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Chapter 2

Sounding of the Atmosphere

TT1

Andreas Fink, Serge Janicot and Doug Parker

1 Scientific justification and objectives

It is the general goal of the AMMA Radiosonde Group (ARG or TT1 group) to assist in the development and maintenance of a coordinated network of radiosonde, PILOT balloon, VHF/UHF and GPS Total Columnar Water Vapour (TCWV) stations during the AMMA EOP period and beyond to address specific AMMA scientific objectives for atmospheric research and monitoring.

AMMA is planned around three nested timescales that will be referred to in the following text:

- LOP studies are based on long-term observations, including archived data and rescued datasets;
- EOP (Extended Observing Period) studies are to be based around the years 2005 to 2007, during which a coordinated set of observations of the atmosphere, land and ocean systems will be obtained. Multi-season observations are to be made in order to evaluate variability in the system, as well as mechanisms of 'memory' between seasons.
- SOP (Special Observing Period) studies will take place in the summer of 2006. The SOP is aimed at intensive observations of particular processes and is subdivided into four periods according to particular scientific goals:

1) SOP0 Dry season processes: January/February 2006
2) SOP1 Monsoon onset: 1 June – 30 June 2006
3) SOP2 Monsoon maximum: 1 July – 15 September 2006
4) SOP3 Late Monsoon: 15 September – 30 September 2006

The upper air networks of radiosoundings, pilot balloons, UHF/VHF profilers and GPS stations are crucial for the success of AMMA. Good upper air observations are essential for the generation of reliable model analyses, which are in turn necessary for environmental monitoring over the continent and the downstream Atlantic. Upper air data is also needed for quantifying the basic physical processes of the atmosphere. The current operational network consists of some stations that have a good recent record of soundings, and a number which are experiencing problems. AMMA aims at upgrading the existing stations and will also add a few additional stations for the EOP. AMMA strives for the new stations at Tamale, Abuja and Cotonou to be incorporated in the long term operational network.

The most extensive set of upper air measurements over the continent was conducted during the GATE experiment in 1974 (Kuettner and Parker 1976; their Fig 4). These soundings remain a valuable resource for monsoon studies (and are soon to be archived at the British Atmospheric Data Centre (BADC)). ERA-40 reanalyses assimilating the radiosondes from the GATE year are also now available. However, during GATE much of the emphasis, including the majority of the observational subprograms, was focused on weather systems over the Atlantic Ocean; during AMMA we aim to integrate the atmospheric sounding network with observations of both the continental and ocean systems.

The WAMEX project of 1979 also involved increased soundings over the continent. These data are stored as part of the FGGE archive.

Six stations in the region (Dakar, Niamey, Abidjan1, Tamanrasset, Addis Ababa and Douala), are currently members of the GCOS Upper Air Network (GUAN), and are therefore subject to scrutiny by the GUAN group. One of the objectives of the AMMA radiosonde group will be to arrange similar support and attention to other key stations within the African Monsoon domain.

2 Observing Strategy

2.1 Overall strategy

All suitable operational radiosonde stations in the AMMA region are listed in Table 2. The upgrading of stations and the deployment of radiosondes has been designed around some key arrays of stations.

In order to plan and prioritise the soundings, we have organized the stations into key arrays – identified as "instruments", for the purposes of different scientific programmes within AMMA. Several stations appear in more than on of these arrays, highlighting the importance of these soundings to a number of AMMA objectives. We suggest four groups of arrays (some of which consist of sub-arrays; see also Fig.1)

(i) Monsoon array

Monsoon Inflow Stations: Conakry, Abidjan, Cotonou, Douala, Bangui

Climate array: Cotonou, Tamale, Parakou, Abuja, Niamey

This array is needed for study of the monsoon seasonal cycle, and for understanding of the monsoon and ITCZ dynamics and fluxes throughout the full EOP period. The Monsoon Inflow Stations monitor the profiles along the southern part of the summer monsoon region, in the zone where the low-level monsoon winds are carrying moisture from the humid boundary layer over the Gulf of Guinea and the Congo basin. The Climate Array quadrilateral monitors the seasonal, intra-seasonal, synoptic and diurnal variations in the monsoon, as it penetrates inland, feeding moisture into the continent. For this reason, higher frequency soundings (4 per day or more) are desired during the SOPs.

Note that there is likely to be extension of the climate array with soundings from the Ron Brown research vessel in the Gulf of Guinea during SOP1.

(ii) Zonal (Sahelian) array

This comprises a series of stations lying in the Sahelian zone across the continent, from Sal to Addis Ababa, including Conakry (Fig.1).

[1] Note however that, despite being a GCOS station, Abidjan has not operated since its gas station exploded in June 2001

This array is needed for the study of synoptic variability in the monsoon, since weather systems are initiated in the east of the continent and propagate towards the west and into the Atlantic (where they are known to initiate a majority of tropical cyclones). Furthermore, it is thought that intraseasonal fluctuations in the rainfall, including the monsoon onset, are manifested as slowly-propagating anomalies moving from the west. This array is also needed for validation of satellite winds and temperatures, and for data assimilation studies. Owing to the northward advance of the monsoon, and the strengthening of the synoptic variability, this array is of highest importance around the period of the summer monsoon, including the onset and retreat phases.

(iii) Northern stations

Agadez, Tombouctou, Tessalit, Tamanrasset

These stations lie in a critical zone on the southern fringes of the Sahara. The soundings are needed for measurements of the northern structure of African easterly Waves (AEW) disturbances, which are known to be of importance in synoptic development further south, and in propagation over the Atlantic (Reed et al. 1977, Pytharoulis and Thorncroft 1999), but have never been observed with comprehensive upper air data. Tombouctou, being further west, is best placed for such study of AEWs, which tend to amplify as they move across the continent.

Tessalit is perfectly placed to observe the monsoon trough and heat low in the summer months, in a zone where the model errors due to aerosol loadings can be large. In this regard, its position is better than that of Tamanrasset, whose climate is somewhat affected by the Hoggar Mountains.

These northern soundings also represent an extension of the meridional Climate Array in the summer period. They are needed for understanding of monsoon dynamics and the role of the diurnal cycle in the zone of strongest thermodynamic gradients, during the monsoon peak. In this context, the data from the Northern Stations will be used in association with surface observations from the northern extensions of the flux station network.

These stations are of primary interest in the summer periods, when the low-level thermodynamic gradients are located in the Northern Sahel.

(iv) SOP Flux networks (quadrilaterals, see Fig. 2)

Southern quadrilateral: Cotonou, Parakou, Niamey, Tamale, Abuja

Northern quadrilateral: Parakou, Tahoua/Birni/tAgadez/Kano, Tombouctou, Ouagadougou, Niamey

Western quadrilateral: Bamako, Dakar, Sal, Conakry, Nouakchott

At the centre of each quadrilateral, a meteorological radar is to be deployed. These quadrilateral arrays are needed in process studies, for estimation of budgets in the water vapour and energetics of each region. Such diagnostics are necessary for studies of cloud systems and hydrology. These methods have been employed in related studies within the GATE, TOGA-COARE and IHOP experiments, for example. A frequency of at least 4 soundings, during the SOPs, is needed for these purposes.

Due to limitations in hydrogen production, such high sounding frequencies may only be possible through the use helium. Therefore, the costs and logistic challenges of distributing helium bottles to the above-mentioned stations must be explored. The price of 9cbm helium in Niger is about $130 per cylinder.

The US ARM programme will secure 4-daily soundings at Niamey throughout the year of 2006. A temporary station, to be deployed during the SOP in a location to the east of Niamey, is required to complete the northern quadrilateral of stations. Possible temporary sites for this station include Birni n'Konni (13.80N, 5.25E) and Tahoua (14.90N, 5.25E). The Tahoua site would be priority. A substitute

MODEM ground station from ASECNA Dakar can be relocated to Tahoua along with a spare DCP for telecommunication purposes. The hydrogen provision problem has to be tackled. If a temporary radiosonde facility is not available, Agadez or Kano are also possibilities to act as a completion of the northern quadrilateral, making additional soundings as the easternmost point in the northern quadrilateral.

Note that we must be sensitive to the errors in budget estimates, which may arise where stations are located close to major topographic features. For instance there may be problems arising from coastal circulations at Dakar and Cotonou.

The anticipated frequencies of soundings on these stations are outlined in Table A1 of Appendix 1. Note that 'responsive' soundings are those which will be deployed flexibly, to support other observational activities (e.g. aircraft and radar) at relatively short notice.

Intensive observing IOPs have been proposed by TT8 for the onset period (around 22 – 26 June suggested) and mature monsoon (probably the main aircraft detachment of SOP2-a2. It is considered that owing to the high demands on staff, particularly in gas generation that these IOPs cannot be sustained for more than 5 days in each case (but see note below regarding helium options).

Ideal sounding capacities, bearing in mind the known facilities and personnel at each site, were suggested for the following stations:

Agadez	4
Abuja	8
Cotonou	8
Niamey	8 (using ARM and ASECNA's two GIP 3 hydrogen generators in parallel)
Ouaga	4
Parakou	8
Tamale	8
Tombouctou	4
Tahoua	2
(Kano	2)

2.1.1 Contributing parties to the AMMA radio-sounding program

The currently available budget (~2,5 M€) comprises three sources: AMMA-EU (~ 2.1 M€), AMMA-France (~0.23 M€) and AMMA-UK (~0.17 M€). The majority of the budget is from AMMA-EU and this will deal with most of the infrastructure needs.

The US ARM programme will fund 4 radiosoundings/day at Niamey during the entire year of 2006. Contact person is Kim Nitschke (nitschke@lanl.gov).

The US GCOS programme is funding a new electrolytic hydrogren generator at Dakar (~80k$). It is planned to be installed in March/April 2006.

The SCOUT balloon program will contribute to some responsive soundings at Niamey during SOP 2006.

Funded ship-based radiosonde programmes

Within the French AMMA/EGEE programme, the funding of 90 (40) Vaisala sondes to be launched during the EGGE 3 (4) cruises in the Golf of Guinea between 25 May and 07 July 2006 and in September 2006 is secured. The sounding data are transmitted to the GTS in real-time.

Within the German AMMA and SOLAS programmes, the funding of twice daily (total 64) and (total 52) Vaisala sondes to be launched during two METEOR cruises in the tropical and subtropical Atlantic Ocean (06 June-08 July 2006 and 11 July-08 August 2006) is secured. The sounding facilities are provided by the German Weather service (DWD) and the data are transmitted to the GTS in real-time.

Details of the sounding programme on the Ron Brown research vessel are presently unknown.

For further details on the AMMA oceanographic component (e.g. cruise tracks), the reader is referred to the TT6 document.

Other:

Dropsondes will be released from the British BAe146 and French Falcon during SOP 0, SOP 1 and SOP 2. The release of driftsondes is also planned for SOPs. It is intended to transmit data from these soundings to the GTS in real time. For details, the reader is referred to the corresponding TT7 and TT8 documents.

Contacts to the European AMDAR programme revealed that it is planned to enhance the daily provision of enroute data and profiles from or to African airports. These data (wind and temperature) are collected and transmitted in real time to the GTS by commercial aircrafts.

Contributed funding:

The project will rely on the large, existing and new operational commitment from ASECNA and other Meteorological organisations (e.g. Nigerian Meteorological Service (NIMET), Ghana Meteorological Agency (GMA), and Algerian Meteorological Service).

2.1.2 Communication and infrastructure improvement needs (radiosondes)

SYNOP surface and TEMP and PILOT upper-air data are transmitted into the GTS via the regional meteorological telecommunication network of WMO Region I (Africa). In short and in principle, the Regional Telecommunication Hubs (RTHs) are Niamey, Brazzaville and Dakar. Niamey collects the data from Ghana, Togo, Benin, Nigeria, Burkina and Niger. Brazzaville collects the data from Cameroon and the Central African Republic and other countries. Dakar collects data from Ivory Coast, Mauritania, Mali, Guinea and other countries. Dakar, Niamey and Brazzaville are transmitting the data to Toulouse. Technically, the data are mainly communicated through the regional aviation safety telecommunication network maintained by ASECNA.

Several stations require new communications systems. More specifically, several ASECNA stations need a radiolink or another fast connection between the observer's buildings and the CAT (Centre Automatique de Télécommunication) building for an automatic transmission of TEMP messages into the GTS. A benchmark system is about to be installed at the new radiosonde station of Cotonou. If successful, other stations will be equipped with this system jointly by ASECNA and AMMA-EU (see list below).

Five SUTRON DCPs (Data Collection Platforms) funded by AMMA-EU are available at Dakar (for training purposes and a spare part), Cameroon (Ngaoundere), Benin (Parakou), Ghana (Tamale) and Abuja (Nigeria). A training of Ghanaian, Nigerian and ASECNA technicians funded by AMMA EU took place at Dakar from 30 Nov. 2005 to 02 Dec. 2005. Currently, TT1 strives for sufficiently long METEOSAT windows for TEMP transmission. Until Meteosat 9 is operational in mid-2006, the availability of time windows is limited due to a communication failure on Meteosat 8.

Where needed we recommend a backup communication system through local mobile phone networks or satellite phones during SOP 2006.

Automatic monitoring of transmission of data from stations in the network is being conducted by the ECMWF and can be viewed online at:

http://www.ecmwf.int/products/forecasts/d/charts/monitoring/amma/

These pages also quantify the assimilation of the data into the ECMWF model. For new stations, close attention will be paid, manually, to the communication of data to the GTS, until the station is regarded to be reliably established.

2.1.3 GPS Total Columnar Water Vapour (TCWV) Measurements

A TCWV 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. TCWV provides a column-integrated observation of water vapour with a high temporal frequency (15 min – 1 h), which is not the case with the radiosounding network. Such a high frequency can provide useful information on the diurnal cycle. The 3D-Var or 4D-Var assimilation of these water columns, associated with other observation types (the satellite water channels of MSG and others), can provide a much finer analysis of the space-time water vapour field in the WAM. Assimilation of GPS data is planned for the future re-analysis that will be conducted after the field experiment.

Presently 5 permanent GPS stations (IGS network) exist in the domain of interest for AMMA: 25°W-15°E by 5°S-20°N. . At the EOP scale, the objective is to implement 3 stations along a north-south axis (Djougou, Niamey, Gao) to document the seasonal excursion of the WAM as well as shorter fluctuations associated to monsoon surges, heat low dynamics and Inter-Tropical Front (ITF) meridional migrations, and to monitor meridional gradients of integrated moisture associated with the different steps of the WAM and especially the abrupt shift of the monsoon onset. At the SOP scale, the monitoring of the water vapour along a second meridional transect (Tamale, Ouagadougou, Tombouctou) west of the EOP transect will allow to monitor the non-zonal part of the monsoon flow at a much higher temporal resolution and to enhance the assimilation process through a more dense and regular observational network, which contributes to the process studies.

Olivier Bock (bock@aero.jussieu.fr) from the Service d'Aéronomie du CNRS is coordinating the TCWV measurement campaign.

Six GPS TCWV stations are then planned:

- EOP: Djougou (Bénin), Niamey (Niger), and Gao (Mali) within or near the three mesoscale sites. These stations have been installed in summer 2005.
- SOP: Tombouctou (Mali), Ouagadougou (Burkina), and Tamale (Ghana) to enhance the temporal resolution (15 min. – 1 hourly) of RS-based TCWV values. These stations will be installed at the beginning of 2006.

One difficulty in the operation of these GPS stations is with the transfer of raw GPS data from the stations to the analysis centre in Paris. This transfer represents an amount of 500 Kb per day per station. The TCWV atmospheric product is only obtained after these raw data are processed. A two-week delay is required for obtaining precise (climate-quality) products (this delay is related to the availability of precise satellite orbits). Such a processing is planned for the EOP data. A near-real time processing is considered for the SOP. This depends mainly on the telecommunication capability that can be made available by the time of the SOP. Presently, two Inmarsat phones are in operation in Benin and Mali. The communications are very irregular and would not permit near-real time operations. Local cellular phone network solutions are under study for the SOP. If near-real time data transmission will be possible is not yet determined.

2.1.4 UHF/VHF profiler measurements

The expected five UHF/VHF wind profilers define an observational network with a high time and vertical resolution from which the 3D synoptic circulation of the WAM can be retrieved, especially when

it is co-located with radio soundings and GPS TCWV measurements. It provides continuous high-frequency time and scale measurements of the atmospheric boundary layer and its interaction with the African easterly waves and the AEJ, the intra-diurnal to seasonal fluctuations of the ITF, the evolution of the low-level nocturnal jet, the fluctuations due to gravity waves with periods from hour up to several days in the energy budget and momentum transport. It allows also to measure flux of energy in lower stratosphere, stratospheric-tropospheric exchanges and studies of the deep and precipitant convection.

Bernard Campistron (camb@aero.obs-mip.fr) for the Laboratoire d'Aérologie of CNRS is coordinating the UHF/VHF measurement campaign. Presently the status for the array is the following one:

- It is planned to implement at Djougou a VHF profiler for an 18-month period beginning in February-March 2006 to participate to the SOP and partly the EOP. This instrument will provide vertical profiles of wind speed and direction, vertical velocity, radar reflectivity, turbulence data, virtual temperature if acoustic sources for RASS are implemented and water vapour mixing ratio (tentative, to be validated). These measurements will be associated with those done at the same location with the radiosoundings, the GPS TCWV, and the XPORT (EOP) and RONSARD radars (SOP). The combination with an UHF profiler on the same site should be possible at least for the SOP but this is still uncertain at the present time due to technical and funding issues.

- A UHF instrument, belonging to ASECNA, is presently doing measurements at the Bamako airport. The objective is to organize the data collection since presently they are stored locally for the last four months only. ASECNA has also planned to implement a similar instrument at Ouagadougou in September 2005. Another one might be implemented at N'Djamena. This instrument is not specifically "AMMA instrument" as it has not be funded by AMMA and its implementation has not been discussed in AMMA. So it is not fully integrated in the observation strategy of TT1 but its data will be very fruitful for some of the AMMA objectives

The US ARM programme is currently looking at having a 1290 MHz UHF profiler at Niamey sometime in May/June 2006. This has not been secured yet.

2.2 List of sites, instruments and relevant maps

The list of instruments whose main attachment is TT1 is given in Table 1a below, while Table 1b lists the instruments attached to another TT but whose deployment is closely related to the TT1 strategy.

Table 1a: TT1 List of instruments (P1: priority 1; P2: priority 2).

#	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	3 GPS stations in Djougou, Niamey and Gao	1st Meridional Transect
EE1	AE.RS_1	Andreas Fink	fink@meteo.uni-koeln.de	8 P1 RS stations (Conakry, Abidjan, Cotonou, Douala, Tamale, Parakou, Abuja, Niamey) and 1 P2 (Bangui)	Monsoon Array

Table 1a (followed): TT1 List of instruments (P1: priority 1; P2: priority 2).

EE2	AE.RS_2	Serge Janicot	serge.janicot@lodyc.jussieu.fr	6 P1 RS stations (Sal, Dakar, Bamako, Niamey, N'Djamena, Khartoum) and 1 P2 (Ouagadougou)	Sahelian Array
EE3	AE.RS_3	Doug Parker	doug@env.leeds.ac.uk	4 P1 RS stations in Agadez, Tombouctou, Tessalit and Tamanrasset	Northern Array
EF5x	AE.VHF_O	Bernard Campistron	camb@aero.obs-mip.fr	1 CNRM VHF radar in Djougou	Ouémé Méso site
EA1x	AE.VHF_BO	Bernard Campistron	camb@aero.obs-mip.fr	2 Asecna UHF radars in Bamako and Ouaga	Sahelian Array

Table 1b: List of instruments closely related to TT1.

#	Code	PI Name	E-Mail Address	Instrument	Platform	TT
SF1	AS.GPS_1	M.-N. Bouin, O. Bock	bock@aero.jussieu.fr ; bouin@ensg.ign.fr	3 GPS stations in Tamale, Ouagadougou and Tombouctou	2nd Meridional Transect	8
SE1	AS.RS_1	Andreas Fink	fink@meteo.uni-koeln.de	5 P1 RS stations (Cotonou, Parakou, Niamey, Tamale, Abuja)	SOP Southern Quadrilateral	8
SE2	AS.RS_2	Doug Parker	doug@env.leeds.ac.uk	4 P1_EOP RS stations (Parakou, Agadez, Tombouctou, Niamey), 2 P1_SOP (Tahoua, Ouaga) and 2 P2 (Birni, Kano)	SOP Northern Quadrilateral	8
SE3	AS.RS_3	Tbd	Tbd	4 P1 RS stations in Bamako, Sal, Conakry and Dakar + 1 P2 (Nouakchott)	SOP Western Quadrilateral	8
SE5	AS.RS_D	Nobert Kalthoff	norbert.kalthoff@imk.fzk.de	Radiosonde station at Dano by FZK	Dano	8

Table 2: Radiosonde stations in the AMMA region, and their operational priorities for AMMA EOP.

Country	Station Number	Station Name	Latitude	Longitude	AMMA priority
COTE D'IVOIRE	65578	ABIDJAN	05 15N	03 56W	1
NIGER	61024	AGADEZ	16 58N	07 59E	1
MALI	61291	BAMAKO/SENOU	12 32N	07 57W	1
GUINEA	61832	CONAKRY	09 34N	13 37W	1
BENIN	65344	COTONOU	06 21N	02 23E	1
SENEGAL	61641	DAKAR/YOFF	14 44N	17 30W	1
CAMEROON / CAMEROUN	64910	DOUALA R.S.	04 01N	09 42E	1
SUDAN / SOUDAN	62721	KHARTOUM	15 36N	32 33E	1
NIGERIA	65125	ABUJA	09 15N	07 00 E	1
CHAD / TCHAD	64700	NDJAMENA	12 08N	15 02E	1
NIGER	61052	NIAMEY-AERO	13 29N	02 10E	1
BENIN	65330	PARAKOU	09 21N	02 37E	1
CAPE VERDE / CAP-VERT	8594	SAL	16 44N	22 57W	1
GHANA	65418	TAMALE	09 30N	00 51W	1
ALGERIA / ALGERIE	60680	TAMANRASSET	22 48N	05 26E	1
MALI	61202	TESSALIT	20 12N	00 59E	1
MALI	61223	TOMBOUCTOU	16 43N	03 00W	1

Table 2 (followed): Radiosonde stations in the AMMA region, and their operational priorities for AMMA EOP.

ETHIOPIA / ETHIOPIE	63450	ADDIS ABABA-BOL	09 02N	38 45E	2
NIGERIA	65046	KANO	12 03N	08 32 E	2
CENTRAL AFRICAN REP	64650	BANGUI	04 24N	18 31E	2
CAMEROON / CAMEROUN	64870	NGAOUNDERE	07 21N	13 34E	2
MAURITANIE	61415	NOUADHIBOU	20 56N	15 57W	2
MAURITANIE	61442	NOUAKCHOTT	18 06N	17 02W	2
SENEGAL	61687	TAMBACOUNDA	13 46N	13 41W	2
BURKINA FASO	65503	OUAGADOUGOU	12 21N	01 31W	2
CHAD / TCHAD	64750	SARH	09 09N	18 23E	2
COTE D'IVOIRE	65548	MAN	07 23N	07 31W	
BURKINA FASO		DANO	11 10N	03 05W	
		ASECNA Substitute DKR			
		ASECNA TRAINING NIM			

Figure 1 displays the sites and their priorities within the AMMA international programme during the Enhanced Observing Period (EOP).

Figure 2 displays the sites and their priorities within the AMMA international programme during the Special Observing Period (SOP) in 2006.

As already mentioned, it is considered to temporarily move the substitute MODEM ground stations at ASECNA Dakar to Tahoua during at least the SOP 1/2 June-September period.

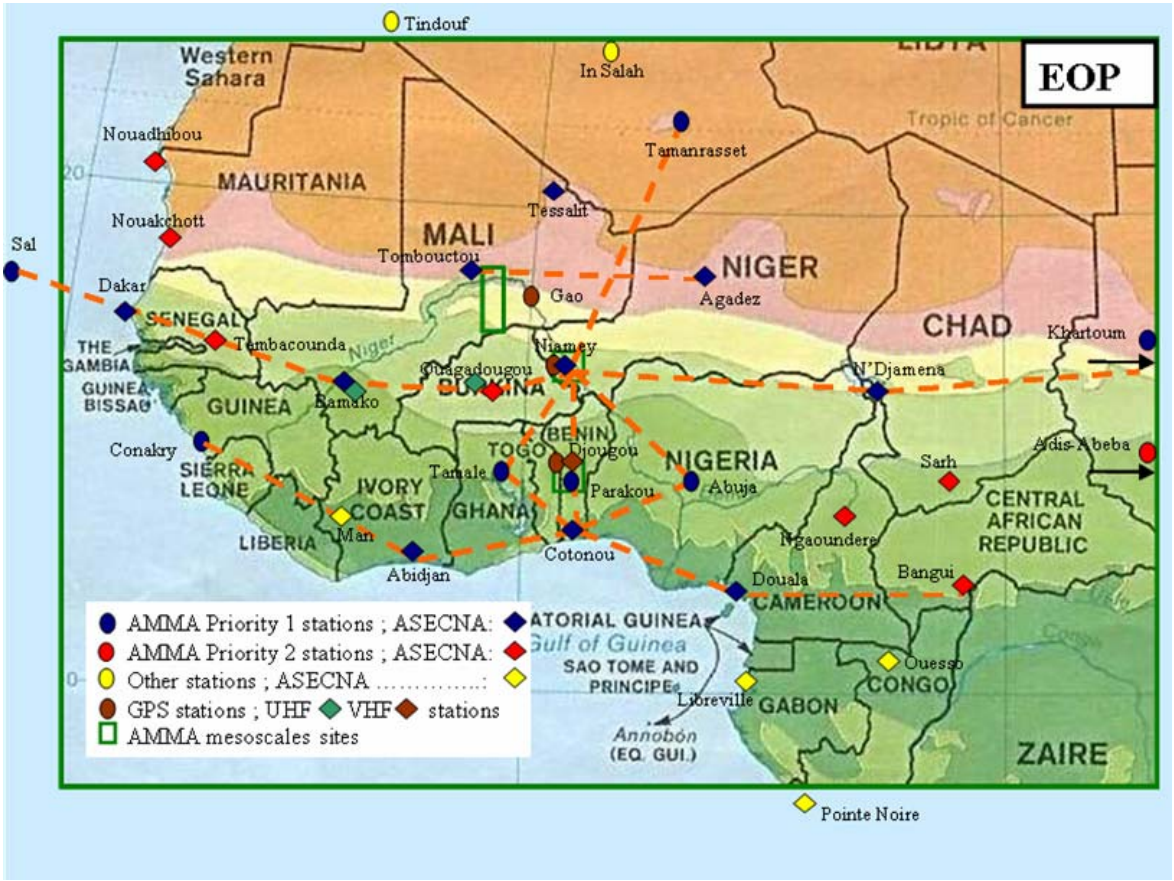

Fig. 1: Locations, priorities, transects (arrays), GPS, UHF/VHF profiler and the mesoscale sites of AMMA international during EOP

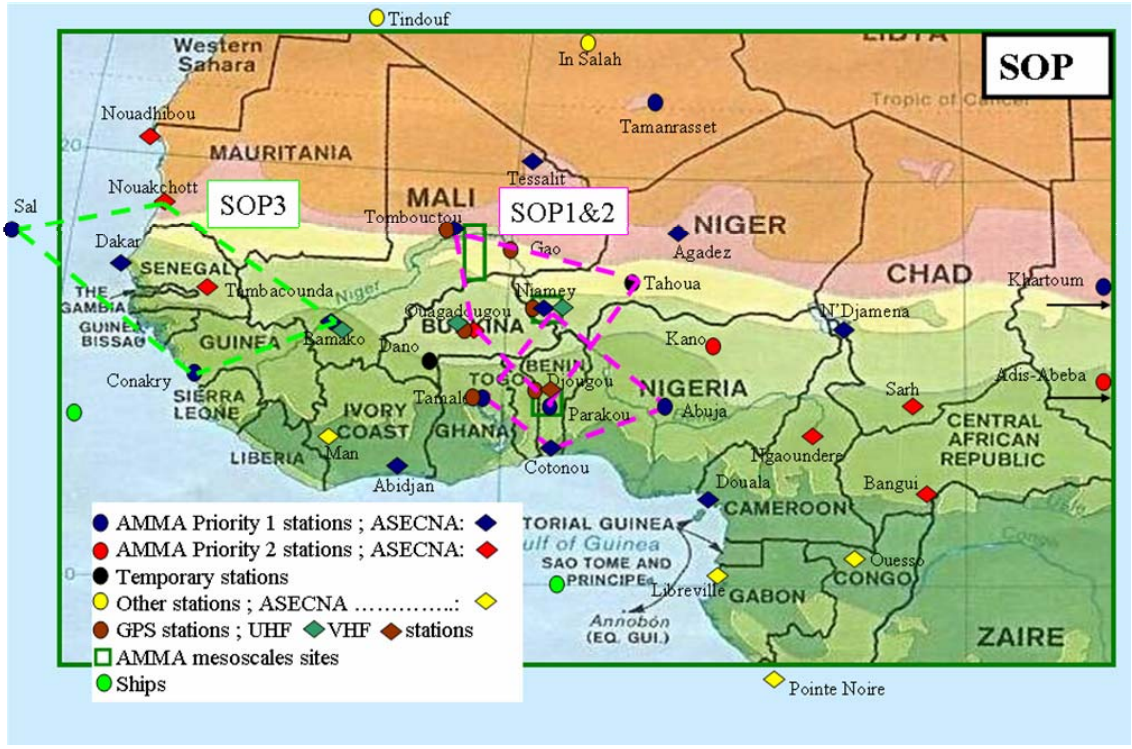

Fig. 2: Locations, priorities, quadrilaterals (flux arrays), GPS, UHF/VHF profiler and the mesoscale sites of AMMA international during SOP 2006

2.3 Priorities (Radiosondes)

Two priorities have been agreed by this TT for the AMMA EOP radiosoundings: priority 1 and 2, where '1' is the highest one. Station priorities are indicated in Fig. 1 and Fig. 2, as well as in Table 2. Seven-teen (17) priority 1 and 9 priority 2 stations have been identified based on scientific justification. A close partnership with ASECNA has been developed (11 out of 17 P1 stations) whose staff will operate the soundings, among which are 11 out of the 17 P1 stations.

No specific priorities have been defined for the SOP. A number of soundings in the SOP will be defined to be 'responsive', that is, deployed in response to the day-to-day requirements of coordination with aircraft and radar.

For the SOP period a GRAW radiosonde system operated by Forschungszentrum Karlsruhe (FZK) as a responsive research sounding stations will be deployed at Dano, Burkina Faso, in conjunction with other ground-based instruments. This system will be deployed with the aim of making downstream observations of systems moving to the west from the intensive mesoscale sites of Niamey and Djougou. Data are transmitted via ftp and the German Weather Service in real-time to the GPS The strategy for the deployment is managed by TT8 and is described in the TT8 document.

Priorities for telecommunication and infrastructure are as follows:

Upgrade priorities (by the end of 2005):

1) Improvement of telecommunication. New Data Collection platforms (DCPs) at Ngaoundere, Parakou, Tamale, and Abuja. Direct links to the GTS at Cotonou, Douala, Nouakchott, Dakar and Ndjamena (by 12/05).
2) Replacement of existing Digicora I stations by refurbished Digicora II stations in the ASECNA network (by 12/05).
3) Upgrade of existing Digicora II stations in the ASECNA network (by 12/05).

4) Replacement of key STAR stations by refurbished Digicora II stations (by 12/05).
5) Operation of 4 new stations (Tamale, Parakou, Cotonou, and Abuja) in early 2006. Cotonou has become operational in June 2005, and is transmitting properly to the GTS since 27 October 2005.
6) Implement training of operators on the VAISALA/MODEM groundstations, on VAISALA (RS92) and MODEM (M2K2) PTU GPS sondes and on DCPs (by 12/05). A MODEM M2K2 training took place in Cotonou in early June 2005 and in Parakou in mid-December 2005.

Finally due to the special scientific requirements of the funded programmes, there is a set of additional constraints on the priorities for the radiosondes. AMMA-EU has defined a priority A and B (with A being higher priority) for its own interests. These priorities take into account both the EOP and SOP needs of AMMA-EU. The differences between the EU priorities A and B, and the international AMMA EOP priorities 1 and 2 are

7) Tessalit is priority A for the EU project. The existence of this station was not apparent at the time of the EOP 1-2 definitions. It is perfectly-placed to sample the monsoon trough and heat low.
8) Ouagadougou is priority A for the EU and priority 2 for EOP. This is because of the station's importance in the SOP, as part of the northern quadrilateral, but its relative unimportance for the EOP, on longer time and space-scales.
9) Abidjan, Conakry, Douala, Khartoum and Sal (priority 1) are lower priority for the EU (priority B). This is because the main focus of activity for the EU project is around the longitudes of Gourma, Niamey and Djougou.
10) AMMA-ACI has placed a special priority on the activation at Cotonou – all of the funds from this French programme will be directed at Cotonou.
11) AMMA-UK has a budget for radiosondes which will be deployed in the northern quadrilateral, to the north of Niamey. The sondes will be deployed during the EOP and SOP, and additional sondes will be specifically deployed in support to the UK Bae146 aircraft operations.

2.4 Other critical issues

There is a clear strategy for the deployment of additional resources should they become available. Our first aim would be to support those EOP Priority 1 stations which are not covered by the existing funded projects (primarily Khartoum and Conakry). However the situation of the two stations is different. AMMA has established links with the met. Service in Guinea, an evaluation of the existing station was made and ASECNA is willing to help in the deployment, should the appropriate funds be available. In Khartoum, links with the Meteorological Service and the evaluation of the station remain to be done.

This Abidjan station has for a long time been a major priority for AMMA. Asecna is in the process of transferring the station to a new location and this has nothing to do with the refurbishing of the old gas station. What we wanted to do is refurbish this old gas station just for AMMA. Asecna is going to start building the new station before the end of the year and might not want to spend money in the old gas station. What is sure is that the new station will not be ready for AMMA.

The radiosonde station of Kano (Nigeria) equipped with a Digicora I has been tested successfully using RS80 GPS sondes. It is considered to activate this station with 00 and 12 UTC soundings for the SOP1 period from 01 June to 15 September 2006.

The Algerian Meteorological Service OMN has confirmed that Tamanrasset can do two additional soundings at 06 and 18 UTC during SOP 1 and 2 provided that the additional helium, balloons and sondes costs are supplied. A cooperation contract is negociated between CNRS and ONM Algeria.

3 Deployment

3.1 Planning

The planning of the deployment of infrastructure is detailed and updated in a station-by-station fashion in the ARGIS document available under http://www.meteo.uni-koeln.de/amma and reproduced here in the Annex. Similarly, the planning of the consumables deployment during EOP/SOP is available from the EXCEL spreadsheet "Consumable_planning.xls" that can be downloaded under the same URL (given here in Table 2).

3.2 Logistical considerations

The consumables and infrastructure for the ASECNA RS stations within the AMMA network will be purchased, installed and launched by ASECNA. Therefore, shipping, handling and customs clearing will be dealt with through ASECNA. Consumables for Ghana and Nigeria will be ordered by ASECNA and shipped by the manufacturer to Accra and Lagos, respectively. Universities of Cologne and Leeds will manage the infrastructure installation and training at the new stations Tamale (Ghana) and Abuja (Nigeria) in close cooperation with the national meteorological services The Ghanaian and Nigerian meteorological services have agreed to assist in customs clearing and transportation.

4 Partnership

Training for stations on the ASECNA network will be conducted through the existing ASECNA facilities at EAMAC (Niamey). The radiosonde manufacturers will travel to Africa to convey the new techniques to the training schools (for engineers and for operators).

MODEM has already performed two trainings at the new Cotonou station at and in Parakou.

There are two important stations that are outside the ASECNA network, in anglophone countries (Tamale and Abuja). After discussions with the operating agencies in these countries, it was agreed that training and installation will be conducted in each country by a Vaisala technician in January 2006.

Within the framework of the US ARM programme, a training on the operations of a Vaisala Digicora III groundstation is conducted at Niamey in early January 2006.

5 Organisation of TT1

5.1 Leaders, core group, membership

The group currently consists of the following members:

- **Andreas Fink (U. Koeln)**
- **Anton Beljaars (ECMWF)**
- **Arona Diedhiou (LTHE-IRD, Niamey)**
- Boubacar Madina Diallo (DMN Guinea)

- Cherif Diop (DMN Senegal)
- **Chris Thorncroft (U. Albany, SUNY)**
- **Doug Parker (U. Leeds)**
- **Francis Dide (DMN, Benin)**
- Frank Roux (Laboratoire d'Aerologie, Toulouse)
- Ismail Fudl El Moula Mohamed (Meteorological Authority, Khartoum)
- **Jean Blaise Ngamini (ASECNA Dakar)**
- Jean-Luc Redelsperger (CNRM, CNRS, Toulouse)
- Mahaman Saloum (DMN, Niger)
- Karim Traoré (DMN, Niger)
- Infeanyi Nnodu (NIMET, Nigeria)
- Mama Konate (DMN, Mali)
- Michael Douglas (National Severe Storms Laboratory/NOAA)
- Mohamed Kadi (DMN, Algeria)
- Olivier Bock (IPSL, France)
- **Serge Janicot (LOCEAN Paris)**
- **Thierry Lebel (LTHE-IRD, Grenoble, Niamey)**
- Lamin Mai Touray (Dept of Water Resources, the Gambia)
- Zinede Minia (Meteorological Department, Ghana)

The group is presently co-chaired by Andreas Fink and Serge Janicot.

Core group members are listed in bold. We have aimed to include representatives of relevant scientific communities, and from the major national and pan-national groups.

Each of the major funding agencies has its own management committee who are also represented in this TT.

5.2 Internal coordination

The internal communication is mainly performed via e-mail exchange and teleconferences among the core group

5.3 External diffusion of the information and reporting

Various reports have been produced and are available under the “Leeds” and “Cologne” web pages. The reporting to the AMMA ISSC is guaranteed by the ISSC membership of Andreas Fink .

Monitoring of the performance of stations in the network, and in the assimilation of data, is being conducted by ECMWF and can be viewed online at:

http://www.ecmwf.int/products/forecasts/d/charts/monitoring/amma/

The RS consumable deployment planning is closely coordinated with the SOP TT leaders (e.g. Jim Haywood and Jacques Pelon for TT7 and Doug Parker and Cyrille Flamant for TT8.

ANNEX 1 : Radio Sounding Frequency at the various stations

Table A1: Anticipated soundings on the EOP and SOP network. Yellow indicates stations operating one sounding per day (usually 1200 UTC), green indicates 2 soundings per day, and the numbers denote the additional soundings needed, above the normal operational levels, to achieve these frequencies. The red cells indicate stations that will do four-times daily soundings during SOP. The additional soundings needed are indicated (last update: Dec. 2005)

	Type	**Additional AMMA consumables (EOP + SOP)**											
StationName		2005/1	2005/2	2005/3	2005/4	2006/1	2006/2	2006/3	2006/4	2007/1	2007/2	2007/3	2007/4
ABIDJAN	V	0	0	0	0	0	0	0	0	0	0	0	0
ADDIS ABABA-BOLE		0	0	0	0	0	0	0	0	0	0	0	0
AGADEZ	V	0		61	92	90	151	246	31	0	0	0	0
BAMAKO/SENOU	V	0	0	0	0	0	0	0	0	0	0	0	0
BANGUI	M	0	0	0	0	0	0	0	0	0	0	0	0
CONAKRY	V						30	92					
COTONOU	M	0	22	92	92	181	262	358	123	90	91	92	31
DAKAR/YOFF	V	0	0	0	0	20	0	0	0	0	0	0	0
DANO	G						50	50					
DOUALA R.S.	V	0	0	0	0	0	0	0	0	0	0	0	0
KHARTOUM		0	0	0	0	0	0	0	0	0	0	0	0
MAN													
ABUJA	V	0	0	0	0	121	262	358	123	90	91	92	31
KANO	V	0	0	0	0		60	154		0	0	0	0
NDJAMENA	V	0	0	0	0	91	91	92	31	0	0	0	0
NGAOUNDERE	V	0	0	0	0	0	0	0	0	0	0	0	0
NIAMEY-AERO	V	0	0	0	0	0	182	184	0	0	0	0	0
TAHOUA	M						60	154					
NOUADHIBOU	V	0	0	0	0	0	0	0	0	0	0	0	0
NOUAKCHOTT	V	0	0	0	0	0	0	0	0	0	0	0	0
OUAGADOUGOU	M	0	0	0	0	31	151	246	31	0	0	0	0
PARAKOU	M	0	0	0	31	121	262	358	123	90	91	92	31
SAL		0	0	0	0	0	0	0	0	0	0	0	0
SARH		0	0	0	0	0	0	0	0	0	0	0	0
TAMALE	V	0	0	0	0	121	262	358	123	90	91	92	31
TAMANRASSET	V	0	0	0	0	0	60	154	0	0	0	0	0
TAMBACOUNDA	M	0	0	0	0	0	0	0	0	0	0	0	0
TESSALIT	V	0	0	0	0	0	60	154	0	0	0	0	0
TOMBOUCTOU	V	0	0	0	0	90	151	246	31	0	0	0	0
DDT DKR	V+M	0	0	0	0	0	0	0	0	0	0	0	0
EAMAC NIM	V+M	0	0	0	0	0	0	0	0	0	0	0	0
ASECNA responsive							100	100					
non-ASECNA responsive							30	30					

ANNEX 2: AMMA Radiosonde Task Group: Implementation Strategy, as for 19/12/2005

Immediate priorities:

1) Upgrade of Communications/IT-Equipment on key stations in existing network (by 09/05).
2) Installation of new stations at Cotonou, Parakou, Abuja and Tamale (by 05/05-12/05). Cotonou is active since 05/2005.

Upgrade priorities (by the end of 2005):

3) Replacement of existing Digicora I stations by refurbished Digicora II stations (except Dakar that will be equipped with a new Digicora III MW21) in the ASECNA network (by 12/05).
4) Upgrade of existing Digicora II stations in the ASECNA network (by 12/05).
5) Replacement of key STAR stations by refurbished Digicora II stations (by 12/05).
6) Implement training of operators on the VAISALA/MODEM groundstations, on VAISALA (RS92) and MODEM (M2K2) PTU GPS sondes and on DCPs (by 12/05)

Status of existing stations

Each station name is followed by its code (when it exists), the country, the operator, the AMMA priority (1 or 2), the EU priority (A or B)

Digicora MW11 (I) stations

Addis Ababa (GCOS station), Ethiopia, ASECNA, P2, B

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora	None (priority 2)	
Communications/IT-Equipment	??	None	
Gas generation	??	None	
Building	??	None	

Agadez (61024), Niger, ASECNA, P1, A

	Status, July 2005	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora MW11 (1994) with MF12	Upgrade to RS92 (Refurbished Digicora II)	12/05, 27 kE, ASECNA AMMA-EU
Communications/IT-Equipment	VSAT	Cable/Radiolink to VSAT building;	12/05, 4 kE, ASECNA/ AMMA-EU
Gas generation	GIP 3, two old ones	None for twice-daily soundings	
Building	OK, but old (1974)	none	
Power Supply	Less reliable	Power Generator or UPS	ASECNA AMMA-EU

Dakar (61641 GCOS station), Sénégal, ASECNA, P1, A

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora I MW11 (1989) and STAR	New Digicora III MW21	09/05, 52 kE, ASECNA AMMA-EU
Communications/IT-Equipment/	No automatic transmission to CAT,	Automatic transmit to CAT via radiolink	12/05, 4 kE, ASECNA
Gas generation	GIP 3 (Electrolyser unserviceable)	New Electrolyser	US GCOS programme
Building	OK	None	

Douala (64910 GCOS station), Cameroon, ASECNA, P1, B

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora MW11 (1986)	Upgrade to RS92, Digicora II	12/05, 13 kE, ASECNA, GCOS support
Communications/IT-Equipment	No automatic transmission to CAT,	Automatic transmit to CAT via radiolink	5 kE, ASECNA
Gas generation	GIP 3	None	
Building	OK	None	

Niamey (61052 GCOS station), Niger, ASECNA, P1, A

	Status, September 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora MW11 (1994) and STAR (with MF12)	Upgrade to RS92, Digicora II	09/05, 27 kE, ASECNA AMMA-EU
Communications/IT-Equipment	No direct connection to CAT	Cable/Radiolink to VSAT building	09/05, 4 kE, ASECNA, AMMA-EU
Gas generation	GIP 3	None	
Building	OK	None	
Power Supply	OK	None	

Khartoum (62721), Sudan, Meteorological Authority, Sudan, P2, B

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora	None	
Communications	Unserviceable	None	
Gas generation	??	None	
Building	??	None	

Sarh (65548), Niger, ASECNA, P2,B

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora I		
Communications			
Gas generation			
Building			

Tamanrasset, (60680 GCOS station), Algeria, DMN Algeria, P1, A

	Status, May 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora I	None	
Communications/IT-Equipment	??	None	
Gas generation	??	None	
Building	??	None	

Tessalit, (61202), Mali, ASECNA, Abandoned due to logistic problems

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora I	Upgrade to RS92, Digicora II)	12/05, 27 kE, ASECNA AMMA-EU
Communications/IT-Equipment		None	09/05, 7,5 kE, ASECNA AMMA-EU
Gas generation		Two new GIP 3	12/05 12 kE, , ASECNA AMMA-EU
Building	To be determined		

Tombouctou (61223) Mali, ASECNA, P1, A

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora MW11 (1994)	Upgrade to RS92, Digicora II)	12/05, 27 kE, ASECNA AMMA-EU
Communications/IT-Equipment	VSAT	Cable/Radiolink to VSAT building;	12/05, 4 kE, ASECNA/ AMMA-EU
Gas generation	GIP 3	None	
Building	OK	None	

Digicora MW15 (II) stations

Abidjan (65578 GCOS station), Cote d'Ivoire, ASECNA, P1, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora II	Upgrade to RS92	Asap, NOAA/GCOS
Communications/IT-Equipment	No direct connection to CAT	Install	12/05, 4 kE, ASECNA, AMMA-EU
Gas generation	Electrolyser destroyed by June 2001 accident	GIP 3 needed	12/05 12 kE, ASECNA AMMA-EU
Building	Under construction	Complete construction	ASECNA

Man (65548)Cote d'Ivoire, ASECNA, Status of the station unclear

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora I		
Communications			
Gas generation			
Building			

N'Djamena (64700) Chad, ASECNA, P1/A

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora MW15 (1999)	Upgrade to RS92	12/05, 10 kE, ASECNA AMMA-EU
Communications/IT-Equipment	No automatic transmission to CAT,	Automatic transmit to CAT via radiolink	12/05, 4 kE, ASECNA
Gas generation	GIP 3	None	
Building	OK	None	

Ngaoundere, Cameroon, ASECNA, P2/B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora II	Upgrade to RS92	12/05, 10 kE, ASECNA
Communications/IT		DCP currently shipped	
Gas generation	GIP 3	None	
Building	OK	None	

Nouakchott (61442), Mauritania, ASECNA, P2, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	Digicora MW15 (1999)	Upgrade to RS92	12/05, 10.0 kE, ASECNA AMMA EU
Communications/IT-Equipment	No automatic transmission to CAT,	Automatic transmit to CAT via radiolink	12/05, 5 kE, ASECNA
Gas generation	GIP 3	None	
Building	OK	None	

Star stations

Bamako (61291), Mali, ASECNA, P1/A

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	STAR (1994), PC (DOS 6.22)	Replace by a refurbished DIGICORA II	12/05, 27 kE, ASECNA AMMA-EU
Communications/IT-Equipment	No direct connection to CAT	Install	09/05, 5 kE, ASECNA
Gas generation	GIP 3	None	
Building	OK	None	

Bangui (64650), Central African Republic, ASECNA, P2/B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	STAR	Install new groundstation	12/05, 35-60 kE, ASECNA
Communications/IT-Equipment	Automatic transmission to CAT	None	
Gas generation	GIP 3	None	
Building	OK	None	

Nouadhibou (61415) Mauritania, ASECNA, P2, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	STAR (1994),	Install new groundstation	12/05, 35-60 kE, ASECNA
Communications/IT-Equipment			
Gas generation			
Building			

Ouagadougou (65503) Burkina Faso, ASECNA, P2, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	STAR	Replace by refurbished DIGICORA II	12/05, 27 kE, AMMA EU
Communications/IT-Equipment	Automatic transmission to CAT	None	
Gas generation	GIP 3	None	
Building	OK	None	

Tambacounda (687) Senegal, ASECNA, P2, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	STAR	Install new groundstation	12/05, 35-60 kE, ASECNA
Communications/IT-Equipment	???	None	
Gas generation	GIP 3	None	
Building	OK	None	

Others

Sal (08594 GCOS station), Cape Verde, Cape Verde Meteorological Service, P1, B

	Status, May 2004	Proposed actions	Date, cost, source
Groundstation	ATIR US INC (radiotheodolite)	None	
Communications/IT-Equipment	??	None	
Gas generation	??	None	
Building	??	None	

Status of new stations

Abuja (65125), Nigeria, NIMET, P1, A

	Status, December 2005	Proposed actions	Date, cost, source
Groundstation	None	New DIGICORA III MW 21 is in Cotonou	
Communications/IT-Equipment	To be reviewed	DCP is in Lagos	
Gas generation	None	Two new GIP 3 presently in Cotonou	
Building	None	To be finished in early January 2006	NIMET
Power Supply	To be reviewed	To be reviewed	

Cotonou (65344), Benin, ASECNA, P1, A

	Status, December 2005	Proposed actions	Date, cost, source
Groundstation	MODEM SR2K2	None	
Communications/IT-Equipment	Manual transmission working	Automatic transmission to CAT via radiolink	09/05, 4 kE, ASECNA
Gas generation	GIP 3	None	
Building	OK, amendments completed	None	
Power Supply	OK, no outages	None	

Parakou (65330), Benin, DMN Bénin/ASECNA, P1, A

	Status, December 2005	Proposed actions	Date, cost, source
Groundstation	None	MODEM SR2K2 on site	
Communications	None	DCP available	
Gas generation	Gip 3	None	
Building	OK	None	
Power Supply	Reliable, outages infrequent	Supply of an UPS	09/05, AMMA-EU DMN Benin

Tamale (65418), Ghana, Met. Service, Ghana, P1, A

	Status, January 2006	**Proposed actions**	**Date, cost, source**
Groundstation	None	DIGICORA III MW 21 currently shipped from Cotonou to Accra	
Communications	VSAT	DCP is in Accra	
Gas generation	None	Two GIP-3 in Accra	
Building	Completed in January 2006		GMA/AMMA-EU
Power Supply	OK	UPS provided by AMMA EU	

Conakry (61832), Guinea, DMN, P1, B

	Status, December 2005	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora MW11 (1993)	Upgrade	
Communications/IT-Equipment	VSAT, no automatic link to VSAT building	None	
Gas generation	Electrolytic gas generator, US manufacturer (1994) Type MZ8 / AK029T	Replace some wear parts	
Building	OK	None	
Power Supply	Poor, also problems with water supply	Site survey to be conducted by an ASECNA technician	

Status of ASECNA training sites

Dakar, Senegal, ASECNA, Training/Spare station

	Status, October 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora I and Star	Refurbished Digicora II	27 kE, AMMA EU NIMET

Niamey, Niger, ASECNA, Training

	Status, October 2004	**Proposed actions**	**Date, cost, source**
Groundstation	Digicora I and Star	Refurbished Digicora II	09/05,ACI/CNRS (France)