Inter-hemispheric comparison of the ionosphere-plasmasphere system.

N. Bergeot, J. B. Habarulema, J.-M. Chevalier, E. Pinat and P. J. Cilliers
“What are the differences in the inter-hemispheric conjugacy between the ionosphere and that in the lower, middle and upper atmospheres, and what causes those differences?”

From: Kennicutt, et al., 2015 - A roadmap for Antarctic and Southern Ocean science for the next two decades and beyond, International Steering Committee of the Scientific Committee on Antarctic Research (ISC-SCAR), Antarctica Science.
BEZA-COM: Interhemispheric Comparison of the Ionosphere-Plasmasphere System. 2019-2021

One of the goal of BEZA-COM is to provide inter-hemispheric comparison of the I/Ps implying:

*A characterisation of the climatological behaviour of the Total Electron Content (TEC) in the I/Ps, over European, South African regions.*
GNSS data processing


- **Outputs:** TEC maps in IONEX format in TECu (1 TECu = $10^{16} \text{e}^{-}\text{m}^{-2}$)
  - Sampling rate : 15 min.
  - Grid resolution : 0.5° x 0.5°
TEC time-series at conjugate locations.

<table>
<thead>
<tr>
<th>Region</th>
<th>Data processing</th>
<th>#Stations</th>
<th>Extracted coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU (EPN)</td>
<td>TEC at IPP</td>
<td>1998-2017</td>
<td>57-320</td>
</tr>
<tr>
<td></td>
<td>TEC maps</td>
<td>1998-2017</td>
<td>E20 / N35 EURG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E95 / N35 EURB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E20 / S35 SAFG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E95 / S35 SAFB</td>
</tr>
</tbody>
</table>

14 years of TEC maps for South Africa
19 years of TEC maps for Europe
Conjugate locations: E95° N-S 35° (Geomag. Coord.)
Empirical TEC-model

Empirical model based on F10.7P index (~ EUV emission from the Sun)

The data set is then employed to constrain an empirical model to predict the vTEC at a given time and location from F10.7P solar index in entrance using a least-square adjustment. To minimize the differences between the modelled and observed TEC we considered:

- An eight-order polynomial function between the TEC and F10.7P
  \[ TEC = F10.7P \sum_{i=0}^{8} (\alpha_i t^i + \beta) \]
- A discretization with respect to the month of the year.

\[ F10.7P = \frac{F_{10.7} + F_{10.7A}}{2} \]
Daily-TEC climatological patterns - Europe

TEC presents mean differences with observed values of 0.5 ± 1.2 TECu for European region (~57000 data/month).

The maximum TEC occurs mainly around 13:00 for any of the time definitions (UTC, SLT and MLT) and are quite constant over the year.

\[ F10.7P=120 \text{ sfu} \]

Max. TEC = 42 TECu in March
Min. TEC = 7 TECu (F10.7P=120 sfu) in December
The maximum TEC occurs mainly around noon for any of the time definitions (UTC, SLT and MLT) and are quite constant over the year.

\[ F_{10.7P} = 120 \text{ sfu} \]

Max. TEC = 36 TECu in March
Min. TEC = 2 TECu in November
The maximum of the TEC is higher during the daylight (10 to 55% for hours between 10:00 and 15:00) in the Northern hemisphere compare to the Southern for February to September.

The maximum of the TEC is higher (5 to 20% for hours between 10:00 and 15:00) in the Southern hemisphere from November to January.

The minimum TEC (i.e. during low solar zenith angle between 22:00 and 6:00) is also higher in the Northern hemisphere for the period February-September (16 to 80%).

The minimum TEC is higher in the Southern hemisphere (16 to 45%) during from November to January.

The time of occurrence of the minimum TEC is generally constant over the year for the European region.

Intense I/P activity
Ex. St Patrick Storm 2015

March 17, 2015 - Onset 03:30 UTC
Dst = -223 nT – Geom. Storm (Kp=7)
Intense I/P activity
Ex. St Patrick Storm 2015

Europe
South Africa

Hour (UTC)
Next Steps

- An identification of the mechanisms that regulate inter-hemispheric differences, asymmetries and commonalities in the I/Ps from low to high-latitudes.
Next Steps

- A study of the different responses of the I/Ps during extreme solar events and induced geomagnetic storms in the two hemispheres.
Next Steps

- A separation of the ionospheric and plasmaspheric contribution to the TEC.

**POSTER N°40 : Ionosphere-Plasmasphere empirical model over Antarctica region.**

\[
P_{\text{TEC}} = T_{\text{EC}} - I_{\text{TEC}}
\]

[Diagram showing the separation of ionospheric and plasmaspheric contribution to TEC with labeled distances and regions.]

[Graph showing electron density and temperature data with a URL: http://cdaac-www.cosmic.ucar.edu/]

http://cdaac-www.cosmic.ucar.edu/
Comparison with IRI 2018

Comparison with IRI-2018 for moderate solar activity level

$F_{10.7} = 120$ sfu

Max Differences:

> 30 TECu in December over Europe.

> 45 TECu in September over South Africa.
RESOURCE
Radio Sciences Research on AntarctiC Atmosphere


Resource is a new scientific research programme: RESOURCE (Radio Sciences Research on AntarctiC Atmosphere).

RESOURCE wish to represent:
• the need of the scientists that investigate the atmosphere by means of radio observation,
• the requirement of the scientists that want to remove or to mitigate the atmospheric noise from their radio measurements.

Join us!
lucilla.alfonsi@ingv.it
nicolas.bergeot@oma.be