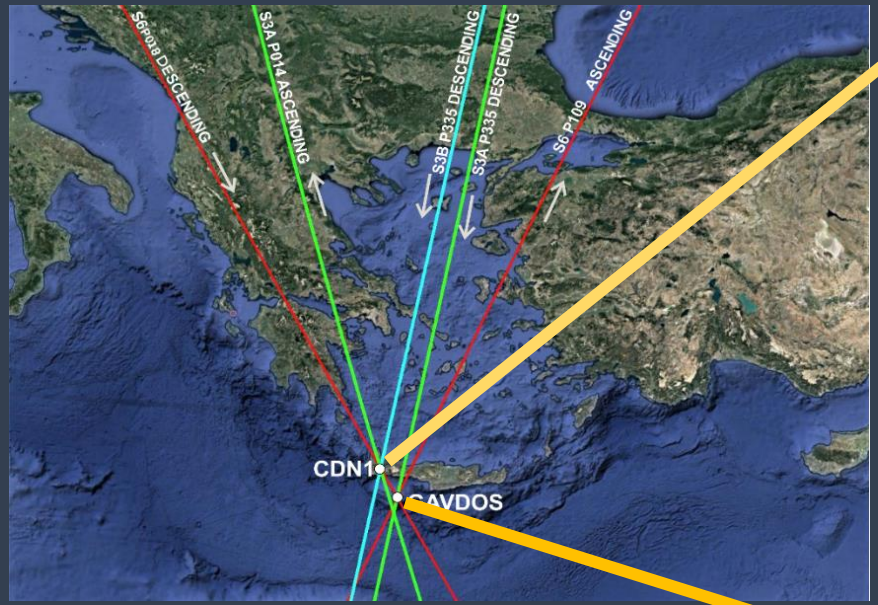
Performance of the CDN1 Transponder & Current Results of the ESA Permanent Facility for Altimetry Calibration in Crete

Stelios Mertikas(1), Craig Donlon(2), Dimitrios Piretzidis(1,3), Costas Kokolakis(1,4), Robert Cullen(2), Pierre Femenias(4), Marco Fornari(5), Francois Boy(6), Berthyl Duesmann(2), Mingsen Lin(7), Yongjun Jia(7), Lei Yang(8), Xenophon Frantzis(1), Achilles Tripolitsiotis(4)

(1) Technical University of Crete, Greece;
(2) ESA/ESTEC, Netherlands;
(3) Space Geomatica, Greece;
(4) ESA/ESRIN, Italy;
(5) RHEA for ESA, Netherlands;
(6) CNES, France;
(7) NSOAS, China;
(8) First Institute of Oceanography, China.

ESA Permanent Facility for Altimetry Calibration

Transponders at ESA PFAC, Crete



Crete (CDN1 Transponder)

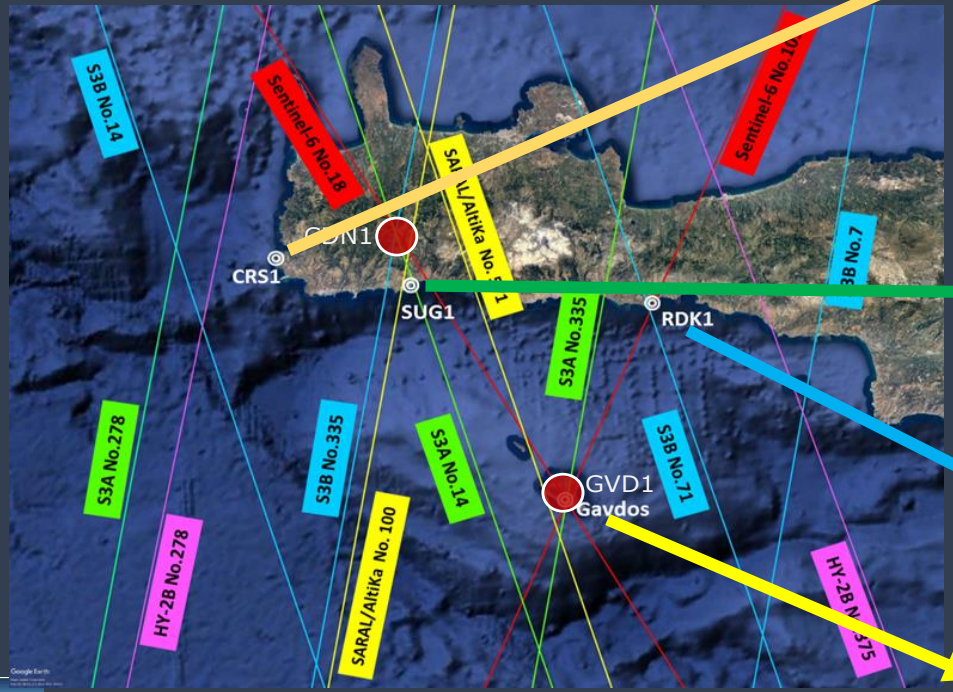
- Multiple Cross-over (S3A, S3B, JA3, S6, AltiKa, SWOT),
- Low clutter,
- Cross-calibration,
- Crystal clear signal of satellites (No interference).

Gavdos (GVD1 Transponder)

S3A, Sentinel-6 (A109 & D18), CryoSat-2
Sea-Surface Cal/Val

ESA Permanent Facility for Altimetry Calibration

Sea-surface infrastructure, Crete

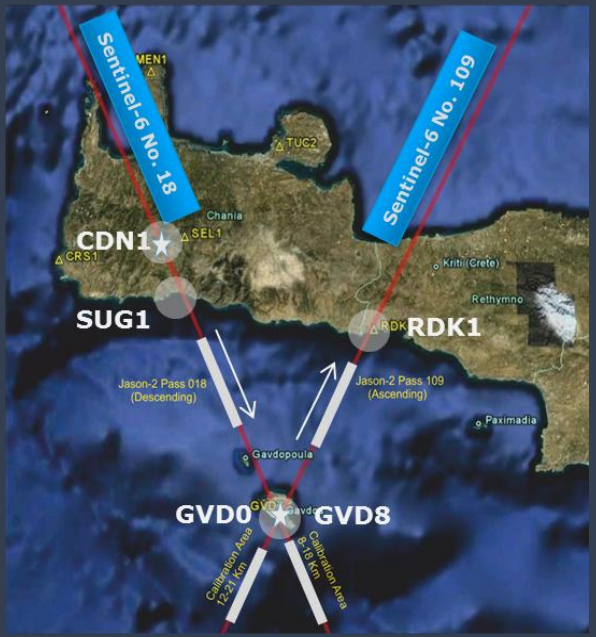


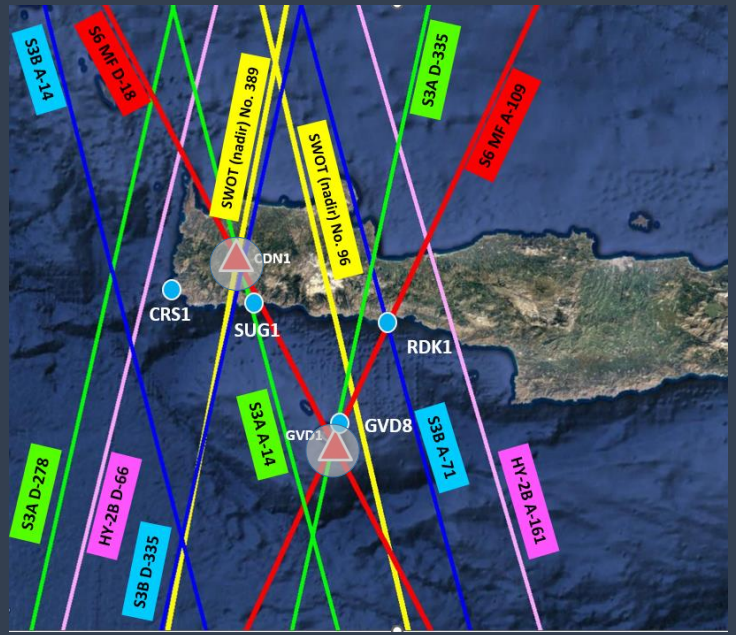
SUG1 Cal/Val site (South Crete)

Gavdos Cal/Val site

RDK1 Cal/Val site (South Crete)

Sentinel-6 Cal/Val: A one-of-kind geometry





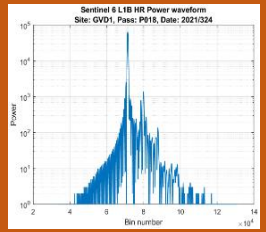
- ✓ **4 sea-surface & 2 transponder Cal/Val sites,**
- ✓ **Crossovers with S3A, S3B, JA3, S6, CryoSat-2, AltiKa, SWOT,**
- ✓ **Redundant, Confident results, Directional errors.**

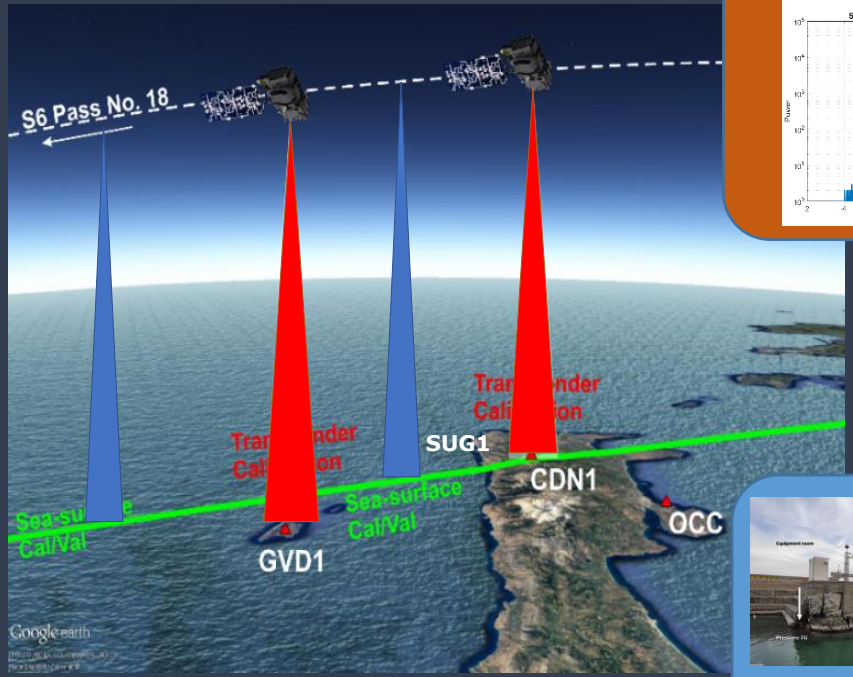
Simultaneous Transponder & Sea-Surface Cal/Val

GeoMatLab

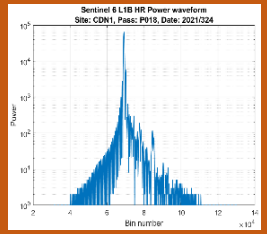
esa
European Space Agency

GVD1 Transponder

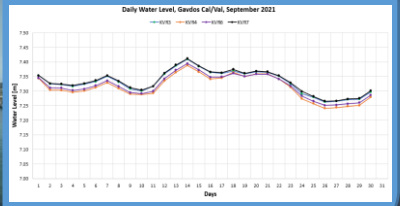




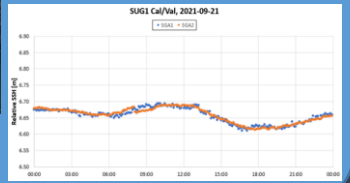
CDN1 Transponder



Gavdos sea-surface



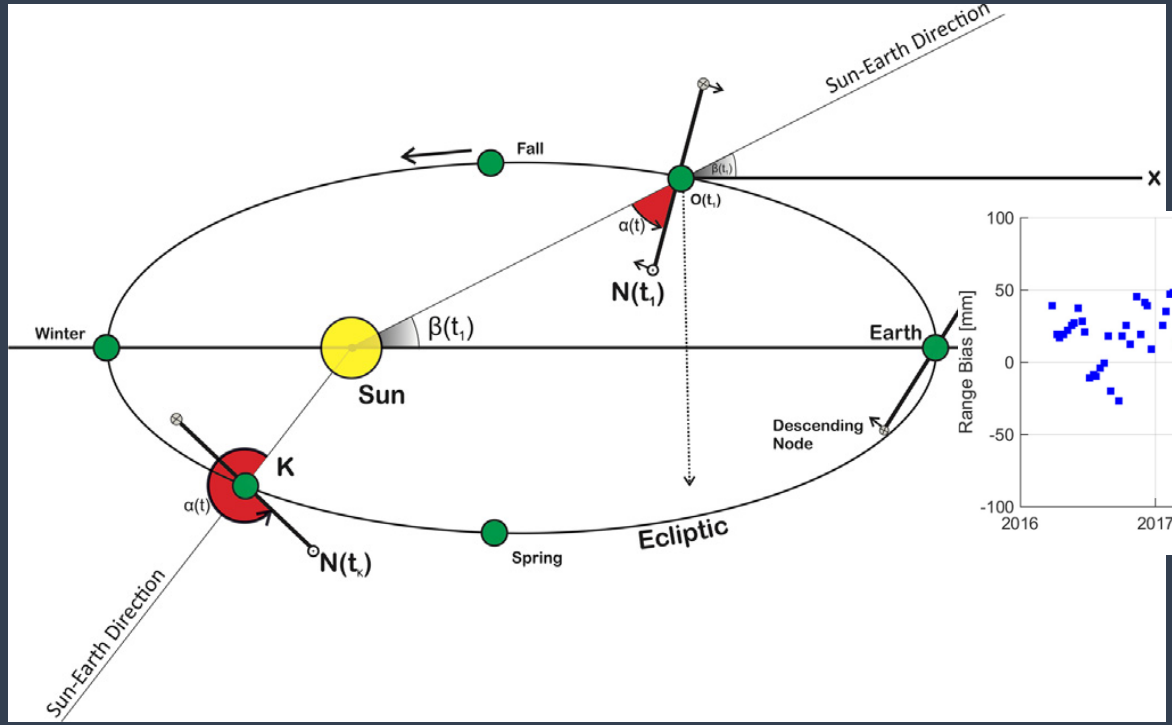
SUG1 sea-surface

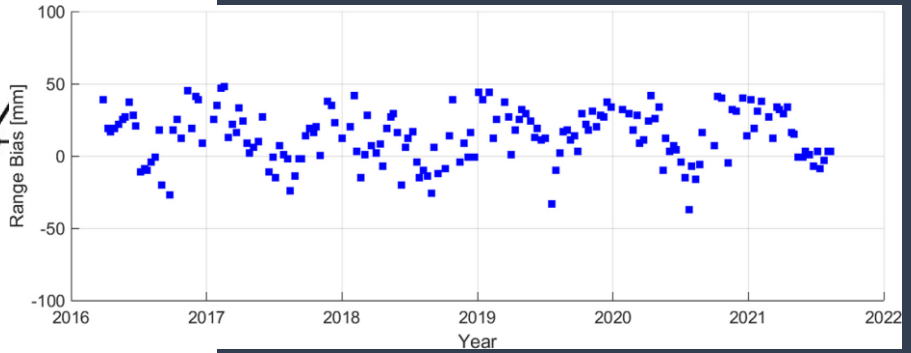


Space Geomatics P.C.

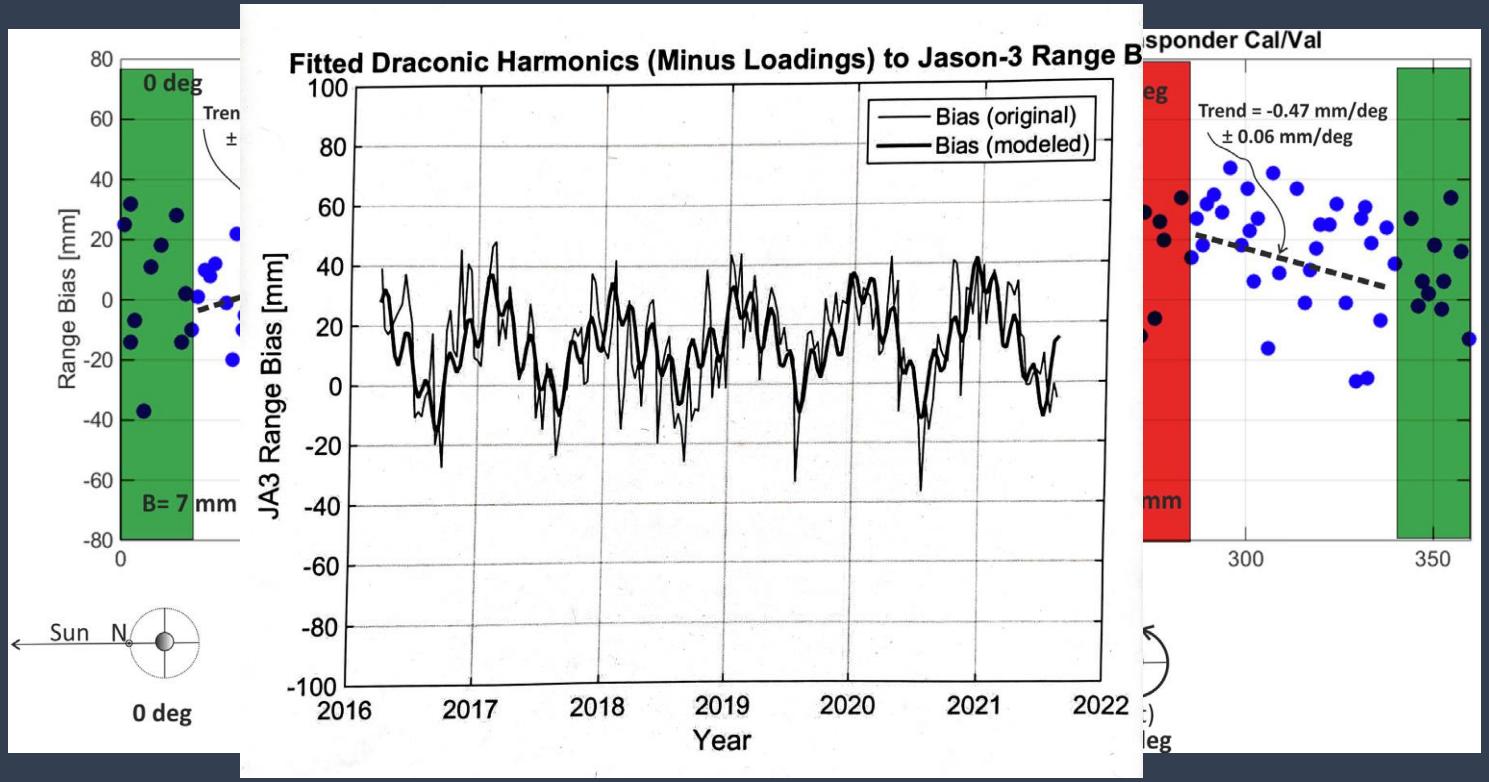
ESA Permanent Facility for Altimetry Calibration

Tandem of JA3 & S6 Over CDN1 Transponder

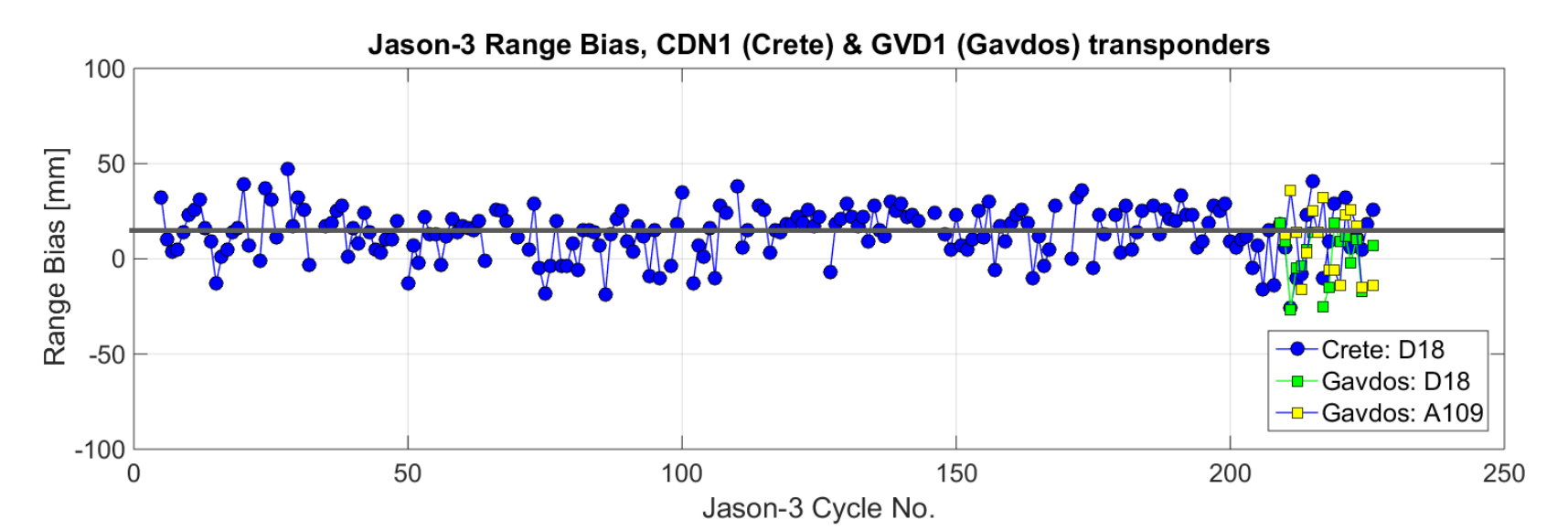




Tandem of JA3 & S6 Over CDN1 Transponder

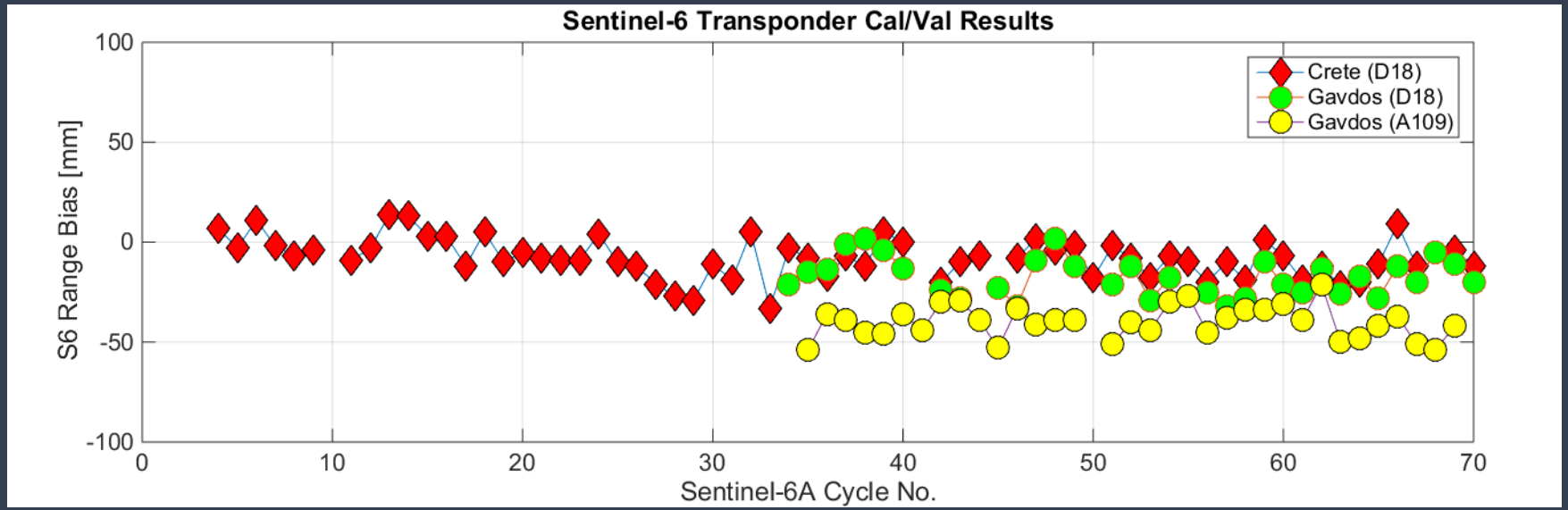


CDN1 Transponder Cal/Val: Jason-3



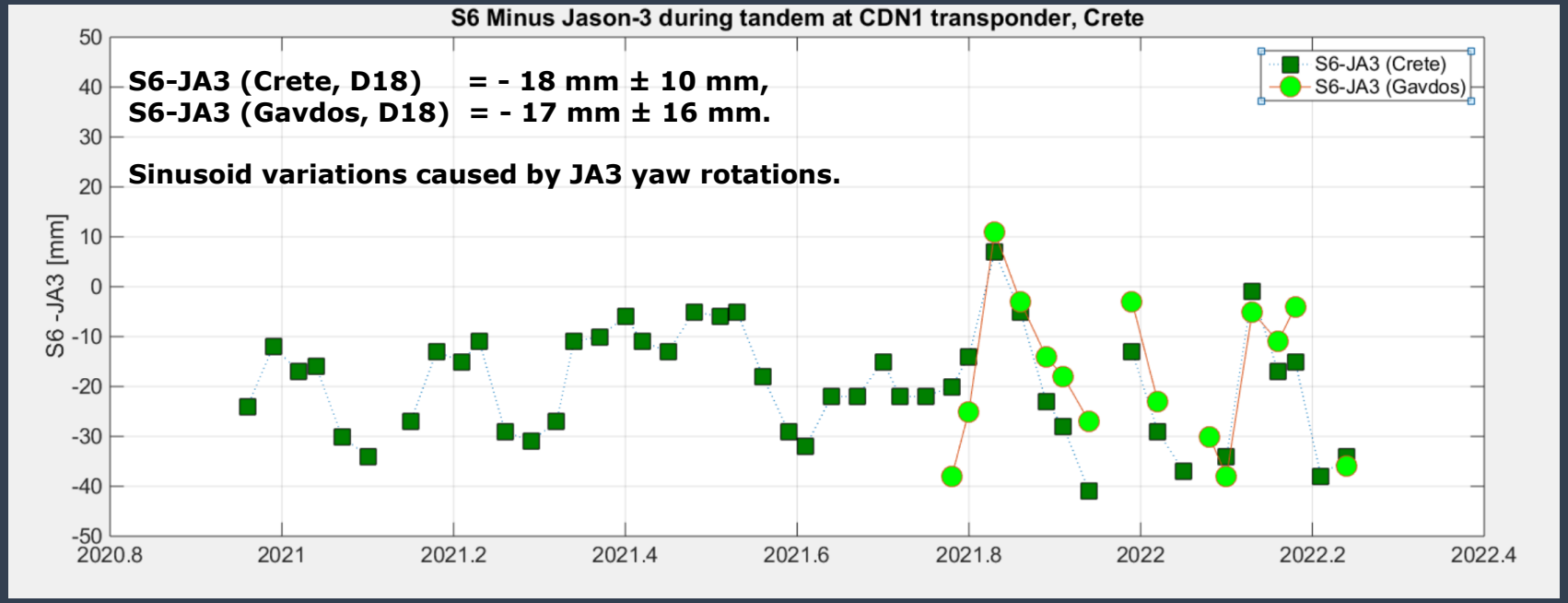
- Crete (D18): Range Bias = + 14 mm ± 1 mm, D18, GDR-F, Cycles 5-226,
- Gavdos (D18): Range Bias = +2 mm ± 4 mm, D18, GDR-F, Cycles 209-226,
- Gavdos (A109): Range Bias = +8 mm ± 5 mm, A109, GDR-F, Cycles 209-226.

Crete & Gavdos Transponder Cal/Val: Sentinel-6

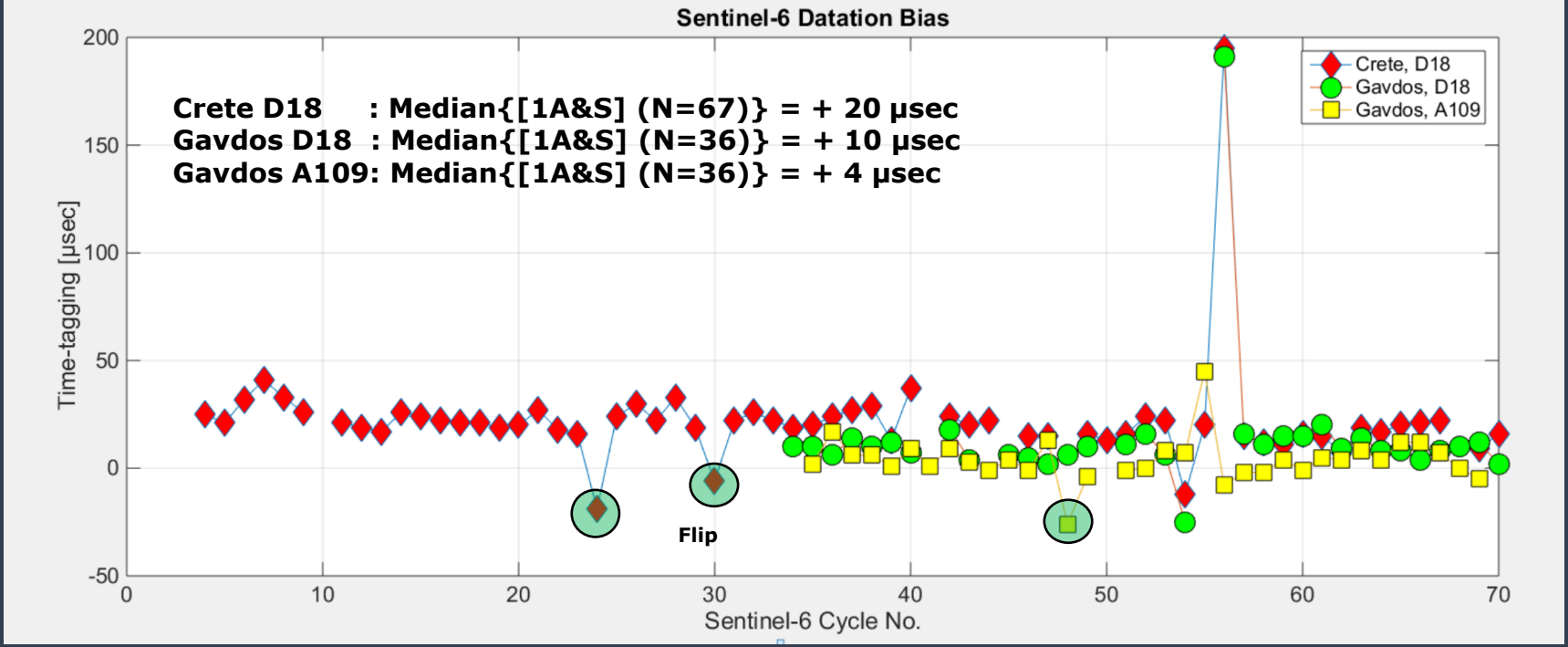


- Crete (D18): Range Bias = - 7 mm ± 1 mm, D18, NTC, POE, Cycles 4-70,
- Gavdos (D18): Range Bias = -10 mm ± 4 mm, D18, NTC, POE, Cycles 34-70,
- Gavdos (A109): Range Bias = -40 mm ± 5 mm, A109, NTC, POE, Cycles 34-69.

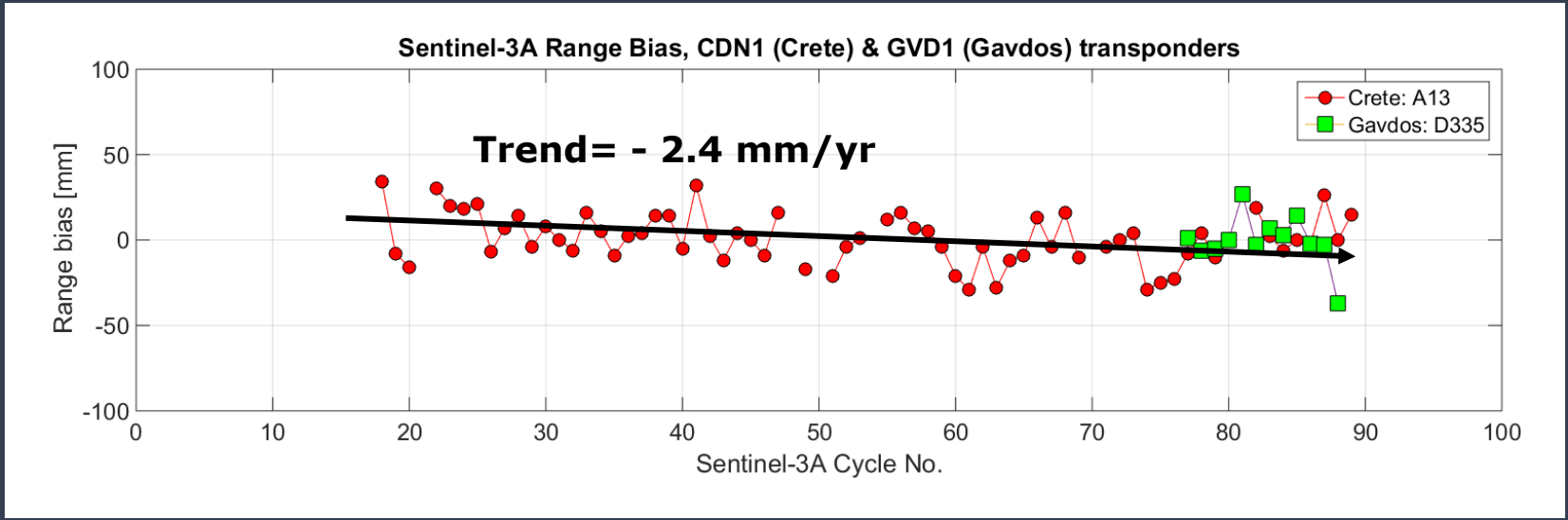
Difference in Range Bias [S6-MF minus Jason-3]



Sentinel-6 MF Time Tagging Bias

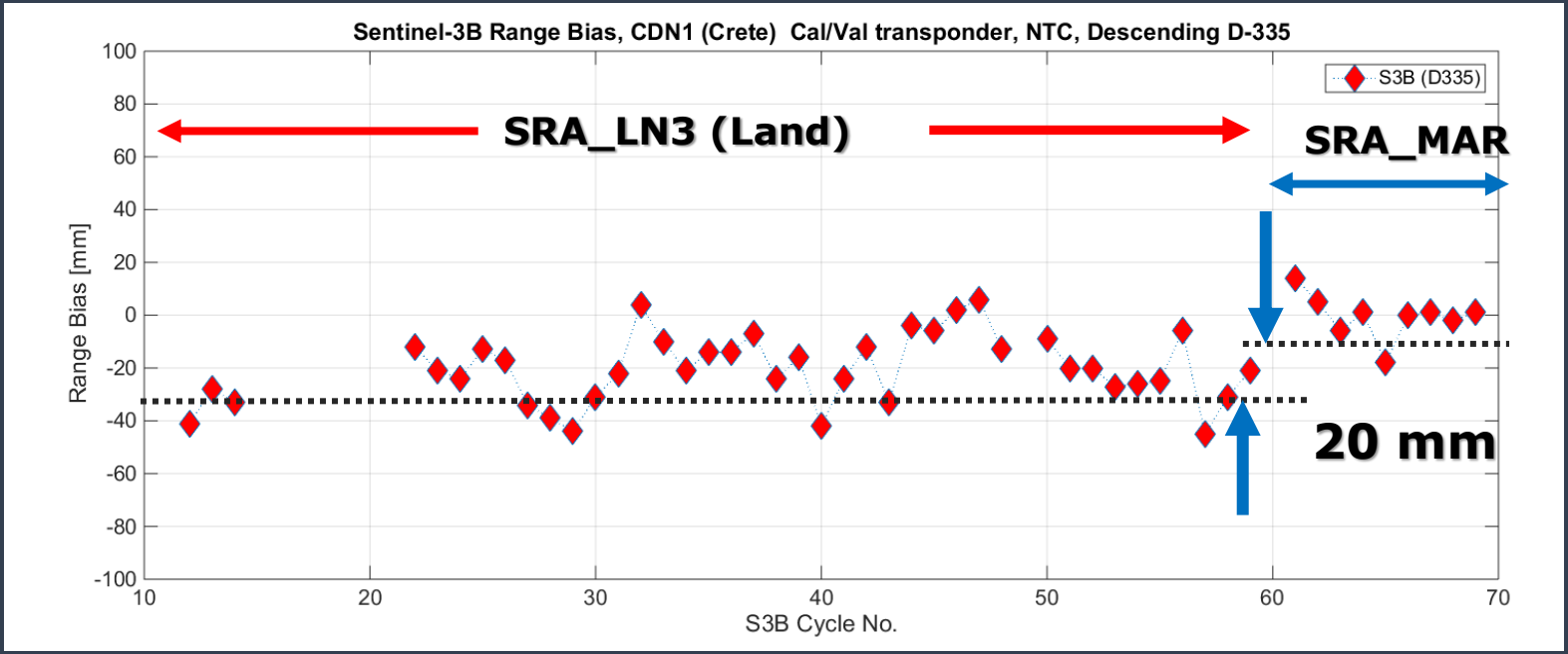


Sentinel-3A Transponder Cal/Val Results



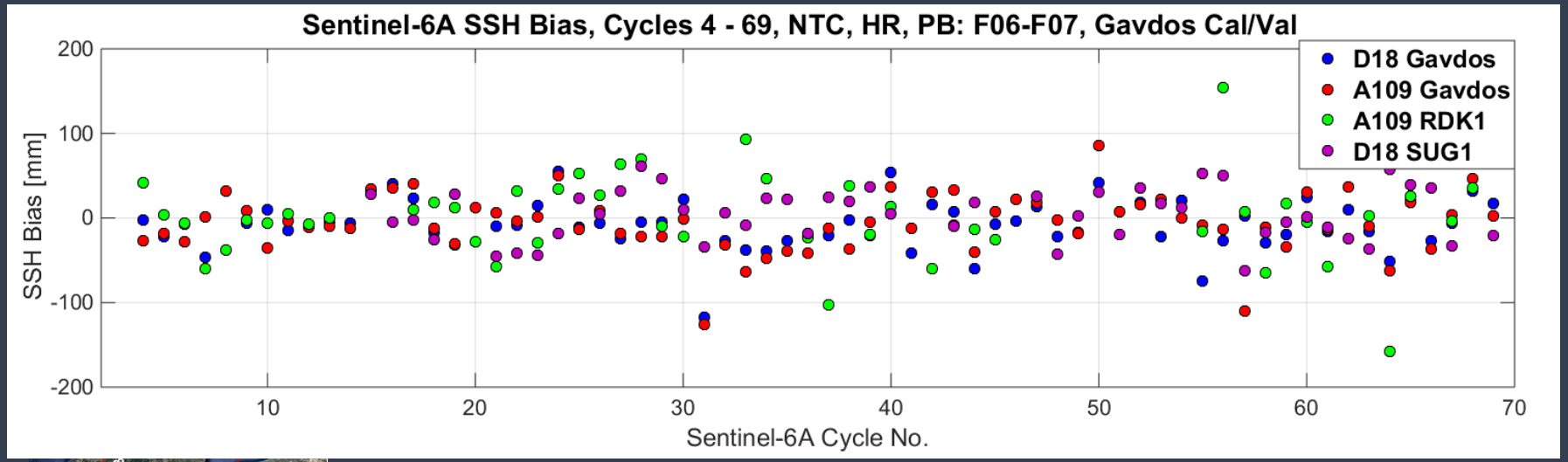
- Crete (CDN1): Range Bias = + 1 mm ± 3 mm, A13, NTC, Cycles 18-89,
- Gavdos (GVD1): Range Bias = +0.3 mm ± 3 mm, D335, NTC, Cycles 77-88.

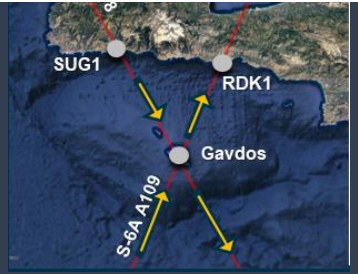
Sentinel-3B Transponder Cal/Val Results



- Crete (CDN1): Range Bias = - 20 mm ± 3 mm, D335, NTC, Cycles 11-59,
- Crete (CDN1): Range Bias = 0 mm ± 3 mm, D335, NTC, Cycles 61-69.

Sentinel-6 MF, Sea-Surface Cal/Val Results





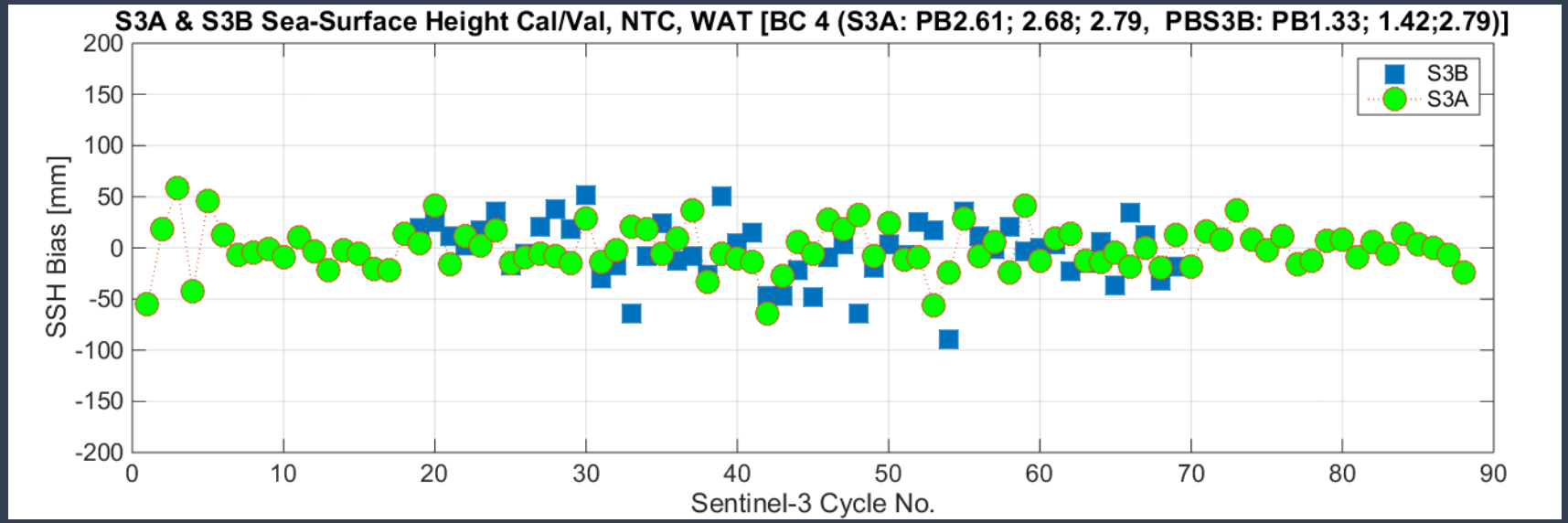
GVD (D018): -8 mm ± 4 mm

GVD (A109): -4 mm ± 5 mm

RDK (A109): +1 mm ± 7 mm, **Overall Mean = -3 mm**

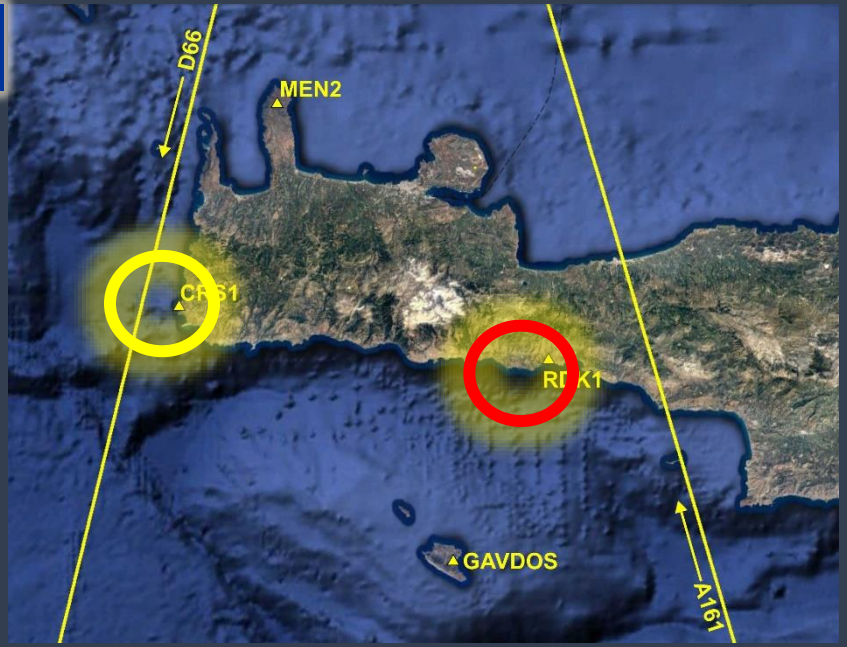
SUG (D018): +3 mm ± 5 mm

Sentinel-3A& S3B Sea-Surface Height Cal/Val

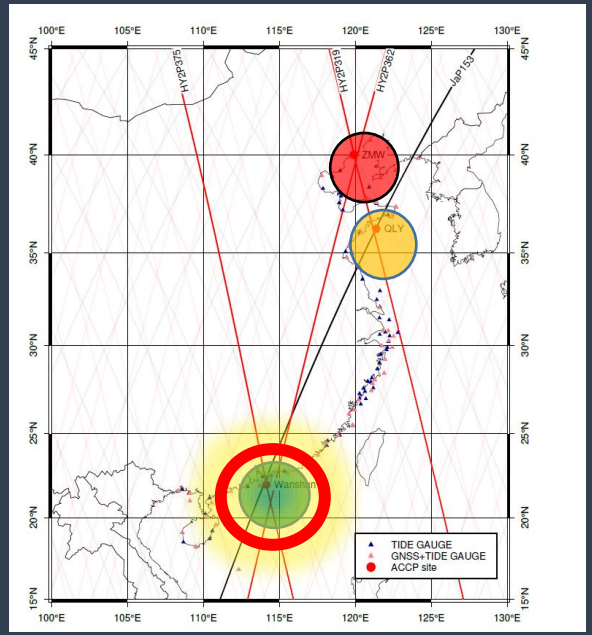


S3A SSH Bias = -1 mm ± 3 mm (FRM ± 3 cm)
S3B SSH Bias = -3 mm ± 5 mm (FRM ± 3 cm)

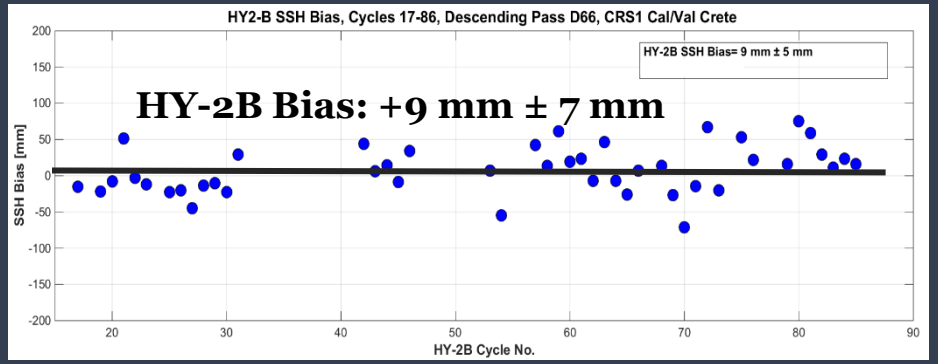
HY-2B & -2C SSH Cal/Val (Crete, China)

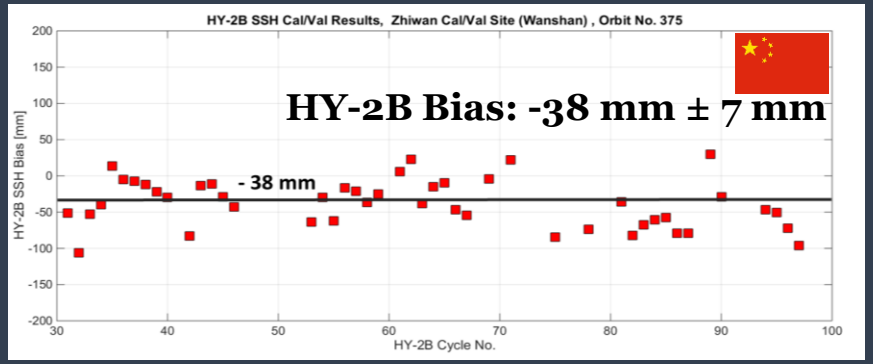


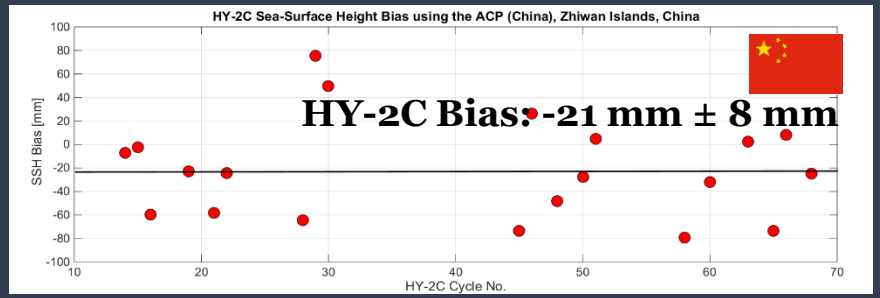
Wanshan Islands

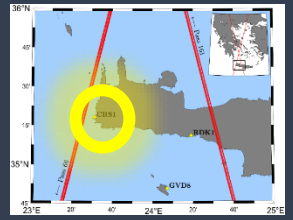


HY-2B & -2C SSH Cal/Val (Crete, China)









Transponder Working Group Setup

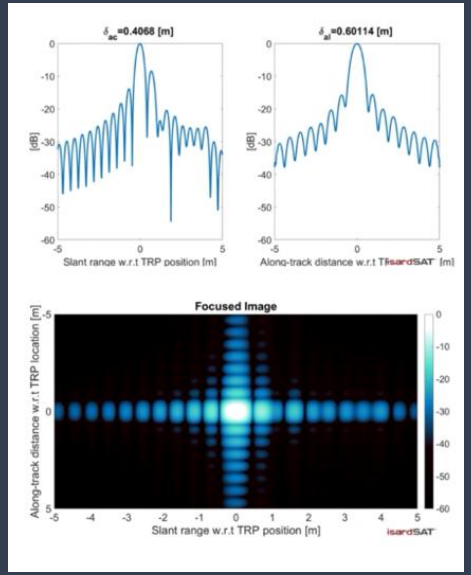
- **To evaluate Cal/Val Results collectively for Sentinel-6,**
- **Puts into Action the FRM Strategy for objective results,**
- **Short time and Effective teamwork,**
- **25 Meetings till today,**
- **Dedicated FTP site for ease communication & Results,**

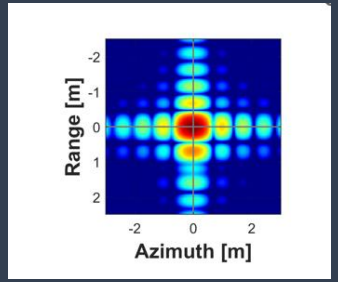
Led by ESA/ESTEC [Craig Donlon, Marco Fornari]:

- Technical University of Crete, Space Geomatica, Greece;
- IsardSAT, Catalonia;
- ARESYS, Italy;
- CLS & CNES, France;
- Eumetsat;
- NOAA, USA;
- JPL, USA.

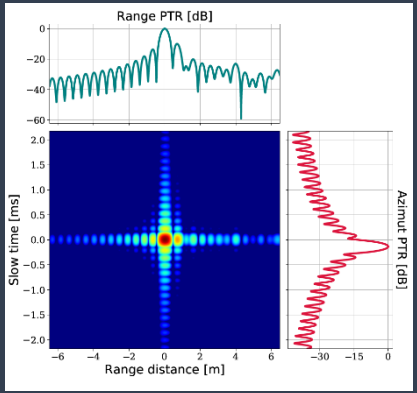
Transponder Working Group

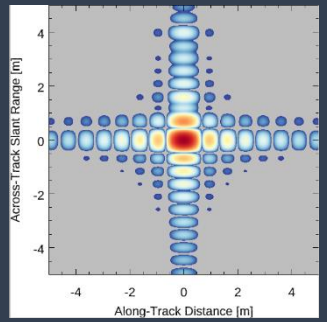
isardSAT





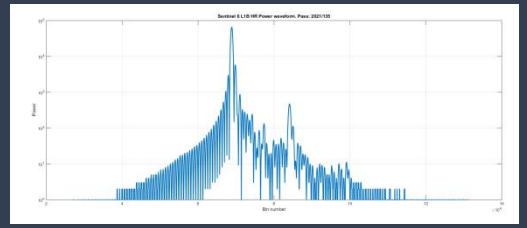
Aresys

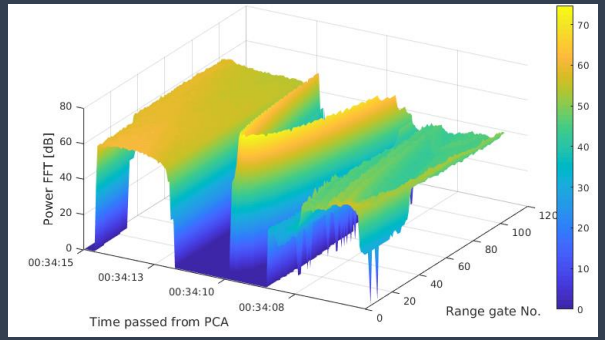




NOAA

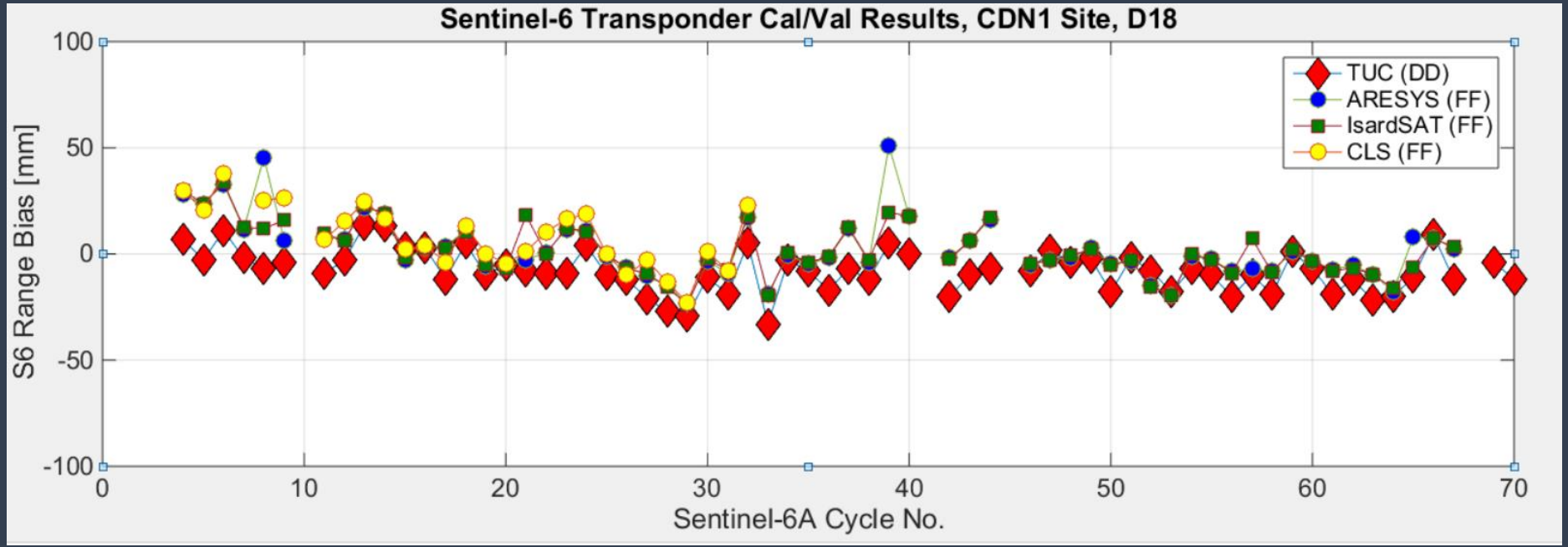
TUC/Space Geomatica



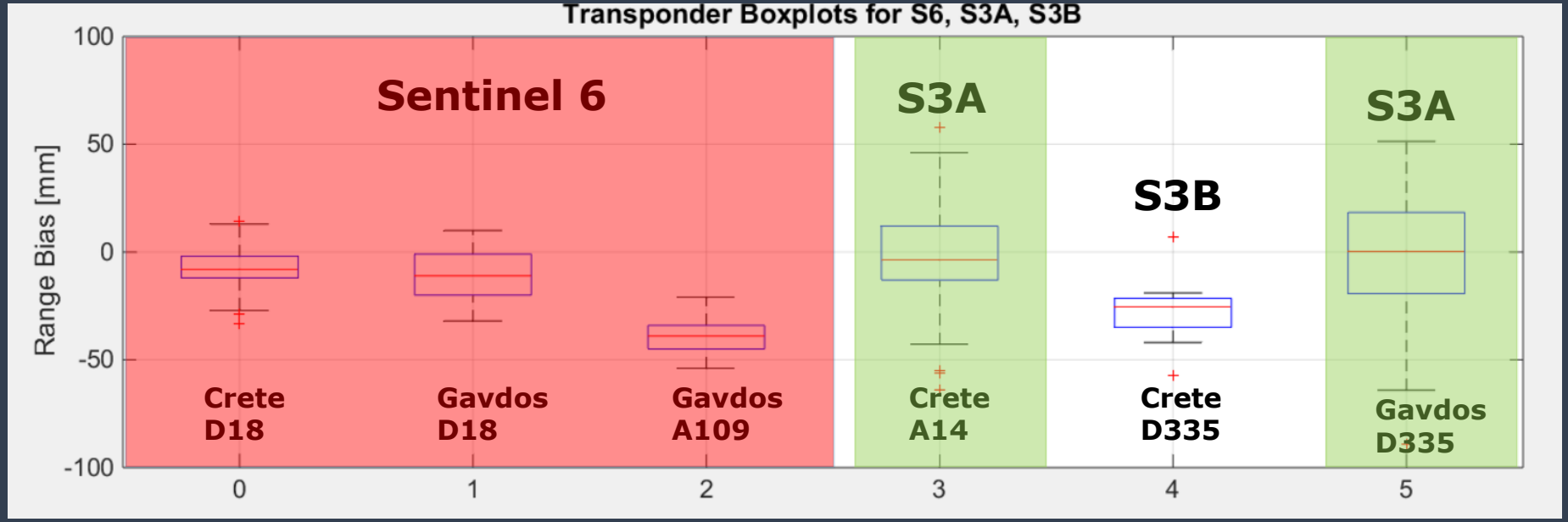


CNES/CLS

TPX- Range Bias @ CDN1 Transponder



Transponder Range Bias for S6, S3A, S3B



Concluding Remarks

ESA Permanent Facility for Altimetry Calibration:

- Transponder & Sea-Surface Ground infrastructure,
- Diverse Instrumentation, Settings & Processing,
- Ascending & Descending orbits (Directional Errors),
- Different satellites & Results are cross-examined,
- Reliability & confidence on results has been built up;
- Patterns & structures in transponder results understood;
- Data & Results are screened for their quality, daily and monthly;
- Connect ground reference to absolute time;
- Uncertainty Budget in FRM Standards.

Acknowledgments

FRM4S6 & S3MPC