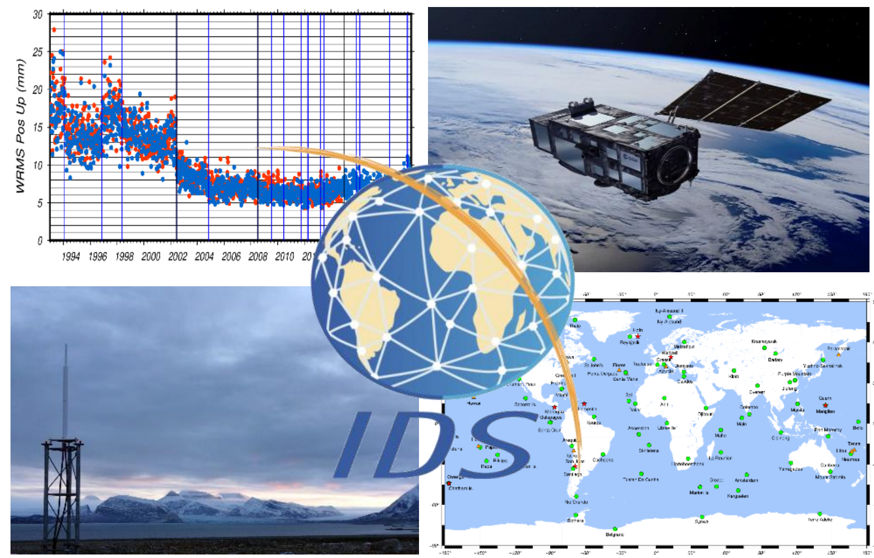
Evaluation of the ITRF2020-u2024 by the IDS Combination Center



Guilhem Moreaux
Collecte Localisation Satellites

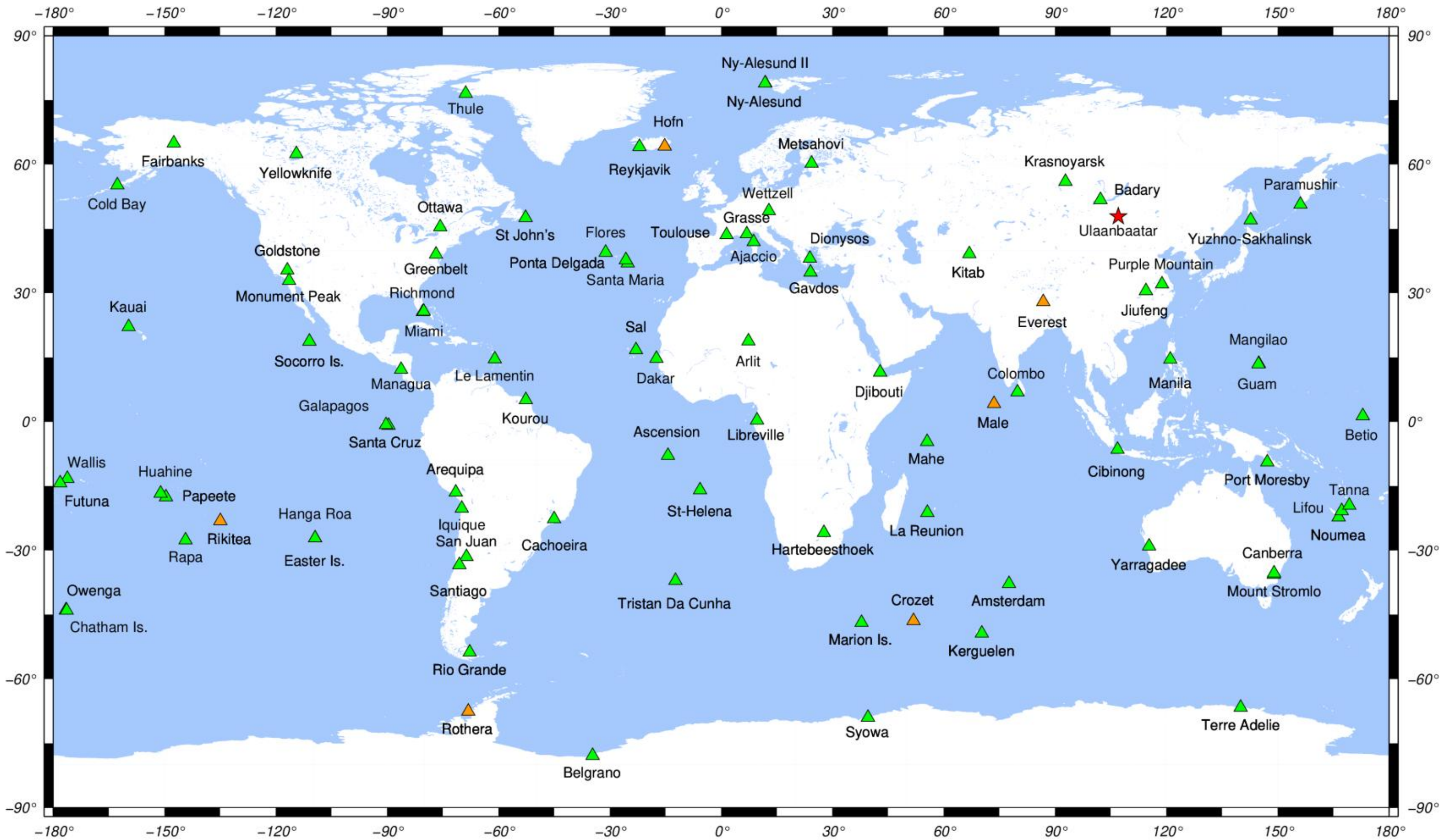
IDS AWG 2025 – Athens (Greece) – 2025/11/06

ITRF2020-u2024 vs ITRF2020-u2023

	ITRF2020-u2024	ITRF2020-u2023
Number of stations	222	215
Number of sites	90	89
Total Number of discontinuities	103	99
Nb of discontinuities from Earthquakes	45	43
Nb of discontinuities from the Technique	20	19
Nb of stations/sites with discont.	62 @ 45	60 @ 43
Number of positions/velocities	322	311
Number of different velocities*	104	111
Sites with PSD corrections	8	8

* Velocities which differ by more than 0.01mm/s

ITRF2020-u2024 DORIS Network

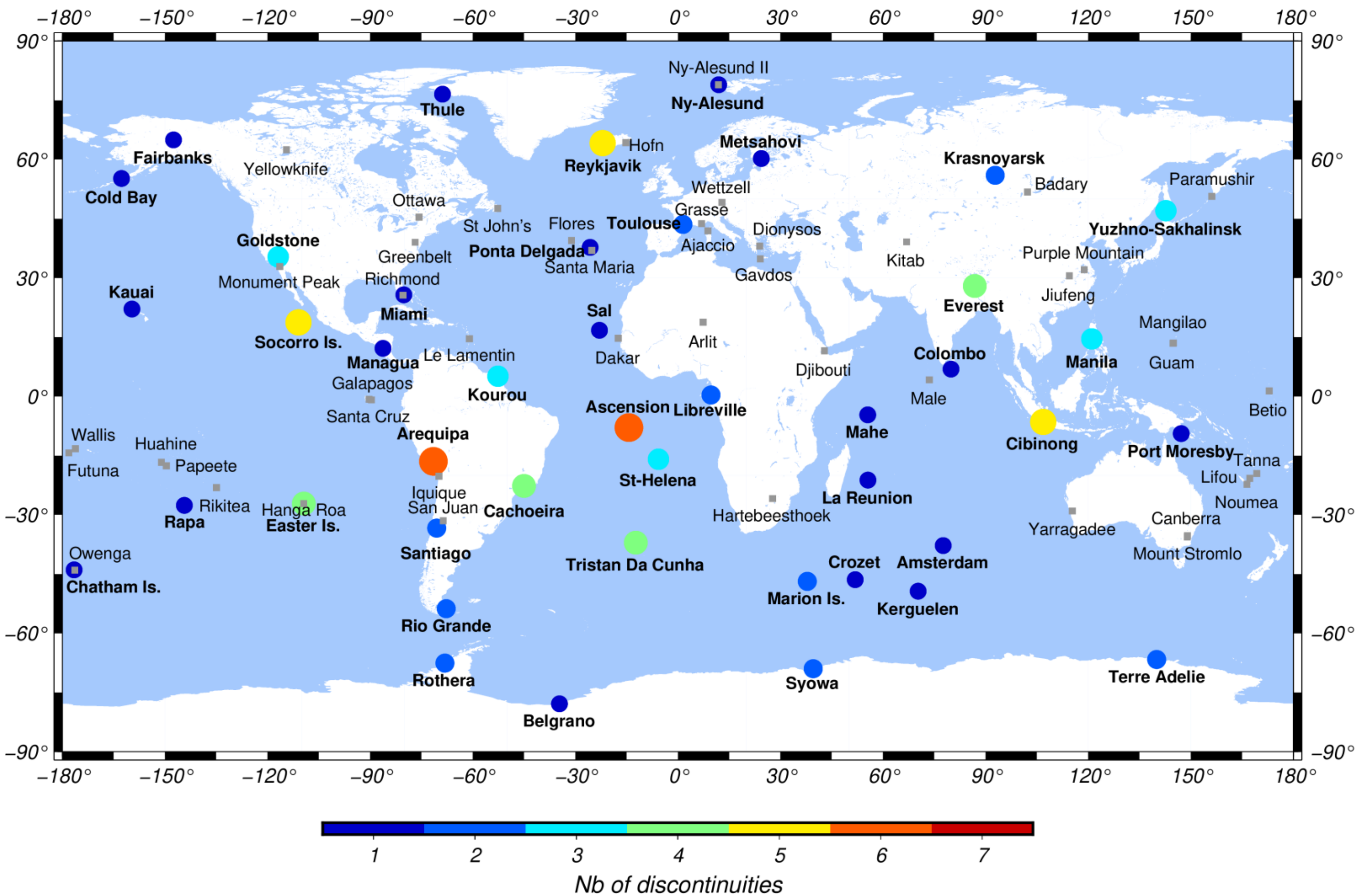


Site with no new beacon since ITRF2020-u2023.

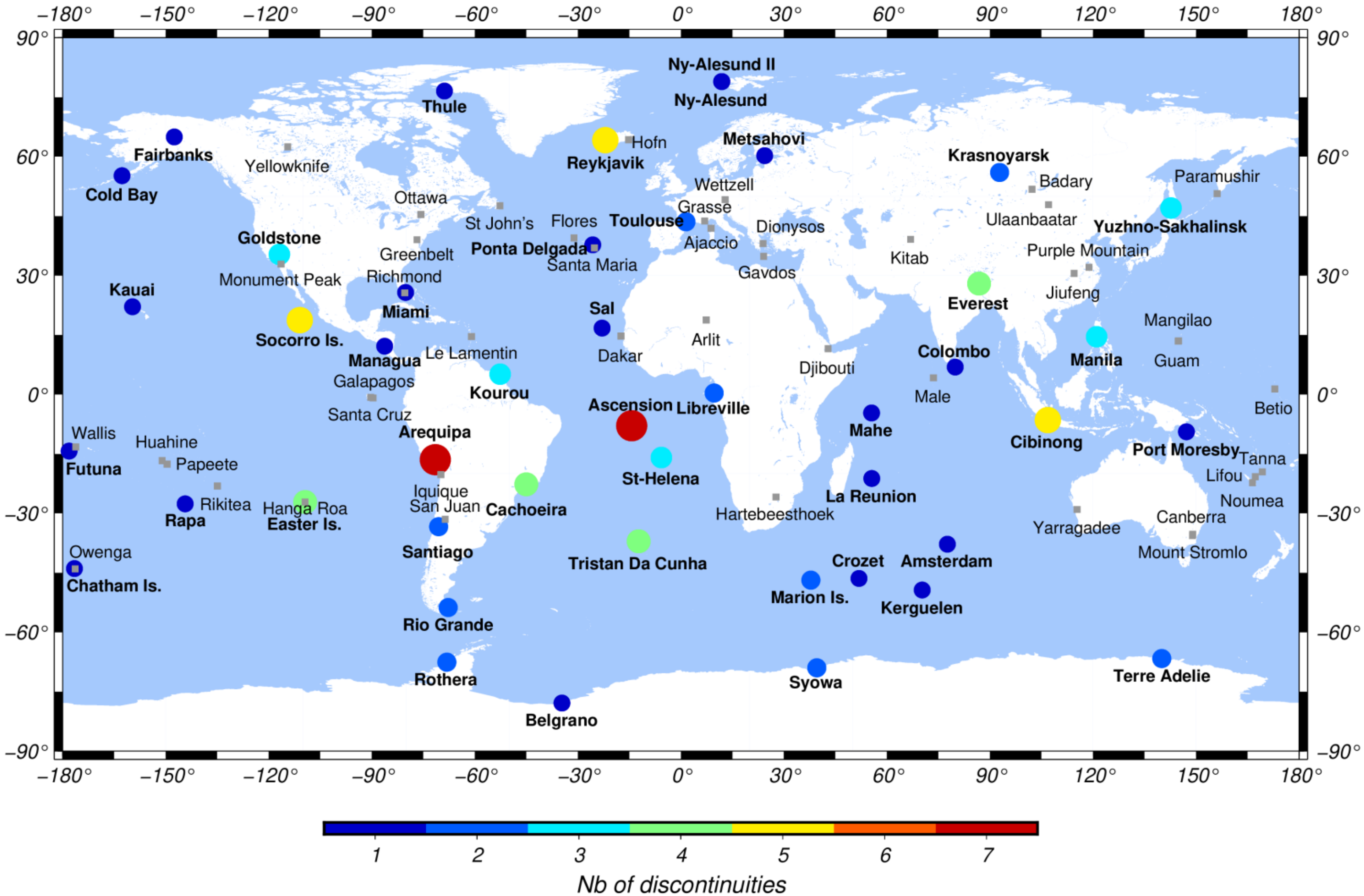
Site with new beacon(s) since ITRF2020-u2023.

New site since ITRF2020-u2023 (Ulaanbaatar).

ITRF2020-u2023 DORIS Discontinuities



ITRF2020-u2024 DORIS Discontinuities



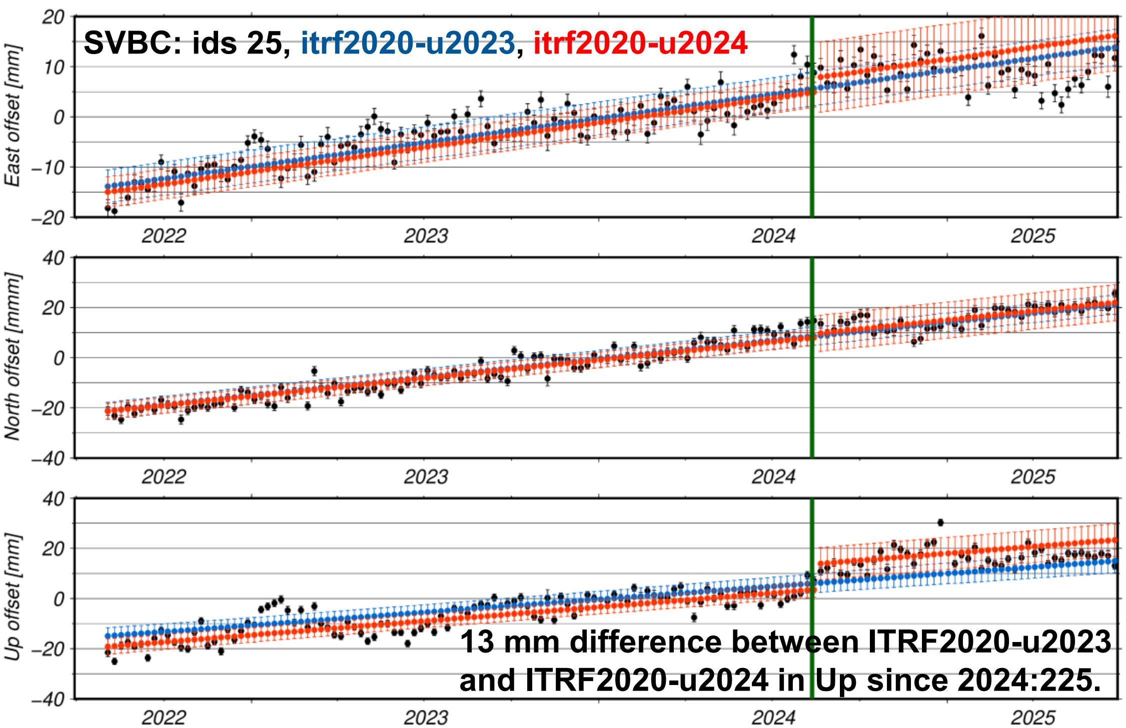
ITRF2020-u2024 vs ITRF2020-u2023 Discontinuities

Station	Date	Comments
ARFB	22:146:43341	Earthquake
ASDB	05:010:00000	Data gap
FUTB	06:123:55600	Earthquake
SVBC	24:225:00000	Unknown origin (intense ice melting?)

Three new discontinuities during ITRF2020-u2023 time span, i.e. before 2024.0.

ITRF2020-u2024
New Svalbard Discontinuities in 2024/08

Frank Lemoine found a paper which dealt with a higher ice melting rate in Svalbard during summer 2024.
doi: 10.1073/pnas.2503806122




PNAS RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES OPEN ACCESS

Svalbard's 2024 record summer: An early view of Arctic glacier meltdown?

Thomas Vikhamar Schuler[a,1], Rasmus Emil Benestad[b], Ketil Isaksen[b], Halfdan Pascal Kierulf[c], Jack Kohler[d], Geir Moholdt[d], and Louise Steffensen Schmidt[a]

Edited by Eric Rignot, University of California Irvine, Irvine, CA; received February 18, 2025; accepted June 28, 2025

A record-breaking melt season affected the Arctic glaciers of Svalbard in summer 2024 by a substantial margin. Across the entire archipelago, glacier melting corresponded to an anomaly of up to four SD and exceeded any previous observation. The pan-Svalbard mass loss in summer 2024 amounts to ~61.7 ± 11.1 Gt and corresponds to 1% of the total ice volume on Svalbard and is comparable to that of the Greenland ice sheet (55 ± 35 Gt), which occupies an area about 50 times larger. Altogether, Svalbard and other glacier regions surrounding the Barents Sea lost 102.1 ± 22.9 Gt of ice in a single year and contributed 0.27 ± 0.06 mm (of which 0.16 mm alone is due to Svalbard) to global sea-level, putting the circum-Barents region among the strongest contributors to global sea-level rise in 2024. Most of the 2024 glacier melt occurred during a 6-wk period of persistent atmospheric circulation pattern causing record-high air temperatures, an event with an extremely low recurrence interval under current climate conditions. However, future climate projections suggest that such temperature levels will become increasingly commonplace by the end of the 21st century, potentially even surpassing those of 2024. Svalbard's summer of 2024 serves as a forecast for future glacier meltdown in the Arctic, offering a glimpse into conditions 70 y ahead.

Arctic land ice | climate change | sea-level rise

The accelerated warming of the Arctic causes widespread glacier mass loss, contributing to global sea-level rise (1, 2) and having potential implications for large-scale ocean circulation like the Atlantic Meridional Overturning Circulation (3, 4). Regionally, glacier melt impacts fjord circulation (5, 6), marine ecology (7, 8), as well as related wildlife and local communities. The majority of the world's land ice mass, outside the ice sheets, resides in the Arctic, of which less than 10% is in Svalbard (1). Despite a much smaller glacierized area, the sea-level rise contribution of Svalbard in 2024 was comparable to that of the entire Greenland ice sheet (9). Here, we quantify the record mass loss during summer 2024, which corresponds to about 1% of the total ice volume on Svalbard (10), significantly exceeding any previous estimates (11). Most of the record melting happened over 6 wk of persistently high air temperatures, a statistically rare situation for current climate conditions. However, our study shows that 2024 summer temperatures will be frequently reached in just a few decades and exceeded toward the end of the 21st century. The summer of 2024 on Svalbard thus provided a window into Arctic glacier meltdown in a warmer future, highlighting the severe mass loss of glaciers and its repercussions in other regions of the Arctic beyond Svalbard.

Glacier Mass Balance 2024

The High-Arctic archipelago of Svalbard (Fig. 1*E*) is recognized as especially exposed to rapid warming, with rates above the already elevated Arctic temperature increase (12). This implies increased mass loss from glaciers (11, 13) that occupy about 53% of the land surface (14). Due to the large area fraction with elevations close to the transition between ablation and accumulation areas, pushing this transition upward may cause major mass loss (15). The total mass balance (TMB) of a glacierized region responds to the exchange of mass and energy between the atmosphere and the glacier, as well as between the ocean and the submarine glacier fronts. The former is termed the climatic mass balance (CMB), and the latter is known as frontal ablation (FA), the sum of frontal melting and ice calving (16). CMB is typically monitored by in situ measurements at individual glaciers, whereas FA usually is determined from remotely sensed information. Ingesting atmospheric forcing, glacier–climate models can simulate the CMB over large spatial and temporal scales. Based on atmospheric reanalysis (17) and weather forecast data (18), the CryoGrid community model (19) computes CMB for all glaciers in

Significance

Affecting global sea-level rise, mass loss from Arctic glaciers has implications far beyond their geographical location and is relevant for related geosciences, as well as ecological and biosciences and the general public. Combining in situ observations, remote sensing, and modeling, we quantify the mass loss of all glaciers on Svalbard during the record-warm summer of 2024, that by far exceeds previous levels. Analyzing historic temperature records and projections of future climate, we find that temperature levels as in 2024 represent a rare situation for contemporary climate conditions but will be frequently reached in a few decades. We suggest that the summer of 2024 in Svalbard serves as an analogue for the widespread meltdown of Arctic glaciers in a warmer world.

Author affiliations: [a]Department of Geosciences, University of Oslo, Oslo NO-0316, Norway; [b]Climate and Environment Department, The Norwegian Meteorological Institute, Oslo NO-0313, Norway; [c]Geodetic Institute, Norwegian Mapping Authority, Hønefoss NO-3507, Norway; and [d]Glaciology and Geology Section, Norwegian Polar Institute, Tromsø NO-9296, Norway

Author contributions: T.V.S. designed research; T.V.S., R.E.B., K.I., J.K., G.M., and L.S.S. performed research; H.P.K. contributed new reagents/analytic tools; T.V.S., R.E.B., K.I., H.P.K., J.K., G.M., and L.S.S. analyzed data; and T.V.S., R.E.B., K.I., H.P.K., J.K., G.M., and L.S.S. wrote the paper.

The authors declare no competing interest.

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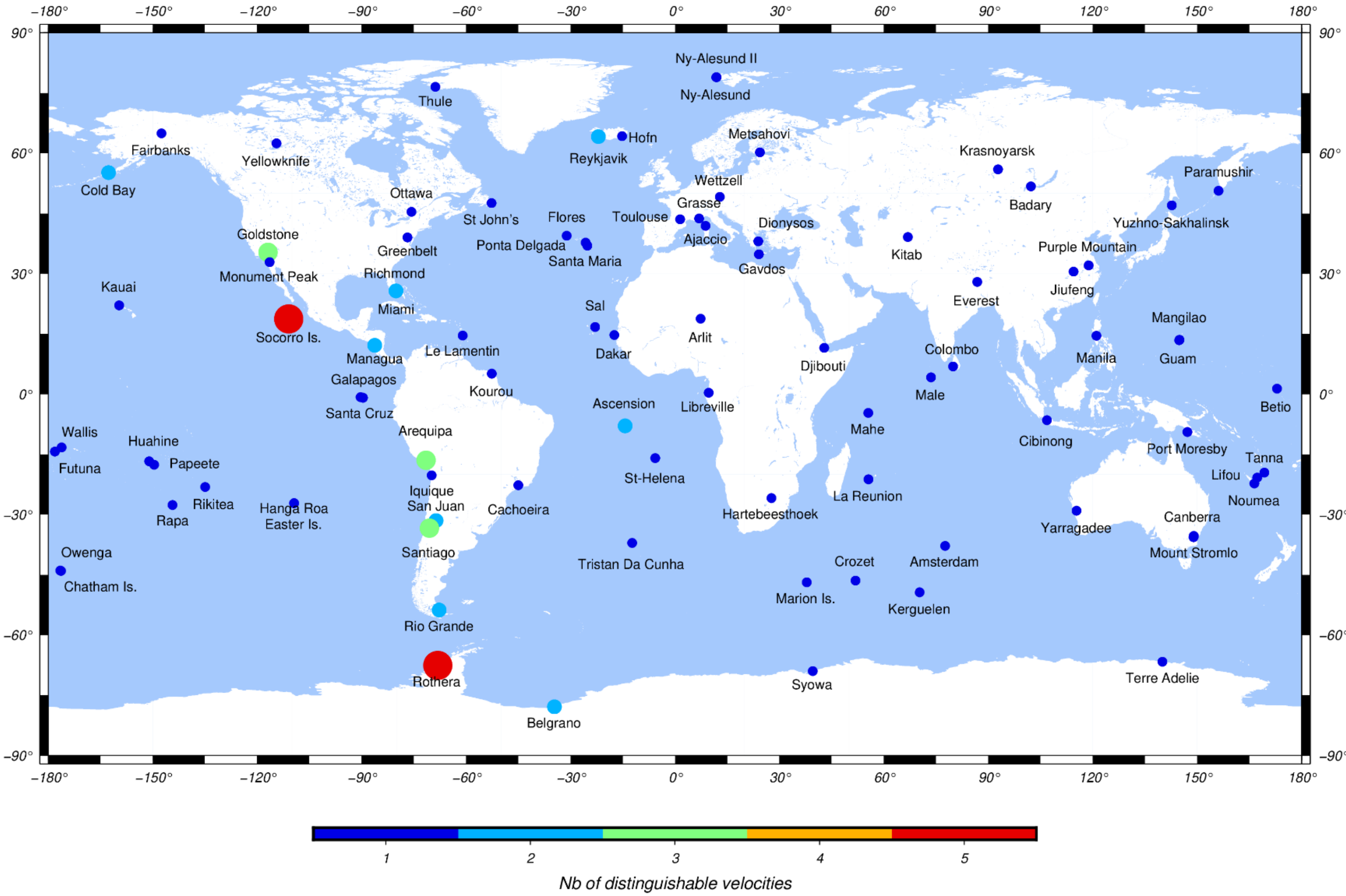
[1]To whom correspondence may be addressed. Email: t.v.schuler@geo.uio.no.

This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2503806122/-/DCSupplemental.

Published August 18, 2025.

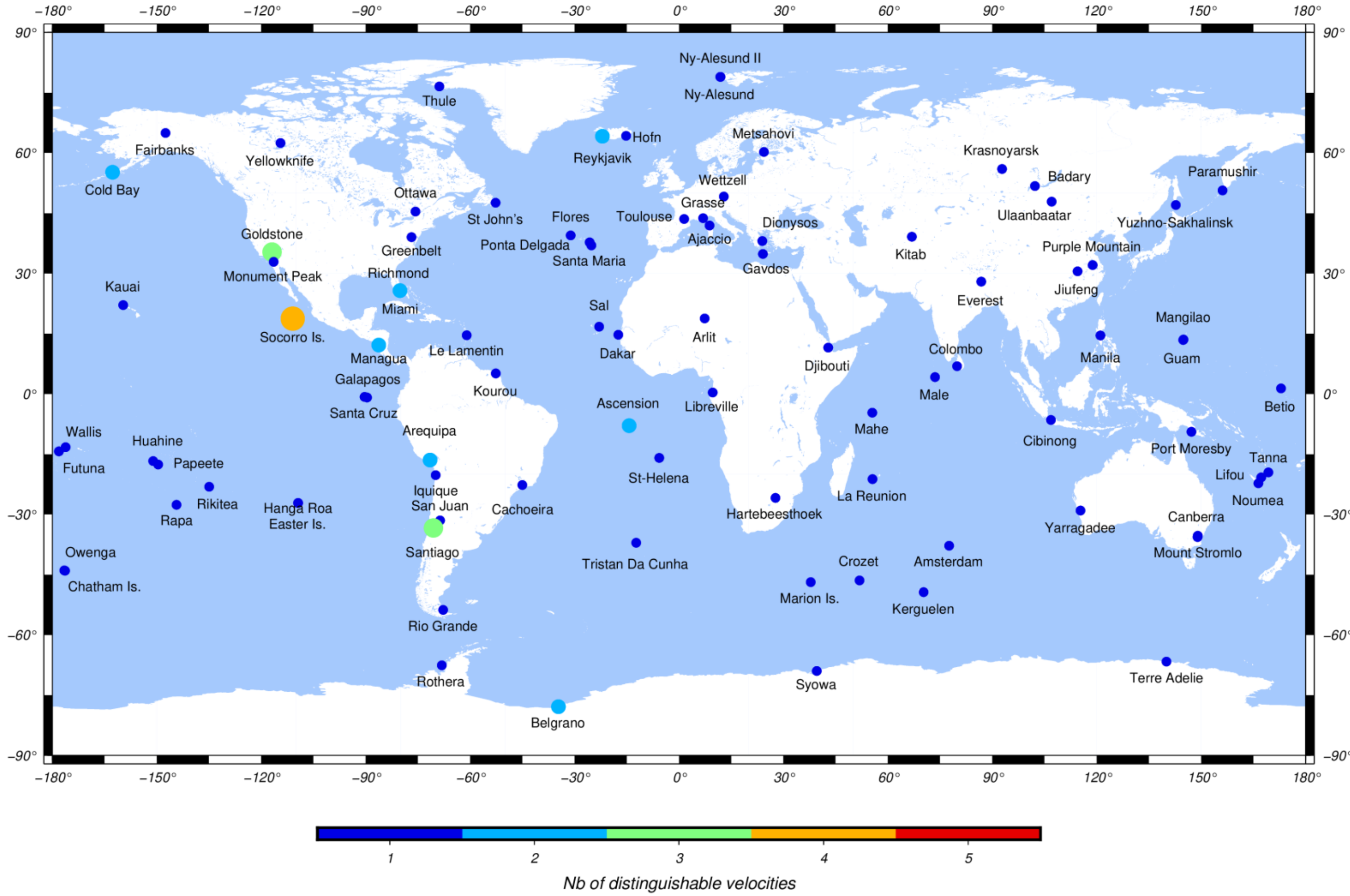
ITRF2020-u2023 Velocities

Number of velocities which differ by more than 0.01 mm/s

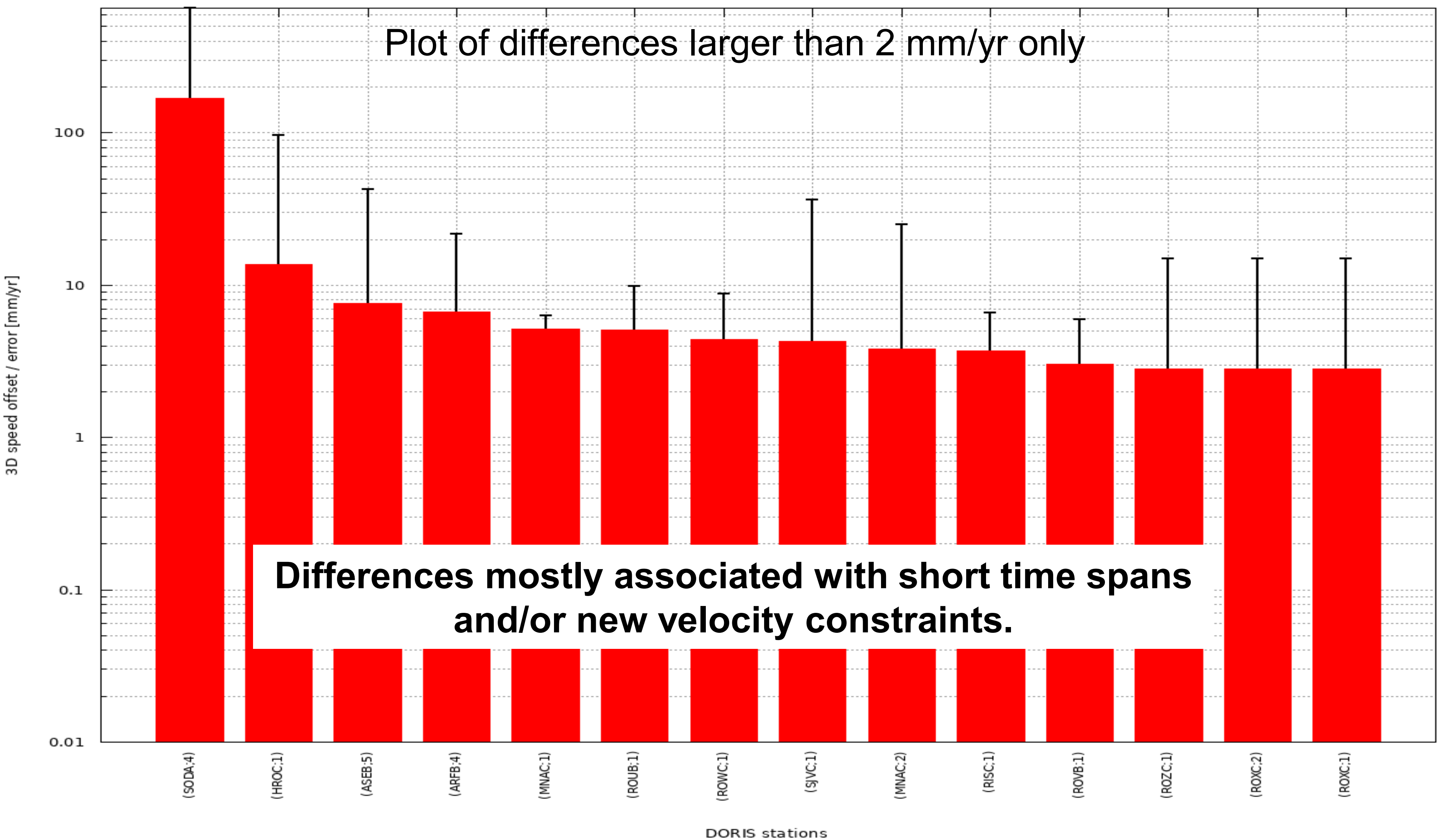


ITRF2020-u2024 Velocities

Number of velocities which differ by more than 0.01 mm/s

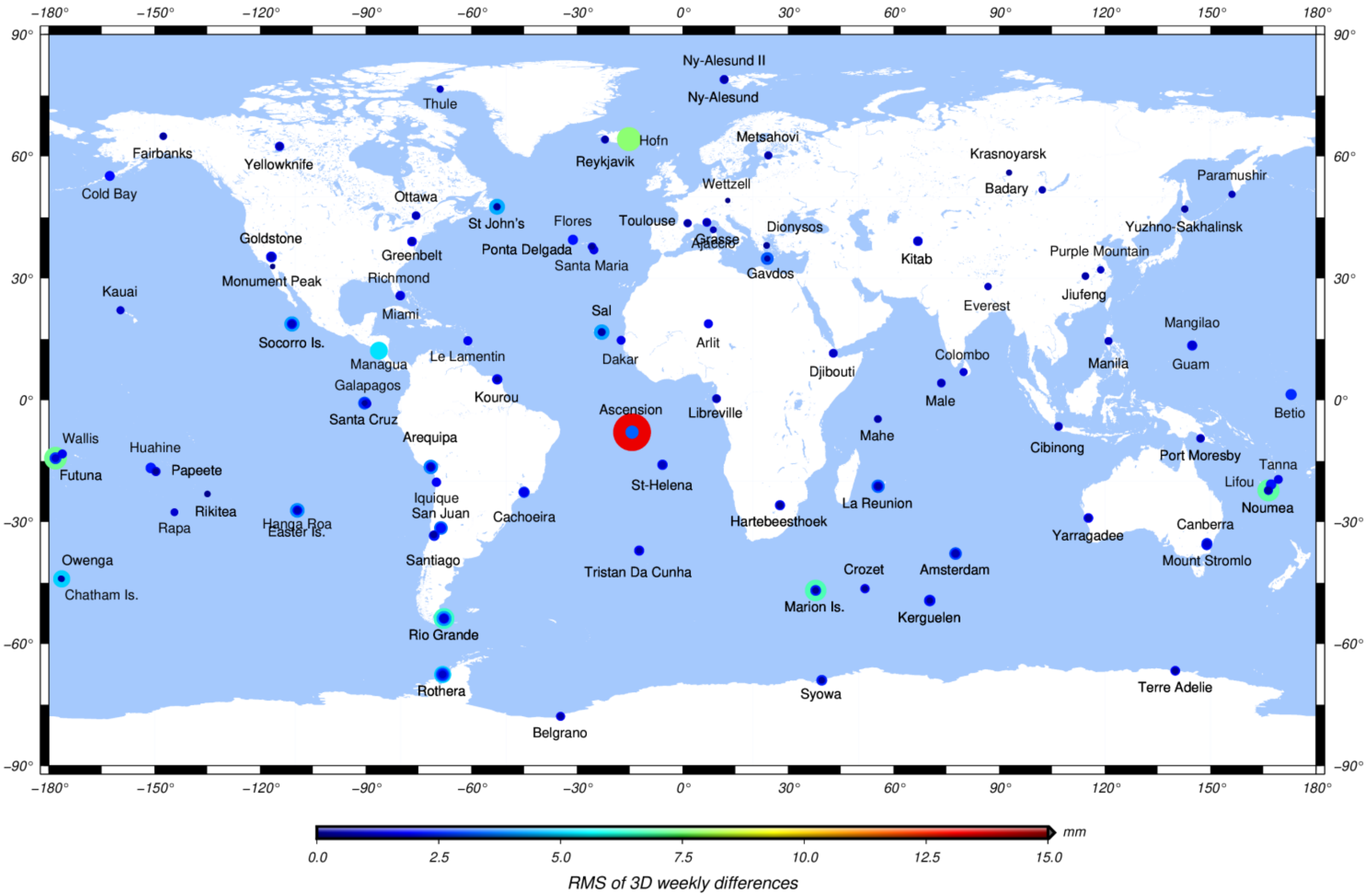


ITRF2020-u2024 vs ITRF2020-u2023 Velocity Differences

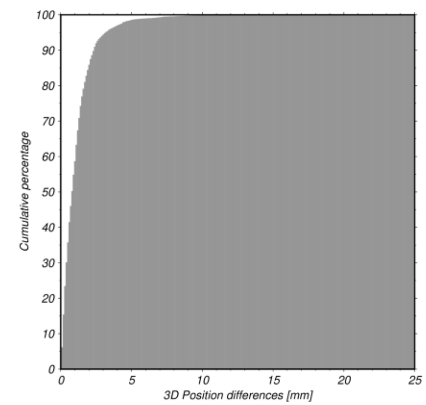


ITRF2020-u2024 vs ITRF2020-u2023 Position Differences

Weekly station position differences from 1993.0 to 2024.0

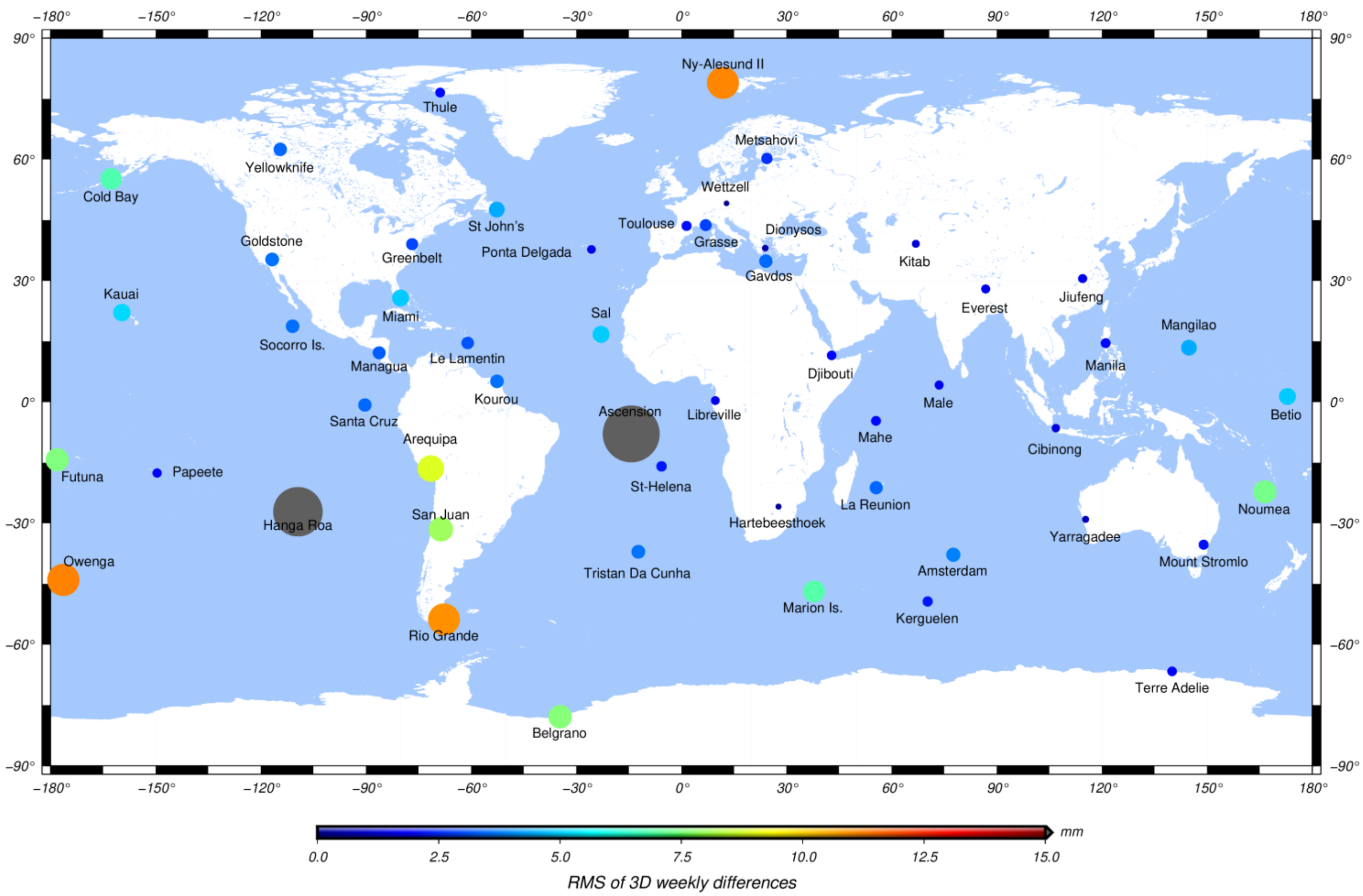


	[mm]
Max	**30.3**
Median	**0.8**
RMS	**2.0**
Mean	**1.2**
STD	**1.6**

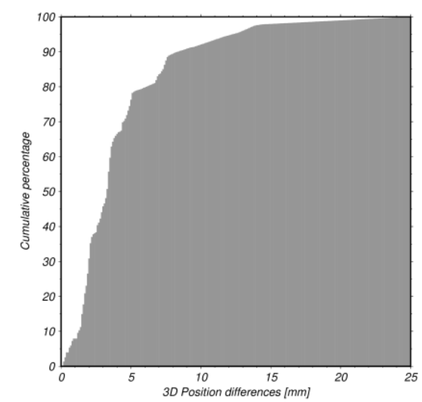


ITRF2020-u2024 vs ITRF2020-u2023 Position Differences

Weekly station position differences from 2024.0 to 2026.0

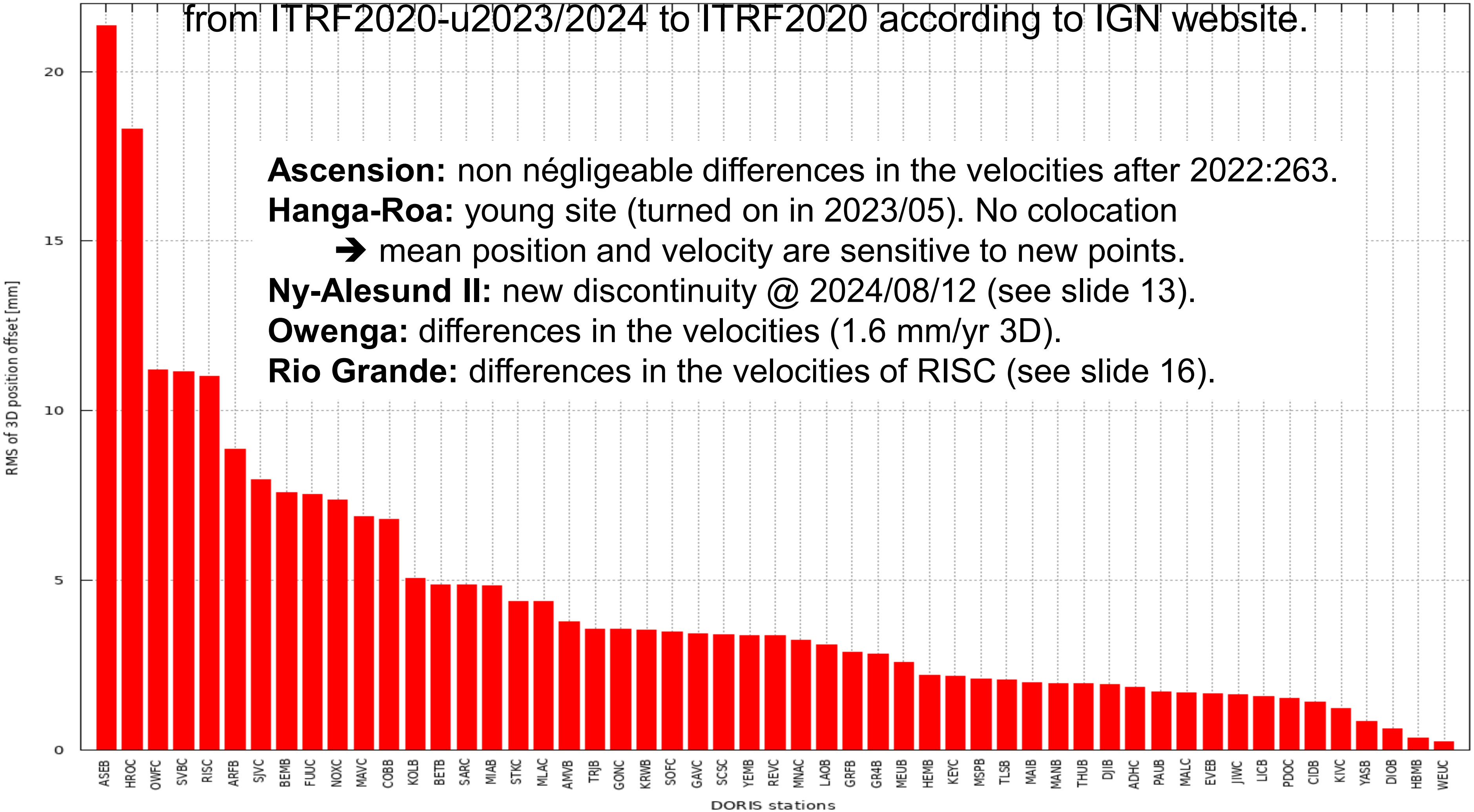


	[mm]
Max	**30.1**
Median	**3.3**
RMS	**6.1**
Mean	**4.4**
STD	**4.2**



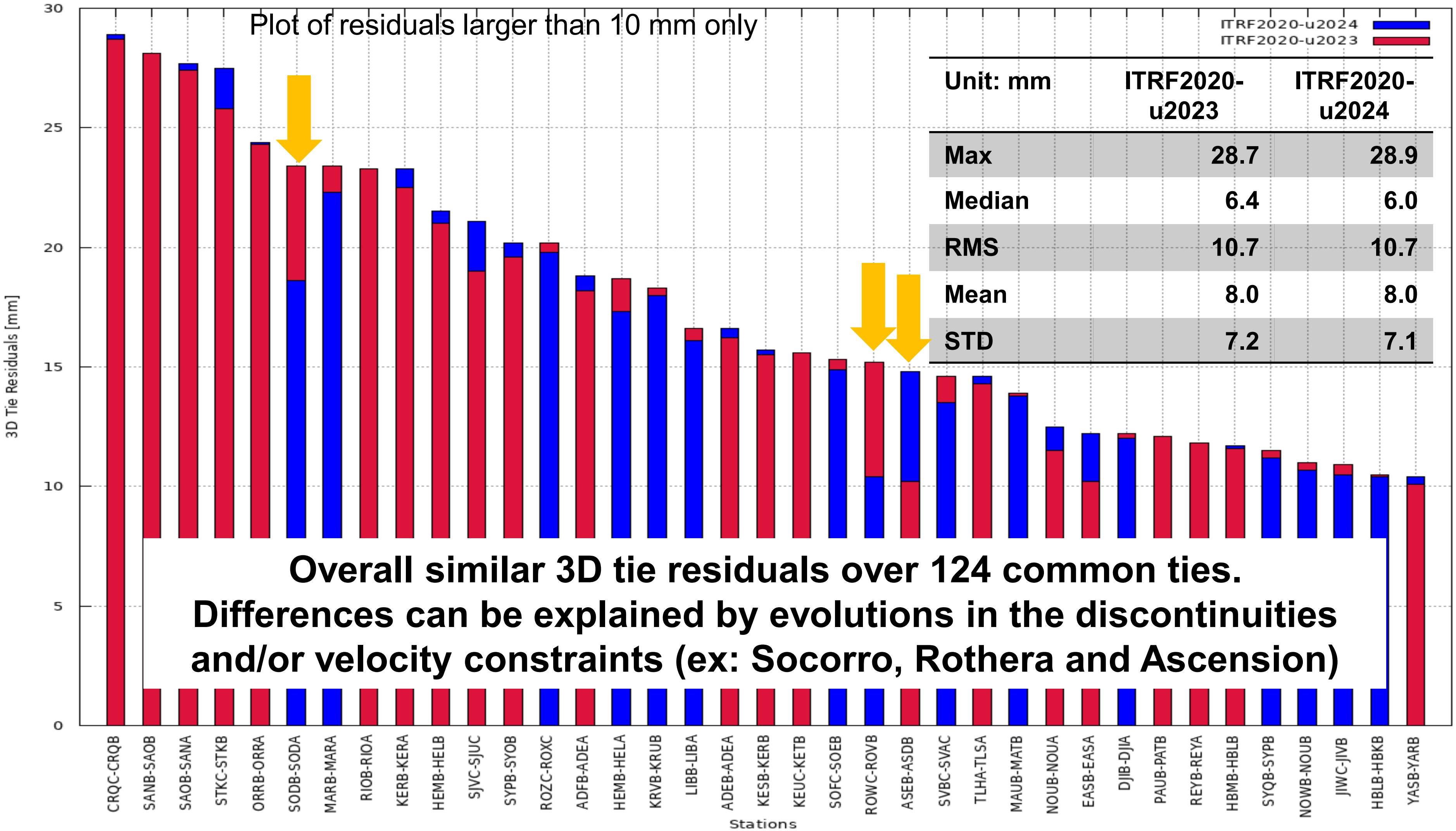
ITRF2020-u2024 vs ITRF2020-u2023 Position Differences from 2024.0 to 2026.0

No Helmert parameter transformation since zero Helmert parameters from ITRF2020-u2023/2024 to ITRF2020 according to IGN website.



Ascension: non négligeable differences in the velocities after 2022:263.
Hanga-Roa: young site (turned on in 2023/05). No colocation
➔ mean position and velocity are sensitive to new points.
Ny-Alesund II: new discontinuity @ 2024/08/12 (see slide 13).
Owenga: differences in the velocities (1.6 mm/yr 3D).
Rio Grande: differences in the velocities of RISC (see slide 16).

ITRF2020-u2024 vs ITRF2020-u2023 Tie Residuals wrt IGN Ground Ties



Unit: mm	ITRF2020-u2023	ITRF2020-u2024
Max	28.7	28.9
Median	6.4	6.0
RMS	10.7	10.7
Mean	8.0	8.0
STD	7.2	7.1

Overall similar 3D tie residuals over 124 common ties. Differences can be explained by evolutions in the discontinuities and/or velocity constraints (ex: Socorro, Rothera and Ascension)

ITRF2020-u2024 – DORIS Evaluation

- **That second ITRF2020 update is not limited to the adding of observations over 2024. It also includes discontinuity and velocity updates before 2024.0.**

- **ITRF2020-u2024 looks very similar to ITRF2020-u2023. However, we observe 3D position differences larger than 5 mm for few sites after 2024.0 due to new discontinuities and/or velocity constraints.**

Back-up Slides

Annual & Semi-annual station position corrections

Comments on ITRF2020-u2024-psd-doris.snx

PSD corrections in the up direction:

- **ITRF2020-u2023: XXX_U**

  9 ALOG_U AREB A ---- 01:174:73993 m   2 4.21614879695667e-02 2.87387e-03

- **ITRF2020-u2024: XXX_H**

  9 ALOG_H AREB A ---- 01:174:73993 m   2 4.15768515743337e-02 2.69394e-03

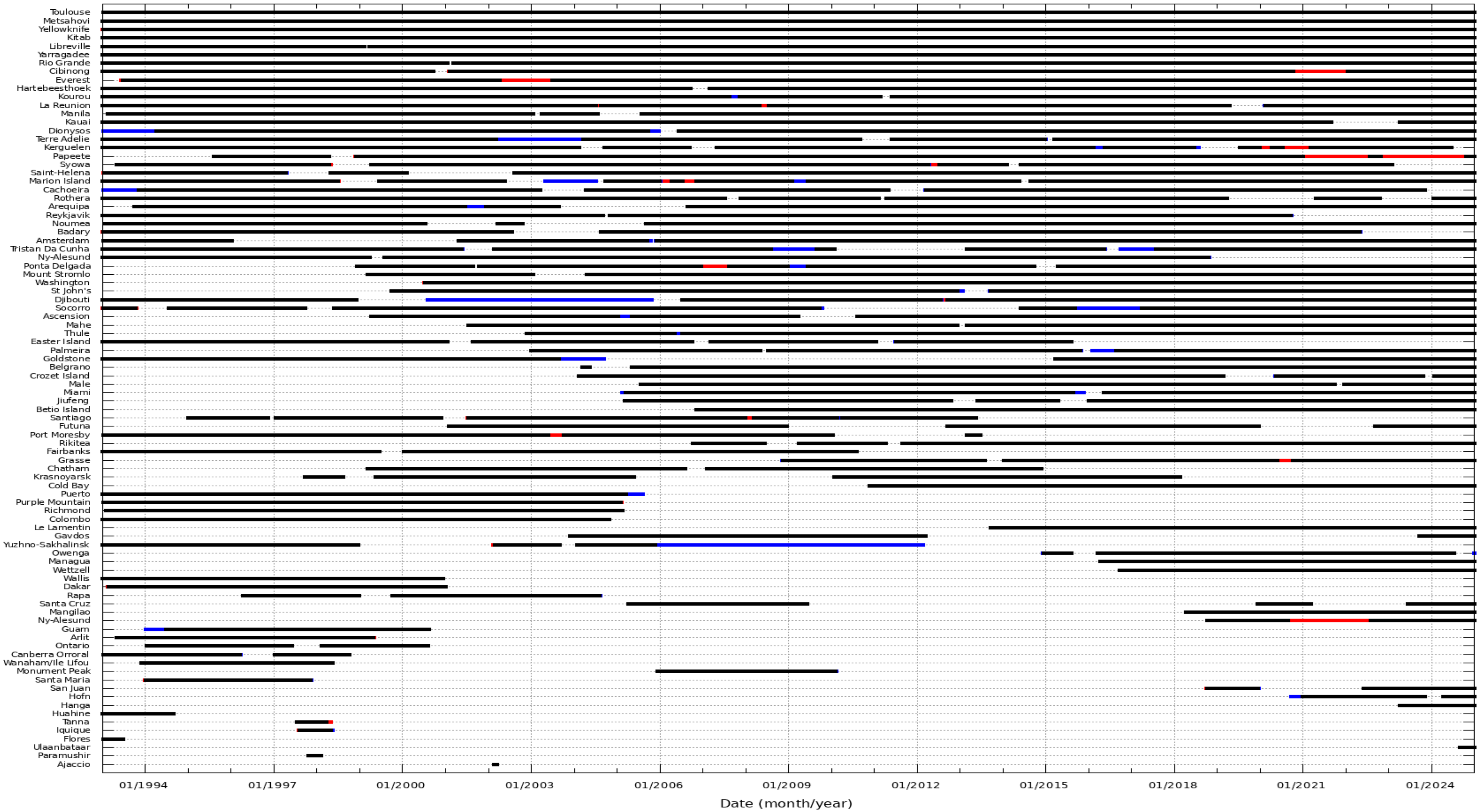
Communicated to IGN on 2025/10/02 09:59 and corrected by IGN on 2025/10/02 11:29.

Comments on ITRF2020-u2024-IDS-TRF.SNX

- Height stations have point codes (physical monument used at site) which do not match the ones contained in codomes_doris.snx file distributed by IGN (B vs A).
  - CHAB, COLA, DAKA, GALA, MANA, MARA, RIOB, SAOB.
- No position and velocity for:
  - AREA - soln = 4, i.e. from 2001/06/23 to 2001/11/20 (AREA end).
  - MARB - soln = 2, i.e. from 2003/01/27 to 2004/08/15 (MARB end).
  - REYB - soln = 2, i.e. from 2000/06/17 to 2000/06/21.
- NB:
  - all the listed station acronyms are also associated to an IGS station.
  - Same observations were made for ITRF2020-u2023.

ITRF2020-u2025 vs ids25d02
Site Time Spans

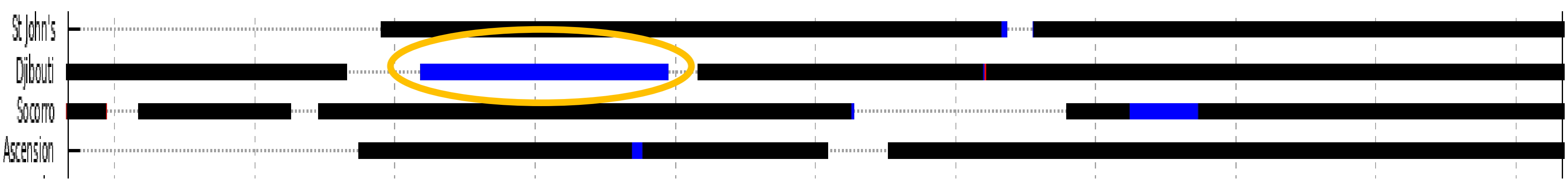
In ITRF2020-u2024 and ids25d02   **In ids25d02 only**   **In ITRF2020-u2024 only**



ITRF2020-u2024 vs ids24d02
Site Time Spans

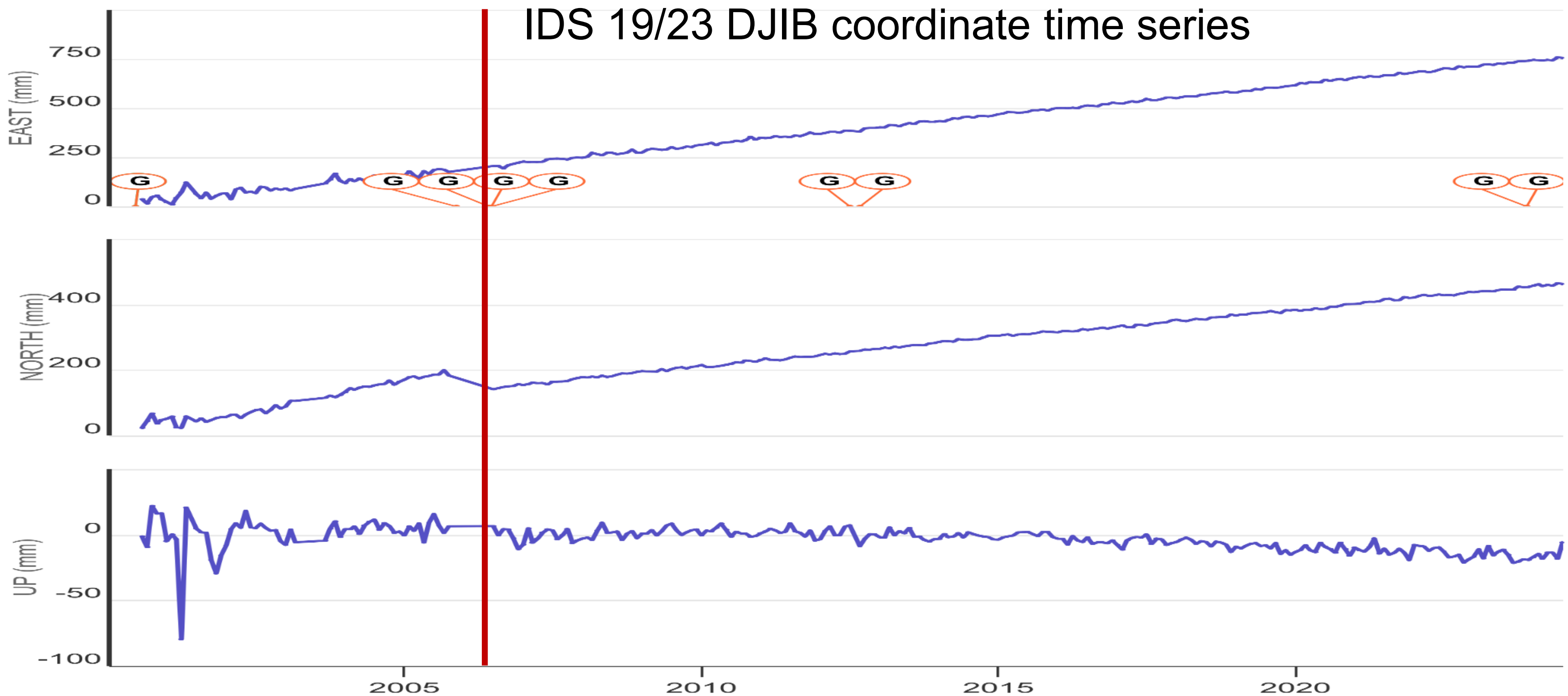
Most of the differences for sites such as Cibinong, Everest, Goldstone, Socorro, Terre Adélie and Yuzhno-Sakhalinsk are due to the adding in one solution of few points either just before or after a lack of data.

But, what about Djibouti?



Djibouti – DJIB DORIS station

- **As in ITRF2014/2020/2020-u2023, no mean position and velocity for DJIB before the antenna change in 2006/06/11. What about introducing that time interval of more by than 5 years with a discontinuity and an unconstrained velocity?**



ITRF2020-u2024 vs ITRF2020-u2023 Velocities (1/2)

Site	Comments
Arequipa	ITRF2020: 2 velocities ITRF2020-u2023: 3 velocities New velocity with new ARFB discontinuity ITRF2020-u2024: 2 velocities Same velocities for ARFB(3), ARFB (4) and ARFB (5)
Rio Grande	ITRF2020: 1 velocity ITRF2020-u2023: 2 velocities ITRF2020-u2024: 1 velocity New equality velocity constraint with RISC
Rothera	ITRF2020: 1 velocity ITRF2020-u2023: 5 velocities ITRF2020-u2024: 1 velocity

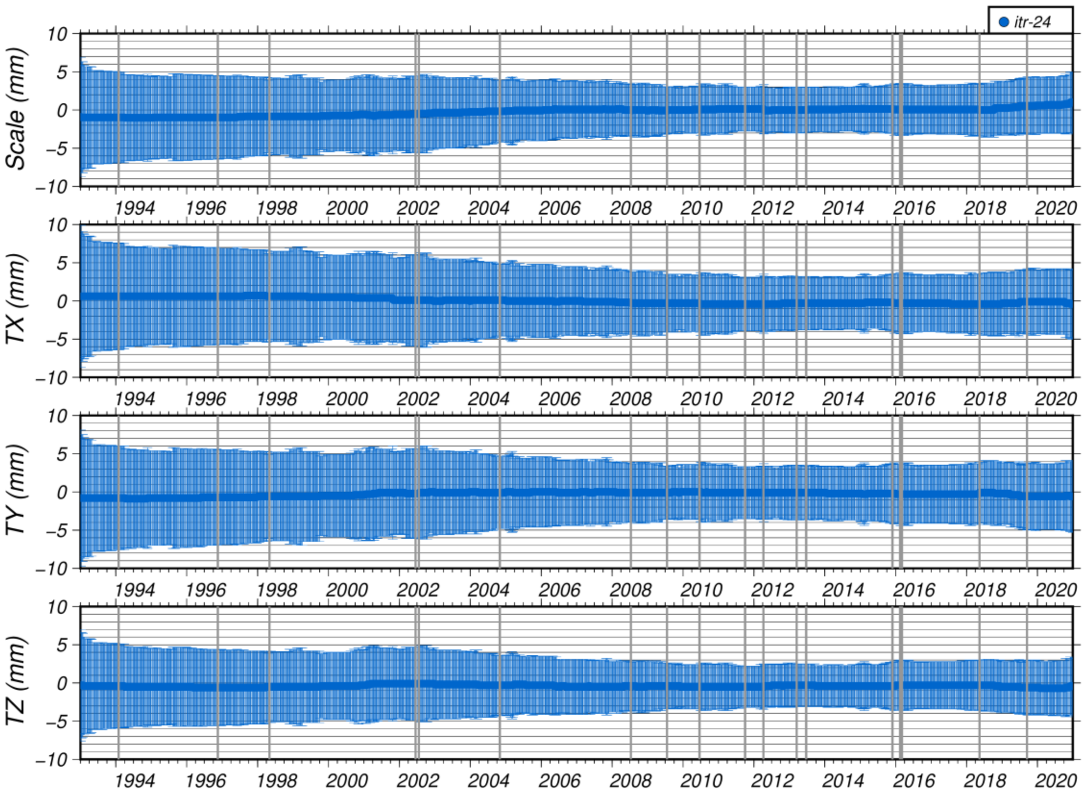
ITRF2020-u2024 vs ITRF2020-u2023 Velocities (2/2)

Site	Comments
San Juan	ITRF2020: 1 velocity ITRF2020-u2023: 2 velocities Different velocity for new station SJVC included in ITRF2020-u2023 ITRF2020-u2024: 1 velocity Same velocity for SJUC and SJVC.
Socorro	ITRF2020: 1 velocity ITRF2020-u2023: 5 velocities No more velocity equality constraints over SODA time intervals ITRF2020-u2024: 4 velocities Equality velocity constraint over SODA(4), SODB(1) and SODB(2).

ITRF2020-u2024 vs ITRF2020

ITRF2020 website: "The alignment of ITRF2020-u2024 to ITRF2020 implies that there is no Helmert transformation between the two solutions, i.e., all transformation parameters between ITRF2020-u2024 and ITRF2020 are zero."

ITRF2020-u2024 weekly propgations (PSD included) vs ITRF2020 (PSD included)
Time span = ITRF2020 time span (1993.0-2021.0)



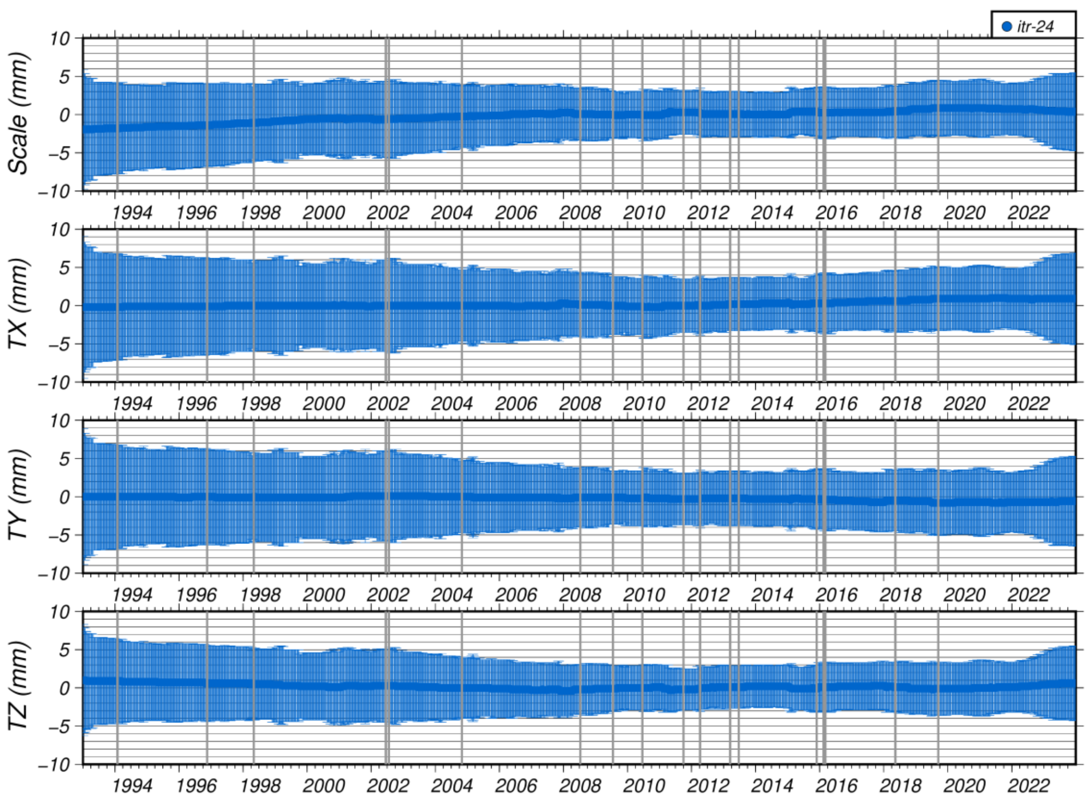
	Mean	RMS	Trend
Scale	-0.250	0.540	0.055
Tx	0.050	0.390	-0.043
Ty	-0.320	0.420	0.017
Tz	-0.400	0.430	0.001

Units: mm, mm/yr

ITRF2020-u2024 vs ITRF2020-u2023

ITRF2020 website: “The alignment of ITRF2020-u2023/24 to ITRF2020 implies that there is no Helmert transformation between the two solutions, i.e., all transformation parameters between ITRF2020-u2023/24 and ITRF2020 are zero.”

ITRF2020-u2024 weekly propgations (PSD included) vs ITRF2020-u2023 (PSD included)
Time span = ITRF2020 time span (1993.0-2024.0)

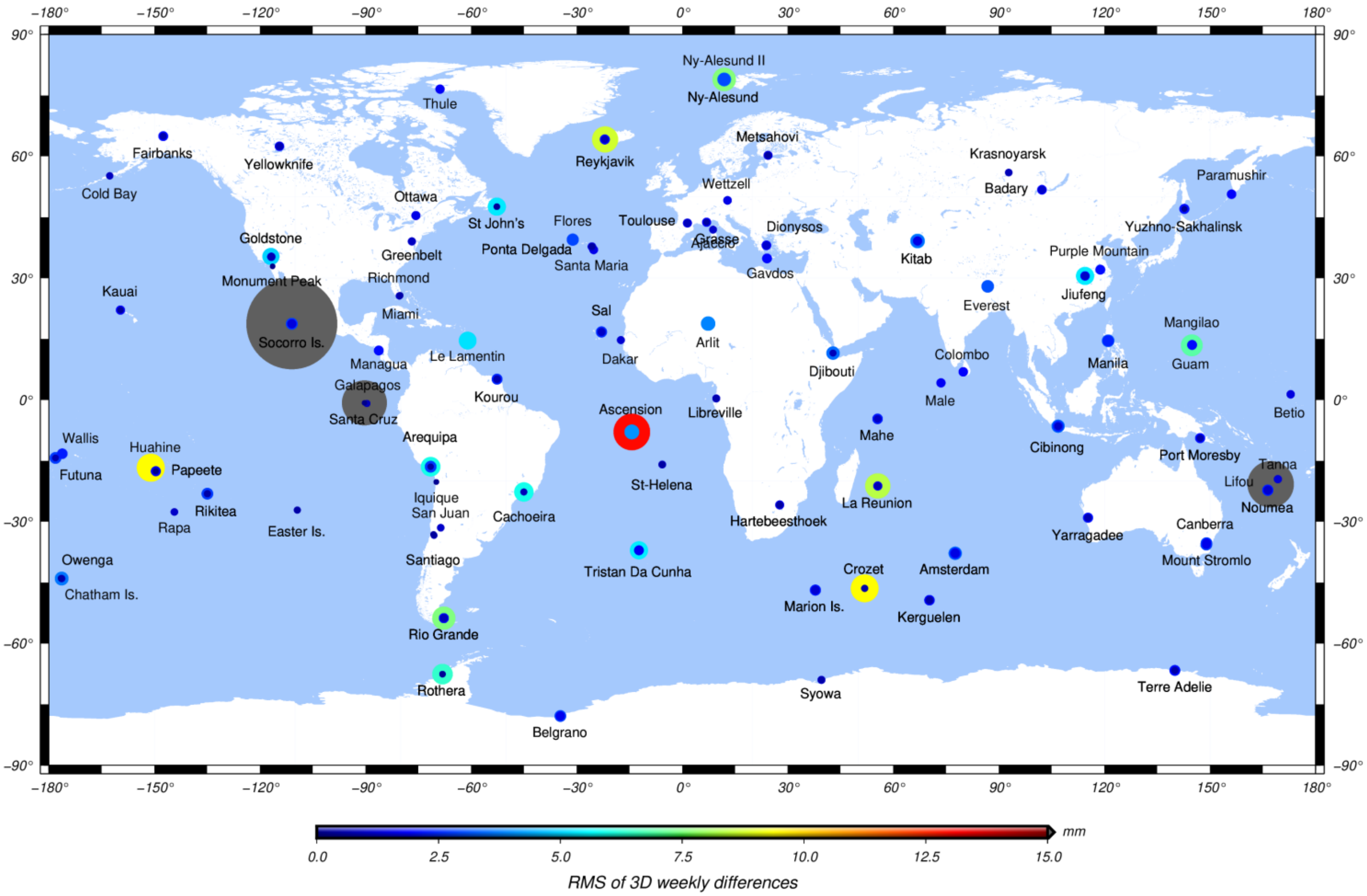


	Mean	RMS	Trend
Scale	-0.220	0.780	0.078
Tx	0.200	0.410	0.034
Ty	-0.240	0.360	-0.025
Tz	0.190	0.370	-0.019

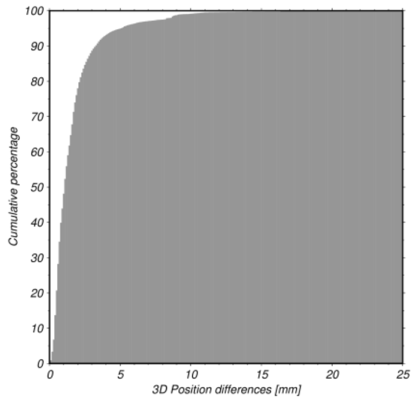
Units: mm, mm/yr

ITRF2020-u2024 vs ITRF2020 Position Differences

Weekly station position differences from 1993.0 to 2021.0

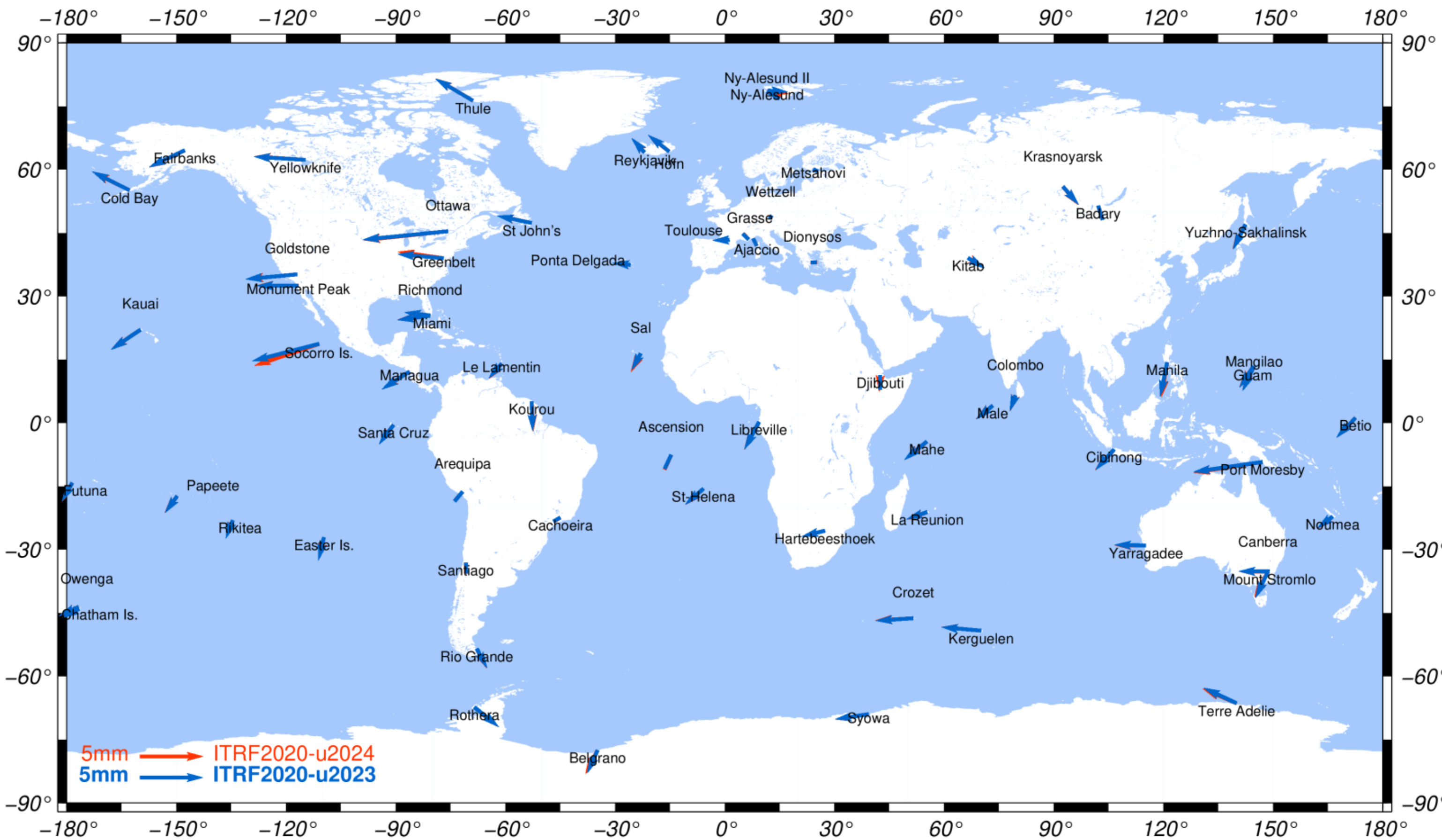


	[mm]
Max	117.8
Median	1.1
RMS	3.3
Mean	1.8
STD	2.8



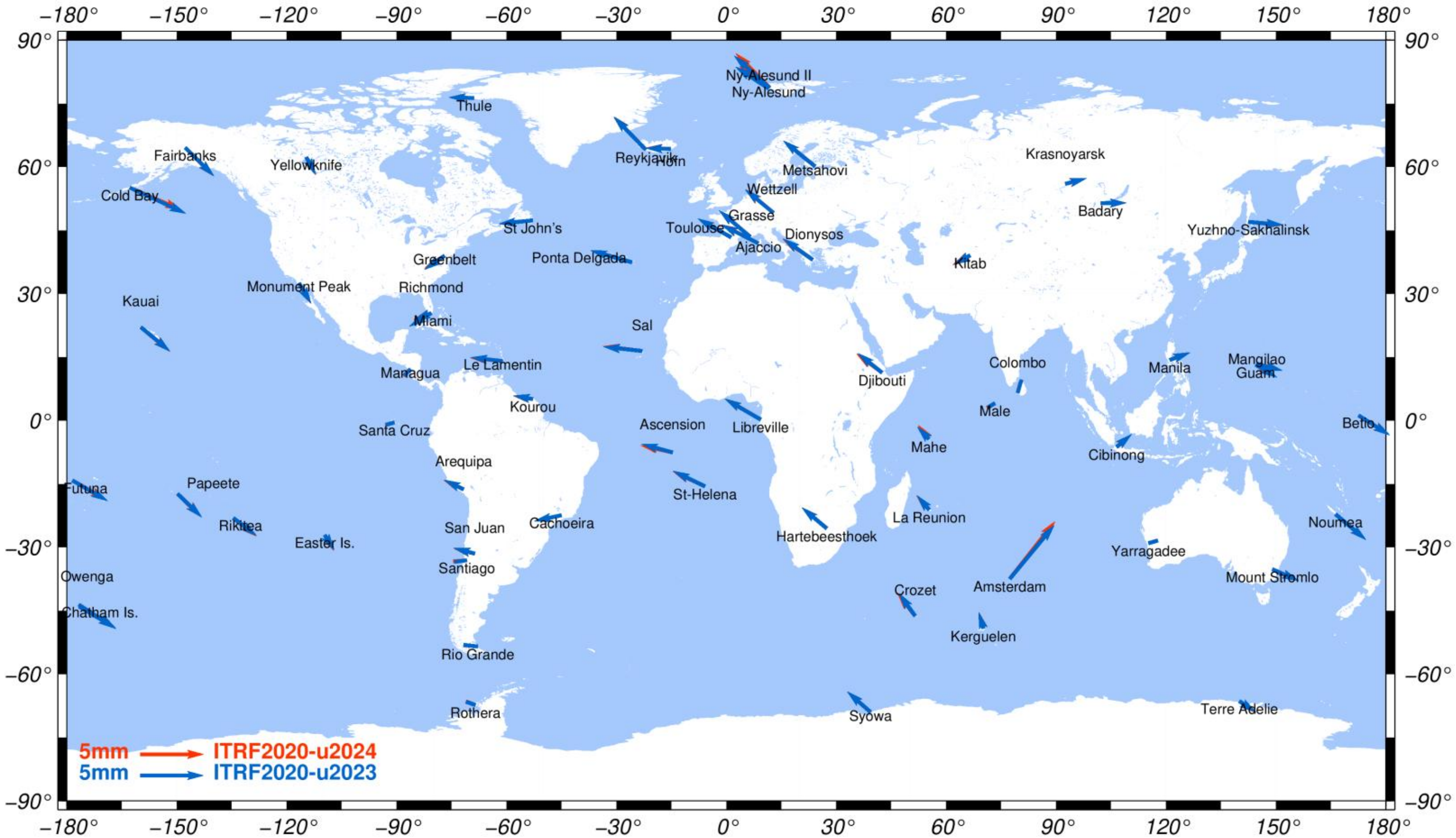
ITRF2020-u2024 vs ITRF2020-u2023

Annual corrections in CM – North component
(plot of coefficients larger than their errors only)



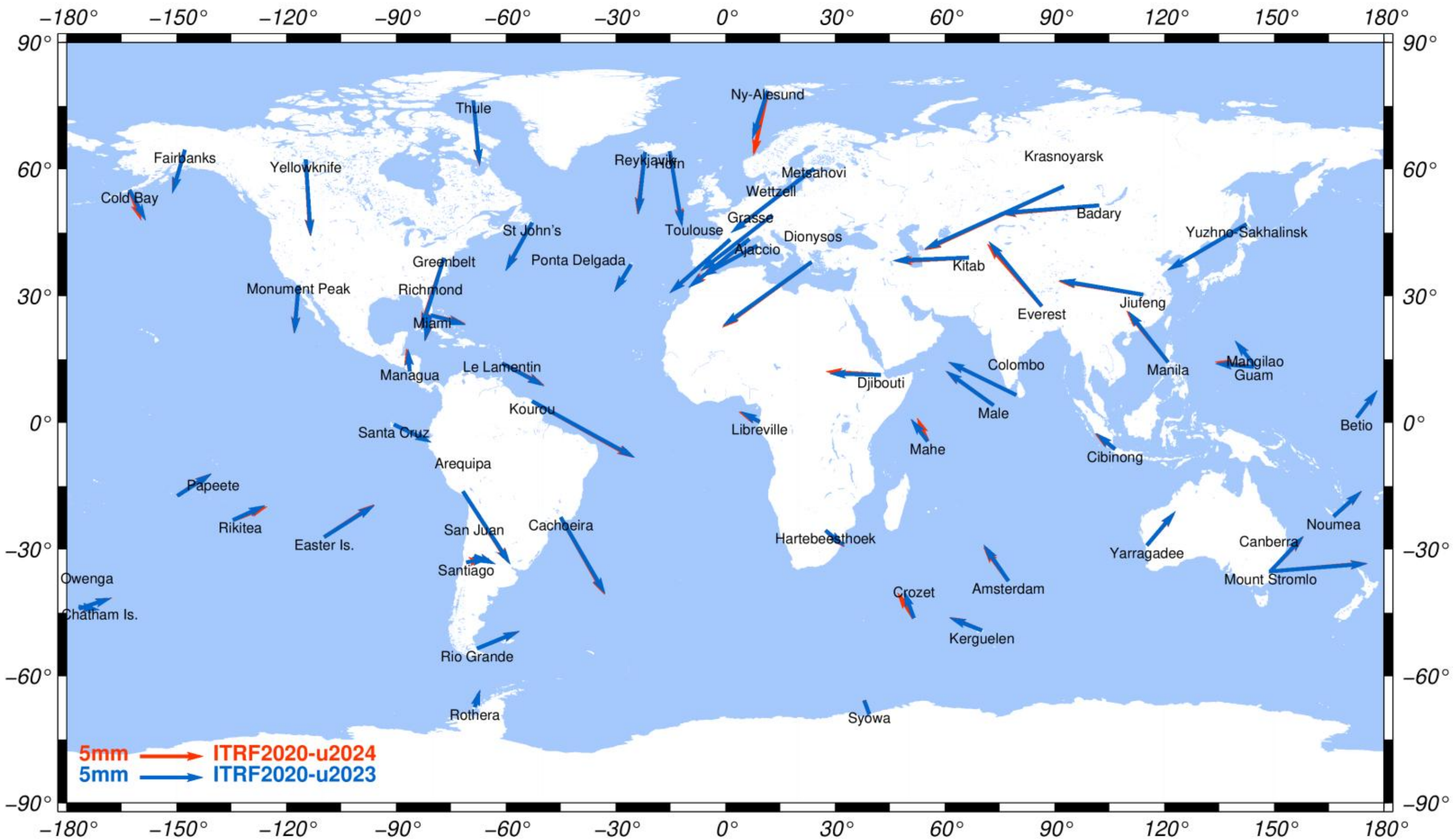
ITRF2020-u2024 vs ITRF2020-u2023

Annual corrections in CM – East component
(plot of coefficients larger than their errors only)



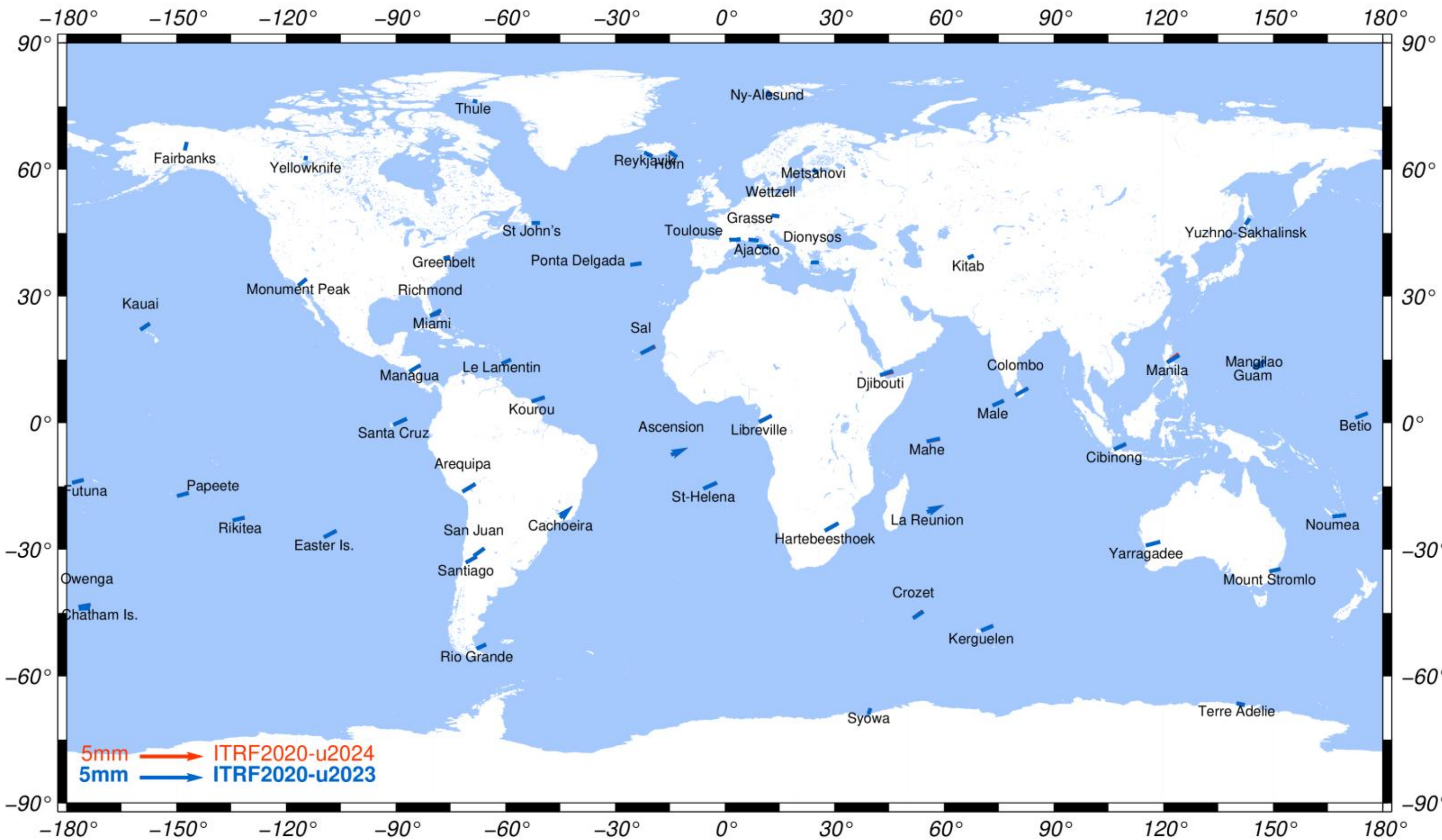
ITRF2020-u2024 vs ITRF2020-u2023

Annual corrections in CM – Up component
(plot of coefficients larger than their errors only)



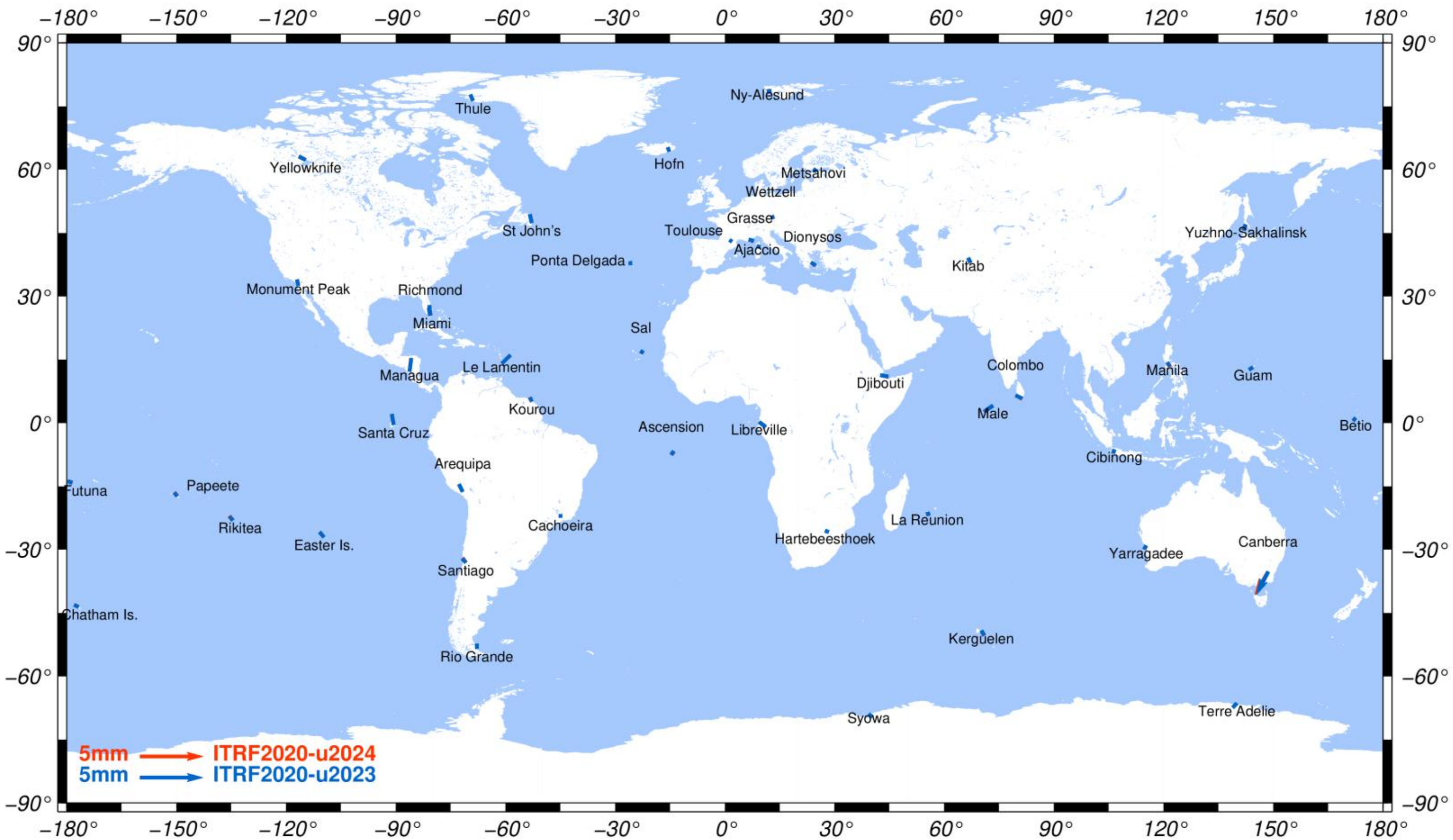
ITRF2020-u2024 vs ITRF2020-u2023

Semi-annual corrections in CM – North component
(plot of coefficients larger than their errors only)



ITRF2020-u2024 vs ITRF2020-u2023

Semi-annual corrections in CM – East component
(plot of coefficients larger than their errors only)



ITRF2020-u2024 vs ITRF2020-u2023

Semi-annual corrections in CM – Up component
(plot of coefficients larger than their errors only)