Analysis of the tie vector residuals at the DORIS sites

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Definition, motivation and input

- **What are the ITRF2014 tie residuals?**

  Differences between the:

  - **Physical/measured tie vectors used in the computation of the ITRF2014.**
  - **Difference between the ITRF2014 coordinates of the pair of stations involved in the measured tie vector.**

- **ITRF2014 tie residuals**

  File: ITRF2014-Tie-Residuals.dat

  Source: ITRF2014 web site http://itrf.ign.fr/ITRF_solutions/2014/

- **ITRF2014 DORIS solution**

  File: ITRF2014-IDS-TRF.SNX

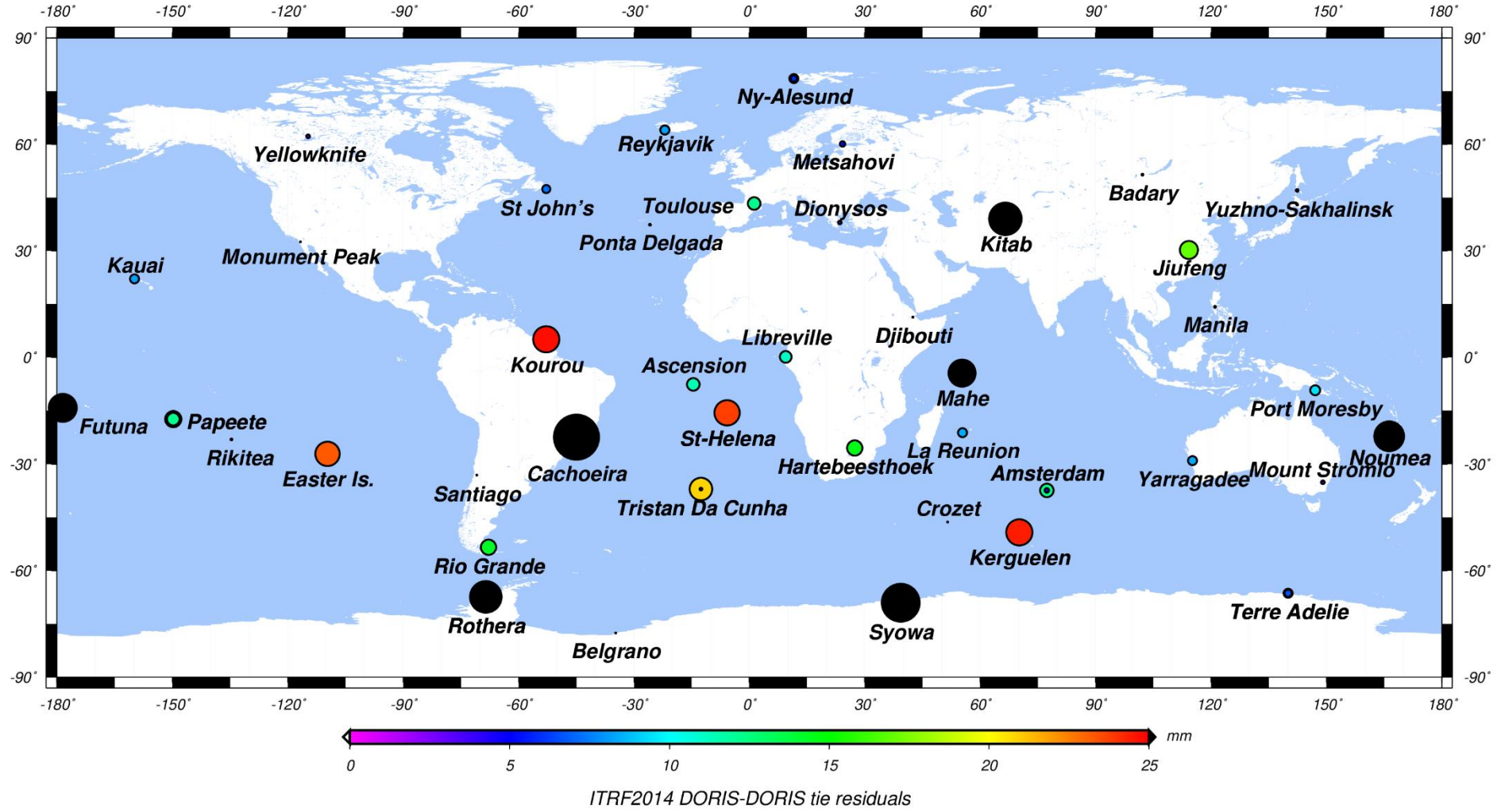
  Source: ITRF2014 web site

STEP 0

ALL THE TIES

3D ITRF2014 tie residuals

59 pairs of stations @ 42 DORIS sites

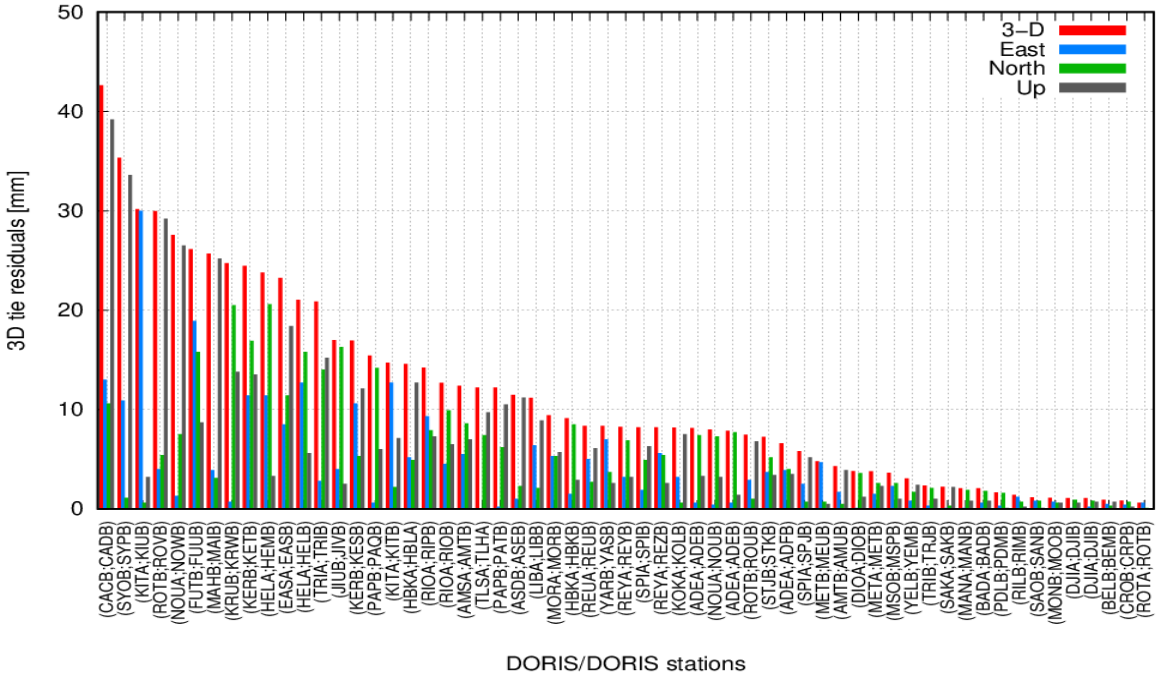


ITRF2014 DORIS-DORIS tie residuals

ITRF2014 tie residuals

http://ids-doris.org

59 pairs of stations @ 42 DORIS sites



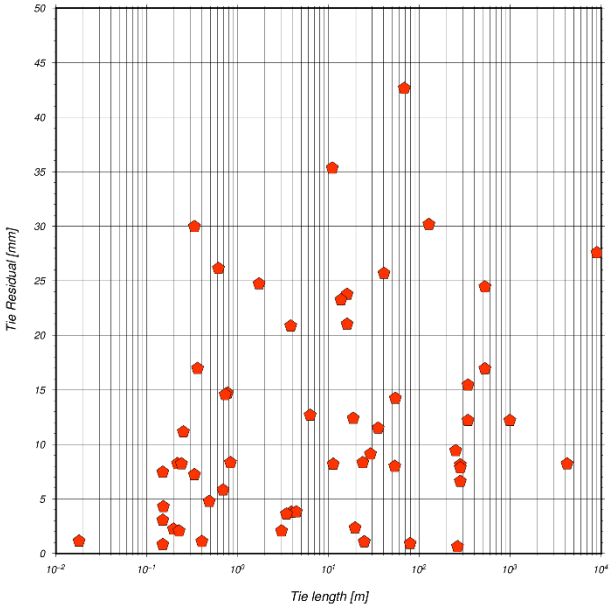
Unit: mm	North	East	Up	3D
Max	20.6	30.0	39.2	42.6
RMS	7.7	6.9	11.1	15.2
Median	3.7	2.5	3.5	8.3
Mean	5.5	4.3	7.1	11.5
STD	5.4	5.5	8.6	9.9

For 27 over the 59 tie residuals, one component represents more than 75% of the 3D tie residual.

- 3 for the East.
- 12 for the North.
- 12 for the Up.

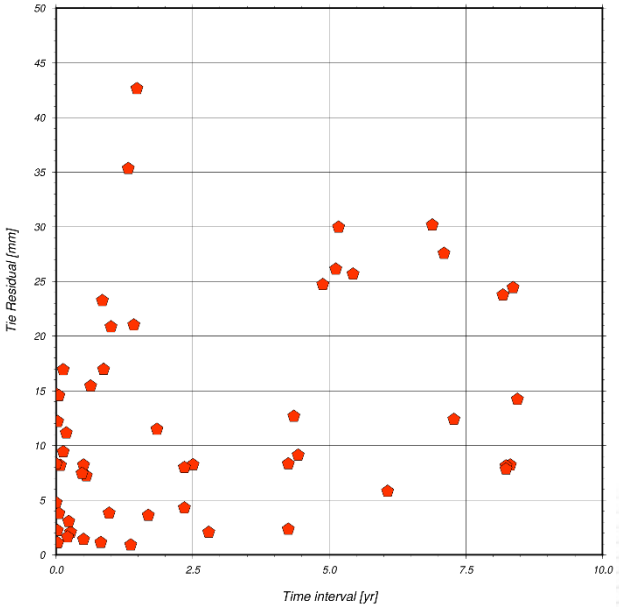
ITRF2014 tie residuals

vs distance between 2 stations



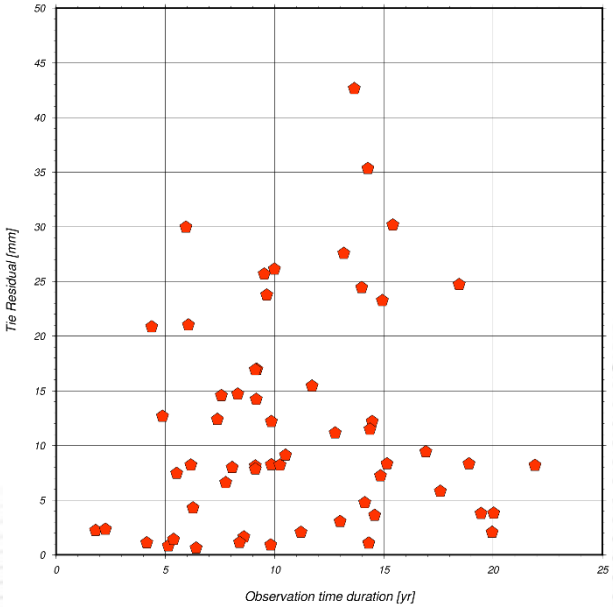
Correlation coefficient: 0.19

vs time interval between 2 stations



Correlation coefficient: 0.09

vs observation time length

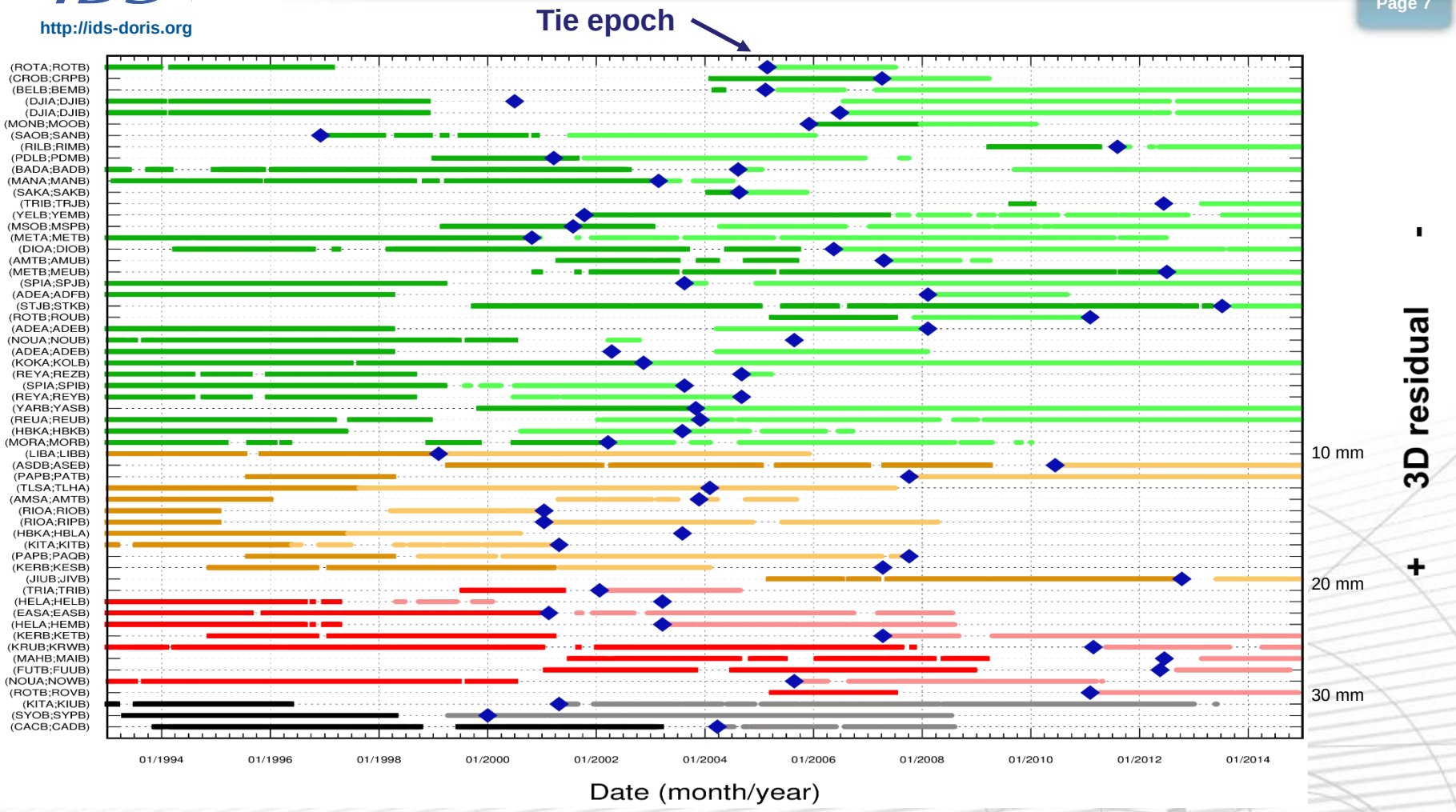


Correlation coefficient: 0.09

No correlation with neither the distance nor the time interval nor the observation duration.

ITRF2014 tie residuals

http://ids-doris.org



No correlation with neither the tie epoch nor the time interval nor the observation duration

Preliminary Conclusions

- **Largest residuals are observed:**
  - **Mostly in the tropical region of the southern hemisphere (0°S-30°S).**
  - **On islands (Futuna, Easter Island, Tristan, St-Helena, Mahé, Nouméa, Kerguelen).**
  - **In the SAA region (Cachoeira, Kourou, St-Helena, Tristan).**
  - **But also and suprisingly in the Antarctic (Syowa, Rothera).**

- **The tie residuals seem to be correlated with:**
  - **Neither the distance between the two stations.**
  - **Nor the time interval between the end and start of the two stations.**
  - **Nor the duration of the observation time of the two stations.**
  - **Nor the tie epoch.**

First Investigations

- **Syowa:**
  - **Tie residual (25.3 mm) is smaller than the tie measurement error (50 mm).**

  ➔ **Tie residual is ok.**

- **Tristan:**
  - **Tie residuals (TRIA vs TRIB: 20.9 mm ; TRIB vs TRJB: 2.3 mm) are smaller than the ITRF2014 station coordinate formal errors.**

  ➔ **Tie residuals are ok.**

➔ New analysis with questionable tie residuals only,

i.e. larger than the tie error or the ITRF2014 coordinate errors.

STEP 1

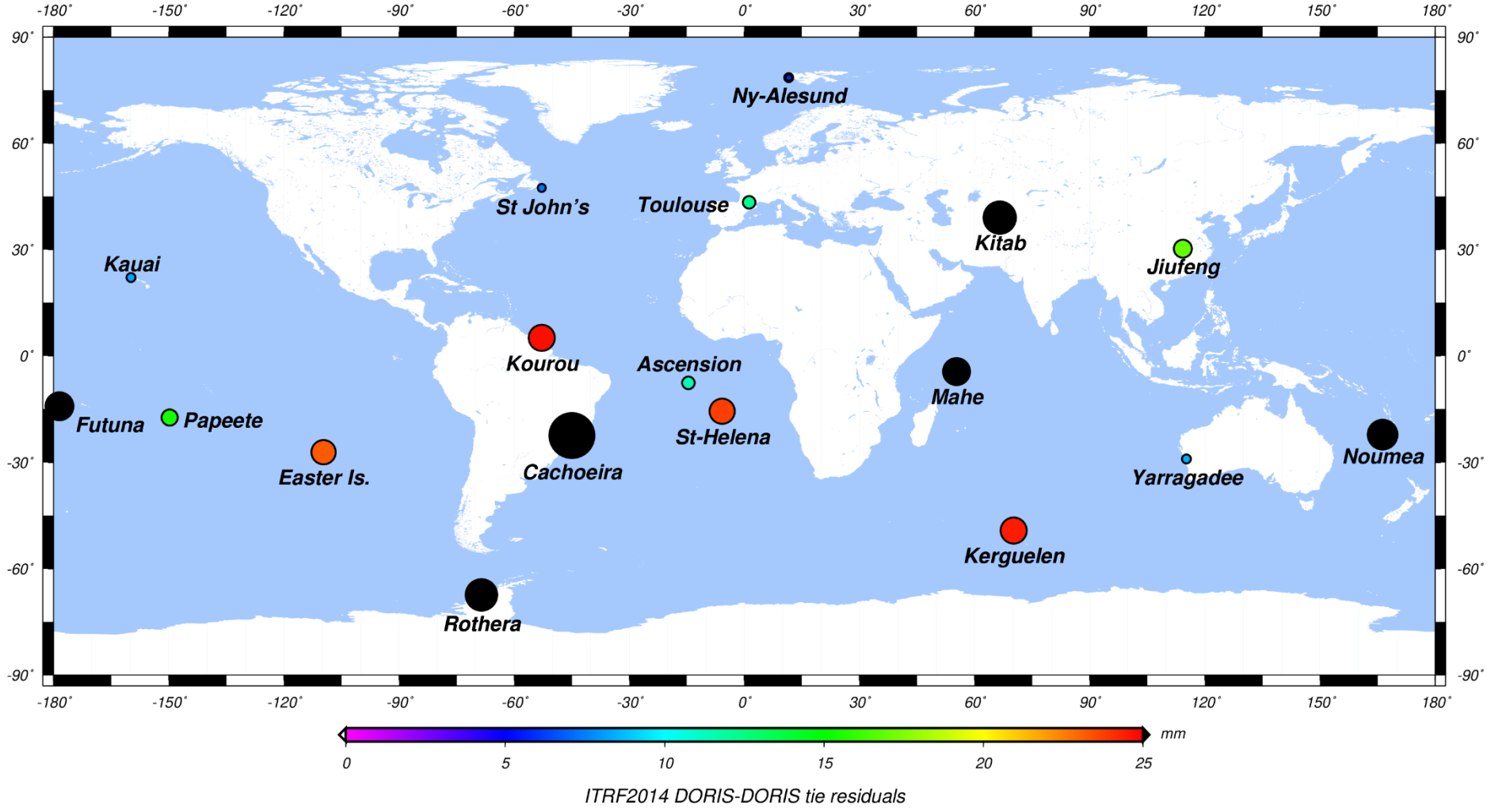
REMOVE TIES WITH TIE RESIDUALS

SMALLER THAN THE TIE MEASUREMENT ERROR (6)

SMALLER THAN THE ITRF2014 COORDINATE FORMAL ERRORS (37)

3D ITRF2014 tie residuals

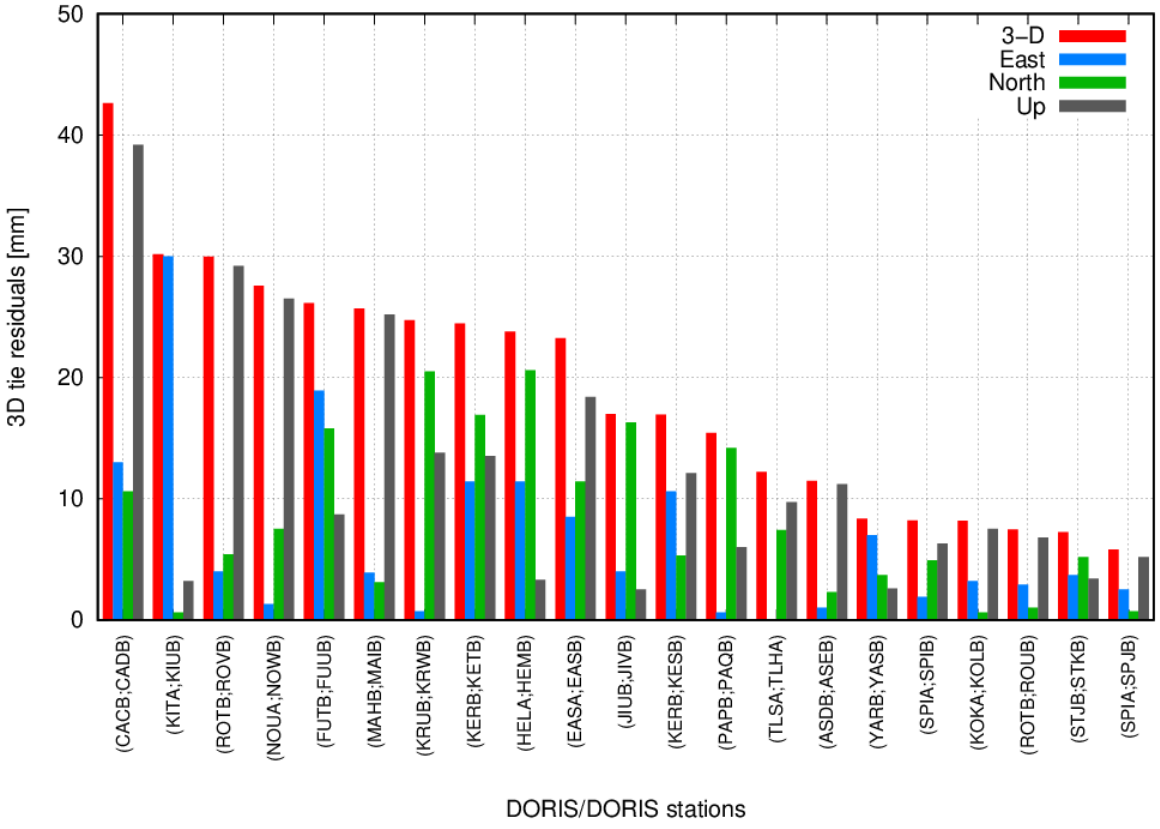
21 pairs of stations @ 18 DORIS sites



ITRF2014 DORIS-DORIS tie residuals

ITRF2014 tie residuals

21 pairs of stations @ 18 DORIS sites



Unit: mm	North	East	Up	3D
Max	20.6	30.0	39.2	42.6
RMS	10.6	9.8	15.6	21.2
Median	5.4	3.9	8.7	17.0
Mean	8.3	6.7	12.1	18.9
STD	6.7	7.3	10.1	10.0

For 12 over the 21 tie residuals, one component represents more than 75% of the 3D tie residual.

- 1 for the East.
- 3 for the North.
- 8 for the Up.

First Conclusions

- **Most questionable discrepancies are observed:**
  - **Mostly in the tropical region of the southern hemisphere (0°S-30°S).**
  - **On islands (Futuna, Easter Island, Trsitan, St-Helena, Mahé, Nouméa, Kerguelen).**
  - **In the SAA region (Cachoeira, Kourou, St-Helena).**

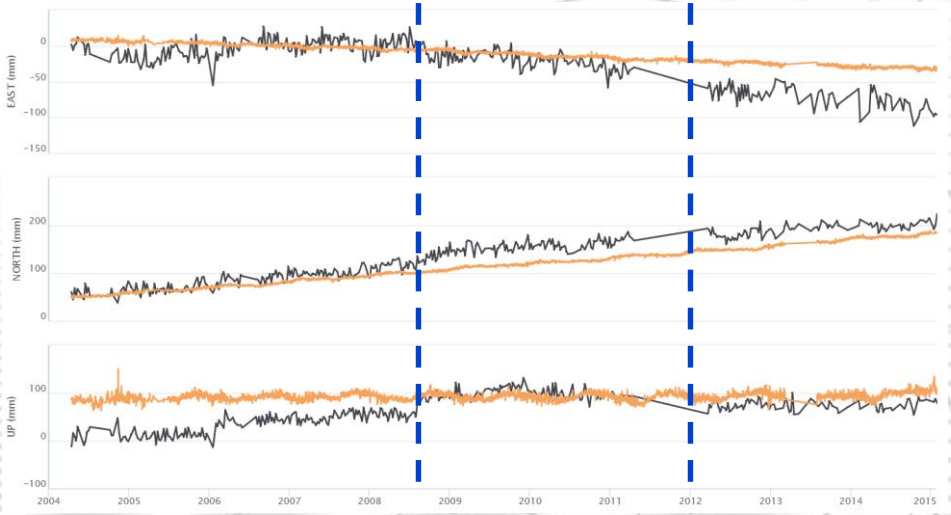
Site by site investigations - Cachoeira

- **1 tie residual**
  - **CACB vs CADB in 2004:085: 42.6 mm 3D mainly from the Up (39.2).**
    Distance between the two stations is around 68 m.

CADB

- **ITRF2014 solutions**
  - **CACB: 1993:318 - 2003:075**
  - **CADB: 2004:102 - 2014-362 (with two discontinuities in 2008:215 and 2011-355).**
  - **Same velocities for all the stations and all the epochs.**

- **Antenna on a sheet metal roof.**
- **The station is located in the SAA region.**
- **The first discontinuity is close to the first Jason-2 data in the AC series (2008:195).**



Coordinate time series of CADB (DORIS) and CHPI (GPS).

Site by site investigations - Kitab

- **2 tie residuals**
  - **KITA vs KITB in 2001:115: 14.7 mm 3D (tie vector ≈ 77 cm 3D).**
  - **KITA vs KIUB in 2001:115: 30.2 mm 3D mainly in the East (30.0). Tie vector ≈ 128 m 3D.**

  ➔ Origin of the high value? from KITB, KIUB?

KIUB

- **ITRF2014 solutions**
  - **KITA: 1993:003 - 1996:147**
  - **KITB: 1996:147 - 2001:119**
  - **KIUB: 2001:147 - 2014:362**

    (1 discontinuity in 2013:146 due to an earthquake of M5.7 - NNE of Bulung'ur, Uzbekistan).
  - **Same velocities for all the stations and all the epochs.**
- **IGN makes also available a tie vector between KITB and KIUB in 2001:115.**

  Let's see what this give for ITRF2014.

  ➔ 18.1 mm 3D (mainly in the East) for a tie vector of around 128 m 3D.

Explanation: « The site surveys reports specify that both antennas (KITA and KITB) showed defect in installation with lack of verticality and a deviation of 1 cm between the 2GHz center phase and the antenna reference point »

Site by site investigations - Rothera

- **3 tie residuals**
  - **ROTA vs ROTB in 2005:054: 0.6mm 3D (tie vector ≈ 263 m 3D).**
  - **ROTB vs ROUB in 2011:033: 7.5 mm 3D (tie vector ≈ 15 cm 3D).**
  - **ROTB vs ROVB in 2011:033: 30.0 mm 3D mainly in the Up (29.2). Tie vector ≈ 33 cm 3D.**

  ➔ Origin of the high value? from ROUB or ROVB?
- **ITRF2014 solutions**
  - **ROTA: 1993:003 - 2005:058 (2 discontinuities in 1997:047 and 2002:013 of unknown origins)**
  - **ROTB: 2005:085 - 2007:189**
  - **ROUB: 2007:315 - 2011:038**
  - **ROVB: 2011:100 - 2014:341**
  - **Same velocities for all the stations and all the epochs.**
- **IGN makes also available a tie vector between ROUB and ROVB.**

  Let's see what this give for ITRF2014.

  ➔ 23.1 mm 3D mainly in the Up (22.6 mm).

  Still 3 times larger than ROTB vs ROUB.

  ➔ investigation to be made on the antenna height.

ROVB

Site by site investigations - Nouméa

- **2 tie residuals**
  - **NOUA vs NOUB in 2005:236: 8.0 mm 3D**
  - **NOUA vs NOWB in 2005:236: 27.6 mm 3D mainly in the Up (26.5) for a tie vector of nearly 9 km 3D. But, there are several stations from NOUA to NOWB.**

NOWB

- **ITRF2014 solutions**
  - **NOUA: 1993:010 - 2000:191**
  - **NOUB: 2002:083 - 2002:286**
  - **NOWB: 2005:247 - 2011:121**
  - **NOXB: 2011:240 - 2014:362**
  - **Same velocities for all the stations.**
  - **3D A-posteriori error of 15 mm (resp. 10, 6, 4) for NOUA (resp. NOUB, NOWB, NOXB).**

- **IGN makes also available two tie vectors between NOUB and NOWB in 2005/08/23 and between NOWB and NOXB in 2011/07/28.**

  Let's see what this give for ITRF2014.

  ➔ **28.2 mm 3D for NOUB vs NOWB for a tie vector of nearly 9 km 3D !!!**

  ➔ **8.7 mm 3D for NOWB vs NOXB for a tie vector of nearly 35 cm 3D.**

Site by site investigations - Mahé

- **1 tie residual**
  - **MAHB vs MAIB in 2012:168: 25.7 mm 3D mainly in the Up (25.2) for a tie vector of nearly 41 m 3D.**

- **ITRF2014 solutions**
  - **MAHB: 2001:189 - 2012:344 (one discontinuity in 2009:126 for beacon change)**
  - **MAIB: 2013:055 - 2014:362.**
  - **Same velocities for all the stations and all the epochs.**

- **ITRF2014 estimates the tie residual between (MAHB;1) and (MAIB;1) while the tie epoch suggests to use the second period of MAHB (MAHB;2).**

Then, the tie residual decreases to 4.2 mm 3D.

➔ **No problem with that site.**

MAIB

Summary and Conclusions

- **ITRF2014 gives access to 59 tie residuals at 42 DORIS sites.**
- **After deleting the residuals smaller than either the measured tie error or the ITRF2014 position errors, we end up with 21 tie residuals at 18 DORIS sites.**

- **No correlation between the tie residuals and the tie length, the tie epoch (➔ no correlation with the DORIS antenna type), the time interval between the stations and the duration of the observations.**

- **The 5 most questionable residuals have different origins:**
  - **The SAA impact on some DORIS missions such as Jason-2 (ex: Cachoeira).**
  - **Use of the wrong solution epoch in the ITRF2014 estimation of the tie residual (ex: Mahé).**
  - **Position of the 2GHz phase center wrt the antenna reference point.**
  - **Use of inappropriate measured ties (ex: Kitab).**
  - **Very long distance (larger than 1 km) between the two DORIS stations (ex: Nouméa).**