The SASSCAL / MAWF Weather Stations Network in Namibia

Overview of equipment and data transfer

Report compiled by Dr B. Strohbach

School of Natural Resources and Spatial Sciences
Polytechnic of Namibia
P/Bag 13388
Windhoek

October 2014

1. Contents

2. Background 2
3. Type of equipment employed 2
   Mike Cotton Systems 2
   Campbell Scientific / Young 5
4. Network 8
5. Communication 11
   MCS130 Logger 12
   Campbell CR1000 logger 12
   Communication via GPRS-network 12
   Communication via satellite 15
   SASSCAL WeatherNet Website 15
6. Planned activities and methodological approaches 15
   Subtask 1: Site selection, erecting new stations 15
   Subtask 2: Maintenance of the stations 15
   Subtask 3: Making data available to end-users 15
7. References and further reading 16

2. Background

Through the BIOTA project (2000 - 2009) 21 high end weather stations meeting WMO standards have been bought for deployment in Namibia. Some of these stations are replacing older equipment at the BIOTA observatories (Jürgens et al., 2010), while some are / will be placed in new strategic localities. These 21 stations update their readings hourly on the web via the cell network or satellite communication. The Ministry of Agriculture, Water and Forestry (MAWF) supported this project with 17 Automatic Weather Stations (AWS) on their research stations. In addition, 14 other weather stations of different technical standard are currently operated by private individuals and primarily tourism lodge operators across the country. Data from these stations is displayed on the web under the Namibia Weather Network. The Namibia Meteorological Service runs a number of automatic and manual weather stations. The World Meteorological Organizations lists 127 rainfall stations for Namibia.

3. Type of equipment employed

Two types of weather stations are currently in use:

Mike Cotton Systems

These stations are build and sold by the Company Mike Cotton Systems in Cape Town, South Africa (see www.mcsystems.co.za for details). These stations were initially installed at the BIOTA observatories in 2001. The logger had a capacity of storing data for about 6 months, but no capacity to download data via the cellphone network. Thus a 3-monthly routine was developed to visit the stations and manually download the data. Later models (from 2007 onwards) of the logger were equipped with a cellphone logger, enabling us to have the data download via the cellphone (GSM / GPRS) network. The buffer size, however, was reduced, allowing the station to only store data up to 8 weeks (not quite 2 months).

The stations were mounted on a 2 m pole (Figure 1), and equipped as follows (Table 1).

Table 1: Typical configuration of the Mike Cotton System AWS's used during the BIOTA project, and later by the Ministry of Agriculture, Water and Forestry.

	Model	Installation notes
Logger	MCS130 10-channel logger	
Power supply	6 V rechargeable lead-acid battery, recharged via the logger from a solar panel	The initial system (without cellphone modem) worked on a 3.6 V lithium battery, which was not recharged. Battery lifetime was at least 3 years.
Wind speed	MCS177	2 m above ground level
Wind direction	MCS176	2 m above ground level
Sunshine duration, intensity	MCS155	2 m above ground level
Air temperature	MCS151	1.5 / 2 m above ground level, in

		a radiation shield*
Air relative humidity	MCS174 or Vaisala	1.5 / 2 m above ground level, in a radiation shield *
Rainfall	Davis raingauge	1.5 m above ground level, on own stand next to (ca 2 - 3 m away from) main station
Soil temperature	MCS151S	10 cm below ground
Leaf wetness		2 m above ground level
Air pressure	MCS157	In logger box, ca 1.6 m above ground. Only installed retrospectively from 2010 onwards

* The installation of the air temperature sensors was originally at 1.5 m height, and only later adjusted to the required 2 m above ground level.

The Ministry of Agriculture, Water and Forestry bought 16 similar stations, but installed these on a 10 m pole (Figure 2). This allowed them to install the wind speed and direction sensors at the required height of 10 m above ground level. The Pyrometer (Sunshine intensity) was also installed at that height. The GSM antenna (Yagi-type antenna) and the solar panel were installed 7 m above ground, to have a better reach (GSM network) or be out of reach of vandalism / thieves (solar panel). The Yagi-antenna is said to have a reach of up to 50 km, depending on topography and placement of base station.

<u>Advantages of the MCS-stations:</u>

a) cheap

b) Build in South Africa, spare parts thus readily available, not directly dependant on exchange rate fluctuations

b) easy to install, with sensors being linked to logger with a normal RS11 jack (telephone jack).

<u>Disadvantages of the MCS-stations:</u>

a) Limited adaptability

b) Only sends out data, not able to address logger remotely

c) Sensitivity of logger to nearby lightning strikes (changes date settings on logger, making the receiving of data difficult)

d) Data is sent out to a proprietary IP, linked to the manufacturer's internet server. Creates a certain dependability on the manufacturer for data transmission

e) Resetting can only be achieved by undoing the power supply.

Figure 1: Typical MCS-station, here with Yagi-antenna and solar panel, at Okamboro outside Okahandja.

Figure 2: Modified MCS-station as used by the MAWF, on a 10 m pole. This allows the station to fulfil WMO standards. This station is at Kalimbeza in the Zambezi region.

Campbell Scientific / Young

At the end of the BIOTA project, remaining funds were invested in the purchase of high-quality weather stations to replace the aging MCS-stations. One of the targets was to provide a long-term solution to climatic data without a continuous need to replace sensors or to download data. The AWS were to conform with WMO standards, and were meant to provide data for numerous follow-up projects after BIOTA (including SASSCAL). SASSCAL Task 001 is building on this particular set of weather stations in Namibia, and is expanding the station network in the neighbouring countries of Angola, Zambia and Botswana.

A combination of a Campbell CR1000 logger (see www.campbellsci.com), with a range of Young sensors (see www.youngusa.com), was installed (Table 2).

Table 2: Typical configuration of a Campbell / Young station, as installed at the end of the BIOTA project and presently used by the SASSCAL project.

	Model	Installation notes
Logger	Campbell CR1000	
Power supply	12 V rechargeable lead-acid battery, recharged via a regulator from a solar panel	Initially the solar panel was installed at 4m height for easy cleaning, and not to interfere with the pyrometer (installed above it). After several theft cases, these were placed at 7 m height.
Communication	Siemens MC35i Terminal Cellular Engine	This modem can be replaced by a satellite communication modem. Tests are currently underway with Meteosat modems
Wind speed	Young Model 05103	Combination sensor, installed 10 m above ground level
Wind direction		
Sunshine duration, intensity	Envco WE300 Solar Radiation Sensor?	4 m above ground level. No exact details available on model.
Air temperature	Young Model 41382	Combination sensor, installed 2 m above ground level, in a radiation shield
Air relative humidity		
Rainfall	Young Model 52202	1.5 m above ground level, on own stand next to (ca 2 - 3 m away from) main station
Soil temperature		10 cm below ground. No exact details available on model.
Leaf wetness	Decagon Devices LWS	Initially placed near ground level in some vegetation, but presently standardized at 2 m above ground level
Air pressure	Young Model 61302	In logger box, ca 1.6 m above ground.

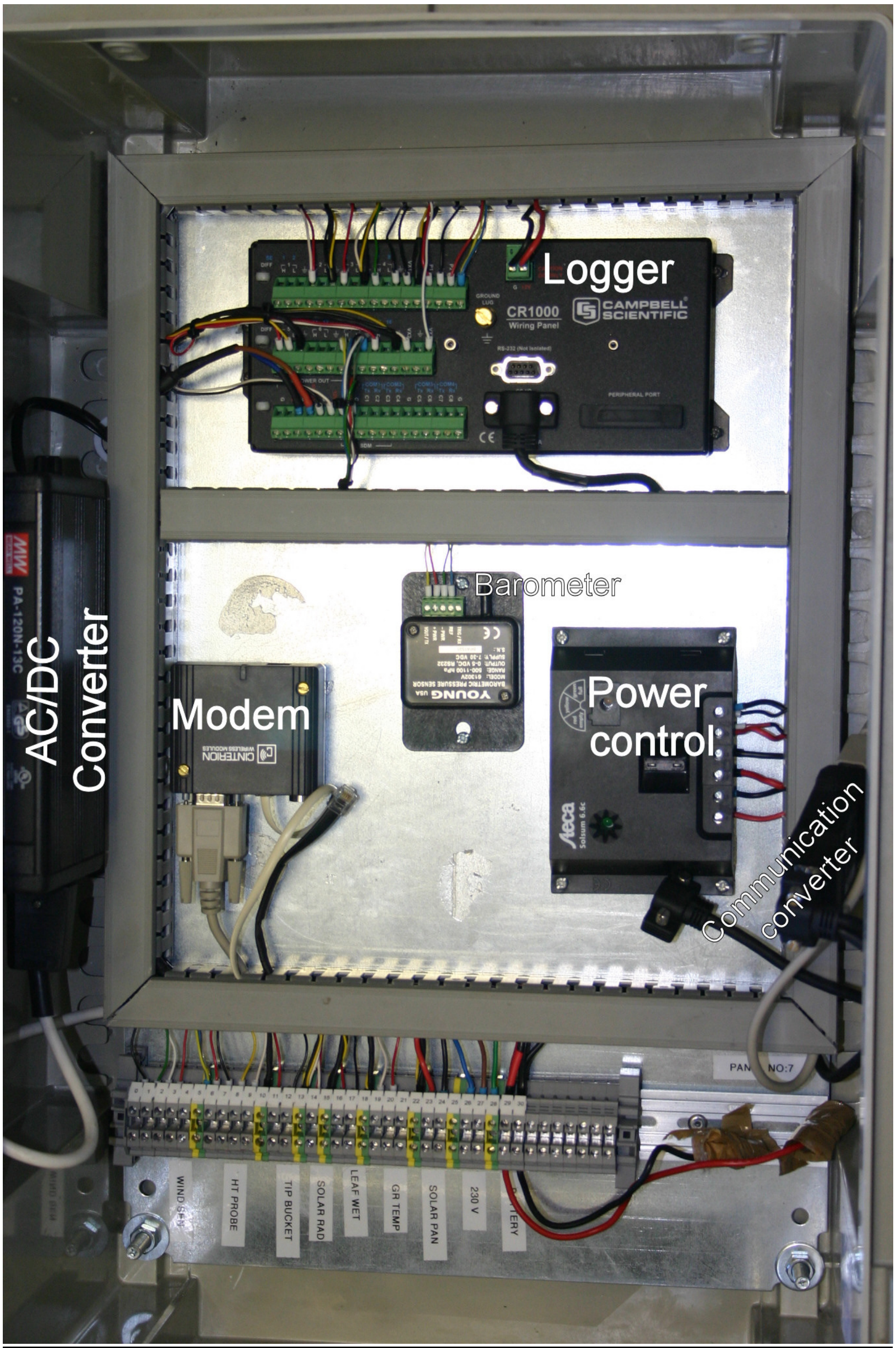

Figure 3: View inside the Campbell / Young Logger enclosure.

<u>Advantages of Campbell / Young Stations:</u>

a) Highly versatile, programmable logger

b) Through a fixed IP address, the logger can be addressed remotely via the GPRS network. This allows for regular downloads of data from "difficult" stations, update of software, resetting of loggers, etc.

c) The loggers can be individually reprogrammed to take additional sensors for specific purposes (not unlimited, though).

d) Highly accurate, well-calibrated sensors

Disadvantages of Campbell / Young Stations:

a) Very expensive system

b) As all parts are imported, spare parts are not readily available in southern Africa, requiring a delivery time of up to 2 months.

c) Installation is difficult, as sensors need to be individually wired and the wires individually attached to the logger unit. This already led to thousands of dollars damage due to wrong wiring.

4. Network

The SASSCAL / MAWF automated weather station network presently consists of 38 stations in Namibia (Table 3). Their positions are illustrated in Figure 4.

Table 3: AWS's forming part of the SASSCAL / MAWF weather station network in Namibia. Stations which were part of the original BIOTA-network (2001 - 2009) are shaded in green.

Station name	Position (Lat / Long)	Nearest Town, Region	Make	Owner
Mahenene	-17.444333°S, 14.784806°E	Outapi, Omusati	MCS, 10 m tower	MAWF (DART)
Kalimbeza	-17.555833°S, 24.521667°E	Katima Mulilo, Zambezi	MCS, 10 m tower	MAWF (DART)
Sachinga	-17.673333°S, 24.031667°E	Katima Mulilo, Zambezi	MCS, 10 m tower	MAWF (DART)
Ogongo	-17.678528°S, 15.294806°E	Ogongo, Omusati	Campbell / Young, 10 m tower	SASSCAL
Oshaambelo	-17.842861°S, 14.770083°E	Outapi, Omusati	MCS, 10 m tower	MAWF (DART)
Mashare	-17.8946°S, 20.2085°E	Mashare, Kavango East	Campbell / Young, 10 m tower	SASSCAL
Ngoma	-17.900278°S, 24.706944°E	Katima Mulilo, Zambezi	MCS, 10 m tower	MAWF (DoF)
Bagani	-18.094639°S, 21.559972°E	Divundu, Kavango East	MCS, 10 m tower	MAWF (DART)
Hamoye	-18.23475°S, 19.732306°E	Rundu, Kavango West	MCS, 10 m tower	MAWF (DoF)

Alex Muranda	-18.3643°S, 19.2562°E	Kavango West	Campbell / Young, 10 m tower	SASSCAL
Okashana	-18.411111°S, 16.638528°E	Omuthiya, Oshikoto	MCS, 10 m tower	MAWF (DART)
Okapya	-18.4725°S, 17.339083°E	Oshivelo, Oshikoto	MCS, 10 m tower	MAWF (DART)
Sonop	-19.0101°S, 18.9039°E	Grootfontein, Otjosondjupa	Campbell / Young, 10 m tower	SASSCAL
Mannheim	-19.168611°S, 17.763056°E	Tsumeb, Oshikoto	MCS, 10 m tower	MAWF (DART)
Tsumkwe	-19.6156°S, 20.442°E	Tsumkwe, Otjosondjupa	Campbell / Young, 10 m tower	SASSCAL
John Pandeni	-19.707778°S, 18.035°E	Grootfontein, Otjosondjupa	MCS, 10 m tower	MAWF (DART)
Waterberg	-20.3971°S, 17.3529°E	Okakarara, Otjosondjupa	Campbell / Young, 10 m tower	SASSCAL
Omatjenne	-20.442667°S, 16.493472°E	Otjiwarongo, Otjosondjupa	MCS, 10 m tower	MAWF (DART)
Okomumbonde	-20.483278°S, 17.343167°E	Okakarara, Otjosondjupa	MCS, 10 m tower	MAWF (DART)
Omatako Ranch	-21.5094°S, 16.7291°E	Okahandja, Otjosondjupa	Campbell / Young, 10 m tower	MAWF (DART)
Erichsfelde	-21.5986°S, 16.9012°E	Okahandja, Otjosondjupa	Campbell / Young, 10 m tower	SASSCAL
NFRC	-22.005639°E, 16.917972°E	Okahandja, Otjosondjupa	MCS, 10 m tower	MAWF (DoF)
Okamboro	-22.009494°S, 17.041386°E	Okahandja, Otjosondjupa	MCS, 2 m*	SASSCAL
Sandveld	-22.0445°S, 19.1321°E	Gobabis, Omaheke	Campbell / Young, 10 m tower	SASSCAL
Wlotskasbaken	-22.3149°S, 14.4621°E	Wlotskasbaken, Erongo	Campbell / Young, 10 m tower	SASSCAL
NBRI	-22.5707°S,	Windhoek, Khomas	Campbell / Young,	SASSCAL

	17.0957°E		10 m tower	
NBRI2	-22.57238°S, 17.094806°E	Windhoek, Khomas	Campbell / Young, 10 m tower, with satellite modem	SASSCAL
Claratal	-22.7876°S, 16.8144°E	Windhoek, Khomas	Campbell / Young, 10 m tower	SASSCAL
Kleinberg	-22.9895°S, 14.728167°E	Walvis Bay, Erongo	MCS, 2 m**	SASSCAL
Ganab	-23.1218°S, 15.5383°E	Erongo	Campbell / Young, 10 m tower	SASSCAL
Narais / Duruchaus	-23.1301°S, 16.8849°E	Khomas	Campbell / Young, 10 m tower	SASSCAL
Rooisand	-23.294528°S, 16.114667°E	Khomas	MCS, 2 m*	SASSCAL
Tsumis	-23.729778°S, 17.193861°E	Rehoboth, Hardap	MCS, 10 m tower	MAWF (DART)
Dieprevier	-24.1296°S, 15.8947°E	Solitaire, Hardap	Campbell / Young, 10 m tower	SASSCAL
Kalahari	-24.162833°S, 18.476722°E	Stampriet, Hardap	MCS, 10 m tower	MAWF (DART)
Nico	-25.341833°S, 17.853639°E	Mariental, Hardap	MCS, 10 m tower	SASSCAL
Gellap Ost	-26.4011°S, 18.0072°E	Keetmanshoop, Karas	Campbell / Young, 10 m tower	SASSCAL
Kairos	-27.6745°S, 17.8195°E	Karas	Campbell / Young, 10 m tower	SASSCAL

* To be upgraded to a 10 m tower soon

** Due to security reasons, kept at 2 m assembly.

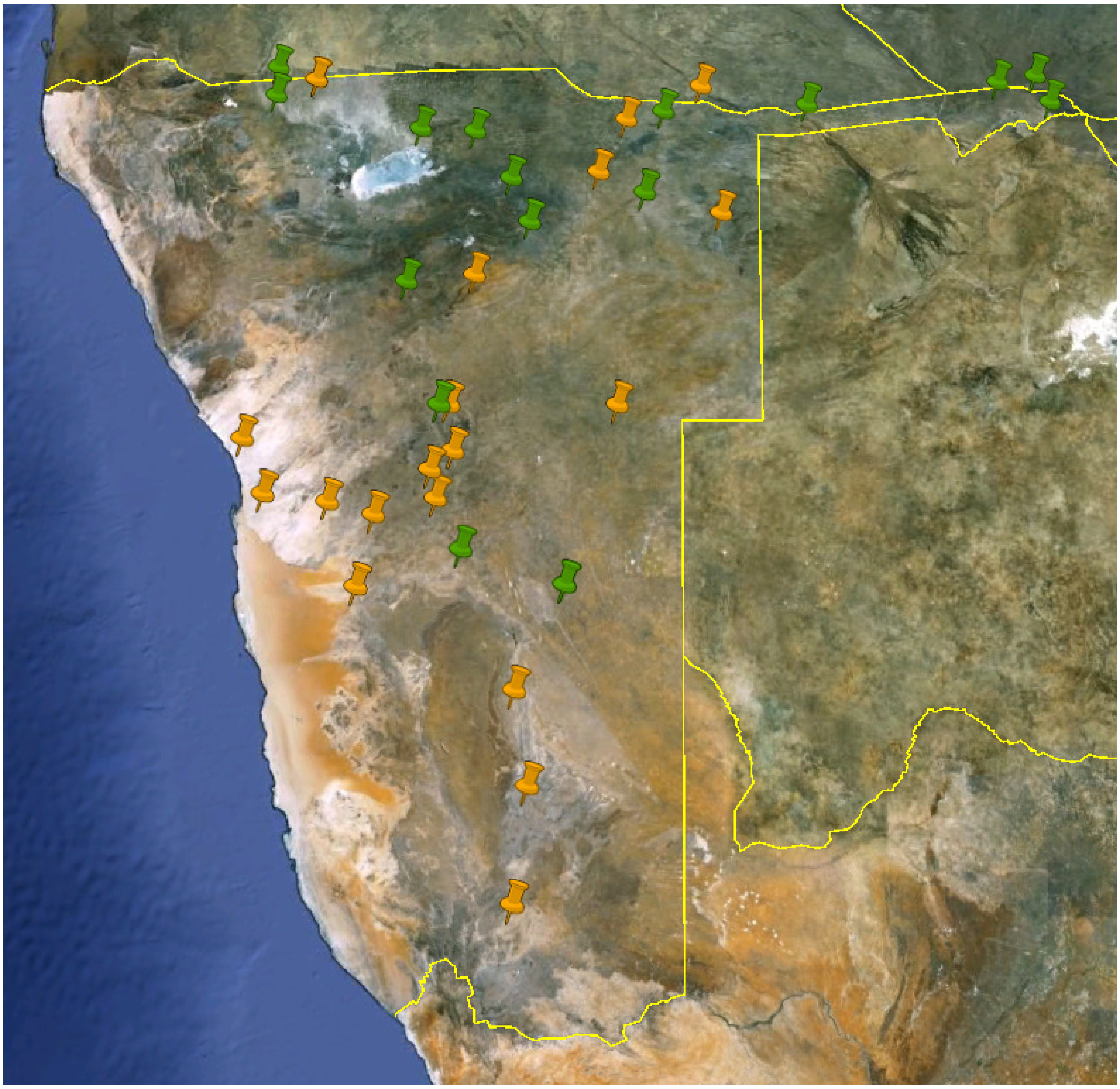

Figure 4: Distribution of the SASSCAL / MAWF weather stations in Namibia. Orange pins denote SASSCAL stations, green pins MAWF stations.

5. Communication

The main aim of the SASSCAL weather station network is make climatic data available to a wide audience of researchers and the general public, as close to real-time as possible. For this reasons. three criteria are considered in the development of this network:

a) reliable, complete collection of climatic data, without missing data

b) reliable communication of data to a centralised database

c) Immediate release of data via the internet to all interested parties, for free

In order to achieve this, the following communication settings are used in the different loggers:

MCS130 logger

The MCS130 logger is storing the hourly averaged reading into two buffers: a temporary and a long-term buffer. Every hour, on the hour, a connection is made to the GPRS network, and the previous hour's data uploaded as a text string to a receiving IP address. Once a text string is uploaded successfully, it is cleared from the temporary buffer. Should the modem fail to make a connection, a series of repeated attempts is made by the logger to connect to the GPRS network and to upload its data in the temporary buffer - including all data which was previously not uploaded and cleared from the temporary buffer. The temporary buffer stores data for about two days, after which the oldest data becomes overwritten by the latest data. The same data is stored in the long-term buffer, which has a capacity of about two months worth of data. Once the buffer is full, however, data is not overwritten - the logger keeps the oldest data in it's memory.

The logger is pre-programmed to download data to a specified IP address, making the data available to a website of the supplier (www.avitrack.co.za). From this server, the data is automatically forwarded to the SASSCAL server (by special arrangement). A certain dependency to the supplier however remains.

The MCS130 logger cannot be addressed remotely, making it thus impossible to download data or to clear data from the buffer remotely. The logger is susceptible to electromagnetic interference from lightning strikes nearby, which leads to the changing of the logger date or the jamming of the modem functioning. This leads to interruptions in data delivery (although the data is still stored in the long-term buffer). For this reason, it is recommended to schedule a field visit to each MCS logger every two months to (a) download all data from the long-term buffer, (b) clear this buffer, (c) reset the date and time on the logger if necessary[1] and (d) reset / restart the logger if necessary.

Campbell CR1000 logger

The Campbell CR1000 loggers are programmed in a very similar way. The main differences are, however, (a) that data are directly sent to the SASSCAL server, not to a intermittent server. (b) The storage capacity of the server is considerably greater - at least 12 months (tested), and (c) the logger is, via a fixed IP address linked to the SIM card, remotely addressable. The loggers are also (or at least seem to be) fairly resistant to electromagnetic inference through lightning. The logger has been programmed to switch off the modem for five minutes every hour on the half hour, in order to ensure that a good connection to the GPRS network exists once the logger connects at the full hour to transmit its data.

Communication via GPRS-network

The most cost-effective way of communication is via GPRS-network, offered by both cellular communications companies in Namibia. However, there are differences in the services offered by the two companies. The network of MTC is well-established, reaching many of the most remote places, whereas the network of TN Mobile (formerly Leo) is still being expanded (Figure 5). However, it has been found that the TN Mobile network works more reliable, and is easier to connect to. For MTC, SIM's on a special telemetry contract had to be obtained in order to connect to the GPRS network. In contrast, even TN Mobile's prepaid cards are automatically open to the GPRS network. The cost implications are huge - with MTC, a monthly contract administration fee needs to be paid, and is about 3 times more than the actual expenses due to data transfer. In the past we also constantly

[1] Care needs to be taken that the logger time is kept to summer time constantly, in order to avoid confusion and data loss.

experienced problems with interruptions with the service due to assumed "late" payments - i.e. payments, which were done in good time, but were not traced by the accountants of MTC in good time, resulting in the disconnection for a couple of days in service. Queries regarding service interruptions could not be answered by front-desk staff, and often were unanswered for a number of days (own experience).

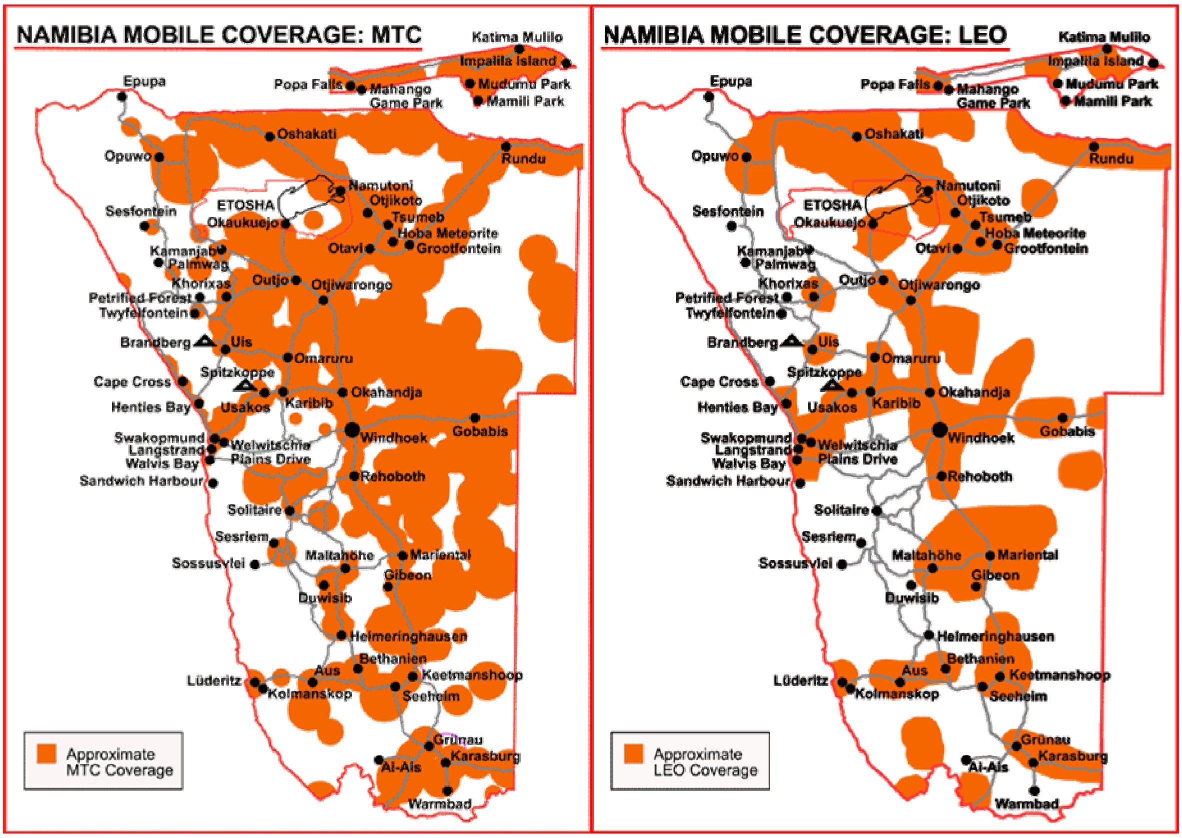

Figure 5: Approximate cellphone coverage by the two cellphone companies in Namibia. Left: MTC, right: TN Mobile (ex Leo). The TN Mobile network is constantly expanding, though. Source: www.namibweb.com.

All AWS's are equipped with a high-gain Yagi antenna. The reach of these antennas is said to be approximately 50 km in line of sight. This holds true for most AWS's, with some notable exceptions (which I am aware of): Hamoye (sending to Arendsnes BS, 24.1 km) and Gellap Ost (sending to Berseba BS, 50.4 km) are constantly faced with interruptions. The reasons are not clear - could be obstructions in the line of sight (Figure 6 a and b). In contrast, Ganab, sending to Gamsberg BS over 74.9 km, has a fairly stable data delivery (Figure 6 c). Due to obstructions, it was decided to not yet install an AWS at Kanovlei, which would need to send its data to Maroelaboom BS (73.2 km). Obstructions are likely to occur in this radio path (Figure 6 d). Similar radio path diagrams can be obtained for any given location from the service providers on request, or, if the base station is known, obtained with the aid of Google Earth. These diagrams, including some modelling with Google Earth, help immensely in the planning of the final location of a new AWS.

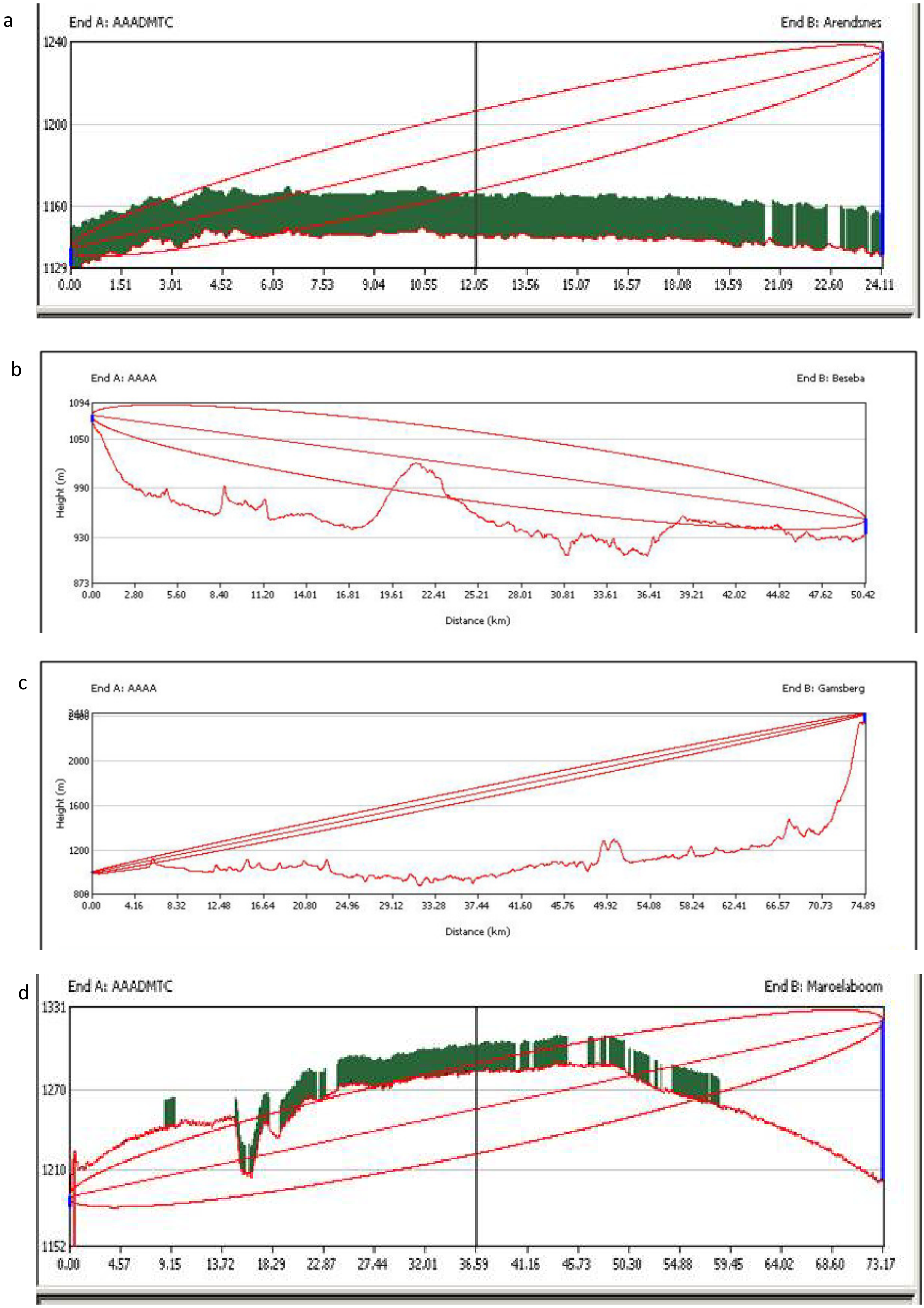

Figure 6: Radio paths for a number of selected AWS's to the nearest base station (BS). a: Hamoye, b: Gellap Ost, c: Ganab, d: Kanovlei. These radio path diagrams have been provided by MTC.

Communication via satellite

The Campbell CR1000 loggers allow also the possibility to communicate via satellite communication, provided a suitable modem is installed. This possibility allows the installation of AWS's in locations outside the present GSM network. The station "NBRI2" is presently a test station, communicating via the METEOSAT satellite. Exact details on the technology are not available, but this communication avenue will enable the installation of planned weather stations at Kanovlei, Giribes and Marienfluss.

SASSCAL WeatherNet Website

The data collected by the weather stations is made available on the SASSCAL WeatherNet website (www.sasscalweathernet.org/index.php). This website also makes data available for collaborating stations in Angola, Botswana and Zambia. Next to hourly data, daily and monthly summaries are available and are also downloadable as csv-type files. On request, a daily e-mail is sent out to users, detailing the daily minimum and maximum temperatures as well as the precipitation during the past 24 hours.

6. Planned activities and methodological approaches

Besides the definition of WMO standard design it will be crucial to develop criteria and a strategy for the spatial design of the future stations which reflects various scientific requirements, user needs and technical aspects, also taking into consideration the quality and reliability of the private stations. The design should equally reflect the regional dimension. Within the frame of the SASSCAL initiative, the following tasks are planned.

Subtask 1: Site selection, erecting new stations

Within the first year, the final site selection needs to be accomplished. This will be done specifically considering the needs of both the bush encroachment project (task 73) as well as the Biodiversity Observation network (task 159). Additional factors to take in account are needs by especially climate modellers (task 6) as well as other research initiatives within the MAWF in need of good quality climatic data.

Subtask 2: Maintenance of the stations

Regular maintenance trips to all stations are planned, as well as ad hoc trips to stations which show problems with specific sensors. The purpose of these trips is to have a continuous stream of good quality climatic data, with as little gaps as possible.

Within this project, we want to target especially forestry and agricultural research and extension staff who are stationed at the MAWF stations equipped with AWS's for training to do basic maintenance. The team of knowledgeable staff able to install and do mayor maintenance tasks is also to be increased.

Subtask 3: Making data available to end-users

As new stations are erected, these are to be included into the data stream available on the internet. This task will be ad hoc, as new stations are erected, but should be completed within the first two years of SASSCAL.

A second facet to this subtask will be inclusion of other data sources (like the station of the Namibia Weather Network and the Namibia Meteorological Services) into a coherent database, available to climate and environmental researcher alike.

For an update on the progress on these tasks, and a detailed implementation schedule, please refer to the current Principal Investigators for the task, Mr J. Theron and Ms S. Kruger.

7. References and further reading

Decagon Devices, Inc. (2014). Decagon Devices, Inc. Retrieved October 6, 2014, from http://www.decagon.com/

Elena Travel Services & Car Hire. (2014). Namibia Travel Adviser: Hotels, Lodges, Safaris, Tours, Car Hire, Namibia travel shop. Retrieved October 7, 2014, from http://www.namibweb.com/

Envco. (2009). Envco Environmental Equipment Suppliers. Retrieved October 6, 2014, from http://www.envcoglobal.com/

Jürgens, N., Haarmeyer, D. H., Luther-Mosebach, J., Dengler, J., Finckh, M., & Schmiedel, U. (Eds.). (2010). *Patterns at Local Scale: The BIOTA Observatories* (Vols. 1-3, Vol. 1). Göttingen & Windhoek: Klaus Hess Publishers.

MC Systems. (2002). MC Systems - Meteorological Data Recording Suppliers. Retrieved October 6, 2014, from http://www.mcsystems.co.za/

Namibia Weather Network. (2014). Namibia Weather Network - Namibia Weather. Retrieved October 6, 2014, from http://www.namibiaweather.info/

R. M. Young Company. (2008). R. M. Young Company. Retrieved October 6, 2014, from http://www.youngusa.com/

SASSCAL. (2014). SASSCAL WeatherNet - Welcome to the weather stations of Angola, Botswana, Namibia and Zambia. Retrieved October 6, 2014, from http://www.sasscalweathernet.org/index.php

W. M. O. (2008). *Guide to Meteorological Instruments and Methods of Observation* (Seventh edition.). Geneva: World Meteorological Organisation.

.