

GEWEX Atmospheric Boundary Layer Study (GABLS)

Reporting period: Jan 2006-Dec 2006

Starting date: 2002

URL: www.gewex.org/gabls.html and www.met.wau.nl/projects/Gabls/index.html

Chair(s) and term dates: Bert Holtslag, Wageningen University, NL

Overview:

The objective of GABLS is to improve the representation of the atmospheric boundary layer in regional and large-scale models for weather forecasting and climate studies, which should also benefit air quality and earth system studies.

Status: Past year activities:

In February 2006, a special issue of Boundary Layer Meteorology on the first GABLS bench-mark case for stable boundary layers was published. This includes an introductory and overview paper (Holtslag, 2006), a paper with summary results for Large-Eddy Simulation (LES) models (Beare et al, 2006), a paper on the performance for single column (1D) models (Cuxart et al, 2006), as well as five additional papers highlighting specific issues.

The stable case selected and studied is a simple, shear-driven boundary layer created by an imposed uniform Geostrophic wind, with a specified surface-cooling rate over ice. This attains a quasi-steady state SBL (after about 9 hours). Overall the results indicate that the models show quite significant differences for the mean temperature and wind profiles as well as the turbulent fluxes and other model outputs for the same initial conditions and forcing conditions. It appears that this is very strongly related to the choice of the turbulent length scale and/or the stability functions in the turbulence schemes, and not so much to the vertical resolution. Overall the results for the different LES models are much closer than for the 1D models.

Interestingly the models in use at operational weather forecast and climate centres typically allow for enhanced mixing resulting in too deep boundary layers, while the typical research models show less mixing in more in agreement with the 'Large Eddy Simulation' results for this case. Because of the enhanced mixing in weather and climate models, these models tend to show a too strong surface drag, too deep boundary layers, and an underestimation of the wind turning in the lower atmosphere (e.g., Svensson and Holtslag, 2006). At the other hand, by decreasing the mixing and surface drag, a direct impact on the atmospheric dynamics ('Ekman pumping') may be noted. When the models with enhanced mixing are coupled to a surface energy balance, they also produce too high surface temperatures (Steenefeld et al, 2006a).

To proceed, a second GABLS bench-mark case was selected on basis of observed boundary-layers during CASES99 covering three diurnal cycles over land. This case has been studied and prepared by the Meteorology group at Wageningen University (Steenefeld et al, 2006b). Detailed observations for three nights are available with rather different characteristics (fully turbulent, intermittent turbulent and non-turbulent). This case is set up for the inter-comparison of different column models within GABLS using prescribed surface temperature (coordinated by Gunilla Svensson). For a more detailed intercomparison of LES and 1D models a morning transition will be selected in this period (currently in preparation by Sukantu Basu). In addition a LES case is set up for a full diurnal cycle (by Vijant Kumar).

The goal of the GABLS2 inter-comparison of LES and column models is on the behavior and performance of the various models in comparison with the available observations, with a special focus on the diurnal cycle at clear skies. In addition, the proposed case has received interest from the GLASS/LOCO community as a suitable case to study also the interaction of the ABL with the land surface. Initial results were presented and discussed at the combined LOCO/GABLS workshop (Sept. 2005) and at 17th BLT in San Diego (Svensson and Holtslag, 2006). In addition the CASES99 data is currently used for intercomparison of mesoscale models (Steenefeld et al, 2006c).

New directions:

GABLS will contribute to exploration of the ARM97 case for further evaluation of the diurnal cycle over land, with special considerations of land, boundary layer and cloud interactions. This may be organised as a broad GMPP activity. In addition a contribution to study cross a section within AMMA will be explored.

Future: Next year's foreseen activities:

In the next year the column model results for GABLS2 case (part of CASES99) will be further analysed in comparison with observations and LES. Also the case will be used for inter-comparison of meso-scale models. Cooperation with GLASS-LOCO activity is sought on land-boundary layer interaction for this case as well. In addition a special LES case is set up for the study of the morning transition, which later will also be used for inter-comparison of column models.

Key results:

- BLM special issue in February 2006 on GABLS1 results
- Invited talk iLEAPS + summary contributions to IGBP and iLEAPS newsletters
- Initial results GABLS2 presented at BLT in San Diego which attracted much attention.
- Increased awareness at Operational Centres for relevance of stable boundary layer (SBL), in particular role of momentum mixing (ongoing work at Met. Office and ECMWF).
- GABLS model results are increasingly used as a benchmark test for model development within GEWEX and used in other communities, like for air pollution dispersion (Jeff Weil) and for large canopy studies (Ned Patton).

Issues and Recommendations:

Issues for attention by the SSG:

Encourage operational centres to participate in GABLS!

Contributions to COPES:

The GABLS project and results were presented by Bert Holtslag at the COPES meeting in Trieste (September 2005), and were well received.

Summary:

The objective of GABLS is to improve the representation of the atmospheric boundary layer in regional and large-scale models for weather forecasting and climate studies, which should also benefit air quality and earth system studies.

The approach is two set up inter-comparison studies for prototype boundary layers. So far two cases have been studied. GABLS1 focussed in particular on the evaluation of the representation for stable boundary layers. GABLS2 deals with the representation of the diurnal cycle in clear skies over land.

List of key publications:

Beare, R.J.; MacVean, M.K.; Holtslag, A.A.M.; Cuxart, J.; Esau, I.; Golaz, J.C.; Jimenez, M.A.; Khairoutdinov, M.; Kosovic, B.; Lewellen, D.; Lund, T.S.; Lundquist, J.K.; McCabe, A.; Moene, A.F.; Noh, Y.; Raasch, S.; Sullivan, P.; 2006. An Intercomparison of Large-Eddy Simulations of the Stable Boundary Layer. *Boundary-Layer Meteorology* 118(2), 247-272.

Cuxart, J., Holtslag, A.A.M., Beare, R.J., Bazile, E., Beljaars, A., Cheng, A., Conangla, L., Ek, M.B., Freedman, F., Hamdi, R., Kerstein, A., Kitagawa, H., Lenderink, G., Lewellen, D., Mailhot, J., Mauritsen, T., Perov, V., Schayes, G., Steeneveld, G.J., Svensson, G., Taylor, P., Weng, W., Wunsch, S., & Xu, K-M., 2006. Single-Column Model Intercomparison for a Stably Stratified Atmospheric Boundary Layer. *Boundary-Layer Meteorology*, 118(2), 273-303.

Holtslag, A.A.M.; 2006. GEWEX Atmospheric Boundary-layer Study (GABLS) on Stable Boundary Layers. *Boundary-Layer Meteorology*, 118(2), 243-246.

Holtslag, A.A.M.; Steeneveld, G.J.; Wiel, B.J.H. van de; 2006. Exploring variability of model results in the GEWEX Atmospheric Boundary Layer Study (GABLS). In 17th Symposium on Boundary Layers and Turbulence, 22-25 May 2006, San Diego, California (pp.8.2). Boston: American Meteorological Society.

Steeneveld, G.J.; Wiel, B.J.H. van de; Holtslag, A.A.M.; 2006a. Modelling the Arctic Stable boundary layer and its coupling to the surface. *Boundary-Layer Meteorology*, 118(2), 357-378.

Steeneveld, G.J.; Wiel, B.J.H. van de; Holtslag, A.A.M., 2006b. Modeling the Evolution of the Atmospheric Boundary Layer Coupled to the Land Surface for Three Contrasting Nights in CASES-99. *Journal of the Atmospheric Sciences* 63, 920-935.

Steenveld, G.J.; Mauritsen, T.; Bruijn, E.I.F. de; Svensson, G.; Holtslag, A.A.M.; 2006c: Mesoscale Model Intercomparison and Observational Evaluation for Three Contrasting Diurnal Cycles in CASES-99: Focus on the Stable Boundary Layer. In 17th Symposium on Boundary Layers and Turbulence, 22-25 May 2006, San Diego, California (pp.8.8). Boston: American Meteorological Society.

Svensson, G.; Holtslag, A.A.M.; 2006. Single column modeling of the diurnal cycle based on CASES99 data - GABLS second intercomparison project. In 17th Symposium on Boundary Layers and Turbulence, 22-25 May 2006, San Diego, California (pp.8.1). Boston: American Meteorological Society.

List of meetings, workshops:

- GABLS-LOCO workshop, September 2005, De Bilt, NL
- GABLS special session and meeting at 17th BLT, May 2006, San Diego, CA
- Invited Contribution to iLEAPS conference Jan 2006
- Pan-GEWEX, Frascati, Italy, Oct 2006
- Stable boundary layer workshop in Sedona, Arizona, Nov, 2006

Planned meetings, workshops:

- June, 2007, Stockholm, Sweden

List of members and their term dates where appropriate:

Members:

Bob Beare (Met.Office)
Joan Cuxart
Gunilla Svensson
Jocelyn Malliot
Fred Bosveld
Frank Beyrich
Anton Beljaars
Larry Mahrt

Proposed vice chair:

Gunilla Svensson, Stockholm University, Sweden (starting Jan 2007)

Proposed panel member:

Sukanta Basu