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Constraints on the latitudinal structure of the deep zonal flows of Jupiter and Saturn

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The atmospheres of the gas giants are dominated by strong alternating east-west zonal flows at the cloud-level. Jupiter's flows have a significant asymmetry between the northern and southern hemispheres, while on Saturn the wind pattern is more symmetric with a wide eastward flow at the equatorial region, and smaller scale jets extending to high latitudes. How deep these winds penetrate into the planets' interior and what is their latitudinal structure has remained a fundamental open question until recently, when both Juno at Jupiter and Cassini at Saturn enabled addressing these questions, through accurate gravity measurements performed by both spacecraft.

For Jupiter, the zonal winds at the cloud level have been shown to be closely linked to the asymmetric part of the planet's measured gravity field, implying that the flow extend ~3000 km deep. However, measurements coming from several sources (e.g., Juno microwave radiometer measurements) suggest that in some latitudinal regions the flow below the clouds might be somewhat different from that observed there. Here we use the measured gravity field, both asymmetric and symmetric, to examine which latitudinal range of the observed cloud-level winds is most likely to extend deep below the clouds. We find that the winds between latitude 25S and 25N dominate the wind-induced gravity field, with contribution also coming from the winds at latitudes 25 to 50 north and south. These findings are also consistent with magnetohydrodynamics constraints. We also find, that in order to match the gravity data, the winds must be projected inward in the direction parallel to Jupiter's spin axis, and that the decay of the winds should occur in the radial direction. The Saturn case is less constrained, as the gravity signal is more symmetric and the symmetric part of the gravity field is strongly affected by the internal structure of the planet. Nonetheless, the gravity field implies that the cloud-level winds extend ~9000 km deep and westward flows, which differ somewhat from those at the cloud-level, must exist poleward of the equatorial superrotating region.

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