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DESMEX

A Novel Semi-airborne EM System for Mineral Exploration

First Results from Combined Fluxgate and Induction Coil Data

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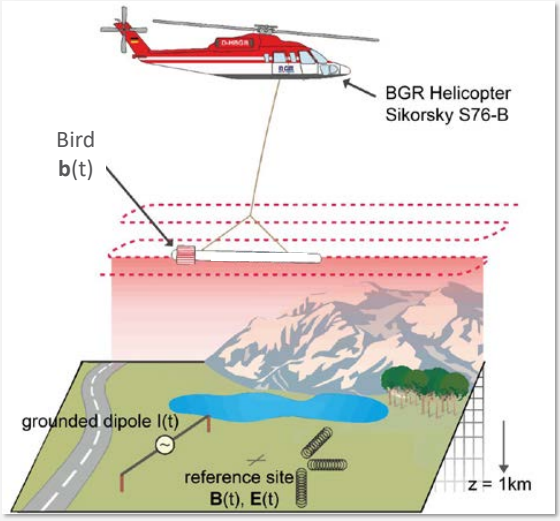
Semi-Airborne Electromagnetics

- Grounded electrical dipole source with1-2 km length
- Measure magnetic field (variations) in the air
- Accurate motion sensors to correct for related noise
- Frequency domain processing (similar to CSEM)
- 3D modeling and inversion of the data



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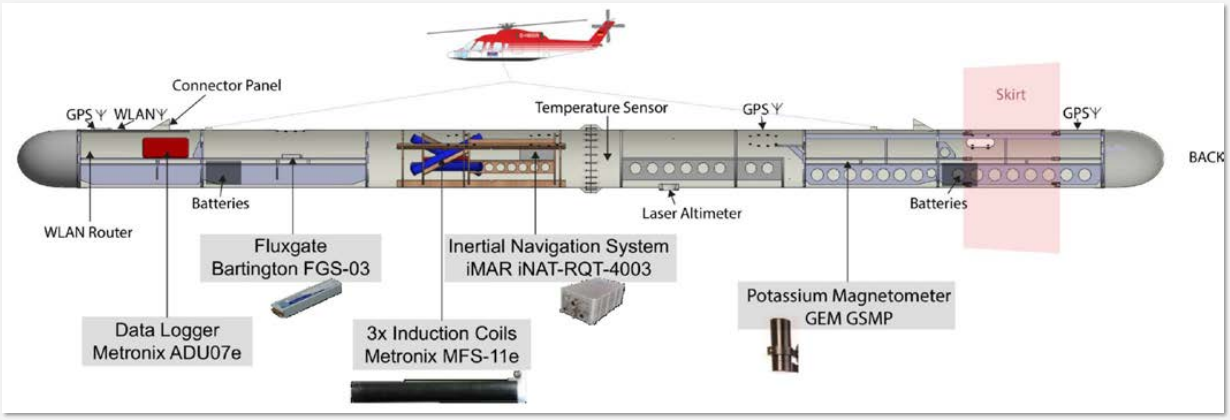
Measurement System



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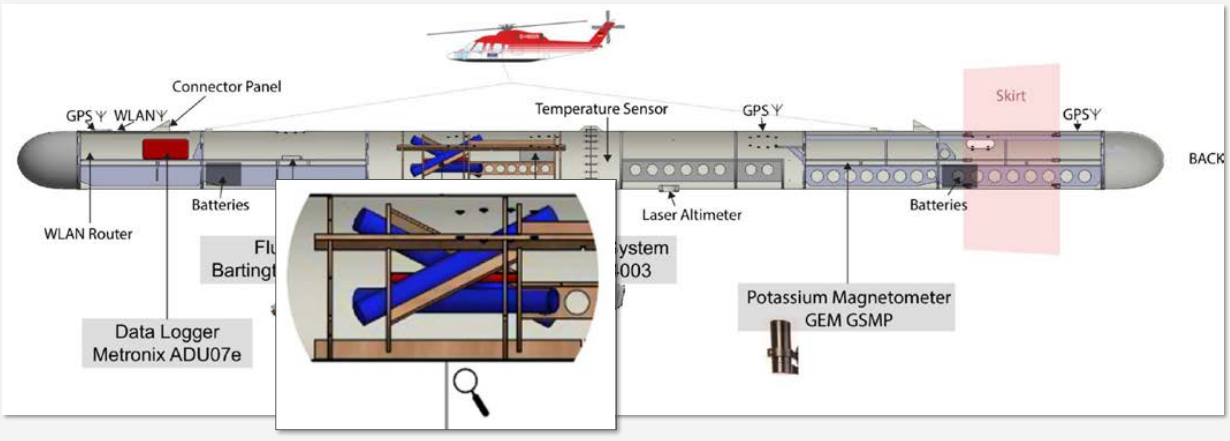
Measurement System



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System Specifications

	Fluxgate 	Coils 	Potassium Mag. 	INS 
Data	mag. field variations (Bx, By, Bz)	oblique mag. field variations (Bu, Bv, Bw)	magnetic total field intensity (Btot)	Position Orientation Acceleration Angular Vel.
Samplingrate	16384 Hz	16384 Hz	20 Hz	400 Hz
Sensitivity	< 6 pT rms/√Hz @ 1 Hz Sensor axis orthogonality < 0.1°	0.5 fT rms/√Hz @ 1000 Hz	0.3 pT @ 1 Hz (abs. +/- 0.05 nT)	Attitude < 0.01° Drift: < 0.01°/hr

Flight Velocity: ca. 60 kts // 115 km/h
Flight Height: 42m below helicopter and 50-60 m above topography
System Weight: ca. 300kg

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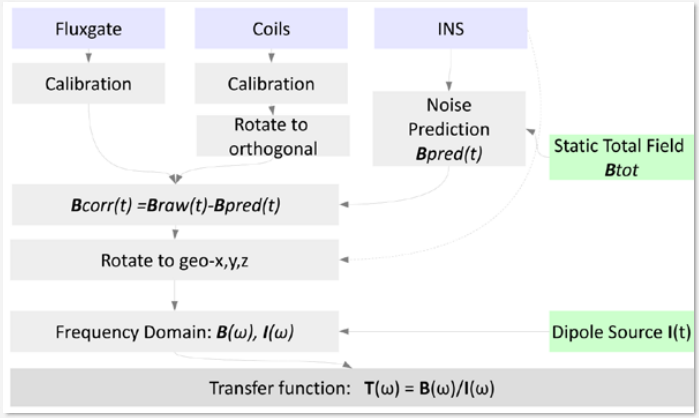
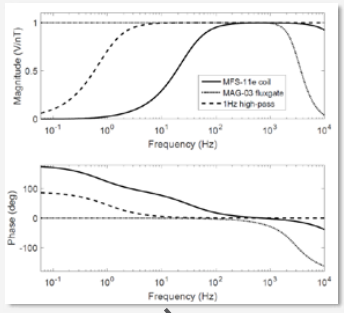
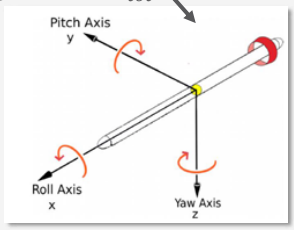
Processing Scheme



Instrument Response functions



Static Magnetic Field $\mathbf{B}_{tot}$



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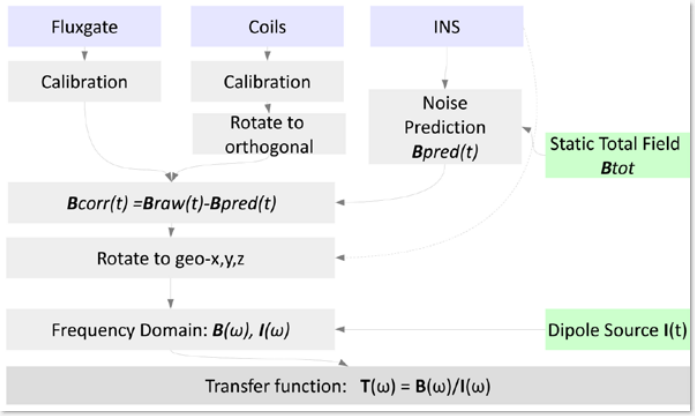

Noise Prediction in Bird fixed coordinates:

- Predict Noise with Static Field $\mathbf{B}_{tot}$, IMU Data $\mathbf{R}^T(t)$ and instrument response $C(t)$

$$\mathbf{B}_{pred}(t) = C(t) * \mathbf{R}^T(t)\mathbf{B}_{tot}$$

- Procrustes Analysis to avoid misalignment Errors of the Prediction:

$$\mathbf{B}_{cal}(t) = s\,\mathbf{B}_{pred}(t)\mathbf{T} + c$$

$$\mathbf{B}_{cor,bird}(t) = \mathbf{B}_{obs,bird}(t) - \mathbf{B}_{cal}(t)$$

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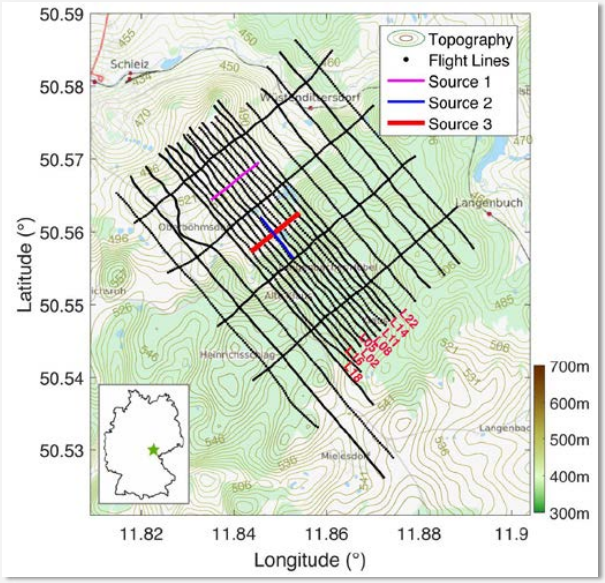
Flight Experiment

- Measurement Area of 4x4 km
- 1km dipole length
- 10.41 Hz, 20A, rectangular source signal
- 25 flight lines above three source positions

- Previous Measurements: ERT, HEM, LOTEM, …



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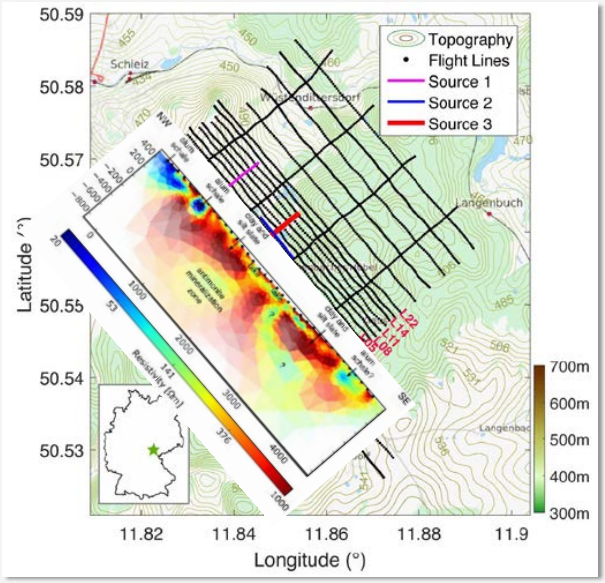

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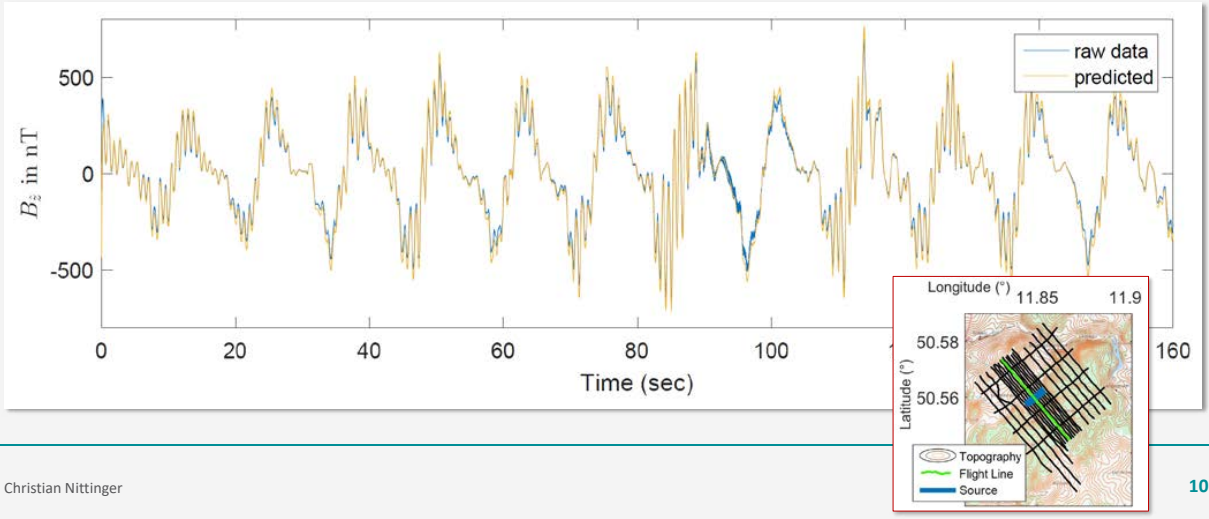
Data Processing – Raw Data vs. Predicted Data (Fluxgate)



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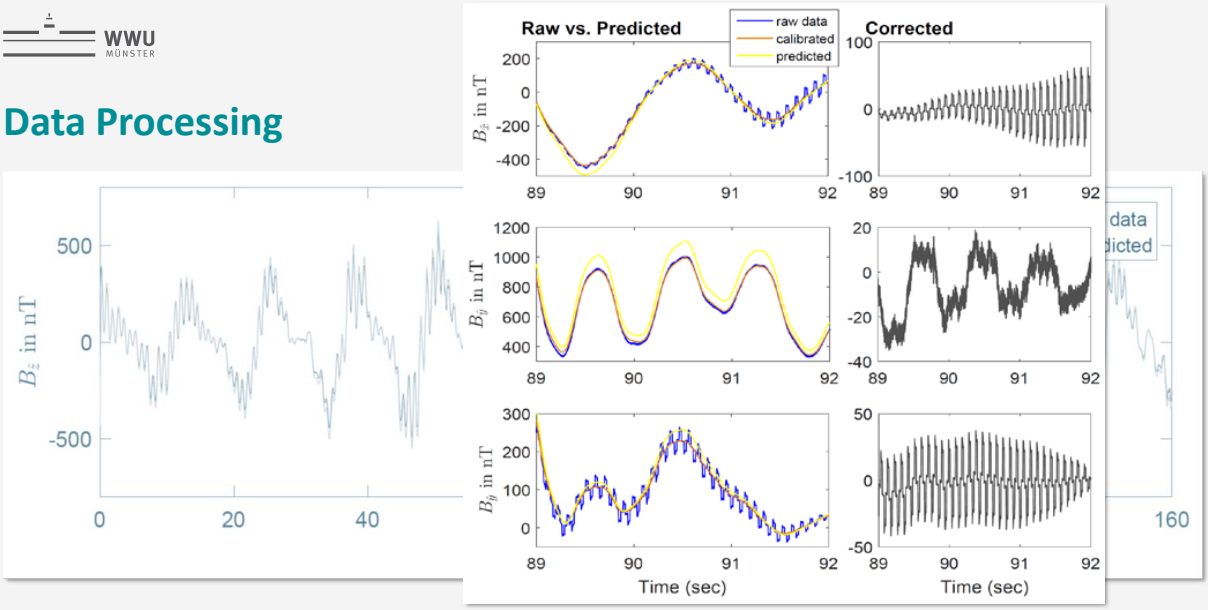
Data Processing



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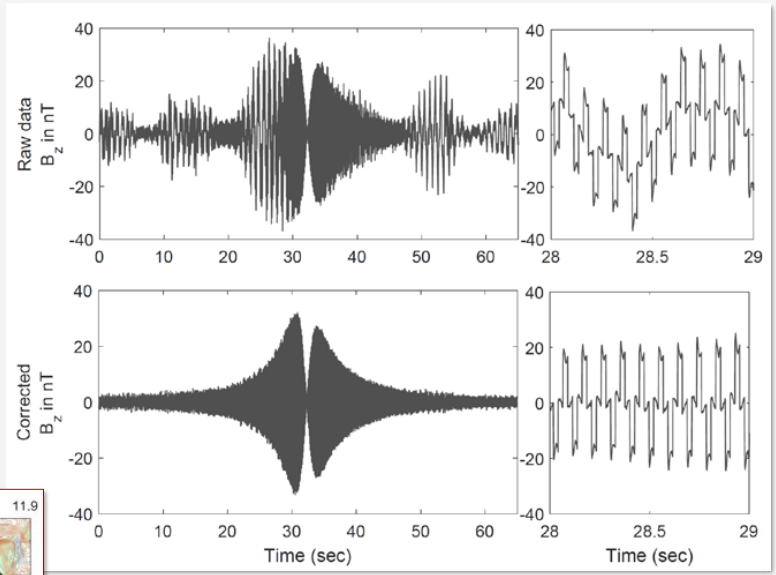
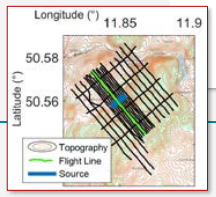
Data Processing
Coil Data Example

- Bz Component in nT (after Deconvolution)
- 10Hz high-pass filtered for visualization
- Processing Scheme helps to correct for high-frequency noise as likely as for low-frequency noise





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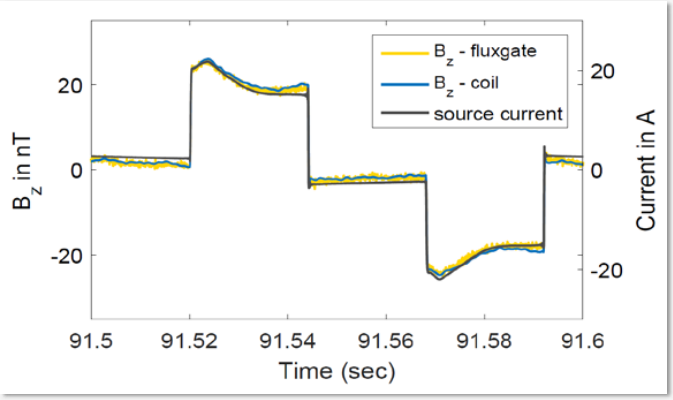
Data Processing – Source current vs. measured signal



- 20A current s
- Clean signal from source current in the time series data

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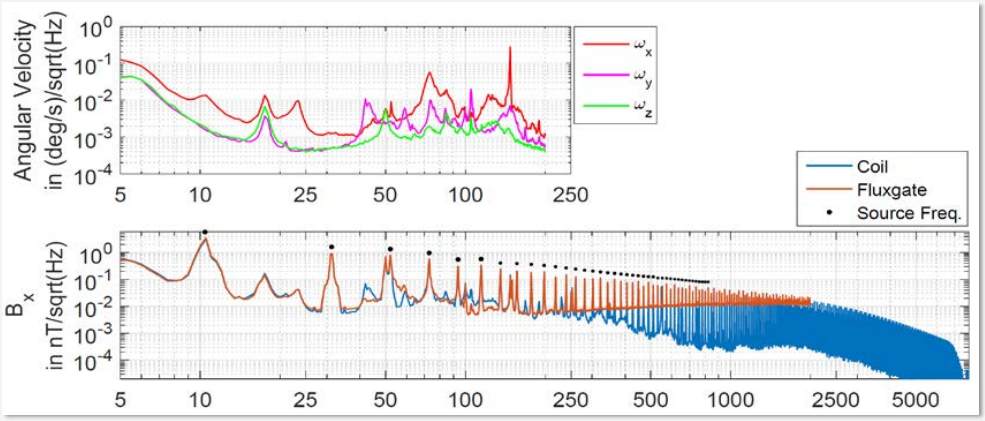
Data Processing – Spectra Comparison IMU vs. Mag. Field



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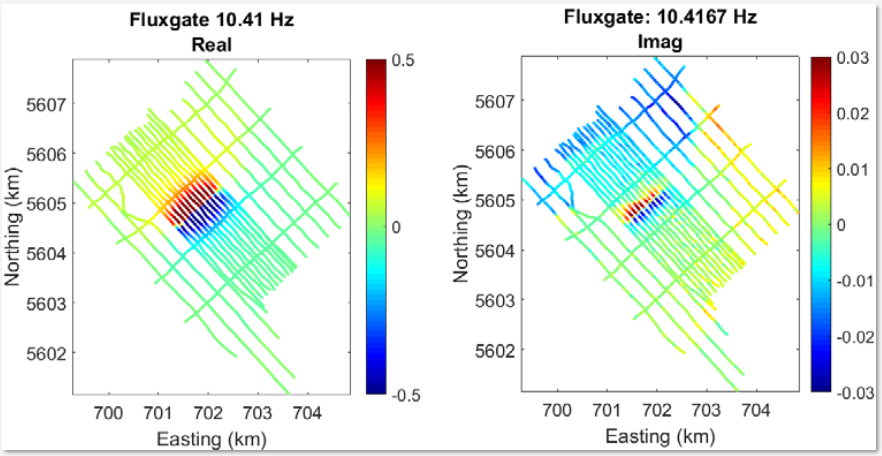
Data Processing – Transfer Functions Tz(ω) = Bz(ω)/I(ω)



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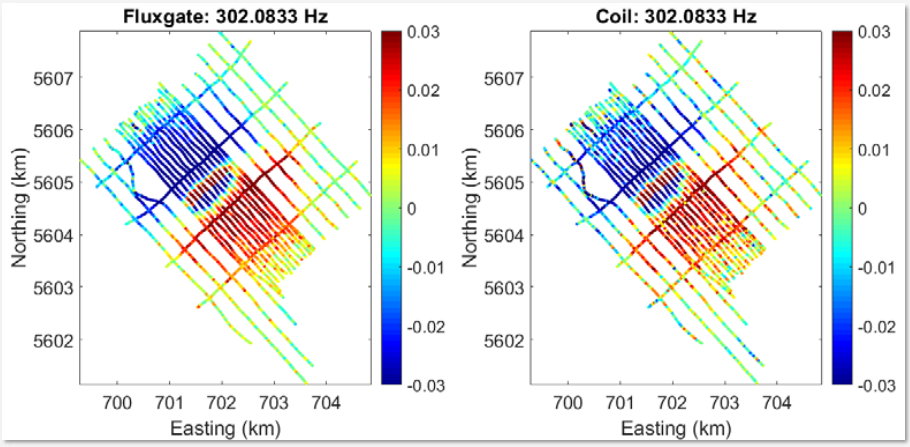
Data Processing – Imaginary Part of Tz(ω)



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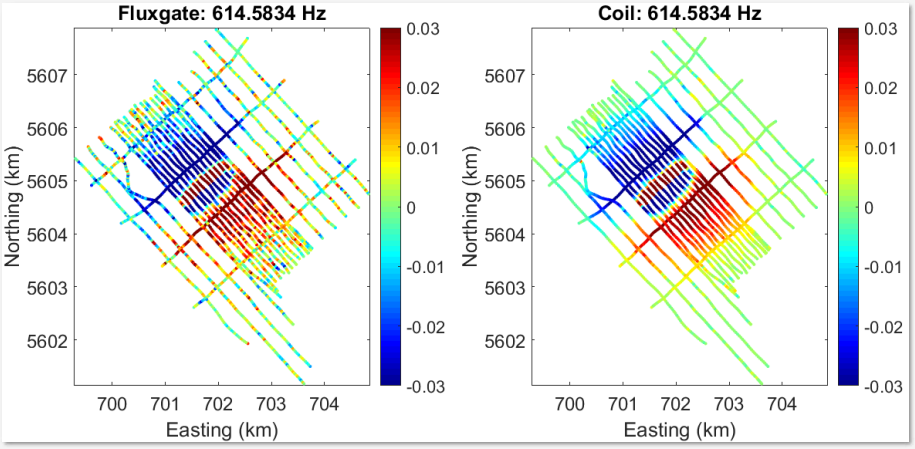

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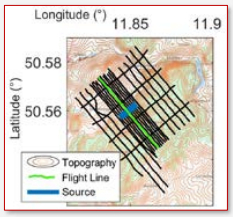
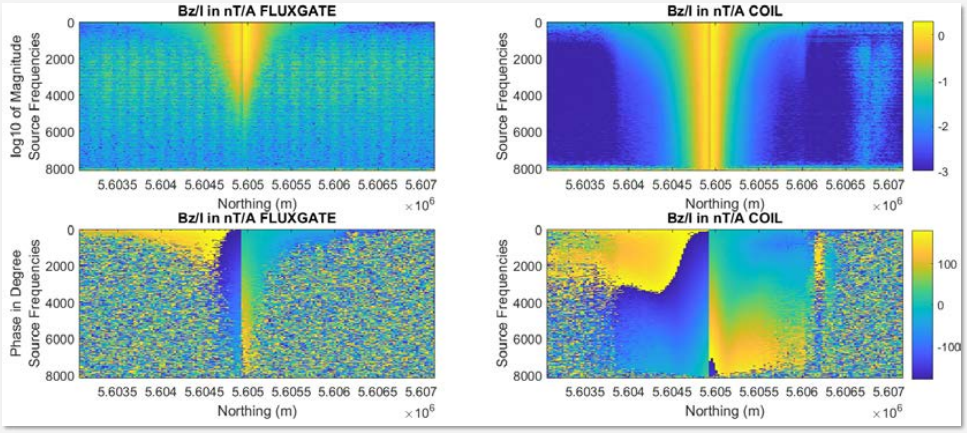
Data Processing (5) – Pseudosections of a flight line





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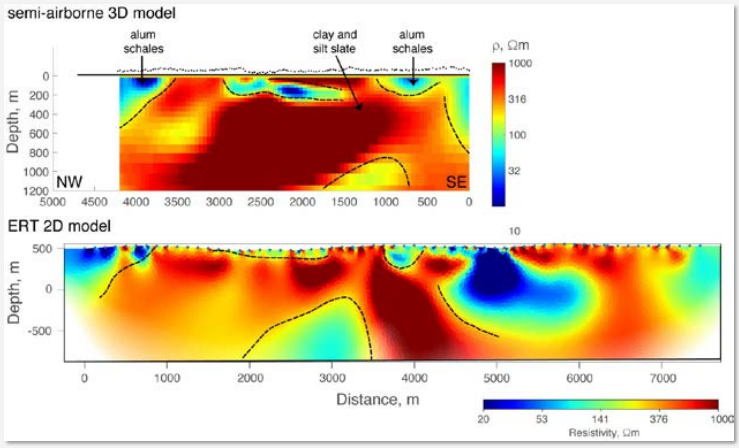
Modeling Results

- 3D inversion model compares well to ground-based ERT Model

More at EMTF Contribution:
3D Inversion of the Semi-airborne Electromagnetic Data from Germany

M. Cherevatova *et al.*



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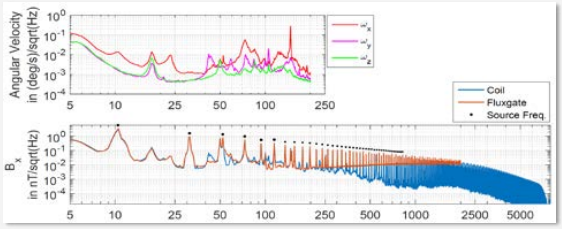
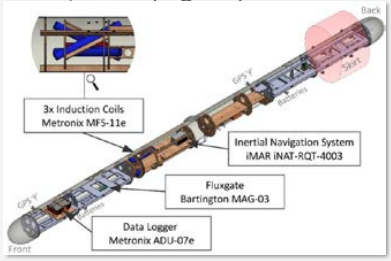
Conclusions



- Frequency domain airborne system with a range of 1Hz-10kHz
  → grounded source 10.41 Hz, choose freqs. that avoid noise peaks (motion/anthropogenic)
- Beneficial combination of Fluxgate, Coil and IMU (+ TMI in next flights)
- Inflight system noise < 50pT/sqrt(Hz) at frequencies 10-400Hz
  and < 1pT/sqrt(Hz) at frequencies > 400Hz
- Calibration/processing + data quality can potentially be further improved
  → induced voltages in induction coils not yet considered
- Flight area of ca. 4x4km, can be increased by the use of two simultaneous sources



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Acknowledgements

* DESMEX Working Group Members

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