AMMA Land surface Model Intercomparison Project Experimental Design

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March, 2006

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Executive Summary

This report is draft 1 of a description of the AMMA (African Monsoon Multidisciplinary Analysis) Land surface Model Intercomparison Project (ALMIP). It is part of the AMMA-EU (European Union) and API (Action Programmée Interorganisme: AMMA French program) work packages (WP) 4.1.

West Africa has been subjected to extreme climatic variability over the last half century, with predominantly relatively wet years during the 50s and 60s being followed by a much drier period during the 70s-90s. Seasonal to interannual prediction of the west-African monsoon, which is the main precipitation driving mechanism, has therefore become a research topic of utmost importance, however, a thorough understanding of this complex system has proved illusive. The deficiencies with respect to modeling the African monsoon arise from both the paucity of observations at sufficient space-time resolutions, and because of the complex interactions of the relevant processes at various temporal and spatial scales between the biosphere, atmosphere and hydrosphere over this region.

The AMMA project was organized in recent years with the main goal of obtaining a better understanding of the intra-seasonal and interannual variability of the west-African monsoon (WAM), which is to be accomplished through an extended period of intensive observations and field campaigns together with model developments and improvements. In particular, land-atmosphere coupling is theorized to be significant in this region. The magnitude of the north-south gradient of surface fluxes (related to soil moisture and vegetation) exerts a strong influence on the position of the tropical front and possibly the strength of the monsoon and the African Easterly Jet (AEJ). A high priority goal of AMMA is therefore to better understand and model the influence of the spatio-temporal variability of surface processes on the atmospheric circulation patterns and the regional water cycle.

The strategy proposed in AMMA to develop a better understanding of fully coupled system is to break the various components into more manageable portions which will then provide insight into the various important processes. The first step is to begin with the land surface in off-line or uncoupled (without atmospheric feedbacks) mode. The idea is to force state-of-the-art land surface models with the best quality and highest (space and time) resolution data available in order to better understand the key processes and their corresponding scales. The AMMA project therefore affords the possibility to improve the understanding of critical land surface processes over west Africa within the context of an Land Surface Model (LSM) intercomparison project. The critical aspect of such a project is the LSM forcing database, which consists in two components, the land parameter data and the atmospheric forcing. In addition, the database consists in forcing at three distinct scales (regional, meso and local scale).

In order to address the known limited ability of LSMs to simulate the surface processes over western Africa, ALMIP has the following main objectives: i) intercompare results from an ensemble of state-of-the-art models, ii) determine which processes are missing or not adequately modeled by the current generation of LSMs over this region, iii) examine how the various LSM respond to changing the spatial scale (three scales will be analysed: the local, meso and regional scales), iv) develop a multi-model climatology of “realistic” high resolution (multi-scale) soil moisture, surface fluxes, and water and energy budget diagnostics at the surface, and v) evaluate how relatively simple LSMs simulate the vegetation response to the atmospheric forcing on seasonal and inter-annual time scales.

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CHAPTER 1

INTRODUCTION

West Africa has been subjected to extreme climatic variability over the last half century, with predominantly relatively wet years during the 50s and 60s being followed by a much drier period during the 70s-90s. These radical fluctuations in the regional hydro-meteorological regime correspond to one of the strongest inter-decadal signals observed for the entire planet over the last century, and they have had dramatic socio-economic consequences for the people and the relatively agrarian-dominated economies of this region. Seasonal to interannual prediction of the west-African monsoon, which is the main precipitation driving mechanism, has therefore become a research topic of utmost importance. However, a thorough understanding of this complex system has proved to be illusive. The deficiencies with respect to modeling the African monsoon arise from both the paucity of observations at sufficient space-time resolutions, and because of the complex interactions of the attendant processes at various temporal and spatial scales between the biosphere, atmosphere and hydrosphere over this region.

1. AMMA

The AMMA project was organized in recent years with the main goal of obtaining a better understanding of the intra-seasonal and interannual variability of the west-African monsoon, which is to be accomplished by a long term observation period consisting in a 10-year period starting in 2001 (LOP), a prolonged period of intensive (EOP: extended observation period, 2005-2007) measurements, and a short-term period of enhanced field observations (SOP: special observation periods, several months in 2006). See Fig. 1.1 for a schematic. AMMA, therefore, provides a good context for improving our knowledge of the surface-atmosphere-hydrology coupling over the pertinent spatial and temporal scales. Land-atmosphere coupling is theorized to be significant in this region (e.g. Koster et al. 2004), thus improvement of the modeling of the related processes is critical. In addition, it is hoped that insights into land-atmosphere coupling can not only be used to improve understanding of the African monsoon, but also can be extended to other tropical and temperate regions of the world.

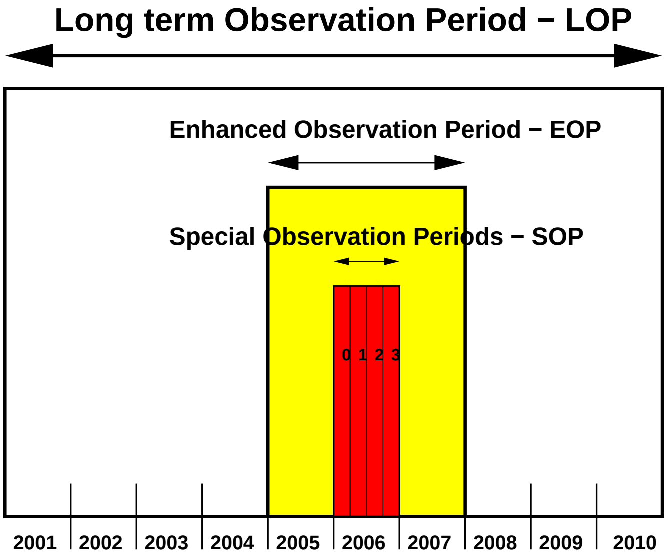

Fig. 1.1. The AMMA Observation (OP) time frames. The SOPs are shown in red (note that in contrast to what is represented in the figure, there are time intervals between each of the four SOPs).

2. Land Surface Processes and the WAM

The link between SST anomalies and monsoon variability has been well established (e.g. Janicot et al., 1998), but there is considerable evidence that the meridional gradients of soil moisture and the associated fluxes (which are related to the vegetation distribution) are important to the WAM on many spatio-temporal scales.

Mesoscale soil moisture (and vegetation) spatial distributions are theorized to have an impact on the development and maintenance of convection principally occurring along AEWs (e.g. Taylor et al. 1997). The sensible heat flux spatial distribution also controls the strength and positioning of thermal low pressure circulations over West Africa on meso to synoptic scales. The magnitude of the north-south gradient of surface fluxes (related to soil moisture and vegetation) also exerts a strong influence on the position of the tropical front and possibly the strength of the monsoon and the African Easterly Jet (AEJ). A high priority goal of AMMA is therefore to better understand and model the influence of the spatio-temporal variability of surface processes on the atmospheric circulation patterns and the regional water cycle.

Large scale climate models have had a notoriously difficult time in simulating many of the features of the African monsoon, notably the precipitation interannual variability, and it is theorized that this is partially related to the land surface representation owing to the significant land-atmosphere coupling in this region (e.g. Walker and Rowntree, 1977). Indeed, studies over the years have highlighted the influence of the surface from intra-seasonal time scales all the way up to long-term prediction of the WAM. The mesoscale soil moisture distribution is theorized to have an influence on monsoon onset on daily to weekly timescales, and the associated feedbacks can then influence the soil moisture on interannual timescales. In terms of the interseasonal link between soil moisture and the monsoon, statistical relationships between Sahelian rainfall and Guinean soil moisture have been shown (Philippon and Fontaine, 2002), but the physical mechanisms that govern these feedbacks at regional and interannual scales are not yet understood. Some studies have theorized that there are significant interannual vegetation-precipitation feedbacks (e.g. Zeng and Neelin, 2000). At decadal or multi-decadal timescales, the combined effects of soil moisture and vegetation processes (and spatial variability) are considered to amplify influences of oceanic variability on the atmosphere. Finally, for climate change scenarios, there are vegetation feedbacks (which are related to soil moisture) owing to natural and anthropogenic influences. Therefore there is a need for improved land surface representations for semi-arid and tropical climates for climate models. Interactive and more realistic vegetation and improved land surface sub-grid parameterizations, developed with the aid of observations and mesoscale modeling studies, are also needed to explore the influence of the surface (mainly soil moisture and vegetation) on the long term prediction of the WAM within regional and global climate model frameworks.

3. LSM Intercomparison projects

Numerous field experiments have been done over the years with the objective of improving the understanding of the link between the land-surface and the atmosphere. Some examples of some of the most published studies are HAPEX-MOBILHY (André et al. 1986), FIFE (Sellers et al. 1988), BOREAS (Sellers et al. 1997), and Cabauw, the Netherlands (Beljaars and Bosveld 1997). These data sets have been of great value in terms of Land Surface Model (LSM) model development, evaluation and intercomparison studies.

In particular, the Project for the Intercomparison of Land-surface Parameterization Schemes (PILPS: Henderson-Sellers et al. 1993) has increased the understanding of LSMs, and it has lead to many improvements in the schemes themselves. In Phase-2 of PILPS (Henderson-Sellers et al. 1995), LSMs have been used in so-called “off-line mode” (driven using prescribed atmospheric forcing), and the resulting simulations have been compared to observed data.

The first attempt by PILPS to address LSM behavior at a regional scale was undertaken in PILPS-2c (Wood et al. 1998). Multi-year basin-scale LSM simulations over the southern Central Plains of the US were evaluated using a river routing model and observed daily river discharge. Sub-grid runoff parameterizations were shown to be of critical importance in terms of correctly simulating river discharge for the spatial scales considered (1x1 degree grid elements).

The GSWP (Phase 1: Dirmeyer et al. 1999) was an “off-line” LSM intercomparison study which produced 2-year global data sets of soil moisture, surface fluxes, and related hydrological quantities. This project was used as a means for testing and developing large-scale validation techniques over land, it served as a large-scale validation and quality check of the ISLSCP Initiative I (Meeson et al. 1995; Sellers et al. 1995) data sets, it undertook a global comparison of a number of LSMs, and it included a series of sensitivity studies of specific parameterizations (which lead to improvements in some models).

The Rhône-AGGregation LSM intercomparison project (Rhône-AGG: Boone et al. 2004), was an intermediate step leading up to the next phase of the GSWP (Phase 2: Dirmeyer et al. 2005), for which there will be a broader investigation of the aggregation between global scales (GSWP-1) and the river scale. This project differed from the aforementioned PILPS basin-scale studies primarily because the impact of changing the spatial scale on the LSM simulations was investigated. The importance of sub-grid parameterizations (from the mesoscale up to approximately the GCM scale) related to evaporation, runoff and cold season processes on the regional scale water balance were highlighted.

The AMMA project affords the possibility to improve the understanding of critical land surface processes over west Africa within the context of an LSM intercomparison project. The wealth of observations from the local to the regional scale opens the door to the possibility of building upon and extending our understanding of scaling impacts on model simulations in an even more detailed manner than in previous intercomparison studies. This is especially true in moving from the local (where detailed processes can be identified and their simulation evaluated) to the mesoscale. The ALMIP (AMMA Land surface Model Intercomparison Project) has therefore been conceived as a step towards a better understanding and model representation of surface processes over west Africa.

CHAPTER 2

ALMIP

The land surface and the atmosphere are coupled over a large range of spatial and temporal scales over western Africa. The strategy proposed in AMMA to develop a better understanding of fully coupled system is to break the various components into more manageable portions which will then provide insight into the various important processes. The first step is to begin with the land surface in off-line or uncoupled (without atmospheric feedbacks) mode. The idea is to force state-of-the-art land surface models with the best quality and highest (space and time) resolution data available in order to better understand the key processes and their corresponding scales. As no one LSM is perfect, it is of interest to inter-compare an ensemble of model simulations at various spatial scales. This multi-model "off-line" technique has been used by numerous intercomparison projects (see Chapter 1), and it is also used in land data assimilation systems (LDAS) such as the North American LDAS (NLDAS: Mitchell et al. 2004) and the Global LDAS (GLDAS: Rodell et al. 2004). The objective is to glean sufficient information from the off-line simulations in order to better understand the fully coupled system.

1. LSM simulations over West Africa

The international community recently identified the need to improve LSM representation of semi-arid processes (Bastidas et al. 2002), and an intercomparison project under the auspices of PILPS is currently underway (PILPS Semi-arid: note that this project is focused over a region in the south-western part of the US). In addition, there has not been a large concerted international effort to inter-compare LSMs over a tropical region (with models confronted by actual measurements).

Simulations of the land surface state in off-line mode are currently being collected and analysed within the GSWP2 project at a global scale for the time period 1986-1995 at a one-degree spatial resolution. The LSMs have been forced by hybridized atmospheric reanalysis data and land surface parameters from the ISLSCP-II initiative (see Dirmeyer et al. 2005). Although there is relatively little in the way of model validation data over Africa at the regional scale during this time period, some information can be gleaned about the level of agreement among LSMs (in terms of the representation of the processes) by intercomparing the outputs from 15 LSMs.

The monthly average (September) total evapotranspiration (Evap: mm day^{-1}) from the GSWP2 LSMs is shown in Fig. 2.1 Note that the data shown herein were downloaded in August, 2005, from the GSWP2 ICC (International Comparison Center). Model acronyms and further information can be found at http:// grads.iges.org / gswp /. This month was selected as the monsoon is retreating, and differences among the LSMs should be relatively significant during this time period. Indeed, very large differences exist not only in the magnitudes, but also the spatial distribution of Evap.

The critical feature of the surface influencing the regional circulation during the monsoon season are the meridional surface (flux) gradients. The longitude averaged Evap for several monsoon months are shown in Fig. 2.2. Peak Evap values at the height of the monsoon (August) range from approximately (excluding an outlier LSM) 2.5 to 4.5 mm day^{-1}, which is obviously a relatively large range. Note that the magnitude of the Evap gradient and even it's sign (for some latitudes) vary significantly among the models, despite the fact that most of the models use the same atmospheric forcing and land surface parameters. This underscores the need

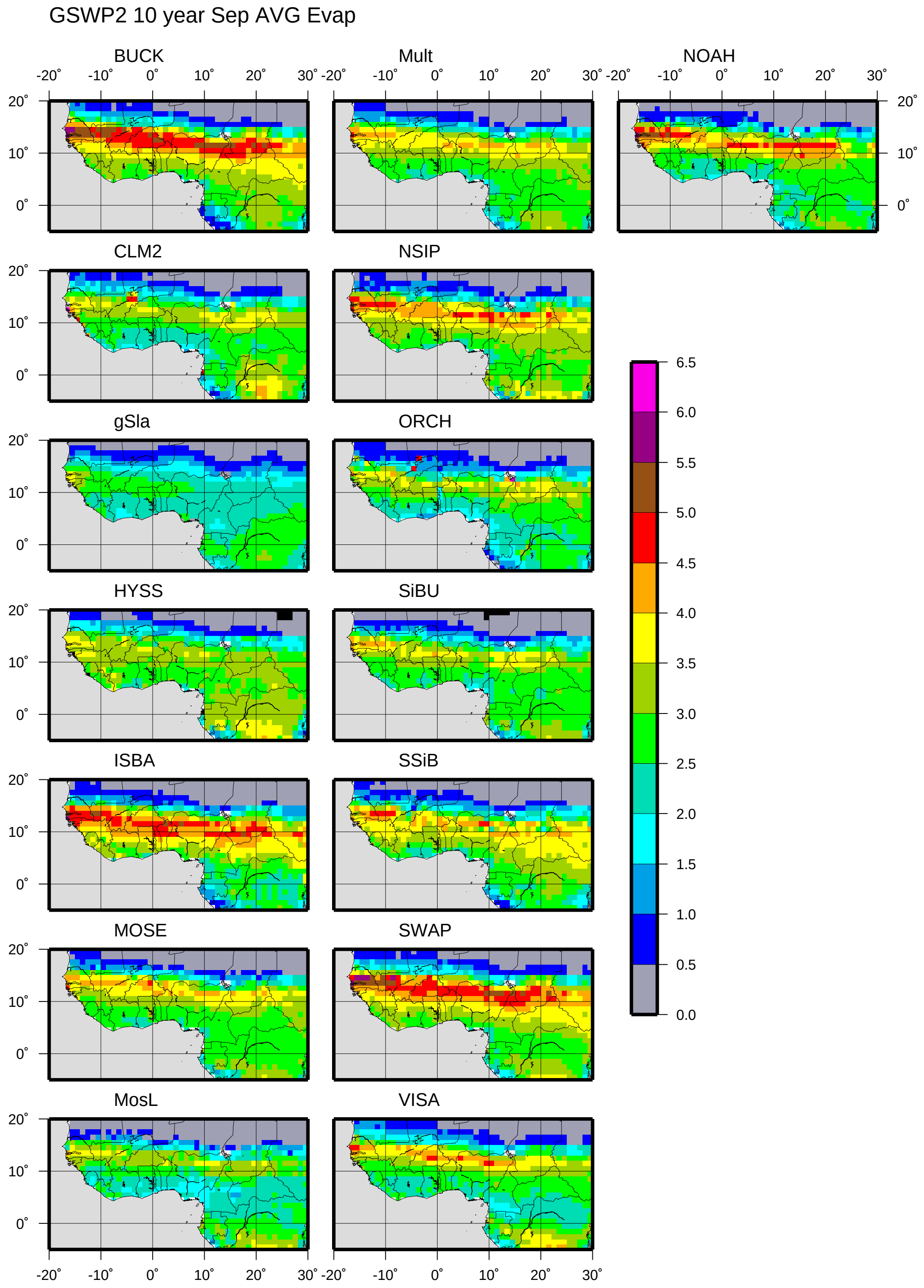

FIG. 2.1. The 10-year average September evapotranspiration flux (mm day^{-1}) from GSWP2 for 15 LSMs. Data were taken from the control (B0) experiment.

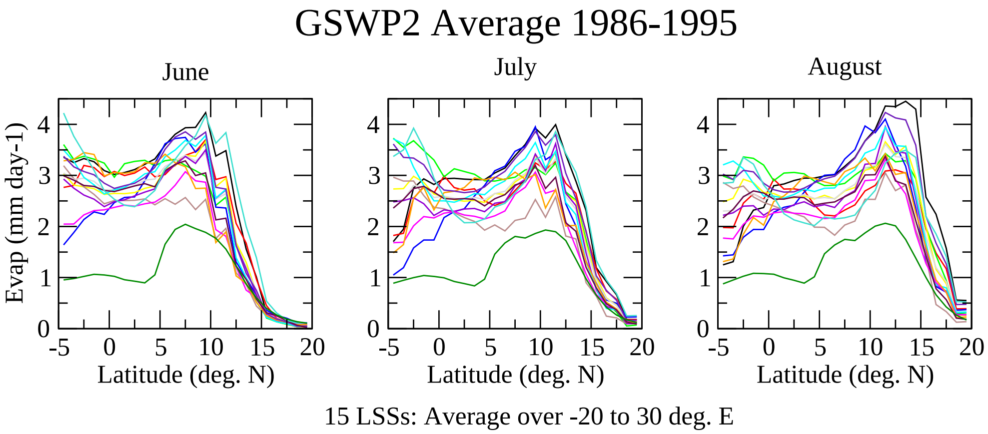

FIG. 2.2. The 10-year average September evapotranspiration flux (mm day^{-1}) from GSWP2 for 15 LSMs. The fluxes have been averaged over the longitude range shown in Fig. 2.1 (-20 to 30 east longitude). Data were taken from the control (B0) experiment.

to improve the understanding and modeling of the key land surface processes in this region.

2. ALMIP Objectives

In order to address the known limited ability of LSMs to simulate the surface processes over western Africa, ALMIP has the following main objectives:

- 1 Inter-compare results from an ensemble of models
- 2 Determine which processes are missing or not adequately modeled by the current generation of LSMs over this region.
- 3 Examine how the various LSM respond to changing the spatial scale. Three scales will be analysed: the local, meso and regional scales.
- 4 Develop a multi-model climatology of "realistic" high resolution (multi-scale) soil moisture, surface fluxes, and water and energy budget diagnostics at the surface.

- 5 Evaluate how relatively simple LSMs simulate the vegetation response (in terms of physiology and spatial distribution) to the atmospheric forcing on seasonal and inter-annual (several year) timescales.

These objectives will be addressed through the different phases of ALMIP. ALMIP (phase 1) will be conducted in 2006 with LSMs and SVAT (Soil Vegetation Atmosphere Transfer) models, which will permit the investigation of issues 1 to 5, and in particular, scaling problems and model sensitivity to forcing data at different scales. A second ALMIP phase (ALMIP-2) will be conducted (tentatively) in 2007. It will be extended to a larger range of surface models, including ecological and hydrological models. This second phase will permit a further investigation of items 2, 3 and 5, and the role of the different processes in the west African land-surface-atmosphere system. The organization of ALMIP-2 will be addressed in 2006.

Along the lines of previous LSM intercomparison projects, the overall goal of objective 1 is to attempt to identify problems with the models, biases, outliers and their overall ability to represent the regional land surface "climate". An attempt will be made to identify process which are causing the largest inter-model scatter. Item 1 has links to AMMA Work Package 4.1 which covers tools and methods developments for modeling activities.

Item 2 is essentially an extension of item 1, and it will be addressed in 2 phases, the first of which consists in comparison of model simulations with detailed local scale observations from the AMMA measurement campaigns. Part of the second phase consists in comparing the LSMs to specialized ecologically based schemes (involved in AMMA: WP2.3, which consists in land surface process studies). Indeed, there are several specialized vegetation models participating in AMMA, which have been in training over west Africa for years (e.g.s STEP, Mougin et al. 1995, and TREEGRASS, Simoni et al. 2000).

Item 3 will take advantage of the intense measurement campaigns within the AMMA-CATCH window. In addition, satellite data from the OSI and LAND-SAFs (SAF: Satellite Application Facility) and AMMA-SAT (PRECIP) projects, and other products (such as AMSR) will also aid in evaluating the spatial distribution of modeled processes. Owing to the large range of spatial scales considered (simulations and validation), it is anticipated that some insight into scaling laws will be obtained. This could be of great value for integrated studies related to the water budget (WP1.2) and land surface processes (WP2.3).

The multi-scale climatological surface state variable dataset in item 4 has a number of hydrological and meteorological research applications (such as exploring the strength, nature and relevant scales of the land-atmosphere coupling addressed in WP1.3) in WPs2.3 and 1.4. For example, realistic soil moisture will be used in studies related to the surface and convection at CNRM, and the possibility of imposing fluxes from the off-line database in an atmospheric model will be explored (see, for example, Dirmeyer and Zhao, 2004). In addition, the surface variables will also serve as input into impact models (used for water resources issues in WP3.3 as well as for health impact studies, such as mosquito population dynamics models: WP3.4). Using multiple LSMs is preferred to a single model because, generally speaking, an ensemble average tends to be superior than an individual model representation (this is especially important in light of the GSWP2 results over this region).

Item 5 will apply to those LSM which can simulate the plant biomass (or Leaf Area Index: LAI) as a prognostic variable. Indeed, many LSMs now include the capacity to simulate the temporal evolution of the vegetation, and this aspect of LSMs (intended for atmospheric or large scale hydrological applications) has not before been inter-compared at the regional or meso scale. The vegetation modeling intercomparison is innovative and particularly suitable for land surface processes studies (WP2.3) and land-atmosphere feedback (WP1.3) issues in AMMA.

CHAPTER 3

DATABASE

The LSM forcing database consists in two components, the land parameter data and the atmospheric forcing. The forcing data are at three different spatial resolutions: the regional scale [0.50°: similar to a Numerical Weather Prediction (NWP) model], the mesoscale (0.10°), and the local scale. The regional scale domain is shown in Fig.3.1 (-20 to 30 east longitude, -5 to 20 north latitude), and the sub-regional AMMA-CATCH window is highlighted in purple (with the three intensive observation mesoscale "squares" shown). Numerous local scale sites will be located within the AMMA-CATCH transect. The dataset currently covers the period from 2001-2005. The dataset will be enhanced as time goes on owing to the incorporation of newly available datasets which will be integrated into the database.

1. Land Parameters

The ECOCLIMAP database (Masson et al. 2003) provides land surface parameters over the entire globe at a maximum spatial resolution of 1 km. It is intended for use by LSMs which are coupled to GCM, NWP, mesoscale meteorological research or hydrological models. Due to it's relatively high spatial resolution, it is ideally suited for LSMs using the so-called surface tile approach. The vegetation phenology annual cycle is derived from the International Geosphere-Biosphere Programme (IGBP) 1-km Advanced Very High Resolution Radiometer (AVHRR) monthly Normalized Difference Vegetation Index (NDVI) over the time period from April, 1992 to March, 1993. There are 12 surface classes in ECOCLIMAP, which are shown in Table 1.

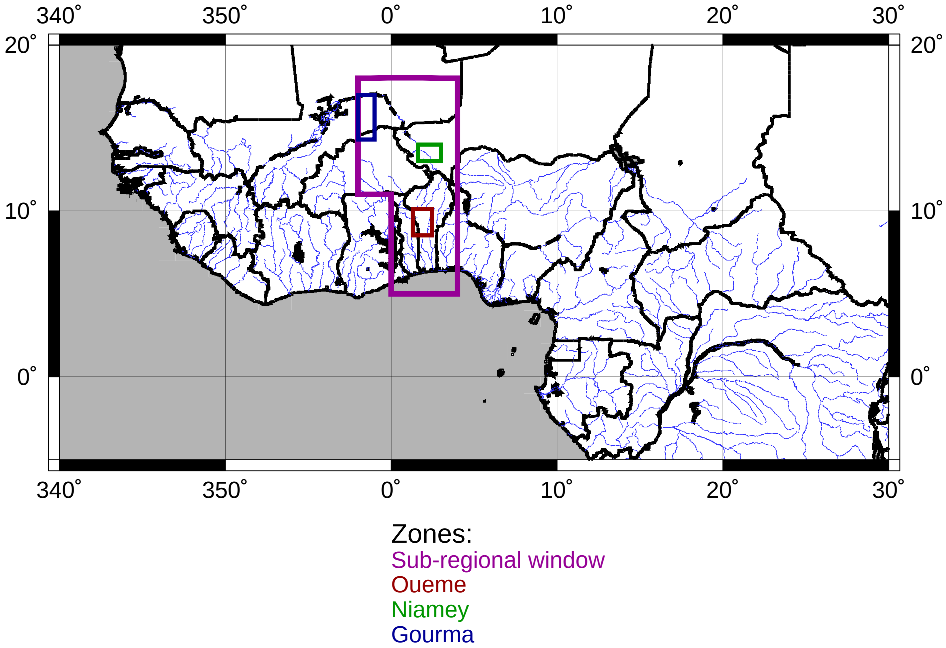

FIG. 3.1. The regional scale domain is shown, with the sub-regional AMMA-CATCH zone outlined in purple. The three mesoscale intensive observation "squares" are also shown within the AMMA-CATCH window. Numerous local scale measurement sites are located within the CATCH zone.

The key model parameter is the Leaf Area Index (LAI), as empirical relationships are used by ECOCLIMAP to relate it to most of the parameters which characterize the temporal evolution of the vegetation and strongly modulate the surface energy balance, such as vegetation cover fraction, albedo and surface roughness. It is important to note that the land parameters are derived from a combination of the land classification and climate data, so that hundreds of values for each parameter are in fact possible at each grid cell or pixel. As ECOCLIMAP automatically aggregates the land surface parameters to the scale of the computational grid, the parameters are available for the mesoscale and regional scale. See Masson et al. (2003) for further details (notably on the "aggregation rules" which vary for each parameter).

TABLE 3.1. The ECOCLIMAP land-use classification.

Index	Land Use Classification
1	baresoil
2	rocks
3	permanent snow
4	deciduous broadleaf trees
5	coniferous trees
6	evergreen trees
7	C3 crops
8	C4 crops
9	irrigated crops
10	natural herbacious: temperate
11	natural herbacious: tropical
12	swamp, herbacious gardens

The main drawback of ECOCLIMAP within the context of simulating realistic surface fluxes over western Africa is that there is no vegetation interannual variability. It is possible that data from an ancillary product, such as *LAI* from the MODerate-resolution Imaging Spectroradiometer (MODIS: http://modis.gsfc.nasa.gov/), could be used to modify the vegetation parameters on a year-to-year basis for ALMIP, but currently the default ECOCLIMAP parameters will be used.

At the local scale, in situ parameters will be used for two sites located in Mali (the Agoufou station is located at 15^o 20.675'N 1^o 28.745W) and Dahra in Senegal. More local scale data will be available well into 2006 and beyond (eg.s the AMMA meso-scale super sites in Benin and Niger), so currently only these two sites are being considered for ALMIP (phase 1).

2. Atmospheric Forcing

The atmospheric forcing consists in data from several different sources, which are described herein.

a. NWP Model forcing

The basis for the forcing is data from the European Centre for Medium-range Weather Forecasts (ECMWF) NWP model forecast (FC). Note that in ALMIP the FC is used, as opposed to the re-analysis product ERA-40 which currently only extends to 2002. The forcing variables are the air temperature (T_a), specific humidity (q_a) and wind components (V_a) at 10m, the surface pressure (p), the total and convective rain rates (P_r and CP_r, respectively), and the downwelling longwave (LW_d) and shortwave (SW_d) radiative fluxes. This data has been interpolated from it's original grid to a 0.5^o cylindrical equidistant projection, and it is at a three hour time step.

Note that there is a well known spin-down problem in terms of the ECMWF model precipitation, so that it is advisable to avoid using this field from the early stages of a forecast. However, logically the forecast period should be kept as short as possible so that a compromise must be made. Therefore, the database consists in a series of 36 hour forecasts at 12 UTC every 24 hours, and the first 12 hours are not used. The result is that a daily 24 hour forecast is used to build the forcing. This is shown schematically in Fig. 3.2. The ECMWF FC data comprises the Exp. 1 atmospheric forcing dataset for ALMIP.

b. Remotely sensed products

In order to obtain more insight into land surface processes, it is of interest to investigate the impact of using independent sources for the forcing variables (in an attempt to “improve” the NWP based forcings). Because of the relatively low density of observations over western Africa, however, it is necessary to take advantage of remotely sensed data to “fill in the gaps” in both time and space. One of the main tasks of AMMA-SAT is to organize existing data over western Africa for the research activities within AMMA, and to develop new datasets. For ALMIP 1 in

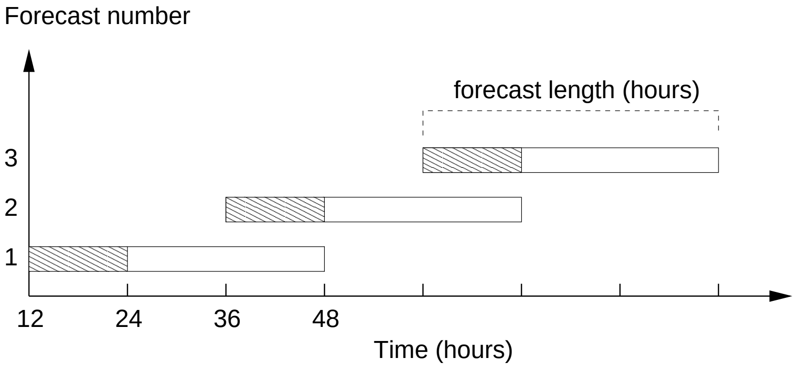

FIG. 3.2. ECMWF forecast data used in forcing database. Each 36 hour forecast period begins at 12UTC daily. The hatched region corresponds to the portion of the data which is not used (i.e. the first 12 hours), so that 24 hours of data retained (i.e. from 12 to 36 hours) for each forecast period.

2004-2005, two remotely sensed products are merged with the NWP model data in order to create the so-called “merged forcing” datastet. The result of the merging of remotely sensed and NWP data will be two additional datasets covering two spatial resolutions (see Fig. 3.3). The first (baseline or control) dataset incorporates the regional domain (refer to Fig. 3.1) and consists in NWP model output data only. The second dataset is also at the same spatial resolution, but incorporates the so-called “merged” dataset. The third dataset is also “merged” but it is at a higher spatial (mesoscale) resolution.

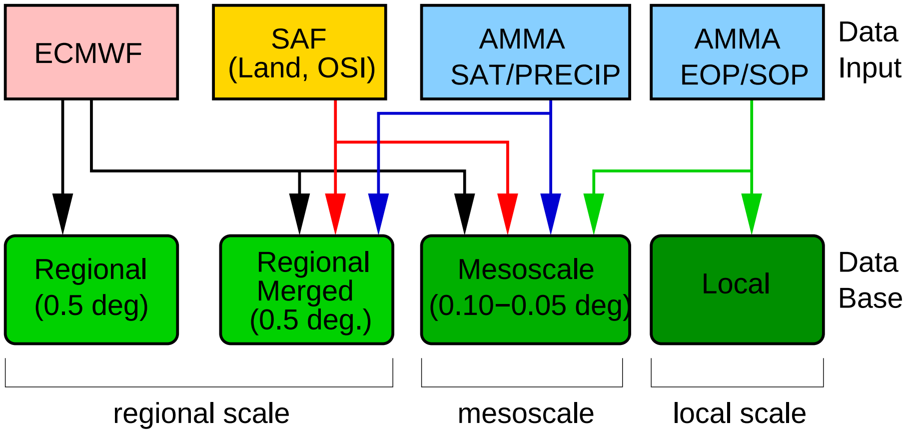

FIG. 3.3. Forcing database inputs used at each spatial scale.

The Experiment 2 "merged forcing" datastet (see the next section for more details on Experiment 2) use two remotely sensed products are merged with the NWP model data. The precipitation (Chopin et al. 2004) from AMMA-SAT (AMMA-Satellite component: http:// ammasat.ipsl.polytechnique.fr) is used in place of the NWP total precipitation, and the downwelling radiative fluxes from OSI-SAF (Oceans and Ice - Satellite Applications Facility: http://www.osi-saf.org) are substituted for the corresponding NWP fluxes.

The precipitation probability is provided at a 3km resolution (and a 15 minute time step). The total precipitation rate is obtained by multiplying the probability by the potential precipitation intensity (which is derived from GPCP). The resulting precipitation product is linearly aggregated to two resolutions: 0.5 degree spatial and 3-hour temporal resolutions for Exp. 2 (regional scale), and 0.1 degree spatial and 1-hour temporal resolutions for Exp. 3 (mesoscale/CATCH).

The OSI-SAF downwelling radiation products are available at at 0.10° with a time step of 3 hours for 2004. Starting in 2005, the same fields from the LAND-SAF (http://landsaf.meteo.pt) will be used (0.05° and a 30 minute time step). The shortwave radiation flux is computed using a radiative transfer model combined with a cloud mask. The longwave radiative flux is computed using an empirically based method which utilizes low level atmospheric NWP outputs (temperature and humidity), in conjunction with the satellite based cloud mask information. Details on the algorithms can be obtained at the aforementioned websites. The same basic algorithms are used in both SAFs, so a certain degree of continuity is expected between 2004 and the ensuing years.

It should be noted here that the atmospheric forcing hybridization techniques used in projects such as GSWP2 (Dirmeyer et al. 2006) and by Ngo-Duc et al. (2005) for long term integrations (10 and 50 years, respectively), were not used herein, rather a simple "merging" was done (i.e. replacement of certain NWP variables by a satellite-based product). Essentially, hybridization consists in multiplying certain variables (eg. for the case of precipitation and radiative fluxes) by a corrective factor which varies in space and time in order to force temporal averages of the hybridized forcing to agree with those from some ancillary dataset (which is usually based on a merged product based on observations and satellite data). The temporal average is usually dictated by the observational-satellite based product, which are oftentimes monthly (at large scales).

The main reason merging is used in ALMIP is that by using remotely sensed data, errors in the location of active precipitation zones are compensated for in a slightly better fashion (there is evidence that the monsoon does not migrate far enough north in the ECMWF model predictions for example). In addition, the AMMA-SAT precipitation product uses GPCP data, so that the monthly averages should be consistent with this dataset (which is often used in hybridization methods).

The main issue that arises from the merging of the three data sources (OSI-SAT, AMMA-SAT and ECMWF) is consistency. Thorough checks were done, and the downwelling fluxes from OSI-SAF and the precipitation from AMMA-SAT were found to be relatively consistent: areas with rainfall from AMMA-SAT were co-located with reduced solar radiation and increased atmospheric emissivity. The consistency is not surprising since both products rely heavily on MSG-based data.

An example of a sample time series at 0^oE and 15^oN is shown in Fig. 3.4 for part of July, 2004. At this location, the ECMWF model rarely produces precipitation (which tends to be quite light), while four relatively significant events are seen in the AMMA-SAT time series. Note that the first two rain events occur during the daytime, and there is a corresponding reduction in the downwelling shortwave flux from the OSI-SAF dataset. The latter two precipitation events occur during the night, the this signal is seen in the OSI-SAF downwelling longwave radiative flux.

The behavior at this point represents a fairly consistent response (and coherence between the remote-sensing based products).

In terms of the energy balance and hydrology, the consistency between the available energy at the surface and the precipitation fields is critical. Tests were then done in order to examine the impact of inconsistencies between the new precipitation and radiative flux fields and the meteorological state variables (notably the air temperature and humidity). The conclusion was that there is not a straightforward way to modify the atmospheric state variables to be consistent with the fluxes (radiative and precipitation). Part of the problem is related to the fact that the fluxes are average quantities (and therefore reflect processes occurring during the three-hour time step: for example, reduced solar radiation associated with a rain event). The meteorological state variables are, however, instantaneous values: there is much less consistency between these variables and the flux variables. This seems to be especially true over the region of interest (western Africa) since the precipitation during the monsoon season has a significant (relatively short temporal scale) convective component. This implies that a rain event which occurs within a three hour time step might not be reflected in the air temperature at the end of a three hour time step, while it would be reflected in the flux variables.

TABLE 3.2. The composition of the atmospheric forcing database (2002-2005) for Exp.s 1-2. (regional scale NWP and Merged datasets). P represents precipitation rate, and the downwelling solar and longwave atmospheric radiative fluxes are represented by SW_d and LW_d, respectively. The lowest (NWP) model level air temperature, specific humidity and wind speed are given by T_a, q_a and V_a, respectively. The surface pressure is denoted by p.

Exp.	P	LW_d, SW_d	T_a, q_a, V_a, p
1 Regional scale 2002-5	ECMWF-FC	ECMWF-FC	ECMWF-FC
2 Regional scale Merged			
2004	AMMA-SAT	OSI-SAF	ECMWF-FC
2005	AMMA-SAT	LAND-SAF	ECMWF-FC

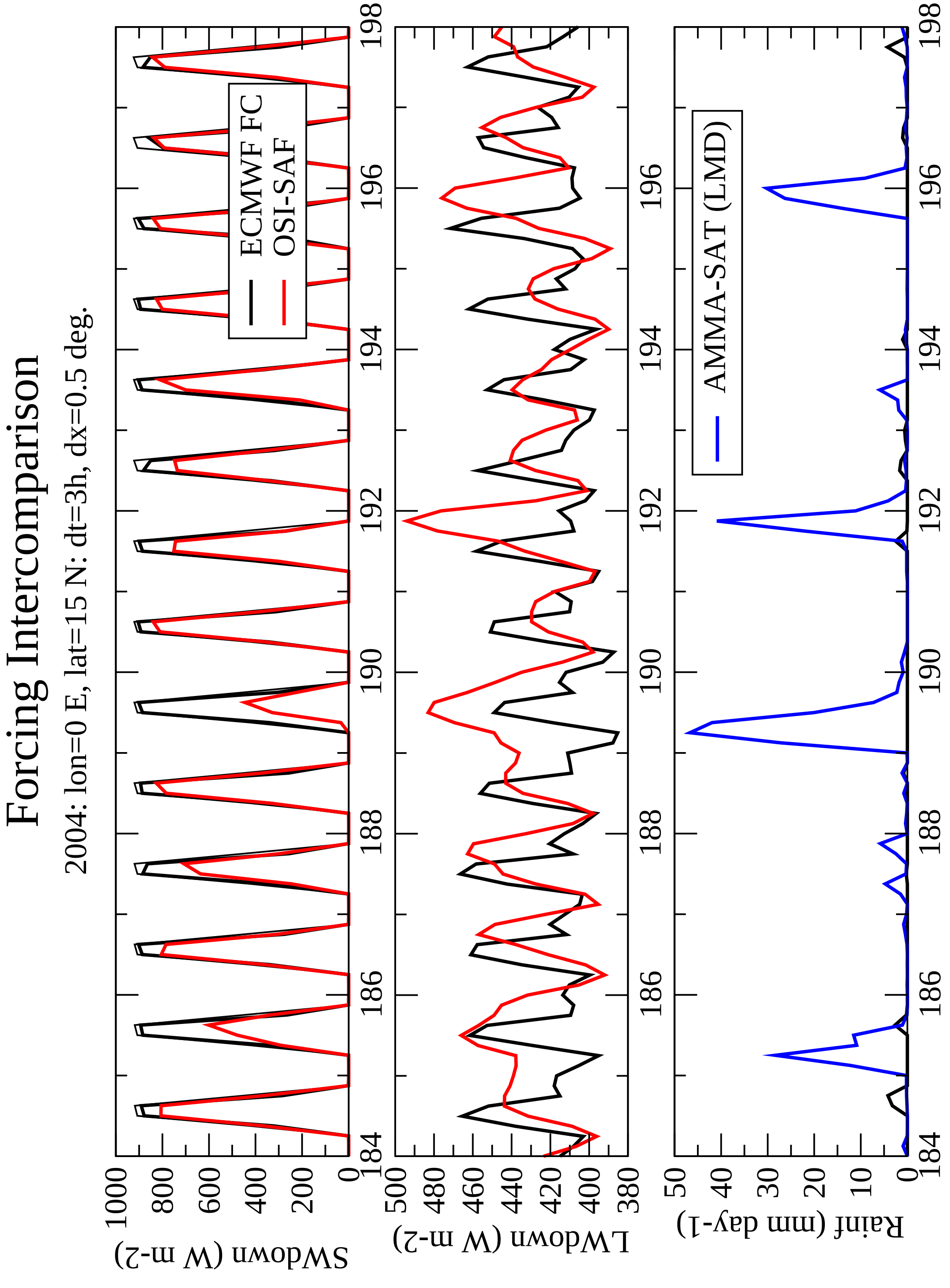

Fig. 3.4. The downwelling shortwave radiation fluxes from OSI-SAF and ECMWF (uppermost panel), the corresponding downwelling longwave fluxes (middle panel), and the total precipitation rate from ECMWF and AMMA-SAT (bottom panel) are shown for a single 0.5 degree grid box for part of July, 2004.

Obviously the use of a shorter forcing time step would probably reduce this lack of consistency between the flux and instantaneous fields. The conclusion is that simply replacing the flux fields in the NWP data for Exp.s 1 and 2 does not have a significant impact using a 3-hour time step (a more detailed examination of this problem will be undertaken in terms of the Exp. 3 data which is currently under preparation since a shorter time step will be used).

c. Local scale data

The final dataset consists in observation data at the local scale. Currently, there are data from the Mali site in 2004 (E. Mougin and L. Kergoat), however, as time goes on, more local scale data will become available and eventually there will be several sites from a meridional transect (which will allow testing of LSMs for a large range in land cover and climate conditions). The local scale phase of ALMIP will take place last (tentatively in autumn, 2006). As the local scale flux data processing is very time consuming and many stations are to come on-line this year during the SOP, there will only be limited local scale data for the near term.

3. Evaluation Data

The obvious problem in doing simulations over western Africa (and in fact, for many large domain area applications) is the lack of evaluation data. There are currently three ancillary remotely sensed datasets which are being examined in terms of their potential for ALMIP LSM evaluation or comparison over the regional and mesoscale model domains.

a. Leaf Area Index

The first is available within AMMA-SAT: MODIS *LAI* for 2003 and 2004, and LAND-SAF based *LAI* for 2005. This product is at a relatively fine spatial resolution and is available at a monthly frequency. There are two potential uses for this product. First, this data will be compared to the model simulated LAI (for those groups who can and accept to simulate the vegetation as a supplemental exercise: see Chapter 4 for more details). The second potential use concerns modifying the ECOCLIMAP vegetation parameters in order to better represent the actual state of the vegetation (2003-005). This task, however, represents a significant amount of work and thus is still deemed to be tentative at the time of the writing of this document. But it is known that the vegetation can have significant inter-annual variability over western Africa, so that an attempt will be made to produce this data (but currently no experiment has been defined using this data).

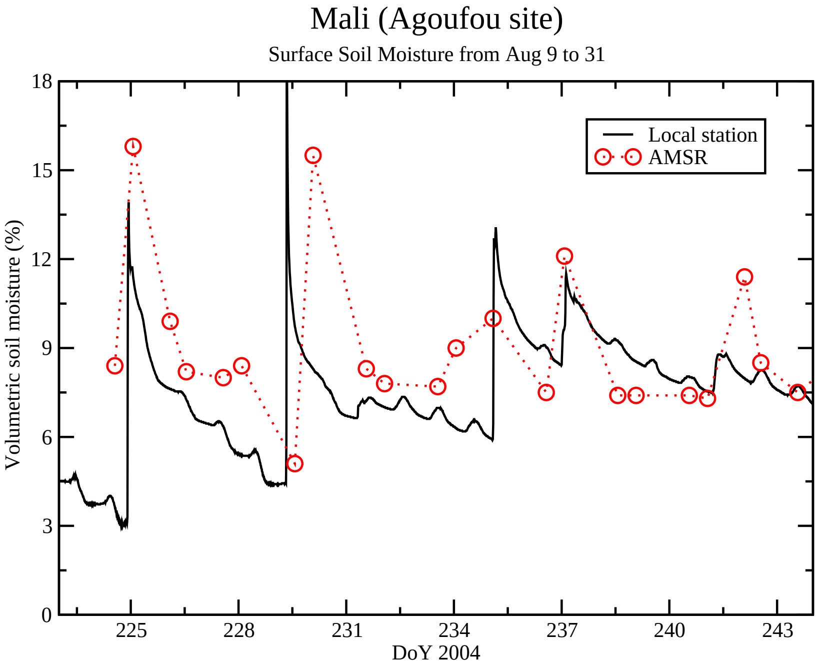

Fig. 3.5. AMSR data compared to local scale soil moisture (de Rosnay et al. 2005) at a West African site.

b. Soil Moisture from AMSR-E

The second dataset under investigation currently is the soil moisture product from the Advanced Microwave Scanning Radiometer (AMSR). Surface soil moisture information is available two times per day on a 25km equidistant grid. An interesting potential use of AMSR data is to bridge the gap from the local scale to the mesoscale. We are currently comparing local scale measurements of soil moisture with those from AMSR and have found a good agreement (Fig. 3.5) at the Mali site, despite significant scale differences between the local scale soil moisture measurement and the AMSR estimation at a scale of 25km. A summary of the potential data sources, their resolutions, the respective fields and what time periods they cover is shown in Table 3.3. At the time of the writing of this report, NASA-GSFC reprocessing the soil moisture product, and this new product will be compared to model results. We anticipate that the comparison will be complex (in particular, it is likely that some sort of normalization or scaling will need to be undertaken in order to compare the model and AMSR-E derived soil moisture fields), but some early results indicate that this effort might yield some interesting results.

We are also going to look into comparing the soil moisture with other remote-sensing based products as they become available, such as a soil moisture product from ERS-2 SAR (Synthetic Aperture Radar) data.

c. LST

The *LST* (land surface temperature) is now available from LAND-SAF starting in mid-July, 2005. Although the comparison with land surface model surface temperature is not necessarily straightforward, this field will be compared to model simulations.

TABLE 3.3. The different sources for the forcing database (2003-2005). Note that data shown in the lower part of the table can be used for model evaluation. The sensible heat flux, latent heat flux, ground heat flux, net radiation, land surface temperature (LST), sub-surface soil temperatures, volumetric soil water content and plant biomass are represented by H, LE, G, R_{net}, T_s, T_g, θ and b_M, respectively. The remaining symbols are defined in the text.

Source	Variable	Resolution	Dates
AMMA-SAT/ PRECIP	P_r-Probability	3 km → 0.05° 15min	2004+
OSI-SAF	SW_d, LW_d	0.10°, 3h	2004
ECMWF (FC)	T_a, q_a, V_a, p_s SW_d, LW_d, P_r CP_r	0.50°, 3h	2003+
LAND-SAF	SW_d, LW_d	0.05°, 30min	2005+
AMMA EOP, SOP	T_a, q_a, V_a, p_s SW_d, LW_d, P_r CP_r	local	2004+
AMMA EOP, SOP	H, LE, G, R_{net}, T_s, T_g, θ, LAI, b_M	local	2004+
AMSR-E	θ_s	50km, 2x d^{-1}	2003+
ERS-2	θ_s		2003+
AMMA-SAT	MODIS LAI	0.01°, monthly	2003+
LAND-SAF	LST (T_s)	0.05°, 15min	2005+
LAND-SAF	LAI	0.05°, 10-days	2005+

CHAPTER 4

EXPERIMENTS

A series of experiments at several spatial scales is currently planned. The idea is not to overwhelm the model participants by limiting the requested simulations. The baseline runs are indicated, and additional (optional) sensitivity runs are described. The participant model names and their corresponding contacts and institutions are summarized in Table 4.1.

Table 4.1. The ALMIP participants. An $*$ is used to indicate tentative participation as of September, 2005. Partner institutions are indicated in parentheses.

Model Acronym	Institute, Location	Contact(s)
ORCHIDEE	LMD, Paris, France	J. Polcher, T. Orgeval
ISBA	CNRM, Toulouse, France	A. Boone
TESSEL	ECMWF, Reading, UK	A. Beljaars
JULES	CEH, Wallingford, UK	C. Taylor, P. Harris
SETHYS	CETP, Vélizy, France	C. Ottlé, B. Decharme
IBIS$*$	ISE, Montpellier, France	C. Delire
NOAH	CETP (NOAH, USA)	C. Ottlé, B. Decharme
NSIPP	UPMC (NASA-GSFC, USA)	A. Ducharne
SSiB	U. Nantes (UCLA, USA)	I. Poccard-Leclercq, Y. Xue
Mike-SHE	U. Copenhagen	A. Norgaard, I. Sandholt

1. Simulations

a. Experiment 1: Regional Scale

The control or baseline experiment consists in running an LSM using the ECMWF FC data "as-is", along with ECOCLIMAP parameters. The effective or grid-box average parameters will be provided, and the aggregation "rules" are defined in Masson et al. (2003) and were also used in Rhône-AGG (Boone et al., 2004). In addition, the parameters (and their corresponding areal cover fraction in each grid cell) for up to 12 distinct patches or surface types will also be given for LSM groups who wish to run their models in so-called “tile mode”. Each modeler using this option will need to determine a correspondence between the ECOCLIMAP land cover classes and their tile definitions (refer to Table 3.1). Schemes which use fewer classes (eg. trees, grass, baresoil) can request the full set of tile parameters from ALMIP (we will do the aggregation if needed).

We would like participants using the tile option to report the values of the requested output variables (see Table 4.5) for all of the tiles within each grid box and at each output time step. This is especially important for models which choose to simulate the vegetation (this is discussed in more detail in section 2.e. of this Chapter).

This experiment will cover the regional domain over the time period from Jan. 1, 0 UTC, 2002 to Dec. 31, 24 UTC, 2005. The participants may initialize 2002 as they see fit: some may wish to treat it as a spin up year, others might wish to use an alternative method (such as climatological values from their model from GSWP2 if they performed these runs: see Rodell et al. 2005 for a discussion on LSM initialization). The year 2003 provides a transition between the spin-up year and the year for which results are to be reported. Again, an optimum between minimizing the impact of imperfect initial conditions and not over-loading the participants has been sought. Currently, it is planned that results from 2002-2003 will not be examined (or reported): the analysis and the intercomparison will focus on the two-year period 2004-2005.

b. Exp. 2: Regional Scale Merged

This run is nearly identical to the control run, except that the merged forcings are used: this simulation uses the same ECOCLIMAP parameters and the same atmospheric forcing spatial and temporal resolutions. The difference is that the "merged" forcing is used: the periods are from mid-June through September, 2004, and mid-July through September, 2005. This means that groups only need to report results for this experiment for the seven-month period from June 1, 0UTC, 2004 to Dec. 31, 24UTC, 2004, and the six-month period from July 1, 0UTC, 2005 to Dec. 31, 24UTC, 2005.

Note that LAND-SAF products begin in mid-July, 2005, while the AMMA-SAT precipitation is available in June, 2005. We are therefore investigating the possibility of somehow producing a coherent set of radiative fluxes for the June-mid July, 2005, period in order to include this important monsoon transition period in the merged forcing. The basic idea of Exp.2 is to explore the impact of incorporating remotely sensed data on the regional scale simulations of the surface variables by comparing these results to those from Exp. 1. Technically, this forcing database should be improved owing to the incorporation of remotely sensed data.

c. Exp. 3: Mesoscale

Although the downscaled data will be processed over the entire regional domain, due to the size of the resulting database the modelers will be asked to run using the mesoscale database only over the CATCH window. This will then permit the LSMs to take into account the large meridional surface parameter and atmospheric forcing gradients which characterize this region and influence the WAM. The impact of changing the spatial scale of the atmospheric forcing and the land surface simulations between Exp.s 2 and 3 will be examined.

This experiment uses the "merged" forcing, but at 0.10^o spatial and hourly temporal resolutions. This means that the AMMA-SAT precipitation will be aggregated (upscaled) to this grid and time step, while the OSI-SAF fluxes will have to be interpolated in time to 1 hour intervals. In contrast, the LAND-SAF radiative fluxes can be averaged-up to an hourly time step. In addition, the use of an hourly time step implies that the NWP-based atmospheric state variables will have to be downscaled in space and time: a simple method will be used (as the precipitation spatial and temporal variability are assumed to be the most critical to the land surface processes). This work is ongoing.

This experiment covers the same time period as in Exp 2. Results are to be reported at the 0.10^o resolution, and multiple tile schemes will again be provided with the parameters for each land cover or class and will be expected to report all of the variables for each tile.

There will also be a possibility of a more robust evaluation of schemes using observations from within the three heavily instrumented mesoscale regions, but only if the ALMIP experiment is extended to include the AMMA-SOP in 2006. Thus this is something which might be realized on the long term, but not within ALMIP in 2006. The data for this experiment will tentatively be distributed around mid-2006.

d. Exp. 4: Local scale

There is currently one site for which data is available (Gourma, Mali). Meteorological data for forcing LSMs is available, and soil moisture measurements at Agoufou are at the following depths: 5, 10, 40, 120, and 220 cm . There are also soil temperature sensors at 5 and 40 cm soil depths. (Note, currently the possibility of having sensible heat flux data is being investigated. Updates on the status of this item will be forwarded to the participants).

We are also currently investigating the use of data at the Dahra site, in Senegal (Inst. of Geography, Copenhagen Univ., contact: Inge Sandholt). This site is only "operational" during the rainy season and drying down periods, and data for 2004 is currently ready (2005 data is being processed). This site is located outside of the CATCH window, but does afford the opportunity to test the models in an interesting context. Some of the potential model simulation evaluation data include: reflected radiation, transmitted radiation, surface (IR) temperature, soil temperature and moisture at three depths, soil heat flux and net radiation.

There are two potential local scale experiments which are currently envisioned. The first consists in driving the models with parameters derived from ECOCLIMAP, but using the local scale forcing (Exp. 4a). These results will then be compared to a second set of local scale runs using parameter data derived from the local scale measurements (Exp. 4b). This will give an idea of the usefulness of large-scale database parameters in terms of representing local scale processes. The results from these two experiments can then be compared to the results from Exp.s 1-3 at the same grid points. In this way, the impact of using observed or model-derived large scale atmospheric forcing can also be studied.

e. Exp.s 1v-4v: Simulated vegetation

This experiment consists in re-running Exp.s 1-4 while simulating some vegetation related quantity (LAI, biomass, etc...) as a prognostic variable. More and more LSMs have this capacity, and it would be of interest to inter-compare this aspect of the LSMs (for those participating LSMs which have this option or wish to test it). In addition, as mentioned in Chapter 3, high spatial resolution MODIS and LAND-SAF LAI data are available over this region for comparison with the LSM simulations (and possible evaluation). The experiments, spatial scale and input forcing data are summarized in Table 4.2. The forcing data and their units are provided in the next section.

TABLE 4.2. The proposed ALMIP experiments. ECO denotes ECOCLIMAP based parameters. Note that experiments 1v-4v consist in running with vegetation as a prognostic variable (which is optional). There are therefore 5 requested baseline runs covering 3 scales. An additional 5 "interactive vegetation" runs (denoted using "v": 6-10) are optional. Further sensitivity runs will also be discussed. Exp. 1 will cover 2002-2005. Exp.s 2. and 3. encompass the last 7 (6) months of 2004 (2005). The local scale experiments (Exp.s 4) cover sub-sets of this period, depending on available data.

	Experiment	Exp. X	Atmospheric Forcing and scale	Land Param. Forcing and scale
1	Baseline Regional	1	0.50 ECMWF	0.50 ECO
2	Merged Reg.	2	0.50 ECMWF, AMMA-SAT, SAFs	0.50 ECO
3	Mesoscale	3	0.10 (ECMWF, AMMA-SAT)	0.10 ECO
4	Local	4a	local/site	1km ECO
5	Local	4b	local/site	local/site
6	Regional	1v	0.50 ECMWF	0.50 ECO
7	Merged Reg.	2v	0.50 ECMWF, AMMA-SAT, SAFs	0.50 ECO
8	Mesoscale	3v	0.10 (ECMWF, AMMA-SAT)	0.10 ECO
9	Local	4v-a	local/site	1km ECO
10	Local	4v-b	local/site	local/site

2. Input Forcing

a. Land surface parameters

The input physiographic parameters are provided by ECOCLIMAP, and they are listed in table 4.3. The symbol t is used to indicate a time dependence (here, a single climatological annual cycle). The parameters are at a 10-day frequency: modelers can use these parameters at this time step, or they may interpolate linearly to a smaller time step (daily or smaller) as they see fit. Note that some models might need additional parameters, but it is preferable (if possible) to derive such parameter values from ECOCLIMAP. This can be addressed on an individual LSM basis, but note that in order to keep the intercomparison exercise as meaningful as possible, the modelers should attempt to adhere to the values given by ALMIP. Modelers needing additional parameters not related to those given (such as a topographic index, etc.) should contact the ALMIP team.

TABLE 4.3. The input land surface parameters with a time dependence (decadal) are indicated by t. Parameters denoted by a p ("patch" or tile) are also available for each sub-grid tile (12 possible) for each grid cell. Note that f_$surface$ gives the normalized fraction of each natural surface type within each grid cell, therefore the sum is unity (even if the coverage of the natural land surface is less than one). Tile_frac gives the same information but as a function of class index.

Variable	Description	Units
Frac_Veg (t,p)	Vegetation cover fraction	-
Albedo (t,p)	Total Albedo	-
Albedo_soil	Soil Albedo (dry)	-
Emis (t,p)	Surface Emissivity	-
LAI (t,p)	Leaf Area Index	m2/m2
$z0$ (t)$*$	Surface roughness length	m
Green (t,p)	Greenness or green leaf fraction	-
Rsmin (p)	Jarvis-type minimum stomtal resistance	s/m
Sand	Soil texture (Sand and clay fractions)	-
Clay	Soil texture (Sand and clay fractions)	-
SoilDepth (p)	Soil total depth	m
RootDepth (p)	Soil root-zone depth	m
Land_mask	binary FLAG if a land grid box	-
f_$surface$	Grid box fraction of each land surface type	-
Tile_frac (p)	Fractional coverage of each land type	-

The forcing data is provided on a two-dimensional (101x51) grid for Exp.s1-2. However, the ALMIP participants need only run their model at the points indicated by "1" in the field Land_mask. Indeed, this is especially important as some components of the merged forcing (Exp.2) are not valid over the ocean. Details about how to report the values will be given during spring, 2006.

b. Atmospheric forcing

The atmospheric forcing variables are shown in Table 4.4. They will be provided at a three hour time step for Exp.s 1 and 2, at a 1 hour for Exp.3, and at a 30 minute (possibly 1 hour maximum) time step for Exp. 4. The convective rain rate (CRainf) is provided for those LSMs which make the distinction between large scale and convective precipitation (or need a convective fraction, which could then simply be defined as the ratio of CRainf to the total rainfall, Rainf). Note that the CRainf is not available in the merged datasets. Most of the LSMs probably only need the wind module as input, but the wind vector components are provided nonetheless. The wind speed, air temperature and specific humidity correspond to a 10 m height above the surface.

The models needing the low level atmospheric CO_2 concentration, should use a constant (space and time) prescribed value for simplicity. Observations of atmospheric CO_2 in western Africa indicate a rather low amplitude annual cycle with an average value of approximately 375 ppmv (Kergoat, personal communication).

A separate atmospheric forcing file for each year is provided, beginning Jan. 1, at 0UTC, and ending at Dec. 31, 24UTC: the first time is therefore provided for initialization. Note that this implies that the forcing values for the first time step in the 2004 forcing file are identical to the last values in the 2003 file. It is assumed that LSMs will linearly interpolate the forcing data to their LSM time step. For example, the air temperature passed to a LSM at time 4.5UTC should be the average of the provided forcing values at 3UTC and 6UTC.

TABLE 4.4. The input atmospheric forcing variables.

Variable	Description	Units
Rainf	Rainfall rate	kg/m2s
Tair	Near surface air temperature	K
Qair	Near surface specific humidity	kg/kg
PSurf	Surface pressure	Pa
SWdown	Surface incident shortwave radiation	W/m2
LWdown	Surface incident longwave radiation	W/m2
CRainf	Convective Rainfall rate	kg/m2s
Wind_N	Near surface northward wind component	m/s
Wind_E	Near surface eastward wind component	m/s

3. Output Diagnostics

a. Simulation

A preliminary set of output diagnostic variables is shown here, and they are essentially the same as those from the Rhône Aggregation and GSWP2 intercomparison projects (although a few new variables have been added, such as the canopy conductance), less the cold season process variables. See the ALMA web site (http://www.lmd.jussieu.fr / ALMA /) for more information on variable definitions and sign conventions. The flux variables should be output as three-hour averages (over the same interval as the forcing data). Variables denoted by an $*$ (Table 4.5) should be instantaneous values (at the end of the corresponding time step).

Note that the last value in Table 4.5 is marked by $**$: this is used to indicate output for Exp.s.1v-4v (i.e. the optional simulations for which some metric describing the vegetation is a prognostic variable). Here is it presumed to be LAI, however, some schemes might use a plant biomass or several variables to simulate the vegetation temporal evolution. All relevant prognostic variables should be reported, and for each tile or plant functional type (PFT). For example, ISBA will report up to 12 LAI values at each grid point (i.e. one per tile) at each requested output time interval. Variables which might have several values as a function of depth are denoted using (z).

Table 4.5. The output variables to be reported. All variables are averages over the requested time interval, except for those indicated by an $*$ below. Note that schemes using a tiling option are to report all of the relevant variables for each tile at each grid point and time step.

Variable	Description	Units
SWnet	Net shortwave radiation	W/m2
LWnet	Net longwave radiation	W/m2
Qle	Latent heat flux	W/m2
Qh	Sensible heat flux	W/m2
Qg	Ground heat flux	W/m2
DelSurfHeat	Change in surface heat storage	J/m2
Rainf	Rainfall rate	kg/m2s
Evap	Total Evapotranspiration	kg/m2s
Qs	Surface runoff	kg/m2s
Qrec	Recharge	kg/m2s
Qsb	Subsurface runoff	kg/m2s
DelSoilMoist (z)	Change in soil moisture	kg/m2
DelSurfStor	Change in Surface Water Storage	kg/m2
DelIntercept	Change in interception storage	kg/m2
VegT $*$	Vegetation Canopy Temperature	K
BaresoilT $*$	Temperature of bare soil	K
AvgSurfT $*$	Average surface temperature	K
RadT $*$	Surface Radiative Temperature	K
Albedo $*$	Surface Albedo	-
SurfStor	Surface Water Storage	kg/m2
SoilMoist (z)	Average layer soil moisture	kg/m2
SoilTemp (z)	Average layer soil temperature	K
ECanop	Interception evaporation	kg/m2s
TVeg	Vegetation transpiration	kg/m2s
ESoil	Bare soil evaporation	kg/m2s
EWater	Open water evaporation	kg/m2s
RootMoist	Root zone soil moisture	kg/m2
CanopInt	Total canopy water storage	kg/m2
ACond	Aerodynamic conductance	m/s
CanopCond	Canopy conductance	m/s
WaterTableD	Water table depth	m
LAI $**$	Leaf Area Index	m2/m2

If an LSM does not compute a variable shown in Table 4.5, then a missing value should be reported (for example, models using a skin temperature approach to solve the surface energy budget will not report DelSurfHeat). Again, refer to the ALMA web site for a detailed description of the variables. It is requested that a missing variable be defined as 1.0×10^{20}, rather than zero. A simple program will be run on the output data to ensure that the energy and water balances are reasonable. If a problem is found, the model group will be contacted and given the opportunity to track down the error and or to rerun/resubmit their results.

All outputs should be reported in NetCDF format using the version2 ALMA convention (http:// www.lmd.jussieu.fr /ALMA /convention_2.html), however, if outputting in NetCDF format poses a problem for a particular modeling group, then the data can be submitted in compressed ASCII (if a modeler wishes to use this option, an appropriate ASCII format will be provided by ALMIP). A sample output data NetCDF header will be provided to the participants as an aid. A template for the outputs will be posted on the ALMIP web site within the next month (http://www.cnrm.meteo.fr / amma-moana/ amma_surf/ almip/).

b. Ancillary Data

An additional set of parameters or variables which is to be provided in a separate file is shown in Table 4.6. These outputs are critical for computing useful diagnostics and understanding model differences. An example is the soil wetness index (SWI):

$$SWI = \sum_{i=1}^{N_r} \Delta z_i \left(\frac{\theta - \theta_{wilt}}{\theta_{fc} - \theta_{wilt}} \right) / \sum_{i=1}^{N_r} \Delta z_i$$

where N_r is the number of soil layers from the surface to the base of the root zone, and Δz_i is a model soil layer thickness (the index i should be 1 for the surface, and increase downward). The wilting point and field capacity volumetric water contents are represented by θ_{wilt} and θ_{fc}, respectively. a modeler may use either their own set of soil hydrological parameters, or ALMIP can provide a set based the regression relations from Cosby et al. (1984) using the ECOCLIMAP sand and clay fractions.

Also, it would be useful to report things such as a root zone vertical distribution factor, additional stomatal resistance parameters, etc.

Participants should also report any additional variables in this file which have values that differ from those provided by the ALMIP team which are important for analysis of the results (for example, a prognostic soil albedo, soil hydrological parameters).

TABLE 4.6. Additional outputs which vary in space (horizontal and/or vertical, and also possibly as a function of tile) and possibly time. VWC represents volumetric water content (m^3 m^{-3}).

Variable	Description	Units
SoilThick	Soil model layer thickness	m
SoilWilt	Wilting Point VWC	m^3 m^{-3}
SoilFieldCap	Field Capacity VWC	m^3 m^{-3}
SoilSat	Porosity	m^3 m^{-3}
RootFrac	Normalized root fraction	-

CHAPTER 5

CALENDAR

The calendar is shown in Fig. 5.1, and items relevant to ALMIP activities are highlighted. The input data (Chapter 4) for Exp.s 1-2 will be distributed in March, 2006. The Exp. 3 data will be distributed in the middle of 2006. Currently the AMMA-DB (database) group is negotiating when local scale data can be released to the participants of ALMIP (Niger and Benin sites).

The first results will be due at the end of summer, 2006. This will give us the chance to check results, and possibly iterate with the groups if any problems are found. The first ALMIP workshop is tentatively scheduled for February, 2007.

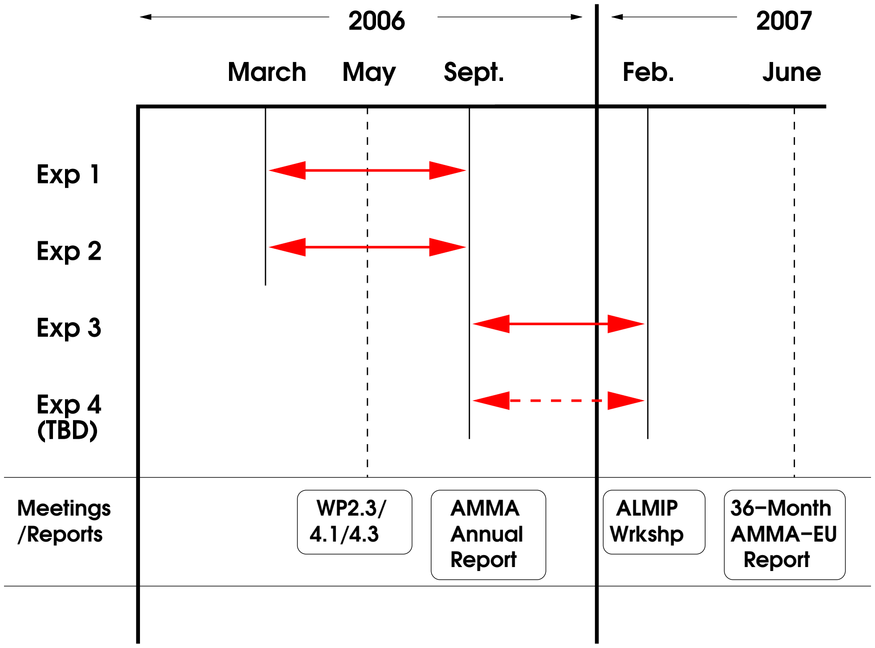

FIG. 5.1. The calendar for ALMIP.

APPENDIX A

ACRONYMS AND DEFINITIONS

AEJ	African Easterly Jet
AEW	African Easterly Wave
ALMIP	AMMA Land surface Model Intercomparison Project
AMMA	Analyses Multidisciplinaires de la Mousson Africaine African Monsoon Multidisciplinary Analysis
AMSR	Advanced Microwave Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
API	Action Programmée Interorganisme
CEH	Centre for Ecology and Hydrology
CETP	Centre d'Etude des Environnements Terrestre et Planétaires
CNRM	Centre Nationale Recherches Météorologiques
CNRS	Centre National de la Recherche Scientifique
ECMWF	European Centre for Medium-range Weather Forecasts
GCIP	GEWEX Continental-scale International Project
GCM	Global Climate Model (Modele Global de Climat)
GEWEX	Global Energy and Water cycle EXperiment
GLASS	Global Land Atmosphere System Study
GLDAS	Global Land Data Assimilation System
GSWP	Global Soil Wetness Project
GSWP2	Global Soil Wetness Project-Phase 2
HAPEX	Hydrological and Atmospheric Pilot EXperiment
IBIS	Integrated BIosphere Simulator
IGBP	International Geosphere-Biosphere Programme
ISE	Institut des Sciences de l'Evolution
ISBA	Interaction Sol-Biosphre-Atmosphre
ISLSCP	International Satellite Land Surface Climatology Project
JULES	
LAI	Leaf Area Index
LDAS	Land Data Assimilation System
LSM	Land Surface Model
LSS	Land Surface Scheme
LMD	Laboratoire de Météorologie Dynamique
MODIS	MODerate-resolution Imaging Spectroradiometer
NCEP	National Center for Environmental Prediction
NDVI	Normalized Difference Vegetation Index

NetCDF	NETwork Common Data Format
NLDAS	North-American Land Data Assimilation System
NOAH	NCEP-Oregon State-Air Force-Hydrology Lab model
NWP	Numerical Weather Prediction (model)
ORCHIDEE	ORganising Carbon and Hydrology In Dynamic EcosystEms
PFT	Plant Functional Type
PILPS	Project for the Inter-comparison of Land-surface Parameterization Schemes
SEtHyS	Suivi de l'Etat Hydrique des Sols (monitoring the soil hydrological state)
SAR	Synthetic Aperture Radar
SVAT	Soil Vegetation Atmosphere Transfer
TESSEL	
WAM	West African Monsoon
WP	Work Package

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