Automatic Magnetic Observatory for Drilling Assistance

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Magnetic Field

Daily variation up to:
D: 2°
F: 600nT
I: 0.5°

Even more (10-29-2003):
D: 20°
F: 2000nT
I: 2.5°

\[ B_{\text{total}} = B_{\text{main}} + B_{\text{crustal}} + B_{\text{diurnal}} \]
### Single shot measurement

**F(B\text{total or TMI})**
- Automatic instrument
- Temperature insensitive
- No need to be oriented
- <1nT accuracy
- 1 Hz sampling

**Declination & Inclination (Dip)**
- Manual procedure
- Need a target to determine the true north
- Complex protocol to compensate the errors
  - Misalignment
  - Offset
  - Mechanical
- + - 15 - 20 min
- < 0.01° accuracy
Observatory measurements

- 1 sec or 1 min data
- 10-100 pT (<0.001°) resolution
- Only variations around a reference
- Accuracy depends on the baselines determination

- Once a day/week
- For computing the baseline (reference)
Automation

AutoDIF: automatic absolute measurement

Non magnetic construction
Positioning accuracy: 0.001°
Angular resolution: 1”

Same protocol as traditional DIFlux
True north reference by mean of target pointing
Laser/Photocells + retroreflector

• Single shot measurements (without variometer)
  • Up to 6 measurements/hour
  • Accuracy: <0.01°
• Observatory mode
  • 1 min or 1 sec data (variations)
  • Same accuracy
Comparison

Are the automatic measurements correct?

Good fitting
Reference theodolite: Zeiss 010B
Tested during intercomparison session (IAGA workshop)
The geographic north reference

The target (true north reference) remains a problem

- Determining its azimuth by any method
  - Sunshot, starshot, gyro, DGPS, …
  - Keeping this azimuth constant (no drift)
- Long distance between target and instrument
  - What appends in case of snow storm, fog, condensation, frost, …?
FOG Gyro as north seeker

Principle: sensing the earth rotation

The FOG sensitive axis is placed in the horizontal plan
- North-south: maximum speed rotation
- East-west: null speed rotation

\[ \omega = \Omega_e \cos(\phi + \varepsilon) \cos(\psi + \gamma) + b \]

The sensor is mounted on the horizontal axis
- Same frame as fluxgate sensor
- Double reversal: bias & alignment compensation

\[ \omega_{res} \approx \Omega_e \cos(\psi) \cos(\phi) \]

2 sets of measurements for compensating the possible scale factor error
FOG Gyro (bis)

KVH DSP-1750 single axis (unshielded)
- Good specifications
- No need for special license
- Small & lightweight
- Low magnetic disturbance
- Low cost

Optimum between noise bias drift:
5 min acquisition (1kHz) per positions

Emcore Emp 1.2k
- 10X better specifications
- Needs for special license
- Less than 500g/ 3.3” dia.
- More expensive

Futur developments
AutoDIF Gyro

1 complete measurement/hour:
Magnetic + gyroscope

Dependency over latitude:
Belgium \( \cos(\phi) = 0.64 \)
DeadHorse \( \cos(\phi) = 0.34 \)

\[
\sigma_{e2} \approx \sigma_{e1} \frac{\cos(\phi_1)}{\cos(\phi_2)}
\]

\[
N_2 = N_1 \left( \frac{\cos(\phi_1)}{\cos(\phi_2)} \right)^2
\]

\[ N_2 \approx 3.5N_1 \]
Conclusion

- The range of daily variation can be several degrees
- It is possible to measure the whole vector automatically
  - In single shot mode
  - With variometer
- The embedded north seeker prototype is promising
- Improvement
  - Bias stability.
  - Other FOG: Emcore Emp 1.2k
    - Bias stability: 0.005°/hr (the current one is 0.05°/hr)
    - Noise 0.0015°/sqrt(hr) (again 0.013°/sqrt(hr))