# EO-MINERS

European Technology Platform on Sustainable Mineral Resources

COOPERATION

GEO GROUP ON EARTH OBSERVATIONS

## TOWARDS SUSTAINED AND ACCEPTED GEO-SPATIAL INFORMATION PRODUCTS FOR MINING AND RESOURCES MANAGEMENT


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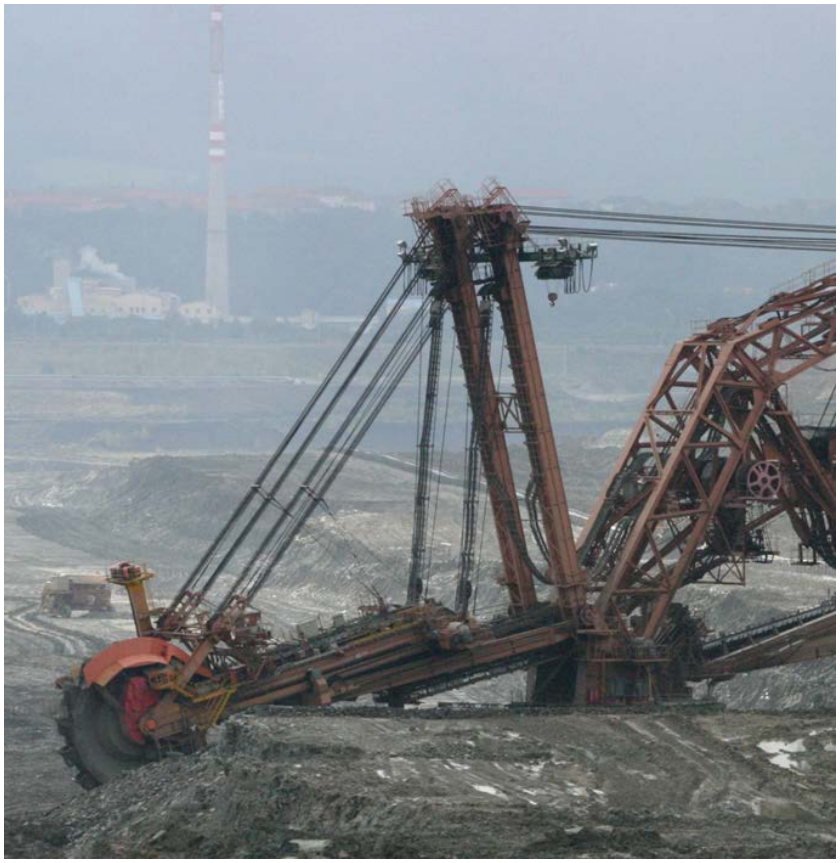
http://www.eo-miners.eu

# Project Structure



- Funding Instrument: CP-SICA-FP7
- Total Project Costs: 4.062.877 €
- EC Contribution: 3.120.837 €
- Duration: 36 months
- Consortium: 14 partners, 8 countries
- Coordinator: BRGM (France)
- Start Date: 01 Feb. 2010

# Content

- Introduction
- Developing Indicators
- Remote Sensing based application development for the three test sites
- Standards & Protocols for Remote Sensing based Product development
- Conclusion & Outlook

# Scientific Objectives

Assess **policy requirements** at macro (public) and micro (mining companies) levels and **define environmental, socio-economic, societal and sustainable development criteria** and **indicators** to be possibly **dealt using EO**

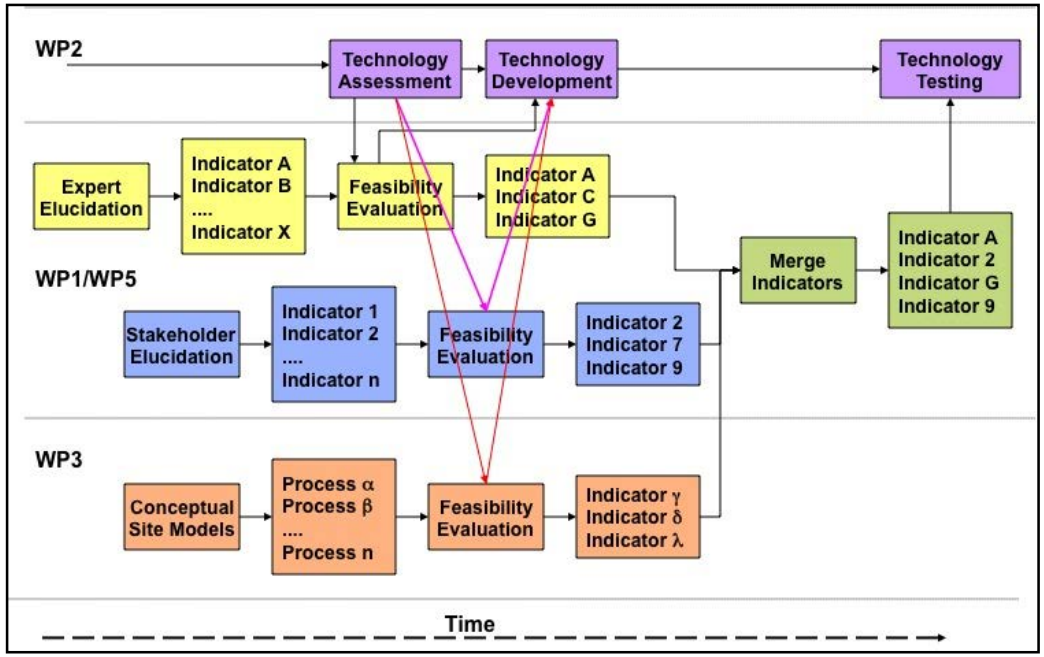
demonstrate the capabilities of **integrated EO-based methods and tools** in:
- monitoring,
- managing
- contributing reducing the environmental and societal footprints of all phases of a mining project

Contribute making **reliable and objective information** about affected ecosystems, populations and societies, basis for a sound **"trialogue"** between industrialists, governmental organisations and stakeholders

WP1 → WP2, WP3 → WP4, WP5

# Developing Indicators

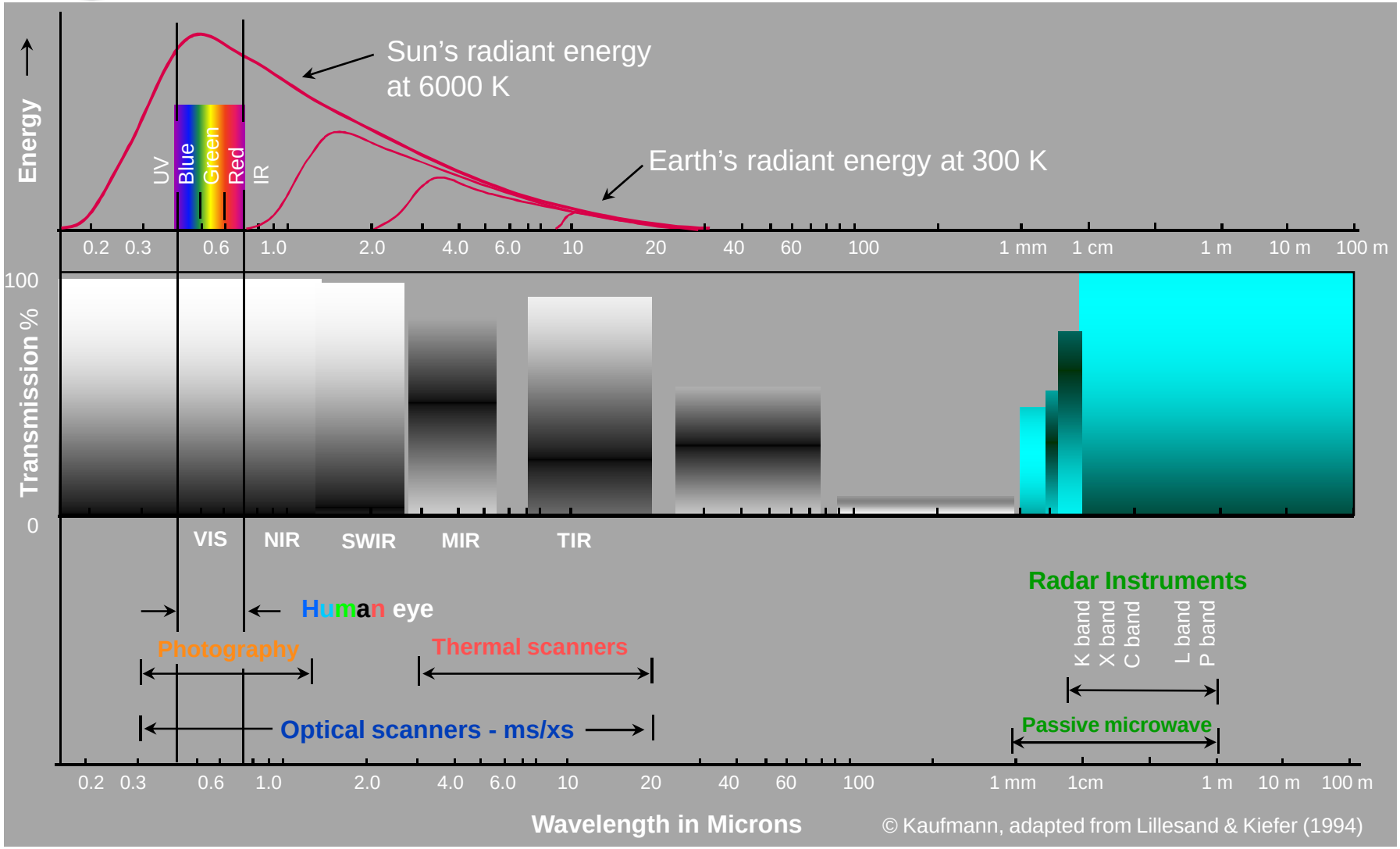
- A multi-pronged, iterative approach is used:
  - heuristic set of candidate indicators by expert elucidation
  - examination of site-specific conceptual models for the study sites
  - a semi-deliberative approach with input from outside stakeholders
- The resulting candidate set was tested during stakeholder interviews
- The indicators are checked for measurability by EO-experts
- The final set of indicators will be subject to stakeholder evaluation during site workshops at the end of the project.



# Candidate Indicator Categories

- A Land-use
- B Mass Flows
- C Energy Flows
- D Air quality and other nuisances
- E Water quality
- F Transport
- G Geotechnical hazards and accidents
- H Industrial and other accidents
- I Social impacts
- J Regional development
- K Economic vulnerability/resilience

# Blackbody Radiation, Atm. Transmission and Regions of Operation for EO Sensors



# Test Sites

Czech Republic - Sokolov mining area:

- area is largely affected by lignite mining activities:
  open casts, closed mines and dump sites
- acid mine drainage (AMD) and related heavy metal contamination

South Africa - Witbank coalfields:

- major impact of mining due to land degradation and water pollution
- collapsed abandoned underground mine sites have undergone spontaneous combustion

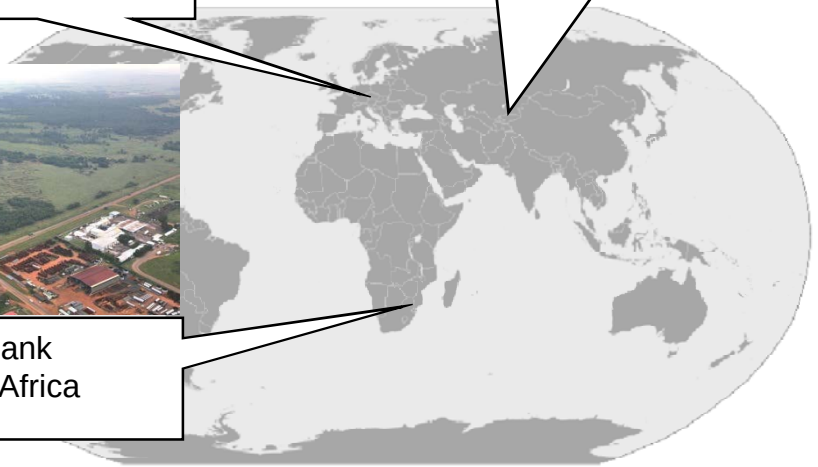
Kyrgyzstan - Makmal gold deposit:

- necessity of a regular monitoring of soil and water on heavy metals content
- impact zone of a tailing dump

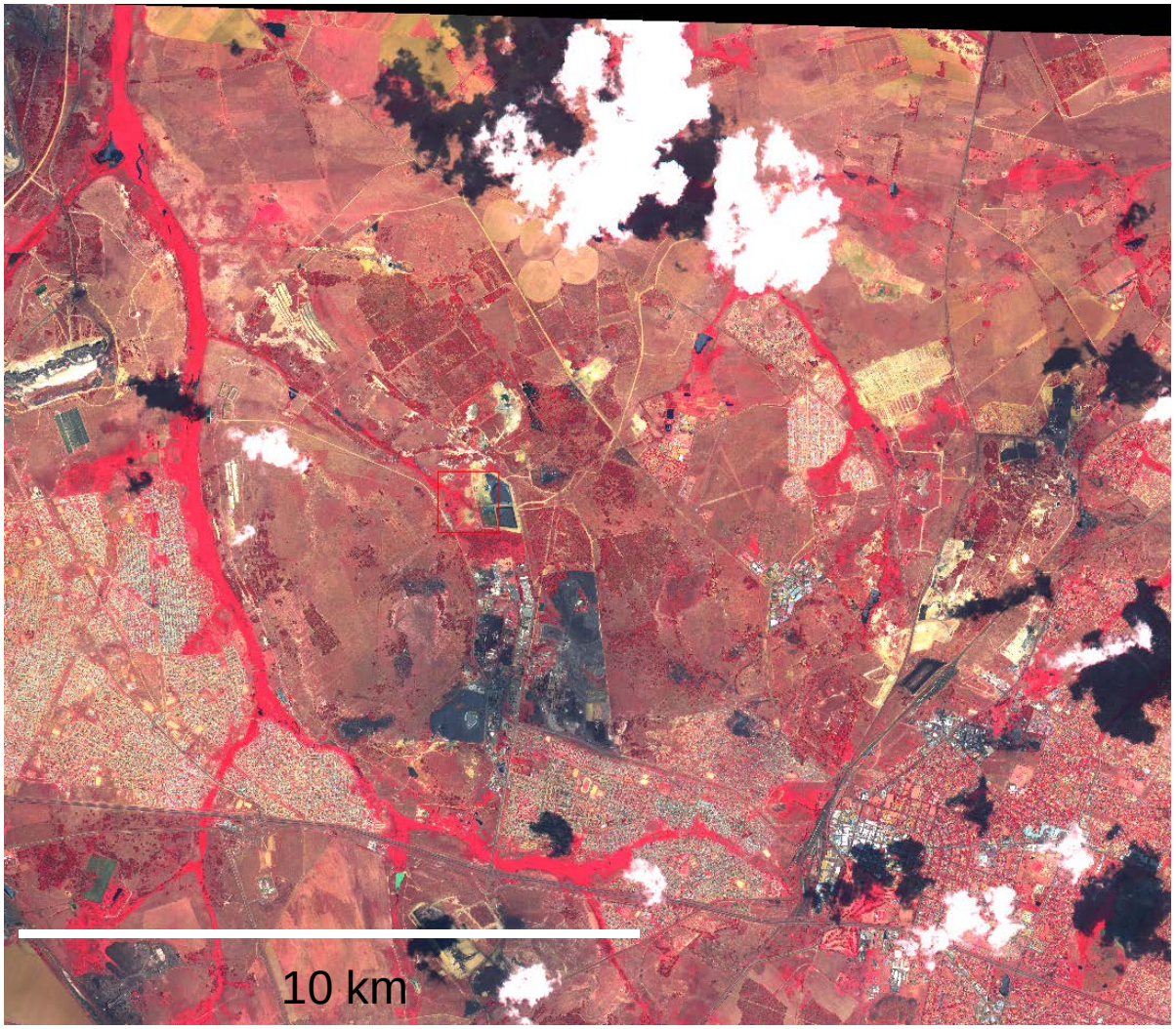
Sokolov
Czech Republic

Makmal
Kyrgyzstan

Witbank
South Africa



# eMalahleni – Mpumalanga province




High resolution satellite data: WorldView-II

bands:
1 panchromatic (pan)
8 multispectral (ms)
(VIS, SWIR)

sensor resolution (GSD)
pan: 0.46 m GSD at nadir
ms : 1.8 m GSD at nadir

dynamic range 11-bit

swath width 16.4 km at nadir

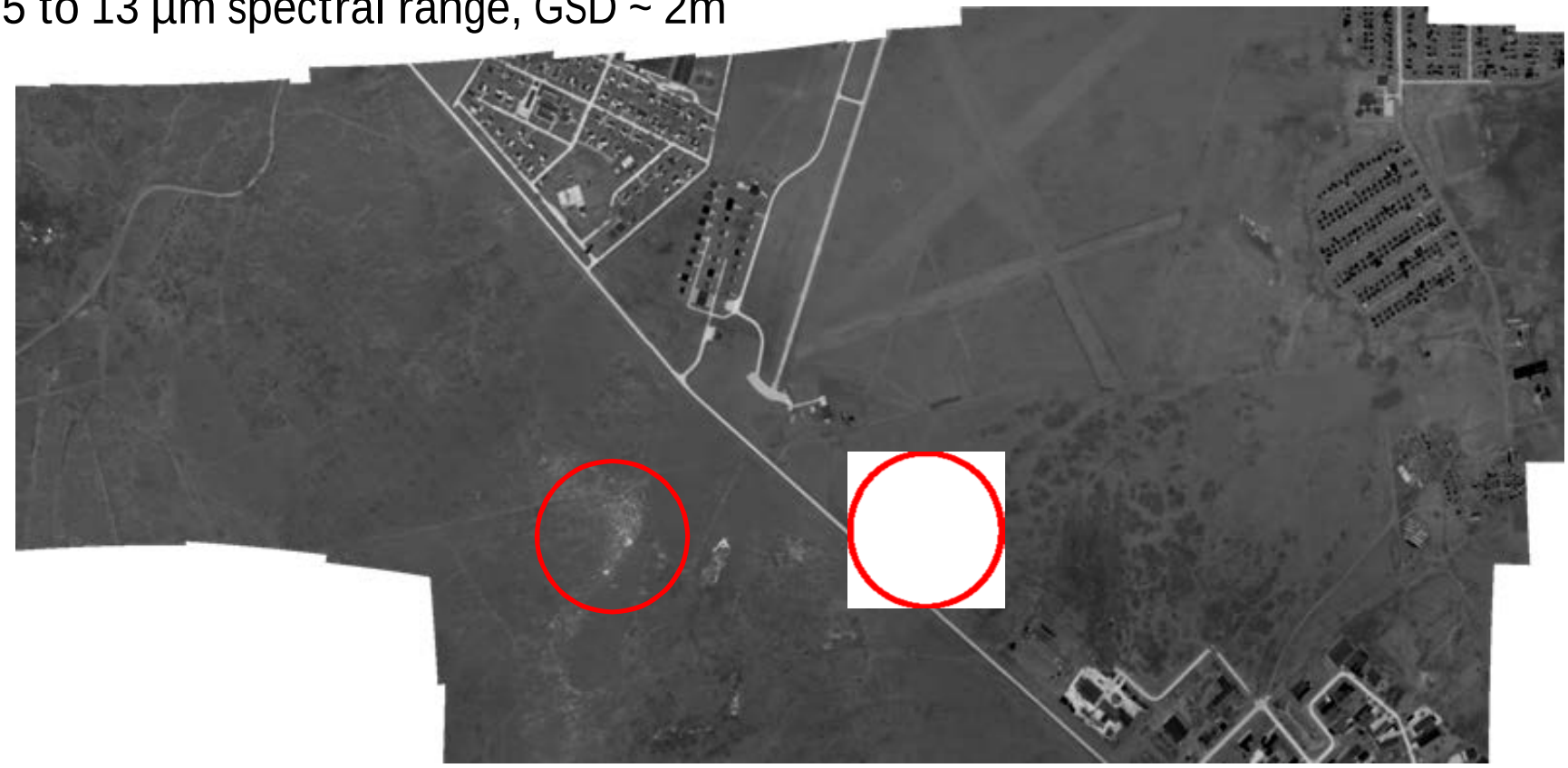
# eMalahleni - South Africa

Abandoned and active mine sites in close neighborhood of urban settlements:

- unpredictable surface movements
- spontaneous coal fires and acid mine drainage (AMD)

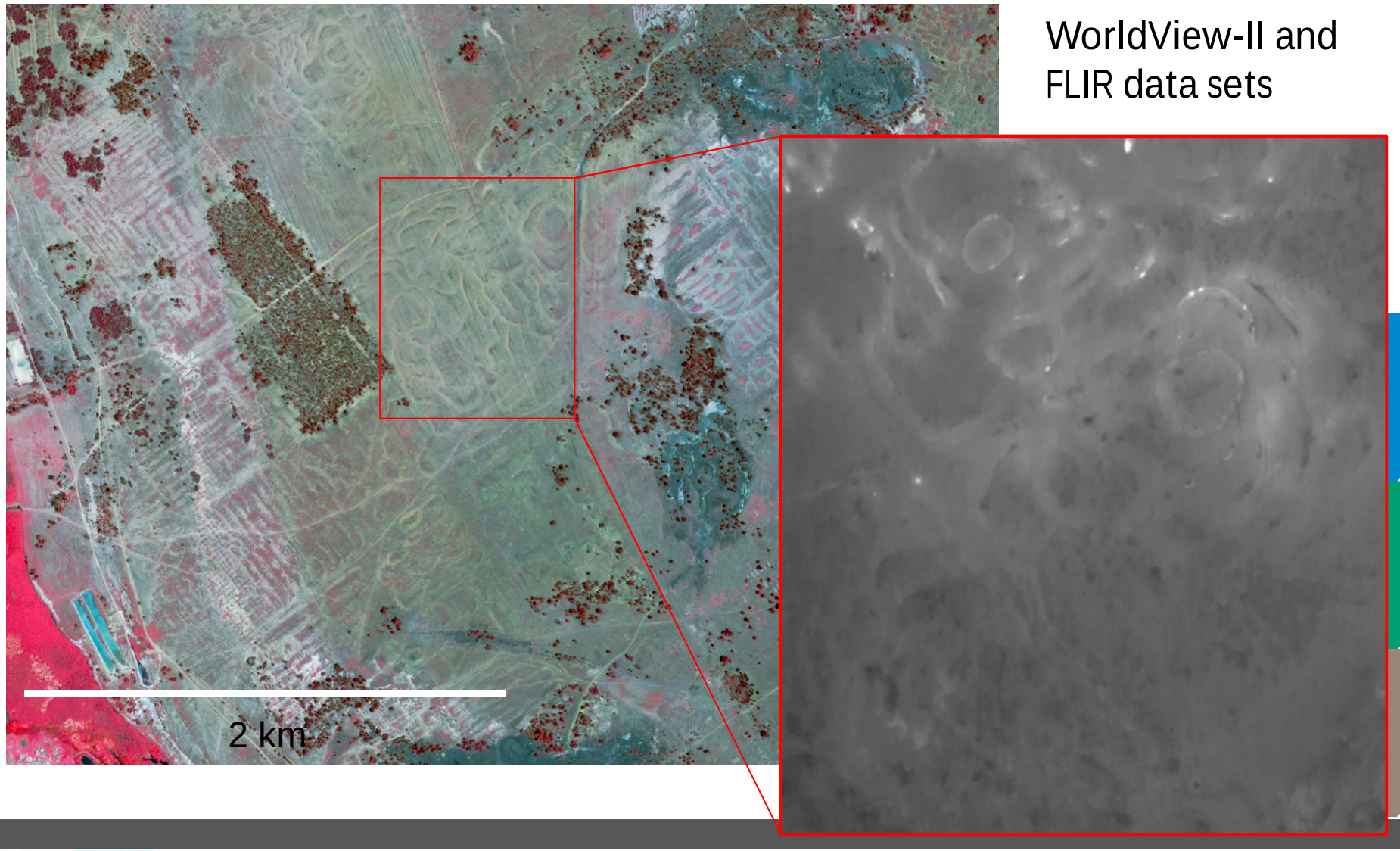
# Coal Fire related Temperature Anomalies

Thermal night time Survey using a Matrix Detector: FLIR P640
640 x 480 Pixels, [ -40 – 500°C]
16 bit quantification, +/- 0.03 °C  sensitivity
7.5 to 13 µm spectral range, GSD ~ 2m



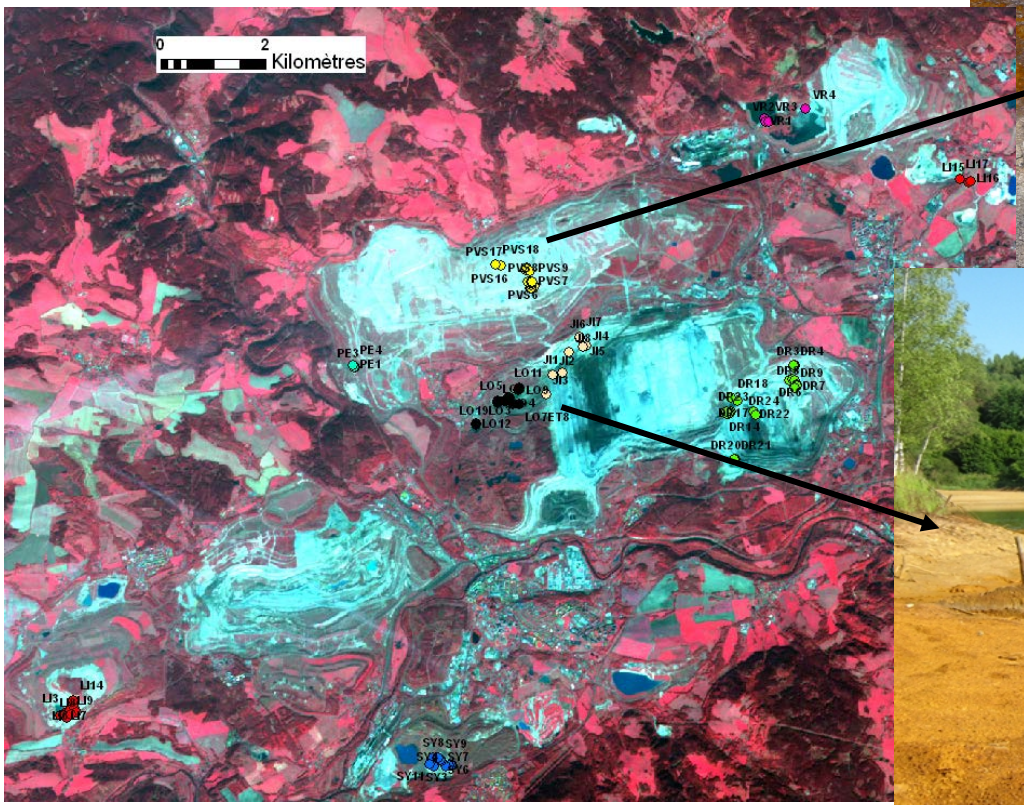
# Abandoned Mine Sites and Coal Fires

WorldView-II and
FLIR data sets

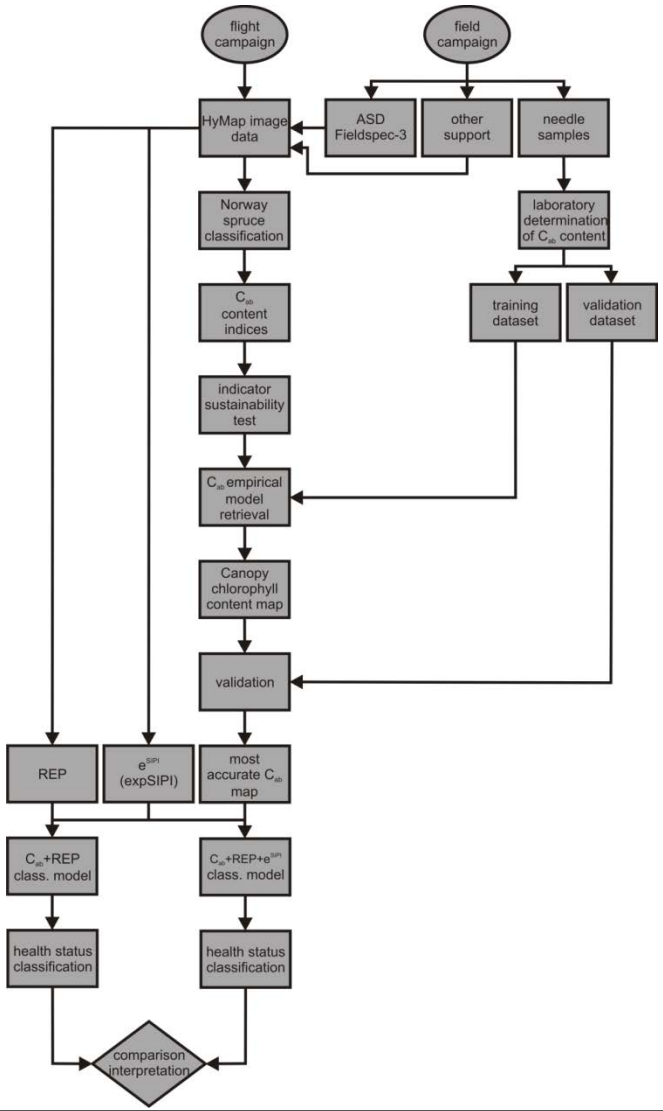


# Sokolov – Czech Republic

Acid Mine Drainage (AMD), related heavy metal contamination and influenced vegetation health status

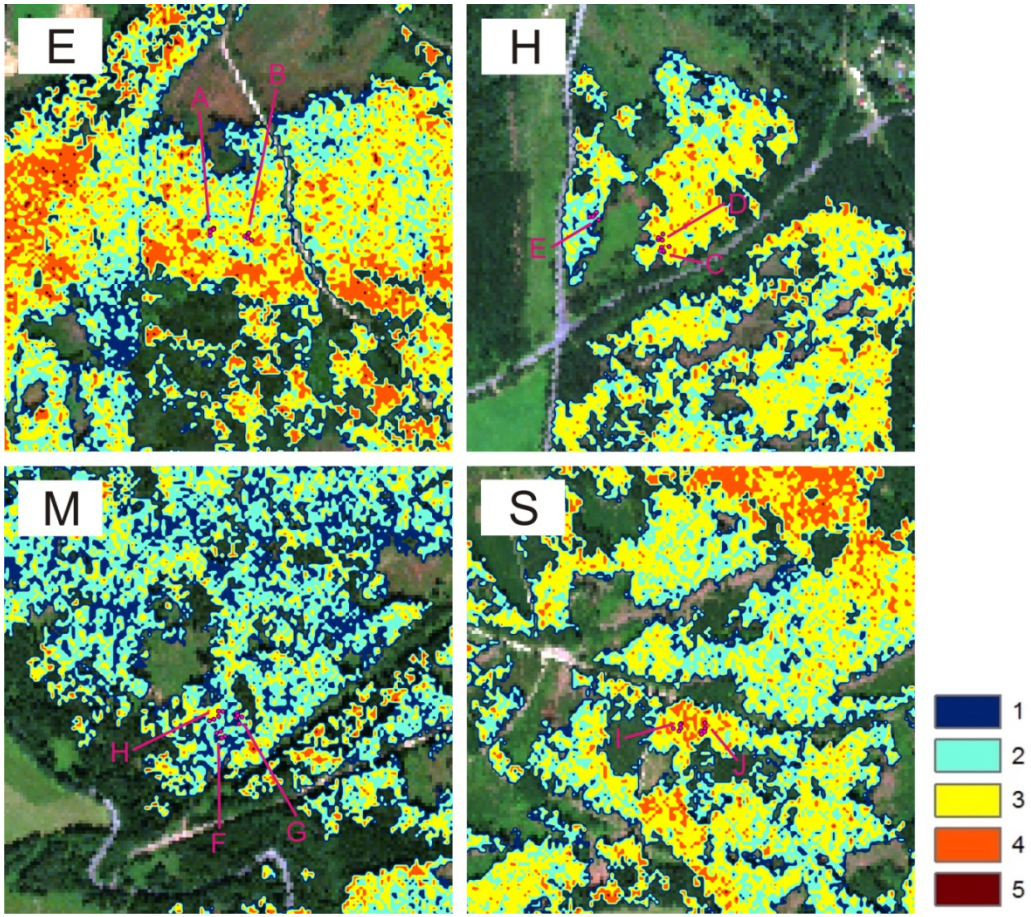



# Vegetation mapping


- **Chlorophyll ($C_{ab}$) retrieval**
- **$C_{ab}$ integrated together with other parameters derived from the HyMap multi-flight line data to assess subtle changes in physiological status of macroscopically undamaged foliage of Norway spruce**

# Vegetation mapping

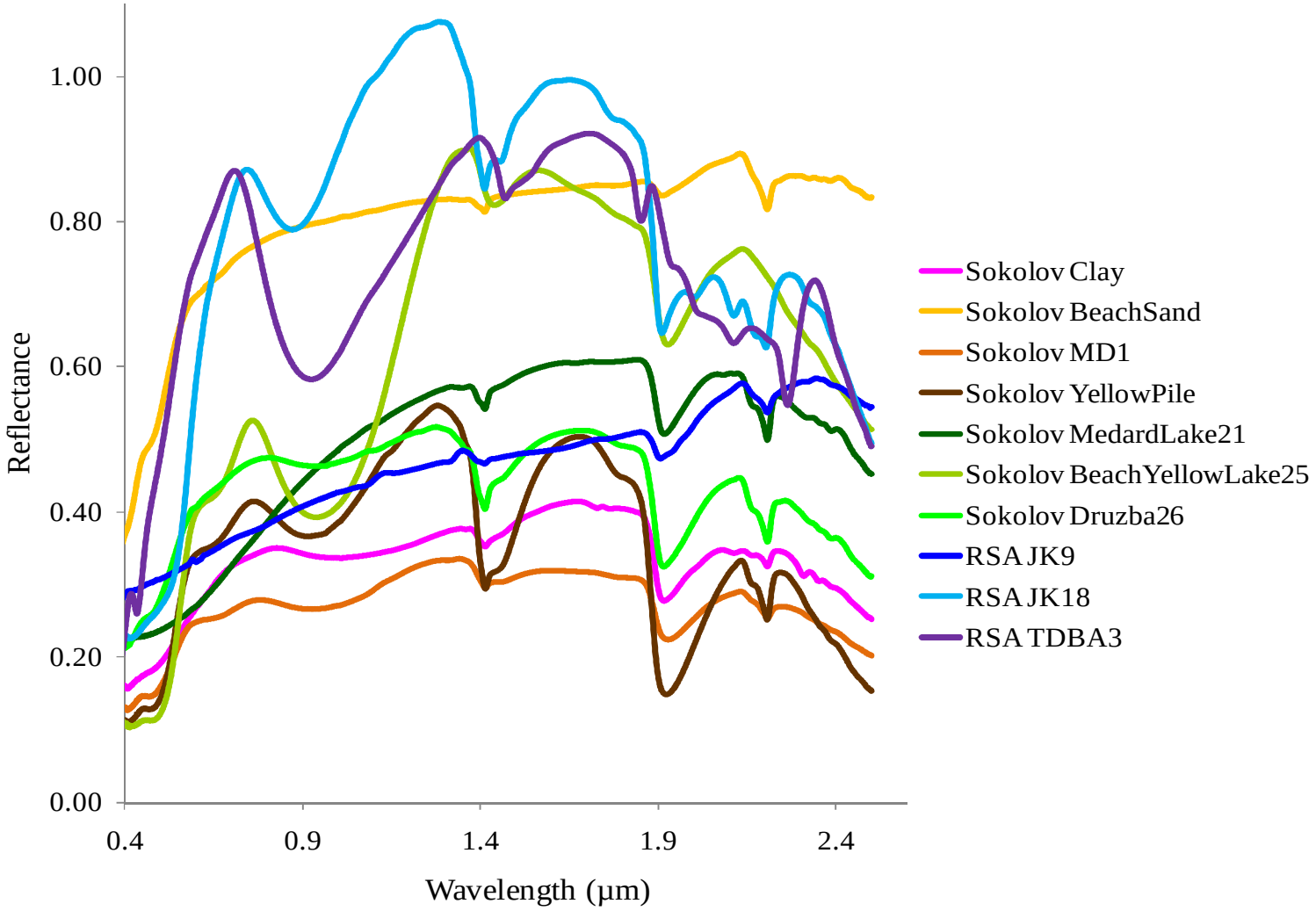



**Statistical classification of Norway spruce health status by integrating the indicators $C_{ab}$, REP and expSIPI.**

**Color scale 1-5 – health status classes for the trees without visual damage symptoms**

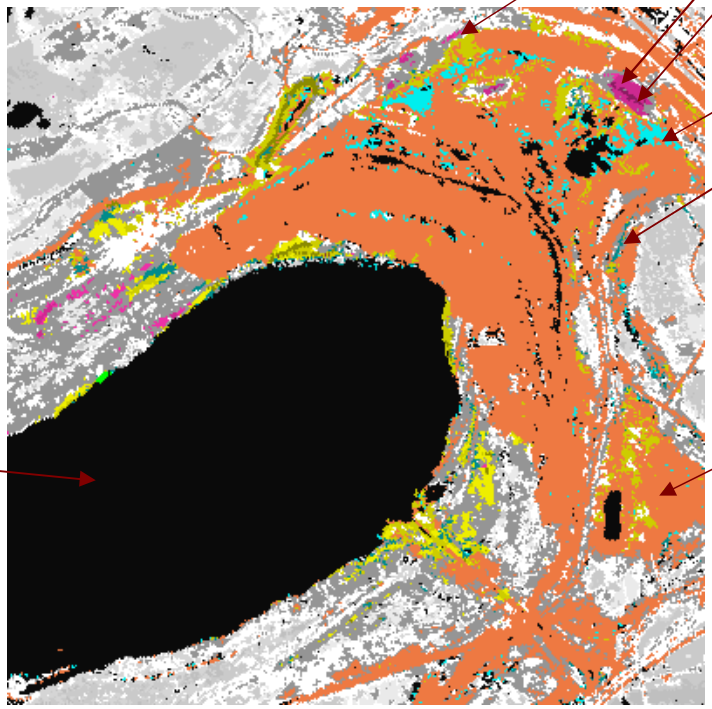
**1 - the worst and 5 - the best result**

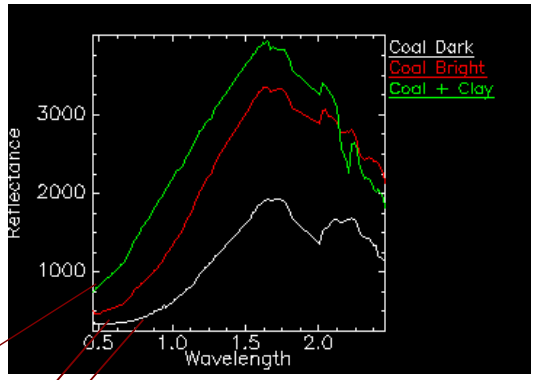
# Reflectance spectra VIS-NIR-SWIR reflectance spectra for hyperspectral thematic mapping

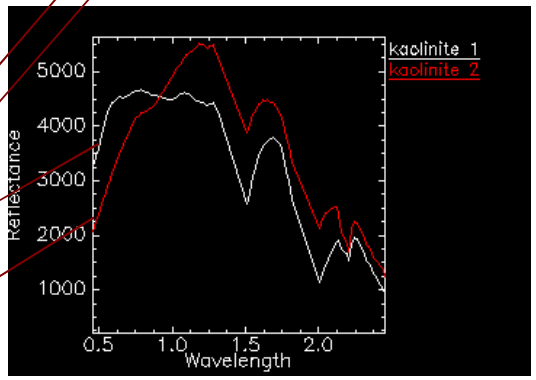


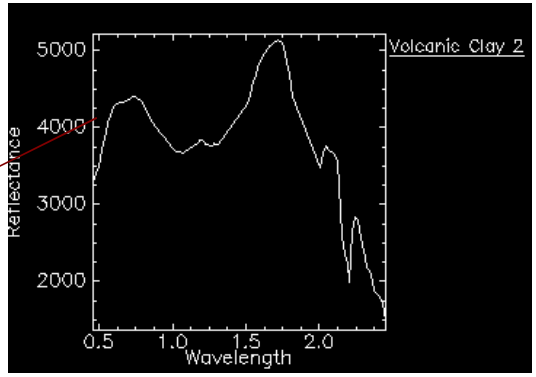
# Mineral mapping

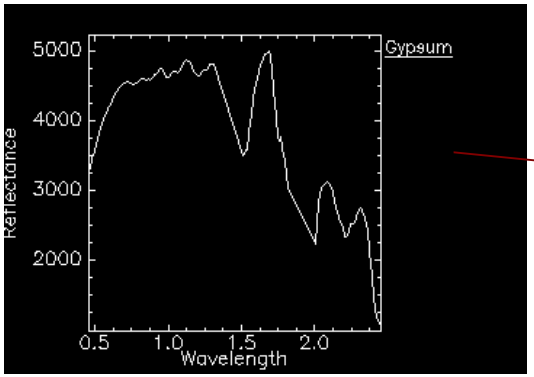
- Fe-Oxide/Hydroxide
- Volcanic clay 1
- Volcanic clay 2
- Fe Clay 1
- Fe Clay 2
- Fe Clay 3
- Coal + Clay
- Coal Bright
- Coal Dark
- Kaolinite 1
- Kaolinite 2
- Gypsum





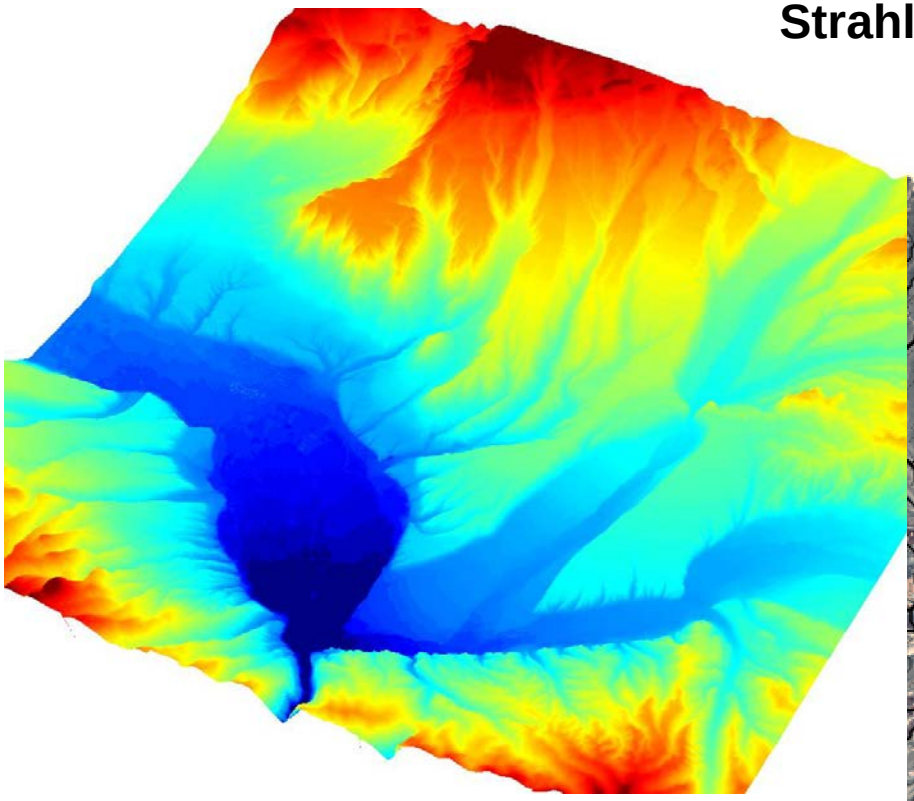
# Kazarman – Kyrgyzstan

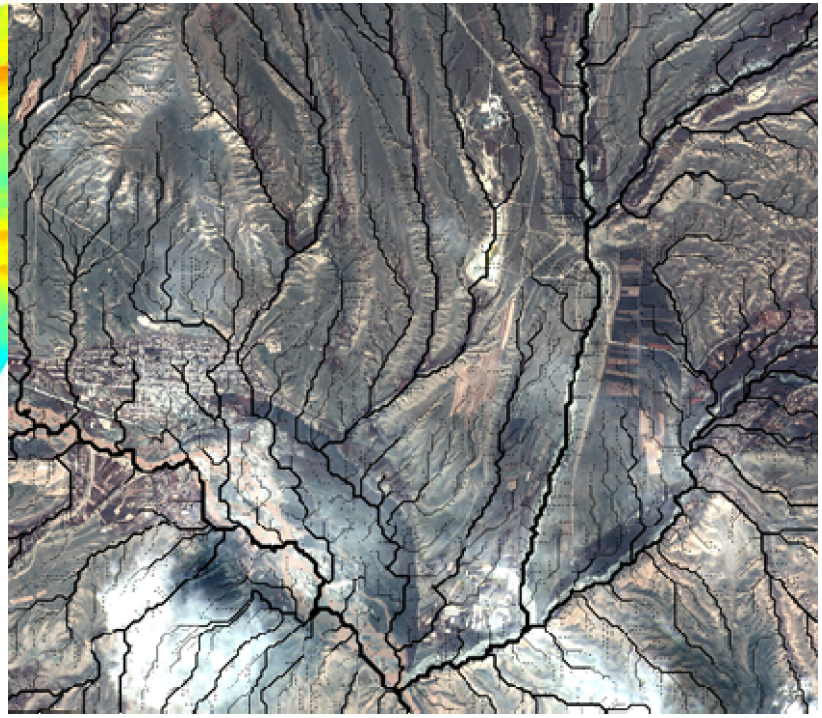
**Existing tailing pond: Investigation to secure ground-water resources:**

- **Modeling of potential surface and subsurface flow directions**
- **taking dust samples and**
- **spectradiometric measurements of the tailings and from soils on different locations**

# Calculating Flow Accumulation

**WorldView-II derived DEM and calculated Strahler network**

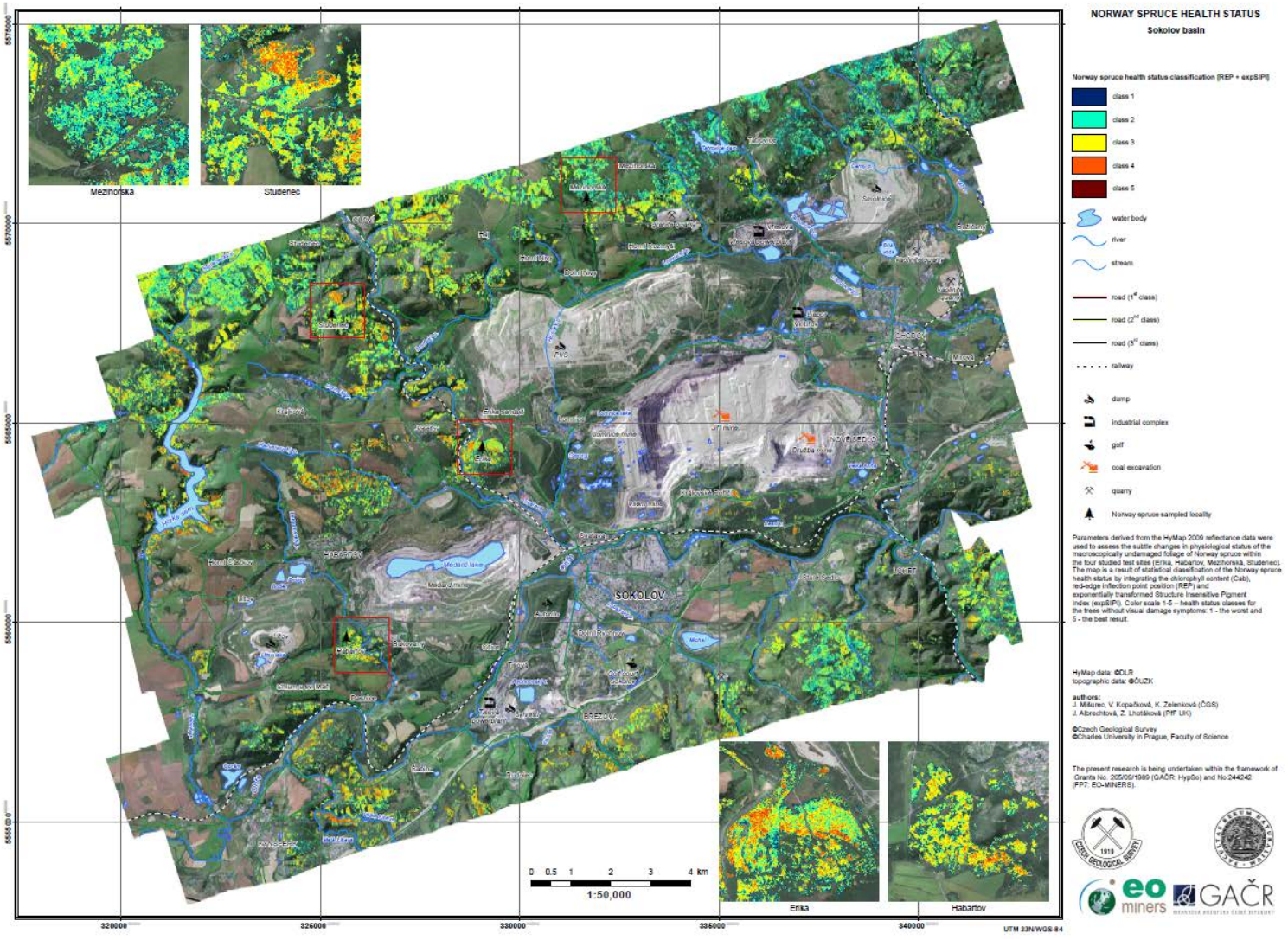




# EO product development

| Environmental issues | Causes | Indicators | Measureable parameters | Potential for EO assessment of parameters | EO data availability for parameters | Task / status | Comments | Investigating institute |
|---|---|---|---|---|---|---|---|---|
| Water quality | AMD | **Water Quality**: **E4** Acid drainage generation potential (distribution of sulphidic iron minerals) | Distribution of secondary iron oxide minerals | YES – Hyperspectral airborne data, ASTER or Hyperion satellite | Airborne hyperspectral available for '09,'10 and '11 (although cloudy), Landsat, AVNIR-2 and some ASTER imagery | Selected AMD-related minerals can be mapped | Selected AMD-related minerals can be mapped. Map scale? | DLR and TAU and BGS |
| | | | Surface drainage map | YES – SRTM, LiDAR or elevation derived from stereo airborne photography or satellite imagery such as ASTER | 5 m DEMs derived from Cartosat stereo images (although not validated) and some ASTER imagery | Raw DEM exists | Ideally a hydrologically correct DEM is needed (calculation: ArcGIS), dGPS data required | Czech Geological Survey, BGS |
| | | | Groundwater table and flow directions | YES – ground network required unless regional scale when GRACE satellite data could be utilised. ALERT | No suitable data available yet(?) | topographic information exists | Difficult to model - Is there a ground water model available? | ? |

# EO product development



# Standards & Protocols

Standards

- are a pre-requisite for quantitative analysis and have to be traceable to (inter)national calibration standards, e.g. ISO TC 2011 or DIN/EN
- simplify the processing chain and data exchange
- allow maintenance, evolution and checks of results

Accomplished

- standardized preprocessing of reflective & thermal imagery
- homogeneous database of reference measurements following agreed standards and protocols
- harmonization with & extension of existing quality indicators/ quality layers
- in-line with current standardization activities, e.g. EUFAR, CEOS

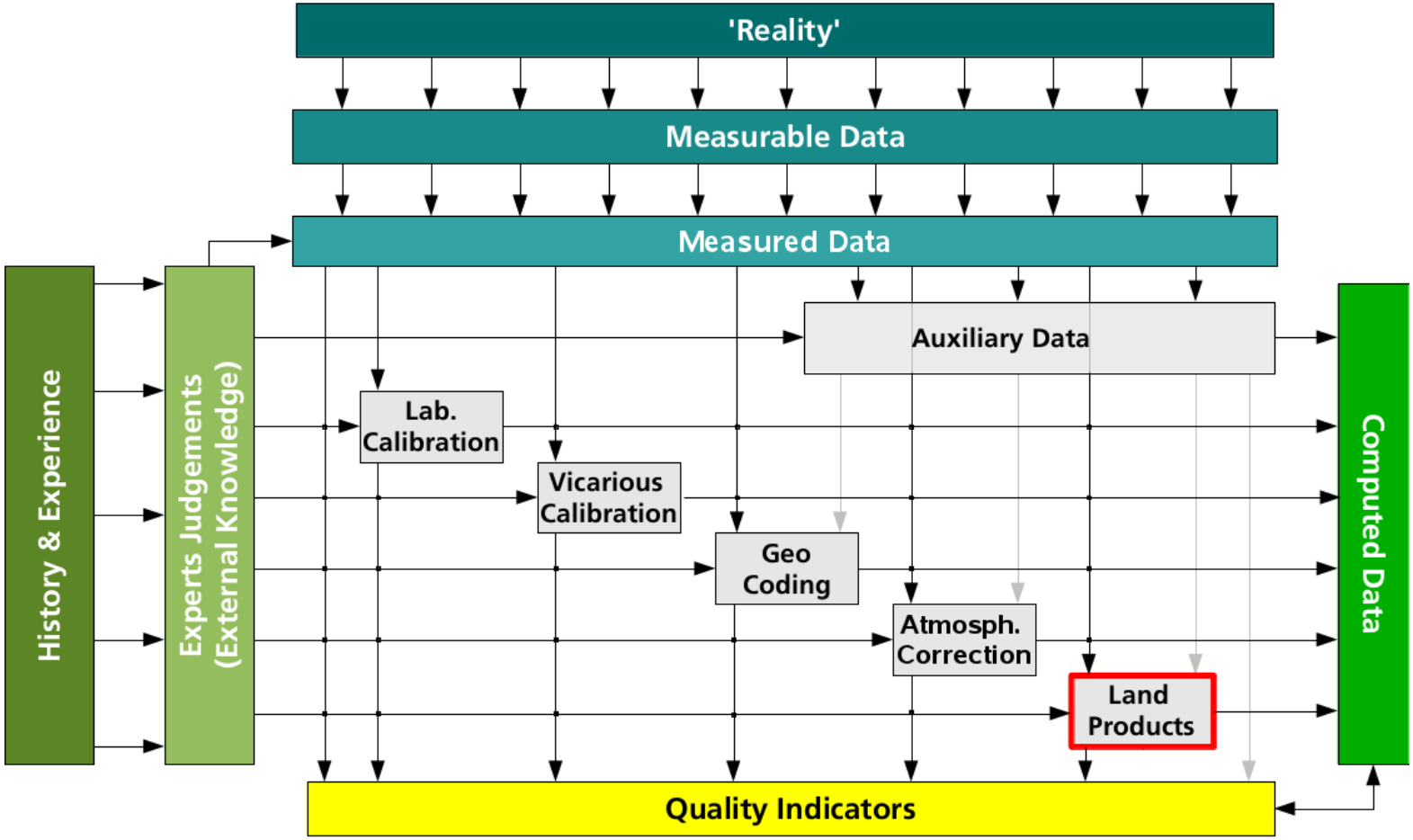
Ongoing Activities

- improvement of processing work-flow, including airborne TIR data
- definition of TIR quality layers & combination with reflective quality layers
- definition of data products, including meta-information, referenced to existing standards to support multi-sensor applications and combination of data from the reflective and thermal domain.

# Standards & Protocols

| Parameter | Recommended usage | Report format | Validity (spatial extend) | Validity (processing level) | Dissemination | Status | Comment |
|---|---|---|---|---|---|---|---|
| | | (T)ext report (I)mage flags | (P)ixel (L)ine (C)olumn (B)and (D)atacube | (L0) raw data (L1) radiance (L2geo) (L2atm) (L2atm+geo) | (I)nternal usage (P)ublic | (I)n use (P)reparation (N)ot started | |
| **Sensor calibration / System correction** | | | | | | | |
| Aggregarted interpolated pixel mask ("corrected") | C | I | P | L0, L1, L2geo, L2atm, L2atm+geo | I | I | |
| Aggregared bad pixel mask ("not corrected") | C | I | P | L0, L1, L2geo, L2atm, L2atm+geo | P | I | |
| **Image data artifacts / Processsing errors** | | | | | | | |
| Saturated pixel / overflow | C | I | P | L0, L1, L2geo, L2atm, L2atm+geo | I | P | |
| Pixels affected by saturation in preceding bands | P | I | P | L0, L1, L2geo, L2atm, L2atm+geo | I | N | Specific problem in frame-transfer CCDs (e.g., AISA Eagle) |
| **GPS / IMU - related / Geo. correction** | | | | | | | |
| Problems with position information | C | I | L | L2geo, L2atm+geo | P | N | Due to rapid platform movement, no DGPS available, … |
| Problems with altitude information | C | I | L | L2geo, L2atm+geo | P | N | Due to rapid platform movement, no DGPS available, … |
| Interpolated pixel during geocoding | C | I | P | L2geo, L2atm+geo | - | - | |
| Interpolated position information | P | I | L | L2geo, L2atm+geo | - | - | Due to data gaps, erroneous signal, … |
| Interpolated altitude information | P | I | L | L2geo, L2atm+geo | - | - | Due to data gaps, erroneous signal, … |
| Synchronization problem | P | I | D | L2geo, L2atm+geo | - | - | |

# Quality assessment & Current Developments



# Expected Results

- EO-based tools for updating geo-spatial information in mining regions, for monitoring mining related changes – and possible impacts – contributing to more sustainable extraction of natural resources

- EO techniques should be used to improve existing and often only selective approaches recording of environmental impacts. An important aspect is the development of validated data products and their acceptance by industry and supervisory authorities (standards & protocols)

- Addressing GEO (Group on Earth Observation) and GEOSS (Global Earth Observation System of Systems) process and tasks, by using project out-puts to define core elements of an environmental observing system and examining how this system fits in GEO and contributes to building GEOSS