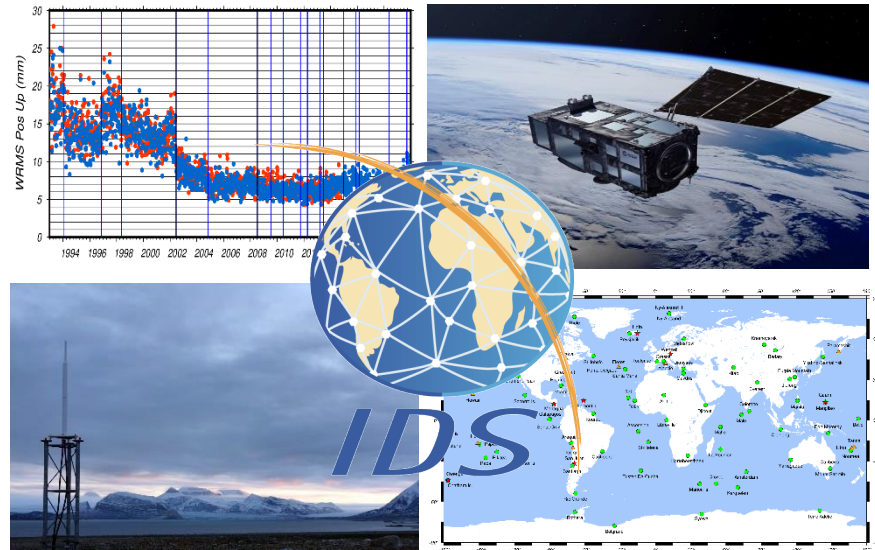
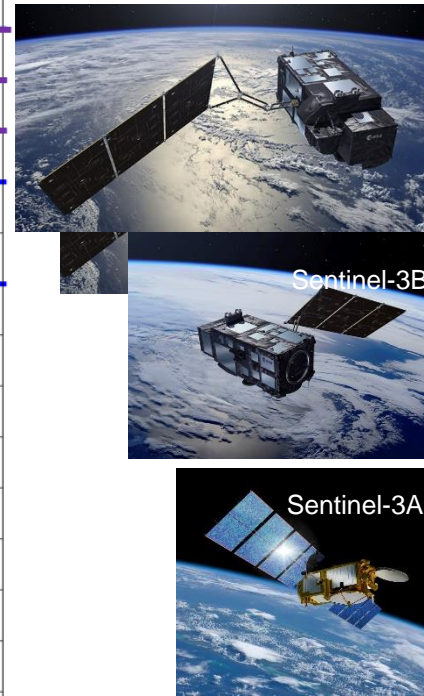
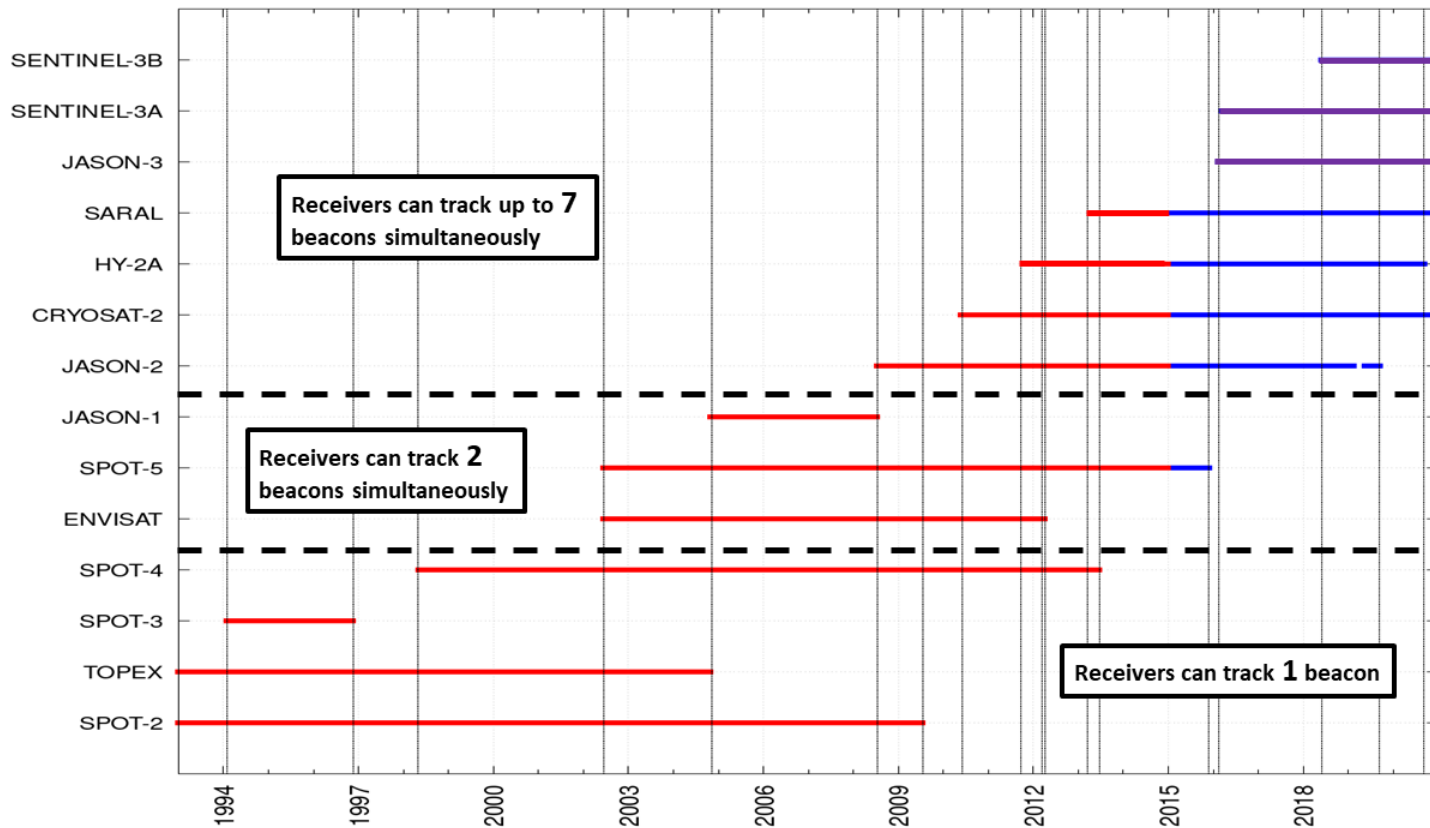


IDS Processing for ITRF2020 and Beyond

Guilhem Moreaux (CLS)
Frank Lemoine (NASA)





Since 1993:

- There have been a total of 14 DORIS missions.
- Between 2 to 7 missions have flown simultaneously.

Almost every mission is unique. (e.g. *shape, macromodel, attitude law, availability of ancillary data*).

Satellites have used 3 orbital planes (66° , 92° , 98.6°).



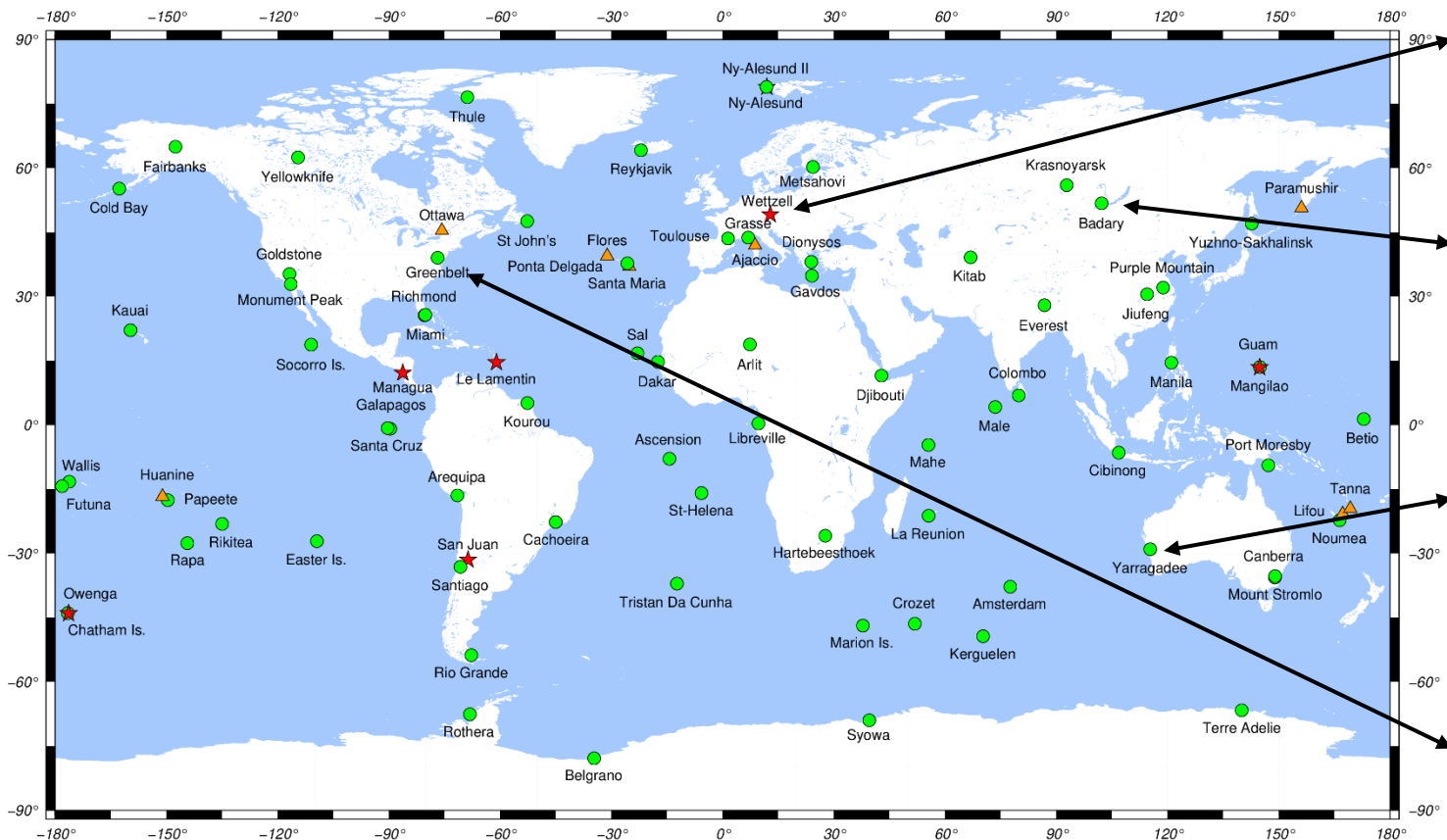
The IDS contribution to ITRF2020 is based on 4 solutions from 4 different software packages.

AC	Software	Series number	Solution Type	Time Span	EOPs
ESA	NAPEOS	11	NEQ	1993.0-2021.0	Motion+rate+LOD
GOP	BERNESE	65	COV	1993.0-2021.0	Motion+rate
GRG	GINN-DYNAMO	42	COV	1993.0-2021.0	Motion
GSC	GEODYN	40	NEQ	1993.0-2021.0	Motion
IDS	CATREF	15	COV	1993.0-2021.0	Motion

- IERS Standards applied (new mean pole model, Desai & Sibois HF tidal EOP model...).**
- + Use of DORIS RINEX data (format associated with DGXX receivers).**
- + New phase center ALCATEL antennae corrections.**
- + Precise SPOT-5 solar panel angle values.**
- + South Atlantic Anomaly mitigation strategies for SPOT-5, Jason-1/2/3, Sentinel-3A/B.**
- + Improvements to Radiation-pressure modelling for DORIS satellites.**
- + Use updated GOCE+GRACE gravity models for POD compared to ITRF2014.**
- + Corrected DORIS satellite offsets for HY-2A & SARAL.**

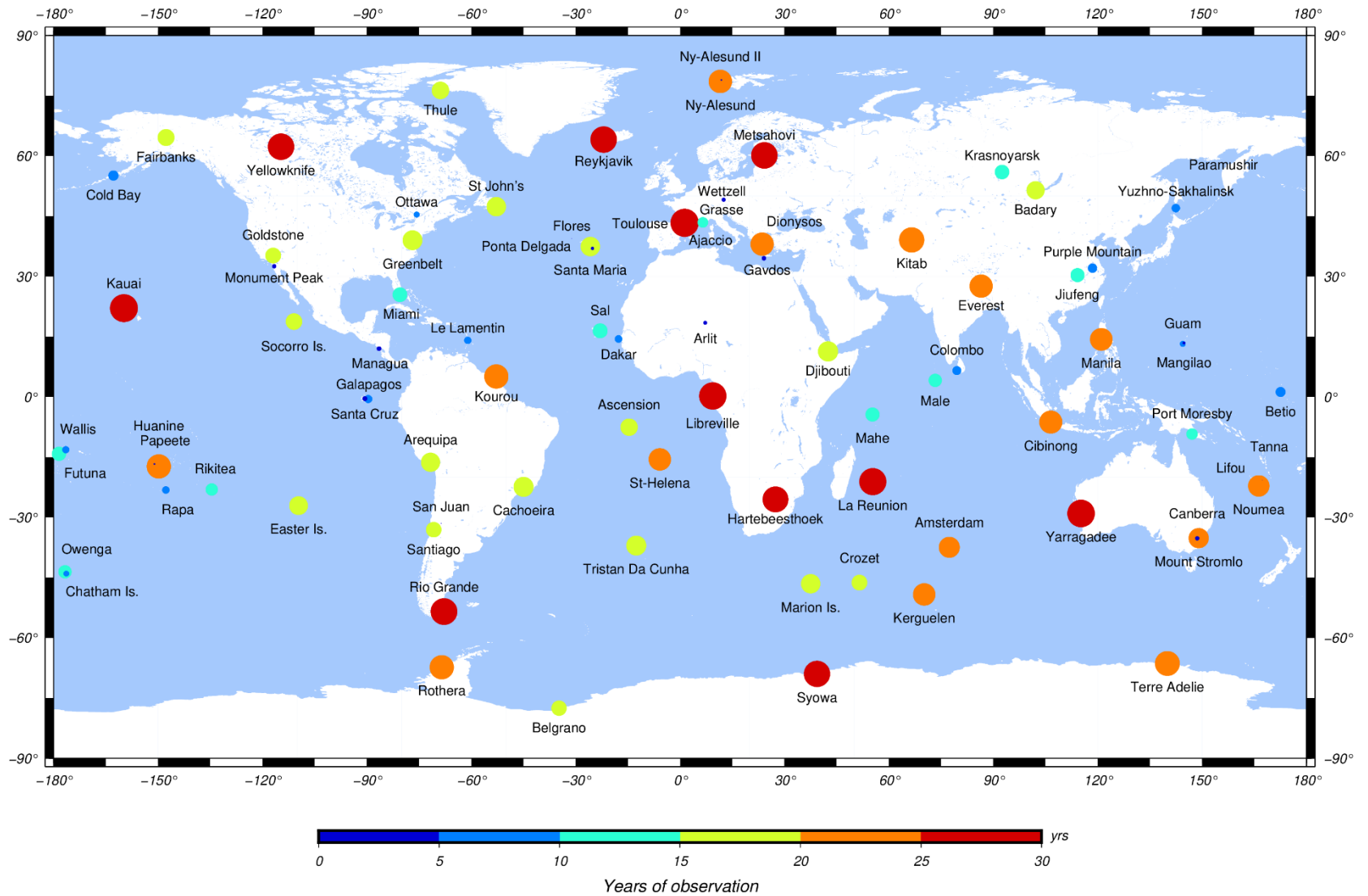


The IDS ITRF2020 network



**Very homogeneous geographical distribution over time.
Contains 201 stations @ 87 sites including four 4-Technique sites.
57 sites are co-located with at least one other IERS technique.**



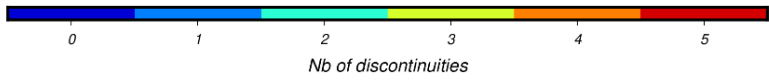
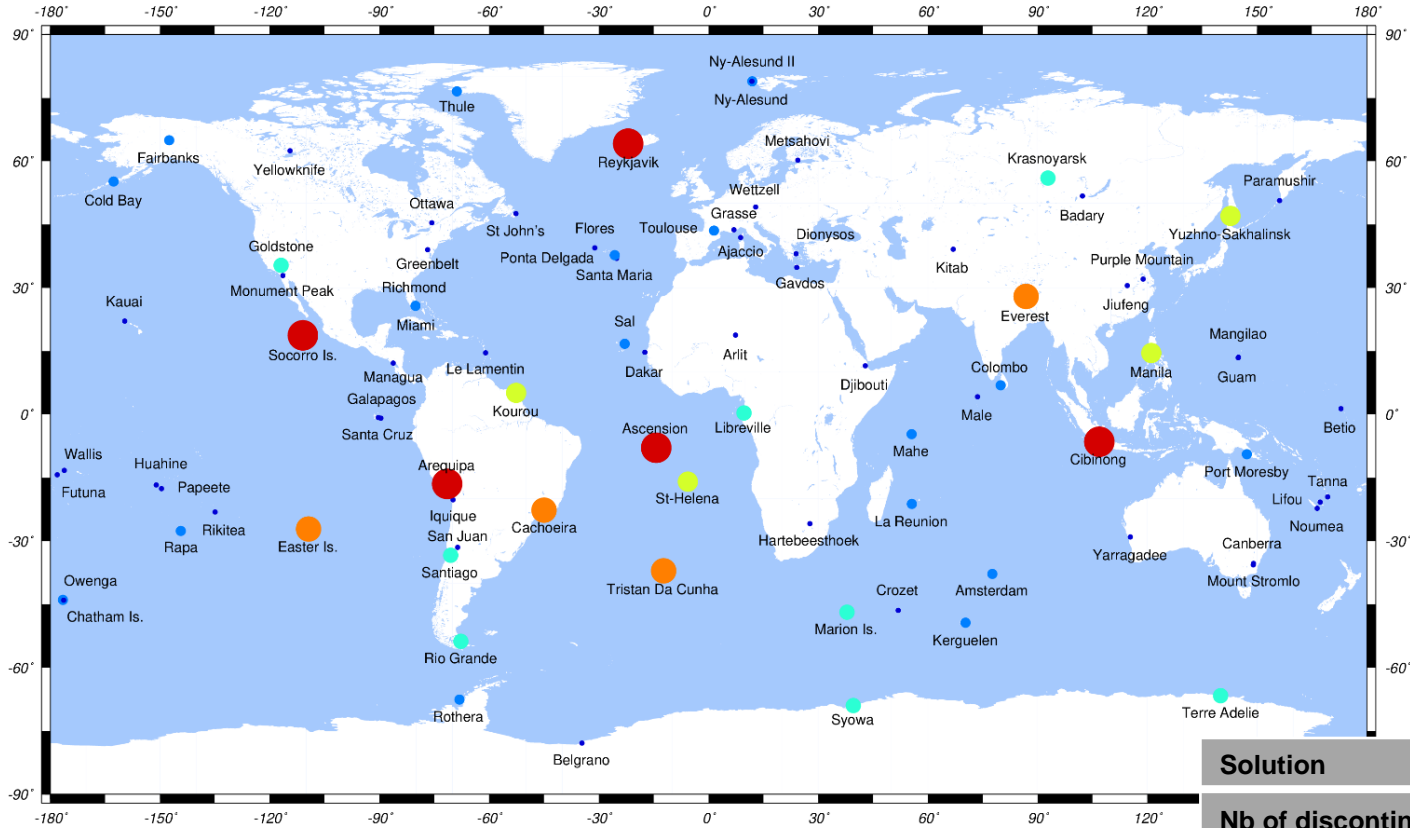


The IDS ITRF2020 solution includes 26 sites (30%) with more than 20 years of observation.



Nearly half of the ITRF2020 discontinuities are due to Earthquakes.

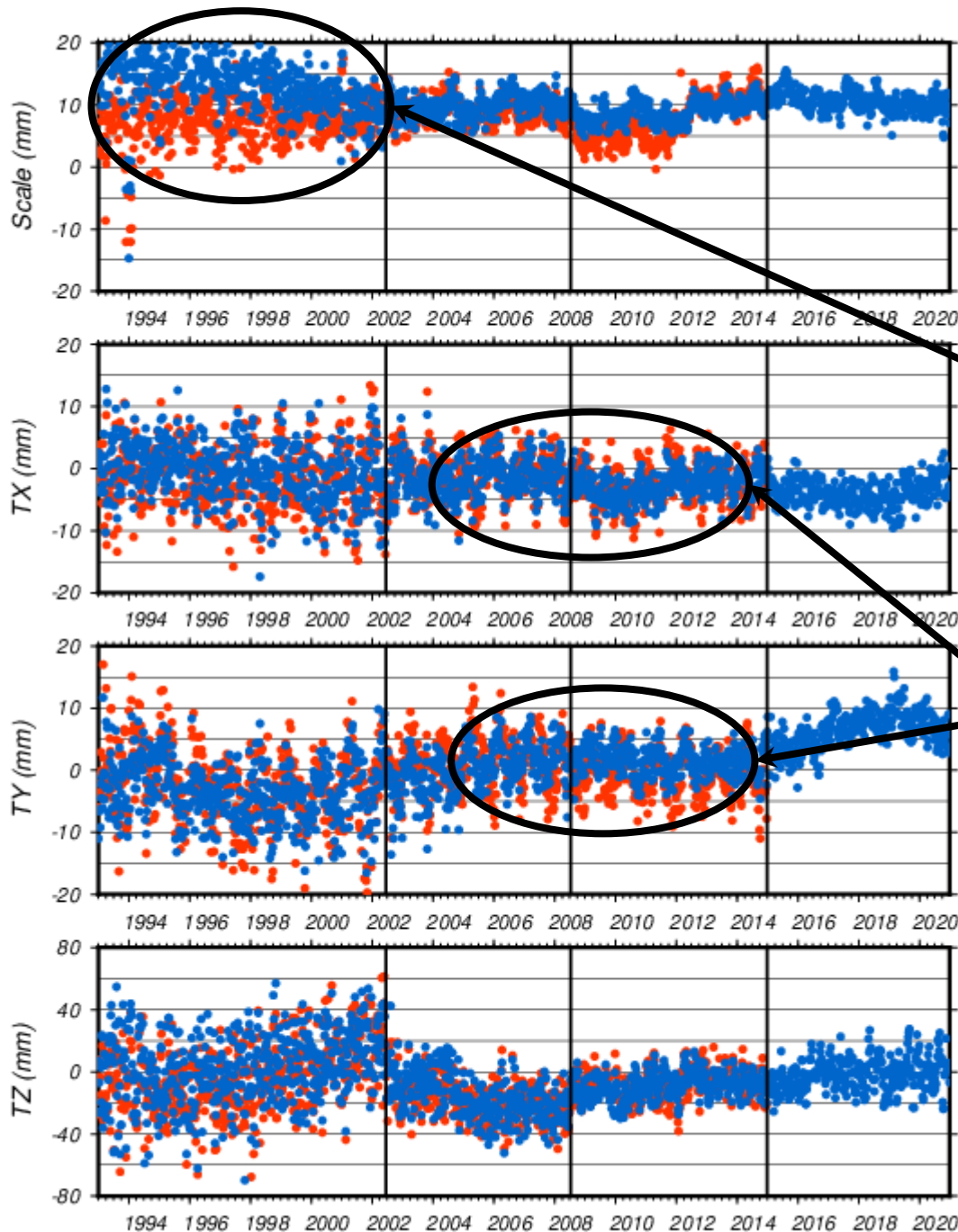
49 of the 87 sites are free of any discontinuity.



Solution	ITRF2020
Nb of discontinuities	89
Nb of seismic discontinuities	44
Nb of technical discontinuities	15
Nb of unknown discontinuities	30

Origin and scale wrt ITRF2014

ids 09 (ITRF2014) – ids 16 (ITRF2020)
Time period: 1993.0-2021.0

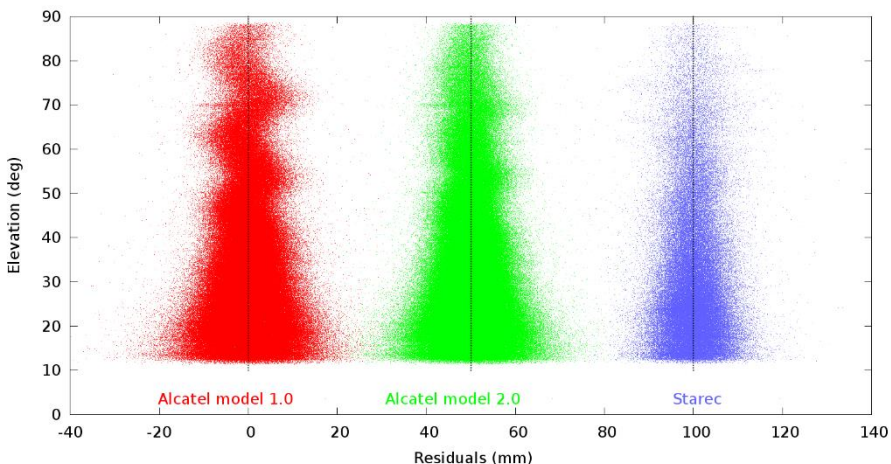


Scale difference until 2002.5

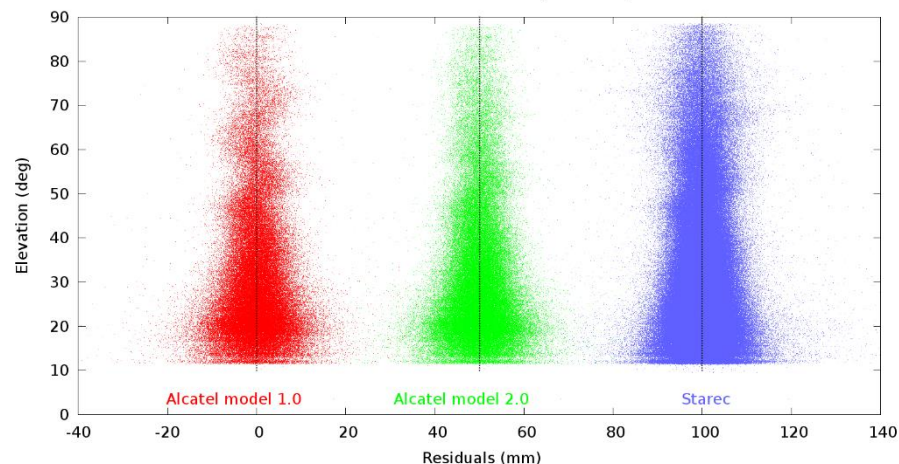
IDS-ITRF2020 includes a better modelling of non-conservative forces (radiation pressure) on Jason-1/2/3 satellites to diminish the 118-day draconitic signal.

DORIS Alcatel Antenna: Evaluation of Phase Center Models

SPOT-2 residuals from 1994 (ascending)



SPOT-2 residuals from 2003 (ascending)



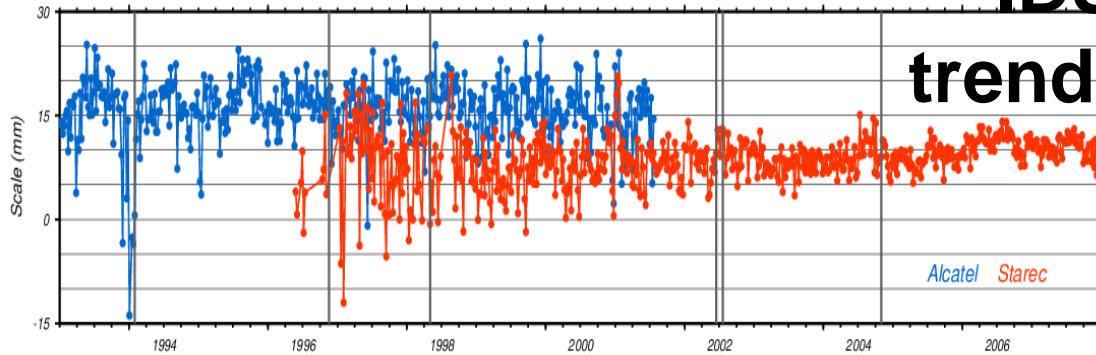
Legend: **Alcatel Model 1.0** **Alcatel Model 2.0** **Starec**

SPOT-2 residuals as a function of elevation, sorted by antenna model. Ascending observations only. Results for years 1994 and 2003. The values for the Alcatel model 2.0 are shifted by 50 mm and for the Starec by 100 mm.

From: Štěpánek and Filler, 2022, Adv. Space Res., doi: 10.1016/j.asr.2022.02.024

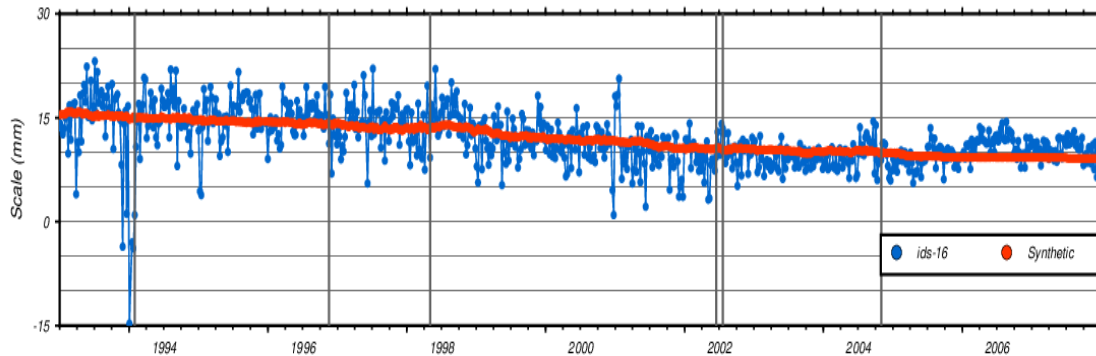
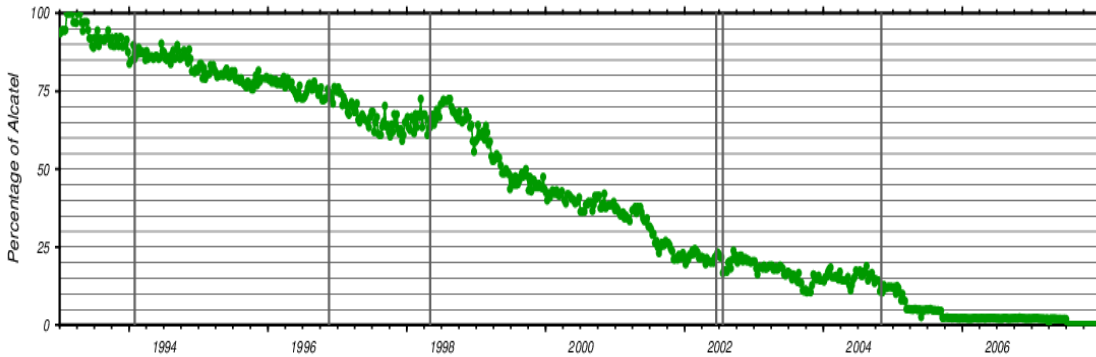
New **Alcatel 2.0 Phase Center** model (*from CNES anechoic chamber measurements*) used for ITRF2020 is clear improvement over prior model used for ITRF2014. Reference offset position for new PCO model may need to be checked (next slide)

IDS 16 ITRF2014 scale trend from 1993.0 to 2002.5



Alcatel = IDS 16 with only Alcatel antennas
Starec = IDS 16 with only Starec antennas

Mean Alcatel scale = 15.85 mm
Mean Starec scale = 9.12 mm



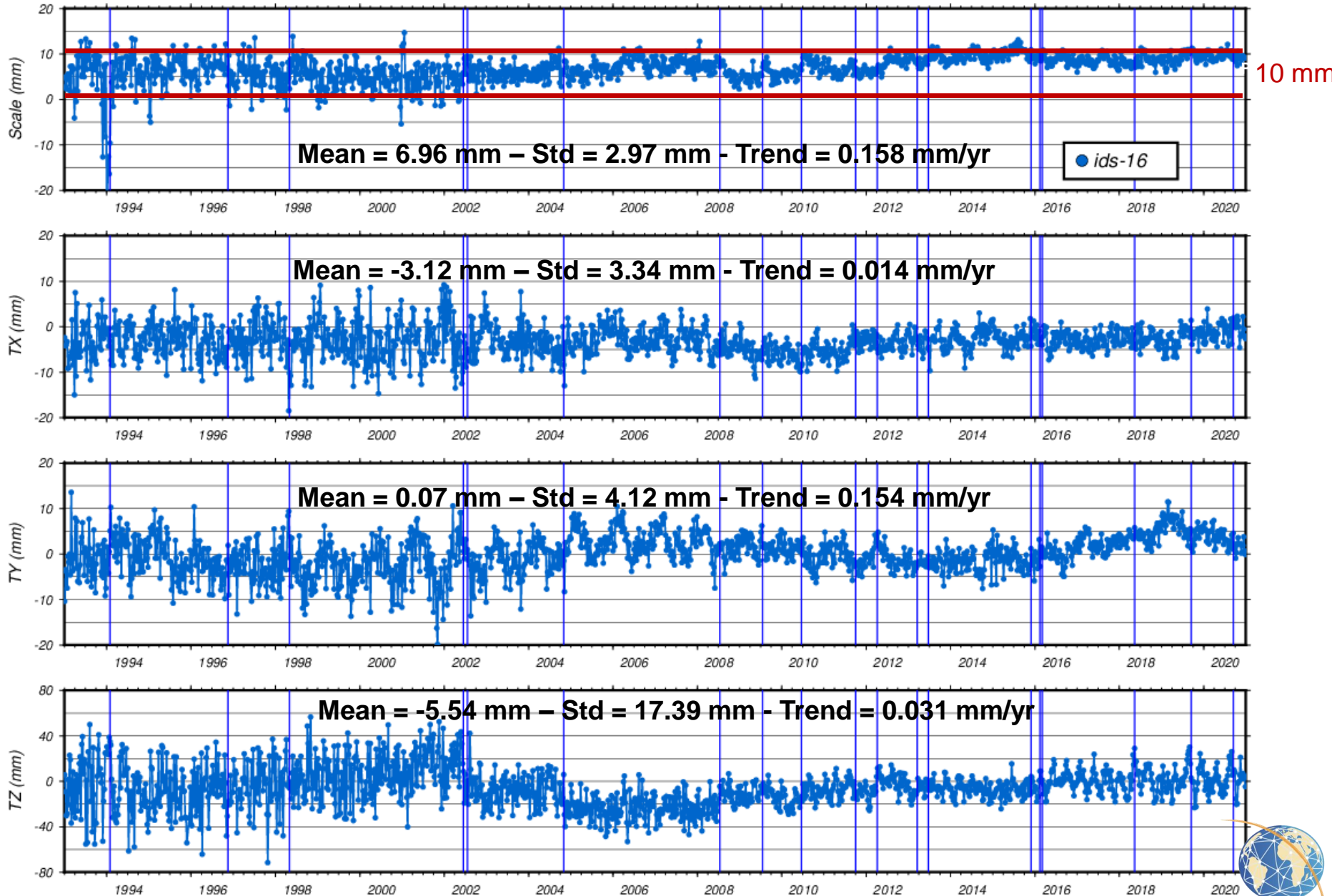
Synthetic =
Alcatel scale x perc + Starec scale x (1 - perc)

Good agreement between the true and synthetic IDS 16 scales

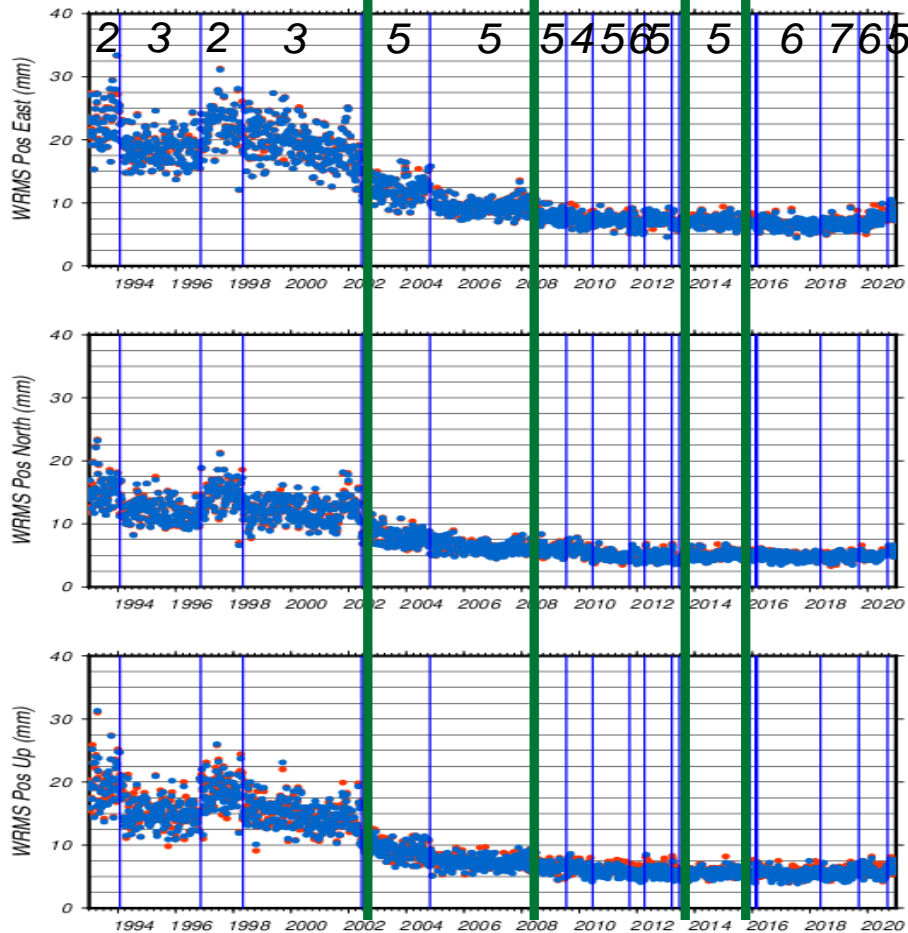
IDS 16 ITRF2014 scale trend from 1993.0 to 2002.5 is the consequence of the new Alcatel PCV and gradual replacement over time of the Alcatel antennas.



IDS 16 ITRF2020 Helmert Parameters



Generation of DORIS receiver



IDS 16 ITRF2020 Station Position Residuals

		WRMS [mm]
1993.0-2002.5	East	19.9 ± 3.3
	North	12.7 ± 2.3
	Up	16.0 ± 3.1
2002.5-2008.5	East	10.5 ± 1.0
	North	7.0 ± 1.3
	Up	8.2 ± 1.5
2008.5-2015.9	East	7.3 ± 0.9
	North	5.3 ± 0.8
	Up	6.1 ± 0.8
2015.9-2021.0	East	6.9 ± 0.9
	North	5.0 ± 0.6
	Up	5.8 ± 0.8

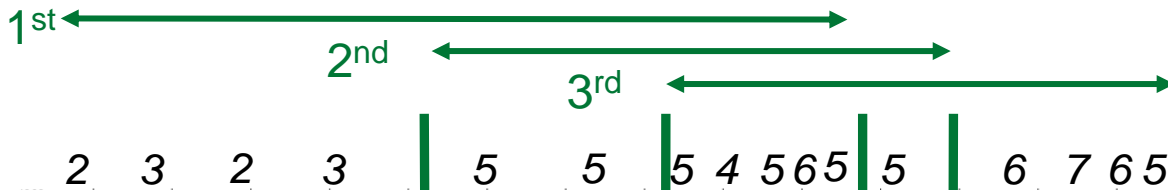
Results improved:

- when more satellites are available
- with the evolution of DORIS receiver capabilities.

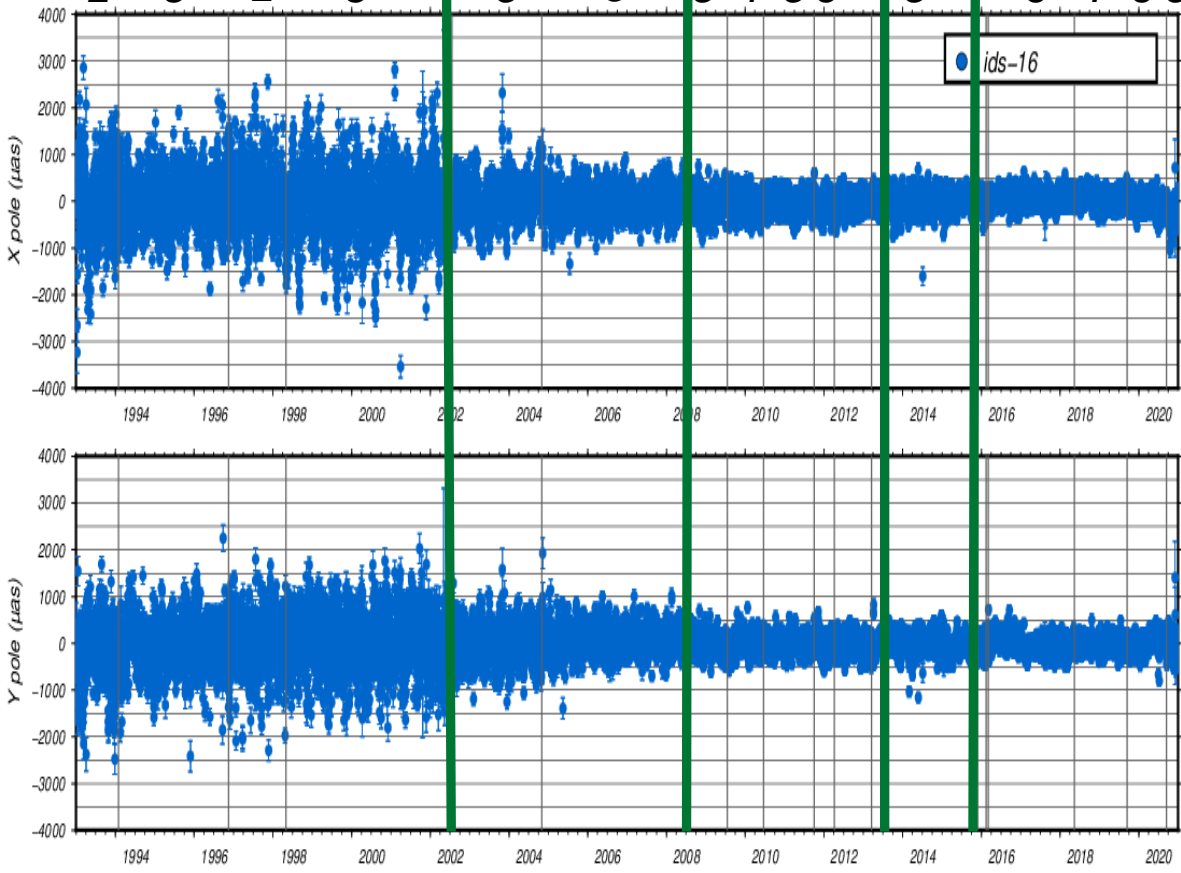
ENU WRMS below 7.5 mm since mid-2008.



Generation of DORIS receiver



IDS 16 ITRF2020 EOPs wrt IERS C04



	Std ΔX [μas]	Std ΔY [μas]
1993.0-2002.5	664	588
2002.5-2008.5	331	321
2008.5-2015.9	204	191
2015.9-2021.0	198	171

**Results improved with the evolution of DORIS receiver capabilities.
STD of differences with IERS C04 below 200 μas since mid-2008.**





Lessons from the ITRF2020 Processing

- Extension of the long DORIS history for 26 sites.
- Improve the evaluation/validation of the DORIS ground antenna PCV.
- Use of quaternions for both bus and solar panels helps to reduce presence of draconitic signals
 - ➔ **IDS request to the space agencies for quaternion release.**
- Evaluation of the single-satellite solutions allow to reduce the discrepancies between the ACs and so the IDS origin and scale
 - ➔ **To be continued.**
- **Possible improvements for ITRF202X:**
 - Second order ionospheric correction.
 - Satellite antenna PCV.
 - Better modelling of satellite oscillators.
 - More AC contributions (IGN, INASAN, GFZ...).

