Latest developments in AROME physics

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METEO FRANCE
Toujours un temps d'avance

Outline

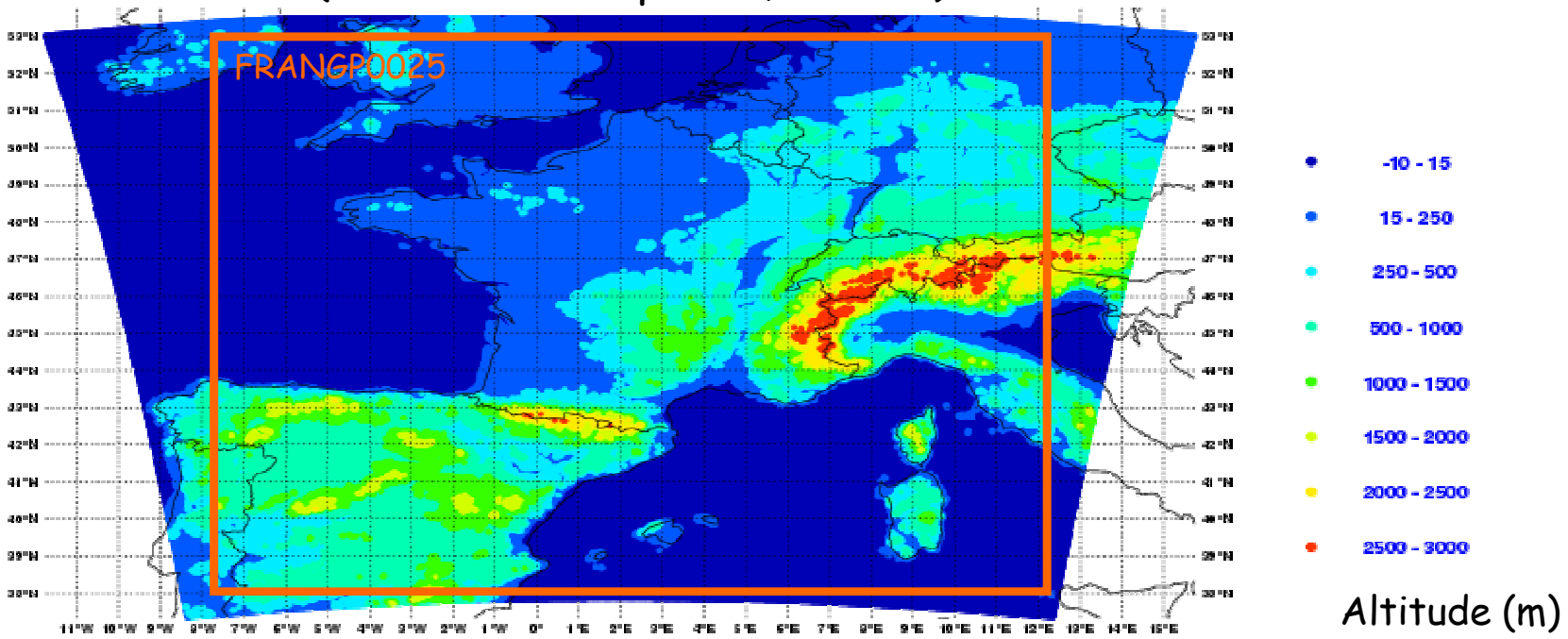
- Status and content of oper suite

- Developments and perspectives on :
  - Shallow clouds
  - Surface
  - Turbulence

AROME France Oper

- Since September 2011 : CY36T1_op2

(750x720xL60 points, dt=60s)



CONTENT (physics part):

- Hail diagnostic

- Improvements for low clouds

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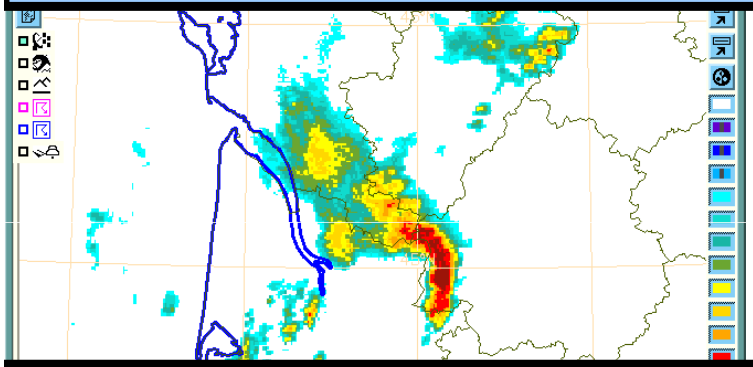
Hail

OBSERVATIONS :

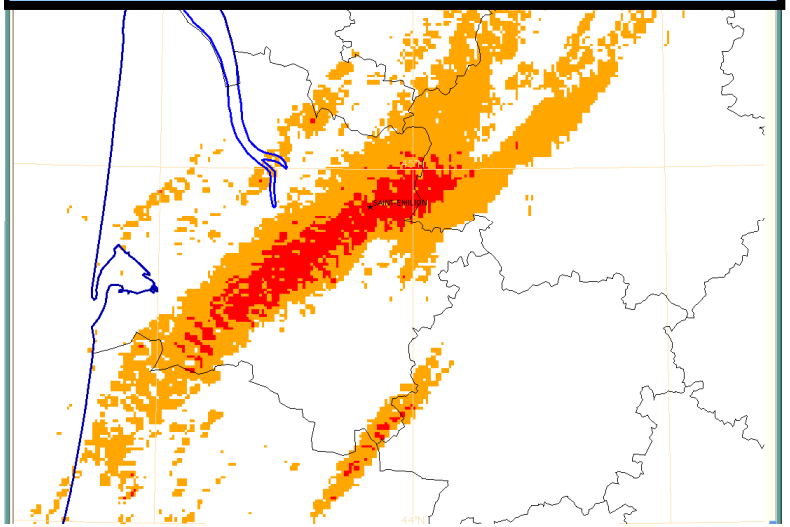
Observation (reflectivity at 2h30 UTC)



Hail risk (from radar)

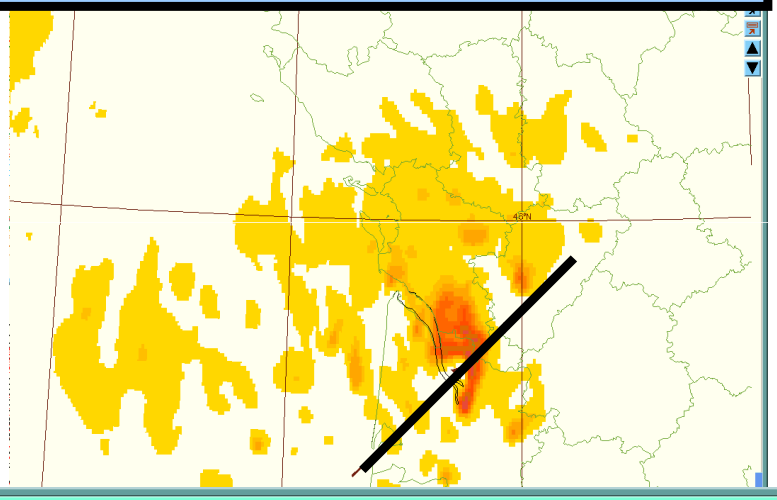
Orange : hail

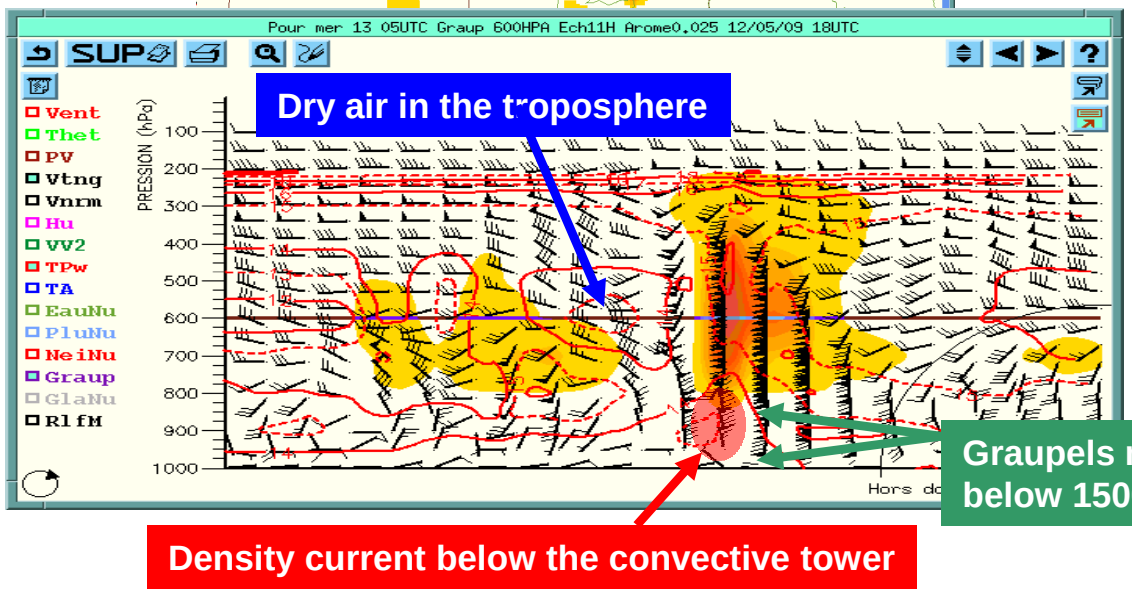
Rouge : strong hail



AROME :

Graupels at 600hPa at 5UTC (r18)

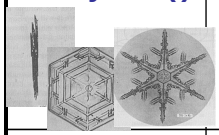
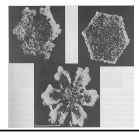
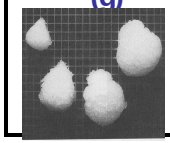




In ICE3 microphysics scheme, hail is part of 'graupel', but graupel never reach the soil *(except in winter or/and over montains)* -> Forecasters need something else to forecast hail with AROME

Evaluation of ICE4 scheme in AROME

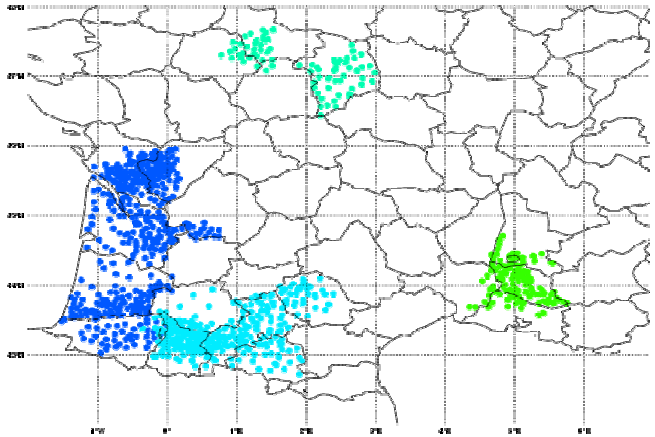
- In operational AROME version, ICE3 is used (hail is part of graupels)
- ICE4 separates graupel and hail as 2 prognostic species
- ICE4 has been evaluated over 2009 on South West of France

TYPE	Caracteristics
Ice crystals (i) 	D~10-100µm
Snow (s) 	D~1-10mm ρ_s~100kg/m^3 V~0,3-1,5m/s
Graupel (g) 	Hail and graupels D>7mm $\rho_g > \rho_s$ V~1-5m/s V_{lim}=10m/s

Grêlimètres

(30x40cm polystyrene plate) :

ANELFA Network (1054 grêlimètres) :



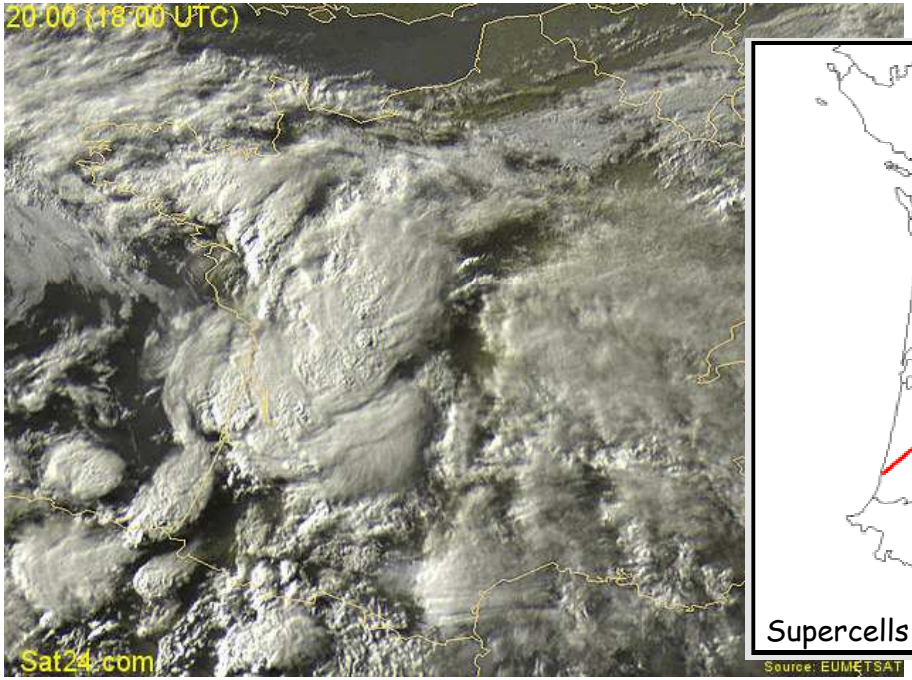
- Disappointing results : Scheme very sensitive to the time step, and too active (small amount of hail but everywhere there is graupel in altitude)
- Despite a lot of sensitivity tests, we did not manage to tune the scheme correctly

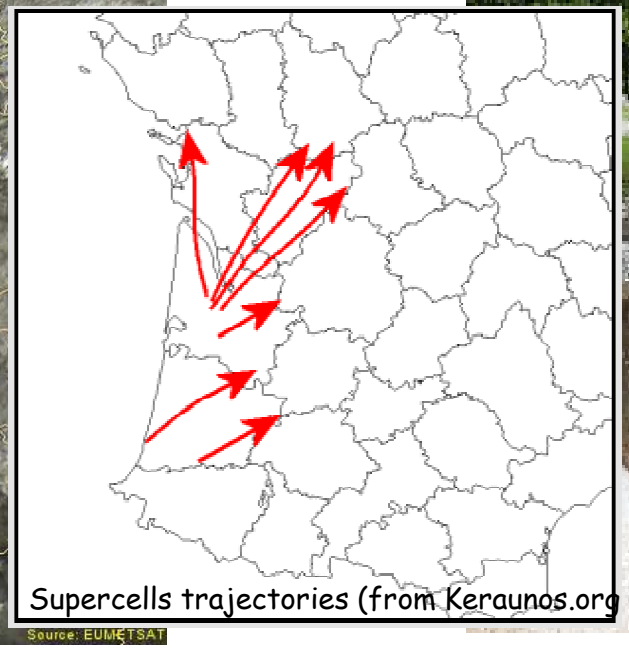
=> not ready for operational use

=> We tried to diagnose hail in the model with ICE3 :

1. Compute each time step, vertically integrated graupel content
2. Save in files the maximal value since last file (as for gusts)

11 May 2009 case





Supercells trajectories (from Keraunos.org

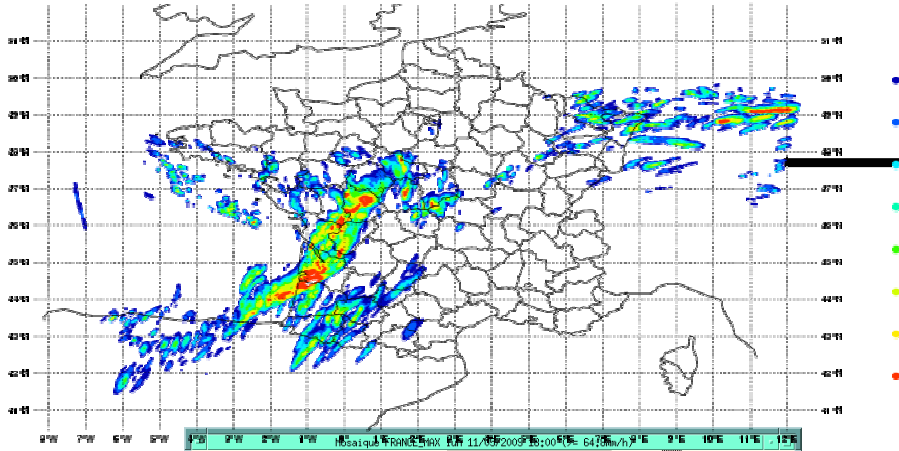
7 strong supercells observed over the South West of France in the afternoon

Hailstones up to 5cm of diameter

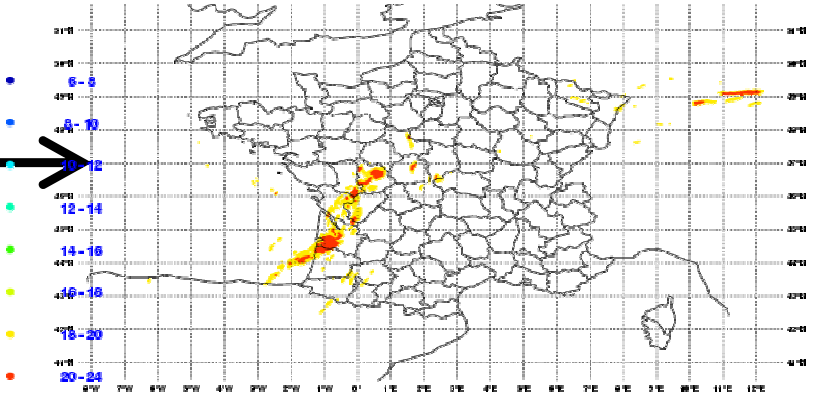
-> Significant damages on vineyards (Cognac, Margaux ….),vegetable cultures, high-school and factories, car crashs, Bordeaux-Merignac airport trafic disturbed …

Hail diagnostic (ex on 11 May 2009)

Hail diagnostic (max over 12h) :

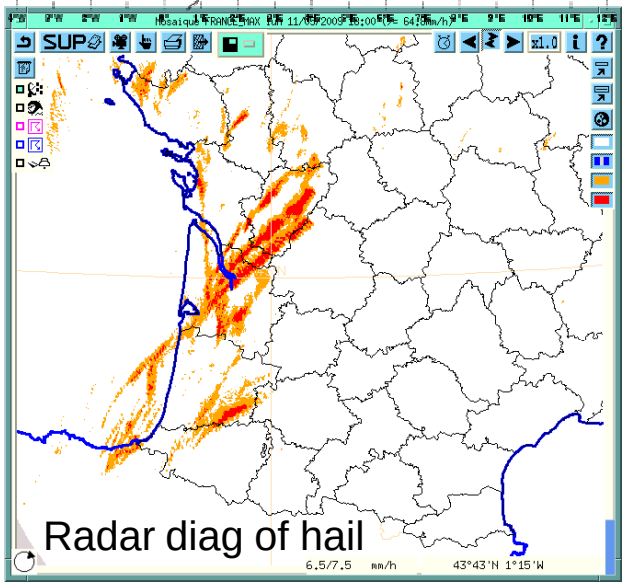


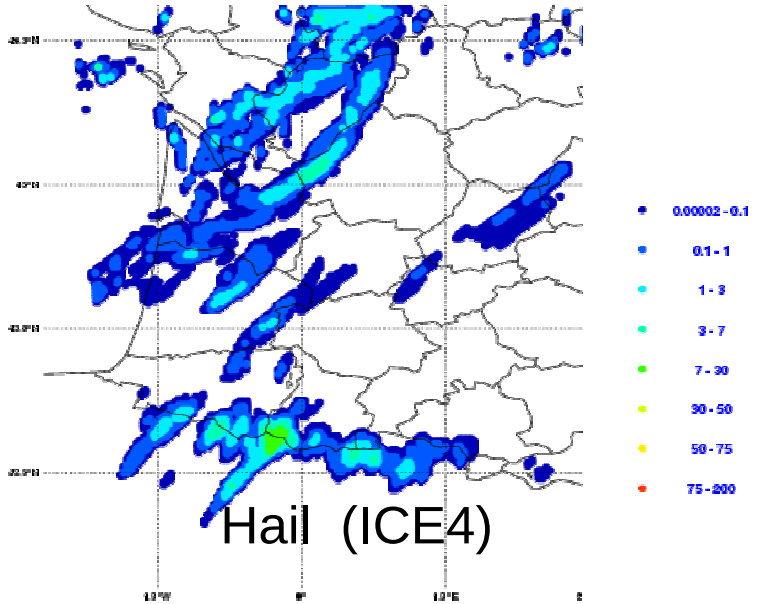
(Thresholds at 16 et 20 kg/m²)



small hail

large hail





(diag available for forecasters since September 2011)

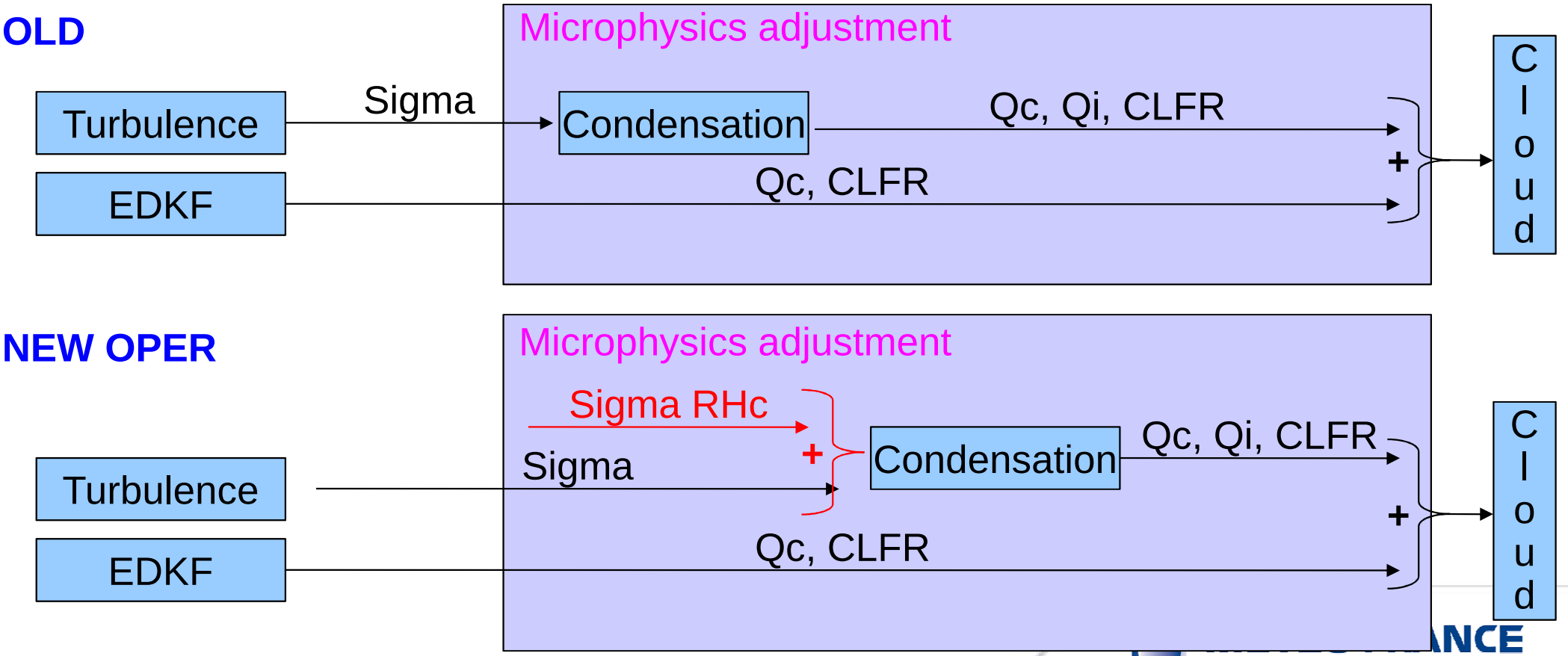
Positively evaluated during 2009 year, few 2010 cases, and 2011 summer

Modifications for subgrid clouds

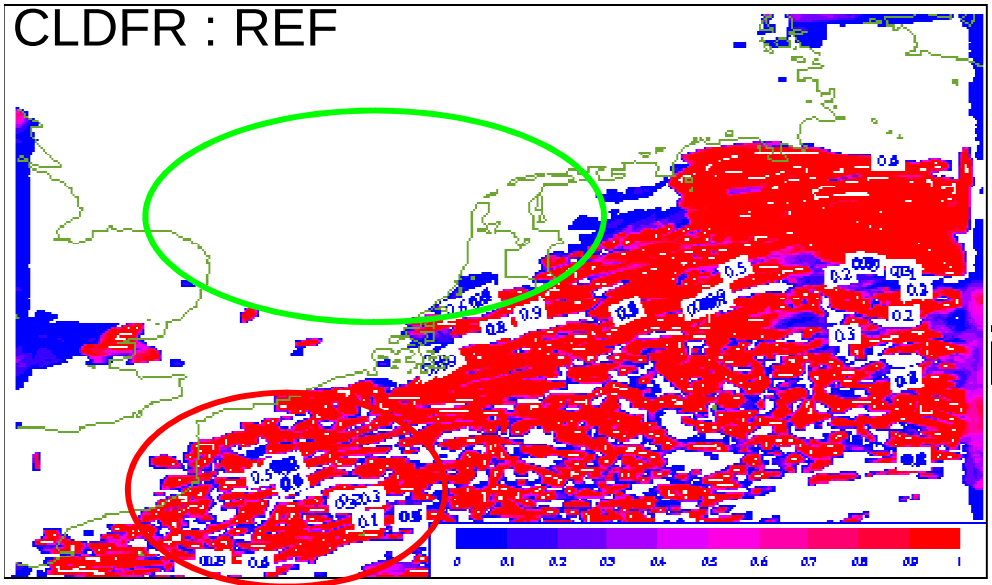
- AROME statistical cloud scheme uses $Q = \frac{q_t - q_{sat}}{\sigma_s}$ (=normalized distance to saturation)

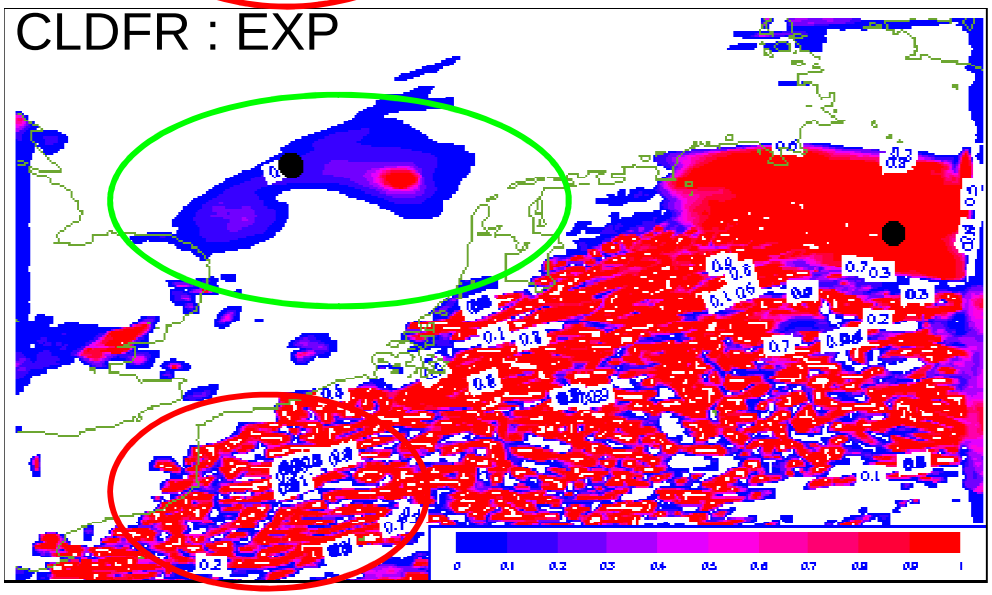
  In the previous version, σ_s comes from turbulence, but in stable situation, this term is too weak and AROME did not produce clouds

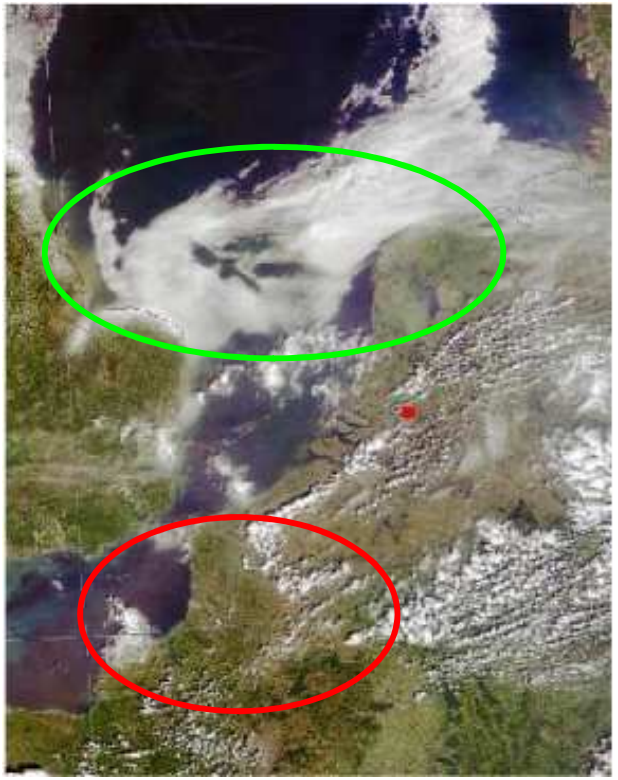
Following Wim de Roy ideas, we add σ_{RH_c} and $\sigma_s = \sqrt{\sigma_{turb}^2 + \sigma_{RH_c}^2}$ $\left(\begin{array}{l} \alpha = 0{,}02 \\ \sigma_{RH_c} = \alpha \times q_{sat} \end{array} \right)$



Example 1 : 13 May 2008 :







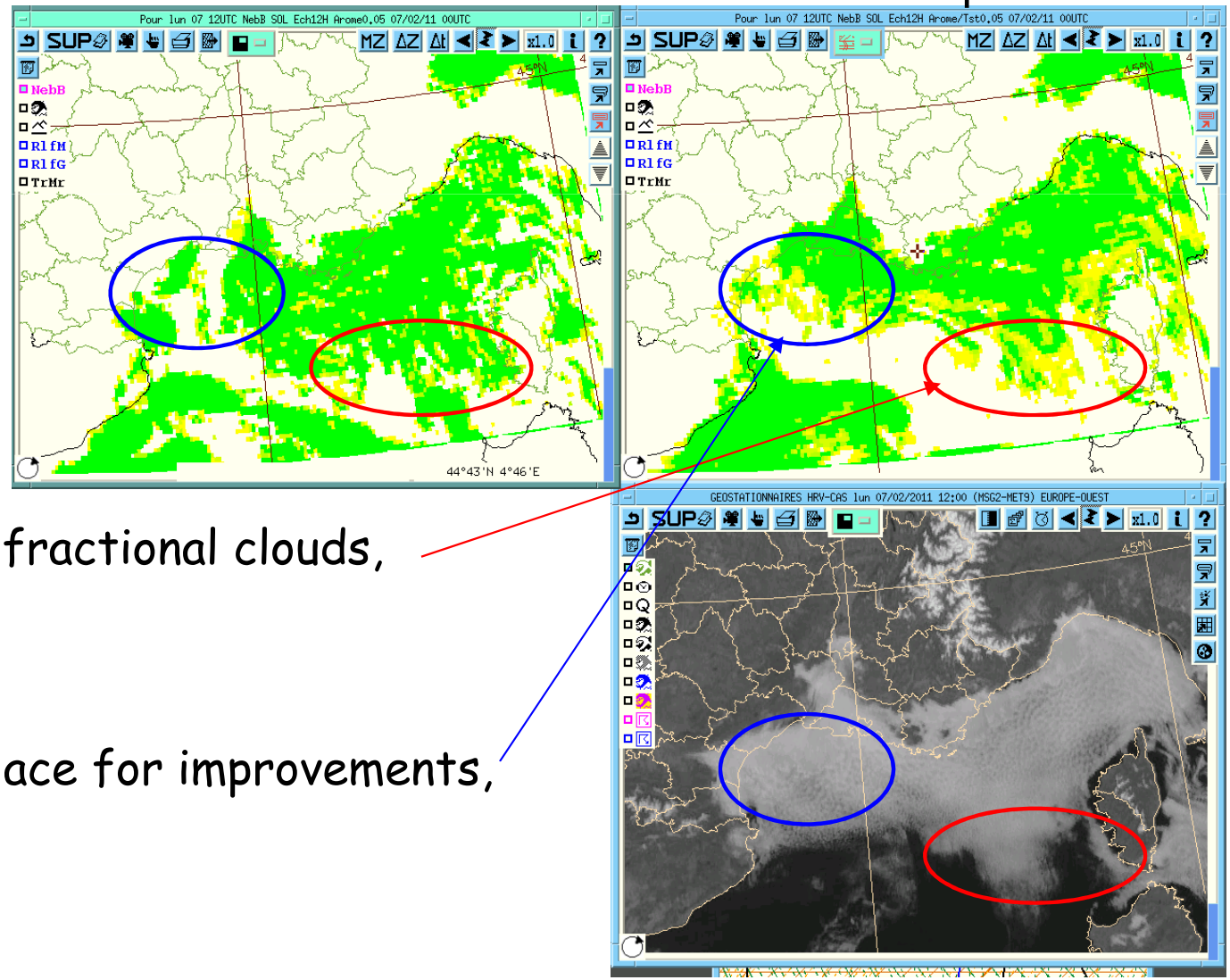
Add clouds at some places they were missed

Still over-estimation of cloud fractions on the South

Example 2 : 7 February 2011 :

AROME-ref

AROME-exp



More fractional clouds,

Still place for improvements,

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Outline

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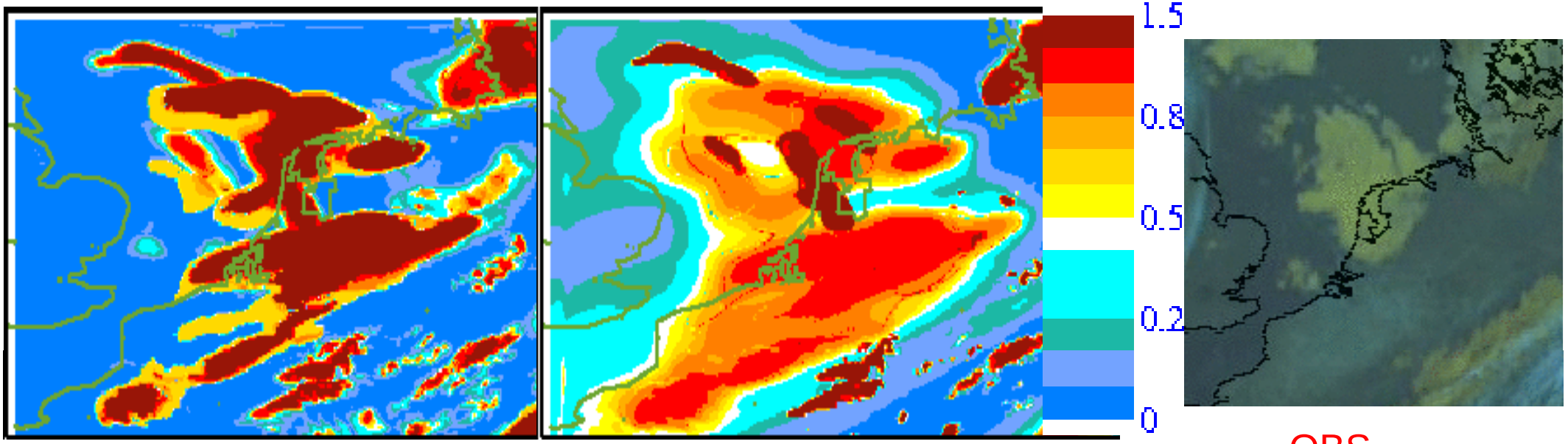
Microphysics : adjustment to saturation

- Change threshold in microphysics adjustment

Total cloudiness : 20100409 +1 TU

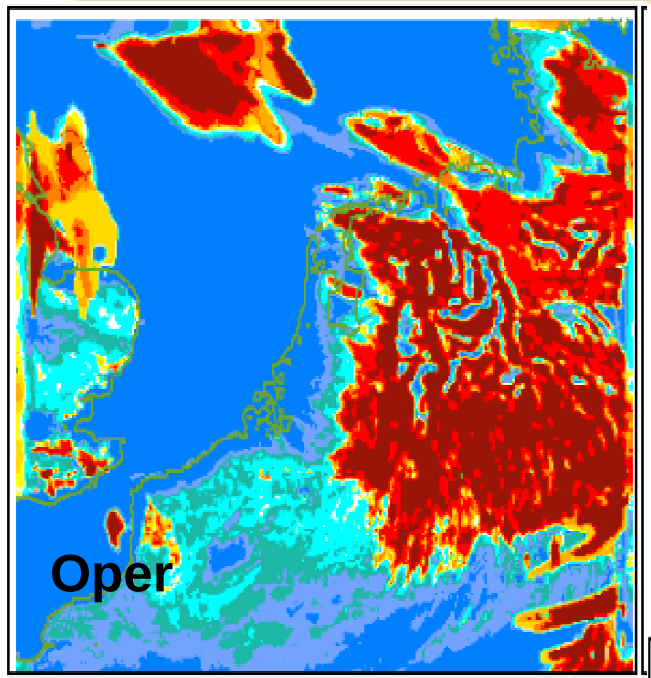


OPER : (if qc+qi < 10^{-6}, then q_c =0, q_i=0 and CF=0)

EXP : (if qc+qi < 10^{-12}, then q_c =0, q_i=0 and CF=0) (modification mostly on cirrus)

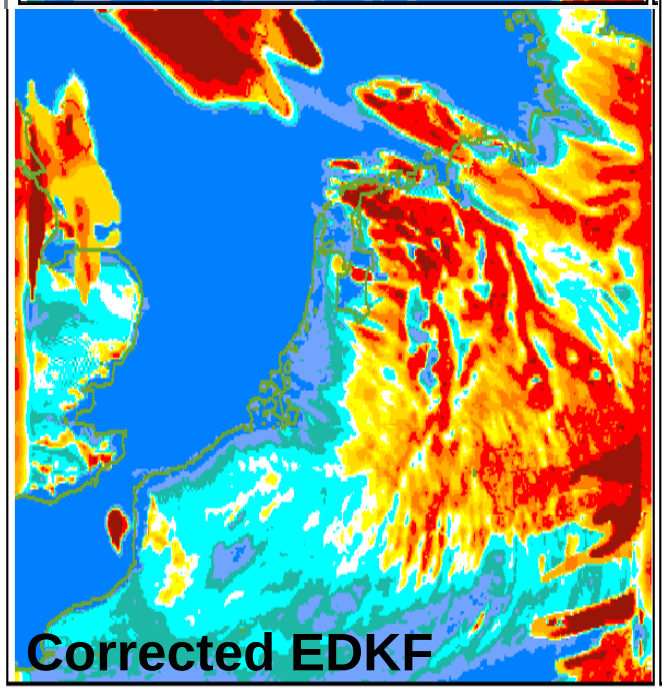
OBS

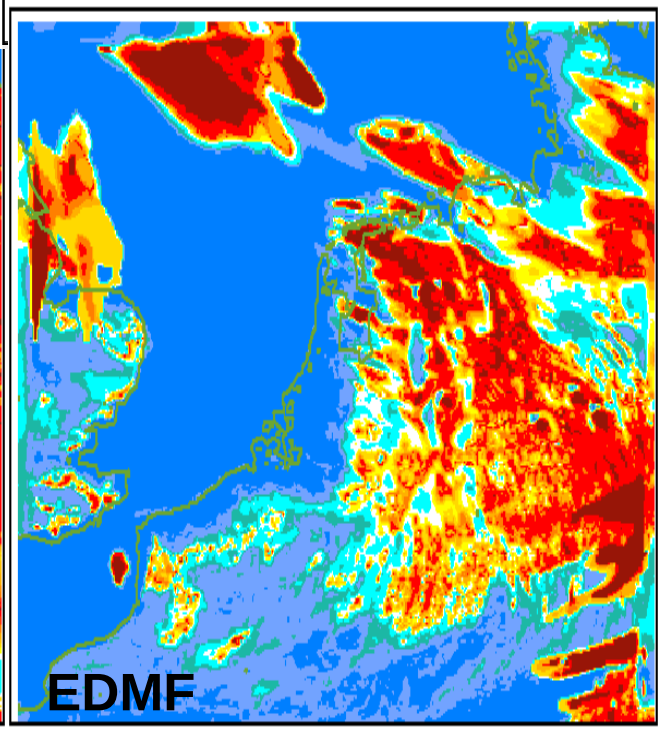
Modifications in shallow convection scheme



Corrections in EDKF *(Pergaud et al, 2009)* scheme (ice, guess used, convergence)
-> results closer to EDMF, used at KNMI

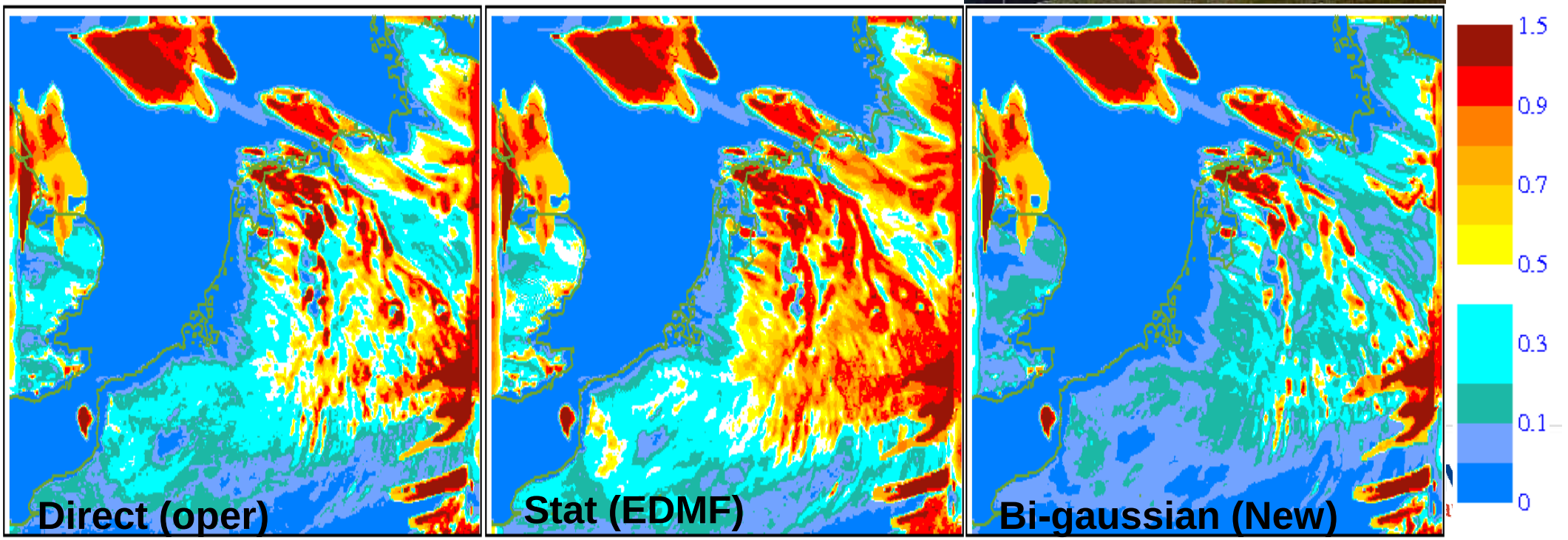
(Total cloud fractions, 9 April 2010 12TU)





Subgrid cloud schemes

- 3 methods are available :
  - « Direct » : direct use of q_c calculated in the updraft (Pergaud et al, 2009)
  - « Stat » : provide a σ_{shal} (which will be added to the one of turbulence scheme) given to adjustment process.
  - « Bi-gaussian » : bi-gaussian PDF used (Perraud et al.,2010) (2nd peak modelled using EDKF updraft specifications)



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New version of ECOCLIMAP

Available in surfex6 (CY37T1)

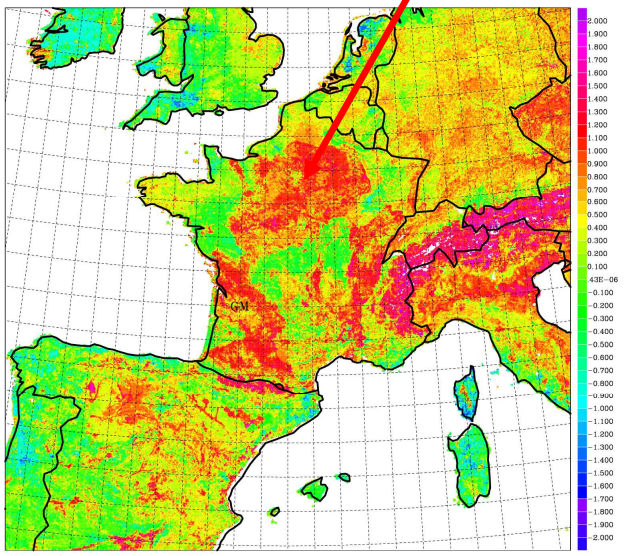
Comparison of ECOCLIMAP2 / ECOCLIMAP1 databases for surface covers :

Proportion of C3 cultures decreases but bare lands and grasslands increases

In ECOCLIMAP1, vegetation stats growing sooner than in ECOCLIMAP2

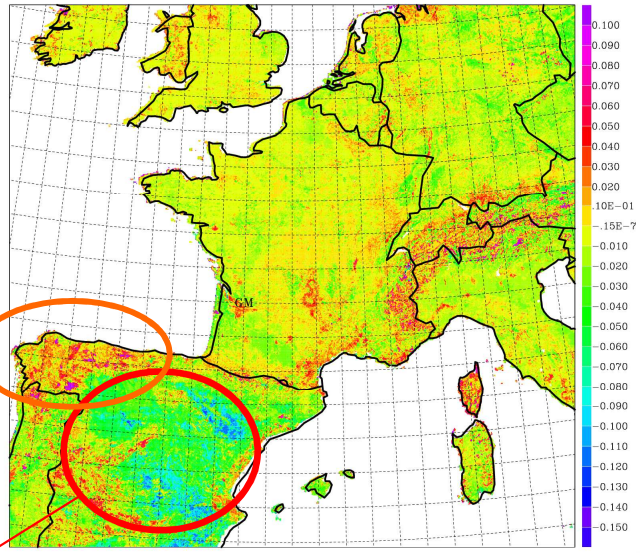
Example of impacts on surface parameters :

LAI in March ECO1-ECO2 :



LAI ECOCLIMAP1 – LAI ECOCLIMAP2

Albedo in March ECO1-ECO2 :



ALBEDO ECOCLIMAP1 – ALBEDO ECOCLIMAP2

More coniferous

More bare soil

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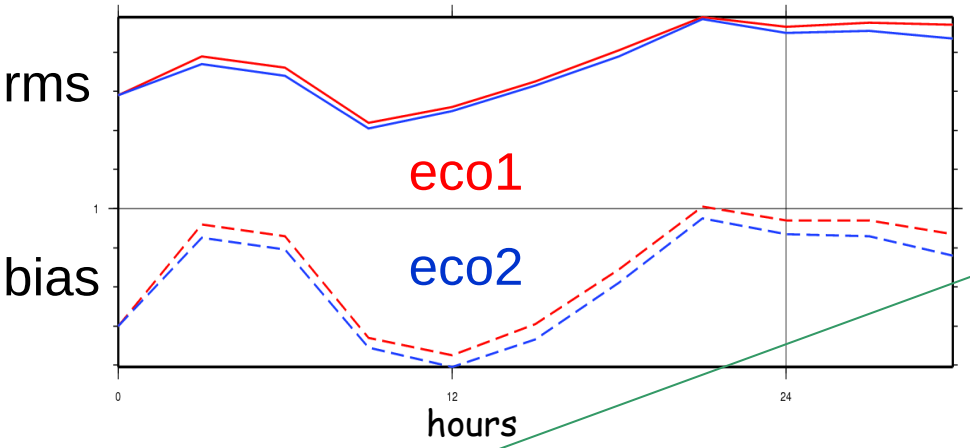
New version of ECOCLIMAP

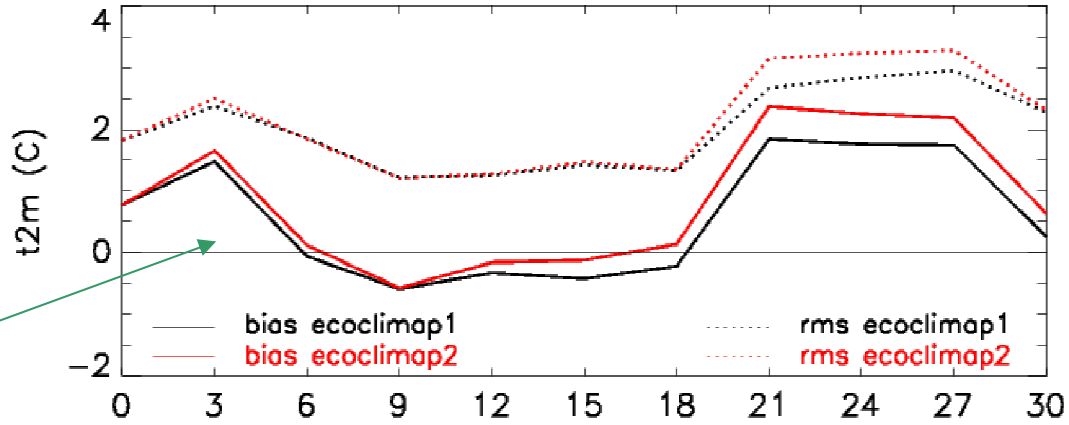
Impact on AROME real cases simulations ECOCLIMAP1 / ECOCLIMAP2 :

(12 days in 2007 (1 per month) without significant clouds over France r0+

+ on V_{10m} :

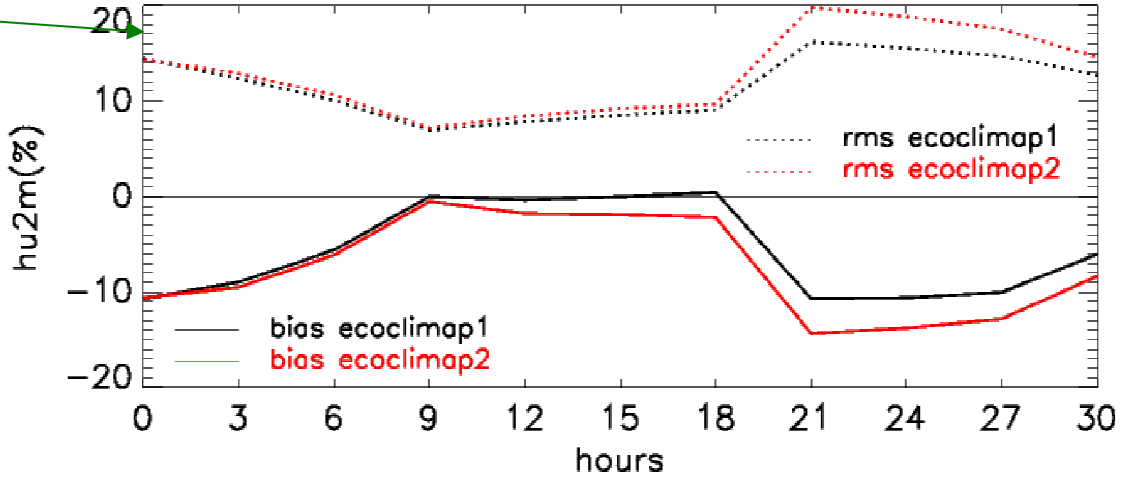


mean RMS and BIAS of T2M 20070804
(1200 stations)



+/- T_{2m} , - on Hu_{2m}

mean RMS and BIAS of HU2M 20070804
(967 stations)



Example of 4 August 2007:

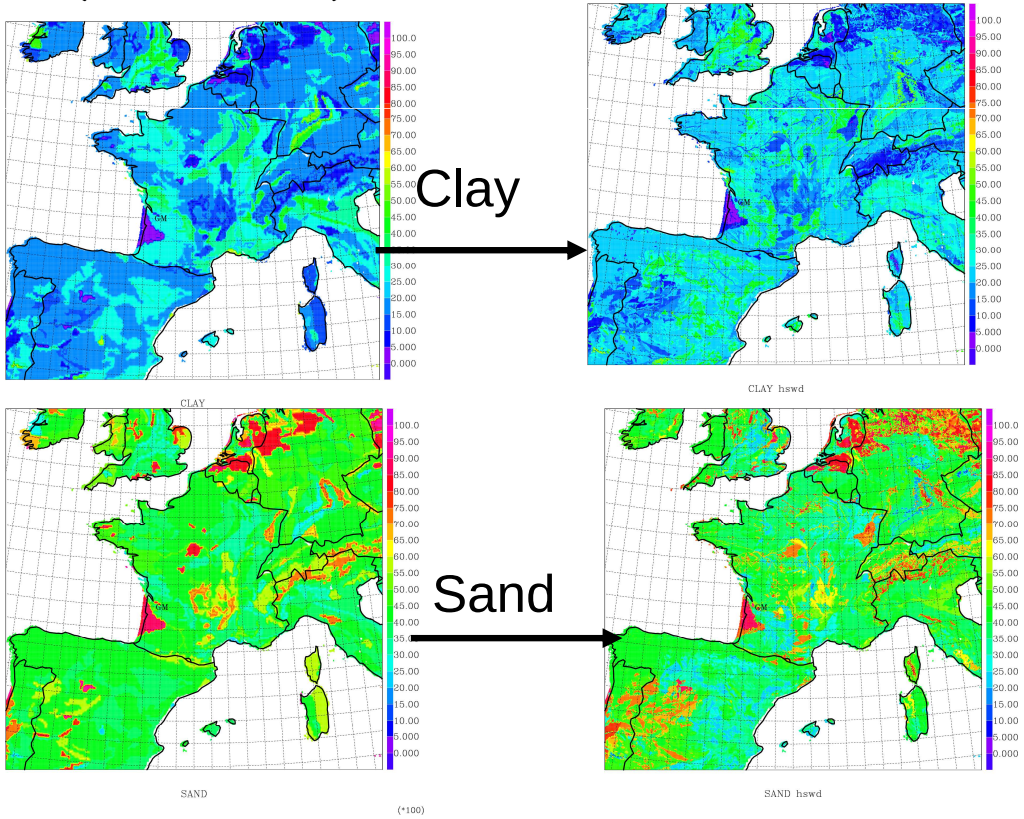
Differences linked with LAI modifications -> Ecoclimap2 more realistic ?

Tests with data assimilation

New version of clay and sand climatologies

OPER (10km database)

New (1km HWSD database)



- Neutral impact in dynamical adaptation mode (ongoing tests with data assimilation)

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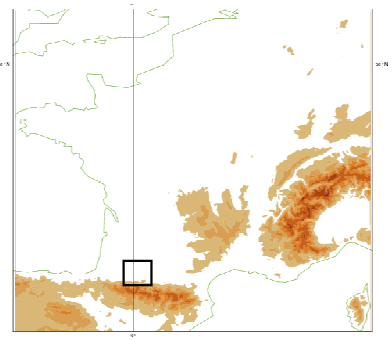
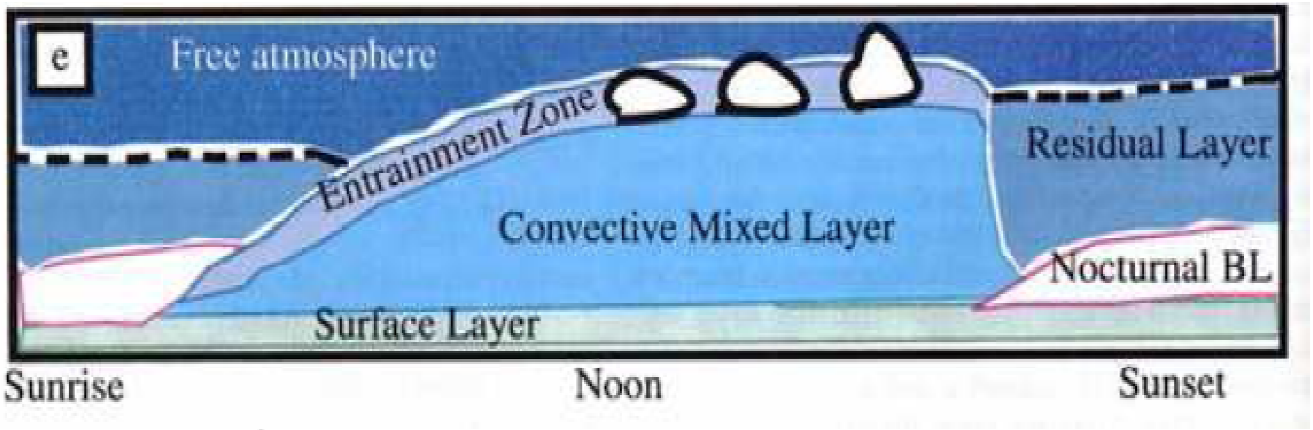
participation to the BLLAST experiment

- Boundary Layer Late Afternoon and Sunset Turbulence



15 June- 8 July around Lannemezan (SW of France) (http://www.aero.obs-mip.fr)

To study the transition from the mixed layer convective boundary layer to a residual layer overlying a stably-stratified surface layer in late afternoon

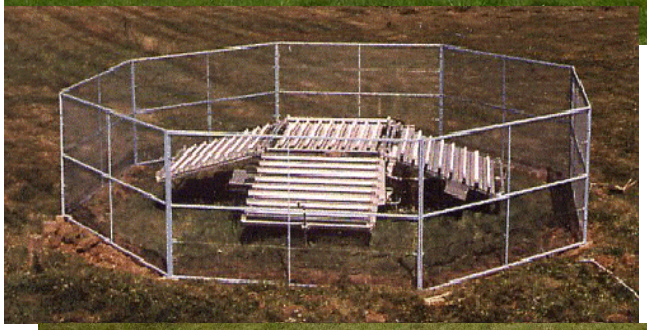


- For the model point of view, data to evalutate quality in terms of :
  - Vertical structure of the atmosphère
  - turbulence scales
  - Entrainment, wind shear quantification
  - Surface heterogeneity (Q and T soil, VEG, surface budgets…)

(http://bllast.sedoo.fr/campaigns/2011/)

BLLAST observations

14 June-8 July 2011
11 IOPs



Instrumented towers (6 at 10 m, 1 at 60 m)
tethered baloons, radiosoundings
Instrumented aircrafts and Unmanned aerial vehicules,
UHF radars, sodars, lidars
Scintillometers

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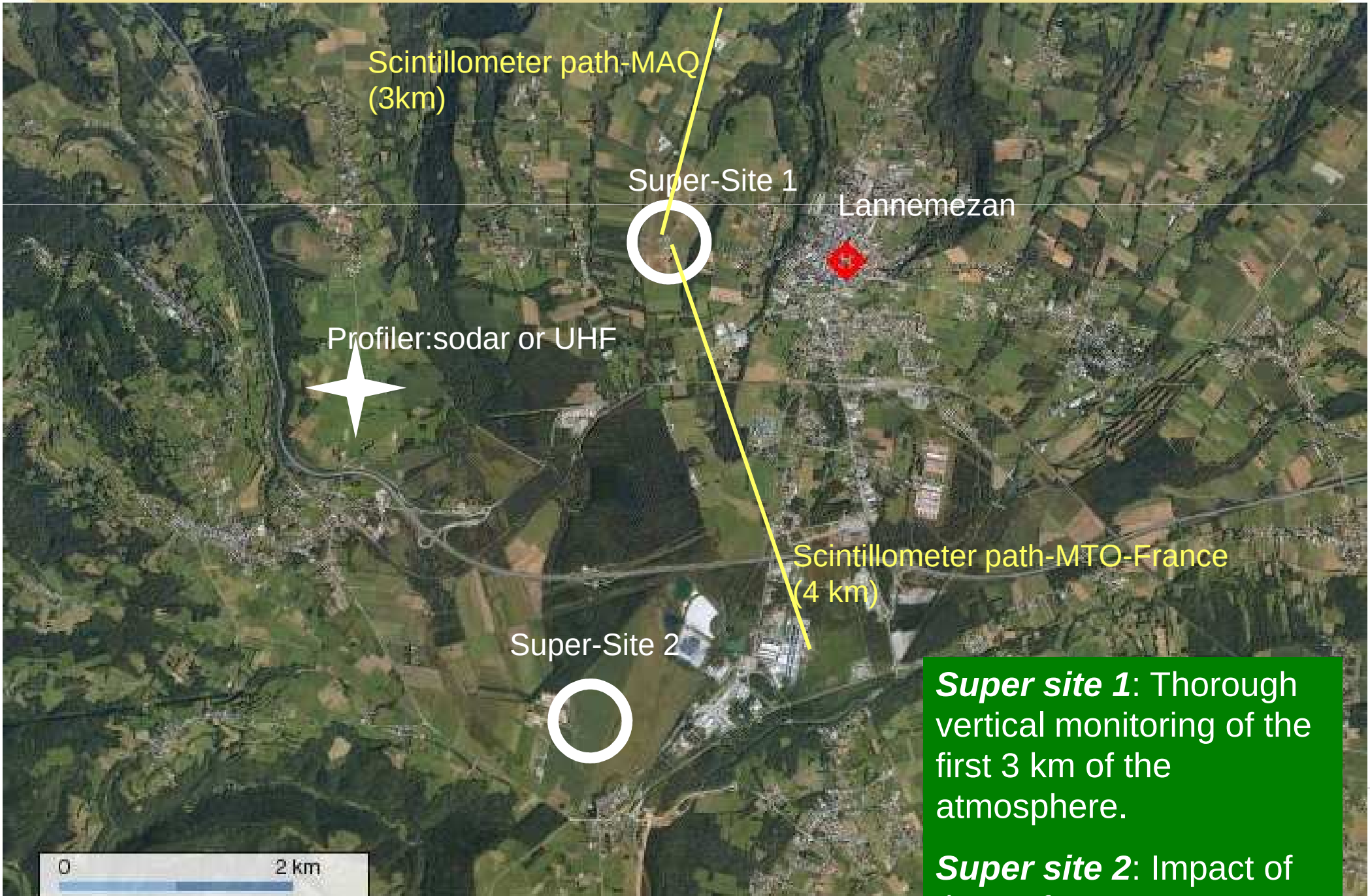
BLLAST observations

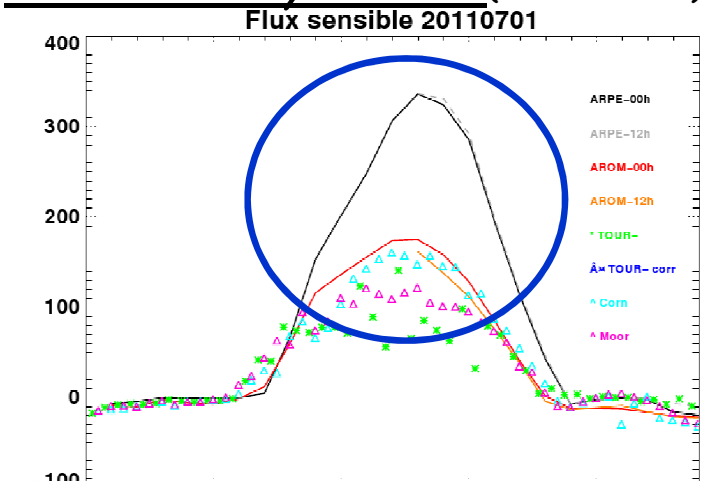


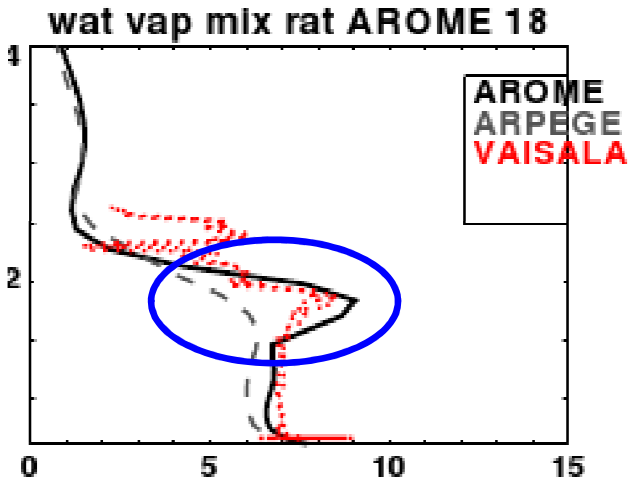
Super site 1: Thorough vertical monitoring of the first 3 km of the atmosphere.

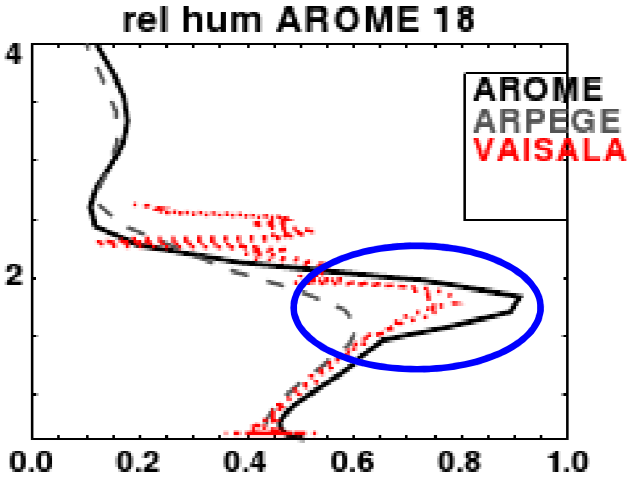
Super site 2: Impact of

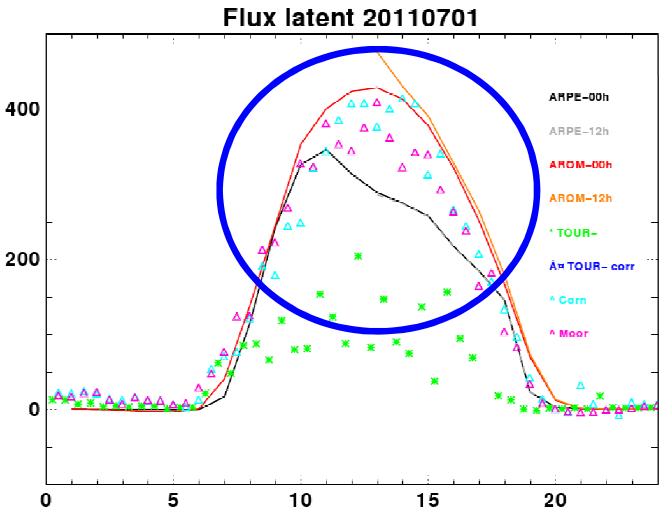
First results from the BLLAST campain

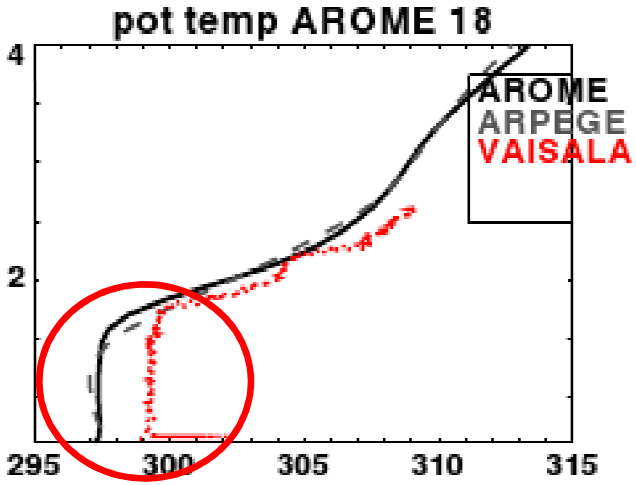
Ex : 1st July 2011 : (F. Couvreux)











AROME performs better than ARPEGE in terms of sensible heat flux and moisture

Models are too cold in the boundary layer

Deeper evaluation ongoing…

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Perspectives

- Next E-suite (Nov 2011) : Modifications for subgrid-clouds, shallow convection, new orography database, ECOCLIMAP2 and HWSD ?
- 2012 : test the use of lake surface temperature climatologies
- Evaluation of models during BLLAST
- Tuning of bi-gaussian PDF in subgrid cloud scheme
- Test EDKF with Rio et al. (2010) entrainment/detrainment
- 2014 : Thanks to a new supercomputer : 1.3km x 90levels ? -> preparatory tests

Latest developments in AROME physics

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