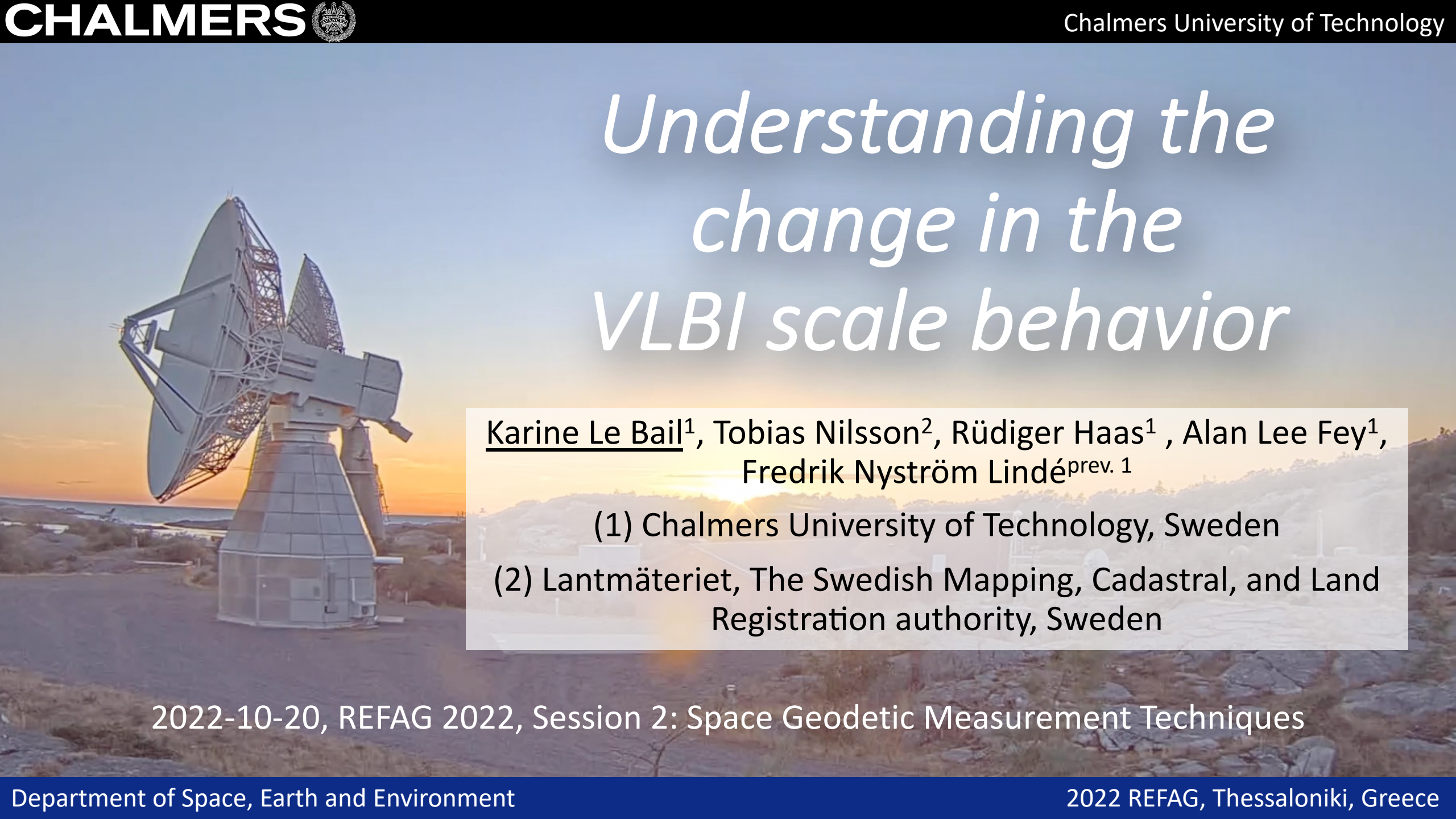

Understanding the change in the VLBI scale behavior

Karine Le Bail[1], Tobias Nilsson[2], Rüdiger Haas[1] , Alan Lee Fey[1], Fredrik Nyström Lindé[prev. 1]

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

2022-10-20, REFAG 2022, Session 2: Space Geodetic Measurement Techniques

Outline

Motivation

Why is the scale derived from the VLBI solution drifting after 2013.75?

Data, method and results

Investigation of possible reasons (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 OSO solution

Individual solutions processed with ASCOT (VLBI analysis software):

- **OSO_{IVS}**: OSO contribution to ITRF2020 IVS combination.
- **OSO_{REP}**: reprocessed in May 2022.
- **OSO_{EXT}**: OSO contribution to ITRF2020 IVS combination extended to 2022.50.

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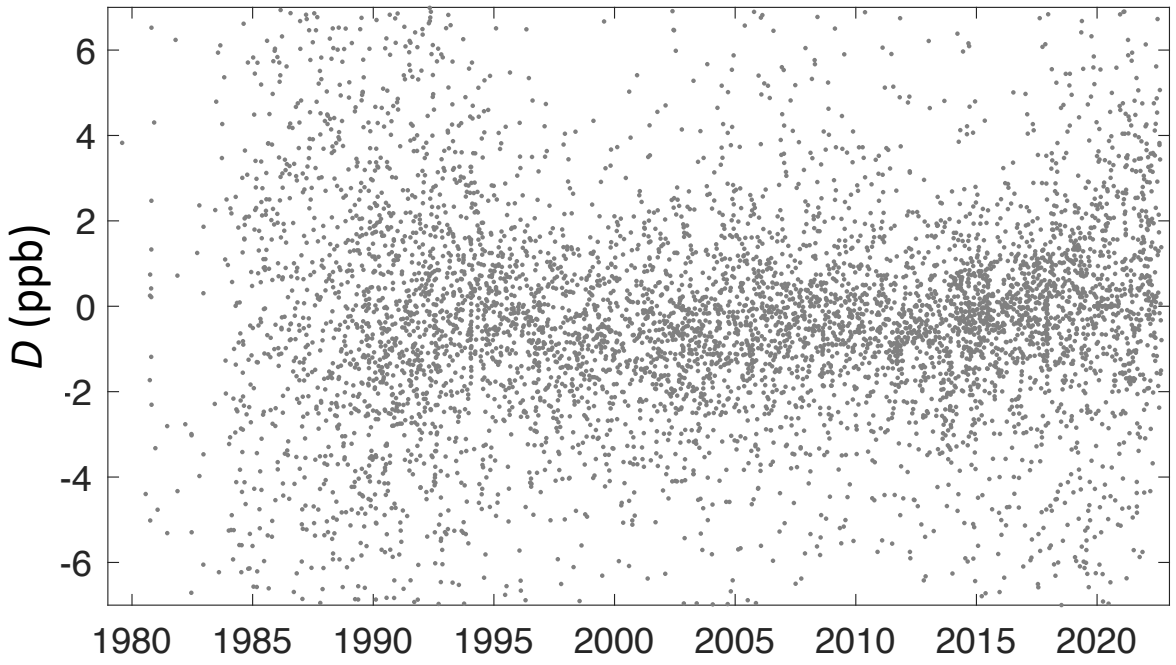
Scale factors	Time span	# sessions	Drift (ppb/yr)
OSO_{IVS}	1995.00-2013.75	2752	0.018 +/- 0.004
OSO_{IVS}	2013.75-2021.00	884	0.146 +/- 0.028
OSO_{REP}	2013.75-2021.00	884	0.138 +/- 0.028
OSO_{EXT}	1995.00-2013.75	2415	0.023 +/- 0.007
OSO_{EXT}	2013.75-2021.00	884	0.153 +/- 0.028
OSO_{EXT}	2013.75-2022.50	1400	0.149 +/- 0.020

Helmert parameters : OSO_{EXT} w.r.t. ITRF2014



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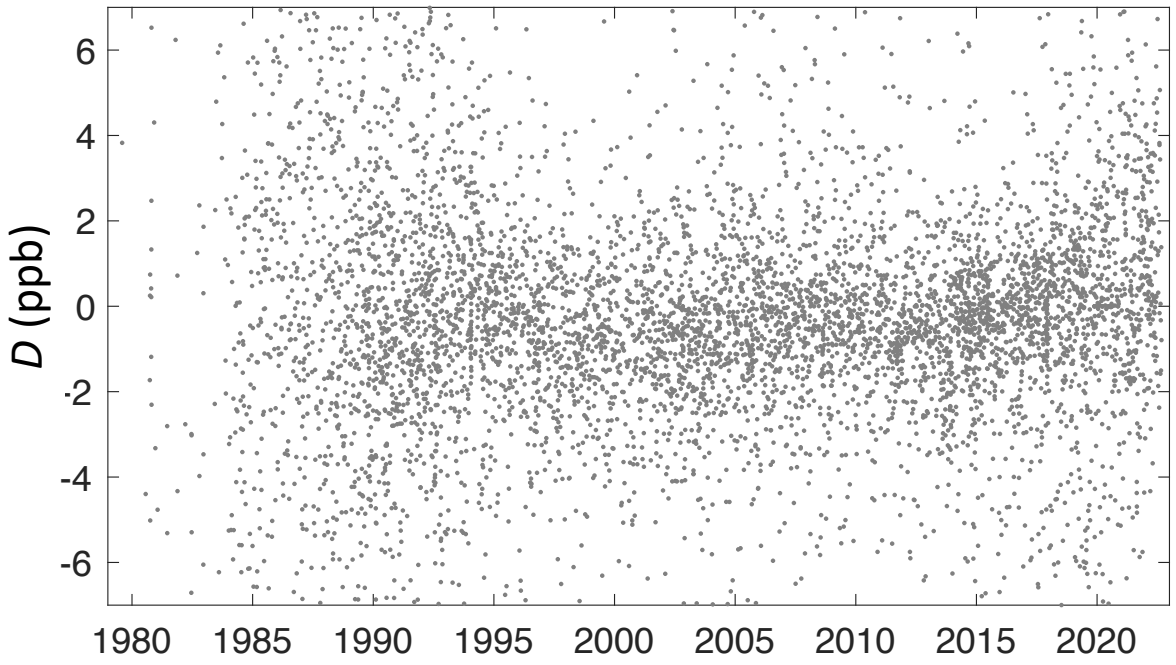

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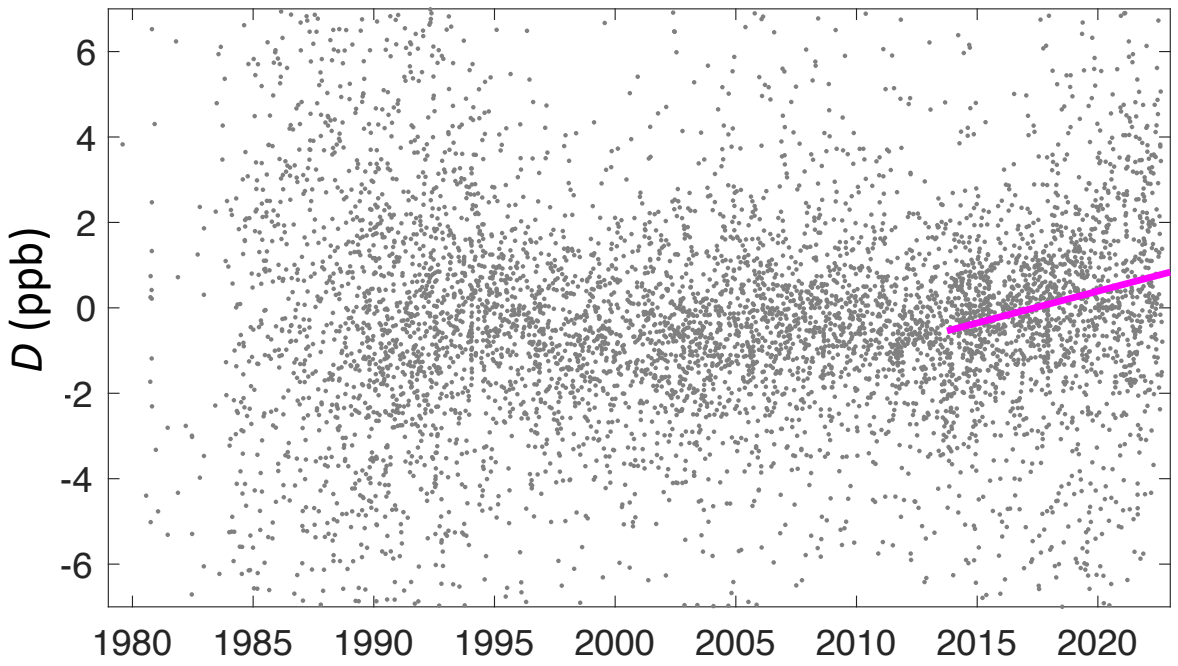


Searching for a needle in a haystack…

- Analysis strategies and models
- A change in the station network
- Stations to be investigated in detail:
  - Category 1: Noisy data
  - Category 2: Mismodeling or missing critical station events

VLBI-scale Working Group
Chaired by John Gipson

Searching for a needle in a haystack…

- Analysis strategies and models

- A change in the station network

- Stations to be investigated in detail:
  - Category 1: Noisy data
  - Category 2: Mismodeling or missing critical station events

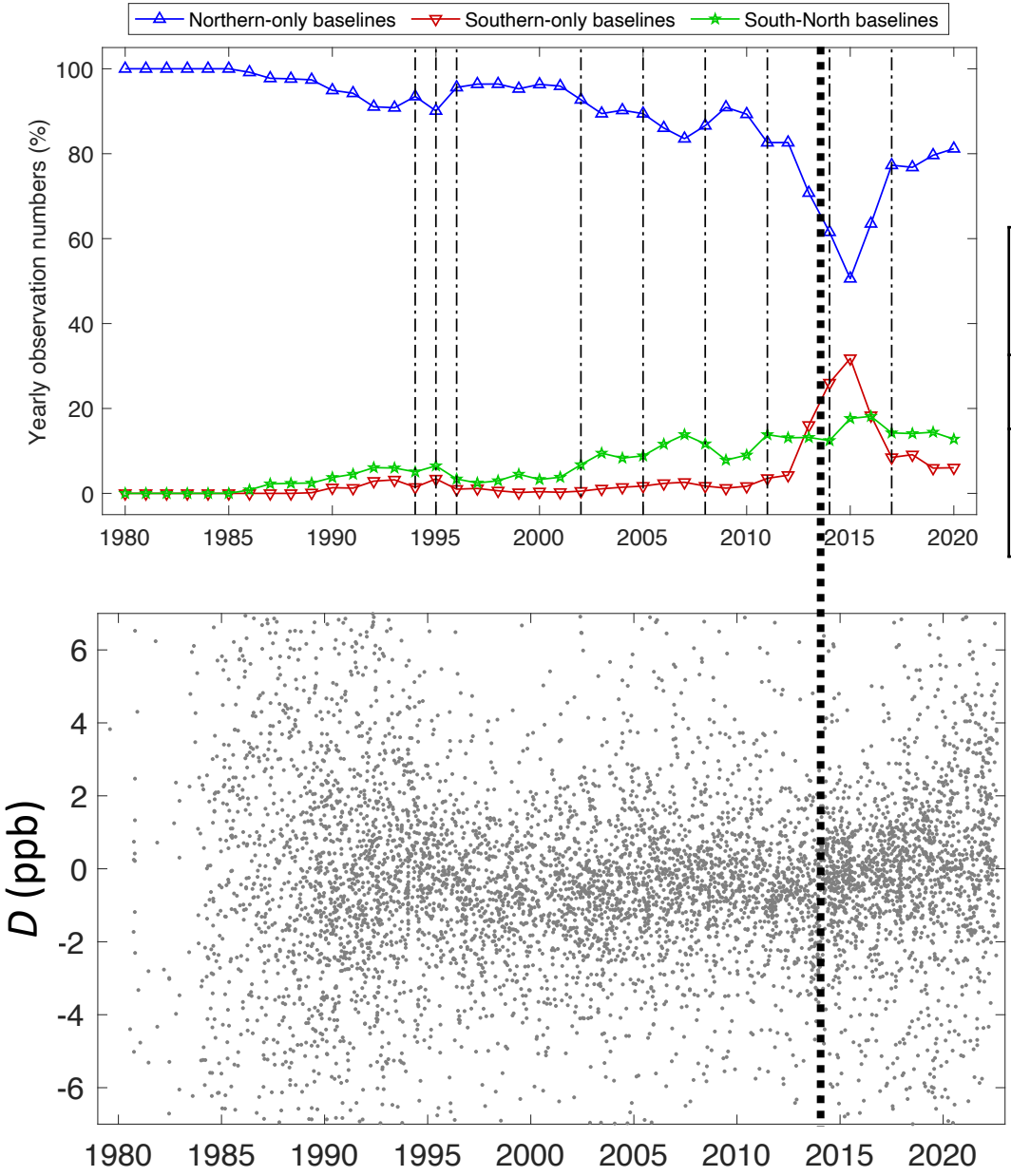
VLBI-scale Working Group
Chaired by John Gipson

Network homogeneity

- VLBI network evolution in the past 9 years:
  - Transition to VGOS
  - Additional VLBA sessions
- Comparison:
  - Network volumes
  - North / South baseline counts
  - Solution without 70 VLBA sessions since 2013.75

The IVS S/X legacy network

● Cooperating S/X VLBI stations



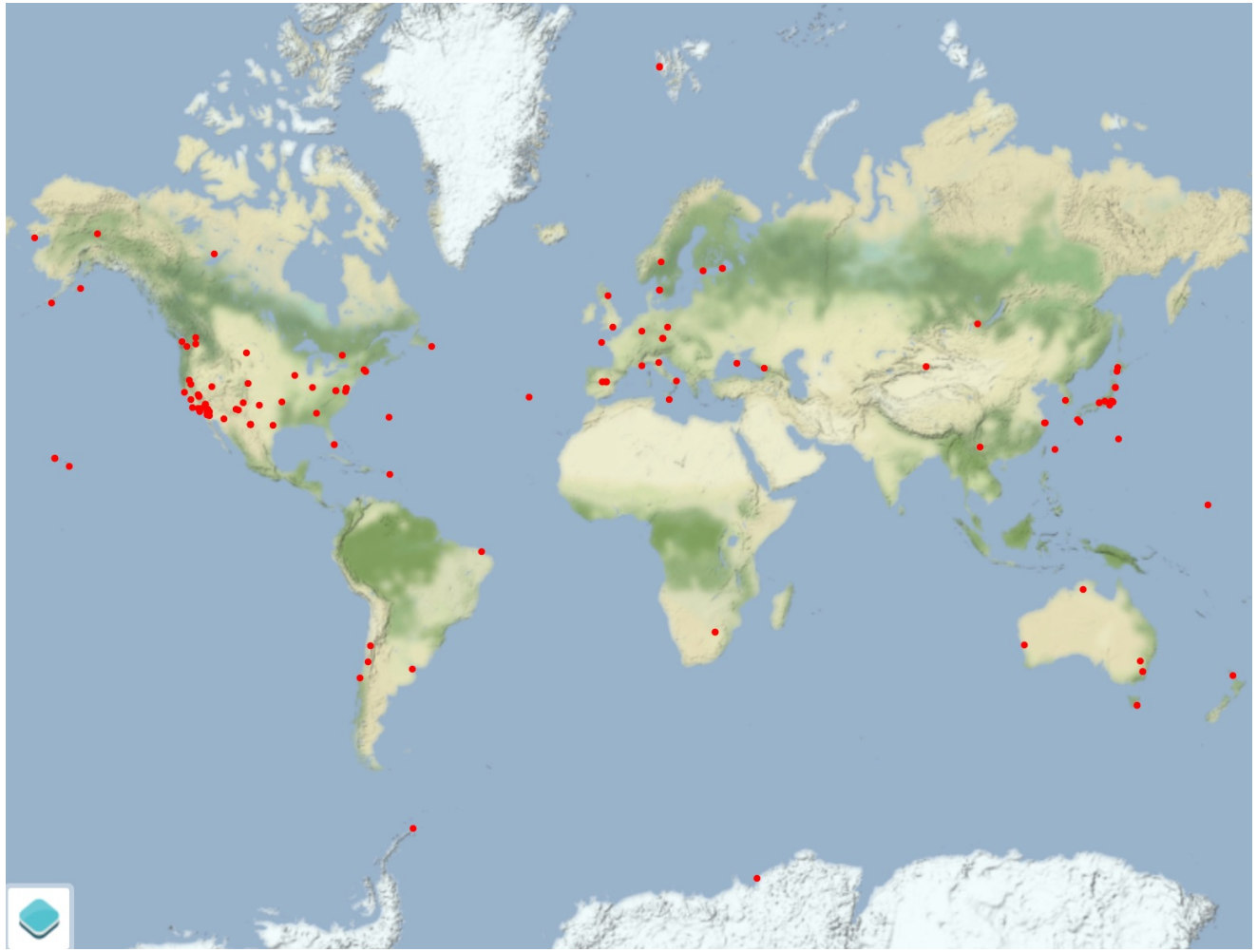
Network homogeneity

Scale factors		Time span	# sessions	Drift (ppb/yr)
OSO_{REP}	All sessions	2013.75-2021.00	884	0.138 +/- 0.028
OSO_{REP}	No VLBA sessions	2013.75-2021.00	814	0.148 +/- 0.029

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

Particular stations to be investigated

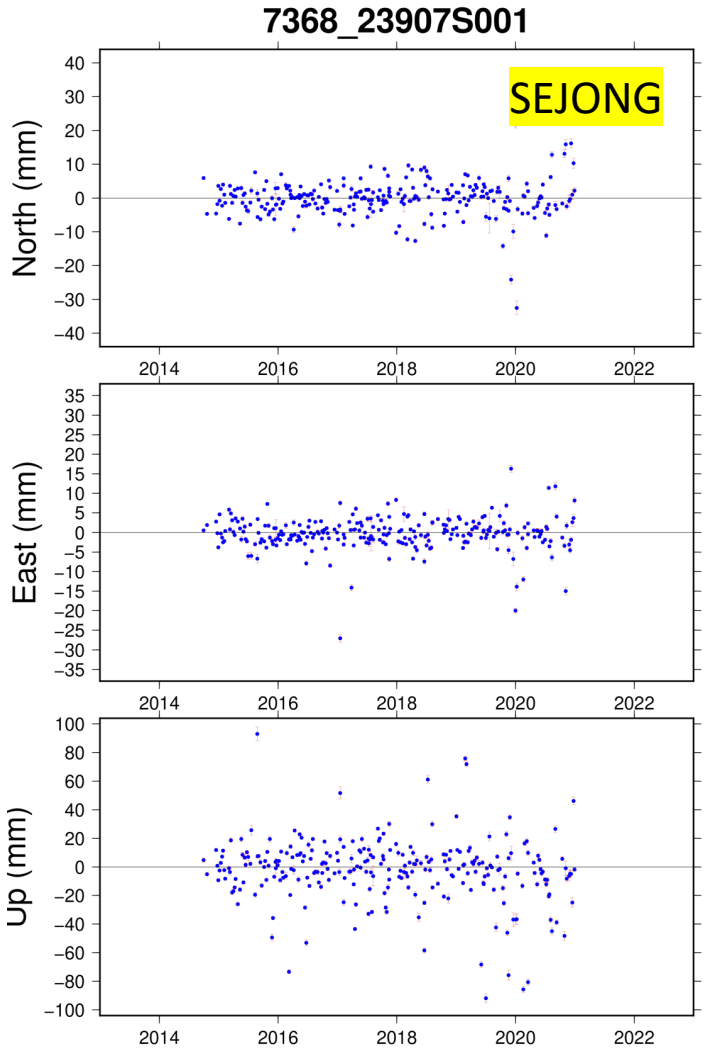
- Time series of station position residuals w.r.t. ITRF2020 (de-trended with seasonal signals removed):
  - 154 VLBI stations
  - 70 stations observed at least until 2013.75
  - BEAST (Bayesian Estimator of Abrupt change, Seasonal change, and Trend). See Zhao et al. (2019).
- Two categories: noisy or abrupt change
- Three stations studied in this presentation:
  - Sejong
  - Yebes40m
  - Ny-Ålesund



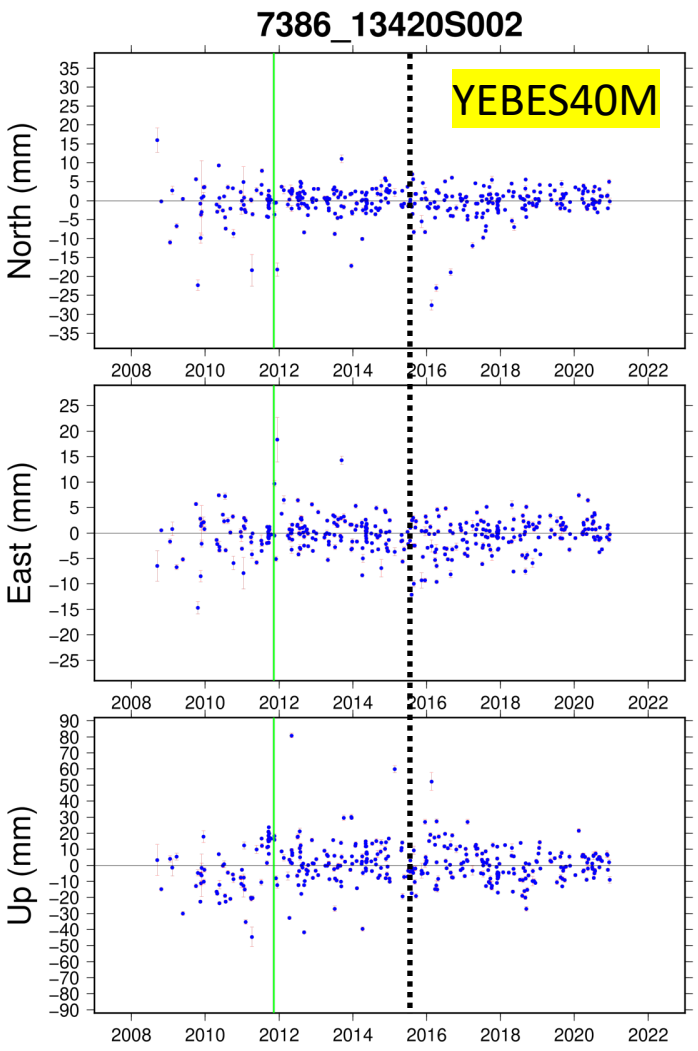
Maps of IVS stations. ***Credit:*** ITRF website.

The case of Sejong and Yebes40m

- 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

The case of Sejong and Yebes40m

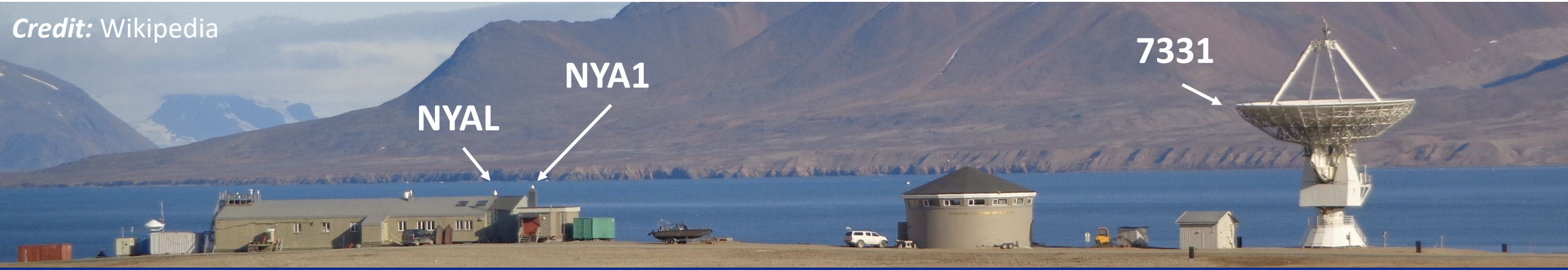
Scale factors		Time span	# sess.	Drift (ppb/yr)
OSO_{REP}	All stations	2013.75-2021.00	884	0.138 +/- 0.028
OSO_{REP}	Without SEJONG	2013.75-2021.00	884	**0.046** +/- 0.028
OSO_{REP}	Without YEBES40M	2013.75-2021.00	884	**0.106** +/- 0.029

✓ 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?

The case of Ny-Ålesund



The case of Ny-Ålesund

Scale factors		Time span	# sessions	Drift (ppb/yr)
OSO_{REP}	All stations	2013.75-2021.00	884	0.138 +/- 0.028
OSO_{REP}	Without NYALES20	2013.75-2021.00	884	0.173 +/- 0.029

The case of Ny-Ålesund

Scale factors		Time span	# sessions	Drift (ppb/yr)
OSO_{REP}	All stations	2013.75-2021.00	884	0.138 +/- 0.028
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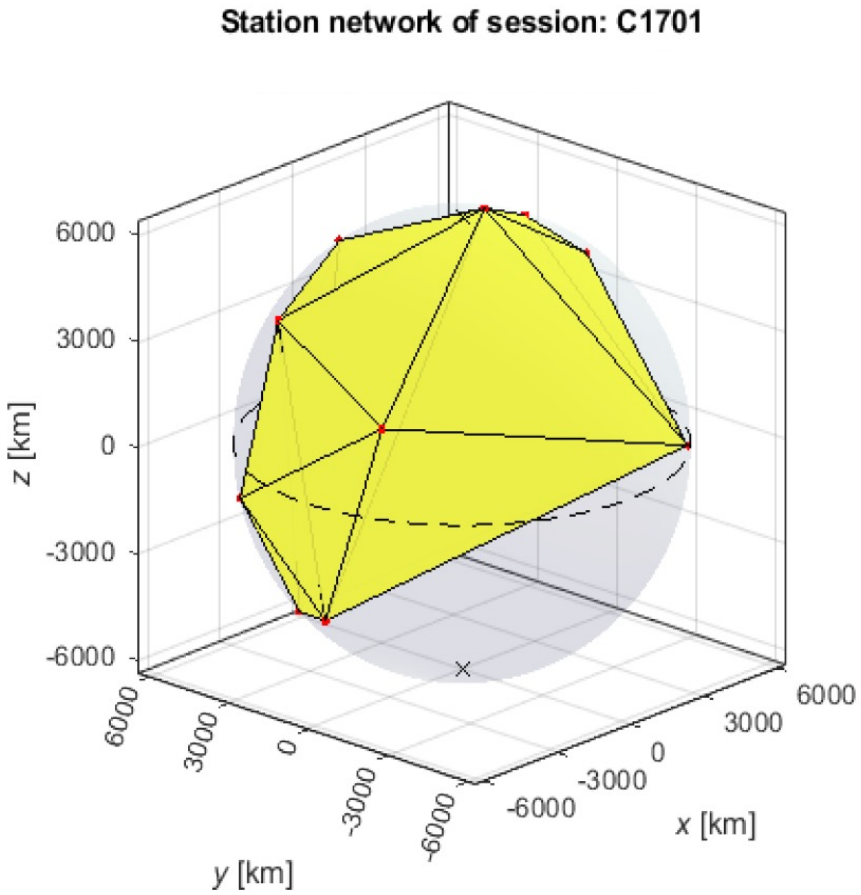
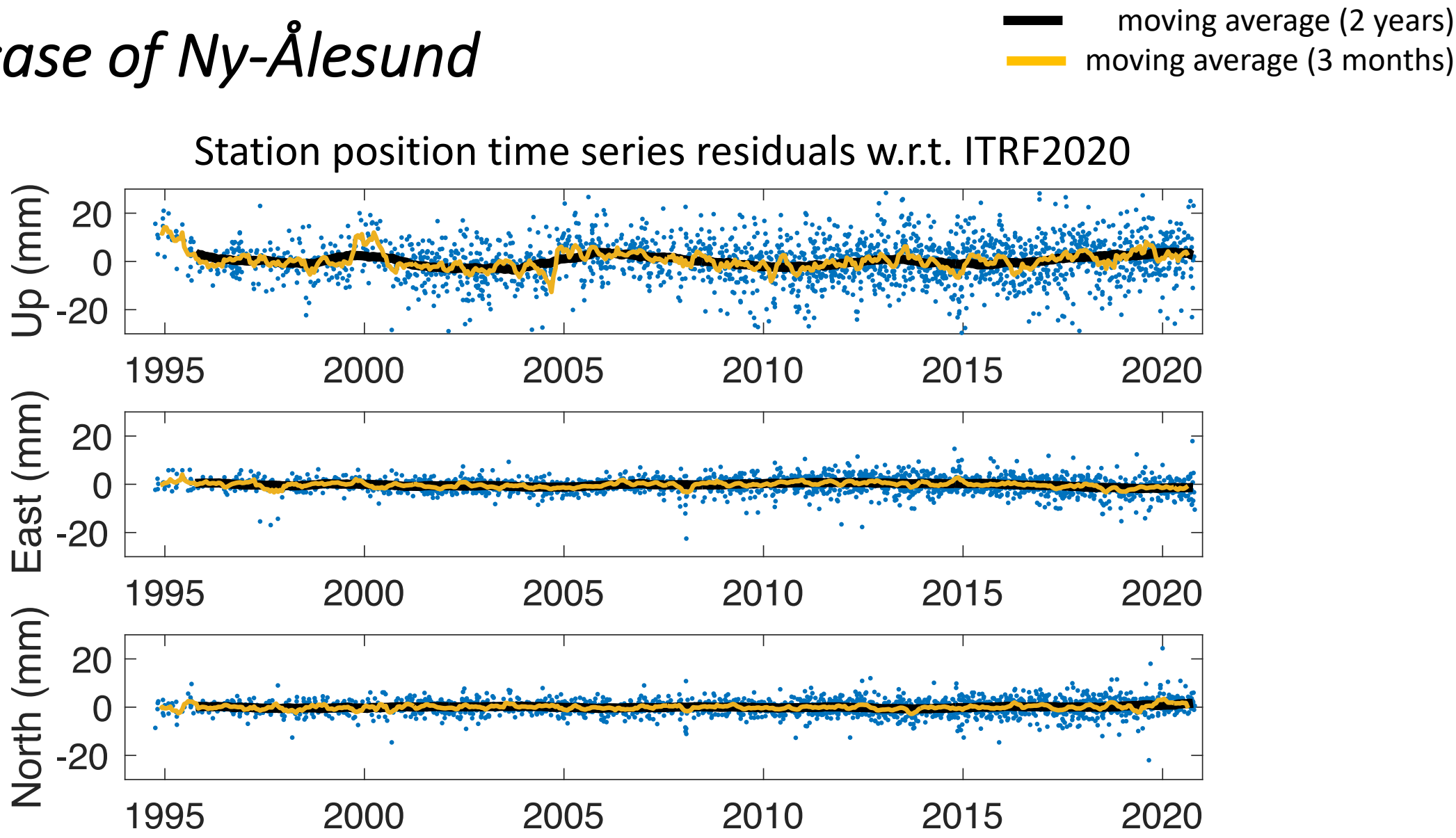


Credit: F. Nyström Lindé, Master thesis

The case of Ny-Ålesund



The case of Ny-Ålesund

Credit:
EUREF Permanent GNSS Network
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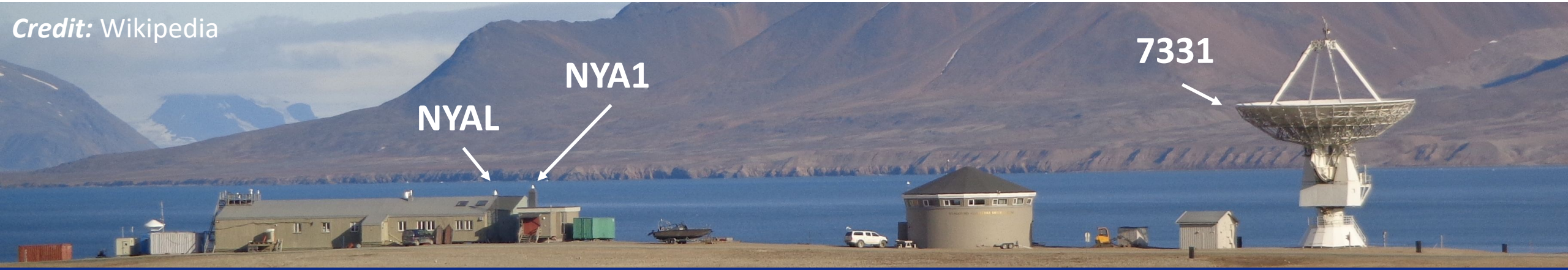
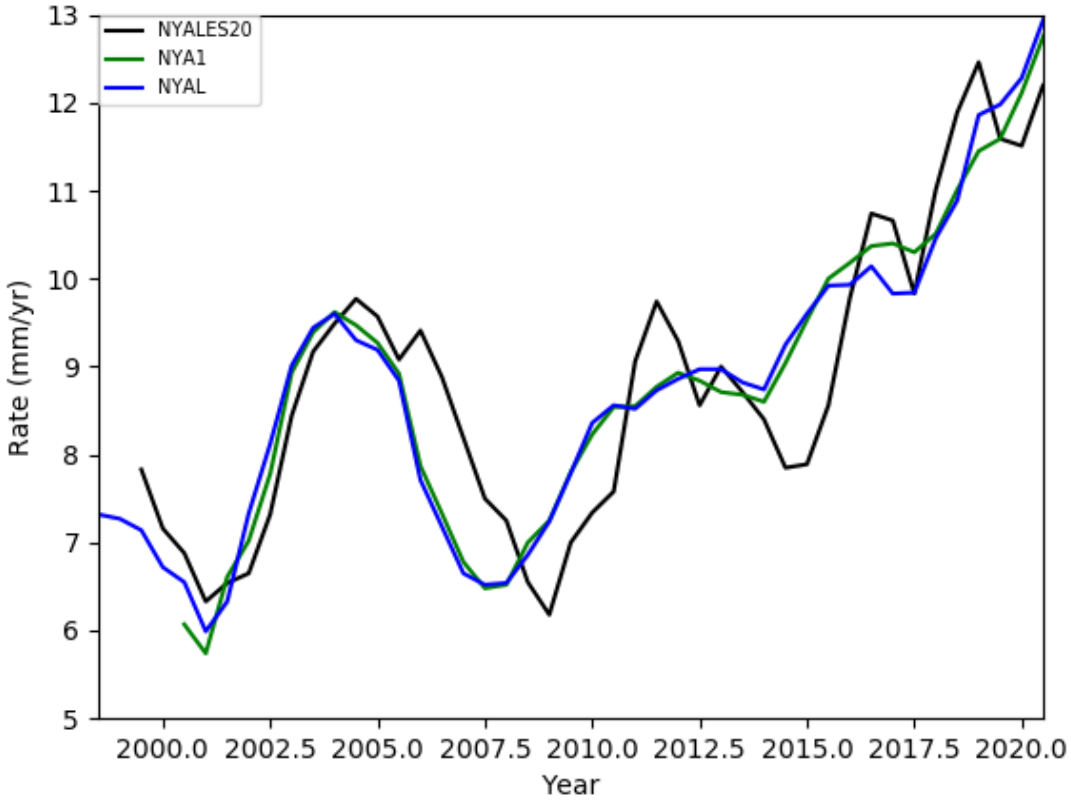


The case of Ny-Ålesund

Z-component velocities for
7331 (VLBI) and NYAL (GNSS) in ITRF2020

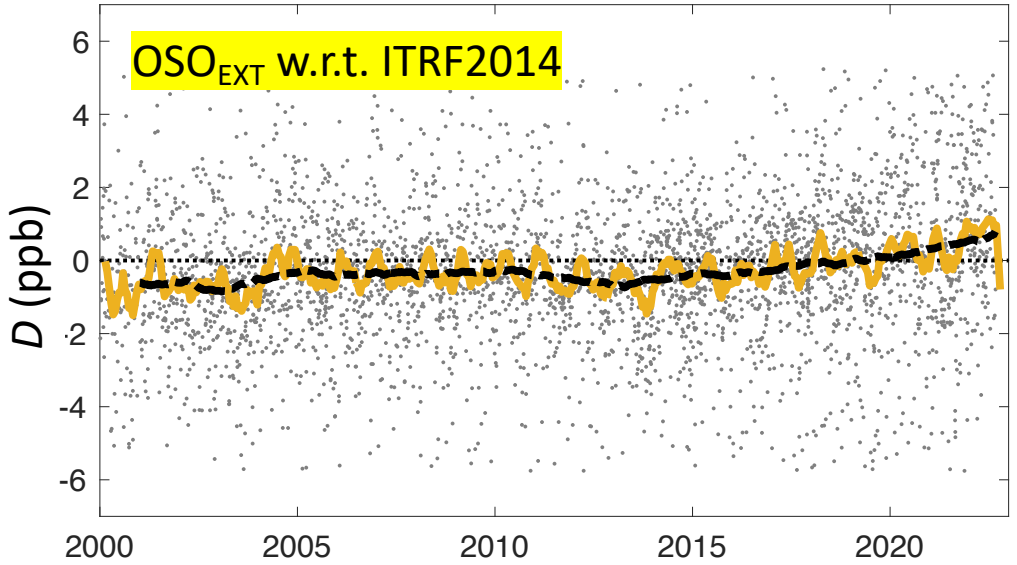
Data span	Station	VZ (mm/y)
	VLBI 7331	10.55 +/- 0.09
00:000-98:047	GNSS NYAL	5.88 +/- 2.13
98:047-00:340	GNSS NYAL	9.75 +/- 2.47
00:340-01:249	GNSS NYAL	10.32 +/- 0.46
01:249-04:186	GNSS NYAL	10.32 +/- 0.46
04:186-16:233	GNSS NYAL	10.25 +/- 0.09
16:233-00:000	GNSS NYAL	12.77 +/- 0.31

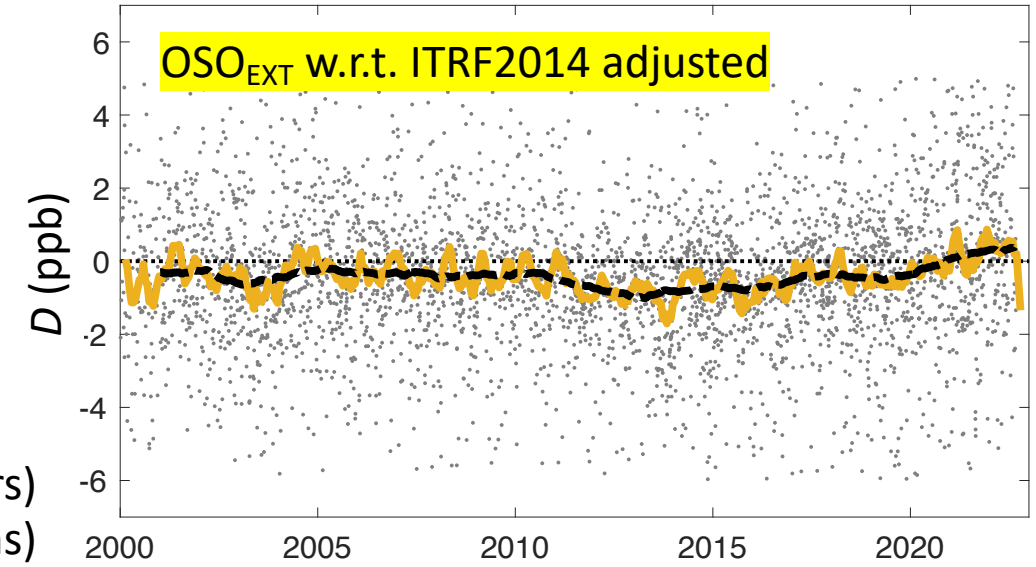


Credit: H. Kierulf

The case of Ny-Ålesund

Scale factors		Time span	# sessions	Drift (ppb/yr)
OSO_{REP}	All stations	2013.75-2021.00	884	0.153 +/- 0.028
OSO_{REP}	ITRF2014 adjusted	2013.75-2021.00	884	0.123 +/- 0.029





moving average (2 years)
moving average (3 months)

The case of Ny-Ålesund

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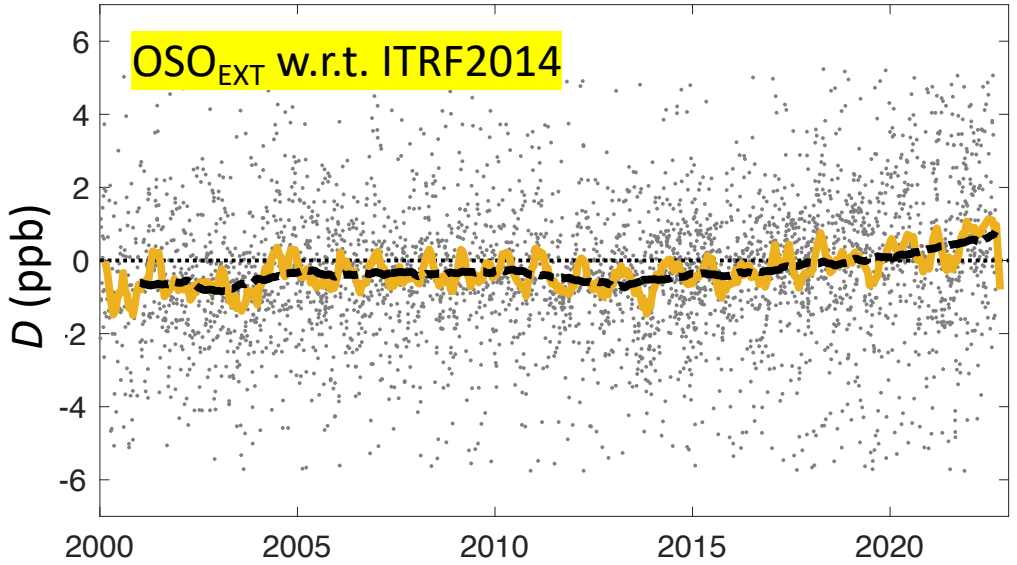
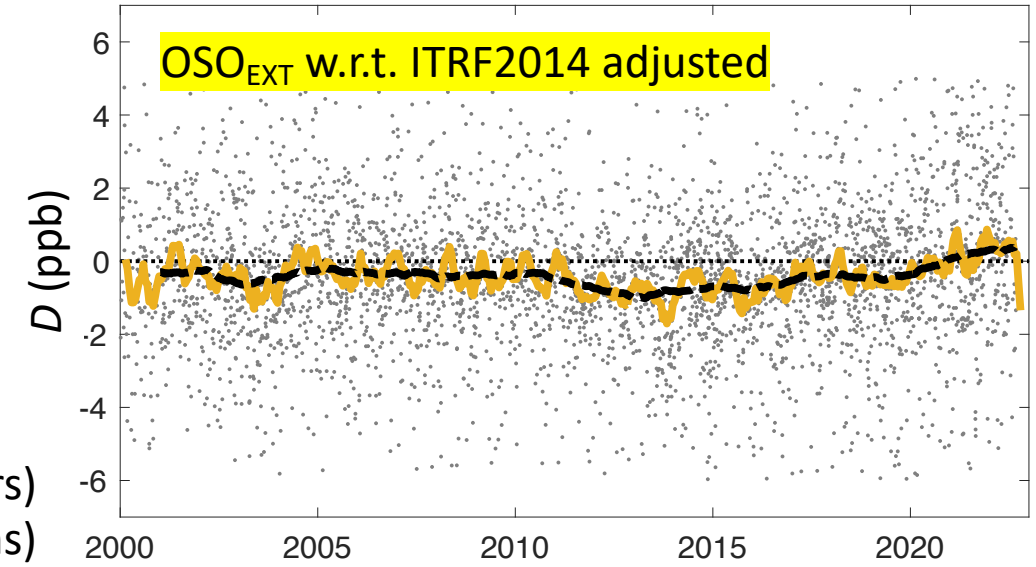
OSO_{REP}	ITRF2014 adjusted	2013.75-2021.00	884	0.123 +/- 0.029

Scale factors		Time span	# sessions	Drift (ppb/yr)
OSO_{REP}	All stations	2000.00-2023.00	3278	0.055 +/- 0.005
OSO_{REP}	ITRF2014 adjusted	2000.00-2023.00	3278	**0.011** +/- 0.005





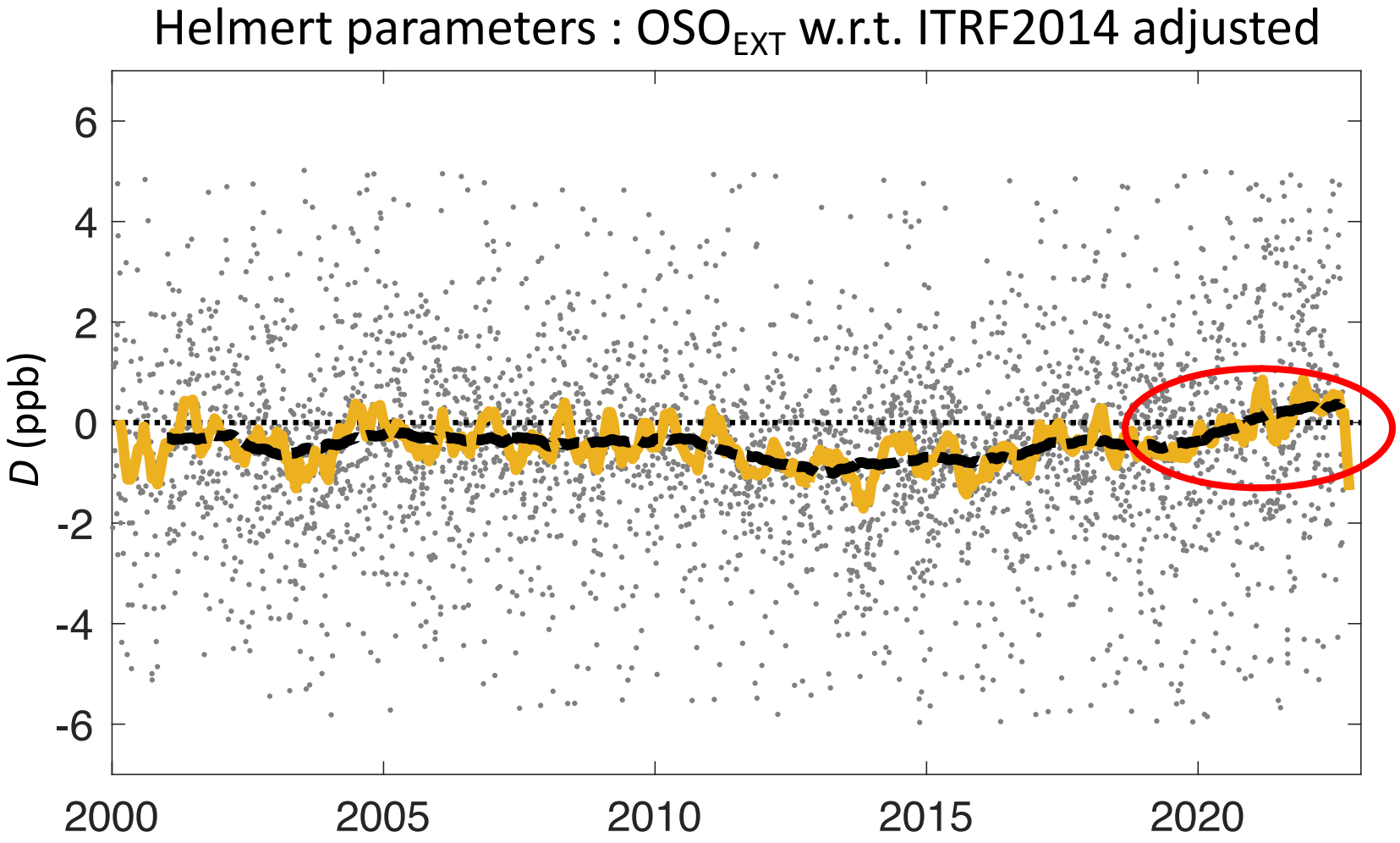
moving average (2 years)
moving average (3 months)

The case of Ny-Ålesund

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

❑ But, changing the velocity model / introducing discontinuity does (to be confirmed).

The case of Ny-Ålesund



Results

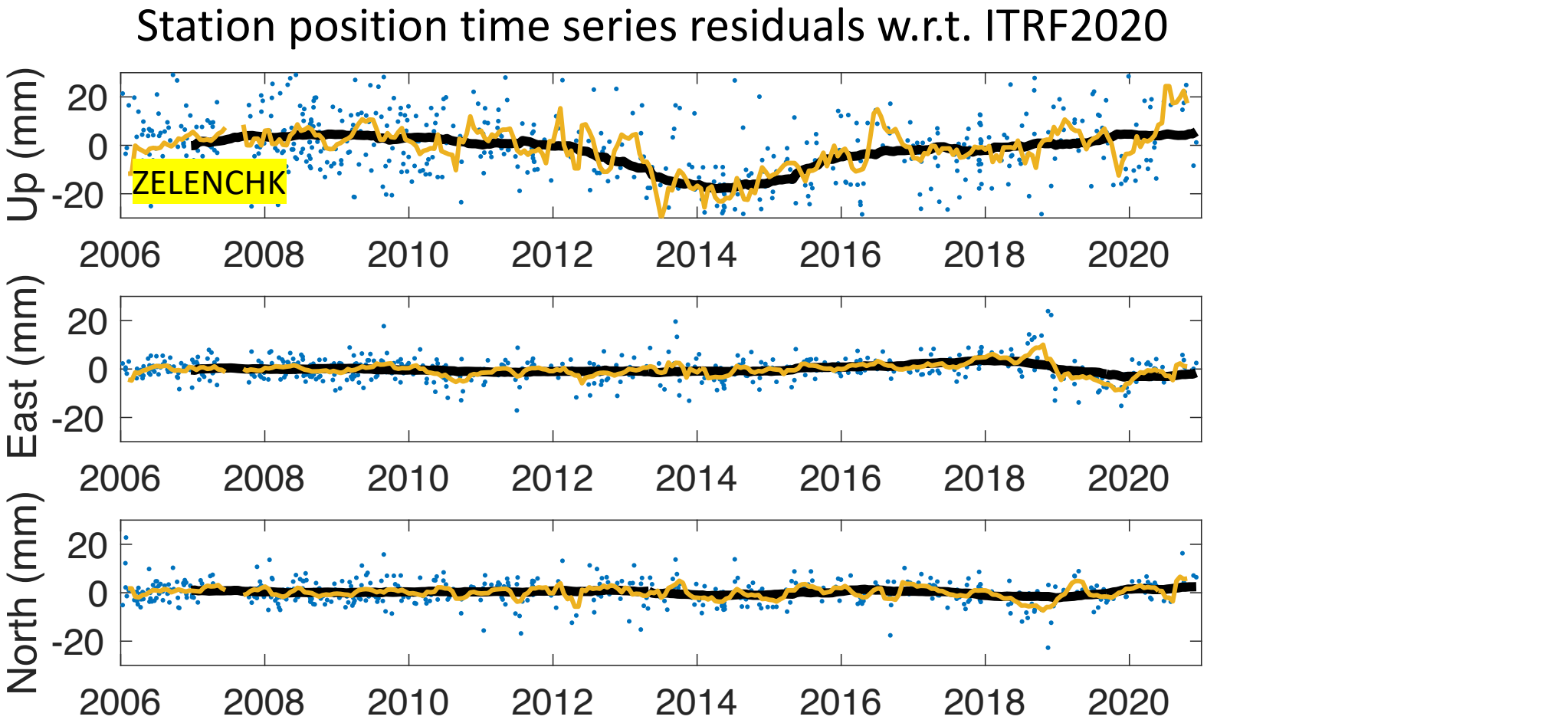
Scale factors	2013.75-2021.00	Drift (ppb/yr)
OSO_{REP}	All stations	0.138 +/- 0.028
OSO_{REP}	ITRF2014 adjusted	**0.108** +/- 0.029
OSO_{REP}	ITRF2014 adjusted + no SEJONG	**0.011** +/- 0.029

Scale factors	2013.75-2021.00	Drift (ppb/yr)
OSO_{REP}	All stations	0.138 +/- 0.028
OSO_{REP}	ITRF2014 adjusted	**0.108** +/- 0.029
OSO_{REP}	ITRF2014 adjusted + no YEBES40M	**0.073** +/- 0.032

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.
  - Use CATREF to confirm the results on Ny-Ålesund (add two discontinuities).
  - Investigate other stations.
- Perspectives of this work:
  - This work focuses on only one individual VLBI solution (OSO).
  - IVS Working Group on Scale: Unified testing strategy for all IVS analysis centers in collaboration with the IVS combination center.

Another suspect…



Necessity to keep track of station events…

To be continued…

Credit: found on Twitter