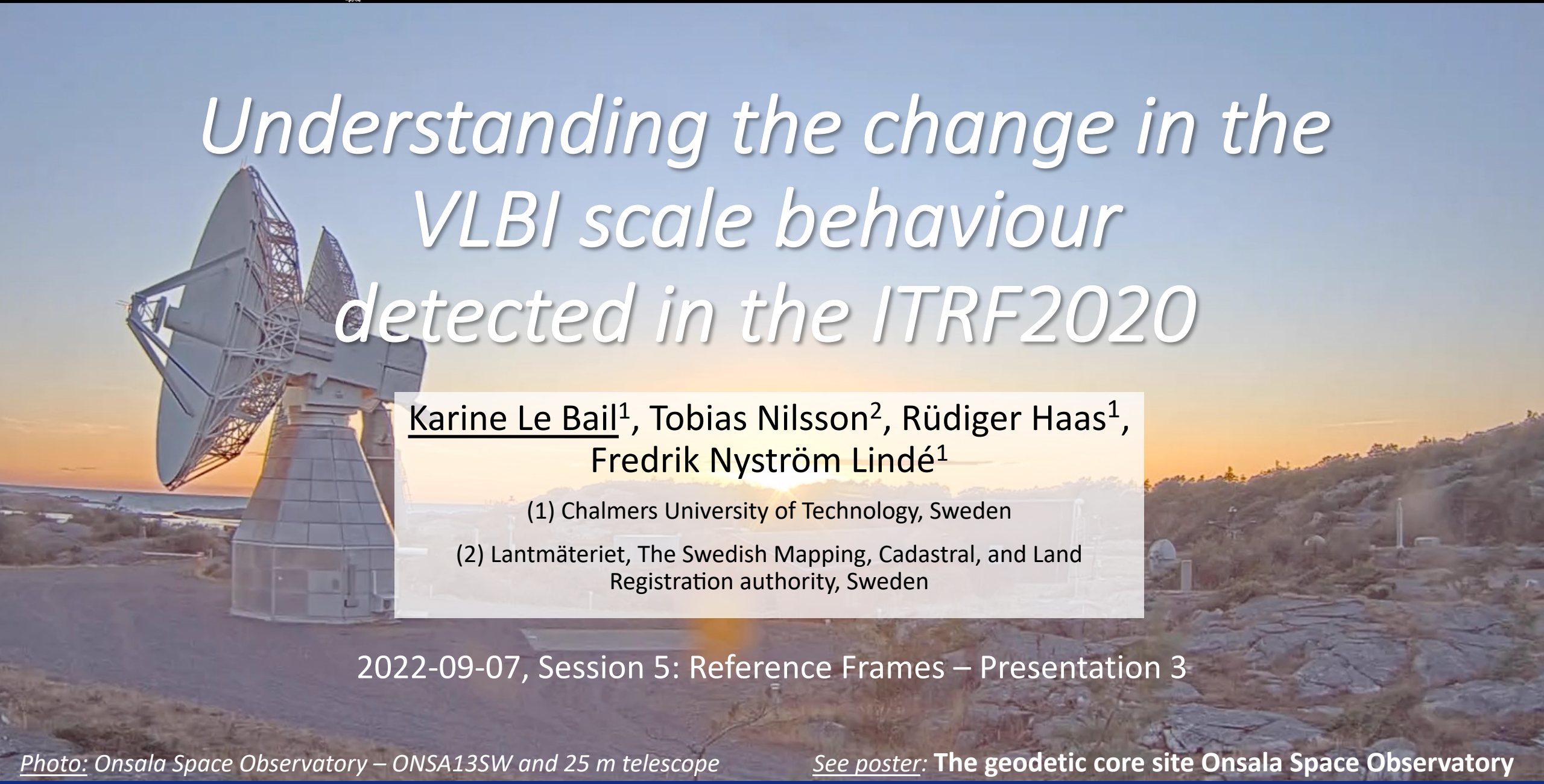


Understanding the change in the VLBI scale behaviour detected in the ITRF2020

Karine Le Bail[1], Tobias Nilsson[2], Rüdiger Haas[1], Fredrik Nyström Lindé[1]

(1) Chalmers University of Technology, Sweden

(2) Lantmäteriet, The Swedish Mapping, Cadastral, and Land Registration authority, Sweden

2022-09-07, Session 5: Reference Frames – Presentation 3

Photo: Onsala Space Observatory – ONSA13SW and 25 m telescope

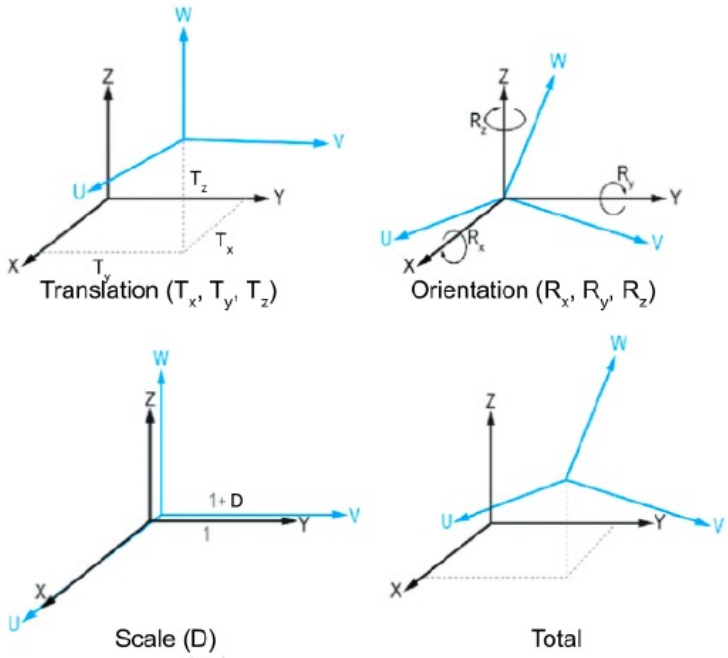
See poster: **The geodetic core site Onsala Space Observatory**

Outline

- Context – The new realisation of the International Terrestrial Reference System: the ITRF2020.
- Motivation – Why is the scale derived from the VLBI solution drifting after 2013.75?
- Data, method and results – Investigation of possible reasons as change in the VLBI network or station modeling, using an individual VLBI solution (OSO).
- Conclusions – Is there one reason?
- Perspectives – Could there be more?

The International Terrestrial Reference Frame

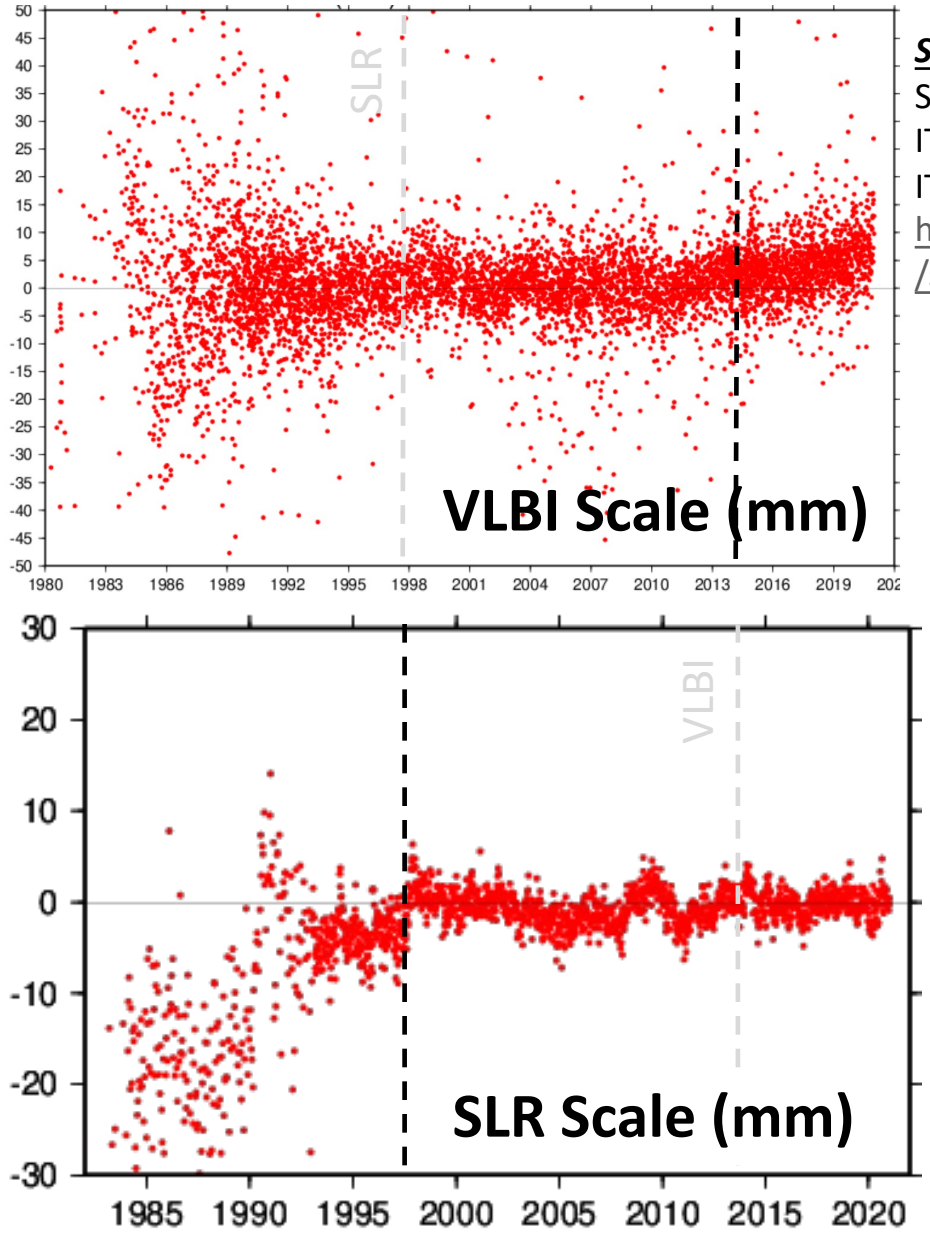
- IERS ITRS Product Center : International Terrestrial Reference Frame (ITRF)
- Combination of 4 Space Geodesy techniques (solutions + local ties):
  - GNSS (Global Navigation Satellite Systems)
  - VLBI (Very Long Baseline Interferometry)
  - SLR (Satellite Laser Ranging)
  - DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite)
- Helmert transformation parameters:
  - 3 translation components
  - 1 scale factor
  - 3 rotation angles



Credit: Malys et al. 2021

ITRF2020

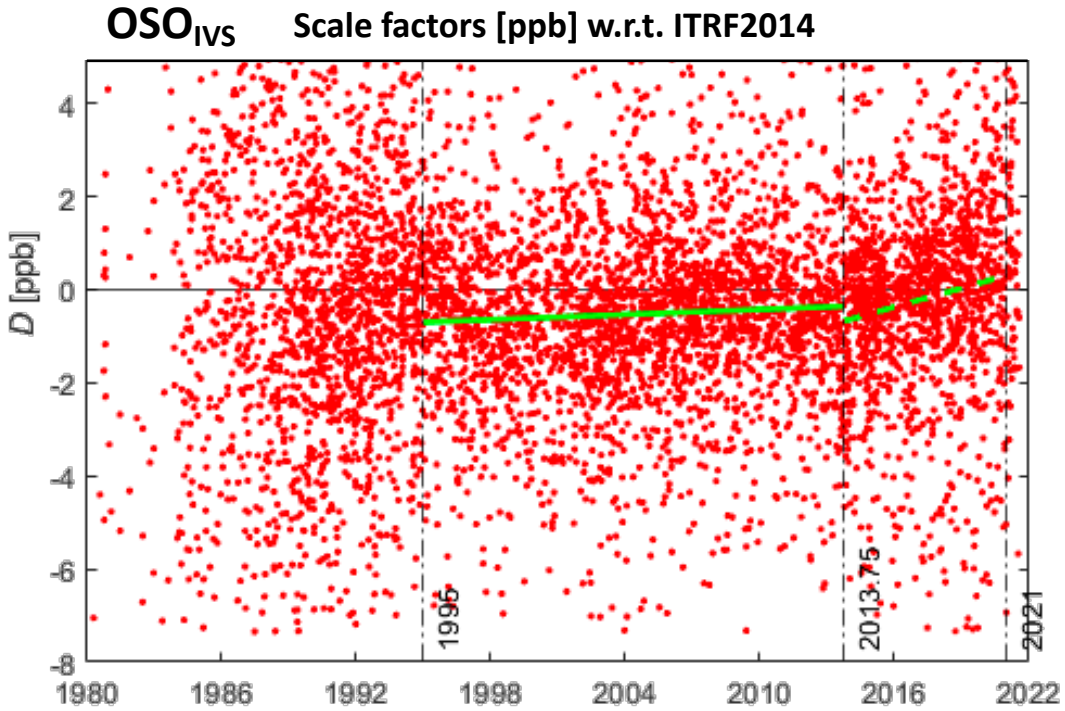
- ITRF2020 specifications:
  - Orientation: Alignment to ITRF2014
  - Origin: SLR
  - Scale: SLR (1997.7-2021.0) and VLBI (up to 2013.75)
- VLBI scale behaviour after 2013.75
- Causes investigated:
  - Network homogeneity
  - Station mismodeling
  - Station technical apects



Source: VLBI and SLR scales w.r.t. ITRF2020 from the ITRF website https://itrf.ign.fr/en/solutions/itrf2020

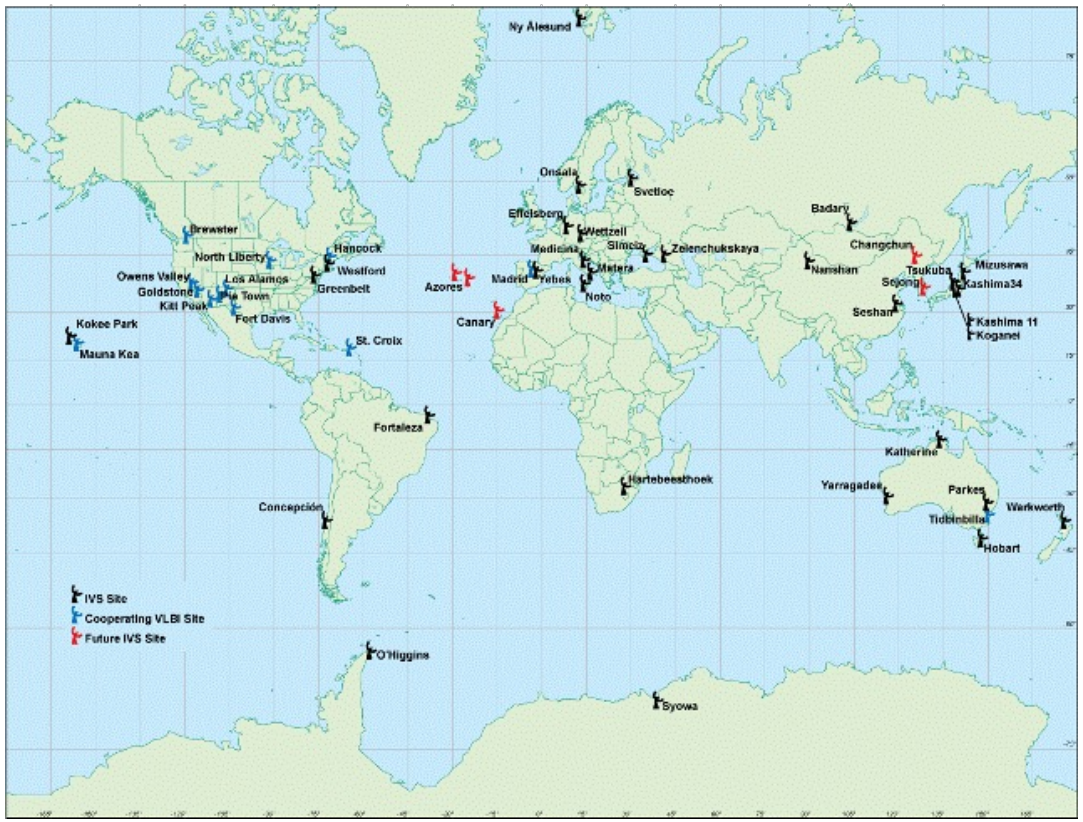
Data and method

- Helmert parameters calculated from individual solution w.r.t. ITRF2014.
- Individual solution processed with ASCOT (VLBI analysis software):
  - **OSO_{IVS}**: OSO contribution to ITRF2020 IVS combination
  - **OSO_{REP}**: reprocessed in May 2022



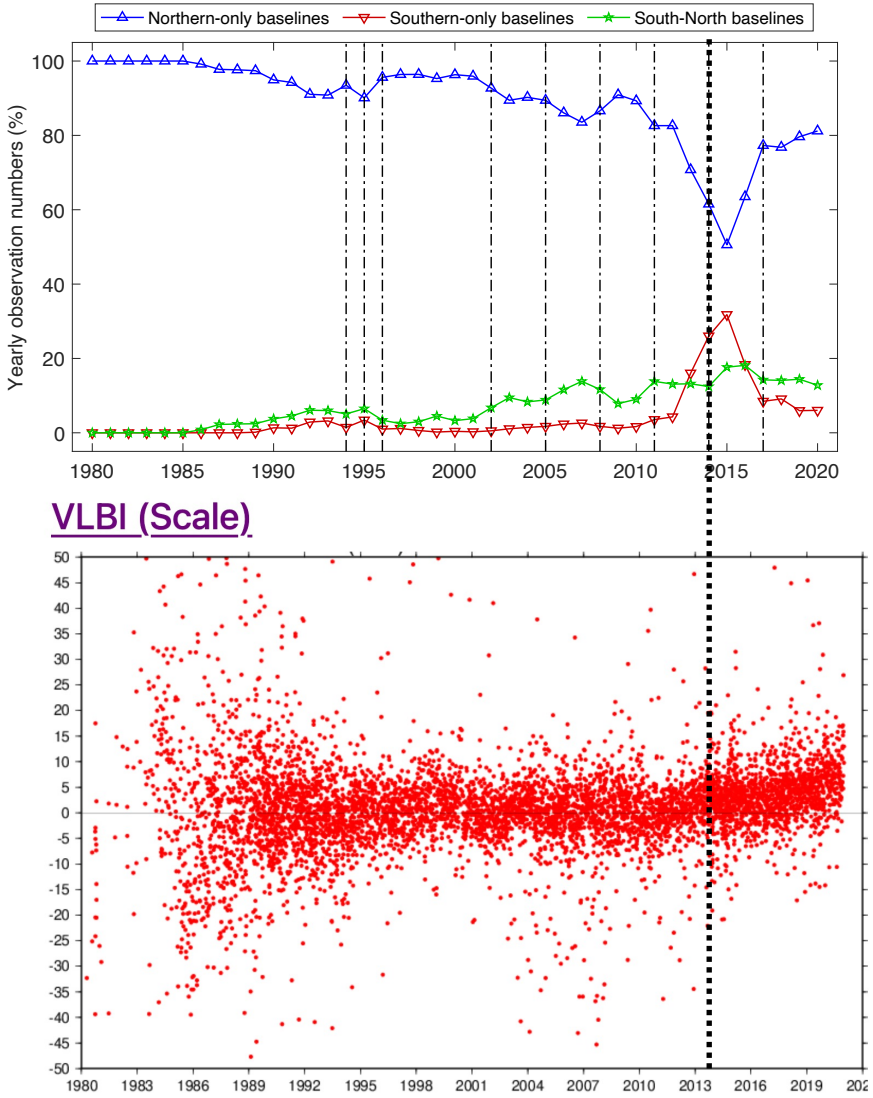
Scale factors	Time span	# sessions	Drift (ppb/yr)	Mean (ppb)
OSO_{IVS}	1995.00-2013.75	2752	0.015 +/- 0.005	-0.609
OSO_{IVS}	2013.75-2021.00	1006	0.079 +/- 0.019	-0.370
OSO_{REP}	**2013.75-2021.00**	**1006**	**0.075 +/- 0.018**	**-0.360**

Network homogeneity



Source: IVS map of stations from https://ivscc.gsfc.nasa.gov/stations/ns-map.html

- VLBI network evolution in the past 9 years:
  - Transition to VGOS
  - Additional VLBA sessions
- Comparison:
  - Network volumes
  - North / South baseline counts
  - Solution without the 71 VLBA sessions since 2013.75



Source: VLBI scale w.r.t. ITRF2020 from the ITRF website https://itrf.ign.fr/en/solutions/itrf2020

Network homogeneity

Scale factors		Time span	# sessions	Drift (ppb/yr)	Mean (ppb)
OSO_{REP}	All sessions	2013.75-2021.00	1006	0.075 +/- 0.018	-0.360
OSO_{REP}	No VLBA sessions	2013.75-2021.00	935	0.074 +/- 0.019	-0.372

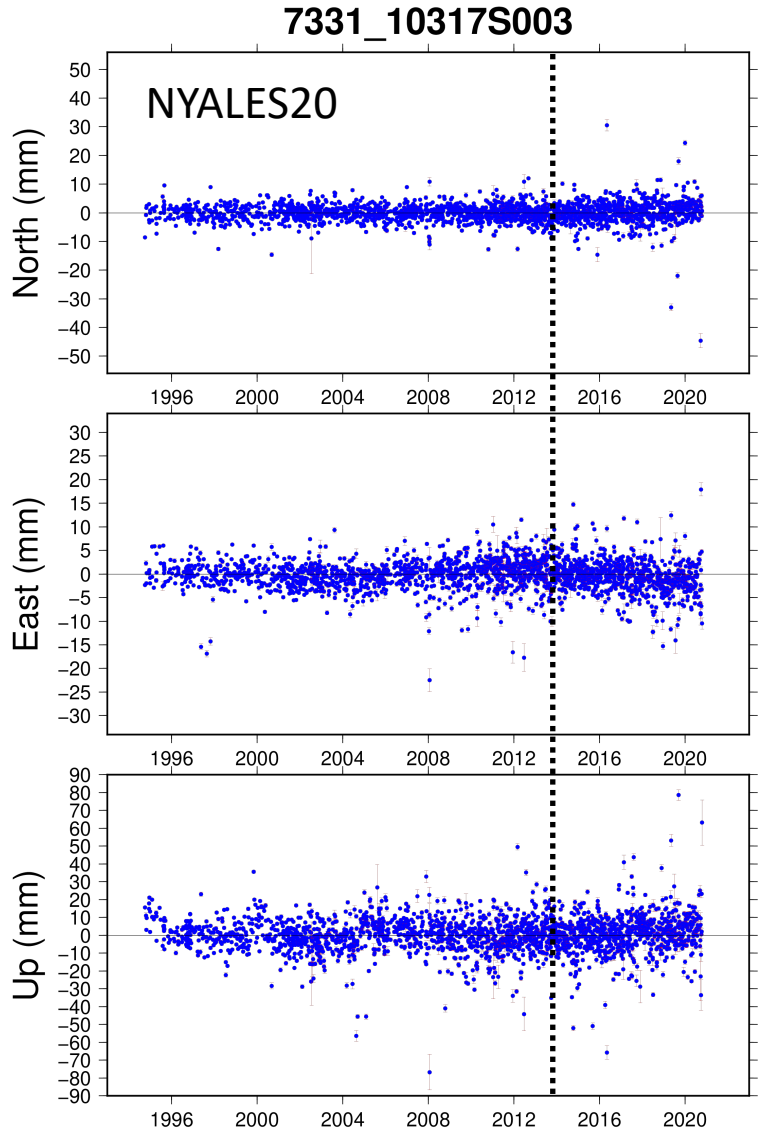
- Conclusion: no direct connection between the network evolution and the scale drift

Mismodeling

- Mismodeling that could cause an artificial linear drift in the station position time series (uplifting for example)
- Simulations:
  - NYALES20 and KOKEE: would need between 1.1 and 1.6 cm/yr to cause the VLBI scale to drift at a level of 0.074 ppb/yr.

Scale factors		Time span	# sessions	Drift (ppb/yr)	Mean (ppb)
OSO_{REP}	All stations	2013.75-2021.00	1006	0.076 +/- 0.018	-0.360
OSO_{REP}	Without NYALES20	2013.75-2021.00	1006	0.080 +/- 0.021	-0.294

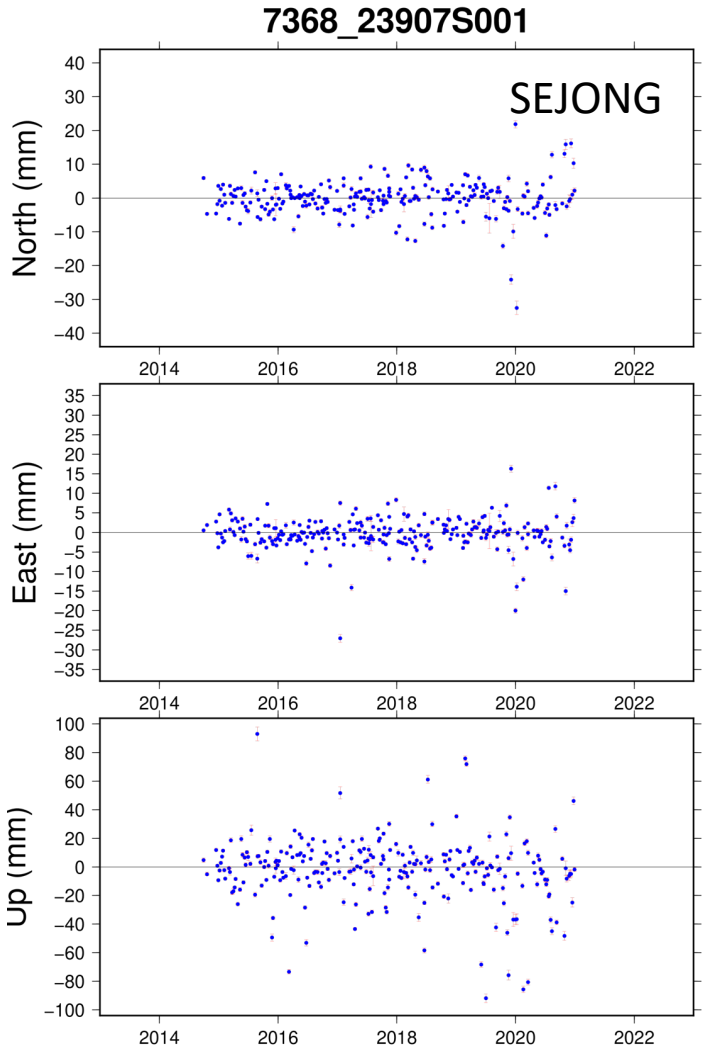
➢ Conclusion: Removing NYALES20 from the analysis does not decrease the VLBI scale drift.



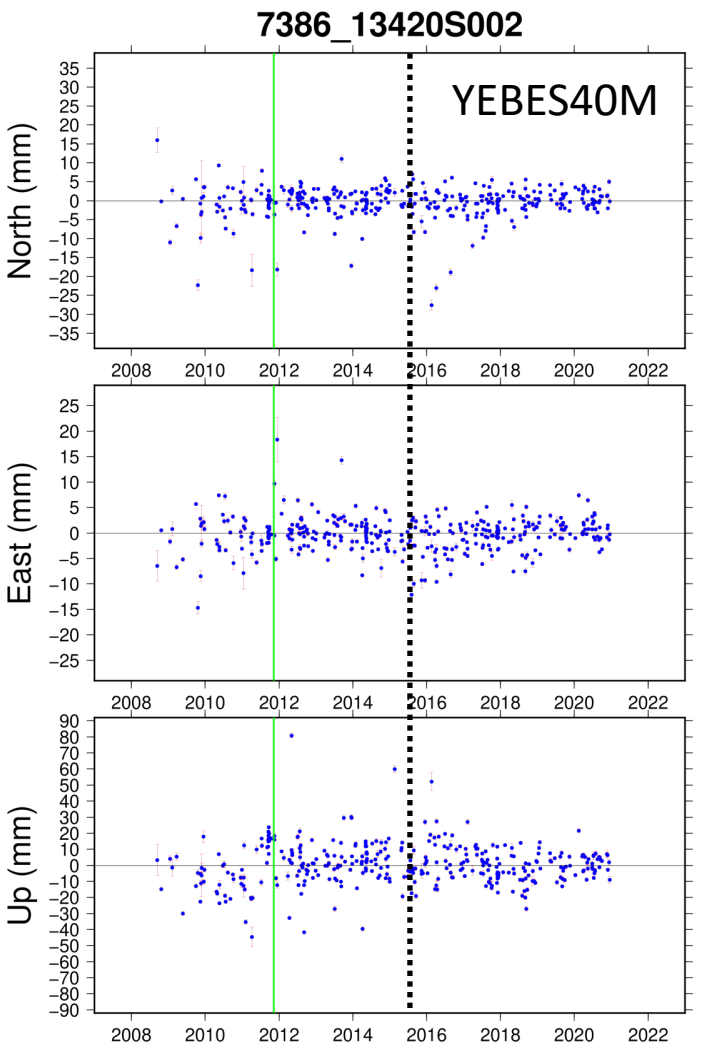
Source: NYALES20 position time series residuals w.r.t. ITRF2020 from https://itrf.ign.fr/en/solutions/itrf2020

Station technical aspects (1/2)

- SEJONG, new S/X station in the IVS network
- YEBES40M sub-reflector:
  - *End of 2011*: readjustment of the sub-reflector (added discontinuity)
  - *November 2015*: new sub-reflector model implemented (Q band)



Source: SEJONG position time series residuals w.r.t. ITRF2020 from https://itrf.ign.fr/en/solutions/itrf2020



Source: YEBES40M position time series residuals w.r.t. ITRF2020 from https://itrf.ign.fr/en/solutions/itrf2020

Station technical aspects (2/2)

Scale factors		# sess.	Drift (ppb/yr)	Mean (ppb)
OSO_{REP}	All stations	1006	0.075 +/- 0.018	-0.360
OSO_{REP}	Without SEJONG	1006	**0.050** +/- 0.018	**-0.408**
OSO_{REP}	Without YEBES40M	1006	**0.045** +/- 0.018	**-0.485**

- ➢ Conclusion: Removing SEJONG or YEBES40M from the analysis decreases the VLBI scale drift.
- Removing SEJONG and YEBES40M from the analysis?
- Strategy to adopt for the next IVS contribution to the ITRF?

Conclusions and perspectives

- The VLBI scale drift seems to be the result of a combination of several factors.
- Ongoing work:
  - Calculation of the scale w.r.t. the ITRF2020.
  - Study of each of the time series of VLBI station position residuals w.r.t. ITRF2020 in order to identify stations with potential mismodeling or discontinuities to be taken into account for the next ITRF realisation.
- Perspectives of this work:
  - This work focuses on only one individual VLBI solution (OSO).
  - Proposal to the IVS Working Group on Scale: unified testing strategy for all IVS analysis centers in collaboration with the IVS combination center.