Exploiting top of Canopy Sun Induced Chlorophyll Fluorescence by the FloX. From Instrument performance to data processing

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JB Hyperspectral Devices - brief history

- **2005**: ESA-CEFLES2
- **2007**: ESA-SEN3EXP
- **2009**: ESA-fluorescence
- **2010**: ESA-HyFLEX
- **2011**: ESA-SEN2EXP
- **2012**: F-Bus
- **2013**: Founding of JB Hyperspectral Devices
- **2016**: Middle of 2016
JB Hyperspectral Devices is a start-up company founded in 2016 and based in Düsseldorf, Germany. The primary working focus is the design and production of an advanced and unique hyperspectral field instrument for the passive measure of Sun Induced chlorophyll Fluorescence (SIF) using atmospheric absorption lines.

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<th>FloX system</th>
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**Intro**

**Products**

**FloX system**

**Data Processing**

**Examples**

**AirFloX**

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**Andreas Burkart**

**Tommaso Julitta**

**Paul Näthe**
Field system for the continuous measurement of solar radiance and reflected radiance. Due to the 2 internal spectrometers FloX is used to measure the Sun Induced Chlorophyll Fluorescence plus and hyperspectral reflectance.

Field system for the continuous measurement of solar radiance and reflected radiance. The VIS Nir reflectance is used for optical monitoring of vegetation, water, snow and atmosphere.

Active panel for field use mimicking the emission of the chlorophyll fluorescence. Used in field calibration and instrument check.
FloX system specifications

**Size**

Weight: 12 kg  
Dimensions: 57 X 38 X 24 (cm)

**Consumption**

**Day time - switch** (8 am - 8 pm)  
12 V DC (10 to 14 V)  
100 Watts (peak with full active cooling)  
60 Watts (average)  
**Night time**  
1 Watt

**Data storage**

32 GB sd card is used for backup.  
(about a year of autonomy)

**Data stream**

Embedded PC for daily data stream and system functioning check,  
Connectivity based on LTE network or LAN for internet access
## FloX system specifications

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<th>Feature</th>
<th>Fluo Range spectrometer</th>
<th>Full Range Spectrometer</th>
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The FloX is the ground reference instrument for the ESA FLEX calibration/validation.
FloX functioning

Optimization of upward channel
Optimization of downward channel
Collection of upward channel
Collection of downward channel
Collection of Dark Current upward
Collection of Dark Current downward
FloX functioning

- Optimization of upward channel
- Optimization of downward channel
- Collection of upward channel
- Collection of downward channel
- Collection of Dark Current upward
- Collection of Dark Current downward

Digital Number

wl [nm]

850 700 750 800

UPWARD - 1
DOWNWARD
FloX functioning

- Optimization of upward channel
- Optimization of downward channel
- Collection of upward channel
- Collection of downward channel
- Collection of upward channel
- Collection of Dark Current upward
- Collection of Dark Current downward
In order to guarantee high quality data the system is *thermoregulated* with an active CCD cooling.
16 FloX systems running over different ecosystems
Broadleaf forest, needleleaf forests, croplands

4 RoX systems running on Fresh water quality monitoring,
Snow optical properties, Atmospheric analysis
FloX raw data

In each measurement cycle 5 spectra for each spectrometer are saved. Approx. 500-600 cycles per day.

FULL RANGE SPECTROMETER

FLUO RANGE SPECTROMETER

Need of data-processing
FloX data processing

FloX data processing is based on 2 open source R packages (FieldSpectroscopyCC and FieldSpectroscopyDP) Developed in collaboration with MPI, Unimib and FZJ which enable:

i) the conversion of raw data into radiance;
ii) the calculation of reflectance;
iii) the calculation of reflectance based Vegetation Indices;
iv) the SIF retrieval (FLD likes methods and Spectral Fitting Methods).

Preliminary quality check parameters are calculated based on:

i) stability of the illumination condition during the measurement cycle;
ii) saturation of the channels;
iii) Solar Zenith Angle.

Time series are filtered accordingly.

Packages available at https://github.com/tommasojulitta
In the framework of ESA FLEX mission the AtmoFLEX project has been funded by ESA. One objective is the **realization of a database to standardize the processing chain** and to offer standardized data products:

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- Top of canopy solar irradiance
- Top of canopy reflected radiance
- Reflectance
- Reflectance based Vegetation iindices
- Field atmospheric correction
- Top of canopy fluorescence
- Different temporal aggregation (daily mean, midday value etc)
Majadas (Spain)

Permanent installation since December 2016.

Site
Mediterranean savanna
Ecosystem: oak trees *(Quercus ilex)*, and herbaceous species.

Set up
Automatic rotating arm allows the measurement of the two spots.
Permanent installation since November 2017.

**Site**
Broadleaf forest oak trees

**Set up**
Tall tower installation. FloX installed at approx. 95 meters from the top of the canopy

Quality check – data filtering
AirFloX
Airflox

Custom built UAV plane
Specific requirements:

- Gimbal;
- 2.5 kg payload for high altitude flight;
- Flight time > 1.5 h;
- Electrical propulsion;
- Ceiling altitude > 4 km;
- Remote control and autopilot;
- Multiple failsafe and backup systems;
- < 25 kg take off weight
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