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Noise Reduction of 1sec Geomagnetic Observatory Data without Information Loss

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Traditional fluxgate magnetometers used at geomagnetic observatories are optimized towards long-term stability.

Typically, such instruments can only resolve background geomagnetic field variations up to a frequency of approximately 0.04 Hz and are limited by instrumental self-noise above this frequency. However, recently the demand for low noise 1 Hz observatory data has increased. IAGA has defined a standard for definitive 1sec data. Induction coils have low noise at these high frequencies, but lack long-term stability.

We present a method to numerically combine the data from a three axis induction coil system with a typical low-drift observatory fluxgate magnetometer. The resulting data set has a reduced noise level above 0.04 Hz while maintaining the long term stability of the fluxgate magnetometer. Numerically we fit a spline to the fluxgate data. But in contrast to such a low pass filtering process, our method reduces the noise level at high frequencies without any loss of information.

In order to experimentally confirm our result, we compared it to a very low noise scalar magnetometer: an optically pumped potassium magnetometer. In the frequency band from [0.03Hz to 0.5Hz] we found an rms-noise reduction from 80pT for the unprocessed fluxgate data to about 25pT for the processed data.

We show how our method improves geomagnetic 1 sec observatory data for, e.g., the study of magnetospheric pulsations and EMIC waves.