EGU General Assembly 2019

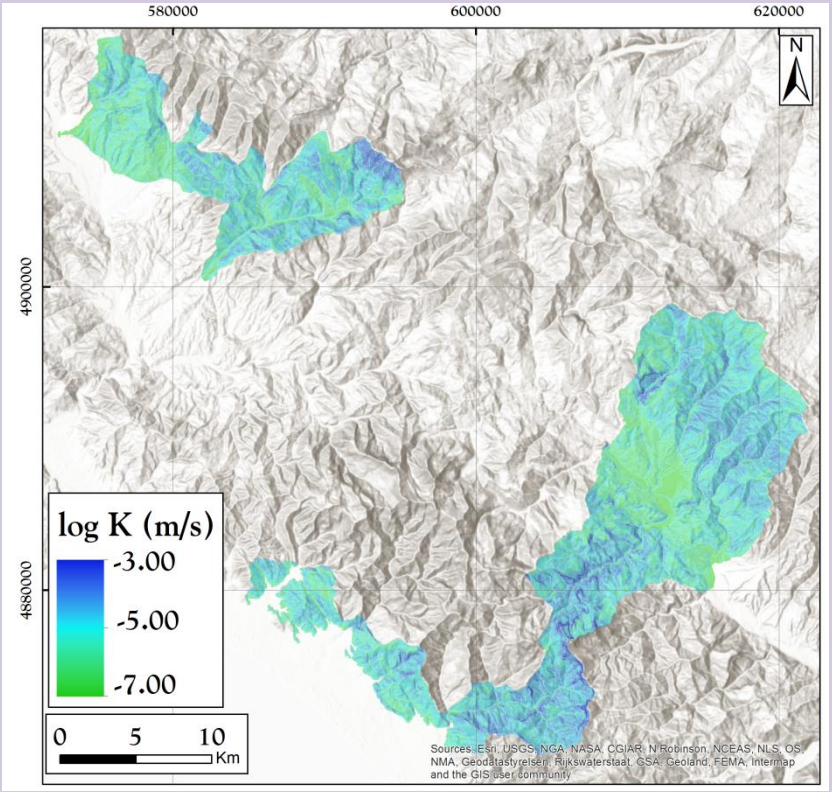
Vienna | Austria | 7–12 April 2019

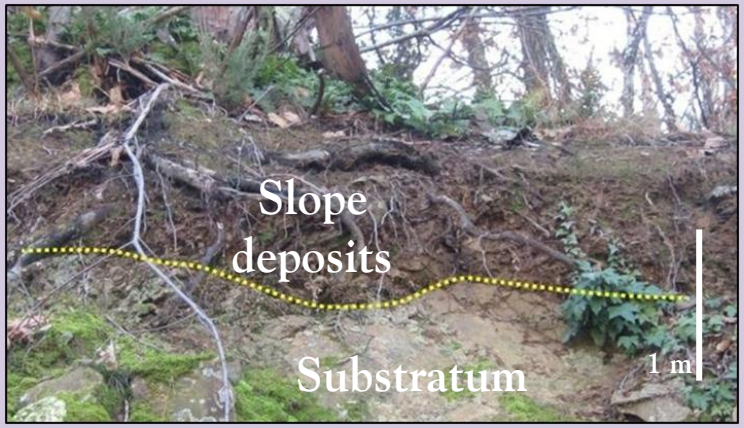
Spatial analysis of hydraulic conductivity for slope deposits at catchment scale in Northern Tuscany, Italy

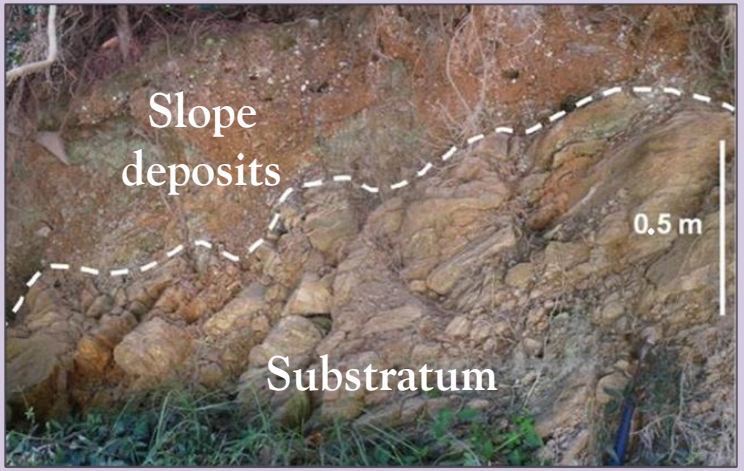
Michele Pio Papasidero [1],
Leonardo Disperati [1], Marc Vinches [2],
Pierre-Alain Ayral [2], Anne Johannet [2]

(1)DSFTA, University of Siena, Siena, Italy
(2)LGEI-IMT Mines Alès, University of Montpellier, Alès, France

Analysis of **site-variability** and **spatial distribution** at **catchment scale** of hydraulic conductivity of slope deposits (SD)







Slope deposits are **unconsolidated** (Quaternary) **soils** that unconformably cover the geological substratum

Spatial analysis of hydraulic conductivity for slope deposits at catchment scale in Northern Tuscany, Italy - Michele Pio Papasidero (michele.papasidero@unisi.it)

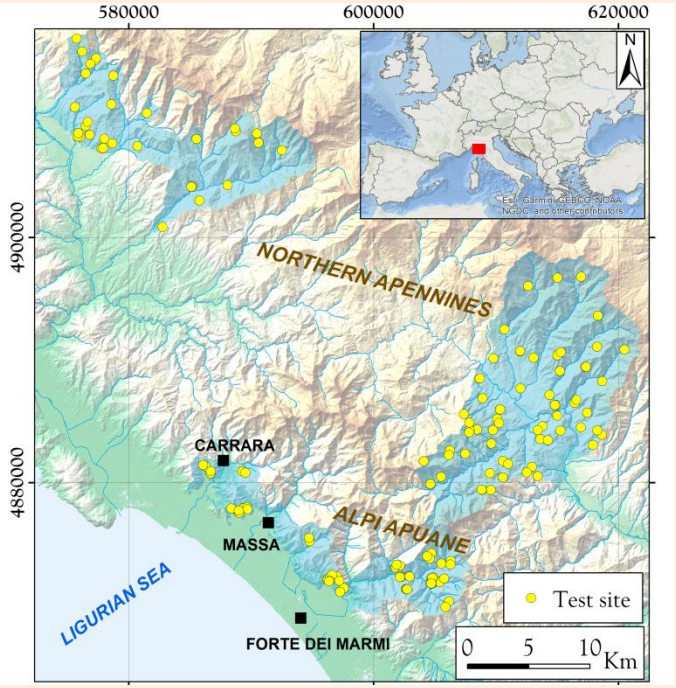
Study area is represented by **2** regions (**420 km²**) in Northern Tuscany (Italy)

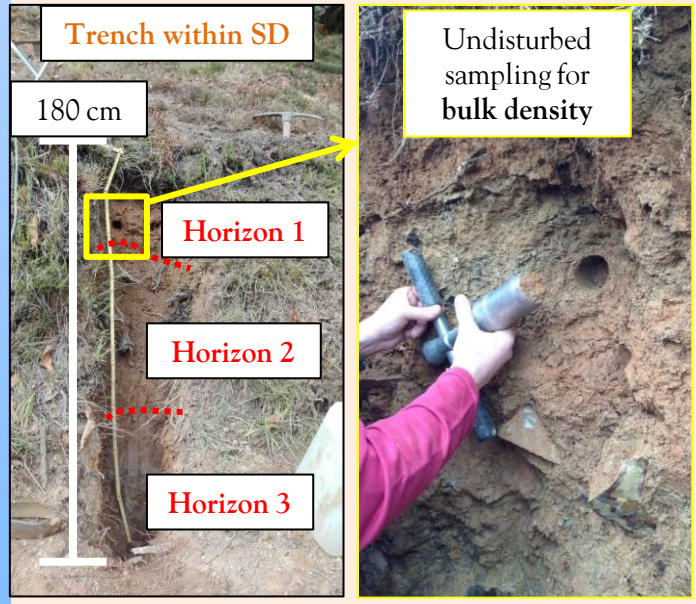
Field survey

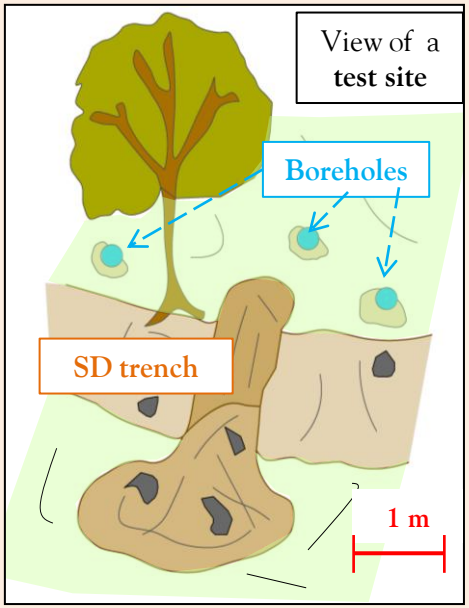
- ✓ **Trench** within SD (depth, texture, structure, soil sampling)
- ✓ **Hydraulic conductivity tests** (Ktests) within 1-5 boreholes close (≤ 10 m) to the trench. Ktests performed by using **constant** and **falling** head permeameters (*LeFranc* tests)

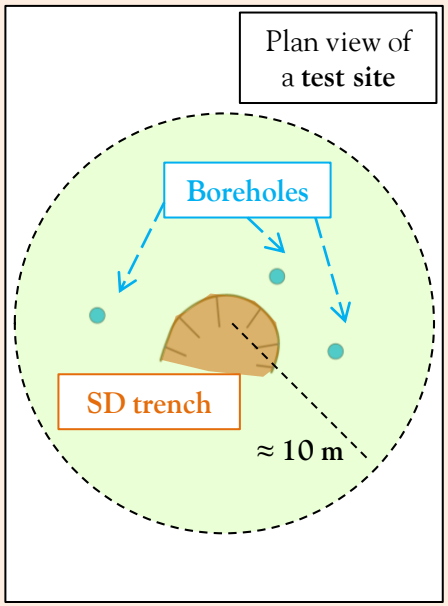
Laboratory

- ✓ Grain size, Atterberg limits, specific gravity of solids, bulk density







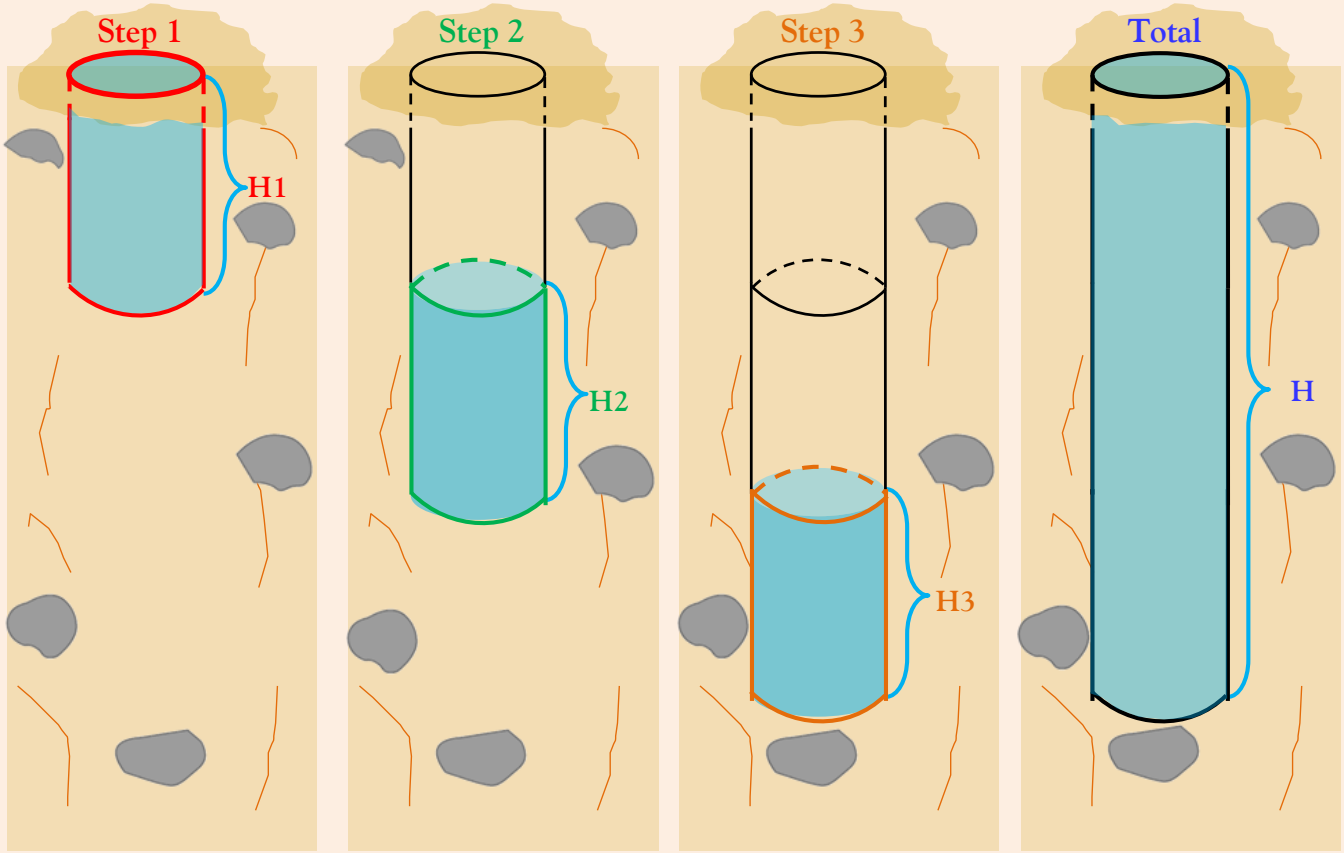


Field survey: Ktests

A total of **721** Ktests (**150** test sites) have been performed following this approach:

- **steps of increasing borehole depth** (Step 1, Step 2, Step 3, **Step n**….) in order to evaluate variation of K with depth
- total depth (Total)

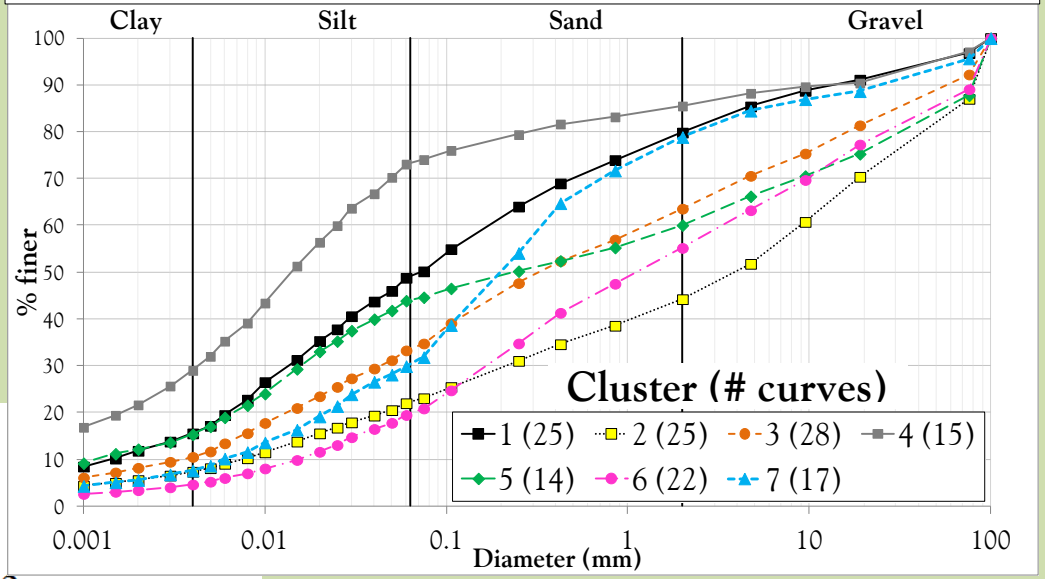
Borehole diameter **7-10 cm**

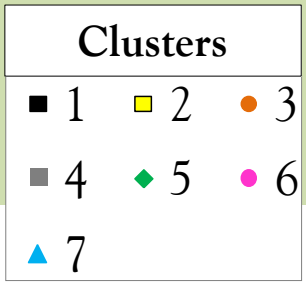


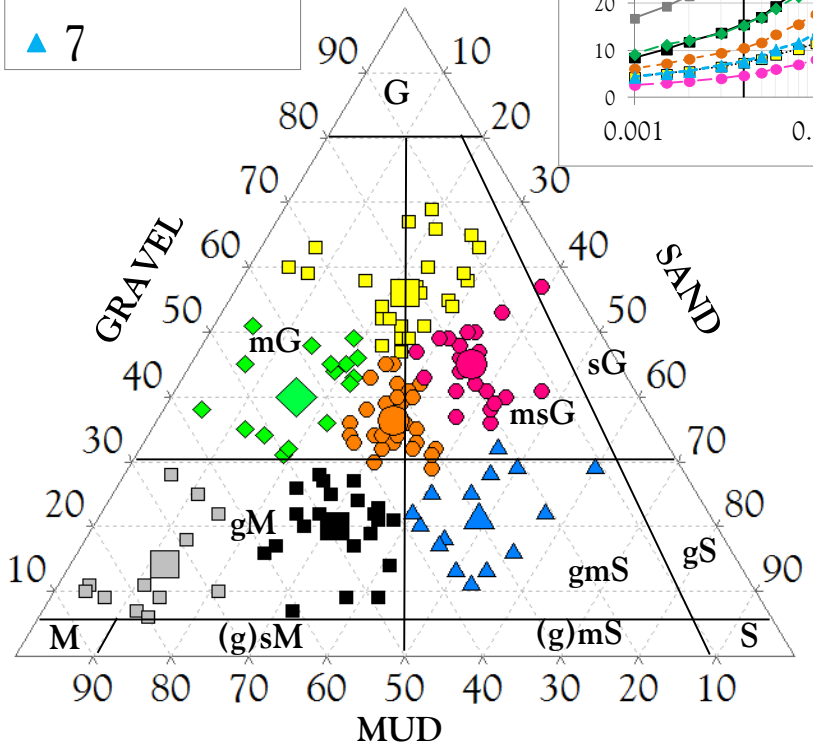
Grain size data - 146 samples

C_u (d_{60} / d_{10})	
Interquartile range	Range
80-630	7-38,000

K-means clustering of grain size curves

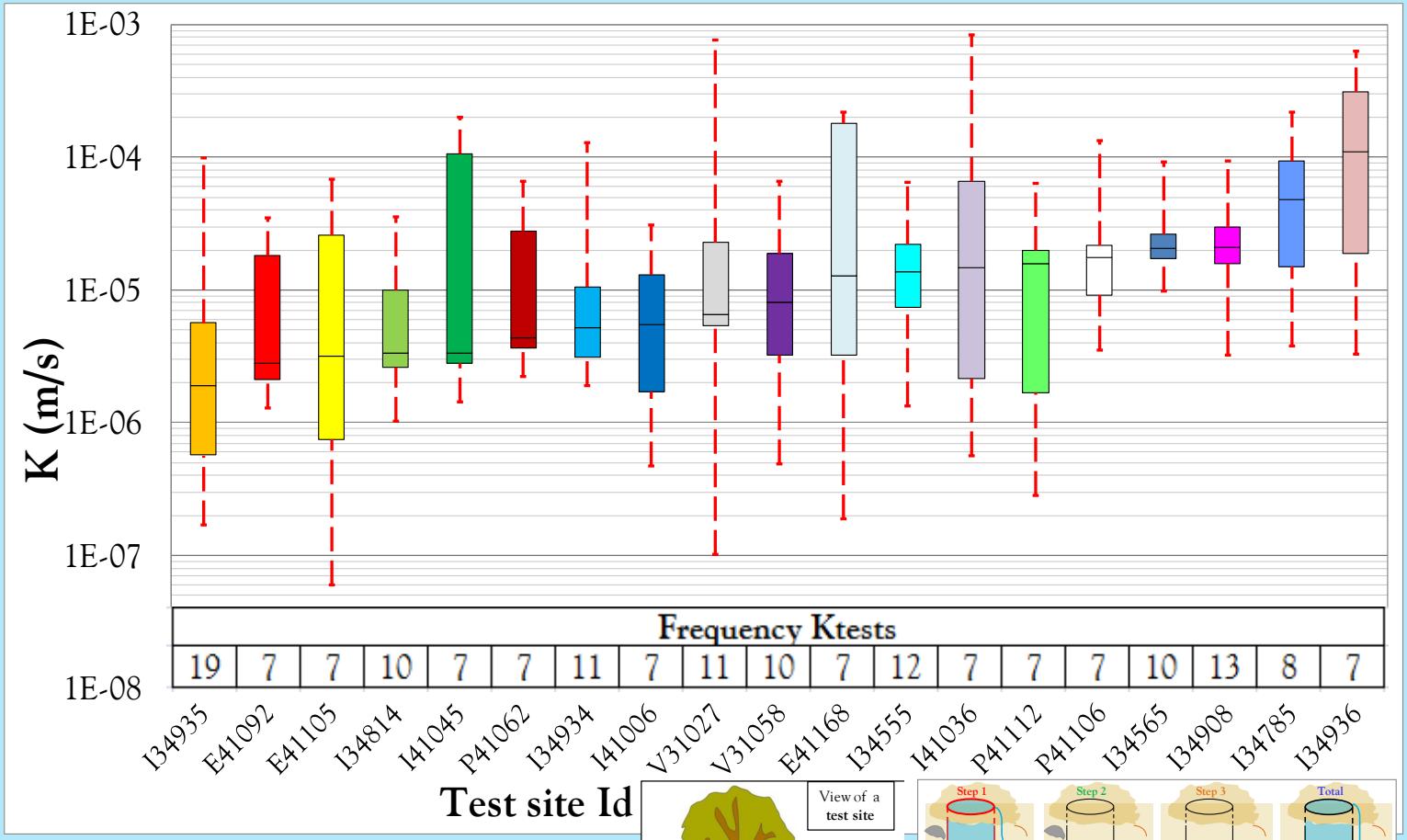




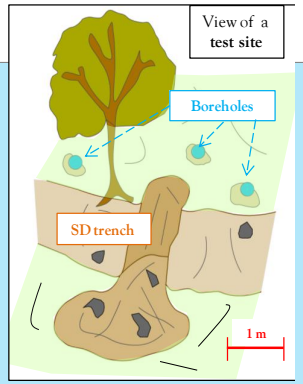


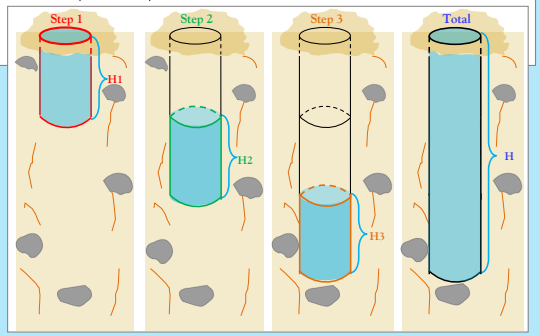
Frequency (%)	Texture Class	Description
34	mG	*muddy Gravel*
30	msG	*muddy sandy Gravel*
24	gM	*gravelly Mud*
12	Others	-

Site variability of hydraulic conductivity

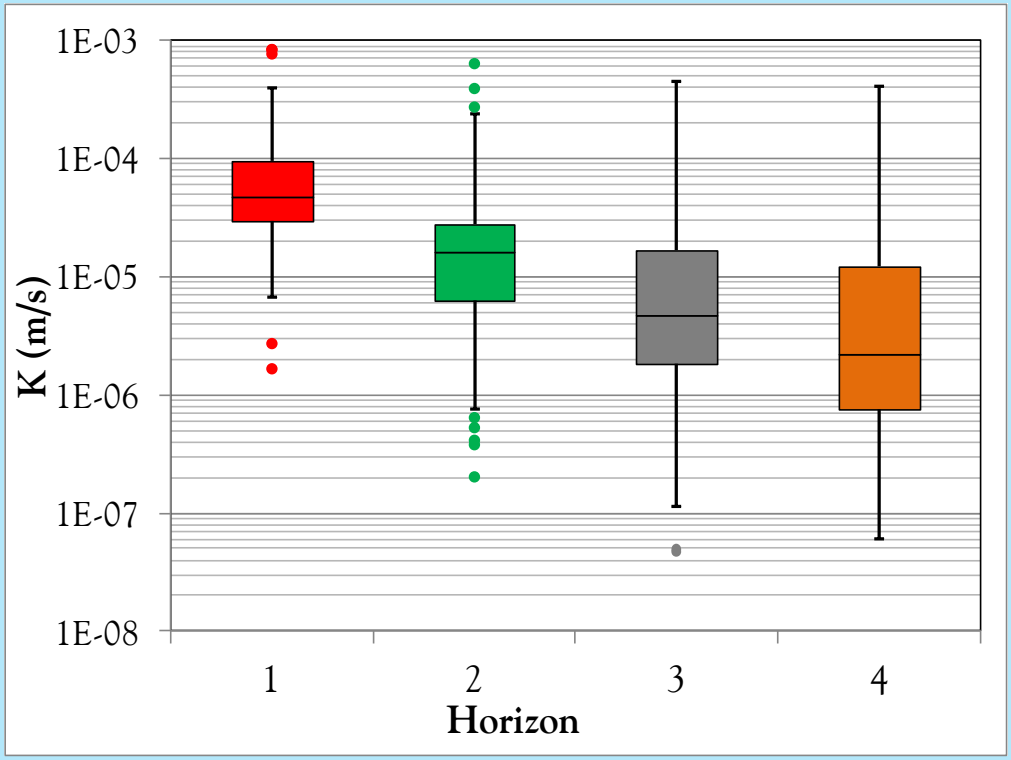


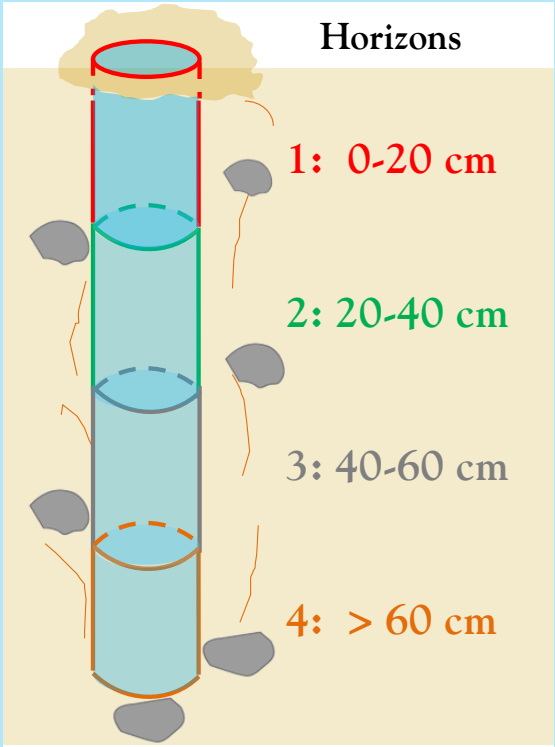
log K (m/s)	
Median of Interquartile range	Median of Range
0.8	1.9



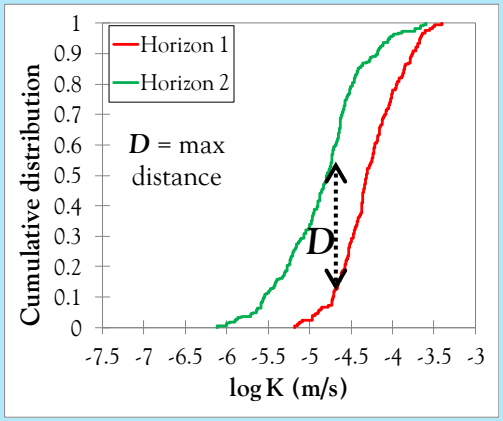


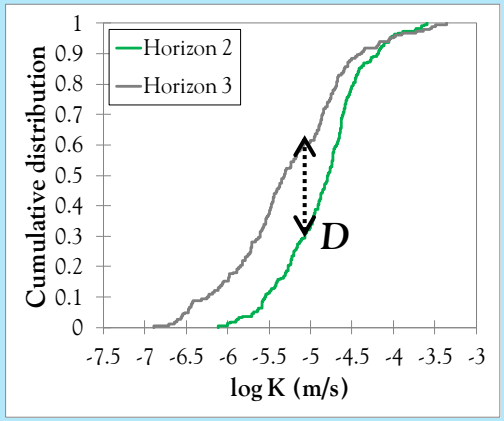
Hydraulic conductivity by horizons

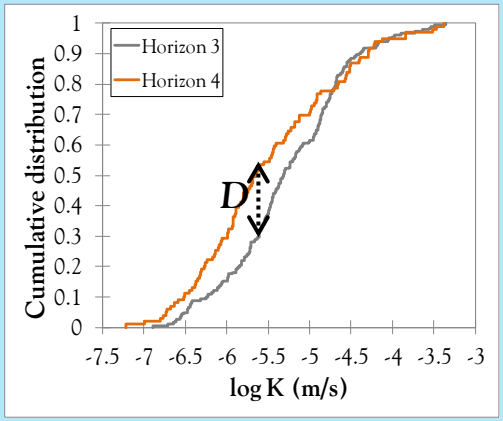




Kolmogorov-Smirnov test: horizons 1, 2, 3 and 4 are **ALL** statistically each other different

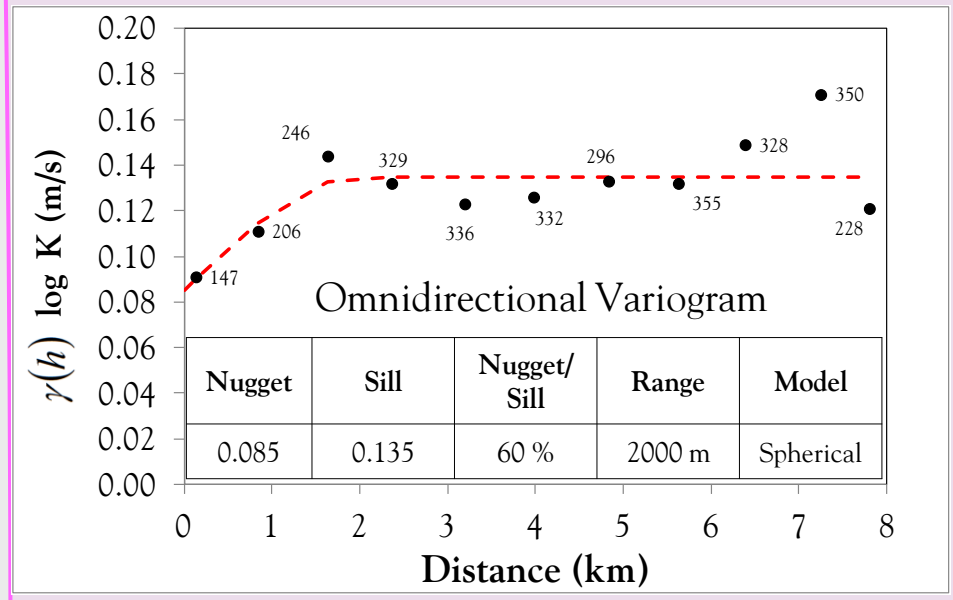




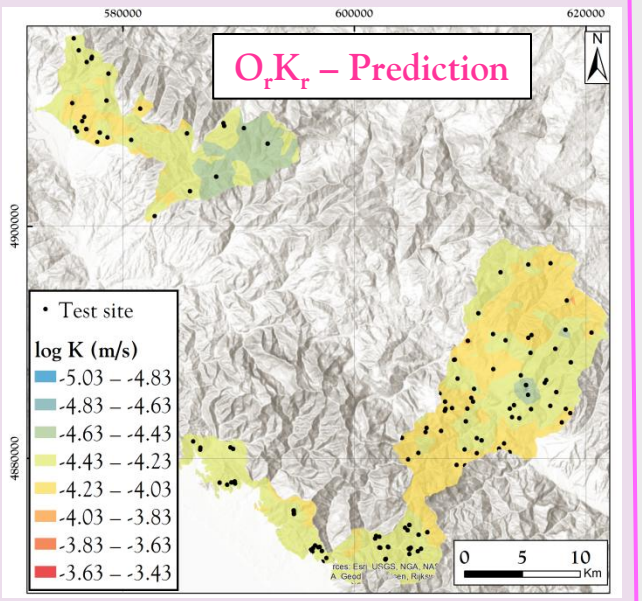


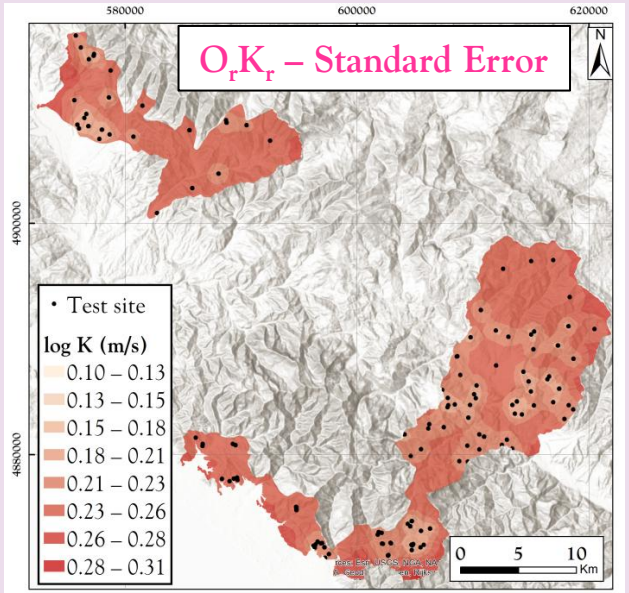
Spatial analysis of hydraulic conductivity for slope deposits at catchment scale in Northern Tuscany, Italy - Michele Pio Papasidero (michele.papasidero@unisi.it)

Horizon 1 (0-20 cm) – Ordinary Kriging (O_rK_r) and Inverse Distance Weighting (Idw)

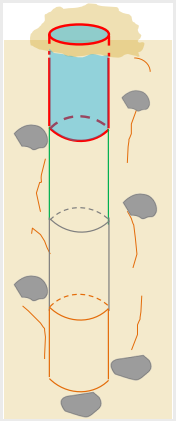


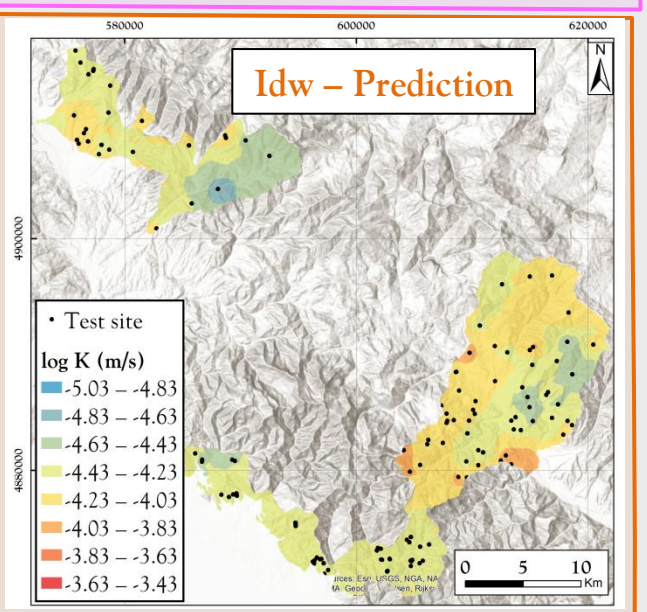
Nugget	Sill	Nugget/ Sill	Range	Model
0.085	0.135	60 %	2000 m	Spherical





Power	1
Range	2500 m



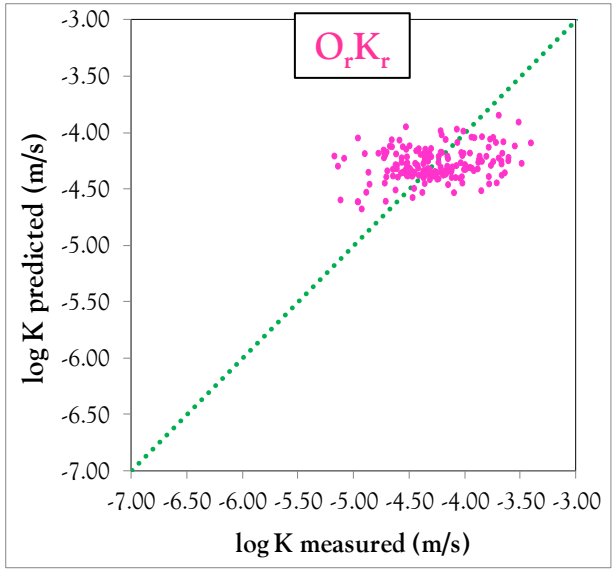


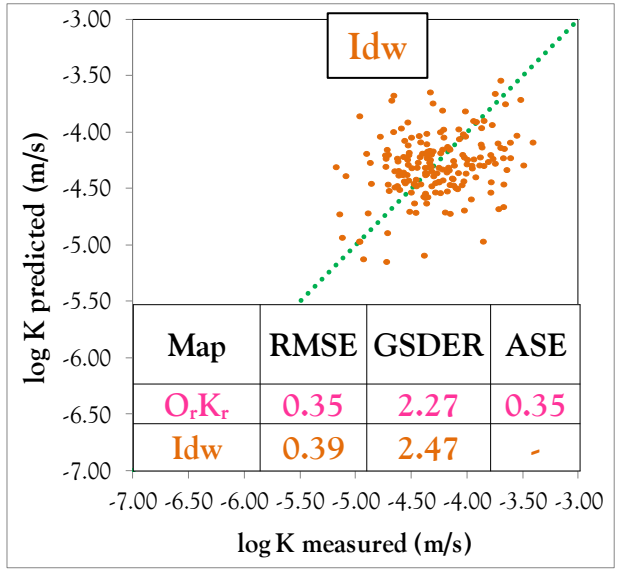
Horizon 1 (0-20 cm) – Ordinary Kriging (O_rK_r) and Inverse Distance Weighting (Idw)

Cross-validation

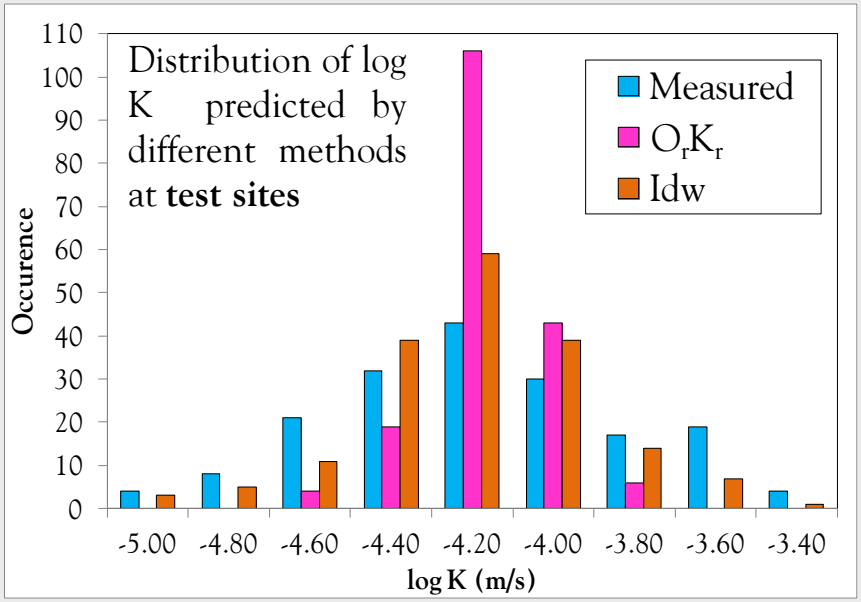
Procedure

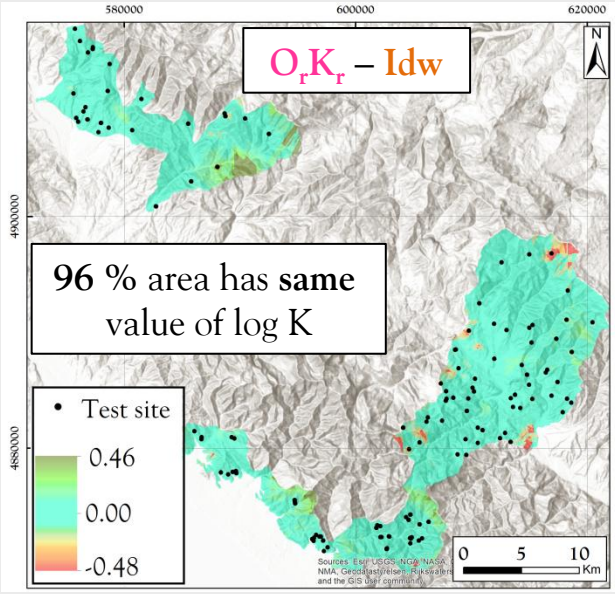
1. **Remove** the **first** point in the dataset, then use the **remaining** (n-1) points to **predict** the value at the **location** of the **removed** point.
2. **Repeat** step 1 for **whole** dataset, and calculate the statistics.





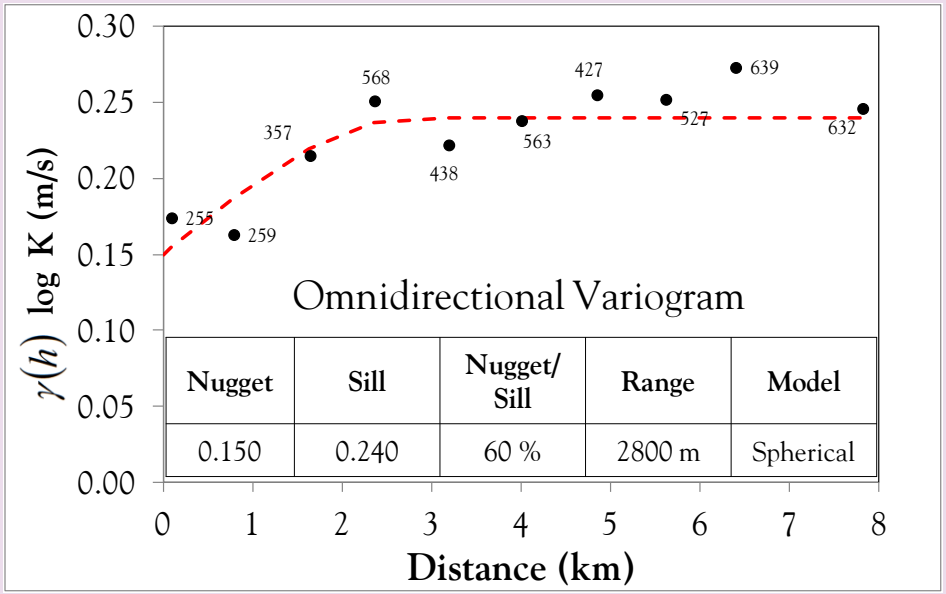
Map	RMSE	GSDER	ASE
O_rK_r	0.35	2.27	0.35
Idw	0.39	2.47	-



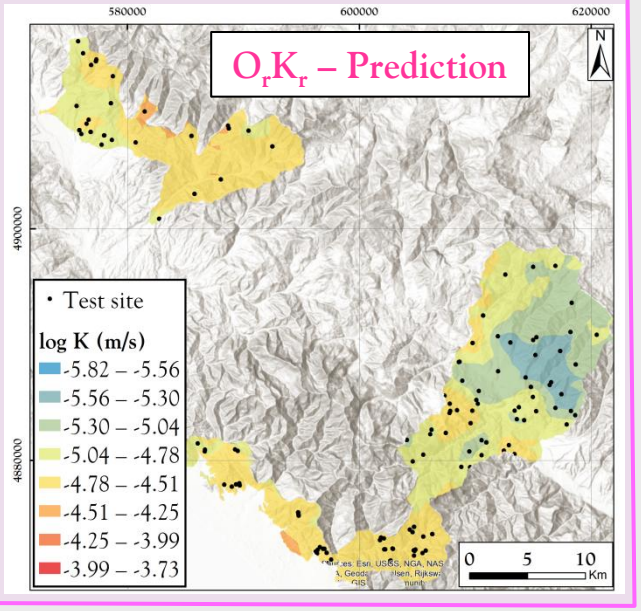


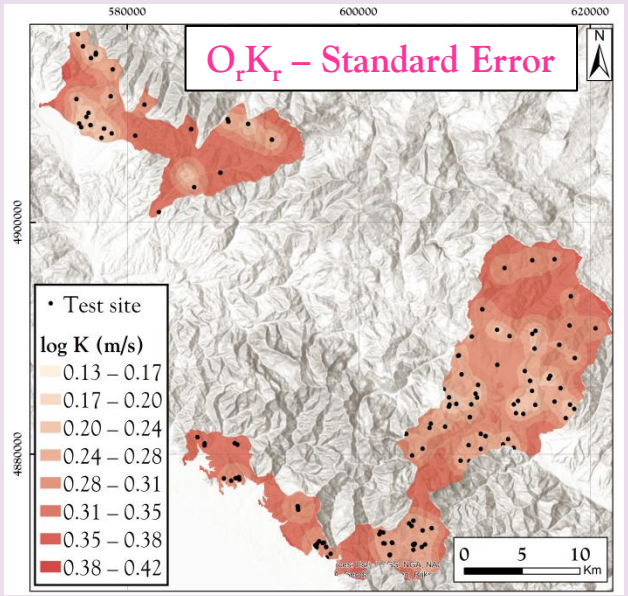
Spatial analysis of hydraulic conductivity for slope deposits at catchment scale in Northern Tuscany, Italy - Michele Pio Papasidero (michele.papasidero@unisi.it)

Horizon 2 (20-40 cm) – Ordinary Kriging (O_rK_r) and Inverse Distance Weighting (Idw)

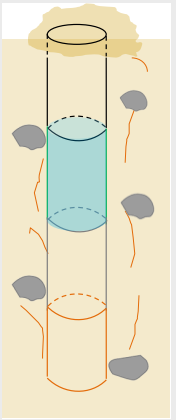


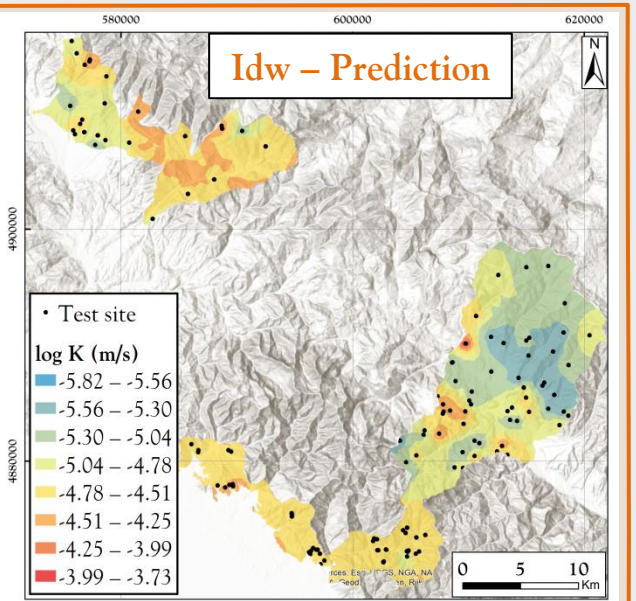
Nugget	Sill	Nugget/ Sill	Range	Model
0.150	0.240	60 %	2800 m	Spherical



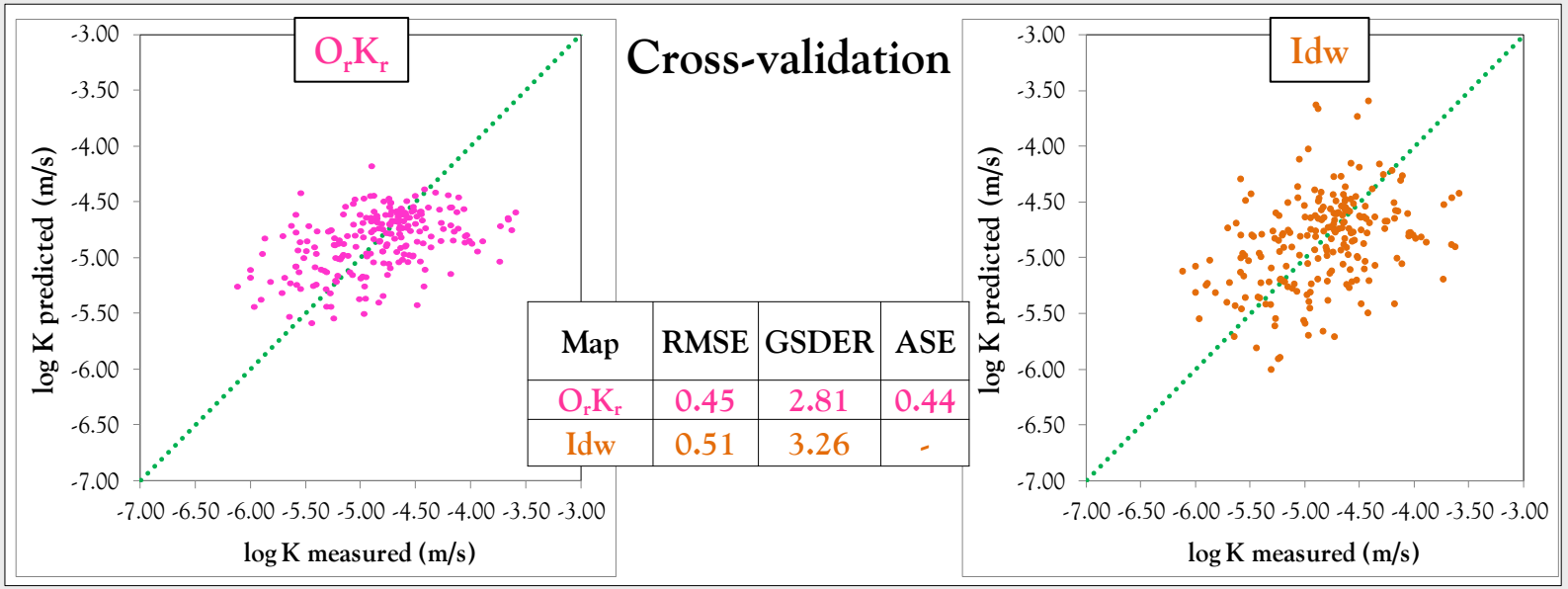


Power	2
Range	3000 m



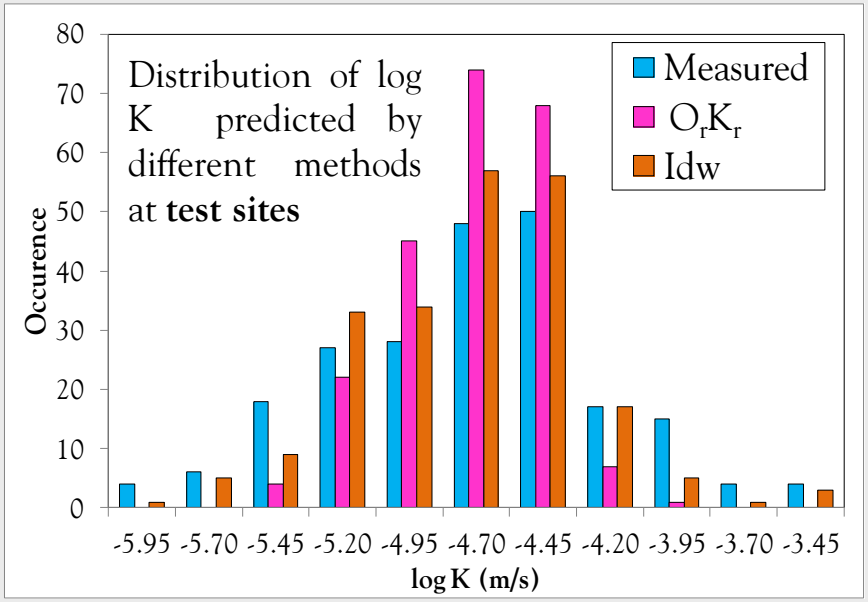


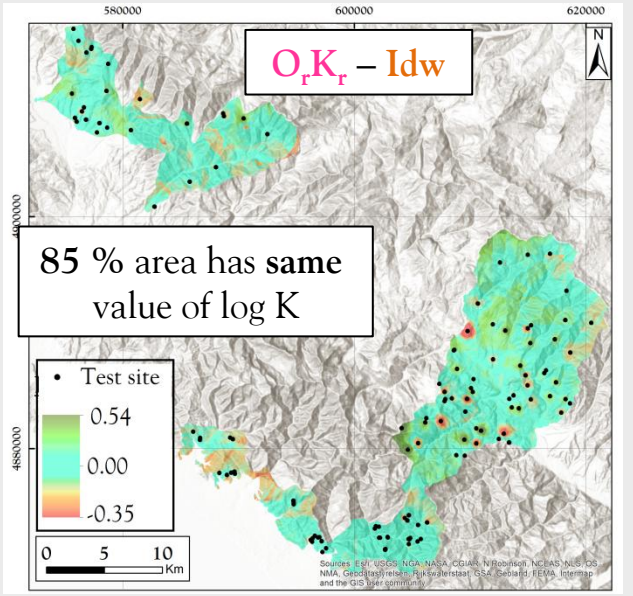
Horizon 2 (20-40 cm) – Ordinary Kriging (O_rK_r) and Inverse Distance Weighting (Idw)



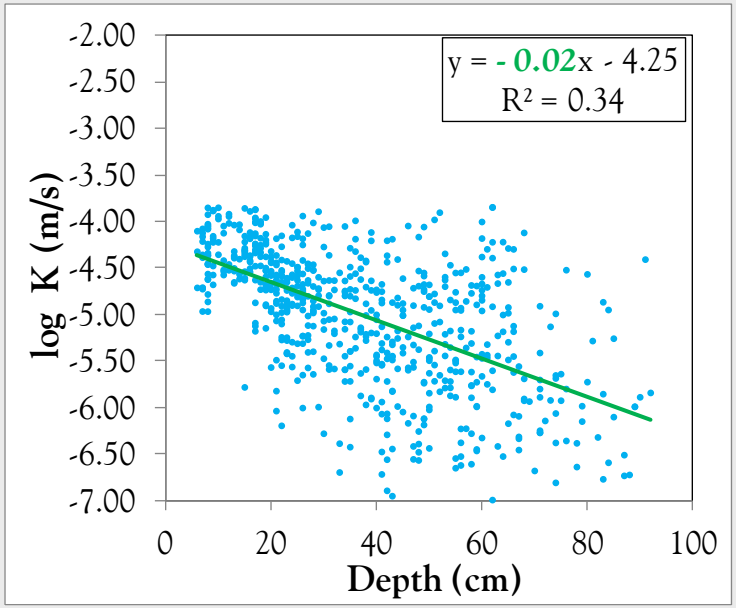
Cross-validation

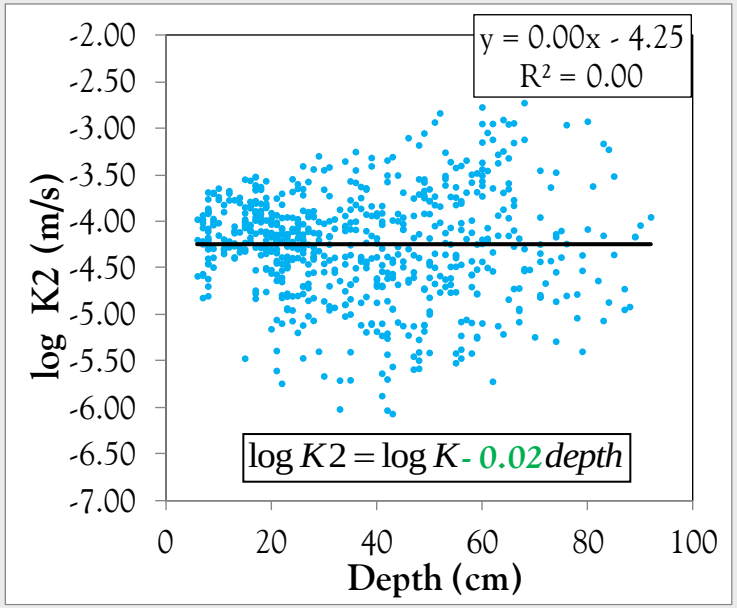
Map	RMSE	GSDER	ASE
O_rK_r	0.45	2.81	0.44
Idw	0.51	3.26	-



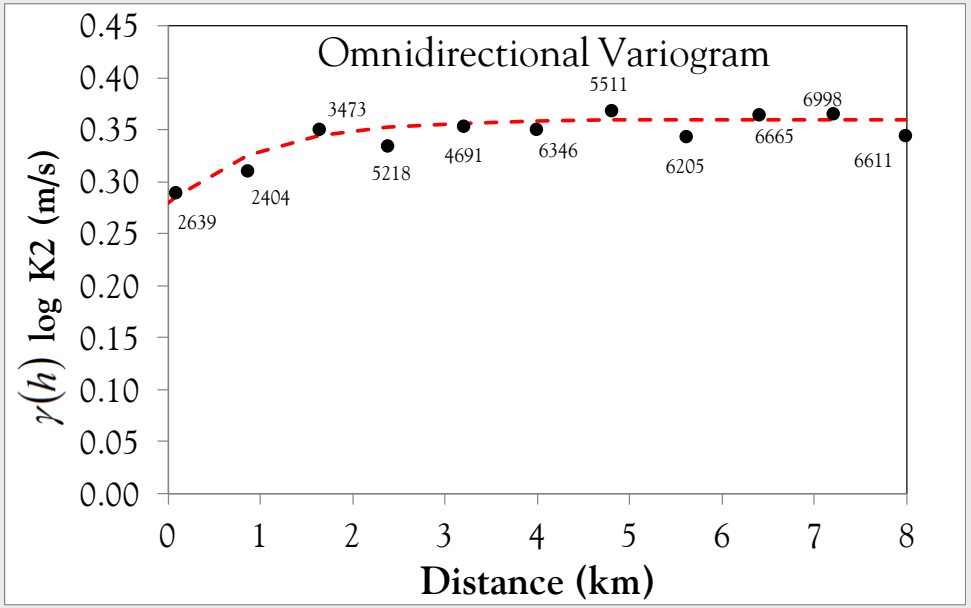


All Ktests – Detrend analysis

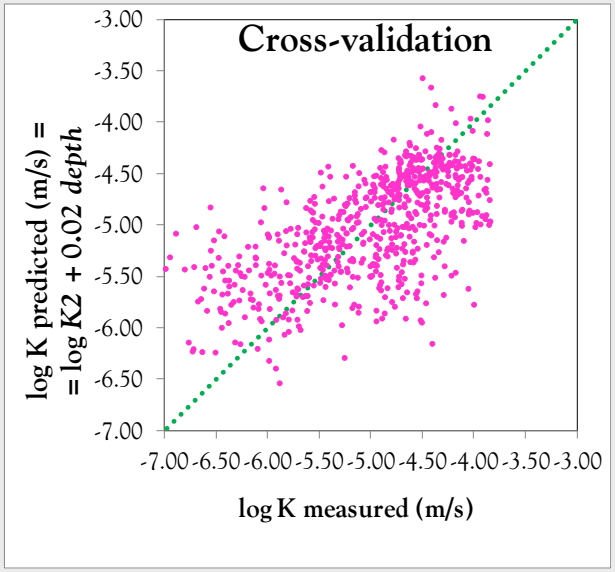




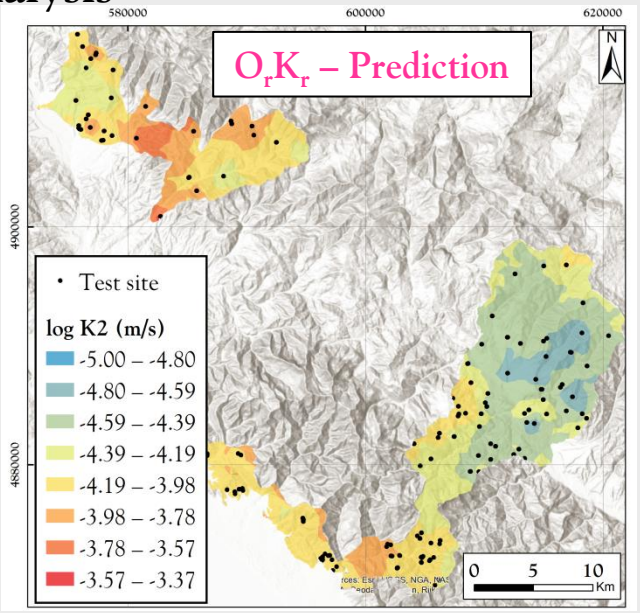
Parameter	log K2
Nugget	0.28
Sill	0.36
Nugget/Sill	80 %
Range	3000 m
Model	Exponential

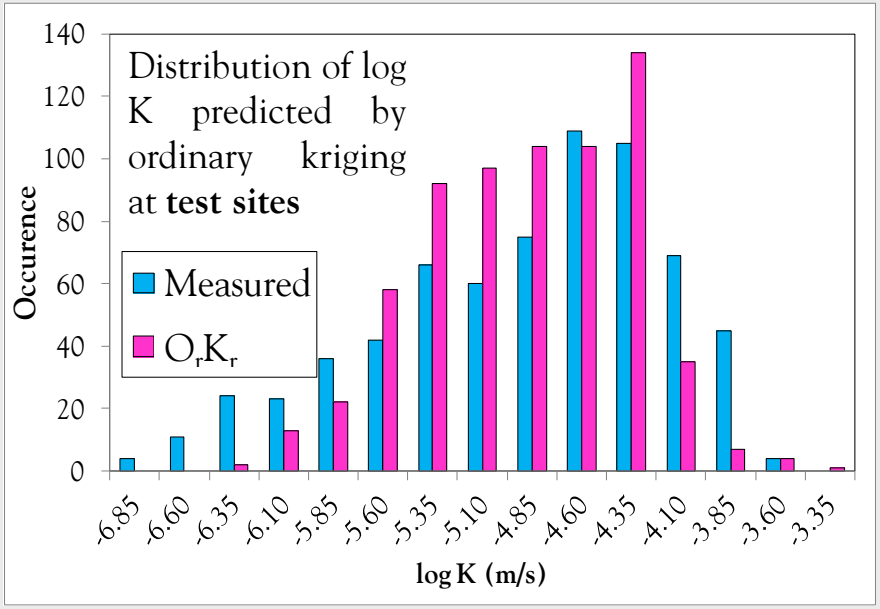


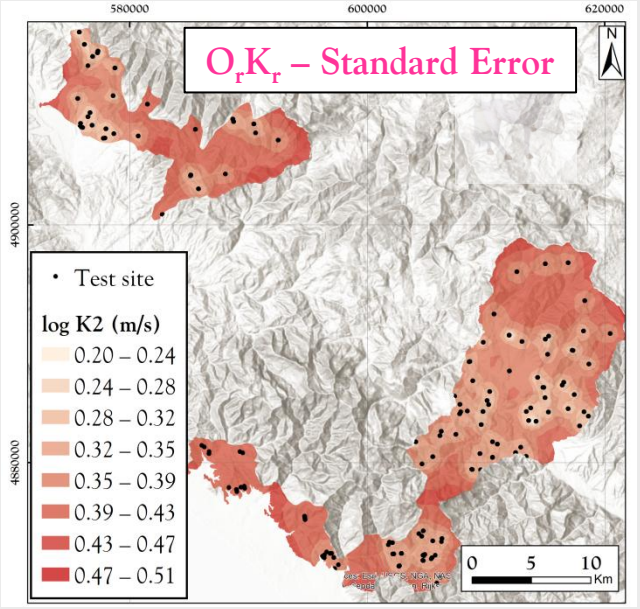
All Ktests – Detrend analysis



Error	log K (m/s)
RMSE	0.55
GSDER	3.57
ASE	0.48







- ✓ **Texture classes** of slope deposits are mostly muddy gravel (***mG***), muddy sandy gravel (***msG***) and gravelly mud (**gM**). The interquartile range of C_U is ≈ 80-600
- ✓ **Site variability** of log K in term of **interquartile range** and **range** is respectively **0.8** and **1.9**
- ✓ **Negative** trend of log K with **depth** and **different** distribution of log K among **horizons**
- ✓ Spatial structure of log K in the experimental variogram characterized by an **high nugget/sill**
- ✓ **Geostatistical methods** are implemented to obtain continuous maps of log K:
  - ❑ **Horizons** approach: **Ordinary Kriging** and **Inverse Distance Weighting** provide maps each other **similar** of log K for the corresponding horizons
  - ❑ **Inverse Distance Weighting** is able to predict **extreme** values of log K
  - ❑ **Detrend** approach: **Ordinary Kriging** allows to include the effect of depth
- ✓ Following up
  - ❑ Continue geostatistical approach for **horizon 3** and **4**
  - ❑ **Implement other** methods to obtain continuous maps of log K (**Empirical Bayesian Kriging**, etc..) and/or use the **pedotransfer function** (**already** developed by multilinear regression analysis)
  - ❑ Integrate the role of different geological **substratum** in the spatial analysis of log K


Thank you for attention