First results of the GyroDIF at the Livingston Island Geomagnetic Observatory, Antarctica

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The 2017-2018 Antarctic survey at the Livingston Island geomagnetic observatory (LIV) has been devoted to deploying and testing the GyroDIF, an automatic DIflux developed by the Royal Meteorological Institute based on a gyroscope (aka gyro) to refer the declination (D) to the true north. We compare the baselines of the magnetic field elements obtained with the GyroDIF with those arising from a manual DIflux theodolite. The GyroDIF-based magnetic inclination (I) baseline compares well with manual determinations; however, the D baselines from both instruments are more divergent due to the low resolution of the gyroscope and an additional magneto-optical effect affecting the true north measurements.

The LIV Observatory (62.662° S, 60.395° W) is operative since 1996. It is equipped with a 3-axis fluxgate (FGE), a proton vector magnetometer, a scalar magnetometer and a DIflux. Although it is only manned during the austral summer, power availability allows continuous recording of the variometers and satellite transmission of 1-min data. In January 2018 a GyroDIF has been set up to provide absolute measurements all year round (Fig. 1). Its operation is similar to that of the manual DIflux, but true north referencing is based on an integrated gyro. Installation details can be found in Marsal et al. (2017).

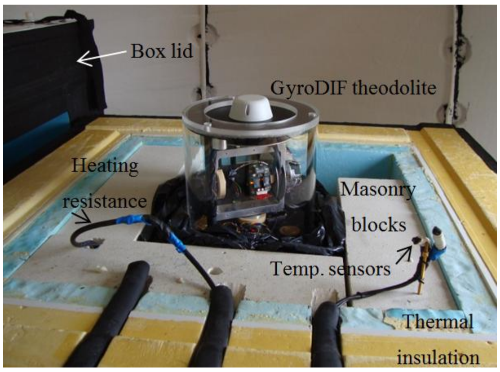

Figure 1: GyroDIF within its thermally insulated box at LIV.

The gyro is a fiber optic sensor noting the projection of the Earth's rotation vector along its axis. To compensate the gyro bias and collimation errors, the sensor up/down positions are performed scanning the full horizontal circle in 10° intervals. Combining their output in different ways we get the Earth's angular speed along the gyro axis and the cited errors. Once the circle is swept, the first combination provides a cosine curve whose phase gives the true north position. Such measurements, however, reveal a 0.1°, translating into 40 nT in Y. Reducing this uncertainty below 2 nT requires applying a Gaussian filter over a time window spanning one month of true north data. Monitoring of the gyro bias also reveals anomalous data arising from unstable temperature.

Fig. 2 shows a comparison of our FGE baselines over the last survey, obtained from the DIflux on one hand (red dots), and from the GyroDIF on the other (blue dots). The two sets of the H and Z baselines are in good agreement, indicating accurate GyroDIF I measurements. However, the D-derived E (magnetic East) baseline, obtained after combining the magnetic and the gyro data, deserves some comments: a) the large dispersion of the blue dots around the filtered value is a result of the aforementioned large of the true north measurements; b) the large offset between both datasets results from a biased value of the true north position. The reason is probably related to a coupling between the gyro optics and the magnetic field itself, known as magneto-optical effect (under study). Such an offset is expected to be nearly constant over the next surveys, in which case it may be corrected.

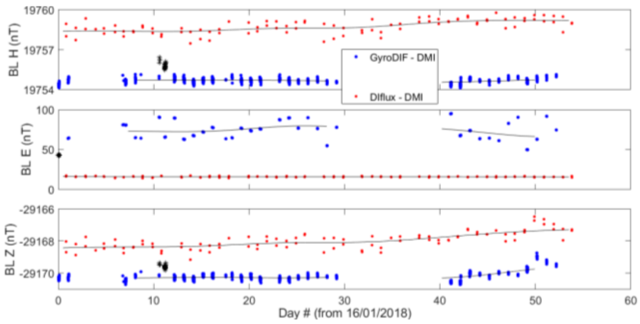

Figure 2: Comparison of baselines of H, E and Z components for the LIV FGE, obtained from the DIflux (red dots) and from the GyroDIF (blue dots).

References:

Marsal, S., Curto, J. J., Torta, J. M., Gonsette, A., Favà, V., Rasson, J., Ibañez, M., and Cid, Ò., 2017. An automatic DI-flux at the Livingston Island geomagnetic observatory, Antarctica: requirements and lessons learned. Geosci. Instrum. Method. Data Syst., 6, 269-277, https://doi.org/10.5194/gi-6-269-2017, 2017.

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