Global Land Atmosphere System Study (GLASS)

Jan Polcher, Roni Avissar, Peter Cox, Paul Dirmeyer, Hoshin Gupta, Ann Henderson-Sellers, Paul Houser, Randy Koster, Taikan Oki, Andy Pitman, Pedro Viterbo

GLASS is a proposal by GMPP/WGNE, in collaboration with other GEWEX panels and BAHC, to coordinate the development and evaluation of the next generation of complex land-surface schemes.

- The **aim** is to improve land-surface schemes for the benefit of numerical weather prediction and climate models.
- GLASS proposes to achieve these goals by providing a structure to facilitate and promote land-surface scheme (LSS) inter-comparisons.

1. Evolution towards the next generation of complex land-surface schemes

The end of the 80' saw the implementation of the first complex LSSs in GCMs. The community is currently moving towards the next generation of complex LSSs.

The higher complexity of the schemes will move them from the status of GCM parameterizations to that of independent models. The interaction with the atmosphere becomes thus a coupling problem.

Three workshops have contributed to this evolution :

- IGBP/GEWEX, La Jolla, 1997
- ECMWF/GEWEX, Reading, 1998
- GEWEX/INSU, Gif-sur-Yvette, 1999

1.1. New features in the next generation LSSs

The greening of the surface :

⇒Introducing the carbon cycle.
⇒Dynamical vegetation.

Vertical vs. horizontal complexity :

More emphasis on the horizontal complexity of LSSs :
⇒It is needed for surface hydrology.
⇒Model evaluation and data assimilation will benefit.

Land/Atmosphere interactions : Our understanding of the sensitivity of the atmosphere to surface processes needs to be improved before new feedbacks are introduced.

Integrator of observations : LSSs will be used in assimilation mode to construct global datasets of surface variables.

2. Achievements in LSS validation

PILPS :

⇒ Established the first generation of complex LSSs.

⇒ Introduced some basic concepts in the community.

⇒ Showed how difficult the coupled problem is.

GSWP :

⇒ Raised the question of the meaning of soil moisture at the $1^\circ \times 1^\circ$ resolution.

What is needed for the next generation ?

⇒ Validate the new processes with off-line point simulations.

⇒ Address the sub-grid variability issues.

⇒ Study the interaction of LSS with the planetary boundary layer.

⇒ Perform coordinated sensitivity experiments with GCMs.

⇒ Help modelers participate in inter-comparison projects.

⇒ Document and distribute atmosphere/land-surface interfaces.

2.1. From the point to the GCM grid-box.

Land surface schemes are applied from the plot scale to the regional scale and in a forced or coupled mode.

Because of the high heterogeneity of the surface and the complex interactions between the surface and the planetary boundary layer, it is not clear how the concepts used by LSS transfer from one application area to the other.

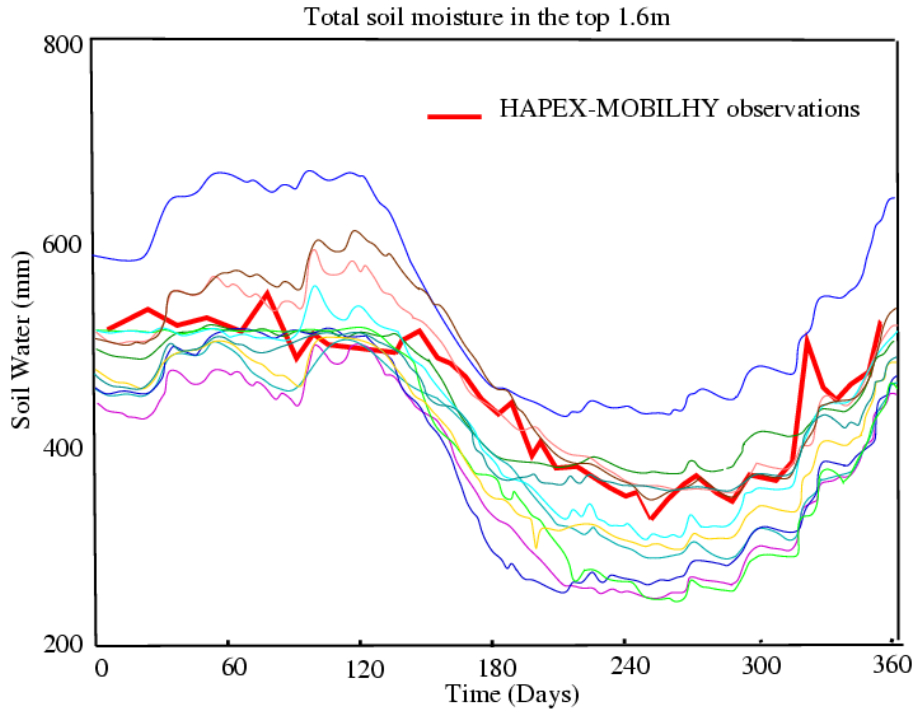
Soil moisture will be used here as an example to show how these different applications of LSSs complement each other and how they contribute to our understanding of surface processes.

This reasoning also applies to other variables or concepts used in LSSs.

2.2. Soil moisture : local and off-line.

Because of its large spatial heterogeneity soil moisture measurements are only representative of small areas.

PILPS-2 compared LSSs forced with atmospheric data from available measurement sites. Soil moisture simulated by LSSs can be validated at the local scale with *in-situ* observations.

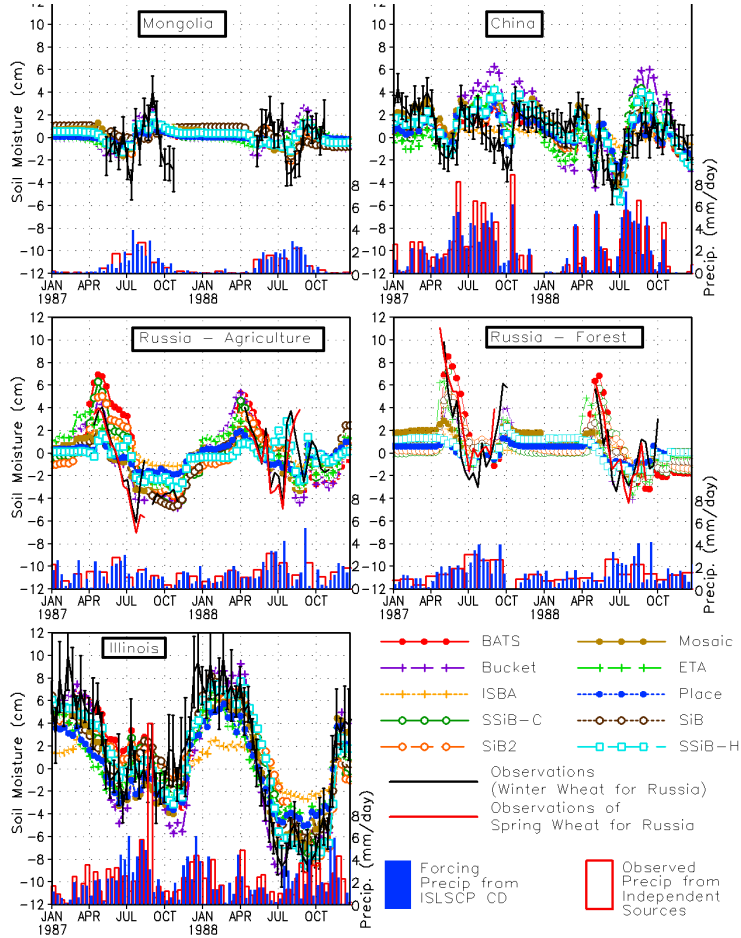


Shao et al., 1996, Global and Planetary Change

2.3. Soil moisture : global and off-line.

In the GSWP experiments LSSs are applied globally at a resolution of $1^\circ \times 1^\circ$ using observed atmospheric data.

This utilization is closer to the GCM application but poses the problem of soil-moisture validation.



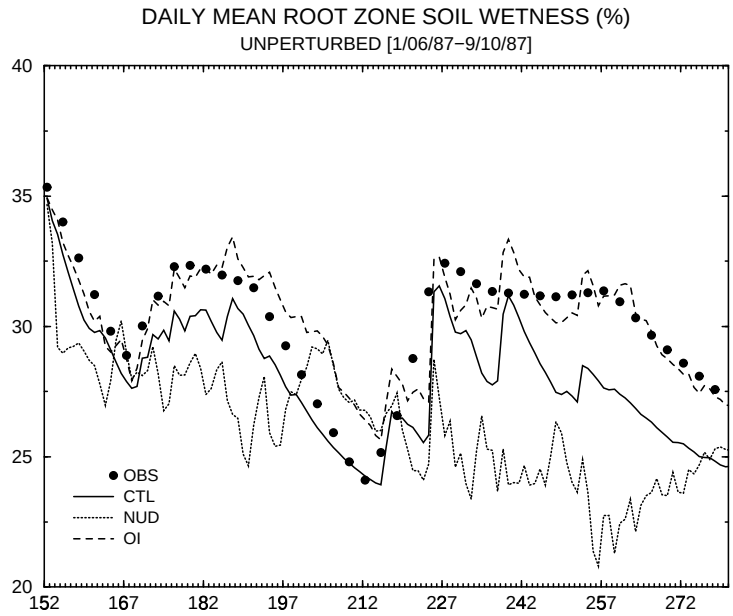
Entin et al. (1999)

Observed soil moisture anomalies may still provide useful information at these scales.

2.4. Soil moisture : local and coupled.

A single column atmospheric model coupled to a LSS can be used to improve our understanding of the interactions and to evaluate data assimilation methods.

Using 4 month of the FIFE data the ECMWF compared a nudging (NUD) and an optimal interpolation (OI) technique to assimilate 2m temperature and humidity observations.



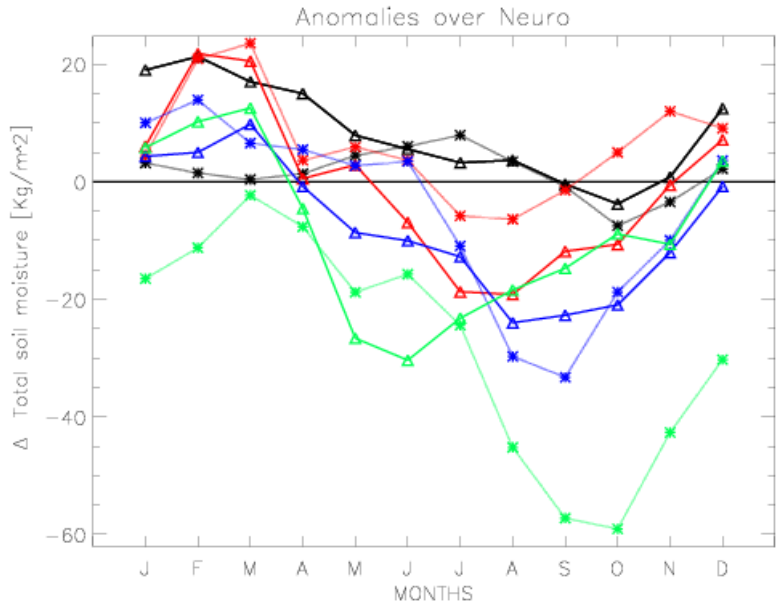
The IO method yields soil moisture values and fluxes which are in good agreement with observations.

Douville et al., 2000, Q.J.R.M.S

2.5. Soil moisture : global and coupled.

LSSs coupled to GCMs are for instance used to predict the impact of climate change on water resources.

A European project addressed this issue by performing time slice experiments in a doubled CO_2 environment with 4 GCMs (4 colors) coupled to 2 LSSs each .



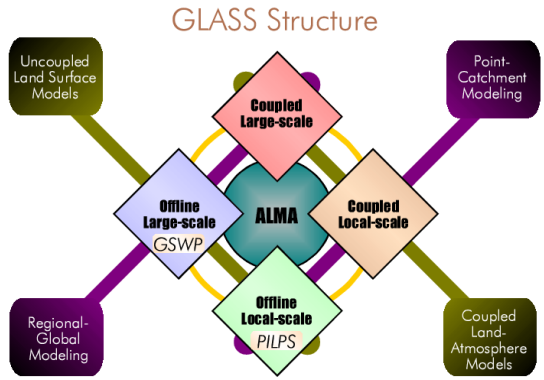
The uncertainties in the predicted soil moisture changes over Northern Europe is caused in part by different sensitivities of the LSSs.

Polcher et al., 1998, GEWEX News.

3. Organization and management

GLASS will coordinate LSS inter-comparisons from local to global scales and from off-line forcing to fully coupled.

It will ensure progress in all applications of LSSs and advance our understanding of the concepts needed to represent surface processes at various scales.



- The 4 scientific actions will coordinate projects in their field. A 5th action will provide the infrastructure.
- The science panel of GLASS will coordinate the 5 actions.
- The science panel will ensure that GLASS contributes to land-surface modelling needs of other GEWEX activities and BAHC.
- WGNE, IGBP/BAHC and the GEWEX panels will be represented on the science panel.

The first science panel meeting took place in Sydney in July 2000.

4. Local-scale/Off-line action

Coordination : Ann Henderson-Sellers, Andy Pitman

PILPS will continue the phase 2 projects. Next in line is PILPS 2e on the Torne River Basin (P.I. : Dennis Lettenmeier). It will validate cold-season processes in LSSs. Other projects will follow :

- A CO_2 flux validation with the EuroFlux data from Loobos site will be organized (P.I. : Nicolas Viovy).
- Valdai mature forest data will be used to explore the snow/vegetation interactions (P.I. : Alan Robock).
- A PILPS experiment with ARM/CART data will prepare a parameter estimation exercise and an inter-comparison with a simplified coupling (cf. local coupled action).
- South Ontario field measurements will be used to validate cold-season processes with high quality data (P.I. : Diana Verseghy).

Contacts with CSE's will be established in view of organizing PILPS experiments in climatic zones not yet studied.

PILPS-2e is launching the ALMA activities and set new standards for collaboration in LSS inter-comparisons.

5. Global-scale/Off-line action

Coordination : Paul Dirmeyer, Taikan Oki

GSWP-2 will use the ISLSCP-II data to perform global off-line simulations over a 10 year period. Inter-annual variability of soil moisture will be the focus.

In the meantime GSWP-1.5 will help prepare phase 2 (P.I. : Taikan Oki)

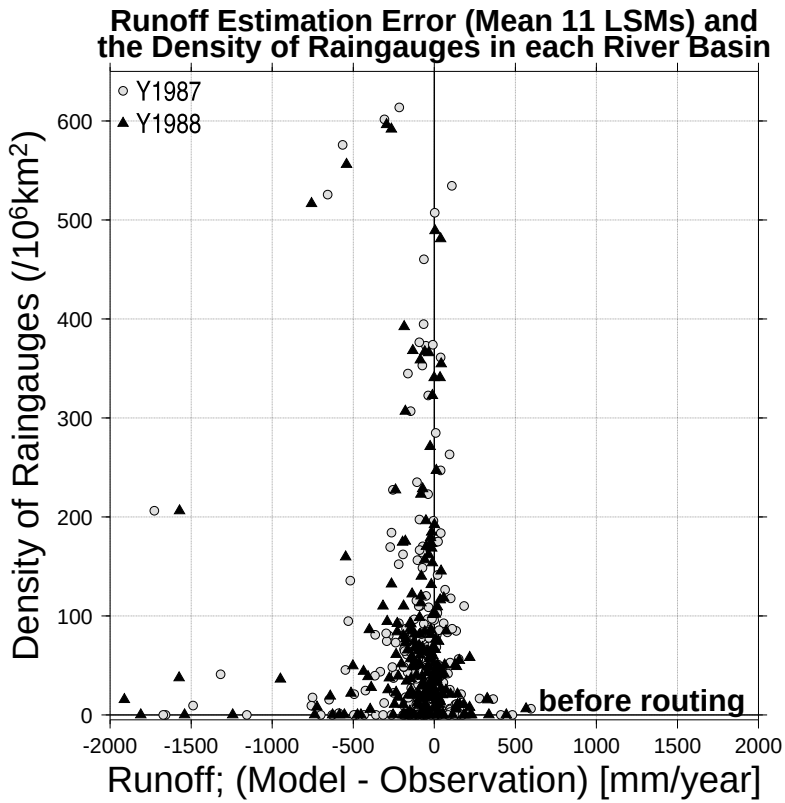
The following questions will be addressed :

- How Sensitive are LSSs to errors in the forcing data ?
- How well can LSSs be validated at the global scale with remote sensed data ?
- Are the drying out cycles of LSSs comparable ?
- Do LSSs operate in similar soil moisture stress ranges ?

The added value to GSWP-1 will be :

- Updated and improved forcing data and
- the participation of more schemes.

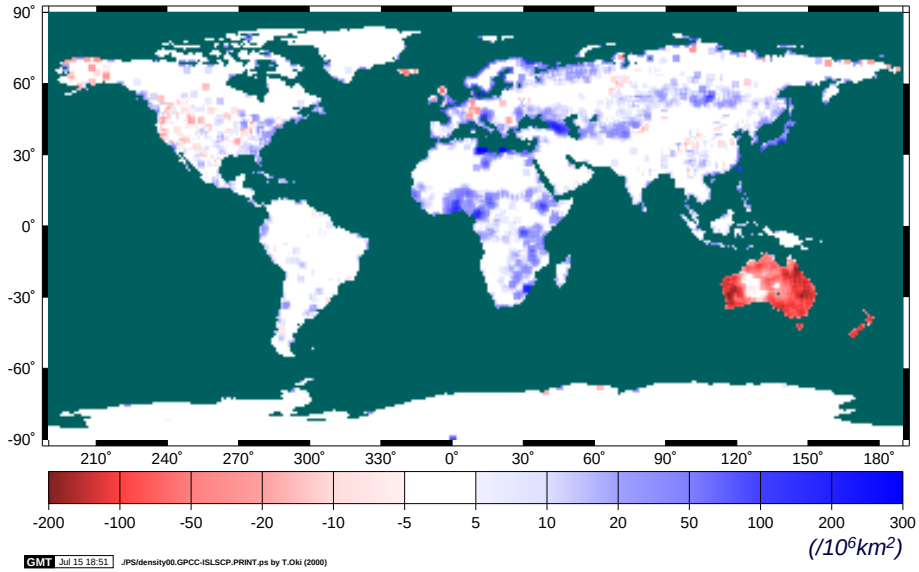
5.1. Improved data sets for GSWP-1.5 : precipitation



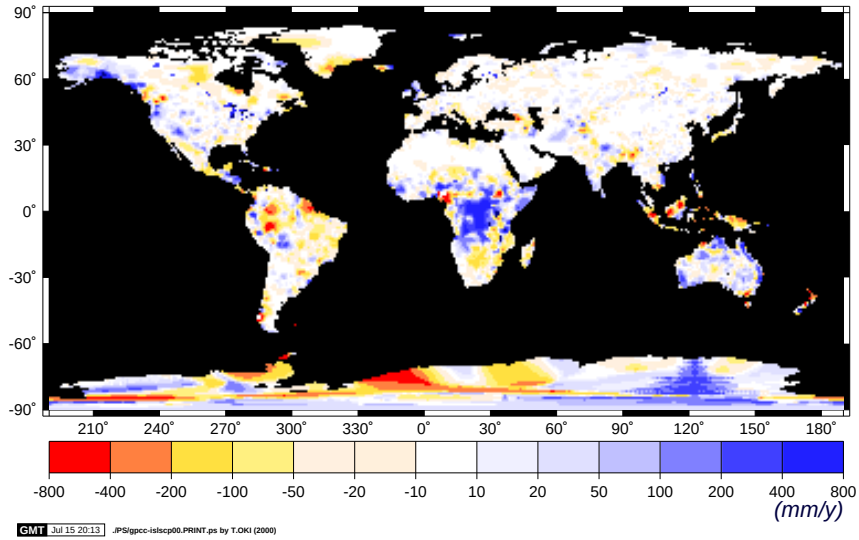
Full Screen

Quit

Difference in Density of Raingauges [GPCC-ISLSCP] 1987/88



Difference [GPCC(V003) - ISLSCP Initiative I] for 1987/88

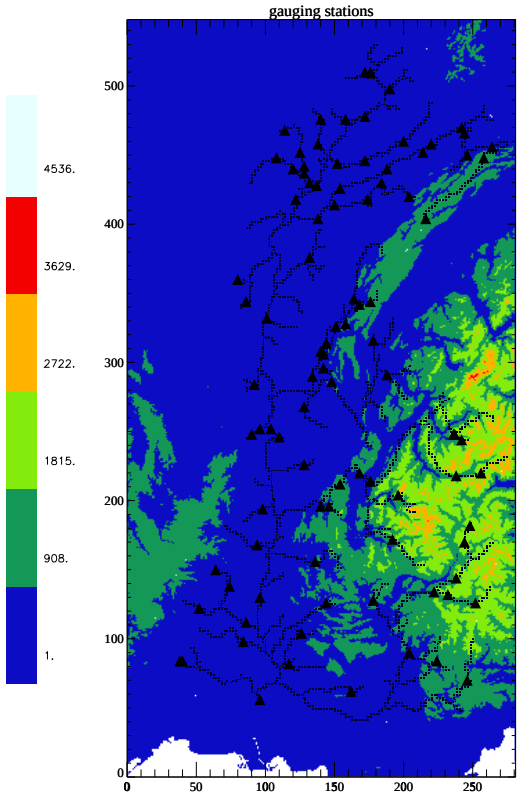


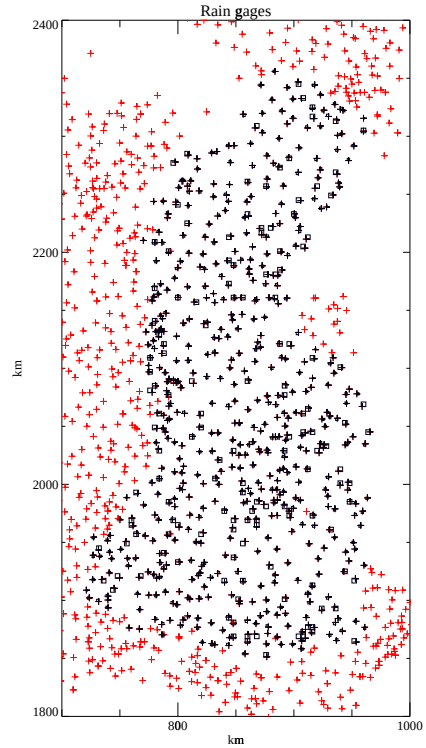
Full Screen

Quit

5.2. Soil moisture aggregation experiment

The aggregation experiment will help understand the meaning of soil wetness at a $1^\circ \times 1^\circ$ resolution and its model dependence (P.I. : Joel Noilhan). Thanks to a financial contribution from INSU and Météo-France data from the Rhône Basin will be used.





6. Local-scale/Coupled action

Coordination : Hoshin Gupta, Paul Houser, Pedro Viterbo

This group will concentrate on the ARM/CART data. It will distribute a simplified single column model (SCM) and extend the PILPS experiments to the coupled system.

The scientific questions are :

- What are the feedbacks between the PBL and LSSs ?
- How does the PBL interact with the surface heterogeneity ?
- Is the sensitivity of the LSS different in off-line and PBL-coupled modes ?

The planed sequence of events is :

- Off-line inter-comparison with the ARM/CART data set.
- Application of the parameter estimation to ensure that the same effective parameters are used.
- Inter-comparison with the schemes coupled to the common SCM.
- Evaluation of data assimilation methods in the coupled context.

7. Global-scale/Coupled action

Coordination : Peter Cox, Randy Koster

Two aspects of land-surface atmosphere interactions are considered to require ***model independent assessments*** :

- Climate sensitivity to anthropogenic forcing
- Climate variability and predictability.

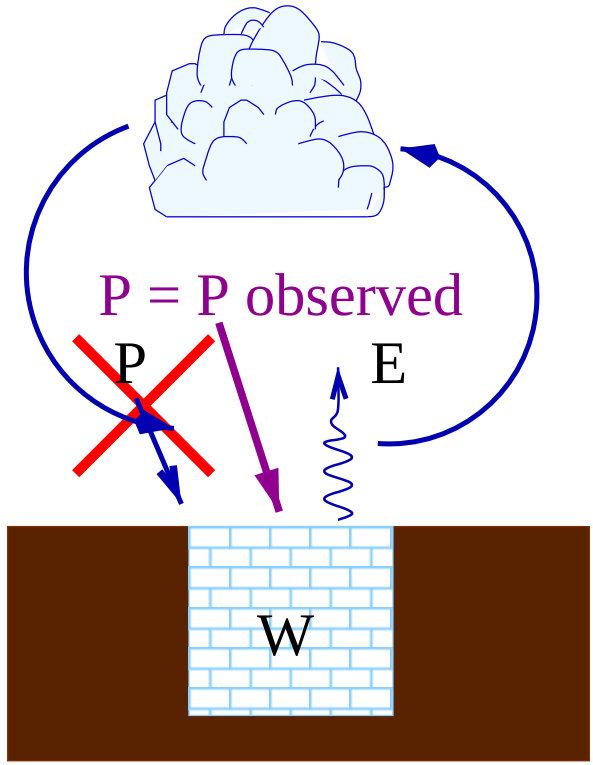
The first experiment in this action will evaluate the impact of improved surface conditions on short term forecasts (P.I. : Randy Koster). It should yield information on :

- The geographical distribution of the strength of the land-atmosphere feedback,
- its inter-model variation, and
- its role in the predictability of the hydrological cycle.

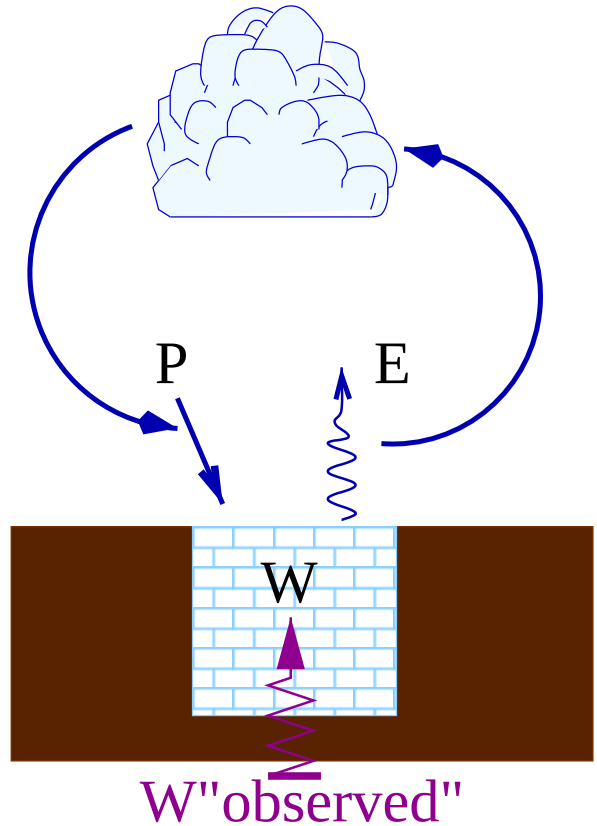
Two experimental designs are under consideration for the moment :

7.1. Predictability and climate variability

A flux correction method



Relaxing soil moisture towards "observed" values.



Both experimental set-ups will demonstrate the impact of land conditions on precipitation.

In any case the experiments will :

- require forcing data with a high temporal resolution and
- induce inconsistencies in the coupling between the surface and the atmosphere.

A flux correction method

- It is simple to implement.
- Offers the possibility to correct other atmospheric fluxes at a later stage.
- Combinations of fluxes corrections may be explored.

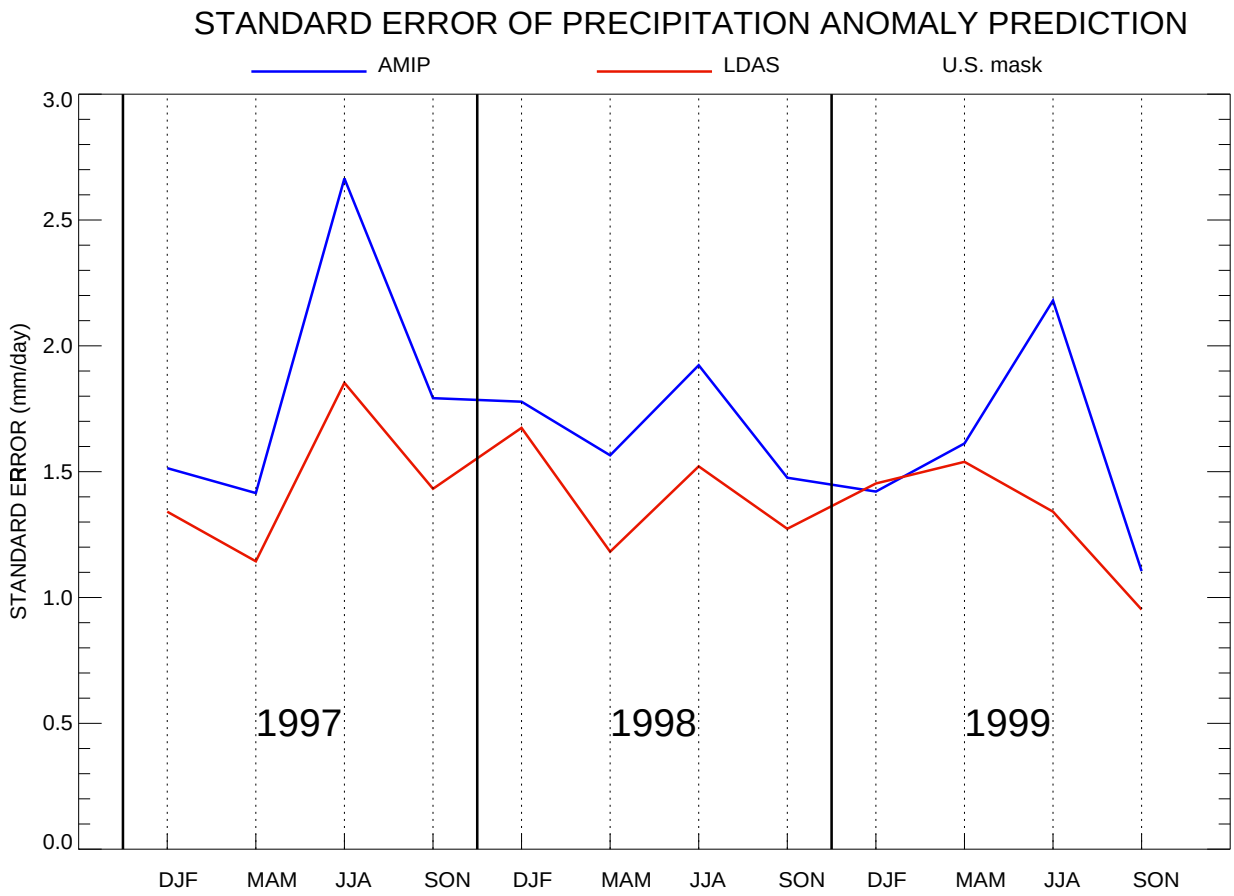
Relaxing soil moisture towards "observed" values.

- The soil moisture fields can be generated and validated in collaboration with the GSWP project.
- Relaxation time for the soil moisture will be scheme dependent and may be difficult to specify.

Both experimental designs have "AMIP-style" simulations as a reference.

The initialization issues of surface processes can be explore by stopping at a given point in time the flux correction or the relaxation.

Results from a highly preliminary version of Phase 1 of the experiment. (A more careful "demonstration" experiment is currently being performed.)



Full Screen

Quit

The flux correction method will be thoroughly evaluated with 3 GCMs in the next few month.
This should allow to propose by mid-2001 an experimental design to the community.

7.2. Other topics of the global coupled action

The experiments on the climate sensitivity to anthropogenic forcings will combine land-use and increased CO_2 concentration. The aim is a model independent assessment of the impact of climate change on the water cycle and surface processes. A project will be submitted to the next call for proposals by the EU.

The coupled action will maintain close contact with the two AMIP diagnostic sub-projects which deal with the role of LSSs in determining the quality of the climate simulated by GCMs.

8. Advancing Land-surface Modeling and Analysis (ALMA)

Coordination : Jan Polcher, Taikan Oki

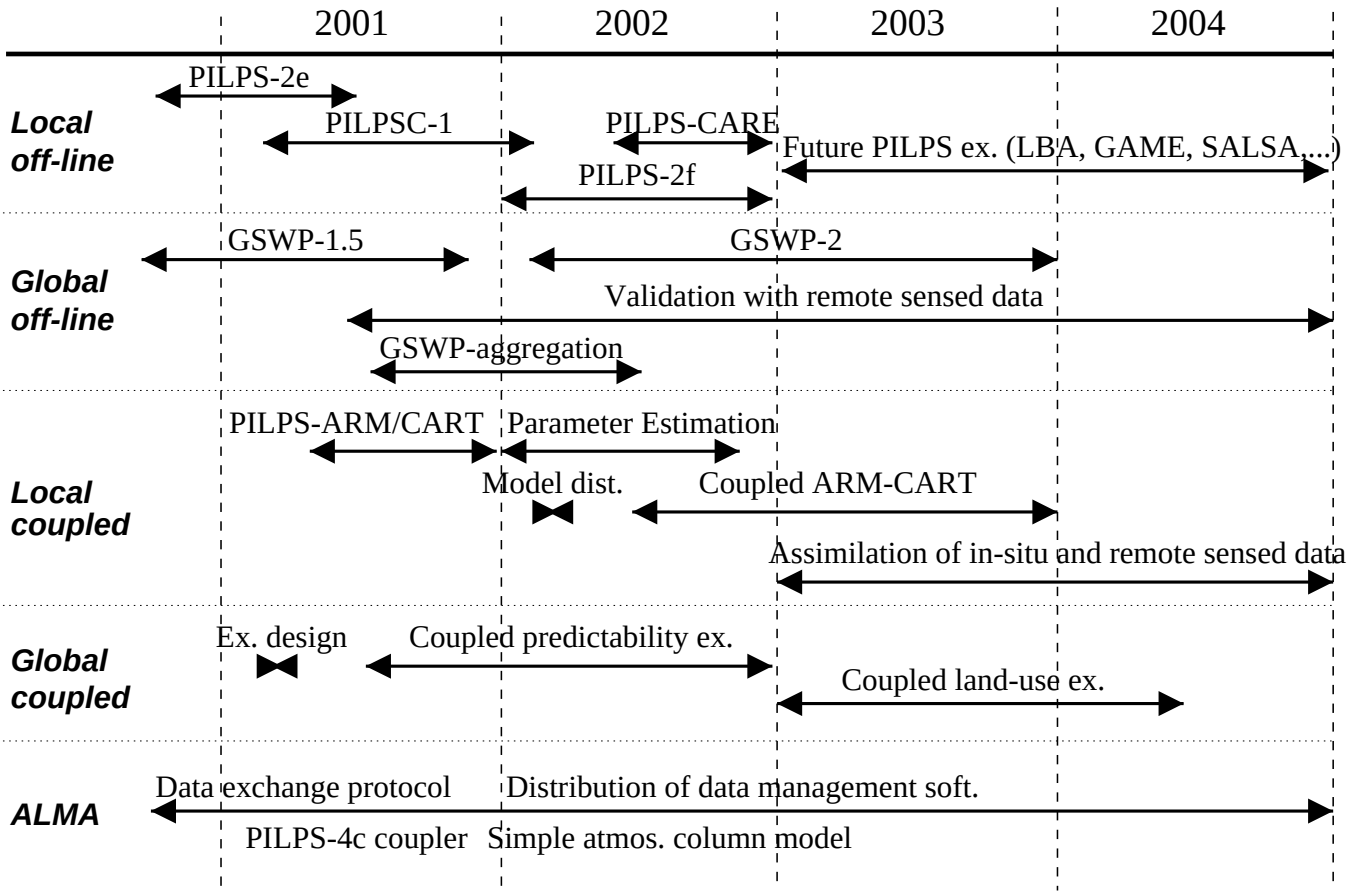
The aim is to facilitate the inter-comparison activities within GLASS. It will also help the community to move towards standard methods for coupling LSSs to atmospheric models.

- Provide standards for data transfer. The first version is available and used by the PILPS and LDAS projects.
- Ensure that data from past experiments remains available.
- Distribute software for the modelling and analysis of land-surface processes

Current actions :

- PILPS-2e is using the standard data transfer methods. ALMA provides the technical support for the users.
- Software is distributed for participants to quality-check their data before sending it to the inter-comparison center
- Provide LSS drivers based on the interface defined in PILPS-4c : http://www.lmd.jussieu.fr/PILPS4c.html

9. Time line


2001
2002
2003
2004
Local off-line
PILPS-2e
PILPSC-1
PILPS-CARE
Future PILPS ex. (LBA, GAME, SALSA,...)
PILPS-2f
Global off-line
GSWP-1.5
GSWP-2
Validation with remote sensed data
GSWP-aggregation
Local coupled
PILPS-ARM/CART
Parameter Estimation
Model dist.
Coupled ARM-CART
Assimilation of in-situ and remote sensed data
Global coupled
Ex. design
Coupled predictability ex.
Coupled land-use ex.
ALMA
Data exchange protocol
Distribution of data management soft.
PILPS-4c coupler
Simple atmos. column model

10. Conclusion

The main innovations GLASS will bring to land-surface inter-comparisons are :

- Provide a framework which facilitates the inter-comparison and validation of LSSs.
- Initiate PILPS type inter-comparisons for simulated CO_2 fluxes.
- Integrate step-wise the coupling to the atmosphere in the inter-comparisons.
- Encourage validation of LSSs with remote sensed data and work towards data assimilation.
- Establish the role of land-surfaces for the predictability at short to seasonal scales.

The following actions will be taken in the next few month

- The implementation plan will be finalized before the end of the year.
- Ensure links with the other GEWEX panels and IGBP projects.