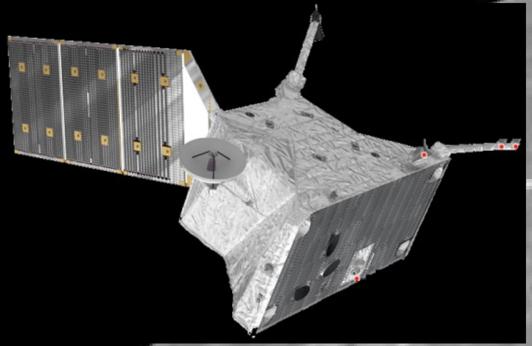

An independent solution for the precise orbit determination of Mercury planetary orbiter (MPO)

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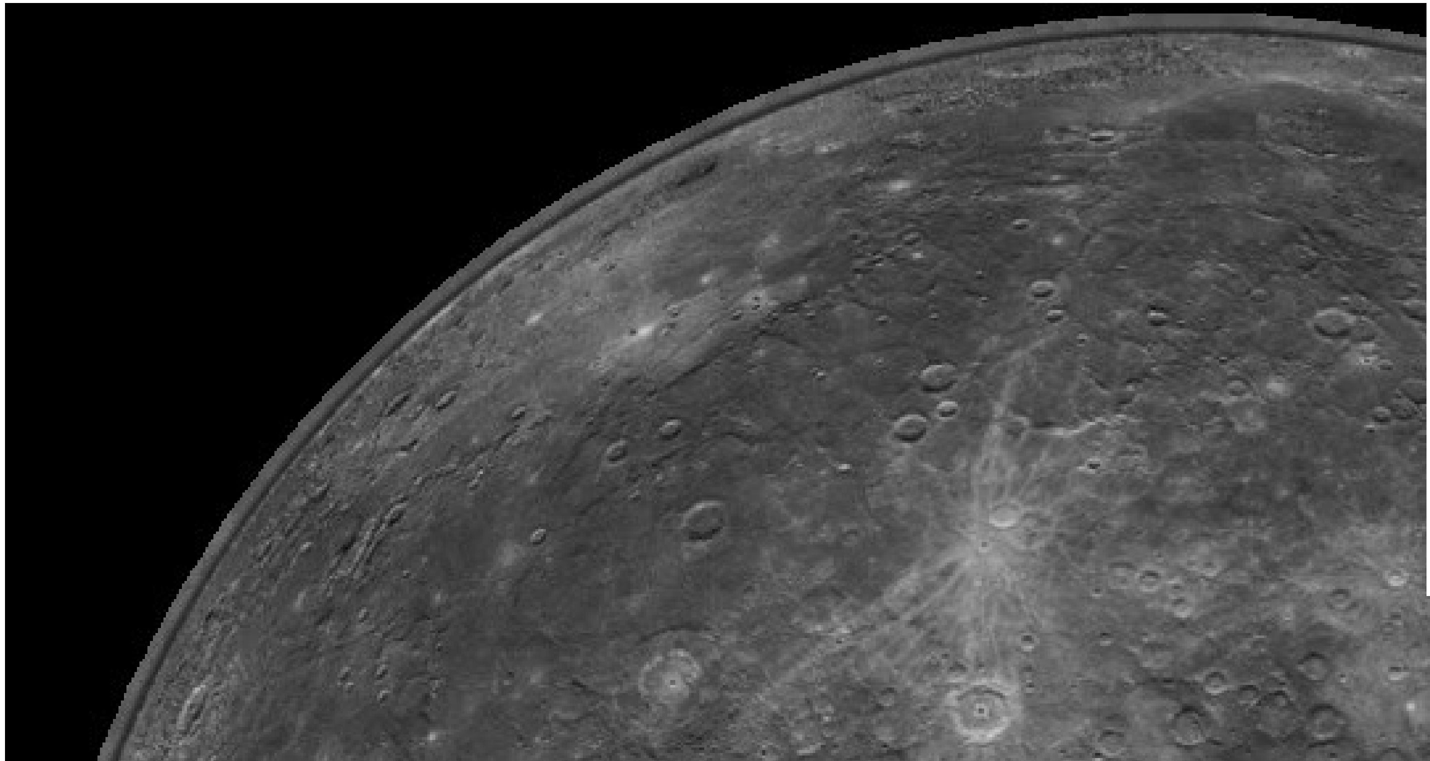
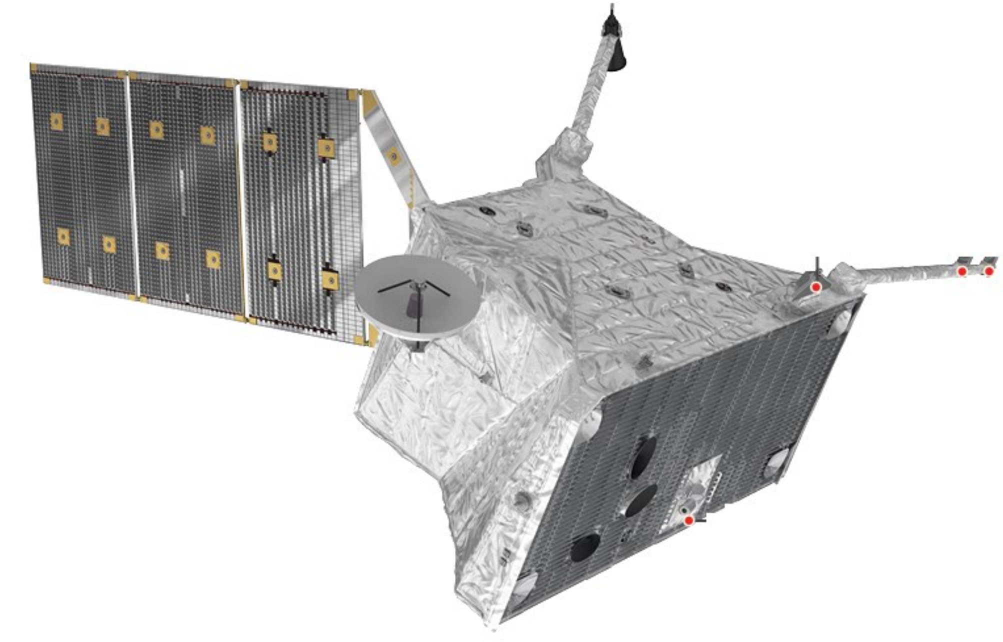
Introduction

- **Mercury:** one of the least explored planets in the Solar System
- **BepiColombo:** An ESA/JAXA mission to Mercury which will arrive in 2025
- **MPO:** Mercury planetary orbiter
- **MORE:** Mercury radio science experiment

Goal of this study:

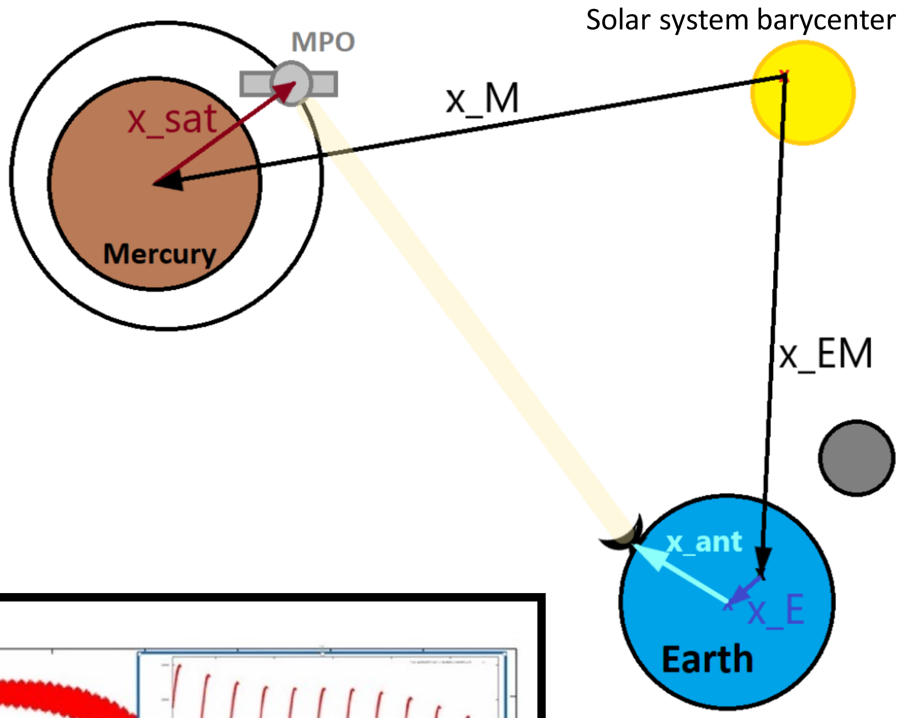
- An independent assessment of the accuracy of MPO orbit determination and Mercury gravimetry using Doppler observations
- Closed loop simulation based on previous studies (Cicalo et al, 2016, Milani et al, 2001…)



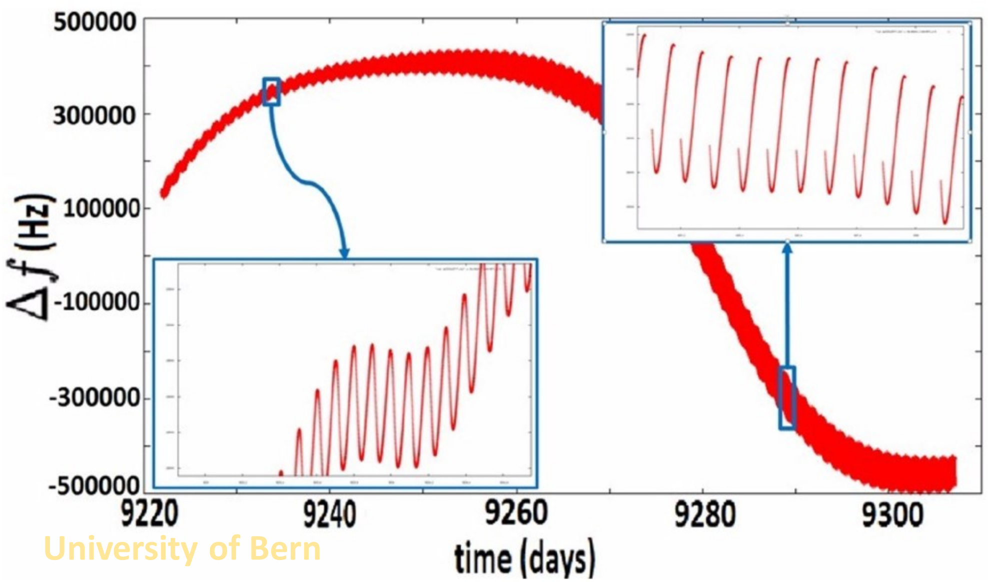


Force model:
- Gravity field HGM050 d/o 50
- Sun and planets third body gravitational perturbation
- Tidal perturbations (Sun)
- Solar and planetary radiation pressure

The S/C macromodel
- 33 surfaces with area and normal directions
- Optical properties in visible and IR



Simulation of Doppler data:
- 2-way X-band and K-band
- White noise on the observations:
  - 4 mHz on X-band
  - 1.5 mHz on Ka-band
- Station and planetary eclipses



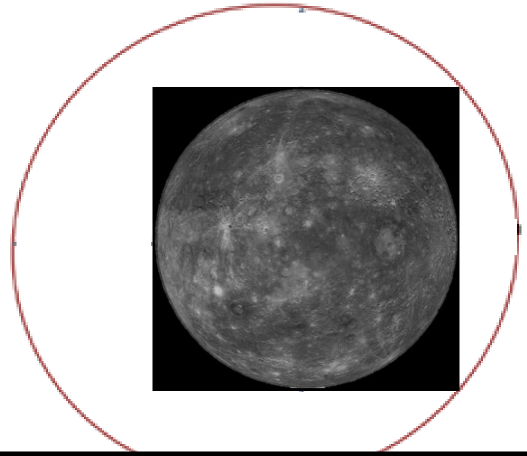
Model description

Orbit determination steps:

- Use a full force model (gravity field d/o 50 + SRP) to produce synthetic Doppler observations
- Use a degraded force model (gravity field d/o 30 + modelled accelerometer measurements) with errors on initial state vector as the " a priori" knowledge of the orbit
- Solve for the initial state vector of the arcs (pre-fit solution)
- We combine normal equations over 1 year of mission and solve for the coefficients of the gravity field. arc parameters are pre-eliminated
- We will use the recovered gravity field to solve for the orbit in the second iteration (post-fit orbit)

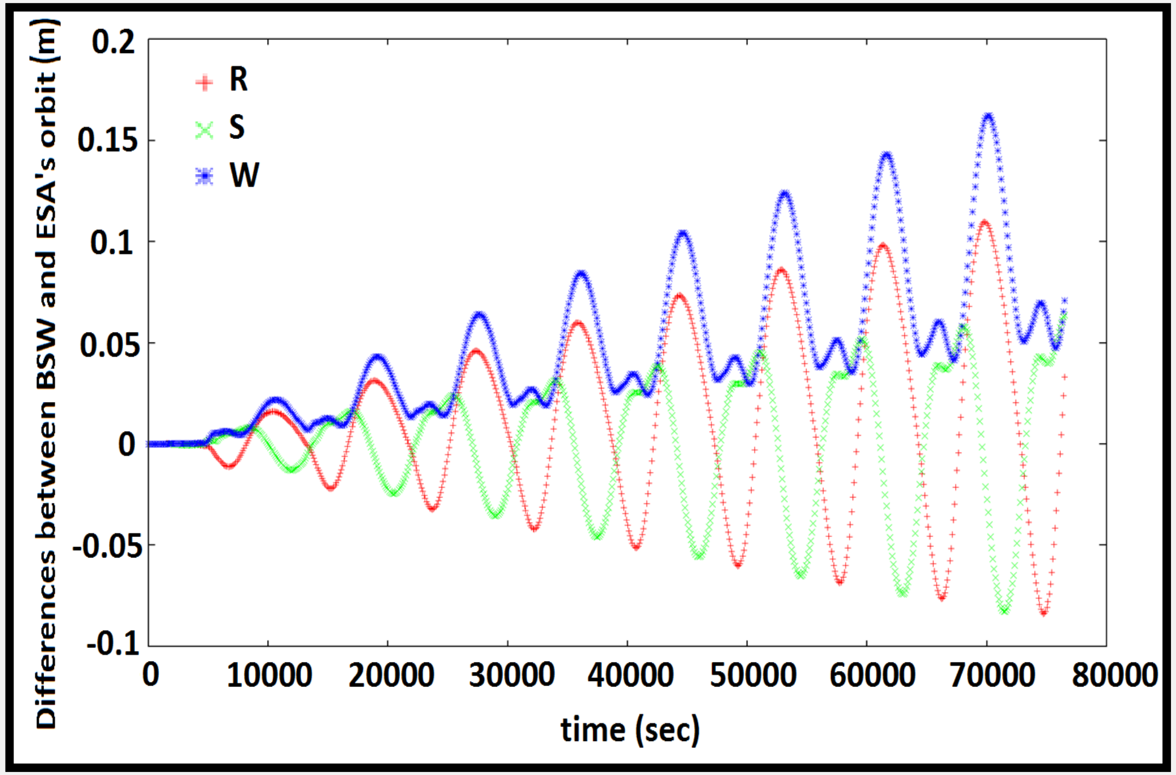
Bernese GNSS software (BSW)

- An orbit determination software developed at AIUB
- Planetary extension of Bernese software also used for planetary POD of GRAIL and Europa mission



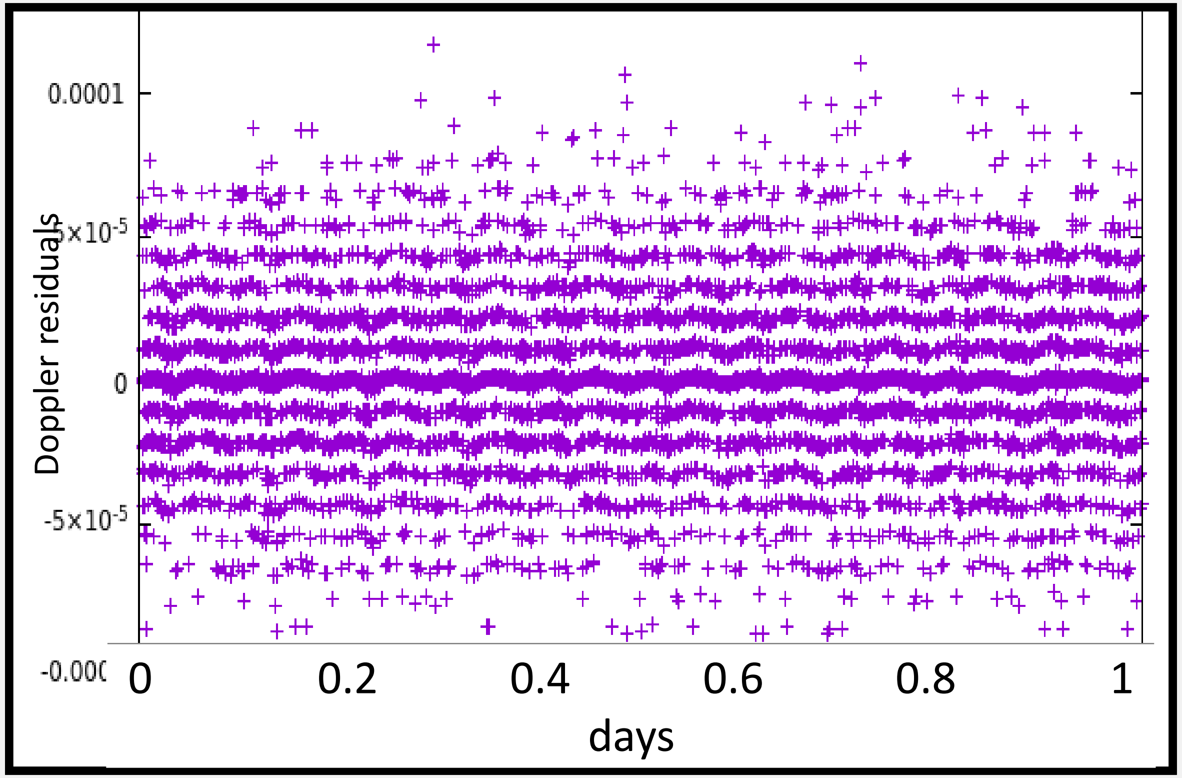
Model verification

Orbit verification
Propagated orbit has been verified against ESA's orbit

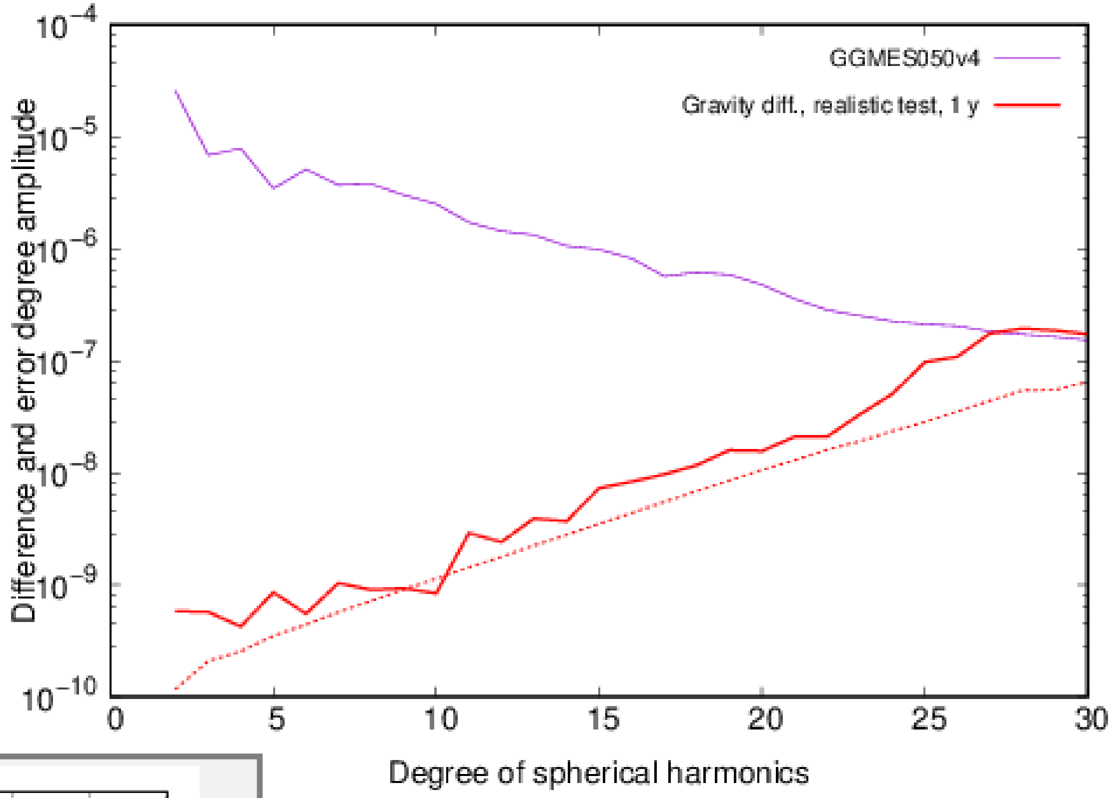


Zero test: A test for model verification

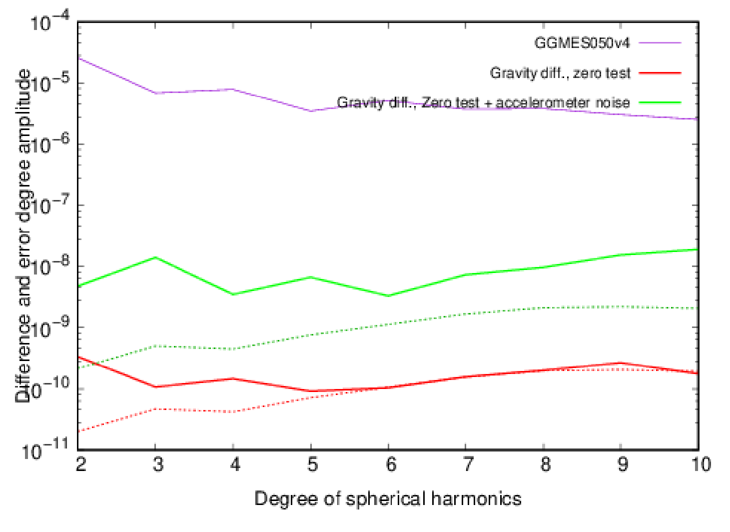
- No Doppler noise, No initial condition error
- We use the same force model in simulation and parameter estimation
- Doppler residuals are in the order of 1E-5 Hz



- We use a gravity field with d/o 50 as synthetic reality as
- We use the same degraded gravity field with d/o 30
- We use 1 year of Doppler observation
- We solve up to d/o 30
- A posteriori RMS of unit weight 0.0013 Hz
- Consistent with previous studies



- A zero test solution
- Same force model for simulation and estimation
- Solving for up to d/o 10
- Red: No Doppler noise, No initial error
- Green: Doppler noise , initial error



An orbit solution…

- A fit with a perturbed field and starting from perturbed initial conditions
- Daily RMS of position and velocity residuals are plotted in for 30 days of the mission.
- Expected RMS of position error:
  - 0.5 m in the radial direction
  - Around 10 meters in the other directions
- Preliminary results, ongoing validation of iterated orbits