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ReinMag

(manual)

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Contents

1. Basics

ReinMag was developed for the calculation of deviation coefficients needed for the removal of magnetic interference in the signals, measured by magnetometer sensors, which is caused by the maneuvering of an aircraft flying within the Earth's magnetic field. Compensation is performed using Geosoft Oasis Montaj.

Requirements

Modern magnetometers have a very high sensitivity at a high sampling rate. The interference effects associated with the airframe of the aircraft are much greater than the resolution of the magnetometer. Moreover, a heading error of the magnetic sensor is possible. Thus, the deviation of the magnetic field measurements is a factor limiting the accuracy and sensitivity of the airborne magnetic measurements.

One of the important aspects taken into account during the development of ReinMag is the ability to control the quality of compensation in flight. This often allows us to notice the change in deviation parameters and perform the calibration again. For this purpose, the compensation parameters may be used by NavDat data acquisition system.

To ensure the accuracy of the compensation we recommend measuring all the parameters of the magnetic field with a sampling frequency of 100 Hz or higher.

The compensation algorithm is purely mathematical, no additional sources of the magnetic field are applied. Therefore, the same data can be compensated using different sets of parameters. It means that if after a flight you have found that the deviation parameters changed, you can repeat the calibration flight and apply a new set of parameters to "repair" the results of the previous flight.

Magnetic interference sources

Magnetic interference of the aircraft has several sources. Among them:

- permanent magnetism, from ferromagnetic parts in the aircraft; this type of interference is mathematically described by a vector which is constant with respect to the aircraft's axes;
- induced magnetism, created by the Earth's magnetic field in soft iron or paramagnetic parts; this part can be described by constant 3x3 matrix which is multiplied by external field vector to represent the vector of interference;
- eddy-currents magnetic field, by electric currents induced in electrically conducting paths of the airframe, directly proportional to the rate of change of the magnetic flux, it is also described by constant 3x3 matrix;
- magnetic sensor heading error;
- additional influence of the moving parts, such as elevators or rudder, or fuselage vibrations;
- electrical and mechanical influence.

The value of the interference depends on the type of aircraft and the sensor installation method. Usually, for airborne magnetic survey deviation is of the order of 1–10 nT, the eddy-current magnetic fields in most cases are one order smaller. Magnetic sensor heading error is up to ±0,2 nT.

In order to ensure sufficient accuracy of compensation, it is necessary for the effect of moving parts, as well as mechanical and electrical effects, not to exceed 1 nT. This can be tested on the ground in a place with a low magnetic gradient and noises. These sources of interference are not accounted for by the model and will determine the residual deviation, so their effect should be minimized.

As it was mentioned above, the estimated deviation parameters are specified by a vector, a matrix multiplied by the field vector, a matrix multiplied by the field derivative vector. For the scalar measurements, their interference can be described by inner product with the magnetic field direction vector. This vector is obtained by measurements of an additional vector magnetometer, which must be installed close to the scalar sensor.

It is worth noting that the linear part of the interference of the sources, which are not included in the model, will be also compensated.

Despite the seeming simplicity of the model, the interference cannot be solved just by high-path filtering of the measured magnetic field. In real conditions, the aircraft flies in the field with a non-zero gradient, and even at high altitude, the gradient cannot be neglected. Changes of the speed and/or altitude lead to changes in the measured value of the magnetic field in the same frequency band with the influence of the deviation, and the magnitude of these changes is comparable to the magnitude of the deviation.

Compensation basics

Essentially magnetic deviation is a value that depends in a known manner on the current orientation of the aircraft with respect to the Earth's magnetic field, and the rate of change of the orientation. This dependence is defined by a set of constant coefficients. If these coefficients are known, the deviation value can be calculated using current aircraft motion parameters and subtracted from the magnetometer measurements.

The deviation cannot be neglected, because its value may exceed the value of the anomalies of the magnetic field on the survey altitude. Also, it cannot be just filtered, since the characteristic time of deviation changes is from one to a few seconds, and corresponds to a distance of tens to hundreds of meters. Thus, filtering will lead to loss of detail in the measurement of the anomalous magnetic field.

To calculate the deviation coefficients, it is necessary to perform a calibration flight at a high altitude – preferably more than one thousand meters above the ground surface. The main purpose of getting to that altitude is to exclude the high-frequency component in the anomalous magnetic field. Then, any changes of the measured magnetic field with the characteristic times of the order of a few seconds are due to a change in the orientation of the aircraft with respect to the vector of the magnetic field, or to a change of coordinates of the aircraft with the influence of the magnetic field gradient. Since the motion parameters – coordinates and speed – are measured using a satellite navigation system, and the orientation parameters are measured using a fluxgate magnetometer, the estimation problem for the parameters of deviation becomes solvable.

Any magnetic survey is usually carried out along a series of parallel lines of a certain direction (ordinary lines). In addition, the survey technique involves flying along several lines perpendicular to the ordinary ones (tie lines). To maximize the quality of the compensation, it is better to perform the calibration flight in these four directions. Furthermore, it is important for the calibration lines to have a single intersection point (Figure 1). This allows evaluation of the deviation component associated with the angle of yaw.

Remark. *If for some reason the calibration flight includes less than four directions, the obtained compensation parameters can be used* ***only*** *for the directions of the calibration lines. Otherwise, they will be appropriate for any flight direction.*

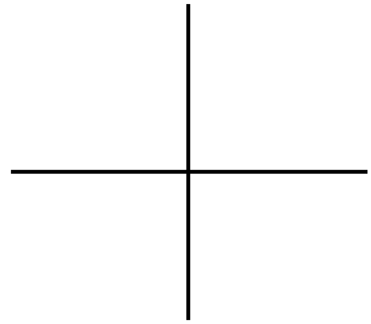

Figure 1. The lines of calibration flight

The obtained during the calibration flight in four directions compensation parameters are applicable to any direction, for example, for diagonal intersecting lines. However, you should check the operation of the magnetic sensor in a given direction to avoid the dead zones of the sensor.

During calibration flight in all four directions, the aircraft carries out ±10° rolls, ±5° pitches, and ±5° yaws. The data processed by the ReinMag in order to obtain a stable set of deviation coefficients. The computed coefficients are used in real-time in NavDat software to ensure the compensation quality and in post-processing mode in Geosoft Oasis Montaj.

Compensation stages

There are four stages of compensation:

1. collecting the compensation data (calibration flight);
2. data processing for compensation coefficients;
3. use of these coefficients in real-time;
4. data post-processing with use of the compensation coefficients.

Calibration flight

The calibration procedure takes approximately 20 minutes. Calibration lines can be prepared before the flight or created by means of the NavDat software. Everything on board should be functioning in the way it will function during the survey. Aircraft systems consuming the most energy, such as a heater or air conditioner, should be turned off or rearranged in the mode in which the compressor and the ventilation system are working continuously. It must be borne in mind that such a mode should be kept during the entire survey, not only in the calibration flight. Failure to comply with these rules leads to poor compensation performance.

Compensation must be carried out in magnetically quiet conditions at a high altitude, away from the influence of the Earth at a height of at least 1000–2000 meters above the ground surface. Flying each of the four lines, the aircraft should perform three complete oscillations in roll, pitch and yaw. They must be as smooth and symmetrical as possible, with a period of approximately 5–10 seconds. The intensity of the maneuvers must be coordinated with the supposed flight mode during the survey. The aircraft should carry out ±10° rolls, ±5° pitches, and ±5° yaws. The aircraft should be controlled only by those aircraft controls that are used on the survey lines. For example, do not over-use the rudder if it is not used in a flight along a straight line.

The order of the maneuvers does not matter. But it really matters how precise the central point is passed, both for altitude and cross-track error. For this purpose, the maneuvers should be stopped and continued after the central point is passed.

Remark. *It is recommended to perform a calibration flight at the beginning of each survey,and then every two–four weeks, and whenever the magnetic conditions onboard are changed.*

Remark. *It should be checked before every flight that all the equipment parts are on their places, all the doors are open or closed and locked as it was during the calibration.*

Remark. *Any change in the position of the magnetic sensor, scalar or vector, requires a new calibration flight.*

For more information regarding the magnetic compensation theory, please see the website http://geotechnologies-rus.com/en/downloads_en.html

2. Self-Oscillating Quantum Sensor Installation

Self-oscillating quantum sensors, Scintrex CS-3 for example, are known to have a heading error. Moreover, they can’t function with the field directed along its optical axis (polar orientation) or orthogonal to it (equatorial orientation). The functioning zone, where we can neglect the heading error, is limited by two cones. One of them has a generatrix directed at an angle of $0° + \alpha$ with respect to the equatorial plane. The second cone has a generatrix directed at an angle of $90° – \alpha$ with respect to the equatorial plane (Figure 2). To be safe, let’s consider $\alpha = 15°$, i.e. the apertures of these cones are 150° and 30° respectively.

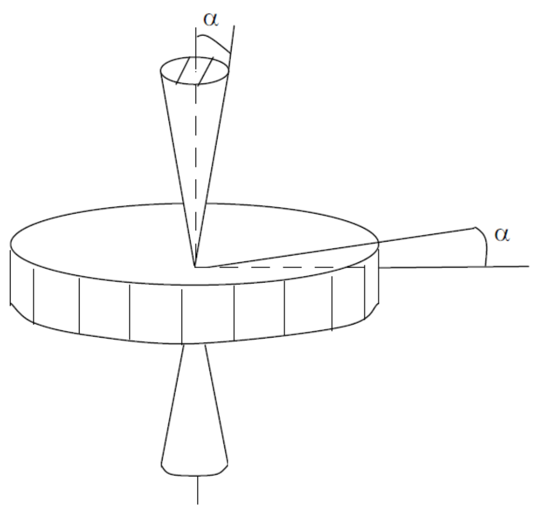

Figure 2. Functioning zones of a quantum sensor

A magnetic survey, as it was already mentioned, is usually carried out along a set of ordinary and tie lines, orthogonal to each other. So, we have four main flight directions. Let’s consider these four cases of the field direction with respect to the axes of the aircraft. We’ll get another cone, having a vertically directed axis (z) and an aperture defined by the magnetic field inclination angle β (Figure 3). The angle γ between any two neighboring directions of the magnetic field can be calculated from the following equation:

$$\cos \gamma = \sin^2\beta.$$

Note, the surface of this cone will contain the field vector for any other flight direction.

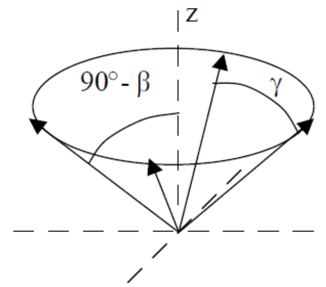

Figure 3. Magnetic field cone

To optimize the angle of sensor installation we'll choose the following criteria: The field vector for the four main flight directions should be equally declined from the boundary of the functioning zone. The result will obviously depend on the magnetic field inclination. We can suggest three installation methods.

Method I

This method should be applied to the cases of inclination in the range of $\beta_1 < \beta < \beta_0$ (the values $\beta_0 \approx 63°$ and $\beta_1 \approx 35°$ are described further). The optical axis should be installed vertically: $\nu = 90°$ (Figure 4). In this case, all flight directions give the same distance to the sensor dead zones: $75° - \beta$ to the polar zone and $\beta - 15°$ to the equatorial zone. A minimal distance of 12° will be in case of $\beta = \beta_0$.

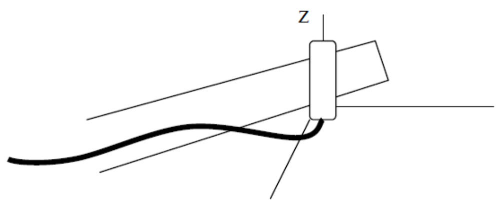

Figure 4. Vertical axis orientation

Method II

This method should be applied to the cases of inclination in the range of $\beta_0 < \beta < 90°$. The optical axis is better to install at $\nu = 45°$ inclination approximately. In case of the optimal value of the axis inclination, the field vector will decline from the dead zones to the angle δ defined by the equation

$$\sin(2\delta + 30°) = (4\sin^4\beta / (3\sin^2\beta - 1)) - 1.$$

While β changes from 90° to β_0 the optimal value of ν changes from 45° to almost 49°. Moreover, the maximal distance from the dead zones will be achieved for the sensor declined in the horizontal plane to the angle of 45° (Figure 5). Thus, the horizontal projection of the optical axis should be directed to the angle of 45° with respect to the horizontal projection of the magnetic field. So, we should take the magnetic field declination into account.

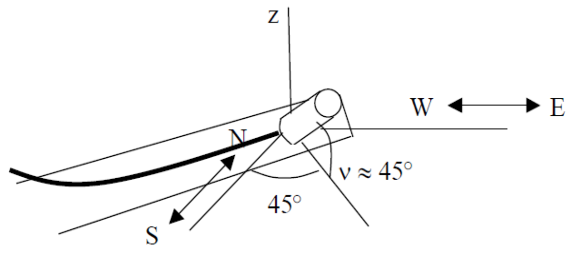

Figure 5. Inclined axis orientation

The minimal value of δ for this method

$$\beta - 15° - \nu \approx \beta - 60°$$

is achieved when the optical axis and the field vector are in the same vertical plane.

In the case of $\beta = \beta_0$ the four main directions of the magnetic field will decline to the angle of 10–13° from the polar and equatorial zones. This fact limits the possible angles of aircraft motion. This is the most difficult case. If $\nu = 49°$, the closest direction of the field to the optical axis will touch the boundary of the functioning zone, but it will decline to the angle of 13° for all the four main directions. If $\nu = 45°$, the closest direction of the field to the optical axis will decline to the angle of 3° from the boundary of the functioning zone, but it will decline to the angle of only 10° for two of the four main directions. The maximal declination of the field from the boundary is 20–40°. We have it when the horizontal projections of the magnetic field and the optical axis are orthogonal.

Method II.a

This is a modified version of Method II. If the survey is performed in one direction only (there and back), you can install the sensor in the West-East plane (Figure 6), taking the magnetic declination into account. The optical axis inclination can be calculating as follows:

$$\sin \beta \sin \nu = \cos 45° = 1/2$$

or

$$\nu = \operatorname{asin} [1/(2 \sin \beta)].$$

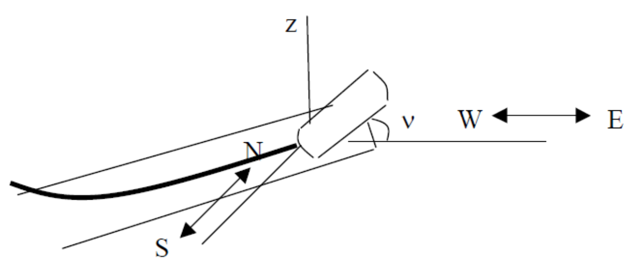

Figure 6. Inclined axis orientation in the W-E plane orthogonal to the horizontal projection of the magnetic field

In the case of $\beta = \beta_0$ the angle ν is approximately 53°, in case of $\beta = 60°$ it is close to 55°, in the case of $\beta = 70°$ it is 48°, the minimal value of ν is 45° for the vertical magnetic field.

Method III

This method should be applied to the cases of inclination in the range of $0° < \beta < \beta_1$. The optical axis should be installed at 45° to the horizontal projection of the magnetic field vector in horizontal plane (Figure 7). Obviously, we have some restricted flight directions in this case. The field vector will decline from the equatorial dead zone to the angle δ defined by the equation

$$\cos(\delta + 15°) = \sin^2\beta + \cos\varepsilon \cos^2\beta,$$

ε is the angle between the horizontal projection of the magnetic field vector and the equatorial plane of the sensor. Thus, the minimal value of $\varepsilon = \varepsilon_0$ is defined by the following equation

$$\cos\varepsilon_0 = (\cos 15° - \sin^2\beta) / \cos^2\beta \approx (0.996 - \sin^2\beta) / \cos^2\beta,$$

and the maximal deviation of the magnetic field with respect to the main one is $45° - \varepsilon_0$ to the direction of the equatorial plane of the sensor. In case of $\beta = \beta_1$ the angle $\varepsilon_0 \approx 18.5°$, so to avoid the equatorial zone the maximal allowed deviation of the flight direction ≈ 26.5°. In case of $\beta = 0°$ the maximal allowed deviation is 30°.

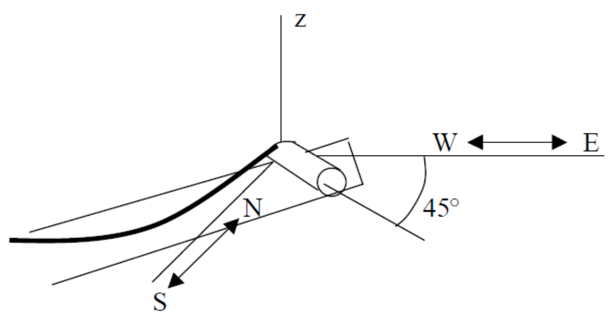

Figure 7. Horizontal axis orientation

When the field vector comes close to the polar dead zone,

$$\cos(\delta + 15°) = \sin\theta \cos\beta,$$

θ is the angle between the horizontal projection of the field vector and the optical axis. Obviously, for $\beta > 15°$ field vector will never get into the polar zone. In other cases, the minimal possible angle θ_0 is calculated from the equation

$$\sin\theta_0 = \cos(15°) / \cos\beta,$$

and the maximal allowed deviation in the direction of polar zone is $45° - \theta_0$. In case of $\beta = 0°$ the maximal allowed deviation is 30°.

Boundaries for the method choosing

The inclination angle β defines the switching from one method to another. Switching from Method I to Method II is performed at $\beta_0 \approx 63°$. Switching from Method I to Method III is performed at an angle, defined by equation

$$\tan \beta_1 = 1/2, \quad \beta_1 \approx 35°.$$

It is reasonable to decrease the value of β_1 while we are far enough from the equatorial zone. Method I is preferable, because it has no restricted flight directions.

The angle β can be calculated from the geomagnetic latitude φ_m:

$$\tan \beta = 2 \tan \varphi_m.$$

The relation between geographic and geomagnetic latitudes is shown in Figure 8.

Remark. *It is necessary to control the limits of angles of aircraft motion, because the heading error at the functioning zone boundary can significantly affect the compensation result.*

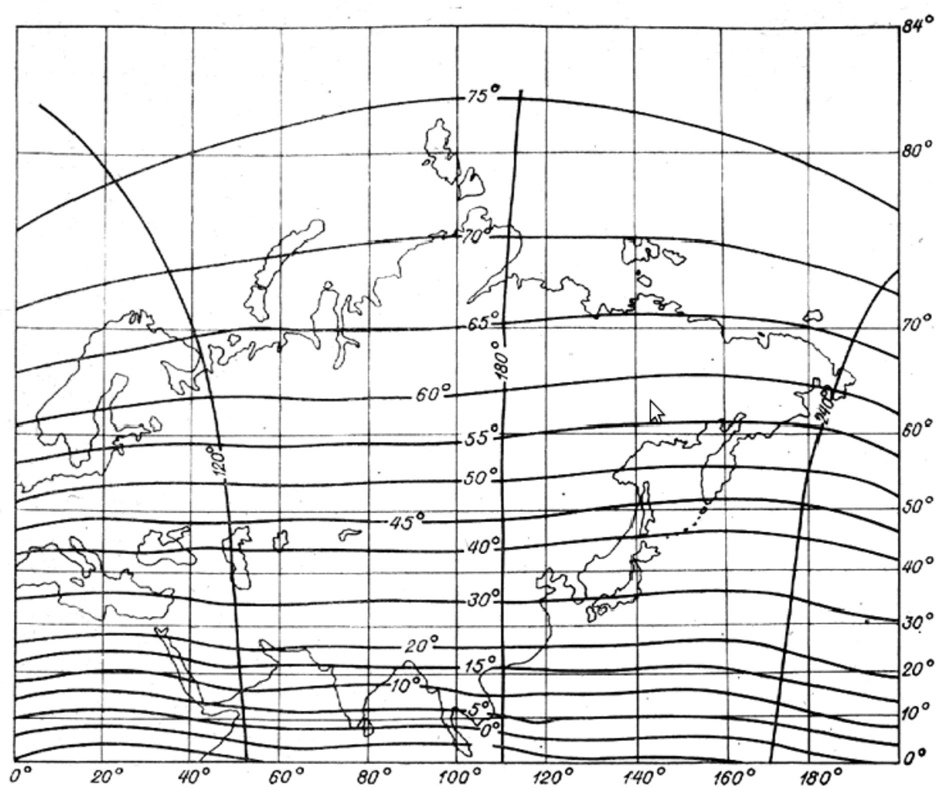

Figure 8. Geomagnetic latitude

3. ReinMag Description

ReinMag was developed to calculate a set of coefficients, which is used to compensate for the magnetic interference of the aircraft in the signals, measured by a scalar magnetometer, which measures the magnitude of the magnetic field. Compensation is performed in the post-processing in Geosoft Oasis Montaj, as well as in real-time in using NavDat software.

The input data for ReinMag are:

- file of GT-Mag *.MAG format, received in calibration flight, containing the basic parameters of the magnetometer;
- file of Geosoft *.XYZ format, containing magnetic field measurements obtained during the calibration flight.

The output data for ReinMag are:

- Geosoft script of *.GS format for compensation in post-processing mode, containing the necessary instructions to eliminate the deviation;
- file magcom.mgc required by the NavDat software to compensate in real-time.

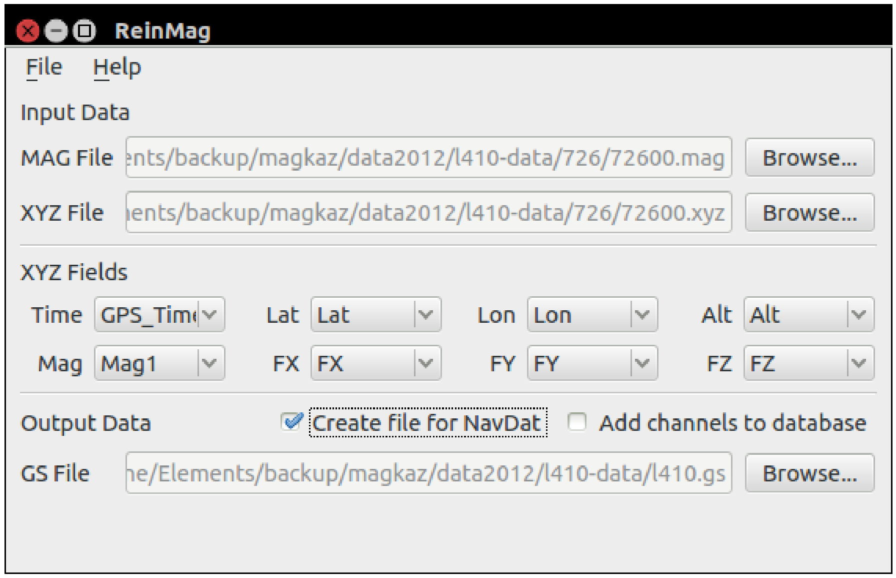

Figure 9. ReinMag interface

ReinMag interface and operation

The ReinMag window contains three parts. The upper one is **Input Data**. It has two fields:

- **MAG File** – to select MAG-file; push Browse... to choose it using standard menu;
- **XYZ File** – to select XYZ-file; push Browse... to choose it using a standard menu.

Both files should contain data of the same calibration flight.

Before you submit a file to the input XYZ of ReinMag, please ensure the proper quality of data by means of Geosoft Oasis Montaj. If the file contains corrupted data, it is better to remove them (substitute by a "*" – DUMMY). Corrupted data are those associated with getting into the dead zone, or affected by interference from electrical or atmospheric noises. After editing the data please use the menu Export to XYZ to save file keeping comments.

It is necessary for the XYZ-file to have all the "Line" marks corresponding to different directions of the calibration flight, excluding all data between the Lines.

Remark. *To ensure the accuracy of the calibration it is necessary to perform a correction related to variations in the magnetic field, and also, if GPS base station data are available, it is better to use navigation solution in differential mode.*

The middle part **XYZ Fields** contains the description of XYZ-file parameters. ReinMag fills all the fields automatically after opening the file. If the file contains a comment with the channel title – the software will select the appropriate title for every channel. If not, channel names will be ordered alphabetically: X, Y, Z1, Z2, … In any case, the user can choose the channel names manually. The channels are:

- **Time** – time of day, HH:MM:SS;

- **Lat** – latitude, degrees (please, leave 6 or more digits after decimal point);
- **Lon** – longitude, degrees (please, leave 6 or more digits after decimal point);
- **Alt** – altitude, meters (please, leave at least 1 digit after decimal point);
- **Mag** – magnetic field magnitude measured by scalar (quantum) magnetometer, nT (please, leave 2 or 3 digit after decimal point);
- **FX** – X component of magnetic field measured by vector (fluxgate) magnetometer, nT;
- **FY** – Y component of magnetic field measured by vector (fluxgate) magnetometer, nT;
- **FZ** – Z component of magnetic field measured by vector (fluxgate) magnetometer, nT.

Remark. *The order and direction of the axes of fluxgate sensor do not matter. But it is necessary to keep the same names for the whole survey, because they will be fixed in the compensation script.*

The bottom part – **Output Data**. It contains the following fields:

- **GS File** – to select the name of GS-file; push Browse... to choose it using standard menu;
- **Create file for NavDat** – choose it to save "magcom.mgc" file needed for real-time compensation in NavDat; file will be saved in the folder of GS-file;
- **Add channels to database** – choose it to add commands to create new channels in Geosoft database, it is useful for the first compensation for magnetic survey database.

For compensation in Geosoft database the following additional channels are needed:

- three channels of directional cosines of magnetic field vector, which will be calculated from FX, FY, FZ; their names are formed by adding prefix 'n' to the fluxgate channels names (FX → nFX etc);
- three channels of time derivative of directional cosines of magnetic field vector, which will be calculated from nFX, nFY, nFZ; their names are formed by adding prefix 'd' to the fluxgate channels names (FX → dFX etc.);
- a channel for compensated magnetic field; its name is formed by adding prefix 'C_' to the Mag channel name (Mag → C_Mag);

If the database already contains these channels, adding channels commands may cause an error. That is why adding channels script should be run only once. After the first compensation use the script obtained with turned off **Add channels to database**.

In case the names were changed for some reason, the script file can be modified in any text editor. Just do not change the numbers.

After all fields are filled, you can start data processing. For this purpose, select **File → Run**. If any field was filled incorrect, ReinMag will report about the error. Error messages can be as follows:

- **XYZ file reading error** – ReinMag could not open XYZ-file for reading;
- **MAG file reading error** – ReinMag could not open MAG-file for reading;
- **GS file writing error** – ReinMag could not open GS-file for writing;
- **MAG&XYZ file reading error** – MAG and XYZ-files are not fitting each other.

If there are no errors, ReinMag will start processing. The status line will show the current state. There are the following states:

- **Reading** – data reading for calibration lines;
- **Derivatives calculation** – magnetic field vector time derivative calculation;
- **Intersection detecting** – searching for the intersection of all calibration lines;
- **Deviation parameters calculation** – getting an estimation of the parameters for compensation.

The final message in the status line will be **Done. X% points processed**. X is the part of measurements used for calculation with respect to the total data volume. If there are 50% or less, it is better to check XYZ file once more. Hardly the obtained script will fit the compensation quality requirements. An example of the compensation script is shown in Figure 10. For the switched off **Add channels to database** it will not contain commands with NEWCHAN.

```
/-------------------------------------------------------------------------------------------------
/Magnetic compensation script from /Work/40300.xyz
/-------------------------------------------------------------------------------------------------
SETINI     MATH.EXP="nFX = FX/sqrt(FX*FX+FY*FY+FZ*FZ)"
GX         math.gx
SETINI     MATH.EXP="nFY = FY/sqrt(FX*FX+FY*FY+FZ*FZ)"
GX         math.gx
SETINI     MATH.EXP="nFZ = FZ/sqrt(FX*FX+FY*FY+FZ*FZ)"
GX         math.gx
SETINI     FILTER.IN="nFX"
SETINI     FILTER.OUT="dFX"
SETINI     FILTER.FILE=""
SETINI     FILTER.FILTER="-1.25,-1.25,-1.25,-1.25,0,1.25,1.25,1.25,1.25"
GX         filter.gx
SETINI     FILTER.IN="nFY"
SETINI     FILTER.OUT="dFY"
SETINI     FILTER.FILE=""
SETINI     FILTER.FILTER="-1.25,-1.25,-1.25,-1.25,0,1.25,1.25,1.25,1.25"
GX         filter.gx
SETINI     FILTER.IN="nFZ"
SETINI     FILTER.OUT="dFZ"
SETINI     FILTER.FILE=""
SETINI     FILTER.FILTER="-1.25,-1.25,-1.25,-1.25,0,1.25,1.25,1.25,1.25"
GX         filter.gx
SETINI     MATH.EXP="C_Mag = Mag - nFX*(22.4) - nFY*(-37.8) - nFZ*(-39.2)"
GX         math.gx
SETINI     MATH.EXP="C_Mag = C_Mag - nFX*nFX*(24.2) - nFX*nFY*(3.6) - nFX*nFZ*(15.3) - nFY*nFY*(32.3) - nFY*nFZ*(-46.3)"
GX         math.gx
SETINI     MATH.EXP="C_Mag = C_Mag - dFX*nFX*(4.3) - dFX*nFY*(-5.3) - dFX*nFZ*(-1.4) - dFY*nFX*(0.2) - dFY*nFY*(-1.9) - dFY*nFZ*(0.4) - dFZ*nFX*(-4.8) - dFZ*nFY*(-0.0)"
GX         math.gx
/-------------------------------------------------------------------------------------------------
/Made by ReinMag(c)
/-------------------------------------------------------------------------------------------------
```

Figure 10. Output script

```
SETINI     NEWCHAN.NAME="nFX"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="dFX"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="nFY"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="dFY"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="nFZ"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="dFZ"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="5"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
SETINI     NEWCHAN.NAME="C_Mag"
SETINI     NEWCHAN.DTYPE="Double"
SETINI     NEWCHAN.SIZE="10"
SETINI     NEWCHAN.FORMAT="Normal"
SETINI     NEWCHAN.DISPWIDTH="10"
SETINI     NEWCHAN.DISPDIG="3"
SETINI     NEWCHAN.ARRAYSIZE="1"
GX         newchan.gx
```

Figure 11. Adding channels script

If the **Add channels to database** flag is on, the upper part of the script will contain the commands starting with NEWCHAN (Figure 11). These commands can be added or removed in working script by means of any text editor. You can also add the corresponding channels in Geosoft Oasis Montaj. Just check the channel names in the script and keep the rules of adding prefixes, so the new compensation script will be correct. If you have changed the names in database, please do not forget to change them in the compensation script.

After the compensation script is made, you can compensate the survey data in Geosoft database. Select all the lines to compensate and run the obtained script.

Compensation quality

The best way to see the compensation quality is to check the results of compensation on calibration flight data. For this purpose, apply the obtained script to the corresponding lines. You can compare the results of high-pass filtering of compensated and non-compensated fields. The length of the filter should be about one kilometer. Filter results for the compensated field will deviate from zero only for aircraft position changes, mainly with altitude changes. Field decreases with increasing altitude and vice versa. You can check the value of vertical gradient – it should be of the order of 0,01 nT/m. Figure 12 shows an example.

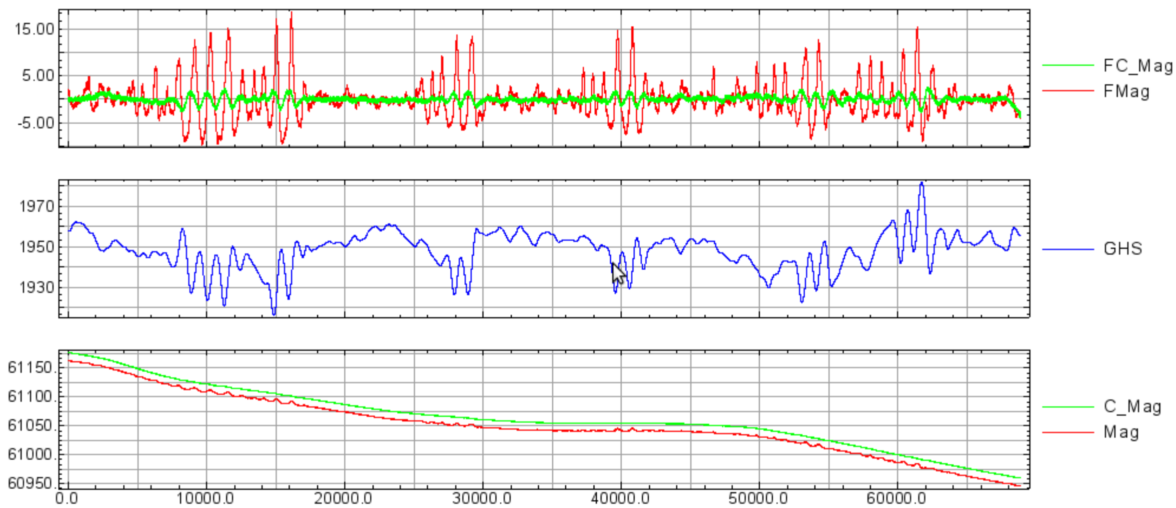

Figure 12. Compensation quality: FMag — high-pass filtering results for non-compensated value, nT, FC_Mag — high-pass filtering results for compensated value, nT, GHS — GPS altitude, meters, Mag — non compensated value, nT, C_Mag — compensated value, nT, x axis shows fiducial for 100 samples per second

Also, you can check the field value in the intersection point – it should be the same for all four directions. Just take the vertical gradient into account.