Westfälische Wilhelms-Universität Münster

DESMEX

GEOPHYSIK WWU MÜNSTER

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GEFÖRDERT VOM
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Processing of single source and double source semi-airborne EM data

Summary

Spectral analysis of airborne EM data involves a trade-off between spectral and spatial resolution. Long time windows (good resolution in frequency domain) correspond to large spatial averaging. This is particularly problematic in semi-airborne EM surveys, where the primary field exhibits strong spatial gradients. In turn, short time windows (high spatial resolution) correspond to low spectral resolution. This is particularly problematic for a double source survey, since spectral leakage in combination with low spectral resolution yields overlapping signals in frequency domain. A proper selection of these parameters is pre-requisite for unbiased transfer function estimates.

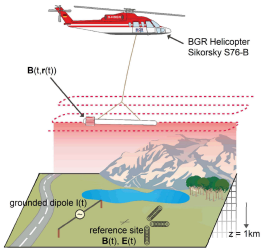

Figure 1: Schematics of the semi-airborne survey geometry.

Single source data

We estimate transfer functions of type

$$B_{x,y,z}(\omega,\mathbf{r}) = \mathscr{B}_{x,y,z}(\omega,\mathbf{r})I(\omega)$$

between airborne magnetic data and the source current. Preprocessing includes motion noise removal, rotation to geog. coordinates and calibration. We use time windows of 8-32 multiples of the fundamental source period and collect harmonics of 2-8 adjacent windows within ½ octave on the frequency axis as independent realizations.

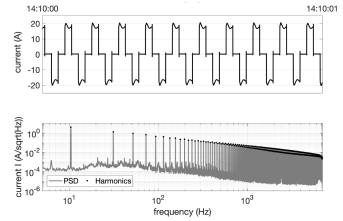

Figure 2: 1s time series of a 20A current injection with a repetition rate of 96 ms (10.417 Hz) and power spectral density of the current.

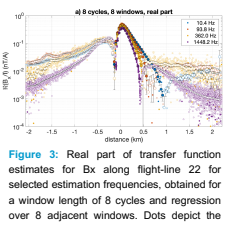

Figure 3: Real part of transfer function estimates for Bx along flight-line 22 for selected estimation frequencies, obtained for a window length of 8 cycles and regression over 8 adjacent windows. Dots depict the ratio of fourier coefficients within each band, circles show the regression estimates.

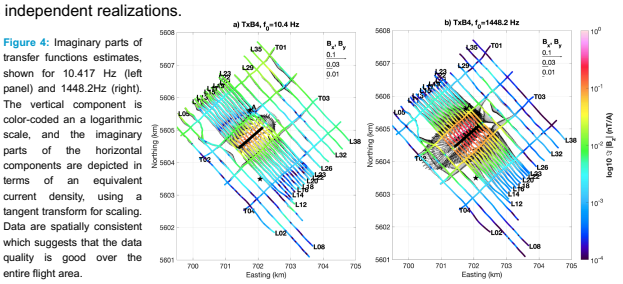

Figure 4: Imaginary parts of transfer functions estimates, shown for 10.417 Hz (left panel) and 1448.2Hz (right). The vertical component is color-coded an a logarithmic scale, and the imaginary parts of the horizontal components are depicted in terms of an equivalent current density, using a tangent transform for scaling. Data are spatially consistent which suggests that the data quality is good over the entire flight area.

Double source data

In the DESMEX main experiment in 2017 conducted near Schleiz (Thuringia), two sources were operated simultaneously with different fundamental periods. Separation of the two source signals was carried out in frequency domain. However, due to spectral leakage, several harmonics overlap and must be disregarded for processing.

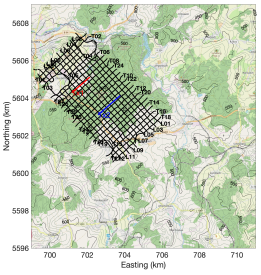

Figure 5: Flight map. Transmitters Tx1 and Tx2 were operated simultaneously with current switching cycles of 134 ms and 96 ms duration, resp..

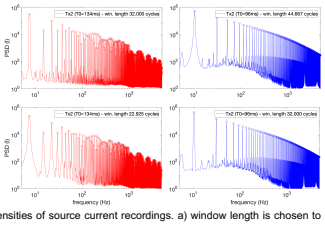

Figure 7: Power spectral densities of source current recordings. a) window length is chosen to be a multiple of the fundamental period of Tx1 (134 ms) and b) Tx2 (96 ms), resp. Note how spectral leakage depends on the window length.

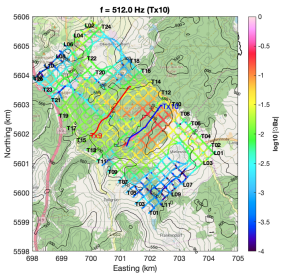

Figure 9: Imaginary parts of vertical magnetic to current transfer functions, estimated separately for two transmitters Tx9 and Tx10. Both transmitters were operated simultaneously but at different fundamental frequencies. Overlapping harmonics were disregarded. There is no obvious distortion from overflight of the other transmitter.

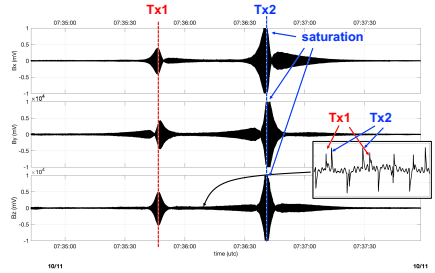

Figure 6: Time series along flight line L06 across the LIAG transmitter (Tx1, T_0=134 ms) and the LOTEM transmitter (Tx2, T_0=96 ms).

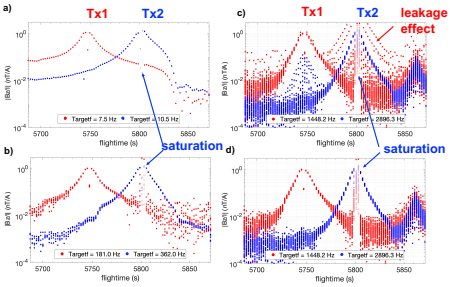

Figure 8: Vertical magnetic field to current ratios (transfer functions), separately estimated for Tx1 and Tx2. Spectral estimation used 32 cycles of the Tx1 source period (134 ms). All harmonics within a bandwidth of ⅓ octave were collected. Note the distortion of all Tx1 transfer functions in the vicinity of Tx2, which is due to over-saturation.

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