Representation of the afternoon transition in Numerical Weather Prediction models: evaluation with BLLAST data

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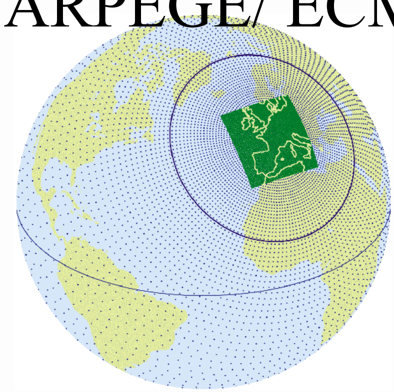
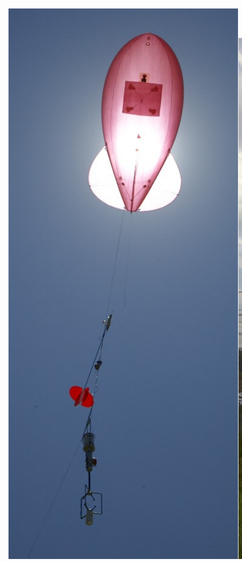
1. Motivations and Methodology
2. Reproduction of synoptic and diurnal variability
3. Reproduction of afternoon transition
4. Conclusions

AROME

ARPEGE/ ECMWF





turbulent probe on tethered balloon

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Motivations:

- Improve models = an often justification to deploy instruments in field campaign but not so often used *(ex: Atlaskin and Vihma, 2012)*
-BLLAST field campaign provided a large data set to evaluate finely the vertical structure of meteorological variables and turbulence
- Can we use the NWP models to derive advection for future studies: how good are they in representing the afternoon transition ?

The methodology:

- Extract the model outputs at several points around the location of deployment
-> for 3 models (AROME, ARPEGE, ECMWF)
- Compare the surface energetic budget and the thermodynamical vertical structure with observations **for IOP days**

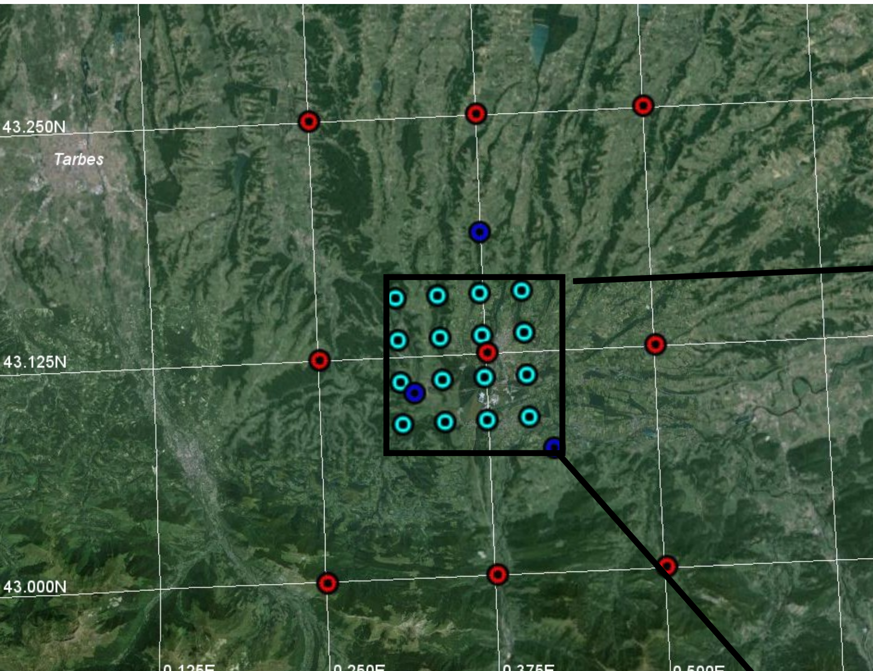
Methodology :

Models

9 pts -> ECMWF : 16 km

3 pts –> ARPEGE : 10km

16 pts-> AROME : 2.5km



Varying resolution and parametrization

Observations

RS: MODEM and Vaisala + SUMO

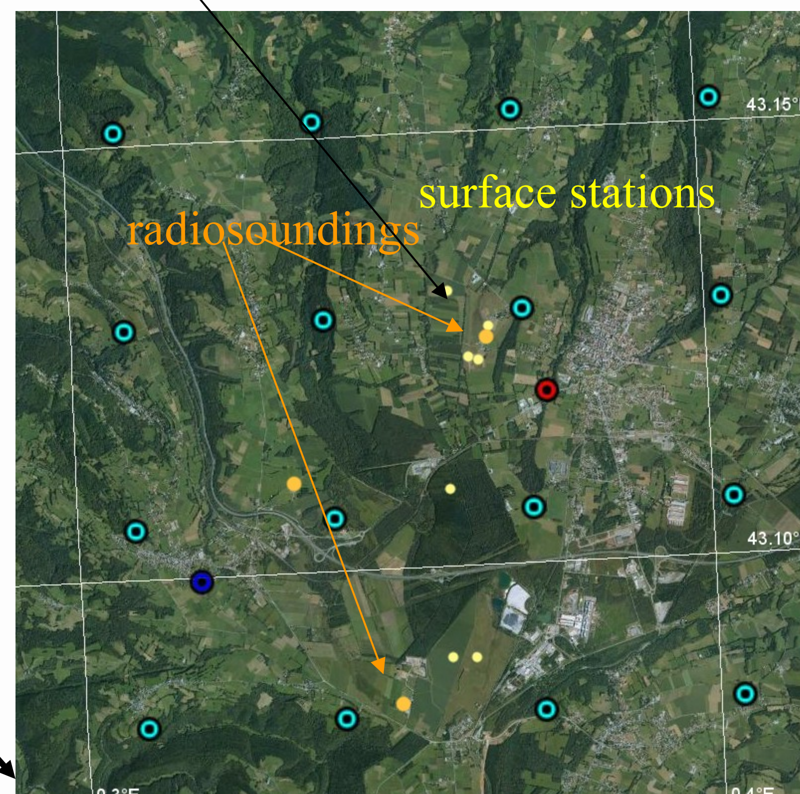
Surface sites: 7 types : surface fluxes, radiative fluxes, meteorological var

UHF: boundary layer height

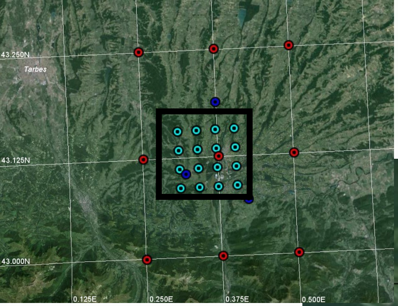
Aerosol lidar: boundary-layer height

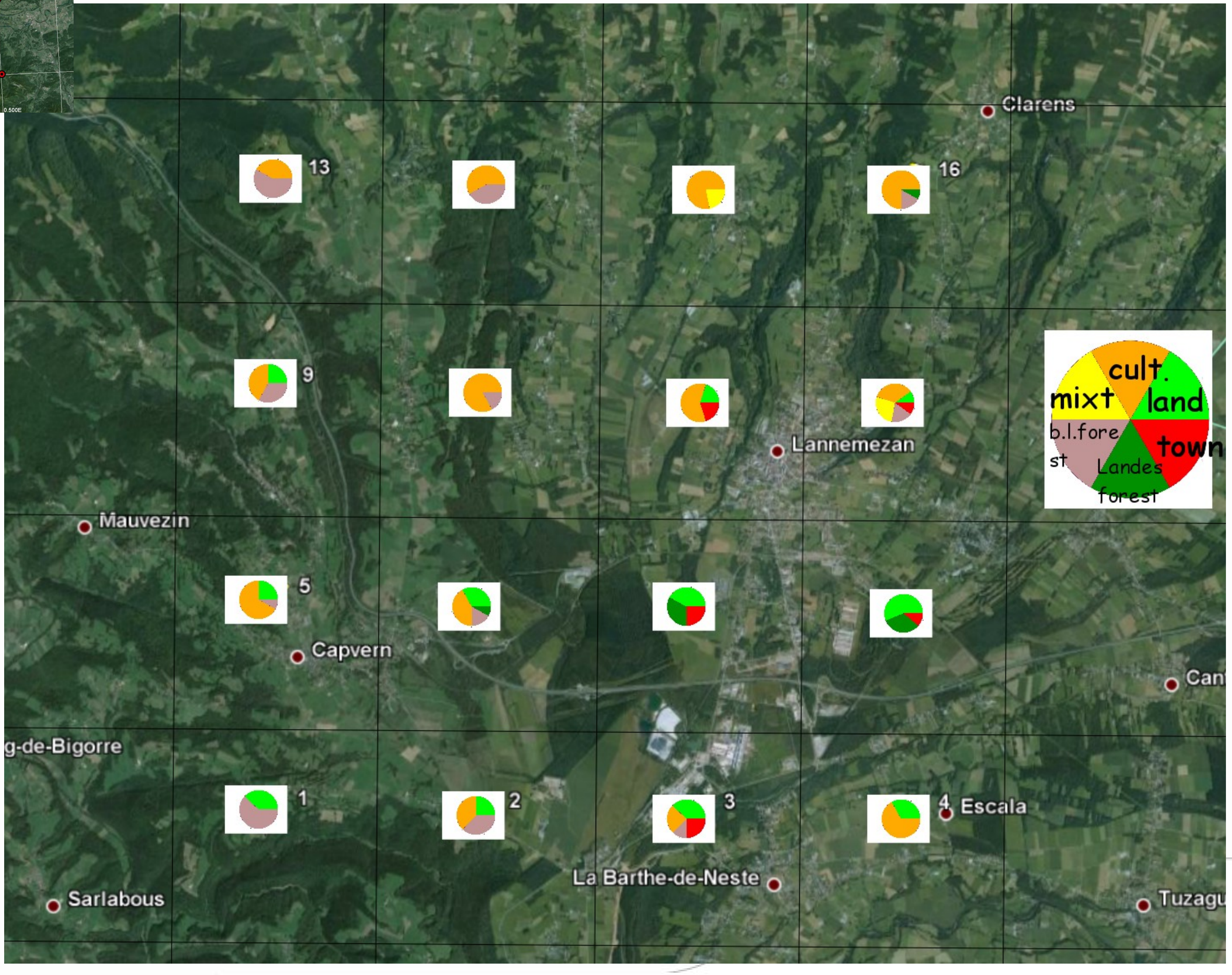
Lidar doppler: turbulent kinetic energy

Balloon turbulent probe: tke



Methodology :





Characteristics of each points :

Tables:

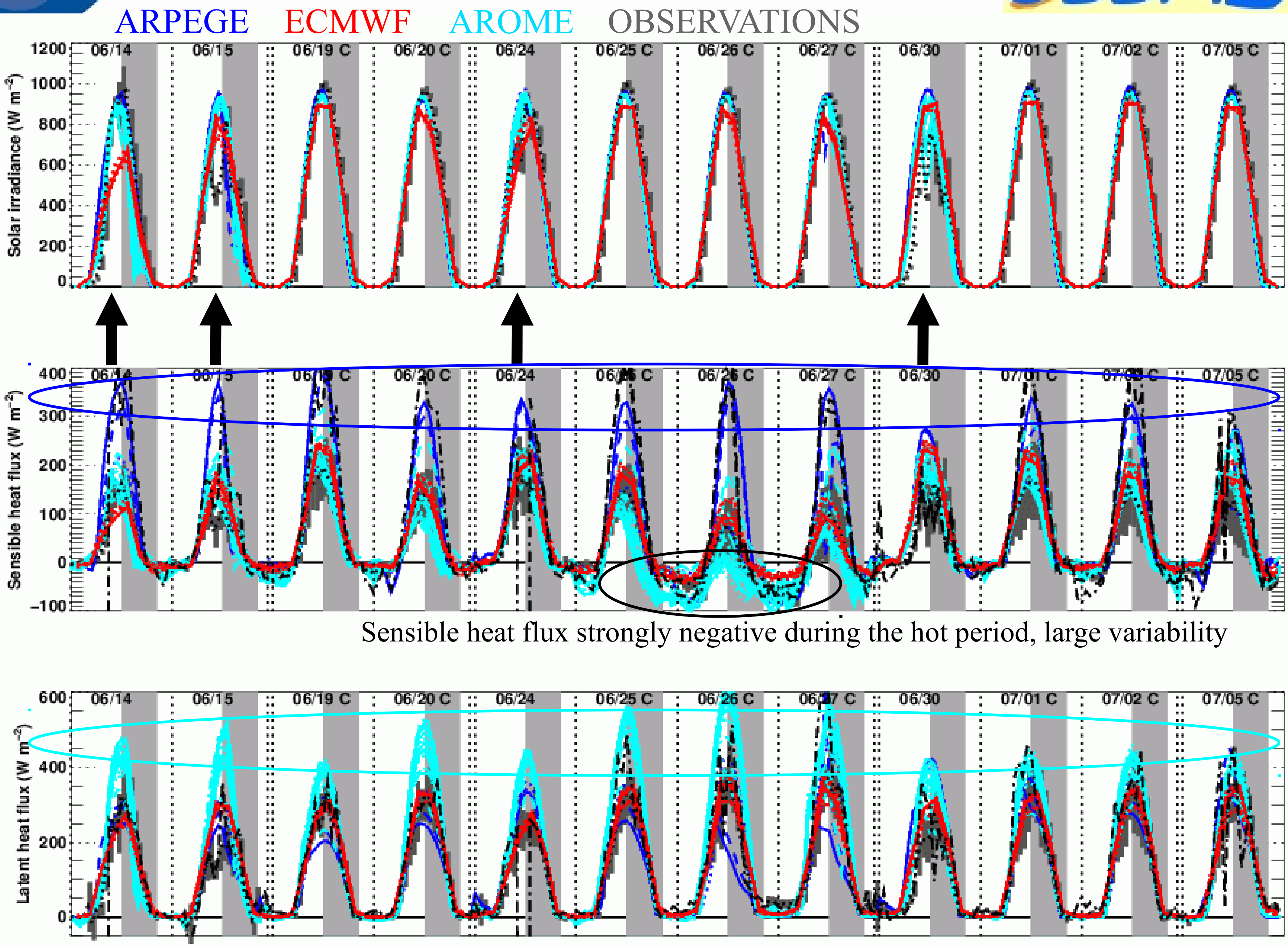
Name	ARO1	ARO2	ARO3	ARO4	ARO5	ARO6	ARO7	ARO8	ARO9	ARO10	ARO11	ARO12	ARO13	ARO14	ARO15	ARO16
alt	535	611	595	558	552	605	609	593	532	567	579	575	505	521	529	527
veg	0.95	0.93	0.92	0.92	0.92	0.93	0.85	0.94	0.93	0.91	0.91	0.91	0.93	0.92	0.88	0.90
LAI	3.4	3.5	3.2	3.4	3.5	3.4	3.3	3.2	3.5	3.7	3.3	3.5	3.8	3.7	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
albedo	0.177	0.185	0.191	0.198	0.195	0.186	0.159	0.169	0.186	0.189	0.195	0.185	0.175	0.180	0.192	0.188

Name	ARP1	ARP2	ARP3	ECM1	ECM2	ECMWF3	ECMWF4	ECMWF5	ECMWF6	ECMWF7	ECMWF8	ECMWF9				
alt	701	477	778	1068	894	772	510	491	463	282	314	325				
veg	0.86	0.84	0.85	19/1-0.56	19/1-0.86	19/1-0.9	19/1-0.92	19/0-1	19/1-1	19/1-1	19/0-1	19/0-1				
LAI	3.67	3.18	3.58													
zo	1.8	0.17	1.93	6.2	5.1	4.8	0.65	0.62	0.88	0.65	0.62	0.62				
albedo	0.12	0.2	0.12	0.149	0.149	0.149	0.15	0.15	0.15	0.15	0.15	0.15				

Albedo in observations :

- Edge site : alb_wheat=0.15 ; alb_grass=0.24
- Corn site : ~0.14 [0.07,0.165]
- Moor site : ~0.2 [0.18,0.22]

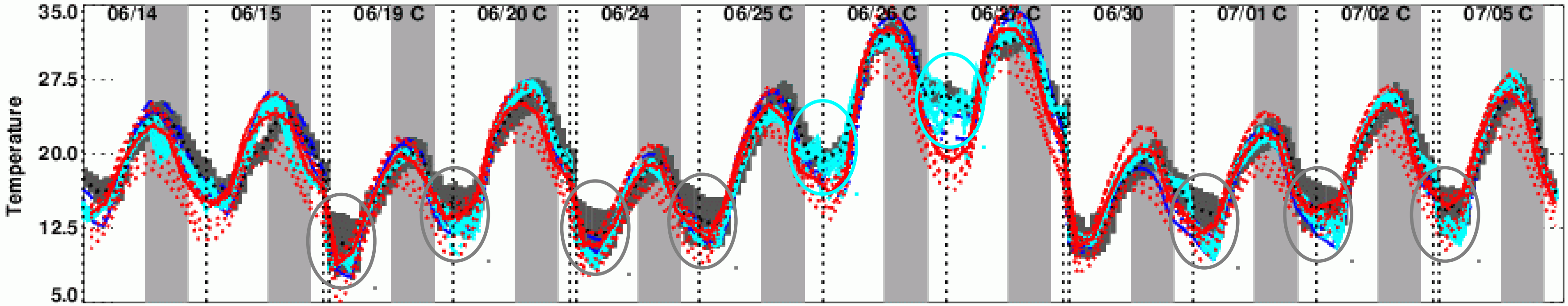
Radiative and turbulent fluxes: all IOPs



Sensible heat flux strongly negative during the hot period, large variability

Meteorological variables: all IOPs

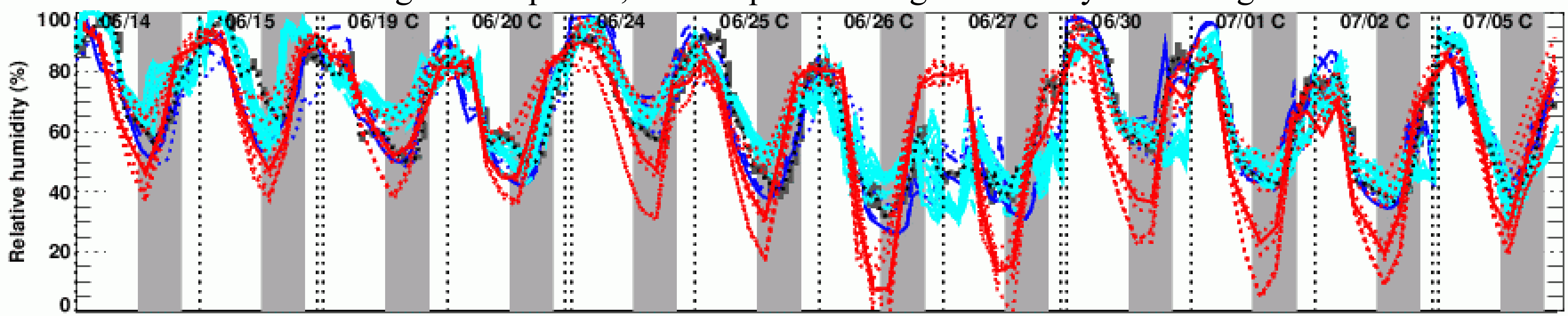
ARPEGE ECMWF AROME OBSERVATIONS



ECMWF : often too cold at night during the hot period

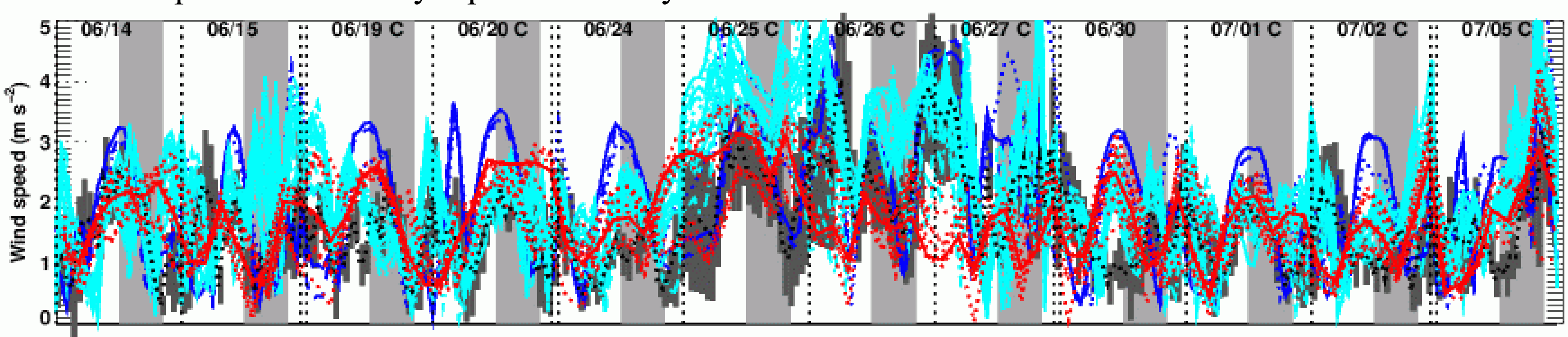
Good synoptic variability

During the hot period, models produce large variability of T at night not in observations

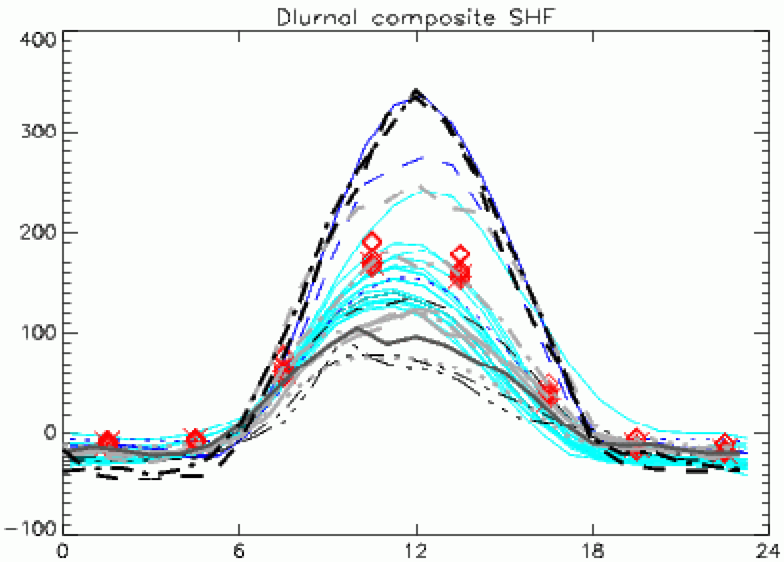


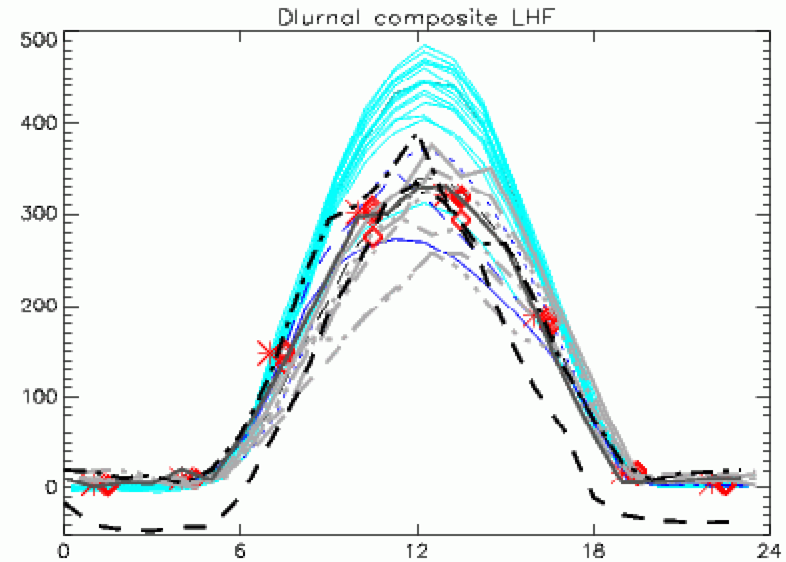
ECMWF : often too dry at day

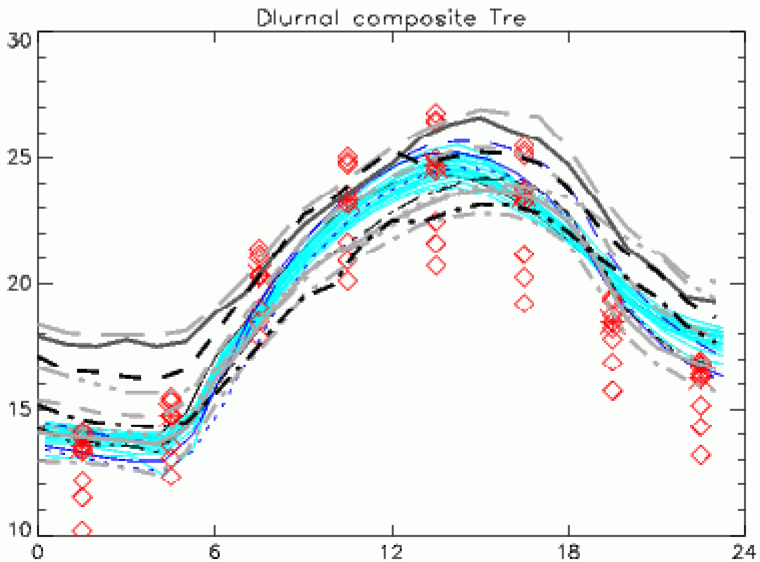
Better representation of synoptic variability of the wind in AROME



Diurnal cycle composite:



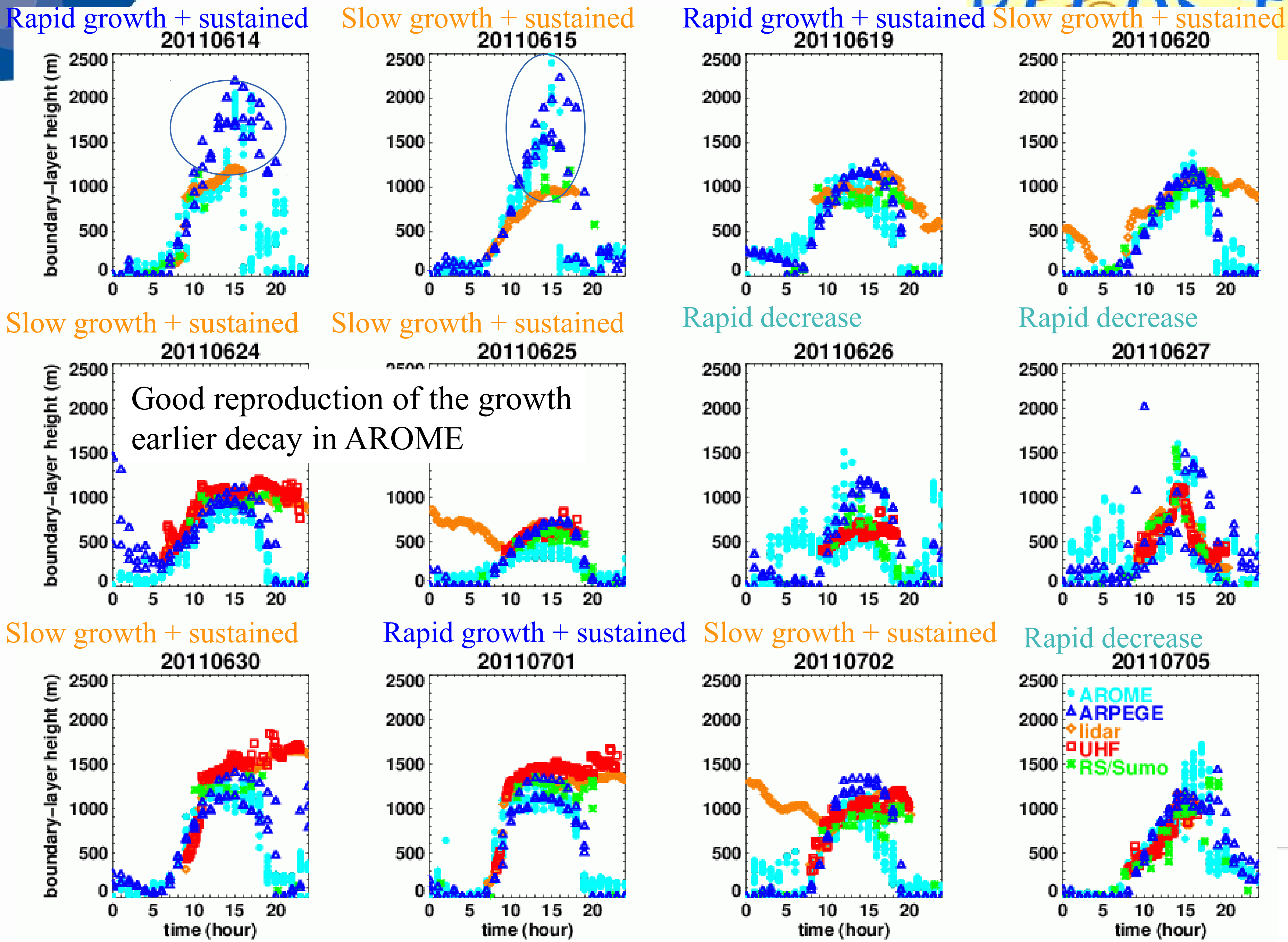




ARPEGE AROME
ECMWF OBSERVATIONS

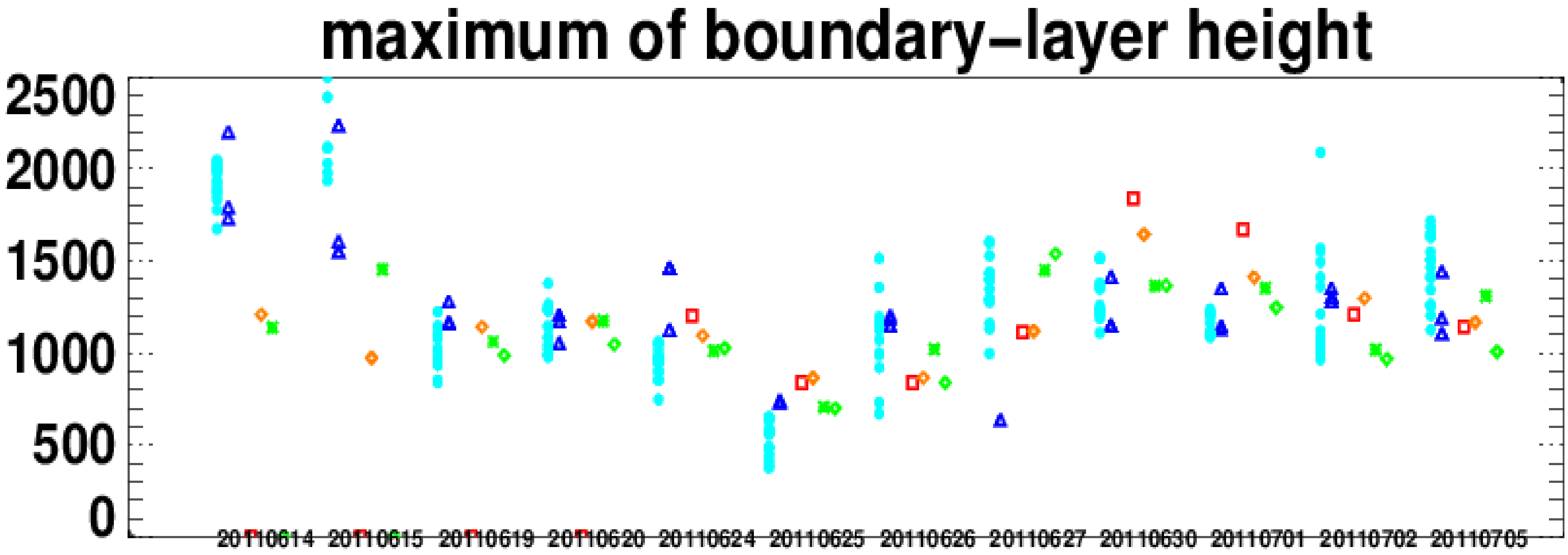
No direct link betwen H & T or LE & T

Boundary-layer heights: all IOPs



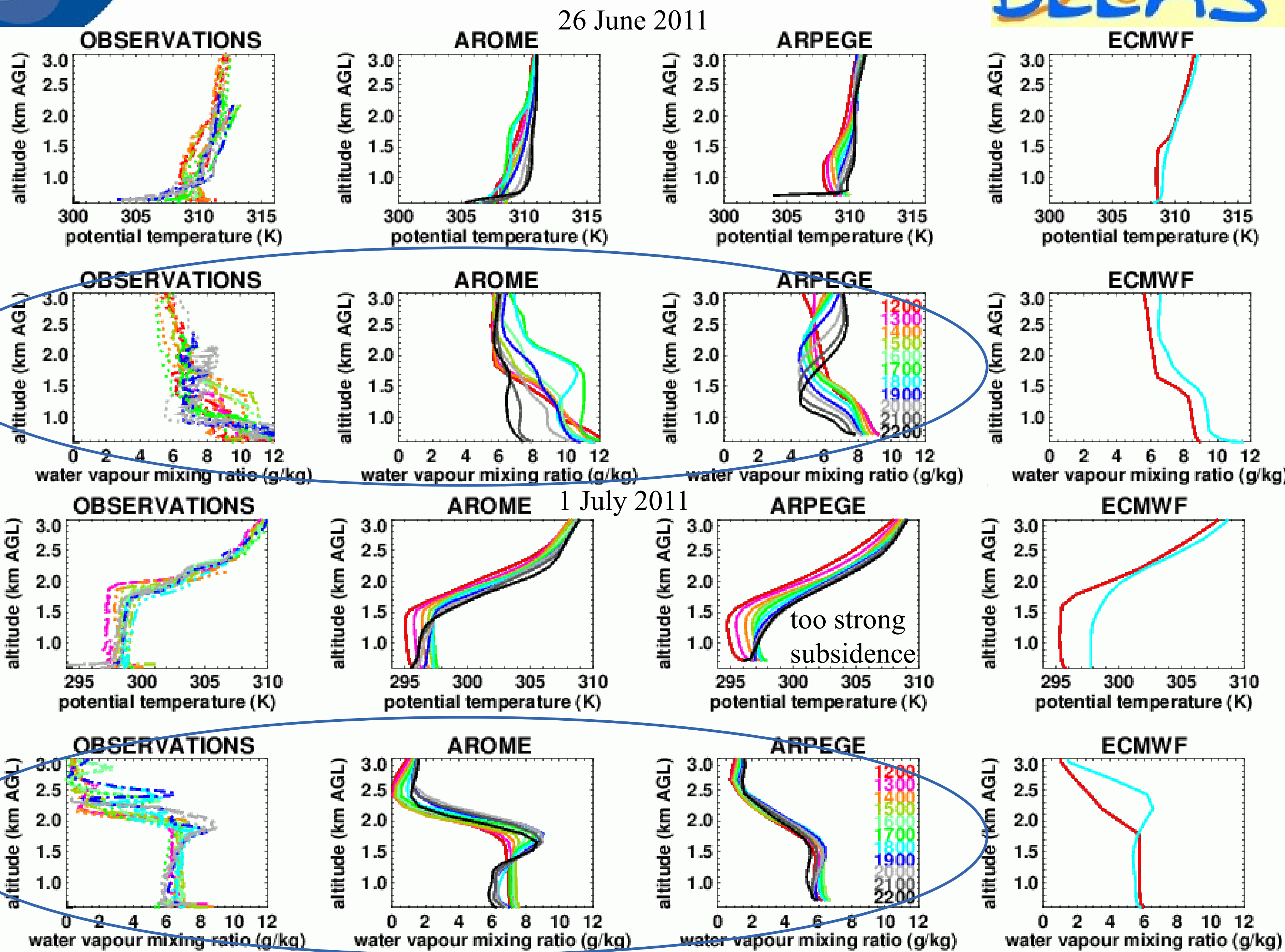
Good reproduction of the growth
earlier decay in AROME

Boundary-layer heights: all IOPs



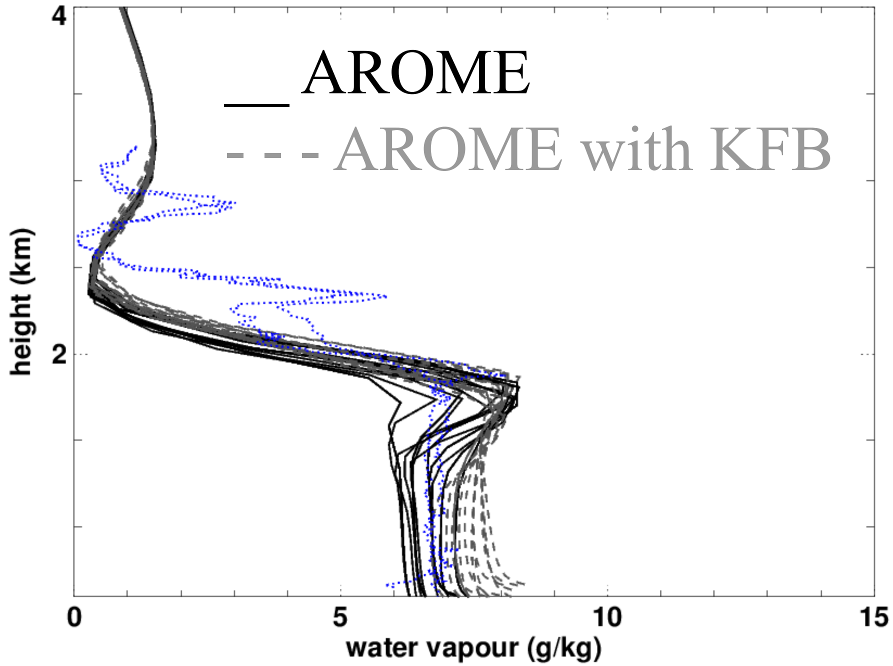
Synoptic variability well reproduced by models

Evolution of vertical structures: 2 cases

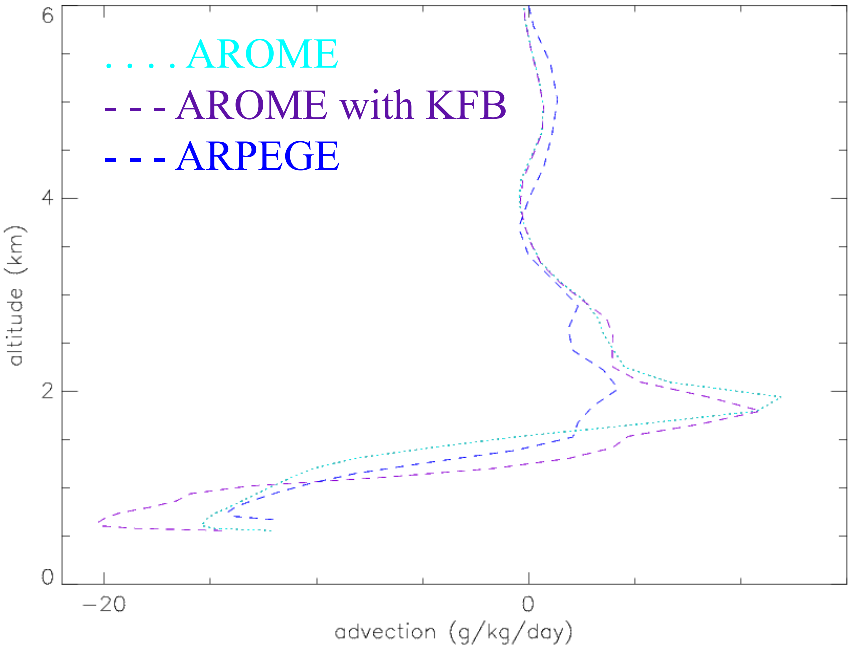


Impact of boundary-layer scheme

01/07/2011 at 1600



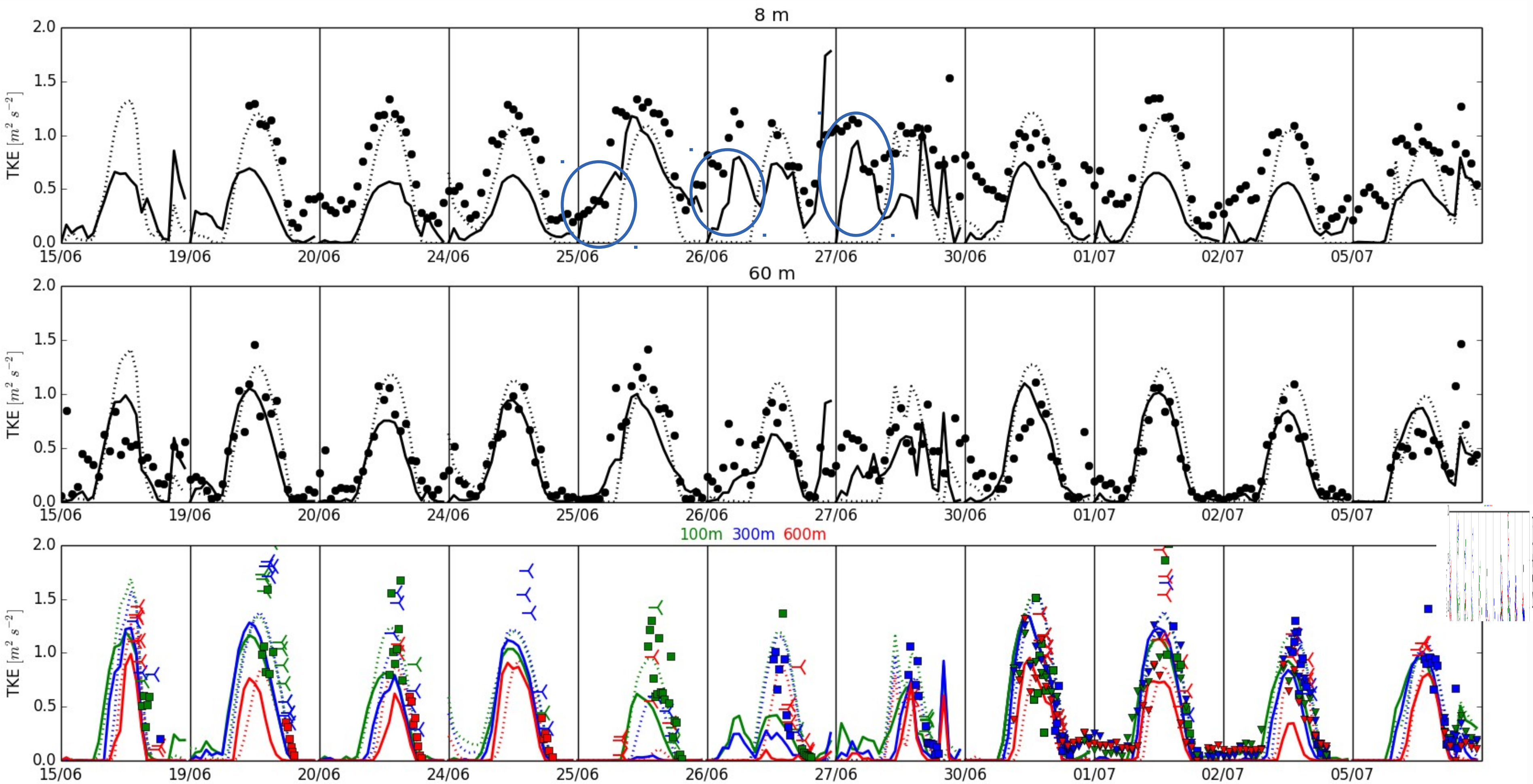
Mean advection from 1200 to 1800



Impact of parameterization remotely and then advected over the area

Similar behaviour btw ARPEGE and AROME/KFB

Turbulence kinetic energy: all IOPs



- AROME underestimates the value close to the surface but does predict some tke in the morning
- AROME & ARPEGE predict the right order of magnitude of tke in the boundary layer

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Reproduction of synoptic and diurnal variability : summary

• Models represent the main ingredients of the synoptic variability : clear / cloudy days, hot period, high/low BLH, ...

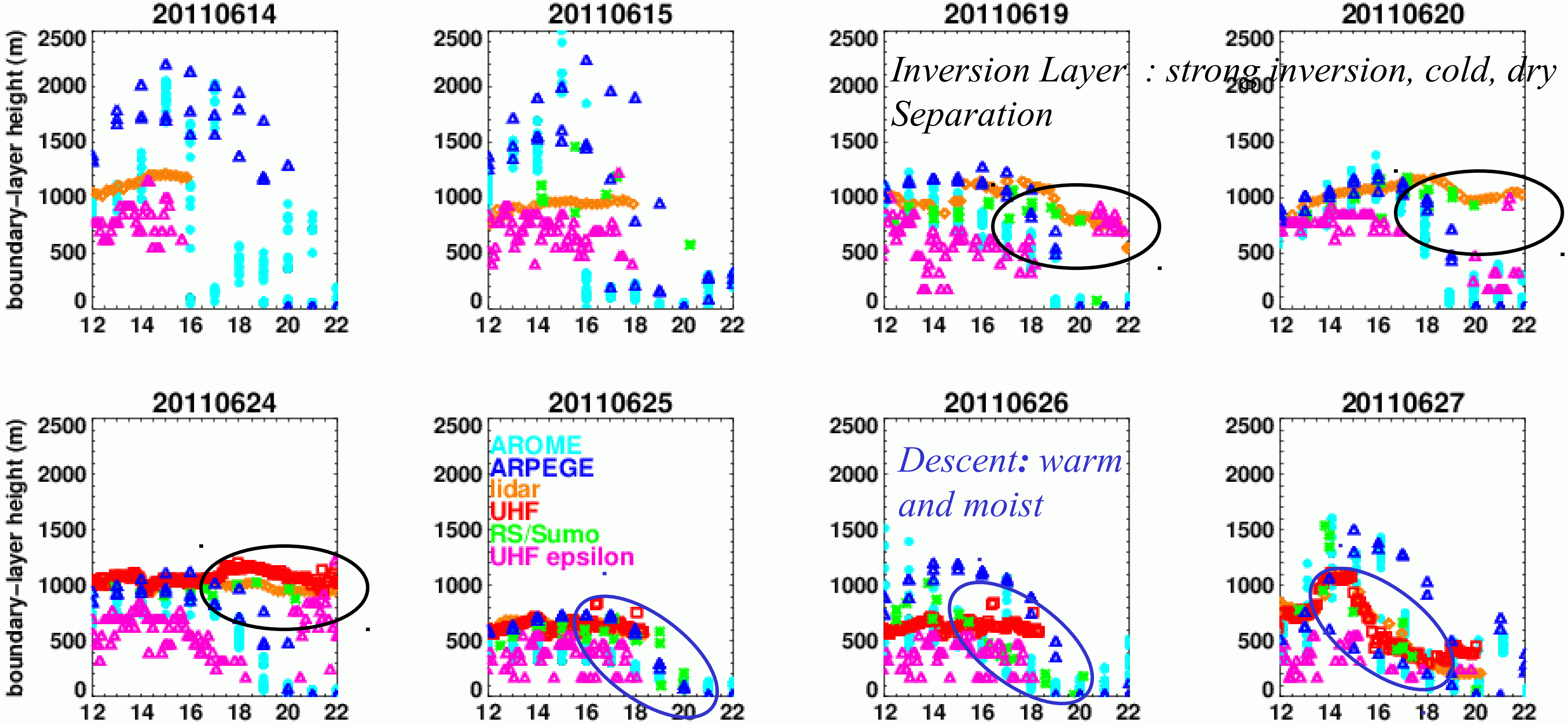
• Some systematic biases : too much LE for AROME, too much H for ARPEGE too dry at day in ECMWF ... but no direct link to Temperature

• Different types of growth of the blh well reproduced

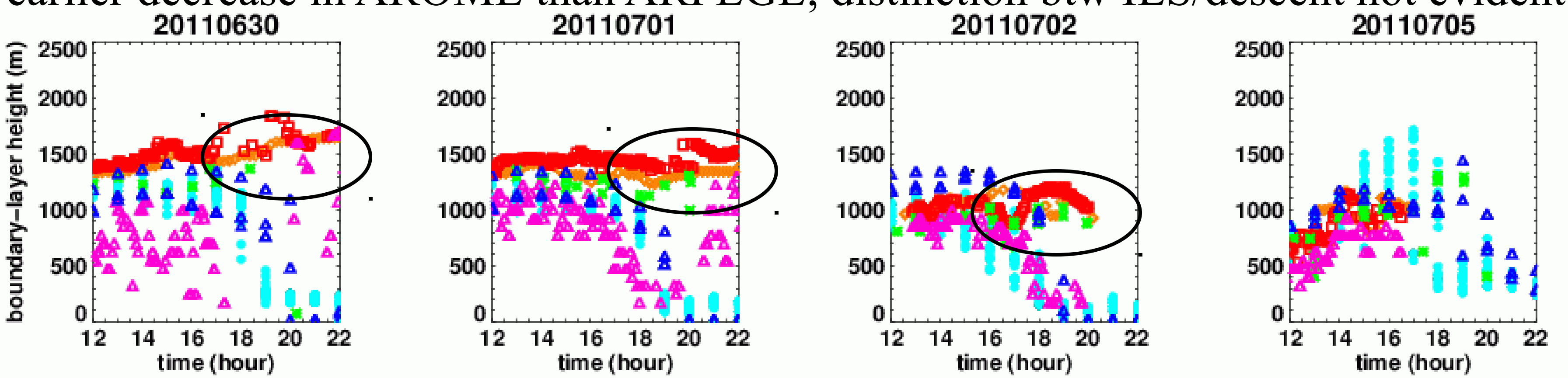
• Vertical profiles : better representation of the vertical profile of wvmr in AROME partly due to the parameterization

• Good order of magnitude of the tke for both AROME and ARPEGE

Afternoon transition: Tke

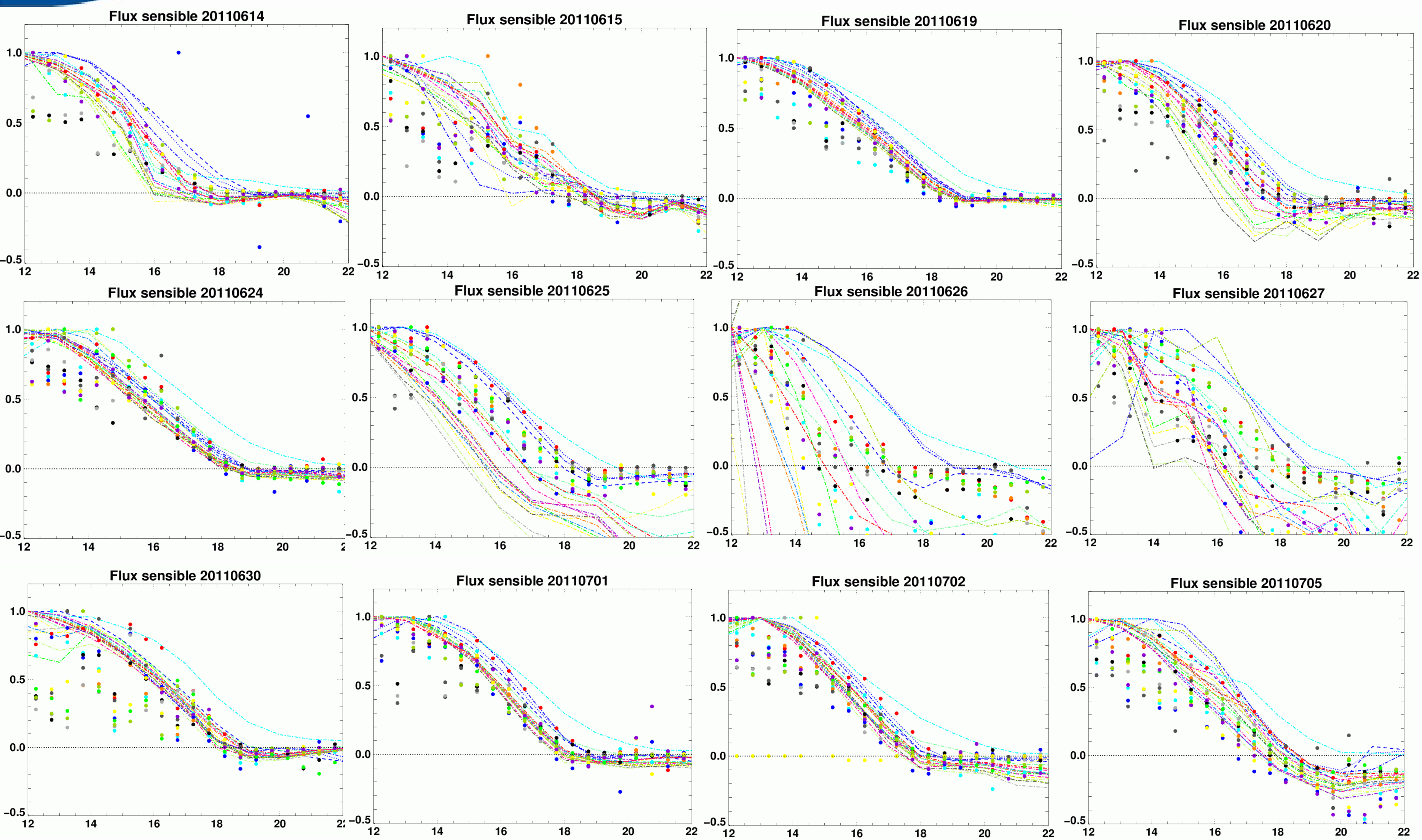


earlier decrease in AROME than ARPEGE; distinction btw ILS/descent not evident



Afternoon transition: Sensible heat flux

ARPEGE AROME OBSERVATIONS



AROME-pt3 : slower decrease of H (and also pt8) -pt2,9 : quicker decrease of H : similar cover:land, culture & forest
AROME variability among points ~ variability among sfce stations ; ARPEGE : slower decrease
Hot period : more variability in the decrease in models than observations

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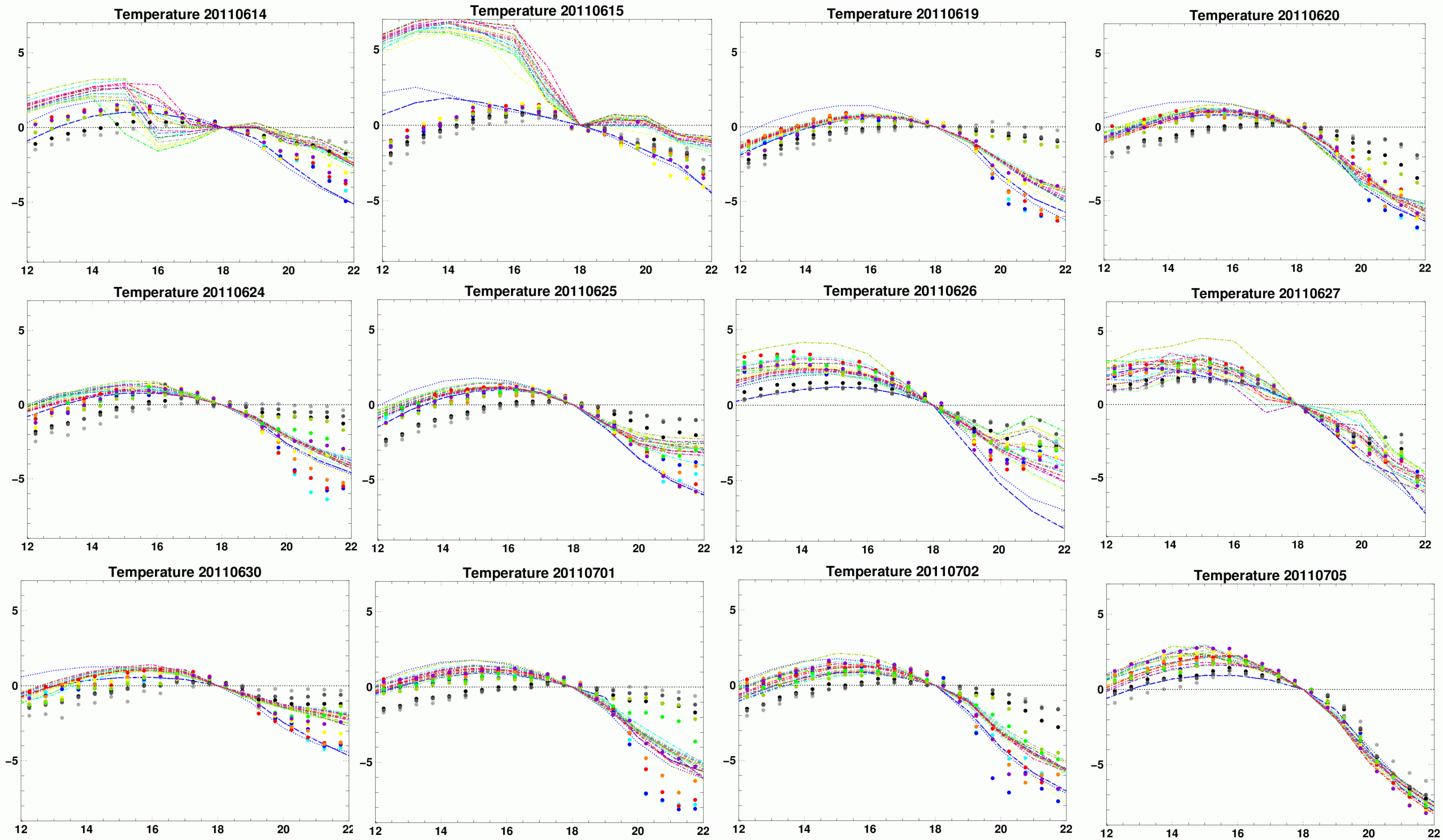
Afternoon transition: 2m-temperature



AROME : no direct ling in the behaviour of H and 2m-tre (no special behaviour of the previous points
AROME : less variability among points than among sfce obs ; ARPEGE : very close among points
26 and 27 June : more or same variability among points that among sfce obs

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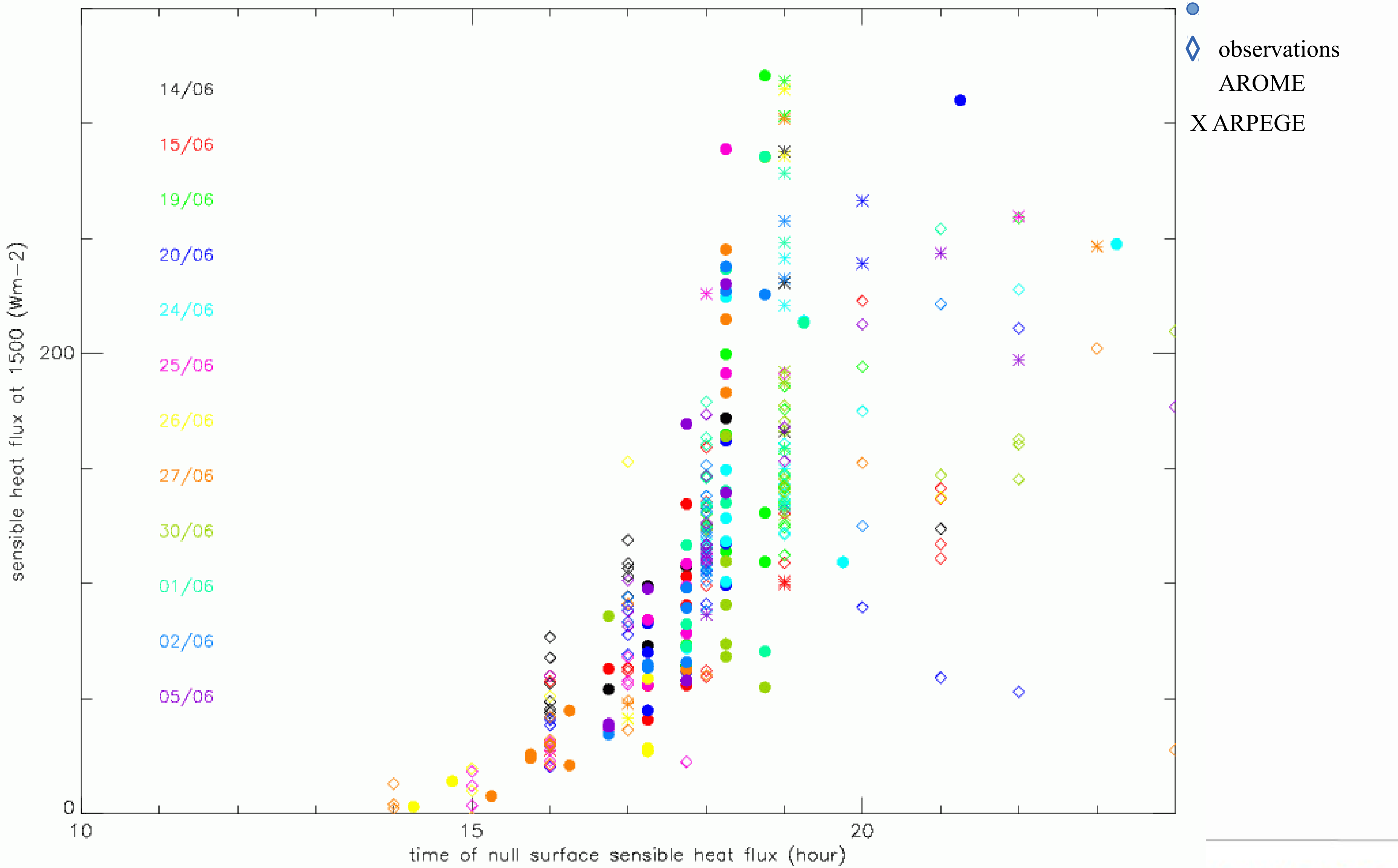
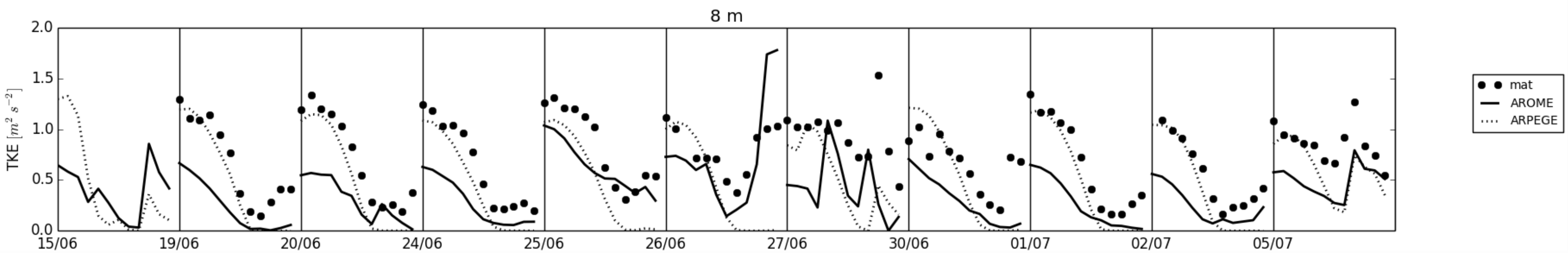
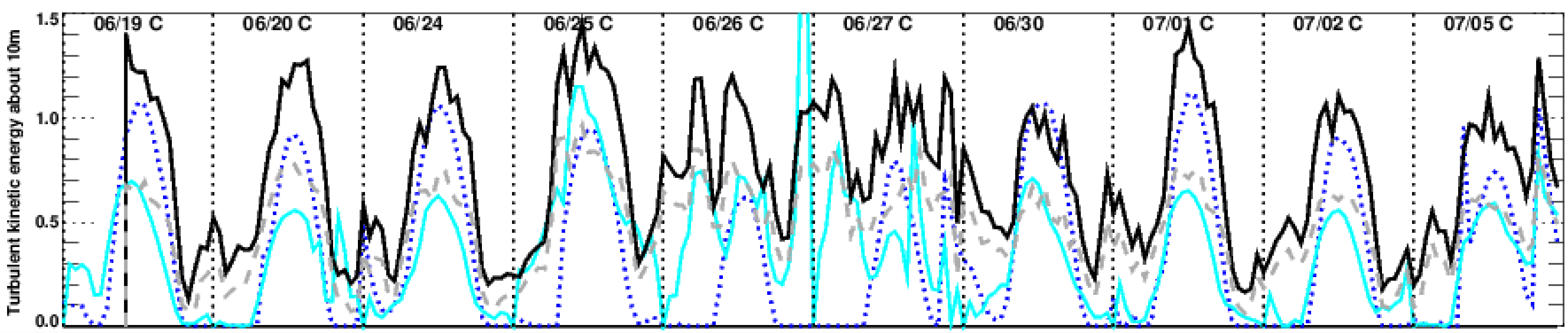
Towards a prediction of the transition?



relation between H_15h =f(H=0) as in Bosveld et al (2014)
range of H=0 wider in models, in particular later

Afternoon transition: Tke





___ observations - - - <w'²> __ AROME . . . ARPEGE

AROME underestimates the value close to the surface

Better agreement with estimation from w'² => 1D-scheme valid?

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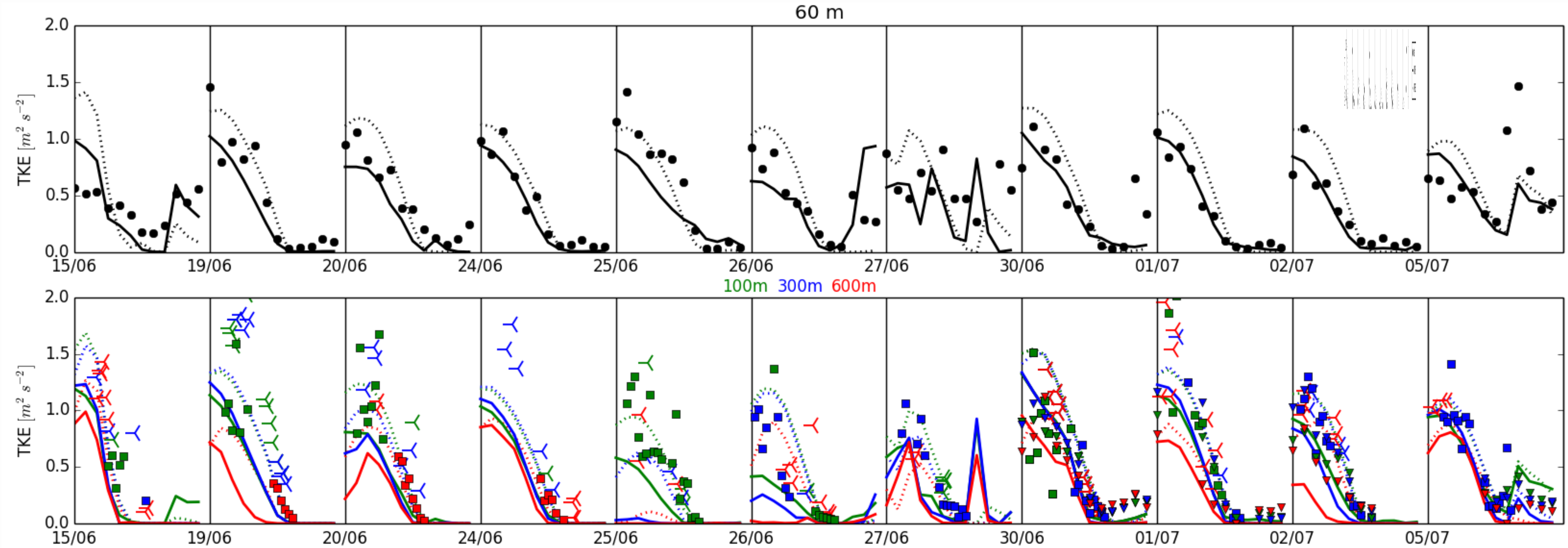
Toujours un temps d'avance

Afternoon transition: Tke



AROME & ARPEGE: earlier decrease of tke at higher levels
Observations: earlier decrease in w² (cf lidar measurements) not really in tke?

Conclusions:

- **well reproduced synoptic variability** : cloud cover, blh variability (*reproduction of the three types*), hot period (*small rh diurnal cycle, higher ws, small day H, negative night H, large LE*)
- **systematic biases** different for each model: *ARPEGE too large H, AROME too large LE, dry bias at night in ECMWF, dry boundary layer in ARPEGE, cold boundary layer in all models*
- **first evaluation of the model tke** : *good order of magnitude (slight underestimation of AROME), synoptic variability of diurnal cycle better reproduced by AROME*
- **Afternoon transition**: two types (*ILS/descent*) not really reproduced, stable BL very thin in ARPEGE, relationship btw $\langle H \rangle_{15}$ and t_H0
- **1D-assumption:** questionned in the transition; strong anistropy in the low levels and in the boundary-layer during transition

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Afternoon transition: vertical profiles