Near-Surface Variability of Shear and Compression Wave Speeds due to Wet/Dry Cycles

Oak Ridge Institute for Science and Education (ORISE)
National Science Foundation-Mathematical Sciences Graduate Internship Fellowship (NSF-MSGI)

It is a common knowledge that geophysical properties of soil are highly variable and the mechanical properties of the same soil specimen change with soil water saturation. However, the general assumption is that if the density, temperature, moisture, and confining pressure for a given specimen of soil are the same, the soil will have the same geophysical properties, particularly, the shear and compression wave speeds.

To quantify and visualize the variability, which is understood between different types of soil or for the same type but different sites, I analyzed 33 samples of seismic data (wet/dry cycles) based on the level of saturation, gravimetric and volumetric water contents. I developed an automatic algorithm to estimate P- and S-waves arrival-times by interpolating the moistures level intervals and using the well-known Poisson Ratio relation. I employed the method of **Non-parametric Kernel Density Estimation (KDE)** to estimate the Probability Distribution Function (PDF) and to quantify the degree of variability through unconditional and moisture content conditional (Using **Clustering**) scenarios, see Figures.

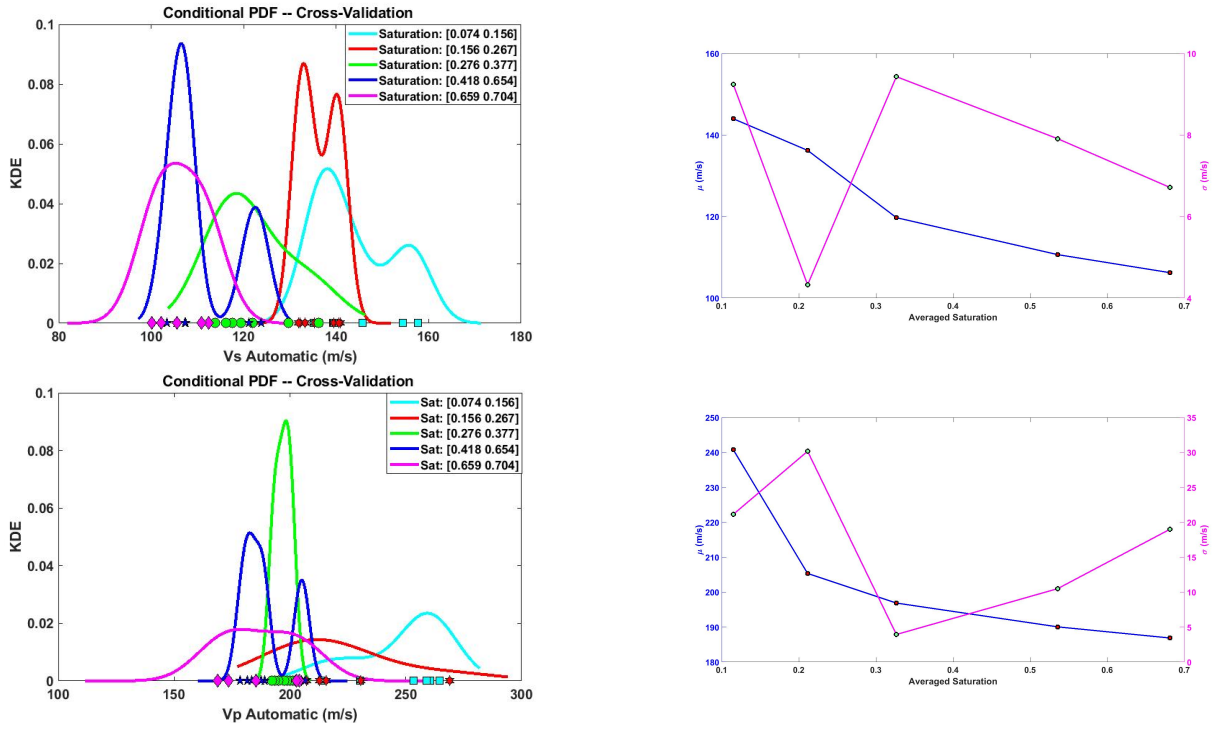

Figure 1: Conditional Clustered Data - V_s vs V_p

I established an **Optimal Bandwidth** for PDF estimations by employing the **Asymptotic** and **Maximum**

Likelihood Cross-Validation optimizations methods. I explained how the cross-validation method gives the better PDF estimates as it correctly estimates zero probability for bimodal distribution and showed that the asymptotic method results in the bandwidth which prescribes a substantially non-zero probability for the values that are not present in the data. Using MatLab simulation, I illustrated the V_s and V_p time arrival calculations and demonstrated how the developed automatic procedure results in more consistent data with less variation, see Figures.

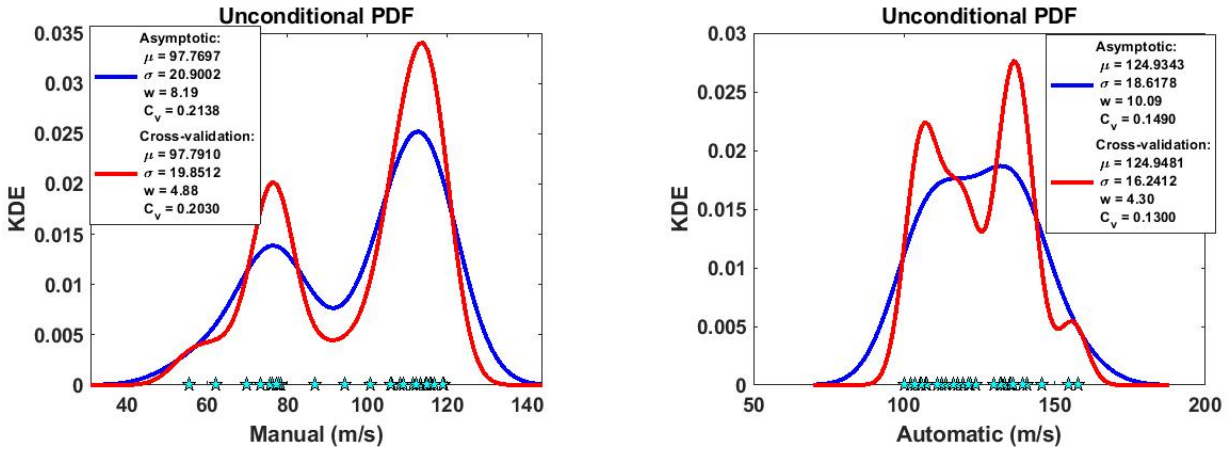

Figure 2: Shear Wave V_s

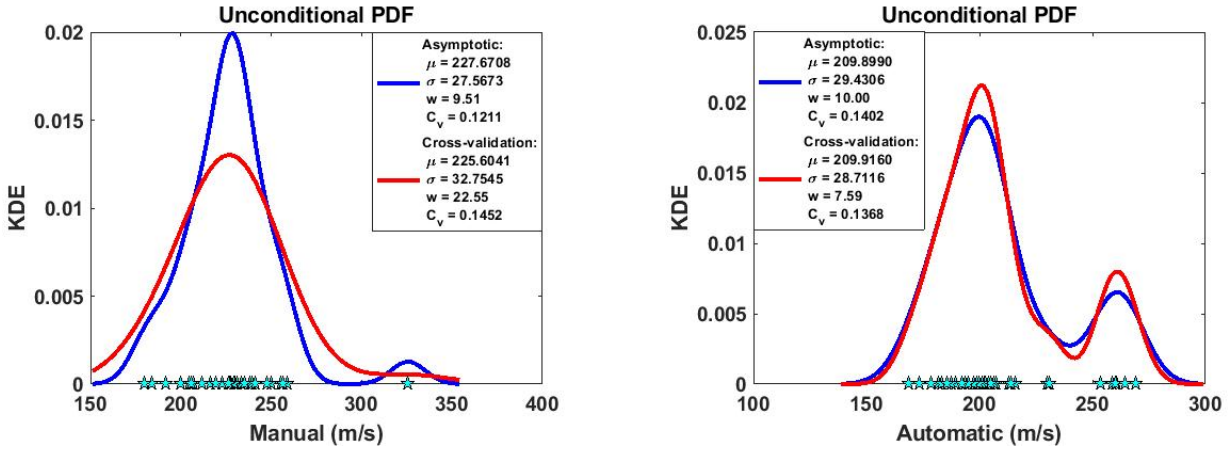

Figure 3: Compression Wave V_p