Instrumental Calibration of Copernicus Altimeters

… and a few more

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isardSAT®

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Outline

PART I

- CAL modes & parameters, impact in the geophysical estimations
- Altimeter Instrument Behaviour of the Copernicus missions

  (and a few more missions if available)

PART II

- Sentinel-3 calibration orbital reconstruction from Moon Observation measurements

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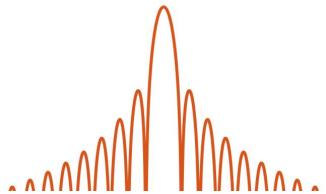
Calibration Parameters

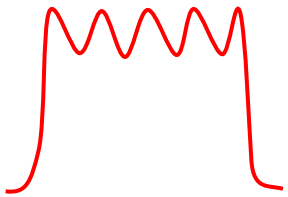
CAL1 Products



(Internal Calibration Path Waveform)

- Internal Delay
- Integrated Power
- PTR Width
- Burst Power & Phase
- Attenuation Steps
- Phase Difference
- Secondary Lobes (monitoring)

CAL2 Products



(Rx Transfer Function Waveform)

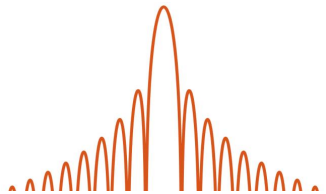
- CAL2 normalised shape
- Slope (monitoring)
- Standard Deviation (monitoring)

… + USO

+ CAL4

Calibration Parameters

CAL1 Products

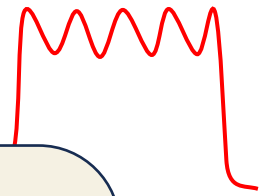


(Internal Calibration Path

- **Internal Delay**
- **Integrated Power**
- **PTR Width**
- Burst Power & Phase
- Attenuation Steps
- Phase Difference
- Secondary Lobes (monitoring)

How do they impact the L2 geophysical parameters? SSH, winds, waves

CAL2 Products



ction Waveform)

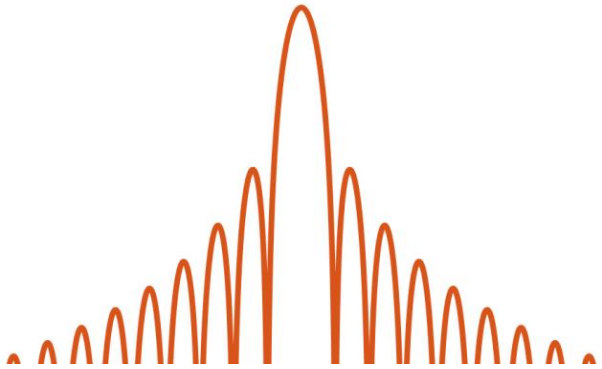
shape
)
on (monitoring)

… + USO

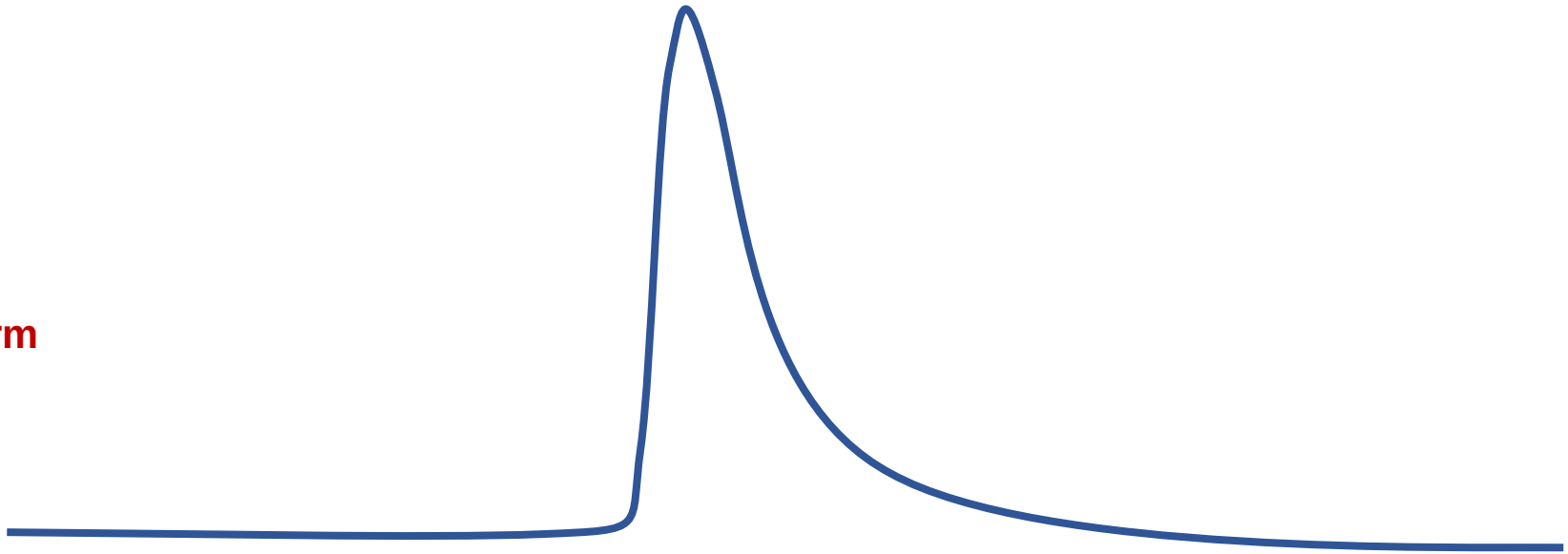
+ CAL4

Impact in science data

CAL1 Products → impact in → Geophysical Retrievals



Internal Calibration Path Waveform

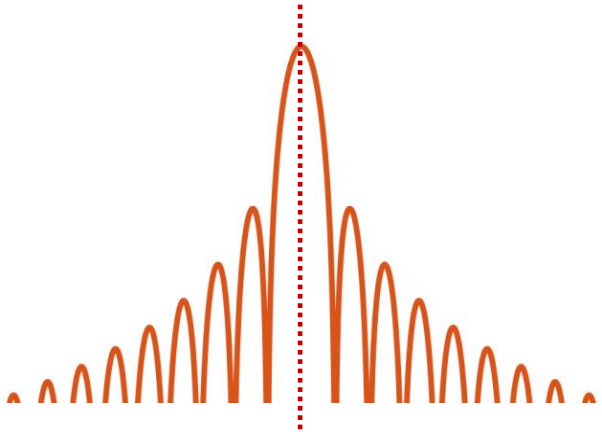


Open Ocean Waveform

Impact in science data

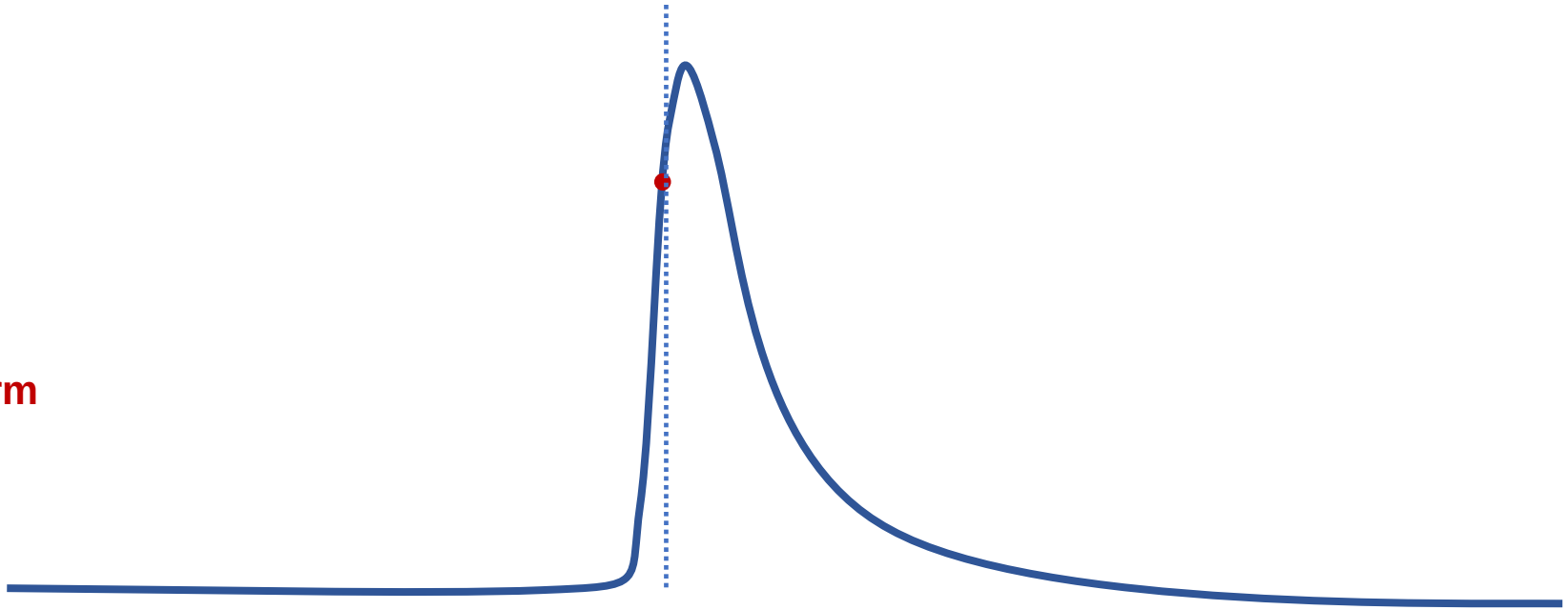
CAL1 Products → impact in → Geophysical Retrievals

Max Position



Internal Calibration Path Waveform

Epoch → **Sea Surface Height**

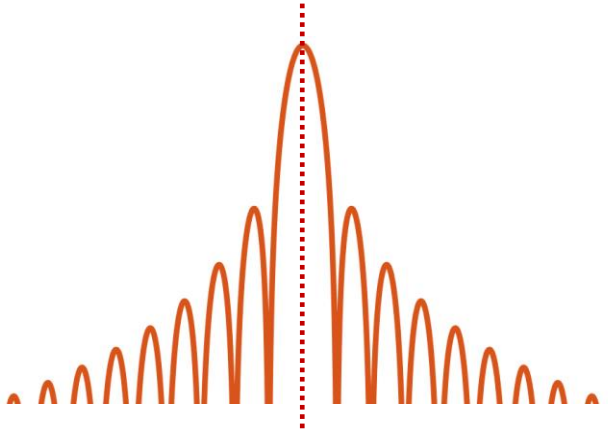


Open Ocean Waveform

Impact in science data

CAL1 Products → impact in → Geophysical Retrievals

Max Position… or Centre of Gravity



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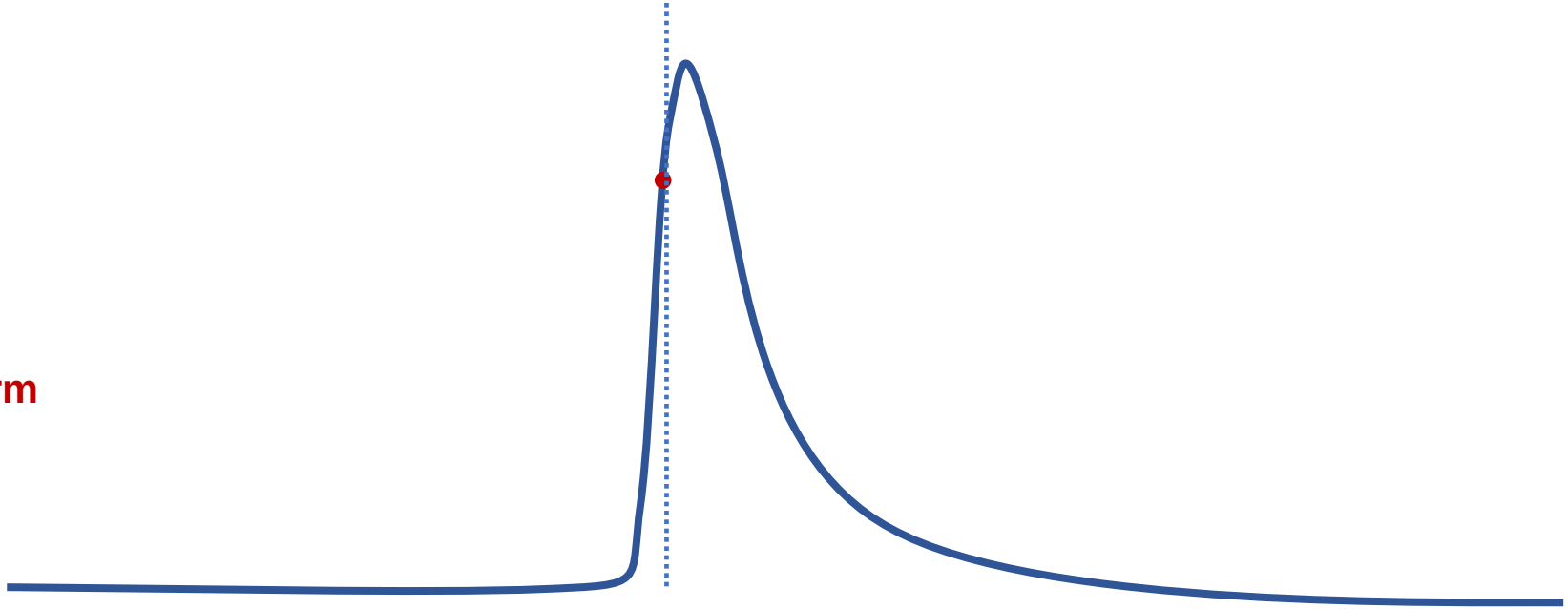

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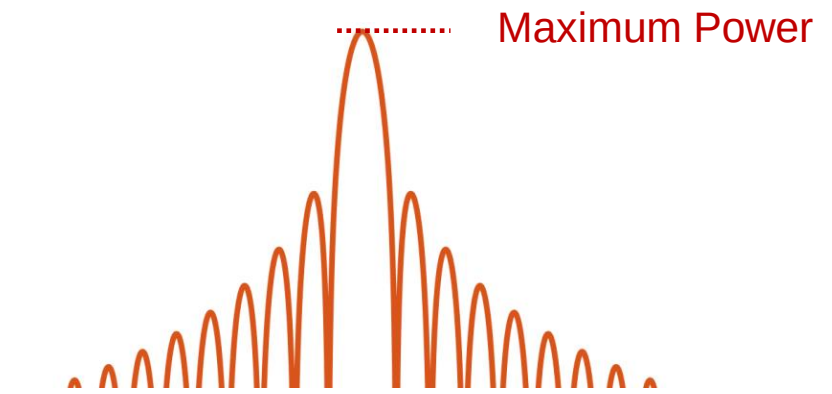

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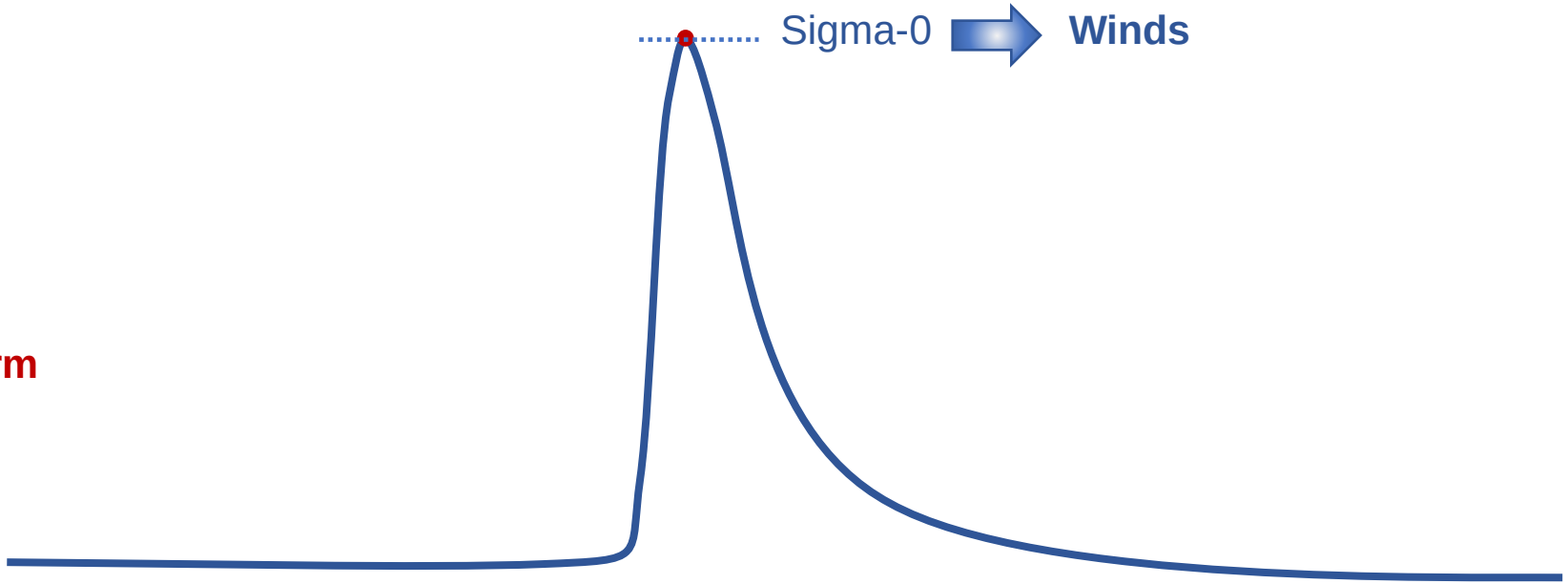

Open Ocean Waveform

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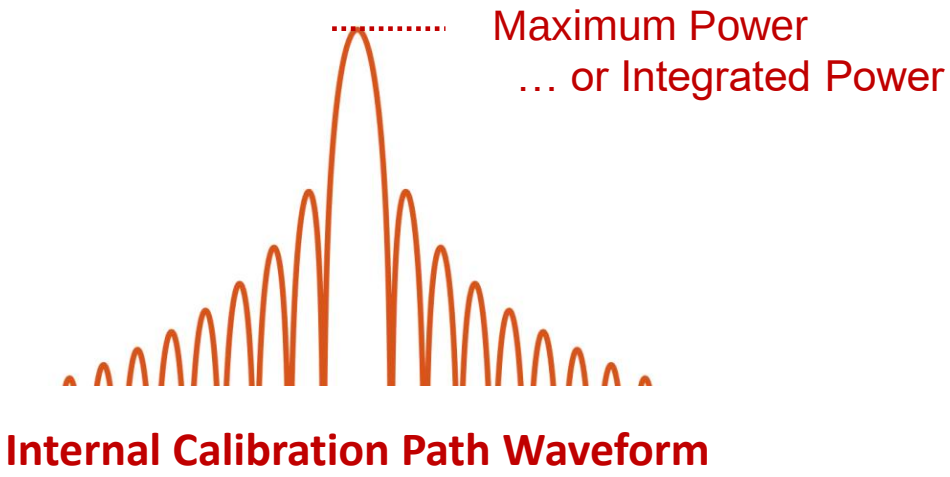

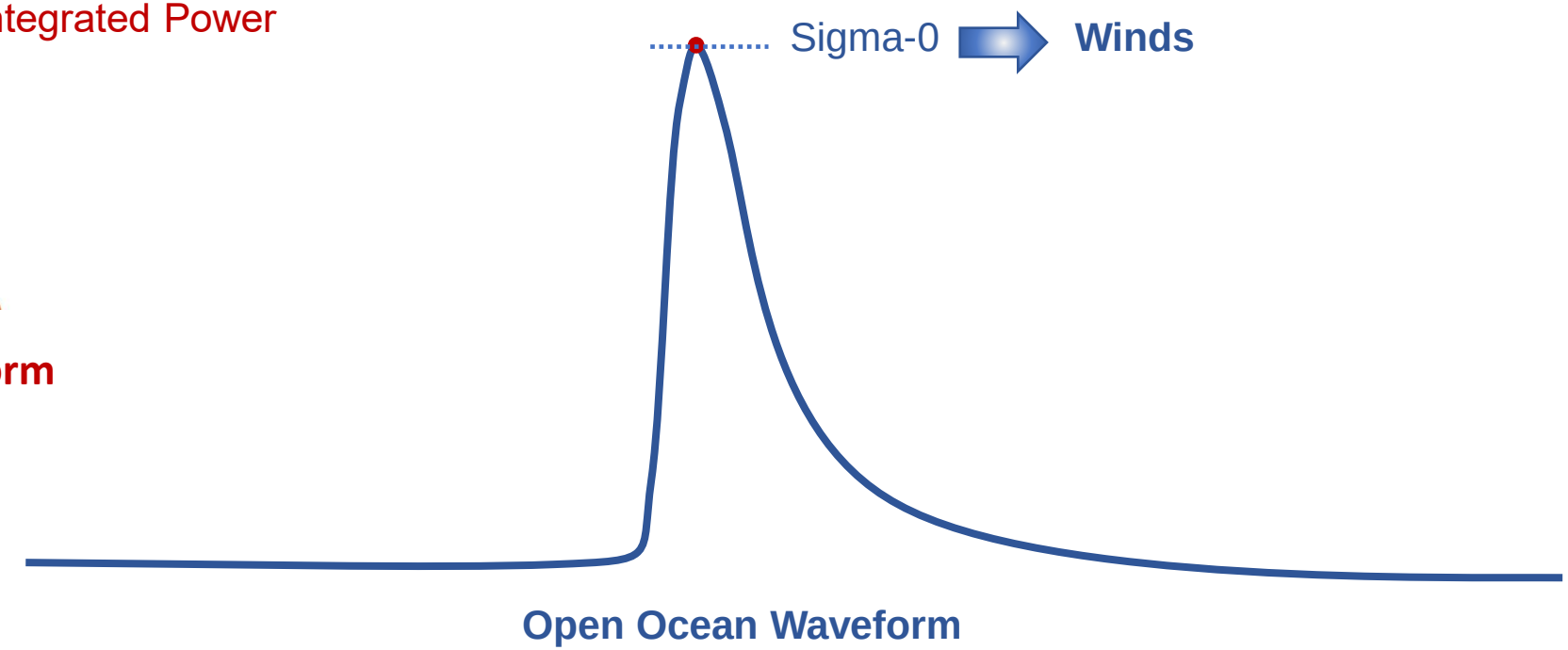

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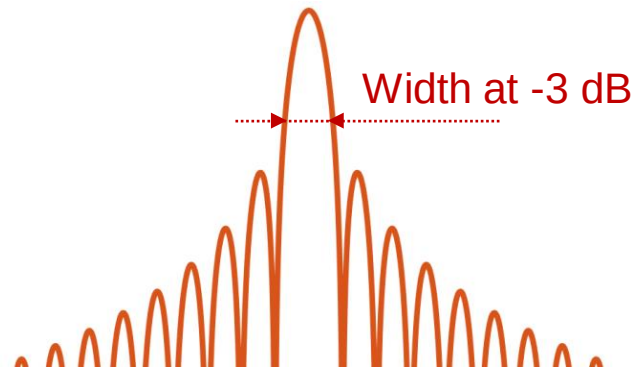
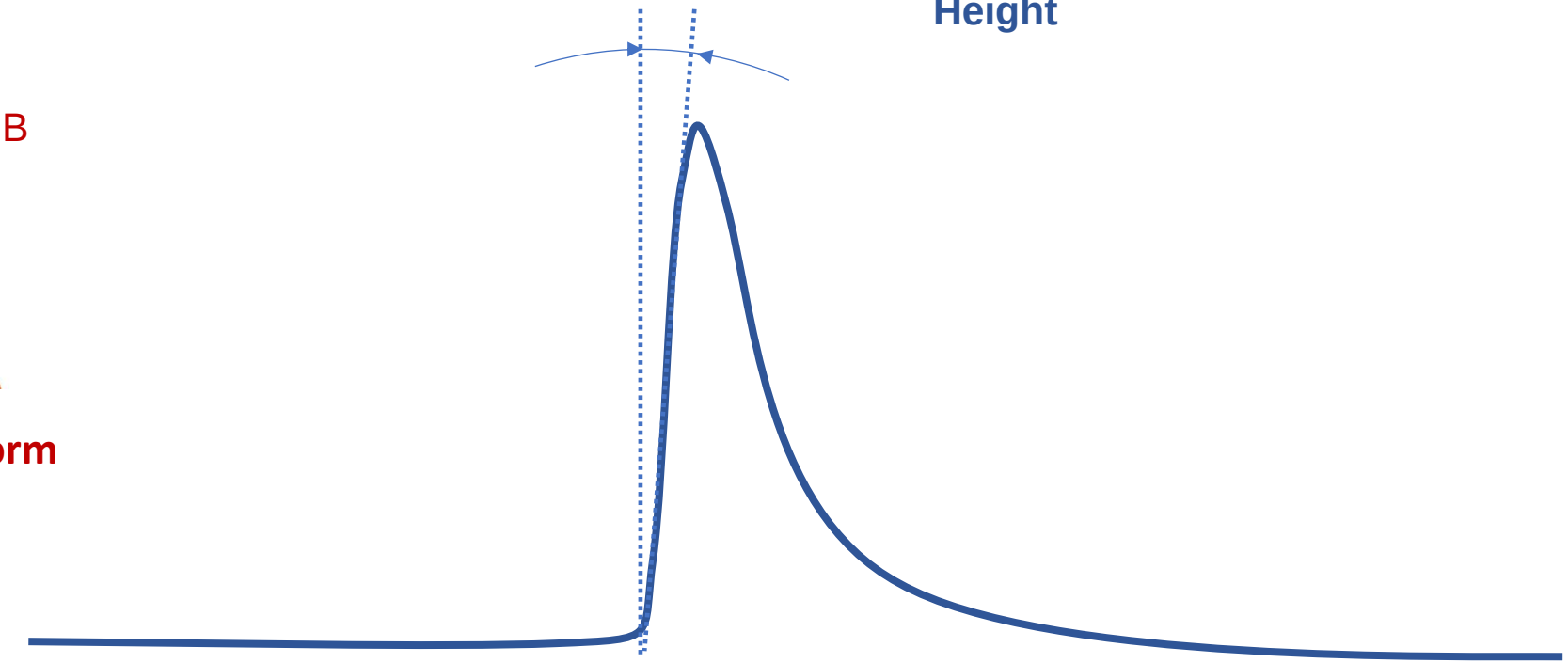


Internal Calibration Path Waveform

Leading Edge Slope → **Significant Wave Height**



Open Ocean Waveform

Impact in science data

Other **calibration** parameters impact in **science** data:

The **CAL2** calibration waveform compensates the whole science **waveform shape** for the Transfer Function of the altimeter Rx chain.

The **Burst Power and Phase** corrections improve the **stack alignment**.

The **ATT attenuation steps** tables corrects for the actual onboard science waveforms attenuation (**sigma-0**).

The **USO clock period** have a multiplicative impact in the final range (**SSH**).

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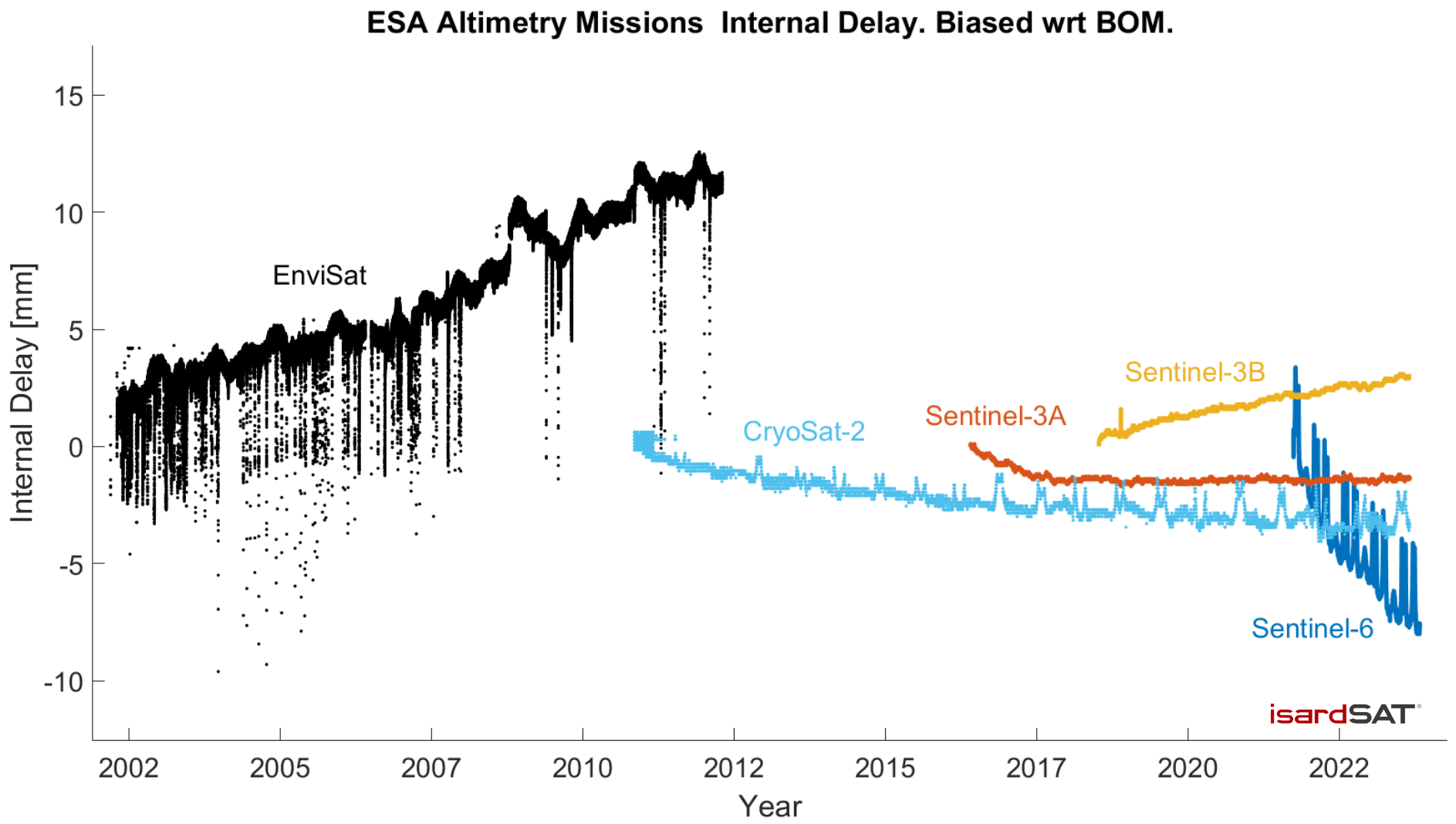
Altimeter instrument behaviour



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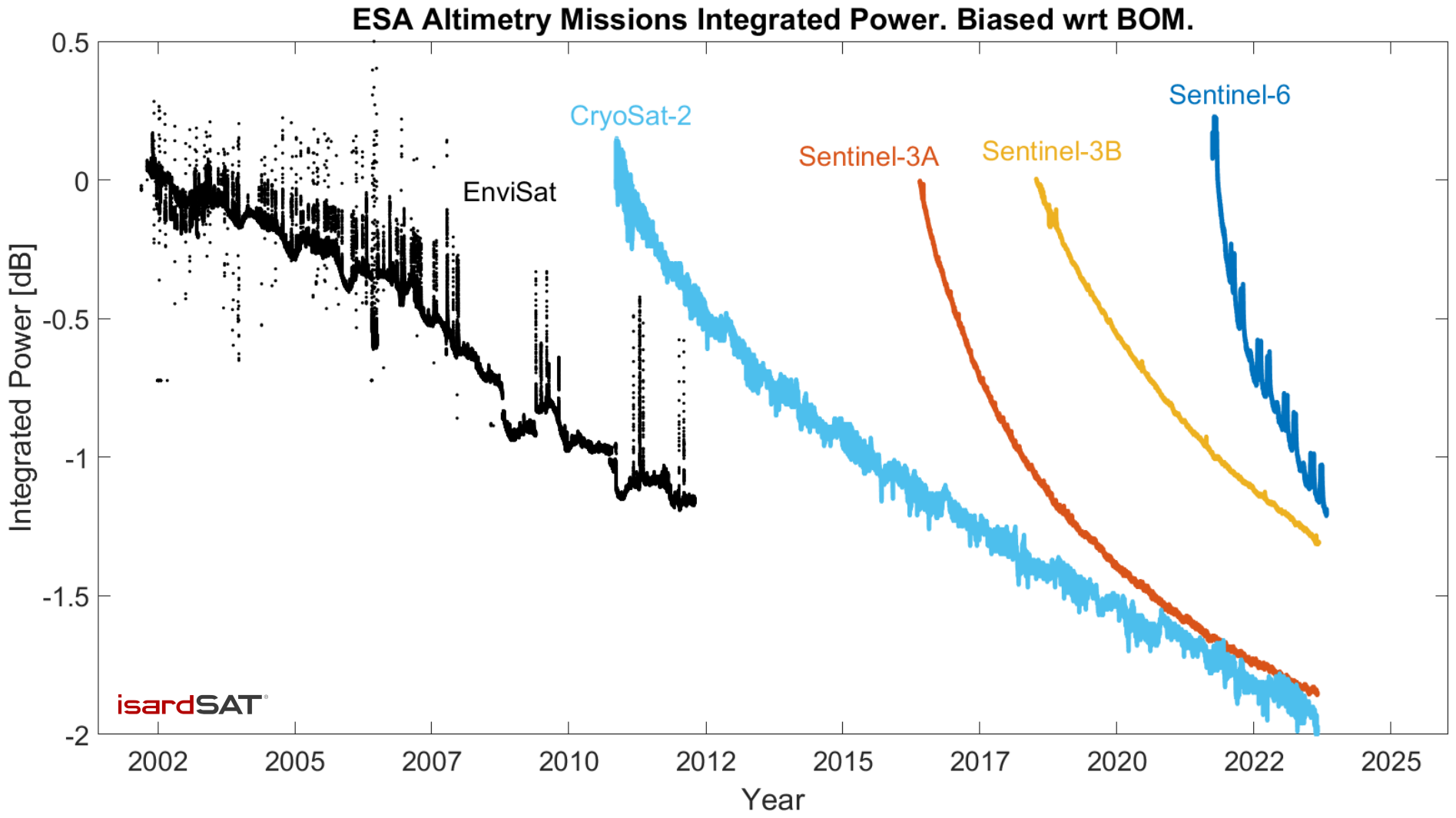

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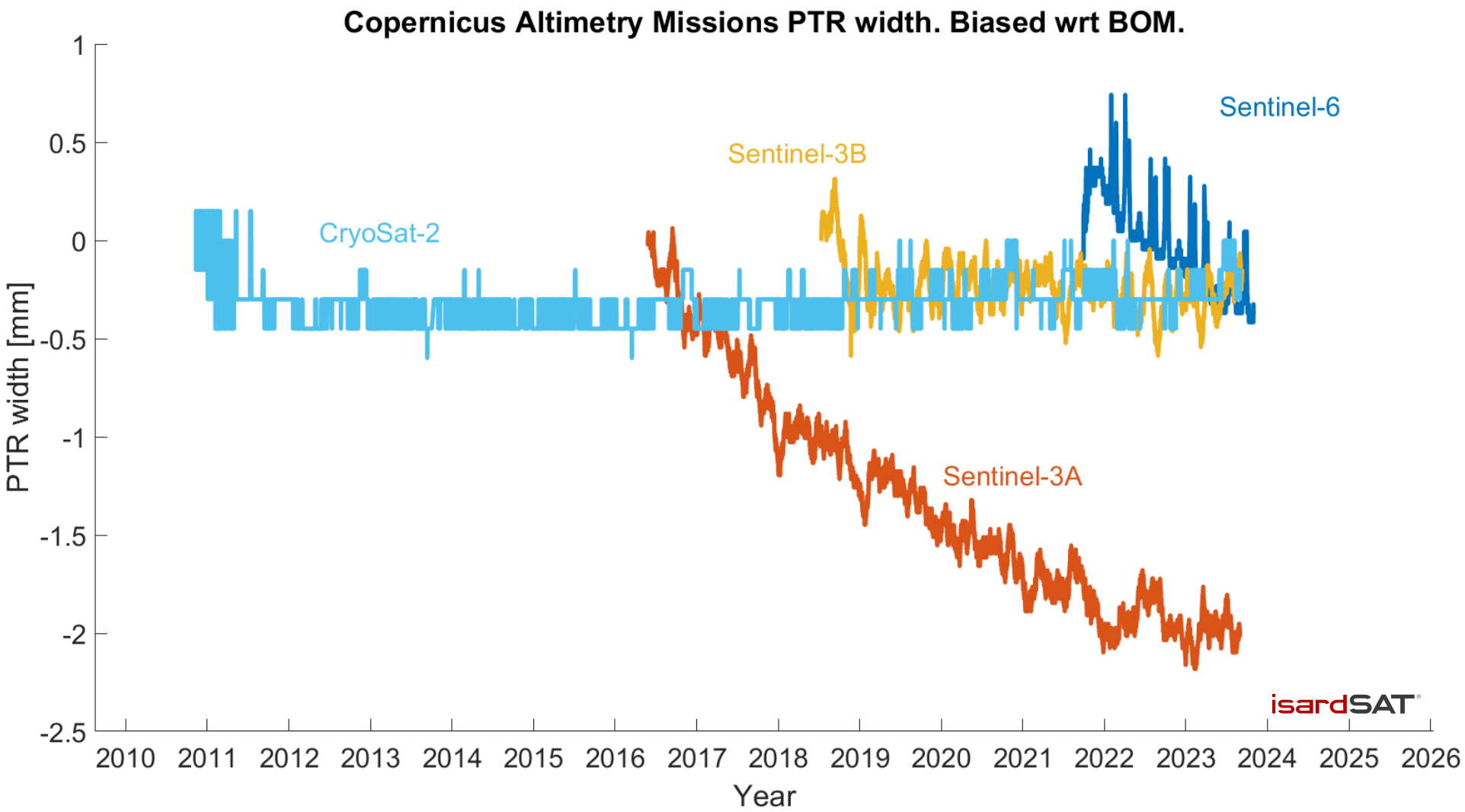

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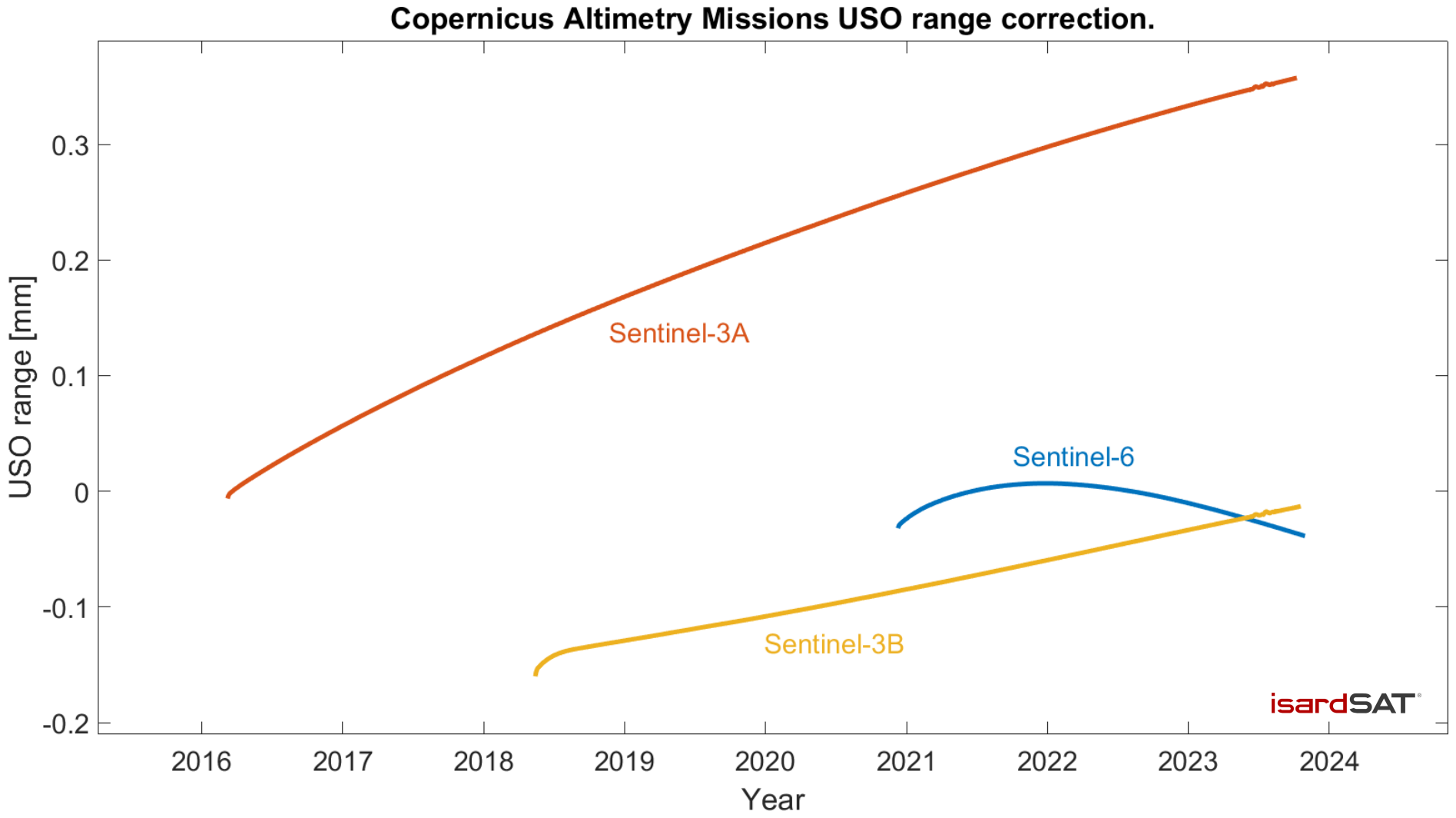
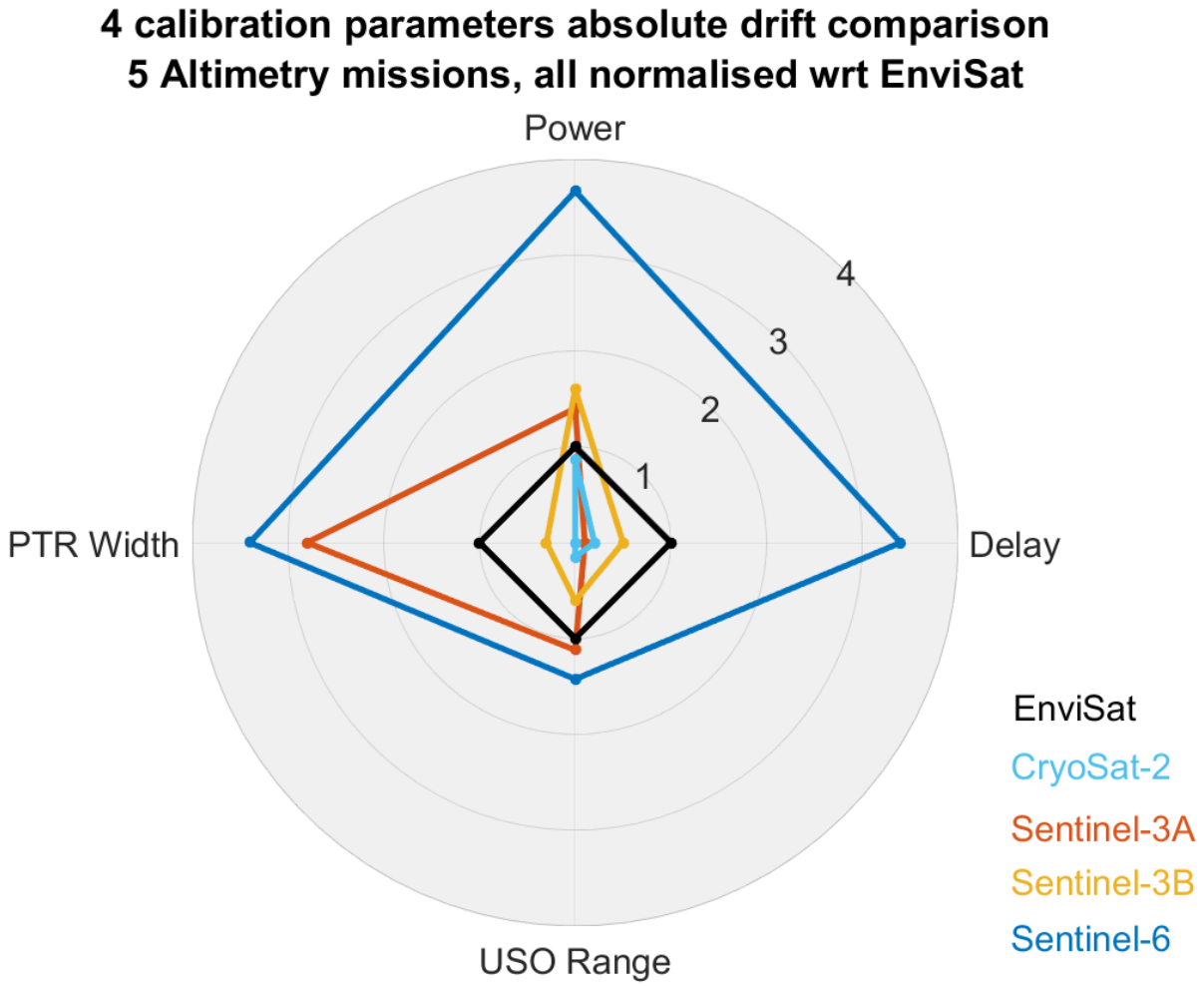


Altimeter instrument behaviour



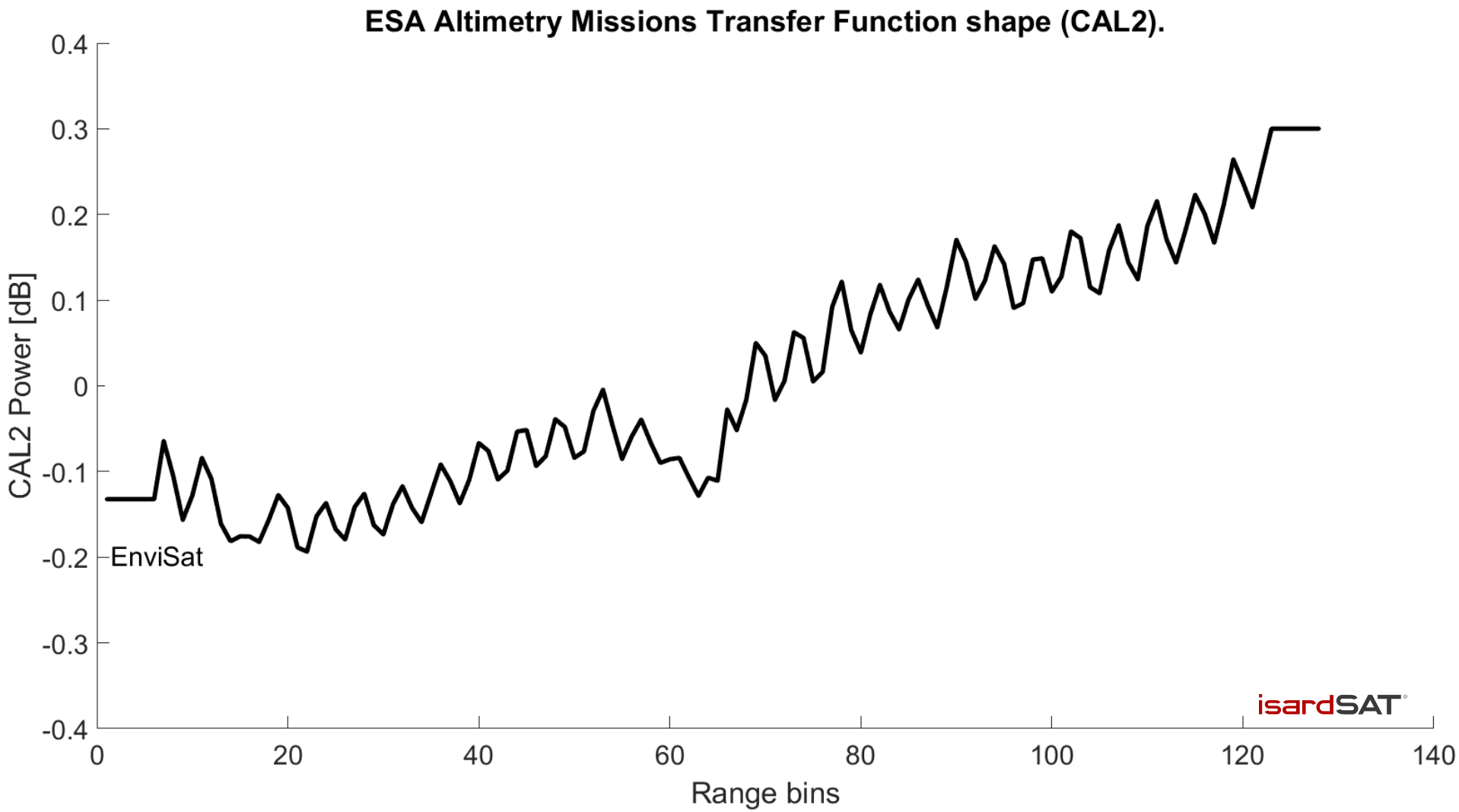
Altimeter instrument behaviour

Summary table with all values presented in the previous figure:

Calibration Parameters Drifts	Delay mm/year	Power dB/year	Width mm/year	USO mm/year
EnviSat	+ 1	– 0.15	+ 0.1	+ 3.3
CryoSat-2*	– 0.2	– 0.13	– 0.00	+ 0.5
Sentinel-3A	– 0.1	– 0.21	– 0.28	+ 3.7
Sentinel-3B	+ 0.5	– 0.24	– 0.03	+ 2.0
Sentinel-6	– 3.4	– 0.55	– 0.34	– 4.7

* Thanks to Aresys (Laura Fioretti) and ESA (Marco Fornari) we have been able to show CryoSat data.

Altimeter instrument behaviour



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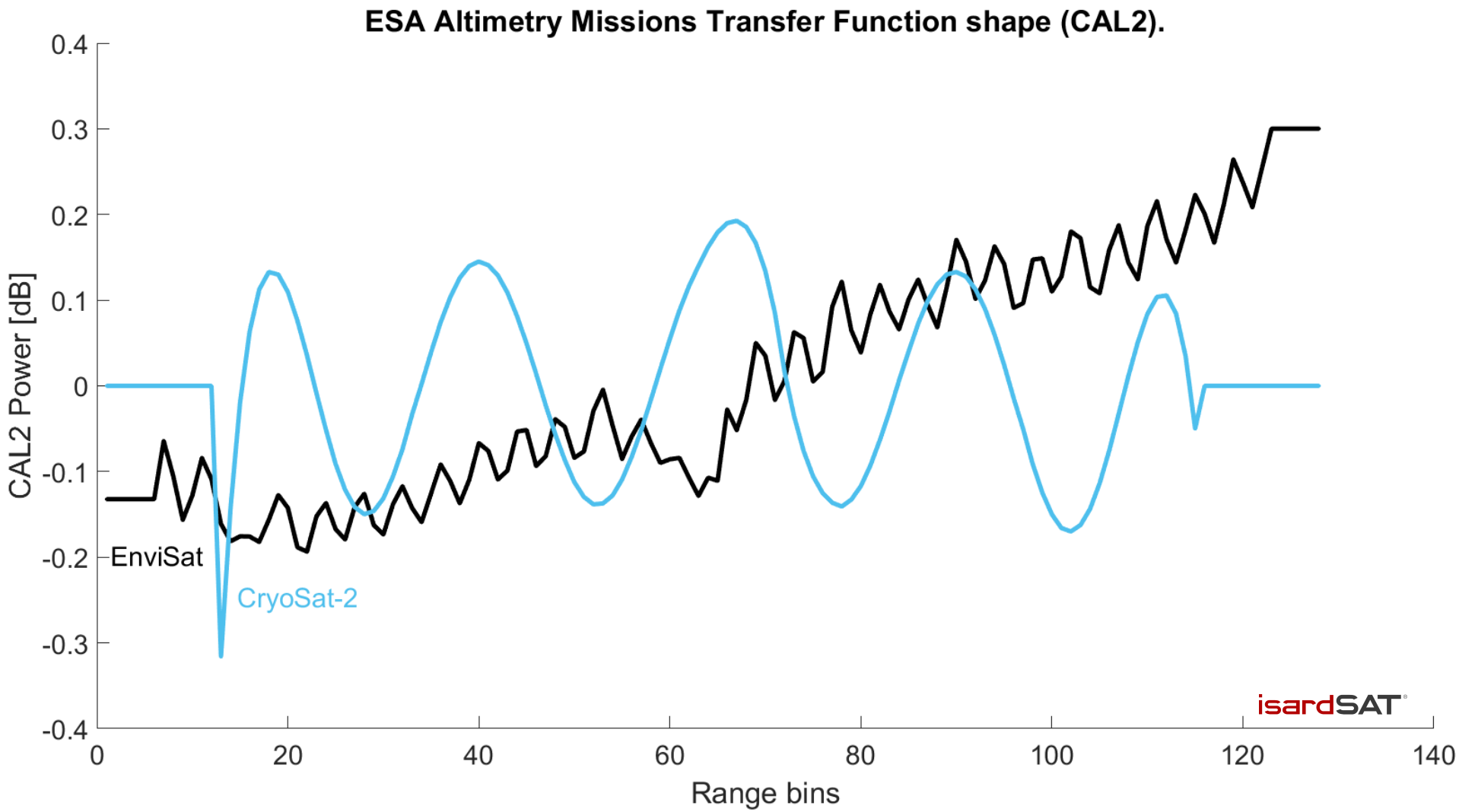

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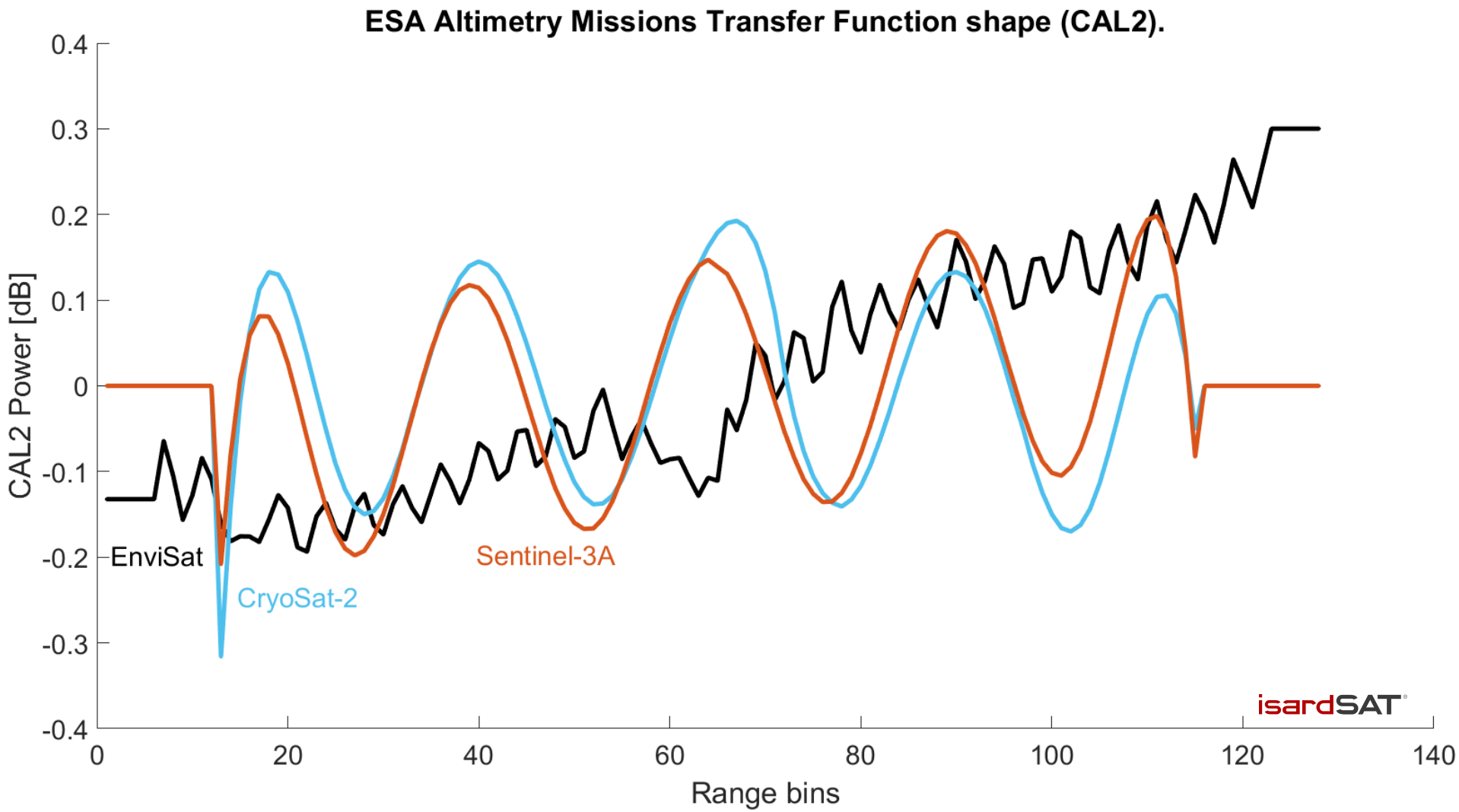

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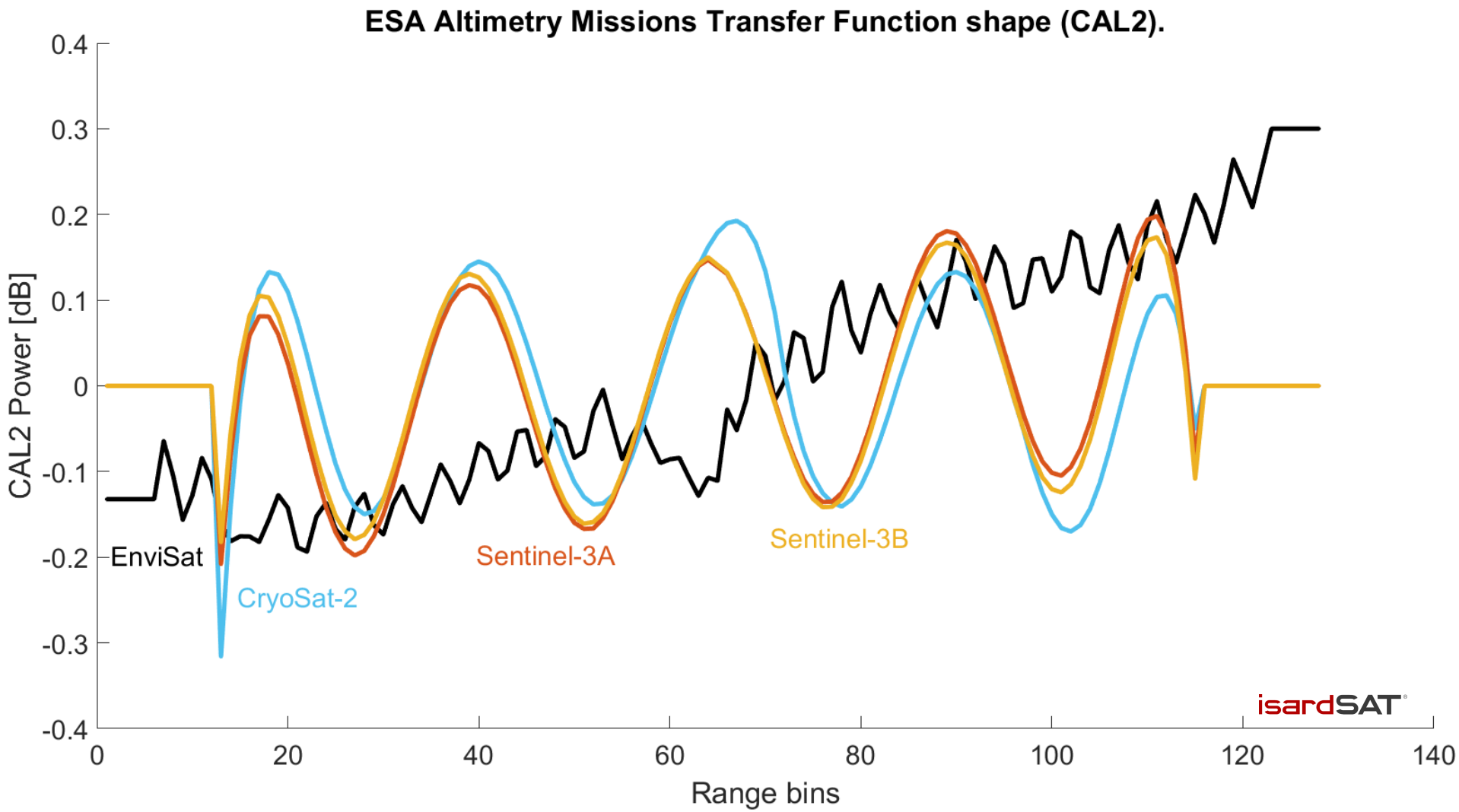

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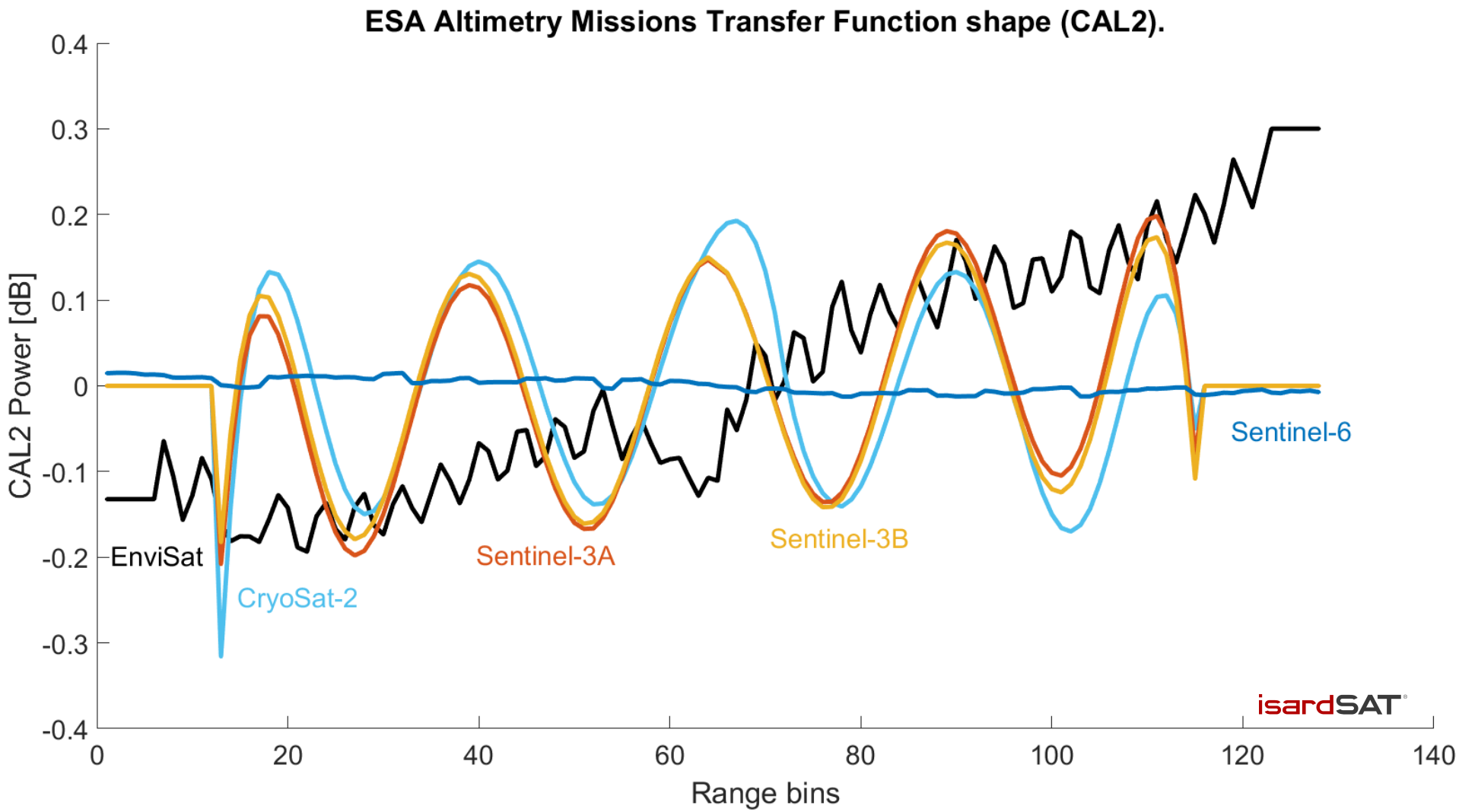
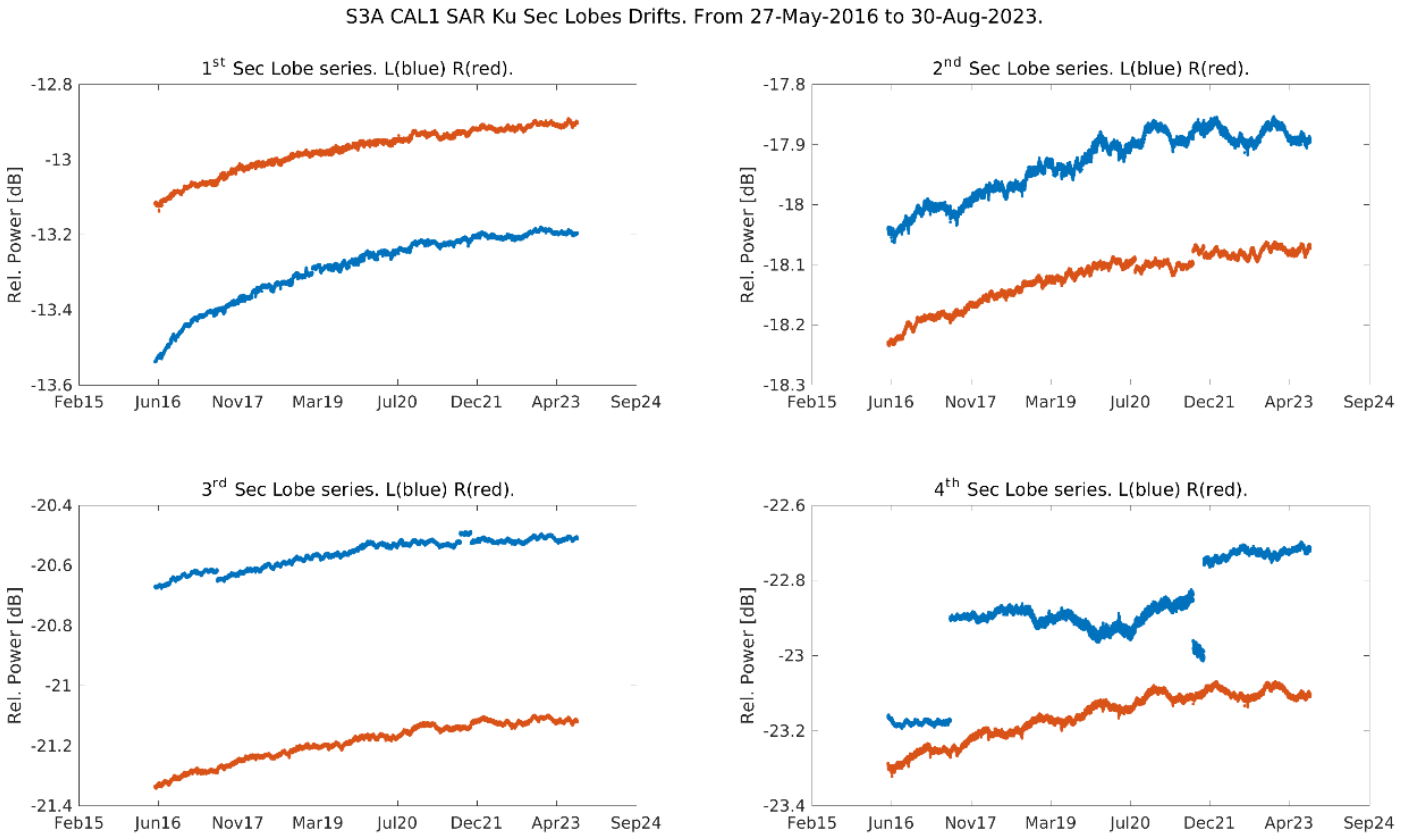


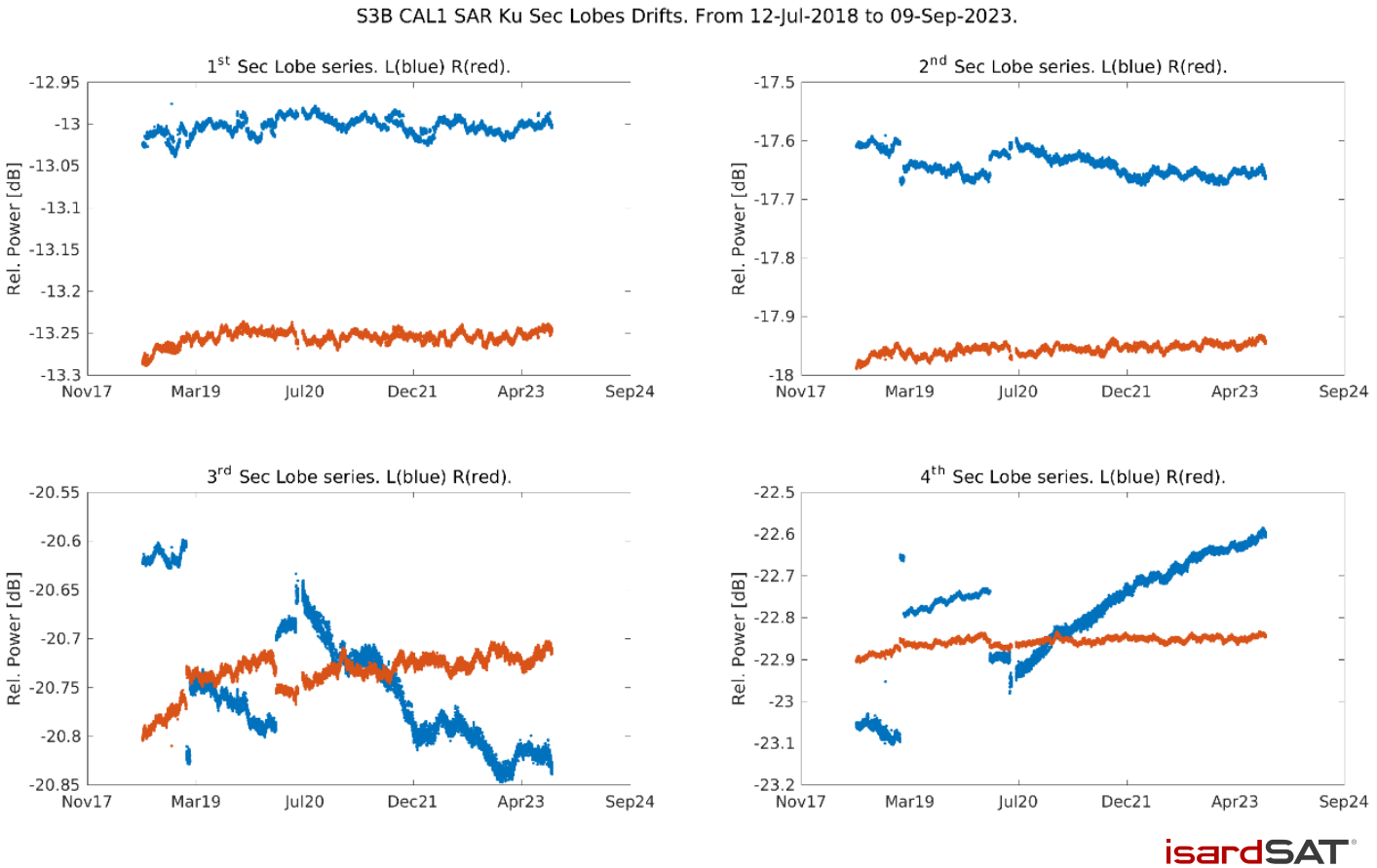
Secondary Lobes Relative Power Progression

S3A



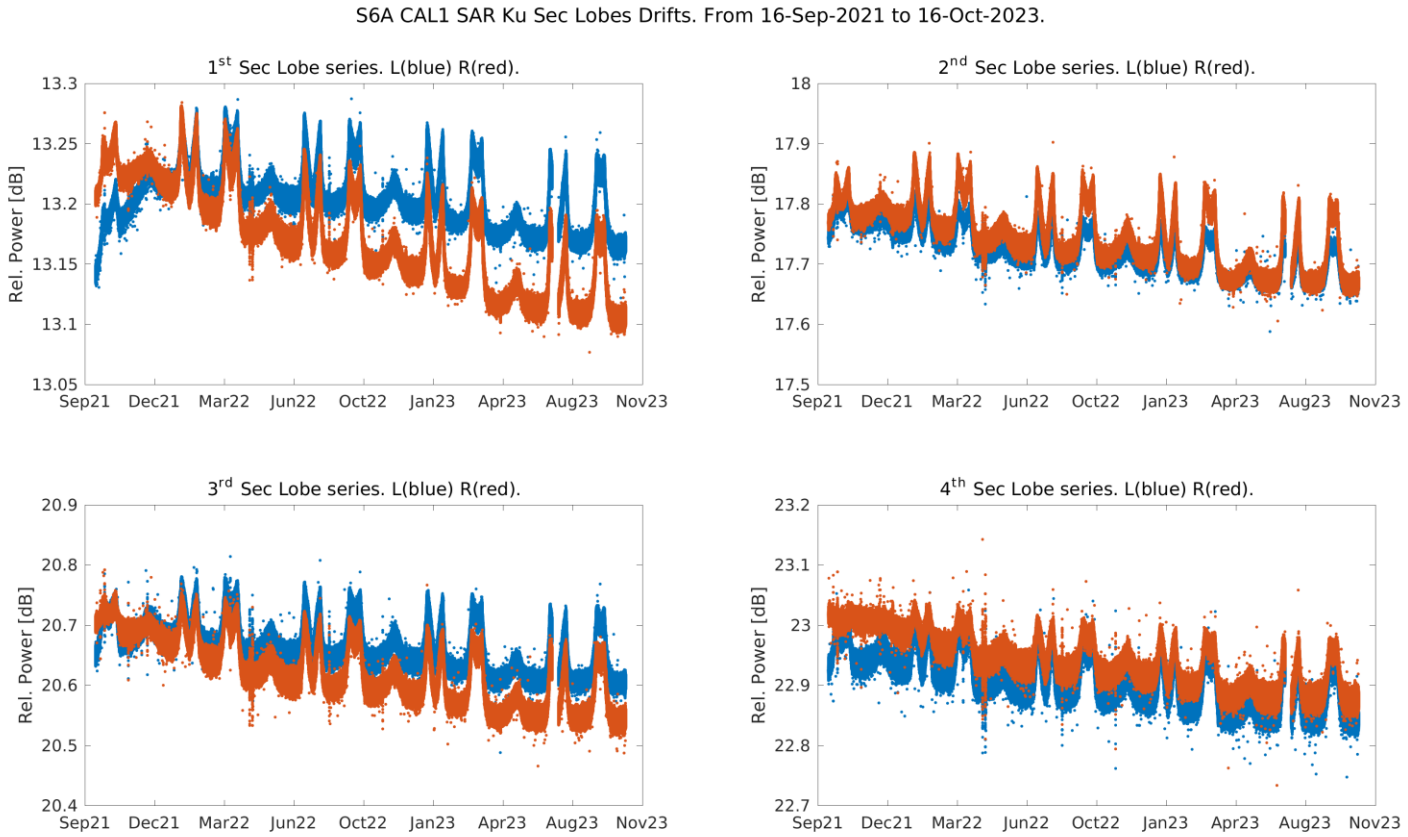
Secondary Lobes Relative Power Progression

S3B



Secondary Lobes Relative Power Progression

S6



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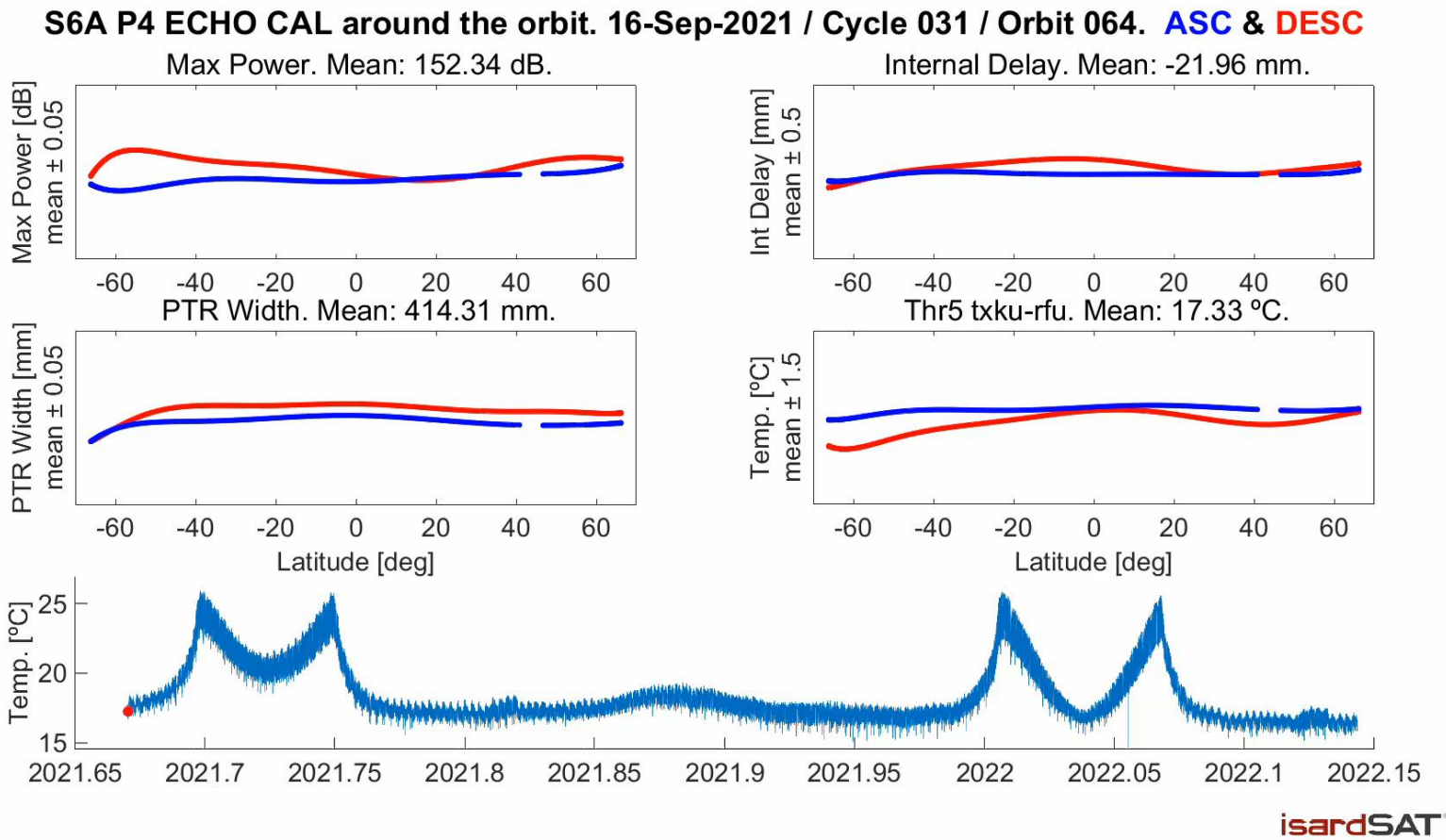
S3 CAL1 Orbital Reconstruction

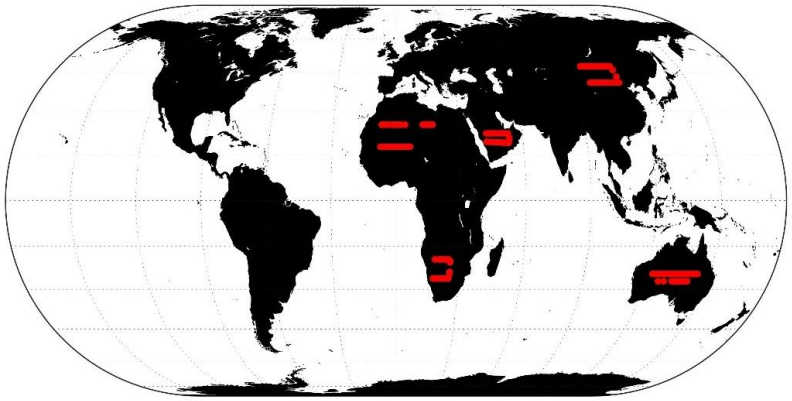


S3 CAL1 Orbital Reconstruction

What about **S3**?

S3 calibration measurements are done over 5 deserts (specific latitudes).

No “around-the-orbit” measurements.



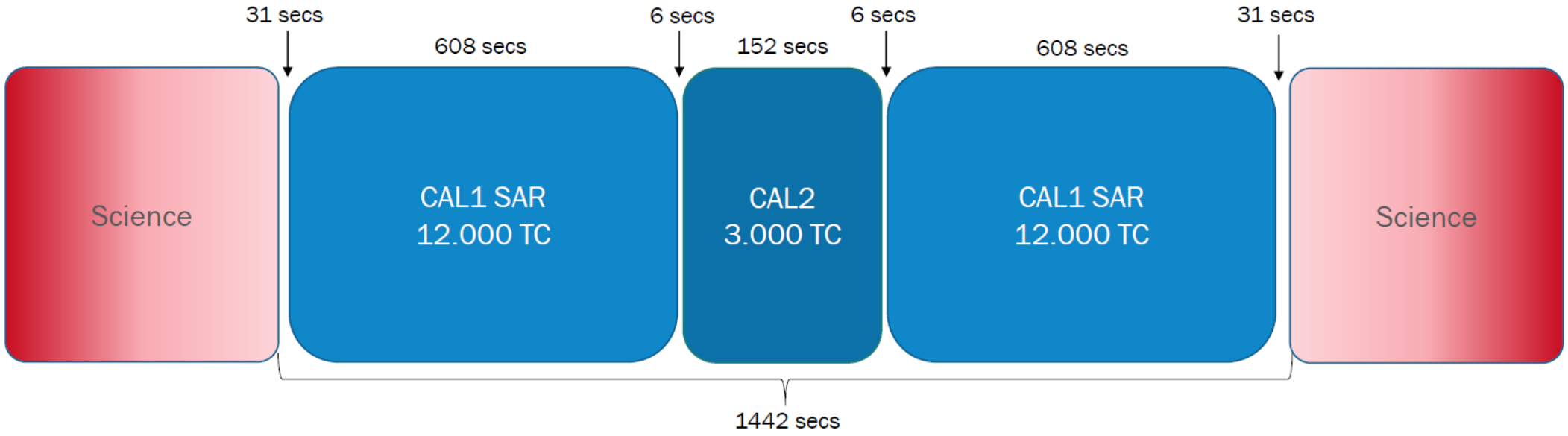
It would be interesting to know the orbital behaviour of the main CAL1 parameters.

Currently, every alternate month, a 24 minutes S3A or S3B **Moon Observation** is performed over non-fixed latitudes, rotating the platform (roll manoeuvre).

This scenario can be used for gathering CAL1 data and, after enough Moon Cal measurements, build an orbital behaviour of CAL1 measurements.

S3 CAL1 Orbital Reconstruction

isardSAT has defined and agreed with the agencies and industry (TAS) a new calibration sequence for doing the reconstruction:



This has been approved and is ready to be implemented by EUMETSAT Ops Team.

During 2024, isardSAT® will start a study for the S3 CAL1 orbital reconstruction.

It will be performed within the S3MPC project, funded by ESA.

Conclusions

- The 3 Copernicus altimeter's instrument behaviour are nominal, with all calibration parameters compliant with mission requirements.
- The different instrumental corrections compensates the science data for the possible drifts and excursions.
- The initial S3 & S6 power drops are now much more stable.
- S6 shows stepper drifts than other missions.
- There are approaches for accounting for the whole CAL1 shape: numerical retracking, complex RIR correction (by Salvatore Dinardo et al., EUMETSAT).

- isardSAT® will develop a solution for the Sentinel-3 calibration orbital reconstruction from Moon Observation measurements, among other studies on CAL1 SAR and CAL2.

Acknowledgements

- The different isardSAT® assessments and studies on calibration measurements here presented have been performed under the following projects:
  - S3MPC (Sentinel-3 Mission Performance Cluster), by ESA
  - COPAS (Copernicus Altimeter Service), by EUMETSAT / EU
  - Sentinel-6 Poseidon-4 Level 1 GPP, by ESA
  - EnviSat RA2 Expert Support Laboratory , by ESA
- aresys has helped providing CryoSat-2 calibration datasets.
- ThalesAlenia Space has contributed with dedicated discussions.

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Research and services provider enterprise in the Earth Observation Field