8A.5 INTERCOMPARISON OF SINGLE-COLUMN MODELS FOR GABLS3: PRELIMINARY RESULTS

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1. INTRODUCTION

The GEWEX Atmospheric Boundary-Layer Study (GABLS) focuses on the representation of stable boundary layers in atmospheric models (Holtslag, 2006). One of the main goals of GABLS is to provide a mondial platform for the atmospheric boundary layer research community through the organisation of model intercomparisons. Here we focus on single column models (SCM's), which can be both research models and SCM's derived from operational weather and climate models. Two SCM intercomparison case studies have been performed so far in the context of GABLS. One highly idealised case over snow with prescribed surface temperature (Cuxart et al., 2006) and a second case based on observations taken during the CASES 99 stable boundary layer experiment also with prescribed surface temperature (Svensson and Holtslag, 2007).

In these previous studies it was found that especially the complexity of real world boundary conditions and the lack of interaction with the surface make it difficult to confront the models with observations. Holtslag et al. (2007) showed that SCM's tend to represent stable boundary layers better when they are allowed to interact with the surface.

A third GABLS SCM case was set up by asking the modellers to run their SCM models with full physical interaction, e.g. interaction with their own soil vegetation and radiation schemes. The specific characteristics of the Cabauw site e.g. its flat topography (van Ulden and Wieringa, 1995; Beljaars and Bosveld, 1997) makes it well suited to study decoupling around sunset, low level jet formation and the morning time transition to convective conditions (Angevine et al. 2002).

A reasonable ideal case was found in the Cabauw long observational dataset (Baas et al., 2008). It consists of the period July 1st 2006 12 UTC to July 2nd 2006 12 UTC. This is an (almost) clear sky period with reasonable constant geostrophic wind over time of typically 7 m/s resulting in a turbulent stable boundary layer over night with a pronounced temperature drop and a well developed low level jet at around 200 m height, caused by an inertial oscillation.

To make comparison with observations possible care was taken to prescribe realistic advective tendency terms to the SCM's. These were estimated from both local observations and hind casts of several 3D NWP models. (Bosveld et al., 2008).

The description of the 3rd GABLS SCM case can be found at www.knmi.nl/samenw/gabls. Here preliminary results of the 3rd GABLS SCM intercomparison and evaluation case are presented. The study is preliminary since other modellers are also invited to contribute.

2. MODELS

In Table 1 the six models that joined this preliminary intercomparison are listed with their characteristics. The models range from an operational global model with course vertical resolution and K-diffusion with long tails to models with TKE-schemes and run at higher vertical resolution.

Name	Institute	Nlev	BL.Scheme	Skin
ALADIN	Meteo France	41	TKE	No
AROME	Meteo France	41	TKE	No
GLBL38	Met Office	38	K (long tail)	Yes
ACM2	NOAA	155	K+non-local	No
D91	WUR	91	K	Yes
RACMO	KNMI	80	TKE	Yes

Table1. The models with their characteristics.

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To study the influence of the prescribed horizontal advection one of the models (RACMO) was also run with no horizontal advection (RCNOADV). For this run vertical advection (subsidence) was kept to prevent the model from producing clouds.

3 OBSERVATIONS

Observations are taken from the continuous observational program of Cabauw. These include profiles of wind speed, wind direction, temperature and humidity from the 200 m tower. A Windprofiler/RASS provides wind speed, wind direction and (sonical) temperature above the tower. Incoming long wave and short wave radiative fluxes are from the Cabauw Baseline Surface Radiation Network (BSRN) site. Upward radiative fluxes are taken from the Cabauw land surface field site, sensible and latent heat flux observations from eddy correlation measurements. Soil heat flux observations are derived from soil heat flux plates in the soil extrapolated to the surface to correct for storage in the upper soil layers.

4 RESULTS

4.1 *Surface fluxes*

Figure 1 shows time series of the downward long wave radiation. Each model has its own long wave radiation transfer scheme. During night time most of the models show the same value which is approximately 10 W/m^2 lower then the observed long wave radiation. The global model follow the observations much better. At the end of the period some models produce clouds which results in an overestimation of downward long wave radiation.

Friction velocity is shown in figure 2. Observed friction velocity is derived from 10 m wind speed together with a roughness length for momentum of 0.15 m and an estimate of the atmospheric stability. This value is representative for the regional scale around Cabauw. Friction velocity as derived from local eddy-covariance measurements gives substantial lower values representative for the local grass land with a roughness length of 0.03 m. Friction velocity based on regional scale roughness is probably more representative for what the developing boundary layer “feels”. The regional value of 0.15m is also prescribed to the models. The figure shows a reasonable similarity between models and observations. Large fluctuations in the observations in the first 5 hours are caused by the convective conditions in the afternoon.

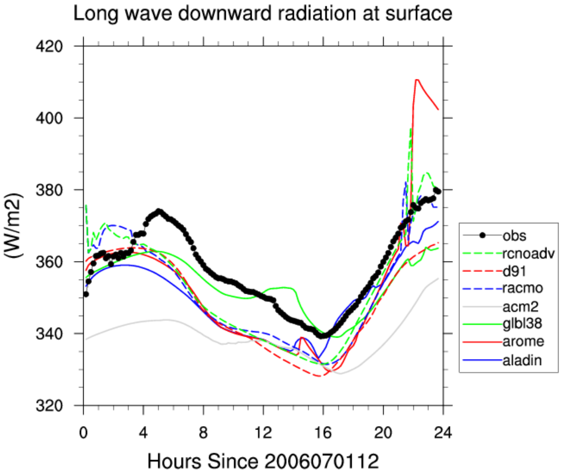

Figure 1. Long wave downward radiation at the surface for the models together with the observations. Note: On the time-axis 12 indicates 0:00 UTC which is approximately local midnight.

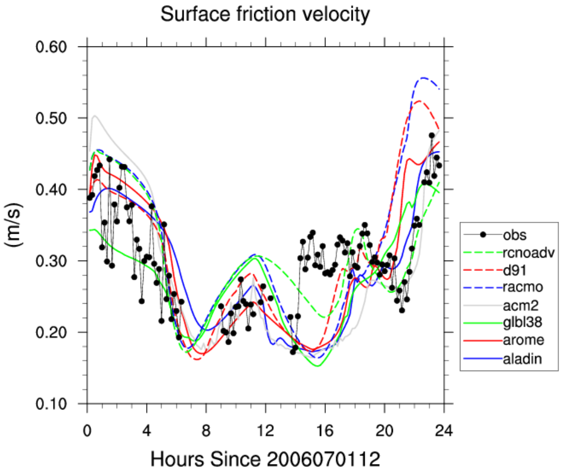

Figure 2. Friction velocity for the models together with the observations.

4.2 *Surface Temperature*

Figure 3 shows time series of the 2 m temperature from the models together with the observations. Although the general signature of the temperature change is well captured by the models (Fast decrease during the first hours after sunset, followed by a more gradual decrease in the subsequent hours) a substantial spread (4 K) in attained minimum temperature is observed with the global model spot on the observations.

4.3 Wind at 200 m

Figure 4 shows time series of the 200 m wind. For each model the first level above 200 m was chosen. The 200 m level is interesting because it exhibits a substantial inertial oscillation after the onset of decoupling around sunset.

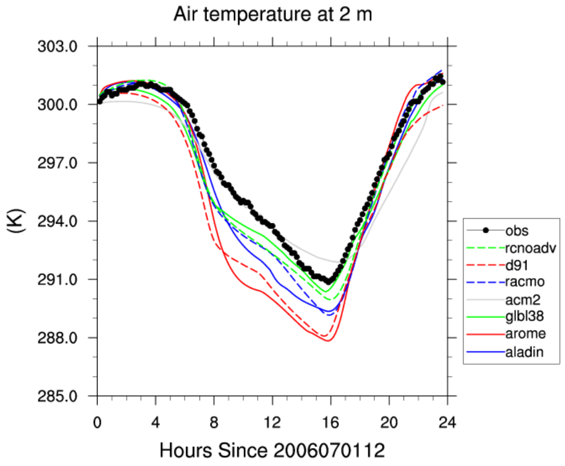

Figure 3. Air temperature at 2 m for the models together with observations.

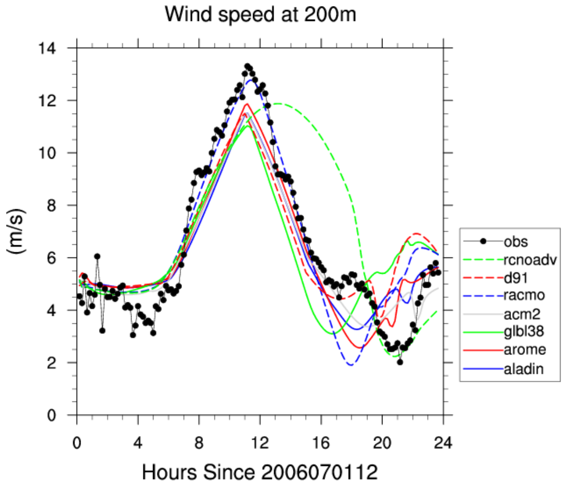

Figure 4. Wind speed at 200 m for the models together with observations.

The inertial oscillation is affected by horizontal momentum advection especially after midnight. This is clearly seen for most of the models, which show a sharp decrease in wind speed after midnight, much sharper then would be expected when no advection was present as simulated by RCNOADV.

4.4 Profiles of potential temperature

Figure 5 shows vertical profiles of potential temperature at midnight in the lowest 500 m. Temperature gradients in the lowest 200 m are well represented. One of the models have cooled 2 K more then is observed. Some differences in stable boundary layer height can be observed among the models. The global model show a deeper and less steep stable layer.

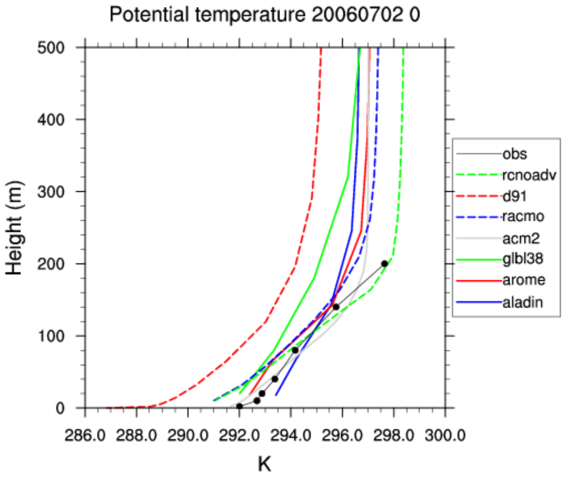

Figure 5. Vertical profiles of potential temperature at local midnight for the models together with observations.

4.5 Profiles of wind speed

Profiles of wind speed are displayed in figure 6. Models tend to underestimate wind speed. Also here differences in stable boundary layer height can be seen with the observations suggesting that the actual height is just in between.

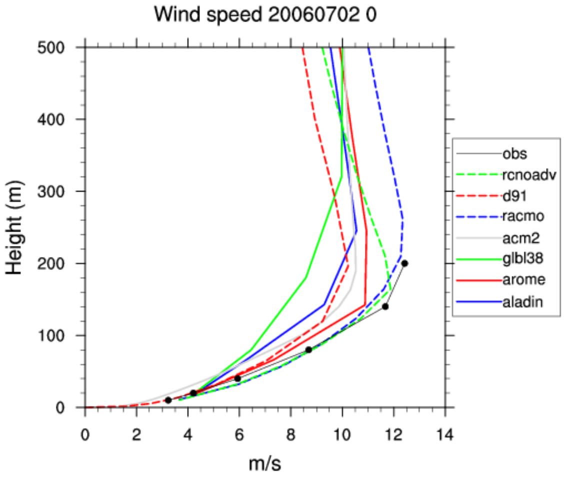

Figure 6. Vertical profile of wind speed at local midnight for the models together with observations and a RACMO run with no horizontal advection.

5 CONCLUSIONS

The Cabauw site with its flat and homogeneous terrain and its long observational record has enabled the selection of a relatively ideal case. By carefully prescribing the forcings on the vertical column as they change in time the models are able to reproduce the gross features of the stable boundary layer like: onset of decoupling, signature of surface temperature over time and evolution of the inertial oscillation. Differences between models occur in details which can now be studied in depth by comparing with observations.

6 REFERENCES

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