INVESTIGATION OF IONOSPHERIC SCINTILLATION OVER SOUTH AFRICA AND THE SOUTH ATLANTIC ANOMALY USING GPS SIGNALS: FIRST RESULTS

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1. INTRODUCTION

Ionospheric scintillation is measured in terms of rapid variations in the amplitude and phase of radio signals traversing the Earth's ionosphere. Such variations negatively affect transionospheric radio communications as well as the accuracy of navigation by means of the Global Positioning System (GPS). During severe scintillations, some GPS receivers may experience loss of lock on the signals from some transmitting satellites, thus leading to a decrease in the accuracy of the derived position.

Ionospheric scintillations are common near the geomagnetic equator where it is associated with the ionospheric equatorial anomaly and its associated sharp gradients in the electron density at about 10-20 degrees north and south of the geomagnetic equator. Models for predicting ionospheric scintillation have been based mostly on observations in the Northern Hemisphere. The extent of ionospheric scintillations over the mid-latitudes of the Southern Hemisphere is not well known. The Hermanus Magnetic Observatory, being the designated Regional Warning Centre for Africa of the International Space Environment Centre, embarked on a campaign since December 2006 to quantify ionospheric scintillations over South Africa and the South Atlantic by means of signals from GPS satellites.

2. SOUTH ATLANTIC ANOMALY

Of particular interest is the region of the South Atlantic Anomaly, i.e. the region in the South Atlantic Ocean where the Earth's magnetic field is weakest and its shielding effect from high energy particles emanating from the Sun is reduced. See Figure 1. The reduced magnetic field results in a higher level of high energy particle precipitation in this region than anywhere else on the Earth during solar storms. It is not know yet whether such precipitation leads to an increase in ionospheric scintillation.

3. OBSERVATION EQUIPMENT AND LOCATIONS

Ionospheric scintillations are observed at L-band frequencies (1.22 GHz and 1.57 GHz) by means of dedicated GPS receivers (Novatel/ GPS Silicon Valley GSV4004B), which are capable of sampling the amplitude and phase of GPS signals at a 50 Hz sampling rate. Such receivers have been installed by the HMO at the following locations as part a project on Polar Space Weather studies during the International Polar Year: In Antarctica (71.67ºS, 2.84ºW, operating since December 2006), On Marion Island (46.86ºS, 37.85ºE, operating since August 2007) and on Gough Island (40.35ºS, 9.88ºW, operating since September 2008). The observations from these locations are sent to the HMO daily via satellite link.

4. RATE OF CHANGE OF TOTAL ELECTRON CONTENT

Ionospheric Scintillations can also be inferred from the rate of change of the total electron content (ROTI) as derived from GPS signals measured with dual frequency receivers used for surveying. The current network of receivers are shown in Figure 3. The HMO is using GPS signals from the network of GPS receivers in Southern Africa to characterise the extent of ionospheric scintillations over South Africa, with a particular interest in the potential impact of such scintillations on the operation of the Square Kilometre Array for Radio Astronomy, for which South Africa is one of two contending regions.

5. FIRST RESULTS

This paper presents first results of the above campaign, comparing scintillations during geomagnetically quiet times from these observatories with periods of increased geomagnetic activity following solar storms such as illustrated in Figure 2.

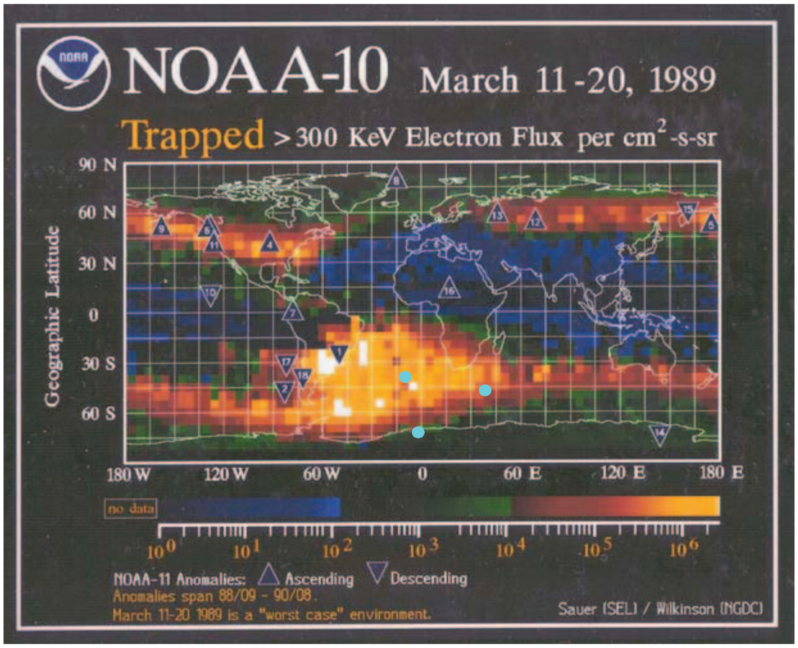

Figure 1. Flux of energetic electrons observed by a polar orbiting satellite 800 km above the Earth's surface during a large magnetic storm. Note the increased flux over the South Atlantic Anomaly. The blue circles incidate the locations of the Ionospheric Scintillation Monitors installed and operated by the HMO. Image Credit: NOAA.

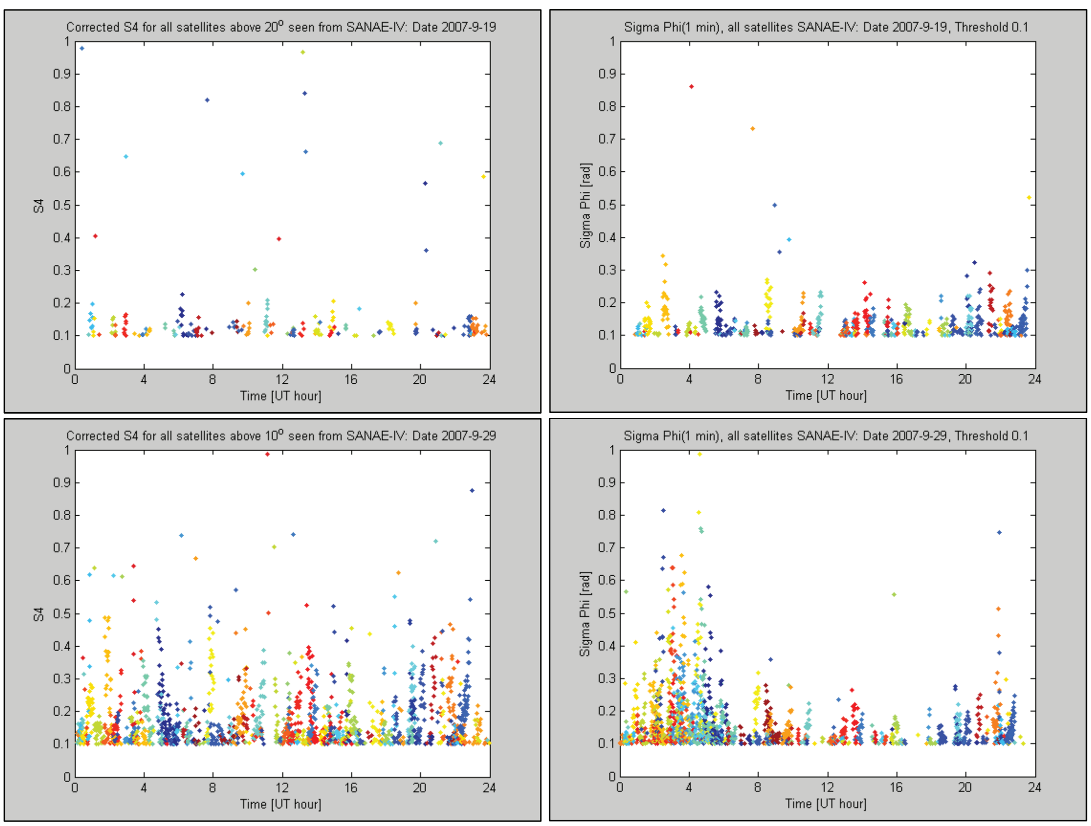

Figure 2. Ionosperic Scintillations observed at SANAE-IV in Antarctica on geomagnetically quiet and active days as obtained from the GSV4004B ionospheric scintillation monitor installed at SANAE-IV in December 2006. Top two panels pertain to quiet day with low geomagnetic activity ((2007-09-19, Kp<1) and bottom two panels show the same during a geomagnetically active day during the same time of the year (2007-9-29, Kp(max)=5). Left panels show amplitude scintillation (S4) and right panels phase scintillation (Sigma Phi). Note the increase in the scintillation during the geomagnetically active day.