# ESTIMATING TROPOSPHERIC DELAYS FROM DORIS DATA IN A MULTI-SATELLITE MODE

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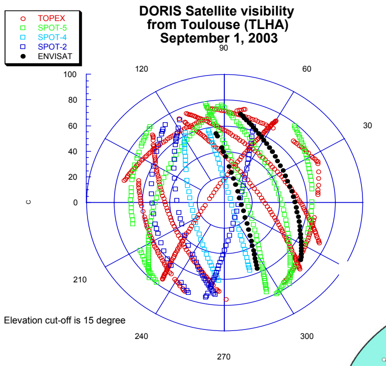
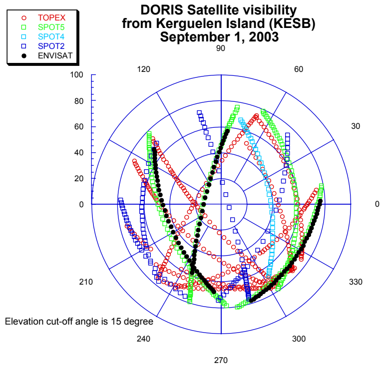
**Summary** : The goal of this poster is to assess the accuracy of DORIS-derived tropospheric delays by comparison with GPS/IGS combined solutions. Results from 24 DORIS/GPS collocated sites show agreement of 0 to 10 mm for mean offsets per stations, and about **16 mm for RMS** for the total zenith tropospheric delay.




For mid-latitude and equatorial regions, the SPOT Passes (helio-synchronous satellites) are almost oriented North-South

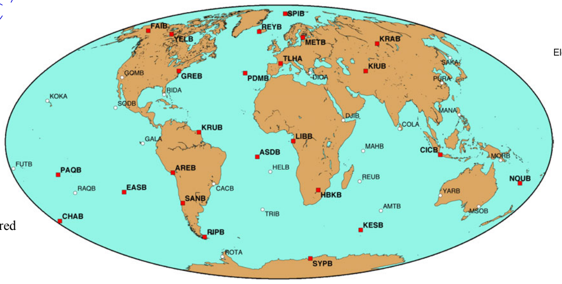
DORIS satellites passes are very short in time (typically 20 minutes for LEO satellites)

For such a station, all portions of the sky are then well covered even with 1 day of data



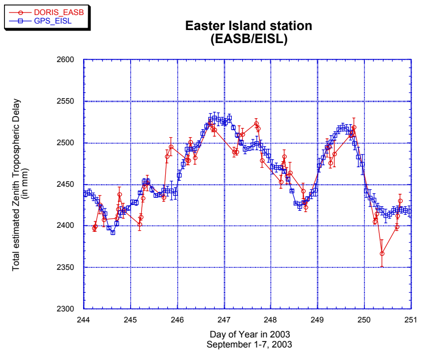

For station at very high or very low latitude, TOPEX passes tend to be low on the horizon

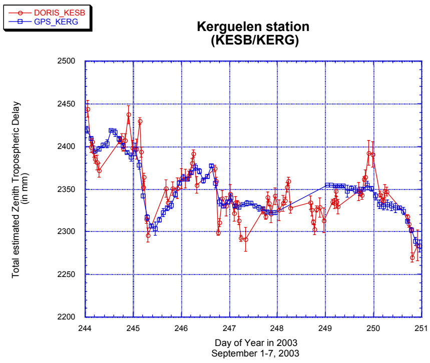
However, SPOT satellites give a good geometry (the elevation angle is highly variable during each satellite pass), allowing for excellent determination of the zenith total tropospheric delay

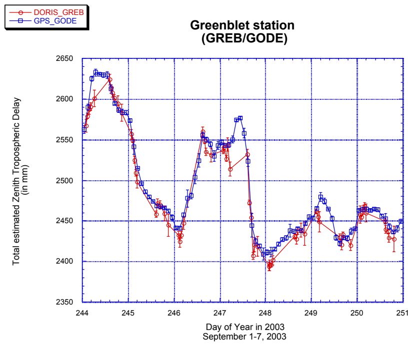


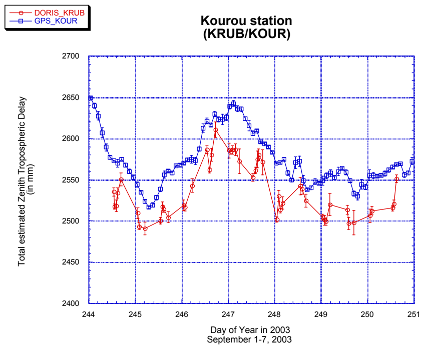
Actual GPS-DORIS collocations (Sep 1-7, 2003)
(collocations in red, other DORIS stations in white)

Map courtesy of Herve Fagard (IGN/SIMB)




## Estimating the zenith tropospheric correction from DORIS data:

All our DORIS estimations were done using the GIPSY-OASIS II software developed at JPL (http://gipsy.jpl.nasa.gov/orms/goa/).

In order to save CPU time, we have estimated the tropospheric correction per segment instead of using a random walk process for every measurement (typically every 10 seconds, when available). These segments (batch intervals) can only start at the beginning of a DORIS satellite pass (no need to estimate a new parameter when there is no available DORIS data). However, we do not reset the parameter if the time duration between 2 passes (from 2 different satellites) is less than a specific value (30 minutes).

DORIS tropospheric zenith delays are then not estimated at regular intervals.

We have used in our estimation, all DORIS satellites except JASON : SPOT2, SPOT-4, SPOT-5, TOPEX and ENVISAT.

e have processed 7 days of DORIS data (from Sep 1 to Sep 7, 2003), on a daily basis (using 30 hours of data to avoid day boundary problems)

## Discussion on individual results:

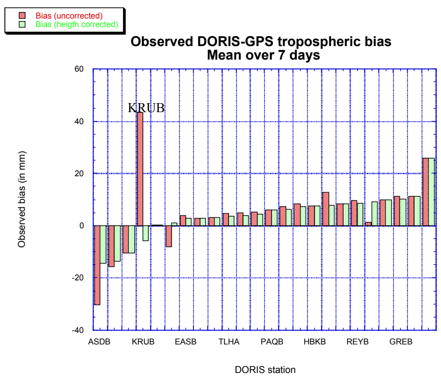
On these 4 plots (EASB,KESB,GREB and KRUB), GPS-derived Zenith Tropospheric delays are depicted in blue (every 2 hours) . We have used in all our comparisons the IGS combined tropospheric products (**http://igscb.jpl.nasa.gov/**). Our DORIS results are given in red and they are expressed at the epoch of start of some of the satellite passes.

It can be seen that the tropospheric variability, as observed by GPS, is very coherent with the DORIS results.

There is no visible bias between DORIS and GPS solutions (see also below), except for the Kourou stations (KRUB). In this case, the DORIS and GPS instruments are quite far apart (25 km in horizontal and more than 180 m vertically. There are then good reasons for a possible bias between GPS and DORIS due to the geographical variability of the atmosphere.

The formal errors of the GPS estimates are always smaller than the DORIS formal errors. The formal error of the DORIS results vary in time, depending on the number of available data and observed satellites geometry.

In any case, GPS series are much more smoother (they are also a combination of several individual GPS solutions)




## Discussion on DORIS/GPS bias:

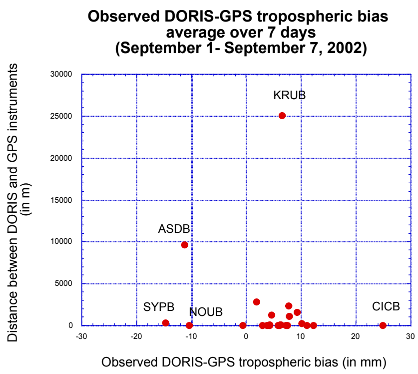
It must be noted that some collocated sites may have DORIS and GPS that could be rather far apart (see table below)

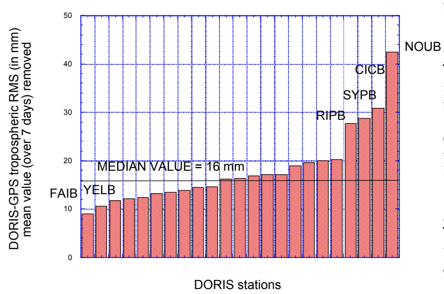
First we need to take into account the difference in height of the DORIS and GPS antenna to really compare the same tropospheric content. From the left figure we can see that the observed mean bias between DORIS and GPS zenith tropospheric delay is much smaller when applying the height correction for the dry tropospheric delay. It is specially visible for the Kourou station with the large height difference of 184 m).

The DORIS-GPS ZTD bias ranges from -15 mm (ASDB) to + 25 mm (CIBB)

On the right side, we present the estimated bias as a function of distance between the DORIS-GPS instruments. As Kourou (KRUB) and Ascencion (ASDB) collocations are quite far (over 10 km), there are good reasons for DORIS and GPS to see a different troposphere behavior.

In our opinion, there is in this plot a common bias of about 5 mm that can be explained by the -3 ppb scale factor that we usually see between our DORIS reference frame and the ITRF. 3 ppb = 3*1.0E-9*6400*1E6= 19.2 mm (equivalent to 6.4 mm in ZTD). Using our DORIS reference frame would then cancel this common bias




## Discussion on the RMS results:

If we remove a bias per station (estimated over the full 7 day period), the differences between DORIS and GPS Total Zenith delay have a median RMS of 16 mm.

Generally, stations at high latitude (with more SPOT data) have a better agreement with GPS. While stations at the equator or mid-latitude show slightly worse results. If we exclude 4 stations (out of 24), the RMS are less than 20 mm.

## Conclusions

We have shown that high quality tropospheric delays can be estimated from DORIS data (1 to 2 cm accuracy)

| Station Name | DORIS acronym | GPS Acronym | Distance (in m) | Height difference (in m) |
|---|---|---|---|---|
| Kitab | KIUB | KIT3 | 6 | 0.9 |
| Ponta Delgada | PDMB | PDEL | 6.2 | 0.6 |
| Papetee | PAQB | THTI | 6.7 | 1.4 |
| Libreville | LIBB | NKLG | 14.4 | 3 |
| Noumea | NOUB | NOUM | 14.8 | 0 |
| Krasnoyarsk | KRAB | KSTU | 20.2 | 6.8 |
| Hartebeestoech | HBKB | HARB | 24.8 | 1.3 |
| Kerguelen | KESB | KERG | 25.9 | 1.3 |
| Arequipa | AREB | AREQ | 36.1 | 1.9 |
| Earter Island | EASB | EISL | 40.5 | 3.8 |
| Rio Grande | RIPB | RIOG | 40.8 | 1.1 |
| Cibinong | CICB | BAKO | 41.9 | 2.9 |
| Yellowknife | YELB | YELL | 48.8 | 1.1 |
| Chatham | CHAB | CHAT | 61.4 | 2.5 |
| Santiago | SANB | SANT | 72.7 | 1.4 |
| Greenbelt | GREB | GODE | 205.9 | 5.9 |
| Syowa | SYPB | SYOG | 312.1 | 7 |
| Fairbanks | FAIB | FAIR | 1073.4 | 20.7 |
| Toulouse | TLHA | TLSE | 1272 | 3.7 |
| Spitzberg | SPIB | NYA1 | 1580.7 | 31.4 |
| Reykjavik | REYB | REYK | 2362.4 | 3.2 |
| Metsahovi | METB | METS | 2796.9 | 31.3 |
| Ascencion | ASDB | ASC1 | 9605.1 | 59.4 |
| Kourou | KRUB | KOUR | 25055 | 184.8 |

Actual DORIS-GPS collocations (Sep 1-7, 2003)