

International Heliophysical Year: GPS Network in Africa

C. Amory-Mazaudier · S. Basu · O. Bock · A. Combrink ·
K. Groves · T. Fuller Rowell · P. Lassudrie-Duchesne ·
M. Petitdidier · E. Yizengaw

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Abstract The main scientific objectives of the International Heliophysical Year are to discover and study all the physical processes coupling the Earth to the Sun. During the IHY a number of scientific instruments are being deployed all over the world. This brief report presents the scientific objectives, the GPS receiver network over Africa and the long lasting research planned for the next decades in Africa.

Keywords Heliophysics · Africa · GPS receivers · Sun–Earth connections

C. Amory-Mazaudier (✉) · M. Petitdidier
Centre National de la Recherche Scientifique, Centre d'étude des Environnements Terrestre
et Planétaire, Velizy, France
e-mail: christine.mazaudier@cetp.ipsl.fr

S. Basu
Boston University, Boston, MA, USA

O. Bock
Service d'Aéronomie (SA)/CNRS & LAREG/IGN, Paris, France

A. Combrink
Hart RAO, P.O. Box 443, Krugerdorp 1740, South Africa

K. Groves
Air Force Research Laboratory, Hanscom AFB, MA, USA

T. Fuller Rowell
University of Colorado/CIRES and NOAA/Space Weather Prediction Center, Boulder, CO, USA

P. Lassudrie-Duchesne
ENST, Université de Bretagne, Brest, France

E. Yizengaw
UCLA, Institute of Geophysics and Planetary Physics, Los Angeles 900095-1567, CA, USA

1 Introduction

“In 2007, fifty years on from IGY (International Geophysical Year), scientists and engineers from all 191 member States of the United Nations will participate in an international coordinated observation campaign on fundamental questions in Earth and space sciences. The IHY (International Heliophysical Year) will provide a unique opportunity to coordinate observations from the current impressive fleet of international space missions, with data from ground based observatories (from the presentation of IHY: <http://www.woosa.unvienna.org>).”

In the frame-work of the IHY, and under the UNBSS project (United Nations for Basis Space Science) many ground based scientific instruments are being deployed in developing countries and particularly in Africa see <http://ihy2007.org> .

The first section of this brief report presents the scientific objectives of IHY and the UNBSS initiative. The second section is devoted to the networks of GPS receivers deployed over Africa for different scientific projects and the third section covers plans for long lasting geosciences in Africa.

2 Main Scientific Objectives of the IHY and Management of IHY

The IHY project was suggested in 2001 to celebrate the 50th anniversary of the International Geophysical Year (IGY).

“The objectives of IHY 2007 are:

- *to understand the processes and drivers that affect the terrestrial environment and climate;*
- *to provide a global study of the Sun-Heliosphere system outward to the heliopause;*
- *to foster international cooperation in space science now and in the future;*
- *to communicate the unique scientific results of the IHY to the scientific community and to the public.”* (Extract from Harrison et al. 2005)

The IHY project promotes the participation of developing nations in the international global studies of the Sun–Earth System. A specific initiative is the “United Nations Basic Space Science Initiative (UNBSSI)”. It is based on the tripod concept: instruments, observation and education (Davila et al. 2007; Kitamura et al. 2007). Low-cost scientific instruments are deployed all over the world (magnetometers, GPS receivers, radio telescopes, VLF receivers, and others) and particularly in Africa.

Scientists from the developing and industrialized nations meet face-to-face during international IHY/UNBSSI workshops. They discuss and develop collaborative projects. Low-cost scientific instruments are provided by scientists from industrialized nations to scientists from developing nations. The developing nations provide sites for the instruments, maintain the instruments, and control the quality of the data. All the data are included in IHY data bases. (See reports of the Committee of the Peaceful uses of Outer Space, 2007).

3 Global Positioning System and GPS Receivers in Africa

The Global positioning System (GPS) is a system of 24 satellites orbiting the Earth at approximately 20,000 km altitude. Each satellite transmits a radio wave signal to GPS

receivers. By determining the time by the GPS signal to reach a receiver one can calculate the distance to the satellite and know exactly the position of the receiver on the Earth (Kouba and Héroux, 2000). Different errors in the determination of the distance between the satellite and the GPS receiver are introduced while transversing through the ionosphere (an ionised layer surrounding the Earth between 90 and 1,000 km) and the troposphere (atmospheric layer at the altitude range of 0–15 km). The analysis of the satellite signal errors leads to the determination of geophysical parameters, such as the total electron content (TEC) in the ionosphere (Kintner and Ledvina 2005; Komjathy et al. 2005) or atmospheric water vapour distribution in the troposphere (Hoyle et al. 2003). The GPS first initiated for positioning and navigation purposes is now used by many scientists in different fields of research (geodesy, geology, oceanography, meteorology, and ionospheric studies are some of them).

The GPS network deployed over Africa for the IHY combines different networks of GPS receivers:

IGS: <http://igscb.jpl.nasa.gov>, International Geodesy System,

AMMA: <http://www.amma-international.org>, Analyse Multidisciplinaire de la Mousson Africaine,

SCINDA: www.fas.org/spp/military/program/nssrm/initiatives/scinda.htm, Scintillation Network Decision Aid,

AGREES: African GPS Receivers for Equatorial Electrodynamics Studies (Proposed)

Table 1 gives the geographic coordinates of the GPS receivers involved in the IHY. At the present time 35 GPS receivers are operating in 27 countries in Africa. In the near future, with the AGREES network, ten more GPS receivers will be operational: the global IHY GPS network will include 45 GPS receivers in 32 different African countries.

Figure 1 presents this IHY GPS network. Figure 2 shows the GPS receiver network related to the SCINDA project. The SCINDA GPS receivers are located at the equatorial latitudes and are used to study ionospheric scintillations. Figure 3 illustrates the GPS receiver network concerning AMMA. The AMMA GPS receivers are located in West Africa and are used to study the African Monsoon.

The IGS receiver network (not shown here) is composed of 19 GPS receivers in 13 different countries (see Table 1).

4 Long-Lasting Research in Africa Based on GPS Network

In the past, geophysical data were very scarce in Africa. It is now time to develop continuous measurements over Africa. GPS receivers are low-cost instruments compared to ionosonde and radar. GPS receivers are easy to maintain and provide continuous measurements, hence they are very good candidates for long-lasting research in Africa.

From a questionnaire circulated, the following were indicated as the areas of research involving GPS data:

- Atmospheric studies ->atmospheric water vapour, assimilation of data for models
- Ionospheric studies ->total electron content, electron densities, geomagnetic storms scintillations, assimilation of data for the International Reference Ionosphere (IRI) model ...
- Geodesy ->precise point positioning

(22 scientists from 16 countries (14 African countries) answered the questionnaire).

Table 1 Geographic coordinates of the GPS receivers

Country	Town	Geographic Latitude North	Geographic Longitude East	Project	GPS N°	Country N°
Benin	Djougou	09° 41' 31.5"	01° 39' 41.9"	AMMA	1	1
Niger	Niamey	13° 28' 45.3"	02° 10' 59.5"	AMMA	2	2
Mali	Gao	16° 15' 07"	0° 0' 21"	AMMA	3	3
Ghana	Tamale	09° 33' 15.32"	-0° 51' 42.21"	AMMA	4	4
Mali	Tombouctou	16° 43' 50.32"	-2° 59' 50.82"	AMMA	5	5
Burkina Faso	Ouagadougou	12° 21' 11.52"	-1°30' 44.71"	AMMA	6	6
Burkina Faso	Koudougou	12° 15'	-2° 20'	GIRGEA-IHY	7	6
Cape Verde	Sal island	14°	-22°	SCINDA-IHY	8	7
Nigeria	Akure	6.8°	5.3°	SCINDA-IHY	9	8
Nigeria	Ibadan	7°	3.9°	SCINDA-IHY	10	8
Ethiopia	Bahir Dar	11.5°	37.4°	SCINDA-IHY	11	9
Ethiopia	Addis Ababa	8°	38°	SCINDA-IHY	12	9
Ivory Coast	Abidjan	5°	-4 °	SCINDA-IHY	13	10
Cameroon	Yaounde	3.9°	11.5°	SCINDA-IHY	14	11
Congo	Brazzaville	-4.2°	15°	SCINDA-IHY	15	12
Senegal	Dakar	14.685°	342.5352	IGS	16	13
South Africa	Prétoria	-25.8869°	27.7075°	IGS	17	14
South Africa	Krugersdorp	-25.8901°	27.6870°	IGS	18	14
Kenya	Malindi	-2.9959°	40.1944°	IGS	19	15
Uganda	Mbarara	-0.6015°	30.7379°	IGS	20	16
Gabon	Franceville	-1.6312°	13.5520°	IGS	21	17
Gabon	Libreville	0.3523°	9.6698	IGS	22	17
Morocco	Rabat	33.9981°	353.1457°	IGS	23	18
South Africa	Richards bay	-28.7956°	32.0784°	IGS	24	19
South Africa	Simonstown	-34.1879°	18.4395°	IGS	25	19
South Africa	Sutherland	-32.3802°	20.8105°	IGS	26	19
South Africa	Sutherland	-32.3814°	20.8109°	IGS	27	19
Zambia	Lusaka	-15.4255°	28.3110	IGS	28	20
Algeria	Tamanrasset	22.79°	5.53°	29	21
Mozambic	Nampula	-15,123	39,258	IGS	30	22
Tanzania	Dar Es Salaam	-7	39	IGS	31	23
Botswana	Maun	-20	23	IGS	32	24
Namibia	Windhoek	-22,575	17,089	IGS	33	25
Sao Tome Isl.	Sao Tome	0,345	6,738	IGS	34	26
Southern Oce.	Marion Island	-46,876	37,861	IGS	35	27
Algeria*	In Salah	27.22N	2.37E	AGREES	36	21
Angola*	Huambo	12.73S	15.78E	AGREES	37	28
Chad*	N'Djamena	12.11N	15.05E	AGREES	38	29
Chad*	Faya-Largeau	17.92N	19.12E	AGREES	39	29
Egypt*	Asawan	24.08N	32.93E	AGREES	40	30
Libya*	Marzuq	26.N	14.15E	AGREES	41	31
Libya*	Tripoli	32.90N	13.18E	AGREES	42	31

Table 1 continued

Country	Town	Geographic Latitude North	Geographic Longitude East	Project	GPS N°	Country N°
Mauritania*	Bir Moghrei	25.23N	11.62W	AGREES	43	32
Mozambic*	Beira	19.75S	34.97E	AGREES	44	22
Tanziana*	Songea	10.68S	35.65E	AGREES	45	23

5 Main Objectives of IHY in Africa

- To maintain and increase the GPS network over Africa in order to study the variability of the Earth's environment related to solar phenomena at different time scales: minute, hour, day month, year, and solar cycles, during magnetically quiet and disturbed periods.
- To build a GPS data base for Africa—The National Geophysical Data Centre is in charge of this task.
- To develop space science experiments in Africa
- To promote excellence of space science research and education in Africa with African Universities in the worldwide network of Universities.

The IHY-Africa Space Weather Science and Education Workshop took place in Addis Ababa (Ethiopia) during November 12–16, 2007 after the 2nd Africa SCINDA Workshop on November 11, 2007 (See <http://kuiper.colorado.edu/IHY-Africa>). 128 participants attend the meeting. Around 72 participants are African scientists from 20 different countries. This workshop will be organized by an International Scientific Organizing Committee (Co-Chairs : Sunanda Basu from Boston University and Tim Fuller-Rowell from University of Colorado) and a Local Organizing Committee (Chair : Gizaw Mengistu from University of Addis Ababa).

The following decisions were taken during the meeting

- organisation of international observations campaigns, the first Whole Heliosphere Interval was from March 21 to April 16, 2008
- increase of the existing permanent GPS networks (IGS–SCINDA- AGREES)
- support of the AMMA GPS network after 2009
- Development of national GPS networks in all African countries
- organization of training schools
- help of African students to obtain scholarships
- training of PhD scientists in Africa with two supervisors (one from the country of the African student and one from a foreign country)
- development of the best practices ->ethic rules must be applied

See http://www.icsu-africa.org/ihy_report_2007.pdf for a detailed report of the IHY-Africa Space Weather Science and Education Workshop.

6 Conclusion

The IHY/UNBSS project is a unique opportunity to share knowledge and education, on space science between scientists from developing and industrialized countries.

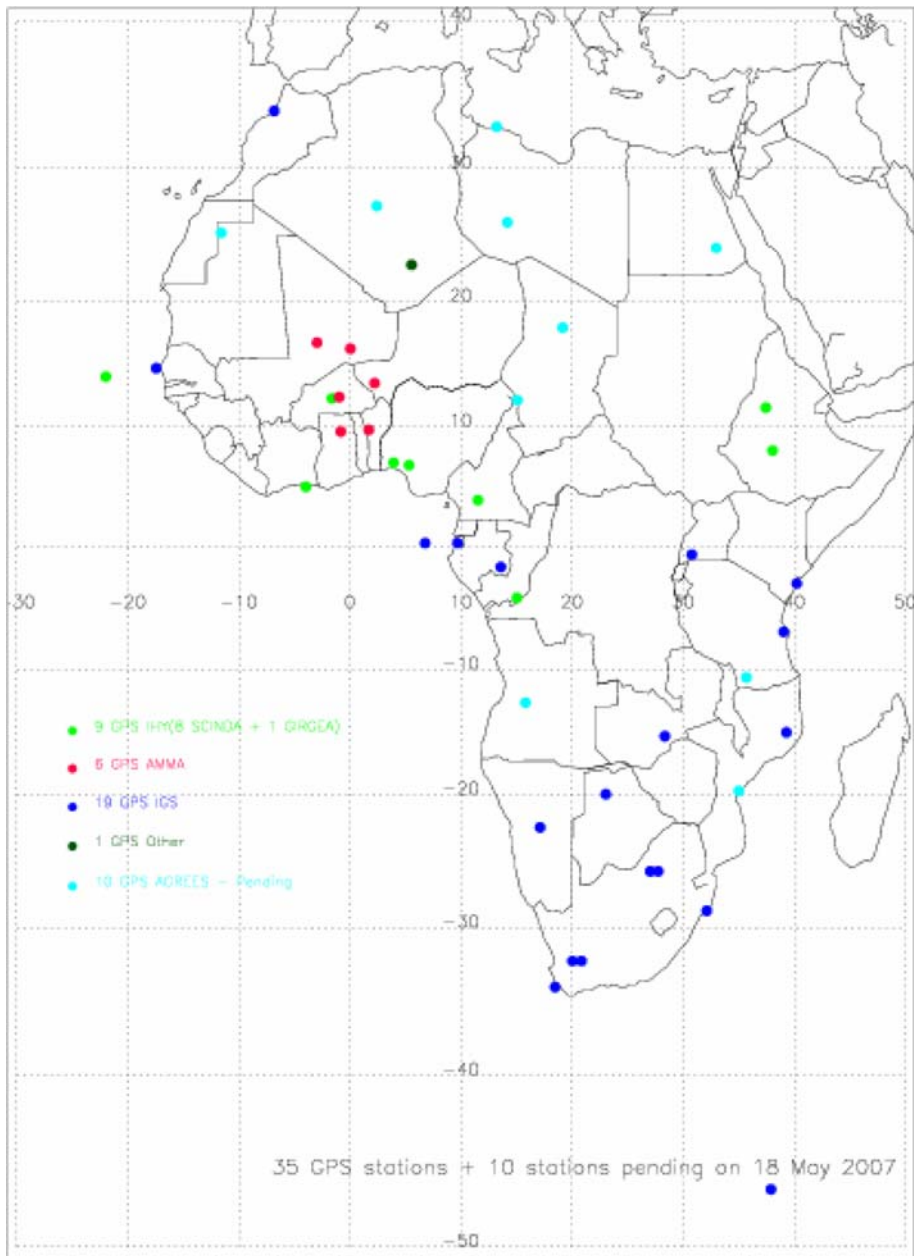


Fig. 1 Map with the different networks of GPS receivers involved in the IHY project

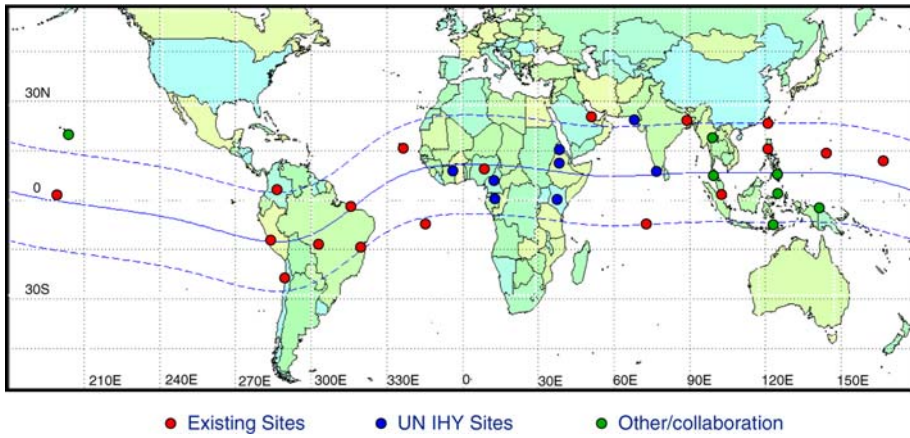


Fig. 2 Map of the SCINDA network of GPS receivers (figure given by Keith Groves)

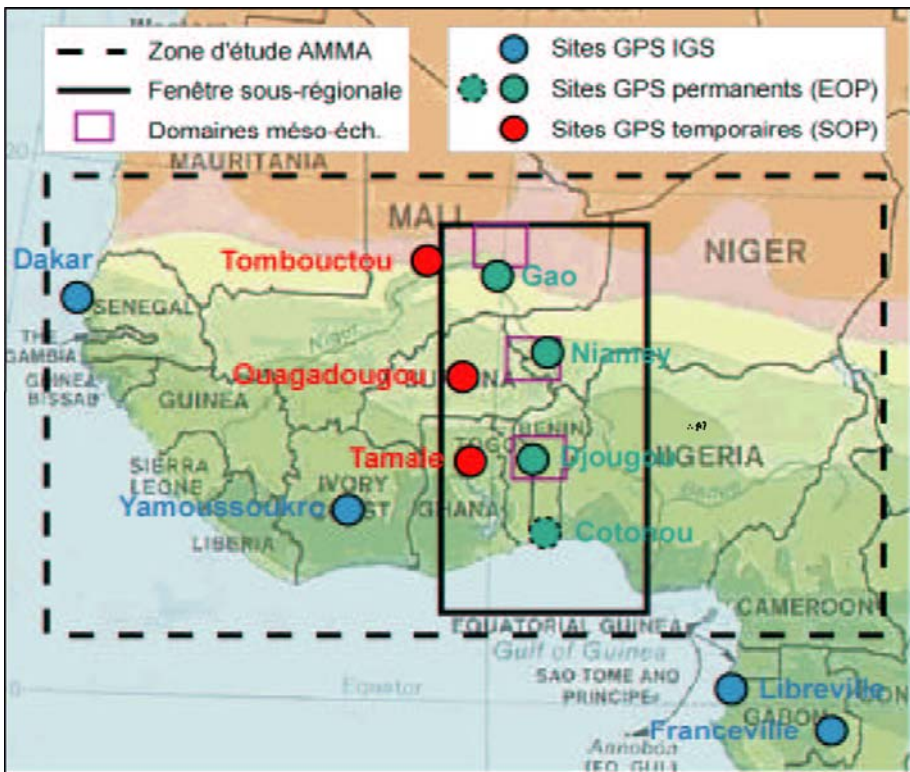


Fig. 3 Map of the AMMA network of GPS receivers (figure given by Olivier Bock)

IHY allows collaboration between geophysicists and solar physicists, a necessity for all the global studies of the Sun–Earth System.

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