Recent updates in AROME physics

Y. Seity, S. Riette, R. Honnert, C. Zecchin, D. Ricard
(Météo-France CNRM)

ASM Meeting
Toulouse, April 2018

Outline

- Microphysics
- Turbulence/Shallow convection
- Surface
- Diagnostics
- AROME@500m

Outline

- Microphysics (ICE3/ICE4, ~~LIMA (in CY45T1)~~, Cloud scheme)
- Turbulence/Shallow convection
- Surface
- Diagnostics
- AROME@500m

Modified version of ICE3 (S. Riette) :

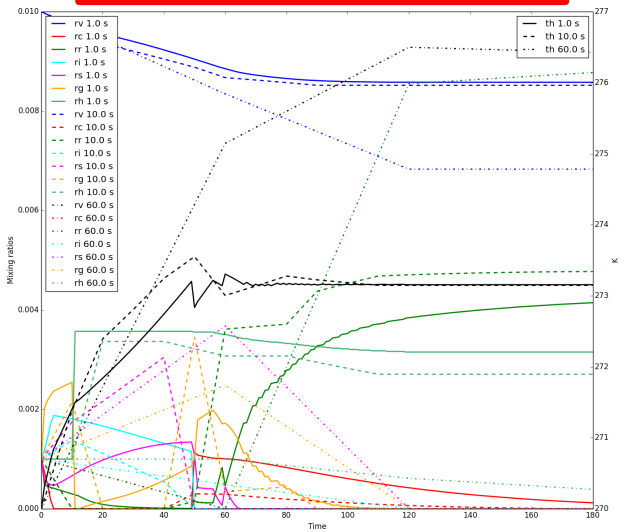
- A lot of changes in ICE3 :
  - Complete rewriting of rain_ice in order to reduce time step length sensitivity
  - bugfixes
  - Code optimisation

- Less graupel inside clouds (because modified choice of wet/dry growth)
  → thresholds of hail diagnostic have to be changed

- +6 % CPU

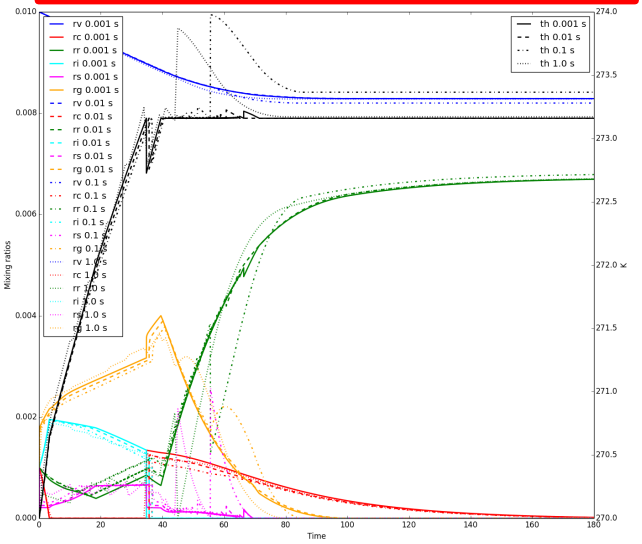
Modified ICE3 : 0D tests
ex : heat budget

Oper dt=1,10.,60s

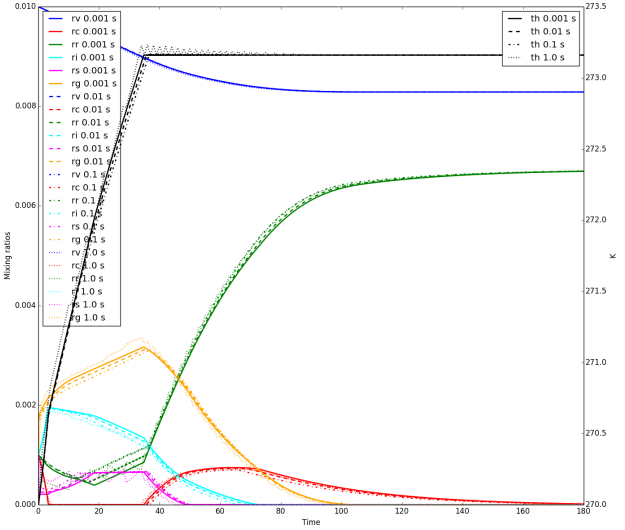


- Heat budget in order to stop processes when impact on T should stop it.
- Example : melting when latent heat release → T < 0°C
- ~ 10 processes concerned
- → in CY45T1 and 43T2_op

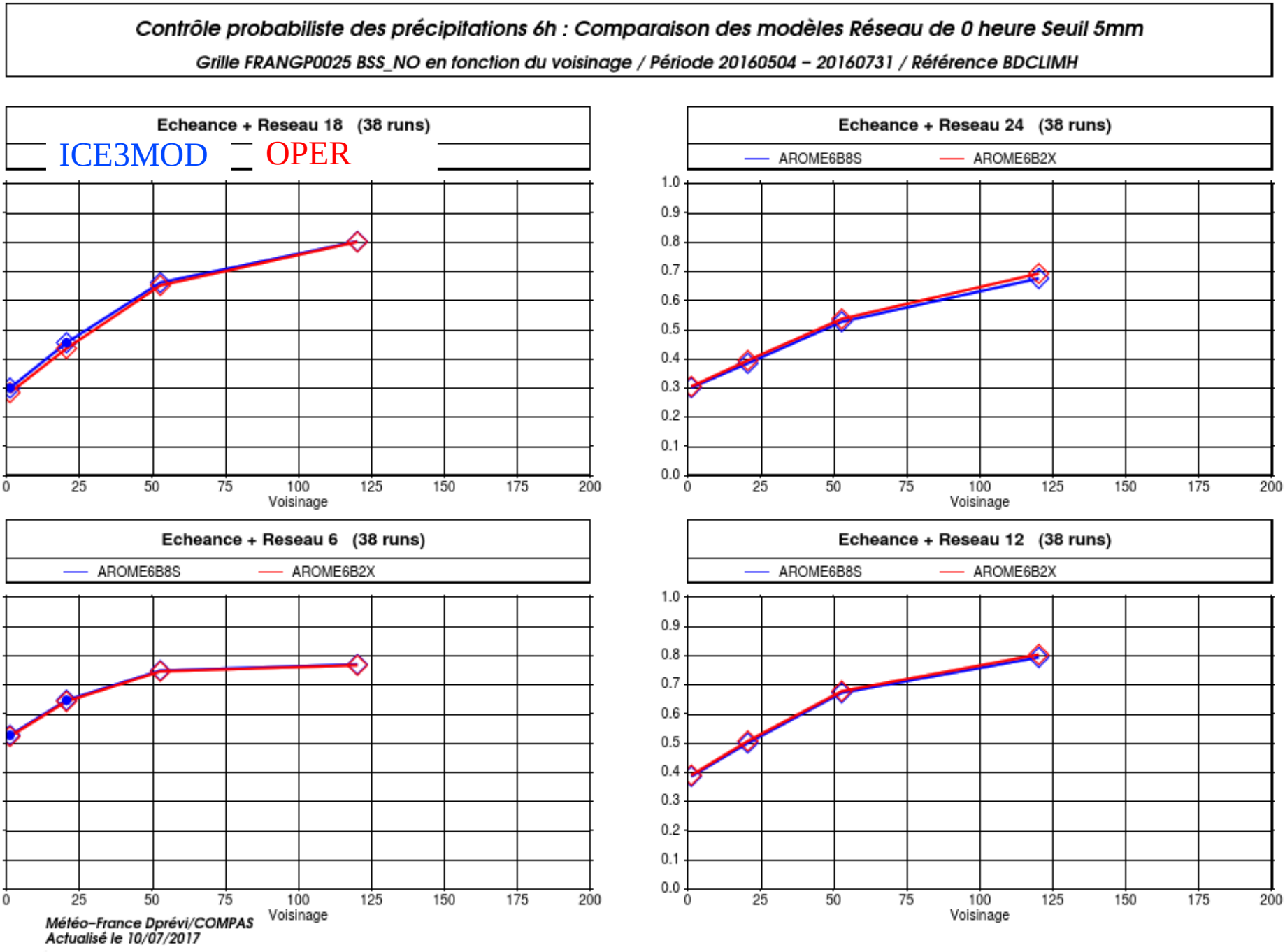
Oper dt=0.001,0.01,0.1,1s



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



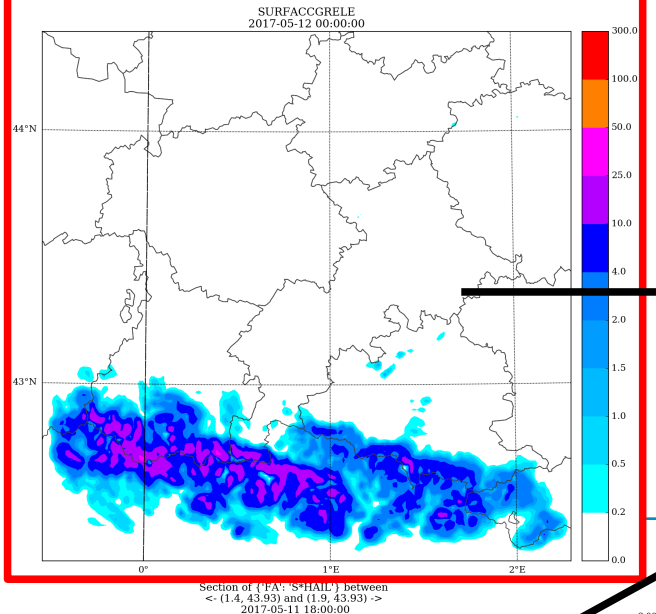
Evaluation ICE3-new (scores RR6 summer):



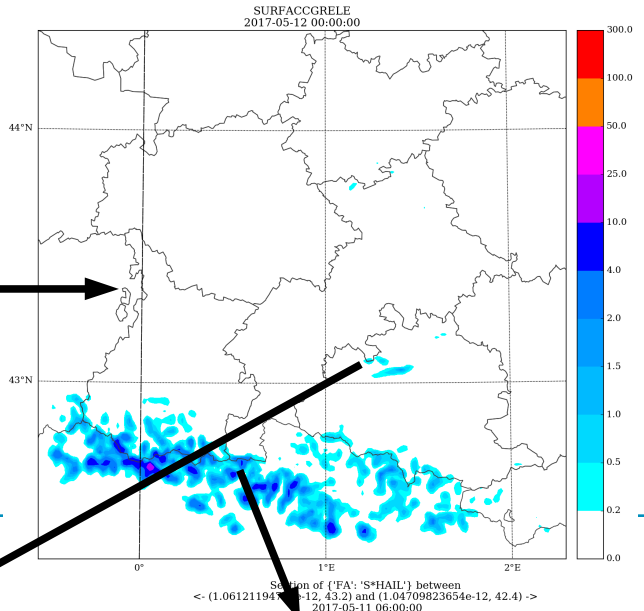
ICE4 : Ex 11 May 2017

(tests to reduce strong hail accumulations over orography)

ICE4 : HAIL 24h accumulated

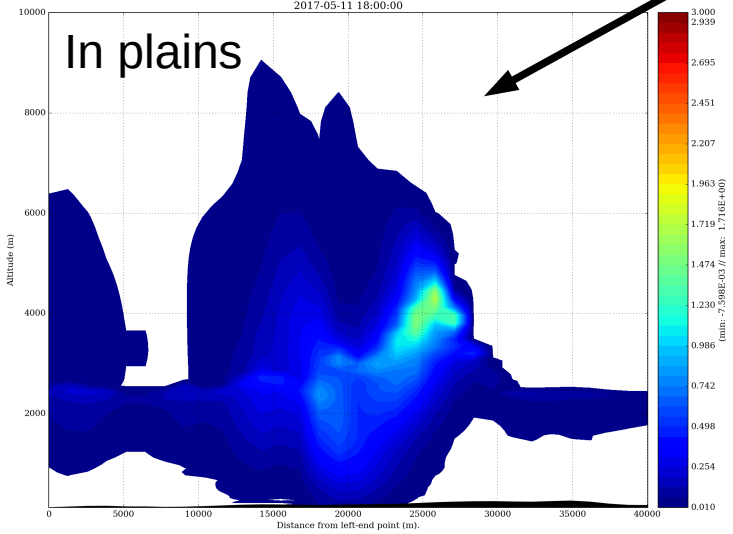


ICE4_test : 24h acc. Hail :

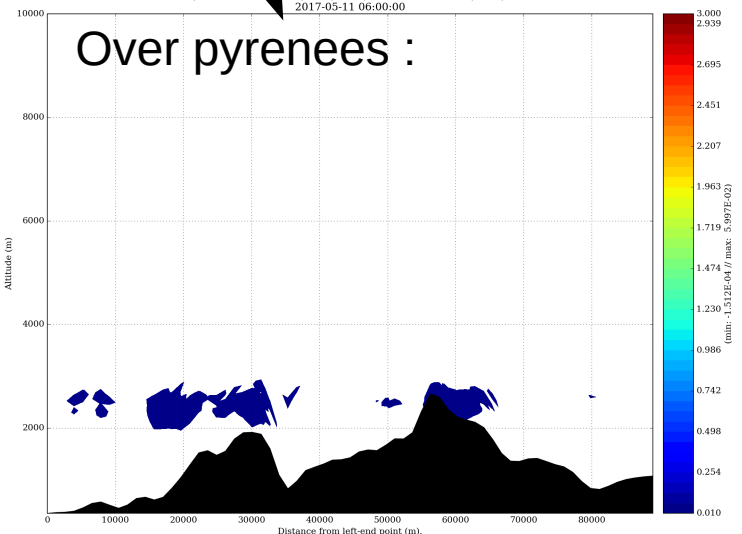


All that is not wet growth has been removed from graupel content which can be converted into hail (snow melting for instance)

In plains



Over pyrenees :

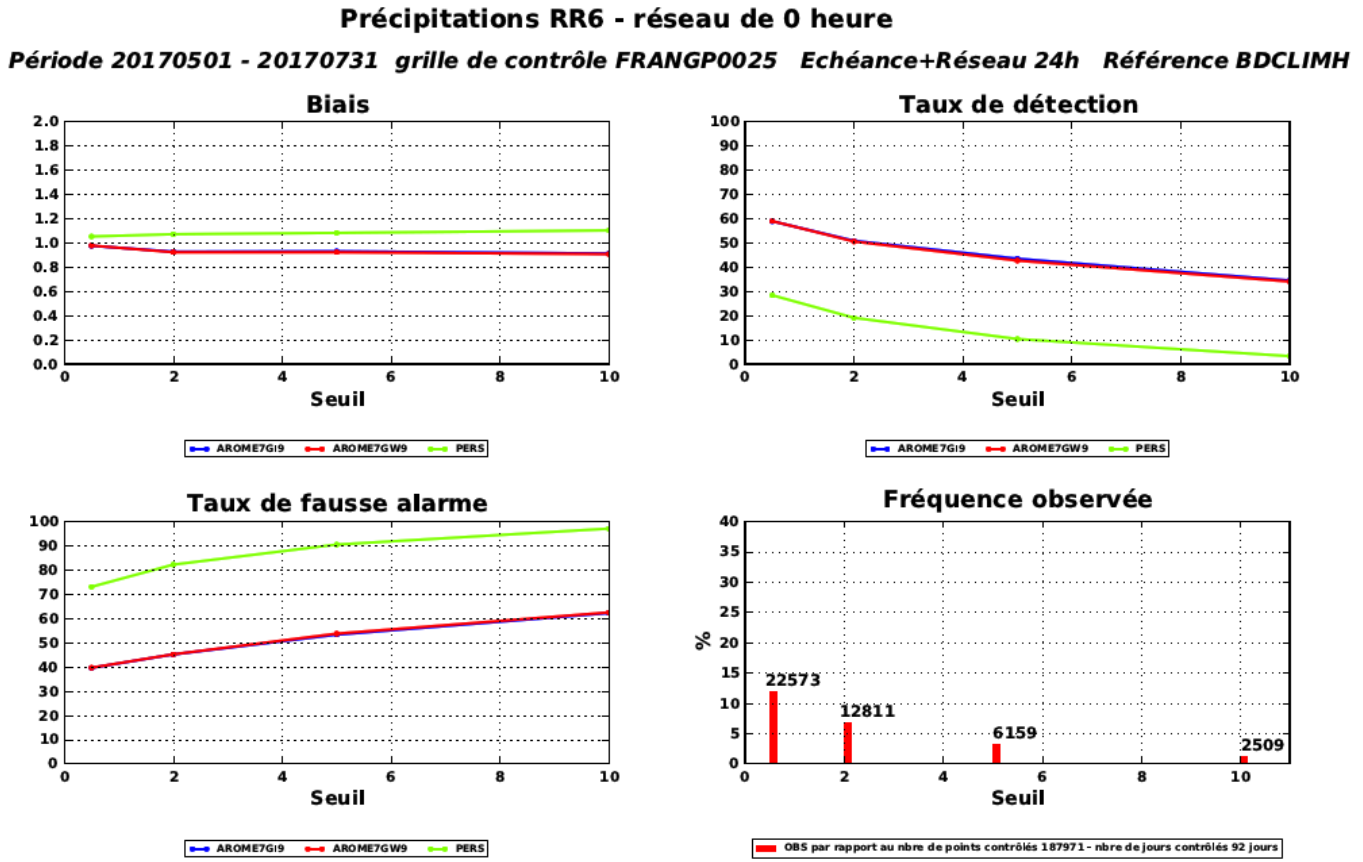


→ Reduced accumulation over orography, similar in plains.

This test version has been evaluated on a 3 months summer period

Scores of ICE4/ICE3 ...

- Neutral scores (T2m/Hu2m, V10m, Pmer, RR6, RR24, profiles...)



- ICE4 has been improved compared to previous versions.

- May be still an over-estimation of hail over orography.

- Not better than ICE3 hail diagnostic (with +6 % CPU time) → not in oper

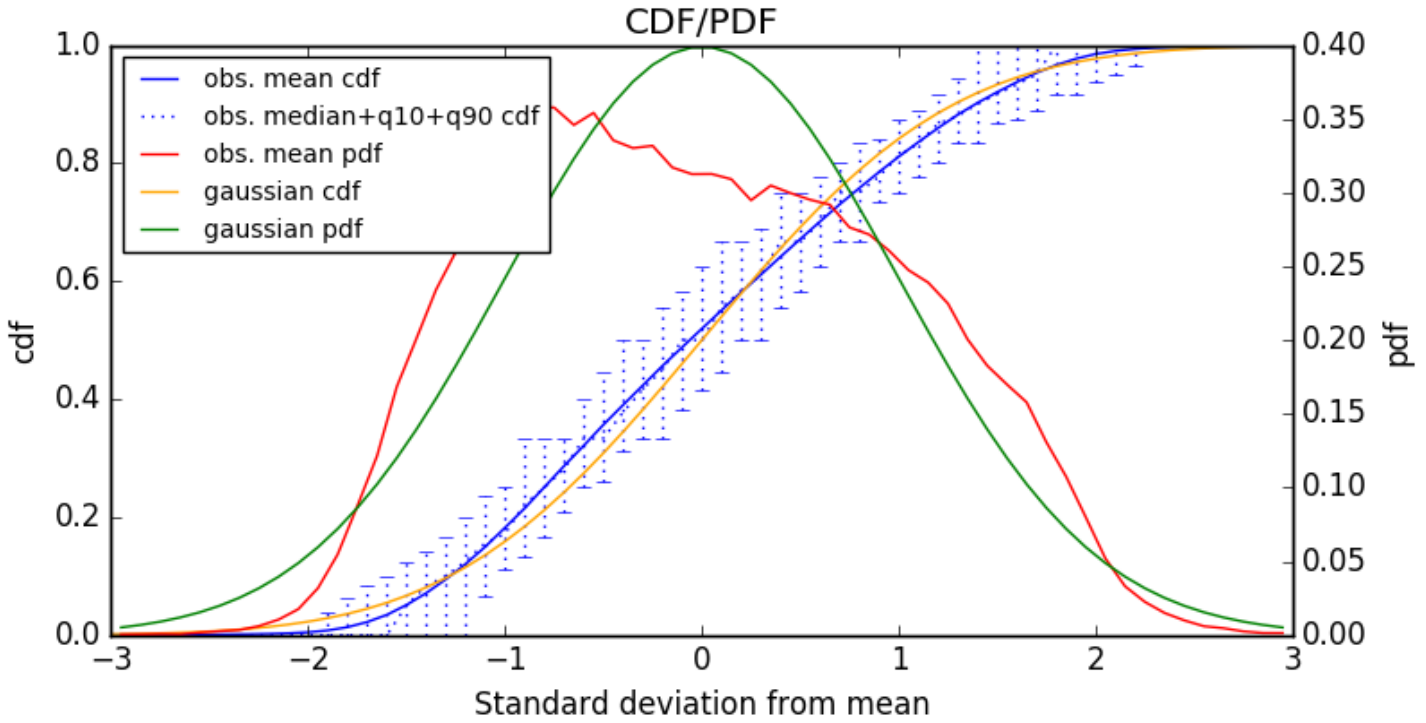
0D tool for microphysics

- What is it ?
  - python tool that call fortran routines of microphysics
  - same initial condition for all schemes
  - no transport (horizontal, sedimentation)
- Status
  - includes LIMA and ICE3/ICE4
  - now includes Thompson (2-moment bulk) and SBM (bin) from WRF
- Technical outlooks
  - improve initialisation to allow a fair comparison
  - maybe include other schemes from WRF, ARPEGE and/or LMD
- Scientific outlooks
  - characterise time-step dependency in the different schemes
  - compare schemes with given initial state

METEO FRANCE

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

METEO FRANCE

Outline

- Microphysics
- Turbulence/shallow convection
- Surface
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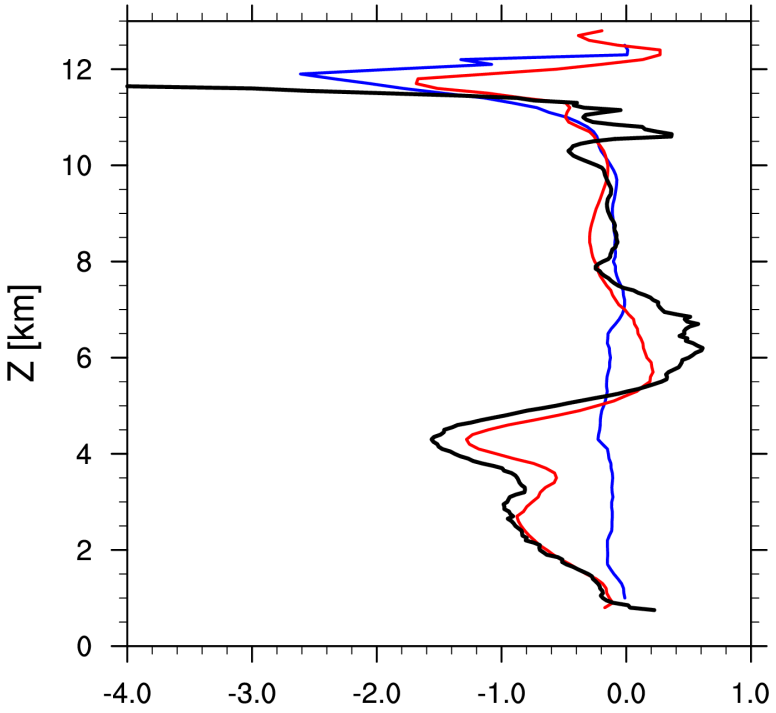
- AROME@500m

Turbulence parameterization: impact on deep convection

Evaluation on idealized simulations : LES (Δx = 50m) 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)

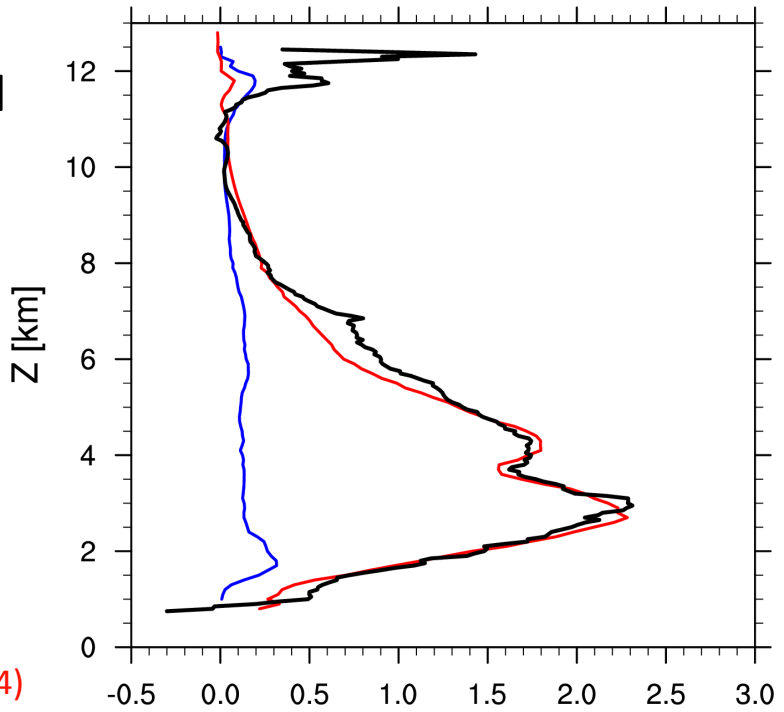
(Cuxart et al 2000)

$$\overline{w's'} = -K\frac{\partial \overline{s}}{\partial z} \qquad s = r_{np}, \theta_l$$

Hgrad (1km run)

(Moeng et al 2014)

$$\overline{w's'} = C\left(\frac{\partial \overline{w}}{\partial x}\frac{\partial \overline{s}}{\partial x} + \frac{\partial \overline{w}}{\partial y}\frac{\partial \overline{s}}{\partial y}\right) \qquad (C = 3\Delta x^2/12) \qquad s = r_{np}, \theta_l$$



$\overline{w'r'_{np}}$ *(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
→ more details on the poster ...

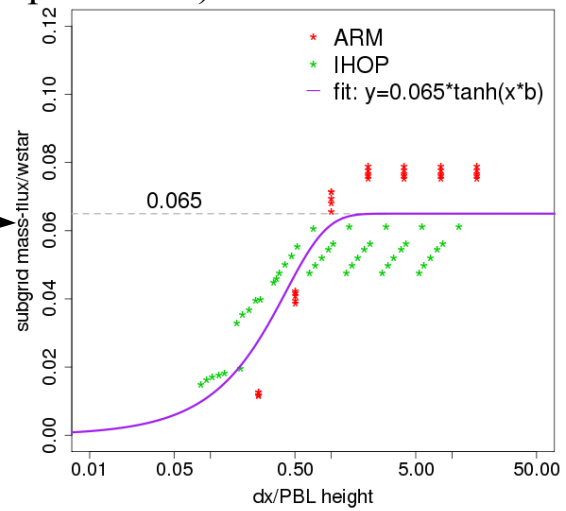
Verrelle A., Ricard D. et Lac C., MWR, 2017

METEO FRANCE

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

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

Coarse grained LES →



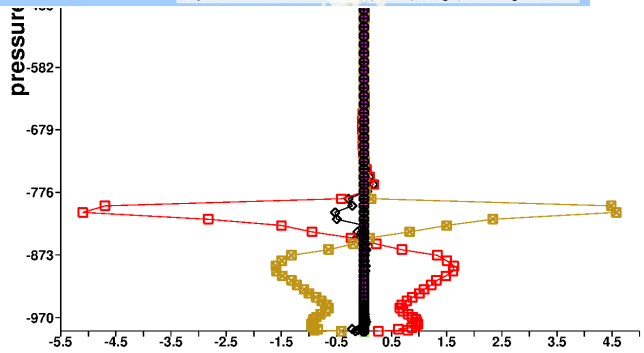


Fig. 1: Profile of 24 h water budget differences (made by DDH) between the reference and modified. Red –vertical advection, Yellow - vertical turbulence.

- 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)

Outline

- Microphysique
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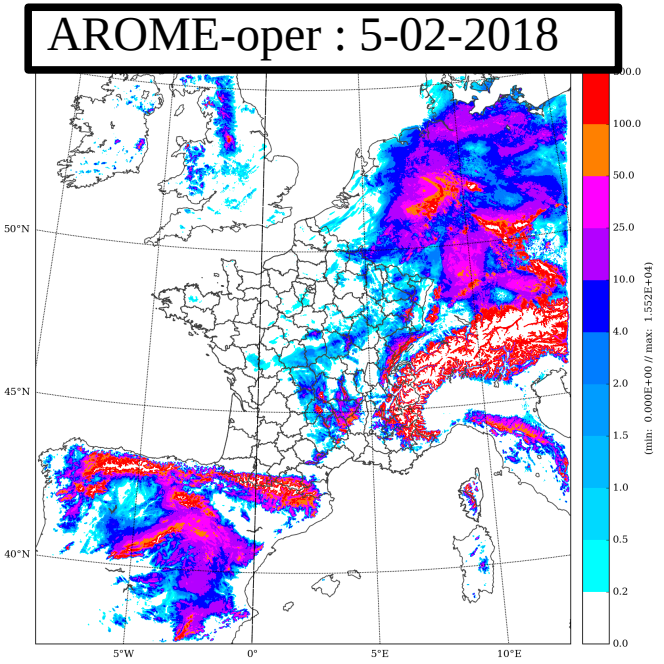
Problems in the snow melting in plains (ex February 2018)

Surface Snow :



Problems in the snow melting in plains (ex February 2018)

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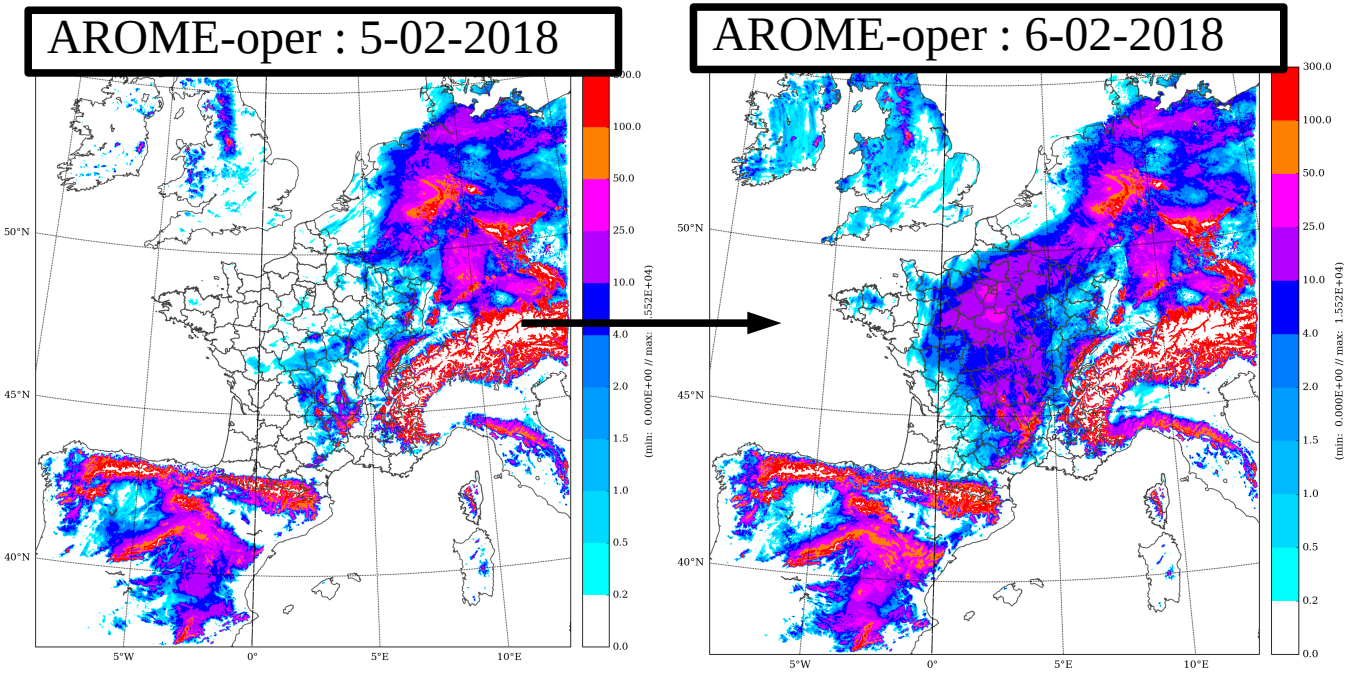

Problems in the snow melting in plains (ex February 2018)

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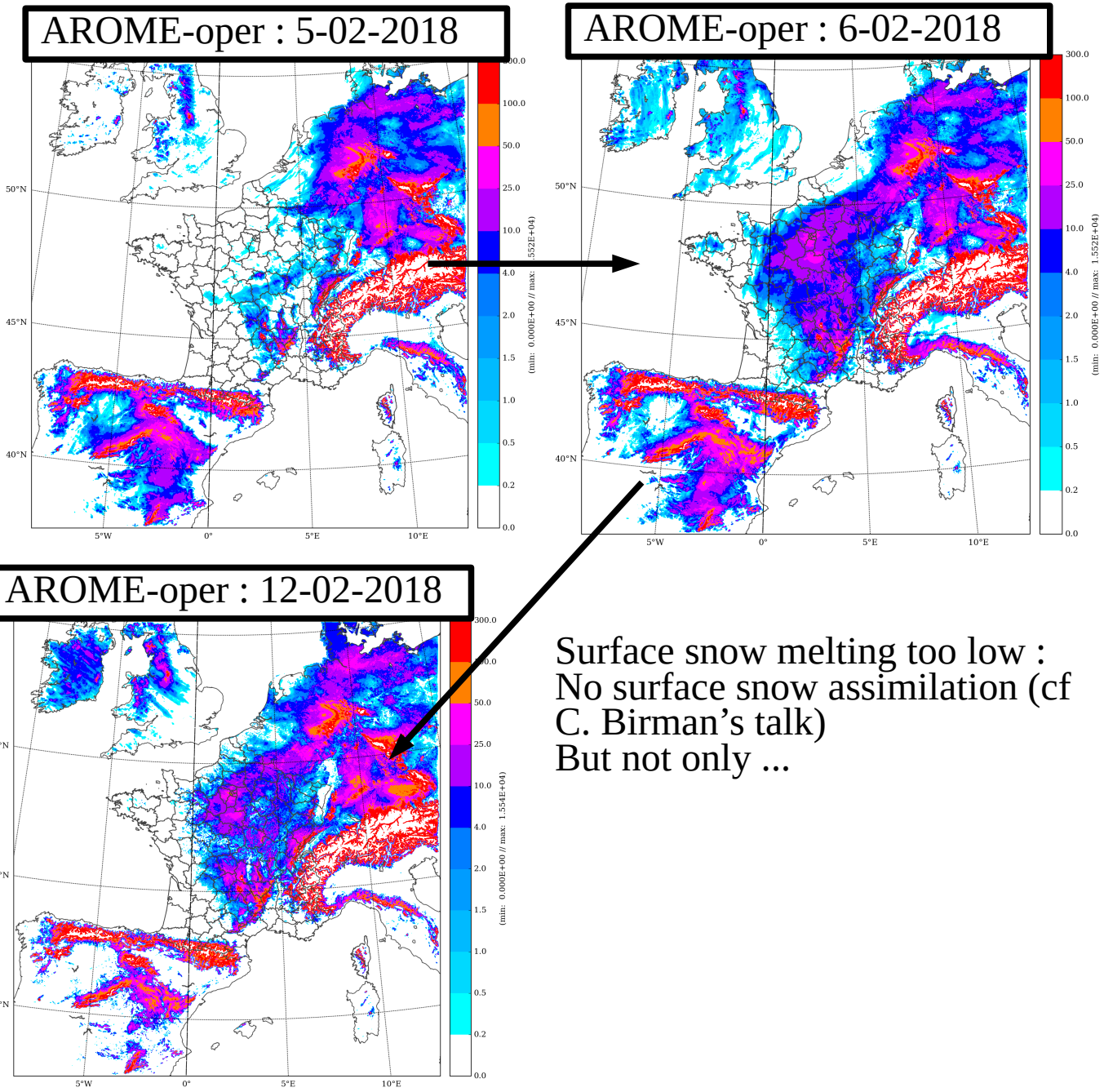


Surface snow melting too low :
No surface snow assimilation (cf C. Birman's talk)
But not only ...

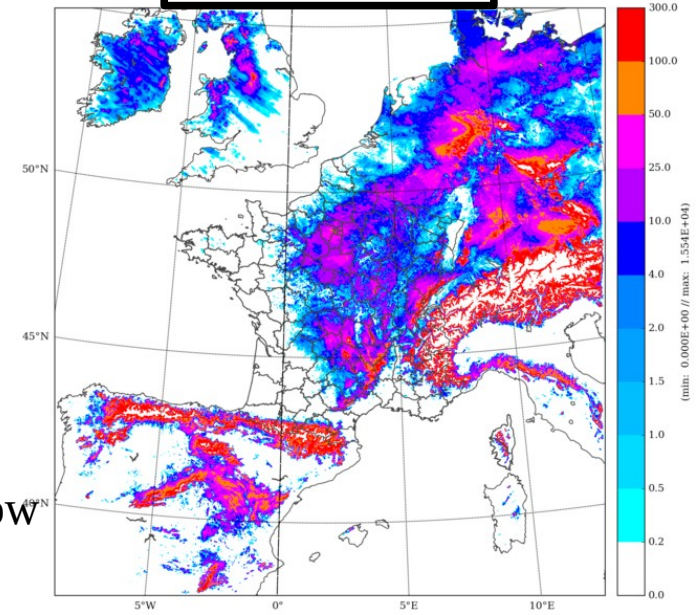
Test of alternative snow option in SURFEX (EBA)

Surface snow
12-02-2018 :

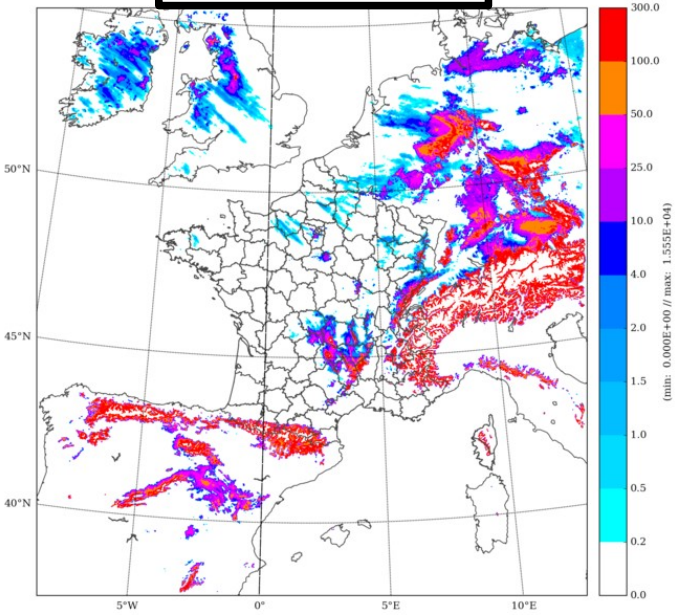
EBA modified snow fraction calculation and snow melt formulation :

- More realistic snow fractions over vegetation, faster snow melt
- T2M + where snow removed
- T2M – during daytime where snow Still present (albédo).

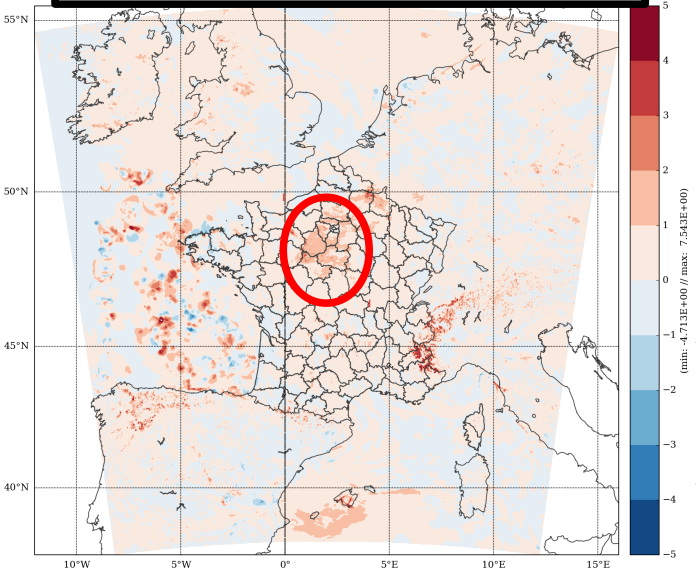
AROME-oper



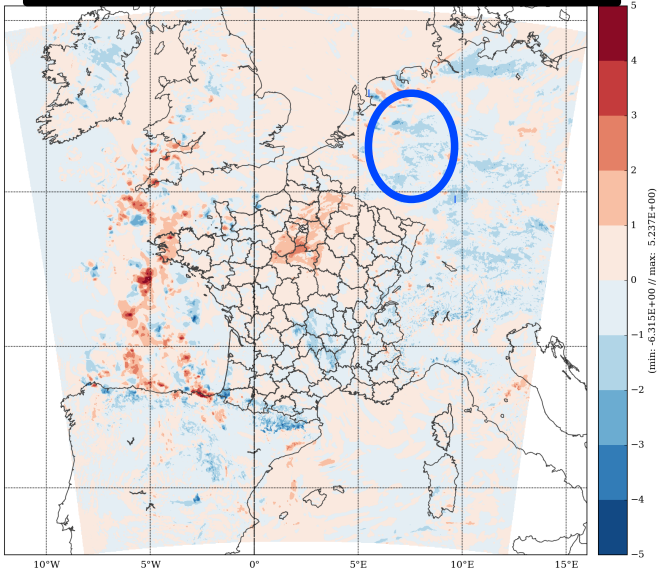
AROME-EBA



T2m (EBA-oper) @ 5TU



T2m (EBA-oper) @ 12TU



More advanced versions of Surfex

ECOCLIMAP-SG (in Surfex v8.1)

→ New definition of surface characteristics. Derived from ESA-CCI satellites products @ 300m

→ covers removed, directly LAI, ALBEDO …

→ Ongoing tests in AROME : OK on T2m/Hu2m after some tuning but problems on V10m over forests linked with higher trees than in Ecoclimap → need to work on the z0/drag parametrisation

ISBA-DIFF

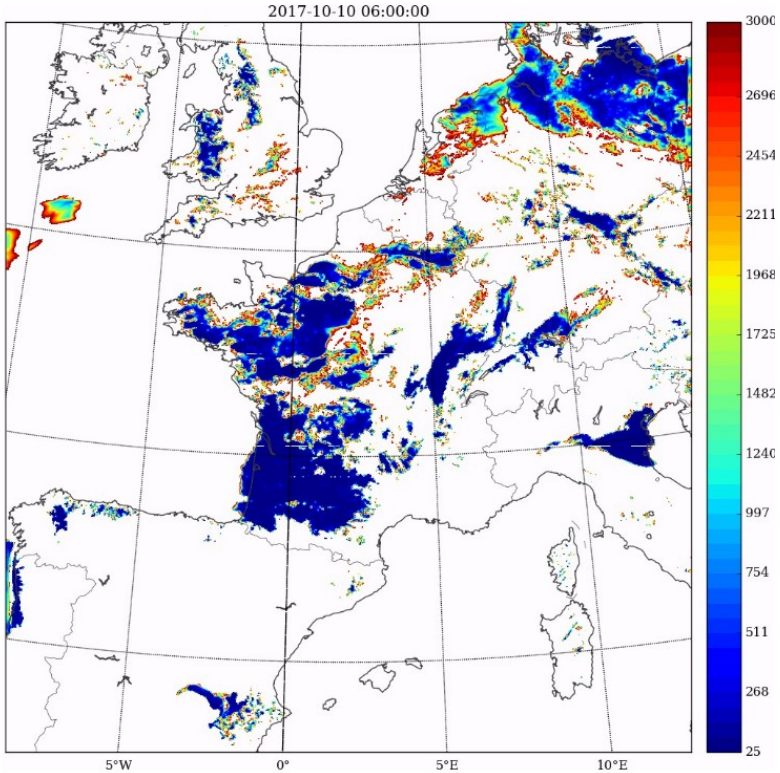
→ Plan to start some tests with data assimilation by the end of 2018 ...

Plan

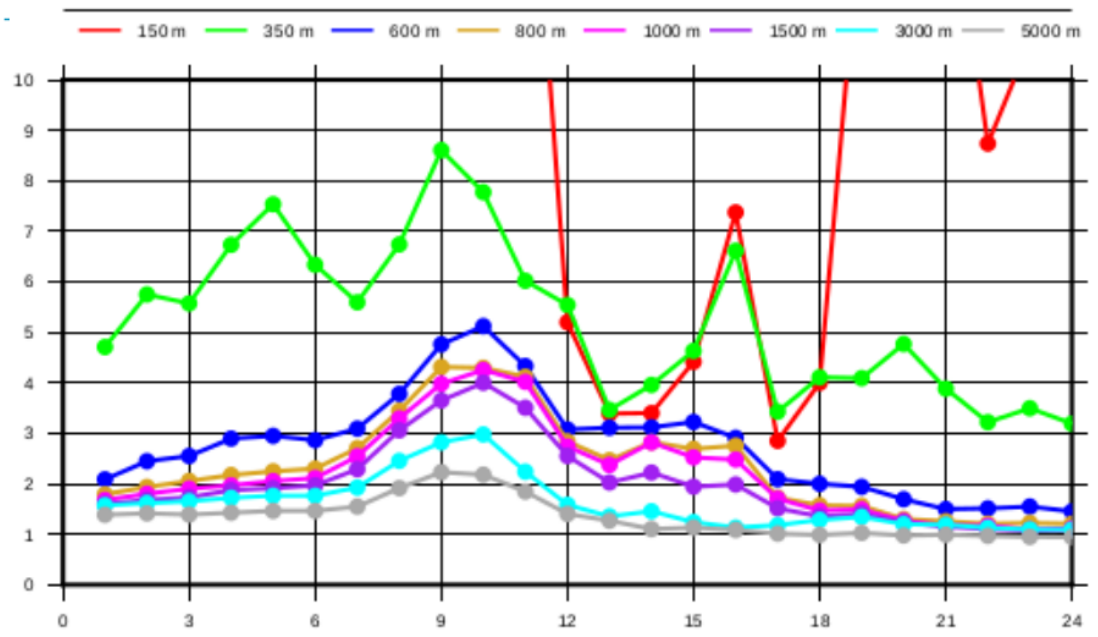
- Microphysique
- Turbulence/shallow convection
- Surface
- Diagnostics (for our 43t2_op AROME/ARPEGEs)
- AROME@500m

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



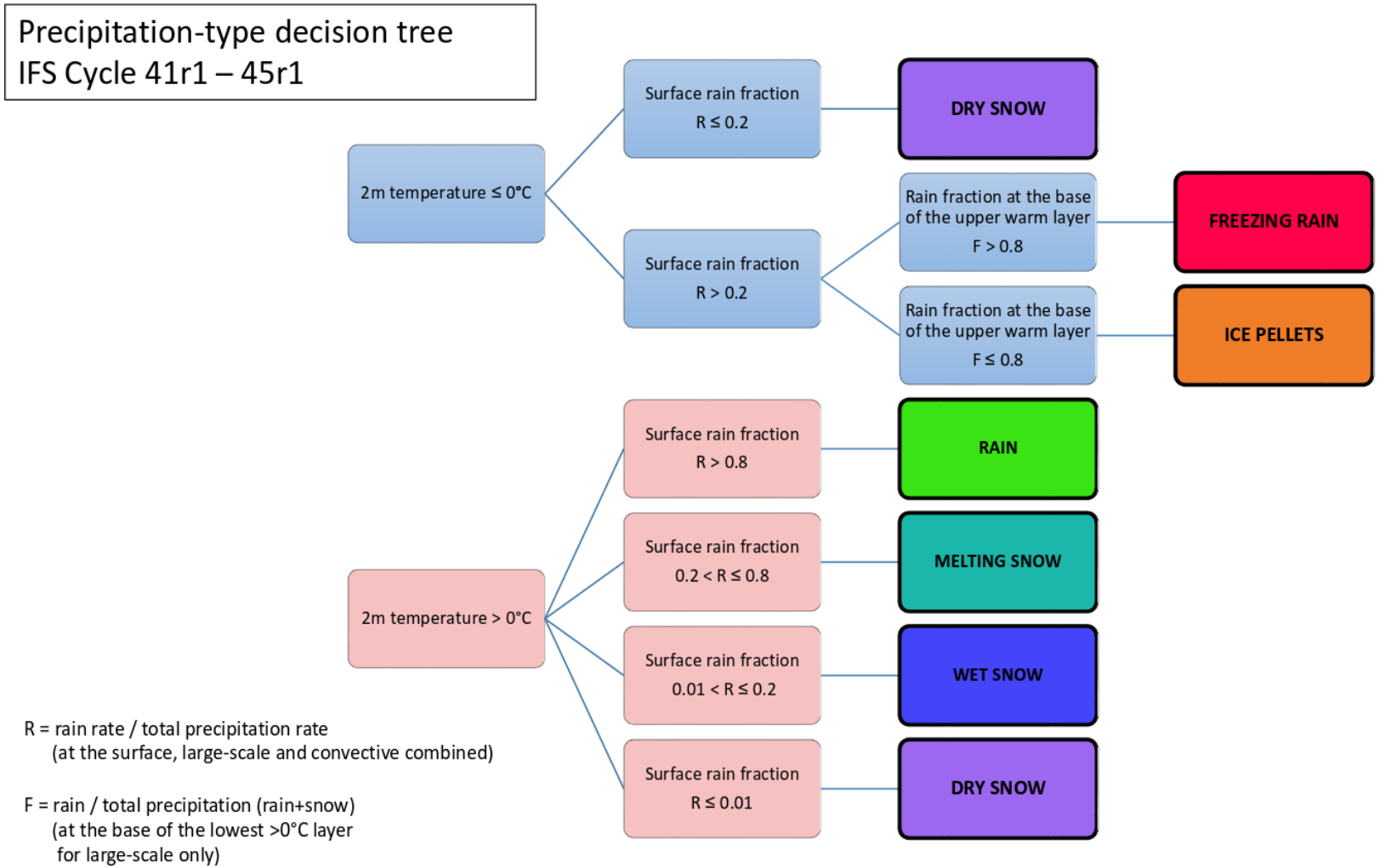
Sept. to Nov. 2017 Bias compared with 138 obs over France :



From I. Sanchez

Surface precipitation type

- To be created by the end of 2018
- Based on IFS method ?



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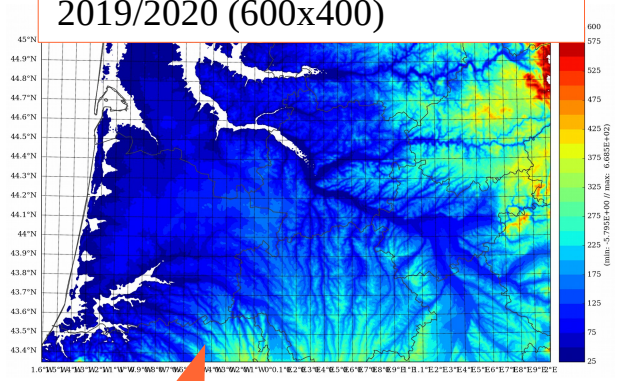
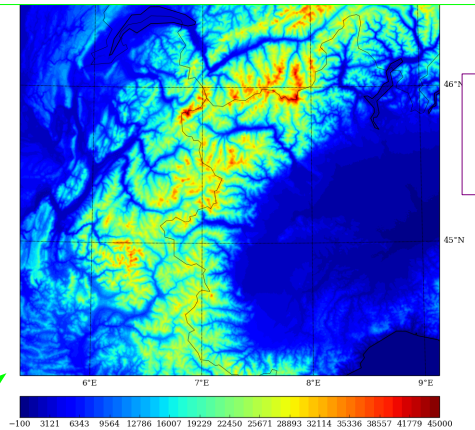
AROME_500m for field experiments

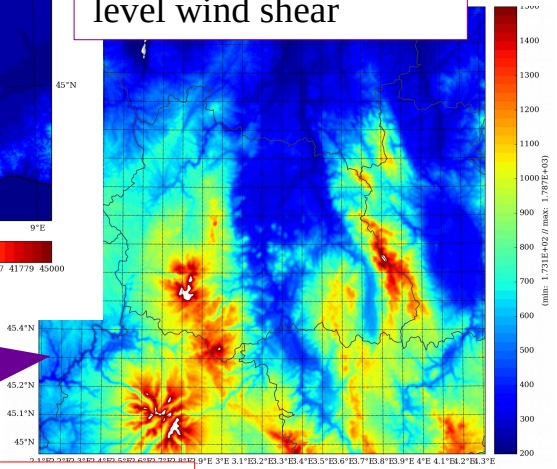
To prepare SOFOG3D-2019/2020 (600x400)

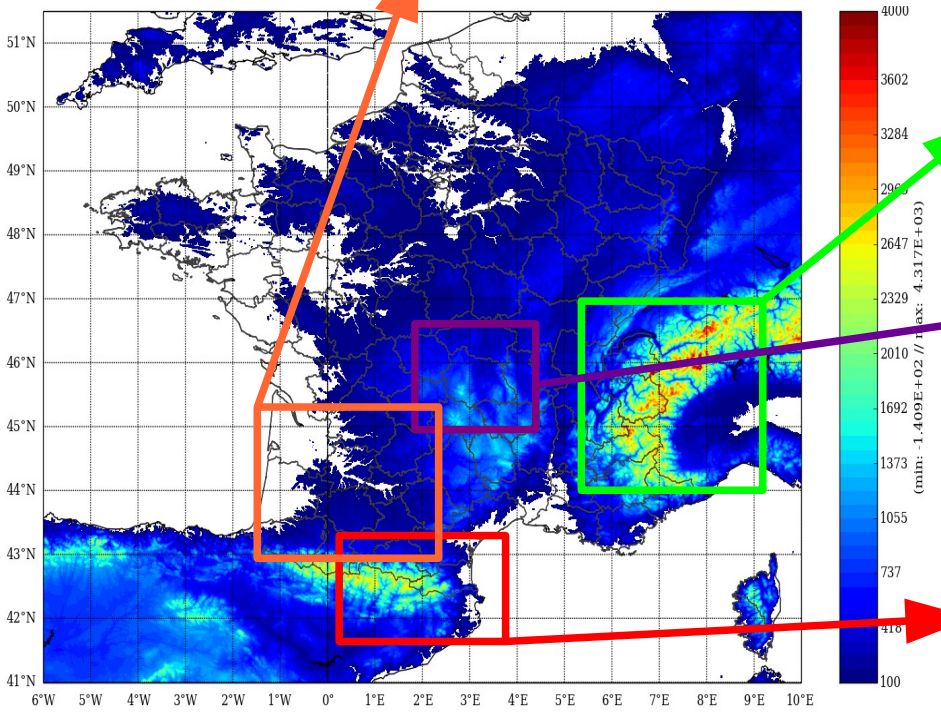


PASSY-2015(640x640) : radiation/surface

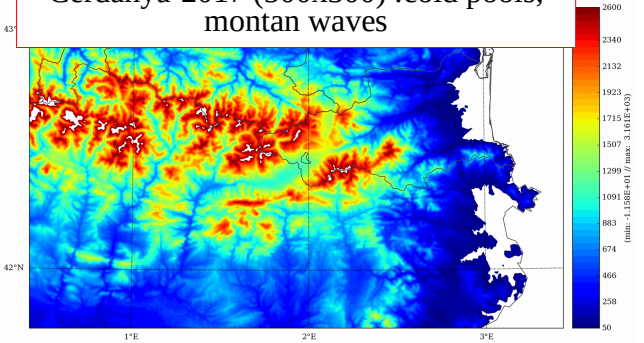


Clermont-Aulnat 2017-2018 (360x360) : Low level wind shear



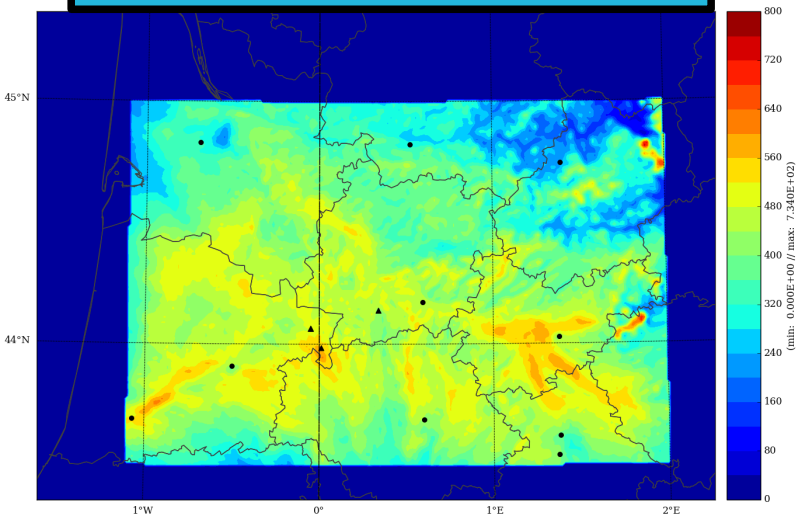


Cerdanya-2017 (500x300) :cold pools, montan waves

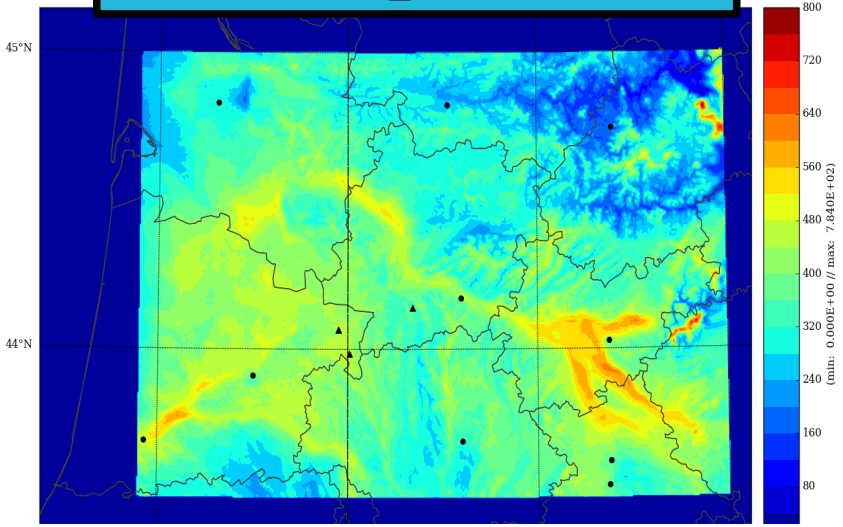


AROME_500m 6 months climatology

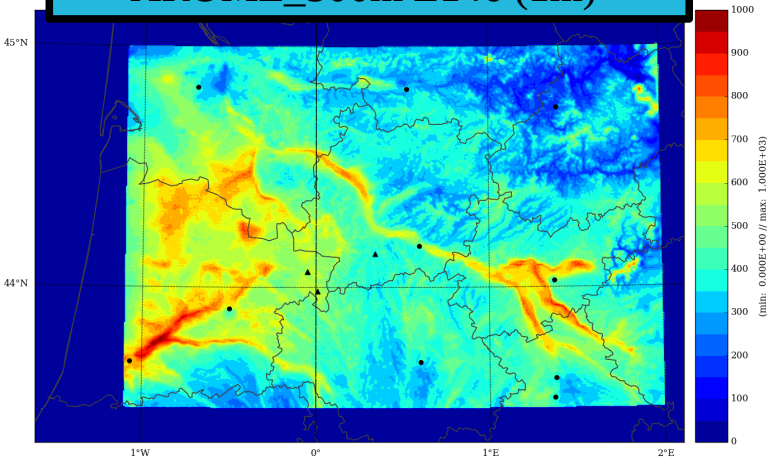
Total duration of fog (in h) :
AROME@1,25 km



Total duration of fog (in h) :
AROME_500m L90

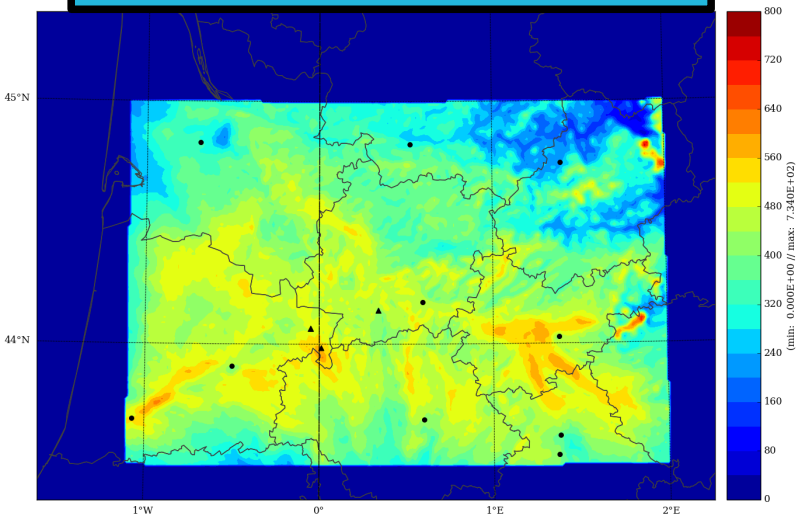


Total duration of fog (in h) :
AROME_500m L146 (1m)

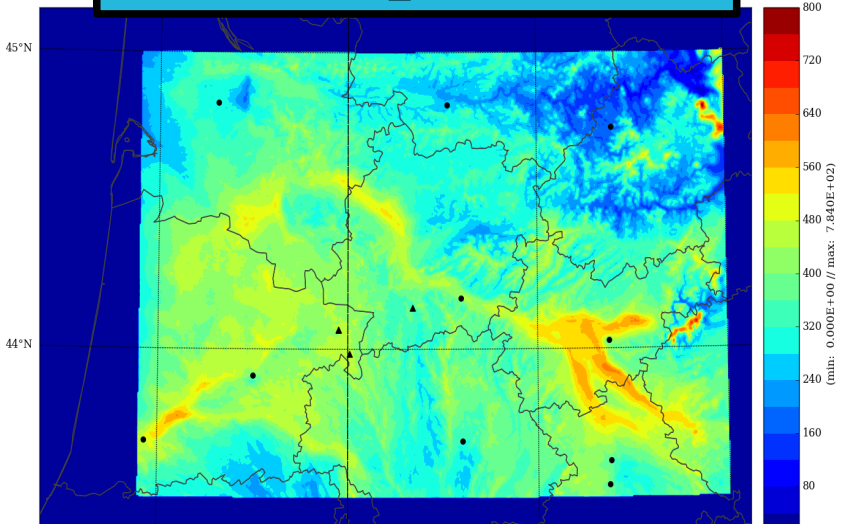


AROME_500m 6 months climatology

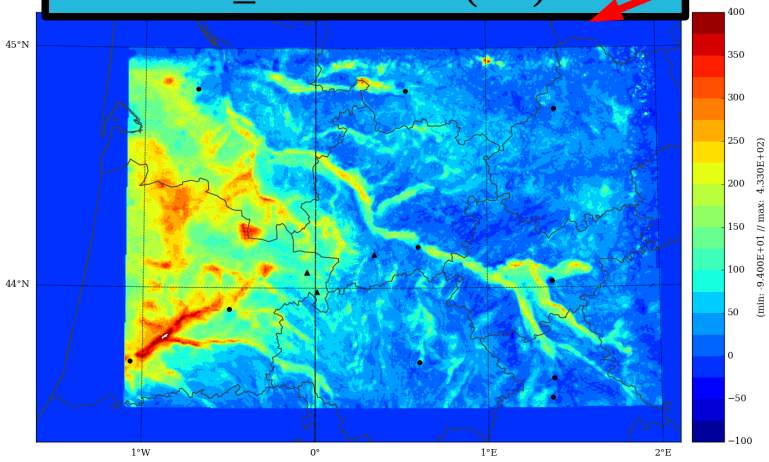
Total duration of fog (in h) :
AROME@1,25 km



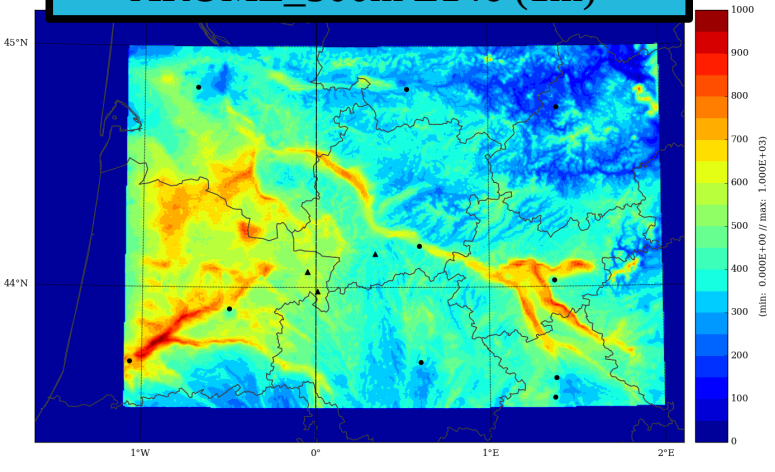
Total duration of fog (in h) :
AROME_500m L90



AROME_500m L146 (1m) - L90



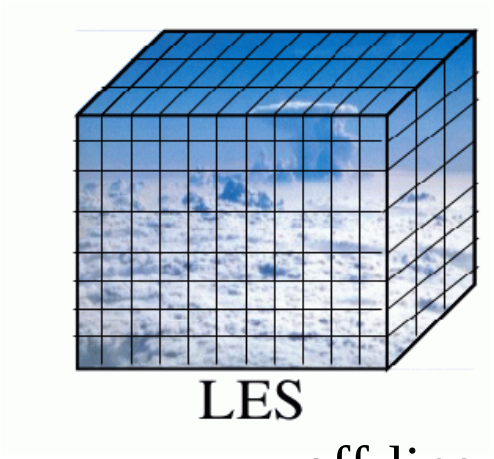
Total duration of fog (in h) :
AROME_500m L146 (1m)



→ ongoing work...

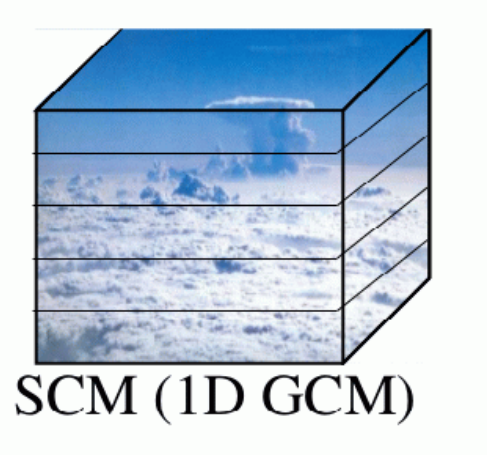
HIGH-TUNE PROJECT

To develop a strategy for tuning at the process scale
To improve the representation of low clouds and
Better understand and represent the cloud radiative effect



LES=Predilection tool
for parameterization
development

SCM/LES : exactly
the same set-up



- off-line radiative code based on a 3D Monte Carlo algorithm (PhD : N.Villefranque)
- comparisons LES/SCM : 12 cases shallow convection
- A statistical tool:
- history matching (D. Williamson)
- metric definitions & selection of ensemble of parameters

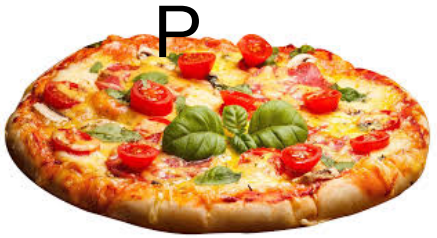
=> determine the range of possible values of free parameters

Thank you for your attention...

Just to remind you for this evening Sport Side Meeting (if not already done) :

21:30 ...

P



W

B

Please give 10 € to Yann Seity or Eric Bazile for the PWB before Tuesday 12am

Recent updates in AROME physics

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ASM Meeting
Toulouse, April 2018