EPSC Abstracts
Vol. 13, EPSC-DPS2019-1742-3, 2019
EPSC-DPS Joint Meeting 2019

EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

In-orbit performance evaluation and improvement of BepiColombo Laser Altimeter (BELA)

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Abstract

The goal of this work is to simulate the BELA measurements in-orbit around Mercury and to study the instrument performance in determining the topography and surface properties of Mercury. We also discuss possible approaches to improve the instrument performance.

1. Introduction

The BepiColombo Laser Altimeter (BELA) [1][2] is one of the instruments of Mercury Planetary Orbiter (MPO) and it has been developed by a consortium led by the Physikalisches Institut - University of Bern (WP) and the DLR Institute of Planetary Research Berlin. The main goal of BELA is to provide information on Mercury's terrain and surface properties. In this study we model the instrument in-flight and we determine whether the instrument performance can achieve these goals. For this simulation we use the planetary extension of the Bernese GNSS Software [3] that has been developed at the Astronomical Institute of the University of Bern (AIUB).

2. Modelling

In order to set-up a proper simulation, MPO orbit, BELA performance, a ground model and environmental conditions during the mission are modelled.

For modelling the orbit of MPO around Mercury, we use an extensive force model, including Mercury gravity field GGMES_100V07 (up to d/o 50), solid tides, solar and planetary (albedo+IR) radiation pressure, third body perturbations and relativistic effects. To consider the effect of non-gravitational forces on the spacecraft, we use a 33-plates macromodel of MPO, including both visible and IR optical properties.

For the ground model, we use a Digital Terrain Model (DTM) generated by MESSENGER camera data [4] and we use the derivative of this DTM as the local slope model. For surface roughness, we divide the planet's surface into two type of terrains: smooth terrains and rough terrains and we specify a value based on Mercury Laser Altimeter (MLA) measurements for each type of terrain [5]. Finally, for the reflectance model we use a scaled version of an albedo map created at 1000 nm from the Mercury Dual Imaging System (MDIS) data.

The modelling of the BELA instrument in our simulation is based on the test results obtained in the "Starsim" laboratory of the University of Bern. On top of this, we add the impact of solar noise [6] and the degradation effects during the mission nominal life [7] on the results.

3. Performance in-flight

To determine the performance in-flight, we use the laser altimetry performance model described in [8]. At each observation time we determine the range, pulse width and pulse energy measurement error [9]. Fig. 1 shows the three main components of range measurement error. It can be clearly seen that the error due to pointing uncertainty is the dominating part of range measurement error. The gaps in the data are due to high probability of false detection at higher altitudes.

Then from the measurement errors, we predict the performance of instrument in determining the surface properties, e.g., surface slopes, roughness and surface albedo. We also study the instrument systematic errors and the impact of a potential calibration on the measurement accuracy improvement.

Finally, we produce a performance map over the surface of Mercury and we study the attainable topography and the expected accuracy on the measurements of surface properties, e.g., local slopes/roughness and albedo.

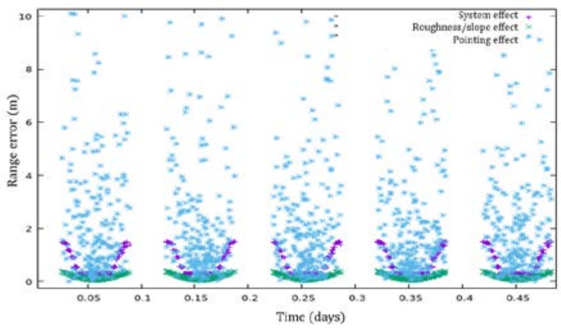

Figure 1: Components of range measurement error. Purple: Instrument systemic error, Green: Error due surface roughness and slope, Blue: Error due to pointing uncertainties.

4. Summary and Conclusions

We present the expected performance of BELA during its primary mission orbits around Mercury, and we predict the accuracy of measurements of topography and the surface properties. We also suggest potential calibrations of instrument systematic noises and updates to the data processing which could result in improved performances.

Acknowledgements

This study has been funded with the support of the Swiss National Foundation (SNF) and NCCR PlanetS.

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