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A time-dependent model of the Earth's magnetic field and its temporal change of the period 1957 to 2007

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A spherical harmonic representation of the Earth's magnetic field and its secular variation for the period 1957 to 2007 is derived. In order to have a robust estimate of the secular acceleration, we use order 6 B-splines as basis function for the temporal evolution of the Gauss coefficients, and constrain the third time derivative of the field to be small. The model, designated C^3FM2, combines methodologies used to derive C^3FM1 (Wardinski Holme, 2006) and GRIMM (Lesur et al., 2008). Similar to C^3FM1, the new model fits satellite main field models in 1980 and 2001 to 2006 and is built from annual differences of monthly or annual observatory means (secular variation estimates). The most likely set of Gauss coefficients which account for the observed secular variation is sought iteratively, where the error covariance matrix within the least squares solving is assumed to be non–diagonal.

We also derive a model under the frozen-flux constraint. Here, our application of the frozen flux constraint differs in two points to the applied constraints of previous studies by Constable et al. (1993) and Jackson et al. (2007). First, our model is set up to have zero absolute flux change, instead of having zero flux changes of individual flux patches because some of these individual patches are not resolved without doubt. Second, instead of having exactly the same flux configuration at some epochs, we parametrised our flux constrained in time in order to make this constraint continuous. Although, an unconstrained model indicate that the absolute flux change during a 50-years interval can be considered as significant, the effective contribution of diffusive processes to the observed secular variation is not. Specifically, the absolute flux changes during this period never exceed 3 per cent of the absolute flux integral. We find this in good agreement with previous results.