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Time-lapse CSAMT measurements to record the hydrological response of the Lodève landslide to heavy meteorological events

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The Lodève landslide is a slow moving (3 to 4 mm/yr) and deep (60 m) rotational instability, located in the South-East of France, 60 km North from Montpellier (Hérault department). It is located in the Lodève basin, a set of connected steep head valleys marking the southern limit of the karstic Larzac plateau, and particularly prone to hydraulically triggered landslides. The unstable slope was progressively formed by the erosion of the upper limestone and sandstone units. The local tectonics build up resulted in a series of vertical North/South faults and fissures, allowing the water to infiltrate down to the deeper Triassic clay and evaporite layers. During heavy rainfall events, an amount of the meteoritic water infiltrates along these flow paths, down to the clay and evaporite layers from the Norian and Rhaetian era, leading to the rapid recharge of the units, the onset of high pressure in the confined layers and the decrease of the cohesion of the rock material and of the shear strength.

The Controlled Source Audio-frequency Magneto-Telluric (CSAMT) method is a low-impact, non-invasive active frequency domain electromagnetic sounding technique, deriving from the Magneto-Telluric (MT) method. An electromagnetic signal is produced a few km away from the studied site, and the electric and magnetic transfer functions of the plane wave signal are recorded at multiple frequencies, permitting the computation of far-field MT impedance tensor. CSAMT is characterized by a good vertical resolution and large depths of investigation, but poor sensitivity to the first tens of meters. For these reason, it is expected to be a good candidate method to conduct time-lapse studies in the context of pseudo-1D layered subsurface.

CSAMT data were acquired at the landslide from November 2018 to March 2019 at 8 different stations. The landslide is assumed to be a pseudo-1D medium with a tilted flat surface topography. The aim was to observe the variations of electrical resistivity related to the hydrogeological response to the heavy rains observed during the monitoring period. Sensitivity tests were realized with the software custEM. Measurements were taken at ten fundamental

frequencies ranged from 510 to 9600 Hz with a Phoenix's System-2000.net equipment and were repeated every months except in February.

The data quality is uneven from one station to another next. Most station showed significant variations in apparent resistivity. The observed variations were interpreted in a one-dimensional context, revealing lateral variations in the hydrogeological response of the slide. Complementary TDIP and DC data and high temporal geochemical and geophysical monitoring of properties at two boreholes were used to constraint the CSAMT interpretation.