WORKSHOP/MEETING SUMMARIES

GLASS WORKSHOP SETS NEW EXPERIMENTAL STRATEGY ON TESTING LAND–ATMOSPHERE INTERACTIONS

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The goal of this Global Land-Atmosphere Systems Study (GLASS) workshop (co-sponsored by GEWEX/WCRP and KNMI) was **to identify an experimental strategy to address the importance of land–atmosphere interaction in surface model calibration and data assimilation**. The following questions were addressed at the workshop:

• Are the results of the offline surface model evaluations in the context of the Project for Intercomparison of Land Surface Parameterisation Schemes (PILPS) or the Global Soil Wetness Project (GSWP) affected by the lack of land surface-atmosphere feedback?

• Is the use of offline land surface models in Land Data Assimilation Systems (LDAS) making optimal use of the assimilated data?

The workshop was attended by 30 participants with backgrounds ranging from numerical weather prediction (NWP) to climate modelling, and from parameterization design to data assimilation. The first day was devoted to 13 scientific presentations, giving examples of land-atmosphere interaction in global climate modelling experiments and comparing calibration results of single-point experiments with either an offline land-surface model or one coupled to a model for the overlying atmosphere. Another set of presentations was devoted to sharing experience with land data assimilation systems operated in the US and in Europe. A third set of presentations addressed the technical interface between a (tiled) land model and a single column model (SCM) for the atmosphere. These highlighted that the degree to which land–atmosphere feedback affects the results of the model simulations varies widely between the existing modelling systems, and it is not at all clear whether this is a property of the land model, the boundary layer parameterization, of even more complex 3-dimensional interactions in the energy and water cycles simulated by the models. On the data assimilation aspect, the use of atmospheric screen level observations or surface temperature observations requires degrees of freedom by an atmospheric component in the model system. This makes the resulting control variables sensitive to the coupling between the land surface and the atmosphere in the model used for the data assimilation.

There is clearly a need for a new set of experiments designed to quantify the role of land–atmosphere feedback in land surface modelling and data assimilation. These experiments are supposed to take a next step in the complexity chain from offline land surface models to fully coupled GCMs. They should do so by focussing on the land–atmosphere coupling by means of turbulent exchange, but discarding the processes related to radiation and formation of precipitation. The main scientific questions that have to be addressed in these experiments are:

1. Under what conditions does land–atmosphere interaction play a significant role in the evolution of land-atmosphere fluxes and state variables? This question is related to both short-time scales (that determine the evolution of the atmospheric boundary layer, diurnal cycles of fluxes and profiles) and long climate time scales, where equilibrium partitioning of precipitation and energy at the land–atmosphere interface may be dependent on the coupling.

2. Does the absence of this coupling in PILPS-like calibration/evaluation experiments put a strong constraint on the general applicability of the results of these experiments? In other words, would calibration in a coupled model yield a different result owing to a reformulation of the sensitivities of the surface model to atmospheric forcings and vice versa?

3. Is the solution of a land data assimilation experiment using an offline land surface model configuration different from a system that includes land–atmosphere feedback? Or, similarly, does the degree of coupling between the land and the atmosphere change under influence of data assimilation? A number of clear situations can be identified in which the answer can be immediately provided. For instance, the assimilation of snow cover requires the atmospheric forcing of an offline surface model to be compatible with the existence of a snow cover (air temperature below freezing level).

However, it is not clear how critical the land–atmosphere coupling is for other situations, and what is the optimal solution to account for these feedbacks.

In a series of discussion rounds taking place on the second workshop day, the contours of an experimental strategy addressing these questions have been formulated. As in PILPS, a number of experimental stages were defined, roughly following the three main questions posed above.

In *Phase 1*, the central aim will be to make an inventory of conditions (climate, land cover and heterogeneity, synoptic situation) where modelled fluxes and state variables are sensitive to the land-atmosphere coupling. For a number of locations and time periods, the behavior of land surface models in an offline and a coupled mode will be compared. The coupling will involve the use of a Simplified Atmosphere Model (SAM) that is able to calculate the vertical exchange processes due to turbulence, thermodynamics and radiation, but does not necessarily compute the precipitation and radiation forcing to the land surface. The land-surface behavior will mainly be explored by analyzing the sensitivity of modelled quantities to perturbations in the forcings (precipitation, radiation, atmospheric quantities) and surface conditions. Greater discrepancies between these responses to perturbations from an offline and a coupled land-surface model imply a greater role of land–atmosphere coupling. For experiments covering the seasonal or even interannual time scale, a consistent data set containing the relevant atmospheric and land surface forcings is non-existent. Use could be made of atmospheric profiles or multi-level tendencies extracted from a simulation of a high resolution limited area model, nested in a time series of analyzed atmospheric fields. As such, the limited area model acts as a physical interpolator of the analysed fields. SAM and offline surface model calculations should both use radiation and precipitation time series simulated by this limited area model, as these variables are considered to be dominated by large scale processes that can not be represented adequately in this simplified local coupling. Locations for which these experiments are carried out should at least cover a wide range of climatic and land cover conditions, and preferably be co-located with local field experiment sites (see below). The participating models should be able to be operated both in an offline and coupled mode. The atmospheric component of the SAM should be able to pick up lateral driving forces affecting the local vertical profiles, while the surface model receives precipitation and radiation forcings from an external database. A number of technical issues remain to be resolved. An important one is that the atmospheric profiles should be consistent with the precipitation and radiation that is provided. Relaxation to the profiles from the host model is probably ensuring optimal compatibility.

These experiments may be helpful in identifying the conditions under which land–atmosphere feedback may be significant in the given combination of the land surface scheme and the overlying boundary layer model, it will not be easy to attribute the nature of this coupling to either of the SAM components. As an example, it is well known that land–atmosphere coupling plays a major role in the development in stable boundary layers, but the degree to which either the surface temperature dependencies in the land model, the flux-profile relationships in the PBL-model or the turbulent or radiative coupling itself is responsible for the strength of the stratification remains yet unclear. For this, it should be possible to exchange land models and boundary layer schemes using a general coupling interface.

Phase 2 of our proposed experiment aims at identifying the nature of the land–atmosphere coupling by varying the combinations land model – boundary layer model on a systematic way. It will necessarily use a common land–atmosphere coupler (which is being established within the Assistance Land Surface Modelling Activities action of GLASS), and start with providing a single boundary layer model, to which a range of land surface models can be connected. If responses to perturbations in the forcings (as applied in Phase 1) behave differently for different land surface schemes, they should be considered to be (at least partially) responsible for the strength of the coupling for the conditions concerned. If all land schemes behave similarly, additional investigations in the boundary layer scheme sensitivities have to be promoted, for instance in the context of the GEWEX Atmospheric Layers Study (GABLS) initiative.

The relation between data assimilation and land–atmosphere feedback will be addressed in *Phase 3* of the proposed experiment plan. In this phase, a combination of an offline model and SAM should be allowed to assimilate additional data that are not present in the forcings already provided. If the forcings from the nested limited area model are used, these additional data could consist of surface state variables (soil moisture, snow), atmospheric quantities (screen level parameters, surface heating rates), surface fluxes or combinations of these obtained from co-located field experiments or remote sensing. There are four combinations of model coupling (offline or coupled) and data assimilation (do or do not assimilate additional data), and comparisons between subsets of these four experiments may reveal the significant properties of the system. For both experiments where data assimilation is applied, the comparison between the offline and coupled simulations may be used to detect whether the land–atmosphere coupling can result in a different optimal solution of the model's control variable(s). For a perfect model, the additional data should not lead to a correction of the control variables. The increments that are calculated, however, may be different for the offline and coupled simulations. When, for instance, the increments in the offline model configuration are greater than the coupled system, this may point at internal adjustment of the model state under influence of the overlying atmosphere, for instant by a negative feedback cycle between the land and the PBL. Alternatively, for both experiments with a coupled system, the data assimilation may actually alter the significance of the land–atmosphere coupling, for instance, by bringing the surface model into a more robust state in which propagation of perturbations becomes less significant.

The design of this coupling-experiment clearly addresses the two-way coupling between the land surface and the overlying Atmospheric Boundary Layer (ABL). It could actually serve as a first step for a GLASS-GABLS collaboration. However, many details have yet to be resolved before a "call for participation" can be distributed over the scientific community. A selection of suitable data sets (a first list has been compiled during the workshop) or limited area models has to be made, as well as a clear definition of the way perturbations are applied and model output is diagnosed. To be able to exchange the atmosphere and land models that are mutually coupled, the interface has to be finalised and a set of suitable models must be defined. And, last but not least, an experiment team should be formed that will take the initiative and coordinate the analysis. People that are interested in joining a coordination team are kindly invited to contact members of the GLASS and GABLS panels.

MISSISSIPPI RIVER CLIMATE AND HYDROLOGY CONFERENCE

New Orleans, Louisiana USA
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Approximately 175 meteorologists, hydrologists, water managers, science teachers, and representatives from local organizations attended the Mississippi River Climate and Hydrology Conference sponsored by the GEWEX Continental Scale International Project (GCIP). The purpose of this meeting was to review the research findings resulting from the past 6 years and to provide directions for future research under the follow-on, GEWEX Americas Prediction Project (GAPP). GCIP has had many major scientific achievements since it started in 1995, including: 1) closure of water and energy budgets in the Mississippi River Basin, 2) development of land surface and hydrological models, and 3) water resource management applications. The New Orleans meeting marked the successful completion of the GCIP science program.

More than 150 scientific oral and poster presentations were delivered in the science sessions. Topics covered included the fundamental aspects of climate and hydrology in the Mississippi River Basin in the areas of observations, modeling, process studies, and applications. Some highlights of the scientific presentations in the five major GCIP science sessions are briefly described in the following paragraphs.

Many aspects of water and energy budget studies were presented, including comparisons of water and energy processes using observations and data assimilation system outputs, observational studies of individual processes, modeling studies that describe and validate water and energy processes from mesoscale to the continental scale. A presentation was given on the Water and Energy Budget Synthesis (WEBS) during the period of 1996-99 for GCIP in which different model outputs were compared with observations. The results of this research have been summarized in the WEBS CD-ROM (see page 10).

Studies on warm season precipitation presentations included observational analyses, model simulations, and studies of processes that affect the warm season precipitation over North America included an overview of North American Monsoon Experiment (NAME), which has the goal of determining the sources and limits of predictability of warm season precipitation over North America.

There were presentations on predictability studies showing the effects of land-surface processes on the