Motion Noise Reduction for Airborne EM using Natural Signal in DESMEX

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Airborne EM using Natural Signal

Airborne electromagnetic measurements using natural signal provide a dense data coverage of large areas in short time and with small effort. The audio-magnetotelluric signal is much weaker than the signal of a nearby transmitter. Hence, airborne systems require an extremely low noise level for passive measurements.
The strongest noise source of airborne EM data is motion noise due to sensor movements in the Earth's magnetic field. As part of the DESMEX II project, we aim to optimize the DESMEX induction coil airborne system to meet passive EM requirements. We use an Inertial Navigation System (INS) to measure sensor movements and predict the signal input caused by motion (Becken et al., 2020). The INS samples with 400 Hz, thus allows for low frequency corrections.
However, the "cleaned" data recorded with undamped sensors are still afflicted with remaining motion noise and the noise level is too high compared to natural signal strength.
To reduce the noise level, we built a damped sensor platform using vibration-insulating foam material. Damping characteristics were tested on the ground and under flight conditions.

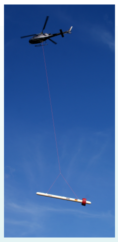
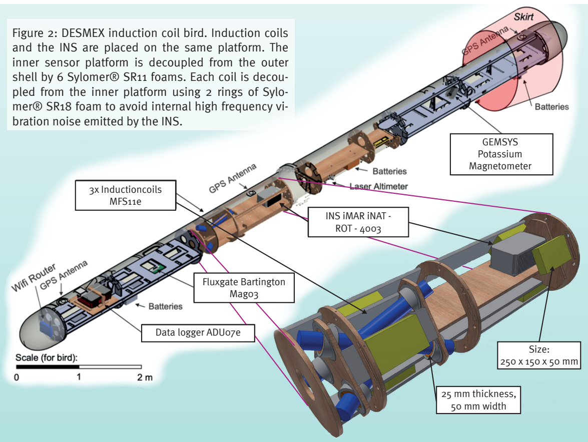


Figure 1: Flight with the DESMEX induction coil airborne system.

The DESMEX Induction Coil Bird

Figure 2: DESMEX induction coil bird. Induction coils and the INS are placed on the same platform. The inner sensor platform is decoupled from the outer shell by 6 Sylomer® SR11 foams. Each coil is decoupled from the inner platform using 2 rings of Sylomer® SR18 foam to avoid internal high frequency vibration noise emitted by the INS.



Foam Material Tests

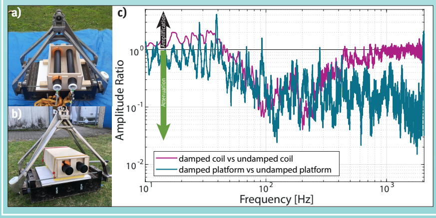


Figure 3: Comparison of damped and undamped test platform using hit-induced vibrations on Sylomer foams (Woelke, 2021). a) Set up with damped coil (SR18). b) Set up with double damping (box on SR11). c) Amplitude ratio showing damping characteristics. Values <1 indicate attenuation.

Conclusion

The new vibration-insulated sensor platform reduces motion noise on all components with up to >1 order of magnitude between 70 and 1000 Hz. Presuming strong natural signal, the noise level on the horizontal magnetic field components drops below natural signal level between ~200 and 1000 Hz. The natural signal level of the vertical component depends on the subsurface structure and could be accessible in regions of strong lateral conductivity contrast.
With the new sensor platform, passive airborne EM using the DESMEX induction coil system seems to be feasible in a limited frequency range and needs to be tested in future work. Accessing lower frequencies might be possible with further improvement of the system.

Acknowledgements

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Flight Tests

Tests under flight condition were carried out in August 2020 (ground station and undamped sensor) and April 2021 (damped sensor) in the Harz Mountains. The bird was attached to the helicopter with a 42 m long rope and was towed at 70 m above ground in August 2020. In April 2021, we flew at 300 m above the ground. Electromagnetic noise emitted by the helicopter can vary because of different helicopter types used for the test flights (AS350 B2, Sikorsky S-76B).

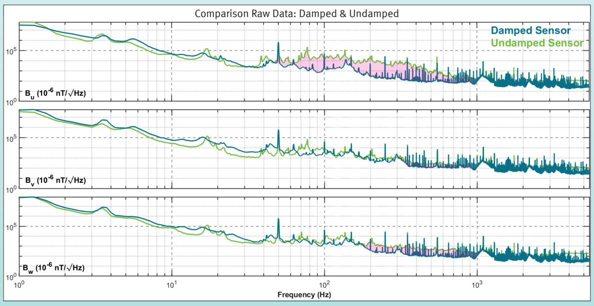
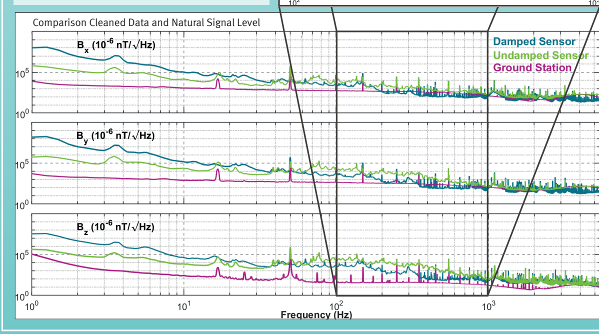


Figure 4: Spectra of raw data recorded with undamped sensor (green) and damped sensor (blue) along a flight line with nearly N-S orientation. The reduction of motion noise depends on the component, the red shaded area shows the noise level reduction. B_U: α = 16°, β = 26.57°; B_V: α = 16°, β = -26.57°; B_W: α = -30°, β = 0° in body coordinate system (α positive clockwise and β positive downwards).

Figure 5: Spectra of cleaned and rotated (north, east, down) timeseries along a flightline. The ground station (magenta) indicates the level of the natural signal. Spectra of flight data with undamped sensor platform and damped platform are shown in green and blue, respectively. In the green shaded frequency range, the noise level of the damped platform is lower than the level of the natural signal. Between 200 and 320 Hz, the noise level is lowest on B_x which roughly corresponds to the flight direction. Due to the tilted sensor configuration in the induction coil bird with predominantly longitudinal coil orientation, the sensors are more sensitive to noise in this direction.



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