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JÜLICH FORSCHUNGSZENTRUM

Analyzing SMAP fusion algorithms with airborne active and passive L-band microwave remote sensing

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Joint active and passive microwave platform development

Combination of PLMR2 and DLR F-SAR onboard the Dornier DO228 aircraft

- F-SAR is able to operate in 4 frequency bands (X, C, L and P)
- Dual (F-SAR) channel operation

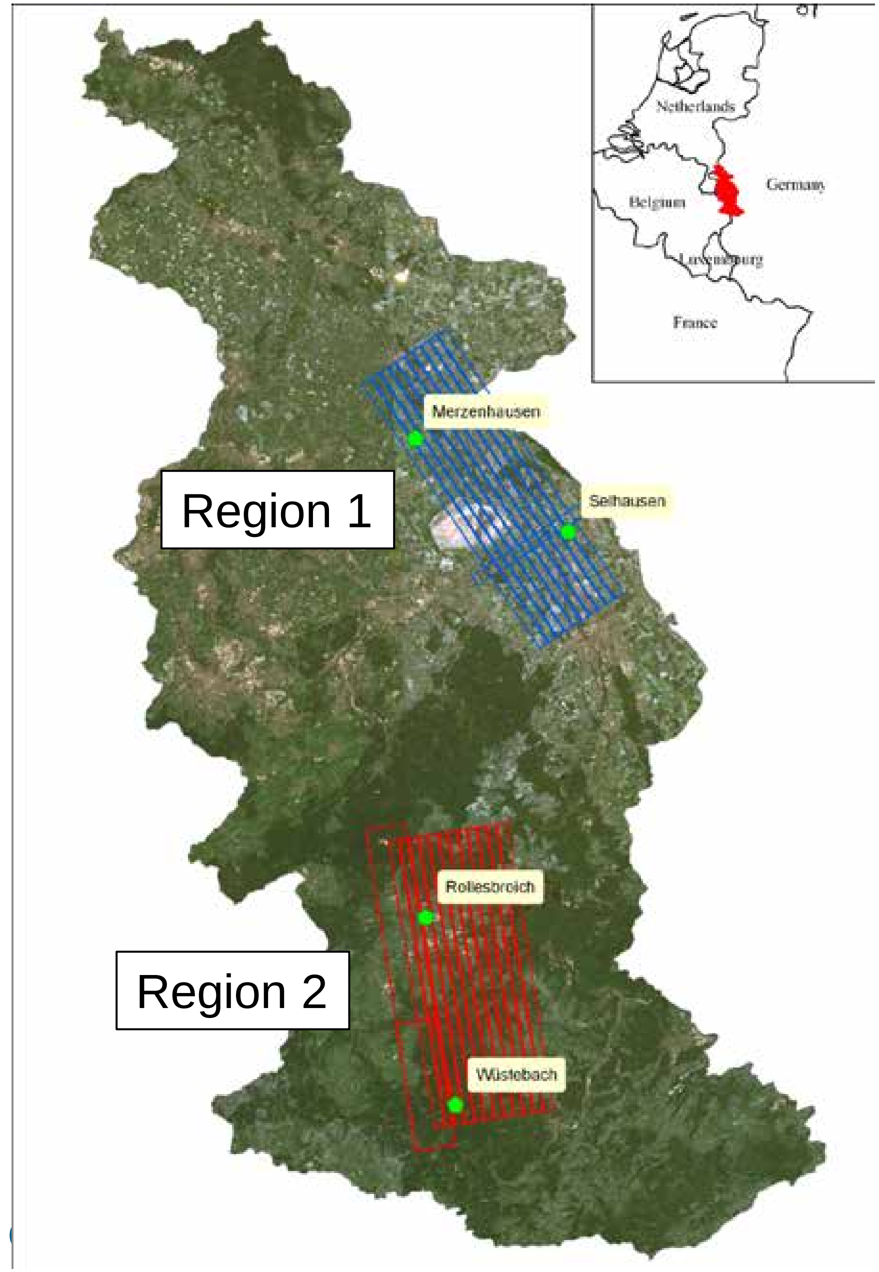
- Polarisation: Dual linear (V and H)
- Incidence angles: +/- 8°, +/-22°, +/- 38° @ pushbroom

The 2013 campaign

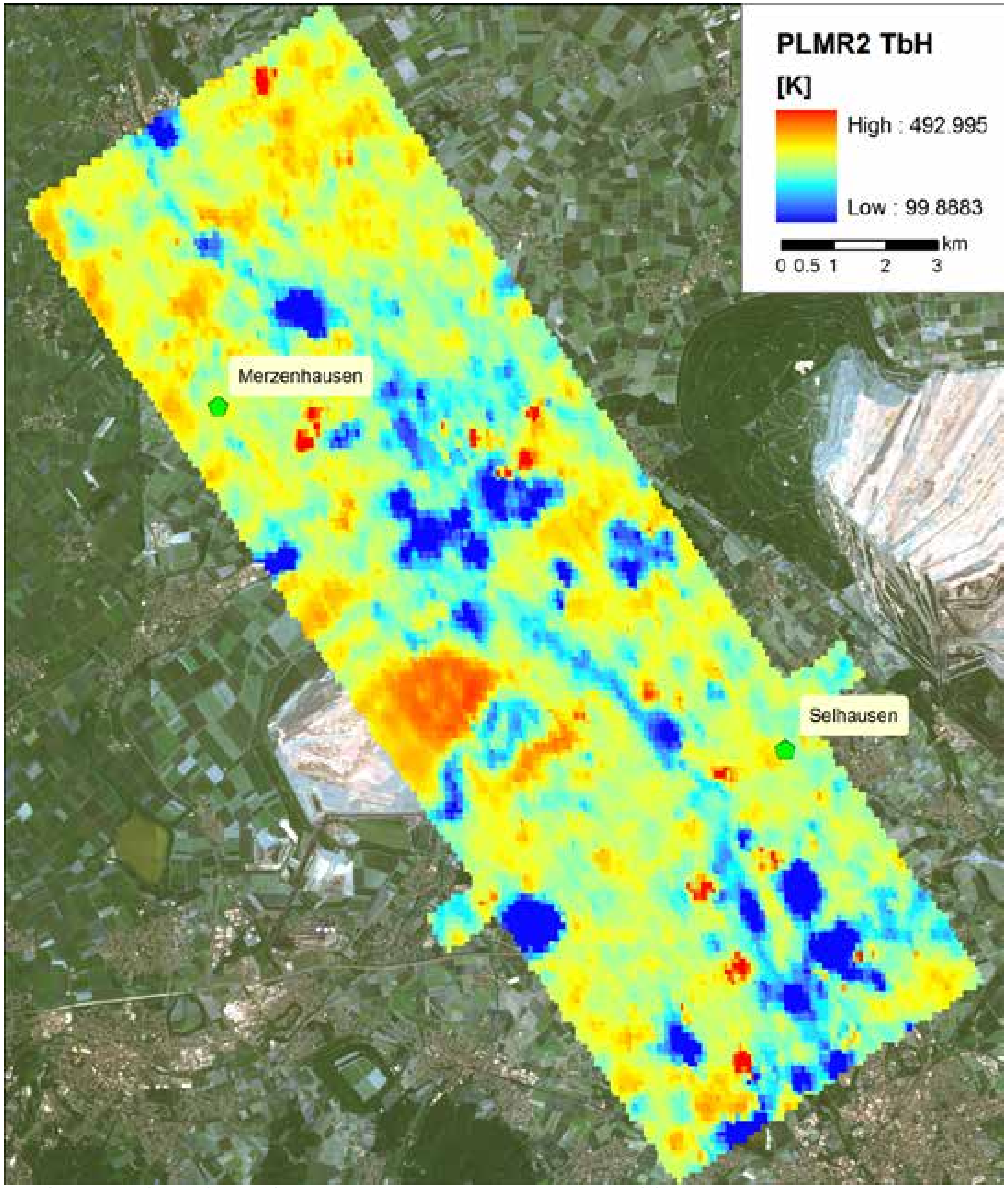
A-P measurements in the very heterogeneous Rur catchment:

Region 1 (agricultural land)
- 2013-04-17
- 2013-04-25
- 2013-05-14

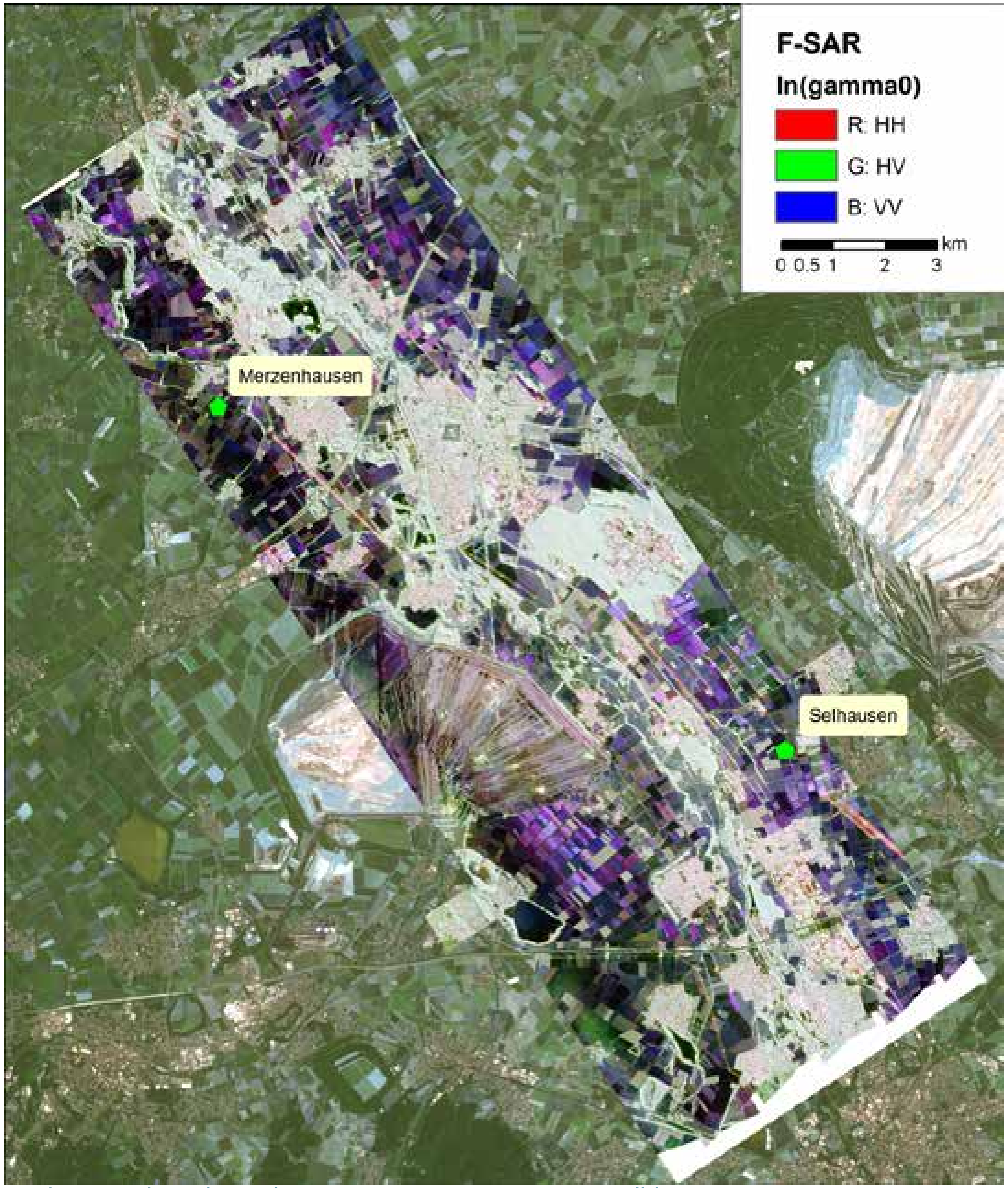
Region 2 (forest, grassland)
- 2013-04-18
- 2013-04-29
- 2013-05-06



PLMR2 Tb


PLMR2 TbH
[K]
High : 492.995
Low : 99.8883
km
0 0.5 1 2 3
Merzenhausen
Selhausen

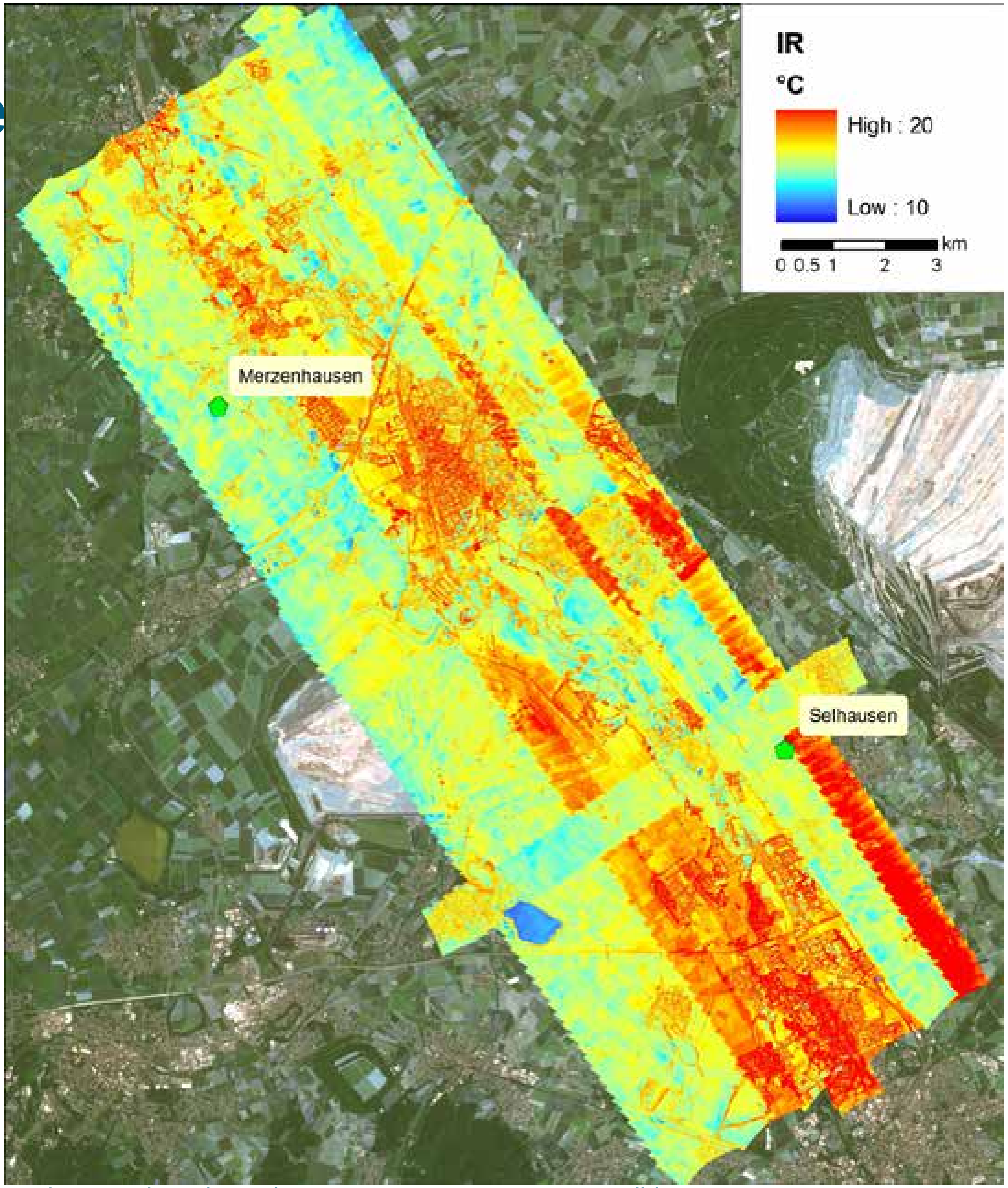
F-SAR ln(γ0)


F-SAR
ln(gamma0)
R: HH
G: HV
B: VV
km
0 0.5 1 2 3
Merzenhausen
Selhausen

Surface temperature

IGI DigiTerm

Complete solution for automated workflow for the generation of directly georeferenced thermal images

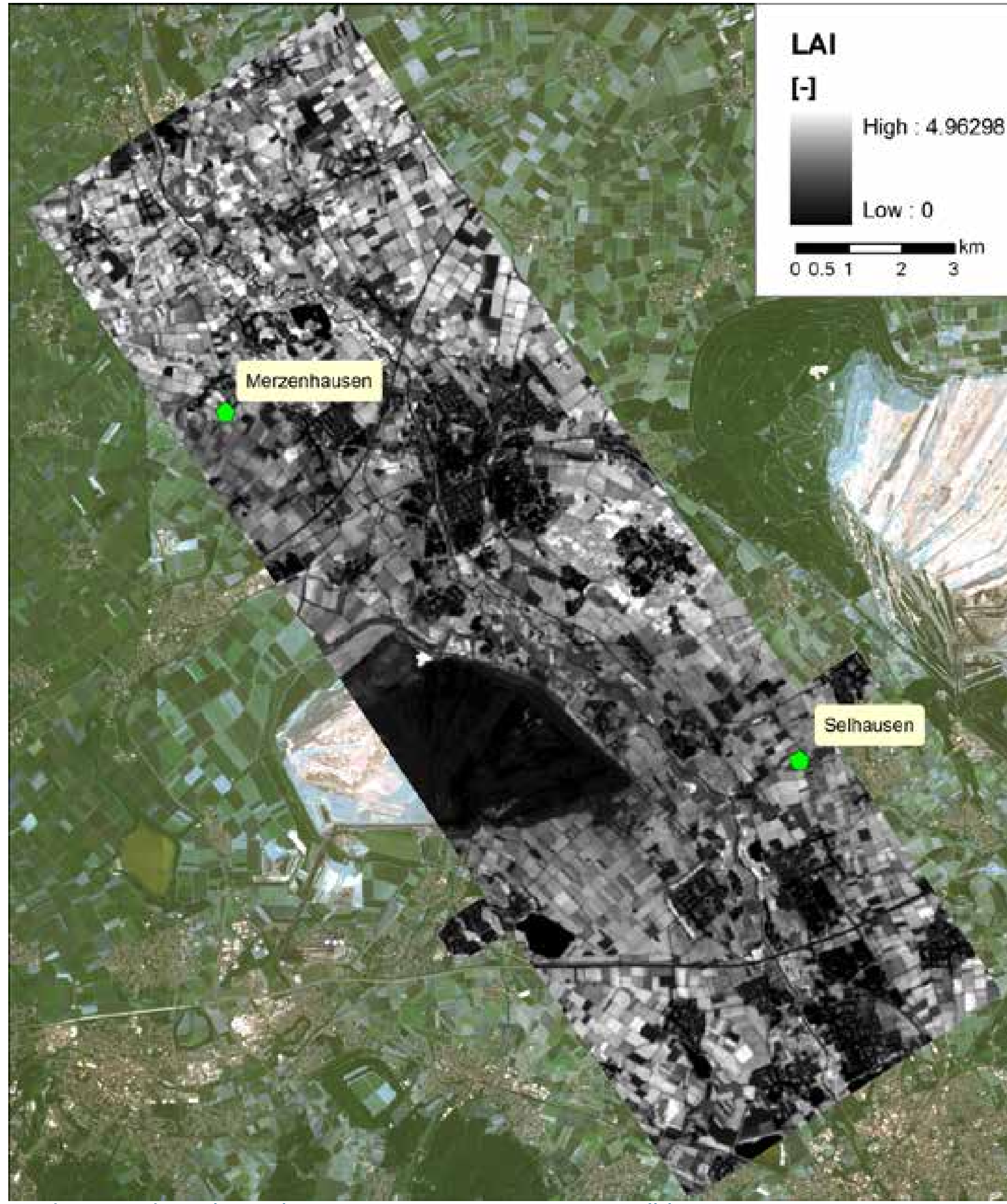


Landsat-based LAI

LAI estimation:

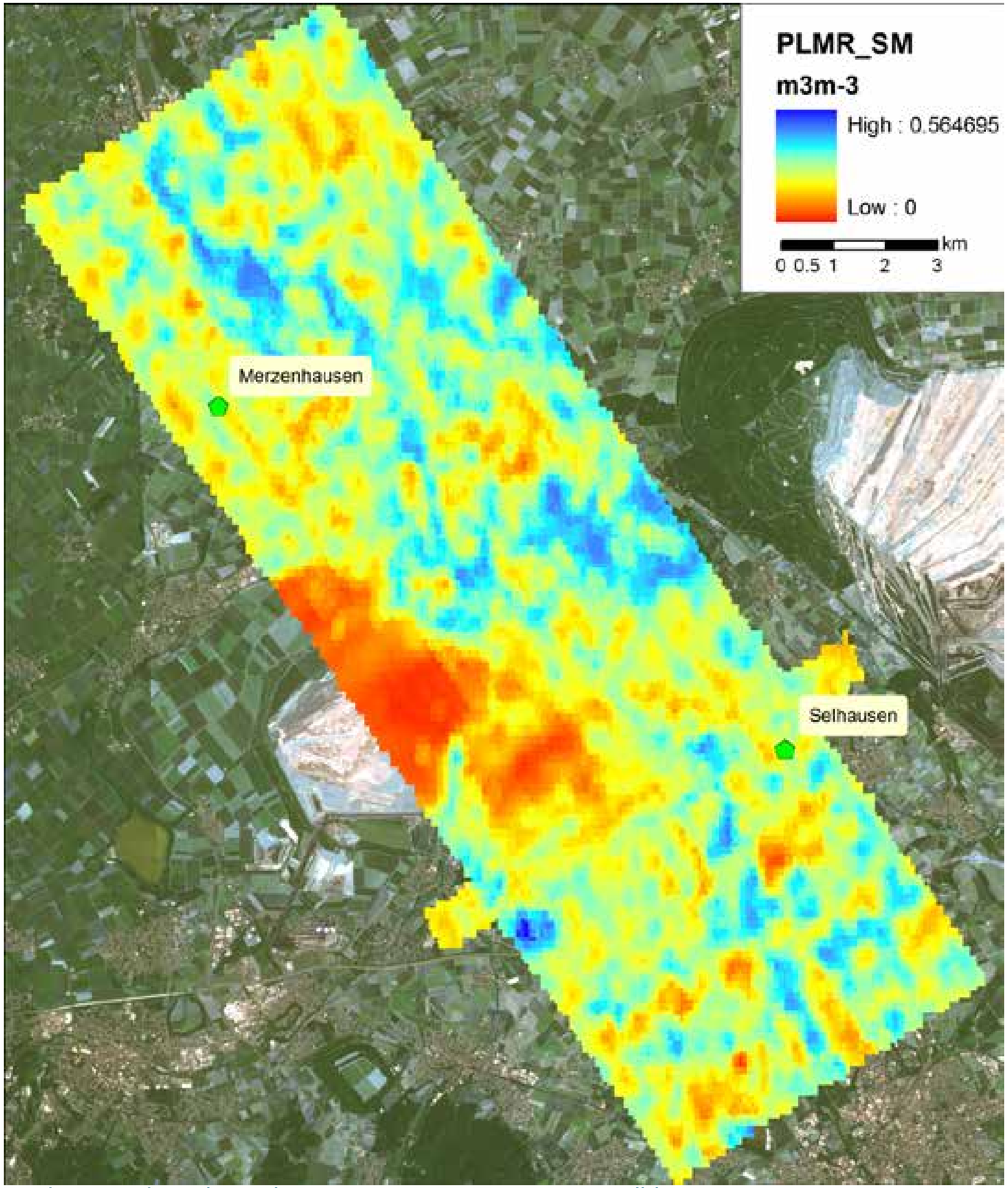
1. **NDVI = (NIR – Red) / (NIR + Red)**
2. **FVC = (NDVI - NDVIs) / (NDVIv - NDVIs)**
3. **LAI = -ln (1-FVC) / k(θ)**

FVC: Fractional Vegetation Cover
NDVIs: NDVI at bare soil
NDVIv: NDVI at full vegetation
k(θ): Light extinction coefficient



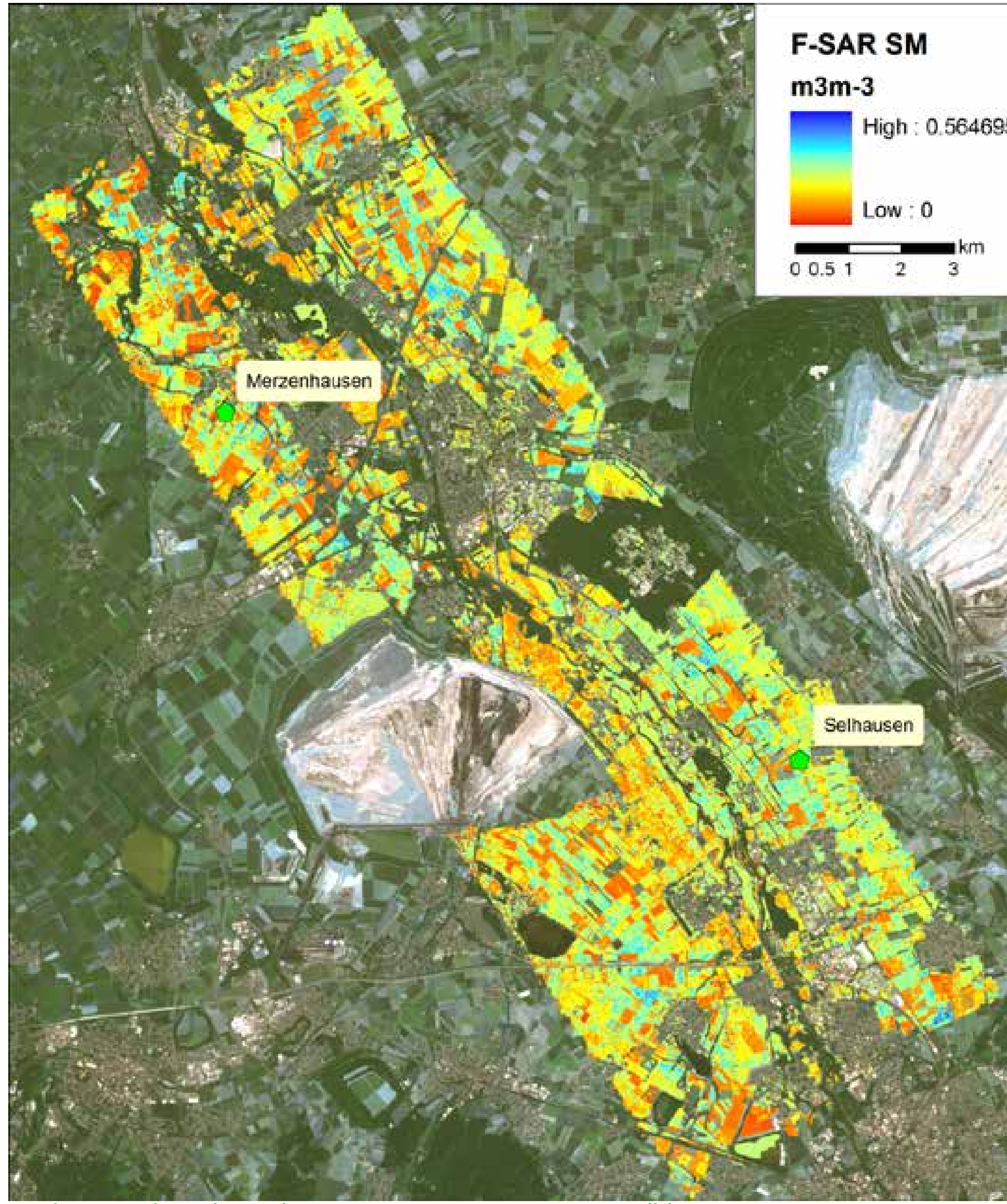
PLMR2 SM

- L-MEB radiative transfer model
- Utilizing LAI, soil map, surface temperature, …
- Calculated on footprint level for different incidence angles with subsequent interpolation



F-SAR SM

- polarimetric, hybrid decomposition for separating soil and vegetation contributions (Jagdhuber et al., 2013)
- Extracted soil component is inverted for soil moisture using a polarimetric soil scattering model



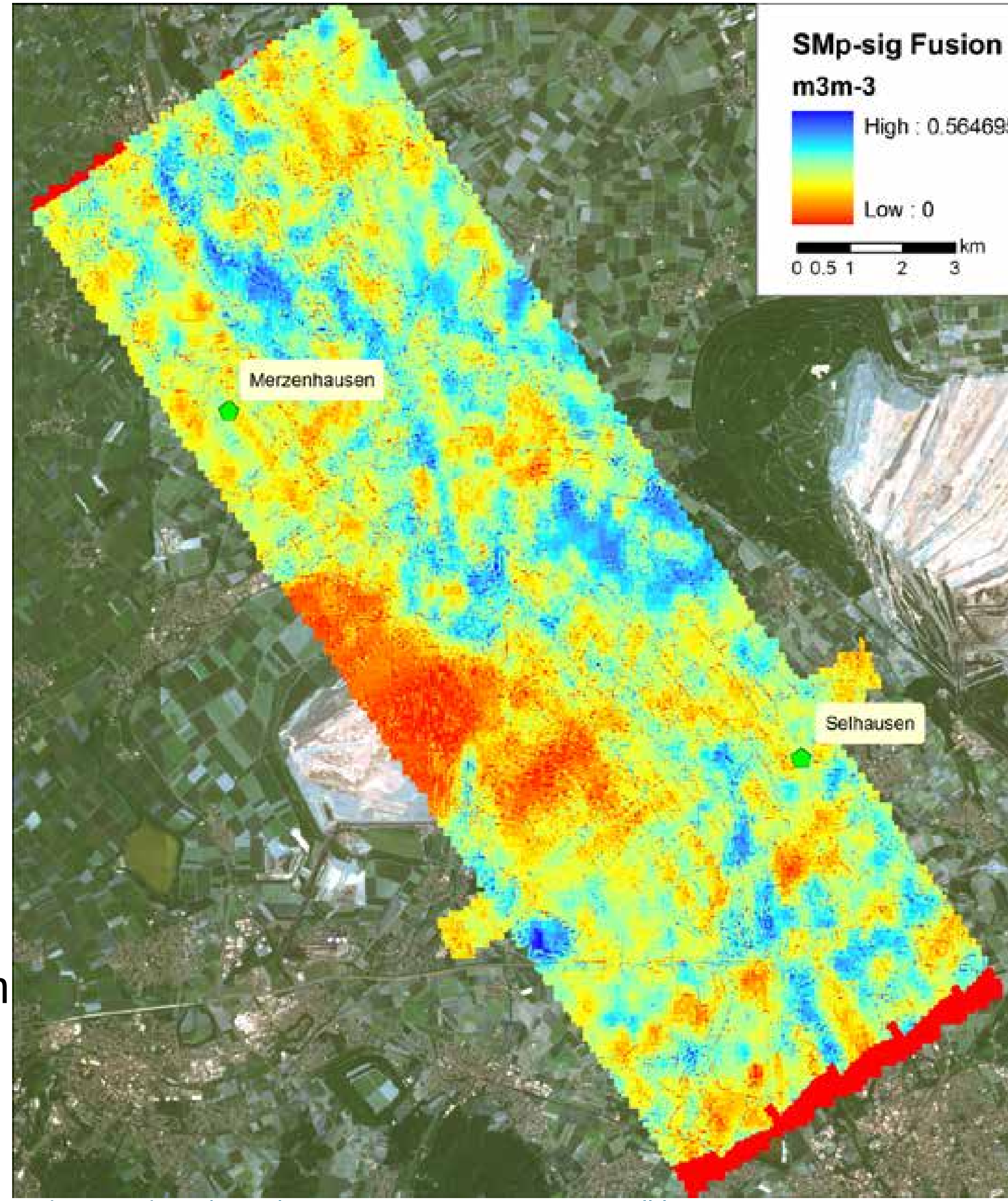
Algorithm A
SMAP Alternative

Disaggregation of the radiometer soil moisture product

(Das et al. 2011):

$$\theta_{fuse}(M) = \theta_{passive}(C) + \beta_1\left(\ln(\sigma_{active}(M)) - \ln(\overline{\sigma_{active}(M)})\right)$$

C: Coarse scale
M: Medium scale
θfuse: Fused active-passive sm
θpassive: Radiometer sm
σactive: Radar backscatter
β1: Scaling parameter



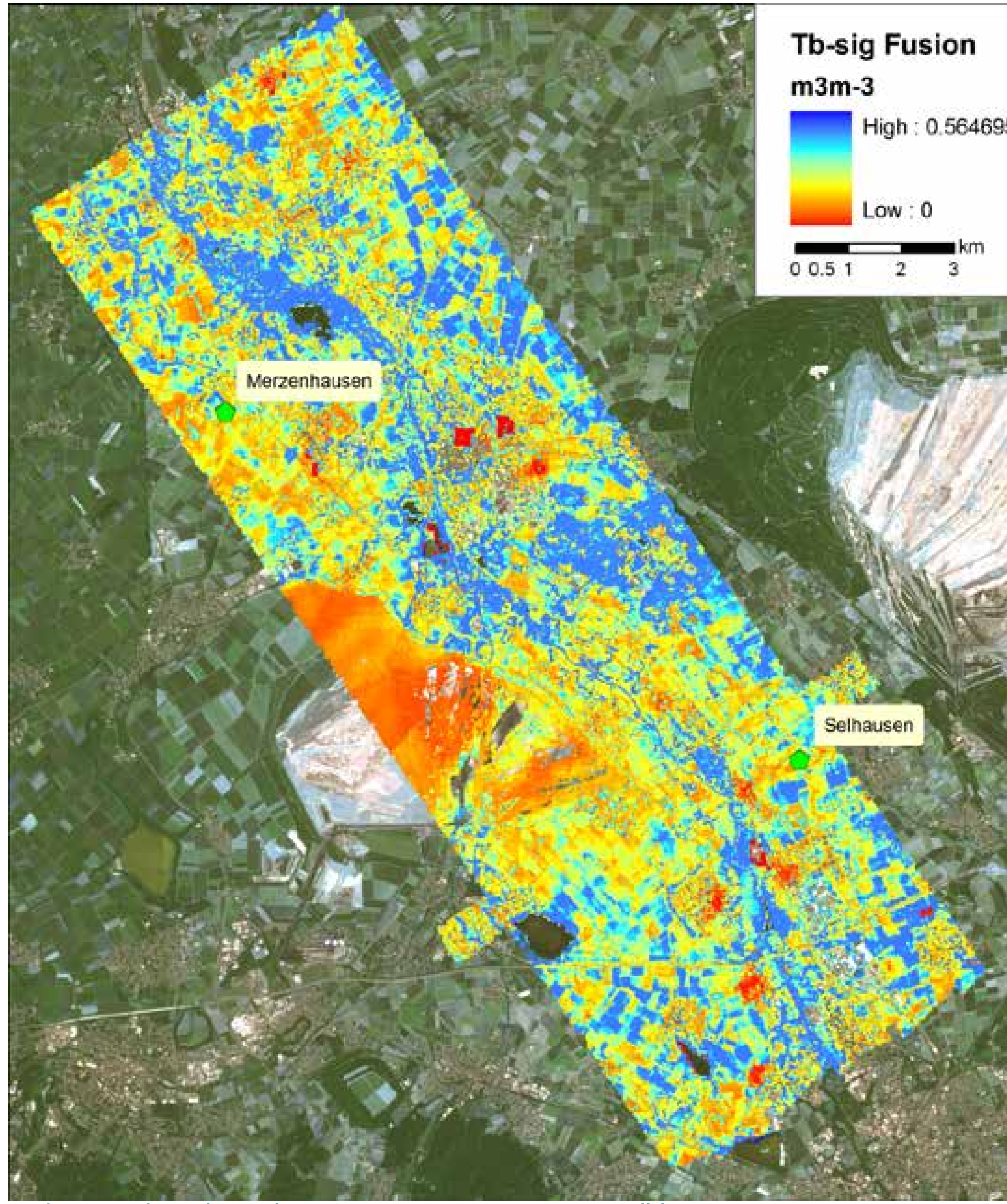
Algorithm B
SMAP Baseline

Disaggregation of radiometer brightness temperatures

(Das et al. 2014):

$$Tbv(M) = Tbv(C) +$$
$$b_2((svv_{active}(M) - \overline{svv_{active}(M)})$$
$$+ G(\overline{shv_{active}(M)} - shv_{active}(M)))$$

C: Coarse scale
M: Medium scale
Tb: Brightness temperature
σactive: Radar backscatter
β2: Scaling parameter

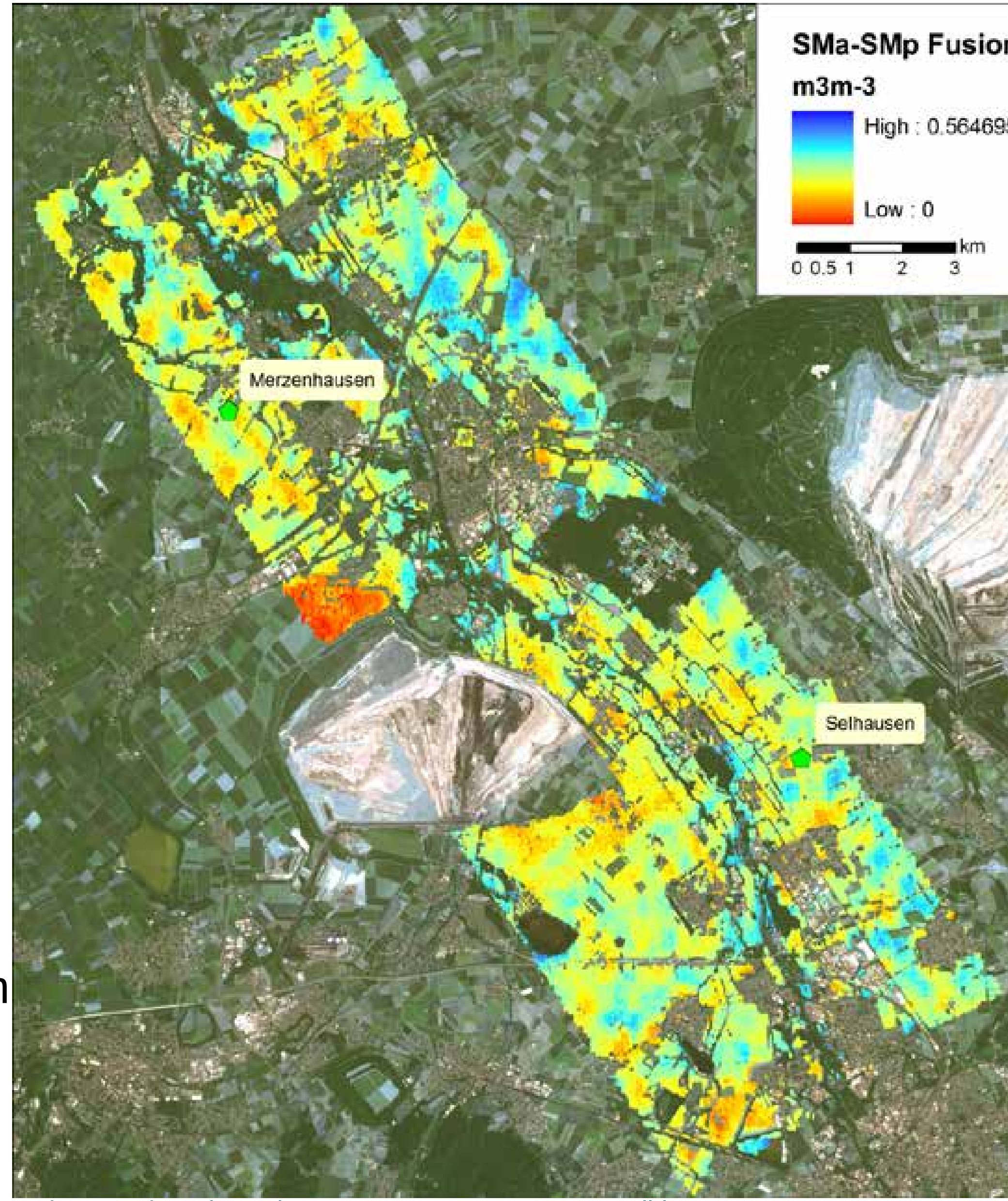


Algorithm C

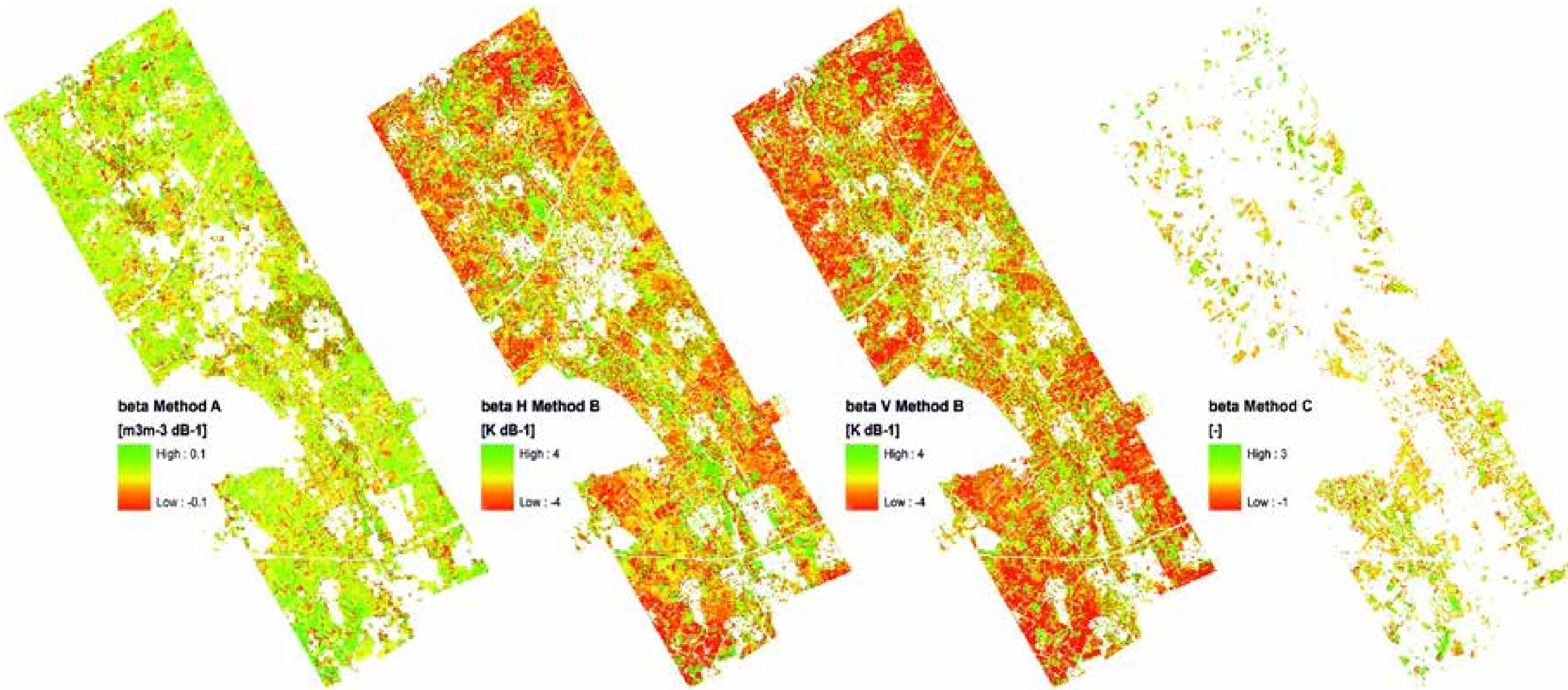
Fusion of two soil moisture products:

$$q_{fuse}(M) = q_{passive}(C) + b_3(q_{active}(M) - \overline{q_{active}(M)})$$

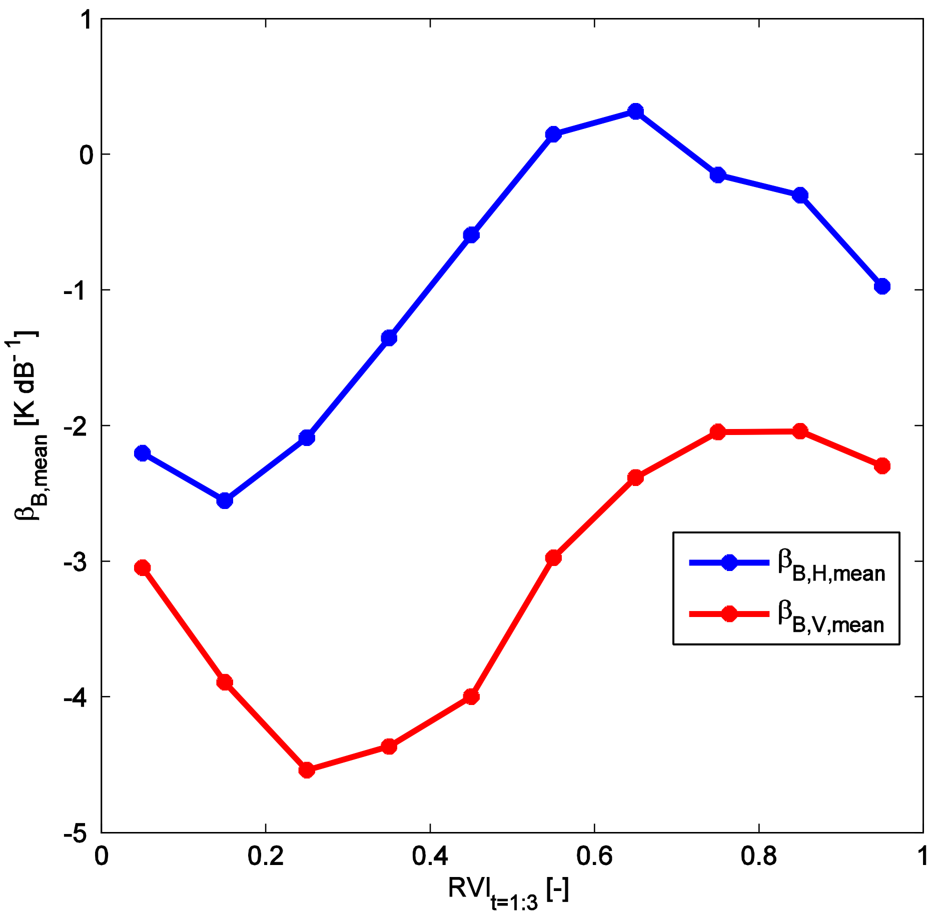
C: Coarse scale
M: Medium scale
θfuse: Fused active-passive sm
θpassive: Radiometer sm
θactive: Radar sm product
β3: Scaling parameter



beta estimation

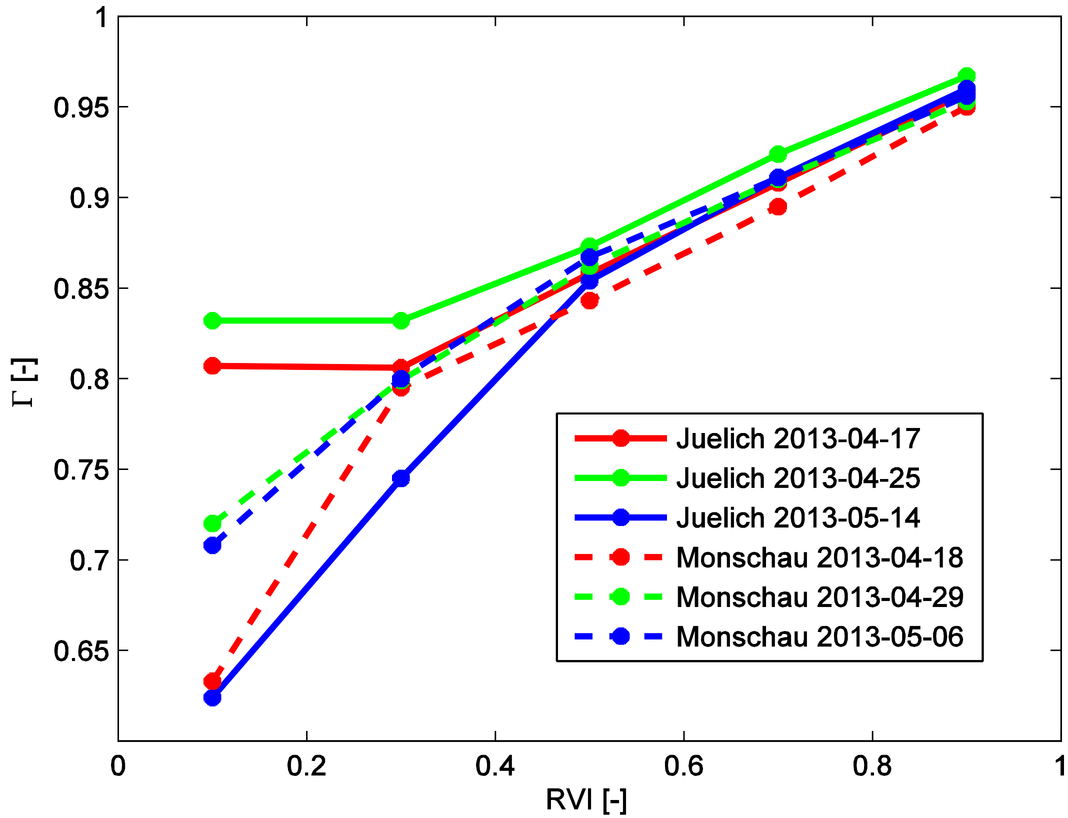


Relationship of beta with RVI



Similar to studies by Wu et al. 2014 and Das et al. 2014

Gamma estimation



$$Tbv(M) = Tbv(C) +$$
$$b_2((svv_{active}(M) - \overline{svv_{active}(M)})$$
$$+ G(\overline{shv_{active}(M)} - shv_{active}(M)))$$

Validation results

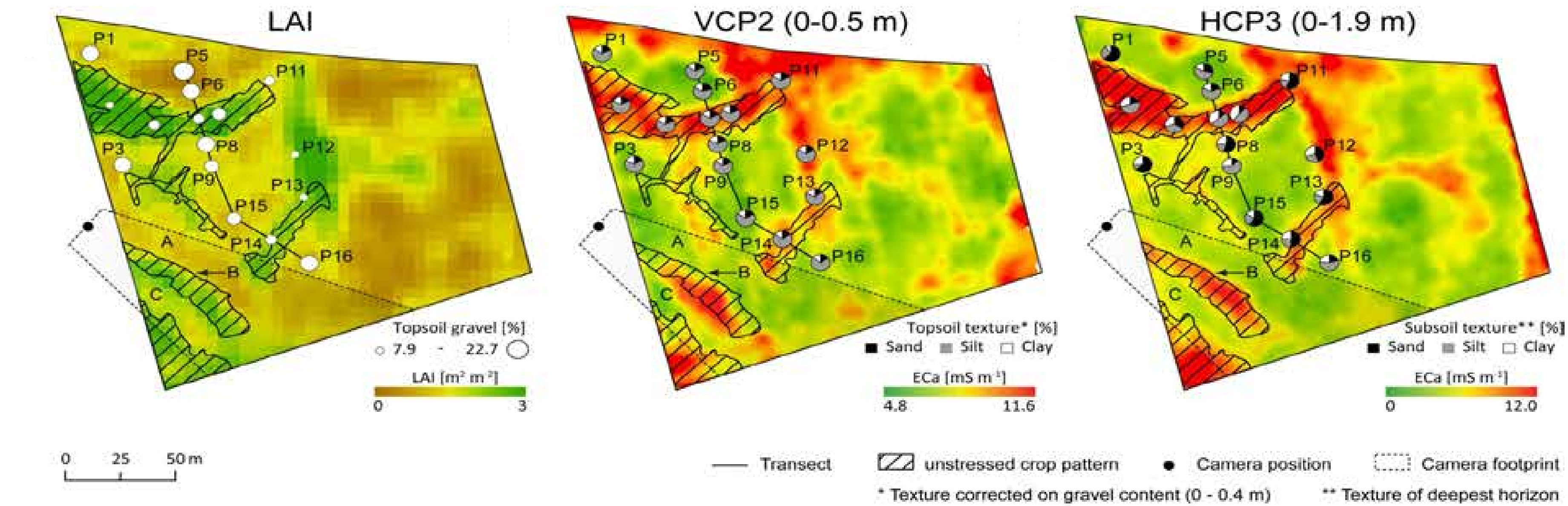
		RMSD [m^3m^{-3}]	
Soil Moisture retrieval method	Scale	Juelich	Monschau
PLMR2 only (θ_{Tb})	C	0.0639 (59)	0.0701 (18)
Method A ($\theta_{\theta,\sigma}$)	M	0.0831 (148)	0.0940 (57)
Method B ($\theta_{Tb,\sigma}$)	M	0.0655 (162)	0.0771 (98)
Method C ($\theta_{\theta_{Tb},\theta_\sigma}$)	M	0.0779 (106)	-
FSAR only (θ_σ)	M	0.0796 (116)	-

Soil moisture retrieval accuracy RMSD [m^3m^{-3}], for different fusion methods and scales over three flights per test region. In brackets the number of pixels used for validation is given.

Subsurface heterogeneity observed by RapidEye

Subsurface heterogeneity observed by EMI

Electromagnetic Induction (EMI)



Conclusions

- SMAP active-passive soil moisture fusion methods were analyzed in a very heterogeneous region
- SMAP Baseline algorithm performs best, also because sm inversion is supported by higher resolution auxiliary data (LAI, soil temperature)
- Fusion methods are able to perform similar on a higher spatial scale as radiometer-only soil moisture products on coarse scale, but not better
- beta and Gamma are linearly related to RVI
- Subsurface heterogeneity needs to be accounted for on this high spatial scale

Outlook: Copula-based active-passive fusion

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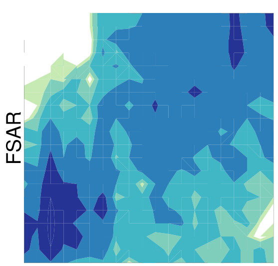

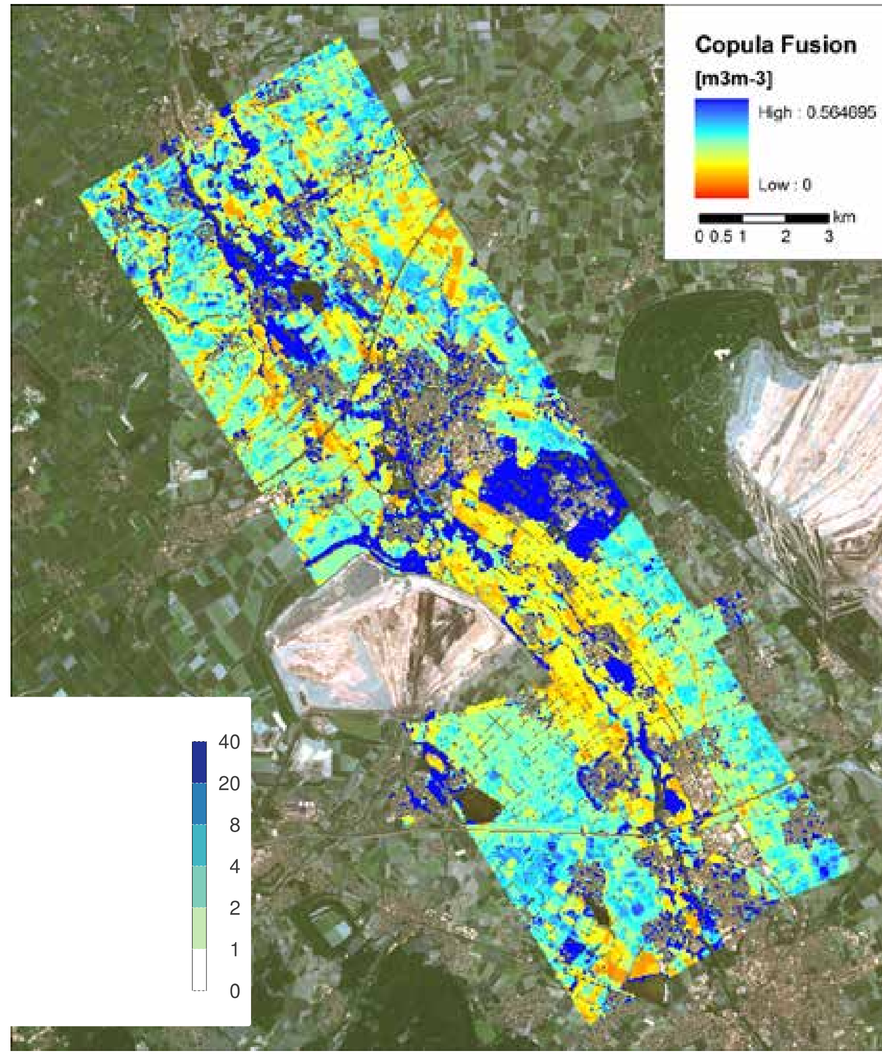

Outlook: Forward modeling of beta

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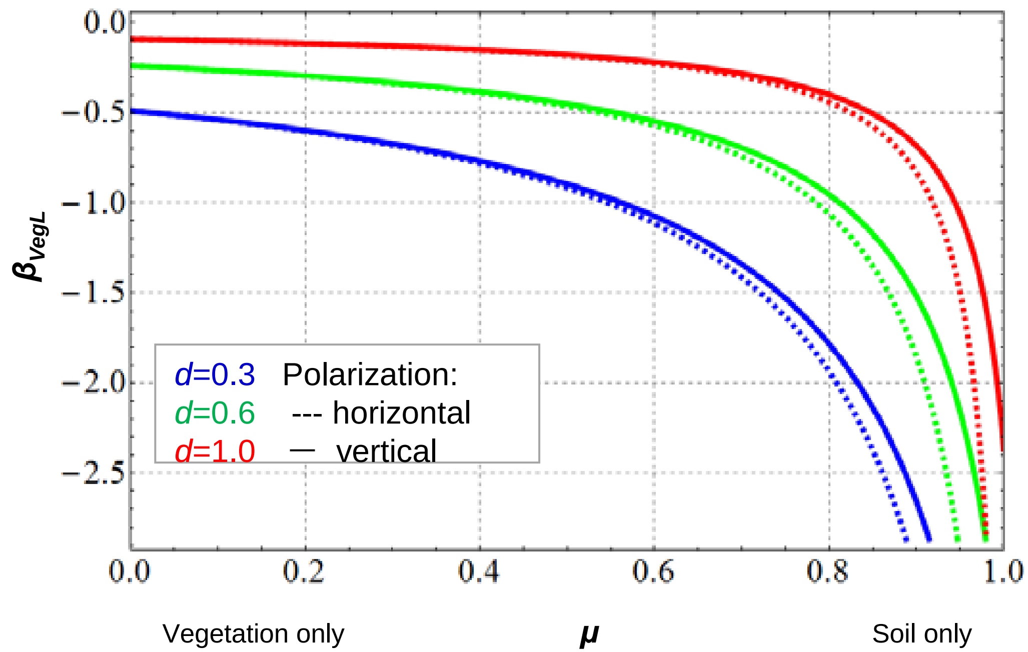

Variation of vertically (solid) and horizontally (dashed) polarized β_{VegL} for different vegetation heights (d) [m] along the ground-to-volume ratio (μ); θ=40°, Vol=0.01, $\varepsilon_L''=\varepsilon_{St}''=10$, $\varepsilon_{St}'=70$, ks=0.3, kl=1.5.

The key objective of the Alliance is to prepare Helmholtz centers and science community for the utilization and integration of bio/geo-physical products provided by the next generation radar remote sensing missions (e.g. Tandem-L) into the study of natural and anthropogenic impact on Earth's ecosystems.

http://hgf-eda.de/

Further remote sensing activities

Tomorrow 13:30 – 15:30

Discussion group 2: Remote Sensing

A fully automated Sentinel-1 based flood mapping service

Sandro Martinis, DLR Oberpfaffenhofen

Overview on current optical remote sensing sensors for environmental research and future prospects

Daniel Sprengler, GFZ Potsdam

Active-Passive Microwave Sensing for Soil Moisture Estimation and Validation: The SMAP Mission

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