Characterization of GNSS amplitude scintillations over African and American Longitudes at varying elevation angles during the maximum phase of solar cycle 24

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Outlines

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Introduction

Based on its safety and economic benefits, GNSS is fast replacing terrestrial Nav infrastructures.

Having approved GNSS as a tool to achieve full optimization of the global airspace, ICAO has mandated all of its regions, under the auspices of regional Ionospheric Studies Task Force (ISTF) to establish a framework for understanding the phenomenology of ionospheric scintillations in each region, with a view to proffering mitigation strategies to scintillation impacts on GNSS systems.
Conventionally, ionospheric scintillation data processing for scientific investigations usually adopts high elevation masking ($30^\circ$), with a view to suppressing multipath effects. However, for application purposes, signals from all satellites within the field of view of the receiver are used for position determination.

The accuracy of the position estimate is dependent on the receiver’s capability to discriminate against deeply scintillated signals, and discard them during position fixing.
Data Resources

GPS Receivers 2012/2013 amp. Scint data

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The data were grouped on daily and monthly scales at varying elevation angles (10°, 20°, and 30°).

We characterized the entire data sets at intense Scintillation level (S4 > 0.7) over each month along six sets of 2-hourly bins to observe the local time distributions of scintillations.
we manually inspected the daily data for 30 extremely-quiet days (EQDs) in 2013. EQD is defined as a day with a daily \( \Sigma K_p \) within the range: \( 3^- \leq \Sigma K_p \leq 3^+ \) and daily 8-hourly \( K_p \) values of 0 or \( 1^\pm \) (Table 1).

For each satellite, attention was paid to the repeatability of S4 values with a 4-minute shift every day.

We determined multipath-induced impacts on the measured scintillation data by averaging the daily repeated S4 values with four minutes shifts over the selected 30 quiet days. In order to isolate ionospheric-induced scintillations...
Having characterized the data along 10° elevation masking, we determined the percentage of intense scintillation data (originally at 10° elevation) that were missed when 20° and 30° elevations data cut-off criteria were adopted. We defined the percentage scintillations missed (% Scint_{missed(i)}) as:

\[
% \text{Sc int}_{missed(i)} = \frac{\text{Sc int samples} (10^\circ) - \text{Sc int samples} (i^\circ)}{\text{Sc int samples} (10^\circ)} \times 100
\]

where \( i = 20^\circ, 30^\circ \).
DAKAR AND NATAL MAR EQUI

30°

20°

10°

DKR

NAT

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DAKAR AND NATAL JUN SOLS

30° (a)  20° (b)  10° (c)

DKR

NAT

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DAKAR AND NATAL SEP EQUI

30°

20°

10°

DKR

NAT

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DAKAR AND NATAL DEC SOLS

30°

20°

10°

DKR

NAT

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Local time Distributions of Intense Scintillations at Dakar

Table 2: Percentage of intense scintillation data at 10° elevation that were missed at 20° and 30° elevations data cut-off criteria

<table>
<thead>
<tr>
<th>Year</th>
<th>Data coverage</th>
<th>Non-scintillation months</th>
<th>% intense scintillations at 10° elevation suppressed at 20° elevation masking</th>
<th>% scintillations intense at 10° elevation suppressed at 30° elevation masking</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Sep.–Nov.</td>
<td>-</td>
<td>Sep. (61.5%), Oct. (60.2%), and Nov. (66.4%)</td>
<td>Sep. (92.3%), Oct. (91.1%), and Nov. (93.2%)</td>
</tr>
<tr>
<td>2013</td>
<td>Feb.–Dec.</td>
<td>Jun.–Jul.</td>
<td>Generally over 60% for active months, except Mar. (57.4%) and Oct. (48.2%)</td>
<td>Generally over 90% for active months, except Mar. (82.1%) and Apr. (76.2%)</td>
</tr>
<tr>
<td>2014</td>
<td>Jan.–Feb.</td>
<td>-</td>
<td>Jan. (76.1%), Feb. (59.1%)</td>
<td>Jan. (98.6%), Feb. (88.6%)</td>
</tr>
</tbody>
</table>
Ionospheric scintillations over Addis Ababa (2013)

Polar plots of high elevation (≥ 30°) scintillations (S4 ≥ 0.5) over Addis Ababa (2013)
Ionospheric scintillations over Addis Ababa (2012)

Polar plots of high elevation (≥ 30°) scintillations (S4 ≥ 0.5) over Addis Ababa during 2012

IPP traces of satellites that experienced scintillations and C/NOFS tracks over Addis Ababa.
GPS satellites scintillations high elevation (≥ 30°) (S4 ≥ 0.5) on the 10th April, 2012
EGNOS scintillations on the 10th April, 2012
GPS satellites scintillations high elevation (≥ 30°) (S4 ≥ 0.5) on the 10th April, 2012
EGNOS scintillations on the 11th April, 2012
Ion density and vertical ion drift velocity measured on-board CNOFS

April 10, 2012

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April 11, 2012
Longitudinal variability of equatorial plasma bubbles

Burke et al. (2004), JGR
Conclusions

1. Scintillation events recorded the highest daily distribution of occurrences around 22–02 LT.

2. Scintillation occurrences were high during March and September equinox, and low or non-existent during June solstice. Unlike Akala et al. [2014; 2015], which reported January as off season for equatorial scintillation occurrences in Africa, significant events were recorded in January at Dakar. We observed that the climatology of GNSS scintillations over Dakar is close to that of South America.
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Thank You
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