DEMMIN

Durable **E**nvironmental **M**ultidisciplinary **M**onitoring **I**nformation **N**etwork
-
Agricultural Research at the TERENO German Northeastern Lowlands Observatory

D. Spengler[1], E. Borg[2], F. Renke[2], C. Conrad[3], C. Hohmann[1], T. Sachs[1], S.Itzerott[1]

*[1] Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences*
[2] German Aerospace Center (DLR)
[3] Julius-Maximilians-University Würzburg

Background – Agricultural Production

1972/73 1977 1987 1998 2009

TURKMENISTAN

Amu Darya

Bukhara   Samarkand

TAJIKISTAN

Tedjen   Mary

Kashkadarya

Sukkhandarya

AFGHANISTAN

Country border

Irrigated region

N

0   75   150   300 km

Data source: NASA

Projection: Geographic
Datum: WGS 1984

Conrad et al. (2014)

Conrad et al. (2014)
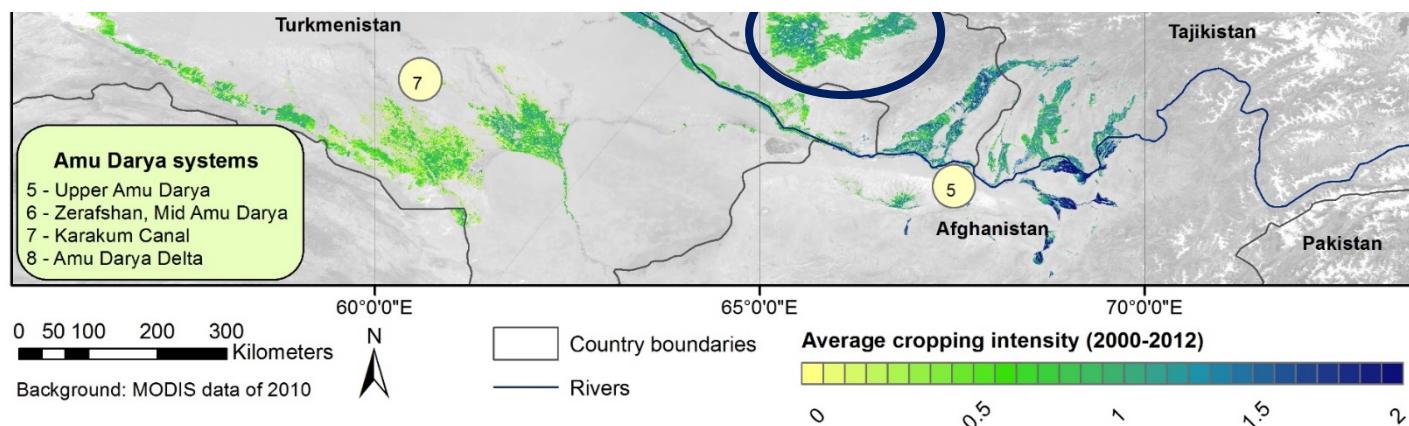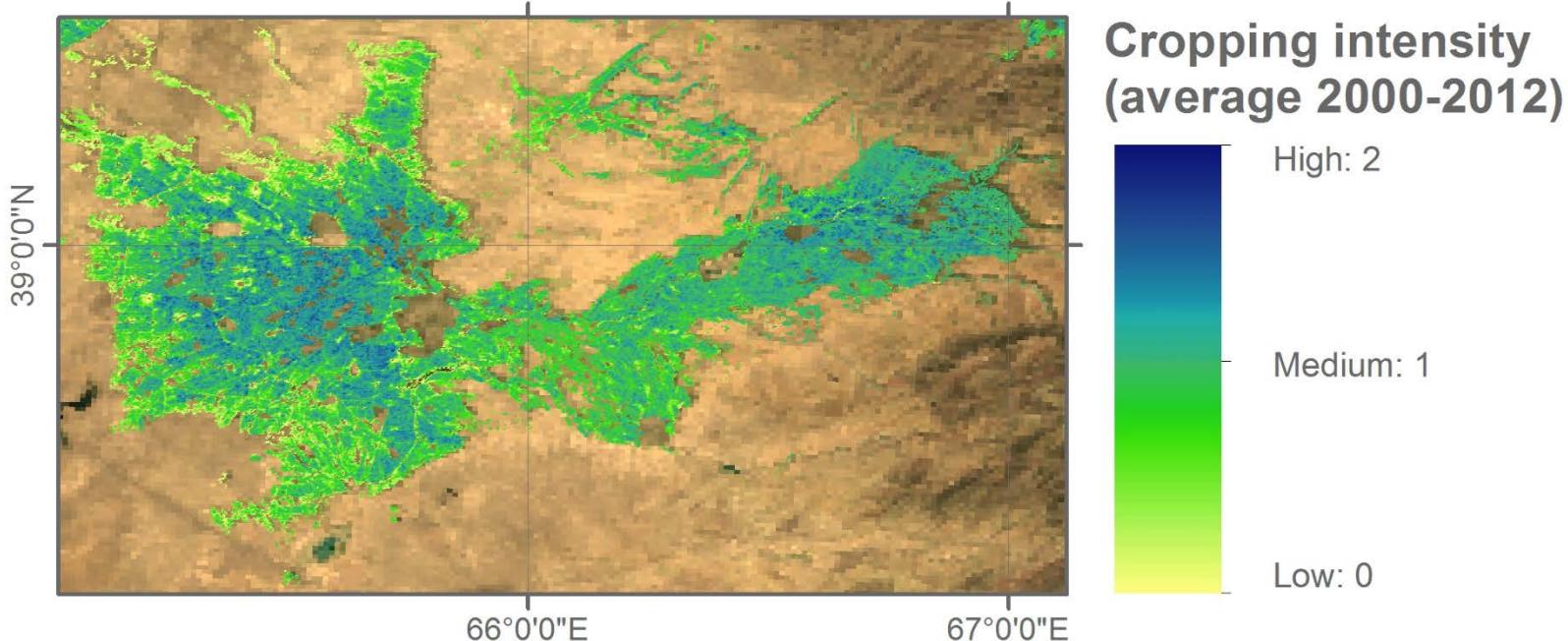
Information requirements of users:
- Repetition rate is often to low for time-critical applications,
- Duration of processing of value added product is often to long,
- Continuous quality of value added products is often insufficient
- Standardization of information is insufficiently developed

**Calibration/Validation aspects concerning remote sensing:**
- Insufficient standardization of in-situ-data (statistical basis is often too small)
- Insufficient amount of available in-situ-data (in kind and quantity)
- Unqualified measuring strategies for calibration / validation of remote sensing data

Operational stage of applications in the remote sensing:
- Processors are often prototypically (insufficient operationally usable),
- Insufficient validation strategies for operational processors

Calibration and Validation Sites support solving these open issues

Borg et al. (2009 a)

VALERI –

VAlidation of **L**and **E**uropean **R**emote sensing **I**nstruments

Rovaniemi
Hirsikangas
Hyytiäiä
Norunda
Järvselja
Marsta
Cabauw
Chibolton
Demmin
Lindenberg/ Falkenberg
Sonian Forest
Romilly-sur Seine
Gilching
Tharandt
Le Lazac
Fundulea
Plan-de-Dieu
Nezer
Sud-Ouest
Puéchabon
Les Alpilles 1/2
Pirene
Barrax
Barrax
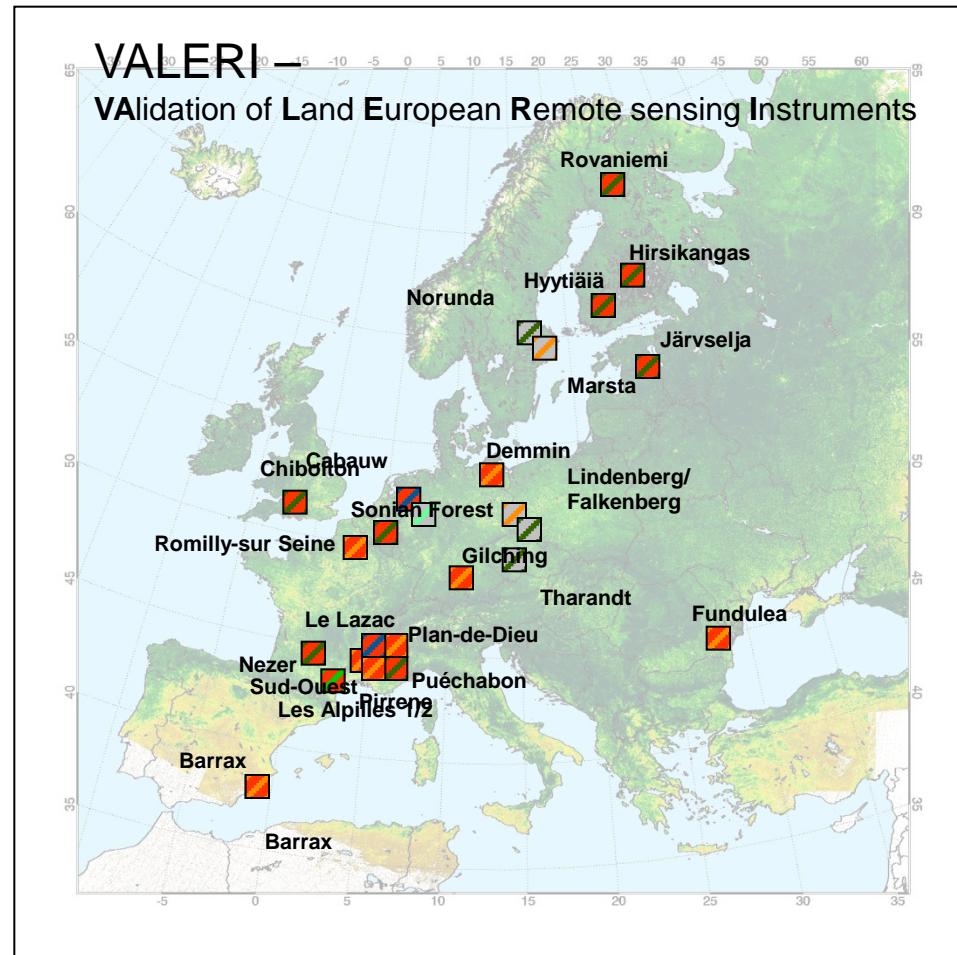
Operational Test Sites In Europe

Thematic Objective

⬡ **Meteorology**

⬡ **Remote Sensing**

Land Use

🟩 **Meadow / Pasture**

🟩 **Wood / Forest**

🟩 **Natural Vegetation**

🟧 **Crops**

Analysis Moment

2009
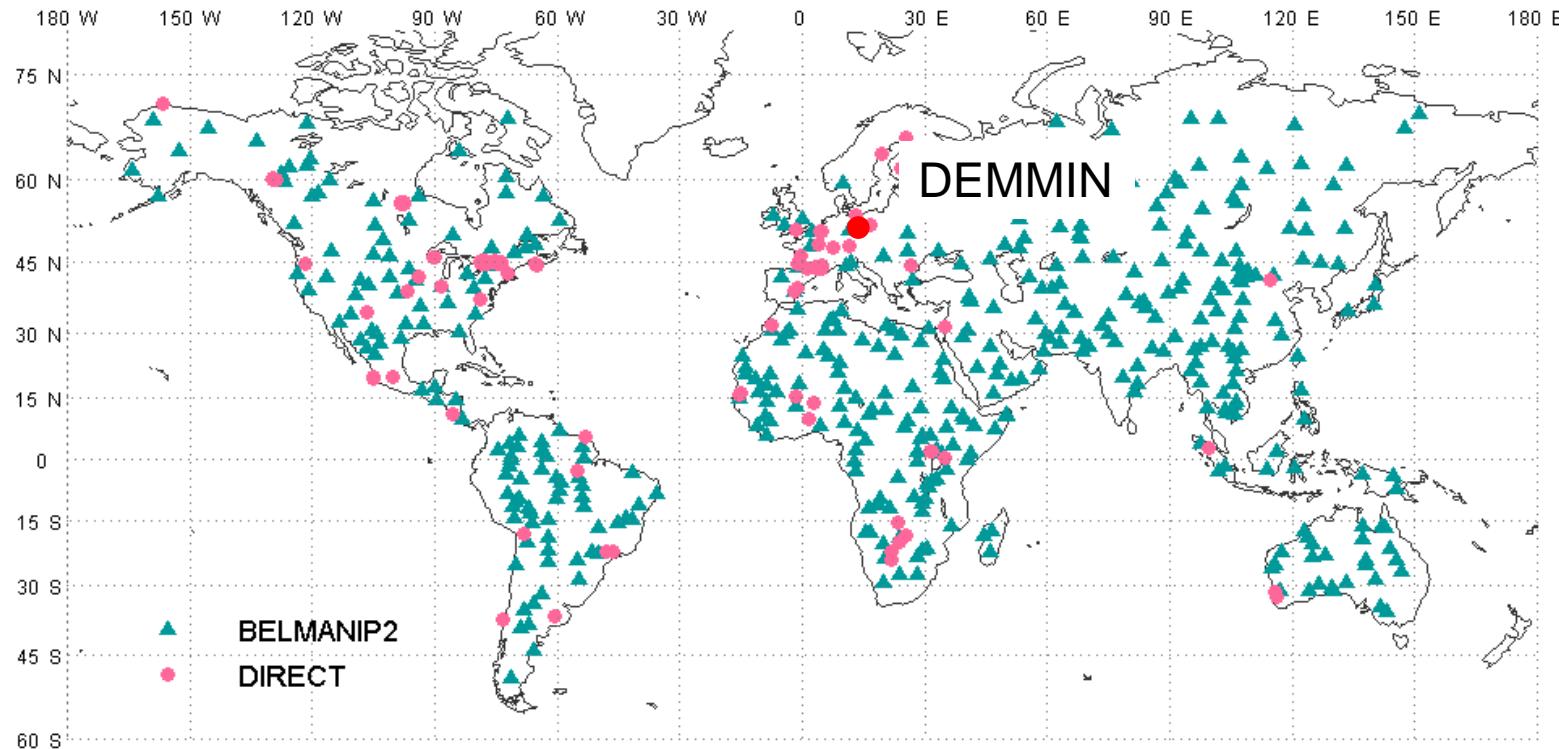
Borg et al. (2009)

BELMANIP2 + DIRECT

Baret, F., Morissette, J., Fernandes, R., Champeaux, J.L., Myneni, R., Chen, J., Plummer, S., Weiss, M., Bacour, C., Garrigues, S. and Nickeson, J.E., 2006. Evaluation of the representativeness of networks of sites for the validation and inter-comparison of land biophysical products. proposition of the CEOS-BELMANIP. IEEE Trans. Geosc. Remote Sens., 44(7): 1794-1803

Garrigues, S., Lacaze, R., Baret, F., Morisette, J.T., Weiss, M., Nickeson, J.E., Fernandes, R., Plummer, S., Shabanov, N.V., Myneni, R.B., Knyazikhin, Y. and Yang, W., 2008. Validation and intercomparison of global Leaf Area Index products derived from remote sensing data. J. Geophys. Res., 113, G02028: doi:10.1029/2007JG000635

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 %
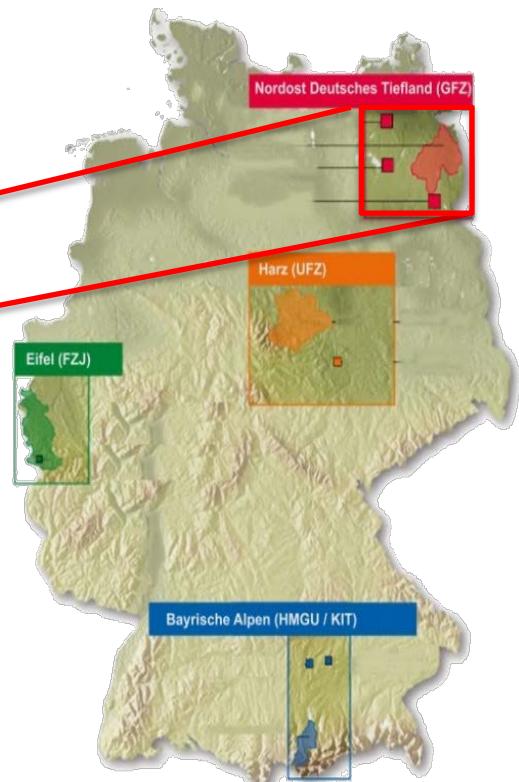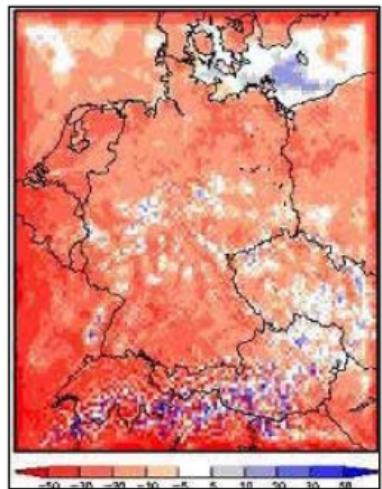
Spatial distribution of climate change on

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
(GFZ stations)

Durable Environmental Multidisciplinary Monitoring Information Network (DEMMIN)

DEMMIN

● Berlin

- CAL/VAL site for remote sensing missions and methods at agricultural areas (since 2000)
- Cooperation with farmers managing approx. 30,000 ha
- Test-site region has an dimension of 30 to 30 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)

→ Cal/Val site for new sensors and missions

Pommeranian Lowlands
- flat country / end moraine

Hinterland of Mecklenburg lake district
- hilly country / ground moraine

Legende

- 0a – Beltsee
- 0b – Arkonasee
- 1 – Ostseeküstenland
- 2 – Vorpommersches Flachland
- 3 – Rückland der Mecklenburgischen Seenplatte
- 4 – Höhenrücken und Mecklenburgischen Seenplatte
- 5 – Vorland der Mecklenburgischen Seenplatte
- 6 – Elbetal

Festland
Grenze des Testfeldes DEMMIN

0   9   18   27   36   45 km

© LUNG

Formation of observatory DEMMIN with respect to landscape zones

(http://www.umweltkarten.mv-regierung.de/script/)

Borg et al. (2009)

Hydrology and Soil Cover

Soil types of DEMMIN
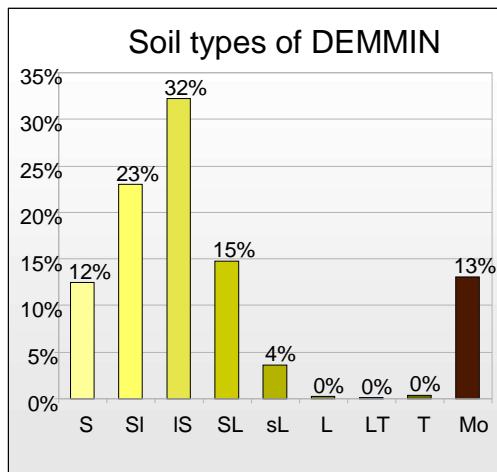
Hydrological Characterization:

• 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

Borg et al. (2009)

DEMMIN - permanent data infrastructure

Data infrastructure

Environmental network*:
43 (+8) environmental stations (DLR: 23 (+ 8 add
small stations, GFZ: 20)

Soil moisture network*:
63 gauging stations (below agricultural fields)

4 Radar Reflectors

2 Eddy Flux Towers (1 operation, 1 in constr.)

1 Crane Platform

1 Lysimeter-Hexagon

**7 Stations for radiation measurements ***

Data Transfer

1 Basis station + Basis station gateway

3 Frequencies

4 Relay-Stations

*   15 ' data interval / Web-based data access

**   1' data interval

- Soil moisture station
- Environmental station (GFZ / TERENO)
- Environmental station (DLR / DEMMIN)
- Phenology station (DWD)

Environmental measurement stations

Soil moisture network

Remote Telemetry Unit & Transmitter

3 m

Wind Speed / Wind Direction

Energy Supply / Solar Set (9V 460 mAh)

Air Temperature / Air Moisture

2 m

WET Leaf Wetness

Incident and reflected solar Radiation (310-2800 nm)

Incident and emitted thermal Radiation (310-2800 nm)

1 m

Barometric Pressure (500-1500 mbar)

Rain Gauge 0.2 mm Resolution

Soil Temperature (05, 10, 20, 30, 50, 100 cm Depth)

Soil Moisture (10, 20, 30, 40, 50, 60, 70, 80, 90, 100 cm Depth)

→ Input data for Soil Moisture and Evapotranspiration modelling

Lysimeter Station: Context TERENO SoilCAN
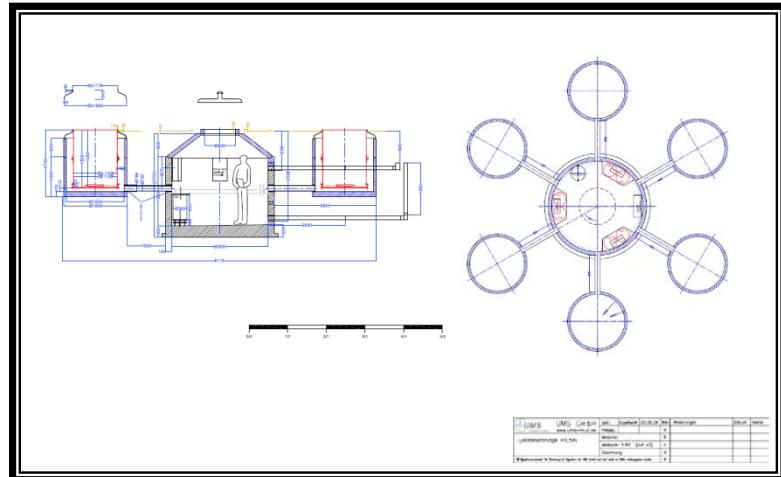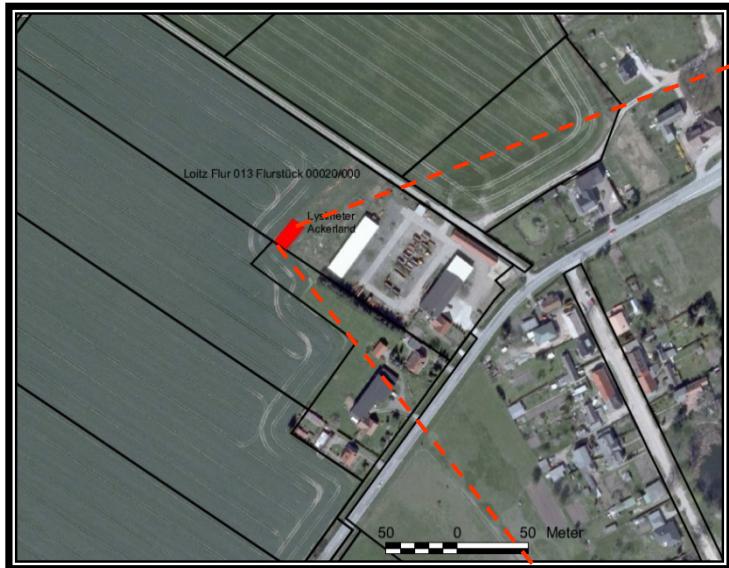
- Automated lysimeter station Rustow –

- 6 medal cylinder filled with undamaged soil monoliths placed on a balance

Von Unold, G. (2011): http://www.ums-muc.de/lysimeter_systeme/lysimeter/meteo_lysimeter.html (last access: 18.08.2013)
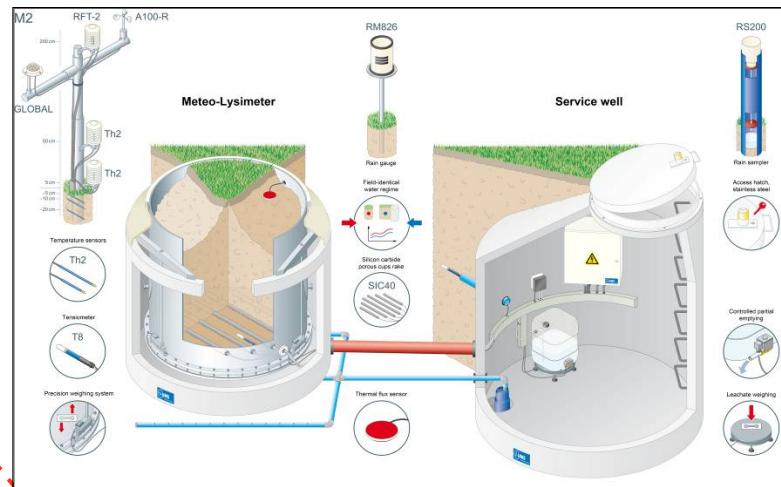
Monitoring of vegetation with research crane

Scope

Derivation of structural components of tree canopies and biophysical parameters within the changing phenology from remote sensing data.

14.04.2012   15.05.2012   15.06.2012   25.07.2012   15.08.2012   23.08.2012   20.09.2012
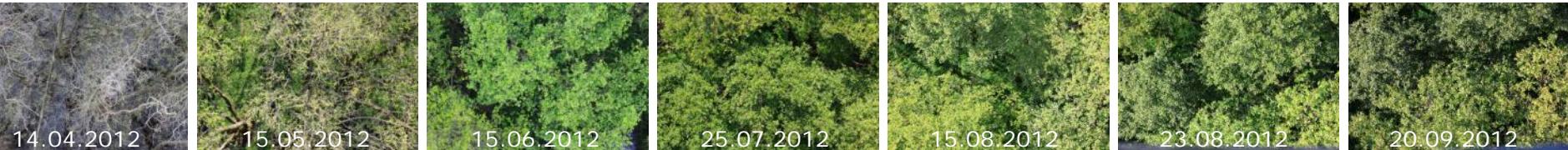
Parameters of interest:

- Crown components (leaf, bark, soil)
- Spectral reflectance,
- Chlorophyll a+b,
- Carotenoid,
- Leaf water content,
- Vitality,
- Leaf area index

Clasen et al. 2015

Biosphere-atmosphere exchange fluxes of heat and GHG

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

Water level and temperatures
Sediment temperatures
Heat flux plates
O_2 sensors

Re-wetted peat land
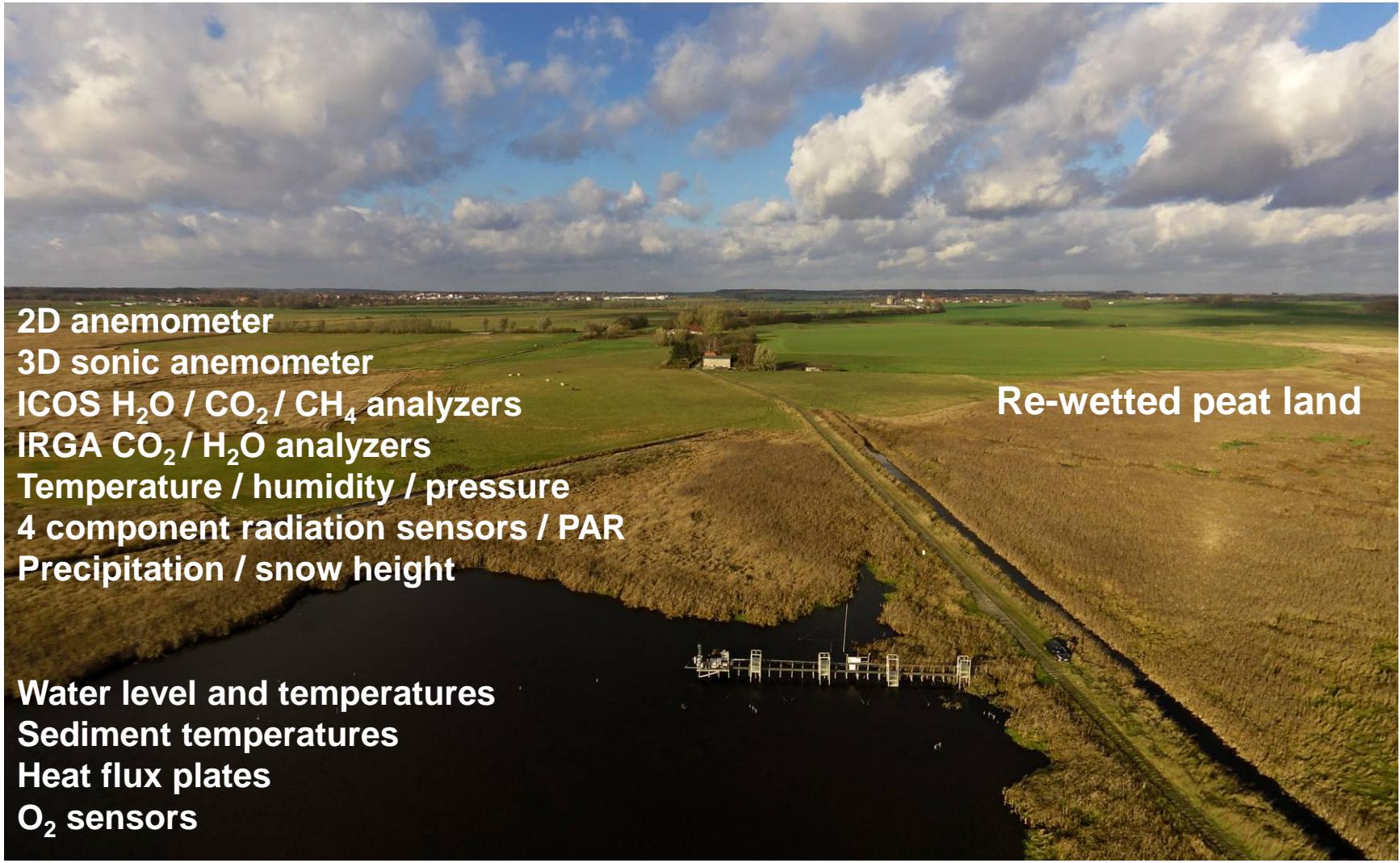
Operative Processing Chain for In-situ-Data
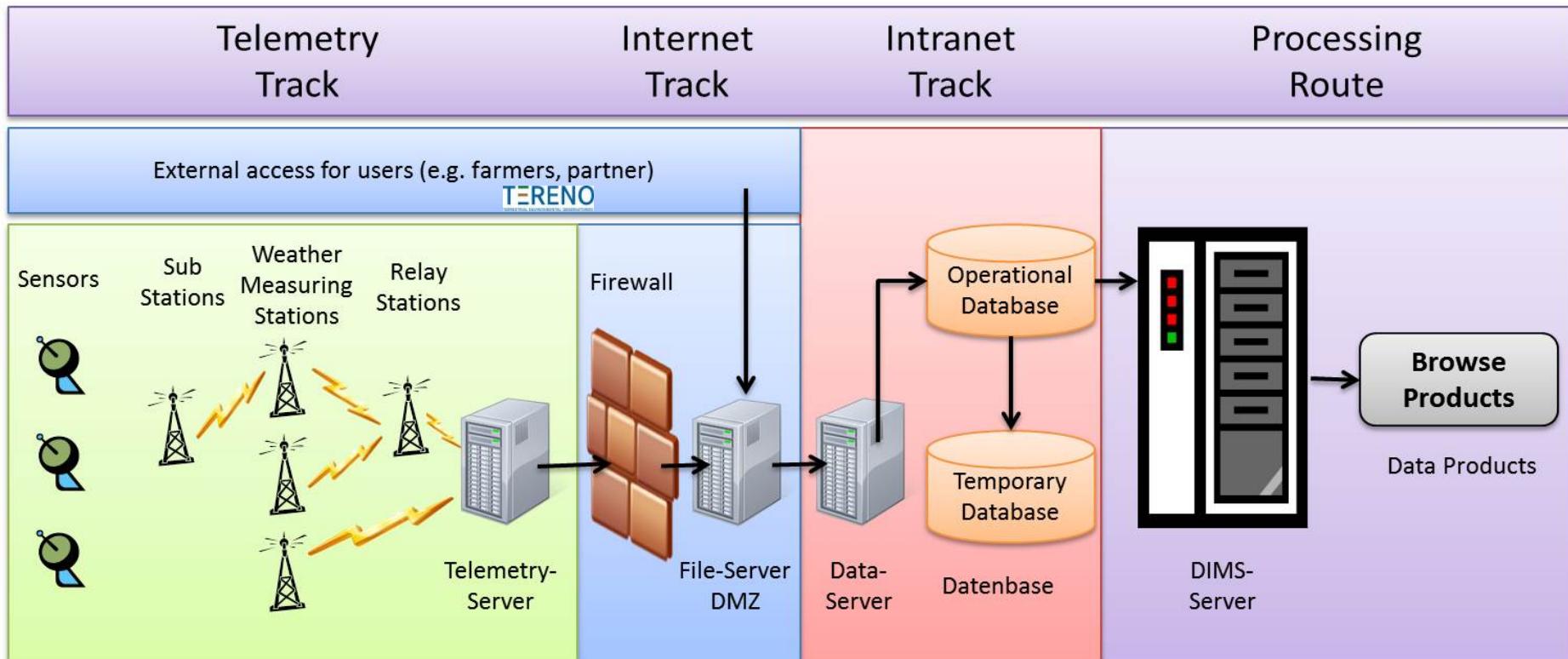
1 Base station + Base station gateway

3 Frequencies

4 Relay-Stations

* 15 ' data interval / Web-based data access

** 1' data interval

Borg, et al. 2014

In-situ-Data Browse Products
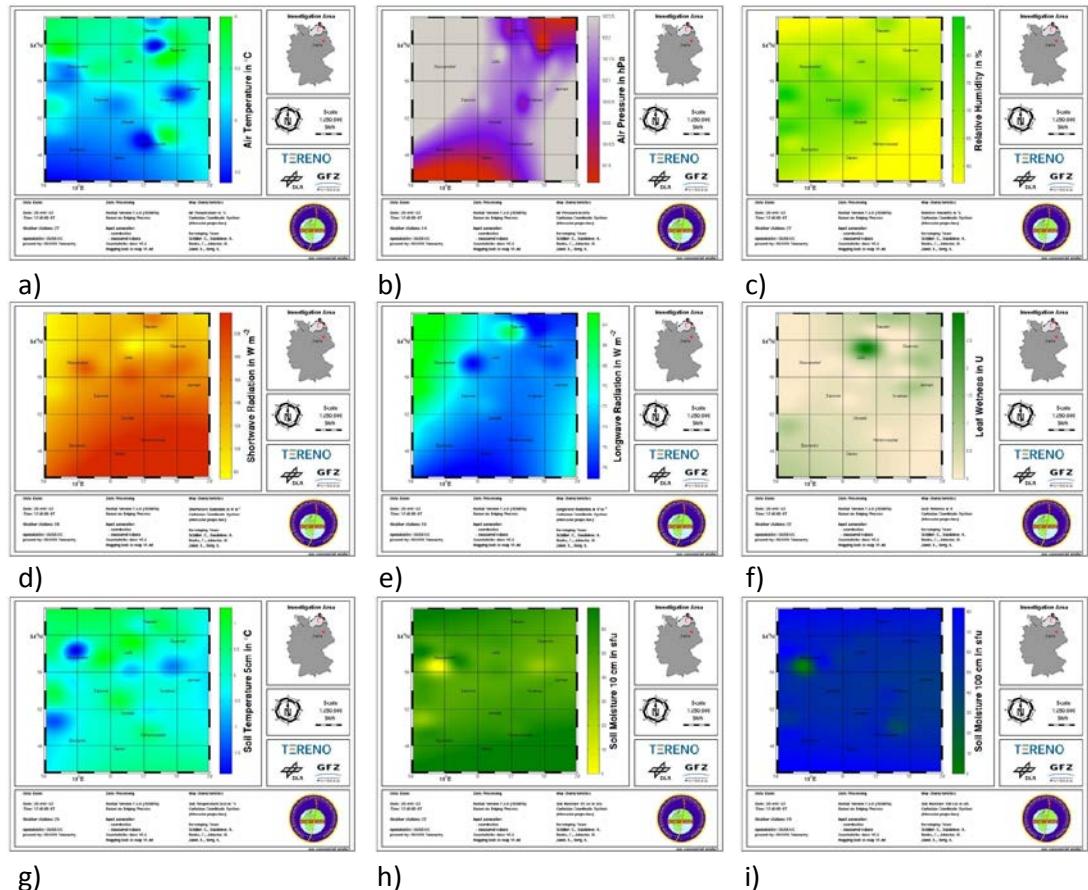
Sample products showing parameter distribution of a) air temperature, b) air pressure, c) relative humidity, d) shortwave, e) longwave radiation, f) leave wetness, g) soil temperature – 5 cm, h) soil moisture – 10 cm, i) soil moisture – 100 cm (http://demminweb.dlr.de)

# Monitoring / Field Campaigns / Experiments

- Measurements of soil and vegetation data at TerraSAR-X data acquisitions

- ASD-spectral measurements

- Soil moisture analysis

- Vegetation parameter (LAI, cover, crop type, phenology, height, chlorophyll, biomass , yield)

- Soil analysis (geophysical measurements, soil parameter)

- Experiments for new sensors/mission (e.g. TET, Sentinel, Landsat)

- Experiments for in-situ equipment

11 day cycle (March – October, 2012 - 2016)

DEMMIN Research Objectives – Interim Recap

DEMMIN Research Objectives – Interim Recap

GFZ Helmholtz Centre POTSDAM DLR

Ground Based	Near Ground
Optical data	
Airborne	Spaceborne

Ground Based	Near Ground
Thermal data	
Airborne	Spaceborne

Airborne	
SAR data	
	Spaceborne

In-situ data

+

Data synthesis, time series analysis
(Co-operation of all DEMMIN partners)

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

Soil surface parameter
(soil organic matter, soil moisture)

Yield Forecast

Method development

Cal/Val Site for airborne and space-borne EO systems

Mesoscale Evapotranspiration Modelling

Soil Pattern Analysis for Organic Matter Determination at Regional Scale (TERENO-NO)

Soil pattern detection at different test fields

Multitemporal remote sensing data
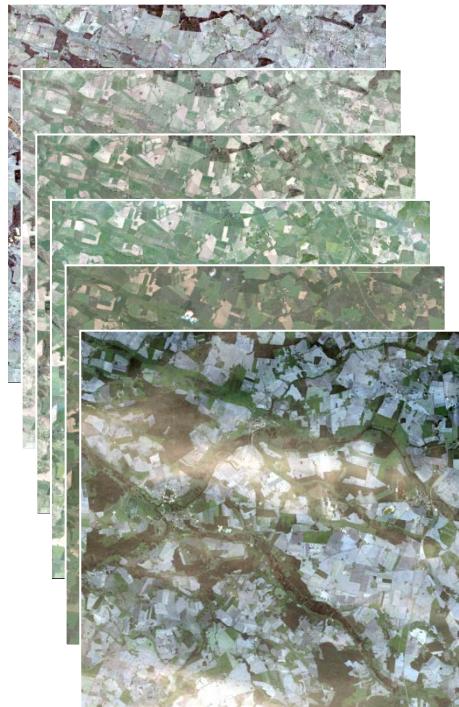
Selection of bare soil fields → Multitemporal synthetic bare soil data
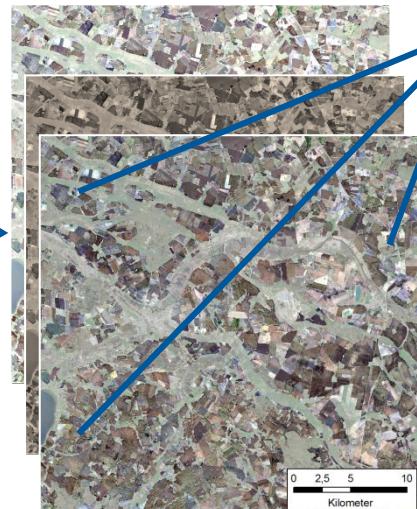
(based on NDVI + in field homogeneity)

RapidEye

Prediction Model p60
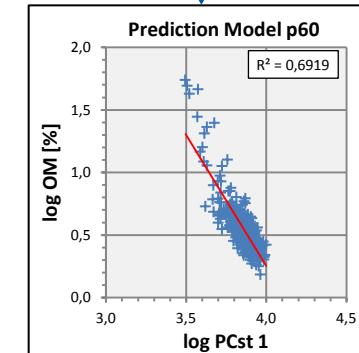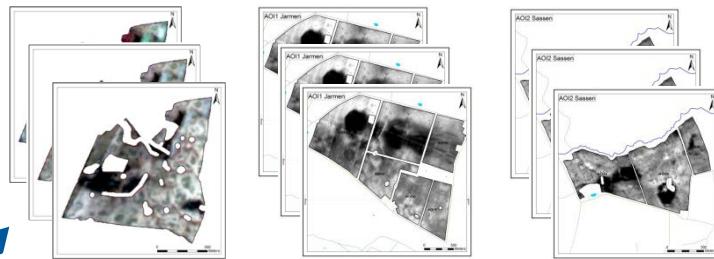
Regional regression model based on laboratory analysis

R²: 0.692; RMSE: 7.487 %
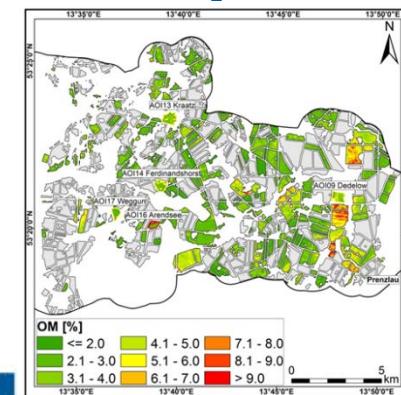
Soil map generation (test site Demmin (Quillow))

OM [%]
- ≤ 2
- 2,01 - 3
- 3,01 - 4
- 4,01 - 8
- 8,01 - 15
- 15,01 - 30
- > 30.01

OM [%]
- <= 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0
- 7.1 - 8.0
- 8.1 - 9.0
- > 9.0

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

Soil Moisture Analysis Based on Multisensoral RS Data

Hyperspectral Data

5D modelling of canopy reflectance with varying soil moisture content

Winter wheat (ripening)
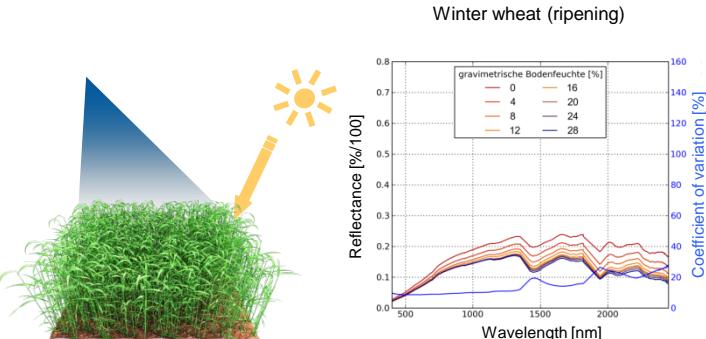
Minimisation influences on of vegetation soil moisture index
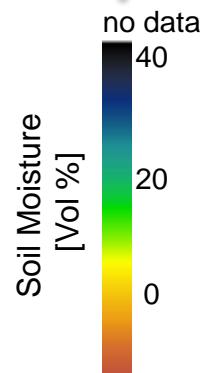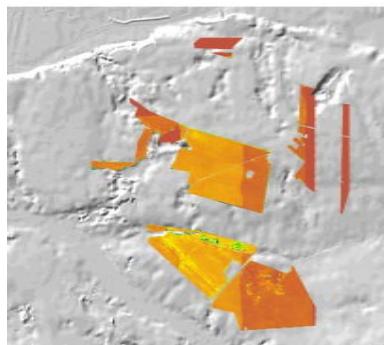
Microwave Data

X-Bragg Model
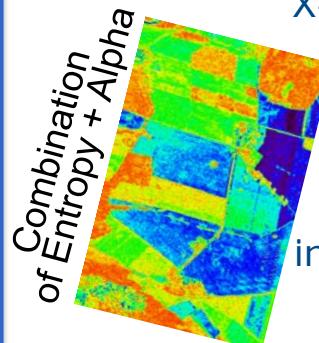
Combination of Entropy + Alpha

Soil moisture inversion after Topp et al.

Soil Moisture [Vol %]

no data
40
20
0
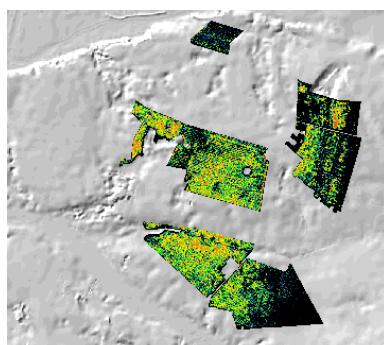
Thermal Data

Combination of multitemporal thermal data with HS data
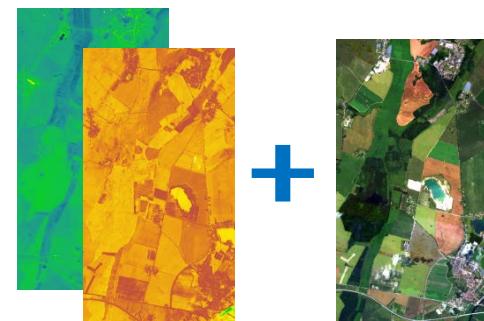
Calculation of Apparent Thermal Inertia for Soil Moisture Estimation

Synergethic Data Analysis, going beyond field scale

Kuester et al. 2014, Spengler et al. 2013

Soil Moisture Modelling
(in cooperation with DWD)

- Measuring of soil moisture under crops
- Simulation of water balance for different depths (METVER)

- Results show higher dynamic compared to field measurements, especially at growing period
- Water is detracted (e.g. transpiration, plant use) before reaching sensors in 50/70cm depth

→ Input data for Evapotranspiration modelling
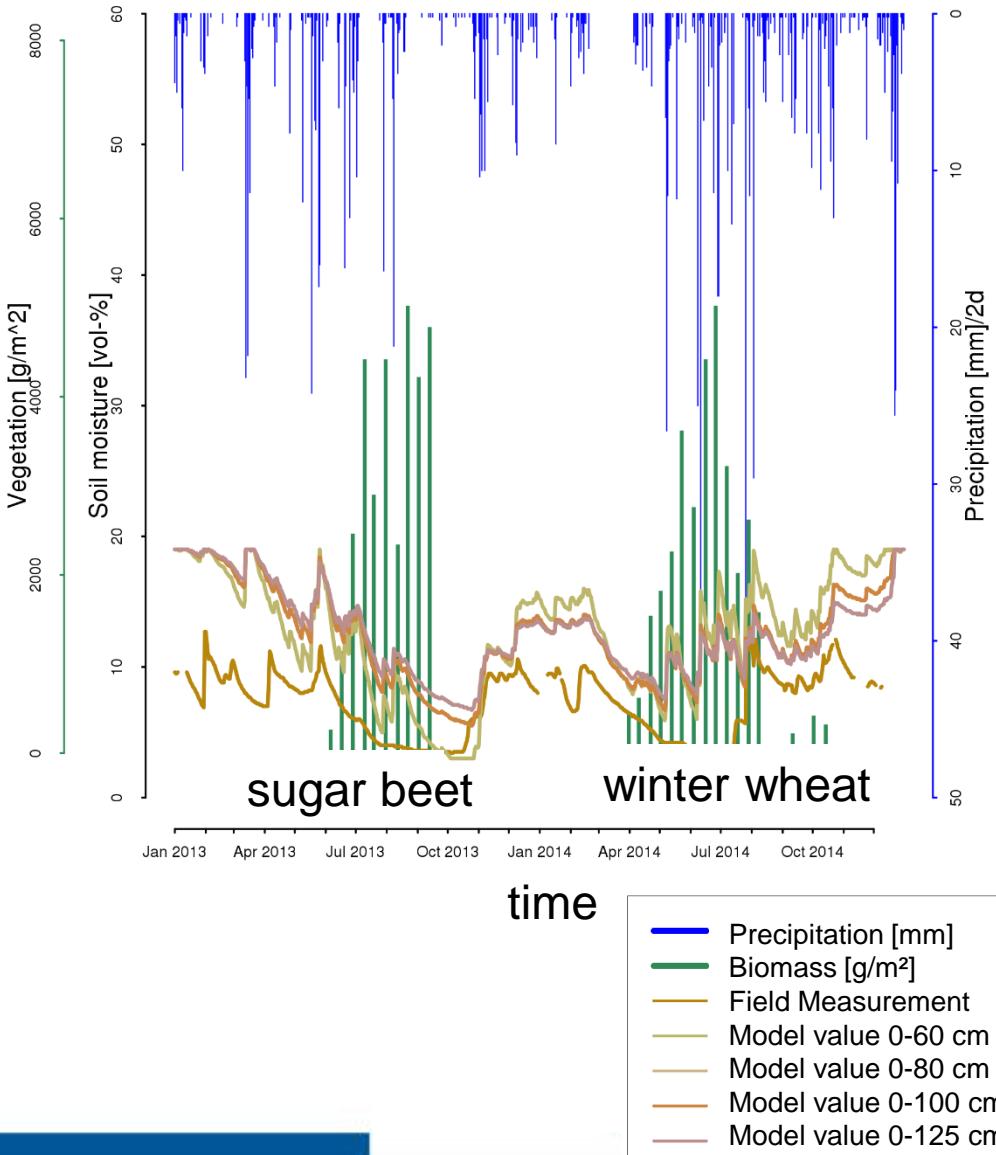
DEMMIN combines in-situ and EO data analysis with expert knowledge (scientist + farmers)

DEMMIN is one of the best observed agricultural areas in Germany (> 100 RS data sets / year)

DEMMIN / TERENO data are free to access via TERENO data portal

DEMMIN welcomes you for joint research
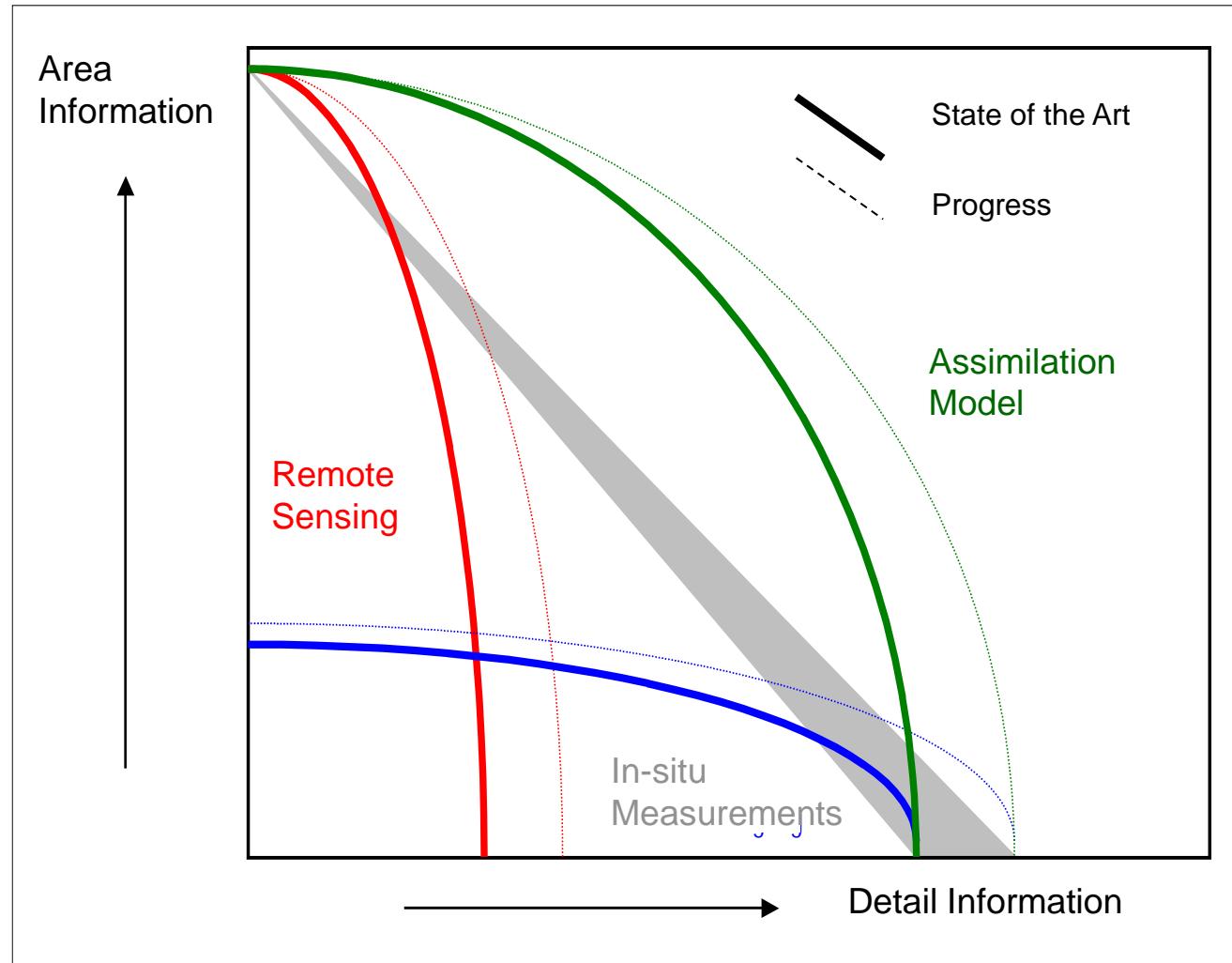
Borg, et al. 1998

Baret, F., Morissette, J., Fernandes, R., Champeaux, J.L., Myneni, R., Chen, J., Plummer, S., Weiss, M., Bacour, C., Garrigues, S. and Nickeson, J.E., 2006. Evaluation of the representativeness of networks of sites for the validation and inter-comparison of land biophysical products. proposition of the CEOS-BELMANIP. IEEE Trans. Geosc. Remote Sens., 44(7): 1794-1803

Blasch, G., Spengler, D., Hohmann, C., Neumann, C., Itzerott, S., Kaufmann, H. (2015): Multitemporal soil pattern analysis with multispectral remote sensing data at the field-scale. - Computers and Electronics in Agriculture, 113, p. 1-13.

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Borg, E.; Lingner, S.; Grunwald, A., 1998: Präventiver Umweltschutz - Potential der Fernerkundung für eine nachhaltige Landnutzung .- In: Spektrum der Wissenschaft, 2(1998).- S.122-125.

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Literature

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Clasen, A., Somers, B., Pipkins, K., Tits, L., Segl, K., Brell, M., Kleinschmit, B., Spengler, D., Lausch, A. and Förster, M. (2015). Spectral Unmixing of Forest Crown Components at Close Range, Airborne and Simulated Sentinel-2 and EnMAP Spectral Imaging Scale. remote sensing, 26.

Conrad, C., Schönbrodt-Stitt, S., Löw, F., Sorokin, D., & Paeth, H. (2016). Cropping Intensity in the Aral Sea Basin and Its Dependency from the Runoff Formation 2000–2012. Remote Sensing, 8(8), 630.

Garrigues, S., Lacaze, R., Baret, F., Morisette, J.T., Weiss, M., Nickeson, J.E., Fernandes, R., Plummer, S., Shabanov, N.V., Myneni, R.B., Knyazikhin, Y., and Yang, W., 2008. Validation and intercomparison of global Leaf Area Index products derived from remote sensing data. J. Geophys. Res., 113, G02028: doi:10.1029/2007JG000635

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Von Unold, G. 2011): http://www.ums-muc.de/lysimeter_systeme/lysimeter/ meteo_lysimeter.html (last access: 18.08.2013

Thank you very much for your attention

**D. Spengler[1], E. Borg[2], F. Renke[2], C. Conrad[3], C. Hohmann[1], T. Sachs[1], S.Itzerott[1]**

Contacts   daniel.spengler@gfz-potsdam.de, erik.borg@dlr.de, sibylle.itzerott@gfz-potsdam.de

Affilitation   [1] *Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences*
[2] *German Aerospace Center (DLR)*
[3] *Julius-Maximilians-University Würzburg*

Why do we need a calibration and validation test site for Earth observation?

Remote Sensing includes diverse e.g. platforms, sensors, methods for interpretation

There is an urgent requirement for in-situ-data for validation of value added data

Cal-val of remote sensing requires numerous environmental parameters

Requirement for operationally measured cost- and labour-effective in-situ-data
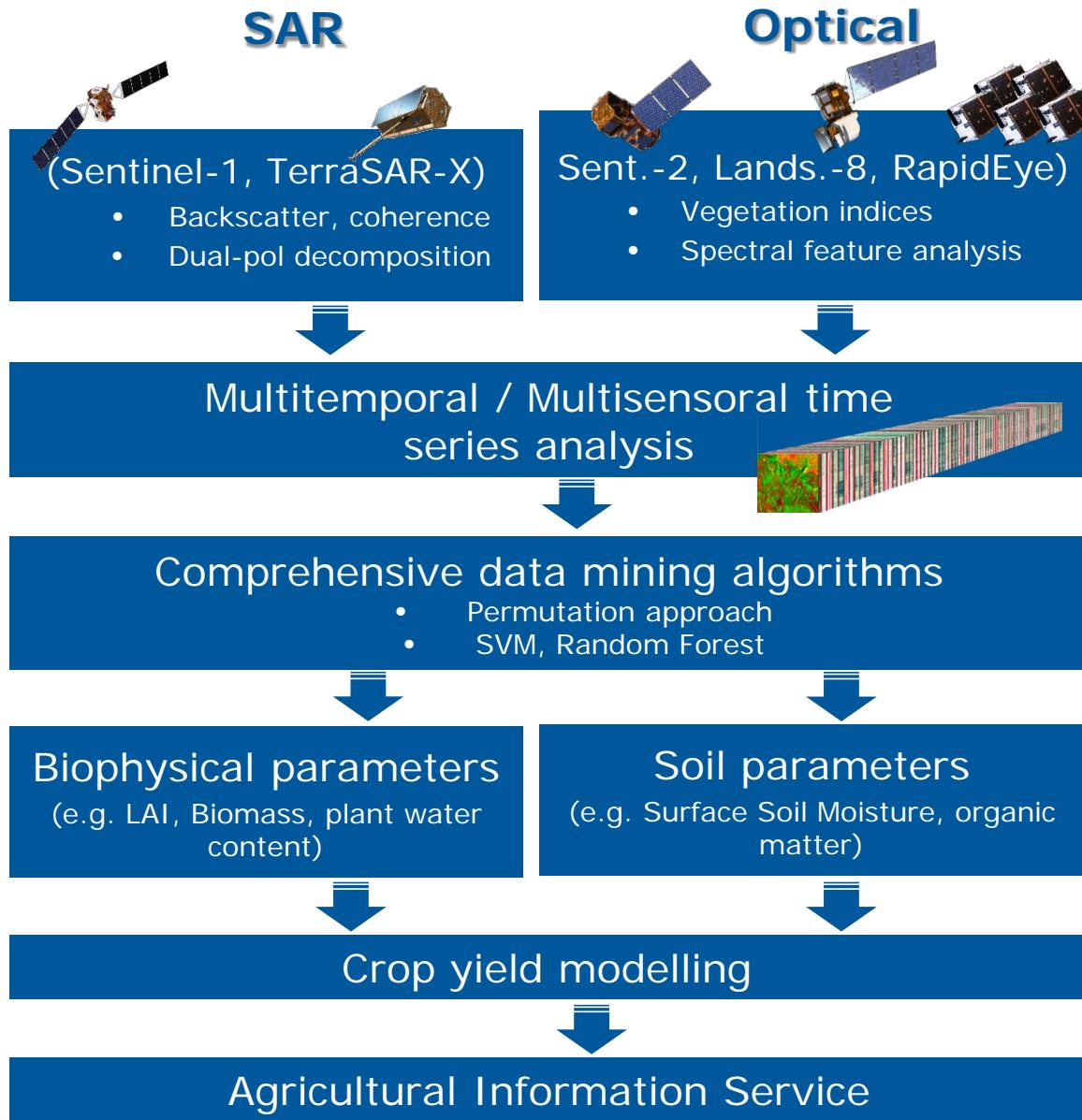
GFZ Helmholtz Centre POTSDAM   **DLR**

Performed / Planned Cooperations:

- **TERENO**   http://www.tereno.net,
- **ESA**   ftp://pcf:Ciqcsp01@uranus.esrin.esa.int/PH/Deliverables/,
- **NEREUS**   http://www.nereus-regions.eu/home,
- **USGS**   http://calval.cr.usgs.gov/sites_catalog_template.php?site=demm,
- **SMOS**   Soil Moisture and Ocean Salinity
- **TerraSAR-X, Tandem-X, Sentinel-1, Tandem-L, LANDSAT 8, SMAP, TET**
- **JECAM**

Performed / Planned Cooperations:

- **AGRISAR 2006 / Eagle 2006:**
  - Objective: assessment of Sentinel missions-1 /-2 and improving of interpretation methods for radar and optical data, generation of in-situ and airborne data (weekly), simulation of prospective sentinel data and information products
  - Partner: >15 national and internationsl research centers.
- **TERENO (SoilCAN)**
  - Objective: Measurement and documentation of climate-relevant parameters , climate research and climate impact consulting for regional development of climate-sensitive regions
  - Partner: 6 research centers (e.g. Research Center Jülich – FZJ, Helmholtz Centre for Environmental Research – UFZ, Karlsruhe Institute of Technology – KIT, German Research Centre for Geosciences – GFZ, German Aerospace Center - DLR) and partners.
- **TechnologieErprobungsTraeger (TET) 2013:**
  - Objective: Validation of the fire detection system onboard the TET Mission
- **PHENOS (funded by Federal Ministry of Economics and Energy (BMWi), DLR Project Management Agency):**
  - Objective: development and validation of algorithms / models for the operational detection of optimal phenological time slots for an cost optimized land use classification for Sentinel 2 data
- **Tech4Times (funded by Federal Ministry of Economics and Energy (BMWi), DLR Project Management Agency):**
  - Objective: Development of remote sensing based value added products for sustainable agriculture.