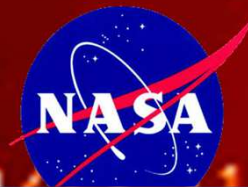


Future Direction of AMBER: Inner-Magnetospheric Array for Geospace Science (iMAGS)

Endawoke Yizengaw

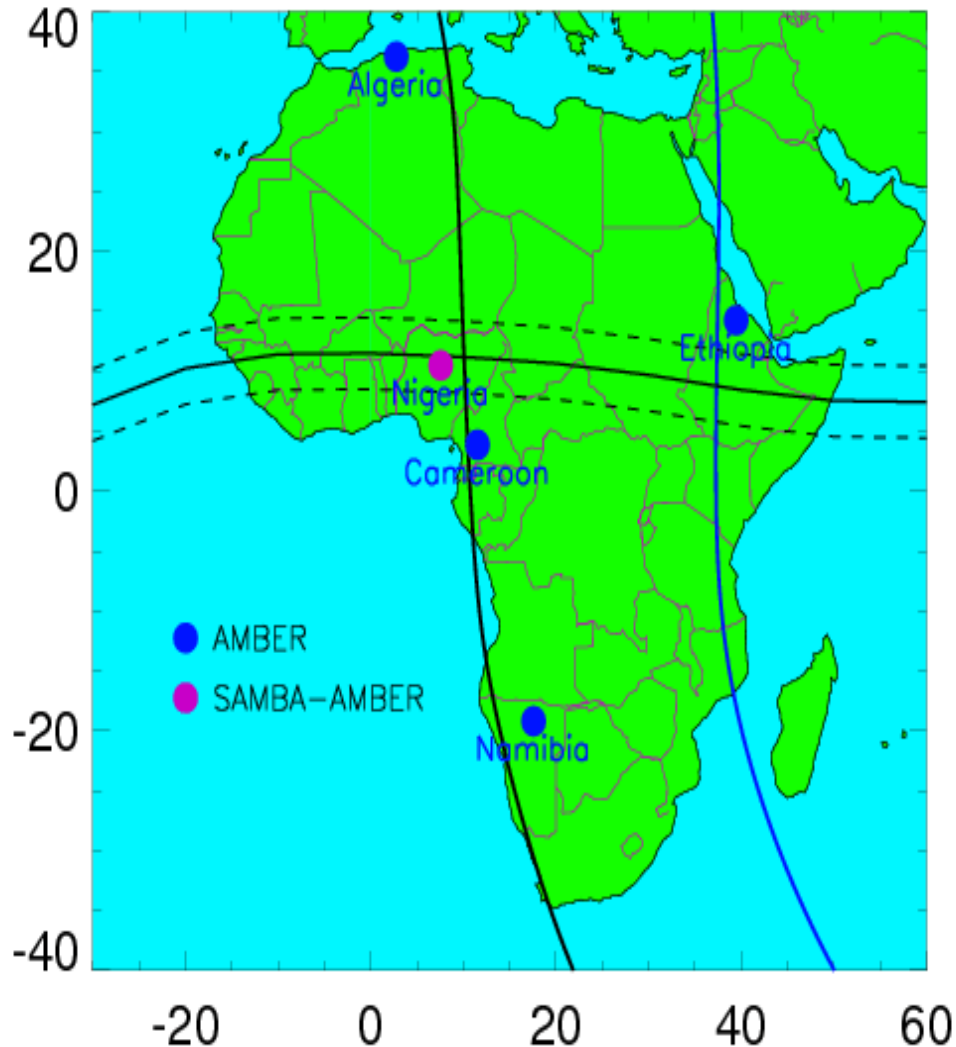
Institute for Scientific Research, Boston College, USA

Team Members: M. Moldwin (UM); E. Zesta (NASA); A. Boudouridis (SSI); and AMBER team members around the world!



IHY+10: The Origin of AMBER (NASA-IHY)

AMBER (African Meridian B-field Education and Research)

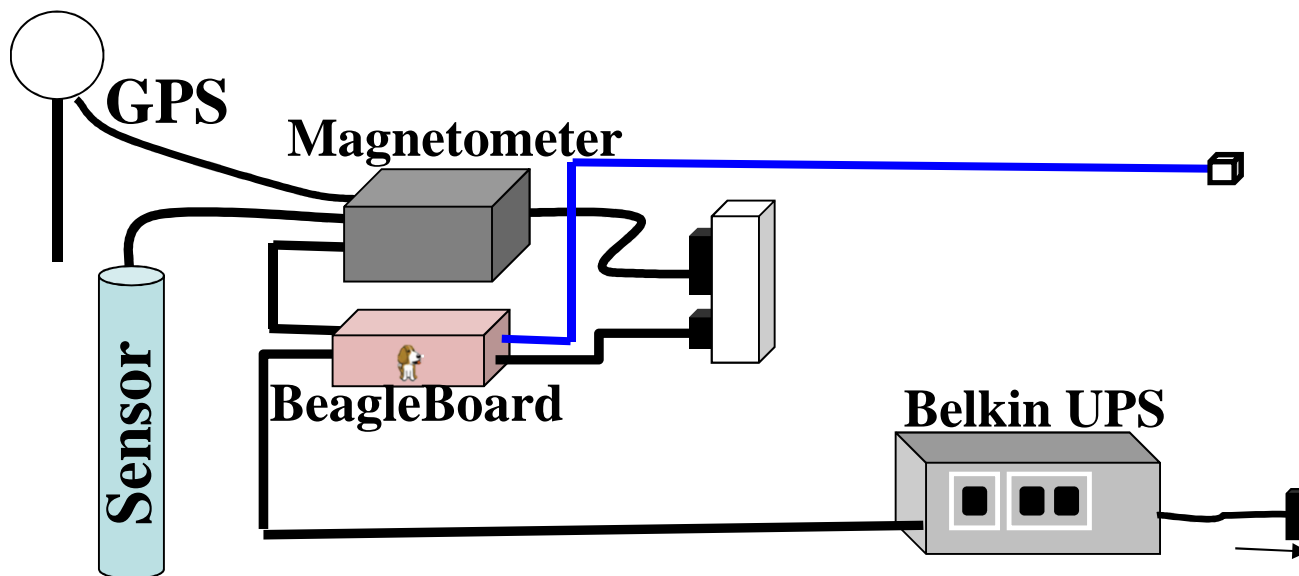


Objectives: To investigate

→ the processes governing electrodynamics of the equatorial ionosphere as a function of local time, longitude, magnetic activity, and season, and

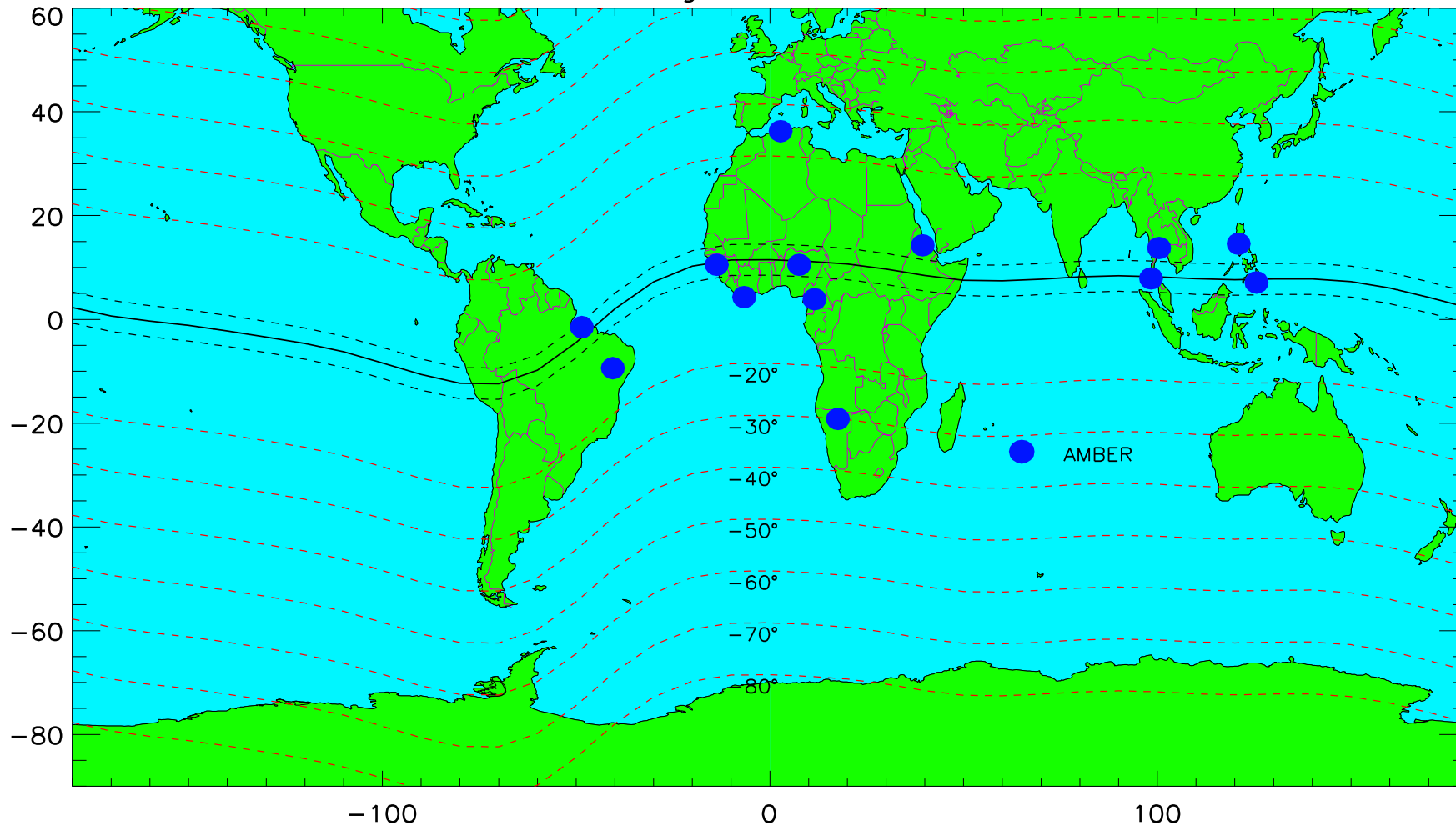
→ ULF pulsation strength and its connection with equatorial electrojet strength at low/mid-latitude regions.

Instrument & its Setup at the site



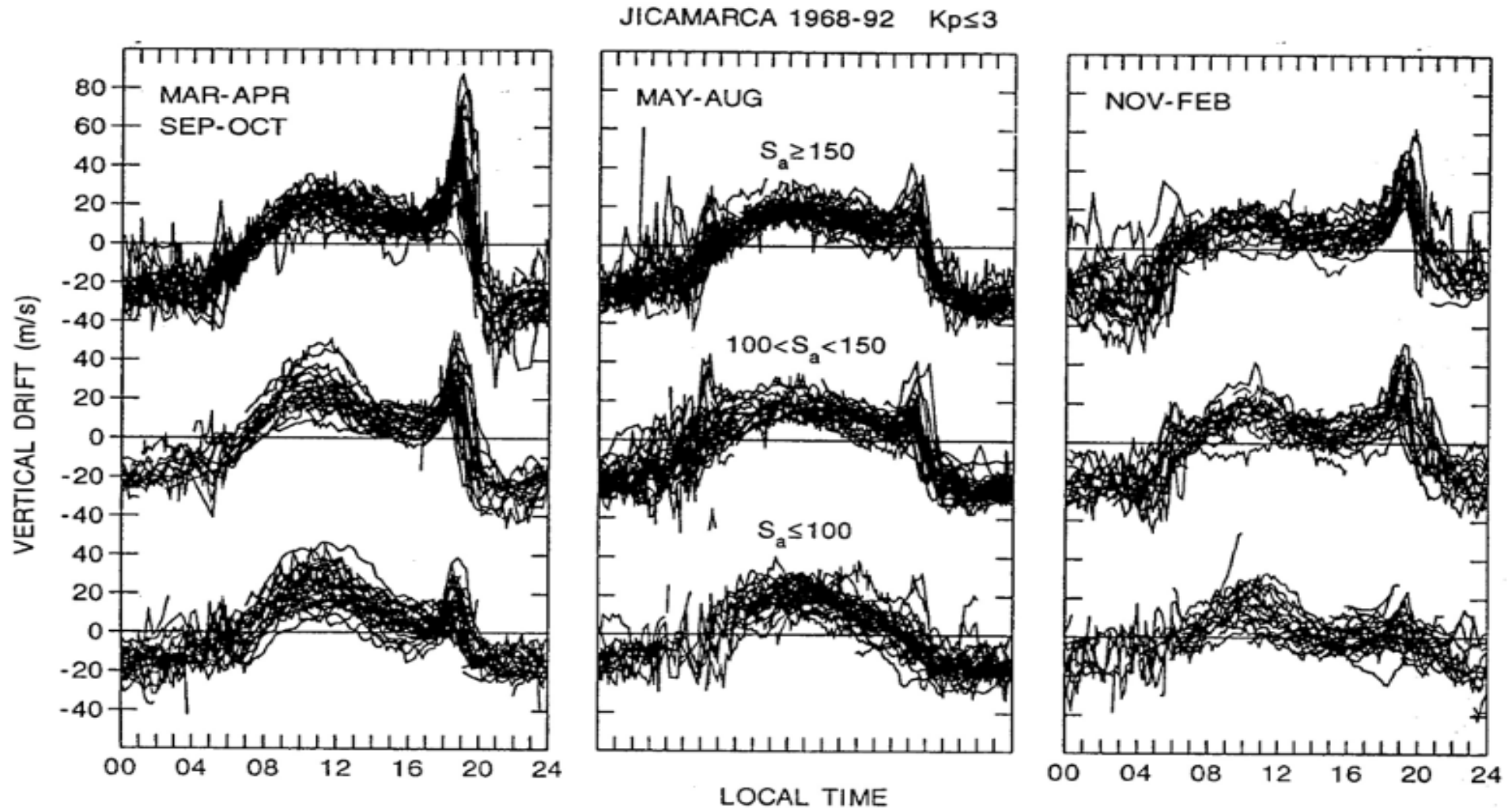
Expansion of AMBER Network (AFOSR)

AMBER Magnetometers Network



Objectives: To investigate the longitudinal variability of dayside electrodynamics

Is equatorial electrodynamics longitudinal dependent?



Scherliess and Fejer, JGR, 1996

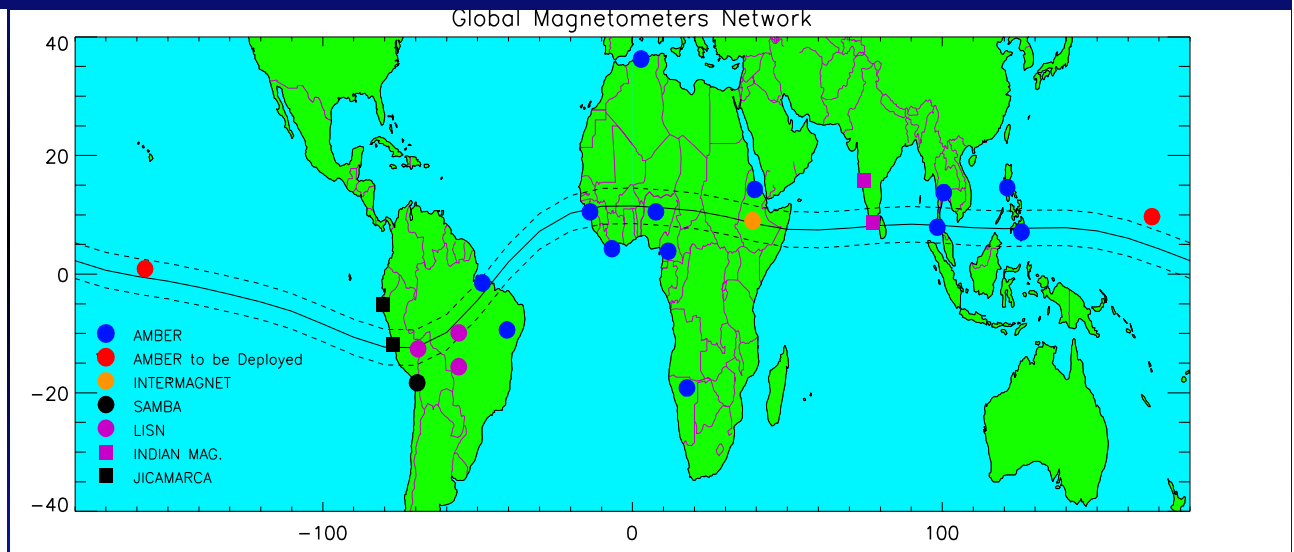
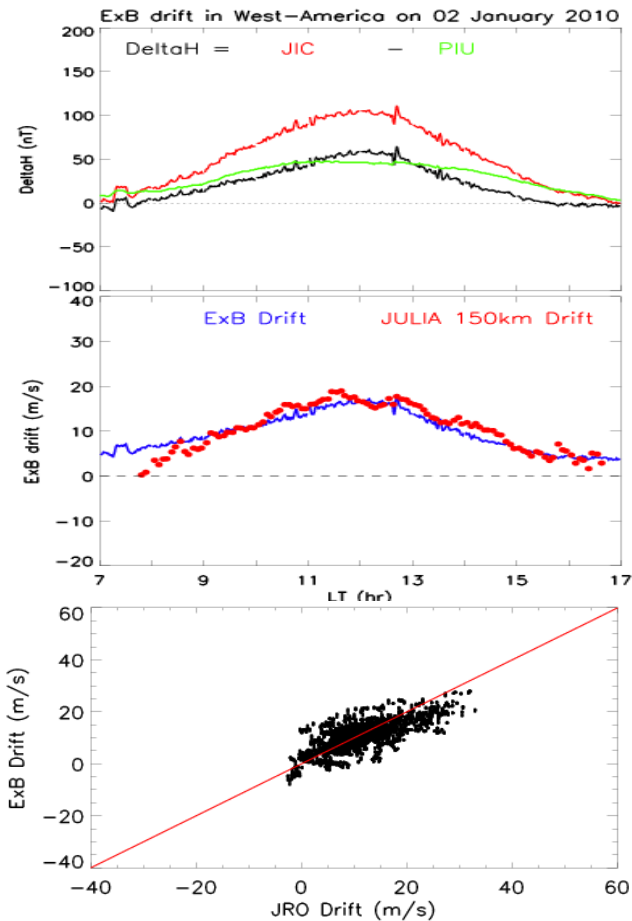
→ Is the drift at Jicamarca the same at different meridians?

→ **AMBER** monitors dayside electrodynamics at different longitudes



AMBER provide longitudinal variability of dayside electrodynamics

$$J_X = \left(\sigma_P + \frac{\sigma_H^2}{\sigma_P} \right) E_X = \sigma_C E_X \longrightarrow \text{EEJ current}$$



➔ Magnetometer at off the equator

$$\mathbf{B}_{\text{Obs}} = \mathbf{B}_{\text{main}} + \mathbf{B}_{\text{SQ}} + \mathbf{B}_{\text{FAC}} + \mathbf{B}_{\text{RC}} + \mathbf{B}_{\text{MP}}$$

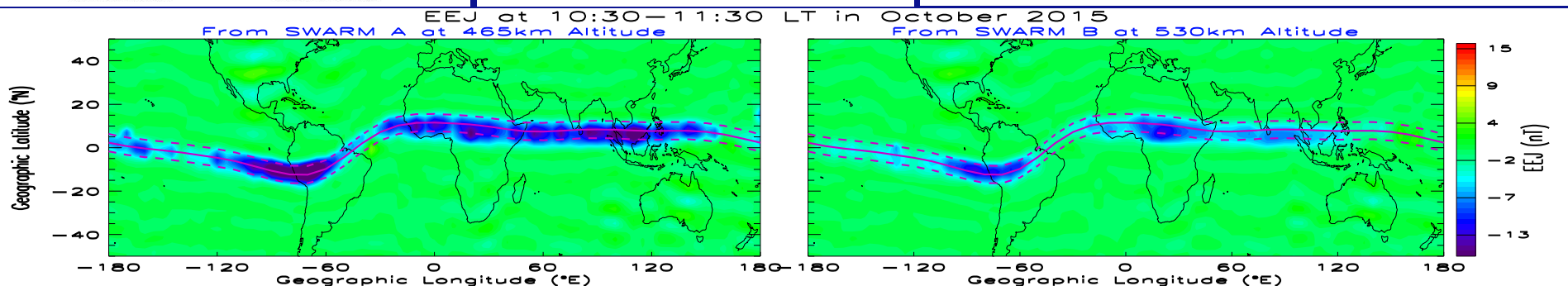
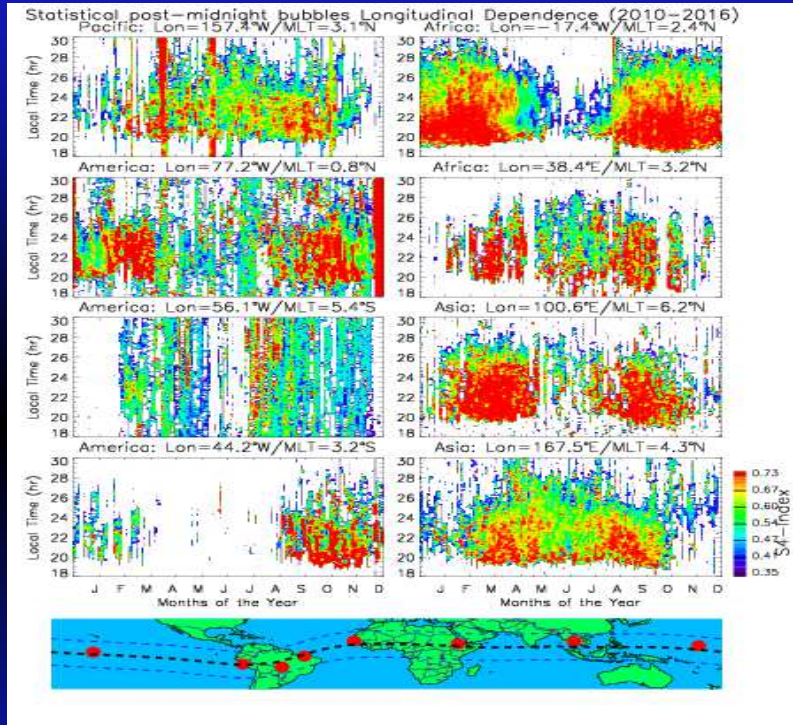
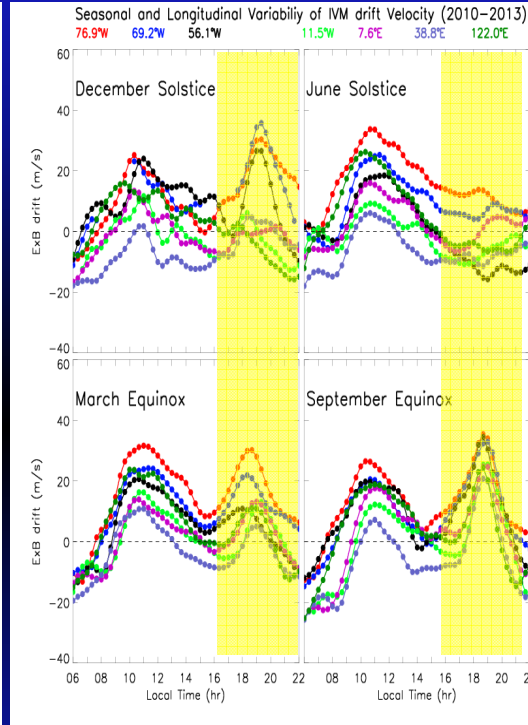
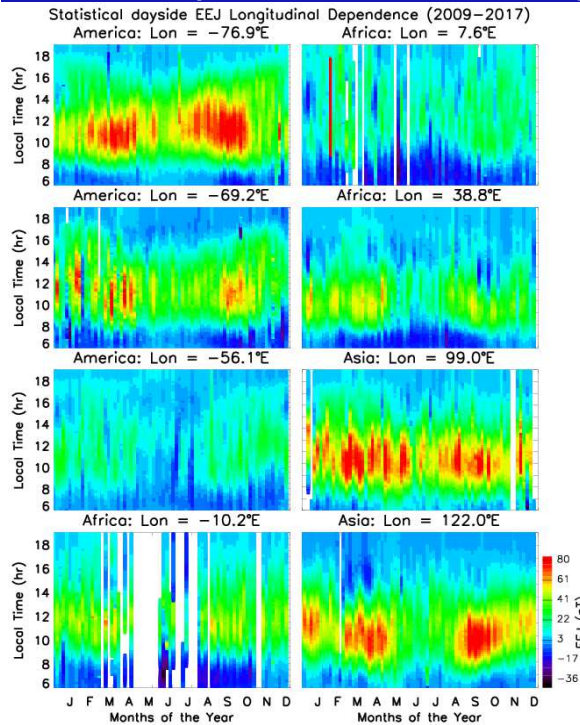
➔ Magnetometer at the equator

$$\mathbf{B}_{\text{Obs}} = \mathbf{B}_{\text{main}} + \mathbf{B}_{\text{SQ}} + \mathbf{B}_{\text{FAC}} + \mathbf{B}_{\text{RC}} + \mathbf{B}_{\text{EJ}} + \mathbf{B}_{\text{MP}}$$

Longitudinal and Seasonal Variability of Equatorial Electrodynamics and Ionospheric Irregularities!

Dayside and evening side drifts

Bubbles or Scintillations



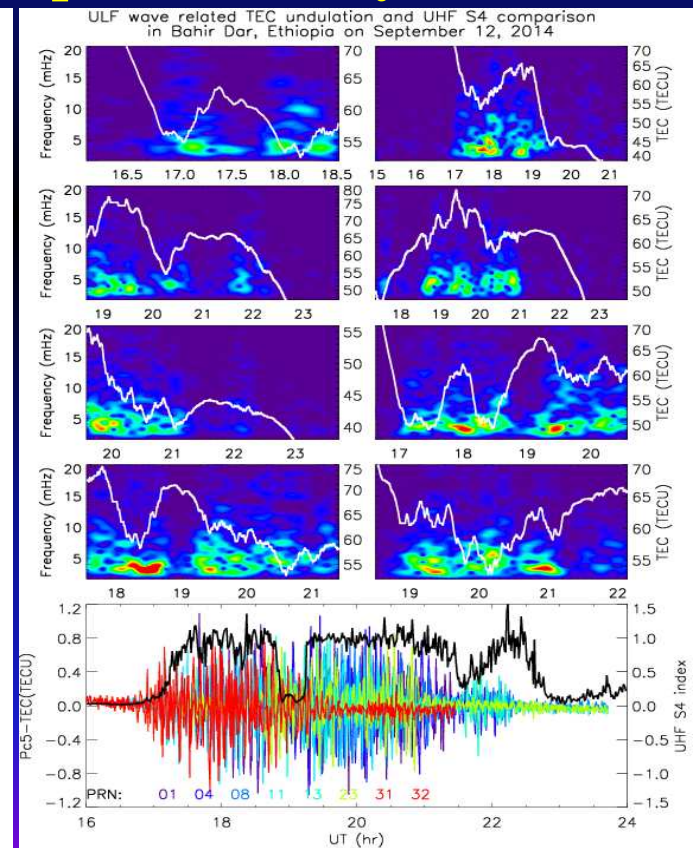
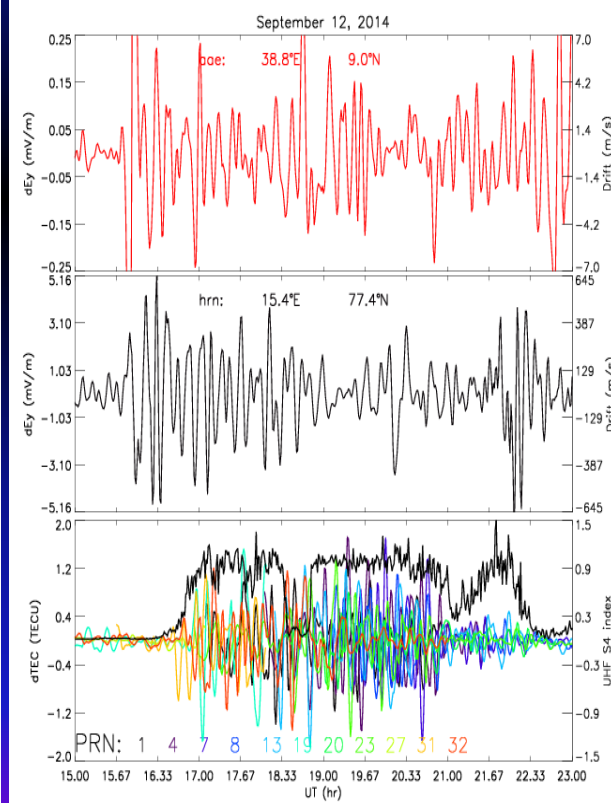
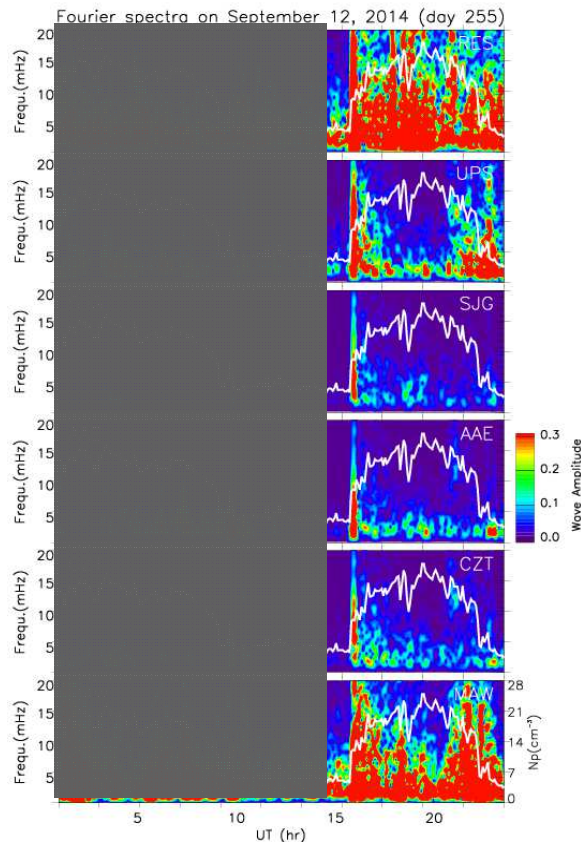
➔ If not the drift, then what controls the longitudinal variability of bubbles?

Solar Wind-Magnetosphere-Ionosphere impact on technological systems!

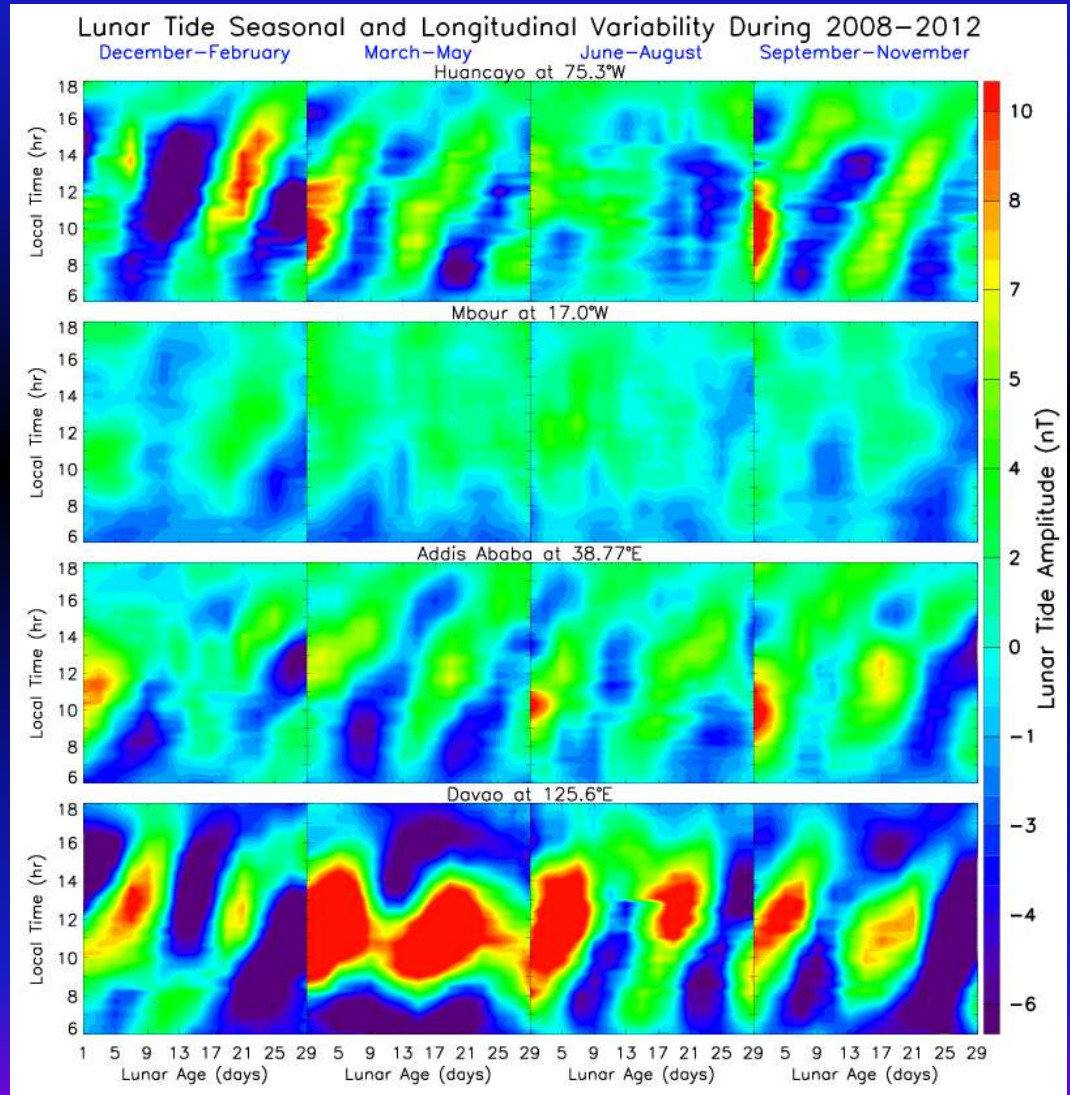
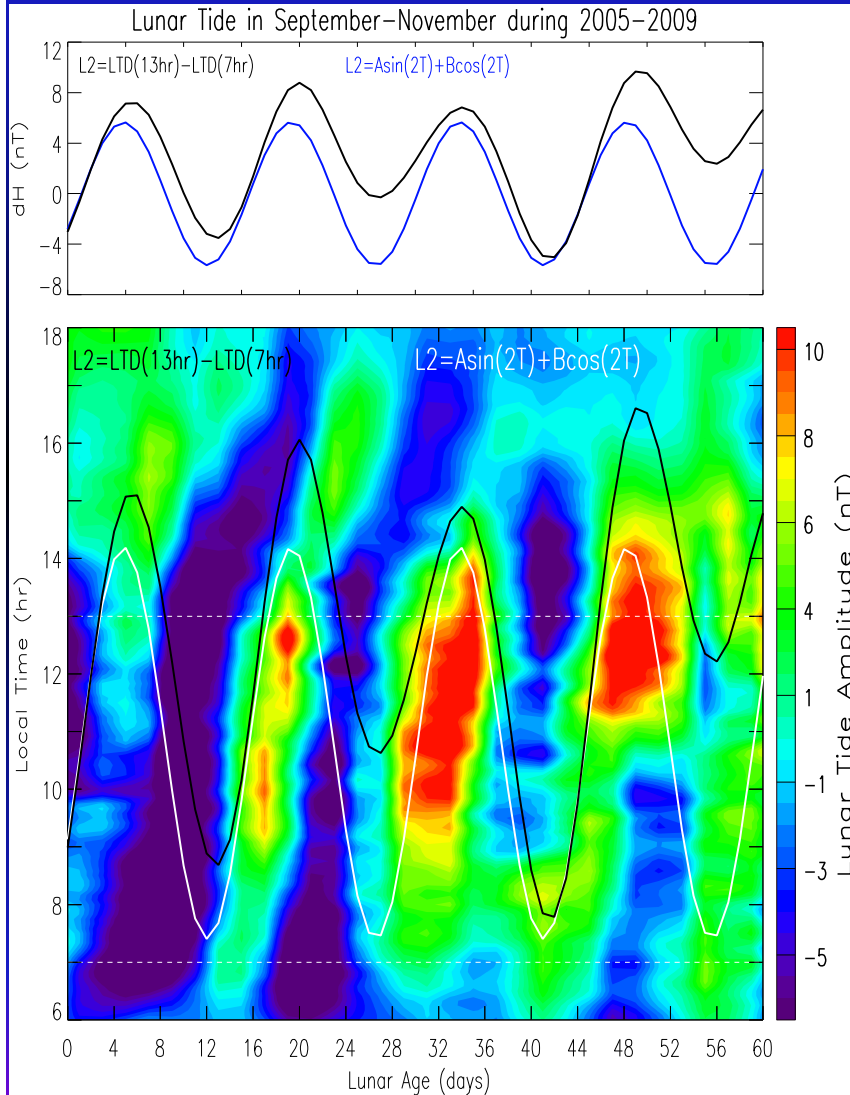
→ AMBER contribute in tracking Solar Wind-magnetosphere-ionosphere coupling impact on ionospheric disturbance

ULF wave penetration to low-latitudes

ULF wave associated E-field fluctuation and its impact on ionospheric density



Longitudinal and Seasonal Variability of Lunar Tide Effect on Equatorial Electrodynamics



Yizengaw and Carter., AG, 2017

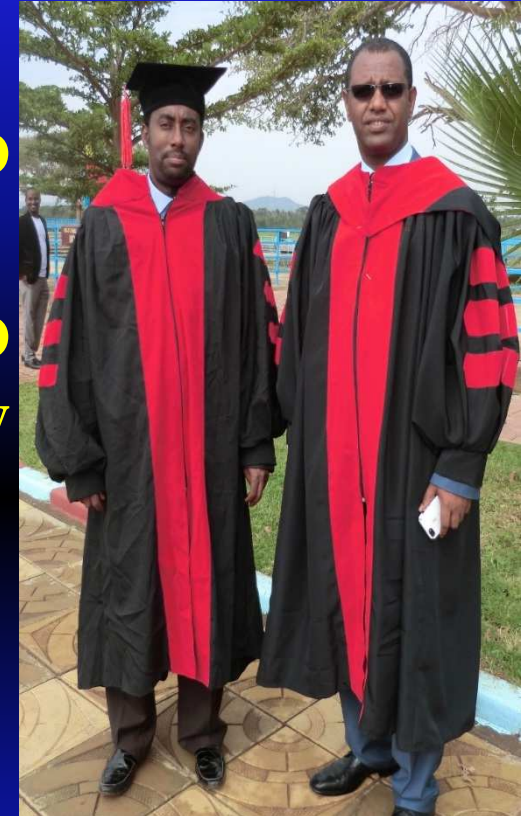
AMBER Publication & Capacity Building Milestone

So far AMBER have

- ✈ **Supported 2 senior and mid-career researchers**
- ✈ **Graduated students (2 PhD in Ethiopia, 1 PhD in Algeria, 1 MSc in Nigeria)**
- ✈ **Currently Students (2 PhD in Ethiopia, 1 PhD in Nigeria, 1 PhD in Cameroon, 1 PhD in Ivory Coast, 1 PhD in Chile, 1 PhD in Thailand)**

Postdocs

- ✈ **Edigardo Pacheco (BC, now at Jicamarca), Brett Carter (BC, now at RMIT).**
- ✈ **Produced about 40 peer-reviewed publications and over 50 conference presentations**
- ✈ **We are ripe for more dense future output**

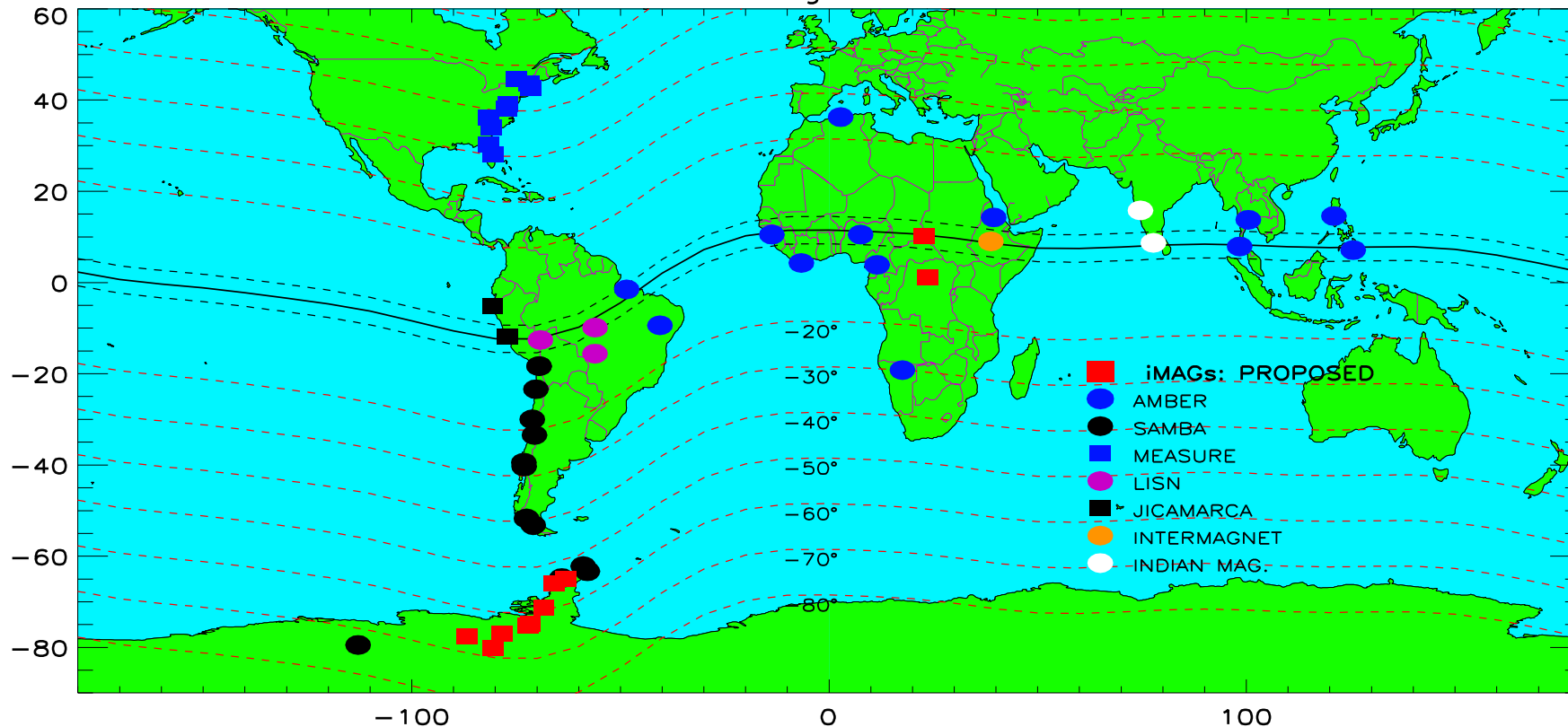


AMBER – iMAGS (NSF - operation)

iMAGS (Inner-Magnetospheric Array for Geospace Science)

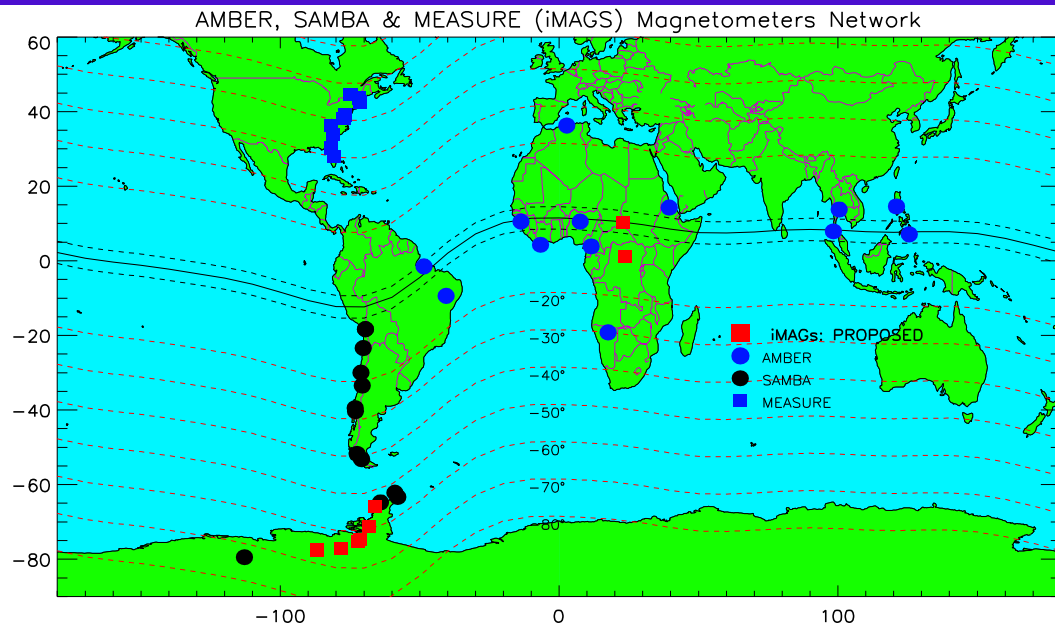
Merging AMBER, SAMBA, MEASURE Networks

iMAGS & other Magnetometers Network



Team members: E. Yizengaw (PI, BC), M. Moldwin (Co-I, UM), E. Zesta (Co-I, NASA), A. Boudouridis (SSI); M. Magoun (BC)

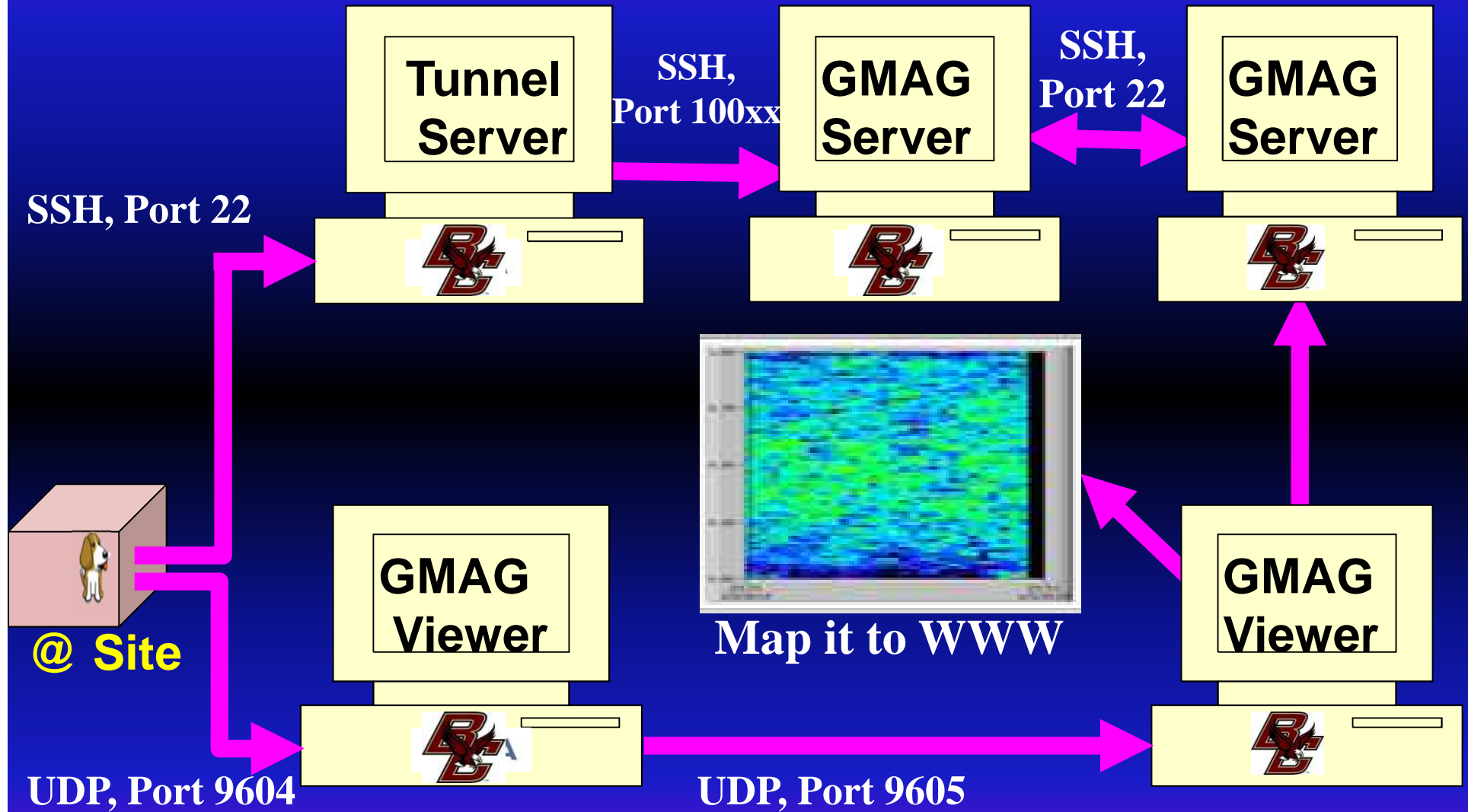
Objective of iMAGS magnetometer Array



➔ To understand the processes governing electrodynamics of the equatorial ionosphere as a function of local time, longitude, magnetic activity, and season

- ➔ To understand the Solar Wind – Magnetosphere – Ionosphere coupling impact on the equatorial density distributions that important for the communication and navigation systems
- ➔ To estimate the plasmasphere mass density
- ➔ To monitor the GIC currents not only at high latitudes but also at the equatorial region where the GIC get amplified by EEJ in the same way it gets amplified by AE at high latitudes

Data returning procedures



Our Database

<http://magnetometers.bc.edu/>

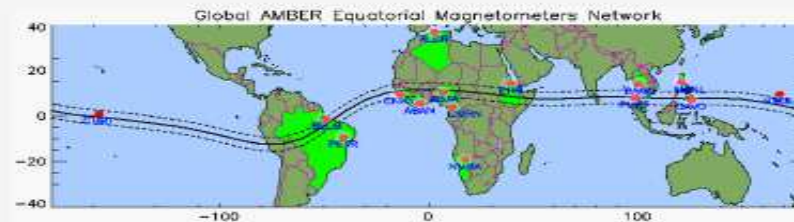
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AMBER NETWORK



To gain a more complete global understanding of equatorial ionosphere motions, deployment of ground-based magnetometers in Africa is essential. The currently funded African Meridian E-Field Education and Research (AMBER) magnetometer array comprises seven magnetometers stationed in Adigrat, Ethiopia; Medea, Algeria; Yaounde, Cameroon; Tsumeb, Namibia; Abuja, Nigeria; Conakry, Guinea; and Abidjan, Côte d'Ivoire. The network has been extended equatorially to Asia with stations at Bangkok and Phuket, Thailand.

AMBER stations are used to connect the European IMACE-SAMNET-SECMA arrays to low and dip-equator latitudes, and link up with South African Intermagnet and Antarctic magnetometers in the southern hemisphere.

While providing complete meridian observation in the region and filling the largest land-based gap in global magnetometer coverage, the AMBER array addresses two fundamental areas of space physics: first, the processes governing electrodynamics of the equatorial ionosphere as a function of latitude (or L-shell), local time, longitude, magnetic activity, and season, and second, ULF pulsation strength and its connection with equatorial electrojet strength at low/mid-latitude regions.

In coordination with GPS receivers in Africa, the AMBER magnetometer network provides a great opportunity to understand the electrodynamics that governs equatorial ionosphere motions. While magnetometers routinely observe the F region plasma drift mechanism (E_z drift), GPS stations monitor the structure of plasma at low/mid-latitudes in the African sectors. Combined observations provide enormous opportunity to understand the unique equatorial ionospheric structures in the African sector.

Further stations will soon be established at Petrolina and Belem, Brazil, and at Davao and Manila, Philippines.

The AMBER project creates sustainable research/training infrastructure within the African universities, enabling opportunities for space science undergraduate students to perform further research activities within their own countries.

Abuja
Algeria
Cameroon
Ethiopia
Namibia
Abidjan
Conakry
Davao
Manila
Petrolina
Belem
Bangkok
Phuket

→ You can search by day numbers or by station name

→ You can download ASCII data (1 min, 1 sec, and half sec resolution)

→ You can download summary plots for a quick look!

→ You can download Electrojet data (daily plots and ASCII data)!

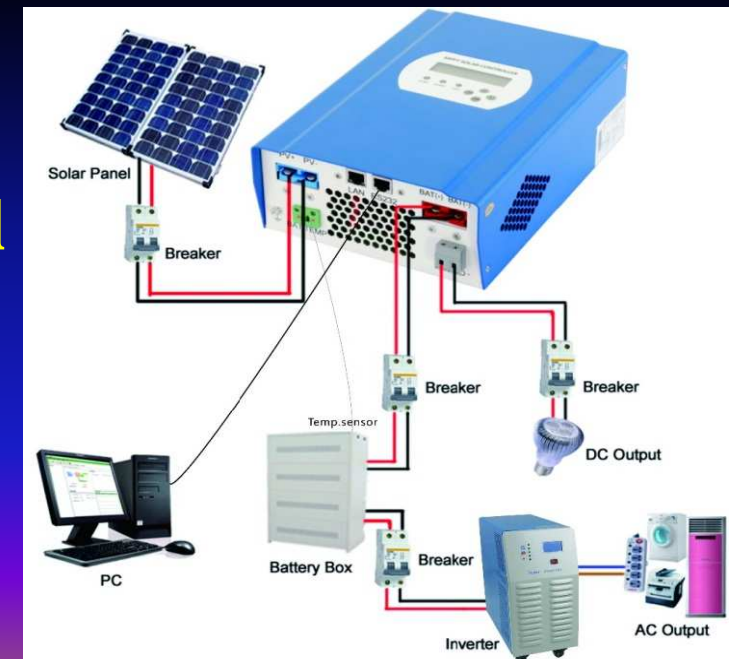
Grand Challenges

→ Two prominent grand challenge problems

→ **Power fluctuation issue:** Lack of funding to augment with solar panel

→ **Internet Connectivity issue:** Expensive to use other alternative options

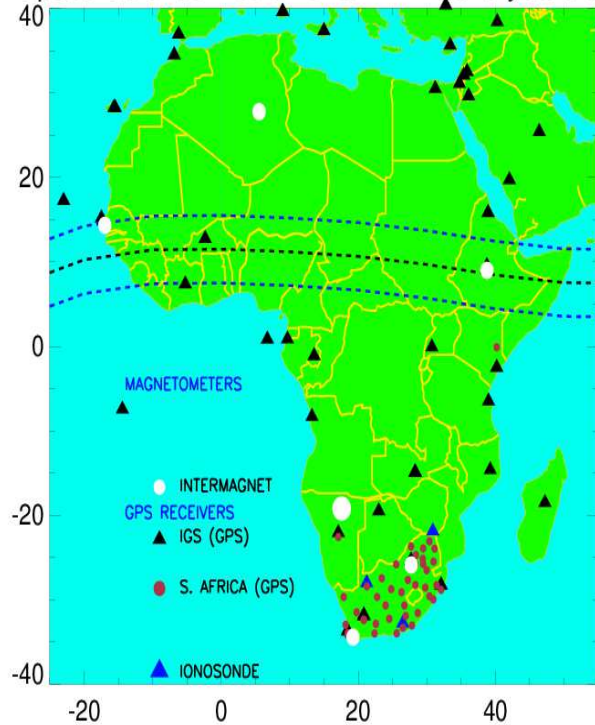
→ The collaborative agreement signed with different international agencies may help improve these grand challenges!



Evolution of Instrumentation in Africa and Its Significant Outputs!

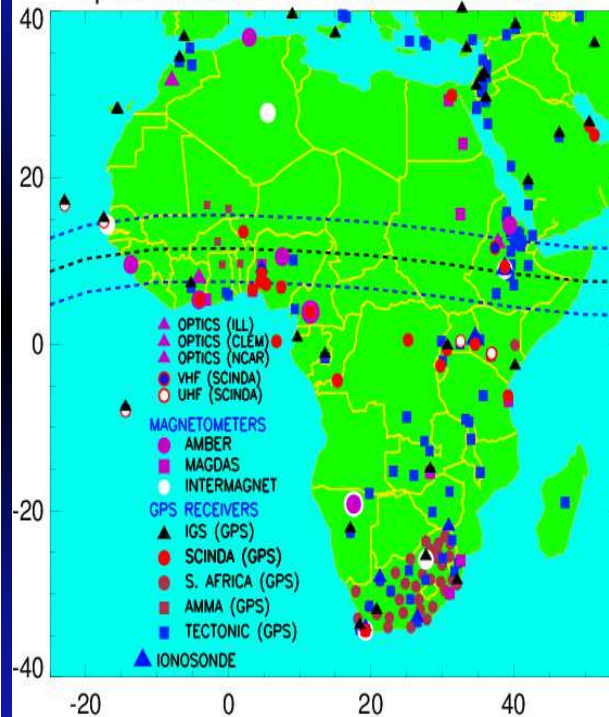
In 2007

Space Science Instruments in Africa: 5 years ago



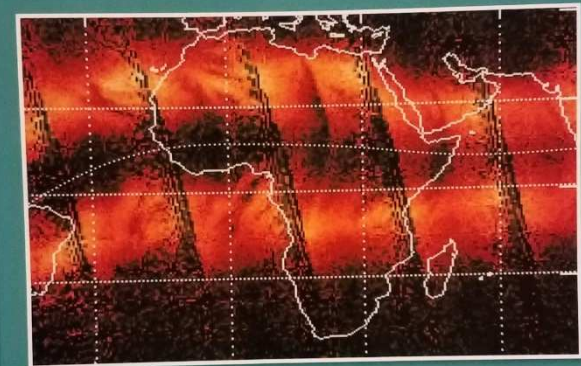
In 2015

Space Science Instruments in Africa: Now



Significant Legacy!

Ionospheric Space Weather
Longitude Dependence and
Lower Atmosphere Forcing



Timothy Fuller-Rowell, Endawoke Yizengaw,
Patricia H. Doherty, and Sunanda Basu
Editors

AGU
American Geophysical Union

WILEY

Thank You!