

Influence of errors in non-gravitational force modelling on the Genesis and GNSS orbit and geodetic parameter estimations

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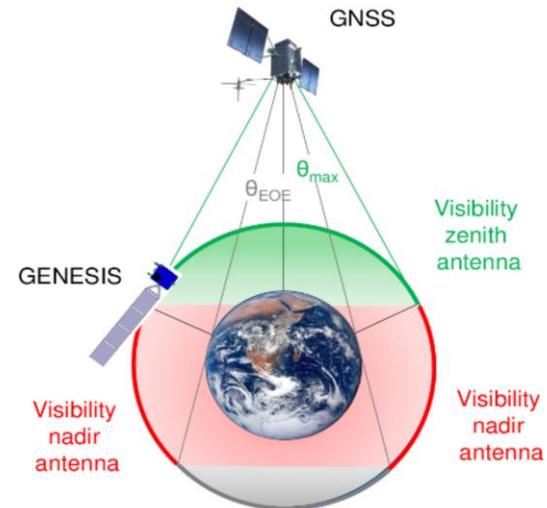
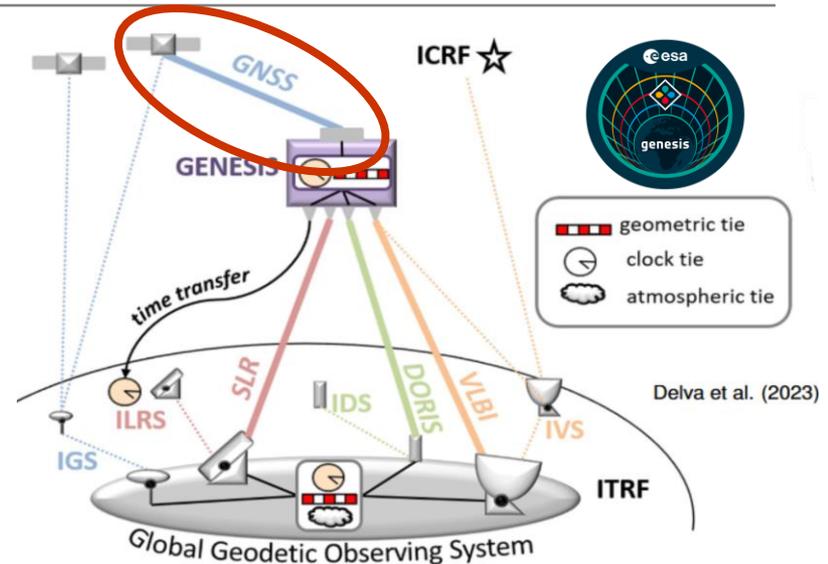
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The Genesis Mission

Mission

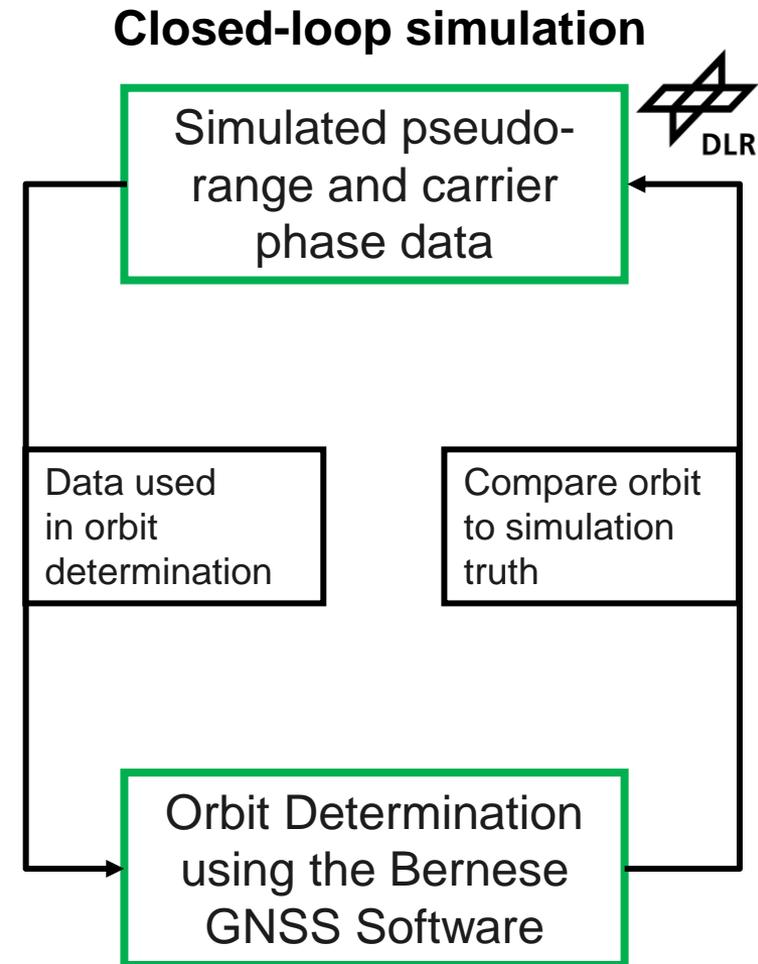
- Approved by ESA, planned to launch in 2028
- Space tie: Combines VLBI, SLR, DORIS and **GNSS**
- Orbit at an altitude of 6000 km (due to VLBI constraints)
- equipped with **zenith and nadir pointing GNSS antennas**
- Aims to improve the accuracy and stability of the Terrestrial Reference Frame



Simulated Data

Data

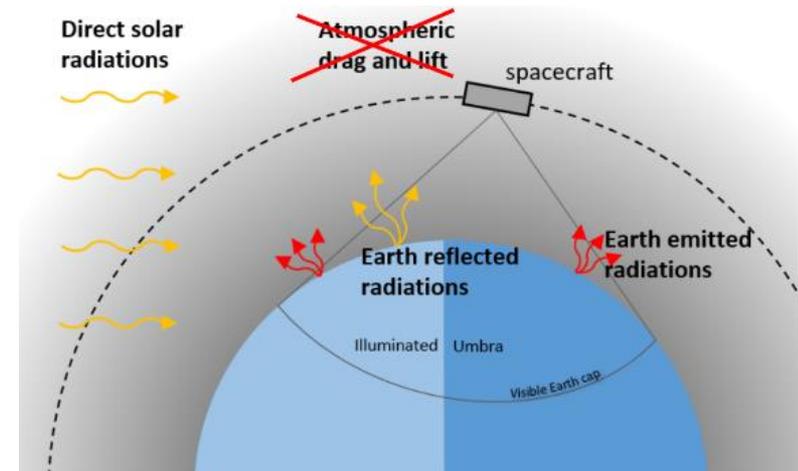
- **Simulated pseudo-range and carrier phase data** generated at the DLR (O. Montenbruck, P. Steigenberger)
- 37 days in 2023: 001, 011, 021, ..., 361
- Comparison to simulation truth enables **quantitative analysis** (closed-loop simulation)
- Different software → **“natural” uncertainties**



Modeling and Constraining

Non-gravitational Modeling

- Solar (**SRP**) and Earth Radiation Pressure (**ERP**) modeled (no drag)
- Spacecraft geometry and optical properties introduced using macro model (**MAC**). **Errors are included here**
- Current data still boxing model



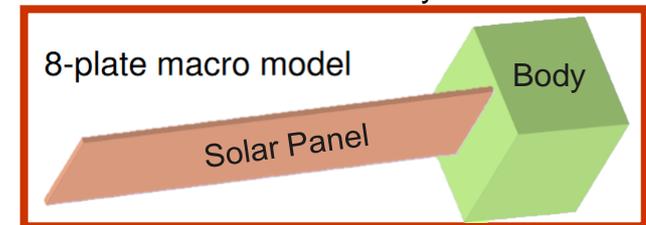
Constraining

- Piecewise Constant Accelerations (**PCAs**) set up to absorb modeling errors
- Magnitude constrained by a-priori standard deviation σ_{abs}

- **Relaxed:** $\sigma_{abs} = 5 \cdot 10^{-9} \text{ m/s}^2$
- **Strict:** $\sigma_{abs} = 1 \cdot 10^{-10} \text{ m/s}^2$



Courtesy: ESA



Genesis-Only Orbit Determination

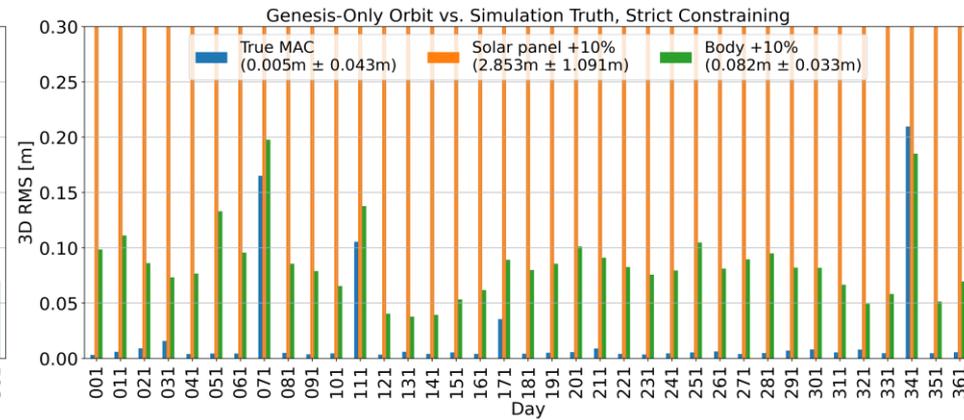
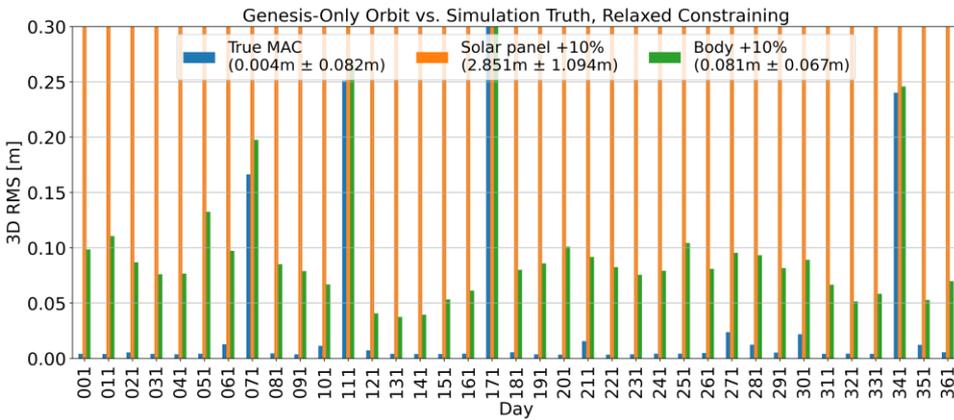
Ground station coordinates, GNSS orbits and geodetic parameters are **fixed**

Constraining

- Relaxed constraining shows some days on which the orbit significantly deteriorates (**problem days**), i.e., 071, 111, 171, 341
- Median RMS becomes a little larger for strict constraining

MAC errors

- Body error results in noticeable orbit degradation
- Largest orbit differences for **solar panel errors**, almost 3 m median RMS

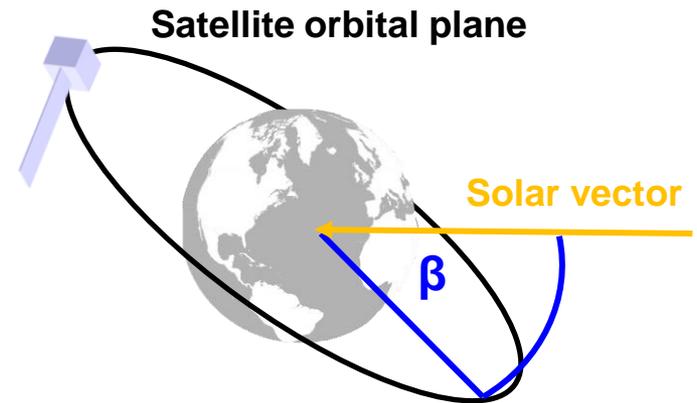


Genesis-Only Orbit Determination

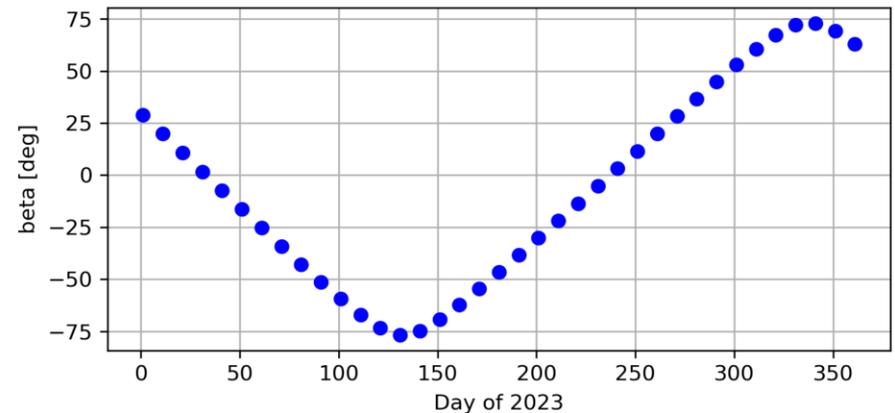
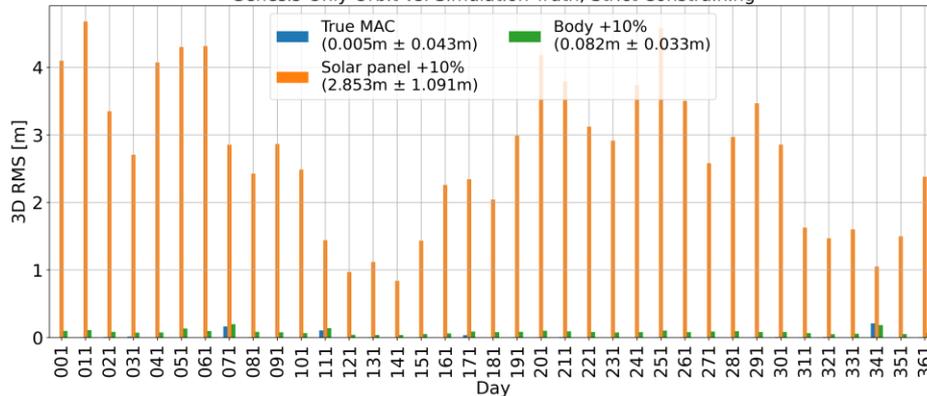
Solar panel error

The RMS shows a pattern that corresponds to the **Sun's β -angle**

→ **Smaller angle, larger RMS**



Genesis-Only Orbit vs. Simulation Truth, Strict Constraining



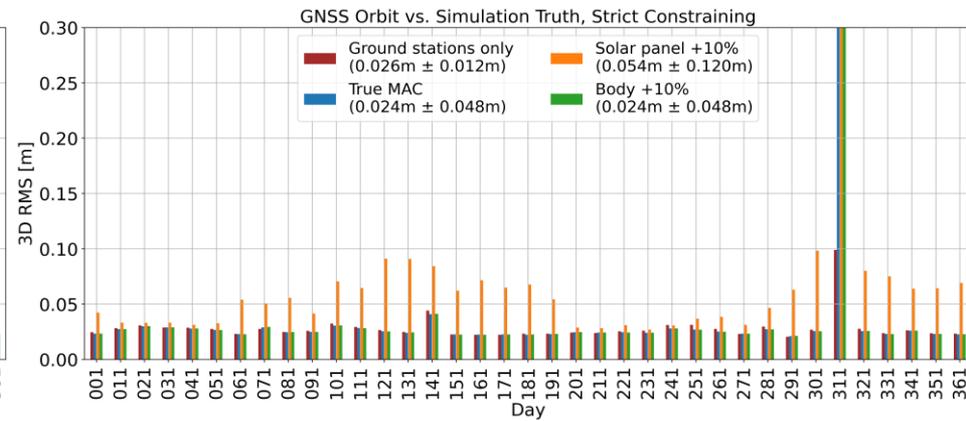
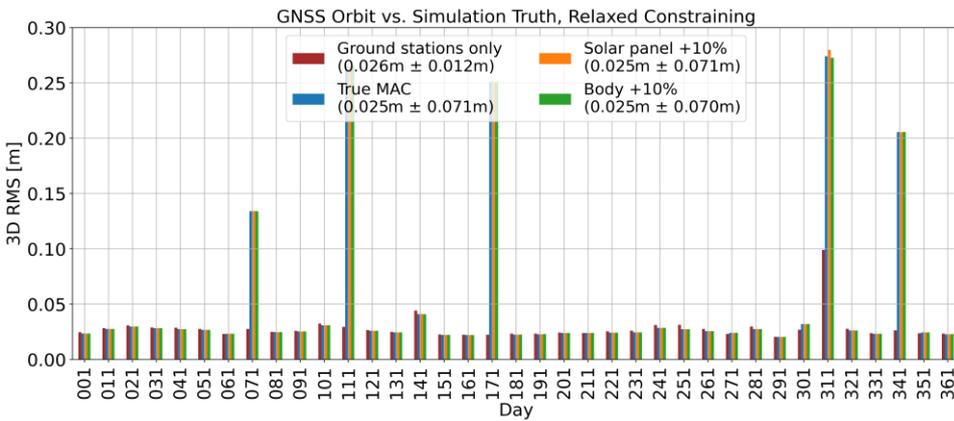
GNSS Orbits and Geocenter

Now: ground station coordinates, GNSS orbits and geodetic parameters are **estimated as well**

GNSS Orbits

Problem days still visible for relaxed constraining

- GNSS orbits on DOY 311, for which the RMS is larger already, are degraded even more
- Modeling errors only visible for stricter constraining

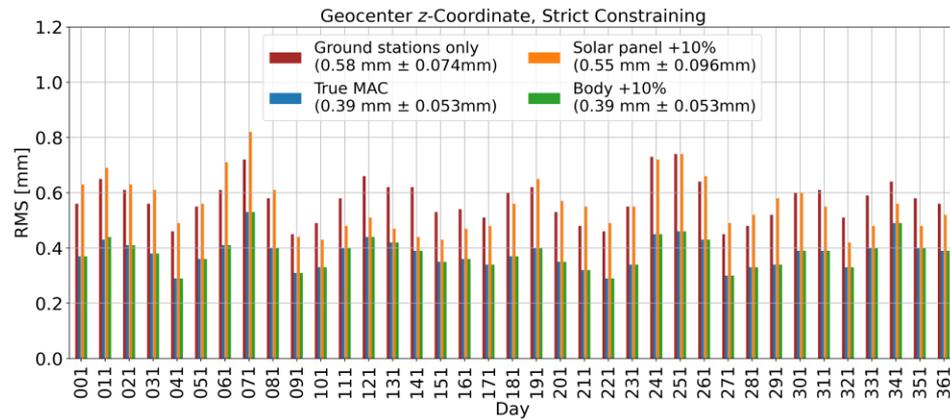
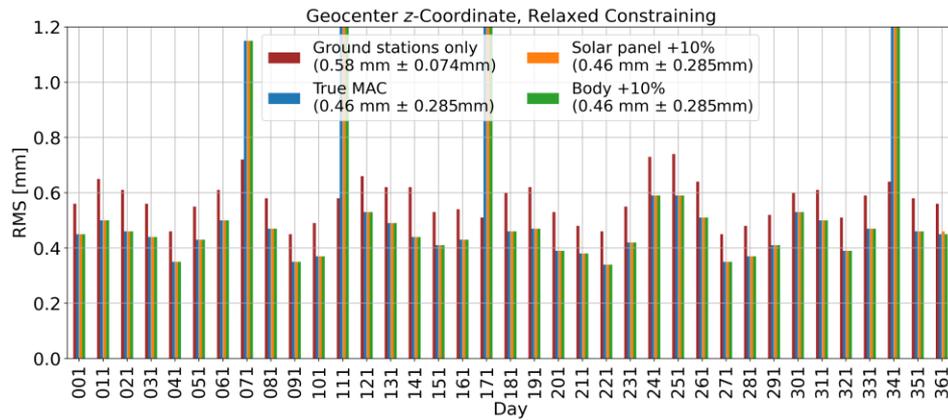


GNSS Orbits and Geocenter

Geocenter

- Problem days still visible, but not DOY 311
- With relaxed constraining, overall improvement of formal errors, on some days even with solar panel error
- Strict constraining again “removes” problem days, but modeling errors become more prominent

→ **Genesis modeling errors can degrade geocenter coordinates**



Summary

- **Constraining** of the Genesis orbit **plays an important role** in the determination of Genesis/GNSS orbits and geodetic parameters
 - Depending on what the **end goal** is (better Genesis orbit? Improved geocenter coordinates?) **tighter or more relaxed constraining** seems to be necessary
 - **Problem days** need to be addressed
 - through constraining (but modeling errors become larger, optimisation?)
 - through data screening? (Issues with zenith antenna)
 - The **optical properties** of the spacecraft need to be accurately known, especially for the **solar panel**
- **Orbit parametrization and Genesis GNSS data processing are not trivial and need to be further studied**

The **new satellite design** (Sentinel 6) needs to be studied as well