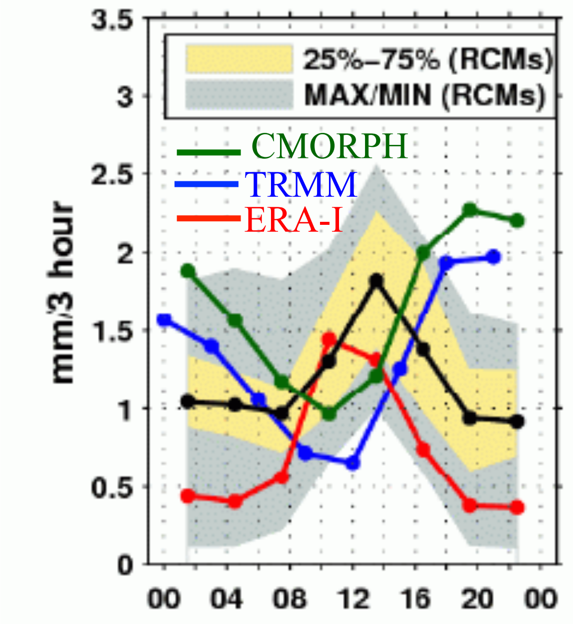
Evaluation of the representation of daytime convection over land by parametrized models in semi-arid conditions

F. Couvreux, C. Rio, R. Roehrig, F. Favot, M.-P. Lefebvre , F. Guichard

Nikulin et al.. CORDEX-Africa. Jcli. 2012

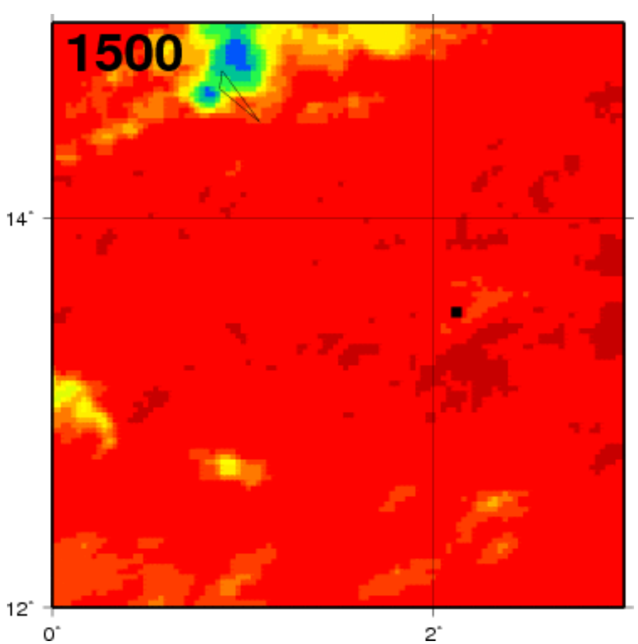


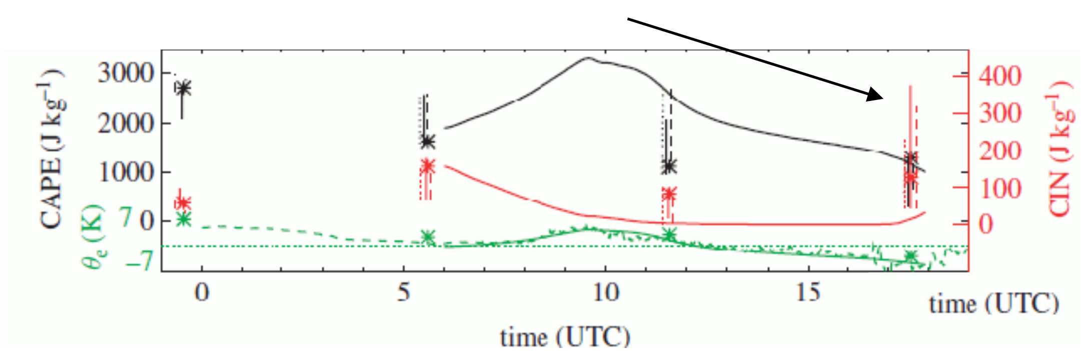
Main questions:

- Representation of the diurnal cycle of convection (triggering)
- In a semi-arid environment (Bo~10, here also decreasing CAPE in the afternoon…) : a relatively unknown environment

Methodology:

- use of well-observed case-study where LES has been evaluated
- intercomparison of SCM against LES (here only french models)

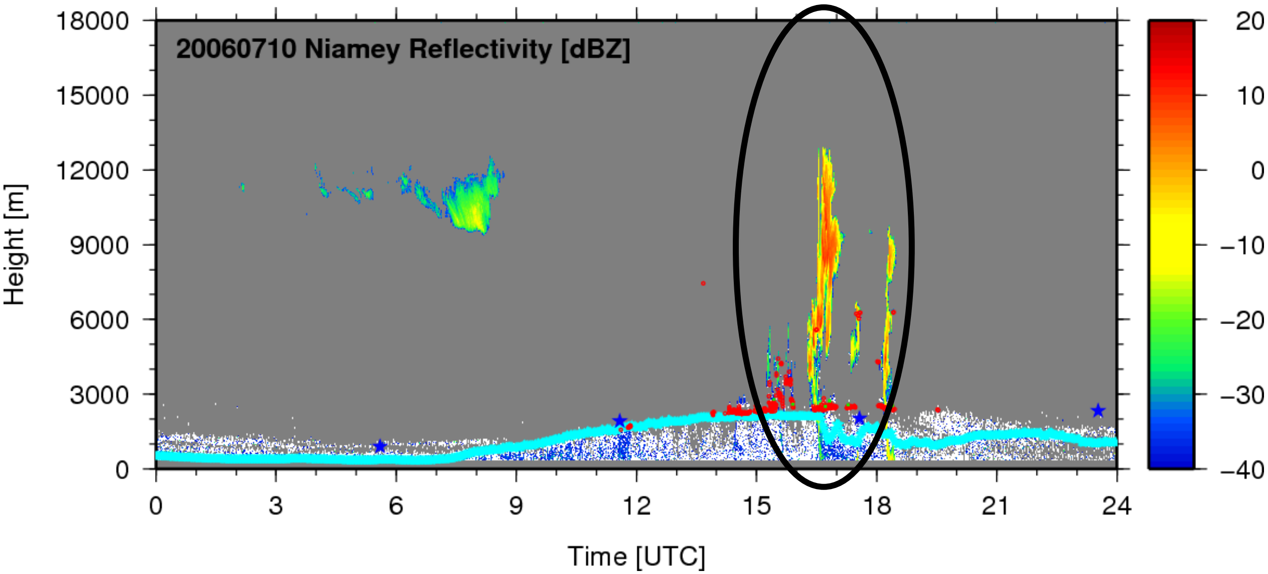




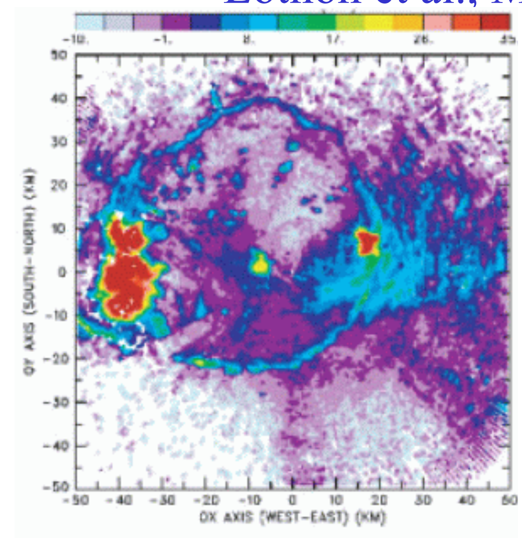
EMBRACE

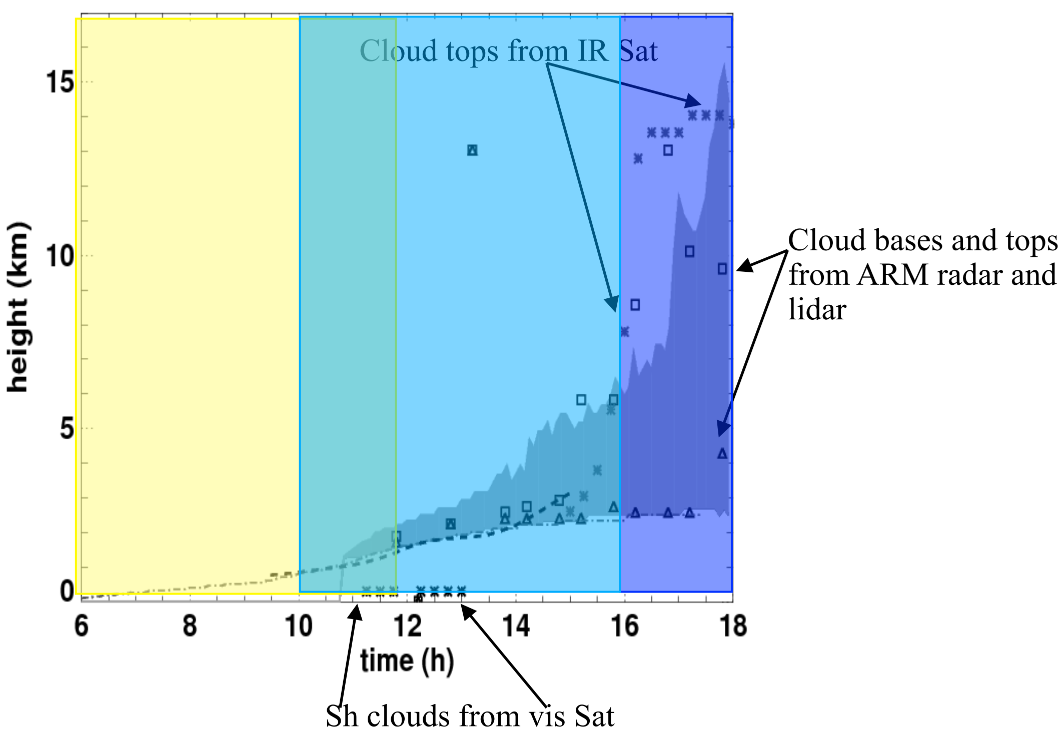
METEO FRANCE

A Single-Column Modelling case derived from the AMMA observations 10 July 2006 over Niamey



Detailed observations:
Lothon et al., MWR, 2011





A large-eddy simulation:
Couvreux et al., QJRMS, 2012

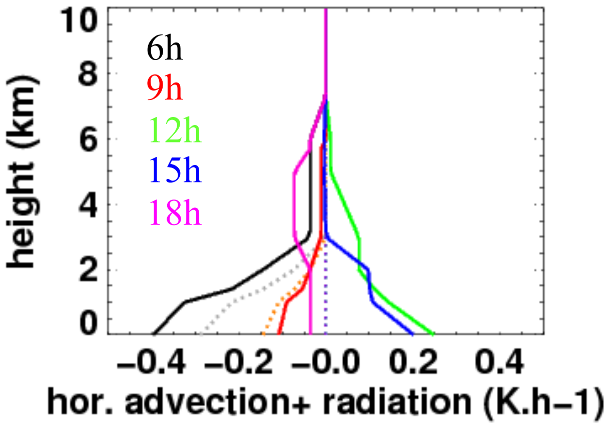
1 Boundary –layer characteristics

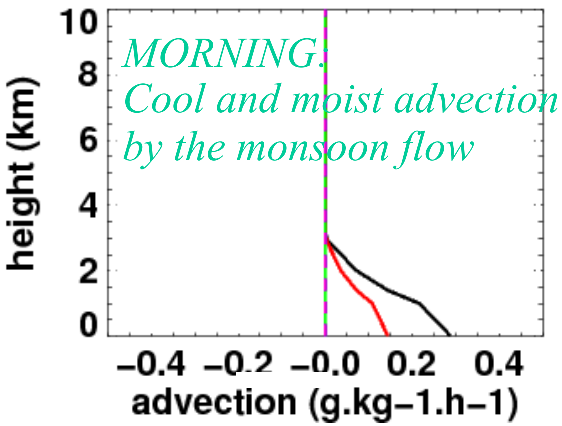
2 Cumulus layer characteristics

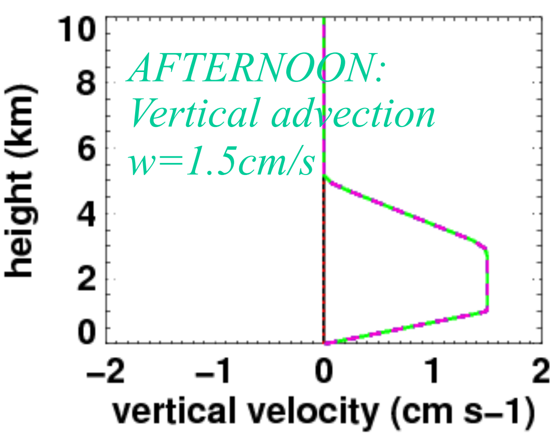
3 Convection initiation

Same set-up for LES and SCM: (Couvreux et al., QJRMS, 2012)

Large-scale advections

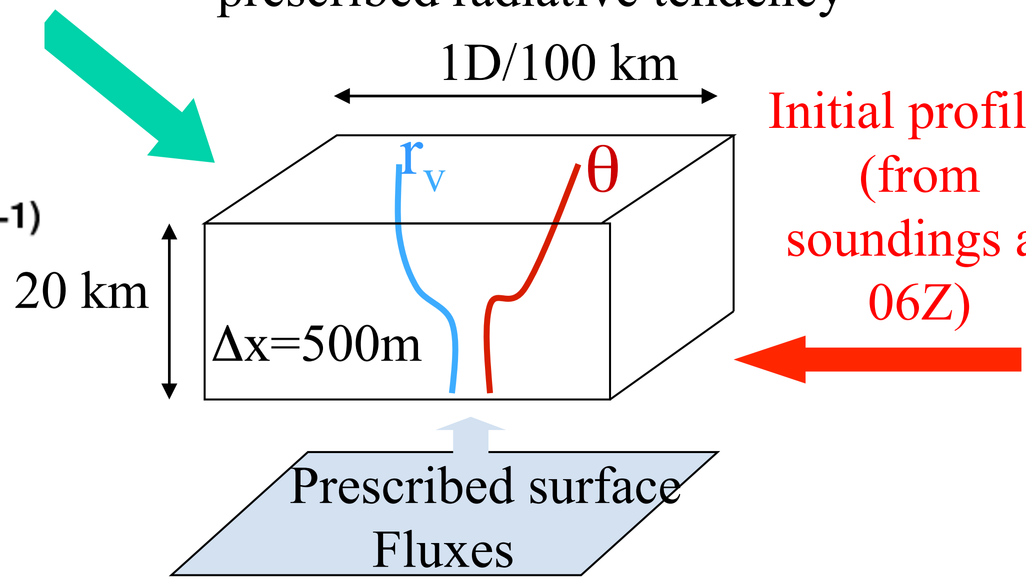




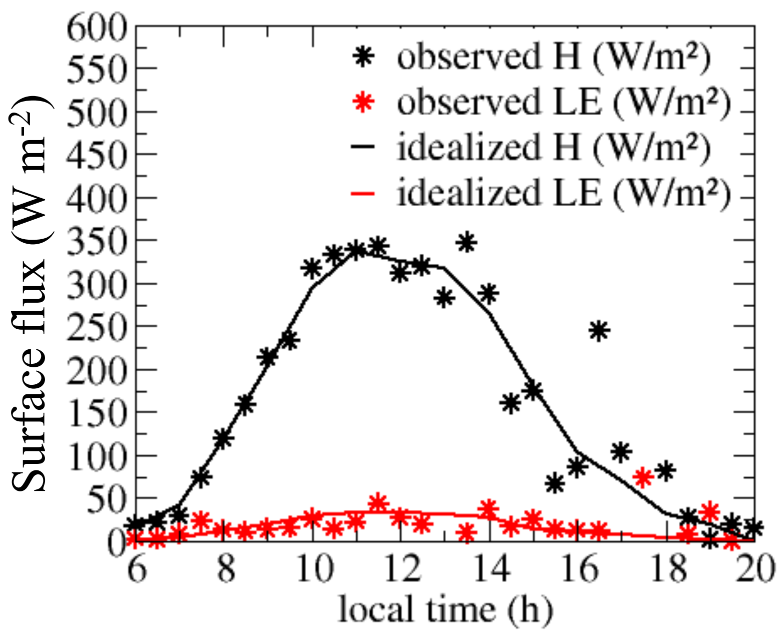


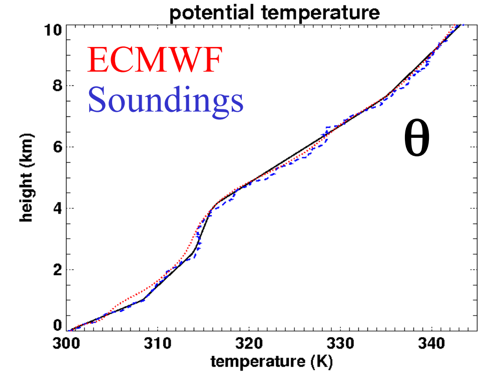
Parametrizations:

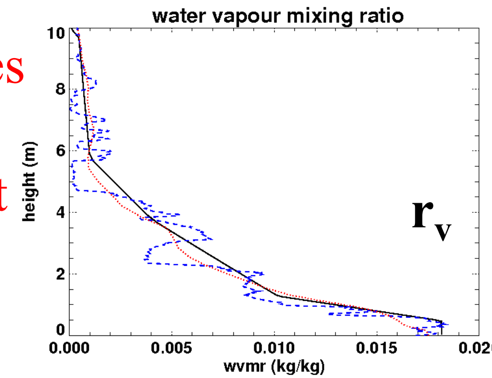
- turbulence/ microphysics/convection
- no radiative scheme but prescribed radiative tendency

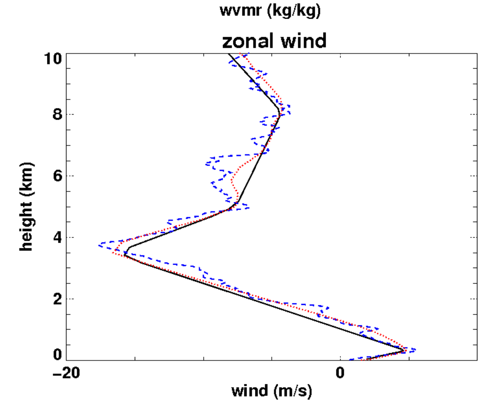


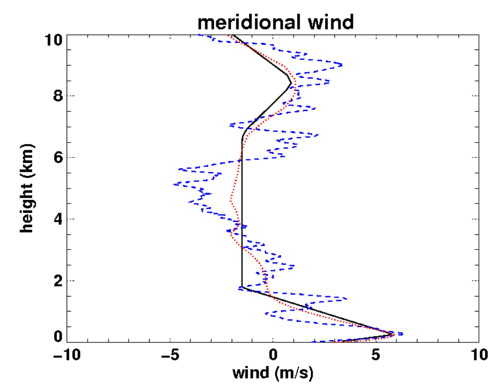
Initial profiles (from soundings at 06Z)









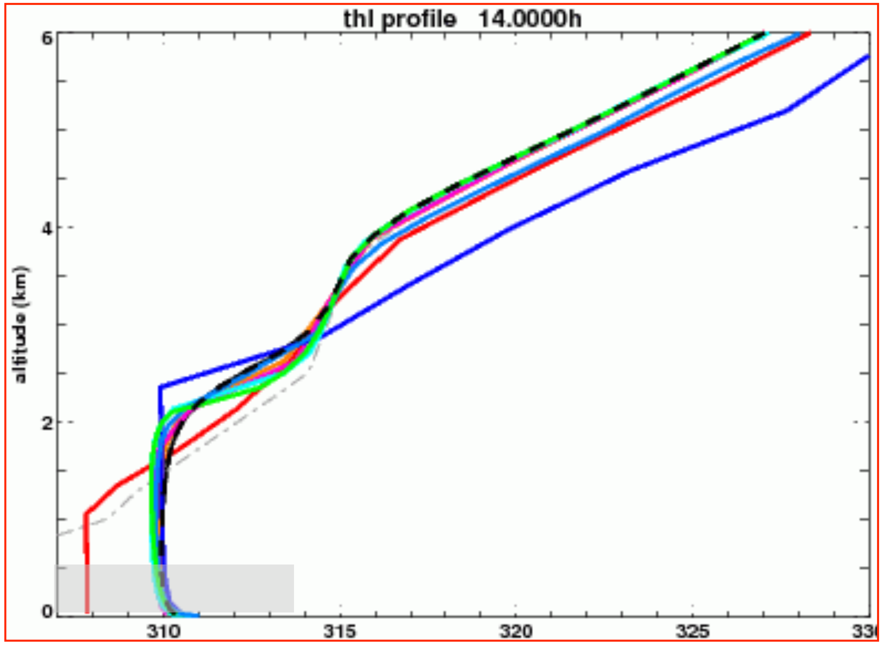


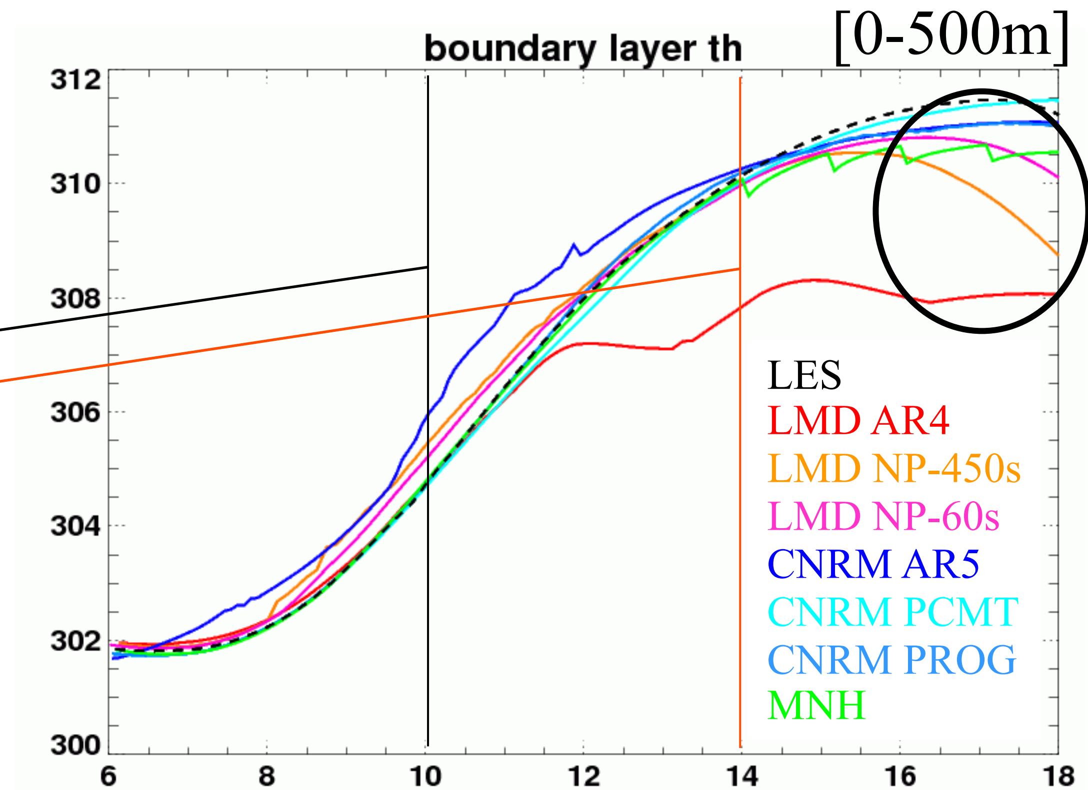
The different physics of the single column models evaluated:

Model	Boundary Layer	Shallow convection	Deep Convection	Cloud Scheme
CNRM-AR5 31l , 300s	diagnostic Tke (Ricard and Royer, 93), non local lm (Lendering and Holtslag, 04)	No	Mass-flux scheme (Bougeault 85) (dyn+turb Convergence)	Strati: statistical **exponen-gaussian** law of s Conv: from cv prec fl
CNRM-PCMT 80l, 300s	Progn Tke, non local lm (Cuxart et al. 00, BougeaultLacarrere,89)	Same scheme than deep	Piriou et al (07) Guérémy (11) CAPE + prognostic eq for w	Strati; cf from **triang.** Pdf Conv: from cv area
CNRM-PROG 80l, 300s	See CNRM-PCMT	See Meso-NH	As CNRM-AR5 + cld depth> 3km	As CNRM-AR5
LMD-AR4 39l, 450s	Kz=f(Rilocal) G=1K/km	No scheme	Emanuel (93) CAPE closure	**Log-normal law** from qv_conv or prescribed sig Bony& Emanuel (01)
LMD-NP 39 l, 450/60s	TKE (Mellor and Yamada, 74) +MF (Hourdin et al., 02)	Mass-flux scheme from ground Rio and Hourdin (08), Rio et al (10)	Emanuel (93) + cold pools + ALE/ALP (Grandpeix et al., 2010)	**Bi-gaussian/log-normal** law for CVPP/CVP+LS
Meso-NH	Mass-flux scheme Pergaud et al., 08	Mass-flux scheme	KFB	Bougeault : **exponen-gaussian** law of s

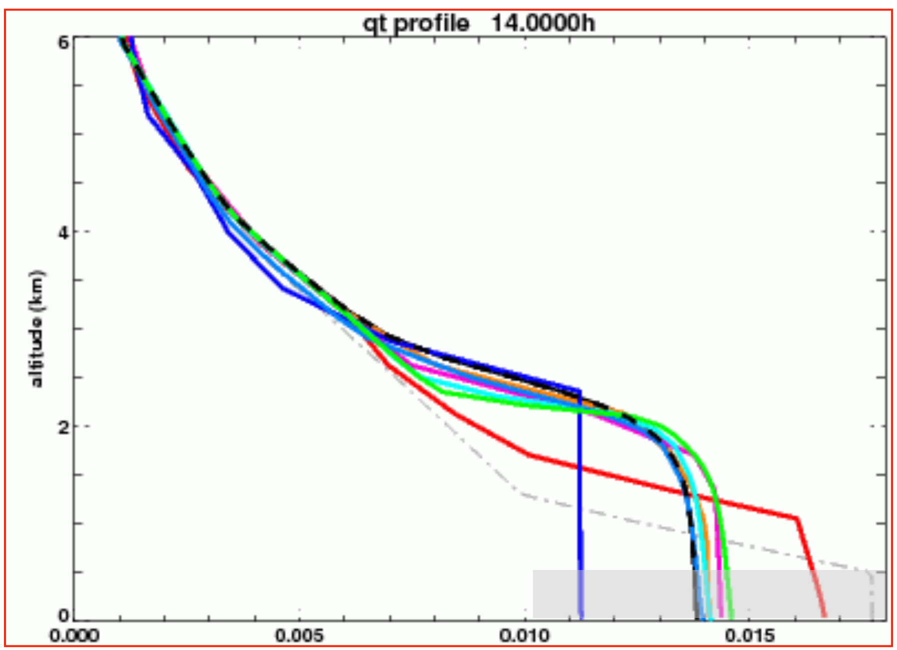
3 different models : in total 6 configurations

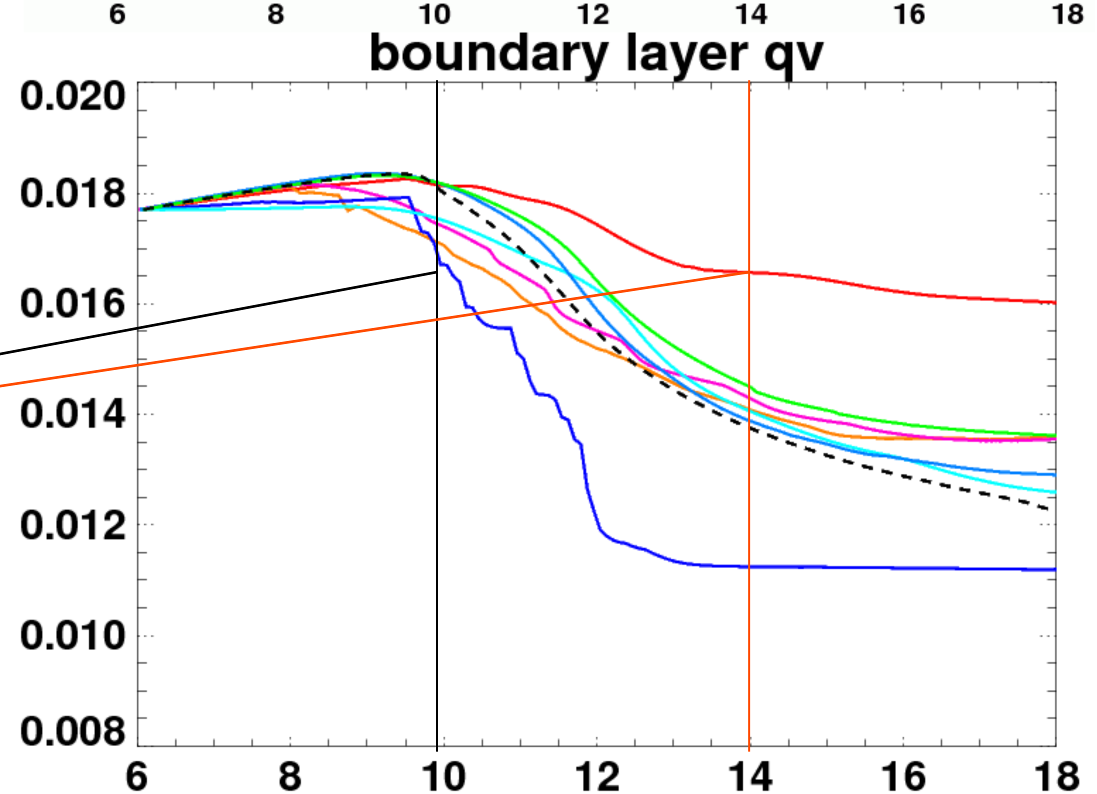
The boundary layer:



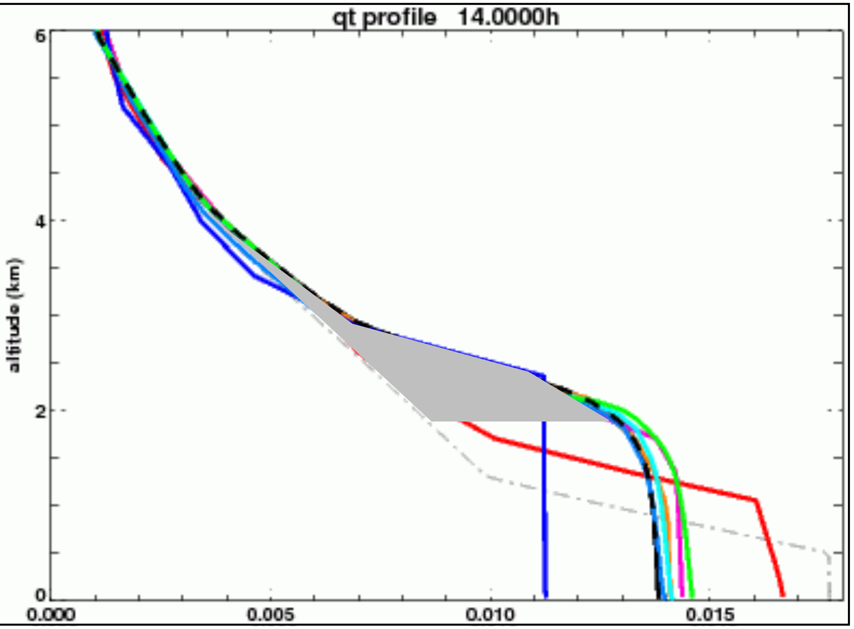


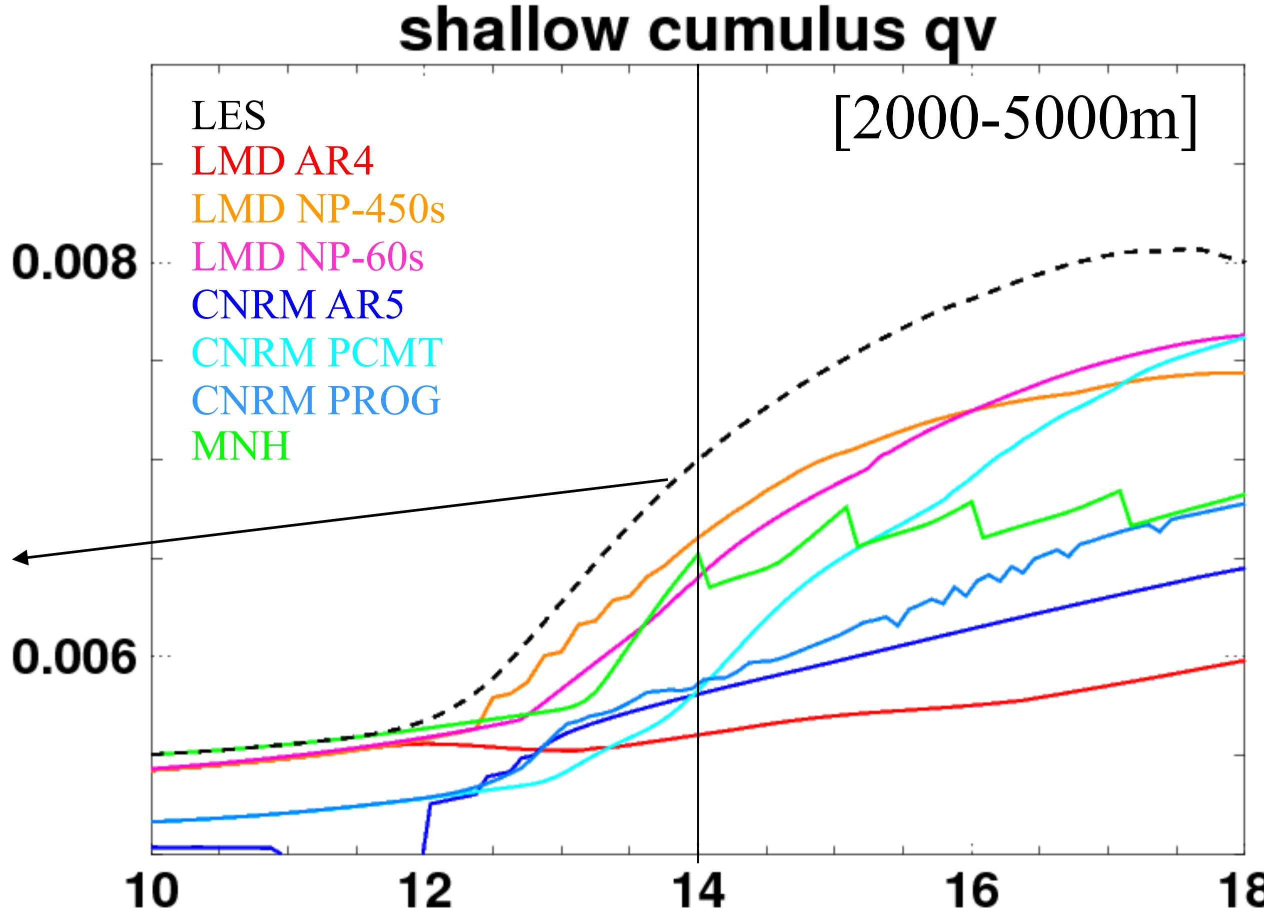
A relative good representation except for CNRM-AR5 and LMD-AR4

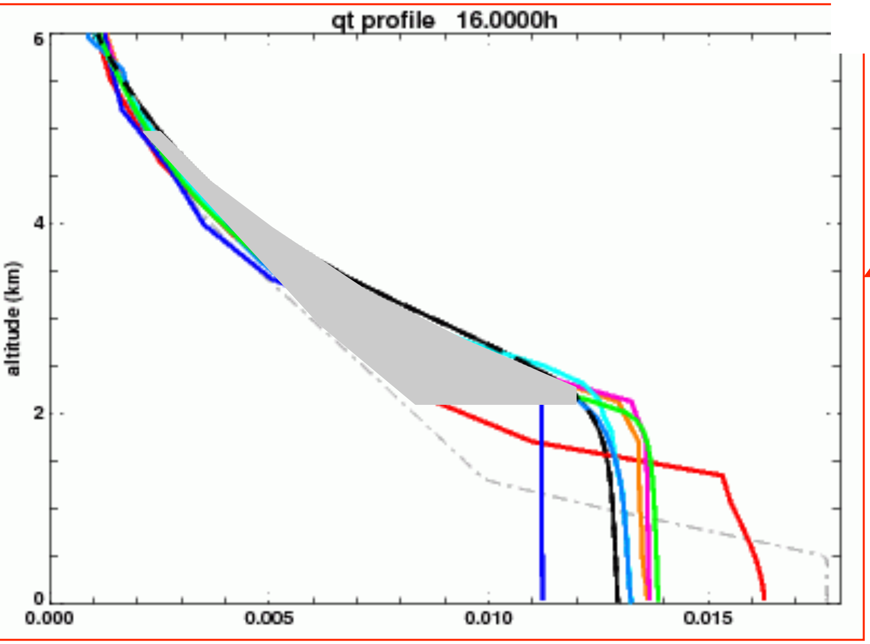




The cumulus layer:

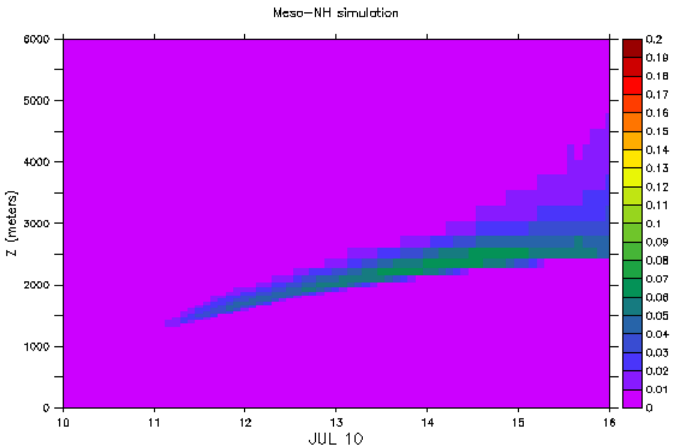




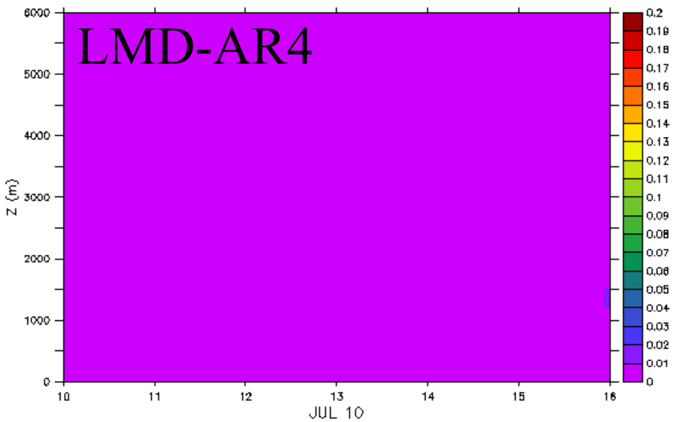


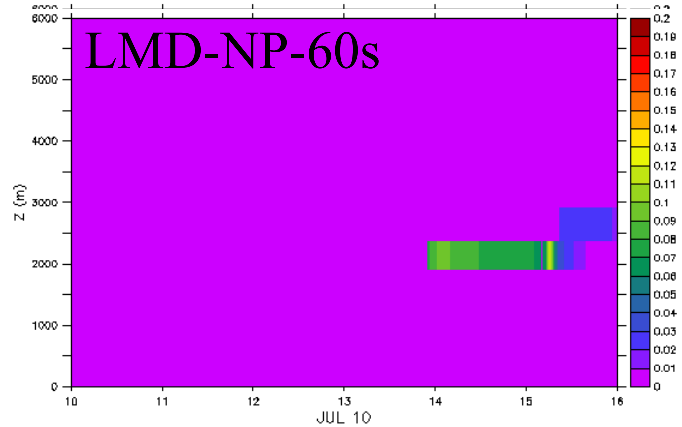
A misrepresentation of the moistening in the mid-levels by all models

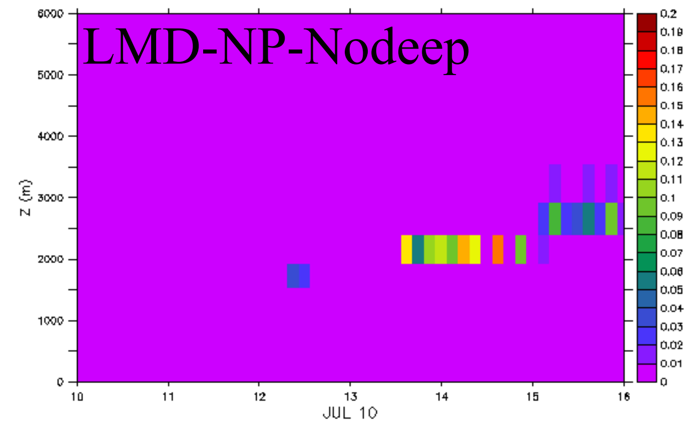
The cumulus layer:

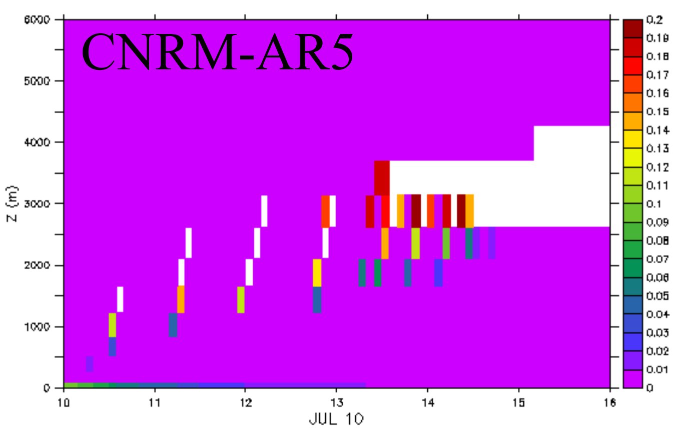


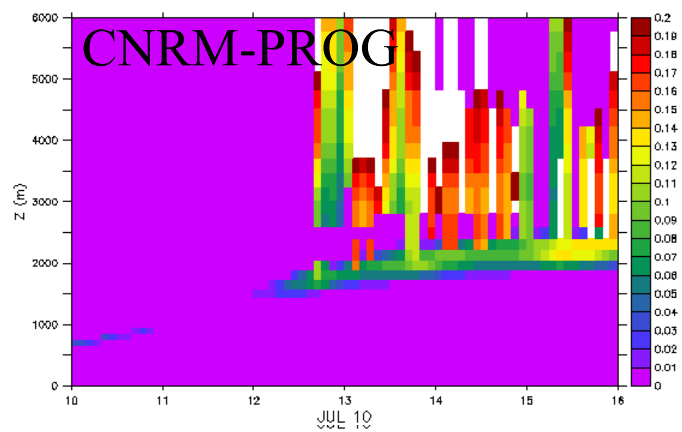
Too large cloud fraction (also condensate) when present

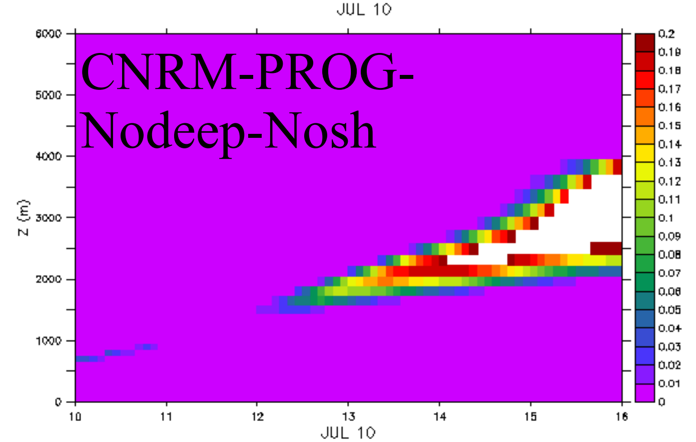








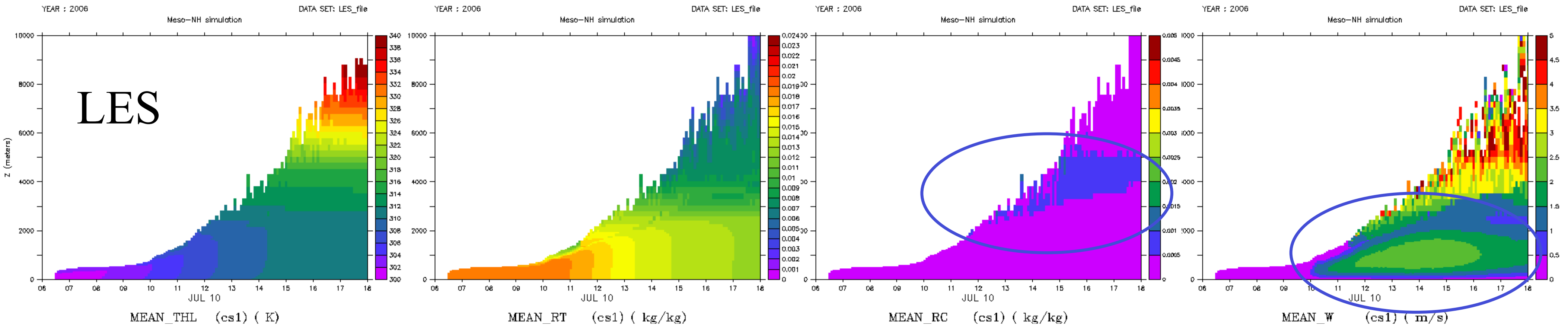


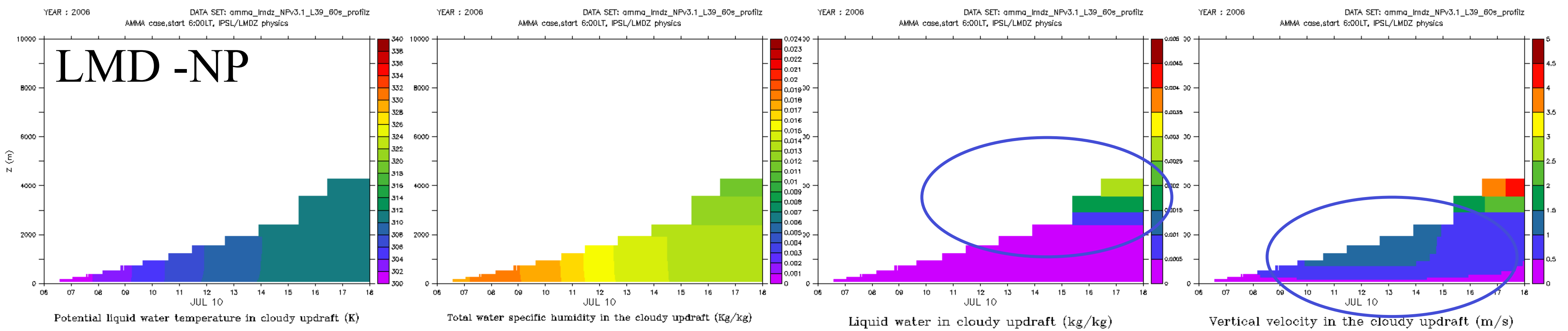


-> if looking at cloud content : too much condensate

The boundary and cumulus layer:

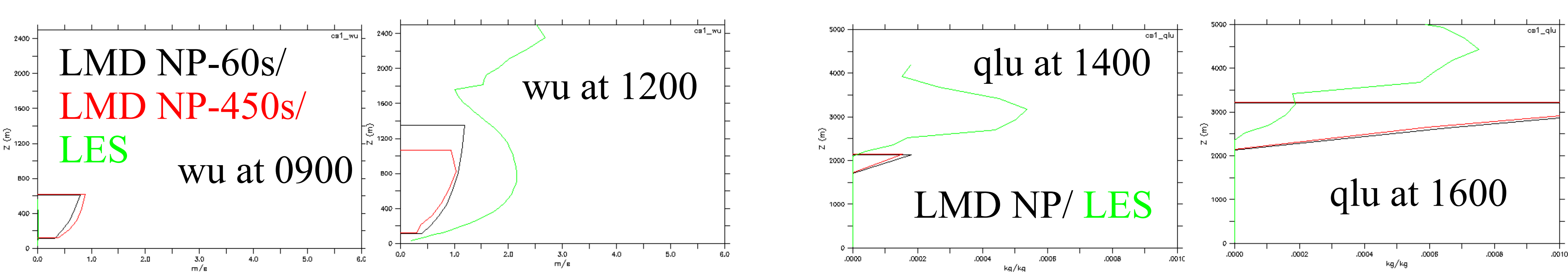
use of the conditional sampling to evaluate the thermal parameterization





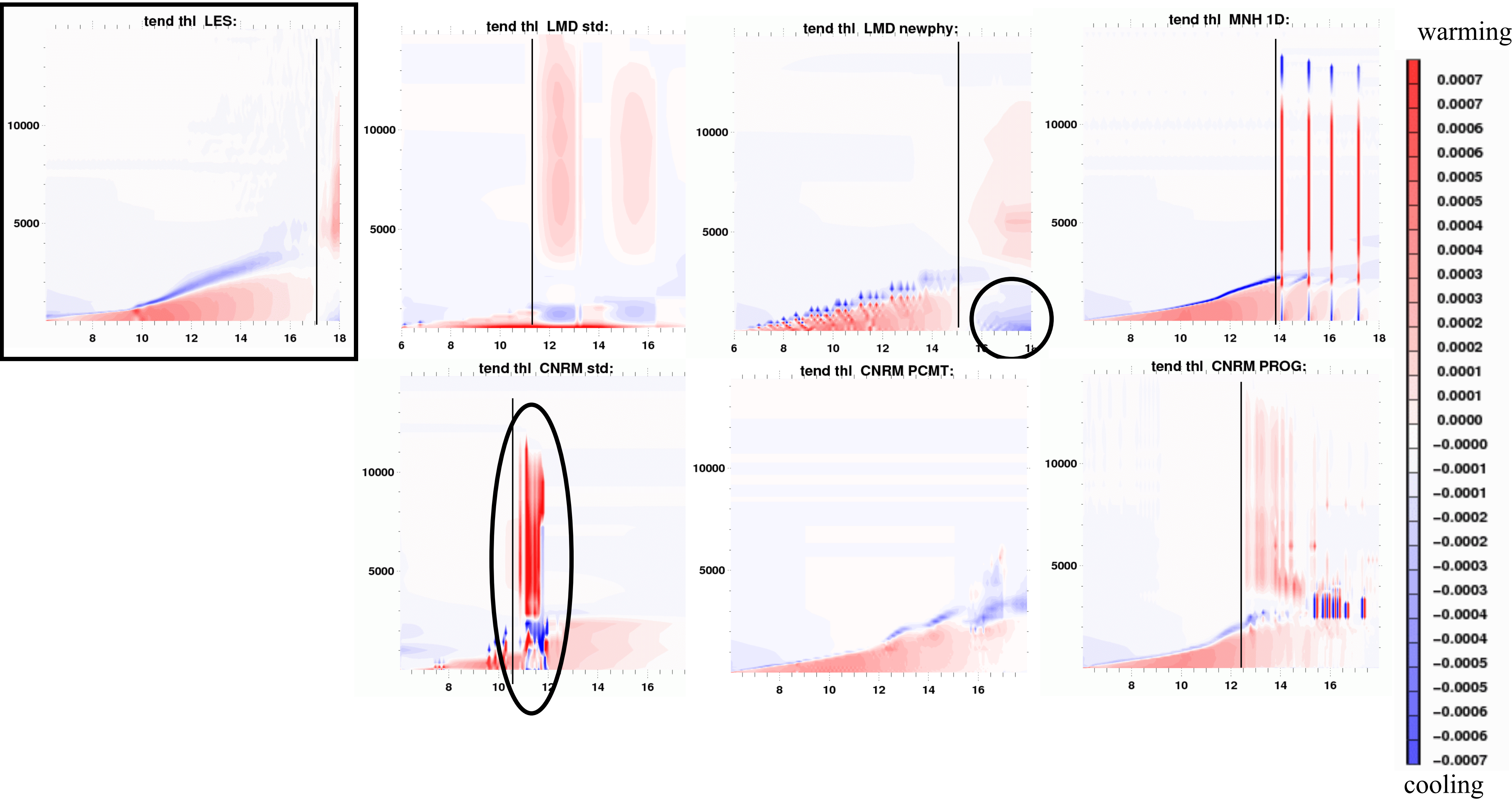
Thermals have the right thl and qt characteristics

-> still some issues for the vertical velocity underestimated and the cloud fraction :



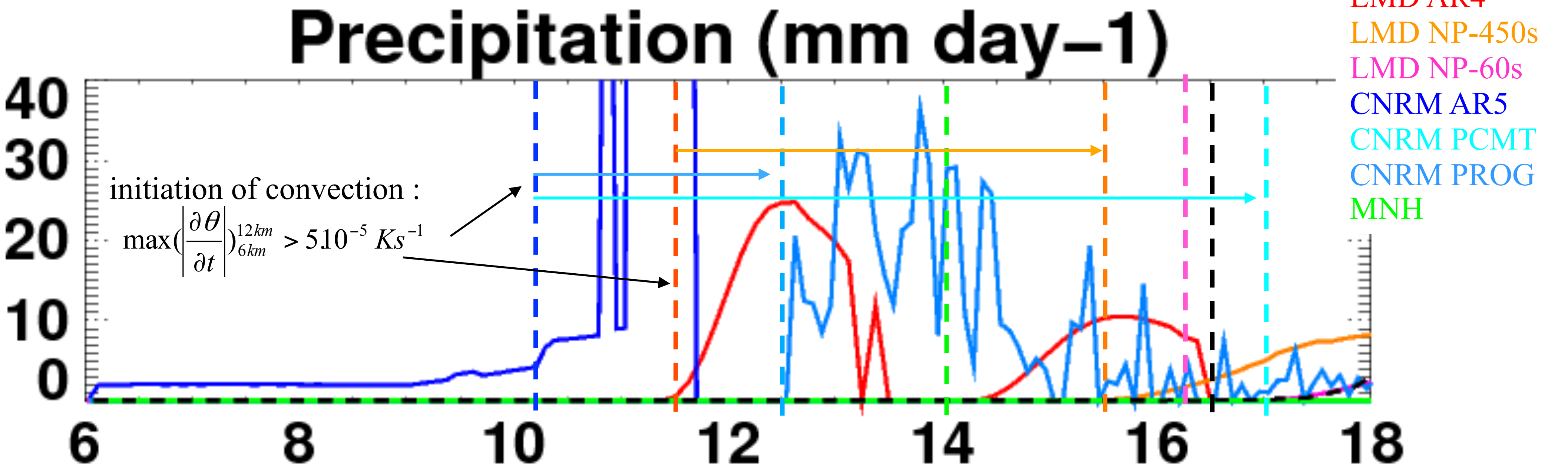
The convection initiation:

Potential temperature tendency (K s-1) :



Different time of initiation among the different configurations (also different intensity of convective tendency)

The convection initiation:



CNRM std: too many clouds/precipitation -> CNRM PROG-PCMT -> improve time of initiation
LMD std: initiation of convection too early but no clouds -> LMD new : better initiation & precipitation but~no cloud
MNH: too early initiation, no cloud and no precipitation : much improved in new

Conclusion:

The last version of the climate center models:
-> correctly represent the boundary-layer characteristics at least after 1200UTC
-> have difficulties in representing the relatively long shallow cu phase of this case and the associated humidification of the mid-levels
-> present a large variability in term of timing of convective initiation :
deep convection too early or not (PCMT) except for LMDnew
-> the new physics (LMD/CNRM) allow to delay the initiation of convection but still not enough

What to do next?
- Further extensive comparison (internal characteristics of deep convection, shallow convection, …) in order to understand the different behaviours.
- Do some sensitivity tests ? -> similar behaviour than in LES?
- Run some ensembles to get an uncertainty around the behaviour of the different model configuration

-Surface-coupled SCM intercomparison :
- One more degree of complexity

Thank you

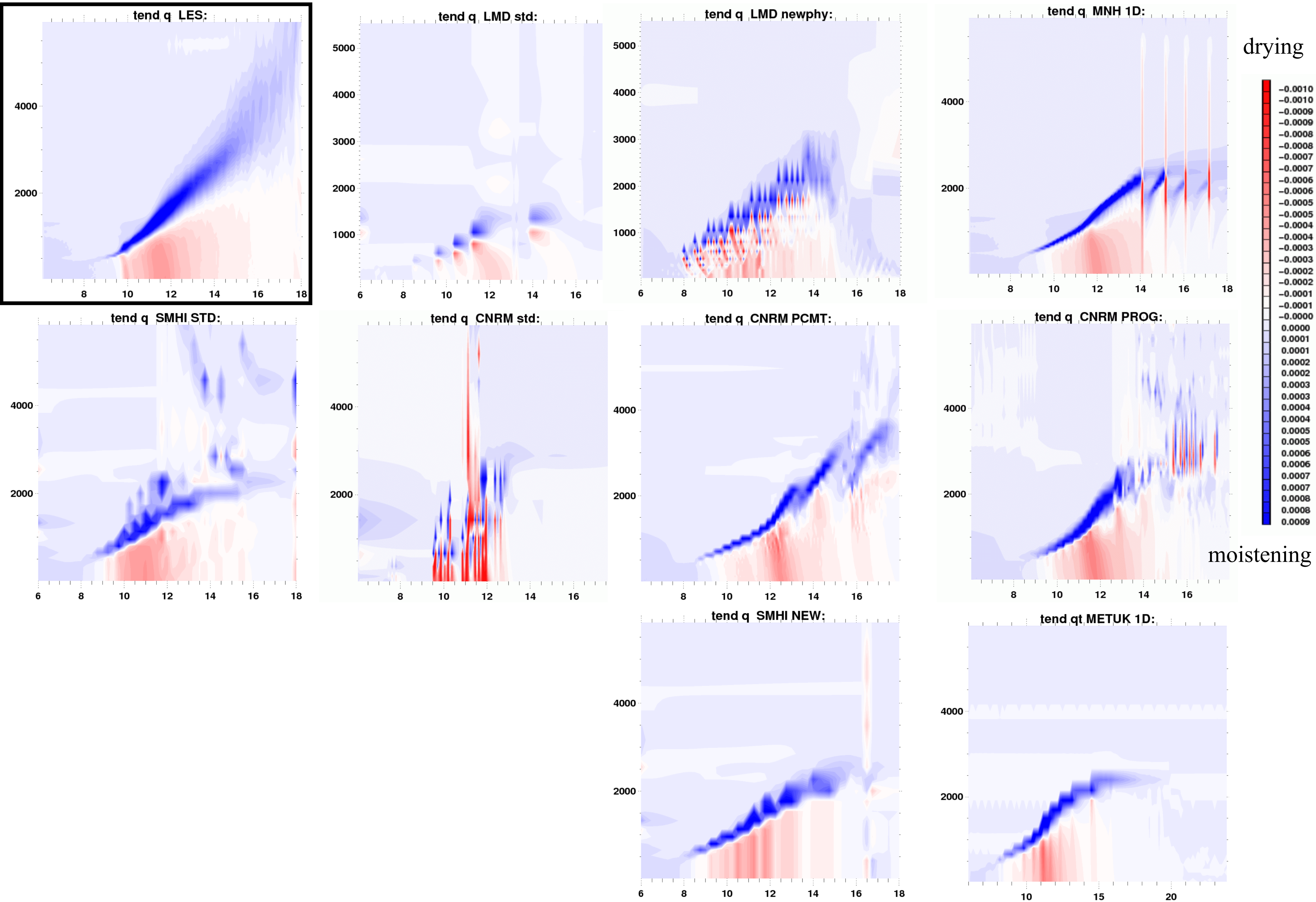
See also Poster 2C13 by C. Rio et al. for details on the behaviour of LMD-NP

The different Convection scheme:

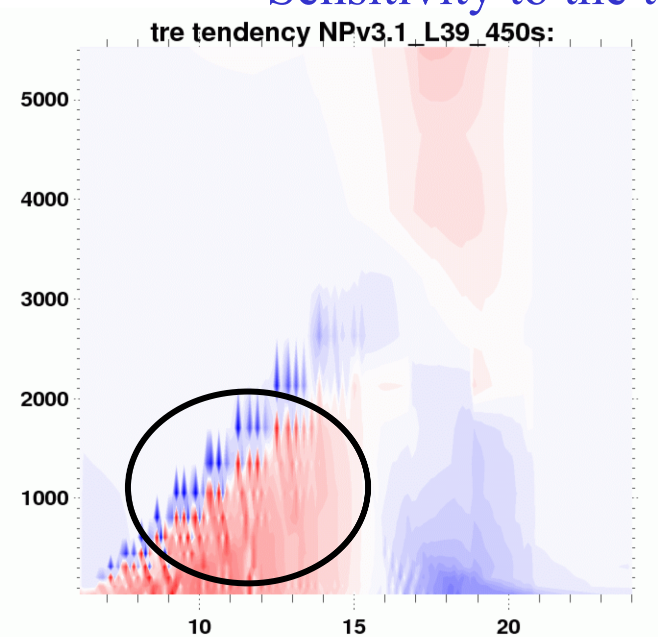
Model	Triggering	Closure	Downdraughts	Entrainment/ Detrainment
CNRM-std 31l , 300s	Moisture convergence in the low level and unstable vertical temperature profile	dynamical and turbulent moisture convergence = precipitation + detrainment	No	Prescribed vertical profiles btw max-min+exp transition Detrainment deduced from s conservation
CNRM-PCMT 80l, 300s	Progn eq for w, on if wup>0	CAPE closure-> area (t=3h)	No	Organised (K&F90) + Turbulent (f(wu)
CNRM-PROG 80l, 300s	Moisture convergence in the low level and unstable vertical temperature profile + cld depth > 3km	As CNRM-AR5	No	As CNRM-AR5
LMD std 39l, 450s	B(lcl+40hPa) > CIN	CAPE closure	Yes	episodic mixing & buoyancy sorting (uniform PDF)
LMD new 39 l, 450/60s	ALE > CIN	ALP closure: Mb=ALP(th+wk)/ (CIN+2wb²)	Yes + cold pools	episodic mixing & buoyancy sorting (bell-shaped PDF)

In the following: evaluation of the BL, the cumulus and the initiation of convection

Total humidity tendency: g/kg/s

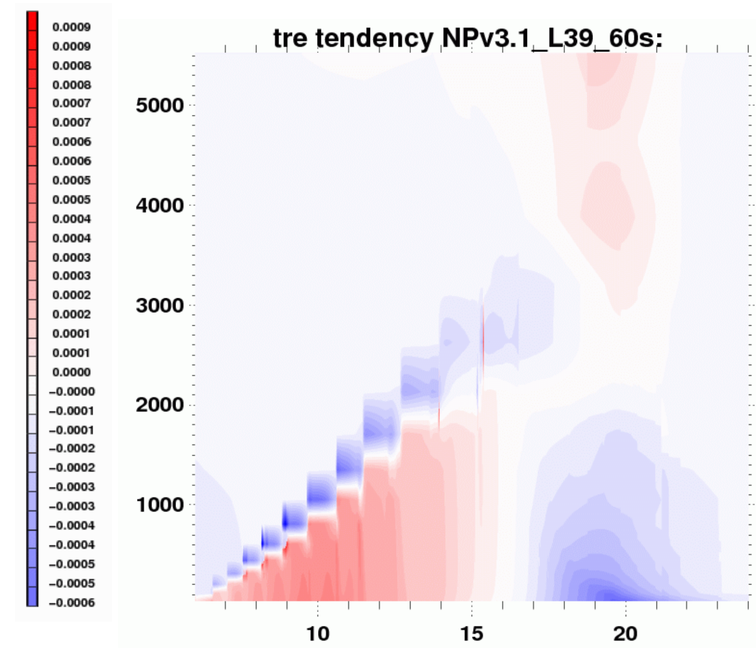


Sensitivity to the time step in LMD/SMHI :

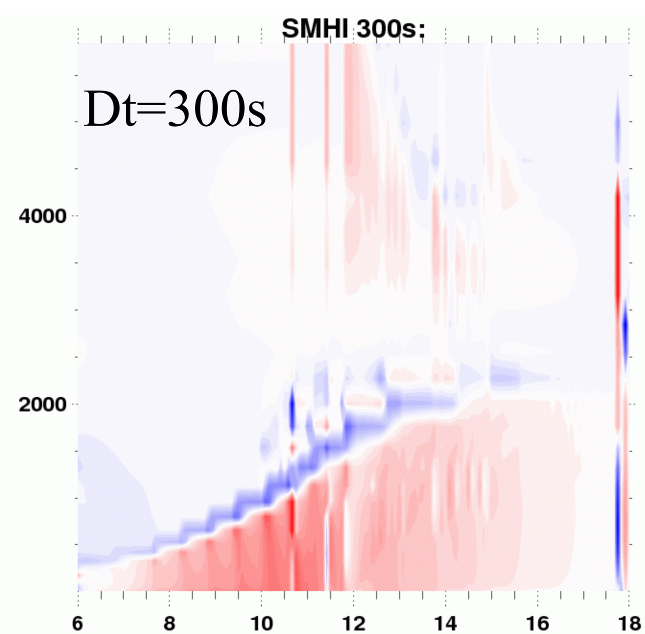


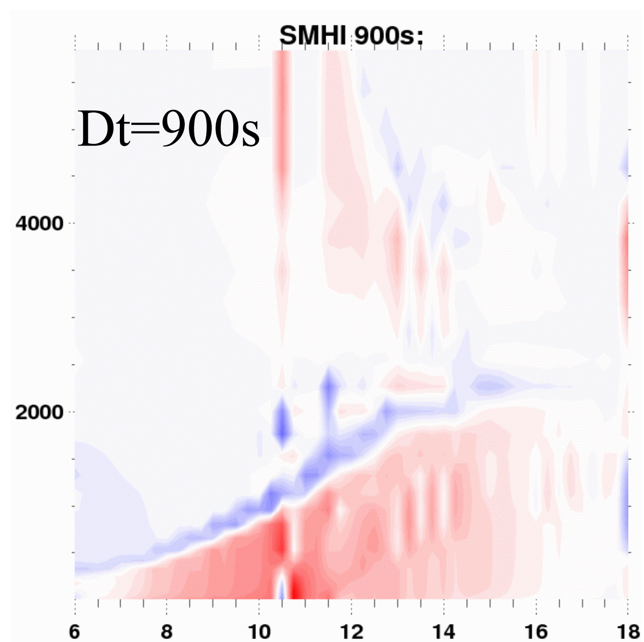
LMD new physics :

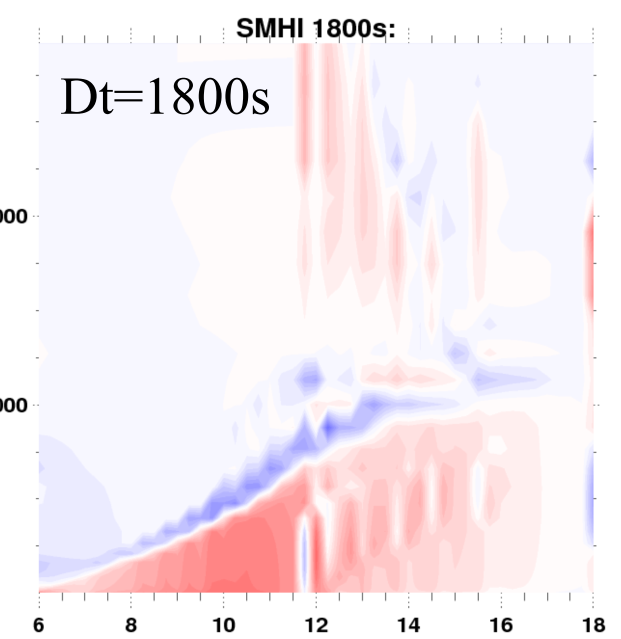
Many instabilities reduced at higher timestep



SMHI :relatively stable







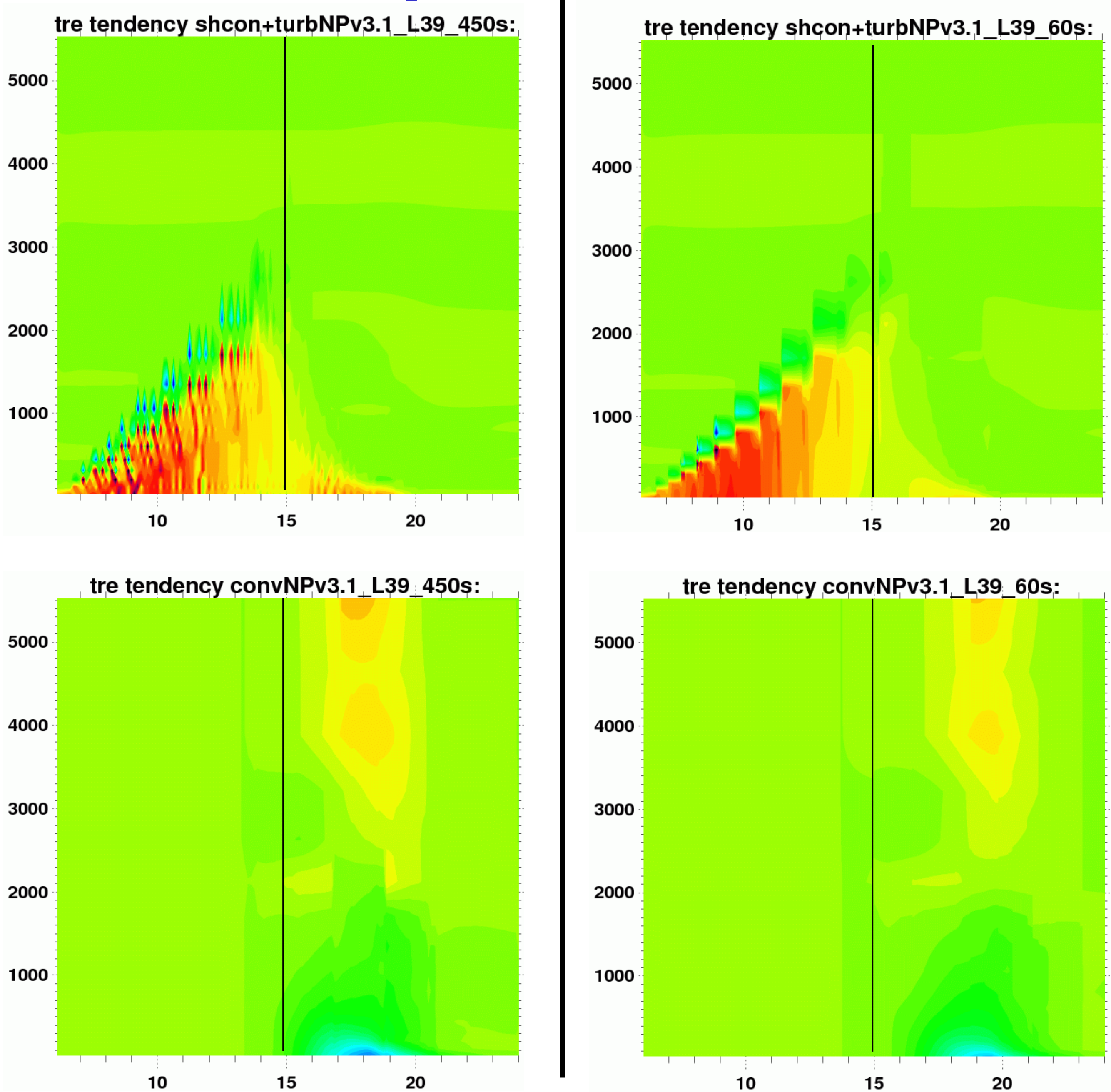
Sensitivity to the time step in LMD: modification of the contribution of thermals and deep convection =add a slight delay for initiation of convection

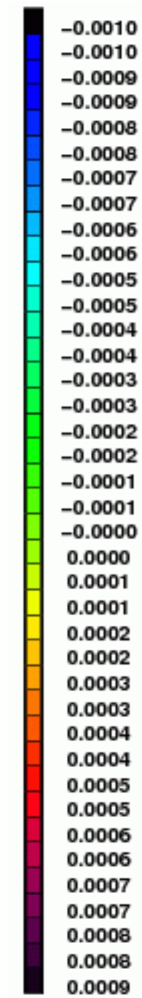
Boundary-layer processes

Dt=450s

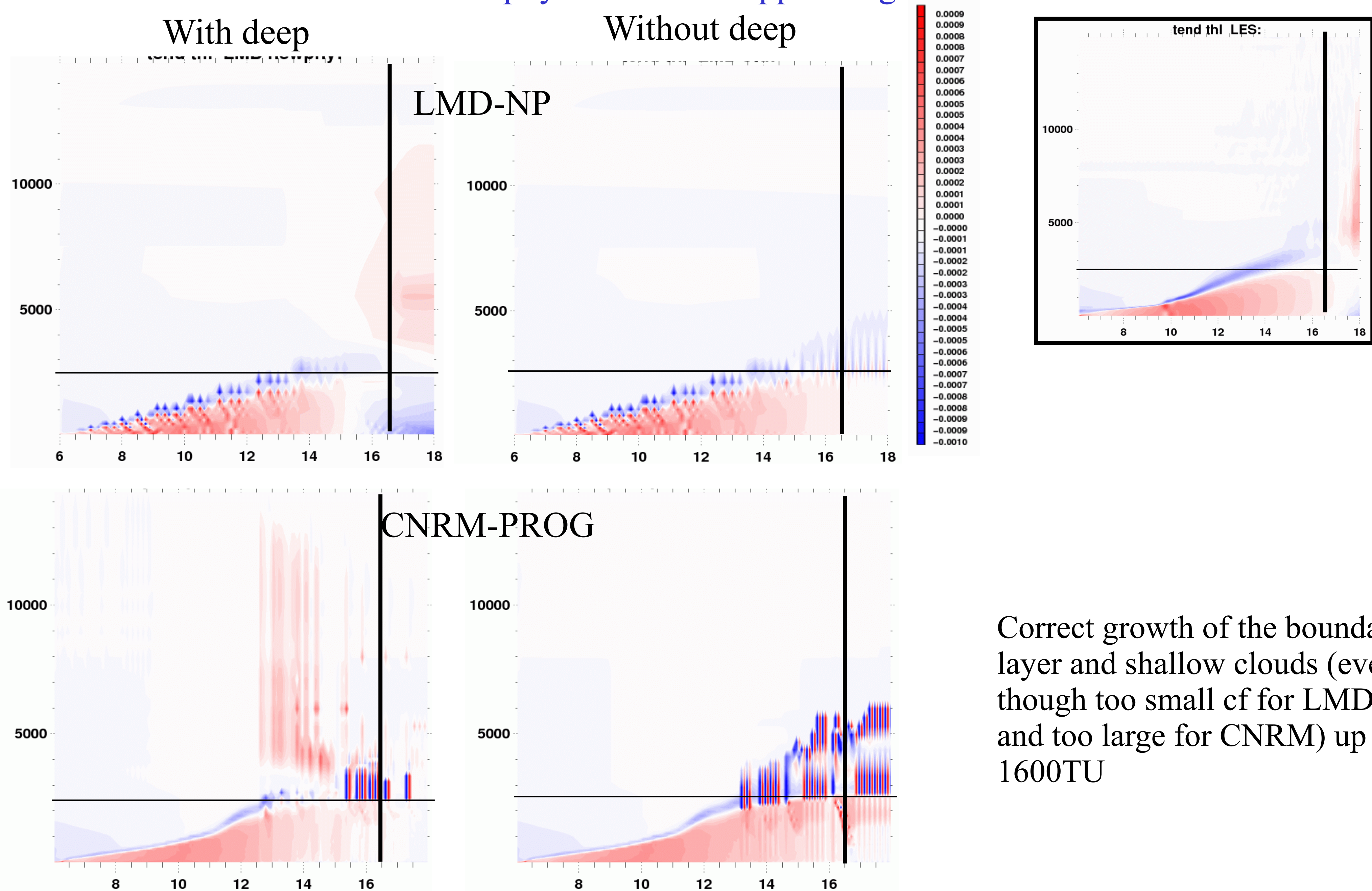
Dt=60s

Convective processes





Some tests in the new physics : when suppressing deep convection : LMD/CNRM



Tendency of θl from the physics

Correct growth of the boundary layer and shallow clouds (even though too small cf for LMD and too large for CNRM) up to 1600TU

The cumulus layer:

A look at the moisture distribution in the cumulus zone and the deep convection zone