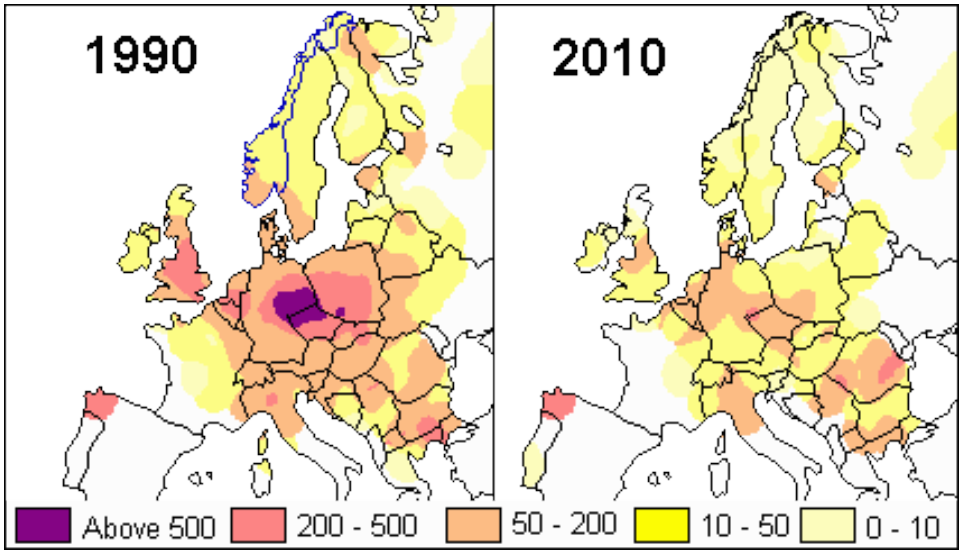
Hyperspectral-based detection of tree physiological status – projects in the Western part of the Czech Republic

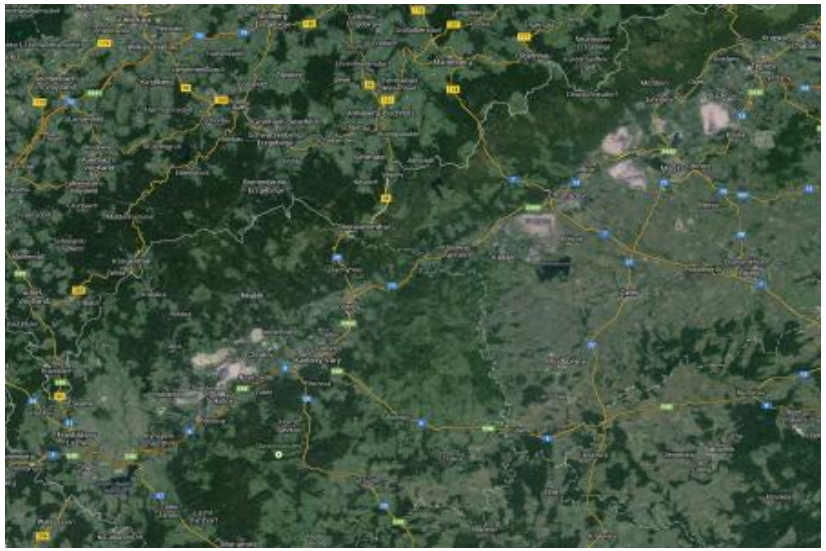
Jana Albrechtova

Charles University in Prague, Faculty of Science, Prague, Czech Republic, albrecht@natur.cuni.cz

Black Triangle in Europe

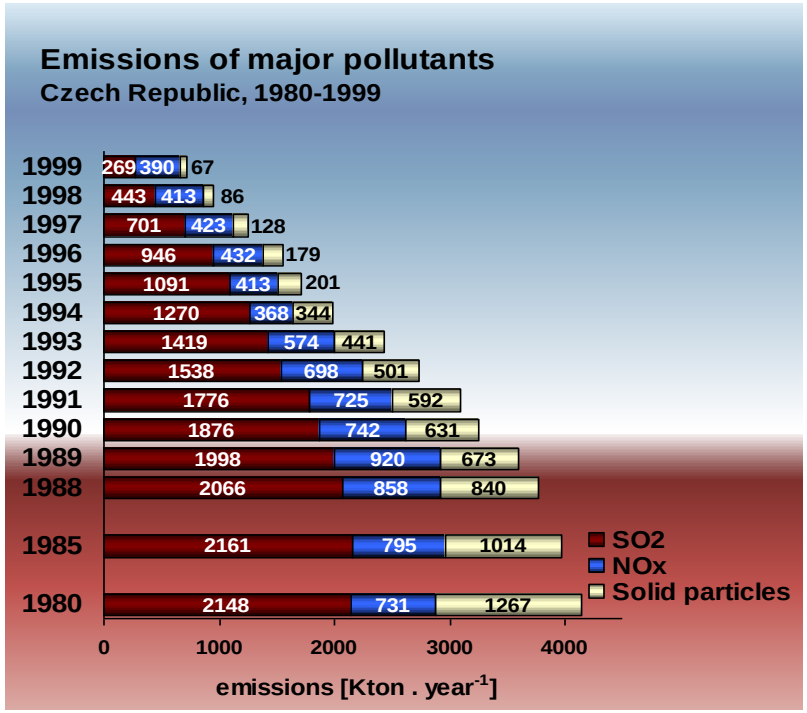
SO_2 in Europe (Tons per km2)

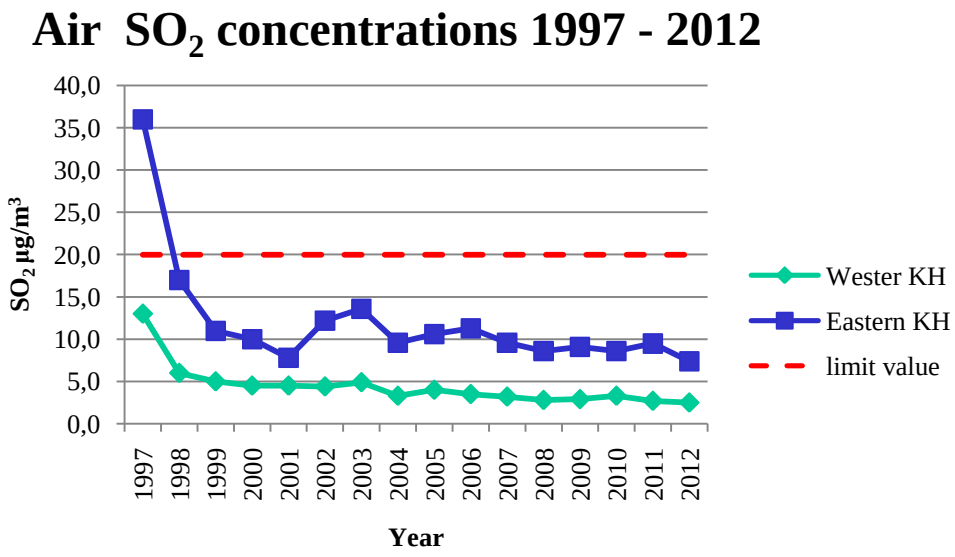




http://wgbis.ces.iisc.ernet.in/energy/HC270799/SOE/nor/soeno97/acidrain/state.htm

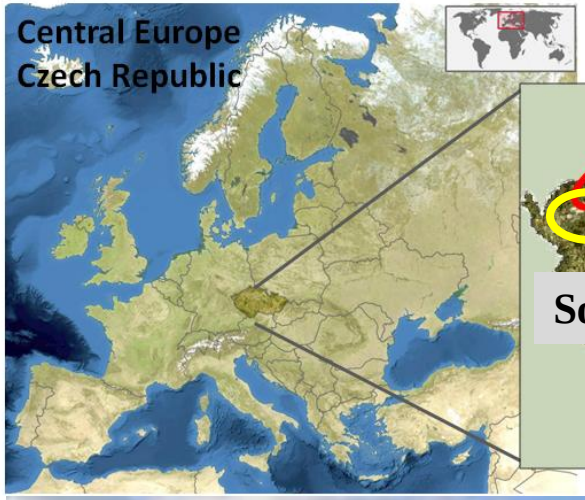
Black Triangle in CZ: forests in mountains, strip mines, reclamation sites



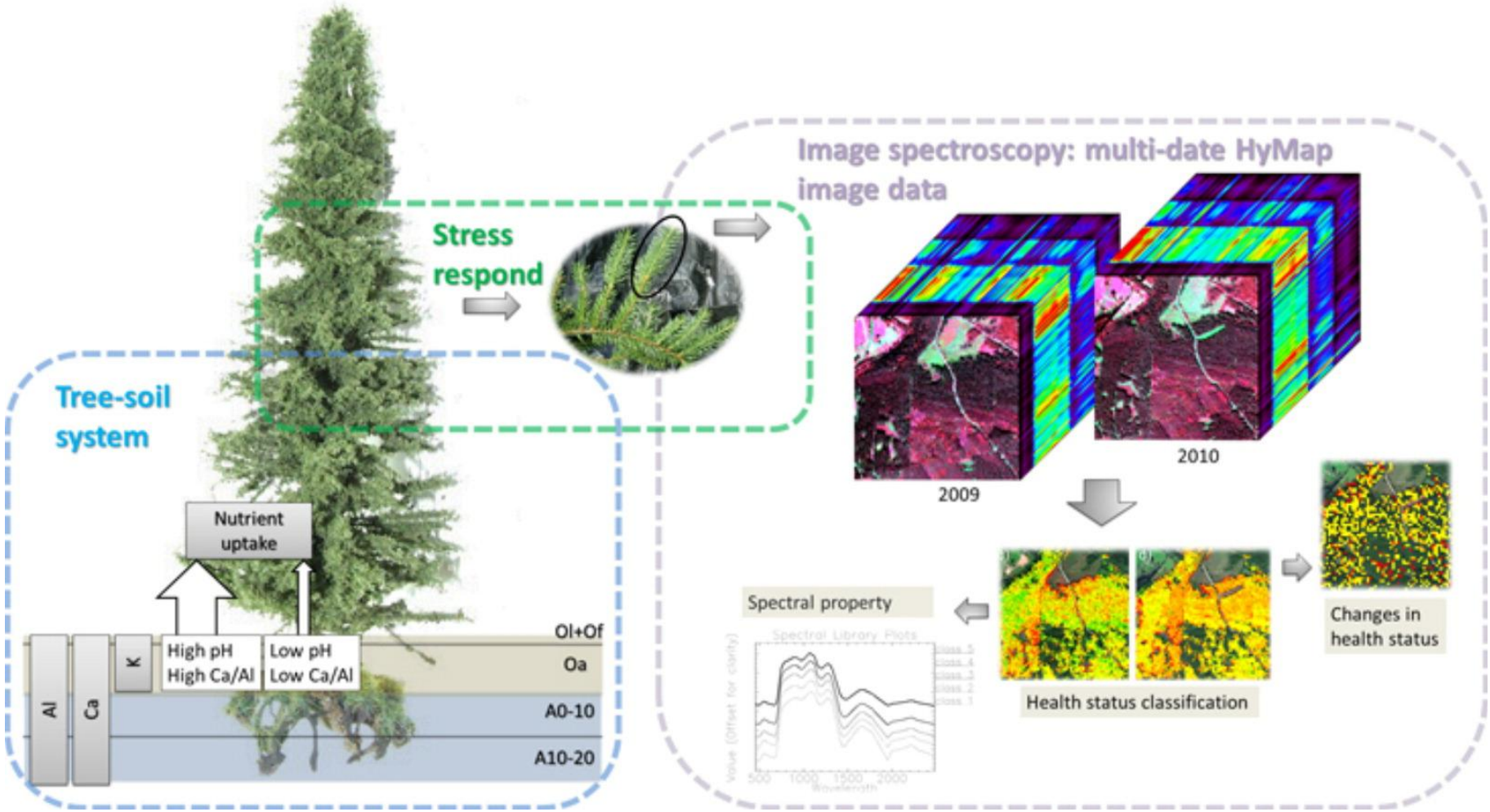


The 1970-1990´s: dead forests in the Krusne hory Mts.

Black Triangle in CZ: forests in mountains, strip mines, reclamation sites



Hyperspectral data for detection of subtle changes in tree health status



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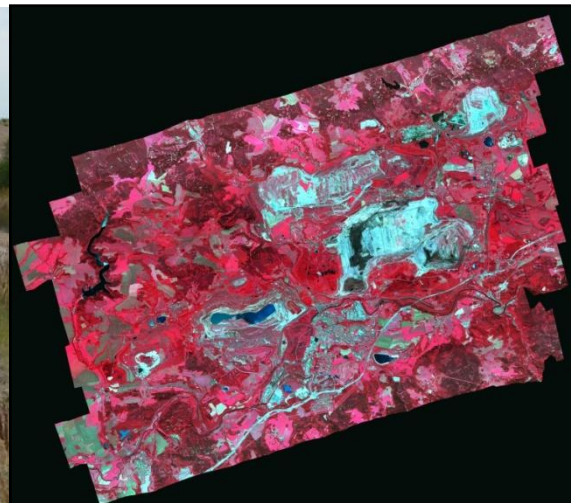
1. Hypso: Hyperspectral Sokolov (2009-2013)

Assessment of Mining Related Impacts Based on Utilization of Airborne Hyperspectral Sensor

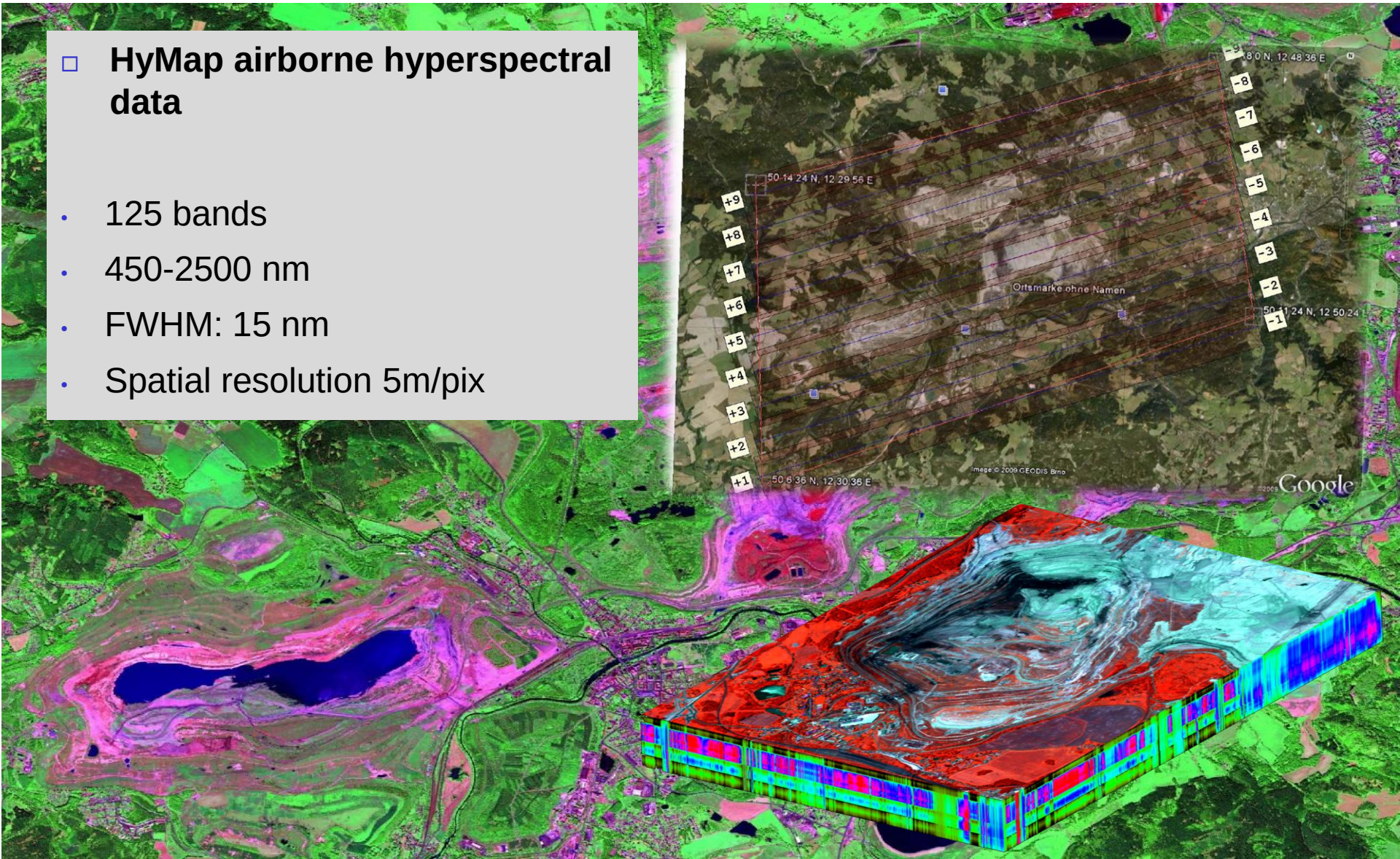
- **Primary Investigator:**
  - **Czech Geological Survey** – Veronika Kopačková (CGS)
- **Co-Investigator:**
  - **Faculty of Science Charles University in Prague** – Dr. Jana Albrechtová, Dr. Zuzana Lhotáková, Dr. Lucie Kupková, Dr. Markéta Potůčková
  - **CzechGlobe** – Ing. Jan Hanuš

- **Test site:**
  - Sokolov lignite basin
  - Western part of the Czech republic
  - Affected by long-term coal mining



1. Hypso: Hyperspectral Sokolov (2009-2013)

Sokolov : HyMap data 2009 and 2010



1. Hypso: Hyperspectral Sokolov (2009-2013)

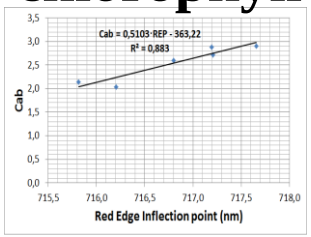
Sokolov : HyMap data 2009 and 2010

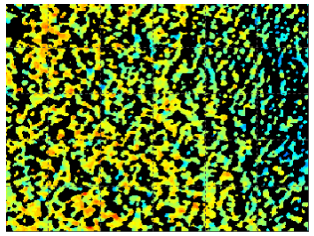
Construction of chlorophyll maps

Field campaign

Lab determination of photosynthetic pigments

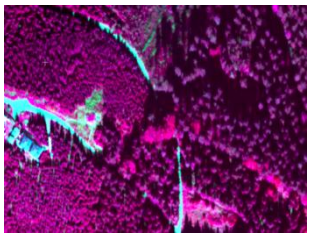
Regression equiations for chlorophyll content





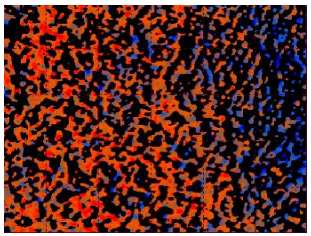
Chlorophyll map

Index value



hyperspectral data From air campaign

Spectral indicators



Crown classification

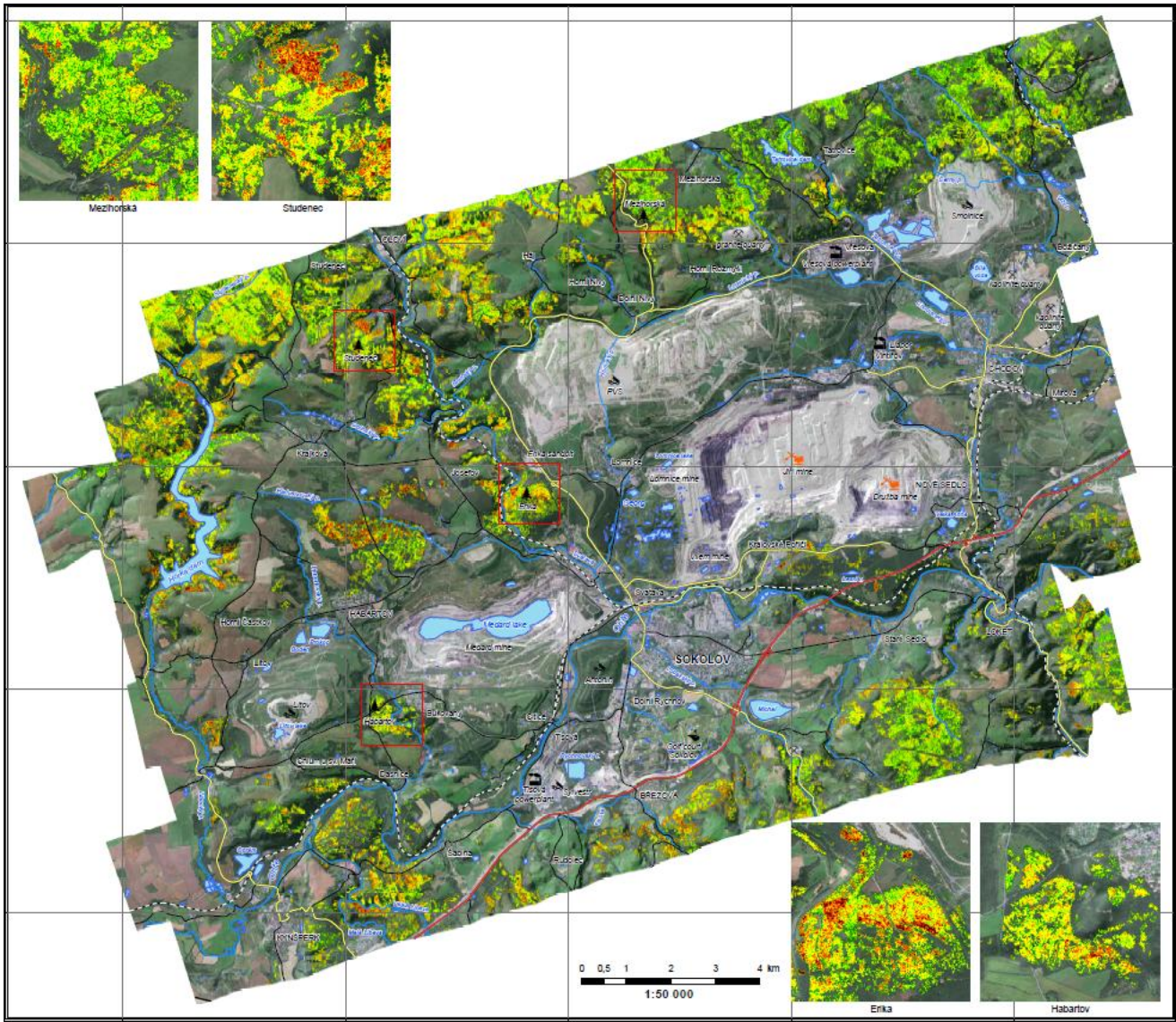
1. Hypso: Hyperspectral Sokolov (2009-2013)

Sokolov : HyMap data 2009 and 2010

Map of chlorophyll content in Norway spruce

(mg/g d.m.)

- **Less than 1.21**
- **1.21 – 2.37**
- **2.38 – 3.35**
- **3.36 – 4.13**
- **More than 4.13**

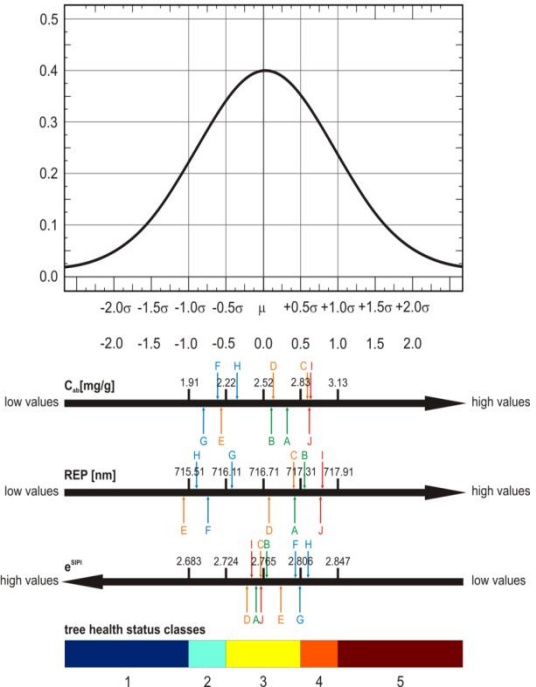


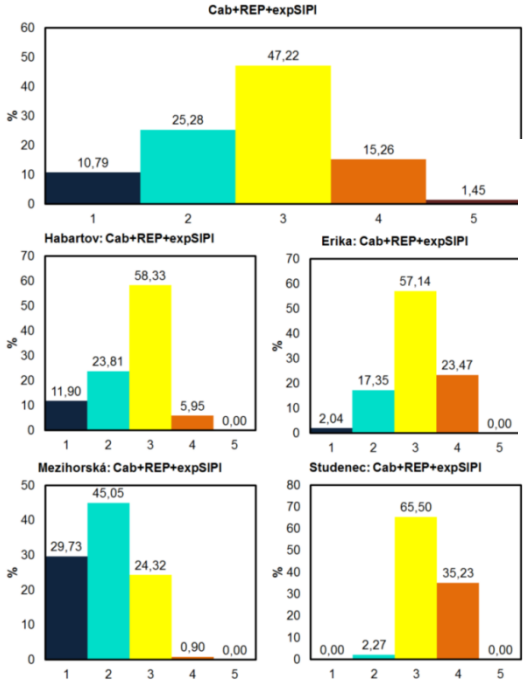
1. Hypso: Hyperspectral Sokolov (2009-2013)

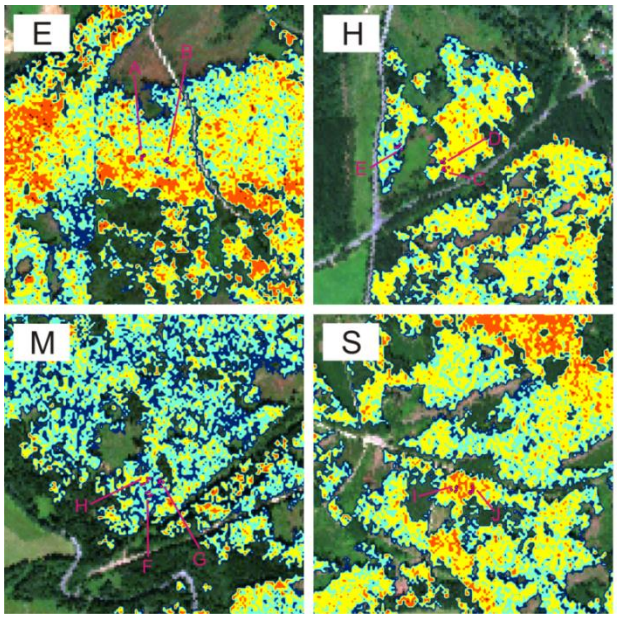
Sokolov : HyMap data 2009 and 2010

- **Norway spruce health status classification**

- Integration of the derived C_{ab} content with other vegetation indices: REP and SIPI
- Statistical classification method
- Asymmetries of the health class frequencies at the studied sites







Health status classes for the trees without visual damage symptoms
1 - the worst and 5 - the best result

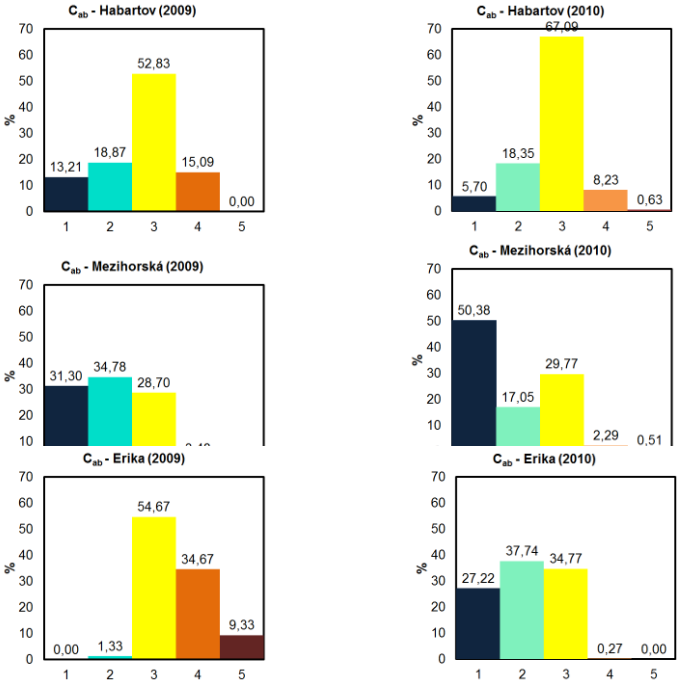
MIŠUREC, J., and KOPAČKOVÁ, V., LHOTÁKOVÁ, Z., HANUŠ, J., WEY ERMANN, J., ENTCHEVA-CAMPBELL, P., ALBRECHTOVÁ, J., 2012: Utilization of hyperspectral image optical indices to assess the Norway spruce forest health status, Journal of Applied

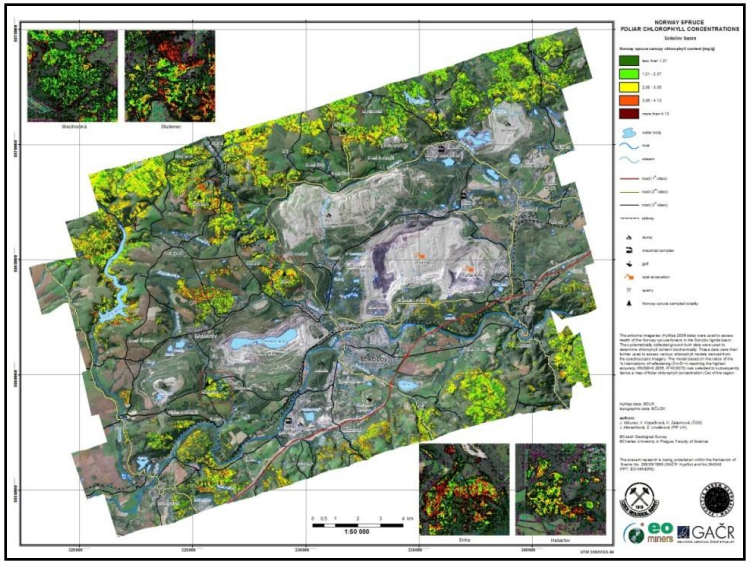
1. Hypso: Hyperspectral Sokolov (2009-2013)

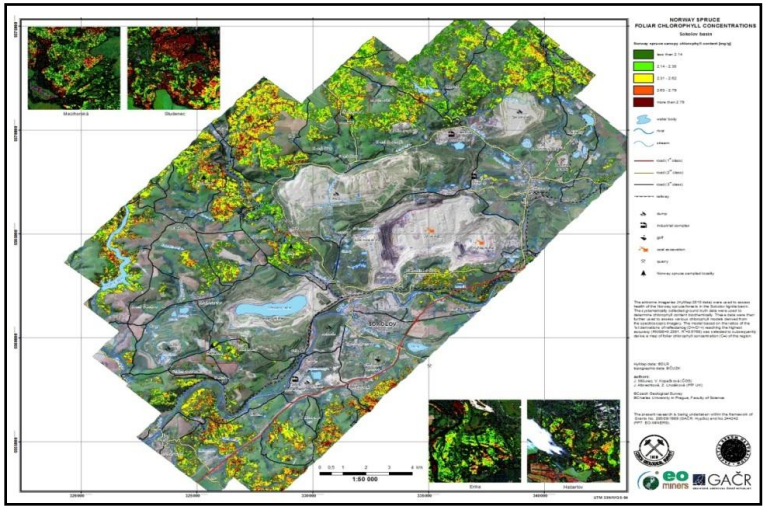
Sokolov : HyMap data 2009 and 2010

Method verification

HyMap 2009 HyMap 2010







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1. Hypso: Hyperspectral Sokolov (2009-2013)

Sokolov : HyMap data 2009 and 2010

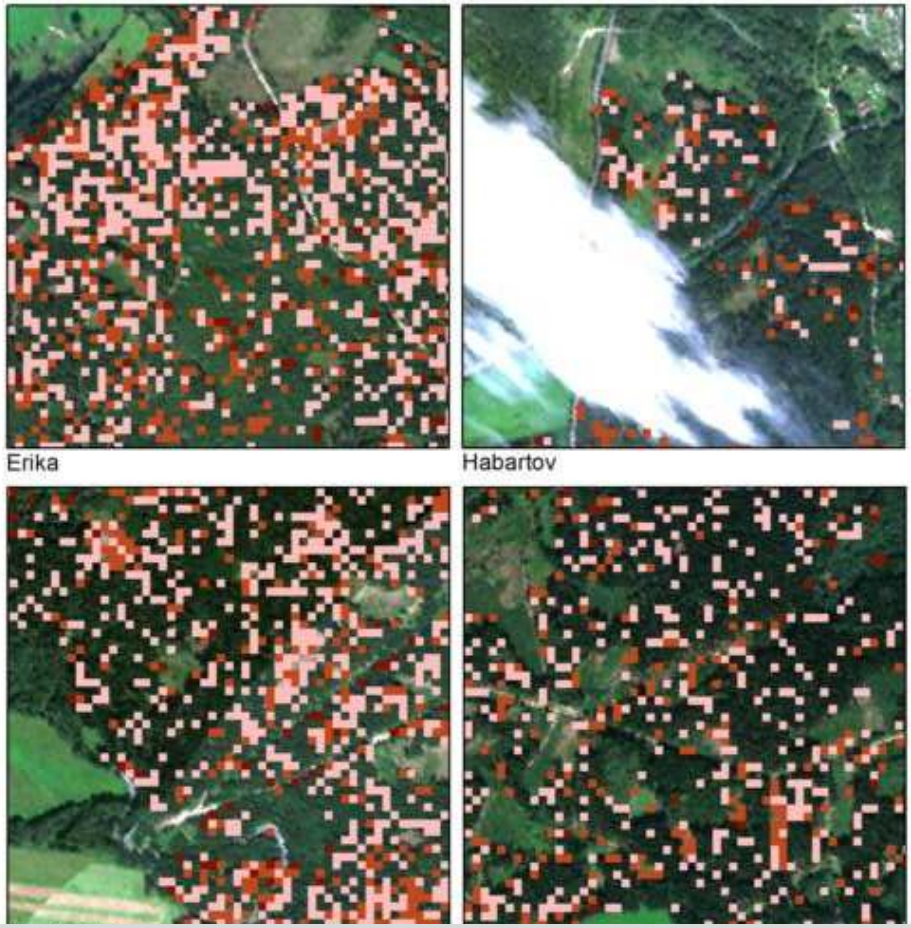
Method verification

Worsening comparing 2009-2010:

3 and more degrees decreases

2 degrees decrease

1 degree decrease



Kopačková V, Misurec J, Z. Lhotáková, F. Oulehle & J. Albrechtová 2014. 2014: Using multi-date high spectral resolution data to assess thephysiological status of macroscopically undamaged foliage on aregional scaleVeronika International Journal of Applied Earth Observation and Geoinformation, Volume 27, Part B, 2014, 169 - 186

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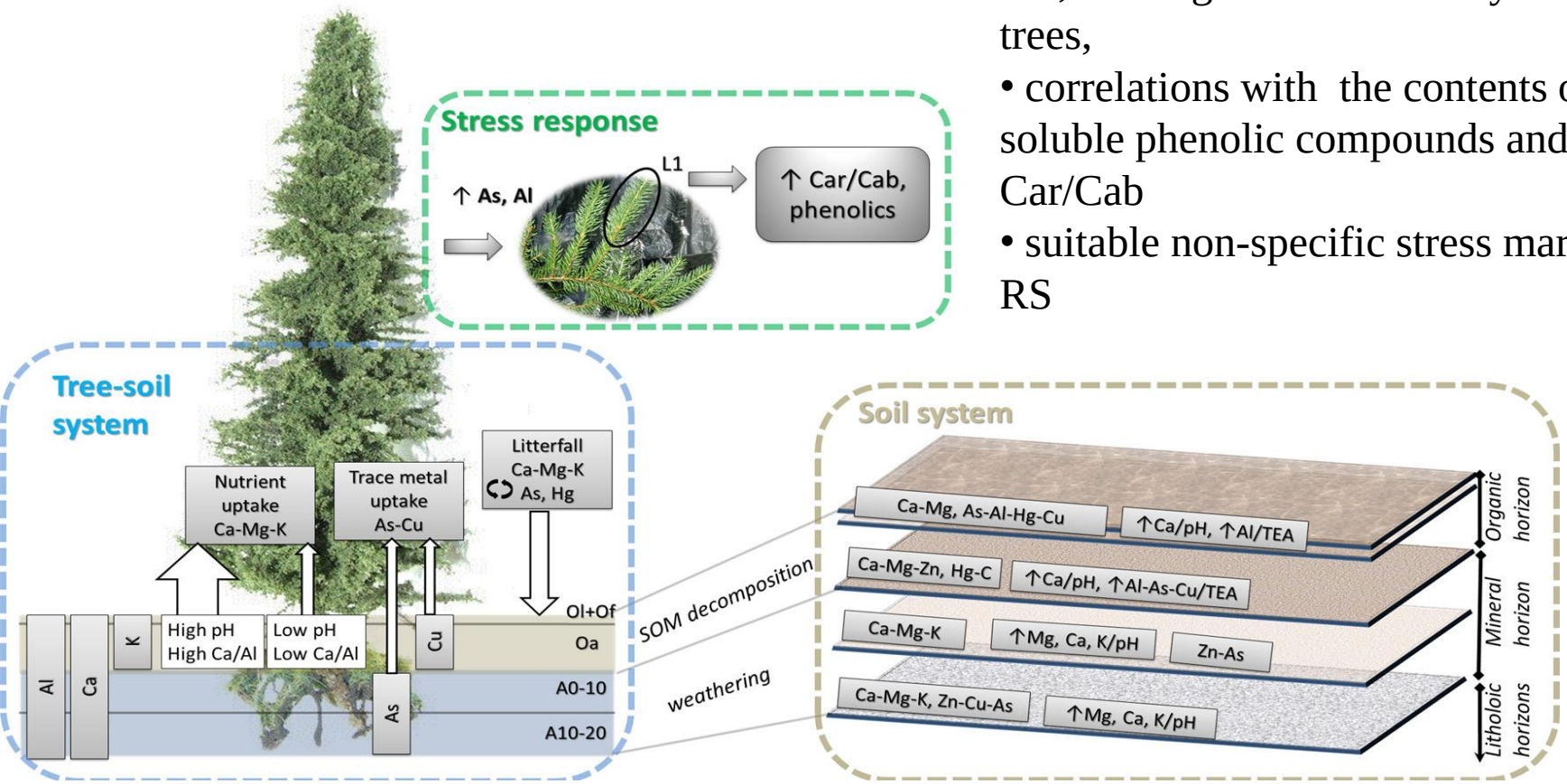


- Factor analysis to identify soil-foliage biochemical links
- Al, As –high bio-availability for spruce trees,
- correlations with the contents of soluble phenolic compounds and Car/Cab
- suitable non-specific stress markers: RS

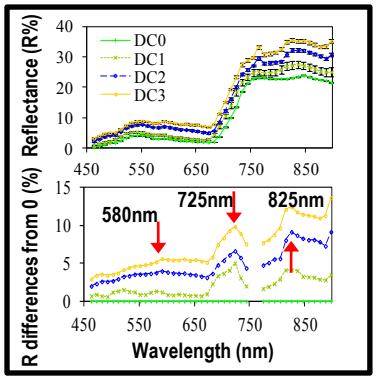
V. Kopačková, Z. Lhotáková, F. Oulehle & J. Albrechtová 2014.*Assessing forest health via linking the geochemical properties of a soil profile with the biochemical parameters of*

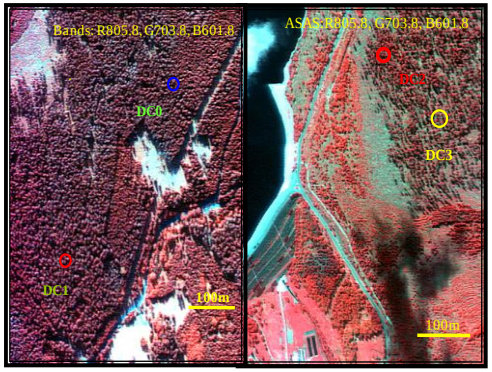
2. NASA - Hyperspectral Krusne hory Mts. (1997- 2000)

NASA project „Forest recovery in the Czech Republic“ NAG5-5192 (CFDA #43.002), **(1997-2000),** UNH, Complex Research Systems Centre, USA,

PI: Barrett N. Rock, UNH
Petya Campbell

Co-I : Jana Albrechtová

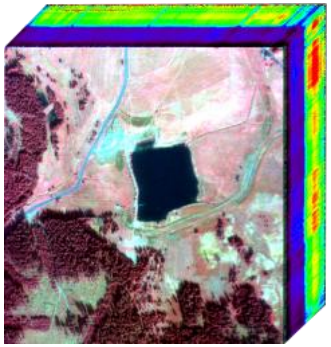




ASAS'98 images and spectra of healthy (DC0) and damaged (DC 1-4) canopies (Entcheva et al. 2004)

ASAS: Airborne Solid-state Array Spectroradiometer (ASAS) NASA Goddard Space Flight Center, USA.

ASAS 1998:



Detection of previsible damage stages (DC0 a DC1):

Optical indices: C1, RE1 and RARSc

Derivative indices: D714/D704 and Dmax/D704

Inverted Gaussian model (IGM)

•*Albrechtová J, Rock BN, Soukupová J, Entcheva P, Šolcová B, Polák T. Biochemical, histochemical, structural and reflectance markers of damage in Norway spruce from the Krušné hory used for interpretation of remote sensing data. Journal of Forest Science, 2001, 47, (Special issue), p. 26-33*

•*Campbell, PKE, Rock, BN, Martin, ME, Neefus, CD, Irons, JR, Middleton, EM, Albrechtová, J. Detection of initial damage in Norway spruce canopies using hyperspectral airborne data. In: International Journal of Remote Sensing, 2004, 25, 24, s. 5557-5583*

3. INMON: Hyperspectral Krusne hory Mts. (2012-2015)

Inovation of methods for monitoring of health status of Norway spruce stands in the Krusne hory Mts. with the use of hyperspectral data

The main goal: assessment of the temporal changes in the physiological status of Norway spruce forests in the Krušné Hory Mts. using two hyperspectral data sets acquired in 1998 and 2013.

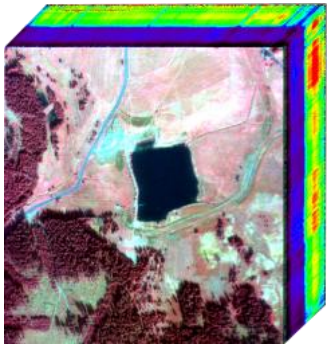
- Project team:
  - **Faculty of Science, Charles University in Prague**

    PI: Dr. Jana Albrechtová, Dr. Zuzana Lhotáková, Dr. Lucie Kupková, Dr. Markéta Potůčková, Mgr. Lucie Červená, Mgr. Monika Kovářová
  - **Czech Geological Survey**

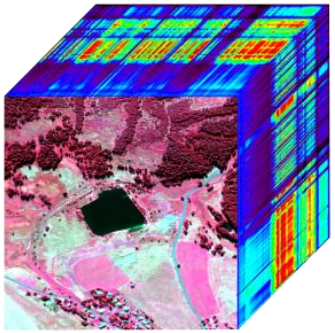
    Mgr. Veronika Kopačková, Mgr. Jan Mišurec
  - **University of Maryland BC, NASA GSFC**

    Dr. Petya Entcheva-Campbell

ASAS 1998:



APEX 2013:



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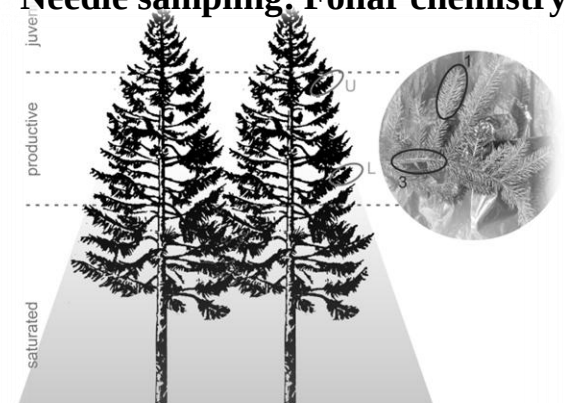
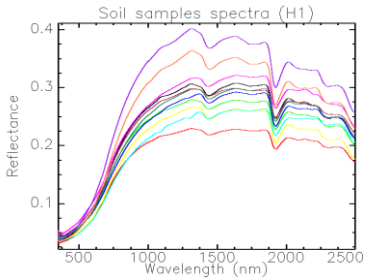
Groundtruth:

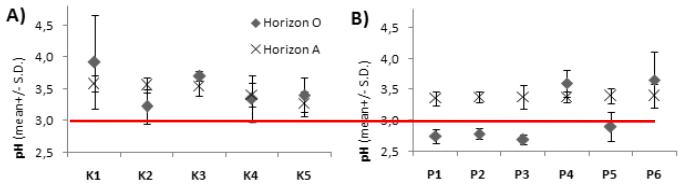
Needle sampling: Foliar chemistry – laboratory spectroscopy



LAI measurements

Soil analyses:





1. Charles University in Prague, Faculty of Science, Prague, Czech Republic, albrecht@natur.cuni.cz
2. Czech Geological Survey, Prague, Czech Republic
3. CzechGlobe, Academy of Sciences of the Czech Republic, České Budějovice, Czech Republic
4. Joint Center for Earth Systems Technology, University of Maryland Baltimore County and NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Conclusions

1. **North Western Czech Republic: unique area affected by extreme environmental pollution and socio-economic changes**

   temporal changes in the decline/recovery in forest extent, function and health, and the conversion from spruce forest cover to other forests or other cover types connected with socio-economic driving forces

2. Ideal test site for forest health evaluation, testing the methods

3. Ideal test site for forest health evaluation, in context with socio-economic changes

New projects and collaboration welcome

Figure 2 (top). The land cover of Krusne hory Mountain is predominantly Norway spruce; also deciduous forests, pastures and herbaceous scrubland (Corine 2006, EEA). Points mark the locations of field plots used in the study of spruce health by Lomsky et al. (2013). With crosses (red DC3, black DC2, purple CD1 and blue DC0) are marked the approximate locations of the sites (45, 10-12 per DC) of field data collections by the team in 1998.

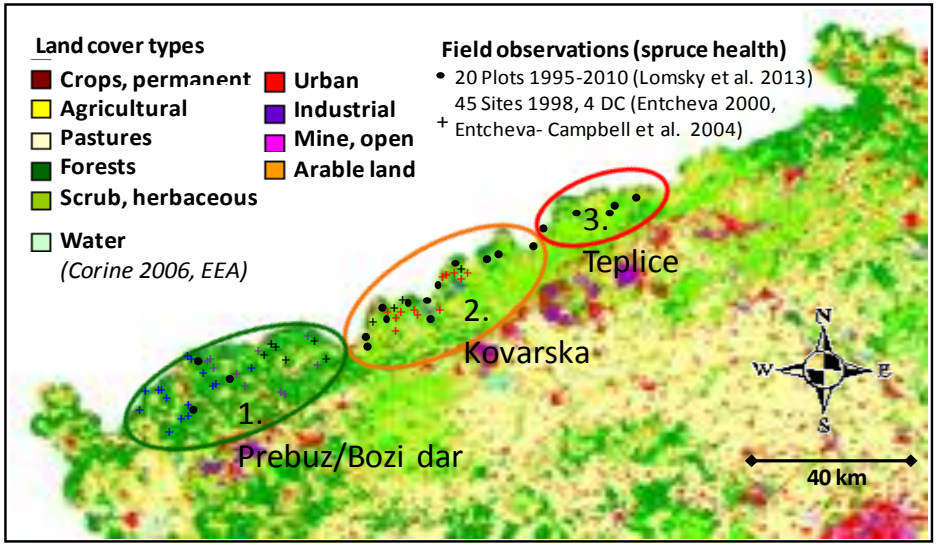


Figure 3 (bottom): Norway spruce damage level in 1999, based on % of defoliation and mortality. Damage level: 0 (up to 10%), 1(10-25%), 2 (25-60%), 3(60-80%), 4 (more than 80%). (UHUL, Lndsat-TM, 1990-1999, *http://old.uhul.cz/zelenazprava/index.php*)