CZECHGLOBE – A NEW INFRASTRUCTURE FOR INTERDISCIPLINARY RESEARCH

Global Change Research Centre
Academy of Sciences of the Czech Republic
Brno, Czech Republic
Frantisek ZEMEK
Jan HANUS, Marian PAVELKA, Jan NOVOTNY
Presentation overview

• Mission of CzechGlobe
• Organizational structure of CzechGlobe
• Remote Sensing in CzechGlobe
• Expected outputs
• CzechGlobe Remote Sensing and EU standards
Mission of CzechGlobe infrastructure

**Infrastructure** – technical facilities for multi-disciplinary research that focuses on global change and its impacts on the atmosphere, terrestrial ecosystems and society.

**Global Change** could be regarded as a wide spectrum of *biophysical and socio-economic changes and mutual processes* affecting the function of the planet Earth.

Main financial source – EU Operation programs
The core CzechGlobe research:
- Monitoring the long-range transport of greenhouse gases in the atmosphere
- Exchange of CO₂ between the atmosphere and ecosystems
- Investigation geological and hydrological cycles
- Production of regional climate change scenarios
- Impact of the changing environment on plants - from cell/leaf level to canopy/ecosystem level (upscaling)
- Innovation platform – e.g. development of the 3rd generation biofuels
CzechGlobe organization structure

Division 1: Climate Analysis and Modelling
- Department of climate change analysis
- Department of climate modelling
- Department of climate impacts on agrosystems

www.czechglobe.cz
CzechGlobe organization structure

**Division 2**

**Ecosystems Analysis**

- **Department of matter and energy fluxes**
- **Department of Remote Sensing**
- **Department of biodiversity research**
- **Department of landscape carbon deposition**
- **Department of biogeochemical and hydrological cycles**
CzechGlobe organization structure

**Division 3: Impact Studies and Physiological Analyses**
- Laboratory of plant ecological physiology
- Department of impact experiments
- Laboratory of metabolomic and isotopic analyses

**Division 4: Innovation and Mitigation Techniques**
- Department of human dimension of global change
- Laboratory of algae physiology and biotechnology
- Laboratory of short rotation coppice
CzechGlobe spatial distribution infrastructure

- atmospheric station of greenhouse gases monitoring
- network of ecosystem stations for monitoring and quantification of carbon fluxes within ecosystems
- metostations
- network of catchments monitoring geo- and hydrological cycles
- physiological, metabolomic and isotopic laboratory
- airborne laboratory of process imaging
- PC terminals of supercomputers for climate simulations, data analyses and process imaging of Remote sensing
- systems of long-term impact experiments
- innovation equipment for the development of third-generation biofuels
CzechGlobe spatial distribution infrastructure

- Atmospheric station (altitudinal monitoring of GHG)
- Eddy covariance stations: ICOS – Integrated Carbon Observation System
CzechGlobe spatial distribution infrastructure

- Operated eddy covariance sites

- Wetland
- Beech Forest
- Montane Spruce Forest
- Montane meadow
- Agrosystem
Why remote sensing in CzechGlobe infrastructure

• **Upscaling information** from plant physiology measurements/results to spot/ecosystem scale

• Quantitative RS approaches are able to **bridge scaling gap between leaf-to-canopy level eco-physiological processes** using combined **multi-scale radiative transfer (RT) and ecological modelling**

• **Radiative transfer models track the path of EM radiation** but they need parameterization from plant anatomy and physiology measurements (leaf structure&shape, chlorophyll and water contents, etc.)
Objectives of RS in CzechGlobe

- Using RS methods - to generate **actual and potential** (modelled) maps/time series of **ecosystem state indicators** on different spatial and temporal scale.

- **Series of maps** will indicate dynamic changes of the plant physiological processes and functions, especially processes involved in carbon cycle.
Up-scaling of Cab content in Coniferous Forests

- FLIGHT/FIELD campaign
  - AISA sensor
  - Solar Radiance

- “REAL” Reflectance image data of canopy

- Ground measurements
  - Biochemical & structural properties

- Validation

- Map of biochemical parameter: water content

- TREE CROWN LEVEL

- Database of SIMULATED Reflectance image data of canopy

- Inversion Radiative Transfer model

- Parameterization Radiative Transfer model

www.czechglobe.cz

EuroGEOSS Madrid 25/1/2012
Up-scaling of Cab content in Coniferous Forests

Quantitative remote sensing

- physical models of vegetation radiative transfer e.g. coupled PROSPECT and DART model
- Estimation of biophysical and biochemical parameters of vegetation

The example of leaf chlorophyll content (Cab) map retrieved by neural network from sunlit pixels of both immature and mature Norway spruce crowns acquired on airborne AIS/A Eagle hyperspectral images during the flight/ground campaign HYPERTREES 2006.

The example of leaf chlorophyll content (Cab) map retrieved by neural of both immature and mature Norway spruce stands acquired from CHRIS/PROBA satellite image data.
Objectives of RS in CzechGlobe

Aims

- **Simultaneous airborne imagery data acquisition** by the passive imaging spectroradiometers (HS) and active LiDAR scanner
- Development of **standard operational algorithms** for processing of the airborne imaging spectroscopy and LiDAR data
- Development of **LiDAR and HS fusion within RT models** to estimate reliably of biochemical and biophysical parameters of vegetation
- Exploration of **RS chlorophyll fluorescence signal** as optional vegetation parameters and plant photosynthetic processes (FLEX)
- **Testing RS data/technique** in detecting the newly identified stress induced functional links between **metabolic indicators** and physiological/phenological traits
- **Assimilation of RS maps/time series** into the **dynamic ecological models** to reduce their uncertainty
Building RS infrastructure

Key components of RS infrastructure

Flying Laboratory of Imaging Systems (FLIS) + field campaign instrumentation + educated staff

FLIS

- Photogrammetric **aircraft** with two acquisition open slits for imaging RS instruments

- Airborne imaging **spectroradiometer** with sensors visible and near infrared (**VNIR**) short wavelength infrared (**SWIR**), thermal infrared (**TIR**) spectral regions

- **IMU/GPS** units

- Full-waveform Light Detection And Ranging (**LiDAR**) airborne laser scanner for mapping the geometrical characteristics of the Earth surface objects (provided and operated by project AdMaS)
RS team experience

Experience in

- Laboratory/field spectrometry (leaf optical properties)
- Imaging spectroscopy (ground & airborne & satellite)
- Ground support of hyperspectral flight campaigns
- Pre-processing of hyperspectral image data (radiometric, geometric, atmospheric corrections)
- Radiative transfer modeling (DART model)
- Quantitative remote sensing (e.g. chlorophyll estimation using imaging spectroscopy)
RS team experience

Post-processing of hyperspectral data

- Radiometric corrections - calibration to radiometric values - CaliGeo
- Geometric corrections – Geo-orthorectification - PARGE
- Atmospheric corrections – removes effect of atmosphere - ATCOR4
RS team experience

Ground based image spectroscopy

- Spatial resolution up to 2 mm, spectral resolution up to 2.5 nm

- Imaging spectroscopy of forest canopy
- Imaging spectroscopy of meadow canopy
RS team experience

Airborne data acquisition
RS team experience

Airborne image spectroscopy - AISA Eagle system

- Spatial resolution up to 0.4 m, spectral resolution up to 2,5 nm
- Spectral range 400-970nm, up to 260 spectral bands

Hyperspectral sensor AISA Eagle mounted in an aircraft

Visualization of hyperspectral data by so called Data Cube

www.czechglobe.cz
RS team experience

Field campaign

- Spectral measurement of ground reference targets by FieldSpec-3 spectroradiometer
- Artificial reference targets painted by Nextel Suede Coating
- Actual state of atmosphere is estimated from Microtops II measurements
- GPS surveying
Expected output types

Remote sensing products/time series at four processing levels

**Level 1:** airborne raw RS data – the FLIS acquired RS imaging spectroscopy data and LiDAR point clouds without any processing.

**Level 2:** airborne post-processed RS data – the FLIS calibrated, corrected and standardized RS imaging spectroscopy and LiDAR data.

**Level 3:** air/space borne spatial products – interpretations of the RS data as:

  - **Thematic maps** (classes) – e.g., actual land cover/use, plant functional groups/types.
Expected output types

**Level 3:**

- **Categorical maps** (qualitative variables) – e.g., qualitative stages of actual vegetation phenology
- **Continuous fields** (quantitative variables) – e.g., content of foliage pigments, water and other detectable biochemical compounds or elements, amount of photosynthetically active and inactive plant biomass

**Level 4: Modelled spatial products** – projections of potential spatial distribution of the plant functional types and their ecophysiological processes simulated by the ecological models (soil properties, dynamic climatic conditions, behaviour of the predefined plant functional types,...)
Archiving of hyperspectral data

- Data sets are stored in formats which are in agreement with outputs of **EUFAR** consortium
- Acquired hyperspectral data are stored in **ENVI bsq** format. Intention to store data in **HDF5 format** in future
- Each data set contain **quality layers** developed within **EUFAR JRA2 - HYQUAPRO** activity
- **Metadata** are stored in **xml** files which are **INSPIRE (ISO 19115)** conformant
Linkage RS CzechGlobe with EU standards

EUFAR HYQUAPRO Quality Data Product Layers

• GPS / IMU related errors / Geometric correction
  – Problems with position information and interpolated position information
  – Problems with attitude information and interpolated attitude information

• Atm. correction / Atm. Conditions
  – Cloud mask
  – Cloud shadow mask
  – Haze mask

• Terrain related
  – Critical local viewing and illumination geometry

• Sensor calibration/data artefacts
  – Aggregated bad pixel mask ("not corrected")
  – Aggregated interpolated pixel mask ("corrected")
  – Saturated pixel / overflow
Thank you for your attention