**Introduction**

- **Drone-based electromagnetic (EM) sensing for semi-airborne surveys** promises higher data quality, better geophysical structure resolution, and lower cost compared to ground-based or typical (semi-airborne) techniques, especially in terms of providing very high spatial data density.

- **Source-oriented analysis** (SOA) of such densely sampled transient EM (TEM) data is proposed to estimate the induced current distributions in the presence of geoelectric structures to obtain high resolution resistivity images of the subsurface.

- **SOA promises to be a more intuitive, effective approach to resolve subsurface geoelectric structure** compared to “well modeled” techniques including 1D and 3D inversions.

- **Early work on TEM SOA occurred in the 60s and 70s**, when it was determined that the approach was suitable for data acquisition capabilities of that time as well as being too expensive.

- **Recent advent of high data density drone-based EM acquisition systems** (UAV) and their much lower cost compared to ground or aircraft surveys, means it’s time to revisit the TEM SOA subject.

**Study Goals**

- **Describe source-oriented analysis approach as applied to TEM explore** model study of multiple large loop sources on ground surface and drone-based magnetic field data acquisition flying a few meters above the ground surface for a buried target structure.

- **Establish efficacy of the source-oriented modeling approach** to provide different diffusing current distribution interactions with the subsurface structures, thus improving model accuracy inherently.

- **Indicate prospects for further development and capabilities** of the technique.

**Source-Oriented TEM Methodology**

**TEM SOA** is inspired by gravity and magnetics analysis, where the static fields are uncoupled, and the method (adding subtracting mass or magnetization) is also very simple. In TEM, however, the fields are coupled both spatially and temporally. Therefore creating and modifying time-lapse current distributions in particular ways that varies in sensitivity to specific structural elements. So TEM SOA uses multiple sources to provide different diffusing current distribution interactions with the subsurface structures, thus improving model accuracy inherently. Sources on both sides of the target area are required. Figure 1 shows the simulated output model, survey layout, and a sketch of multiconcurrent current evolution. Figure 2 shows the overall TEM SOA processing flow chart.

**Fig. 2. TEM SOA flow chart. See text for explanations.**

Figure 3 shows the reference model data for a single time slice of data for one loop source; the magnetic field profiles $H_x$, $H_y$, and $H_z$ and the cross section of current density $j_x$ are perpendicular to the simulated basin structure such that we are solving a two-dimensional (2D) problem. (3D in its future.) The $H_y$ profile is well-behaved and relatively straightening out to the current distribution; the position of the $H_y$ profile maximum closely corresponds to the lateral position of the current maximum in the earth. So the initial step focuses on the $H_y$ data stream.

The first adjustment step finds a time slice of the starting model – likely an interpolation between two time slices – that maximizes the position of the current to the best possible match. This is called a time slice. There are several ways to define an error model for this adjustment. Though widely used, least squares error model makes a stronger assumption that the current density is an adjustment, an approximation that minimizes LS. Using adjustments from an accurate starting model maintains spatial and temporal coupling integrity of TEM fields to a high degree.

**Fig. 3. Starting model and simulated data. (Top) Magnetic field profiles (blue $H_x$, black $H_y$, green $H_z$). Cross section of current density $j_x$ (black). (Bottom) Current density $j_x$ (black). Current density data interpolated and current density subsampled 30 cm on uniform halftone.**

**Conclusions**

- **TEM SOA concept is described and shown to be effective for modeled test case.**

- **TEM SOA enhanced by drone data acquisition provided by low cost drone-based systems.**

- **Resistivity imaging constructed with well matched modeled buried basin structure.**

- **Imaging result can stand alone or be used as starting point for further TEM modeling.**

- **TEM SOA can be advanced, e.g., using source-oriented modeling for TEM.**