Geophysical Research Abstracts
Vol. 18, EGU2016-9147, 2016
EGU General Assembly 2016

Magnetotellurics as a multiscale geophysical exploration method

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Magnetotellurics (MT) is a geophysical method based on the use of natural electromagnetic signals to define subsurface electrical resistivity structure through electromagnetic induction. MT waves are generated in the Earth's atmosphere and magnetosphere by a range of physical processes, such as magnetic storms, micropulsations, lightning activity. Since the underground MT wave propagation is of diffusive type, the longer is the wavelength (i.e. the lower the wave frequency) the deeper will be the propagation depth. Considering the frequency band commonly used in MT prospecting (10-4 Hz to 104 Hz), the investigation depth ranges from few hundred meters to hundreds of kilometers. This means that magnetotellurics is inherently a multiscale method and, thus, appropriate for applications at different scale ranging from aquifer system characterization to petroleum and geothermal research. In this perspective, the application of the Wavelet transform to the MT data analysis could represent an excellent tool to emphasize characteristics of the MT signal at different scales. In this note, the potentiality of such an approach is studied. In particular, we show that the use of a Discrete Wavelet (DW) decomposition of measured MT time-series data allows to retrieve robust information about the subsoil resistivity over a wide range of spatial (depth) scales, spanning up to 5 orders of magnitude. Furthermore, the application of DWs to MT data analysis has proven to be a flexible tool for advanced data processing (e.g. non-linear filtering, denoising and clustering).