# Orbit determination of Cryosat-2, going from format 2.2 to DORIS Rinex data

Ernst Schrama[1]        Pieter Visser[1]

Delft University of Technology

e.j.o.schrama@tudelft.nl

# This presentation

- Setup of the POD scheme

- What makes RINEX processing more difficult

- Result that were obtained

# Setup POD scheme (1)

- Satellite status,
  - All looks ok, no major problems, last I heard was a RCS update a year ago
- We looked at Jun-2010 to Nov-2024
- AOCS Three star cameras,
  - We use them to determine where the AOCS is in nominal attitude mode.
  - During maneuvers the 4 degree yaw steering mode is stopped
  - Quaternions of the S/C are provided by FTP ($\cong$ one month delay)
- CS2 increasingly depends on realistic dynamic modelling, and it becomes more of an issue in the ongoing solar cycle

# Setup POD scheme (2)

- Coordinates
  - DPOD2020 v3.1 IDS beacon coordinates
  - SLRF2020 All ILRS coordinates in this system
- Ocean loading by station/beacon
  - Chalmers ocean loading calculator based op FES2012 or similar
- Doppler beacon frequency offset estimated by pass
- Tropospheric zenith delay parameters estimated by pass
- Earth rotation parameters from IERS EOP
- Initial state vector comes from Diode navigator orbits
- More rigorous editing to reject noisy data

# Setup POD scheme

Two runs

- Run 89 : 10 second Doppler data (this is format 2.2) in 6 day arcs
- Run 94 : DORIS RINEX data is converted in 10s Doppler in 3 day arcs

Challenge

- RINEX processing will cause more work because you need to take care of solving the IDS clock onboard relative to the master beacons.
- RINEX data turns out to be more noisy
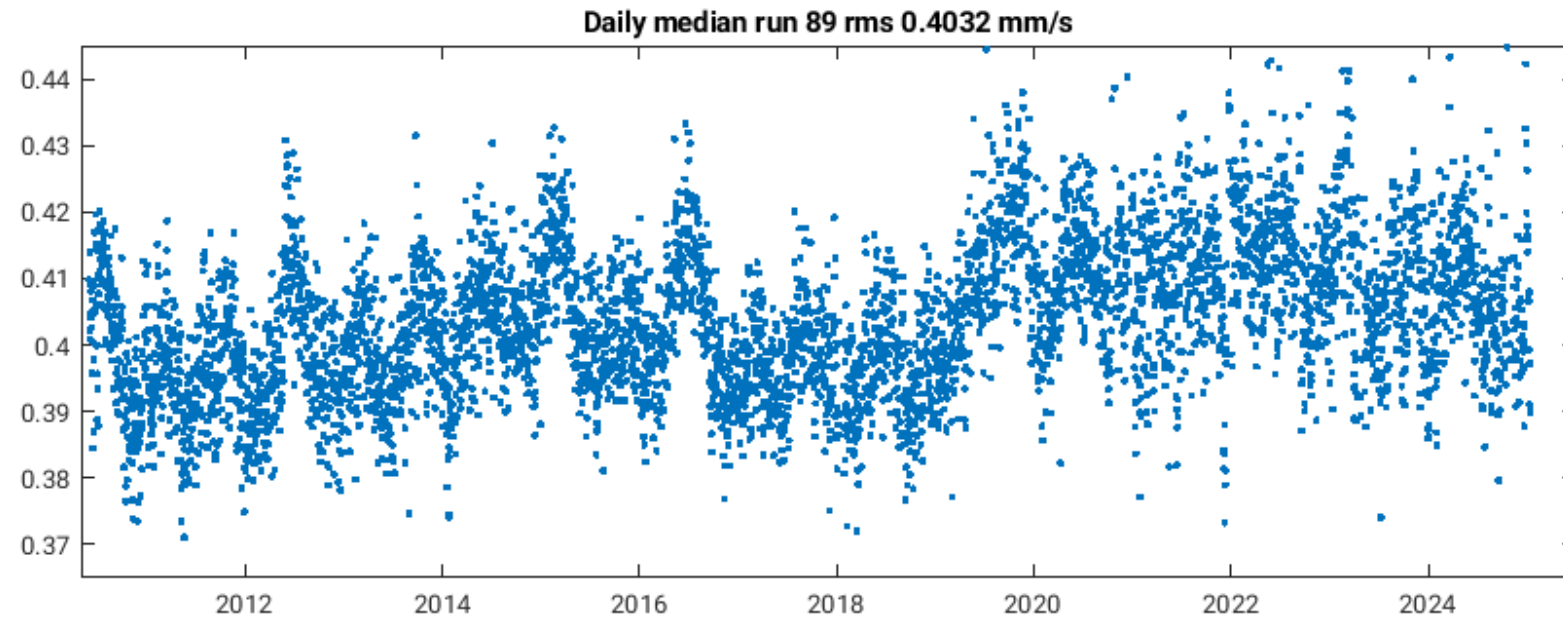
# Other noticeable differences

- Format 22 :
  - Ionospheric Doppler correction is on the product
  - Tropospheric Doppler correction is on the product
  - Combined antenna Doppler offset are on the product
  - Time tag is already corrected

RINEX :
  - Either you do the receiver clock correction yourself, or you take it from the product (the latest versions have it). Differences around 1 micro second level
  - Ionospheric correction is derived from both frequencies
  - Tropospheric correction is evaluated from transmitted meteorologic data
  - You need to check the eccentricity vectors (487 mm correction for the STAREC beacons)
  - I used JM Lemoine's software for the processing of the RINEX data.

Daily median run 89 rms 0.4032 mm/s

Format 2.2

Daily median run 94 rms 0.4297 mm/s

RINEX
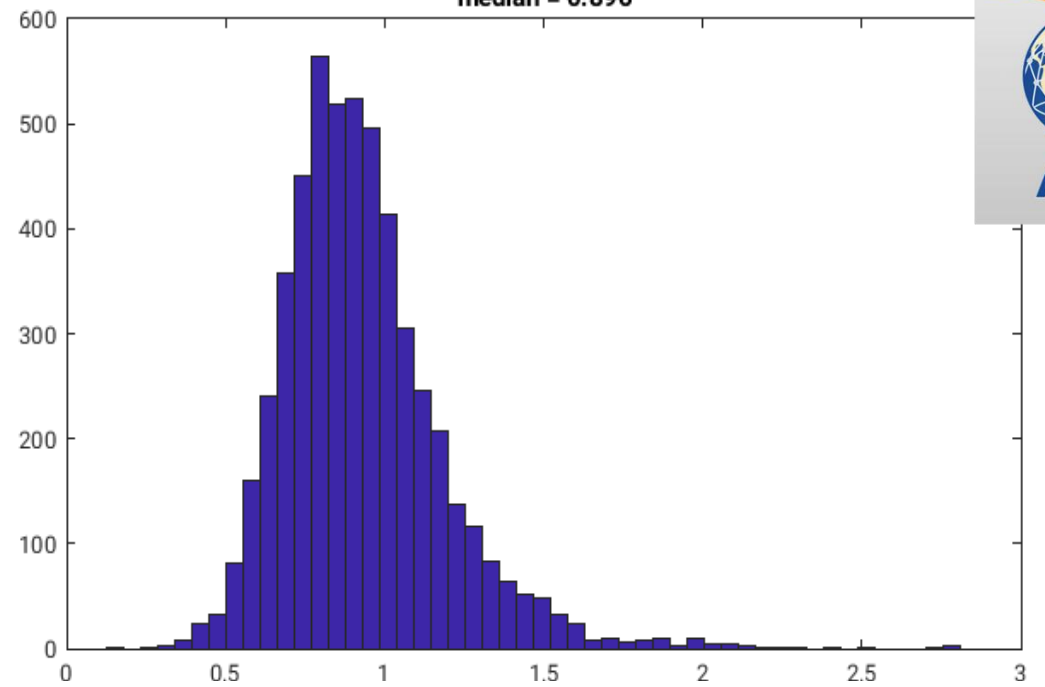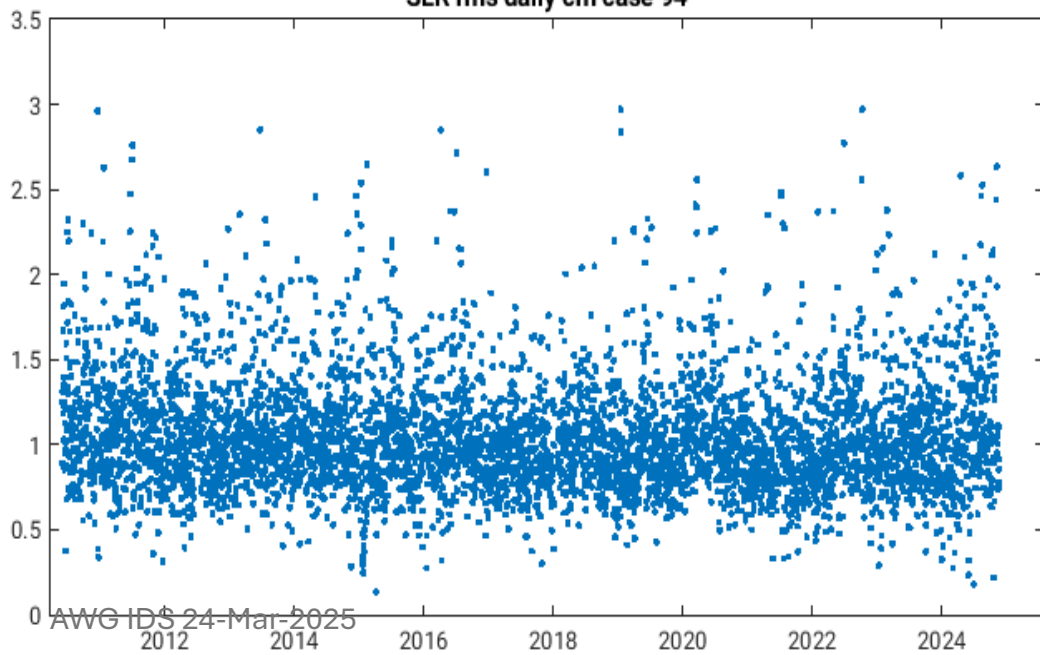
Daily median run 89 rms 0.4032 mm/s

Format 2.2

Daily median run 94 rms 0.4297 mm/s
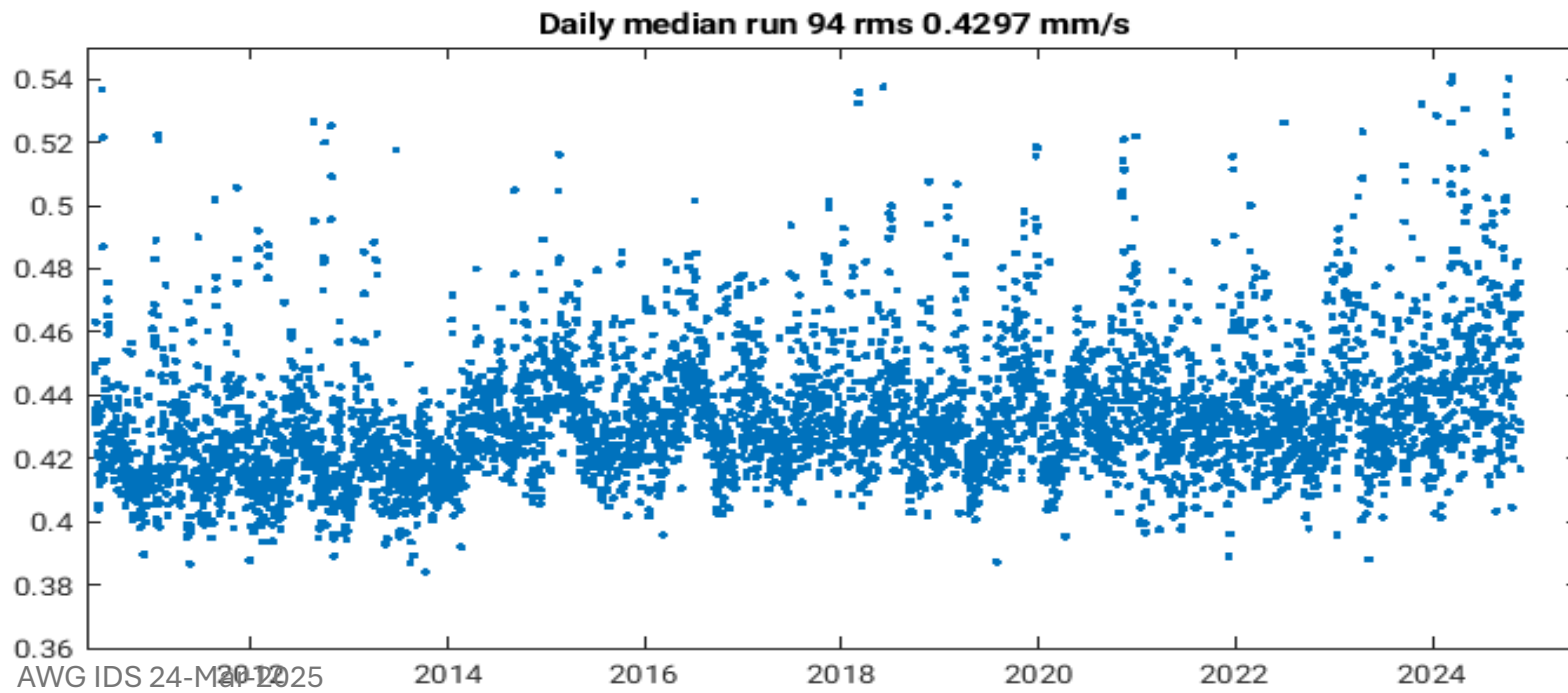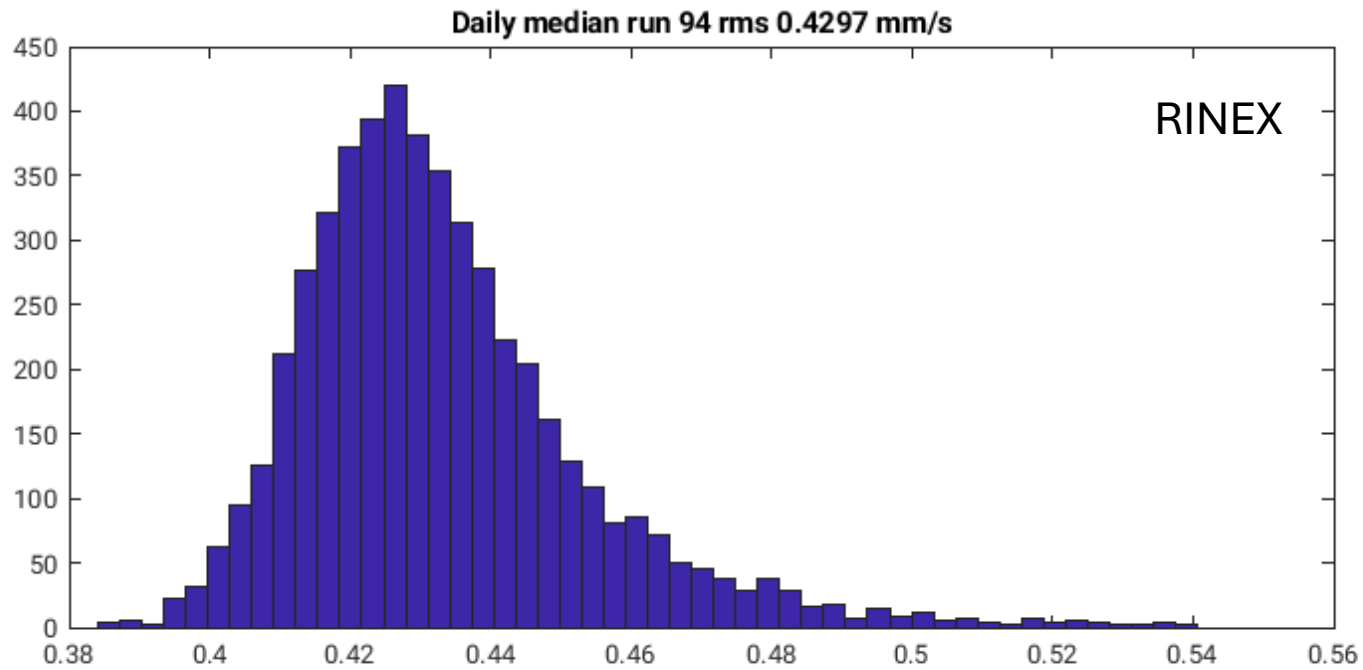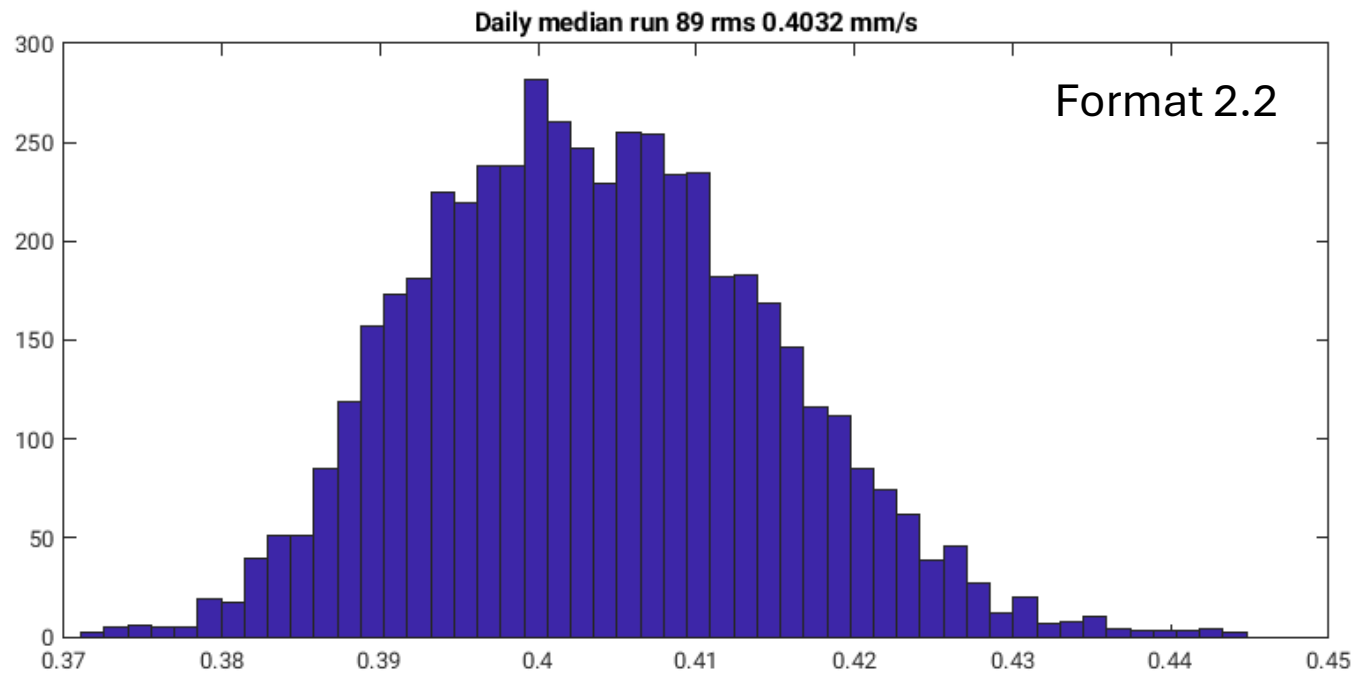
RINEX

SLR rms daily cm case 89
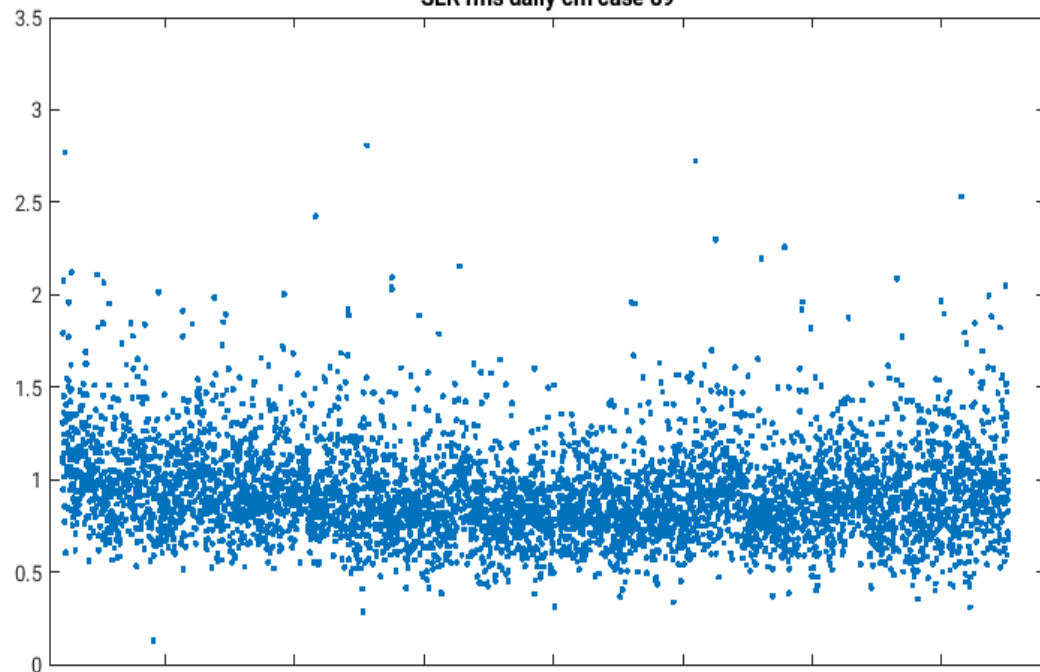
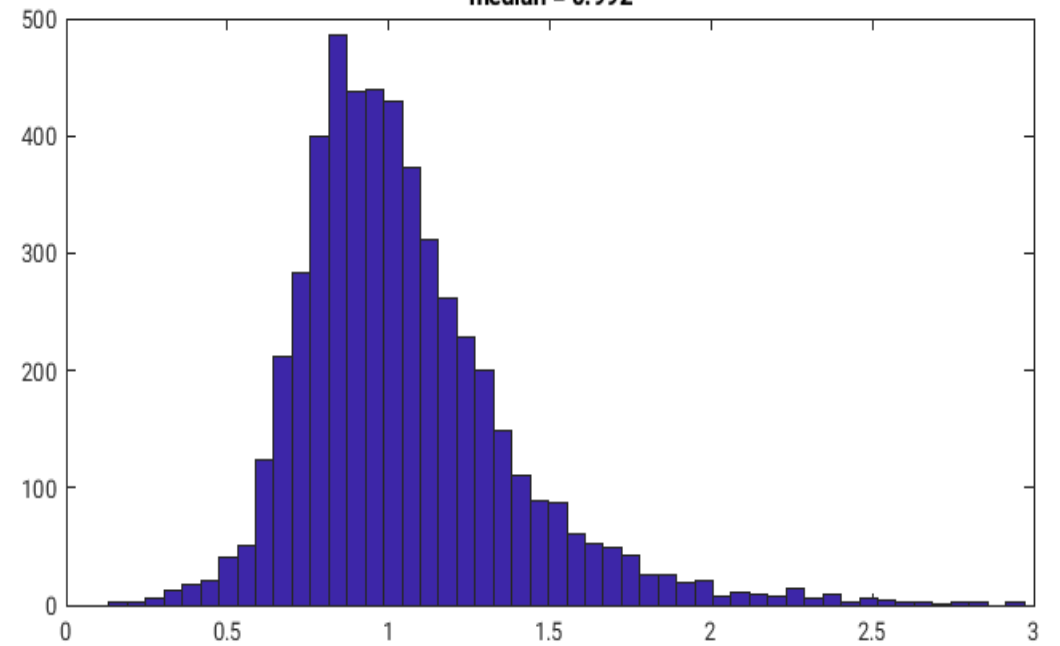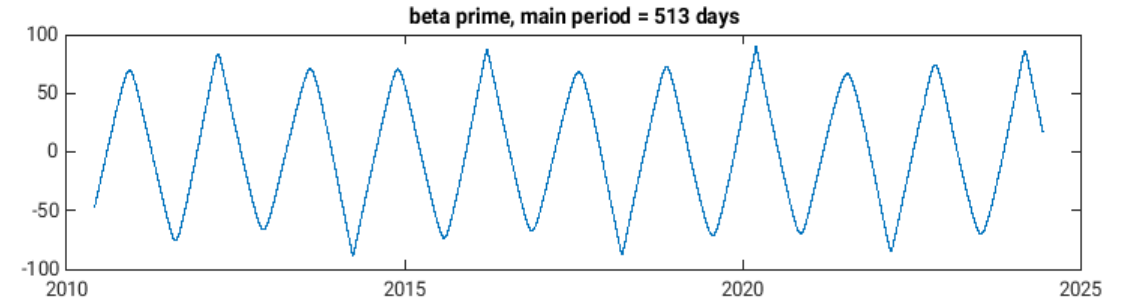median = 0.896

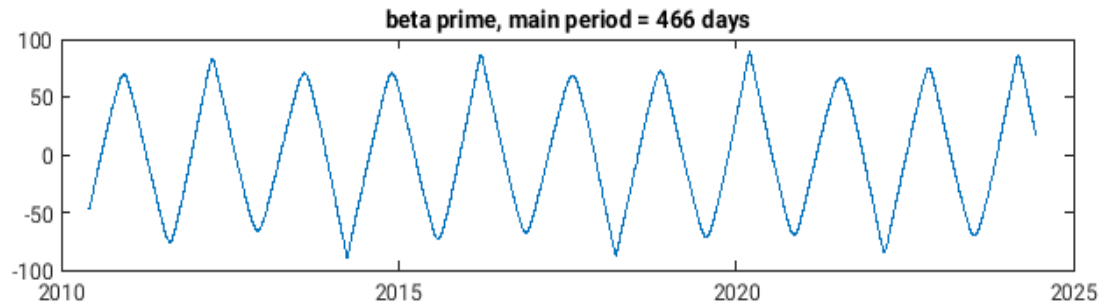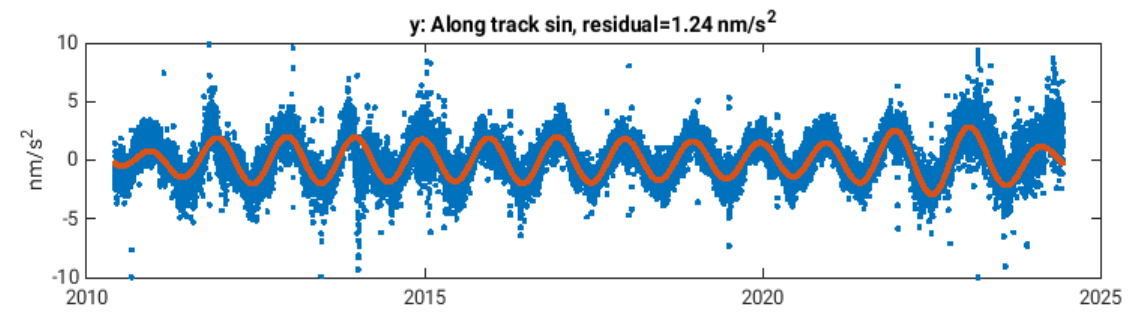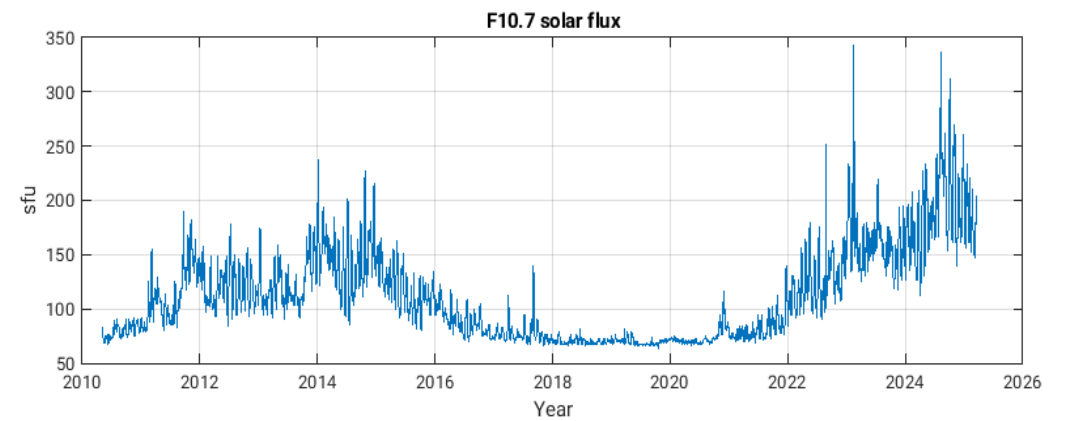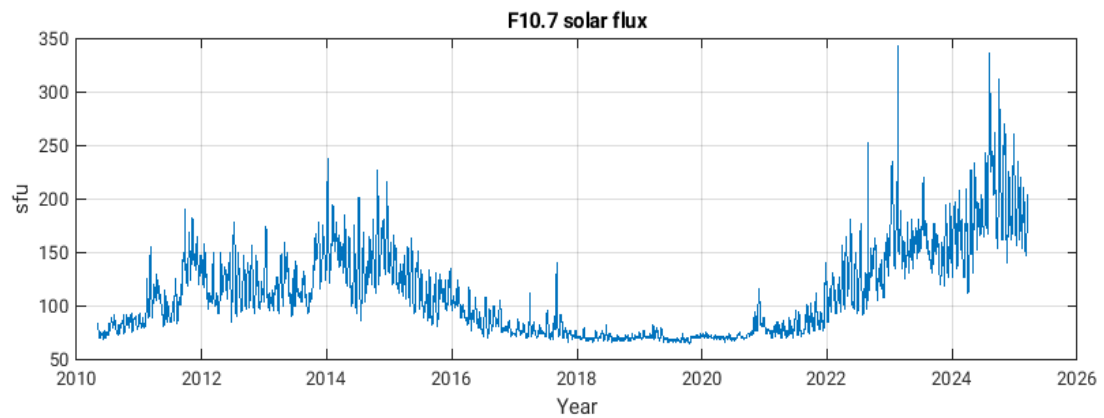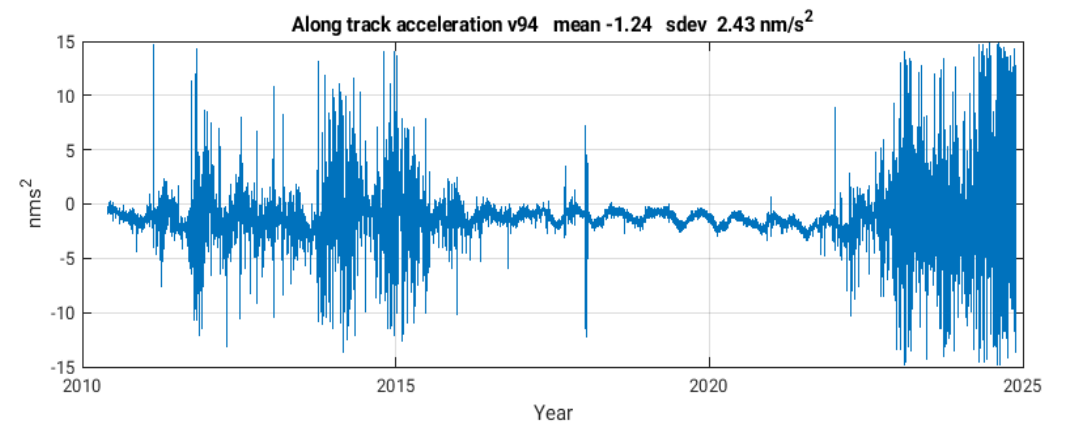SLR rms daily cm case 94

median = 0.992

AWG IDS 24-Mar-2025

Format 2.2

RINEX

Along track acceleration v89   mean -1.19   sdev 2.14 nm/s$^2$

Along track acceleration v94   mean -1.24   sdev 2.43 nm/s$^2$

F10.7 solar flux

Format 2.2

RINEX

Radial rms 0.70 cm POE DPOD2020 (89)

Format 2.2

Radial rms 0.74 cm POE DPOD2020 (94)

RINEX

AWG IDS 24-Mar-2025
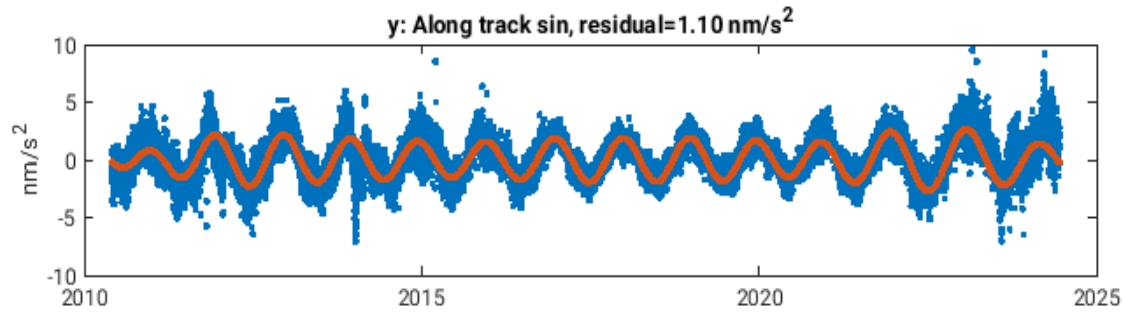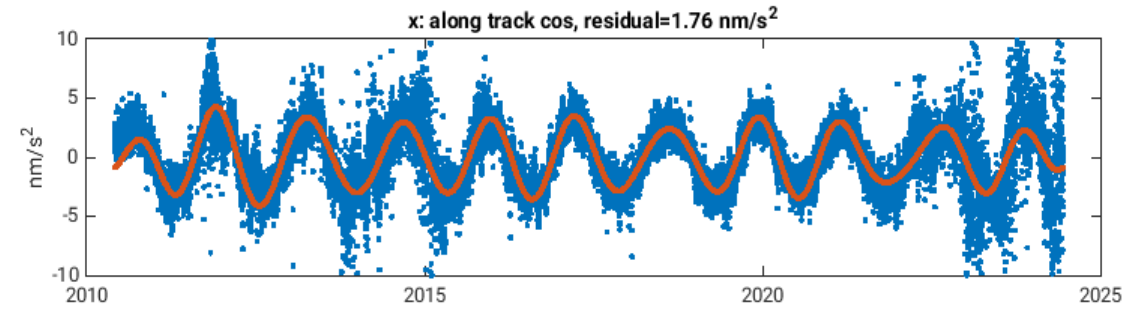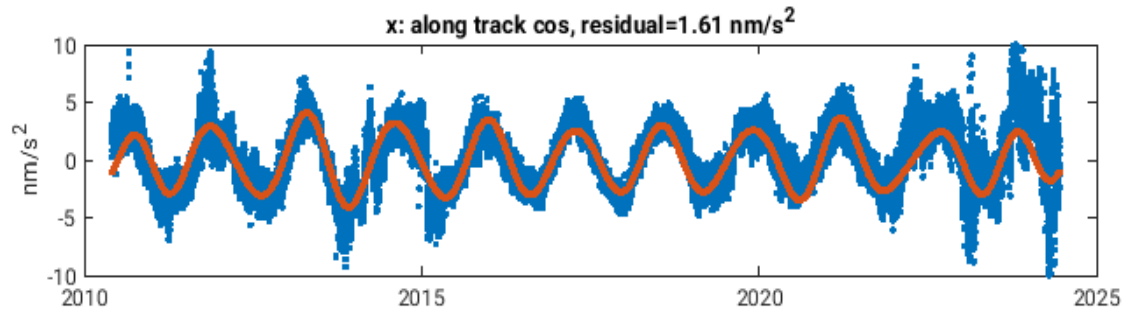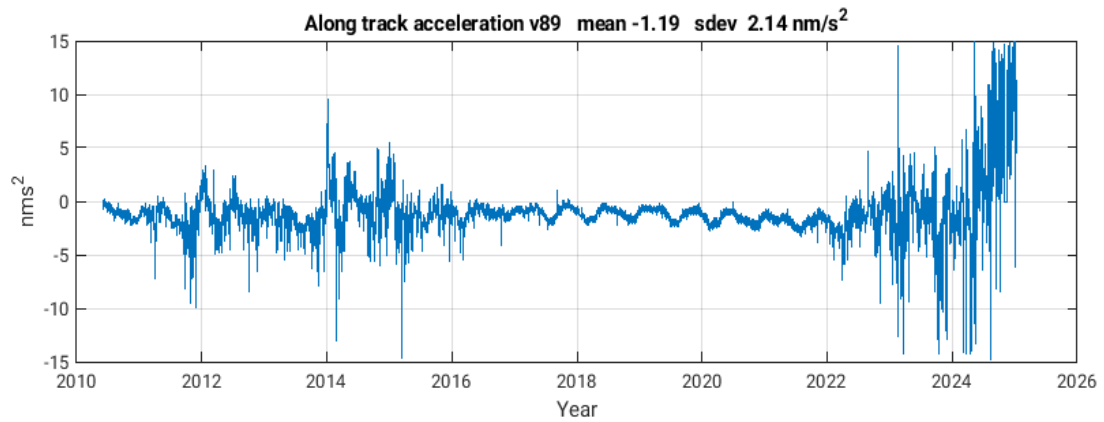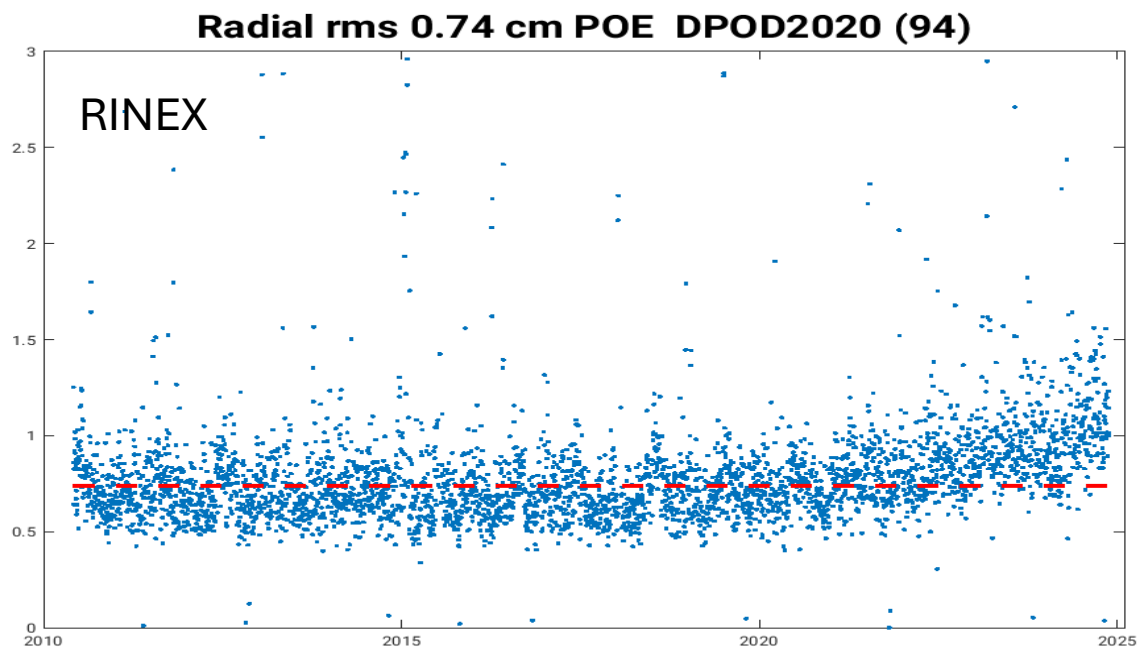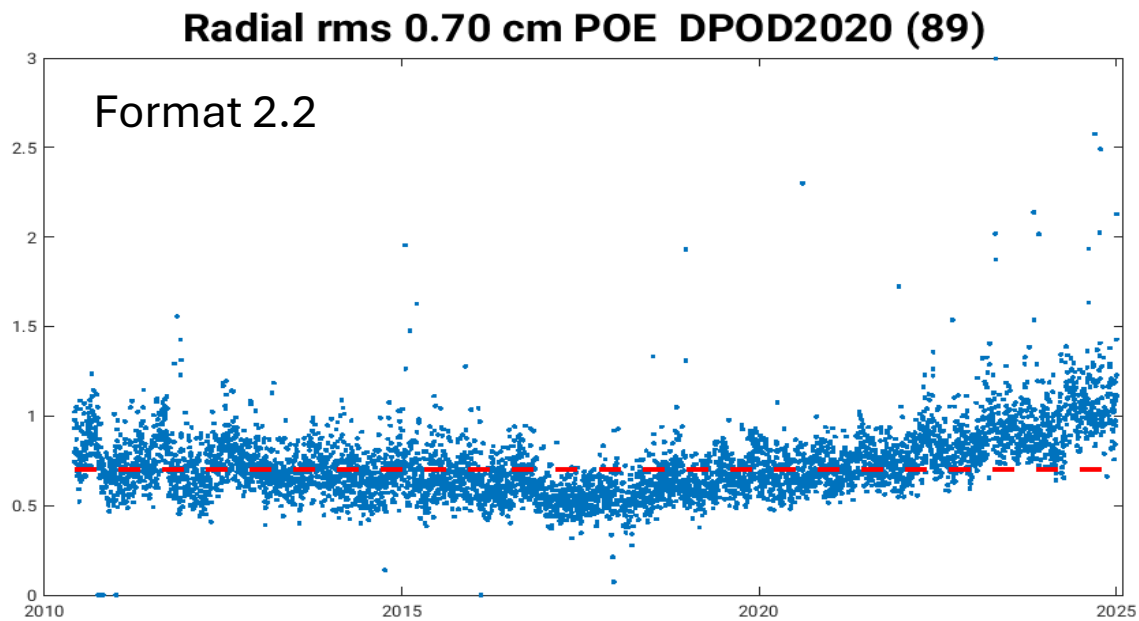
# Conclusion

- Format 2.2 is clearly less noisy

- Still the results with RINEX data seem to be very compatible

- Took me a while to figure out the eccentricity vector problem