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Inferring the depth of the atmospheric circulation on Jupiter and Saturn through the gravity measurements by Juno and Cassini

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Abstract

In approximately two years the Juno and Cassini spacecraft will both perform close flybys of Jupiter and Saturn respectively, obtaining for the first time a high precision gravity spectrum for these planets. We discuss how this data can be used to estimate the depth of the observed jet streams on these planets. This can be done in several ways: 1. measurements of the high order even harmonics which beyond J_{10} are dominated by the dynamics; 2. measurements of odd gravity harmonics which have no contribution from a static planet, and therefore are a pure signature of dynamics; 3. upper limits on the depth can be obtained by comparing low order even harmonics from dynamical models to the difference between the measured low order even harmonics and the largest possible values of a static planet; 4. direct latitudinally varying measurements of the gravity field exerted on the spacecraft. We discuss how these methods may be applied and show that given the expected sensitivities of Juno and Cassini the odd harmonics J_3 and J_5 will have the best sensitivity to deep dynamics, allowing detection of winds reaching only ~ 100 km deep, if those exist on Jupiter and Saturn (Kaspi, 2013). For this analysis we use a hierarchy of dynamical models ranging from deep compressible GCMs to simplified thermal wind models in order to relate the three-dimensional flow to perturbations of the density field, and therefore to the gravity field.