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Position Paper on the Status of GLOSS in Africa

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This position paper provides an overview of the status of the Intergovernmental Oceanographic Commission (IOC) Global Sea Level Observing System (GLOSS) programme in Africa. GLOSS-Africa has significantly improved in many respects in the past decade. However, it will be seen that a considerable amount of work and investment is required to enhance the status of the programme in the continent to the levels specified in the GLOSS Implementation Plan 1997.

In this report, we summarize:

1. the scientific and practical justifications for GLOSS in Africa;
2. the status of the GLOSS Core Network in Africa;
3. existing tide gauge data sets (PSMSL and UHSLC) and 'data archaeology;'
4. training courses held and planned and the availability of training materials;
5. a brief set of national overviews;
6. the roles of national GLOSS Contacts and Regional Co-ordinators;
7. plans for network upgrades in West Africa;
8. recommendations and resources.

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1. THE SCIENTIFIC AND PRACTICAL JUSTIFICATIONS FOR GLOSS IN AFRICA

Chapter 3 of the GLOSS Implementation Plan 1997 (download from http://www.pol.ac.uk/psmsl/training/gloss.pub.html) outlines the many scientific and practical applications of sea level information. Scientific applications include research into ocean tides and the space and time-scales of variability in the ocean circulation; studies of the sea level changes which occur as a consequence of climate change; and investigations of geological processes which result in sea level changes, of which the longest wavelength are due to Glacial Isostatic Adjustment (sometimes called Post-Glacial Rebound) and of which the most dramatic are those caused by earthquakes.

Two scientific topics are of great concern to Africa and receive a great deal of publicity. The first relates to investigations of the El Niño – Southern Oscillation (ENSO) phenomenon, which causes large sea level changes in the Pacific and Indian Ocean and which is related to fluctuations in global weather patterns. The second concerns long term changes in global sea level. Recently (June 2001), the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR) concluded that global-average sea level rose within a range of 10 - 20 cm during the past century, while global mean sea level is projected to rise by 9-88 cm between 1990 and 2100 (with a central value of 48 cm) for the full range of emission scenarios. These changes have potential social, economic and environmental consequences for coastal zones.

Practical applications of sea level information include coastal engineering, in which sea level data are needed as instantaneous levels, as well as statistics of extreme levels over long periods. Short-term measurements, often with real-time data transmission, are needed for ship movements in harbours and ports, for issuing storm surge and tsunami warnings, and for the operation of sluices and barrages. Over a longer period, data are needed for tidal analysis and prediction, for control of siltation and erosion (particularly important in West Africa), for the protection of coral reefs (important in East Africa), for inputs to models to estimate the paths of pollutants and to forecast water quality, and for the design of reclamation schemes and the construction of disposal sites. In addition, they have application to studies of upwelling (e.g., Moroccan and Namibian coasts) and fisheries throughout tropical areas. Historically, many national datum levels for land surveys are based on measurements of mean sea level over some defined period. These levels are often used to define state and national boundaries, for example as specified in the United Nations Convention on the Law of the Sea. Low water levels are used as the datum for tidal predictions and for the datum level in hydrographic charts.

Scientific and practical applications interact in many ways. For example, knowledge of long term sea level rise will need to be input into the engineering design of coastal structures, many of which will have a lifetime of many decades or a century. Insight into the rate of sea level rise may also help in the understanding of complex coastal processes, such as sedimentation and erosion, which may result in high costs. A second example concerns sea level data assimilation into numerical models (e.g. storm surge, water quality). Understanding of the correct physics in such models is clearly a ‘scientific’ pursuit. However, once processes are understood, and necessary data are made available, their use is ‘practical’. In all of these scientific and practical applications, the reliable exchange of high-quality data, nationally, regionally and even globally, can improve our ability to predict change on a range of time-scales. This exchange of data and operational experience, within a global programme but with local applications, is something which GLOSS and GOOS must actively support and encourage.

2. THE STATUS OF THE GLOSS CORE NETWORK IN AFRICA

The Implementation Plan describes the requirements for a GLOSS Core Network (GCN), consisting of 287 sites worldwide, complemented by regional densification where appropriate. The GCN is intended to form a 'baseline' of high-quality sites to which regional networks can be appended. The Plan also states requirements for sub-networks for application to the study of long term sea level trends (GLOSS-LTT), ocean circulation (GLOSS-OC) and satellite radar altimeter calibration (GLOSS-ALT). However, it is the need for the GCN, and for its regional densification, which concerns us most in this report.

Figure 1 shows sites in Africa in the GCN (ignore the various symbols for the moment). It can be seen that major sites were identified by GLOSS working groups, with approximately 500 km spacing between them and with locations of oceanographic interest (e.g., Strait of Gibraltar) included. This set of stations is clearly not enough to satisfy the complete set of scientific and practical requirements. However, it is at least a starting baseline around which proposals for regional densification can take place. Two examples of densification include the network of island stations in the Western Indian Ocean, and plans for stations on the North African coast as part of the MedGLOSS programme of IOC and the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM).

The Permanent Service for Mean Sea Level (PSMSL) provides each October a summary of the status of GLOSS from its viewpoint. The same month (October) is chosen each year so as not to bias the statistics because of the seasonal cycle of data receipts. An 'operational' station from a PSMSL viewpoint means that recent MSL monthly and annual values have been received at Bidston, have been checked as far as possible, and have been included in the databank. (The PSMSL databank is referred to further below.) For each of the GCN stations, the year of the last data entered into the databank, if any, is used to place the station into one of four categories:

- Category 1: 'Operational' stations for which the latest data is 1996 or later;
- Category 2: 'Probably operational' stations for which the latest data is within the period 1986-1995;
- Category 3: 'Historical' stations for which the latest data is earlier than 1986;
- Category 4: For which no PSMSL data exist.

Stations in each category are shown by the different symbols in Figure 1. It can be seen that there are only four Category 1 stations outside of East and Southern Africa and Indian and Atlantic islands, in spite of GLOSS being a mature programme commencing in the mid-1980s. Two of these (Ceuta and Las Palmas, Canary Islands) are in full operation. A third is in operation at Dakar, Senegal. However, there is some doubt as to the quality of its long-term maintenance (see Annex I). The gauge at Lagos, Nigeria was destroyed by a recent storm.

Figure 1 does not provide the only test of 'operational status' and other assessments can be found in GLOSS documentation (e.g. in the report of the 6th GLOSS Experts meeting in 1999, see above PSMSL training page). However, we do believe that it gives a reliable general impression of the status of sea level recording in Africa.

A further indicator of the status of the programme concerns the availability of Global Positioning System (GPS) receivers at or near gauges to monitor vertical land movements, and thereby to identify the separate contributions of land and 'real' sea level changes in the gauge records. An up-to-date survey of GPS installations at gauges can be found at http://sonel.ensg.ign.fr/stations/cgps/surv_update.html. This shows that an encouraging start has been made, with stations in, for example, South Africa (several locations), Egypt, Cape Verde Is. and Ceuta (Spain) (one station each). However, many more are required.

From these various assessments of programme status in Africa, it is clear that much work remains to be done.

3. EXISTING TIDE GAUGE DATA SETS (PSMSL AND UHSLC) AND 'DATA ARCHAEOLOGY'

Even though the current sea level network in Africa is not as extensive as one would like, there is a considerable amount of existing information which can be used for research and education.

Tide Gauge Data Sets

The two main international data sets of sea level information are those of the PSMSL and the University of Hawaii Sea Level Center (UHSLC). The PSMSL is the global databank for long term sea level information from tide gauges and contains over 47000 station-years of monthly and annual mean sea level values. The UHSLC evolved from the former Tropical Ocean – Global Atmosphere (TOGA) databank, was one of the two World Ocean Circulation Experiment (WOCE) databanks, and is now the GLOSS/WOCE Fast Sea Level Centre.

Figures 2 and 3 show the distribution of data held by the PSMSL and UHSLC (its Joint Archive for Sea Level). Detailed listings of data holdings can be found at http://www.pol.ac.uk/psmsl/pub/nucat.dat and http://uhslc.soest.hawaii.edu/uhslc/data.html) respectively. All data are freely available either via the web or on CD-ROM for people without web access. Note that these two centres are by no means the only relevant ones. For a list of web sites of the other centers, see the PSMSL web page http://www.pol.ac.uk/psmsl/.

Figure 3 also indicates African stations capable of delivering data in 'fast' mode (which at present means within a few weeks) via telephone or satellite or other fast means to the GLOSS Fast Centre at UH. At the present time, the UHSLC maintains a number of near-real time sea level stations on the African continent and nearby islands. The network (as of August 2001) consists of five stations. Handar encoders are installed at Lamu and Mombasa, Kenya, and Zanzibar, Tanzania. Mombasa is presently down but is expected to be serviced by late August 2001. Aquatrak acoustic gauges are operated at Dakar, Senegal and Palmeira, Cape Verde. The latter is down but will be serviced by September 2001.

A considerable amount of tide gauge data are likely to be required in quasi-real time in future for assimilation into and validation of deep ocean and coastal (e.g. storm surge) models. The definition of 'fast' will depend on the application. For example, for storm surge work, 'fast' means within an hour or so. For deep ocean modelling, 'fast' could mean within a couple of days or a week.

Figure 4 shows some representative time series of annual mean sea level from Africa indicating two of the main features of the data set: long time series discontinued (or in difficulty at present) but encouraging efforts to undertake new recordings, especially in East Africa.

Data Archaeology

At the 6th and 7th sessions of the IOC Global Sea Level Observing System (GLOSS) Group of Experts in 1999 and 2001, and at the 16th session of the IOC Committee on International Oceanographic Data and Information Exchange (IODE) in 2000, the topic of data rescue of historic tide gauge data in non-computer form (charts, tabulations etc.) was discussed. These mostly paper-based data sets are of potential great value to the sea level community in a range of applications, of which the most obvious is the extension of existing sea level time series as far back as possible in order to understand more completely the timescales of sea level change. It is essential that, for the priority sites at least (e.g. GCN sites), the charts are digitized to provide hourly (or similar) sea level values in computer form, with the resulting data sets made available to the international community and, of course, to the chart-owners. Chart digitizing has historically been a labour-intensive activity. However, the availability of new scanner-based packages seems to provide the possibility for speeding up the work considerably.

In order to obtain a first estimate of how many such charts exist from GLOSS and other priority sites, and to make an estimate of the total effort required for their digitization, a GLOSS/IODE questionnaire has been circulated to the combined mailing lists. (Additional copies may be obtained via psmsl@pol.ac.uk). We are certain that such historic data exist in Africa (e.g., data sets held at SHOM in France), and that a 'data archaeology' exercise for African sites following on from the questionnaire would a major benefit to both GLOSS and GOOS in the continent.

4. TRAINING COURSES HELD AND PLANNED AND THE AVAILABILITY OF TRAINING MATERIALS

GLOSS (or GLOSS-related) training courses have been held a rate of approximately one per year since 1983. These have been held in all continents and in all languages, with the majority of the first courses held at the Proudman Oceanographic Laboratory (POL), UK. The most recent courses were at POL (97), University of Cape Town (98), University of São Paulo (99) and Jeddah (2000). Courses are planned for the near future in Israel, Chile, Caribbean and Malaysia.

A number of sea level specialists from West and East Africa have attended courses at POL. However, there has only been one course held in the continent itself (in 1998) and follow-up courses are badly needed. The hosting of such of course requires lecture and computer facilities, with the possibility for 'hands on' training with tide gauge and geodetic equipment. It is also advantageous if the host establishment or country contains a sufficient number of suitable lecturers, to keep the need for external experts to a minimum.

For people unable to attend courses, most of the training materials employed in a typical course are available on the web at the PSMSL training page (http://www.pol.ac.uk/psmsl/training/training.html).

5. A BRIEF SET OF NATIONAL OVERVIEWS

Annex I provides a set of very brief remarks on the status of recording in each country. We hope that together they may reflect the status in Africa overall. However, please forgive and inform us of any omissions or mistakes. The PSMSL web site (see above) contains a set of ‘country reports’ from some countries including Kenya, Tanzania, Mauritius, Seychelles, Mozambique, Madagascar and South Africa. These provide a considerable amount of further information.

6 THE ROLES OF NATIONAL GLOSS CONTACTS AND REGIONAL CO-ORDINATORS

The Implementation Plan describes the responsibilities of national ‘GLOSS Contacts’ and ‘Regional Coordinators’ who are fundamental to the development of the programme in each country and region respectively. They have the responsibility to smooth data flow and to promote GLOSS in a number of important ways.

The Plan explains that IOC funds neither group for their GLOSS activities. Their support (e.g. the staff time they set aside for the work) is assumed to stem from the national contributions required of all IOC Member States participating in the programme. In the case of African countries, this issue is obviously connected to the general question of the availability of resources.

The resources required of a GLOSS Contact are primarily staff-time to undertake the tasks described above (which one assumes will be agreed with the Director of his organization), together with adequate means for communicating with IOC. Email etc. is now readily accessible in most parts of Africa. However, it must be said that communication with a number of nominated Contacts in Africa is still patchy.

In the case of Regional Coordinators, staff-time and communications are again important issues. However, a Coordinator should also ideally have the resources to hold regional workshops and training courses, visit gauge sites in the region, prepare reports and stimulate the many scientific and other uses of sea level data. Such additional resources are almost entirely lacking.

The current Regional Coordinators are Dr. Charles Magori (Kenya), representing East Africa, who has recently replaced Dr. Mika Odido; Prof. Geoff Brundrit (South Africa), representing Southern Africa; and Drs. Angora Aman (C∗te d’Ivoire) and Adeleke Adekoya (Nigeria), representing West Africa. Angora Aman has recommended in particular that:

- regular official letters must be sent by IOC to Directors of West African tide gauge services so that proper local funds are made available for GLOSS activities;
- funds should be made available for visits within the region (e.g. to inspect gauge sites) and for digitization (data archaeology).

7. PLANS FOR NETWORK UPGRADES IN WEST AFRICA

West Africa has received considerable attention within GLOSS since the formation of the programme. A large number of specialists have attended training courses and various initiatives have been made with regard to tide gauge installations. However, for several reasons the region remains one of the most data-sparse.

Four current activities may be mentioned which are attempting to provide more reliable long term data flow:

1. Two tide gauges will be installed in Ghana with the help of the National Institute of Oceanography (NIO) in Goa, India and of IOC. The investment will include meteorological stations and training. The NIO is also interested to know if its assistance programme can be extended beyond Ghana.
2. The French Institut de Recherche pour le Développement (IRD) is considering the role of gauges in West Africa as an extension to the tropical Atlantic PIRATA programme of fixed moorings. A gauge at Pointe Noire is also under consideration.
3. Discussions are taking place to ensure the long-term viability of the Lagos, Nigeria gauge.
4. IOC is attempting to confirm the long-term viability of the former US gauges at Cape Verde and Dakar.

8. RECOMMENDATIONS AND RESOURCES

The development of GLOSS in Africa has been discussed at a number of recent meetings and workshops. For example, at the only GLOSS training course held so far in Africa, at the University of Cape Town (UCT) in 1998, recommendations were made by the many young scientists present for the formation of an African GLOSS Network to coordinate future sea level activities in Africa (including elements involving GPS, altimetry, data analysis, training etc.), with the suggestion that there be 3 overlapping regional groups (west, south and east). The UCT meeting also pointed to the fact that GLOSS in Africa requires a major programme of tide gauge upgrades and, in addition, suggested that maximum use should be made of Regional Oceanographic Data Centre developments. All of these recommendations were consistent with those of the Pan-African Conference on Sustainable Integrated Coastal Management (PACSICOM) also held in 1998.

At the 6th session of the GLOSS Group of Experts in 1999, the UCT/PACSICOM recommendations were endorsed completely and several actions were considered. For example, to signal the need for major investment in West Africa, the support for installation of gauges at suitable locations in Ghana was approved (Annex I). At the larger scale, a possible bid to the Global Environment Facility (GEF) of the World Bank for GLOSS resources was considered, although no action has been taken so far. It is hoped that the GOOS Africa Meeting in Nairobi, Kenya, (November 2001) can provide advice to the programme on how to proceed. However, it is clear that the acquisition of a number of tide gauges, GPS receivers etc. is not the only issue; major developments are required for training and related infrastructure in several countries before the flow of high-quality GLOSS data can be assured.

Figure 1

Distribution of PSMSL Stations

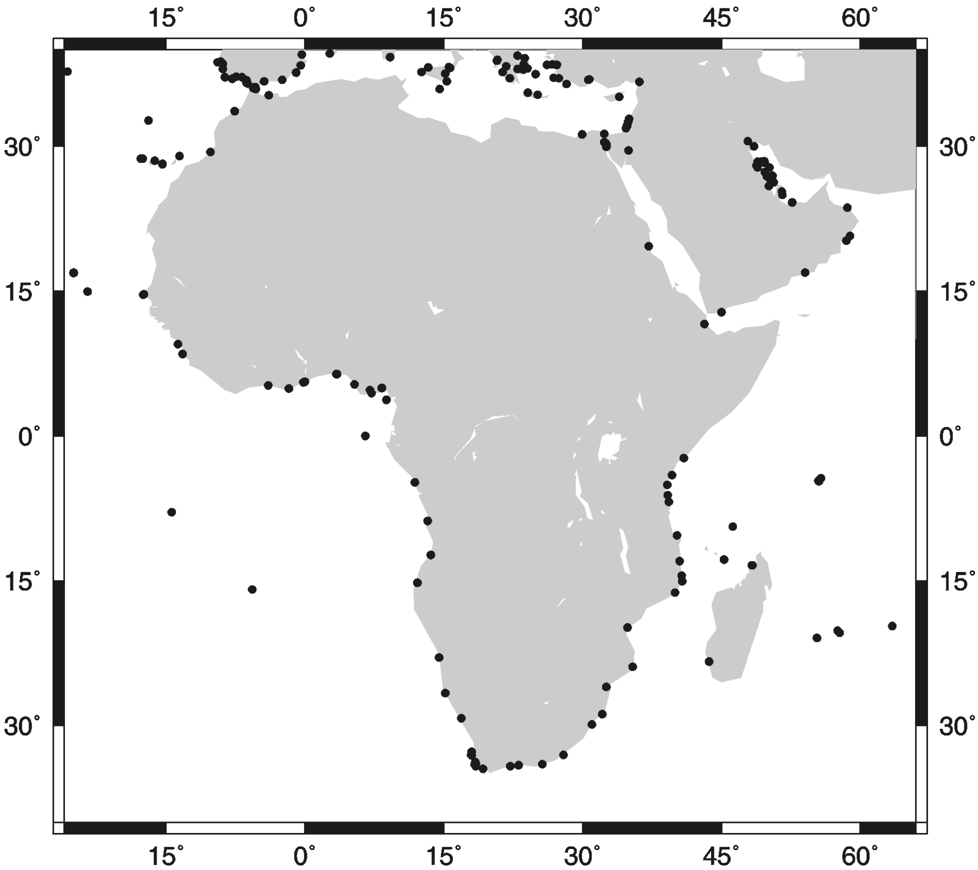


Figure 2

GLOSS status within the PSMSL dataset. October 2000

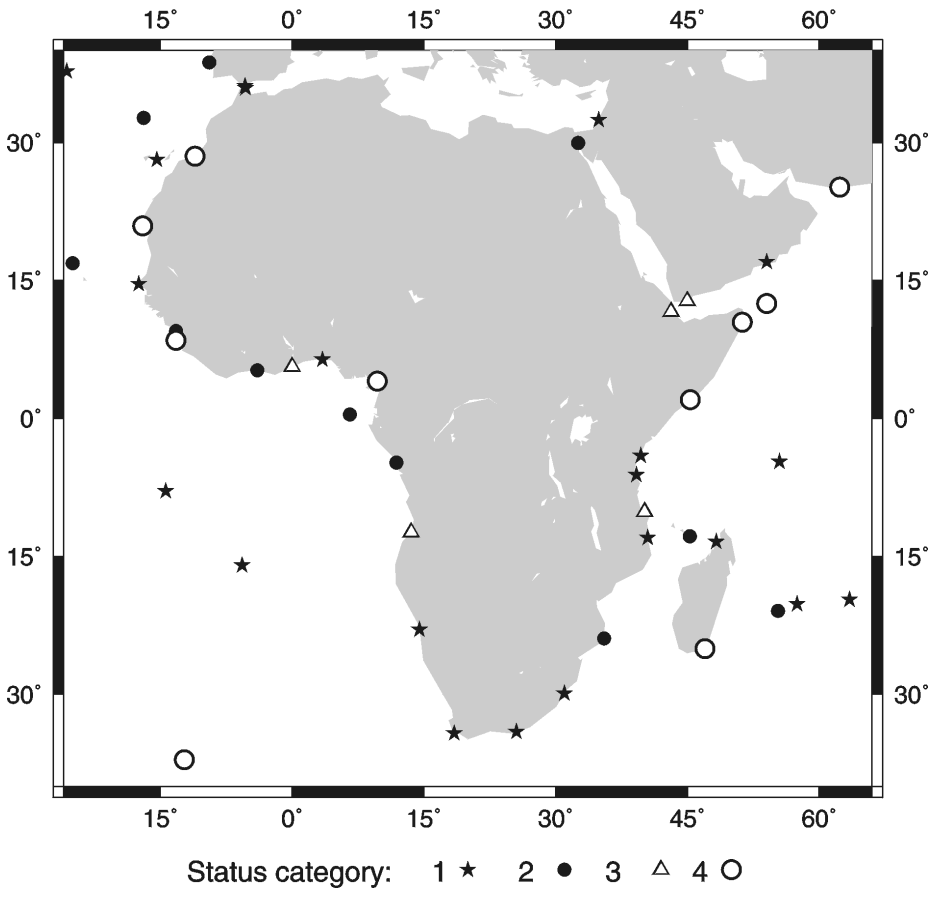


Figure 3

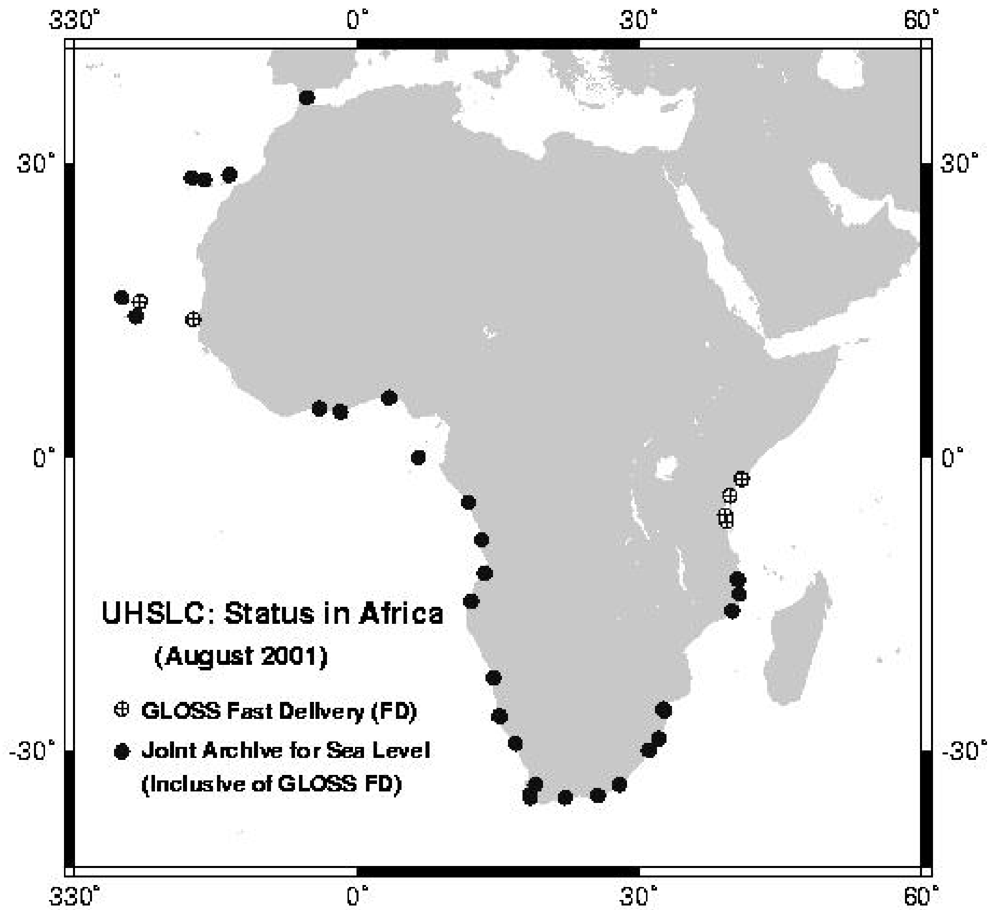
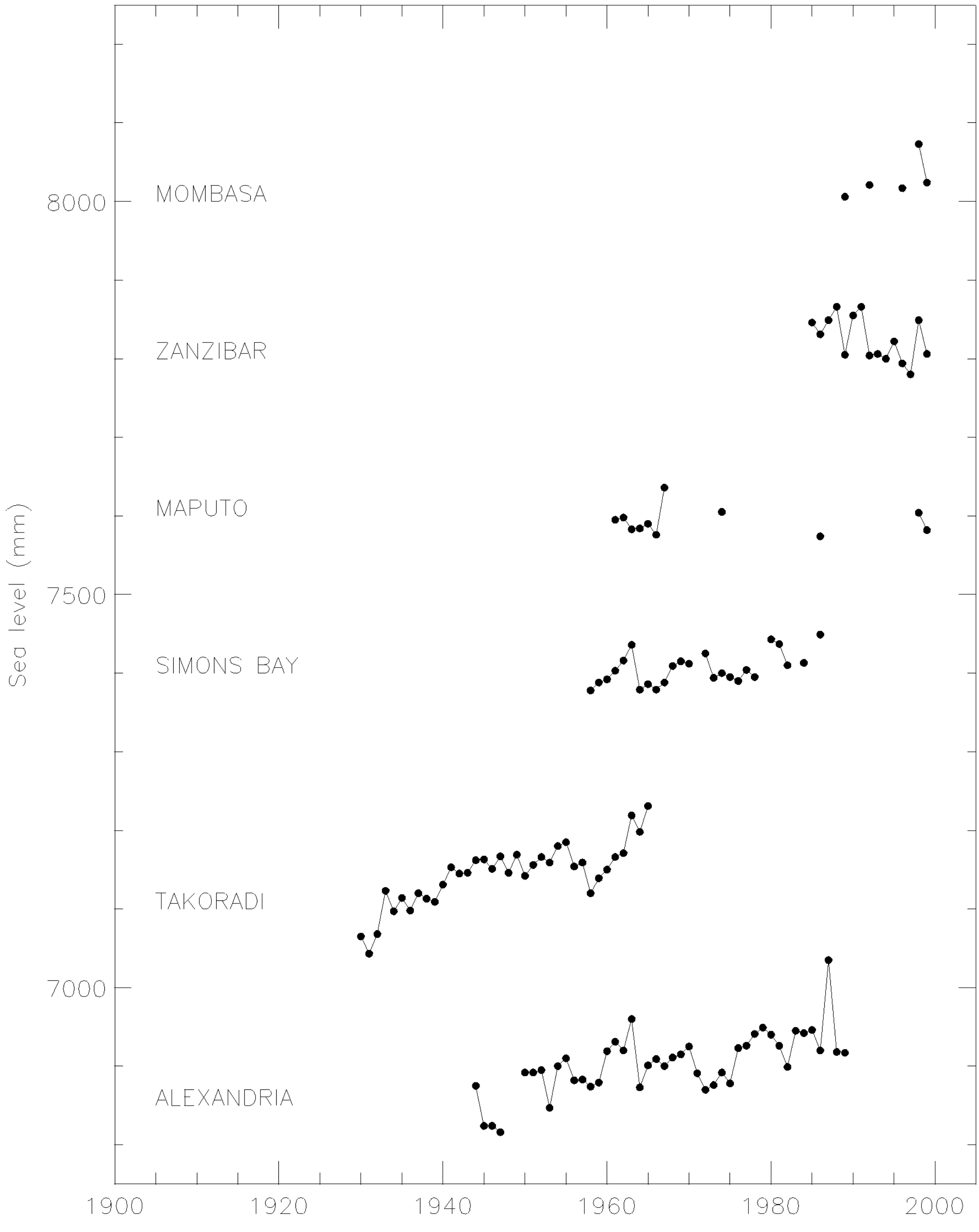

330°
0°
30°
60°
30°
0°
-30°
UHSLC: Status in Africa
(August 2001)
GLOSS Fast Delivery (FD)
Joint Archive for Sea Level
(Inclusive of GLOSS FD)

Figure 4

Long Term Changes in Sea Level from some stations in Africa



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ANNEX I

Brief comments on GLOSS-related interactions between IOC and each country in recent years.

No mention of a country implies little or no contact.

Egypt - has a history of extended tide gauge recording at Alexandria and at locations connected with the Suez Canal. Plans are underway by the Survey Research Institute for a new gauge at Alexandria and possibly another location. One scientist has attended has attended GLOSS courses at POL (1997) and Jeddah (2000).

Algeria - One person from military management attended POL (1997) course. Gauges are thought to be operated by the Hydrographic Service at Oran, Algiers and Jijel but no data available.

Morocco - Two gauges are operated by the Direction de l'Equipment. However, they require upgrades. We understand that plans exist for gauges at Rabat on the Atlantic coast and at another location in collaboration with the French Navy. Installation of a planned MedGLOSS gauge at Nador on the Mediterranean coast by a group from Israel was abandoned due to the political situation. One scientist attended the POL (1997) course and a scientist from the Direction has been accepted to join the GLOSS Group of Experts.

Mauretania - a GLOSS Core Network gauge was suggested at Nouadhibou (Cap Blanc) for many years, and the site was visited by a consultant from Germany on behalf of IOC around 1986. Since then no developments.

Cape Verde Is. - a Next Generation Water Level Monitoring System (NGWLMS) gauge (a US acoustic gauge) was installed in the mid-1990s at Palmeira with direct data transmission to NOAA in Washington. The last data available is from 1996. NOAA withdrew from installing and maintaining gauges outside of the US around 1998 but left the gauges and other equipment in place in most cases but without maintenance. The station was moved to Sal Island in March 2000 to be near the Met Office (INMG) with GPS nearby and data processed by the University of Hawaii. Recently, we heard from Jose Manual Moreno (INMG, Cape Verde) that the gauge was not working but he was trying to solve the problem. One scientist from Cape Verde attended the 6th GLOSS Group of Experts (GE6) Session in 1999. However, contact with him has since been lost.

Senegal - a NGWLMS was also installed in Dakar in the mid-1990s and is still operating, with the same maintenance concerns as for Palmeira. Local scientists do not maintain it or have direct access to the data. An IRD (France) pressure gauge was also located in Dakar but IRD no longer considers it owns it. One specialist attended the Cape Town GLOSS training course in 1998. One scientist attended the GE6 Session.

Côte d’Ivoire - data exist from Abidjan and Port San Pedro although very little is in databanks. The Laboratoire d’Océanographie et de Géophysique Spatiale (LEGOS) group in Toulouse has an agreement with Dr. Angora Aman to digitize charts from the locally operated Port San Pedro gauge and provide software support. One specialist attended the Cape Town GLOSS training course in 1998. Dr. Angora Aman is also the nominated GLOSS Regional Contact for French-speaking West African countries.

Ghana - has some of the longest tide gauge records in Africa (e.g. Takoradi in the west of Ghana). Tema (the port of Accra in east Ghana) is a GLOSS Core Network site. Gauges installed at both places by German consultant around 1986 were not successful. Recently, India has agreed to provide 2 gauges for Tema and Takoradi. One scientist attended the Cape Town GLOSS training course in 1998. Gauges along the Côte d'Ivoire and Ghana coasts would be of potential value for upwelling studies.

Atlantic Islands - the UK (POL) operates gauges at Ascension and St. Helena.

São Tome – Historical data are available from TOGA studies in the 1980s. More recently, the LEGOS group in Toulouse receives real time data from São Tome. The station has a pressure gauge and a barometer and is owned by IRD. Data have been sent since 1999 for validation to UHSLC.

Nigeria - a number of scientists from Nigeria have attended GLOSS meetings and training courses. Most recently, Dr. Adeleke Adekoya attended the Cape Town 1998 course and the GE6 1999 Session and he is the nominated GLOSS Regional Contact for English-speaking West Africa. Two gauges existed at Lagos until 2000 when both were destroyed by a storm. One was a NGWLMS acoustic gauge (see above) and the other was a float gauge. Plans are in progress to investigate possible replacement (a pressure gauge has been suggested).

French groups have suggested Congo - a gauge at Pointe Noire, but funding is not yet decided. Pointe Noire has the longest existing data set from this part of the coast (data for 1955-88). IRD has asked LEGOS for advice if they should install a gauge there and LEGOS is conducting a study. This may be of use for upwelling studies, although may be affected by Congo River runoff.

The South African Hydrographic Office operated Namibia - prior to 1999 gauges at Walvis Bay and Luderitz. However, they have since been transferred to the Namibian Ministry of Agriculture with plans for modernization in place. One scientist attended the Cape Town 1998 training course.

South Africa - contains a number of gauges with records staring in the mid-1950s. However, only a partially successful upgrade programme from float to acoustic gauges in the 1990s led to an interruption in the supply of good quality data. Several scientists attended the 1998 training course at the University of Cape Town, from which Prof. Geoff Brundrit is South African GLOSS Contact and Regional Contact for Southern Africa.

Mozambique - some data have come from Mozambique in recent years although quality is a major issue. One scientist attended the 1998 Cape Town GLOSS training course.

Madagascar - recent data exist from Nosy Be.

Tanzania - recent data exist from Zanzibar. One scientist attended the 1998 Cape Town training course.

Kenya - recent data exist from Lamu and Mombassa. A number of scientists from Kenya have attended GLOSS Experts meetings and training courses (most recently GE6 1999 and Cape Town 1998 respectively) and Dr. Charles Magori is the nominated GLOSS Regional Coordinator for East Africa (replacing Dr. Mika Odido).

Djibouti – at the Jeddah GLOSS course in 2000 the gauge at Djibouti was claimed to be operational but no recent data flows to data banks as problems with hardware. An effective gauge there would be an ideal complement to Aden (Yemen) which is installing new gauges. One specialist attended the Jeddah GLOSS training course in 2000.

Sudan - last data are from 1994 when Port Sudan gauge expired. Plans are in place for new systems. One specialist attended the Jeddah GLOSS training course in 2000.

Indian Ocean Islands - Mauritius has recent data from Port Louis and Rodrigues. Seychelles has recent data from Pt. La Rue. Mauritius scientists have attended several GLOSS training courses.