GABLS4: an intercomparison of models in extremely stable conditions over Antarctica

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Motivations: parameterization deficiencies in stable conditions; a new GABLS case

- Under strongly stable stratification and depending on the parameterization used, GCM/NWP models still have an excess of mixing or strong decoupling with the surface → warm or cold bias (Holtslag et al. 2013) => work on parameterizations + need of LES reference for parameterization development

- A 4th GABLS4 intercomparison => focus on very stable conditions (Ri > 1), surface interaction (simple surface=snow), easier initialization + observations dataset

![ECMWF and ARPEGE bias maps](surf-temperature-bias-vs-modis-data-freville-et-al-2014)
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

« American » Tower

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.51</td>
<td>41.9</td>
</tr>
<tr>
<td>30.15</td>
<td>32.7</td>
</tr>
<tr>
<td>22.79</td>
<td>25.3</td>
</tr>
<tr>
<td>15.43</td>
<td>17.9</td>
</tr>
<tr>
<td>07.03</td>
<td>8.8</td>
</tr>
<tr>
<td>Surface</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Snow and ice

- T(surface)
- T(-1 to -10 cm)
- T(-10 to -30 cm)
GABLS4: several steps & 3 intercomparisons

- **Stage 0**: Land Surface Model (LSM=snow scheme) driven by observations for 15 days: 7 institutes = 9 diff configurations

- **Stage 1**: Single Column Model (SCM) with all the physics and surface interaction: 36h forecast starting the 11\textsuperscript{th} Dec 2009: 13 institutes

- **Stage 2**: Large-Eddy Simulation (LES) and SCM, stage1 atmospheric forcing but \textbf{prescribed} surface temperature: 11 institutes

- **Stage 3**: LES and SCM. "ideal GABLS4" or simplified: \textit{no} radiation, \textit{no} specific humidity, \textit{constant} geostrophic wind, \textit{no} advection, Ts \textit{prescribed}. Easier for the LES community and DNS: 9 institutes

1\textsuperscript{st} Workshop was organized in Toulouse 20-22 May 2015

Surface scheme intercomparison: 1/net radiation

Large scatter due to albedo, snow temperature and emissivity
Systematic biases in models
Surface scheme intercomparison: 2/ sensible heat fluxes
New simulations with a given albedo = 0.81, emis., z0m=0.001, z0h, snow characteristics, prescribed vertical grid

Less variability with the new simulations especially during day time (mainly due to the prescribed albedo). During night, the variability is probably due to the turbulence scheme.
1D atmospheric scheme (coupled) intercomparison: 2/ sensible heat fluxes

Stage 1: 1st Simulations
- 20 W/m²
- 15 W/m²

Stage 2: New simulations
- 8 W/m²
- 6 W/m²

New simulations with a given albedo = 0.81, emis., z₀m=0.001, z₀h, snow characteristics, prescribed vertical grid.
GABLS4 : Wind profile at 18h

For some models, fine vertical grid does not improve the LLJ

1st Simulations

New simulations with a given albedo = 0.81, emis., z0m=0.001, z0h, snow characteristics, prescribed vertical grid

For some models, fine vertical grid does not improve the LLJ
Comparison to tower observations & surface sensible heat fluxes

**MESONH temperature**

**MESONH windspeed**

**sensible heat flux**

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10 Wm\(^{-2}\)=50%

10 Wm\(^{-2}\)=100%

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observations
LES
42m
33m
25m
18m
9m
3m

Zo=10-2/- - - 10-3
MesoNH
PALM
CLMM
HHL
PPL
MCSU
SAM
PALES
Eddy-correl° obs
Gradient obs

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E R A N C E
nps d’avance
LES Intercomparaison : 1/ temperature evolution

Deep CBL during the day, variable boundary layer at night.
LES Intercomparaison:
1/ temperature evolution

Mesonh
PALM
SAM
NCSU
HH

temp
t=17UTC (01LT)

MesoNH
MesoNH (zo)
PALM
CLMM
HH
JPL
NCSU
SAM


pot temperature

A CBL at -30°
t=05UTC (13LT)

different stabilities
For a given Δz
t=17UTC (01LT)

SAM-> higher CBL
NCSU-> smaller inversion (cf resolution)
LES intercomparison: distributions at observed levels

Observations

Observations

PDF THT MNH

PDF THT PALM

PDF THT HH

PDF THT JPL

PDF THT CLMM

PDF THT SAM

PDF THT UKMO

05h

z=7m

z=39m

more or less skewed distribution
LES intercomparison: distributions at observed levels

Symmetrical distribution
Large variability among models
Conclusions & Future steps

- Large variability for the sensible heat fluxes between models for LSM, SCM and LES

- New simulations with prescribed roughness length, emissivity... reduced the scatter during daytime (\(\Rightarrow\) role of surface interaction) but not during nighttime (\(\Rightarrow\) role of turbulence scheme)

- Large differences among LES models in term of horizontal distribution, structures especially at night
  Not shown in LES : sensitivity to the horizontal & vertical resolution in particular at night ; No convergence at night (PALM\(\Rightarrow\) 1m, JPL \(\rightarrow\) 2m, HHLES \(\rightarrow\) 0.25m)

  At night, everything happens in the first 60m \(\Rightarrow\) very high res\(\circ\)
  \(\rightarrow\) need to define another setup : restart at 0830 for a smaller domain and higher resolution (tests with HHLES \(\rightarrow\) 0.25m)
Acknowledgements

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