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Determination of the Rotation from Vector Magnetic Field Sensor System to Star Camera Head System using Quaternion Representation and GRIMM Inversion Scheme

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An important, but challenging task for the preparation of a reliable satellite magnetic field vector data set is the handling of the attitude information. Additionally to the Star Camera readings itself, the determination of the rotation between the system of coordinates linked to the magnetic field sensors and the attitude reference system of coordinates (i.e. Star Cameras) is essential. In principal the rotation angles should not vary with time, but it has been found for CHAMP that slightly adjusting these angles in time leads to an improved quality data set. These angles are usually expressed in Euler angles, but rotations can alternatively be described in a quaternion representation. Starting from the well established inversion scheme of the GRIMM geomagnetic model family, the calculation of the unknown rotation between an arbitrary system of coordinates linked to the magnetic data and the reference system of coordinates of the Star Cameras has been introduced using the plain quaternion representation. The quaternion representation is chosen because it avoids multiple solutions and is expected to improve numerical stability. The implementation is flexible enough to cover either only a rotation estimation given a magnetic field model, or a co-estimation of the rotation and the magnetic field model through an iterative approach. First we applied this upgraded scheme to noise free synthetic vector field data as a proof of concept. Then we applied the scheme to CHAMP vector magnetic field readings. The rotation estimation scheme, its convergence and stability have been evaluated. The agreement between our results and those of other modelers has been checked. With CHAMP in orbit for almost 10 years the full range of solar activity levels have been covered. The influence of local time and other environmental (i.e. solar activity) conditions have been investigated.