Probabilistic approach in hydrogeophysics to better articulate geophysical data with hydrogeological models

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In the midst of global change, effective water resources modelling is crucial in addressing the water-food-energy nexus challenge. With increased withdrawals from scarce resources, the sustainability of water supply depends on quantifying water fluxes within the critical zone interfaces especially in the unsaturated zone (UZ), located between the atmosphere and groundwater. .

The percolation of precipitation through the unsaturated zone, which controls groundwater recharge, depends on the physical properties of the soil, including water storage and water fluxes, which can only be obtained by knowing the water content profile. The unsaturated zone suffers from limited knowledge of the heterogeneities within the porous medium. Hydrogeophysics provides tools that limit these uncertainties and the non-uniqueness of parameters affecting hydrogeological modelling, enabling a better understanding of the unsaturated zone and have significantly improved the spatial and temporal characterization of physical parameters in porous media.

This project proposes a methodology to evaluate the sensitivity of water saturation (Sw) and of seismic attributes to the physical parameters of porous media. We use a Bayesian framework to characterize how uncertainties propagate from geophysical data to hydrological models. This approach consists in developing a grid search algorithm written in Python to find the key parameters for different facies described in the study of Carsell and Parrish (1988). The mean value of the parameter given by this study is used as reference simulations (Fig.1) and the standard deviation provides the range of the water profile simulations.

At present, wave propagation has been included to the systematic study. This was done by using the model proposed by Solazzi et al (2021), that considers the variation of wave propagation (Biot-Gasmann) and bulk density with saturation (van Genuchten), Fig 1 We calculate the sensitivity of P-wave and S-wave velocities, travel times and surface wave dispersion to the physcal parameters. In the next stage we will apply this methodology to real data from Dangeard et al. (2021) on the Orgeval critical zone observatory.

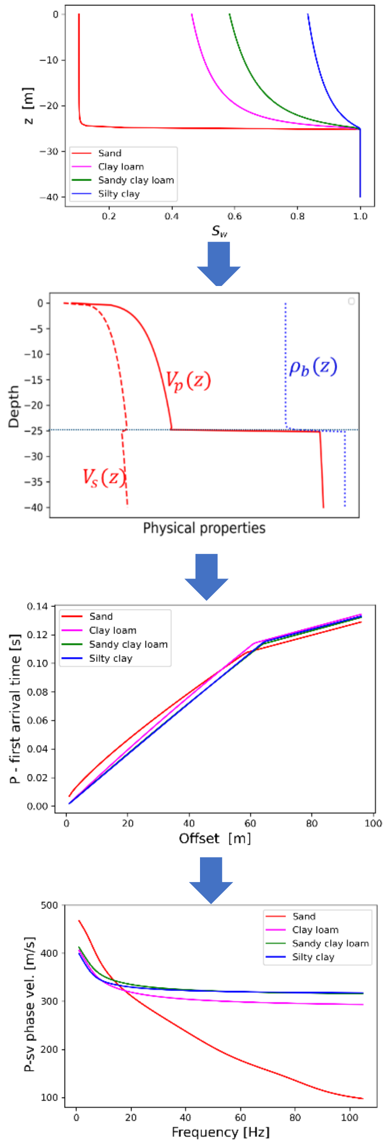

Figure 1: Graphical representation of the process for solving the forward problem. for Sw (van Genuchten) and wave propagation using Solazzi et al (2021) model.

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