Impact of accelerometer modelling and parameterization on the BepiColombo orbit determination and gravimetry experiment

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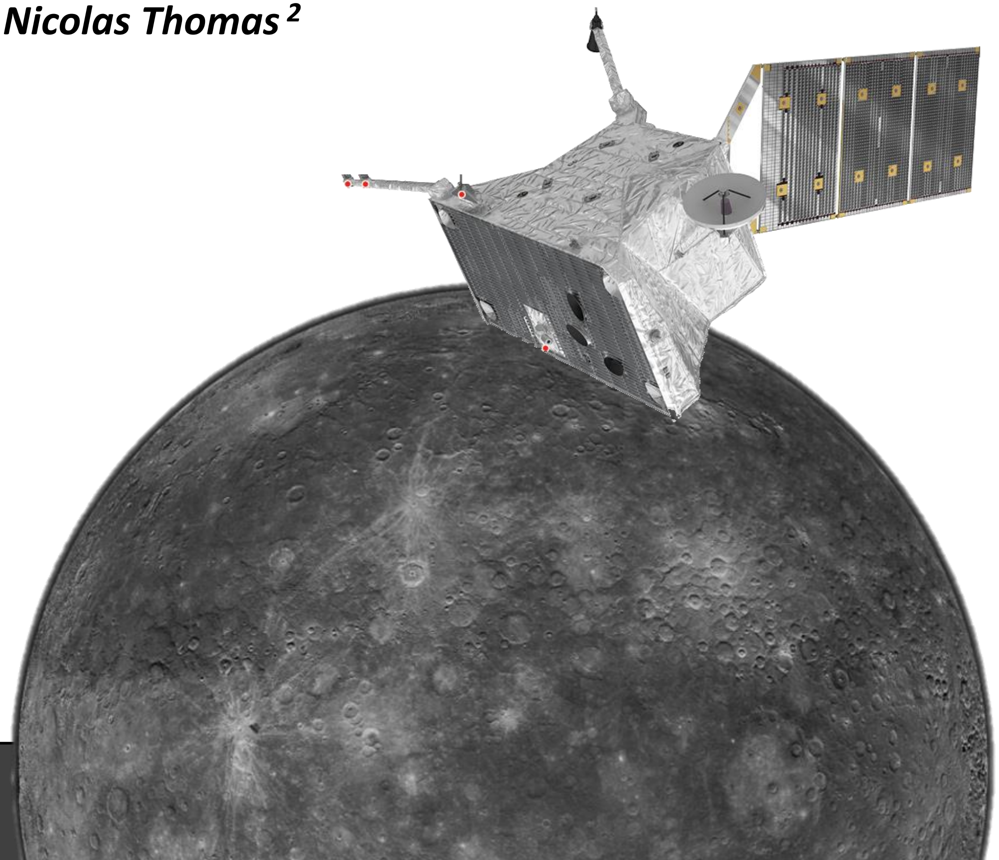

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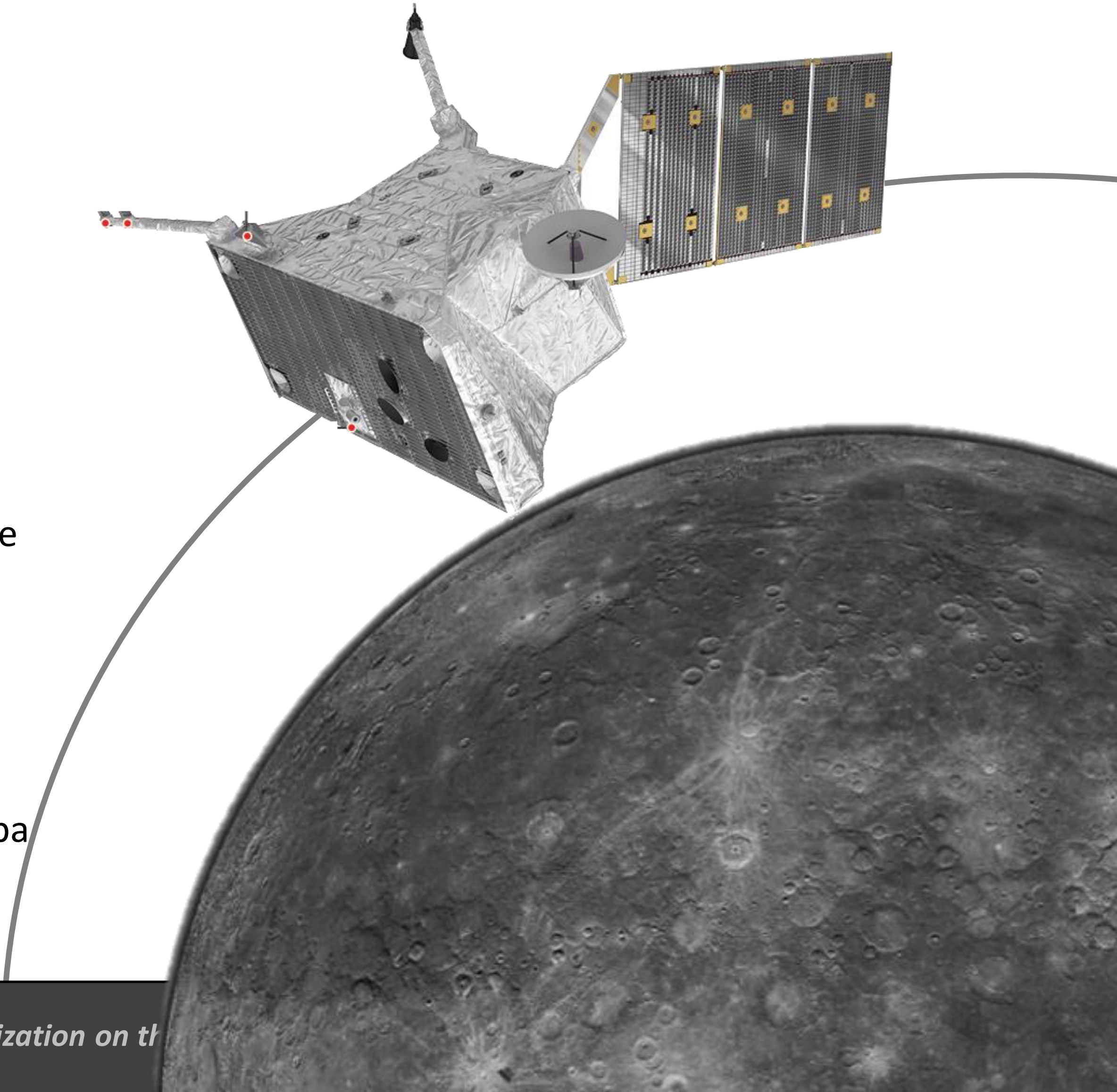
Introduction

Mission:
BepiColombo mission
Launch: October 2018
Arrival to Mercury: Dec. 2025
MPO: Mercury planetary orbiter

Relevant on-board instruments:
ISA: Italian Spring Accelerometer
MORE: Mercury Orbiter Radio-science Experiment

Goal of the study:
Impact of accelerometer noise modelling and its parameterization on the MPO orbit determination and gravimetry experiment

Tool:
Planetary extension of **Bernese GNSS software**
Developed at the Astronomical institute of the University of Bern
Also used for planetary POD for GRAIL and for mission concepts at Europa



Model description

Simulation

Force model:

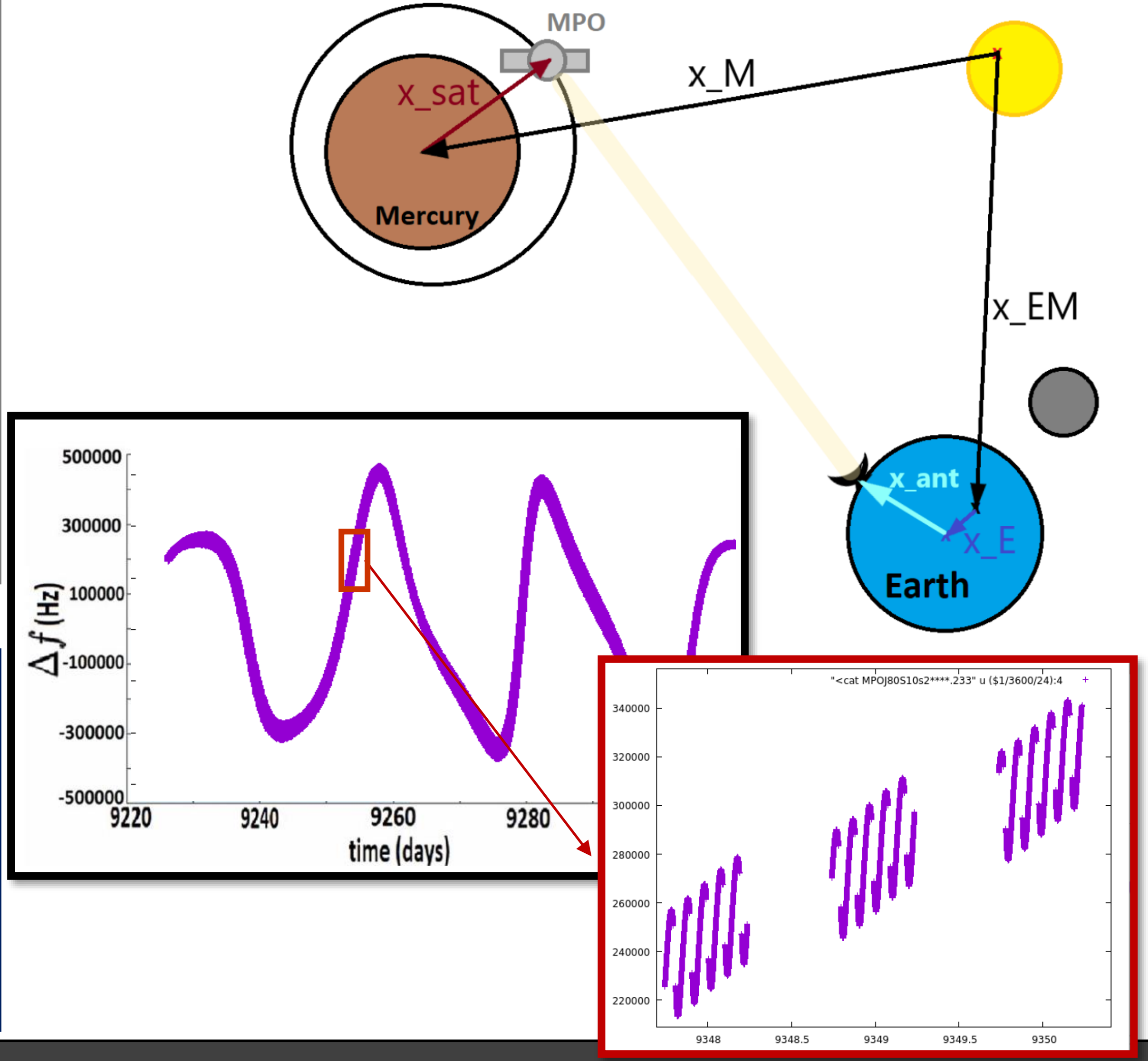
- Mercury gravity field HGM050 d/o 50
- Sun and planets third body gravitational perturbation
- Tidal perturbations (Sun)
- Solar and planetary radiation pressure

Simulation of Doppler observations:

- 2-way X-band and K-band
- White noise on the observations
- Station and planetary eclipses

Simulation of accelerometer measurements:

- White and colored noise based on ISA team publications
- Random biases are added to the accelerometer measurements (constant for every two weeks)



Parameter estimation

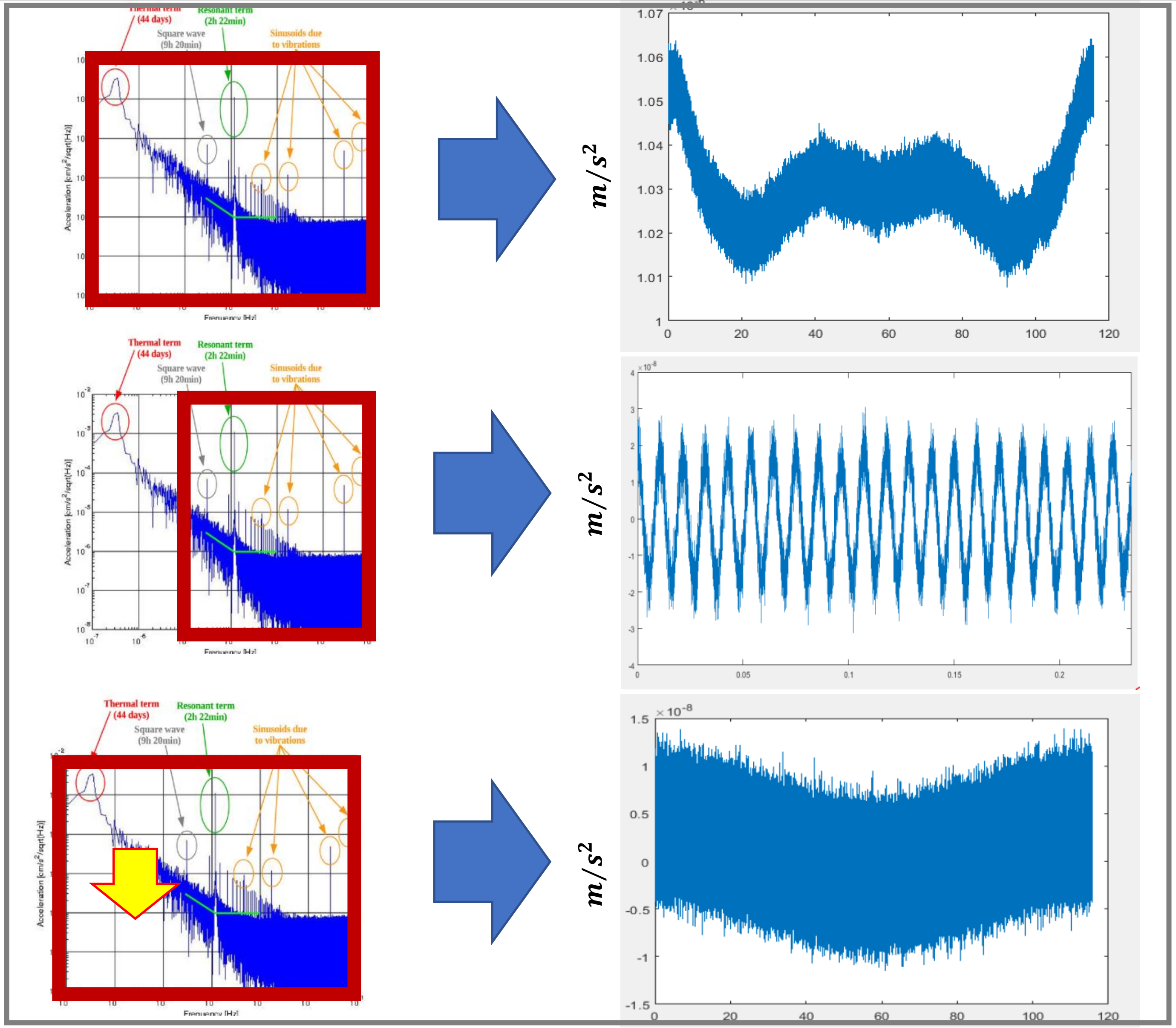
Assumptions:

- Error on the initial state vector of each arc
- NO knowledge of non-gravitational forces

We solve for:

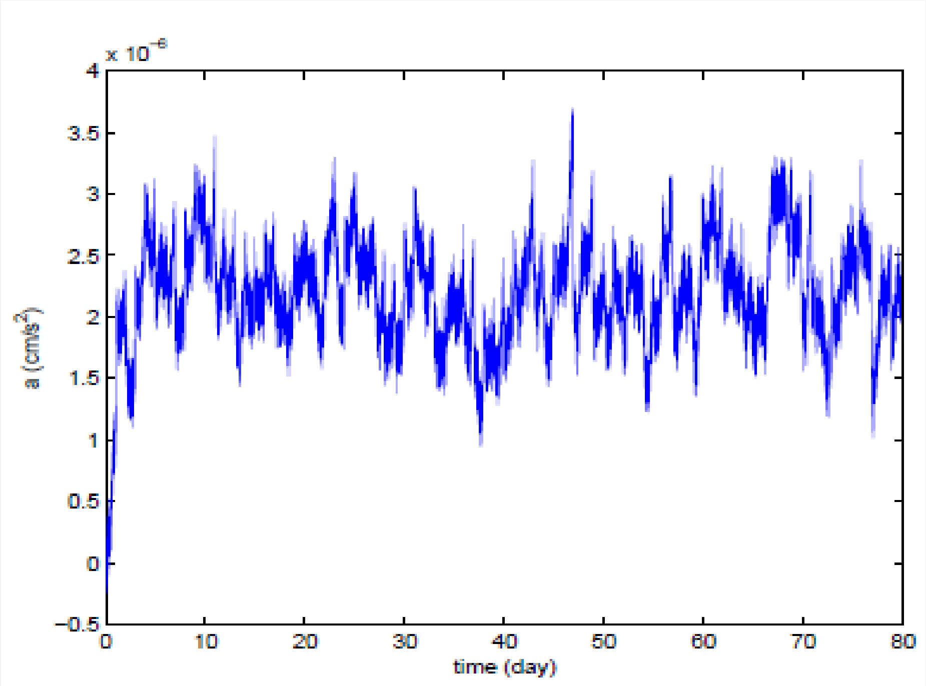
- Initial state vector of the arcs
- Coefficients of the gravity field
- Accelerometer parameters

Model description



$$A_{meas} \simeq B + S_f A_{true} + A_{noise}$$

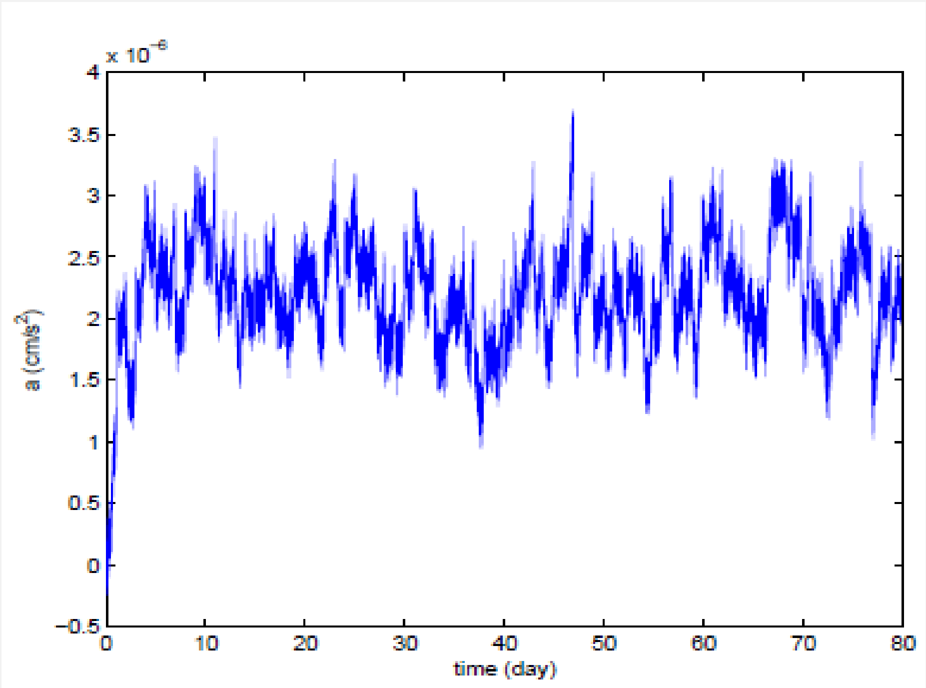
Alessi et al (2012)

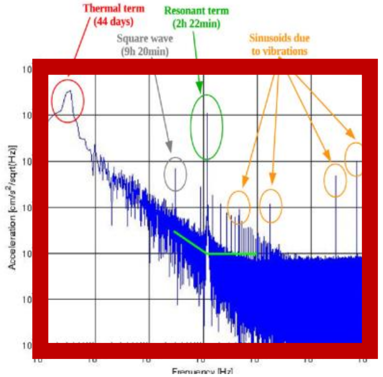


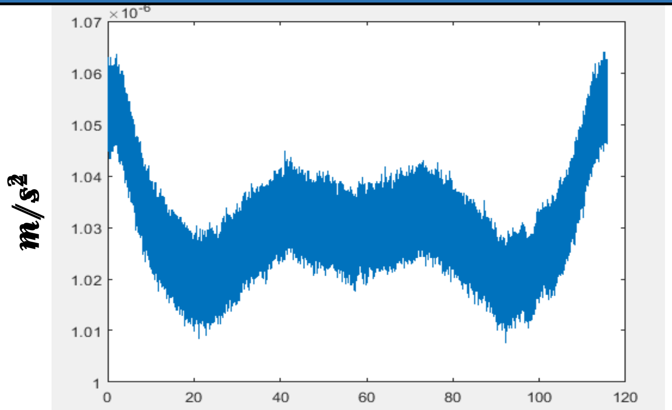
Model description

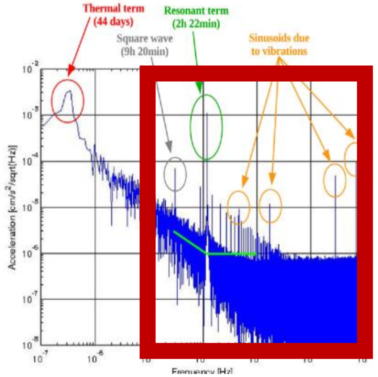
Accelerometer model

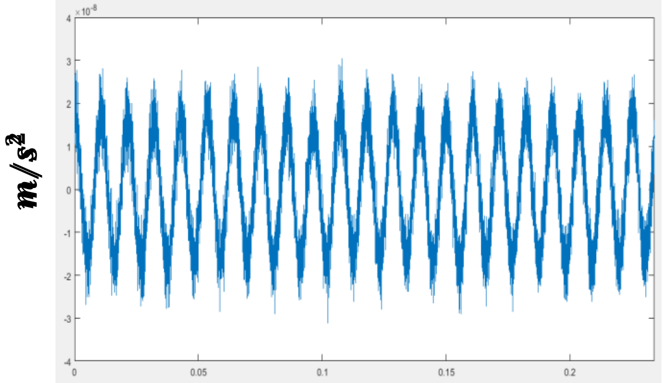
Alessi et al (2012)

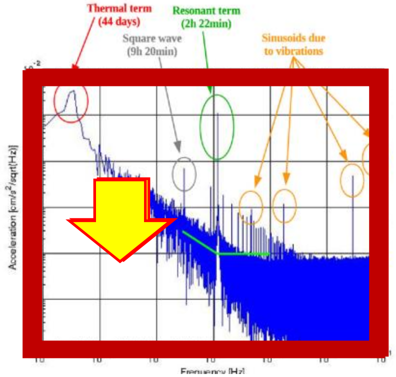


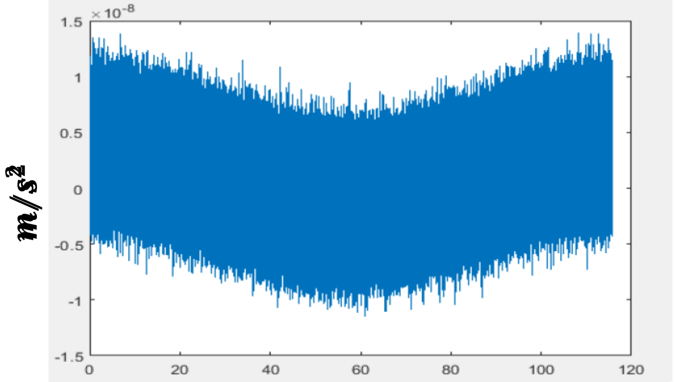








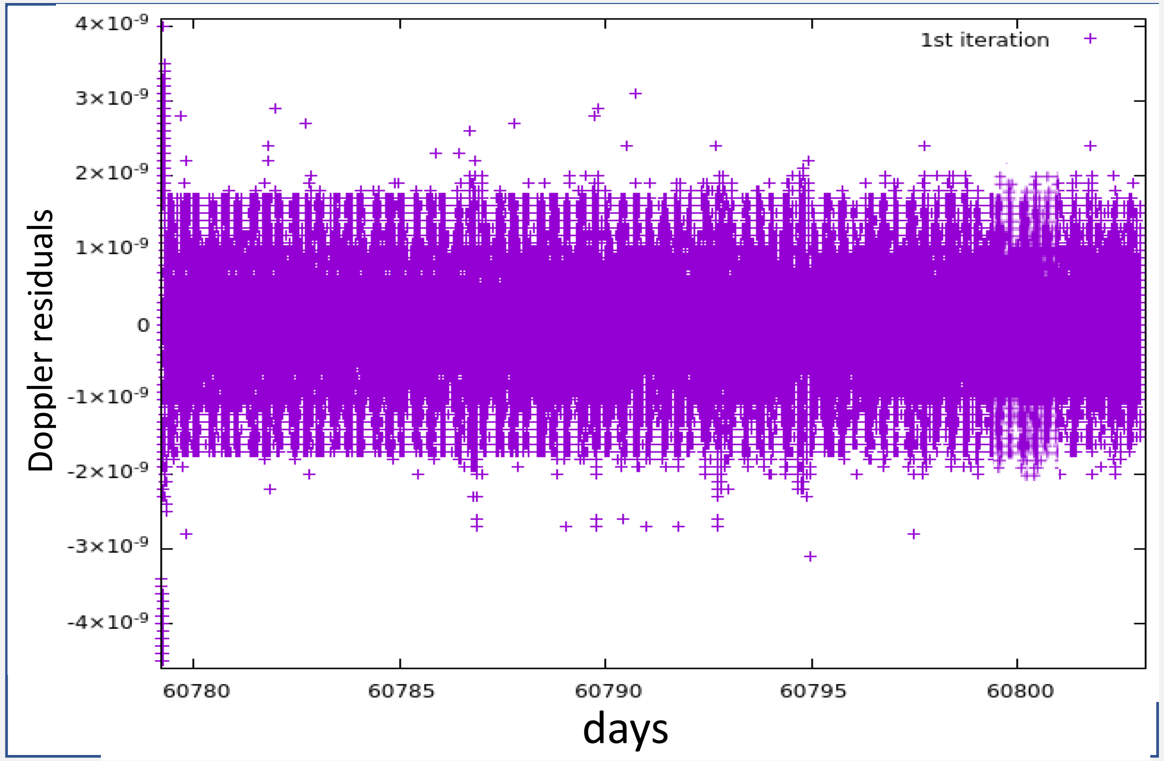




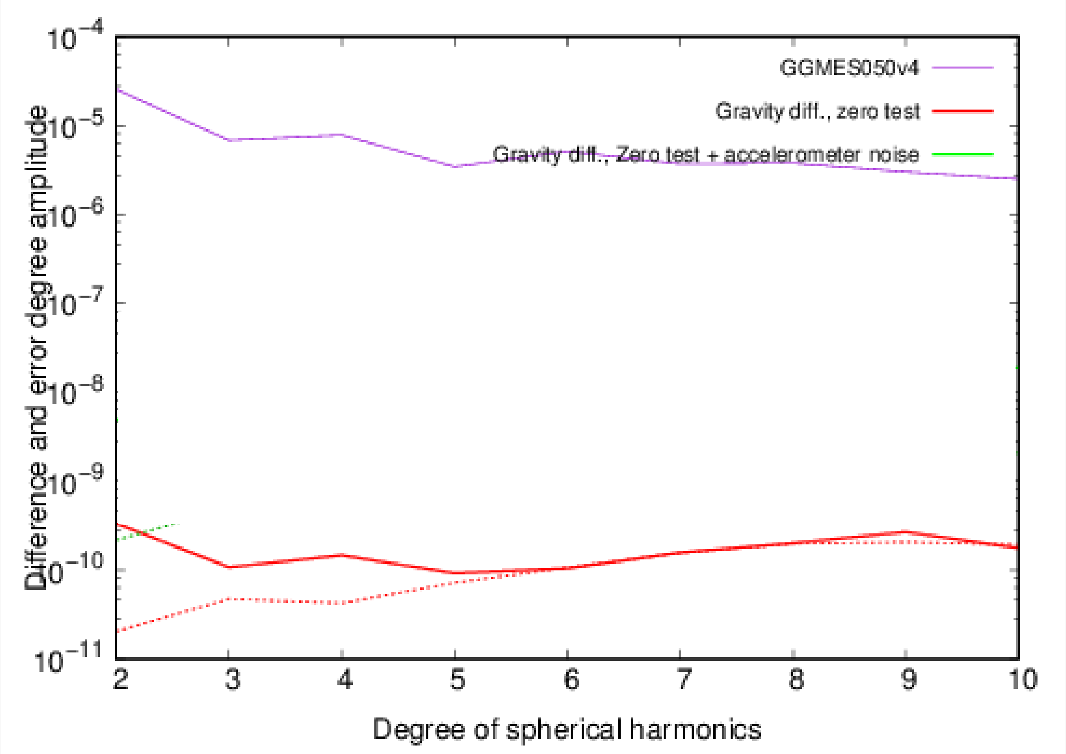
Model verification

Zero test: A test for model verification

- No Doppler noise, No initial condition error
- We use the same force model in simulation and parameter estimation
- Doppler residuals are in the order of 1E-5 Hz

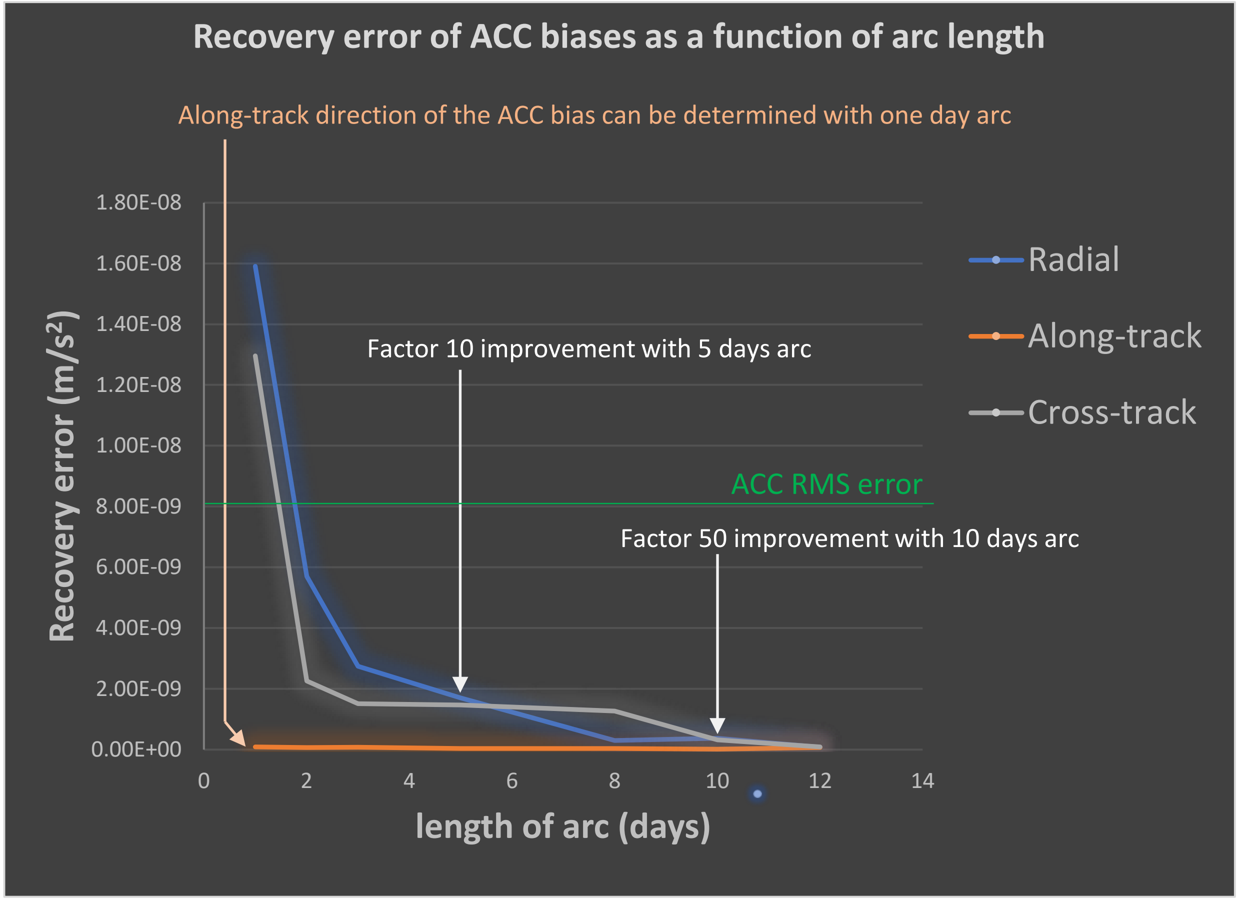


- A zero-test solution
- We use a gravity field with d/o 10 as synthetic reality as
- We use the same gravity field with d/o 10
- We use 1 month of Doppler observation
- We solve up to d/o 10
- Red: No Doppler noise, No initial error
- Green: Doppler noise , initial error

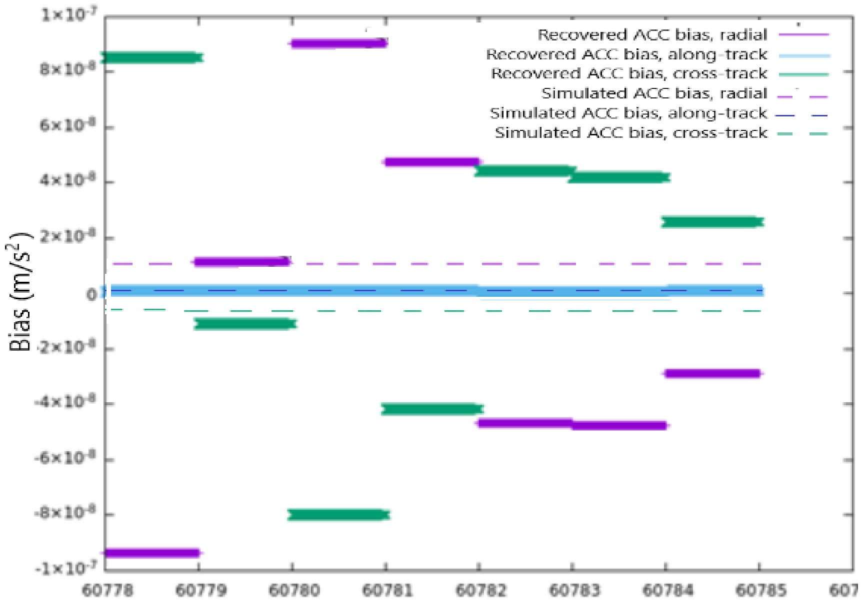


Sensitivity analysis

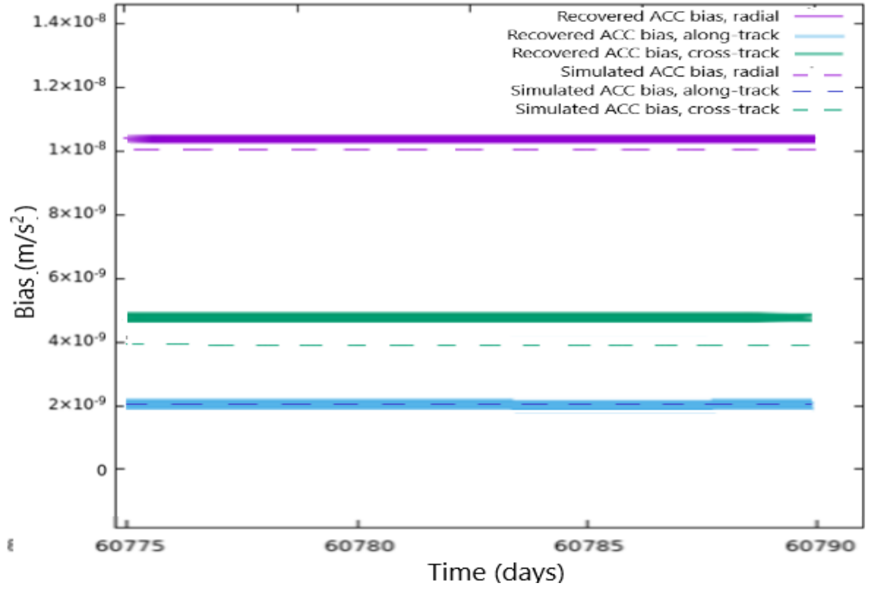
Recovery of the accelerometer parameters to the arc length



Recovery of ACC bias
Using 1 day of observation

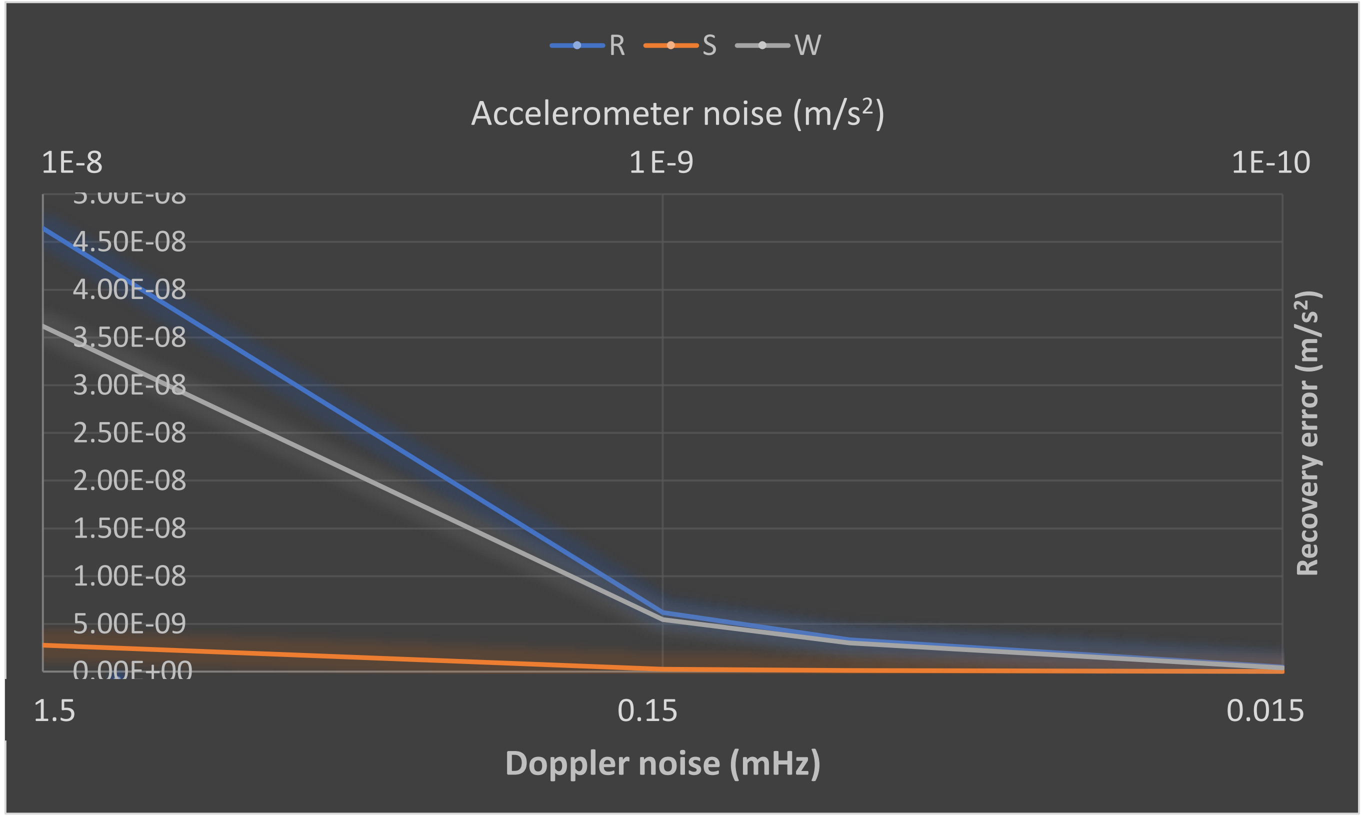


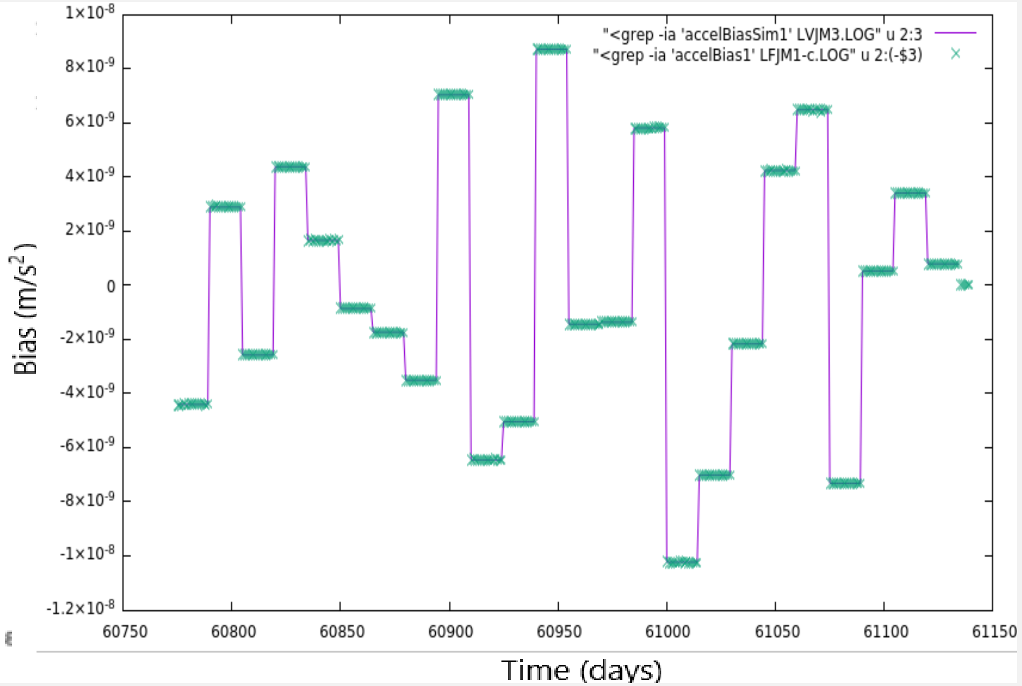
Recovery of ACC bias
Using 15 days of observation



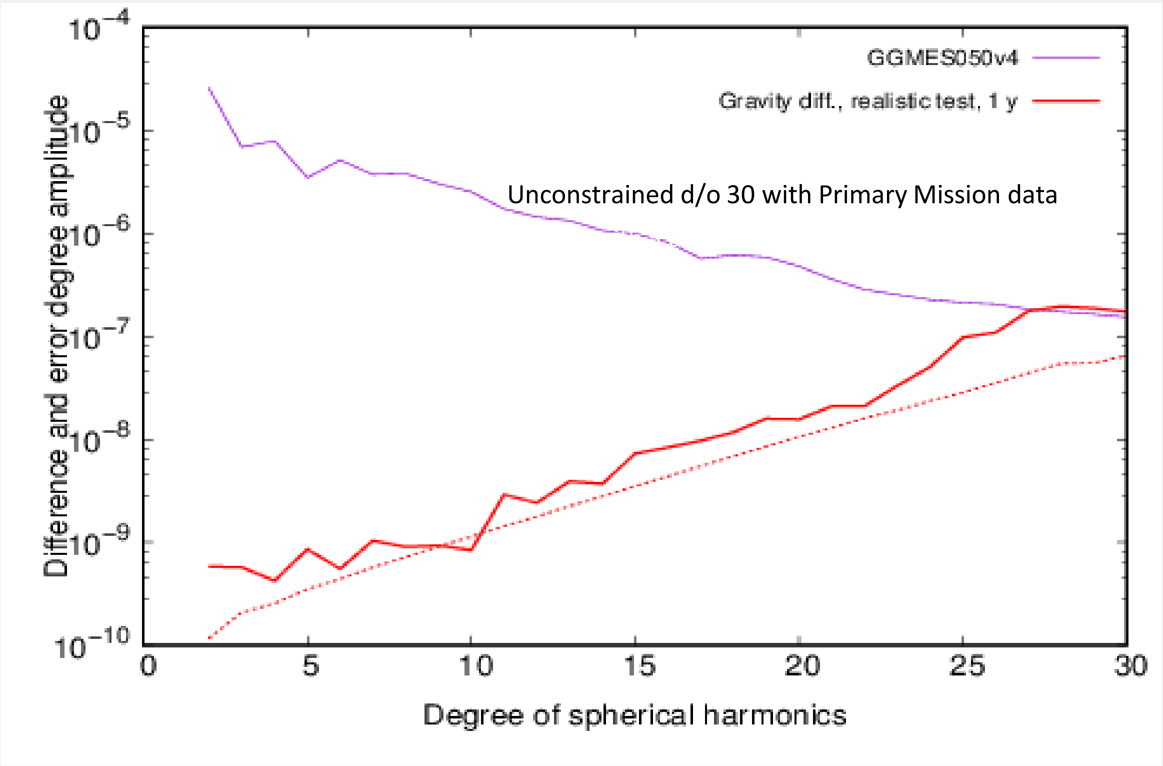
Sensitivity analysis

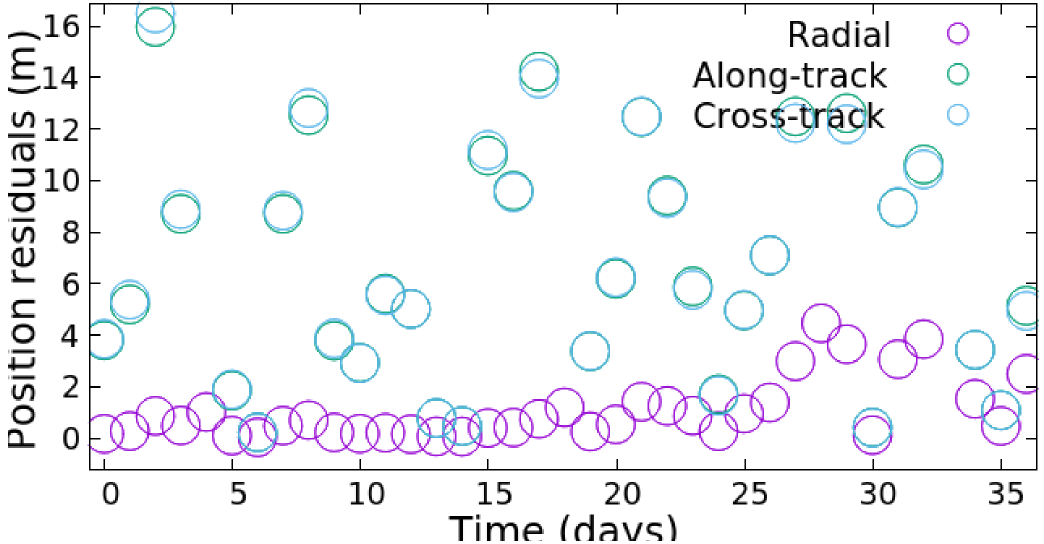
Recovery of the accelerometer parameters to the Doppler and accelerometer noise

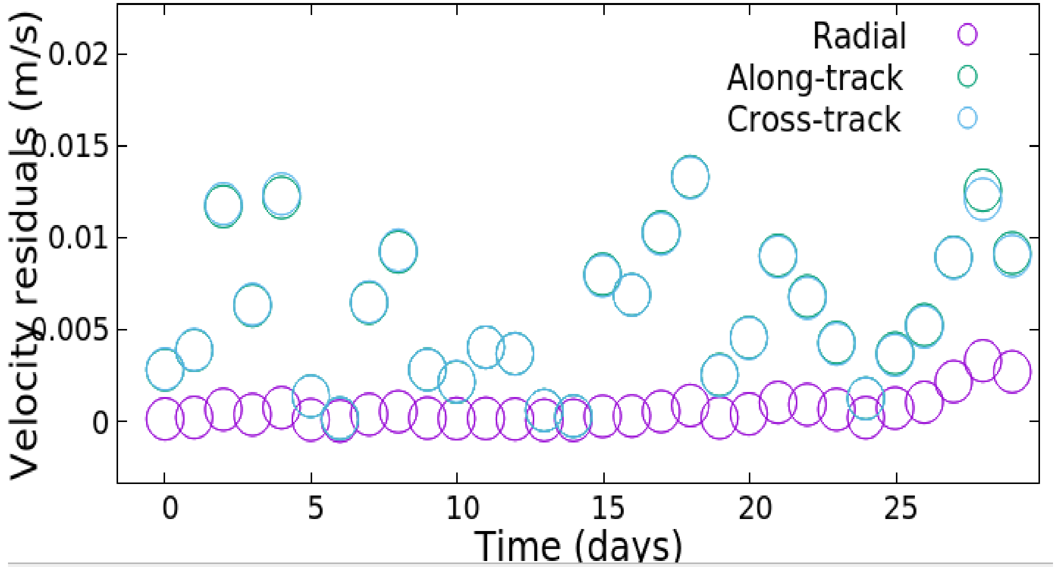




- Recovery of the gravity field, spacecraft orbit and accelerometer parameters
- At least 5 days of observation for the recovery of the ACC parameters
- Different assumptions on the accelerometer noise and bias lead different results for the recovery of the orbit and the gravity field







- If the a priori field is similar/close to the real field the process is
- If a degraded field is used, accelerometer parameters must be dealt with very carefully.
- If not constrained, the ACC parameters can absorb the unmodelled dynamics and ruin the solution
- Stochastic pulses / empirical accelerations are needed to absorb the unmodelled dynamics and avoid them from going to the ACC parameters.
- One solution is to first solve for the orbit/gravity by ignoring the ACC parameters and solve for them using the recovered field
- Testing different orbit determination strategies
- Full results, including the final accuracy of the gravity/orbit recovery in different cases will be presented in the paper to be submitted