Study of the diurnal cycle at DomeC (Antarctica): impact of the snow and PBL scheme in 3D and 1D experiment.

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Parameterization of Stable Boundary Layer
in Numerical Weather Prediction Models
Helsinki 3/5 dec. 2012

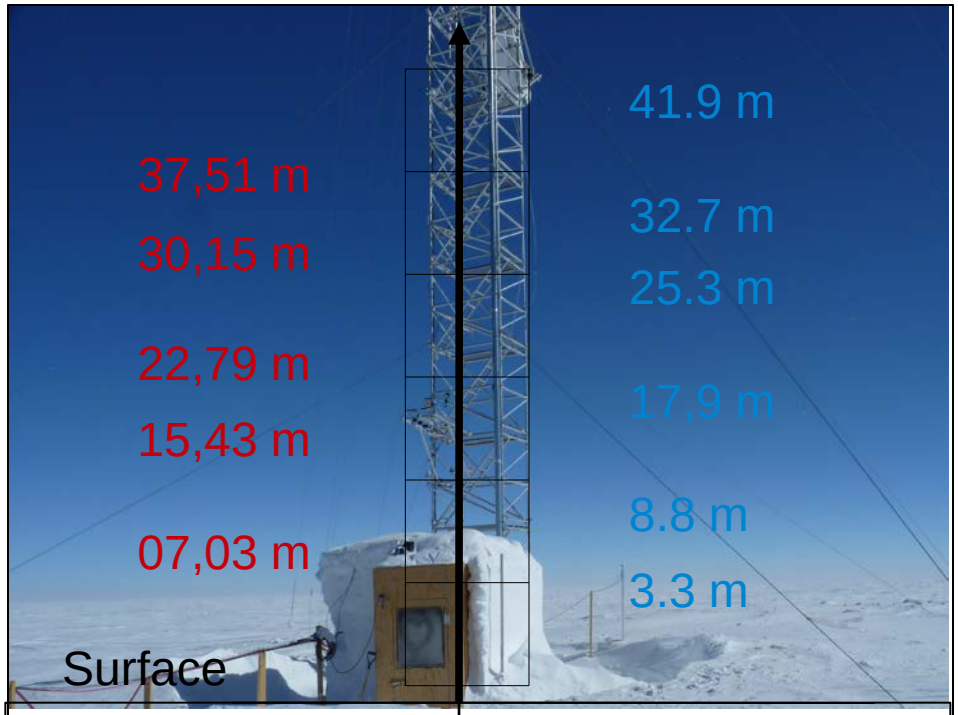
cnrs INSU Observer & comprendre

METEO FRANCE Toujours un temps d'avance

Outline

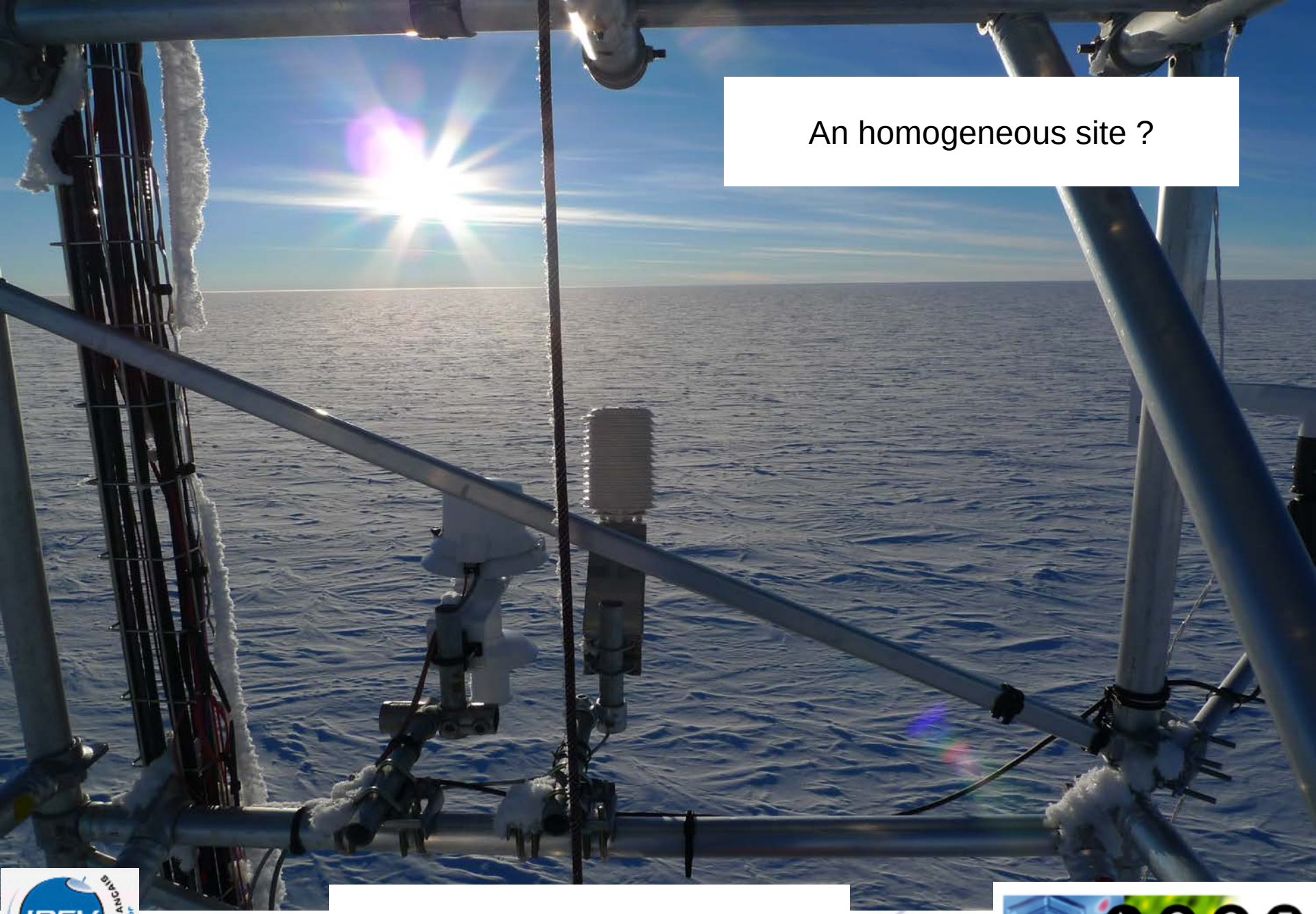
- Observations
- Dome C : Antarctic Plateau, an homogeneous site ?
- Numerical experiments :
  - Case1: 4th Dec 2009
  - Case2: 27th Nov 2009 (not shown)
  - "Climate mode"
- 1 D experiment for case1
- Conclusions and perspectives

Observations: Antarctic Plateau Dome C / Concordia



- High frequency parameters (10 Hz) from 6 ultra-sonic anemometers : 3D Wind components and sonic temperature
- Low frequency parameters (30 min) : air temperature (ventilated and not ventilated), relative humidity, wind speed and direction (**Young**)
- 1 minute solar radiation components
- Sub and surface temperatures
- Radiometer HAMSTRAD (P. Ricaud)
- RS (1 or 2 per day)

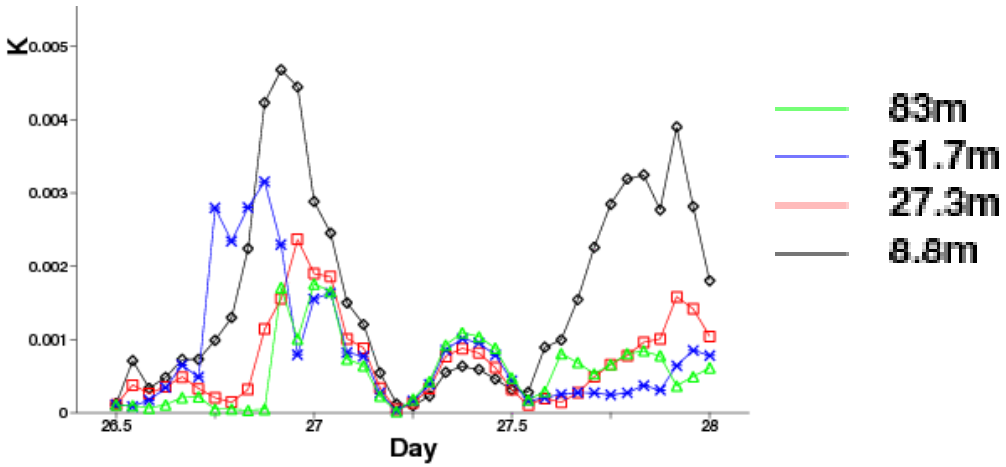
Thanks to Gert König Langlo (AWI for PMR, Bremerhaven, De) Christian Lanconelli (ISAC, Bologna, It), Andrea Pellegrini (ENEA, Roma, It), Eric Fossat (LUAN, Nice, Fr)



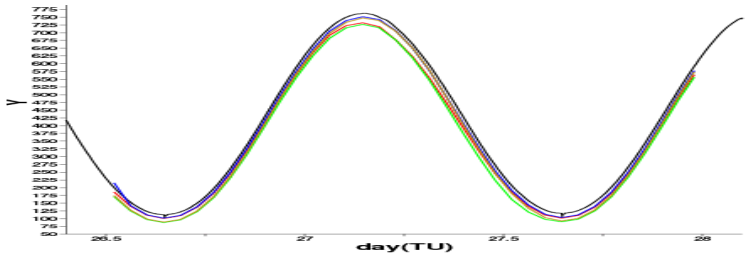
LGGE tower 45m

Spatial Variability around Domec (25km2)

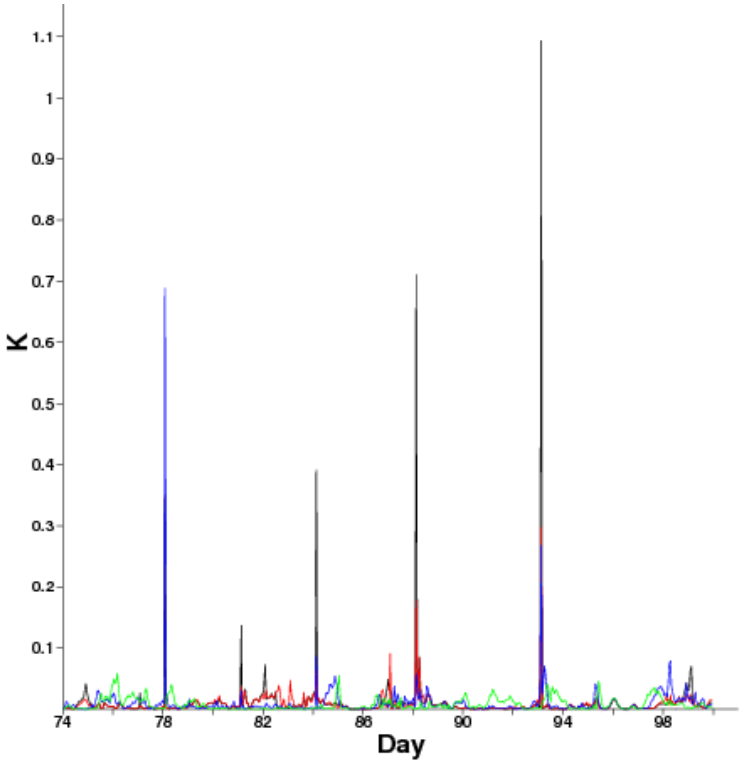
STD for temperature at different level (Case 2)



Shortwave radiation downward



STD for temperature at different level « Climate mode »



The temperature STD is very small with a « shifted diurnal cycle »
So at least for the model the site is homogeneous → it makes sense to compare the model directly to the observations.

Numerical Experiment : 2.5km (100x100pts)

•**AROME** (Seity et al, 2011) : Nh model based on ARPEGE/ALADIN dynamical core with the Méso-Nh physical parametrization. AROME is included in the unified software ARPEGE/ALADIN/IFS and activated by namelist (logical switch)

•Lateral boundary condition (LBC) from the operational ARPEGE analysis (4DVAR)
•Initial file (upper air and surface) from ARPEGE analysis

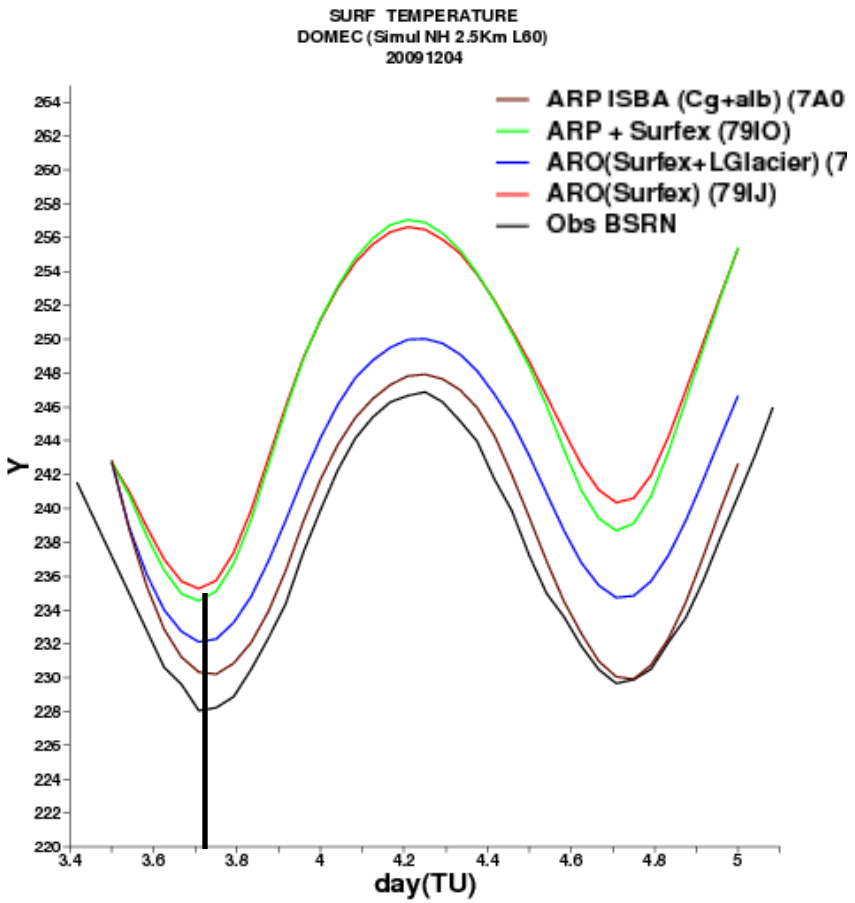
•Horizontal resolution: 2.5km , time step=60s (SL), preliminary test with 60 and then 90 vertical levels

•Two types of experiment with AROME and ARPEGE physics:
- •36h forecast on 3 "optimum " dates chosen with low winds, observation available, almost no clouds etc … → create 1D cases
- •"climate mode" the model is driven only by the LBC every 6h no reinitialization in the domain and for the surface fields

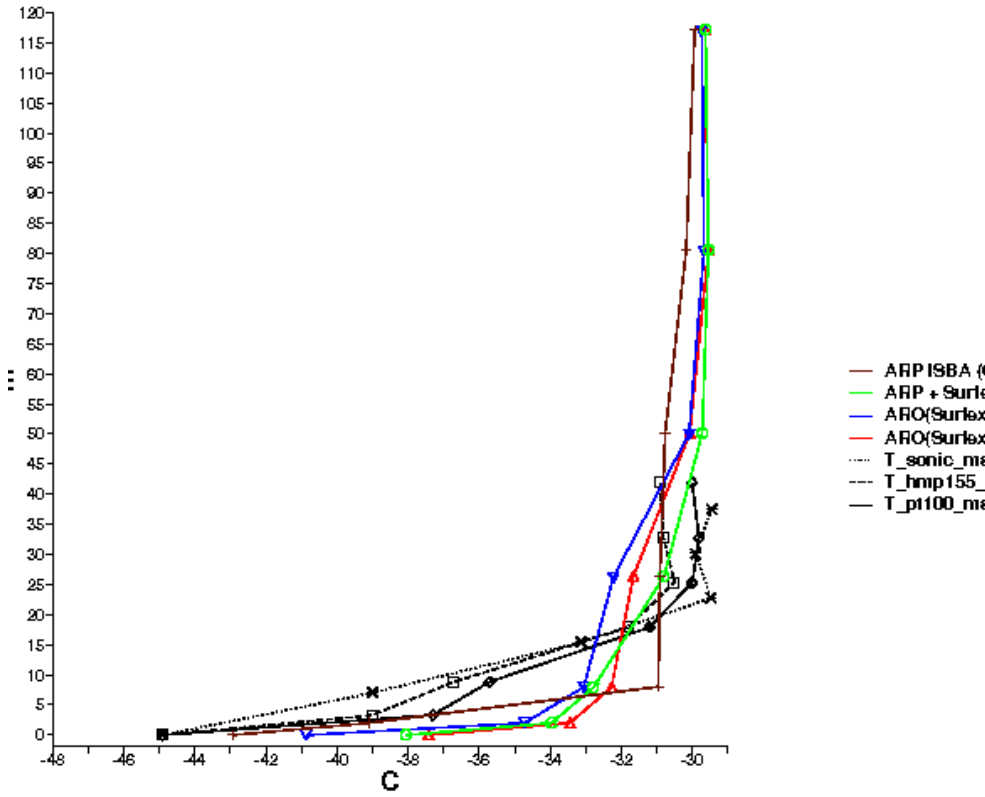
PHYSICS in ARPEGE/ALADIN/AROME

	ARPEGE/ALADIN Global model (10km to 55km) and LAM (7.5km)	AROME (NH) 2.5km
Surface	ISBA(Noilhan, Planton (89), Giard Bazile (2000)) OR SURFEX	SURFEX With ISBA, TEB, Ecume, etc
Turbulence	TKE (Cuxart et al 2000)	
Mixing length	Bougeault Lacarrere (89)	
	Modified by the shallow cloud thickness and deep convection	
Shallow Convection	KFB (Bechtold et al 2001)	PMMC09 (Pergaud et al 2009)
Deep Convection	Moisture Convergence (Bougeault 85)	Explicitly resolved
Clouds (PDF)	Smith (90)	Bougeault (82)
GWD	Described in annexe of Catry et al. 2008	no
Microphysics	Ql,Qi,Qr,Qs Lopez(2002) Bouteloup et al (2005)	Ql,Qi,Qr,Qs,Qg Pinty and Jabouille 1998
Radiation	RRTM for LW (Mlawer et al. 1997) and Morcrette et al. 2001 for SW (6b)	

December, 4th 2009 (Case1) Init:03/12/09 at 12UTC



03/12/09 at 18UTC



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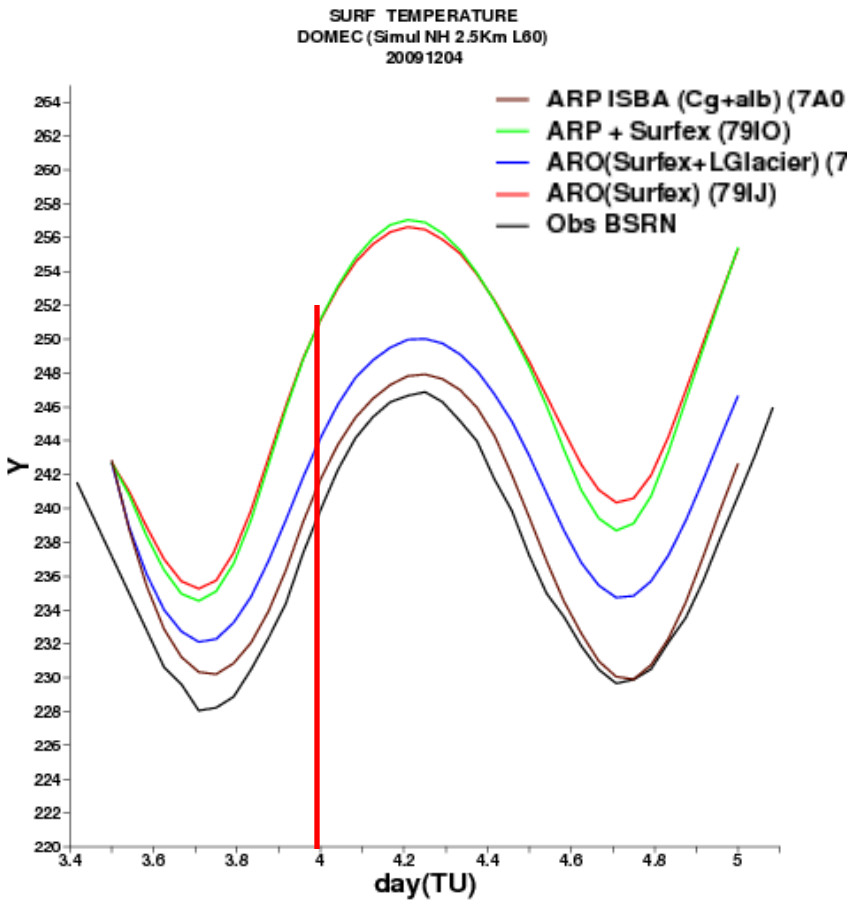

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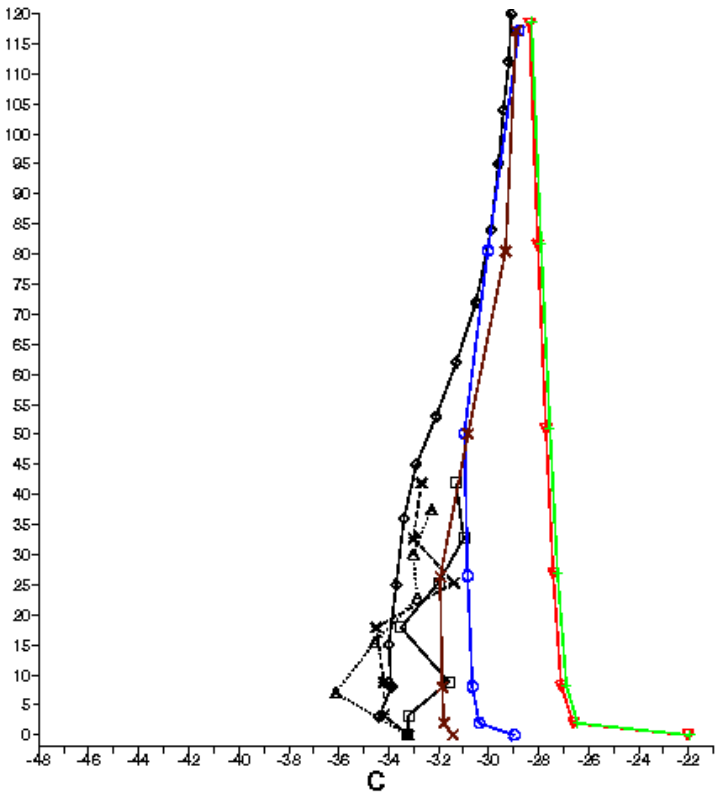

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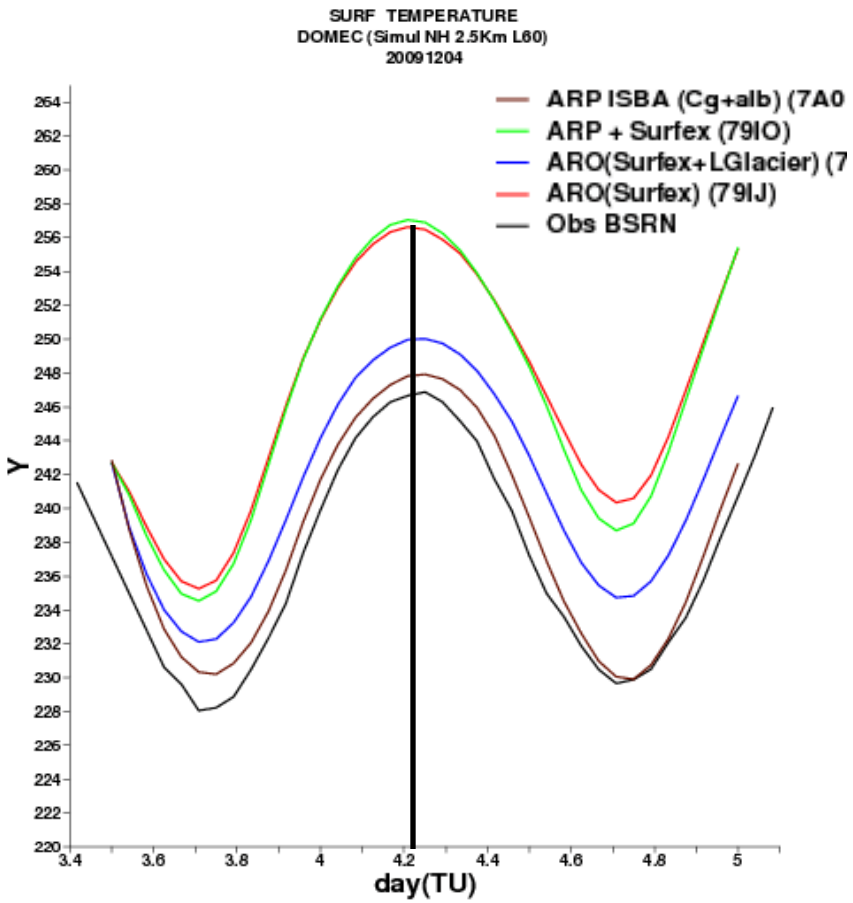

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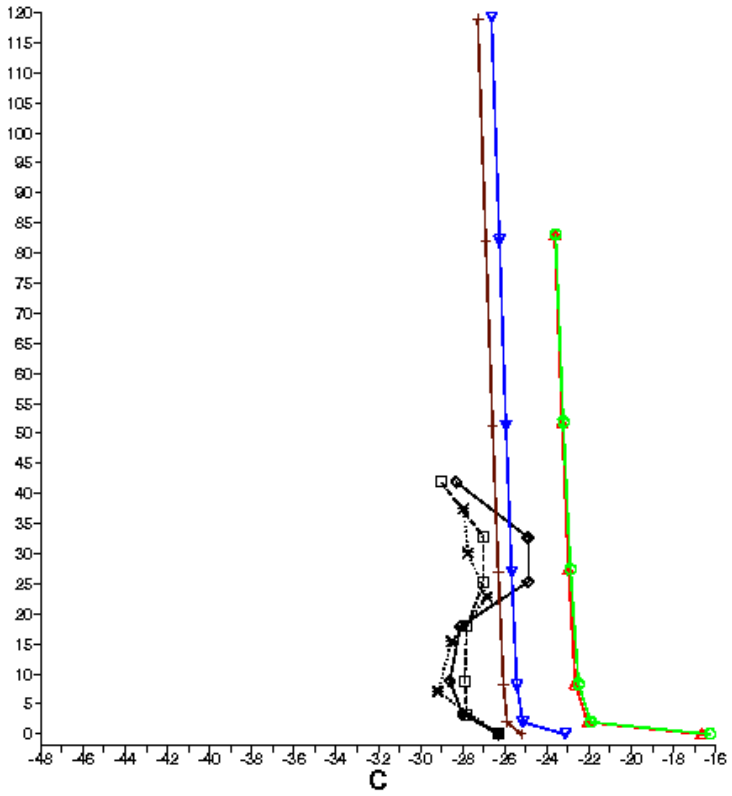

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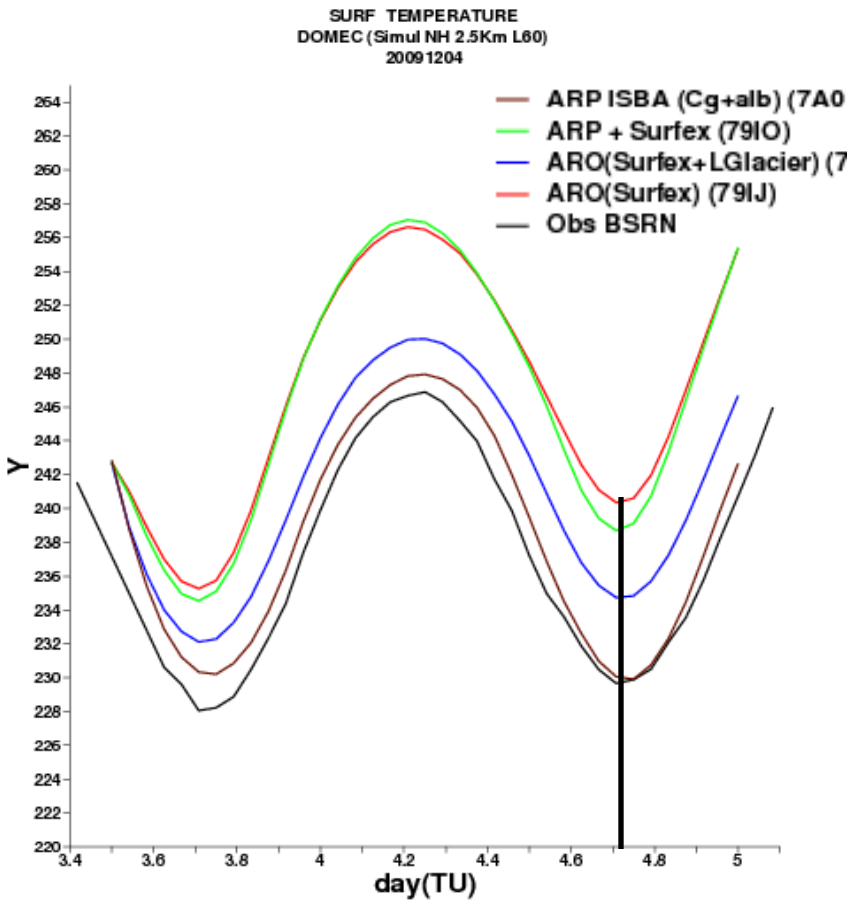

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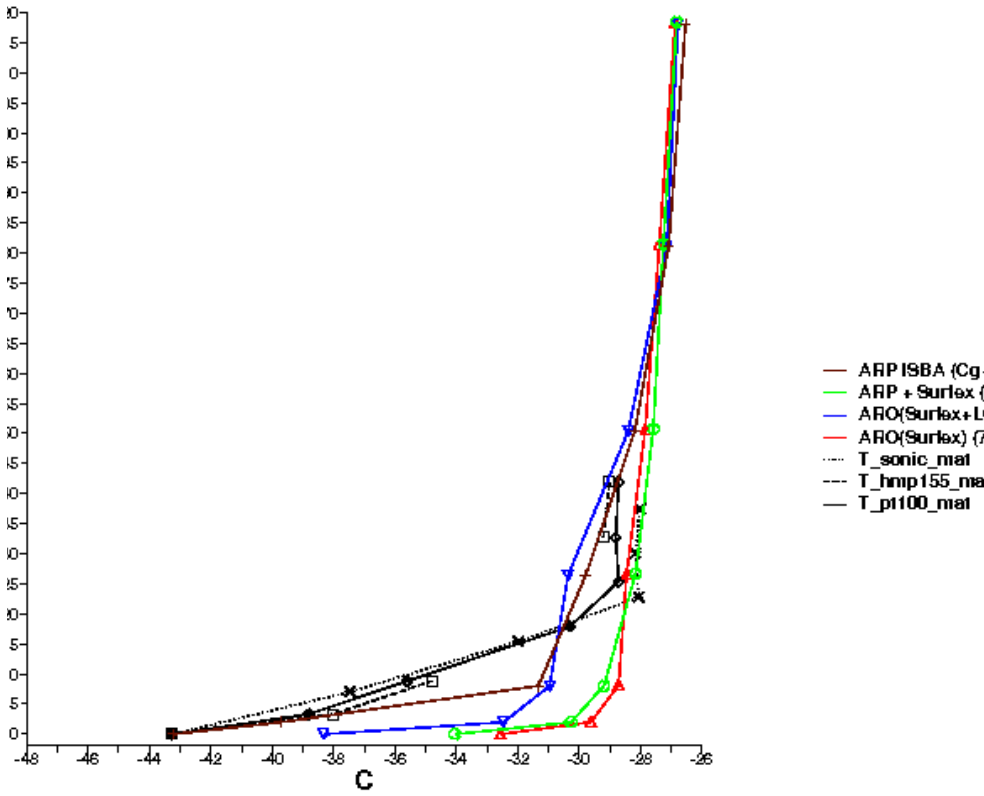

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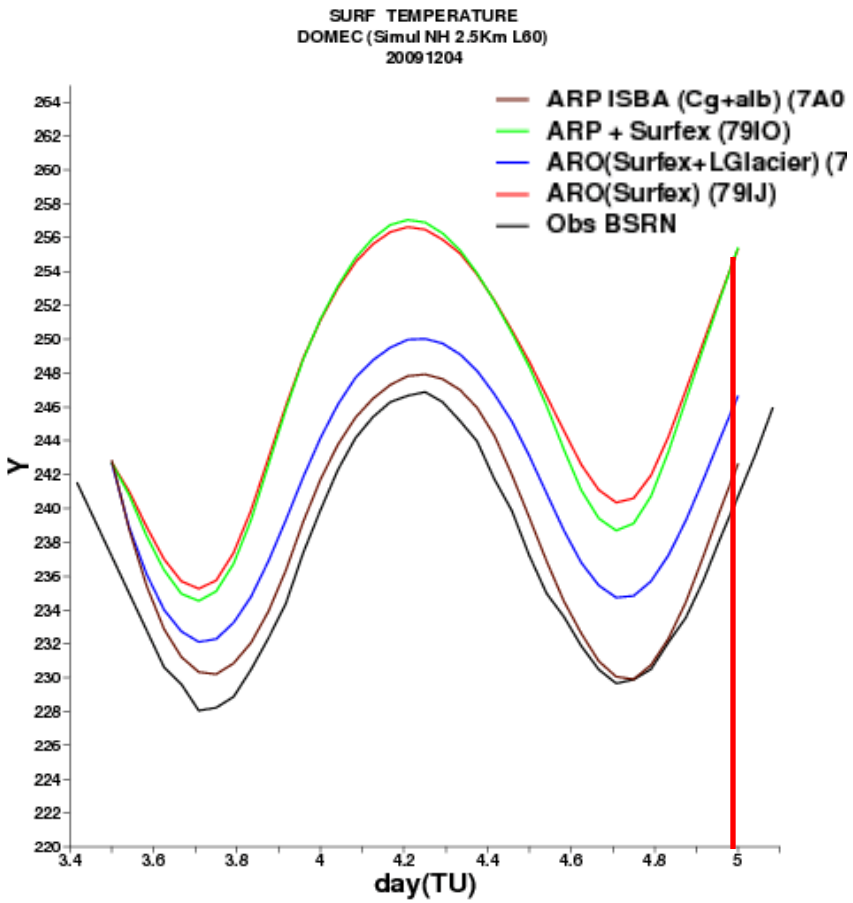

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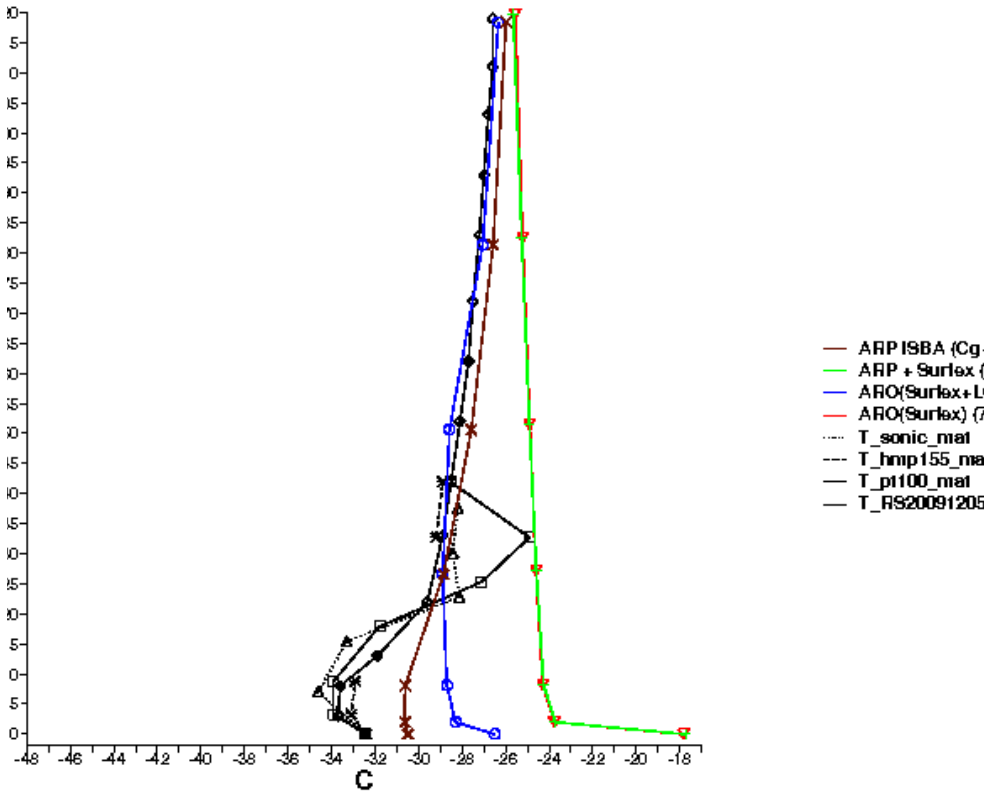
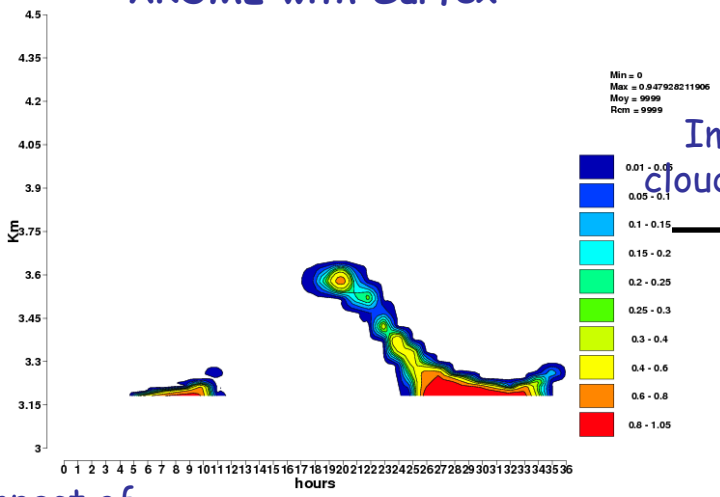


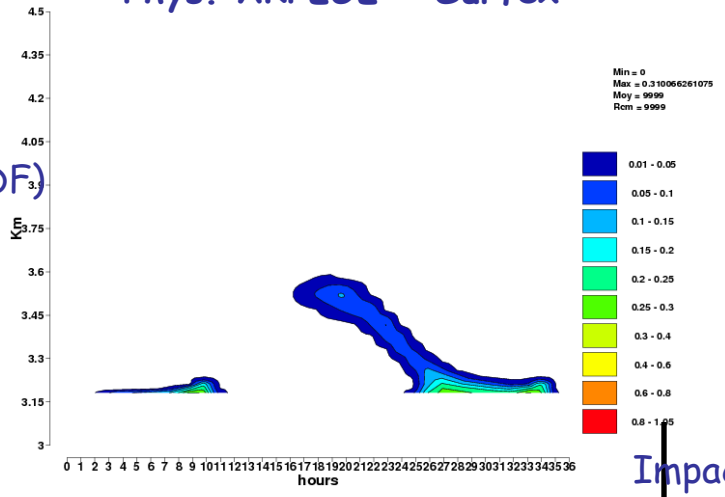
December, 4th 2009 (Case1) Init 03/12/09 at 12UTC
Cloud Cover

AROME with Surfex



Impact of the cloud scheme (PDF)

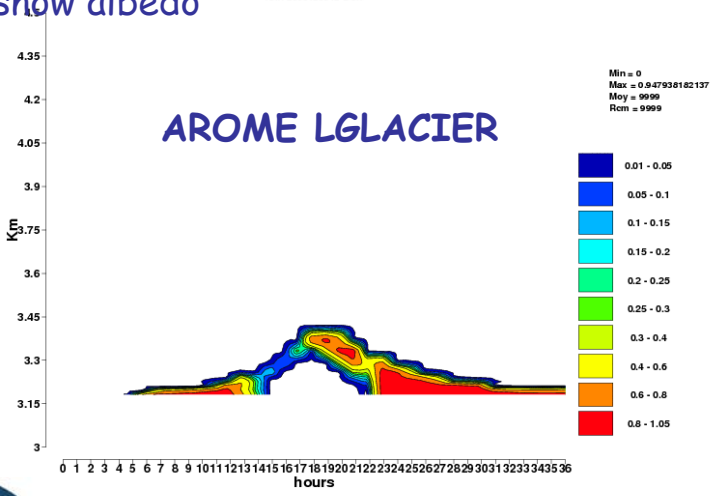
Phys. ARPEGE + Surfex



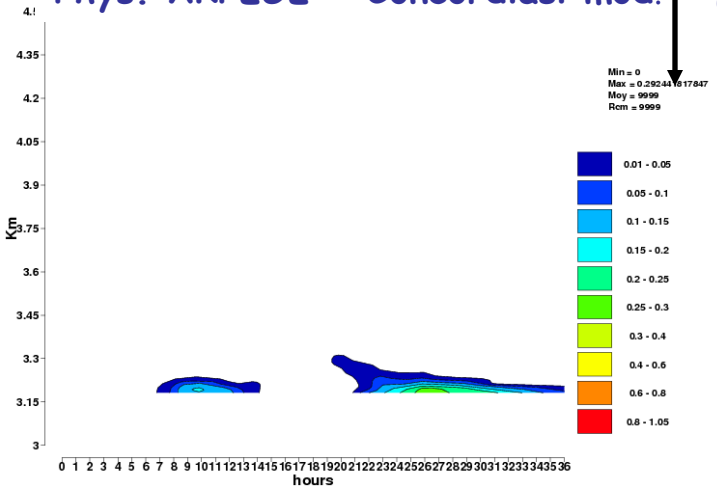
Impact of
The snow albedo

Impact of
the snow albedo+
Cg

AROME LGLACIER

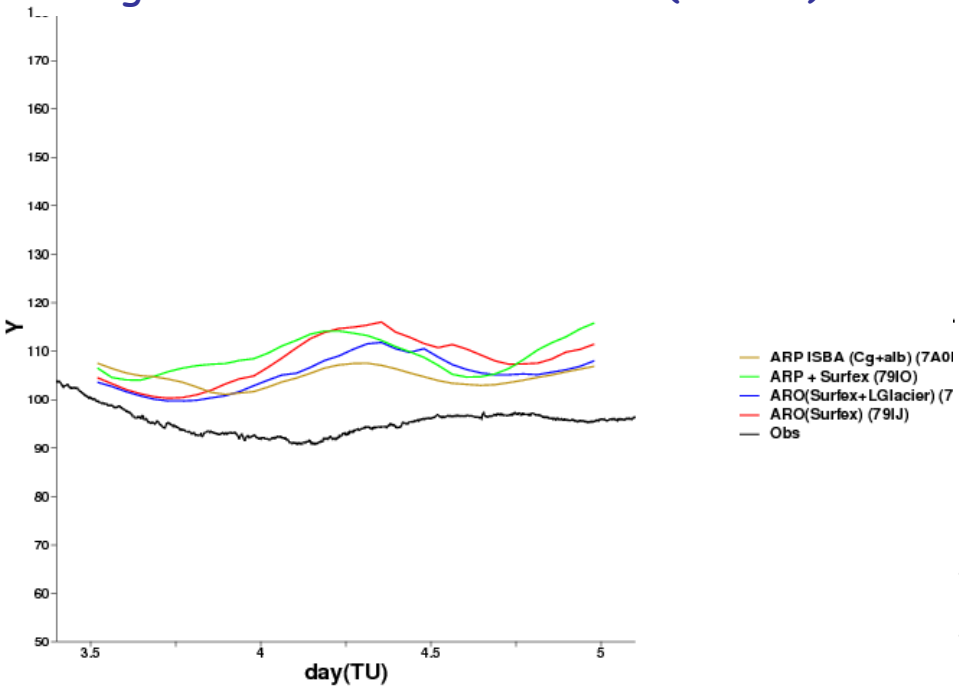


Phys. ARPEGE + Concordiasi mod.

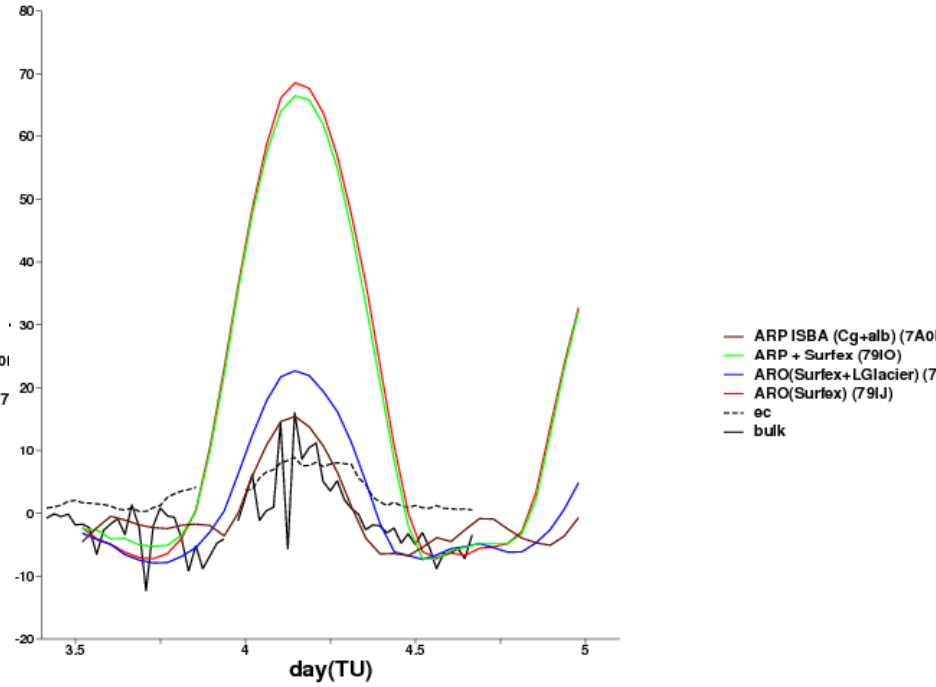


December, 4th 2009 (Case1) Init: 03/12/09 at 12UTC

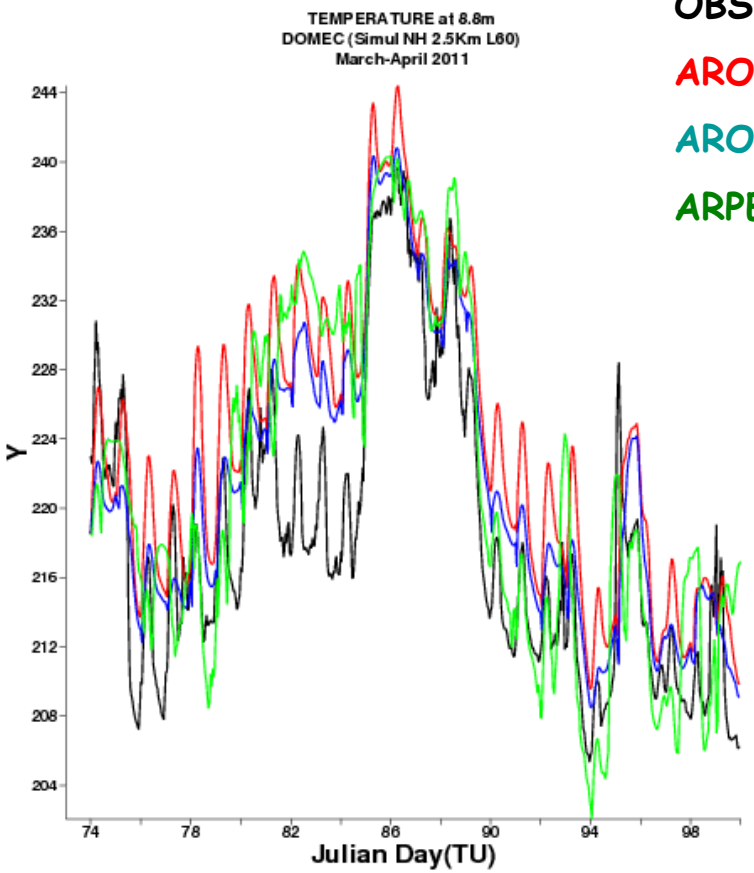
Long wave downward radiation (W/m2)



Sensible heat flux (W/m2)



Experiment in “Climate” mode
2011/03/14 → 2011/04/08 with 2 physics package



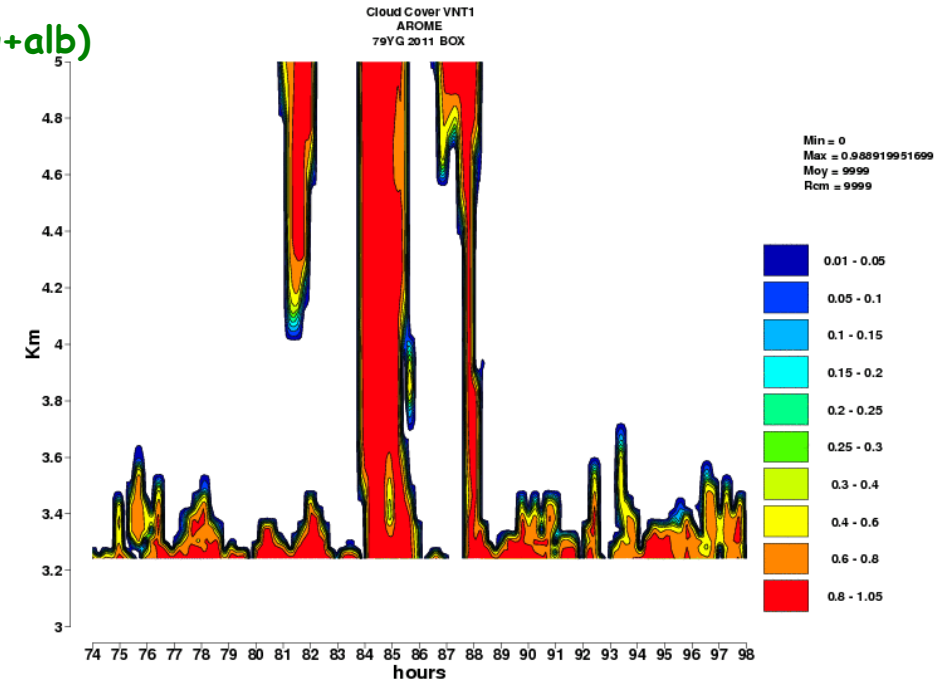
OBS

AROME

AROME Lglacier

ARPEGE (Cg+alb)

Cloud Cover



How to compute the dynamical forcing for a 1D model ?

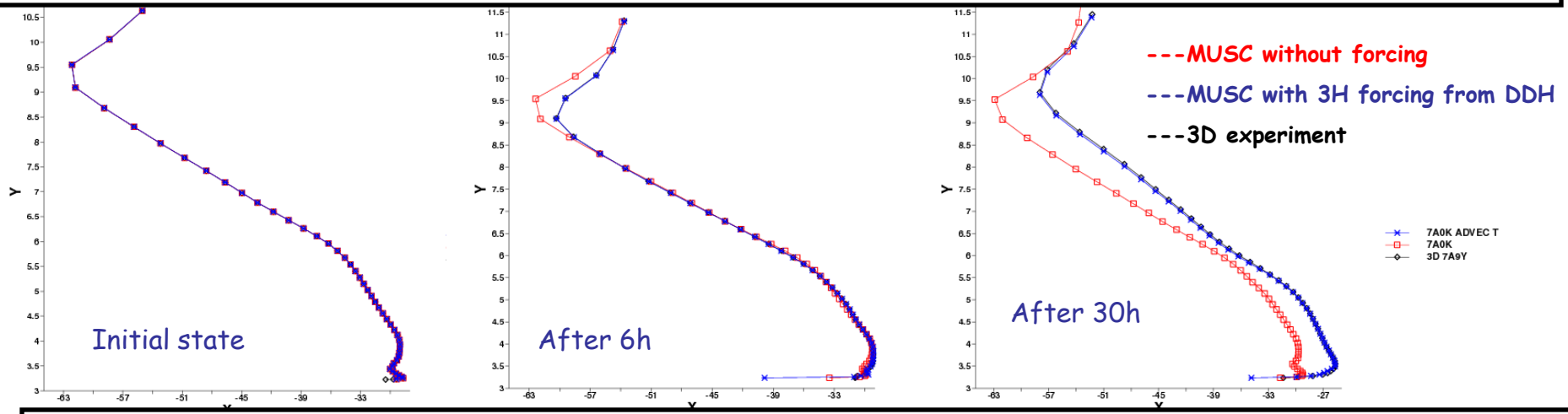
- From a 3D experiment :
  - Classical method: from horizontal fields at different level → dependency to the grid, instantaneous output → requires some time and space filtering
  - DDHtool box available in ARPEGE/AROME: computes the budget for each variable. The DDHtool can be use for a single vertical profile or a "box" around the site : all the physical processes are diagnosed and the total tendency so the dynamical forcing can be deduced from:

$$\frac{\partial T}{\partial t} = Dyn + \underbrace{\frac{\partial T}{\partial t}_{rayt} + \frac{\partial T}{\partial t}_{turb} + \frac{\partial T}{\partial t}_{shal} + \ldots}_{Physique\_AROME\_ou\_ARPEGE}$$

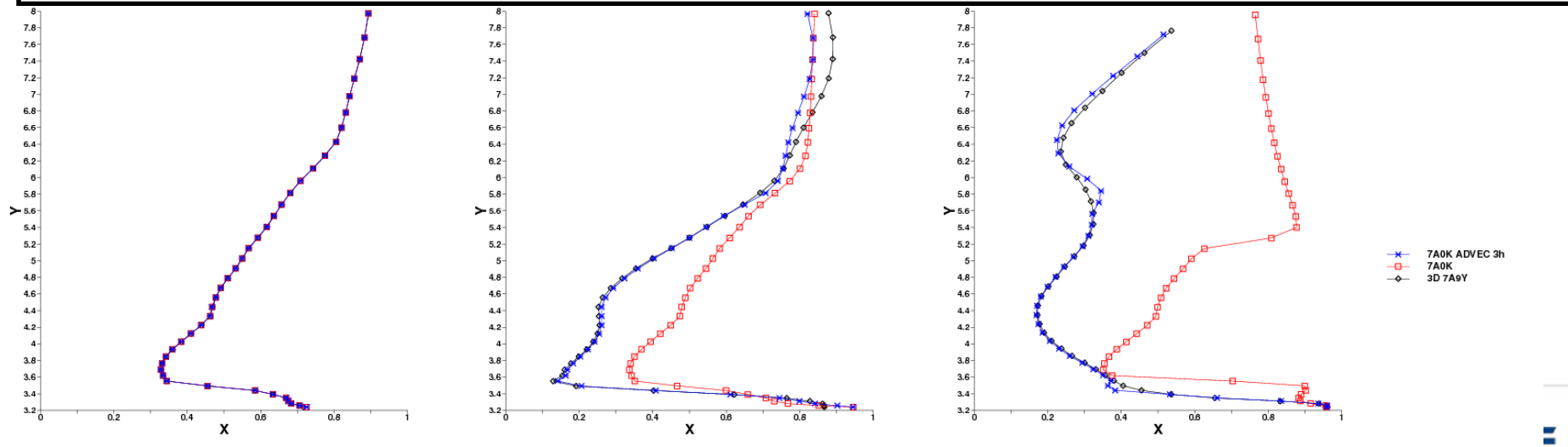
- In a ideal case, the dynamical term must be the same if we use different physics or options in the same model ? Otherwise, it gives us an idea about the uncertainties for the 1D experiment

Impact of the dynamical forcing in MUSC at Dome C. Case 1: 3/4 Dec. 2009

Temperature Profile Case 1



Relative humidity Profile Case 1

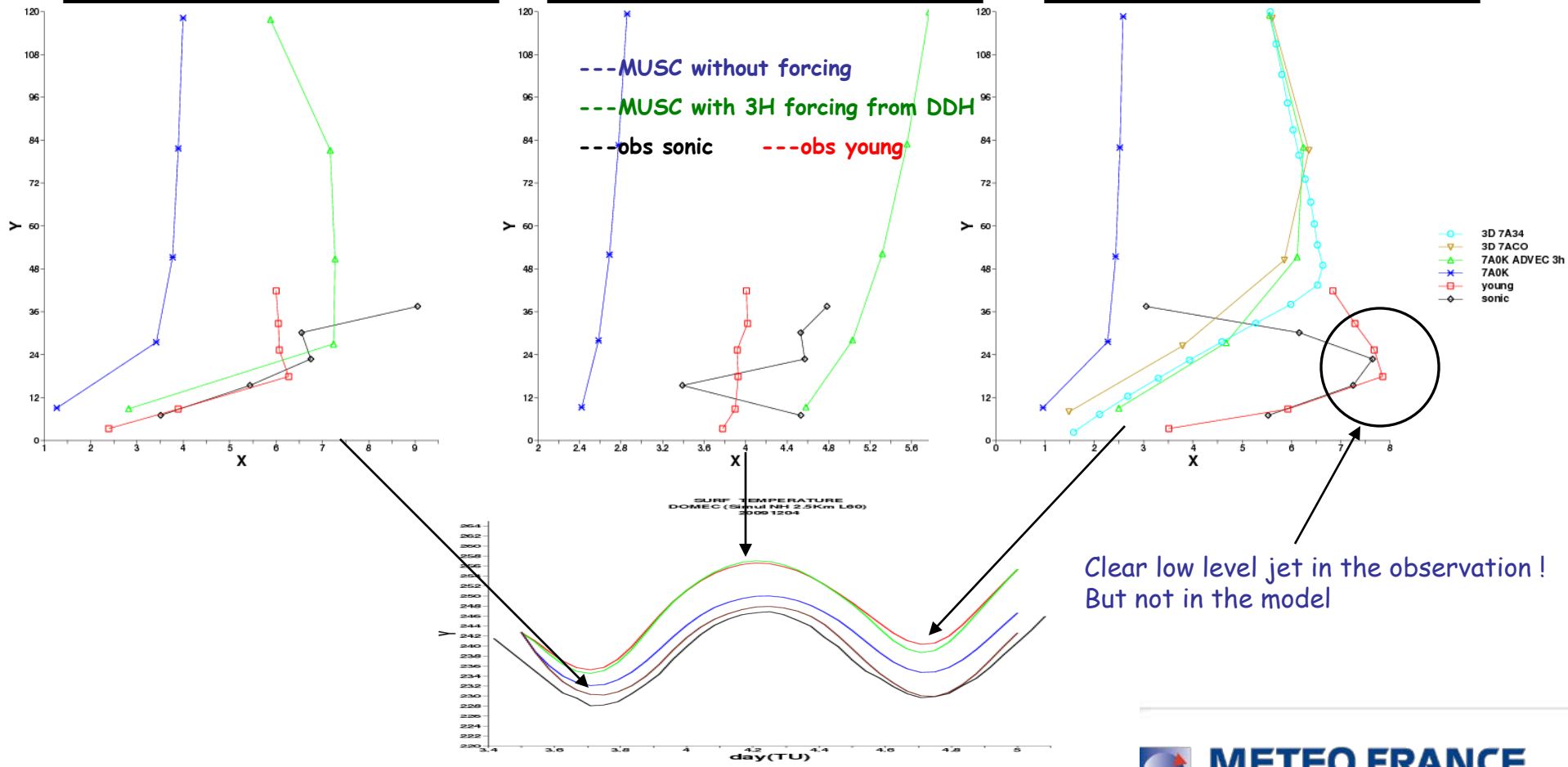


Impact of the dynamical forcing in MUSC at Dome C. Case 1: 3/4 Dec. 2009

Wind Profile Case 1
20091203 18TU

Wind Profile Case 1
20091204 06TU

Wind Profile Case 1
20091204 18TU



Clear low level jet in the observation !
But not in the model

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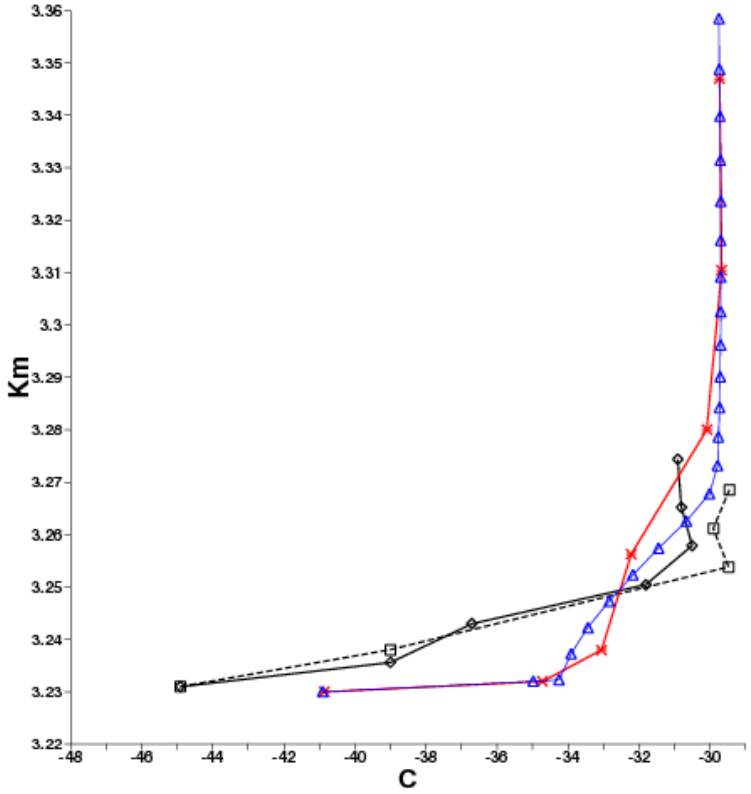
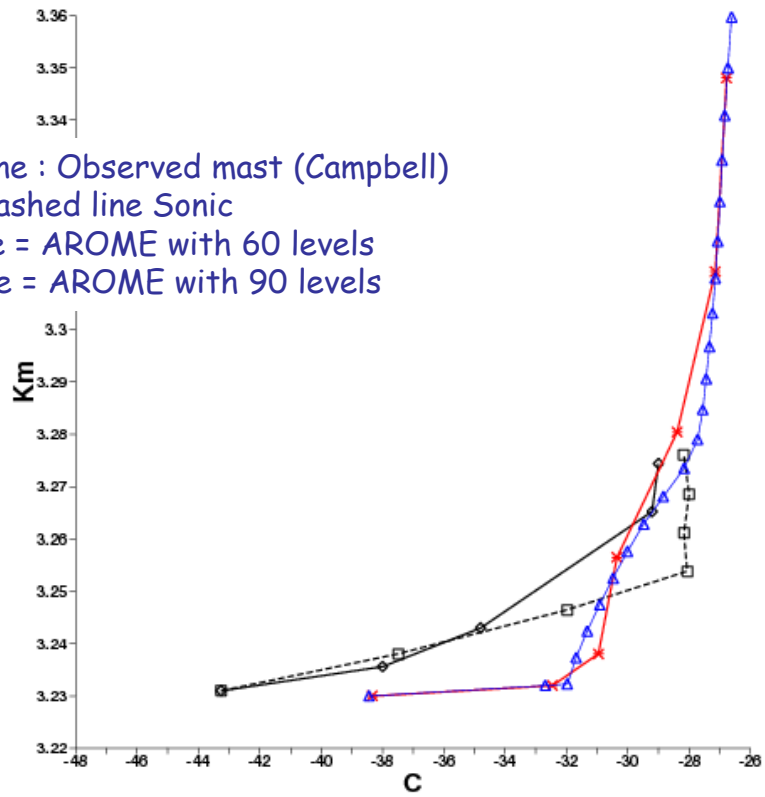
Number of vertical levels (Case 1)

20091203 18TU



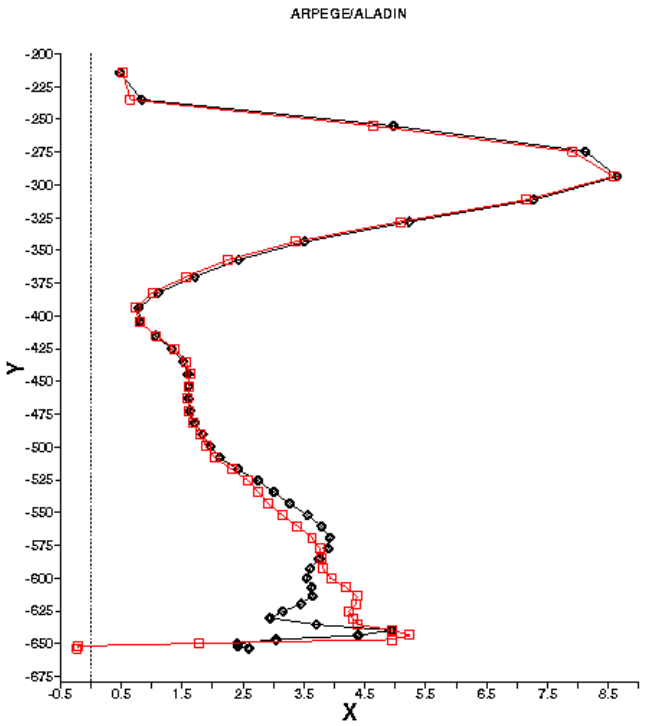
20091204 18TU



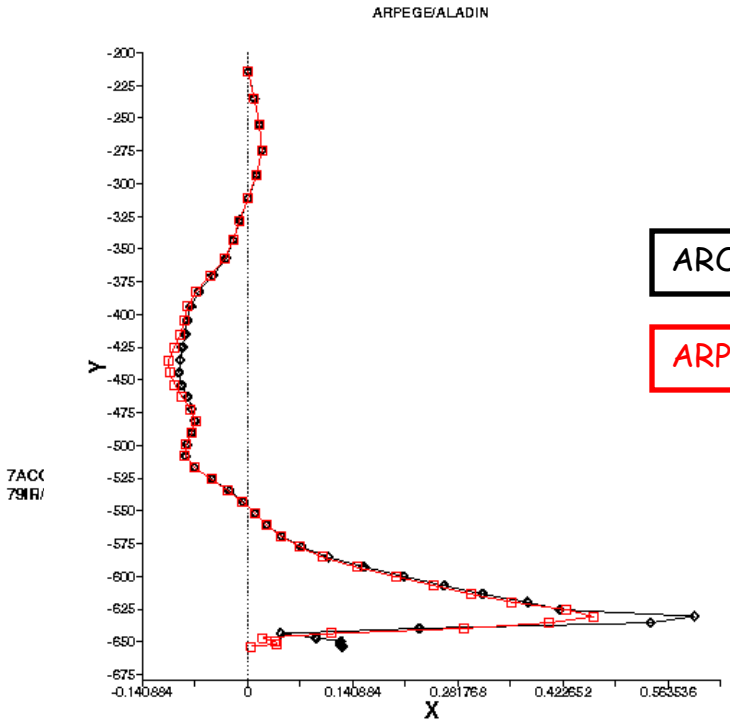
Black line : Observed mast (Campbell)
Black dashed line Sonic
Red line = AROME with 60 levels
Blue line = AROME with 90 levels

No clear improvement with more levels (x3) in the PBL !
Unfortunately ? so weaknesses are probably in the parameterization …
But more test are required especially on longer period (Climate mode)

Impact of the advection computed over 3h, 6h or from AROME ?



T advection between 12h and 18h



Qv advection between 12h and 18h

AROME with Glacier

ARPEGE with Cg and Alb

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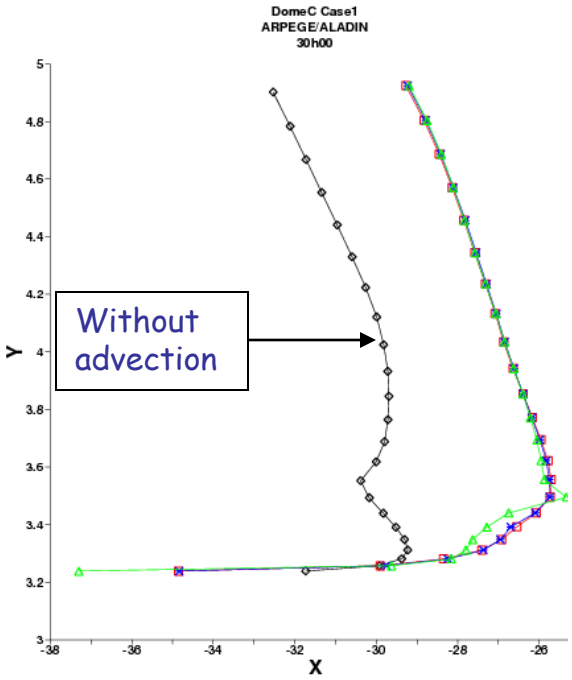
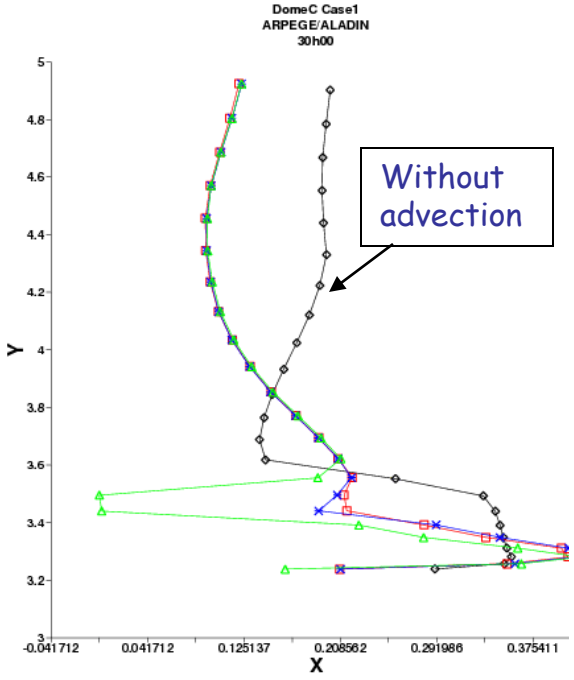
Toujours un temps d'avance

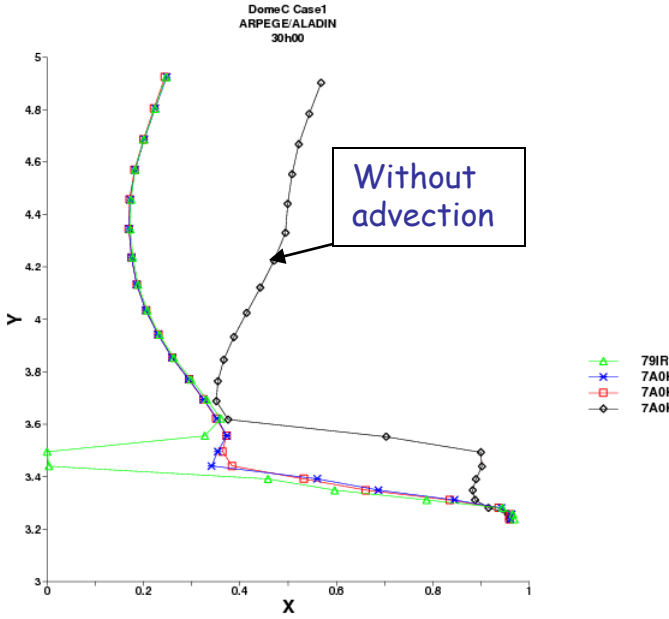
Impact of the advection computed over 3h, 6h or from AROME ?



Temperature after 30h



Specific Humidity after 30h



Relative Humidity after 30h

Conclusions & Perspectives

- Several 3D experiments at 2.5km have been performed:
  - AROME physics with SURFEX and a specific option (Lglacier)
  - ARPEGE physics with the snow scheme used during the CONCORDIASI experiment or with the SURFEX scheme used in AROME
  - Number of vertical level 60 → 90
- Overestimation of low clouds:
  - Problem of the cloud scheme (PDF Function) ?
  - Underestimation of the mixing ?
  - Initial conditions ?
- Perspectives for 1D GABLS:
  - Create an “ensemble forcing”
  - Simplified the advection term
  - geostrophic wind forcing instead of wind advection ?
  - More comparison :surface fluxes, snow temperature (snow pack), TKE
- 1 year experiment in “Climate Mode “