Sentinel-3A and Sentinel-3B SAA effect

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Sentinel-3A and -3B USO shared by DORIS and GPS clocks

DORIS estimation of USO frequency

- Based on pseudorange measurement
- Only beacons equipped with atomic clocks
- Polynomial model
- No estimation short-term variations including SAA effects

GPS estimation of USO frequency

- Epochwise estimation sampling
- Sampling at the level of seconds or tenths seconds
- Modeling of short-term frequency variations including SAA effects

Introductions of GPS clocks estimates into DORIS data procesing

Already used in Jalabert & Mercier paper for Sentinel-3A

Jalabert, E.; Mercier, F., 2018. Analysis of South Atlantic Anomaly perturbations on Sentinel-3A Ultra Stable Oscillator. Impact on DORIS phase measurement and DORIS station positioning, *ADVANCES IN SPACE RESEARCH*, 62(1):174-190, DOI: 10.1016/j.asr.2018.04.005

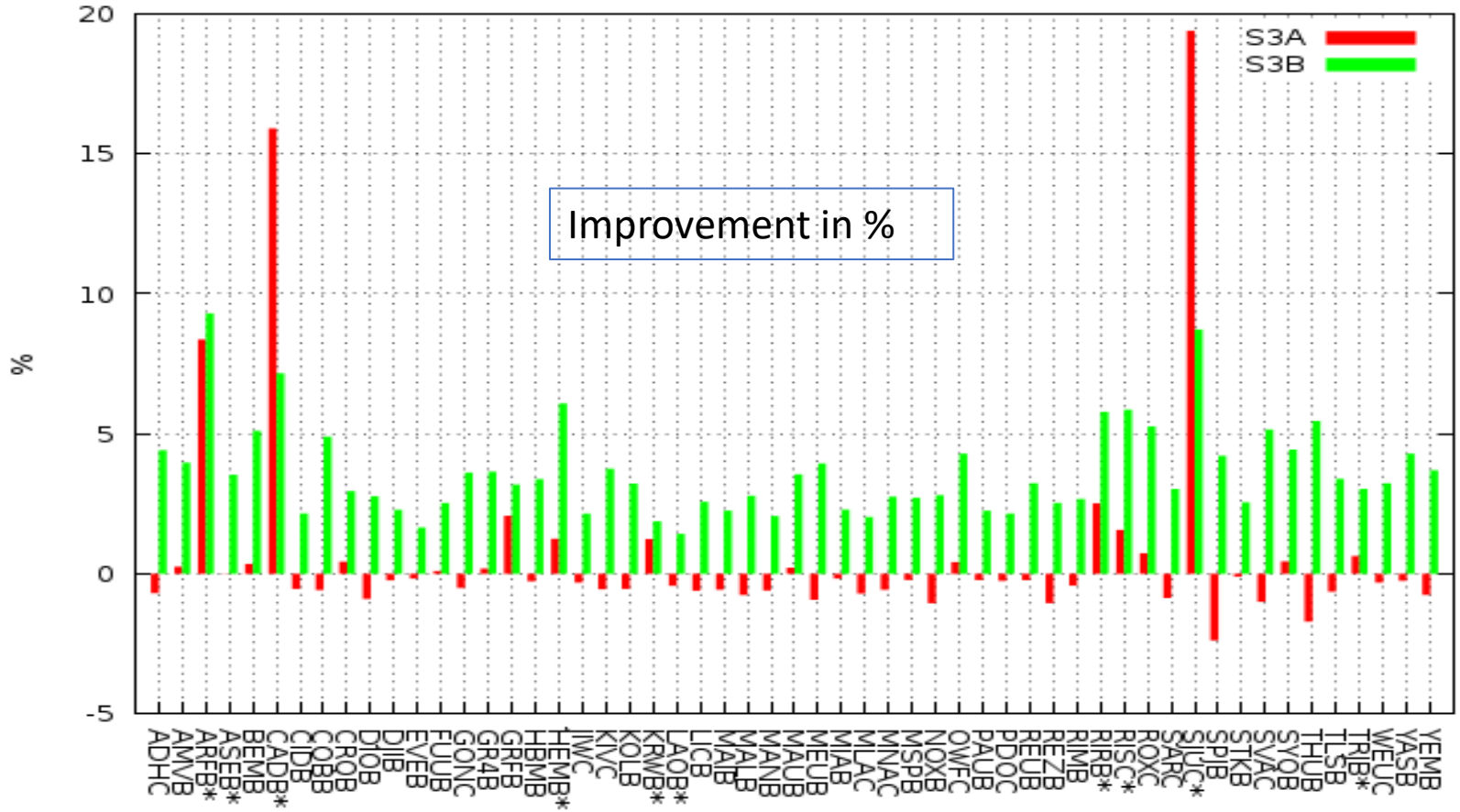
- Clocks estimation 120 s sampling interval, 90 days of data
- POD effects
- Station Vertical bias only

In our experiment

- Time span 1 year of data (from day 180/2018 to day 180/2019)
- Both Sentinel-3A and Sentinel-3B satellites
- 5 sec sampling interval (boxcar filer smoothing 105 s for Sentinel-3A and 45 s for Sentinel-3B
- Both Sentinel-3A and Sentinel-3B satellites
- SAA maps
- Station 3D positioning impact
- Verification by GPS coordinates + measured local ties (co-located sites)
- Combined Sentinel-3A and Sentinel-3B solution as a reference to estimate SAA impact on station positioning for other satellites

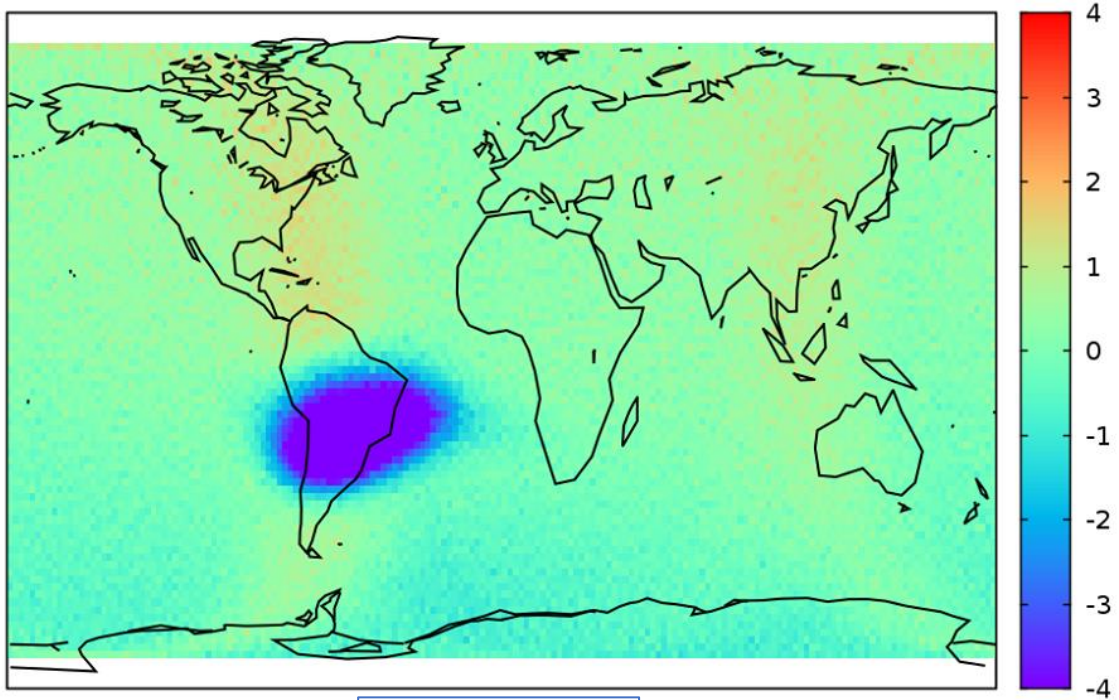
Post-fit DORIS Doppler residuals improvement

- Sentinel-3A improvement only for SAA stations
- Sentinel-3B improvement for whole network
- Reason of this difference: higher noise in Sentinel-3A clock series

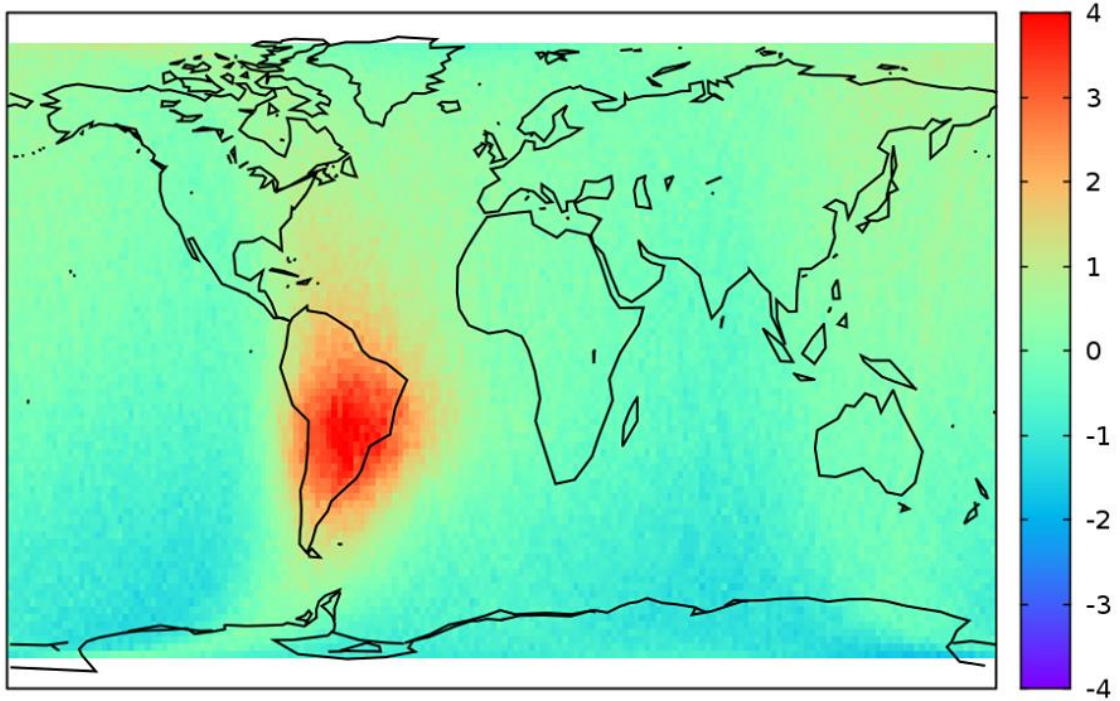


SAA maps (1)

- USO frequency bias in ps/s
- Different sign for both Sentinels
- Different shape of the SAA area for both Sentinels



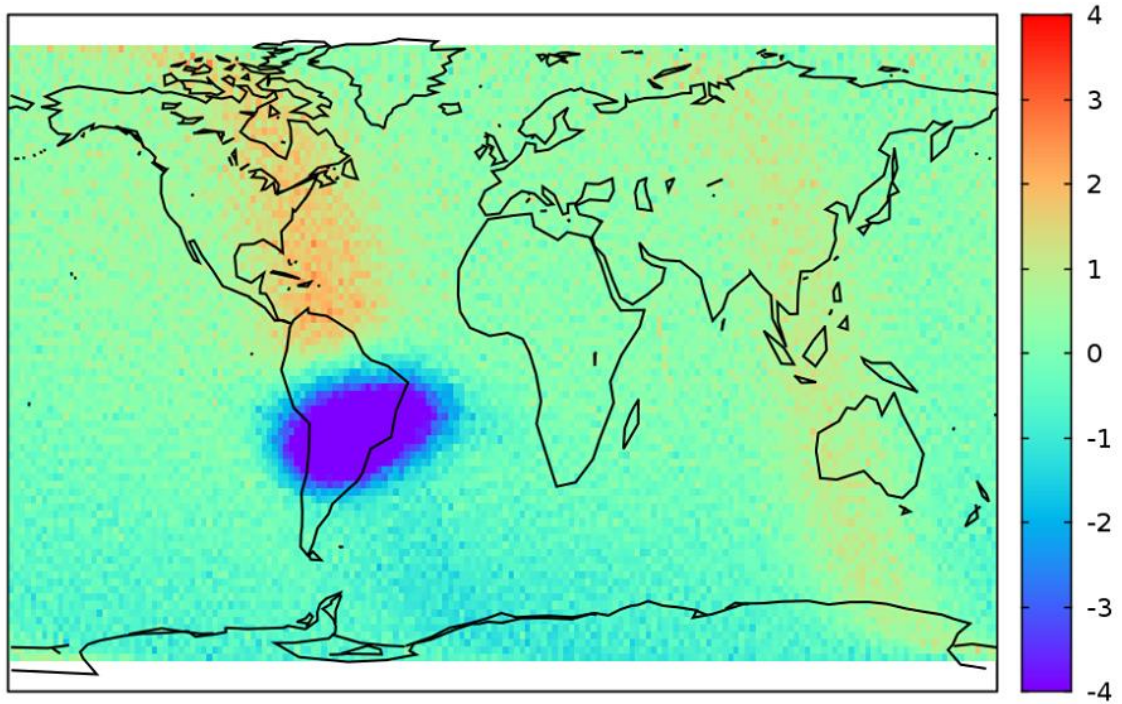
Sentinel-3A



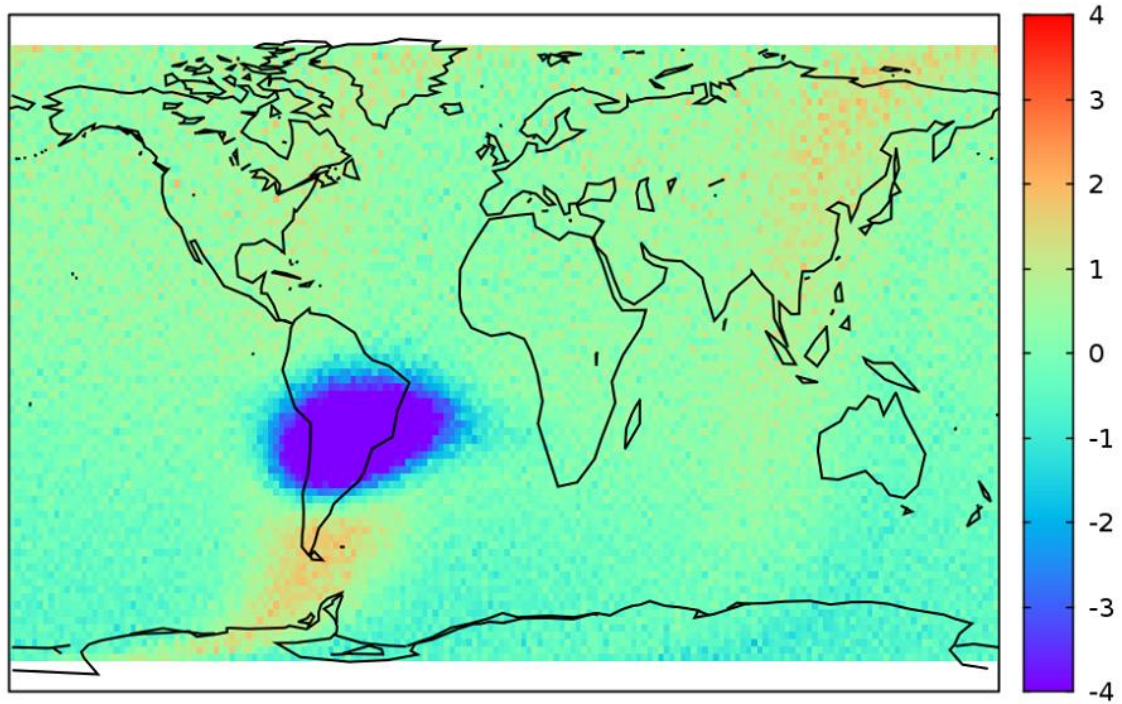
Sentinel-3B

SAA maps (2)

- South-North and North-South paths for Sentinel-3A
- Very quick recovery effect
- “Overcompensation”



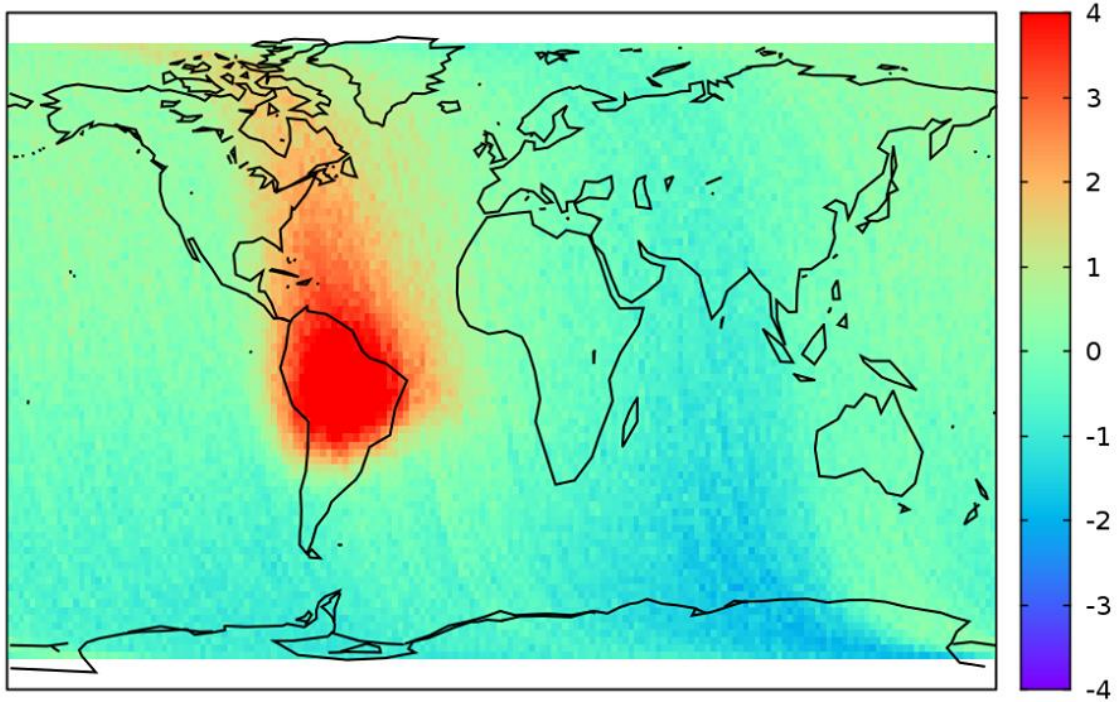
South-North



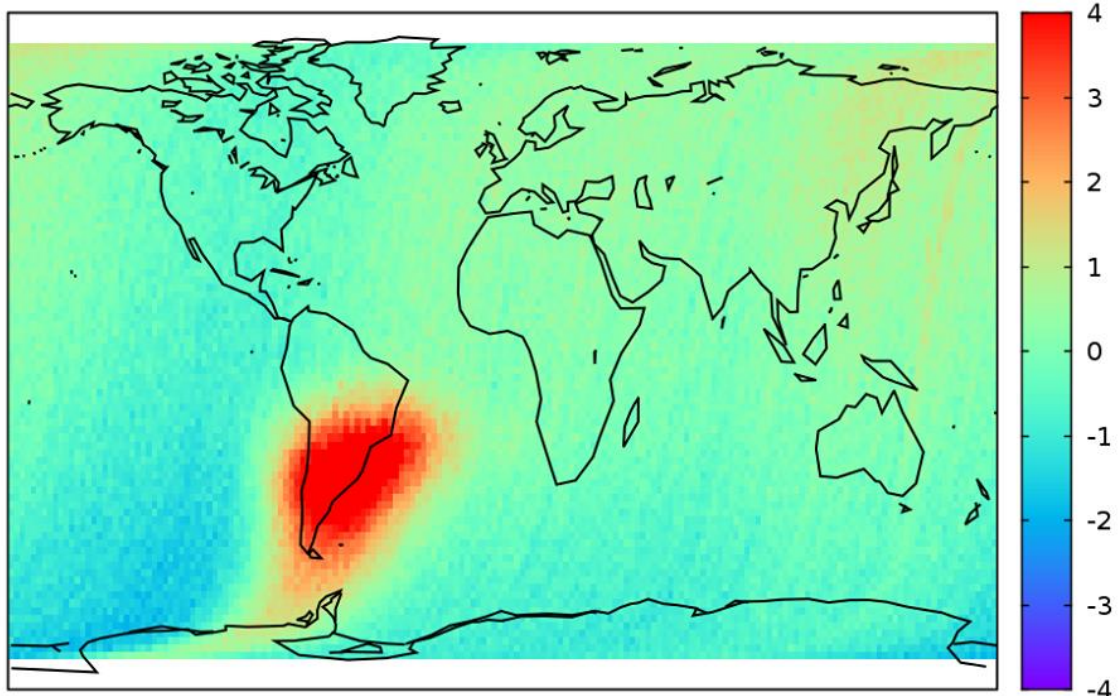
North-South

SAA maps (3)

- South-North and North-South paths for Sentinel-3B
- Strong memory effect. Slow recovery
- Possible USO resistance for initial part of SAA pass



South-North



North-South

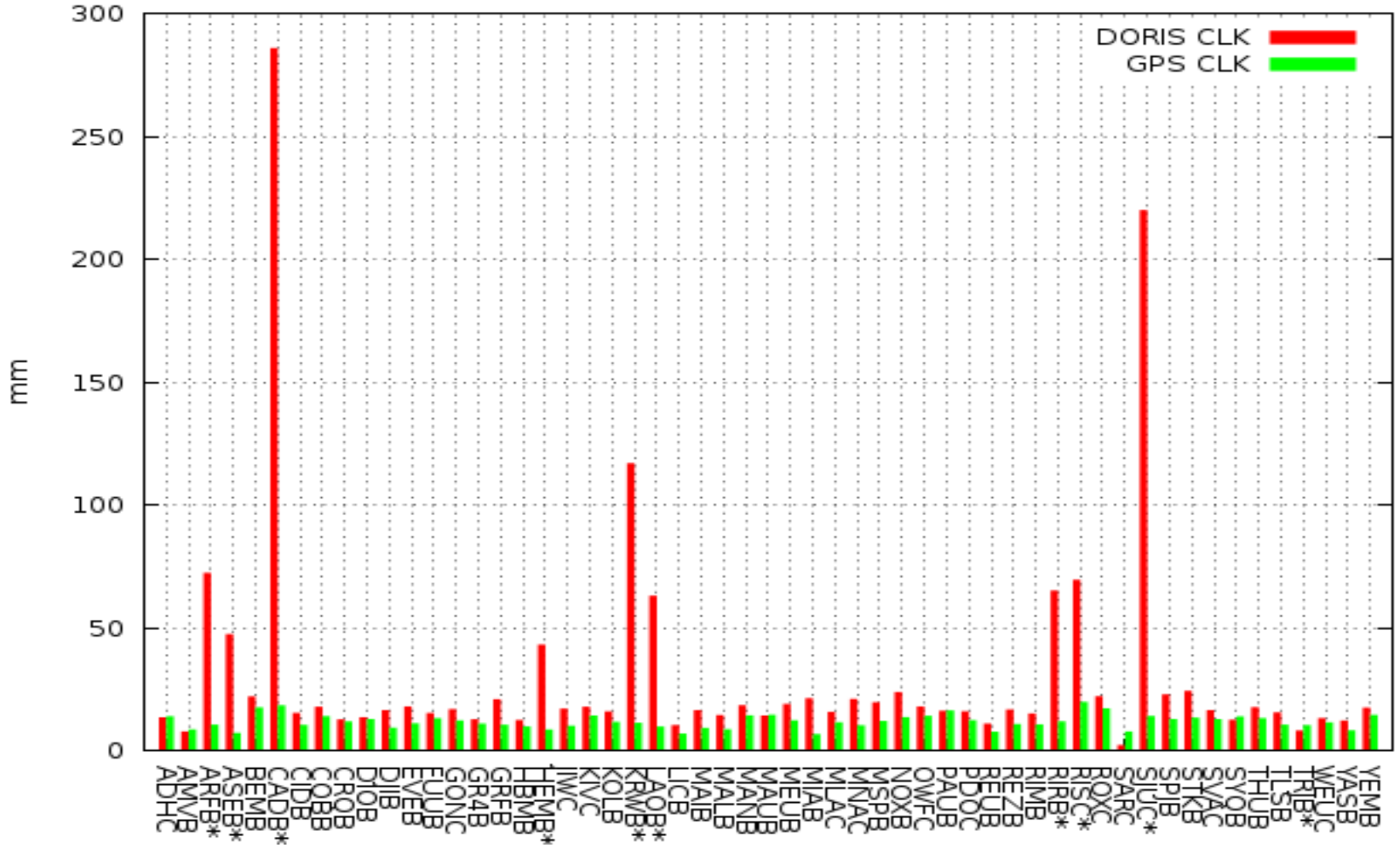
Station positioning (1)

- Estimated station coordinates differences
- Solutions with and without GPS clocks
- Unit: mm

Sta/Sat	Sentinel-3B			Sentinel-3A			
	Latitude	Longitude	Height	Latitude	Longitude	Height	Height (J&M2018)
KRWB	5	17	14	23	-87	-3	-23
RICB/RIRB	6	13	-7	-4	-51	13	14
CADB	-24	-6	-81	20	231	40	30
HEMB	-6	9	11	2	32	19	19
ARFB	31	-32	-23	9	41	-31	-50
ASEB	19	6	1	-24	-21	13	13
SJUC	-53	-55	-43	41	170	-29	-
LAOB	-5	15	3	-29	10	10	-

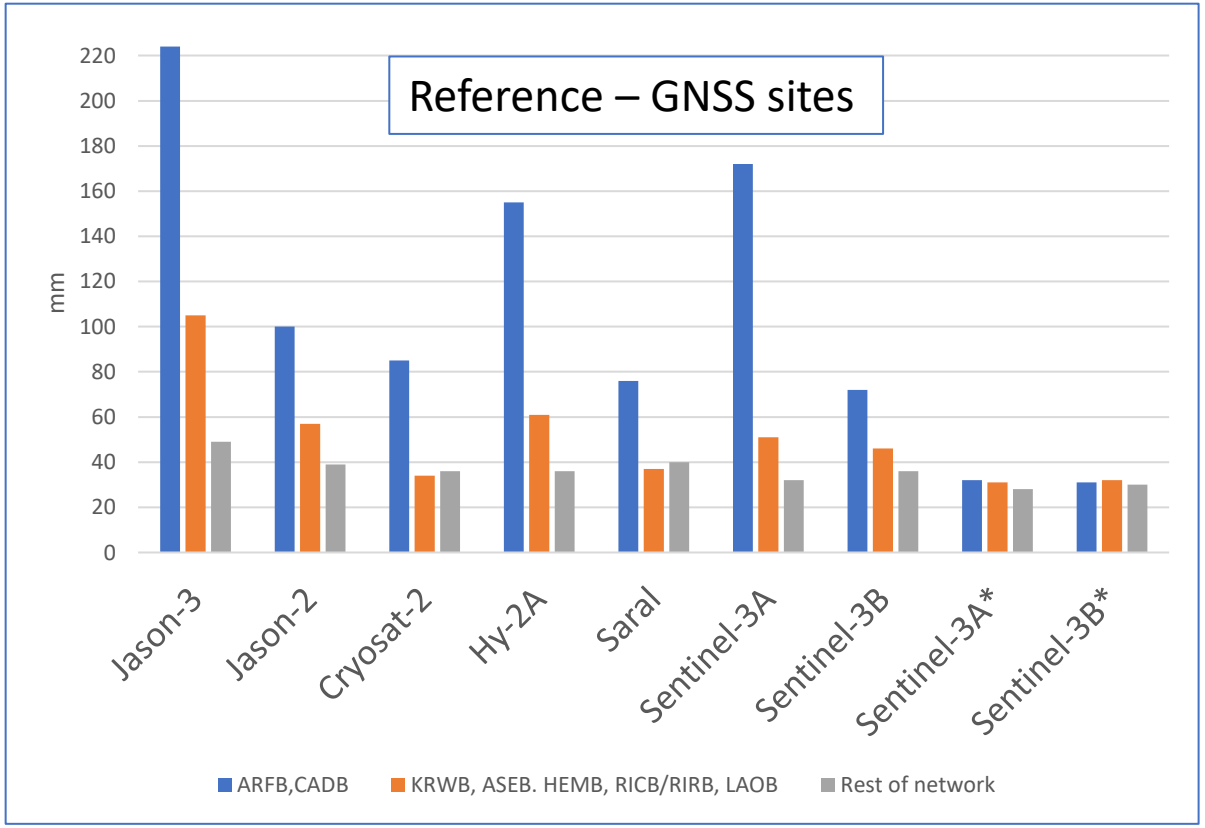
Station positioning (2)

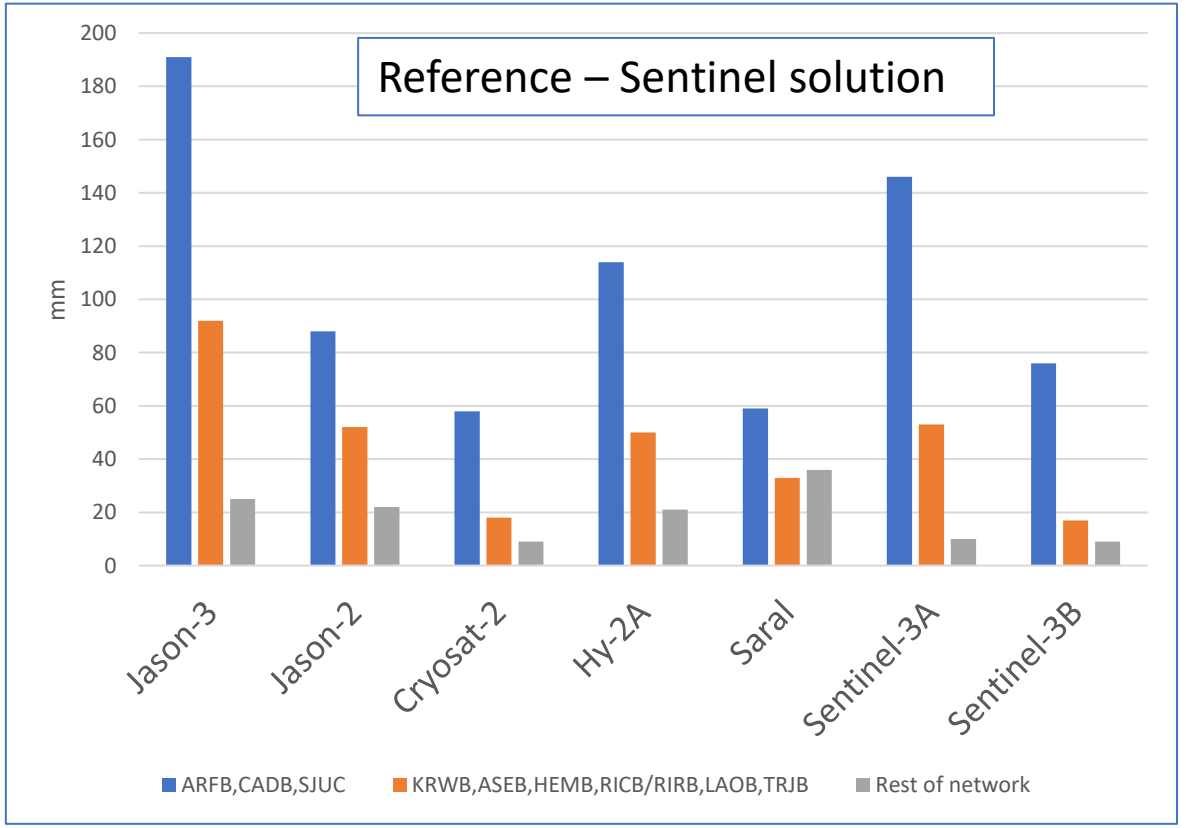
- Mutual 3D differences between Sentinel-3A and Sentinel-3B single sat. positioning
- Up to 20 mm for all the stations when GPS clocks introduced



Station positioning (3)

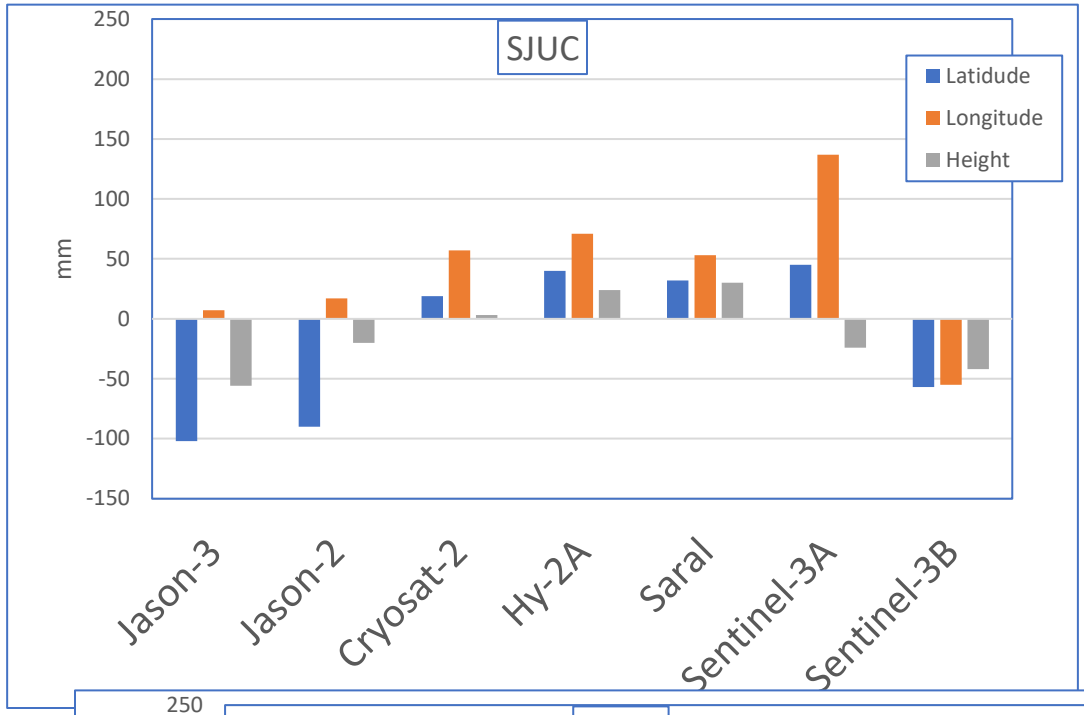
- Single-satellite station positioning for Sentinel-3A, -3B, Jason-2, -3, Cryosat-2, Hy-2A and Saral. 3D differences for 3 groups of stations (inner SAA, margin SAA, outside SAA)
- References : 1. GNSS coordinates + local ties
  2. Sentinel-3A + Sentinel-3B combined solution with GPS clocks

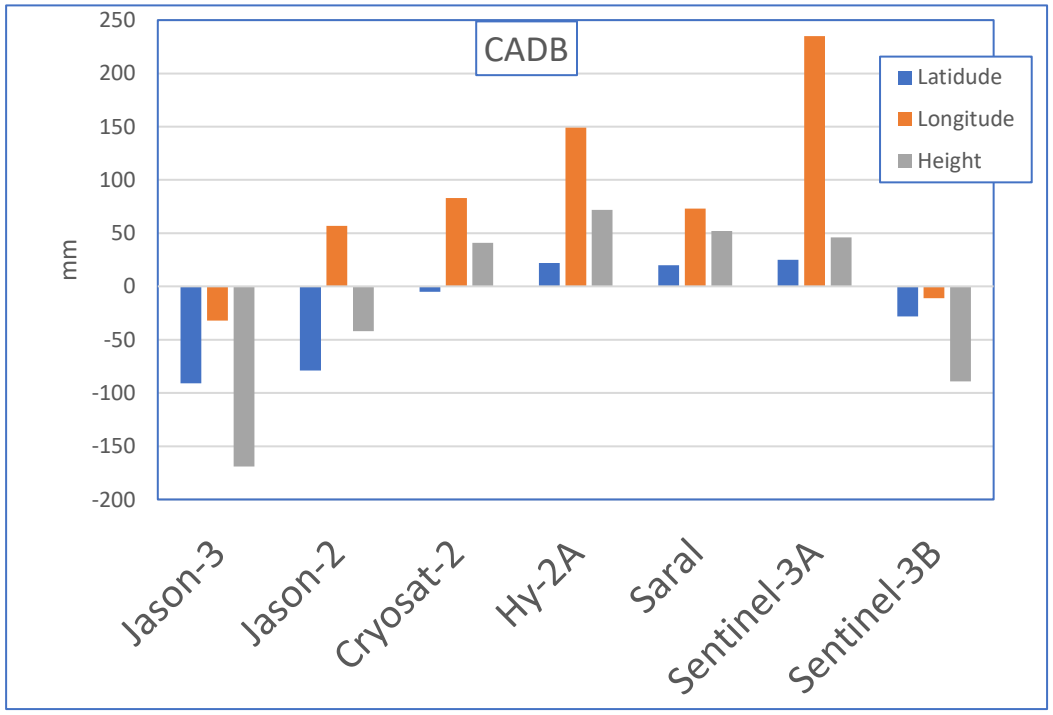


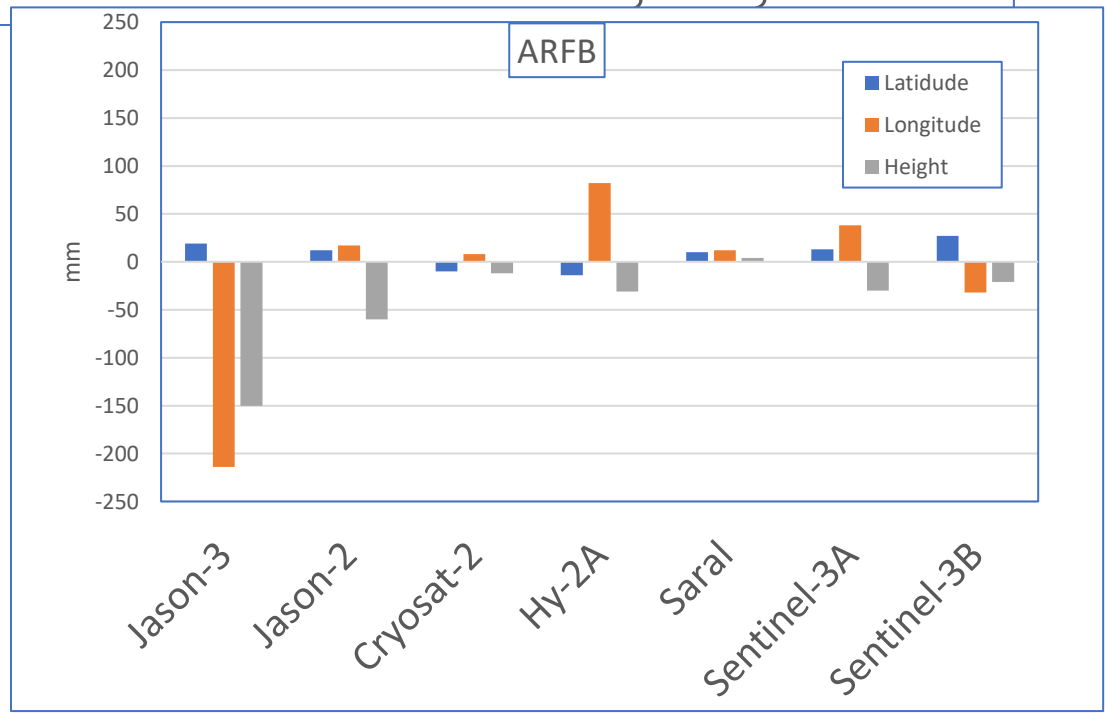


Station positioning (4)

- SJUC, CADB, ARFB
- Similarity for Sentinel-3A, Saral, Hy-2A and Cryosat







Conclusions

- Sentinel-3A and Sentinel-3B USOs are affected by SAA
- Characteristics of USO frequency anomalies are different for Sentinel-3A and Sentinel-3B
- Introduction of GPS-estimated clocks solves the SAA problem
- Probably all satellites included in the experiment are affected by SAA (not significant for Saral)

Future prospects

- GPS clock introduction for Sentinels as possible IDS standard? (Is then DORIS solution still independent from GPS biases?)
- SAA DORIS data corrective models based on GPS clocks estimation?
  - Separately for ascending and descending passes
  - Could be Sentinel-3A model help also for Cryosat-2, Hy-2A and Saral?

Thanks for your attention

For details, please read

Štěpánek, P.; Bingbing, D.; Filler, V.; Hugentobler, U., 2020. Inclusion of GPS clock estimates for satellites Sentinel-3A/3B in DORIS geodetic solutions, JOURNAL OF GEODESY, 94(116):, DOI:10.1007/s00190-020-01428-x