GABLS4: an intercomparison case to study the stable boundary layer with surface interactions on the Antarctic plateau.

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A.A.M. Holtslag (WU), G. Svensson (SU), T. Vihma (FMI) and …

Outline

- Motivations
- Why the Antarctic Plateau and DomeC ?
- Intercomparison case:
  - Large scale forcing
  - 1D (SCM) and snow scheme (LSM)
  - LES intercomparison
- Acknowledgments and questions ?

Motivations

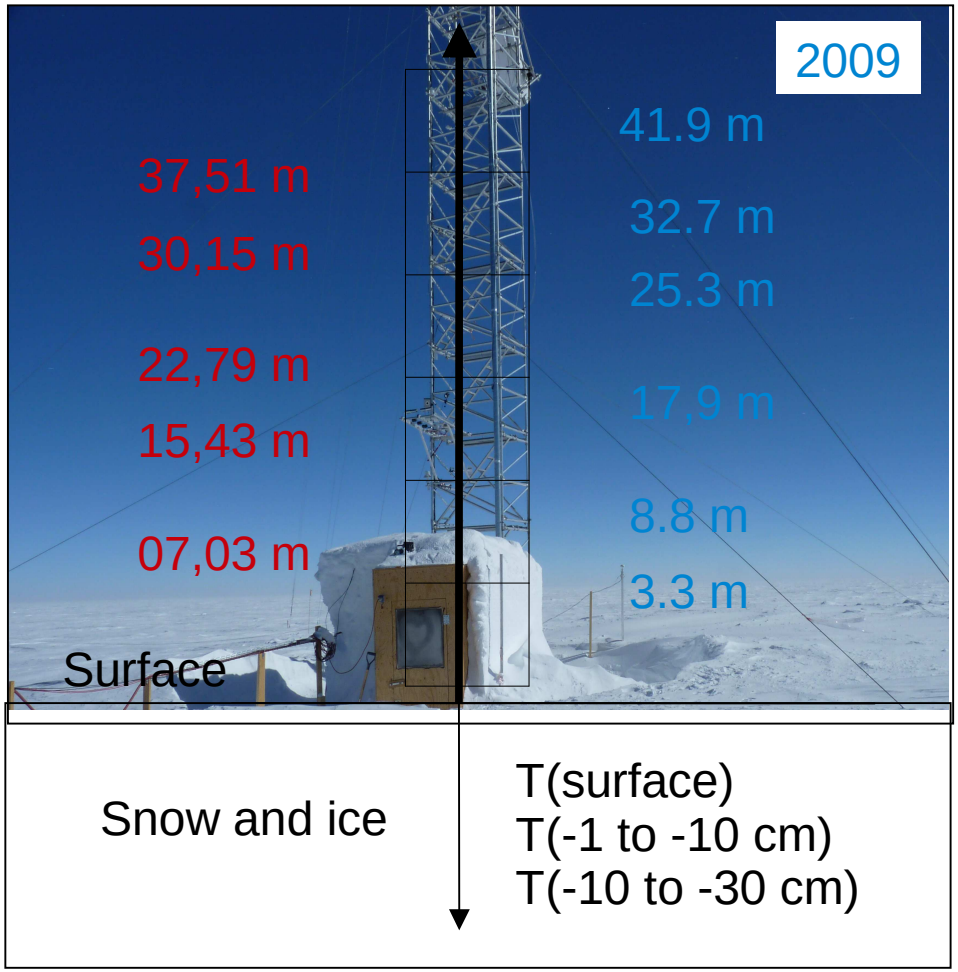
- Under strongly stable stratification and depending on the parametrization used, GCM/NWP models still have an excess of mixing or strong decoupling with the surface → warm or cold bias (Holtslag et al 2013)
- Some NWP models use a Turbulent Kinetic Energy (TKE) scheme such as ARPEGE, AROME, WRF, DWD, but under strong stable conditions the TKE is underestimated
- Following Galperin et al 2007 and Zilitinkevich et al 2008 turbulence survives for Ri>>1.
- Study the transition and the decay of the turbulence… same behaviour with the BLLAST data (see http://bllast.sedoo.fr/) ?

Motivations

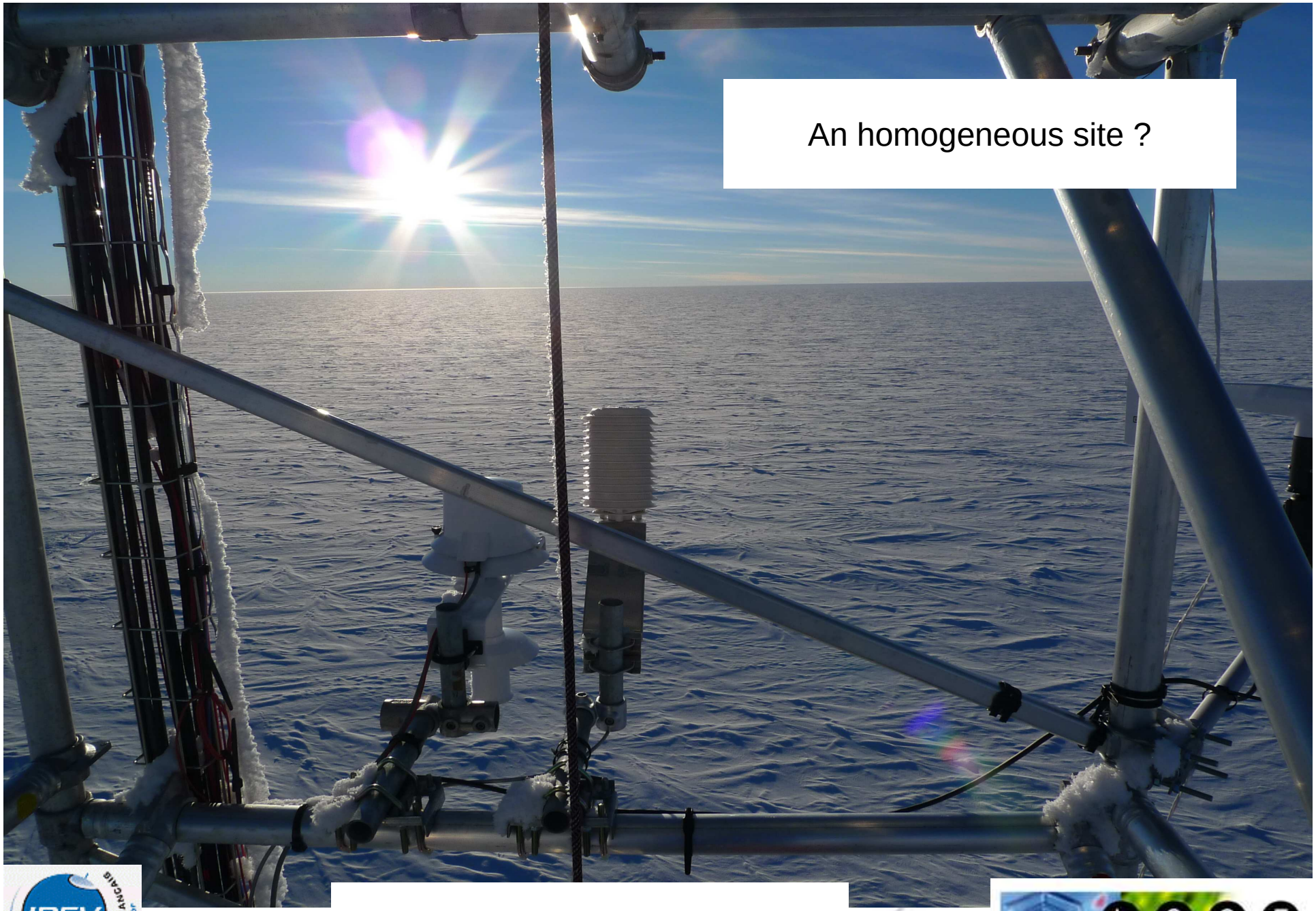
- 3 previous GABLS (GEWEX Atmospheric Boundary Study) case:
  - GABLS1 (Cuxart et al. 2006, BLM) ideal case only turbulence (Ri~0.25) Ts prescribed
  - GABLS2 (Svensson et al 2011, BLM) diurnal cycle (Ri ~0.2/0.4) Ts prescribed
  - GABLS3 (Bosveld et al 2012, Ecmwf proceedings) composite case from Cabauw data : surface scheme with initial Bowen ratio (Sh/Lh) with (Ri ~0.4/0.6)

- GABLS4 : Stronger Ri > 1, surface interaction, easier initialization only temperature, surface fluxes, TKE observed, 2 radiosondes per day, mast data, …

Observations: Antarctic Plateau Dome C / Concordia



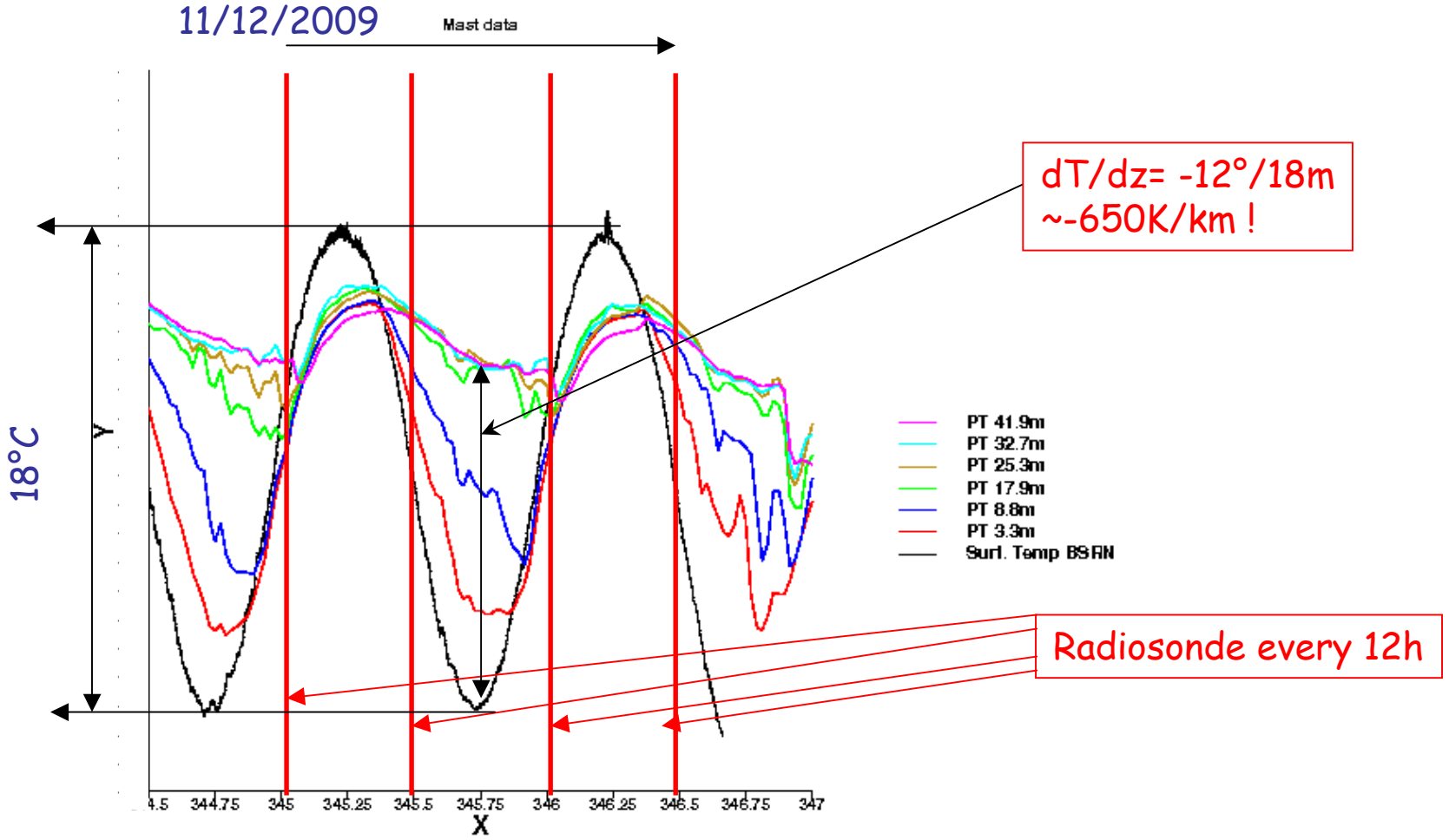
- High frequency parameters (10 Hz) from 6 ultra-sonic anemometers : 3D Wind components and sonic temperature
- Low frequency parameters (30 min) : air temperature (ventilated and not ventilated), relative humidity, wind speed and direction (**Young**)
- 1 minute solar radiation components
- Sub and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



LGGE tower 45m

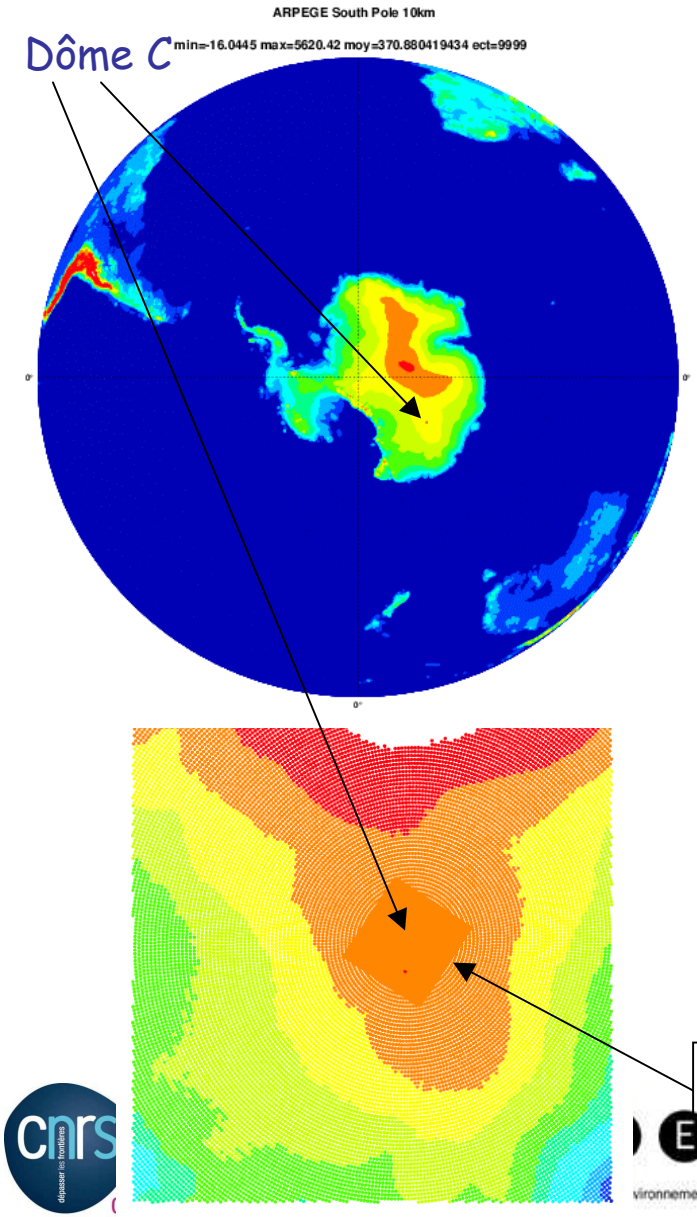
Laboratoire de Glaciologie et Géophysique de l'Environnement

Temperature evolution (Mast data)



Case study

Large scale forcing



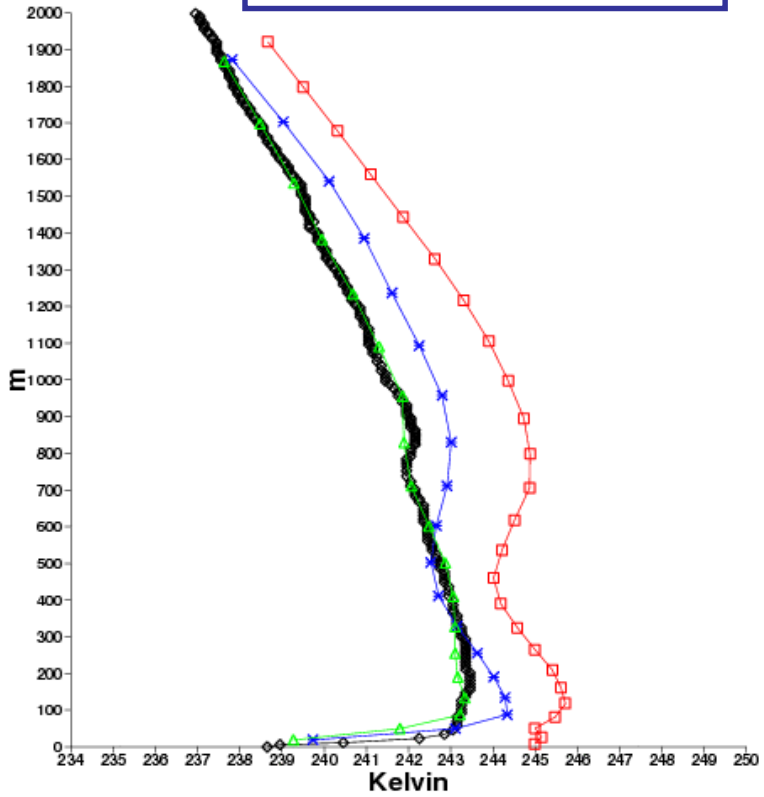
Lateral boundary condition (LBC) from a 4DVAR re-analysis done with the global model ARPEGE stretched on the south pole (10km)
(used and available for the Concordiasi experiment):

- Improvement of the snow scheme
- Using radiosonde at 00UTC and 12UTC (not used in the operational real time analysis in 2009) and all the levels of the sounding data

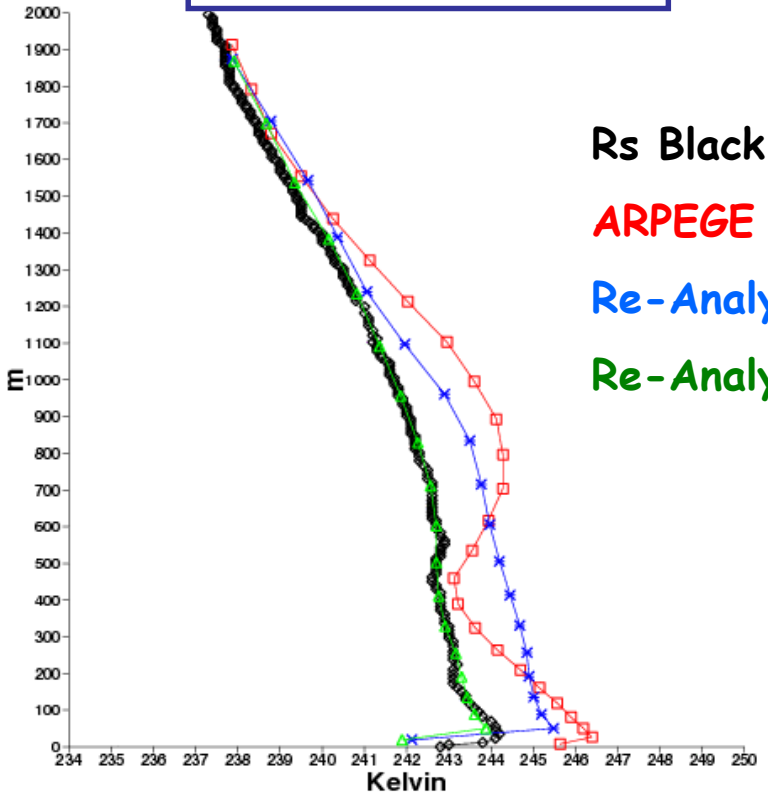
- **Forcing terms:** computed with several experiment done with a LAM at 2.5 km AROME (Seity et al, 2011) and with the ARPEGE physics at 2.5km. Two configurations: 60 vertical levels with a time step=60s (SL) and 90 vertical levels with 45s..

Temperature (Kelvin)

20091211 at 00UTC



20091211 at 12UTC



Rs Black line

ARPEGE oper Analysis

Re-Analysis Guess

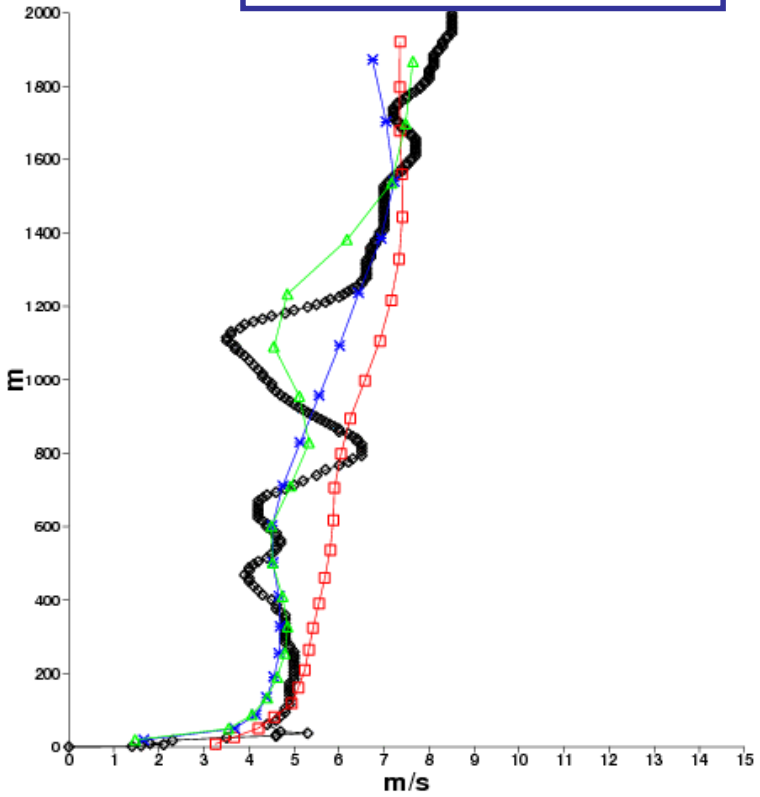
Re-Analysis 4DVar

Analyse oper (red line)

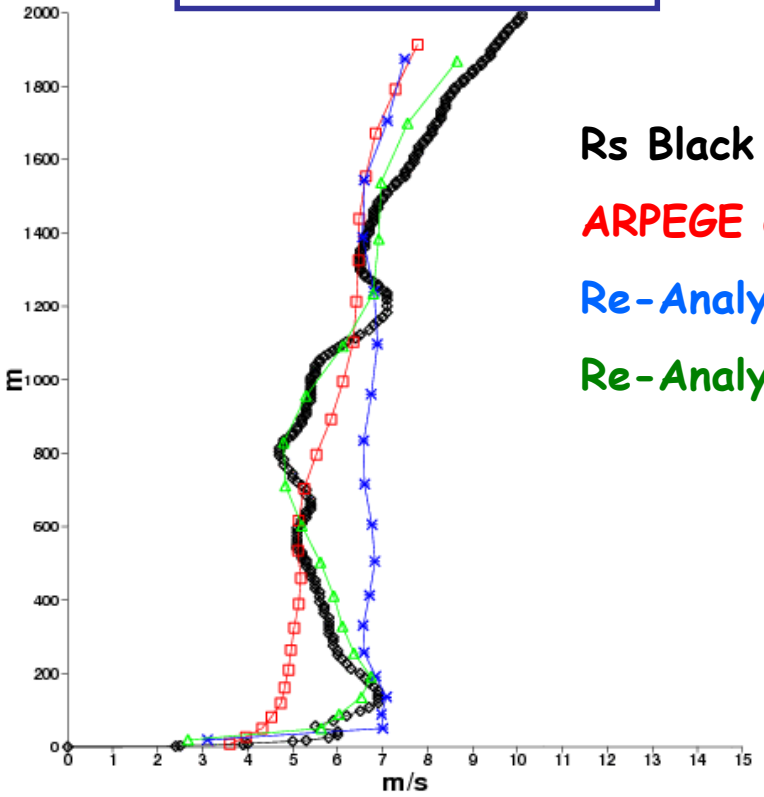
4DVar re-analysis done with ARPEGE stretched over the Antarctic Plateau (10km) with high resolution of RS

Wind Speed (m/s)

20091211 at 00UTC



20091211 at 12UTC



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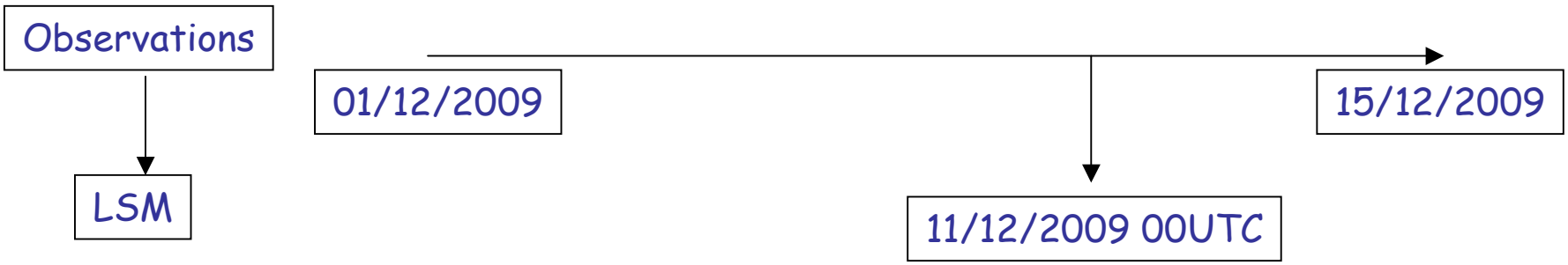
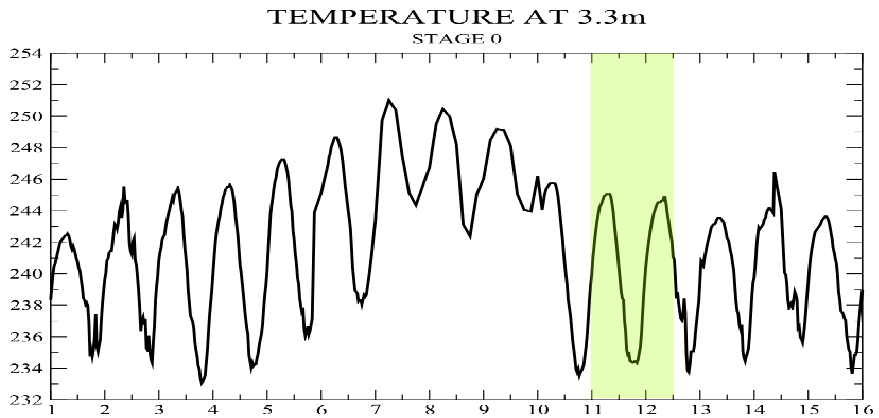
GABLS4 : Stage 0 → Dec 2014

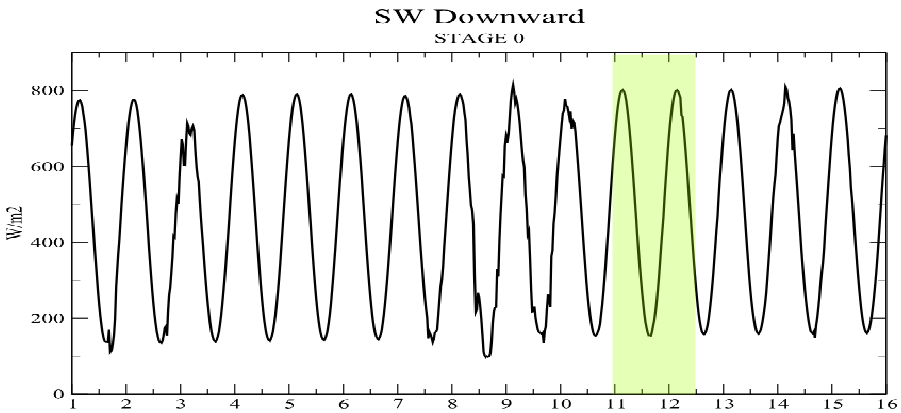
- For GABLS4 intercomparison, we follow the DICE experiment such as
  - Same NetCdf file with additional output :
  - **Stage 0: LSM forced by observations** (T,Rh,WS, SWd, LWd,RR)
    - comparison of snow models during 15 days vs observed temperature profile, surface fluxes
    - Soil initial conditions for stage 1

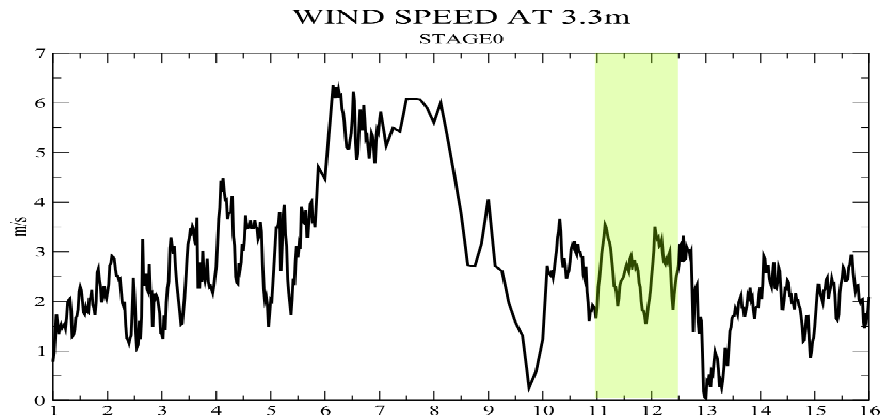


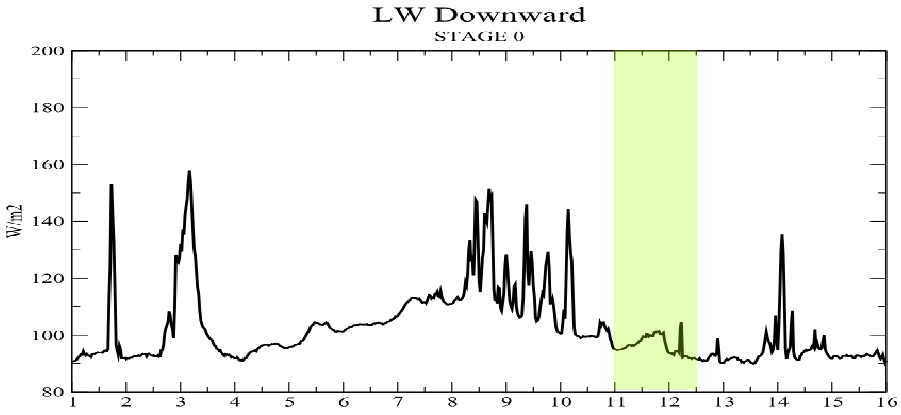
GABLS4 :Stage 0

- LSM forced by observations: T,Rh, wind at 3.3m , SWD, LWD,RR



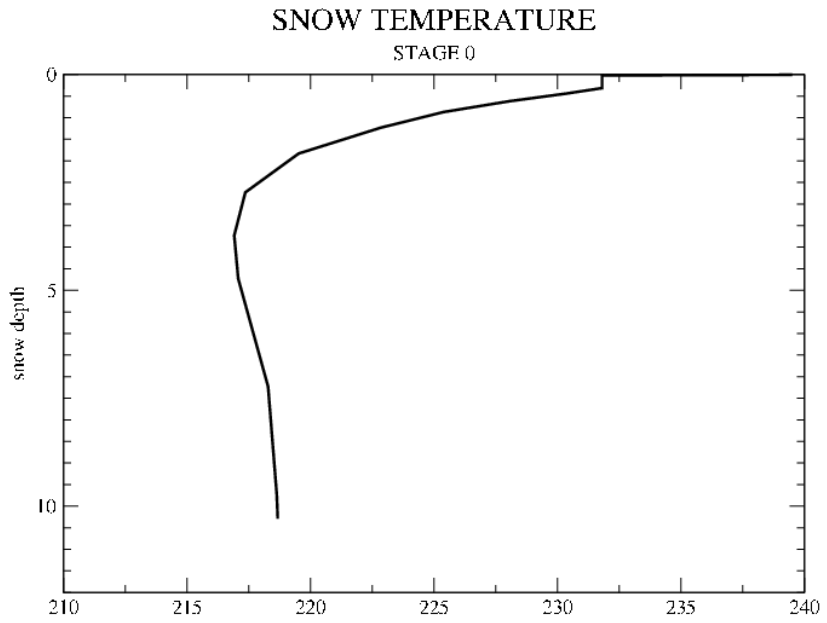


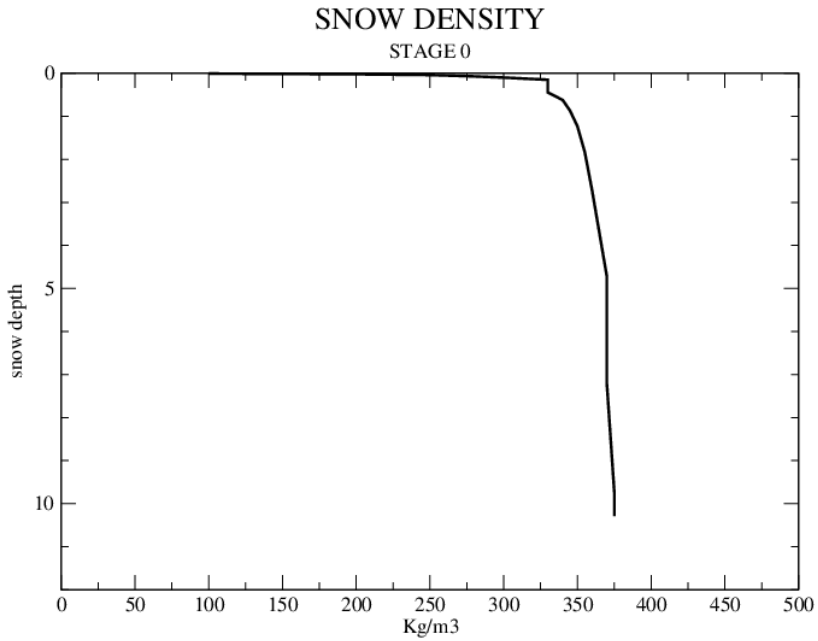




GABLS4 :Stage 0

- Initial profile (1st Dec. 2009 at 00UTC) for the snow temperature and snow density computed with SURFEX-CROCUS scheme (Brun et al. 1992, 1989)





GABLS4 : Stage 1 → Dec 2014

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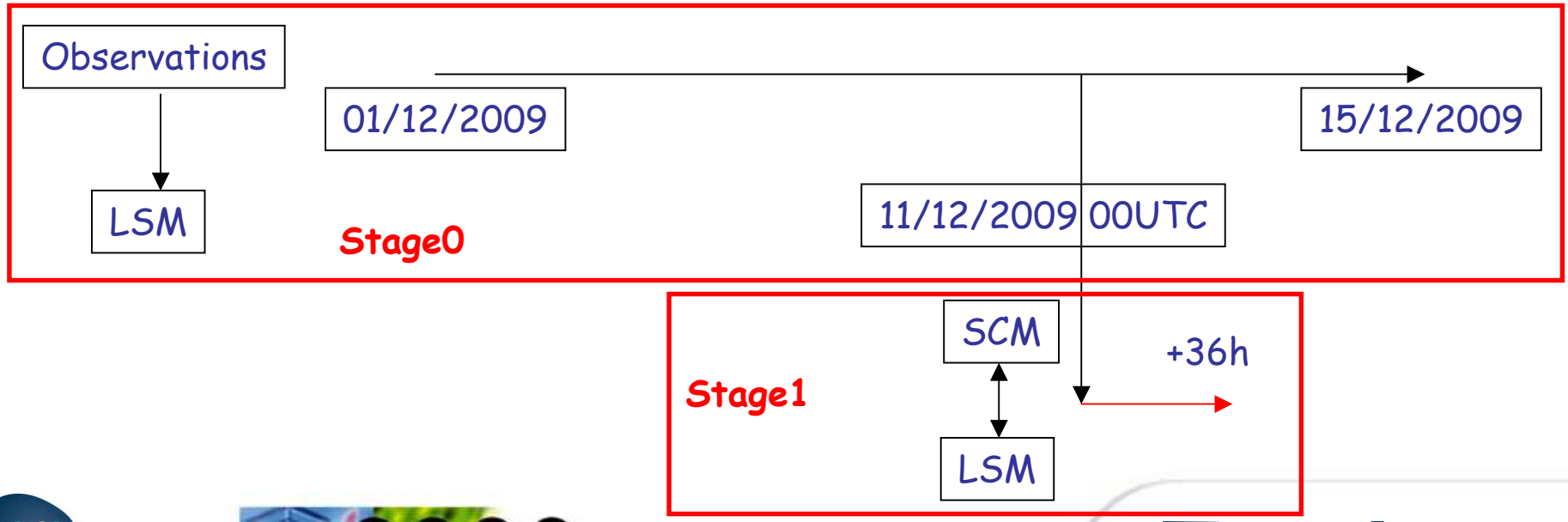
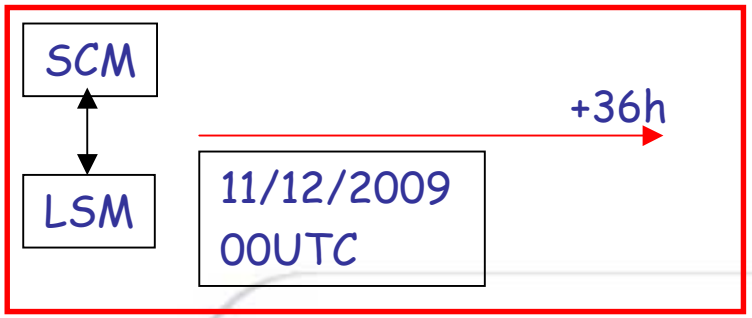


GABLS4 : Stage 1 → Dec 2014

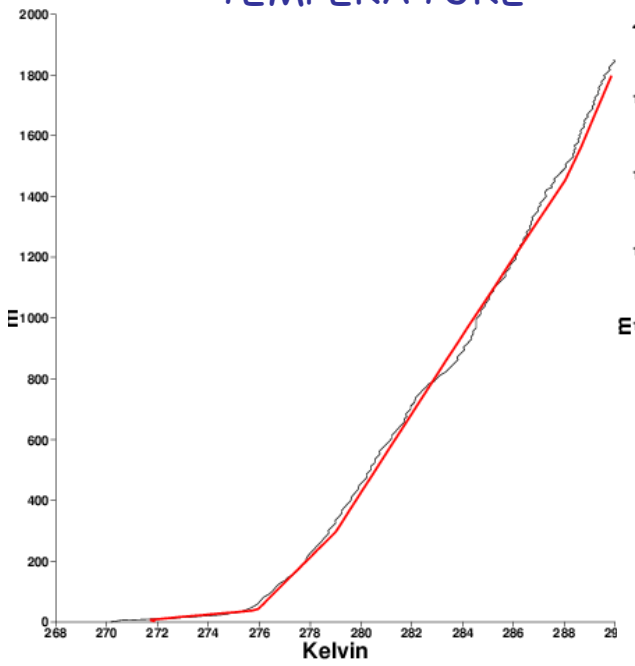
- **Stage 1: SCM with the LSM used in Stage 0**
  - Date 11th December 2009 starting at 00UTC (→ +36h)
  - Initial profile coming from the RS for T and Q , the wind is initialized with the geostrophic wind.
  - Temperature and humidity advection (hourly)
  - Geostrophic wind (hourly)
  - Two options:
    - **Stage 1a** : use the surface and soil initial conditions from stage 0 experiment.
    - **Stage 1b**: use the given surface and soil initial conditions
    - **LES are welcome**



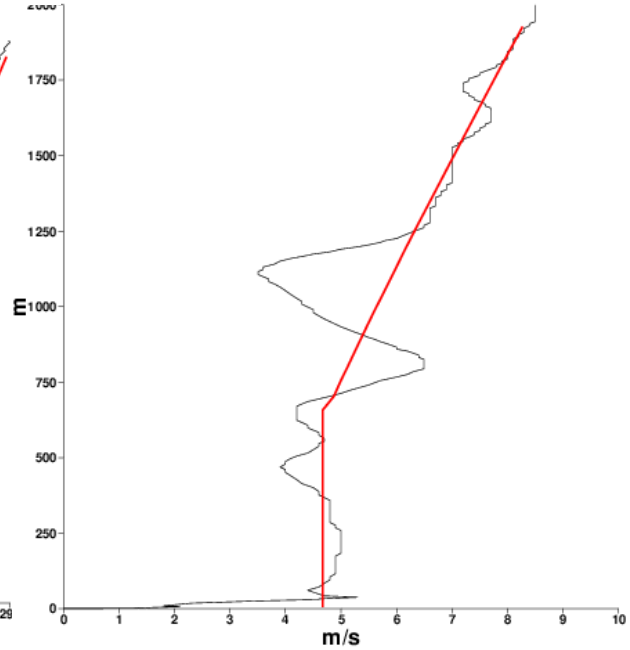
GABLS4 : Stage1a and 1b

- Initial profile based on the radiosonde data but simplified (red)

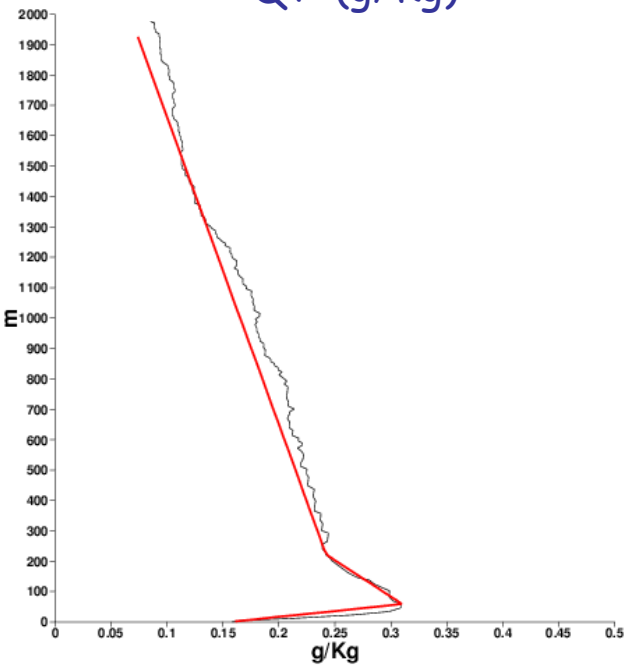
POTENTIAL TEMPERATURE



WIND SPEED (m/s)

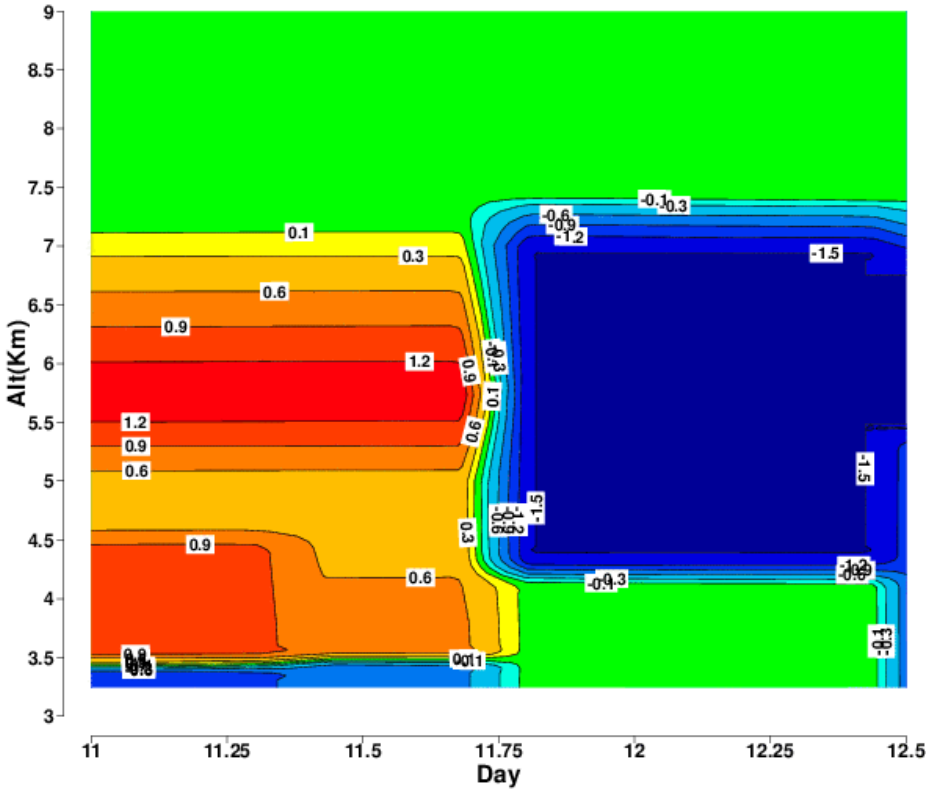


Qv (g/Kg)

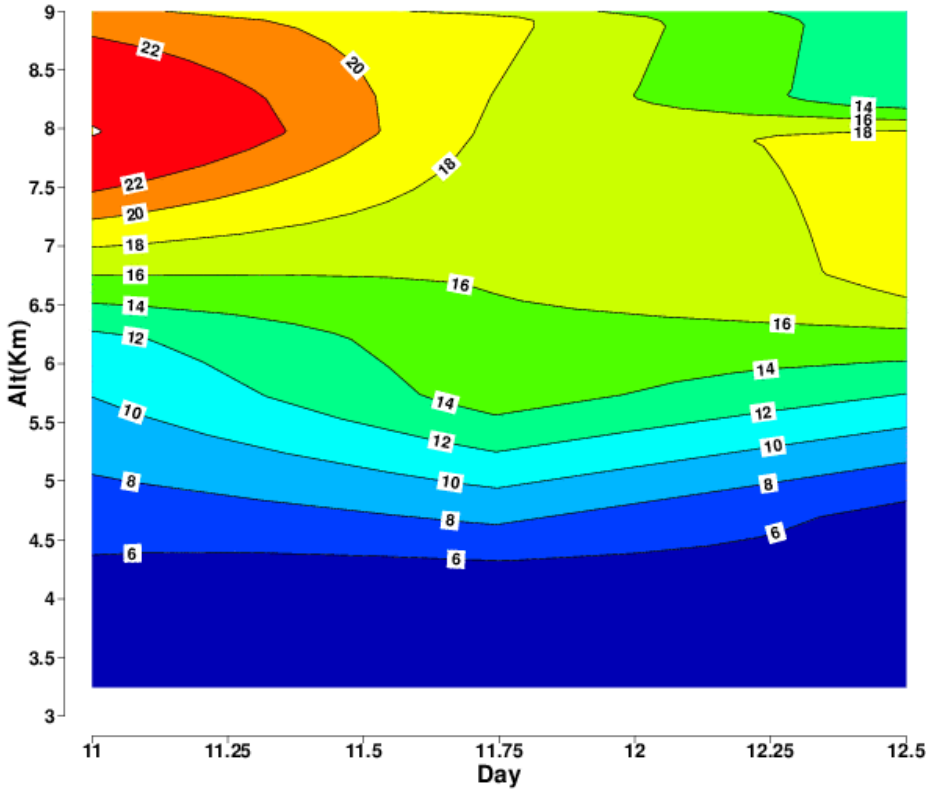


GABLS4 : Stage1a and 1b

TEMPERATURE ADVECTION (K/Day)



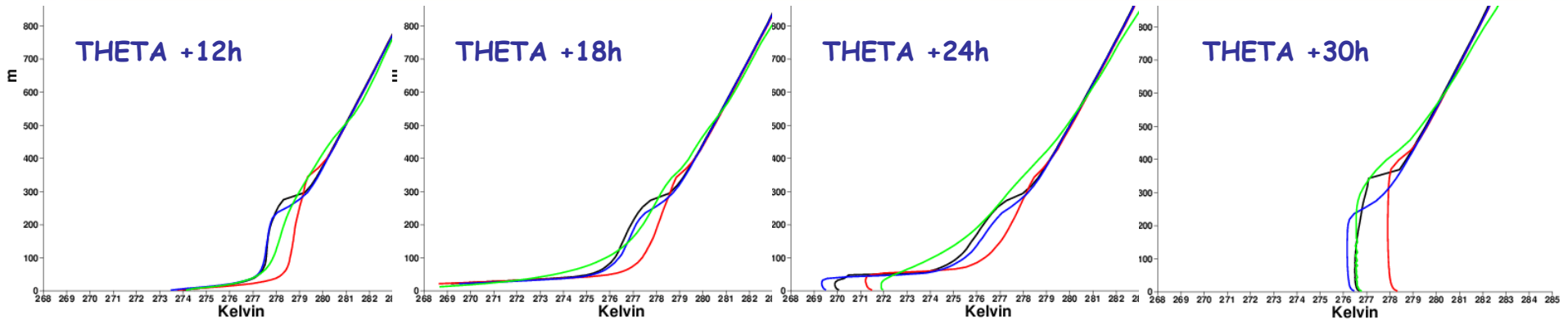
GEOSTROPHIC WIND (m/s)



GABLS4 : Part 2

- **Part2**: starts the 1st January 2015 (!), results before 1st May 2015 ?
  - **Stage 2**: LES and SCM same atmospheric forcing used in stage 1 but the surface temperature is prescribed.
  - **Stage 3**: "ideal" or simplified GABLS4 case: no radiation, no specific humidity, constant geostrophic wind, no advection, Ts prescribed. Easier for the LES community and for other community. Stage 3 is also interesting for SCM.

GABLS4 : very preliminary SCM output

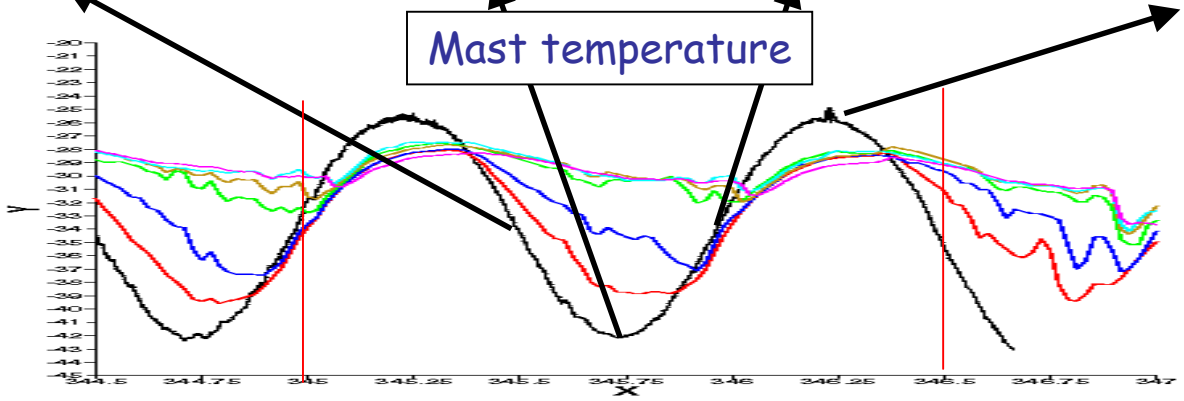


Mod1

Mod2

Mod3

Mod4



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Acknowledgements

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•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 Etienne Vignon (LGGE), William Maurel (Météo-France,CNRM/GAME), Eric Brun (Météo-France,CNRM/GAME) and not forgetting Irina Sandu (ECMWF) as a most valuable beta tester for the atmospheric forcing used in the SCM.

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

GABLS-4 : GEWEX Atmospheric Boundary Layer Study

SCM/LSM and LES intercomparison at DomeC (Antarctic Plateau)

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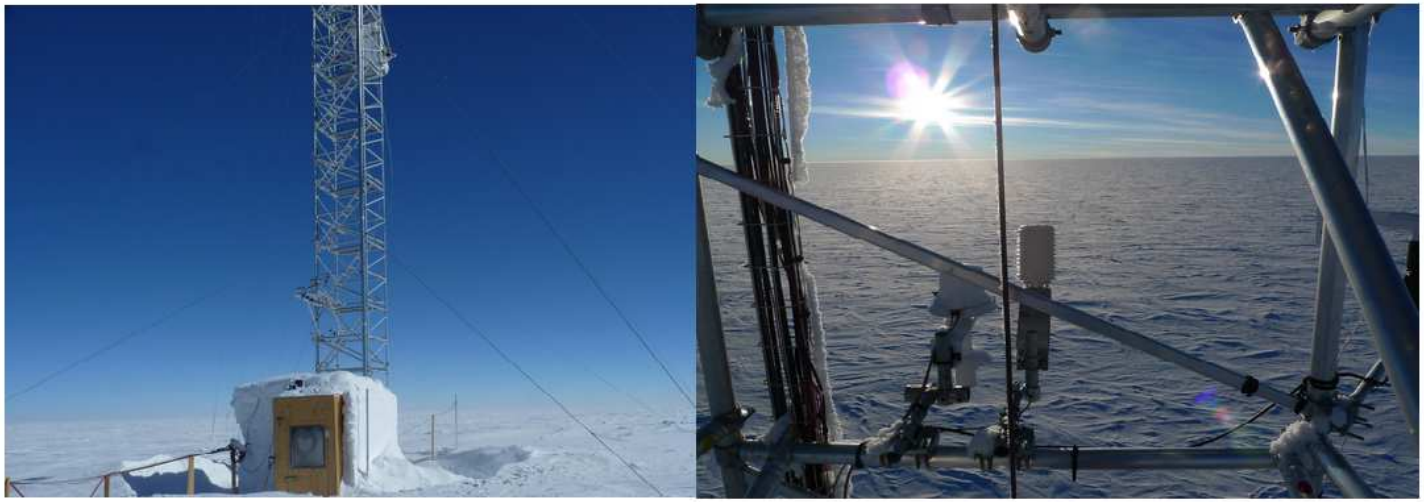
(3) Meteorology and Air Quality Section, Wageningen University, the Netherlands,

(4) Department of Meteorology and Bert Bolin Centre for Climate Research, Stockholm University, Stockholm

(5) Finnish Meteorological Institute, Helsinki, Finland,



From O. Traullé (left) and E. Brun (right)

Introduction :

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- If you intend to participate please email to : eric.bazile@meteo.fr
- For specific questions related to:
  - LSM: Patrick.LeMoigne@meteo.fr
  - LES: Fleur.Couvreux@meteo.fr

Some weaknesses for Ri >> 1

- Following Galperin et al 2007 and Zilitinkevich et al 2008 turbulence survives for Ri>>1. Is it the case with "all" the turbulence scheme and with the TKE scheme ?

$$\mathrm{Pr} = \frac{K_m}{K_h}$$