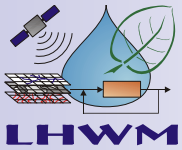

Soil moisture retrieval from co-polarized ALOS PALSAR backscattering in the Zwalm and Alzette catchments

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Outline

- Possibilistic soil moisture retrieval
- Application to study sites
  - Study sites
  - Field measurements
  - Retrieval method
  - Results
- Conclusions

Possibilistic soil moisture retrieval

*Verhoest et al. (2007). A possibilistic approach to soil moisture retrieval from ERS synthetic aperture radar backscattering under soil roughness uncertainty. *Water Resour. Res.*, 43, W07435.

SAR backscatter over bare fields function of:

- SAR properties: frequency, polarization
- Incidence angle
- Soil moisture (dielectric constant)
- Soil roughness

  - Unknown, though very important in retrieval process
  - Parameters: RMS height, Correlation length, autocorrelation function

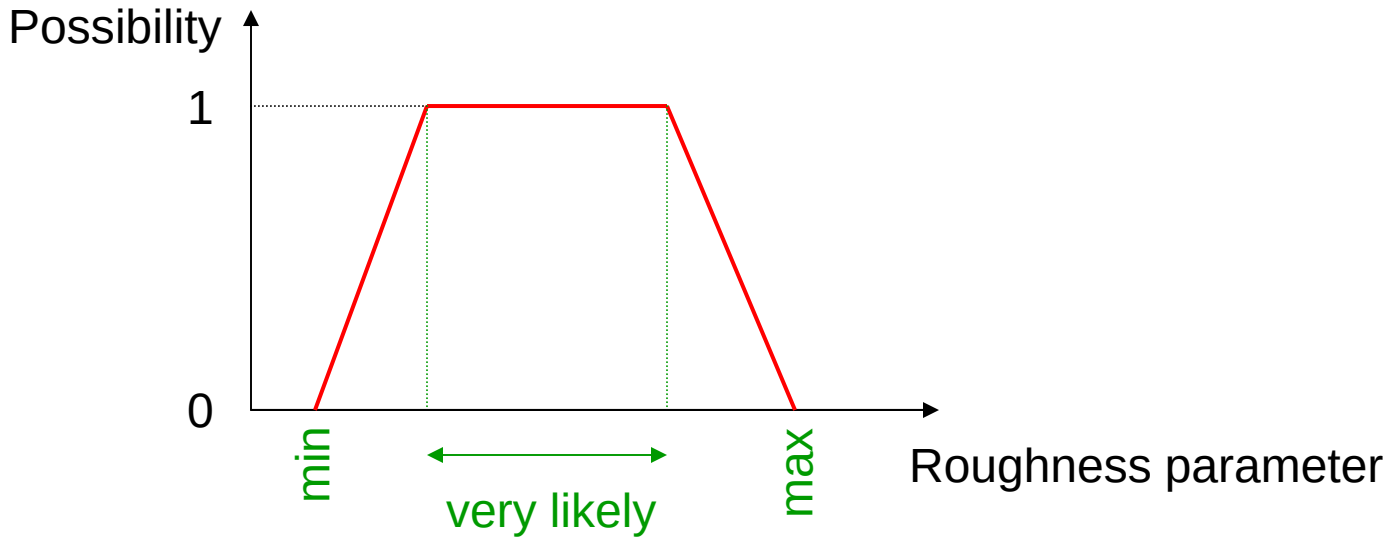
    Measurements reveal large variability for one type of tillage
    Difficult to specify a single value for each parameter

But: If we would know the tillage state of a field (GIS/crop calendar/expert knowledge), could we then assign a roughness class to this field, having an interval for RMS height and correlation length?

Possibilistic soil moisture retrieval

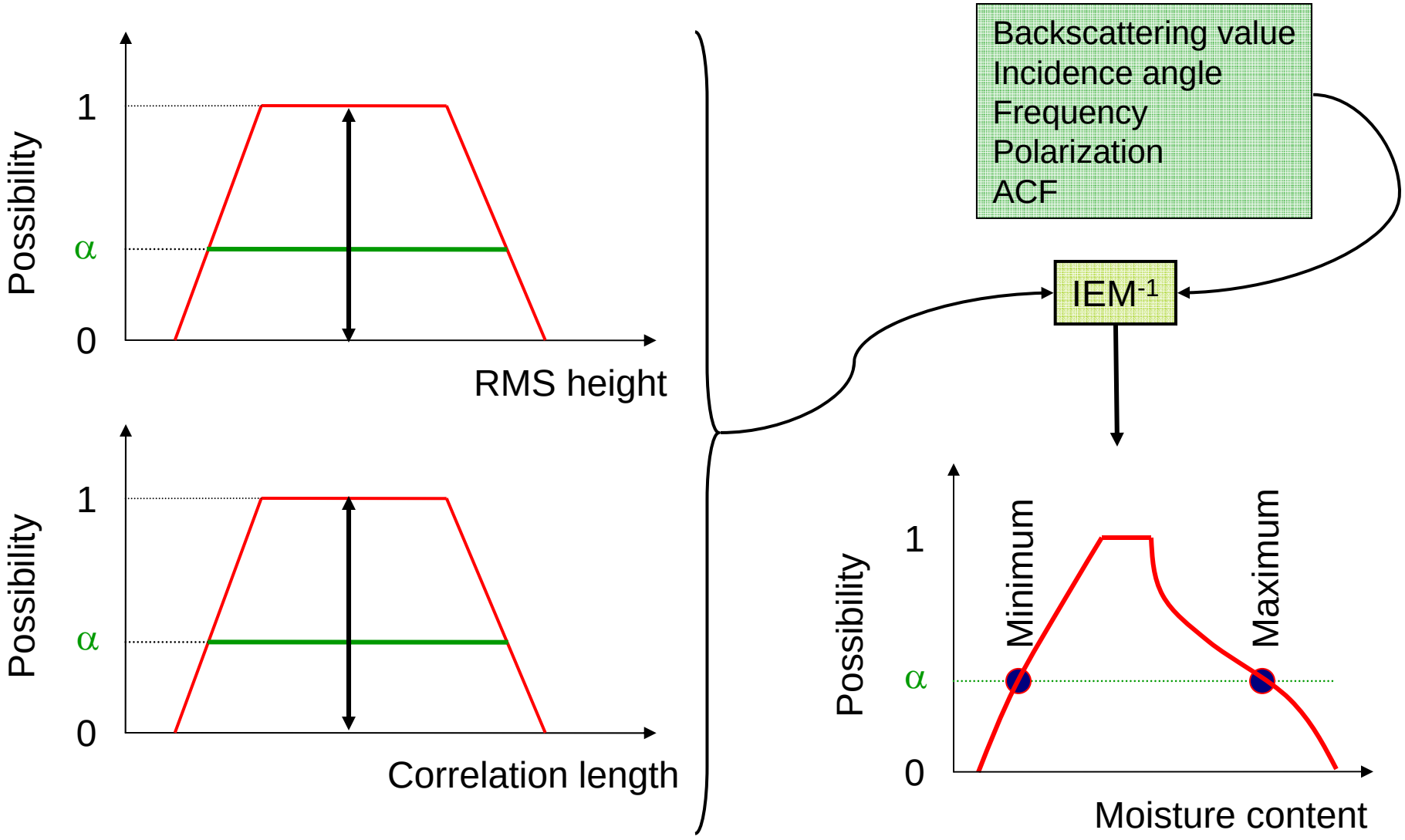
A Roughness class can be defined by parameters having:

- A minimum value below parameter values are not possible
- An interval in which parameters values are unsurprising, normal or usual
- A maximum value above parameter values are not possible



A possibility distribution reflects the knowledge of an agent about a quantity and its ranging

Possibilistic soil moisture retrieval

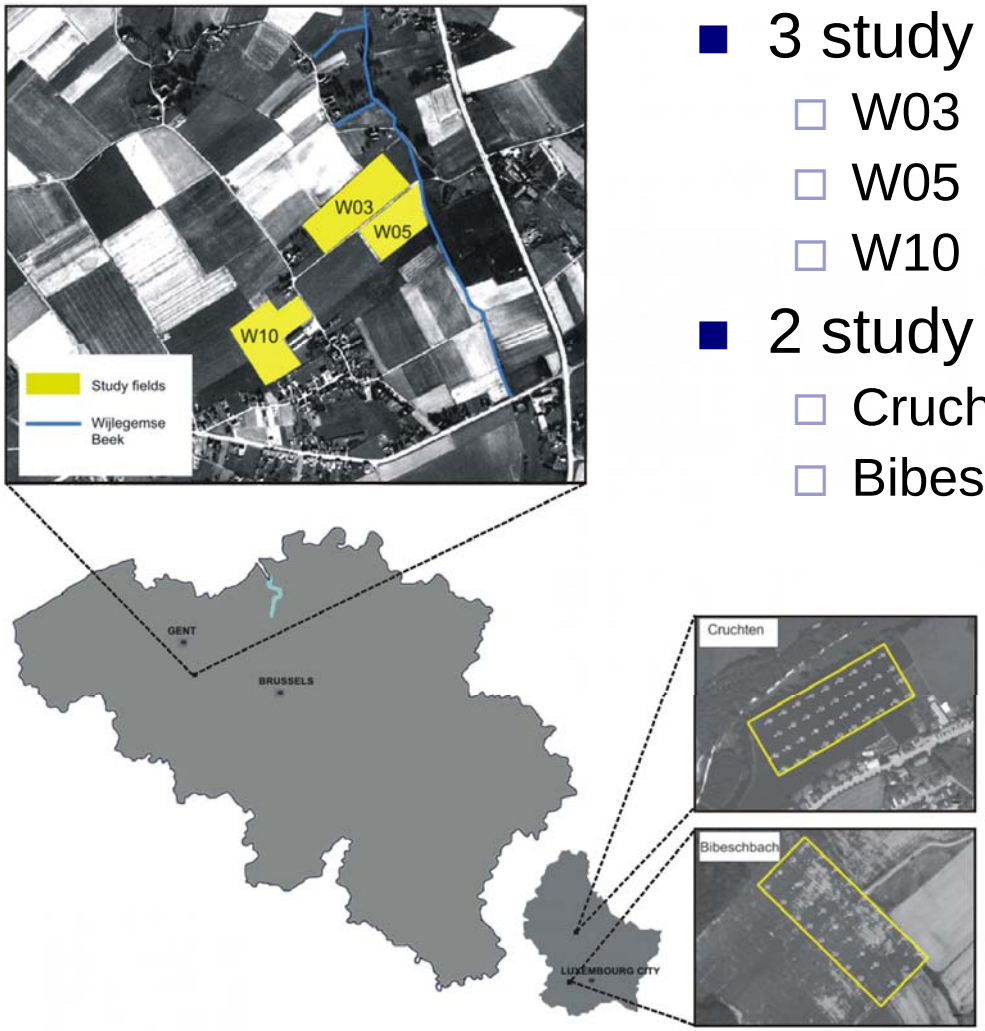


Possibilistic soil moisture retrieval

Pignistic transformation converts a possibility distribution into a probability distribution function (pdf), or vice versa

This pdf can then be used to estimate the mean soil moisture content (dielectric constant) and a standard deviation as a measure for the prediction accuracy

Experiment - Study area



- 3 study fields in Zwalm catchment:
  - W03
  - W05
  - W10
- 2 study fields in Alzette catchment:
  - Cruchten
  - Bibeschbach

Experiment - Field measurements

- Alzette: 2 PALSAR HH acquisitions on 19.02.08 and 19.03.08
- Zwalm: 3 PALSAR HH acquisitions on 11.06.07, 10.07.07 and 27.07.07
- Intensive field campaigns were organized, measuring:
  - Soil moisture
  - Soil roughness (only on bare fields of the Alzette)
  - Bulk density
  - Wheat vegetation: fresh biomass

Wheat field W05

gravimetric soil moisture sampling

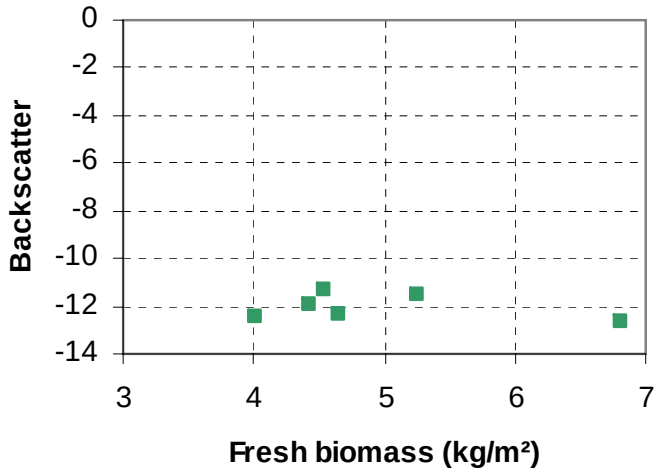
measuring surface roughness with 4-m meshboard

Experiment - Field measurements

Field	Date	Crop	Bulk density (g/cm^3)	Fresh biomass (kg/m^2)	Soil moisture (vol%)	Average Roughness (s,l) (cm)	σ^0 (dB)
Alzette							
Bibesbach	19.02.08	none	1.35		35.70	(1.14,8.80)	-15.09
Bibesbach	19.03.08	none	1.35		40.71	(1.14,8.80)	-14.17
Cruchten	19.02.08	none	1.48		39.06	(0.97,8.52)	-15.04
Cruchten	19.03.08	none	1.48		40.91	(0.97,8.52)	-14.13
Zwalm							
W03	11.06.07	wheat	0.99	6.81	27.11		-12.68
W03	10.07.07	wheat	0.99	5.25	31.70		-11.49
W03	27.07.07	wheat	0.99		33.55		-10.90
W05	11.06.07	wheat	1.35	4.65	27.84		-12.38
W05	10.07.07	wheat	1.35	4.02	32.27		-12.46
W05	27.07.07	none	1.35		31.03		-12.98
W10	11.06.07	wheat	1.05	4.53	22.79		-11.35
W10	10.07.07	wheat	1.05	4.43	27.12		-11.91
W10	27.07.07	none	1.05		32.41		-12.42

Experiment - Field measurements

- Sensitivity of backscattering to wheat fresh biomass (Zwalm)

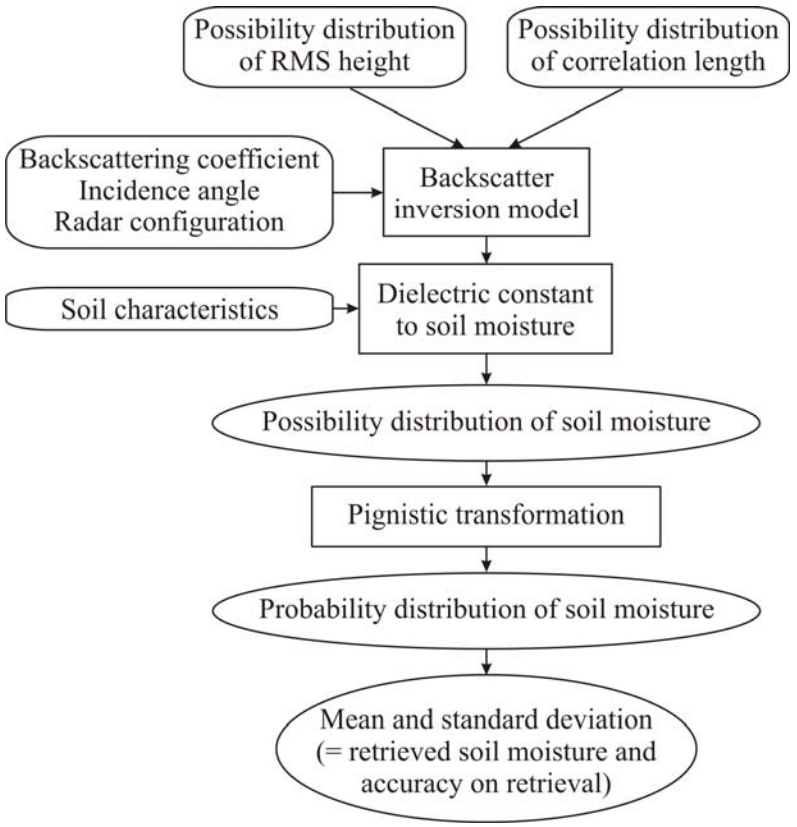


- L-band more or less insensitive to wheat vegetation

  ↳ Possibilistic retrieval technique applicable to all fields

Experiment - Retrieval method

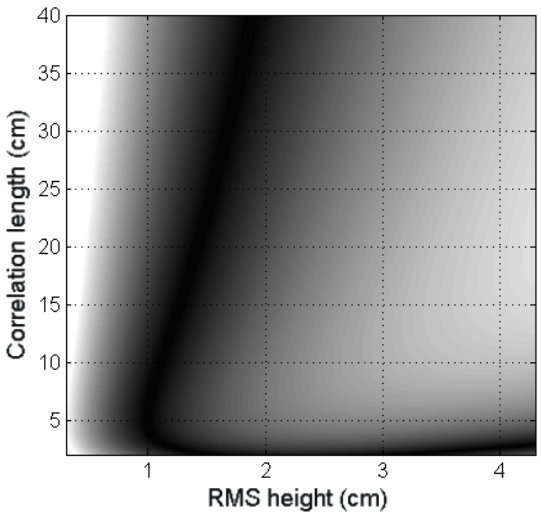
Flow chart



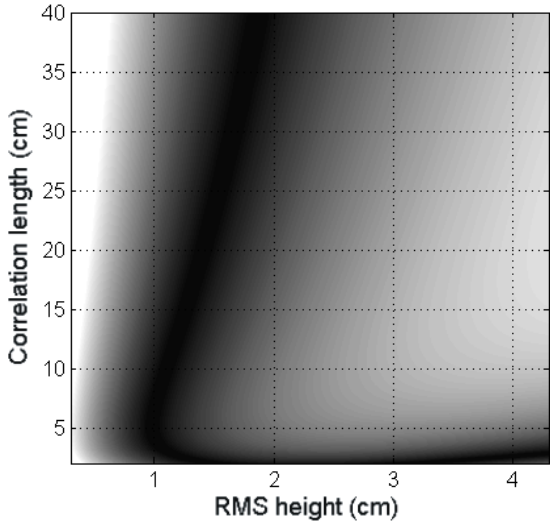
Experiment - Retrieval method

- Selection of ‘roughness possibility distributions’ by calibrating IEM, given soil moisture and backscattering measurements: average absolute error (dB)

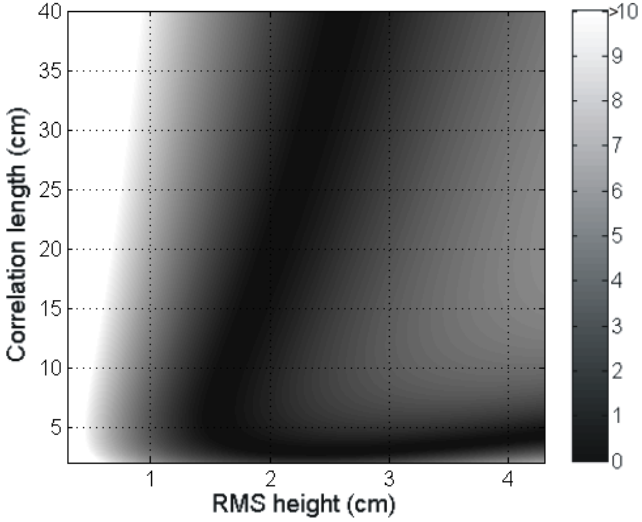
Bibeschbach



Cruchten

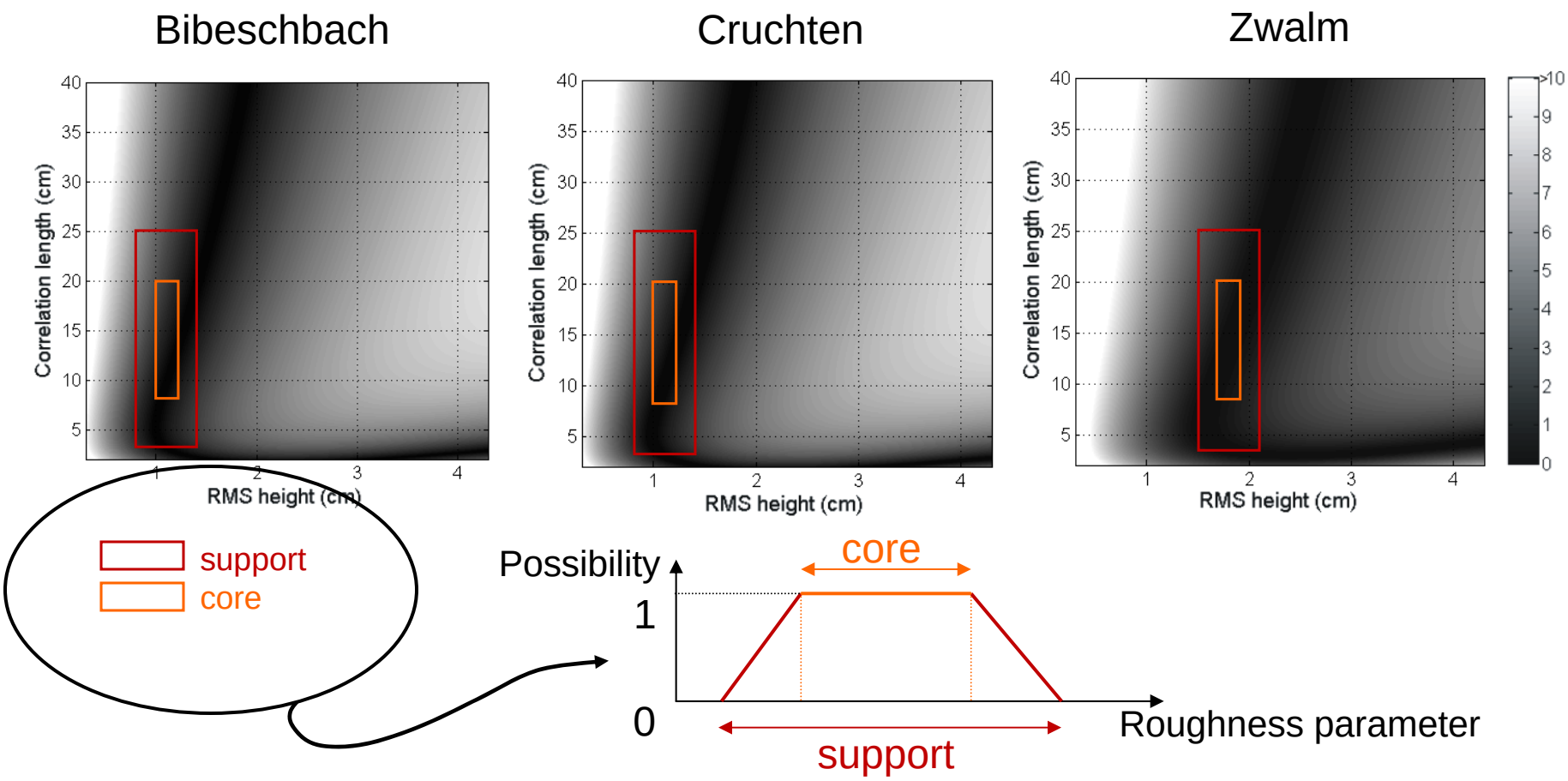


Zwalm



Experiment - Retrieval method

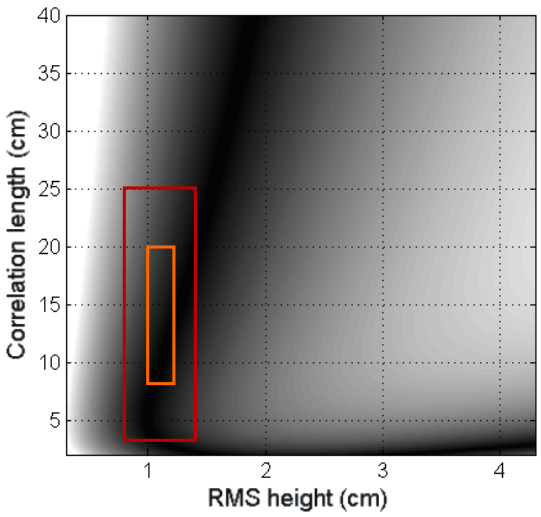
- Selection of ‘roughness possibility distributions’ by calibrating IEM, given soil moisture and backscattering measurements: average absolute error (dB)



Experiment - Retrieval method

- Comparison of support and core with in situ measurements of RMS height and correlation length:

Bibeschbach



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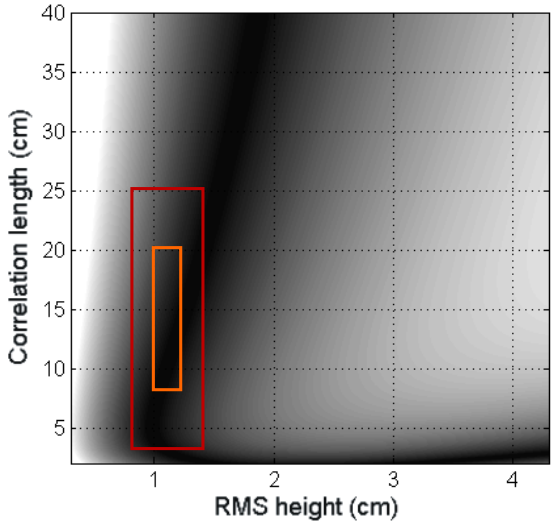
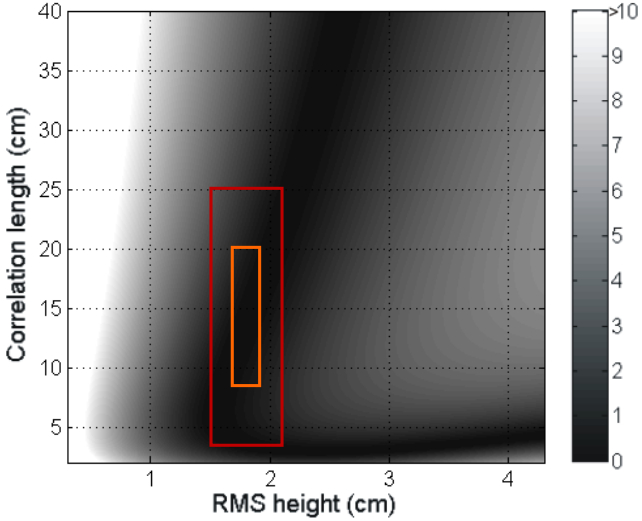


Zwalm

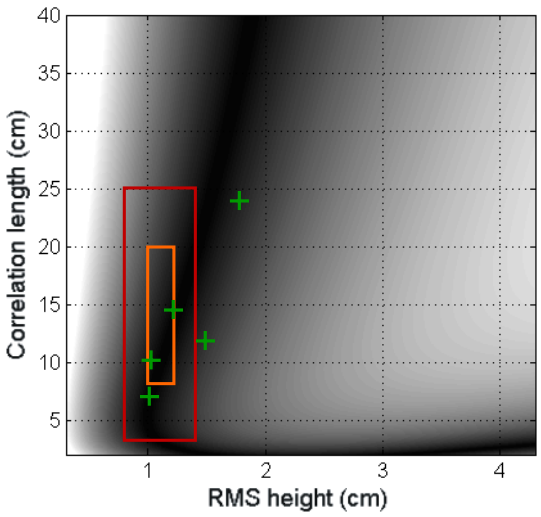


support
core

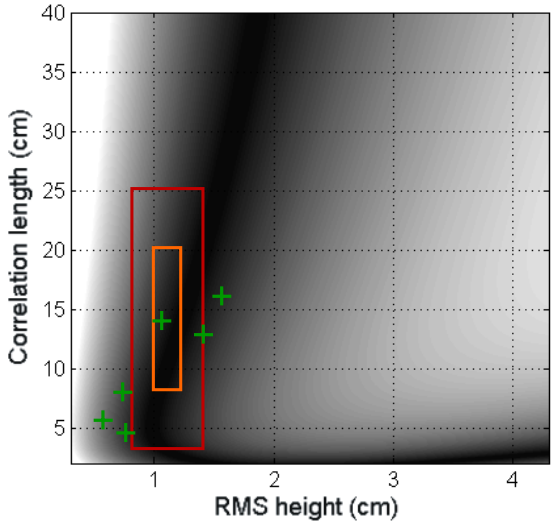
Experiment - Retrieval method

- Comparison of support and core with in situ measurements of RMS height and correlation length:

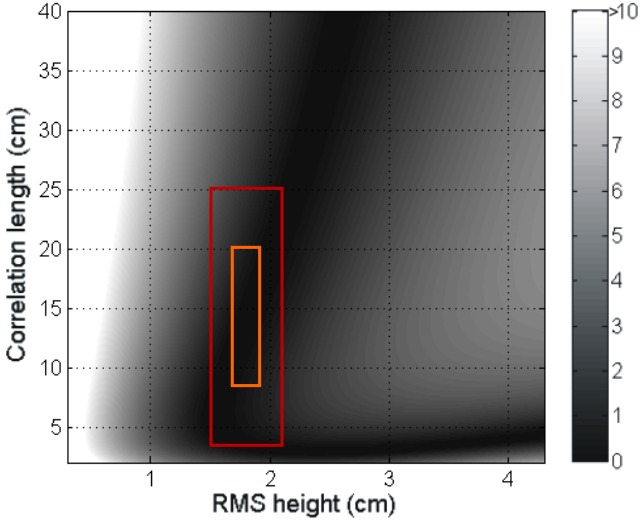
Bibeschbach



Cruchten



Zwalm



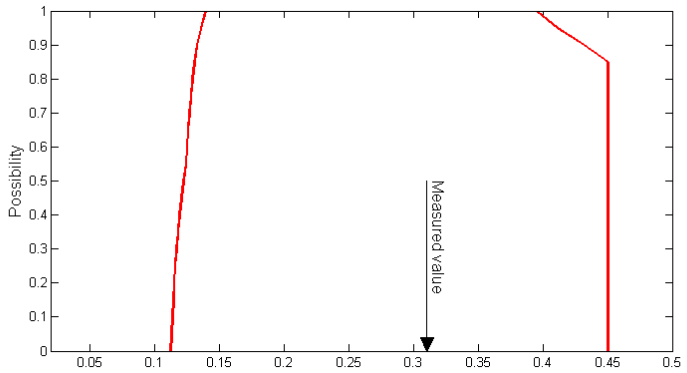
support
core
\+ Measurements

- No perfect match with defined possibility distributions
- In good agreement with roughness parameters that result in lowest error with IEM
- Possibility distributions could be improved by considering a relationship between RMS height and correlation length

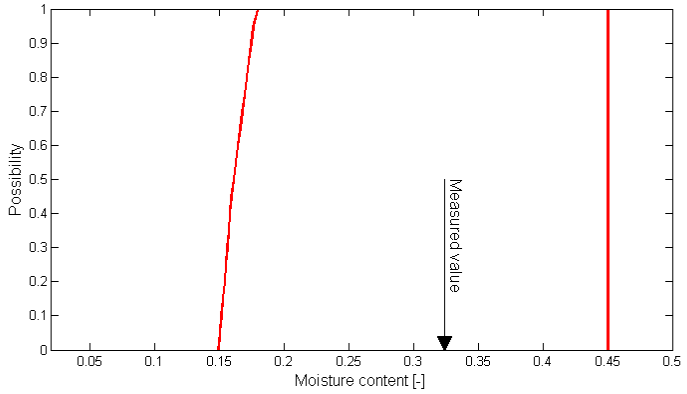
Experiment - Results

- Soil moisture possibility distributions for the Zwalm catchment on 27.07.07:

Field W05



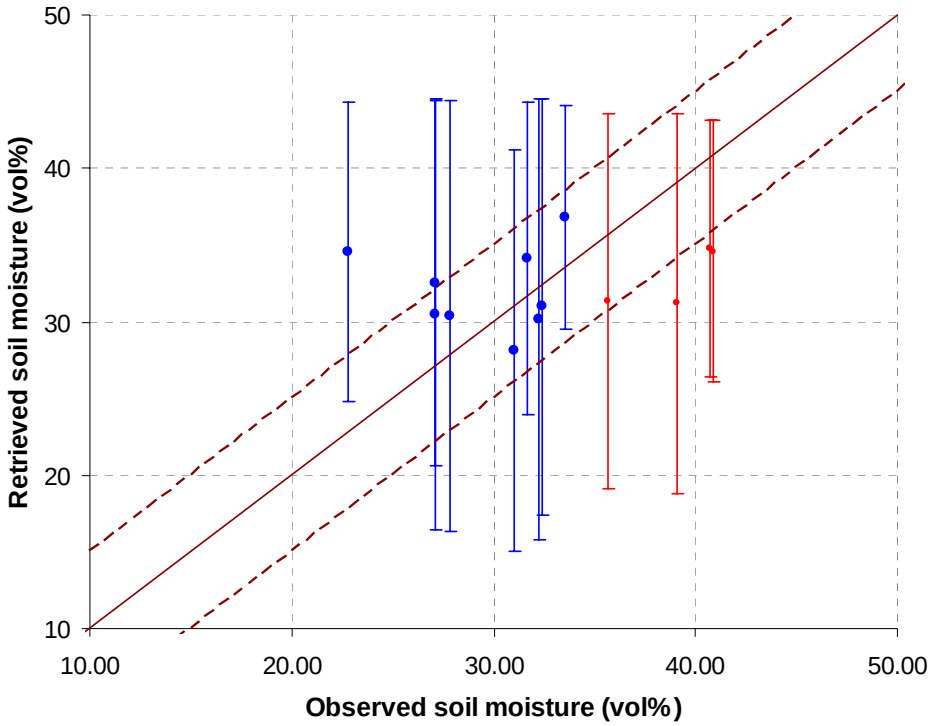
Field W10



Experiment - Results

- Retrieved vs. observed soil moisture for Zwalm and Alzette
- Overall RMSE = 5.36 vol%
- Standard deviations give an idea about uncertainty on soil moisture
- Underestimations for wet soil conditions due to cut-off at

  45 vol%
- Overestimations at intermediately wet conditions due to neglecting relationship between RMS height and correlation length, causing unlikely parameter combinations that result in very high soil moisture contents



Conclusions

- At L-band, backscattering is more or less insensitive to wheat vegetation, even for relatively high fresh biomass
- Parameterization of roughness is uncertain; assignment of possibility distributions for one tillage, enabling retrieval of soil moisture and an uncertainty measure
- Soil moisture retrieval using the presented possibilistic approach results in an overall RMSE of 5.36 vol%
- It is expected that the retrieval results (mean soil moisture content and its uncertainty) will improve when considering a relationship between RMS height and correlation length