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Stereo topographic models of Mercury after three MESSENGER flybys

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ABSTRACT

From photogrammetric analysis of stereo images of Mercury obtained during three MESSENGER flybys, we have produced three digital terrain models (DTMs) that have a grid spacing of 1 km and together cover 30% of the planet's surface. The terrain models provide a rich source of information on the morphology of Mercury's surface, including details of tectonic scarp systems as well as impact craters and basins. More than 400 craters larger than 15 km in diameter are included in the models. Additionally, the models provide important test cases for the analysis of stereo image data to be collected during MESSENGER's orbital mission phase. Small lateral offsets and differences in trends between stereo DTMs and laser altimeter profiles may be due to remaining errors in spacecraft position, instrument pointing, or Mercury coordinate knowledge. Such errors should be resolved during the orbital mission phase, when more joint analyses of data and detailed orbit modeling will be possible.
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1. Introduction

Mercury is the smallest and the least explored of all the terrestrial planets. Considerable information on a planet's history and on the processes that have acted on its surface can be obtained from the studies of the planet's surface morphology. Until recently, however, only limited information was available for Mercury. Stereo images collected by the Mariner 10 spacecraft during flybys of Mercury in 1974–1975 have been used to reconstruct maps of surface topography (Cook and Robinson, 2000; Watters et al., 2001). These maps, however, suffered from difficulties in the radiometric and geometric calibration of the Mariner 10 vidicon sensors. Moreover, stereo coverage was restricted to portions of the southern hemisphere (~20% of the planet's surface). Topographic data have also been obtained from Earth-based radar delay and Doppler data (Slade et al., 1997), but only along linear profiles in equatorial areas and with limited spatial resolution (approximately 5 km in longitude and 100 km in latitude).

The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft is only the second probe to visit the innermost planet. The spacecraft is equipped with a well-calibrated imaging system (Hawkins et al., 2007, 2009), and data obtained during three Mercury flybys in 2008–2009 (Solomon et al., 2008) included images that allowed stereo topographic reconstructions for a substantial portion of the planet not covered by Mariner 10. The stereo analysis in this paper constitutes an important test case for MESSENGER's orbital mission phase, to begin in March 2011, when dedicated stereo mapping sequences will be obtained at near-global coverage.

2. Data

2.1. Camera system

MESSENGER's Mercury Dual Imaging System (MDIS) consists of two framing cameras, a wide-angle camera (WAC) and a narrow-angle camera (NAC), co-aligned on a pivot platform and equipped with identical 1024 × 1024-pixel charge-coupled device (CCD) sensors (Hawkins et al., 2007). NAC, the principal tool for stereo analysis in this paper, consists of a compact off-axis optical system that has been geometrically calibrated using laboratory as well as in-flight stellar observations (Hawkins et al., 2007, 2009). Image mosaics are obtained by a combination of pivot platform movement and spacecraft motion.

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