AMMA Gourma mesoscale soil moisture network report - January 2007

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1) Scientific objectives

The AMMA mesoscale soil moisture network has been implemented over the Gourma mesoscale site since 2004. This network is spanning 2° in latitude between 15°N and 17°N. In 2007, the network includes 10 soil moisture stations, of which 8 stations are specifically designed for soil moisture monitoring, (EF14 instrument) and 2 soil moisture stations are associated to sap flow and flux measurements.
The aim of the AMMA Gourma mesoscale soil moisture network is to capture spatial and temporal dynamics and variabilities of soil moisture. These variability are strongly related to the considered soil-vegetation systems, to precipitation patterns and to a very strong climatic North-South gradient.

2) Soil Moisture stations location, characteristics and installation

Documentation of the spatial and temporal variabilities of soil moisture is performed using local measurements and satellite observations. According to remote sensing and satellite application developed at CESBIO, the soil moisture network deployed in Gourma-Mali is specifically designed for soil moisture remote sensing and validation. To this end:

- the vertical resolution in the soil is very fine (first sensor at 5cm depth),
- both soil moisture and soil temperature profiles are monitored,
- the deployment over the mesoscale window allows to document (i) the Nord-South gradient along a 2.5° latitude gradient, (ii) different soil texture and vegetation types, (iii) different levels of a typical sand hillslope (top, middle and bottom) on Agoufou (site 17), (iv) each soil moisture station is located next to a raingauge station.
- in addition to the local stations network, transect measurements are performed by the ground team on the different sites (Agoufou, Ebangui-Mallam, Ekia, Figure 1), allowing to monitor surface soil moisture at the kilometric scale. These measurements allow to address upscaling issue from local point to kilometric to satellite resolution.

Table 1 provides detailed information concerning soil moisture stations (reference, location, sensors types, date of installation) and Figure 1 is a schematic representation of their location over the mesoscale site. The same installation protocol is used for each station installation. Figure 2 show an example of soil moisture station. For each station and each sensor depth, calibration is performed, based on gravimetric local soil moisture measurements. Gravimetric measurements are performed at different stage of the rainy season to ensure calibration robustness in various soil moisture conditions.

Automatic measurements are complemented by field measurements made on the vegetation monitoring sites along 1km transects. Spatialised data are also used to validate satellite products such those derived from AMSR-E data (Advanced Microwave Scanning Radiometer on the Earth Observing System -EOS-aqua satellite). Three of the stations include a full meteorological measurements suitable to perform land surface modeling and assimilation of remote sensed data. In addition to the climatic gradient, this

network allows to document soil moisture variability at smaller scale, with 4 stations installed in the same basin at different level of the slope (Agoufou site17, see Table 1). Colors in Figure 1, obtained from a Landsat image, indicate the surface types. Green areas correspond to sandy dune systems. This type of surface represents 65% of the area of the meso site. Eight stations are installed on sandy soil. Dark green represent 5% of the area, with clay soil type area, covered by acacia forest (one station, in Kelma). The rest of the mesoscale site (30%) is covered by rocky areas in red in Figure 1. One flux station is installed on this rocky area in Eguerit, where soil moisture measurements are performed at 10 and 20cm depth.

Site		Location		Sensors types and depth (cm)		date
		lat	lon	Soil Moisture	Temperature	
	Agoufou					
17 - P1	Bottom of hillslope	15°20.437N	1°28.726W	7CS616 5, 30, 60, 120, 150, 250, 400	4 PT108 5, 30, 60, 120	Apr 2005
17 - P2	middle of hillslope	15°20.675N	1°28.745 W	6 CS616 5, 30, 60, 120, 180, 250	2 PT108 5, 30	Apr 2006
17 - P3	top of hillslope	15°20.72′N	1°28.748W	5 CS616 5, 10, 40, 120, 220	2 PT108 5, 40	Apr 2004
17 - P4	Sap flow	15°20.21′N	1°28.78W	7 CS616 5, 30, 60, 120, 150, 250, 500	3 PT108 5, 30, 60	Jan 2006
BB - P5	Bamba	17°05.941N	1°24.1083W	6 CS616 5, 40, 80, 120, 180, 250	5 PT108 5, 10, 40, 80, 120	Apr 2004
4 - P6	In Zaket	16°34′17.7N	1°47′21.5 W	7 CS616 5, 10, 30, 80, 120, 180, 250	4 PT108 5, 10, 30, 80	Jul 2005
12 - P7	Ekia	15°57.906N	1°15.206W	7 CS616 5, 10, 30, 80, 120, 180, 250	4 PT108 5, 10, 30, 80	Jun 2005
EM - P8	Ebang Mallam	15°23.875N	1°20.729W	7 CS616 5, 10, 30, 80, 120, 180, 250	4 PT108 5, 10, 30, 80	Apr 2005
20 - P9	Kelma	15°16.583N	1°33.9667W	4 Théta-probes 5, 20, 80, 100	4 PT108 5, 20, 80, 100	Jun 2005
40 - P10	Eguerit	15°30.16N	1°23.46W	2CS616 10, 50	4 PT108	Apr 2005
25 - P11	Kinia	15°03.06N	1°32.76W	7CS616 5, 10, 30, 80, 120, 180, 250	4 PT108 5, 10, 30, 80	Mar 2007

Table 1: the AMMA Gourma soil moisture network, location, characteristics and date of installation

Transect measurements are used for upscaling application. These field measurements obtained for a few days during summer field campaigns have been compared to the data recorded by the automatic soil moisture stations and a transfer function has been established between the two data sets. This transfer function has been applied to the 2004-2006 data set. It is used for upscaling purpose and comparison with remotely sensed soil moisture (Baup et al. 2007).

Soil texture and soil density were measured on the Agoufou local site at different levels of a hillslope. These local measurements showed at bottom of the hillspole the following fractions: 9.6% of clay, 15.8% of silt and 74.6% of sand. Soil texture is getting more sandy at the top of hillslope with 3.4% of clay and 94.2% of sand. Soil density is measured to be 1.69 g/cm3 and 1.51 g/cm3 at top and bottom of hillslope respectively. For such sandy soil the volumetric water content varies from about 23% at saturation to residual value less than 1%.

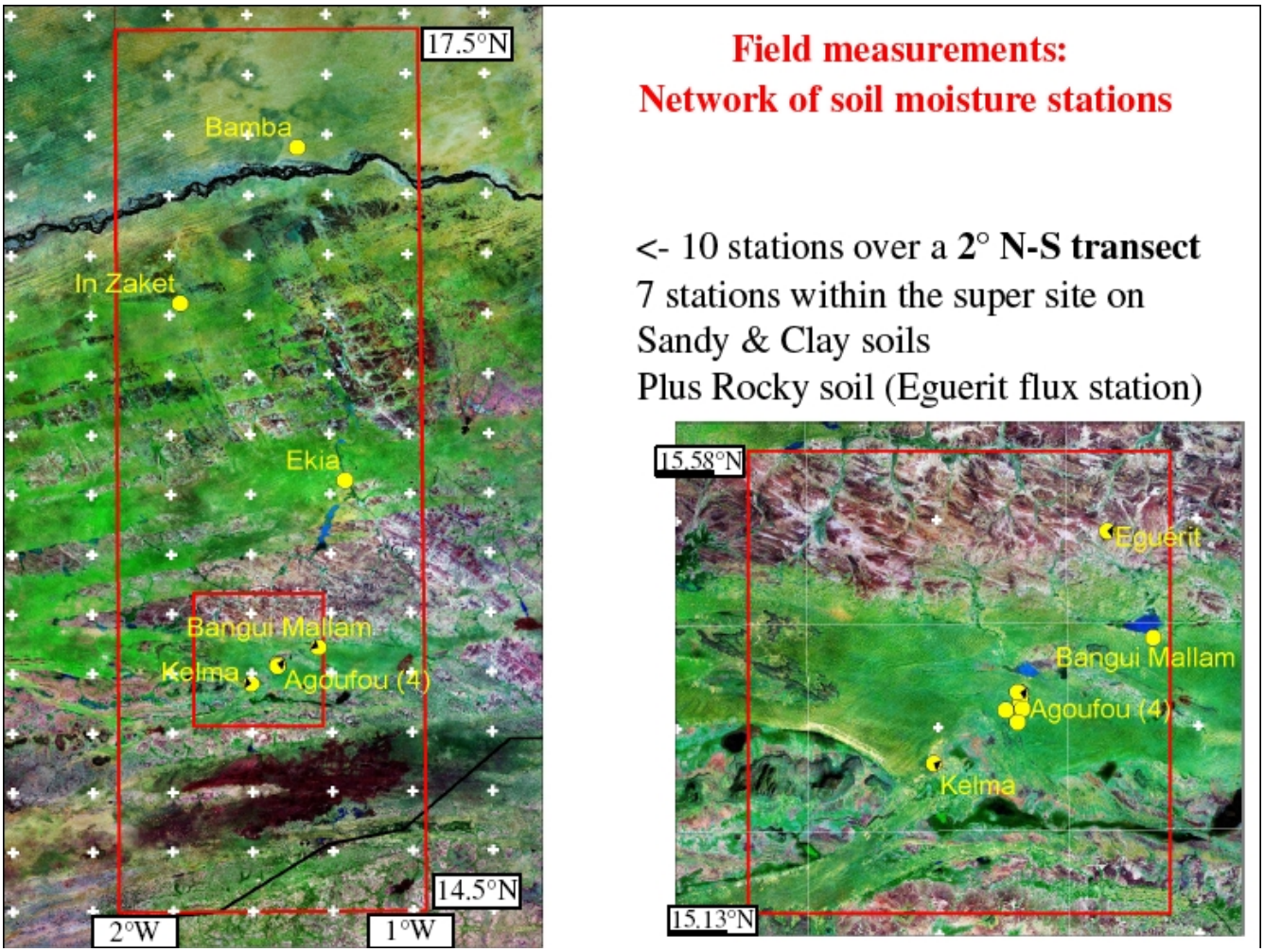


Figure 1: AMMA Gourma soil moisture network: Location of the stations (yellow) over the Gourma mesoscale site (left) and within the Gourma supersite (right). White cross indicate location of the center of AMSR-E satelliet pixels for which daily soil moisture products have been available since 2002. The station installed in 2007 in Kinia, located south of Kelma, must be added to this figure.

Field measurements:
Soil Moisture Stations -> Local Information

- 7 moisture sensors (CS616)
  from 5 cm to 2.5m deep.
- 4 temperature sensors (PT108)
  from 5 to 80 cm.
- Continuous monitoring
  (15 min time step)

Local calibration:

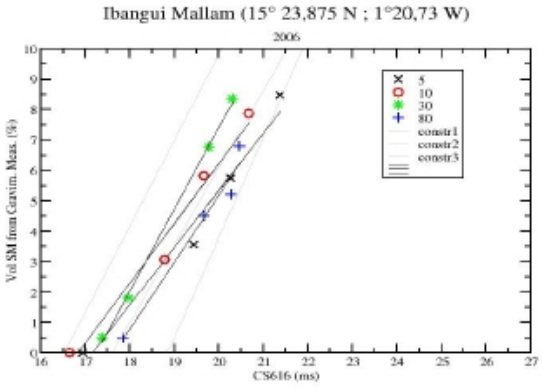
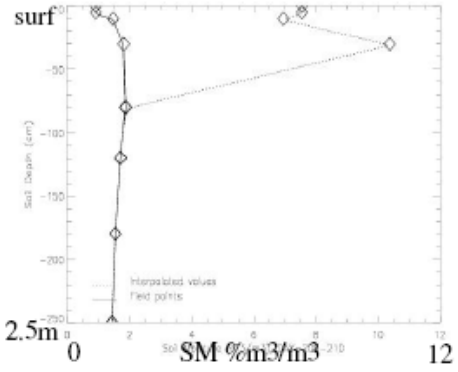
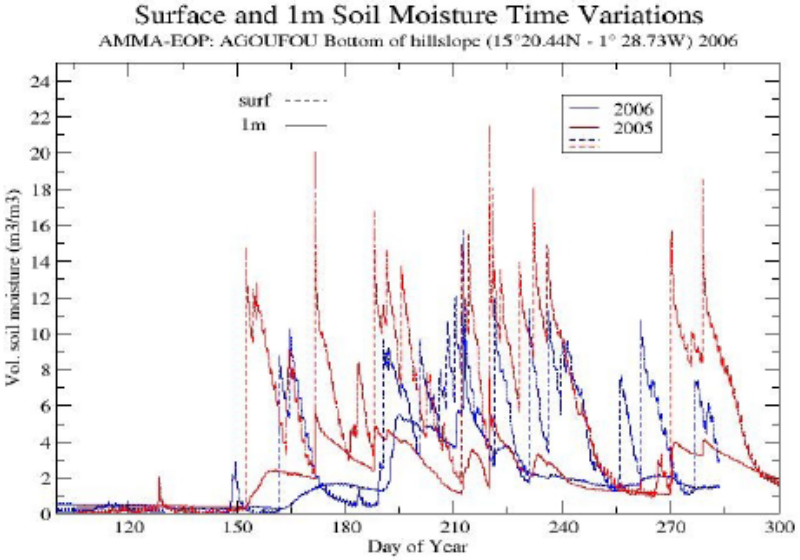


Figure 2: Soil moisture station installed with CS616 sensors. For each station, calibration is performed from gravimetric measurements of soil moisture at each sensor depth, repeated in different soil moisture conditions.

Field measurements:
Soil moisture dynamics



Ebangui Mallam soil moisture vertical profile
before after rain: P= 61mm DW=51mm



Agoufou SM dynamics
at different depths

Figure 3: on top left the vertical profile of soil moisture is represented in Ebangui Mallam station on doy 209 and 210 (28 and 29 July) 2006, before and right after a precipitation event. Water budget is computed at the scale of the station. The bottom right graph depicts the temporal evolution of soil

moisture in Agoufou (station 17-P1) in 2005 (blue) and 2006 (red) for the surface-5cm (dotted line) and 1st metter (continuous line) soil moisture.

3) Technical informations

Missing data (to be updated)

- 17-P3: acquisition problems lead to missing data from Apr-2004 to Jun-2004 and from Sep-2004 to Feb-2005
- BB-P5: missing data from December 2005 to April 2006.
- BM-P8: missing data from Nov to Dec 2005.
- 4-P6: station was stolen in Aug 2005: missing data from Aug 2005 to Oct 2005.

Data acquisition

Automatic measurements are acquired at 15min time step. Each soil moisture station is equipped with a campbell CR10X and a storage module. There is not any automatic wireless data transmission, the data are get by direct connection on the CR10X.

Data processing and delivery to database

Data are processed with fortran90 programs under linux scripts. The final products are volumetric soil moisture (in m3/m3) and temperature (°C) vertical profiles provided every 15 min for each of the eight soil moisture stations related to EF14 instrument. The full 2005 data set will be provided in ascii format to both AMMA and CATCH data bases in early 2007. The full 2006 data set will be provided later in June 2007.

4) References related to the Gourma soil moisture network (description and/or use of data)

2007

Baup F., E. Mougin, P. Hiernaux, A. Lopes, P. de Rosnay, I. Chênerie, “Radar signatures of sahelian surfaces in Mali using ENVISAT-ASAR data”, IEEE TGRS in press, 2007

Baup F., E. Mougin, P. de Rosnay, F. Timouk, I. Chênerie “Surface soil moisture estimation over the AMMA Sahelian site in Mali using ENVISAT/ASAR data” Remote sens Env. in press, 2007

2006

de Rosnay P., Baup F., Timouk F., Le Dantec V., Kergoat L., Lavenu F., Mougin E., EGU General Assembly; Vienna, 2-7 April 2006. Poster presentation: "Multi-scale soil moisture monitoring in the Gourma meso scale site: from local station network to remote sensing approaches"

AMMA Land surface processes, Forschungszentrum Karlsruhe, Institute for Meteorology and Climate Research (IMK-IFU), Garmisch-Partenkirchen, Germany- 10-12-May 2006 Oral: " Multiscale soil moisture monitoring: local station network and remote sensing " de Rosnay P. et al.

AMMA workshop, Nov 2006, Toulouse France session organisation: “Land surface, remote sensing and modelling” de Rosnay et al “Soil Moisture Remote Sensing over the Gourma Mesoscale Site”

6th SMOS Science Workshop, TUD, Denmark- 15-17-May 2006 Poster: "Multiscale validation of SMOS brightness temperature and products overWest Africa" de Rosnay P. Kerr Y., Pellarin T., Polcher J.

Baup F., Mougin E., de Rosnay P.. Timouk F., Lavenu F., Chenerie I., EGU General Assembly; Vienna, 2-7 April 2006. Poster presentation: "Surface soil moisture estimation of sahelian rangelands (Mali) using ENVISAT ASAR data"

Delon C., Serça D., Tulet P., Dupont R., Boissard C., de Rosnay P., EGU General Assembly; Vienna, 2-7 April 2006. Poster presentation: "NO emissions from soils and impact on tropospheric chemistry in the framework of AMMA"

Delon C., Serça D., Boissard C., Dupont P., Laville P., de Rosnay P., Delmas R., ILEAPS conference; Boulder, 21-26 January 2006 "NO emission from soils: a neural network approach"

2005

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de Rosnay P., Baup F. Timouk F., Couderc C., Le Dantec V., Kergoat L., Lavenu F., Mougin E., AMMA 1st International conference; Dakar, 28 November - 4 December 2005. "Soil moisture monitoring in the Gourma meso scale site: from local station network to remote sensing approaches"

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Mougin E., Baup F., Ceschia E., Damesin C., Delon C., Demarez V., de Rosnay P., Epron D., Hiernaux P., Jarlan L., AMMA Gourma EGU 2nd General Assembly; Vienna, 24-29 April 2005. Poster presentation: "Overview of research activities at the Gourma meso-scale site (Mali)"

Mougin E., Kergoat L., Le Dantec V., Hiernaux P., Seghieri J., Lavenu F., Timouk F., de Rosnay P., Baup F., Berg A., Mangiarotti S., Demarez V., Mougenot B., Ceschia E., Tracol Y., Jarlan L., Damesin C., Delon C., Serça D., Lacaaux-Galy C., Dupont R., Epron D., Gignoux J., Leroux X., Mazzega P., Guichard F.,Colloque ECCO; Toulouse 5-7 December 2005. "Approche multi - échelle du fonctionnement des éco - agrosystèmes d'Afrique de l'Ouest dans le cadre du projet AMMA"