4.2.3 : Field Campaigns: EOP-LOP

Laboratoires: CESBIO, CETP, CNRM, DOPS, DRO, ELICO, CETP, HSM, IGN, LA,LAPA, LAREG, LBCM, LCME, LDL, LEGOS, LEM,LERMA, LGIT, LISA, LMTG, LOA, LODYC, LSCE, LTHE, SA, USMM
Coordinators: T. Lebel (LTHE), S. Janicot (LODYC), C. Liousse (LA), B. BOURLES (LEGOS)

Overall strategy (written in French)

Temporelle : le phasage général de AMMA décrit en introduction de la section 4.2 correspond au minimum indispensable pour i) des études fines du cycle saisonnier et de la variabilité interannuelle (les trois années EOP), ii) réaliser un éventail plus large de conditions climatiques et les réponses lentes du système couplé en se concentrant sur les variables les plus facilement accessibles (les années d'encadrement de l'EOP).
Spatiale : une fois les périodes d'observation fixées, la stratégie spatiale est fortement contrainte par les aspects humains, matériels et opérationnels. Des requis minimums ont été établis sur une base disciplinaire, puis une stratégie d'ensemble s'est construite progressivement en fonction des financements envisagés. Malgré des avancées importantes réalisées en 2004 (financements API, IP, NERC), il ne sera pas possible de réaliser un échantillonnage homogène sur tous les sites de méso-échelle, ni de déployer tous les capteurs en théorie accessibles, ceci avant tout pour des raisons de ressources humaines mobilisables.

i) Dispositif à l'échelle régionale

Elle est couverte i) par deux réseaux régionaux (Radio-sondages et GPS) ; ii) par un ensemble de fenêtres sous-régionales inégalement instrumentées. L'observation satellitaire constitue un complément indispensable pour compenser ces hétérogénéités et pour fournir des informations sur les zones non couvertes par les fenêtres sous-régionales. L'utilisation conjointe des données sol localement denses et des données satellitaires à couverture régionale permettra de valider certains produits (par exemple les produits pluie de type *CMAP*, *GPCC* ou les produits aérosols de type *Infrared Difference Dust Index* – IDDI – de METEOSAT ou *Aerosol Index* – AI – de TOMS…) ou de développer de nouveaux algorithmes.
La modélisation régionale : modèles de climat régionaux proposés par les allemands, MM5, MAR couplé ; modèle de végétation du CESBIO ; modèle de transport d'aérosols ; modèle de simulation de champs de pluie.

Liste des instruments :

- ***le réseau de radio-sondages*** est équipé et financé par diverses sources (les stations en gras-italique sont les stations ***GCOS***)
  - réseau opérationnel opéré et financé par ASECNA, avec renforcement des sondages sur financement UE-IP durant la SOP : ***Abidjan***, ***Niamey***, Agadez, Bamako, Dakar, ***Douala***, N'Djamena, Tessalit, Tombouctou, ***Sal***,
  - stations à créeer ou ré-équiper sur crédits UE-IP : Mina (Nigéria), Tamale (Ghana)
  - station créée sur crédit ACI Climat (F) : Cotonou
  - station créée par le projet Allemand IMPETUS : Parakou et fonctionnement payé sur IP
  - stations à l'accès encore incertain : ***Tamanrasset*** (Météorologie Algérienne) et Conakry (la station a existé mais ne fonctionne plus).
  - Outre la couverture régionale qu'elles assurent, ces **16 stations** sont réparties en différents groupements sous-régionaux décrits en section suivante.
  - Quatre autres points de sondage seront disponibles en SOP : deux sur l'océan à bord du Ron Brown et de l'Atalante ; deux sur le continent (stations mobiles ISS, liées à SPOL, sur les sites de Tahoua et Gao)

- Quatre autres stations (Man, Ouagadougou, Sarh, Tambacounda) appartiennent à la zone d'étude mais ont été classées en priorité 2
- Stations des pays périphériques (Nouakchott au Nord-Ouest, Bangui et Brazaville au Sud-Est, stations d'Afrique de l'Est)
- L'ensemble de ces éléments est récapitulé dans le tableau 1 en fin de cette chapitre.

- ***le réseau de GPS*** s'appuie sur le réseau IGS déjà en place (Dakar, Yamassoukro, Tamanrasset, Libreville). Il est proposé d'ajouter trois stations sur les sites de Djougou (financement API), Niamey (financement ST), Gao (financement API).
- ***les réseaux opérationnels*** : synoptiques, pluviométriques, hydrométriques ;

Priorités / Calendrier

Pour le réseau de radio-sondages, des priorités ont été définies dans la stratégie de remise à niveau du réseau de radiosondages, d'une part dans le contexte de base EOP (1 radiosondage par jour de Mars 2005 à Octobre 2007, 2 radiosondages par jour de Mars 2006 à Octobre 2006), d'autre part dans le contexte intensif SOP (Mai à Septembre 2006). Tout d'abord des priorités ont été définies sur le choix des stations elles-mêmes dans le cadre du projet international AMMA d'une part (dont les 16 stations P1), dans le cadre du projet européen AMMA_IP d'autre part (dont 11 stations P1). Ces priorités croisent en partie seulement le réseau des stations gérées par l'ASECNA. On indique aussi dans le tableau 1 les stations appartenant au réseau GCOS. On indique ensuite le niveau d'équipement sol des stations (MW11 –Digicora I - et MW15 – Digicora II - de Vaisala, STAR de Degreane). Concernant les stations gérées par l'ASECNA, la stratégie de l'ASECNA est de remplacer les stations MW11 par des stations MW15 « rétrofitée » pour suivre les nouvelles sondes RS92, de rétrofiter les stations MW15 pour suivre les sondes RS92, et de remplacer les stations STAR par de nouveaux équipements à définir. Le calendrier proposé par le ARG (AMMA Radiosounding Group) pour la remise à niveau du réseau de radiosondages est le suivant :

Priorités immédiates :

- Mars 2005 : Remise à niveau du réseau de télécommunication sur le réseau existant pour assurer le transfert sur le GTS de tout ce qui fonctionne (financement IP)

- Mai 2005 : Installation des nouvelles stations Cotonou (financement ACI_FNS de 220 K€), Tamale (financement IP) et Parakou (créée par le projet IMPETUS, financement IP) ; activation d'une nouvelle station à Minna (financement IP)

Priorités suivantes : Fin 2005

- Remplacement des stations existantes MW11 par stations MW15 rétrofitées sur le réseau ASECNA (financement IP et ASECNA)
- Rétrofit des stations existantes MW15 sur le réseau ASECNA (financement IP et ASECNA)
- Remplacement des stations STAR (financement IP et ASECNA)
- Formation des opérateurs sur le suivi des RS92 (financement IP).

Le financement IP est de l'ordre de 2 M€. On compte sur un démarrage de AMMA_IP au 1er Janvier 2005. Les financements IP seront orientés suivant les priorités P1/P2 définies. Cependant pour Dakar (site proche de la Direction de l'ASECNA) et Niamey (proche de l'EAMAC), l'objectif est de remplacer ces stations plus tôt (Mars 2005 si possible).

Problèmes à traiter

- Le calendrier GCOS est incertain, ce qui pose problème notamment pour la station d'Abidjan qui doit être remise en état (la situation politique en Côte d'Ivoire ne va pas non plus faciliter les choses).
- Le FSP/MAE RIPICESA doit apporter 450 K€ pour le réseau de radiosondages ; cependant là aussi, les incertitudes sur la mise en place de ce projet, prévue initialement avant la fin

2004, sont non négligeables. Enfin des financements nationaux (NERC, US) sont prévus et consacrés aux phases intensives de la SOP.

- La potentialité de remise à niveau du réseau dépend des coûts des équipements qui seront proposés par les fournisseurs sélectionnés. Actuellement ceci est encore flou et dépendra aussi de la stratégie appliquée en termes d'appels d'offres : par exemple, Vaisala proposerait a priori des prix moins élevés à l'ASECNA qu'à AMMA_IP, mais les procédures d'appel d'offres passant par l'ASECNA risquent de prendre plus de temps.
- accès aux données des réseaux opérationnels pas encore totalement acquis pour toutes les données (à préciser dans le cadre du projet européen, notamment).

ii) Dispositifs sous-régionaux

Cinq dispositifs régionaux, décrits en section 1 (voir aussi carte), ont été formés, dont quatre concernent l'EOP. Chacun de ces sous-domaines correspond à l'étude d'une catégorie de problèmes.

Les domaines d'étude :

- le domaine océanique, principalement le Golfe de Guinée, (en EOP campagnes bi-annuelles EGEE avec le Suroît en 2005 et l'Atalante en 2006-SOP1, et données LOP des ORE et du réseau de marégraphes : instruments EF 11 à EF13 et LF10 à LF14)
- l'hexagone échantillonnant le gradient climatique est centré sur l'étude du cycle saisonnier de la mousson, des rétro-actions et des effets-mémoires ; les radio-sondages (instruments européens avec participation française), le réseau GPS (AE.GPS_1) et les stations de mesure de flux (AE.Flux_G, AE.Flux_Ncw, AE.Flux_O) viennent en appui de ces études ;
- le quadrilatère bilans d'eau (AE.RS_Q1, et tous les instruments du sites de méso-échelle de l'Ouémé) est centré sur l'étude de la fermeture des bilans d'eau et des rétro-actions continent-atmosphère;
- le transect sahélien est dédié aux études de transport d'aérosols (AE.Dust_ST) et de la variabilité saisonnière de ce transport ainsi qu'aux liens entre la convection et le JEA, ainsi qu'à l'étude de la dynamique des systèmes convectifs.

Les liens avec la modélisation

Pour le domaine océanique, des modèles numériques de grande échelle spatio-temporelle (CLIPPER) permettront de conditionner aux frontières des modèles régionaux de plus fines échelles, développés notamment dans le Golfe de Guinée.

Le quadrilatère bilans d'eau définit une zone privilégiée pour l'étude du couplage entre les modèles atmosphériques à aire limitée et les modèles hydrologiques régionaux, type POWER.

Le transect sahélien formé par les trois stations aérosols terrigènes, serviront à valider le modèle émission-transport-dépôt *CHIMERE Dust*.

Compléments à envisager et/ou priorités

- Voir ci-dessous *questions à traiter*.

Priorités en cas de restriction ou de disponibilité tardive des fonds

- En ce qui concerne le réseau de GPS, deux scénarii ont été envisagés. Un scénario complet incluant une station à Conakry a été placé en priorité 2, compte tenu de son coût et malgré son intérêt, compte tenu des incertitudes sur la station de radio-sondage. Le transect retenu (Djougou, Niamey, Gao) met l'accent sur la documentation des variations de vapeur d'eau intégrée en relation avec la dynamique du flux du mousson et du JEA (présence prévue du radar VHF du CNRM et envisagée du lidar allemand en co-localisation à Djougou).

Questions à traiter

- Stratégie réseau sous-régional pour les ***stations de flux***. La mesure des flux de surface a fait l'objet d'un financement dans le cadre de l'IP et d'un projet britannique financé par le NERC. Six stations de flux chaleur sensible + rapport de Bowen et trois stations H2O/CO2

seront acquises sur ces crédits. L'objectif est de disposer du même nombre de stations H2O/CO2 que de stations *chaleur sensible*. A cette fin il est prévu d'installer une station H2O/CO2 du réseau CLASSIC sur le site du Gourma et d'acquérir deux stations sur les crédits API pour être installée une sur le super-site de Banizoumbou (Niger) et l'autre sur le super-site de la Donga (Bénin). Les données stations de flux, outre leur intérêt pour des études locales de bilan hydrique et de couplage seront utilisées pour les WPs 1.1, 1.2 et 1.3. La stratégie d'échantillonnage souhaitée diffère pour le WP 1.1 (gradients régionaux d'énergie statique humide, donc répartition sur un transect méridien) et pour le WP 1.2 (fermeture des bilans à la méso-échelle, avec nécessité d'échantillonner les couverts végétaux représentatifs d'une zone donnée). Une stratégie de compromis serait d'installer trois stations sur chaque site de méso-échelle et de répartir les trois stations restantes au Sud (2: Lamto ? et site de GLOWA_VOLTA) et au Nord (1 station à Tessalit, 20°N).

- La disponibilité du ***radar VHF*** du CNRM en 2005 est peu probable, compte tenu de son emploi sur un autre projet. L'intérêt d'un tel outil capable de documenter en continu les variations de profils de vent et d'humidité (moyennant un nouvel algorithme développé au CNRM) est indéniable, surtout en co-localisation avec le GPS et une station de radio-sondage. Une incertitude demeure néanmoins sur la faisabilité d'une préparation en temps voulu pour cet instrument, des travaux étant à réaliser pour pouvoir l'amener au Bénin.
- L'intégration de la stratégie EOP au niveau européen reste à faire, en particulier pour ce qui concerne cette échelle sous-régionale (prise en compte des mesures sur les sites de GLOWA-VOLTA).

iii) Les sites de méso-échelle et les super-sites

Les mesures des trois sites de méso-échelle principaux présentés en 1.2.3, seront complétées par celles de nos collègues européens du projet GLOWA-VOLTA et Burkinabais sur le bassin du Niakambé (super-sites de TITAO et DANO, voir tableau des super-sites dans la partie introductive de la section 4.2).

La stratégie générale

Les sites de méso-échelle sont répartis le long du gradient climatique pour permettre une intégration régionale via les mesures satellitales et la modélisation. Il manque un site au sud de 7°N pour que l'ensemble du gradient soit bien documenté, d'autant que sur cette zone la couverture nuageuse rend moins efficace l'imagerie satellitaire.

Les sites de méso-échelle sont documentés par deux types d'instruments. D'une part on dispose de réseaux réalisant un échantillonnage homogène (pour la pluie par exemple les réseaux de pluviographes CL.Rain_G, CL.Rain_N, CL.Rain_O). D'autre part, lorsqu'un tel échantillonnage n'est pas réalisable on identifie des sous-zones qui vont être intrumentées plus densément : ce sont soit les super-sites dont la liste est donnée dans la table 7, soit des versants ou des groupes fonctionnels. Cette instrumentation plus serrée sur des sites qui correspondent aux principaux « hydro-écosystèmes » d'un site de méso-échelle donné vise à permettre l'identification des paramètres des modèles couplés hydrologie-végétation qui seront ensuite utilisés dans les modèles de plus grande échelle. Ces sites sont également les lieux privilégiés de la validation satellitaire.

Sur chaque site de méso-échelle, l'accent a été mis en phase préliminaire sur l'homogénéisation des mesures hydrologiques (pluie, écoulements, nappes) et de végétation (identification des groupes fonctionnels). Pour l'EOP, l'objectif est l'instrumentation en mesures de flux de surface (voir section précédente) et en mesures de dynamique de la végétation à l'échelle d'un groupe fonctionnel (mesure d'indice foliaire et mesure des échanges gazeux à l'échelle des feuilles).

Dans le domaine de la chimie et des aérosols, les sites de méso-échelles serviront de base à l'étude de la caractérisation des mélanges d'aérosols (aérosols désertiques, aérosols carbonés, sulfate, embruns marins, aérosols de pollution) et de la variabilité saisonnière de la composition chimique et des propriétés radiatives de ces mélanges. Les sites de Cotonou et Djougou au Bénin sont les sites

privilégiés pour observer les variations saisonnières de l'ozone et du monoxyde de carbone pendant l'EOP.
On disposera ainsi d'un ensemble unique de mesures co-localisées atmosphériques (incluant les GPS et les radars sur le site de l'Ouémé), hydrologiques, de végétation et de chimie-aérosols. Ceci permettra de mettre en œuvre le modèle climatique régional RegCM3 pour réaliser des simulations sur toute la période de l'EOP et des tests de sensibilité aux émissions pour les espèces gazeuses et mélanges d'aérosols à l'échelle régionale. Les mesures à haute résolution des champs pluviométriques permettront de développer des algorithmes de désagrégation pour forcer les modèles hydrologiques à partir des modèles climatiques, comme cela est en cours de test sur la région de Niamey, grâce au suivi réalisé depuis bientôt quinze ans (Onibon et al., 2004).

Compléments à envisager et/ou priorités

Toutes les mesures d'appui aux WP 2.3.3 (intégration régionale via paramétrisation adéquate des modèles de surface) et 4.1.2 (intercomparaison et validation des modèles de surface) sont prioritaires, les mesures d'appui aux WPs 2.3.1, 2.3.2 et 2.4 étant maintenant bien en place ou sur le point de l'être. Les opérations suivantes, encore dépourvues de financement dans le cadre des programmes ECCO, sont donc prioritaires :

- Suivi de la végétation (LAI, Flux de sève, échange gazeux à l'échelle des feuilles) sur le bassin de la Donga.
- Campagnes de scintillométrie (scintillomètre du LTHE disponible pour l'Ouémé ; disponibilité du scintillomètre du CESBIO sur le Gourma à préciser).
- Campagnes ciblées de validation de missions satellitaires (voir WP 4.3) pour l'humidité des sols et la végétation.
- Campagnes complémentaires pour le suivi de l'eau profonde, dont la dynamique, sur le bassin de l'Ouémé tout du moins, joue un rôle dans les écoulements de surface. Mise en œuvre de la RMP (résonance magnétique protonique).

Problèmes à traiter

- A défaut de disposer d'un véritable site de méso-échelle dans la partie sud du domaine d'étude, il était envisagé de relancer les mesures sur le site de Lamto (végétation, flux, bilan hydrique local). Les conditions politiques rendent difficilement envisageables cette action. Des sites de rechange vont être explorés dans le sud du Bénin (P1) ou sur le bassin de la Volta (P2).
- Il existe encore une certaine hétérogénéité entre les trois principaux sites de méso-échelle. Sur le site du Gourma, les mesures hydrologiques sont limitées au suivi d'une mare et ne semblent pas pouvoir être intensifiées par manque de personnel disponible et compte tenu des coûts générés par l'éloignement du site. Sur le site de l'Ouémé le suivi de la végétation devrait être du niveau de celui réalisé sur les deux autres sites mais, là aussi, les forces manquent.
- Les sites de méso-échelle, et surtout les super-sites, concentrent des capteurs dont l'installation et la maintenance sont souvent délicates. Sur chacun de ces sites un support logistique de base existe puisqu'ils sont suivis depuis plusieurs années dans le cadre des ORE. L'intensification des mesures va néanmoins nécessiter une logistique accrue. Des visites de terrain vont avoir lieu en novembre et décembre 2004 pour définir les besoins et la manière de les satisfaire.

4.2.3a 5 year plan

Objectives

This WP will ensure the data provision throughout the AMMA project for the study of the inter-annual variability of the WAM, the associated processes and impacts. To do so it is necessary to provide a detailed documentation of ground sites (e.g. catchments, local sites) and to ensure a coherent deployment of instruments during the long term and enhanced observing periods. The strategy consists of the LOP long-term monitoring (2001-2009) while EOP will complement and enhance the operational measurements carried out by national services during the period 2005-2007. This WP will also ensure the coherency between the EOP activities and the SOP deployment (in terms of observing strategy, site coordination, logistics). The observations concerned by this workpackage are specific to AMMA (that is, they to not include the observations carried out by operational national services). The list of observations is given in the *LOP_EOP instrumentation table* in the appendix. The EOP-LOP sites are designed so as to cover the array of scales needed to document in order to address the core scientific questions of AMMA.

Regional scale:

- an enhanced radiosounding network (see map) organized along three zonal transects (Saharan axis, Sahelian band, southern coast), one meridional transect, and a quadrilateral for water budget computation, to better document some of the key-element of the WAM dynamics:
    - the Saharan heat low dynamics,
    - the southerly monsoon entrance along the southern coast of West Africa,
    - the northeasterly inflow coming from the Mediterranean sea area and the dry intrusion domain
    - the interactions between synoptic scale easterly waves and mesoscale convective systems along the Sahelian transect
    - the meridional excursion of the whole atmospheric monsoon system
    - the water budget in an area located in the middle of the latitude range of the seasonal monsoon cycle
- a meridional transect for the monitoring of emission, transport and (wet and dry) deposition of atmospheric chemical species and burning aerosols, and address the specific objectives:
    - to provide the climatology of ozone and CO vertical profiles over West Africa (see WP1.1)
    - to quantify the climatic impact (1) on regional scale of mixed aerosols over West Africa (zoom on secondary aerosol formation and transport from anthropogenic and biogenic origins), of deposition, and of major West African cities, (2) and of black carbon emission and mixed aerosols over West Africa on global climate
    - to construct inventories of (1) biogenic emission of NOx and COVs from soil and vegetation over West Africa, (2) biomass burning for gases and particles (including savanna and forest fires, domestic and agricultural fires, (3) fossil fuel for gases and aerosols
- a Sahelian transect to focus on mineral dust emission, transport and deposition along the year to address the specific objectives:
    - to compute the mass and composition budget (emission/deposition) of mineral dust
    - to determine factors which control seasonal and interannual variability, and discriminate the role of precipitation, vegetation development, and dynamical conditions

- the EGEE program (two oceanographic campaigns per year (2005-2007) in spring and fall in the Guinea gulf), associated with the long-term ORE-PIRATA array, ORE-SSS, oceanographic R/V and merchant ships transits, meteorological measurements (Sao Tome met station), release of PROVOR profilers and SVP buoys (ARGO-CORIOLIS program), to study from decadal to intra-seasonal timescales :
    - the oceanic circulation in the upper layers and its variability
    - the related variability of the interactions at the ocean-atmosphere interface
    - focusing at the set-up of both the African monsoon and the equatorial upwelling during spring
- the implementation of GPS sites are examined to provide complementary continuous high-frequency measurements of water vapour with
    - a monitoring along the meridional axis in the CATCH window with 3 or 4 GPS of the integrated moisture content in the troposphere from intra-diurnal to seasonal time scale, associated with the fluctuations of the ITF, heat low dynamics and monsoon surges
    - a monitoring of meridional gradients of integrated moisture associated with the different steps of the monsoon and especially the abrupt shift of the monsoon onset

Mesoscale

- three mesoscale sites (Gourma in Mali, Niamey degree square in Niger, Ouémé catchment in Bénin), are designed to sample the meridional gradients in climate and vegetation. The focus of these sites in on the continental water budget and the vegetation dynamics. A long term monitoring started in 2001 and will last until 2009
    - monitoring of the intraseasonal and interannual variability of the water budget (P, Q, I, E) at the mesoscale, in connection with the intraseasonal variability of the rainfall signal at the regional scale, using dense networks of raingauges, streamflow and water table recording stations, associated with meteorological stations and flux measurement stations (see maps);
    - documentation of the spatial patterns of the rainfields from the convective to the mesoscale witht the aim of linking these patterns to the regional atmospheric circulation;
    - observation of the vegetation dynamics to study its link with the water cycle and to be used as calibration/validation data for satellite monitoring of the environment;
- operational radars (Abidjan and Niamey, needing an important retooling and upgrade; newly installed radar at Ouagadougou and the soon to be installed S band radar at Linguere North-East of Dakar) are a potential help for monitoring the cycle of the rainy systems and the associated rain characteristics;
    - to gain a better knowledge of the life cycle of MCS's in the region;
    - to obtain a better documentation of the fine structures of the associated rainfields.

Convective scale and local scale based on supersites and intensive local sites

One main supersite exists on each mesoscale site (Hombori in Mali, Kori de Dantiandou in Niger, the Donga watershed in Benin) and each of these include one or several intensice local sites equipped

- to study of the local water cycle, with an emphasis on the link between soil moisture dynamics, runoff generation and vegetation dynamics;
- integration of the water balance over small catchments (Wankama - 2 km² - in Niger, Ara - 5 km² - in Benin);
- the X-port radar, associated with optical disdrometer measurements, will provide accurate maps of precipitation above the Donga catchment for hydrological applications, as well as useful insights of the physical processes governing the precipitation systems

- to analyse the regulating factors of the wet and dry deposition, especially linking to the vegetation dynamics
- to provide local in situ data for the construction inventories at the regional scale (see above)

Other measurements document regional/synoptic atmospheric structures with local observations looking at the interactions between these structures at the mesoscale. The high temporal frequency of these measurements provides a link with the synoptic scale. It is thus difficult to attribute a precise spatial scale to these measurements. A sodar/UHF/VHF profilers system will be installed at Djougou/Parakou to provide complementary continuous high-frequency time and scale measurements of:

- the atmospheric boundary layer and its interaction with the easterly waves and the AEJ
- the intra-diurnal to seasonal fluctuations of the Inter-Tropical Front (ITF)
- the role of gravity waves with period from hour up to several days in the energy budget and momentum transport

All these site implementations are envisaged also by taking into account the availability of permanent local staff necessary to maintain the instrumentation working well over the long-term period. While LOP measurements are for the most part funded by national contributions to existing projects (CATCH, EGEE, GLOWA-Volta, IDAF, IMPETUS, PHOTONS-Aeronet), and a part of EOP should be funded by AMMA_IP, other EOP instruments need additional funding from this API_AMMA.

Work content

In 2005, the Enhanced Observing Period (EOP) will start with the aim of increasing the time and space resolutions of the various measurements. The coordination of the institutions – European and African – managing this large array of measurements is a major task of the workpackage. For instance, the climatic and vegetation gradients must be appropriately sampled in a coherent way (same kind of sensors and sampling protocols). This coordination will take place through meetings in Europe and field trips to Africa. Training of African scientists and technicians is a very important component of the activity of the teams involved in LOP_EOP. A large meeting will be organized in early 2005 to ensure a good planning of operations.

Regional scale:

- Upgrading the **radiosounding network** (see map in Figure 1)

An upgraded radiosounding network is an essential component of the EOP and SOP field experiments. An international working group has been addressing this issue for one year (see the on-going actions in the one-year plan). The objective is to get a good level of information of (often) ill-documented key-areas for the WAM dynamics (see the objectives at the beginning of the 5-year plan). A list of stations is given in Table 1 at the end of this section 4.23. We got funds from the ACI_Climat, we should get funds from the FSP/MAE, and the AMMA_IP should be funded too. Some of these stations can be put on priority 2 if necessary (Bangui, Conakry, Ouagadougou). We worked on the estimation of the needs following the statistics of ECMWF, and we are in discussion with ASECNA to get more local information about the difficulties encountered by the national met services. We worked also on the price levels for stations and consumables during the AMMA_IP discussions with VAISALA. We are now working on defining a MOU with ASECNA for the definition of the implementation plan. One problem is that VAISALA decided to stop the production of RS80 sondes, largely used in Africa, and proposed to us in the AMMA_IP to use RS92SGP sondes. The issue has been discussed with ASECNA and we plan to come to an agreement by early 2005.

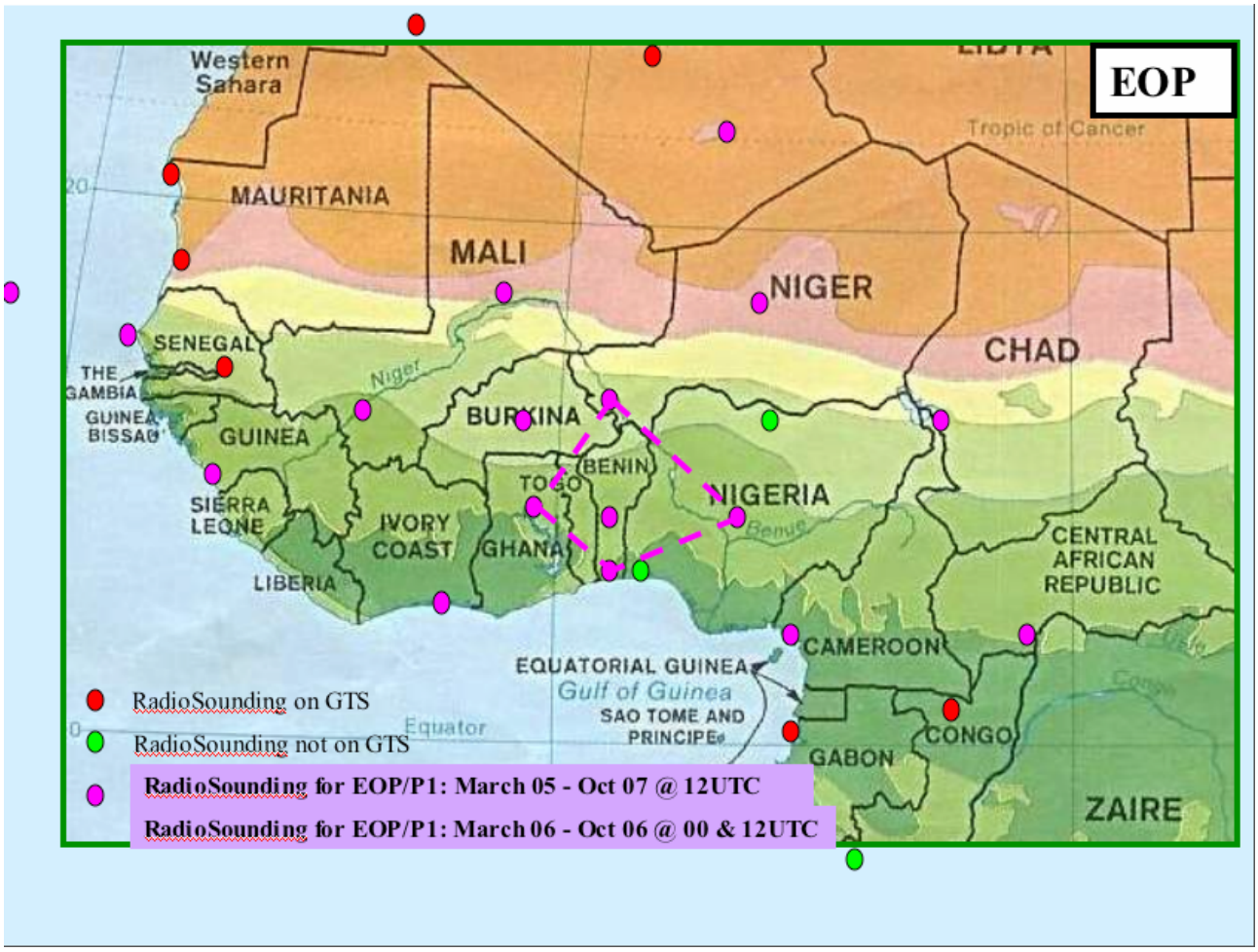

Figure 4.2.3.1: Carte des radiosondages AMMA-EOP / Map of the AMMA-EOP RS network (see also the map in the Figure given in the introduction of section 4.2 of this document).

- **GPS sites**

A GPS network can significantly contribute to improve our knowledge of the atmospheric water cycle in the WAM and to document its variability from the mesoscale to interannual scale. GPS provides only a column integrated measure of the water water but this information is available at high temporal frequency (30 mns), which is not the case with the radiosonding network. An assimilation 4D-Var of these water columns associated with other observation types (the satellite water channels of MSG and others) can provide a much more fine analysis of the space-time water vapor field in the WAM (That would be probably possible during AMMA re-analysis). Presently, 5 GPS sites exist in Africa (IGS network), but none of them are located inside the CATCH window. The objective is to implement 3 or 4 stations along a north-south axis (2 or 3 possibly funded by the API_AMMA, one by the IGS, see previous section on the strategy) to document the seasonal excursion of the monsoon as well as shorter fluctuations associated to monsoons surges, heat low dynamics and ITF meridional migrations. Following a convincing evaluation work by the PI of the instrumented, an exploratory mission is scheduled for the end of 2004 and the installation of the stations is planned for the first half of 2005.

- Emission, transport and (wet and dry) deposition of atmospheric chemical species and burning aerosols

The in situ EOP measurements are concentrated on the intensive local sites located within the mesoscale sites (see below). At the regional scale the aim is to produce a climatology of ozone and CO over West Africa, from the ozone soundings (Cotonou), the MOZAIC aircraft ozone and CO data, ozone and CO ground-based measurements from AMMA super-sites (Lamto, Djougou), satellite and global modelling

- **Mineral dust emission, transport and deposition**

Mineral dust emission, transport and deposition are studied along a Sahelian transect with 3 super sites: Banizoumbou (Niger), Ségou (Mali) and M'bour (Senegal). Each of these sites will be equipped with the instrument listed in the instrumentation table. These instruments will ensure the monitoring of :

- dust concentration (PM10) at the ground level (TEOM)
- total, wet and dry dust deposition by the means of passive and automated collector
- column-integrated aerosol content (Photon-AERONET photometer)
- vertically resolved aerosol content (micro-LIDAR – collaboration ISAC-CNR Italy). Dust emission will be studied only at Banizoumbou super site (see WP4.2.2).

- **EGEE program**

ORE PIRATA and SSS :

The PIRATA measurements (4 buoys in the GG measuring in real-time daily 24h-mean and at postponed time high frequency oceanographic and surface atmospheric 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 continuation of the PIRATA program after 2005 (end of the consolidation phase of this "pilote" program) must be a priority for AMMA, at least in the GG during the whole duration of the AMMA program, and the deployment of ATLAS buoys in the GG and off Senegal especially during the SOP experiment could be considered. The SSS ORE motivations are to collect and validate sea surface salinity (SSS) measurements (thanks to thermosalinographs mounted on merchant voluntary ships and oceanographic research vessels) in order to better understand and to quantify the impact of SSS on the climate variability, through its potential effects on the mixed layer depth, via the barrier layer formation, and the heat content that influences air-sea energy exchanges. Such data sets are of particular interest of the framework of AMMA.

Meteorological station:

A meteorological station have been acquired in 2002 in the framework of EGEE, and has been implemented on the São Tome Island in 2003, in order to extend the atmospheric measurements, already available along the equator thanks to the PIRATA ATLAS buoys, towards the east of the Gulf of Guinea. Its implementation is linked to the maintenance of a tide-gauge already maintained in the port of São Tomé by IRD and LEGOS. The station will be maintained on place during the whole duration of the AMMA program and even maybe later in the framework of PIRATA or CLIVAR/Atlantic observation networks. The data obtained from this station will be available and retrievable on the SMT in 2004.

R/V transits validations:

The transits of the vessels crossing the area of interest will be, when possible, instrumented and validated (as already done in 2002 and 2003). This implies the providing of XBT, PROVOR (CORIOLIS) and/or PALACE and SVP (NOAA/AOML), and eventual people on board. The PIRATA dedicated cruises will also been used, as done with the PIRATA- FR12 cruise in January-February 2004, along with the cruises of the IFREMER programs NERIS and ZAIANGO/BIOZAIRE. During the validation of transits, sea surface water samplings maybe done for analysis of salinity, nutrients and CO2 parameters. Transits by the R/V Marion Dufresne and by the R/V Beautemps-Beaupré are planed in boreal summer 2004 in the area that will be used for validation, through XBT and PROVOR deployments, thermosalinograph, meteorological and VM-ADCP measurements.

Contribution to West African observation systems:

A particular effort have to be done in order to maintain as well as possible the networks of coastal stations and tide gauges network developed many years ago, and particularly the stations that can ensure daily measurements of SST, sea level and meteorological parameters. A prior contribution will consist in the inventory and validation of all the data acquired since the last years. All the validated data will be transmitted to the AMMA community and to the CORIOLIS data center. A re-installation of a tide gauge at Pointe Noire is planed as this particular location is well representative of the open sea climatic observed conditions, and consists in an useful tool for validation and calibration of altimetric data. Financial and technical supports have to be given to some of the Oceanographic Research Centres (CRO Dakar, Abidjan, Cotonou, Pointe Noire, Ghana) in order to ensure good data acquisition and data quality during the whole AMMA period, along with the formation of African technicians and scientists directly involved and interested by the program. The current political troubles in Ivory Coast led to postpone the work on the Abidjan station.

The EOP measurements: EGEE cruises

The EGEE oceanographic cruises will be carried out during the three years of the EOP time period of AMMA, from 2005 to 2007. In order to sample the GG during contrasted climatic situations, the cruises have to be carried out during extreme seasons, ie boreal spring-summer (equatorial upwelling upset, in phase with the monsoon setting, around May-June), and boreal fall-winter (absence of equatorial upwelling, harmattan period over the coastal countries of west Africa, the ITCZ being in its southernmost position). The repetition of the cruises during two opposite seasons all along three consecutive years will allow to better assess the seasonal and interannual variability and to be able to dissociate these two types of variability in the measured one. In order to assess the variability at different time scales in the best conditions, the cruise tracklines have to be systematically the same, and to run through the PIRATA buoys located in the region. The 10°W meridional section, already carried out several times during the PIRATA and both EQUALANT cruises, will be privileged. The cruises will also “close” the GG area (for example 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 pass by São Tomé, to maintain the meteorological station and for intercalibration of sensors and measurements carried out at sea and by the station. 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 below). The duration of these cruises should be around 30 days, and they will need the presence onboard of about 12 people (at least 8 scientists and at maximum 4 observers of surrounding countries, ie Ivory Coast, Bénin, Sao Tome and Principe, Equatorial Guinea, Congo, Nigeria, Gabon we’ll have to deal with for measurements in their exclusive economic zone waters). The track lines and ports of scale are also depending on the politic situation in these countries and may accordingly be modified!

Detailed description and interpretation of measurements of hydrology, currents and tracers (nutrients) carried out during the cruises, in narrow symbiosis with satellite measurements (JASON, SEAWIFS, TRMM/TMI, MSG and SMOS), which in particular make it possible to put in perspective the "specific" and synoptic campaigns in a more general context of space-time variability. These analyses should especially allow to better understand the oceanic processes responsible for the SST, sea surface salinity (SSS) and mixed layer variability, and also the processes responsible for the upwelling onsets. The work will also consist of the synthesis of observational results obtained in different programs to obtain a consistent picture of oceanic processes that are relevant for the SST anomaly pattern on intraseasonal to decadal time scales and their representation in ocean general circulation models. A combination of observational results from different ship cruises as well as profilers and moorings within PIRATA, CORIOLIS and other nationally funded projects (eg JASON program) should allow to give a detailed description of the mean circulation and its variability during the period of the 2006 AMMA-SOP project. This

includes the identification of the mean pathways and transports of the main current branches that supply the eastern and coastal upwelling regions. The role of oceanic circulation for the intraseasonal, seasonal and interannual variations of the SST will be addressed by combining the obtained results regarding the oceanic circulation with results from the surface flux measurements within the PIRATA program. The observational results are compared to results of ocean general circulation models (mostly CLIPPER and MERCATOR) that should be able in simulating surface and subsurface temperature, salinity and currents, in particular within the tropics.

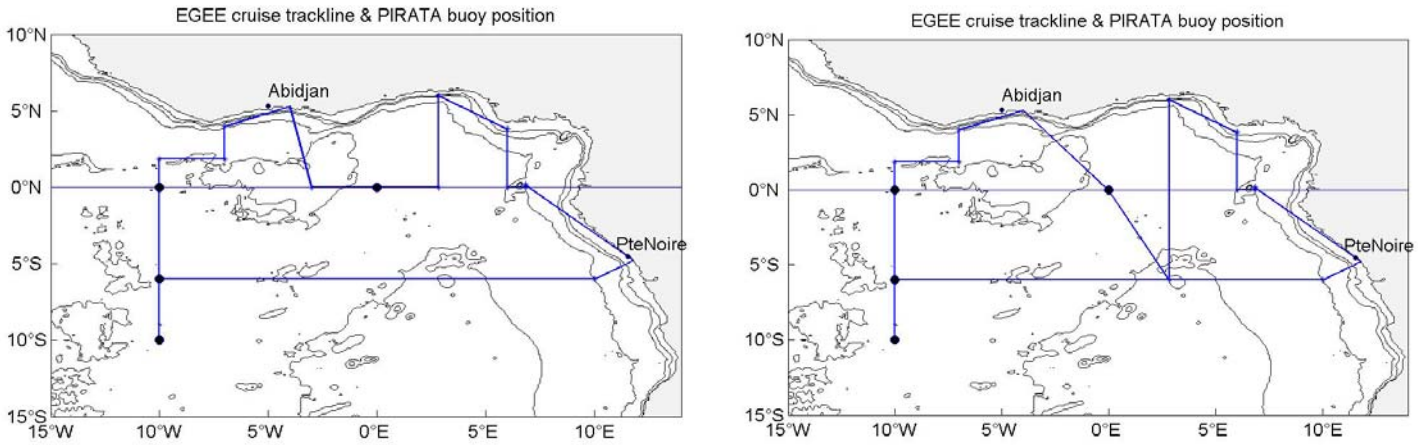

Figure 4.2.3.2 *EGEE cruises eventual tracklines, with a favored meridional section around 2°50'E, south of Benin and of the "CATCH" area. The option on the right side is slightly more expensive in vessel time. The position of the four ATLAS buoys of the PIRATA network are also represented (black dots). The passing through the 10°S-10°W buoy will depend upon the PIRATA program demand (visit of the buoy at least once a year), but the zonal section at 6°S could be shifted at 10°S.*

Mesoscale, convective and local sales

There are strong connections and coordination between the various actions on the mesoscale sites, supersites and intensive local sites. They are thus presented in a common section below.
The core of these measurements is made of high time resolution automated recording of rainfall (a hundred stations), runoff (in the order of 20 stations), ground water levels (several dozens of stations), radiative and energy budgets (one station on each of the super-sites and intensive local sites, as shown on the map), fluxes measurements along the meridional transect, other meteorological parameters on the same sites, soil water profiles, sap flows, leaf area index, wet and dry deposits for the analysis of rainwater and aerosol organic and mineral chemistry, gases concentration. Atmospheric chemical species and aerosol measurements are carried out on the intensive local sites.

- ***Water cycle***

At the mesoscale operation of the long term monitoring network (2001-2009 - See maps). Intensive observations on the supersites started in 2003 (Donga, Benin) and will be reinforced in 2004 on the Kori de Dantiandou (Niger). Hydrological observations started on the Gourma site in 2003.

- ***Rainfields from ground data***

The raingauge networks on the Niamey and Ouémé site are similar in density and area covered (40 to 50 digitized recording raingauges on a 12,000 km² to 14,000 km² area) They are not regularly distributed in space so as to provide a documentation of rainfall variability pattern from a few km scale to the mesoscale.
Additional raingauges are or will be installed for convective scale studies and to contribute to the study of the water balance closure at small scales.
These data will be used as calibration/validation data for radar and satellite algorithms.

- ***Hydrological processes***

Operation of soil moisture sites (TDR, tensiometers) to study the role of soil moisture in the partitioning of rain water between runoff and infiltration. These sites are also equipped with a meteorological station and, latter, with a flux station (see below).
Geophysical and geochemical campaigns will help gain a better documentation of the various surface and sub-surface processes involved in runoff generation.

- ***Vegetation dynamics***

SAP flow measurements
Phenology, PAR measurements, fluxes (see below).

Flux stations

Flux measurements are a required complement to the other hydrological measurements carried out since 2001 on the mesoscale and super sites. They are needed to i) study the closure of the water balance at the mesoscale; ii) contribute to the documentation of the regional gradient of moist static energy playing a role in the monsoon dynamics. The CEH-Wallingford (UK) is the main operator of this program (AMMA-IP and NERC funding). A precise strategy of measurements will be discussed when the outcome of the requested funding is known. The number of stations is a key variable to design this strategy. This number is in the range 9 to 18, depending on funding and human resources. A support is asked to PNRH in 2004 and to the API in 2005 for buying 3 stations.

- ***Emission and deposition of atmospheric chemical species and burning aerosols***

-Characterization**,** Hygroscopicity and radiative properties of mixed aerosols from ground-based measurements at Lamto and Djougou. (real time measurements of black carbon, of particulate size, of absorption and diffusion ; size segregated aerosol mass and chemistry (organic and inorganic), hygroscopicity and optical properties).
-Soil texture and moisture, vegetation ecological description (LAI, biomass density, FPAR ..), soil content of nitrogen and carbon; a database of emissions for NOx and COVs for natural and human disturbed ecosystems will be derived. Validation will be performed through in situ measurements of NOx and COVs fluxes and associated parameters (energy budget, meteorology, emission factors …) during both wet and dry seasons.
-In-situ measurements of anthropogenic pollutants (SO2, COV, NOx, CO, HAP, ...) from ground stations in 2 major west African cities and from a mobile station, geopolitical and satellite data, regional distribution of fuel consumption and anthropogenic activities, to provide regional distribution of emission factors for gases and aerosols.

- ***Radar XPORT***

-X-port was developed for hydrological applications. The data acquisition protocol will be focused on the best estimate of precipitation. For that purpose volumetric scan will be acquired every 5 mn. These scans will be composed of 10 PPIs (elevation 0 to 20), and 30 sec vertical mode.In that mode

the data will be acquired. This scanning strategy could be adjusted if justified, for example during the SOP when the Ronsard will be operating or to coordinate with airplane flights.
-The X-Port radar, as the disdrometer will be operating during the period 2005-2008. The radar is installed on a test site in Cotonou since October 2004 and the DMN staff training has started. While the overall maintenance and data control will be supervised by the IRD researchers and technical staff, DMN-Bénin is strongly implicated in the project and their technicians will be involved in the data acquisition.
-These measurements will be used in association with other Doppler radars (during SOP), with disdrometer, with the dense rain gauge network and hydrological measurements, and with satellite derived information to analyse the three-dimensional structure and evolution of wind and precipitation of the precipitating systems passing or developing over the region near Djougou. A co-supervised PhD project is planned between LTHE and CETP to develop a composite product (rain estimation,3D dynamics and microphysics) with the network of 2 polarized, doppler radar operating at attenuated frequencies.
-Precipitation systems in the Sudanese region will be characterized by these combination of sensors through studies related to classification of the rainy events with respect to their pluviometric impact and their characteristics at all scales, links between the various observed characteristics of rainy events (3D structure, rainfall amounts, efficiency, trajectory), comparison of their pluviometric characteristics with those of the Sahelian region, analysis of the seasonal and interannual variations of these rainy events characteristics

- ***Exploitation of operational radars***

The situation has not evolved favourably on these insturments. Abidjan is not working and is not accessible anyway. Niamey is totally out of order and there is no hope to replace it by 2006. The new radar in Ouagadougou is under military operation and, up to now, it proved impossible to get access to it. Only Dakar and the new radar due to be installed in the North of Senegal are still considered for use in AMMA.

Other measurements (VHF, UHF)

- UHF/VHF

The CCMA is interested to see a wind profiling system implemented in West Africa to address some of the objectives listed in the introduction. The VHF profiler will operate in Djougou (Benin), where XPORT and RONSARD radar will be installed. The most economic solution proposed was to couple the emitter of IPEV VHF and the large antenna of VHF CNRM (The current emitter of VHF CNRM is not transportable in Africa) At time of proposal, no definitive response on the possible use of IPEV VHF emitter has been received. Good hope is to get it at least at mid-2005, if not before. In this perspective the following schedule has been proposed (if IPEV agrees to lend the emitter by the end of 2005, the schedule will be shifted to try to get in the field the VHF in 2005):

2005: Preparation of the instrument: Upgrading the VHF profiler. Tests of the instruments during around a 2-month period in a continuous operating mode. Analysis of the results and eventual correction and improvement. Define the operation mode in Africa in concert with AMMA executive committee. Writing the software for the automatic operation and test of the radar (real time) such as data recording and web forwarding for direct survey in France and elsewhere. Improvement or creation of methodologies for data analysis and atmospheric variables retrieval.

2006-2007: Participation to the field EOP campaign: April 2006: transport, installation, test. 1 June 2006 to October 2006 (SOP): VHF in a continuous operating mode. October 2006 to June 2007: VHF radar in an unattended continuous operating mode. 14months of operation in total, with a possibility of extension to 2008.

Data processing, raw data editing, data analysis in the frame work defined in the scientific objectives: After a careful data quality control, vertical profiles of direct (standard) and indirect (more sophisticated retrieval) atmospheric variables measured by the profilers (see the list in a previous

section) will be delivered to the AMMA community data base. Note that in real time during the field campaign the community will access time height sections of profiler observations.

4.2.3b 1 year plan

Quick overview of 2004 activities.

A couple of months only have elapsed since the 2004 API funding became available in the laboratories. Therefore, most of the work carried out in 2004 was related to the LOP actions funded through the *ORE* programs. The LOP measurements continued in 2004 with local densification in preparation of the EOP (see Table 2 at the end of this section for a comprehensive description of the LOP deployment, as for October 2004. The XPORT radar (EF2: AE.RADX_0) is on its test site in Cotonou. Exploratory missions for the GPS, VHF and Van (EF33: AE.VAN_Od) are scheduled to take place at the end of November 2004). The M'Bour TEOM and the Cinzana photometer (EF30:AE.DUST_ST) were installed. The Cinzana TEOM will be installed in early 2005. Validation of the PIRATA-FR12 cruise and of the transits by the R/V Marion-Dufresne and the R/V Beautemps Beaupré in boreal summer done. Replacement of the Sao Tome Met station done (LF11: OL.StMet_ST). Lamto was put in a stand by mode due to the political events in Ivory Coast.

Objectives

The main objective in 2005 is to install the EOP instruments, following the planning described in the individual AMMA Instrument sheets.

Work content

A part from new specific EOP activities the LOP monitoring will continue, ***providing the ORE funding is available***.

Regional scale:

- Radio-soundings

*See the planning of activity given in the introduction of this section (*Echelle Régionale*).*

- GPS sites

Installation of the three EOP stations. Upgrading of the IGS stations.

- Mineral dust emission, transport and deposition

Installation of the TEOM *at Cinzana. Power supply in Banizoumbou. Deposition catchers and micro Lidar to be installed at the three stations.*

- EGEE program
  - PROVOR profilers will be deployed in the GG and measurements of currents, SST and SSS acquired all along the route.
  - Treatment and validation of the very first measurements of the São Tomé meteorological stations (LF11: OL.StMet_ST) will be done. Fluxes calculated from these data will be compared to CEP and ECMWF numerical outputs.
  - 2005 EGEE cruises to be carried out (EF11, EF12, EF13).
  - The inventory of the West African coastal stations and tide gauge networks will continue (LF12: OL.Cot_Afr).
  - The project of oceanic and atmospheric measurements off Dakar has to be finalized, in straight relationship with the IDYLE program.

Mesoscale

- The XPORT radar (EF2: AE.RADX_0) will be deployed in Djougou
- The Van (EF33: AE.VAN_Od) will be deployed in Benin, under the supervision of A. Mariscal, an engineer from LA being posted there in January 2005.

- Starting of O3 radiosoundings at Cotonou (EF33: AE.RS03_Od)
- VHF test of new configuration

TABLEAUX ET FIGURES POUR LE WP 4.23

Tableau 1. Stations de radio-sondage AMMA

Station	Coordonnées	AMMA	IP	ASECNA	GCOS	Eqt station	EOP	SOP
Agadez	16 58N ; 07 59E	P1	P1	1		MW11	X	X
Bamako	12 32N ; 07 57W	P1	P1	1		STAR	X	X
Cotonou	06 21N ; 02 23E	P1	P1	1		New station	X	X
Dakar	14 44N ; 17 30W	P1	P1	1	1	MW11	X	X
Minna	09 37N ; 06 32E	P1	P1			New station	X	X
N'Djamena	12 08N ; 15 02E	P1	P1	1		MW15	X	X
Niamey	13 29N ; 02 10E	P1	P1	1	1	MW11	X	X
Parakou	09 21N ; 02 37E	P1	P1			New station	X	X
Tamale	09 30N ; 00 51W	P1	P1			New station	X	X
Tamanrasset	22 48N ; 05 26E	P1	P1		1	MW11	X	X
Tombouctou	16 43N ; 03 00W	P1	P1	1		MW11	X	X
Abidjan	05 15N ; 03 56W	P1	P2	1	1	MW15	X	X
Douala	04 01N ; 09 42E	P1	P2	1	1	MW11	X	X
Sal	16 44N ; 22 57W	P1	P2		1	US	X	X
Conakry	09 34N ; 13 37W	P1	P2			New station		X
Tessalit	20 12N ; 00 59E	P1	P2	1		MW11	Pb logist	
Nouakchott	18 06N ; 17 02W	P2	P2	1		MW15		X
Ouagadougou	12 21N ; 01 31W	P2	P2	1		STAR		X
Addis Abeba	09 02N ; 38 45E	P2	P2		1	MW11		
Bangui	04 24N ; 18 31E	P2	P2	1		STAR		
Man	07 23N ; 07 31W	P2	P2	1		MW15		
Ngaoundere	07 21N ; 13 34E	P2	P2	1		MW15		
Nouadhibou	20 56N ; 15 57W	P2	P2	1		STAR		
Sarh	09 09N ; 18 23E	P2	P2	1		MW11		
Tambacounda	13 46N ; 13 41W	P2	P2	1		STAR		

Tableau 2. Bilan de l'instrumentation super-site acquise ou modifiée durant la phase 2001-2004

	Eau et Végétation (CATCH)							
	Végétation		**Cycle eau continental**				**Mesures météorol.**	
Site	**Groupes fonctionnels**	**Biomasse**	**Pluie**	**Ecoulements**	**Nappes: piézo.**	Eau du sol	**Stations météo**	**Bilan radiatif**
Banizoumbou	*à mettre en place*		**5+*10***	**9**	**12**	**4**	**1+*1***	
Djougou/ Donga	*à mettre en place*		**18**	**6**	**12+*15***	**2+*7***	**1**	
Agoufou	3 groupes identifiés	**35 sites** (1*1 km²)	**8** 4			**2**	**2**	**2**

En italique : stations en cours d'installation ou prévues début 2005, déjà financées
En gras : appareils enregistreurs haute résolution.

	Chimie atmosphérique (IDAF)						**Aérosols (PHOTONS)**		
Site	**Dépôts** (azote, soufre, carbone)		**Emissions Climatologie (NOx, COVs, particules)**		**CO, Ozone, BC, physicochimie aerosol (taille, propriétés)**		**Aérosols**		**Bilan radiatif**
	ORE-LOP	AMMA-EOP	ORE-LOP	AMMA - EOP	ORE-LOP	AMMA-EOP	**ORE**	**AMMA**	
Banizoumbou	IDAF*+				IDAF*+		***Photomètre***	TEOM	Flux incident (vis./IR)
Djougou/	IDAF*+			Van*	IDAF*+	Van*	***Photomètre***		
Agoufou	IDAF*						***Photomètre***		
Cinzana							***Photomètre***	TEOM	Flux incident (vis./IR)
M'Bour							***Photomètre***	TEOM	Flux incident (vis./IR)
Lamto	IDAF*+				IDAF*+	Néphélomètre *Grim CO- O3*	*Photomètre*		Flux incident (vis/IR)

IDAF* : chimie pluie, aérosols minéraux, gaz

IDAF+ : station IDAF* avec en supplément collecte aérosol chimie par classe de taille (pour l'organique, inorganique, la masse totale), Aethalomètre.

Van* : CO, Ozone, SO2, NOx, Compteur, Granulomètre APS, Mesures de flux (énergie, NOx, COVB), rayonnement (Vis, IR), météo.

Tableau 3. Liste des instruments EOP

#	Code	PI Name	E-Mail Address	Instrument	Platform
EF1	AE.GPS_1	M.-N. Bouin, O. Bock	bock@aero.jussieu.fr; bouin@ensg.ign.fr	**4 GPS stations (optionnel :3)**	Meridional Transect
EF2	AE.RadX_O	Marielle Gosset	Marielle.Gosset@hmg.inpg.fr	**X Band Hydromet. Radar**	Djougou
EF3	AE.Dsd_ Or	Marielle Gosset	Marielle.Gosset@hmg.inpg.fr	**Disdro Parsival**	Djougou
EF4	AE.OSP_Od	Laurent Barthès	barthes@cetp.ipsl.fr	**Optical Spectro Pluviometer**	Dakar puis Djougou
EF5	AE.VHF_O	B. Campistron		**CNRM VHF**	Ouémé (Djougou)
EF6	AE.BaCO2_G	Laurent kergoat	Laurent.kergoat@cesbio.cnes.fr	**CO2 Baloon**	
EF7	AE.Flux_G	Franck Timouk	Franck.timouk@cesbio.cnes.fr	**1 CLASSIC H2O flux station**	Gourma-Hombori
EF8	AE.Flux_Ncw	Bernard Cappelaere	bernard.cappelaere@mpl.ird.fr	**1 H2O flux station**	Niamey-Wankama
EF9	AE.Flux_Odc	Sylvie Galle	galle@cixi.isol.ird.fr	**1 H2O flux station**	Ouémé-Donga
EF11	OE.Navire_GG	Bernard Bourles	bourles@ird.fr	Sea water samples	Atalante in 2005
EF12	OE.XBT_GG	Bernard Bourles	bourles@ird.fr	Temp. profiles with perdable sounds	Guinea Gulf
EF13	OE.CTD_GG	Bernard Bourles	bourles@ird.fr	Seabird 911sounds (t, salinity, 02)	Guinea Gulf
EF14	CE.SW_G	Patricia de Rosnay	patricia.derosnay@cesbio.cnes.fr	Campbell CS616 for soil moisture	Gourma Meso Site
EF15	CE.VegSoil_G	Josiane Seghieri	seghieri@ird-ml.org	Vegetation monitoring	Gourma Meso Site
LF16	CE.PAR_Ga	Eric Mougin	Eric.mougin@cesbio.cnes.fr	PAR and LAI measurements	Gourma-Agoufou
EF17	CE.Sap_Ga	Valérie Le Dantec	valerie.ledantec@cesbio.cnes.fr	2 sap flow/ soil moisture stations	Gourma-Agoufou
EF18	CE.Rain_Nc	Luc Descroix	descroix@ird.ne		Niamey SS central
EF19	CE.Run_Nc	Luc Descroix	descroix@ird.ne	Network of 9 recording streamgauges	Niamey SS central
EF20	CE.Gwat_Nc	G. Favreau	Favreau@msem.univ-montp2.fr	Level recorders in 6 drilled boreholes	Niamey meso site
EF21	CE.SW_Nc	B. Cappelaere	bernard.cappelaere@mpl.ird.fr	4 sites Watermark et TDR	Niamey SS central
EF22	CE.SWsan_Nc	Luc Descroix	descroix@ird.ne	Soil water neutron probe	Niamey SS central
EF23	CE.Veget_Ncw	Nicolas Boulain	boulain@msem.univ-montp2.fr	Li COR LAI-2000 and Li COR 6400	Niamey-Wankama
EF24	CE.Run_Odc	Luc Seguis	seguis@ird.fr	1 seuil jaugeur on 3 transects: 3 total	Donga, transects
EF25	CE.WChem_O	Christophe Peugeot	peugeot@ird.fr	Chemical Analysis: surf/ground water	Ouémé
EF26	CE.WChem_Od	Luc Seguis	seguis@ird.fr	Chemical Analysis: surf/ground water	Ouémé-Donga
EF27	CE.Gwat_Odc	Luc Seguis	seguis@ird.fr	Network of 27 piezo in drilled wells	Donga, transects
EF28	CE.SW_Odc	Sylvie Galle	galle@cixi.isol.ird.fr	3 stations on 4 transects: 12 in total	Donga, transects
EF29	CE.Veg_Odc	Josiane Seghieri	seghieri@ird-ml.org		
EF30	AE.Dust_ST	Jean-Louis Rajot	rajot@ird.ne	3 sites (TEOM, micro-LIDAR, Photometer)	Sahelian Transect
EF31	AE.RSO3_Od	Valérie Thouret	thov@aero.obs-mip.fr	Ozone Radio-sounding	Djougou
EF32	AE.Aerosol_La	Cathy Liousse	lioc@aero.obs-mip.fr	Aerosol measurements at Lamto	Lamto Station
EF33	AE.VAN_Od	Dominique Serça	serd@aero.obs-mip.fr	Labo Van	Djougou

Tableau 4. Liste des instruments LOP

#	Code	PI Name	E-Mail Address	Instrument	Platform
LF1	AL.Met_Gh	Franck Timouk	Timouk@cesbio.cnes.fr	Station Météo Campbell	Hombori (Gourma)
LF2	AL.Met_Nc	Luc Descroix	descroix@ird.ne	Station Météo Campbell	Banizoumbou (Ny)
LF3	AL.Met_Od	Sylvie Galle	galle@ird.fr	Station Météo Campbell	Djougou (Ouémé)
LF10	OL.SSS_AE	Thierry Delcroix	thierry.delcroix@cnes.fr	Thermosalinographes sur navires	Ships in Equat. Atlantic
LF11	OL.StMet_ST	Bernard Bourles	bourles@ird.fr	Campbell Met. Station	Sao Tomé
LF12	OL.Cot_Afr	Bernard Bourles	bourles@ird.fr	Thermometers Network	
LF13	OL.Buoys_AE	Bernard Bourles	bourles@ird.fr	ATLAS PIRATA buoys	Pirata Network
LF14	OL.Prov_AE	Bernard Bourles	bourles@ird.fr	ARGO Profilers	Ships in Equat. Atlantic
LF15	OL.Drift_AE	Bernard Bourles	bourles@ird.fr	Drifting buoys	Ships in Equat. Atlantic
LF16	CL.Rain_G	François Lavenu	Francois.Lavenu@ird-ml.org	8 recording raingauge network	Gourma meso site
LF17	CL.Rain_N	Thierry Lebel	Thierry.Lebel@hmg.inpg.fr	30 recording raingauge network	Niamey meso site
LF18	CL.Rain_0	Christian Depraetere	Christian.Depraetere@inpg.fr	30 recording raingauge network	Ouémé meso site
LF19	CL.Rain_Od	Luc Le Barbé	Luc.Le-Barbe@ird.fr	Network of 18 recording raingauges	Ouémé-Donga
LF20	CL.Pond_Nc	B. Cappelaere	bernard.cappelaere@mpl.ird.fr	Network of 6 level recorders on pools	Niamey SS central
LF21	CL.Run_O	Christophe Peugeot	peugeot@ird.fr	14 recording streamgauge network	Ouémé meso site
LF22	CL.Run_Od	Luc Seguis	seguis@ird.fr	Network of 6 recording streamgauges	Ouémé-Donga
LF23	CL.ADCP_O	Christophe Peugeot	peugeot@ird.fr	Accoustic Doppler Current Profiler	Ouémé
LF24	CL.Gwat_N	G. Favreau	Favreau@msem.univ-montp2.fr	Level recorders in wells (aquifer)	Niamey meso site
LF25	CL.Gwat_Od	Luc Seguis	seguis@ird.fr	21 village sites (11 recorders)	Ouémé-Donga
LF26	CL.Depot_RW	C. Galy-Lacaux	lacc@aero.obs-mip.fr	5 stations IDAF (4 avec aethalomètre)	Regional Window

Tableau 5. Campagnes de documentation de sites

CF1	CC.geophy_Odc	Henri Robain	Henri.Robain@bondy.ird.fr	Résistivimètres SYSCAL Pro et R2
CF2	CC.scintil_Od	Jean-Martial Cohard	Jean-Martial.Cohard@hmg.inpg.fr	Scitillomètre flux de chaleur sensible

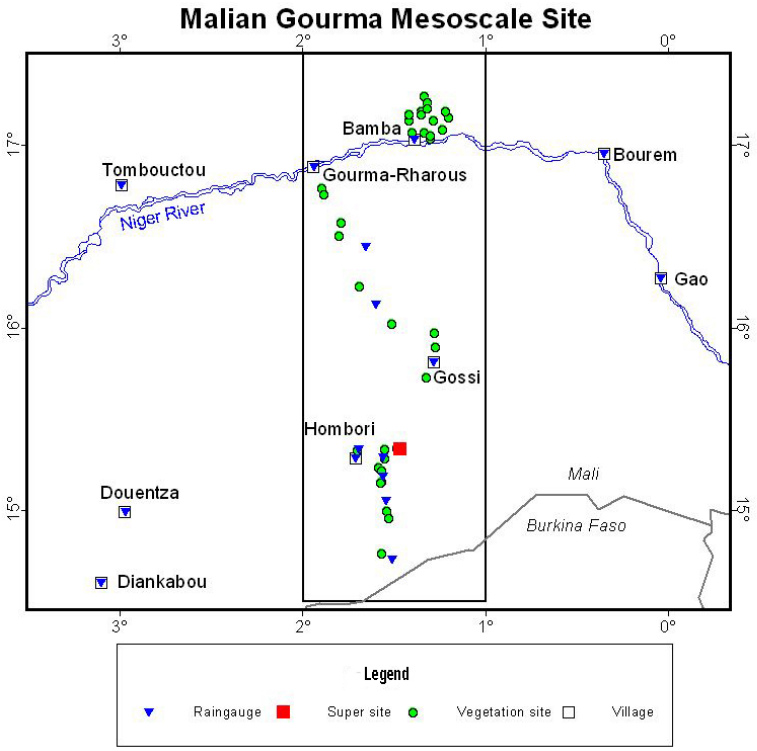

Figure 4.2.3.3a: Equipment on the Gourma mesoscale site

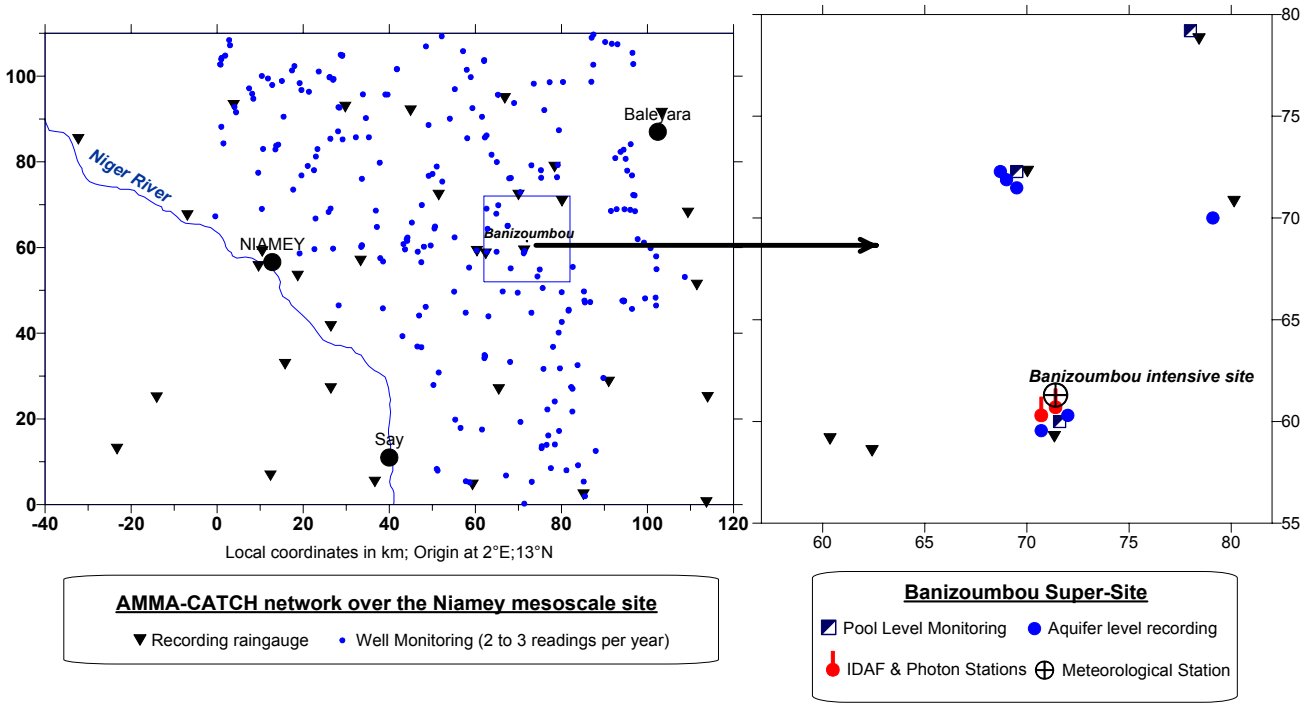

Figure 4.2.3.3b: Equipment on the Niamey mesoscale site

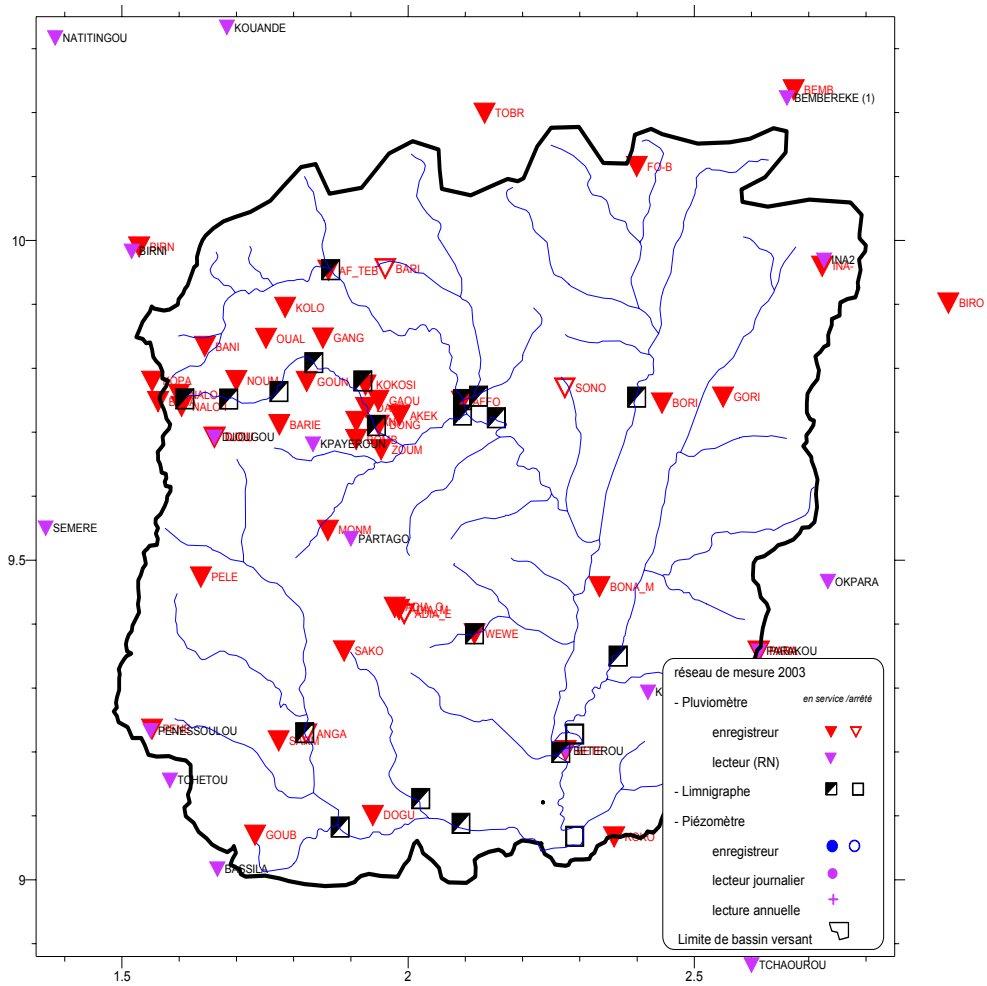

Figure 4.2.3.3c: Equipment on the Ouémé mesoscale site