The statistical probability of deep flow structures that fit Jupiter's asymmetric gravity

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Juno's measurements of Jupiter's North-South asymmetric gravity field allowed estimating the depth of the zonal jets through the relation between the measured density anomaly and the flow field. While the deep zonal jets structure has many degrees of freedom, the gravity measurements are manifested only by four gravity harmonics, which implies that the problem is ill-posed. Hence, any suggested solution for Jupiter's deep jets that fit the gravity measurements is non-unique. Here, we perform a thorough statistical analysis of the deep flow structures' range that is bounded by physical considerations. We begin by examining the vertical range of the deep flow, where the meridional structure of the zonal wind is identical to the measured cloud-level profile. Then, we relax the constraint on the meridional profile and allow reasonable variations from the cloud-level profile along with the varying vertical decay. Finally, we examine random meridional profiles that are independent of Jupiter's measured cloud-level profile and explore the possibility that the interior wind structure, which influences the gravity measurements, is entirely different from the cloud-level flow. A sample population of vertical decay structures is used to compare the statistical likelihood of the various cases. We find that only a relatively narrow envelope of vertical solutions can fit the gravity data. Deep flow profiles constructed from perturbations to the cloud-level winds allow a more extensive range of solutions, yet when the patterns differ substantially from the cloud-level observed wind profile, the ability to match the gravity data reduces significantly. Moreover, only 1% of the tested random zonal wind profiles yield any solution that fits the gravity data. Overall, we find that while interior wind profiles that diverge considerably from those at the cloud-level are possible, they are statistically unlikely. In addition to the gravity measurements, Juno's microwave radiometer (MWR) measurements might reveal information about the wind's structure below the cloud level. Inspired by the MWR's nadir brightness temperature estimations, which are dominated by ammonia abundance, we show that depth-dependent flow profiles are still compatible with the gravity measurements if the variation at depth from the measured cloud-level meridional profile is not too substantial.