



Performance assessment of the Gavdos DORIS station in support of satellite altimetry precise orbit determination and absolute positioning

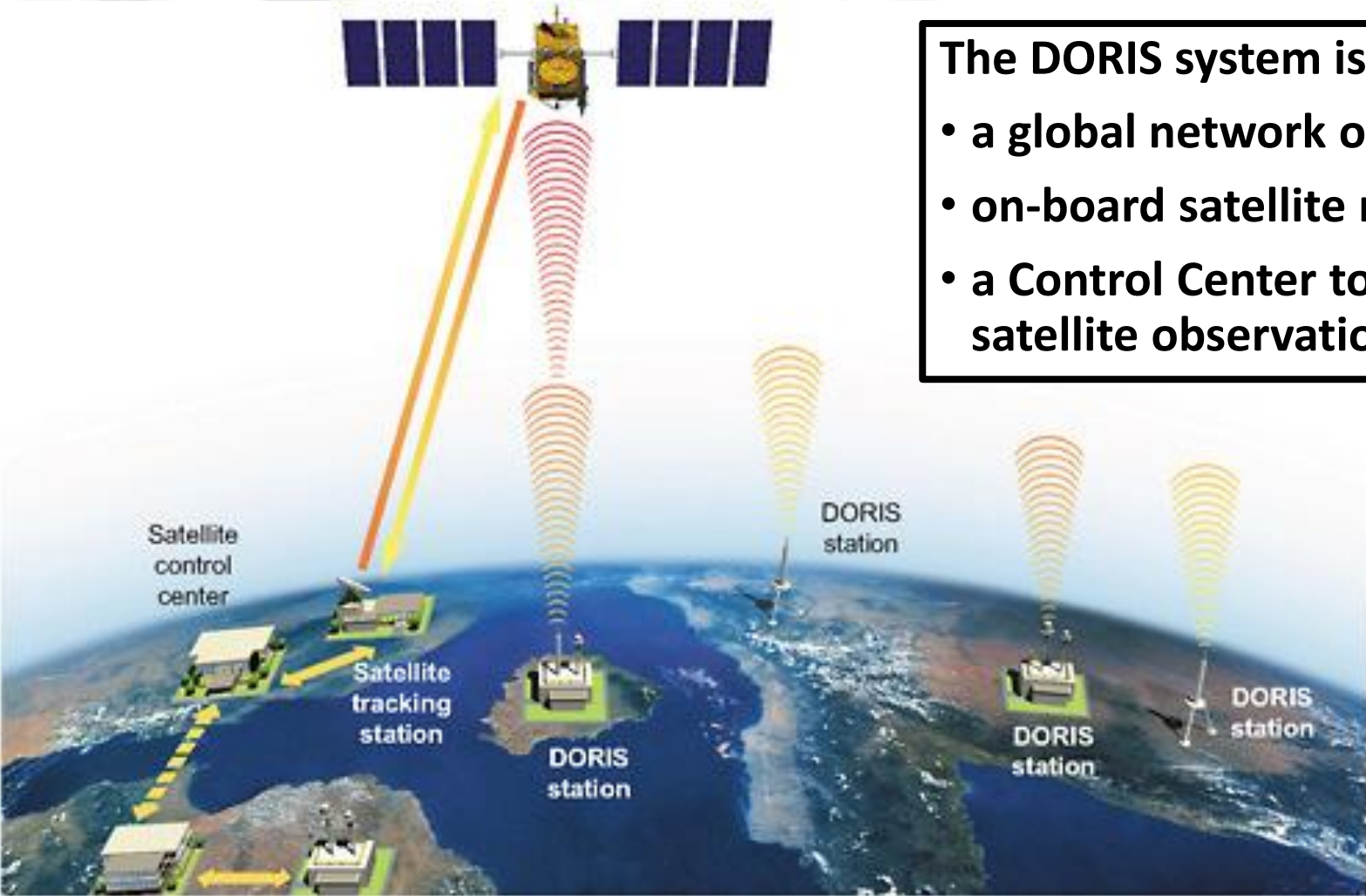
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- 5) Technical University of Crete (TUC), Greece



The DORIS System

Doppler Orbitography and Radiopositioning Integrated by Satellite



The diagram illustrates the DORIS system architecture. A satellite is shown in orbit above the Earth. On the ground, there is a satellite control center and a satellite tracking station. Several DORIS stations are also shown on the ground. The satellite is shown transmitting signals to the ground stations, and the ground stations are shown receiving signals from the satellite. The diagram also shows the satellite receiving signals from the ground stations. The diagram is a 3D rendering with a blue sky and a green Earth.

The DORIS system is composed of :

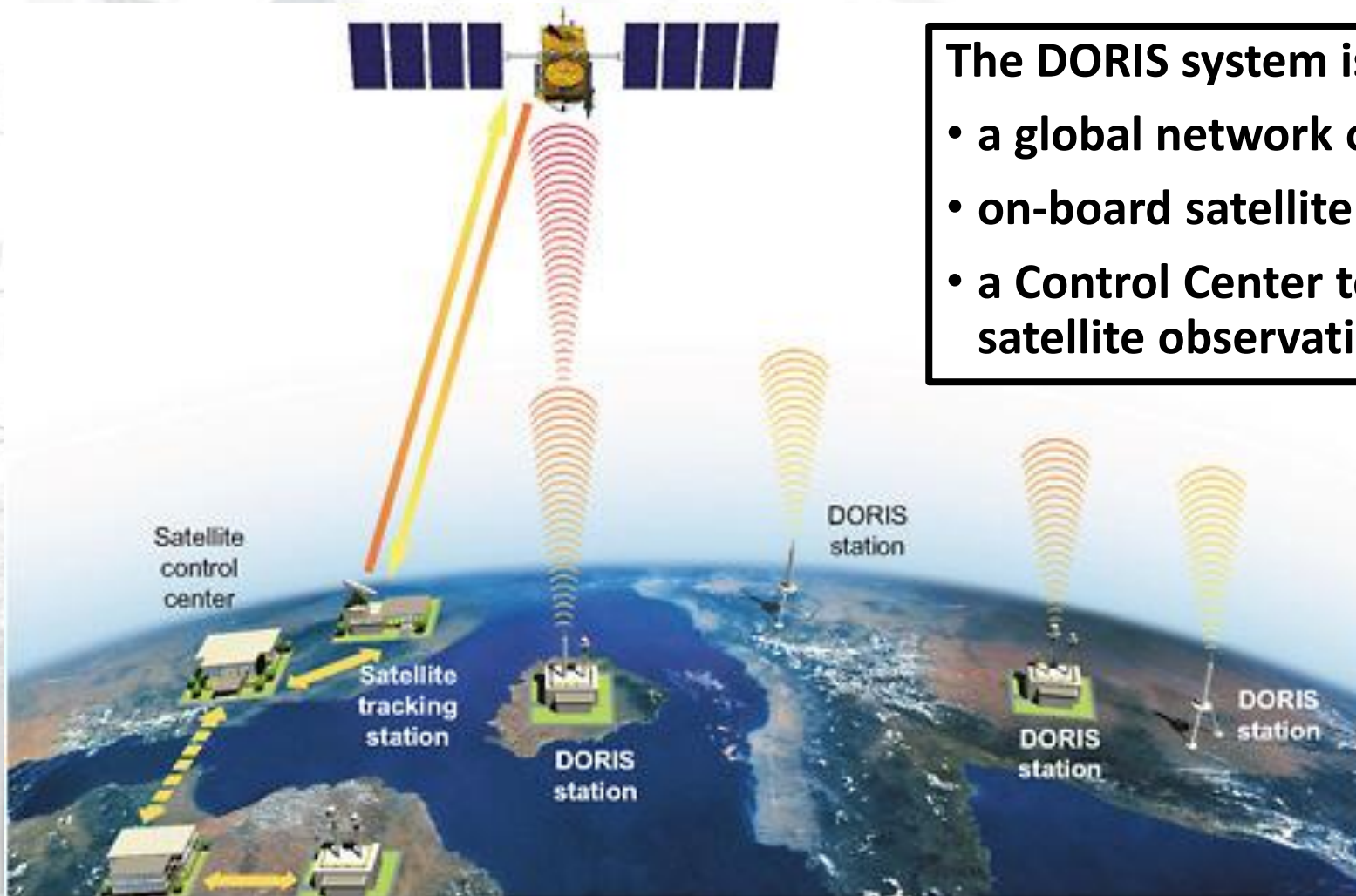
- a global network of emitting stations,
- on-board satellite receivers,
- a Control Center to receive the DORIS satellite observations.

DORIS was developed by CNES and IGN and has been in operation since 1990

2nd International Review Workshop on Satellite Altimetry Cal/Val & Metrology – Chania – 2025/09/25

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The DORIS Technique

Based upon the accurate measurement of the Doppler shift of radio frequency signals

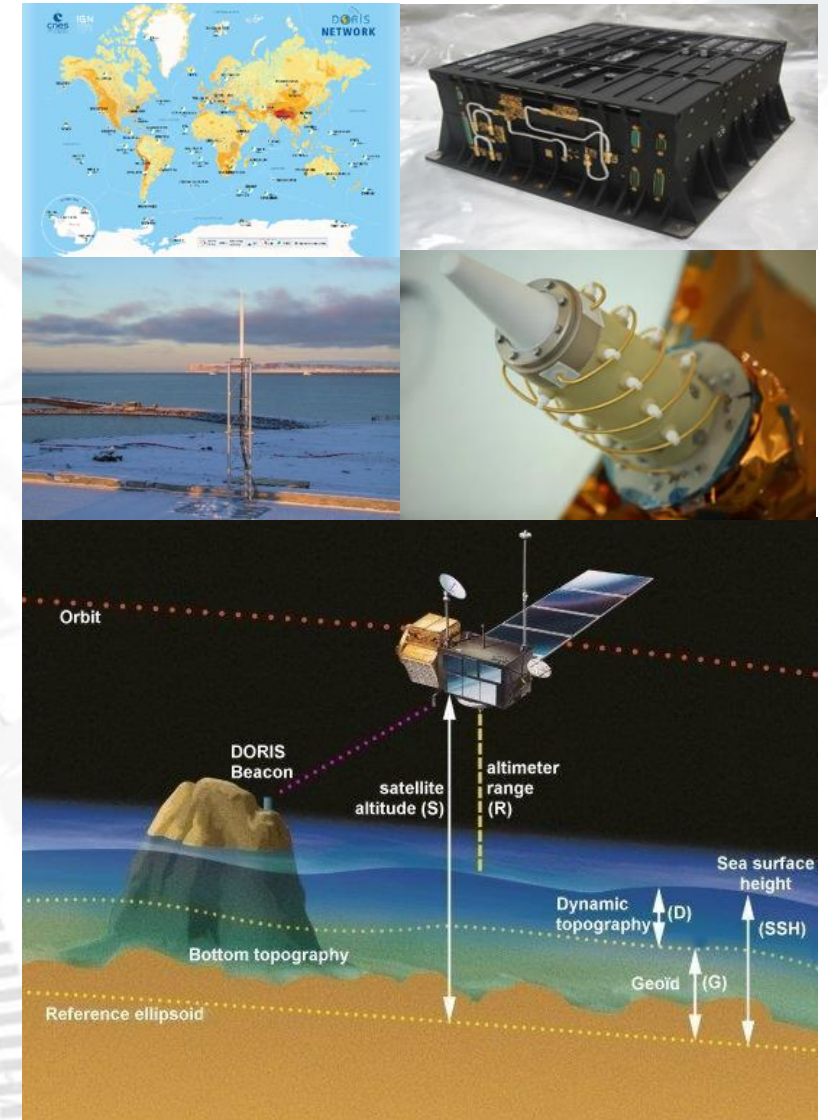
- transmitted from ground beacons and,
- received on board the spacecraft.

Every 10 seconds, the DORIS receiver measures the Doppler shift in the frequency of the radio signals transmitted by the ground beacons.

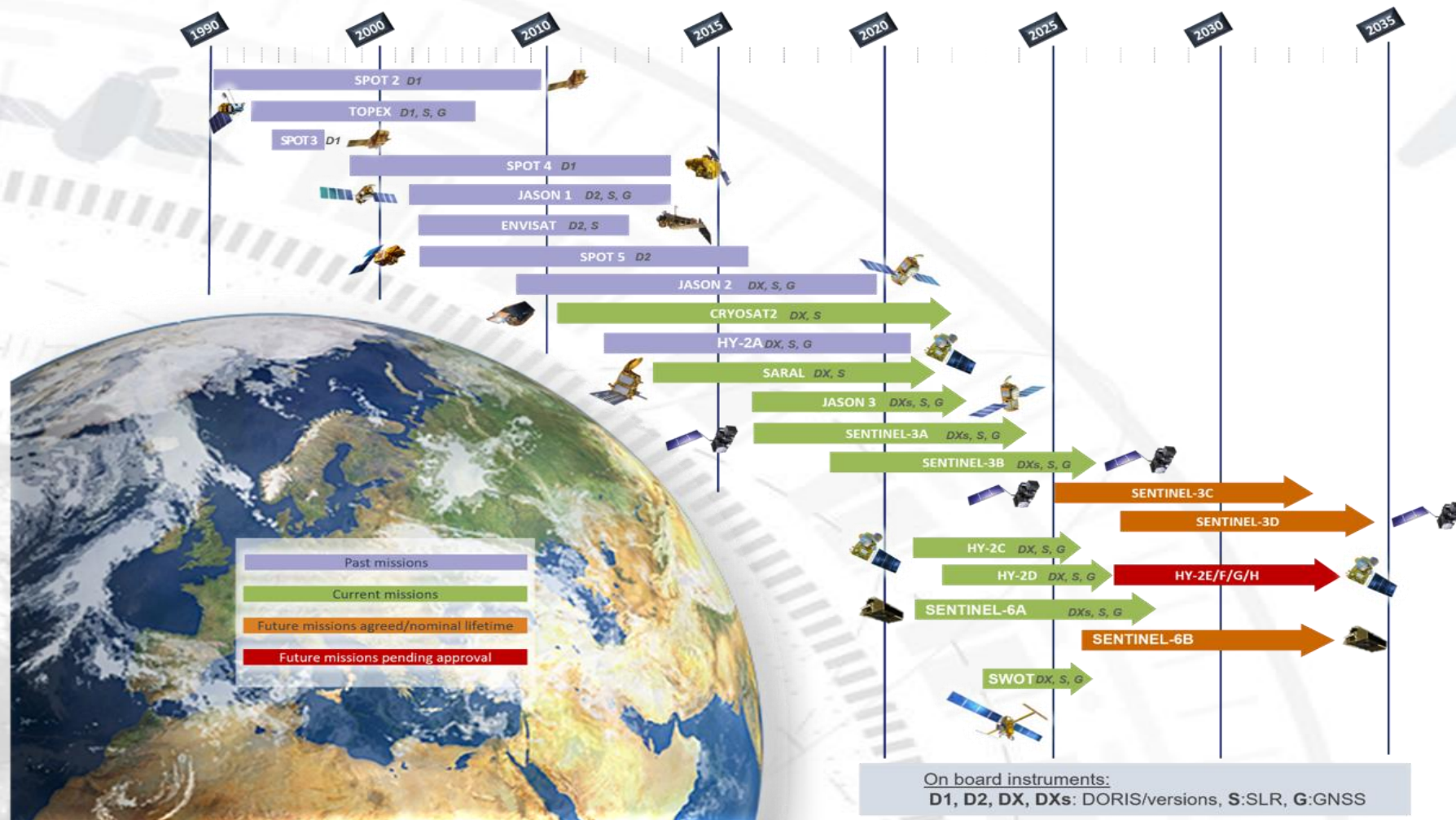
DORIS receiver can track up to 7 beacons simultaneously thanks to its 7 processing units.

Doppler measurements are made at:

- 2.03625 GHz for precise measurements,
- 401.25 MHz for ionospheric correction of the propagation delay.



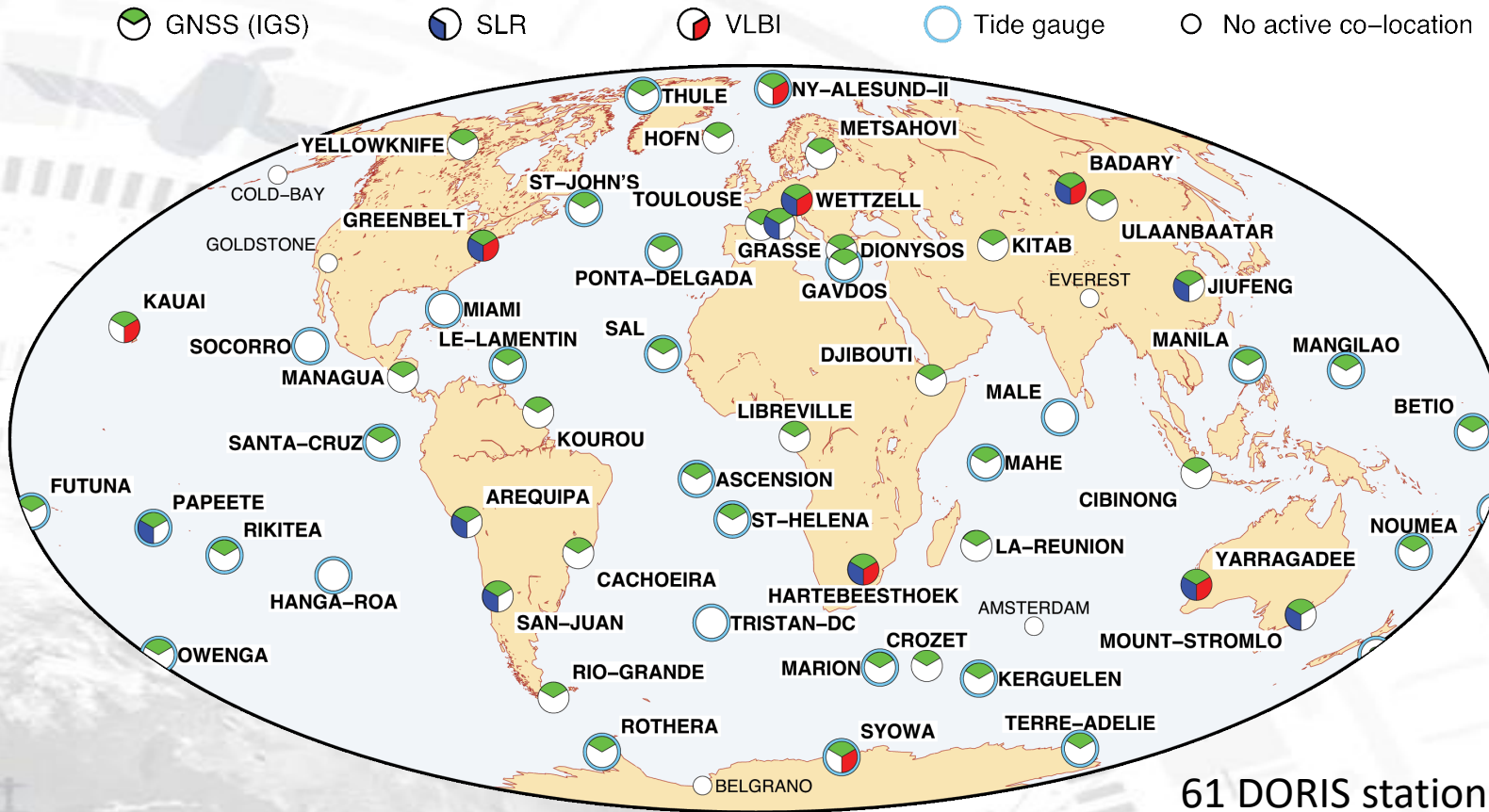
The DORIS Constellation



**DORIS is on board almost all the altimetric missions since 90's.
DORIS missions until 2035 and beyond.**



The DORIS Network: serving POD and Geodesy



Everest



Ny-Alesund



Arequipa



Socorro Island

Major Advantages

Very even distribution of stations: half of the stations are located on islands or coastal areas.

Co-location with other space geodetic techniques and tide gauges (half of the stations)

Long time series: half of the current stations were commissioned before 1995.

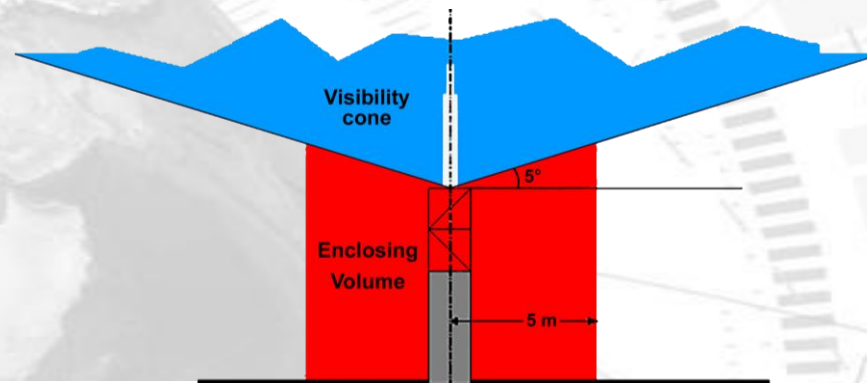
DORIS Station General Requirements

- **Functional requirements**

- **Continuous service** 24/7 365 days operation
- Continuous feed and power stability is required to generate the DORIS signal
- Radiofrequency authorization from the local Authority in the host country
- **RF interferences management** with nearby equipment
- Maximum distance between the beacon (transmitter) and the antenna: 45 m

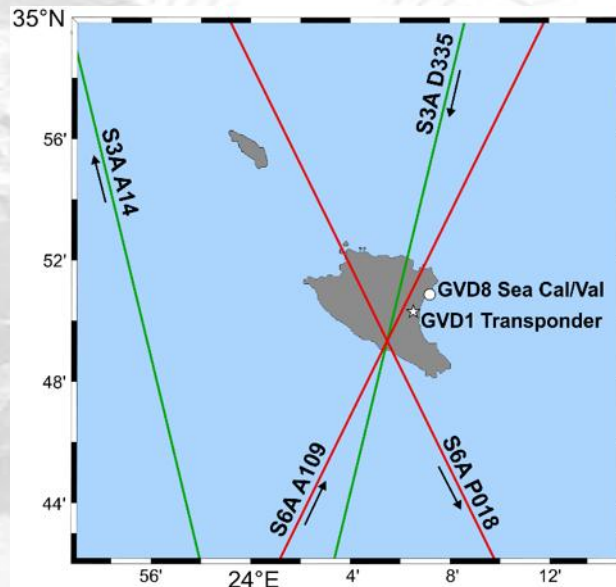
- **System requirements**

- **Doppler collisions management between co-visible stations**
- **Clear view of the sky:** visibility from LEO satellites
- No metal object or reflective surfaces in the antenna vicinity (multipath)
- **Stability of the antenna monument**
- Close maintenance to avoid long service interruptions



DORIS @ Gavdos Island

- **Specific geographical location for satellite altimeter calibration**
 - **Cross-over point** of several altimetry satellites: Envisat/Jason-2; Sentinel-3A/Sentinel-6A
 - DORIS presence at this calibration site essential for POD, vertical velocity estimation...
 - Co-location with GNSS stations (GVD0; GVD2; GVDG) and tide-gauge
- **DORIS experimental station (not part of the permanent network)**
 - **First occupation: 09/2003 => 03/2012; Acronym “GAVB”**
 - Station decommissioning in 2014 due to other priority projects at IDS
 - Installation of a **new DORIS station (GAVC) in 2023** following the calibration site renovation



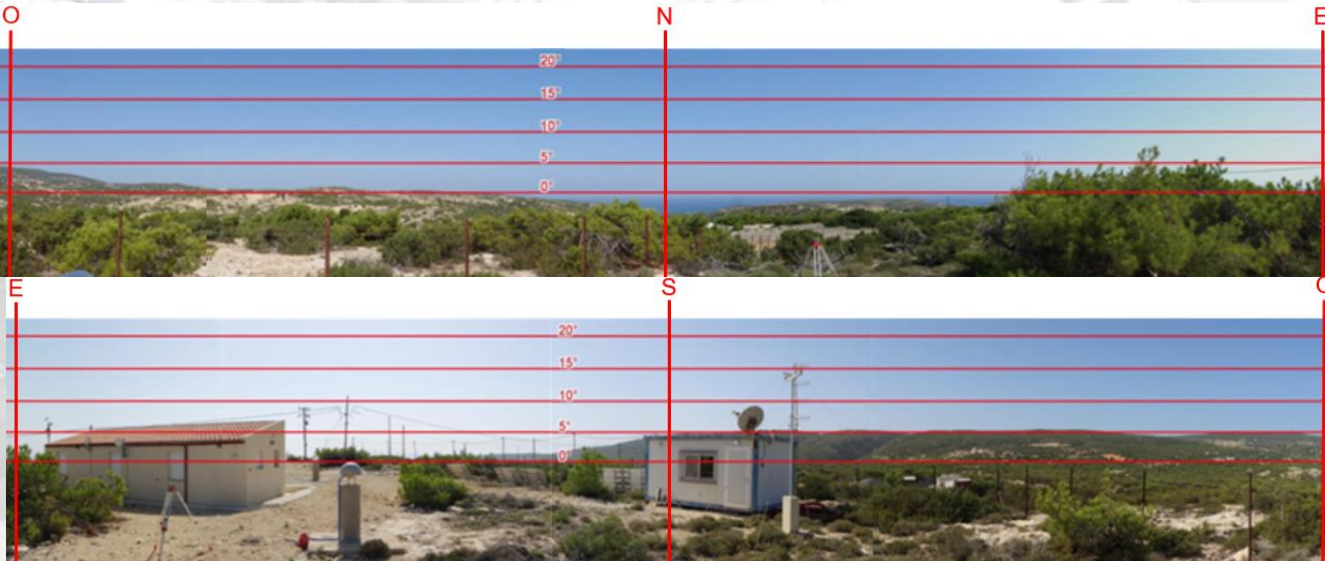
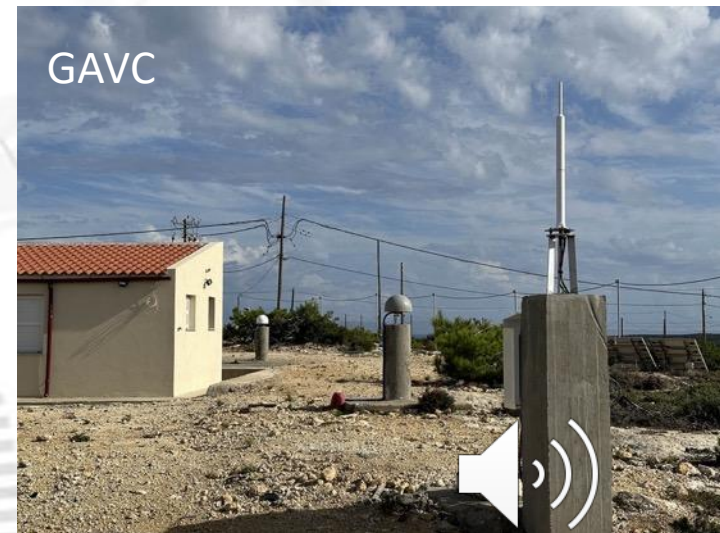
DORIS @ Gavdos Island

- **GAVB: 2003-2011**

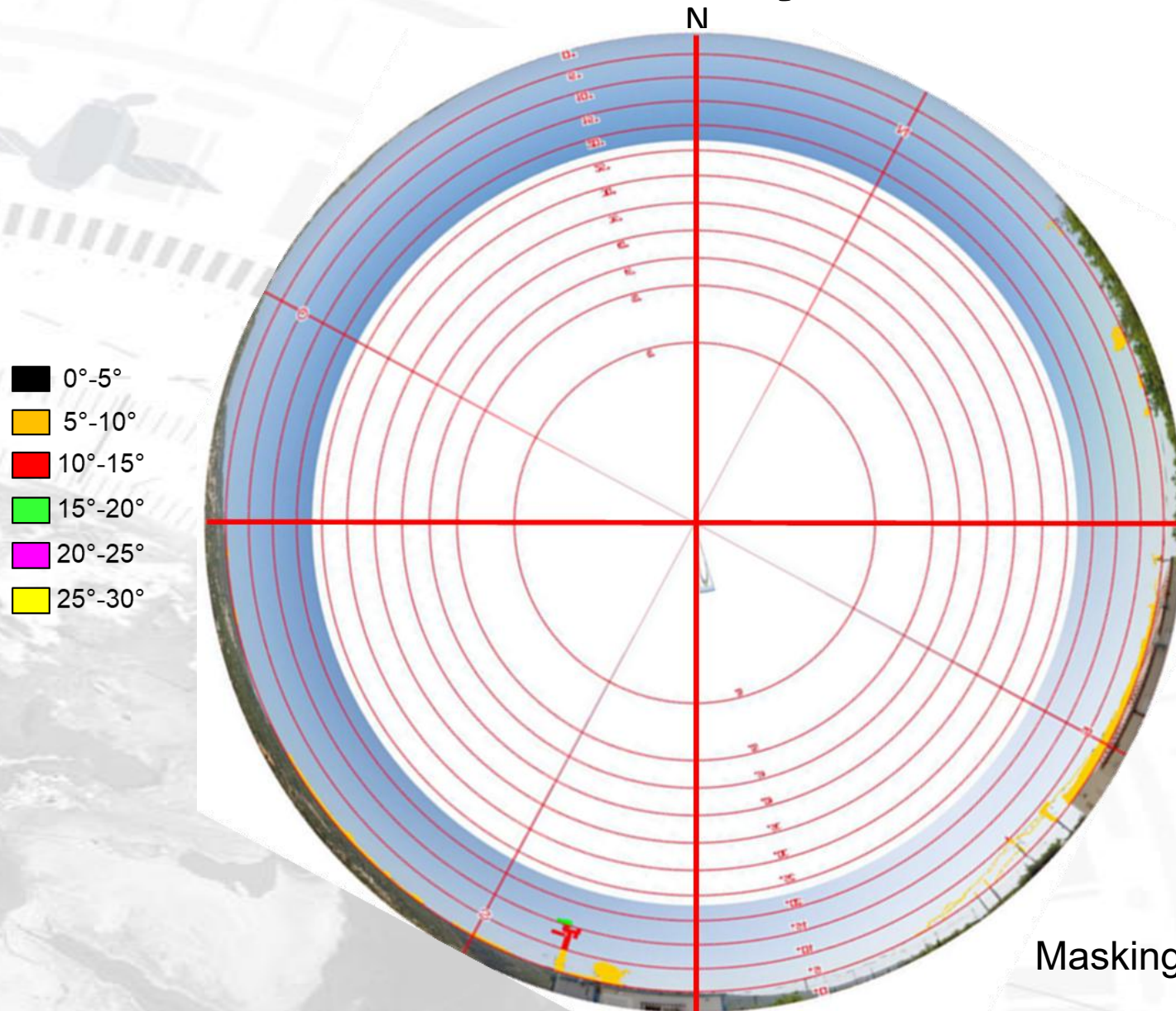
- Shifted frequencies with factor $k=18$
- 3rd generation DORIS beacon + Starec B Antenna
- Multiple service interruptions: data availability rate: 62%

- **GAVC: from 2023**

- Shifted frequencies with factor $k=13$
- 4th generation DORIS beacon + Starec C Antenna
- **Excellent data availability rate: 99%**
- **Excellent sky visibility: masking rate = 0.4% above 5°**



GAVC Fisheye view



Masking rate $> 5^\circ = 0.4\%$

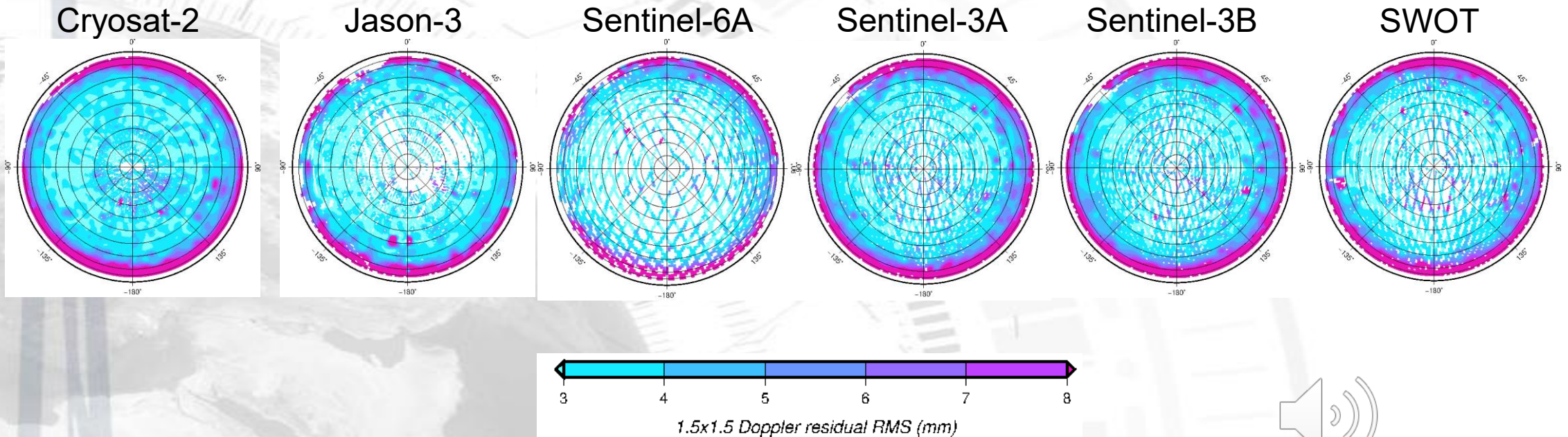


POE RMS mapping per satellite (Nov 2023 – Aug 2025)

- **Assessment methodology:**

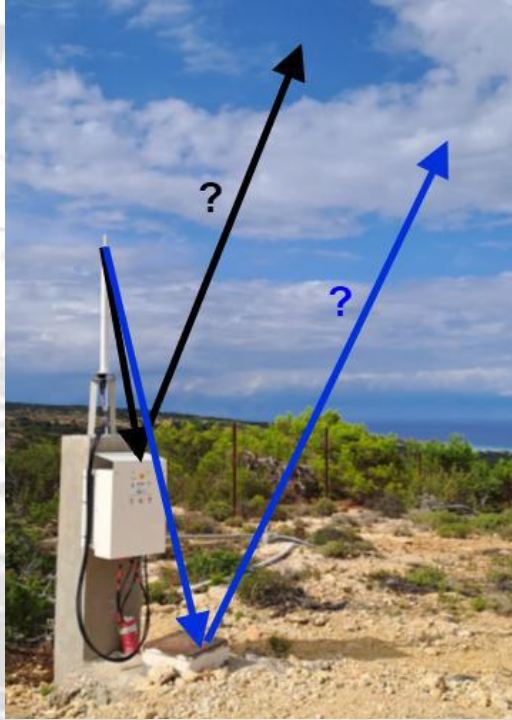
- Signal phase analysis: DORIS 2GHz residuals from CNES POE (Precise Orbit Ephemeris)
- The RMS of all values in a $0.5^\circ \times 0.5^\circ$ square is computed.
- The resulting maps are compared with the fisheye/panoramic views (360° views) from IGN to explain what causes the larger residuals (obstruction, multipath effect...)

- **GAVC Results:**

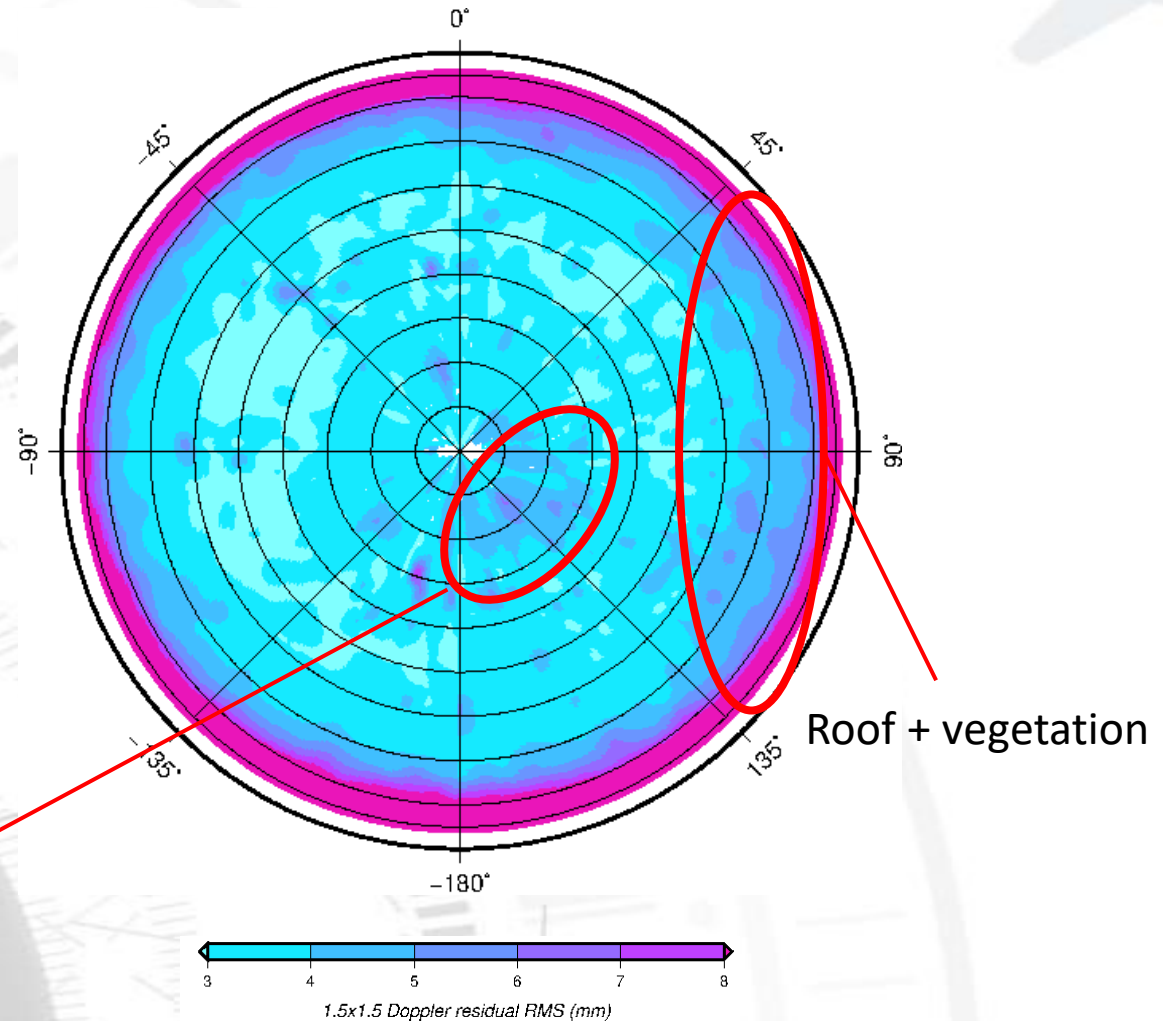


POE RMS mapping: combination of all satellites

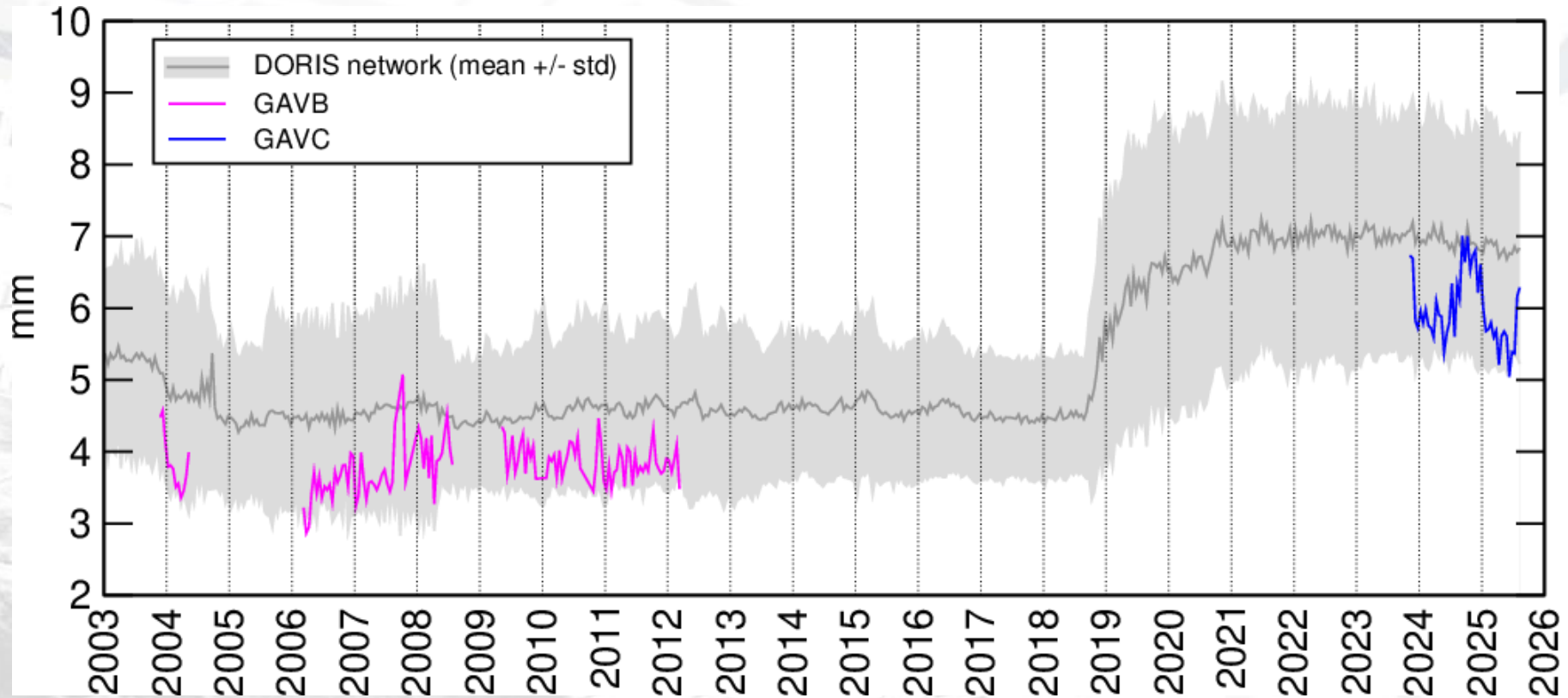
- Satellites: Saral + Cryosat2 + S-6A + S-3A + S-3B + Jason-3 + HY-2C + HY-2D + SWOT



Multipath on the inspection window? On the B4G box?



Gavdos POE RMS ranking



Gavdos
POE
ranking



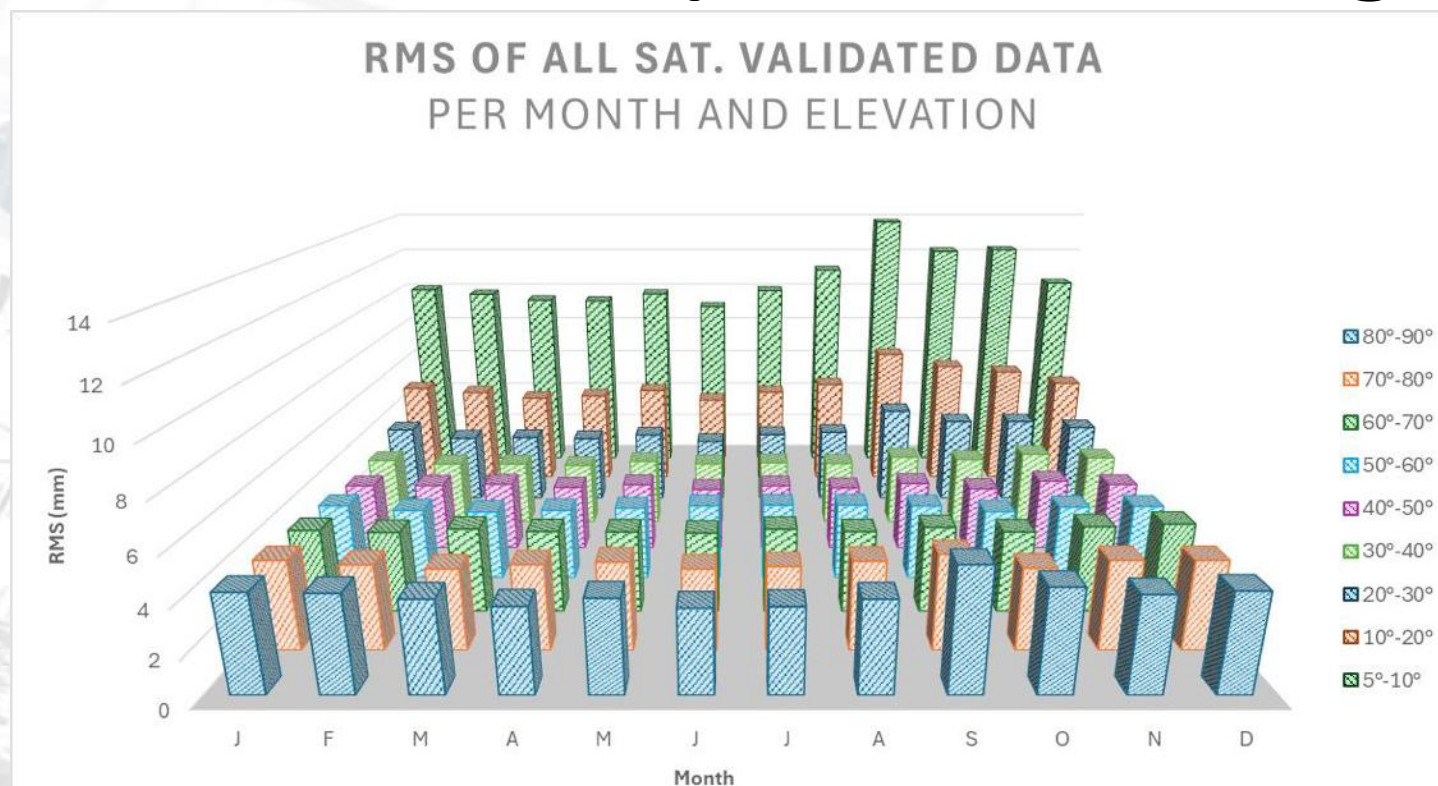
18 21 13 13 13

21 9



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POE RMS statistics (Nov 2023 – Aug 2025)



POE residuals analysis conclusion:

The POE residuals are slightly higher:

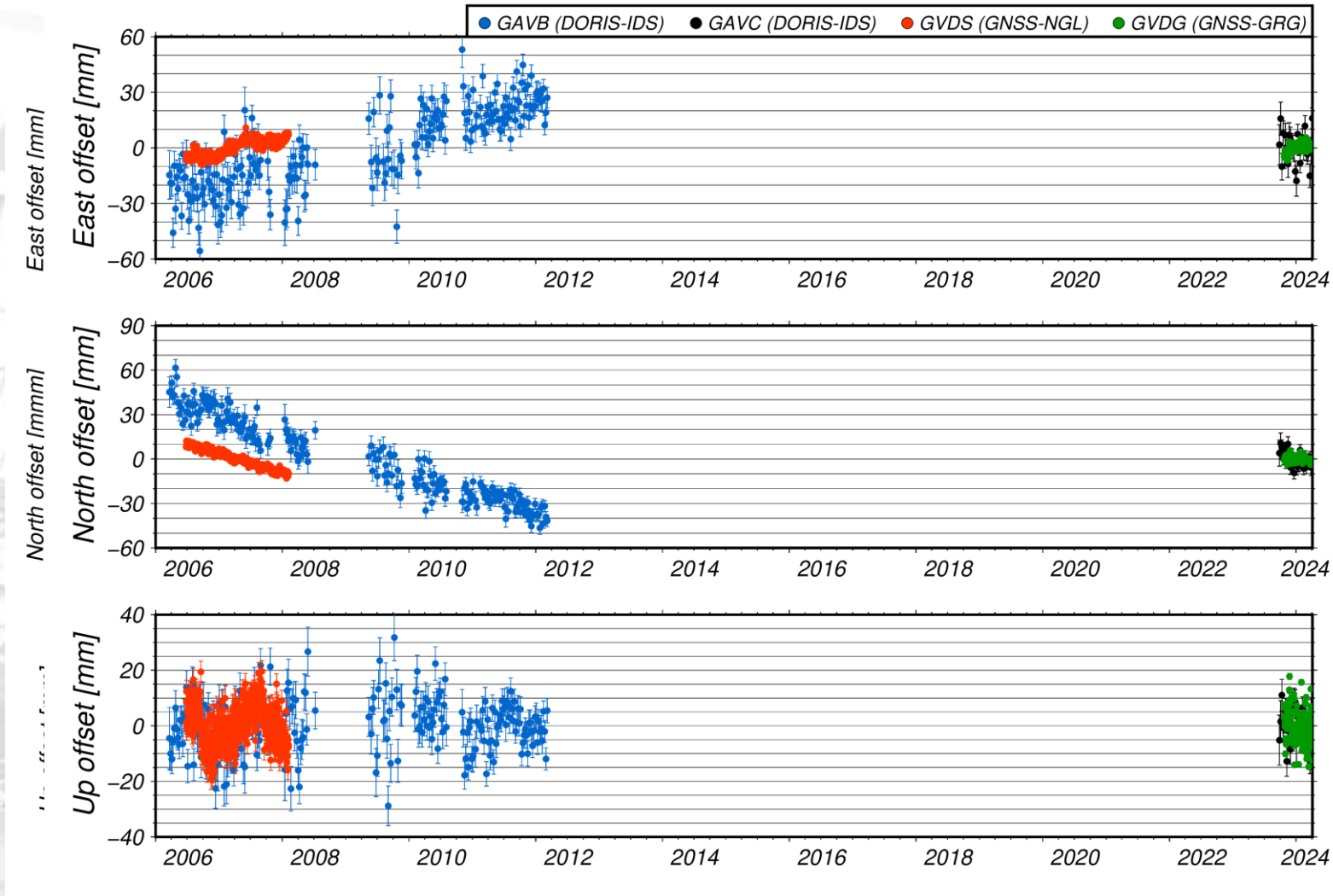
- at low elevation in the East direction (building roof + vegetation)
- at high elevation in the SE direction (multipath on a smooth surface?)

POE residuals are very good, leading to good ranking of Gavdos among all the DORIS stations (21st in 2024)

An annual signal is observed in the POE RMS time series, with higher values (~+40%) during Sept-Nov period.



Gavdos - DORIS Coordinate Time Series

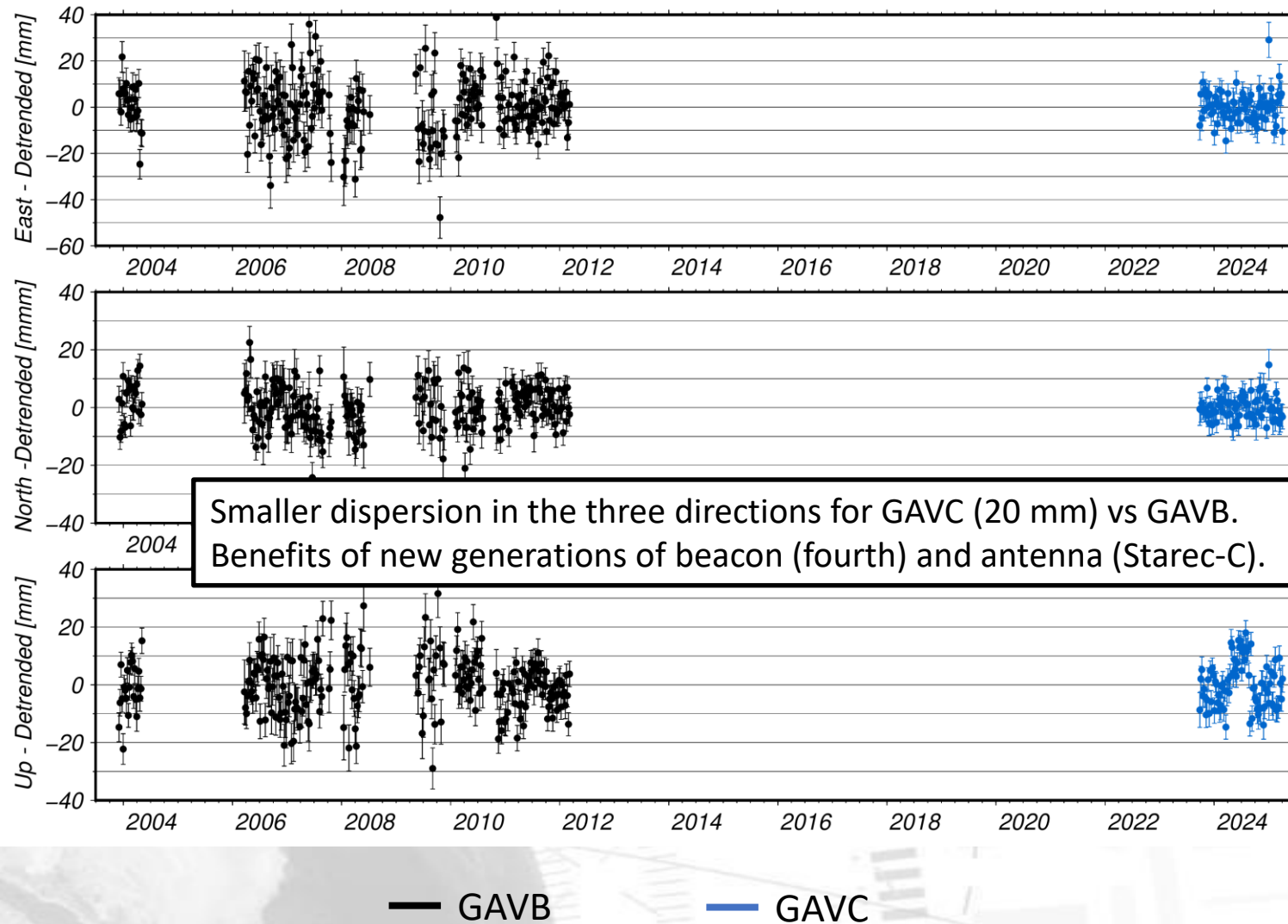


— GAVB

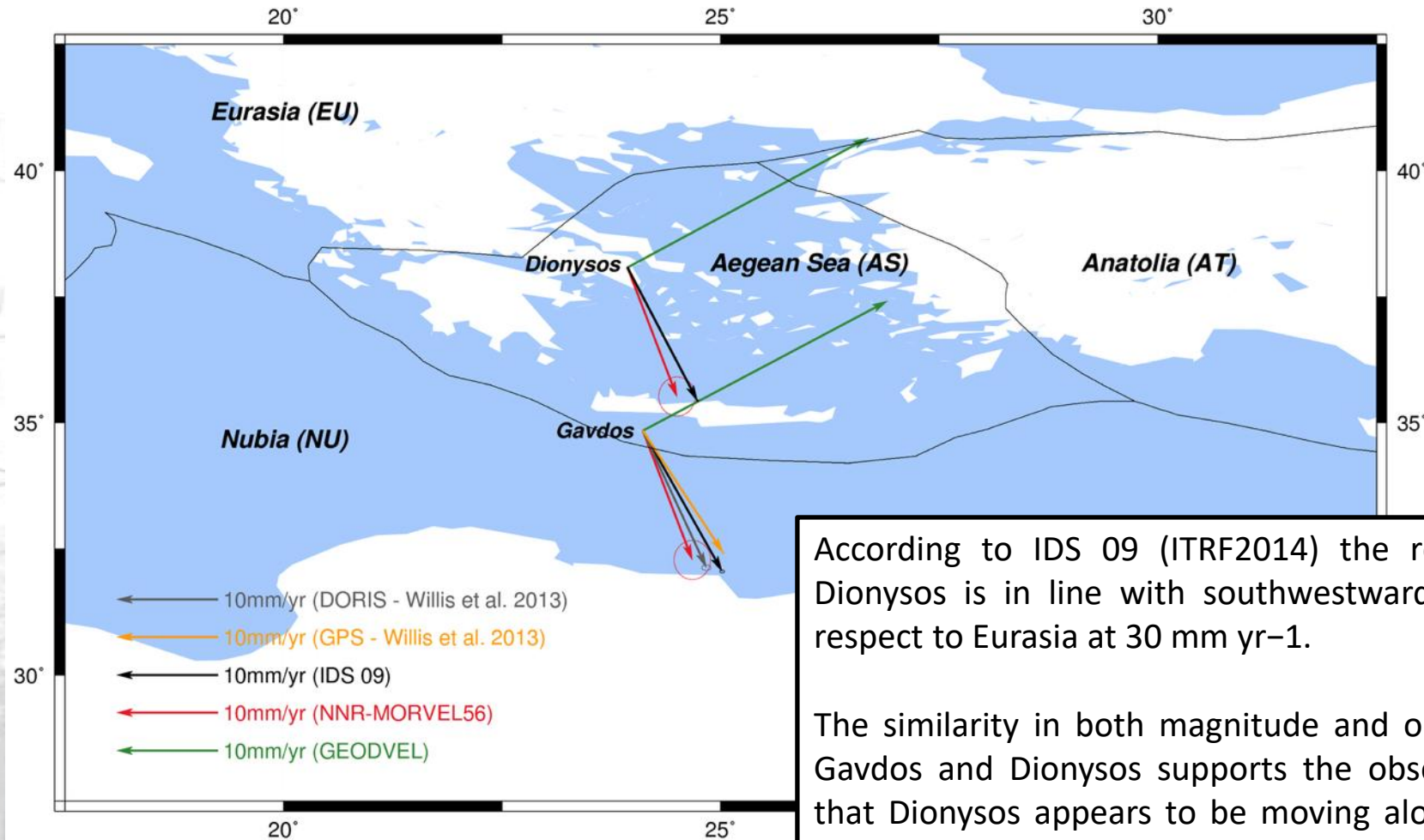
— GAVC



Gavdos - DORIS Coordinate Time Series (detrended)



Gavdos - DORIS Velocities

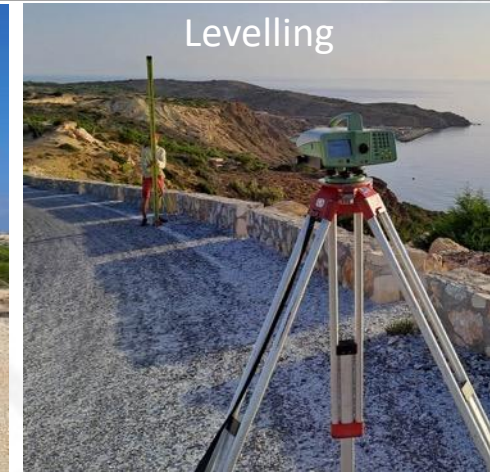
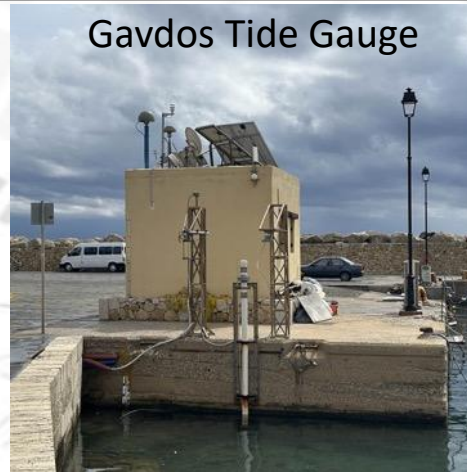


According to IDS 09 (ITRF2014) the relative motion of both Gavdos and Dionysos is in line with southwestward motion of the Aegean region with respect to Eurasia at 30 mm yr⁻¹.

The similarity in both magnitude and orientation of the DORIS velocities for Gavdos and Dionysos supports the observation from McClusky *et al.* (2010) that Dionysos appears to be moving along with the southern Aegean and so that these two sites belong to the same small plate: the SW Aegean/Peloponnisos plate.

Local Tie Survey and Levelling

After the installation of GAVC DORIS station and GVDG GNSS station in 2023, IGN carried out a high-precision surveying to determine tie vectors between all instruments and high-precision levelling between the Cal/Val site and the Gavdos tide gauge.



Tie vectors in Cartesian coordinate system (ITRF2020 ep.2023.73):

Tie Vector	ΔX (m)	ΔY (m)	ΔZ (m)
GAVC > GAVB	0.363	6.316	-5.043
GAVC > GVDG	1.772	38.145	-25.775
GAVC > GVD0	0.202	20.680	-14.032
GAVC > GVD2	0.108	6.203	-5.239

NB: Report and SINEX file (12618_IGN_2023-268_V10.SNX) will be soon available at itrf.ign.fr website



Conclusion

- The Gavdos Cal/Val site has been very well equipped since its modernization in 2022: new transponder, 3 GNSS stations, DORIS station and 2 sets of meteo. sensors.
- The new DORIS station in Gavdos benefits from very good hosting conditions: reliable power supply, clear view of the sky, monument stability...
- The Gavdos DORIS station is one of the best stations in the network for its contribution to POD.
- DORIS is an independent technique for coordinates and velocities monitoring with reliable data from several years of observation.
- The high-precision measurements performed by IGN (high-accuracy height differences between all instruments reference points, including the transponder and the tide gauge) will soon be used.



Please send any question you may have to:
ids.central.bureau@ids-doris.org

More information on DORIS @
<https://ids-doris.org>



The International DORIS Service



The IDS is an IAG service created in 2003 to:

1. develop and support DORIS scientific applications,
2. provide access to DORIS data, products and documents,
3. contribute to the IERS realizations (ITRF),
4. support GGOS objectives.

<https://ids-doris.org>

- **Next IDS Events:**

- Hybrid format, hosted by the National Technical University of Athens (NTUA), on November 3rd and 5th, 2025
- DORIS Analysis Working Group Meeting, Athens, November 6-7, 2025

- **New Working Groups:**

- « NRT ionospheric application », Chair: Ningbo Wang (AIR/CAS)
- « Integrated Clock Correction Strategies for DORIS », Chair: Patrick Schreiner (GFZ)

