Global distribution of ionospheric scintillations from the Real-Time GPS ROTI

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Abstract

A global real-time monitoring system has been implemented in the frame of ESA-ESTEC/EGNOS-PO-funded project MONITOR. It is based on world-wide GNSS datastreams distributed by means of NTRIP and provides multiple ionospheric indices and products to the scientific community and industry. In particular, the Rate Of Total Electron Content Index (ROTI) proxy, which is correlated with scintillation activity and has been running for several years for real-time detection and monitoring. It shall also be pointed out that the multiple products, also aiming at the identification of Travelling Ionospheric Disturbances (TIDs), Solar Flares overionization, among other ionospheric perturbations, are useful to properly characterize scenarios where these could occur simultaneously to scintillations. In addition, there is also a new proxy suitable for radio-occultation GNSS measurements, named OSPI.

In this context, a climatological ionospheric scintillation study has been conducted in different latitudinal regions from the UPC-IonSAT database of global ROTI. For this purpose, we have obtained results from several receivers in 30-degree latitudinal strips and distinguishing between North- and South-Hemisphere locations.

Real-Time GPS ROTI

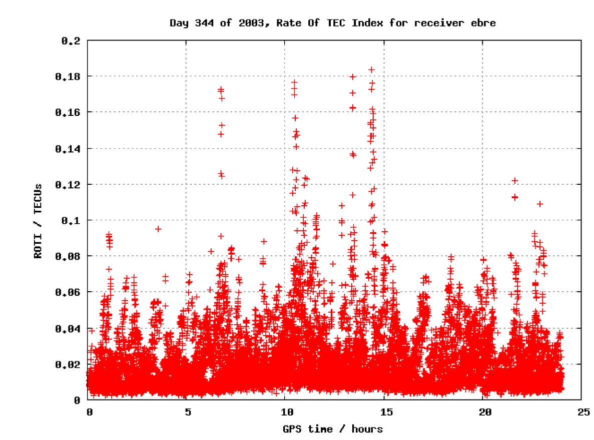
The standard deviation of the TEC-rate (Rate-Of-TEC-Index, ROTI) is commonly calculated over a 5 minutes interval. For this task 30s-GNSS-receiver data is sufficient. Different authors have compared it with direct amplitude measurements, suggesting that ROTI measurements can be a low-cost alternative to high-rate measurements allowing monitoring large areas.

However it must be taken into account that it can be contaminated by variability components with periods of several seconds, likely due in some scenarios to phase multipath or interference.

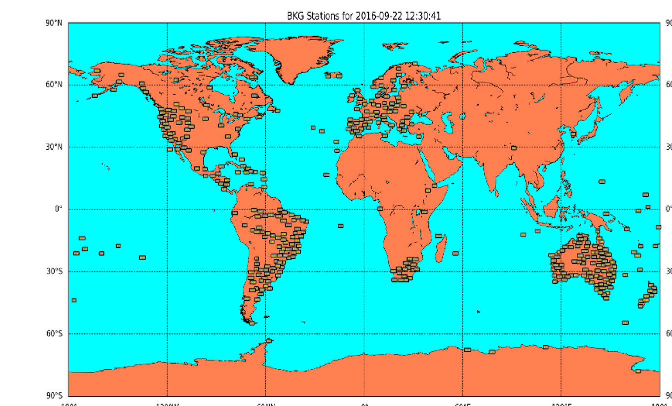
We have adopted the definition of Rate of TEC Index (ROTI) proposed by Pi et al. 1997, i.e.:

The Standard Deviation during 5 minutes of the VTEC change obtained at 30-seconds rate, for each given pair satellite-receiver, directly obtained from LI=L1-L2 meas. in phase-continuous arcs of data.

Global ROTI maps and animations are generated at 30 seconds sampling rate from over 200 datastreams world-wide with a latency below 180s in the frame of MONITOR project.



Example of ROTI evolution for IGS receiver EBRE during the day 344 of 2003

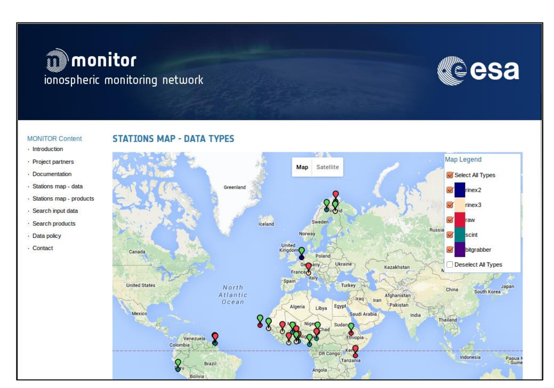


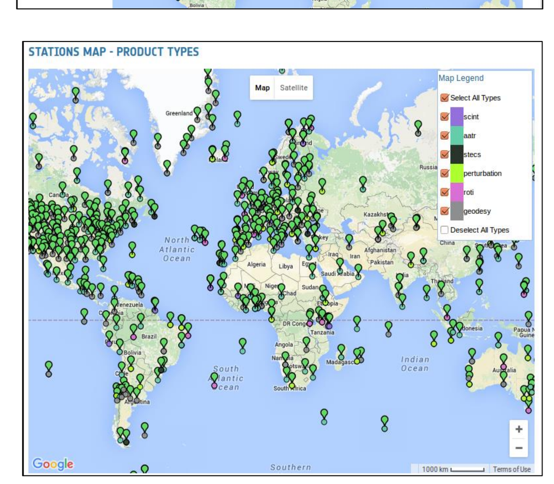
RT-GNSS global network up to +200 datastreams used by UPC-IonSAT (RT-IGS & other nets.)

MONITOR Overview

Monitor is a project from the **European Space Agency**'s GNSS Evolutions Programme started in 2010, aiming at collecting, processing and archiving **ionospheric data and products**, developing **improved scintillation monitoring instrumentation** and establishing a **scintillation monitoring network**. This infrastructure is built in order to allow analysing the ionospheric impact on European GNSS (**EGNOS and Galileo**) **system performance**.

The second phase of Monitor started in 2014, aiming at enabling **a simple/robust data/products collection, processing and access through** monitor.estec.esa.int, implementing a flexible data access policy. Furthermore, it has enlarged the scintillation monitoring network with new stations on ASECNA (Air Traffic and Navigation Services in Africa and Madagascar) sites and integrating data from the CNES (French Space Agency) SAGAIE network [2]; it has improved monitoring instrumentation; added the capability to generate automatic comprehensive reporting; and focused to support EGNOS system and its future evolutions.

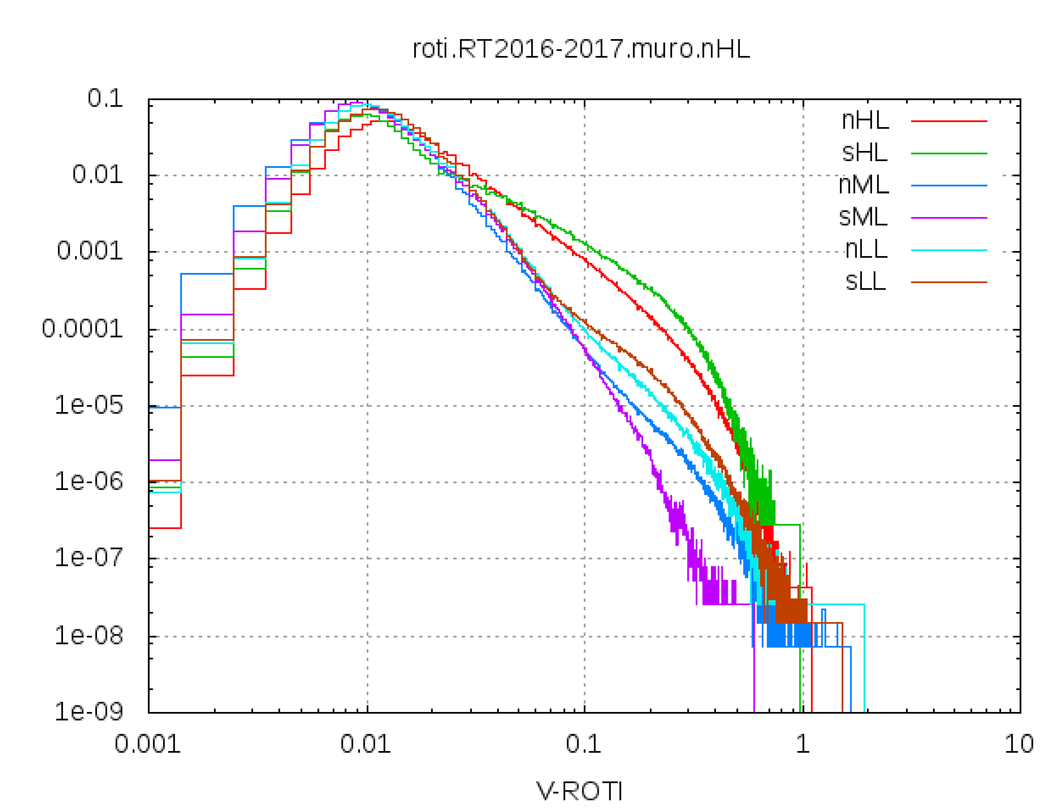




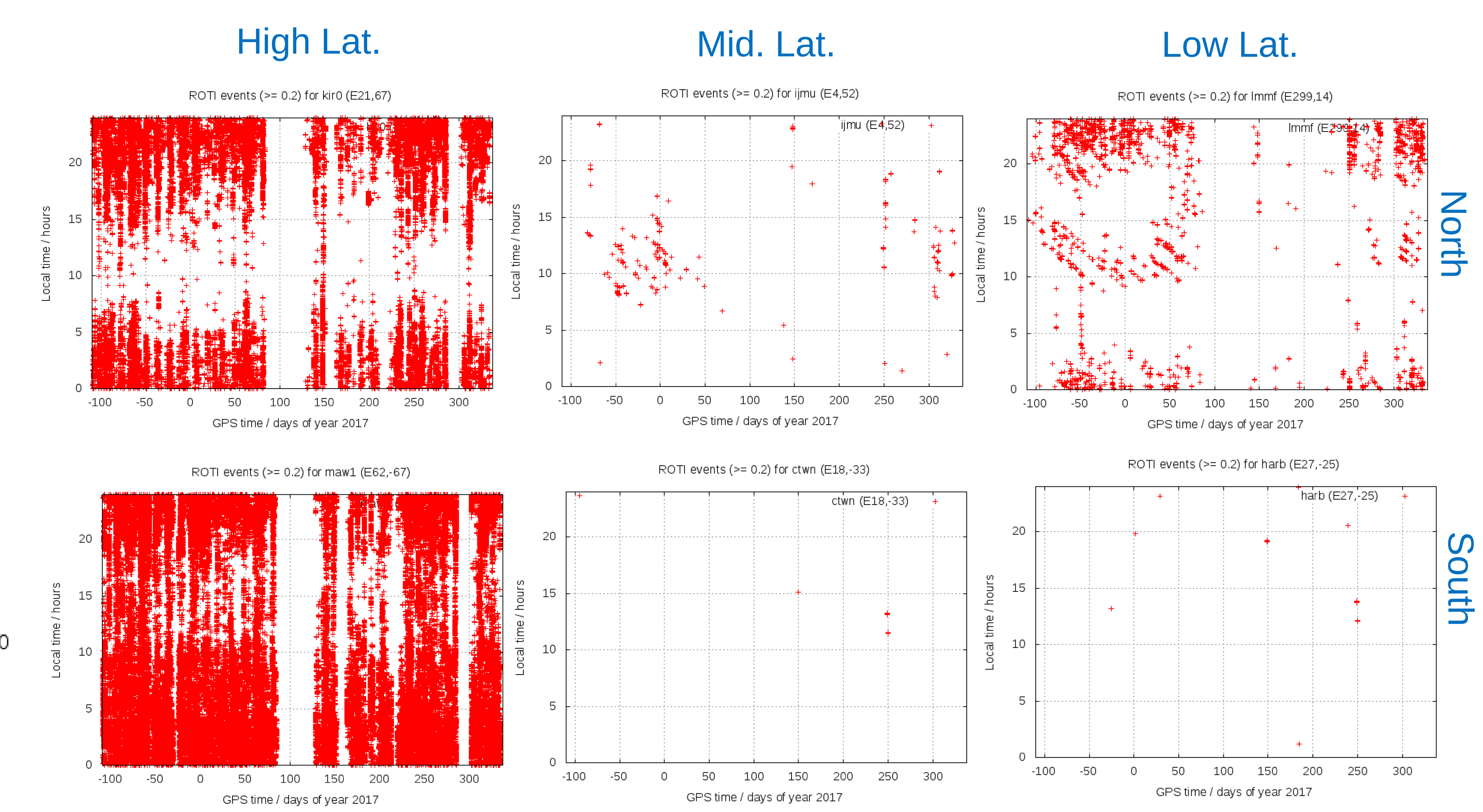
Climatologic ionospheric scintillation study

A climatological ionospheric scintillation study has been conducted in different latitudinal regions from the UPC-IonSAT database of global ROTI (available through monitor.estec.esa.int). For this purpose, we have derived results distinguishing the receivers in 30-degree latitudinal strips and distinguishing between North- and South-Hemisphere locations. For the analyzed period we have considered data from day 200, 2016 to 365, 2017.

As expected, an increased activity can be clearly seen specially after the solar terminator at high latitudes –in both southern and northern hemispheres- as well as at low latitudes in the northern-hemisphere (results for the whole period can be seen in the log-log histogram on the left-hand plot and for certain representative receivers on the right-hand plots).



Log-log histograms of ROTI occurrence for xYL (x = n,s for north,south, Y=H,M,L for high, mid., low latitudes)



RT-ROTI events in LT vs time for the six 30º-latitudinal strips

Conclusions

- ➢ The availability of hundreds of worldwide GNSS stations & corresponding datastreams allow in particular to compute ROTI in real-time.
- ➢ Other UPC-IonSAT ionospheric products are running in RT as well, such as Solar Flare indicator and intensity indices (GSFLAI-SOLERA, SISTED), RT-GIMs & precise Wide Area RTK corrections, which can also be of interest.
- ➢ A climatologic ionospheric scintillation study has been conducted showing the activity distinguishing between six 30-degree latitudinal strips, between North and South hemisphere for the period between day 200, 2016 and 365, 2017.
- ➢ It is shown that the existing continuous monitoring of Real-Time ROTI, among other products, enables revisiting and analyzing the ionospheric high-frequency perturbations.

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Acknowledgements

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