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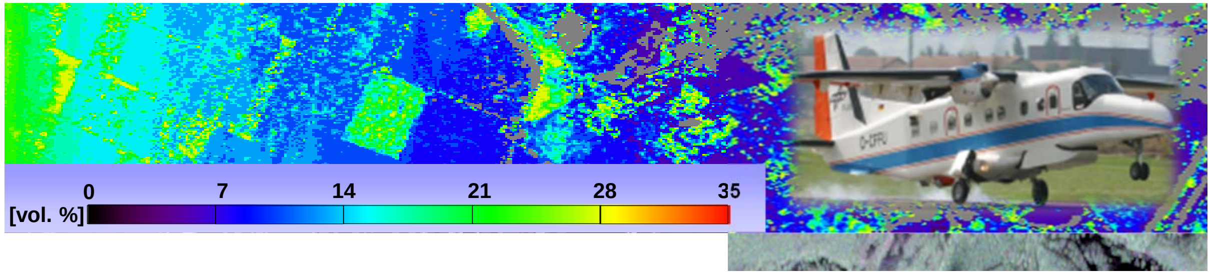

Validation of Distributed Soil Moisture: Airborne Polarimetric SAR vs. Ground-based Sensor Networks

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TERENO Advisory Board Meeting, October, 25-26, 2012, Scheyern, Germany

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Eifel Observatory: Rur Catchment

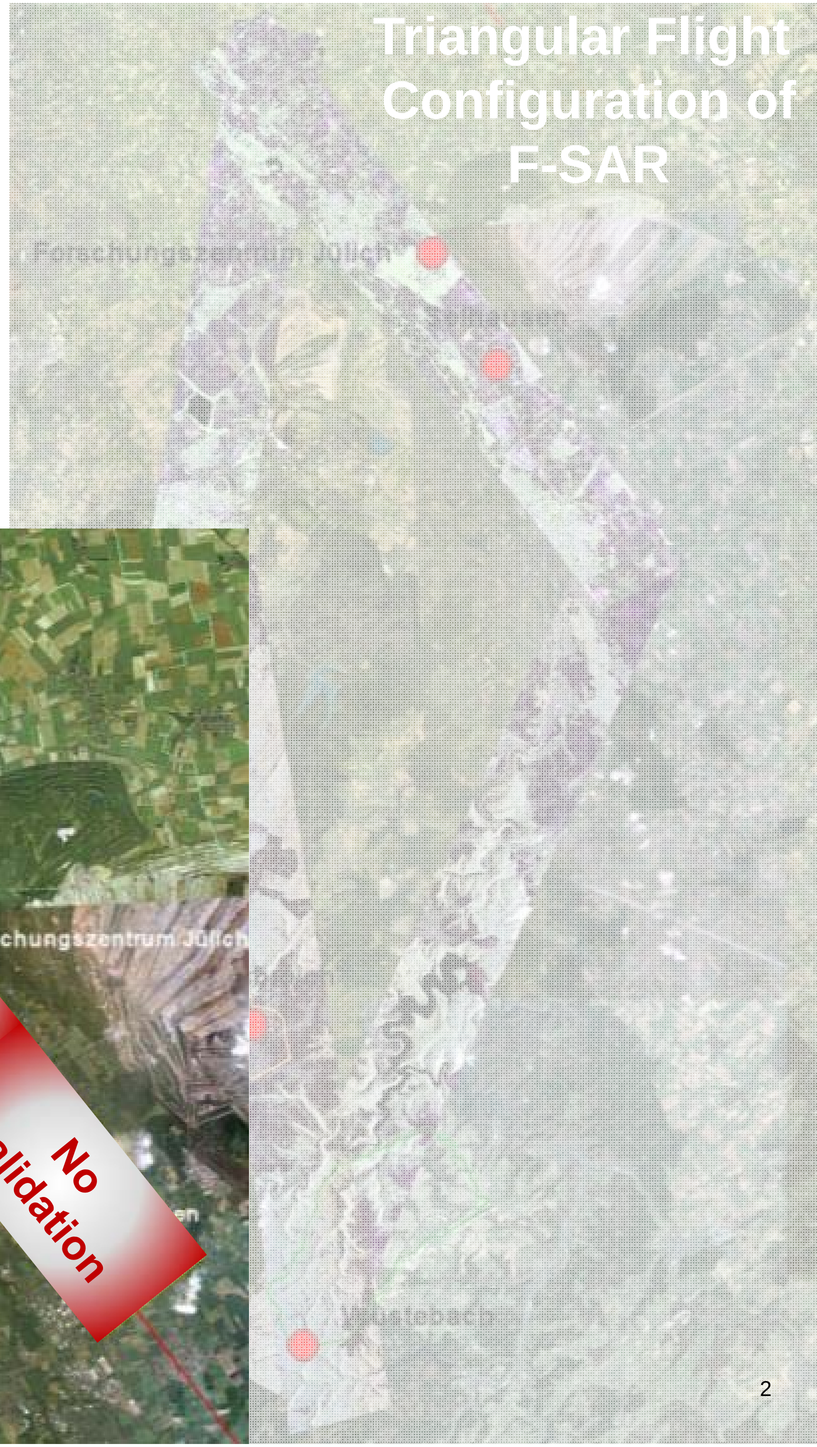
Triangular Flight Configuration

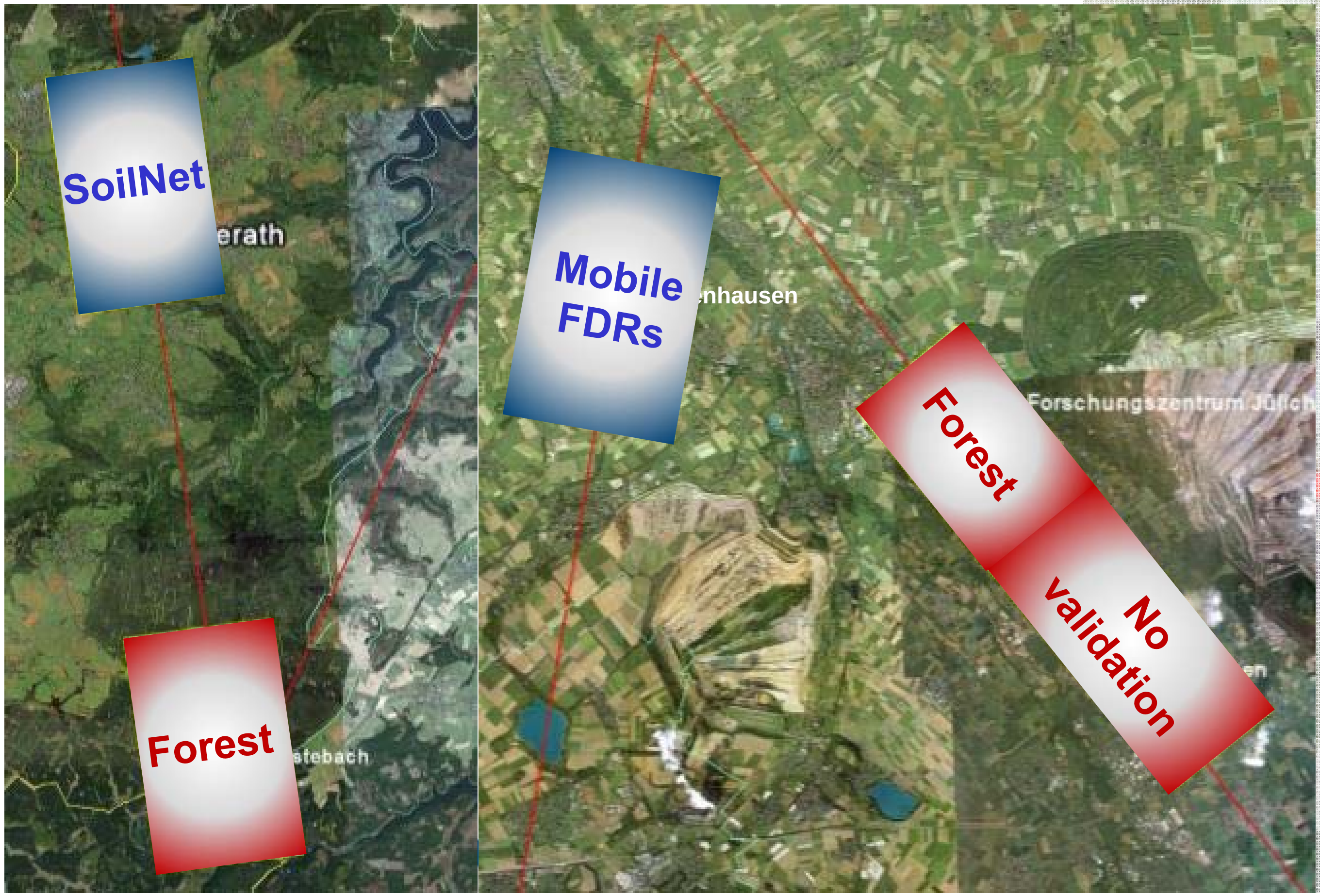
Yellow measurement areas: 5 x 3 km (3) and 10 x3 km

Field Measurements: Soil Moisture, Vegetation

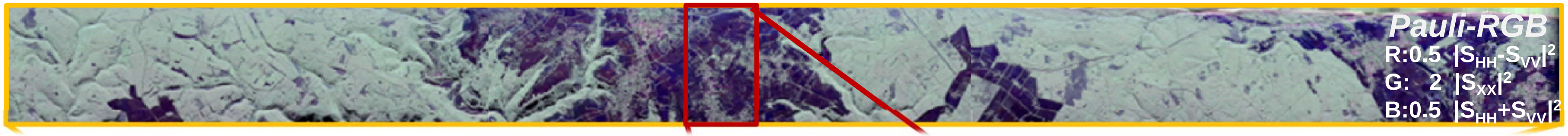
SoilNet (grassland (Rollesbroich), forest (Wüstebach))

Mobile FDR probes (Merzenhausen, Selhausen)

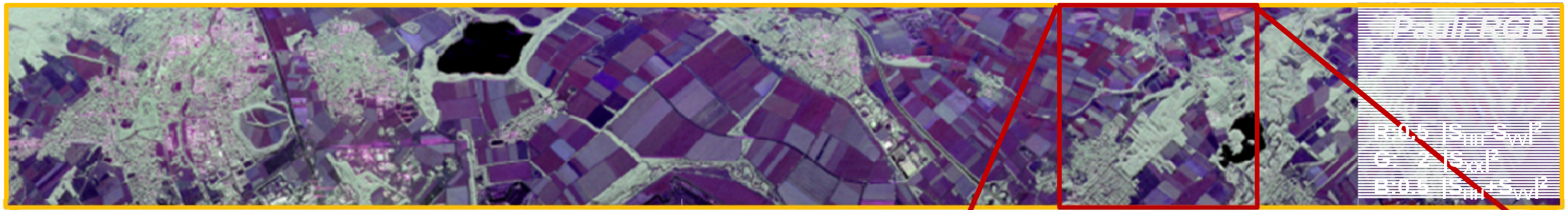




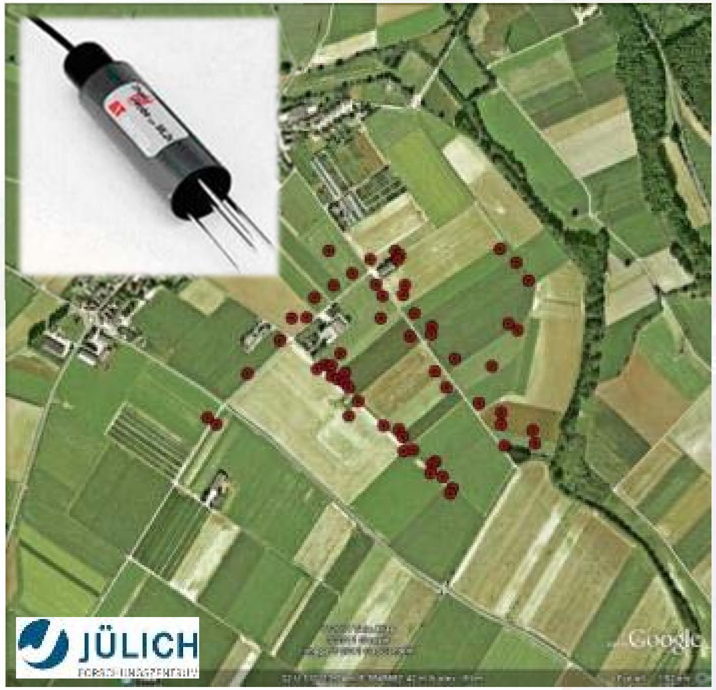
Rollesbroich Test Site in the Upper Eifel Mountain Range



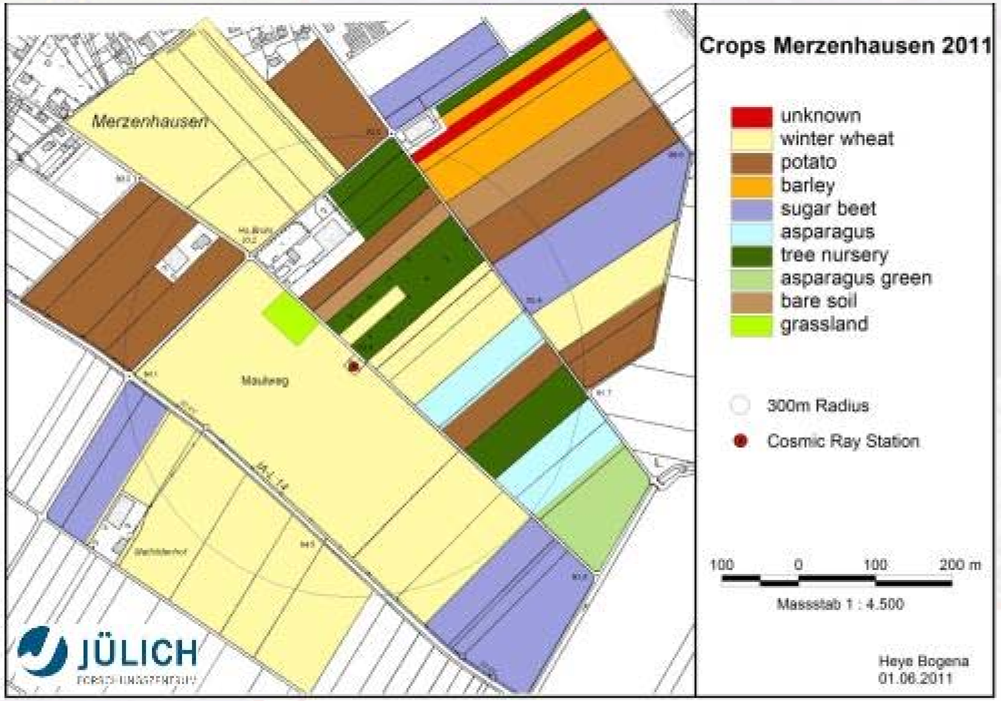
Merzenhausen Test Site in the Rur River Valley



In Situ Measurments on Agricultural Fields



Location of measurements



Field crops

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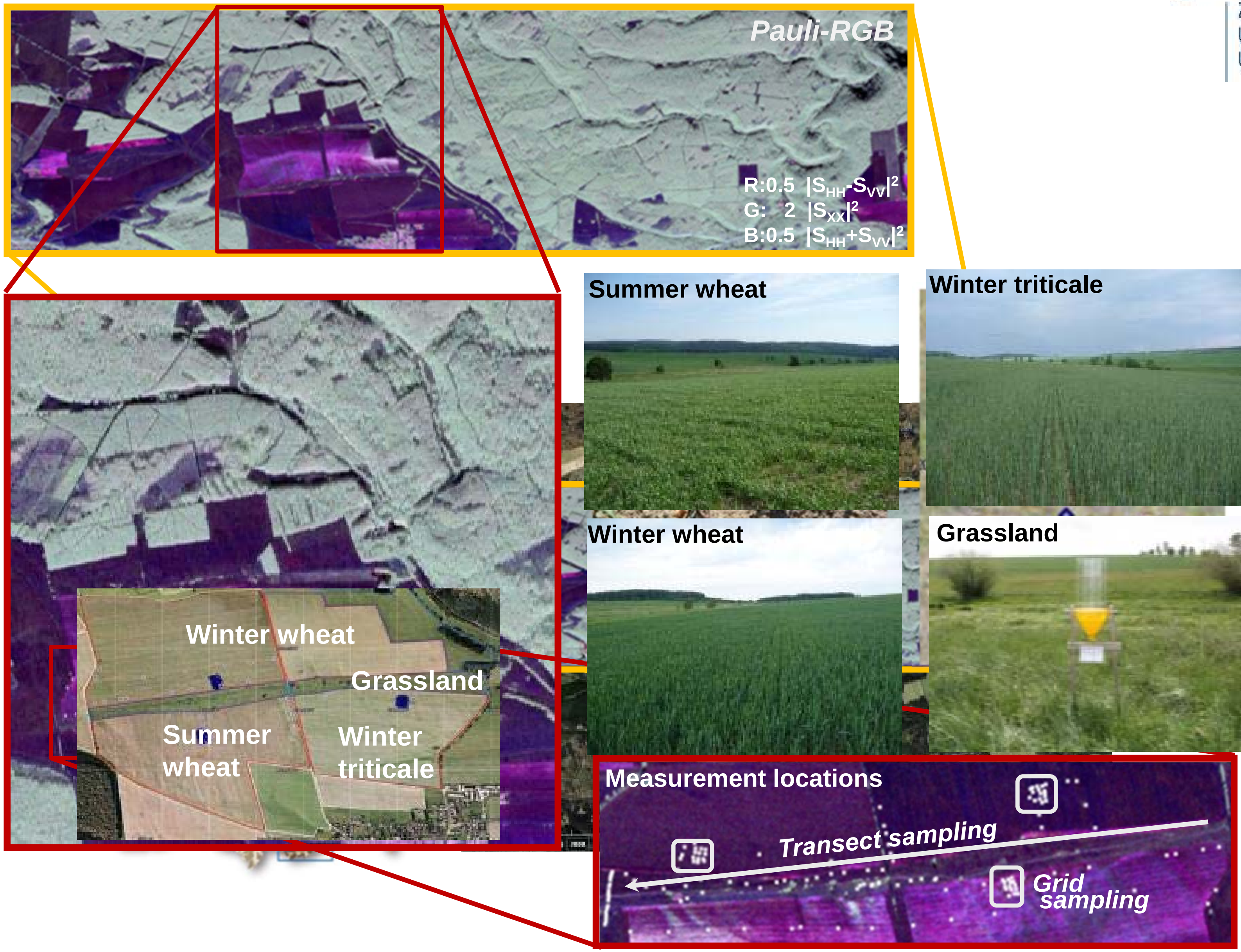
Harz Observatory: Bode Catchment



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Polarimetric Decompositions for Soil Moisture Inversion

Polarimetric Signature | **Surface** | **Dihedral** | **Volume**

signature | ground | vegetation

$$\begin{bmatrix} t_{11} & t_{12} & 0 \\ t_{12}^{*} & t_{22} & 0 \\ 0 & 0 & t_{33} \end{bmatrix} = \left[T_{Bragg}\right] + \left[T_{Fresnel}\right] + \left[T_{RandomDipols}\right]$$

Removal of Vegetation Component and Inversion for Soil Moisture

signature − vegetation = ground

$$\begin{bmatrix} t_{11} & t_{12} & 0 \\ t_{12}^{*} & t_{22} & 0 \\ 0 & 0 & t_{33} \end{bmatrix} - \left[T_{RandomDipols}\right] = \left[T_{Bragg}\right] + \left[T_{Fresnel}\right]$$

↓

Soil moisture

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Graphics from www.vectorarts.net

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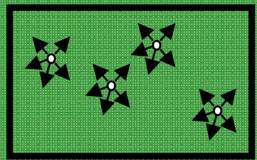
Retrieval of the Ground Scattering Components

-

vegetation

f_{vc}



=

ground

$$\begin{bmatrix} f_s \cos\alpha_s^2 + f_d \sin\alpha_d^2 & (f_d - f_s)\cos\alpha_{d,s}\sin\alpha_{d,s} & 0 \\ (f_d - f_s)\cos\alpha_{d,s}\sin\alpha_{d,s} & f_d \cos\alpha_d^2 + f_s \sin\alpha_s^2 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Hybrid Polarimetric Decomposition

Eigen-based Decomposition of Ground Components

- From eigenvalues: **Intensity** of ground (f_d, f_s)
- From eigenvectors: **Scattering mechanisms** of ground (α_d, α_s)

Physically Meaningful Separation of Scattering Mechanisms (α_d, α_s)

$$\alpha_d + \alpha_s = \pi/2$$

Orthogonality condition

- $\alpha \in [0, \pi/4]$ Surface scattering → α_s
- $\alpha \in [\pi/4, \pi/2]$ Dihedral scattering → α_d

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Soil Moisture Inversion from Surface Scattering Component

Polarimetric SAR data

Surface scattering component *from* ***hybrid polarimetric decomposition***

$$\beta = -\tan(\alpha_s)$$

Surface scattering model

Bragg scatter modeling *with* θ_{loc} *and a* ***variety of soil dielectric constants*** ε_S

$$\beta_m = \frac{R_{HH} - R_{VV}}{R_{HH} + R_{VV}}$$

$$R_{HH}, R_{VV} = f(\varepsilon_S, \theta_{loc})$$

data → **Minimization** ← **model**

Minimization

$$\min_{\varepsilon_s} \{|\beta - \beta_m|\}$$

$$\varepsilon_S$$

Pedo-Transfer Function of

Topp et al. (ε_S<40)
Roth et al. (ε_S>40)

→ **Soil moisture [vol.%]**

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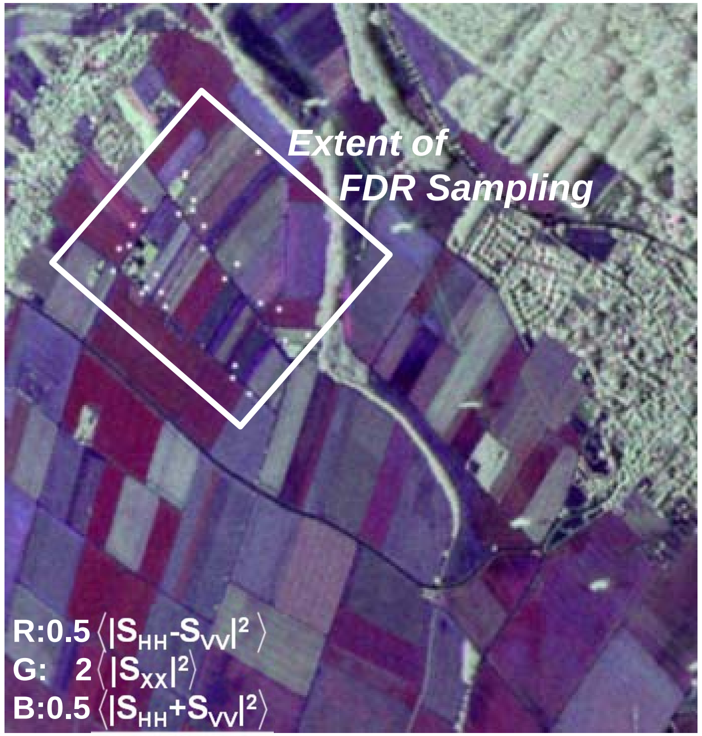
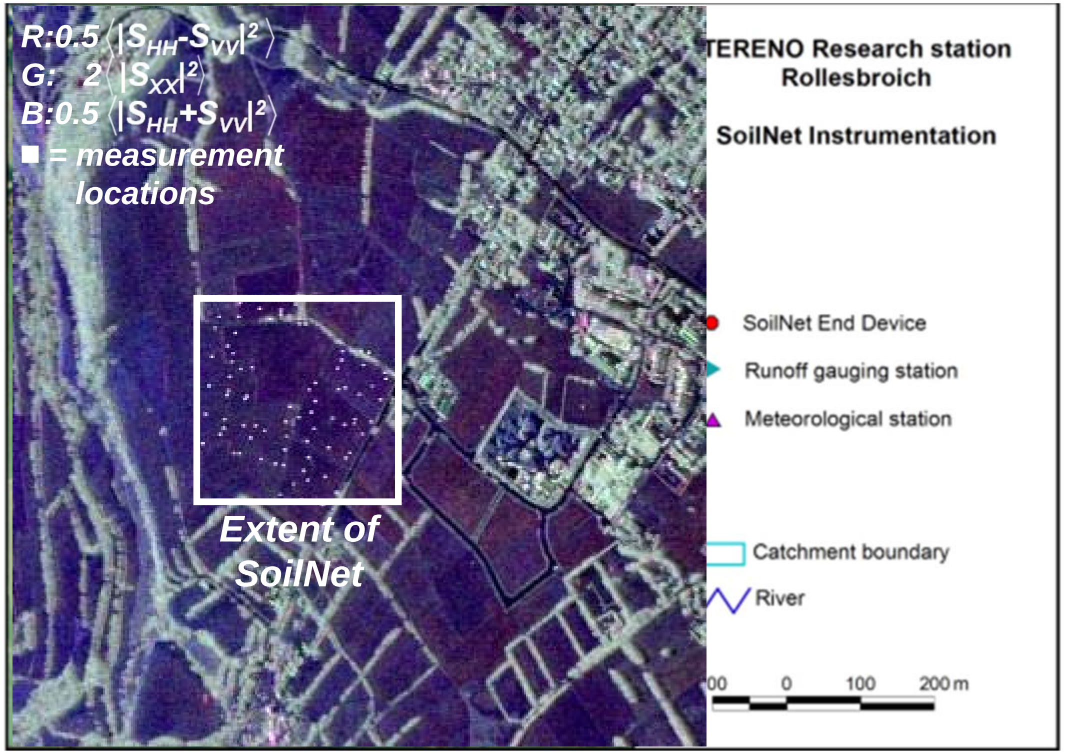
Validation of PolSAR-Derived Soil Moisture with Ground Measurements @ Merzenhausen (Rur) on Agriculture

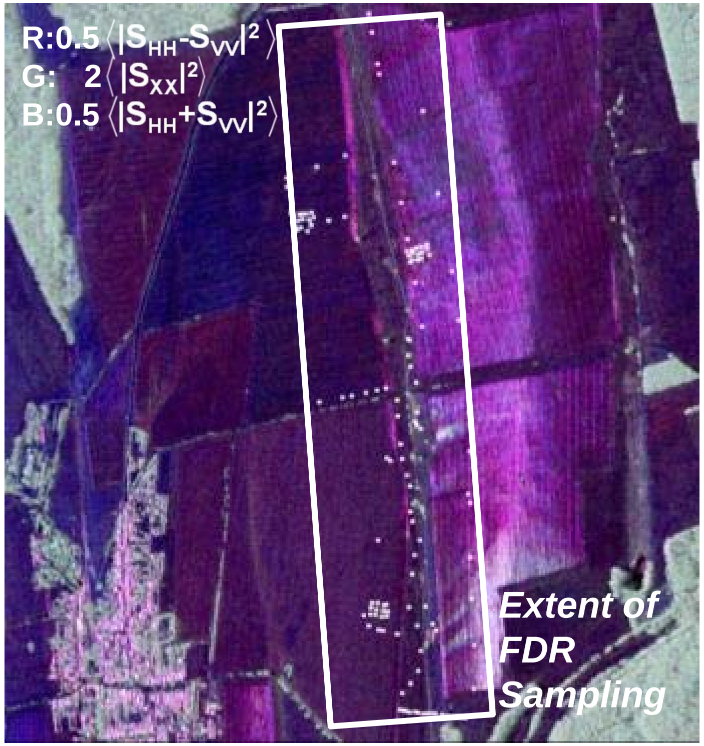


More results are excluded due to a review for publication

Validation of PolSAR-Derived Soil Moisture with SoilNet cluster @ Rollesbroich (Rur) on Grassland



Validation of PolSAR-Derived Soil Moisture with Ground Measurements @ Schäfertal (Bode) on Agriculture/Grassland



More results are excluded due to a review for publication

Summary and Conclusion

- *Inversion of soil moisture under agricultural vegetation is feasible in high resolution with very high inversion rates using decomposition and inversion techniques on polarimetric SAR data @ L-band.*
- *Validation with ground-based sensors (FDRs, SoilNet) revealed a well agreement with the SAR-based moisture estimates resulting in an RMSE of 3-6vol.% for low wetness conditions.*

- *Further investigations on different hydrological situations (highly saturated soils).*
- *Pattern comparison between interpolated ground-based (FDR, SoilNet, GPR) and PolSAR-based soil moistures – similarities and differences between spatial distributions of the soil moisture results.*
- *Performance analyses on the retrieval algorithm for the TERENO 2012 campaign sites.*

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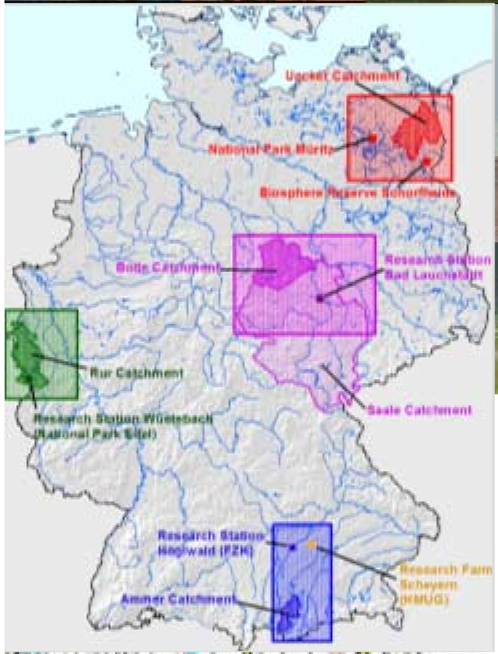

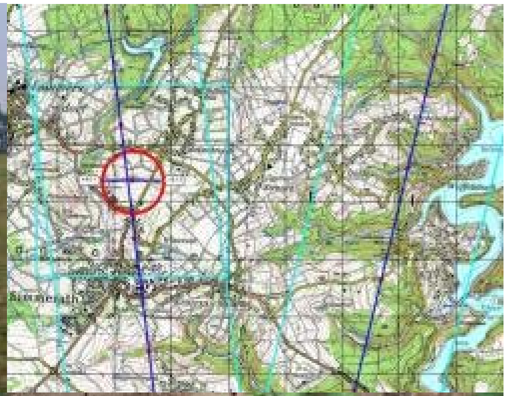

Acknowledgement to the

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