4.2.2 Field Campaigns: SOP-Ground-based

Coordinator : A. Protat

Laboratories: CETP, CNRM, IGN, IRD, LA, LAMP, LBCM, LDL, LEGOS, LGIT, LISA, LMD, LMTG, LOA, LODYC, LOS, LPO, LSCE, LTHE, SA

Objectives

This WP will ensure that the field instrumentation necessary for achieving AMMA's scientific objectives will be provided to the field sites. The overall objectives are outlined at the beginning of WP4.2 as the ground-based instruments activities included in this sub-WP will be also done during the Special Observation Periods.

Description of work

During SOPs the EOP equipment will be largely enhanced in order to study different processes in great detail within the framework of focussed field campaigns. The work necessary to insure a successful field campaign performance includes:

- Preparation of the field phase concerning the scientific instruments and their installation, preparation of the "operation plan" under WP 4.2 coordination
- The field phase during SOP_0, 1 2 and 3, during which resources must be rationally shared depending on the globally approved scientific priorities
- Data analysis and validation period, after which the data will be made available to all participants

Foreseen Deliverables

- Contribution to experiment plan, operations plan, White Book
- Report on readiness of measurement systems
- Delivery of quality controlled data to the project data bank
- Documentation of progress on AMMA web site

Milestones

- M0+6 SOP experiment Planning documents
- M0+12 Dedicated meeting for SOP activities
- M0+12 Readiness of Ground-based instrumentation
- M0+24 Report on the data collected during the SOP
- M0+36 Final report on SOP activities
- M0+48 Report on the analysis and validation of collected data, data transmitted to the AMMA data base

Observational Strategy

The purpose of this section is to describe the observational strategy corresponding to

- the reinforcement of the basic documentation of the atmospheric state during SOP

- the fullfilment of the objectives of the « scientific » work packages that require observations from WP4.2.2, namely all the WPs ! In what follows we describe the individual observational strategy constructed for groups of WPs that are connected to each other.

A - Enhancement of the basic atmospheric state documentation during SOP

This enhancement has to be planned in the framework of the EOP observational strategy. For EOP, the existing radionsoundings over West Africa have to produce twice daily operations, and a series of additional radiosoundings is planned to be deployed in order to document the atmospheric variables twice daily at the scale of West Africa with a relevant spatial coverage (see Fig. 1 below). In the framework of this EOP set-up, a 4-corner area (plus an additional point in the middle of the area) has been defined as the area for meso- to synoptic-scale water budget computation and atmospheric state documentation during SOP. In order to produce relevant environmental observations for virtually all the work packages of this project, two enhancements of radiosounding have to be performed : first during the whole SOP period (around 140 days), the radiosounding temporal resolution has to be upgraded to 6 hours, as has been performed in all major field experiments (e.g., the recent MAP international field campaign). This will allow synoptic scale water budget computations to be performed with satisfying accuracy and the synoptic-scale flows and modulations of these flows to be documented properly. Then, during the intensive observing periods of airborne operations, this radiosounding resolution has to be increased to about 3 hours (8 soundings per day, which means 6 additional to the EOP setup, 4 additional to the previous SOP setup) at the 5 sounding stations of the area in order to provide an accurate description of the environmental conditions for the airborne and ground-based observations at mesoscale and convective-scale.

This enhanced radiosounding mode will be complemented by other sources of data during SOP, in order to provide the most integrated picture of the monsoon climatic csystem and its evolution during the onset and mature phases :

- First, as described in section 4.2.2.2, constant-altitude balloons will be launched regularly in the atmospheric boundary layer during SOP1 and SOP2, in coordination with the airborne (LEANDRE 2, WIND, airborne Doppler radar) and ground-based (Niamey and Djougou radar networks, aerosol/chemistry supersites) SOP observations. During SOP1, the objective will be to document the modulation of the monsoon flow along the north-south gradient, while during SOP2, the objective will be to provide additional information at high spatial resolution about the moisture inflow ahead of the MCSs, which has a large impact on their life cycle. The added value with respect to the enhanced radiosounding operation and the dedicated aircraft flights is the high-resolution and documentation of the boundary layer and its north-south variability, almost continuously during the monsoon onset and mature phase.
- Regular dropsonde launches from high-altitude ballons using the driftsonde technology would also enhance in a significant manner the spatial radiosounding coverage of West Africa. This specific deployment would mostly allow to describe features of the monsoon climate system not fully covered by the enhanced radiosounding operations to be documented : the heat-low region, the west coast of Africa, continental and oceanic easterly waves. This tool fills the gap between radiosoundings at synoptic scale (except around AMMA supersites) and dropsondes launched from aircraft at mesoscale.
- The monitoring of water vapour by the enhanced radiosounding operations during SOP will allow a mesoscale water budget to be computed 4 times a day. The variability of the water vapour field and the modulation of this water budget at higher temporal resolution cannot be assessed. For this purpose, additional GPS stations will be deployed west of the north-south transect formed by the three EOP stations at Djougou, Niamey, and Gao. This will allow water budget computations at a much higher temporal resolution useful for model evaluation.
- Over the ocean, the planned cruises (see details in the following) will also allow additional radiosoundings to be launched (twice daily) during SOP1 and SOP3. During SOP1, these

radiosoundings will allow to document the monsoon flow, its evolution until the monsoon onset and the ocean-land gradient of static energy, while during SOP 3, it will document the environmental conditions associated with the development of tropical cyclogenesis over the ocean.

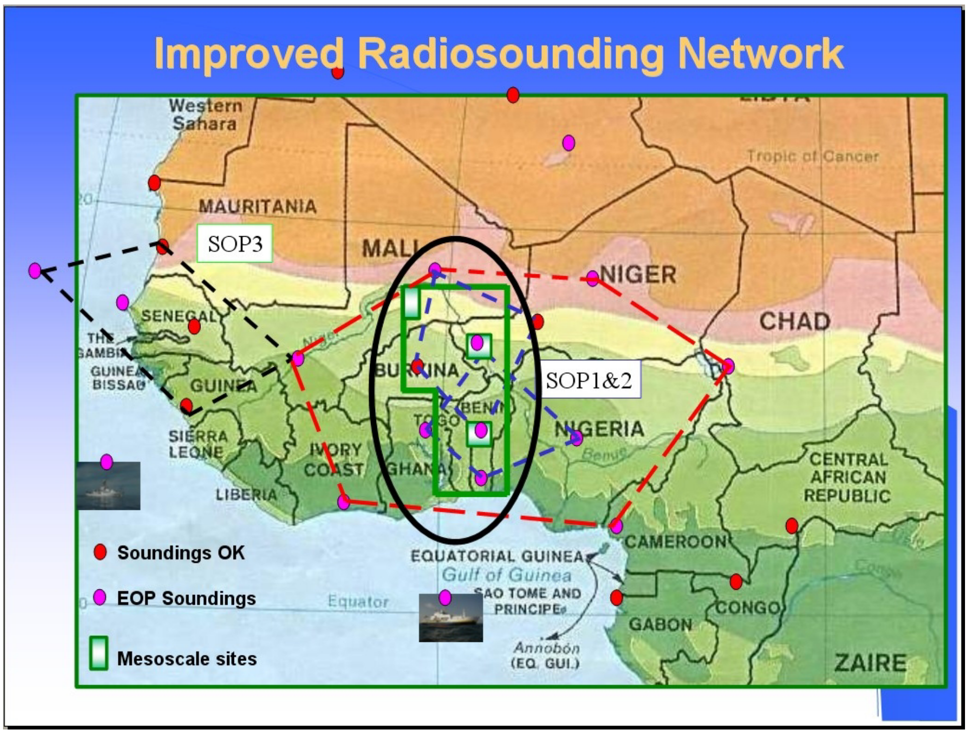


Figure 1 : EOP Enhanced radiosounding network

In addition to the scientific objectives that this set of additional observations and enhanced soundings will help address, they will also naturally be extensively be used in the framework of data assimilation and model evaluation (WP4.1), and validation of satellite products of WP4.3.

B - Observational strategy for WP2.1, WP1.2, WP1.1, and WP4.1

A first group of AMMA scientific objectives is devoted to

- the investigation of the multiscale processes in the atmosphere which control the WAM and its downstream environment (WP2.1 : convection and atmospheric processes), including the interactions between AEWs and MCSs.
- a multiscale estimate of the water budget and its components (WP1.2 : the water cycle and scaling issues in the WAM)
- a better understanding and prediction of the multiscale variability of the aspects of the global climate linked to the WAM (WP1.1 : WAM and the global climate).

These three major objectives of AMMA rely on both observations and model outputs. Regarding the use of model outputs, a major objective of AMMA is to produce state-of-the-art analyses of the atmosphere (WP4.1). For this purpose data assimilation will be used, and a thorough model evaluation will be conducted, using in particular a set of SOP ground-based observations.

The observational strategy for this set of work packages is described in Figure 2.

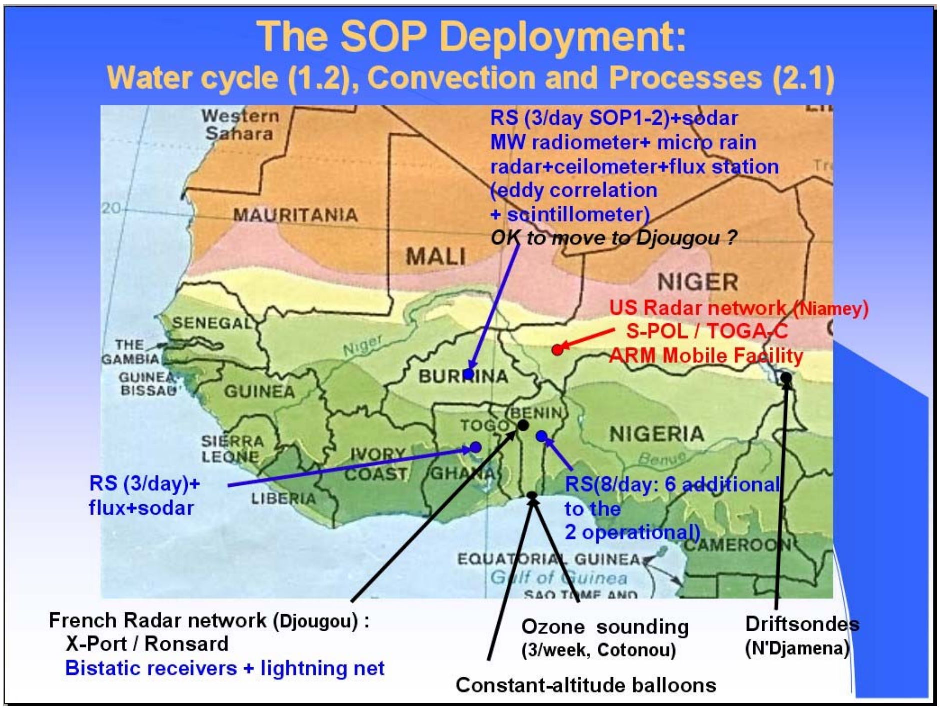


Figure 2: SOP ground-based observational strategy for WPs 1.2, 2.1, 1.1 and 4.1

The instruments reported in black are the French contribution to the ground-based deployment, those in blue are the contribution from the european partners through AMMA-IP, and those in red are the US contribution.

Enhancements to the synoptic radiosounding network (and additional instrumentation listed above) as discussed previously will enable a comprehensive analysis of large-scale thermodynamic and dynamic variations, which will provide an analysis of the passage of AEWs. The network will also measure the large-scale environmental impact of MCSs and thus support the analysis of MCS-AEW interactions. The 3D analysis of the kinematic and thermodynamic structure of the MCSs within the synoptic framework will be afforded by coordinated ground-based and airborne radar observations. There will be two centers of ground-based radar operation, Djougou in Oueme in the south and Niamey in the north. These radar networks will operate on alert and should miss no MCS passage in their sampling area during SOP. It is essential to have two radar nodes because of the strong meridional gradient in the WAM, in which the MCSs to the north have a propensity toward rapidly moving MCS structures. The northern mesoscale convective systems occur in close proximity to the Saharan aerosol source region, and exhibit a larger amount of smaller ice particles. The MCSs to the south appear to be less affected by the Saharan aerosol, but they account for more rainfall. Understanding the WAM entails understanding this meridional gradient of convective behavior.

The north and south dual-Doppler radar pairs will be founded on the basis of the highly successful French experiment COPT81, which documented the kinematics of several west African MCSs by a dual-Doppler radar pair in Ivory Coast (Sommeria and Testud 1984, Chauzy et al. 1985, Chong et al. 1987, Roux 1988, Sun and Roux 1988, Chong and Hauser 1989). The dual-Doppler pairs at Djougou and Niamey will each be similar to the COPT81 dual-Doppler installation. In addition, these dual-Doppler pairs will have polarimetric capabilities, which were not available in COPT81. Polarimetric observations are essential to achieve the goal of understanding the microphysical aspects of the MCSs in the WAM. The dual-Doppler networks will be capable of determining accurate rainfall estimates via polarimetric techniques, vertical echo structure, 3D high-resolution internal circulation of MCSs, and microphysical internal structure at both the northern and southern locations. Collection of the data in a consistent way at the two sites will allow comparison and understanding of the meridional differences in convective structures. From the observed structural differences of MCSs observed at the two sites, it will be possible to determine differences in how the MCSs interact with the AEWs in the northern and southern regions. The dynamical and microphysical differences in MCS observed at the two radar sites will indicate how the mass transports, heating, momentum transports and transport of chemical species accomplished by MCSs varies from north to south. These differences in turn relate to the way that the MCSs act as subsynoptic PV sources and modify the AEWs in which they are embedded.

The **Djougou** site will consist of the French RONSARD C-band Doppler/polarimetric radar, and the French X-PORT X-band Doppler/polarimetric radar. The RONSARD has been used successfully in field projects around the world over the past 20 years, including COPT81 and MAP. The polarimetric capabilities of these two radars provide desired mitigation of attenuation affects at these shorter wavelengths. Differential phase measurements can be used to correct for both specific and differential attenuation. These two radars used together will directly support the hydrological observations in the southern CATCH network. The polarimetric data will also allow aspects of the ice particle characteristics in the upper regions of the MCSs to be inferred, as well as mixing ratios to be diagnosed, and relative fractions of water and ice to be determined. The French dual-Doppler pair will thus document the dynamics, microphysics, and precipitation amounts of the MCSs affecting the southern region. In the area sampled by the Djougou radar network, it is also planned to perform an « atmospheric column documentation », both prior, during and after the MCS passage in the network sampling area. This documentation (there is still ongoing discussion) will likely include a micro rain radar (vertical profiles of dropsize distribution), the profiling microwave radiometer (temperature and humidity profiling), a flux station, a lidar ceilometer (vertical profiles of backscatter coefficient, cloud base), a GPS receiver (water vapour path), a sodar (vertical wind profiles in the lower troposphere), and possibly an UHF/VHF radar from CNRM (vertical profiles of wind, turbulence, and possibly water vapour, see WP4.2.3). A dense network of pluviometers (and possibly an optical spectropluviometer) will surround this vertical documentation. This observational strategy is described in Fig. 3, and the mesoscale area covered with single-, dual-, and triple-Doppler coverage is given in Fig. 4.

The **Niamey** site will consist of the U.S./NCAR S-Pol radar combined with a supplementary C-band radar (either the TOGA C-band or MIT C-band Doppler radars could be used in this role). This dual-Doppler pair will document the precipitation, microphysics, and dynamics of the MCSs closer to the heart of the AEJ and the Sahara. These systems are expected to be more frequently rapidly moving squall types of mesoscale systems, and they are expected to have greater electrical activity than those to the south. The measurements from this site can be directly compared to the observations at Djougou to understand their different dynamical and microphysical structures and behaviors. The microphysical characteristics of the MCSs will be inferred from the S-pol polarimetric radar. The methodology of Vivekanandan et al. (1999) and others will be used to infer the microphysical characteristics of the ice and liquid particles throughout the 3D volumes of the observed MCSs. This methodology has been used successfully with S-Pol in a variety of storm types (e.g. Medina and Houze 2003). The Ka-band observations from S-Pol can be used to deduce liquid water contents (to identify regions of mixed phase) by measuring differential attenuation between the Ka band and S-band frequencies.

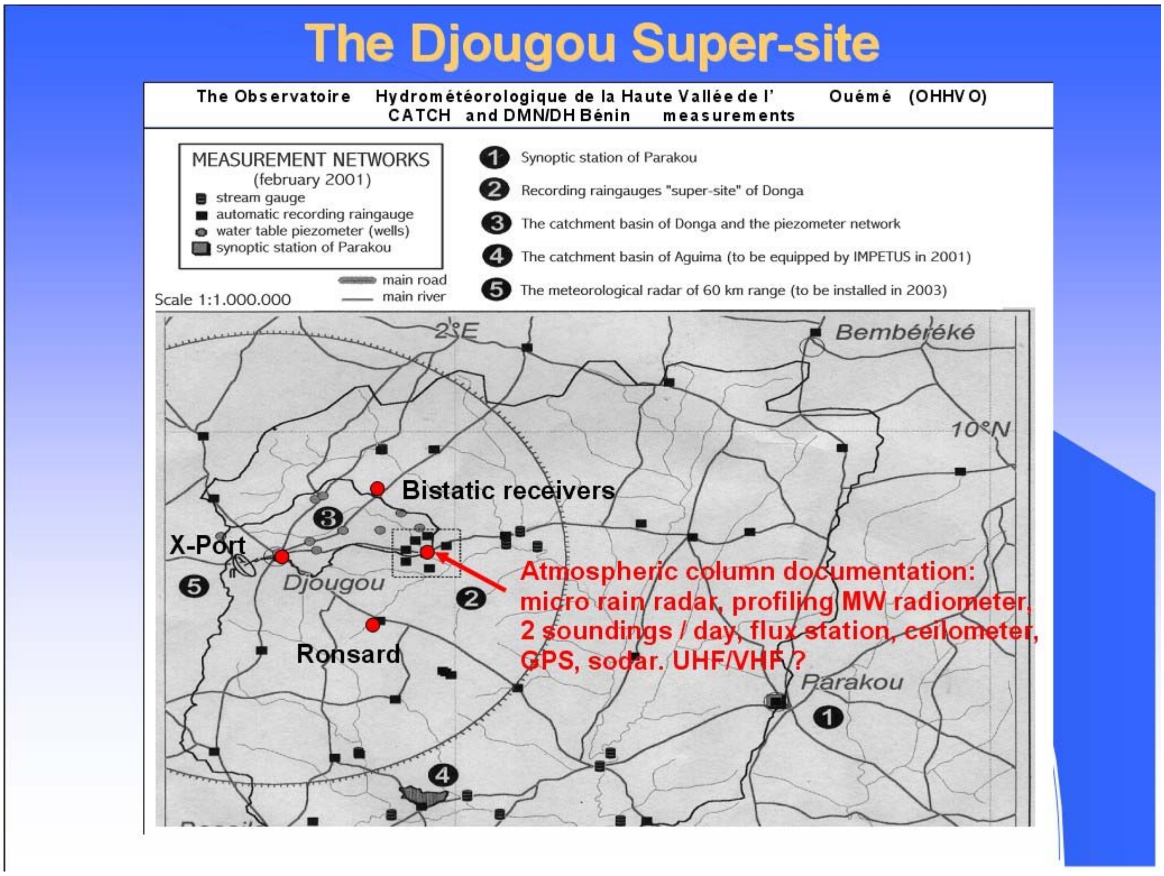


Figure 3 : Description of the Djougou supersite

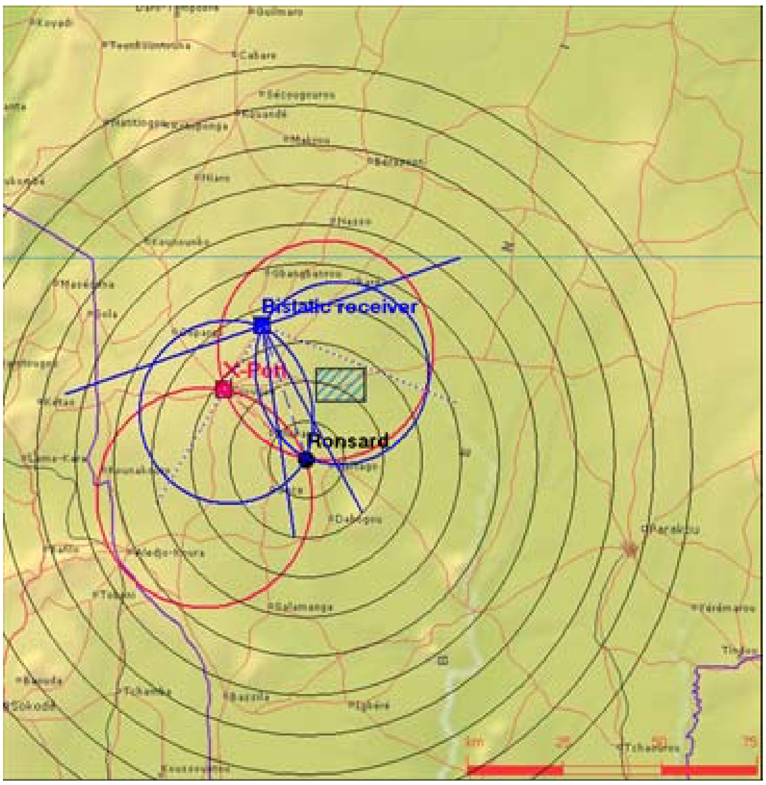


Figure 4: Mesoscale area sampled by the Djougou bistatic radar network

Regarding the WP4.1 activities related to the water cycle, convection, and atmospheric processes, it is clear that the ground-based radar network and additional atmospheric measurements will contribute to several aspects in the validation of large-scale and cloud-resolving models. First, the quantitative precipitation estimate by the radar network (and possibly the pluviometer networks and additional optical spectropluviometers) will be used as a direct validation of precipitation in the models at different scales. The water budget at convective scale and mesoscale retrieved using the radar network will enable a direct evaluation of the different terms of the water budget in a mesoscale model. The microphysical dynamics-microphysics interaction characterization of the MCSs using the two dual-polarization Doppler radars will be extensively used to evaluate the ice phase in mesoscale models. The radar observations (wind + thermodynamics + hydrometeor type) will be compared to mesoscale model outputs and further used as initialisation schemes in the same models. The ARM Mobile Facility (AMF) observations will also be used to evaluate cloud schemes in mesoscale models. The documentation of the diurnal cycle (with a 1-hour resolution) and of its interseasonal modulation (i.e., its correlation with the convective events, the monsoon onset, the dry and moist episodes during the rainy season) will allow the representation of this diurnal cycle (which is actually recognised as a major problem in numerical weather forecast) in large-scale models to be evaluated. The constant-altitude balloons and driftsondes will help assess the performances of NCEP/ECMWF on the meteorological fields (wind speed and direction, pressure, temperature and moisture) in the AMMA region. From a more integrated perspective, the MANDOPAS assimilation system developed at CETP will be used to assimilate most of the ground-based SOP observations (see WP4.1.1 for further details). The 4D dynamic and thermodynamic fields and the water budget retrieved at the scale of West-Africa by MANDOPAS will then be used to evaluate the ECMWF, ARPEGE, and NCEP operational analyses.

C - Coordination between ground-based and airborne operations regarding the investigation of MCS dynamics and internal processes.

A strength of the dual-Doppler and bistatic networks is that they can provide a temporally continuous record of MCS structure throughout the experimental period. However, they only sample the MCSs during their passage over the relatively small area covered by the ground-based radars and bistatic antennas. The time and space scales of the MCSs are such that the systems are typically not observed for their entire lifetimes over the area of radar coverage. For this reason, it is important to supplement the ground based network with airborne radar measurements, as has been done in previous field experiments such as TOGA COARE or MAP. In complement to the ground-based observations, the NOAA P3 aircraft equipped with a scanning X-band Doppler radar will have two objectives, that may not be achievable during the same IOP, but more likely in an alternate way :

- To extend the dual Doppler coverage of MCSs by the ground-based radars. The aircraft in AMMA will have to supplement the coverage of MCSs in the vicinity of either the southern dual-Doppler site (Djougou) or the northern site (Niamey).
- To follow MCSs in their intiation phase and out of the range of the ground based regions in order to cover the life cycles of the MCSs more completely. Further, the NOAA P3 can follow an AEW system as it tracks westward using Dakar as an alternate recovery base if needed.

In addition to the ground-based radiosounding network, additional soundings and in-situ microphysical measurements are required that target more precisely the large-scale environment in the vicinity of MCSs and the thermodynamic information inside the MCSs to assess the interactions between the large-scale environment and the MCSs. These soundings and in-situ microphysical observations will ideally be provided by the following European aircraft with dropsonde capability:

- **French Falcon:** This aircraft will release dropsondes from high altitudes around and inside MCSs to provide the large-scale environment in which the MCSs are embedded and to document the thermodynamic characteristics inside the MCSs. These flights will be coordinated with the NOAA P-3 and the French ATR aircraft carrying out boundary layer measurements pre- and post-storm passage. Specific flight legs should include microphysical sampling in the ice portion of MCSs in order to validate the 3D microphysical characterization of ice phase of the MCSs with the polarization radars at ground.

- **French ATR-42:** This aircraft will fly ahead of and behind targeted MCSs to assess the impact of the MCS on the boundary layer environment. This will support the analysis of the impact of MCSs on the environment and combined with other observations will allow an investigation of boundary layer recovery. This aircraft is also expected to make important aerosol measurements in the vicinity of MCSs, especially to reveal the aerosol characteristics of air being ingested into the convective systems.
- **British BAe 146:** This aircraft will release dropsondes from an altitude of about 12km along meridional transects before and after the passage of MCSs to support the analysis of the evolution of the surface conditions and boundary layer before and after a rainfall event. This will be coordinated with US and French aircraft.

Another aspect that requires a thorough coordination between aircraft operations of the French Falcon and the ground-based observations is the need for in-situ validation of the microphysical characterization of the cloud and precipitating parts of the MCSs. At Djougou and Niamey, the radar networks and their polarization measurements will allow hydrometeor classification and a microphysical characterization of preciptation in ice and liquid phase within the MCSs to be performed, which will then be used for several diagnostic studies (see WPs 2.1 and 1.2 for further details). This microphysical characterization rely on relatively new methodologies which prove to be very efficient but still need in-situ verification for the particular case of West-African deep convection. At Niamey, in addition to the radar network, the ARM Mobile Facility will be deployed. This mobile facility includes a 94 GHz cloud radar and a micro-pulse lidar. From these measurements, the microphysical, dyunamical and radiative properties of the clouds and MCS anvils can be documented. Depending on the methods used to access these properties, there is a need either for in-situ validation or additional information from the in-situ microphysical sensors. As a result, French Falcon flights should be performed in the ice portion of the MCSs above the Niamey site and within the mesoscale area sampled by the two ground-based polarization radar networks.

With this ground-based and aircraft instrumentation in mind, the combination of ground-based radar networks and aircraft operations could be envisaged following two scenarii :

- The first scenario is devoted to the investigation of processes associated with the MCS life cycle. In this scenario the four aircraft take off to document the intiation phase of the MCS if not too far from Niamey, then lands while the ground-based radar network samples the MCS in its sampling area, which saves flight hours. Finally the aircraft take off again when the MCS gets out of range of the radar network to continue the sampling of the life cycle.
- The second scenario is devoted to the detailed documentation of the processes in the largest analysis domain of the MCS when located in the vicinity of the radar network. In this scenario, dropsondes are launched from the French Falcon and British Bae-146 around the radar sampling area to document the large-scale environment of the MCS, while the ATR-42 performs in-situ boundary layer measurements ahead of the MCS. The NOAA P3 performs flight tracks coordinated with the ground-based radar observations in order (i) to extend the coverage of the ground-based radar network and (ii) perform a validation with in-situ microphysics of the characterization of ice phase by the polarization radars. More details about the proposed flight plans are given in WP4.2.1.

D - Observational strategy for WP2.2 and WP4.1

The observational strategy regarding the atmosphere-ocean interactions is described in detail in section 4.2.2.5. Let us remind that wo special oceanographic EGEE cruises are planed during the SOP1 (monsoon onset) and SOP3 (late monsoon), as detailed below. These cruises will also constitute some of the cruises planed in the framework of the EOP (see 4.2.3), and will be carried out at around the same year periods than the EOP cruises, ie late boreal spring-summer (equatorial upwelling upset, in phase with the monsoon setting, around end of May to July), and boreal fall (absence of equatorial upwelling, harmattan period over the coastal countries of west Africa, the ITCZ going back toward or located around its southernmost position). The cruises will be carried out in close collaboration and coordination with the German (partners in the European AMMA-IP) and US (partners in International AMMA and CLIVAR-Atlantic). The measurements obtained during the cruises will be used along with the observation systems used for the LOP and SOP and obtained from the two “Observatoires de Recherche en Environnement” (ORE) PIRATA and SSS, from the operational CORIOLIS-ARGO programs and other measurements got from other international programs (eg GDC at NOAA/AOML) and also other cruises or vessels transits being validated in the framework of AMMA-EGEE.

In particular, the turbulent flux measurements during the cruises will allow flux measurements to be derived at open sea by different methods (inertio-dissipative, correlation and bulk) for parameterization along with meteorological and oceanographic measurements for validation. These fluxes will be used to evaluate the operational analyses (ECMWF, ARPEGE, and NCEP).

E - Observational strategy for WP2.4

This chapter described the ground-based and aircraft operations requested during the intensive field phase of AMMA to achieve the scientific objectives of WP2.4, WP1.1 and 1.2. Ideally, an experimental determination of the 3 dimensional fields of the main aerosol (mineral dust and carbonaceous aerosol from biomass burning or fuel consumption) and chemical compounds (O3, NOx, VOCs) and their emissions and deposition fluxes would be requested; however, a regular grid of aerosol or chemistry measurements network is not conceivable due to the variety of required experimental observations. This is critical for aerosols that can be constituted of a variety of chemical and mineralogical compounds, covering a wide range of particle sizes (~ 0.01 to 10 µm). As a result, the observational strategy for aerosol measurements will be based on the extensive documentation of properties and inflow and outflow of aerosols in/from the Monsoon region along a longitudinal (N/S transport) and a latitudinal transect (E/W transport). This would be made by combining 4 ground-based stations and complementary aircraft and satellite observations. Surface measurements provide with the diurnal and seasonal climatologies that are not accessible through aircraft measurements, as well as by completing the vertical distribution derived from aircraft measurements, especially over land, where aircrafts must be kept above a security height.

The ground-based observational strategy for the documentation of the spatial distribution of the key chemical compounds will be based mainly on aircraft measurements while the investigation of their emissions will be based on the measurements performed at ground-based stations (mainly Djougou, Benin) and complementary satellite observations.

For aerosol studies, the ground-based stations are deployed along two main axes : (1) a East-West axis, allowing for the investigation of mineral dust properties along one of their main transport pathway from their sources (Sahara and Sahel) towards the Atlantic ocean; (2) a North-southern axis, allowing for the study of the aerosol physical-chemical properties in different conditions of mixing, from a pure from a dominant carbonaceous component in the South to a dominant mineral dust contribution at the North; this includes also a marine contribution in the monsoon air flow and a variable sulphate component along the transect. As illustrated in figure 5, the west-east transect includes the “dust-sahelian transect” of EOP stations (M’Bour, Senegal; Cinzana, Mali; Banizoumbou, close to Niamey – Niger), the Banizoumbou site being equipped as super site during the SOP period, and an additional site (N’Guimi) with a minimal equipment being installed close to the Bodele depression, one of the largest dust sources of Northern Africa, at the border with Chad. The North-South transect includes the stations of Lamto (Ivory Coast), Djougou and Cotonou (Bénin), Banizoumbou (Niger). Additional information will be provided by the radiative and optical measurements performed in Tamanrasset.

The instrumentation deployed at the aerosol super sites include total concentration, continuous aerosol sampling for the determination of the chemical (with a zoom on organic aerosol) and mineralogical composition (especially for mineral dust) and the mass size distribution, automatic measurements of the aerosol optical thickness, number size distribution, optical properties (scattering and absorption), vertical distribution (at least night-time, but also day-time at Banizoubou (during SOP0), M’Bour and Djougou (SOP0–2). The aerosol hygroscopic properties will be derived in-situ measurements of CCN concentrations but also derived from laboratory experiments performed on in situ collected samples. Rain collection will be analysed fro chemical composition, a sequential rain-gauge will be used in Banizoumbou to apportion and characterize leached and cloud condensation nucleus.

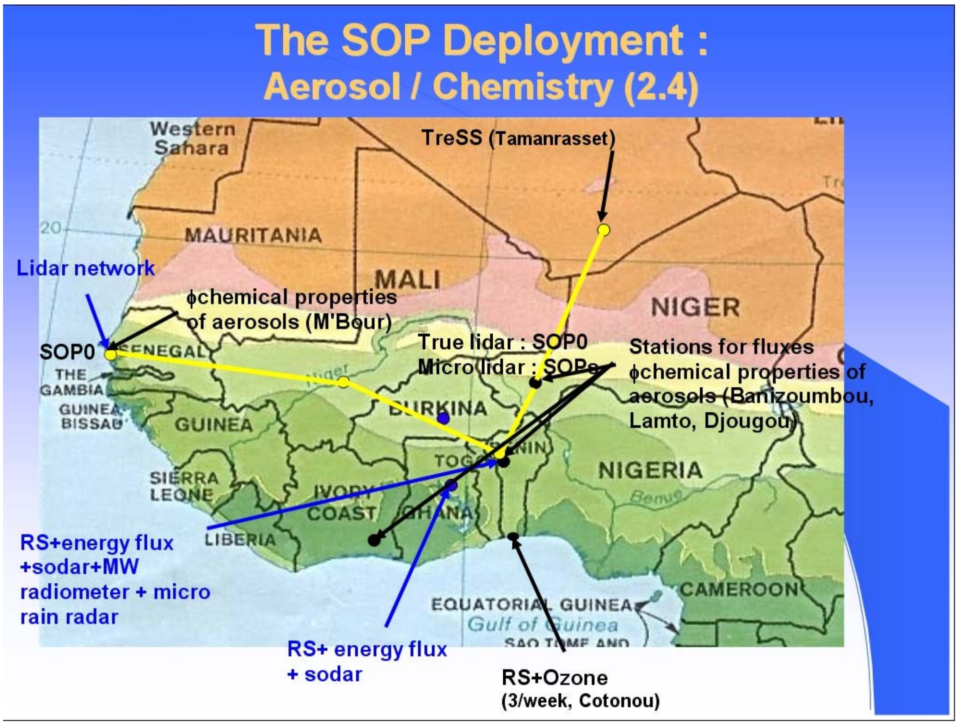


Figure 5: The ground-based observational strategy for WP2.4

The aerosol and chemistry component requires a variety of experimental observations at the surface and in the vertical. The primary platforms required to make these observations are the F / ATR42, the F / F20, and the ground-based stations of Banizoumbou (Niger), M'Bour (Dakar), Djougou (Benin) and Lamto (Ivory Coast). Complementary necessary measurements are made onboard the UK BAe146, D / F20. Ancillary measurements are provided by the ground-based stations of Cinzana (Mali), Zanderji (Niger) and Tamanrasset (Algeria).
The synergy between ground-based and aircraft measurements for the 5-year project as well as for 2005 is tentatively described in the following paragraphs for the four major scientific aspects identified in WP2.4.

E1. Column and local optical closure
In such an experiment an overdetermined set of observations is obtained, and the measured value of a dependent variable, such as light scattering by aerosols, is compared with the value calculated from the measured aerosol chemical and physical properties, using an appropriate model. If the measured and modelled values agree within the range of experimental error and at acceptable level of uncertainty, the model may be considered a suitable representation of the observed system and appropriate for use in higher order models. Poor agreement indicates that there are problems either in the model or measurements that must be corrected before proceeding further. To achieve this objective, ground-based and airborne measurements are necessary. Flight patterns are clear-sky daytime vertical profiles and stack leveled runs of aerosol physico-chemical and optical properties as far as possible above the ground-based station where radiative parameters (column and vertically-resolved) parameters are measured by the means of sunphotometers, surface radiometers, and lidar. This exercise greatly benefit from the coordination with satellite overpasses, e.g. the

AQUA-Train. In the following table, the measured quantities, the location, and the platforms during AMMA are indicated. Over-flight of the different ground-based stations will be informative of the modification of optical properties due to mixing between aerosol species.

Parameter	**Instrument**	**Airborne platform**	**Main ground-based location**	**Period**
Aerosol size-resolved mineralogical composition	Impactors	ATR42 / BAe146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol number size distribution	Optical counter	ATR42 / Bae146 /D-F20	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol shape and mixing	SEM / TEM	ATR42 / Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol spectral optical depth	Sunphotometer	ATR42 / Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol spectral light scattering coefficient	Nephelometer	ATR42 / Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol spectral light absorption coefficient	Aethalometer / PSAP	ATR42 / Bae146 / D-F20	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Direct solar radiation	Pyrheliometer	ATR42 / Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Global solar radiation	Pyranometer	ATR42 / Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Diffuse solar radiation	Shaded pyranometer	Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Long-wave radiation	Pyrgeometer	Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Sun brightness	Solar aureole photometer	Bae146	Banizoumbou / Djougou / M'Bour	SOP 0–1–2
Aerosol vertical profile	Lidar	ATR42 / F20	Banizoumbou / Djougou / M'Bour	SOP 0–1–2

E2. Cloud properties and cloud-aerosol interactions.
Measurements of cloud condensation nuclei (CCN) are needed to address the indirect aerosol effect. CCN provide the linkage between aerosol measurements and clouds; CCN spectra provide concentrations of soluble ions within intervals directly related to the likelihood of cloud interactions. An additional research topic is the modification of aerosol properties by cloud processing, which can change their cloud nucleating properties, lifetimes, radiative properties, reactivity with other atmospheric constituents, and the solubility of dust-associated trace elements, such as iron. This investigation requires clear-sky and in-cloud observations at various altitudes. Straight levelled runs are necessary to document the chemical composition.

Parameter	**Instrument**	**Airborne platform**	**Main ground-based location**	**Period**
Aerosol size-resolved mineralogical composition	Filters	ATR42 / BAe146	Banizoumbou / Djougou / Lamto	SOP 0–1–2
Aerosol number size distribution	Optical / condensation counters	ATR42 / BAe146	Banizoumbou / Djougou / Lamto	SOP 0–1–2
CCN / CN	CCN / CN counters	ATR42 / BAe146	Banizoumbou / Djougou / Lamto	SOP 0–1–2
Aerosol shape and mixing	SEM / TEM	ATR42 / BAe146	Banizoumbou / Djougou / Lamto	SOP 0–1–2
CWC	Lyman-α	ATR42 / BAe146		SOP 0–2
Cloud absorption	PSAP	F / ATR42	Banizoumbou / Djougou / Lamto	SOP 0–2

E3. Chemical emission budget.
In such an experiment the vertical structure of the atmosphere is investigated to look at the vertical distribution of aerosols and gases. In the AMMA region, the vertical distribution of chemical components is governed by the advection within the large convective systems that form over the Sahel. In the case of aerosols, these convective systems are often also responsible for the emissions (e.g., dust). To achieve these objectives, ground-based and airborne measurements are necessary. Flight patterns are clear-sky daytime vertical profiles and stack leveled runs of aerosol size-resolved

mass and various gaseous oxidant concentrations to be flow before and after the convective system events. A combination of various aircrafts is necessary to look at the outflow from the convective systems, which can reach the tropopause.

Parameter	**Instrument**	**Airborne platform**	**Main ground-based location**	**Period**
Aerosol size-resolved mass concentration	Impactors	ATR42 / BAe146	Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol total mass concentration	TEOM		Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol number size concentration	Optical counters	ATR42 / BAe146 / D-F20	Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol vertical profile	Lidar		Banizoumbou / Cinzana / M'Bour	SOP 1–2
Reactive nitrogen species (NOx, NOy, HNO_3, PAN)	O3/Luminol chemical luminescence (MONA),	ATR42 / BAe146		SOP 1–2
Hydro- and organic peroxides	UV fluorescence	ATR42		SOP 1–2
VOCs	GC/MS	ATR42 / F20		SOP 1–2
CO, O_3	Standard analyzers	ATR42 / BAe146	Banizoumbou / Djougou	SOP 2
O_3 vertical profiles	O_3 sondes		Djougou	SOP 2
RO_2 radicals, OH and HO_2	Spectromètre de masse à ionisation chimique (SAMU)	F20		SOP 2

E4. Chemical transport and evolution

In such an experiment the chemical and aerosol distributions and evolution in air masses advected downwind from convective systems are analysed. Data are thus collected on a larger scale than proposed on a larger scale than proposed in 3). Flight patterns are clear-sky daytime transects along the transport outflow direction at various altitudes to document vertical redistribution. A combination of various aircrafts is necessary to follow air masses along their outflow towards the Atlantic in a Lagrangian, or at least semi-Lagrangian way.

Parameter	**Instrument**	**Airborne platform**	**Main ground-based location**	**Period**
Aerosol size-resolved mass concentration	Impactors	ATR42 / BAe146	Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol total mass concentration	TEOM		Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol number size concentration	Optical counters	ATR42 / BAe146 / D-F20	Banizoumbou / Cinzana / M'Bour	SOP 1–2
Aerosol vertical profile	Lidar		Banizoumbou / Cinzana / M'Bour	SOP 1–2
Reactive nitrogen species (NOx, NOy, HNO_3, PAN)	O3/Luminol chemical luminescence (MONA),	ATR42 / BAe146		SOP 1–2
Hydro- and organic peroxides	UV fluorescence	ATR42		SOP 1–2
VOCs (C4–C10, aldehydes, ketones, di-carbonyl and hydroxy-carbonyl compounds)	GC/MS	ATR42 / F20		SOP 1–2
CO, O_3	Standard analyzers	ATR42 / BAe146	Banizoumbou / Djougou	SOP 2
O_3 vertical profiles	O_3 sondes		Djougou	SOP 2

RO_2 radicals, OH and HO_2	Spectromètre de masse à ionisation chimique (SAMU)	F20		SOP 2

F – Other instruments

Finally, it must be mentioned that not all the instruments foreseen during AMMA are already funded. As an illustration, Fig. 6 shows a map with a series of instruments that are waiting for final acceptance. As soon as decisions are made, these instruments will be adde dup to the observational strategy to which they belong.

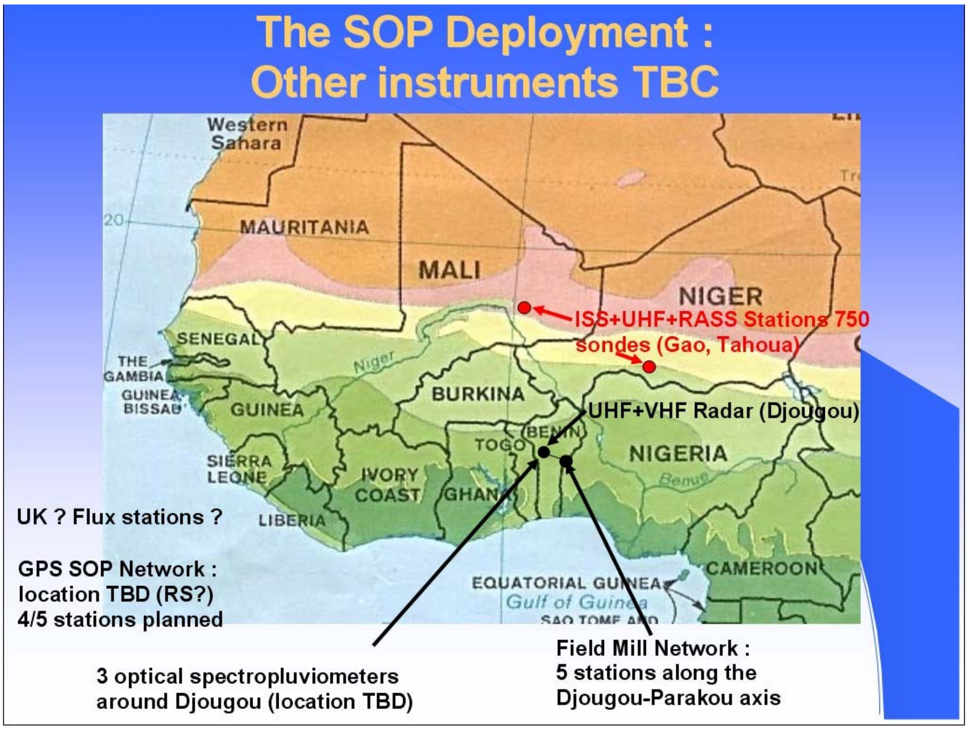


Figure 6 : Map of the instrumentation waiting for final funding decision.

G - Link with the satellite observations (WP4.3)

The different components of the French contribution to the ground-based deployment of instruments in AMMA SOP will be described in the following. Seven contributions have been identified, each addressing different scientific objectives. The links between these ground-based observations and satellite activities are quite straightforward for each contribution. These links are mainly through the validation of spaceborne products which then allows an extrapolation of ground-based observations to larger scales, and through process studies for improvement of spaceborne retrieval methods. In what follows we summarize these links for each scientific theme.

Clouds / Precipitation / Hydrology :

The radar and pluviometer networks will be a main validation point for satellite data by providing a profile of the main hydrometeor type and associated wind under the satellite. It is indeed recognized in WPs 4.2.1 and 4.3 that the quantitative estimate of precipitation from spaceborne microwave radiometry over land requires inputs in terms of dynamics and ice characteristics (density, type of hydrometeors, ...).

Water vapour in the troposphere :

The deployment of the GPS stations during AMMA SOP is part of a thorough effort done to validate spaceborne estimates of water vapour path and profiles (the so-called AMMAVAP project). The activities of this working group are described in WP4.1.1 and 4.3.

Aerosols / chemistry :

A main objective of the deployement of the TReSS station at Tamanrasset, Algeria, is to provide a high-quality set of observations relevant for the calibration/validation of satellite-derived aerosol products over the Sahara, and the specific validation of CALIPSO measurements (combined lidar and IR Radiometer measurements) over the Sahara. The backbone measurements will be provided by CALIOP and the IR radiometer from CALIPSO, PARASOL as well as radiation measurements (CERES). They will be used to assess the variability of:

- the vertical distribution of aerosols in the troposphere [CALIOP],
- the aerosol optical and microphysical properties (columnar averages and vertical distributions) [CALIOP, PARASOL, IR radiometer],
- the radiation measurements at the top of the atmosphere [CERES and IR Radiometer],

in the region of interest (bounded by longitudes 10°W and 20°E, and extending from 15°N to 30°N). The observational strategy will be refined on the basis of the satellite trajectography analyses over Western Africa (to be conducted in 2005).

CALIOP validation aspect include level 1 products (e.g. signal to signal comparison) and level 2 products (e;g. extinction and backscattering profiles, geometrical and optical properties of aerosol layers).

At the Djougou, Lamto, and Banizoumbou supersites, the mineral dust aerosol characterization (size distribution, mineralogical composition, spectral diffusion and absorption properties…) at ground level coupled with airborne measurement will also be used to constrain both ground based and space remote sensing (Lidar…).

The ocean – atmosphere interface :

The turbulent flux measurements will allow getting flux measurements at open sea by different methods (inertio-dissipative, correlation and bulk) for parameterization along with meteorological and oceanographic measurements for validation. At now, if the radiative flux estimates from satellite measurements are rather satisfying, the turbulent flux ones are not, as they still largely depends upon the parameterizations. These measurements will therefore be used to evaluate and improve spaceborne retrievals of turbulent fluxes

1 year plan for coordination of WP4.2.2

The main objectives in 2005 regarding coordination of the ground-based observations during the AMMA SOP will be to take final decisions regarding the strategy of observations at the Djougou supersite, the GPS network deployment, and the lidar network deployment. This can only be done when the CCMA and Scientific Comittee have provided their final decisions regarding the funding that will be available and the instruments that are finally retained for AMMA SOP. This coordination will require in 2005 to establish a close coordination with the AMMA-IP deployment (contact : Susanne Crewell), the UK NERC-funded deployment (contact : Doug Parker), the US-funded deployment (contact : Chris Thorncroft), and the overall EOP ground-based deployment from all countries (contact : Thierry Lebel). It is also important to keep in mind that we need to ensure consistency of observational strategies between the two main supersites (Djougou and Niamey). The other thing to be done is to follow the development status of the different instruments that are not yet fully operational for AMMA.

For these purposes, two meetings will be organized at the end of 2004 and in 2005 : a first meeting that will include the EU and French SOP partners, as well as representatives of the EOP (should be in December 2004). A second meeting will group the French SOP partners (and likely few EOP representatives) in order to take the final decisions regarding the Djougou supersite deployment. At this second meeting the budget of the ground-based deployment should also be refined to provide an almost final cost at the end of 2005.

4.2.2.1 Ronsard radar: Dynamics and microphysics interactions at mesoscale and convective scale during the West African Monsoon

Coordinator : G. Scialom

Laboratories : CETP, LA, LTHE

4.2.2.1.a General information : The RONSARD Radar

The Ronsard radar is a C-band Doppler radar (5.6 Ghz) which will be dual-polarimetric during the AMMA experiment. This radar provides reflectivity, radial velocity and velocity variance in 512 receiving gates 100 m width from 0.6 to 100 km range, and 200 m spaced apart in the most common mode (PRF=1500 Hz), with ± 19.6m/s ambiguous velocity. Another mode exists for larger scale observation (PRF=750 Hz, 0.6-200 km range with range resolution 400 m, ± 9.8 m/s unambiguous velocity range).

This radar was intially mainly aimed at observing precipitating clouds (drops larger than 50-100µm), it was then first modified in 1998 to also provide observations in clear air or non precipitating clouds within the boundary layer. Another transformation presently in progress concerns implementation of the dual-polarization with a double objective: improving precipitation estimation and perform hydrometeor classification. The radar is able to scan azimuthally and in elevation with 0.1 degree resolution. Its typical sequence is a series of consecutive conical scans (PPI) at increasing elevations (the elevation increment may be variable during the sequence). During AMMA, it will also perform scans with fixed azimuth and variable elevations (RHI), and occasionally, data gathering in a single direction (e. g. the vertical). The typical duration of a PPI is 20-25 s, leading to 8 minute duration for exploring 20 elevations.

For clear air sequences, in the common mode, receiving gates are 100m wide and 100m spaced apart. At last, Ronsard will be equipped with two bistatic receivers of the German DLR, allowing a wider coverage of the precipitation area and a more accurate retrieval of the 3D wind field in the common sampling area.

4.2.2.1.b 5 year plan

In the context of an instrumented area together with the X-Port radar around Djougou, the radiosounding network (Cotonou, Parakou, Tamale, Minna/Abuja, Niamey), the ground stations network (hydrometers, pluviometers, disdrometers), and the ATR flights over the area for observing the Planetary Boundary Layer, the Ronsard radar will provide: a) a wider coverage of the precipitation area (since it is less attenuated than X-Port); b) a knowledge of the clear air environmental conditions (wind shear, convergence, CAPE, CIN,…) leading to the effective production of precipitation.

The envisaged studies concern several themes:

- hydrology : Quantitative estimate of precipitation by means of two Polarimetric Doppler radars see contribution of M. Gosset in WP4.2.3 (EOP).

- dynamics of the atmosphere at convective scale and mesoscale and scale interaction and water budget at these scales: This theme was already approached in the COPT 81 experiment over West Africa, but the present context allows a much better instrumental and temporal coverage, allowing a longer series of MCS's sampling with a greater variety of situations.

- microphysical characterization and dynamics-microphysics interaction
This theme will benefit from the presence of two dual-polarization Doppler radars which will allow to identify the type of hydrometeors (by use of an algorithm using polarimetric data) present in the various entities sampled by the radar system : the convective leading edge of the squall line, the reflectivity trough, and the anvil. This will allow a better knowledge of the interactions between these entities (in relation with theme 2) and in particular of the ice phase.

- initiation, development and decay of deep convection
This theme will benefit from the capacities of Ronsard to scan in clear air and precipitation : convergence areas, wind shears, likely to trigger subsequent convective developments, can be identified in the pre-convective environment. This them should benefit from the deployment of other instruments in the framework of the EU AMMA-IP project (profiling microwave radiometer, flux station, lidar ceilometer) and of the insturmentation planned in the framework of the EOP (UHF/VHF radars, sodars, GPS receiver).

- ground validation of satellite data : the radar may be a validation point for satellite data by providing a profile of the main hydrometeor type and associated wind under the satellite.

- validation/initialization of models by radar observations : the radar observations (wind + hydrometeor type) will be compared to model outputs and further used as initialisation schemes in the same models.

4.2.2.1.b Report on 2004 activities

The Ronsard radar is presently being equipped with a second receiver for the dual polarization. The antenna was prealably transformed for that. The next steps are the control of the software which allows performing the two modes, single and dual polarizations. The program of installation of the dual polarization on the Ronsard radar has progressed during the year 2004. The second receiver has been installed. The new software able to work with dual polarization is also installed but not yet tested since additional new materials necessary for working with dual polarization are not yet installed on the radar (there is some delay in the availability of these materials).
First measurements with dual polarization were scheduled to the end of 2004. In spite of the delay, we hope to begin the first measurements with dual polarization by the beginning of 2005. Parallel to this installation, Ronsard is being slightly modified in order to operate with the bistatic receivers of the DLR, allowing enlarging the area for wind retrieval during the AMMA SOP. When the first dual polarization with Ronsard will be available, they will be compared , when possible, with the new Meteo-France dual-polarization radar in Trappes, 20 km far from Palaiseau where Ronsard is presently installed. Preparatory work also concerns Ronsard and X-Port: several sequences must be tested in order to fulfil the various scientific needs of AMMA. Some radar sequences can be simulated by the meso-NH model.
A pre-doctoral work was performed in 2004, in order to prepare AMMA. This work aimed at interpreting simultaneous measurements of Doppler and polarimetric data gathered within a squall line during the MAP experiment (Evaristo, 2004). This work will be followed by a Ph-D thesis work (by the same student) on the scientific objectives of AMMA, in particular the interaction microphysics-dynamics and the role of the ice phase within the African squall lines.

4.2.2.1.d 1 year plan

1) In 2005, since Ronsard works in cooperation with the LTHE X-Port radar and bistatic receivers

from DLR, some simulations of sequences have to be done in order to maximize the area covered by the two radars and the associated bistatic receivers, while minimizing the number of possible sequences and their time duration.
The tests will be performed on radar signals simulated as outputs of meso-NH mesoscale models.

Concerning the methodologies for the wind, precipitation and microphysical retrievals, they will be tested at first on past experiments data sets (like MAP) and /or meso-NH outputs. The tests will concern more precisely:

2) Wind and associated parameters processing: the MANDOP /MANDOPA analysis will be tested on the same data set with one, two or three radars (plus additional physical condition); the VAD/DVAD analyses will be performed slightly after conical sequences achievement. Pressure and temperature perturbations (depending on the wind analytical form) will also be retrieved as a further step on the same data set.

3) Polarimetric data processing: the algorithm of hydrometeor classification (Straka and Zrnic,1999) operational on the S-band S-POL radar will be adapted to Ronsard radar and tested on the first Ronsard polarimetric data when these data will be available. Correction for attenuation will be included in the process. The algorithm will further be enriched with some other pieces of information such as temperature, velocity variance, and terminal fall velocity of hydrometeors.

4) Concerning the scientific theme 'Hydrology by means of two Polarimetric Doppler radars', the programme for 2005 will concern the problem with a single radar and specifically the following points (to be checked from meso-NH and radar simulator):

a. Attenuation and its correction (under progress on X-Port, to be adapted to Ronsard)
b. Correction for advection if the radar sweed is slow, and tests of various methods for this correction
c. Extension to ranges greater than 70 km of the 'useful hydrologic range' by correction of vertical profiles of reflectivities (with differentiation between convective and stratiform rains). This work could be done by student supervised in cooperation LTHE-CETP. Extension to dual radars could be done in a further work.

4.2.2.2 Balloons in AMMA

Coordinator : P. Drobinski

Laboratories : CETP, CNRM, LA, LMD, LODYC, SA

4.2.2.2.a 5 year plan

4.2.2.2.a1 Ballons à volume constant

Objectifs:

Le déploiement dans la couche limite atmosphérique de ballons à volume constant (BVC) dans AMMA est particulièrement intéressant pour la SOP1 et SOP2. Ces lancers seront effectués en synergie avec les moyens complémentaires d'observations sol (radiosondages, radars, mesures en surface, …) et aéroportés (e.g. WIND, LEANDRE-2) : par exemple, la modulation du flux de mousson doit être analysée en relation avec le forçage grande échelle et les flux de surface dont l'hétérogénéité horizontale (gradient nord/sud en particulier) peut affecter les propriétés thermodynamiques du flux de mousson. La synergie doit être recherchée par des lâchers réguliers de BVC, dont l'intervalle de temps reste à déterminer, durant la période d'observation intensive durant laquelle l'ensemble des moyens sol et aéroportés seront déployés. Les BVC mis en œuvre pour l'étude des moussons d'été et d'hiver indienne (BALSAMINE et INDOEX) ont montré leur apport pour documenter la dynamique et la thermodynamique de la basse troposphère associées aux flux de mousson dans les régions tropicales et subtropicales (objectifs SOP1). A ce jour, la faisabilité de la mesure de l'alimentation en humidité des systèmes convectifs (SOP-2) à l'aide de BVC n'est pas démontrée. Des arguments pourront cependant être apportés à la suite des cinq BVC qui seront utilisés dans des conditions proches d'activité convective lors de la campagne probatoire de l'expérience Vasco-Cirene en février 2005.

Le déploiement dans la couche limite atmosphérique de ballons à volume constant (BVC) dans AMMA permettra de contribuer à plusieurs objectifs scientifiques :

- Documentation de la modulation du flux de mousson par les ondes d'Est (max de perturbation des ondes d'Est à 700 hPa)
- Suivi lagrangien de l'humidification du flux de mousson et de son cycle diurne
- Estimation de la pénétration du flux de mousson sur le continent et détermination du « saut de mousson »
- Evaluation quantitative des défauts des modèles globaux et régionaux (e.g. ECMWF) pour les champs météorologiques (force, direction du vent, humidité)
- Evaluation des modèles de recherche (e.g. Méso-NH) pour la compréhension des mécanismes dynamiques associés à la mise en place de la mousson.
- Assimilation pendant AMMA de l'ensemble des données dynamiques et thermodynamiques de la SOP dans l'analyse 3D-VAR MANDOPAS à l'échelle de l'Afrique de l'Ouest. L'apport de données de BVC sera étudié à travers des simulations.

Description du travail

D'un point de vue mise en oeuvre, les problèmes à prendre en compte sont:

Site(s) de lâchers des BVC : les premières études trajectographiques réalisées avec des lâchers de Cotonou (cf. « Travaux en 2003 ») montrant que ce site est trop à l'est, d'autres études trajectographiques devront être conduites en 2004 pour définir un site ou plusieurs sites adaptés.

Altitude de vol des BVC : ce point est directement fonction de la hauteur de la couche de mousson (1000 à 1500 m) de son évolution spatiale et de la structure nuageuse possible. La simulation numérique apportera les éléments déterminants sur le choix du niveau de vol. Un niveau vers 900 hPa reste raisonnable mais peut être redéfini en fonction des simulations numériques et des évaluations nuageuses prévues sur la trajectoire du BVC. Un autre élément important est la hauteur maximale de vol déterminant le volume des ballons en fonction de la charge emportée et qu'il faut définir avant la fabrication des BVC.

Durée des vols: la durée de vol nécessaire pour décrire toute l'extension du flux de mousson du golfe de Guinée au nord de Niamey (environ 1000 km) est de 2 à 5 jours environ (cf. « Travaux en 2003»). Une inconnue reste le comportement de ces BVC au cours du cycle diurne (refroidissement nocturne) et la charge en eau qu'il pourra subir soit par condensation, soit par captation d'eau dans les nuages ou sous les précipitations. Ceci nécessite donc d'avoir une bonne connaissance de la dynamique et de la thermique de vol du BVC, de voir si certaines solutions peuvent améliorer son comportement (bilan IF, surface lisse hydrophobe, …). Un BVC passant dans une zone pluvieuse ira de toute façon au sol vue la charge en eau qu'il prendra. Dans ces cas, un BVC de forme sphérique sans nacelle extérieure pourra permettre un re-décollage avec le rayonnement solaire.

Configuration du BVC (e.g. sphérique avec électronique incorporée) : la forme sphérique avec une électronique incorporée dans le ballon est la plus adaptée à la fois pour sa modélisation (coefficient de traîné isotrope, ….) et pour permettre au ballon éventuellement de re-décoller s'il touchait le sol pendant la nuit ou sous des précipitations. L'étude de ce type de ballon et sa mise en œuvre sont bien maîtrisées par la division ballon du CNES (voir note technique CNES DSO/ED/BA/2003 n°04 rédigé par B. Dartiguelongue).

L'affinement des objectifs scientifiques et l'adéquation de ces objectifs scientifiques avec les contraintes techniques requièrent donc des études préalables :

Une étude scientifique avec des simulations de lâchers de ballons isopycnes à différents niveaux à partir des champs NCEP/ECMWF pour avoir une statistique sur les trajectoires et des simulations de trajectoires isopycnes à partir de simulations Méso-NH à haute résolution pour étudier le détail des trajectoires, en particulier à proximité des zones convectives. Cette étude a pour but de déterminer : (i) le lieu de lâcher des BVC, (ii) l'altitude (ou pression) de vol des BVC, (iii) la durée de vol souhaitée et (iv) la stratégie optimum de lancement des ballons.

Une étude technique préalable pour évaluer la faisabilité techniques des propositions émises et réajuster selon les recommandations techniques. La campagne probatoire Vasco permettra de répondre à une partie de ces impératifs techniques.

<u>4.2.2.2.a2 Driftsondes</u>

<u>Objectifs:</u>

Le concept des driftsondes développé au NCAR/ATD (resp. H. Cole et D. Parsons), est l'emport par ballon d'une nacelle de 24 dropsondes GPS (NCAR RD-93 et/ou Vaisala RD-21) et d'un système automatique de largage (par ex. toutes les 6 h), les données étant transmises soit par relais satellite en orbite basse ou par Iridium. Le but est d'obtenir un système de coût proche du système classique de sondage avec des données arrivant en temps réel sur le GTS (pour être accessible par les centres de prévision météorologique) et des hautes résolutions. Le niveau de vol se situe vers 50-100 hPa et la durée de vol avec les ballons actuels (GSSL) est de 5-6 jours. Des tests réussis ont eu lieu de Février à Septembre 2003 (Cole et al, Phase1 Report, NCAR).

Dans le cadre d'AMMA, l'apport de ce système serait le complément essentiel entre les radiosondages sol (échelle synoptique) et les sondes larguées à partir d'avion autour des systèmes convectifs de méso-échelle (échelle du système nuageux sur une période inférieure à 12 heures). Les driftsondes permettent aussi de remédier à la difficulté de renforcer le réseau de sondages existant sur toute l'Afrique de l'Ouest et sur les zones océaniques et de documenter plus correctement la haute troposphère tropicale.

Les principaux objectifs auxquels les driftsondes contribueraient fortement sont

- Documentation de la structure verticale et horizontale de l'atmosphère aux échelles méso-synoptiques aux résolutions temporelles de 3 à 6h. En particulier couverture de zones mal ou pas échantillonnées par le système de sondages renforcés d'AMMA :
    - Ecoulement Amont (site de lacher des ballons au Tchad)
    - Région du Heat low
    - Régions océaniques (US très intéressés par documenter durant AMMA/SOP avec les driftsondes les systèmes dynamiques traversant l'Atlantique (Ballons de durée de vie plus longue qui nécessitent une collaboration entre NCAR et CNES)
    - Ondes d'Est continentales et océaniques
- Validation haute résolution des sondages satellitaires
- Validation des modèles de prévision et de recherche ; Tests de l'apport de profils verticaux hautes résolutions temporelle et spatiale à la détermination des champs initiaux (analyse 3D ou 4D Var) et prévus (Collaboration THORPEX-AMMA)

De par son apport de données inaccessibles par les moyens instrumentaux existants, les enjeux du développement du système de driftsondes en France dépasse très clairement le cadre d'AMMA. Tout développement ou test réalisé durant AMMA aura donc des retombées plus larges.

Description du travail

Le NCAR est très favorable à l'implication des driftsondes dans AMMA et de manière plus large les rapprochements entre AMMA et le programme THORPEX doit permettre l'implication de la NOAA dans un déploiement de ce système durant AMMA (SOP2 & SOP3). Reconnaissant l'excellence française en matière de mise en oeuvre de ballons basse stratosphère, les USA se sont déclarés très intéressés par une coopération avec le CNES. En 2004, une collaboration s'est engagée et se poursuivra au moins en 2005 et 2006 dans le cadre d'AMMA (cf plus bas)

4.2.2.2.b Report on 2004 activities

1. Constant Volume Balloon (CVB) (PI: Claude Basdevant, IPSL/LMD):

The CVB will be deployed during SOP-1 (monsoon onset) and will allow to address several scientific issues :

- lagrangian trajectory and humidification of the monsoon (diurnal cycle)
- modulation of the monsoon by the african easterly waves (maximum of perturbation at 700 hPa)
- estimation of the monsoon penetration over the continent and determination of the monsoon onset
- quantification of the performances of NCEP/ECMWF on the meteorological fields (wind speed and direction, pressure, temperature and moisture) in the AMMA region.
- validation of research models (e.g. Méso-NH) for the understanding of the dynamical processes associated with the monsoon onset.
- assimilation of the full thermodynamical dataset during SOP-1 in 3D-VAR MANDOPAS at the scale of western Africa. The objective is to compute water vapour budgets from the analyses of the full dataset (ground-based, airborne and satellite-borne measurements). The relevance of the CVB data must be addressed using simulations.

In 2004, the effort was focused on the evaluation of the "technical risks" in the deployment of the CVB and the performance of trajectory simulations. A meeting at CNES was held on 6 October 2004 to make a synthesis of the results:

1) Most of the technical issues were addressed (what type of CVB, the precision on the CVB density,…). One remaining aspect is the performance of the CVB in rainy conditions. Studies are currently conducted at CNES. In addition to that, the same CVB will be launched during the VASCO probatory campaign is similar conditions, so the results of this campaign will benefit to the preparation of AMMA (and the AMMA probatory campaign in June 2005).

2) A large number of simulations have been conducted by Claude Basdevant and Alikaou Traoré (IPSL/LMD). They consisted in isopycn trajectories using both NCEP and ECMWF reanalyses. The simulations helped in defining the density flight level and the launching site. The CVB must be launched between 860 and 900 hPa and three possible launching sites were chosen: a site in western Ghana (to be identified) or two sites in Benin (Cotonou and Djougou). These launching sites were chosen since they allow the best coverage of the instrumented sites in Benin (Djougou for instance). The CVB data will thus be analyzed in synergy with other data during the AMMA SOP-1. Priority is given to the site in Ghana and a mission of site prospection will be organized as soon as contacts with locals are made.

2. Driftsondes (PIs: Philippe Drobinski, IPSL/SA, Jean-Luc Redelsperger, CNRM, *Dave Parsons, NCAR)*:

The Stratospheric Balloon Driftsonde System (SBDS) should be deployed during a continious period of about six weeks balanced beween SOP-2 (convection) and SOP-3 (cyclogenesis). The meeting between CNES, NCAR, GSSL, and US and French PIs of AMMA have outlined following scientific issues which are developed in the context of collaboration between AMMA and THORPEX:

- complement the radiosounding network in regions void of measurements
- impact of the assimilation of the dropsonde data
- quantification of the performances of NWP (NCEP, ECMWF, …) on the meteorological fields (wind speed and direction, pressure, temperature and moisture) in the AMMA region.
- validation of research models (e.g. Méso-NH) for the understanding of the dynamical processes associated with convection and cyclogenesis.

The SBDS will be developed jointly by NCAR/GSSL and CNES as decided at a joint meeting held at CNES on 12-13 October 2004. A letter of agreement will be signed shortly and a probable MoU will follow. The main issue is to combine the two existing and validated systems (the CNES stratospheric balloons and the NCAR dropsonde system which was validated in 2003). It was agreed that 15 SBDS (10 stratospheric open balloons and 5 stratospheric CVB), carrying 40 to 50 NCAR dropsondes each, should be launched during SOP-2. The large number of balloons and dropsondes allow dropsonding at a very short regular interval (every 3 hours) which is thus equivalent to targeting option. For SOP-3, 10 SBDS should be launched. All the SBDS should be launched from N'Djamena (Tchad) at a density level flight between 50 and 75 hPa (trade off between simulated trajectories conducted in 2004 and air traffic control restrictions).

3. Small stratospheric open balloons (PI, Jean-Pierre Pommereau, IPSL/SA):

At the 6 October 2004 meeting in Toulouse, the deployment of small stratospheric open balloons was discussed as part of the whole balloon deployment during AMMA. These balloons should be launched from the instrumented site of Djougou, Benin, during SOP-2 in the framework of the European project SCOUT.

4. Aeroclippers (PI, Jean-Philippe Duvel, IPSL/LMD):

The possible deployment of aeroclippers during AMMA depends (i) on the implication of a large scientific community on SOP-3, i.e. cyclogenesis over Atlantic Ocean (mostly US contribution) and the technical and scientific results of the VASCO probatory mission which will be held in February 2005 in Seychelles. At the "AMMA SOP" meeting held in Toulouse in June 2004, Jean-Philippe Duvel presented aeroclippers trajectories for AMMA SOP-3 and several options for possible launching sites during AMMA were proposed. At present, no funding is asked in the framework of AMMA API 2005.

4.2.2.2.c 1 year plan

1. Constant Volume Balloon (CVB) (PI: Claude Basdevant, IPSL/LMD):

In 2005, the effort will be focused on the visit of the launching site (most probably in western Ghana) and the preparation of a probatory experiment in June 2005. It must be noted that CVB will be launched in the marine boundary layer in moist and convective situations during the VASCO probatory experiment. The results of the deployment of the CVB in such conditions (similar to AMMA except for the continental induced strong diurnal cycle) will be of great interest for the AMMA CVB team.

2. Driftsondes (PIs: Philippe Drobinski, IPSL/SA, Jean-Luc Redelsperger, CNRM):

In addition to the joint development of a CNES/NCAR SBDS (development funded by CNES), additional trajectories will be simulated for the stratospheric open balloons/dropsondes to determine the optimal flight level (which is less accurately predictable and more sensitive to radiation variations) for SOP2 and SOP3 objectives. The collaboration between AMMA and THORPEX will be pursued, where driftsondes correspond to a major observational aspect.

4.2.2.3 Monitoring of variables relevant to the understanding of heat low dynamics, including its diurnal evolution and the impact of aerosol radiative forcing

Coordinator : C. Flamant / P. Flamant

Laboratories : LMD, SA

4.2.2.3.a 5 year plan

General information

The Saharan heat low (SHL) region is key to understand the monsoon dynamics. The SHL is generally (and very roughly) defined as a region bounded latitudinally by 20°N and 30°N, and longitudinally by 15°W and 10°E. The SHL can be characterized as a region of high surface albedo (Fig. 1), overlain by strong synoptic subsidence, where dry (moist) convection is (is not) an important heating process. In addition, the omnipresence of a sand layer heated by shortwave solar radiation absorption presents a secondary heat source in the Saharan planetary boundary layer, also sometimes refered to as the Saharan aerosol layer (SAL). The presence of the dust layer combined with the high soil temperature which is controlled by the earth's surface heat balance, constitute a unique destabilization factor for the Saharan desert mixed layer.
The thermodynamic budget of the thermal low over the Saharan desert is an important element of the climate of the West African region. Also, there is now evidence that the intensity of southerly/southwesterly monsoon flow (including the sudden surge associated with the so called "jump" or onset) is partly controlled by the intensity of the SHL.
Despite its central role, the very little is known on the dynamics of SHL as well as the diurnal and seasonal evolution of its main characteristics (position, horizontal extend, subsidence aloft, thermodynamic budget, radiative budget, cloud cover) and features (SAL, inter-tropical front -ITF). Furthermore, this region is affected by an important horizontal variability of its main characteristics and features at the regional scale.
In the new organisation of the the WP2.1, now subdivided into 6 sub-WPs according to key WAM components, sWP2.1.2 focussed on the Heat Low dynamics which is recognized by as playing a major role in the monsoon dynamics.
Due to the difficult meteorological conditions (heat and dust), this region is difficult to instrument. Nevertheless, in the region of interest (roughly bounded by longitudes 10°W and 20°E, and extending from 15°N to 30°N), 5 sites (including Tamarasset) equipped to launch synoptic meteorological balloons (1 or 2 per day) can be found (see http://www.uni-koeln.de/math-nat-fak/geomet/meteo/winfos/radiosonden/Afrika/index_afrika.html). In addition, the meteorological station of Tamarasset, Algeria (22°47'N / 05°31'E) and the climatological station of the Assekrem (23° 16'N / 05° 38'E) are equipped for monitoring the radiative budget at the surface and microphysical properties of desert dust and biomass aerosol (at the surface), respectively (see Appendix). Even though very valuable, these measurements are not sufficient to comprehend the complex dynamics of the heat low and the role of aerosols in the process. Improved knowledge of

the Saharan heat low dynamics requires concomitant monitoring of:

- the radiation budget,
- the aerosol optical/microphysical properties,
- the vertical distribution of aerosols in the troposphere,
- the PBL structural parameters, as they impact the formation of the SAL.

The diurnal cycle being very marked in this region and the mesoscale variability being important (both in terms of SAL structral parameters and dust emissions), the experimental strategy calls for a complementary ground-based/airborne/spaceborne observational approach to address these key issues. The objective of ground-based (resp. airborne and spaceborne) component of the experimental strategy is to document the diurnal cycle (resp. mesoscale variability) of relevant variables (structural, thermodynamics, radiative, etc..) in the SHL region. **This will partly be achieved during the SOP via the implementation of the Tamanrasset "Supersite" (where *we propose install the Transportable Remote Sensing Station –TReSS- to complement the existing radiative observations) in combination with* airborne explorations north of the ITF [WP4.2.1] and spaceborne observations acquired in the framework of the A-Train [WP4.3]**, as all these platforms can provide a monitoring of the variables relevant to the understanding of heat low dynamics and its variability. It is also of great importance that these measurements be compared with those acquired outside of the SHL region. **This will partly be achieved during the SOP via airborne explorations south of the ITF and the implementation of the Niamey, Banizoumbou and Cinzana "Supersites" [WP4.2]**.
Furthermore, observations (by essence limited in time and space) need to be put in the perspective of numerical modelling [WP4.1]. Besides bridging a gap between ground-based, airborne and space-borne observations, numerical modelling also allows to conduct sensitivity studies, both aspect being crucial for the identification and assessement of processes key to understanding the role of the SHL in the monsoon system [WP2.1].
TReSS is an autonomous and high-performance system designed to observe radiative and structural properties of clouds and aerosol layers, as well as atmospheric boudary layer (ABL) dynamics.The standard payload is made of the following instruments: 1) a multi-wavelength elastic and Raman channels Mini-Lidar with diverse polarization capability at 532 nm, 2) a sun photometer, 3) an IR radiometer, 4) a pyranometer and 5) a full sky visible channel web-type camera. The Mini Lidar has been designed and engineered by the LiMAG team (IPSL/LMD).

The objective behind the deployment of TReSS is two-fold:
- **Monitor the diurnal cycle of variables relevant to the scientific objectives of AMMA,**
- **Provide observations relevant to the validation of selected level 1 and level 2 A-Train products over the Sahara, which in turn will used to assess the mesoscale variability of variables needed to comprehend the complex dynamics of the heat low and the role of aerosols in the process.**

The so-called A-Train is composed of five satellites flying in formation, among which:
- CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) equipped with the nadir pointing backscatter lidar CALIOP, the infra-red radiometer IIR and a large field-of-view camera operating in the visible spectrum,
- PARASOL (Polarization and Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar) dedicated to improving the characterization of the aerosols microphysical and radiative properties (among others),
- AQUA carrying among others the Moderate-Resolution Imaging Spectroradiometer (MODIS), and Clouds and the Earth's Radiant Energy System (CERES) to characterize aerosols microphysical and radiative properties and measure radiative energy fluxes.

Objectives

The two sets of objectives are:

Concerning mainly AMMA:

- to provide an optimal set of observations for improving the knowledge of the heat low dynamics, including its diurnal evolution and aerosol radiative forcing,
- to provide a high-quality set of observations for improving the representation the heat low dynamics and the impact of aerosol radiative forcing in numerical simulations and meteorological analyses (such as provided by ECMWF), in a region where observations are scarce.

Concerning mainly the A-Train:

- to provide observations relevant for the calibration/validation of selected level 2 aerosol products over the Sahara,
- to provide observations relevant for the validation of selected level 1 and level 2 CALIPSO measurements (combined lidar and IR Radiometer measurements) over the Sahara.

Several AMMA scientists have been contacted and have expressed great interest for the measurements and proposed scientific objectives: D. Parker, J. Haywood, J.-L. Redelsperger, J.-P. Lafore, D. Tanré, J.-J. Morcrette, A. Beljaars and A. Tompinks.

a) The Tamanrasset super-site

The backbone measurements for this super-site will be provided by the Mini-Lidar, the sunphotometer and the IR radiometer from TreSS as well as radiation measurements, the soundings and aerosol sampling at Tamanrasset/Assekrem. These are:

- the diurnal evolution of the PBL depth [Mini-Lidar],
- the vertical distribution of aerosols in the troposphere [Mini-Lidar],
- the aerosol optical and microphysical properties (surface measurements, columnar averages and vertical distributions) [Mini-Lidar, sun photometer, IR radiometer, samplers],
- the radiation budget at the surface [seven dedicated instruments in Tamanrasset, see the Appendix, in addition of the TreSS Pyranometer and IR Radiometer],
- the profiles of meteorological variables twice a day (0000 and 1200 UTC).

In addition to these measurements, we propose to equip the super-site with a sonic anemometer to monitor surface turbulent sensible heat fluxe.

Four soundings a day at 00, 06, 12 and 18 UTC (2 supplemental soundings per day) would also be extremely valuable.

b) The A-Train

The backbone measurements will be provided by CALIOP and the IR radiometer from CALIPSO, PARASOL as well as radiation measurements (CERES). They will be used to assess the variability of:

- the vertical distribution of aerosols in the troposphere [CALIOP],
- the aerosol optical and microphysical properties (columnar averages and vertical distributions) [CALIOP, PARASOL, IR radiometer],
- the radiation measurements at the top of the atmosphere [CERES and IR Radiometer],

in the region of interest (bounded by longitudes 10°W and 20°E, and extending from 15°N to 30°N). The observational strategy will be refined on the basis of the satellite trajectography analyses over Western Africa (to be conducted in 2005).
CALIOP validation aspect include level 1 products (e.g. signal to signal comparison) and level 2

products (e;g. extinction and backscattering profiles, geometrical and optical properties of aerosol layers).

Description of work

We have developed a strong cooperation with the Météo Algérienne in order to benefit from the existing infra-structure, logistics and manpower. We will train 2 or 3 algerian students/scientists (TReSS operation in general and lidar operation in particular) that in turn would back-up our main operator during the SOP. We offer to pay for the visit of the trainees.

Pre-SOP

The major task concerning TReSS will be:
- to equip the TReSS plateform with the a sonic anemometer,
- to train the personel need for operating the TReSS remote sensing platform during the SOP (including SOP 0),
- to prepare TReSS for operation in Africa, i.e. work on the airconditioning in the container and an overpressurized tent to store material/spare parts.

From a scientifical point of view, a study will be conducted on the potential of the Mini-Lidar to detect dry intrusion over the Sahelian region. A preliminary study has been conducted using LITE data on 15 and 16 September 1994 (when a dry intrusion was observed) in collaboration with R. Roca.

SOP

We plan for daily operations during SOP 0 (1 month from mid January to mid February) as well as SOP 1 through 3. Dusk-to-dawn operation will be scheduled on days of aircraft operations.
Examples of day-long operations with the Mini-Lidar in a variety of cases encountered in Palaiseau, France, are shown in Figure 1.

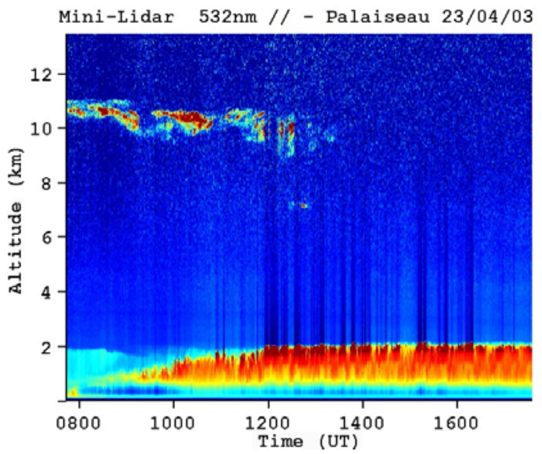


Fig 1a: PBL evolution during morning transition + Cirrus

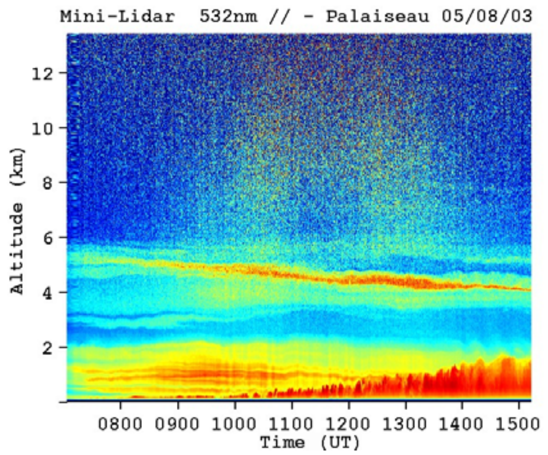


Fig 1b: PBL and elevated aerosol layers

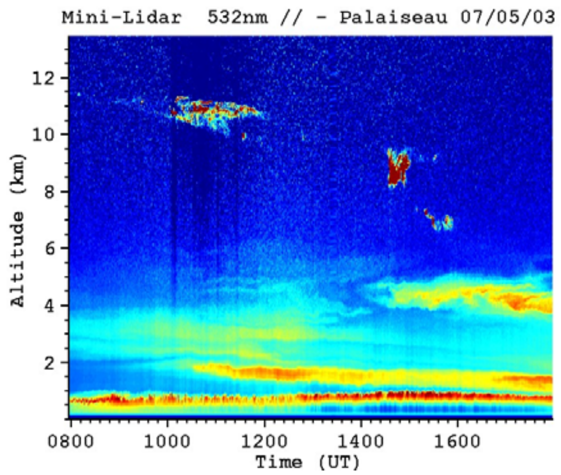


Fig 1c: PBL + Saharan dust layers

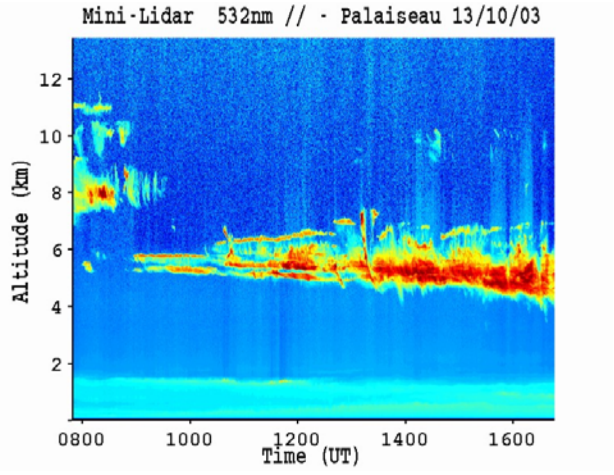


Fig 1d: Water and ice crystal cirrus clouds

Deliverables

During the first 12 months (June 04 – June 05)

- Upgrade of TReSS,
- Submission of a proposal to TOSCA: 'Validation of selected A-Train level 1 and level 2 products over the Sahara using TReSS' to be included in the CALIPSO 2005 validation proposal,
- Planning of the Tamarasset 'Heat Low Super-site' operations in coordination with aircraft operation during all SOPs for addressing the objectives of WP1.3, WP2.1 and WP2.4 relevant to the surface-atmosphere feedbacks and atmospheric dynamics and convection.

During the next 18 months (July 05 – Dec 06)

- Preparation of TReSS for operation in Africa,
- Training of 2-3 Algerians students/scientists for TReSS operation,
- Install TReSS in Tamarasset,
- Perform remote sensing and in situ measurements (see above for details) on the Tamarasset 'Heat Low Super-site' during the SOP,
- Data processing and preliminary analyses,
- Valisation of selected level 1 and level 2 A-Train products,
- Delivery of observations to the database.

Milestones

T0: 1 June 2004

T0+4 mo: Visit of the Tamanrasset meteorological station

T0+16 mo: Acquisition of the sonic anemometer, surface mesonet and microbarographs

T0+17 mo: Integration of TReSS in the adequate container + preparation for operation in Africa

T0+19 mo: Participation to SOP 0

T0+26 mo: Participation to SOP 1-3

T0+30 mo: Delivery to data base

Appendix : Description of the Tamanrasset / Assekrem instrumentation

Variable	Instrument	Station
Total ozone	Dobson	Tamanrasset
Solar radiation: -global -diffuse -direct -I.R -UV-b	4 pyranometers (PSPs) 3 pyrheliometers (NIPs) 2 filter wheels 1 Automatic solar tracker 1 clock drive tracker/w 1 shadow band assembly 1 Automated cavity radiometer UVB-1 pyranometer (Yankee Env. Sys.)	Tamanrasset
Aerosol optical properties	Sunphotometer	Tamanrasset
Greenhouse gases (CO_2, CO, CH_4,..)	Sampler	Assekrem
Surface ozone	Ozone analyzer	Assekrem
Aerosols : - Concentration - Size distribution	Dust analyzer Particle counter	Assekrem
Soot	Aethalometer	Assekrem
Meteorology	Soundings 0000 and 1200 UTC	Tamanrasset
Climatology: -wind speed and direction -temperature -humidity -precipitation -insolation	Surface observations (3 times a day)	Assekrem

4.2.2.3.b Report on 2004 activities

The Météo Algérienne (through Mr M. Kadi) has endorsed our implementation of TReSS at Tamanrasset. A visit of the Tamanrasset site is scheduled for the 11-15 December period for a group of scientists composed of C. Flamant, P. Flamant and J. Cuesta. During this trip, we shall also visit Mr M. Kadi of the Météo Algérienne in Alger. During the visit, a presentation of the AMMA project to the Mété Algérienne staff is scheduled, as well as a discussion on the possible participation of the météo Algérienne to the AMMA project (in terms of forecasts or forecasteers made available to the AOC). We shall also discuss and sign a agreement on data exchanges, as we are very interested in getting the Tamanrasset historical dataset (one of the longest in Africa) to start working on a climatalogy of several of the key variables in the SHL region.

Also, we have chosen the anemometer (from Campbell) to be deployed in Tamanrasset. It should be ordered shortly.

4.2.2.3.c 1 year plan

The major tasks concerning TReSS will be:
- to equip the TReSS plateform with the a sonic anemometer,
- to train the personel need for operating the TReSS remote sensing platform during the SOP (including SOP 0),
- to prepare TReSS for operation in Africa, i.e. work on the airconditioning in the container and an overpressurized tent to store material/spare parts.

4.2.2.4 Aerosols and chemistry

Coordinator : J.-L. Rajot

Laboratories : CNRM, IRD, LA, LAMP, LISA, LMTG, LSCE, LOA, Université du Littoral

4.2.2.4.a 5 year plan

Objectives

They are related to the WP2.4 (Aerosol and Chemistry Processes in the Atmosphere), and in particular to the subWP 2.4.1 "Aerosol radiative properties" and 2.4.3 "Surface processes".

Description of Work

In situ characterisation of aerosols (SOP 0, 1, 2)

The ground-based measurements will be performed at a north-based site (Banizoumbou, close to Niamey - Niger) and at south-based sites (Lamto - Côte d'Ivoire –Djougou – Bénin and Cotonou-Bénin). These will include the mass and number concentration and associated size distribution, the size-resolved chemical and mineralogical composition, a determination of the particle shape, and spectrally-resolved aerosol optical properties (scattering/absorption). (Similar measurements will be performed at M'Bour (Sénégal) during SOP 0 in the frame of "fédération de recherches" FR1818).

Concerning the northern sites, hygroscopic properties of dust aerosol will be obtained from laboratory experiments performed on in situ collected samples. To apportion and characterize leached and cloud condensation nucleus, sequential rain-gauge will be used.

Concerning the southern sites, radiative and hygroscopic properties of mixed aerosols (Dust, Biomass Burning and Fuel Fossil aerosols), their transport with a zoom on organic aerosol will be obtained from the in-situ collected samples analysis performed in laboratory. These analysis will enable to improve chemical and optical closures of mixed aerosols linked to their size at ground level. Moreover,

The instrumentation includes for each super site:

- a TEOM providing the aerosol mass concentration;
- two cascade impactors (4, 8 or 13 stages according to the aerosol type) providing the size-segregated mass concentration and composition;
- bulk filter samplings providing detailed mineralogy and individual particle shape for northern in-situ measurements and detailed mineral, organic and trace chemistry for southern sites;
- various optical counters providing number size distributions
- a nephelometer providing the spectral particle scattering coefficient;
- an aethalometer providing the spectral particle absorption coefficient and the Black Carbon concentrations,
- a sun/sky photometer providing the spectral aerosol optical thickness (AOT) and other column-averaged spectral aerosol optical properties;

Regarding the southern sites, these chemical closures will be also linked to organic sources thanks to NOx and VOC flux measurements for natural and human disturbed ecosystems.

The instrumentation includes:

- a Fast response sensor for isoprene fluxes and automatic chambers for Nox fluxes

To complete at upper levels gases measurements performed at ground level, ozone soundings will be intensified in Cotonou site.

Estimation of the net emission of mineral dust from the WA

Both the deposition and emission fluxes will be measured in Banizoumbou (Niger).

The flux determination method is the gradient method. This is based on concentration measurements performed at two heights, in conjunction to the vertical profiles of meteorological parameters (wind velocity, air temperature, and relative humidity). The standard method for measuring aerosol fluxes will be improved by using, at both heights, an isokinetic sampler able to sample particles up to tenths of microns, from which both the size-resolved mass and number concentrations will be measured. This should provide the size-resolved emission and deposition fluxes. The vertical emission flux of dust aerosols will be connected to the horizontal flux of soil material that will be simultaneously measured at the ground level.

The instrumentation connected to each of the two isokinetic samplers includes :

- an optical counter providing the number size distribution;
- a 4 or 8-stage cascade impactor providing the size-segregated mass concentration (and composition);
- a TEOM providing the bulk mass concentration;
- bulk filter samplings providing detailed mineralogy and individual particle shape.

The horizontal flux will be measured over the field along the main wind directions using a system of 25 micro-masts each equipped with three sand catchers. This experimental set up includes dynamical measurements (anemometers, temperature probes, humidity probes, data logger, …).

The site of Banizoumbou must be equipped for power supply (generator). A buried container will be installed for hosting the instrumentation.

Characterisation of the particulate/dissolved partition of the mixed aerosols

In Lamto and in Djougou, in addition to the super site instrumentation, a CCN counter and a disdrometer will perform mesurements enabling to improve knowledges about interactions betwen CN/CCN and chemistry. These complete sets of measurements will provide information about the influence of the particulate/soluble part of inorganic/organic species and their aging on the CN/CCN ratio. The physical and chemistry analysis of the wet deposition will give detailed information on rainout parametrization, mainly on washout and in-cloud partition.

The instrumentation performing these measurements includes: super site instrumentation +

- CCN counter
- disdrometer

Deliverables

- Test and application of an improved method for mineral dust flux measurements
- In-situ characterisation of dust and mixed aerosol at the ground level
- Data base of aerosols physico-chemical and optical properties (to be used in WP2.4.1)
- Data base for the determination of emission and deposition fluxes of mineral dust and mixed aerosol (to be used in WP2.4.3)

4.2.2.4.b Report on 2004 activities

The Banizoumbou supersite :

The first year has been devoted to the construction and test of instruments:

- Construction and qualification of isokinetic samplers
- Test of instruments to optical properties measurements in laboratory

In addition to the instrumentation test, the experimental strategy for the qualification of collectors and device of deposition and emission measurements has been decided. The super-site localization to Banizoumbou has been identified and the installation of the station for the pre-SOP experiment is in progress after evaluation of the necessary infrastructure (Beginning of the transport of instrumentation to Niger).

The Djougou/Lamto supersites :

Sur la demande API 2004, aucun crédit n'a été alloué à cet instrument prévu pour rentrer en fonction en janvier et juillet 2006. Les demandes API 2004 ont été reportées dans la demande API 2005. Ces demandes 2004 concernaient l'achat d'un flux mètre et d'un impacteur DKT 13 étages.

4.2.2.4.c 1 year plan

The Banizoumbou supersite :

- Upgrading of commercial rain-gauge in sequential rain-gauge and test of the new system
- Calibration of dry deposition collectors in the equipped wind tunnel of Louvain (Belgium) on the period of January-February 2005.
- Construction of the necessary infrastructure for SOP experiments on the identified super-site of Banizoumbou (January March)
- Validation of the vertical flux measurement station during pre-SOP experiment at Banizoumbou (April-June 2005).
- Installation of horizontal saltation flux monitoring station (April-June 2005).

The Djougou/Lamto supersites :

Achats et tests des appareils DKT, fluxmètre, compteur CCN par chacune des équipes imliquées.
Expédition d' une partie du matériel vers Lamto (super site IDAf avec intervenants africains sur place) ou Djougou (site équipé avec instrument 'camion labo LA' et intervenant français détaché spécifiquement)
Tests in situ par les différents intervenants
Programmation des stratégies d'intervention pour la SOP sèche 2006 (SOP0), organisation (réservation des missions fin 2005)

4.2.2.5 Ocean-Atmosphere interactions

Coordinator: Bernard Bourlès
Laboratoires: LEGOS, CNRM, LODYC, CETP, LBCM, LPO+DOPS (IFREMER).

4.2.2.5a 5 year plan

General objectives

In the framework of the SOP, the acquisition of different kinds of measurements that may influence the WAM over the Eastern Tropical Atlantic is of prime importance, in order to provide

the largest number of information to assess the understanding of the WAM onset and ending. These atmospheric and oceanic measurements over the open sea will also allow to get the meridional and zonal surface energy gradients that govern in part the WAM setting up date and its intensity, through the air-sea energy exchanges of energy, heat and humidity.
In this way, two special oceanographic EGEE cruises are planed during the SOP1 (monsoon onset) and SOP3 (late monsoon), as detailed below. These cruises will also constitute some of the cruises planed in the framework of the EOP (see 4.2.3), and will be carried out at around the same year periods than the EOP cruises, ie late boreal spring-summer (equatorial upwelling upset, in phase with the monsoon setting, around end of May to July), and boreal fall (absence of equatorial upwelling, harmattan period over the coastal countries of west Africa, the ITCZ going back toward or located around its southernmost position). The cruises will be carried out in close collaboration and coordination with the German (partners in the European AMMA-IP) and US (partners in International AMMA and CLIVAR-Atlantic). The measurements obtained during the cruises will be used along with the observation systems used for the LOP and SOP and obtained from the two "Observatoires de Recherche en Environnement" (ORE) PIRATA and SSS, from the operational CORIOLIS-ARGO programs and other measurements got from other international programs (eg GDC at NOAA/AOML) and also other cruises or vessels transits being validated in the framework of AMMA-EGEE.

Description of Work

The main goal is the achievement of two oceanographic cruises during the 2006 SOP in order to get some flux and ocean-atmosphere measurements, in addition to the more classical measurements of hydrology and currents along with some bio-geochemical parameters and tracers achieved during the 2005 an 2007 EOP EGEE cruises (see 4.2.3). Thus, the cruises will comprise meteorological measurements, in order to get information on the ocean-atmosphere interactions. The cruise trajectories will be adapted in order to better deal with the objectives of the AMMA SOP two phases. Thus, a particular section will be carried out during the SOP-1 cruise that will complete the SOP terrestrial radio-soundings planed principally from Benin and Niger, at 2°50'E. This section will be carried out in coordination (and simultaneity) with measurements from aircrafts, also used to document the pre-onset and the onset of the monsoon, in terms of fluxes, turbulence and advection of humidity. This section will also be used to closed the sea surface heat budget from both the oceanic and atmospheric sides (see also W.P.4.2.1.2). In order to assess to the variability at different time scales in the best conditions, the cruise tracklines has to repeat some of the sections carried out during the EOP EGEE cruises (see 4.2.3), and to run through some of the PIRATA buoys located in the region. Thus, the 10°W meridional section, already carried out several times during the PIRATA, both EQUALANT cruises, will be privileged.

Turbulence measurements will be achieved thanks to a turbulent flux measurements system. This atmospheric measurements system of radiative and turbulent fluxes will provide notably similar measurements to the ones obtained with the instrumented mast, positioned in the front of the R/V, used during EQUALANT 1999 (see the Equalant program web site *http://nansen.ipsl.jussieu.fr/EQUALANT/*) and POMME cruises. This system will allow getting flux measurements at open sea by different methods (inertio-dissipative, correlation and bulk) for parameterization along with meteorological and oceanographic measurements for validation. These analysis will be carried out for the validation of different SST fields (through comparisons between available climatologies, satellite and in situ measurements), for the validation of atmospheric parameters products at the basin scale, for the validation of the methods used to estimate the fluxes over the GG, and for the comparison of the operational numerical models (CEP model, ARPEGE, NCEP). At now, if the radiative flux estimates from satellite measurements are rather satisfying, the turbulent flux ones are not, as they still largely depends upon the parameterizations. Different methods will be applied in order to reconstruct the net heat balance over the whole GG at short time scales, by mixing satellite products and outputs of atmospheric numerical models. The different methods have to be compared in order to close the heat and salt balances. In that way, a survey of the ocean mixed layer has to be ensured, through the deployment of T/S profilers (PROVOR) and MARISONDE buoys. The PROVOR profilers will be deployed also in the framework of a AMMA-

EGEE specific project (about the mixed layer depth study) funded by the MERCATOR-CORIOLIS program. Another specific experiment of PROVOR deployment could consist in deploying a few profilers around a same point located south of Benin along 2°50'E in order to study the dispersion and also the mixed layer depth with a higher spatial and time resolution. A numerical experiment will be carried out with the CLIPPER and ROMS models in 2005 in order to verify the opportunity of this experiment.

For most of the dynamical studies, the oceanic measurements that have to be continuously acquired are the sea surface temperature and salinity (thermosalinograph), surface and subsurface currents (VM-ADCP), navigation parameters (GPS) and meteorology. To get the subsurface salinity and temperature structures, XBT will be launched "en route" alternatively with "in station" CTD-O2 profiles (from the surface down to about 500-1000m depth; along with L-ADCP measurements if VM-ADCP does not allow to get current measurements below 200m depth) about every 1/2 degree in latitude/longitude. During hydrological profiles, water samplings will be done at different depths, especially for S and O2 parameters (CTD-O2 sensors calibration). Profiles will also be done close to the PIRATA buoys, for comparison and validation of the ATLAS buoys oceanic data, and if possible (at least just before or after their deployment) close to the PROVOR buoys for inter-calibration with the T/S profiles provided by these profilers. Surface Velocity Profiler (SVP) buoys, that also provide daily SST measurements, could also be deployed, in the framework of Global Ocean Observing System (GOOS) program (NOAA/AOML provides the buoys). Furthermore, new special surface velocity profiler should be deployed in the framework of US-AMMA and a cooperation with NOAA/AOML (Dr R.L.Molinari and S.Garzoli), which are equipped with sea-level pressure and surface-wind sensors. Sea surface water samplings will be regularly done for the salinity (thermosalinograph data calibration/validation), nutrients, carbon cycles parameters (DIC, TA…) and C13/O18. In collaboration with Dr M.Rhein (Bremen), Helium measurements will be carried out in order to assess the vertical velocity, inferred from the ratio between the two Helium isotopes.

In addition to the classical meteorological parameters measured by the R/V station, a portable photometer could be embarked (contribution to the Chemical component of the program and particularly to the aerosols study; refer to WP 2.4). Along with pluviometers, a ceilometer (or cloud telemeter) will also allow to assess to the clouds altitude.

To summarize, here is a list of the parameters that should be measured during both SOP cruises :

<u>Ocean, from the vessel</u>:

- Temperature (vertical profiles + surface with thermosalinograph),
- Salinity (vertical profiles + surface with thermosalinograph + samplings),
- Dissolved oxygen (vertical profiles + samplings),
- Nutrients, carbon cyclo parameters, O18 and C13 (samplings)
- Currents (vertical profiles with L-ADCP + surface with VM-ADCP)
- Helium (bottle samplings in the upper layers)

<u>Ocean, from drifters</u> deployed during the cruises:

- Sea surface temperature (SVP; daily)
- Sea surface currents (SVP; daily)
- Sea surface winds (SVP; daily)
- Sea surface atmospheric pressure (SVP; daily)
- Surface to 2000m temperature and salinity profiles (PROVOR; every 10 days).
- Possible surface to 1000m temperature and salinity profiles (5 PROVOR around a same point in the Gulf of Guinea, every day, if funded and opportune).
- Winds and Temperatures at different depths (Marisondes deployed along the 3°E section).

<u>Atmosphere from the vessel</u> (at now, these measurements are only ensured during the SOP1):

- Atmospheric pressure
- Surface Air temperature and humidity
- Solar incident radiation and infra-red incoming radiation
- Wind direction and velocity
- Clouds altitude

- Precipitation
- High frequency turbulent parameters, ie three wind direction components and amplitude, “sonic” temperature, air refraction index, vessel attitude, thermodynamic and radiations measurements…

Atmosphere from balloons:

- Vertical profiles by radio-soundings of temperature, humidity and wind parameters from the ship and also from aircraft along the cross section at 2°50’E (dropsonds to document the atmospheric boundary layer coupled with flux measurements).

SOP 1 cruise :

During the first phase of the SOP, the cruise should “close” the GG area (in order to be able to estimate mass balances) towards the African coast along a section at 6°S, already done during earlier cruises (CITHER and EQUALANT). The cruises should also pass by São Tomé, to maintain the EGEE meteorological station (see 4.2.3).

A meridional section around 2°50’E (*ie* in the south of the " CATCH " box), between the African coast and the equator (or farther south) will have to be carried out in order to better assess the energy meridional gradient (see Figure 4.2.2.5.a just below). This section will also be simultaneously covered from aircrafts. This section is particularly important to sample the onset and the fast latitudinal shift of the monsoon in the best way.

A partial reoccupation of the EQUALANT 2000 cruise in the east of the GG should eventually be carried out with a sampling over the whole water column. The cruise duration will be about 50 days and it will be in two legs (20+30), from Cotonou (BENIN), in order to do carry out twice the meridional section located south of BENIN at about two weeks interval. Such a section could also be sampled thanks to a second R/V, which could be the R/V ANTEA of IRD (if repaired), in order to repeat this section and get SST, SSS, and currents measurements along with to get vertical temperature profiles with XBT and meteorological parameters with a BATOS station. PROVOR profilers and MARISONDE buoys could also be deployed (and maybe even recovered) along with additional radio-soundings, that would allow to get oceano-meteorological and boundary layer measurements during the monsoon setup and its northward fast shift. Previous numerical experiments could define the pertinence of a diffusive experience by deploying a few PROVOR profilers around a same point south of Benin, mostly for mixed layer and heat balance studies in that particular area. Numerical experiments could also been done in order to define a well-adapted strategy for the MARISONDE buoys deployment.

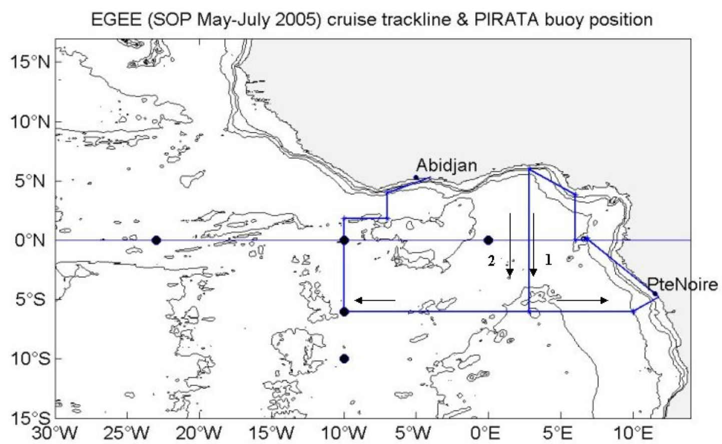


Figure 4.2.2.5a *EGEE cruise eventual tracklines, during the SOP 1 (June-July 2006).A first leg will occupy the easternmost part of the GG, and a second one will repeat the Benin section before sampling the western area of the GG and the 10°W section.*

SOP 3 cruise :

During the third phase of the SOP, in order to get the oceanic and atmospheric conditions during the cyclogenesis period, the cruise should consist in a zonal section off Dakar (Senegal), a section across the Guinea Dome, and a repetition of the meridional section at 10°W (see Figure

4.2.2.5b just below). This cruise duration will be about 20-25 days and it could be carried out simultaneously to an US cruise in the center and the west of the Atlantic basin, around the same latitudes. Close links exist between this part of this project and the IDYLE IRD program that studies coastal upwelling off Mauritania and Senegal from high-resolution numerical experiments. This option will depend upon the availability of the R/V equipped with turbulent fluxes measurements. Actually, a proposal is under progress to carry on “lighter” cruises between Dakar and Cap-Vert from the R/C ANTEA (if repaired) or thanks to the chartering of the R/.V ITAF DEME of CRODT-Dakar (Sénégal). These cruises should be principally dedicated to measurements of temperature in the upper layers in order to assess the mixed layer depth and heat content.

If the R/V equipped with atmospheric measurements is not available, the cruise will consist in the repetition of the 2005 and 2007 EOP cruises trackline.

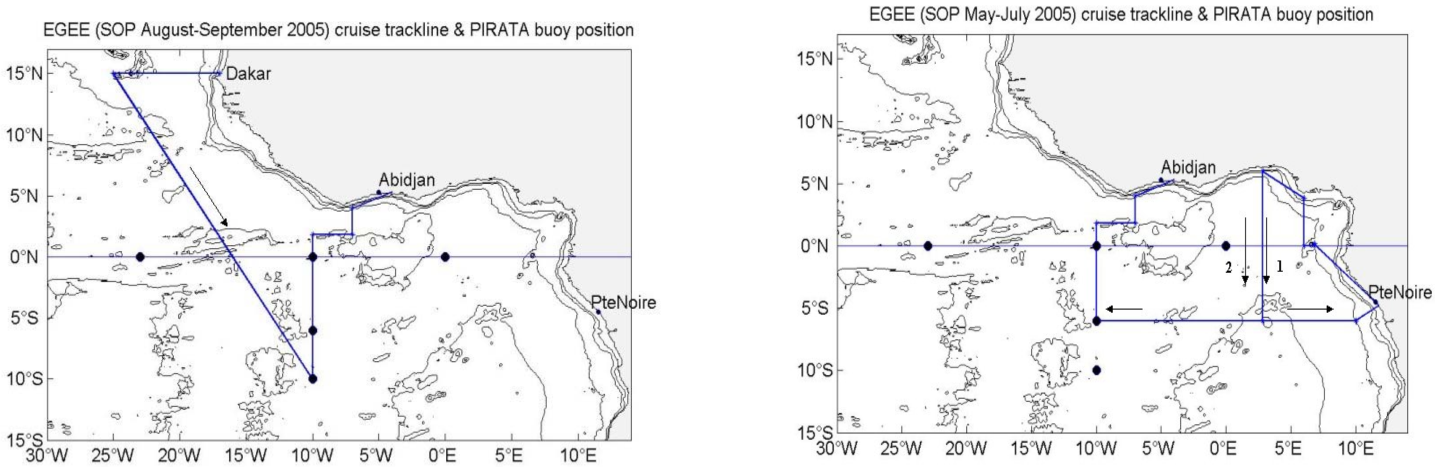


Figure 4.2.2.5b *EGEE cruise eventual tracklines, during the SOP 3 (Late August-September 2006). Either a section will be between Dakar and Cape Verde, before a cross Guinea Dome section and the 10°W section (left), or the cruise will exactly repeat the tracklines of the EOP and SOP1 cruises (right).*

Links to other WPs

Feeding of other WPs

1.1	West African monsoon and the global climate	Analysis of the oceanic processes involved in the SST and air-sea fluxes variability. Provision sea surface temperature forcing fields. Use of atmospheric forcing fields from AGCM runs for ocean simulation.
1.2	The water cycle	Estimate of the fresh water balance on the GG. Structure and evolution of SST, MLD, heat content and associated air-sea fluxes in the GG. Provision of oceanic surface fluxes.
1.3	Surface-atmosphere feedbacks	SST, MLD and fluxes at the ocean-atmosphere interface.
2.1	Convection and atmospheric dynamics	Provision of oceanic surface fluxes and sea surface temperature forcing of the African monsoon on intraseasonal scale
4.1.1	Models	In situ oceanic data for models validation and assimilation
4.2.3	EOP & LOP (Ocean and Atmosphere in the Tropical Atlantic)	In situ data of SST, SSS, surface current, vertical profiles of hydrological parameters, tracers and currents, and atmospheric surface parameters (Tair, wind, fluxes, humidity, radiation…) and fluxes in the eastern tropical Atlantic and the Gulf of Guinea
4.3	Satellite remote sensing	In situ data over the Tropical Atlantic and the Gulf of Guinea for Calibration/Validation processes of satellite measurements and/or products.
4.4	Data base and historical data	In situ data of SST, SSS, surface current, vertical profiles of hydrological parameters, tracers and currents in the eastern tropical Atlantic and the Gulf of Guinea

4.2.2.5.b Report on 2004 activities

No activity had to be reported in this part. The scientific programme starts now (mid 2004).

4.2.2.5.c 1 year plan

1) The buoys of the PIRATA network will constitute a very important source of data sets for the SOP experiment. The PIRATA measurements are and will be used particularly for fluxes estimates, and to assess the seasonal and interannual variability of the upper ocean and lower atmosphere variability. The last PIRATA FR12 cruise has been carried out in January-February 2004, linked with AMMA-EGEE as many additional measurements have been carried out in the Gulf og Guinea. From 2005, the EGEE/AMMA cruises could allow maintaining this network in the GG during the EOP and SOP dedicated cruises. The continuation of the PIRATA program after 2005, ie during the 2006 SOP, is thus a priority for AMMA, and one task is to provide available arguments for its continuation to the organisms and scientific committees responsible for this international program. The maintaining of the buoys at 10W and 0°E along the equator will be a challenge, as they have been destroyed again, due to fishers vandalism activities, in May 2004, four months after their replacing during the PIRATA FR12 dedicated cruise…
2) The algorithms to use in the best way all the ocean-atmosphere measurements and the fluxes over the ocean will be developed, from in situ data acquired during earlier cruises and climatologies, along with data acquired from PIRATA buoys and São Tomé meteorological station. First measurements obtained from this station (October-December 2003) began to be validated in 2004 and their usefulness will be evaluated by comparison with other sources of data representative of the area.
3) Numerical experiments with the CLIPPER and ROMS ocean numerical models will be carried out in order to define the pertinence of a diffusive experience by deploying a few PROVOR profilers around a same point south of Bénin, mostly for mixed layer and heat balance studies in that particular area. Numerical experiments with the same models should also been done in order to define a well-adapted strategy for the MARISONDE buoys deployment (see also WP2.2).
4) Straight relationships have begun to be developed with the IRD IDYLE program. In the framework of the planed works off Senegal and study of the coastal upwelling present there, a short program for special measurements and repeated acquisition during the SOP3 of boundary oceanic and atmospheric layers classical parameters between Senegal and Cap Vert Island should be developed and cooperation and information exchanges are actually on progress in order to elaborate a first document in early 2005.
5) In 2005, the acquisition of radio sounders will be done, along with the needed material for the MARISONDE buoys. Material will be laboratory tested in order to check the acquisition, the quality of the measurements and their transmission via ARGOS.
6) Concerning the turbulent flux measurement system, some first checking and verifications have to be done. The precision of the instruments and sensors has to be verified, the fixing of the sensors to the vessel structures has to be adapted, the acquisition of an other 'little' meteorological station (BATOS) for the flux bulk estimates has to be considered, numerical simulations to check the perturbations due to the vessel structures on the measurements, if a new mast is used or not located in the same condition than during earlier cruises (if the available vessel is the THALASSA or the ATALANTE, where an instrumented mast has already been used and the effects of their structures on the measurements already numerically estimated).

4.2.2.6 Réseau SOP GPS en Afrique de l'Ouest

Coordinator : O. Bock

Laboratories : IGN, LDL, LGIT, SA

4.2.2.6.a 5 year plan

Objectifs

NB : les objectifs liés au cycle diurne étant plutôt du ressort de l'EOP, ils sont décrits dans la partie 4.2.3 du présent document.

Bilans d'eau

Le contenu intégré de vapeur d'eau est un des composants essentiels du bilan d'eau. Son suivi continu avec les observations GPS permet de quantifier la tendance dans la colonne d'atmosphère. La combinaison de ces contenus intégrés avec d'autres observations (précipitations, vent…) permet de faire des bilans d'eau directement à partir de mesures, à l'échelle locale. La combinaison d'observations GPS avec des observations par radar UHF/VHF (profileurs de vent), fonctionnant également en continu, est donc à privilégier (à la fois pour les bilans d'eau et l'étude du cycle diurne).

L'étude du cycle de l'eau dans la mousson est intéressante à différentes échelles et l'interaction entre les échelles est un des thèmes importants de cette étude. Une observation continue multi-instruments sur plusieurs sites d'étude permet d'atteindre en partie cet objectif. Toutefois, pour la grande échelle, il est difficile de disposer de suffisamment de moyens au sol. L'apport des observations satellitaires et de la modélisation (méso-échelle et circulation générale) et donc capitale.

Le suivi continu du contenu intégré de vapeur d'eau par GPS permet de valider et de calibrer à la fois les observations satellitaires et les analyses et simulations des modèles. L'assimilation de ces observations (en particulier sous forme 4Dvar) devrait permettre d'améliorer les bilans d'eau faits à méso-échelle. Un travail dans cette direction est particulièrement important vu la performance actuelle des modèles opérationnels dans cette région du globe [Bengtsson et al., 2004 ; Andersson et al., 2004]. Ce travail est abordé dans le WP4.1.1 de l'API.

Description du travail

La méthodologie proposée consiste à renforcer les observations GPS dans le cadre de la SOP, permettant d'apporter des observations utiles pour les bilans d'eau à méso-échelle (fenêtre Catch). La figure 1, ci-dessous présente une vue d'ensemble des stations GPS existantes et celles que l'on se propose de rajouter dans une version « optimale ».
Face aux problèmes de budget, le CCMA qui soutient fortement les GPS dans AMMA a lors de sa réunion du 2 Nov 2004 recommandé en priorité la solution minimale proposée qui est d'un grand intérêt.

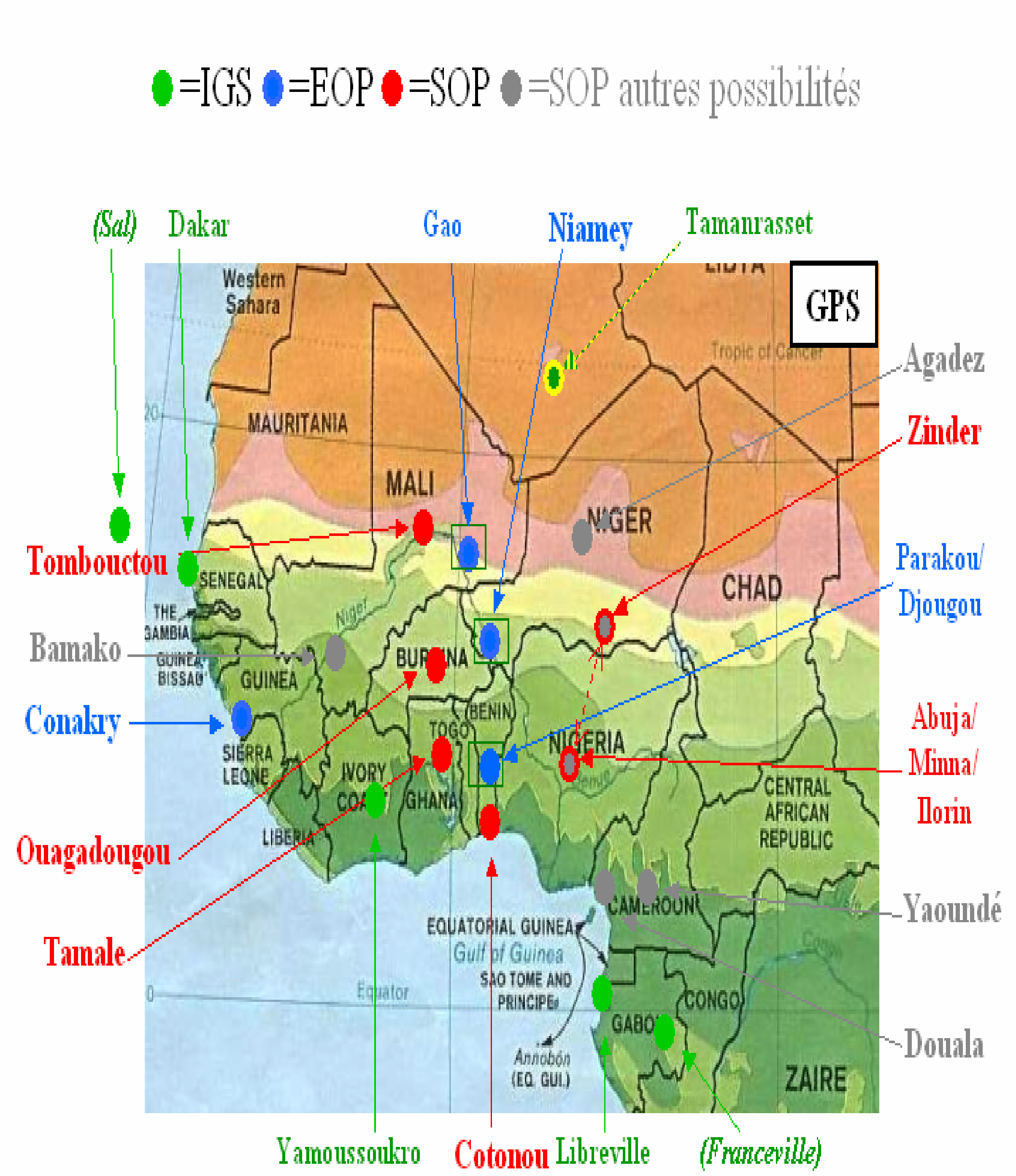


Figure 1 : carte indiquant (1) en vert : les stations GPS existantes; (2) en bleu : les stations proposées dans le cadre de l'EOP (3) en rouge : les stations supplémentaires pendant la SOP. D'autres possibilités envisagées sont indiquées en gris (voir discussion dans le texte).

Implantation optimale

Dans le cadre de la SOP, nous proposons d'ajouter 4 ou 5 stations de manière à densifier le réseau et permettre une descente en échelle dans l'étude des processus.

- 2nd transect méridien (Tamale, Ouagadougou, Tombouctou) : permet d'étudier la partie non zonale du flux de mousson et de renforcer l'assimilation par un réseau d'observation plus dense et plus régulier et donc de contribuer aux études de processus (déplacement / évolution des systèmes convectifs).

- Quadrilatère centré sur Djougou (Tamale, Cotonou, Abuja en complément à Niamey déjà présent pour l'EOP) : en co-localisation avec les radiosondages sur les 4 sites. Sur ces 4 stations, le GPS permet d'avoir un suivi continu de la vapeur d'eau intégrée et donc de compléter les radiosondages (prévus sur les 4 sites) qui permettent de restituer les profils d'humidité et de vent (à 12h ou 6h de résolution). Ces informations, combinées à celles de Djougou contribuent fortement aux bilans d'eau (dans ce contexte, l'observation continue de la vapeur d'eau intégrée à Djougou est primordiale). Cotonou vient également renforcer le transect méridien de l'EOP et avec Djougou permet d'étudier les caractéristiques et l'impact de la brise de mer sur ces bilans d'eau.

Autres possibilités :

- Abuja est un site assez incertain et il pourrait être remplacé soit par un autre site au Nigeria (Minna ou Ilorin) ou par Zinder au Niger. Zinder présenterait l'intérêt de pouvoir documenter une des régions sources de systèmes convectifs (plateau de Jos).
- Le Cameroun est une autre région source de systèmes convectifs (et une région de fortes précipitations). Deux sites pourraient être envisagés : Douala ou Yaoundé.
- Bamako est dans une région de forte évaporation (fleuve Niger) et sur le chemin des systèmes convectifs. Cette station à mi-chemin entre Conakry et les transects méridiens permettrait de renforcer l'assimilation. De plus, un radar UHF profileur de vent a été installé par l'ASECNA en 2004.

Colocalisation avec d'autres instruments : l'ASECNA a prévu d'équiper les principaux aéroports avec des profileurs UHF (6 au total). Le 1er est installé à Bamako. Ouagadougou fera probablement parti des sites équipés avant la SOP.

Implantation minimale

Nous proposons ici une alternative « minimale » au déploiement « optimal » présenté Figure 1. Mais il faut noter que les résultats GPS dépendent aussi de la distance inter-stations (i.e. de la densité du réseau). Conserver des lignes de base de 500km permet de restituer des produits vapeur d'eau de bonne qualité (en principe 2 kg/m^2). Atteindre une échelle intermédiaire (500 km) pendant la SOP est une priorité pour l'assimilation et les travaux utilisant la modélisation (bilans d'eau et processus). Il faudrait donc conserver le 2nd transect méridien (Tamale, Ouagadougou, Tombouctou). Dans cette configuration, on n'accède plus aux études sur la brise de mer (Cotonou), ni aux contraintes de bilan d'eau sur les sommets du quadrilatère, toutefois le centre du quadrilatère est conservé ce qui apporte tout de même une contrainte majeure sur le bilan d'eau. Cette restriction du réseau permet aussi de conserver les sites les plus accessibles. Ces trois stations GPS proviendront du parc INSU. Le coût en équipement sera donc beaucoup plus faible. Toutefois, les contraintes de transmission de données et de traitement sont les mêmes, avec éventuellement la nécessité de fournir des produits vapeur d'eau en temps quasi-réel (12h), s'il est jugé utile d'en disposer pour l'organisation de la campagne (vérification des prévisions et programmation des vols avion).

4.2.2.6.b Report on 2004 activities

1) Pré-étude GPS en Afrique

Une pré-étude a été menée en collaboration (groupe GPS : SA, IGN, LGIT, LDL) sur le potentiel du GPS en Afrique. Les points traités sont les suivants :

- Evaluation de la disponibilité et qualité des données GPS des stations existantes (période 2001-2004)

- Etude des problèmes potentiels liés à l'activité ionosphérique en AO
- Etude de la précision des produits vapeur d'eau GPS en AO (validation interne GPS, comparaisons avec des analyses ERA40 et avec des observations par radiosondage).
- Analyse préliminaire du cycle diurne de la vapeur d'eau

Les principaux résultats sont résumés ici :

- Disponibilité et qualité des données :
  - Seules quelques stations (25%) fonctionnent de manière continue sur le long terme, essentiellement les stations bénéficiant d'un soutien logistique et financier extérieur (CNES, ESA, JPL) et de personnels actifs et impliqués sur place.
  - Les problèmes rencontrés sont essentiellement logistiques (télécommunications) et des pannes matérielles (récepteurs GPS), sans que l'origine des pannes soit très claire.
- Activité ionosphérique :
  - L'activité ionosphérique est particulièrement intense dans cette région, induisant des gradients très intenses de contenu en électrons (TEC) qui peuvent engendrer des variations importantes dans les délais de propagation des signaux GPS et des effets de scintillation. Peu d'études ont considéré l'effet de ces phénomènes pour l'exploitation à précision géodésique des données GPS. Les modèles standards utilisés pour le traitement GPS peuvent encore être améliorés pour cette région.
  - La scintillation provoque une perte de données sur la fréquence L2 généralement en début de nuit. Cet effet a été évalué à 2 % typiquement pour l'année 2001, avec des pointes à 8% lors d'orages magnétiques. Malgré cette perte partielle de données, le traitement GPS permet de restituer des produits vapeur d'eau en continu avec une résolution de 1h.
  - Il faut noter que l'activité solaire était maximale en 2001, alors qu'elle sera minimale en 2006-2007 (cycle de 11 ans).

- Précision des produits GPS :
  - La validation interne sur les positions des stations et les résidus post-traitement, indique une précision comparable aux stations à mi-latitude (répétitivité en position sur les composantes Nord : 3mm, Est : 4mm, Verticale : 6 à 7mm).
  - La comparaison avec des analyses ERA40 indique une dispersion de 3kg/m^2 et des biais résiduels de –2 à +4kg/m^2. Ces résultats comparables à ceux trouvés dans d'autres études (p.ex. campagne MAP, Bock et al., 2004).
  - La comparaison avec des observations par radiosondage donne des résultats similaires (biais de 2.5 à 4kg/m^2 et dispersion de 3 à 4kg/m^2).

- Analyse préliminaire du cycle diurne de la vapeur d'eau: cette première analyse (menée à partir des stations côtières du réseau existant, entre 2001 et 2004) a permis d'observer une modulation annuelle très forte du contenu intégré de vapeur d'eau (passant de 15 kg m^{-2} en hiver à 60 kg m^{-2} en été), avec des fluctuations intra-saisonnières très intenses (passant de 30 à 60 kg m^{-2} en quelques jours au niveau de Dakar et du Cap Vert). Plusieurs modes de variabilité à plus courte échelle sont également visibles : cycle diurne et périodes de 5 à 10 jours (particulièrement marqués à Dakar et à Yamoussoukro).

2) Campagne VAPIC : L'expérience VAPIC, conduite au SIRTA/IPSL du 15 mai au 15 juin 2004 a permis de recueillir une quantité importante de données à partir d'un ensemble d'instruments de télédétection au sol (principalement de vapeur d'eau). Les principaux objectifs de cette campagne sont de préparer la méthodologie d'exploitation multi-instruments de sondage de la vapeur d'eau (sol et spatiale) pour AMMA. Une description plus détaillée de cette experience et des objectifs est donnée dans le WP4.1.1.

3) Préparation du projet d'implémentation GPS pour l'EOP et la SOP : Ce travail a été réalisé en collaboration avec les responsables des différents groupes de travail pour adapter le système

d'observation aux objectifs scientifiques (WP1.1, WP1.2, WP2.1), tenir compte des contraintes logistiques du terrain (WP4.2.2 et WP4.2.3) et préparer la méthodologie d'exploitation des données GPS et autres instruments (WP4.1.1 et WP4.3). Une première prise de contact avec les instituts africains a été faite. Elle sera poursuivi lors des visites de reconnaissance (novembre 2004 pour le Bénin, le Niger et le Mali ; et début 2005 pour les autres pays concernés par le déploiement lors de la SOP).
Il faut noter que deux solutions sont proposées :
- **une solution « optimale »** mettant en œuvre 4 stations permanentes dans le cadre de l'EOP (dont 1 financée sur un programme international de géodésie) et 5 stations temporaires pour la SOP.
- **une version « minimale »** mettant en œuvre 3 stations permanentes dans le cadre de l'EOP et 3 stations temporaires pour la SOP. Cette version permet de réduire le budget d'environ 40 %.
Un résumé pour les aspects SOP et EOP est disponible sur les fiches instruments, avec un budget détaillé pour la version optimale. Les résultats des travaux de 2004 sont décrits plus en détail dans le document sur la « Description de la stratégie d'implémentation GPS : EOP et SOP » (O. Bock et M.N. Bouin). Ce document inclus également le détail du budget de la version minimale.

4.2.2.6.c 1 year plan

(NB: ces travaux servent WP4.2.2 et WP4.2.3, mais les ETP n'ont pas été comptés deux fois !)

Le programme 2005 s'inscrit dans la continuité des travaux réalisés en 2004 :

- Poursuite de l'analyse du cycle diurne de la vapeur d'eau à partir des observations existantes et des premières observations recueillies dans le cadre de l'EOP (dès que les stations permanentes retenues seront installées).
- Travaux méthodologiques :
  - intercomparaisons de contenus intégrés et de profils de vapeur d'eau mesurés depuis le sol et par satellites à partir de la campagne VAPIC et en parallèle sur le domaine AMMA pour les années 1999-2004 (voire 2005).
  - Validation de modèles météorologiques (analyses opérationnelles et réanalyses), également en parallèle sur VAPIC et AMMA.
  - Participation aux travaux d'assimilation avec MANDOPAS et les modèles du CNRM (3Dvar Aladin/Arome.
- Mise en place du réseau EOP
- Préparation du réseau SOP

4.2.2.7 Field Mill Network

Coordinator : S. Soula

Laboratories : LA

4.2.2.7.a 5 year plan

Objectives

The electrical nature of the clouds is linked to a series of processes which start with the charge transfer between cloud particles. The charge is then neutralized or carried out of the cloud by lightning flashes, by the precipitation or by the cloud dynamics. The relation between microphysics and lightning activity is one of the main questions for the understanding of the physical processes in the charge generation. The lightning activity is also a parameter which can help to characterize other components of the meteorological mechanisms, especially the precipitation amount for a given area (Tapia et al., 1998) and the NOx produced by lightning (Levy et al, 1996).

Several works showed the results which can be obtained by associating polarimetric radar data and lightning detection in the characterization of the relation between microphysics and lightning activity (Seity et al., 2003).

The AMMA SOP can allow to perform and to associate different observations concerning the thunderstorm activity. The LA proposes the installation of several stations for electrical parameters measurements. Several objectives can be directly aimed:

- The knowledge of the relations between the lightning activity and the microphysics of the convective system can be improved. Different radars (X and C bands) with polarimetric techniques will be able to describe the cloud particle content.
- An aspect of the AMMA project is the hydrology associated with the African monsoon. The determination of the relationship between precipitation and lightning activity constitutes an interesting objective.
- During the AMMA experiment a network will work on Africa territory for the cloud-to-ground flash detection and localization by using the arrival-time-difference technique in the VLF range (type of the British ATD system for spherics). The association of a local network of stations for the electric field evolution will allow an evaluation of the efficiency of this system. Another lightning detection system in the LF range (for cloud-to-ground flashes) will be installed by the DLR with the objective of the LNOx estimation. Our electric field measurement will be an interesting complement for this system also in term of estimation of the total lightning flash rate.
- Another scientific interest for a field mill network is expressed by the chemistry community of AMMA. One central scientific objective for the chemistry part of AMMA is to assess the budget of NOx over the west african region and how this budget is perturbed by the convective activity. Among the sources of NOx in West Africa, the biogenic soil emissions in the boundary layer and the production of NOx by lightning in the upper troposphere are supposed to be the most important. However, large uncertainties still prevail on the intensity of these NOx sources. A particular effort will be dedicated to the quantification of the soils emissions during the SOP with field observations in Benin. An instrumented van will be located in Djougou (Ouémé basin) to measure the flux of NOx and the NOx concentrations near the surface. A field mill instrument located at or near Djougou will provide complementary information on lightning activity and location. This local scale information although not sufficient to constrain the actual lightning NOx parameterisations represents the unique data set to contrast the lightning intensity of the different mesoscale convective systems that will be sampled by the aircrafts. A network of two or three additional field mills will allow to follow the convective systems during 1 or 2 hours and to relate the aging of NOx in the airmasses sampled by the aircrafts to the evolution of the lightning intensity.
- It must be outlined that DLR (Germany, resp. Th. Fehr) plans to bring a six station LF network, capable to detect cloud-to-ground lightning and to a certain extent intracloud flashes. First results with the University of Munich network indicate that the sensitivity of the system is higher than for the operational detection system (based on Vaisala sensors) that covers Germany at present. Their plan in the moment is to set up the system co-located with the RONSARD, X-Port radar and bi-static receivers (DLR, resp. M. Hagen). The combination of the field mills and the precipitation current measurements with the LA system will give good idea on the electrical state of the (radar-)observed storms.

Description of Work

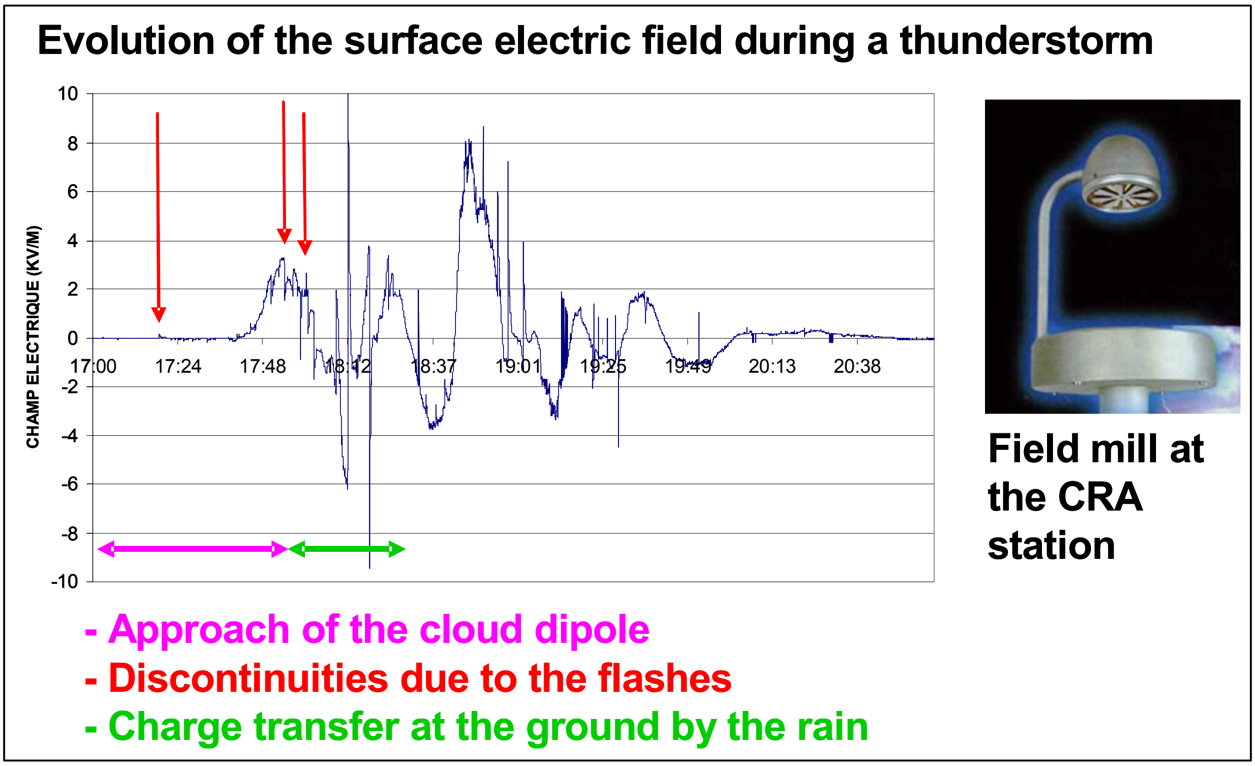
The main parameter provided by the surface stations proposed will be the electric field. The evolution of this parameter during the lifetime of the convective system can allow identify several processes, especially the lightning flashes. The flashes produce electric field discontinuities by suddenly modifying the cloud charge structure, for both flash types cloud-to-ground and intracloud (figure below). The time resolution to evaluate these discontinuities can be of the order of 1 s. The amplitude of the discontinuity depends on the distance and of the amount of the charge or the charges (according the type of flash) neutralized by the flash. The observations made at the CRA clearly show that the lightning discontinuities can be detected at distances up to 30 km from the charge neutralized. So, the electric field evolutions can provide the lightning flash rate for a thunderstorm in a radius of this distance. Five stations will be installed on an axis between Parakou and Djougou (Bénin) with an orientation close to an East-West direction, the probable displacement direction of the convective systems. The distance between each of these stations will be around 25 km. Thus, the lightning activity of a system could be followed during a couple of hours. Furthermore, at each station the precipitation current will be recorded with a specific equipment. The charge carried by the rain will be analyzed in relation with the electric field evolution in order to evaluate its role in the charge transfer.

The knowledge of the lightning activity characteristics is a key question for the LNOx estimation :

- The flash rate
- The global location of the flashes in the convective system
- The type of the flash (ratio intra-cloud cloud-to-ground)
- The evolution of the lightning activity in the storm lifetime

By associating these different parameters obtained by combining the field mill measurements and the other lightning detection systems with the NOx measurements, with the convective system dynamics description, some features of the NOx production by the lightning flashes can be pointed out.

For the time synchronization between each station and with other observations, a GPS device will equip each recording system. The installation of the stations will be possible at local meteorological stations when they exist because the area required is not very large, and it is probable that some stations will require local power supply development.



- T0 + 12 months : preparation of the stations
- T0 + 18 months : Test of the stations at the CRA
- T0 + 21 months : DATA analysis of the pre-campaign
- T0 + 24 months : participation in SOP

- T0 + 30 months : delivery to data base

4.2.2.7.b Report on 2004 activities

This scientific project had not started yet in 2004.

4.2.2.7.c 1 year plan

The instrumental activities in 2005 will be mostly to prepare the stations (if this project is funded).