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A new approach for estimating the Jupiter and Saturn gravity fields using Juno and Cassini measurements, trajectory estimation analysis, and a dynamical wind model optimization

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The ongoing Juno spacecraft measurements are improving our knowledge of Jupiter's gravity field. Similarly, the Cassini Grand Finale will improve the gravity estimate of Saturn. The analysis of the Juno and Cassini Doppler data will provide a very accurate reconstruction of spacial gravity variations, but these measurements will be very accurate only over a limited latitudinal range. In order to deduce the full gravity fields of Jupiter and Saturn, additional information needs to be incorporated into the analysis, especially with regards to the planets' wind structures. In this work we propose a new iterative approach for the estimation of Jupiter and Saturn gravity fields, using simulated measurements, a trajectory estimation model, and an adjoint based inverse thermal wind model. Beginning with an artificial gravitational field, the trajectory estimation model is used to obtain the gravitational moments. The solution from the trajectory model is then used as an initial guess for the thermal wind model, and together with an optimization method, the likely penetration depth of the winds is computed, and its uncertainty is evaluated. As a final step, the gravity harmonics solution from the thermal wind model is given back to the trajectory model, along with an estimate of their uncertainties, to be used as a priori for a new calculation of the gravity field. We test this method both for zonal harmonics only and with a full gravity field including tesseral harmonics.
The results show that by using this method some of the gravitational moments are fitted better to the 'observed' ones, mainly due to the added information from the dynamical model which includes the wind structure and its depth. Thus, it is suggested that the method presented here has the potential of improving the accuracy of the expected gravity moments estimated from the Juno and Cassini radio science experiments.