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Correlating Effects of Scintillation in Atmospheric Regions: Ionosphere
And Troposphere

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REPORT

FINAL REPORT

CESARIA

Correlating Effects of Scintillation in Atmospheric Regions: Ionosphere
And Troposphere

CESARIA – FINAL Report

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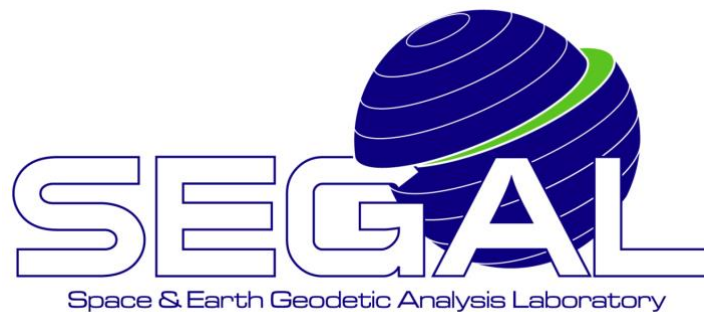
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1 Abstract

This report describes the activities carried out in the framework of the CESARIA (Correlating Effects of Scintillation in Atmospheric Regions: Ionosphere And Troposphere) project, which was a collaborative project between AFRL (Air Force Research Laboratory) and UBI (University of Beira Interior) supported by EOARD (European Office of Aerospace Research & Development). The period was between September 2014 and September 2016.

During the first year, we have focused on the detailed study of correlations between ionospheric scintillation events and sudden variations of the Water Vapor (i.e., perturbations of the lower atmosphere); We have been using GNSS data from SCINDA receivers to assess the influence of Space Weather on GNSS signal. For that purpose, we had to develop scripts to extract the relevant parameters and GNSS software was used for the data analysis. Positioning and tropospheric activity has been investigated in order to correlate with geomagnetic data and solar events.

We also upgraded and maintained some of the SCINDA network, particularly in Africa. In addition, we have installed a station in Portugal for study at mid-latitudes.

We implemented the regular computation of TEC maps using the GNSS data stored in our database, having data from several GNSS stations.

In September 2015, we hosted a GIPSY-OASIS workshop, at the department of Informatics at the University of Beira Interior, with JPL lecturers and participants from several countries, including researchers from our working group.

1.1 Work Package 1 - Correlations between Scintillation events and PWV

Scintillation events can cause sudden changes in coordinate positions (or even prevent their calculation). Algorithms were developed in order to quantify effects in the estimation of PWV before, during, and after the occurrence of scintillation events.

Figure 1 shows an example of such detection attempts.

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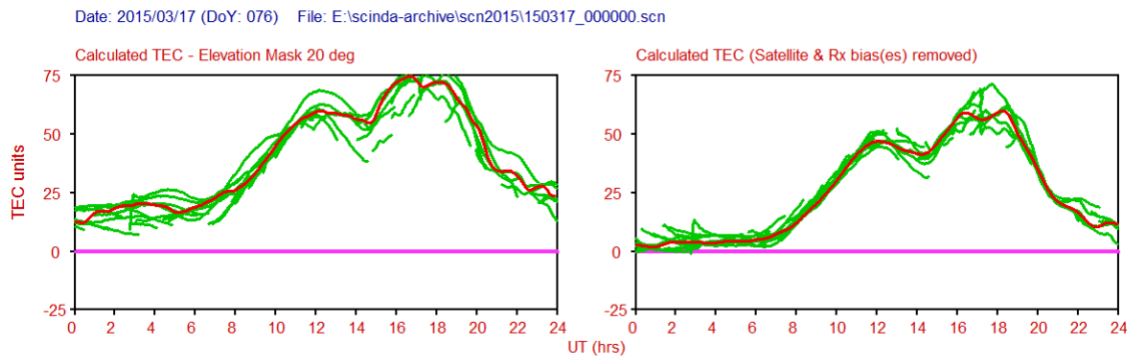


Figure 1 - TEC plots before and after receiver and satellite biases are removed

1.2 Work Package 2 - System Design and Network Development

The major initial investment concerning the research done by the fellowship researchers contracted by SOGRA was focused on the development of an integrated system capable to be installed at remote locations. Figure 1 shows details of the prototype developed that have been installed in the following years at some locations in Africa.



Figure 2 - Prototype developed for the integrated system. (left) cabinet hosting the equipment; (right) antenna monument and solar panels. Example of a system installed in Angola.

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During the development, several aspects of the different components were analyzed and developed, in particular:

a) Receiver - the system has been developed in order to be independent of the receiver used (currently, the system is working with different models from three different vendors).

b) Router - this equipment manages all local processing and the communications using mobile communications (UTMS or EDGE). The collaboration with AFRL (ionospheric research) intends to develop systems that can be used by different applications: ionospheric research implies data acquisition at high frequencies (>20Hz) that it is impossible to transfer using available communications at many worldwide locations. Therefore, local processing is required. Consequently, in the last years, new devices were tested, in particular it was decided to develop the system using a different router with two usb ports (cf **Error! Reference source not found.**). The idea is to have simultaneously mobile communications (using a usb modem) and local storage (up to several GBytes).

SEGAL developed tools that permit to establish 2-ways communications with the remote systems using mobile communications. In particular, SEGAL implemented using SSH tunnels in order to access the remote systems. In countries like Nigeria, mobile communications are using NAT protocols, which prohibits any external access since no unique IP is attributed to the system. Therefore, it is the router that needs to initiate any communication by establishing a permanent VPN tunnel.

c) In the last years, an alternative system to store data and handle the communications using Raspberry Pi mini-computers (cf. Figure 3) was tested. Although such computers have limited computational capacities, they are a very cheap and replaceable alternative to control the entire system.

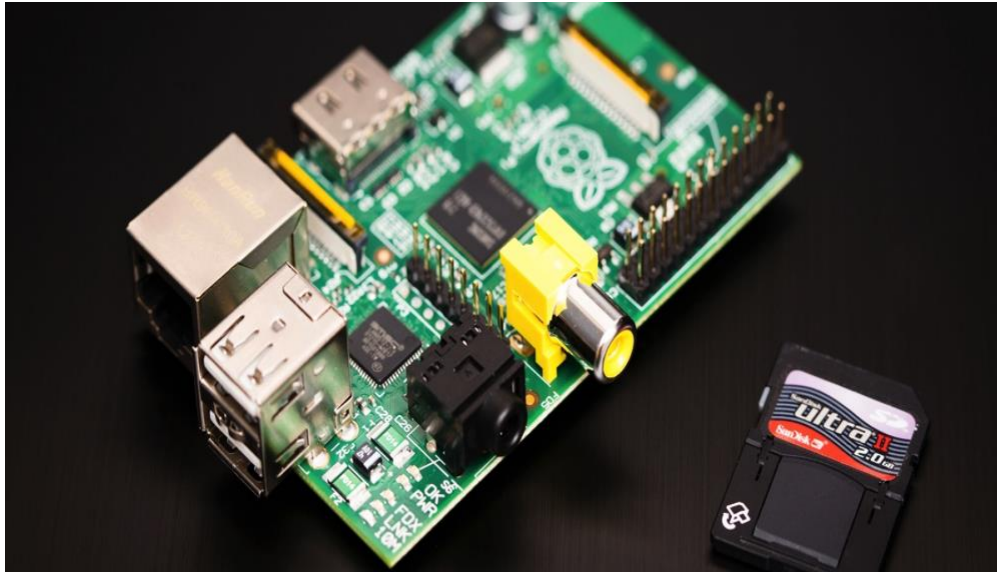


Figure 3 - Raspberry Pi micro-computer without cover.

d) Power management - there is redundant power supply. The receiver and router work both on solar panel and on electrical grid (when available). The radios (used to stream RTK corrections, if necessary for the local partners) only work on the electrical grid.

SEGAL also developed a web page in order to allow to permanently monitoring the status of the data transfer for the SCINDA stations. Figure 4 shows the main page (ordered by date of arrival time of latest received observational file) of the MGN-SCINDA site (located at <http://segal.ubi.pt/GNSS/SCINDA>). SEGAL still maintains this web page, which features have been developed during the execution of the project (e.g., to automatically send warnings to the SCINDA group and local partners when the regular transfer of the data does not succeed).

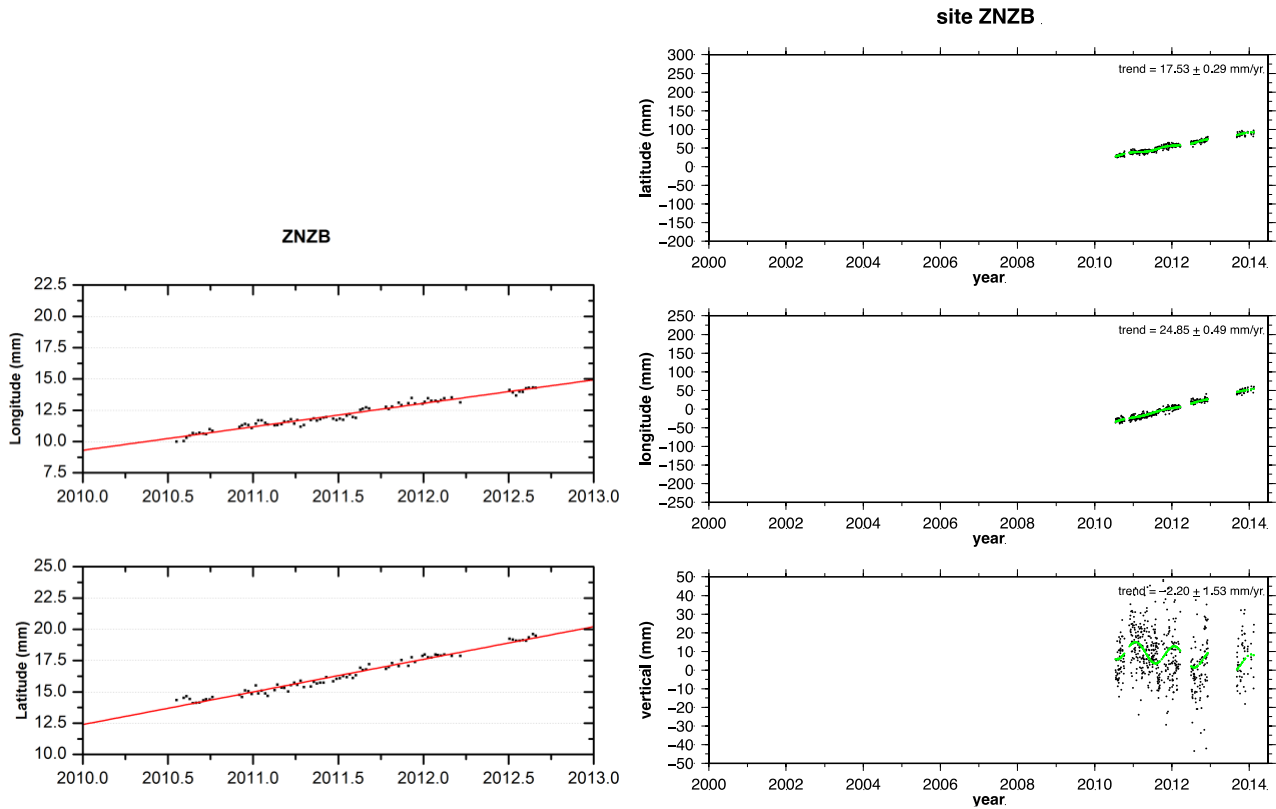


Figure 5 - Time-series for ZNZZ (Zanzibar) site. Left: computed until end of 2012); Right: computed until February 2014.

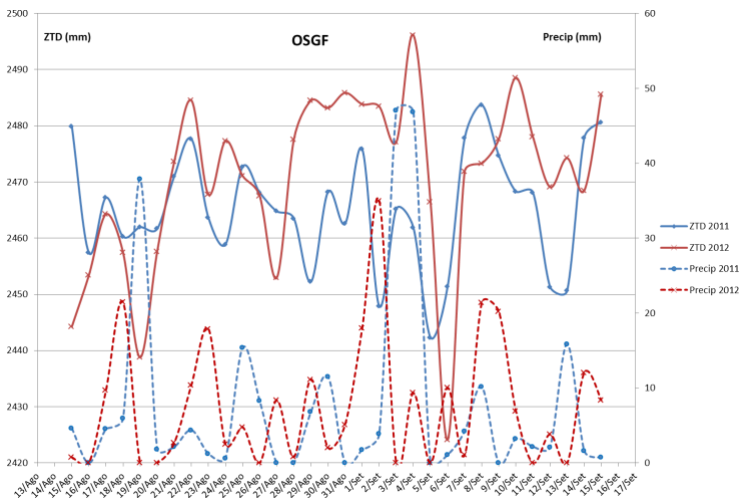


Figure 6 - Correlation between ZTD and Precipitation in Nigeria (Abuja).

If a correlation between ZTD and Precipitation was found, this was not possible between ZTD and TEC.