

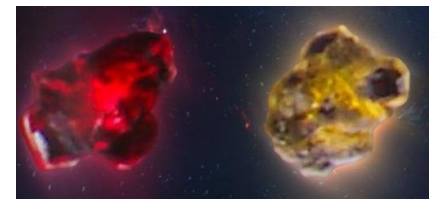
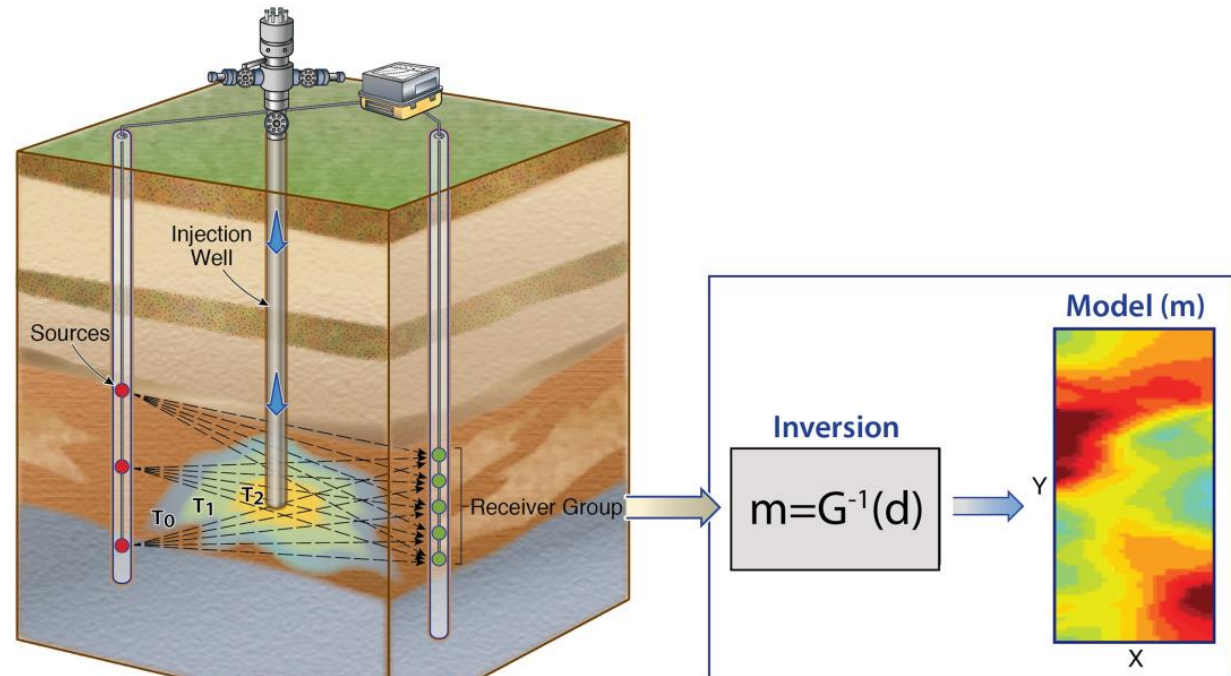
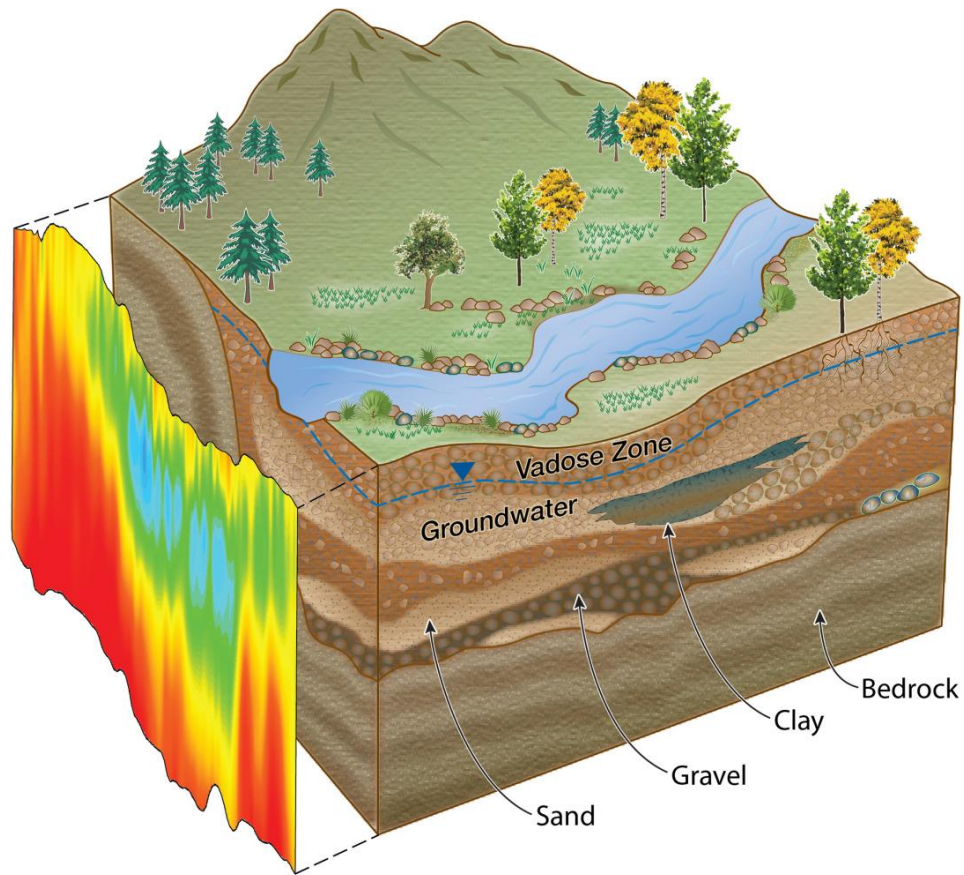
# InnovationS in near-surface geophysics: going beyond standard "stand-alone" imaging surveys

Frédéric Nguyen, University of Liège and KU Leuven

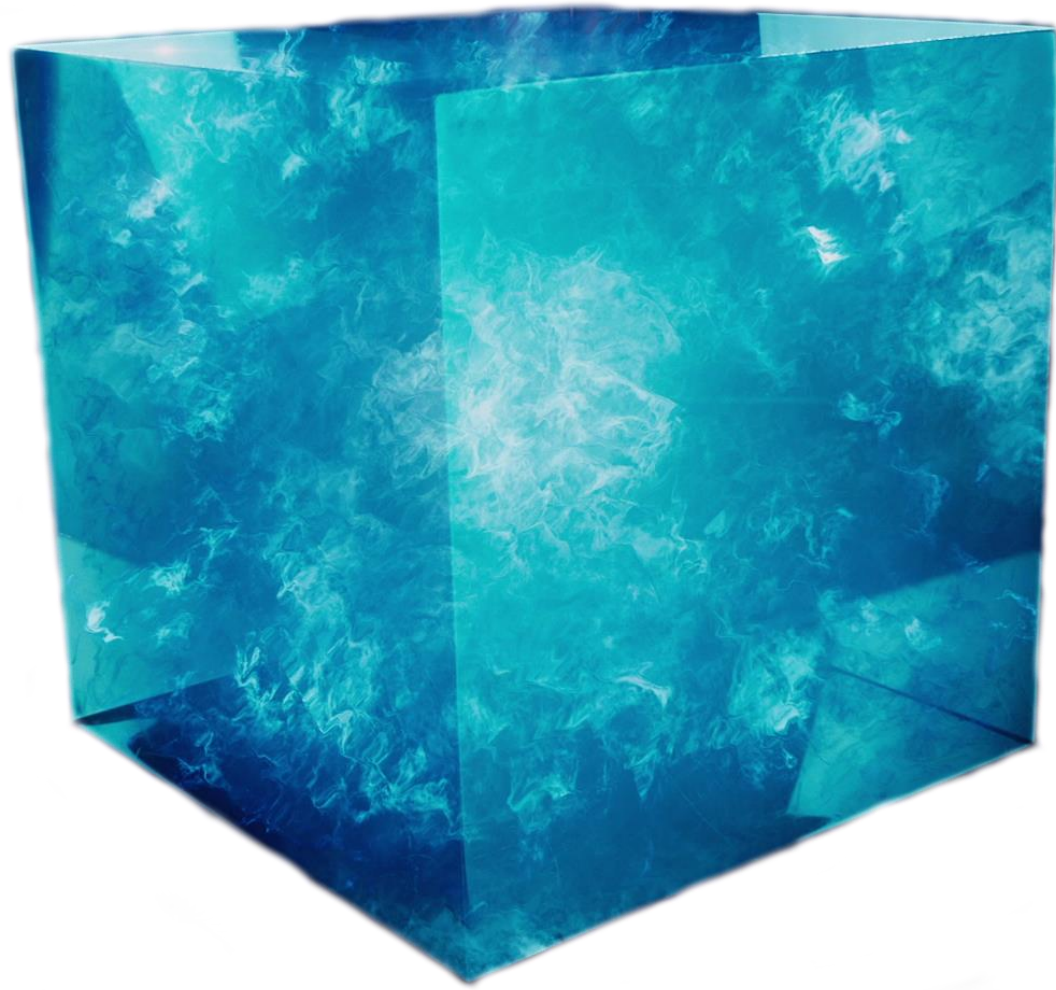
September 11<sup>th</sup> 2019

Groundwater Quality 2019

# Near-surface geophysics: twisting reality?



Space

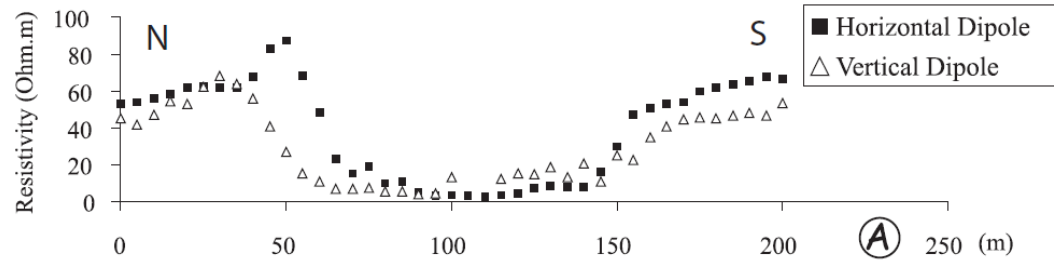




# A historical perspective in images



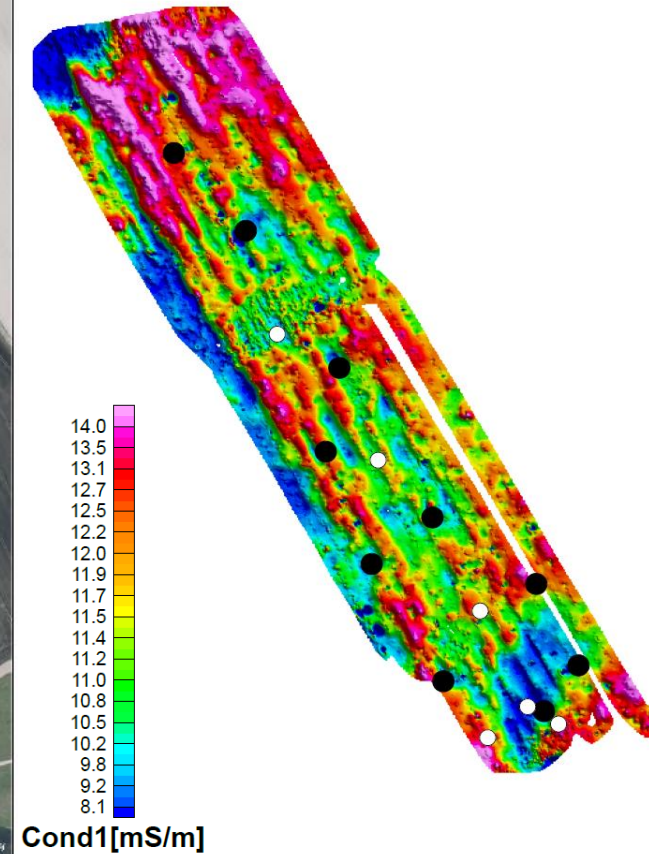
# A historical perspective in images



Nguyen, 2005

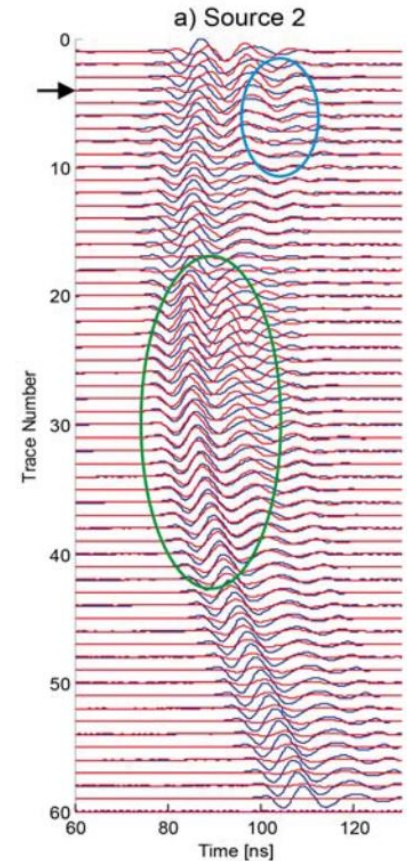
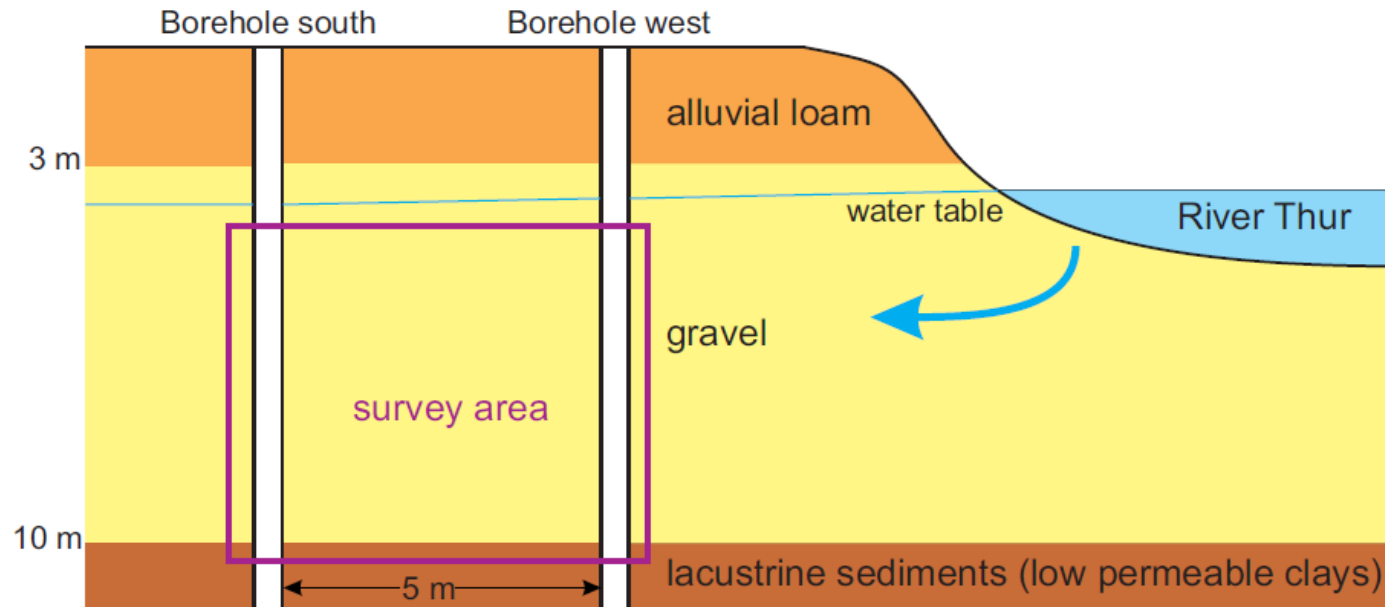
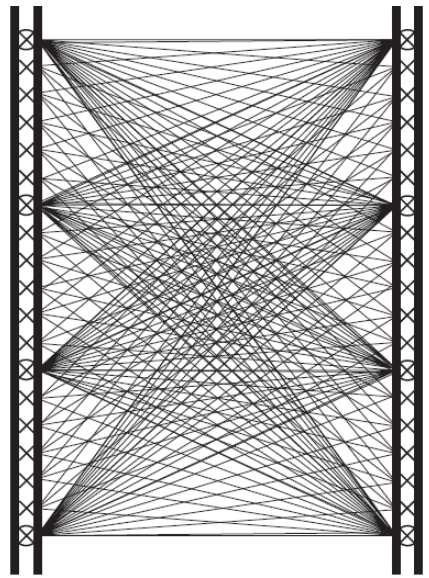


CHAR project, ULiege



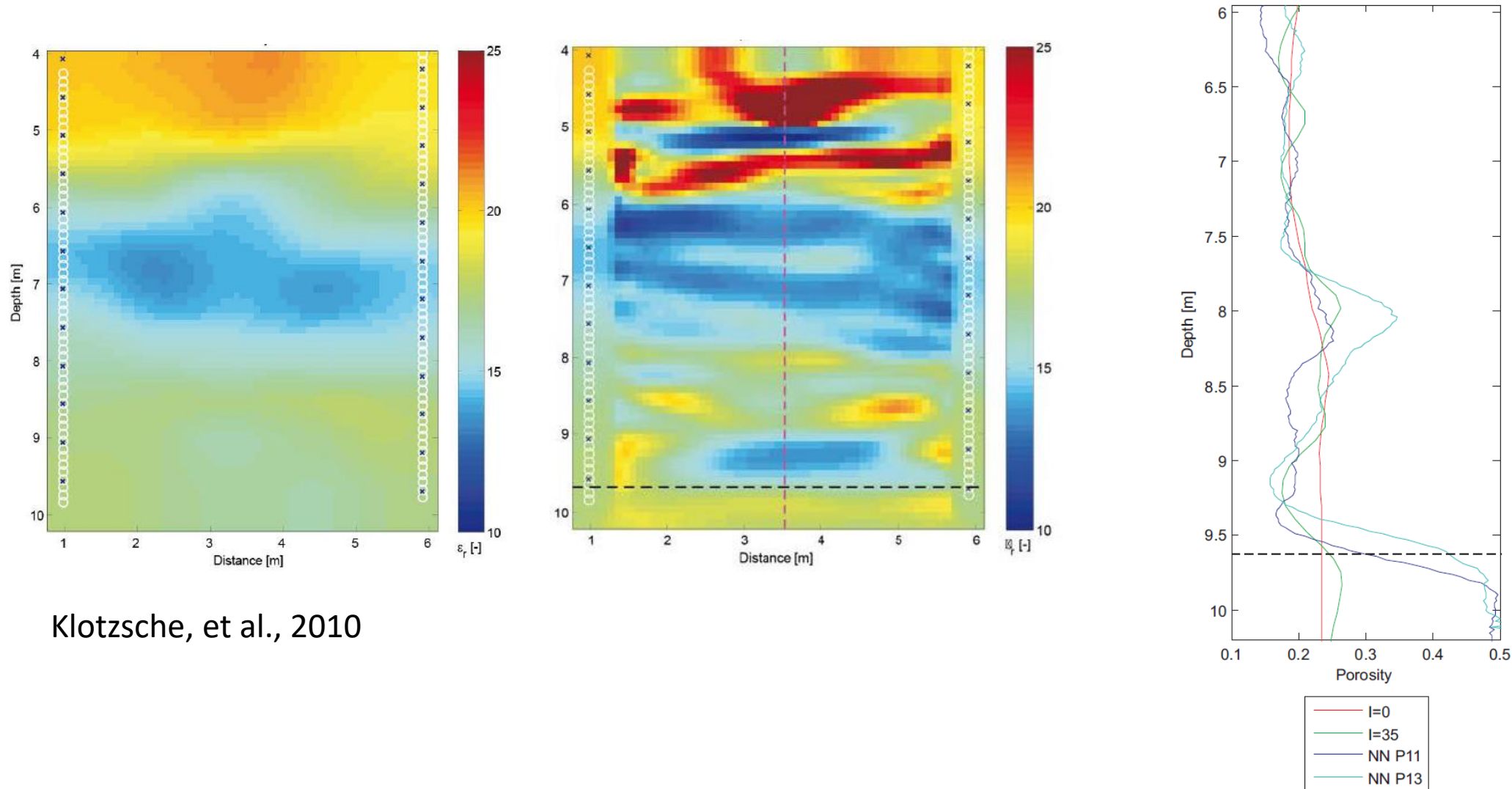


# Advances in modeling physical phenomena to improve imaging



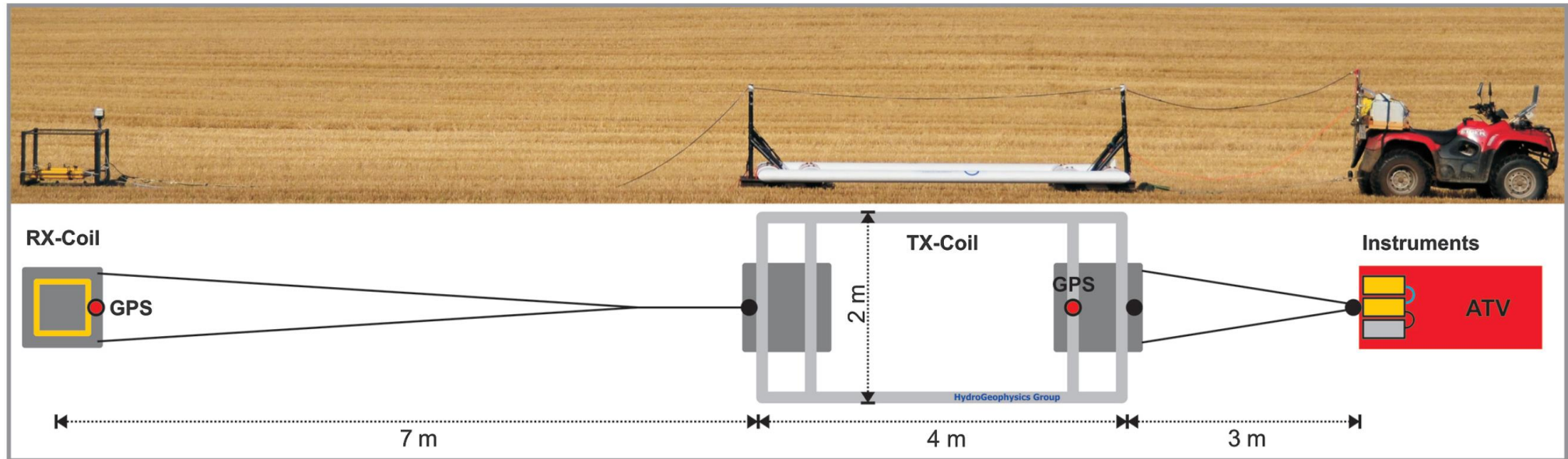
Klotzsche, et al., 2010

# Full waveform inversion brings high resolution

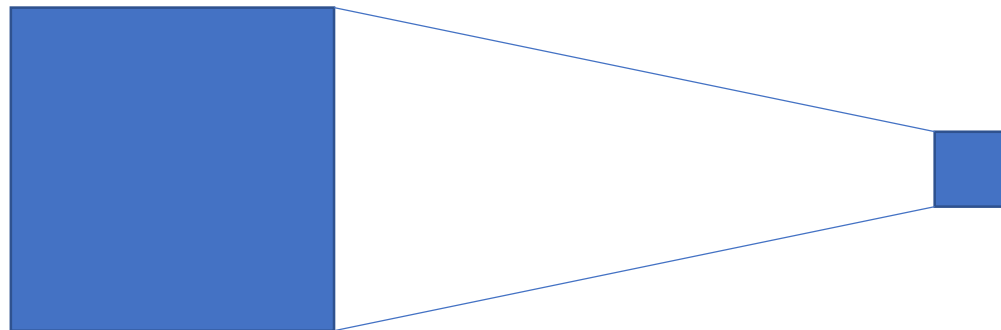


Klotzsche, et al., 2010

# Mapping surveys



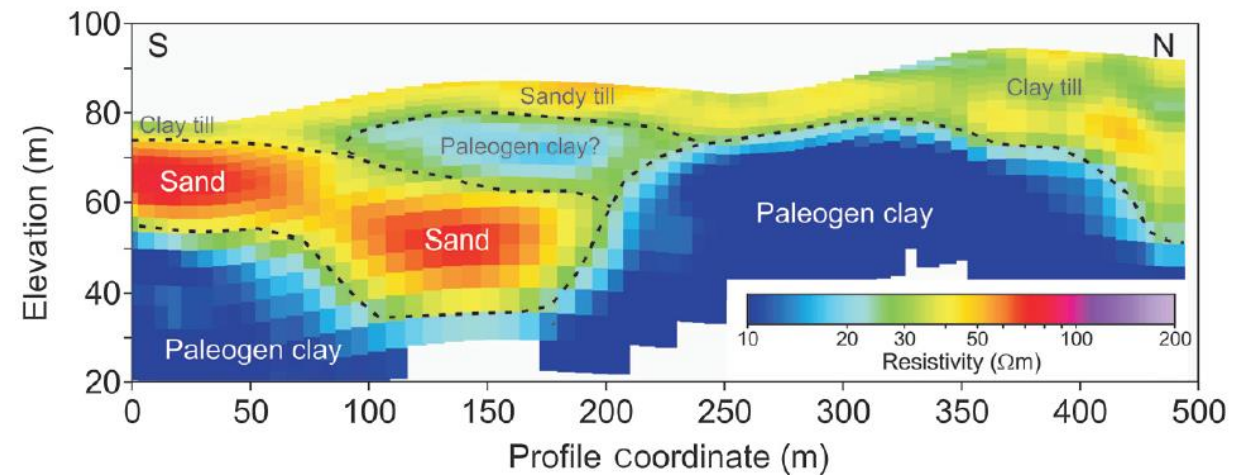
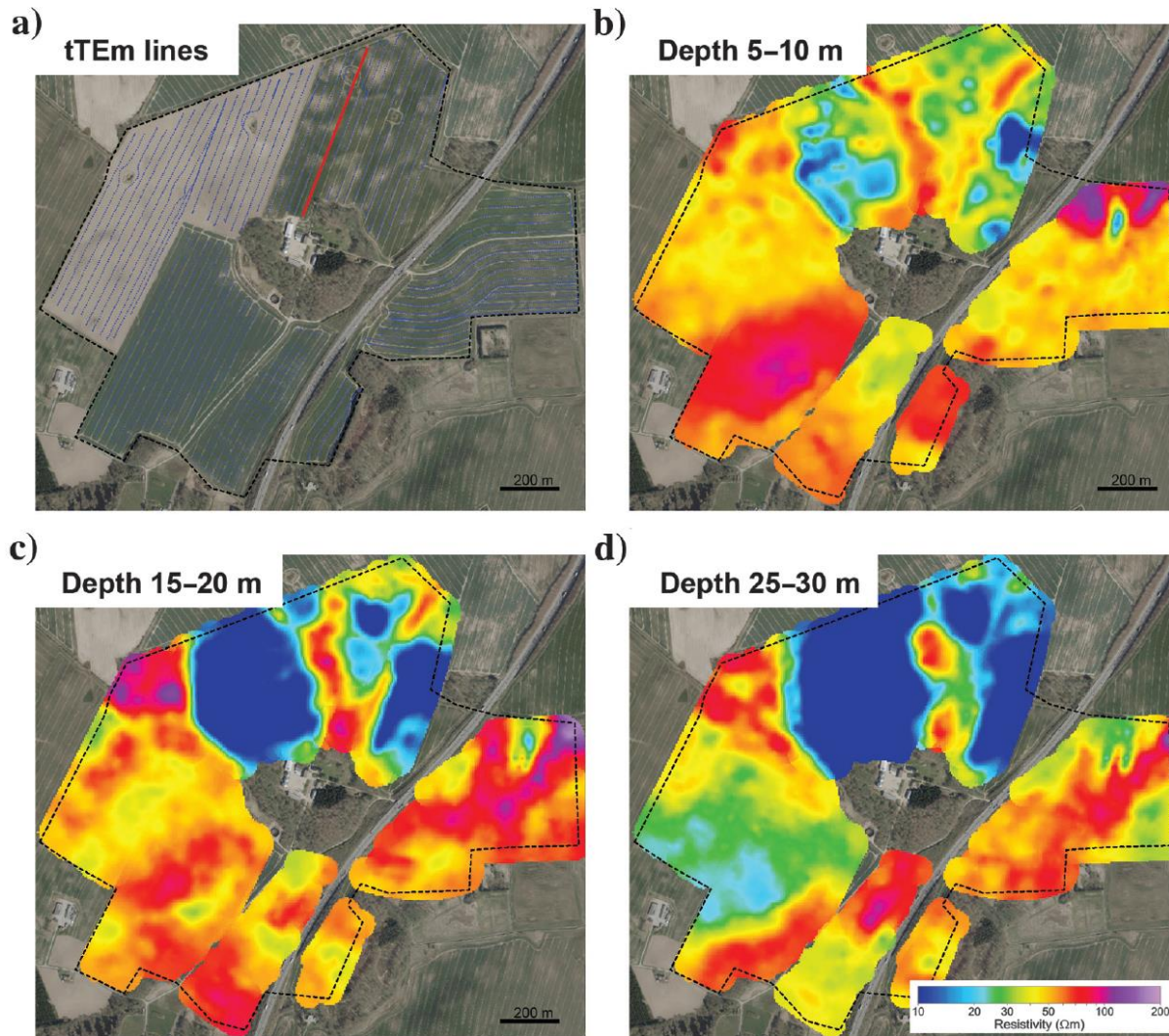
Auken et al., 2019



Challenges: maintaining the depth of investigation while reducing the loop



# Mapping surveys: 2 days to image 1.6 km<sup>2</sup> down to 70 m with a 25 m resolution



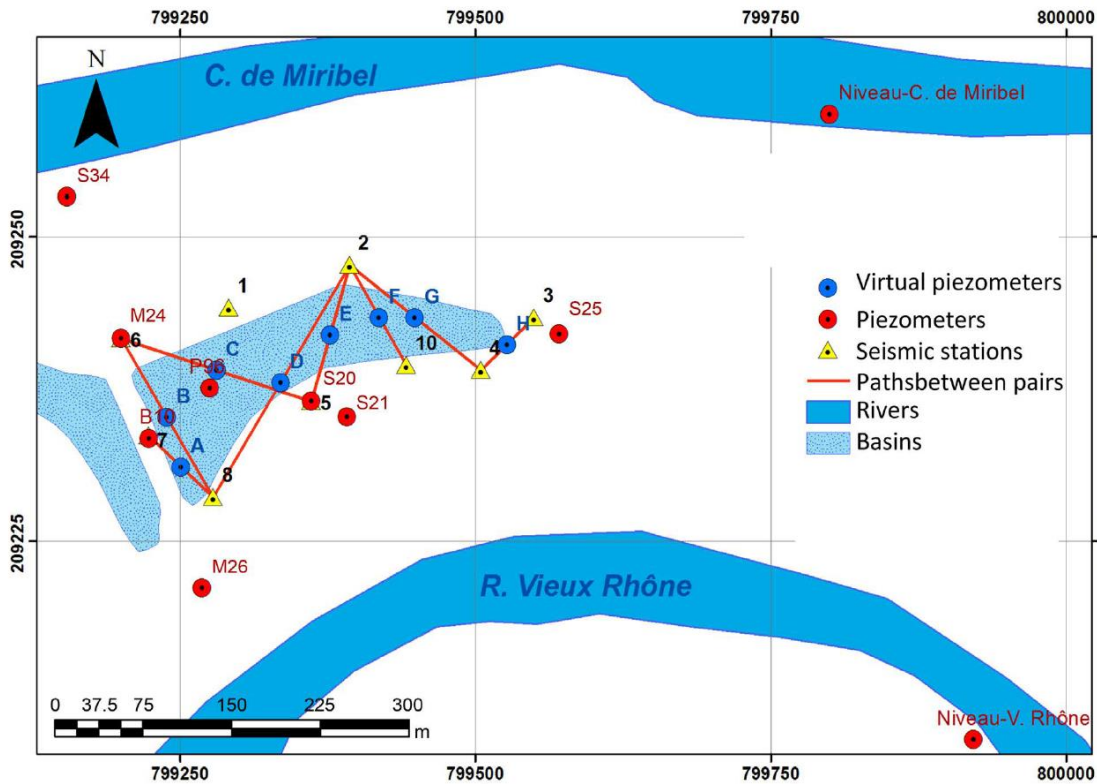
Auken et al., 2019, Geophysics

Monitoring/time-lapse...

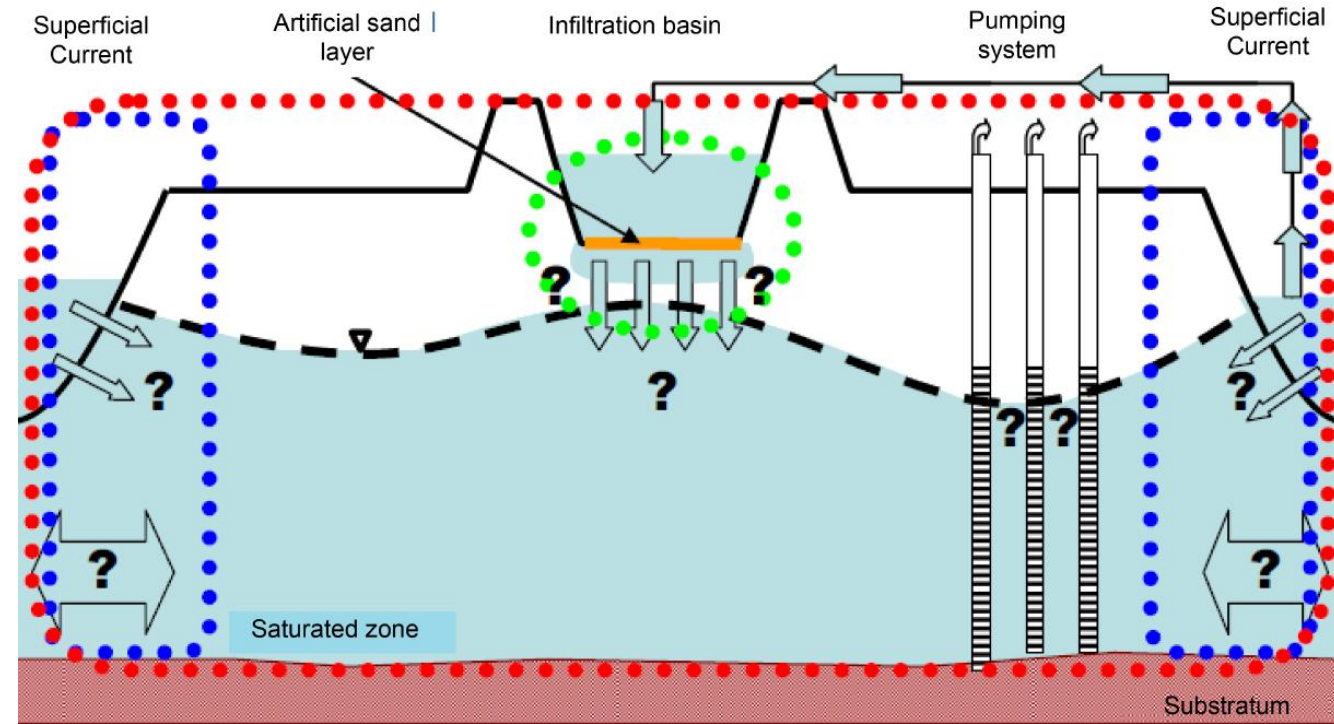




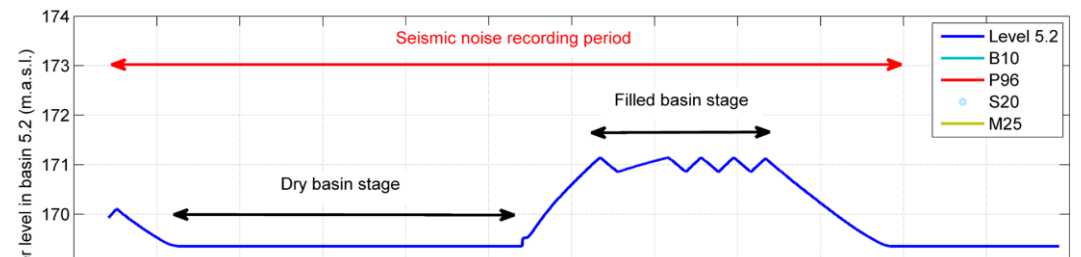
# Data processing: making sense out of noise



Voisin et al., 2017, JWARP

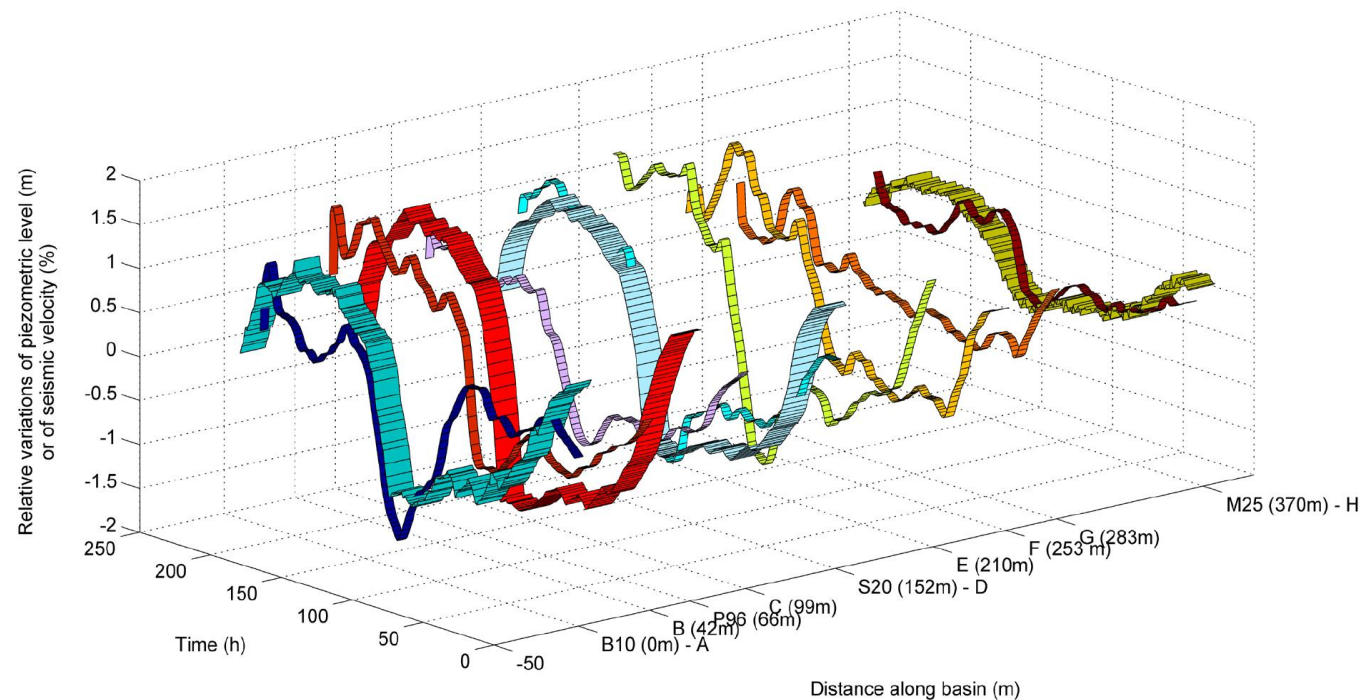
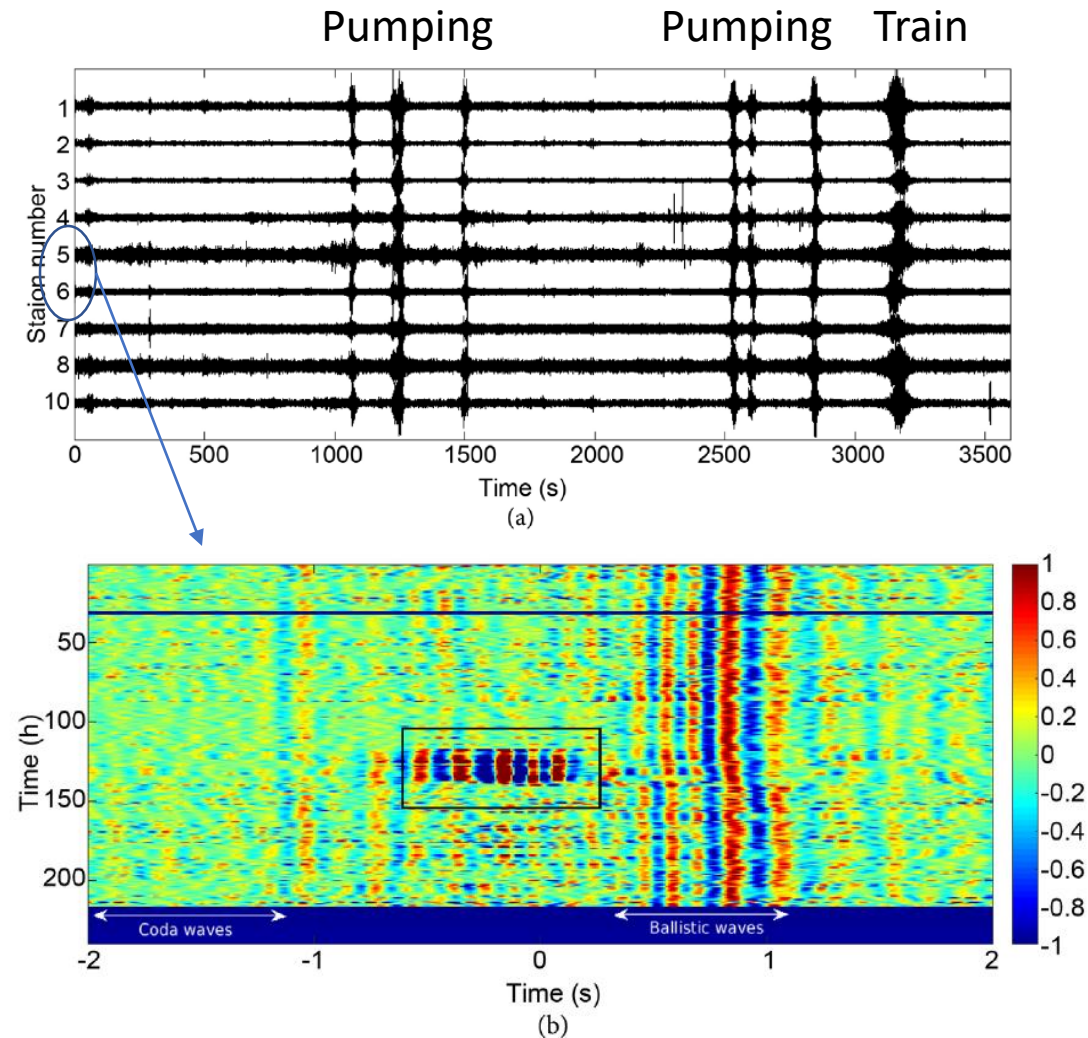


- Infiltration basin/Groundwater exchange
- Superficial current/Groundwater exchange
- Global functioning

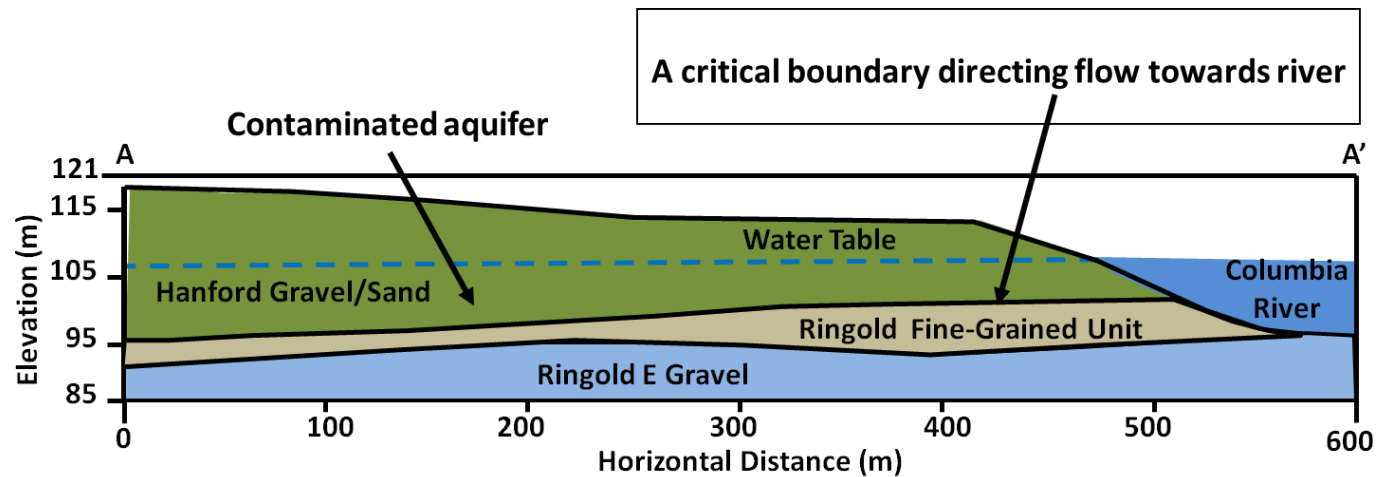




# Data processing: making sense out of noise

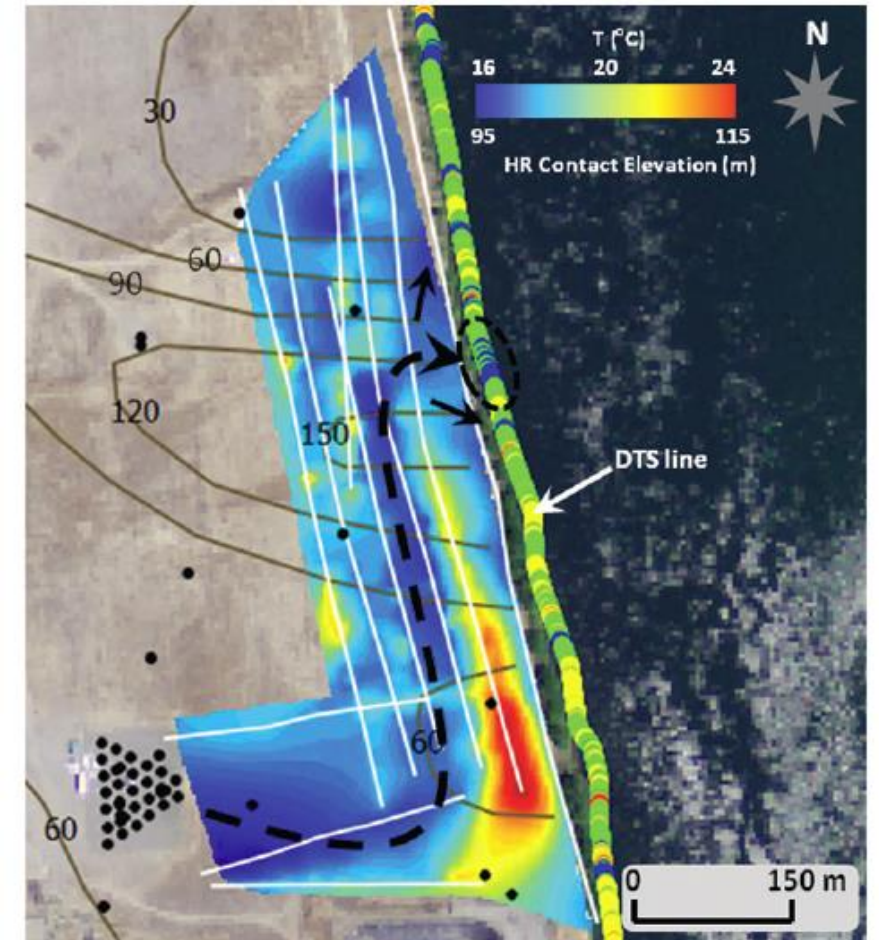


# 4D imaging at Hanford, WA



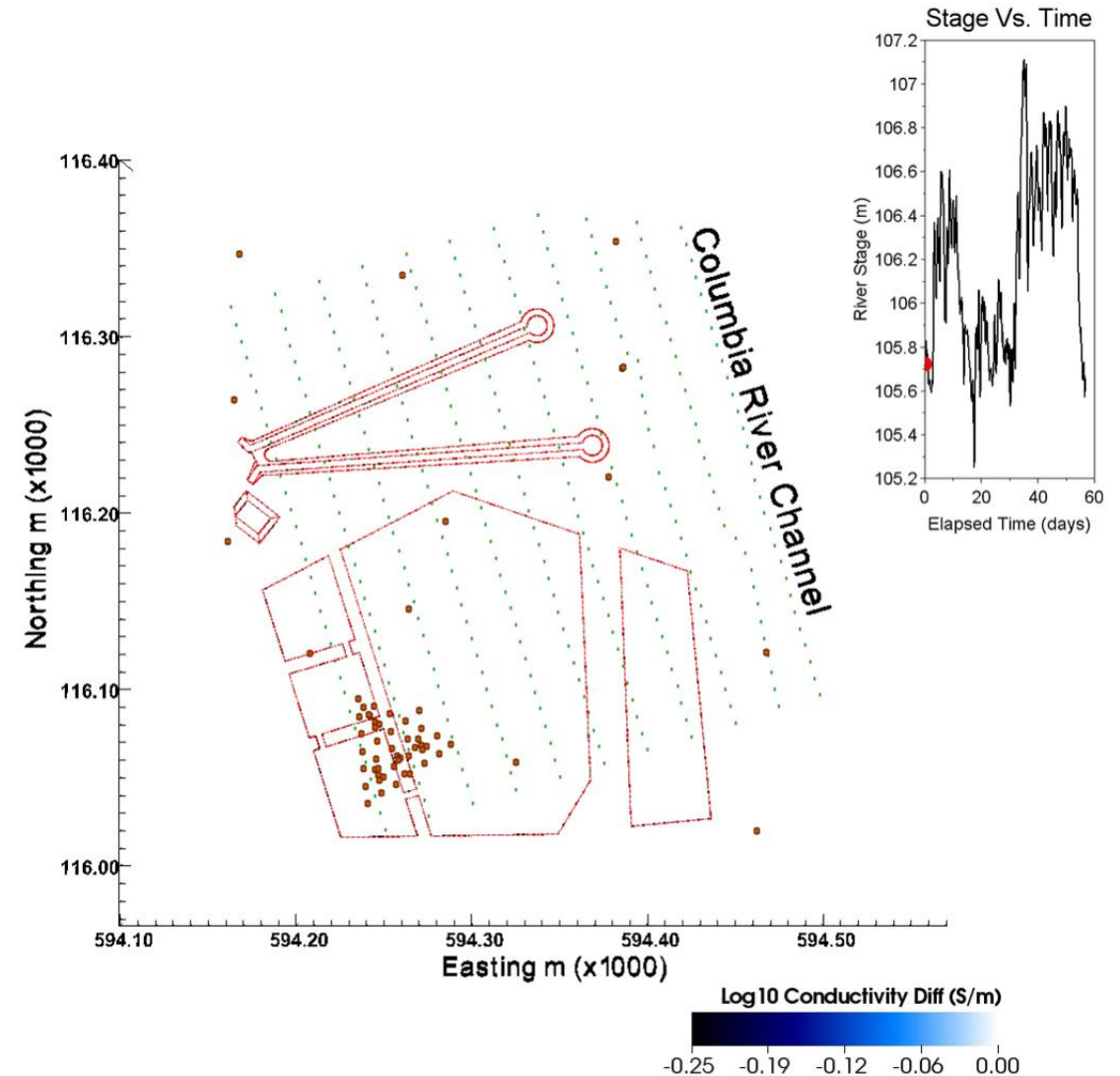
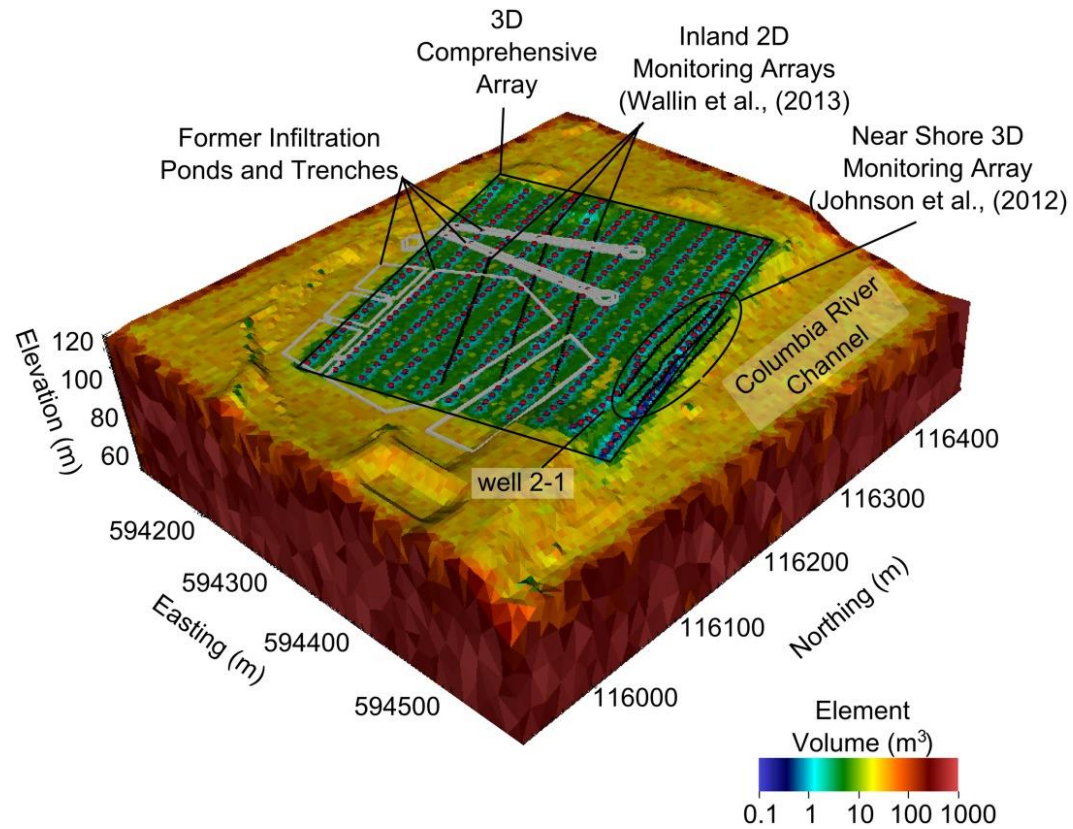
Paleochannels incised into the Ringold unit suspected to channel flow towards the river

Courtesy of Prof. Lee Slater





# ERT 3D + time



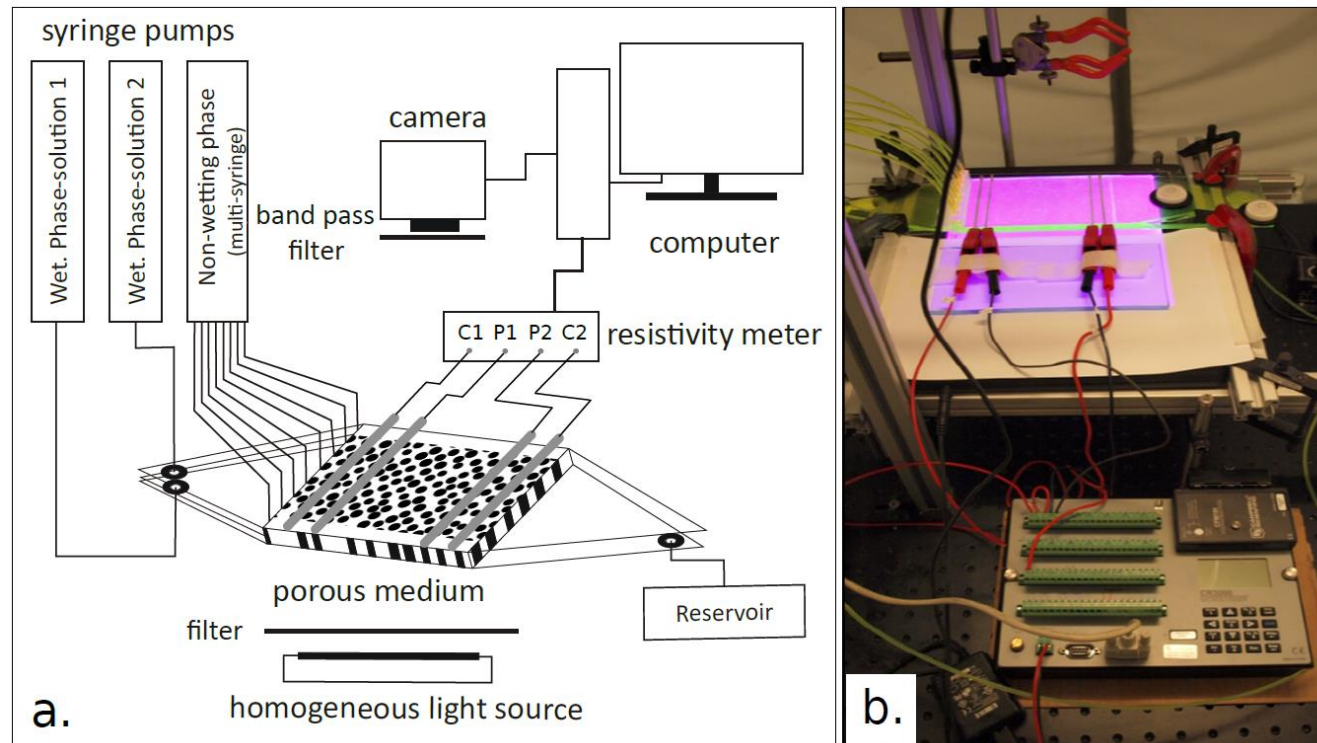
Johnson et al., 2015, WRR





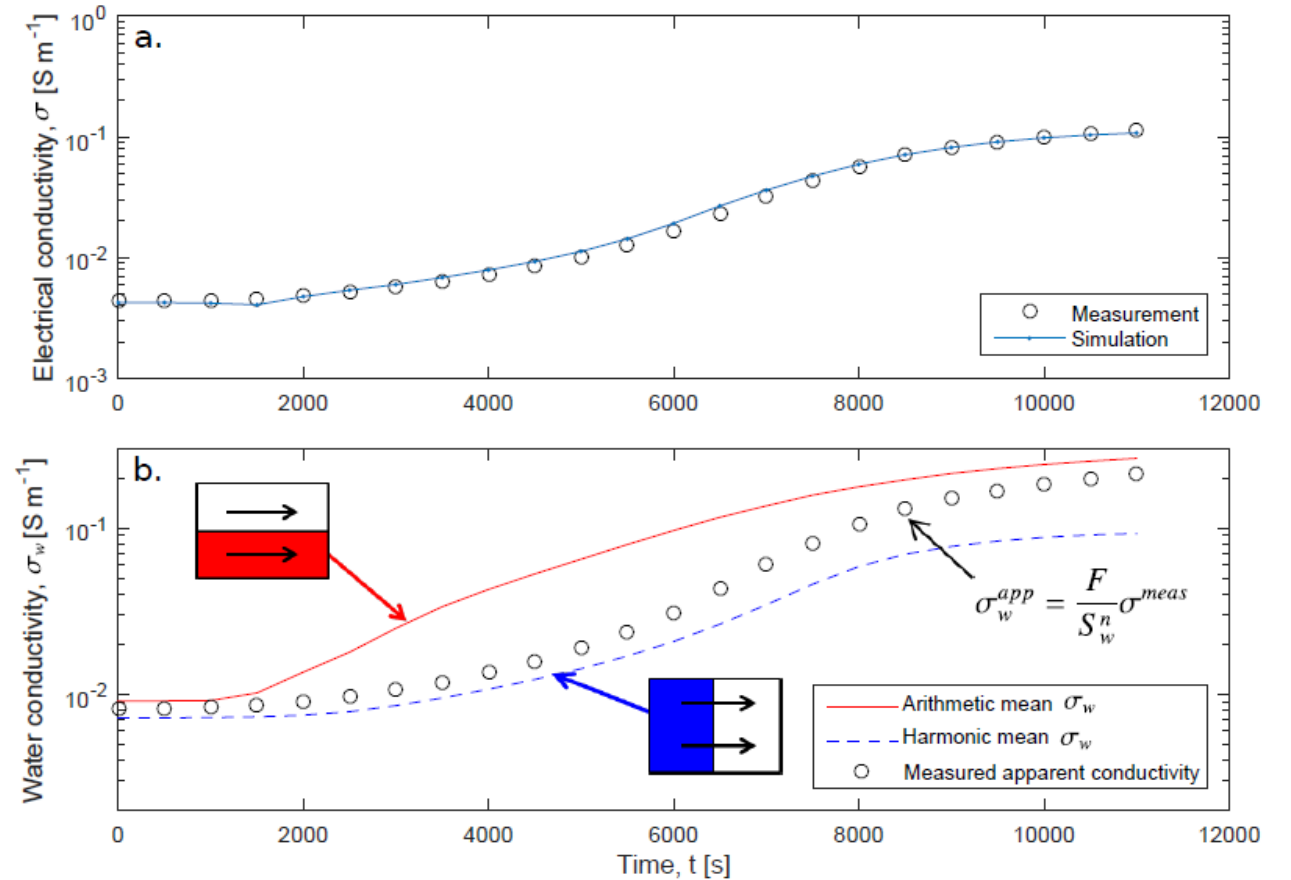
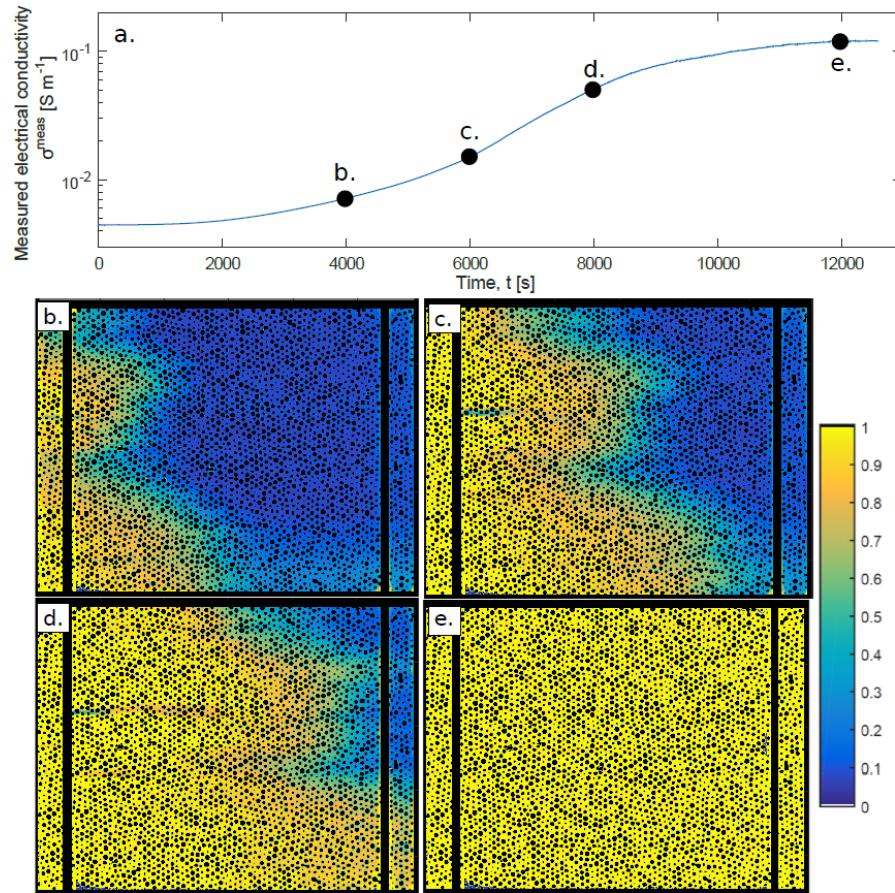
Relation to state variables...

# Petrophysics: the power to quantify...or not



Jougnot et al., 2018

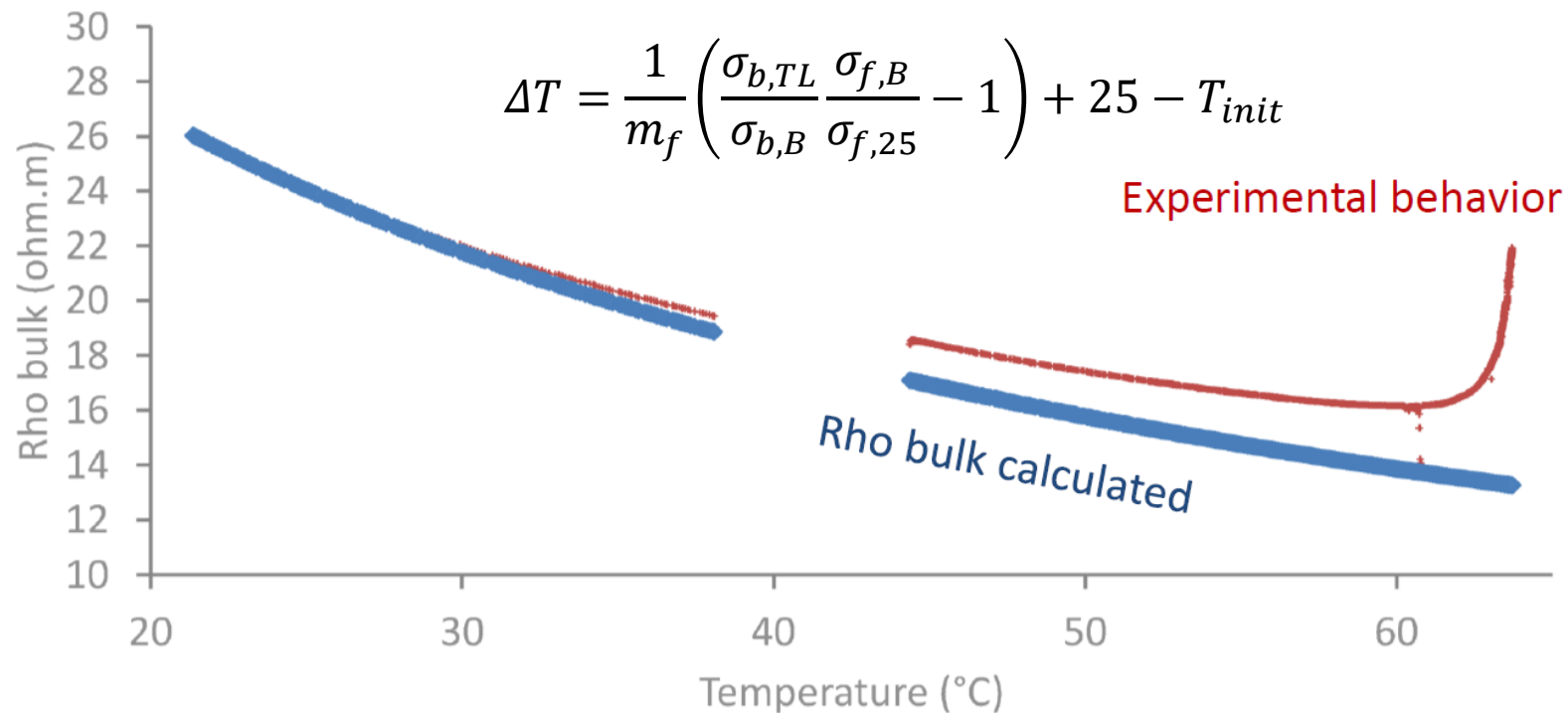
# Petrophysics: testing hypothesis



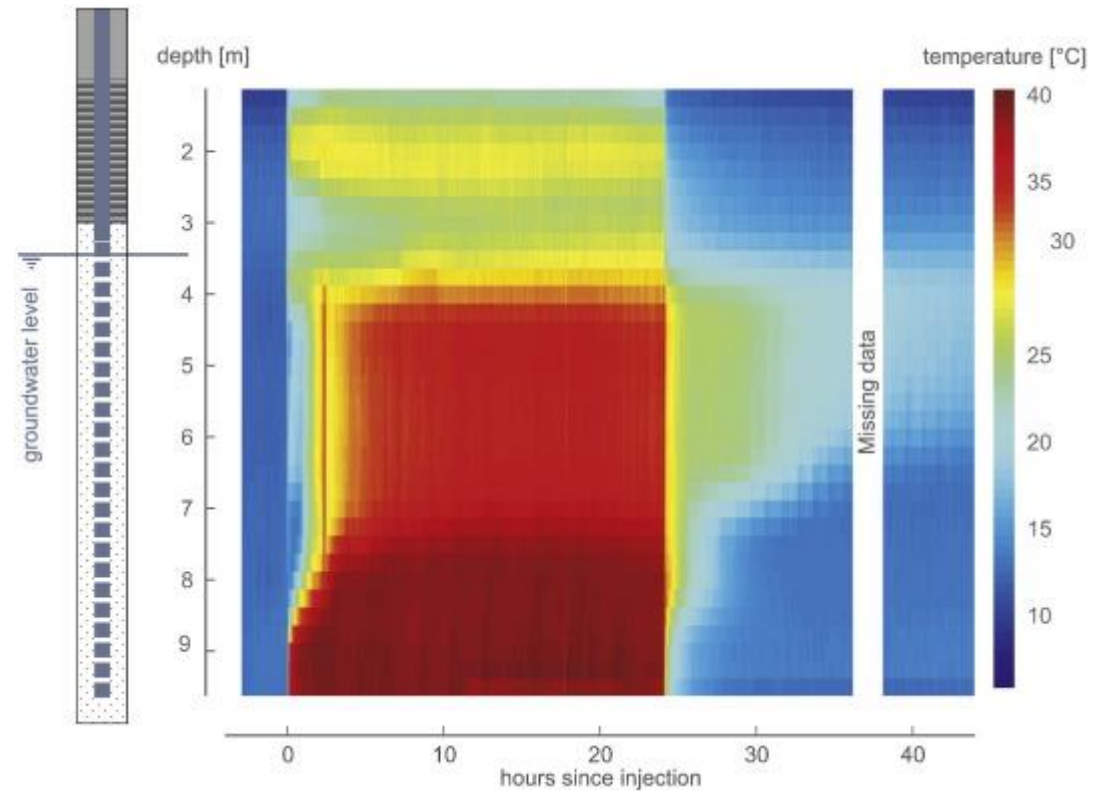
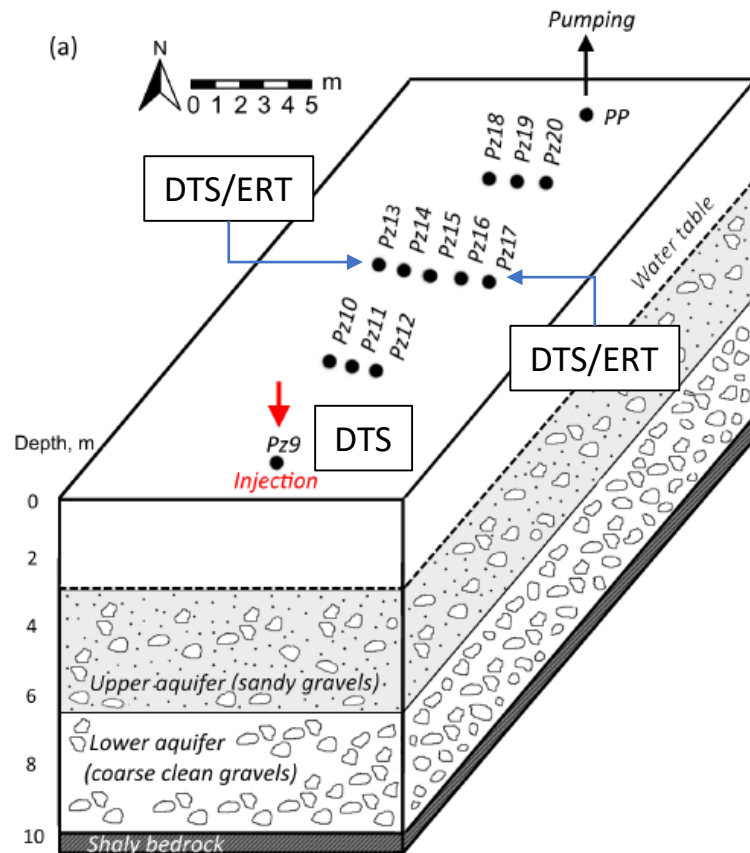


# Process oriented imaging

Water conductivity increases with temperature...2% changes per °C

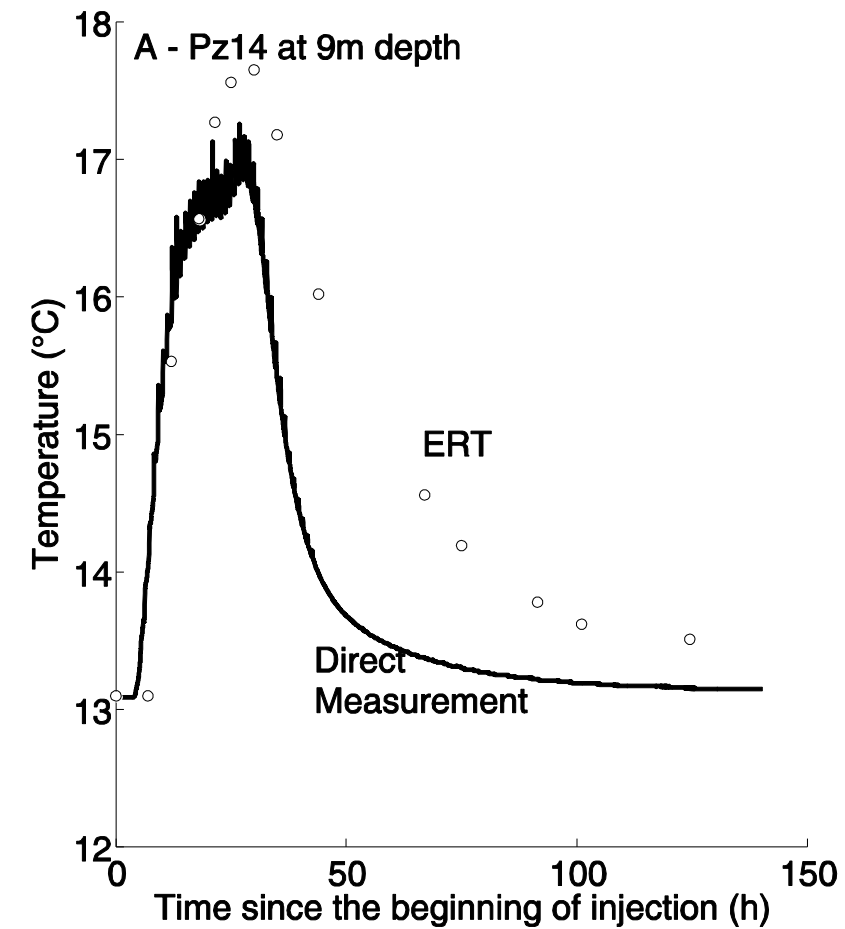
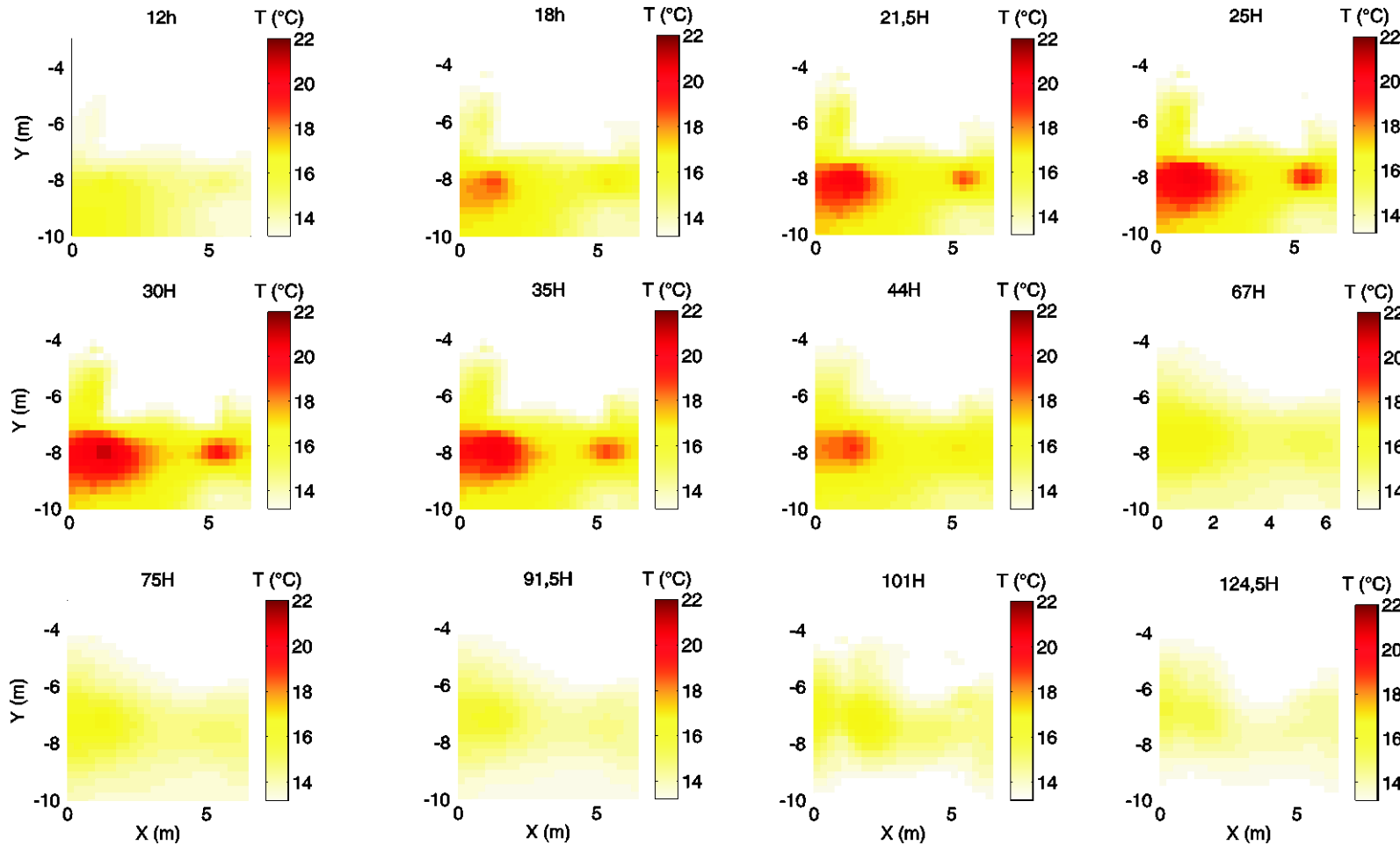


# Process oriented



Wildermeersch et al., 2014

# Process oriented imaging



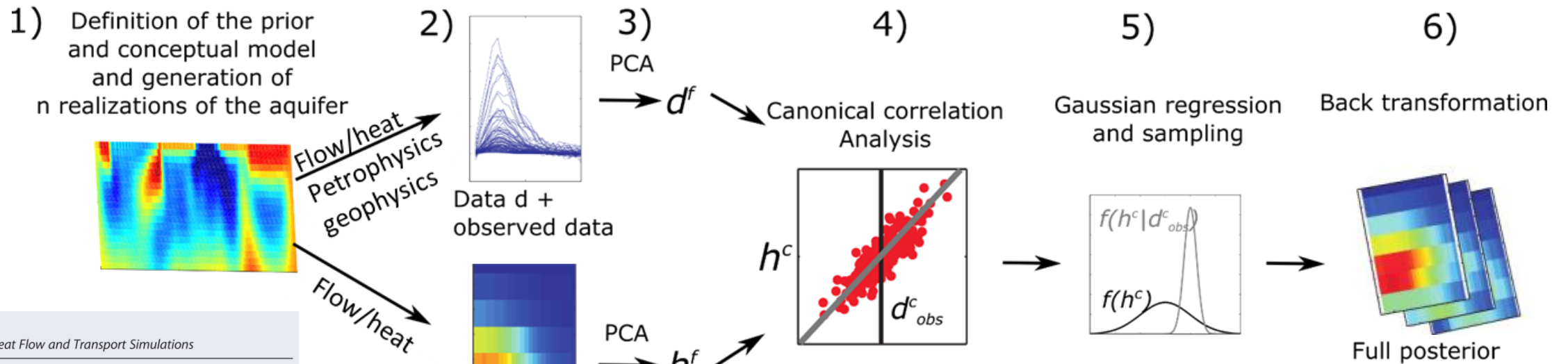


Data integration



# Data integration: geophysics as a fully integrated dataset for groundwater studies

## Prediction-focused approach



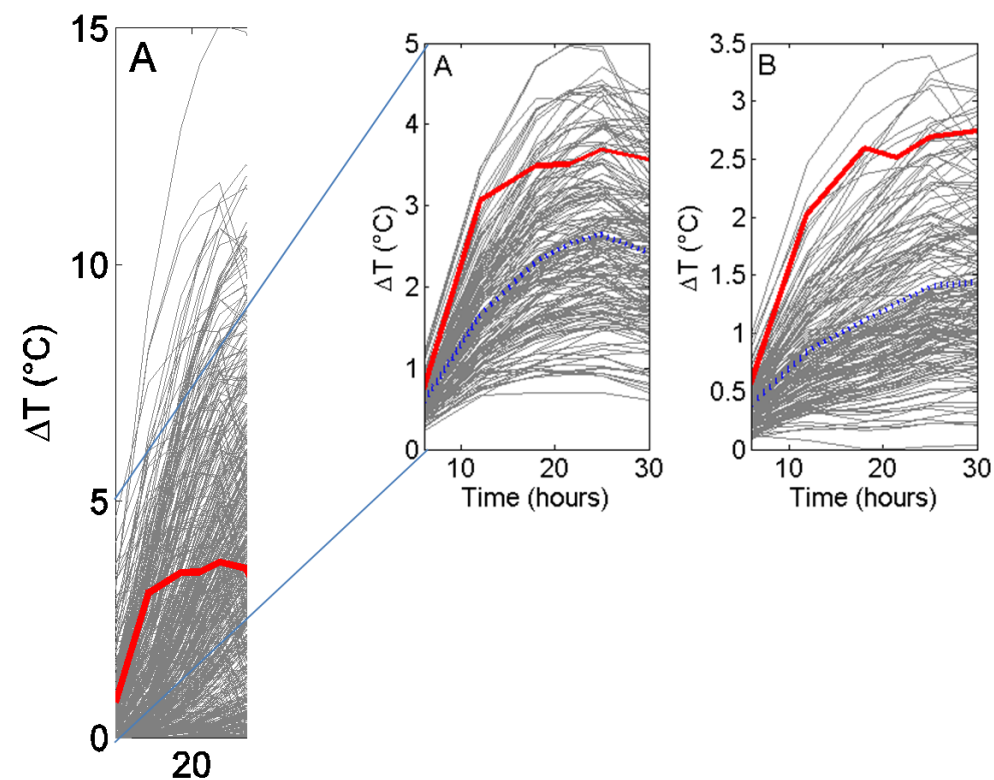
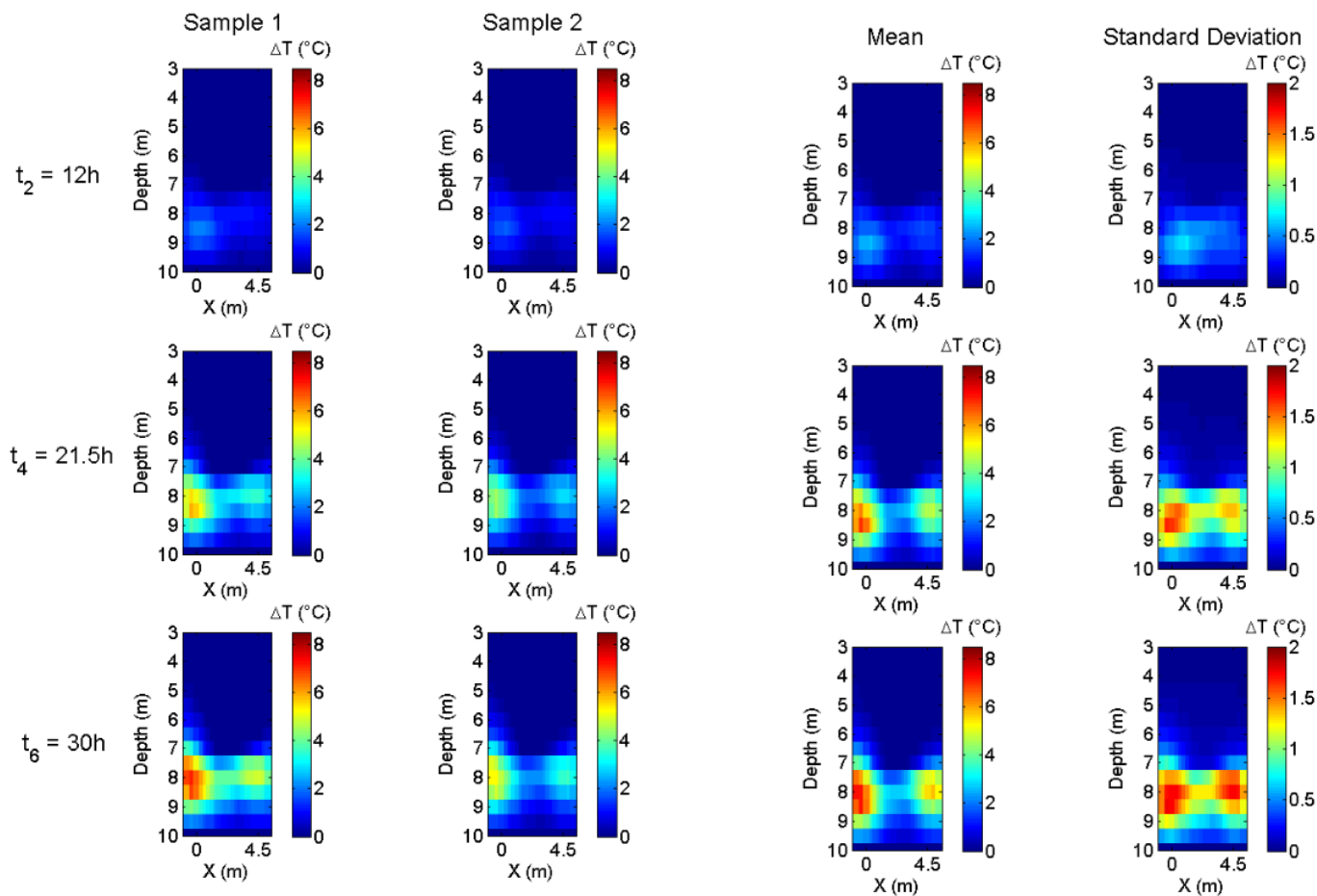
**Table 1**  
Parameters Used for the Heat Flow and Transport Simulations

Parameters	Fixed/variable	Value
Mean of $\log_{10} K$ (m/s)	Variable	U[-4 -1]
Variance $\log_{10} K$ (m/s)	Variable	U[0.05 1.5]
Range (m)	Variable	U[1 10]
Anisotropy ratio	Variable	U[0.5 10]
Orientation	Variable	U[- $\pi/4$ - $\pi/4$ ]
Porosity	Variable	U[0.05 0.40]
Gradient (%)	Variable	U[0 0.167]
$\log_{10} K$ (m/s) – upper layer	Fixed	$10^{-5}$
Longitudinal dispersivity (m)	Fixed	1
Transverse dispersivity (m)	Fixed	0.1
Solid thermal conductivity (W/mK)	Fixed	3
Water thermal conductivity (W/mK)	Fixed	0.59
Solid specific heat capacity (J/kgK)	Fixed	1,000
Water specific heat capacity (J/kgK)	Fixed	4,189

Hermans et al., 2018

See also session S07.27 (Hermans et al.)

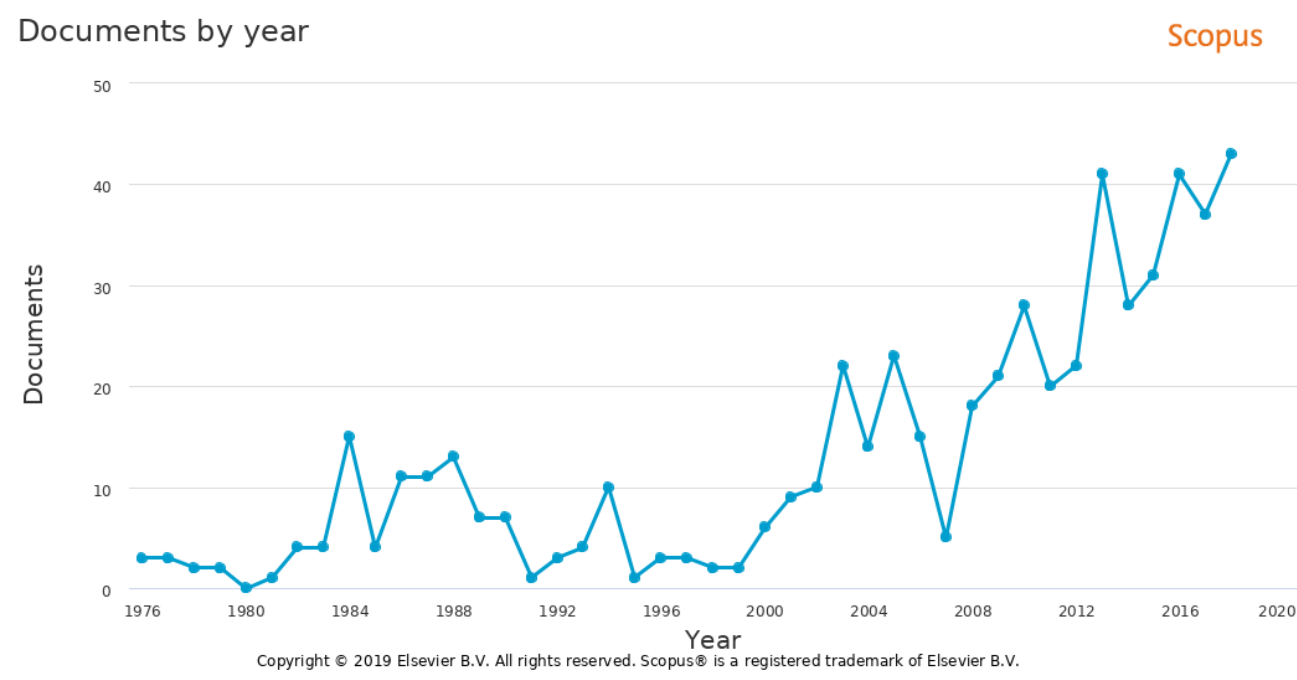
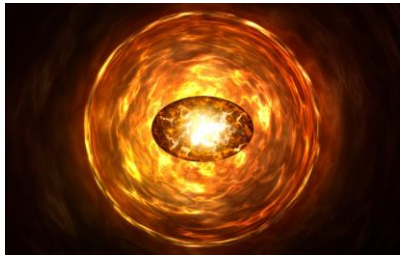
# Data integration





# Conclusions and outlook

- Near-surface geophysics is increasing and will increase in number and societal value.



( KEY ( geophysics ) OR KEY ( hydrogeophysics ) OR KEY ( gpr ) OR KEY ( emi ) OR KEY ( ert ) OR KEY ( seismic ) OR KEY ( nmr ) OR KEY ( mri ) OR KEY ( geophysical ) ) AND ( SRCTITLE ( water AND resources AND research ) OR SRCTITLE ( journal AND of AND contaminant AND hydrology ) OR SRCTITLE ( vadose AND zone AND journal ) OR SRCTITLE ( hydrogeology AND journal ) OR SRCTITLE ( groundwater ) OR SRCTITLE ( advances AND in AND water AND resources ) OR SRCTITLE ( water AND research ) ) 10/09/2019 19:01