

GLASS and GABLS workshop on local land-atmosphere coupling – 19/21 sep 2005**Workshop summary**

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Introduction

The GLASS/GABLS workshop on local land-atmosphere coupling, held in De Bilt between 19 and 21 sep 2005, provided a wide range of new scientific insights in the mutual interaction between the land surface and the atmospheric boundary layer. This document gives a brief summary of the workshop sessions and the final conclusions. A final section is devoted to a first version of the implementation plan of the Local Coupling (LoCo) workgroup of GLASS.

Session summary

Before the combined GLASS/GABLS workshop an informal presentation was held on the preliminary results of the second GABLS intercomparison study (by Gunilla Svensson). In the combined workshop five sessions were organised. Not all presentations are summarized here (see http://www.knmi.nl/samenw/eldas/GLASS_GABLS.html), only some keynote subjects are listed.

The first session was devoted to land-atmosphere interaction for stable boundary layer conditions. *Gert Jan Steeneveld* presented encouraging results of a coupled land-atmosphere simulation of 3 consecutive days for CASES99. His work suggests that, given the right parameters, a simple set of surface energy balance equations is well-suited to describe the role of an interactive surface – pbl system.

The second session was introduced by *Michael Ek*, who presented the derivation and applicability of a general relative humidity tendency equation (on basis of Ek and Holtslag, 2004). This equation may be used as a diagnostic tool to quantify the relative contributions of surface moisture conditions, atmospheric stratification and boundary layer growth in the formation of boundary layer clouds. *Frank Beyrich* advertised the use of LITFASS (Lindenberg Inhomogeneous Terrain – Fluxes between the Atmosphere and Surface – a long term Study) measurements for studying the role of land surface heterogeneity on land-atmosphere interaction as well as boundary layer studies.

In the third session *Luis Bastidas* convincingly demonstrated the impact of land-atmosphere coupling in the process of parameter calibration. Optimal values of parameters both in the land and the atmospheric components of a coupled single column land-atmosphere model were quite different, depending on whether the land-only or the coupled system was used to optimize the parameter values. In additional presentations *Eleanor Blyth* and *Richard Essery* presented the Joint UK Land Environment Simulator (JULES) infrastructure, which could possibly be integrated in the NASA Land Information System (LIS) environment.

The fourth session discussed land-atmosphere interaction diagnostics derived from large scale model experiments. *Paul Dirmeyer* used observations of soil moisture and surface fluxes to compare the GLACE (Global Land-Atmosphere Coupling Experiment) coupling strength to actually measured response of surface fluxes to soil moisture. He concluded that in contrast to observations, the GLACE models tend to give a stronger relationship between evaporation and soil moisture than between evaporative fraction and soil moisture. Also, the strength of the link between sensible heat flux and soil moisture is generally underestimated in the

models. *Anton Beljaars* presented analyses carried out by Alan Betts, where a strong plea was presented to compare model output to observable quantities that express various coupling processes in the land-atmosphere system, in particular net longwave radiation and diurnal temperature range for coupling aspects under stable conditions, and cloud albedo, LCL and BL relative humidity in daytime conditions.

The final session was devoted to data assimilation *Dara Entekhabi* had two messages here: the first is that data assimilation techniques, applied to relatively simple coupled land-atmosphere models, are very helpful in extracting relevant information on coupling processes, as they allow the explicit formulation of errors in both the observations and models. Second, remotely sensed surface temperatures are readily available in a large range of spatial and temporal resolutions, and may be used more to define the actual state of the land surface and overlying atmosphere, for instance the spatial distribution of the aerodynamic exchange coefficient. Also *Joseph Santanello, Jr.* promoted the use of remote sensing, in this case high resolution profiling instruments AIRS and MODIS. He pointed at the relative importance of the atmospheric residual layer in determining the likelihood entering a dry-down feedback cycle: when soil conditions are already dry, a deep nocturnal residual layer allows for a rapid boundary layer growth and thus ventilation after sunrise, promoting a rapid removal of evaporated moisture.

Workshop Conclusions

In a final discussion session the following overarching conclusions and recommendations were formulated. The discussion focussed on project and activities that are currently being carried out or planned to take place in the near future. These activities concern the further analysis of CASES99 stable boundary layer processes, and the diagnosis of hydrological coupling on monthly to seasonal time scales. Some recommendations apply to both categories of experiments.

CASES99

- The first evaluation of PBL modelling results for CASES99 revealed that even for a well-equipped experiment a comprehensive data set that gives relevant diagnostics on the reason of differences between modelled and true states is difficult to collect. It is recommended to carry out LES simulations spanning a (series of) complete diurnal cycle(s) that serve as reference. The possibility of such LES simulations has been demonstrated by Vijayant Kumar and his colleagues.
- In addition, it is recommended to extend the set of meaningful diagnostic evaluations. This work is obviously going on, but further analysis similar to the recent work of Alan Betts (e.g., inspection of net longwave radiation, partitioning between soil and sensible heat, diurnal temperature range) may serve as inspiration for these evaluations.
- It is strongly recommended to repeat the current CASES99 simulations with models in which surface temperature is not prescribed but has a certain degree of freedom, thereby explicitly accounting for interactive land-atmosphere coupling. Rather than including a complex land surface scheme, a simple set of (calibrated) surface energy balance equations (like used by G.J. Steeneveld et al, 2005) is recommended, as it is (a) probably fairly easy to implement in the presently participating schemes, and (b) is easier to standardize among the participating models.

Hydrological coupling

- It is recommended to carry out single column integrations in a different number of locations, both within and outside the so-called hotspots of hydrological land-atmosphere coupling as emerging from the GLACE experiment. These integrations should focus on the mechanisms that cause differences in coupling strengths among large scale models and between models and observations.
- A diagnostic equation like Ek and Holtslag's RH-tendency equation is a powerful tool to stratify the relative contribution of different processes to the coupling strength. This particular diagnostic should be extended to include the relative contribution of lateral advection. Other diagnostics may be formulated, like parameters that express the presence of a residual layer or vegetation stress regime.
- The LITFASS experiments should be added to the list of stations where Dirmeyer et al have retrieved observations to explore the coupling strength in the GLACE results.

General recommendations

- The extension of uncoupled with coupled simulations helps to increase the understanding of the role of coupling in the processes seen in nature. It also reveals possible phenomena not emerging in uncoupled simulations, as is demonstrated in the parameter optimization study by Lui and Bastidas. However, prior to carrying out a series of simulations, it is advisable to
 1. define a null-hypothesis to the experiments (example: coupled models enhance/reduce the sensitivity of boundary layer cloud formation to the formulation of entrainment)
 2. define the diagnostics to be examined (example: cloud formation tendency, entrainment rate, surface flux)
 3. do the simulations with well-defined standardized interfaces (like: multiple uncoupled runs with varying prescribed surface conditions,...)
- Data assimilation concepts (like demonstrated by Dara Entekhabi and Bart vd Hurk) are useful to extract relevant information from both observations and model equations. Often data assimilation frameworks require multiple integrations, and this has consequences for the design of the experiments. Simple models and simple diagnostics may give significant insight in the dominant processes affected by land-atmosphere coupling.
- A project like CASES99 should be analysed a lot further, but it is already time to consider the design of new experimental campaigns, taking place in the context of e.g. AMMA and Southern Great Plains 2007 (SGP07).

References

- M. B. Ek and A. A. M. Holtslag. 2004: Influence of Soil Moisture on Boundary Layer Cloud Development. *Journal of Hydrometeorology*: Vol. 5, No. 1, pp. 86–99.
- Steenefeld, G.J., B. Vd Wiel and A. Holtslag (2005): Modelling the evolution of the atmospheric boundary layer coupled to the land surface for three contrasting nights during CASES99; *J.Atmos.Sci.* (accepted)
- Trier, S., F. Chen, and K. Manning, (2004). A Study of convection initiation in a mesoscale model using high-resolution land surface initiation conditions. *Mon. Wea. Rev.*, 132, 2954-2976.