DEMMIN

Durable Environmental Multidisciplinary Monitoring Information Network -

Agricultural Research at the TERENO German Northeastern Lowlands Observatory

D. Spengler¹, E. Borg², F. Renke², C. Conrad³, C. Hohmann¹, T. Sachs¹, S. Itzerott¹

¹ Helmholtz-Centre Potsdam - GFZ German Research Centre for Geosciences
² German Aerospace Center (DLR)
³ Julius-Maximilians-University Würzburg
Background – Agricultural Production

Conrad et al. (2014)
Background - Cropping Intensity as Indicator for Agricultural Production

Conrad et al. (2014)
Open Issues of Remote Sensing

Information requirements of users:
• Repetition rate is often to low for time-critical applications,
• Duration of processing of value added product is often too 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
Test sites for Remote Sensing

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)

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 %

DEMMIN is part of TERENO – German Nort-Eastern Lowlands Observatory
Free data access via TERENO data portal: http://teodoor.icg.kfa-juelich.de
(GFZ stations)
Durable Environmental Multidisciplinary Monitoring Information Network (DEMMIN)

- 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
Formation of observatory DEMMIN with respect to landscape zones

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

Landscape Zones

Hinterland of Mecklenburg lake district
- hilly country / ground moraine

Pommeranian Lowlands
- flat country / end moraine

Legende

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Borg et al. (2009)
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
Environmental measurement stations

- Remote Telemetry Unit & Transmitter
- Air Temperature / Air Moisture
- Incident and reflected solar Radiation (310-2800 nm)
- Rain Gauge 0.2 mm Resolution
- Soil Temperature (0.5, 10, 20, 30, 50, 100 cm Depth)
- Soil Moisture (10, 20, 30, 40, 50, 60, 70, 80, 90, 100 cm Depth)
- Wind Speed / Wind Direction
- Energy Supply / Solar Set (9V 460 mAh)
- WET Leaf Wetness
- Incident and emitted thermal Radiation (310-2800 nm)
- Barometric Pressure (500-1500 mbar)

Soil moisture network

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

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.

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 H₂O / CO₂ / CH₄ analyzers
- IRGA CO₂ / H₂O analyzers
- Temperature / humidity / pressure
- 4 component radiation sensors / PAR
- Precipitation / snow height

- Water level and temperatures
- Sediment temperatures
- Heat flux plates
- O₂ sensors

Re-wetted peat land
# Operative Processing Chain for In-situ-Data

<table>
<thead>
<tr>
<th>Telemetry Track</th>
<th>Internet Track</th>
<th>Intranet Track</th>
<th>Processing Route</th>
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</thead>
<tbody>
<tr>
<td>Sensors + Sub Stations</td>
<td>Weather Measuring Stations</td>
<td>Relay Stations</td>
<td>External access for users (e.g. farmers, partner)</td>
</tr>
<tr>
<td>Telemetry-Server</td>
<td>Firewall</td>
<td>Operational Database</td>
<td>Browse Products</td>
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<tr>
<td>File-Server DMZ</td>
<td>Data-Server</td>
<td>Temporary Database</td>
<td>Data Products</td>
</tr>
<tr>
<td>DIMS-Server</td>
<td></td>
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</tbody>
</table>

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
Sample products showing parameter distribution of a) air temperature, b) air pressure, c) relative humidity, d) shortwave, e) longwave radiation, f) leaf 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

**Optical data**
- Airborne
- Spaceborne

**Thermal data**
- Airborne
- Spaceborne

**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**

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

**Method development**

**Mesoscale Evapotranspiration Modelling**
DEMMIN Research Objectives – Interim Recap

**Optical data**
- Ground Based
- Near Ground
- Airborne
- Spaceborne

**Thermal data**
- Ground Based
- Near Ground
- Airborne
- Spaceborne

**SAR data**
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**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)

Multitemporal remote sensing data

Selection of bare soil fields → Multitemporal synthetic bare soil data

RapidEye

Soil pattern detection at different test fields

Regional regression model based on laboratory analysis

\[ R^2: 0.692; \ RMSE: 7.487\% \]

Soil map generation (test site Demmin)

Blasch et al. 2015(1), Blasch et al. 2015(2)
Soil Moisture Analysis Based on Multisensornal RS Data

**Hyperspectral Data**
5D modelling of canopy reflectance with varying soil moisture content

**Microwave Data**
X-Bragg Model

**Thermal Data**
Combination of multitemporal thermal data with HS data

Minimisation of vegetation influences on soil moisture index

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


Literature


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. Spengler¹, E. Borg², F. Renke², C. Conrad³, C. Hohmann¹, T. Sachs¹, S. Itzerott¹

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

Affiliation 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

Borg, Fichtelmann (2014)
Data Uses

**SAR**
- (Sentinel-1, TerraSAR-X)
  - Backscatter, coherence
  - Dual-pol decomposition

**Optical**
- Sent.-2, Lands.-8, RapidEye)
  - Vegetation indices
  - Spectral feature analysis

**Multitemporal / Multisensoral time series analysis**

**Comprehensive data mining algorithms**
- Permutation approach
- SVM, Random Forest

**Biophysical parameters**
- (e.g. LAI, Biomass, plant water content)

**Soil parameters**
- (e.g. Surface Soil Moisture, organic matter)

**Crop yield modelling**

**Agricultural Information Service**
Performed / Planned Cooperations:

- **TERENO** [http://www.tereno.net](http://www.tereno.net),
- **ESA** [ftp://pcf:Ciqcsp01@uranus.esrin.esa.int/PH/Deliverables/](ftp://pcf:Ciqcsp01@uranus.esrin.esa.int/PH/Deliverables/),
- **NEREUS** [http://www.nereus-regions.eu/home](http://www.nereus-regions.eu/home),
- **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 international 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.