Quantifying statistics of heterogeneous porous media attributes across scales

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Aims and Objectives

Current:

- Stochastically represent porosity and conductivity fields, for input to a groundwater finite element program.

Future aims:

- Extend GSG to mixture of two materials - bimodal.
- Determination of conductivity distributions when porosity data is exclusively available.

Applications

Must quantify statistical behaviour from sparse field data collection to model:

- Carbon Capture and Storage
- Fracking
- Subsurface pollution remediation

Norway CCS plant in North Sea [1]

Methodology

- Maximum Likelihood Estimates used to fit Generalized Sub-Gaussian model (GSG) to a neutron porosity dataset from Ashwaz field, South Western Iran.

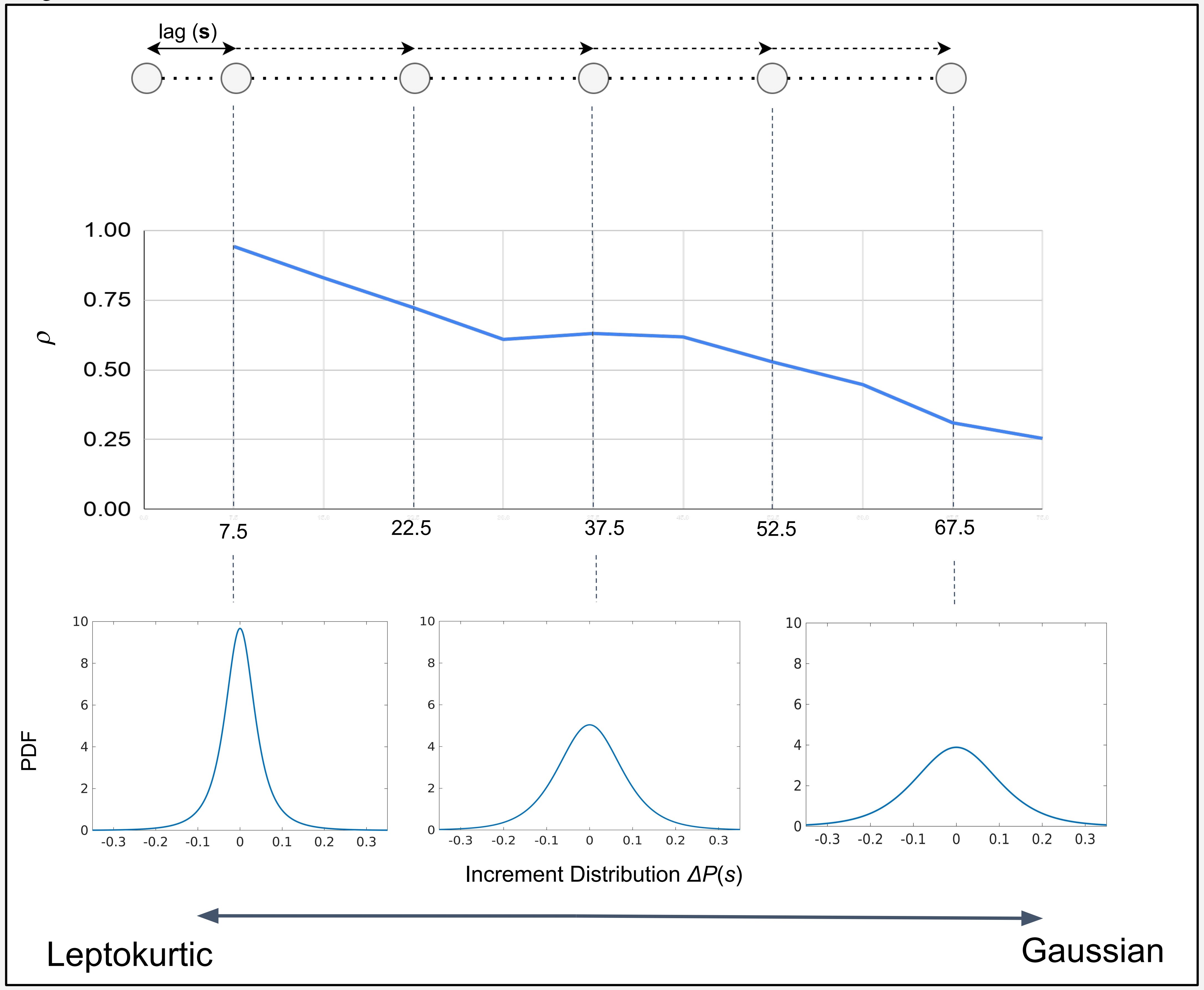
Increment Scaling Behaviour

ΔP(s) Distribution results

Governed by all three parameters of GSG; Variance of U (σ_U), Variance of G (σ_G) and Correlation Coefficient of G (ρ).

σ_U = 0.403 (Variance of U)

σ_G = 0.0831 (Variance of G)



GSG Definition

$$P'(\mathbf{x}) = U(\mathbf{x})G(\mathbf{x})$$

P' : Porosity fluctuations from mean (random field)

U : Independent random positive definite subordinator (log-normal)

G : Zero-mean Gaussian Random Function

Increments:

$$\Delta P(\mathbf{s}) = P(\mathbf{x}+\mathbf{s}) - P(\mathbf{x})$$

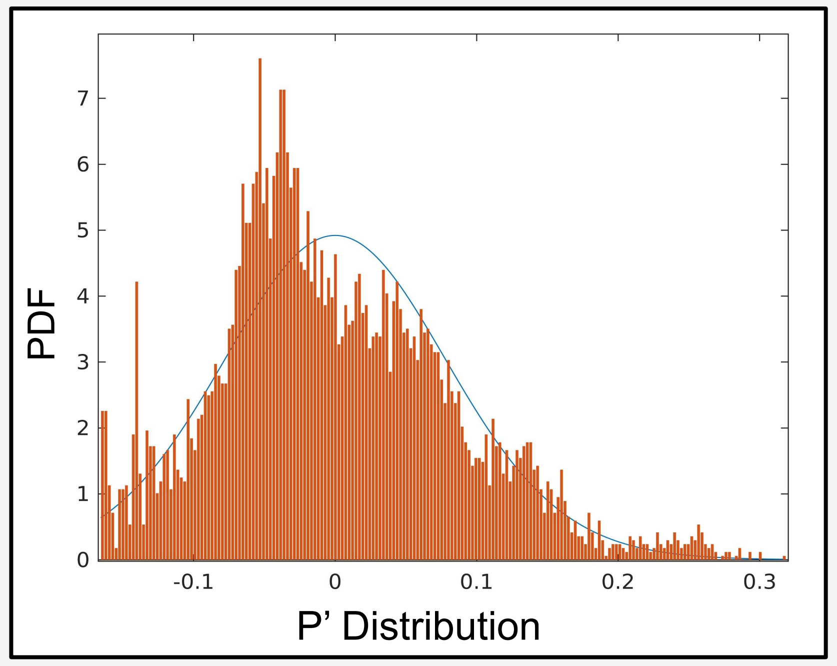
"Difference between pairs of porosity values with a given lag distance between them"

Porosity (P') Distribution Results:

Governed by two parameters determined through MLE.

σ_U = 0.403 (Variance of U)

σ_G = 0.0831 (Variance of G)



References: 1. https://tinyurl.com/y6ldzc9m, 2. Guadagnini, A., Riva, M. and Neuman, S.P., 2018. Recent advances in scalable non-Gaussian geostatistics: The generalized sub-Gaussian model. Journal of hydrology, 562, pp.685-691.