What's new for the physics in the coming month ?

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with several contributions from GMAP Team
Météo-France/CNRM

Aladin/Hirlam
Joint 26th Workshop All Staff Meeting
Lisbon 4-7 April 2016

Introduction

- SURFEX in ARPEGE ..
- PCMT in ARPEGE …
- TTE/EFB some news ….
- Low clouds in AROME ?

SURFEX in ARPEGE …
(Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

- Use the ECOCLIMAP v1 database : ECOCLIMAP (1km), HWSD @ 1km (sand, Clay), GMTED2010 (1km, not used), Albédo MODIS (only available in V8)
- Sea surface fluxes from ECUME or COARE

- ISBA-3L vs ISBA-2L
- One layer snow scheme from Douville.
  - differences with the ARPEGE snow scheme: snow inertia, snow fraction over bg and vegetation, soil freezing.

ARPEGE/ALADIN

(based on Douville et al, 1995, Bazile et al 2002 for the snow fraction on the vegetation)

To take into account the snow on the leaves and the fall below the canopy, a function F was introduced. F is a decreasing function of both the LAI and the snow age through the snow albedo equation

$$P_{sn}^{bg} = \frac{SNW}{SNW + 10}$$

$$P_{sn}^{veg} = P_{sn}^{bg} \cdot F(Lai, snow\_age)$$

$$F = 1 - \frac{Lai}{7} \cdot \frac{\alpha_1 - \max(\alpha_0, \alpha_{SN})}{\alpha_1 - \alpha_0} \qquad \alpha_0 = 0.84 \quad \alpha_1 = 0.87$$

$$LAI \le 2.9 \Rightarrow F = 1$$

AROME (Douville et al, 1995)

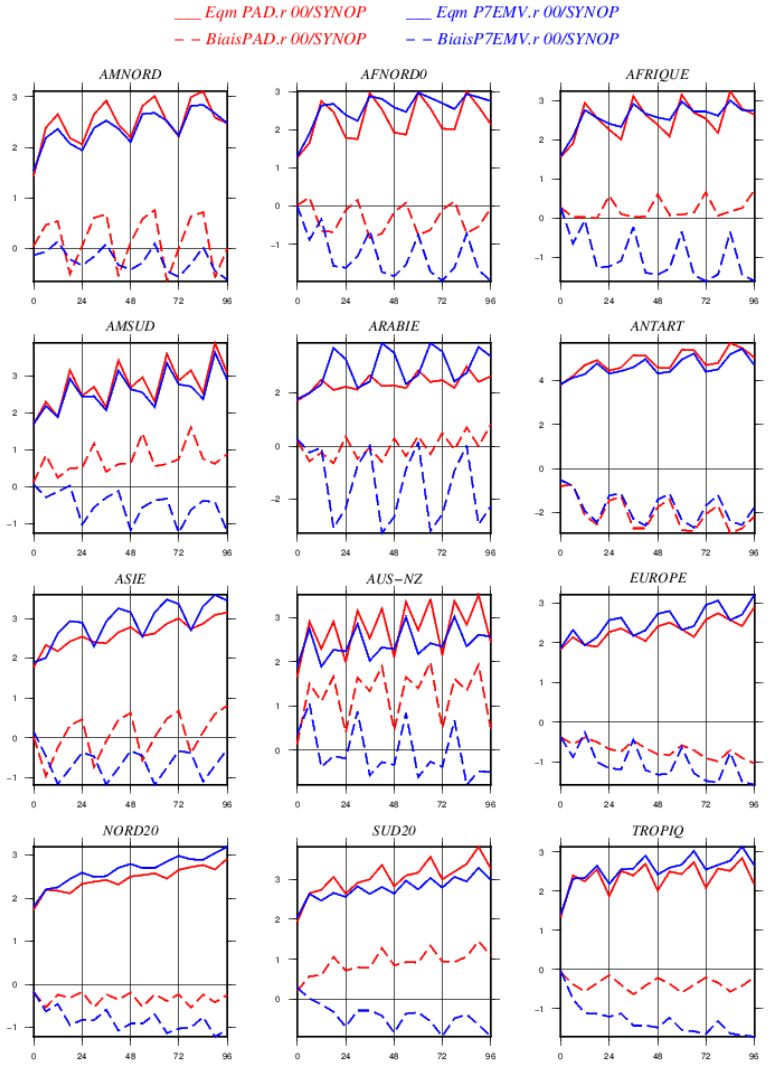
$$P_{sn}^{bg} = \frac{SNW}{SNW + 10 \cdot (1 + z_{0\_oro})}$$

$$P_{sn}^{veg} = \frac{h_n}{h_n + 5 \cdot z_{0\_veg}} \qquad h_n = \frac{SNW}{\rho_{sn}}$$

$$p_{nc} = \min(1, \frac{SNW}{70})$$

Preliminary test in dyn. adaptation
(Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

T2m 20151011-20151024
ARPEGE-SURFEX-Conf AROME(blue)
ARPEGE(red)



T2m 20151011-20151024
ARPEGE-SURFEX-with modified Cg
and min snow albedo=0.65
ARPEGE(red)

Preliminary test in dyn. adaptation
(Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

T2m 20151011-20151024
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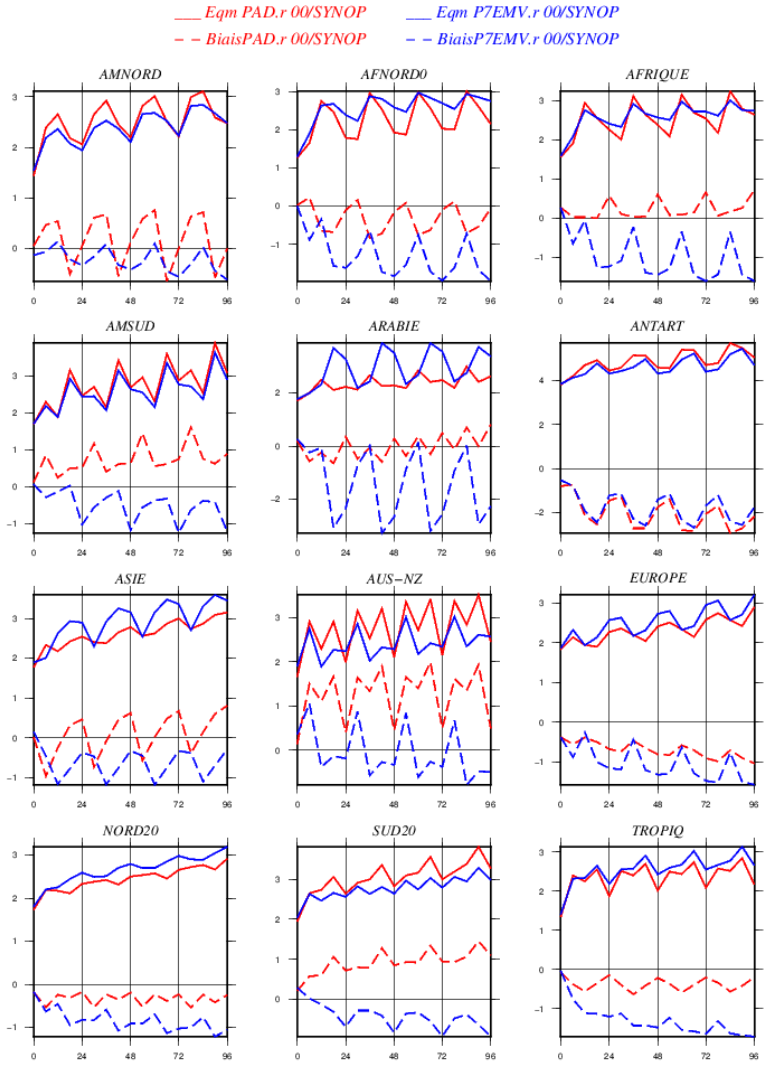
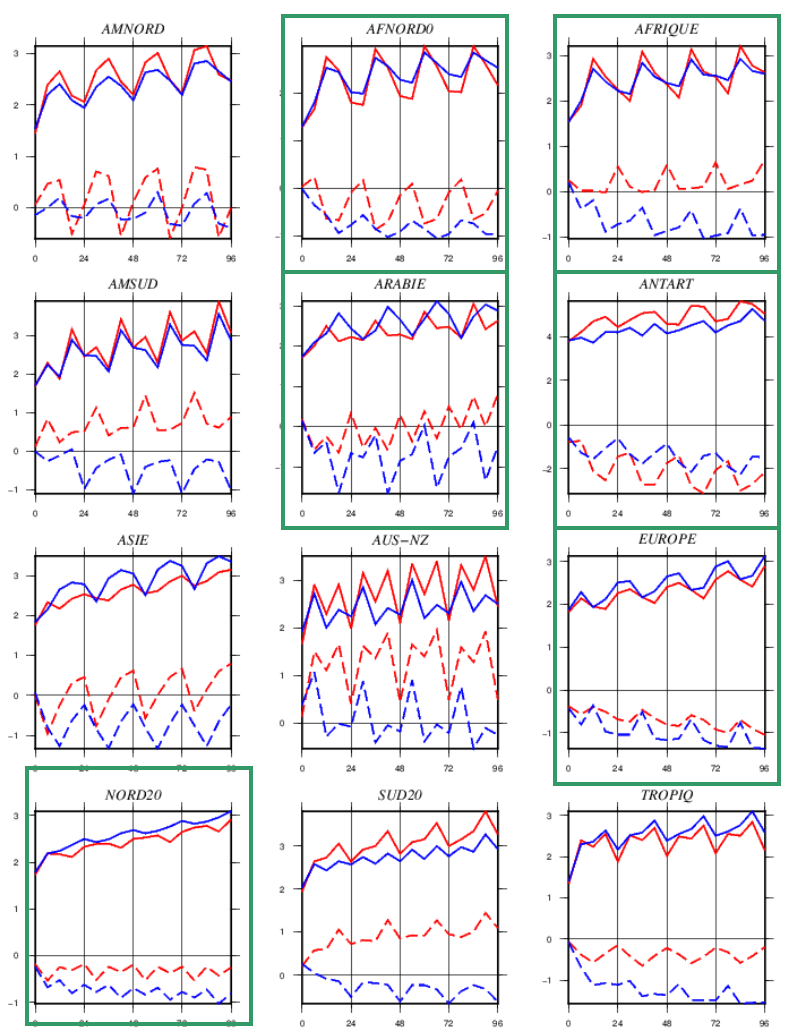
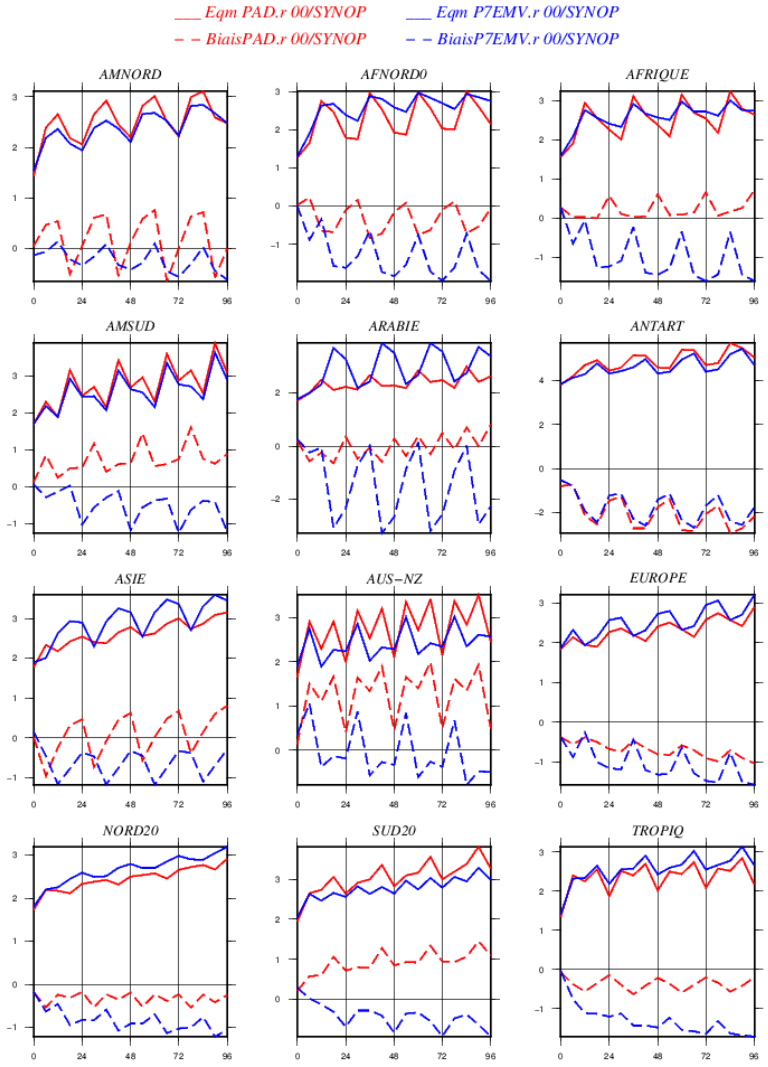


T2m 20151011-20151024
ARPEGE-SURFEX-with modified Cg
and min snow albedo=0.65
ARPEGE(red)

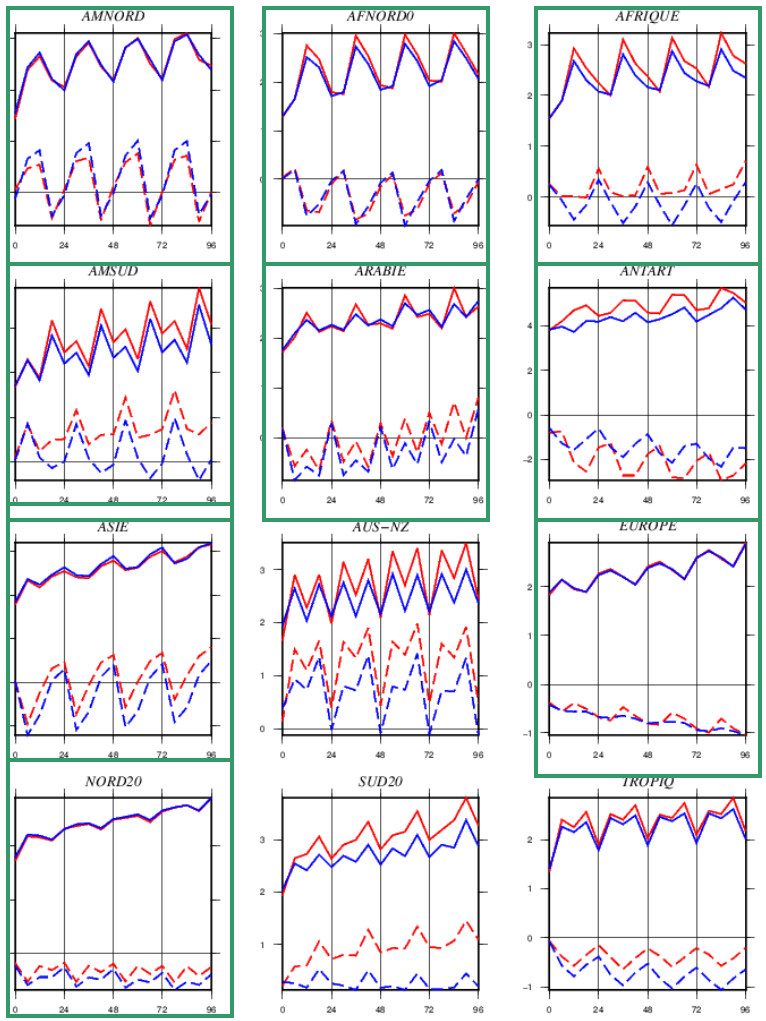


Preliminary test in dyn. adaptation (Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

T2m 20151011-20151024
ARPEGE-SURFEX-Conf AROME(blue)
ARPEGE(red)

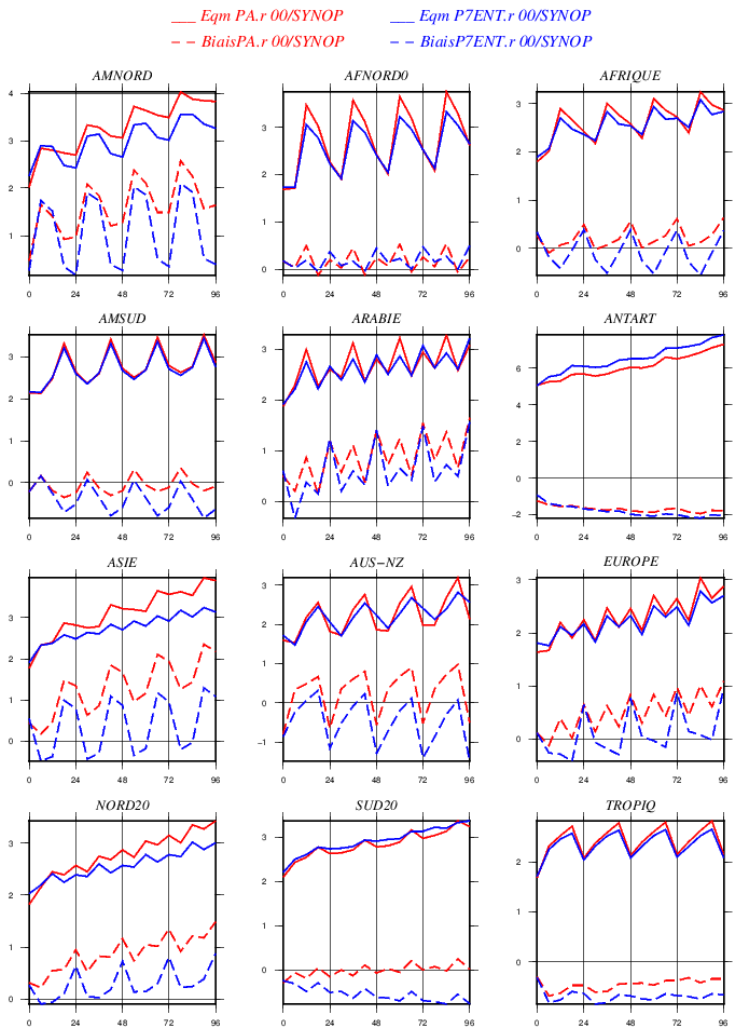


T2m 20151011-20151024
ARPEGE-SURFEX-with modified Cg,
Cv, min snow albedo=0.65, soil freezing
ARPEGE(red)

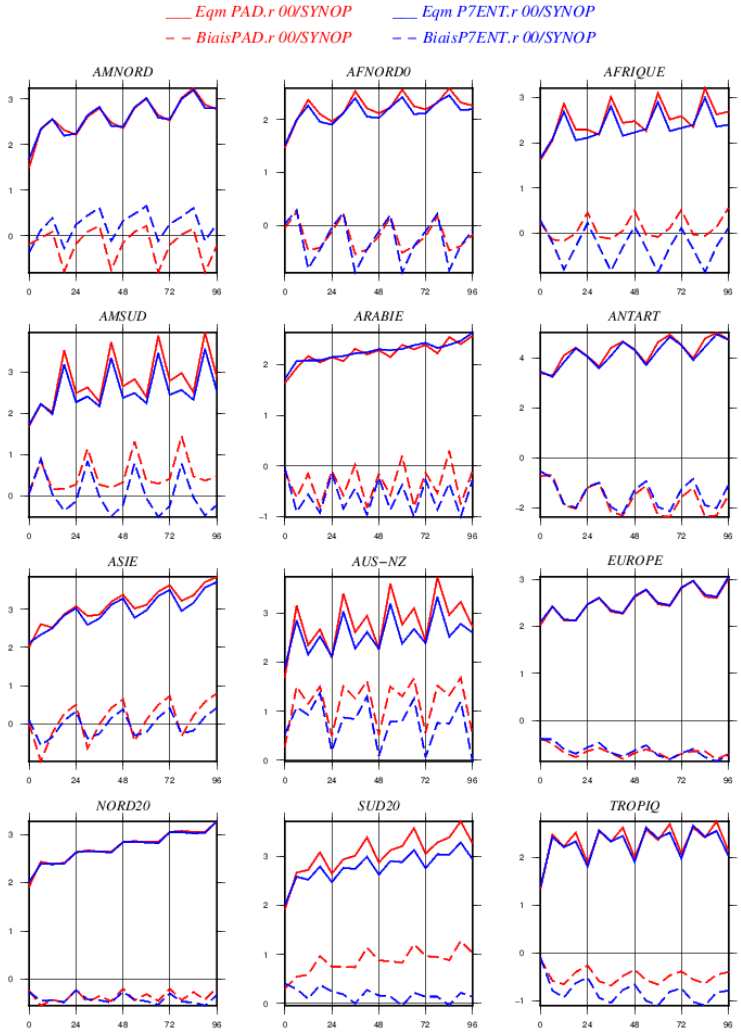


Preliminary test in dyn. adaptation (Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

T2m 20150615-20150819
ARPEGE-SURFEX (blue)
ARPEGE(red)



T2m 20151011-20151207
ARPEGE-SURFEX (blue)
ARPEGE(red)



Preliminary test in dyn. adaptation (Y. Bouteloup, F. Taillefer, F. Bouyssel and GMAP team)

- Status: dynamical adaptation from ARPEGE-ISBA works using coupling surf. **Results are globally positive (in dyn. Adaptation) with** modifications in the SURFEX namelist compared to AROME such as :
- */surfex/SURFEX/ini_data_param.F90

  PCV(JLOOP,:)=0.8E-5 ← 2.E-5 (default)

< IF(PTYPE(JLOOP,NVT_TREE)>0.) PCV(JLOOP,NVT_TREE)= 0.8E-5 ← 1.E-5 (default)

< IF(PTYPE(JLOOP,NVT_CONI)>0.) PCV(JLOOP,NVT_CONI)= 0.8E-5 ← 1.E-5 (default)

< IF(PTYPE(JLOOP,NVT_EVER)>0.) PCV(JLOOP,NVT_EVER)= 0.8E-5 ← 1.E-5 (default)

- */surfex/SURFEX/modd_isba_par.F90

< REAL, PARAMETER :: XTAU_ICE = 25000. ← 3300 (default) (in ARPEGE 1./CGGEL~33000 s)

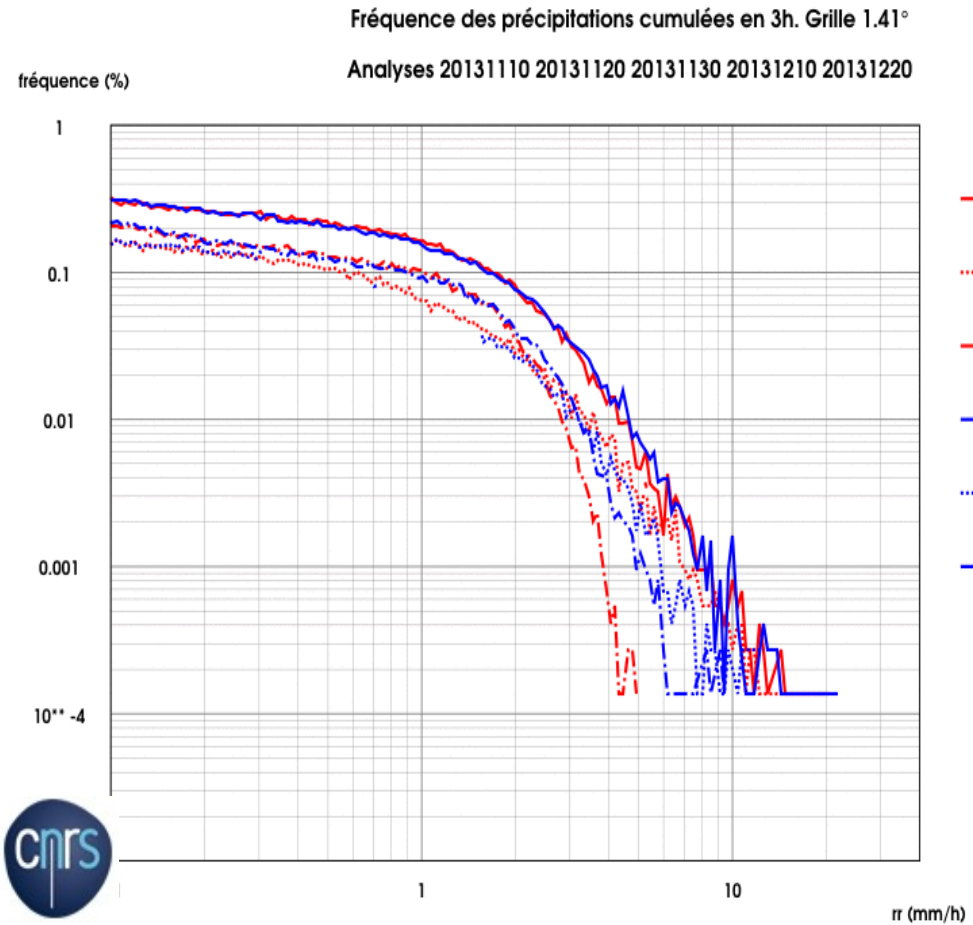
- XANSMIN=0.65
- More evaluation especially during winter for the snow scheme and the soil freezing parameter. Ideally, during a full year with surface assimilation (including soil moisture assimilation)
- Rh2m better, neutral for cc and RR. Wind depends on the area …
- For the 4D Var: running, with no SURFEX in the 131. As coding of needed ISBA fields from SURFEX is not finished, the cycling tests are done with oper isba variables in 131, so no "official" results …
- several surface and soil outputs are necessary: required several modifications in mse
- Time computation +3% for the ARPEGE forecast.

PCMT …
(J.M. Piriou, J.F. Gueremy and GMAP team)

- 5 more pro. Variables (ql_sub, qi_sub, qr_sub, qs_sub, w_updraft)

Cost: +10% and memory +7%

- Recent modifications :
  - implicit solution for turbulence and convection (necessary for long time step)
  - mixed closure: CAPE and moisture convergence



PCMT: CAPE Closure

PCMT: CAPE – CVGQ Closure

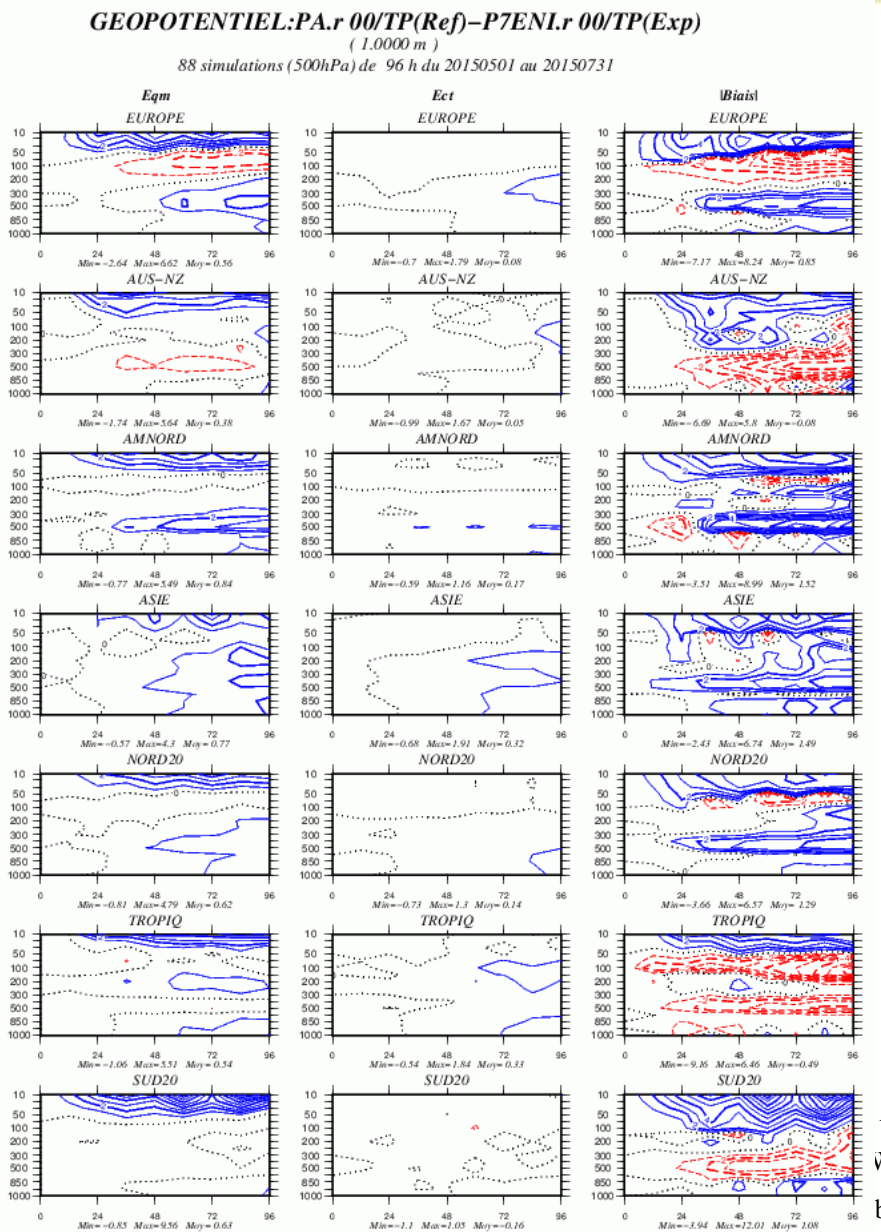
Full line : total RR

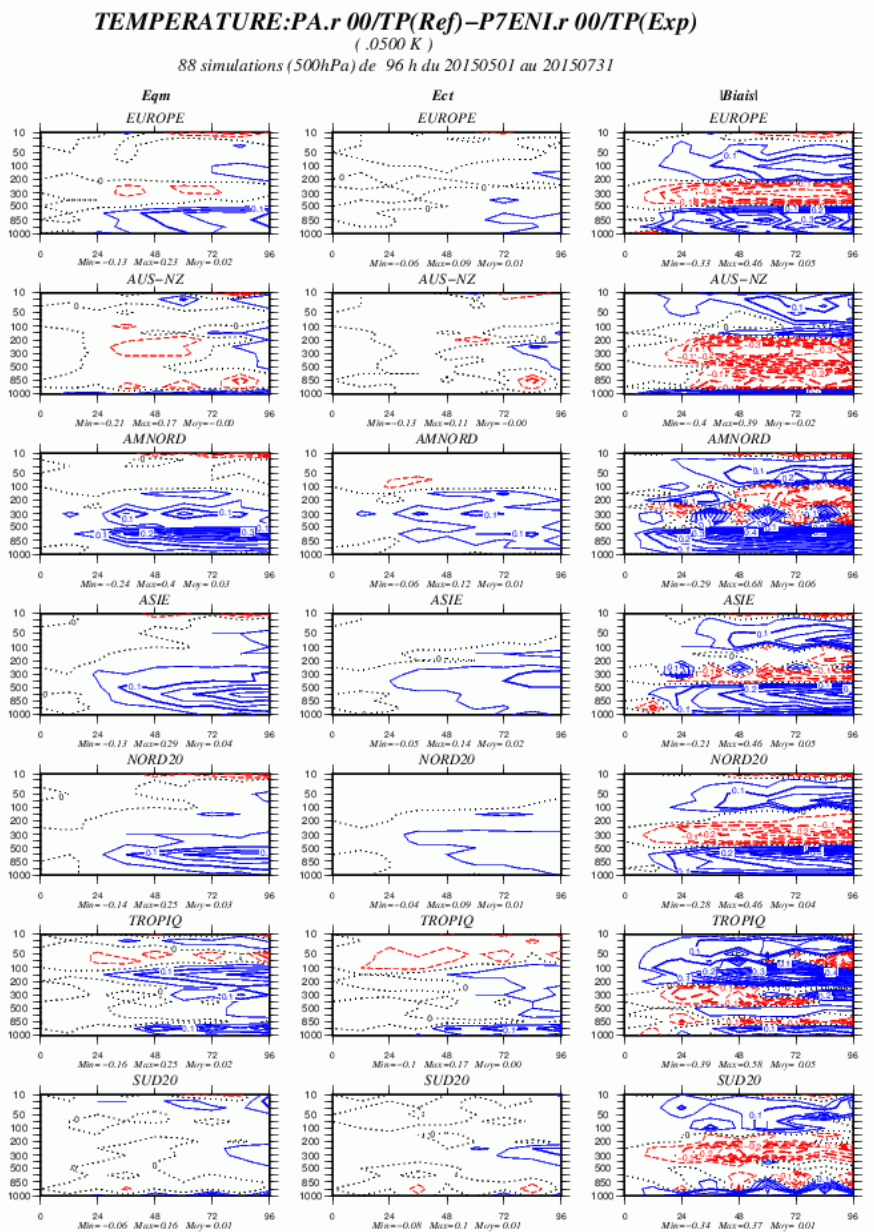
Dotted line : Resolved RR

Dashed line: Sub-grid RR

With the CAPE_CVGQ closure : less high intensity of resolved RR.

PCMT vs Oper T1198
(20150501-20150731)

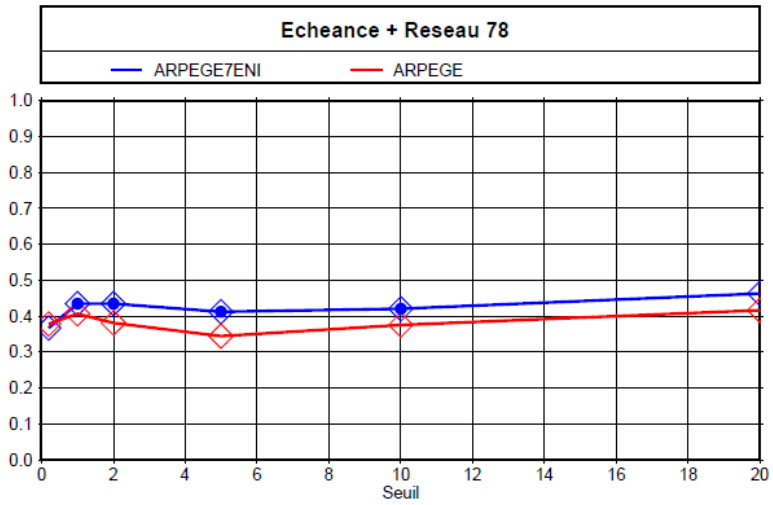


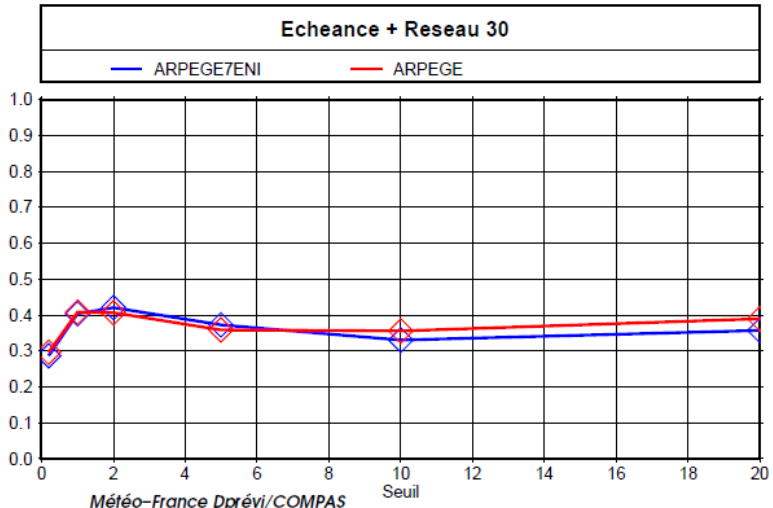


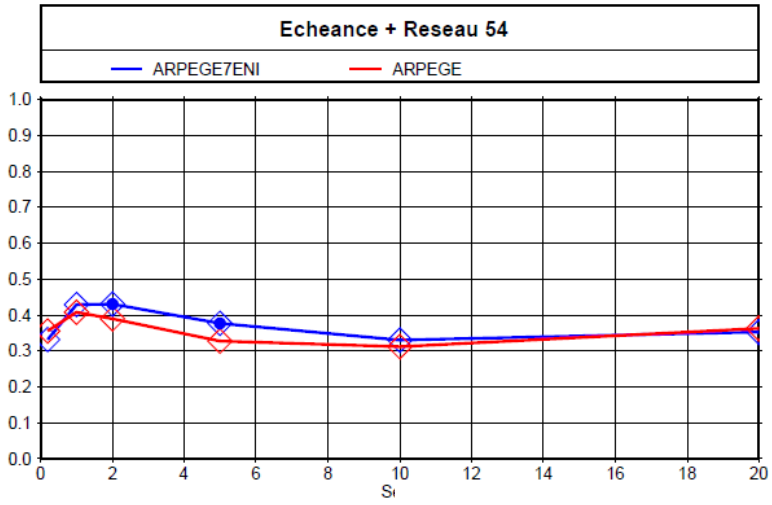
PCMT vs Oper T1198
(20150501-20150731)

Contrôle probabiliste des précipitations 24h : Comparaison des modèles Réseau de 0 heure Voisinage 5.3km

Grille FRANGP01 BSS_NO en fonction du seuil / Période 20150501 – 20150731 / Référence BDCLIMQ





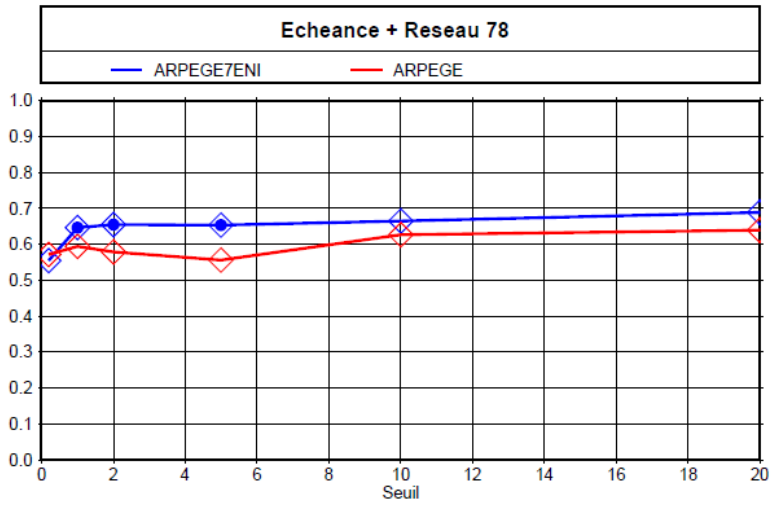


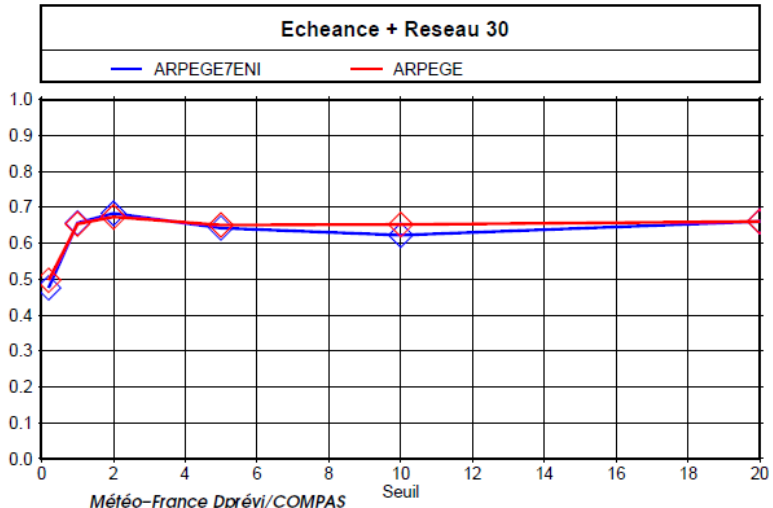
Météo-France Dprévi/COMPAS
Actualisé le 06/02/2016

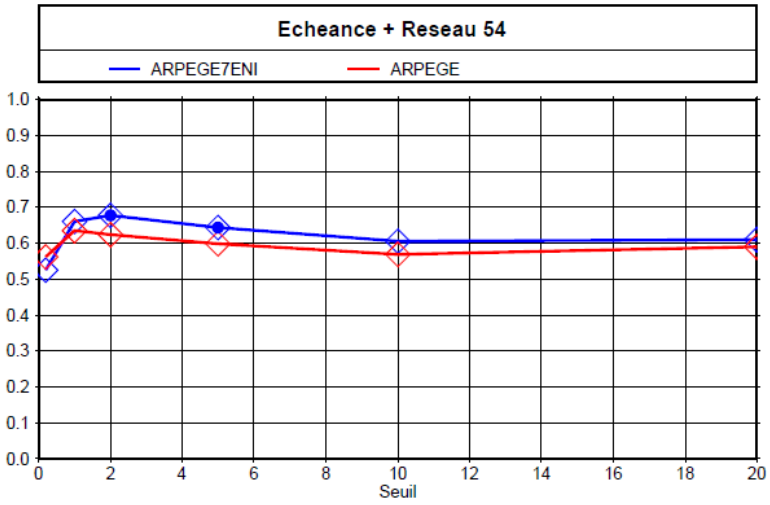
PCMT vs Oper T1198
(20150501-20150731)

Contrôle probabiliste des précipitations 24h : Comparaison des modèles Réseau de 0 heure Voisinage 56.8km

Grille FRANGP01 BSS_NO en fonction du seuil / Période 20150501 – 20150731 / Référence BDCLIMQ





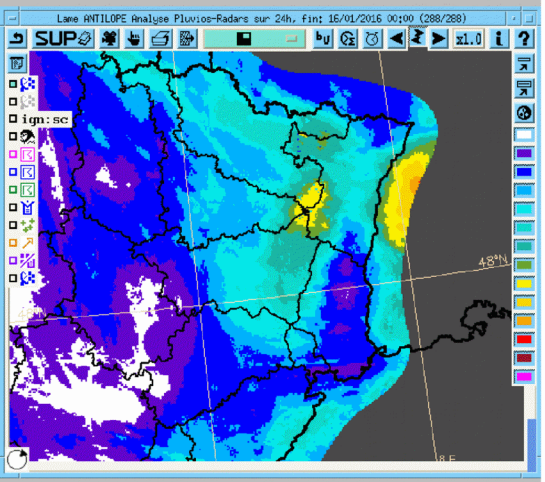


Météo-France Dprévi/COMPAS
Actualisé le 06/02/2016

PCMT vs Oper T1198
(20150501-20150731)

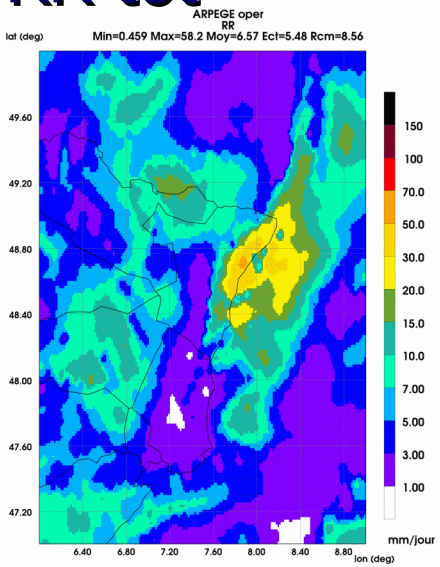
RR tot **RR rés.** **RR sous-m.**

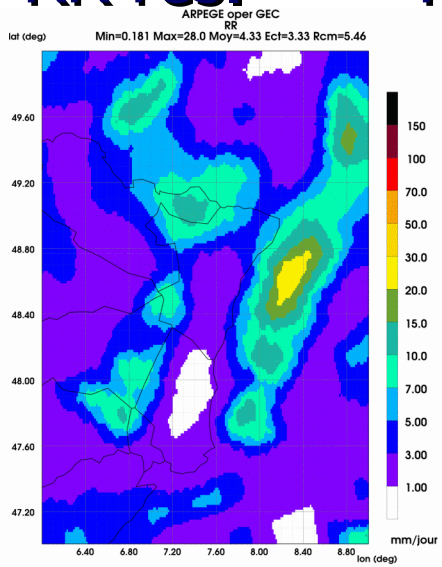
ARPEGE oper

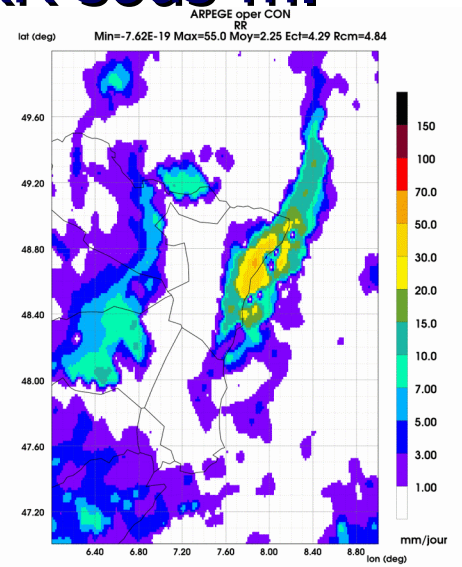


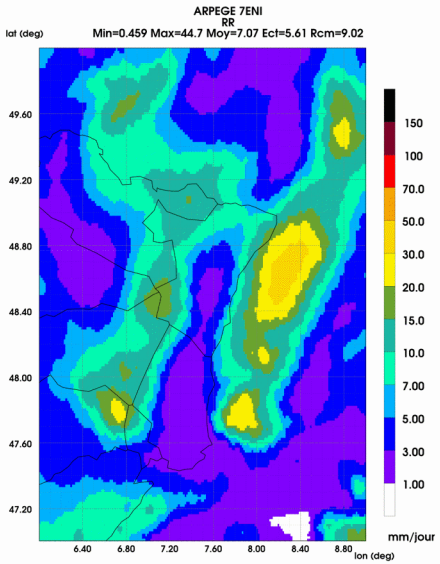
Radar

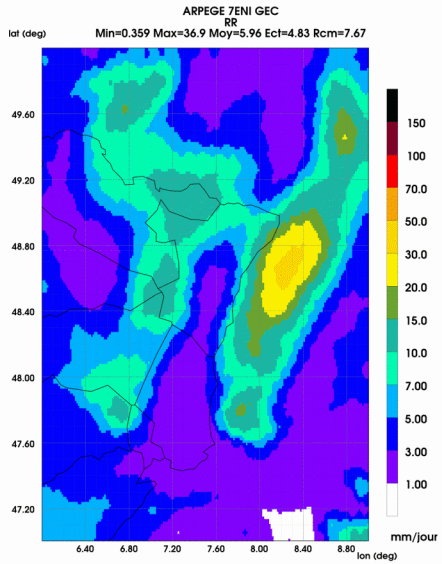
ARPEGE PCMT

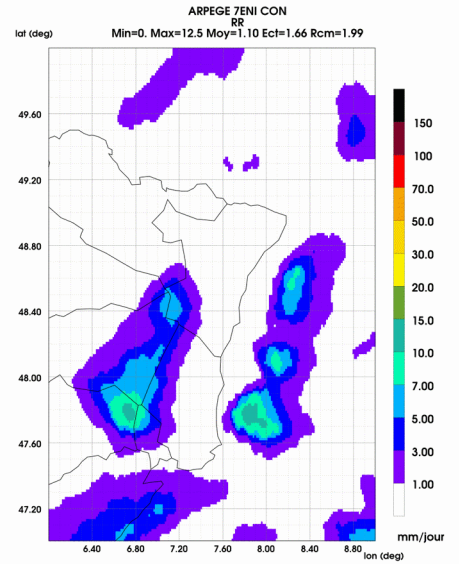












Why TTE / EFB ?

- Mauritsen et al. (2007) suggests to replace the TKE pronostic eq. by the TTE . Angevine et al. (2010) use the TTE eq. with a mass flux scheme in WRF (TEMF)
- Energy Flux Budget Closure (Zilitinkevitch et al, 2013) and a working week was organized in Toulouse in March 2012.
- **Motivations:**
  - improves the stable case : avoid the collapse of the turbulence partly due to the negative thermal production
  - Increase the momentum mixing above 700hPa
  - **Negative aspect** : no humidity in the closure, 5 pro. Eq (TKE, TPE, u'w', v'w', w'theta' + dissipation time scale (l/sqrt(TKE))

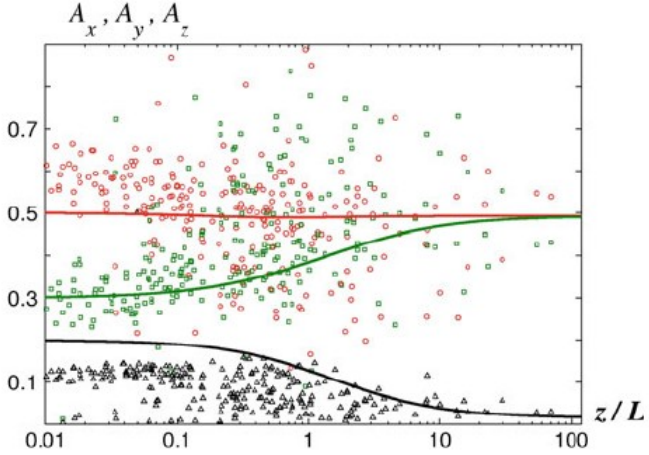


Fig. 3 The shares of the turbulent kinetic energy E_K: longitudinal $A_x = E_x/E_K$ (along the mean wind, *red circles*), transverse $A_y = E_y/E_K$ (*green squares*) and vertical $A_z = E_z/E_K$ (*black triangles*), after the Kalmykia-2007 field campaign of the A.M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences (courtesy of Rostislav Kouznetsov). The *lines* show our inter-component energy exchange model, Eq. 50, with $C_0 = 0.125$, $C_1 = 0.5$ and $C_2 = 0.72$, converted into z/L dependences with the aid of Eq. 71

- **Positive aspect**: Anisotropy, "cheap" options for the implementation:
  - minimal : Only 1 eq for TTE instead of TKE
  - medium : 3 eq: TKE, TTE or TPE and turbulent dissipation time scale

Energy Flux Budget Closure (Zilitinkevitch et al, 2013)

TPE : Turbulent Potential Energy $E_p = \frac{1}{2}\left(\frac{\beta}{\frac{\partial\theta}{\partial z}}\right)\cdot\theta'^2$

$$\frac{\partial e_T}{\partial t} = advec + P_d + \beta(\overline{w'\theta'}) - \frac{1}{\rho}\cdot\frac{\partial\overline{\rho w' e_T'}}{\partial z} - c_\varepsilon\cdot\frac{\overline{e}_T^{3/2}}{l}$$

$$\frac{\partial E_P}{\partial t} = advec - \beta(\overline{w'\theta'}) - \frac{1}{\rho}\cdot\frac{\partial\overline{\rho w' E_P'}}{\partial z} - c_P\cdot\frac{E_P^{3/2}}{l}$$

The buoyancy flux appears with opposite signs and describes nothing but the energy exchange between TKE and TPE. For stable conditions and during transition in late afternoon the Buoyancy flux becomes negative and can be considered as an ultimate killer of turbulence (Zilitinkevitch et al, 2013)

- A prototype of the EFB Closure based on section 4.2 from (Zilitinkevitch et al, 2013) is available in ARPEGE :
  - Pro. Eq for TPE and TKE
  - Vertical component Ez computed with Eq: 92
  - New formulation for Km/Kh
  - Mixing length = BL89 for preliminary test before a pro. Equation for the dissipation time scale (l/sqrt(TKE))

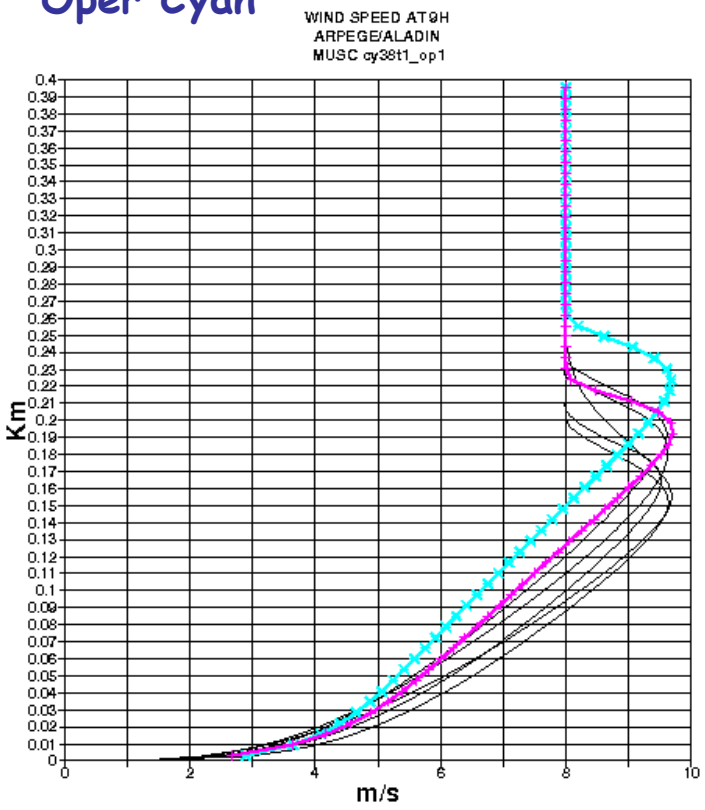
$$K_M = \alpha_M\cdot l\cdot\sqrt{\overline{e_T}} \longrightarrow K_M = 2\cdot C_\tau\cdot E_z\cdot\frac{l}{\sqrt{\overline{e_T}}}$$

$$K_{\theta/q} = \alpha_\theta\cdot K_M\cdot\phi_3 \longrightarrow K_{\theta/q} = 2\cdot C_F\cdot E_z\cdot\frac{l}{\sqrt{\overline{e_T}}}\cdot(1 - C_\theta\frac{E_P}{E_z})$$

EFB in "dry" 1D case GABLS1 and 4

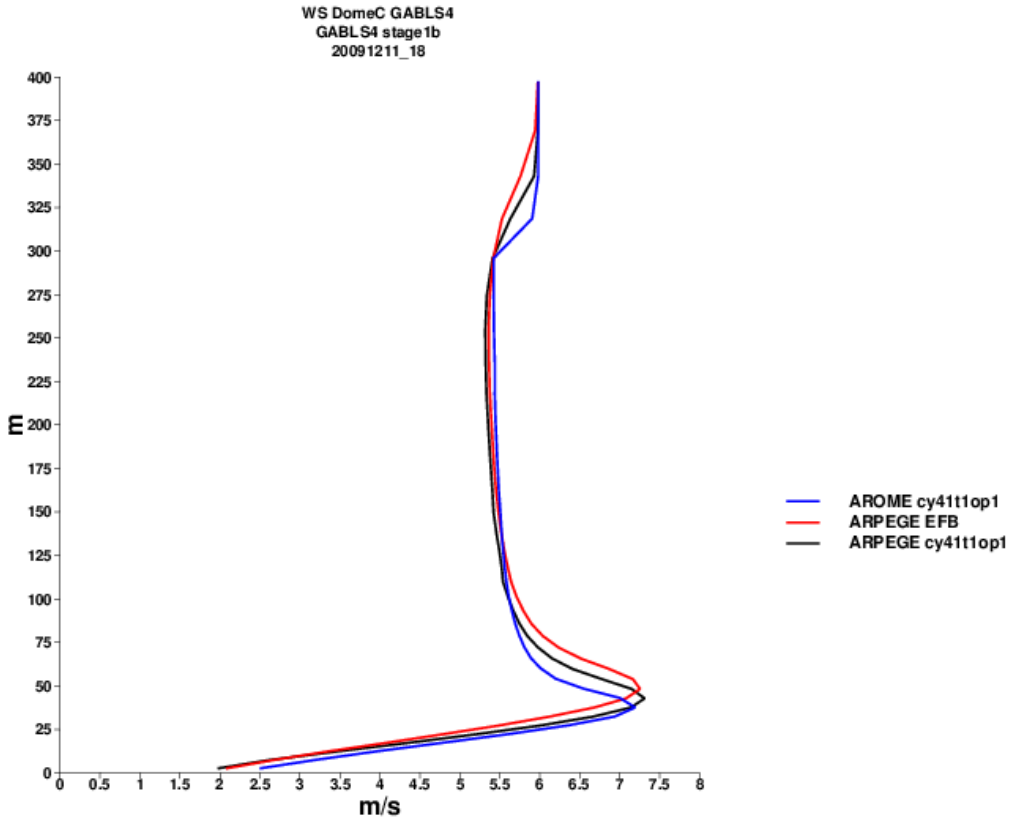
Wind Speed GABLS1

EFB Closure Violet
Oper Cyan



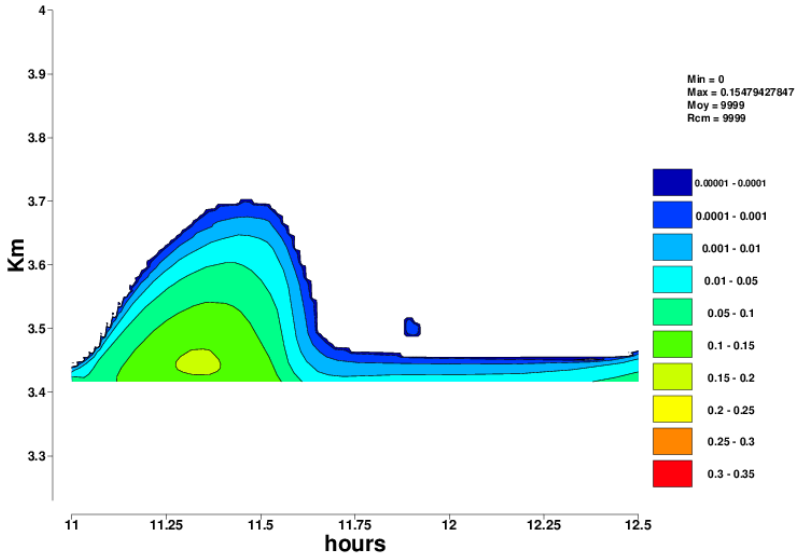
Wind Speed GABLS4 at 18TU

ARPEGE/AROME/EFB

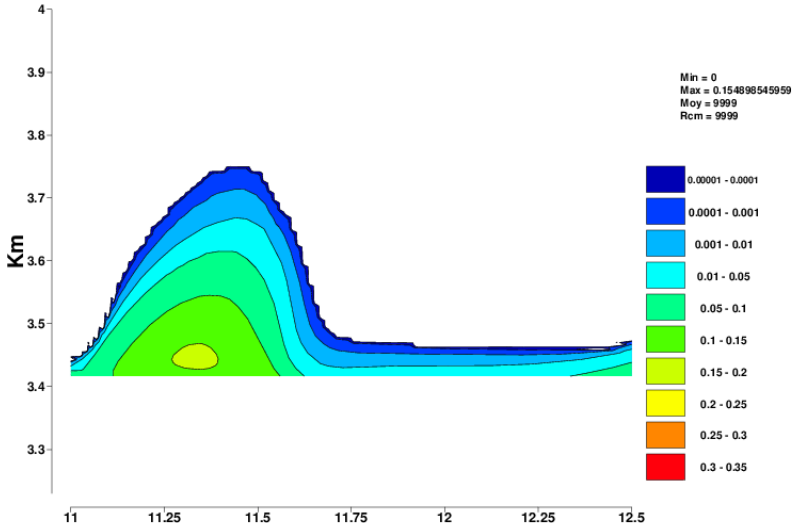


TKE/TPE Evolution in GABLS4

TKE

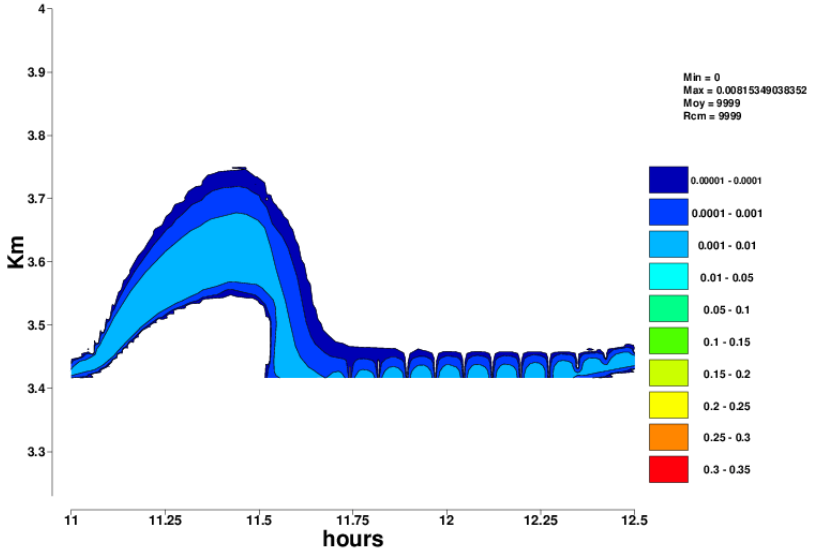


TKE with EFB



TKE is increased with EFB even for the unstable part (?) and during night. Both TPE and TKE are the same order.

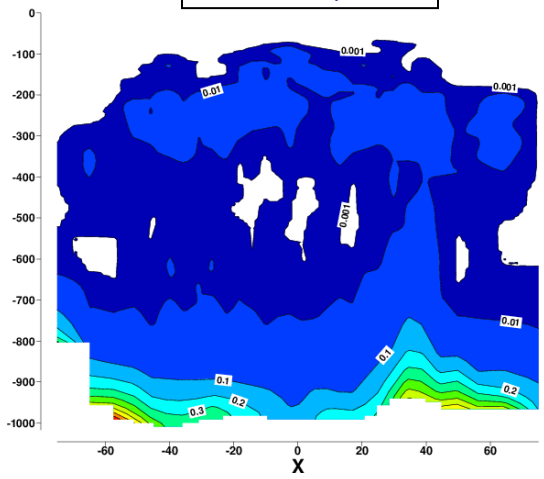
TPE with EFB



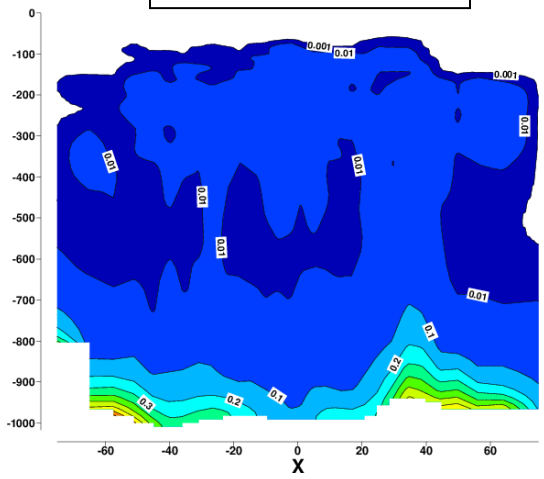
EFB in Global ARPEGE T1198L105

- 10 forecasts up to 96h based on cy41t1op1 with oper dt=360s from 21/05/2015 to 31/05/2015

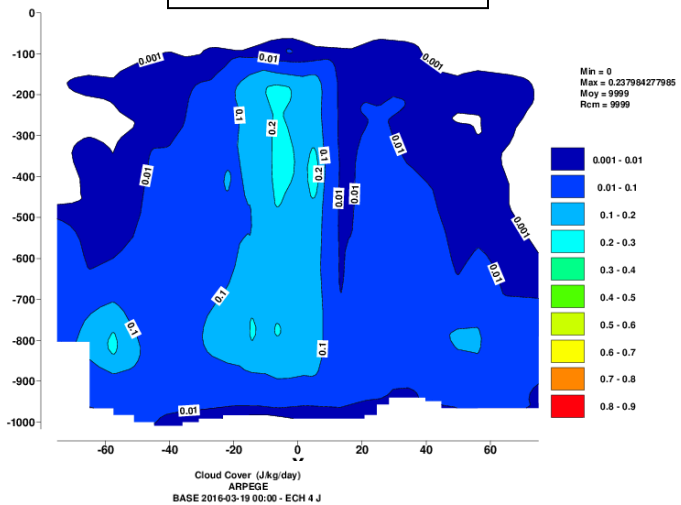
TKE Oper

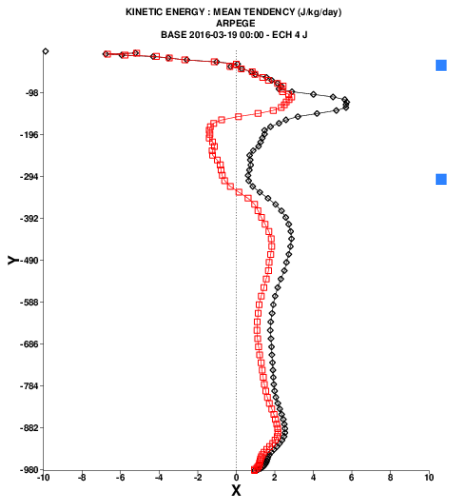


TKE for with EFB

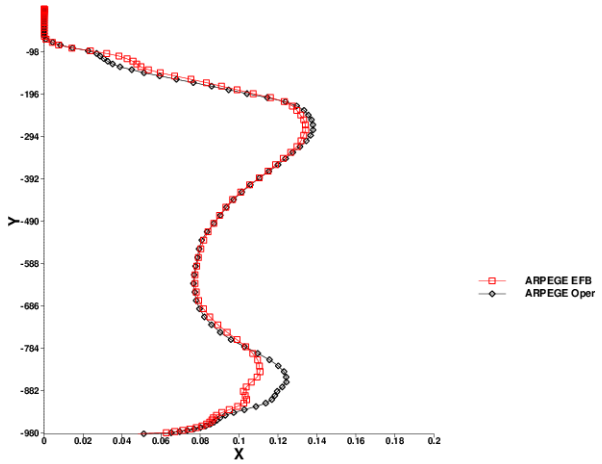


TPE for with EFB





- Positive impact: more mixing for the wind above 700hPa
- Less low cloud ? Why ? Due to the closure ONLY valid for Qv=0. ?



Low clouds …

- Working days at SMHI 23-25 Nov 2015.
- MF input:
  - For the LCC over the sea (channel and Mediterranean):
    - initial condition seems to be responsible BUT it doesn't mean that the PBL parametrization has no responsibility: over sea almost no observation
  - The reason of the overestimation of LCC over the channel and over Medit is probably and unfortunately not the same !
  - Large impact of the modification (algo) of ICE3 for the Medit LCC.
- HARATU+EDMF seems to be more (too ?) active than CBR+EDMF
- CBR+PMMC09 (AROME) is more active than CBR+KFB (ARPEGE) due to the dry thermals and the closure based on latent heat flux.
- **In summary :**
  - **underestimation over land mainly (?) due to an excess of mixing**
  - **overestimation over sea : initial conditions, underestimation of Top PBL entrainment ?**
- **In January 2016: " for the low cloud: underestimation over sea for AROME and ARPEGE although the reverse was mentioned in spring 2015 ! The most surprising is the degradation behaviour of the low cloud forecast based on 18TU, 21TU, 24TU etc .. AROME too dry " New internal report from forecasters.**

Low clouds …

- Several options are available in AROME:
  - CMF_UPDRAFT='RHCJ': Rio et al (2010) modified vertical velocity, entrainment and detrainment
  - Bi-Gaussian : new pdf for the cloud.
  - CMF_UPDRAFT='RAHA'
    - Closure from Rio and Hourdin (2010): The mass flux is computed at the top of the unstable surface layer as the sum of horizontal fluxes

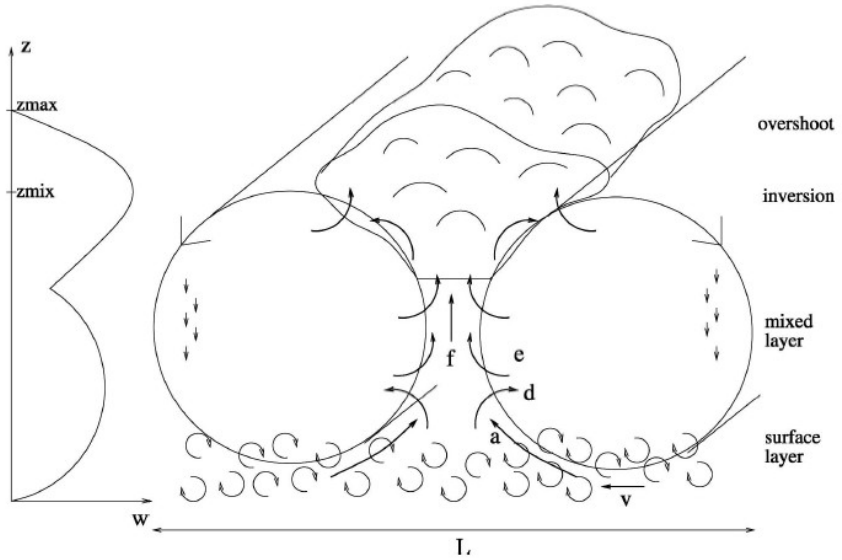
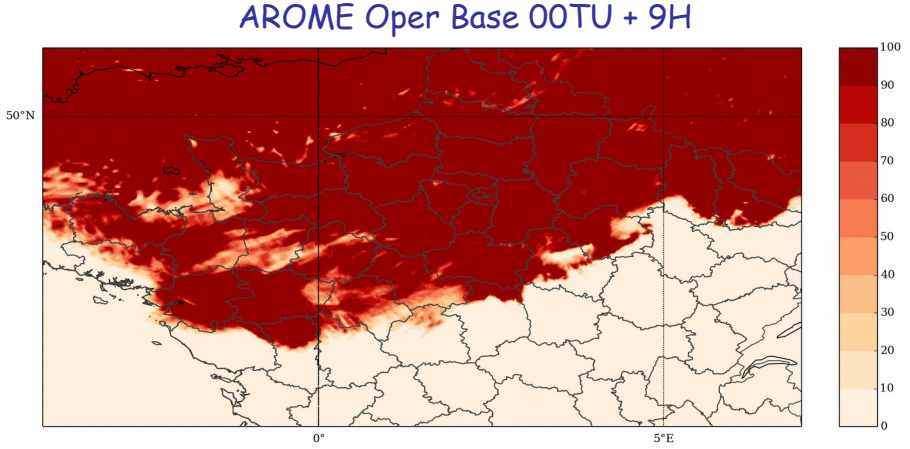


FIG. 1. Physical image sustaining the thermal plume model and corresponding vertical velocity *w*: diffusive turbulence in surface layer and coherent structures in mixed layer. Mass-flux *f* depends on entrainment of air inside the thermal from the surface layer *a*, above *e*, and detrainment from the plume *d*.

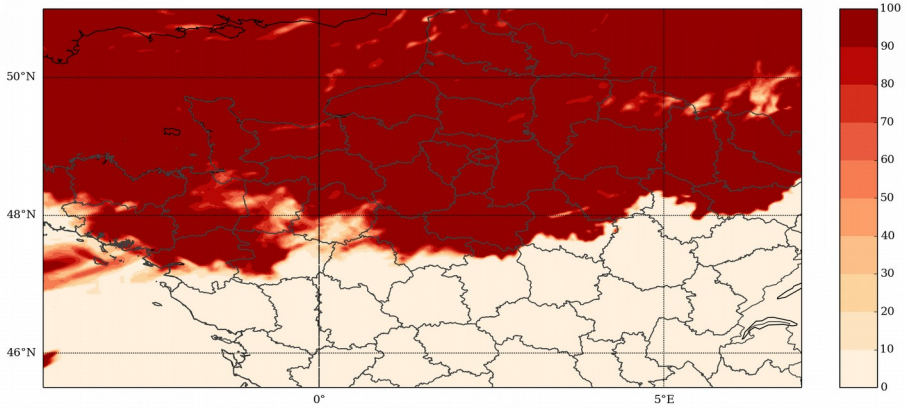
Low clouds …
(with Yann Seity)

- New case 19th March 2016 @ 09TU:

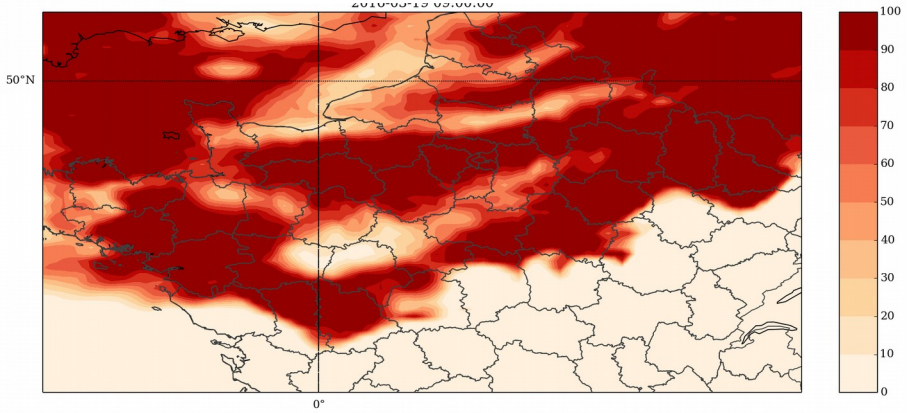
AROME Oper Base 00TU + 9H



HARMONIE-KNMI Base 00TU + 9H

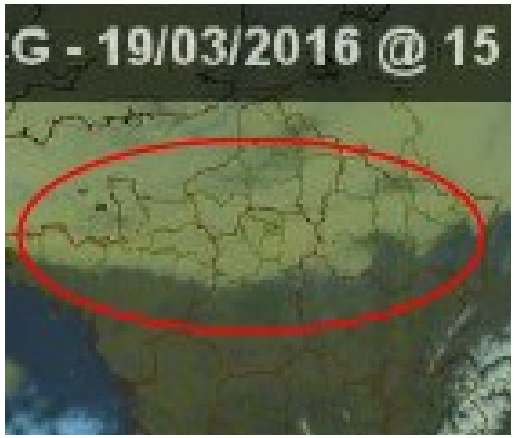


ARPEGE Oper Base 00TU + 9H

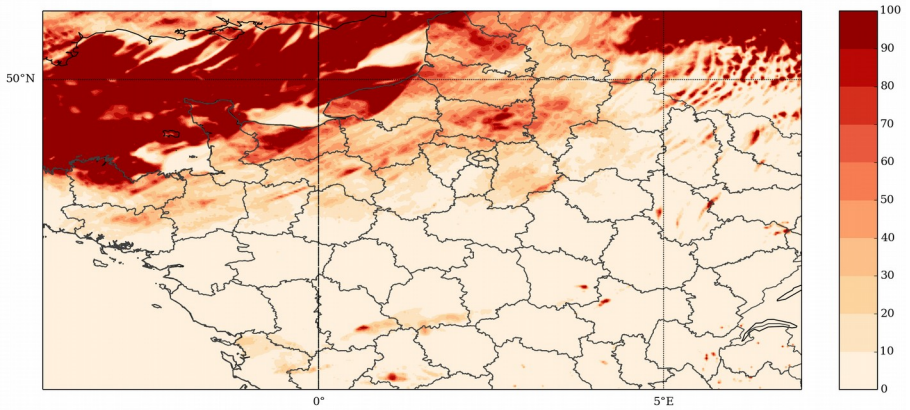


Low clouds …
(with Yann Seity)

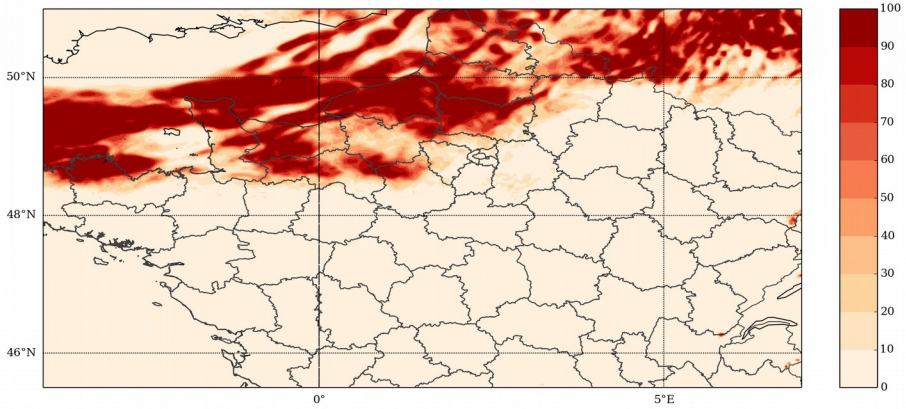
- New case 19th March 2016 @ 15TU:



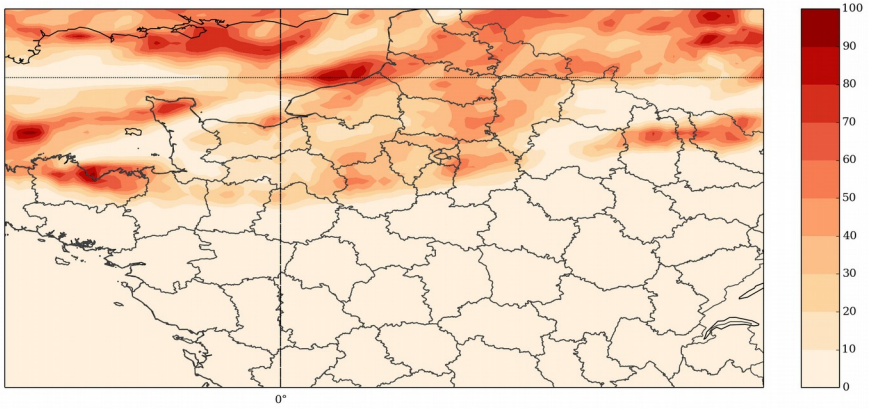
AROME Oper Base 00TU + 15H



HARMONIE-AROME-KNMI Base 00TU + 15H

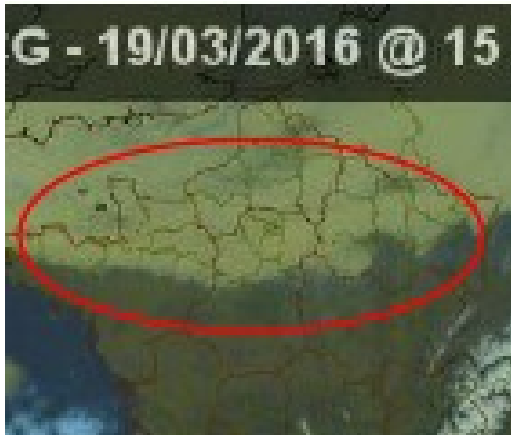


ARPEGE Oper Base 00TU + 15H

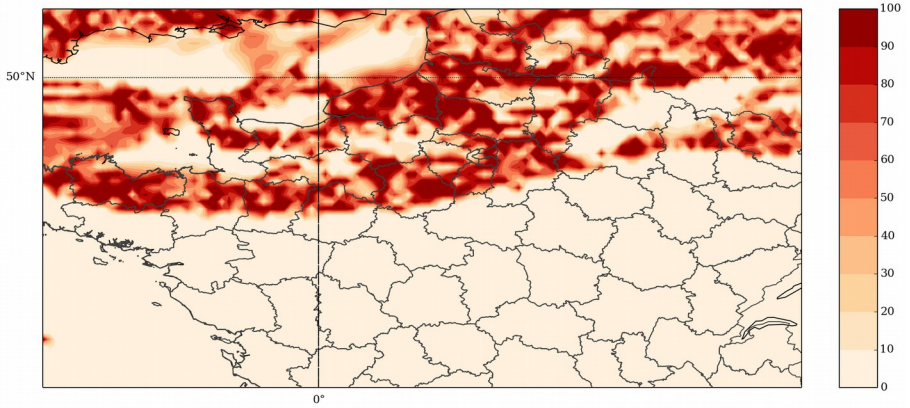


Low clouds …
(with Yann Seity)

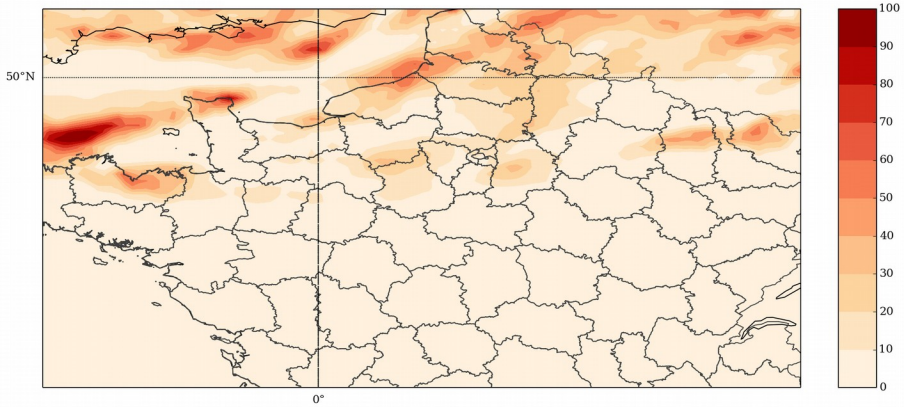
- New case 19th March 2016 @ 15TU:



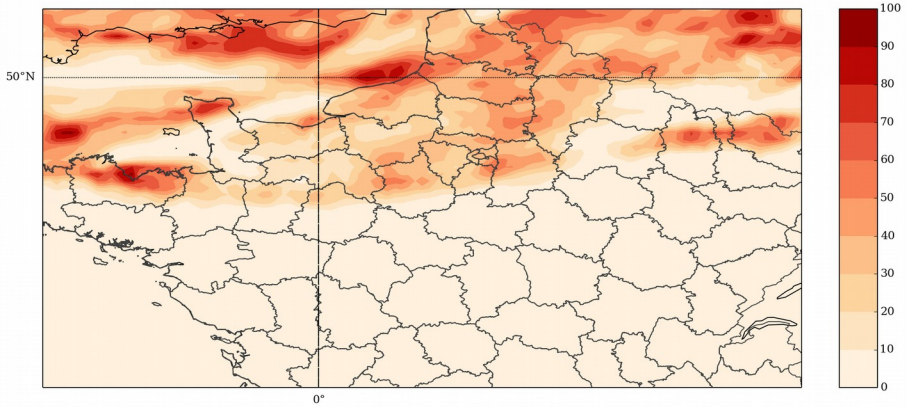
ARPEGE-PCMT Base 00TU + 15H



ARPEGE-EFB Base 00TU + 15H

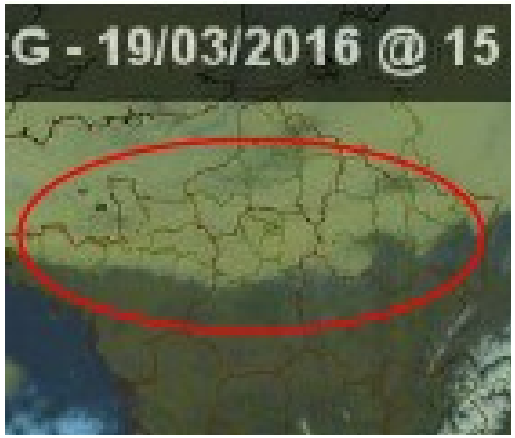


ARPEGE Oper Base 00TU + 15H

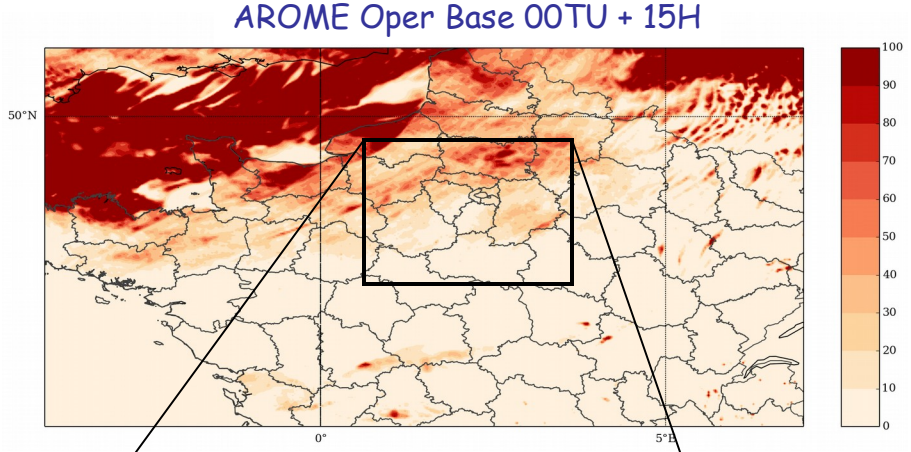


Low clouds …
(with Yann Seity)

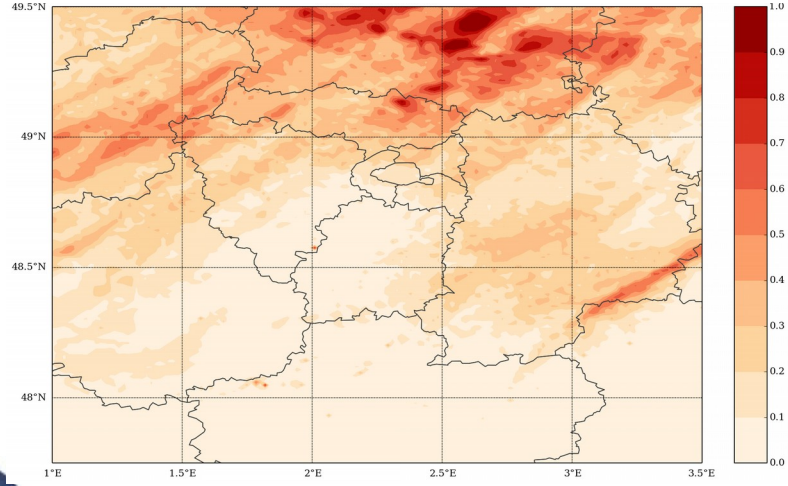
- New case 19th March 2016 @ 15TU: experiments with AROME-Site



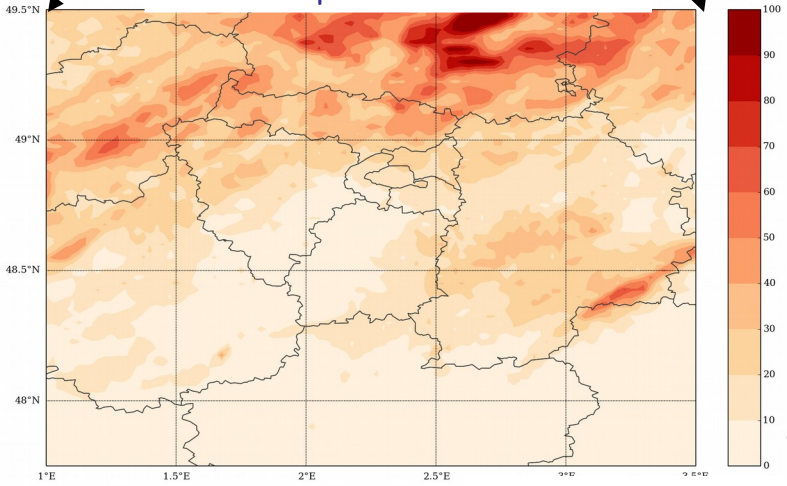
AROME Oper Base 00TU + 15H



AROME-Site LBC from AROME-Oper Base 00TU + 15H



AROME Oper Base 00TU + 15H

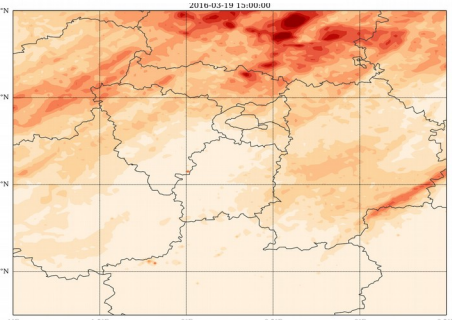


Ala

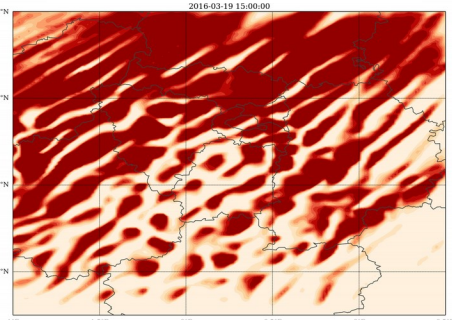
Low clouds …
(with Yann Seity)

- New case 19th March 2016 @ 15TU: experiments with AROME-Site

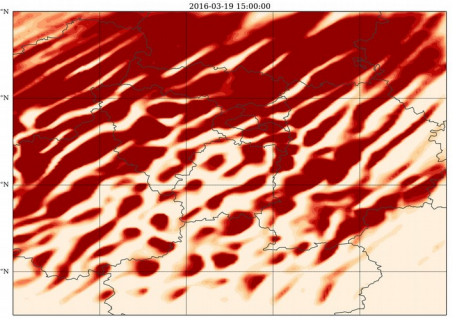
AROME-Site



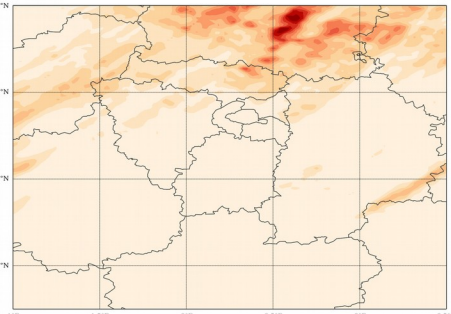
AROME-Site no EDMF



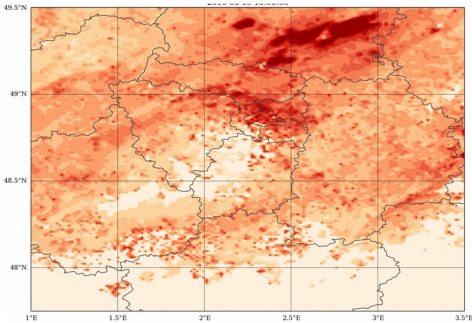
AROME-Site + KFB



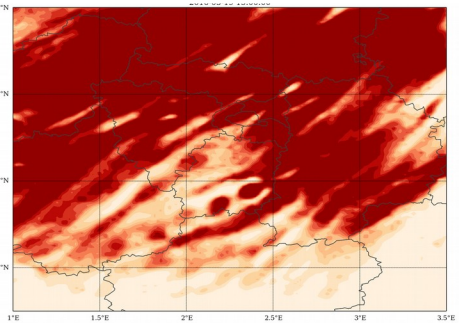
AROME-Site + BIGAU



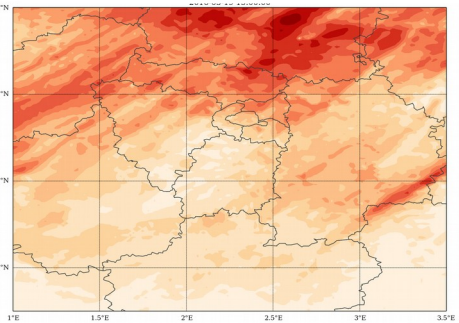
AROME-Site + Updraft=RHCJ



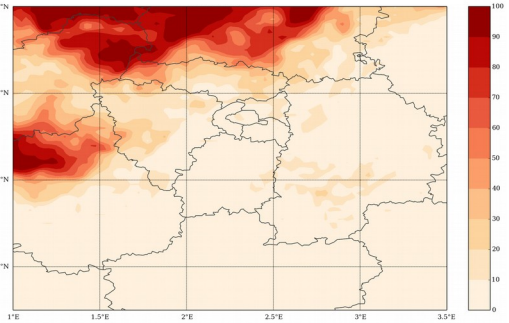
AROME-Site + Updraft=RAHA



AROME-Site + Cloud=STAT



HARMONIE-AROME-KNMI



Several options are available … but unfortunately the choice is very difficult, no clear advantages for one scheme or options … more test and validation are needed

So please come to the WG on clouds with suggestions, ideas … Tuesday 5th April 16h30/18h30 !

METEO FRANCE

Conclusions et perspectives…

- **Surfex:**
  - Results are globally positive (in dyn. Adaptation) with modifications in the SURFEX namelist compared to the AROME one.
  - More evaluation, especially during winter, for the snow scheme and the soil freezing parameter. Ideally with surface and soil moisture assimilation
  - Next step 4Dvar with SURFEX
- **PCMT:**
  - Evaluations against RS and analysis are globally positive
  - Precipitation skill score and diurnal cycle are improved
  - Next step 4Dvar with PCMT and maybe one with PCMT and SURFEX
- **EFB :**
  - Now some positive impact in terms of wind mixing above 700hPa
  - More works is needed : low clouds, Qv in the closure , new pro eq for the dissipation length scale ?
- **Pb of low clouds:**
  - Unfortunately no "available" solution ! Several options exist in AROME and in HARMONIE NEVERTHELESS more evaluations are required to find (if possible) a "common" solution
  - **Side meeting on Clouds: Tuesday 5th April 16h30/18h30 !**