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Juno's sensitivity to the gravitational signature of Jupiter's meridional flows

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Abstract

The Juno spacecraft is currently orbiting Jupiter in a highly-eccentric, 52.9-day orbit, unveiling the interior structure of the gas giant. Since its arrival in Jupiter's system on July 4th, 2016, Juno has completed several revolutions about the planet (15 pericenter passes as of September 2018), revealing fundamental details of Jupiter's interior structure and atmospheric dynamics.

Juno's radioscience experiment provides an extremely accurate determination of Jupiter's gravity field, to an unprecedented level of detail. During gravity-dedicated pericenter passes, Juno establishes a two-way coherent radio link with NASA's Deep Space Network DSS 25 antenna, located in Goldstone's desert, which acquires Doppler measurements at Ka and X bands (32.5 and 8.4 GHz). The two simultaneous radio links enable an incomplete calibration of dispersive noise (up to 75%), mainly induced by solar corona (especially important when the signal passes close to the Sun) and by the Io plasma torus (the signal passes through the torus at every pericenter pass, due to orbital geometry). Earth's tropospheric noise is strongly reduced using the Advanced Media Calibration System, which measures the path delay variations caused by tropospheric water vapor. The resulting end-to-end range rate noise is about 0.015 mm/s at 60 s integration time, therefore enabling a very accurate determination of Jupiter's gravity field.

The data acquired through Juno's state-of-the-art radio system from the first two gravity passes, PJ3 and PJ6, were combined in a multi-arc solution to estimate the zonal coefficients of the spherical harmonic expansion of Jupiter's gravity field [1]. The comparison of the observed even and odd zonal the surface zonal winds extend to a depth of thousands of kilometers [2, 3].

The zonal jets produce a very strong gravitational signal that has been observed for the very first time. In addition, local features at Jupiter's cloud level produce tiny signals that may be detected by Juno's radio system [4]. In principle, these structures may have an e-folding depth which differs from that of the main zonal flows. By the end of the mission (30 July 2021), Juno will complete a total of 25 gravity-dedicated orbits, providing a uniform coverage in longitude of Jupiter's gravitational field. It will be possible to exploit the full data set to determine if any non-zonal component of the gravity field is present and eventually relate it to the gravitational signature of Jupiter's meridional flows. The magnitude of the non-zonal component of the gravity field provides information on the depth of the non-zonal atmospheric circulation, i.e., the meridional flows.

We report on a preliminary analysis of the available data set, which already excludes the case in which meridional flows penetrate as deep as, or deeper than, the zonal flows, according to theoretical predictions. In addition, we report on numerical simulations of the gravity experiment and discuss the expected results at the end of the mission.

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