An inter-comparison of zenith tropospheric delays and gradients from DORIS and GPS

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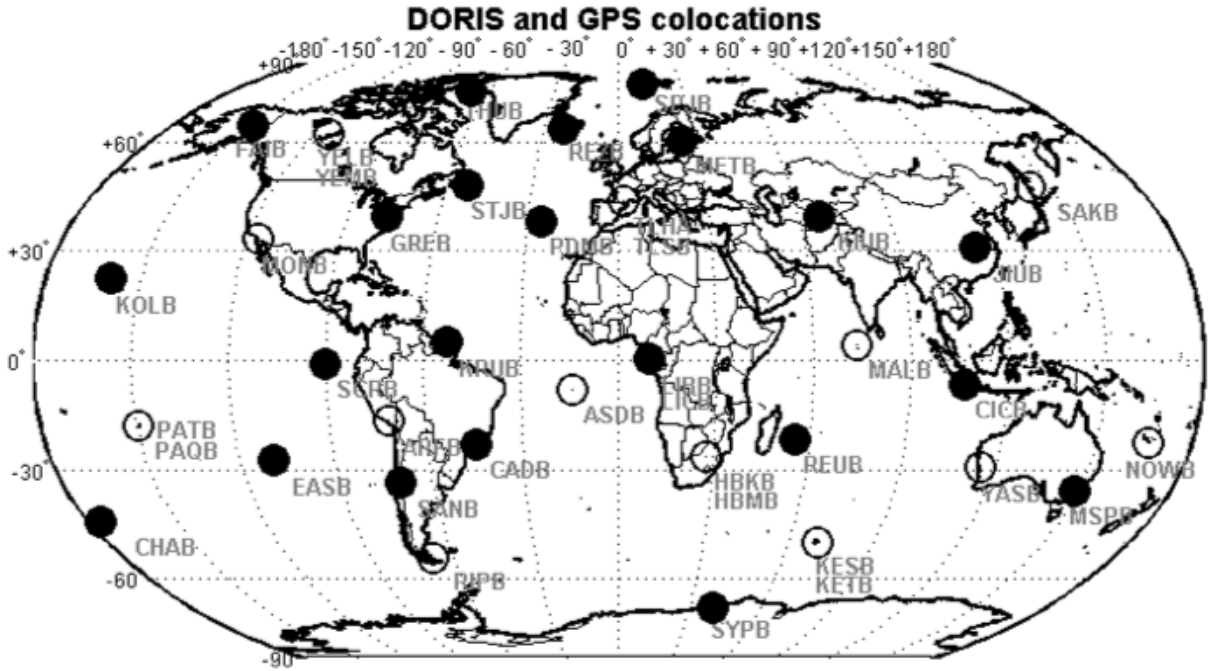
Context and objectives

- Tropospheric delay modelling is an important aspect of geodetic data analysis
  - High temporal variability of tropospheric humidity impacts microwave signal propagation and station position
- Improvement of geodetic software and reprocessing of geodetic data offer new opportunities to the use of tropospheric estimates (ZTDs, gradients) and derived quantities (TCWV)
  - Assessment of quality of different geodetic techniques (GPS, DORIS, VLBI)
  - Assessment of quality of meteorological observations (radiosonde, satellite) and NWP model products (analyses, reanalyses, forecasts).
  - Assimilation of GPS ZTDs into operational weather forecasting systems (e.g. EGVAP project in Europe since 2005)
- This work aims at assessing the consistency of different datasets (geodetic and meteorological)

Data and methods (1)

- Comparison of ZTD estimates from DORIS/IGN and GPS/IGS, period 2005-2008.



Common sites (35)

● With 4 yrs of data (26)

○ < 4 yrs (9)

Some DORIS sites have several closeby GPS stations.

Bock et al., Adv. Space Res., 2010

Data and methods (2)

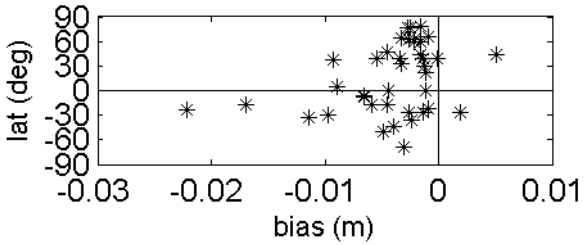
Bock et al., Adv. Space Res., 2010

- DORIS/IGN data processing:
  - Special reprocessing (1993-2008) based on ignwd08 with:
  - GIPSY/OASIS II, 30-h sessions
  - one ZTD every 20 min (per station, not per satellite)
  - No tropo gradients
  - GMF mapping function
  - Cutoff: 10°
  - Station coordinates fixed
  - new gravity field model (GGM03S),
  - special solar radiation pressure

- GPS/IGS data processing:
  - IGS 'trop-new' product (2000-2008)
  - GIPSY/OASIS II, 24-h sessions
  - IGS orbits, clocks, EOPs
  - One ZTD and one GRAD every 5 min
  - NMF mapping function
  - Cutoff: 7°
  - Antenna PCV model:
    - Relative before 5 Nov 2006 / Absolute after
  - IGS 'repro1' product (1995-2007)
  - GMF mapping function
  - Antenna PCV model: absolute
  - Updated IGS 'trop-new' product (2007-present)
  - Similar to repro1

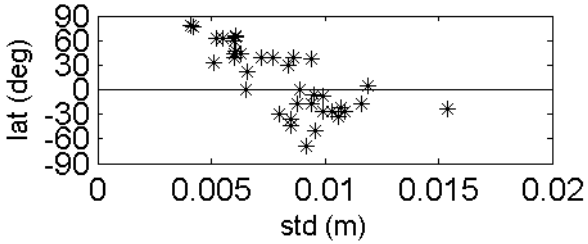
- Post-processing
  - Correct for tropo delay due to difference in height between antenna reference points of paired DORIS and GPS stations
  - Reject ZTDs with formal error > 7mm

GPS solution: IGS 'trop-new'
Year 2007



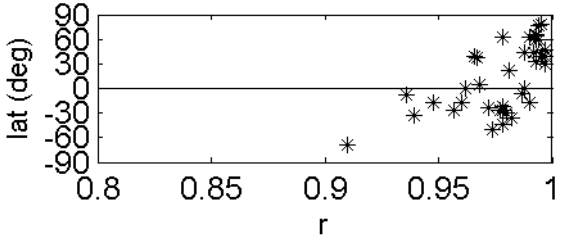
Mean(diff)

-4 mm



Std.dev(diff)

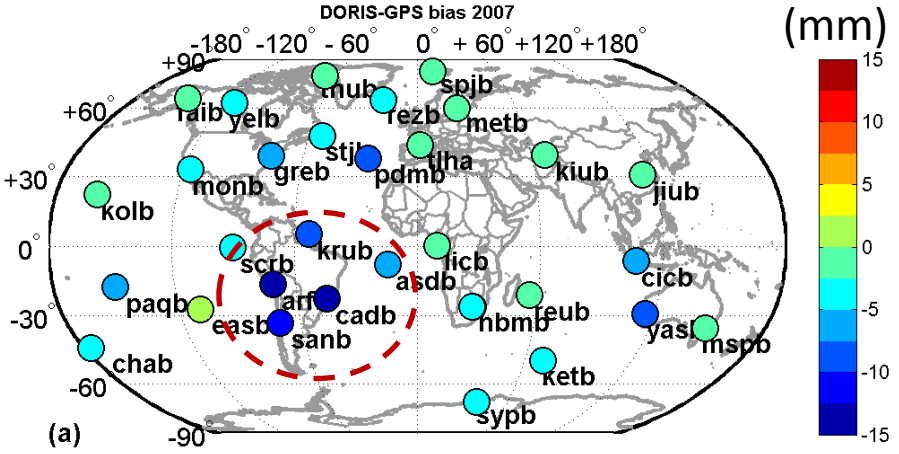
8 mm

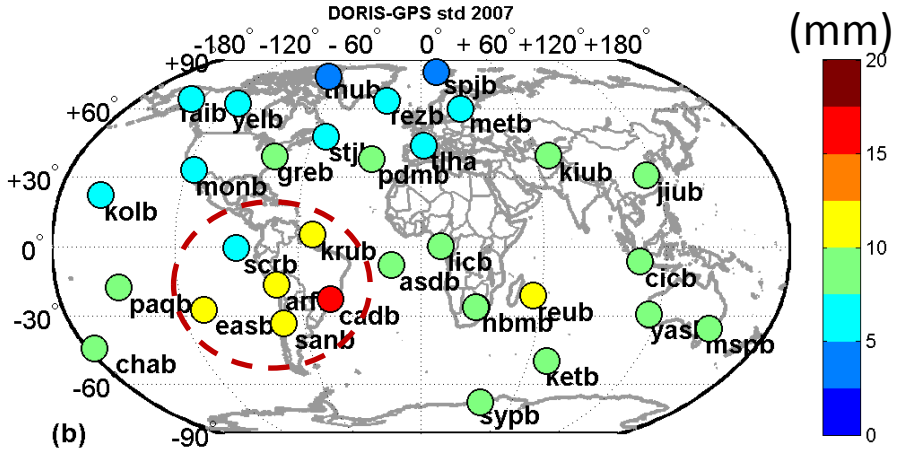


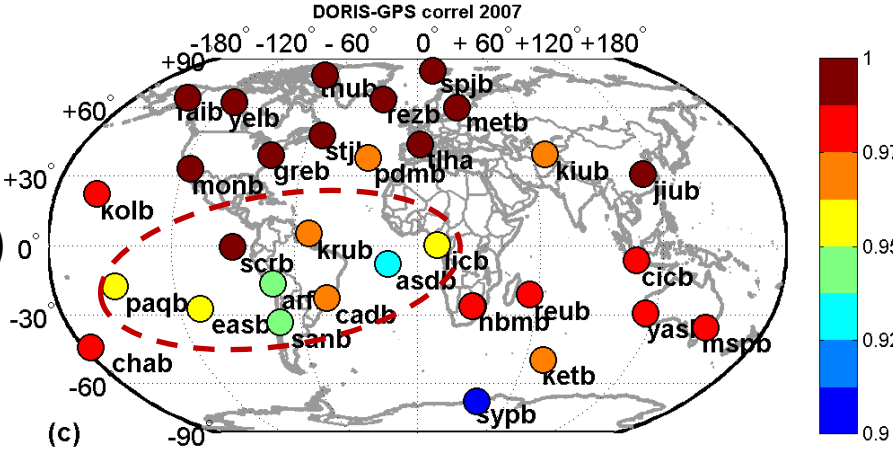
Correlation(DORIS , GPS)

0.978

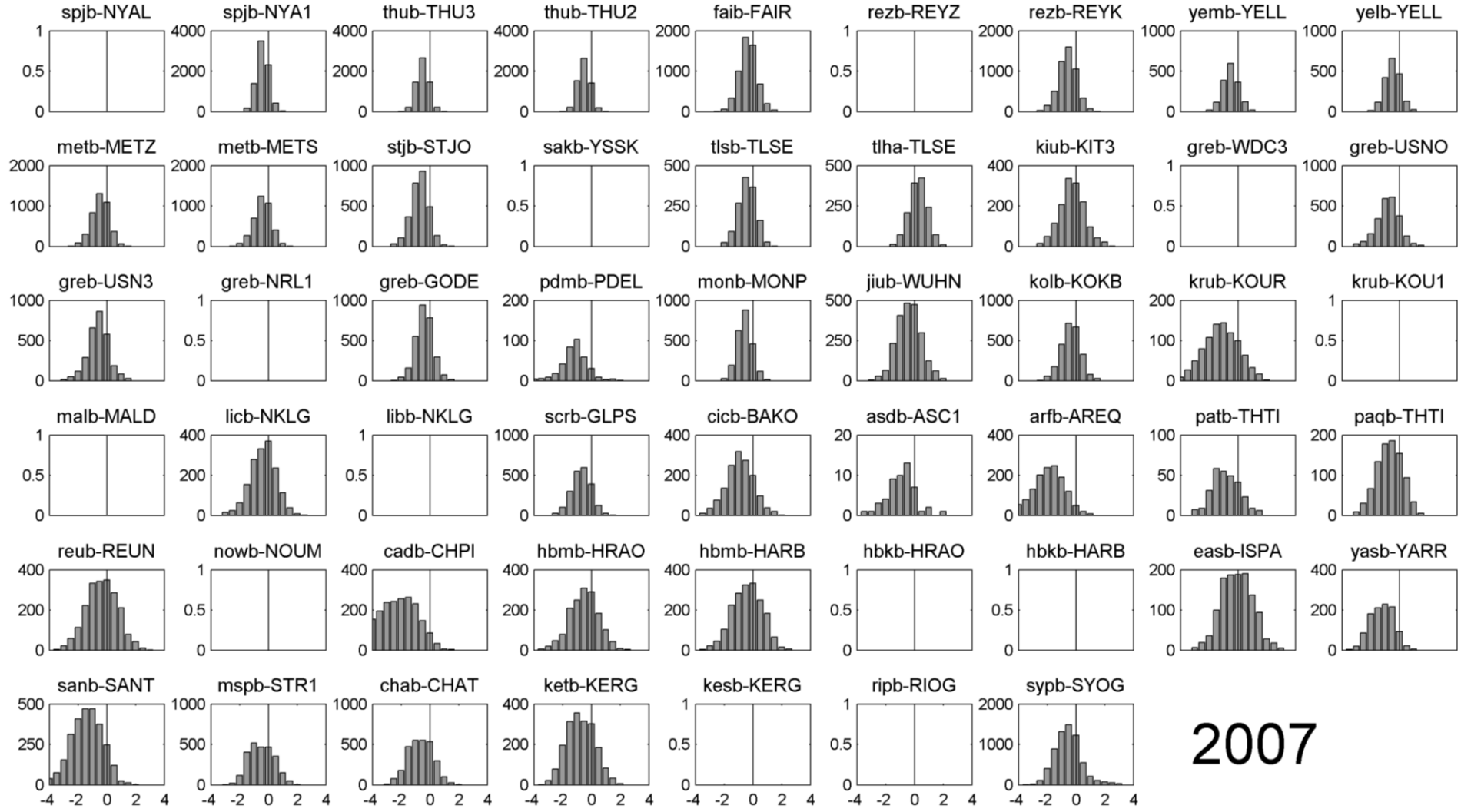
Bock et al., Adv. Space Res., 2010







North

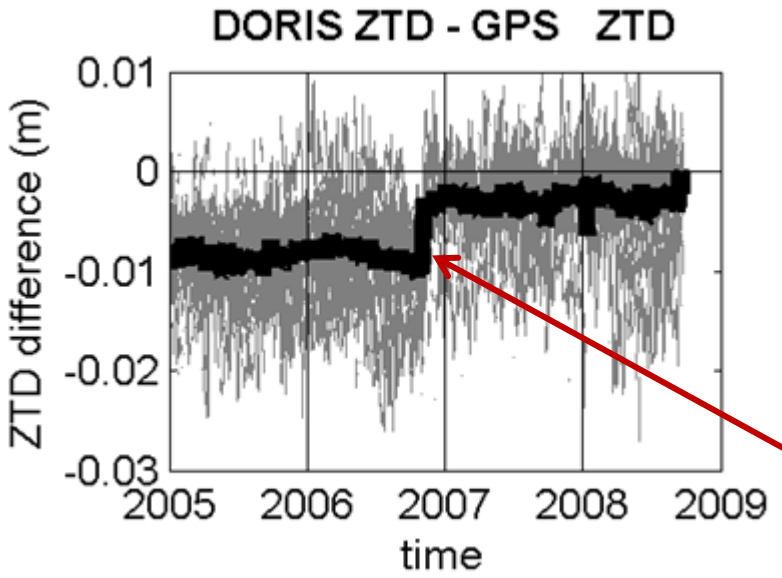


2007

South

Temporal evolution of DORIS – GPS bias (IGS trop-new) 2005 - 2008

Year	Number of comparisons	Median bias (m)	Mean bias ± one SD (m)	Standard deviation (m)	Correlation coefficient	Number of data pairs
2005	42	−0.0078	−0.0089 ± 0.0042	0.0086	0.971	101,190
2006	41	−0.0074	−0.0081 ± 0.0050	0.0089	0.974	106,909
2007	39	−0.0026	−0.0040 ± 0.0048	0.0080	0.978	99,344
2008	36	−0.0017	−0.0034 ± 0.0057	0.0086	0.978	68,995

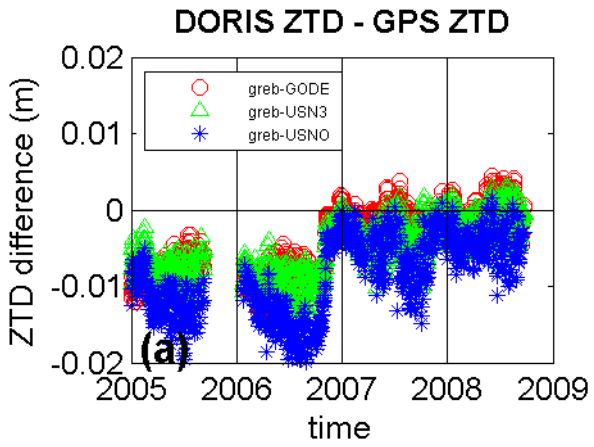


5 Nov 2006:
Shift in GPS ZTD due to change from rel. to abs. APCV and ITRF2000 to 2005.

Impact of GPS station equipment on ZTD solution
(comparison of one DORIS station to several GPS stations)

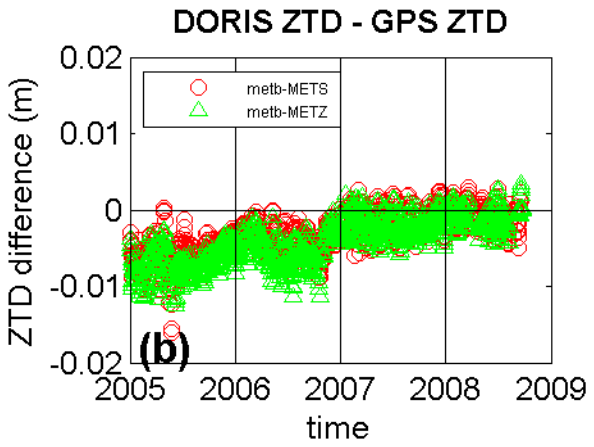
Greenbelt

Rec1-Ant1
Rec2-Ant1
Rec3-Ant3



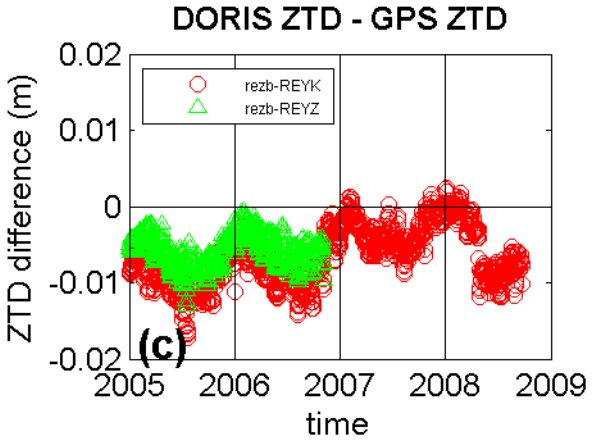
Metsahovi

Rec1-Ant1
Rec2-Ant2



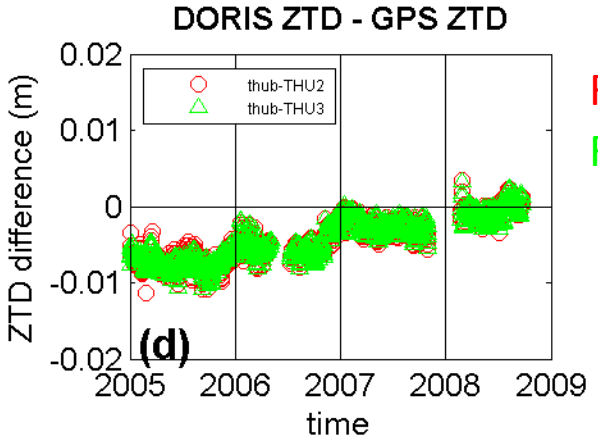
Reykjavik

4 Recv's,
2 Ant, 1 Rad



Thule

Rec1-Ant1+Rad1
Rec2-Ant1+Rad1

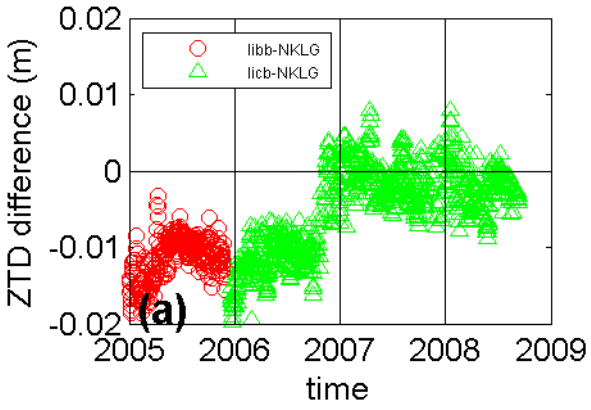


Impact of DORIS station equipment on ZTD solution
(DORIS stations where equipment changed)

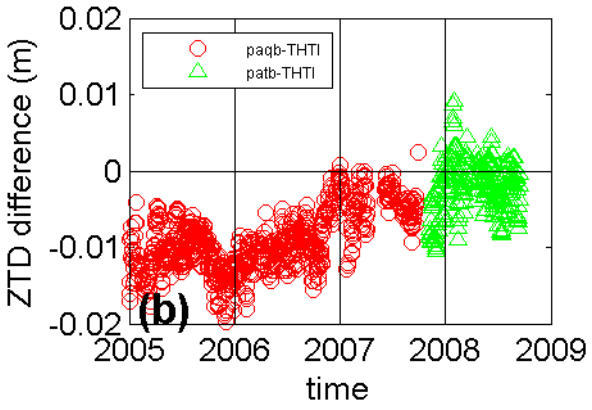
DORIS1
DORIS2

Alcatel->Starec

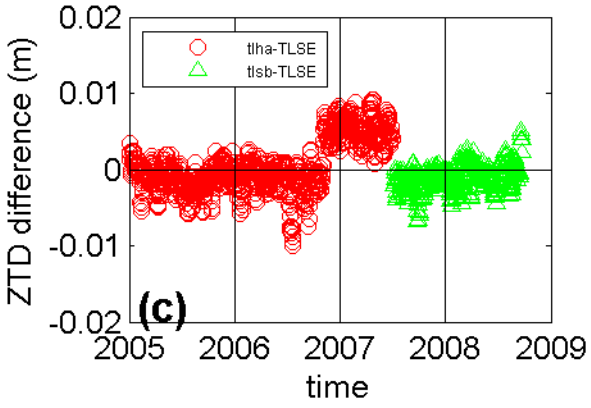
Libreville



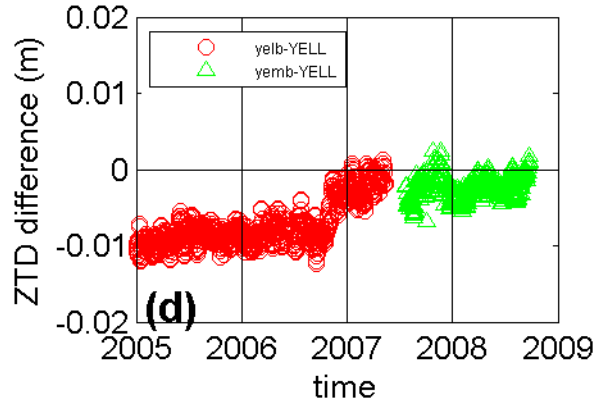
Papeete



Toulouse

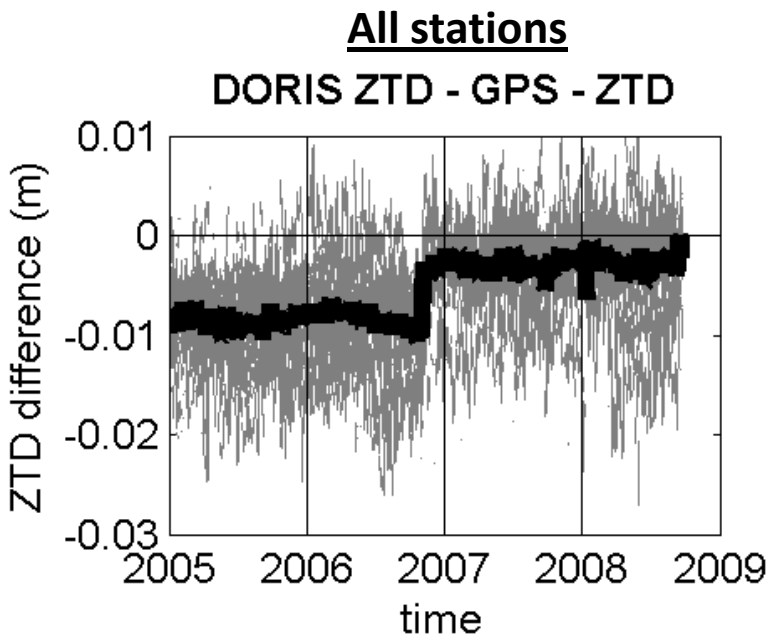


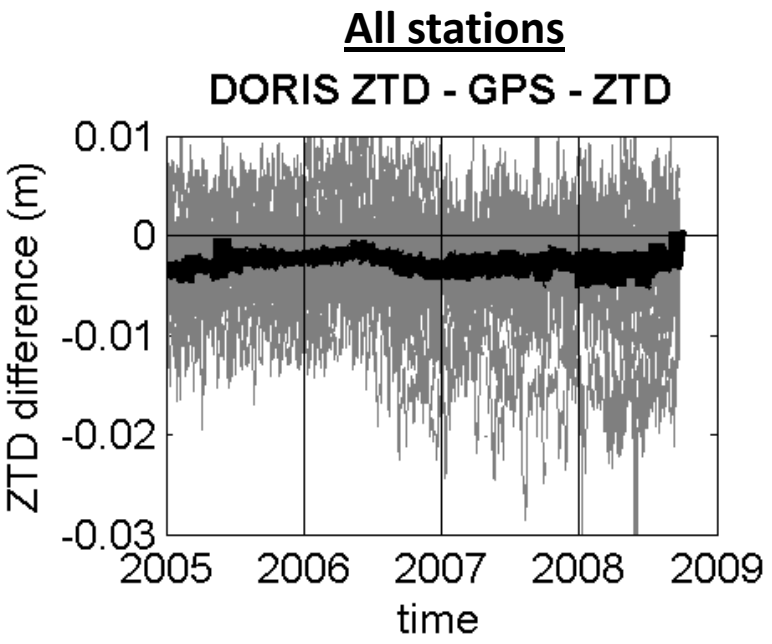
Yellowknife



Temporal evolution of DORIS – GPS bias (IGS trop-new) 2005 - 2008

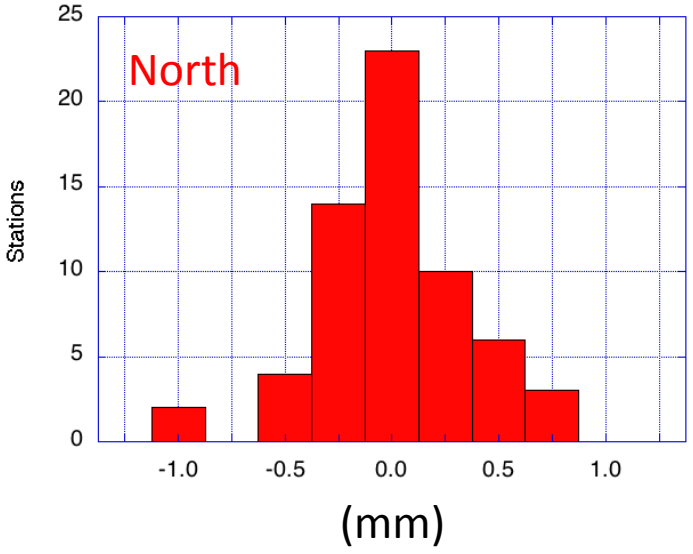
Update with IGS/repro1 and trop_new

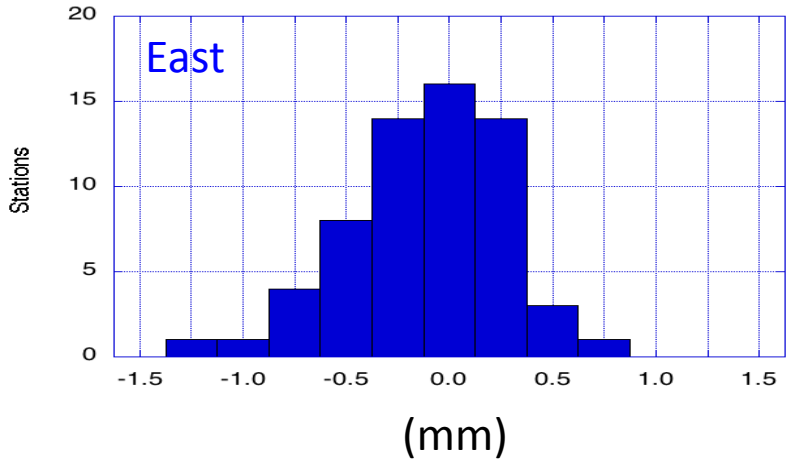




Horizontal tropospheric gradients
(Willis et al., IAG Symp., in press)

- New DORIS data analysis (2007 & 2010)
  - Based on ignwd08 with 1 set of gradient param (GN, GE) / day

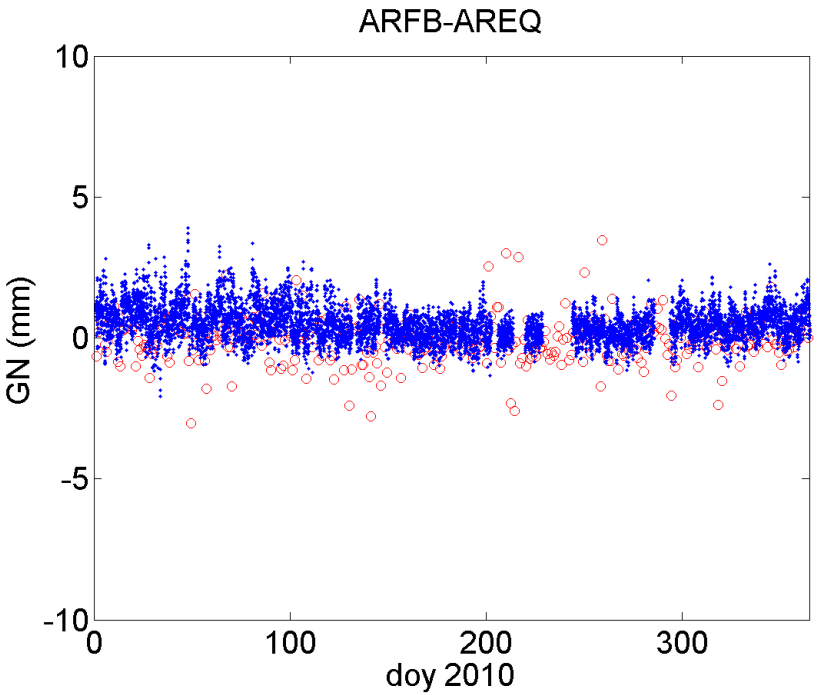


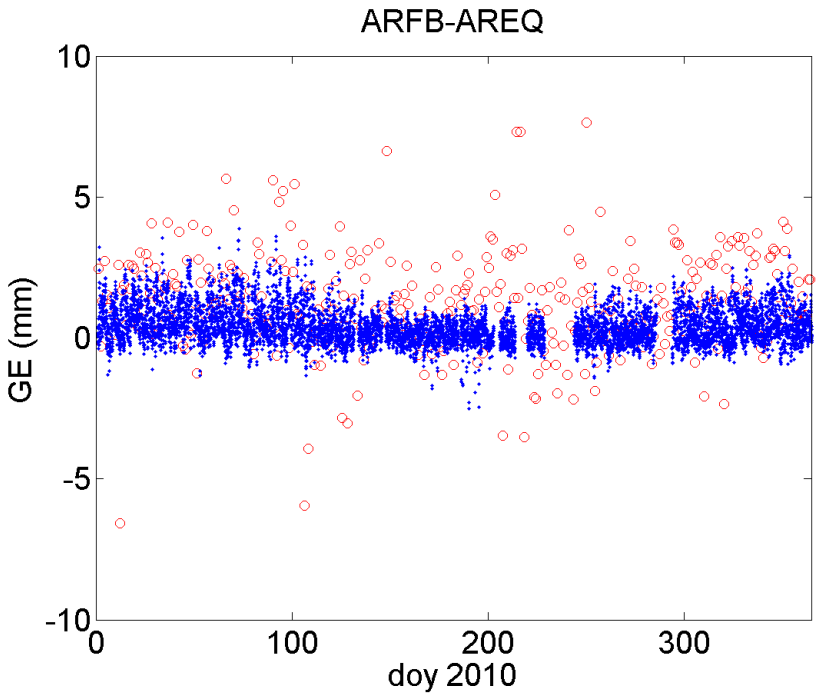


Mean gradients (year 2007 / 57 Sites)

DORIS single station

(Arequipa, -16.5°N, -71.5°E, 2491m)





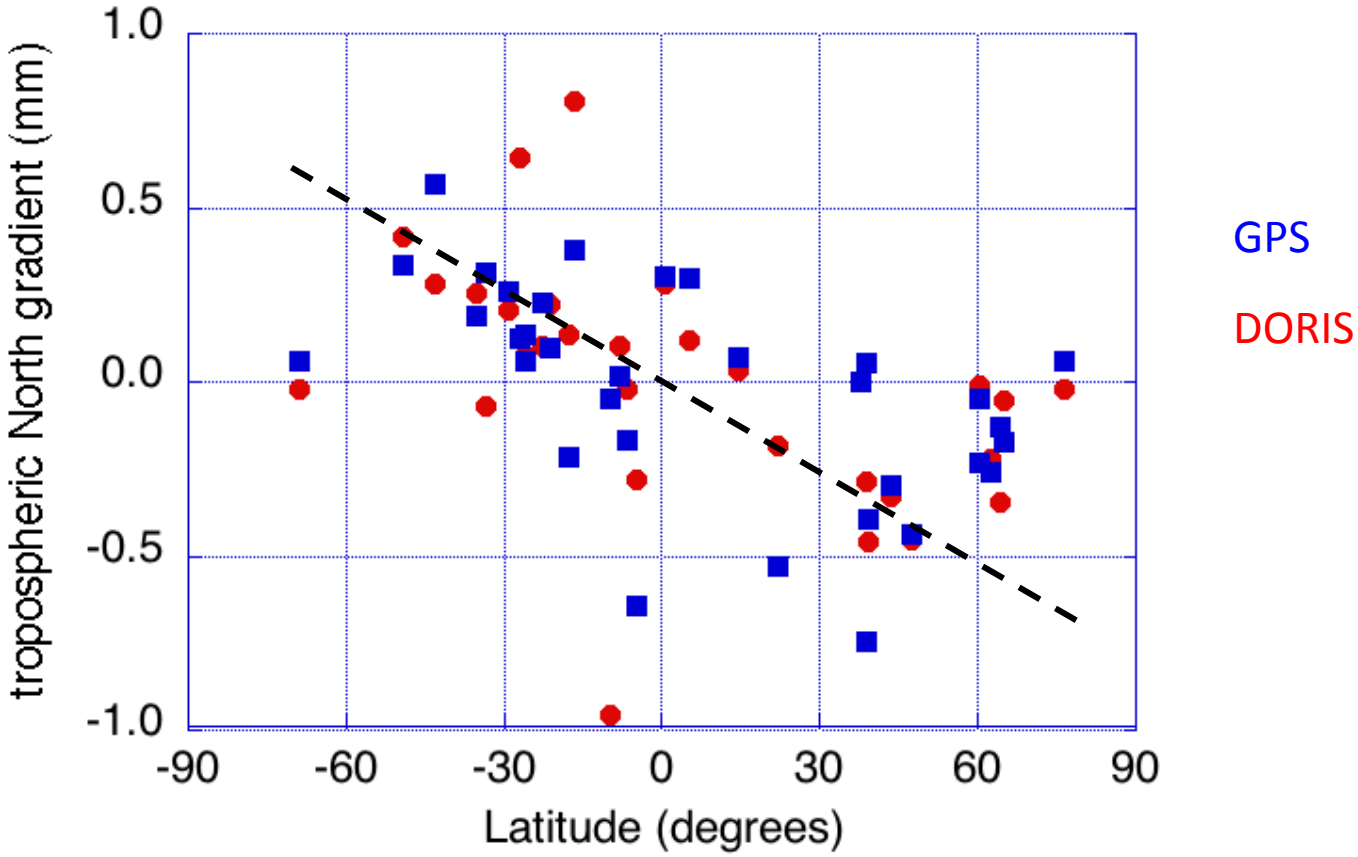
DORIS mean GN = -0.026

GPS mean GN = 0.478

mean GE = 0.810

mean GN = 0.386

North gradient / latitude



(slope predicted by McMillan et al., 1994)

Impact on station coordinates

Solution (ignwd08)	Chi2/ DOF	North (mm)	East (mm)	Up (mm)
w/o gradients	3.11	9.1	11.1	9.2
with gradients	2.39	8.8	11.5	9.0

TBD: reprocess all data (since 1993) and check repeatability

Conclusions

- DORIS ZTD and GPS ZTD agreement (typ. 2007):
  - Median bias (DORIS-GPS) = - 2 mm ; mean bias = - 4 mm
  - Standard deviation = 8 mm on global average ; larger in Southern hemisphere (possible link with SAA ?)
  - Spurious seasonal signal in ZTD difference (due to GPS ?)
- Sensitivity to changes in equipment:
  - DORIS & GPS: change of antenna type has quite similar impact (5 – 6 mm ZTD offset) but DORIS network uses a single type of antenna while GPS network uses multiple antennas and correction models
  - DORIS results not sensitive to other changes or upgrades
  - GPS results sensitive to radome, multipath, type of receiver…
- DORIS and GPS Gradients
  - Agreement: fair (gross features are consistent)
  - Including gradients in DORIS data processing improves slightly geodetic results

Perspectives

- DORIS and GPS comparison: ZTD and gradients
  - Extend study over longer periods (IGS repro1, 1995-2007)
  - GPS can help investigate DORIS error sources (Southern hemisphere)
  - DORIS can help investigate GPS error sources (multipath, APCV…)
  - Confirm impact of changes in equipment (DORIS & GPS)
- Meteorology & climate applications:
  - Produce a reference TCWV dataset from DORIS and GPS
  - Use geodetic TCWV dataset to validate radiosonde, satellite products and models over long periods (1995-present)
  - Analyse TCWV variability (seasonal cycle to diurnal cycle) and trends from the different datasets