4.1.2 Long term objectives

South Ontario field processes : Needs more information !!

Precipitation scale sensitivity experiment : The water fluxes and state variables of land surface schemes are likely to have scale dependent response properties because the hydrologic processes in LSSs are nonlinear and therefore dependent on the temporal variability properties of precipitation forcing which are known to be scale dependent. Because LSSs are used over a wide range of spatial scales with grid dimensions from a few kilometers to a few degrees, it is important to test how sensitive the schemes are to spatial scale, to analyze what can be done to reduce or mitigate the effects of the scale dependency.

The main objective of the study is to test the sensitivity of a number of LSSs to space and time aggregation of precipitation forcing. It is essential to meet this objective in as simple a way as possible so the study should focus primarily only on possible scaling effects of precipitation forcing. The possible effects of spatial variability in model parameters or in other forcing variables will not be considered, at least in the initial phase of the study, nor will possible interactions between precipitation and other scaling effects be considered initially.

Time series of different space-time accumulations of precipitation will be processed through each model. Time series of surface fluxes and state variables will be produced by each model. These will be analyzed to summarize how the aggregate behavior of these outputs depends on the space and time scales of aggregation of the forcing data. The project will provide a computer program to each modeler to process the model outputs.

This work will be done in collaboration with the GSWP action (See section 4.2).

4.2 GSWP

Paul Dirmeyer, Han Dolman, Taikan Oki

The Global Soil Wetness Projects (GSWP) (**?**) aims at evaluating at the global scale the ability of land-surface schemes to model the inter-annual variability of soil moisture. In its first phase, a pilot study, GSWP used data from the ISLSCP Initiative I to force LSS. As ISLSCP-I only provides atmospheric forcing for the years 1987 and 1988 the evaluation of LSSs was limited.

Initiative II of ISLSCP will provide 10 years worth of data and will thus be better suited for the GSWP project. The availability of this data by January 2002 will launch GSWP-2. Additionally, a regional (continental-scale) phase at higher resolution is also planned. In the mean time, preparatory work can be undertaken with the 2 year forcing in order to offer guidance to ISLSCP-II for their choice of original data sets. This phase has been labeled GSWP-1.5

4.2.1 Short term objectives: GSWP 1.5

In preparation of GSWP 2 studies will be undertaken over the ISLSCP-I period. A number of them will be re-runs of the GSWP Pilot Phase. As illustrated by validation studies, the influence from the quality of the forcing data is substantial (**?**). Several years have passed since the release of the original ISLSCP Initiative I dataset, updated version and new estimates of some variables are available now. Therefore it will be worthwhile to substitute such newer datasets in the original ISLSCP forcing and run LSSs again for 1987 and 1988. Along with these re-runs, some issues partly unresolved within the GSWP Pilot Phase should be pursued.

- How can a more general soil wetness index be defined?
  Validation studies have shown that a good correspondence exists between the temporal variation of the soil wetness index from the different LSSs which have participated in the GSWP Pilot Phase, however, the absolute values are very different (**?**) from one scheme to the other. This

is, of course, mainly due to the model biases and different absolute values of soil moisture in the LSSs that have similar effects on the land surface processes, particularly evapo-transpiration. Even though the soil moisture index itself is a normalized parameter, a new soil moisture index may be proposed that relates more closely the soil moisture represented in the LSSs.

- Why do most of the LSSs underestimate the runoff in high latitudes?
  It was also found in a validation study that most of the LSSs tend to underestimate the annual runoff in higher latitudes when compared to observations. This could be caused by the unrealistically low intensity of precipitation in the forcing data. On the other hand, biases in the forcing data such as too dry and warm air masses, too much incoming solar radiation, or too strong wind should lead to an overestimation of the evaporation and thus a lower runoff. If the forcing data is responsible for the underestimated runoff, substitution of the latest datasets will improve the accuracy. It is still possible that the biases are caused by the short-comings of LSSs particularly in the processes related to snow and freezing.

- By how much will seasonal prediction be improved by prescribed surface soil moisture?
  The impact of prescribed surface soil wetness was investigated in the GSWP Pilot Phase, and the seasonal prediction of precipitation on continental scales was found to be improved by giving the suitable soil wetness information estimated by off-line simulations (**?**). However, the cases examined are limited to a particular continent and GCM, and it is expected that number of similar studies will enforce the effectiveness of soil wetness index. This study will be done in coordination with the coupled action (See section 4.4).

- Is the GSWP framework valid at regional scales?
  The target of GSWP is to cover continental scales and dedicated to providing the boundary condition for GCMs. However, there is a need to estimate and utilize soil wetness distributions at regional scales. On the other hand, application of GSWP frame work in regions with higher resolution forcing data from well instrumented catchment such as the Rhone Basin or one of the 5 continenta scale experiments of GEWEX, the sub-grid scale variability within the $1° \times 1°$ ISLSCP data set can be analyzed. This process analysis can help us improve our understanding of the meaning of the soil wetness which will be produced during GSWP 2.

Other studies within GSWP-1.5 will serve the preparation of the second phase of GSWP. This part can be further divided into two; philosophical and technical issues.

The philosophical issues which need to be discussed and recognized among participating researchers before GSWP-2 starts are the following:

- What is the relation between $1° \times 1°$ soil moisture and the observable quantity ?

- How accurately can LSSs simulate soil moisture ?

- What precision is needed for the forcing data to obtain a given accuracy in the simulated soil wetness ?

The technical issues should lead to recommendations for either the preparation of the atmospheric data in ISLSCP Initiative II or the design of the GSWP experiments. It is for instance unclear if it would not be advantageous to use the atmospheric temperature, humidity and wind computed by the re-analysis system on its lowest level instead of the values interpolated to 2 and 10 meters. The impact of the time disaggregation of precipitation needs to be explored further and the potential of new data sets needs to be evaluated.

An information infrastructure capable to deal these points below should be prepared for the GSWP-2 in close collaboration with ALMA (See section 4.5).

- Controlling the albedo used by the LSSs.

- Diagnose "potential" evapo-transpiration in the LSSs.
- Create validation tools for global grids.
- Prepare off-line simulation systems for 10 years integrations.

The implementation of GSWP 1.5 As seen above, GSWP 1.5 is a bridge to support smooth transition from GSWP 1 to GSWP 2. GSWP 1.5 will be organized mainly through three components. The first one is the model production group. Its task is to run the LSSs and estimate the global energy and water cycles for 1987 and 1988. The second one is the data center, which will provide the latest forcing in order to partly update to the ISLSCP Initiative 1 dataset. The data center also collects the outputs from the production group, performs basic quality checks, and provides the data to the validation group and production groups. The third group is for validation. It receives the data from the data center and validates the results of LSSs using in-situ data, satellite data, and other information available for 1987 through 1988. All three groups should in the process improve their system to prepare for the GSWP-2 frame work. A GSWP scientific steering group will be created. Its role in GSWP 1.5 will be to discuss and determine what kind of dataset should be replaced in the original ISLSCP data and prioritize the parameter sensitivity test which should be performed, and how the grid system should be prepared. The steering group should also organize and conduct the regional scale experiments, and negotiate with other research initiatives including GEWEX and BAHC.

4.2.2 Long term objectives: GSWP 2

There will be both a global and a regional (continental-scale) component to GSWP 2, taking advantage of new data and products that have become available since the pilot phase of GSWP, and that will become available over the next two years.

Global Offline Simulation :

The global component of the project will be executed very much along the line of the pilot 2-year GSWP (Dirmeyer et al. 1999). The main innovations will be extension to 10 years (1986-1995), improved data sets for LSS parameter specification, extended data sets for validation (particularly in the later part of the period) and a greater potoential for sensitivity studies and assessment of interannual variability.

Production : ISLSCP Initiative II is currently compiling a ten-year data set of vegetation, soils, and near surface meteorological data. This data set will be the driver for GSWP 2, just as ISLSCP Initiative I was critical for the pilot phase of GSWP. Resolution will likely be maintained at $1^\circ \times 1^\circ$ resolution, to match the resolution of the best available global near-surface meteorology fields.

A major issue for the success of the production effort will be the development of the ALMA interface tools. If ALMA's goals can be realized, it will make model participation in any of the GLASS modeling projects a one-time investment in development. This will ease cross-participation between PILPS, GSWP, and the new GLASS projects.

Sensitivity Tests : Initiative II plans to include multiple choices for many of the data sets:

- Meteorologiy from ECMWF and NCEP Reanalyses
- Vegetation classification from MODIS, GSFC, and U. Maryland
- Rooting depth information from Duke U., and U. Arizona

- Precipitation hybrids from GPCP/ECMWF and GPCP/DX
- Downward radiation from reanalyses and SRB

In addition, information on the top 3-4 dominant vegetation types within each grid box will be included, allowing for offline testing of so-called tiling strategies at the global scale. This range of choices in data sets creates a wealth of opportunities to explore issues of parameter uncertainty and model sensitivity.

Comparison : GSWP 2 will enlist a more complete and imaginative suite of comparisons between models than was attempted in the pilot phase. In addition to drawing on the PILPS metrics for model consistency and balance, hydrologically-based measures like those of Oki et al. (1999) will be employed and expanded. Specific investigation of LSS simulation of snow cover and extent, and performance in specific biomes will be pursued. A broader investigation of the behavior of land surface controls on heat fluxes as in Dirmeyer et al. (2000) will also be pursued. GSWP 2 will orchestrate close coordination between comparison and validation efforts. All individual LSS data will be made available for analysis by the broader community.

Validation : Global experiments demand global validation. Thus, a strong emphasis must be placed upon remote sensing as a validation tool. GSWP 2 will continue to develop large-scale validation techniques for snow cover, near surface soil moisture, and surface temperature that can be measured by satellite. In situ measurements do exist over several regional soil moisture networks (Robock et al. 2000), and additional data are available for selected field experiments such as FIFE and BOREAS. The ten year time frame of GSWP 2 overlaps the observing periods of a number of such regional campaigns.

In addition to direct comparison to measured variables, validation of the LSSs can also be performed by employing their state variables or fluxes as boundary conditions in coupled models. The degree of improvement over control integrations in such simulations can be used as additional measure of the quality and usefulness of GSWP-produced data sets.

Regional Offline Simulation :

The National Centers for Environmental Prediction (NCEP) is undertaking a regional meteorological reanalysis over North America, covering the 22 year period from 1982 through 2003 (DiMego et al. 2000). The reanalysis will be conducted using the Eta atmospheric model coupled to the NOAH land surface scheme. Resolution of the reanalysis will be no coarser than 32 km. This regional data set provides the opportunity to examine issues of aggregation and sub-grid parameterization.

Production : As with the global simulation, it will be advantageous to use hybrid precipitation and radiation fields to remove systematic biases in the model products. These hybrid fields will need to be generated, as they will not be created as part of the reanalysis. Techniques developed for the ISLSCP data initiatives can be directly applied. Similarly, vegetation and soils data will need to be compiled at the proper resolution over North America. Much of this can come from the reanalysis implementation of the NOAH LSS. Overall, there will be a need for extra data preparation compared to the global simulation, but the same infrastructure can be used by both.

Sensitivity Tests : The resolution of the regional reanalysis is ideal for examining issues of aggregation and sub-grid parameterization within LSSs. Thus, one of the fundamental questions raised at the La Jolla workshop (IGPO 1998) can be addressed. There is also strong potential for cooperation with the the GEWEX America Prediction Project (GAPP) on issues of cold-season precipitation and hydrologic aspects of the North American monsoon.

Comparison : Tools and infrastructure for 2-dimensional and spatio-temporal comparison of model products will be completely transportable between global and regional simulations. Extending comparisons to the regional simulations will be straightforward.

Validation : The region has several areas of high-density observations which could be very valuable to land surface modeling at this scale. For example, data from the Oklahoma mesonet and the proximate facilities such as the ARM-CART site, the Illinois State Water Survey, and data from field campaigns such as the bienial Southern Great Plains (SGP) experiments, FIFE, etc. could be of great use for in situ validation. Opportunities for remote sensing validation are prevalent as well.

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4.3 Data assimilation action

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The aim of this action is to monitor and encourage progress within the community on land-data assimilation systems in LSSs. Its activities will lead to assessment of the soil moisture signal in existing and forthcoming observation systems, recommendations on variables which are easily observable, in-situ or remote sensed, and would contribute most to constraining operational land-surface analysis systems. Land-surface variables (temperature, snow and soil moisture) and fluxes (sensible heat flux, evaporation, runoff, melting) evolve under the forcing of atmospheric fluxes (precipitation, downward surface radiative fluxes) and boundary layer temperature and humidity conditions. At the same time, because the surface and the atmosphere are a coupled system, the surface can modify the state of the boundary layer (BL) and the magnitude of the atmospheric fluxes. At the global scale, there is only indirect information related to land-surface variables and fluxes. Data assimilation combines available information with the background (guess) model fields in order to infer an optimal estimate of the land-surface variables. The best estimates of the surface fluxes correspond to short term integrations starting from the optimally estimated variables.

Information on the state of the surface can be gained on the one side from direct observation of the surface but also from the data collated in the lowest layer of the atmosphere. The first type of data could directly be assimilated as it corresponds to variables in the land-surface schemes but it is faced with the problem of surface spatial variability. The second data set on the other hand is readily available through the meteorological network (GTS) and is less affected by spatial variability but the information content on surface processes is indirect. Both approaches are possible and are being applied. The NCEP is preparing a regional surface data assimilation system which is un-coupled from the atmosphere while the ECMWF has implemented a global assimilation system within the coupled land-atmosphere system. In order to evaluate these systems and make progress in land-surface data