Quality assessment of DORIS stations environment based on POD residuals and signal intensity variations

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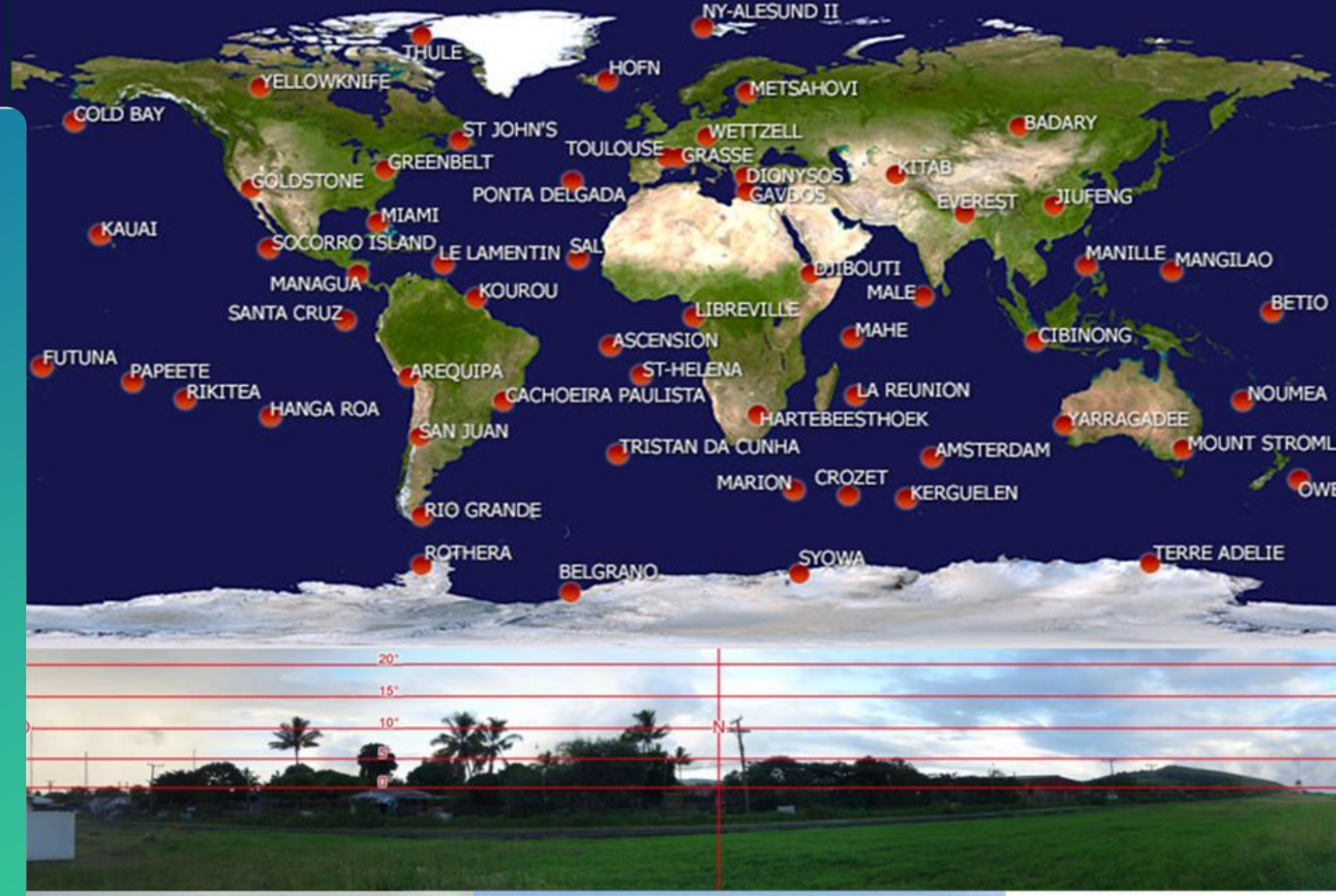
30 Years of Progress in Radar Altimetry Symposium / IDS Workshop
4-5 September 2024, Montpellier, France



Content

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- Purpose of the analysis
- What measurements are analyzed
- Once per year assessment of DORIS stations quality based on POD

❖ Examples of analysis

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Introduction: purpose of the analysis

Analysis necessary for:

- Assessing a **new site**
- Assessing a **site renovation**
- Analyzing data when a **problem** is raised on a station
- Determining the **next renovation** to be conducted

➔ Need for a regular health check of the stations by analyzing:

- The signal **amplitude** (received power)
- The signal **phase** (residuals of CNES POD adjustment)

Introduction: what measurements are analyzed?

AMPLITUDE → Power attenuation = {**measured** received power – **theoretical** received power} on both frequencies (400 MHz & 2GHz).
The theoretical power is given by:

$$P_{theo} = P_{tran} - l_{gr} + g_{gr}(\theta) - p_{path} + g_{boa}(\theta) - l_{boa}$$

gr = ground
boa = on-board
l = cable loss
g = antenna gain
θ = elevation
p_{path} = path loss

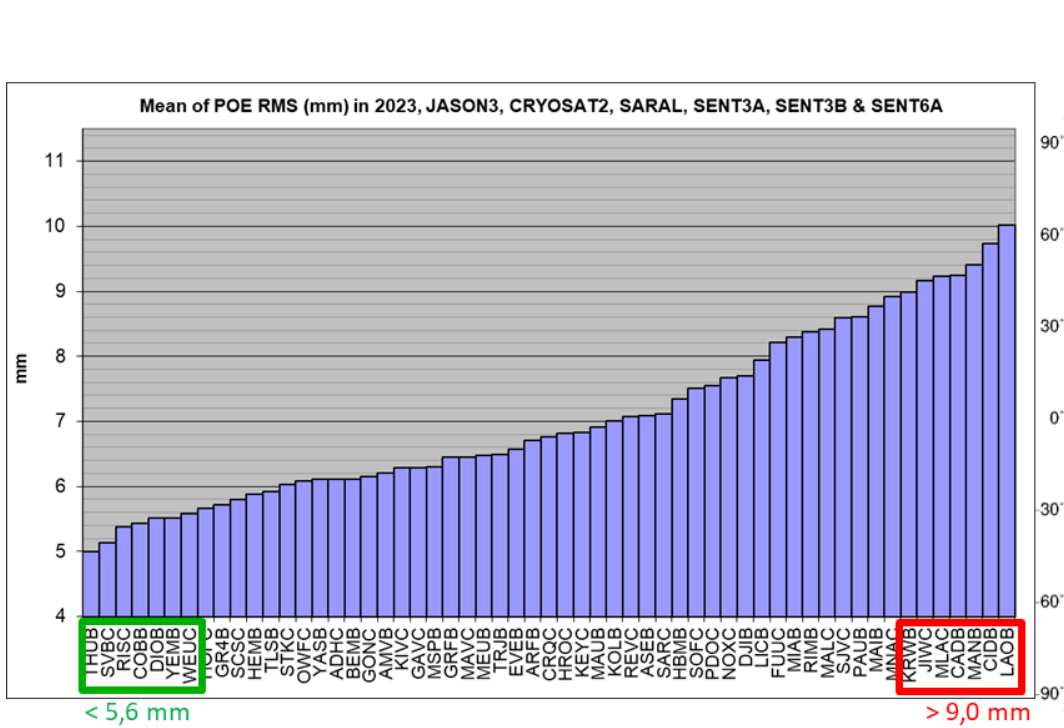
The mean of all values in a 0.5° x 0.5° square is computed. In order to eliminate the biases (cable length, etc.) we subtract the average on the whole geometry.

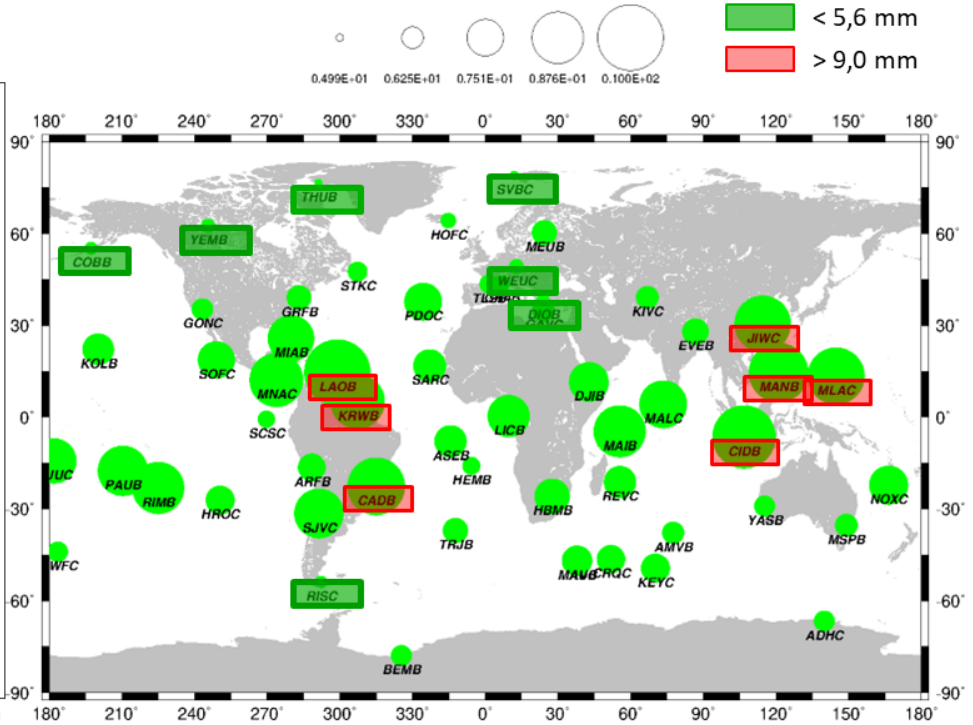
PHASE → POE residuals : DORIS 2 GHz residuals from CNES POE (Precise Orbit Ephemeris)
The RMS of all values in a 0.5° x 0.5° square is computed.

The resulting maps are compared with the fisheye/panoramic views (360° views) from IGN if available, or other pictures of interest

Introduction: yearly assessment of the network quality

Yearly ranking of the DORIS stations based on the average of DORIS POE RMS (here in 2023)





These statistics may guide towards a specific station analysis

Analyzed stations

The following slides will show the analysis results of 9 stations:

- relevant previous analysis
- and more recent ones

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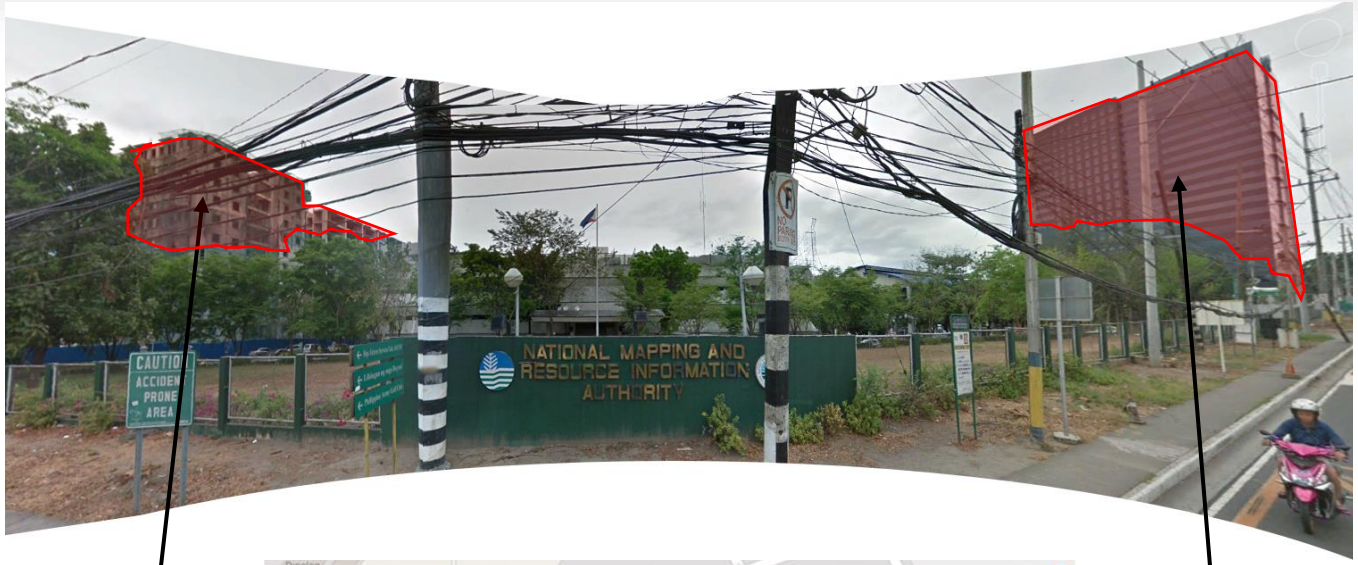
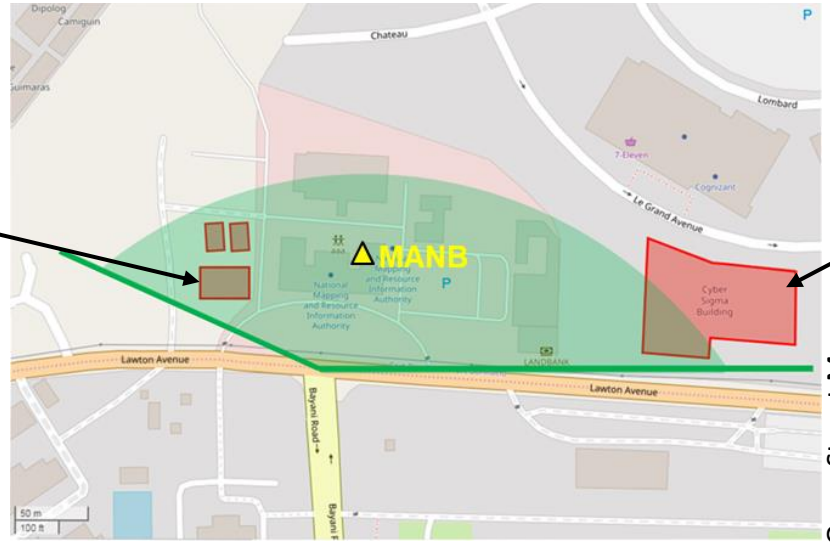
Manilla



Google Street

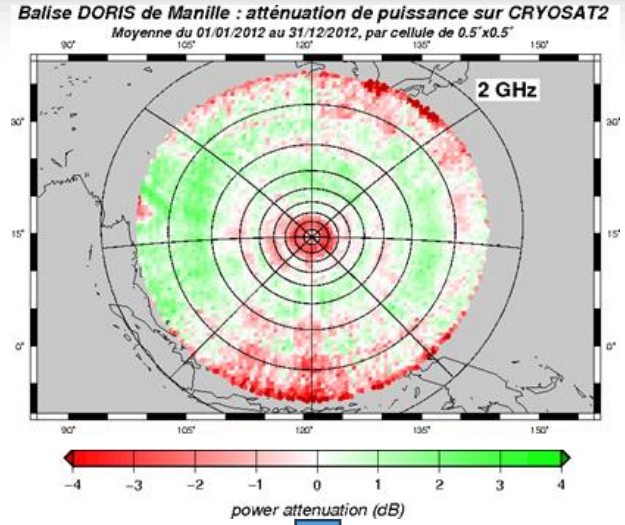


Open Street Map

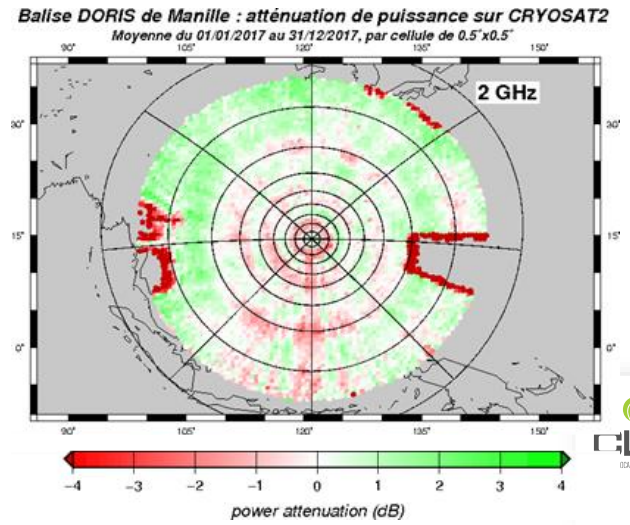
Residential building
(built in 2014-2015)

Office building
(built in 2016)

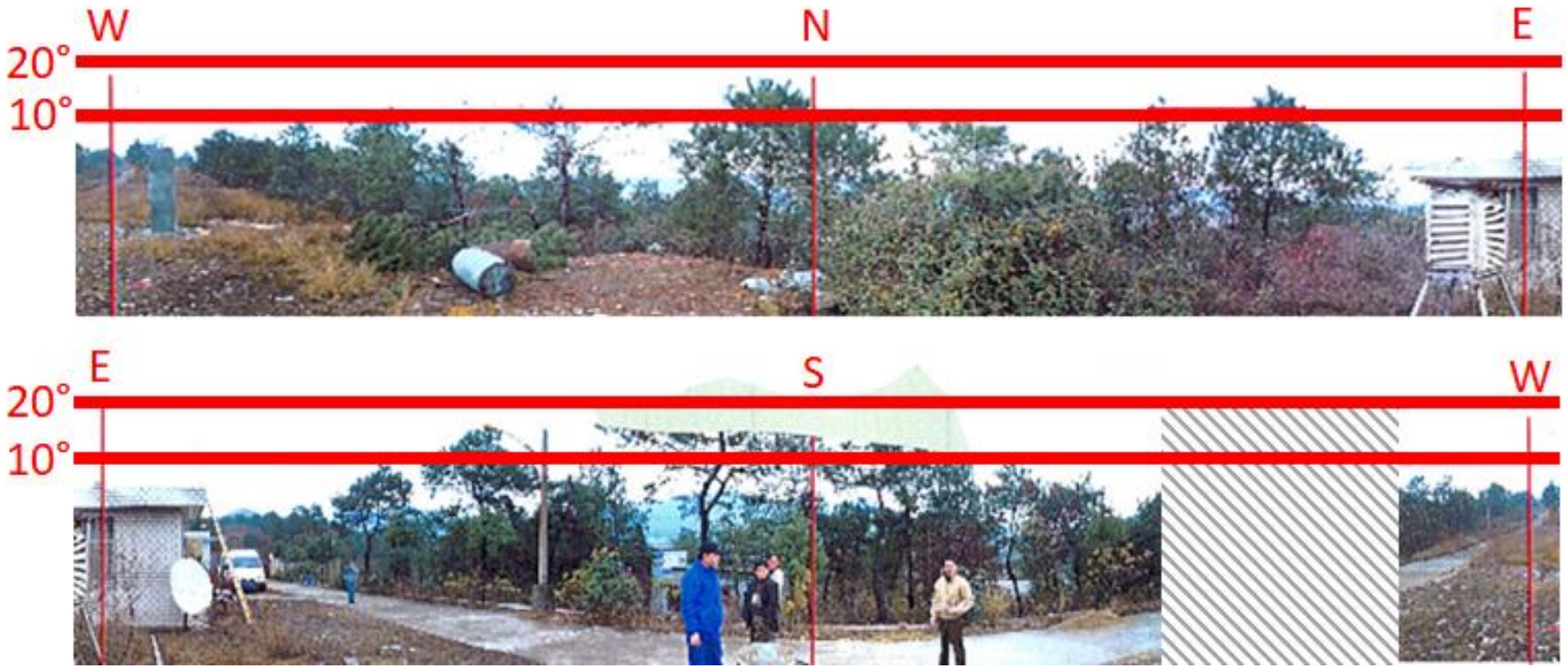
2012



2017

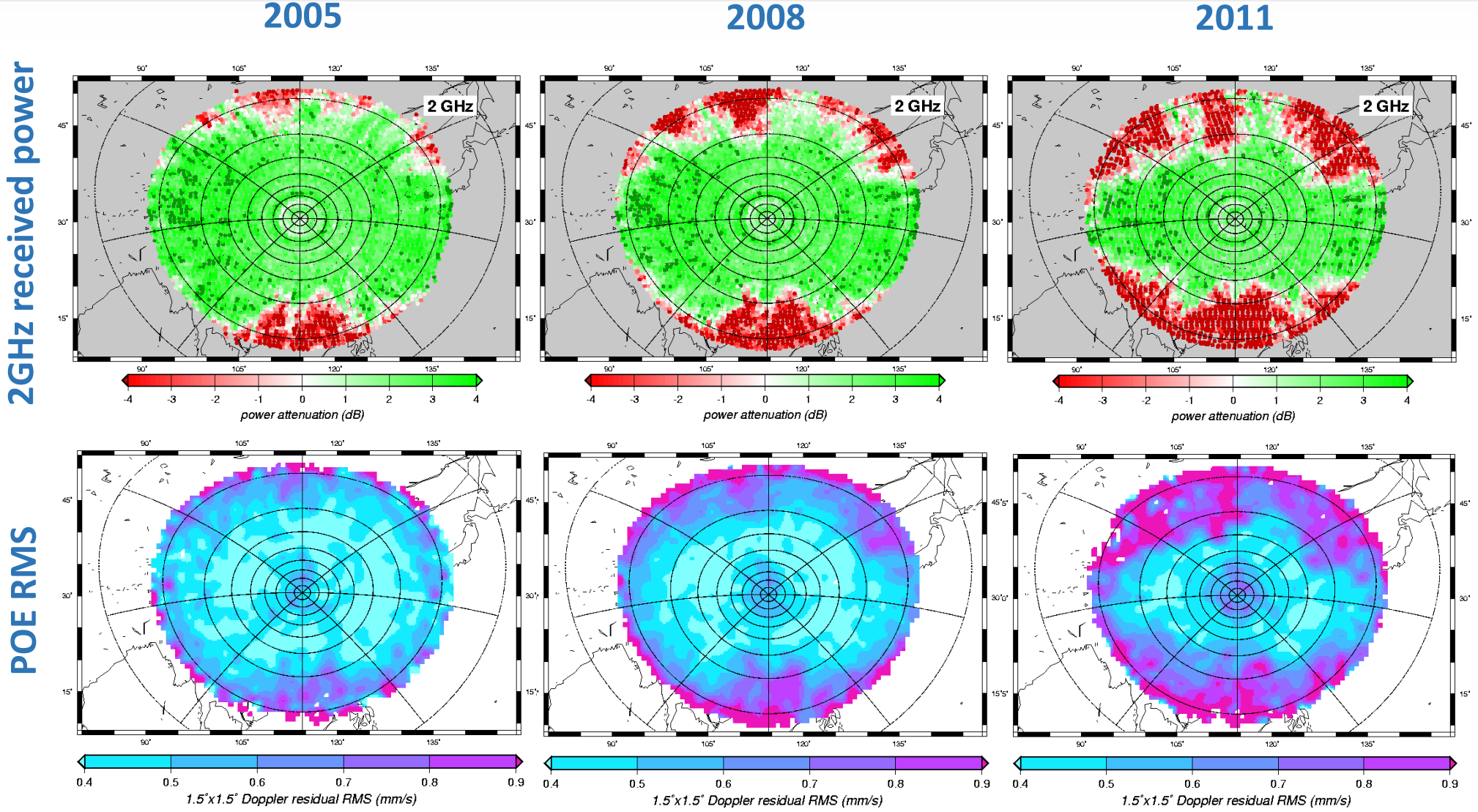


Jiufeng



Pictures taken in 2003, from: Report of the Doris Installation at Jiufeng, IGN, 2005

Jiufeng


2005
2008
2011
2GHz received power
POE RMS
2 GHz
power attenuation (dB)
1.5°x1.5° Doppler residual RMS (mm/s)

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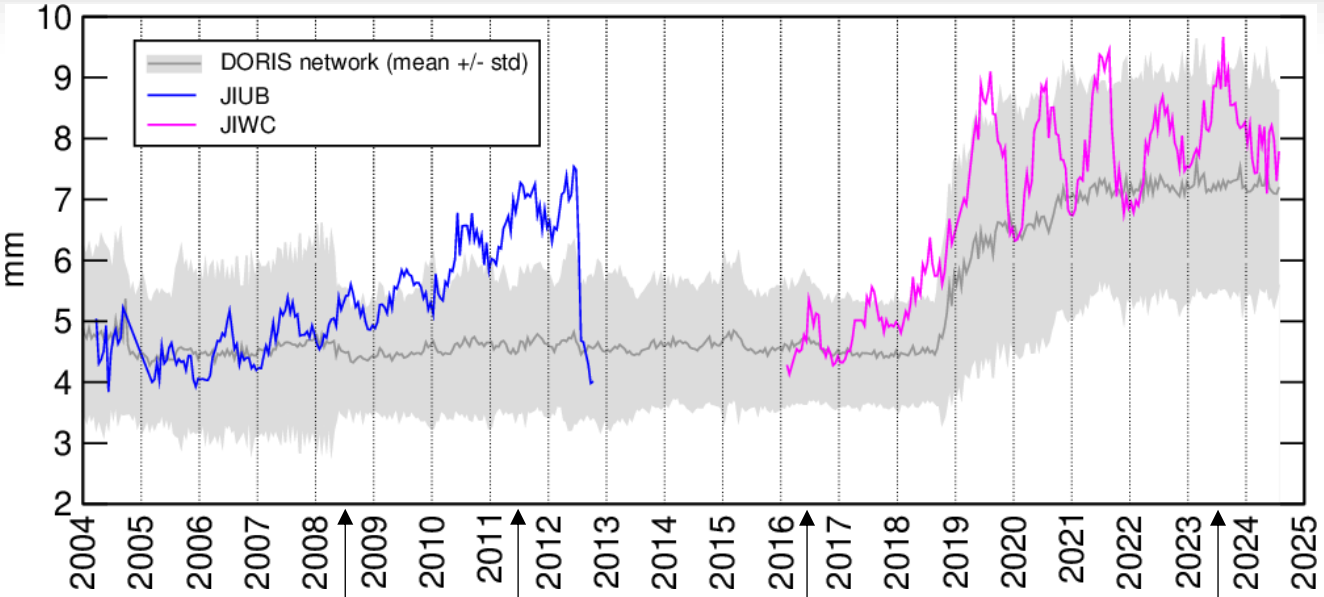
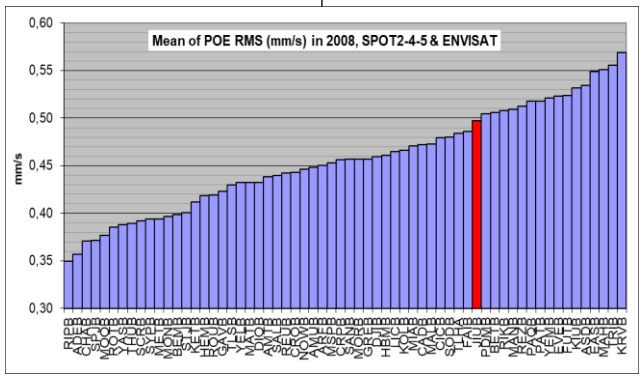
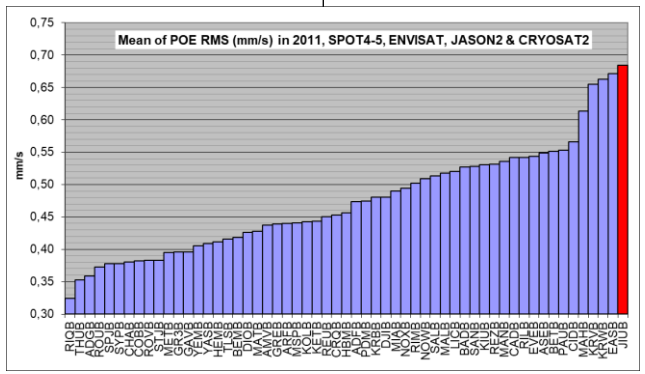
Jiufeng

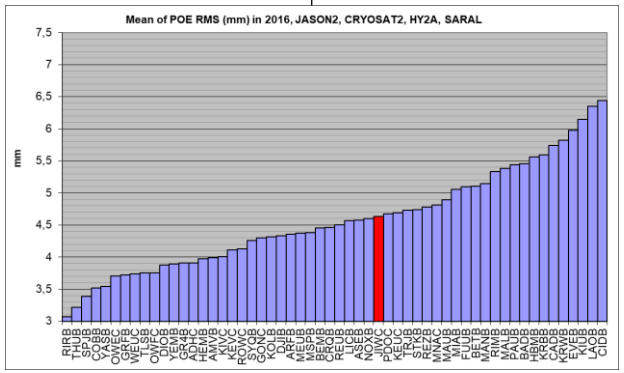
Continuous degradation due to the **vegetation growth.**
Seasonal signal due to the **densification of the foliage** in Summer.

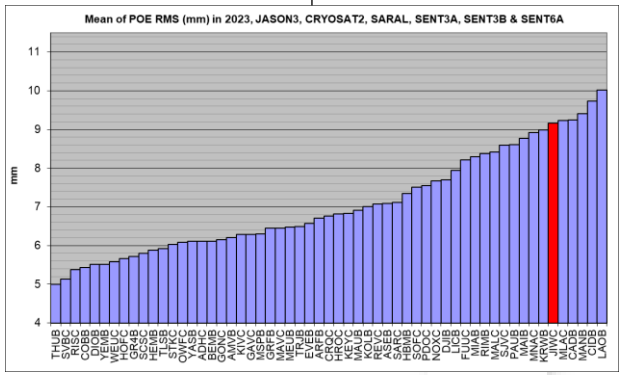


Trees cut-off in 2012









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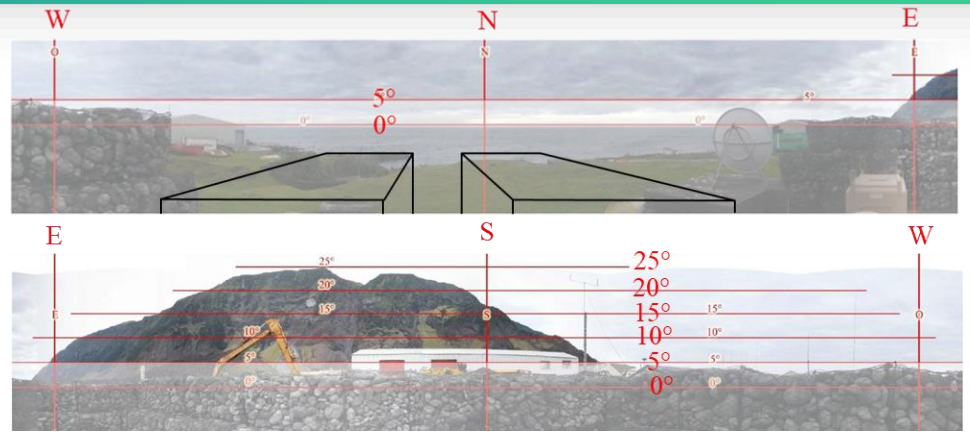
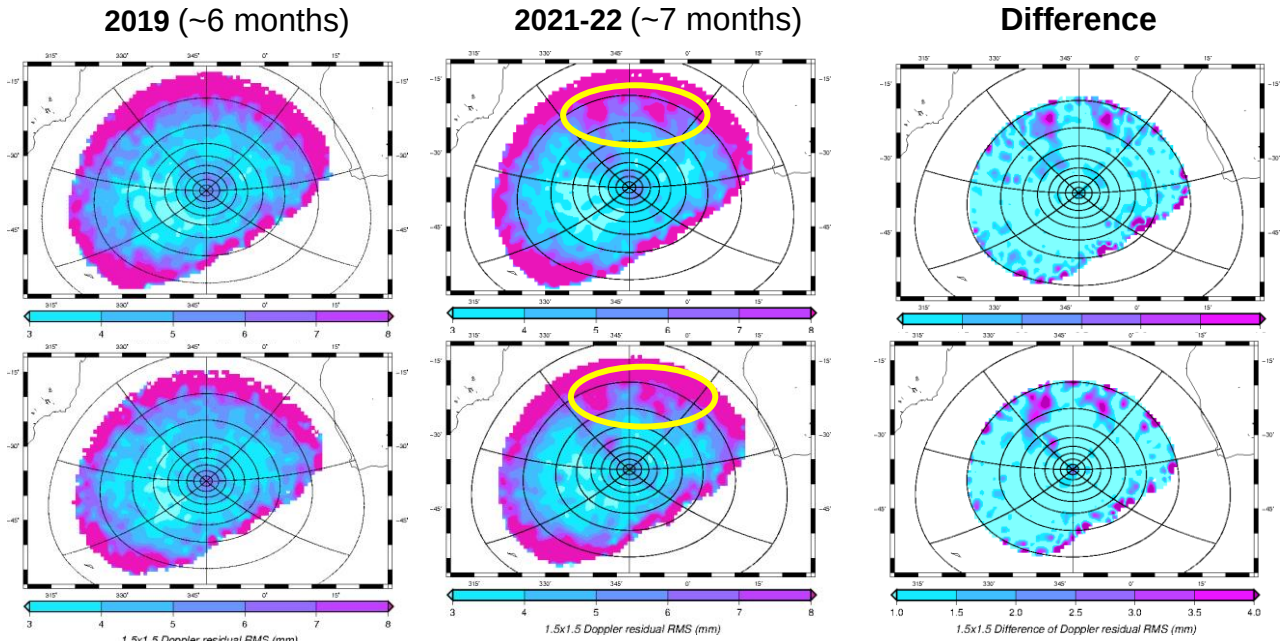
Tristan da Cunha

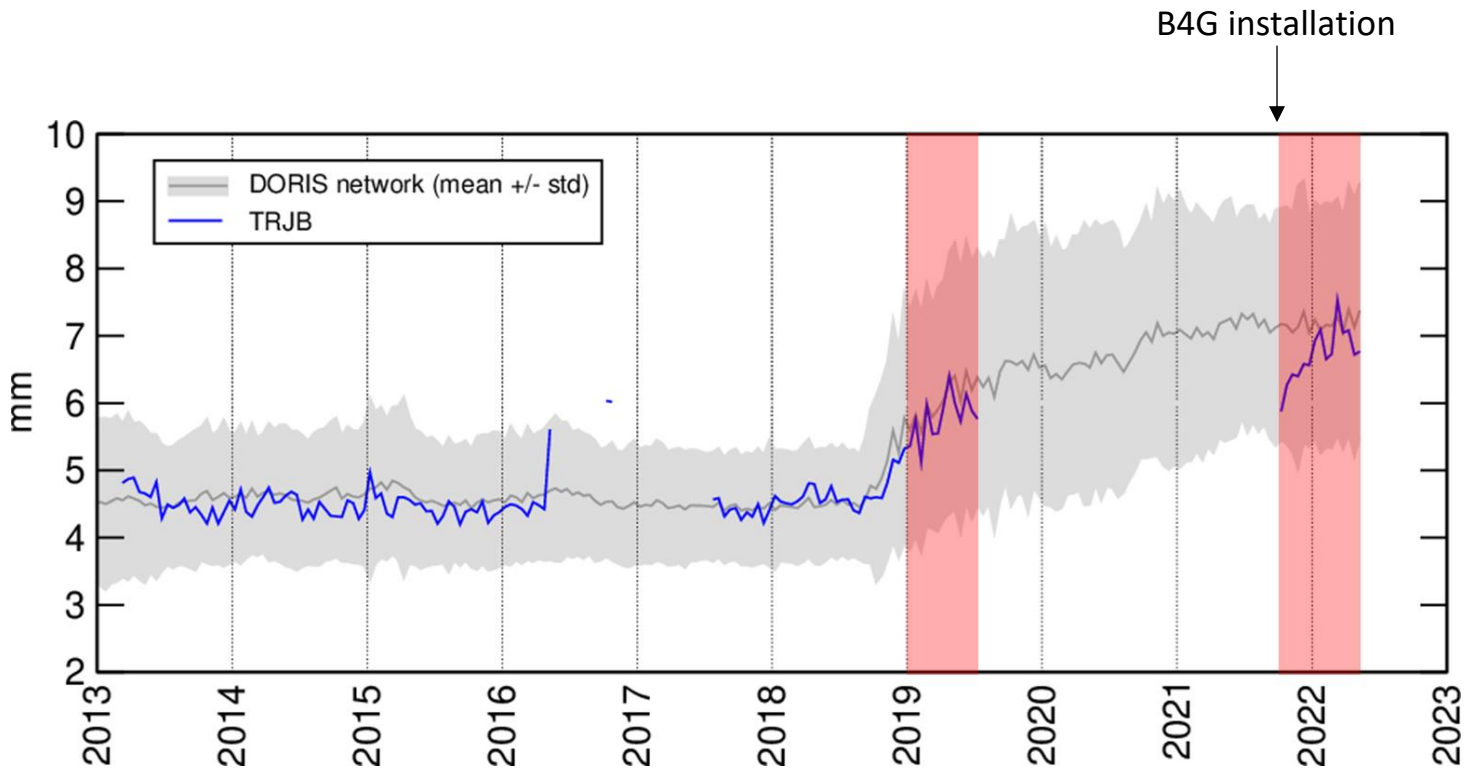
Two containers were installed before the B4G installation in 2021. Impact on data quality?





Impact of the containers: **up to 4 mm**, but **very localized**: ~3-4 % of the whole data is affected (>2 mm difference)

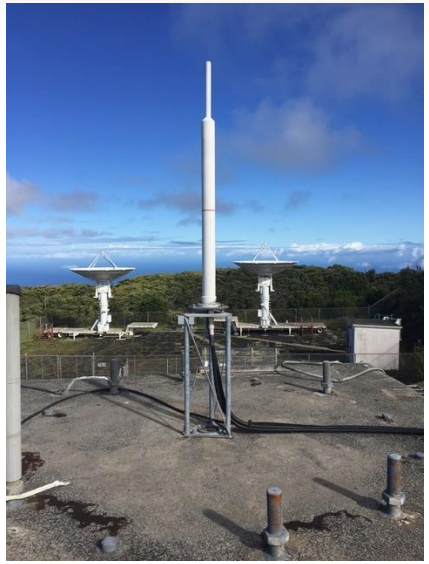
Tristan da Cunha



No impact of the multipaths.
At least, the improvement due to the B4G is well above the disadvantage of the multipath effect.

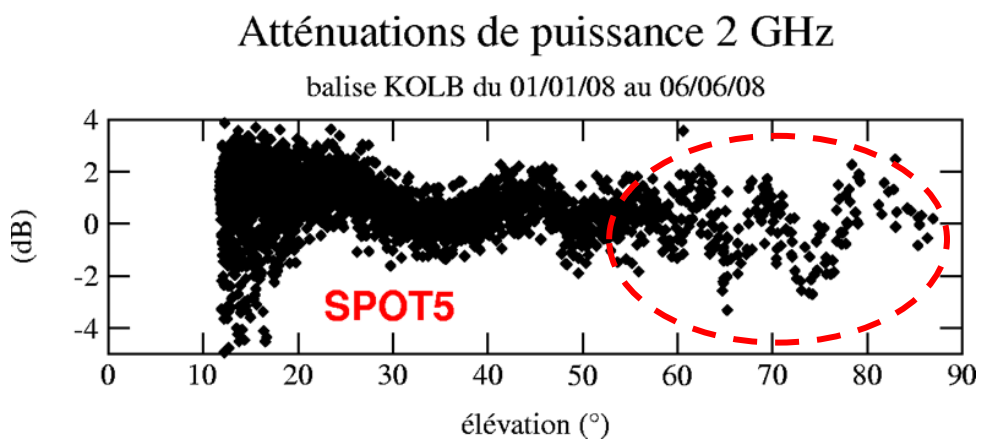
Kauai

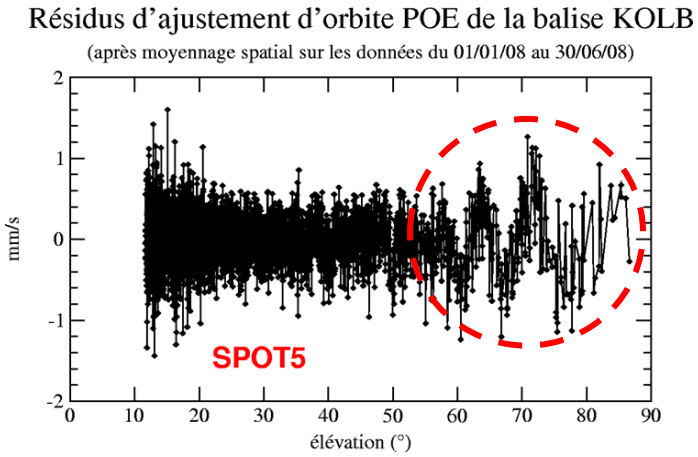
Panoramic view in 2002



2020

Concrete base at the foot of the antenna → impact on the data?

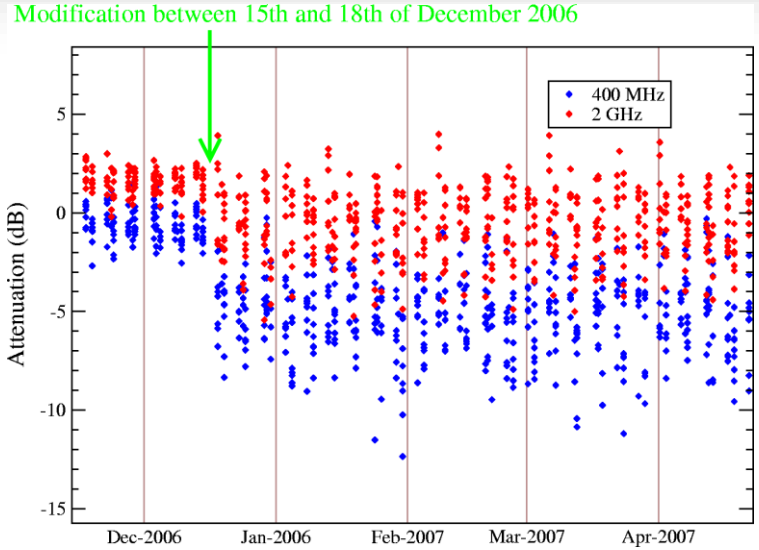


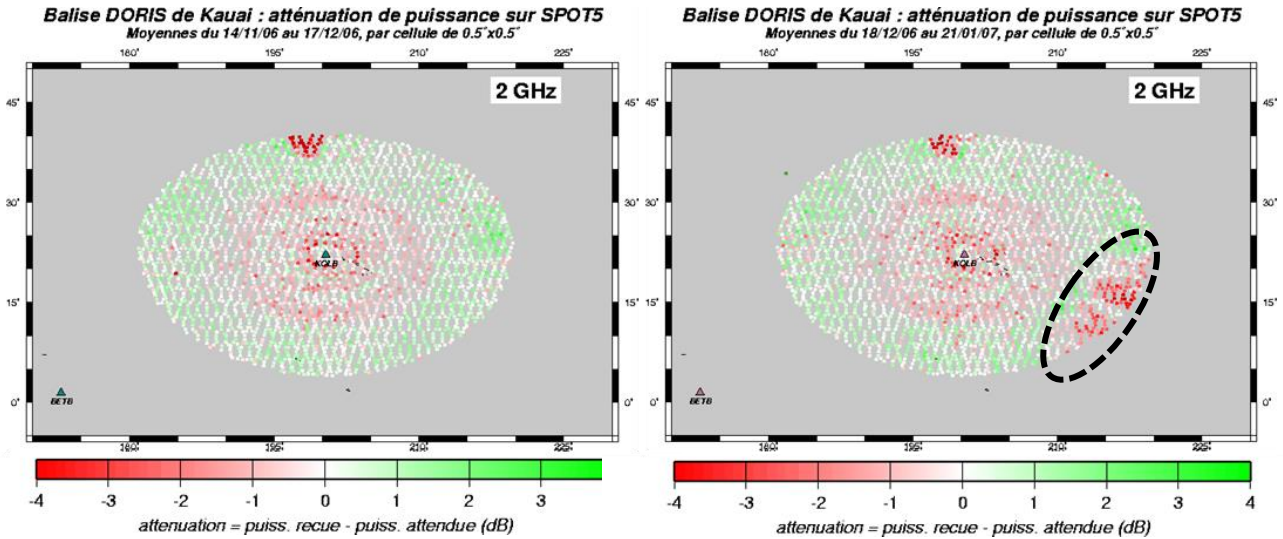


→ **Interference fringes** caused by a combination of direct and indirect signals due to **multipaths** on the concrete base. Same effect as for the former Fairbanks station

Kauai

Sudden drop in the power attenuation mi-december 2006, in the South-East direction.
→ There was a scaffolding there! (dissassembled in 2008)





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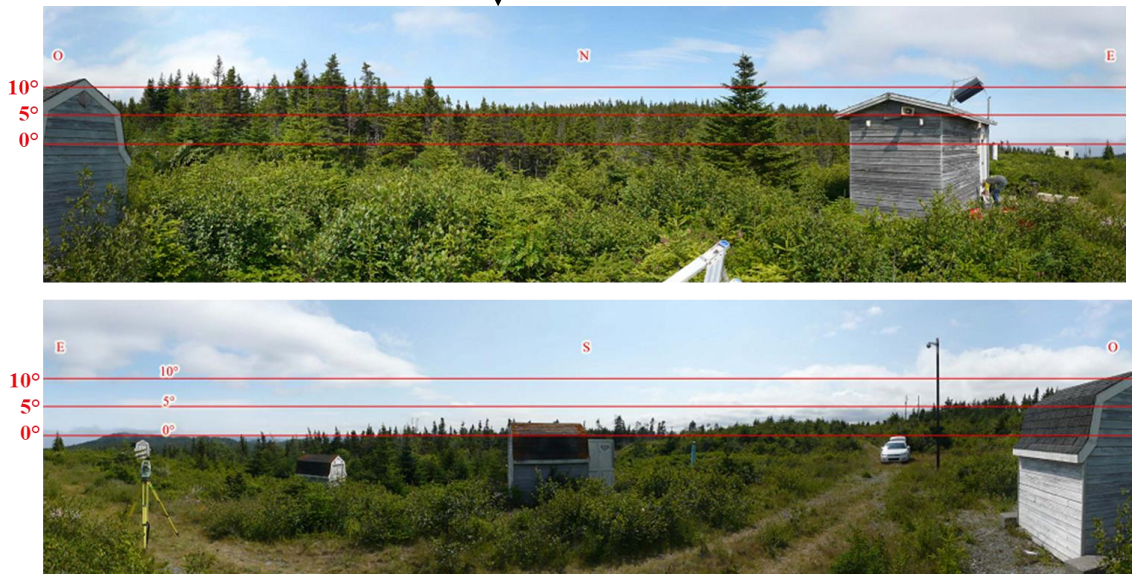
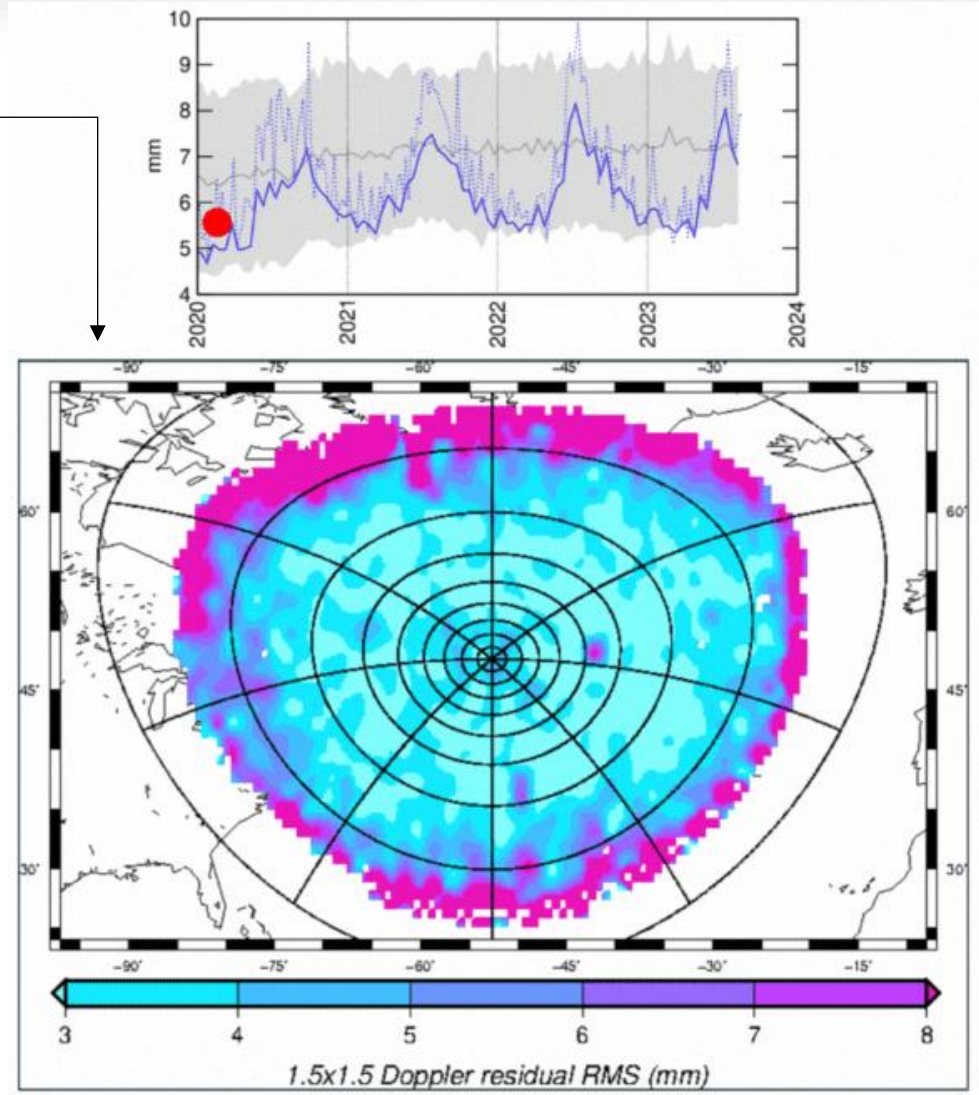
Saint John's

Clear sky view but…



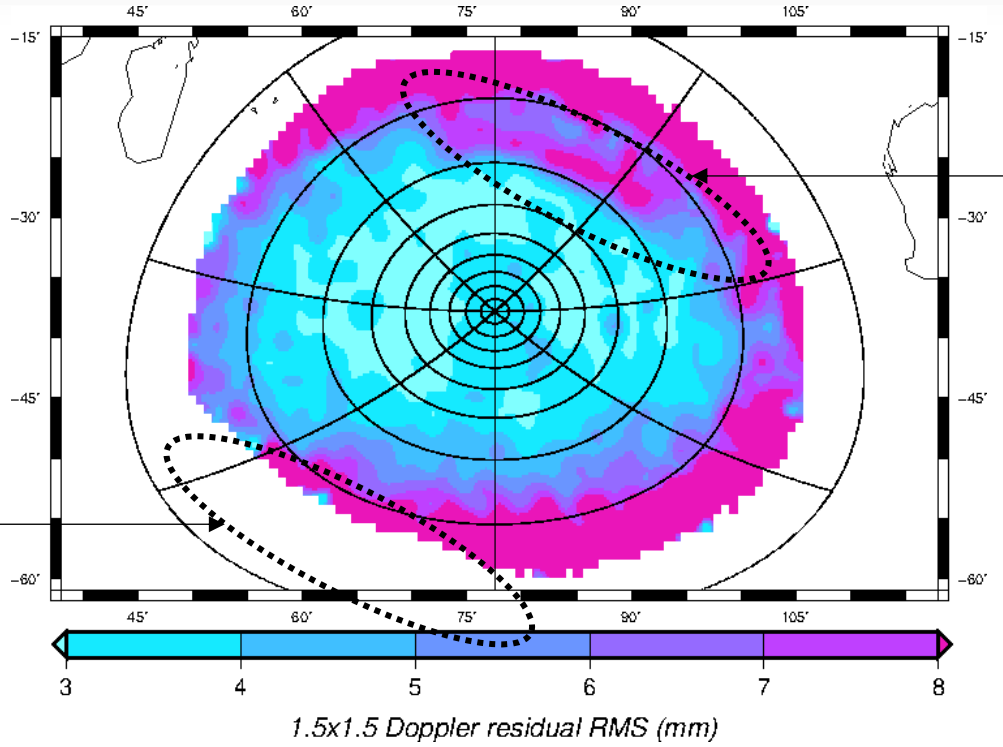


Some artefacts are detected, but they are not persistent.
One **persistent pattern** is detected in the East direction, 30° of elevation. **since mid-2022**.
Unresolved for now

Amsterdam

Volcano

(Amsterdam B4G installation report, IPEV, 10/12/2020)



Host building

(Amsterdam B4G installation report, IPEV, 10/12/2020)

Same obstruction elevation (9°) but not the same impact: due to the diffraction on the building roof, the latter seems higher (impact on residuals up to 20°)

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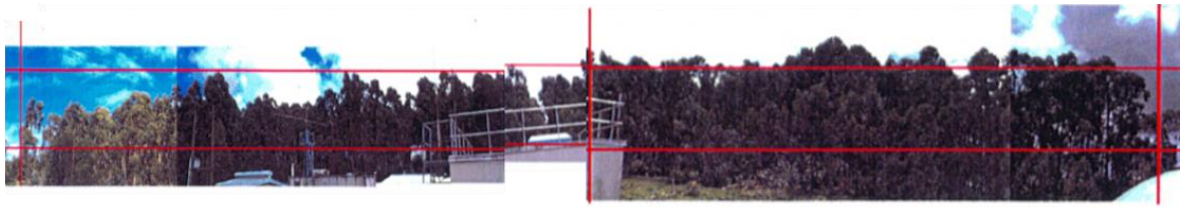
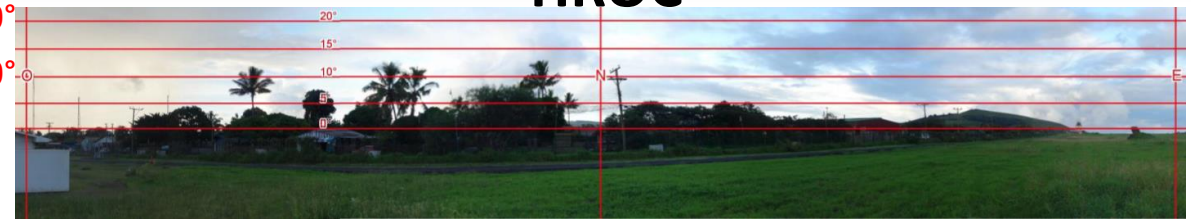
Hanga-Roa

New site on Easter Island, with better sky view

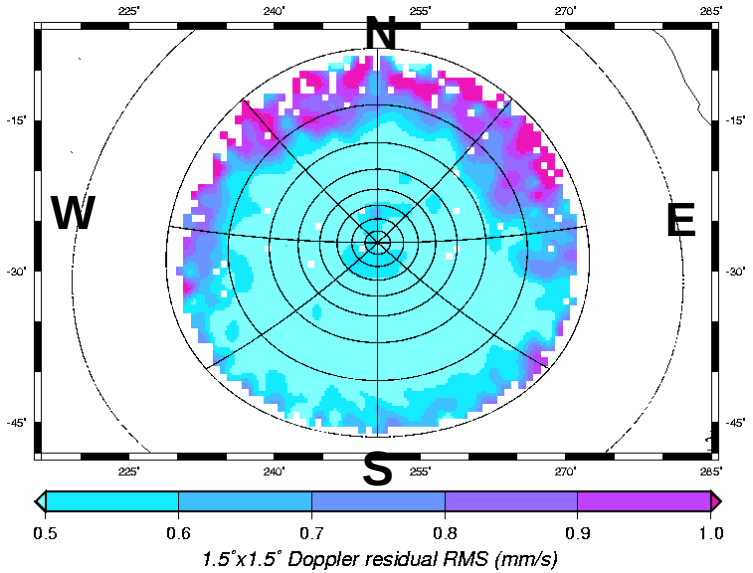
EASB

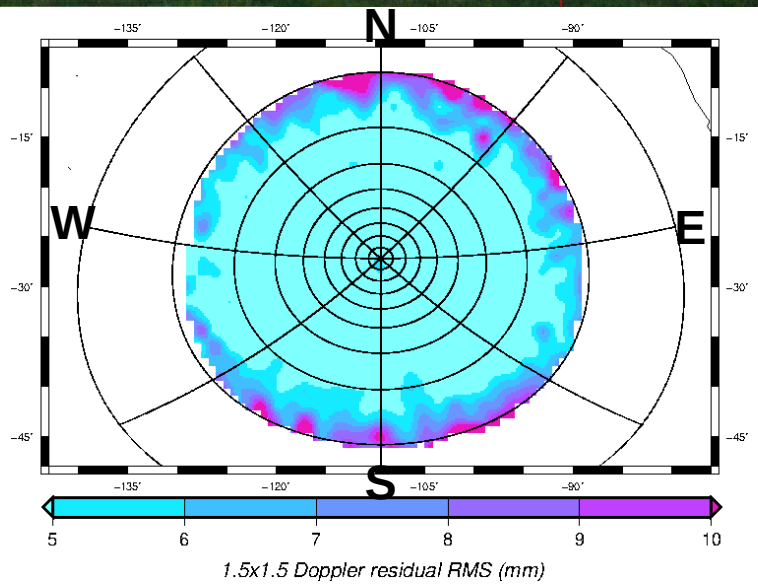


HROC



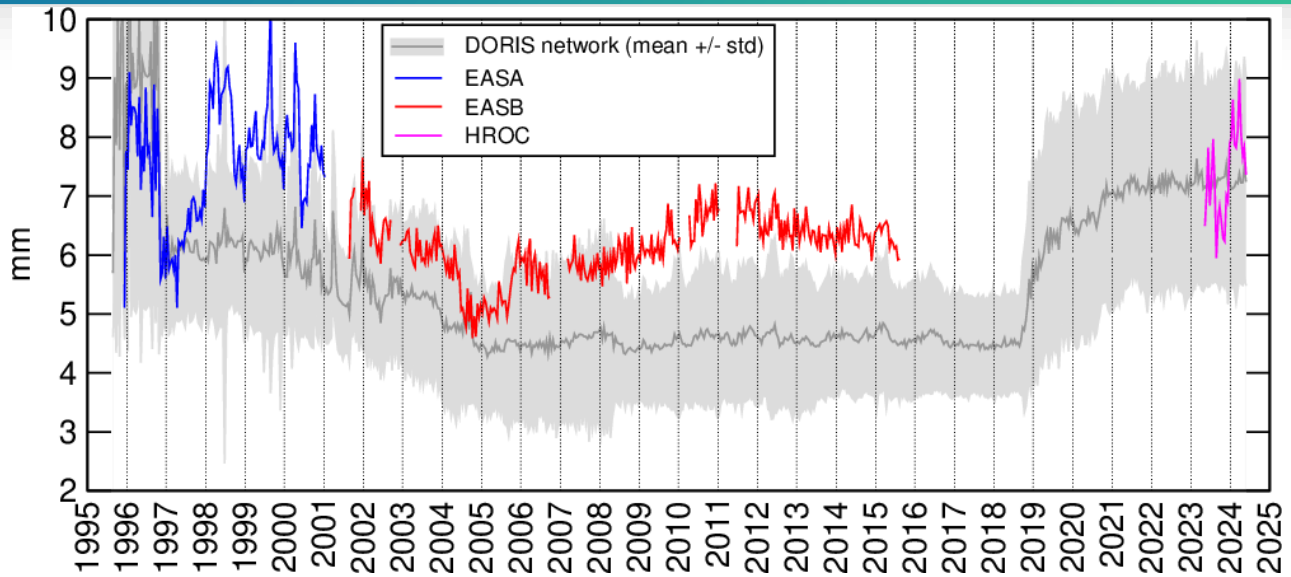
SPOT5
July-Nov. 2009

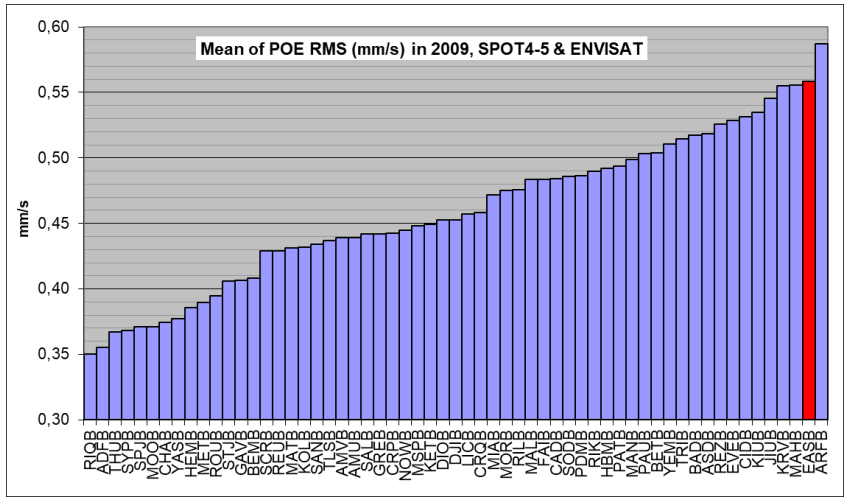


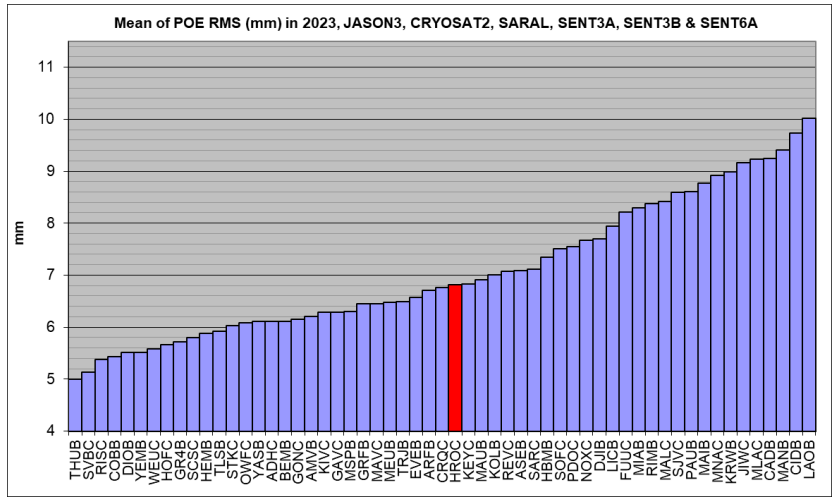


SARAL
May 2023 – May 2024

Hanga-Roa


DORIS network (mean +/- std)
EASA
EASB
HROC
mm


Mean of POE RMS (mm/s) in 2009, SPOT4-5 & ENVISAT
mm/s


Mean of POE RMS (mm) in 2023, JASON3, CRYOSAT2, SARAL, SENT3A, SENT3B & SENT6A
mm

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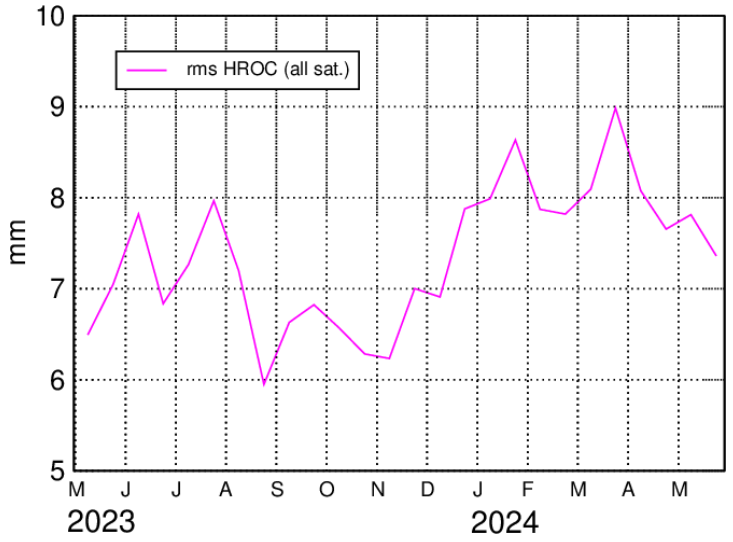
Hanga-Roa & Saint-Helena

HROC



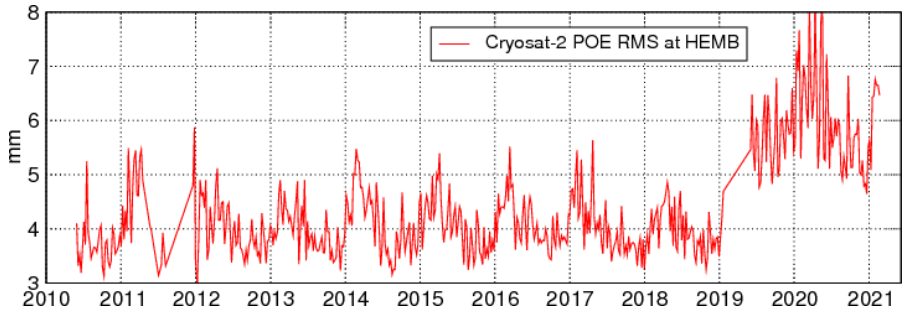
https://www.meteoblue.com

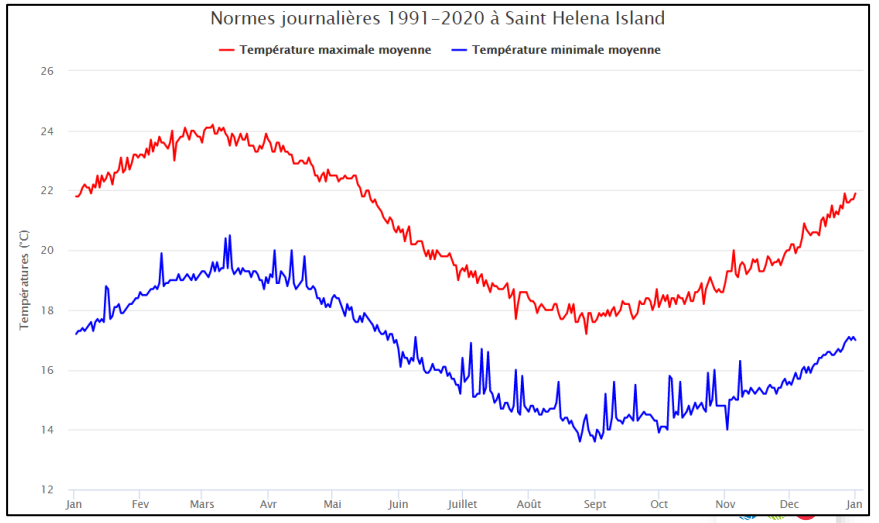
Correlation of the RMS evolution with the mean temperature.

\+ low elevation affected

➔ Mismodelling of the **tropospheric** correction

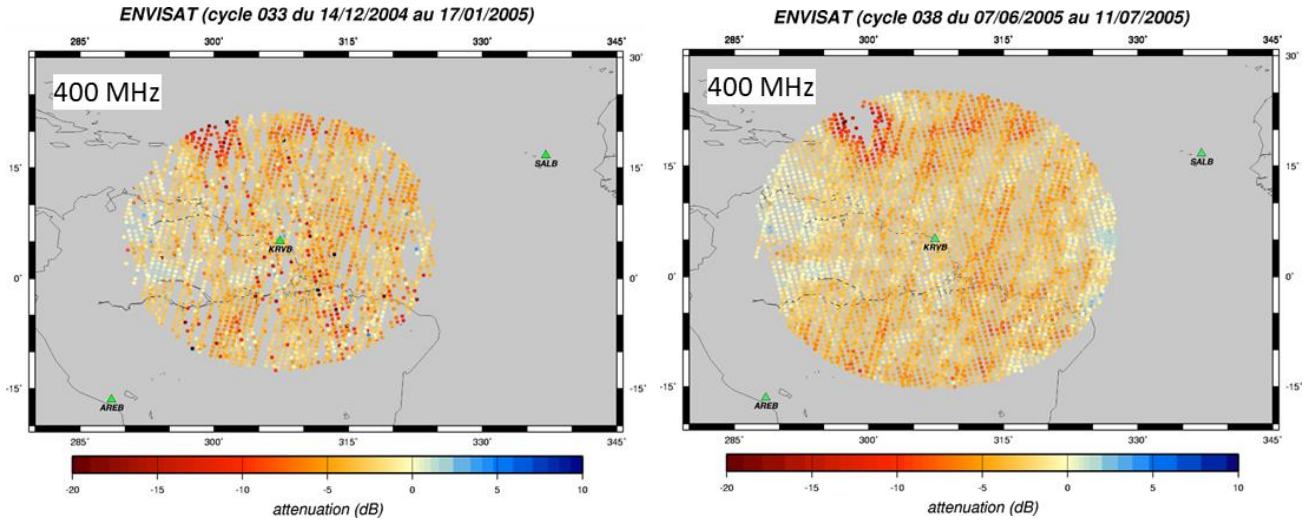
HEMB





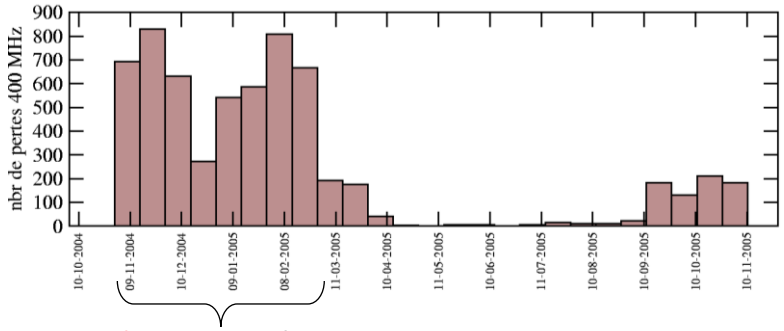
Kourou

The signal power attenuation is more perturbed from December/January than in June/July. Moreover, many passes are missing in Dec./Jan.



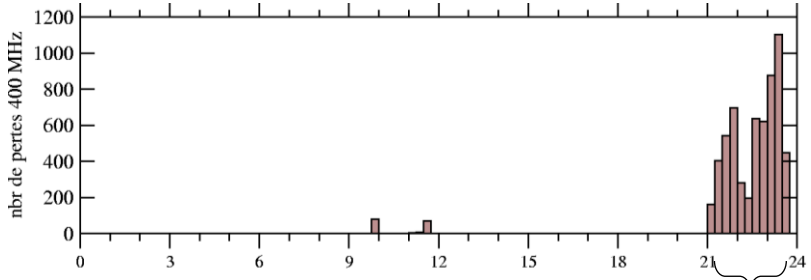
All these observations are typical of **ionospheric scintillations** in the region of South America.
See also the presentation from M. Cherrier (session 12.5) for more recent results

15 days signal losses on SPOT5
Oct. 2004 – Nov. 2005



More losses on the 400 MHz channel from Nov. To Feb.

Signal losses on SPOT5 vs. local hour
Oct. 2004 – Nov. 2005



More losses on the 400 MHz channel after the sunset

Conclusions

❖ Regular assessment of DORIS station quality

- This work has been performed **for almost 20 years**
- Allows to raise or confirm **modifications or specificity in the environment** for some stations

❖ Summary of the perturbation causes

A radio signal may be degraded or lost by:

- Plain mask (building, mountain,…):
  - no data: **obstruction**
  - degradation in the edge of the mask: **diffraction**
- Translucent medium (vegetation): degradation: **refraction**
- Reflection on the ground: **multipaths**
- Poor propagation in the medium: **tropospheric** & **ionospheric** disturbances

(+ radio-interference, not discussed here)

❖ 4th generation beacon (B4G)

- **On-going replacement** of the 3rd generation beacons (B3G)
- Allow **more flexible installation** of the antenna
- Seems to provide **slightly better results** than B3G