The German JECAM site DEMMIN – status and future perspectives.

Spengler, D.; *Ahmadian, N.; Borg, E.; Harfenmeister, K.; Hohmann, C.; Hüttich, C.; Itzerott, S.; Maass, H.; Missling, K.-D.; Schmullius, C.; Truckenbrodt, S.; Conrad, C.*

Earth Observation Technologies for Crop Monitoring: A Workshop to Promote Collaborations among GEOGLAM/JECAM/Asia-RiCE 2018

Taichung City, Taiwan
17-20 September, 2018

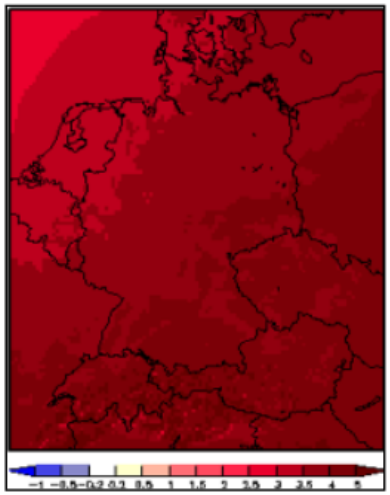
Helmholtz-Zentrum Potsdam
Deutsches GeoForschungsZentrum

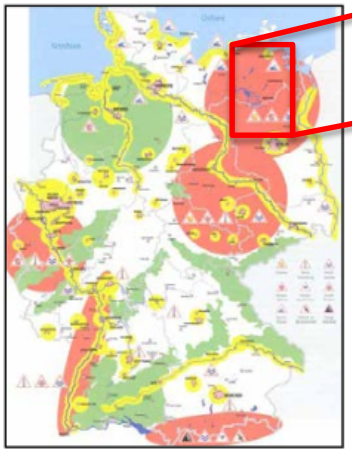
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

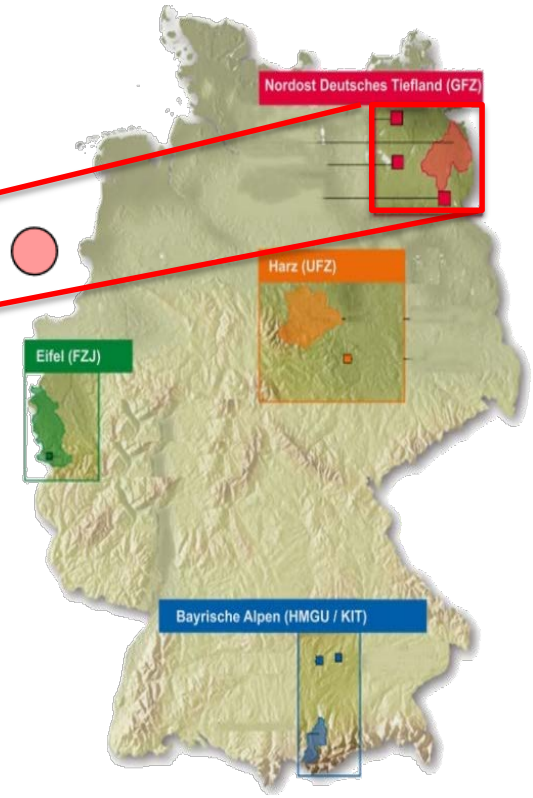
Julius-Maximilians-
Universität Würzburg

PURPOSE OF PROJECT:
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES (TERENO)

- Climatological models forecast a significant climate change (Period: 100 years)
- increase of annual mean temperature between 2.5 to 3.5 C°,
- decrease of annual mean precipitation of up to 30 %





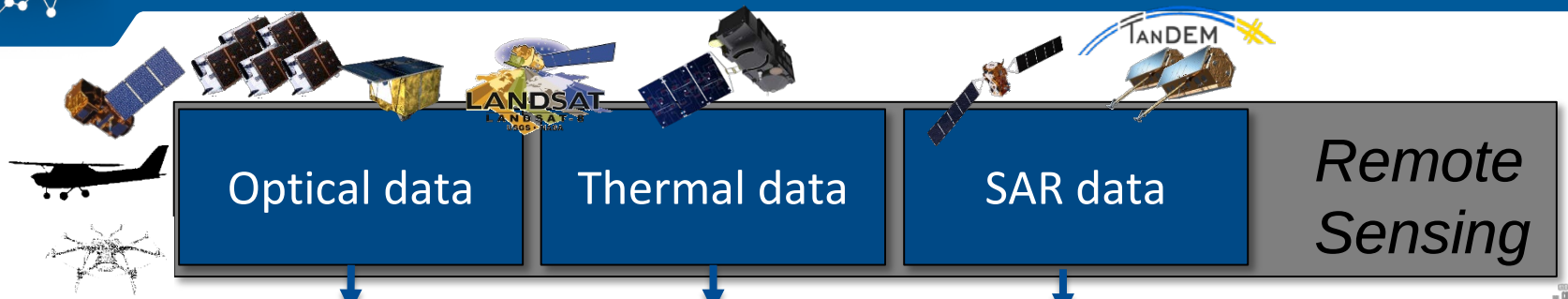


Spatial distribution of climate change on regional scale

DEMMIN is part of TERENO – German Nort-Easthern Lowlands Observatory

Free data access via TERENO data portal:
http://teodoor.icg.kfa-juelich.de

Current overarching main research goal(s)



Optical data | Thermal data | SAR data → *Remote Sensing*

DEMMIN detwork data | External data → *In-situ data*

Mesoscale Evapotranspiration Modelling

Vegetation parameter
(e.g. crop type, phenology, biomass, plant water content, biodiversity parameter)

Soil surface parameter
(soil organic matter, soil moisture)

Yield Forecast

Biodiversity

Validation for airborne and space-borne EO products

Input Hydrological Modelling

Durable Environmental Multidisciplinary Monitoring Information Network (DEMMIN)

- CAL/VAL site for remote sensing missions and methods at agricultural areas (since 1999)
- Cooperation with Farmers managing approx. 30,000 ha
- Test-site region has an dimension of 50 to 50 km²
- Mean Size of fields is 80 ha and in maximum 300 ha

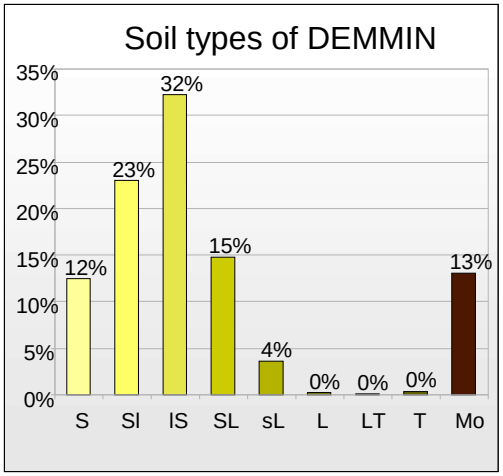
•**DEMMIN Objectives**

•Combination of in-situ data and remote sensing data analysis for:

- Crop parameter estimation (crop type, crop status, crop pattern)
- Soil parameter retrieval (soil moisture, organic matter)
- Evapotranspiration modelling

•→ High resolution data analysis (automatic data processing and analysis of multi sensor data (e.g. TSX, Sentinel-1 & 2, Landsat-8 + in-situ + modelling)

Hydrology, Soil and crop



Hydrological Characterization:

- diffuse, undeveloped water network,
- innumerable lakes and water filled hollows (germ: Sölle)
- Peat bogs along the rivers

Rivers: Trebel, Tollense, Peene

Lakes: Kummerower lake - 0.2 m above sea level Baltic See
Malchiner lake - 0.6 m above sea level Baltic See

Peene: approx. depth 2 - 3 m; approx. slope 0.03%

Pedological Characterization:

- Sand to sandy-loam soils
- Heterogeneous soil cover

Crop Characterization:

- Wheat, barley, maise, potato, sugar beet, rapeseed,
- Everage field sizes: 80 -100ha

Borg et al. (2009)

DEMMIN - PERMANENT DATA INFRASTRUCTURE

Data infrastructure

Agrarian meteorological network:
43 weather stations (GFZ: 20, DLR: 23)

Soil moisture measuring network:
62 gauging stations (agricultural fields)

15min data interval / Web-based data access

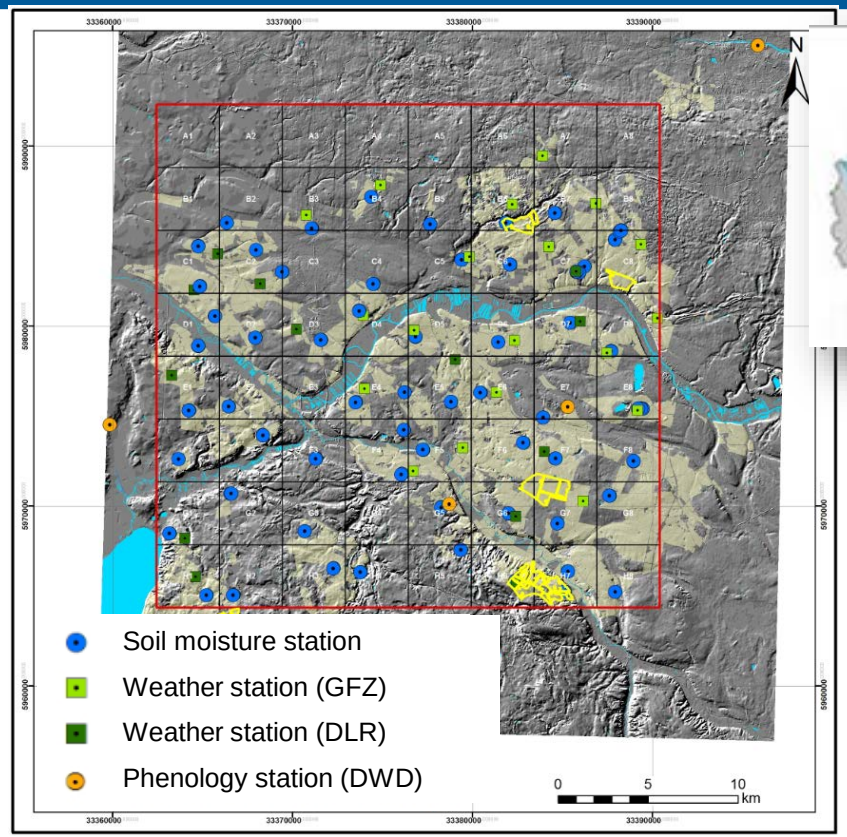
Soil documentation & soil analysis at each soil moisture station:
~110 soil profiles , ~1 m depth;
Parameter: texture, pH, CaCO3, OM

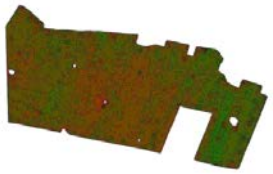
Crop data from association of local agricultural companies, Yield Mapping

Phenology data:
5 observation stations (German Meteorological Service - DWD)

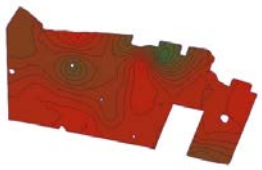
Soil maps, DEM 10, etc.

Large RS Database (> 50 Datasets / year)

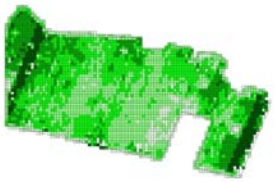




Yield mapping



Soil investigations



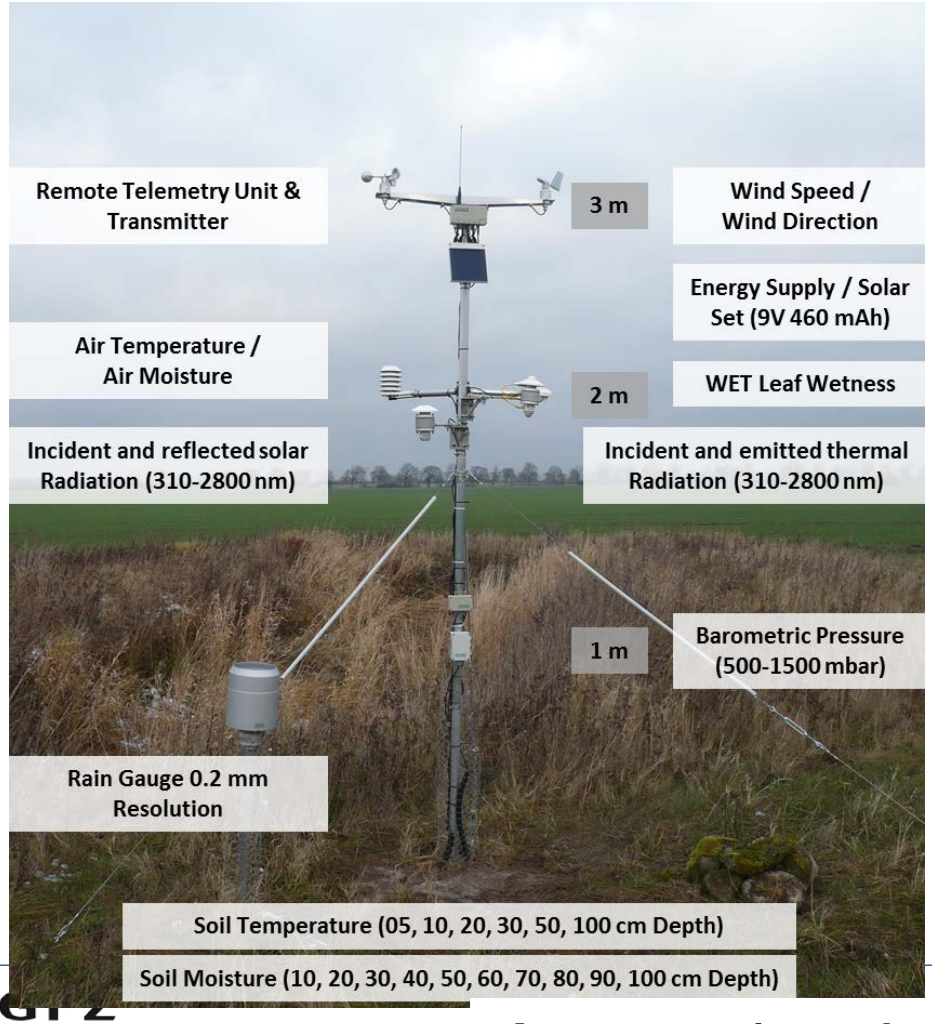
N-Sensor / Biomass

GFZ Helmholtz-Zentrum Potsdam DLR TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

DATA free available with DOI via GFZ data services

DEMMIN - PERMANENT DATA INFRASTRUCTURE

environmental measurement stations



Soil moisture network

→ Input data for modelling

Planning of DEMMIN Eddy Flux Tower at cropland

Eddy Flux Tower

+ HYPERNETS instrument

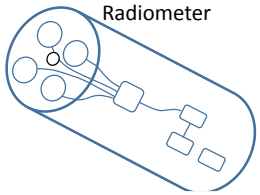
Monitor GHG fluxes

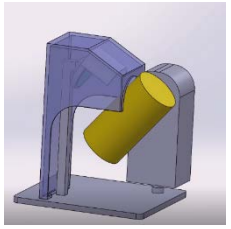
2D anemometer
3D sonic anemometer
ICOS H_2O / CO_2 / CH_4 analyzers
IRGA CO_2 / H_2O analyzers
Temperature / humidity / pressure
4 component radiation sensors / PAR
Precipitation / snow height

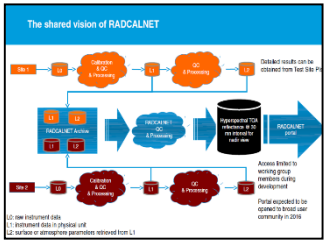
H2020/HYPERNETS project

"instruments"	+	"system"	+	"network"
New low-power, low-weight, low-cost hyperspectral radiometer		Azimuth and zenith pointing for Water and Land BRDF LED calibration source		AERONET-OC and RADCALNET style data portal

HYPERNETS multi-head hyperspectral Radiometer







Globally validation sites (e.g. DEMMIN)

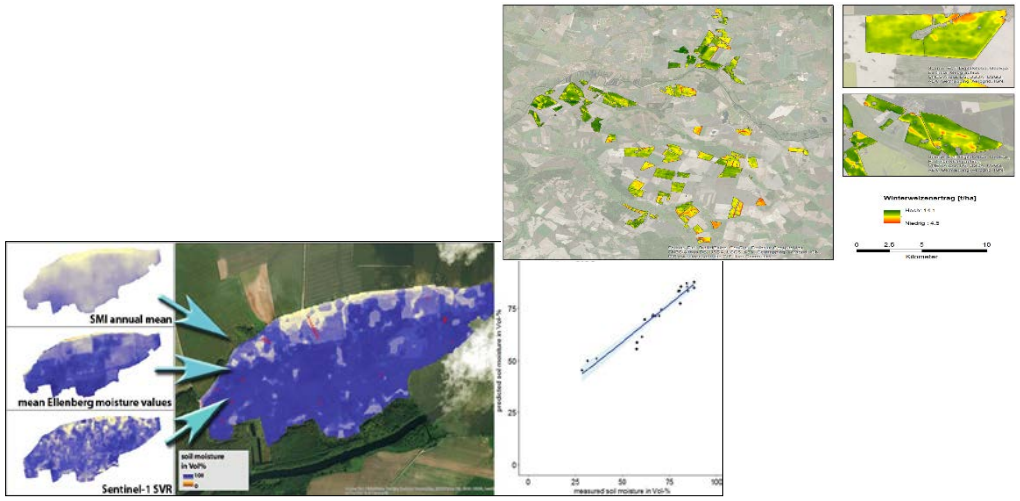
HYPERNETS Consortium (RBINS, TARTU, LOV, CNR, NPL, **GFZ**, CONICET)

Earth Observation (EO) Data Received / Used

Missions	Space Agency / Supplier	Optical / Thermal / SAR	Number of scenes	Challenges
Sentinel-1	ESA	SAR	~ 120/ year	
Sentinel-2	ESA	Optical	~ 15-30 cloud free scenes	clouds
RapidEye	Planet	Optical	~ 10-15 cloud free scenes	clouds
Landsat-8	USGS	Optical / Thermal	~ 5-10 cloud free scenes	clouds
Radarsat-2	CSA	SAR	~ not analysed so far	
Hyperspectral airborn	GFZ	Optical / Thermal	~ 1-2/ year	
UAV	GFZ	Optical / Thermal	~ 1-2/ year	

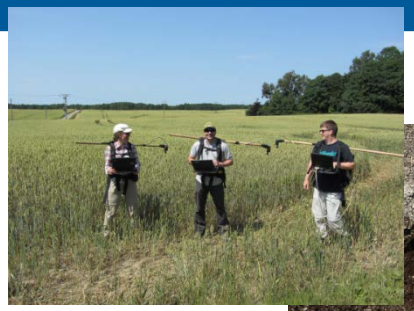
Objectives – Observed Parameters

- Crop identification
- Crop Growth Condition/Stress
- Yield Potential Prediction
- Soil Moisture
- Evapotranspiration Modelling



Monitoring / Field Campaigns / Experiments

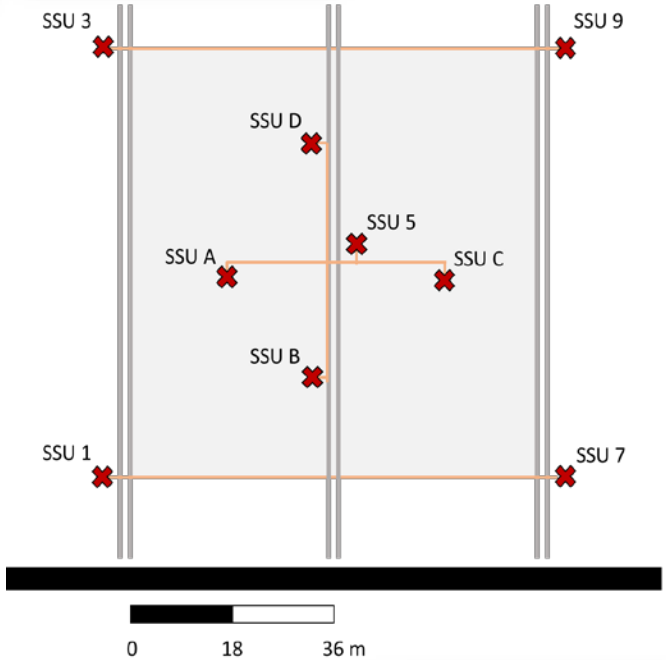
- Measurements of soil and vegetation ever 11 days (25 single points at the test site)
  - Soil moisture analysis
  - Vegetation parameter (LAI, cover, crop type, phenology, height, chlorophyll, biomass , yield
- Soil analysis
  - geophysical measurements, laboratory soil parameter analysis
- ASD-spectral measurements (1-2 times/year)
- 2018 DEMMIN 2.0 student campaigns started
  - 5 campaigns with student groups
  - Standardized sampling – Field Reader

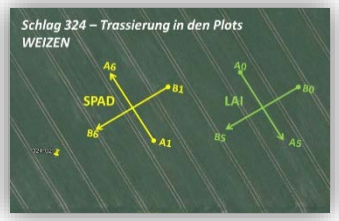


11 day cycle (March – October, 2012 – today)

2018 DEMMIN 2.0
STUDENT CAMPAIGNS

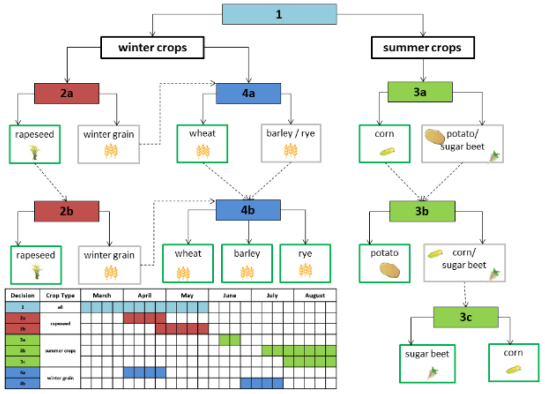
	Parameter	Equipment / Method	Sampling frequency per SSU	SSU
1	Hyperspectral data *	ASD FieldSpec SpectralEvolution	10 5	Only 1, 3, 5, 7, 9 Only 1, 3, 5, 7, 9
	Aerosol optical thickness *	Sun photometer	1	Only at 5
	Cloud coverage	Digital camera	1	Only at 5
	Landscape photos	Digital camera	4	Only at 5
	Fractional vegetation cover	Digital camera	2	All
	Prop. of senescent material	Digital camera	2	All
2	Fractional vegetation cover	Estimate	4 × 1	All
	Prop. of senescent material	Estimate	4 × 1	All
3	Canopy height	Folding ruler Photo of board	4 2	All All
	Leaf Area Index	LI-COR LAI-2200	4 × ABBBB	All
4	Biomass (all)	Gravimetrical	1 quadrat	All
5	Leaf chlorophyll content	SPAD-502Plus	4 + 3+ 3	All
	Soil moisture	HH2 moisture meter	5	All
	Soil moisture	Gravimetrical	5	Only at 5
6	Soil roughness	Pin profiler	4 (45°)	Only at 5 (1 per year)
7	Orientation of planting rows Row spacing Stems per plant	Compass Folding ruler Counting	1 5 5	Only at 5 (1 per year) Only at 5 (1 per year) Only at 5 (1 per year)
	Phenology	BBCH-scale	3 (x students)	All

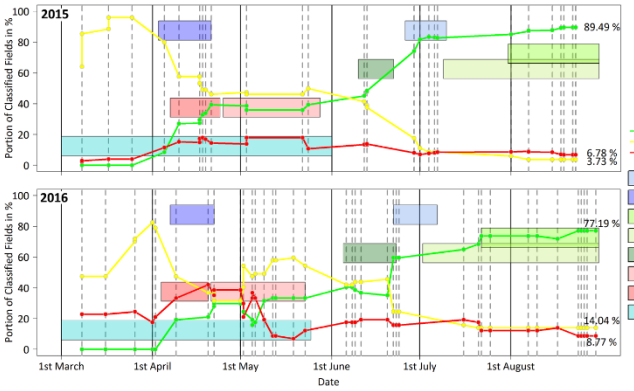


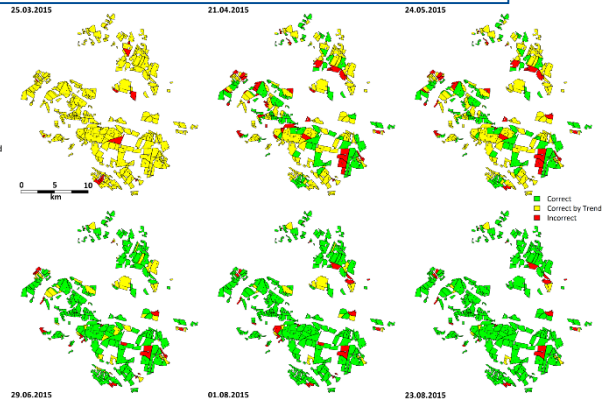


RESULTS: A PROGRESSIVE CROP-TYPE CLASSIFICATION USING MULTITEMPORAL REMOTE SENSING DATA AND PHENOLOGICAL INFORMATION

Projects	TERENO, AgriFusion, JECAM
Study Area	Demmin
Data	Landsat-7 & -8, RapidEye, Sentinel-2, phenology data (DWD)
Method	Rule-based fuzzy C-Means Clustering
Results	OA of 89% (2015) / 78% (2016) / 84% (2017) / 89% (2018)
Benefits	→ independence of training data
	→ first results in spring with improving accuracy during season
Outlook	operational use to access current crop type information at any time







Needs adaption and further validation at other sites

Heupel[Harfenmeister], K., Spengler, D. & Itzerott, S. PFG (2018) 86: 53.
https://doi.org/10.1007/s41064-018-0050-7

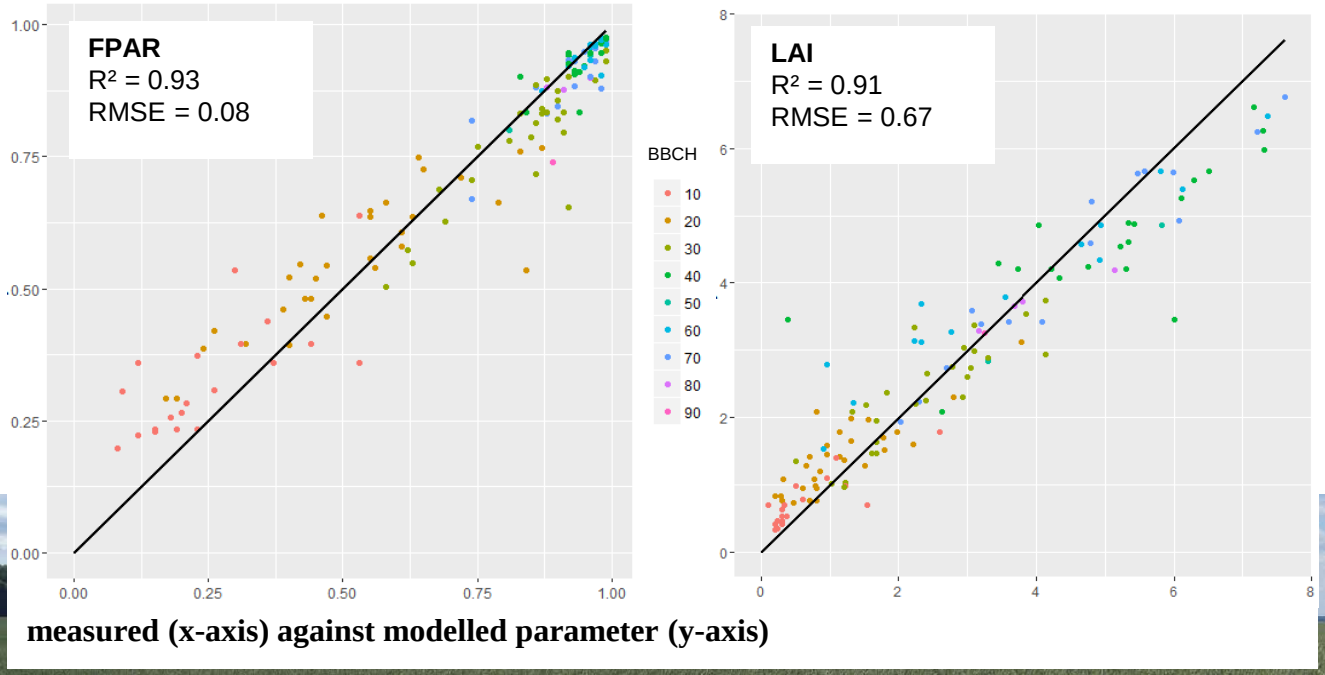
GFZ Helmholtz-Zentrum Potsdam

HELMHOLTZ

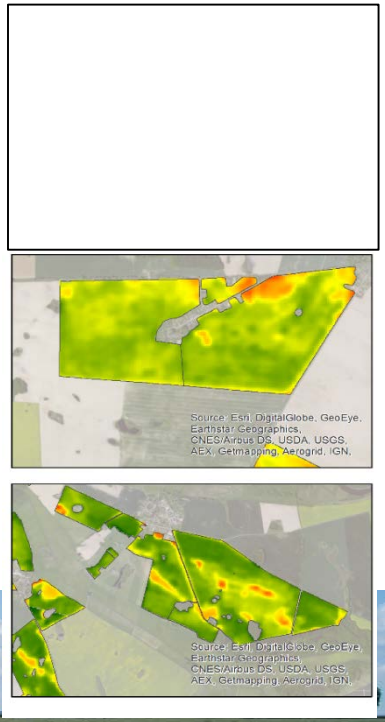
Retrieval of biophysical parameters
Accuracy Asessment by *in-situ measurements*

Determination of FPAR/LAI of winter wheat based on Landsat und MODIS Data

- Data fusion algorithm: STARFM
- Method for parameter retrieval of FPAR/LAI: RandomForest
- Results: high frequent FPAR/LAI maps in 30m resolution (winter wheat)



measured (x-axis) against modelled parameter (y-axis)

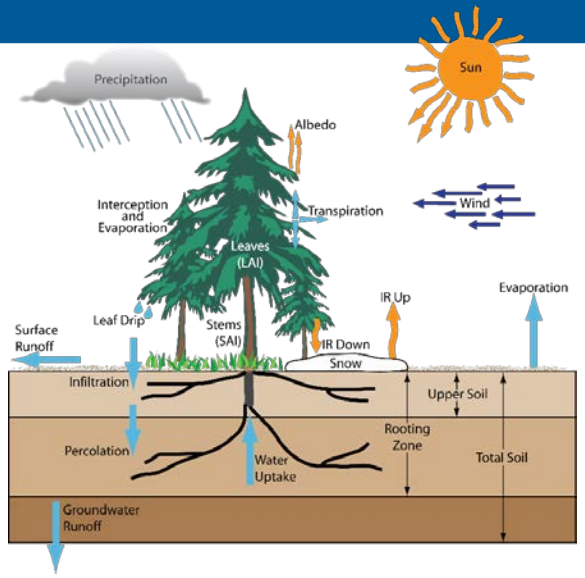


Dahms, T., Seissiger, S., Conrad, C., Borg, E. (2016): Modelling Biophysical Parameters Of Maize Using Landsat 8 Time Series. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLI(B2): 171-

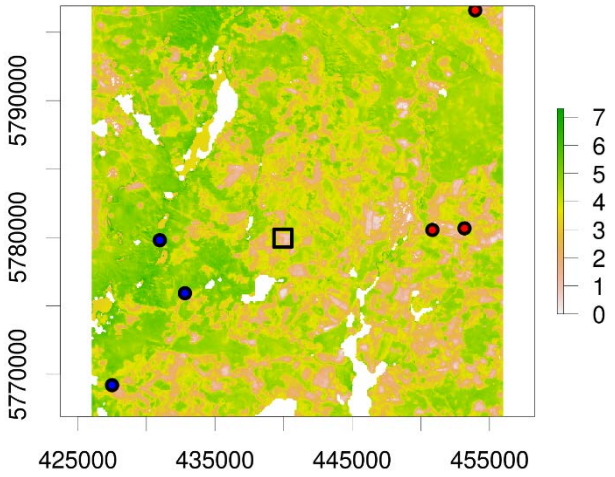
Dahms, T., Conrad, C., Babu, D.K., Schmidt, M., Borg, E. (2017): Derivation of biophysical parameters from fused remote sensing data. 2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Fort Worth, TX, 2017, pp.

Modelling of Evapotranspiration

- Based on METRIC, Allen 2007
- Surface energy balance
  - partly empirical models e.g: soil heat flux
- Selection of reference points with defined ET
  - low vegetation index, high temperatur -> ET = 0
  - High vegetation index, low temperatur, -> ET = reference ET
- Calibration of sensible heat fluxes with reference points
- Calculation of area wide ET
- Challenges: based on thermal data -> very limited data, low resolution



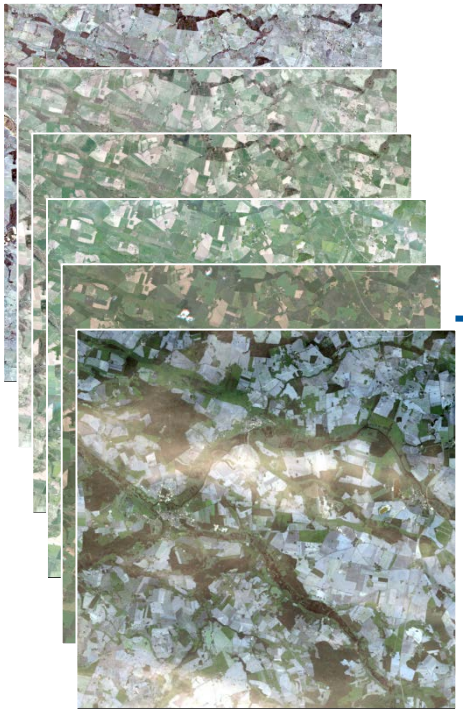
Act. ET [mm/d] 2015-06-13



in development

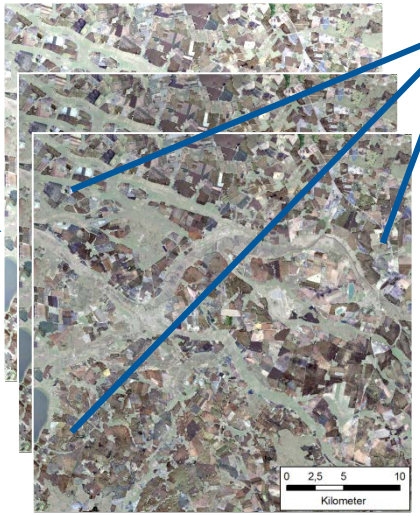
Determination of Soil Parameter – (surface organic matter conent)

Multitemporal remote sensing data



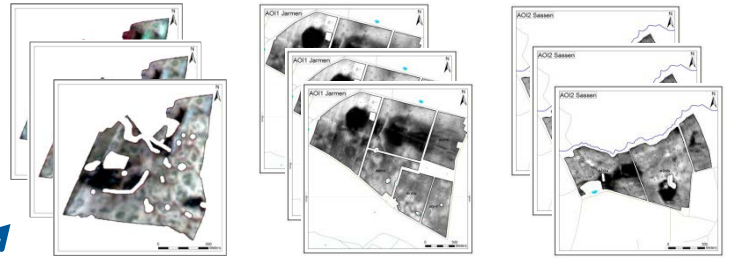
RapidEye

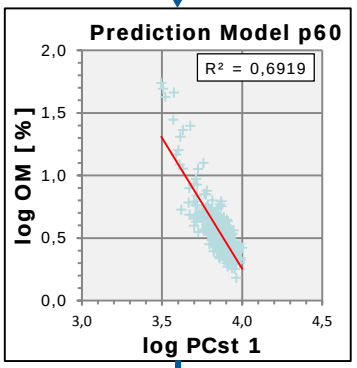
Selection of bare soil fields ☐ Multitemporal synthetic bare soil data



(based on NDVI + in field homogeneity)

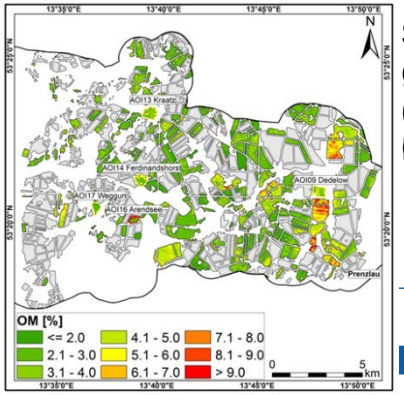
Soil pattern detection at different test fields



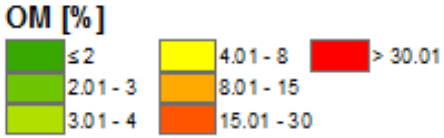


Regional regression model based on laboratory analysis

R²: 0.692; RMSE: 7.487 %



Soil map generation (test site Quillow)



Blasch et al. 2015(1), Blasch et al. 2015(2), Blasch et al. 2016

COLLABORATION

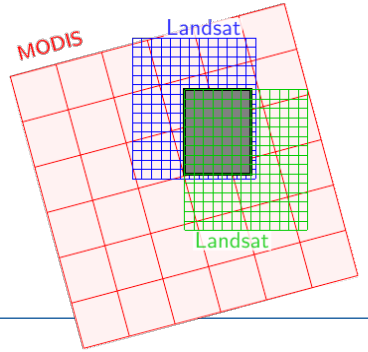
- DEMMIN is core test site for many nat. + international research projects
  - H2020 ERAGAS/GHGmanage, H2020 HYPERNETS, H2020 ERAPLANET GEOEssentials/iCUPE
  - GLAM.DE, AgriFusion, Climate KIC

- Contribution to SAR intercomparison experiment
  - Coordinated from our side by Nima Ahmadian (University Würzburg, Germany)
  - Crop cover data

- Improve contribution to nat./int. Cal/Val activities
- Further collaborations are welcome!

Plans for Next Growing Season

- Optimize students measurements campaigns
- Installation of new instruments
  - Eddy Flux + HYPERNETS
- Do you anticipate using the same type/quantity of EO data next year?
  - Improving of automatic data analysis is foreseen
  - Implementation of further data into the analysis (Radarsat-2, Spot5)
  - Improving thermal data analysis
  - Improving synergetic multi-sensor data analysis



Thank you very much

Contacts:

Daniel Spengler (GFZ Potsdam): daniel.spengler@gfz-potsdam.de
Erik Borg (DLR): erik.borg@dlr.de
Christopher Conrad (Uni Halle/Uni Würzburg): christopher.conrad@uni-wuerzburg.de