Instituto Geográfico Nacional
Centro Nacional de Información Geográfica

Satellite Orientation Effects on Centre of Mass Corrections

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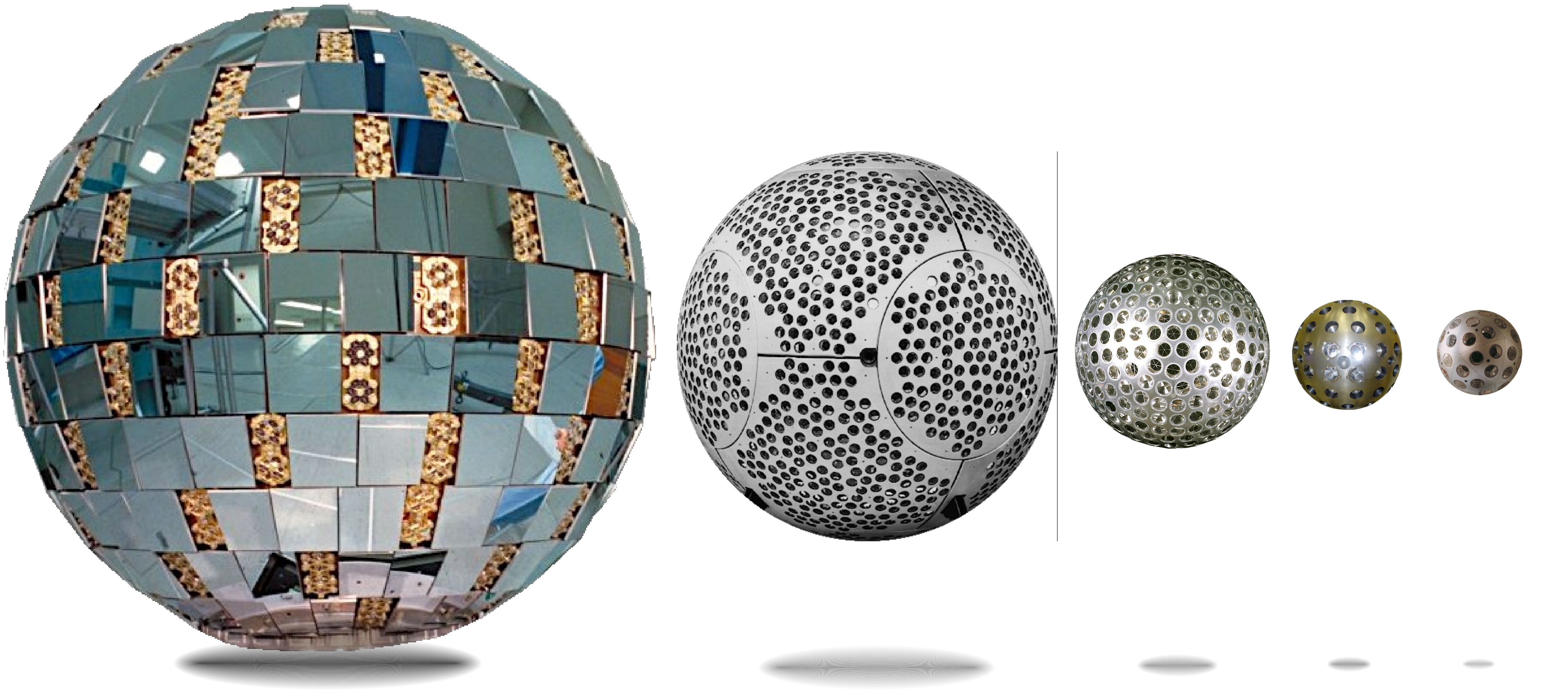


	Ajisai	Etalon	LAGEOS	LARES	Starlette
Diameter m	2.15	1.29	0.60	0.36	0.24
Mass Kg	685	1415	407	387	48
CCRs #	1436	2146	426	92	60

How it all works

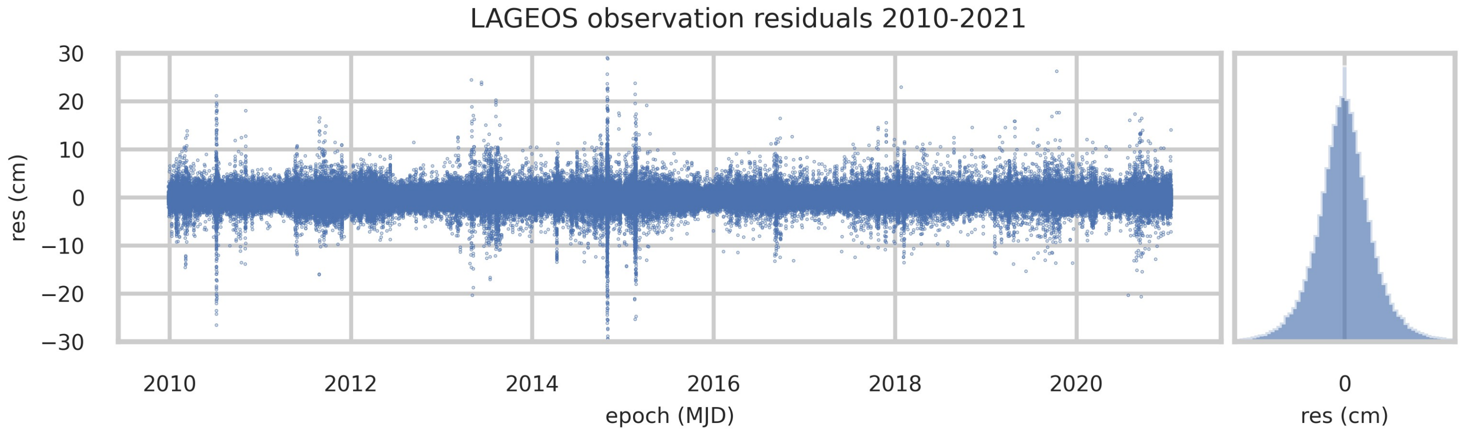
- Satellites in orbit + Lasers on the ground
- Time-of-flight measurements from ground network (+ corrections)
- Accumulation of observations

- Models for
  - Earth rotation
  - Station positions
  - Satellite dynamics
- Least-squares fit of model parameters

How good is our fit? → check residuals

Compare the agreement between observations and fitted model

Checking residuals



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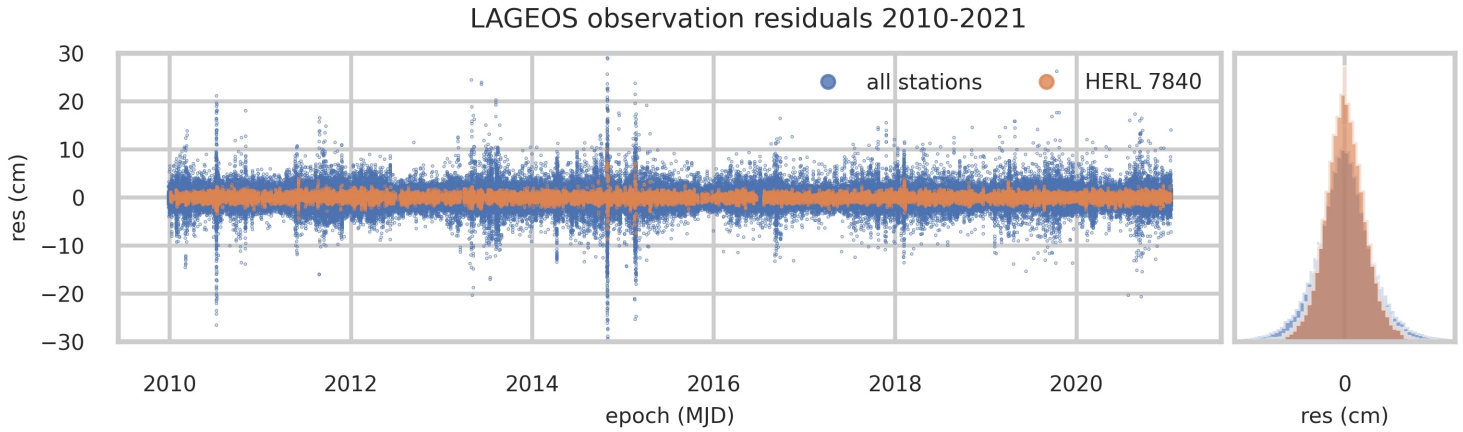

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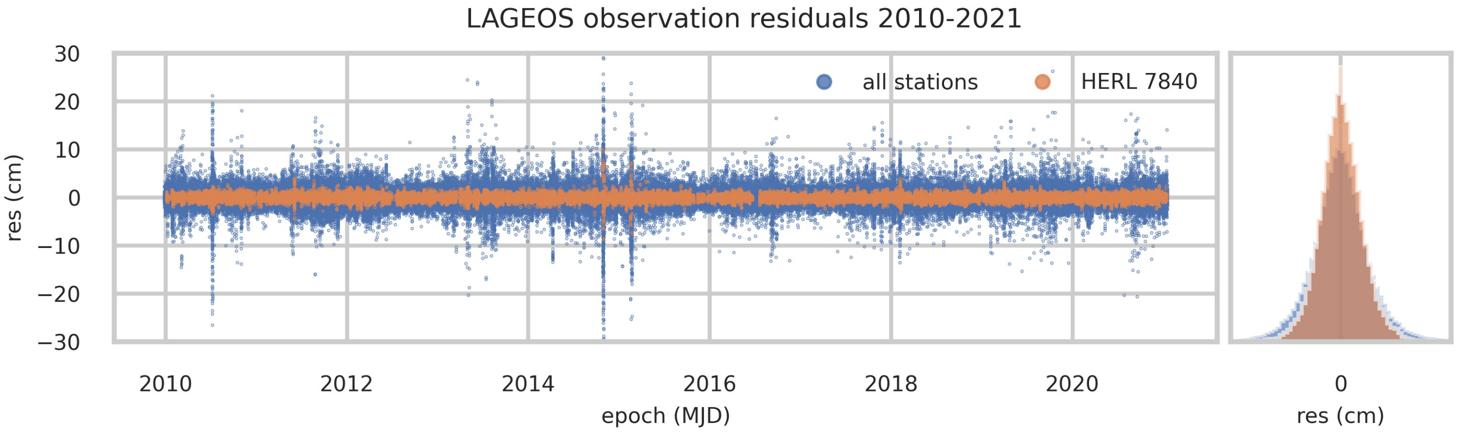

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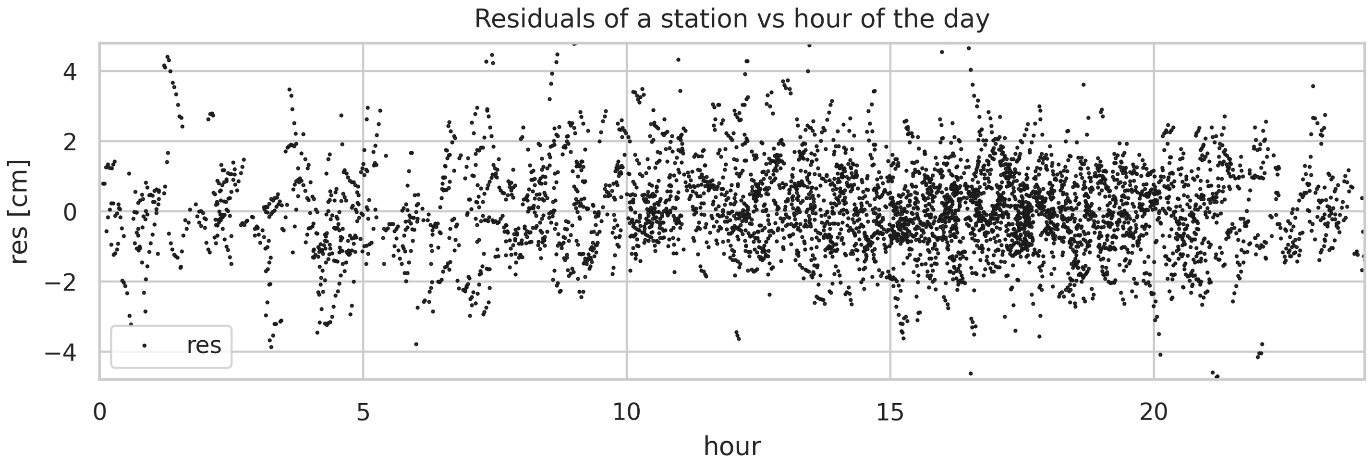
- We can dig in deeper, exploring correlations with other variables

Checking residuals



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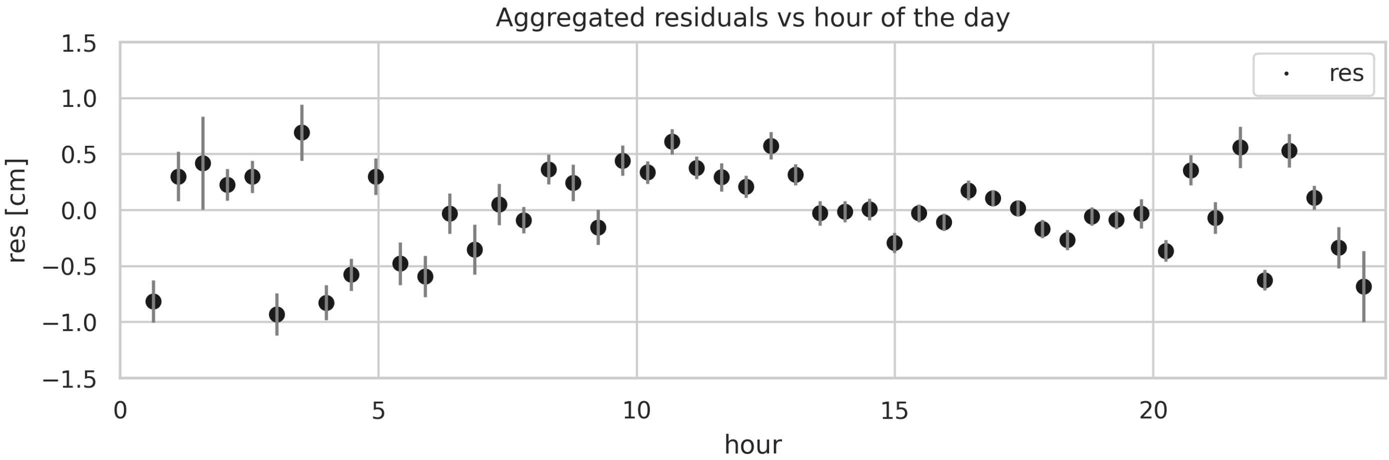
Checking residuals



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- We can group residuals by even intervals and plot the averages
- Now we can detect trends and unexpeced features

Otsubo poster

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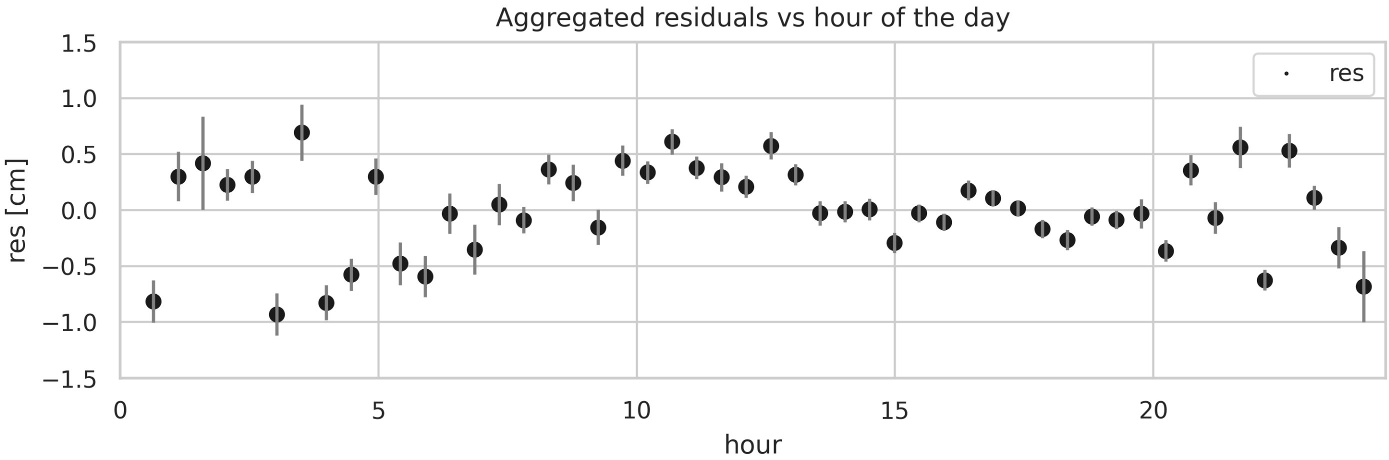

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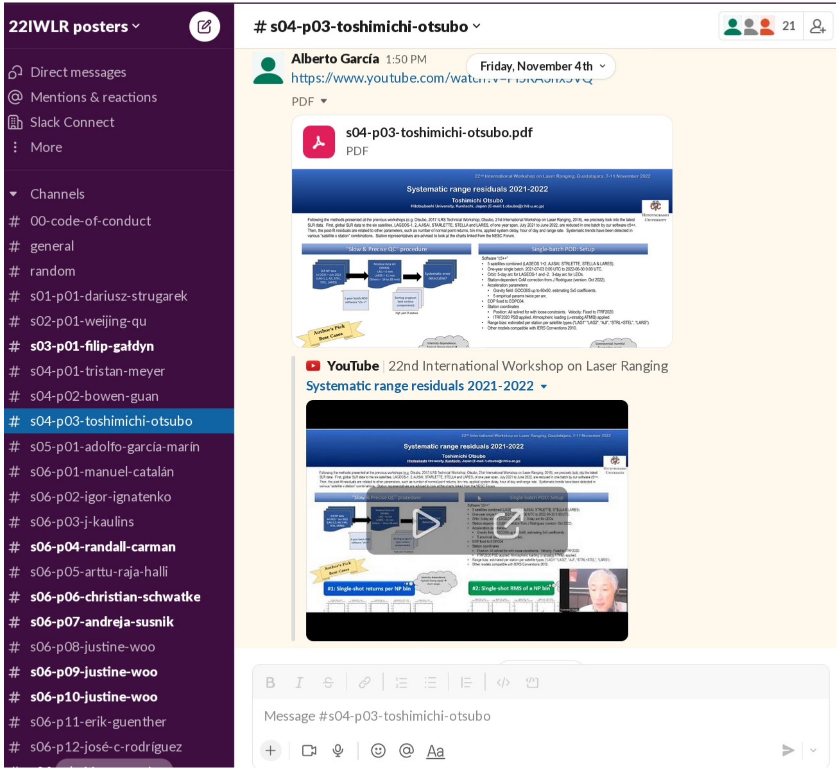
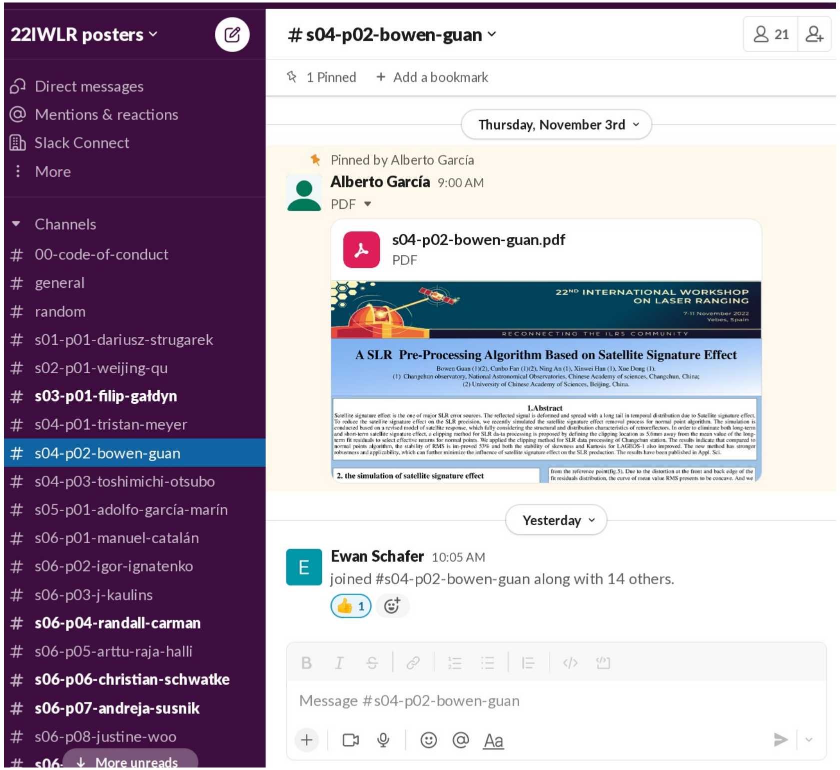
Checking 22IWLR posters in Slack!





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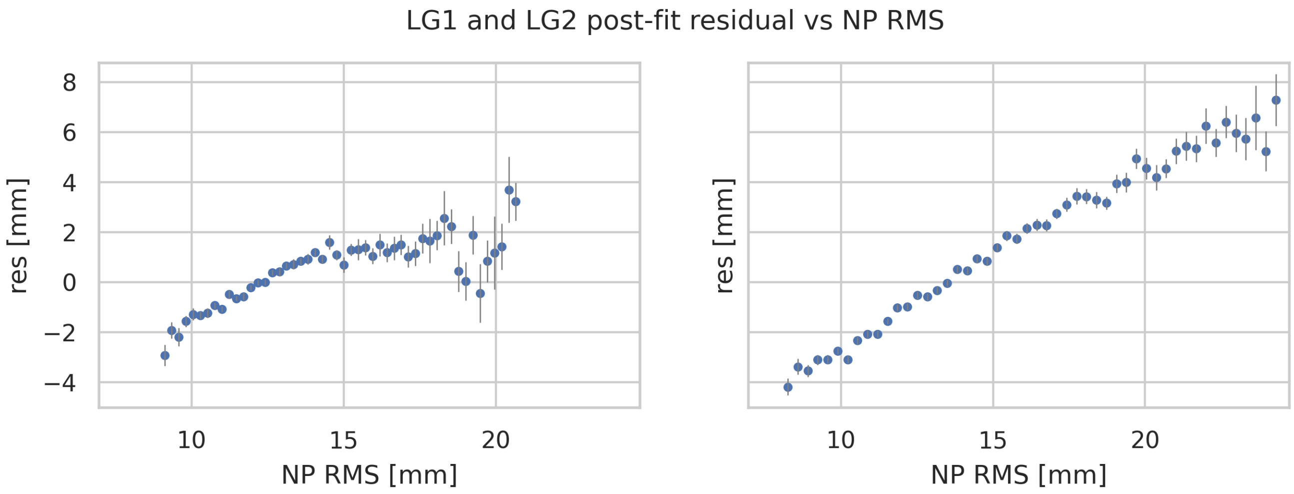
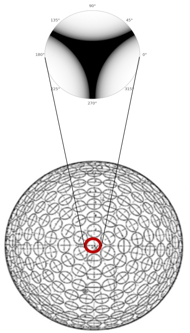


- Residual vs NP RMS, quite marked correlation for SPAD stations
- Systematic or random error?
- Peak to peak close to **10 mm.** Do they go into the coordinates???
- Where does it come from…?

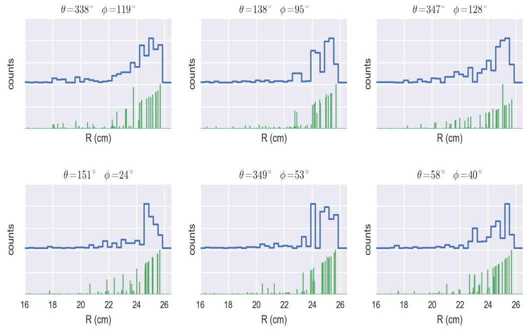
Computation of centre of mass values

- **Averaged** values *by design*
- We consider:
  - Physical characteristics of CCRs (material, size, coating)
  - CCR array geometry (position and clocking)
  - Laser wavelength
  - Satellite orientation ← **BUT** we *average* over all possible orientations

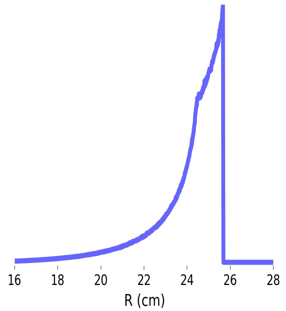
Reflectivity map



Response at arbitrary orientations

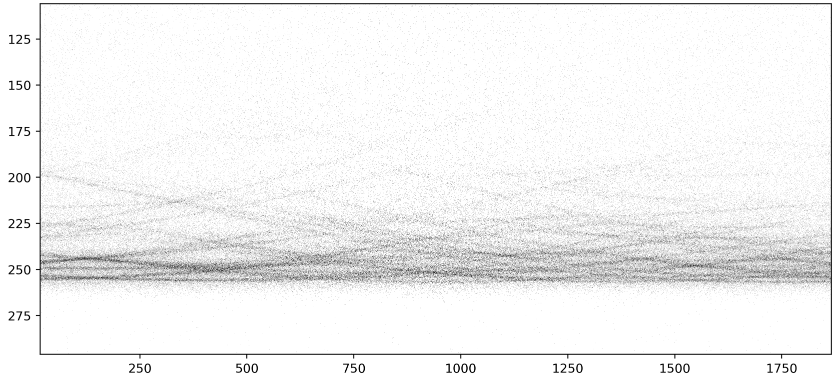


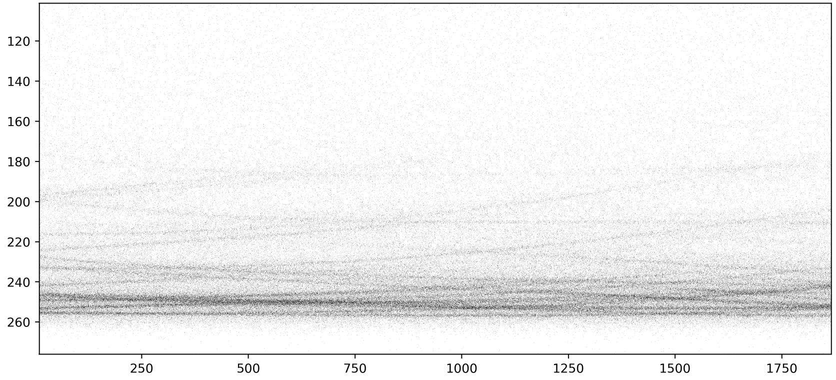
Average over 250K orientations



- What if we don’t average orientations?

→ *Video of simulated LAGEOS passes…*





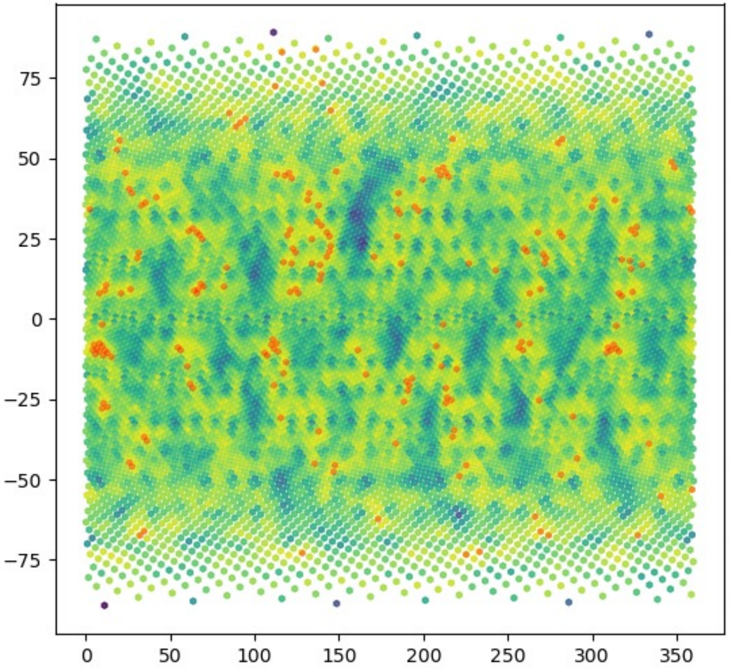
- We “see” different things for different orientations
- The obvious solution: apply the correction for the actual orientation…
- …but this is not known (and if it were, there are some practical problems)

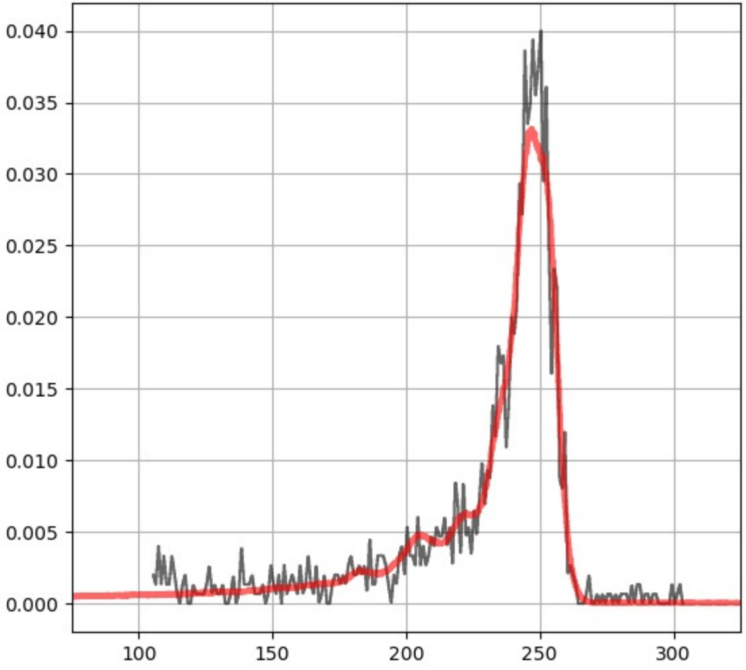
Instantaneous centre of mass values?

Brute force approach:

1) Precompute distributions of returns (and CoM values) for “all” orientations
2) Ask computer to find the best match to the real NP data
3) Apply the CoM for the matched distribution

Matched distributions

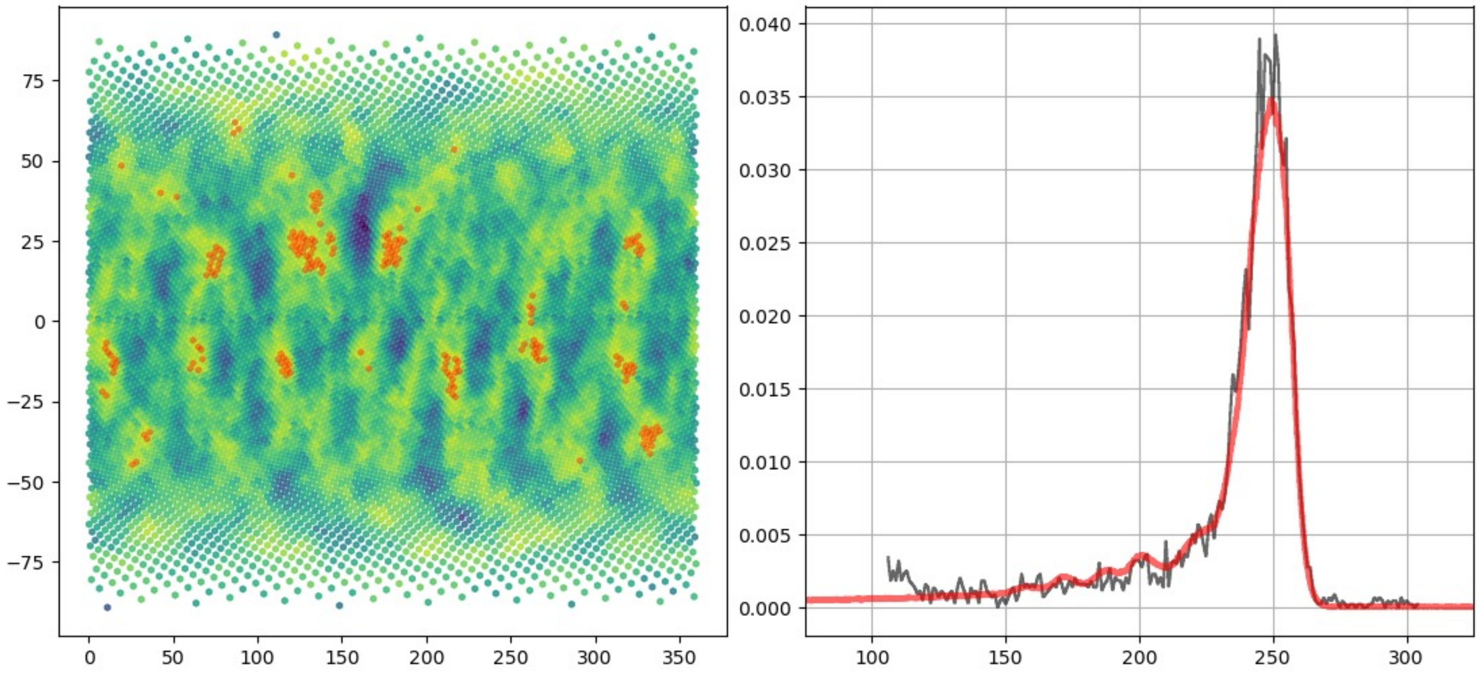




CCR array (matched positions)

Empirical data **Model matched**

Matched distributions



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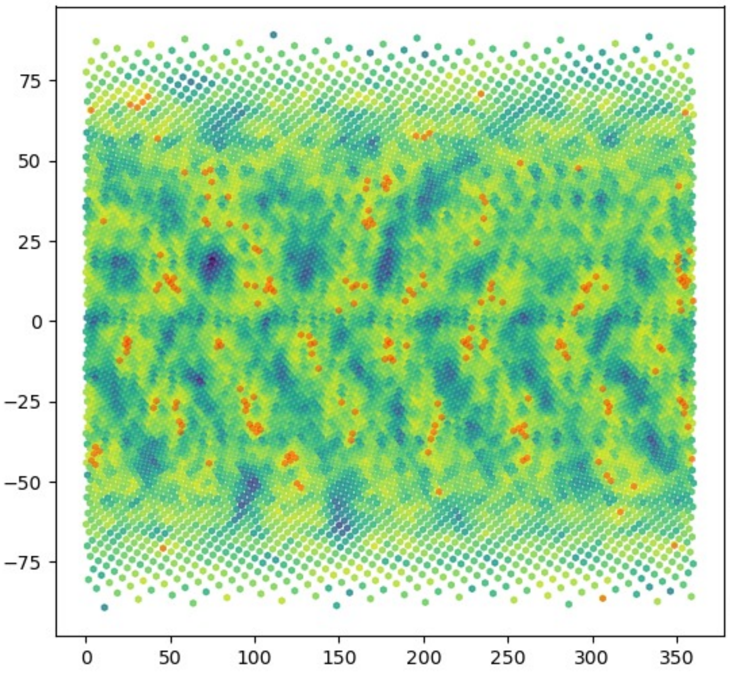

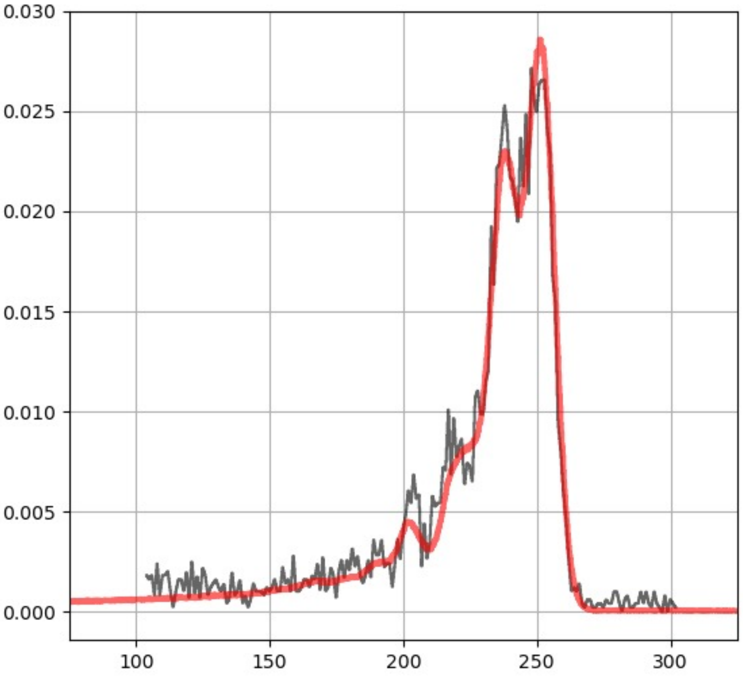

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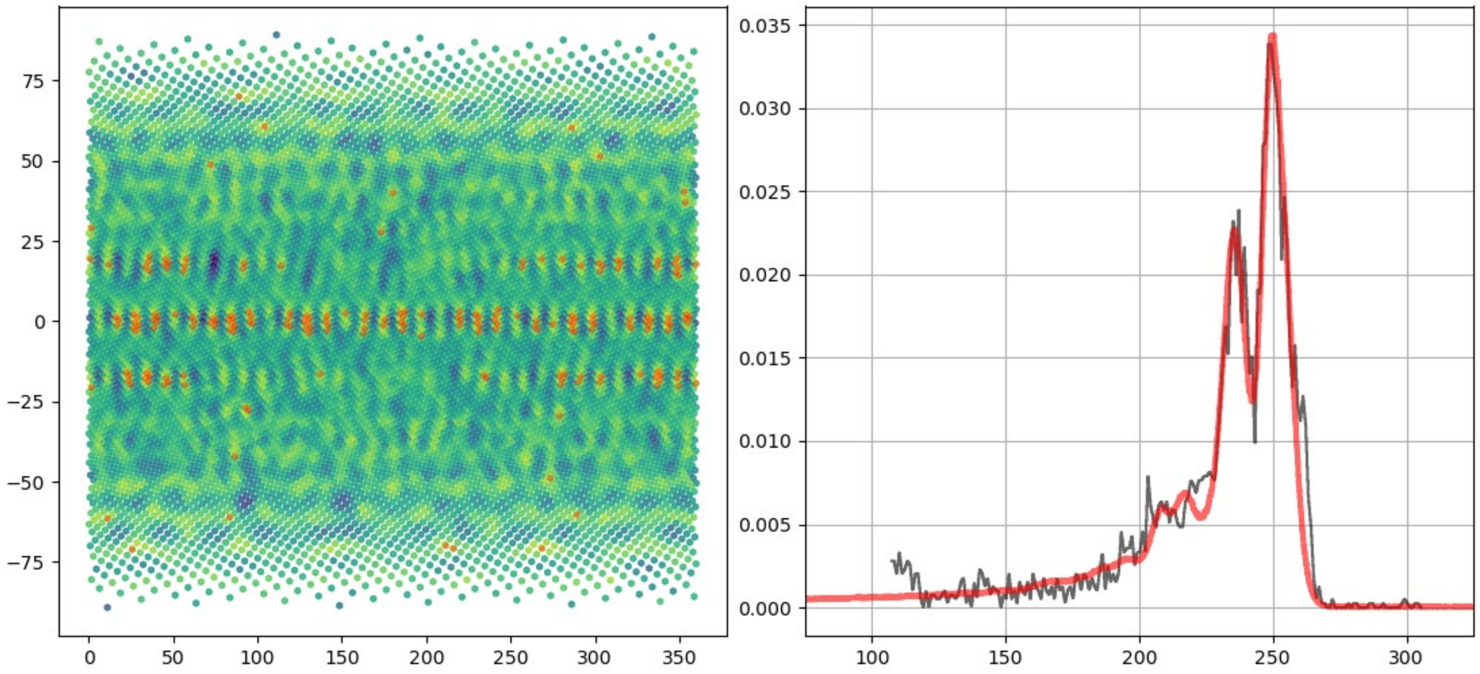

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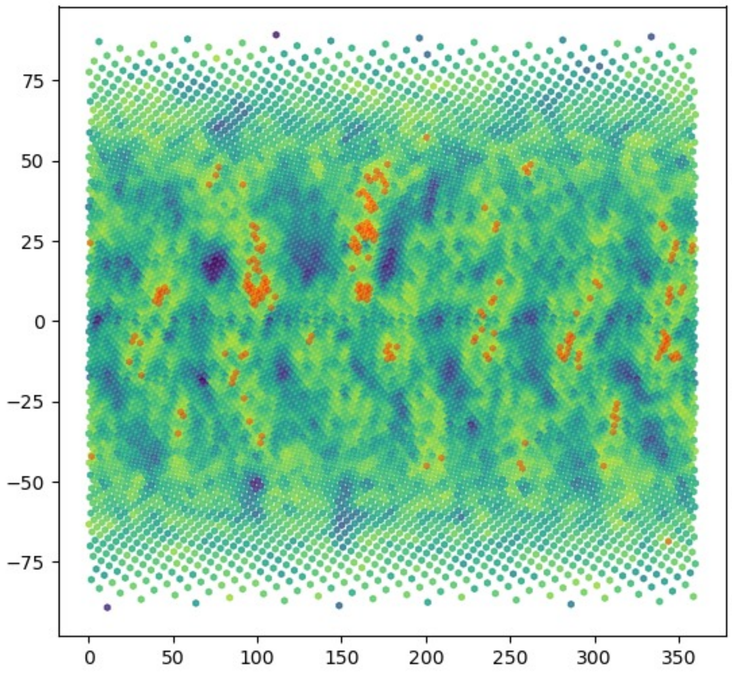

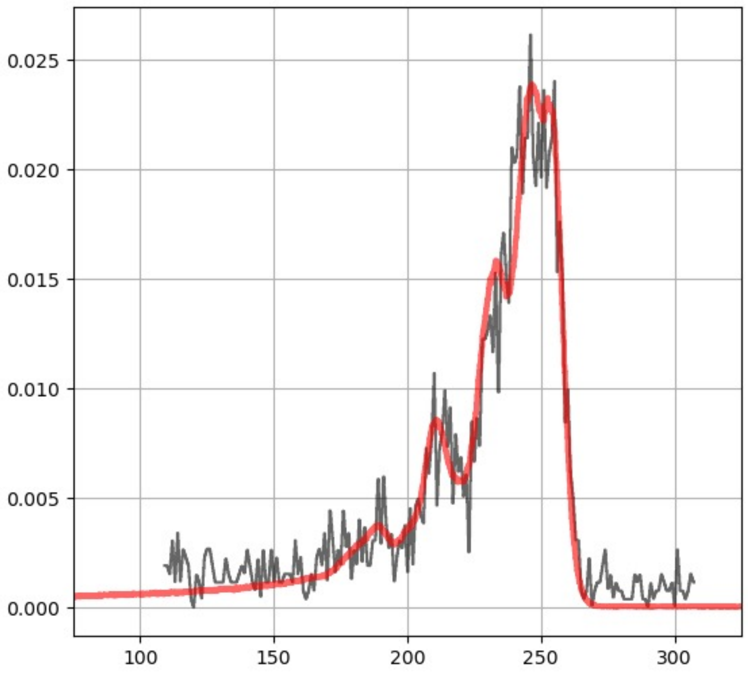

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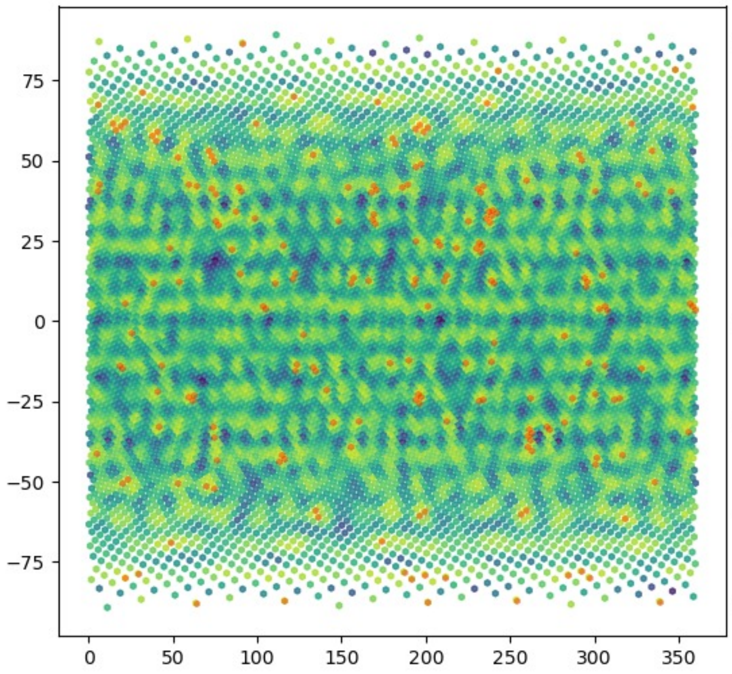

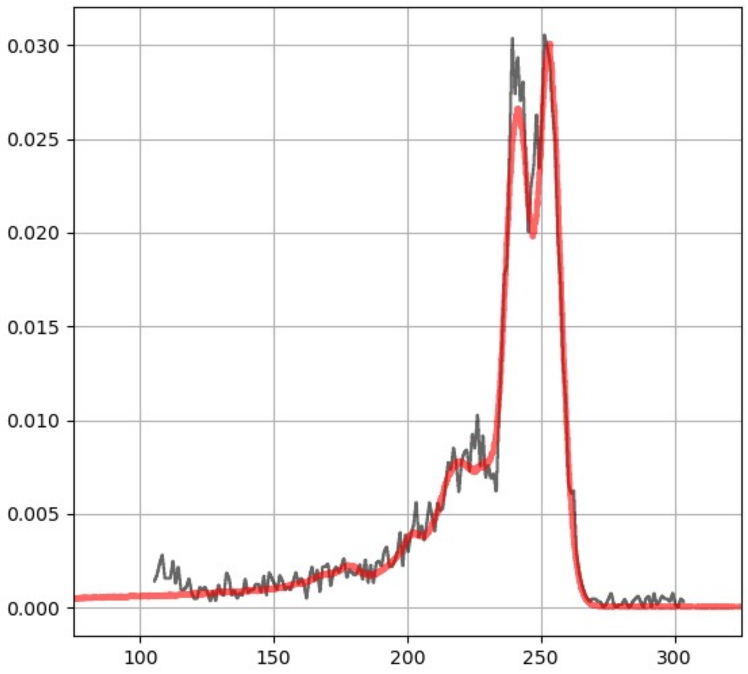

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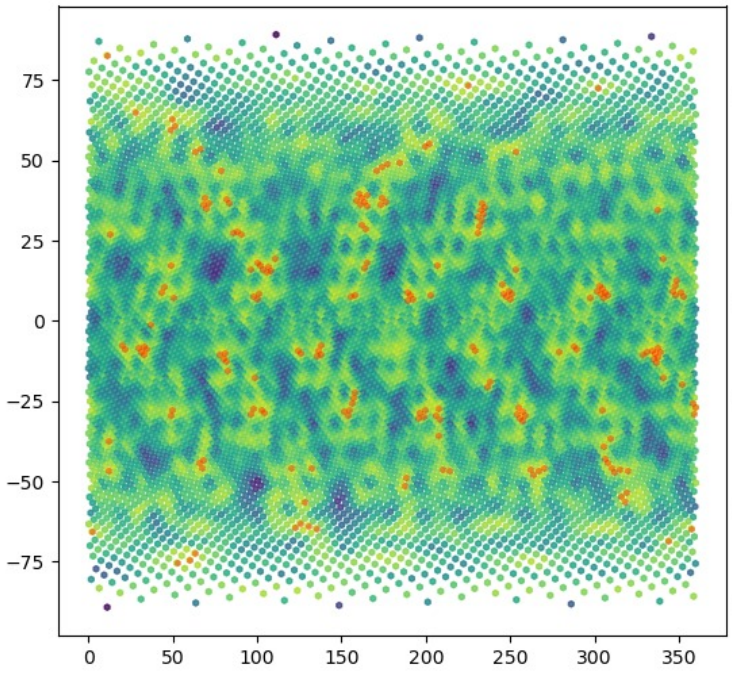

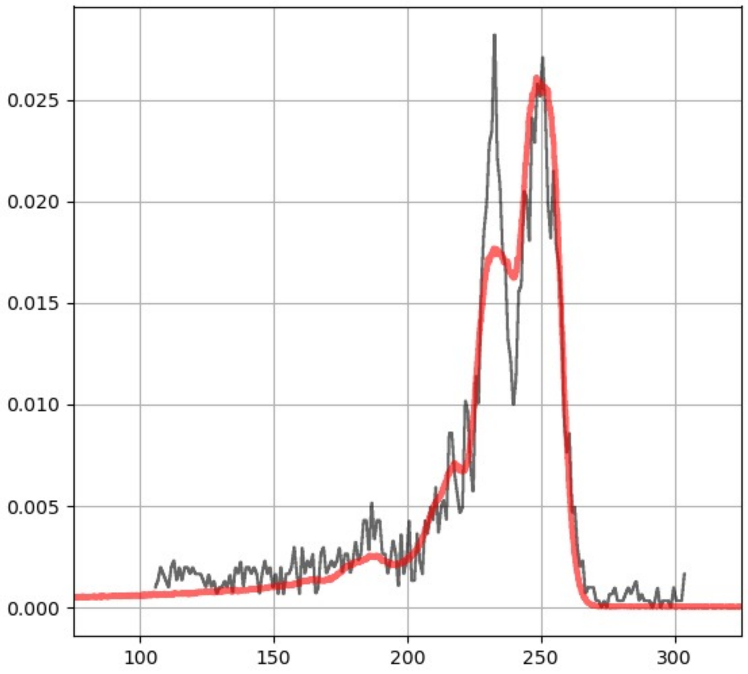

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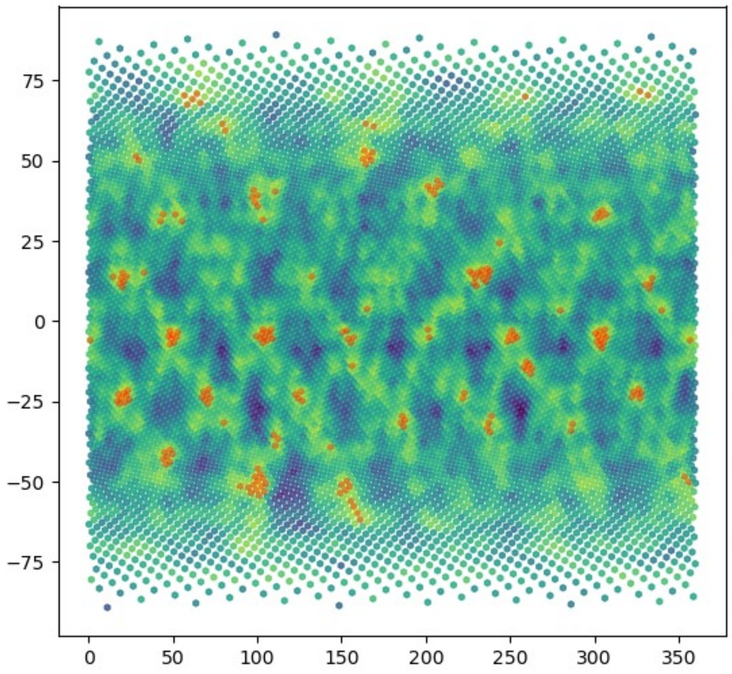

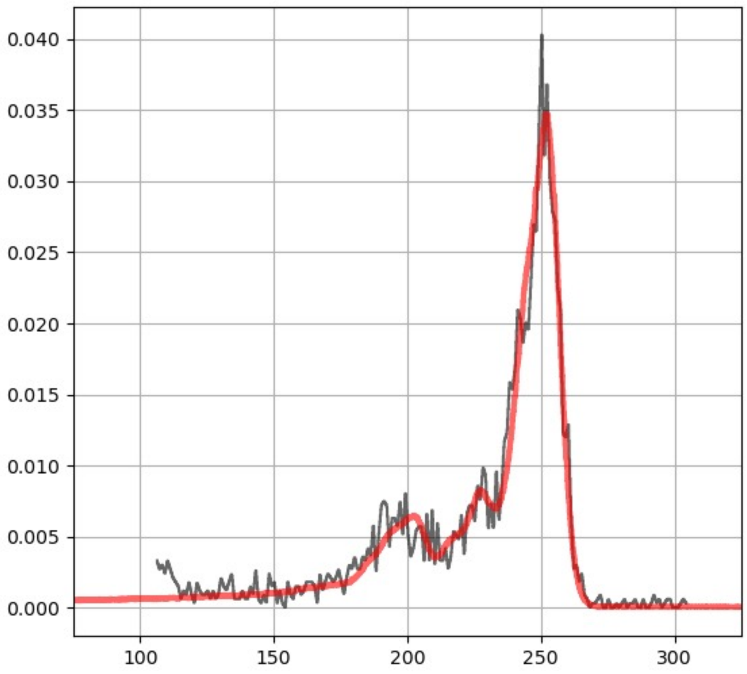

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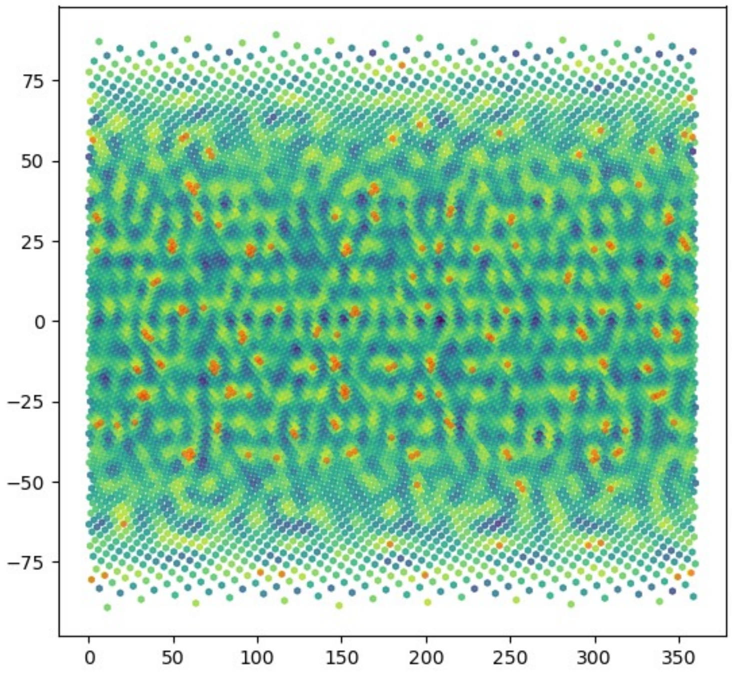

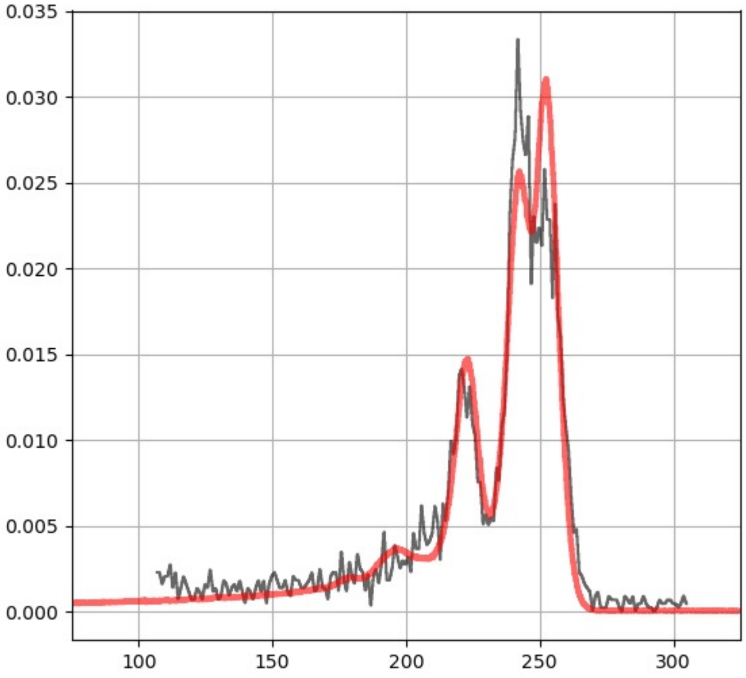

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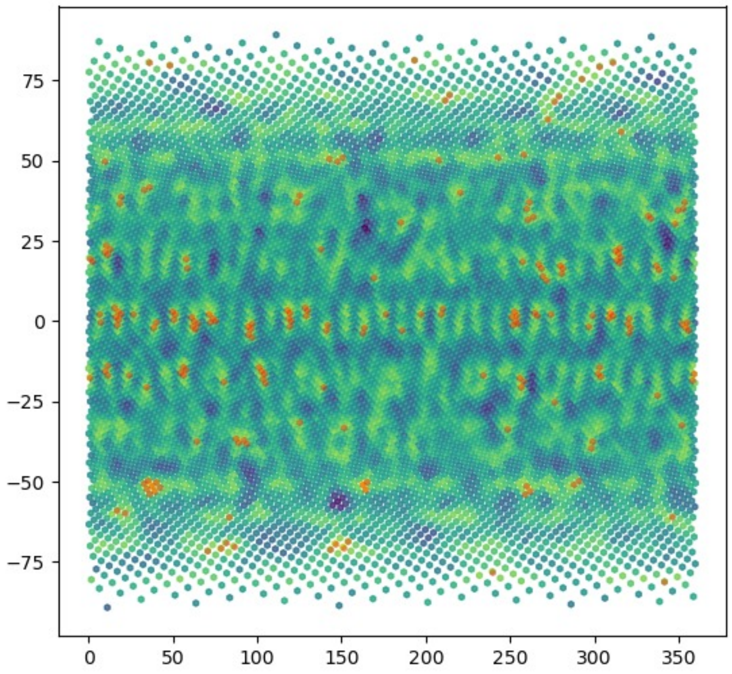

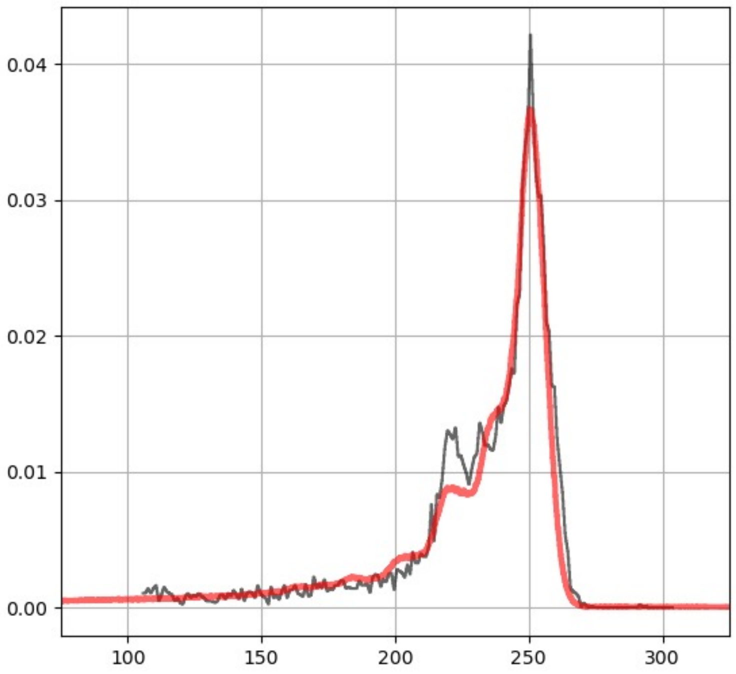

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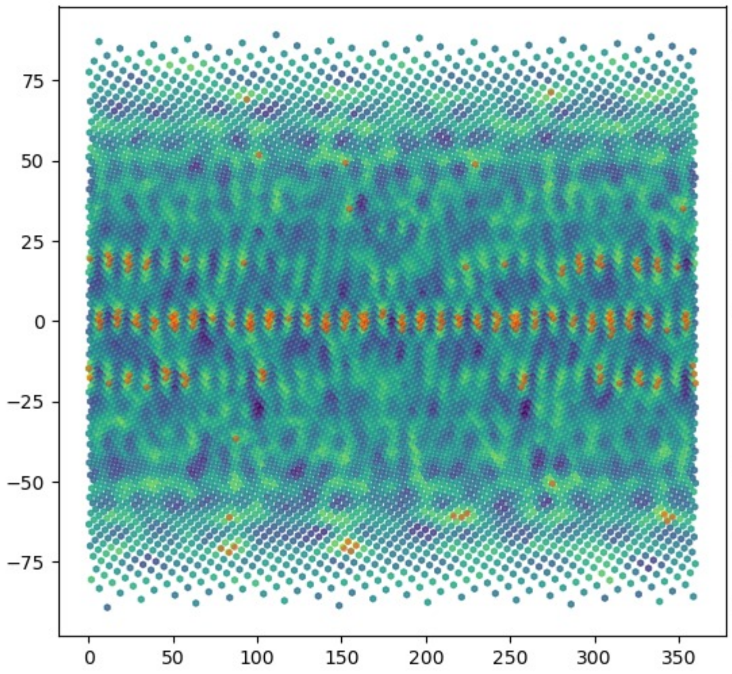

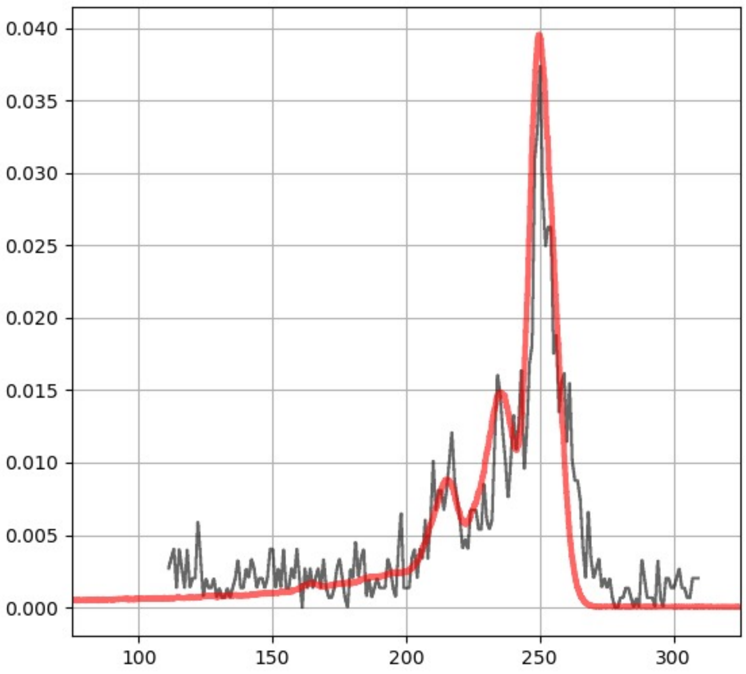

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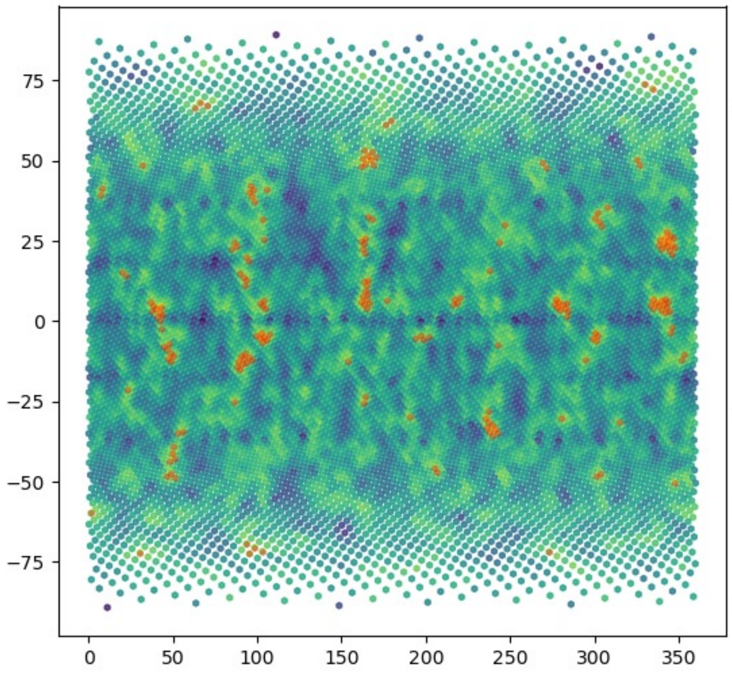

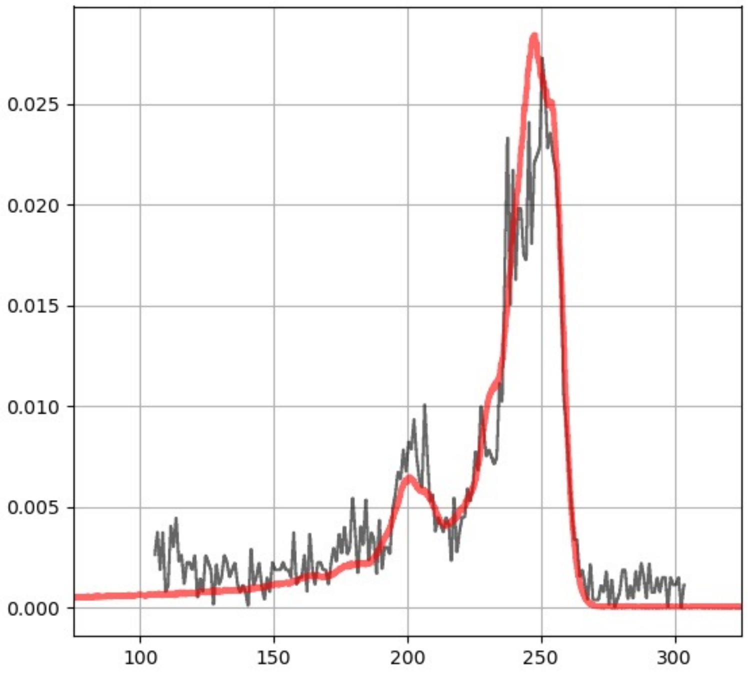

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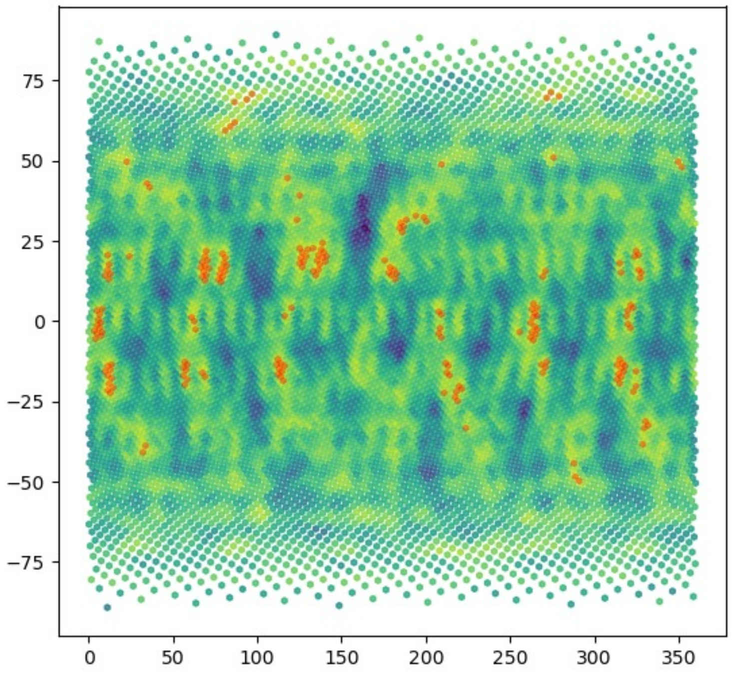

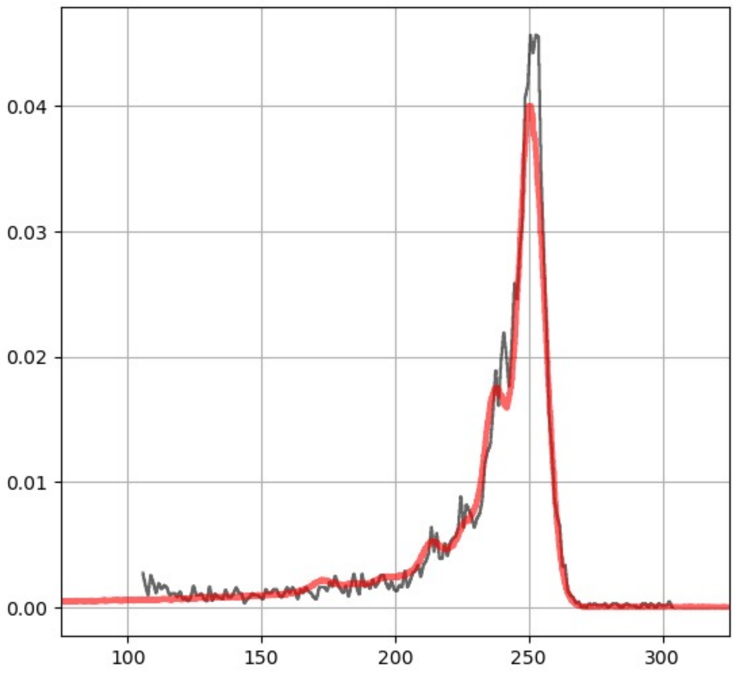

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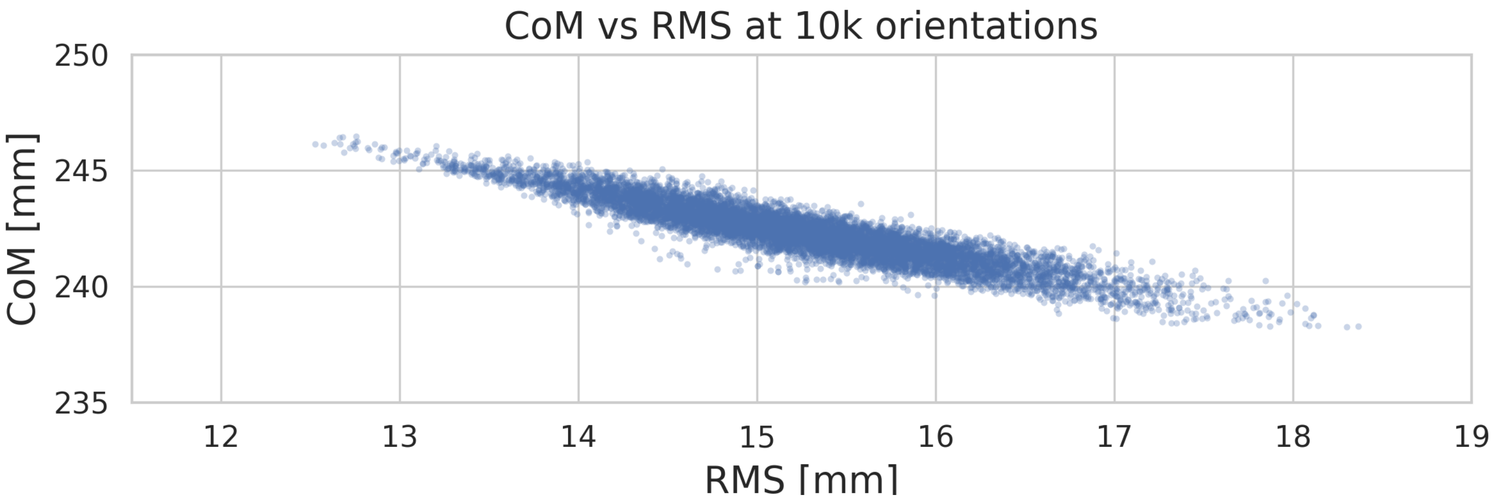

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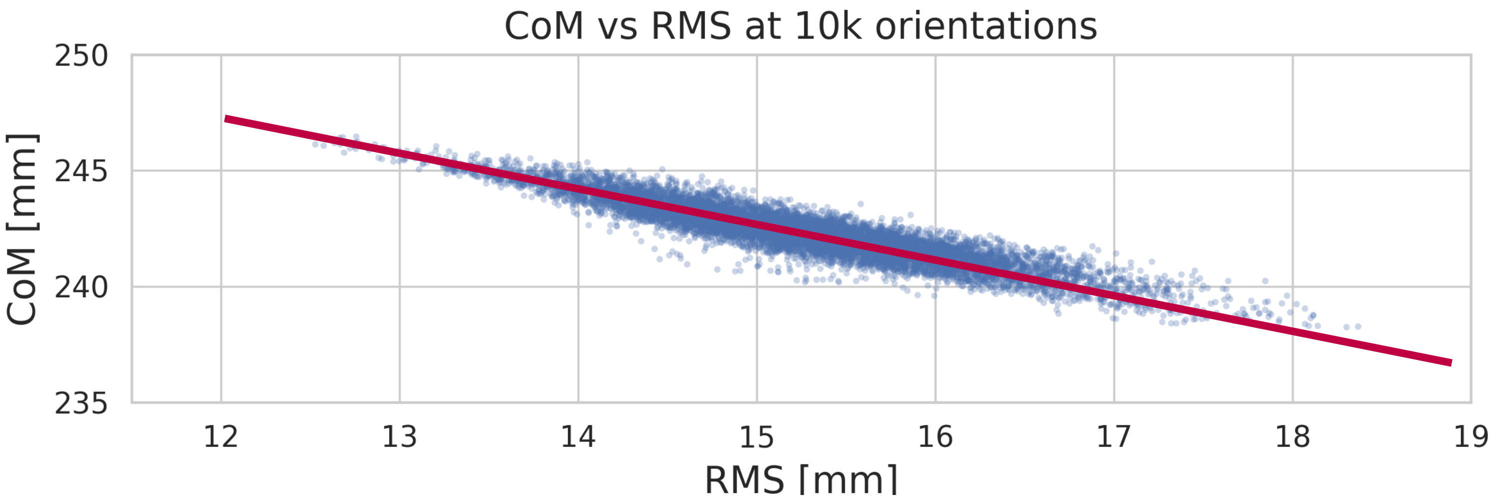

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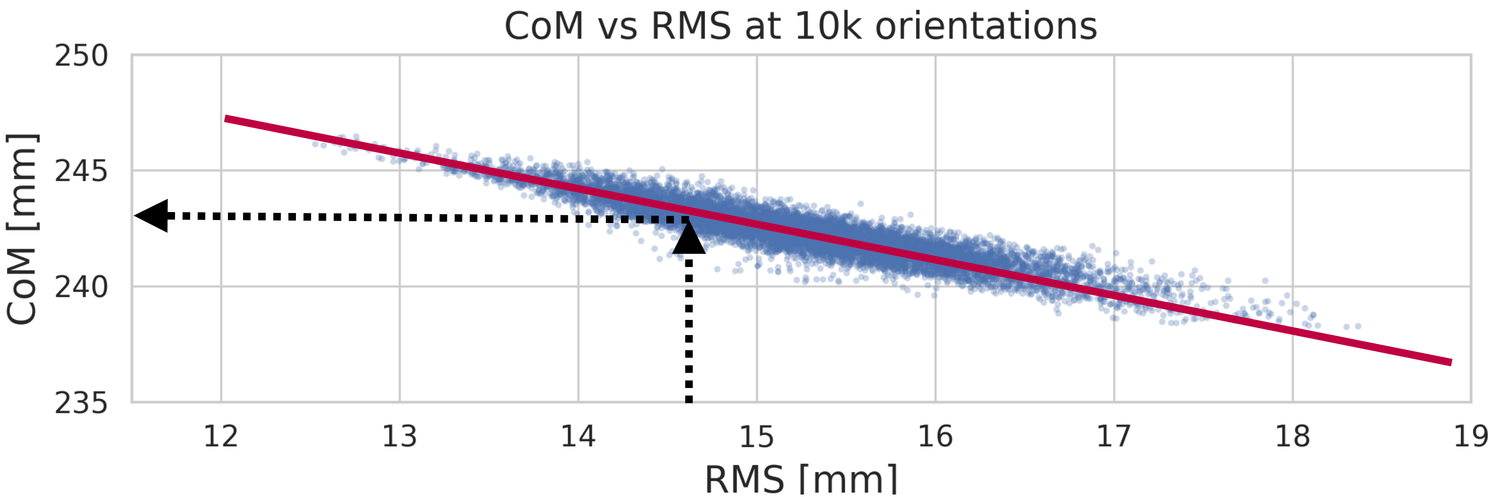
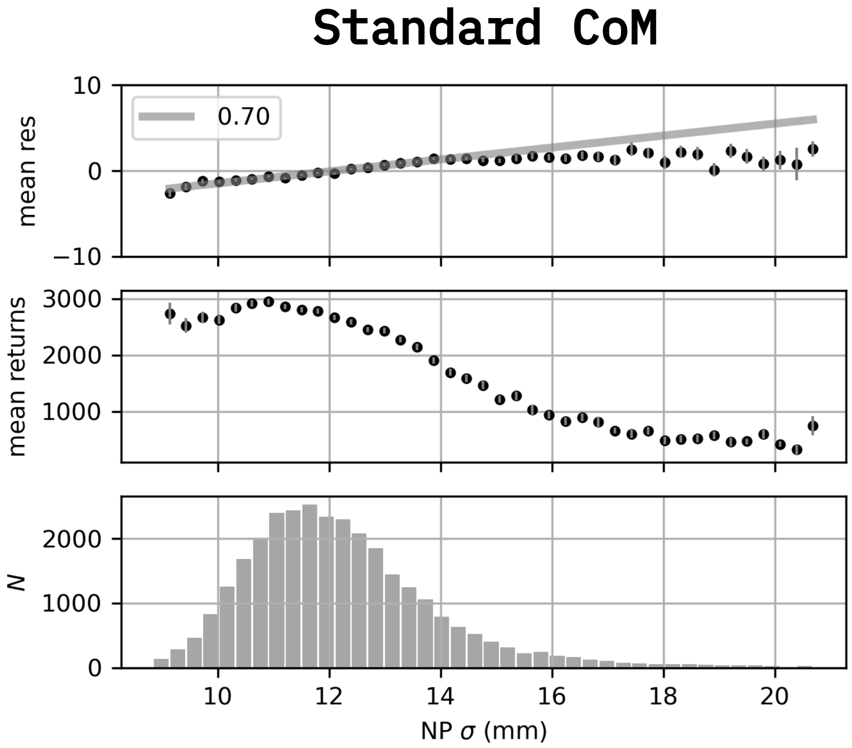


Test

- Regular 7-day arc solutions:
  - LG1/LG2 orbits
  - Stations, EOPs, RBs
  - 2015–2021
- Standard CoM corrections
- RMS-dependent CoM for Herstmonceux

LAGEOS-1: Resids vs NP RMS



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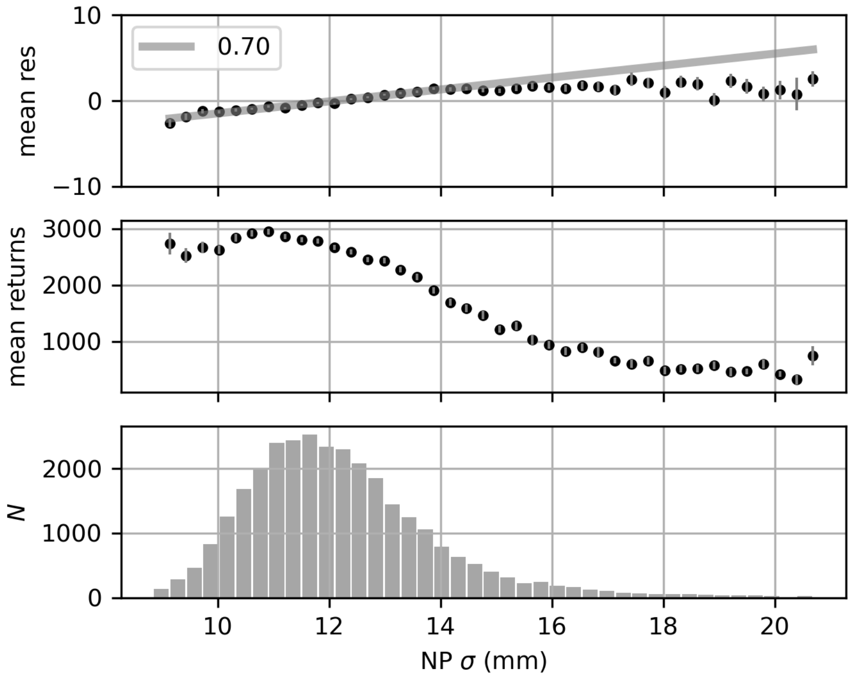
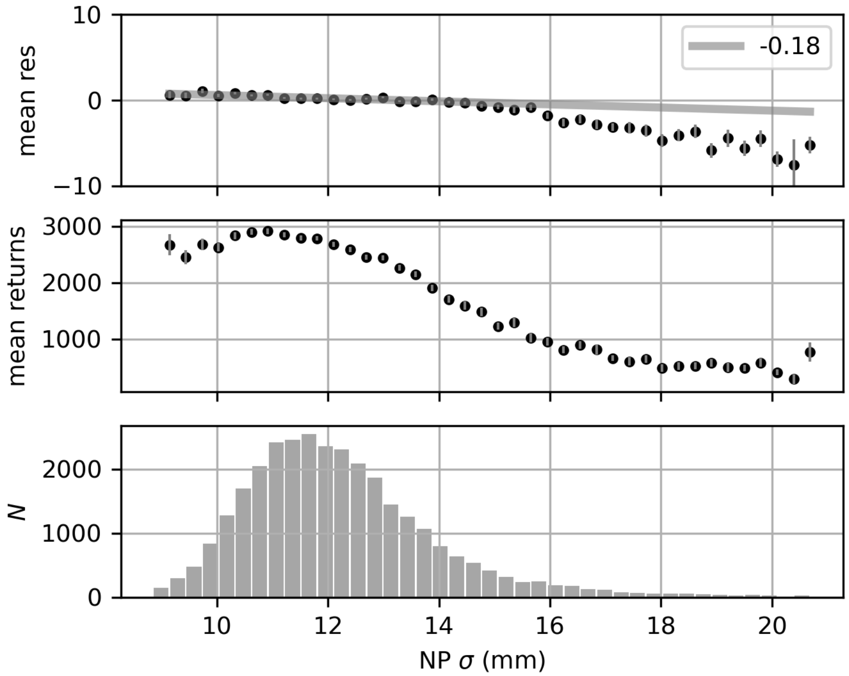
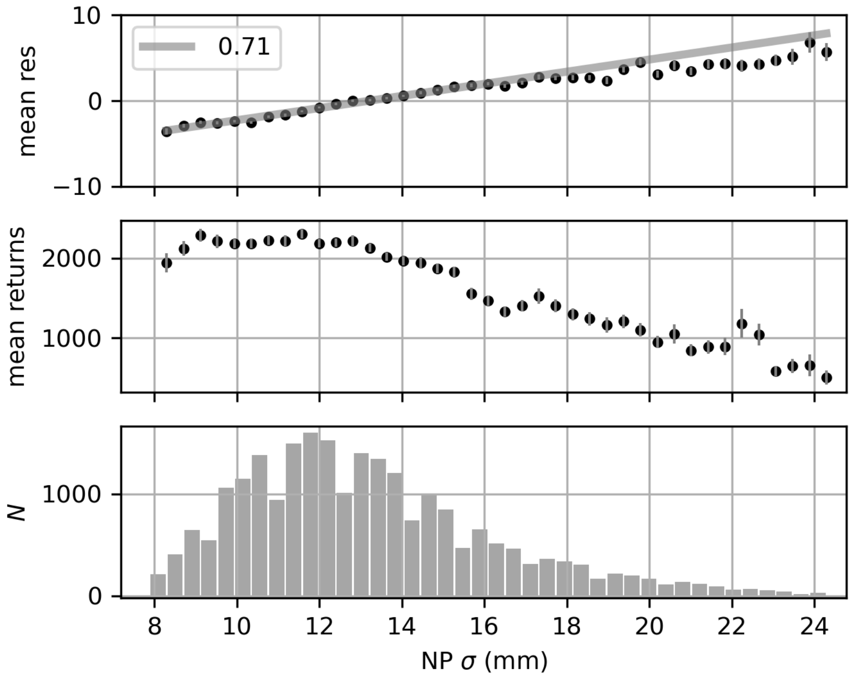


RMS-dependent CoM



LAGEOS-2: Resids vs NP RMS

Standard CoM



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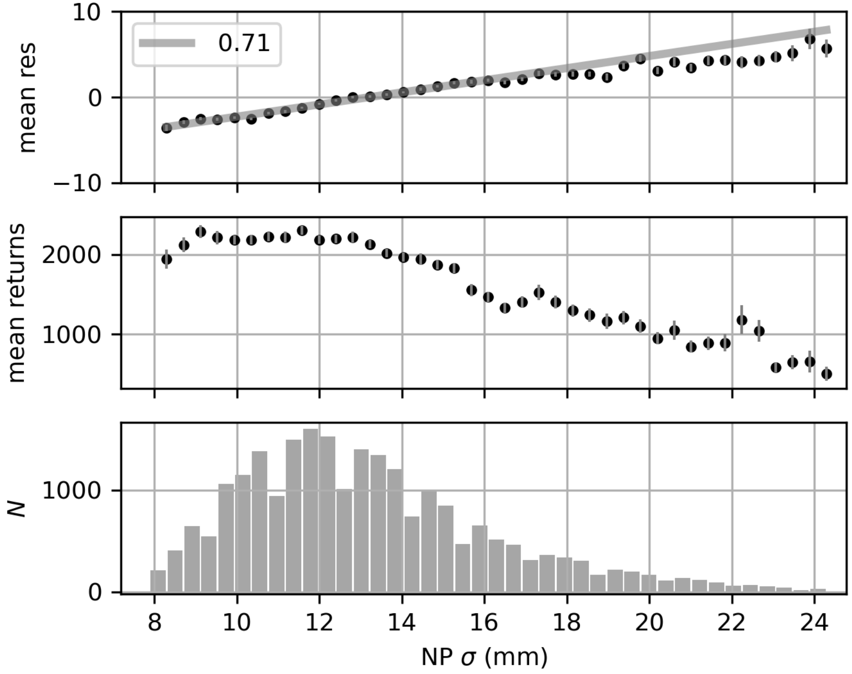

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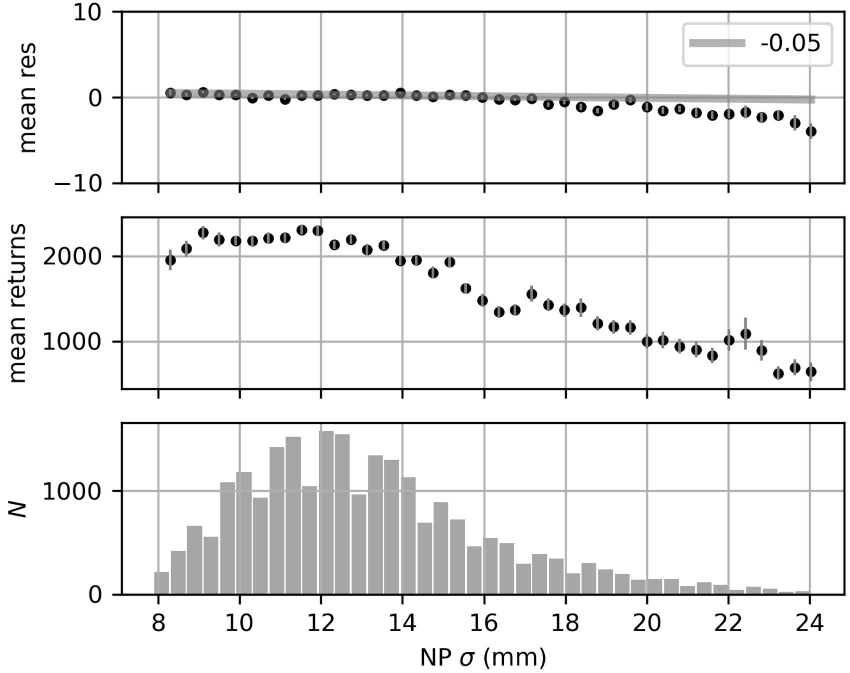
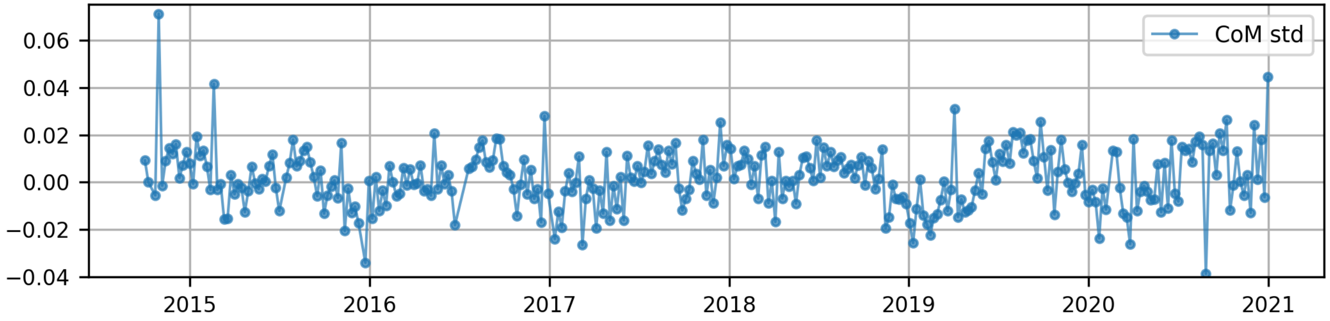


7840 HERL height



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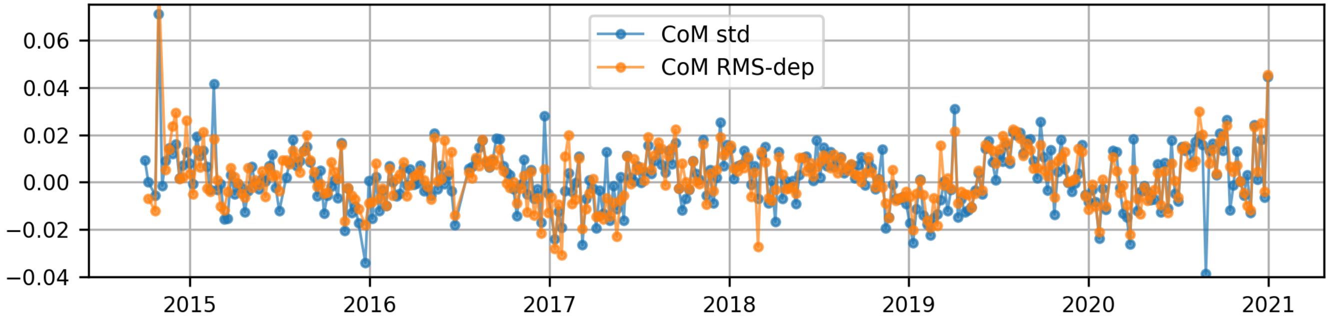
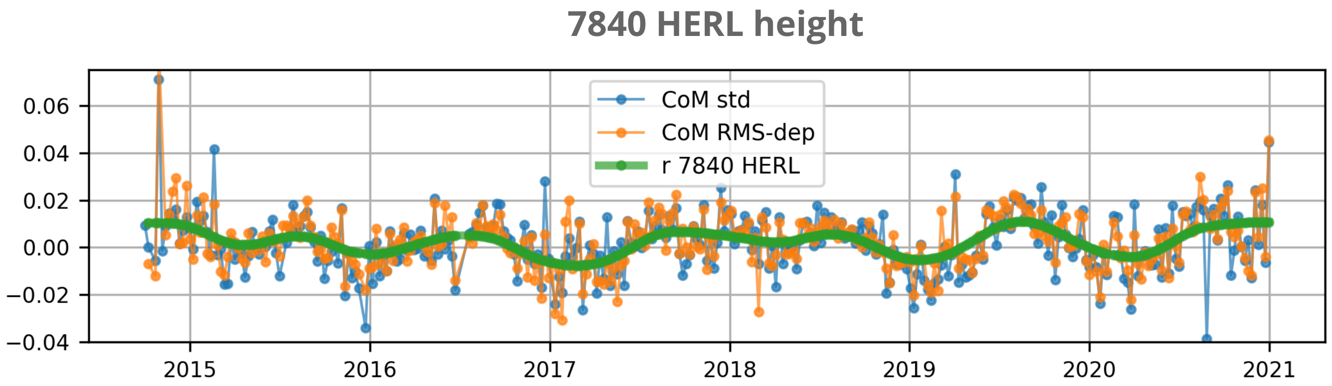
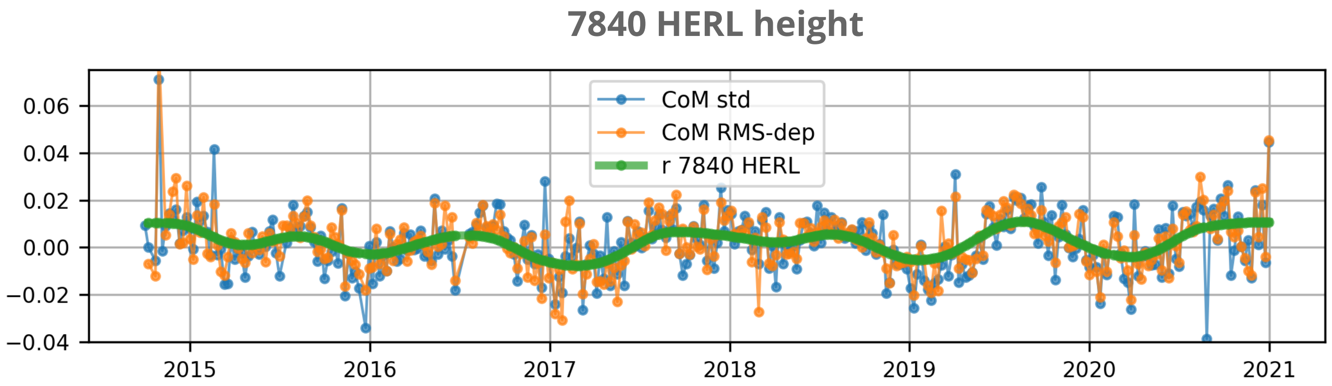




- RMS detrended height (CoM standard): **9.5 mm**
- RMS detrended height (CoM rms-dep): **8.3 mm**



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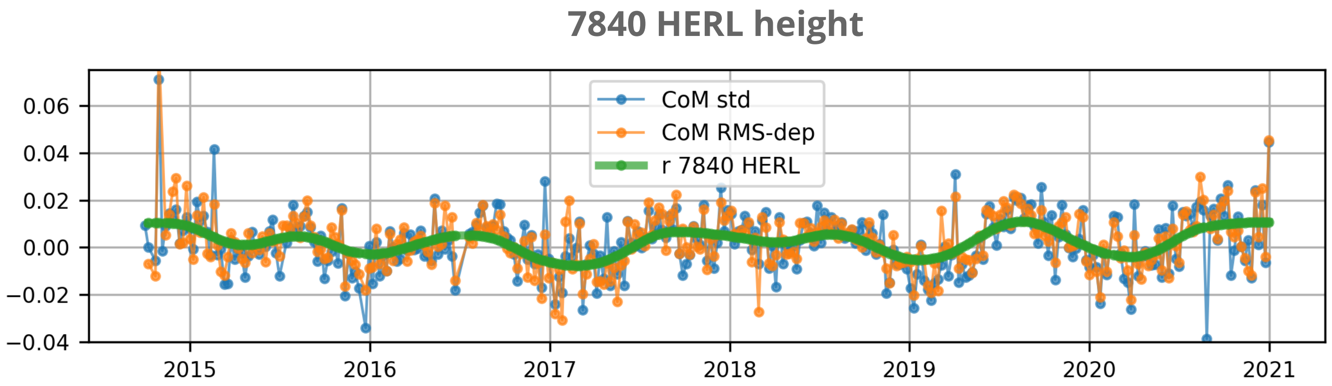

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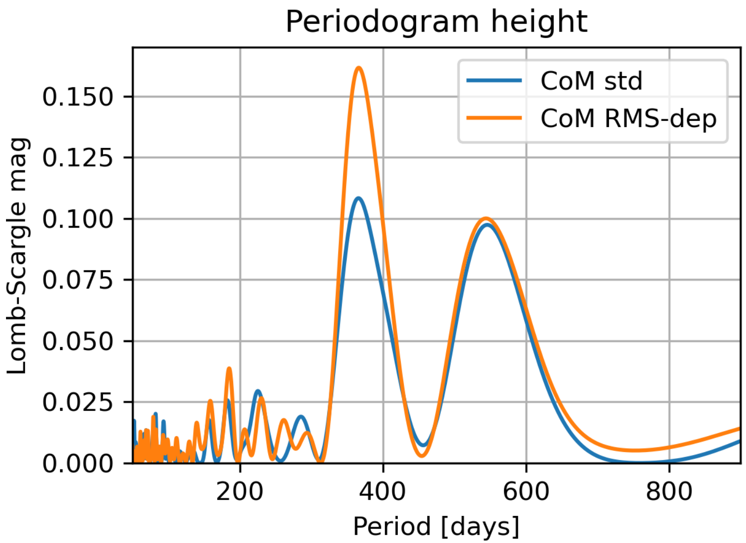

WIP. Some remarks:

- Relative orientation determines the instantaneous distribution of returns
- This results in a distribution of centre of mass values around the mean
- Resids vs NP RMS trend not that scary
- We can take this effect into account to a good extent → RMS is a feature, not a bug
- Impact on geodetic products: limited but positive
- Instantaneous CoM correction possible for high-rate (KHz and beyond)
- More analysis required

Thank you