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Tests of the frozen-flux and tangentially geostrophic assumptions using magnetic satellite data

A. Chulliat (1), N. Olsen (2), T. Sabaka (3)

(1) Laboratoire de Géomagnétisme, Institut de Physique du Globe de Paris, (2) Danish National Space Center, (3) Geodynamics Branch, NASA Goddard Space Flight Center (chulliat@ipgp.jussieu.fr)

In 1984, Jean-Louis Le Mouël published a paper suggesting that the flow at the top of the Earth's core is tangentially geostrophic, i.e., the Lorentz force is much smaller than the Coriolis force in this particular region of the core. This new assumption was subsequently used to discriminate among the very large number of flows explaining the observed secular variation under the frozen-flux assumption alone. More recently, it has been shown that the combined frozen-flux and tangentially geostrophic assumptions translate into constraints on the secular variation whose mathematics are now well understood. Using these constraints, we test the combined frozen-flux and tangentially geostrophic assumptions against recent, high-precision magnetic data provided by the and CHAMP satellites. The methodology involves building constrained field models using least-squares methods. Two types of models are built: models of the core field alone, at a given epoch, with constraints imposed with respect to a reference model at another epoch, for example 1980 when MAGSAT data are available; models of the core field and its secular variation over a given interval of time, for example 1999-2004.