LINKING SPATIAL AND TEMPORAL SUN-INDUCED FLUORESCENCE PATTERNS TO SOIL AND ATMOSPHERIC PROPERTIES IN A HETEROGENEOUS AGRICULTURAL LANDSCAPE

Vegetation:
- alive functional layer
- reacts to environment

We need a **measurement parameter** to understand functioning of vegetation layer at certain moment.
The weak fluorescence signal can be quantified under sun light conditions using the atmospheric oxygen absorption bands (\(O_2\)-A at 760 nm; \(O_2\)-B at 687 nm) and Fraunhofer lines.

**Vegetation parameters and traits**

Biophysical vegetation parameters, such as LAI, Chl content, water content, etc. can be approximated from different Vegetation Indices (calculated from Reflectance). Most of them do not reflect momentary plant status.
SMALL SCALE – 1 M² CANOPY

SFluorBox instrument – continuous measurements of $F_{760}$ and reflectance

SFluorBox installed on ICOS EC-tower in Selhausen

Day courses of $F_{760}$ and NDVI

Daily courses of $F_{760}$ reflect plant photosynthetic activity, in opposite to NDVI index

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REFLECTANCE AND FLUORESCENCE MEASUREMENTS

Airborne data of Rur catchment:
high-performance imaging spectrometer HyPlant

Dedicated fluorescence spectrometer

Spectral ranges:
- 380–970 nm, FWHM 2.6-3.5 nm
- 970–2500 nm, FWHM 8.0-10.4 nm
- 670–780 nm, FWHM 0.2 nm

Spatial resolution:
- 1 m
- 3 m
EXAMPLES OF VI AND FLUORESCENCE MAPS

NDVI

EVI

(All not-vegetated pixels are masked out)
EXAMPLES OF VIS AND FLUORESCENCE MAPS

\[ F_{687} \quad F_{760} \]
ANALYSIS ON THE BIG SCALE

Example: Distribution of mean $F_{760}$ for different crops

- **Green dense canopy** – normal distribution
- **Mixture of different potato varieties** (green and senescent fields) – superposition of few distributions

**Growth phase** – asymmetric distribution

- **Sugar beet**
- **Corn**
- **Potato**

Graphs showing the distribution of $F_{760}$ for different crops with corresponding counts over time.

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ANALYSIS ON THE BIG SCALE

Example: Distribution of mean $F_{760}$ for different crops

Information about structural and photosynthetic state

- **Corn**
  - Growth phase – asymmetric distribution

- **Potato**
  - Mixture of different potato varieties (green and senescent fields) – superposition of few distributions

- **Sugar beet**
  - Green dense canopy – normal distribution

- **Early potato**

- **Sugar beet**

- **Corn**

- **Measurement vs. time**

- **SR vs. time**

- **$mW \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$**

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LINK BETWEEN ATMOSPHERE AND PLANT STATUS

JOYCE measurements and Land Use classification

Regional map with a footprint of JOYCE passive microwave radiometer (TOPHAT)
Retrieval of
- integrated water vapor (IWV),
- cloud liquid water path (LWP),
- tropospheric temperature profiles

Distribution of active vegetation and other land use classes over the area monitored by TOPHAT
IWV distribution value is not static: changes over the day. Hypotheses:

- Pit mine management?
- Atmosphere mixing?
- Vegetation reaction to stress? (stomata closing during midday)?

More information about integrated water vapor measurements by TOPHAT and also on data from MERIS satellite:

POSTER T. Marke
LINK BETWEEN SOIL PROPERTIES AND PHOTOSYNTHESIS

EMI and ECa measurements → depth-specific electrical conductivity (water holding capacity)

Airborne hyperspectral measurements →
NDVI, $F_{760}$ and $F_{680}$

<table>
<thead>
<tr>
<th>Correlation r</th>
<th>$\sigma_1$ (0.1-0.3 m)</th>
<th>$\sigma_2$ (0.3-1.0 m)</th>
<th>$\sigma_3$ (&gt;1 m)</th>
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</thead>
<tbody>
<tr>
<td>NDVI</td>
<td>0.25</td>
<td>0.45</td>
<td>0.72</td>
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<tr>
<td>$F_{687}$</td>
<td>0.18</td>
<td>0.36</td>
<td>0.62</td>
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<tr>
<td>$F_{760}$</td>
<td>0.35</td>
<td>0.62</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Correlation between plant physiological status with deeper soil layers properties

Presentation of Ch. Von Hebel
SUMMARY AND CONCLUSIONS

- The heterogeneity of fluorescence (F) and vegetation indices (VIs) between fields was evaluated.

- Broader distributions are caused by structural effects (growing canopies) or canopy senescence.

- No clear correlation between atmosphere and vegetation indices at 06.06.2014.

**Outlook:**

- To add fluorescence signal (data from 2018).

- Correlation between plant physiological status with sub-soil properties was found.

**Outlook:**

- Other crops
- Other phenological state