Towards remote sensing of vegetation processes

Soukupová et al., 2008

10-Feb 6-Apr 24-May 14-Jun 25-Oct 15-Dec 23-Mar
The highest atmospheric CO$_2$ concentration in the last 800 000 years
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Carbon Flux Monitoring

Source-Sink

Canopy scale

Regional-global scale

Leaf scale
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**Leaf reflectance & steady-state fluorescence (Fs) measurements**

- **Fagus sylvatica**
  - Dark adapted
  - Light adapted
  - Difference (300s)

- Zeaxanthin (532 nm)
- PSII emission (688, 742 nm)

**Vegetation 'process-related' remote sensing (RS)**

- Dissipation into heat (D)
- Chla\(^*\) → Fluorescence (F)
- Photochemical charge separation (P)

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**STEADY-STATE FLUORESCENCE**
To investigate the information content in annual changes of steady-state chlorophyll fluorescence yield (Fs) of evergreen plant species, as being a passively remotely sensed signal.
EXPERIMENT 1

METHODOLOGY

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FLUORCAM (CCD fluorescence camera)

Rhododendron x hybridum

Picea omorika

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EXPERIMENT 1

RESULTS

**Picea omorika**

**Rhododendron x hybridum**
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EXPERIMENT 2

OBJECTIVES

① To test sensitivity of the AISA Eagle VNIR imaging spectroradiometer for sensing the grassland and spruce canopy fluorescence signals.

② To investigate potential relationships between ‘process-related’ vegetation optical indices and eddy-covariance flux parameters.
Airborne Imaging Spectrometer for Applications (AISA Eagle) => *spatial* and *temporal* distribution of the vegetation optical indices.
Eddy-covariance system measures exchange of CO$_2$ and H$_2$O between air and ecosystem canopy resulting in following parameters:

- **NEE** – Net Ecosystem Exchange
- **GPP** – Gross Primary Production
- **R** – Respiration
- **RUE** – Radiation Use Efficiency ($= \text{NEE}/\text{PPFD}$)
- **gRUE** – gross Radiation Use Efficiency ($= \text{GPP}/\text{PPFD}$)
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EXPERIMENT 2

RESULTS i.

Vegetation indices used:

\[
PRI = \frac{(R_{532} - R_{570})}{(R_{532} + R_{570})};
\]

\[
R_{688}/R_{630} \text{ and } R_{740}/R_{800}
\]
Pearson correlation coefficients between eddy-flux physiological parameters and ‘process-related’ VIs (grassland and forest data sets analyzed together):

<table>
<thead>
<tr>
<th>VIs</th>
<th>Respiration</th>
<th>GPP</th>
<th>NEE</th>
<th>gRUE</th>
<th>RUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRI</td>
<td>-0.51</td>
<td>0.16</td>
<td>0.25</td>
<td>0.61</td>
<td>0.52</td>
</tr>
<tr>
<td>$R_{686}/R_{630}$</td>
<td>0.15</td>
<td><strong>0.93</strong></td>
<td><strong>0.91</strong></td>
<td>-0.45</td>
<td>-0.73</td>
</tr>
<tr>
<td>$R_{740}/R_{800}$</td>
<td>0.59</td>
<td>0.33</td>
<td>0.22</td>
<td>-0.93</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Towards remote sensing of vegetation physiological processes using fluorescence signals.
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**REFLECTANCE PARAMETERS**

(LED light source at 644 nm & 760 nm)

\[ \text{NDVI} = \frac{R_{760} - R_{644}}{R_{760} + R_{644}} \]

(LED light source at 531 nm & 570 nm)

\[ \text{PRI} = \frac{R_{531} - R_{570}}{R_{531} + R_{570}} \]

**FLUORESCENCE PARAMETERS**

(LED light source at 470 nm)

\[ F(t) \] – fluorescence at any time

\[ \frac{F_v}{F_m} \] – quantum efficiency of fluorescence

\[ F_s \] – steady-state fluorescence

**REFLECTANCE PARAMETERS**

(LED light source at 644 nm & 760 nm)

\[ \text{NDVI} = \frac{R_{760} - R_{644}}{R_{760} + R_{644}} \]

(LED light source at 531 nm & 570 nm)

\[ \text{PRI} = \frac{R_{531} - R_{570}}{R_{531} + R_{570}} \]

A wide range of **two chips** light emitting diodes (LED’s) as light sources and very sensitive PIN diode sensor allows to construct network of pocket size devices measuring nearly any combination of reflectance and fluorescence parameters.
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OUTLOOK

MULTI-SCALE MONITORING

- Satellite data
- Airborne data
- Watchtower observation
- Ground observation

/spatial resolution/

AISA Eagle

Fs & QY  NDVI  PRI
Chlorophyll steady-state fluorescence is an accurate indicator of the active vegetation season for evergreens.

Fluorescence related optical indices of canopy reflectance can be related with the vegetation radiation use and productivity.

Correct interpretation of the steady-state fluorescence signal needs an appropriate leaf-canopy up scaling approach, based on a joint ground and remote sensing monitoring network.
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QUESTIONS?

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**Beans**

- **LL**: 100 μM photon m\(^{-2}\) s\(^{-1}\)
- **ML**: 350 μM photon m\(^{-2}\) s\(^{-1}\)
- **HL**: 650 μM photon m\(^{-2}\) s\(^{-1}\)

**Experiment**

- **Imaging fluormeter**
- **Fluor-pen**

The bar chart shows the comparison between imaging fluormeter and Fluor-pen under different light levels (LL, ML, HL). The results indicate variations in fluorescence measurements under different illumination conditions.