

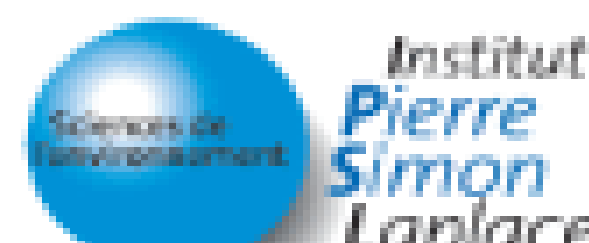


African Monsoon Multi-disciplinary Analysis (AMMA) Land Surface Intercomparison Project (ALMIP) Phase 2: Local to meso Scale Processes



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ALMIP AMMA Land Surface Model Intercomparison Project Phase 2



Introduction

The main goal of the African Monsoon Multidisciplinary Analysis (AMMA) Project (Redelsperger et al., 2009, BAMS) is to obtain a better understanding of the intra-seasonal and inter-annual variability of the West-African Monsoon (WAM). The magnitude of the north-south gradient of surface fluxes (related to soil moisture and vegetation) has an influence on the position of the tropical front and the strength of the monsoon. Therefore, a high priority of AMMA is to better understand and model the influence of the spatial and temporal variability of surface processes on the atmospheric circulation patterns and the regional scale water and energy cycles. This is being addressed through a multi-scale modeling approach using an ensemble of hydrological and land surface models (LSMs) which rely on dedicated satellite based forcing and land surface parameter products, and data from the AMMA observational field campaigns. The coordination of the land surface modeling activities in AMMA is supported by the AMMA Land surface Model Intercomparison Project (ALMIP: Boone et al., 2009, BAMS). The now completed ALMIP Phase 1 dealt with surface processes at the regional scale, and results were used not only to obtain a better idea of surface processes, but also output data was used extensively by the atmospheric modeling community. In ALMIP Phase 2, LSMs will be forced and evaluated using observational data from three heavily instrumented supersites from the AMMA-Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique (CATCH) observing system (Lebel et al., 2009, JH). The AMMA-CATCH window covers a north-south transect encompassing a large ecological gradient (Fig. 3).

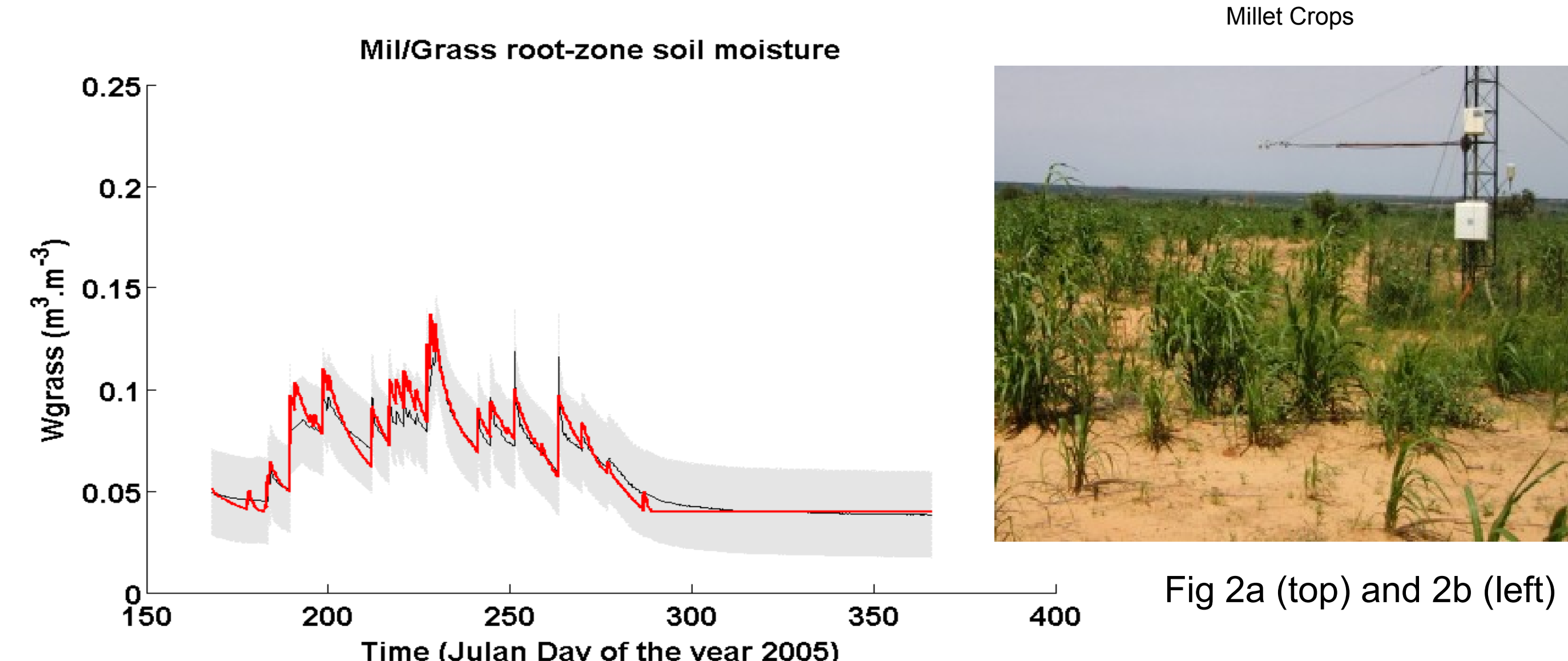


Fig 2a (top) and 2b (left)

Niger local scale site: Wankama

The Wankama site is characterized by sandy soil, and mixed agriculture and fallows with shrubs. An example comparison (Fig 2) for the Niger site (Cappelaere et al., 2009, JH) between root zone soil moisture simulated by the SEThys Savannah LSM model (Fig 2b: Saux-Picart, 2009, JH) compared to observed root zone soil moisture. The grey zone indicates observational uncertainty. The model is able to capture the wet season soil moisture dynamics. Such a semi-arid environment will likely challenge the LSMs, however, a robust modeling of such environments is critical to understanding and modeling the WAM. A photograph of the site (Millet) is shown in Fig.2a.

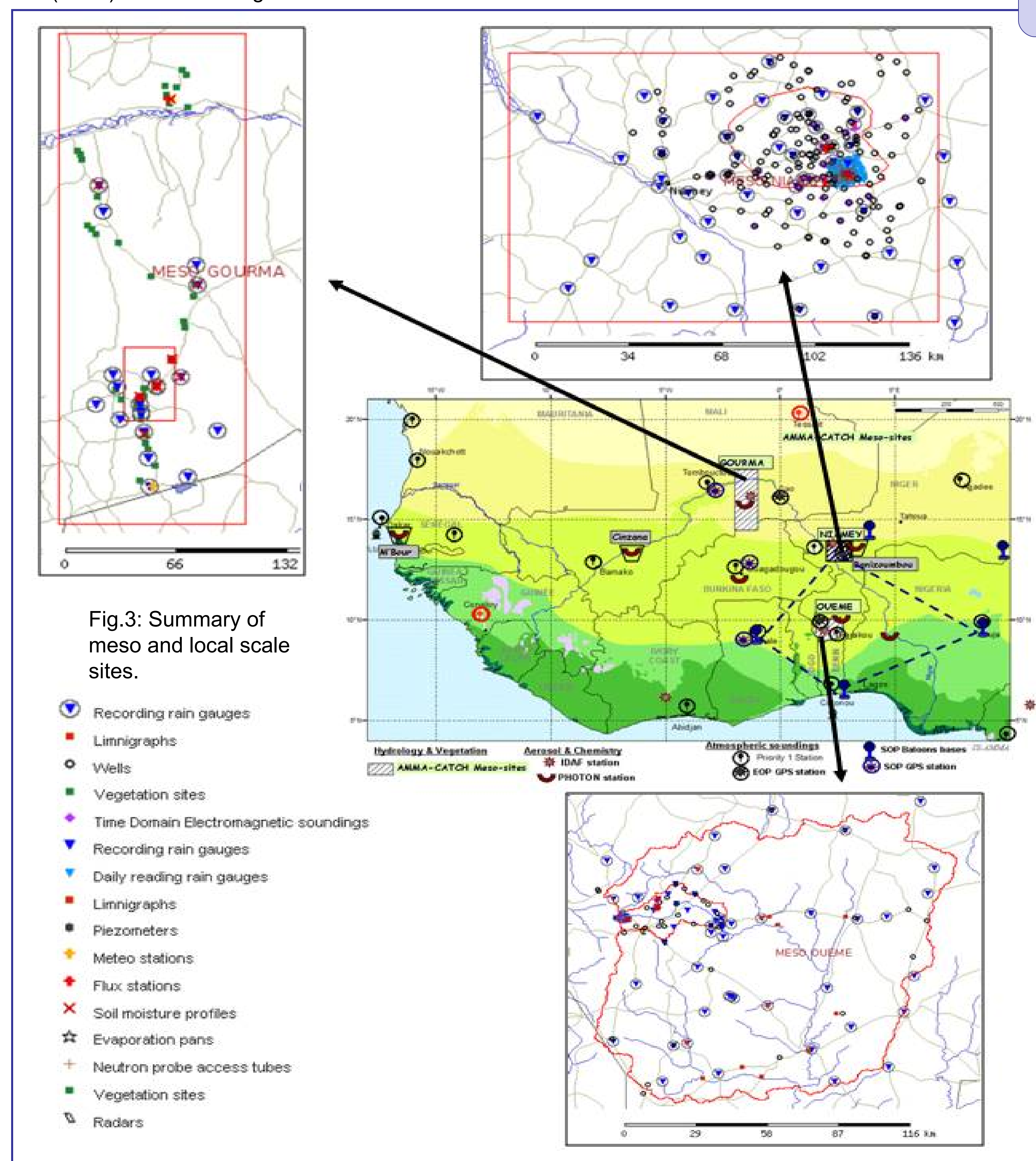
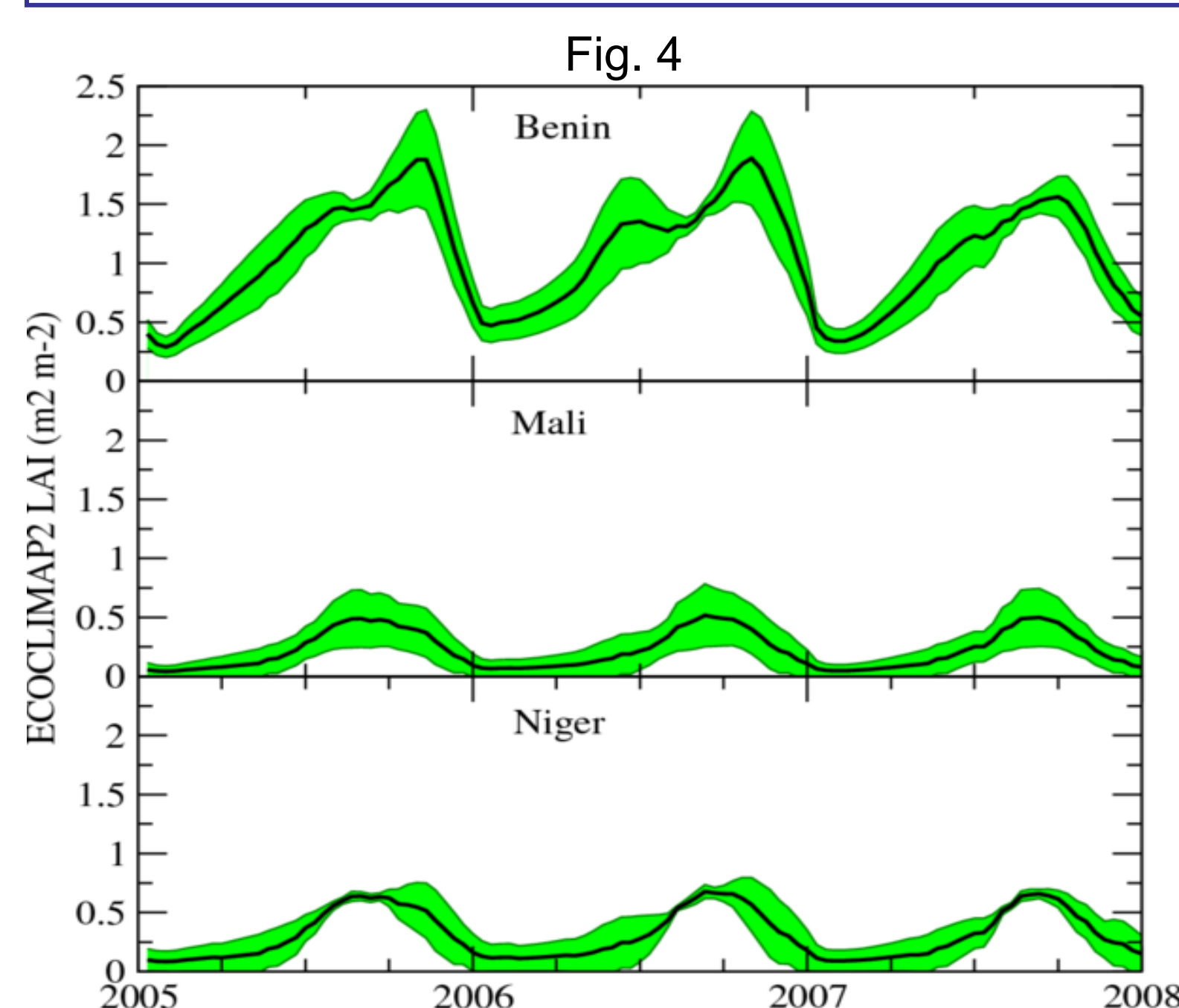


Fig.3: Summary of meso and local scale sites.

- Recording rain gauges
- Limnigraphs
- Wells
- Vegetation sites
- Time Domain Electromagnetic soundings
- Daily reading rain gauges
- Limnigraphs
- Piezometers
- Meteo stations
- Flux stations
- Soil moisture profiles
- Evaporation pans
- Neutron probe access tubes
- Vegetation sites
- Radars



Mesoscale Forcing and Soil-Vegetation Inputs

The domain-averaged Leaf Area Index (LAI) from the ECOClimAP2 database (Kaptué et al., 2011, J Hydromet) is shown in Fig. 4. The spatial variability is indicated in green (1 std). Unlike ALMIP1, ALMIP2 includes year-to-year variability. Detailed classifications are also available (see example for Mali Fig. 2).

Mesoscale downwelling fluxes are from the LANDSAF project. Precipitation is derived using a combined krigged-LaGrangian (Vichel et al., 2009, JH) methodology (nearest neighbor will also be used) based on dense rain gauge networks. Meteorological variables are from ECMWF operational forecast data.

Intercomparison of hydrologically based models and LSMs

Hydrological processes from conceptual hydrological models (e.g. TOPAMMA based on the TOP-Model approach) or distributed models (e.g. MIKE-SHE) will be compared to LSMs coupled to a simple Muskingum-Cunge routing algorithm (Getirana et al., 2011). A schematic of the methodology for obtaining discharge (Fig. 5b) from the for the Oueme basin (Benin). Model simulated discharge from an LSM (here ISBA) after calibration of 3 parameters during 2005 is shown compared to observations (Fig. 5c).

Production functions (such as for evapotranspiration and surface runoff) from hydrological models will be evaluated and compared to values from LSMs. It is hoped that both types of models can benefit from such a comparison.

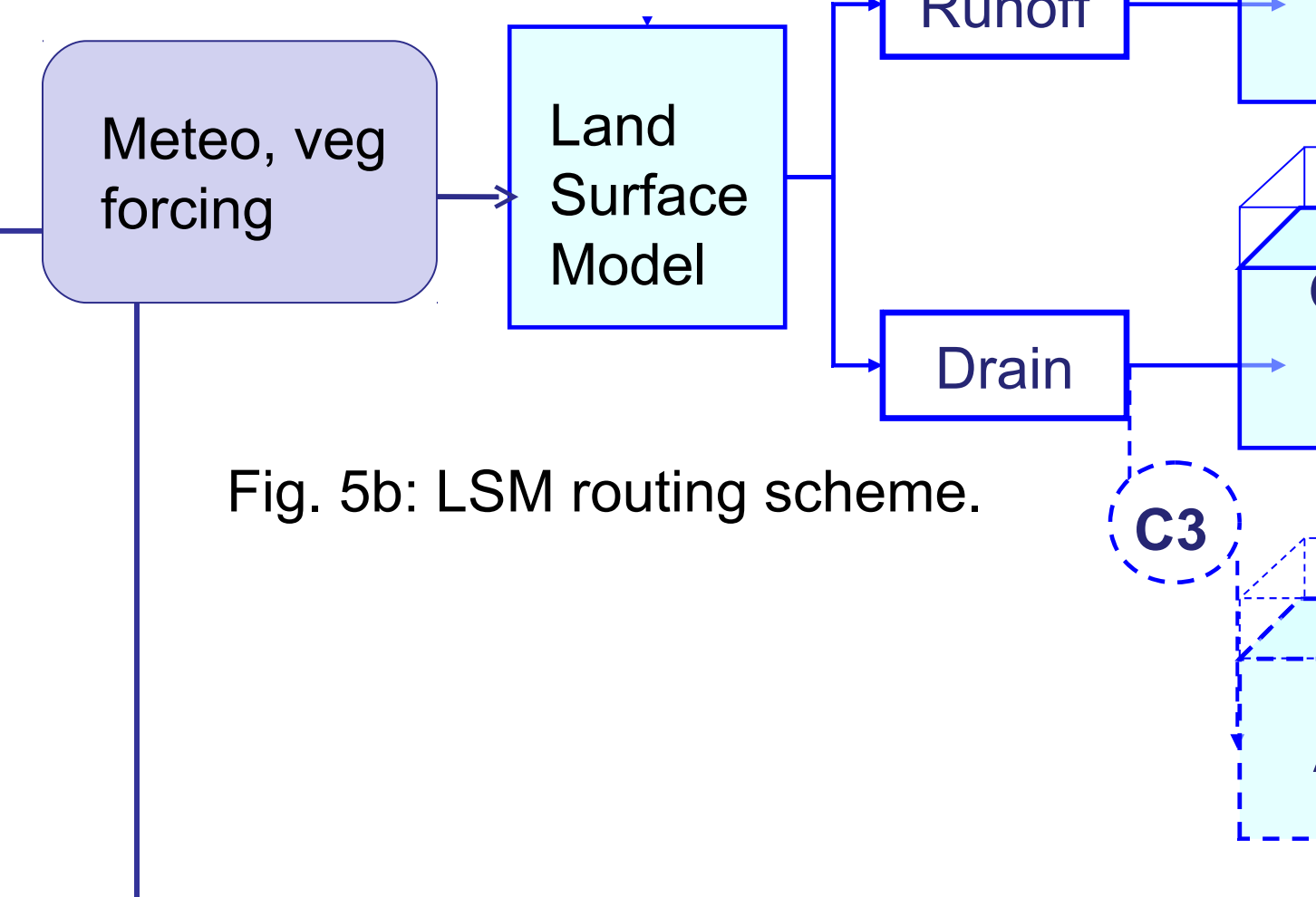


Fig. 5b: LSM routing scheme.

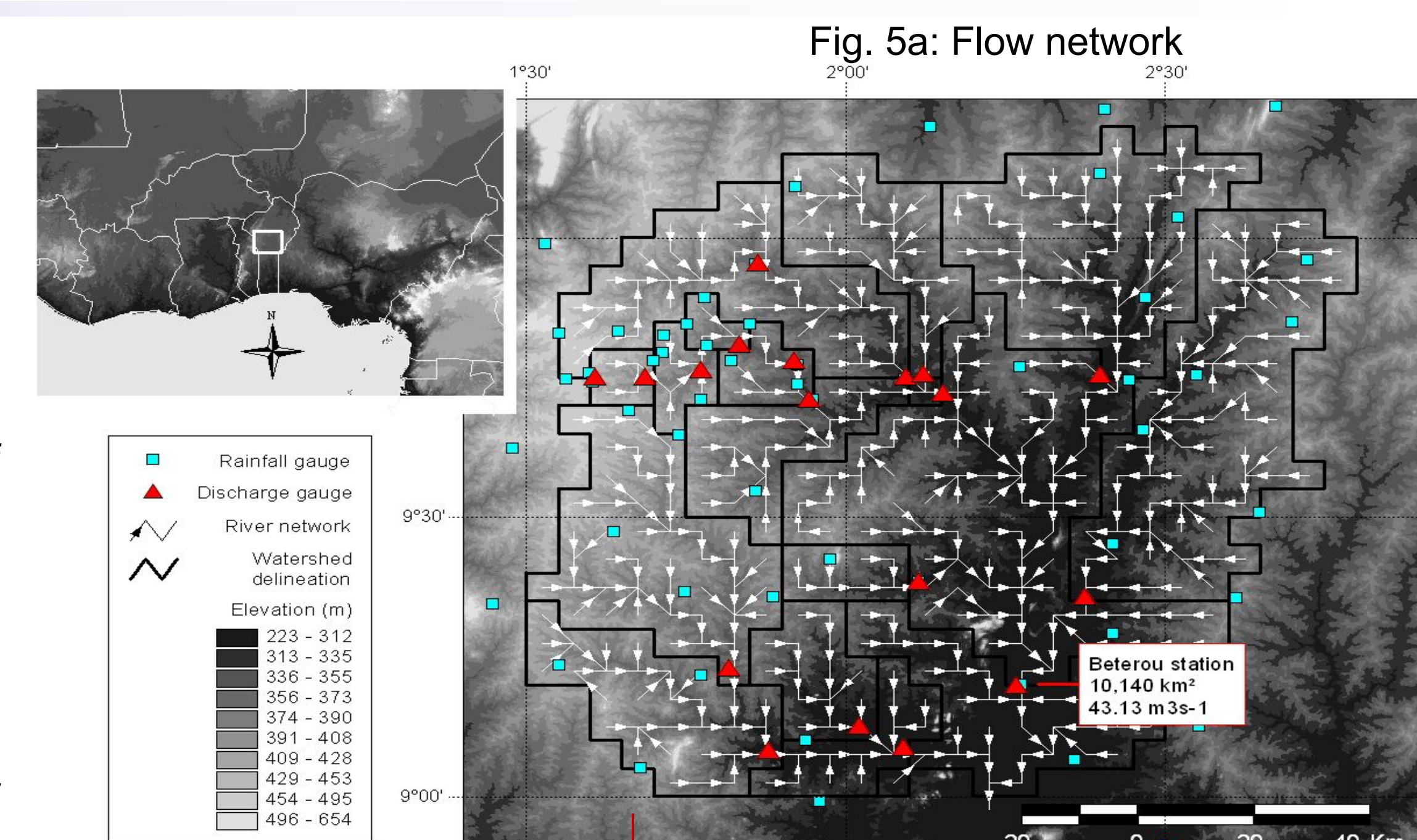


Fig. 5a: Flow network

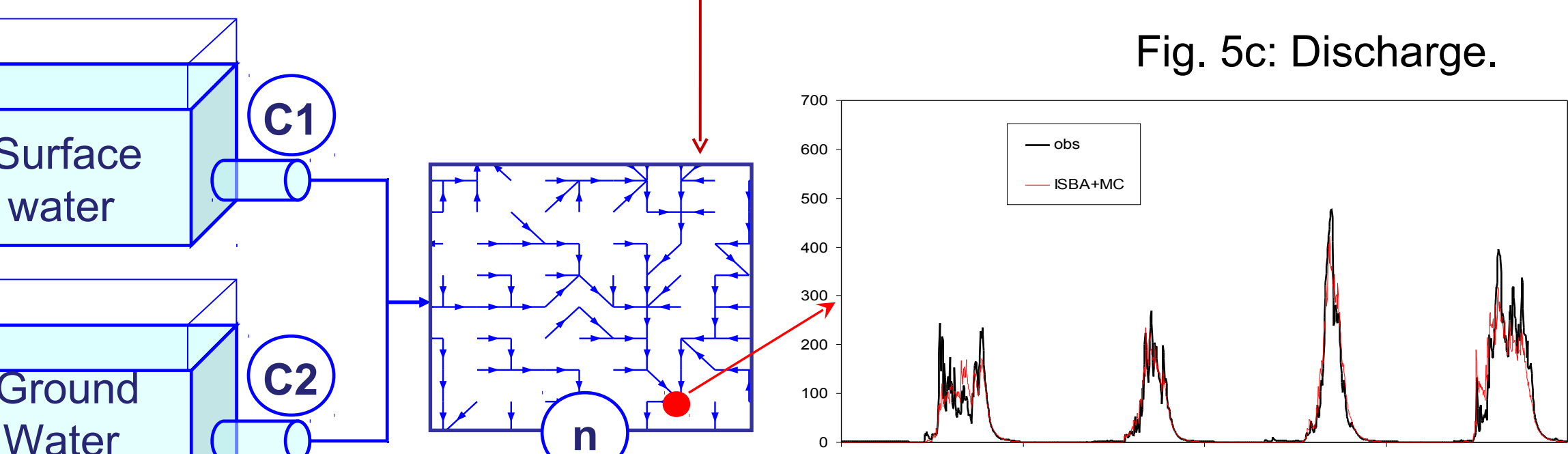


Fig. 5c: Discharge.

- C3 – defines how much drainage goes to the groundwater reservoir
- C1 – concentration time of the surface water reservoir
- C2 – concentration time of the groundwater reservoir
- n – Roughness -Manning coefficient

Benin local scale site: Bellefoungou

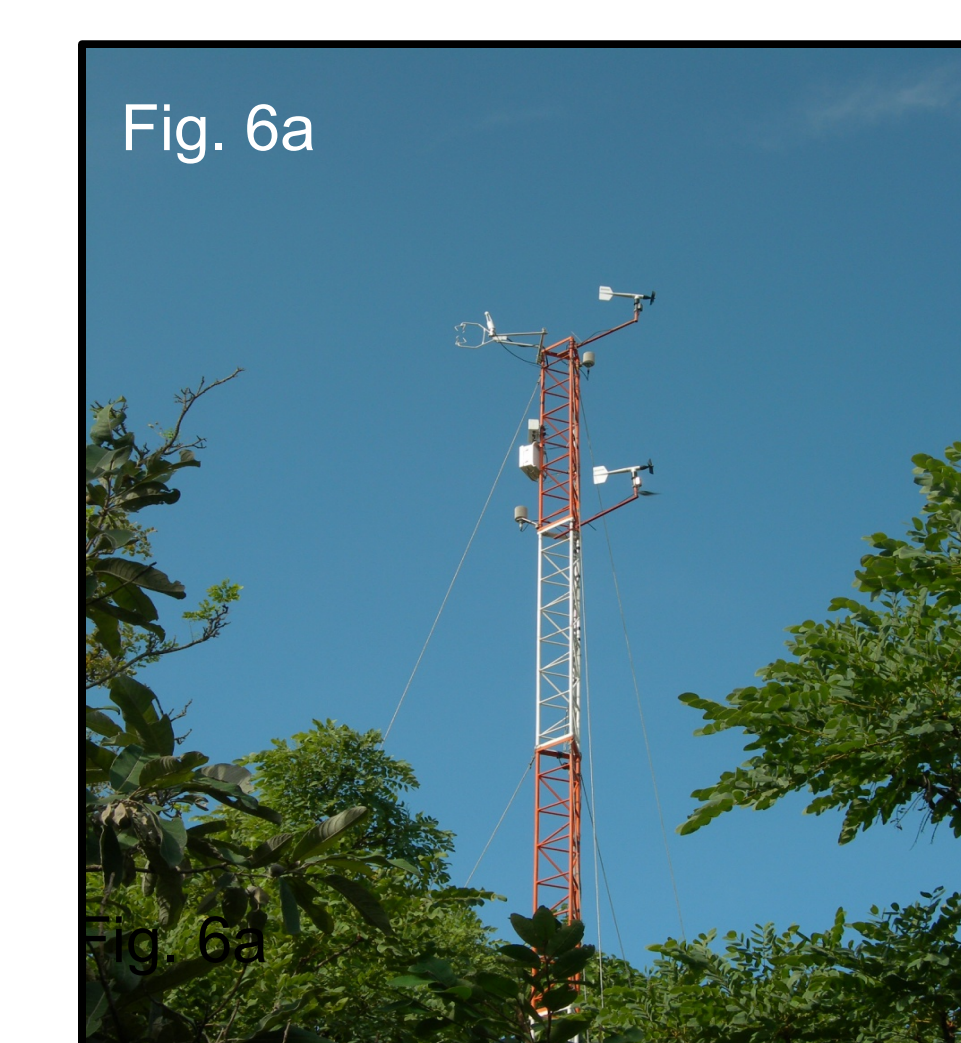
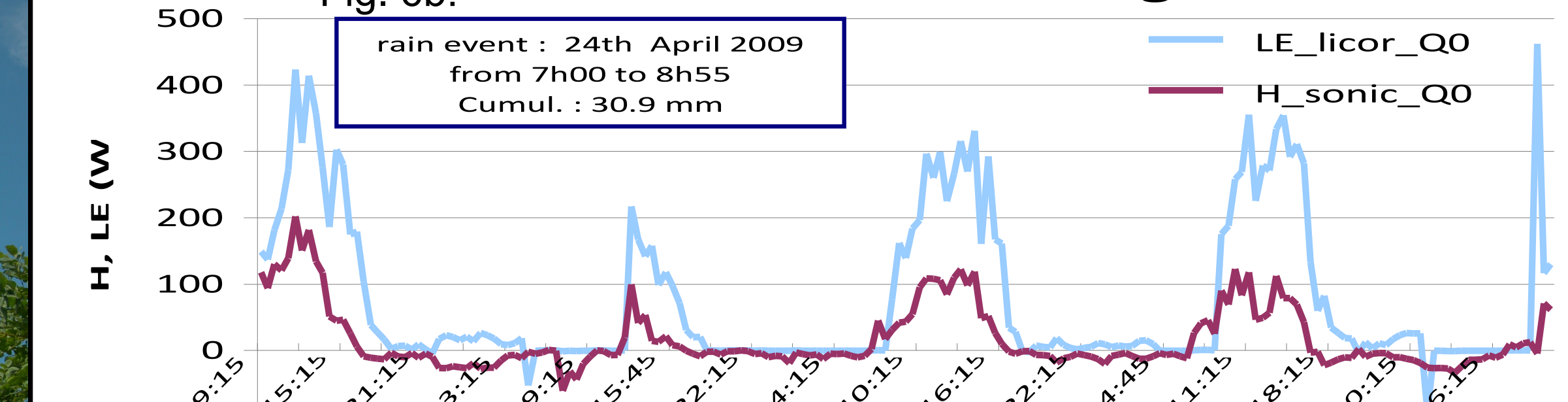


Fig. 6a

Fig. 6b: Rain event at Bellefoungou



Unlike the semi-arid sites in Niger and Mali, the Benin site (Guyot et al., 2009, JH) is characterized by a cleared forest. The tower (Fig. 6a) is situated in a relatively homogeneous forested area with 14m tall trees, with herbaceous under-story vegetation during the wet season. Various radiation and flux measurements have been made by both LTHE and CEH (Wallingford, UK). A sample 4 day time series (turbulent fluxes) are shown in Fig. 6b. Rain events generally take place during night time, thus limiting the impact on the retrieved fluxes.

Conclusions and Perspectives

The main goal of ALMIP2 is to obtain a better understanding and thus to improve the representation of key surface, vegetation and hydrological processes over West Africa, which can then in turn benefit the forecast and regional and global climate modeling communities, and the mesoscale, regional and global scale hydrological modeling communities. Owing to rapidly increasing population and anthropization, along with the possibility for regional changes to the climate, improved modeling is needed for applications in water resource management, disease prevention and control, and adaptive agricultural practice strategies.

Model experiments will be performed for three distinct meso-scale domains within the AMMA-CATCH window which is characterized by strong gradients in vegetation, soils and climate. Different satellite-based datasets have been assembled for evaluating models over the mesoscale regions (LANDSAF products, the Alexi Evaporation product from the USDA: M. Anderson, etc.), along with many discharge and piezometric measurements for hydrological modeling. One to several local scale sites will also be modeled within each meso-domain. An overview sample of some of these sites is presented herein. Simulations will cover the main AMMA field campaign observational window (2005-2007) and extending into 2008.

It is hoped that ALMIP2 will be able to help bridge the gap between GEWEX Regional Hydrology Projects (RHPs) and the Global Land Atmosphere System Study (GLASS), by evaluating and comparing both hydrological and LSM models. Organization and modeling has been taking place within France over the last year: a call to participation for the international community is forthcoming before autumn 2011, with results due by mid-2012. A workshop will be planned for the end of 2012.

For more information (and a list of references cited in this poster), visit http://www.cnrm-meteo.fr/amma-moana/amma_surf/almip2/ If you are interested in participating, please contact A. Boone at aaron.boone@meteo.fr or C. Peugeot at christophe.peugeot@ird.fr. Funding for ALMIP2 preparations in France is currently provided by EC2CO. ALMIP2 is a sub-project of AMMA2.

References: the references with JH herein refer to the Journal of Hydrology CATCH Special Issue, 375 (1–2), 2009. This issue offers a comprehensive overview of AMMA-CATCH related studies (observations and modeling).

ALMIP2 Science Questions:

- Which processes are missing or not adequately modeled by the current generation of LSMs over this region (e.g. endorheic hydrology...)?
- How do the various LSM respond to changing the spatial scale (three scales will be analyzed: the local, meso and regional scales)?
- Can relatively simple LSMs simulate the vegetation response to the atmospheric forcing on seasonal time scale (for several annual cycles) for the diverse climates/vegetation covers?
- How can LSM simulate mesoscale hydrology given their relatively simple representation of such processes?
- What are the impacts of uncertainties/differences in the precipitation on the surface fluxes and hydrological responses of the LSM models?

In order to address these questions, two experiments will be performed with the first one at the mesoscale for each of the three super sites. A second set of experiments will be performed at the local scale for several selected sites within each of the mesoscale squares. The simulations will encompass the 2005-2007 Intensive Observing Period. In addition to evaluation using field data, LSM simulations will also be compared to results from detailed vegetation process and hydrological models that have already been extensively validated over this region. The results will be used in conjunction with those from ALMIP-1 in an effort to evaluate the effect of scale change on key processes. A sample of the different sites is given in the following.

Mali local scale site: Agoufou

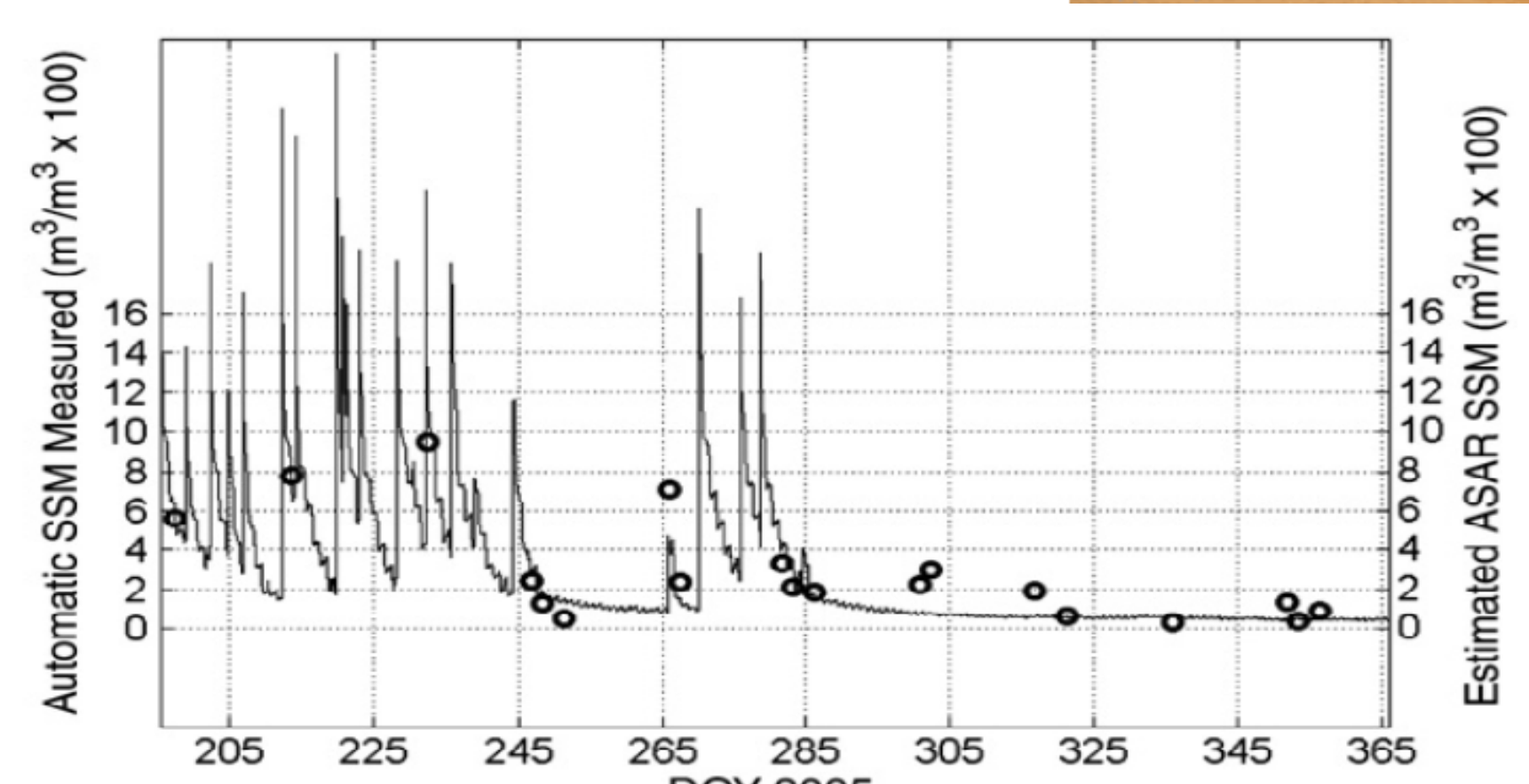
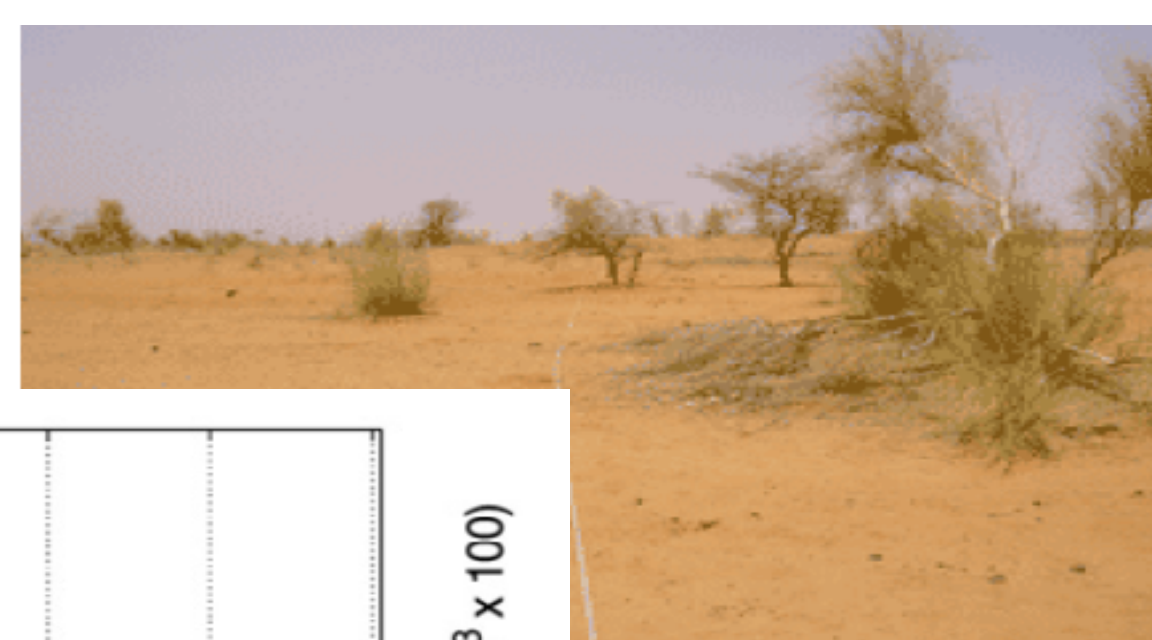


Fig.1a (top) and 1b (at left)

The Agoufou site in Mali (Mougin et al., 2009, JH) is semi arid characterized by sandy soil and widely-spaced shrubs and short seasonal grass (Fig.1a) adjacent to large areas of rocky or loamy very shallow soils. (Fig 2). Observed soil moisture (circles) are shown above (Fig.1b taken from Baup et al., 2007, Rem. Sens. Env.) compared to data derived from ASAR (satellite-based) data. Such data will be used to evaluate the LSMs.

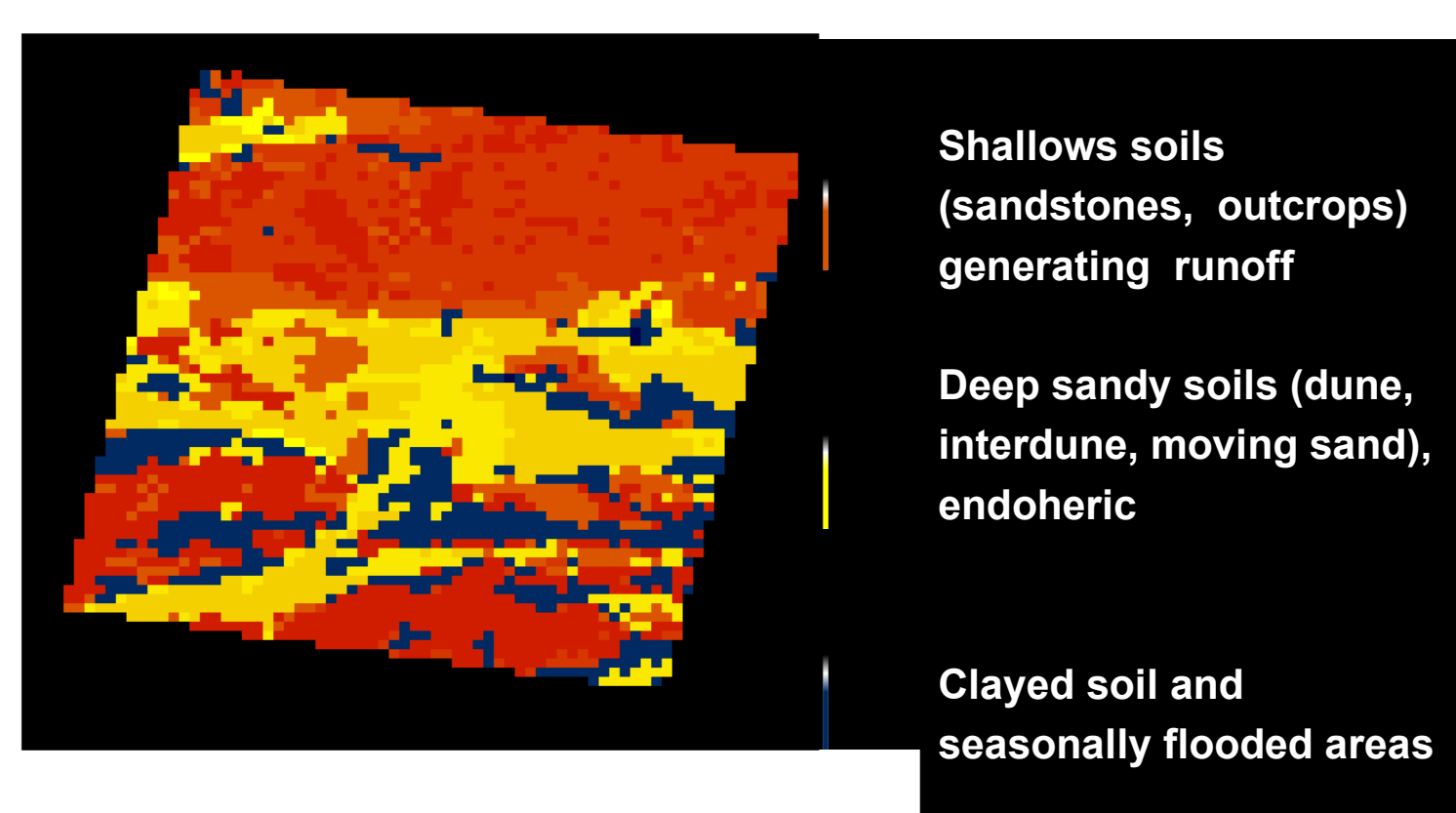


Fig.2 Detailed land cover maps have also been created for each meso-domain in addition to ECOClimAP2. The classification (at left) was derived from LANDSAT for the Mali meso-domain.