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Achievements of the GEWEX Atmospheric Boundary Layer Study (GABLS)

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Motivation

Comparison of climate models with observations for the 2m temperature reveals large differences over land and ice in stratified conditions in winter (Figure 1).

Overall atmospheric models have difficulty in representing stable boundary layers as well as the diurnal cycle. In addition models show large sensitivity to details in mixing formulation and to land surface feedbacks

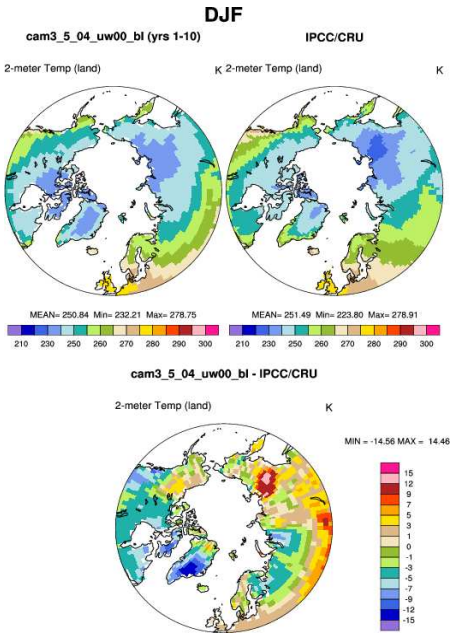
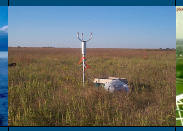
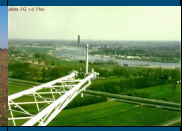


Figure 1: Comparison of NCAR-CAM (using UW PBL scheme; Bretherton and Park, 2009, J. Climate) for winter time conditions in Northern Hemisphere. Upper left figure gives model results, upper right figure shows observed 2m temperatures, and lower figure gives differences up to 15 K.
Similar results are found with HB scheme (Holtslag and Boville, 1993, J. Climate)

GABLS provides a platform for intercomparison and development of boundary layer models and parameterization schemes to benefit studies of climate, weather, air quality, and wind energy (www.gewex.org/gabls)

GABLS1	GABLS2	GABLS3
		
LES as reference	Data (CASES99)	Data (CABAUW)
Academic set up	Idealized forcings	Realistic forcings
Prescribed T_s	Prescribed T_s	Full coupling with surface (SCM) and prescribed T_s (LES)
No Radiation	No Radiation	Radiation (SCM)
Turbulent mixing	Diurnal cycle	LLJ + transitions

SCM: Single Column Model; LES: Large-Eddy Simulation

Some findings and highlights

GABLS1: NWP and climate models show too strong night-time mixing resulting in too deep boundary layers and too less turning of wind

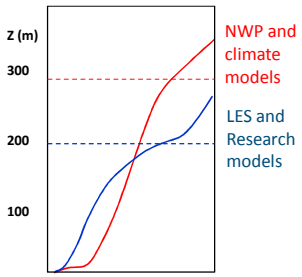


Figure 2: Typical model results for potential temperature profiles in stably stratified boundary layers (Holtslag; Cuxart et al; Beare et al, Boundary Layer Meteorology special issue on GABLS, 2006)

GABLS2
Diurnal cycle of wind too weak
More complex parameterizations do not help

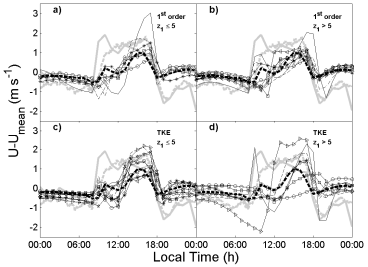


Figure 3: Time series of observed and modeled wind speed deviations (m/s) at 10m a.g.l. for various models with first order and TKE based mixing schemes grouped by height of first model level. *Light grey solid line* is observed in the selected experiment period, the *light grey dashed line* shows the average over the entire CASES-99 campaign (Svensson et al, 2011)

GABLS3
Nighttime cooling too severe in many models (even with enhanced mixing)
Complex interplay of boundary layer with land surface and radiation processes

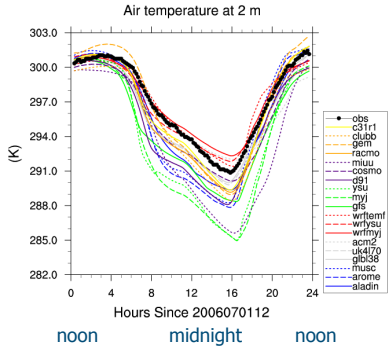


Figure 4: Diurnal cycle of 2m temperature by a variety of Single Column models (colored lines) versus the Cabauw observations (black dots) for GABLSS3 (Bosveld et al, in preparation)

G. Svensson, A. A. M. Holtslag, V. Kumar, T. Mauritsen , G. J. Steeneveld , W. M. Angevine, E. Bazile, A. Beljaars, E. I. F. de Bruijn, A. Cheng, L. Conangla, J. Cuxart, M. Ek, M. J. Falk, F. Freedman, H. Kitagawa, V. E. Larson, A. Lock, J. Mailhot, V. Masson, S. Park, J. Pleim, S. Söderberg, W. Weng · M. Zampieri, 2011: Evaluation of the Diurnal Cycle in the Atmospheric Boundary Layer Over Land as Represented by a Variety of Single-Column Models: The Second GABLS Experiment. Boundary Layer Meteorology, 140 : 177–206.

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