GABLS4 : a model intercomparison study in extremely stable condition

E. Bazile, Fleur Couvreux, Patrick Le Moigne,
CNRM-GAME, Méteo-France, Toulouse, France (*)
&
C. Genthon (IGE), W. Maurel (*)
G. Canut(*) , E. Vignon (IGE, F. Favot(*) & participants..

12th Workshop on Antarctic Meteorology and Climate
June 26-28, 2017 NCAR, Boulder, Colorado USA

SCM: participants

1. IFS : Irina Sandu (ECMWF)
2. CAM5-IPHOC: Anning Cheng (Center for Weather and Climate Prediction, NOAA, US)
3. NCEP/GFS : Weizhong Zheng, Michael Ek (NOAA, US)
4. CMC : Ayrton Zadra (CMC, Canada)
5. WRF : Wayne Angevine (CIRES/NOAA,US) & D. Veron and A. Schroth (University of Delaware, US)
6. ARPEGE/AROME : Eric Bazile (Meteo-France/CNRS, France)
7. LMDz : E. Vignon (LMD/LGGE, France)
8. MAR : Hubert Gallé (LGGE, France)
9. Méso-NH : M. A . Jimenez (UIB, Spain)
10. UKMO-SCM : J. Edwards (MetOffice)
11. RACMO: Peter Baas (TuDelft, Netherland)
12. AROME-HARMONIE : Wim de Rooy (KNMI, Netherland)
13. CSIRO: Jing Huang (Australia)
14. Wur-d91: G-J Steeneveld (Netherland)
15. COSMO: B. Goger and M. Rotach (Univ. of Innsbruck, Austria) not yet
16. COSMO: Matthias Raschendorfer (DWD, Allemagne) not yet
17. ICON: A. Eichorn, J. Schmidli (Univ. of Frankfurt) not yet

Participants

LES:

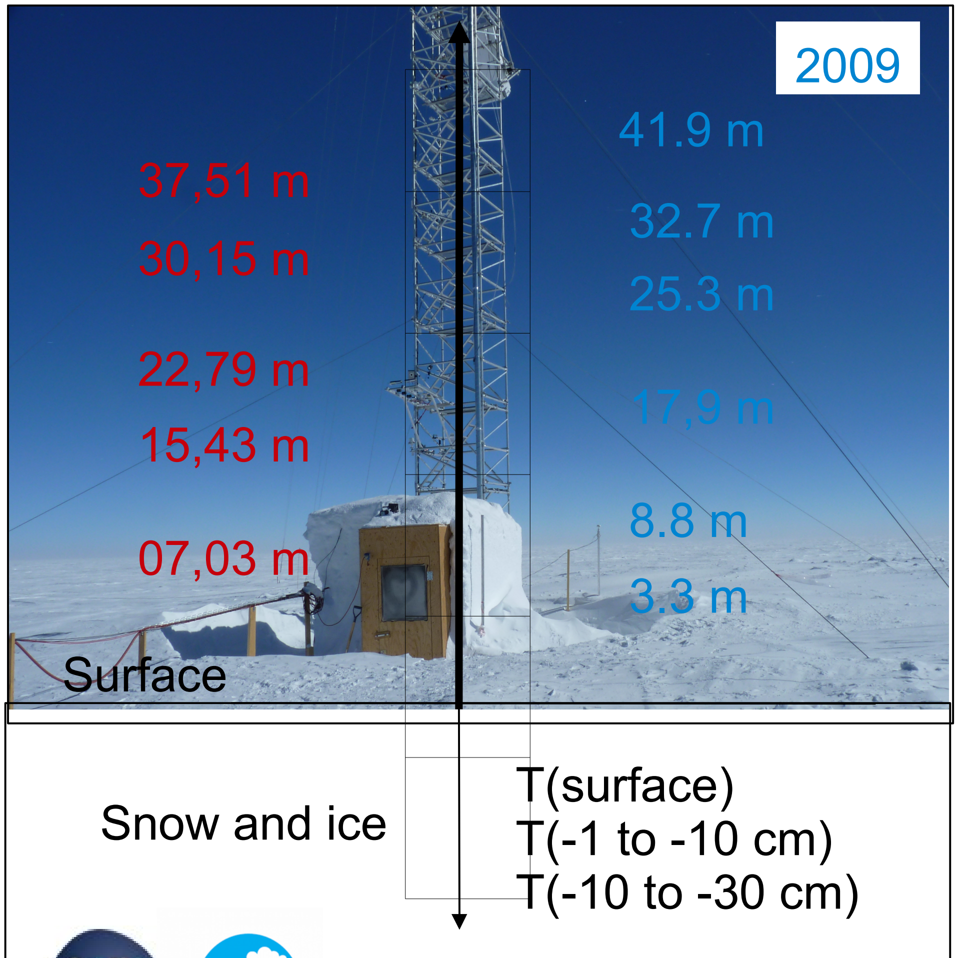
1. Meso-NH : Fleur Couvreux (Meteo-France/CNRS)
2. PALM : B Maronga (IMC, Leibniz Universitat, Hannover, Germany)
3. MicroHH: B. Van Stratum, C. Van Heerwaarden, (MPI & Wageningen U.)
4. JPL-LES : G. Matheou, Chinita Candeais (Propulsion Laboratory, NASA, USA)
5. SAM-LES : A Cheng (Center for Weather and Climate Prediction, NOAA, USA)
6. CLMM-LES : V. Fuka (University of Praha, Praha, Czek Republic)
7. NCSU-LES : S. Basu (North Carolina State University, USA)
8. UKMO-LES : J. Edwards (MetOffice)
9. DALES : A.F. Moene (Wageningen)
10. CSIRO: Jing Huang (Australia)

LSM:

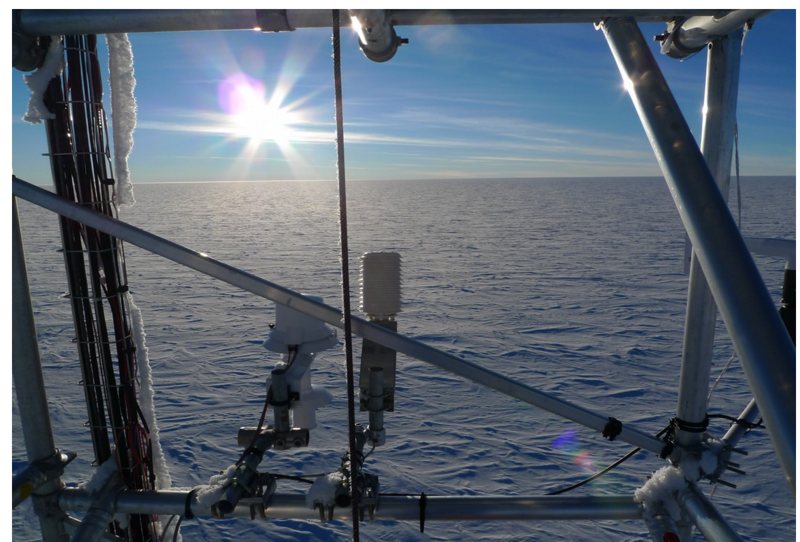
1. SURFEX : P. LeMoigne (Meteo-France/CNRS, France)
2. CAM5-IPHOC: Anning Cheng (Center for Weather and Climate Prediction, NOAA, US)
3. NCEP/GFS : Weizhong Zheng, Michael Ek (NOAA, US)
4. CMC : Ayrton Zadra (CMC, Canada)
5. IFS : E. Dutra, Irina Sandu (ECMWF)
6. LMDz : E. Vignon (LMD/LGGE, France)
7. UKMO-SCM : J. Edwards (MetOffice)

Observations: Antarctic Plateau Dome C / Concordia

« American » Tower



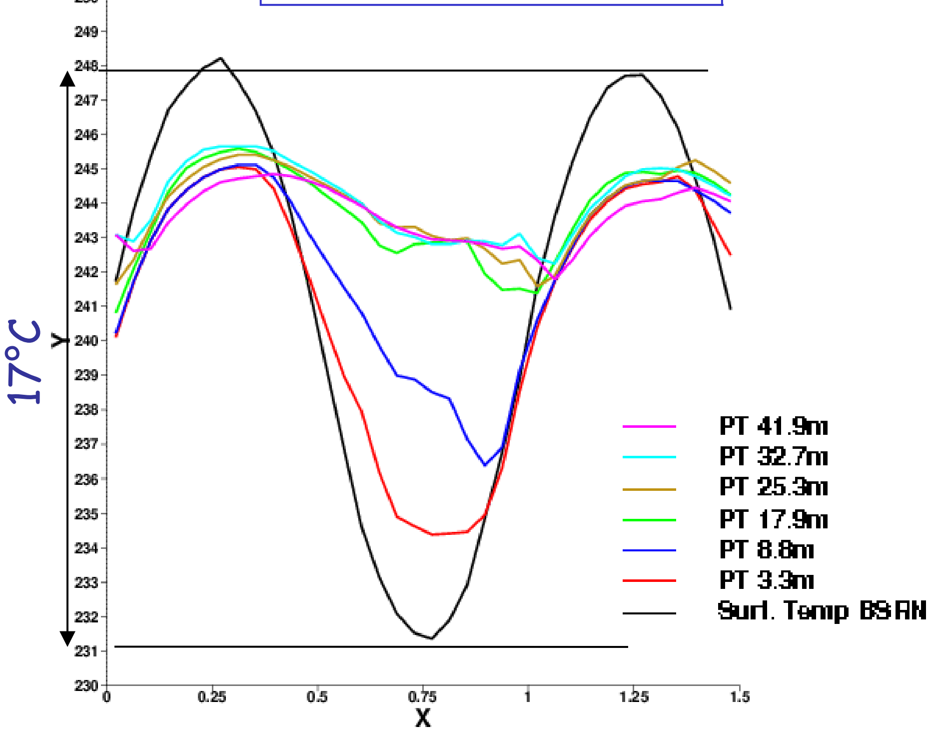
- High frequency parameters (10 Hz) from 6 ultra-sonic anemometers :
  3D Wind components and sonic temperature
- Low frequency parameters (30 min) : air temperature (ventilated and not ventilated), relative humidity, wind speed and direction (**Young**)
- 1 minute solar radiation components
- Sub and surface temperatures
- Radiometer HAMSTRAD (P. Ricaud)
- RS (1 or 2 per day)
- Alt=3233m



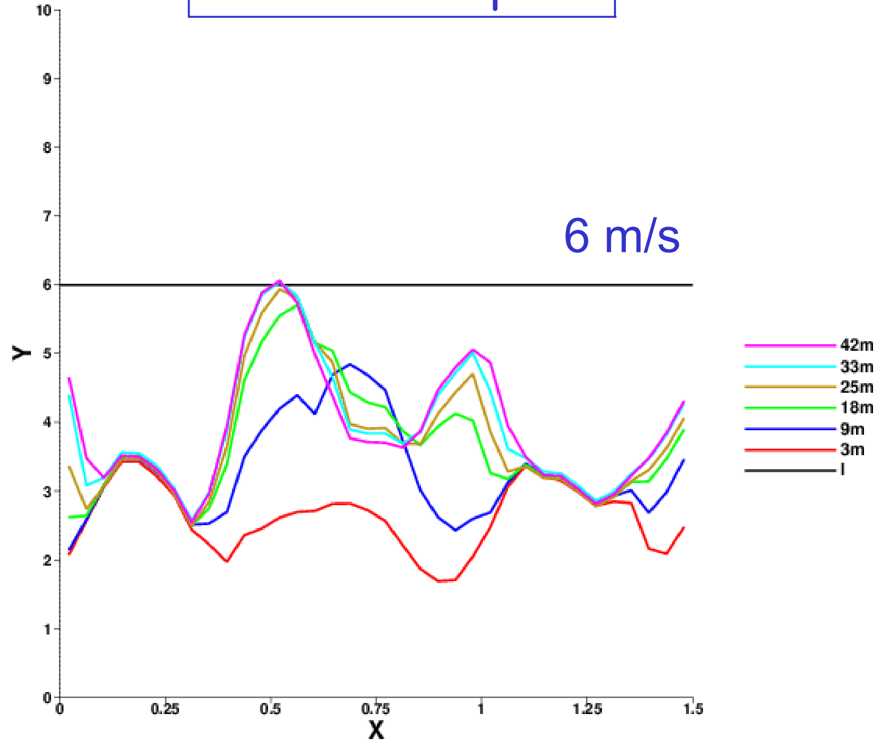
GABLS4

- Focus on very stable conditions with (Ri > 1), weak wind < 6 m/s, no cloud, strong radiative cooling ~ 1.5K/h (GABLS1 = 0.25K/h) and surface interaction

Mast temperature

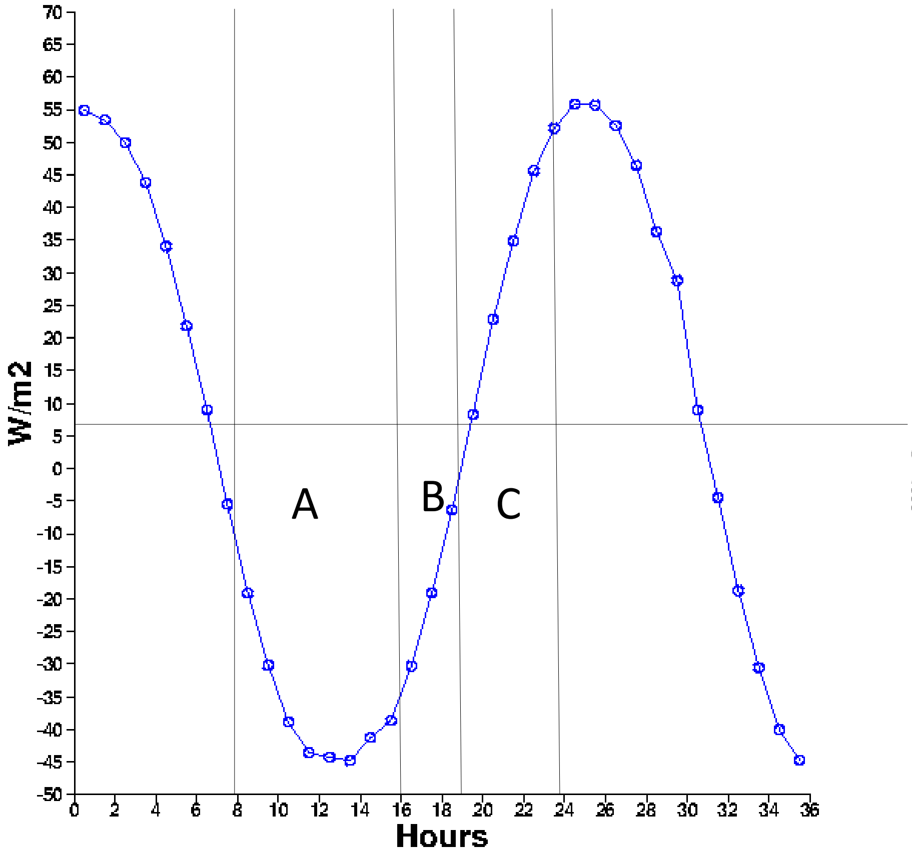


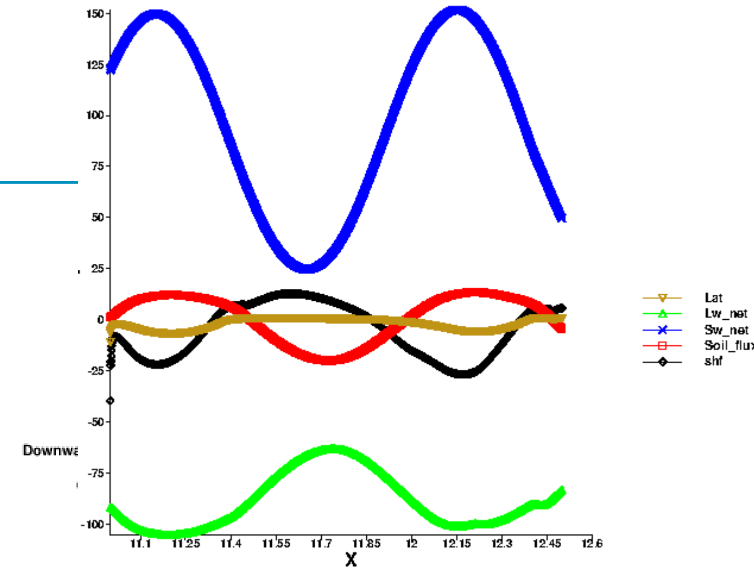
Mast Wind speed



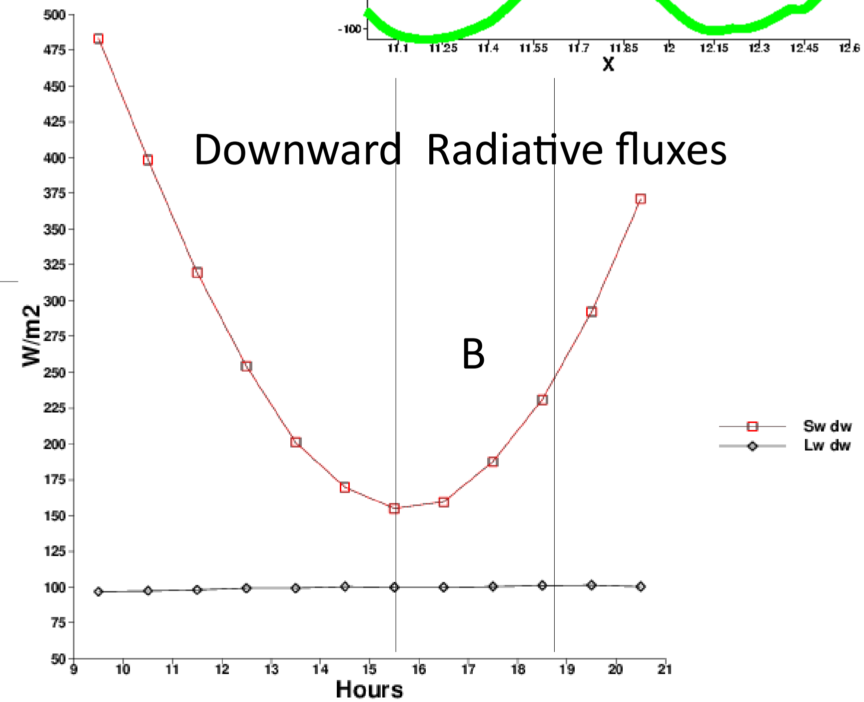
Surface budget

Net Radiative fluxes



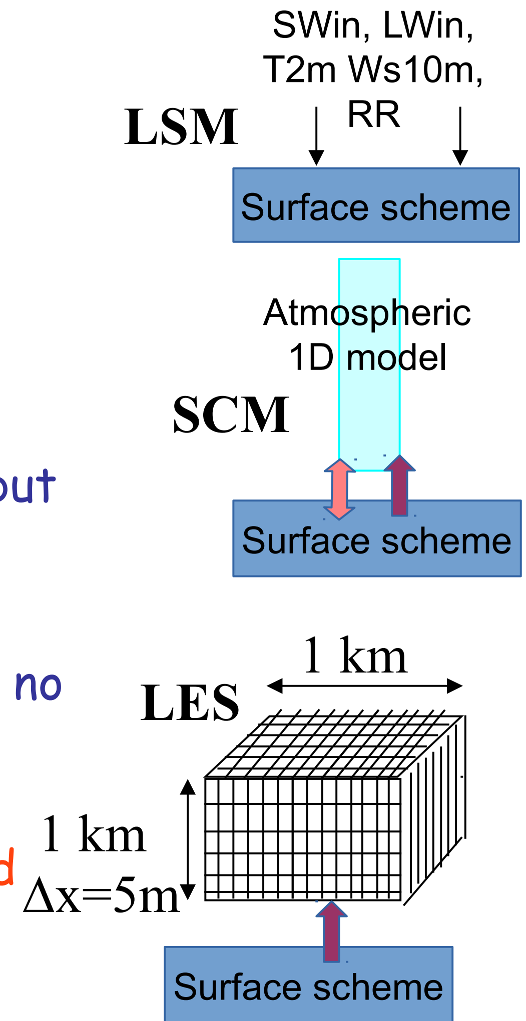


Downward Radiative fluxes



GABLS4: several steps & 3 intercomparisons

- **Stage 0:** LSM (snow scheme) driven by observations for 15 days
- **Stage 1:** SCM with all the physics and surface interaction: 36h forecast starting the 11th Dec 2009
- **Stage 2:** LES and SCM, stage1 atmospheric forcing but the surface temperature is prescribed.
- **Stage 3**: LES and SCM. "ideal GABLS4" or simplified: no radiation, no specific humidity, constant geostrophic wind, no advection, Ts prescribed.
- Can we use stage3 with the LES results to understand the SCM deficiencies in stage2 and stage1 ?



GABLS4: since September 2014

- 1st Workshop organized in Toulouse 20-22 May 2015:
  - GewexNewsletter Vol25 August 2015
  - Presentations and setup available on the GABLS4 website:

  www.cnrm-game-meteo.fr/aladin/meshtml/GABLS4/GABLS4.html

- From de workshop discussion → New setup for LSM, SCM and LES with :
  - prescribed albedo=0.81, z0m=1mm, z0h/q=0.1mm, Emis=0.98 and a given snow conductivity
  - for SCM : a prescribed vertical grid with a first level at 2.5m and 17 levels below 100m (dz ~ 5m)

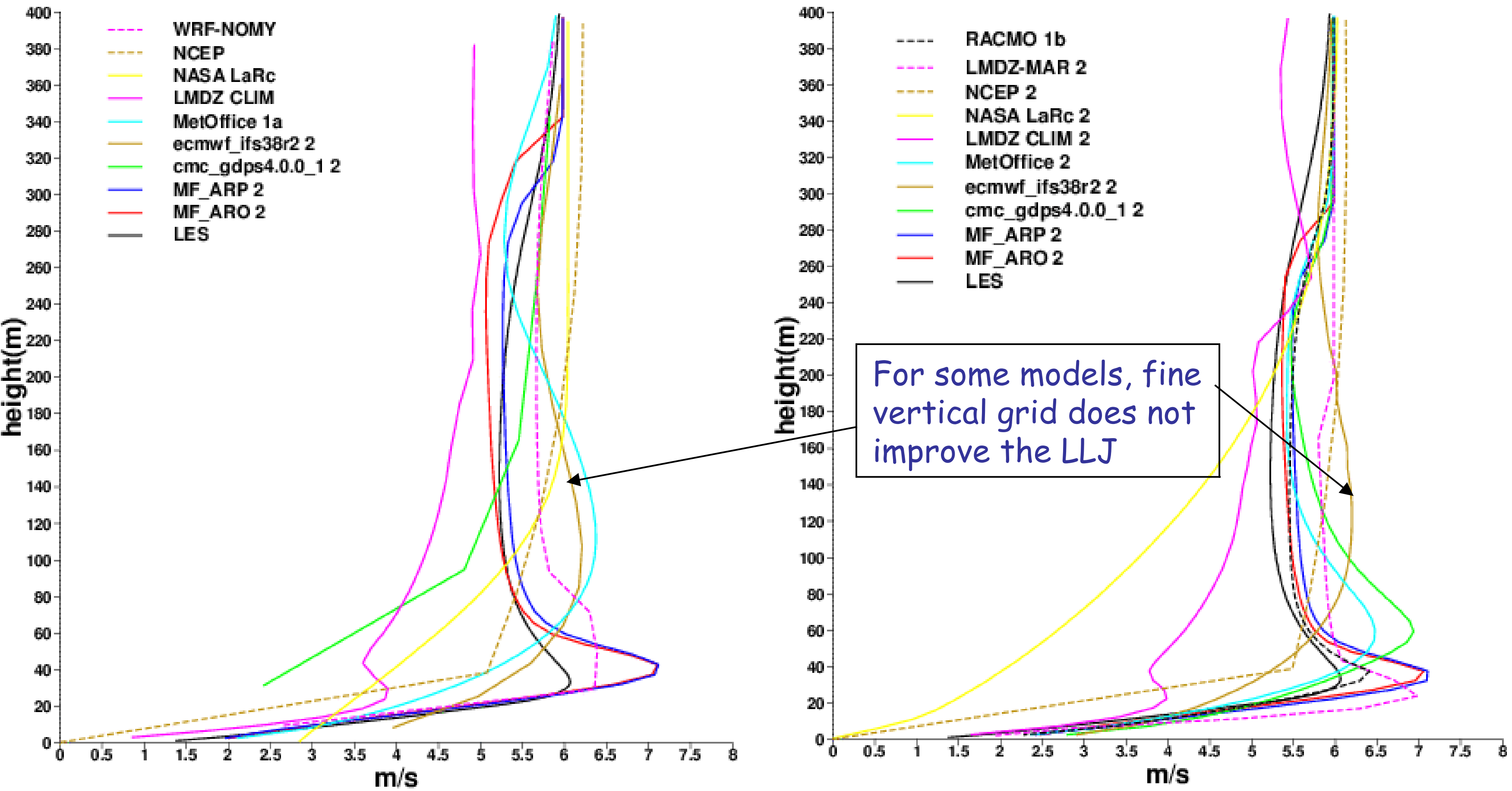
- 26 Oct. 2016: A specific "Shorten ideal case" for LES focusses ONLY on the night period → to "reduce" the uncertainties in the LES results for the stable part

- 31 March 2017 : GABLS4 day dedicated to LES during the Delft workshop organized by Bas Van de Wiel

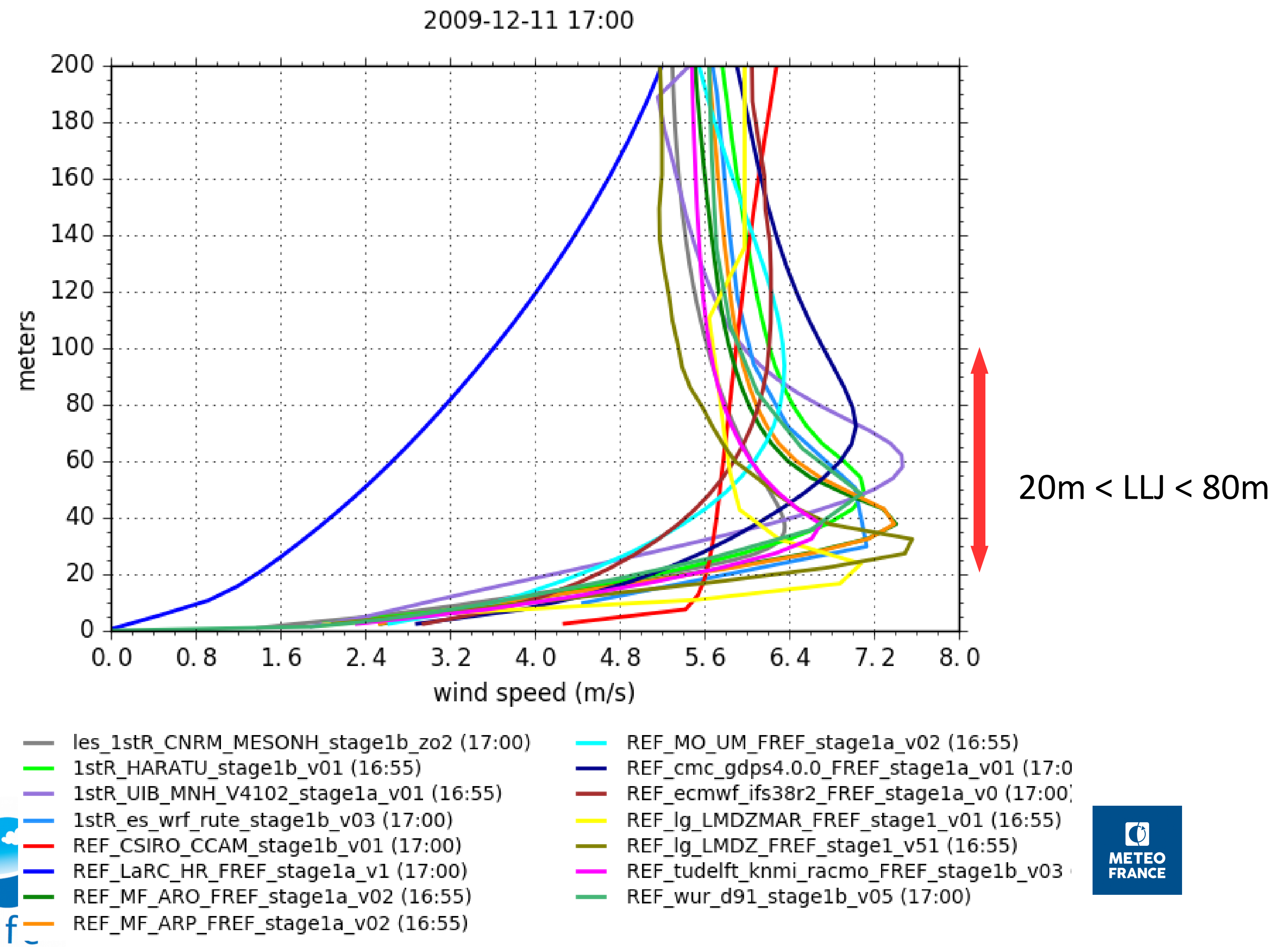
Impact of the new setup SCM

Ws at 18h UTC

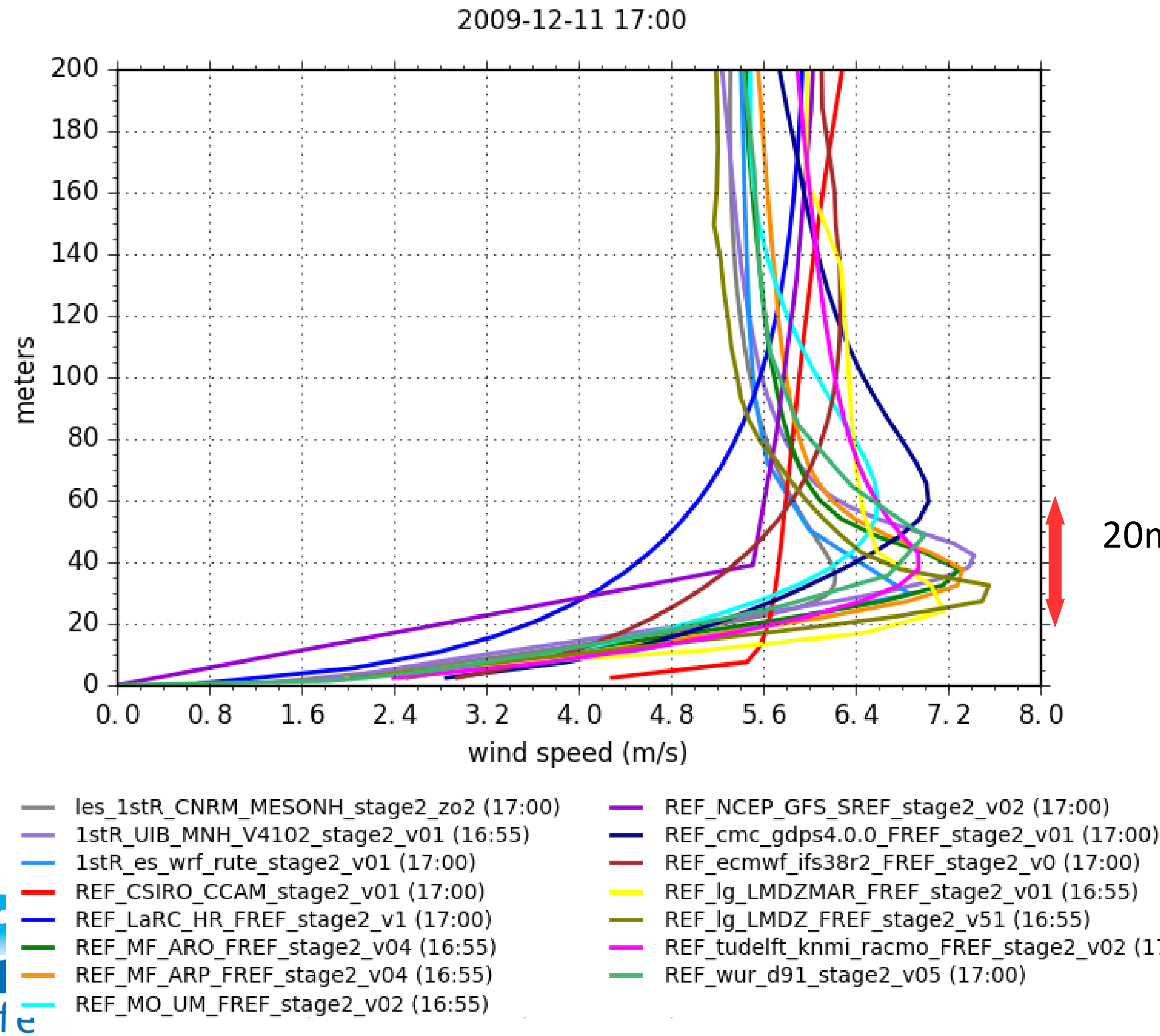
1st Simulations | New setup



Stage 1 : Wind Speed @ 17TU

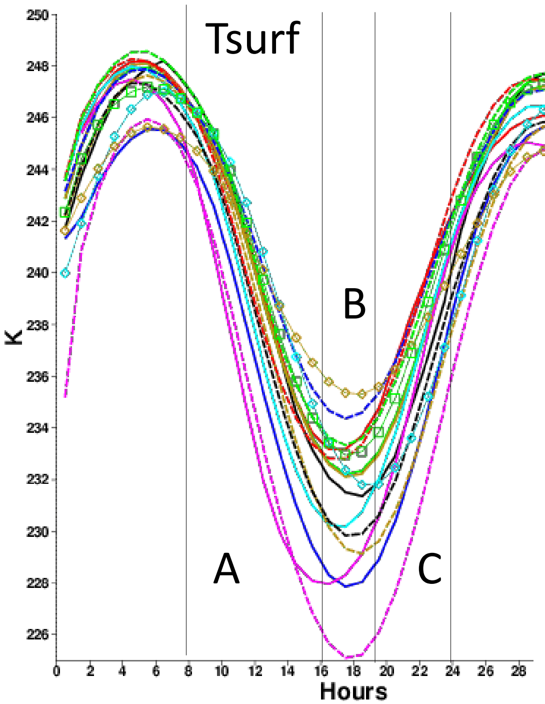


Stage 2 : Wind Speed @ 17TU

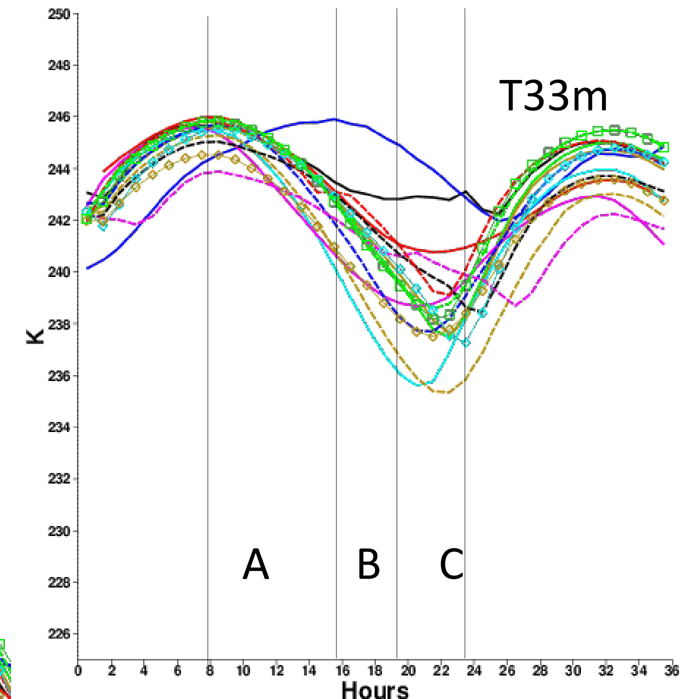


20m < LLJ < 60m

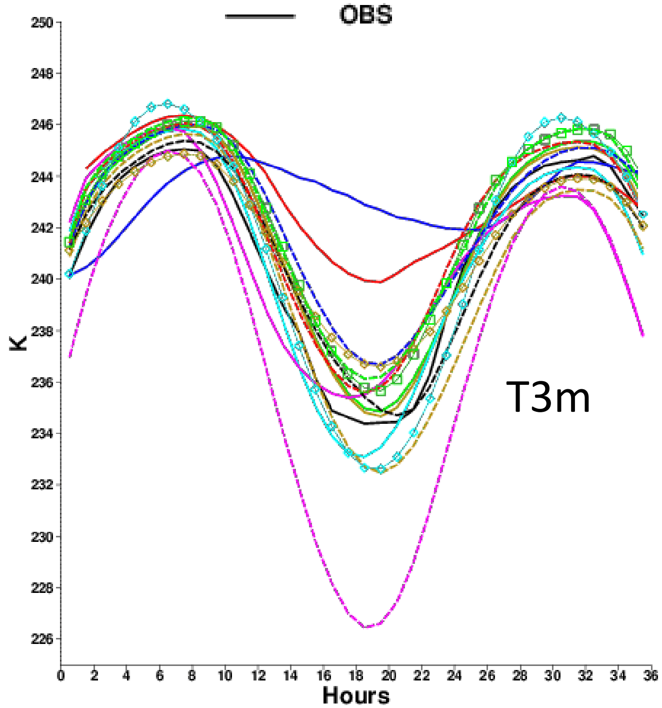
Stage 1 : Tsurf & T3m & T33m



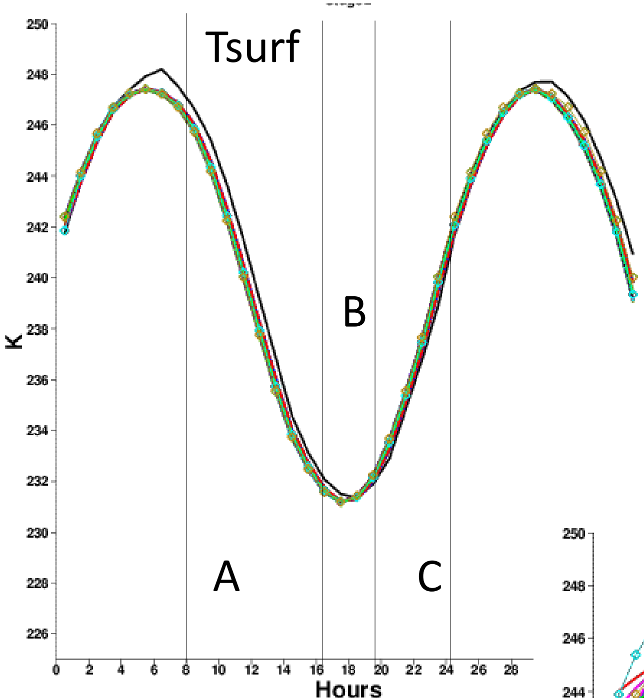
Phase A= Cooling
Phase B= Mixte
Phase C= Heating

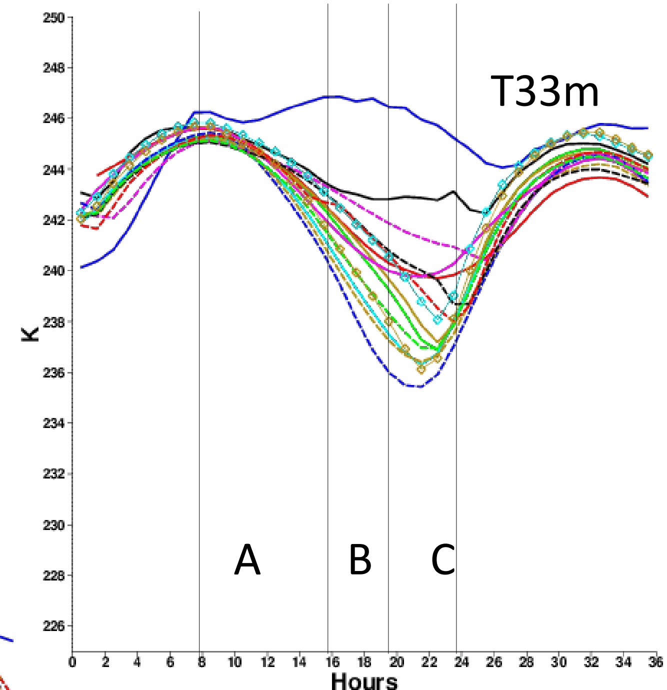


Phase A= Cooling
Phase B= Mixte
Phase C= Heating

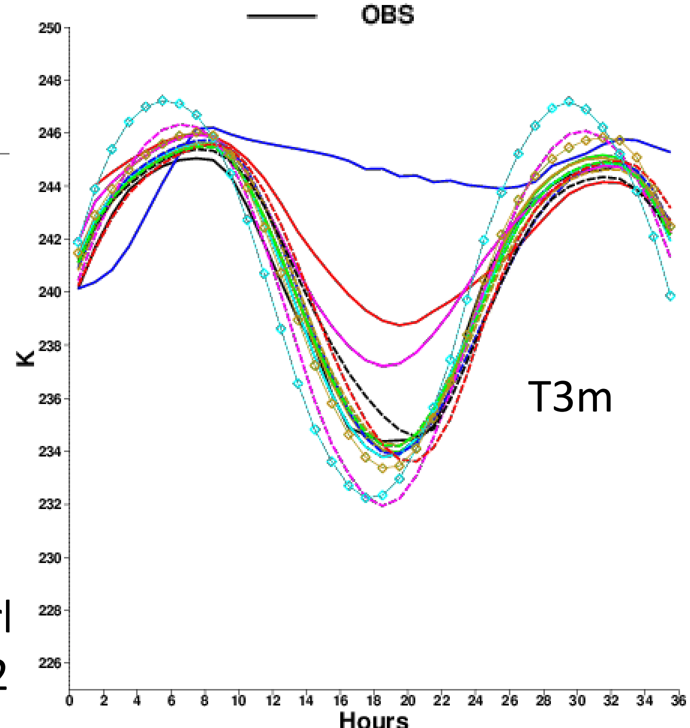


Stage 2 : Tsurf & T3m & T33m





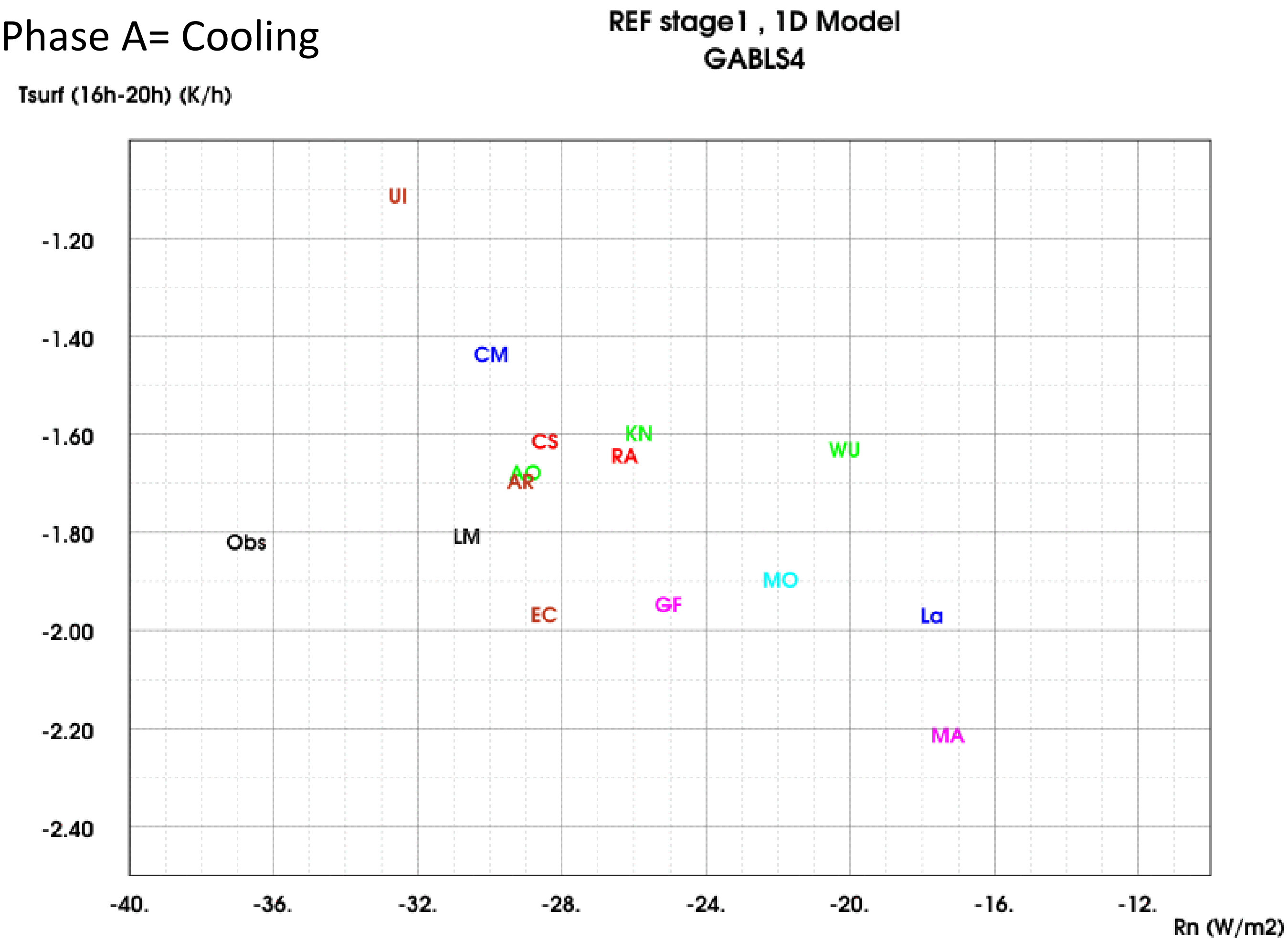
Phase A= Cooling
Phase B= Mixte
Phase C= Heating



Phase A= Cooling
Phase B= Mixte
Phase C= Heating

Tsurf tendency / Net Radiative Flux

Phase A= Cooling

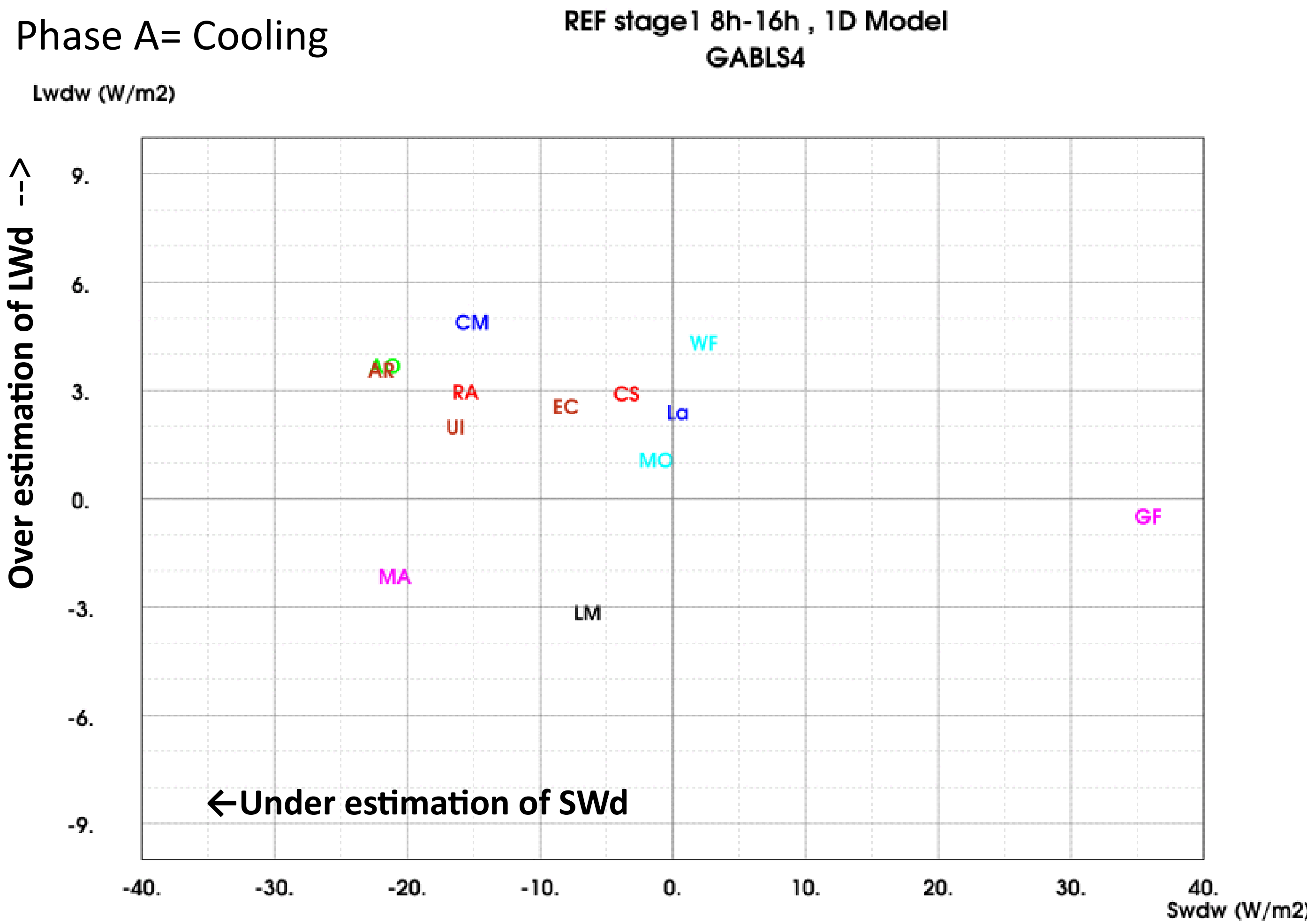


CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

Not enough radiative cooling for all models

LWdw bias / SWdw Bias

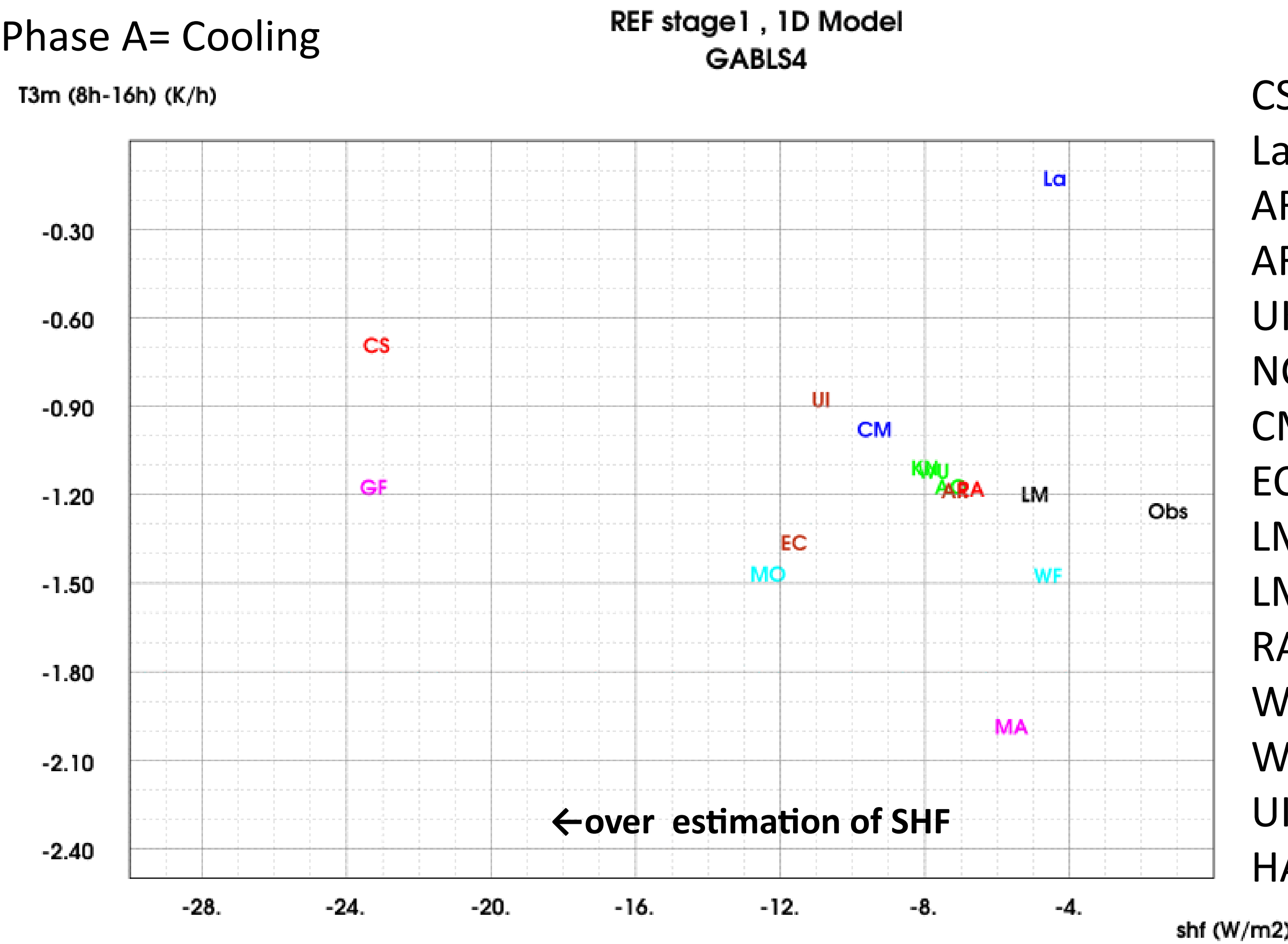
Phase A= Cooling



CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

T3m tendency / Shf (stage1)

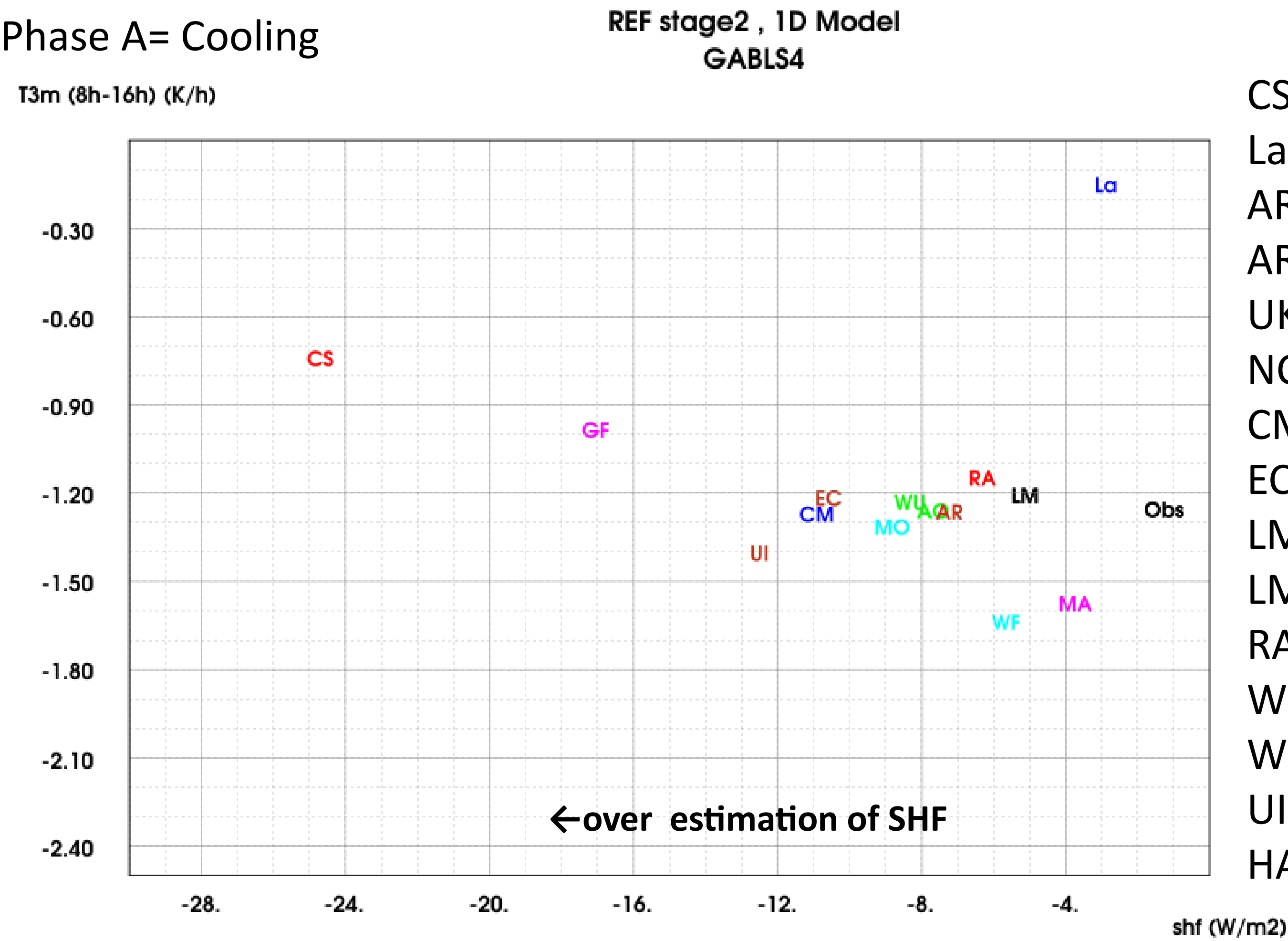
Phase A= Cooling



CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

T3m tendency / Shf (stage2)

Phase A= Cooling

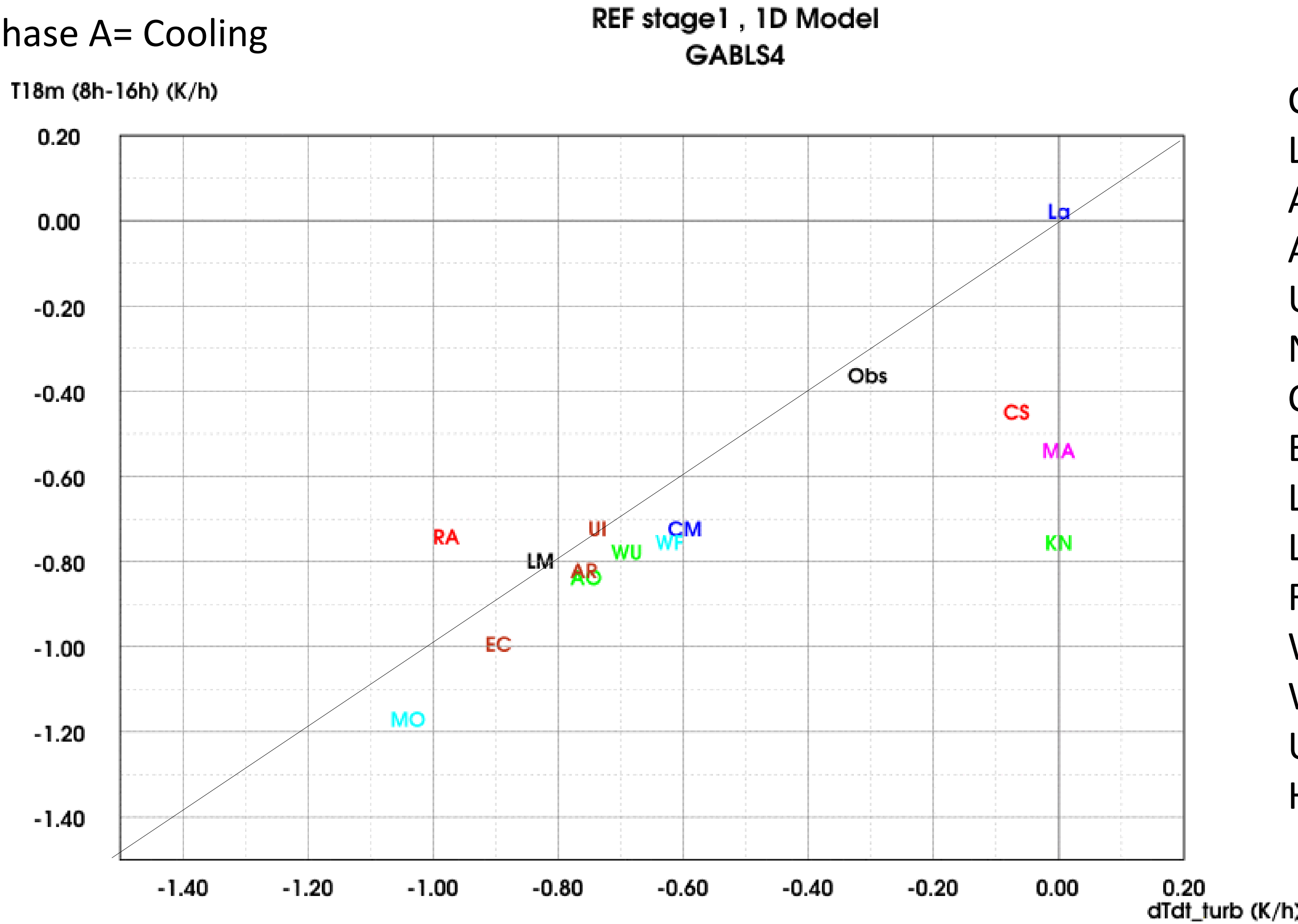


CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

Stage2 : better agreement for dT3m/dt than stage1

Temperature @ 18m (K/h) vs dT/dt_turb (stage1)

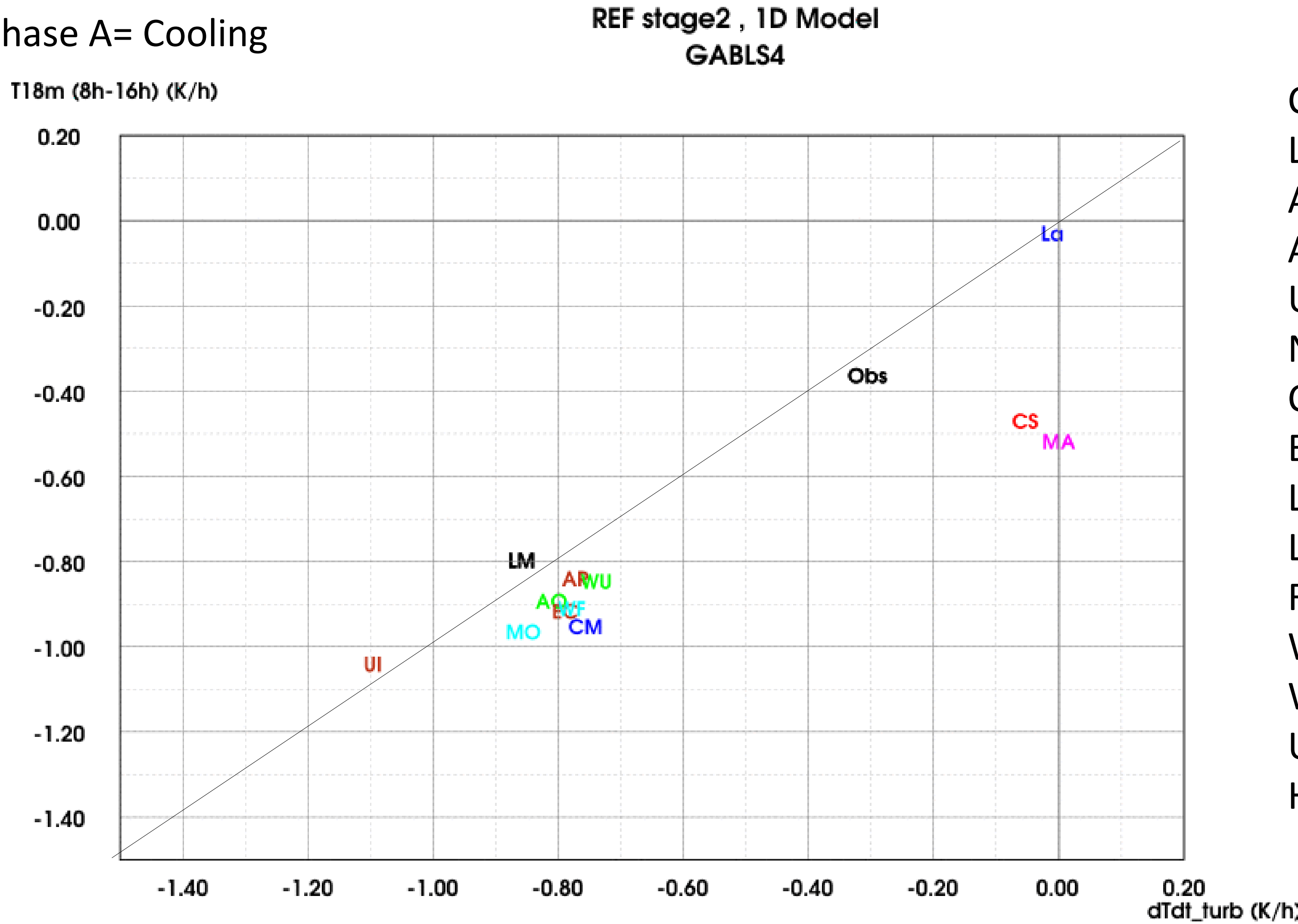
Phase A= Cooling



CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

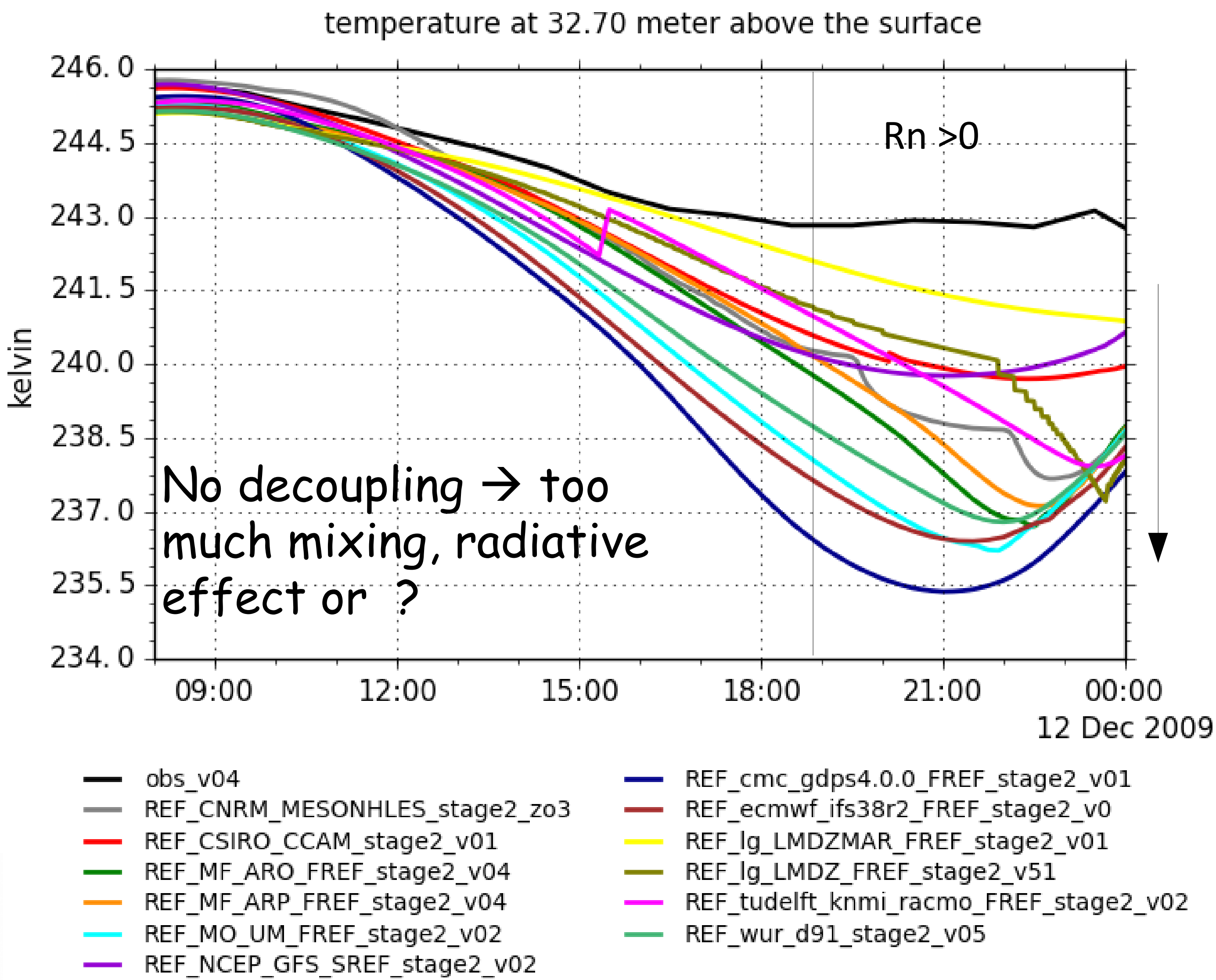
Temperature @ 18m (K/h) vs dT/dt_turb (stage2)

Phase A= Cooling



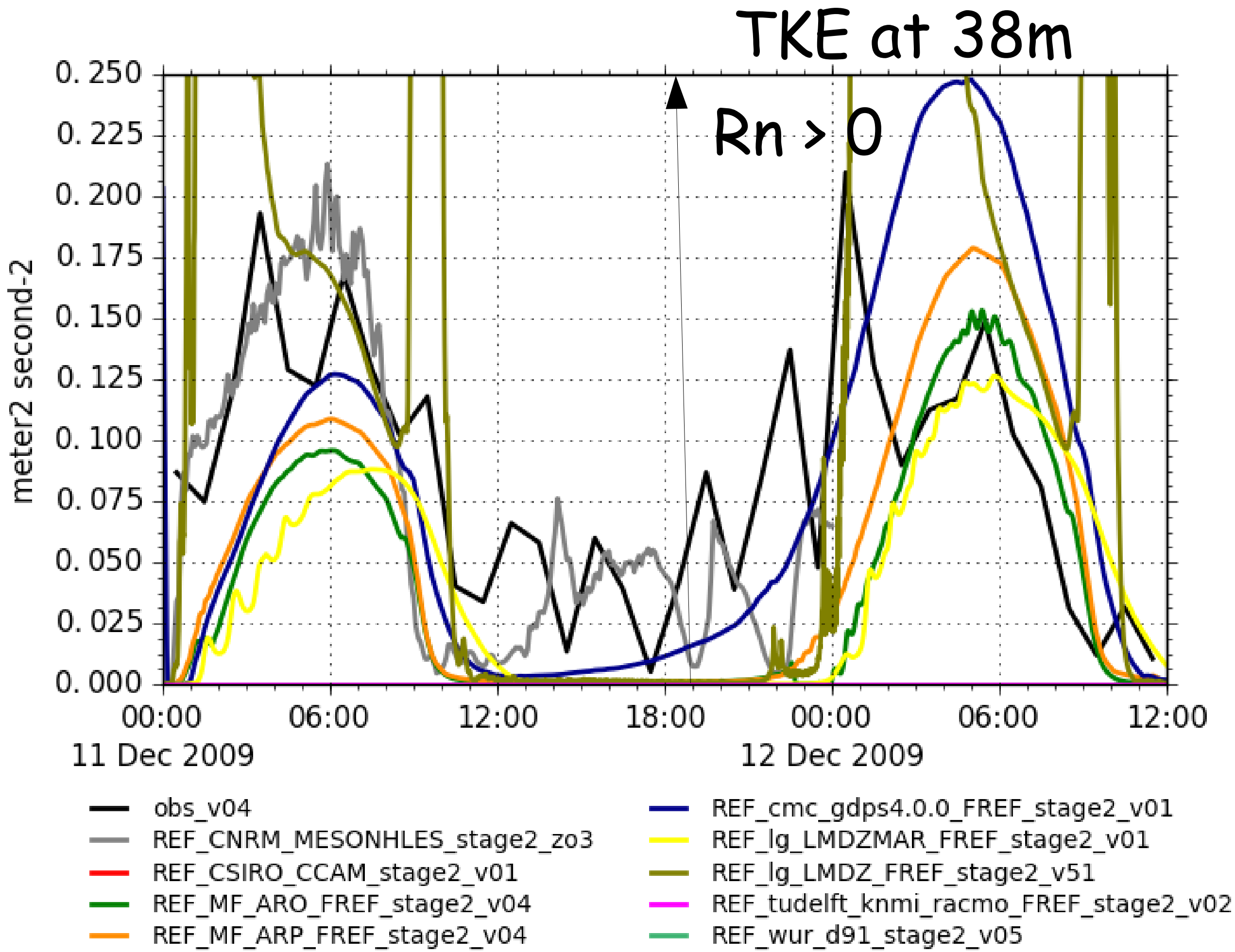
CSIRO_CCAM = CS
LaRC_HR= La
AROME = AO
ARPEGE = AR
UKMO = MO
NCEP_GFS = GF
CMC = CM
ECMWF = EC
LMDZMAR =MA
LMDZ = LM
RACMO = RA
WUR_D91 = WU
WRF_RUTE = WF
UIB_MNH = UI
HARMONIE = KN

Phase C : warming (Rn>0) stage2



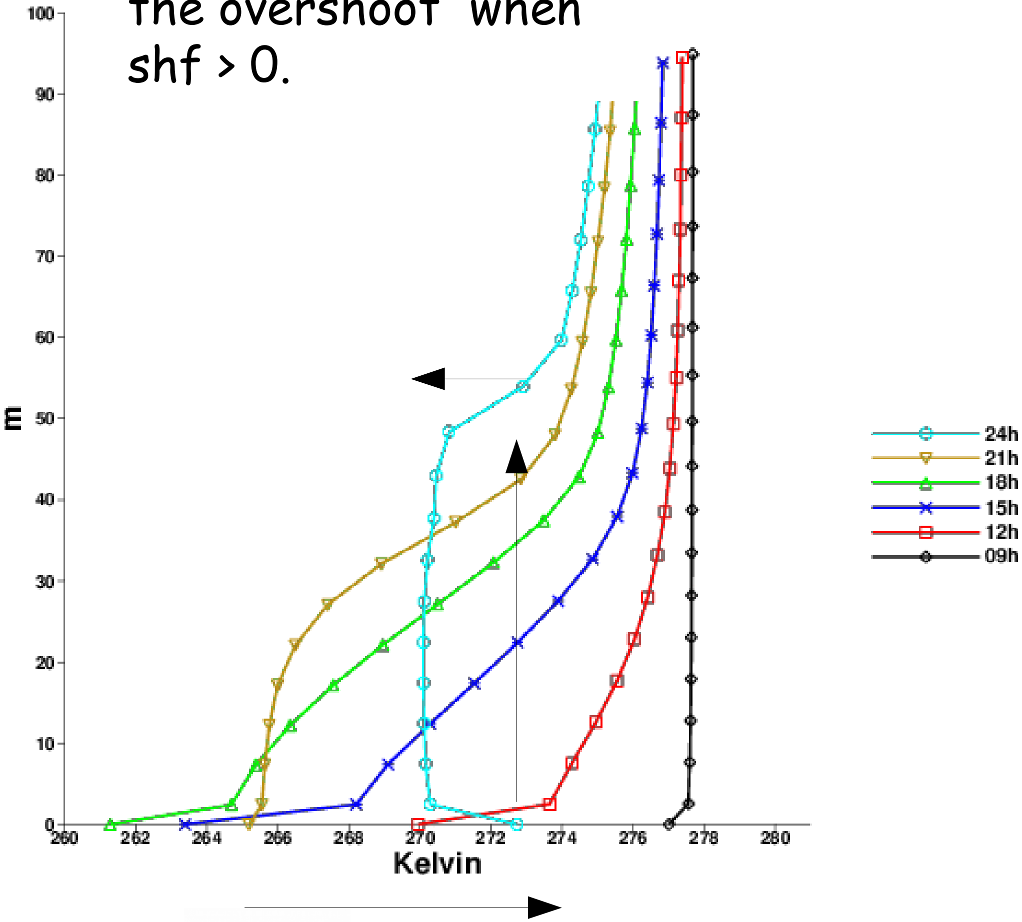
Comparison with the mast data : stage 2

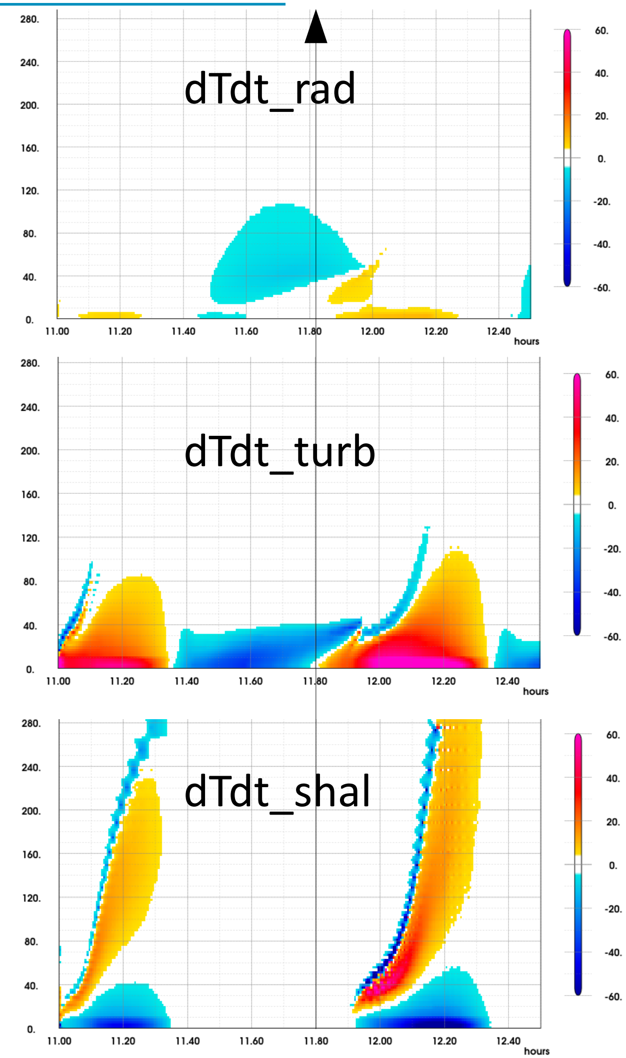
TKE underestimated during night for almost all the SCM



Analysis of cold bias > 20m : phase C

Strong cooling due to the overshoot when shf > 0.

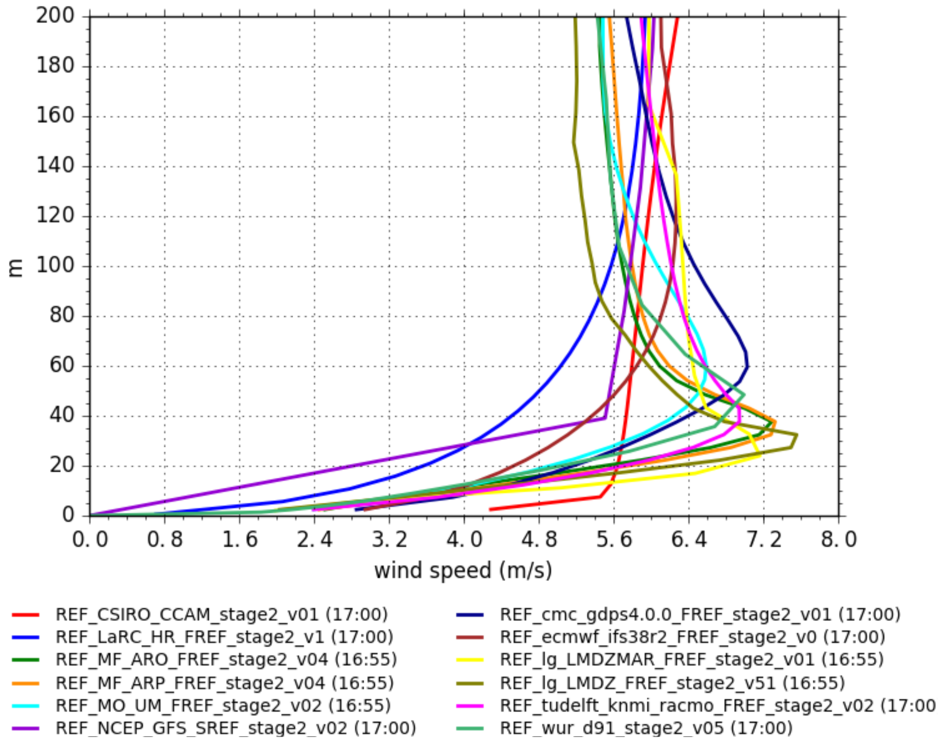




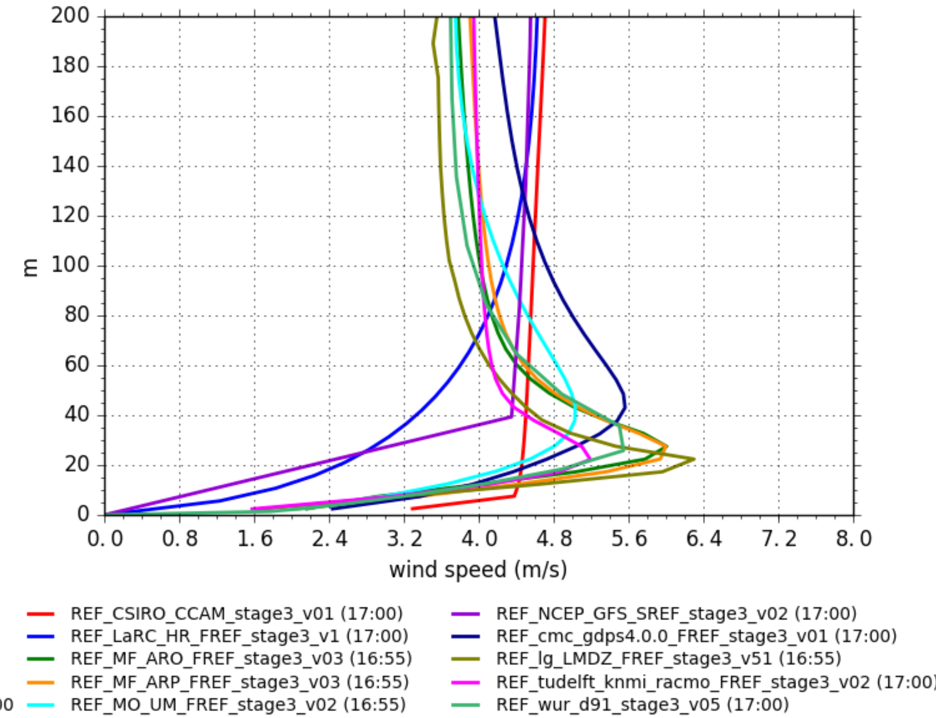
12th Workshop on Antarctic Meteorology and Climate
June 26-28, 2017 NCAR, Boulder, Colorado USA

GABLS4 : comparison between stage2 & stage3

Stage 2 : WIND 17h

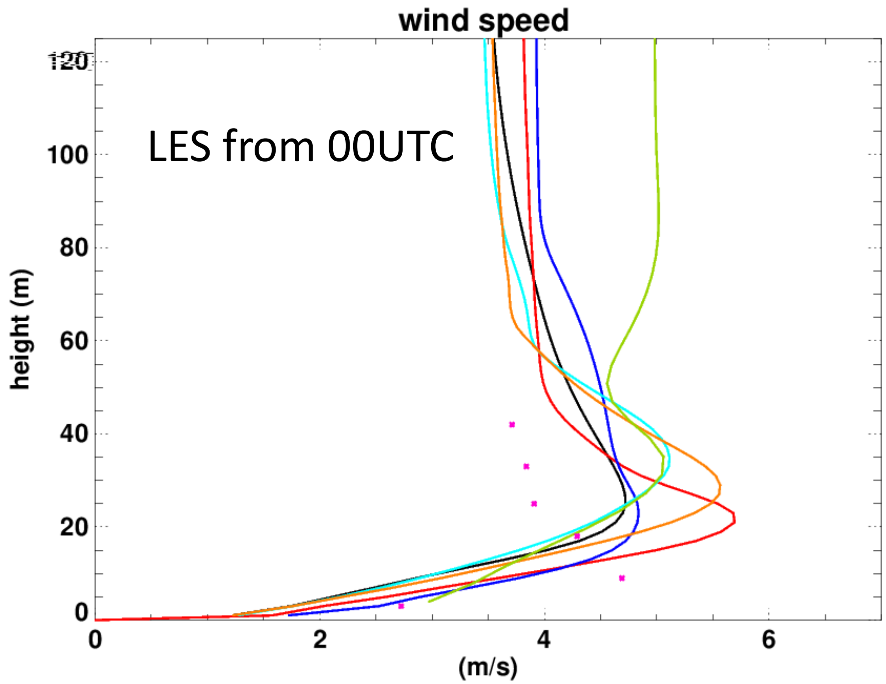


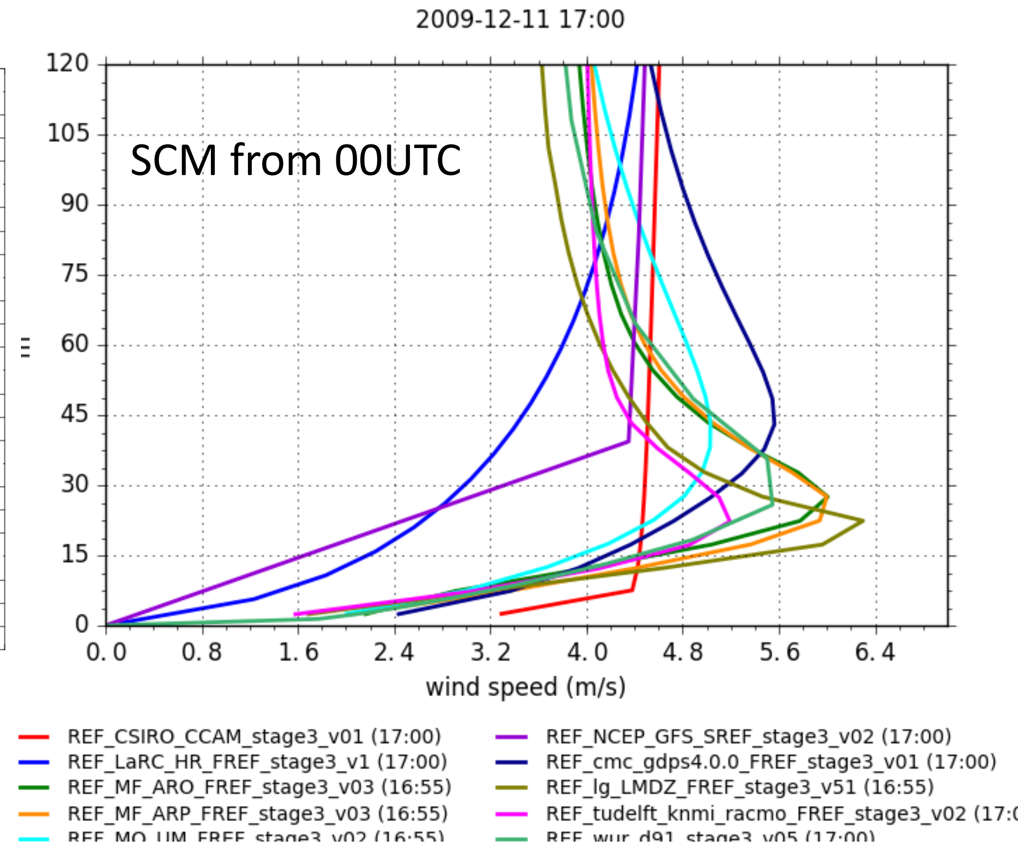
Stage 3 : WIND 17h



The « ideal case » or stage3 is representative to the real case and the differences between 1D models are similar → comparison between SCM and LES on stage 3 will be very useful …

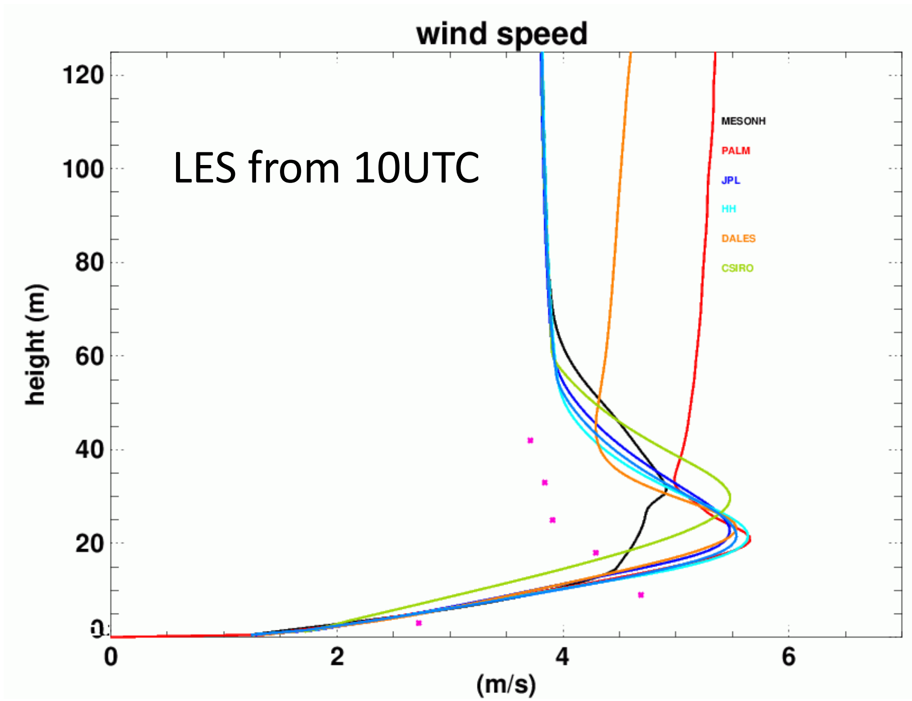
Stage 3: SCM results vs LES @ 17TU

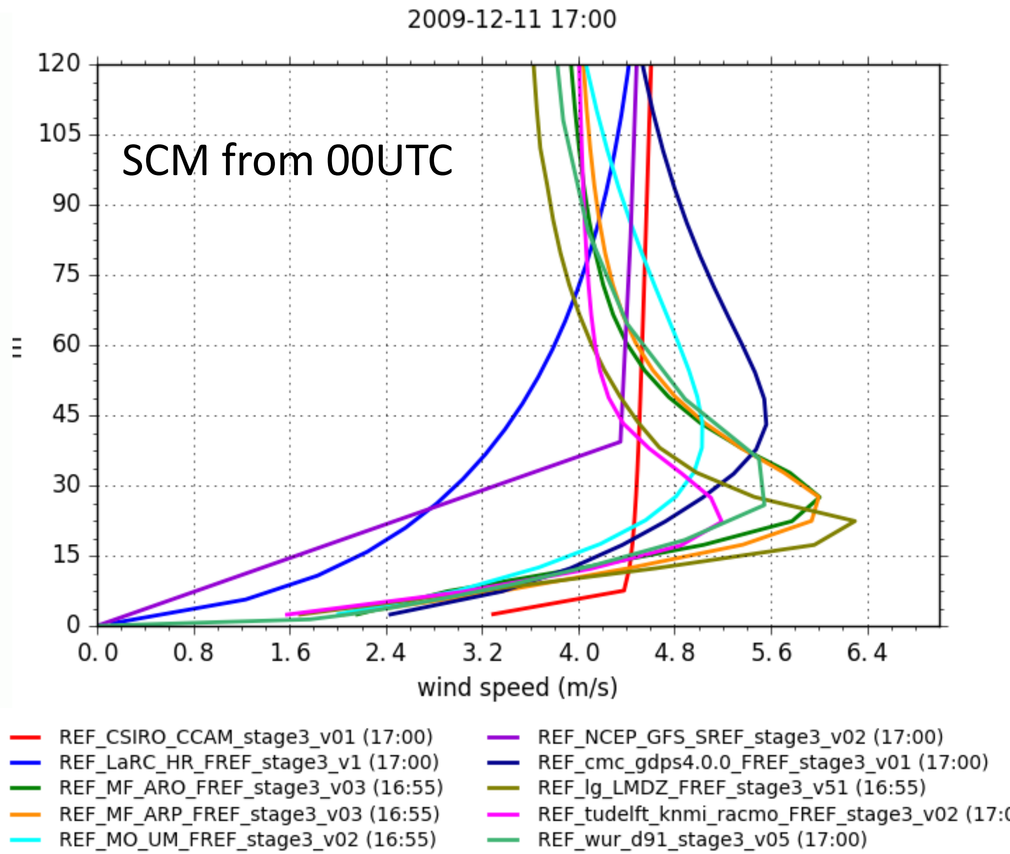




Less variability in LES than SCM output, nevertheless the differencies in LES should be investigated → for LES a « shorten ideal case » was designed ONLY for the stable part

Stage 3: SCM results vs LES @ 17TU

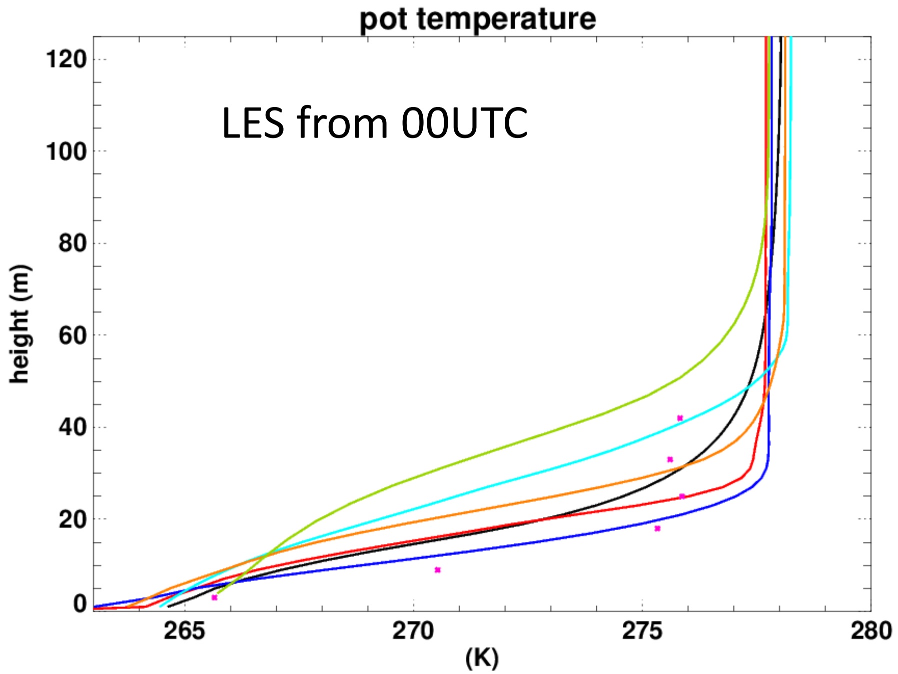


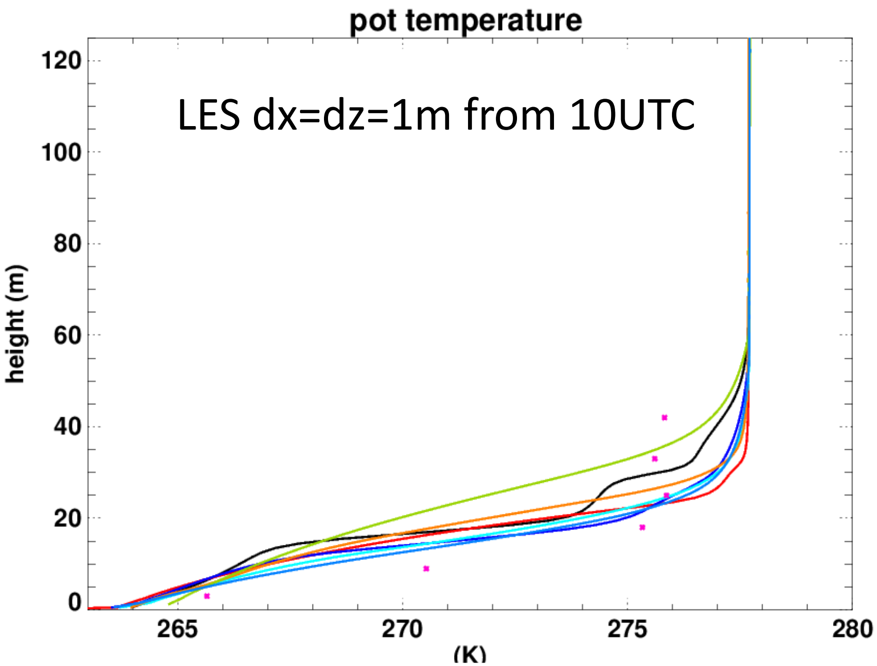


LES based on the « shorten ideal case » : LLJ ~ 20m

Some SCM around 20-30m but more variability ...

Stage 3: SCM results vs LES @ 17TU





The new « ensemble » LES results based on the shorten ideal case reduce the uncertainties → increase the confidence for using LES to validate the SCM in stage 3 …

Summary ...

a) The new setup provides a "cleaner" framework for SCM intercomparison. Although some models do not use the prescribed albedo.

b) Compared to the GABLS1 results, almost all the models are potentially able to create a LLJ even if the LLJ is too high …

c) Stage 2 vs stage1 shows that a prescribed Ts, improves temperature, reduces the variability among SCM but ONLY below 20m.

d) Not enough radiative cooling at the surface for all the models. Underestimation of the SW_dw for many models, the Lw_dw is slightly overestimated by 3 W/m2

Summary ...& plans

a) The cooling observed above 20m comes from:
   a) Turbulence (2/3) & radiation (1/3) for phase A for many models.
   b) Turbulence (or mass flux) for phase C (overshoot)

b) Stage 3 : similar to stage 2 for SCM : height of LLJ, theta profile, **stage 3, with several LES, is very useful for additional SCM evaluation, especially for fluxes not available from observations.**

c) **Even at 1m, turbulence structures (in LES) are still barely resolved at night→ need still a higher resolution for a better convergence in LES result: it is also a challenging case for LES**

d) Next step: Publications and probably a "final" workshop in 2018 ?

Acknowledgements:

The meteorological profiling observation program at Dome C which provides data for model evaluation / validation for GABLS4, is supported by IPEV (program CALVA), CNRS/INSU (program CLAPA) and OSUG (program CENACLAM). The IPY-CONCORDIASI program, supported by CNES, IPEV and CNRS, provided the rawindsonde data

People responsible of the observations at DomeC and those who provided the data for the chosen period : Eric Aristidi (Laboratoire Lagrange, Université Nice Sophia Antipolis, France), Christian Lanconelli (ISAC/CNR, Italy), Ghislain Picard and Laurent Arnaud (LGGE, Grenoble, France), Andrea Pellegrini (ENEA, Italy) and Laura Ginoni. We also thanks Eric Brun (Météo-France,CNRM/GAME) and Irina Sandu (ECMWF) as a most valuable beta tester for the atmospheric forcing used in the SCM.

This work is supported by the french national programme LEFE/INSU

http://www.umr-cnrm.fr/aladin/meshtml/GABLS4/GABLS4.html