Combined Geophysical Approach to Characterizing Subsurface Flow Paths in the Reynolds Creek Watershed (H51D-0509)

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Rationale

Many upland watersheds in the Western US are characterized by snow as the dominant source of precipitation. Understanding how snow melt moves through the subsurface and identifying the flow paths generated are of considerable interest in understanding hydrologic processes in these watersheds.

We present preliminary data from the Reynolds Creek USDA Experimental Watershed in southern Idaho. The geophysical technique electromagnetic induction (EMI) was combined with DC electrical resistivity imaging (ERI) to study a 50m by 50m section of the upper watershed. EMI provides an excellent reconnaissance method allowing large areas to be surveyed rapidly. Subsequent geostatistical analysis of this data, with the relevant ground-truthing, allowed a spatial distribution of soil moisture variations to be produced. The combination with ER imaging introduces an extra dimension to the survey, allowing the identification of subsurface controls on flow paths that are not obvious from inspection of surface topography. This information will aid hydrogeologists in determining the dominant subsurface flow directions and controls in this zero order watershed.

Figure 1. View looking north down the Reynolds Creeek watershed.

Location

The USDA experimental watershed at Reynolds Creek, ID has been collecting hydrological measurements for 40 years. The upper section of the watershed is designated for experimental trials.

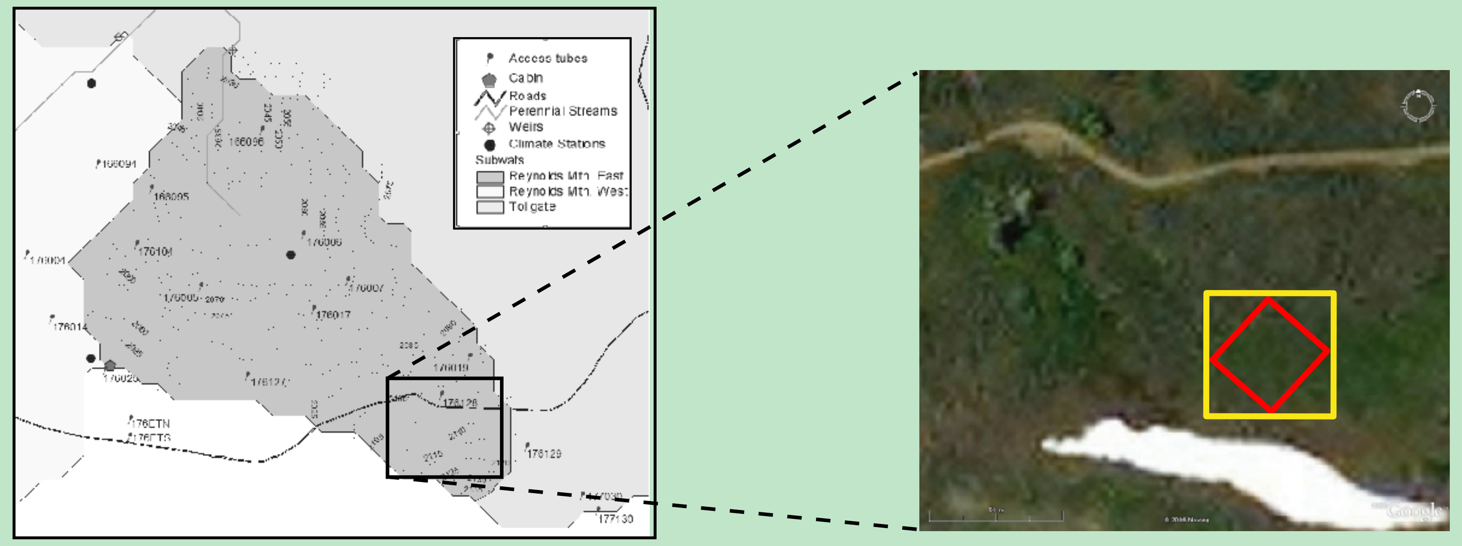


Figure 2. Watershed boundaries (left) with an expanded aerial photograph of the surveyed area with the EMI grid area (yellow box) and ERI grid area (red box) outlines highlighted (right).

Methodology

Electrical resistivity data were collected using the IRIS Syscal R1+ switch 48 resistivity imaging system. A series of orthogonal 2D profiles, see figure 3, were created by collecting data using the Wenner and dipole-dipole electrode configurations, with a minimum electrode and dipole separation of 0.5m. Consideration of the reciprocal error provided an estimate of data error in the field measurements, reciprocal errors were generally <2% for this survey and any errors above this were omitted from the inversion. The Profiler software, based on a regularized objective function combined with weighted least squares, was used in the inversion (http://www.es.lancs.ac.uk/people/amb/Profiler/profiler.htm).

EMI mapping was conducted using a Dualem 1S, integrated with a GPS through an Allegro field computer.

Results

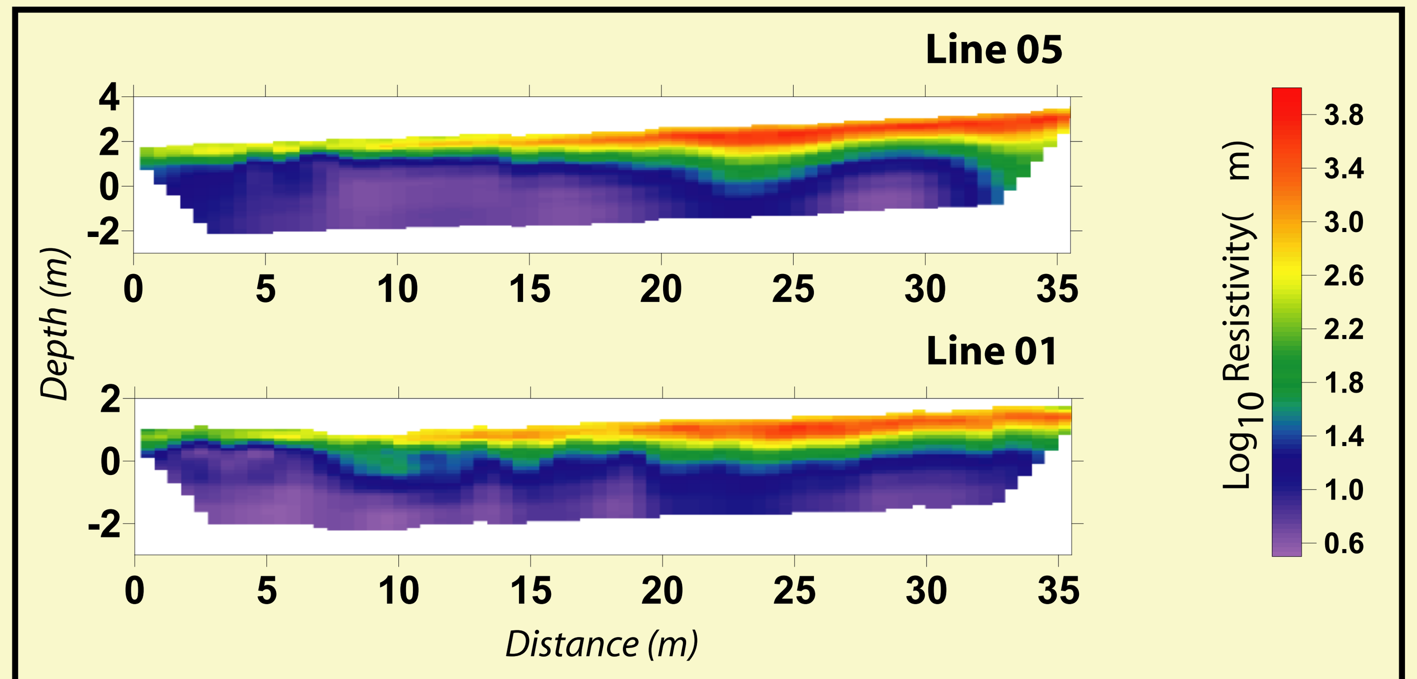
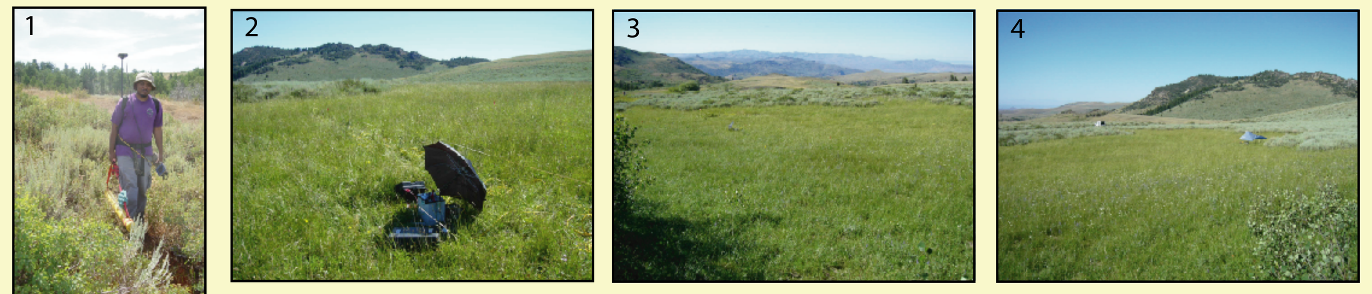


Figure 3. Example ERI profiles from lines 05 (top) and 01 (bottom), illustrating the variation in subsurface topography between the two layers.



Images illustrating the EMI (1) and ERI (2) field set-up and the view looking NW (3) and NE (4) across the grid areas high-lighted in figure 2.

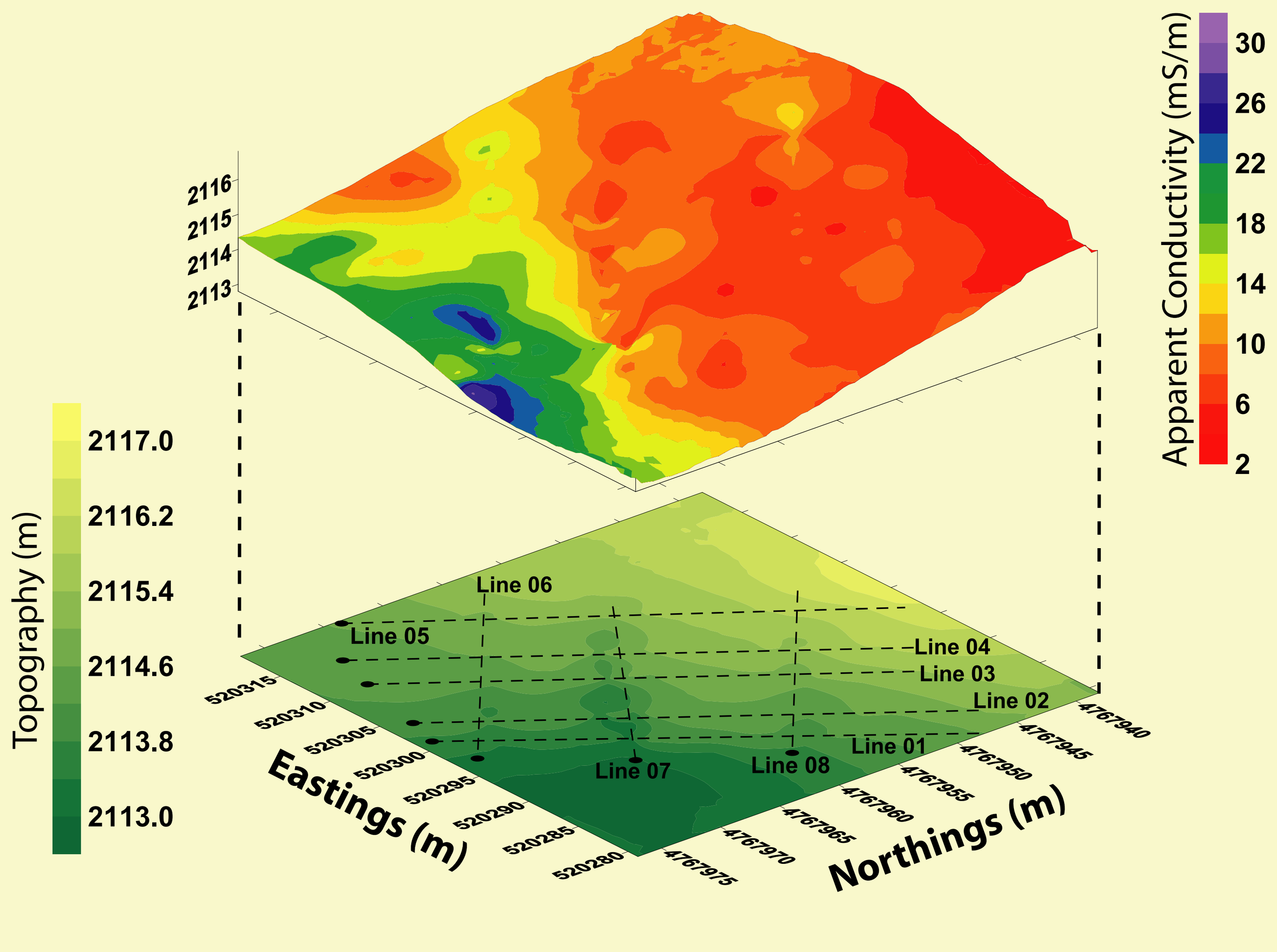


Figure 4. Contoured EMI data draped over the topography (top), the positions of the ERI profiles are shown overlaid on the topography contours for comparison (bottom), the dots indicate the position of electrode 1for each profile.

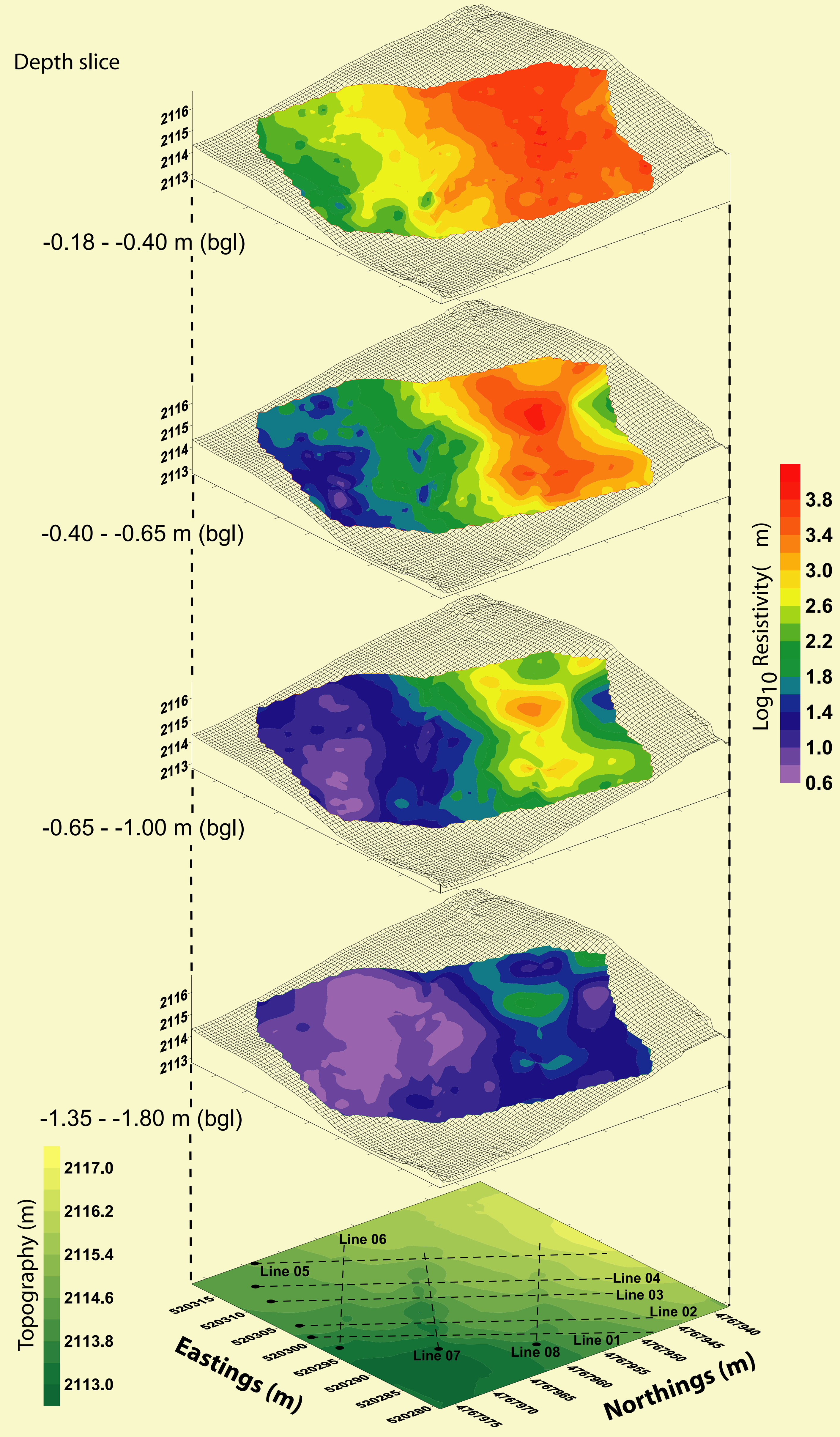


Figure 5. Representative depth slices (bgl - below ground level) taken through the 2D ERI profiles (shown bottom), draped over the topography.

Summary

The resistivity images depict a two layer structure, figure 3, an upper resistive layer overlying a more conductive region; the subsurface composition is very similar, the resistive upper layer resulting from variations in soil moisture, clay percentage and the presence of the root zone. The boundary between these two layers displays significant susbsurface topography throughout the profiles, with resistive channel structures incising into the more conductive lower region.

These susbsurface structures, resulting from a decrease in clay percentage in these regions, are of particular interest because they have the potential to act as perferential pathways for soil water.

The large channel structure evident along a SE - NW trend through the southern half of the ERI depth slices, figure 5, correlates well with a similar trend observed in the apparent conductivity contours in the corresponding region of the EMI data, figure 4.

Work is ongoing to develop a working methodology for the integration of these two datasets with the ERI providing a directed calibration for the EMI response to the subsurface conductivity structure. This can then be combined with the directed soil sampling to provide the calibration for the hydrological parameter mapping.

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