

Absolute Quantum Gravimeter as a promising field sensor for volcano monitoring



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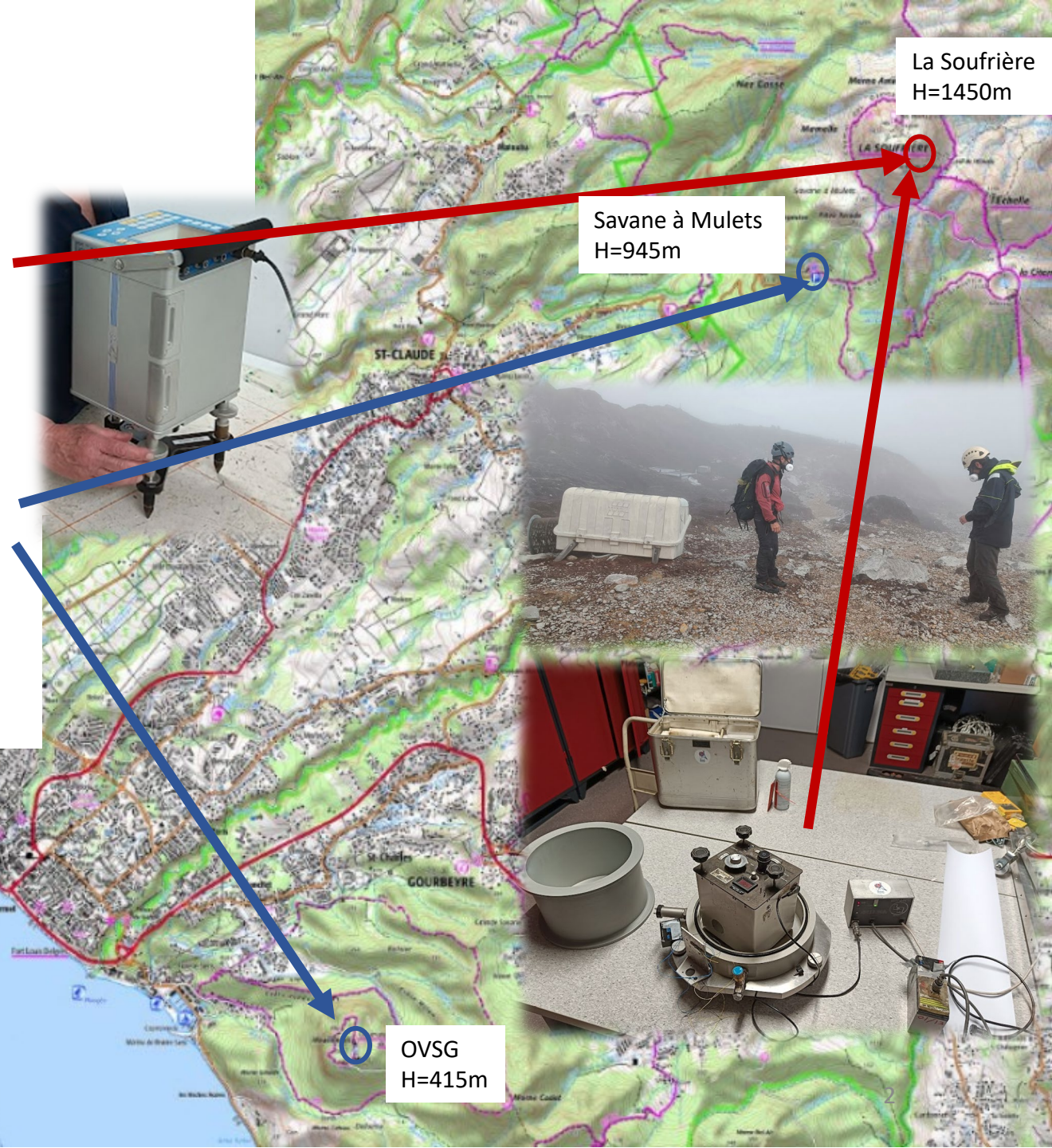
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The Guadeloupe field mission

Objectives

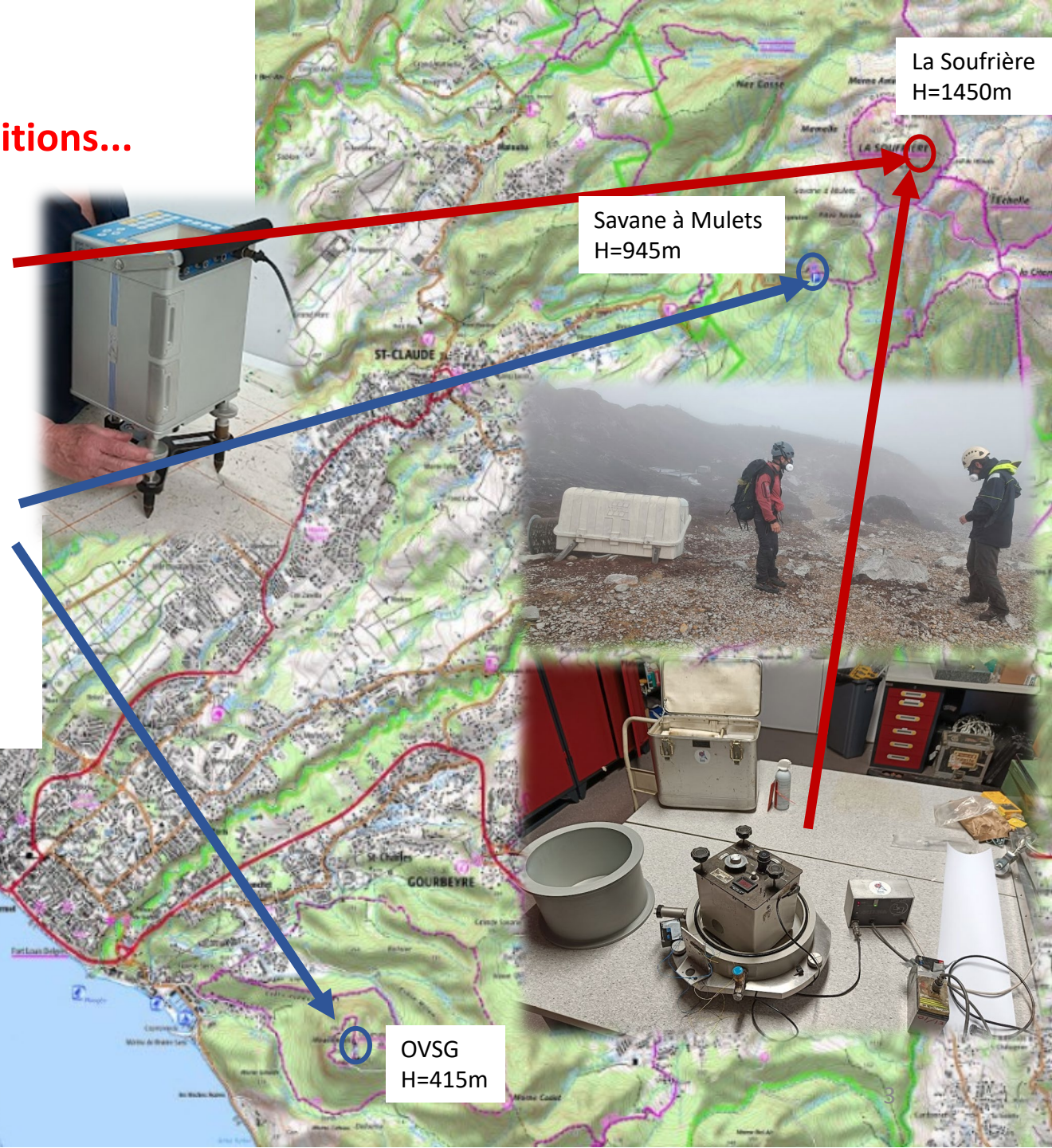
- 1) Identify a site to install a permanent gravity station (L&R D meter, tiltmeters, pressure gauge) at the summit
- 2) Retrieve and reoccupy the sites of the micro-gravimetric network with a CG5
- 3) Conduct absolute gravity measurements at the Volcanological and Seismological Observatory of Guadeloupe (OVSG) + Savane à Mulets with an AQG.
 - ➔ Field testing of the AQG-B01
 - ➔ Can it be operated by anyone?
- 4) Compare AQG and previous A10#14 measurements.



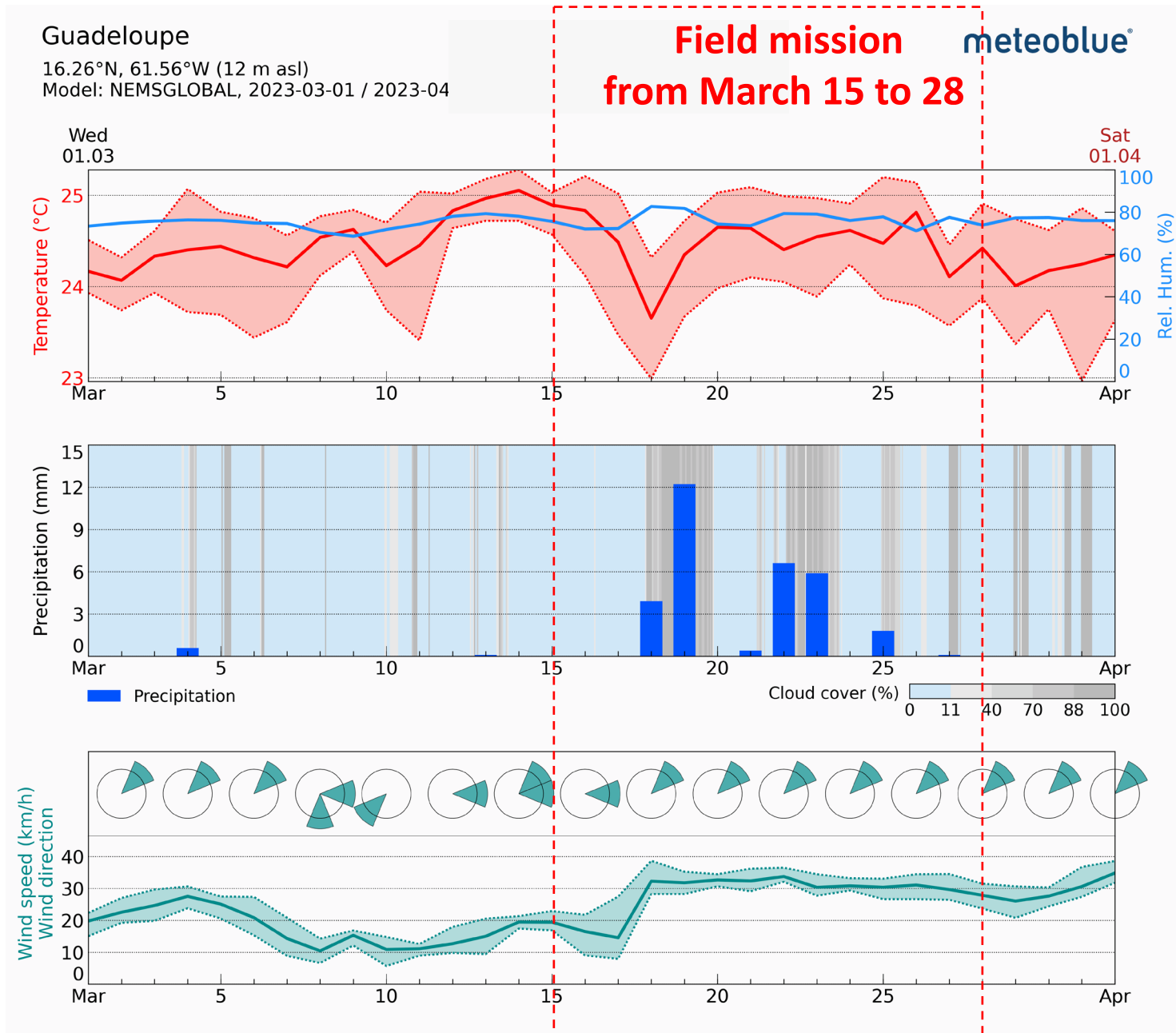
The Guadeloupe field mission

Overall objectives achieved despite the weather conditions...

- 1) Identify a site to install a permanent gravity station (L&R D meter, tiltmeters, pressure gauge) at the summit
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The vagaries of the weather: a well-known but unpredictable major factor in scientific field campaigns



Standard weather conditions

- **<Temperature>** = 24.5°C
- **Relative humidity** 80%

Field mission conditions

- **Heavy rainfall** (up to 12 mm)
- **Sustained winds** (up to 40 km/h)
- **Gusts reaching** 70 km/h

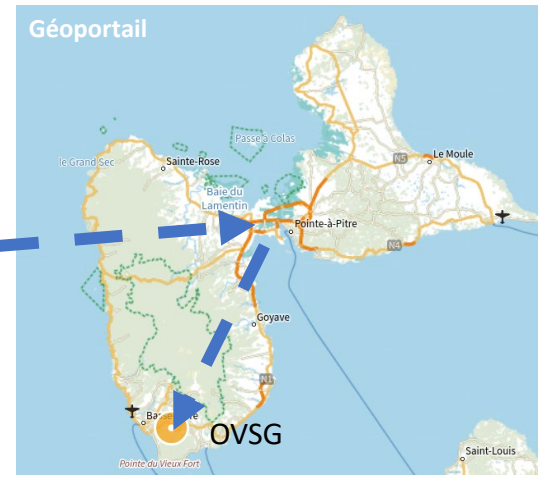
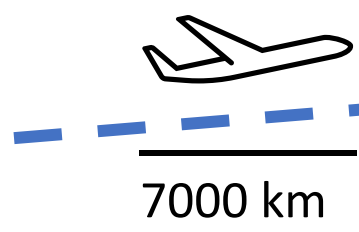
Packaging and transportation



Packaging at LNE Trappes (20/12/2022)



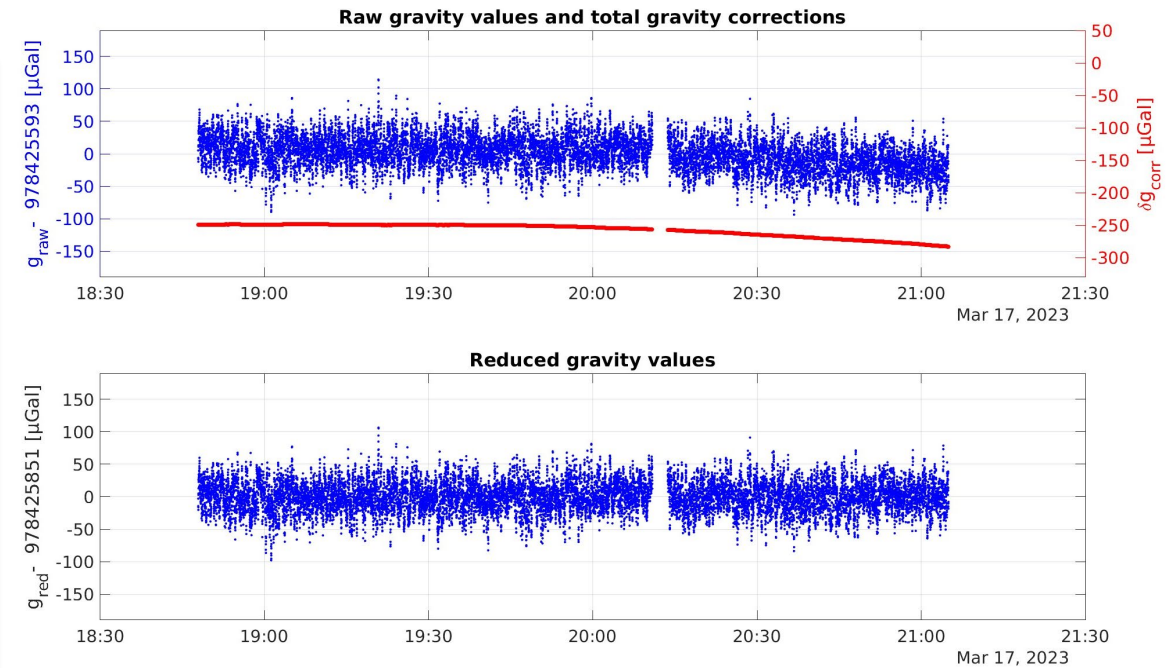
Departure from Trappes (28/01/2023)



Arrival at OVSG Guadeloupe (13/02/2023)

Unpacking – installation – check up

OVSG



First startup after 3 months of shutdown

- **Integrity of the units** after transportation (7000 km) by air and road => **OK**
- **Ability to install the instrument and start it up** (< 45') => **OK**
- **Instrument's capability to become operational** after a long period of dormancy and in different conditions (thermalization 1 night) => **OK**

First gravity measurements on the pillar at OVSG basement

From Diament et al. (2024), in press



Power supply plugs on the standard power outlet

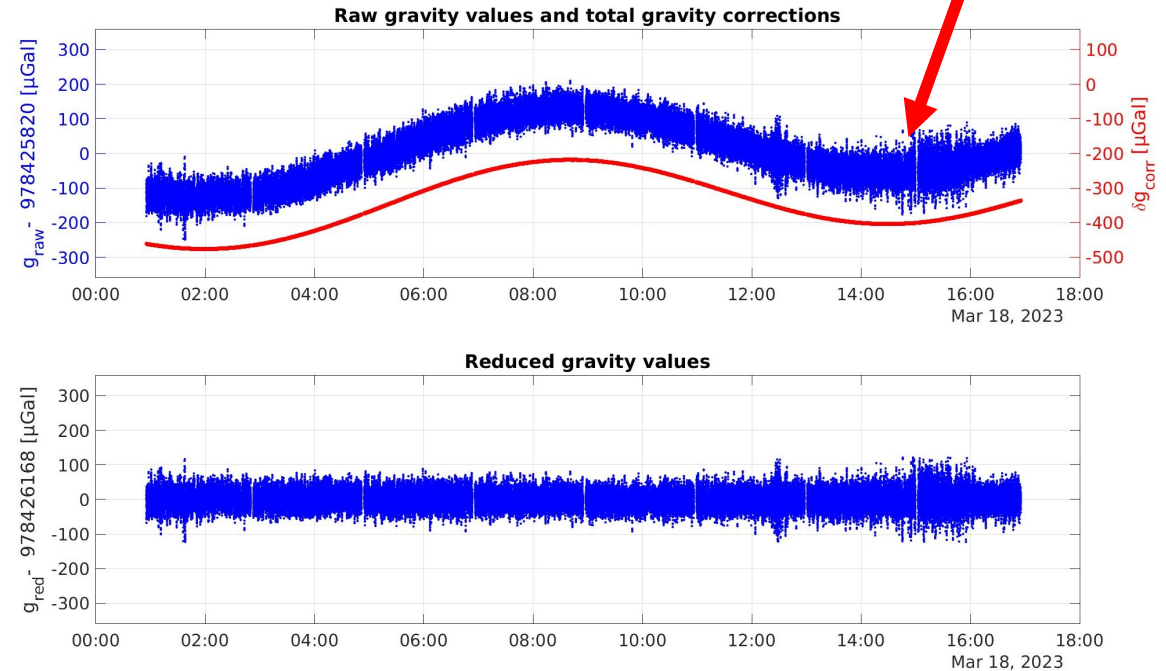


CG5 meter

- Sensitivity at 1 sec $\approx 60 \mu\text{Gal}$
- Sensitivity at 1 h $\approx 1 \mu\text{Gal}$
- Deviation between the values from AQG-B01 and A10#14 are close to the uncertainty of the meters ($15 \mu\text{Gal}$)

The site is a good reference for the gravity monitoring of La Soufrière

Heavy precipitation and strong winds

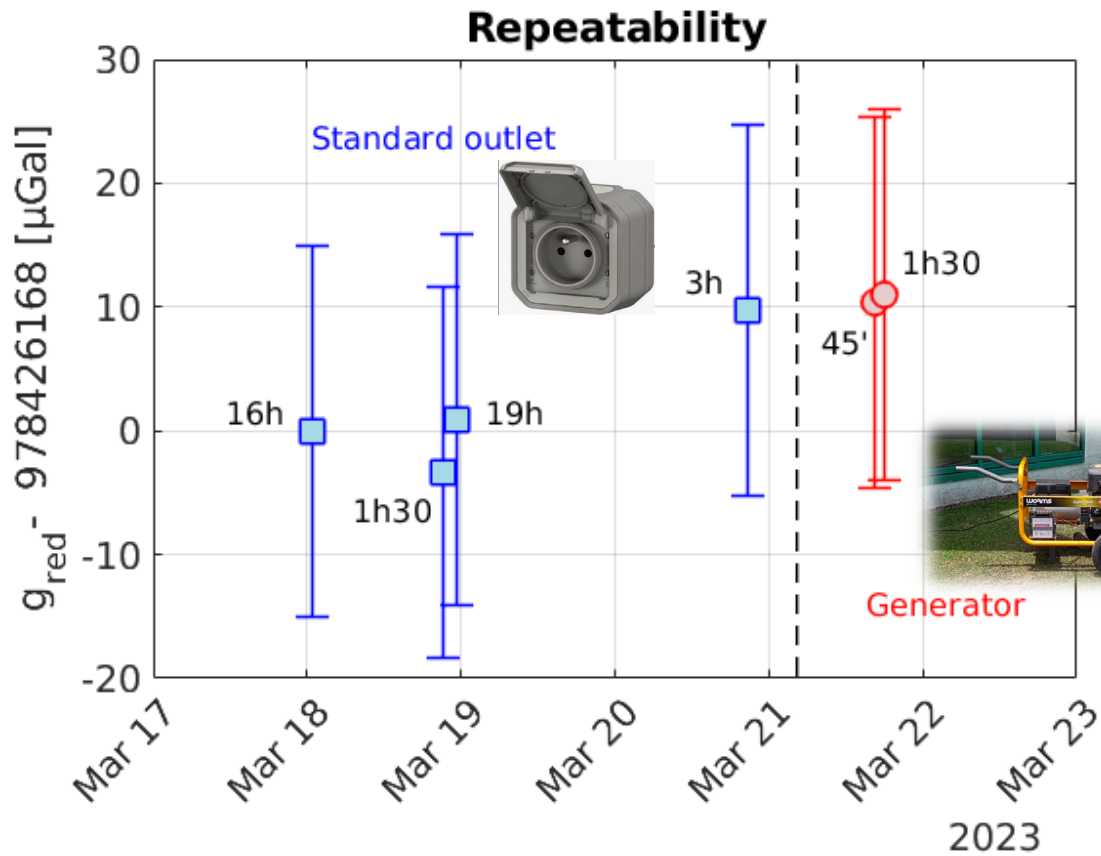


Campaign	Gravimeter	g value [μGal] @h_A10=71.8 cm
18/03/2023	AQG-B01	978425878
26/04/2014	A10#14	978425898
03/06/2013	A10#14	978425901
21/06/2011	A10#14	978425891

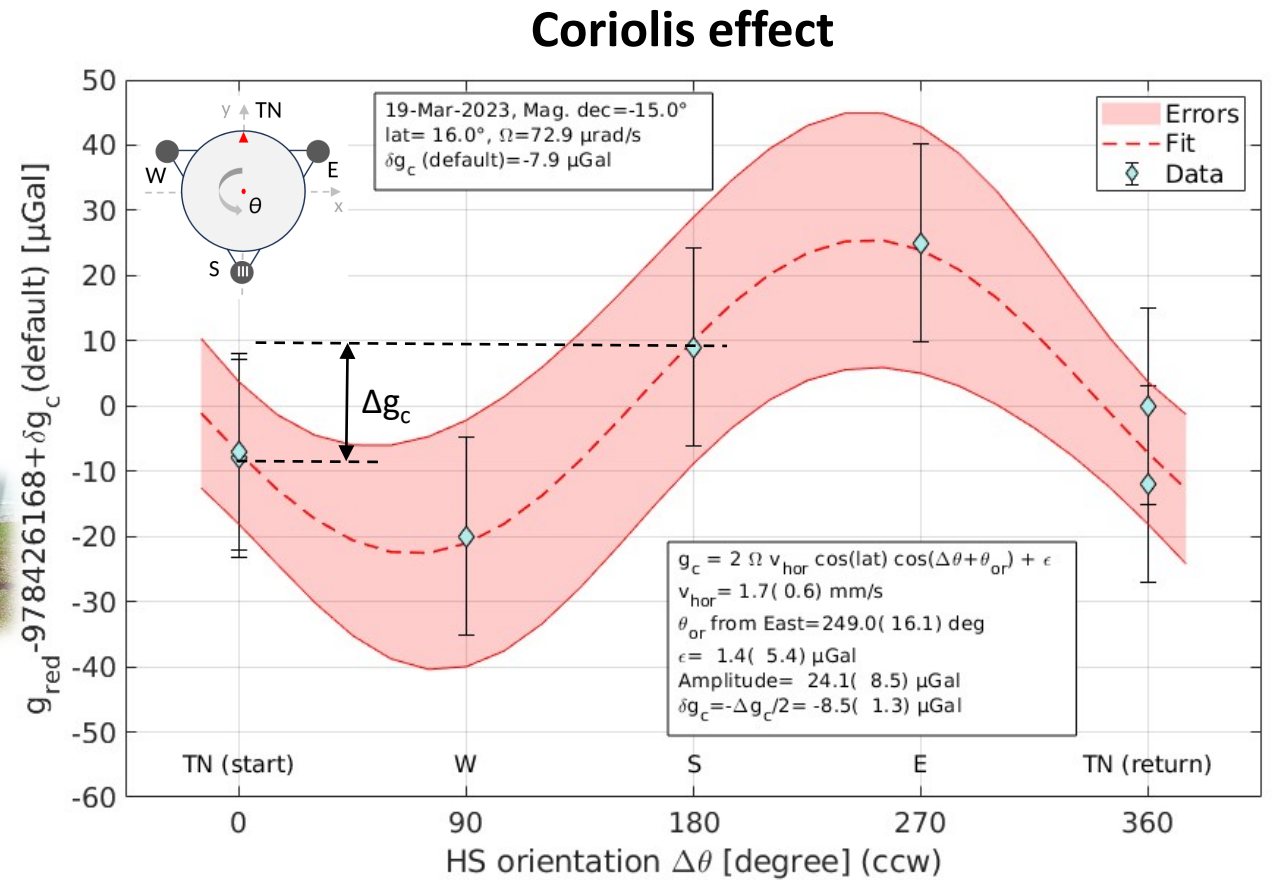
Deviation $\approx 12\text{-}22 \mu\text{Gal}$
Time elapsed ≈ 10 years

Indoor: seismological pillar at OVSIG

- **Repeatability tests** in the North direction with an agreement better than 10 μGal
- **Coriolis effect**: sensor head orientation's effect at low latitude
- **Testing power supply mode**: no difference between a **standard power outlet** and a **generator**



From Diament et al. (2024), in press



With AQG-mTools (Lion et al., in prep.)

Outdoor measurements at OVSG

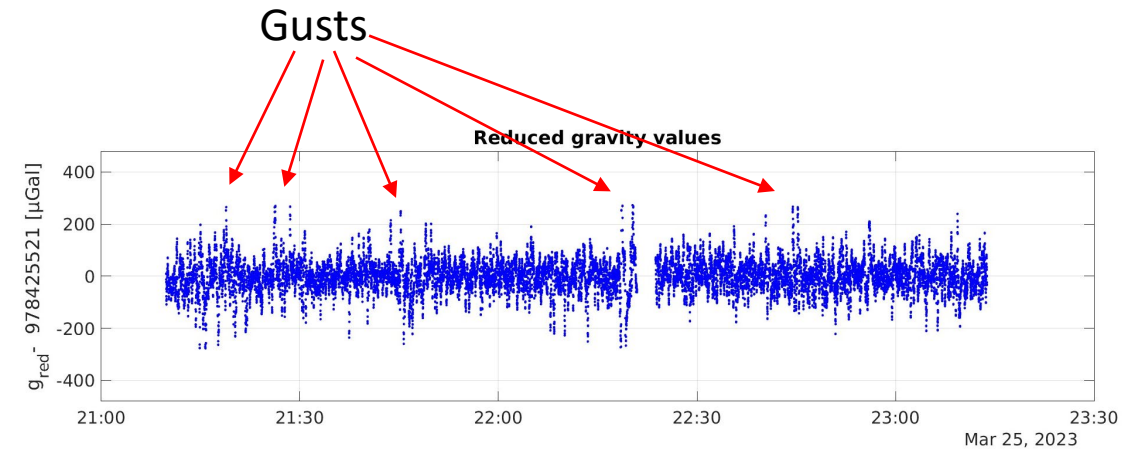


- Power supply connected to the generator
- Intermittent rain every 15 minutes, followed by strong sunshine
- Regular wind (20 km/h) with gusts (up to 70 km/h)

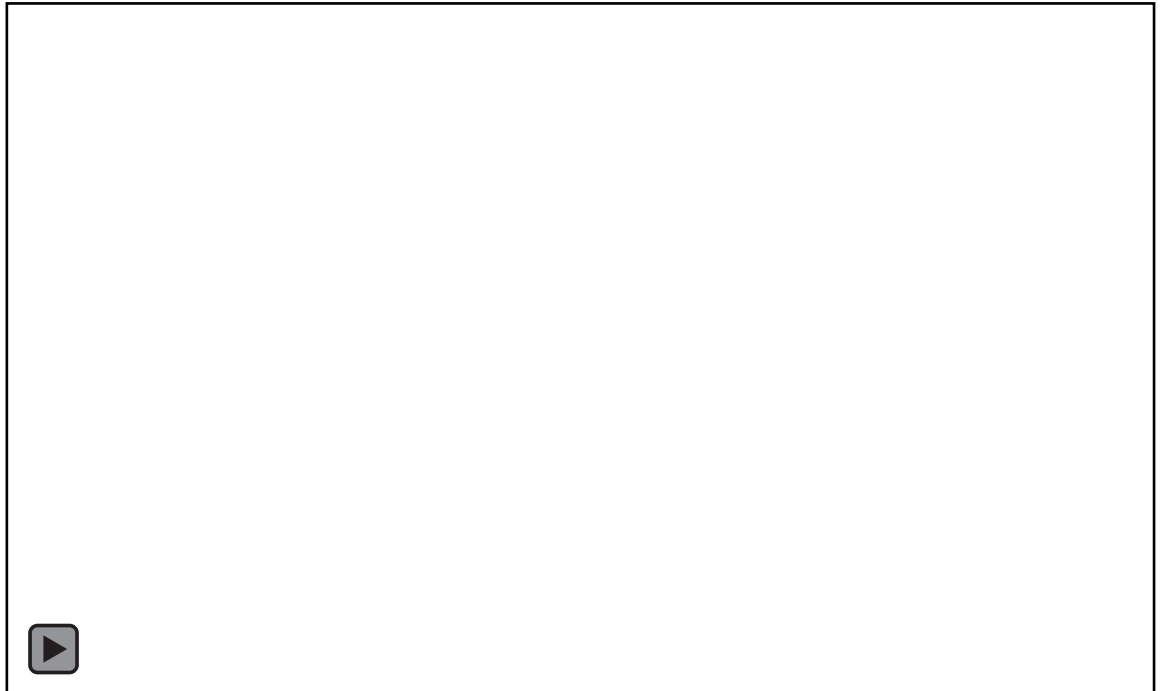
➔ The fiber and cables are weighted and secured

➔ The AQG is protected

➔ Sensitivity $\approx 3 \mu\text{Gal}$ @1h



A day of "normal" weather condition (video)



Measurements close to the summit of the volcano

Unfavorable weather conditions...



Generator



Utility van



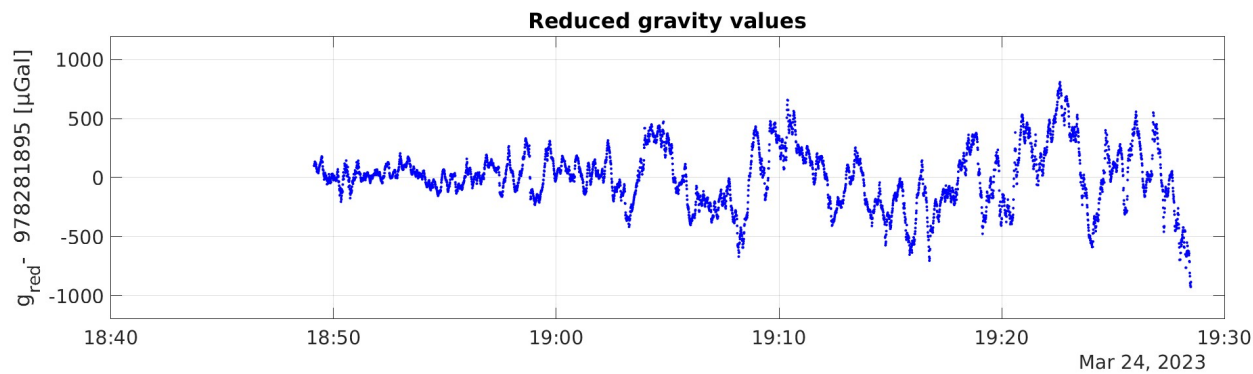
Wind, rain, sun protection



AQG-B01



CG5

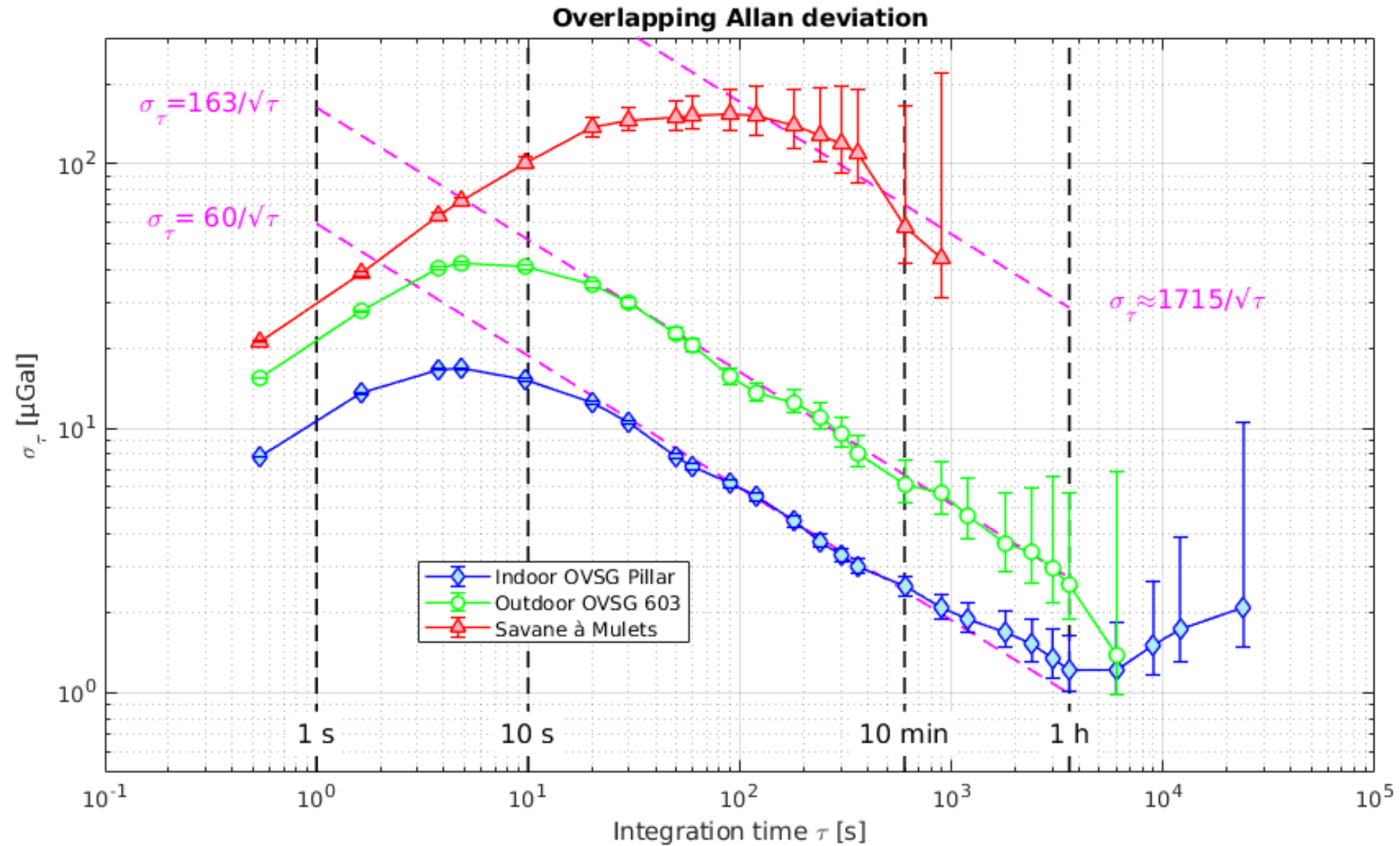


➔ Stability problem due to several strong gusts of wind

Decrease in g related to the observed recent heating of La Soufrière hydrothermal system ?

Campaign	Gravimeter	g value [μGal] @h_A10=71.8 cm
2023	AQG-B01	978281625
2019	A10#14	978281745
2014	A10#14	978281729
2013	A10#14	978281921
2011	A10#14	978281862

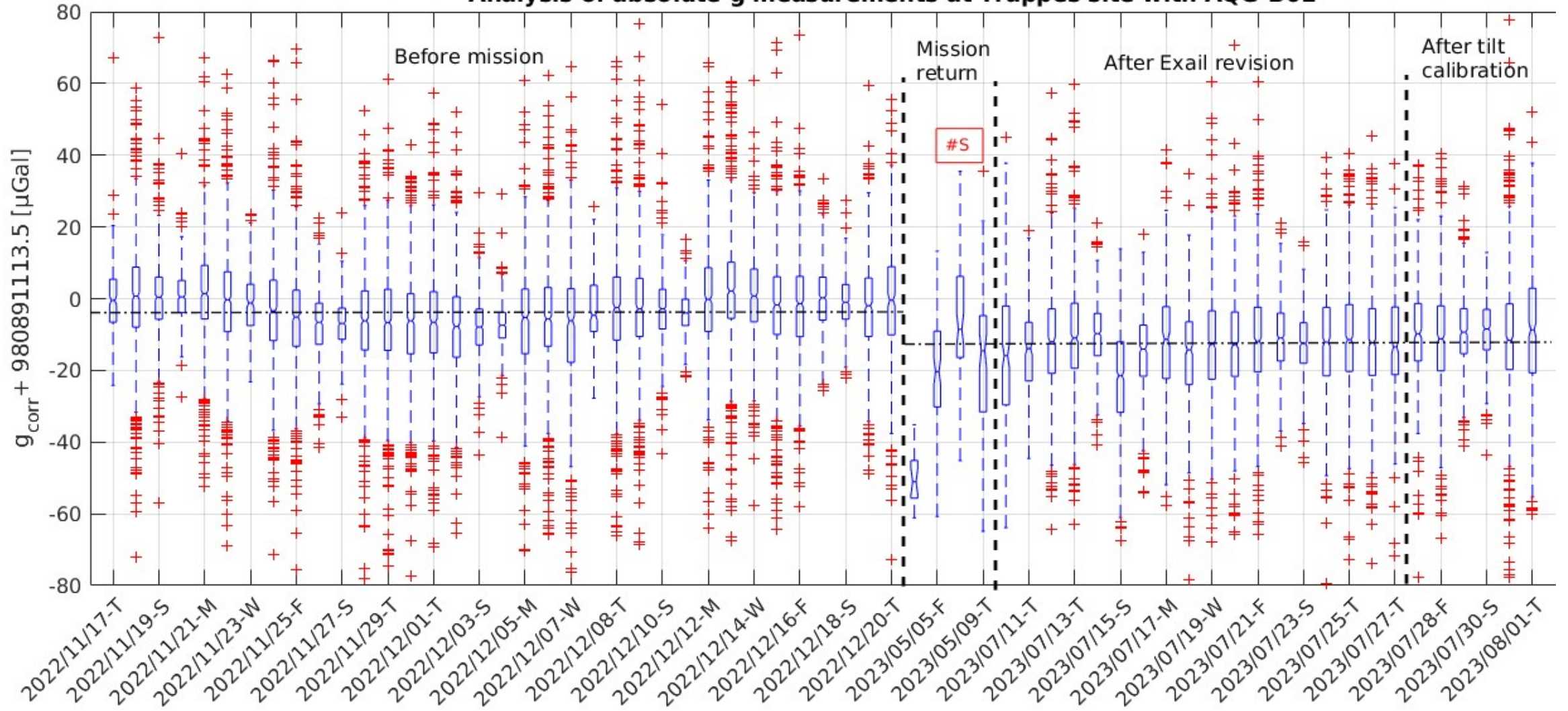
AQG sensitivity under various acquisition conditions



Results from Diament et al. (2024), accepted in IEEE & IMM

Return-back measurements at Trappes (close to Paris - France)

Analysis of absolute g measurements at Trappes site with AQG-B01



Shift about 10 μGal
No explanation yet

Summarized

- ✓ The first Absolute Quantum Gravimeter (version B) produced by Exail for field measurements
 - Is easy to operate
 - Is transportable over long distance and hard trails
 - Can measure on adverse weather conditions
 - Can make 1 point every 2 hours with few μGal sensitivity
 - Can help to survey a volcano

✓ Results in [Diament et al. \(2024\)](#), in press in IEEE & IMM, available in September 2024

- ✓ A user-friendly software, AQG-mTools, has been developed in Matlab. A forthcoming paper by [Lion et al.](#) is in prep. -> **The tools will be soon openly accessible on Github** (or upon request for now)
- Minor points have been addressed to Exail: better connector protection, packaging improvement for transport, a new tripod orientation mechanism, etc.
- Additional tests need to be conducted to :
 - analyze the behavior of the AQG under the influence of wind on both the fiber and the modules embedded within the utility van
 - Understand the jumps of $10 \mu\text{Gal}$