Automatic Magnetic Observatory for Drilling Assistance

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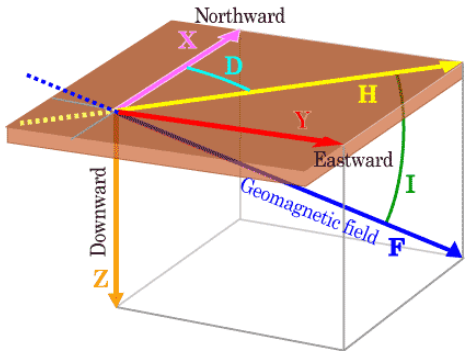
Magnetic Field



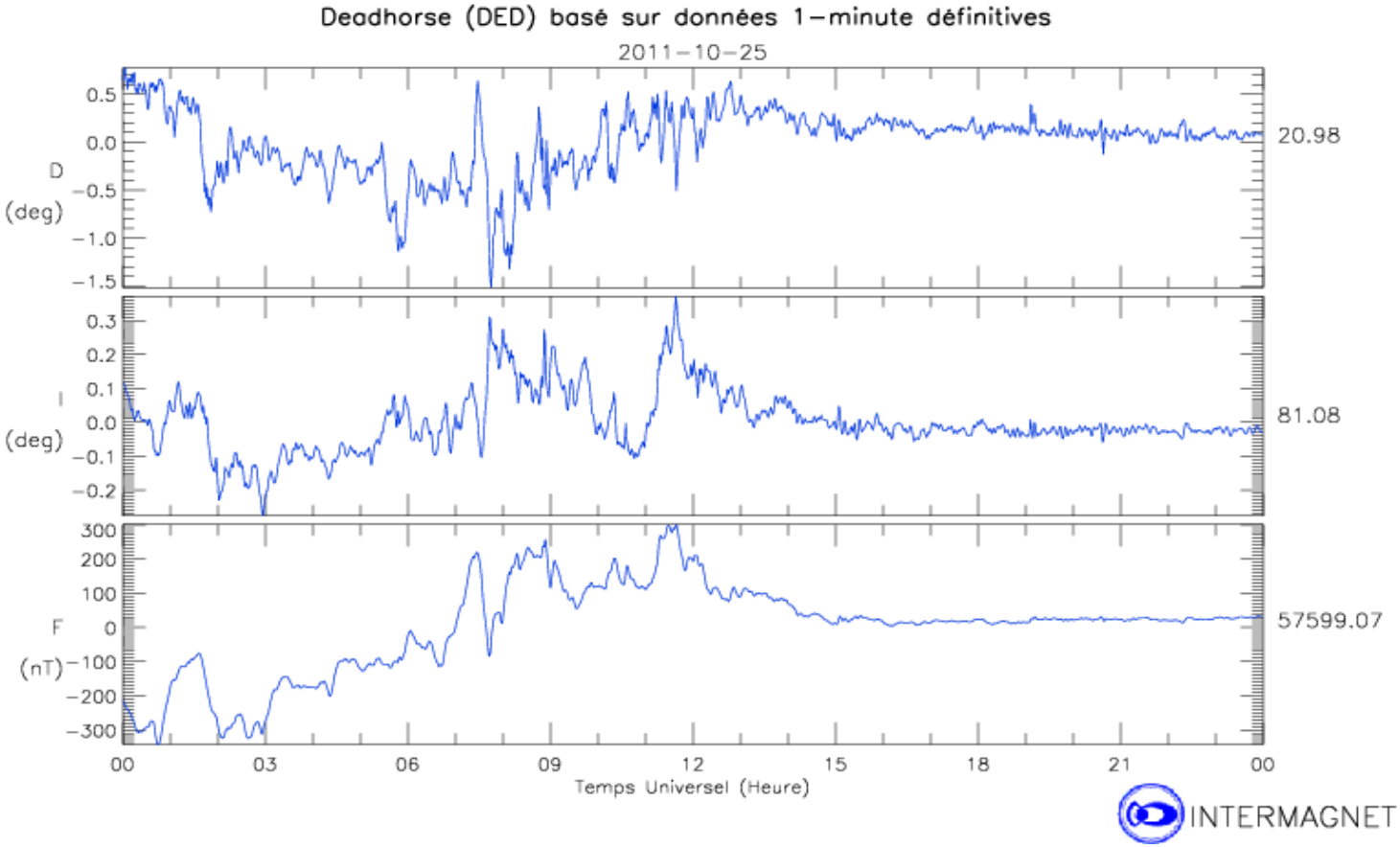
$$B_{total} = B_{main} + B_{crustal} + \mathbf{B_{diurnal}}$$

Daily variation up to:

D: 2°
F: 600nT
I: 0.5°

Even more (10-29-2003):

D: 20°
F: 2000nT
I: 2.5°



INTERMAGNET

Single shot measurement

Quantum Magnetometry Laboratory Overhauser POS-1

F(B_{total} or TMI)
•Automatic instrument •Temperature insensitive •No need to be oriented •<1nT accuracy •1 Hz sampling

Declination & Inclination (Dip)

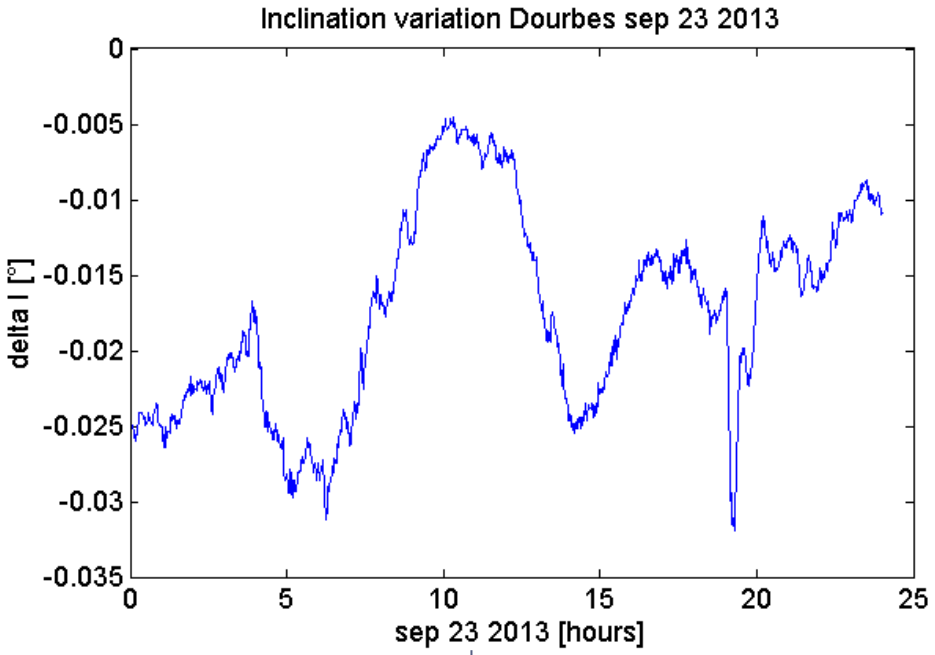
•Manual procedure
•Need a target to determine the true north
•Complex protocol to compensate the errors
  •Misalignment
  •Offset
  •Mechanical
• +- 15 - 20 min
• < 0.01° accuracy

Observatory measurements

Laboratory for ElectroMagnetic Innovation LEMI 025

GemSys dIdD

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



$$I \approx 65.5°$$
$$I = I_0 + \delta I$$

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

Automation

AutoDIF: automatic absolute measurement

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

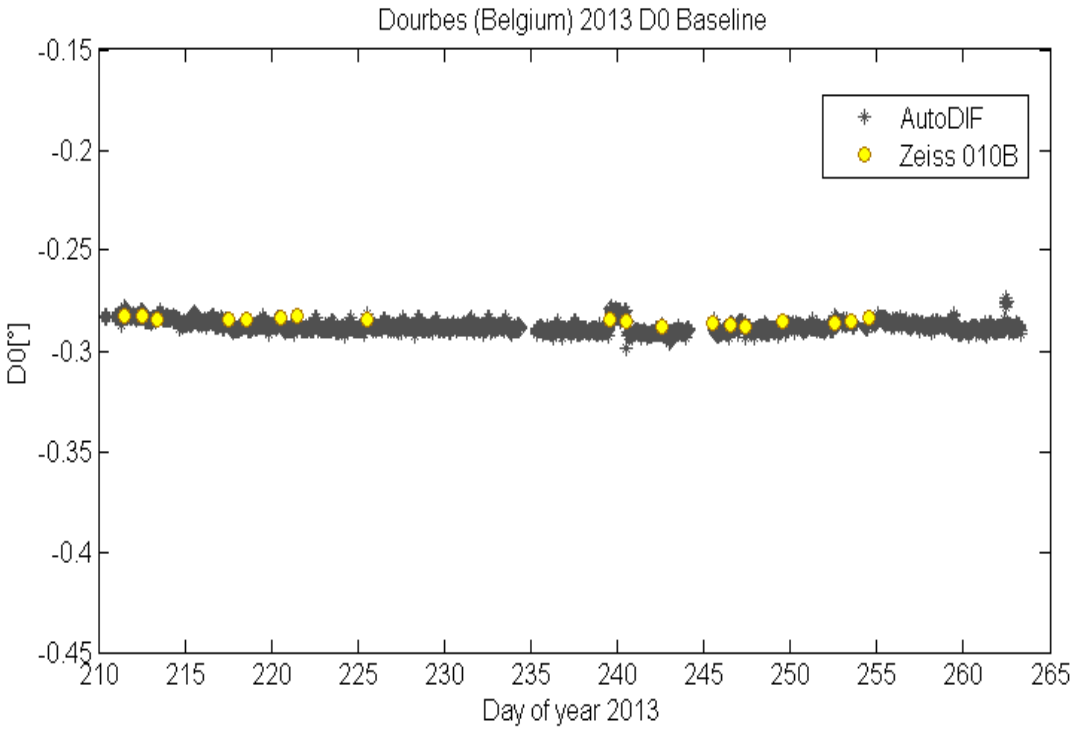
Same protocol as traditional DIFlux
True north reference by mean of target pointing
Laser/Photocells + retroreflector

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

Comparison

Are the automatic measurements correct?

vs



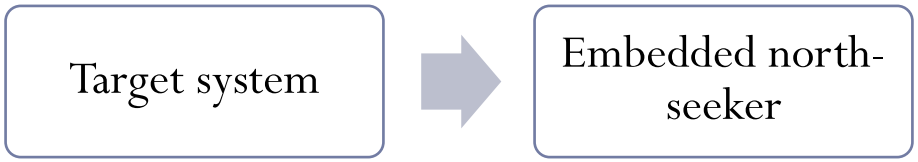
Good fitting

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

$$\omega = \Omega_e \cos(\varphi + \epsilon) \cos(\psi + \gamma) + b$$

The sensor is mounted on the horizontal axis

- Same frame as fluxgate sensor
- Double reversal: bias & alignment compensation

$$\omega_{res} \approx \Omega_e \cos(\psi) \cos(\varphi)$$

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

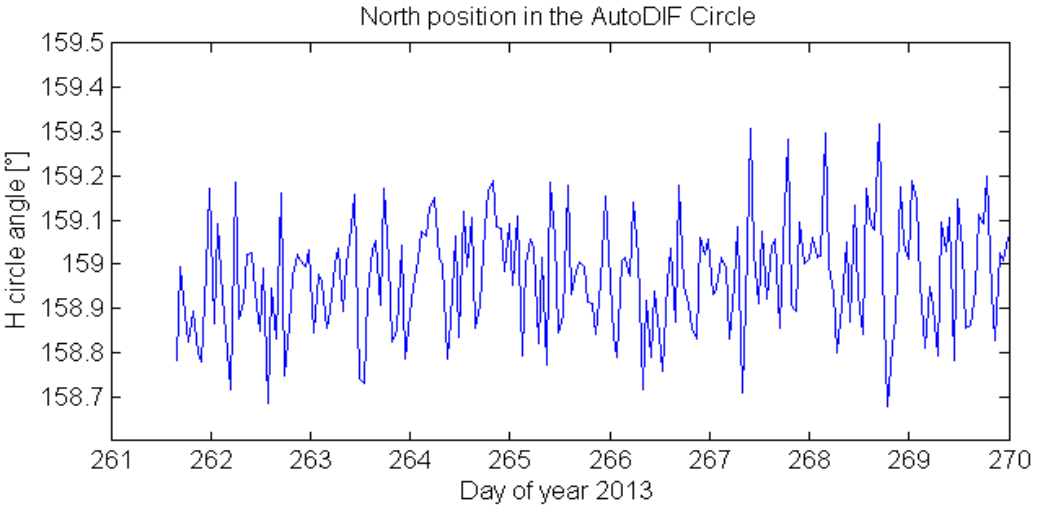
AutoDIF Gyro

1complete measurement/hour:
Magnetic + gyroscope

$$\sigma_e = 0.12°$$

$$\sigma_N = \frac{\sigma_e}{\sqrt{N}}$$

$$\sigma_N = 0.009°$$



Dependency over latitude:

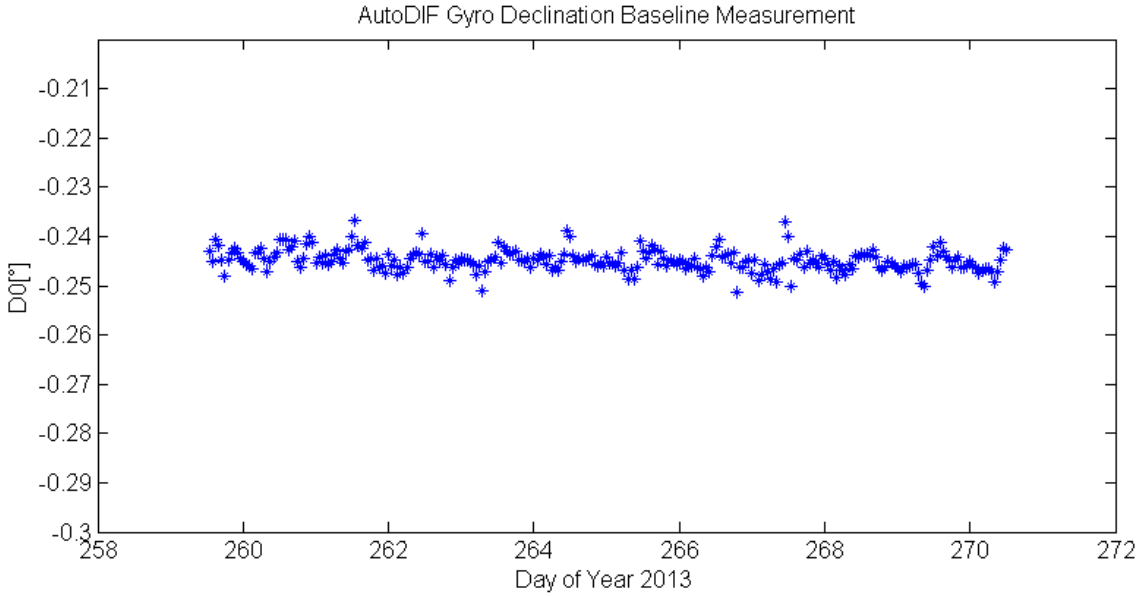
Belgium $\cos(\varphi) = 0.64$

DeadHorse $\cos(\varphi) = 0.34$

$$\sigma_{e2} \cong \sigma_{e1} * \frac{\cos(\varphi_1)}{\cos(\varphi_2)}$$

$$N_2 = N_1 * \left(\frac{\cos(\varphi_1)}{\cos(\varphi_2)}\right)^2$$

$$N_2 \cong 3.5 N_1$$



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))