

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

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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:

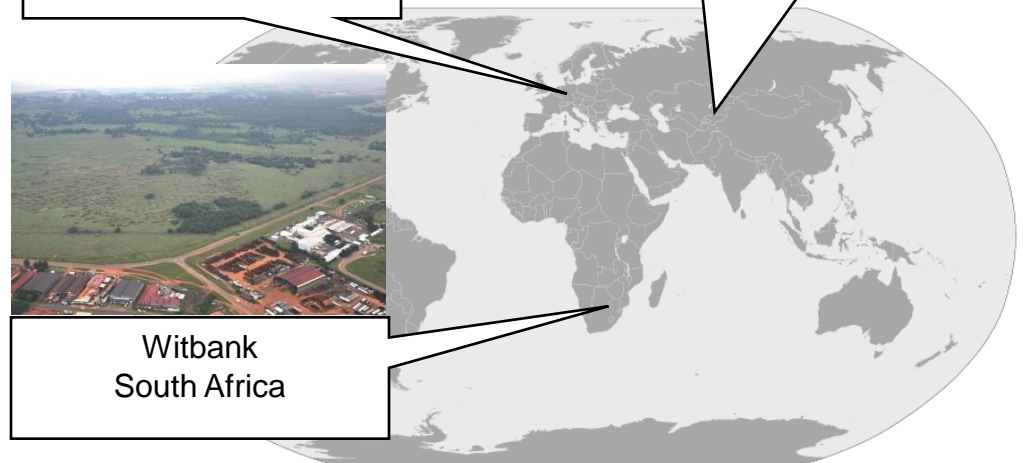
- necessity of a regular monitoring of soil and water on heavy metals content
- impact zone around a tailing dump



Sokolov
Czech Republic

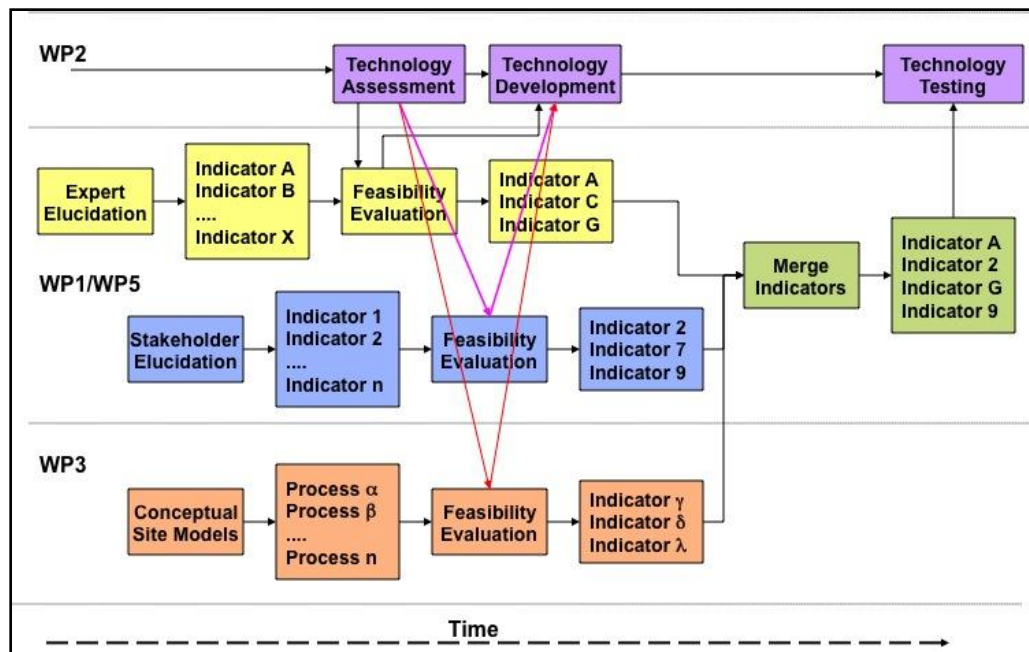


Makmal
Kyrgyzstan



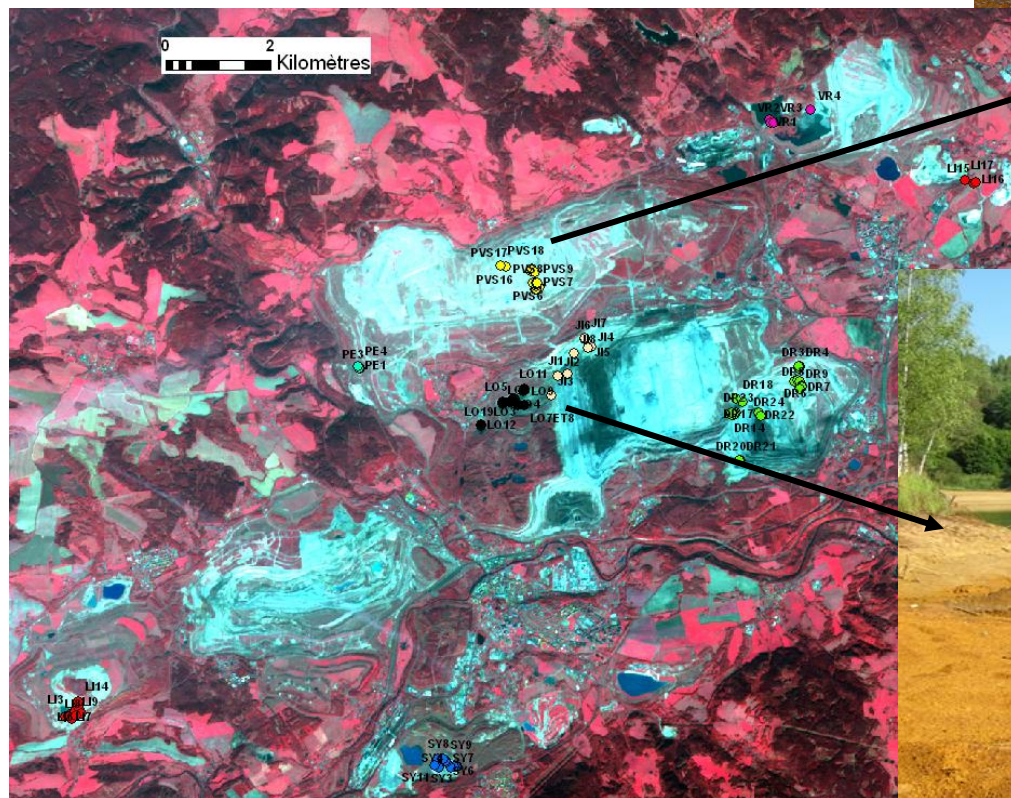
Witbank
South Africa

- 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 presented and are subject to stakeholder evaluation during workshops at the end of the project.



	RS Image data		DEMs		EO & GIS	
test site	data set	Data type	Data set	Resolution	Data set	Data type
Sokolov CZ	Hymap 2009	Hyperspectral VNIR - SWIR	Cartosat 2009	Resolution 5 m	ASD spectra	Spectral library
	Hymap 2010		Cartosat 2010	Resolution 5 m	TIR spectra	
	AHS 2011	Hyperspectral TIR	Cartosat 2011	Resolution 5 m	Temperature measurements	Dust measurements
	orthophoto mosaic	Aerial photographs	GEODIS	Resolution 10 m	Geology	
	CASI ALI ASTER	Hyperspectral VNIR 10 bands VNIR - SWIR 15 bands VNIR – SWIR - TIR	ASTER	Resolution 30 m	Land cover Topographic data	
Witbank ZA	WorldView_II	8 bands VNIR	WorldView_II	Resolution 5 m	ASD spectra	Spectral library
	Landsat TM series	7 bands VNIR - SWIR	SRTM	Resolution 90 m	TIR spectra	Spectral library
	SPOT	2.5 m color			Temperature measurements	Dust measurements
	FLIR survey	Airborne TIR			GIS	
	AISA dual 2012	Hyperspectral VNIR - SWIR			ALERT	
Makmal KG	WorldView_II	8 bands VNIR	WorldView_II	Resolution 5 m	Geology	Chemical analyses ASD spectra
	Landsat TM		SRTM	Resolution 90 m		
	SPOT	2.5 m color	ASTER	Resolution 30 m		

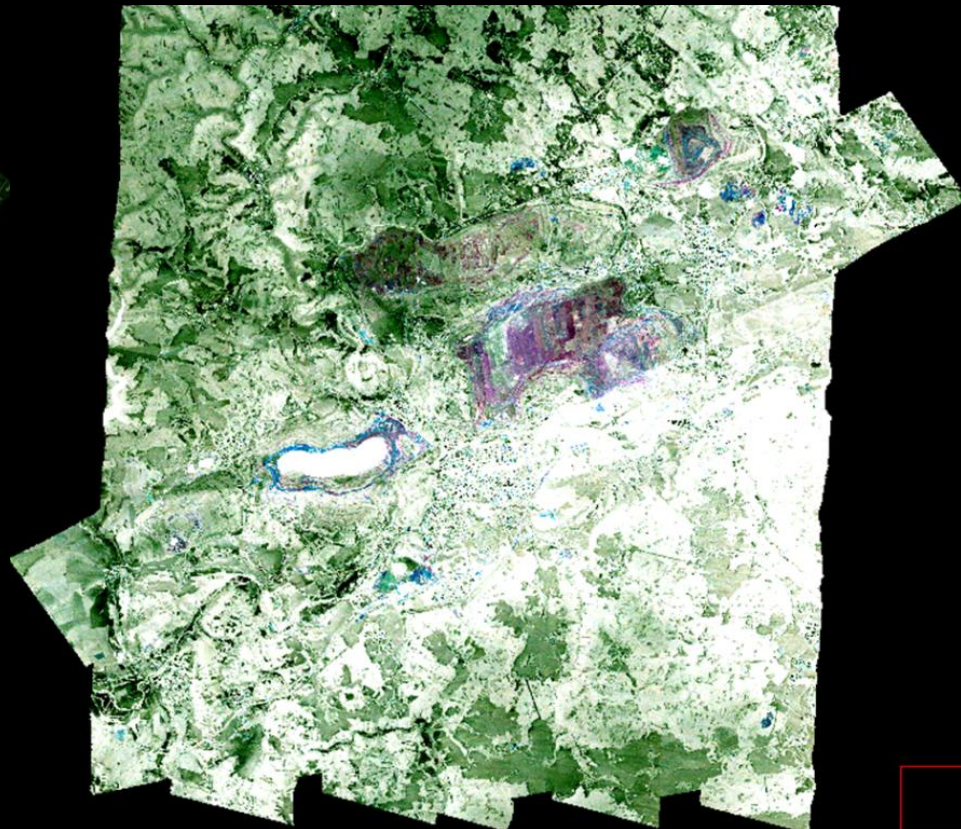
Acid Mine Drainage (AMD), related heavy metal contamination and influenced vegetation health status



HyMap 2010, reflectance

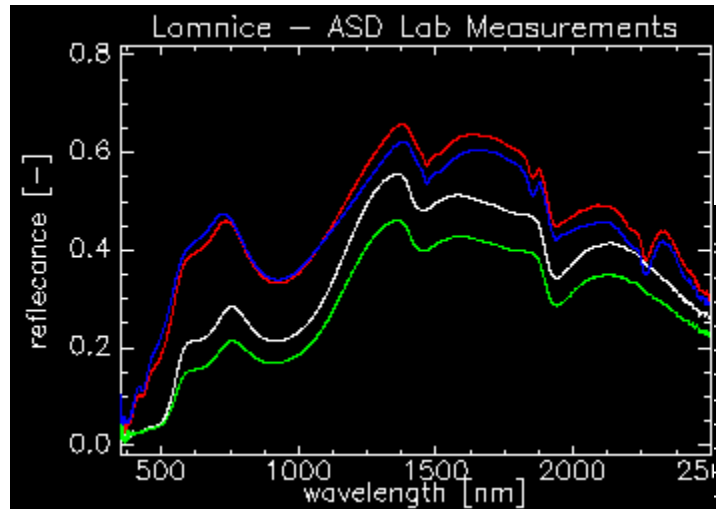


AHS 2011, emissivity

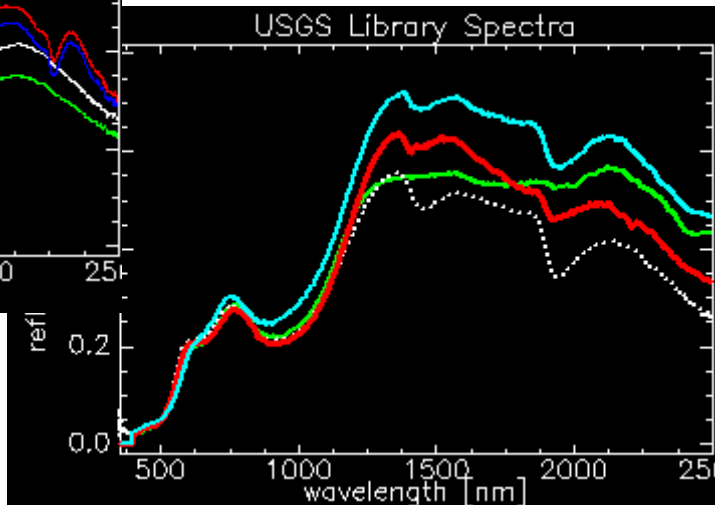


Standardized pre-processing of Reference Measurements

preprocessing & validation of VIS-SWIR

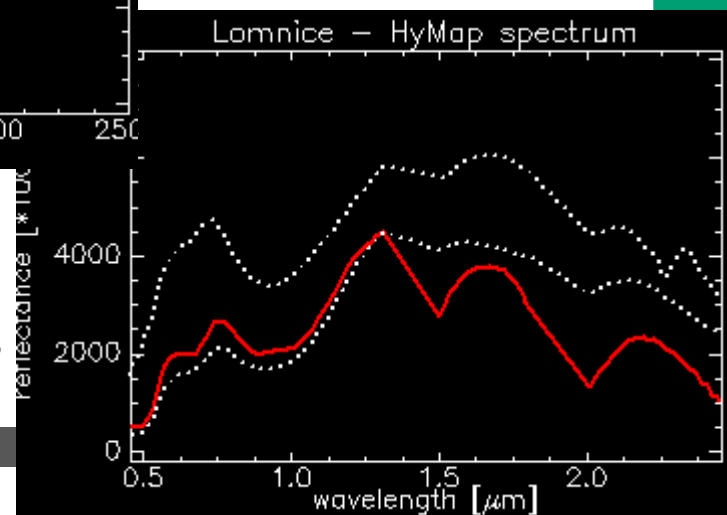


reflectance measurements (lab)
of goethite samples



measured vs. library
spectra of goethite

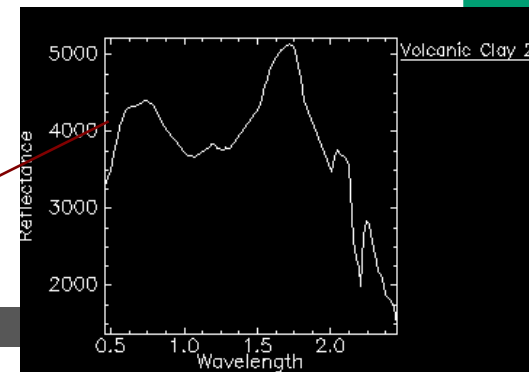
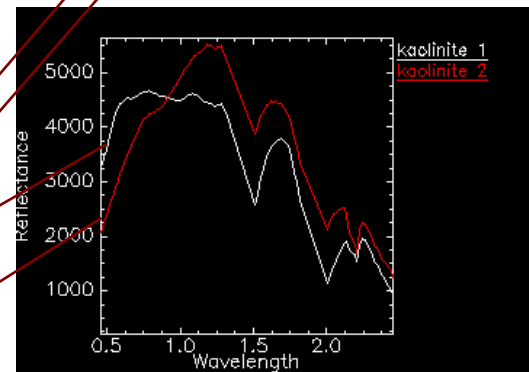
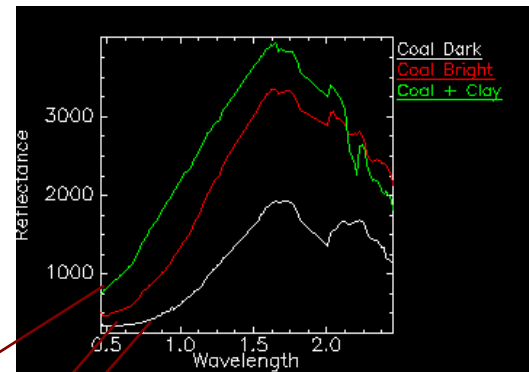
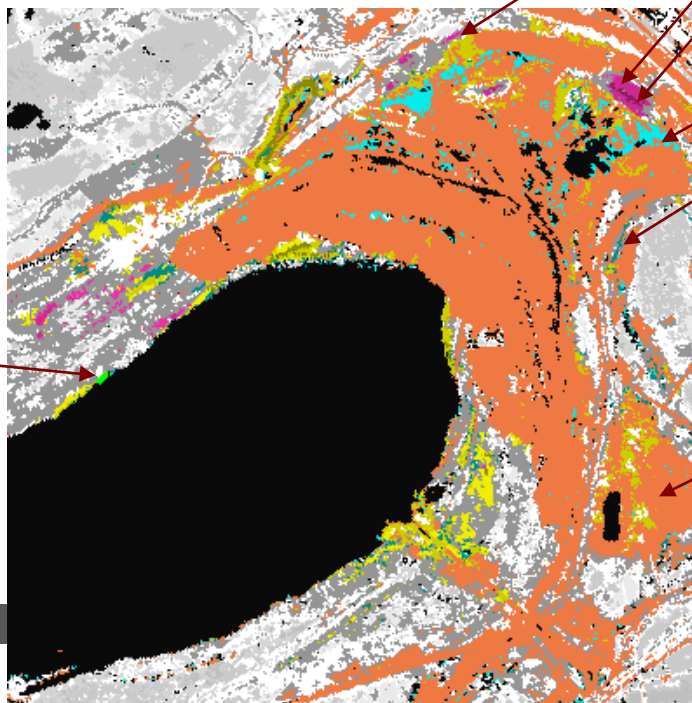
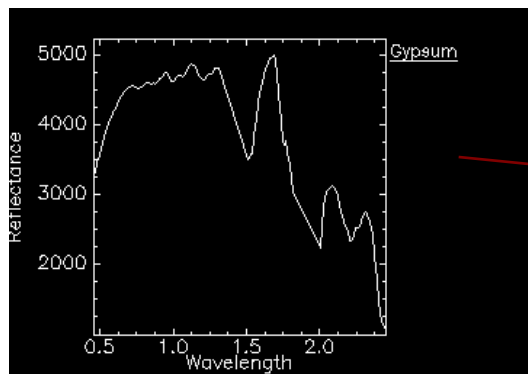
resampled measurements
vs. HyMap image spectrum



Mineral Mapping (VIS-SWIR)

flooded lignite mine

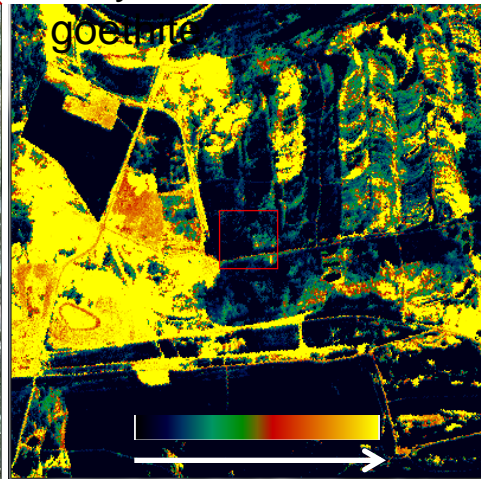
- Fe-Oxide/Hydroxide
- Volcanic clay 1
- Volcanic clay 2
- Fe Clay 1
- Fe Clay 2
- Fe Clay 3
- Coal + Clay
- Coal Bright
- Coal Dark
- Kaolinite 1
- Kaolinite 2
- Gypsum



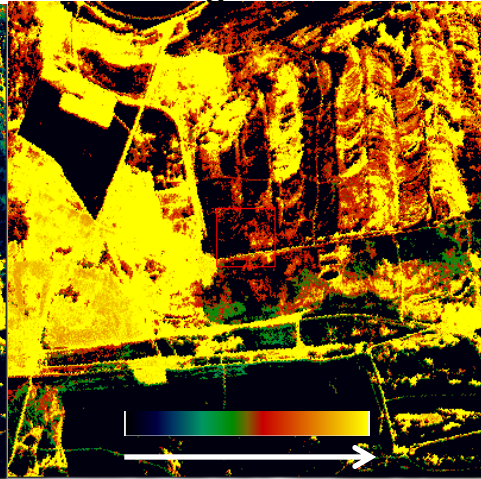
Mineral Mapping (VIS-SWIR)



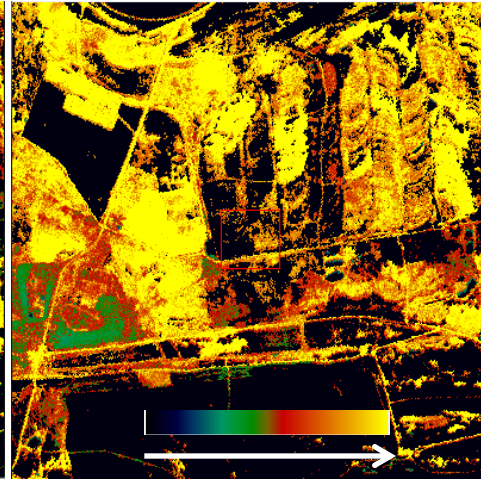
Clay minerals,
goethite



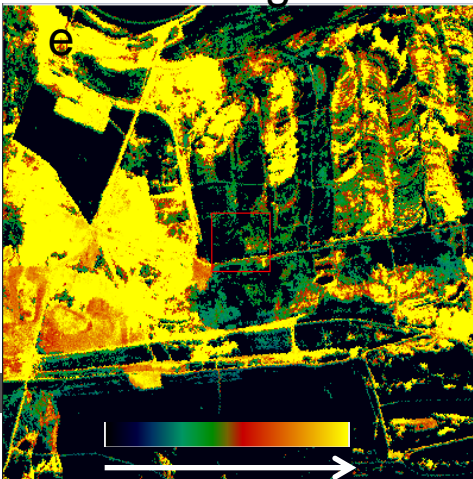
Jarosite+goethite



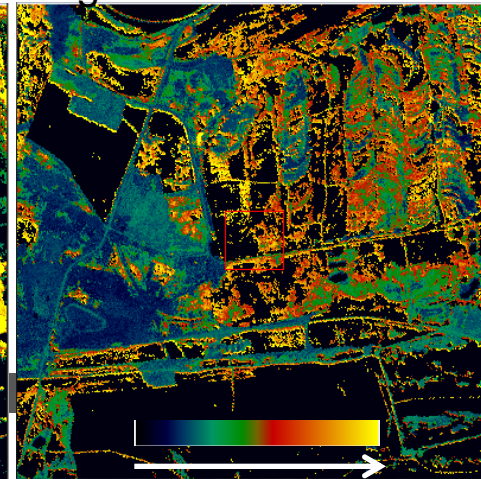
Jarosite



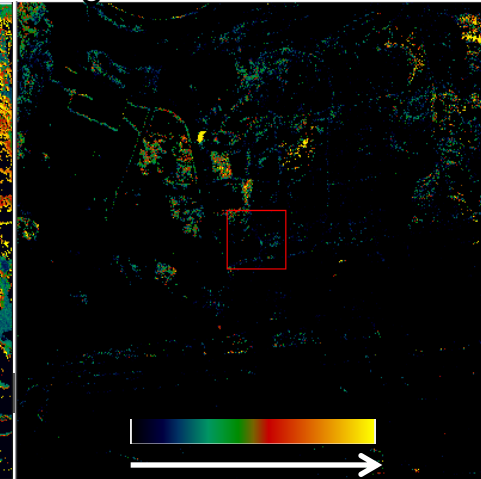
Jarosite+lignit



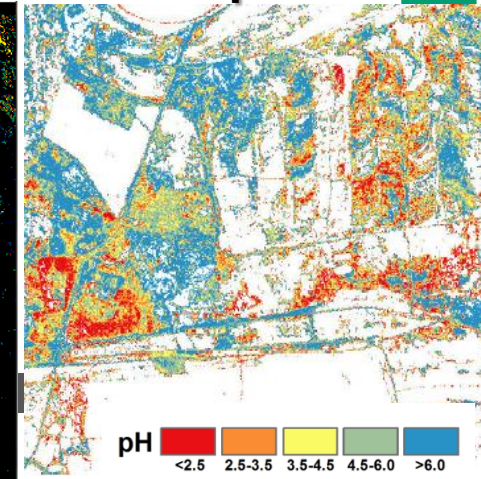
Lignite - weathered



Lignite - fresh



surface pH model

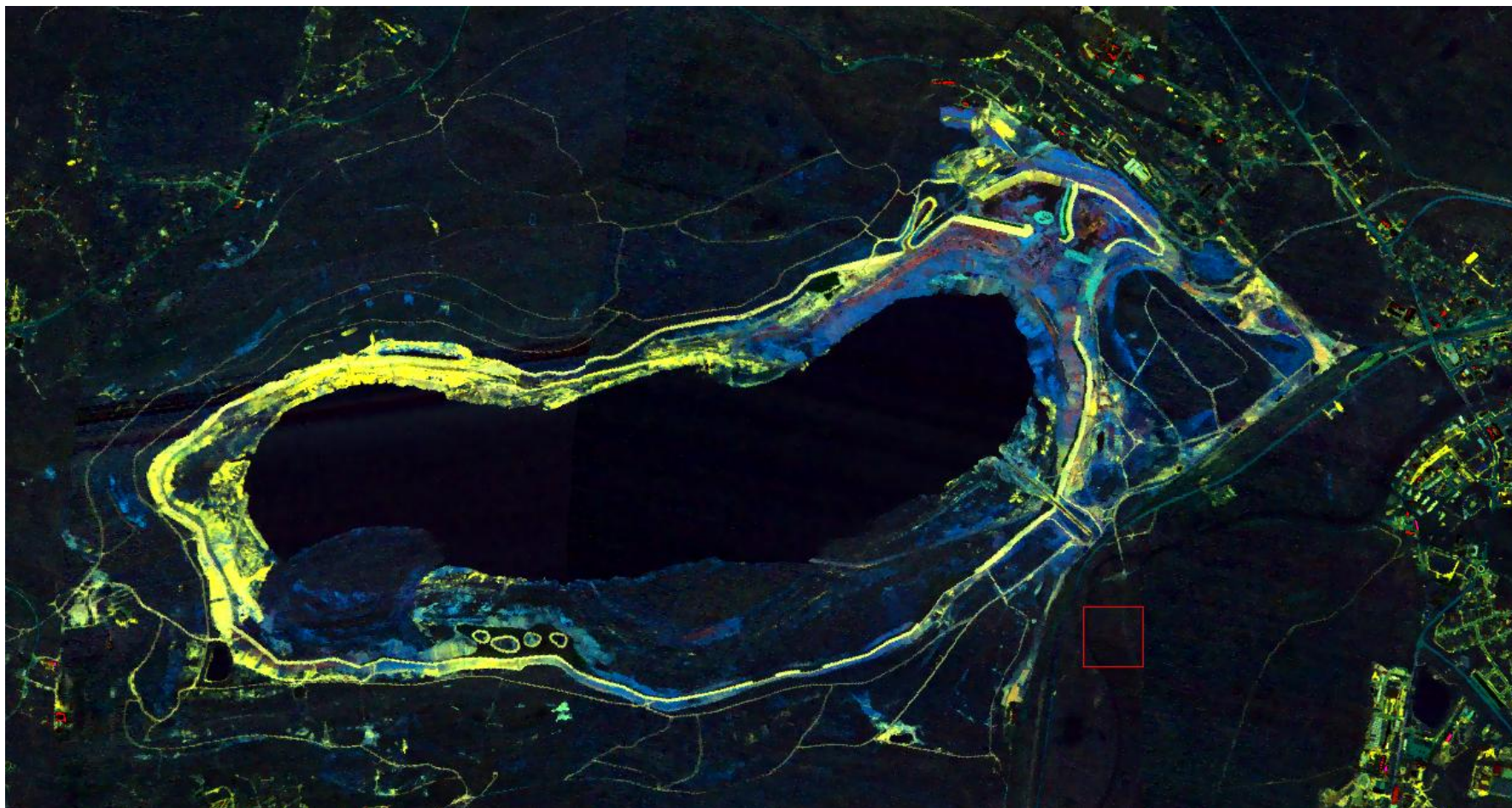


Mineral Mapping (TIR)

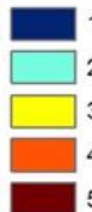
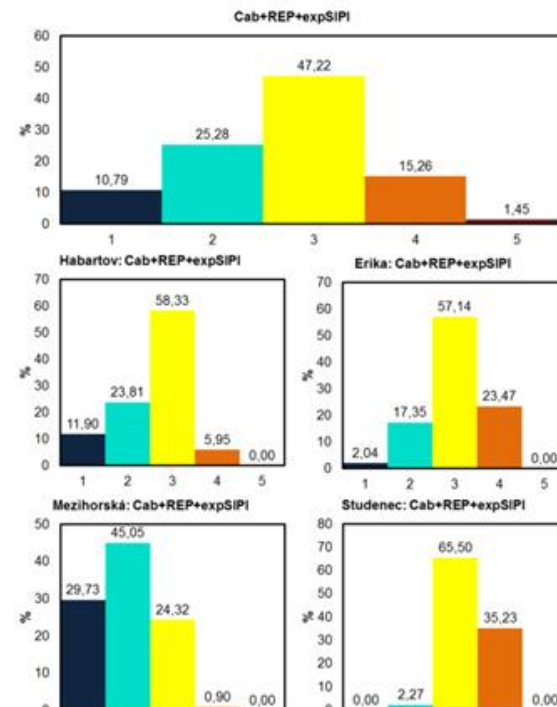
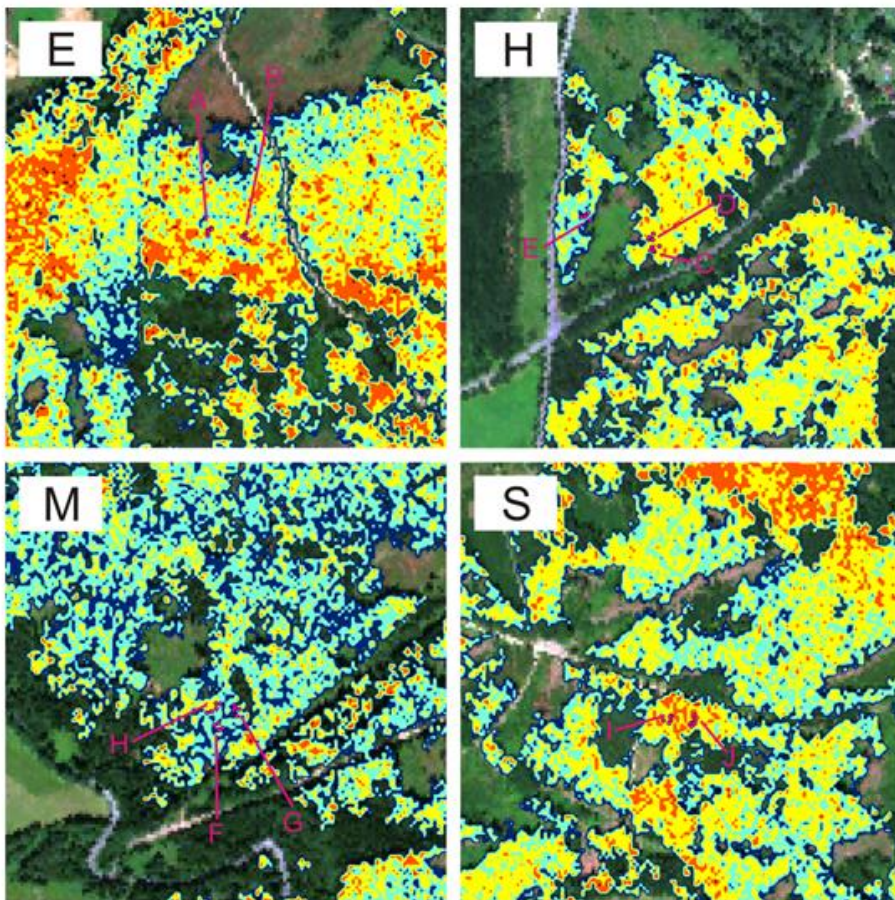
flooded lignite mine

blue : clay;

yellow : quartz



Forest Health Monitoring

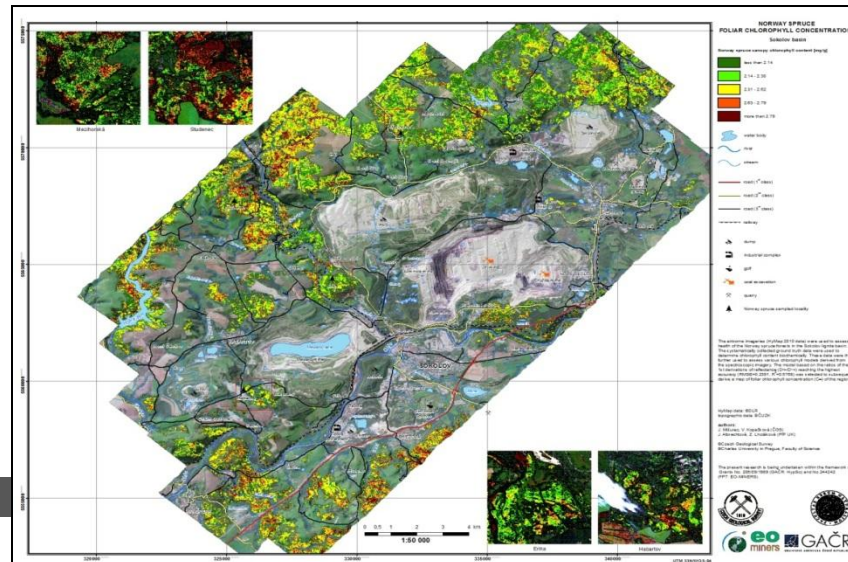
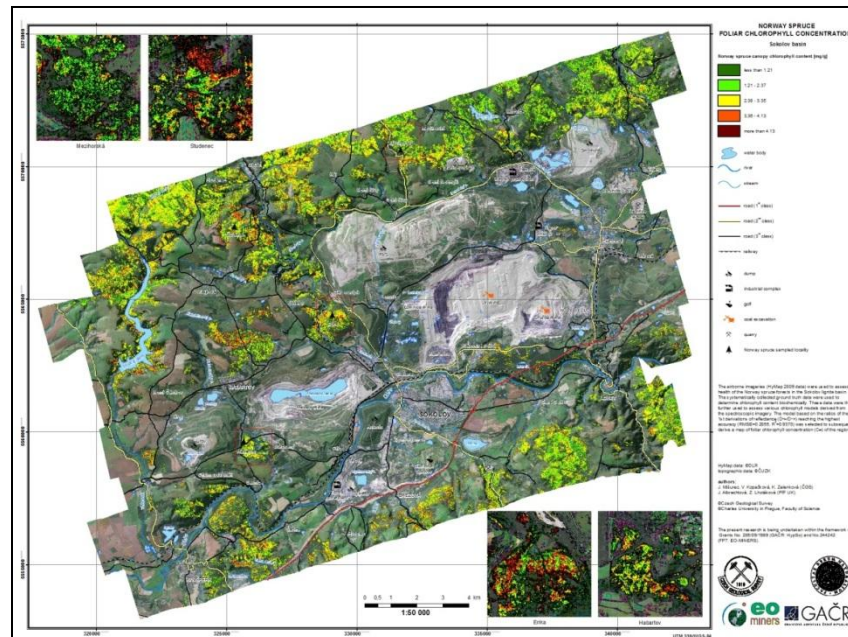
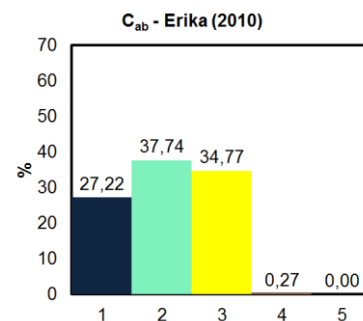
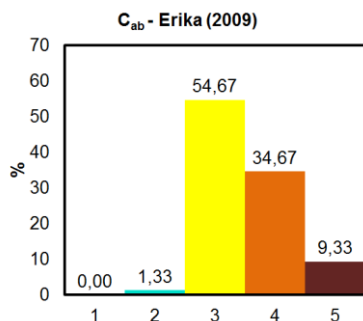
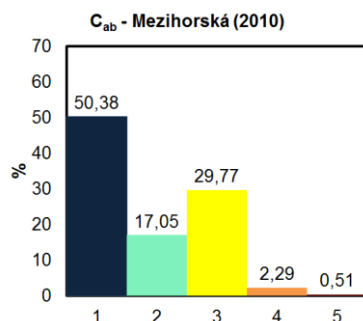
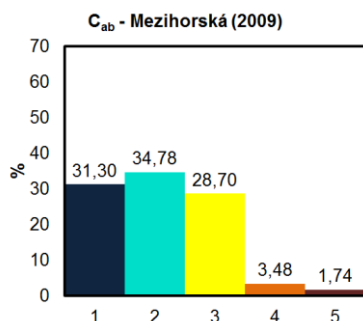
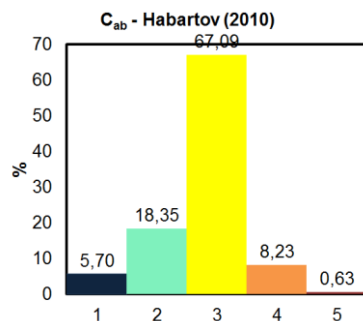
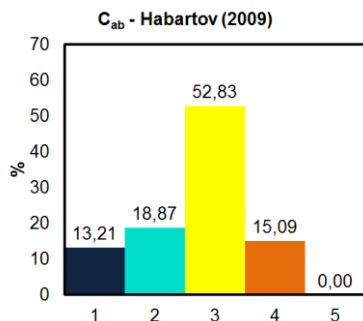


*Relative frequencies (%) :
The entire Sokolov lignite basin area (top) and the individual sites Erika, Habartov, Mezhorská and Studenec (bellow).*

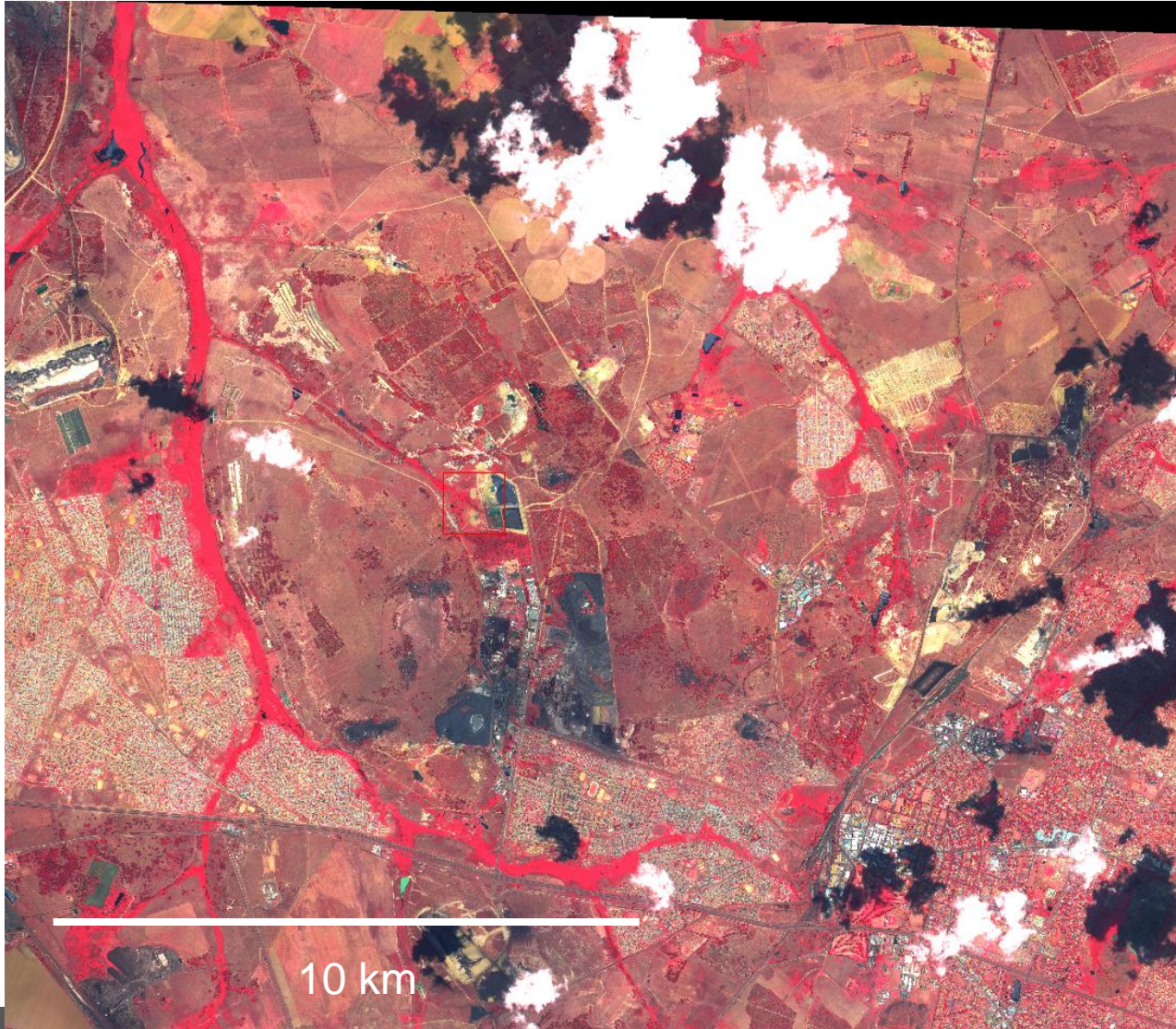
Health status classes for the trees without visual damage symptoms

1 - the worst and 5 - the best result

Temporal Changes in Forest Health



eMalahleni – Mpumalanga Province



eMalahleni (Witbank) – South Africa

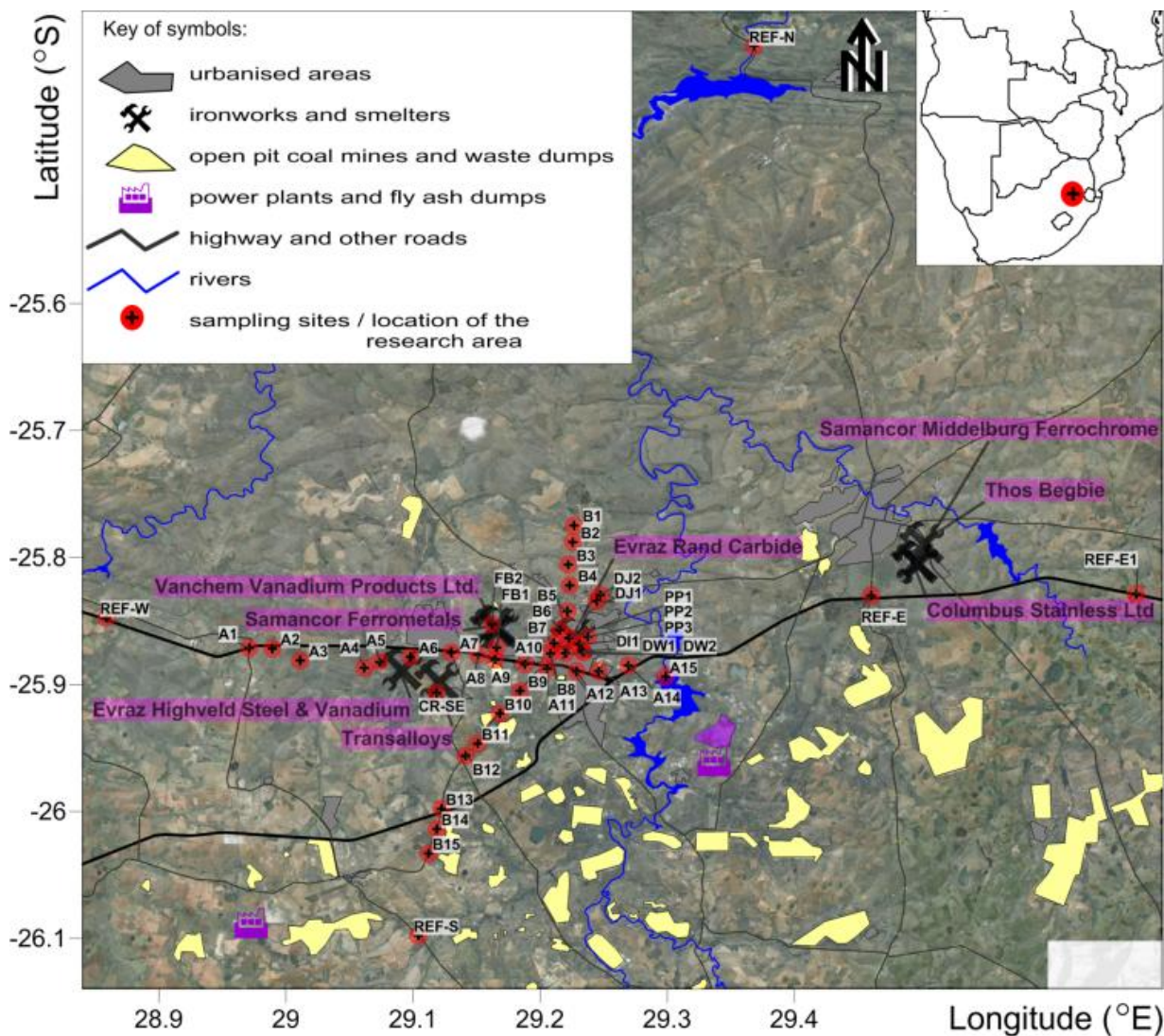


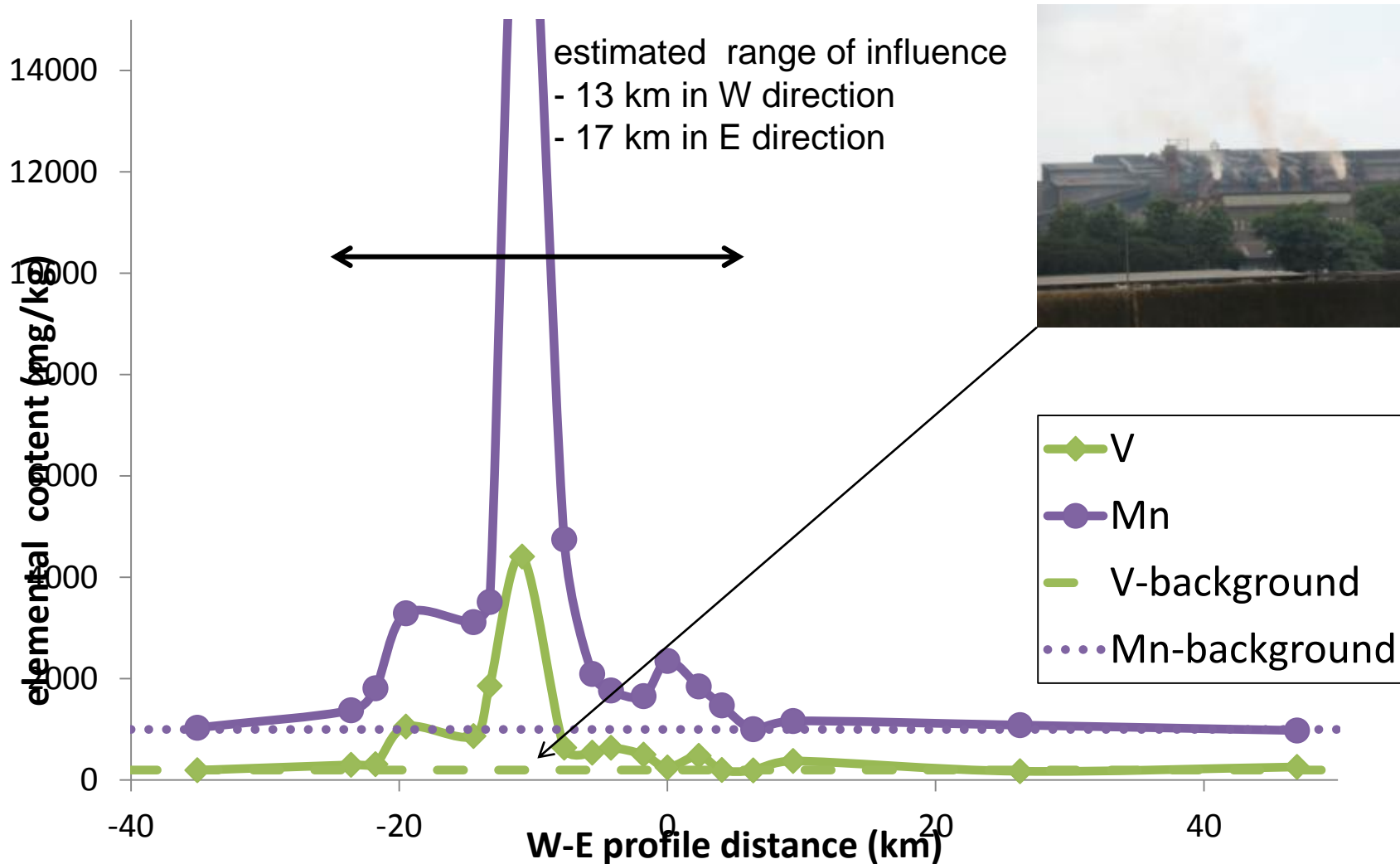
Abandoned and active mine sites in close neighborhood of urban settlements:

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

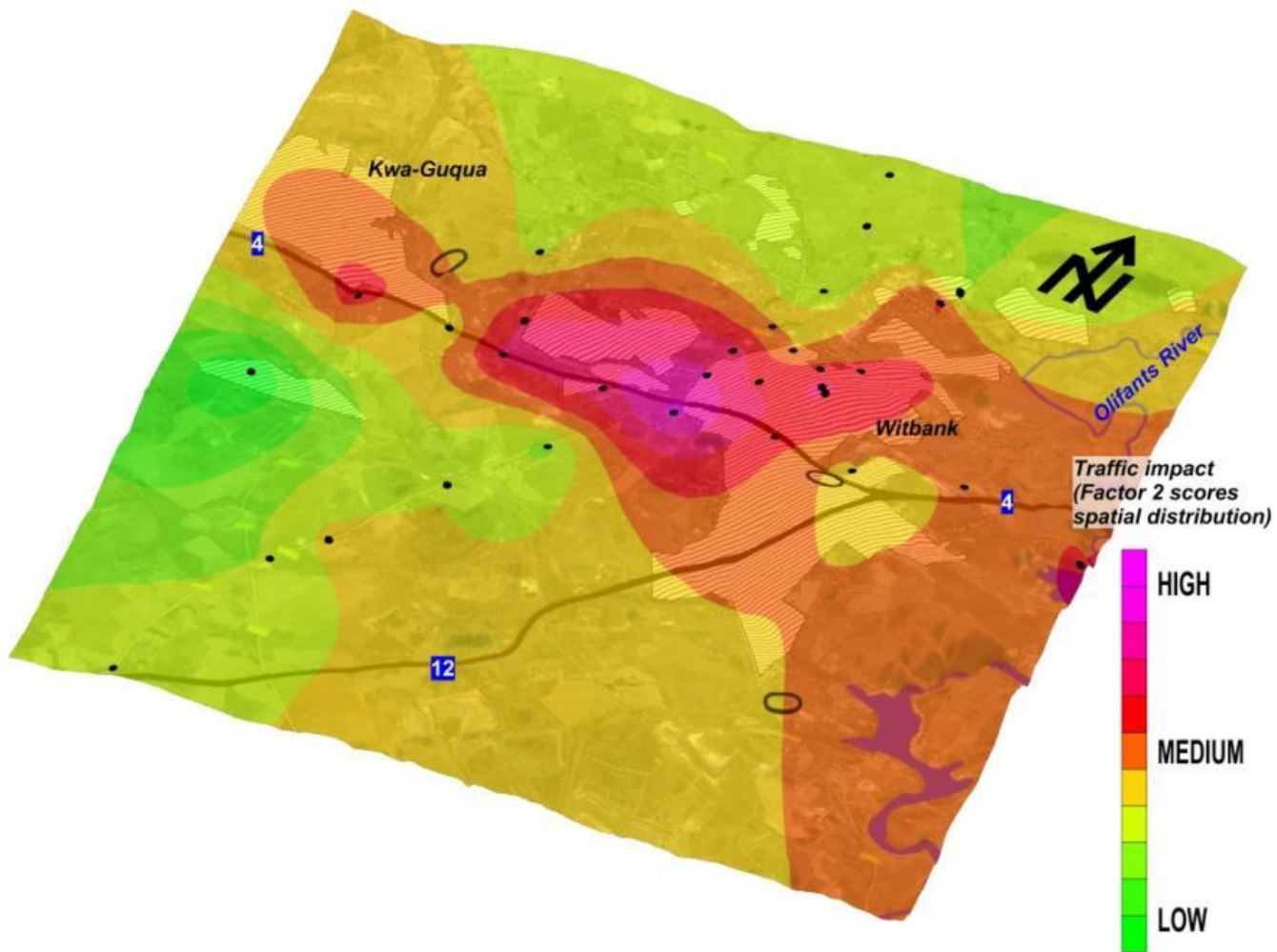


Street Dust Sampling



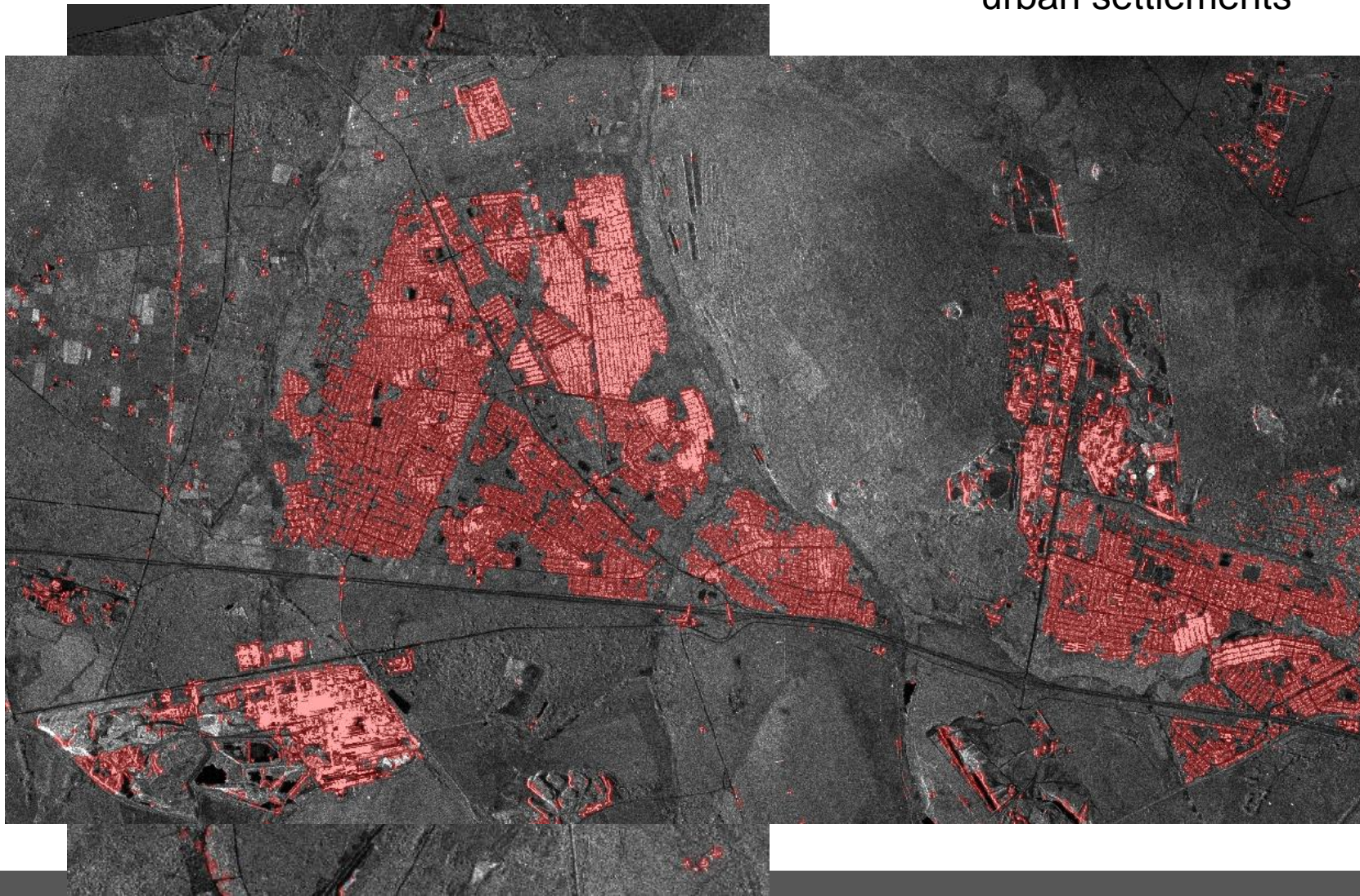


Spatial Distribution of Contamination

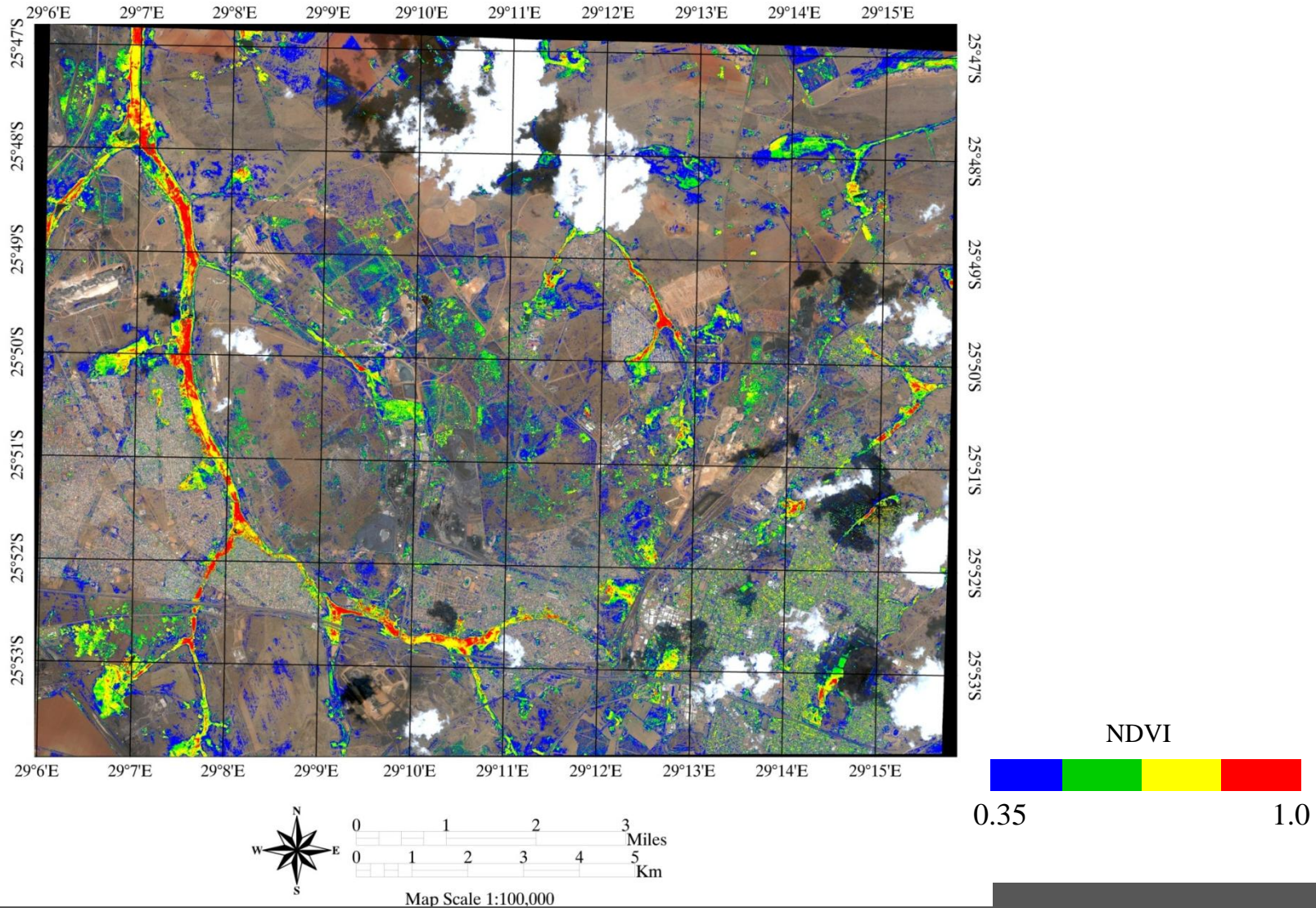


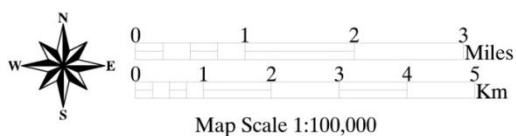
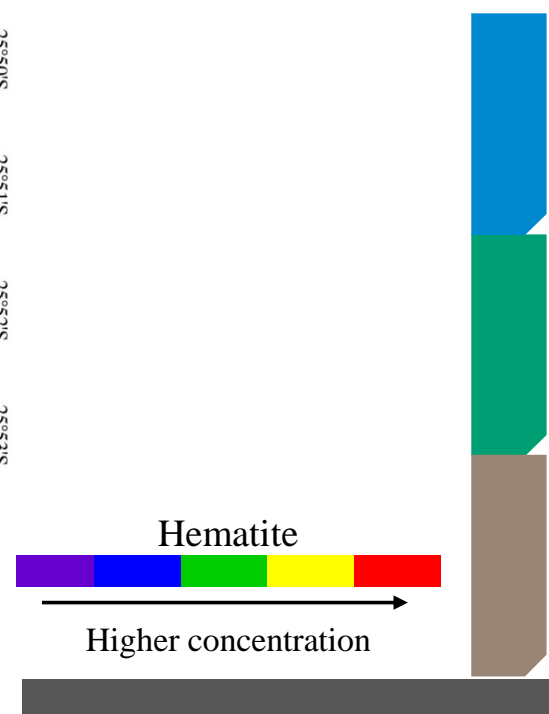
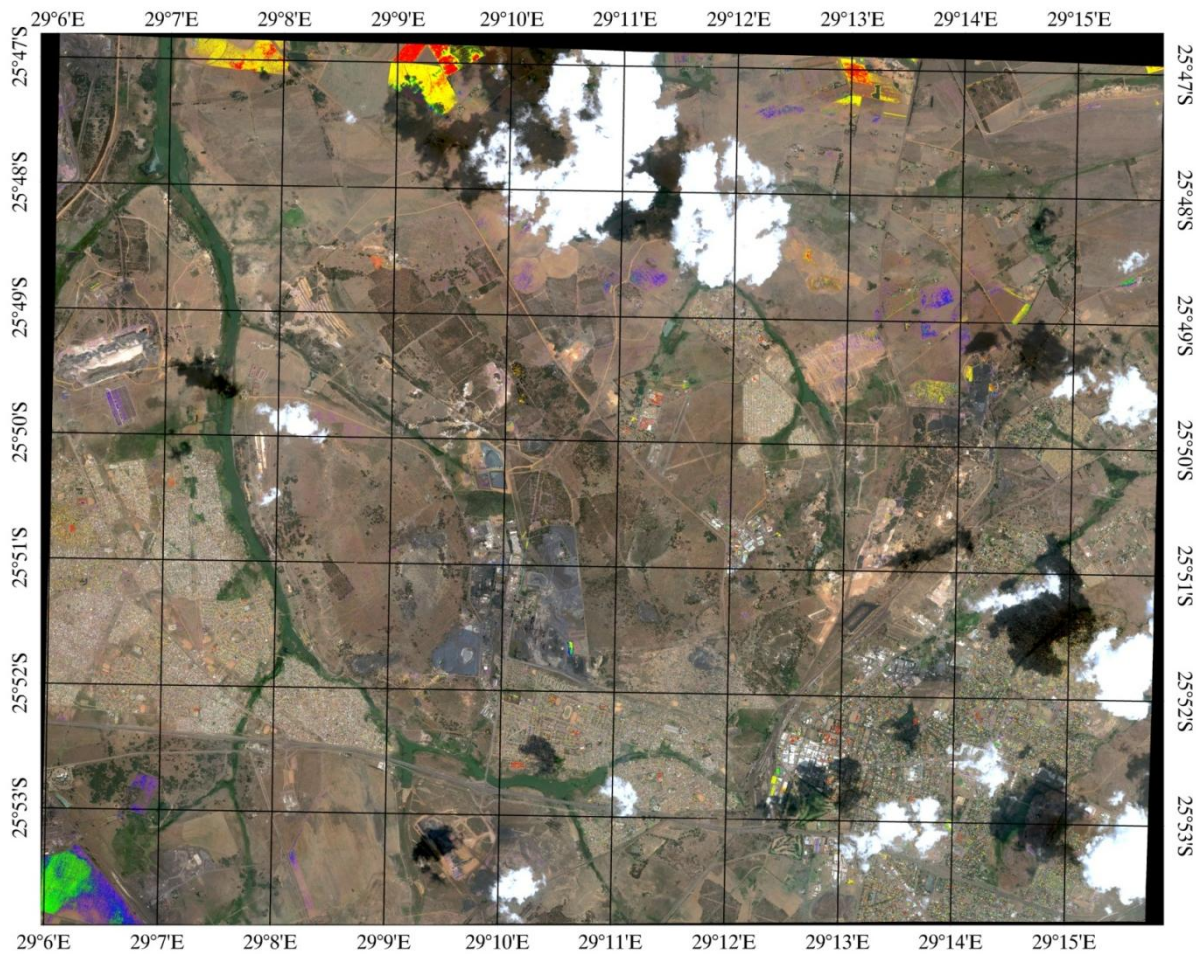
Human Footprint - TerraSAR-X

urban settlements



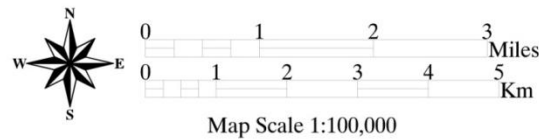
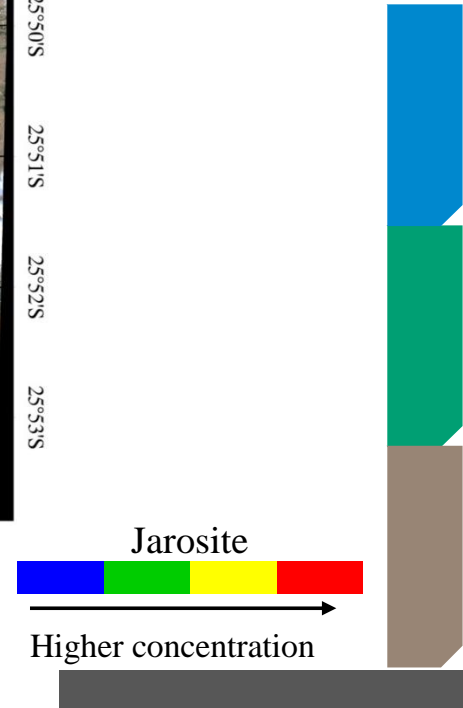
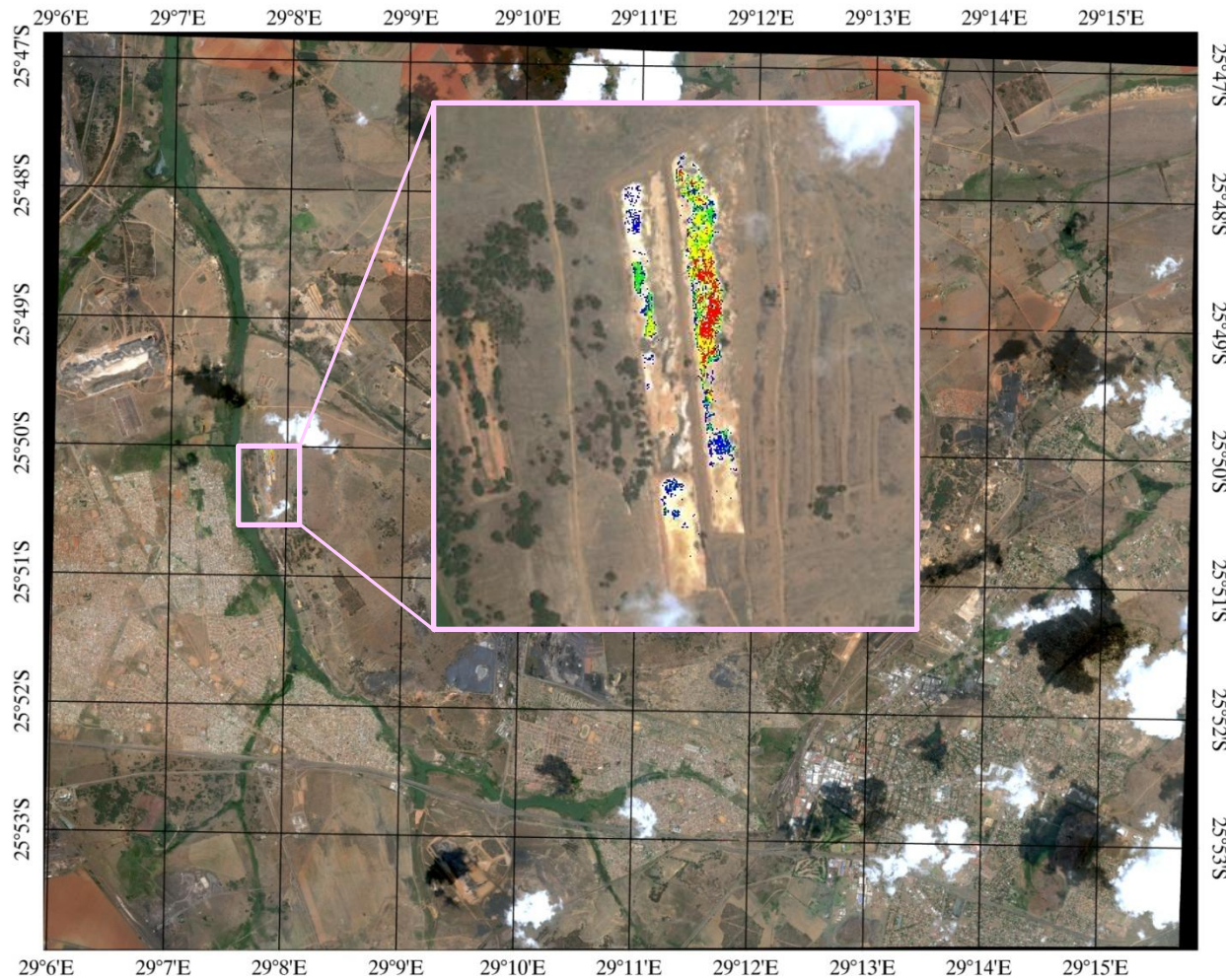
Mineral Mapping







Mineral Mapping



Coal Fire related Temperature Anomalies

Thermal night time Survey using a Matrix Detector: FLIR P640

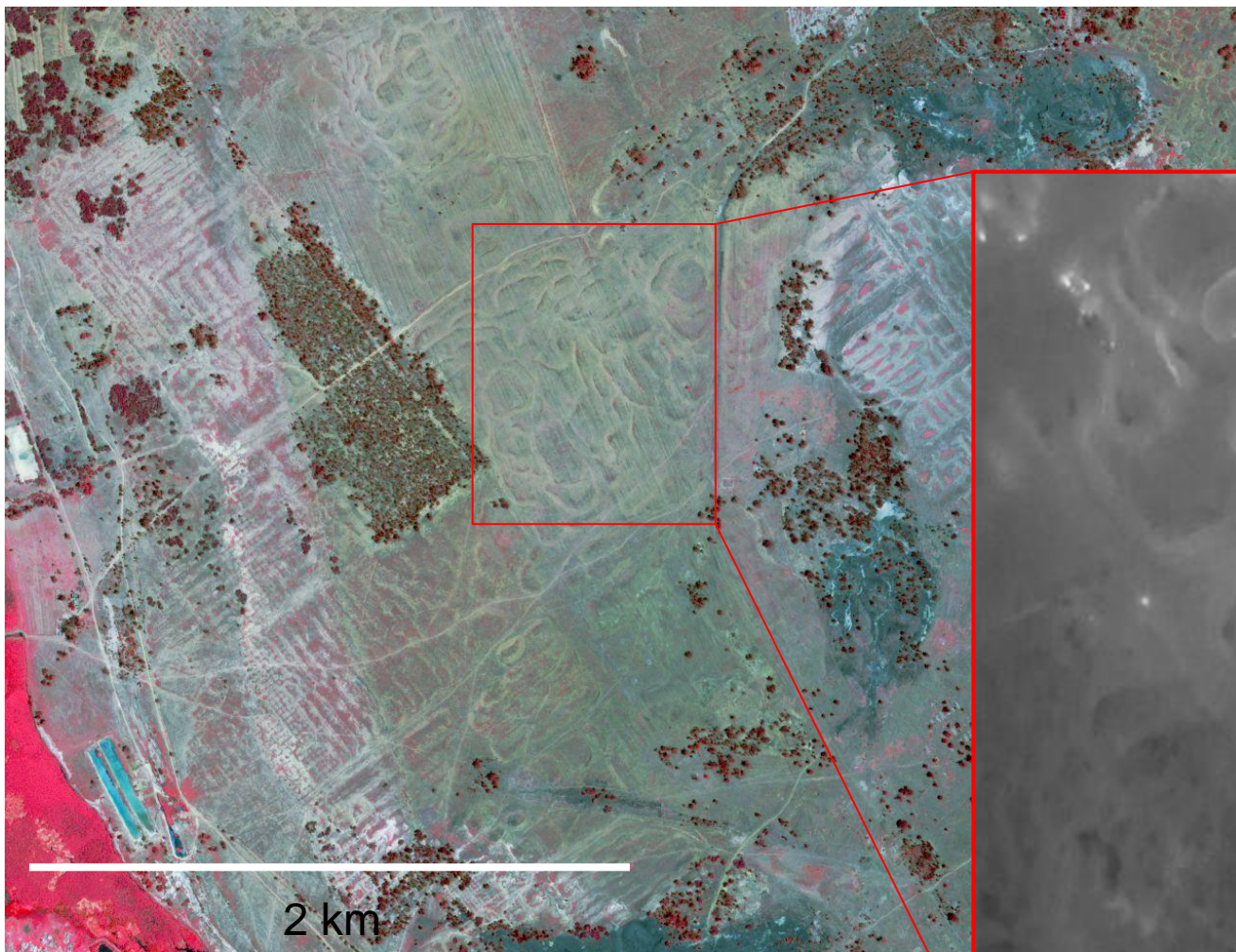
640 x 480 Pixels, [-40 – 500°C]

16 bit quantification, +/- 0.03 °C sensitivity

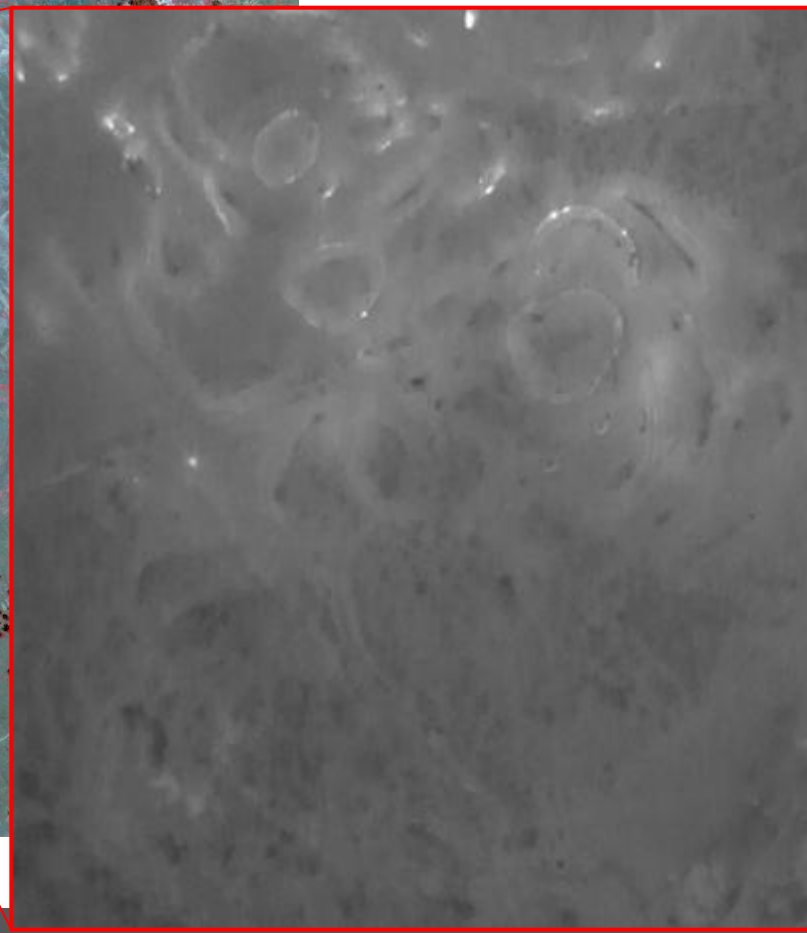
7.5 to 13 µm spectral range, GSD ~ 2m



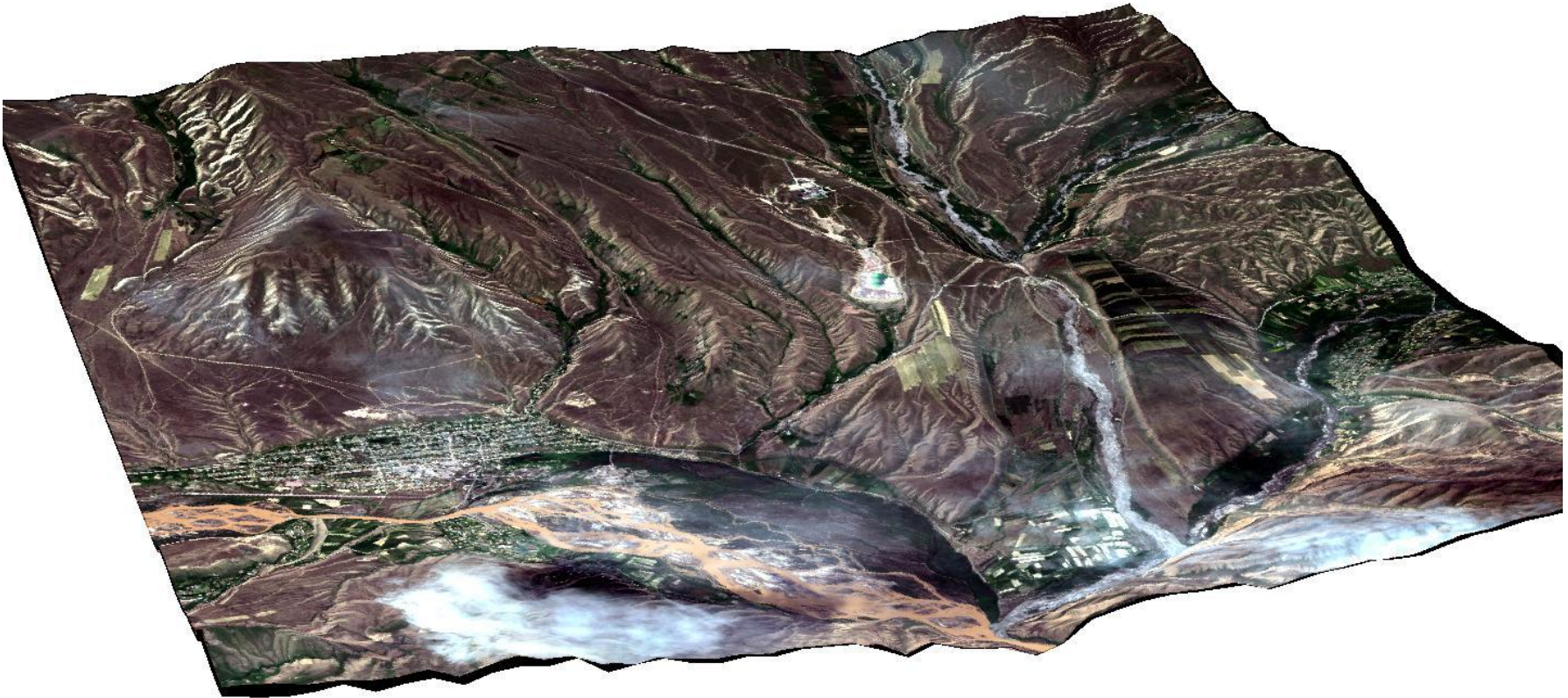
Abandoned Mine Sites and Coal Fires



**WorldView-II and
FLIR data sets**



**Surface and ground-water affected by cyanide contamination ?
Radioactive contamination?**



WorldView-II images draped over WorldView-II DEM

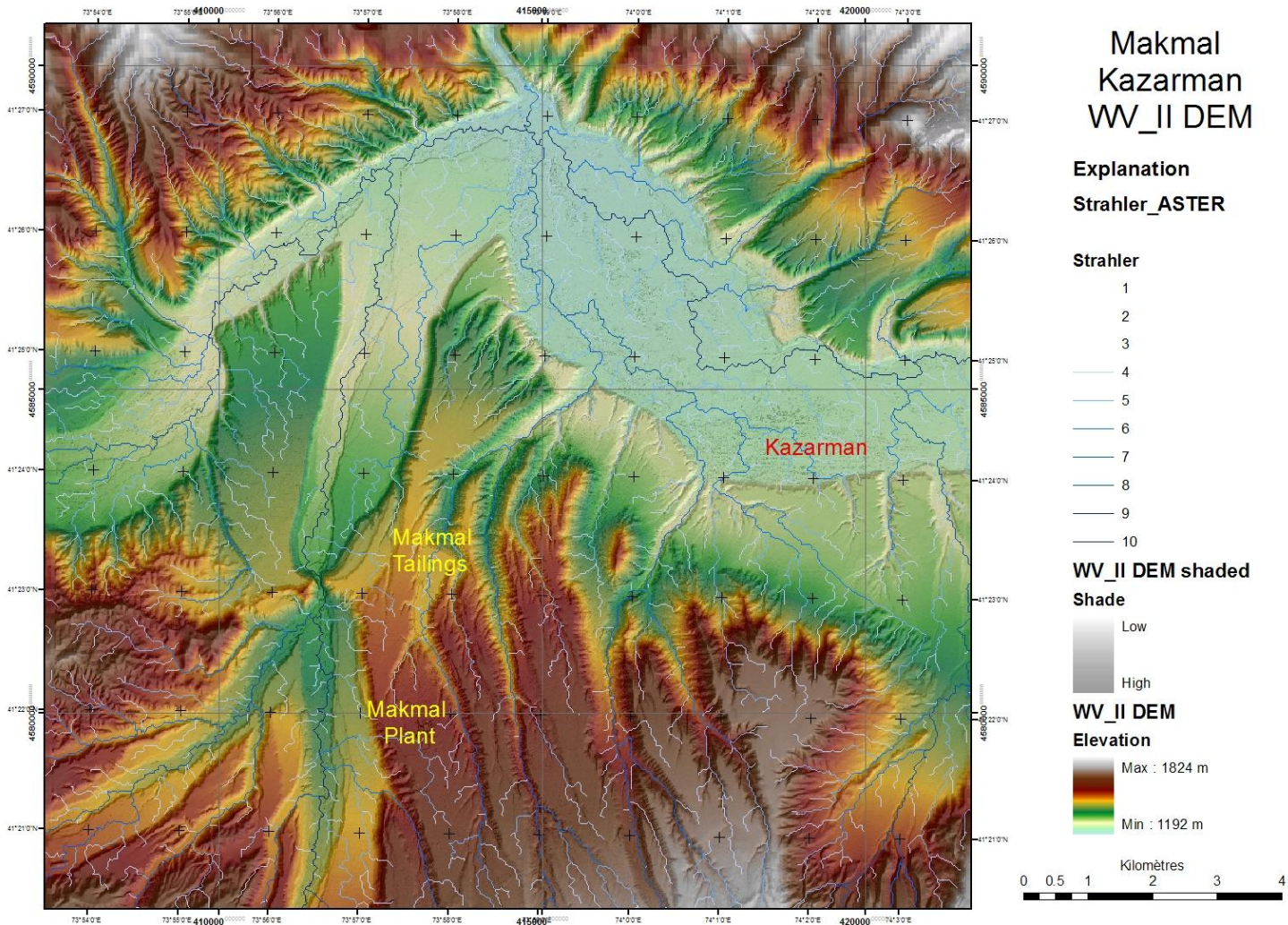
Kazarman – Kyrgyzstan



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

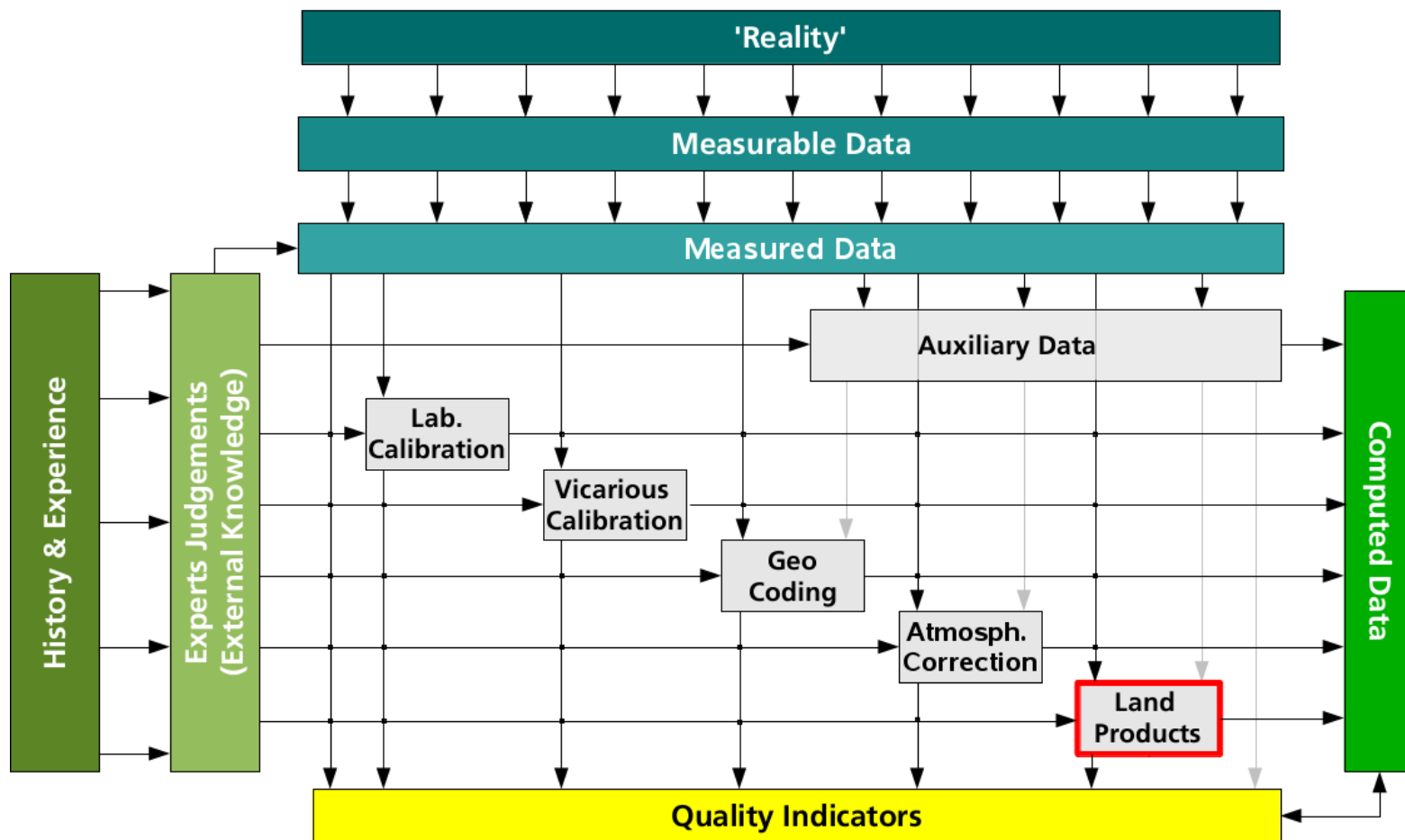
- Modeling of potential surface and subsurface flow directions
- taking dust samples and
- spectroradiometric measurements of the tailings and from soils on different locations





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?	?

Quality assessment & Current Developments



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
- data 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 & product development
- definition of data products, including meta-information, to support multi-sensor applications and combination with auxiliary data sets

- **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**

