Inter-comparison exercise for 25 June 2011 using mesoscale models (WRF, MESO-NH, AROME, ARPEGE): integrating surface processes, boundary-layer dynamics and mesoscale forcings

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BLLAST WUR meeting, 8 February 2016

Overview

- The representation of the surface fluxes by mesoscale models
  - How LU is represented in mesoscale models?
  - How models represent surface fluxes?

- The vertical structure of the low troposphere linked to surface processes
  - How is the temporal evolution of surface variables?
  - How is the evolution of vertical profiles?

Overview (tentative)

- The vertical structure of the low troposphere interacting with mesoscale processes
  - How models represent main variables at 500 and 1000 m?
- The circulation from the 2D point of view of the Vallée d'Aure
  - How is the evolution of the BL along a N-S, E-W vertical cross section?

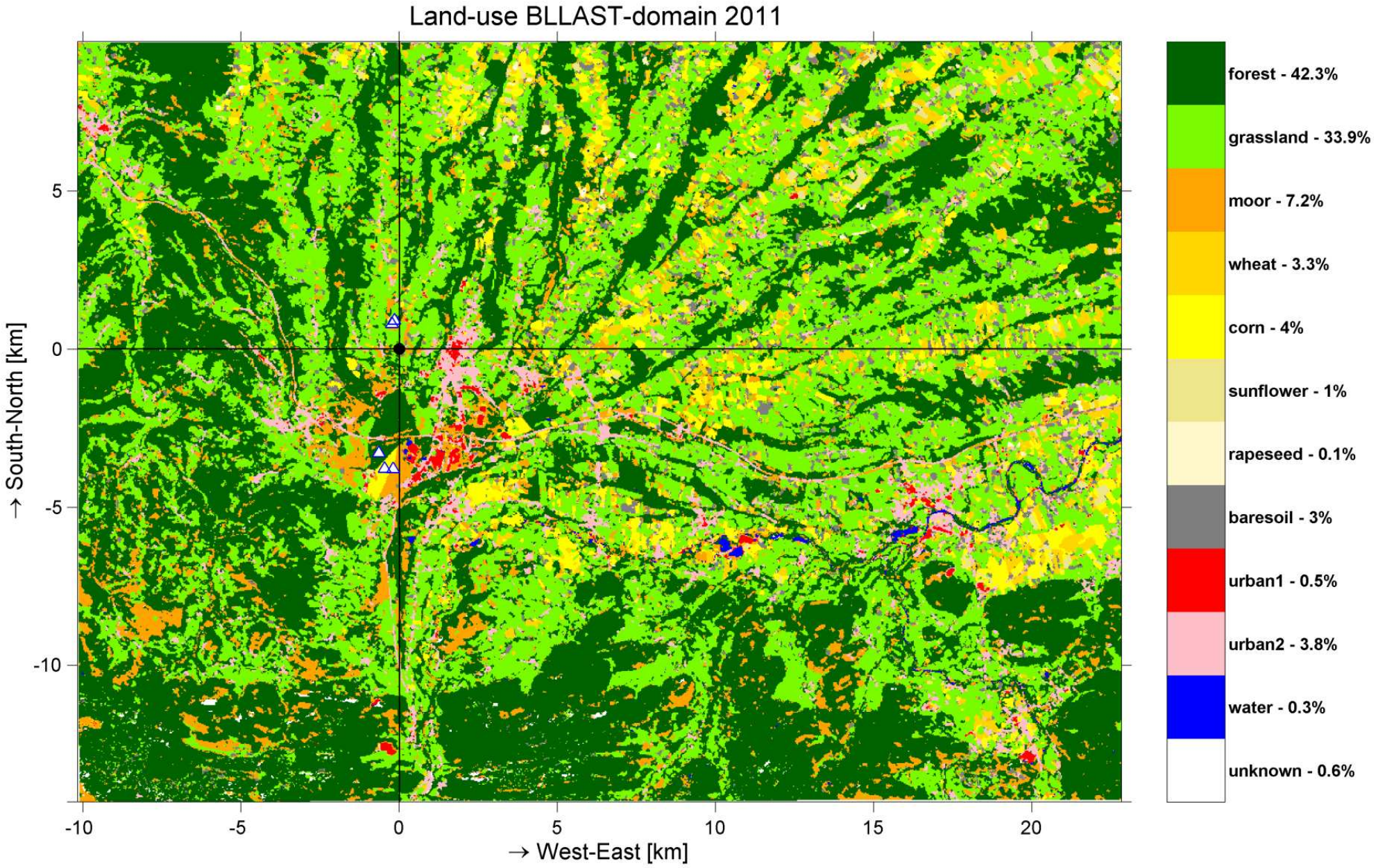
Mesoscale intercomparison

Four different models involved:

Model	Number of domains	Nx, Ny, Nz	Δx,Δy (km)	Dimensions largest domain	Max LU resolution	LSM model	PBL parameterization	Initialization
WRF	2	100x100x50	9, 9 (3, 3)	38.5N-47N/-5E-6E	30''	Noah	MYJ	ERA-Interim 0.75º x 0.75º
MesoNH	2	100x100x60 (120x120x60)	2, 2 (0.4, 0.4)	41.8-46.8N - 2.4-3.9E	1 km	Surfex	TKE scheme	ECMWF 0.125º x 0.125º
AROME	1	240x240x60	2.5	41,5-46,7N / -2.2-5.2E	2,5km	Surfex	TKE scheme + Mass Flux (PMMC09)	AROME-FRANCE
ARPEGE	1	Global T798 L70	10	Global	10km	Isba	TKE scheme + Mass Flux (KFB2001)	ARPEGE-4DVAR

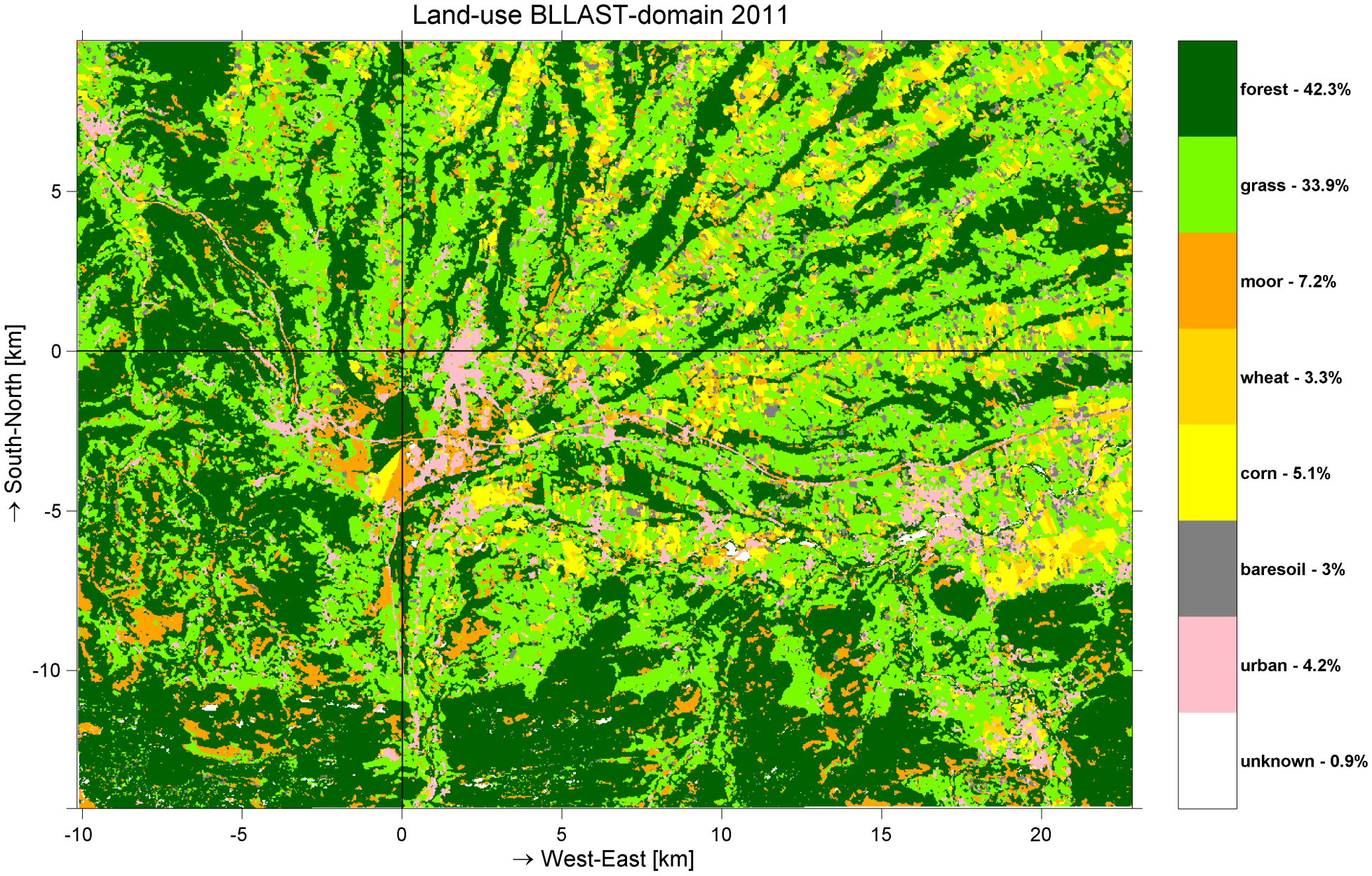
The representation of the surface fluxes by mesoscale models (Hartogensis et al. and Angevine)

Land use maps (real, CESBIO)



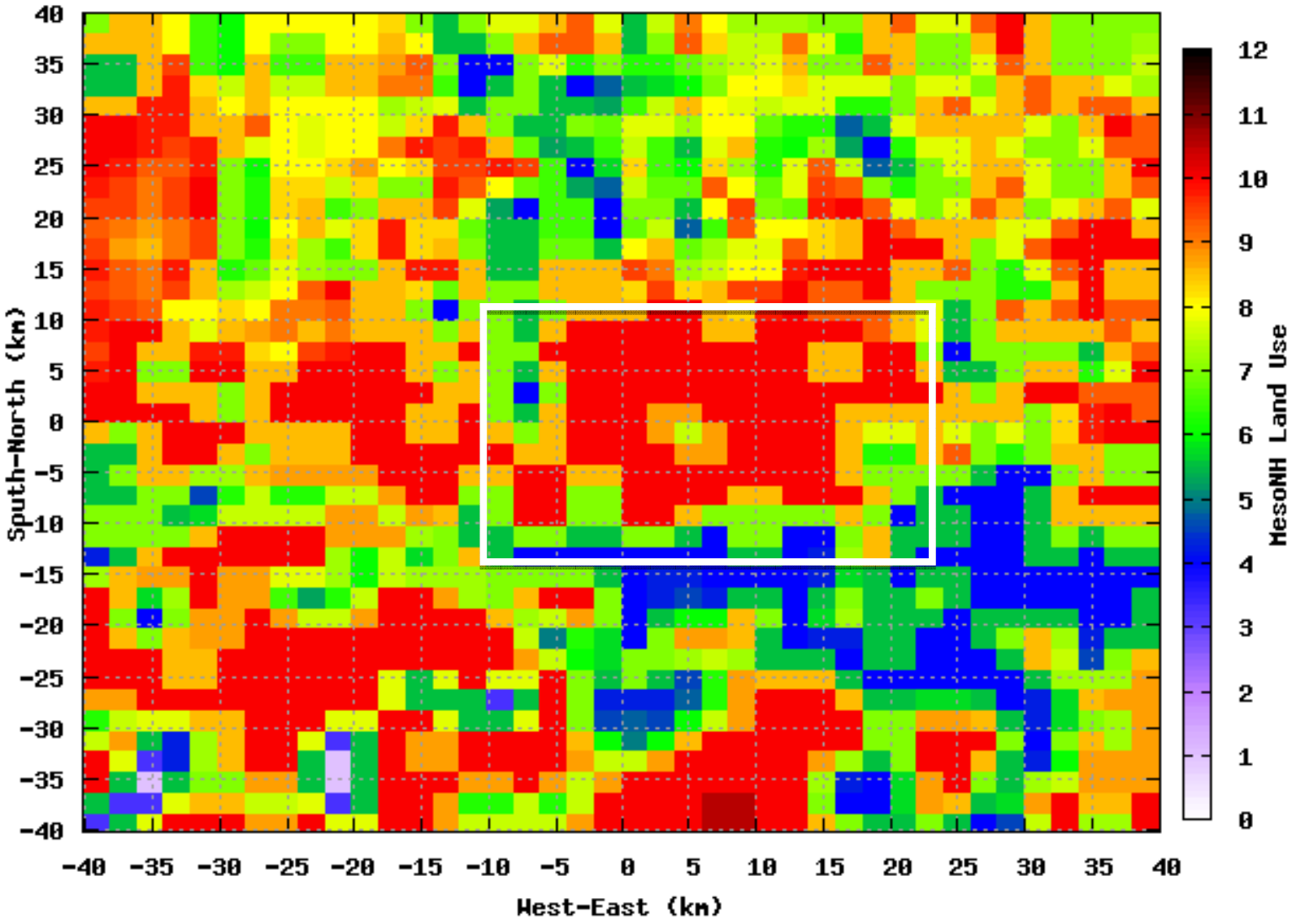
The representation of the surface fluxes by mesoscale models

Land use maps (simplification using obs, Hartogensis et al.



The representation of the surface fluxes by mesoscale models

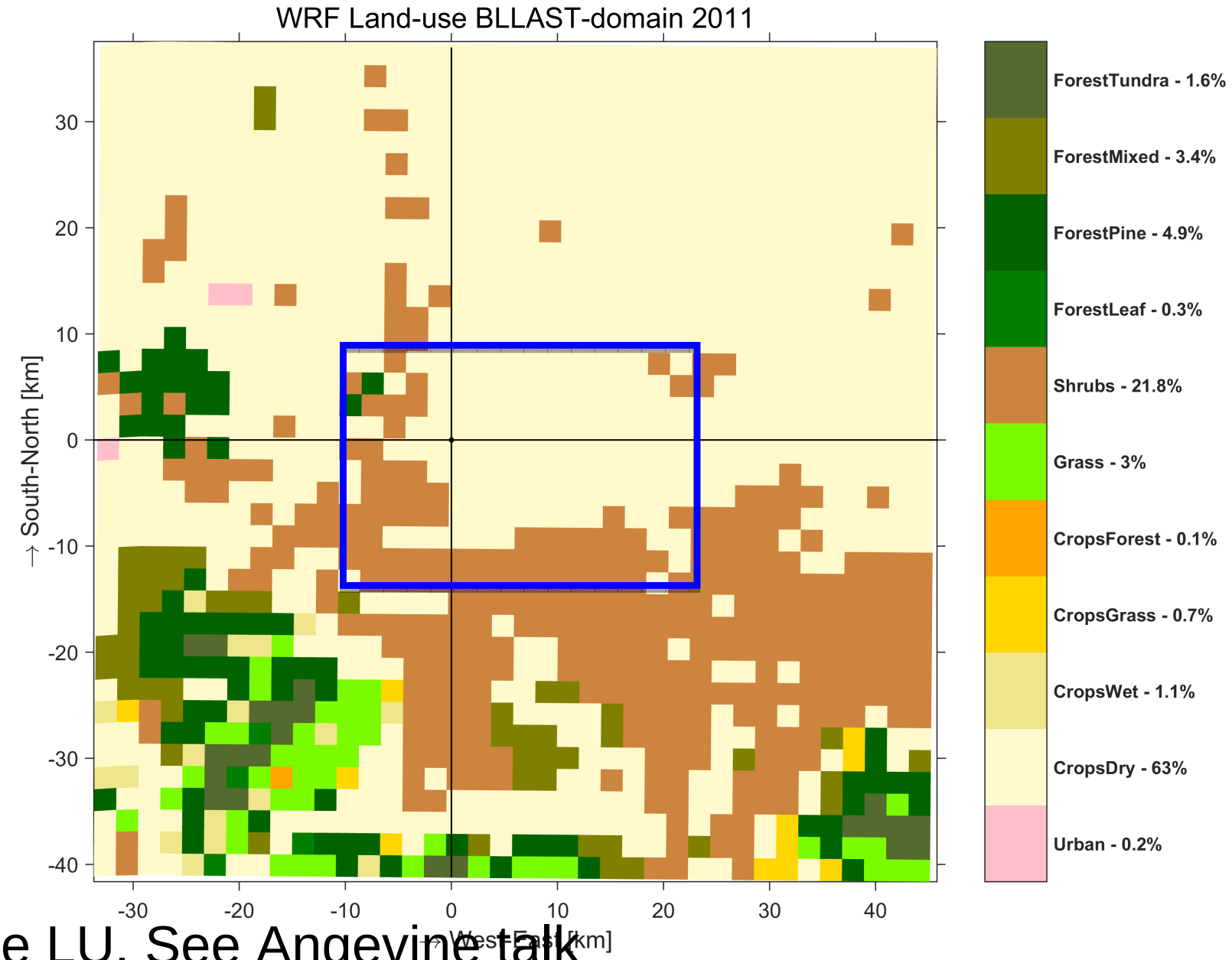
Land use maps (MesoNH)



1: bare ground
2: rocks
3: perm snow
4: deciduous forest
5: conifer forest
6: evergr broadleaf trees
7: C3 crops
8: C4 crops
9: irrigated crops
10: grassland (C3)
11: tropical grass (C4
12: garden and parks

The representation of the surface fluxes by mesoscale models

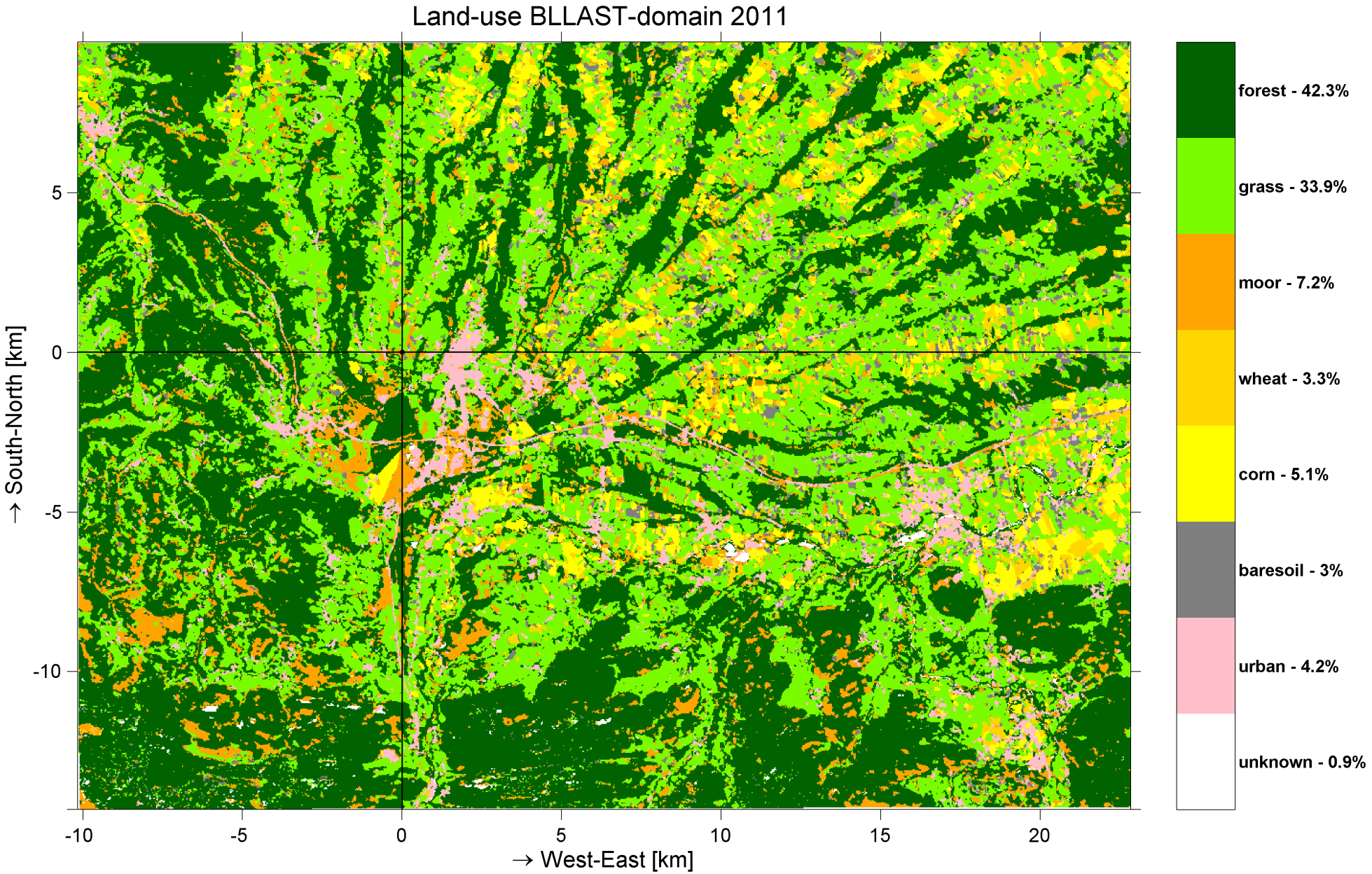
Land use maps (WRF 1', approx 2 km)



Coarse LU. See Angevine talk

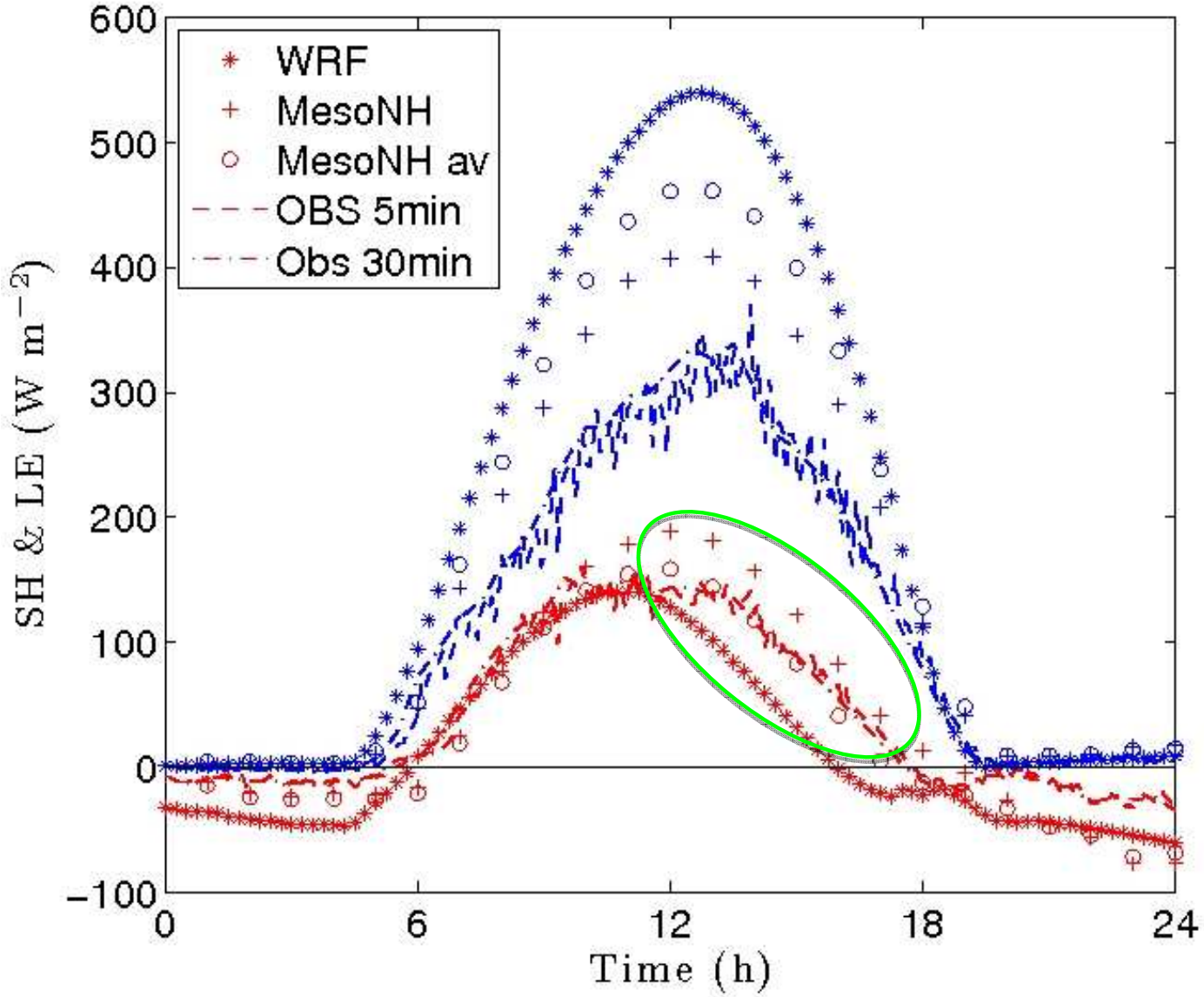
The representation of the surface fluxes by mesoscale models

Land use maps (zoom WRF 1', approx 2 km)

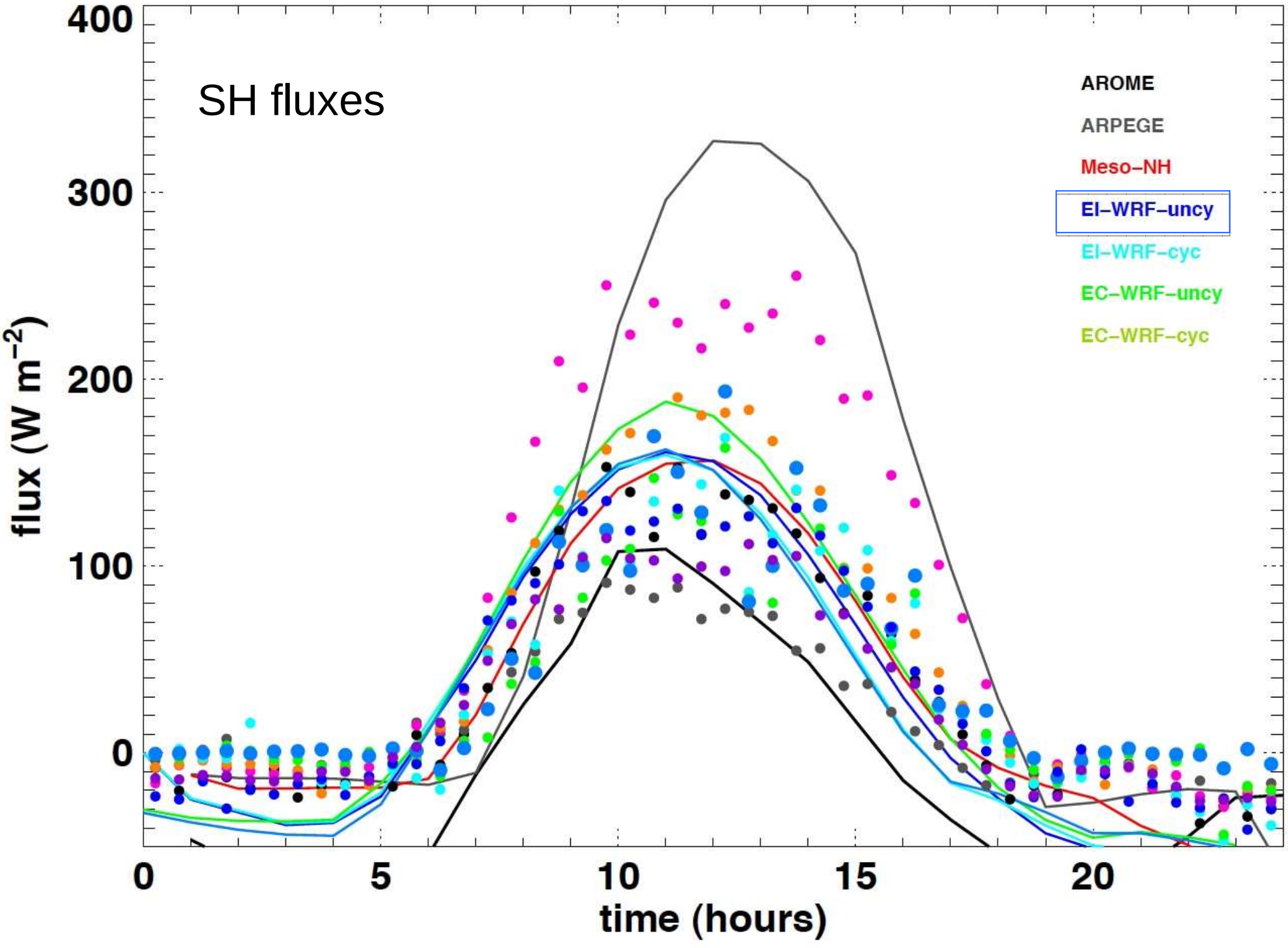


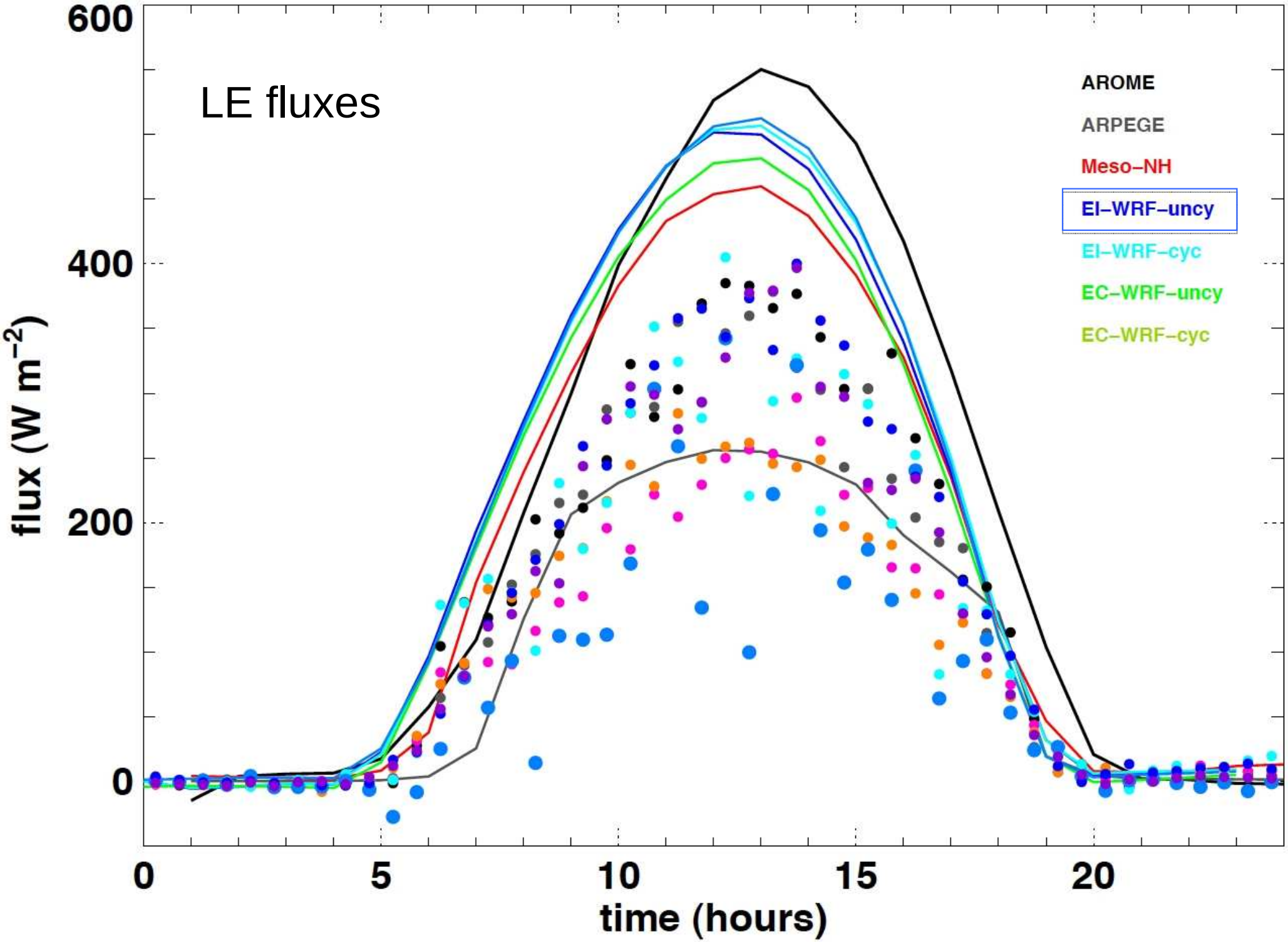
The representation of the surface fluxes by mesoscale models

Back

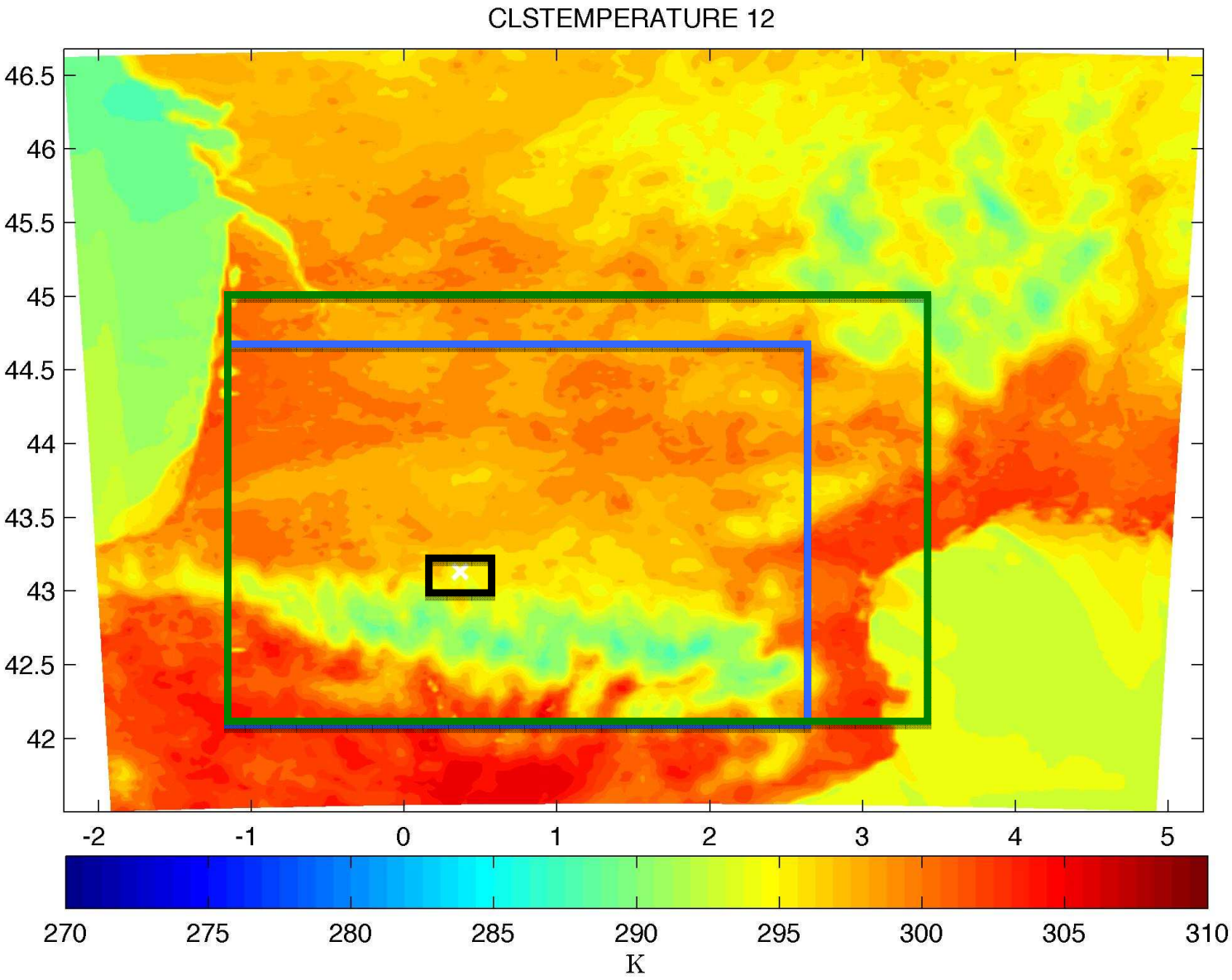


- MesoNH and WRF reproduce SH except during the afternoon.
- Both overestimate LE.

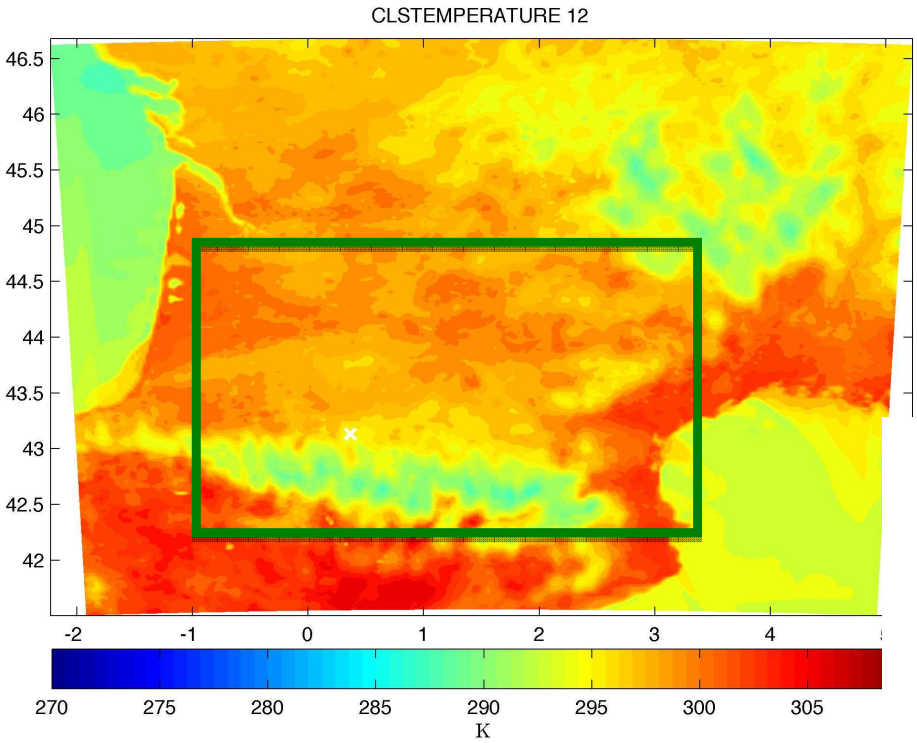

SH fluxes
AROME
ARPEGE
Meso-NH
EI-WRF-uncy
EI-WRF-cyc
EC-WRF-uncy
EC-WRF-cyc
flux (W m^{-2})
400
300
200
100
0
0
5
10
15
20
time (hours)

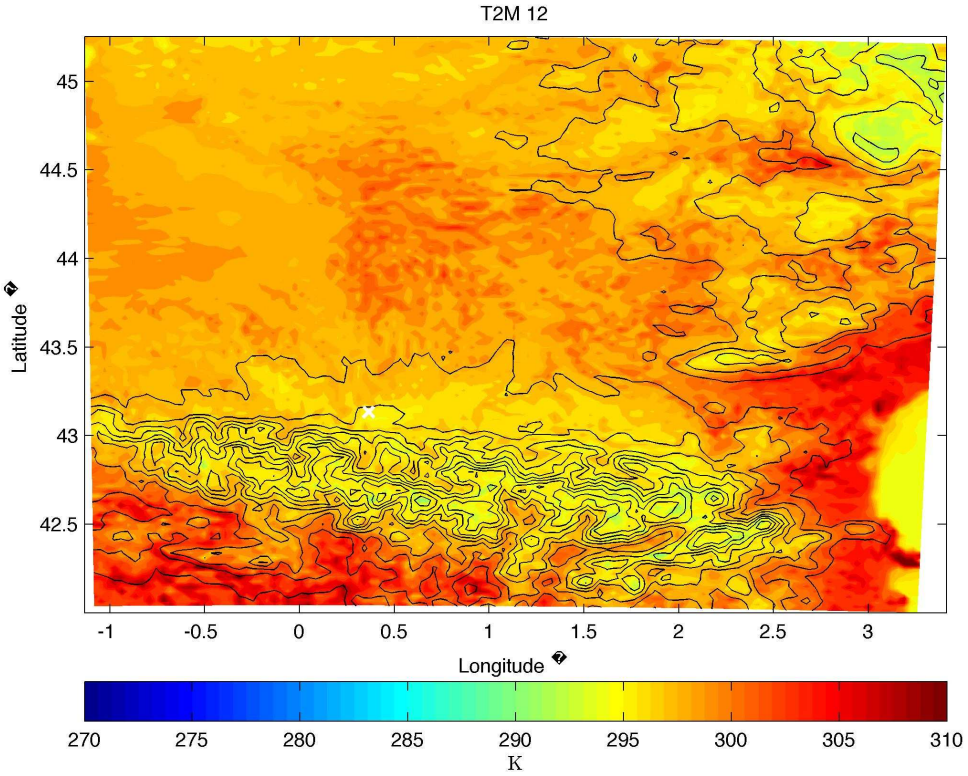

LE fluxes
AROME
ARPEGE
Meso–NH
EI–WRF–uncy
EI–WRF–cyc
EC–WRF–uncy
EC–WRF–cyc
flux (W m^{-2})
600
400
200
0
0
5
10
15
20
time (hours)

Surface 2D: AROME, MesoNH, WRF, OBS (Hartogensis et al.)



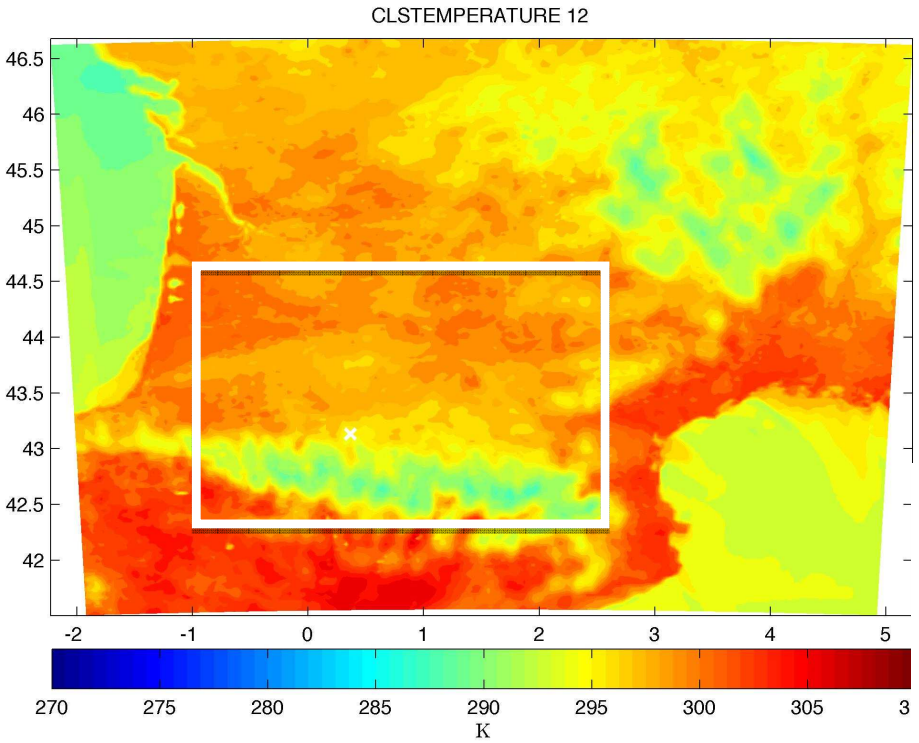
T2m at 12 UTC: AROME vs MesoNH

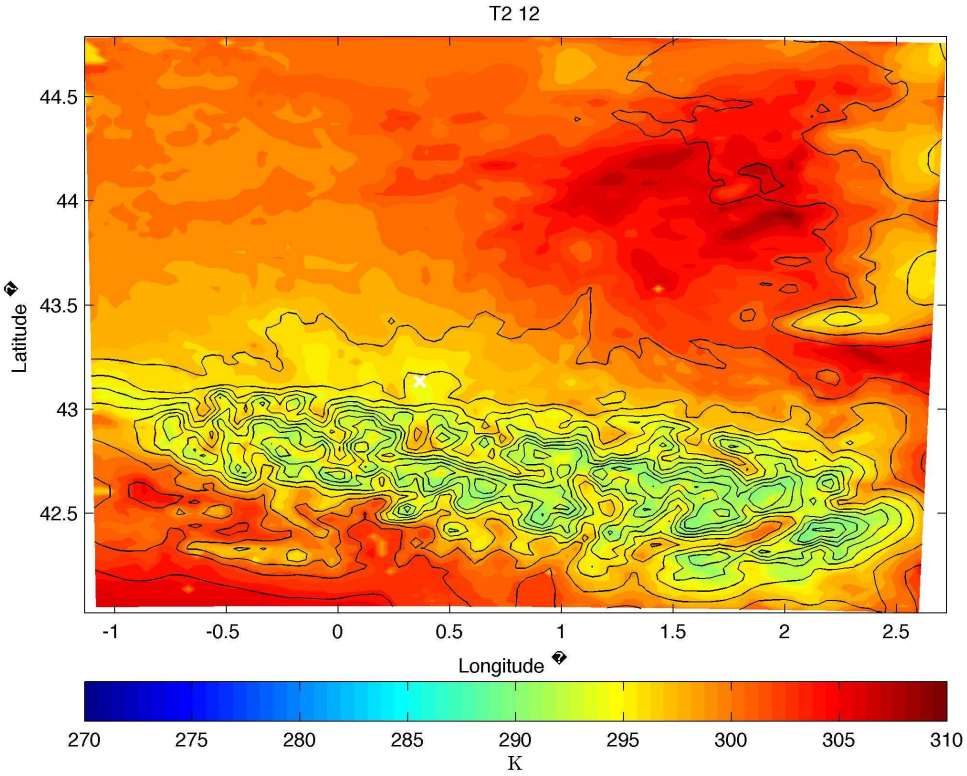




Smaller T by AROME at Pyrenees

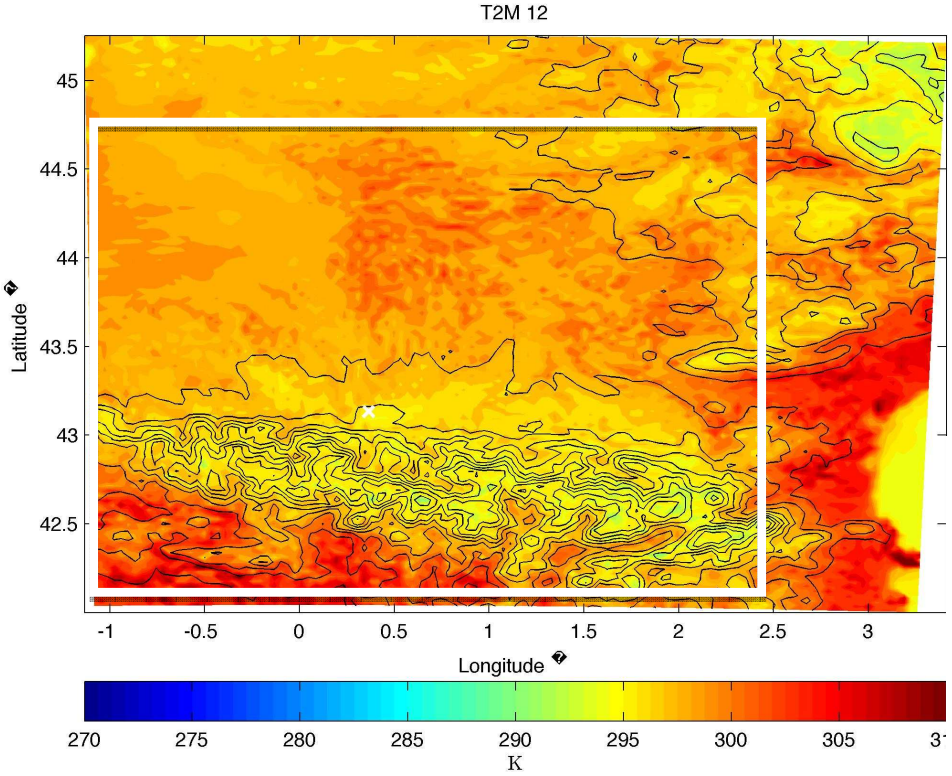
T2m at 12 UTC: AROME vs WRF

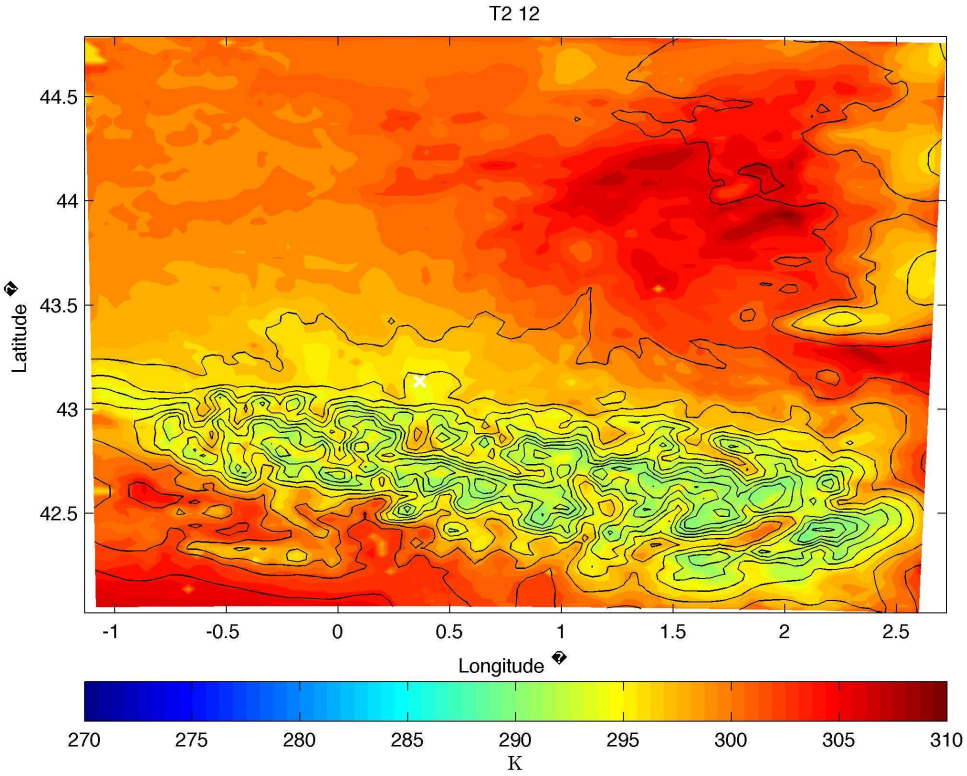




Smaller T by AROME

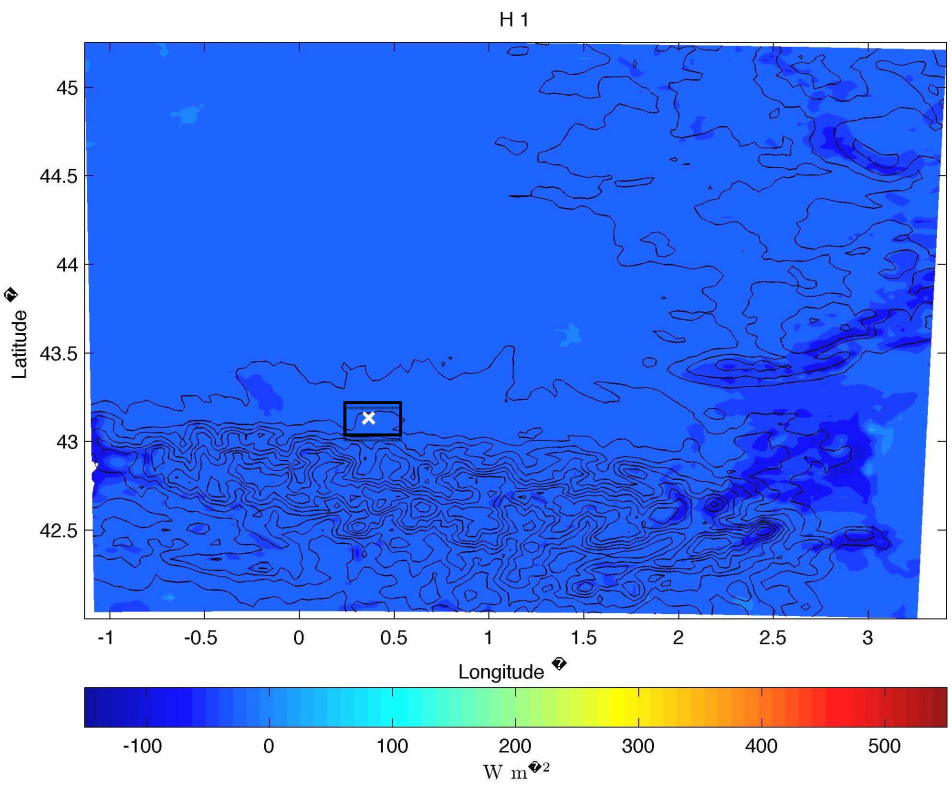
T2m at 12 UTC: MesoNH vs WRF

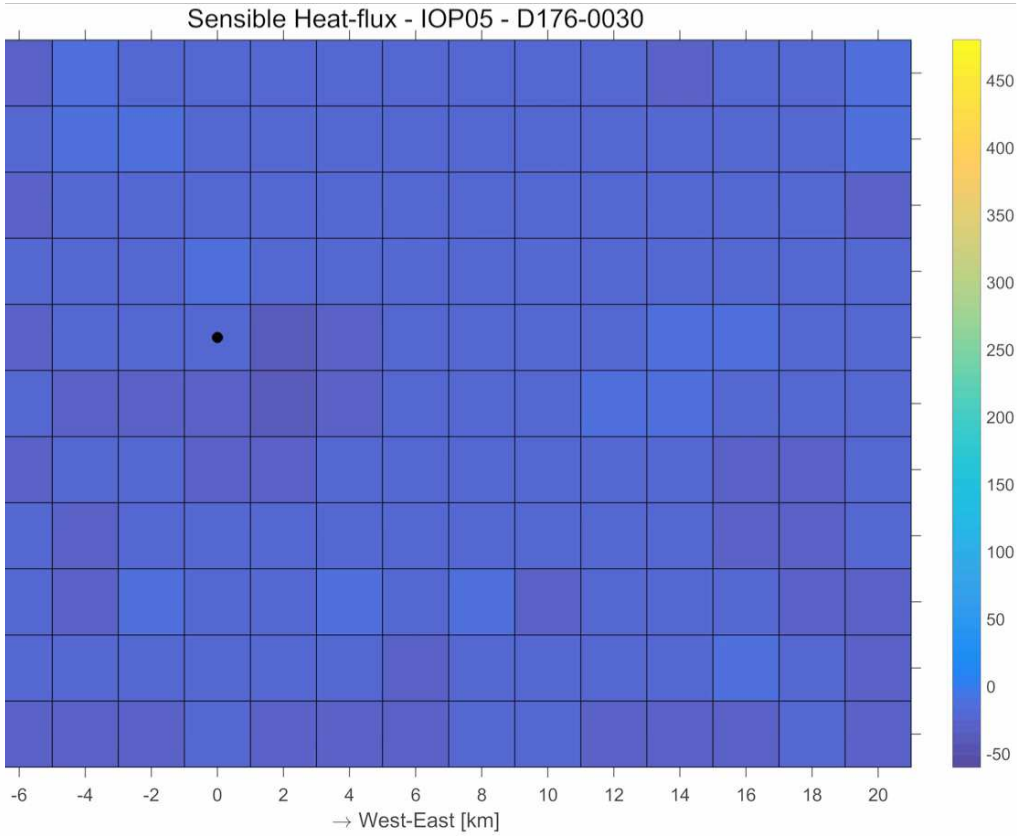




Larger T contrast by WRF

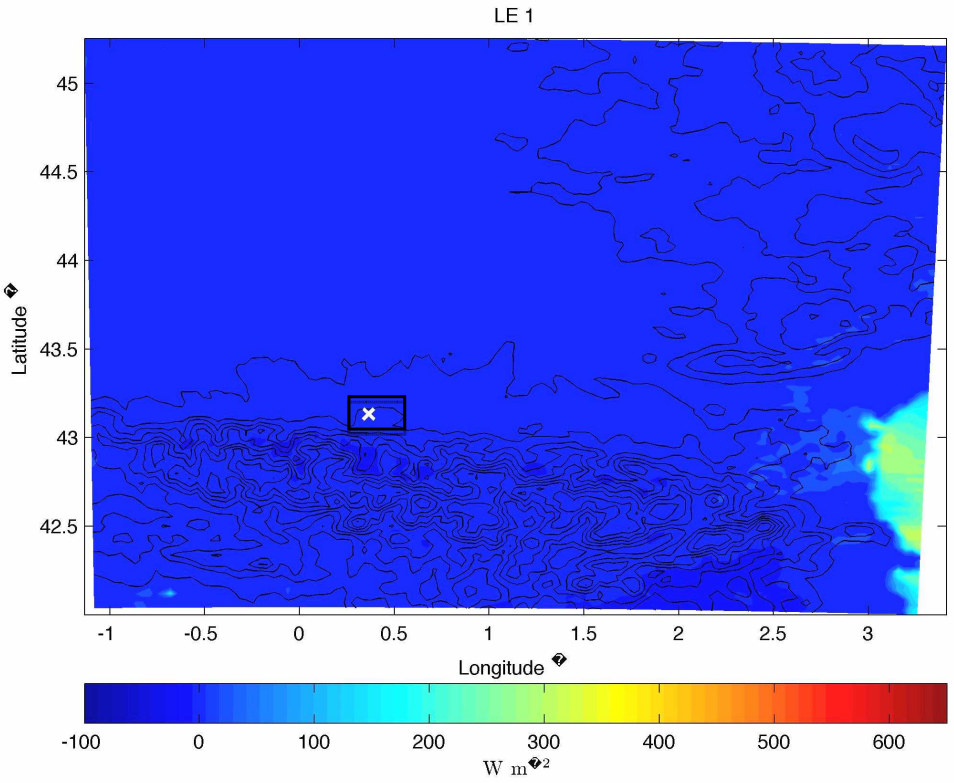
SH: MesoNH vs OBS

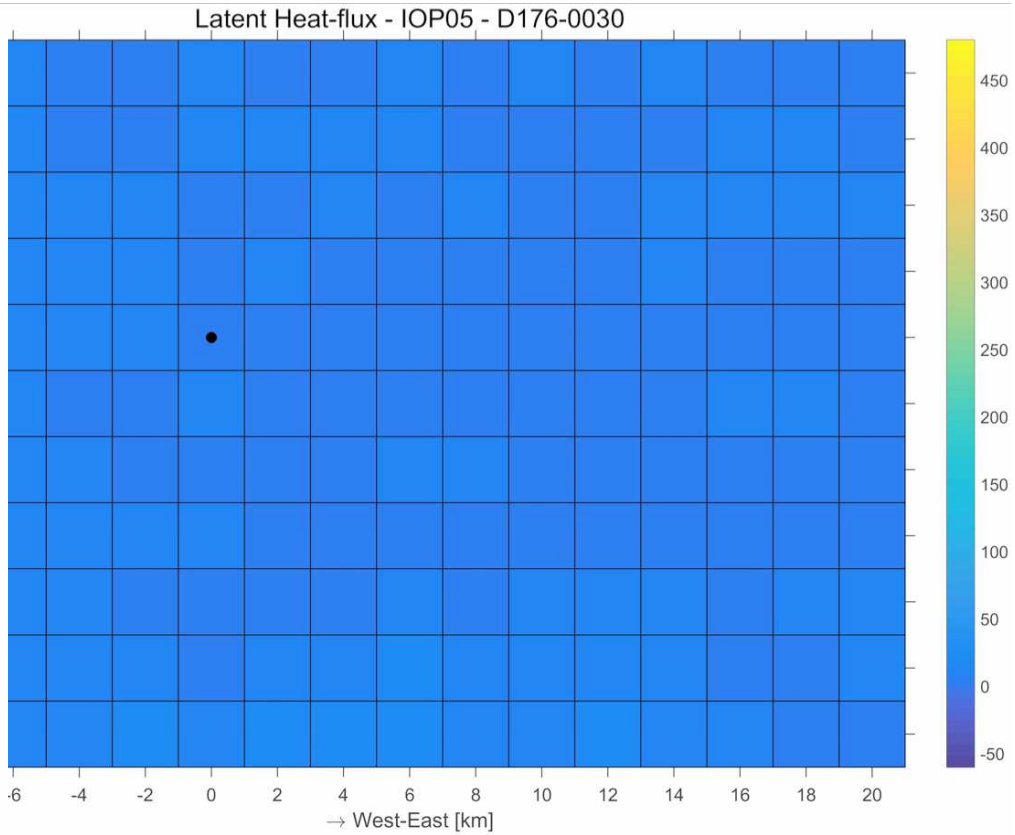




See Hartogensis talk

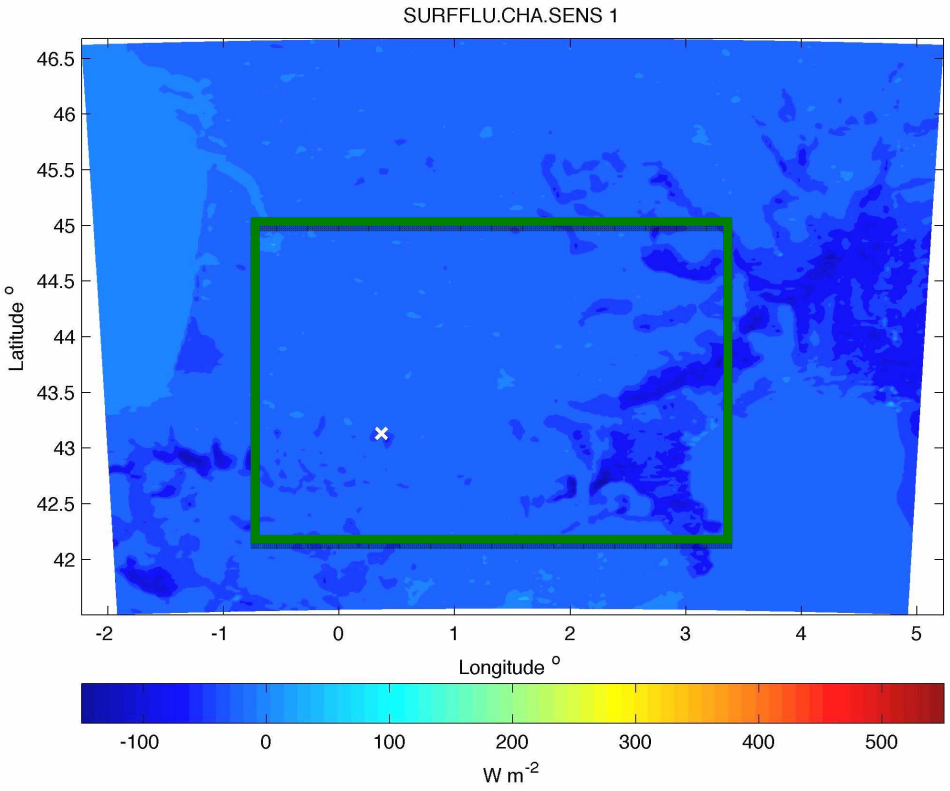
LE: MesoNH vs OBS

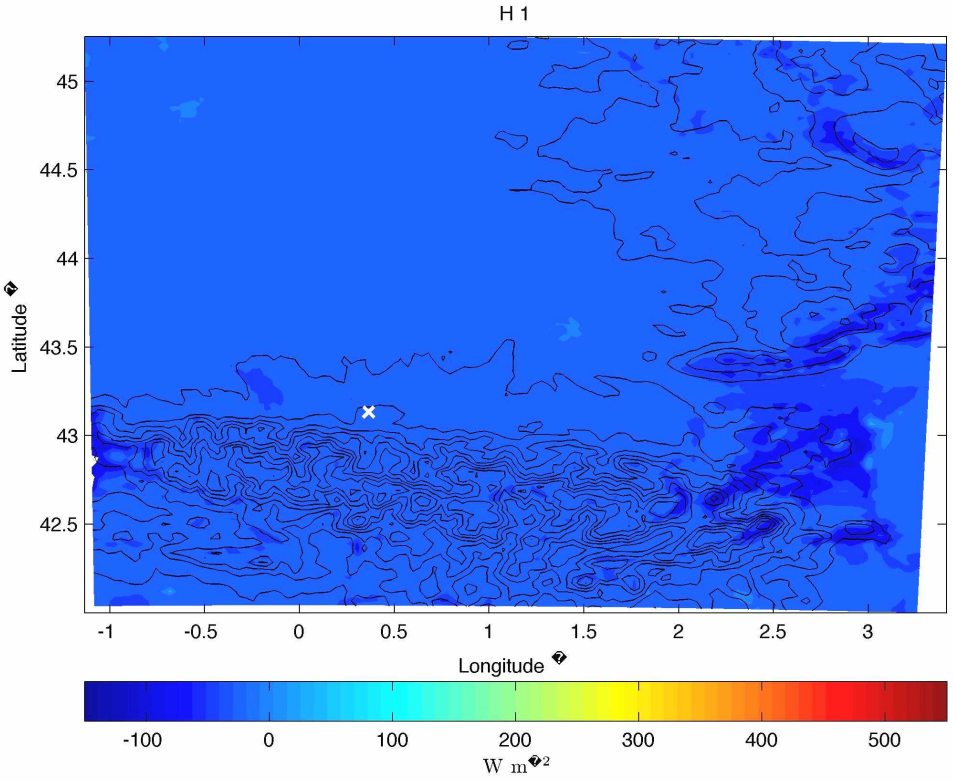




See Hartogensis talk

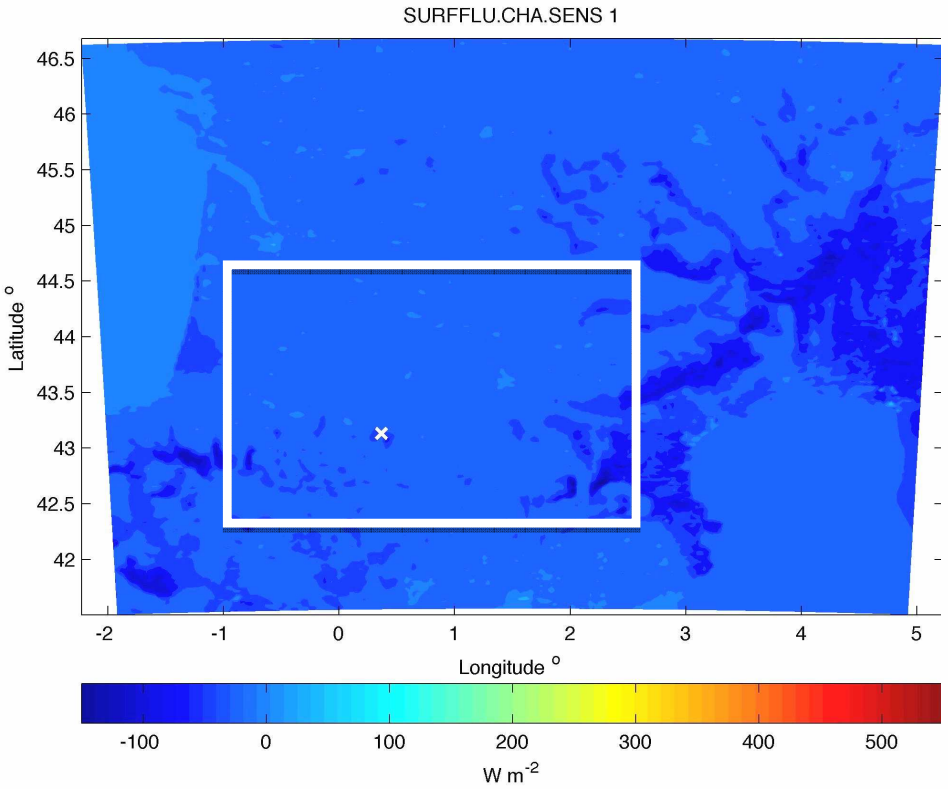
SH: AROME vs MesoNH

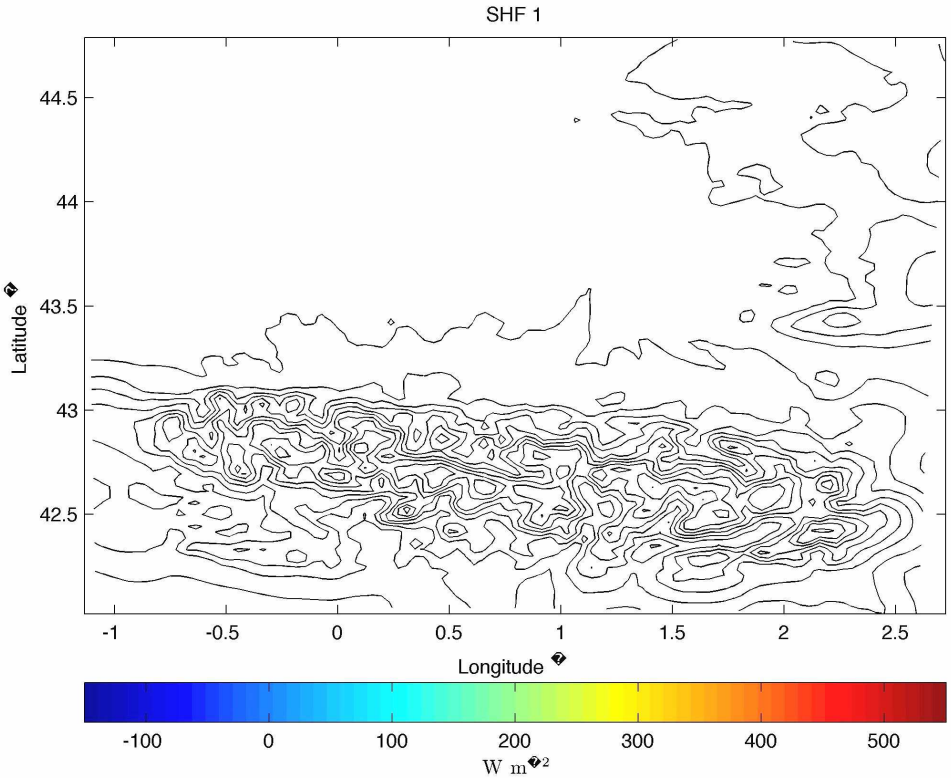




Larger SH fluxes in AROME

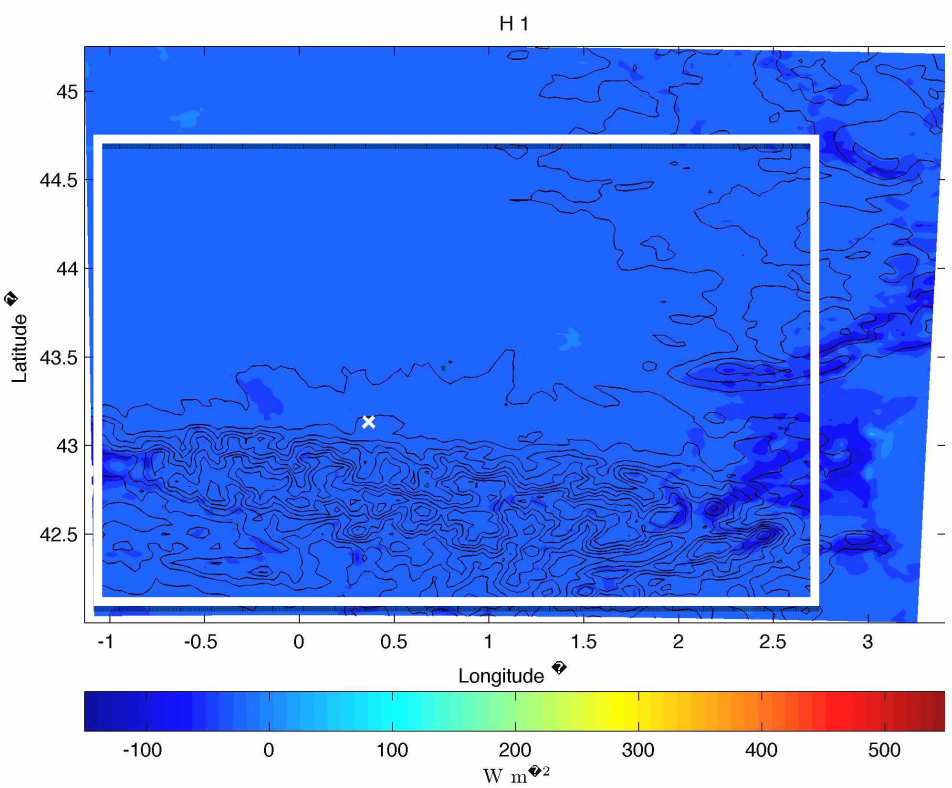
SH: AROME vs WRF

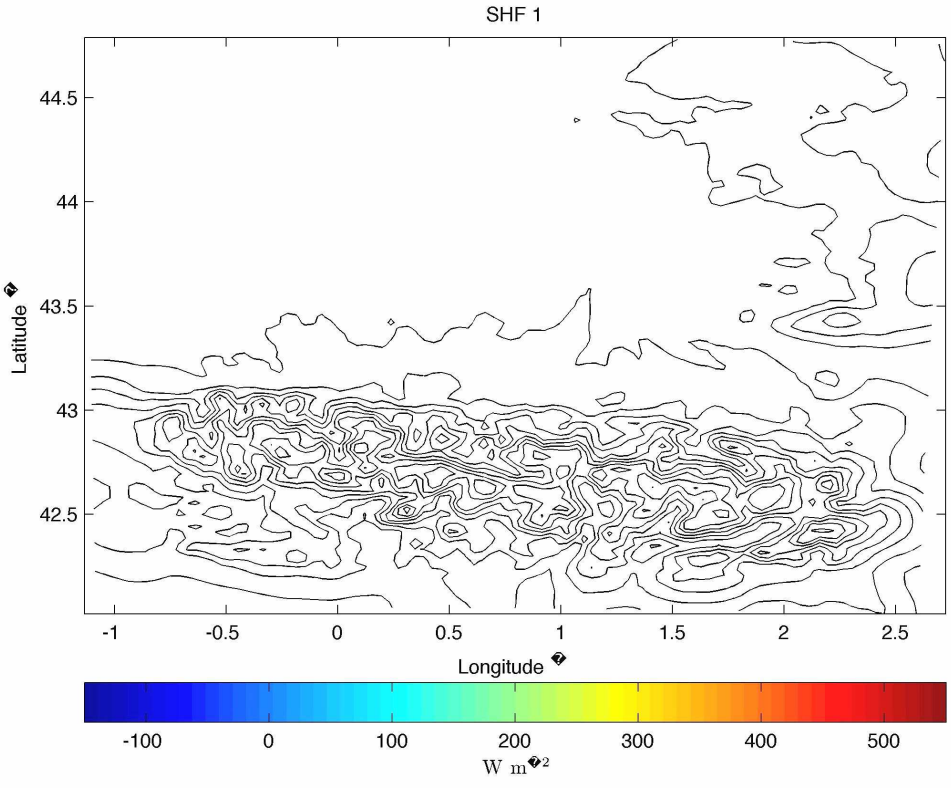




WRF: larger SH at the E smallest at the W

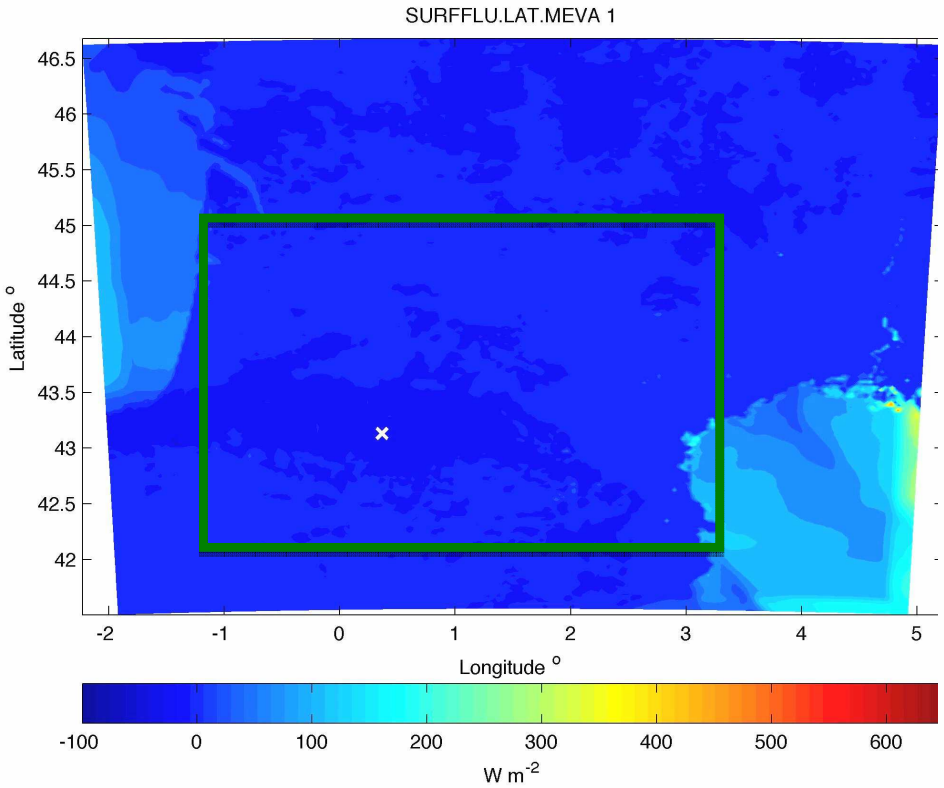
SH: MesoNH vs WRF

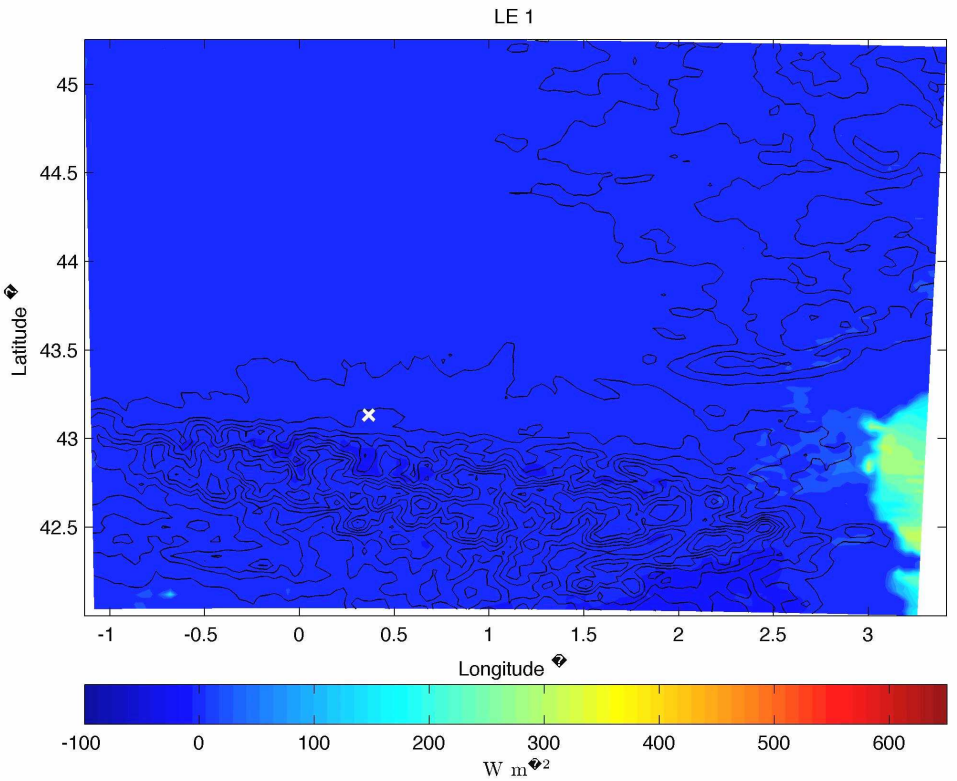




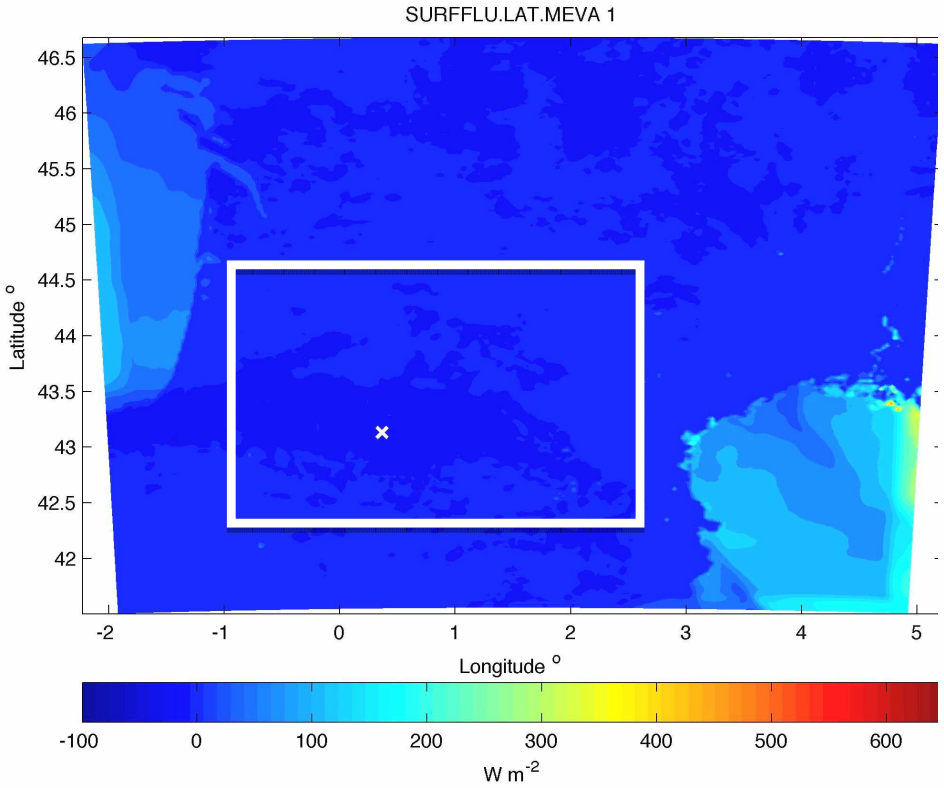
WRF: larger SH during daytime

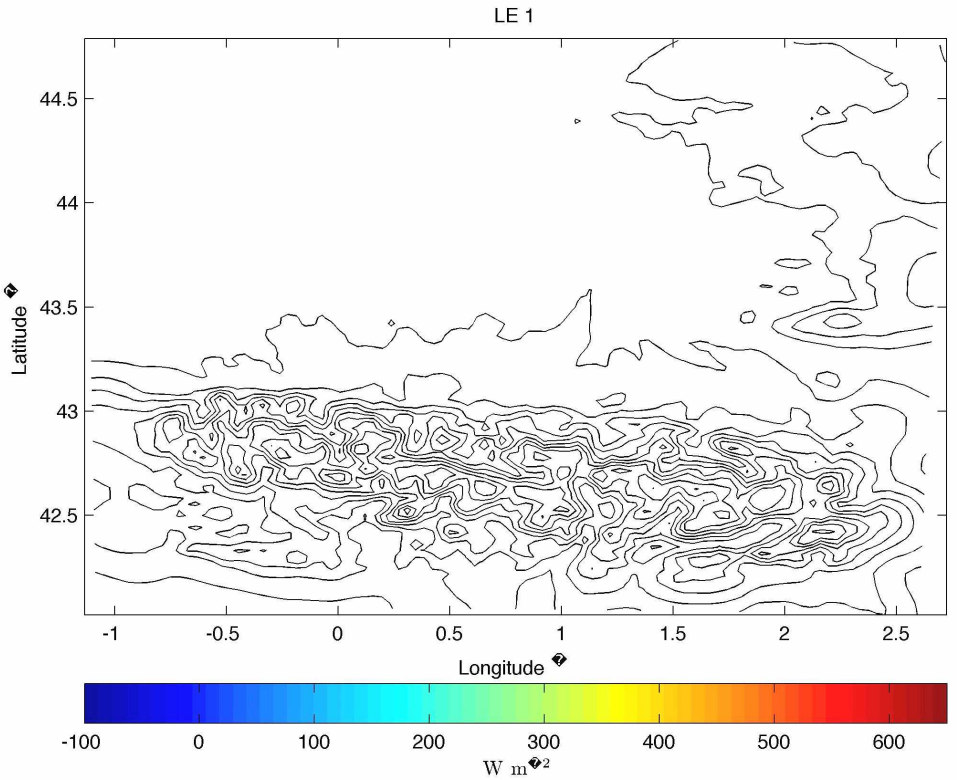
LE: AROME vs MesoNH





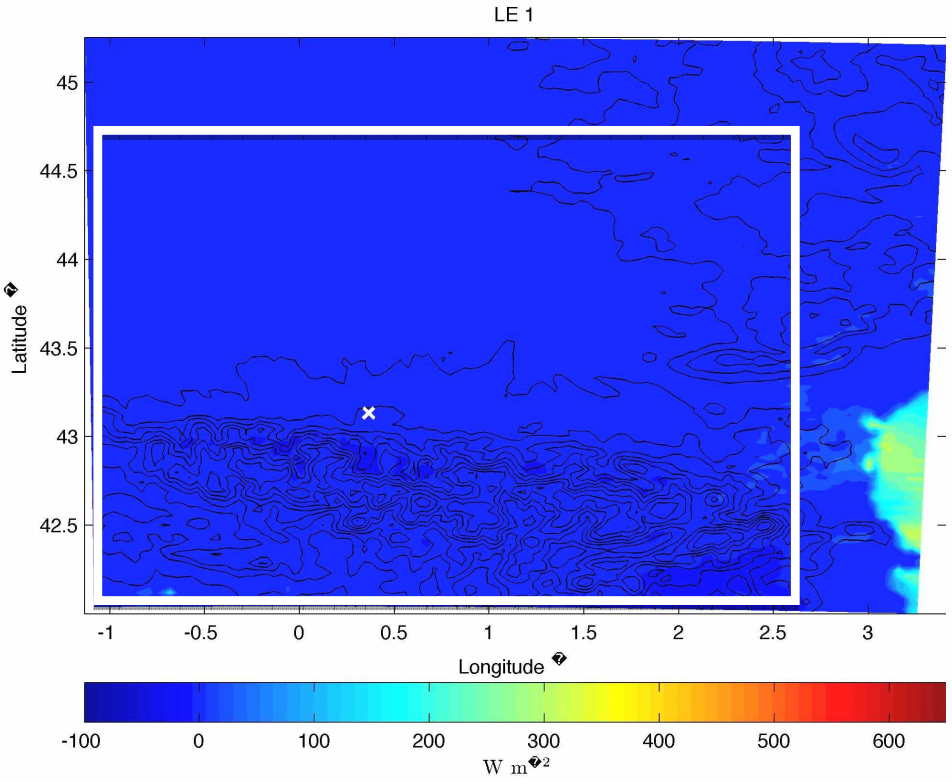
LE: AROME vs WRF

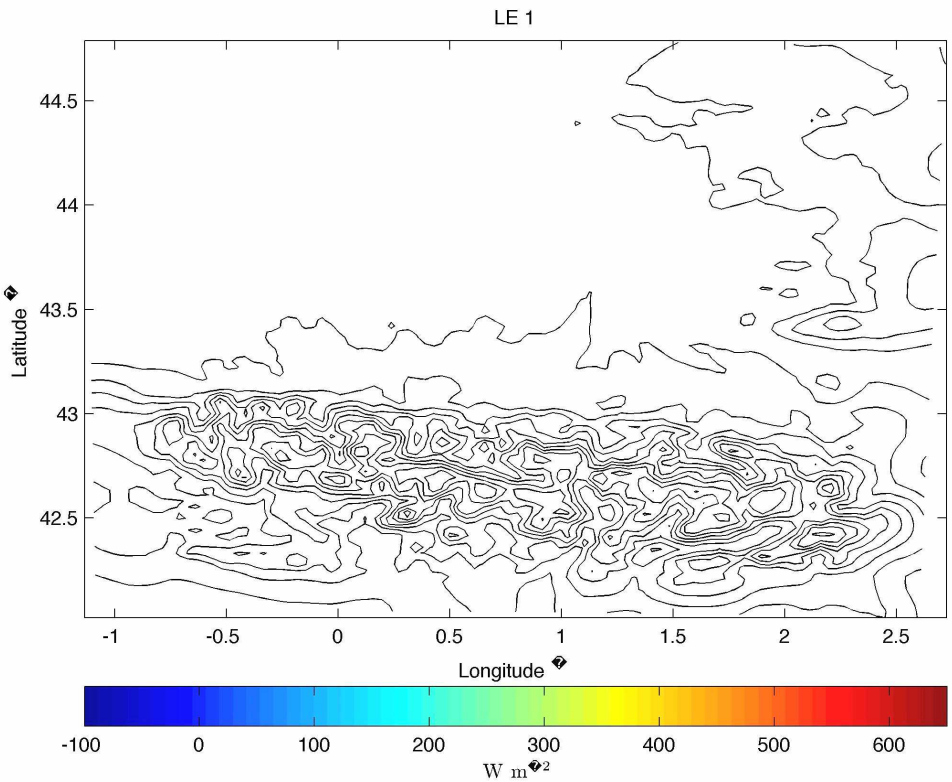




WRF: smaller LE at the E

LE: MesoNH vs WRF



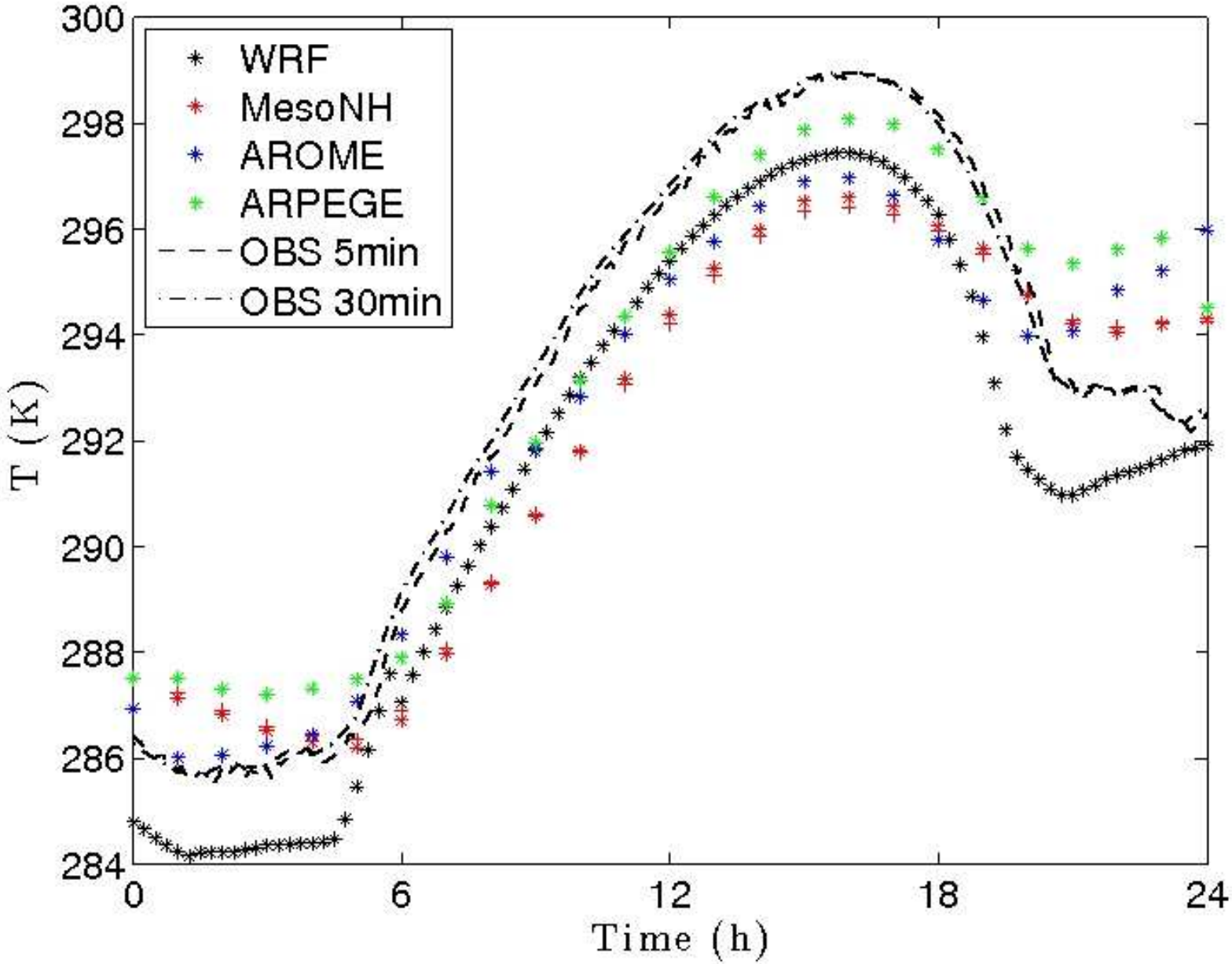


WRF: clearly larger LE in the whole domain

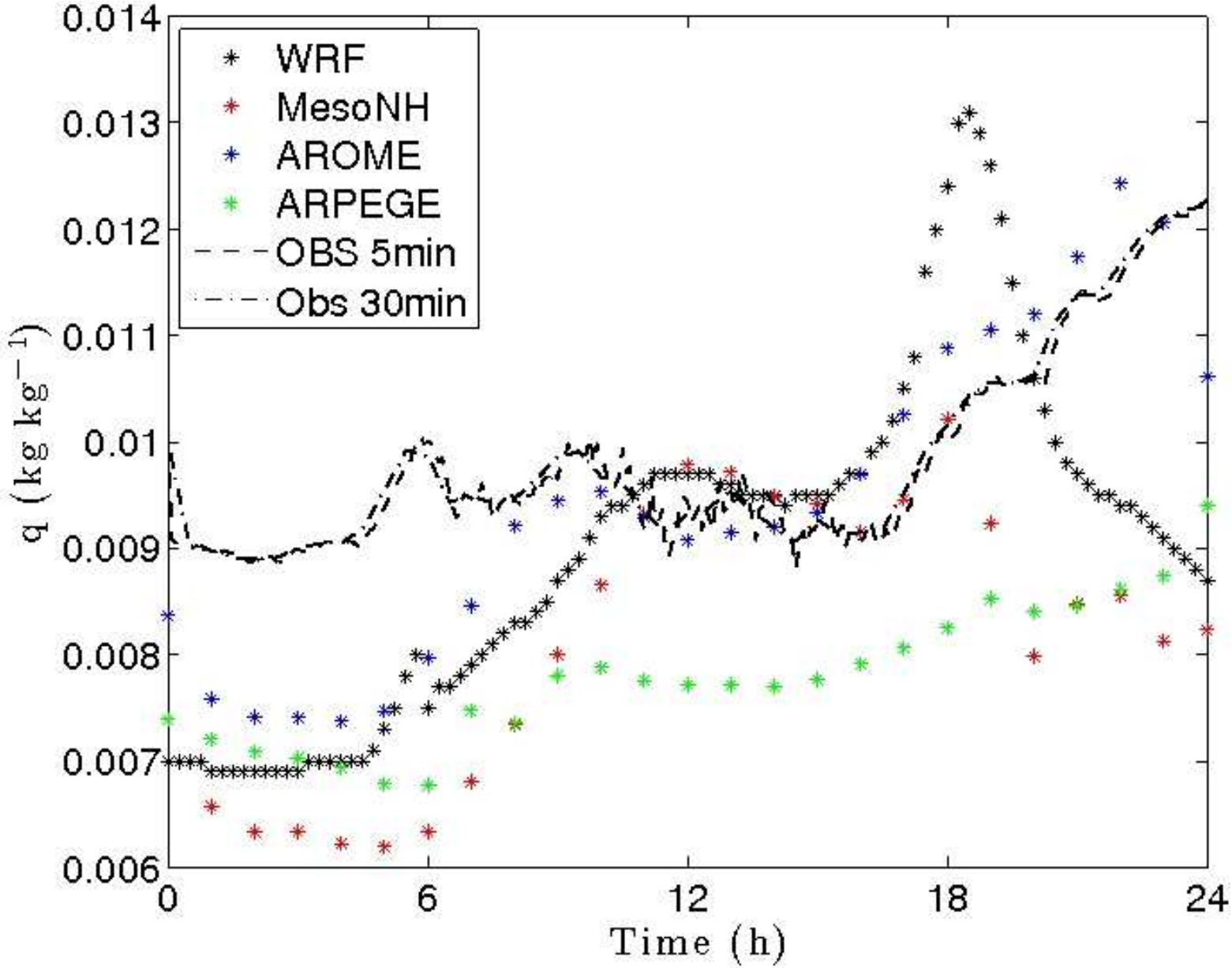
The vertical structure of the low troposphere linked to surface processes

See talks by:

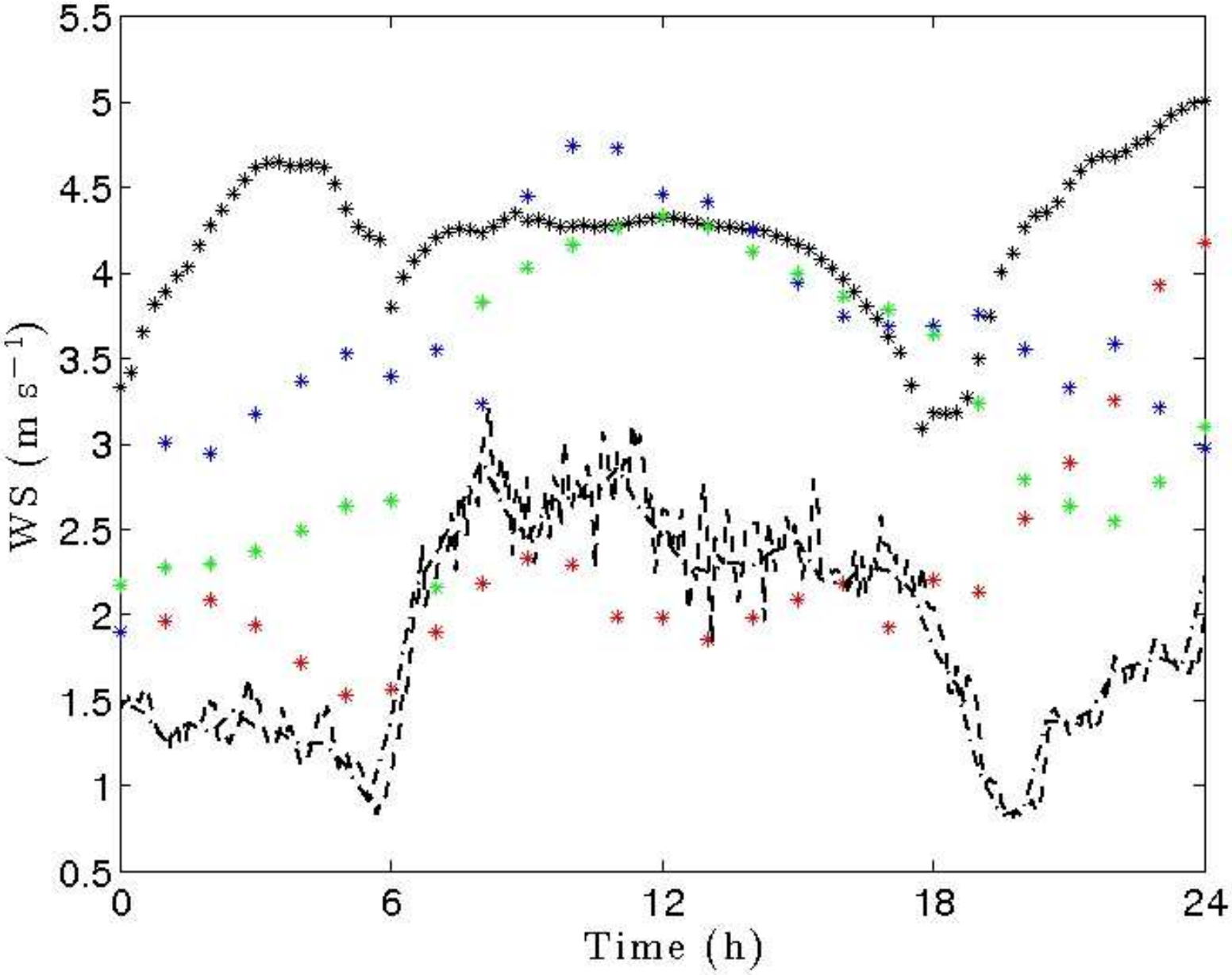
- van de Boer (Moene): Detection of entrainment influences on surface-layer measurements during BLLAST
- Gibert: Evening boundary layer transition using Doppler lidar and in situ observations
- Nilsson: Upon scaling of near-surface TKE in the afternoon transition
- Darbieu (Lothon): Evolution of turbulence structure during the afternoon transition
- Blay (Pino): Countergradient heat flux and lifted temperature minimum near the surface
- Reuder: Effect of surface heterogeneity as seen by SUMO
- Englberger (Lothon): Case study of 1 July, diurnal cycle and impact of roughness heterogeneity



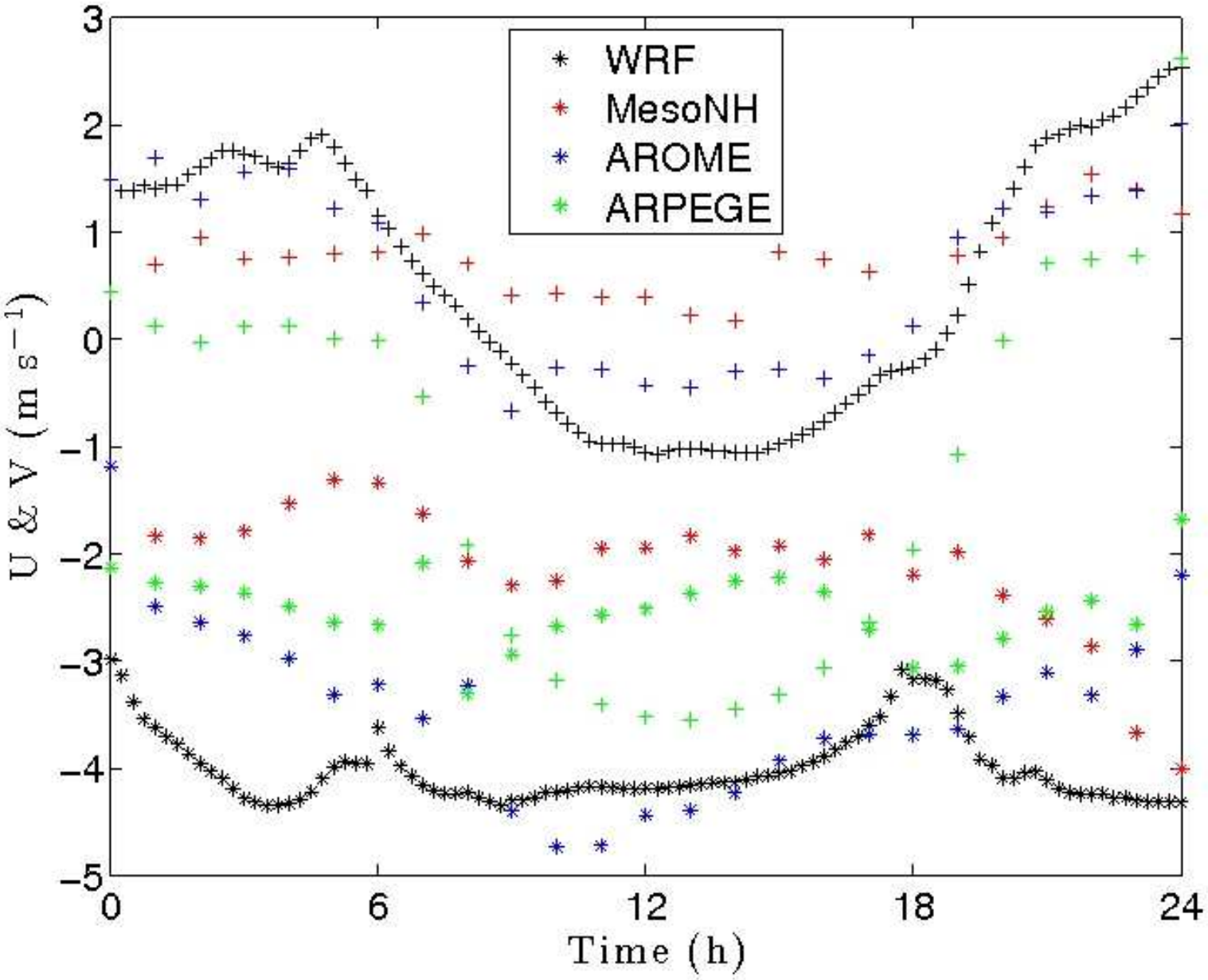
- Models underestimate max. obs. T (smaller heating rate except WRF).
- T decrease is well simulated by WRF. Other models simulate T increase from 18.



- Models start with a really low q for the previous night
- Only AROME (and partially WRF) reproduce the increase during the afternoon. Despite the large LE simulated, models don’t overestimate q. Different behavior when profiles are analyzed.



- Only MesoNH correctly simulates WS during the day (resolution?).
- Models approximately reproduce the increase/decrease of WS during the transitions



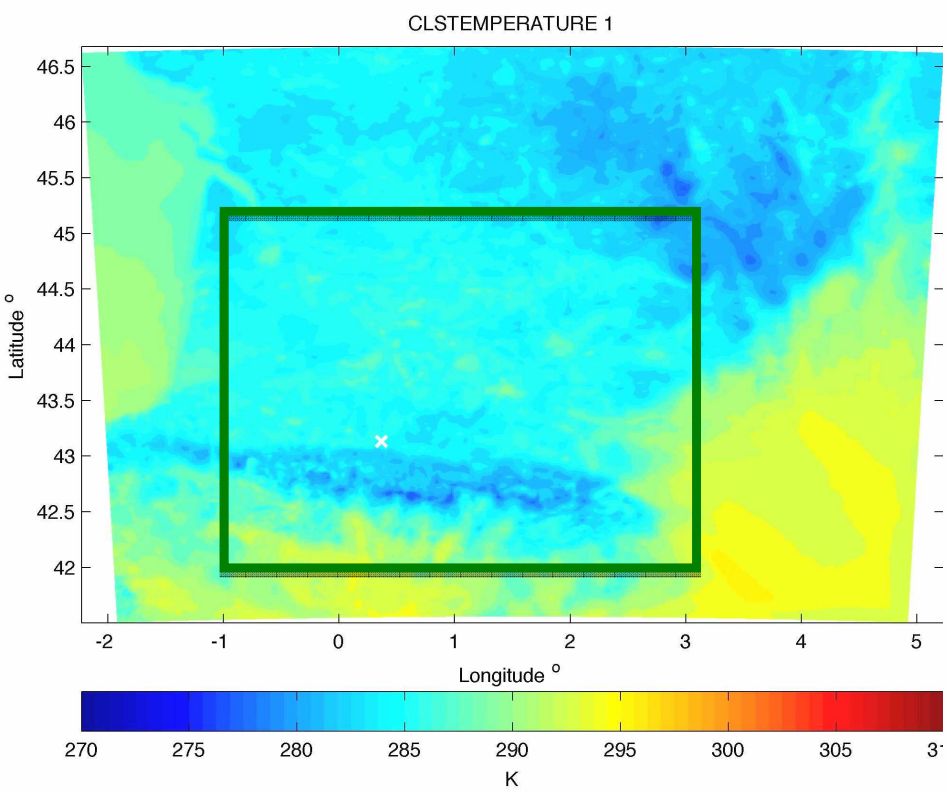
+ V

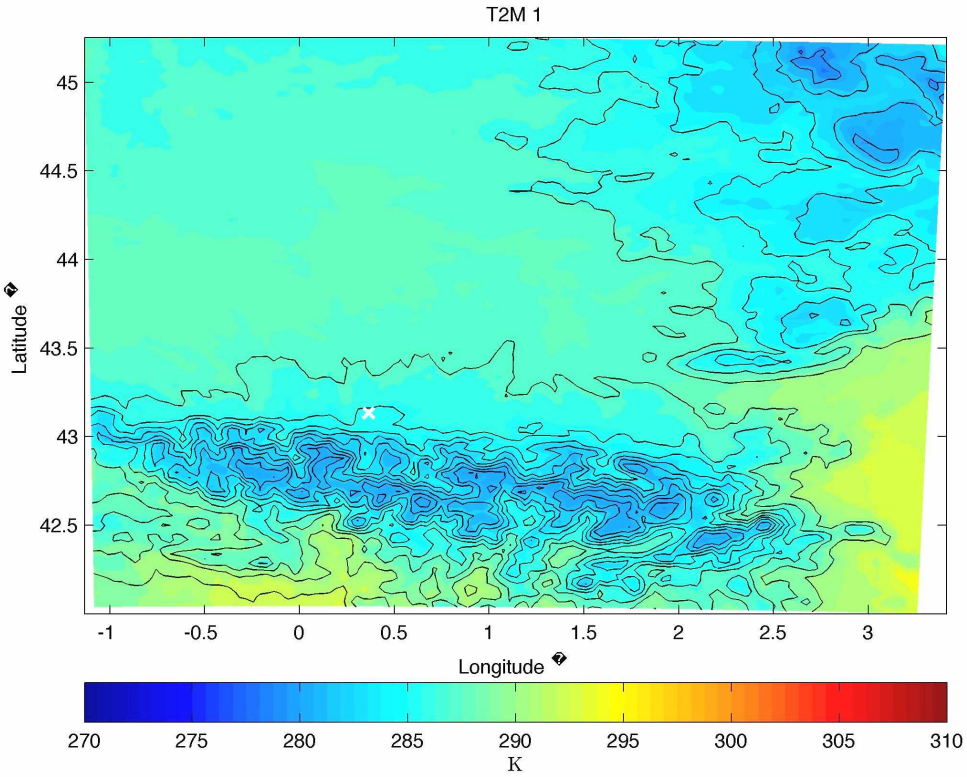
*** U**

- Models simulates always U<0.
- The WD change mountain-valley-mountain is approximately simulated. Large change fro ARPEGE.

Surface mean variables

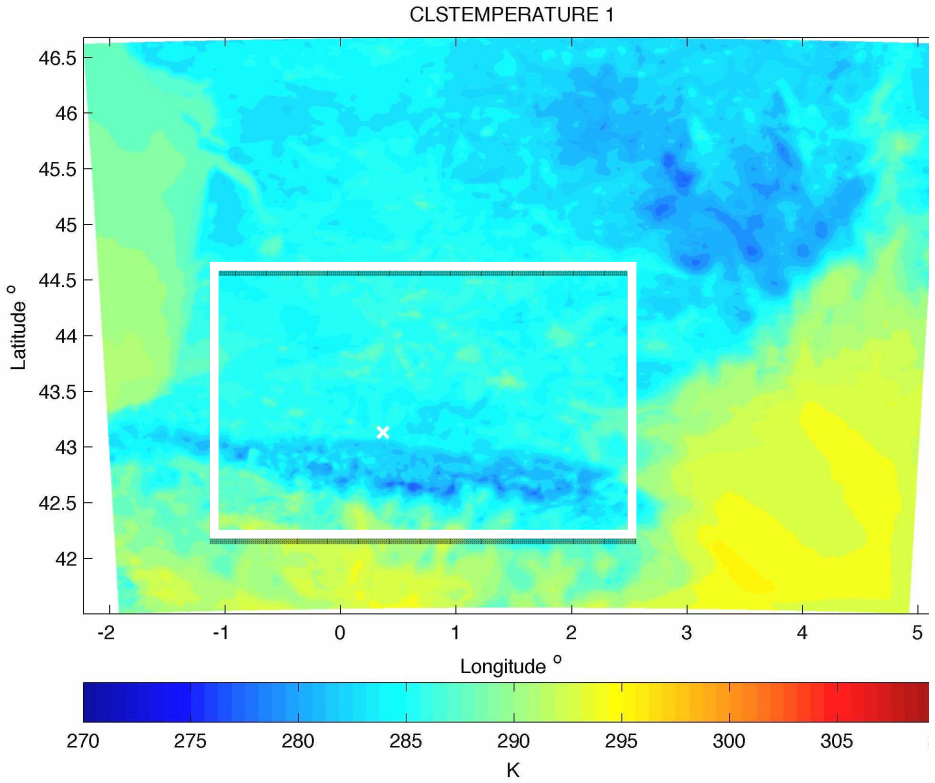
Temperature: AROME vs MesoNH

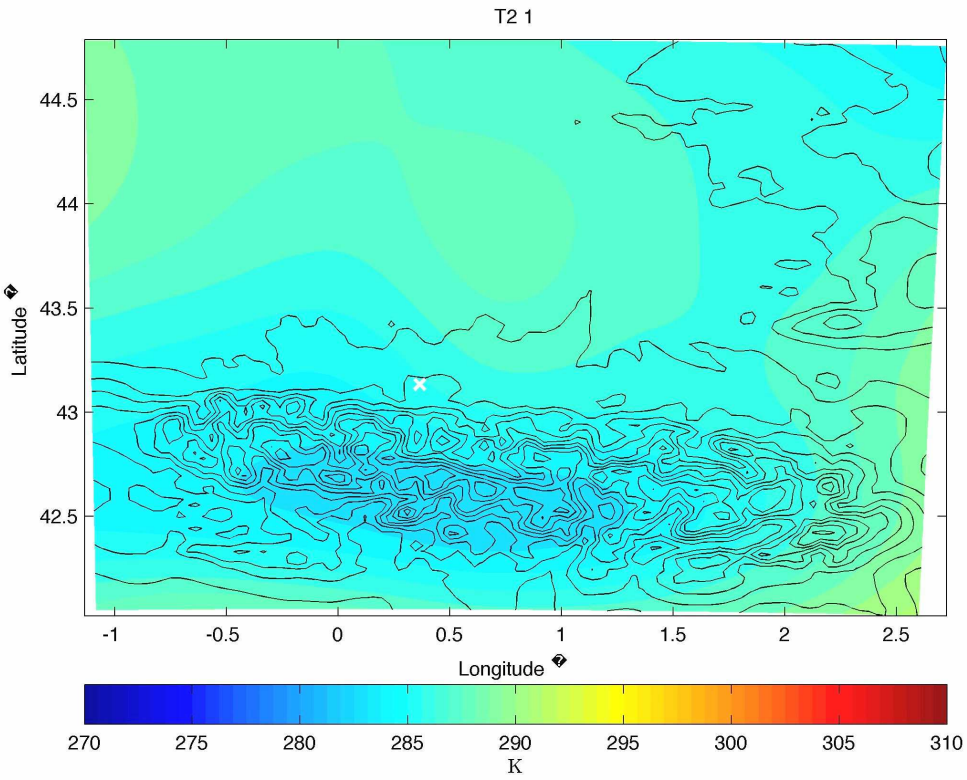




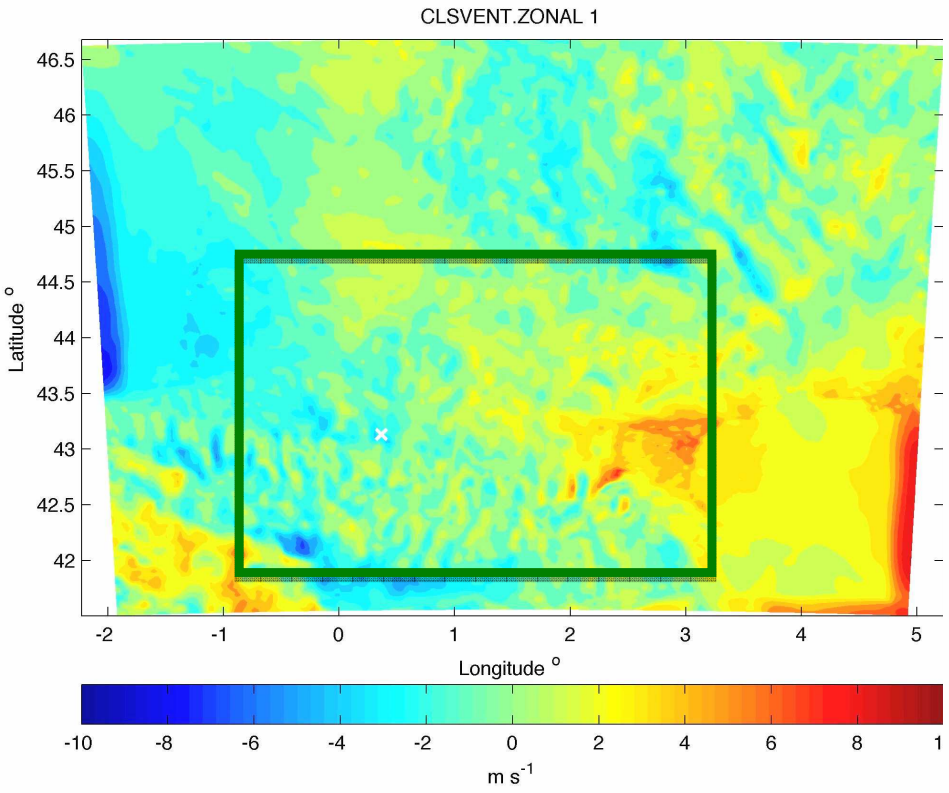
- Daytime larger T contrast for AROME. Influence in mountain-valley winds?

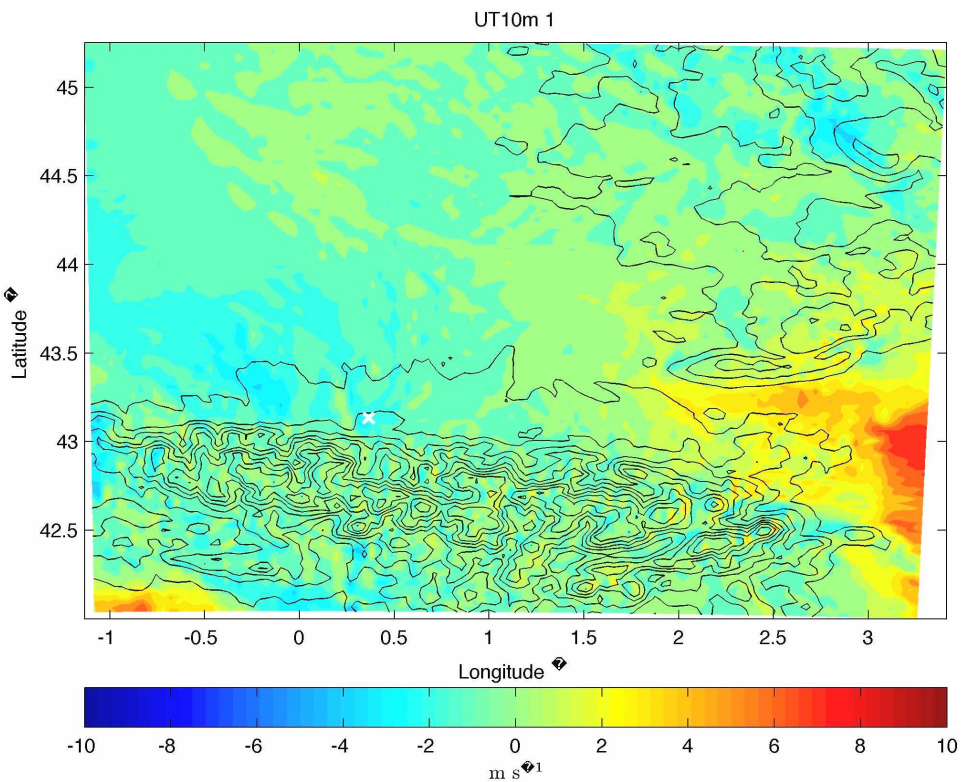
Temperature: AROME vs WRF





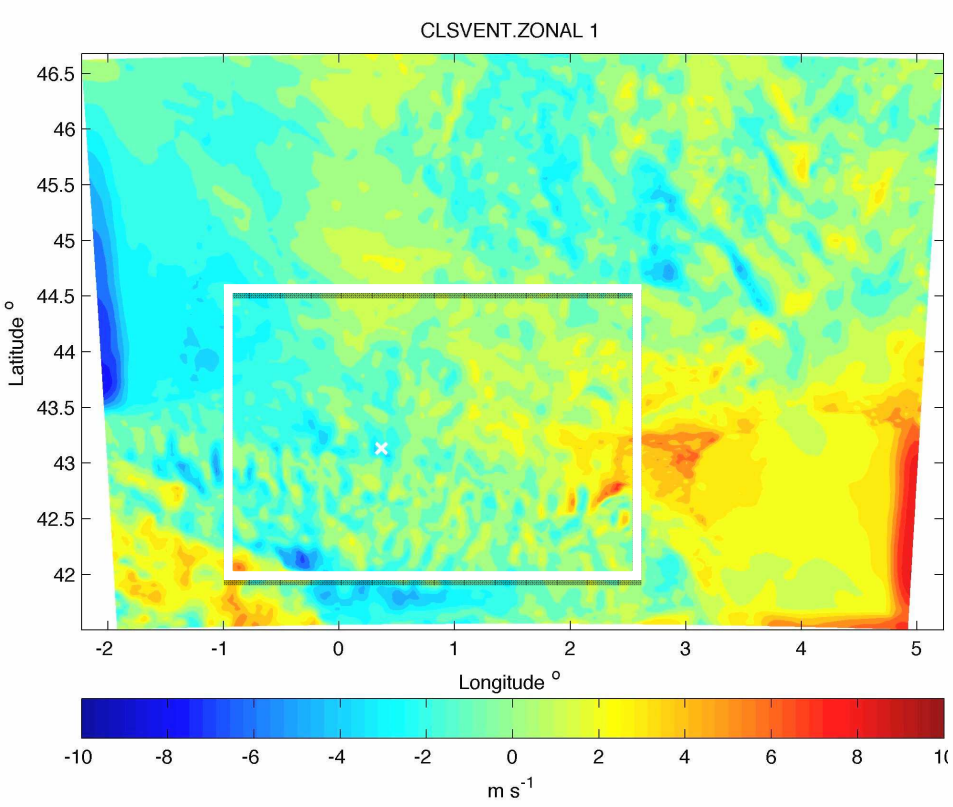
U: AROME vs MesoNH

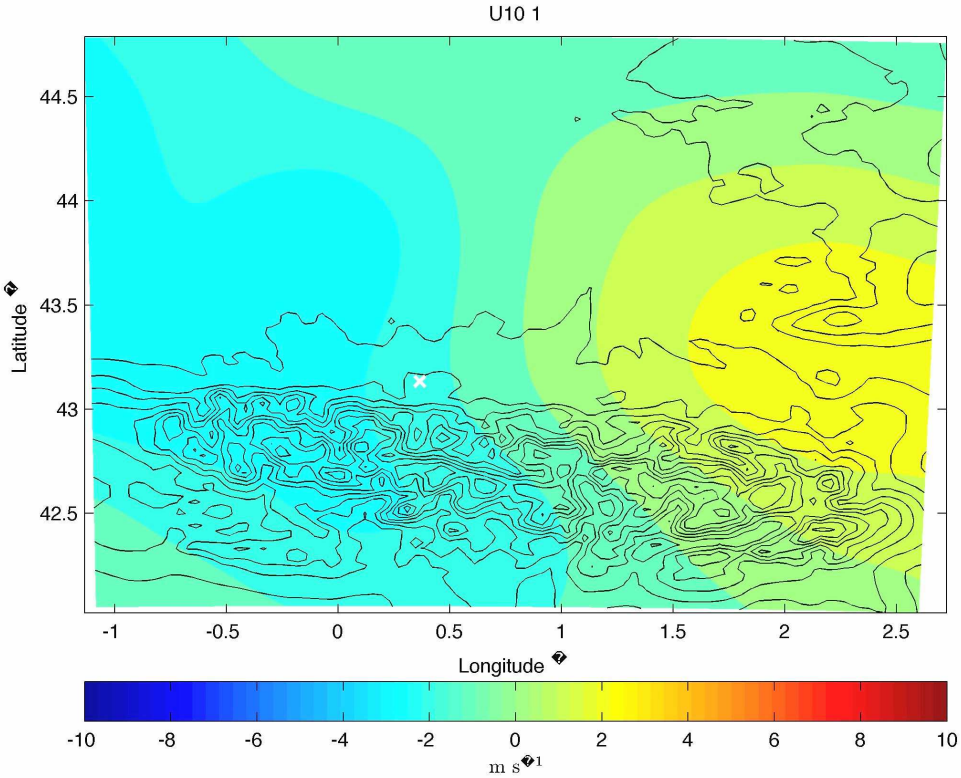




- Daytime clearly organized pattern in AROME with U>0 at the Pyrenees.
- AROME: daytime U<0 in the Lannemezan area. Smaller wind speed for MesoNH

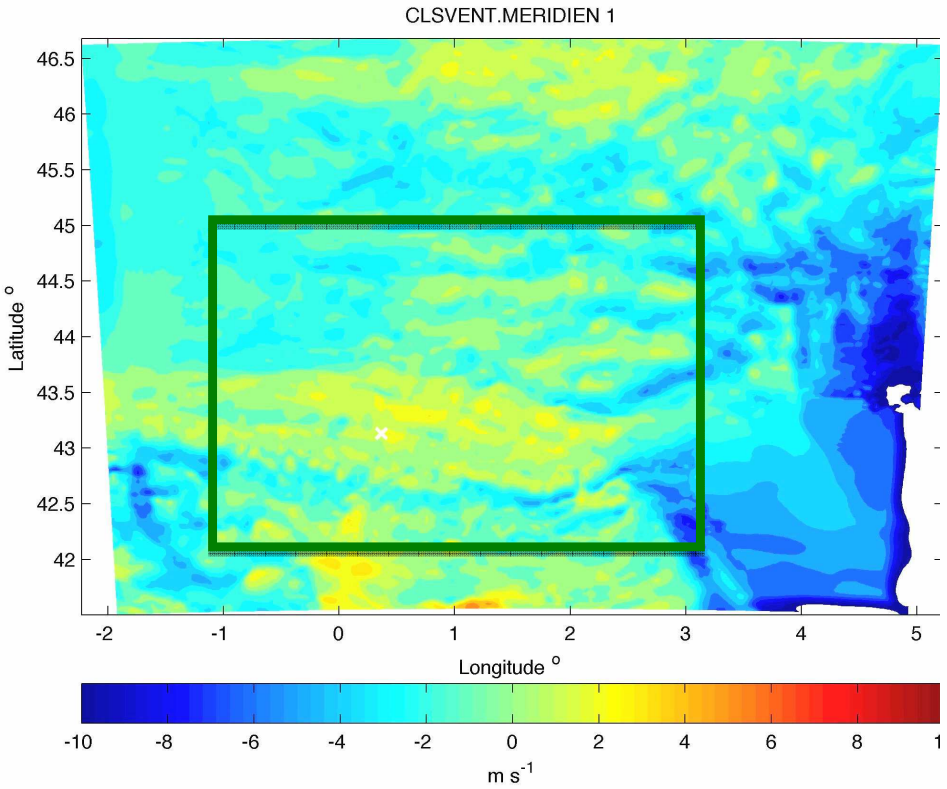
U: AROME vs WRF

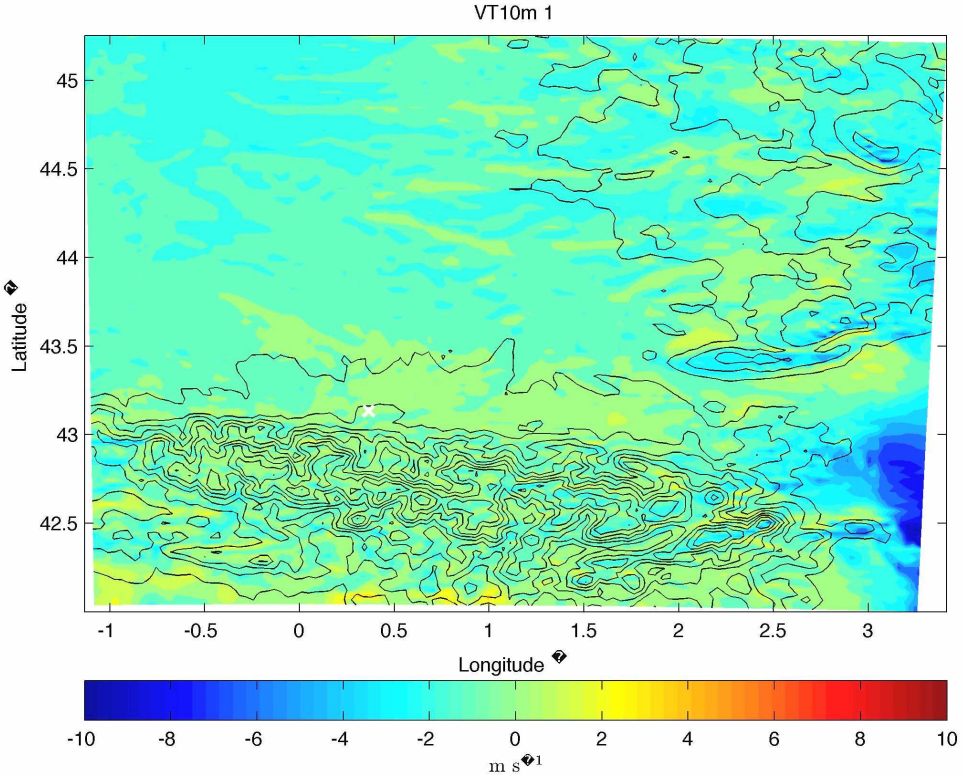




- WRF presents similar pattern to AROME

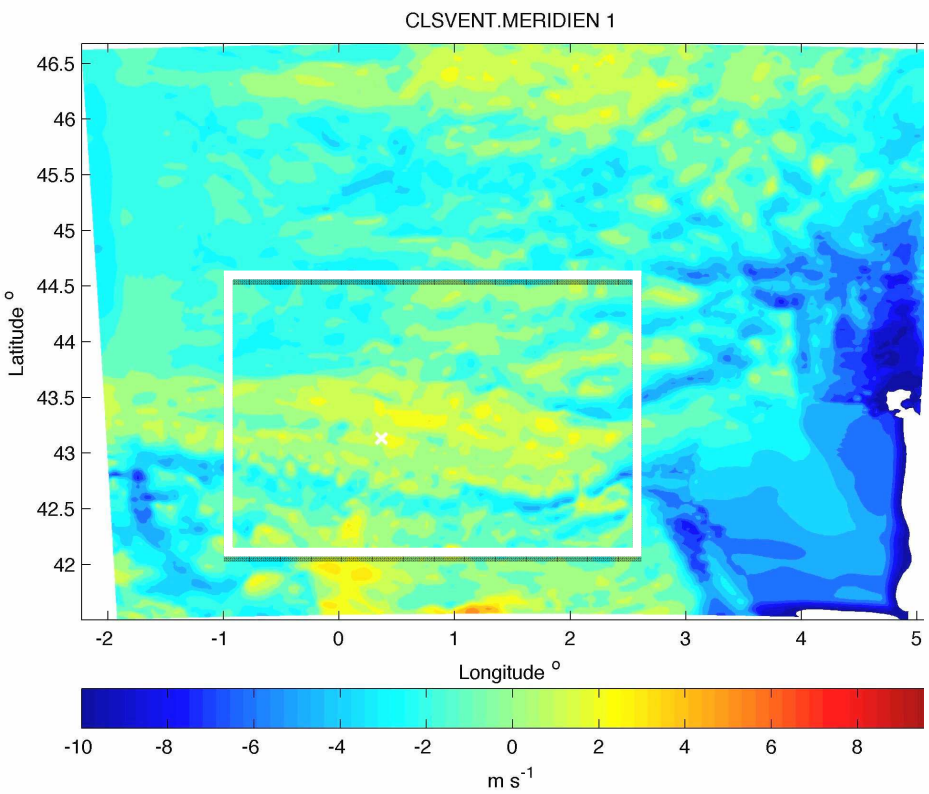
V: AROME vs MesoNH

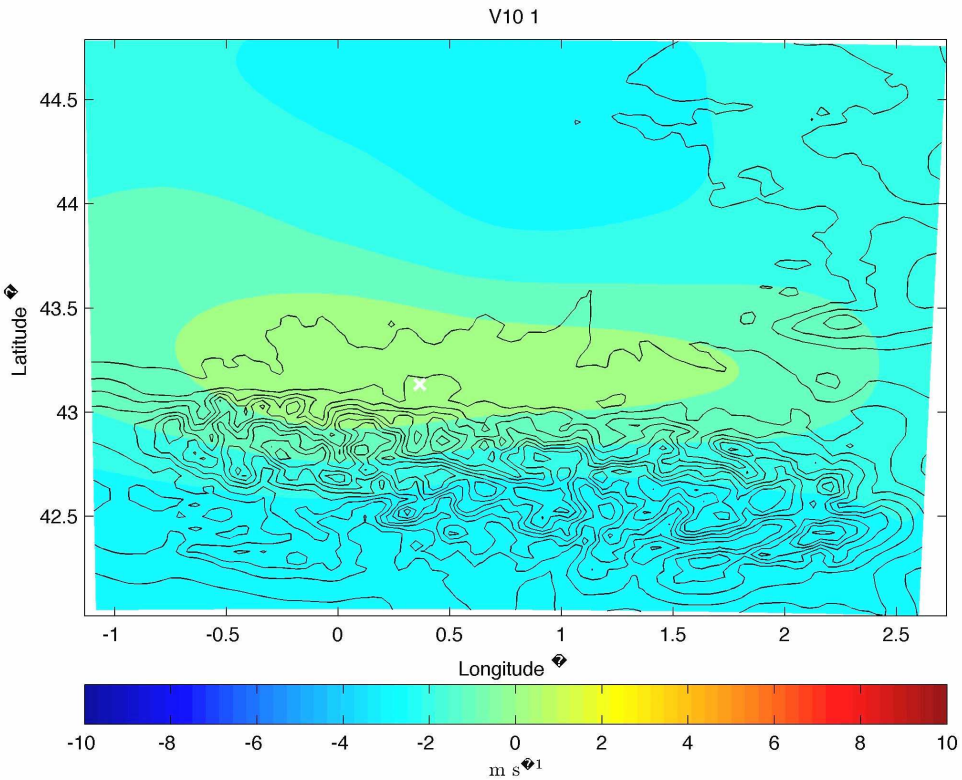




- V>0 during the afternoon at the Pyrenees (N), increasing during the evening. V<0 during late morning.
- Larger V>0 at the Pyrenees for AROME.
- MesoNH seems to smooth V contrast.

V: AROME vs WRF

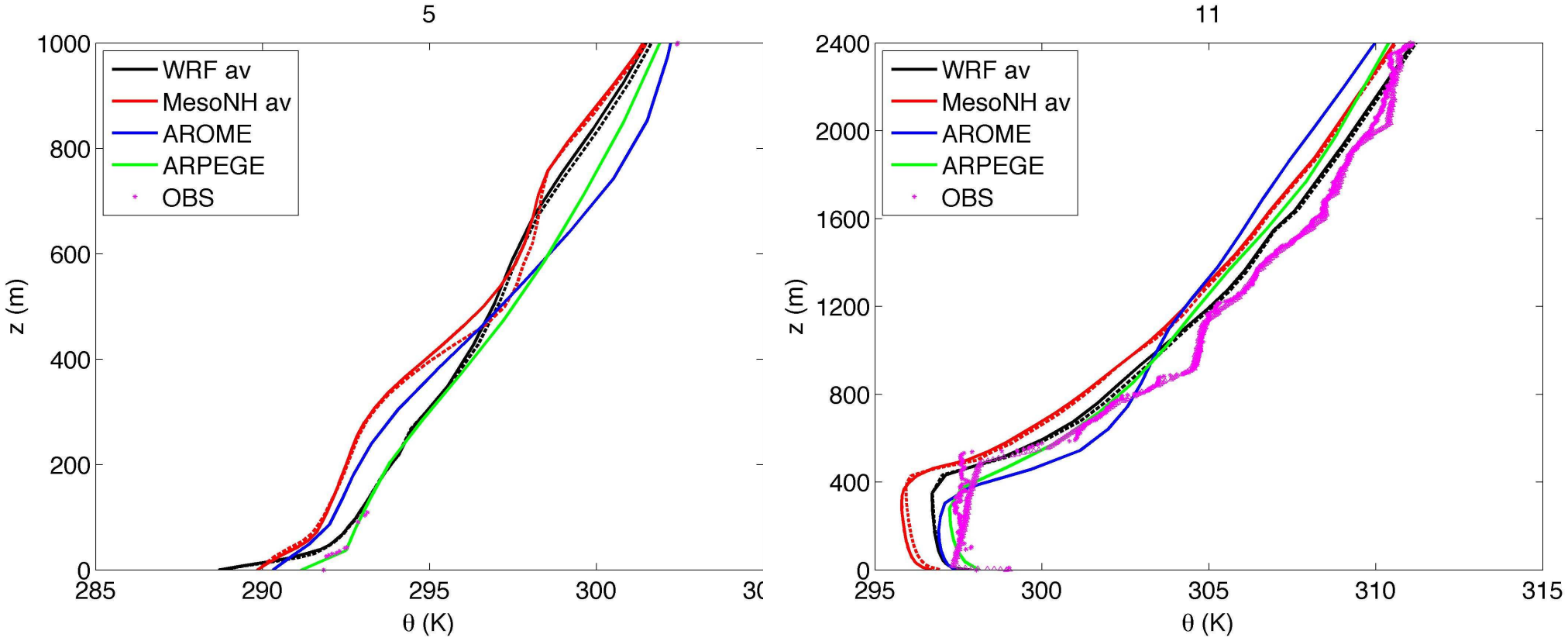




- WRF: V>0 (<0) at the southern (northern) Pyrenees during daytime.
- Larger V during the night for WRF

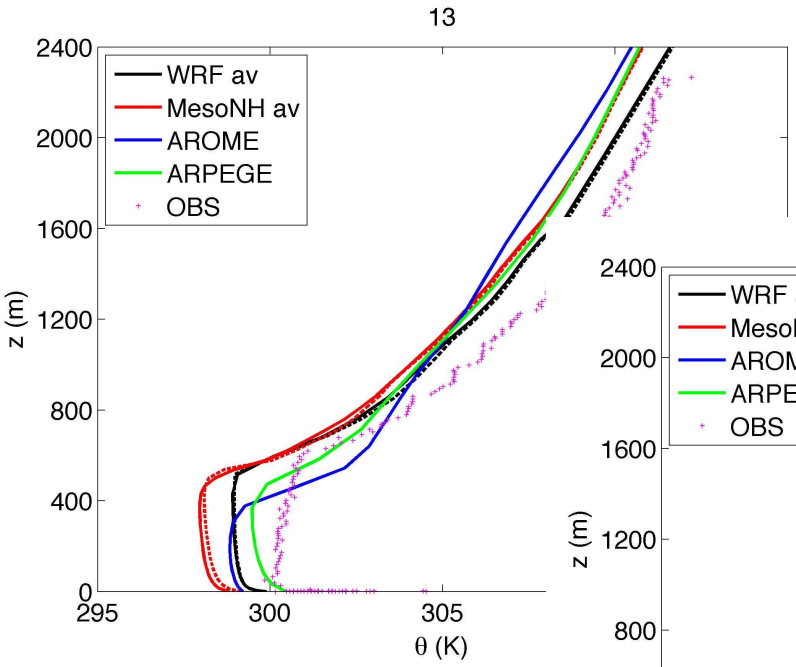
Vertical profiles at LA site. Pot. Temp. night-morning

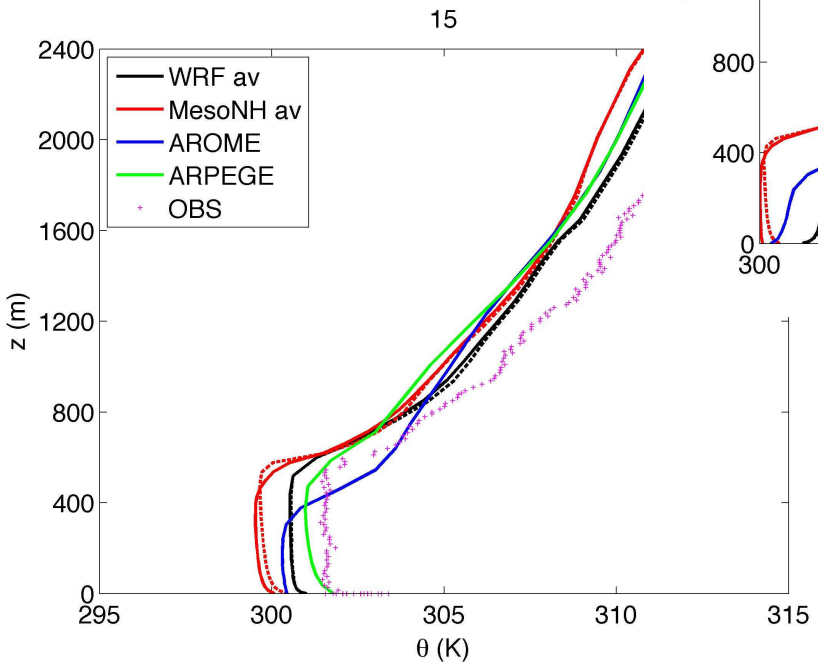
- 5: Only observations near the surface and from 1500 m.
- 11: Too cold BL (MesoNH). Related to surface fluxes.
- 11: Too shallow BL (AROME, ARPEGE).
- 11: Too cold free atmosphere.

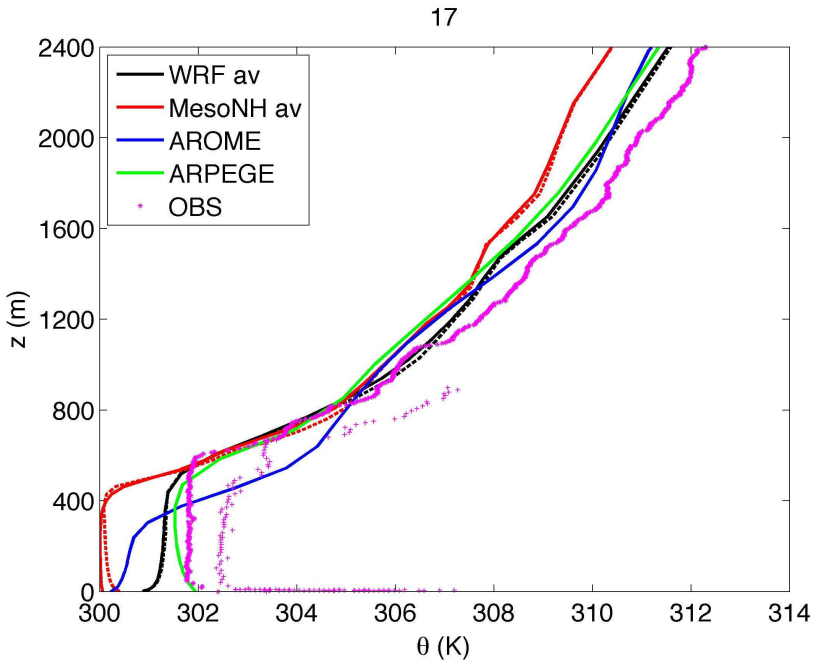


Pot temp afternoon

- 13: Too cold BL (MesoNH).
- 13: Too shallow BL (AROME, ARPEGE).
- 15-17: ARPEGE closer to OBS. Largest SH fluxes. Large BL for others
- 17: SBL already represented by AROME and WRF (SH too low).
- 17: Too shallow BL (AROME).
- Too cold free atmosphere.

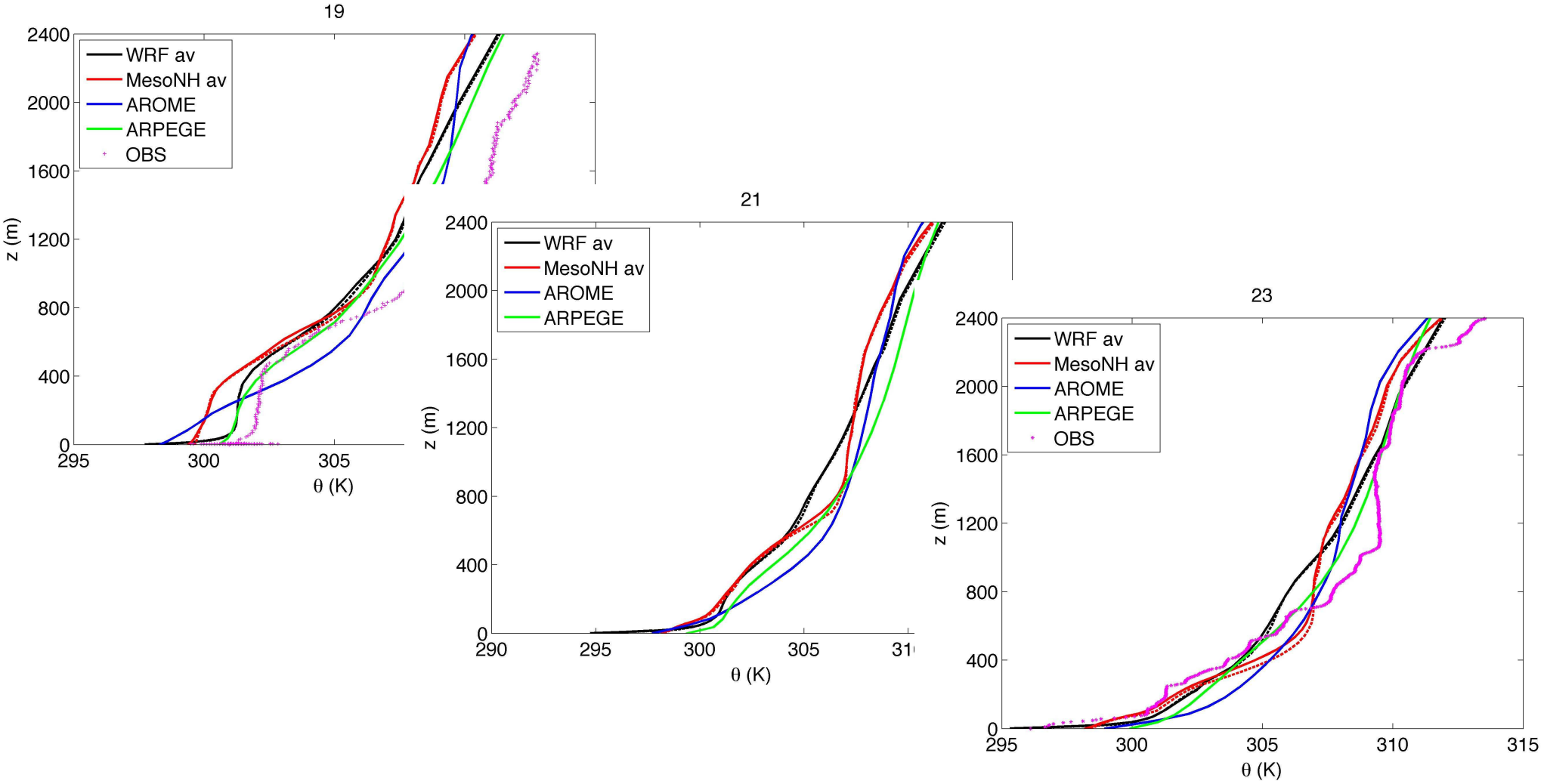






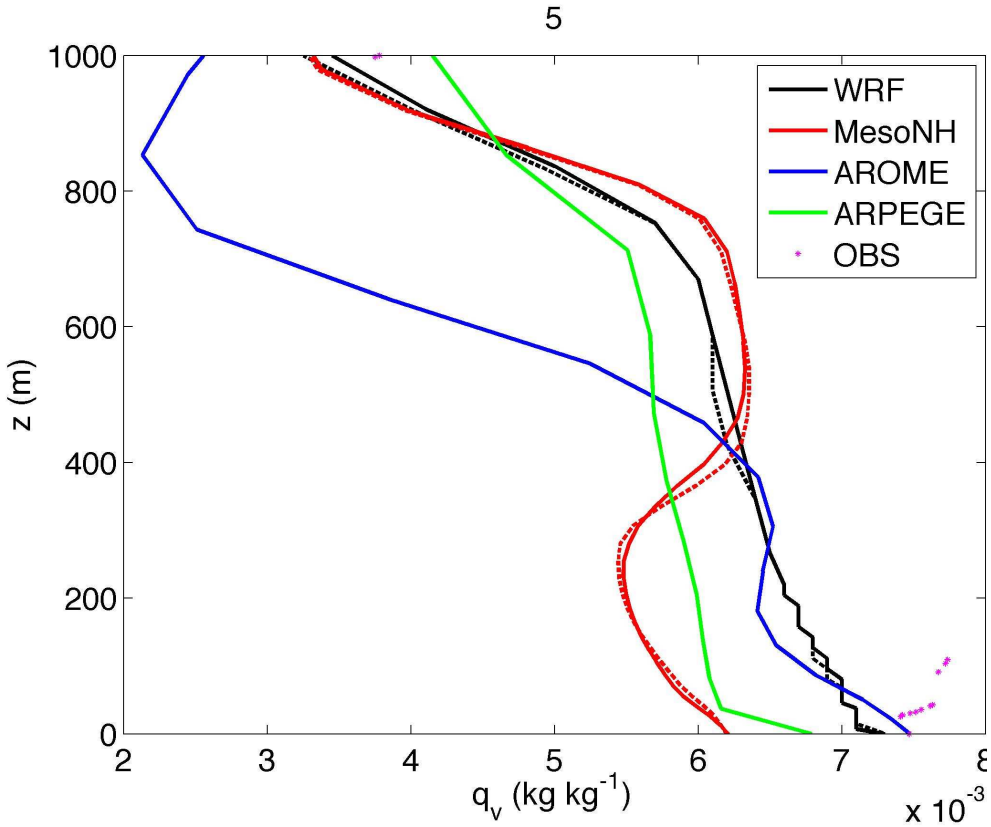
Pot temp evening-night

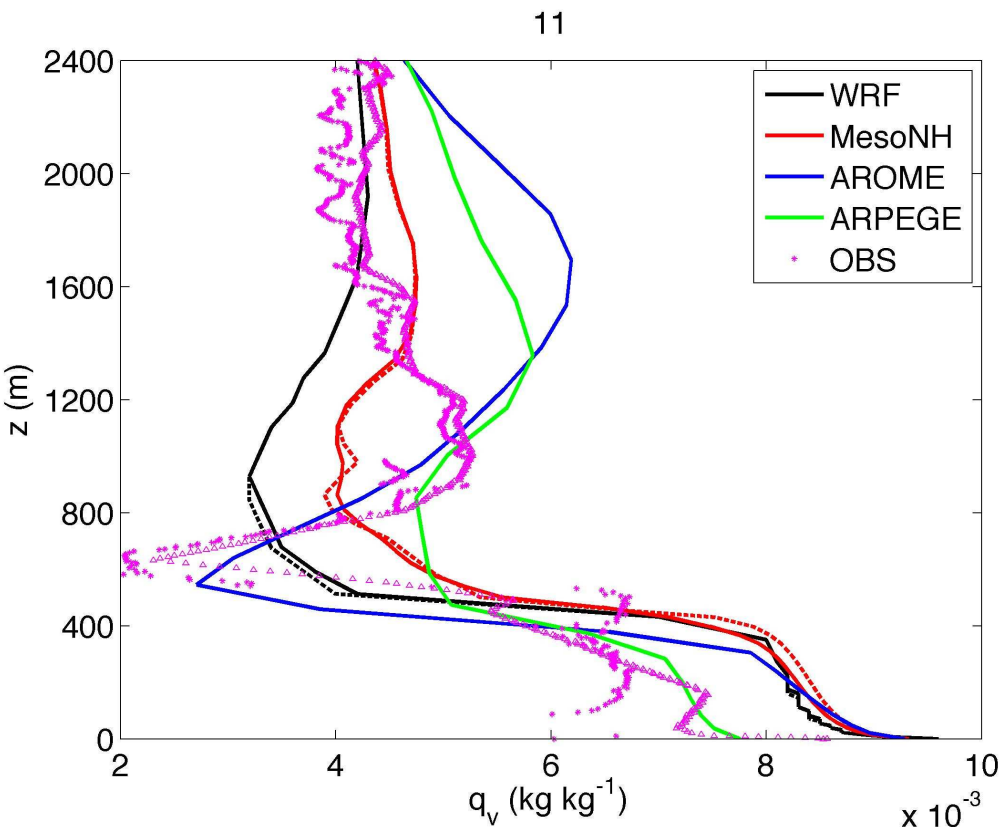
- 19: Not RL for AROME (SH too low). Clearly simulated by WRF
- 23: Too stable BL (AROME, ARPEGE, WRF). SH too low.
- 23: Too high theta near the surface. Correct representation of the FA.



Sp. humidity night-morning

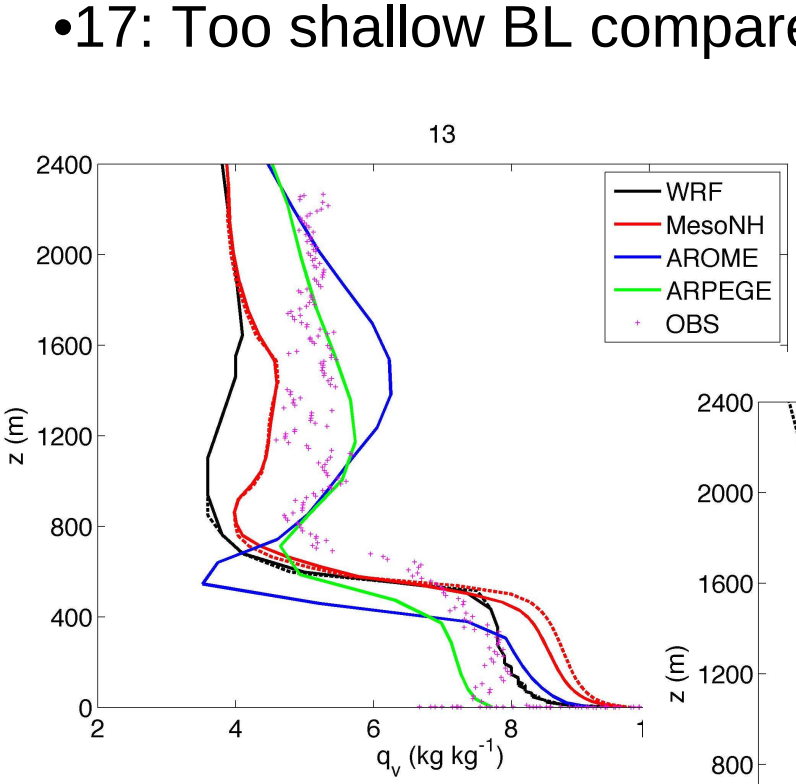
- 5: Observations near the surface and from 1500 m.
- 11: Simulations approximately follow the observed profile.
- 11: Too moist BL except ARPEGE. Largest LE.

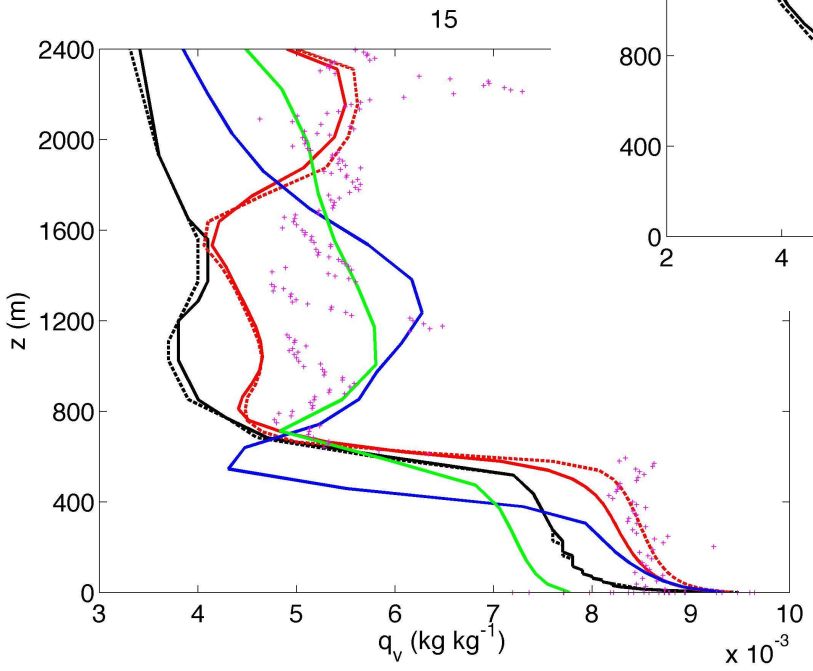


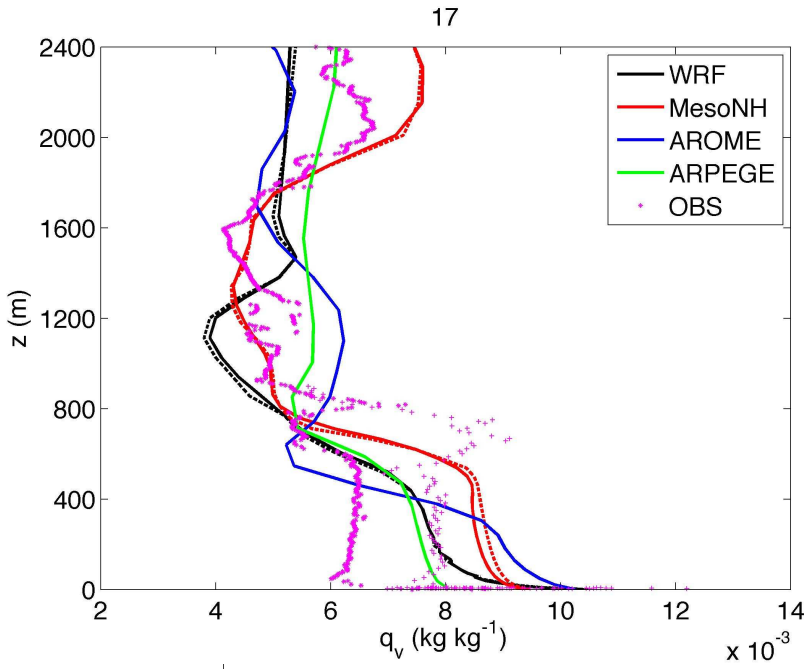


Sp. humidity afternoon

- 13: Too moist BL (MesoNH).
- 13-15: Simulations reproduce q decrease.
- 15: Too dry BL (ARPEGE, WRF). Smallest LE fluxes.
- 17: Dispersions in the OBS. SBL (AROME and WRF).
- 17: Too shallow BL compared with FR.

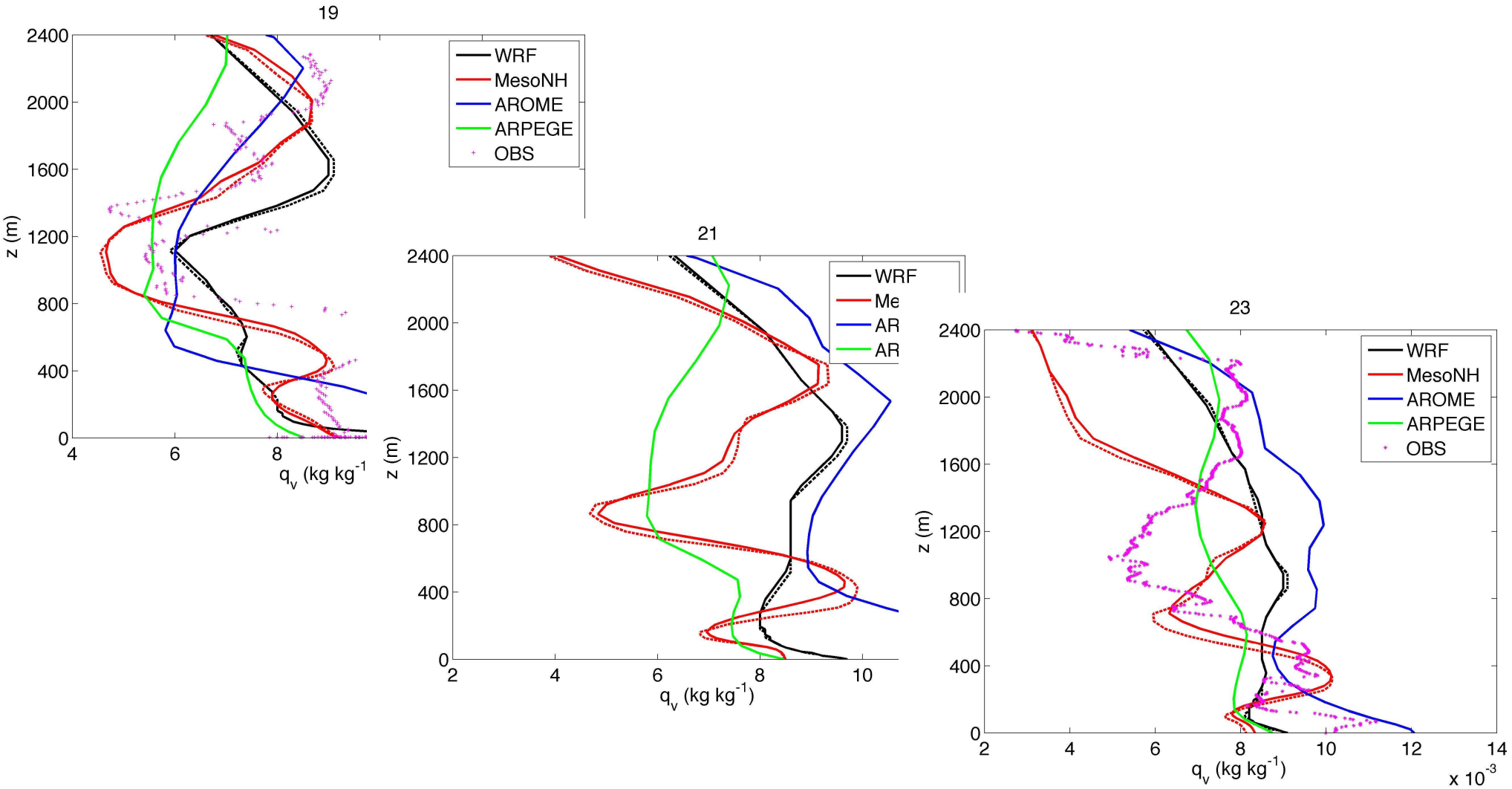






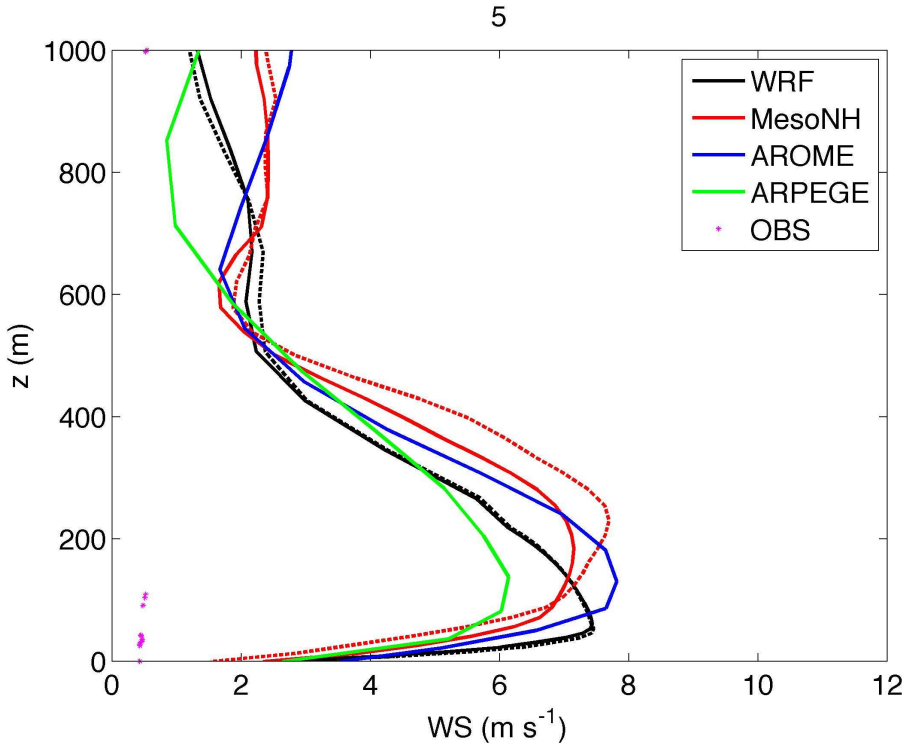
Sp. Humidity evening-night

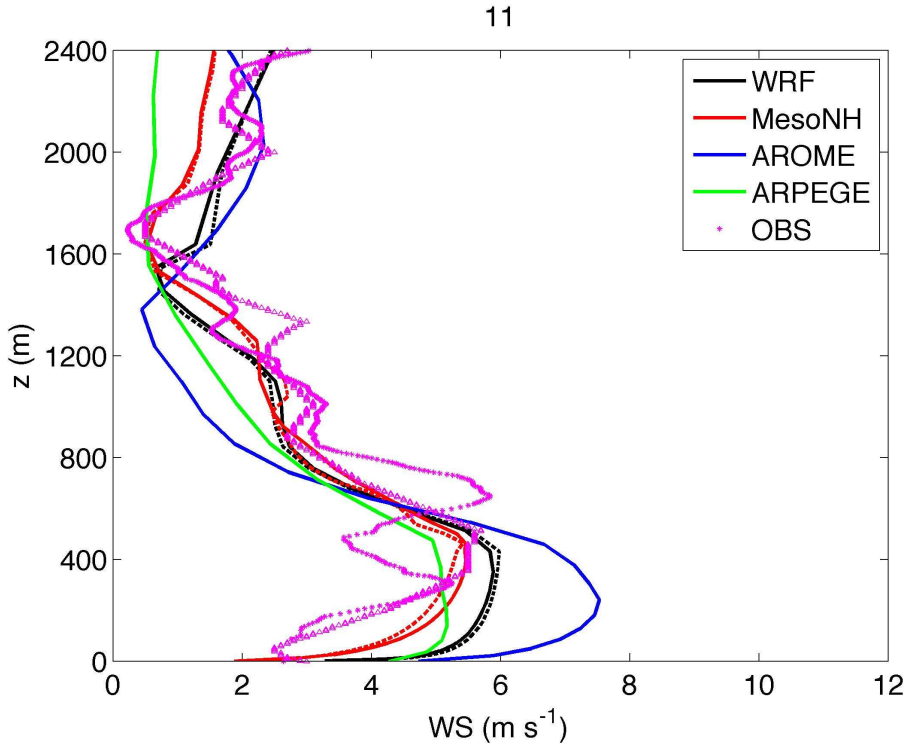
- 19: Only MesoNH reproduce q increase at zi.
- 23: WRF and ARPEGE don’t reproduce q variations with height.



WS night-morning

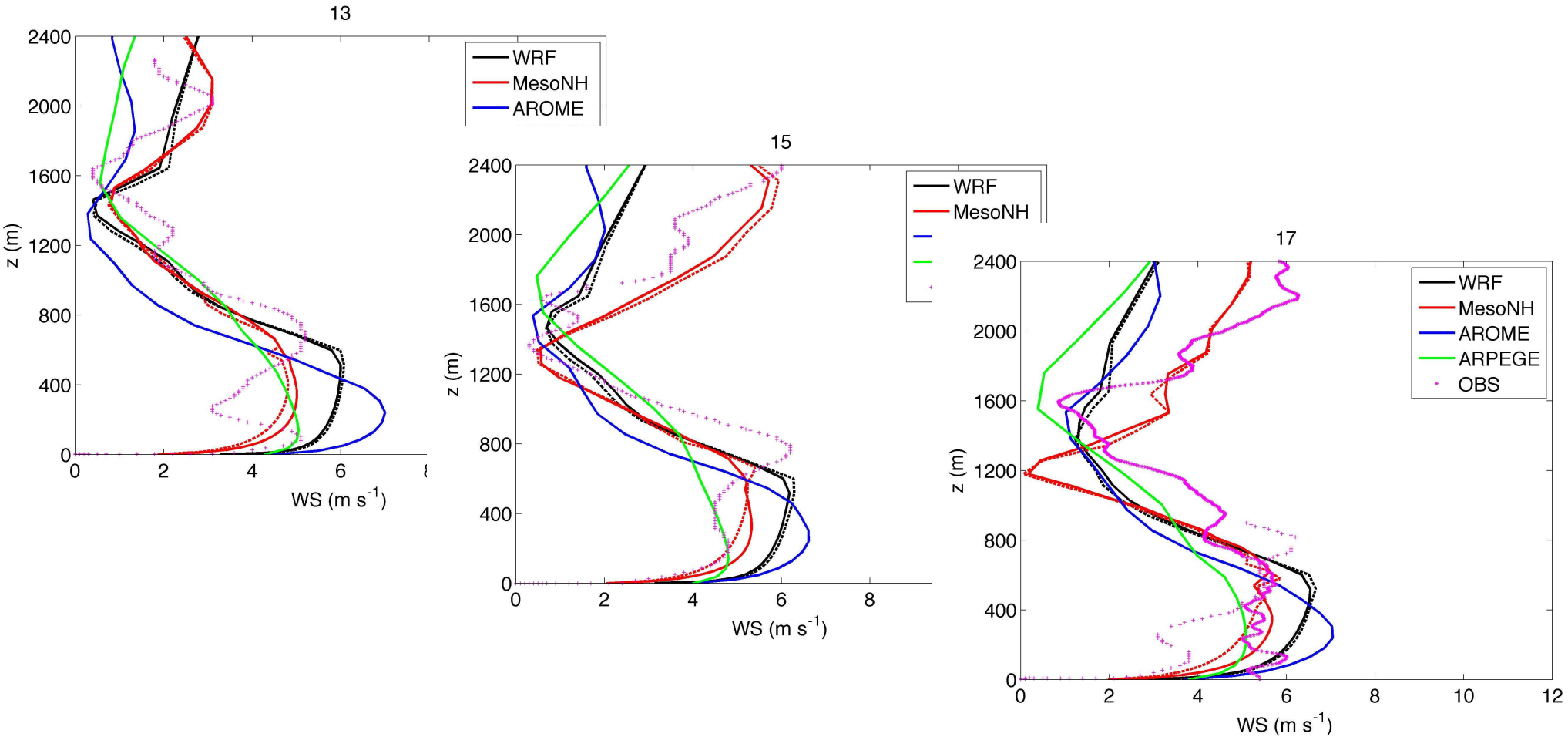
•5: Observations near the surface and from 1500 m. Higher SBL for MesoNH.
•11: The models are not able to reproduce the ws variations observed by CRA.
•11: AROME produces too large ws.





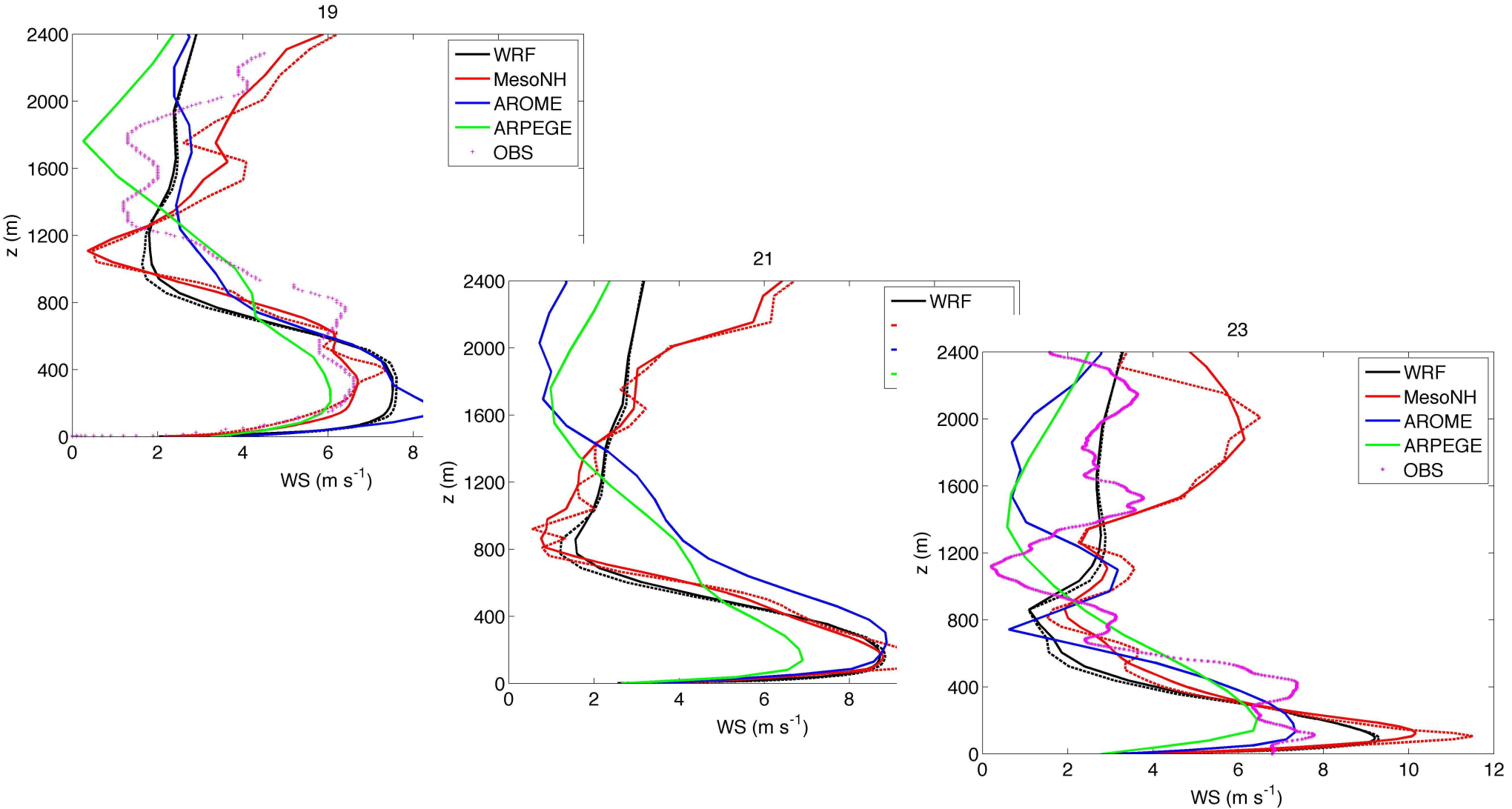
WS afternoon

- 13-15: FR shows change in ws not reproduced by the models near the surface. Upper ws is correctly reproduced.
- 15: models overestimate ws in the BL.
- 17: Observed well mixed profile not reproduced. LLJ simulated



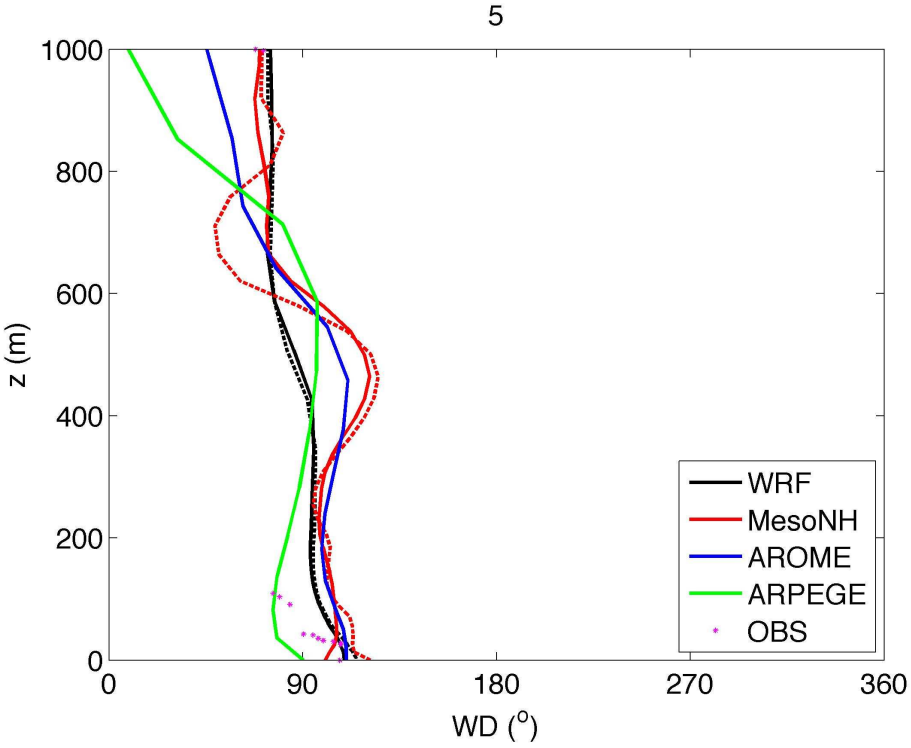
WS evening-night

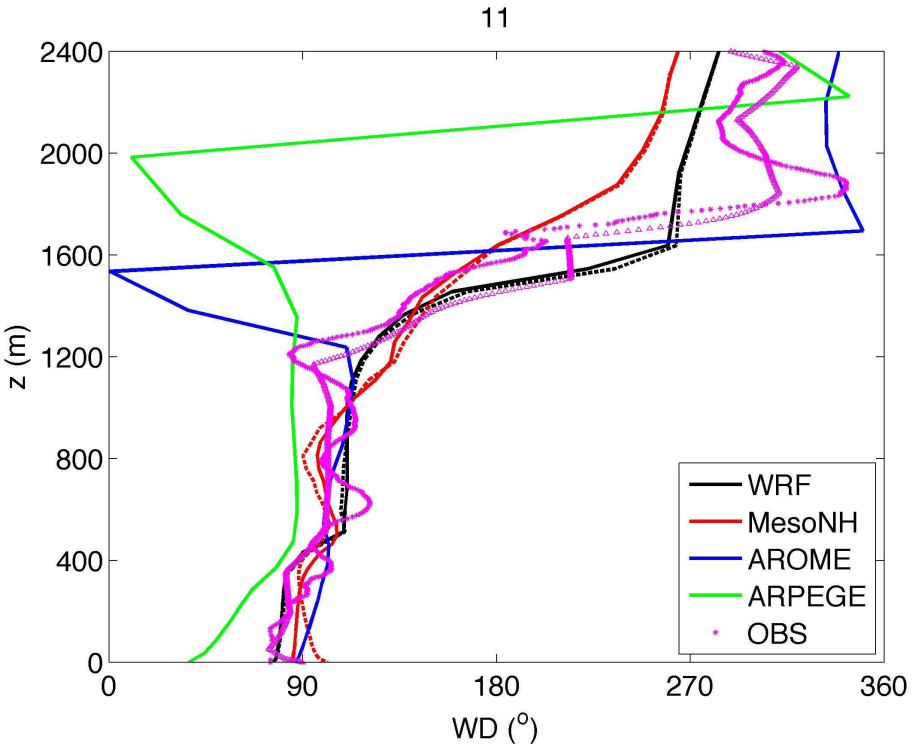
- 19: WRF and AROME overestimate ws.
- 23: Not clear LLJ observed. All the models simulate it.



WD night-morning

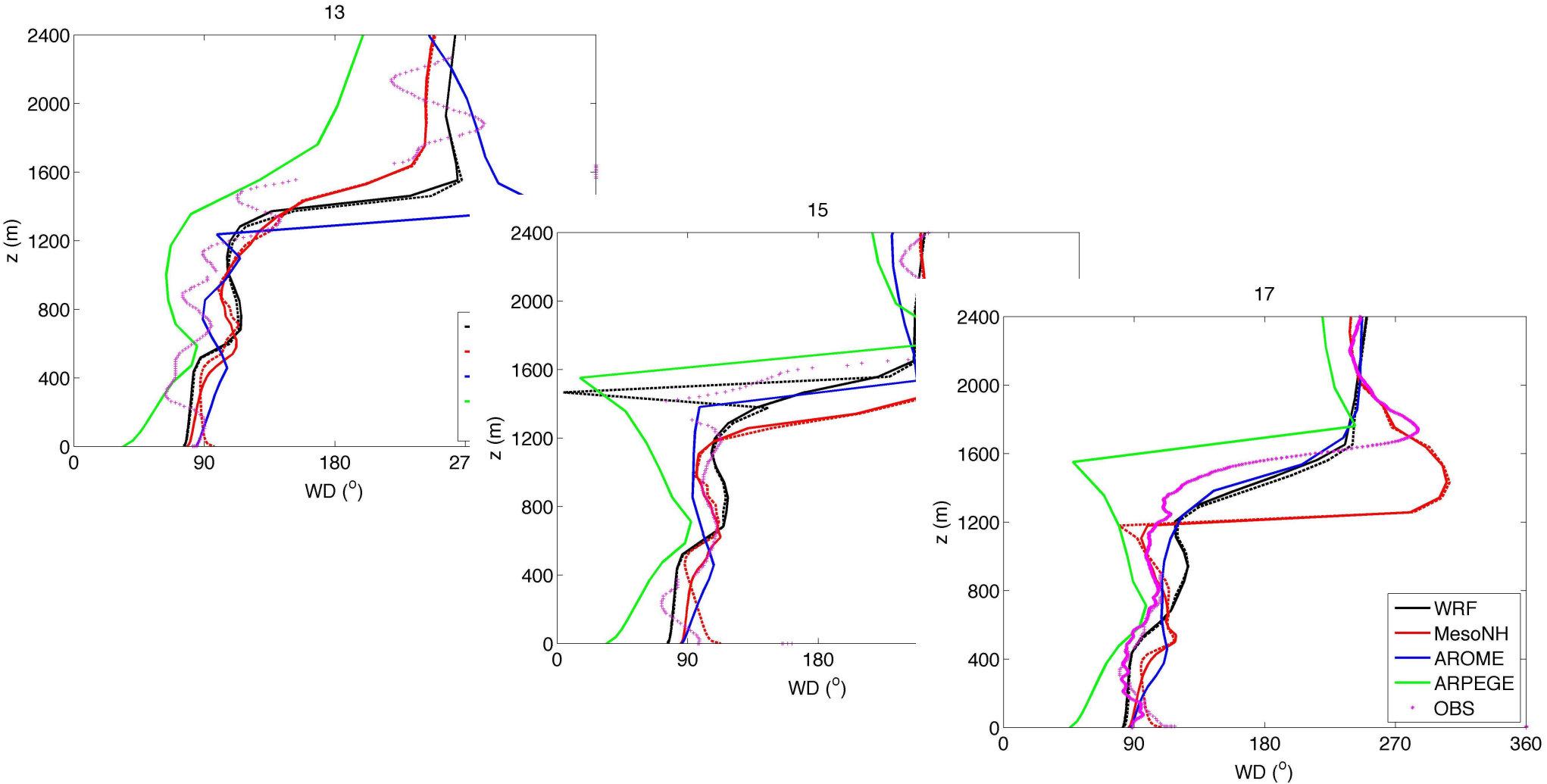
•5: Observations near the surface and from 1500 m.
•11: Besides ARPEGE the models reproduce BL wd and the shear observed around 1600 m.





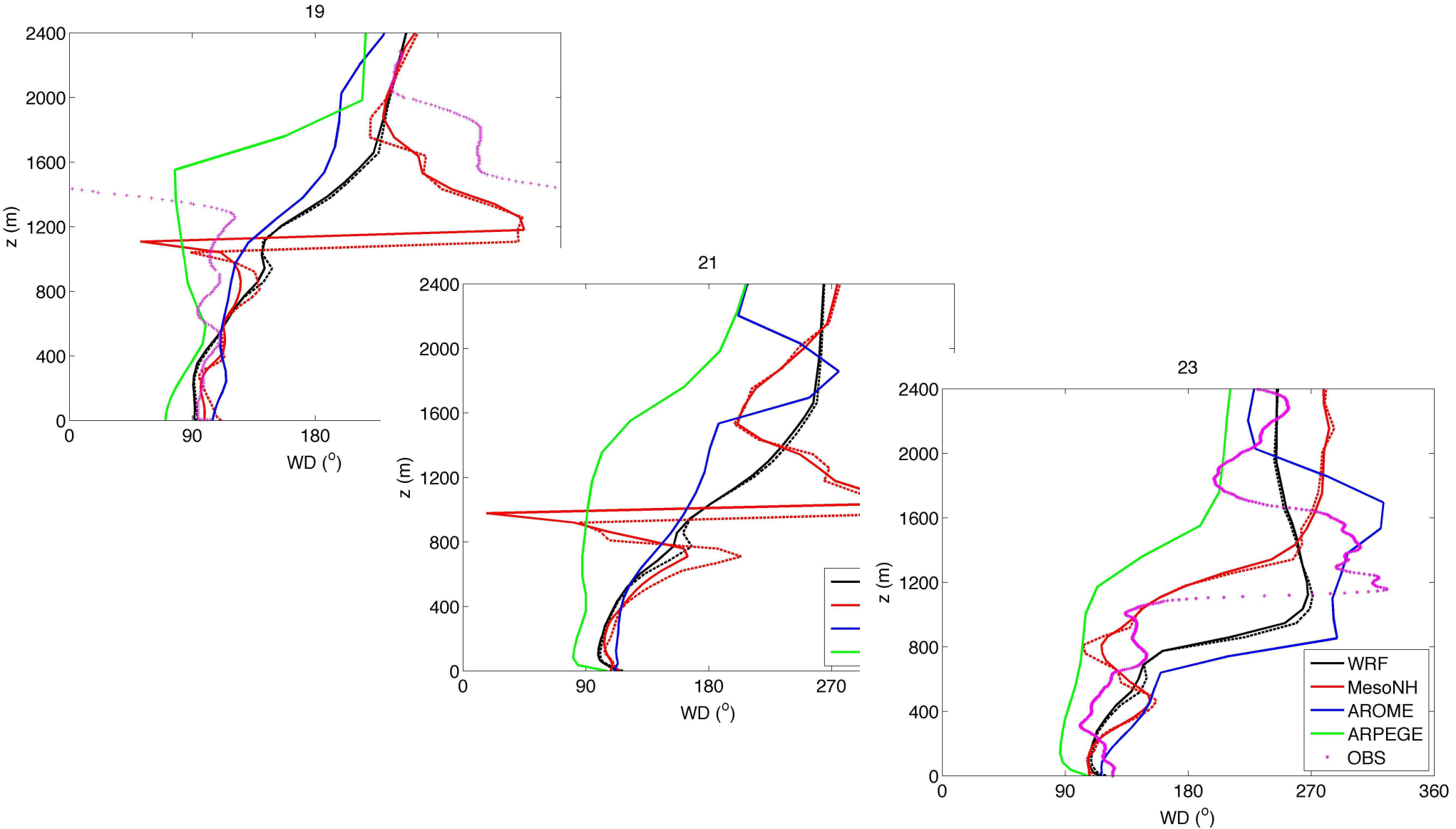
WD afternoon

- The wind shear persists during the afternoon.
- MesoNH (ARPEGE) placed at a lower (higher) height.



WD evening-night

- 19: Surface E, aloft W. The transition is smoothly for the models
- 23: Surface winds tend to veer to the south. W winds persist aloft.



Conclusions

- Despite the spread in the surface fluxes, models seem to reproduce better 25/06 than 01/07 (see Lothon's talk).

- There is a delay for SH>0 in some of the models.

- Smaller theta at the FA reduce entrainment fluxes producing colder BL.

- Variations of q are not well simulated by the models.
- Wind speed and direction is quite well simulated

- Is the previous night correctly simulated? Not a solution

Future work

- Is there any improve modifying the parameterizations? (see Sastre's talk).

- To use raw files to homogenize the plots (surface plots).

- Use statistics to compare the fields. Also include stations outside the campaign.

- Despite the spread in the surface fluxes, models seem to reproduce better 25/06 than 01/07 (see Lothon's talk).
- Is there any improve modifying the parameterizations? (see Sastre's talk).