Mesoscale advection from AROME: computations, analysis and uncertainties

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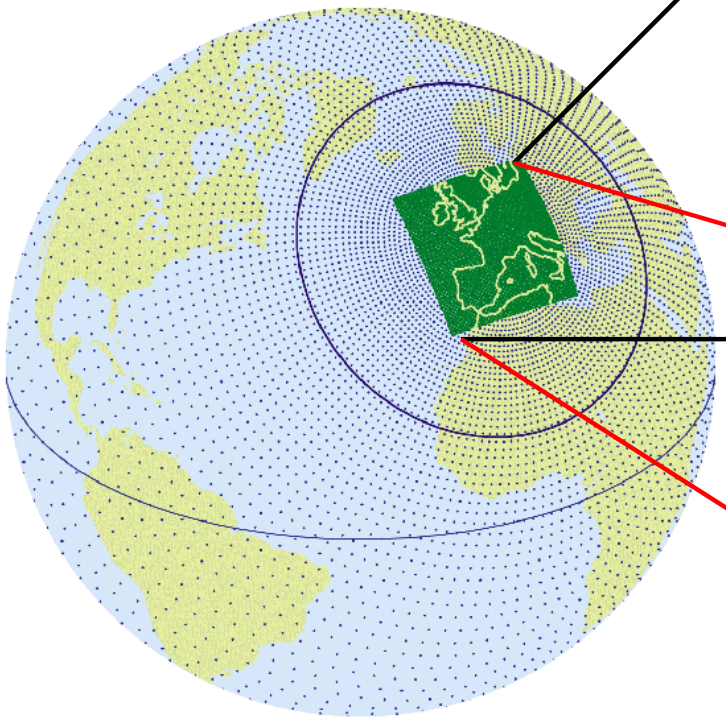
BLLAST Workshop

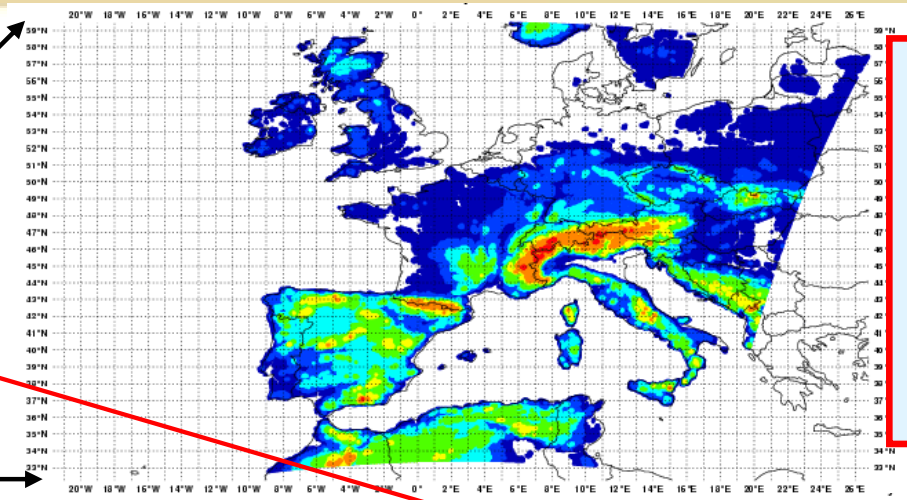
Wageningen 8-9 Feb. 2016

Outline

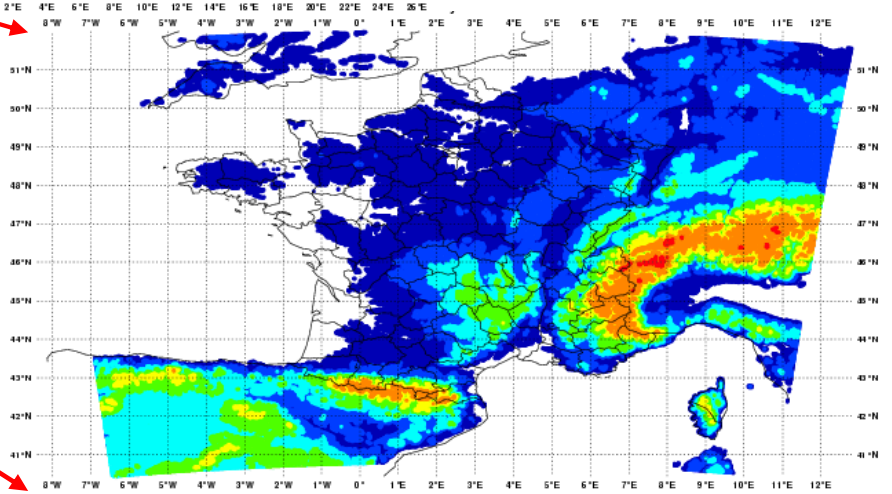
- MétéoFrance model configuration and specific output
- How to compute "Mesoscale" advection ? For which applications ?
- Models experiments: physics, resolution
- Comparison between 25/06/2011 and 01/07/2011
- Application example : case 01/07/2011
- Conclusions

Operational Weather forecasting at Météo-France
July 2011 (BLLAST experiment)





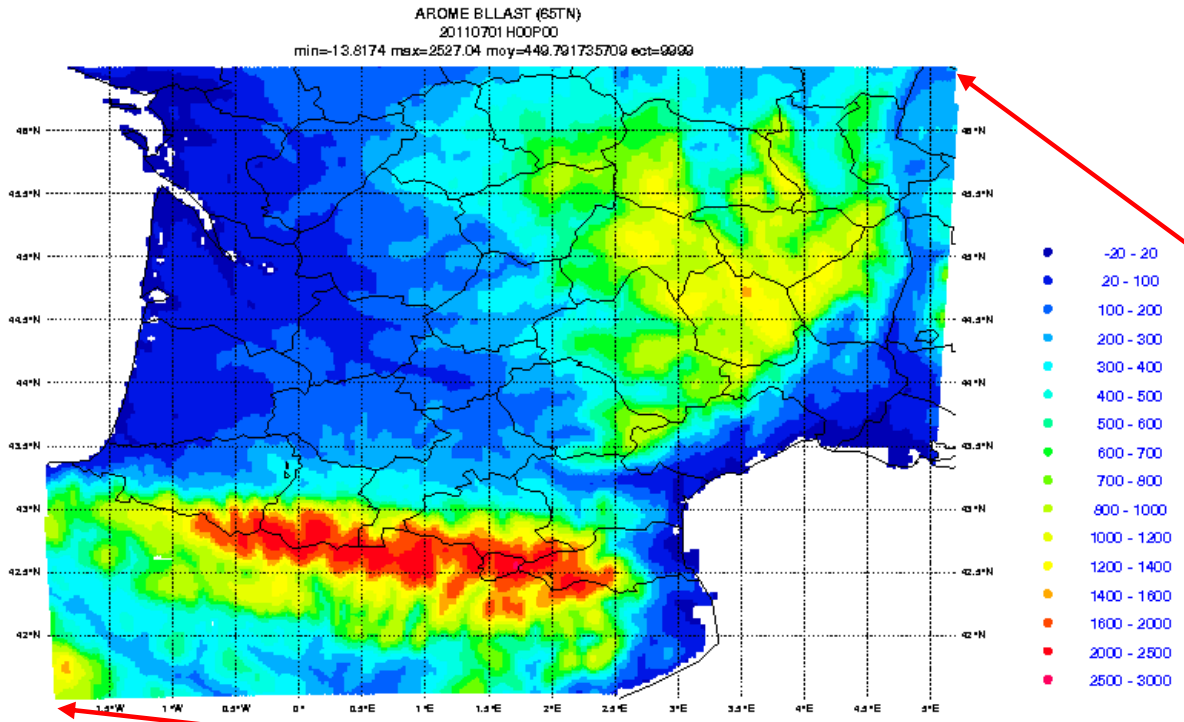
ALADIN :
54h h forecasts
every 6h
dx=7.8 km,
70levels,
time-step=450s (SL)
3DVar Data
Assimilation system

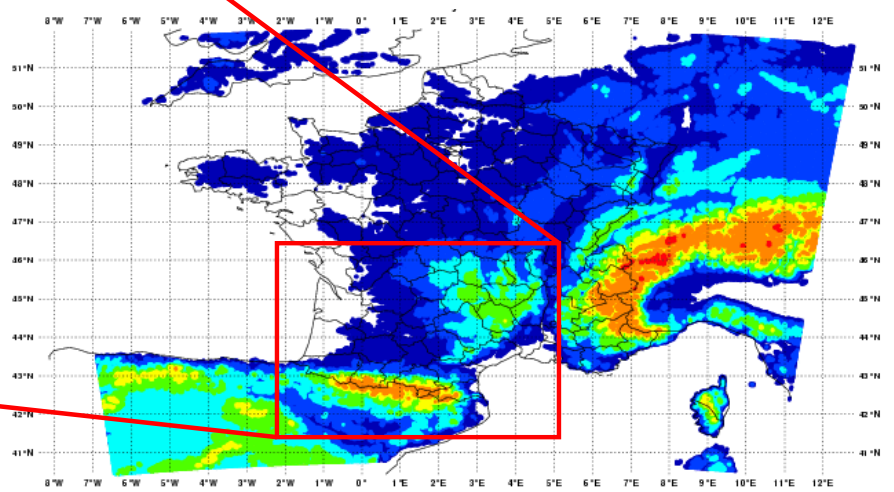


Global ARPEGE-IFS
4-day forecasts every 6 hours dx=10 km on
France, 55km on Australia dt=10mn
Stretching factor c=2.4 and turning of the pole
over the zone of interest
Stretched vertical grid with 70 levels
4DVar Inc Data Assimilation system
(T107 25iter and T323 30iter dx=60km)

Cloud Resolving Model AROME-France
30 h forecasts every 6h
dx=2.5 km, 60 Levels, time-step=1mn (SL)
3DVar Data Assimilation system (RUC3h)

Specific experiment (almost in real time) with AROME





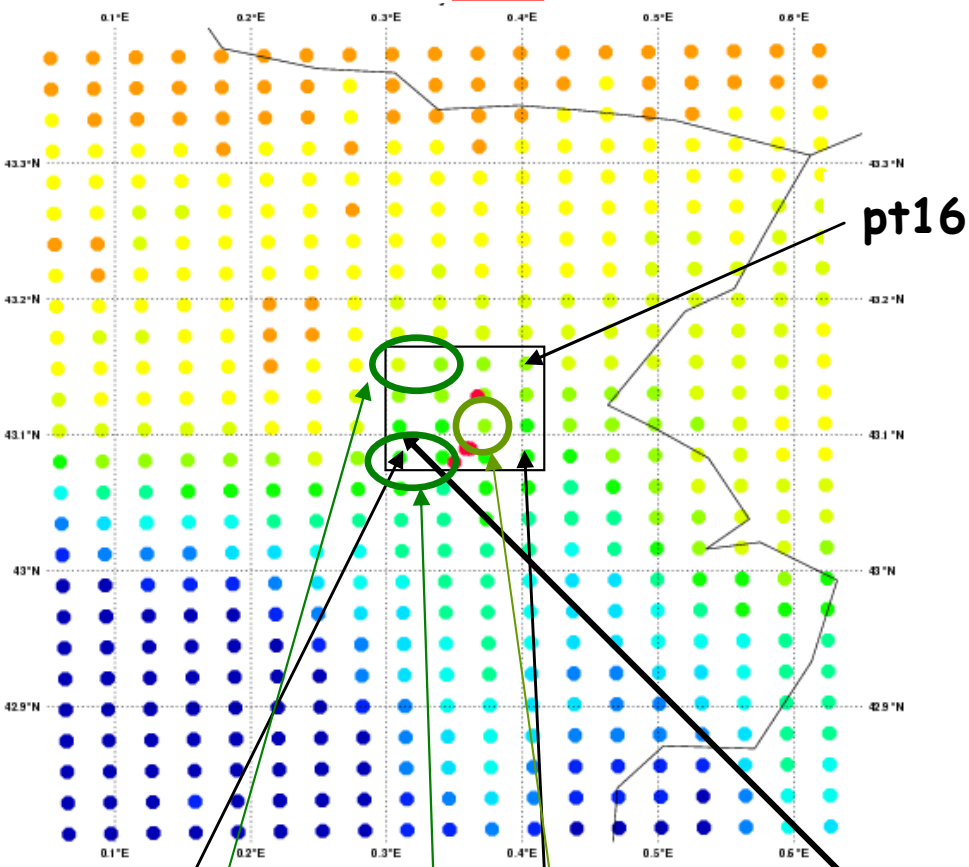
AROME-BLLAST (65TN) :
30h forecasts at 00h and 12utc
NH, dx=2.5 km,60levels, time-step=60s (SL)
LBC and initial file from AROME-France with specific output:
16 vertical profiles around Lannemezan with fluxes, TKE etc ….

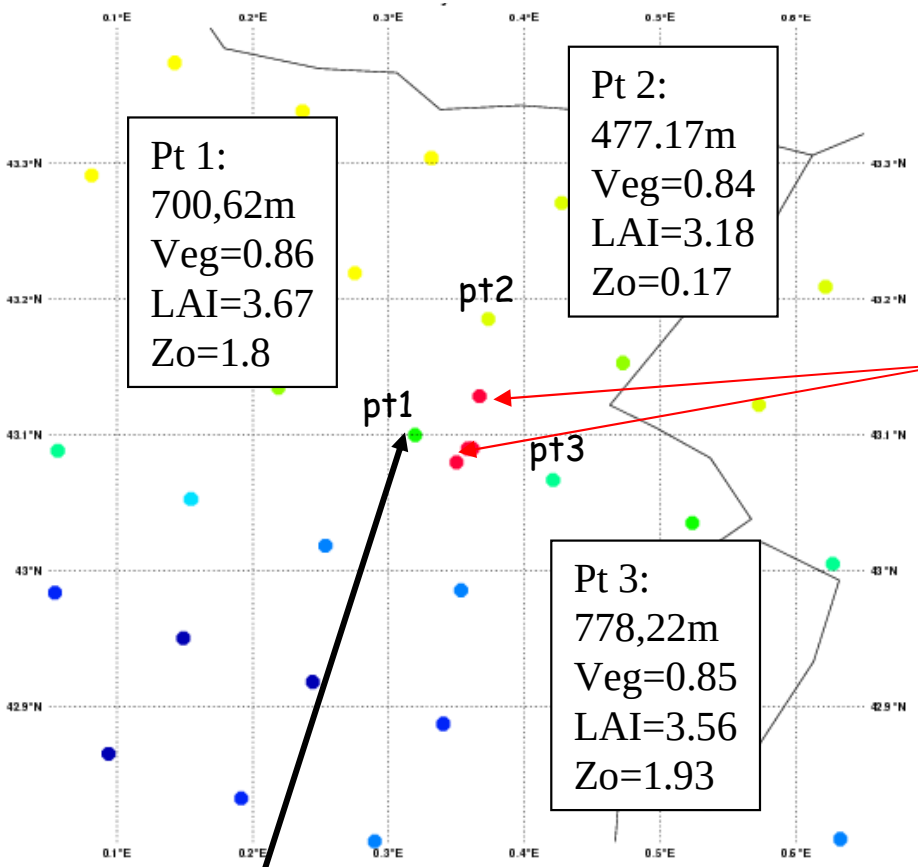
Cloud Resolving Model AROME-France
30 h forecasts every 6h
dx=2.5 km, 60 Levels, time-step=1mn (SL)
3DVar Data Assimilation system (RUC3h)

AROME

	Pt1:	Pt2:	Pt3:	Pt4:	Pt5:	Pt6:	Pt7:	Pt8:	Pt9:	Pt10:	Pt11:	Pt12:	Pt13:	Pt14:	Pt15:	Pt16:
Alt:	535.	611.	595.	558.	552.	605.	609.	593.	532.	567.	579.	575.	505.	521.	529.	527.
Veg	0.95	0.93	0.92	0.92	0.92	0.93	0.85	0.94	0.93	0.91	0.91	0.91	0.93	0.92	0.88	0.90
LAI:	3.4	3.5	3.2	3.4	3.5	3.4	3.3	3.2	3.5	3.7	3.3	3.5	3.8	3.7	3.2	3.5
Zo:	0.78	0.53	0.26	0.16	0.24	0.38	0.45	0.39	0.49	0.37	0.18	0.47	0.83	0.64	0.23	0.38

ARPEGE





How to compute the dynamical forcing or advection ?

- From a 3D experiment :
  - Classical method: from horizontal fields at different level → dependency to the grid, instantaneous output → requires some time and space filtering. Scale = f(dx,dy,dz)

$$T\_advec(t) = \vec{u}(t)\frac{\partial T(t)}{\partial x} + \vec{v}(t)\frac{\partial T(t)}{\partial y} + \vec{w}(t)\frac{\partial T(t)}{\partial z}$$

  - DDHtool box available in ARPEGE/AROME: computes the budget for each variable since t=0 and the output. 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 → the dynamical forcing can be deduced from:

$$\frac{\partial T}{\partial t} = Dyn + \underbrace{\frac{\partial T}{\partial t}_{rayt} + \frac{\partial T}{\partial t}_{turb} + \frac{\partial T}{\partial t}_{shal} + \ldots}_{Physics\_parameterizations}$$

How to compute the dynamical forcing or advection ?

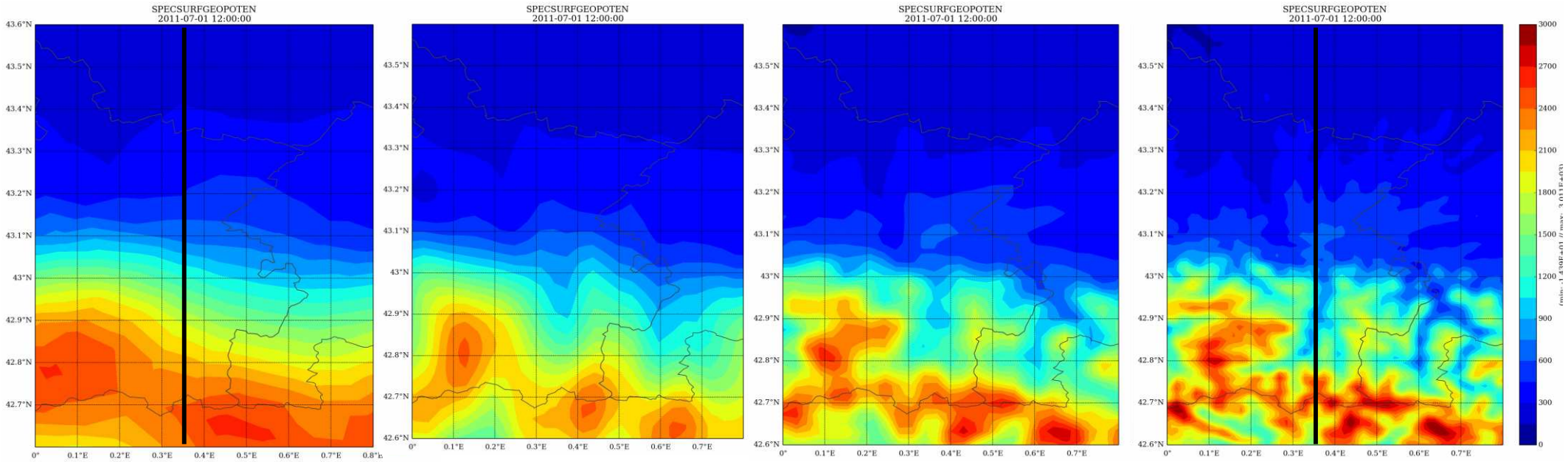
- In a ideal case, the dynamical term should be the same if we use different physics or options in the same model.
- Otherwise, it gives us an idea about the uncertainties …
- Scale : 16 points for AROME 10kmx10km = 100km2 or 3 points for ARPEGE. Minimum temporal mean=1h
- The choice of the forcing and the type (nudging, advection etc..), for 1D or LES simulation, is a compromise between two goals: keep the model close to the observations and let them to develop physics bias

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))	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)	

Experiments

- ARPEGE oper 10km 70L 1st level ~16m (7EQE)
- AROME-BLLAST 2.5km 60L 1st level 10m (6970) (input topo1km)
- AROME-BLLAST 2.5km 60L 1st level 10m with ARPEGE shallow convection (69BI)
- ARPEGE-LAM-2.5km 60L 1st level 10m = AROME dyn + ARPEGE physics (7EPB)
- AROME-BLLAST 2.5km 90L 1st level 5m (7EP3) (input topo250m)
- AROME-BLLAST 1.3km 90L 1st level 5m (7EP4) (input topo250m)



ARPEGE 10km **2.5km topo1km** **2.5km topo250m** **1.3 km topo250m**

Experiments

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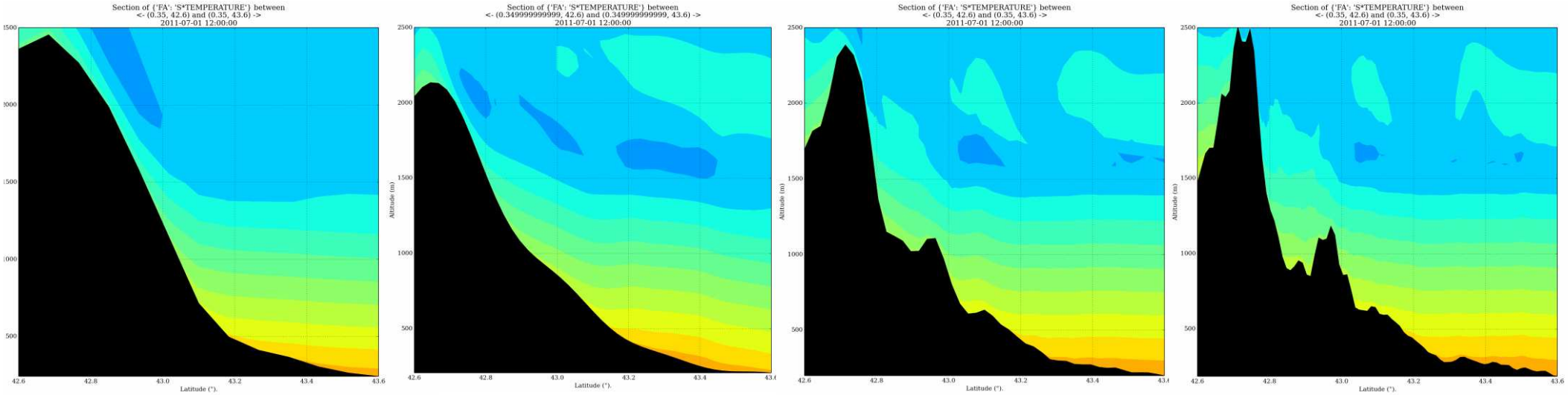
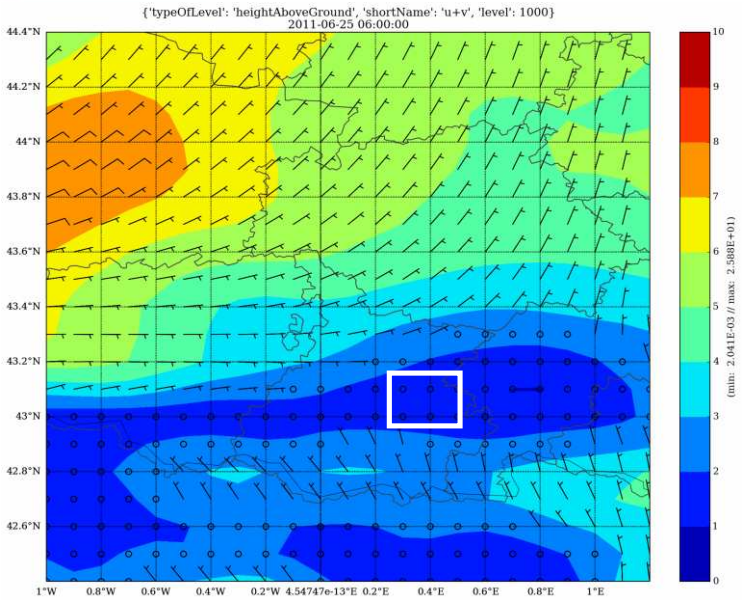


ARPEGE 10km **2.5km topo1km** **2.5km topo250m** **1.3 km topo250m**

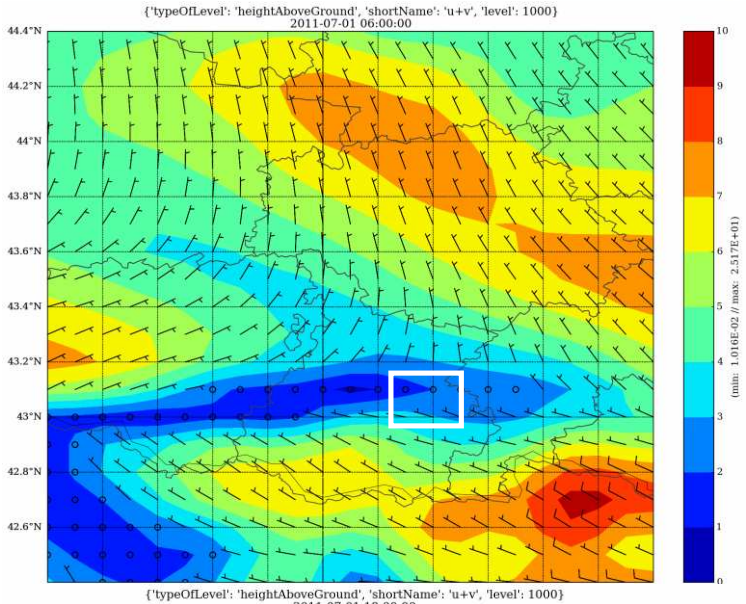
ARPEGE Wind Speed 1000m above ground

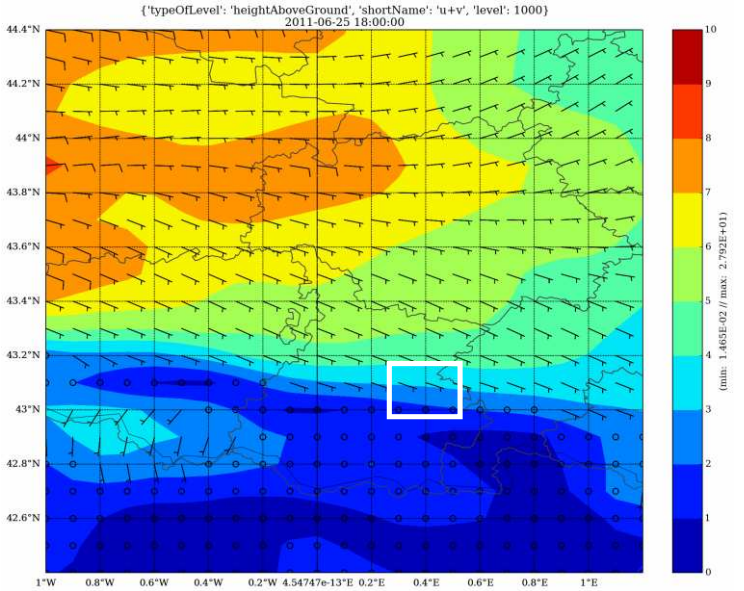
25/06/2011

01/07/2011

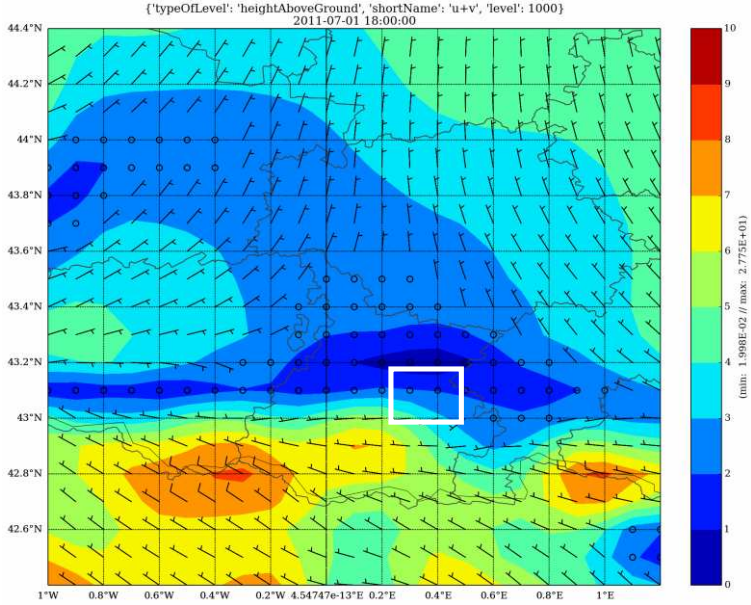


6TU



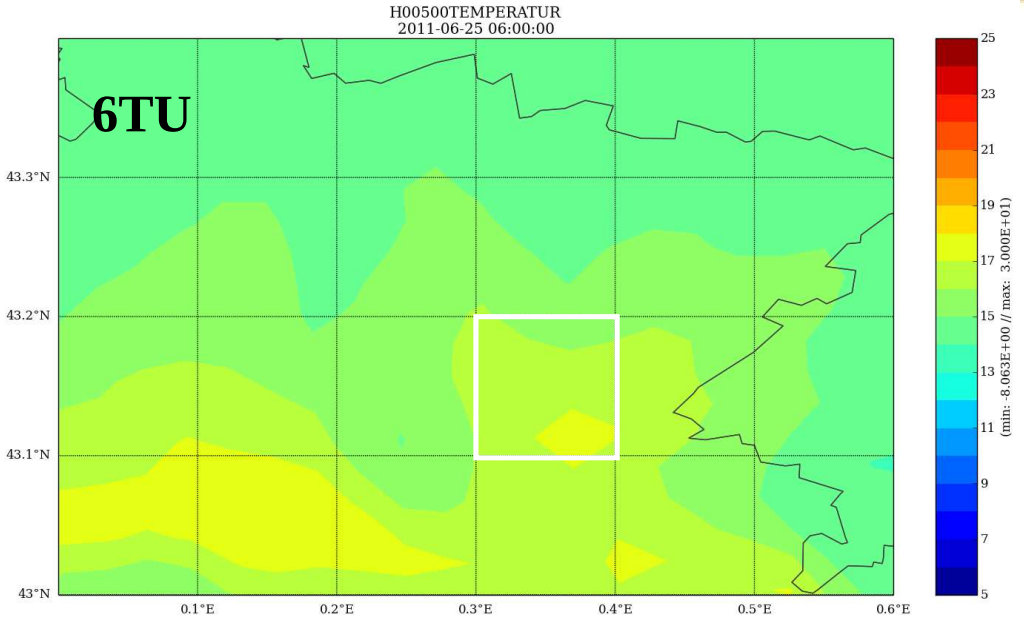


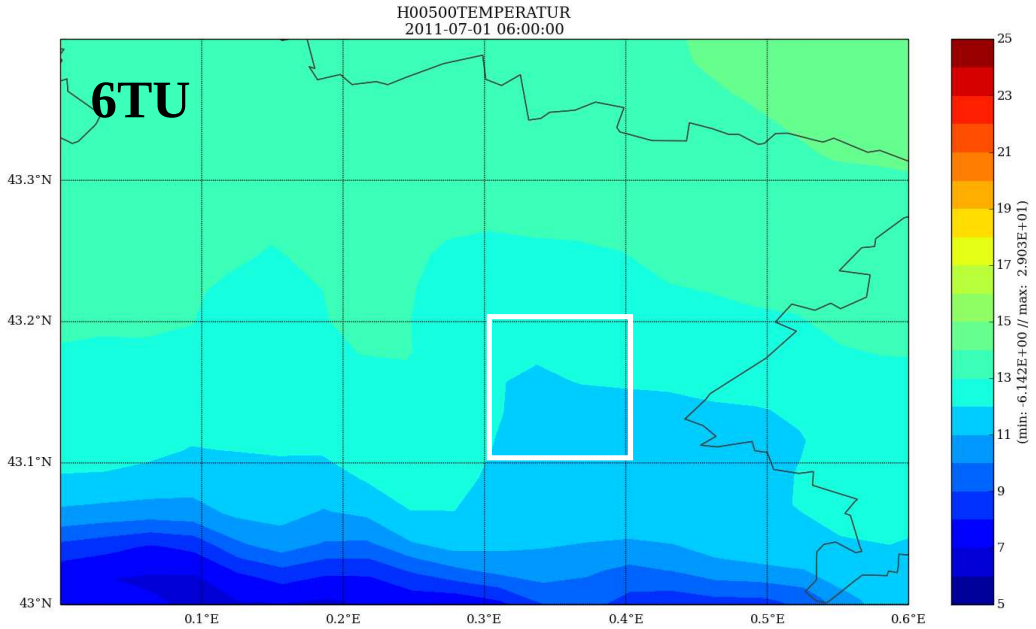
18TU

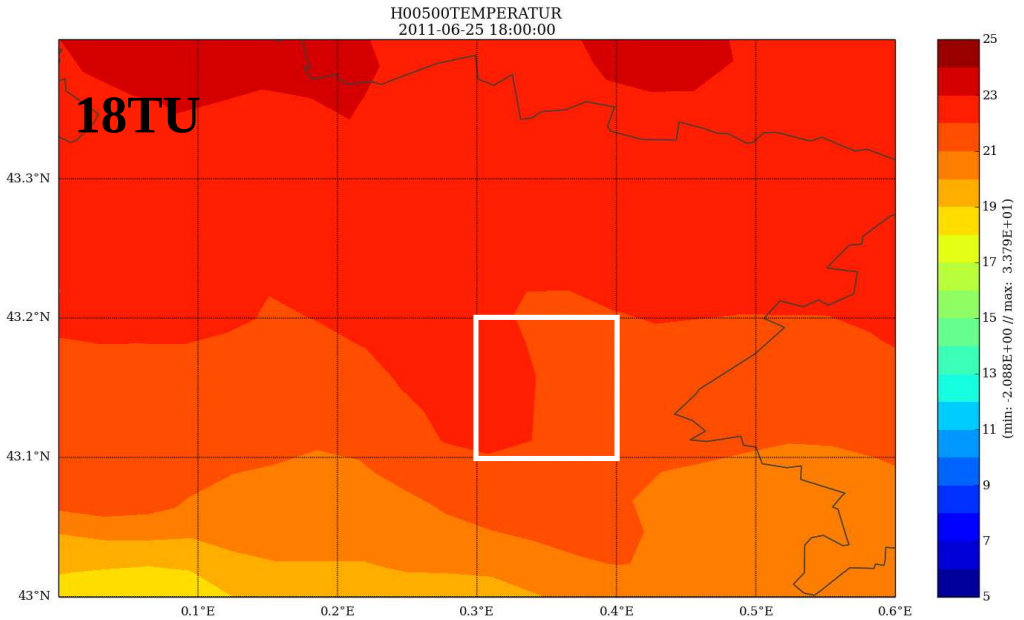


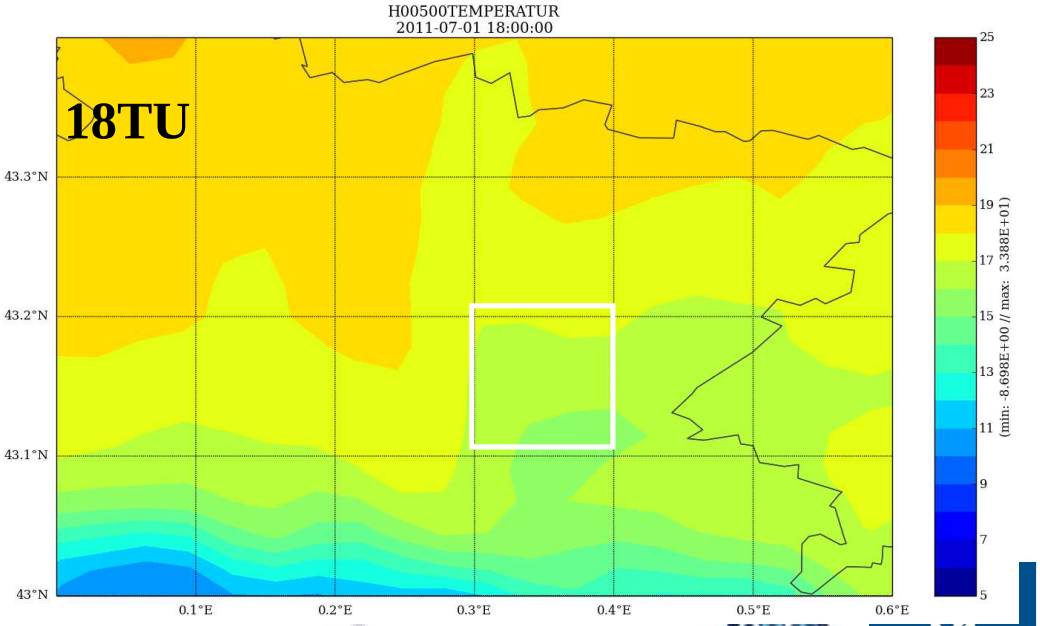
AROME temperature 500m (above ground)

25/06/2011 **01/07/2011**



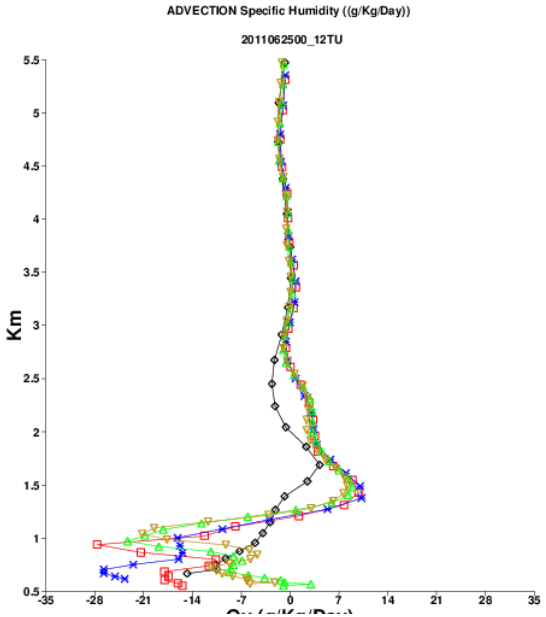




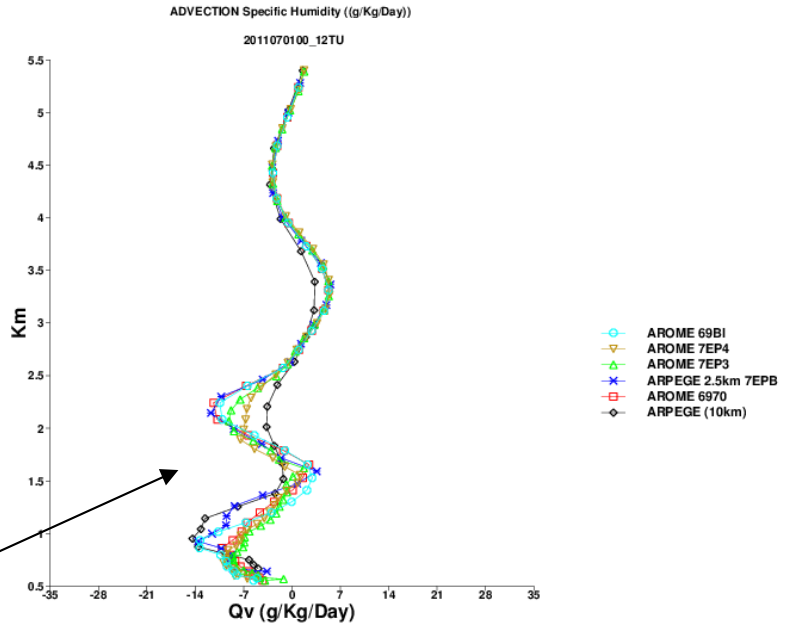


Mean 6h Qv advection (10kmx10km)

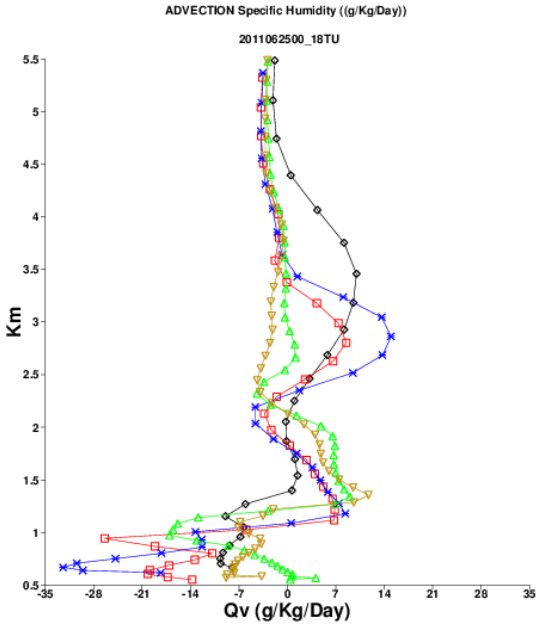
25/06/2011 **01/07/2011**



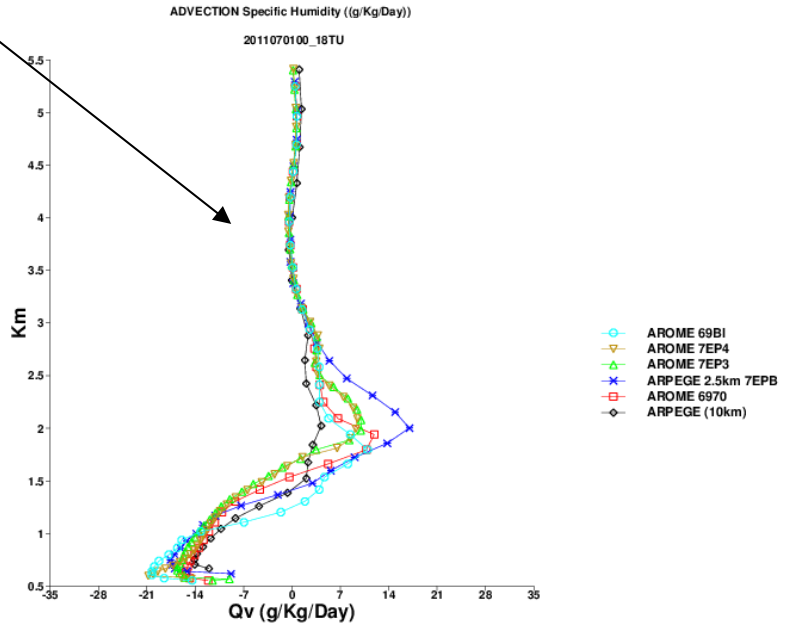
6-12TU



Less variability or uncertainties for Qv advection due to less wind



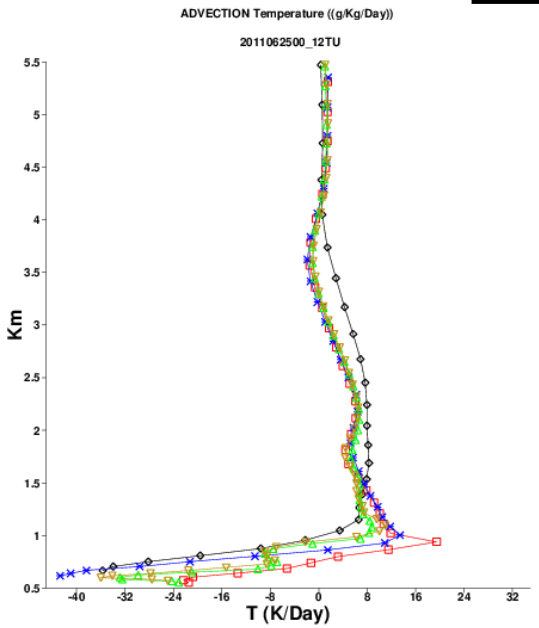
12-18TU

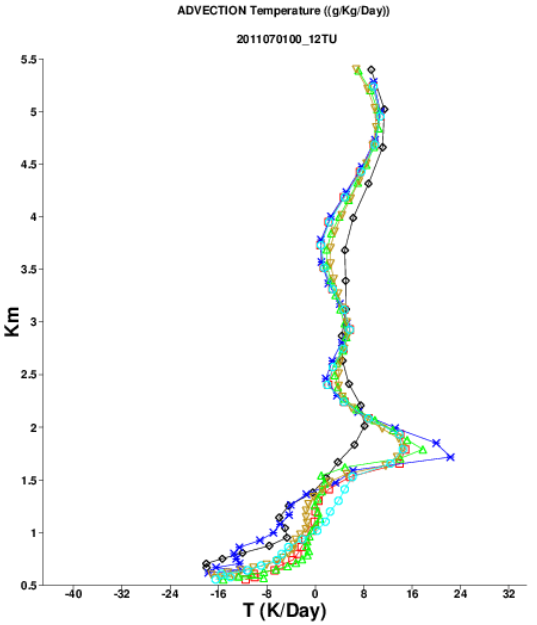


Mean 6h T advection (10kmx10km)

25/06/2011

01/07/2011



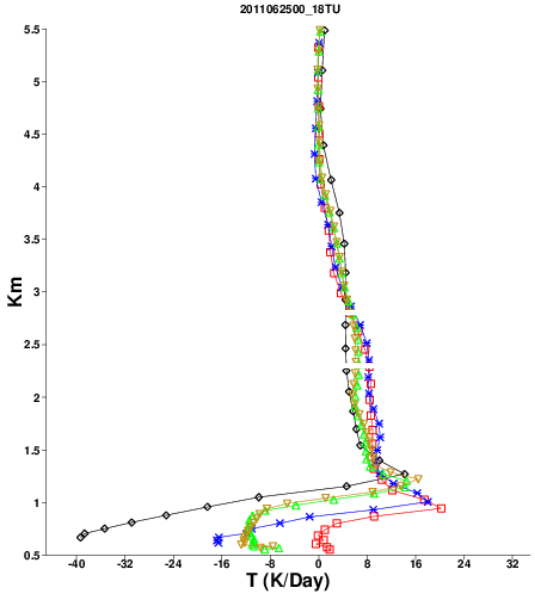


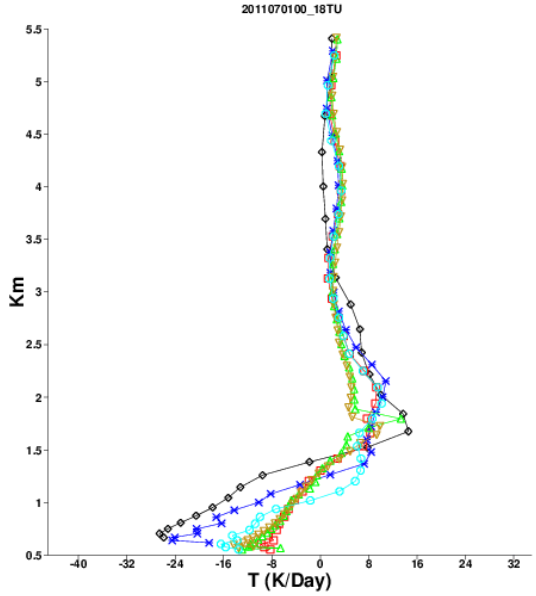
AROME 7EP4
AROME 7EP3
ARPEGE 2.5km 7EPB
AROME 6970
ARPEGE (10km)

AROME 69BI
AROME 7EP4
AROME 7EP3
ARPEGE 2.5km 7EPB
AROME 6970
ARPEGE (10km)

6-12TU

Less variability for T vs QV





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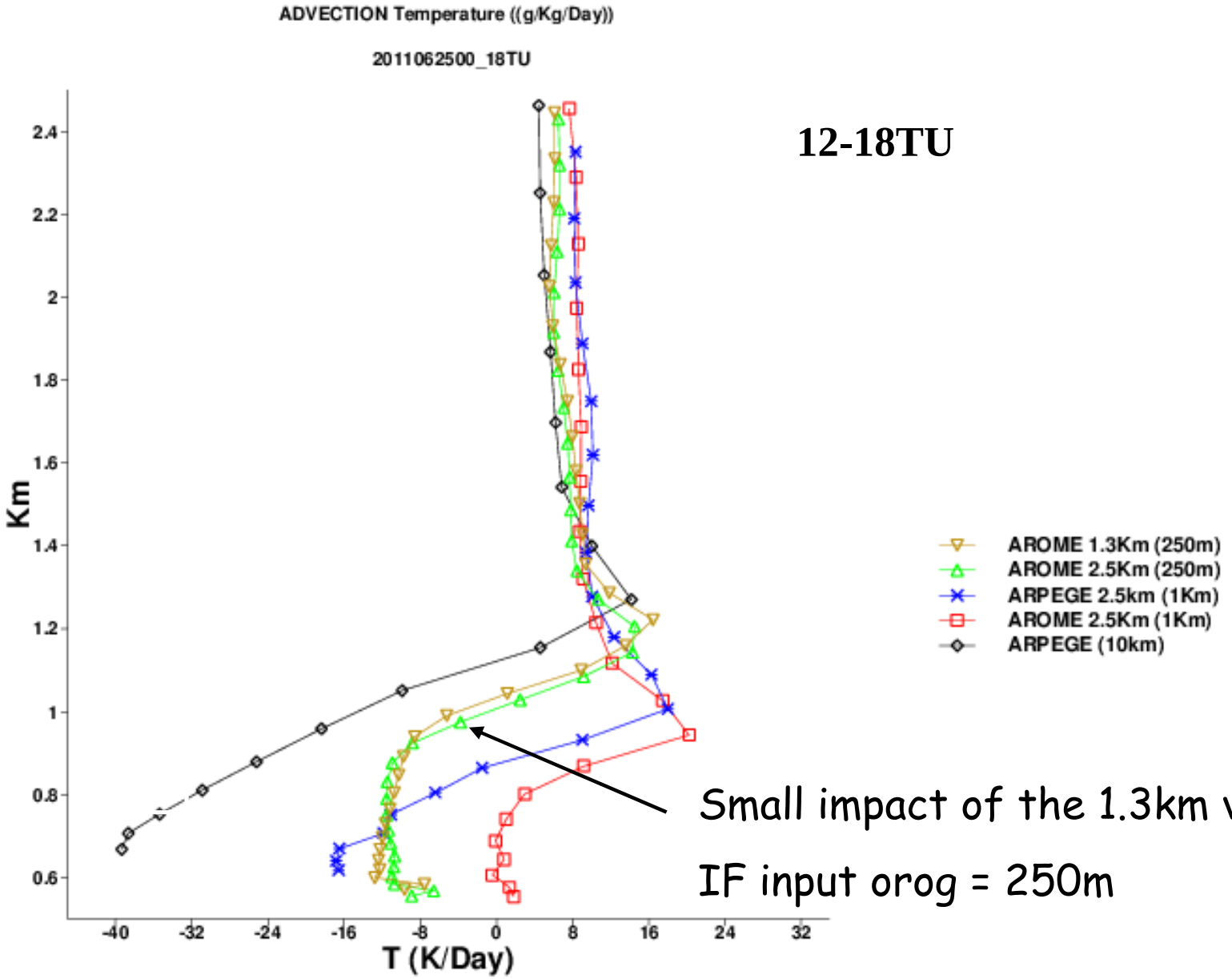
AROME 6970
ARPEGE (10km)

12-18TU

Mean 6h T advection (10kmx10km) 25/06/2011

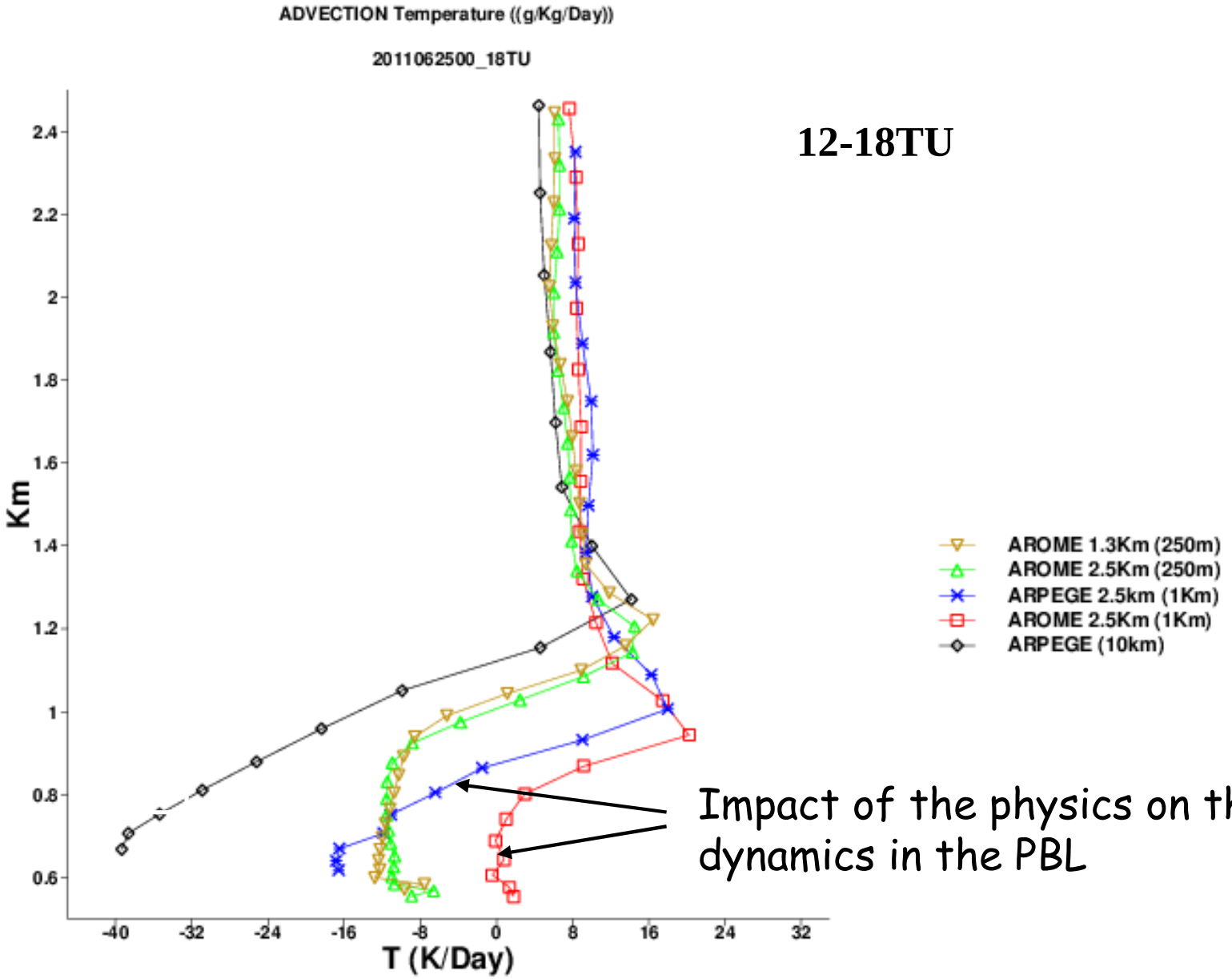


12-18TU

Small impact of the 1.3km vs 2.5km

IF input orog = 250m

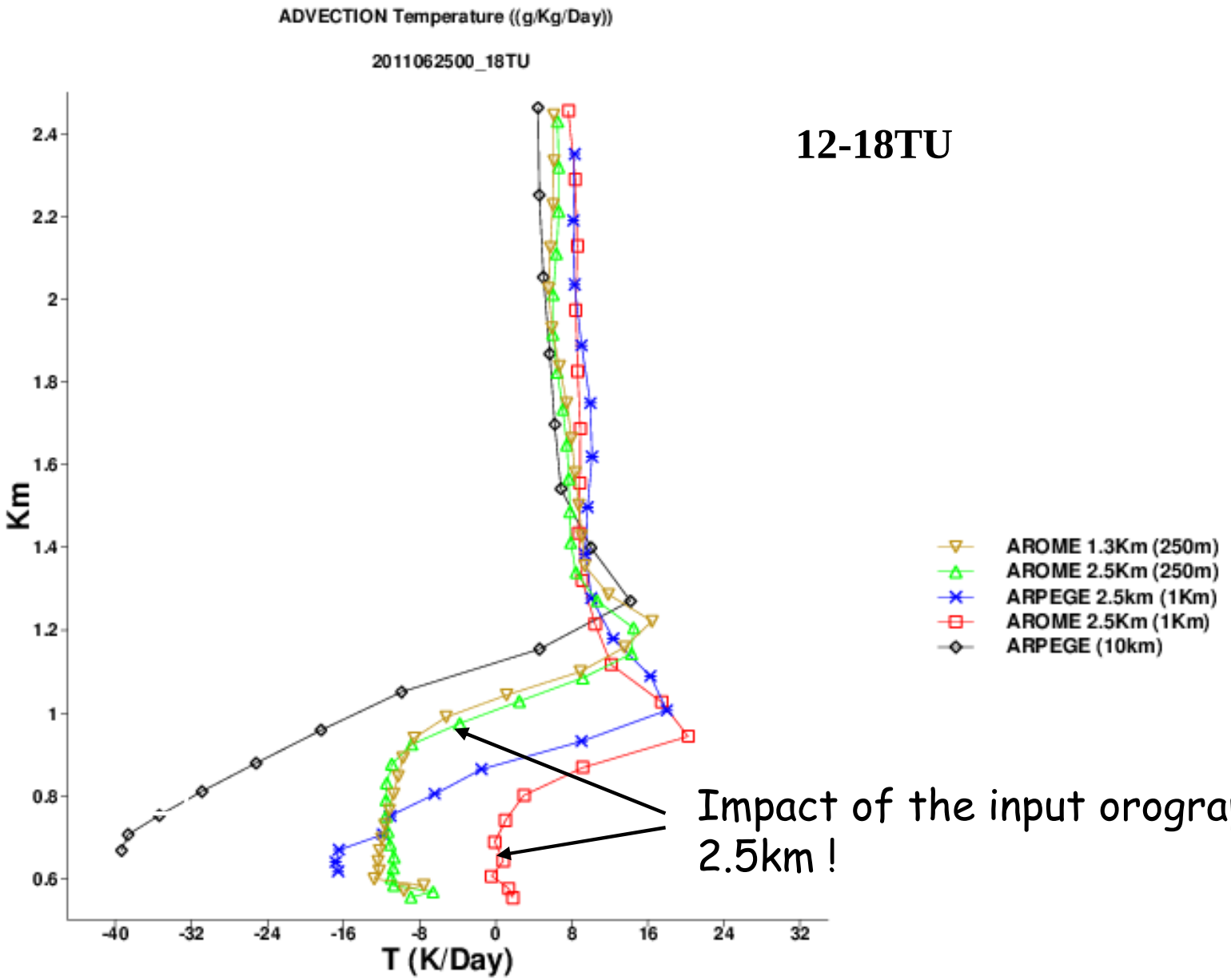
Mean 6h T advection (10kmx10km) 25/06/2011



12-18TU

Impact of the physics on the dynamics in the PBL

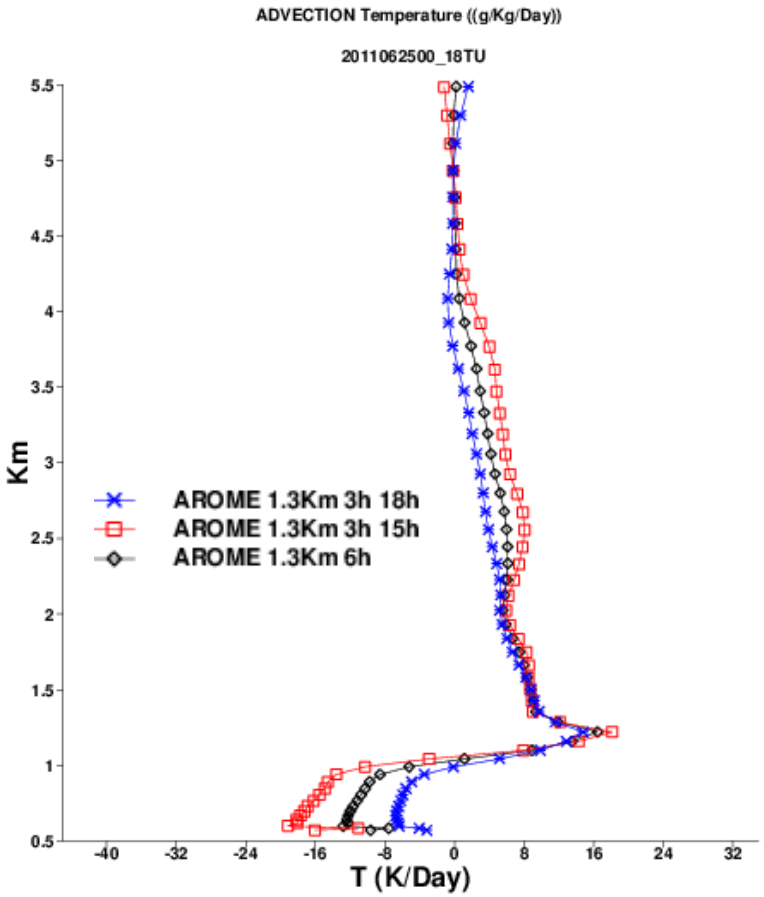
Mean 6h T advection (10kmx10km) 25/06/2011

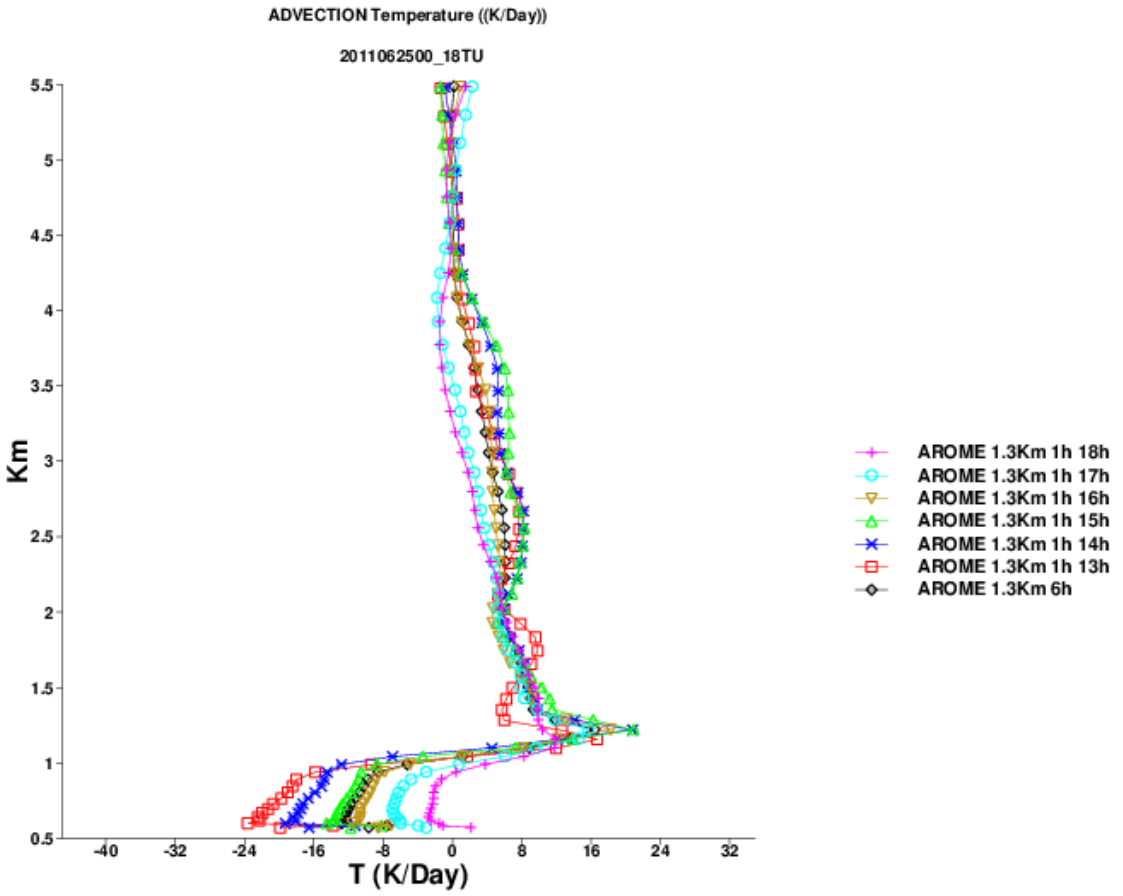


12-18TU

Impact of the input orography at 2.5km !

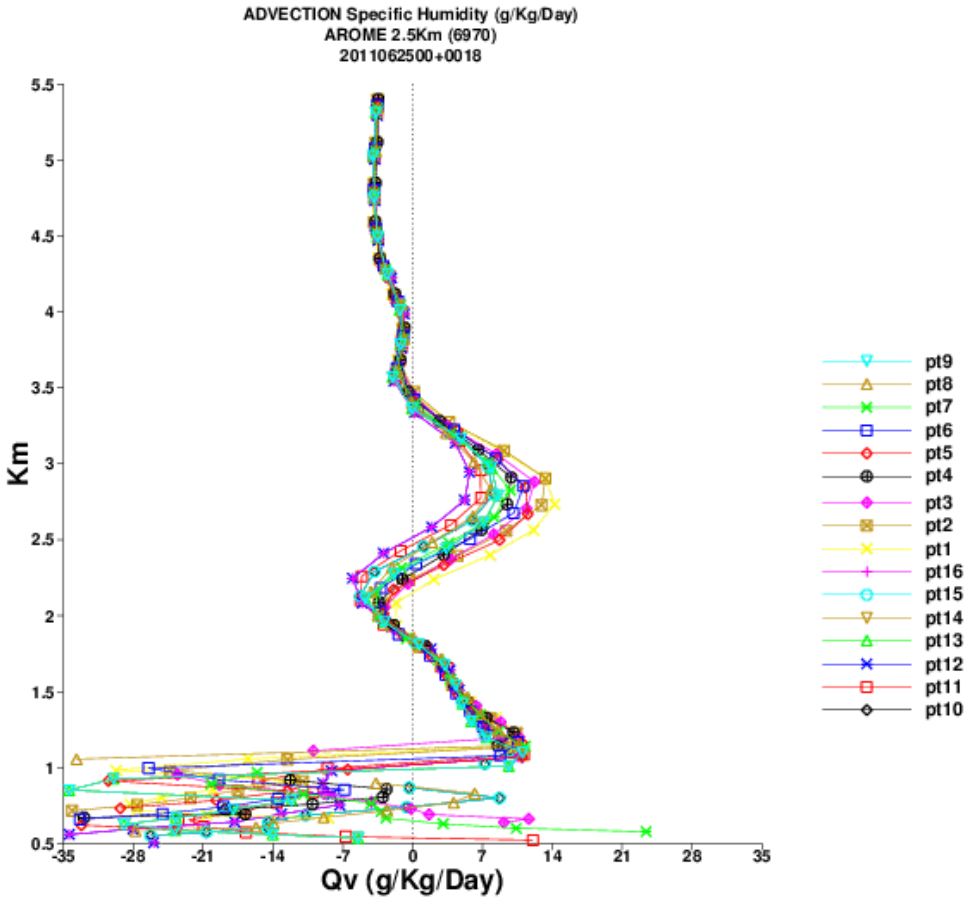
T advection between 12-18h 25/06/2011 AROME 1.3km (7EP4)

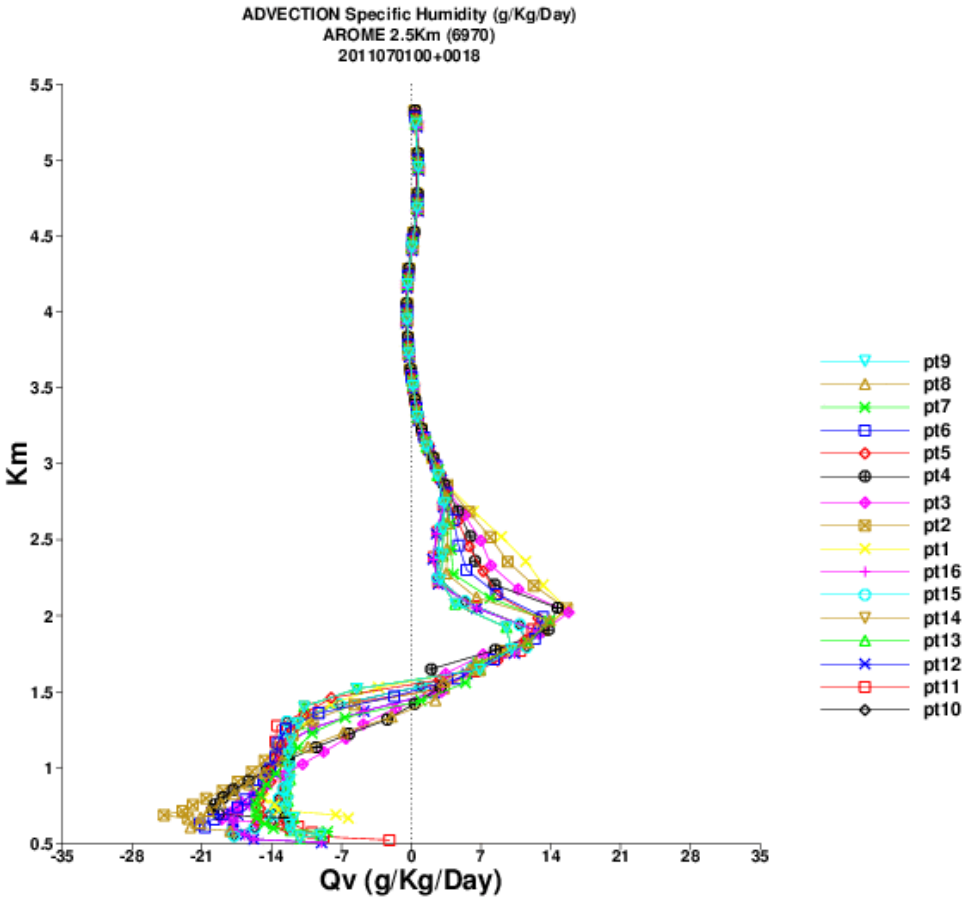




Cold air advection in the early afternoon below 1km

Impact of the input topography
AROME 2.5km (topo 1Km) 6970

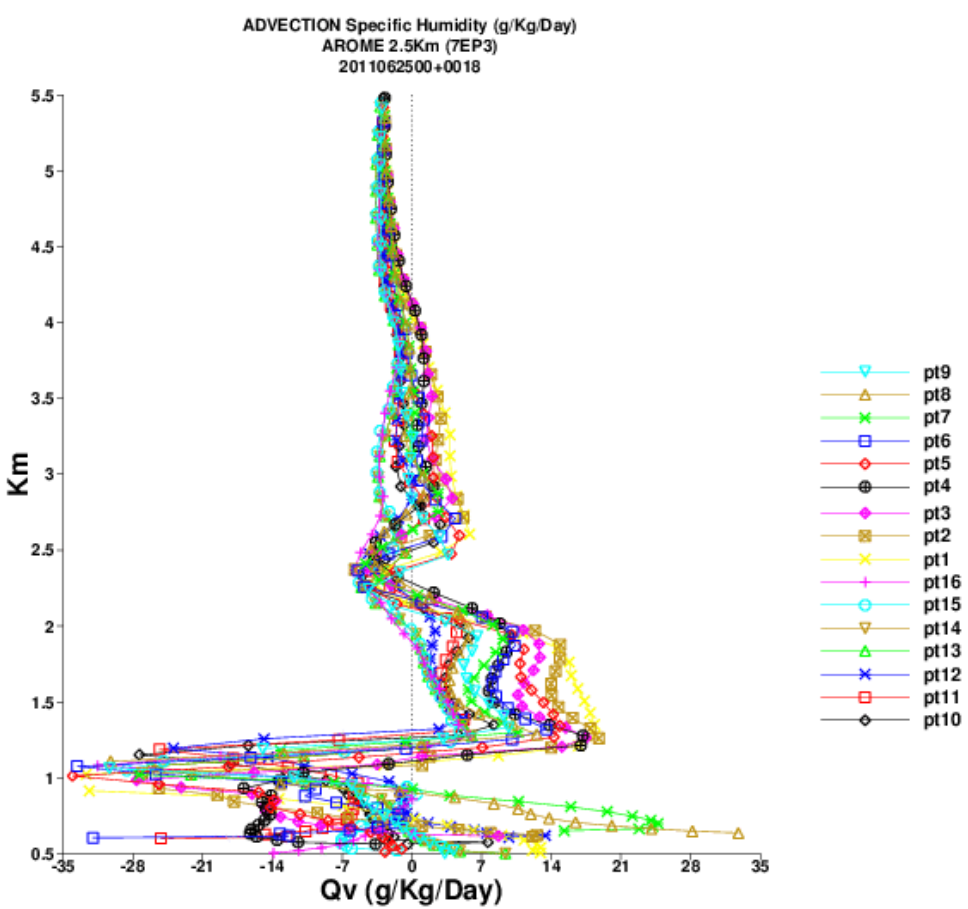


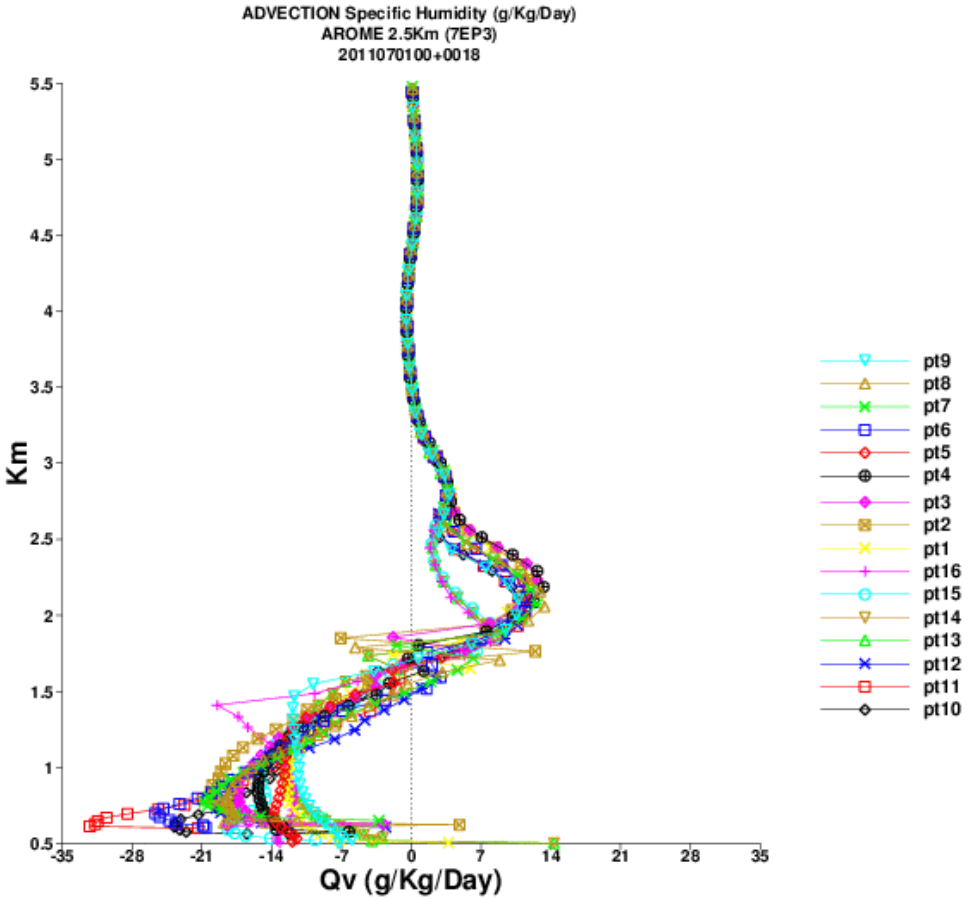


25/06/2011 ADVEC_QV 12-18Tu

01/07/2011 ADVEC_QV 12-18Tu

Impact of the input topography AROME 2.5km (topo 250m) 7EP3

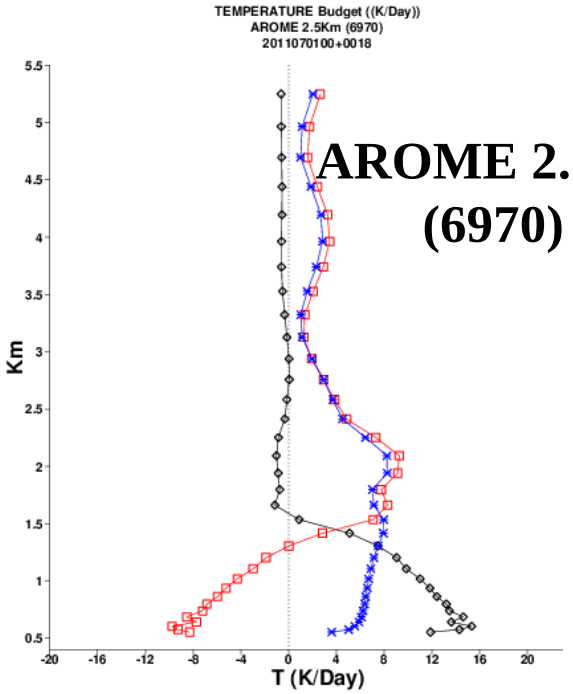




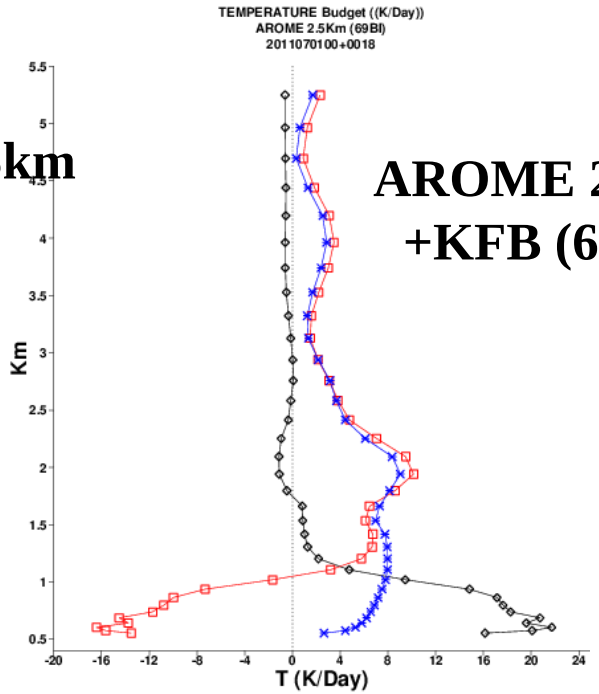
25/06/2011 ADVEC_QV 12-18Tu

01/07/2011 ADVEC_QV 12-18Tu

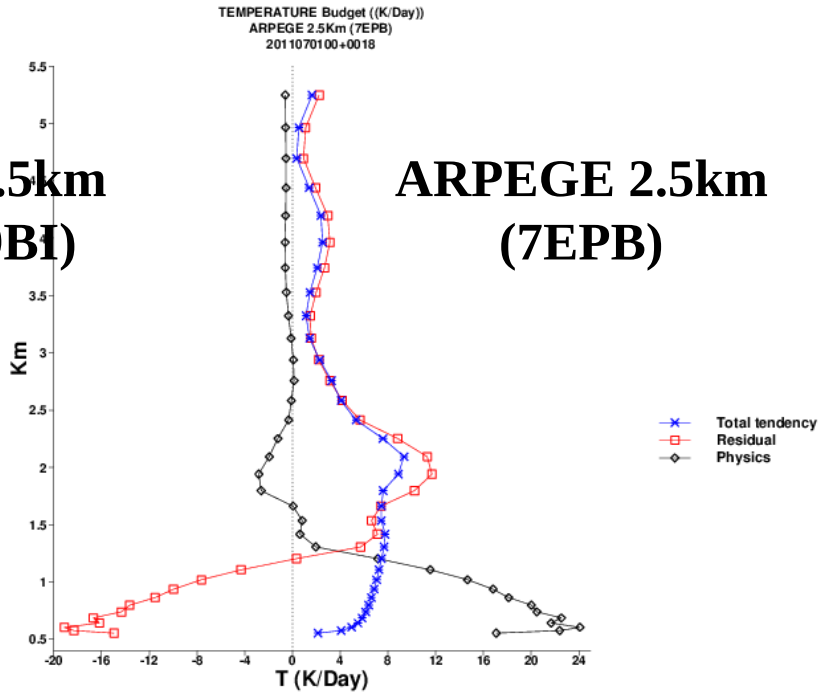
Physics and Dynamic Tendency : Temperature 01/07/2011 12-18h



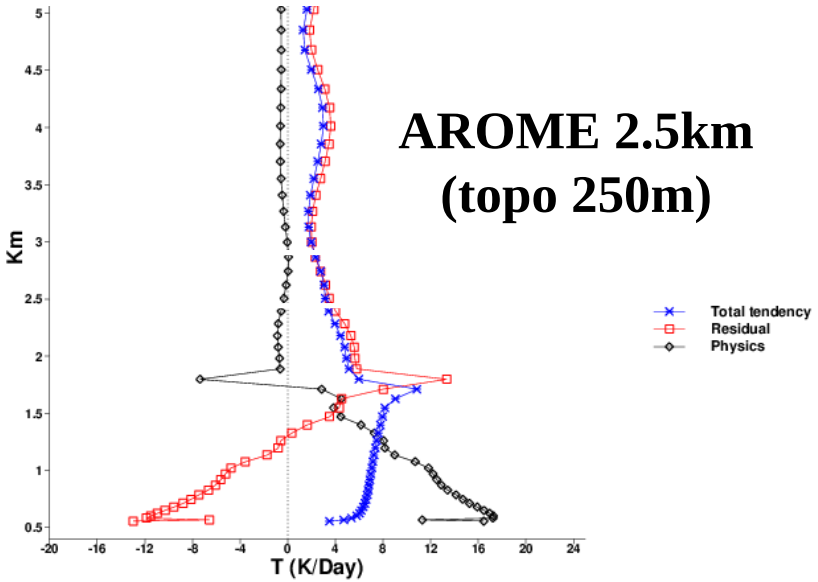
AROME 2.5km (6970)



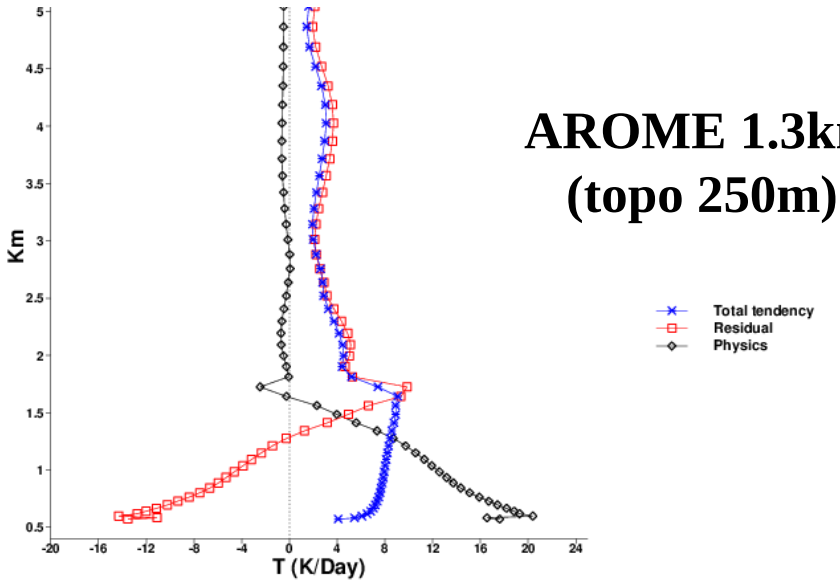
AROME 2.5km +KFB (69BI)



ARPEGE 2.5km (7EPB)



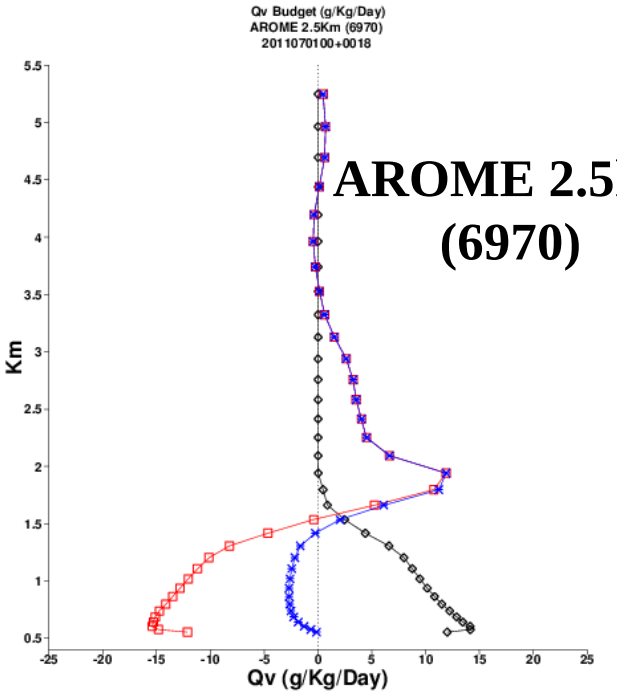
AROME 2.5km (topo 250m)



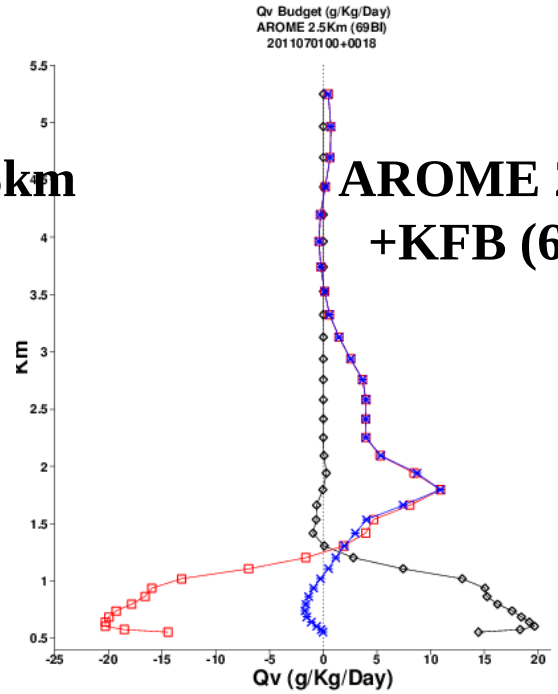
AROME 1.3km (topo 250m)

METEO FRANCE

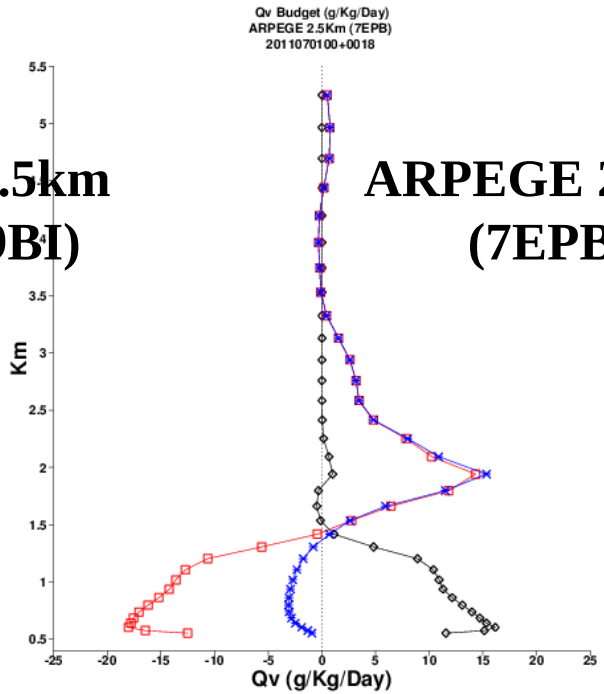
Physics and Dynamic Tendency : Spec. Humidity 01/07/2011 12-18h



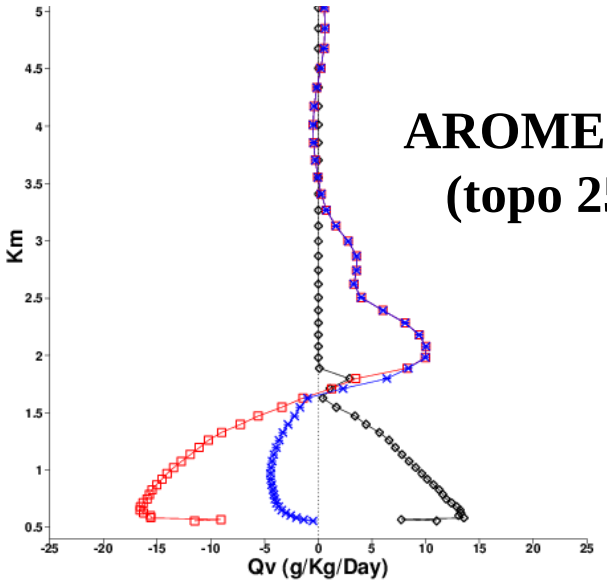
AROME 2.5km (6970)



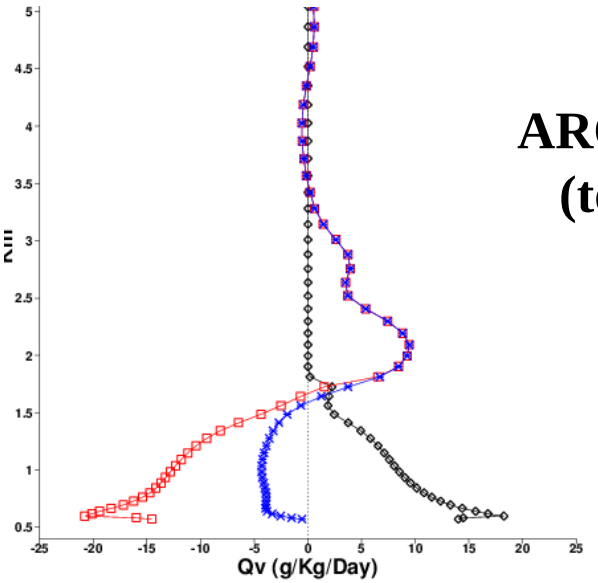
AROME 2.5km +KFB (69BI)



ARPEGE 2.5km (7EPB)



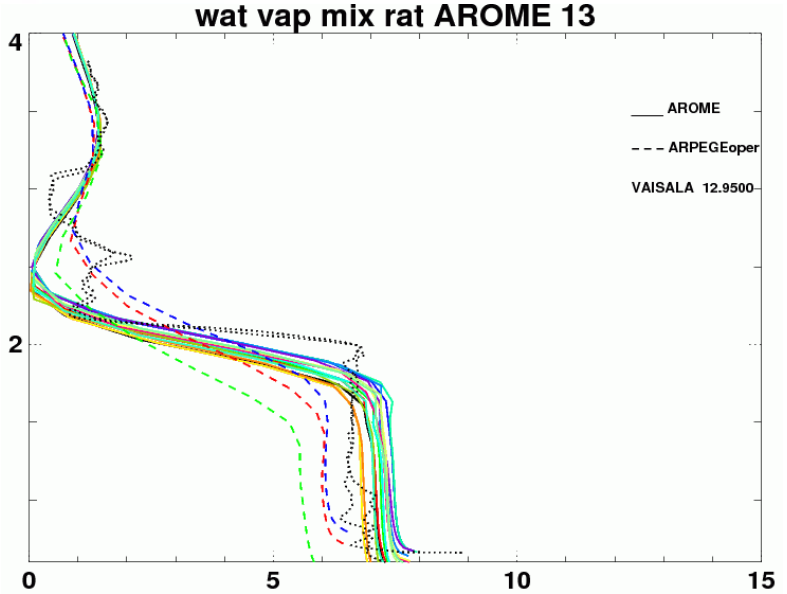
AROME 2.5km (topo 250m)

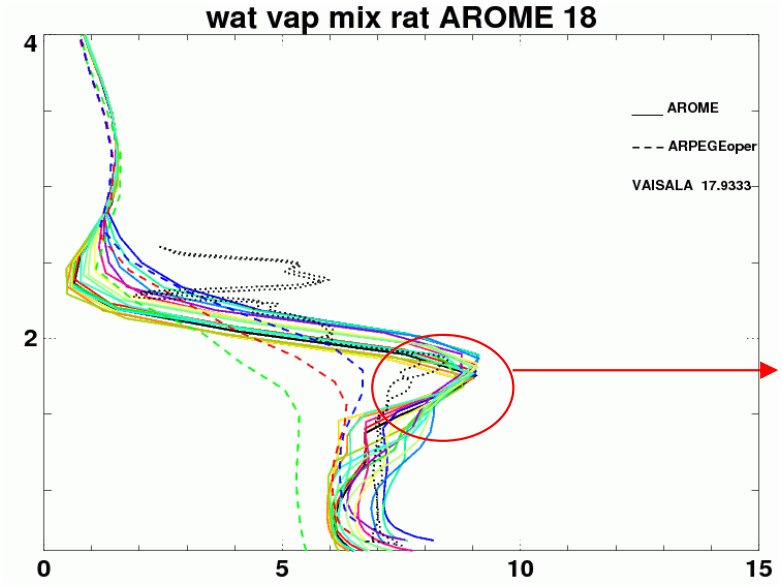


AROME 1.3km (topo 250m)

METEO FRANCE

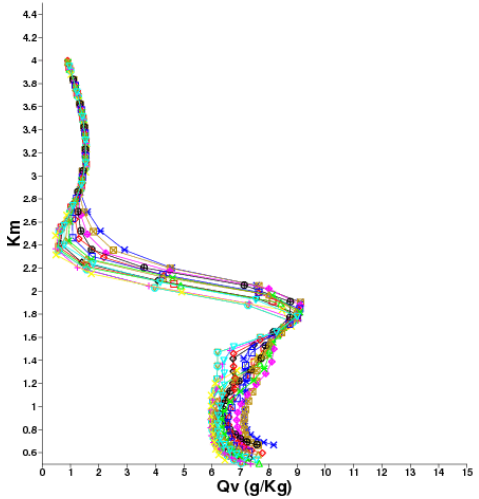
Fine scale structure for the Qv vertical profile ? 20110701 at 18h



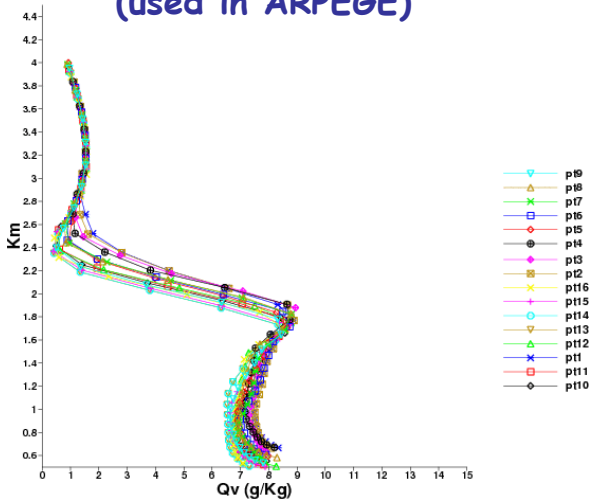


Better profile with AROME why ?
Horizontal resolution or turbulence via the shallow convection ?
Fine scale advection ?

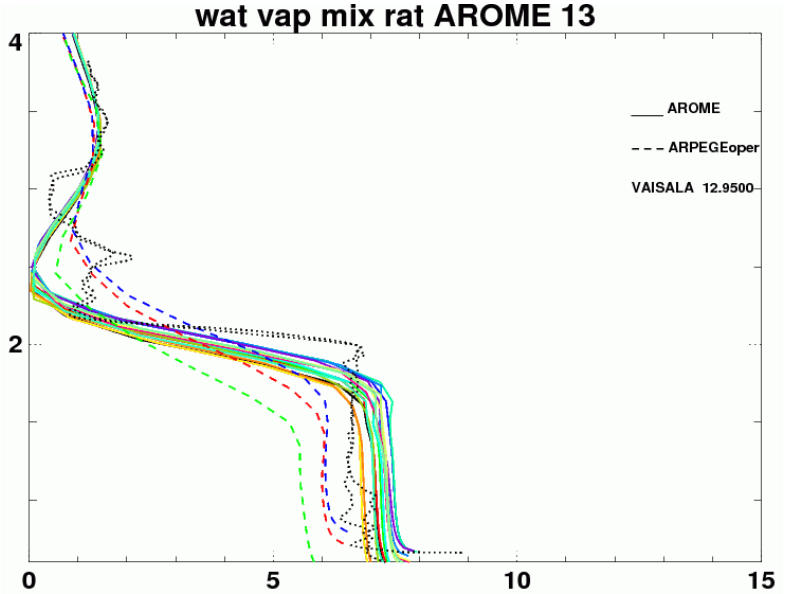
AROME

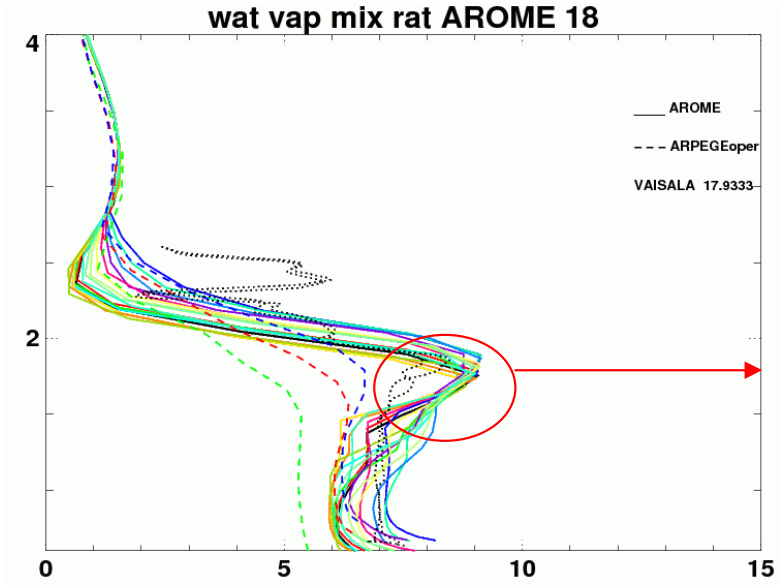


AROME with KFB (used in ARPEGE)



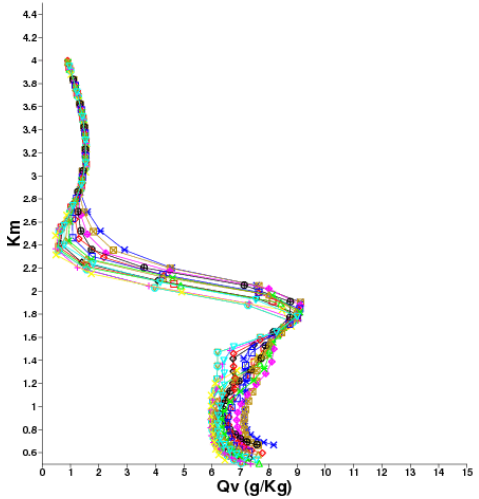
Fine scale structure for the Qv vertical profile ? 20110701 at 18h



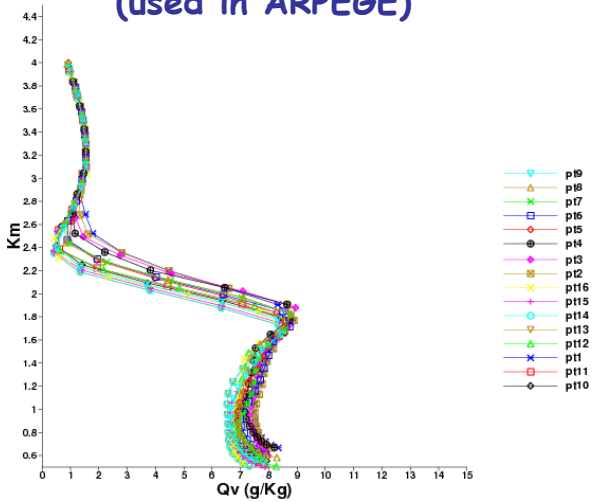


Better profile with AROME why ?
Horizontal resolution or turbulence via the shallow convection ?
Fine scale advection

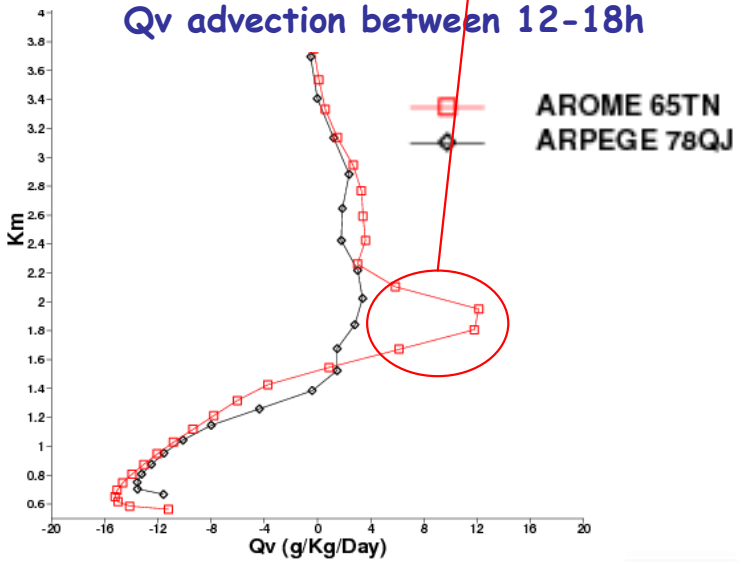
AROME



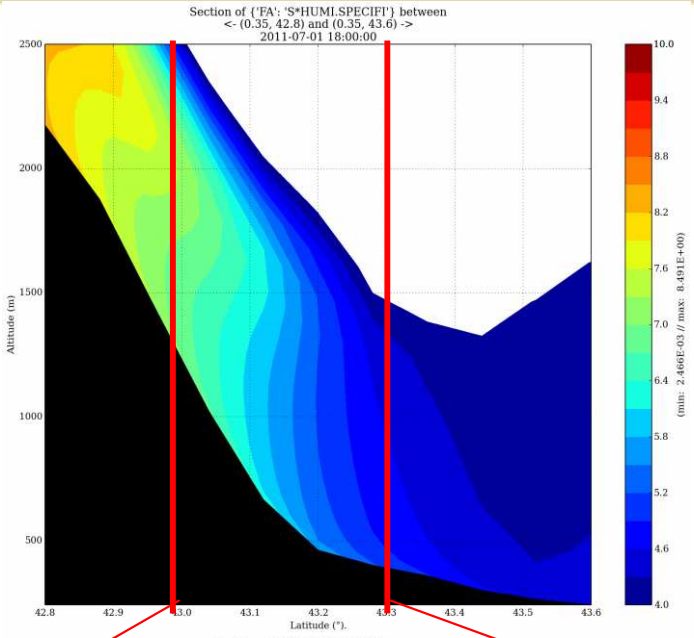
AROME with KFB (used in ARPEGE)

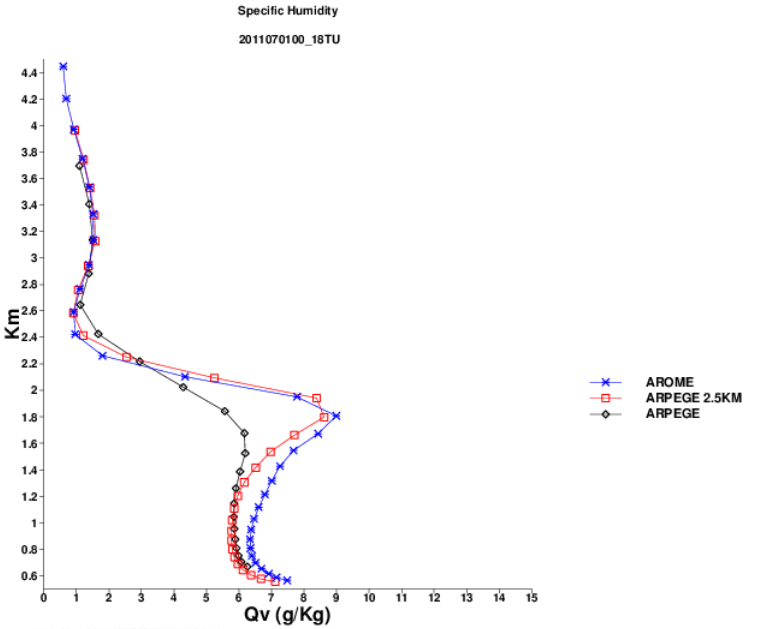


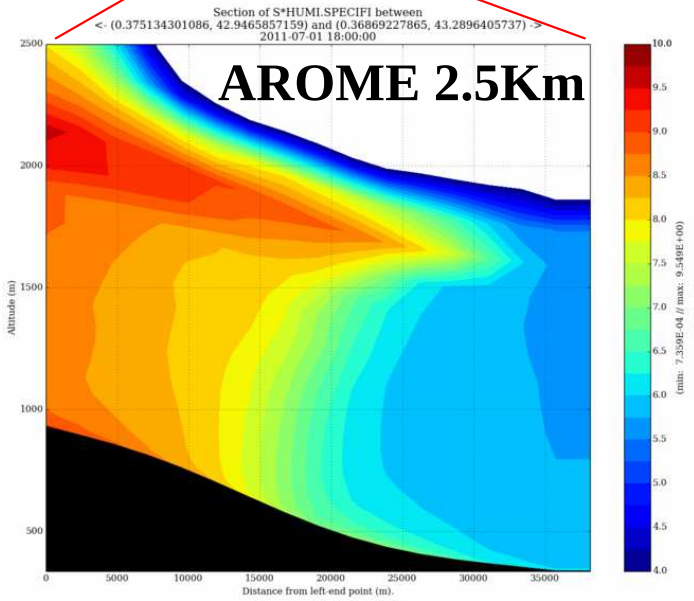
Qv advection between 12-18h

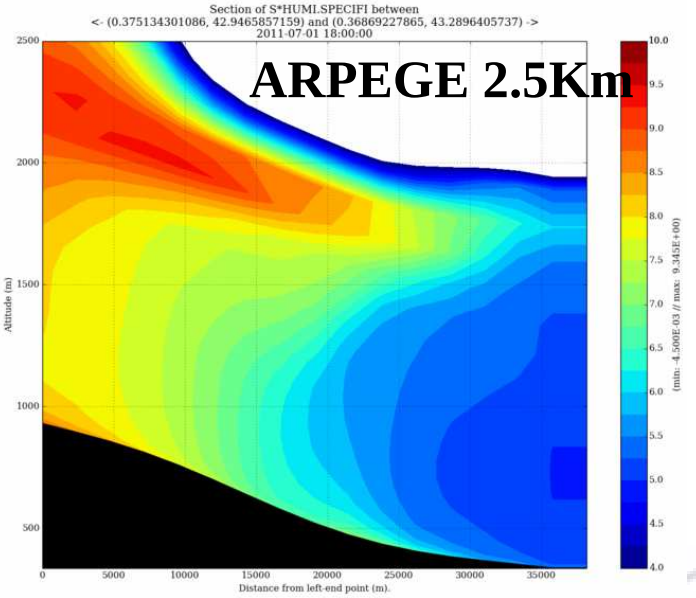


Specific Humidity 01/07/2011 18TU

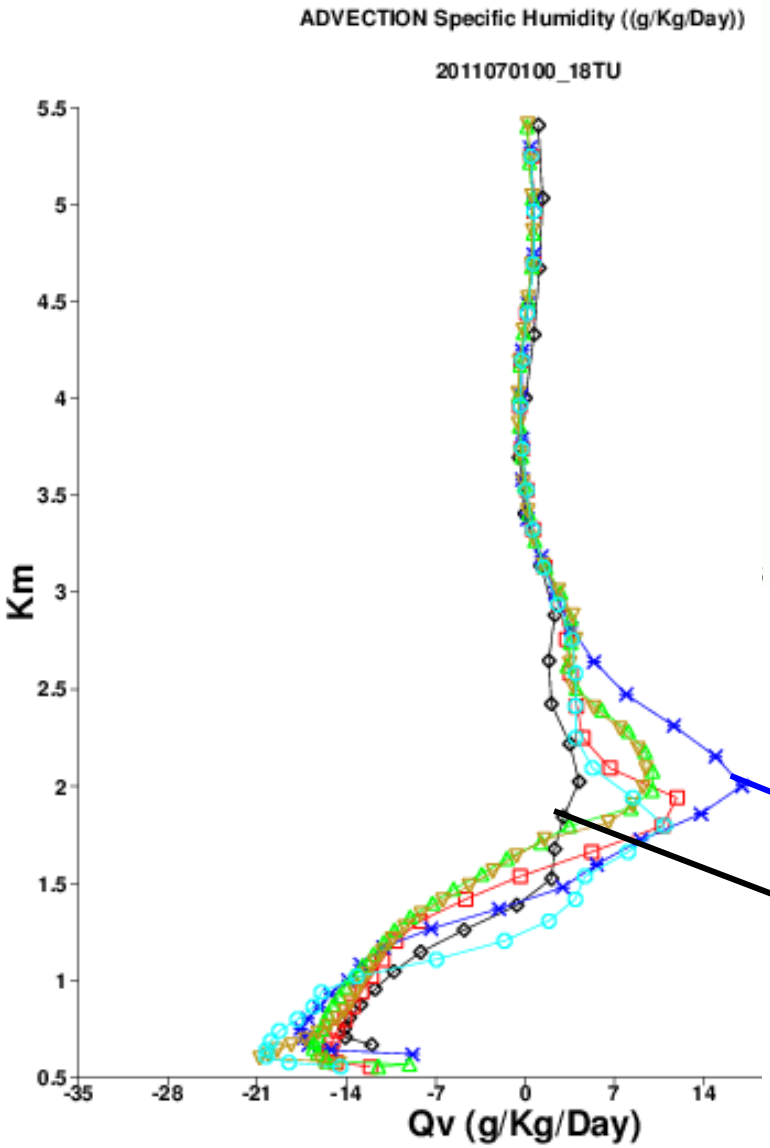


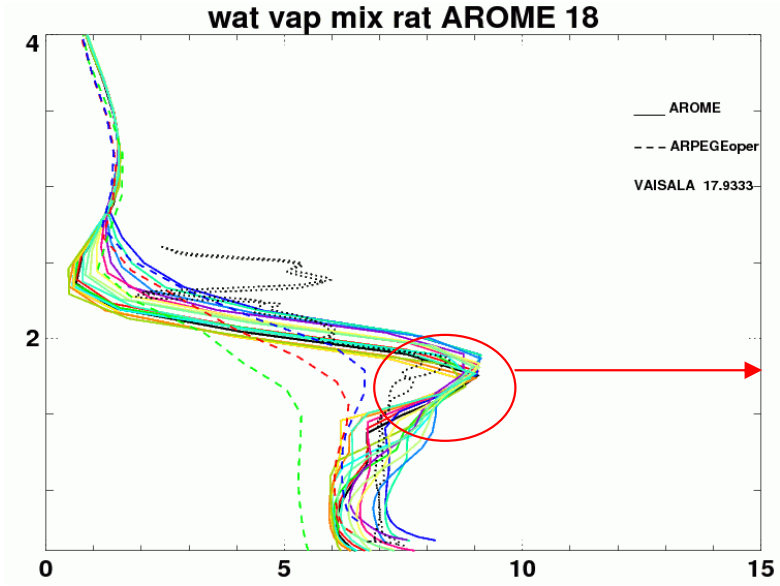






Fine scale structure for the Qv vertical profile ? 20110701 at 18h





Better profile with AROME why ?
Horizontal resolution or turbulence via the shallow convection ?
Fine scale advection

AROME 69BI
AROME 7EP4
AROME 7EP3
ARPEGE 2.5km 7EPB
AROME 6970
ARPEGE (10km)

Qv advection between 12-18h

Conclusions and perspectives

- Advections are now available from different experiments: 10km, 2.5km, 1.3km

- Larger differences on advection between models and physics the 25th June (more wind → more impact of orography ?) than the 1st July 2011

- Large advection differences between the 16 points even if it is a 6h mean ! Especially with the AROME 2.5km (topo 250m) → use the BOX advection instead of individual point

- The max of Qv the 1st July at 1.8Km (well predicted by AROME) is due to a fine scale advection .

- Use this tools for the TKE budget …