A near real-time prototype service to monitor the effects of scintillations on GPS/GLONASS signals on a global scale

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ESA Pilot Project for Space Weather Applications

ABSTRACT

Our aim is to analyze the effects of ionospheric scintillation by using the permanent worldwide GPS/GLONASS observations distributed by the International GPS Service (IGS). Three potential indicators are examined: the occurrence of losses of lock on the L2 frequency, the signal-to-noise ratio (when available) and the phase fluctuations. The prototype service provides global maps of scintillation intensity within two hours using a network of about 50 receivers at a 1 s repetition rate. It also provides daily updated global scintillation maps based on about 300 receivers with a 30 s repetition rate.

PROTOTYPE SERVICE

http://scintillations.cls.fr/

EMPIRICAL SCINTILLATION INDICES

The amplitude and phase scintillations of GPS signals caused by the ionosphere have been widely observed and discussed [1], [2], [3], [4]. They are a matter of concern to SBAS's such as WAAS, EGNOS and Galileo. Our objective is user oriented and was motivated by the following considerations: - First, geodetic receiver data are usually corrupted during severe scintillation conditions - Second, data from a permanent worldwide GPS network (IGS) are available on a near real time basis. Although the IGS receivers sampling rates (1 sample per sec or even 30 sec) are not sufficient to assess the whole scintillation spectrum, interesting results have been obtained.

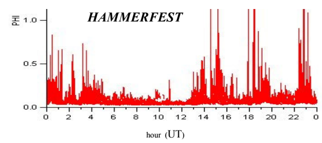
Basically, an empirical scintillation index is deduced from the rate of change of the geometry free linear combination of dual-frequency GPS phase observations. Cycle slips and multipaths are preprocessed. The standard deviation of the resulting time series is calculated over 1 min (respectively 5 min) intervals for data sampled every second (respectively every 30 seconds). This parameter is usually denoted **ROTI**. The normalisation of this index on a classical [0-1] interval results from a comparison with Ionospheric Scintillation Monitors (ISM) data in Africa (data from ESA). External comparisons have been done in Scandinavia (courtesy of IESSG [5]) and South America (courtesy of Boston College [6]).

Various causes for scintillation exist, e.g. ionospheric irregularities, Travelling Ionospheric Disturbances (TID's) [7] or other phenomena such as multipaths. Since each of these effects has its own signature on the GPS signals, it is thus of interest to identify the main categories of scintillations. It is expected that the time intervals chosen for the ROTI calculation should help to separate the TIDs (expected periods greater than 5 min) from the irregularity induced scintillations (high frequency random phenomena).

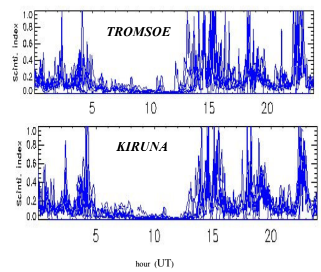
COMPARISON WITH ISM

Example of comparison with Ionospheric Scintillation Monitor (ISM) in Scandinavia during the 29th May 2003 magnetic event

σ_ϕ from ISM *(Courtesy of M. Aquino* [5])



Empirical Scintillation index from the service prototype (same day)



PARTNERSHIP

This service is a contribution to the ESA Space Weather Pilot Project aiming at developing the community of space weather users in Europe. It is part of SWENET. The following partners are also associated to this project. They are technical experts, scientists or users of GPS [8].

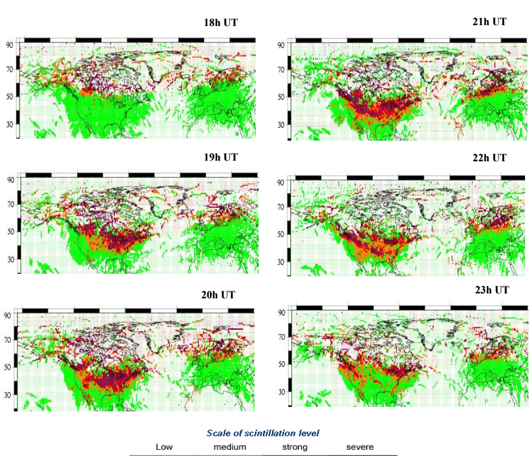
ROB

FUTURE DEVELOPMENTS

- Equatorial / auroral ISM networks
- Detrended σ_ϕ on L1
- Short term forecast model
- Note: For Space Weather applications (navigation, offshore survey, …) a knowledge of the entire system sensitivity is required, not only that of the receiver

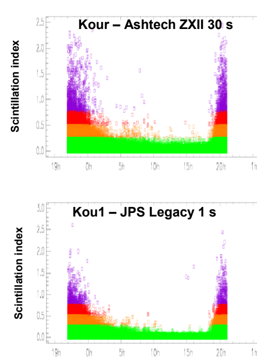
30 October 2003 SOLAR EVENT

~ 1000 GPS sites (30 s samples)

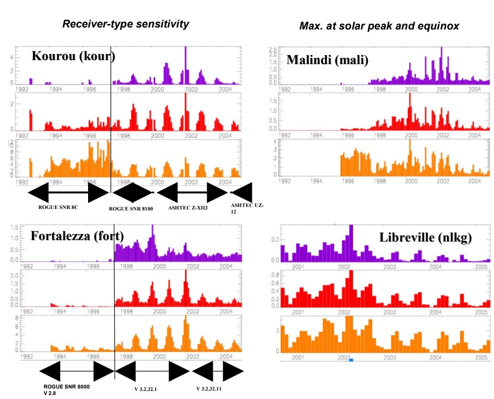


TIME SERIES & EQUATORIAL SIGNATURES

Nighttime scintillation
(Kourou, Nov. 2000)
(Scintillation level : green [<0.25] orange [0.25-0.5], red [0.5-0.75], violet [>0.75])



Monthly scintillation occurrences
(Scintillation level : orange [0.25-0.5], red [0.5-0.75], violet [>0.75])



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