

# Progress of the TU Delft Activities and ASR DORIS special issue status

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# Content

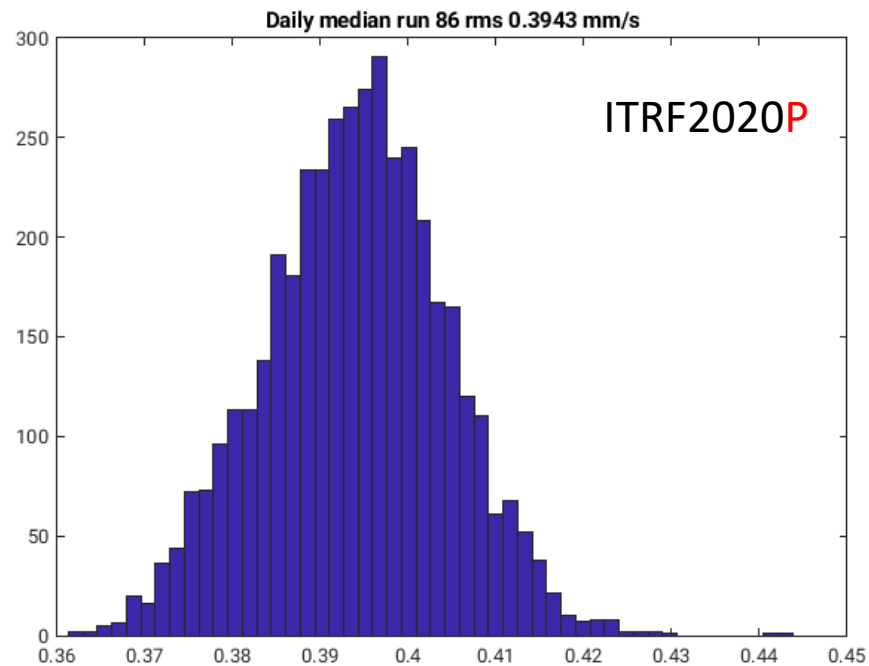
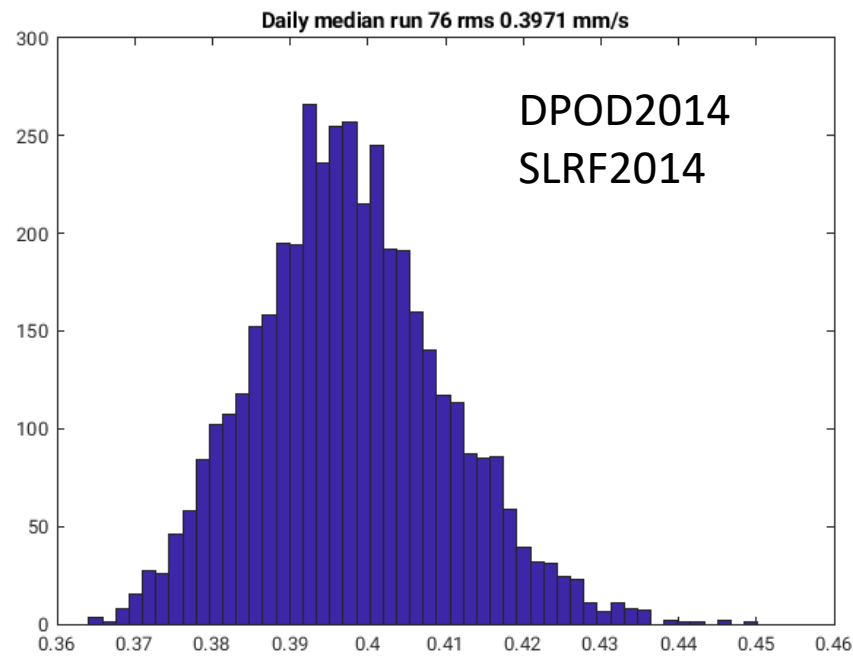
- POD of CryoSat-2
  - Implementation of ITRF2020<sup>P</sup>
  - TVG transition between GRACE and GRACE-FO
- IDS special issue
- Presentation updated relative to what I've sent prior to the mtg.

# Orbit Determination of CryoSat-2

- Satellite status,
  - All looks ok, no major problems
  - Alignment maneuvers with ICESAT-2, regular maneuvers, debris maneuvers
  - Occasional download issues at the ground terminal(s),
- There are 975 arcs, on average 6 days in length, partial overlap
- Activities starting in June 2010 up to start of 2022
- AOCS: three star cameras, we use them to determine nominal attitude law period
  - During maneuvers the nominal attitude law is interrupted (4 degree yaw steering mode)
  - Quaternions of the S/C are provided by FTP (one month delay)
- CS2 increasingly depends on realistic dynamic modelling:
  - DORIS tracking is not like GNSS tracking, there is less geographic coverage
  - SLR data is used to validate the POD process independently
- CS2 POD is a test case for evaluating TVG transition GRACE to GRACE-FO

# Modelling (1)

- Coordinates
  - DPOD2014 IDS coordinates and ITRF2014 SLR coordinates
  - Transition to ITRF2020 for all Doppler and SLR stations
- Ocean loading by station/beacon
  - Chalmers ocean loading calculator based on FES2012 or similar
- Doppler beacon frequency offset estimated by pass
- Tropospheric zenith delay parameters estimated by pass
- Earth rotation parameters from IERS EOP 14 C04
- Initialization first state vector from Diode navigator orbits
- More rigorous editing to reject noisy data



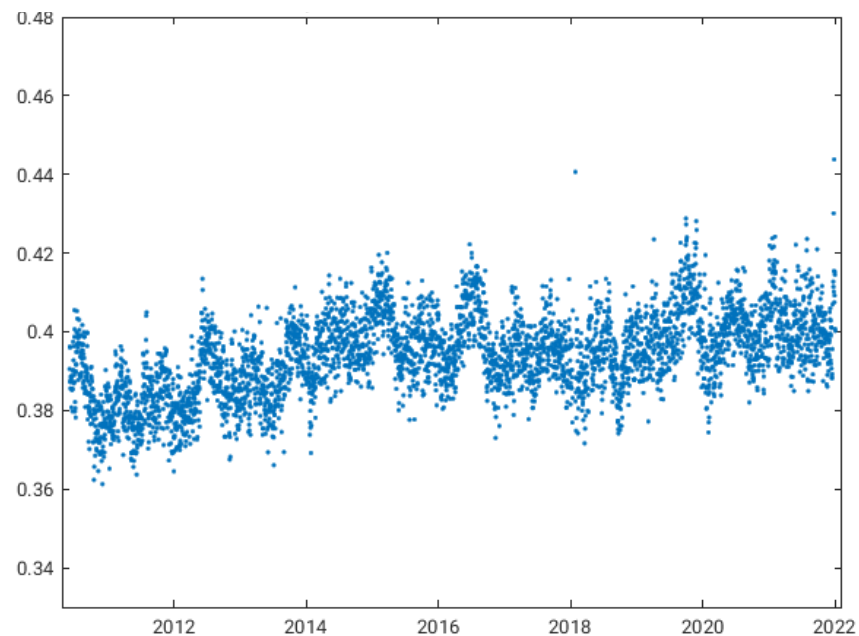
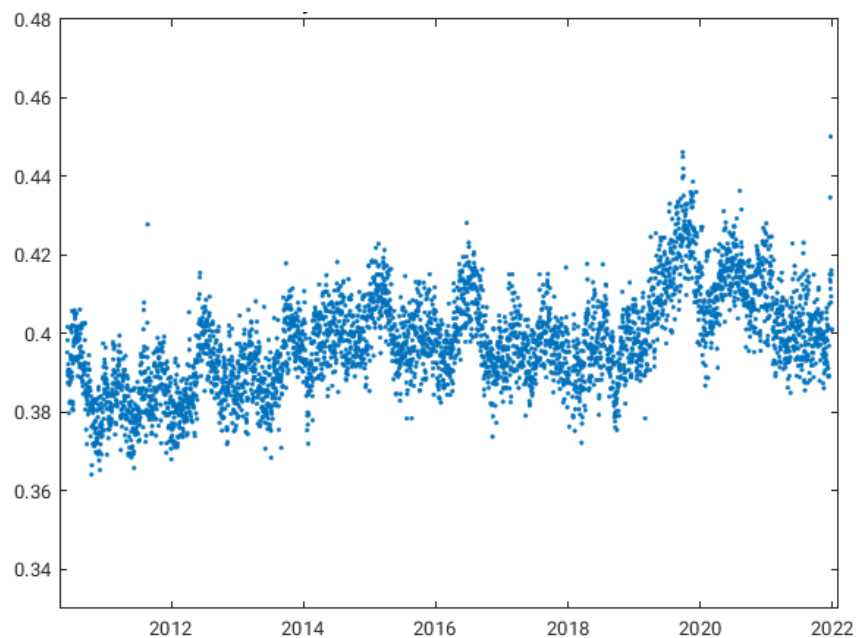
## IDS residuals

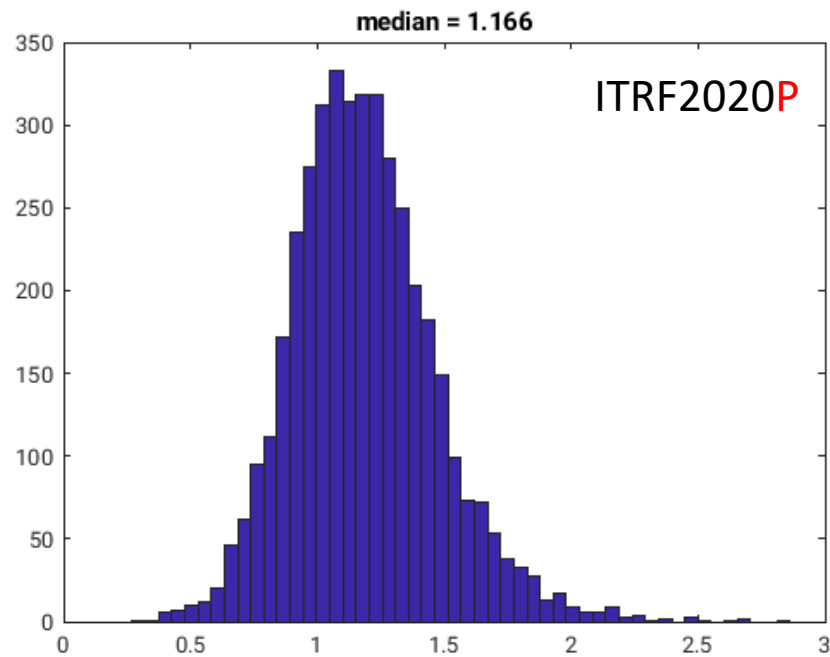
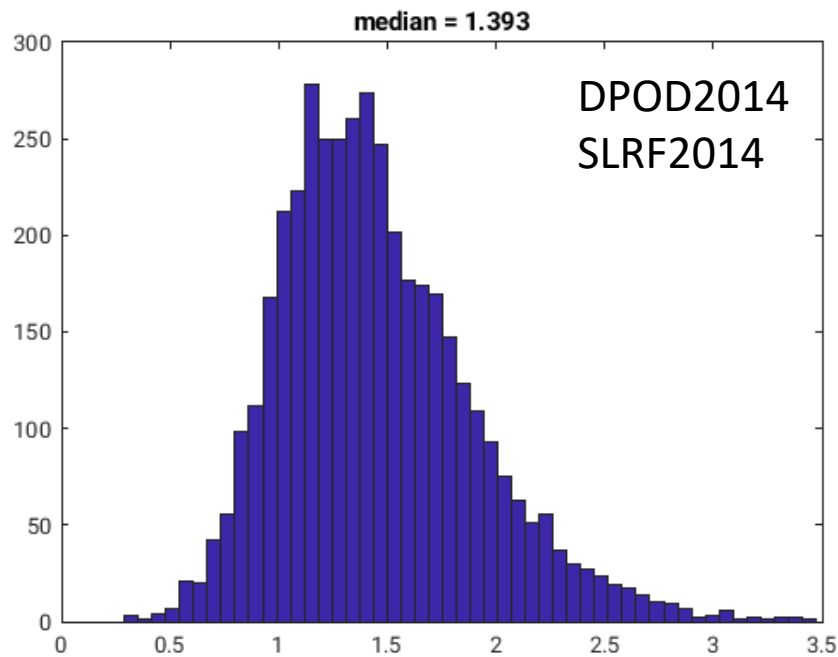
The residuals improve  
from 0.3971 to 0.3943 mm/s

Left: IDS coordinates  
were DPOD2014

Right: Everything is  
Transformed in ITRF2020,  
5 IDS stations that were  
not in the ITRF had  
survey coordinates.

The increase observed in  
2019/2020 is probably  
related to the ITRF



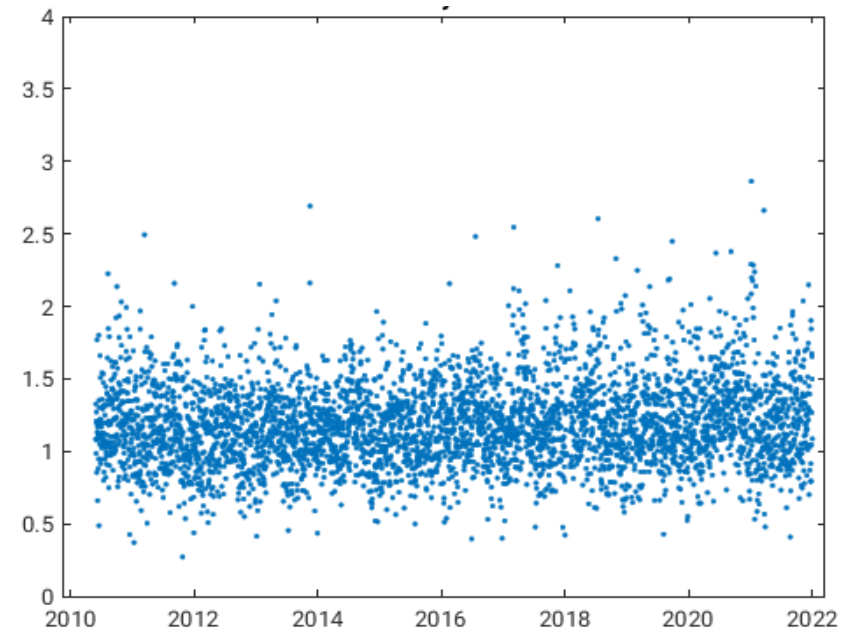
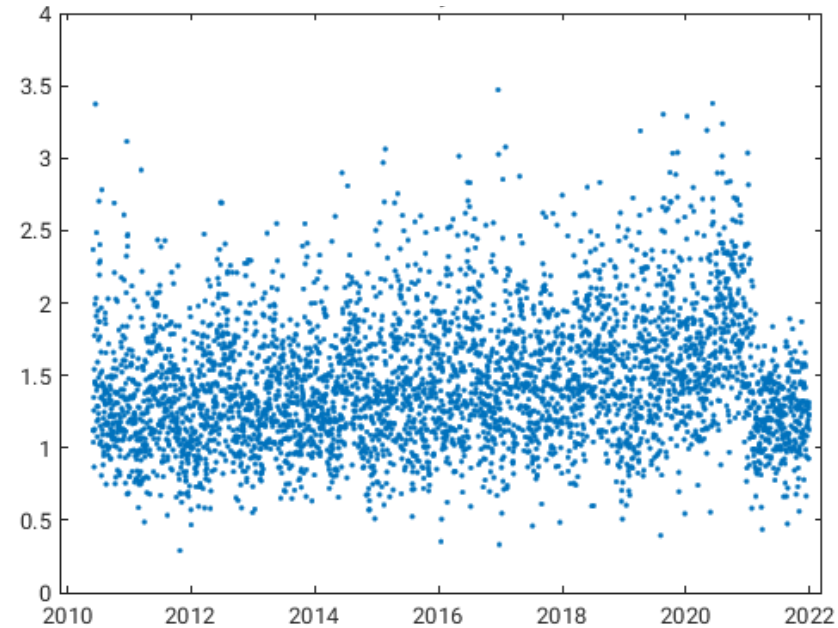


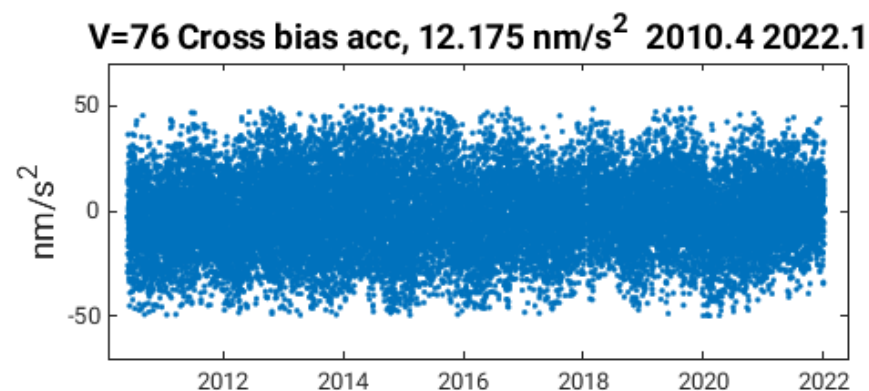
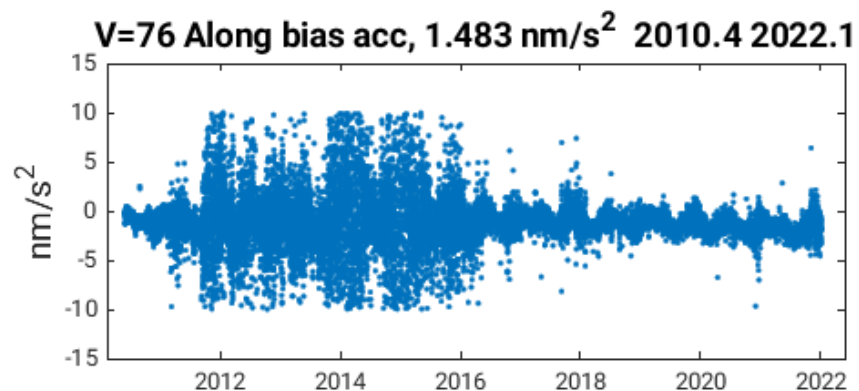
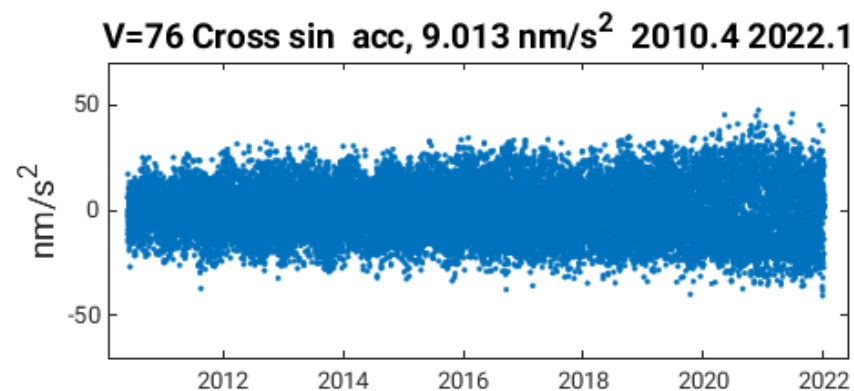
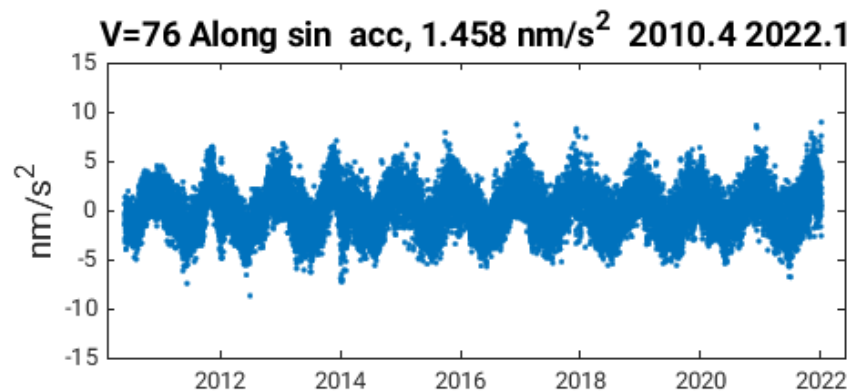
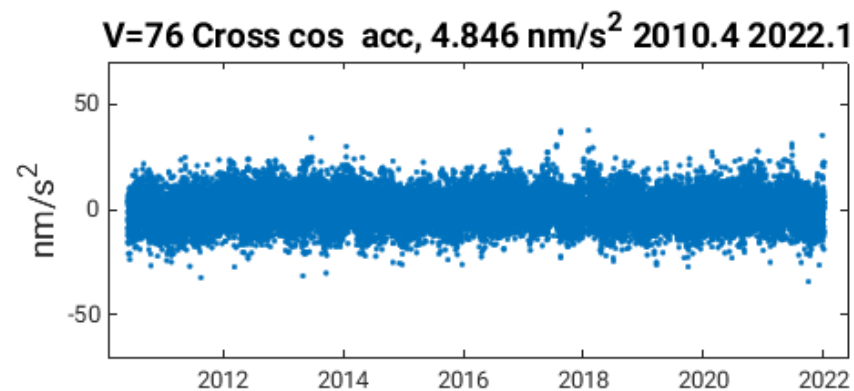
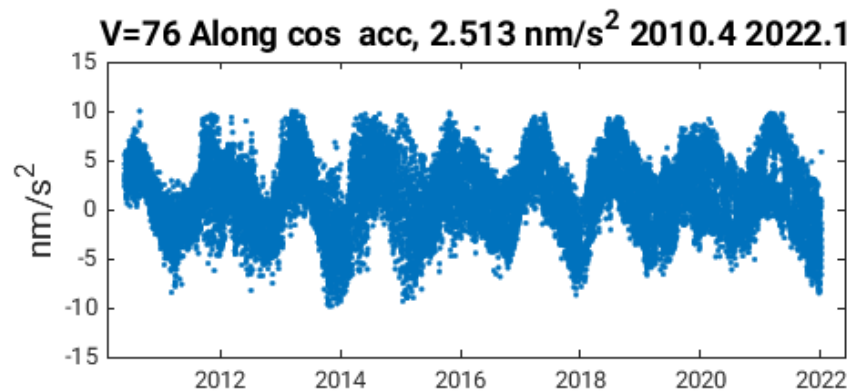
## SLR daily mean rms

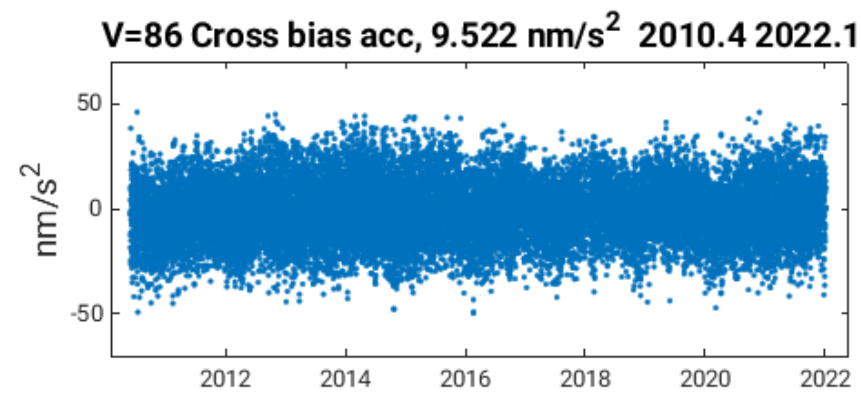
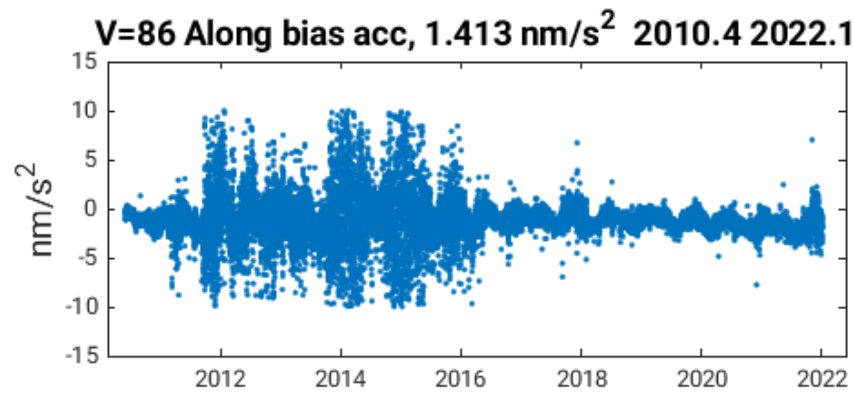
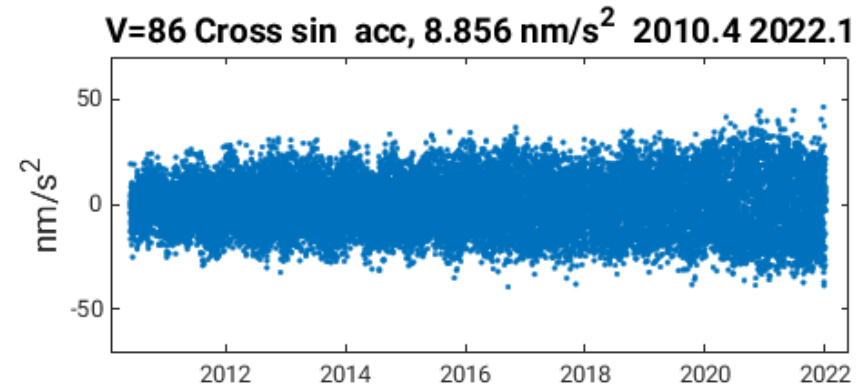
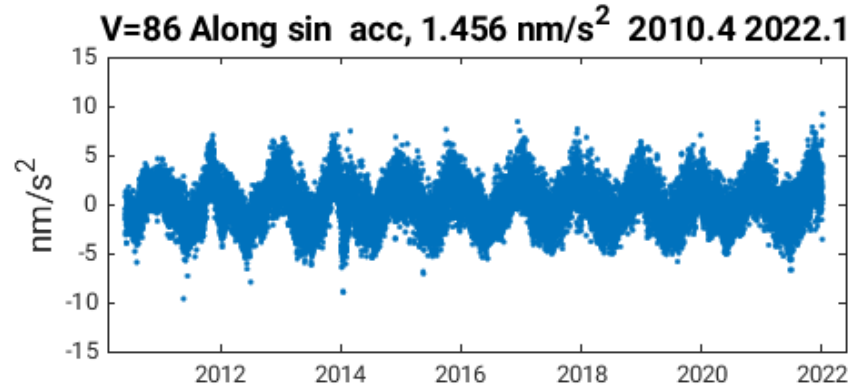
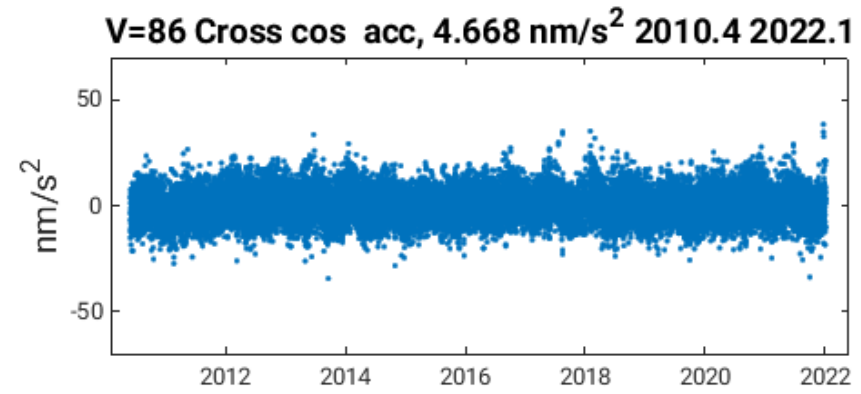
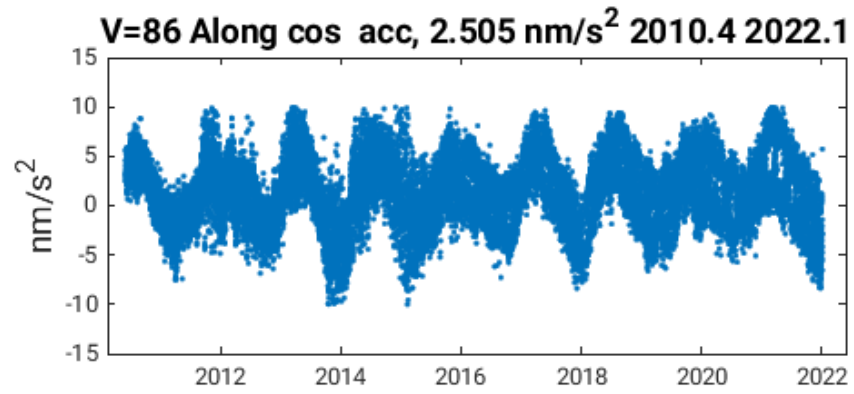
The residuals improve  
from 1.393 to 1.166 cm

Left: SLR coordinates  
were from an old scaled  
Of the ITRF, the IDS  
Coordinates were in  
DPOD2014

Right: Everything is  
Transformed in ITRF2020,  
5 IDS stations that were  
not in the ITRF had  
survey coordinates.



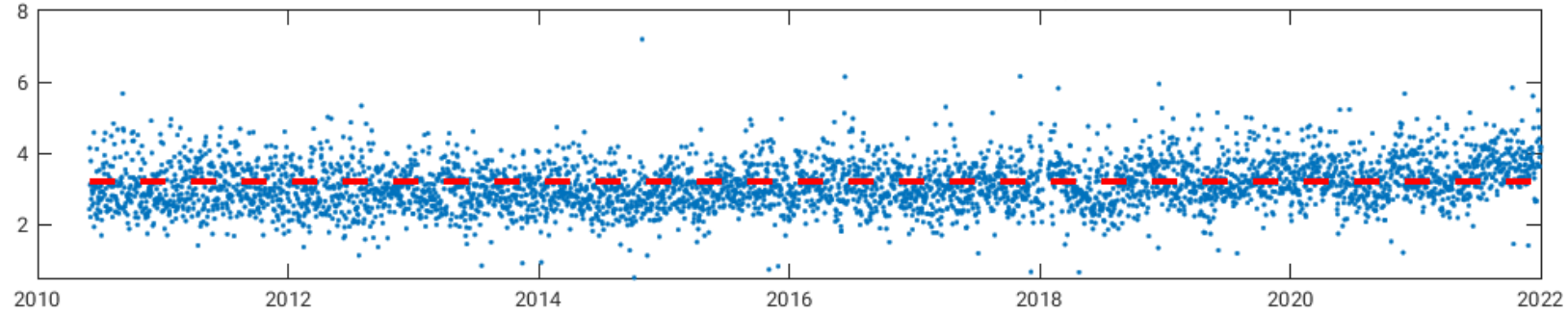




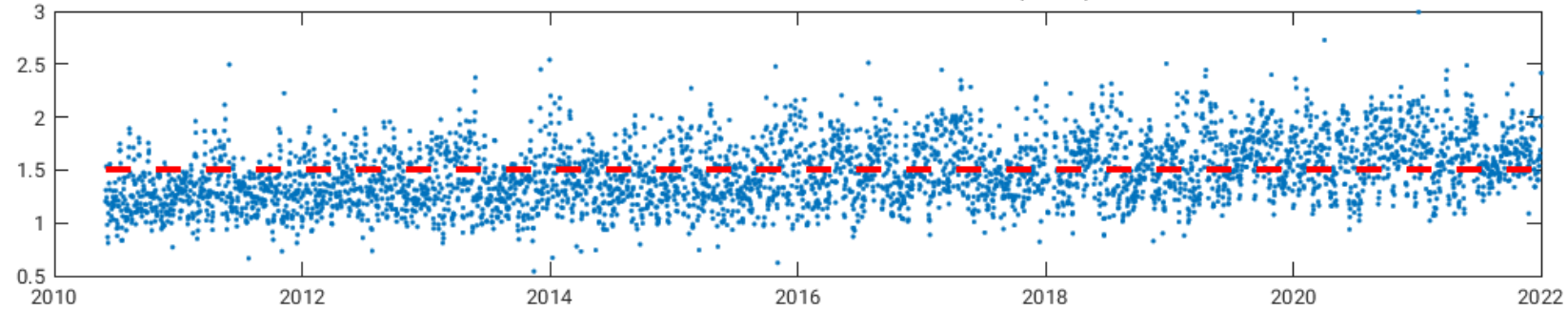
There could be a gas leakage problem (needs to be verified)



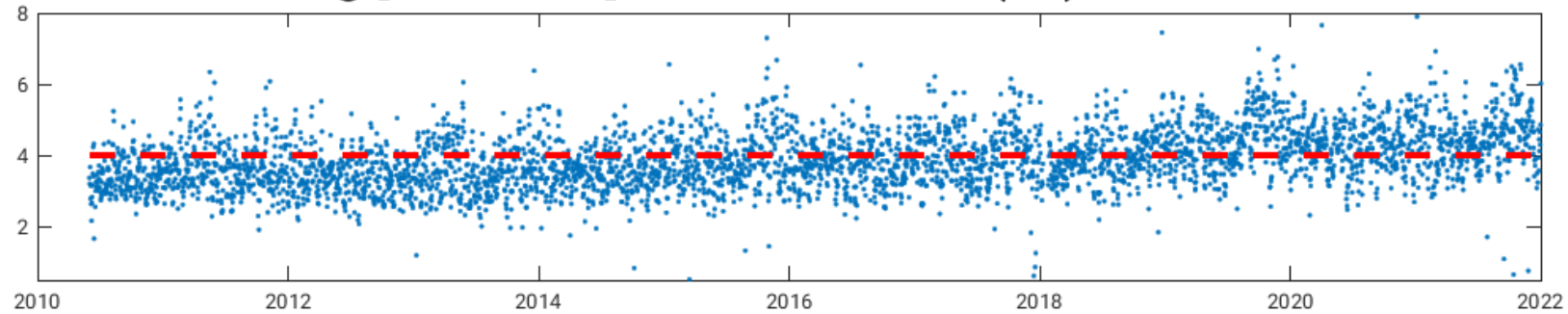
**Cross [0.14 3.20] POE ITRF2020 (86) 5.32 cm 3d**



**Radial [-0.05 1.50] POE ITRF2020 (86) 5.32 cm 3d**



**Along [0.01 3.98] POE ITRF2020 (86) 5.32 cm 3d**



# Modelling (2)

- Gravity models, static part from GRACE/GRACE-FO
- Solar radiation pressure modelling, scaling constant est. once, CNES model
- Drag modelling, MSIS reference model, 3 hourly patches with constraints
- Ocean tides affecting the orbit: via FES 2012 model
- Atmospheric and Oceanic part TVG : AOD1B
- Cryosphere and Hydrology part : via GRACE and GRACE-FO
- Generalized accelerations for along-track, cross-track by once per revolution and a constant bias by arc.
- Solve for empirical accelerations, 6 hourly, patches, piecewise modelling.

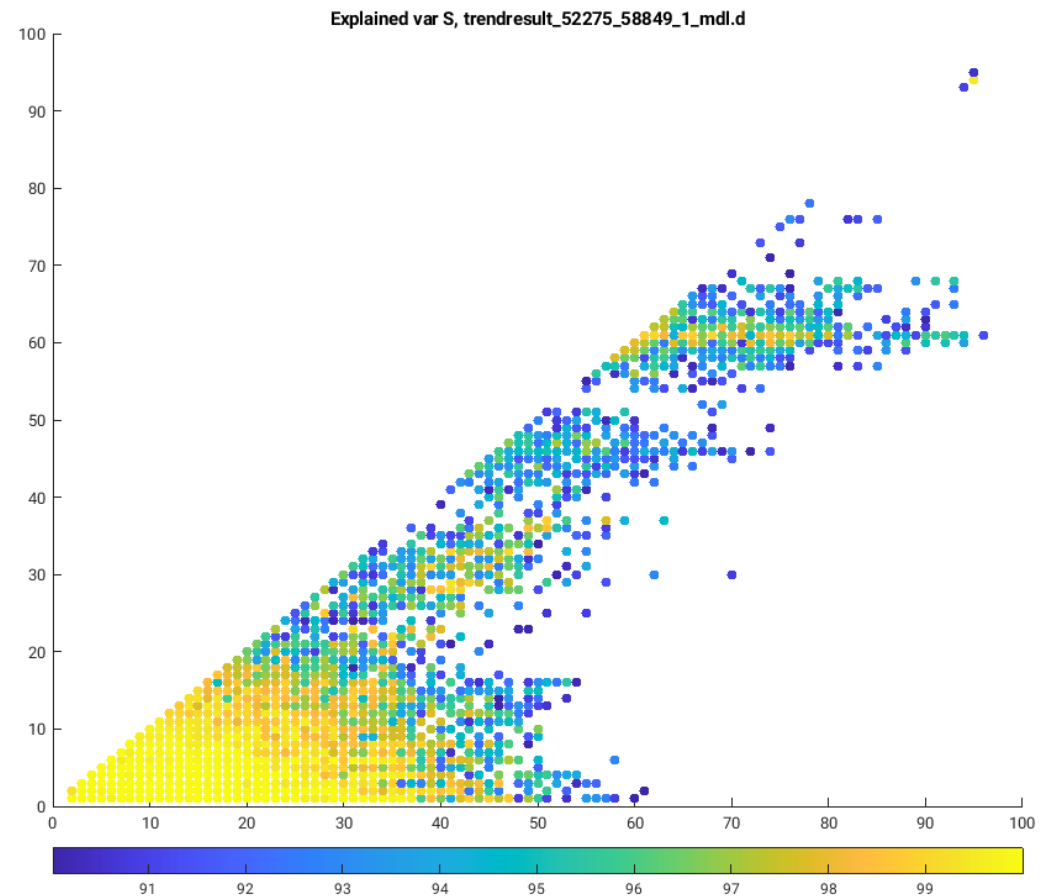
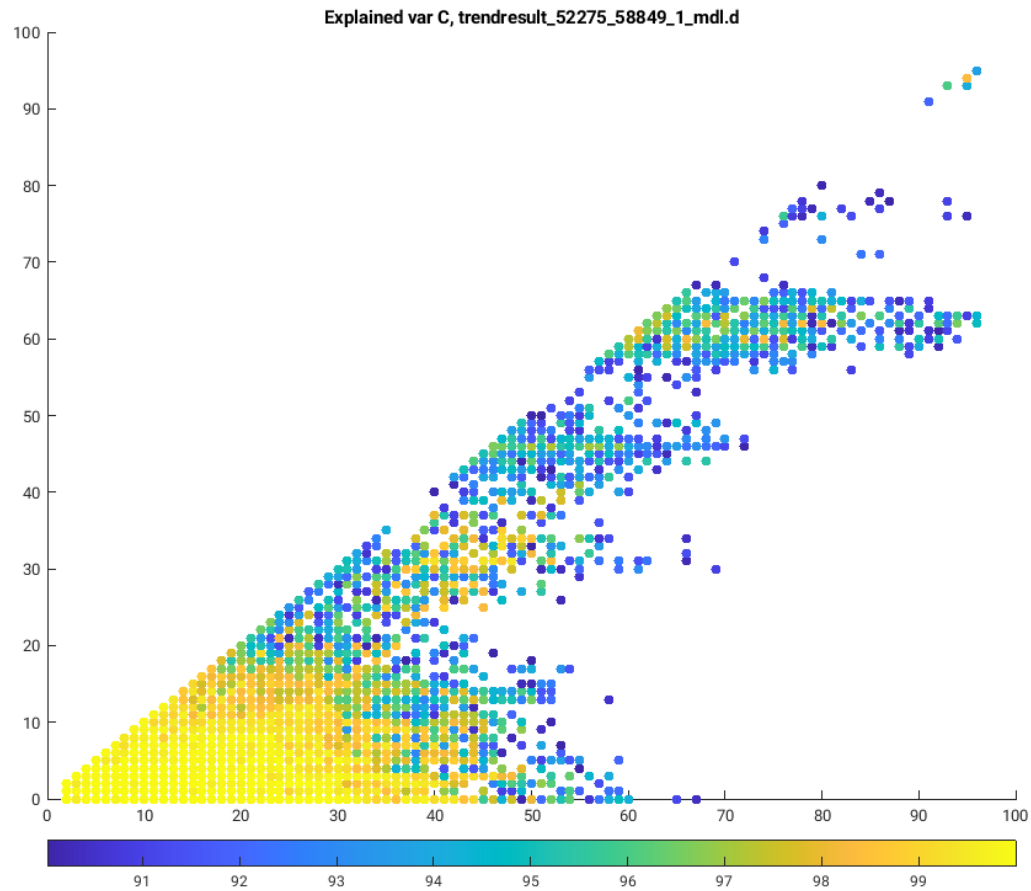
# TVG modelling for TWS component

- Always take AOD1B for each arc, without doubts residuals both for DORIS and SLR benefit from this
- TWS part comes from GRACE and GRACE-FO
- Data gap in GRACE is from 23-5-2017 to 15-6-2018
- GRACE-FO: 15-6-18 -> 19-7-18; 31-10-18 -> 31-12-21
- Q1 : does the gap affect POD processing
- Q2 : can you combine GRACE and GRACE-FO

# TVG model strategy

- Fit a polynomial + harmonic function to the data
- Harmonic on multiples of 2 year period
- Polynomial: 3 or 6 terms
- Select those SH terms where the explained variance of the model is greater than 99%
- Most of the TVG information is contained up to degree and order 36 with some resonant bands at higher degree

# Variance explained model (window 2002-2019)



# TVG models available

ID	mm/s	cm	Along cos	Along sin	Along bias	Cross cos	Cross sin	Cross bias	TVG	#pars	AOD1B
70	0,4036	1,6748							GR	14	Y
71	0,3982	1,4623	2,114	1,666	1,421	4,886	7,535	9,785	GR+GRFO	14	Y
72	0,3985	1,4775	2,110	1,673	1,424	4,749	7,495	9,763	GR+GRFO	14	Y
73	0,3983	1,4627	2,153	1,662	1,422	4,913	7,398	9,743	GR	11	Y
74	0,3983	1,4639	2,117	1,669	1,423	4,888	7,556	9,824	GR+GRFO	11	Y
75	0,3984	1,4740	2,122	1,681	1,422	5,020	7,809	9,881	GR+GRFO	11	Y
76	0,3983	1,4880	2,507	1,442	1,414	4,689	8,732	9,909	--	--	Y
77	0,4127	1,7737									--

Runs 70 and 73 : TVG only GRACE, Runs 71 and 74 GR(all) + GRFO, Runs 72 and 75 (GRACE since 2010 + GRFO)

# Compare to AOD1B run (=76)

ID	Along summed	Cross summed	Delta Along	Delta Cross
71	3,044	13,281	0,176	0,739
72	3,046	13,193	0,174	0,827
73	3,069	13,183	0,151	0,837
74	3,048	13,323	0,172	0,697
75	3,058	13,558	0,162	0,462
76	3,219	14,015		

The simulated signal of the TVG model shows approximately 0.6 and 1.6 nm/s<sup>2</sup> for the along and the cross track components

# Conclusions

- ITRF2020<sup>P</sup> works out better compared to what we had
- CryoSat-2 POD depends for a part on TVG modelling
- Bridge the 2017-2018.5 GRACE to GRACE-FO transition gap
- Ocean/Atmosphere is a separate activity, AOD1B always available,
- SLR residuals are more affected than Doppler residuals
- Cryosphere/Hydrology/Ocean effect comes from GRACE/GRACE-FO
- Most combinations of GRACE and GRACE-FO show empirical accelerations compatible with a GRACE only result, needs to be repeated with the ITRF2020 setup



# Open issues

## ITRF2020<sup>P</sup> implementation

- Too early to show the results after a full implementation of what I found in the SINEX files (also needs ecc info and psd info)
- Missed stations in the observation files are fixed to the site survey results.

## RINEX processing

- There are some preliminary results from a student thesis and separate tests, but no full implementation yet.

# Special issue ASR on DORIS

- Denise Dettmering and Ernst Schrama (we) are ASR guest editors
- So far 8 papers are submitted of which 5 papers are accepted (4) or returned for minor revisions (1) not requiring a new review round
- As far as we know possibly one more paper will be submitted.
- Papers can be submitted until 1-July, the deadline was extended several times, various delay notices from authors
- I'm not sure whether we can convince the ASR editor to go past the deadline of 1-July, we haven't asked actually. It does not sound like a good idea.