400 MHz DORIS signal fades : correlations with ionospheric scintillations

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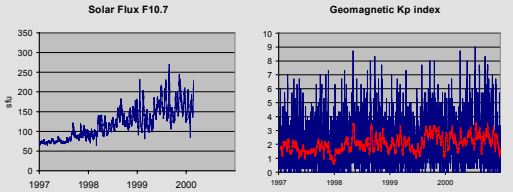
Objectives

DORIS is a dual frequency radioelectric system. A 2 GHz channel is used for the main Doppler observation while a 401 MHz channel allows a very accurate correction of the ionospheric perturbation ($1/f^2$ in distance).

The scintillations are due to small-scale variations of the electron density in the ionosphere. They can perturbate the amplitude and phase of radio-signals even causing total fades. An analysis of the losses observed on the 401 MHz DORIS signal has been done. We try to show correlations with the ionospheric scintillations. Nevertheless, remember that the DORIS system is not severely affected by signal fades of any source (a few percents of the whole data).

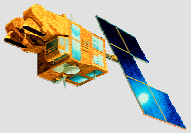
Data

SPOT2, SPOT4 and TOPEX/POSEIDON satellites
The whole DORIS stations network



2 periods : 1997 and 2000
2000 with a high solar and geomagnetical activity
1997 with a weaker solar and geomagnetical activity

SPOT2 results

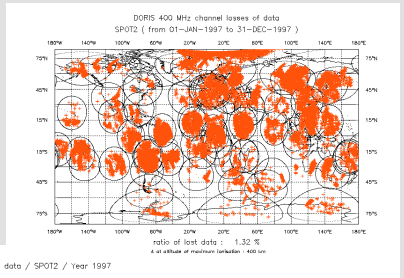


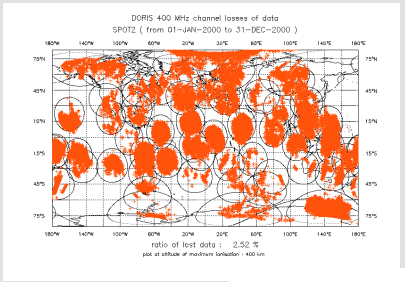
SPOT2, SPOT4 satellites
alt. 860 km, incl. 98
heliosynchronous orbit (20H30 local time at ascending node)

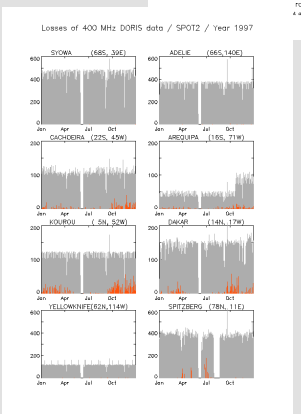
Method

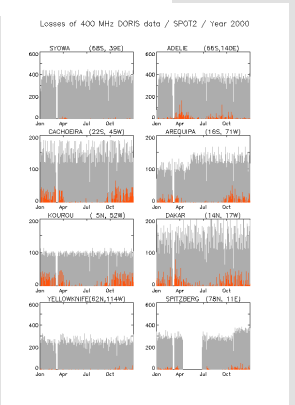
The algorithm to isolate lost data in the 400 MHz telemetry is simple. For each observation, the applied criteria is a coherent 2 GHz quality bit while the 400 MHz quality bit is not or the station identification number is not. This number is included in the beacon message such as the meteorological parameters. The beacon message is transmitted with a modulation of the 401 MHz frequency.

Additional tests are applied to extract losses issued from the beacon failures. The ionospheric scintillations origin signal fades have not been separated from external jamming or internal jamming (iso-Doppler). This last source of perturbation could have been calculated and a-priori deduced. However, in this case, the geographical distribution signature is clearly visible with aligning points along the satellite ground track located in areas of 2 stations with co-visibility of the satellite.









SPOT 2 ratio of lost data : 1% in 1997, 3% in 2000 : figures not critical for the system

SPOT4 : lower ratio (youngest instrument) but with the same signatures

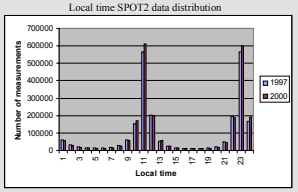
The main caracteristics of the ionospheric scintillations can be found on the maps and stations plots :
- a concentration around the geomagnetic equator and the auroral zones,
- a sensitivity to the sunspot cycle (year 2000 is near the maximum),
- a seasonal variation (see Kourou, Dakar, Terre Adélie).

Time of the day dependence ?

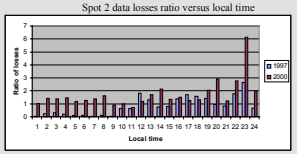
A maximum effect is expected during the sunrise and after the sunset. But as shown in the SPOT2 plots of local time data distribution (left) this situation is infrequent.

Most of the losses occur around 23h local time of the sub- ionospheric point along the ray supposed to be at 400 km altitude (above). It is known that the scintillations are very intense around midnight in the auroral oval region. It is verified with the DORIS 400 MHz data lost at Spitsberg or Terre Adélie stations (right). The high latitude stations contribute a lot to the amount of observations because of the polar orbit.

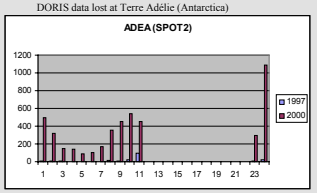
Local time SPOT2 data distribution



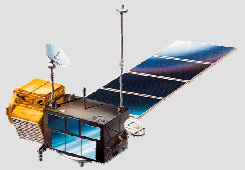
Spot 2 data losses ratio versus local time



DORIS data lost at Terre Adélie (Antarctica)

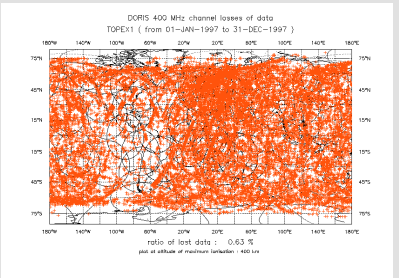


TOPEX/POSEIDON results



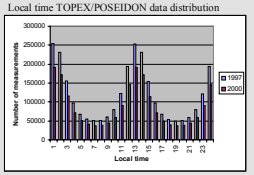
TOPEX/POSEIDON satellite

alt. 1335 km, incl. 66°
2h local time drift of the orbit ascending node every 10 days



TOPEX ratio of lost data :
0.6 % in 1997, 1.5 % in 2000 : not critical for the system

Local time TOPEX/POSEIDON data distribution



With Topex/Poseidon satellite, the correlation of signal fades with the ionospheric scintillations is not so clear than with SPOT.

The distribution map of lost data show lots of aligning points along the satellite tracks . They correspond to internal system jamming. It is more intense with Topex compare to Spot, due to the higher altitude of the orbit. In addition and for the same reason, Topex is more sensitive to external jamming resulting of human activity (radars, …). The effects are particularly intense in Europe.

Topex data losses ratio versus local time