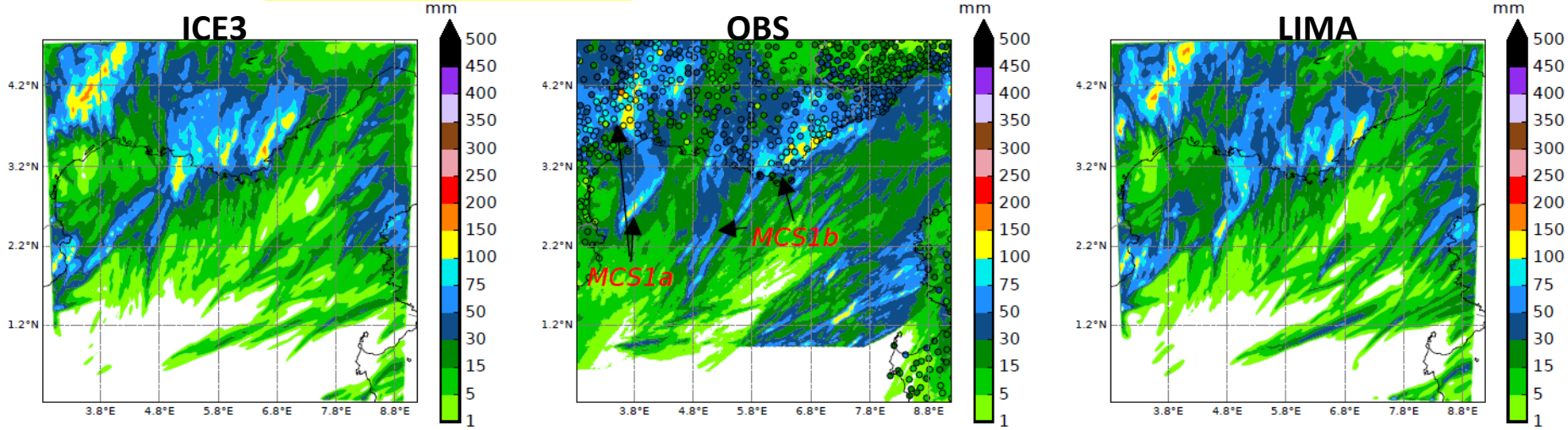
$\overline{w'r'_{np}}$ (m s^{-1}·g kg^{-1})

→ better representation of vertical turbulent fluxes with **Hgrad**
→ more subgrid TKE (more turbulent mixing)
→ less intense vertical velocity in updraft cores

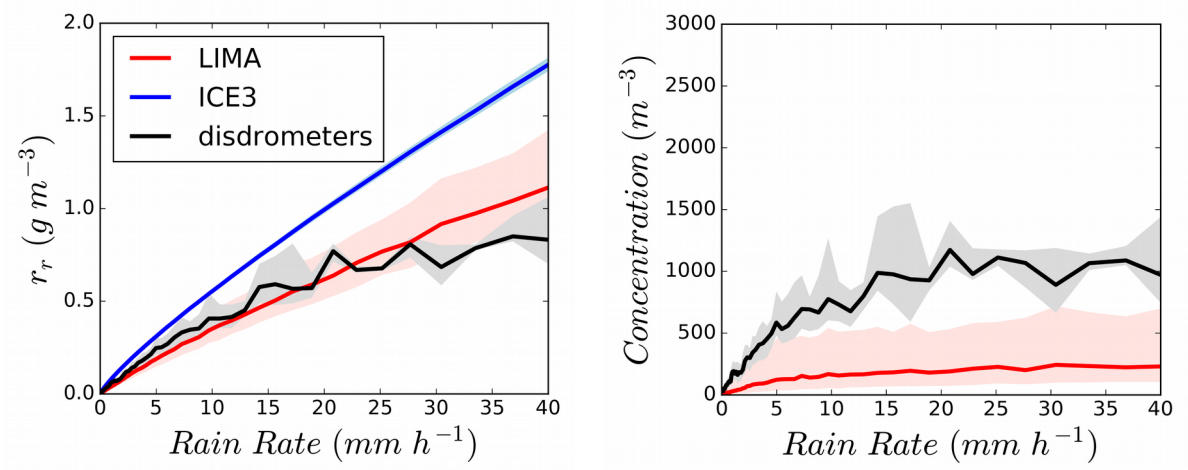
Verrelle A., Ricard D. et Lac C., MWR, 2017

4. Evaluation of LIMA from HyMeX IOP16

Ground precipitation



24-hour cumulative precipitation (mm) over Southeast France at 00 UTC on 27 October 2012



Observed (disdrometers) and simulated rain characteristics, HyMeX IOP 16, 2012/10/26

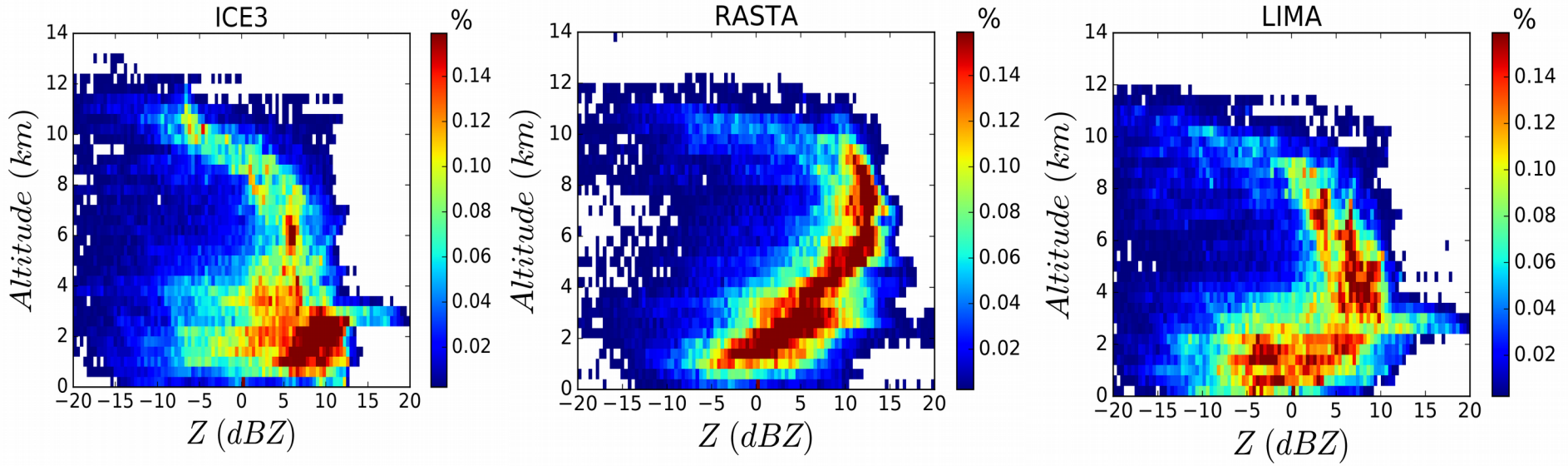
- Small positive impact on cumulative precipitation
- Better estimation of the RWC
- Concentration largely underestimated due to too many large raindrops

METEO FRANCE

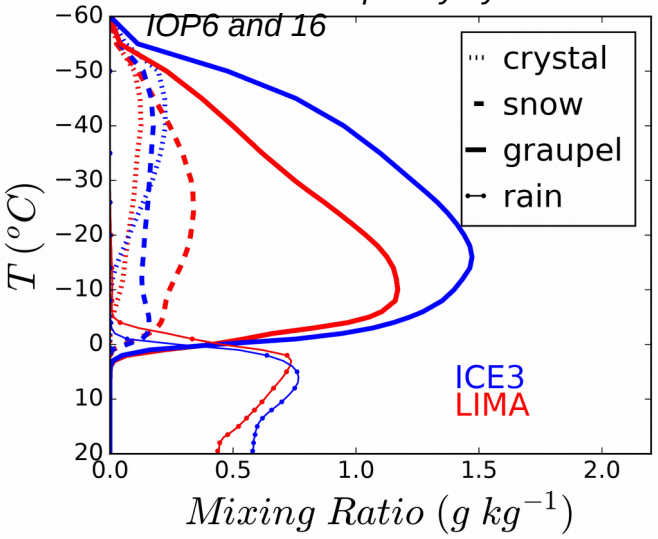
Taufour et al., 2018, QJRMS

4. Evaluation of LIMA from HyMeX

Cloud vertical structure



Contoured Frequency by Altitude Diagrams (CFAD) for the RASTA (Cloud Radar System Airborne) reflectivity for IOP6 and 16

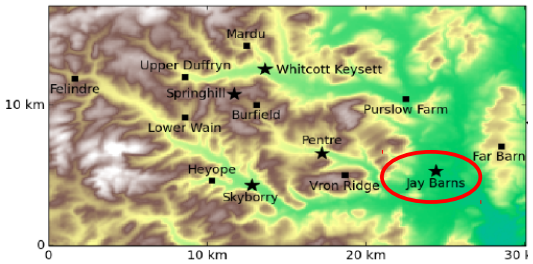


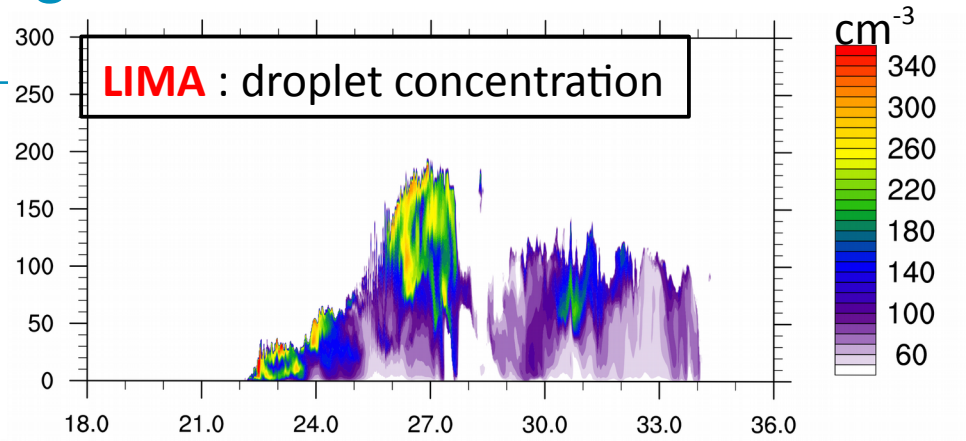
Mean vertical contents in the convective columns for IOP6

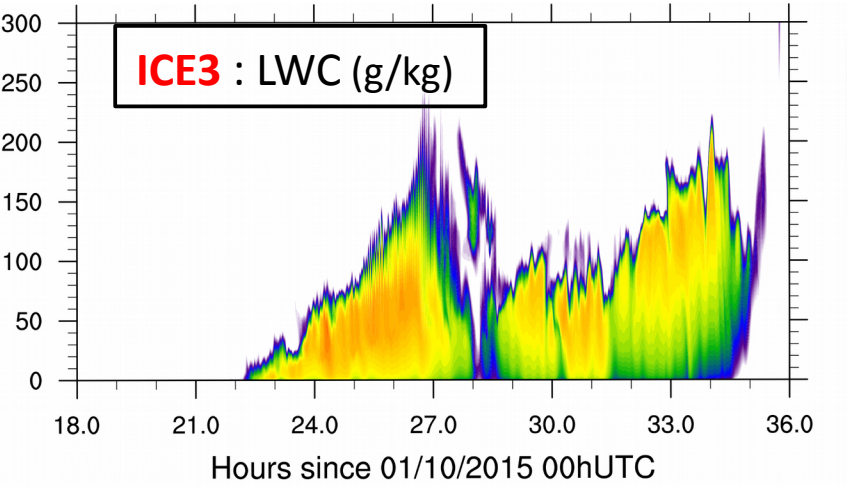
- CFAD : Better comma shape around 3km : better transition beween liquid water and ice
- Better estimation of the cloud top
- LIMA decreases graupel content and increases snow

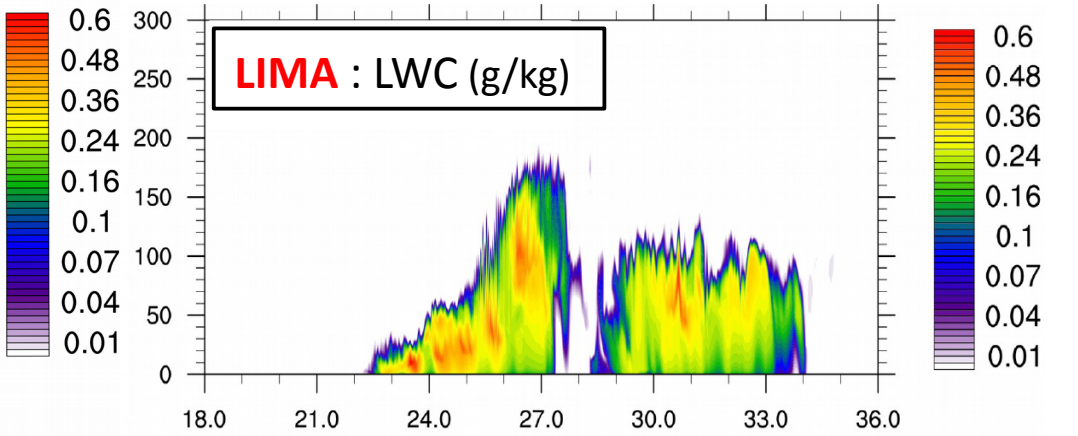
Taufour et al., 2018, QJRMS

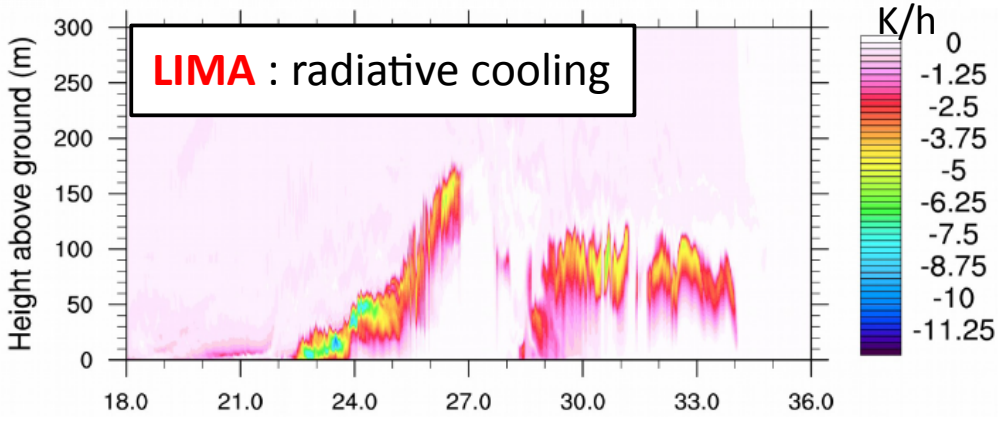
4. Evaluation of LIMA on fog : LANFEX











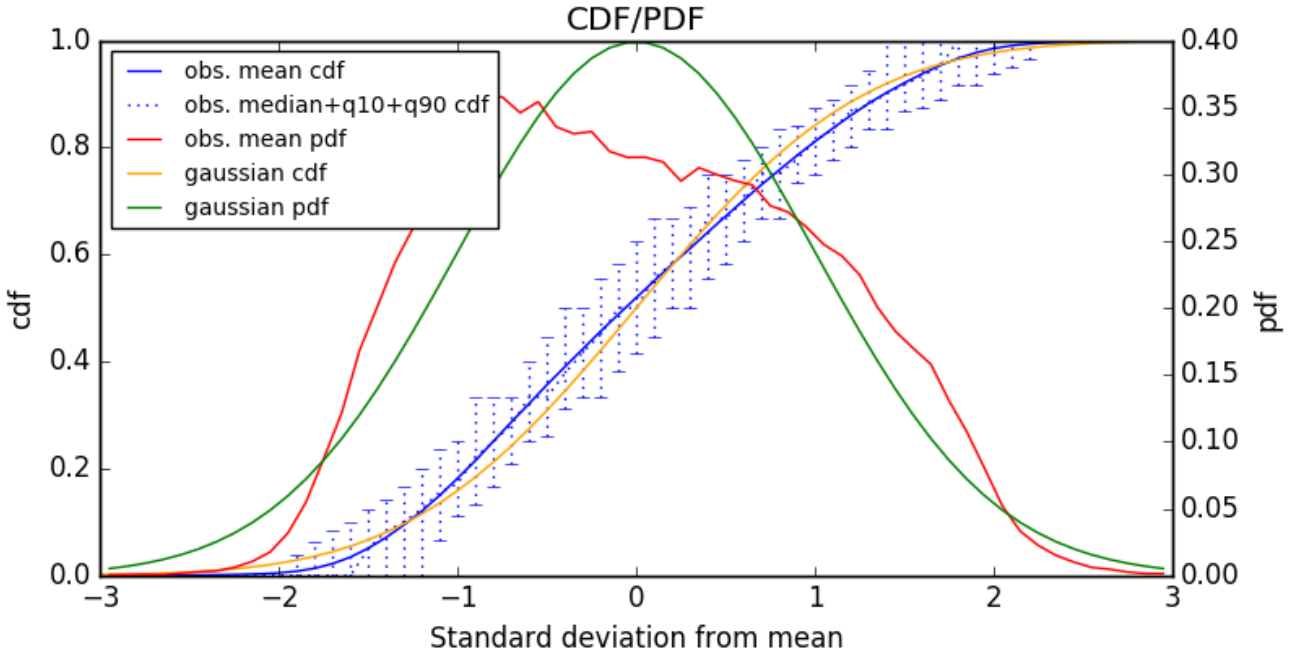
LIMA :

- LWP decreases
- Vertical heterogeneity of microphysical fields which seems realistic

(Δx=100m) ***(From L. Ducongé)***

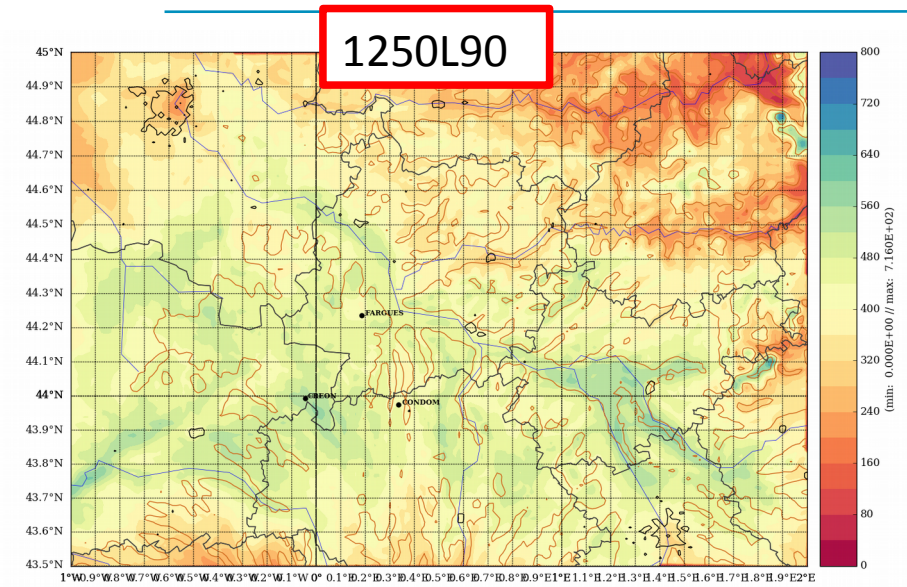
Work on PDF used in the microphysics (S. Riette)

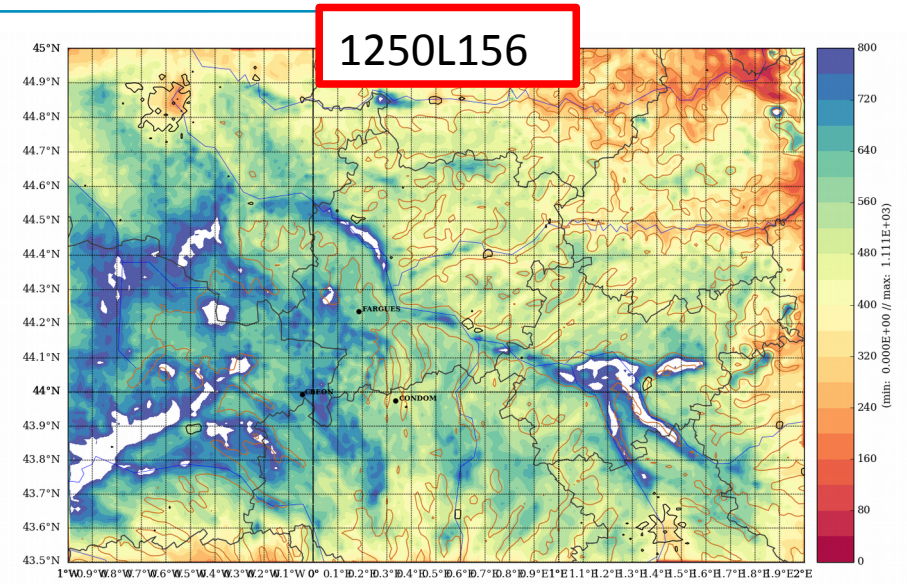
- Goal : harmonise the different PDF used
  - cloud and ice content (adjustment)
  - cloud fraction (adjustment) + surface vs volume fraction
  - covariance s'r'c (adjustment)
  - autoconversion + subgrid precipitation (microphysics)
  - radiation ? assimilation ?



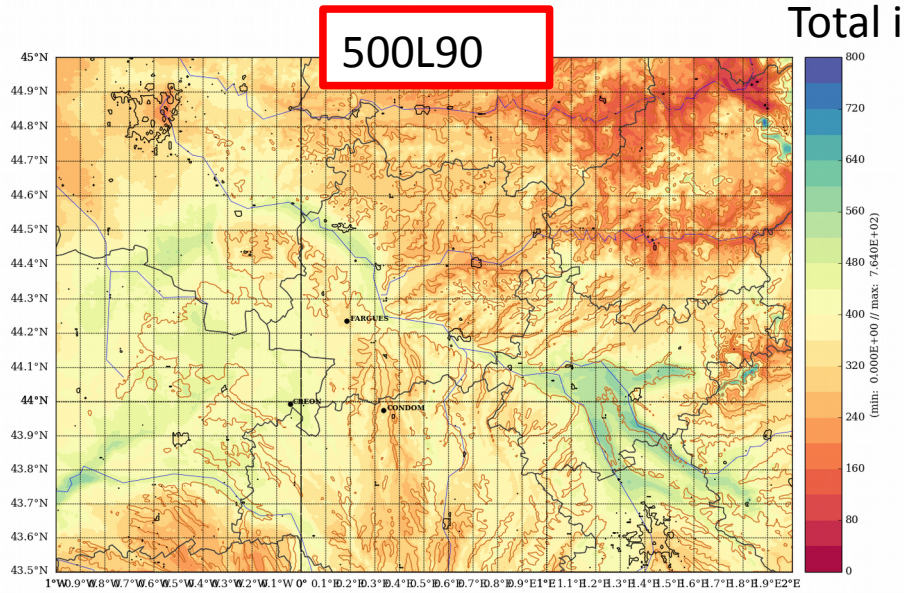
Around 10000 overcast cases on a 1yr period over 3 Cloudnet sites

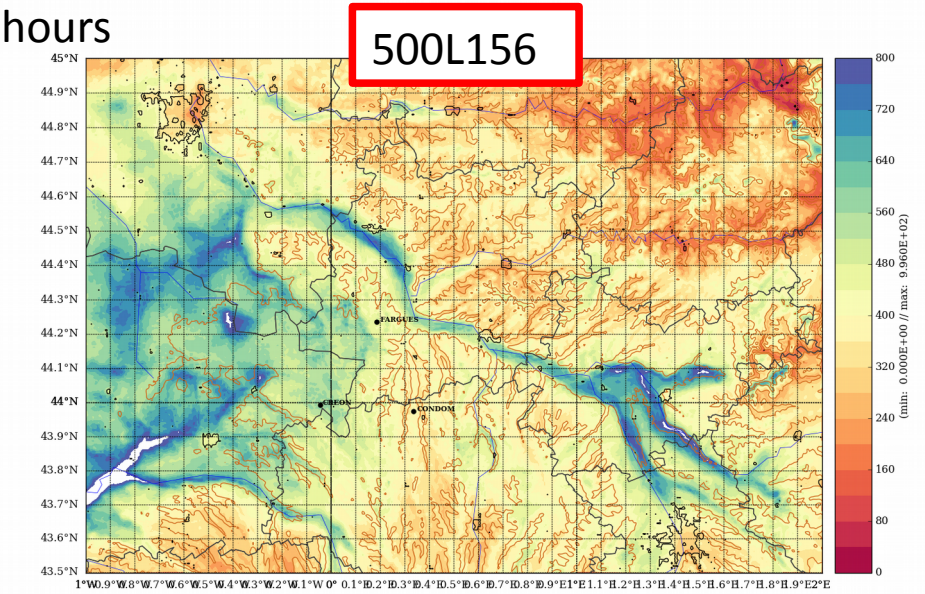
Fog over SO of France from Oct 2016 to March 2017





Total in hours





Scores (4248 h x 10 obs)

	1250L90	1250L156	500L90	500L156
Detection Rate (%)	43.9	54.0	40.4	47.8
FA Rate (%)	55.5	57.0	53.9	54.5
Bias	0.986	1.256	0.876	1.052
CSI	0.284	0.315	0.275	0.304

- 500L90 not better than 1250L90
- Stronger impact of vertical resolution (lowest level at 1m for L156)

Short term outlooks

- Test EcRAD scheme in ARPEGE and AROME
- Test LIMA on fog over 6 months in the SO of France
- Implement ICE3 modifications in LIMA
- Test ideas to mitigate shallow convection in AROME
- Implement and test 3D turbulence in AROME

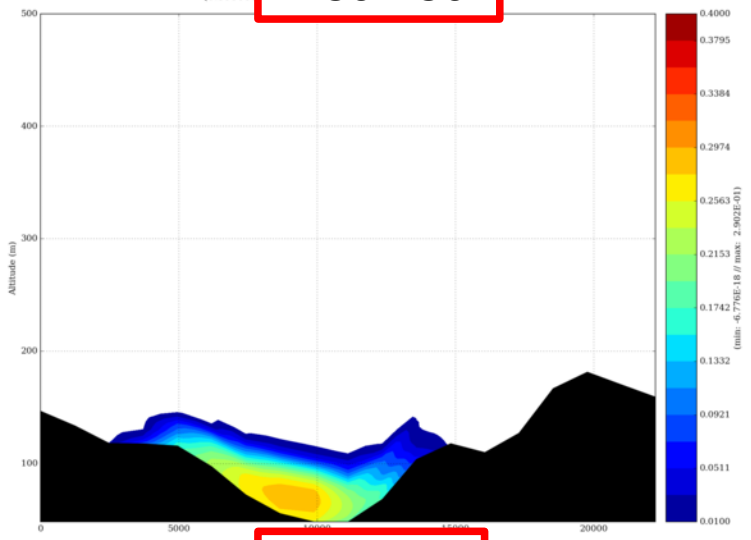
Thank you for your attention !

Y. Seity (Météo-France CNRM/GMAP)
And many colleagues from GMAP/GMME

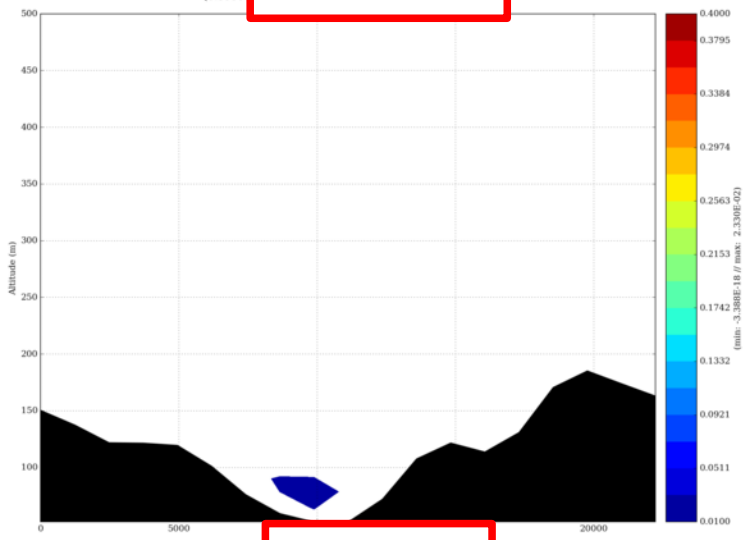
EWGLAM/SRNWP Meeting, October 2018, Salzbourg

Exemple : (31/10/2016 +6TU)

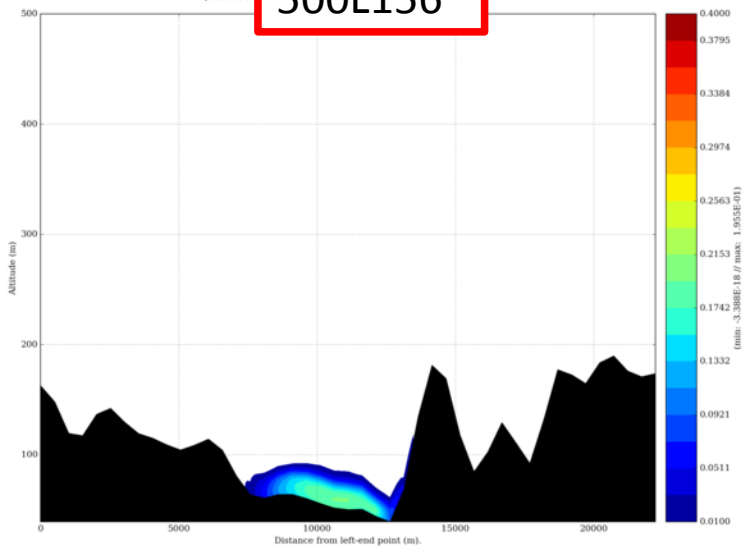
1250L156



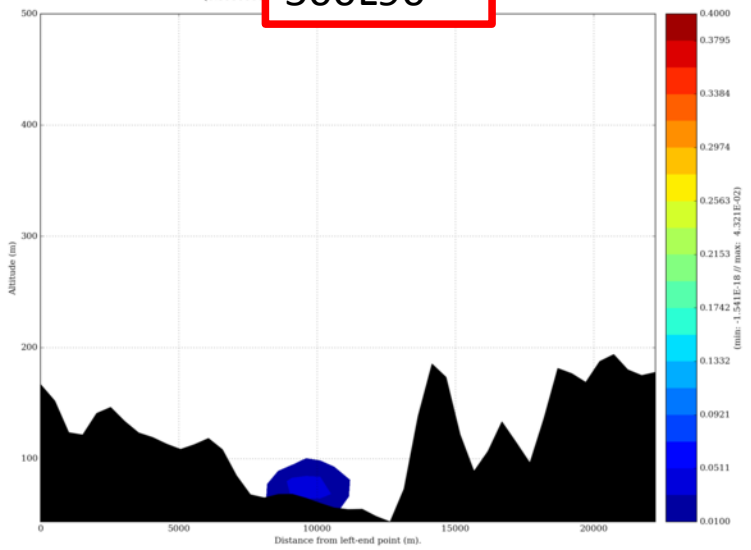
1250L90



500L156



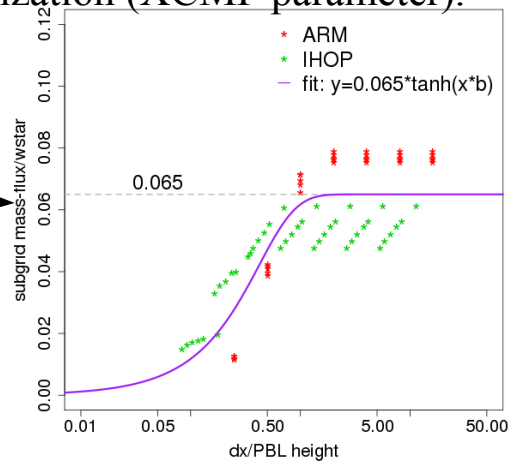
500L90



GRAY-ZONE OF shallow convection (R. Honnert, D. Lancz)

- Test the mitigation of the mass flux scheme initialization (XCMF parameter).

Coarse grained LES



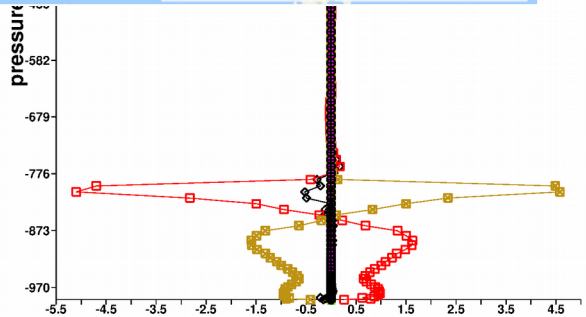


Fig. 1: Profile of 24 h water budget differences (made by DDH) between the reference and modified. Red –vertical advection, Yellow - vertical turbulence.

- 500m resolution AROME over the South of France during 1-15. July 2015
- As expected, the decrease in the turbulence is compensated by the vertical advection, nevertheless the final effect is small.
- Not enough alone to treat the shallow convection gray zone problem, but a part of a final solution, which includes further developments like 3D turbulence and a more suitable set of mass flux equations for high resolution.

Modification of shallow convection parametrization in the gray zone in a mesoscale model, Dávid Lancz, Balázs Szintai, Rachel Honnert (submitted, Boundary-Layer Meteorology)