The West African pilot balloon network during the NAMMA-2006 and implications for the future of the African pilot balloon sounding network

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Introduction

The National Aeronautics and Space Administration (NASA) – African Monsoon Multi-disciplinary Analysis) (AMMA) field program (NAMMA hereafter) was carried out in west Africa and over the eastern tropical Atlantic during August and September 2006 to improve our understanding of the genesis of tropical storms over this region. The main focus was on the role of dust and the variability of African easterly waves in the cyclogenesis.

The primary components of the NAMMA were the NASA DC-8 research aircraft and the meteorological radars based in the Cape Verde Islands at Praia and near Dakar, Senegal. However, a small effort was supported to upgrade the sounding network in countries of west Africa, specifically Mali, Mauritania, Senegal, and Guinea. The objective was to improve the synoptic specification of the African waves leaving the continent to help plan the DC-8 flight missions and to support studies to describe the upstream conditions prior to cyclogenesis over the Atlantic.

Because of the limited funds available, the effort mostly involved trying to bring the existing pilot balloon network over the region up to its former status. This summary describes this effort. It also suggests where the future may lie with regards to the network, based on our experience. More information on our activities may be found at:

http://www.nssl.noaa.gov/projects/pacs/web/NAMMA/e_introduction.html

The pilot balloon network in West Africa has been in place for more than 50 years, and in the past the network was characterized by relatively frequent observations (often 4-times daily) and with high spatial density (more than 20 stations in West Africa). However, the pilot balloon network has decayed in recent decades. Unfortunately it is difficult to describe this decay in detail because much of the observations were not transmitted in real-time and many of the observations have not been digitized and made available in digital archives.

Some details of the effort to improve the network in west Africa prior to the NAMMA aircraft activities are described in an abbreviated, but still lengthy, report in Appendix 1. This provides the flavor of what can happen in an effort that in retrospect allowed too little lead time and was short of resources. Despite our considerable experience in working in Latin America, we were not fully prepared for the experiences we encountered in west Africa.

Implications for the pilot balloon network in west Africa

Our experience with the seriously decayed pilot balloon network we found during NAMMA does not mean that the observations should be abandoned. In the relatively cloud

free environment of the region there would be considerable benefit to having a relatively dense upper wind network. The intensity of tropical waves cannot be adequately described from the current winds over the region; the small scale of the vorticity features cannot be well-resolved from the radiosonde network alone.

Reducing the pilot balloon network's glaring problems – lack of gas and poor data quality being two major problems, is an urgent problem. Fortunately, the gas supply problem can be dealt with by either 1) importing gas cylinders from a central source where it can be produced inexpensively (Europe or the US) or 2) using new technology gas generators to generate on demand the gas needed for balloon inflation. A system now being tested (http://www.hydrogenpowerinc.com/index.html) appears to be fully an order of magnitude less expensive to purchase than current caustic soda generators, and as economical to operate as importing gas cylinders. The availability of an inexpensive and convenient hydrogen source to inflate balloons in remote locations is the largest problem blocking a significant upgrade of the pilot balloon network in the region.

To improve data quality of pilot balloon observations requires regular maintenance of the theodolites and calculation of the winds with computer software that displays and interactively corrects the raw angle data if errors are detected. Currently no error-dectection is possible, with raw angles being entered into a hand calculator and the winds immediately calculated. A keypunching mistake or an incorrect reading from the theodolite cannot be easily detected (or corrected).

Implications for future radiosonde and pilot balloon activities in west Africa

The ASECNA[1] oversees radiosonde observations in many African countries. This has been the case since independence, and is a realistic recognition that each country by itself might not be able to maintain the meteorological networks needed for civil aviation purposes. This arrangement appears to have worked well, and the current radiosonde network is thus somewhat insulated from the economic difficulties of meteorological services in any of the particular countries.

Our original impression was that the problems with maintaining the sounding network in west Africa (both radiosonde and pilot balloon) was due to the non-participation of the individual meteorological services in operating the sounding network. We believed that if each country made the observations, and then used them for forecasting, they would individually see the value of the observations and help support the stations. ***We no longer believe this to be the best strategy.***

Our experience in upgrading the sounding network in west Africa for NAMMA suggests that a radiosonde network for Africa should be operated by a organization that would be essentially *independent* of national meteorological services. Such an organization should have authority to establish and operate sounding sites based on the overall benefit to numerical weather prediction on a regional to global scale. Recommendations from a "scientific oversight committee", rather than from individual met services, would be used to locate stations.

[1] Acronym for French-led agency, based in Dakar, that oversees aviation activities in former French colonies in Africa and Madagasgar.

While somewhat radical, our suggestion is similar to what ASECNA is already doing in much of west Africa. It is also exactly what the NOAA-funded PACS-SONET project did for approximately 10 years in Latin America with pilot balloon observations (which motivated our African work and also this article). It makes little sense to have some countries, because of their favorable economic status, establishing many stations while their neighbors cannot afford – or chose not to support, any stations. It will be *very difficult* to convince all countries in Africa to agree to financially support a radiosonde and pilot balloon network of uniform density for weather forecasting purposes. This would put a major burden on large, relatively poor countries. And very few countries will be willing to support radiosonde observations in a neighboring country that chooses not to make such observations. The only feasible solution to establishing an adequate and uniform network over the continent is to support the network with external funds, and to then run the network for the purposes of NWP and climate monitoring, and fully independent of the host countries. In this sense the network would be little different than a multinational corporation. Satellite observations are provided for Africa by EUMETSAT, the US distributes WAFS data globally, and the US provides polar orbiting satellite for the entire world. Thus, there is no essential reason that atmospheric sounding observations must be made by a National Meteorological Service, if they can be more effectively carried out by another organization.

By contracting individuals to make the soundings, it would actually be possible to increase the likelihood of reliable observations. Observers could be paid a good wage (as opposed to very poor salaries of government workers in many NMS's), and rotated periodically from remote locations to more central locations. Such an organization would essentially be a meteorological service, but focused on making and distributing the observations. It would ensure a more uniform distribution of stations, and maximal impact on continental and global-scale numerical weather prediction.

If establishing an organization to oversee and operate the sounding network over much of Africa sounds too complicated, the alternative is to make mutual aid arrangements with many of the approximately 53 countries that comprise Africa and then to somehow enforce the operation of these stations. The most effective solution should be to obvious to anyone with any international experience.

The existence of such an internationally-funded organization to make radiosonde soundings does not mean that individual countries could not operate their own sounding networks. If the basic sounding network was perceived as not sufficiently dense for good limited area forecasts, an individual NMS could always fund its own stations.

APPENDIX 1: Summary of efforts to strengthen the existing pilot balloon and radiosonde network in West Africa for the NASA-AMMA field program.

Note: photos illustrating the following activities can be seen at: http://www.nssl.noaa.gov/projects/pacs/web/NAMMA/e_photos.html

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In April 2006 we[2] received notification that we would be funded to establish a pilot balloon network in western Africa to describe the intensity of tropical waves propagating over the region prior to their emerging over the eastern Atlantic Ocean. Due to time and funding limitations we decided to focus our attention on four countries: Senegal, Mauritania, Guinea, and Mali. These countries already had existing upper-air stations and a history of making both pilot balloon and radiosonde observations. Guinea, which had not made soundings in some years, was chosen because of the NAMMA community perceived this area to be important, as few observations were available south of Senegal in west Africa (see Fig. 1).

Historical setting

Many aspects of the AMMA field program were discussed during an AMMA Scientific Conference held in Dakar in December 2005. A poster was submitted to this conference with the focus on the importance of upgrading the pilot balloon network prior to the AMMA field phase. At the time of the conference the Principal Investigator (PI) (MD) was unaware of the possibility of any funding for such an activity, but had been encouraged to attend by European counterparts who were organizing the sounding component of AMMA.

At the Dakar meeting the PI became aware of a call for proposals related to the NASA-AMMA effort (NAMMA) which was focused on studying the downstream development of tropical waves into tropical storms over the eastern and Central Atlantic Ocean. A proposal was formulated that proposed describing the wave intensity over west Africa, combined with aircraft observations of the wave over the ocean with the NASA DC-8 aircraft. This proposal was funded, and notification of the proposal's acceptance was received on April 25th.

A science conference was rapidly organized by the NAMMA Chief Scientist (Ed Zipser, U of Utah) and a two-day meeting was held at Howard University in Washington DC on June 4-5th. At this meeting was Jean Blaise Ngamini, the AMMA representative from ASECNA, the Agency responsible for coordinating Aviation activities (including meteorology) for some 16 countries in Africa and in Madagascar. Mr. Ngamini was coordinating the ASECNA sounding network for the AMMA activities, and provided information on the current situation in west Africa as it related to NAMMA. Mr. Ngamini provided us with details of the ASECNA network and mailing addresses for each of the countries involved.

In June 2006 we purchased 5 additional (used) theodolites from an individual who has these and maintains a web site dedicated to meteorological theodolites. These used theodolites averaged $1000 each, versus $8000

[2] "We" here and elsewhere, refers collectively to all of the participants in the pilot balloon set-up activity – the author and co-authors of this report.

for new theodolites. The theodolites and the necessary 30gm balloons were shipped about 1 week prior to our departure for Senegal, which in retrospect, allowed too little time. The first shipment, of three theodolites and balloons to Senegal, was mis-routed by FEDEX's European collaborator and was sent *twice* to Johannesburg, before being sent to Dakar, arriving 10 days late.

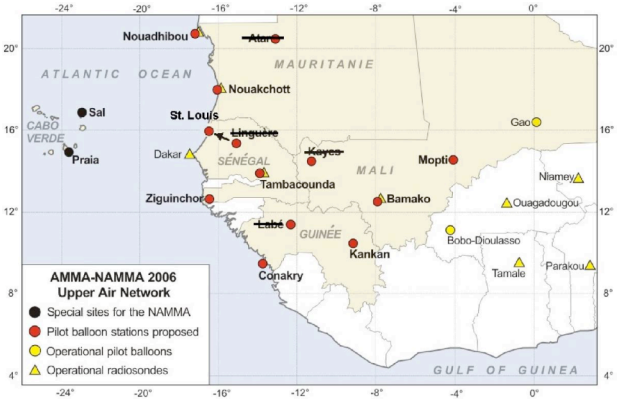

Fig. 1. The planned network, prior to the set-up. Names that are crossed-out were discovered in the field to be impractical to establish. Dakar was also a pibal site.

Establishing the stations

Our NSSL group, consisting of myself[3], PACS-SONET coordinator Javier Murillo, and two University of Oklahoma graduate students with considerable field experience in Latin America (Jose Galvez and John Mejia) traveled to Dakar, Senegal on July 10th. Our intention was to determine the current status of the sounding network, and establish the Senegalese component first, and then travel to the surrounding countries as appropriate. The International headquarters of ASECNA is in Dakar, and their collaboration was viewed as valuable to contact each of the participating countries and to make the travel and training arrangements.

Because of the mis-shipment of materials to Senegal, and also because of the difficulty in determining, from Dakar, the situation in each country, we were delayed in traveling to the other countries in the region. In addition, we needed to obtain permission to establish the observations and travel to the stations within Senegal (4 sites, including Dakar) and a meeting the National Meteorological Service was required. Although one Senegal site was visited early (Ziguinchor) and the observers trained and motivated, observations did not begin until approval was given, after a meeting with DMN Director on Aug 8th, at which payment of the observers was discussed.

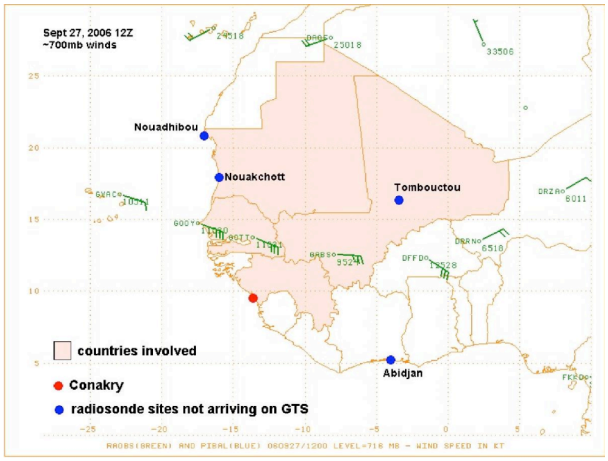

Fig. 2. Example of radiosonde observations arriving via GTS on Sept 27, 2006 at 12Z. The blue dots are stations that have equipment, and may often be making observations (except if gas shortages exist), but whose observations have not been arriving via GTS in recent months. Note the non-uniform distribution of stations, which lie on E-W line.

While waiting for information and the arrival of our shipped materials in other countries, we arranged to have a technical expert in the Met Service of Guinea visit Dakar (at our personal expense) to bring old cylinder heads and to

[3] Rosario Douglas, who speaks some French and has extensive field experience in supporting PACS-SONET activities in Latin America, also accompanied the group.

provide training with the Dakar radiosonde station. This person, we were to discover later, was key to establishing the radiosonde station in Conakry. Unfortunately, the two cylinder heads he brought to Dakar for testing did not work well (they leaked), and we had to order two replacement heads from the Manufacturer, SAGIM, at their (from our perspective - inflated) price of $1500 each.

Mali

Because time was evidently running short (we had purchased restricted tickets from the US to Senegal to save ~$1000 per airfare for each of the 4 official team members), we arranged for travel to Bamako, Mali, on July 25th. A meeting was organized for the following morning to discuss our project and the plan to establish the three proposed pilot balloon sites in Mali. The first item to be discussed, after our explanation of the project, was the payment to the DMN and its personnel. After hearing that air travel to the two sites outside of the main city (Bamako) was irregular and not daily, we discussed ground transport to the sites. An individual was assigned to each of our two teams, which would travel via rental vehicle to the two distant sites (Mopti and Kayes, approximately 500-700 km from Bamako-see fig 2). We were to provide per diem for each individual accompanying us and we needed to rent the vehicles. Unfortunately, rental vehicles were not inexpensive, and with driver amounted to $500 for each 4x4 vehicle for the required 3 days.

The training at the ASECNA pilot balloon site at Mopti went well, as the site was in perfect working order, with gas, balloons and a new theodolite, which had been received within the past 6 months. However, they could not use the theodolite because no one had been sent from the ASECNA headquarters in Dakar to determine the north and otherwise set it up. The observers complained also of insufficient personnel to make pilot balloon observations (only three persons were present, including the one in charge of preparing gas and inflating the balloon, who could not read.)

The travel to the other Mali site, at Kayes, was less fruitful. After a 7 hr drive, including a 2-hr stretch of dirt and mud, we reached the Kayes site. The site was essentially abandoned. Although the excuse was that the site was going to be moved soon to a relatively new airport location, the instrument shelter and all other facilities were in very poor condition. The last time a pilot balloon had been launched at the station was 18 years earlier! The cylinders and supplies, which we had been told were in good condition, were useless. Apparently the observers had been led to believe that we would provide everything needed to make the observations. We returned to Bamako the following morning, unable to do any training.

As we were to arrive back in Bamako on Friday afternoon, July 27th - one day earlier than expected, we had the AMMA Mali representative with us on our trip to Kayes call via cell phone to arrange a training session at the Bamako radiosonde site on the weekend. In this manner we could train the Bamako observers in using a replacement theodolite that we had brought to Mali with us. However, on Friday evening (several hours after we had returned) two individuals from the DMN arrived at our hotel and met with us for a few minutes. They had concluded that training on the weekend was not feasible. No specific reason was given, and we could obtain none from them. We were disappointed, since we had our return flight to Dakar on Sunday afternoon, and this meant we would not be able to set up the Bamako theodolite site without extending our stay, which was already longer than desired.

Out of some desperation we decided to call one of the individuals that had participated in our first meeting, and for whom we had a telephone number - and we explained the situation. He expressed surprise, and thought the training had already been arranged for the weekend. He said that we could come and train on Saturday morning.

We arrived on Saturday morning, and after some effort, replaced the old theodolite (which lacked a working high magnification lens) with our better-condition theodolite. The first pibal observation made with the newer theodolite lasted 40 minutes, compared with an average of 10 minutes with the previous theodolite. This generated a vocal complaint by the station chief that the observers would need to be paid overtime for these observations, since they were accustomed to 10-15 minutes. Fortunately, at the end of the training session it appeared that observations would be made at Bamako.

Interestingly, while visiting ASECNA's Bamako airport forecast office during a break in the training session, we noticed that radiosonde observations from Timbuktu were being plotted. We were unaware that this site was even functioning, since observations were not being transmitted over the GTS. The staff mentioned that Timbuktu had been making radiosonde observations for many months – yet their observations are not available outside of the region. Had we known that Timbuktu was working well, we might have revised our Mali observing network.

The return to Dakar was eventful only in that one of the members discovered shortly before leaving for the airport that they had misplaced their hard copy ticket. At the airport, Air Senegal said that purchasing another ticket was required, and no refund was possible unless a police report had been made in downtown Bamako. As this would have required we miss our flight, there was no practical option but to buy the ticket. We have not see such a police report requirement in any other country, but it reminded us that paper tickets (e-tickets are unavailable) are just like cash in some countries.

We remained in Dakar one day, arranging our travel to Guinea and Mauritania. Because of the limited time available for the set-up of the stations, we split into two groups, one group traveling to Conakry, Guinea and the other to Nouakchott, Mauritania.

Mauritania

The Mauritania team (MD, RD, and John Mejia) were met on arrival by ASECNA personnel at the airport and taken to the hotel. The following morning we met with the ASECNA director, who spoke fluent Spanish, so we communicated in Spanish rather than French, and he translated the essence into French for his staff. We also met with the Met director and all other staff of the Nouakchott meteorology office. The radiosonde site had not made observations for several months due to a shortage of gas generation materials, but a shipment had just arrived (sent from Dakar at our instigation – a much larger shipment had been delayed in France for some time). Gas cartridges were being sent also to the northern radiosonde site of Nouadhibou, via truck, and were sufficient for training and some launches there.

The Nouakchott site was well maintained and run in a relatively exemplary manner. The building was quite new and the hydrogen generators in good condition. The theodolite worked well, though our replacement theodolite could provide more accurate reading – if the observers would persist in being trained on it (it was an unfamiliar design to them).

We immediately became aware that not only low clouds, but heavy dust, could limit pilot balloon observations in Mauritania. The observers had been making pibals in previous months – before the gas supplies ran out, but few soundings exceeded 4 km.

The observers were trained with our software to calculate the winds, this software was installed on the computer that was used for making the radiosonde soundings. Although the observers were trained to process the pibal data in this manner, rather than use their hand calculator, the main problem was in transmitting the data. Observations had not been received from either Mauritania site for some months, and they claimed that there was a problem between Mauritania and Dakar. We suggested using internet to send the data - but the nearest internet was a half km away at the airport terminal building and they said they could not routinely do this – perhaps once per week. Some observers were more willing than others to help out – our personal observation was that the workload was very light and most of the time was spend sleeping/resting or eating/preparing tea while waiting for the next synoptic observation. This was in fact the case at most synoptic stations – there was simply little to do between observations.

After discovering that air transportation to Nouadhibou was infrequent, we arranged for ground transport via the private car of an ASECNA administrator, who drove us. There were numerous military and police checkpoints along the lightly traveled desert road, so it was important to have a French/Arabic speaking person along.

Once in Nouadhibou, we met with the subdirector of the station and agreed to a training session the following day. Initially, we selected a site on the roof of the radiosonde inflation shelter, but this site was in a residential neighborhood a few hundred meters away from the airport terminal building. This site they considered not secure for the equipment, because it could not be locked up easily. They suggested the airport met station, which, despite being an open site, had 24-h guards. However, they had to move one gas generator to the site, which complicated the inflation of the radiosonde balloons (two cylinders are needed for inflating radiosonde balloons since one cylinder is good enough for filling about 1.5 balloons). Thus, the pilot balloons were inflated at one location and the radiosondes at another site. (This was also the case in Dakar.)

We replaced the theodolite at Nouadhibou since their theodolite was in worse condition, but they showed some reluctance to learn the new procedures required. Eventually they realized that it was easier to obtain the decimals degrees with the replacement theodolite. The staff (everyone from the site participated in the training) spent considerable time with the software to process the winds – they appreciated the ease by which bad data could be corrected. Fortunately, internet was available in the Director's office, and they learned how to send the data shortly after the observation was made. Nouadhibou was the most successful of any site in transmitting the data in near-real time.

We returned to Nouakchott feeling that we had been successful overall in Mauritania, and both radiosonde sites seemed to be able to make observations, in addition to the 06 and 18Z pilot balloon observations. Our only concern was whether the gas charges would arrive in time for the sites to continue making radiosonde observations.

Senegal

We had already examined the Dakar pilot balloon site shortly after our arrival in Senegal in July. Although imperfect in several aspects,

observations were seemingly being made there, at least from time to time. The theodolite was eventually replaced by one of ours, and our team members installed and trained the observers in the use of our software to quality control the data.

More difficult was the training of the Senegal sites outside of Dakar. One team that traveled to Tambacounda, the Senegalese radiosonde site 300km east of Dakar, was not allowed to train the station staff – only the station chief, because the training had not been approved and notification had not been given. (The team had asked ASECNA-Senegal personnel to contact the station prior to leaving, but the responsible person was at a meeting, did not get the message, and did not contact the station.) Thus, this site was inadequately trained, despite being ready to make pilot balloon observations. Our team members (JM and JG) wondered why observations were not being made, since everything at the station seemed to be working.

On return to Dakar from Mauritania we discovered that no observations had yet been made in Senegal. We met with the Director of the met service; the main concern was that no financial payment to the observers had been discussed, so no observers had been told to make observations and they were waiting for instructions. After ensuring, via phone calls from the DMN headquarters, that we would be expected, we arranged to travel to the northern Senegal pilot balloon site at St Louis on Aug 8th. This was a site that had previously (in years past) made observations, but the theodolite apparently had developed problems.

Traveling via rental vehicle (with driver) we arrived in St Louis in only 3 hours, and went directly to the airport observation site[4]. The facilities were relatively well-maintained, but the most serious problem was the lack of gas. The gas generator could not be cleaned well for the lack of a cleaning brush, and gas had not been generated in 3 years. (The observers pointed to a hole in the concrete ceiling where the cylinder head had flown off from the last explosion – due to incomplete cleaning of the cylinder.) There was still a small amount of gas in the cylinder, and we managed to make 6 practice balloon launches for training the observers with the new theodolite (again, the old theodolite lacked a good high magnification lens). We trained the observers to process the observations with our software on their new computer – they had received the computer recently but no one had come from Dakar to set it up, so it had remained in the box until we unpacked and prepared it for them.

At the conclusion of our Senegal activities, and when we left on August 10th, we still did not know if the Senegalese sites would function. They had supplies, balloons, gas (except for St. Louis) – only the willingness to make the observations was not guaranteed. As of this writing (Dec 4th) we have not received any indication that observations have been made in Senegal at any of the 4 potential pilot balloon sites.

Activities in Guinea and the radiosonde site at Conakry

Two team members (Jose Galvez and Javier Murillo) arrived in Conakry on July 31st. They prepared the following summery of their experience… The deputy director Yaya Bangoura, Mr. Momo Camara, one driver and one person in military uniform met us at the airport. We had met Mr. Camara previously in Dakar since he traveled there to bring the hydrogen generator heads and to inform us

[4] Leaving the airport after our first session, the right rear wheel and attached axle shaft fell off our rental vehicle. The driver had it fixed, while we continued to the hotel via taxi. The next day, coming apart, it had to be fixed again, half-way to Dakar.

about the status of the Guinean sites. Mr. Bangoura had been in contact with us via email and telephone and made all the arrangements for our visit.

In the hotel we noticed how unreliable electric power was in Guinea. During the peak hours, the hotel was fed by an emergency generator that ran overnight on a regular basis. Although our impression was slightly different the night of our arrival, the next morning we realized that Guinea was the least developed of the three countries we visited during this trip. The trip from the hotel back to the weather service's office in the airport revealed the extent of the economic crisis in this country.

The weak infrastructure is not limited to the electric system. At the hotel, for example, we were told that credit cards would be accepted as a payment method, but days later, at check out, the hotel clerks couldn't communicate with the bank (using a cell phone) to validate the credit card. Since ATM's do not work with foreign cards in Conakry and we didn't have enough cash they have to reluctantly accept the credit card vouchers and let us leave the hotel (and the country) without them being able to validate the cards.

The weather service's entire staff in Conakry (about 10 individuals) are apparently working at the airport. The Direction Nationale de la Meteorologie (DNM) is supposed to function from another building near downtown, but we visited the facilities and they looked abandoned, lacking basic services like telephone lines and even electricity. At the airport, the DNM have a private office, and another working area divided in a cubicle for computers and a small classroom with a desk, some chairs and a board. They have Internet access and computer equipment to display satellite images, but we saw not much evidence of charts, bulletins, or telephone calls requesting data or products, things one normally sees in every weather office.

We met with DNM's director, Mr. Mamadou Lamine Bah, Mr. Boubacar Madina Diallo, and other functionaries to discuss a work plan. The original plan included observations in three sites: Conakry, Labe, and Kankan, but due to the cost and scarcity of materials for gas preparation, the Labe site was discarded. Also, due to time constraints, we did not travel to Kankan, but trained DNM personnel who later went to the site, set up the pilot balloon station and trained additional observers to help with the soundings. We normally prefer to install the sites ourselves mainly to ensure that the theodolite is well aligned. Fortunately, the persons designated to install Kankan were capable and responsible.

Four observers, including Mr. Camara who also covered many other roles, attended the training. Mr. Madina Diallo, who speaks good English, assisted us and greatly facilitated our interaction with the French-speaking people. Jose Galvez speaks enough French to conduct the training sessions, but Mr. Diallo helped improve the communication and allowed Javier Murillo to participate more actively in the training. The subjects covered included theodolite set up and operation, pilot balloon soundings, and use of our software to process the data.

The last two days of training were conducted at the radiosonde station. The theodolite was mounted on the roof of the building using a locally built tripod. Tracking the balloon from the roof of the two-story building complicated its release, but this was the best location given that the building itself and tall trees nearby prevented from tracking it from the ground. The observers had some problems at first to operate the theodolite since the design was not familiar to them, but with practice, they started to feel more comfortable at using it.

In Conakry we witnessed for the first time the process of generating hydrogen with the GIP-3 generators. It is a rather cumbersome and potentially dangerous procedure involving mixing and pouring chemicals and water in a cylinder that has to be sealed quickly after pouring the water. Safety measures, including the use of protective gear, must be carefully followed in order to avoid accidents. There exists a hydrolytic generator at the Conakry site, apparently donated by NOAA, however it was either not functioning or it could not be operated due to an intermittent electric supply. We were told that electric power was only available after 7 PM, but it was not clear for how long it remained hooked up.

We spent the last day of our visit checking the radiosonde system. We began by checking the electric generator, which was not operational. It required replacing the circuit breakers and tightening a few loose connections. There was also a small mechanical problem that one of the observers managed to fix. The radiosonde system (a Vaisala Digicora MW11) was apparently operational although our test launch was unsuccessful due to a mistake in the baseline procedure. We ran out of gas unexpectedly and could not make another test, but there were no reasons to believe that the equipment had any problems. Since August 27, the Conakry site was able to make at least one radiosonde observation at 12 UTC, though with gaps, until October.

It was apparent soon after our arrival, that the DNM did not have many resources to support the NAMMA activity and that any expenses related to the observations had to be covered by NAMMA. These expenses included: diesel for the electricity generator, radiosondes, balloons, chemicals for gas, hydrogen generator parts, shipping, customs fees, office supplies, observer salaries, transportation and other travel expenses (Kankan site), among others.