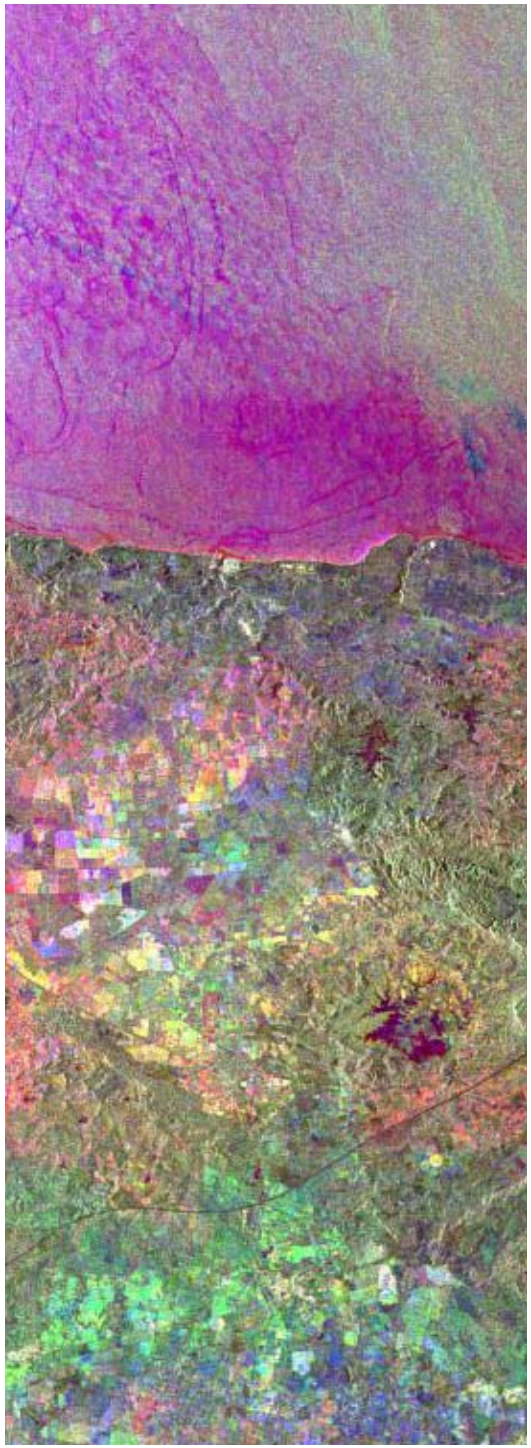


Monitoring top soil moisture through remote sensing to aid hydrologic modelling

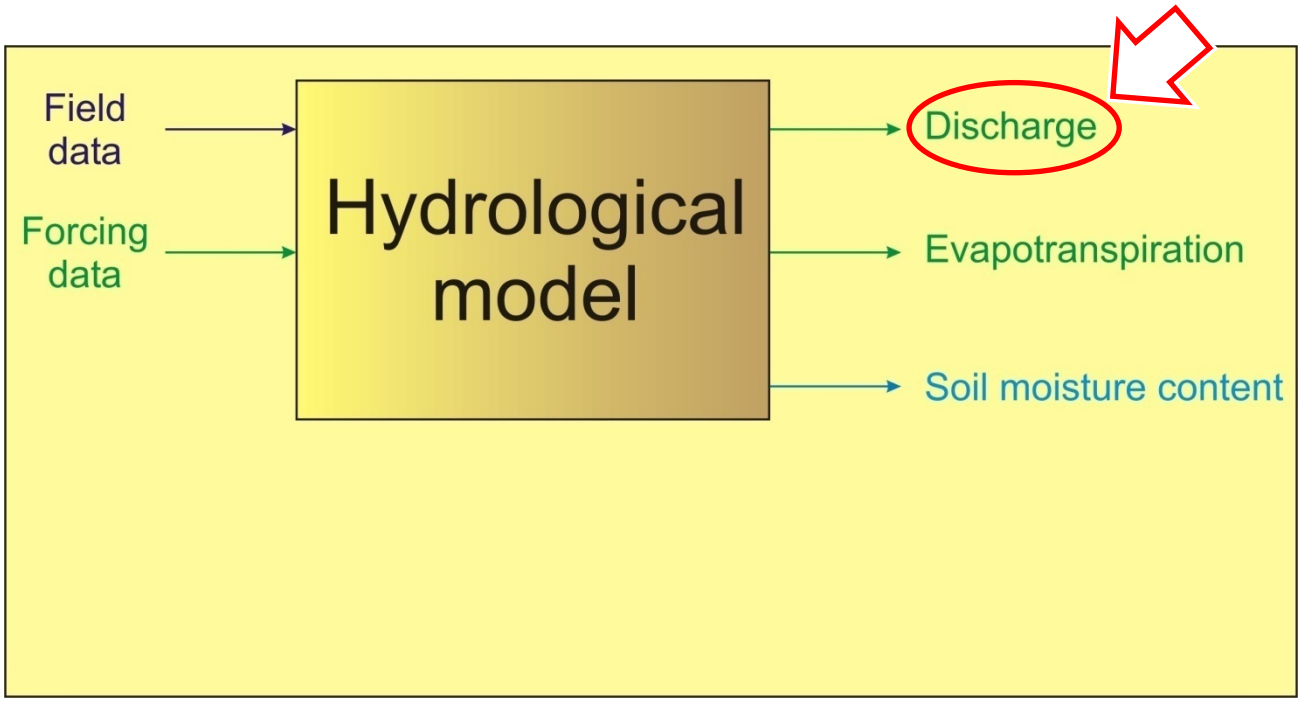
N. Verhoest[1], H. Lievens[1], L. Hoffmann[2], P. Matgen[2], M. Montanari[2], M. Vanclooster[3], S. Lambot[3], J. Minet[3], B. De Baets[4], H. Vernieuwe[4], E. De Keyser[4], V. Pauwels[5], D. Plaza[5]

[1] Laboratory of Hydrology and Water Management, Research Unit “Water Resources Monitoring”, Ghent University
[2] Centre de Recherche Public-Gabriel Lippmann
[3] Department of Environmental Sciences and Land Use Planning, Université catholique de Louvain
[4] Department of Applied Mathematics, Biometrics and Process Control, Ghent University
[5] Laboratory of Hydrology and Water Management, Research Unit “Hydrologic Modeling”, Ghent University

How can soil moisture information improve hydrologic modelling?

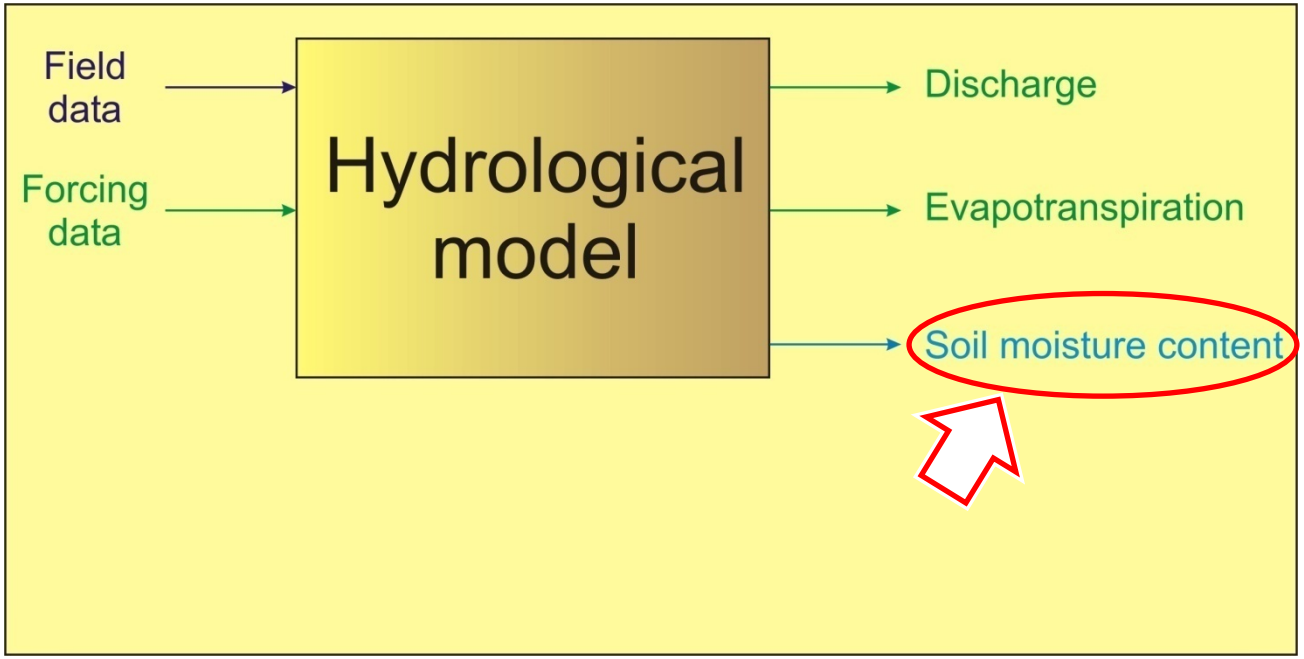
Objective of hydrologic modelling within the HYDRASENS project

- To improve flood predictions after coupling with a hydraulic model
- Hydrologic model should accurately predict upstream inflow hydrograms



How can soil moisture information improve hydrologic modelling?

- Soil moisture is important state variable in hydrologic model as it determines most hydrologic processes
  (infiltration, runoff, evapotranspiration, …)
- Use soil moisture observations to update state variables in the hydrologic model



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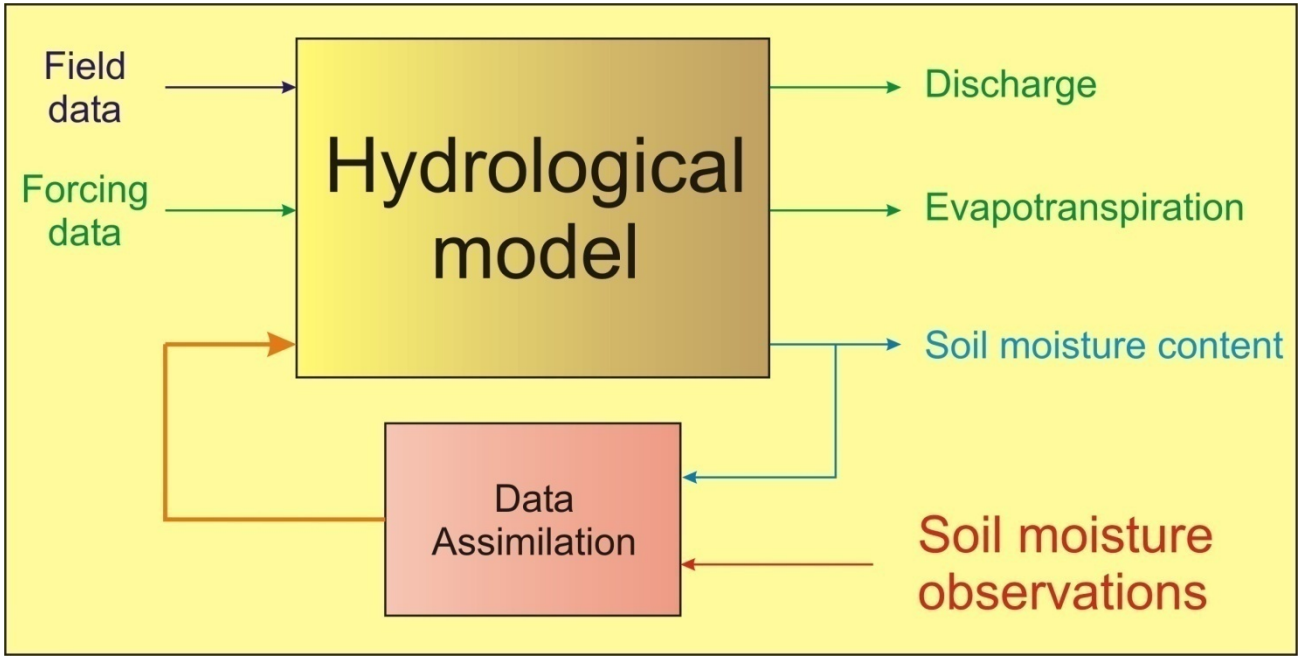
- Data assimilation



How can soil moisture information improve hydrologic modelling?

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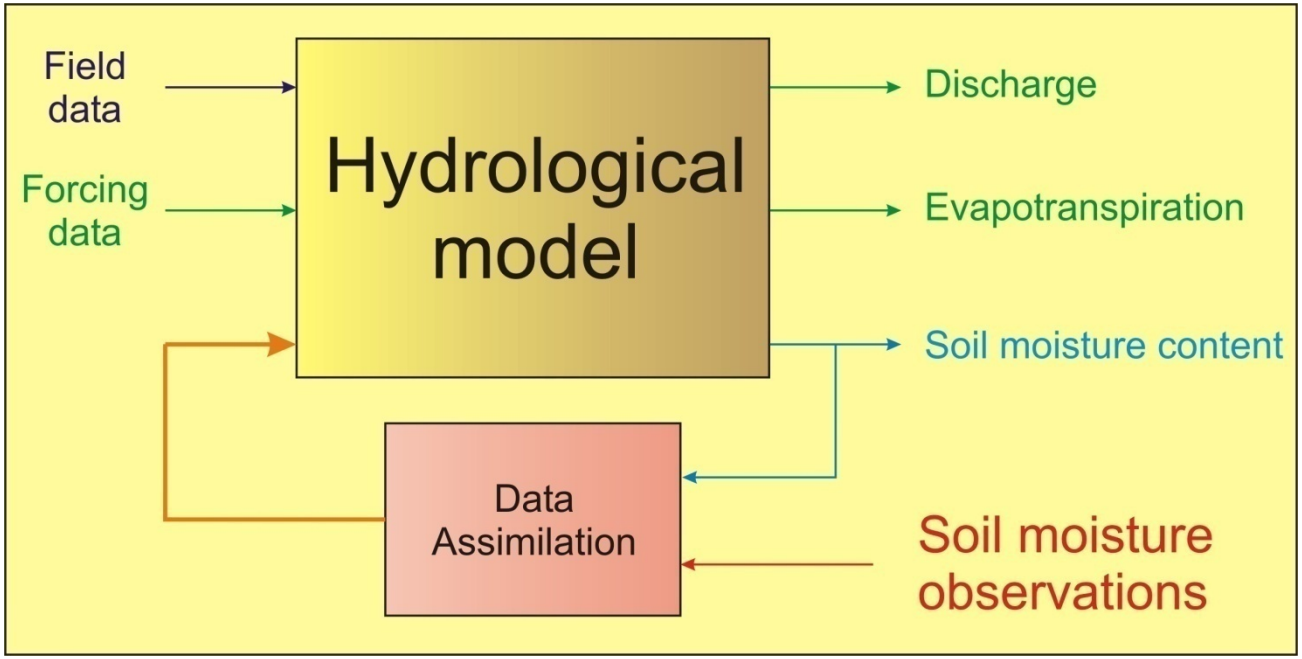
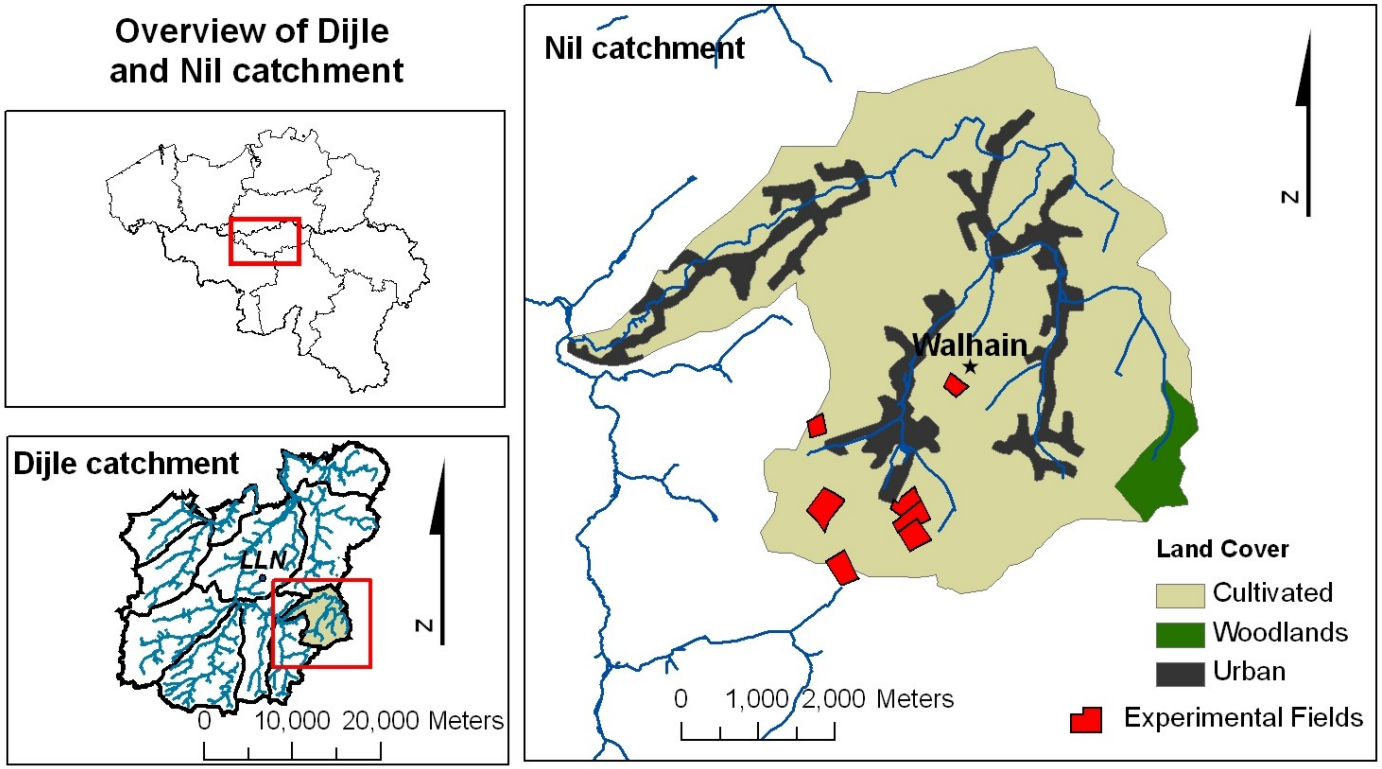
Remote sensing

Data assimilation



Test sites

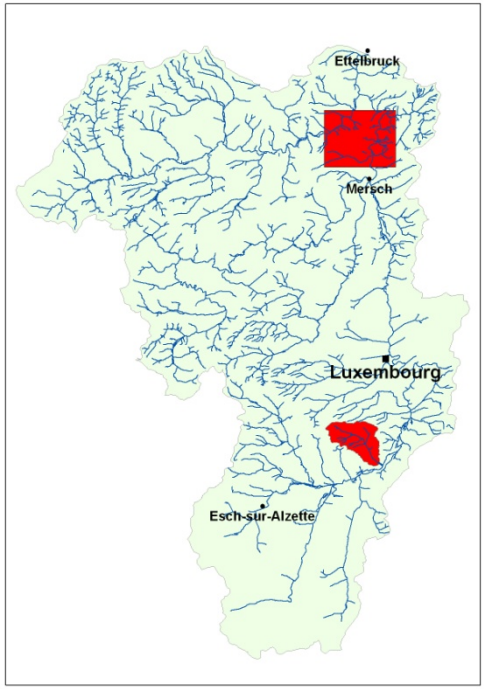
Dijle catchment

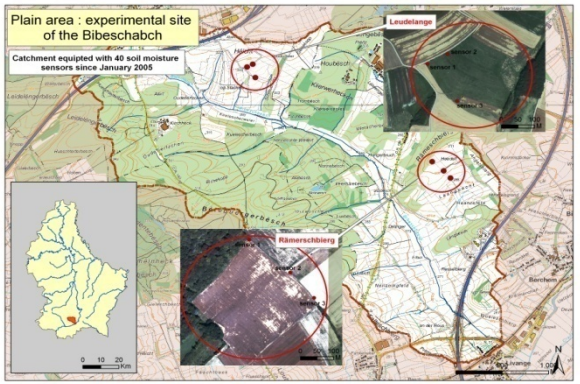


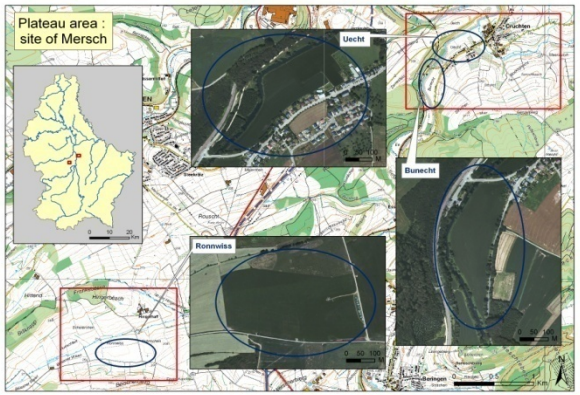
Projected Coordinate System: Belge Lambert 1972
Land Cover class from Corine Land Cover, Région Wallonne

Test sites

Alzette catchment







Types of remote sensing under investigation

Ground Penetrating Radar (GPR)

High resolution soil moisture patterns
Spatial scaling of soil moisture

Synthetic Aperture Radar (SAR)

Basin-wide soil moisture patterns
Spatial scaling of soil moisture

Ground Penetrating Radar (GPR)

Principle

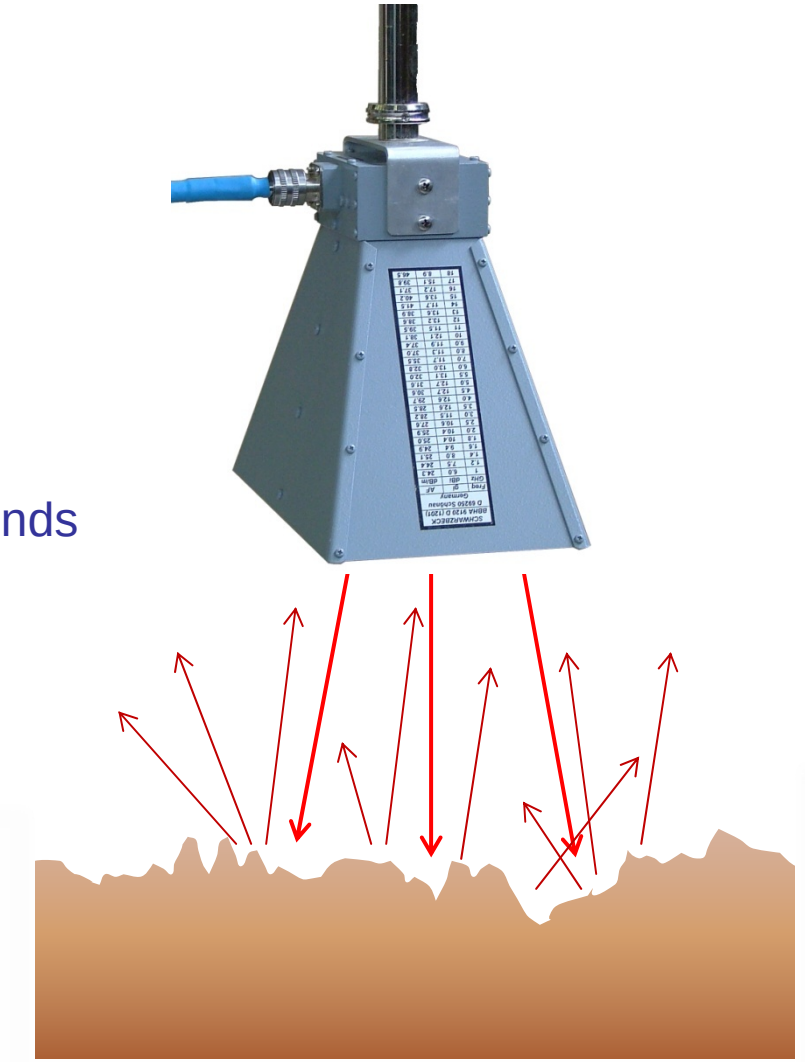
Pulse is emitted by antenna

Pulse scatters at surface

Part of scattered pulse is received by antenna.

Amount of backscattered energy depends on:

- dielectric constant of soil
  (related to soil moisture)
- soil roughness
- vegetation
- electromagnetic properties of the microwave



Ground Penetrating Radar (GPR)

Mounted on a Multi-sensor hydrogeophysical platform

GPR system: VNA + Antenna

Schwarzbeck UWB
Antenna
0,2 – 2 GHz

EM38

GPS Leica 1200

Field laptop

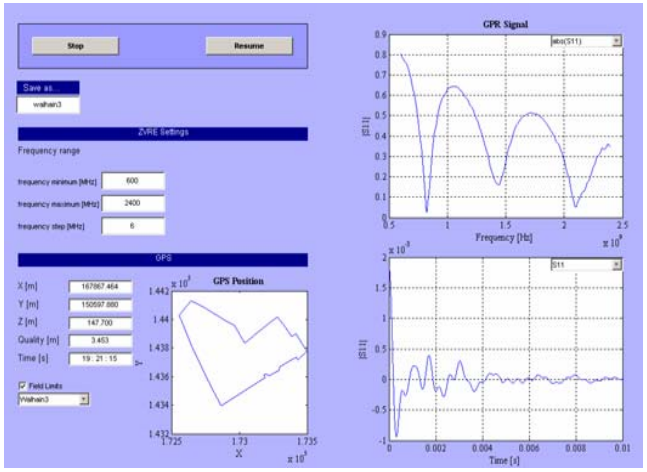
Batteries

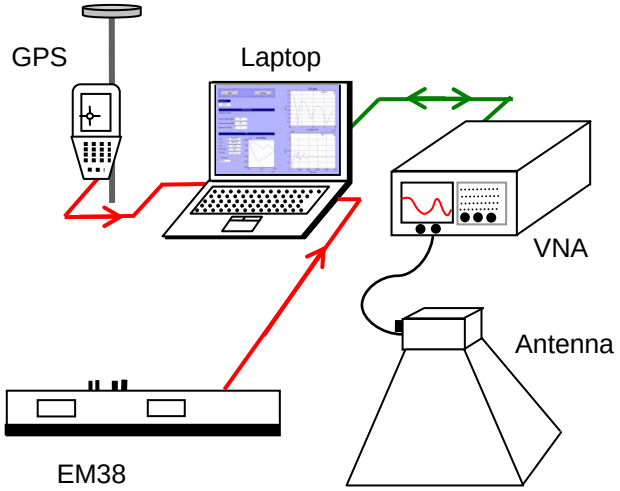
Vinyl Ester reinforced
Fiberglass & PVC
Weight: ~100 kg
Dimensions: 4 x 1,8 x 1,1 m

Ground Penetrating Radar (GPR)

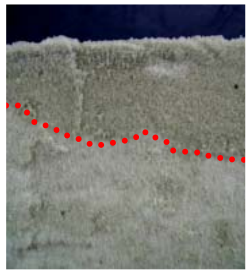
Mounted on a Multi-sensor hydrogeophysical platform

Developing a graphical User Interface integrating GPS, GPR system and EM38



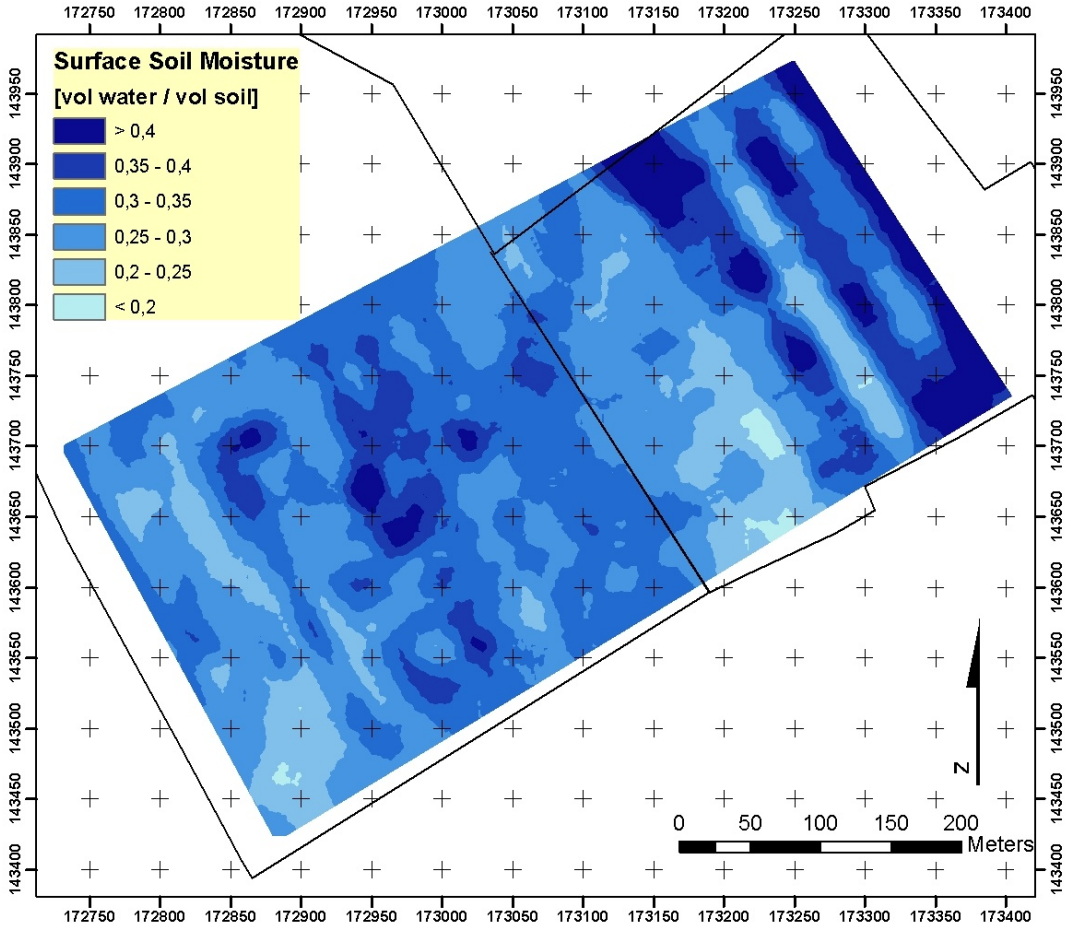


Developing EM-models accounting for soil (moisture) layering



Ground Penetrating Radar (GPR)

Results from field experiments



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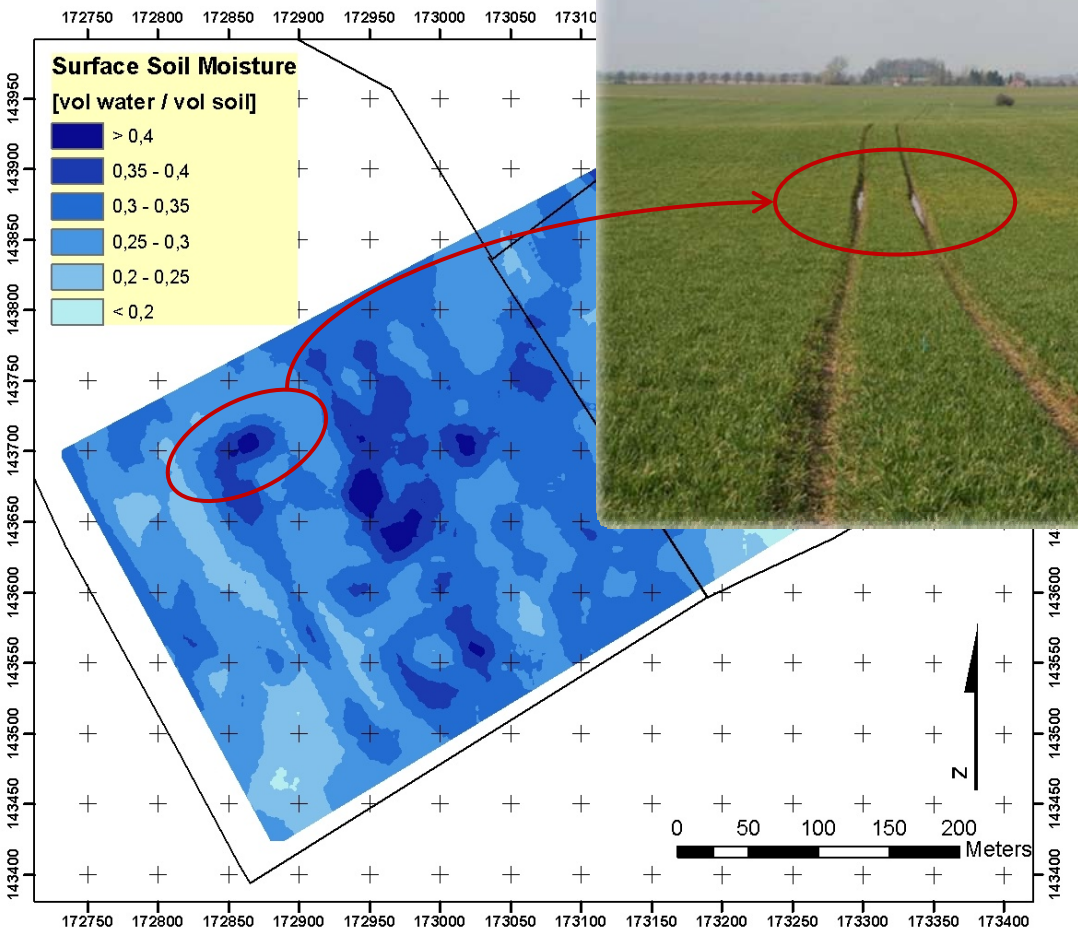
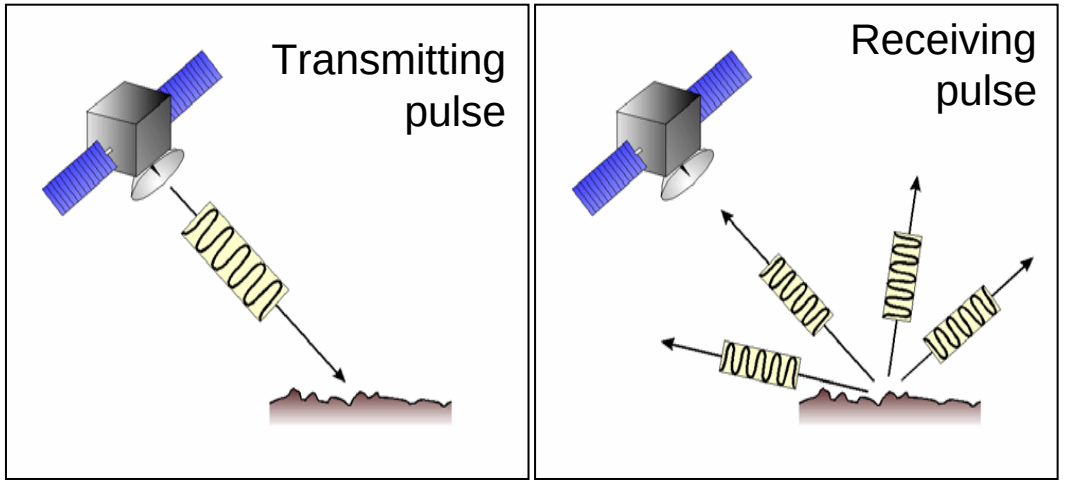
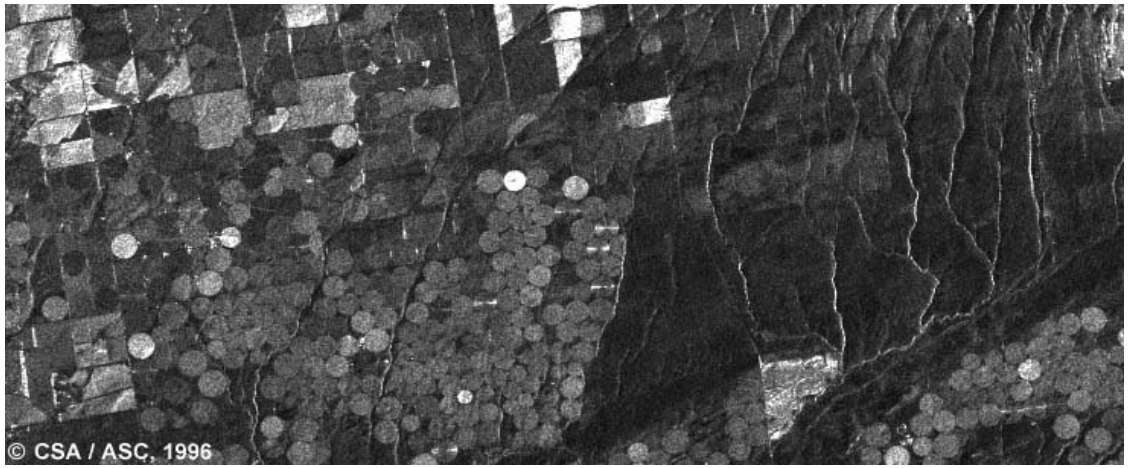


Synthetic Aperture Radar (SAR)

Backscattered energy depends on:

- soil moisture content
- soil roughness
- local incidence angle
- vegetation
- electromagnetic properties of the microwave

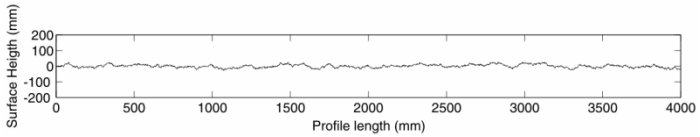




Monitoring top soil moisture through remote sensing to aid hydrologic modelling

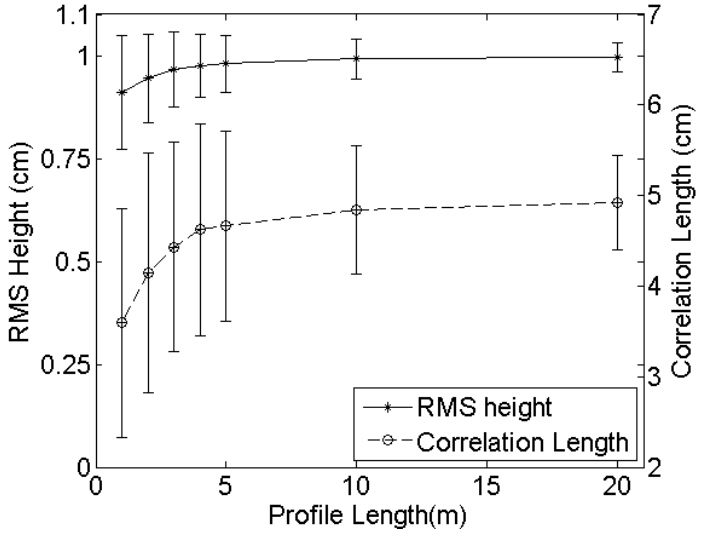
Synthetic Aperture Radar (SAR)

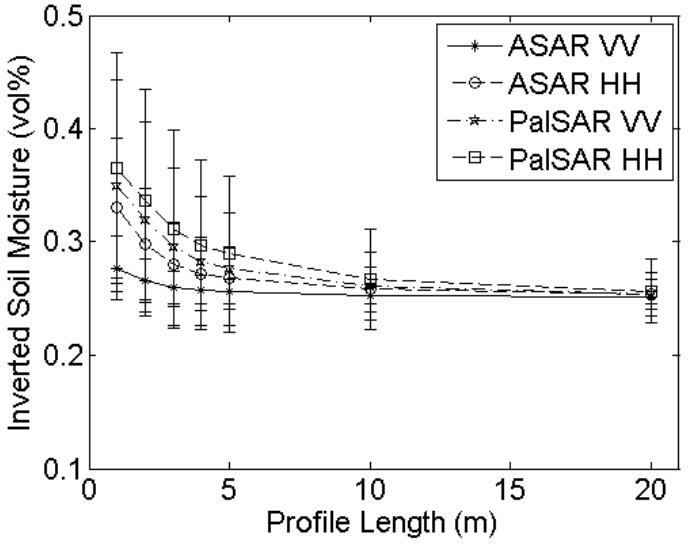
Main difficulty: characterization of soil roughness



Prone to errors!

Largely influences accuracy of soil moisture retrieval

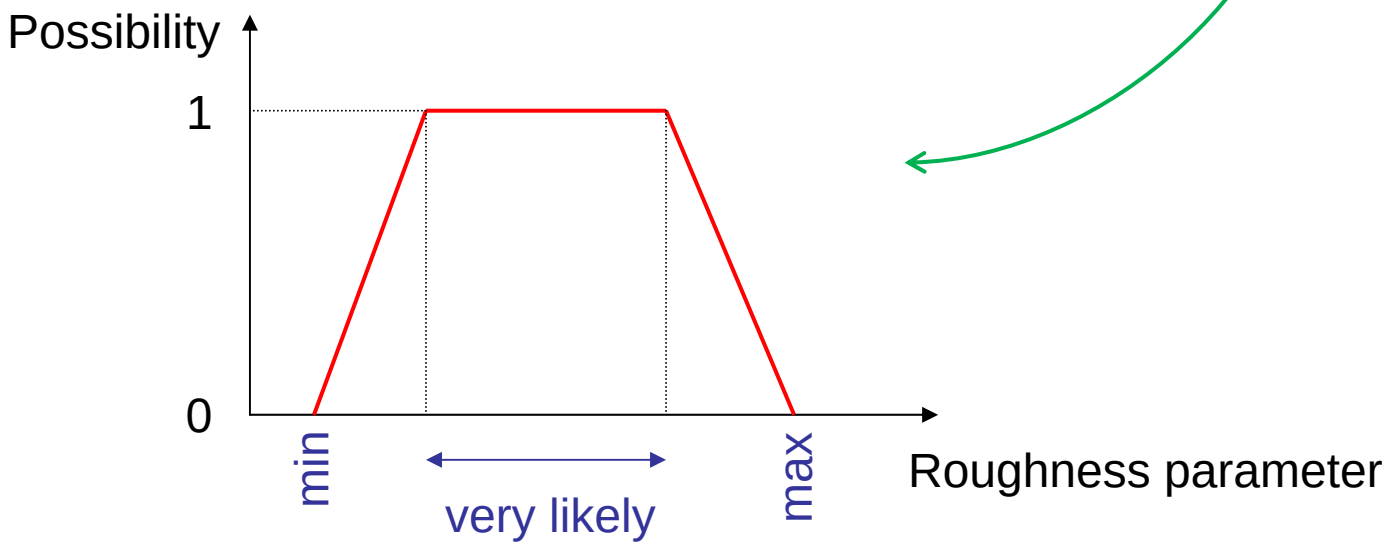




Synthetic Aperture Radar (SAR)

Development of retrieval technique that allows for a fuzzy description of soil roughness

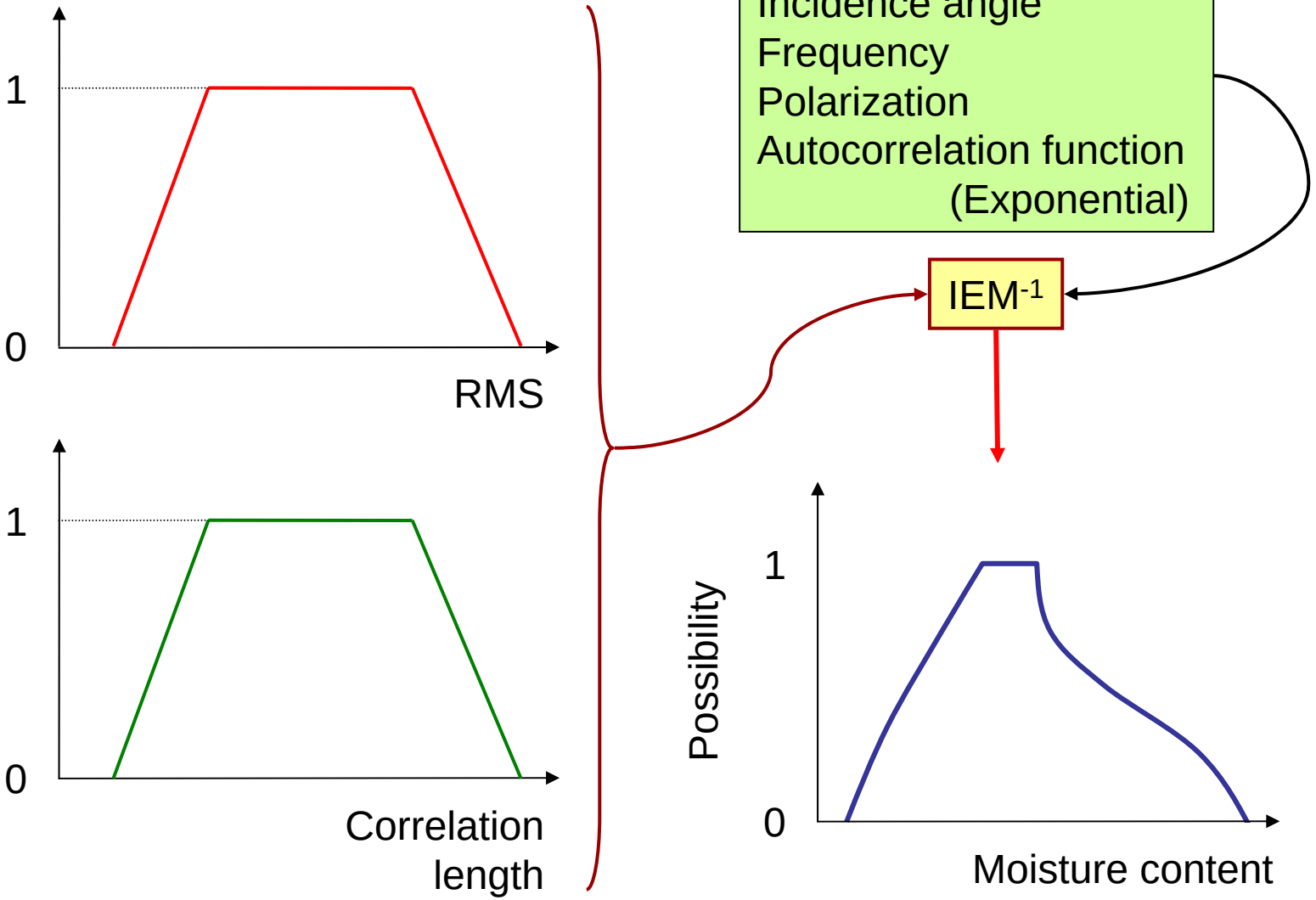
Tillage classes



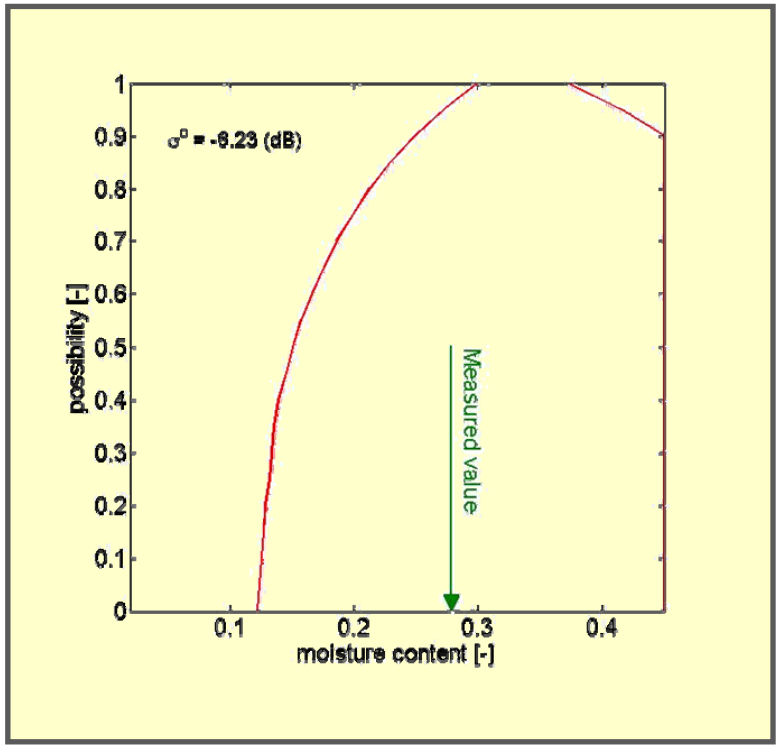
Advantage: technique allows for estimating uncertainty in retrieved soil moisture

Synthetic Aperture Radar (SAR)

Retrieval procedure:

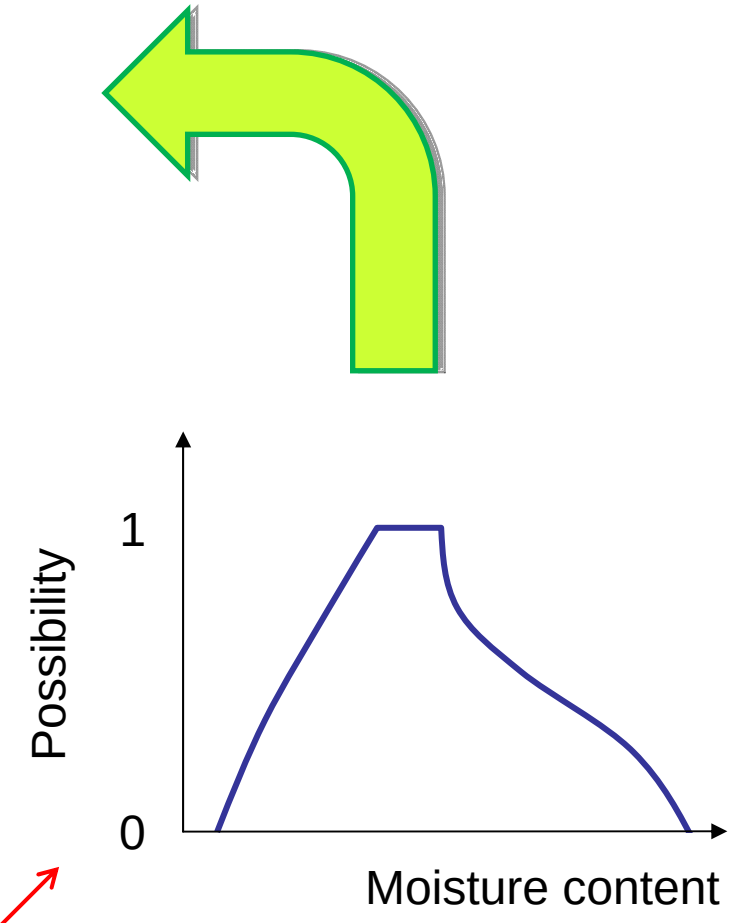


Synthetic Aperture Radar (SAR)



- High uncertainty
- Why? Relationship between roughness parameters:

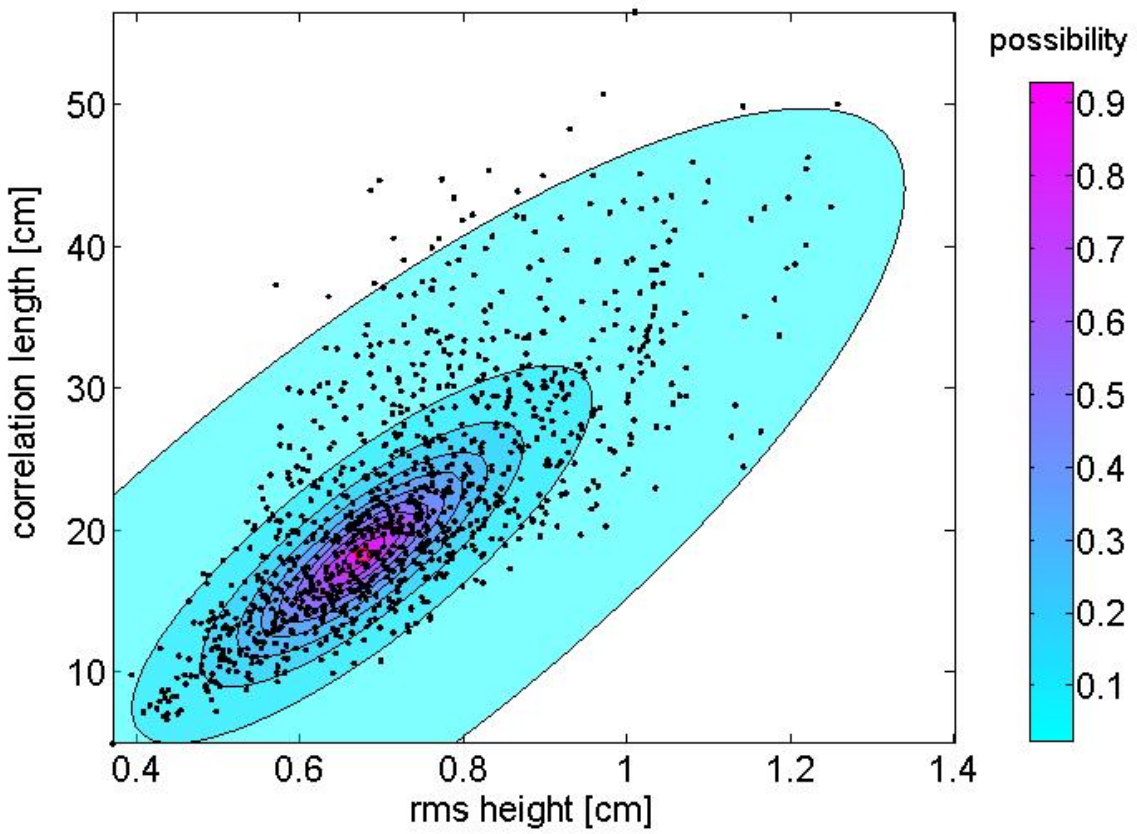
RMS heights ↗ ⇨ correlation length ↗



Synthetic Aperture Radar (SAR)

Current research: accounting for **interactivity** between roughness parameters.

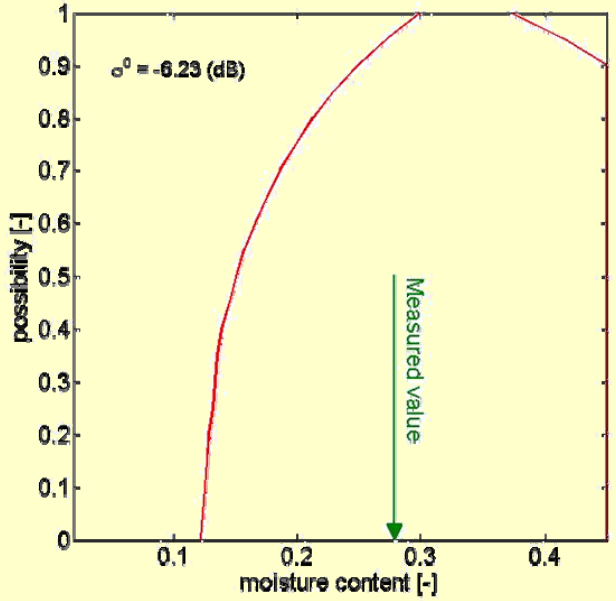
Possibilistic clustering (Gustafson-Kessel fuzzy clustering)



Synthetic Aperture Radar (SAR)

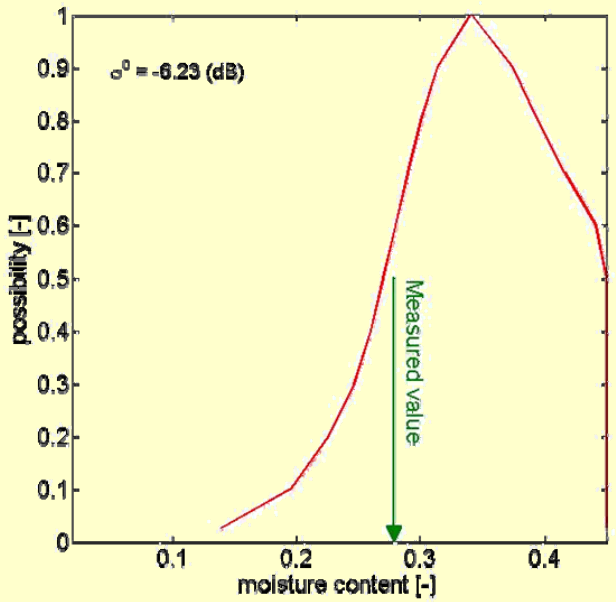
Example

No interactivity



High uncertainty
(wide possibility distributions)

Interactivity



Less uncertainty
(narrower possibility distributions)

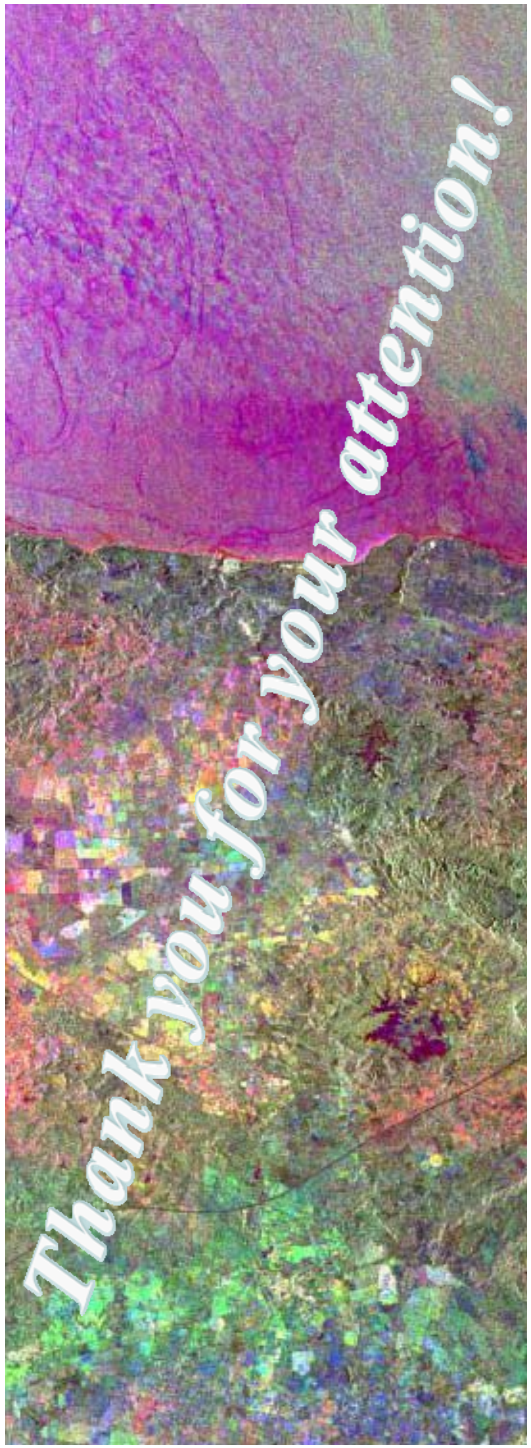
Interactivity reduces uncertainty due to inaccurate knowledge of roughness in retrieved soil moisture

Next steps

GPR
- Validate EM-modelling based retrieval techniques
- Study soil moisture scaling
- Assimilate soil moisture maps in small scale hydrologic model

SAR
- Apply possibilistic retrieval to SAR time series
- Validate methodology for identifying roughness classes
- Assimilate soil moisture maps in catchment-scale hydrologic model

Hydrologic modelling
- Develop data assimilation schemes for coupled hydrologic/hydraulic model
- Develop data assimilation schemes that allow for fuzzy observations
- Develop data assimilation scheme that accounts for spatial scaling of soil moisture
- Validate merit of (uncertain) remotely sensed soil moisture for flood forecasting



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