4.1.2 Land surface models: intercomparison, assimilation & upscaling

Laboratories: LMD, CNRM, CESBIO, CETP, HSM, ENS, CIRAD, ISE Montpellier, LTHE, LGGE, CRC
Coordination: P. de Rosnay

4.1.2.a 5 year Plan

Objectives

Land surface modeling is a relevant methodology to estimate and analyze the soil-plant-atmosphere interactions at various temporal and spatial scales. The present work package aims to provide the necessary developments in modeling and assimilation activities to achieve this goal. The objectives are:

- Development of a multi-scale land surface forcing data base. Evaluation of the data base robustness and consistency at different scales.
- Coordinated use of different land surface modeling approaches including hydrological models, vegetation and crop models as well as integrated land surface models.
- LSM validation and inter-comparison at the three different scales studied in AMMA (local, meso and regional scales).
- Assimilation of remote sensing products such as soil moisture, surface temperature, LAI, in some of the different participating land surface models.

For these four objectives, the upscaling approach of continental water cycle coupled with vegetation models, (from local to catchment, meso and regional scales), is a key scientific investigation of AMMA project. It is considered through different resolutions of the forcing data base.

Strategy

The main difficulty of land surface modeling is the extreme diversity of the spatial scales involved in the processes. The consideration of the interaction between processes at different scales is critical to modeling activities since it controls the processes themselves (WP 2.3), the water budget and the surface-atmosphere feedbacks, all of which are key scientific investigations of WP 1.2 and 1.3. Accordingly, the modeling strategy that we propose is structured in two main components:

- to build a multi scale low-level atmospheric forcing data base over land. This is essential in order to have a coherent multi-disciplinary modeling approach at various scales with a large panel of land surface models: hydrological models, soil-vegetation-atmosphere transfer scheme, crop models, and integrated land surface models.
- to develop an African Land Data Assimilation System which is to be a tool for integrating processes and scales. ALDAS will ensure the synergy between models, satellite observations and field observations at different scales.

This strategy relies on strong interactions between modeling and various observing activities from EOP-LOP, SOP (WP 4.2.x) and satellite observations (WP 4.3). The ALDAS development is based on strong coordination between the French API and the European AMMA-IP project.
The deployment of this modeling strategy is detailed hereafter in the work content.

Work content

- Define and develop a database to force Land Surface Models (LSMs) (at different scales) in collaboration with WP4.2, WP4.3 and WP4.4. It will include precipitation, radiation forcing, near surface atmospheric parameters and surface characteristics. The approach is similar to the Global Soil Wetness Project but with the AMMA data and at regional, meso and local scales. Use of this database to force different LSMs

involved in API-AMMA as these products are only indirect estimations depending on the scheme used.

- Parameterization improvements and coupling between hydrological, vegetation and land surface models. Validation against field measurements at different scales for Sahelian and soudanian sites.
- Upscaling of elementary catchment model to the mesoscale, and coupling with aquifer model. Upscaling of a plot-scale vegetation dynamics model, with spatially explicit tree individuals, to the catchment scale, with hydrologic model coupling. Assessment of the impact of LSM spatial resolution on the simulated processes and of influence of the scale degradation to the land surface models results for different super sites within the AMMA region.
- Inter comparison of the resulting products and comparison with other available products (satellite, field measurements LOP-EOP and aircraft measurements during SOP). This step will be performed in close collaboration with WP1.2 and WP2.3. It also includes specific intercomparison of available formulations for Sahelian catchment-scale hydrologic model components.
- Satellite data assimilation in land surface models (soil moisture, NDVI).
- African Land Data Assimilation (LDAS) : the land surface data assimilation system as prepared by the EU-funded Geoland project will become operational in 2006. In the context of AMMA-IP, evaluation of the new system will be performed for the AMMA area, using SYNOP observations, radiosonde observations, vegetation parameters and precipitation observations as prepared in WP4.4. Recent developments from the French Rhone program will be also applied for assimilation. Another major source of verification data will be from the flux stations which will be deployed. To facilitate model verification and quality control of the flux stations, ECMWF grid point time series (so-called DDH diagnostics) will be sent to CEH every day for the flux station locations.

Foreseen deliverables

- High resolution forcing and parameter data base for land surface models.
- Land surface model inter-comparison at different spatial scales.
- Analysis of the effect of the spatial resolution on the land surface modeling.
- Development and validation of assimilation methodologies for the land surface models.
- Process-based Sahelian land hydrology/vegetation coupled models for local and meso scales.

Links to other WPs

WP	Input to WP4.1.2	Output from WP4.1.2
1.1		Validated land-surface models and long term land-surface states as simulated by these models.
1.2		Land surface models and model based estimates of fluxes for the water balance closure.
1.3		Land surface models and diagnostics on the time scales of their memory. .Initial conditions for LSMs.
2.3	Expertise for improving and validating land surface models	Output from model inter-comparisons at various scales.

WP	Input to WP4.1.2	Output from WP4.1.2
4.2	Atmospheric observations for building forcing data sets	.Provide surface states as a context for the observations.
4.3	Provide surface parameters and radiative fluxes for LSM forcing	Surface states for retrieval algorithms.

4.1.2.b Progress report (expected to be done by the end of 2004)

In 2004, significant work is devoted to organizing the land surface modeling activities at different scales with different models and laboratories. Each model is referenced by a descriptive 'fiche modèle' which summarizes its characteristics in terms of 8 items: general features, science objectives, methodology, domains of applicability, coupling with other models, key persons, collaborations, references. The 'fiches modèles' are accompanying the proposal. A critical point to coordinate the use of this large panel of models is to develop an appropriate forcing data base adapted to the variables and scale requirements of each model.
The forcing data base development is initiated from the global scale approach. A 53 year global scale forcing data set is build, named NCC (Ngo Duc et al. 2004). It is based on the NCEP/NCAR reanalysis project and a number of independent in-situ observations. This data set is the basis of the regional scale 2001-2010 forcing data base of AMMA. The data base is tested as input for the ORCHIDEE LSM and validated with the observed discharges of the world's 10 largest rivers in order to estimate the combined errors of the forcing data and the surface model. The seasonal and inter-annual variations of theses discharges are used for validation.
Further work is required to continue the building of the forcing data base for 2001-2010 in accordance with satellite measurements (WP4.3), PRECIPAMMA and different scales measurements conducted during the LOP-EOP (WP 4.2.3). Because of delay in the recruitment of a post doc, part of this work is reported to 2005. A one day workshop in November 2004 is devoted to initiate this work and to coordinate the different model requirements to define the mutli-scale forcing data base.
Considerable work conducted in 2004 concerns model coupling and developments, with tests and validation, as well as upscaling investigations. In the context of Power development, the Rew_v4.0 precursor model was tested against data over the Donga basin and its parameterization improved. SETHYS land surface model was adapted and coupled to the STEP vegetation model, and validated over Gourma local scale intensive site. An objective calibration procedure of the Soil Vegetation Atmosphere Transfer schemes has been proposed based on the use of the thermal infra-red brightness temperature measurements (Coudert et al., 2004). A hillslope hydrological (ABC-rwf) model and a plot-scale vegetation model (Treegrass) have been coupled for the Niamey site. Scaling laws have been investigated and tested using TGPIX vegetation model. Their incorporation into an actual model is being explored. This leads to a mesoscale surface runoff model adapted to the endoreic landscape conditions of that Sahelian region, and suited to coupling with a mesoscale groundwater model.

These activities are providing inputs to integrated work packages WP 1.2 for the water budget, WP1.3 for the surface-atmosphere retroactions, as well as for land surface processes thematic WP 2.3. The coupling between vegetation models and hydrological models permis the investigation of WP2.3 land surface processes understanding. Upscaling approaches are transversal to these activities in vegetation and hydrological modelsand their coupling.

Publications

Ngo Duc T., Polcher J. and Laval K., "A 53 year forcing data set for land-surface models", Journal of Geophysical Research submitted 2004
Boulain, N. 2004. Effet des facteurs climatiques et anthropiques dans l évolution récente des écosystèmes tropicaux : modélisation spatialisée du bilan hydrique d un petit bassin versant sahélien . PhD. Université Pierre et Marie Curie, Paris.
Coudert B., Ottlé C., Boudevillain B, Guillevic P. and Demarty J., "Multi-objective calibration of a dual source SVAT model: contribution of thermal infrared remote sensing data." In preparation for Journal of Geophysical Research.
Haverkamp, R., Braud, I., Debionne, S., Gandola, F., Roessle, S., Ross, P.J., Sander, G., Vachaud, G., Varado., N. and Zin, I., 2004. POWER: Planner-Oriented Watershed modelling system for Environmental Responses, European Geosciences Union EGU 1rst Assembly, 25-30 April 2004, Nice, France, Geophysical Research Abstracts, vol. 6, 06570.
Jarlan L., Mougin E., Mazzega P.,Schoenauer M., Tracol Y., Hiernaux P., 2004, Control of a simple land surface model using coarse radar remote sensing observations, Remote Sens. Environment, in revision.
Le Lay, M. and S. Galle (subm.). How changing rainfall regimes may affect the water balance? A comparative approach in West Africa. 1. Soudanian Climate. VIIth IAHS Scientific Assembly, Foz do Iguacu, Brasil, subm. to IAHS Publ. (2004).
Varado, N., Ross, P.J., Braud, I., Haverkamp, R., 2004. Assessment of an efficient numerical solution of the Richards' equation for bare soil, J. Hydrology, in revision.
Varado N, Contribution au Développement d'une modélisation hydrologique distribuée. Application au bassin versant de la Donga, au Bénin, Thèse de doctorat Institut National Polytechnique De Grenoble, 2004.

4.1.2.3 2005 Plan

Objectives

- Based on NCC global scale forcing data base, continue the development the multi-scale land surface forcing data base (DB).
- Coherence between regional, meso and local scales will be ensured by the use of input data (satellite and surface measurements) at different scale.
- Validation of the mesoscale surface runoff model and coupling with ground water model for Niger meso scale site.
- Progress in the development of the scalable vegetation dynamics model.
- Validation of the coupled vegetation -land surface model over Gourma site.
- Development of the parameterizations of the sahelian vegetation functioning at the local scale, based on field data.

Work content

- Get and prepare the required data from SAF-Land, ECOCLIMAP, LANDCOVER for the surface characteristics, and ERA-40 reanalysis, PRECIPAMMA, ERBE for atmospheric variables (precipitation, radiative fluxes...). Compile the forcing high resolution data base for 2001-2005, including precipitation, wind speed, solar and infrared radiation, air temperature, air humidity, atmospheric pressure. This forcing data base should be provided at a maximum three hours time step interval in order to allow relevant simulation of the diurnal features of the land surface processes. Compile the high resolution parameters data base including LAI, soil texture, surface albedo, vegetation classification. For land parameters, a daily time step is required.
- Compare the forcing data base and surface parameters to intensive field sites measurements including weather station (Hombori-Agoufou, Banizoumbou).
- Upscaling to mesoscale and regional scale forcing data base by aggregation procedure. Extend the comparison of the data base to super and meso site, where measurements networks allow to documents and validate the forcing and parameters data base (Donga, Aguima, Niamey).
- Test the Coupled surface runoff / groundwater hydrodynamics against the 1992-2002 piezometric recors.

Deliverables

- LSM forcing and parameters data base provided at different spatial resolutions (1km, 10km, 1 degree).
- Coupled surface runoff / groundwater hydrodynamics model for the Niger meso scale site.
- Coupled vegetation phenology / land surface processes system for the Gourma site.