The Role of CORS GNSS Data for Climate Monitoring: Case Study using NIGNET Network

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Introduction

The 2012 rainy season in Nigeria was one of the worse ones in the last decades: heavy rains at the end of August and the beginning of September led to serious floods in most parts of the country.

Causes and Effect:

- Heavy Rainfall
- Overflow of the Water Reservoirs and the subsequent opening of the Dams both in Nigeria and neighboring Cameroon and Niger.
- Causing the destruction of river banks and infrastructures
- Loss of livestock and flash floods in many areas

Introduction Cont.

Causes and Effect Cont.:

- By 29 Sept, the floods had affected about 135000 people.
- Displaced about 65000, injured 202 and
- killed 148.
- By the end of October, more than 7.7 million people had been affected by the floods.
- More than 2.1 million had registered as Internal Displaced Person (IDP).
- 363 people were reported dead.

Introduction Cont.

Causes and Effect Cont.:

- Almost 600000 houses had been damaged or destroyed .
- Out of 36 States in Nigeria, 32 States were affected by the floods

Detail of the floods that affected millions of Nigerians in 2012 (Anambra State)

Introduction Cont.

Why the Study:

- **These statistics/data just show us the importance in better understanding of the climate and monitoring its major parameters.**
- **This poses significant issues in regions lacking climate monitoring instruments.**

Common Methods of Weather Forecast

Some methods of weather forecast are:

- **By Interactive Analysis of Radar and Satellite Imagery.**
- **By Statistical Inferences**
- **Indigenous approach to weather forecast.**
- **By GNSS Meteorology**

Common Methods of Weather Forecast Cont.

- In Nigeria, the prediction model is based on the strong tele-connection between El Nino/Southern Oscillation (ELSO)

- Sea Surface Temperature (SST) anomalies and rain-bearing weather system over Nigeria.

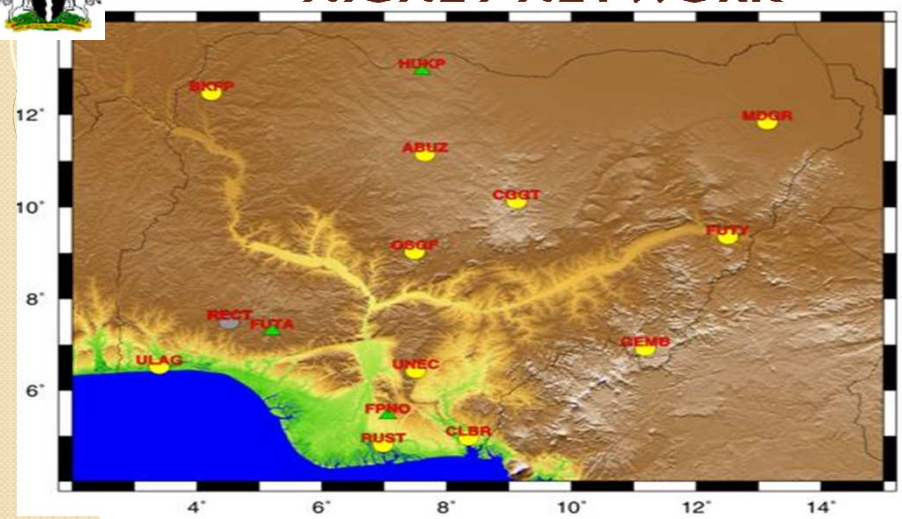
- The model also incorporates phonological and soil information as well as historical daily weather data from 39-meteorological stations spatially distributed over Nigeria for 22 ENSO.

- Thus, most of the present predictions and forecasting models are mere empirical statistical extrapolations

NIGERIAN GNSS REFERENCE NETWORK

- The NIGNET (NIGerian GNSS Reference NETwork) which is formed by state-of-the-art CORS (Continuously Operating Reference Station)/GNSS (Global Navigation Satellite Systems) equipment provide us additional tool to monitor one of the most important meteorological and climate parameters:
  - The quantity of Precipitable Water Vapor (PWV) in the atmosphere which is directly correlated with the precipitation.
  - Precipitable Water Vapor plays a major role in many atmospheric processes concerning physics, thermodynamics and dynamics.

NIGNET NETWORK



Currently, there are 11 stations directly installed by OSGoF. OSGoF also manages more Four stations installed in the framework of Land Reform project and also collaborates with RECTAS (Regional Centre for Training in Aerospace Surveys) on the data maintenance of RECT station at Ife.

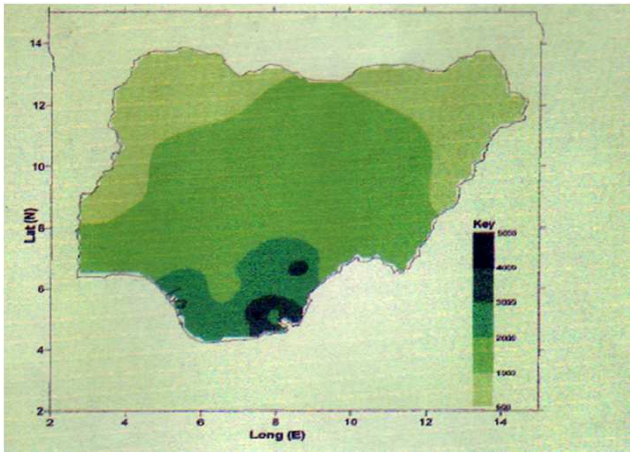
PRECIPITATION (METEOROLOGY)

- **In meteorology, precipitations (which are atmospheric water phenomena) is any product of the condensation of atmospheric water vapour that falls under gravity.**
- **The main form of precipitation include:**
  - **Drizzle**
  - **Rain**
  - **Sleet**
  - **Snow**
  - **Graupel and Hail.**

PRECIPITATION (METEOROLOGY) CONT.

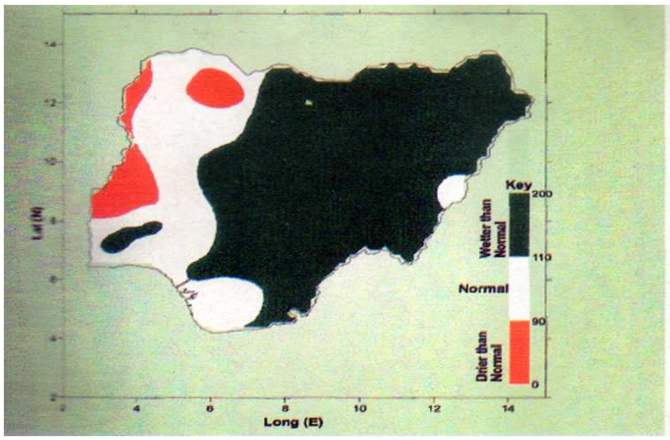
- Global warming is also causing changes in the precipitation pattern globally.
- Mechanisms of producing precipitation include:
  - Convective
  - Stratiform and
  - Orographic rainfall.

NIGERIAN METEOROLOGICAL AGENCY(NIMET) 2012 CLIMATE REVIEW



2012 Cumulative Annual Rainfall

NIGERIAN METEOROLOGICAL AGENCY(NIMET) 2012 CLIMATE REVIEW



2012 Rainfall Anomaly

GNSS AND WATER VAPOR

- In recent years, the use of GNSS observations to sense the Precipitable Water Vapor (PWV) in the troposphere has increased significantly.
- While travelling through the Earth's atmosphere the GNSS signal is going to experience delays caused by:
  - The atmosphere
  - Mainly the ionosphere and
  - Troposphere

GNSS AND WATER VAPOR CONT.

- Most of the scientific software packages (e.g.,
  GIPSY-OASIS
  BERNESE
  GAMIT) are used to estimate the Zenith Tropospheric Delay (ZTD), from where the PWV can be derived knowing temperature and pressure at the site location.

GNSS AND WATER VAPOR CONT.

- The PWV can be derived from the estimated ZWD using the following formulas:

$$PWV = \pi \bullet ZWD$$

$$\pi = \frac{10^6}{\rho R_v \left(K_2' + \frac{K_3}{T_m}\right)}$$

where K_2' and K_3 are empirical physical constants, ρ is the density of liquid water, R_v is the specific gas constant for water vapour, and T_m is the surface temperature.

GNSS AND WATER VAPOR CONT.

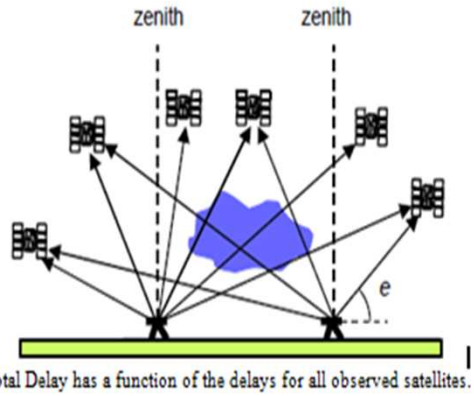


Figure 3 – Zenith Total Delay has a function of the delays for all observed satellites.

RESULTS

- **In this work we are analyzing several periods related with the flood events in 2012 using data from three stations of the network:**

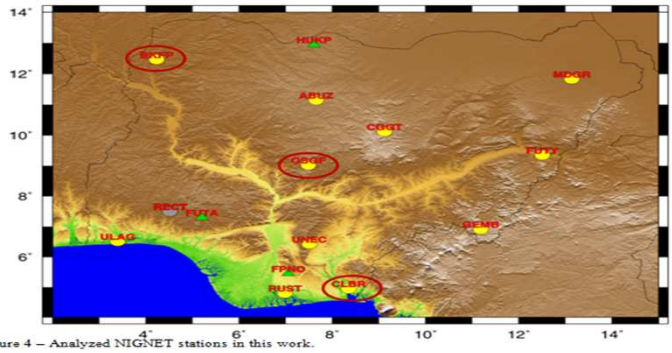


Figure 4 – Analyzed NIGNET stations in this work.

RESULTS CONT.

- The ZTD and Precipitation at Abuja for the entire year of 2012.

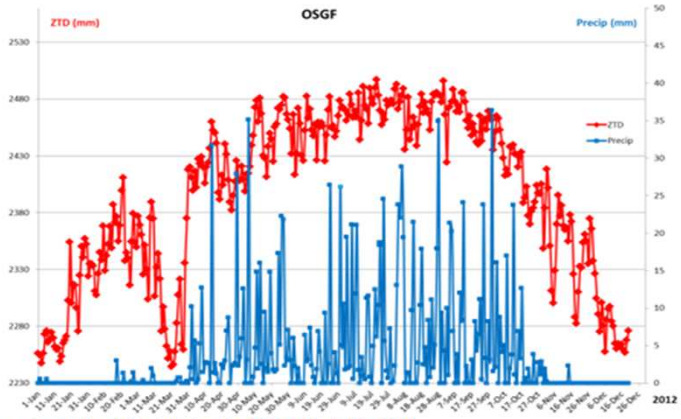
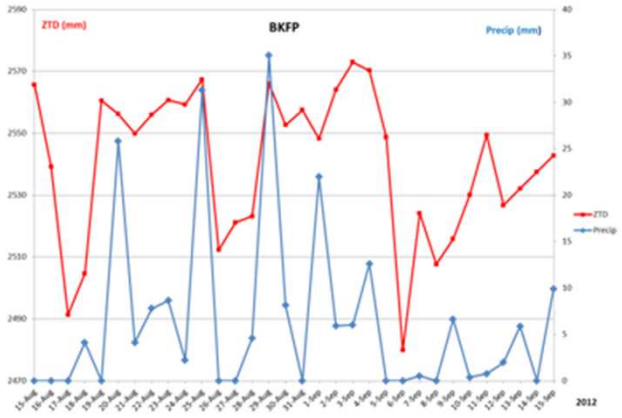


Figure 5 – ZTD and Precipitation for OSGF (Abuja) for 2012

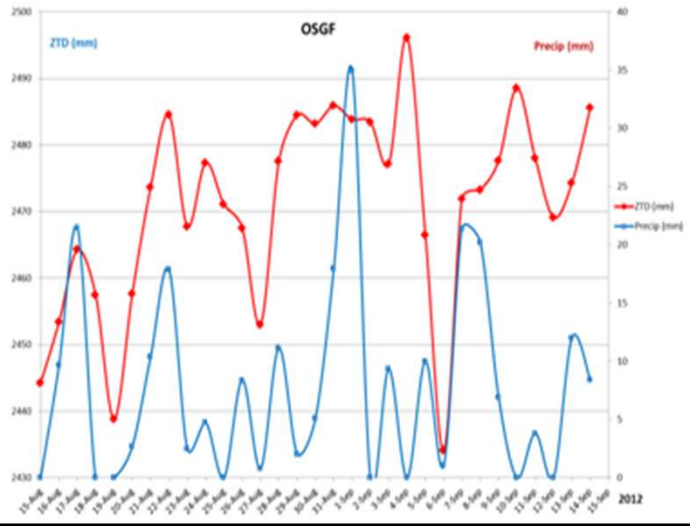
RESULTS CONT.

- ZTD and Precipitation for BKFP (Birnin Kebbi) for August-September 2012



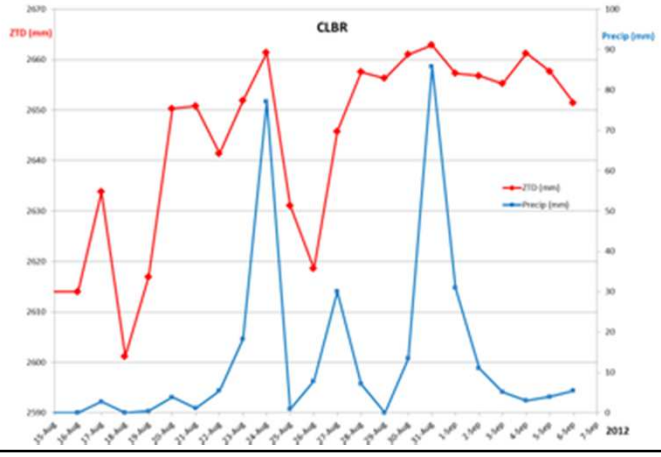
RESULTS CONT.

- ZTD and Precipitation for OSGF (Abuja) for August-September 2012



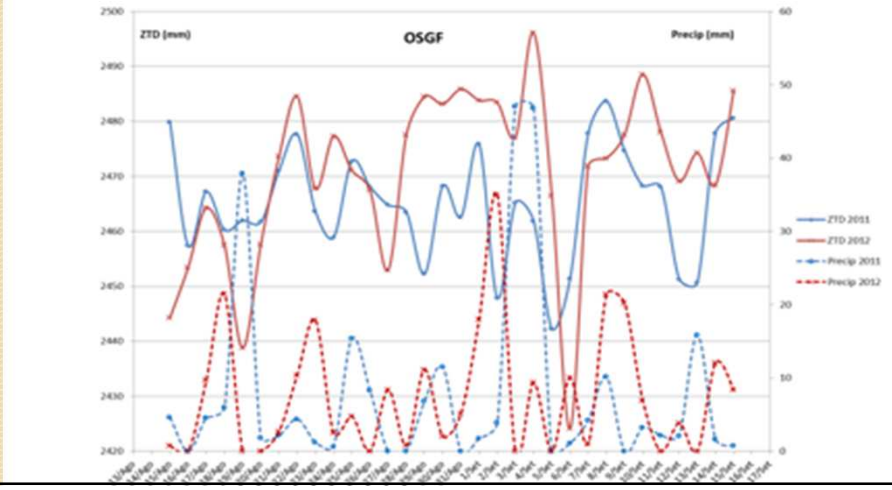
RESULTS CONT.

- ZTD and Precipitation for CLBR (Calabar) for August-September 2012



RESULTS CONT.

- **Comparison between 2011 and 2012 for the ZTD and Precipitation at OSGF (Abuja) for August-September 2012**



CONCLUSIONS

- **Although we were unable to do a very detailed study since we lack a dense spatial coverage and also we missed important meteorological data in order to compute the PWV directly, this study shows that the NIGNET network can be used to detect variations of precipitation through the different periods of the year and the data from NIGNET network can be integrated in forecasting numerical models as it is already being done in other parts of the world. With more data, we will also be able to compare more significantly the differences between different years.**


THANK YOU