

“Quickmaps and history of the effects of ionospheric scintillations on GPS/GLONASS signals”

SDA for ESA Space Weather Applications Pilot Project

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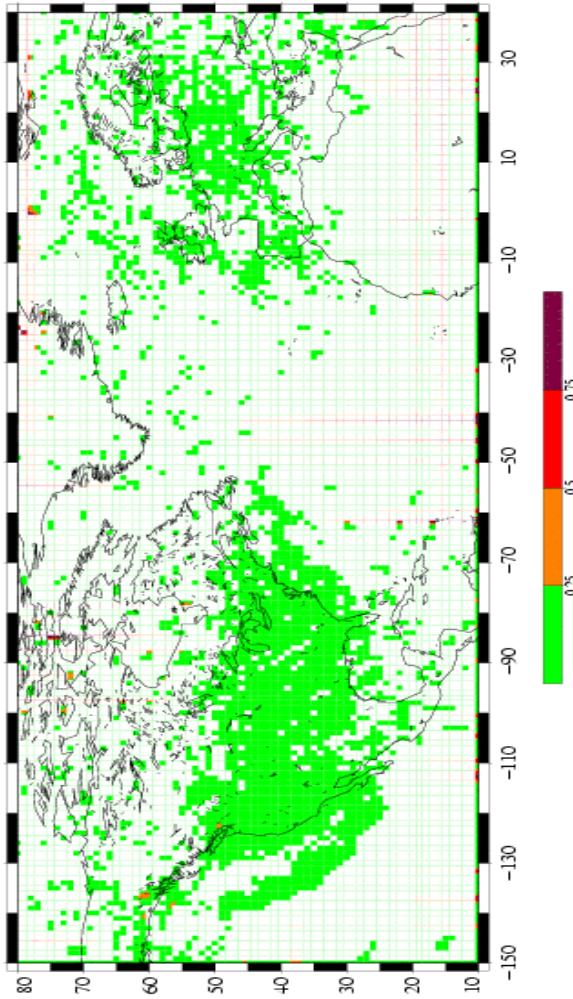
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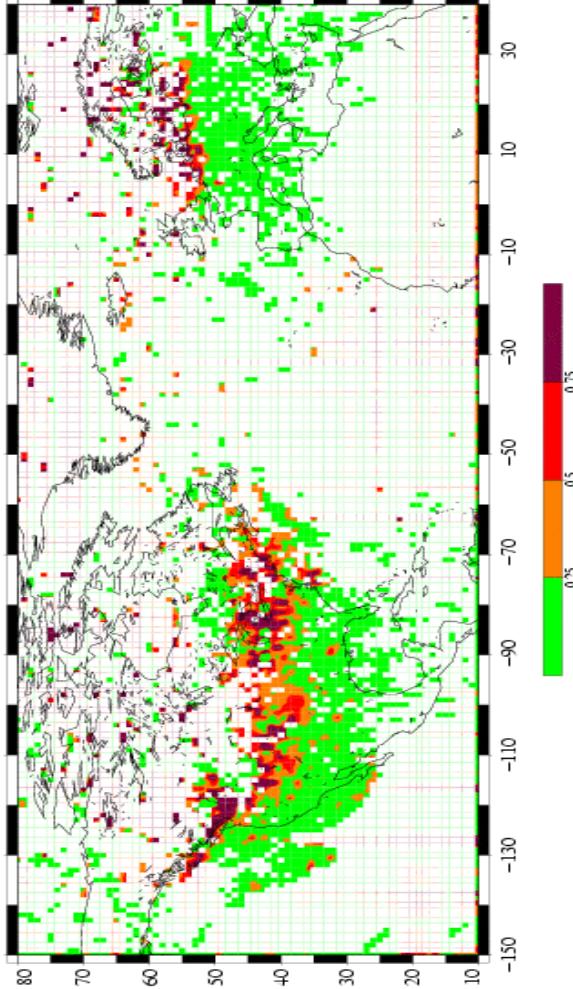
Summary of the objectives

- The main objective of this project is a worldwide and near real time observation of the ionospheric scintillations via their suspected corrupting effects on the permanent GPS/GLONASS ground station networks
 - + worldwide maps and animation & data bank

Empirical scintillation index (~1000 GPS stations) – 30 Oct.2003 – 09:00



Empirical scintillation index (~1000 GPS stations) – 30 Oct.2003 – 21:10



Summary of the user needs

GPS and Telecom's applications

User needs list (Ref. number, - GT for GPS&Telecom.)		Activity / priority				
SCINT-GT	Scintillations	Oil exploration	Airplane nav.	GPS/ATV mission analysis	GPS equip	Telecoms
(nrt/pred)	(nrt/pred)	(nrt/pred)	(nrt/pred)	(nrt/pred)	(nrt/pred)	(nrt/pred)
1	Where and When	1	1	2		1
2	Intensity	1	1			1
3	Worst case		1	2		
4	Prediction	1	1		2	

Priorities from 1 (highest) to 3 (lowest). nrt for near real time, pred for prediction

Scientific applications

Data base & history
Index definition & calibration



ROB

Evaluation of user satisfaction

- **GPS & Telecom's**
 - The SDA succeeds in monitoring the perturbations on GPS signals mainly in terms of carrier phase fluctuations and losses of lock that are clearly induced by the ionosphere. Several technical analysis have been done : local dataset comparisons, sensitivity to the receiver type, worst cases, correlations with Space Weather data... An important result is that under strong scintillation level all of the geodetic receivers on the market are affected.
An alarm test based on a minimum number of satellites tracked has been tested.
However the effort should be continued especially to provide **short delay forecast** typically under one day.

Benefits

- Civil aviation in Pacific, French West Indies, ... 10 Keuros per occurrence of GNSS radionavigation aids perturbation
- Offshore geodetic survey: not estimated but heavy equipments on the fields (ship, helicopters,...)

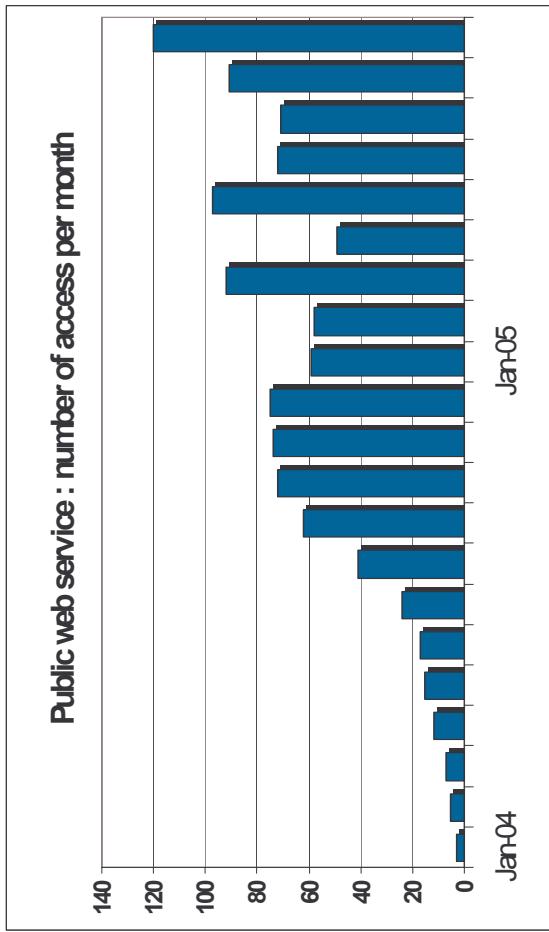
- **Scientific applications**

The SDA suffers several limitations to properly detect the “ionospheric scintillations”. Firstly, the GPS observations are at a 30 s or 1 s repetition rates while 10-50 Hz should be required to cover the spectrum. One can suspect that other ionospheric rapid variations than the scintillations may generate phase fluctuations such as TEC gradients... Finally, only the phase scintillation ($S\phi$) can be monitored systematically, not the amplitude scintillation ($S4$) as SNR is partially available from the GPS permanent network.

However, significant results have been obtained especially by comparison with ISM records at colocated sites in Africa and Scandinavia. The processing of long time series for equatorial sites have shown very consistent signatures of the ionospheric scintillations (diurnal, seasonal, solar cycle). The empirical index needs to be consolidated by permanent ISM calibrations.
IMS: Ionospheric Scintillation Monitor

sustainability of the service & business plan

<http://scintillations.cls.fr>



Non-recurring cost	keuros
Software robustness	39
Product validation + ISMs calibration	35
Forecast model integration & test	80
Matiériel	6
Recurring cost /yr	total
Operational costs /yr	18
Maintenance	10
Business operational cost	35
total	63
Service price /site /yr	10
Total market in 2010 (10 sites at mean)	100
Added value products	x
Other funding sources: CLS, studies, ITT...	x

Prospective for improvement of the service

- Actual benefit of the public service is demonstrative and stimulates new contacts for correlations/understanding of various observed disturbances (TV distribution Brazil, EGNOS) A data bank for aposteriori analysis/statistics (scientists) but recent multipath correction not updated and finally CLS cooperative “à la carte” runs
- First improvement priority is a short term scintillation forecast model (collaborations: IEEA,...) with ISM permanent calibration (ISM management at Kourou...)
- Final use system effects analysis
- Analysis method extension to new GNSS signals (L2C, Galileo...) and to other type of instruments (SARSAT, altimeter...)
- Correlations with other Space Weather thematic such as CME trigger, local magnetic records... Co-funding of an CNES/IAS doctorate on STEREO mission