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Chapter 6

EOP integrative studies on the Niger meso-site

Luc Descroix, Bernard Cappelaere, Guillaume Favreau, Thierry Lebel

This chapter introduces the programme of the so-called TT4 Task Team that hosts AMMA field studies of land processes over the Niger mesoscale site over EOP and LOP.

1 Scientific justification and objectives

1.1 Context

The lasting drought of the 1970's and 1980's over West-Africa was one motivation for setting up the AMMA project. This drought was especially severe in the Sahel, remaining unabated until 1997. At the same time the population growth remains strong (and in Niger, the growth rate is increasing), causing a severe land use change and in most parts, a generalized soil degradation.

One consequence of the drought was a significant reduction of the large river discharges: the Senegal river annual runoff decreases by 60% (1971-90 vs 1951-70) and the Niger river's by 55%, to be compared with an average rainfall deficit of 25-30% (Lebel et al., 2003). Dust transport and aeolian erosion also increased significantly. On the other hand, it is now well known that at smaller scales, the water cycle does not necessarily reflect changes witnessed at the regional scale. The number and duration of temporary pools for instance has significantly increased over the past 30 years. Larger runoff leading to this new hydrological state of Sahelian areas is a natural consequence of the degradation of the vegetation. However there is no well established scheme allowing relating this increase in local runoff to the decrease of the large river discharges. The degradation of the vegetation cover has also resulted in a general stage of active erosion involving soil degradation, and a strong silting up of valley bottoms. This causes significant modifications of the through the modification of the hydrological environment: ponds migration, appearance of spreading areas, changes in stream course and location.

In this respect, AMMA is an unique opportunity to address the scale problems inherent to the understanding of the complex relationships between climate, environment and the water cycle. The Niamey area has a rich history of hydrological observations carried out since the Hapex-Sahel experiment established in 1990 and prolonged by the CATCH observing system. Given this long history of observations and scientific results on rainfall distribution (Ali et al., 2003), runoff processes (Cappelaere et al., 2003), aquifer replenishment (Favreau et al., 2002) and coupled hydrological/vegetation modelling (Boulain et al., 2005), the HAPEX-Sahel site has naturally become one of the three meso-scale sites of the AMMA observing system. Located between 13°N and 14°N, this Niger "meso-site" is central between the Ouémé Sudanian site (9.5°N-10.5°N) and the dry-sahelian site of Hombori, in Mali (15°N-17.5°N)..

1.2 Needs for a long term observing system

In the context briefly recalled above, there are several key scientific questions that remain to be investigated in order to better understand and predict the variability of the water cycle in the Sahel in relation with climate variability, vegetation change and the overall dynamics of the coupled soil-vegetation-atmosphere system. The two figures provided below illustrate how useful has been the long term monitoring of the period 1990-2002 as well as some key additional questions raised by analysing the data collected over this period.

While the general pattern of the annual rainfall field averaged over several years is well known to be primarily organised along a dominant North to South positive gradient, the annual rainfield of any given year recorded by the CATCH-Niger rain observing system shows no consistency with this general pattern as can be seen in Figure 6.1. The role played by various factors (large scale atmospheric forcing, mesoscale organisation of the convection, including possible feedbacks from the surface, local factors like small scale pattern of vegetation and humidity) in shaping the annual rainfield pattern needs further investigations. The scale relationship between annual rainfall patterns and average internannual patterns is also a puzzling question related to critical water ressources related issues.

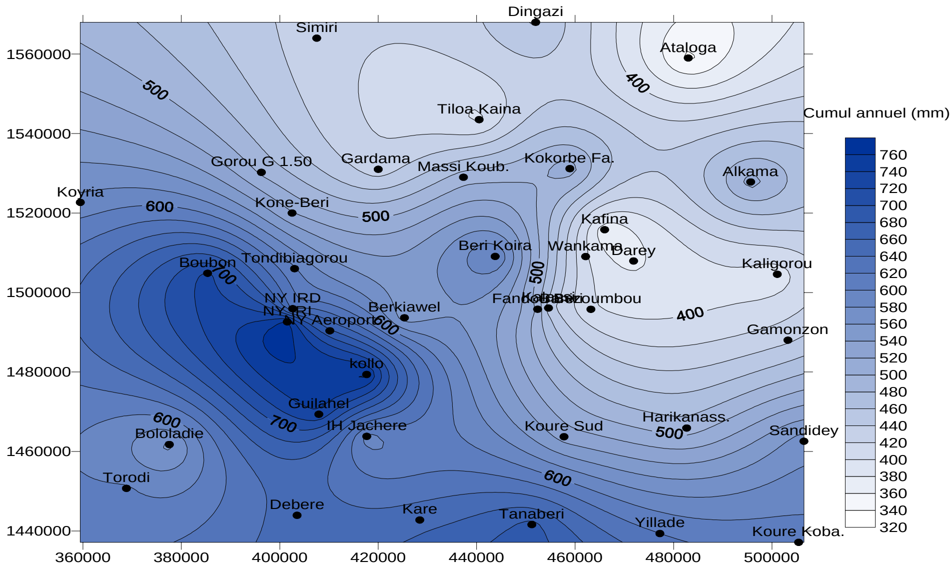

Fig 6.1. The 2005 annual rainfield over the CATCH_Niger area.

In the Niamey area, the unconfined aquifer integrates the changing water balance observed for the past decades. Recent estimates of the groundwater recharge concluded at rates > 20 mm/year, but this figure rely heavily on the poorly known properties of the aquifer (Favreau et al., 2002). While the rise of the water table level is well documented and generalised, the rate of this rising varies significantly from one point to another, as illustrated by Figure 6.2. One question raised by this result is thus whether this is due to changing recharge rates and/or different properties of the unconfined aquifer.

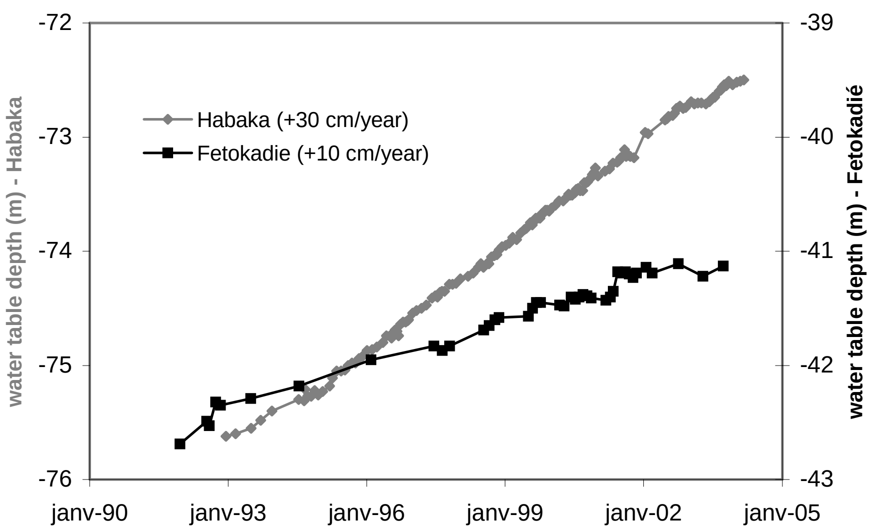

Fig 6.2. Various intensities in water table rises (SW Niger, 1990-2005).

From the two results illustrated above, one may derive several motivations for a continuing monitoring of the Niamey study area, involving of course some adaptation of the observing strategy:

- Observations made over the 1990-2000 period showed the great year to year variability of the rainfall regime with a great impact on the water cycle; this variability combines with the decadal scale signal linked to both anthropogenic activities and large scale climate forcing to generate a great variety of seasonal water balance pattern that needs to be studied over a long period.

- New instruments offer the possibility to gain more insight into the processes conditioning the water cycle in the region; thus the AMMA long term period will not be only a continuation of the pre-existing monitoring but rather a real enhancement focusing on some key processes identified from the past monitoring as being pivotal in the understanding of the water cycle variability of the region. Deep infiltration and recharge of the aquifer, on the one hand, coupling of the hydrology with the vegetation dynamics, on the other hand are among the most essential of these key processes.
- Scale issues are far from being fully understood, despite the work carried out on rainfall scale modelling, which means that an adaptated sampling strategy has to be set up.
- Coupled models remain to be developed, and the specificities of the Sahelian environment (as described in the papers cited in the introduction) have to be taken into account in this development; while climate variability has been drastic over the past 50 years, land use changes play a major role in the surface water increase despite the overall rainfall decrease.
- AMMA provides a unique opportunity to combine a short term strategy of high resolution and density sampling with a long term strategy involving water resources, land use and health issues studies.

1.3 Main scientific objectives

- Refining the computation of the local water balance, in order to better balance the change in runoff with reduction of evapotranspiration on the one hand, reduction in soil water holding capacity, on the other hand.
- How much has the water table recharge increased over the past decades in most of endoreic areas ?
- Has the vegetation harvesting a role in the rainfall reduction ? Is it possible to establish a link between rainfall variability and roughness evolution or albedo increase?
- Obtain a data set that will allow to better address the question of the regionalisation of the water balance.
- Address scale related issues, most notably how the water balance changes from increased runoff at the local scale to diminished streamflow over the large river systems of the region.

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2 Observing strategy

2.1 Overall Strategy

The overall strategy for the SW-Niger meso-site is devised in accordance with the general observational structure of AMMA's field programme, as defined by the AMMA International Science Plan. The LOP monitoring network was built in 2001 largely as the consolidation of pre-existing sets of ground instruments, most of which had previously contributed to the Hapex-Sahel experiment and to the subsequent CATCH program. The LOP network has now become a part of the EOP programme initiated in 2005, taking advantage of a number of new observational components designed to meet the EOP objectives.

While the LOP emphasis was mostly on documenting the interannual variability of the mesoscale land water cycle, the EOP programme aims at investigating land processes at a broader range of scales both in space (from local to meso) and time (from event to seasonal). In addition to a denser space-time sampling of hydrological variables, the monitoring scope is significantly extended during the EOP to include vegetation dynamics and energy budget parameters, in order to capture the major physical and biological processes that are closely associated with the Sahelian water cycle.

As described below (section 2.2), the EOP setup is designed as a spatially-nested structure of sites covering the area-specific hierarchy of scales, including two meso-scale levels (so-called α and β, resp., see below), a super-site, and a few elemental endoreic units, characteristic of the Sahelian local scale. Both point-specific and small-scale integrative measurements are included in the latter. The need for this spatial structure of sites arises from the area's landscape properties, as they control the organization of land processes and the conditions for water budget closure.

This monitoring also aims at building a multi-scale data set to be used in the investigation of the land surface-atmosphere feedbacks. Following the work of Taylor and Lebel, 1998 which is considered to constitute the only empirical evidence of such feedbacks at convective scale in the Sahel, all modelling studies failed to reproduce the persistency patterns of rainfields as observed by the LOP AMMA monitoring of this site. Two requirements stem out of this matter of fact. One is to improve the rainfall monitoring so as to cover a larger spectrum of scales of variability (in this perspective, linking with some SOP measurements – such as the MIT C-band radar, see Chapter 11 – will be of special interest). The second is to study the pattern of vegetations in order to identify factors possibly affecting the triggering or enhancement of convection at convective scale. Some of these factors (roughness for instance) are not obvious to define, least to compute, and one aim of this Task Team is to contribute some methodological advances in this area.

The Niger meso-site also hosts one station of the mineral dust monitoring transect and one station of the IDAF (chemical species emission and deposits) network, which are attached to the TT2a and TT2b sets of instruments, respectively (see Chapters 3 and 4 of this implementation plan).

Other field studies that need to be led in close association with climate, vegetation and water cycle monitoring are included in the TT4 package: this is essentially the case of the health impact studies, (see 2.1.3).

2.1.1 Strategy for hydrologic studies

Here, the general strategy of AMMA mesoscale sites was adapted to the particular context of the Niger site as enunciated above. South-Western Niger is typical of the central Sahel hydrological environment. The long term monitoring (since 1991) of rainfall and water table recharge in this area has shown a very significant modification of the water balance linked to both the drought and the degradation of the vegetation. The enhancement of observations during the EOP aims at further analyzing the processes that couple the various compartments of the hydrologic cycle, and more specifically the interactions between water and vegetation as well as the spatial distribution of groundwater recharge.

The observations strategy takes into account some specific features of the area, mainly the fact that the surface flow is not organized according to the usual tree-like hydrographic structure but as a mosaic of small (a few km² at most) endoreic catchments feeding into ponds or “humid” valley bottoms. Consequently, the hydrological/ vegetation studies are organized following a hierarchy of scales described below in section 2.2.

Following the research carried out in this area over the past 10 years, one major challenge remains to better understand where the water table recharge occurs. To better document the links between the surface and the aquifers, a few experimental catchments will be studied, for the two main configurations of the region:

- Gullies, because very few measurements were made in the past on these elements;
- ponds, to extend the knowledge acquired during 14 years at the Wankama site.

There is a great need for improving the calibration methods allowing the determination of pond areas (by remote sensing) and its evolution during the rainy season and after during the dry season.

One open question is whether the vegetated strips of the tiger bush may also contribute to the recharge of the aquifers. Whereas it is hardly possible to install hydrometric stations in this context, some clue may be obtained through a soil moisture monitoring program. To determine where, how and how quickly does water infiltrate, and eventually, recharge the aquifer depending on the environment, a soil moisture monitoring program started in 2004 and will be enhanced in 2005:

- infiltrometers (Trims type) tests will be made in order to describe topsoil (0-30 cm) hydrodynamics behavior; this is completed by soil physico-chemical analysis;
- soil moisture monitoring: these devices include 8 tensiometers (watermark) and 7 TDR sensors located from 20 to 300 cm depth; the recorder system allows for a continuous monitoring in time;
- Neutron probe tests enable to control soil moisture down to 10-12 meters in order to record deep infiltration below the root system. A specific monitoring of water infiltration around “acacias albida” will be undertaken in order to better apprehend the role of these trees in the water balance;
- A piezometric network will supplement the monitoring system to allow the control of possible water table seasonal fluctuations near the assumed recharge areas.

A side issue tackled by TT4 is erosion. Working both on small endoreic catchments and on larger exoreic tributaries on the right bank of the Niger River, a monitoring program of sediment loads associated with discharge is carried out.

2.1.2 Vegetation monitoring

Vegetation monitoring is carried out as a combination of local measurements of LAI and PAR, to help in the calibration of the vegetation-hydrology model and of calibration campaigns over the Kori de Dantiandou area for satellite validation purposes.

Aerial and satellite data will be used to study the evolution of the vegetation cover over the study area.

2.1.3 Health studies

The malaria prevalence is known to be linked to some environmental parameters as soil moisture, hygrometry, presence of ponds, vegetation, etc. In order to improve our understanding of these links, the observations of both environmental parameters and malaria prevalence will be enhanced.

To that end, a Health/Hydrology program, supported by NOAA, is developed in collaboration with CERMES (a research centre of the Niger Ministry of Health and a member of the Réseau International des Instituts Pasteur and IRD.

The following measurements will be carried out simultaneously in two villages, under two very different micro-climate:

- a set of environmental and micro-climatic data, including rainfall, temperature inside and outside houses, hygrometry and soil moisture in the immediate neighbouring of village population;
- the prevalence of malaria in this two villages, based on mosquitoes counting, mosquitoes analyses, population infested by malaria at a given moment, etc
- this device is completed by studies of malaria prevalence in 10 other village in the same area.

The two villages are located respectively:

- in a typical sahelian “wet land”, a “bas fond” characterized by a dense vegetation due to permanent high soil moisture and recently by appearance of water table due to its rising in endoreic areas; therefore, permanent ponds arebecoming very common in the Dallol Bosso, surrounding the village of Zindarou;
- in a valley of the plateaux area, a more spread configuration; despite the rise in water table, these areas remain dry areas with ponds increasing in number and in extension due to enhancement of runoff caused by natural vegetation removing. The village of Banizoumbou is typical of this configuration.
- Ten other villages are monitored more slightly with malaria prevalence observation.

2.2 Experimental sites covering the hierarchy of scales

- At the mesoscale α, one site is the support of continued and refined studies on the interannual and intraseasonal variability of rainfall the focus being on the documentation of convective structures. This site is a 16 000 km² rectangle (Niamey meso-site denoted N in the table below), over which the present raingauge network of 34 raingauges will be densified locally to allow for a better documentation of the local rainfall variability. The second site partially overlaps the Niamey meso-site (see map). It is named *Kori de Dantiandou* Basin (Nkd, 5645 km²). In order to control the lateral exchange terms, the boundaries were defined from the geometry of the aquifer (see map). This study area thus exceeds the limits of the original 16 000 km² HAPEX-Sahel rectangle, and forms a consistent hydrological entity allowing for a study of the water balance closure. The *Kori de Dantiandou* Basin is however too large for determining precisely all the terms of the water balance equation, especially since the topography is not accurately known. Hence, a smaller meso-scale area was defined. Runoff, soil water content, infiltration and evapotranspiration must be studied at smaller scale to enable an appropriate modelling.

Name	Location	Description
Niamey meso-site (N)	13°-14°N; 1.6°-3°E 16000 km²	The survey of the wrongly-called “Niamey square degree” (~1.5 squ.°) started in 1990. Heavy observations in 1992, monitoring from 1994 to 2002, densification starting again in 2003. Sahelian climate with semi-arid vegetation (Millet crops, Tiger bush, …). Long series of high resolution rain data and groundwater levels.
Kori de Dantiandou Basin (Nkd)	2°15-2°57E ; 13°15’-14°15’N; 5500 km²	Kori de Dantiandou (KD) and adjacent areas. Dry vegetation cover. Land surface process studies, hydrological modelling, coupling with the sub-surface and the atmosphere. Rainfall vs vegetation spatial relationship, at the local scale.

- At the mesoscale β, a composite of endoreic areas covering 1760 km² (Nc, Niger Central Super Site; that means the Dantiandou Basin Central Area) was chosen to compute a more comprehensive and accurate water budget. This smaller area enables the providing of regular land use maps allowing the modelling of vegetation/hydrology interactions and the evolution of water balance due to land use current changes. On this site denser measurements of the various terms of the water balance will be performed. The computation of water budgets on this super-site requires the estimation of lateral groundwater flows along the site boundaries, which can be obtained through aquifer modelling performed over the Nkd meso-scale site. Hydrology will be coupled with vegetation and its evolution using the abc-rwf model.

Name	Location	Description
Niger Central Super Site (Nc)	2°20'-2°49'E; 13°30'-13°52'N, 1760 km²	Subset of endoreic catchments representing core part of Nkd, with a denser rain gauges network and concentration of pool, runoff, soil moisture and flux measurements. The objective is to obtain a more precise assessment of the water balance and to test the hydrological model using the modeling over Nkd to set the outer boundary condition (aquifer).

- At the local scale, 5 intensive sites – elementary endoreic units or fractions of such units – were selected to study basic processes such as infiltration and evapotranspiration, based on flux stations and runoff plots. These 5 sites are representing the various typical situations in the super-site landscape. The main aims are to validate at this elementary scale a coupled vegetation/hydrology model and to describe the processes of changes in water and sediment budget due to land use evolution, at the plot and at the small basin scales.

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Name	Location	Description
Wankama endoreic system (Ncw)	2°39'E; 13°39'N; 2 km²	Typical endoreic system, with full plateau -to- kori-bottom toposequence, including largely cultivated catchment, sandy hydrographic network (ravine, mid-catchment spreading zone, alluvial fan), and kori pond. Comprehensive hydrologic and vegetation process analyses: overland runoff, hydrographic network losses, groundwater recharge, soil moisture, evapotranspiration, crop and fallow vegetation dynamics.
Tondi Kiboro small catchment *including* Sofia Bangou	2°42'E; 13°33'N; <1 km² 2°43'E, 13°32'N, 0.1 km²	Upland small catchment, along ravine running down from plateau to spreading zone. Previous hydrometric record (1993-1994) allows for investigation of changes in runoff due to severe land degradation. Analysis of channel losses. Plateau pond and tiger bush
Kafina endoreic system	2°44'E; 13°44'N; ~1 km²	Upland endoreic catchment with pool
Banizoumbou	2°40'E; 13°32'N	Meteo. and aerosol stations + pond. Malaria/Hydrology program WP 3-4
Zindarou	2°55' E; 13°26'N	Malaria /Hydrology program WP 3-4

- At the boundary between meso and local scale, an intensive network of 66 rain gauges is installed near Banizoumbou : 6 lines of 11 raingauges constitute a 10 km X 10 km square slightly faced to E-N-E (N70°) in order to be perpendicular to squall lines. Each day, two observers are reading the information of quantity of rain fault in the past 24 h. This long term study area will be used for the study of vegetation feed back on rainfall.
- A "Long Term Bocage" operation is planned to begin in 2006. Linked to the previous network, it consists in the planting (by the peasants) of vegetal hedges on a significant area (some hundreds of km²) in order to avoid or to reduce water and wind erosion and to constitute a "bocage" able to impact the boundary layer and the convection. Both operations (bocage and raingauges network) are linked, one of the aims of the latter being to monitor rainfall during some decades (20 years at least) to record possible differences in rainfall behaviour according to the surfaceUse of Satellite data in the modelling strategy

2.3 Use of Satellite data in the modelling strategy

Land surface models coupling the dominant vegetation and hydrology processes in this area are being developed and applied at the various levels of the scale hierarchy described above. While at the smaller scales land modeling mainly relies on field-collected inputs, the super-site and meso -scales require remotely sensed data for model operation.

Specifically, the various information layers that need to be produced, essentially from satellite data, are as follows:

- year-by-year land-use/land-cover maps; given the dominant crop/fallow rotating practice in this largely cultivated area, it is necessary to yearly update this essential information layer that controls a large number of land cover -related parameters of the vegetation and hydrologic models;
- seasonal dynamics of vegetation development, essentially through LAI-related indices over each EOP season; this input will be used as the major validation source for the modelled vegetation dynamics; a 2-week time step is considered to be adequate for this purpose;
- seasonal dynamics of accumulated surface waters; if such information can be produced with sufficient reliability and completeness, it can be used as a very effective validation input to the surface hydrology model component; again a 2-week time step appears as being an acceptable compromise between field variability and acquisition costs;
- soil surface moisture maps; distributed soil moisture information can be very valuable for the hydrologic model component, as it can be used to control the runoff/infiltration process over the simulated domain; assimilation procedures ought to be developed to do so, for the various simulation modes that are being operated in the area, ie., from simplest to most complex: anterior precipitation index, simple energy budget, full SVAT model (Sisvat). Expected frequency is similar to that of two previous layers. Remotely-sensed soil moisture data could provide a very convenient means to partly compensate for the lack of high spatial resolution maps of rainfall inputs over the simulation domain, thereby reducing uncertainties in all simulated state variables of the vegetation and hydrology models.

3 Deployment

3.1 Instruments and related detailed observation program

3.1.1 Hydrology:

The hydrological EOP measurements on the SW-Niger mesoscale site mostly constitute a denser sampling in space and time of the water cycle and related processes. It is based on the LOP monitoring carried out since 2001 (and earlier for rainfall, local runoff and aquifer recharge) and described in ST1 (*LOP monitoring*). The emphasis is on the documentation of the seasonal cycle and its variability (in space; inter-annual, and intra-seasonal for some processes). More specifically the objectives in term of process studies and modeling are the following:

- Investigating small scale variability of certain variables: rainfall (instruments CE.Rain_Nc and CL.Rain_N); soil moisture (instruments CE.SW_Nc and CE.SWsan_Nc), runoff (instruments CE.Run_Nc and CE.Pond_Nc), erosion (   ), PE (instruments AE.Flux_Ncw, AE.Flux_Nc, and AL.Met_Nc), aquifer recharge (CE.Gwat_Nc and CL.Gwat_N) and their impact on the water budgets at larger scale.
- Joint modeling of surface hydrology and aquifer recharge at the mesoscale (Kori de Dantiandou, see list of sites) in order to cross-constrain the transient hydrological balance at the observation scale.
- Investigating the surface feedback effects on rainfall will make use of a specific rainfall monitoring network designed to cover scales of variability not well documented by the LOP monitoring network (see Figure 6-3).

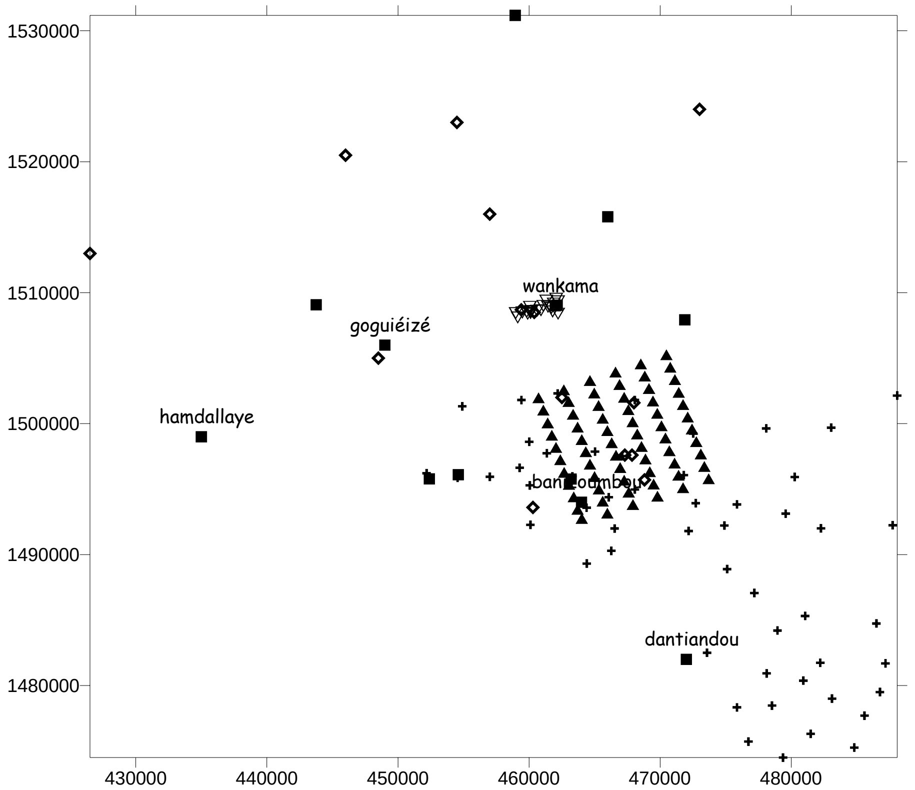


Figure 6-3 : rainfall measurement through embedded networks covering a 50x50 km² area.

- Investigating the role of vegetation in runoff, infiltration, soil moisture and aquifer recharge/discharge. Here the objective will consist in further constraining the hydro(geo)logical balance, combining new methods (mostly geophysics) with the long-term piezometric surveys (Fig. 1). More precisely, for groundwater recharge, the long term chronicles bring information of fundamental importance that will be combined (i) with subsurface geophysics (e.g. RMS sounding) in order to decipher the cause for changing water table rise intensities (equivalent to the apparent annual excess of recharge) and therefore (ii) better constrain the current water table balance, both at the seasonal and decennial scale. At some sites (<1 km²), data and information obtained by various methods (eg groundwater temperature and piezometric monitorings, surface water balance, transient RMS sounding, DC investigations) will be incorporated in a single transient groundwater modelling (1993-present) in order to better constrain the long-term water table balance computed for the whole mesoscale (Favreau et al., 2002).

3.1.2 Vegetation.

The vegetation monitoring consists of:

1) Vegetation will be assessed in all experimental sites as cited in Introduction (Wankama, Tondi Kiboro, Koma koukou): current situation mapping, historical inventory (aerial pictures, IGNN and Corona, satellite files, "Pixy" inventories (Pixy is a small flying device conceived by IRD (Asseline et al., 1998). In all observation season (2005-2006 and 2007), a complete inventory of experimental site will be realized: density of vegetation, evolution intra- and inter-seasonal, on cultivated as well as in natural areas. This will made with the support of colleagues of UAM (Faculty of Biology and Geography). The specific evolution of millet is monitored since 2004 season by the partnership of Cirad and Agrhymet in 11 villages of the square degree, 3 of

them located in the Central Site. This monitoring has been deployed since Dec. 2003 when a first field calibration was realized in order to plan a "land cover mapping" in course (now almost achieved) at CETP laboratory. Another calibration was carried out in October 2005. Methodologies based on optical satellite data classification allow a land cover mapping since 1986 (1986, 1990, 1991, 1992, 1994, 1996, 2003, 2004). This will be continued until the end of EOP and possibly until the end of LOP.

2) At Wankama basin site, a specific study of vegetation is carried out by Nicolas Boulain of HSM-Montpellier. In fallow and millet plots, the parameters for the Treegrass model are measured. It consists in a complete follow-up of phenologic, allometric and photosynthetic characteristics, including vegetation density, biomass and foliar index for shrubs, millet and herbaceous layer throughout the vegetation season. Specifically, parameters measured for all vegetation layers are: density, cover, height, phenology, biomass, foliar area, LAI, photosynthetic parameters, and roots. Crown area and plant diameter are also measured for shrubs and millet, and herbaceous species are identified over time. This is a EOP monitoring, funded from 2004 to 2007.
3) Roselt partners are managing since the beginning of the 1990's a set of 10 enclosed plots where vegetation is assessed in density and quality 2 times a year (once during rainy season, once during dry season); this will be continued on a long period, with specific funding of the *Observatoire du Sahara et du Sahel* (OSS).
4) ICRISAT team driven by Bruno Gérard (partners of AMMA TT4) is carrying out a heavy GIS on the Fakara (including Banizoumbou area) for twelve years: land use is monitored from the beginning of the 1990's and previous pictures show the strong evolution of land use land cover in the last half century. This will be continued as a long term monitoring, with specific funding of ICRISAT and Belgian cooperation program.
5) Field measurements of soil moisture are processed since the rainy season 2004 in 5 villages (4 to 6 sites per village, on different land uses); soil water content is measured at each sampling. This inventory is made each time that ENVISAT satellite is acquiring a radar image in the Central site area. Thus, a vegetation calibration could be made in the same time with few additional time and inversion. This will be continued until the end of EOP.
6) On the Wankama basin, 3 *acacia albida* (gaos) sites will be equipped with soil water content sensors, and with tree-growth sensors and neutron probe access tubes: one in a millet field, another is a fallow and the last one near the pond.

A number of image series are available to build an evolving GIS: aerial pictures of 1950, 1975 and 1992 (IGN and IGNN), Corona (USA) pictures of 1965, Landsat and SPOT satellite products since the 1980's, and since 2002, MODIS data (resolution :5m X 5 m, locally 1m X 1m).

Updating the 1992 vegetation map over the 1°x1° HAPEX square to quantify the vegetation change and its impact on the water cycle is the first priority. A second priority is to produce maps for older periods. These maps are needed to better understand how the vegetation change influenced the hydrology of the region over the past 50-60 years.

Other tasks to achieve are:

- Analysing the seasonal cycle of the vegetation – focusing on millet, fallow trees – in interaction with water constraints.

- Providing a re-parameterisation of the Treegrass model (initially developed for humid tropical eco-systems) and upscaling towards a larger scale model (Tgpix) (instrument CE.Veget_Ncw).
- Investigating the influence of land use changes in water cycle evolution based on farm surveys over the 1°x1° square to validate the SARRA_H crop simulation model for regional yield forecasting and climate change impact studies.
- Determine and analyse the special role of Acacia Albida in the water balance, particularly in the water content of soil and sub soil and the recharge of aquifer;

3.1.3 Health Studies.

Sampling effort will be concentrated on malaria vectors both on aquatic stages and adult mosquitoes. Previous data show good relevance of insecticide house-spraying method rather than classical CDC- light traps. Aquatic stages will be evaluated either by eye-directed rapid sampling or by dipp-in or aquatic net in cases of large breeding sites.

All samples will be recorded in a GIS and all sampling sites will be GPS marked. Environment (temperature, rainfall, humidity of soil and air) will be studied by automatic apparatus for fine steps timing periods. Follow-up of ponds will be made by the Niamey’s hydrology team.

Experience in satellite data image analyzing in the CERMES will be used to study environmental spatial factors.

The experiment consists in equipping two very different villages with in each one, the following devices:

- Hydrology : (automatic monitoring system)
    - 4 Atmospheric temperature sensors
    - 4 Soil moisture sensors
- Health :
    - an insect detector
    - an infra red light source

An OFIDIS analysis software would allow to document the mosquitoes population in real time all year long. This is completed by other sampling in 10 more villages, in order to verify significance of the two instrumented ones.

3.1.4 Validation of aircraft and remote sensing measurement.

This mostly consists in a site documentation in preparation of the SOP campaigns (TT8, TT9).

- Satellite validation:

- radar (ASAR ENVISAT): during the rainy season 2004, 8 measurements campaigns were made to validate with this new sensor sensitive to soil moisture; 5 villages, with 6 observations points in each one (in different land use) : 10 measurements (Thetaprobe) and 2 gravimetric water content measures at each point. This operation has been continued during 2005 rainy season with a large number of ASAR acquisitions.
- SPOT/HRV: High resolution optical data are used to monitor land use. Different archived optical data are used to analyze change in land cover in the last decennials. The map is actualized each year since 2003…
- 2005 to 2007: Ground truth validation will continue simultaneously to satellite acquisitions. It concerns soil moisture measurements and annual actualization of land cover map. A large number of optical (SPOT/HRV) and radar ASAR data are programmed during this period.

- a pool mapping methodology is developed, allowing a monitoring of pool number and sizes for different SPOT optical data acquisitions (in 1986, 1990, 1991, 1992, 1994, 1996, 2003, 2004); this needs validation.

3.2 List of instruments

Table 01 TT4 List of Instruments

Code	Name of Instr.	PI Name	Description of the instrument	Status of Deployment	Site
LF17	CL.Rain_N	Thierry Lebel	30 recording raingauge network	Deployed since 1990	N
LF20	CE.Pond_Nc	B. Cappelaere	6 recording level in ponds network	Deployed since 2000	Nc
LF24	CL.Gwat_N	B Cappelaere	Level recorders in wells (aquifer)	Deployed since 1996	N
EF18	CE.Rain_Nc	Luc Descroix	15 recording raingauge network	Deployed in April 2005	Nc
EF19	CE.Run_Nc	Luc Descroix	Network of 6 recording streamgauges	Deployed in April 2004	Nc
EF20	CE.Gwat_Nc	Luc Descroix	Level recorders, 12 drilled boreholes	6 Deployed from 2000 to 2002; 3 installed in 2004; 3 to be installed in 2006	N
EF21	CE.SW_Nc	B. Cappelaere	4 sites Watermark and TDR	1 installed in July 2004; 3 in July 2005	Nc
EF22	CE.SWsan_Nc	Luc Descroix	Soil water neutron probe	34 Holes drilled in Dec 2004; 10 in 2005-06	Nc
EF23	CE.Veget_Ncw	Nicolas Boulain	Leaf index and gaz exchange meas.[t]	Instrument deployed in 2005	Ncw
EF34	CE.VegIso_Ncw	J. Gignoux	Isotopic analize of water[t]	Beginning in June 2005	Ncw
EA27	CE.Ero_Ncw	I. Bouzou	Erosion measure on plots and catchment	1 site in 2004; 2 sites in 2005 and following	Ncwb
LF2	AL.Met_Nc	Luc Descroix	Campbell Met. Station	Deployed in July 2004	Ncb
LA27	CL.Rain_Nc	Luc Descroix	Local scale rain gauges network	33 deployed in 2005, 33 more in 2006	Ncb
LA28	AL.Met_Nc	I.Bouzou	Campbell Met. Station	Deployed in March 2005	Nikoye Torodi

E-Mails addresses of the PIs are given in Appendix (Table xx).

Table 02 List of Instruments related to TT4

Code	Name of Instr.	PI Name	Description of the instrument	Status of Deployment	Site	TT
EF8	AE.Flux_Ncw	B. Cappelaere	2 H_2O/CO_2 flux stations	Deployed in July 2005	Niamey-Wankama	2a
EE1	AE.Flux_Nc	C. Lloyd / B. Cappelaere	2 HFS flux stations	Deployed in Nov 2005	Niamey SS central	2a
EF30	AE.Dust_ST	Jean-Louis Rajot	Dust monitoring sites	Deployed in June 2005	Banizoumbou and Koma koukou	2b
LF26	CL.Depot_RW	C. Galy-Lacaux	5 stations IDAF (4 avec aethalomètre)	Deployed in 1990	Regional Window	2b
EF1	AE.GPS_1	O. Bock	Niamey GPS station (in a set of 4).	Deployed in March 2005	Niamey airport	1

Table 03 Measurement periodicity

Instrument	dry season	rainy season
Recording raingauges	Each month	Twice a month
Recording water level in ponds, wells and streams	Each month	Twice a month
Recording soil moisture stations	Each month	Twice a month
Recording meteo station	Each month	Twice a month
Recording flux station	Twice a month	Twice a month
Neutron probe counting	Sept-Jan : Twice a month Jan – May : once a month	after each rainy event and twice a week during one month after the last one
Vegetation density measurement	once at the beginning and once at the end of rainy season	once a month
Health/hydrology devices		mosquitoes sampling once a week in the two experimental villages, once a month in the 10 others

Measurement periodicity

Otherwise, during the rainy event:

- stream flow are regularly sampled in order to document the solid transport.
- Flows are measured in order to calibrate the stream gauge stations

After each rainy event, a series of data are collected:

- rainfall amount in the manual raingauges network
- runoff and solid load transport on plots (10 m^2)
- neutron counting is made daily as often as possible.
- Horizontal flux are measured after each event

4 Partnership

List of existing programs:

- Moustapha Amadou (Agrometeorologist at INRAN): influence of vegetation development on aerodynamical roughness ; determination of aquifer recharge areas by neutron probe measurements ;
- Ibrahim Bouzou Moussa (dept of Geography, UAM) and Moustapha Adamou (dept of Agronomy, UAM): characterization and process study (erosion, runoff and infiltration) on the ‘”bas fonds” areas (valleys bottoms);
- Abdou Guéro and Hassan Adamou (DRE: water resources dept of Niger): geophysical study of the Sama Dey pond area, RMS measurements (subsurface geophysics) for constraining transient groundwater modelling.
- Bruno Gérard (ICRISAT): determination of the contribution of runoff from the plateaux on the degradation of landscape; spatial variability of rainfall;
- Jean Bernard Duchemin (CERMES): (AMMA application project): malaria and hydrology: a case study in 15 villages of the Fakara area.
- Seydou Traore (AGRHYMET). 11 villages identified over the 1°x1° square for the monitoring of the determining factors of millet yield (agricultural practices, phenology, pests, yield components).
- Emmanuèle Gautier, Claude Cosandey and Eric Le Breton (LGP, Paris 1 Univ.): measurement of runoff, erosion and solid transportation at Wankama and Tondi Kiboro sites

A long term partnership is activated with ROSELT (Réseau d’Observation Sahélien de l’Environnement à Long Terme) for the monitoring of the Dantiandou super site and with the DMN (meteorological service of Niger) for rainfall monitoring on the meso-scale site and for upgrading the synoptic network of Niger (12 stations).

b. Training program

The TT4 training program includes:

1) two students from Nigeria are performing their Master, one of both being planed to begin a PhD in September, 2006;
2) two student (one from Nigeria, the other from France) started their PhD in September 2005;
3) two other Nigerian student are planned to start their Master in September 2006;
4) Jean Paul Laurent, from the LTHE, is coming at least once a year in order to enhance capacitation in Neutron probe experimentation and in the Campbell dataloggers functioning;
5) Three local technicians are permanently working in the TT4 team: one of INRAN (Hamissou Alassane) and 2 from the Direction of Ressources en Eau (Boubé and Balkissa Alzouma)

6) Four local students and the TT4 coordinator (LD) will be capacitated in GIS in April 2006 (Arc view) and in may in remote sensing.

5 Organisation of the TT.

5.1 Leaders, core group, membership

	Name	First Name	Institution		Email adress
Task Team lead					
(international	DESCROIX	Luc	IRD/LTHE	Hydrology	Descroix@ird.ne
Coordination)	CAPPELAERE	Bernard	IRD/HSM	Hydrology	cappelaere@msem.univ-montp2.fr
Core Group					
In Niger	RAJOT	Jean Louis	IRD/LISA	Aerosols	rajot@ird.ne
	LEBEL	Thierry	IRD/LTHE	Hydrometeorology	lebel@ird.ne
	BOUZOU MOUSSA	Ibrahim	UAM dep geog	Erosion	ibouzou@uva.ne
	NAZOUMOU	Yahaya	UAM dep geol	Hydrogeology	nazoumou@ird.ne
	MAHAMANE	Ali	UAM dep biol	Biology	mahama@refer.ne
In England	LLOYD	Colin	CEH Wallingford	Flux	crl@CEH.AC.UK
Members					
In Niger	BOUBKRAOUI	Stéphane	IRD/LTHE	hydrology	boubkraoui@ird.ne
	AMANI	Abou	AGRHYMET	hydrology	amani@sahel.agrhymet.ne
	BAILLEUL	Charlotte	IRD/LTHE/VI	hydrology	bailleul@ird.ne
	RABANIT	Manon	IRD/HSM/VI	flux	rabanit@ird.ne
	ADAMOU	Moustapha	UAM agronomy	hydrology	adamou@refer.ne
	TRAORE	Seydou	AGRHYMET	agronomy	seydou@agrhymet.ne
	ADAMOU	Hassan	DRE	hydrology	dresirba@intnet.ne
	AMBOUTA	JM Karimou	UAM agronomy	geography	pijd@intnet.ne
	FATONDJI	Dougbedji	ICRISAT	Agro-meteorology	d.fatondji@cgiar.org
In France	BARON	Christian	CIRAD	agronomy	christian.baron@cirad.fr
	BOULAIN	Nicolas	IRD/HSM	biology	boulain@msem.univ-montp2.fr
	FAVREAU	Guillaume	IRD/HSM	hydrogeology	guillaume.favreau@msem.univ-montp2
	GIGNOUX	Jacques	ENS Biologie	Biology	gignoux@biologie.ens.fr
	BOUSQUET	Sandie	ENS Biologie	Biology	sbousque@biologie.ens.fr
	MASSUEL	Sylvain	IRD/HSM	Hydrogeology	sylvain.massuel@msem.univ-montp2.f
	ZRIBI	Mehrez	CETP/CNES	Remote sensing	mehrez.zribi@cetp.ipsl.fr
	GAUTIER	Emmanuèle	U Paris 8, CNRS	Fluvial geomorphol	emmanuele.gautier@cnrs-bellevue.fr
	LE BRETON	Eric	U Paris 1	erosion	eric.le-breton@wanadoo.fr
	AMOGU	Okechukwu	IRD/LTHE	Erosion	Okechukwu.Amogu@hmg.inpg.fr
In England	MORSE	Andy	CEH Wallingford	Hydrometeorology	A.P.Morse@LIVERPOOL.AC.UK
In Belgium	GERARD	Bruno	Univ Louvain la N	agrometeorology	b.gerard@cgiar.org

5.2 Internal coordination

A monthly meeting open to all members of TT4 is held in order to plan and monitor the operations related to the field observations and data base issues.

5.3 How are handled requests for new instruments ?

The requests from PIs regarding installation, travels, and all other logistical matters, are now managed by Hachimou Tahirou Bana (tahirou@ird.ne) and Cheikh Kane (citizenkane@ird.ne) at the IRD representation.

5.4 External diffusion of the information and reporting

A report is diffused after each meeting and all information is diffused by e-mail.

http://www.ird.ne/ammanet/ (click on Niger super site !).

6 Coordination with other TTs.

Permanent contact is established with TT3 and TT5, in the framework of the ORE AMMA-CATCH. This includes a permanent collaboration on instruments, data collection and data analysis. One yearly meeting is organized, including a field visit.

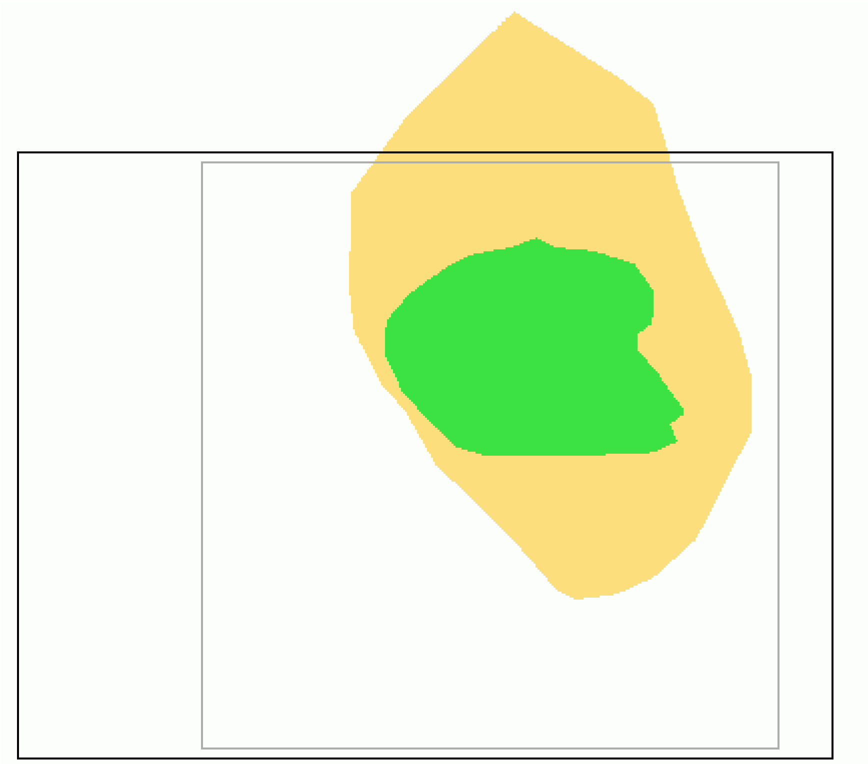
The coordination with TT2a is effective for the installation of instruments and is envisioned for using flux data in hydrological modelling.

Contacts with TT8 are underway to organise ground support for the wet SOP measurements..

Coordination not related to fieldwork will occur through AMMA meetings and workshops.

Appendix1

Maps



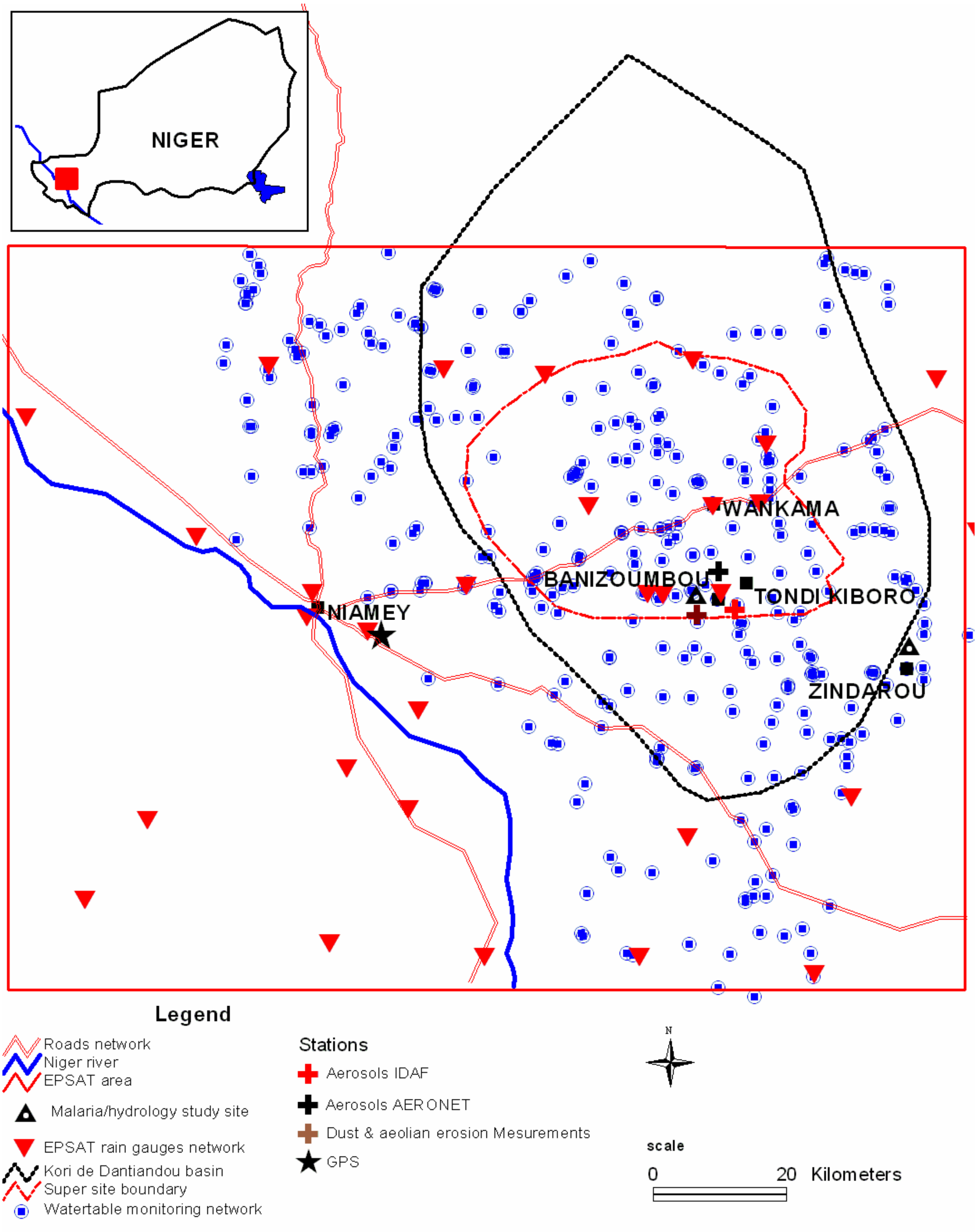
black outer rectangle:
Niamey meso-site (N)

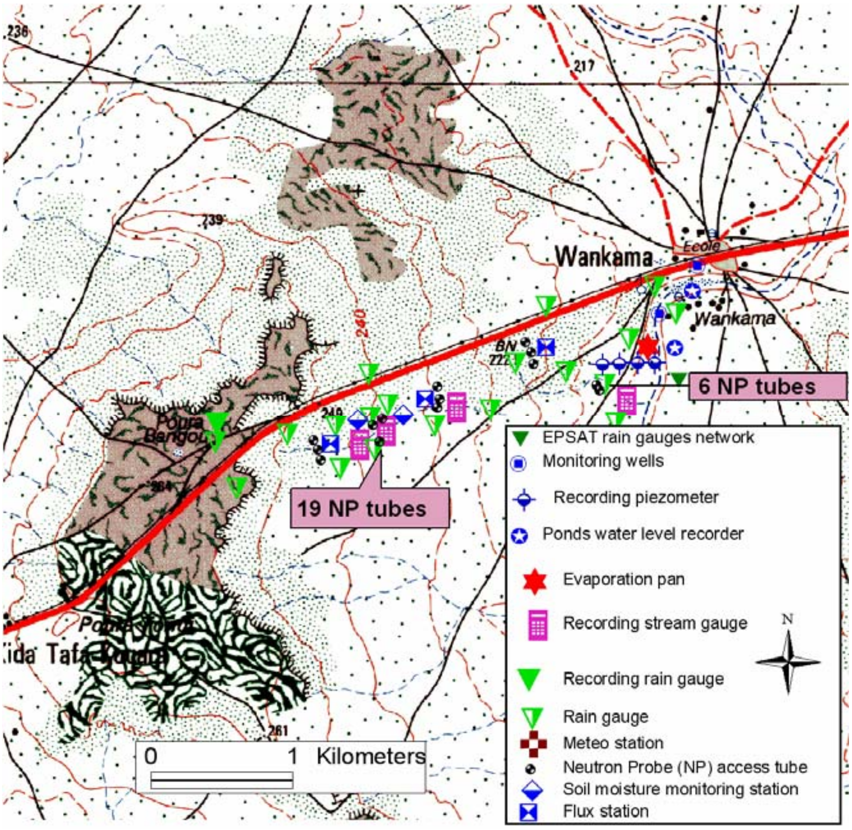
grey square :
Niamey square degree

yellow area : *Kori de Dantiandou* Basin (Nkd)

green area : Niger Central Super Site (Nc)

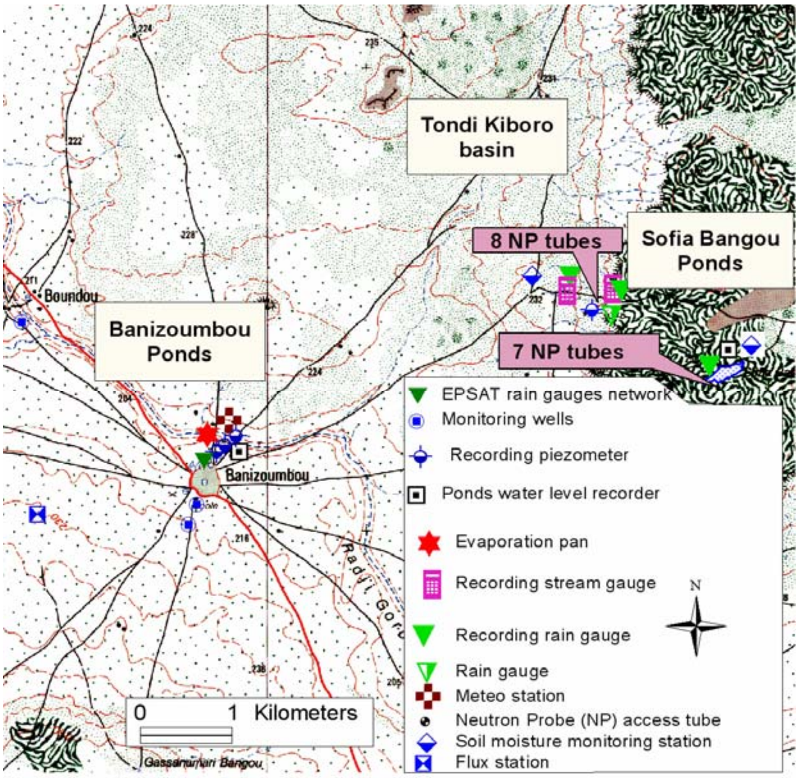
local intensive sites are located within Nc supersite (green)


NIGER
NIAMEY
BANIZOUMBOU
WANKAMA
TONDI KIBORO
ZINDAROU
Legend
Roads network
Niger river
EPSAT area
Malaria/hydrology study site
EPSAT rain gauges network
Kori de Dantiandou basin
Super site boundary
Watertable monitoring network
Stations
Aerosols IDAF
Aerosols AERONET
Dust & aeolian erosion Mesurements
GPS
N
scale
0
20 Kilometers



Wankama experimental cathment

Tondi Kiboro experimental catchment



STATUS OF THE FIELD PROGRAM (November 2005)

	2004	2005												2006												2007												2008
	exist	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	contd.
level recorders on ponds																																						
1 H2O flux station																																						
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Level recorders, 12 drilled boreholes																																						
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