THE GERMAN JECAM SITE DEMMIN – STATUS AND FUTURE PERSPECTIVES.


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

Taichung City, Taiwan
17-20 September, 2018
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%

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

Free data access via TERENO data portal:
http://teodoor.icg.kfa-juelich.de
CURRENT OVERARCHING MAIN RESEARCH GOAL(S)

**Remote Sensing**
- Optical data
- Thermal data
- SAR data

**In-situ data**
- DEMMIN detwork data
- External 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)
**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)
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)

DATA free available with DOI via GFZ data services
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 (05, 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 modelling
Planning of DEMMIN Eddy Flux Tower at Cropland

Eddy Flux Tower
Monitor GHG fluxes
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

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

Globally validation sites (e.g. DEMMIN)
HYPERNETS Consortium (RBINS, TARTU, LOV, CNR, NPL, GFZ, CONICET)
## Earth Observation (EO) Data Received/Used

<table>
<thead>
<tr>
<th>Missions</th>
<th>Space Agency / Supplier</th>
<th>Optical / Thermal / SAR</th>
<th>Number of Scenes</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentinel-1</td>
<td>ESA</td>
<td>SAR</td>
<td>~ 120/ year</td>
<td></td>
</tr>
<tr>
<td>Sentinel-2</td>
<td>ESA</td>
<td>Optical</td>
<td>~ 15-30 cloud free scenes</td>
<td>clouds</td>
</tr>
<tr>
<td>RapidEye</td>
<td>Planet</td>
<td>Optical</td>
<td>~ 10-15 cloud free scenes</td>
<td>clouds</td>
</tr>
<tr>
<td>Landsat-8</td>
<td>USGS</td>
<td>Optical / Thermal</td>
<td>~ 5-10 cloud free scenes</td>
<td>clouds</td>
</tr>
<tr>
<td>Radarsat-2</td>
<td>CSA</td>
<td>SAR</td>
<td>~ not analysed so far</td>
<td></td>
</tr>
<tr>
<td>Hyperspectral airborne</td>
<td>GFZ</td>
<td>Optical / Thermal</td>
<td>~ 1-2/ year</td>
<td></td>
</tr>
<tr>
<td>UAV</td>
<td>GFZ</td>
<td>Optical / Thermal</td>
<td>~ 1-2/ year</td>
<td></td>
</tr>
</tbody>
</table>
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 every 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Equipment/ Method</th>
<th>Sampling frequency per SSU</th>
<th>SSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency per SSU</td>
<td>2018 DEMMIN 2.0</td>
<td>10</td>
<td>Only 1, 3, 5, 7, 9</td>
</tr>
<tr>
<td>Hyperspectral data *</td>
<td>ASD FieldSpec</td>
<td>5</td>
<td>Only 1, 3, 5, 7, 9</td>
</tr>
<tr>
<td>SpectralEvolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerosol optical thickness *</td>
<td>Sun photometer</td>
<td>1</td>
<td>Only at 5</td>
</tr>
<tr>
<td>Cloud coverage</td>
<td>Digital camera</td>
<td>1</td>
<td>Only at 5</td>
</tr>
<tr>
<td>Landscape photos</td>
<td>Digital camera</td>
<td>4</td>
<td>Only at 5</td>
</tr>
<tr>
<td>Fractional vegetation cover</td>
<td>Digital camera</td>
<td>2</td>
<td>All</td>
</tr>
<tr>
<td>Prop. of senescent material</td>
<td>Digital camera</td>
<td>2</td>
<td>All</td>
</tr>
<tr>
<td>Fractional vegetation cover</td>
<td>Estimate</td>
<td>4 x 1</td>
<td>All</td>
</tr>
<tr>
<td>Prop. of senescent material</td>
<td>Estimate</td>
<td>4 x 1</td>
<td>All</td>
</tr>
<tr>
<td>Canopy height</td>
<td>Folding ruler</td>
<td>4</td>
<td>All</td>
</tr>
<tr>
<td>Photo of board</td>
<td></td>
<td>2</td>
<td>All</td>
</tr>
<tr>
<td>Leaf Area Index</td>
<td>LI-COR LAI-2200</td>
<td>4 x ABBBB</td>
<td>All</td>
</tr>
<tr>
<td>Biomass (all)</td>
<td>Gravimetrical</td>
<td>1 quadrat</td>
<td>All</td>
</tr>
<tr>
<td>Leaf chlorophyll content</td>
<td>SPAD-502Plus</td>
<td>4 + 3+ 3</td>
<td>All</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>HH2 moisture meter</td>
<td>5</td>
<td>All</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>Gravimetrical</td>
<td>5</td>
<td>Only at 5</td>
</tr>
<tr>
<td>Soil roughness</td>
<td>Pin profiler</td>
<td>4 (45°)</td>
<td>Only at 5 (1 per year)</td>
</tr>
<tr>
<td>Orientation of planting rows</td>
<td>Compass</td>
<td>1</td>
<td>Only at 5 (1 per year)</td>
</tr>
<tr>
<td>Row spacing</td>
<td>Folding ruler</td>
<td>5</td>
<td>Only at 5 (1 per year)</td>
</tr>
<tr>
<td>Stems per plant</td>
<td>Counting</td>
<td>5</td>
<td>Only at 5 (1 per year)</td>
</tr>
<tr>
<td>Phenology</td>
<td>BBCH-scale</td>
<td>3 (x students)</td>
<td>All</td>
</tr>
</tbody>
</table>
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


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

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)

FPAR
$R^2 = 0.93$
$RMSE = 0.08$

LAI
$R^2 = 0.91$
$RMSE = 0.67$

• 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 temperature -> ET = 0
  – High vegetation index, low temperature, -> 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

in development
DETERMINATION OF SOIL PARAMETER –
(SURFACE ORGANIC MATTER CONTENT)

Multitemporal remote sensing data

Selection of bare soil fields
Multitemporal synthetic bare soil data

Regional regression model based on laboratory analysis

Soil map generation
(test site Demmin)

Soil pattern detection at different test fields

R²: 0.692; RMSE: 7.487 %

Prediction Model p60

(based on NDVI + in field homogeneity)

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

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