Thermal coupling between boundary layer and land surface: The GLASS perspective

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Current activities and projects being run within the umbrella of the GEWEX Global Land Atmosphere System Study (GLASS) are focused entirely on the daytime, during the unstable boundary layer. This means that rightly or wrongly, there are currently no active investigations into the stable boundary layer and its thermal coupling to the land surface by this community.

The motivation for the current focus of GLASS comes partly from the results of previous community studies, the new structure of projects within GLASS and the physics of the land surface where the first-order impact of water and energy cycling is seen during the daytime coupling. Previous studies such as GLACE (Koster et al. 2006, Guo et al. 2006) demonstrated the regions of the globe with a high coupling between soil moisture and precipitation. The focus of this study was the daytime during northern hemisphere summer and hence the unstable boundary layer. Similarly the follow on study (GLACE-2, Koster et al. 2011) looked at atmospheric predictability controlled by soil moisture, but again this study looked at daytime results and the unstable boundary layer.

Interest in landatmosphere coupling generated from this work contributed to one of the new three themes of GLASS (fig. 1). Studies in this area have strived to derive metrics that can be used to identify the coupling strength between the land and the atmosphere for both models and observations. Mixing diagrams and derived diagnostics (Santanello et al. 2009, 2011) are now being used to identify and help understand differences between various models at the process-level. However, again these mixing diagrams are derived for the unstable daytime boundary layer.

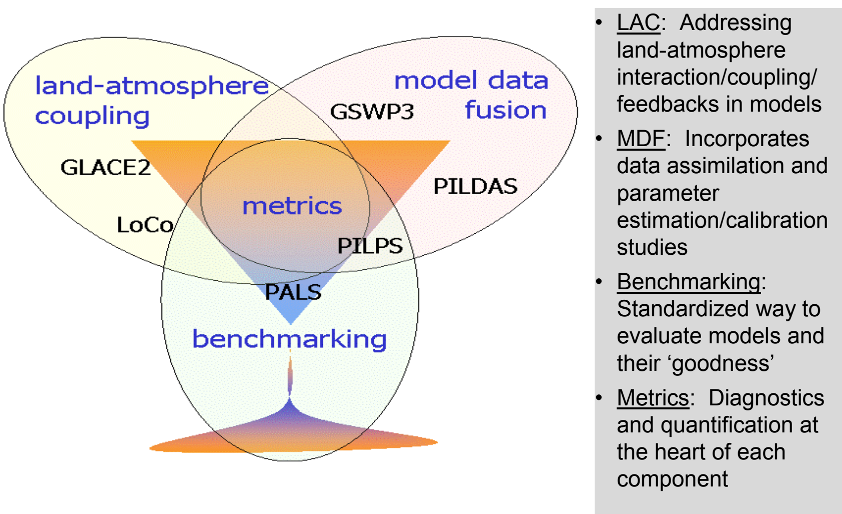

Figure 1: Structure of the Global Land Atmosphere System Study (GLASS)

One of the main motivations for studying land-atmosphere interactions during the daytime comes from the physics of both the surface energy and water balances. The surface energy balance consists of solar and longwave radiation terms, turbulent sensible and latent heat fluxes and the surface soil heat flux. During the daytime all of these terms contribute towards determining the state of the surface. However at night there is no solar radiative flux and the latent heat flux is often small. Hence the energy balance is usually dominated by the longwave radiative fluxes, the turbulent sensible heat flux and the soil heat flux. In addition, due to the small turbulent moisture fluxes during the night, the water balance also consists of fewer terms than it does during the daytime. The land surface community's focus is often determined by the water cycle and usually through the evapotranspiration, thus the daytime holds more scientific interest than the night time.

Despite the lack of interest in the stable boundary layer from the land surface community, the GABLS-3 experiment demonstrated a large variability in the nocturnal screen level temperature between the contributing models. It is possible that some of this variation comes from the initialisation of the soil temperature profile, as an initial discrete profile was imposed rather than using a spin-up period. Changing the resolution of the soil scheme within a land surface model can give differences in the amount of stored energy, even for the same discrete temperature profile. Hence some of the differences in the initial cooling rates for the surface temperature (and hence screen level temperature) seen in GABLS-3 could result from the initialisation.

A closer look at the GABLS-3 results indicate that the spread in screen level temperature is consistent with the spread in downward longwave radiation at the surface. So it is possible that variations in the atmospheric profiles are contributing to the spread in screen level temperatures rather than the thermal coupling of the land to the atmosphere. It is difficult to make any further conclusions without a detailed study of the land components of the models within GABLS-3.

To satisfy the research interests of both the GLASS and GABLS communities, a new project has been suggested which would cover at least a full diurnal cycle. This would enable the land surface community to initially study the unstable boundary layer and the GABLS community to study the stable boundary layer. However, interesting features during the period of the stable boundary layer could then also be studied by the GLASS community, and vice-versa.

The proposal is to run a suite of land surface models with observed atmospheric forcing, in an off-line mode, and evaluate the surface fluxes against those observed. The boundary layer models will then be run with the observed surface fluxes and evaluated against the observed atmospheric profiles (similar to the setup of the GABLS-1 experiment, but with a flux boundary condition rather than a surface temperature boundary condition). Finally the land and boundary layer models will be coupled together and the results for the surface fluxes and atmospheric profiles will be evaluated against the observations. Studying these three sets of simulations should give some initial results on the response of the models to land-atmosphere coupling in both unstable and stable conditions.

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