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Saturn's deep flow structure revealed by the Cassini Grand Finale gravity measurements

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The Cassini Grand Finale gravity measurements, performed during May-July 2017, can shed light upon a long-standing question - what is the nature of the flow beneath Saturn's clouds? Answering this question has important implications not only for the atmospheric dynamics, but also for the interpretation of the interior density structure, composition, magnetic field and core mass. Strong zonal winds exist at the observed cloud-level, forming a wide superrotating region with winds of nearly 500 m/s at the equatorial region, and smaller scale jets extending to high latitudes, but whether these are superficial atmospheric structures or whether they extend deeply into the interior is unknown.
While the low-degree even gravity harmonics, as measured by Cassini, are dominated by the shape and density structure of the planet, the higher harmonics are found to be strongly influenced by differential flow and can be used to decipher its structure. In addition, the odd harmonics can be used for this purpose as they reflect solely the flow. Using Saturn's cloud-level winds and a thermal wind balance we relate the flow to the gravity harmonics. Then an adjoint based inverse model is used to determine the flow structure that gives the best fit between the model calculated gravity harmonics and those measured by Cassini. We present a first-order estimate of the flow structure based on the Cassini measurements, and discuss its implications to the planet's interior structure.