Recent developments in AROME Physics

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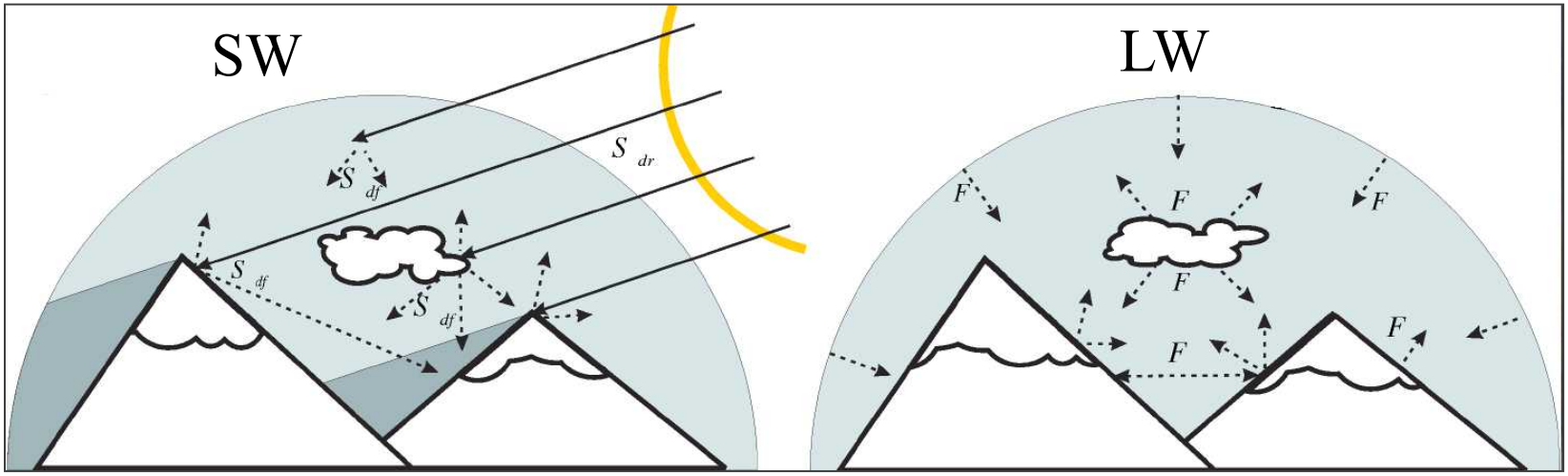
Lisbon, 26th ASM 4-8 April 2016

Outline

- Radiation / Surface
- Turbulence
- Microphysics

Radiation / Surface interaction over Orography



1. Direct radiation

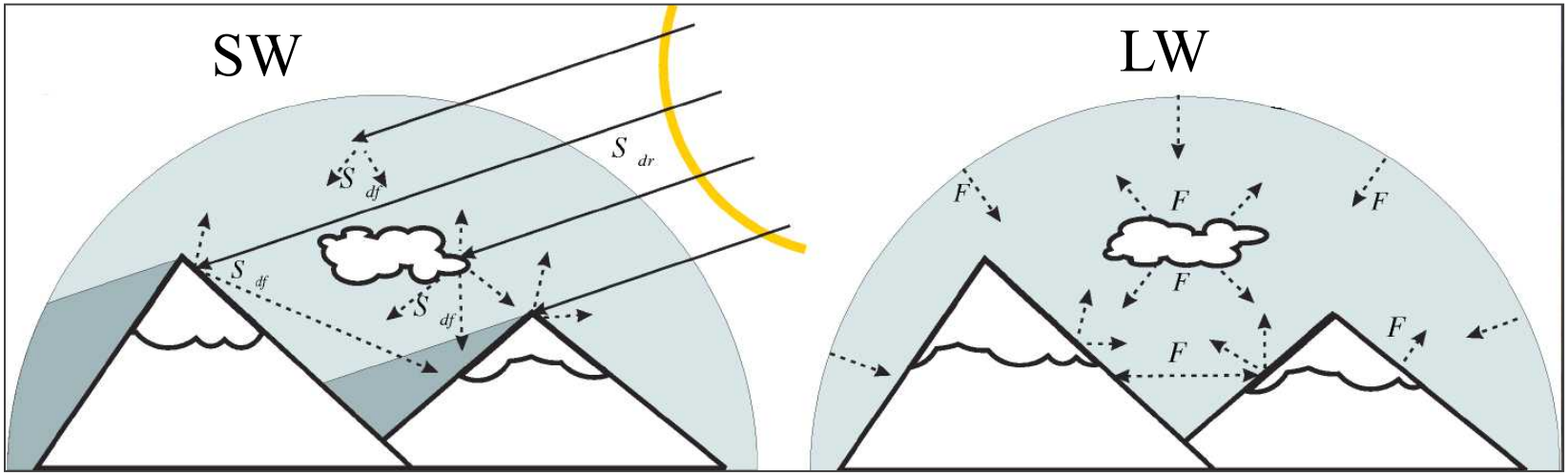
- Slope effect

- Shadows effect

Oper in AROME-France since December 2015

(Collaboration with FMI and ZAMG)

Radiation / Surface interaction over Orography



1. **Direct radiation**

- **Slope effect**

- **Shadows effect**

2. **Diffuse radiation (SVF)**

1. **Sky View Factor (SVF)**

Oper in AROME-France since December 2015

Still not oper (positive bias in T)

(Collaboration with FMI and ZAMG)

SVF calculation

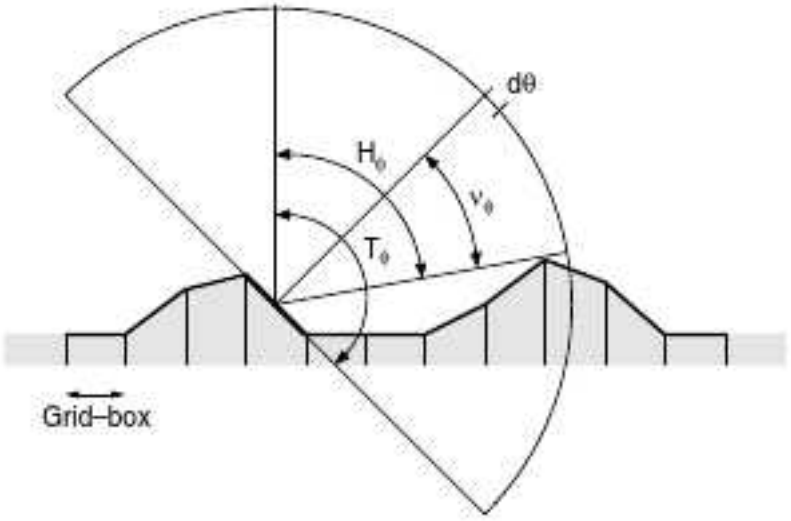
- **Test of 3 calculations of SVF :**

1) **Senkova (2007)** $$\delta_{sv} = 1 - \frac{1}{2\pi}\int_0^{2\pi} \sin[h_h(\theta)]\,\mathrm{d}\theta. \approx 1 - \frac{\sum_{i=1}^{8} \sin(h_{h,i})}{8}.$$

2) **Manners (2012)** take into account tilted surface :

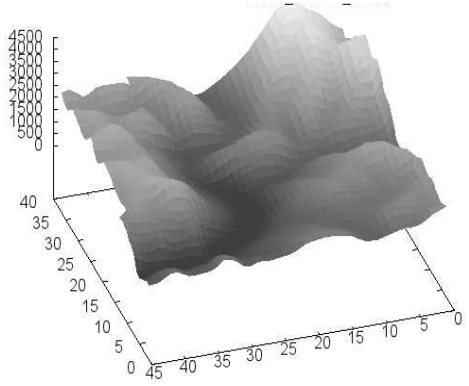
a) Resolved orography (MGS)

b) Subscale orography (MSS)

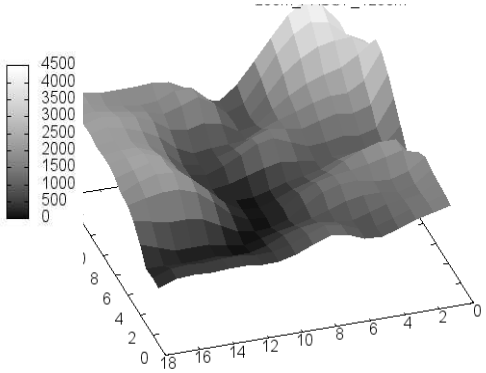


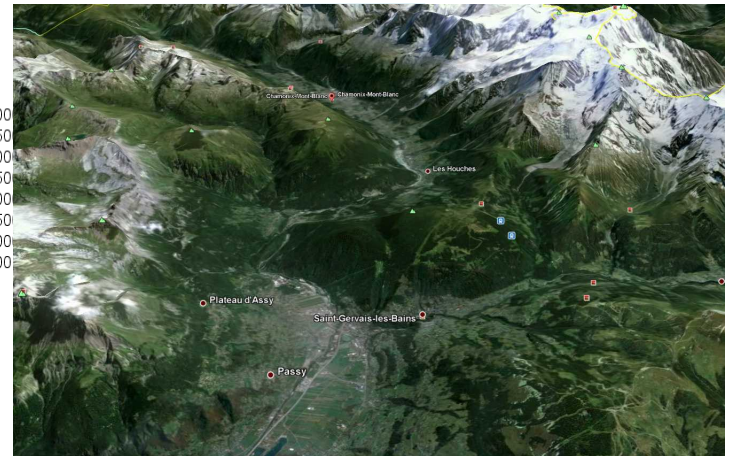
Use of PASSY campain datas

AROME_0.5km :

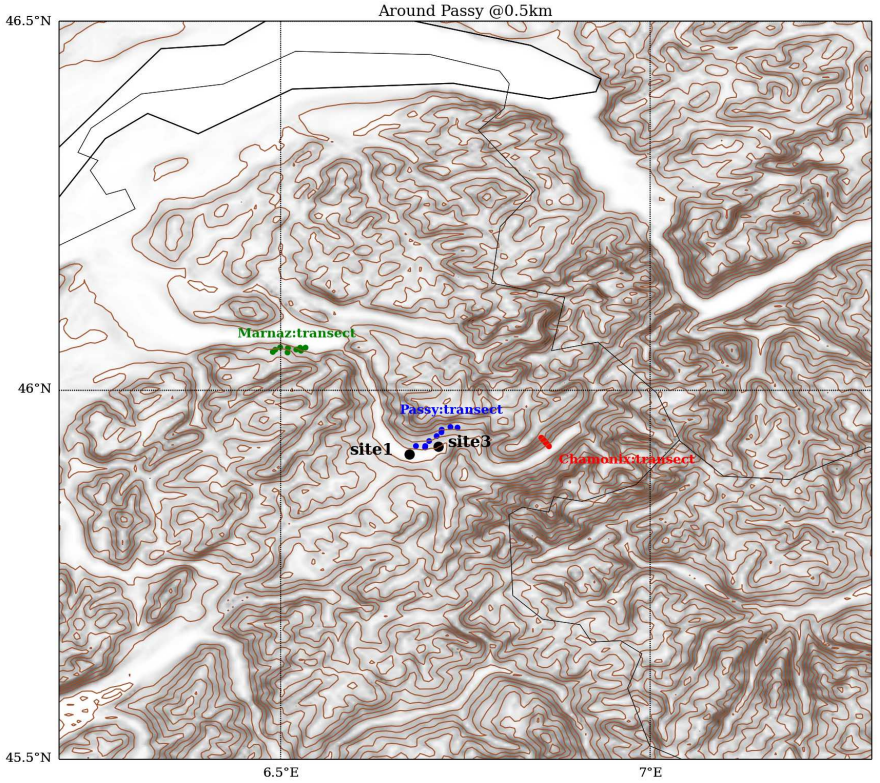


AROME_1.25km :





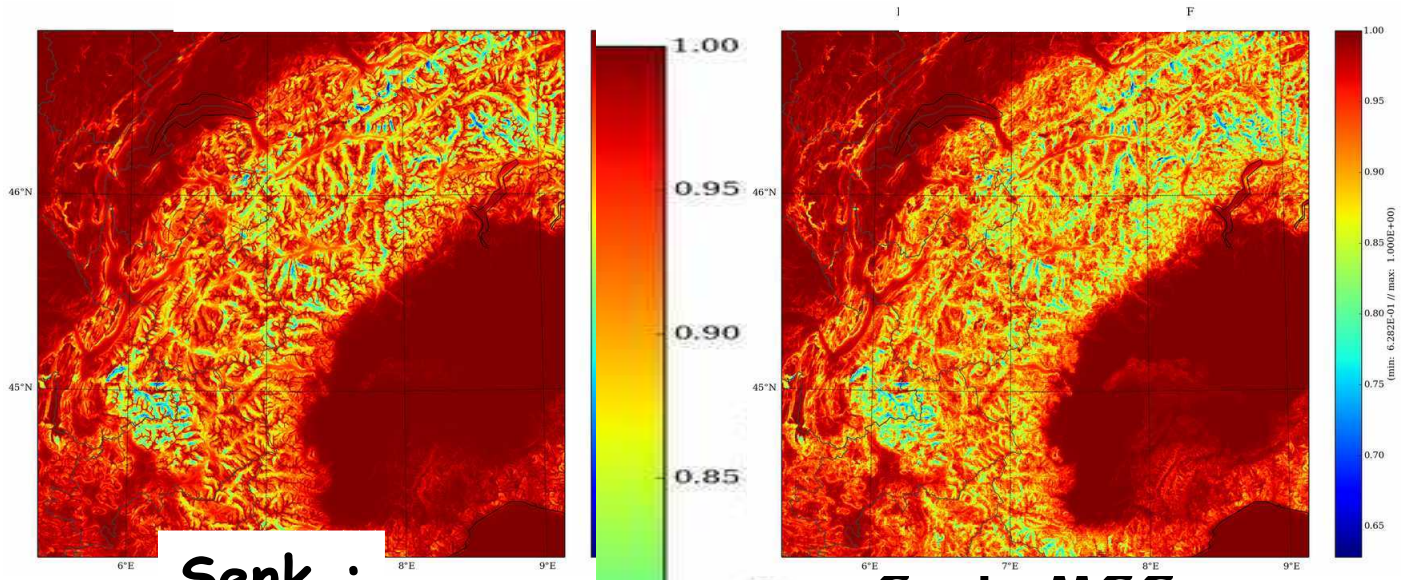
- French field campain to study winter pollution in Chamonix Valley (stable conditions, road trafic + firewood use)
- From January to March 2015.
- 2 POIs : 6-14 Feb and 17-20 Feb.
- Radiation measurments on 2 sites
- 3 Instrumented slopes (T2m, Hu2m) (DECOMBIO Network)
- Others (Scintillometer, Microwave radiometer, Radiosoundings …)



Comparison of SVF

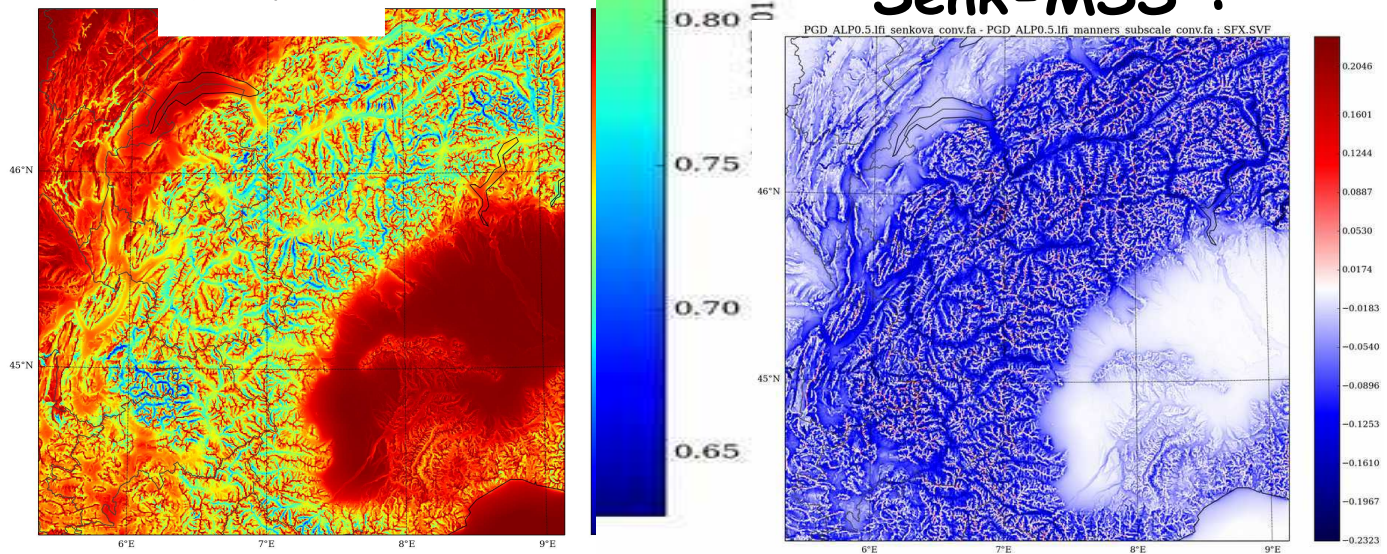
MGS :

MSS :



Senk :

Senk-MSS :

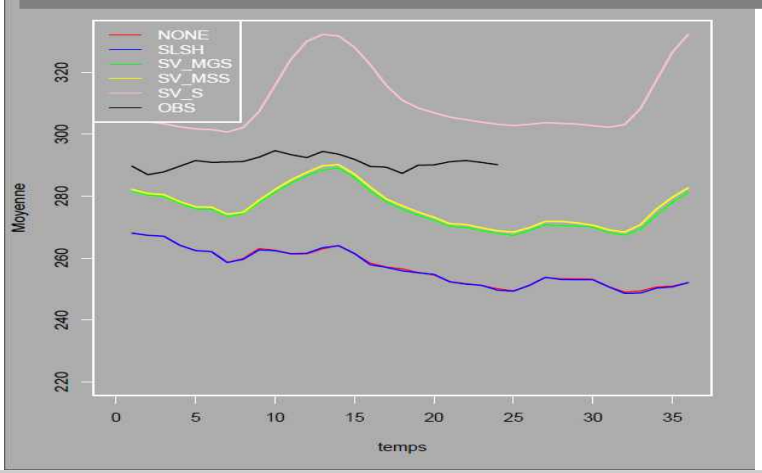


Senk << MGS < MSS

METEO FRANCE

LW Down over Jan-Feb 2015

Comparison at SITE 3 : diurnal cycle

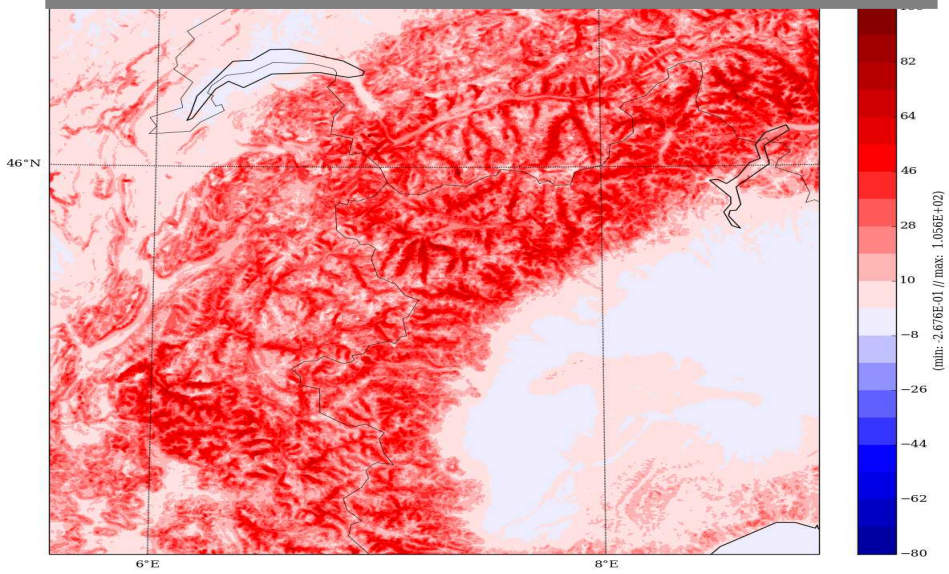


- 25 W/m² deficit in NONE (not due to missing clouds)

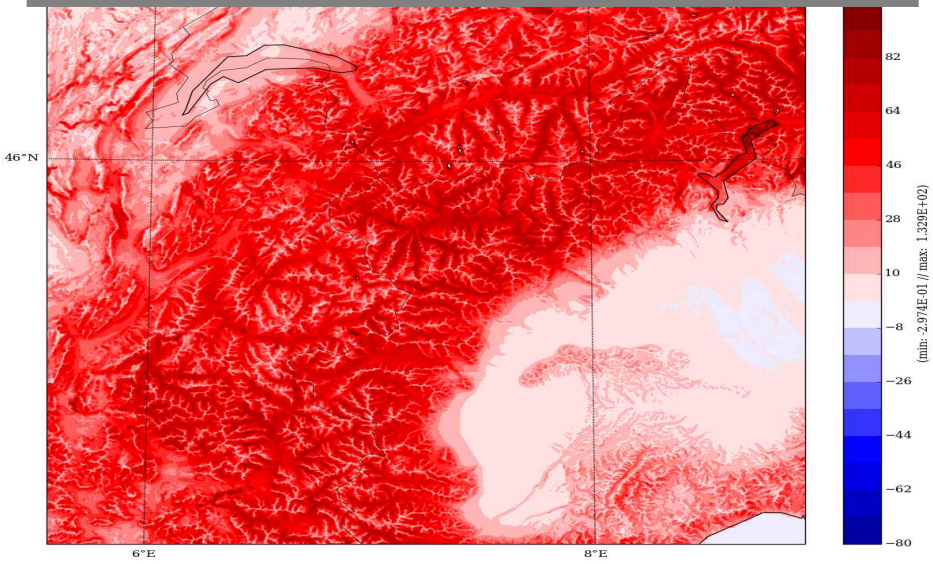
- Partly compensated with MSS or MGS

- Overestimated with Senk with a too strong diurnal cycle (SVF <)

Daily mean LWD radiation : MSS-NONE :

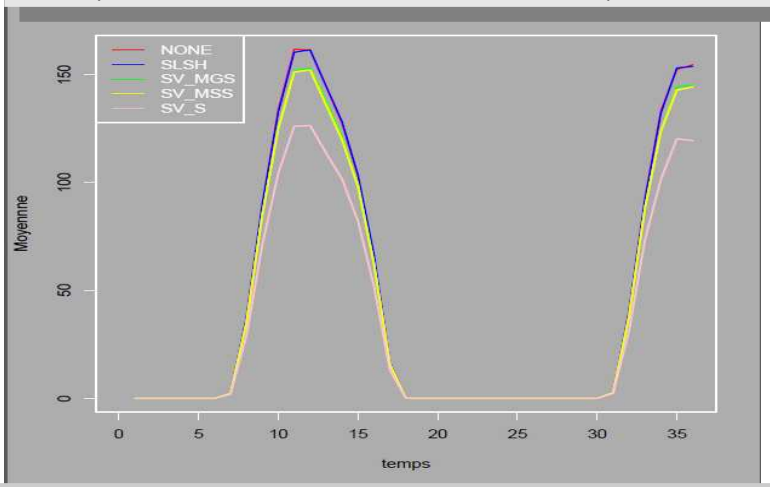


Daily mean LWD radiation : Senk-NONE :



SW Diffuse over Jan-Feb 2015

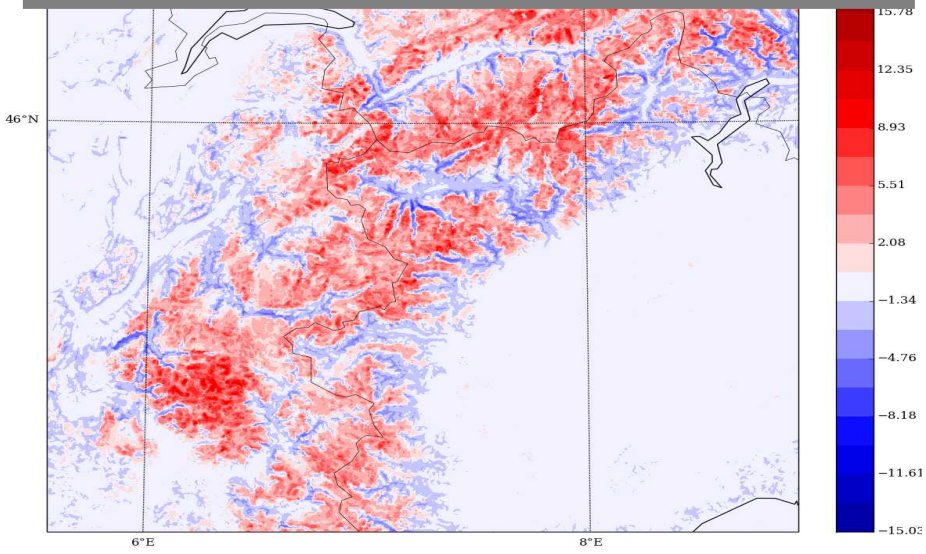
Comparison at SITE 3 : diurnal cycle



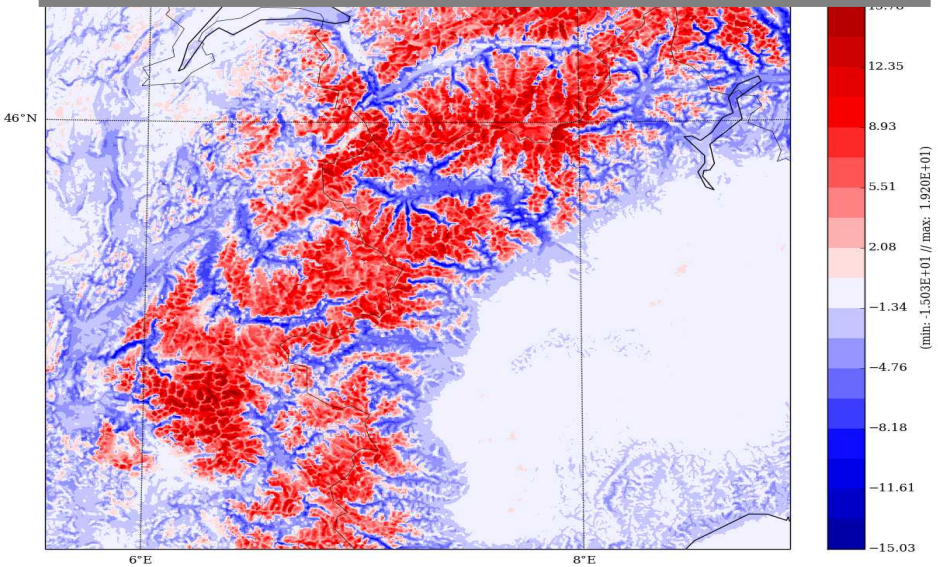
- decrease in Valleys, increase at top (linked with snow?)

- Senk effects > MSS or MGS

Daily mean Diffuse SWD : MSS-NONE :



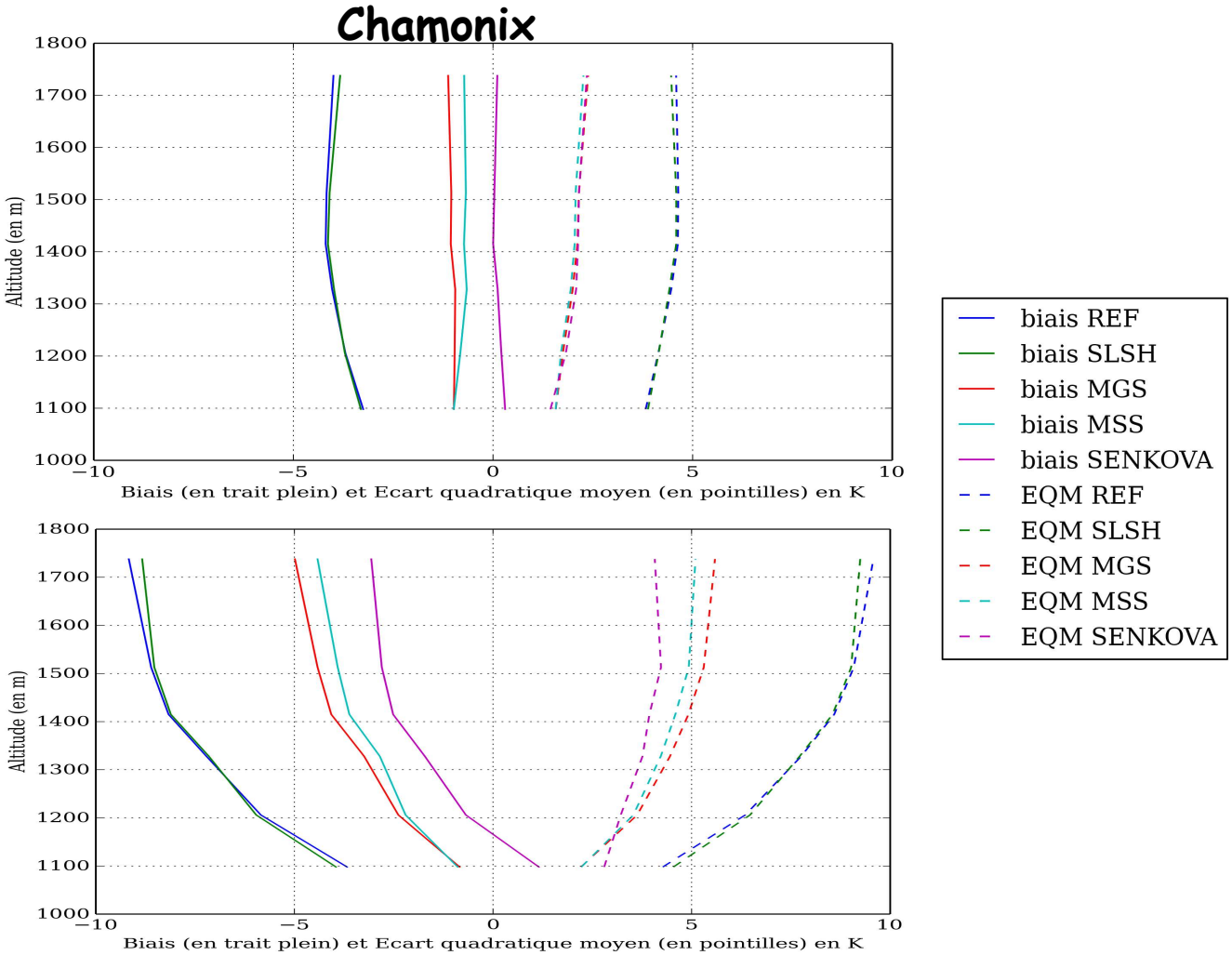
Daily mean Diffuse SWD : Senk-NONE :



Instrumented slopes : 18 TU mean profiles

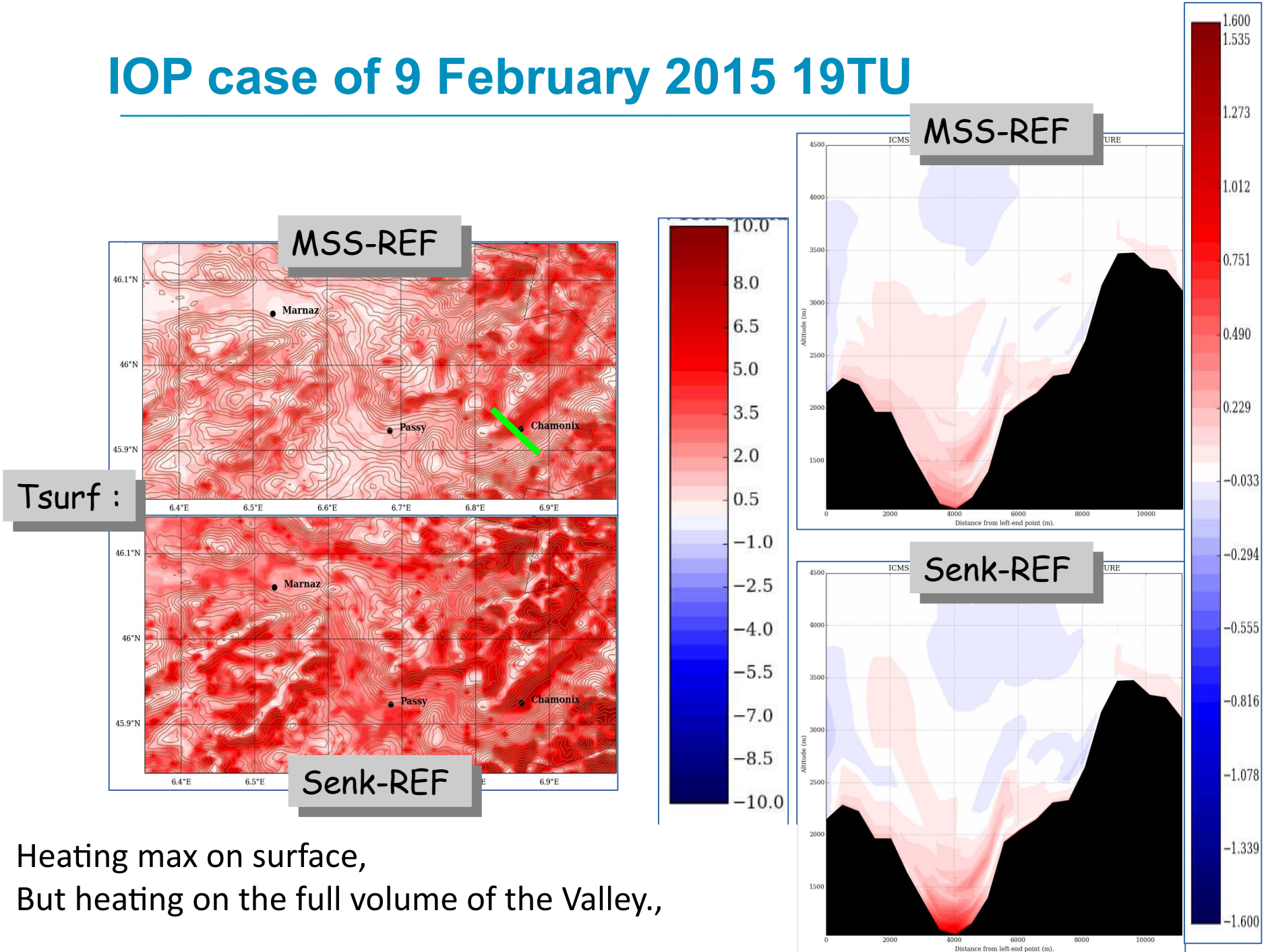
Days with snow/ rain (24 days)

Clear sky days (7)



Negative bias (stronger in Clear Sky days),
Senk seems to be the best simulation.

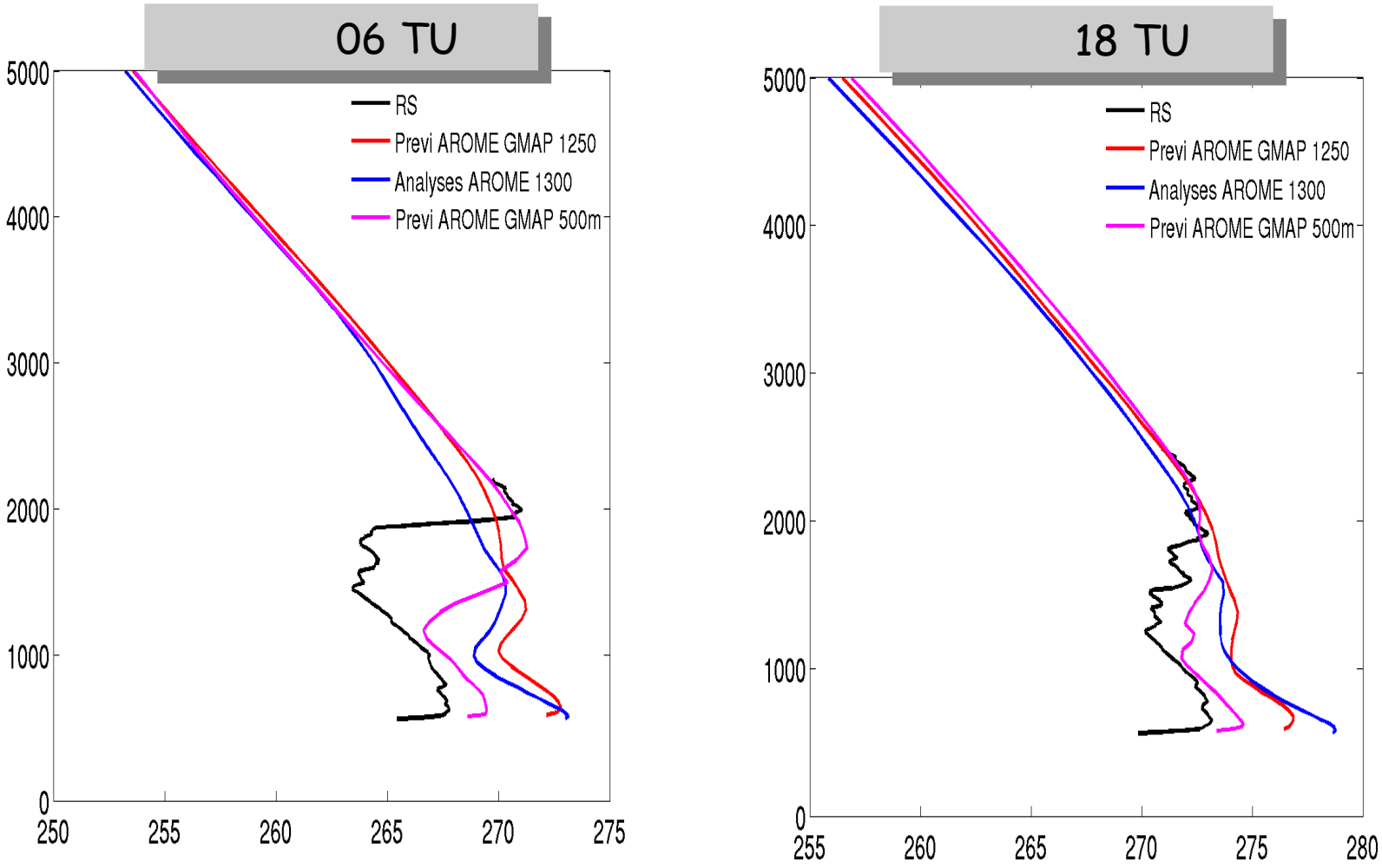
IOP case of 9 February 2015 19TU



Heating max on surface,

But heating on the full volume of the Valley.,

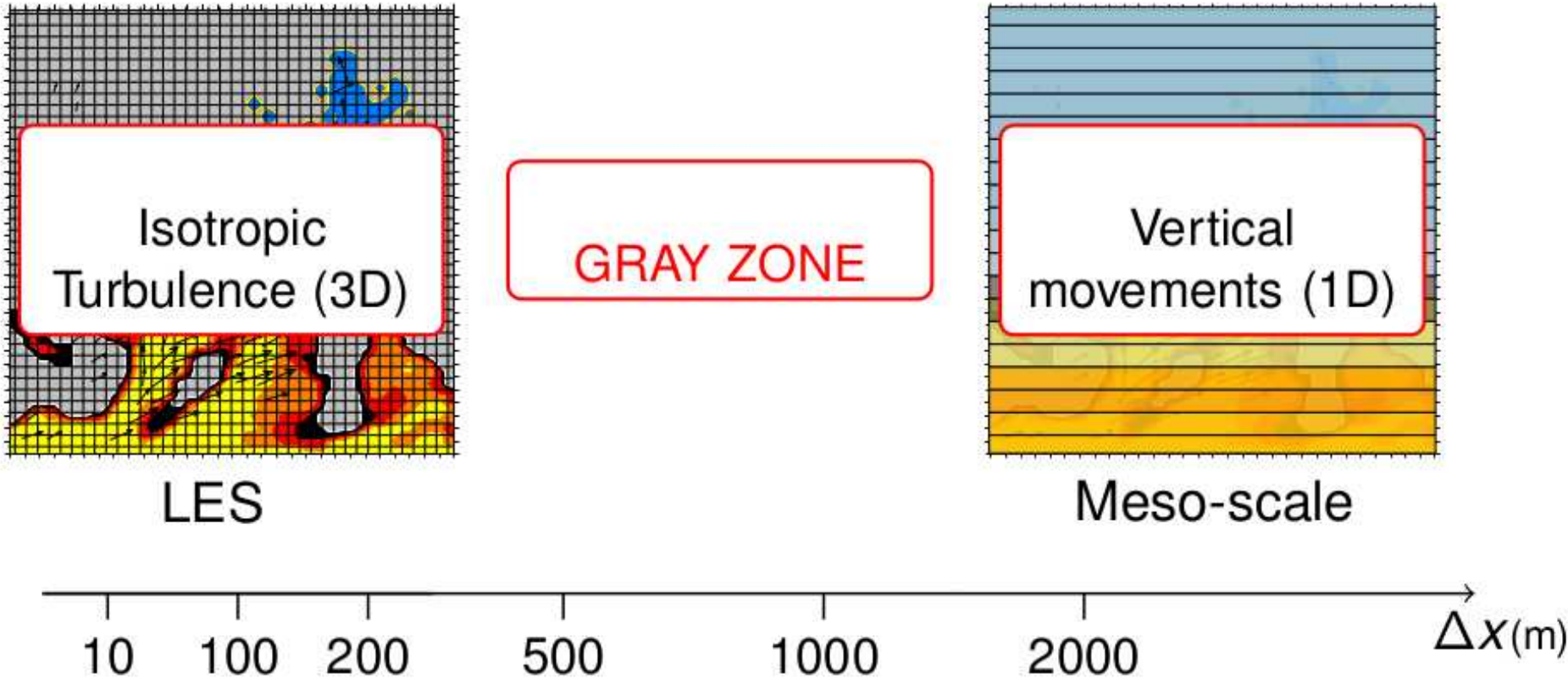
Radiosondings comparison 9 Feb 2015



500m is better than 1300m.

In that case, NONE is already too warm -> SVF effect will give worst results

Turbulence


Isotropic
Turbulence (3D)
GRAY ZONE
Vertical
movements (1D)
LES
Meso-scale
10
100
200
500
1000
2000
Δx (m)

From 1D to 3D turbulence

- Honnert and Masson (2014) : turbulence 1D until about 500 m then 3D is needed.
- Problem of AROME : no 3D turbulence scheme
- Problem of MesoNH : only isotropic turbulence
- Quantification of vertical and horizontal K (eddy diffusivity) and L (mixing length) by LES

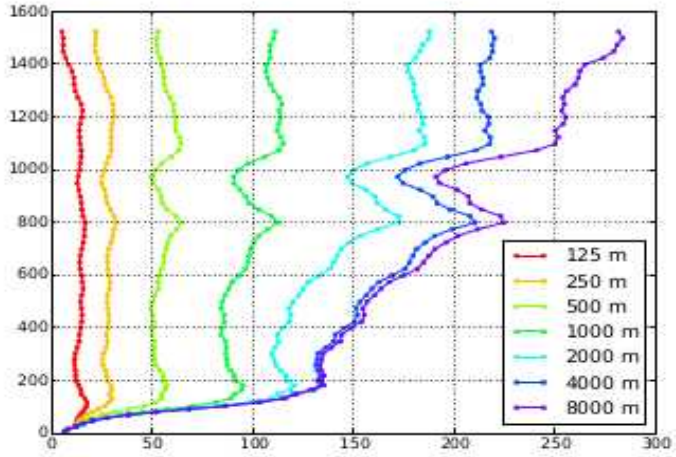
$$\overline{u_i' \phi'}^{\Delta x} = -K(\Delta x) \frac{\partial \overline{\phi}^{\Delta x}}{\partial x_i}$$

$$K(\Delta x) = \alpha L(\Delta x) \sqrt{e(\Delta x)}$$

Honnert R., Masson V., 2014 : What is the smallest physically acceptable scale for 1D turbulence schemes ? Front. Earth Sci. 2 :27

Mixing lengths in the gray zone

(a) Vertical



(b) Horizontal

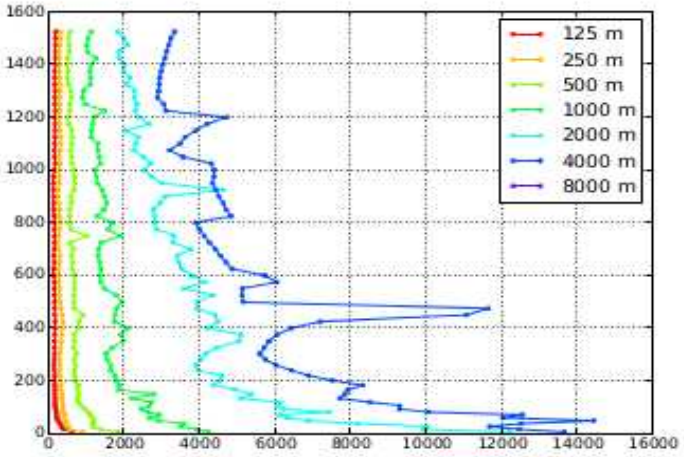
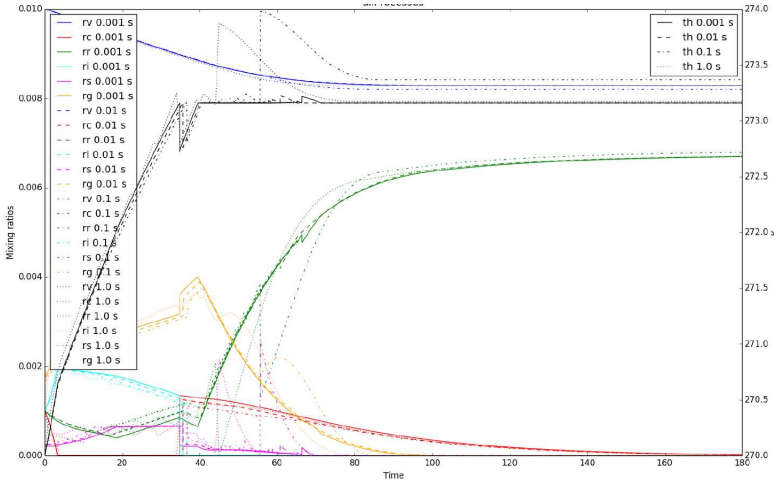


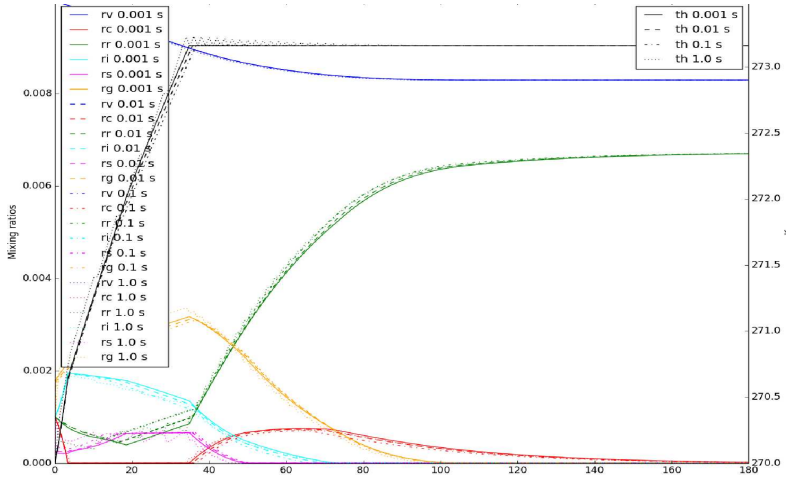
FIGURE : (a)Vertical and (b) horizontal mixing lengths computed at resolutions from 12.5 m to 800 m. CASES-99 (neutral BL)

- Only valid in the BL => inadequate for too small gradients
- Vertical : consistency with existing Lengths : BL89 and DEAR => method valid.
- Horizontal : much largeur than vertical at meso-scale.
- In LES, same order of magnitude => Isotropy.

Microphysics : ICE3/ICE4

1) New algorithmic in order to limit the time step dependency :





Exemple : 0d experiment Ref : without modification, Mod1 : Stop processes if temperature tendency make T cross 0°C ,

But also add a mixing ratio time stepping for graupel wet growth calculation (do not allow a modification of more than 0.1 g/kg in one sub-time step) etc…

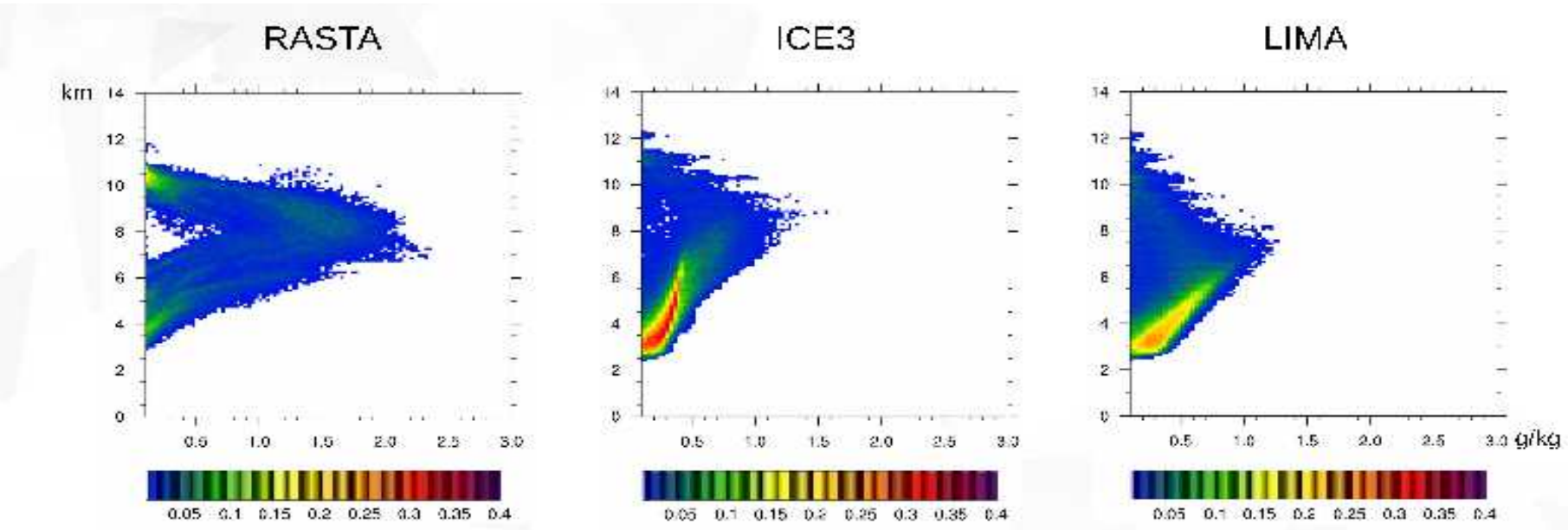
Quite OK up to 10s time step. Not at 60s -> work will continue

2) Modified ICE4 (processes/bugs), but results still not better than hail diagnostic based on vertically integrated graupel content .

3) Ongoing work on diagnostic of "aircraft icing with supercooled droplets", evaluation of supercooled liquid water forecast with AROME.

Microphysics : LIMA 2-moments scheme

Progress in the LIMA scheme validation in MesoNH (using HYMEX datas)

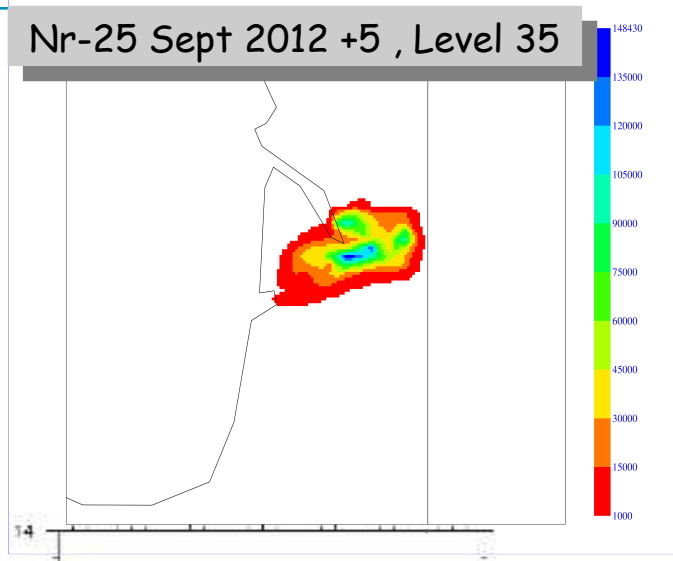


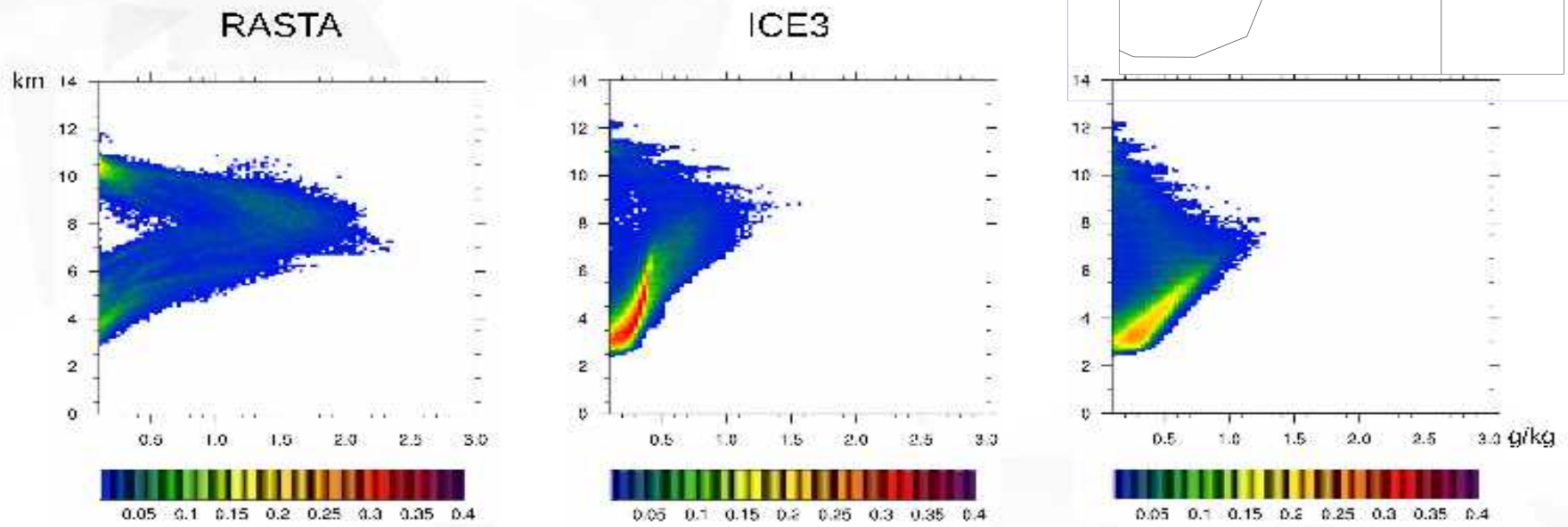
24/09/2012, ice water content vs. altitude frequency diagram during the F20 flight (%)

Microphysics : LIMA 2-moments scheme

Progress in the LIMA scheme validation in MesoNH (using HYMEX datas)

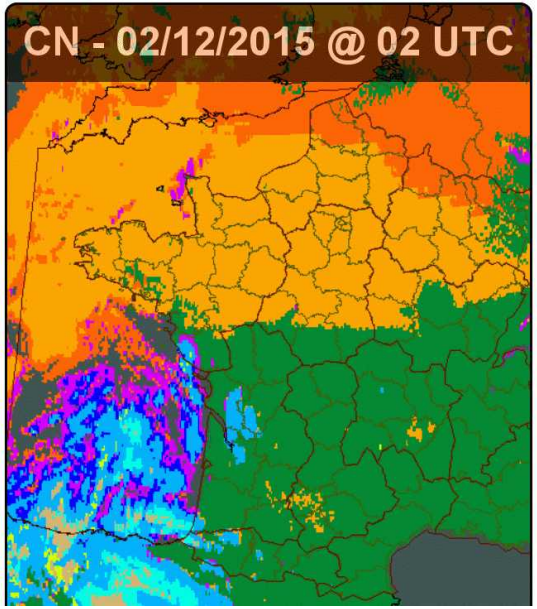
Implementation in AROME as it is in MesoNH (still some problems on large domains)



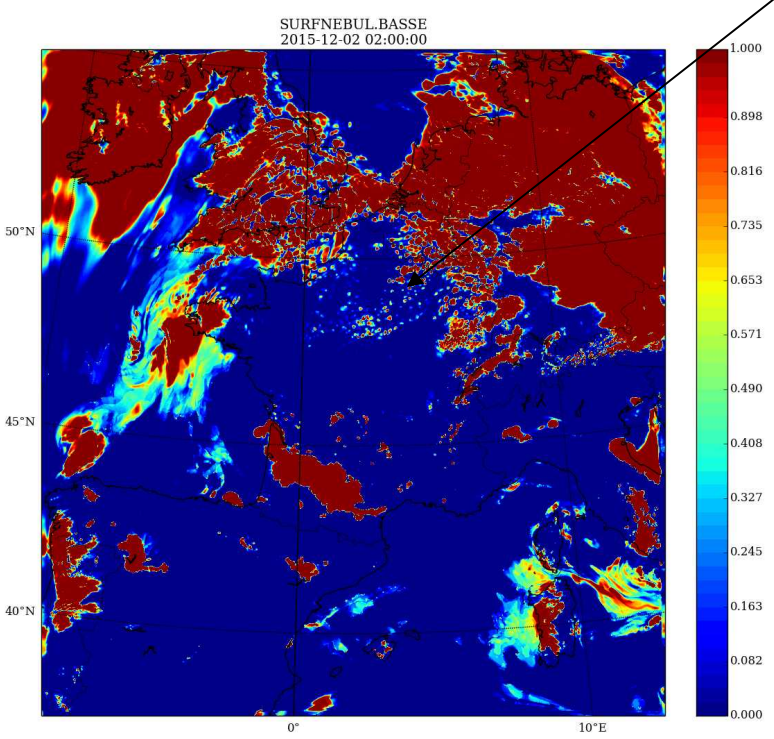


24/09/2012, ice water content vs. altitude frequency diagram during the F20 flight (%)

Some issue… wrong low clouds removing

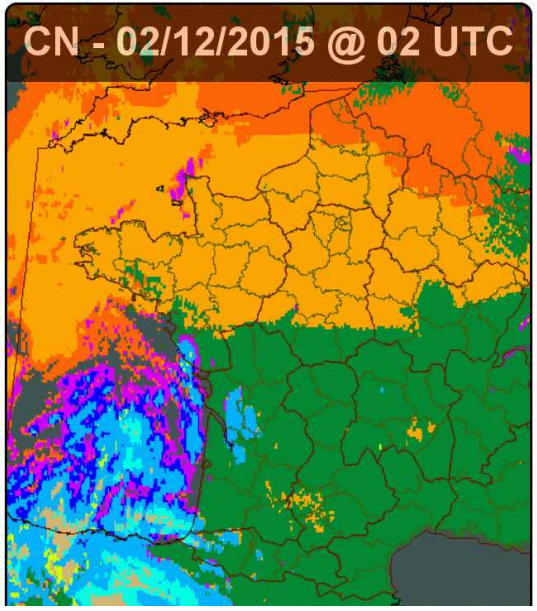


Long range forecasts OK but short range not (clouds are removed)



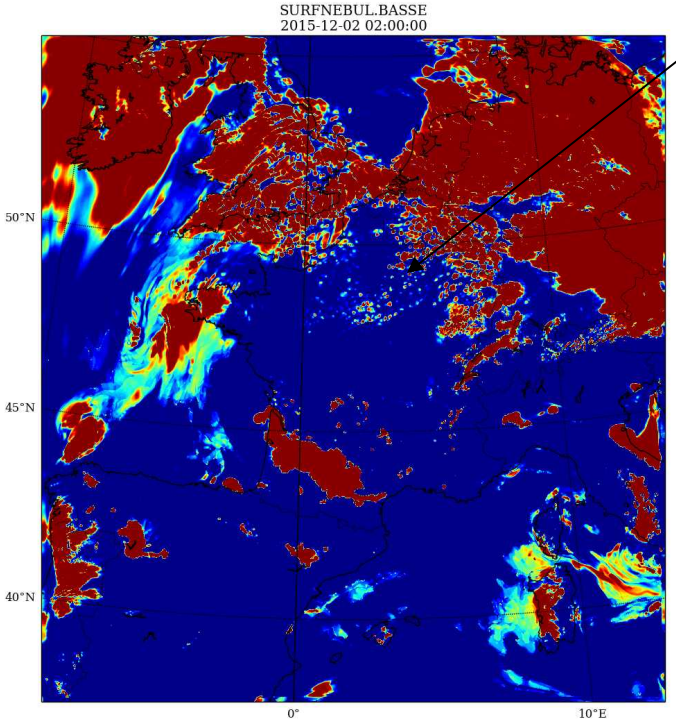
METEO FRANCE

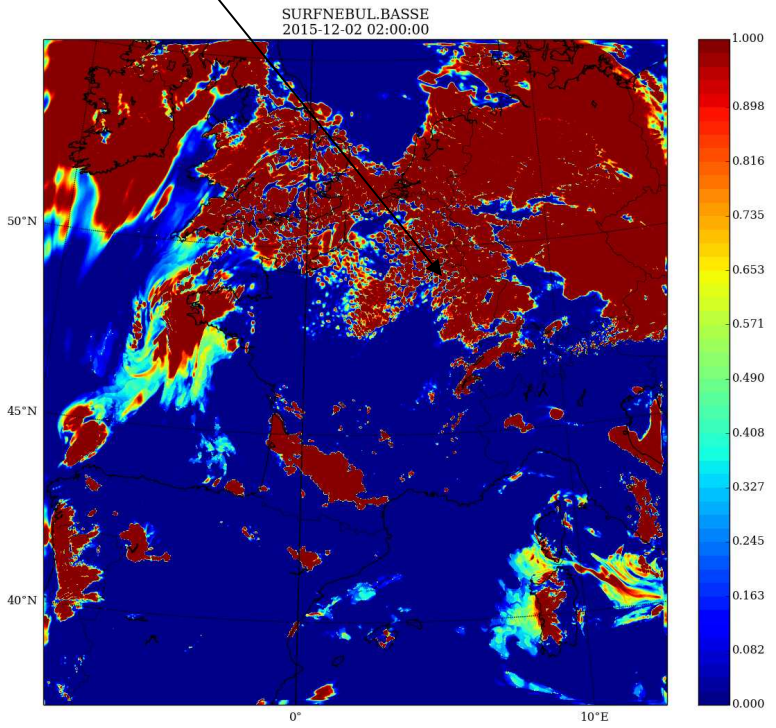
Some issue… wrong low clouds removing



AROME microphysics produces small amounts of rain, not observed by the radar (-> drying when assimilating radar reflectivities)

Less degradation without drying the lowest values of simulated reflectivities



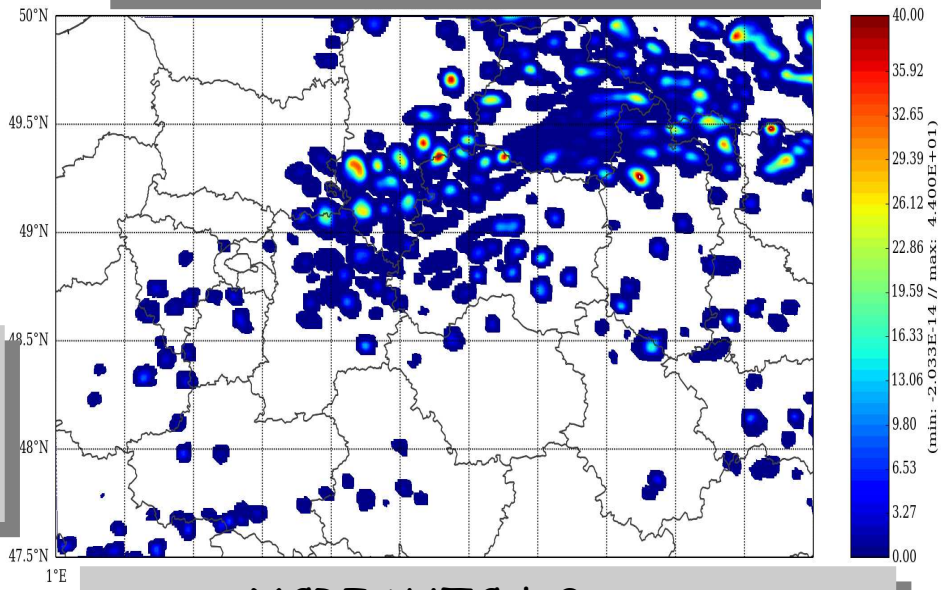


Some issue… wrong low clouds removing

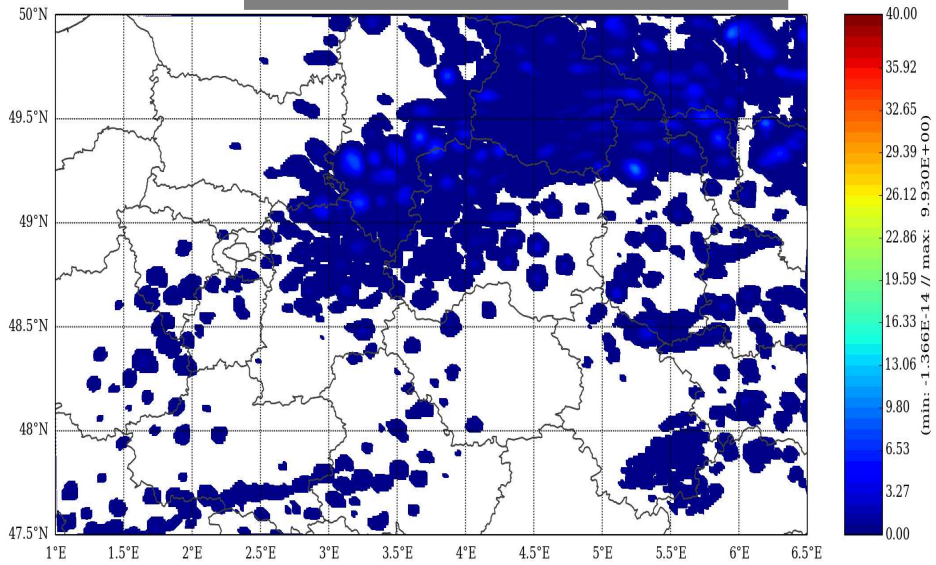
Tunings in the microphysics may also solve this problem… (ongoing work)

S070RAIN :

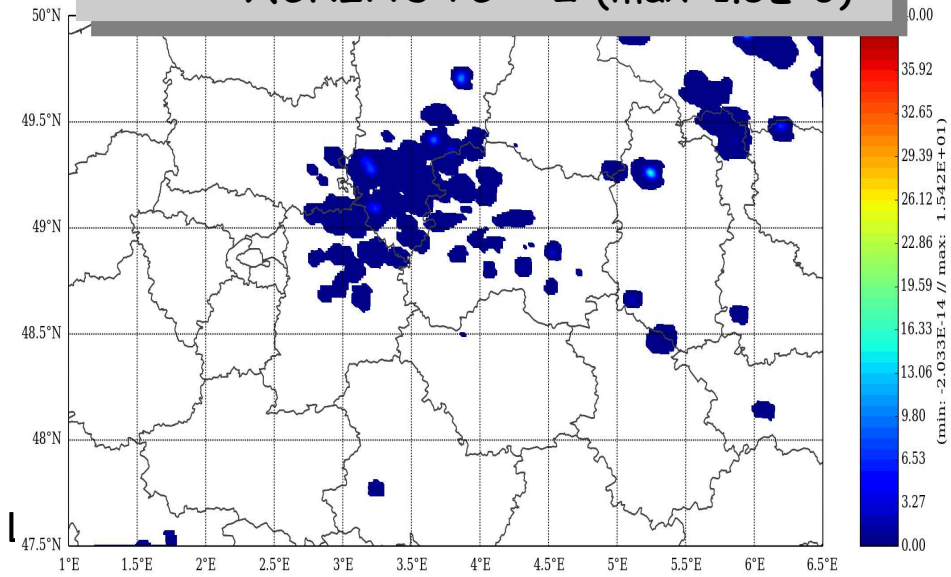
Reference (max=44E-6)



OCND2 (max=9E-6)



XCRIAUTC * 2 (max=1.5E-6)



Next steps for 2016 ...

- Surfex v8 (+Ororad) will be implemented in CY43T1

  (tests of ISBA-Diff, MEB, are planned in AROME)

- Work still needed before using ORORAD SVF in oper (to be sure not to put compensating errors)

- Validation/optimisation of LIMA in AROME

- Understand and propose fix for low clouds under-estimation

Thank you for your attention,

Questions ??

LIMA

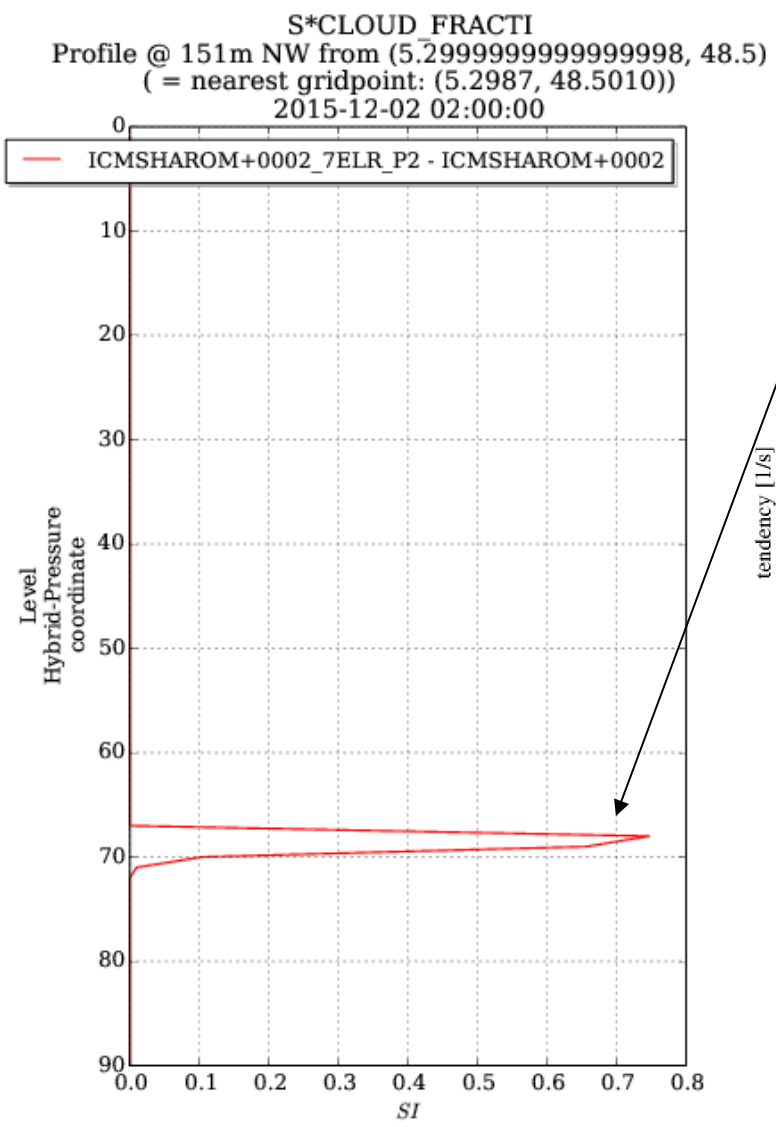
Prospects :

PHD Thesis Marie Taufour (from Oct 2015) :

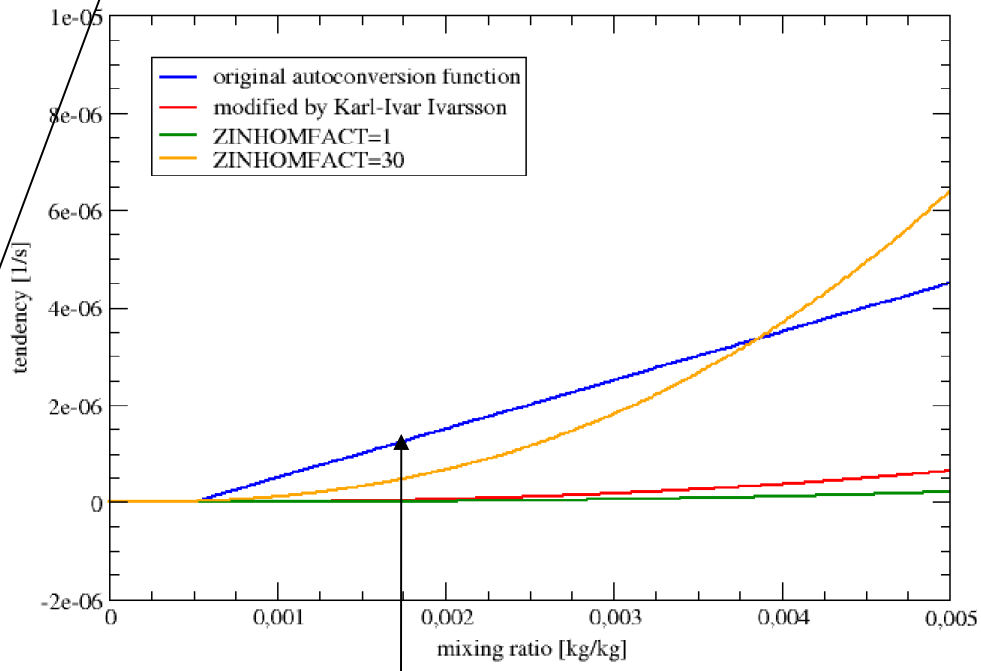
- detailed comparison ICE3/LIMA for HYMEX IOPs, RASTA&polar radars)

- implementation in AROME

Cloud fraction differences: clouds remain

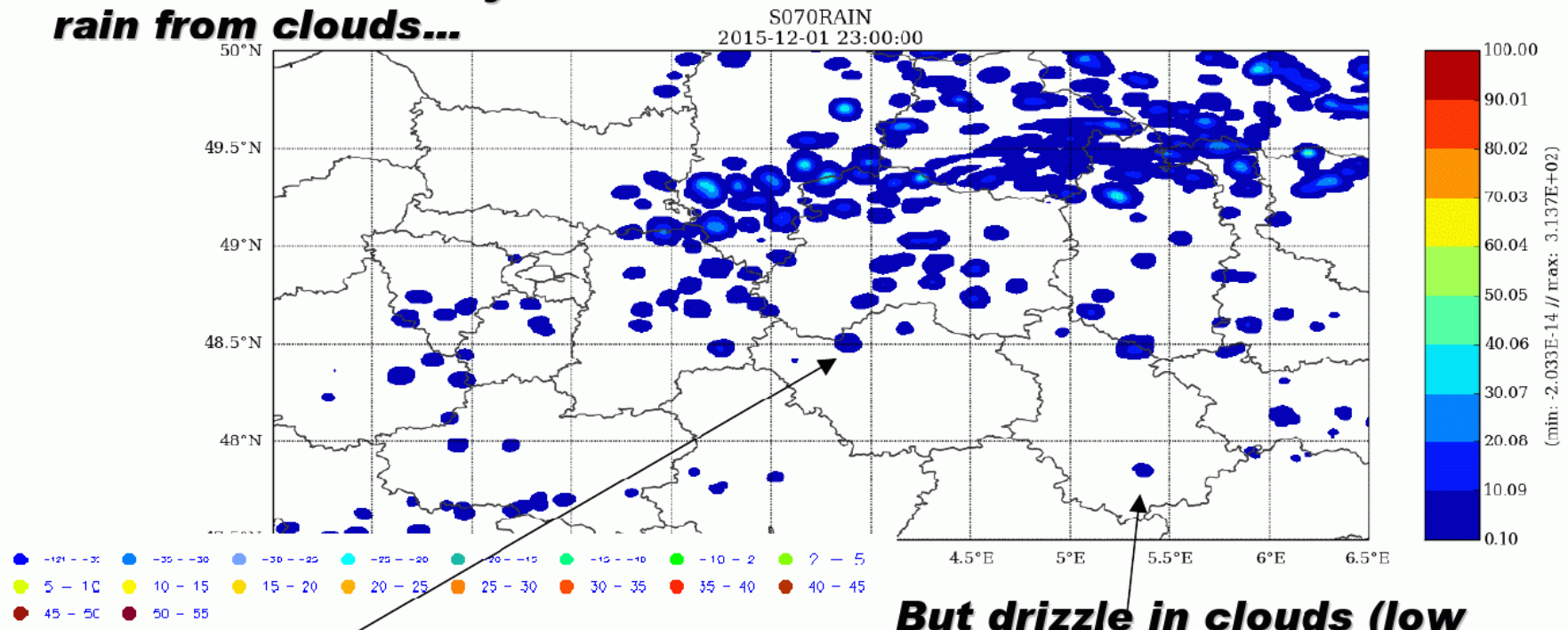


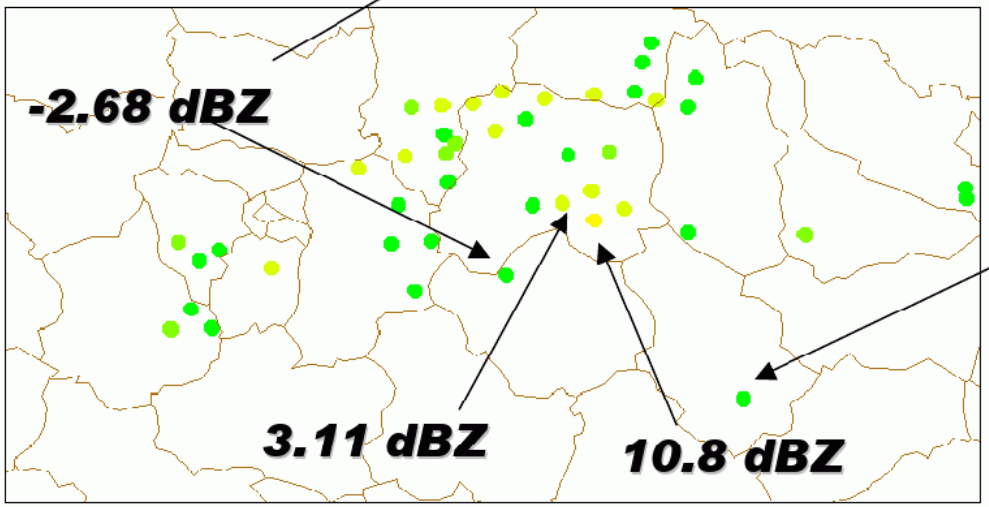
One day of radar assimilation cycling without drying lowest simulated reflectivities Z < 10 dBZ



Problem of ICE3 microphysic? Studies are underway…

no rain detected by the radar: active observations to remove rain from clouds…





But drizzle in clouds (low simulated reflectivity) corresponding at low Qr

-0.4 dBZ : 3.E-6 kg/kg = Qr

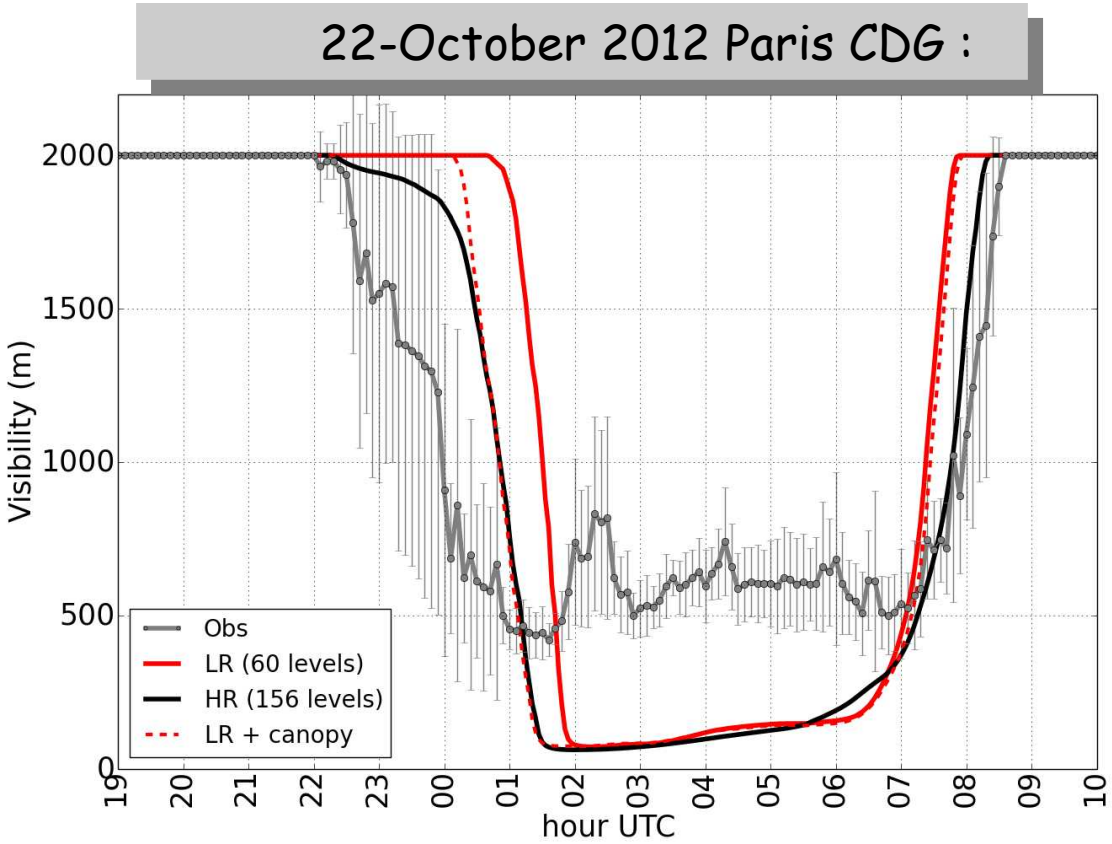
With the observation operator in AROME:

$Qr = 10^{-7}$ kg/kg => Z = -25 dBZ

$Qr = 10^{-6}$ kg/kg => Z = -8 dBZ

$Qr = 10^{-5}$ kg/kg => Z = +9 dBZ

Fog



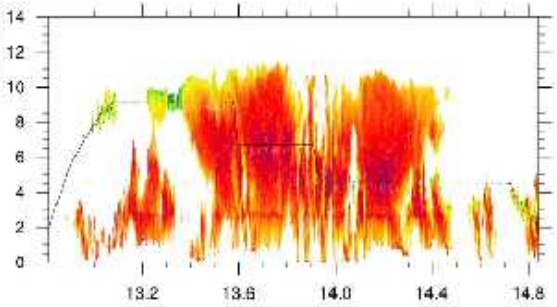
- PHD of A. Philip : Add fog microphysics in Canopy SBL scheme.

Improves fog formation, but not as HR because of local circulations.

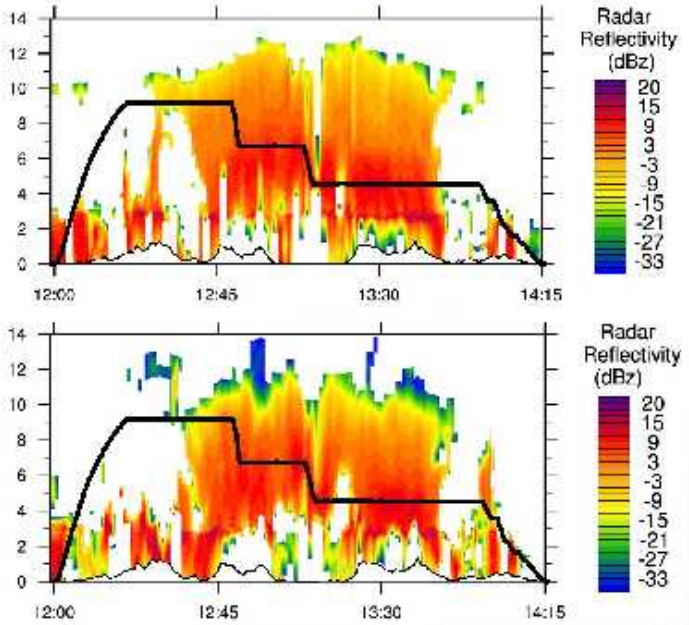
LIMA

LIMA: Cloud representation

Southeastern France, RASTA reflectivities, 2012/10/26



RASTA observations

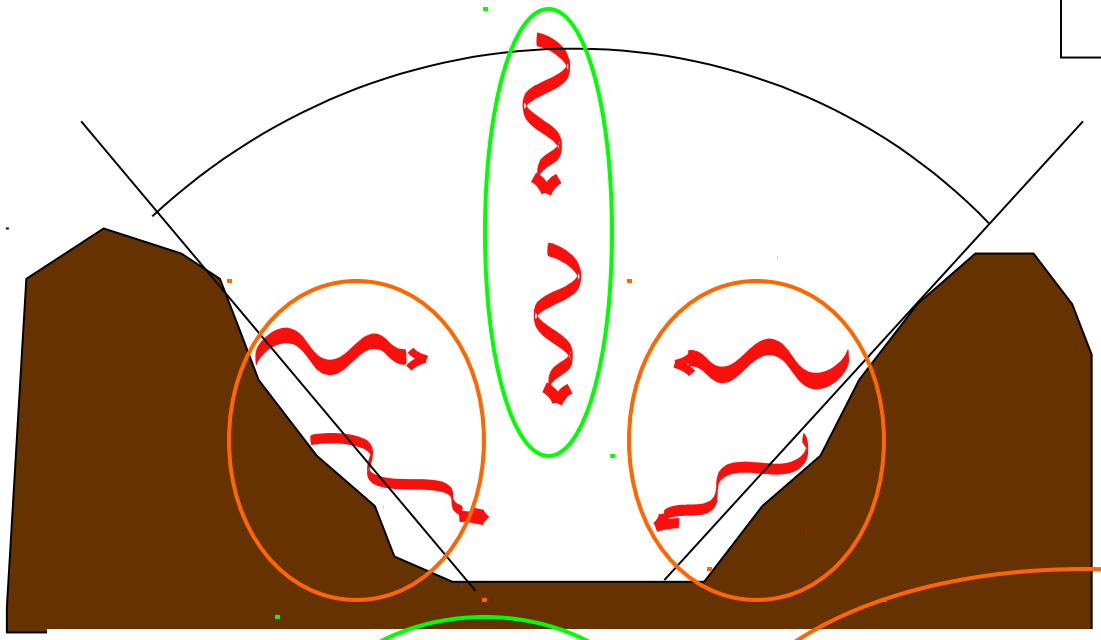


Simulation with ICE3 (top) and LIMA (bottom)

ORORAD : SVF

$$\delta_{sv} = 1 - \frac{1}{2\pi}\int_0^{2\pi} \sin[h_h(\theta)]\,\mathrm{d}\theta \approx 1 - \frac{\sum_{i=1}^{8} \sin(h_{h,i})}{8}.$$

-> Calculé sur grille HR puis moyenné et écrit dans PGD



LW : $$F_{\downarrow} = \delta_{sv} F_{\downarrow 0} + (1 - \delta_{sv}) F_{\uparrow 0,e}$$

SW : $$S_{\downarrow df,1} = \delta_{sv} S_{\downarrow df,0} + \alpha_e (1 - \delta_{sv}) S_{\downarrow,e}$$

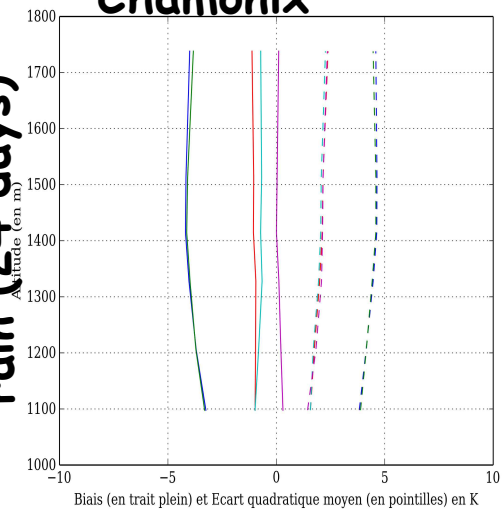
Instrumented slopes : 18 TU mean profiles

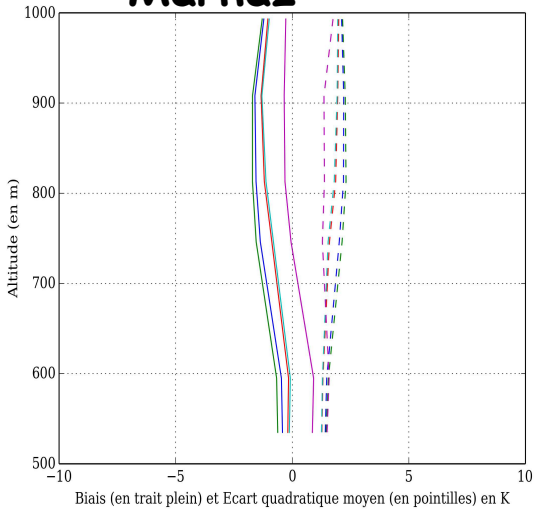
Chamonix

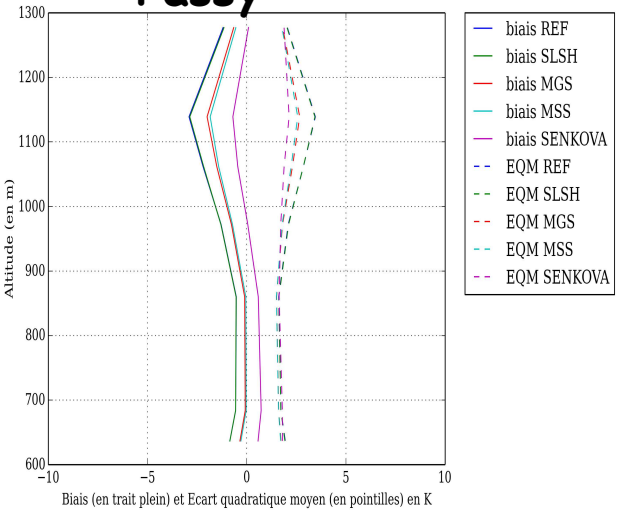
Marnaz

Passy

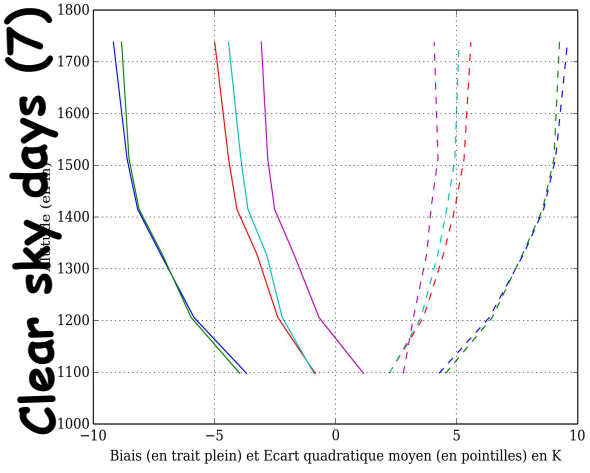
Days with snow/ rain (24 days)

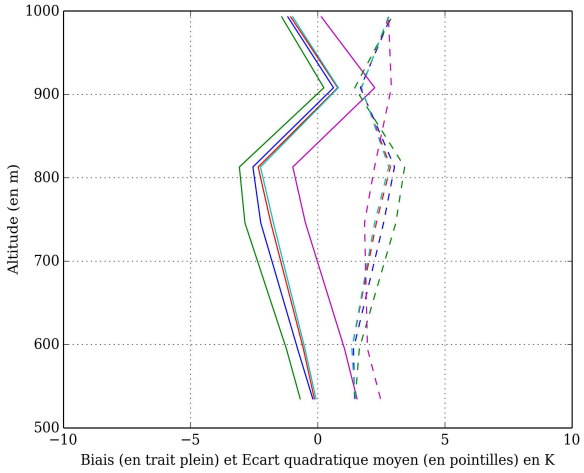


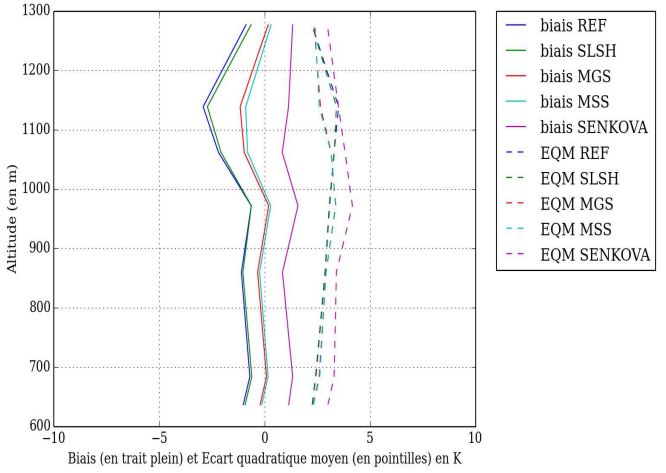




Clear sky days (7)







Negative bias (stronger in Clear Sky days),
Senk seems to be the best simulation.