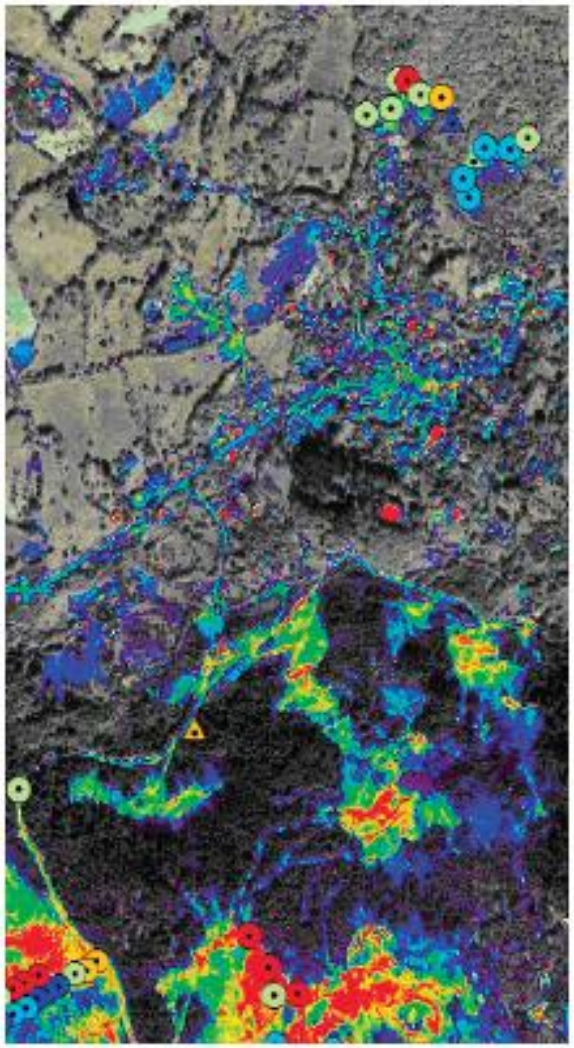


ImpactMin Symposium
27-28 November
Kulturenshus,
Luleå | Sweden

Keynote Presentation

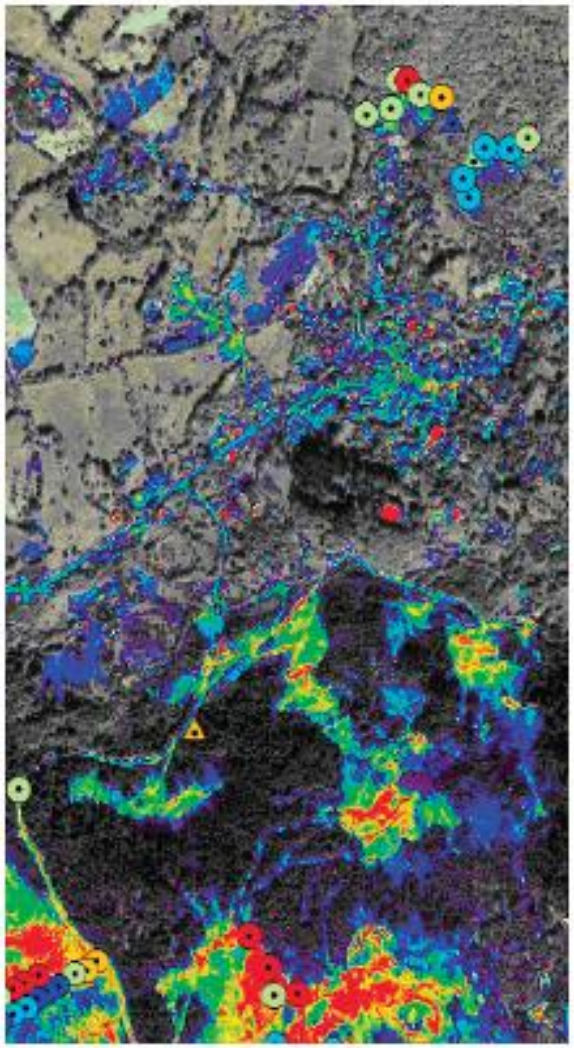
www.impactmin.eu

ImpactMin project is co-funded by the Seventh Framework Programme of the European Union

Earth Observation and Monitoring of Mining Areas - State of the Art and Future Challenges

Norbert Benecke

DMT GmbH & Co. KG (Germany)



ImpactMin Symposium
27-28 November
Kulturenshus,
Luleå | Sweden

Keynote Presentation

www.impactmin.eu

impactMin

ImpactMin project is co-funded by the Seventh Framework Programme of the European Union

DMT

Earth Observation and Monitoring of Mining Areas - State of the Art and Future Challenges

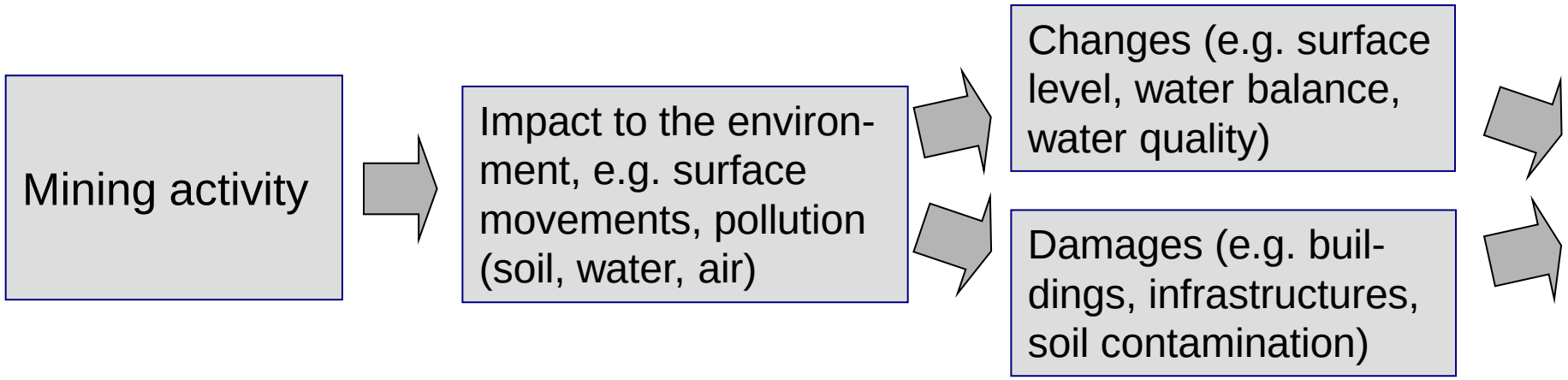
Outline

- Author's background
- Mining & environmental impact
- Specific features of mining impacts
- Examples for mining impacts
- Monitoring of mining areas and spatial information
- Examples for new remote sensing methods
- Detailed example: Monitoring of surface movements
- Conclusions

Author's Background on Monitoring of Mining Areas

- 1991 to 2000: Head of Monitoring Department at RAG Deutsche Steinkohle AG (largest German coal mining company)
  - Responsibility for monitoring of more than 1,000 km² area influenced by underground coal mining, including
    - Environmental Impact Assessment (by EU regulations)
    - Permit procedure (by German Mining Law)
  - System development and operational use of GIS, photogrammetry, laser scanning, multispectral, hyperspectral and radarinterferometric data
  - RAG project manager in several R&D projects including "MINEO" (EU FP6)
- Since 2000 Market Manager Mining at DMT (international service provider for the mining industry)
  - Several operational projects around the world on monitoring areas influenced by mining, oil&gas or infrastructure projects
  - Several R&D projects on monitoring, e.g. EOMD Mining (ESA), Terrafirma (ESA GMES), GMES4Mining (EU/German research funds)
  - Chairman of Working Group 3 (Mine surveying methods and instruments), International Society of Mine Surveying (ISM)

Mining & Environmental Impact



Any mining activity needs legal permission

Monitoring is mandatory part of this permission

- Detection of hazards
- Prevention of hazards
- Documentation

→ Selection of best practice monitoring method(s)

Specific Features of mining impacts (1)

Main sources for mining impacts:

- Surface movements
  - due to underground mining activities
  - due water management for open cast/pit operations
  - both in interaction with particular mining method, specific geological conditions and existing environment
- Critical substances into soil, water or air
  - during mining activities
  - during beneficiation processes
  - during waste disposal
- Hazards from abandoned mines

Main types of impact:

- Damages to houses and infrastructures due to
  - subsidence and subsidence slope
  - disruptions from strain and pressure
  - caves to the surface / sinkholes
- Environmental changes due to water table changes, e.g.
  - Wetlands, drylands in agricultural areas
  - Forest dieback
- Pollution/contamination of soil, water or air

Specific Features of mining impacts (2)

Mining impacts are:

- Relevant on a local or regional level
- Individual cases (need of specific monitoring concepts)

Monitoring of mining impacts is both, community and industry driven - Monitoring must be

- technically operational
- able to answer the questions of the community
- able to fulfil the legal regulations and obligations by the Mining Authority
- cost-effective

Examples for mining impact

Subsidence and disruptions from underground coal mining

Examples for mining impact

Subsidence and disruptions from underground coal mining

Examples for mining impact

Sinkhole from solution salt mining

Examples for mining impact

Development of wetlands by changes in ground water table

Examples for mining impact

Sinkhole from collapsed abandoned mine shaft

Examples for mining impact

Collapse of a slope of an abandoned lignite open pit while flooding

Examples for mining impact

Pollution of soil and water due to abandoned ore beneficiation facilities

(Source: MINEO project web site www..brgm.fr/mineo)

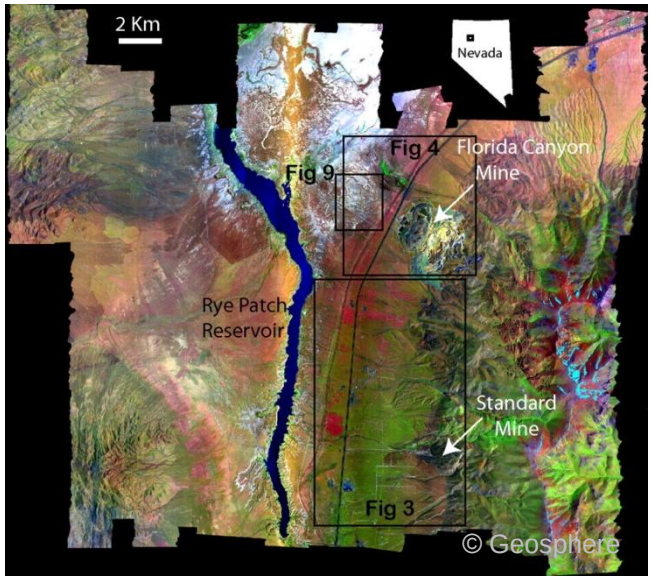
Monitoring of mining areas and spatial information

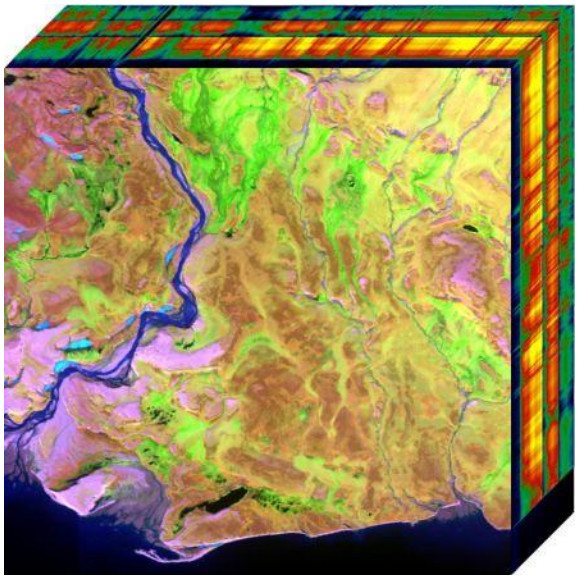
- Manifold spatial information is requested for documentation and monitoring of mining activities
- State-of-the-art methods are:
  - several ground-based methods, e.g. geophysics, geology and engineering surveying
  - some operational remote sensing techniques, e.g. airborne geophysics, airborne laser scanning, photogrammetry and multi-spectral satellites
- New technologies have achieved a promising stage of development:
  - ground-based methods, e.g. high precision permanent GNSS-monitoring or ground-based radar interferometry
  - satellite-based sensors, e.g. hyperspectral mission EnMAP or radar missions like TerraSAR-X or CosmoSkyMed
- EU GMES program will bring new data and services based on SENTINEL satellites (starting in 2013/2014)

Examples for new Remote Sensing Methods

Hyperspectral satellite data

- Identify specific chemical and geometric patterns
- Map and identify mineralogy and chemistry of rocks and soils
- Detect deposits of minerals, hydrocarbons, alteration zones or petroleum

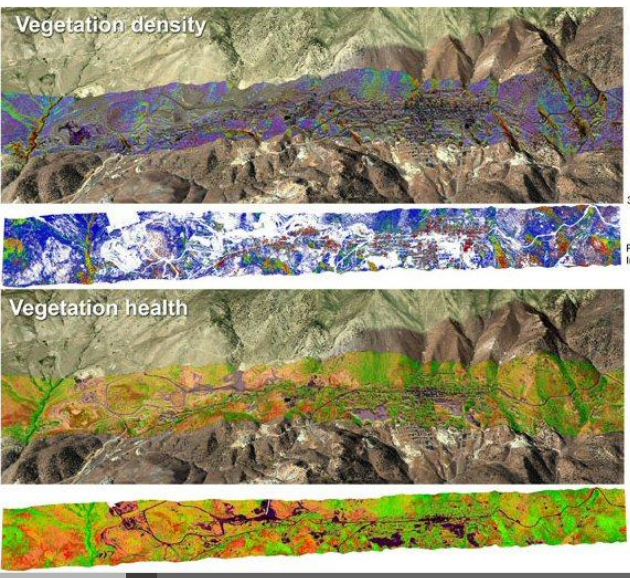


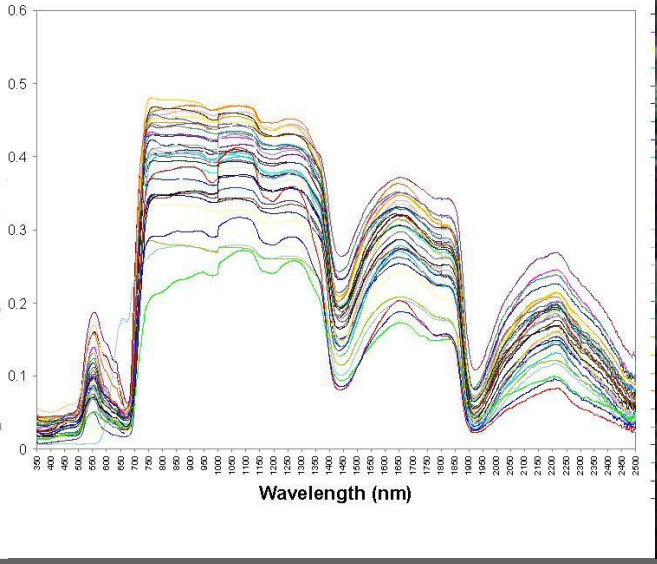


Examples for new Remote Sensing Methods

Hyperspectral satellite data

- Environmental monitoring during and after the operational open pit mining
- Monitoring of the decommissioning process and renaturation
- Evaluation of vegetation density, vegetation health
- Announcement of vegetation stress e.g. sudden oak death, caused by contamination of the soil

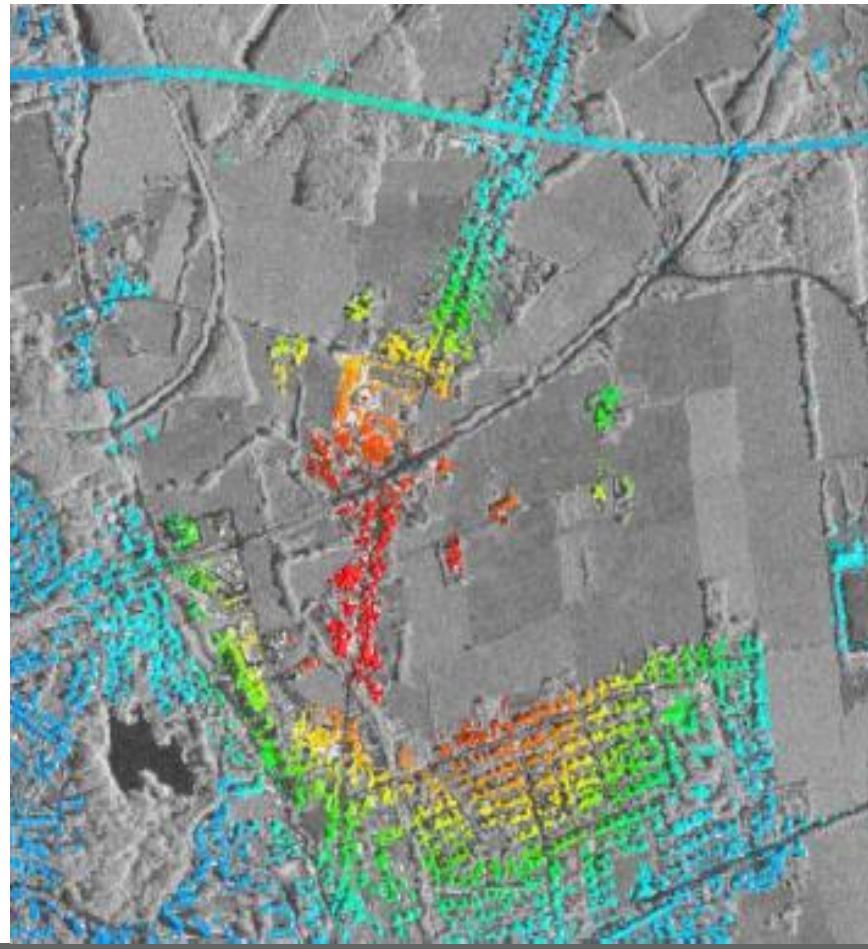




Examples for new Remote Sensing Methods

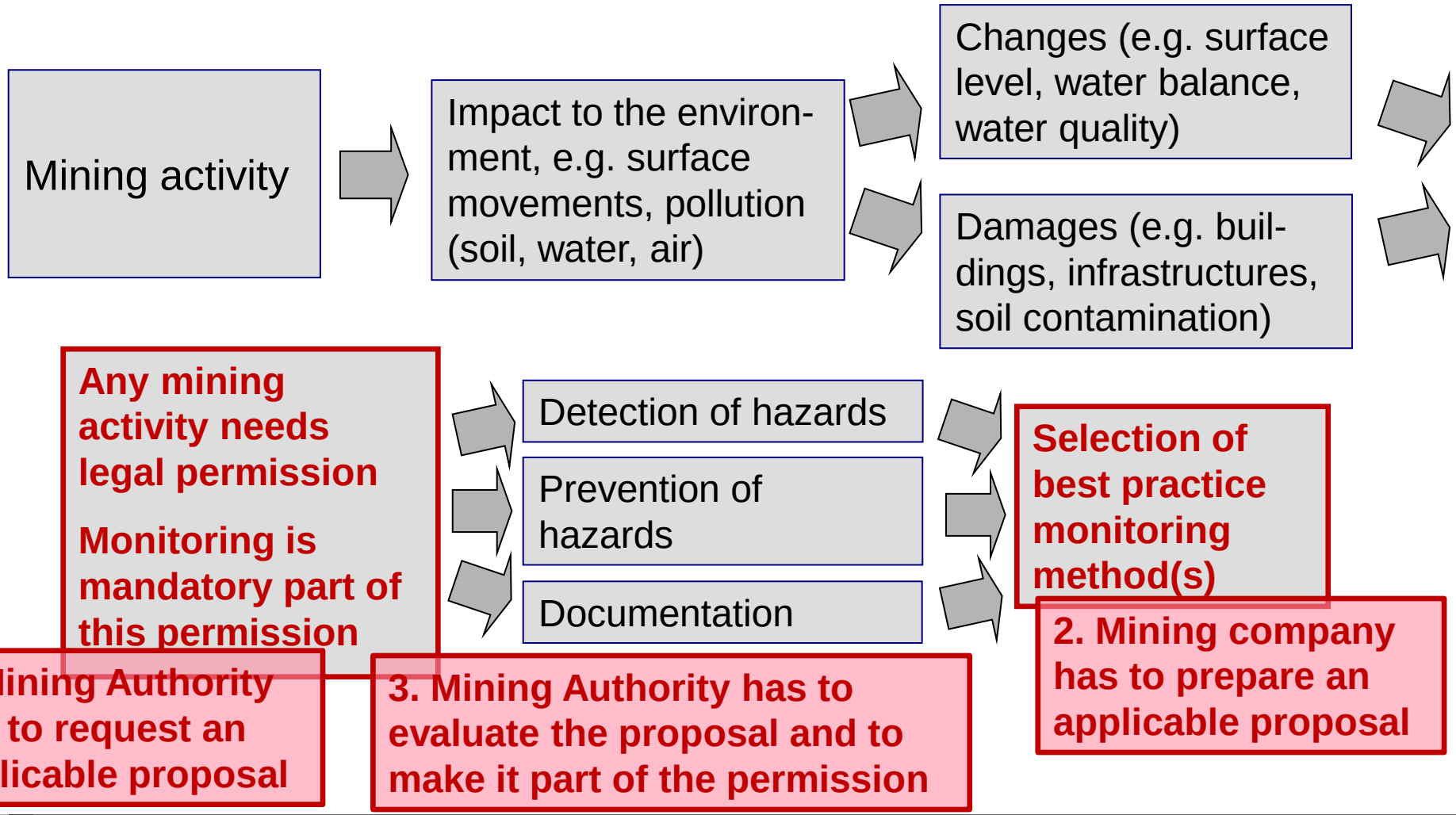
Satellite-based radarinterferometry for large area monitoring

- Advanced radar satellite systems (e.g. TerraSAR-X, CosmoSkyMed, future Sentinel) will have several advantages:
  - Very high spatial resolution (up to 1 m)
  - mapping of small scale movement phenomena
  - high density of reliable points (persistent scatterers)
  - increased opportunities for detection of large movement rates

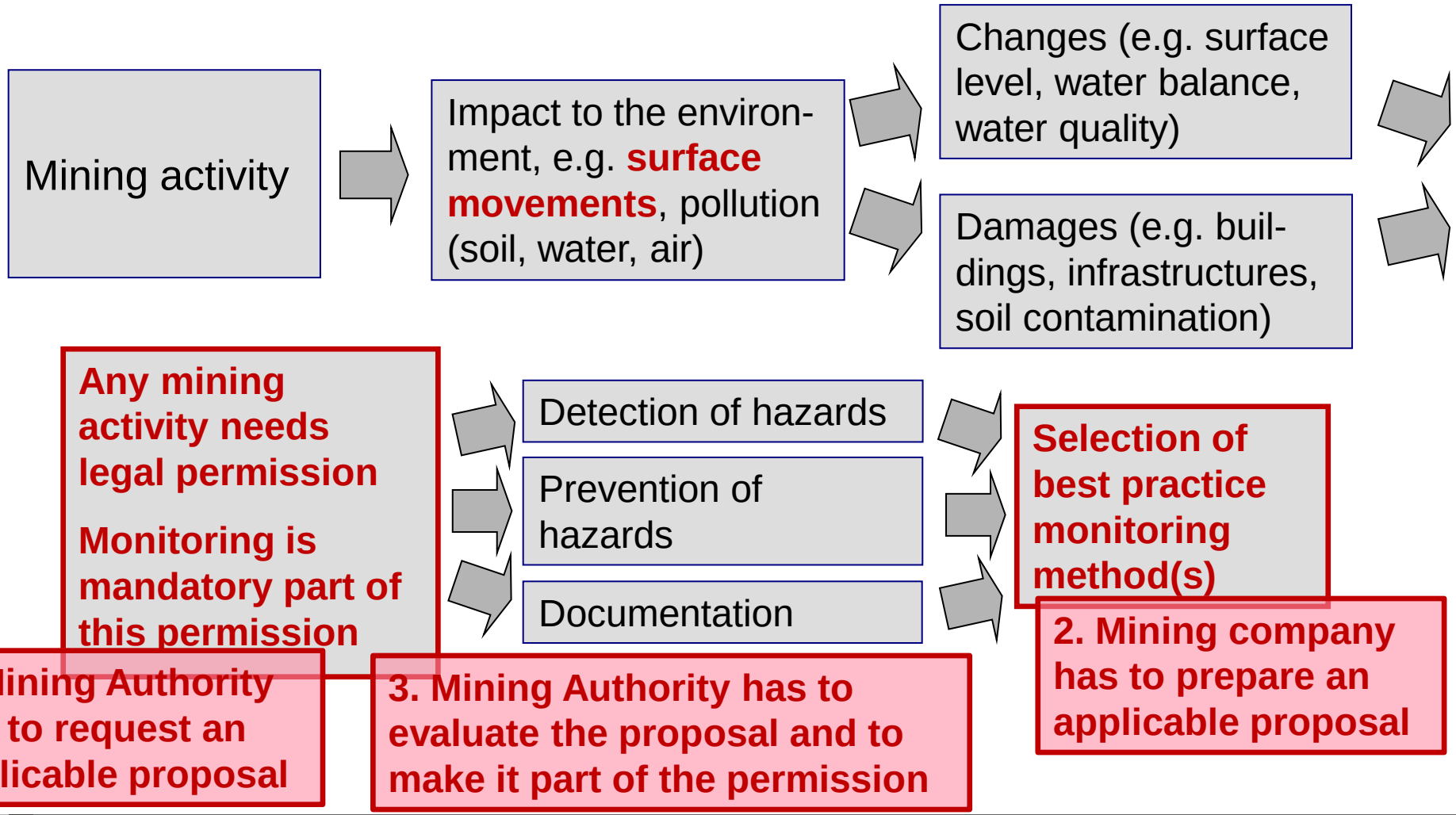


Source: by courtesy of Gamma remote Sensing AG, Switzerland

Mining & Environmental Impact



Mining & Environmental Impact :Example



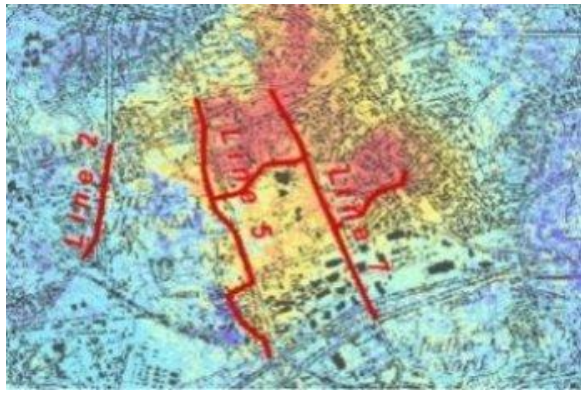
Example: Monitoring of surface movements caused by mining

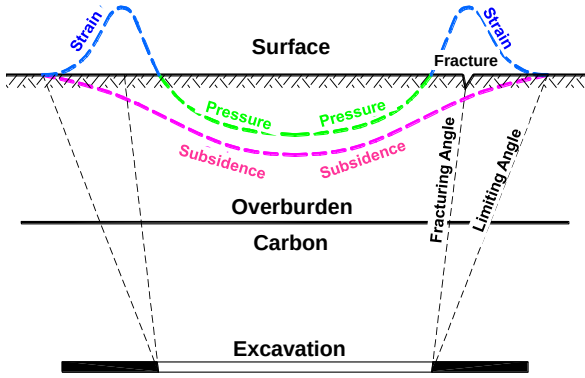
Main technical factors influencing the selection of the best fitting monitoring method(s):

- Type of expected movement (e.g. subsidence, uplift, subsidence slope, horizontal movements, sinkholes)
- Size and velocity of expected movements (e.g. mm/year or cm/week)
- Size and structure of the affected area (e.g. monitoring of the entire area and/or monitoring of specific objects)
- Required accuracy of measurements
- Required spatial density of measuring points
- Required frequency of measurements (e.g. yearly, monthly, weekly, daily, continuous)

Other essential factors:

- Economic efficiency
- Acceptance by legal authorities and the affected community





Example: Monitoring of surface movements caused by mining

Legal acceptance – the German example

- Federal States Mining Authorities are responsible for any mining permission by German Mining Law
- Collateral clauses are ruling the mandatory surface monitoring in each single case considering the statutory regulations about mine surveying (especially accuracy classes)
- Mining companies have to present an adequate monitoring concept to fulfill these regulations
- Responsible mine surveying experts of the Mining Authorities have to evaluate the monitoring concept for permission
- Permission must be “court-proof” in case of any legal dispute

⇨ Implementation of new, innovative monitoring methods requires a serious process of achieving the needed legal acceptance

⇨ Typically not only one new method will be accepted; proven “traditional” methods are requested as control methods

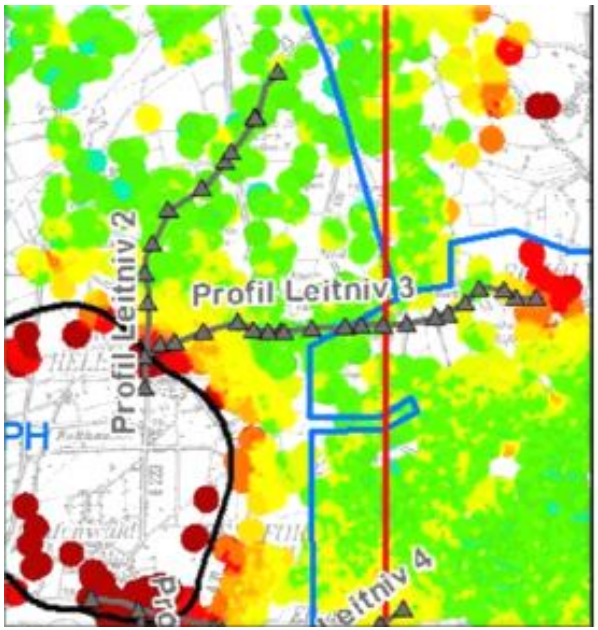
Example: Monitoring of surface movements caused by mining Current example from German mining reality

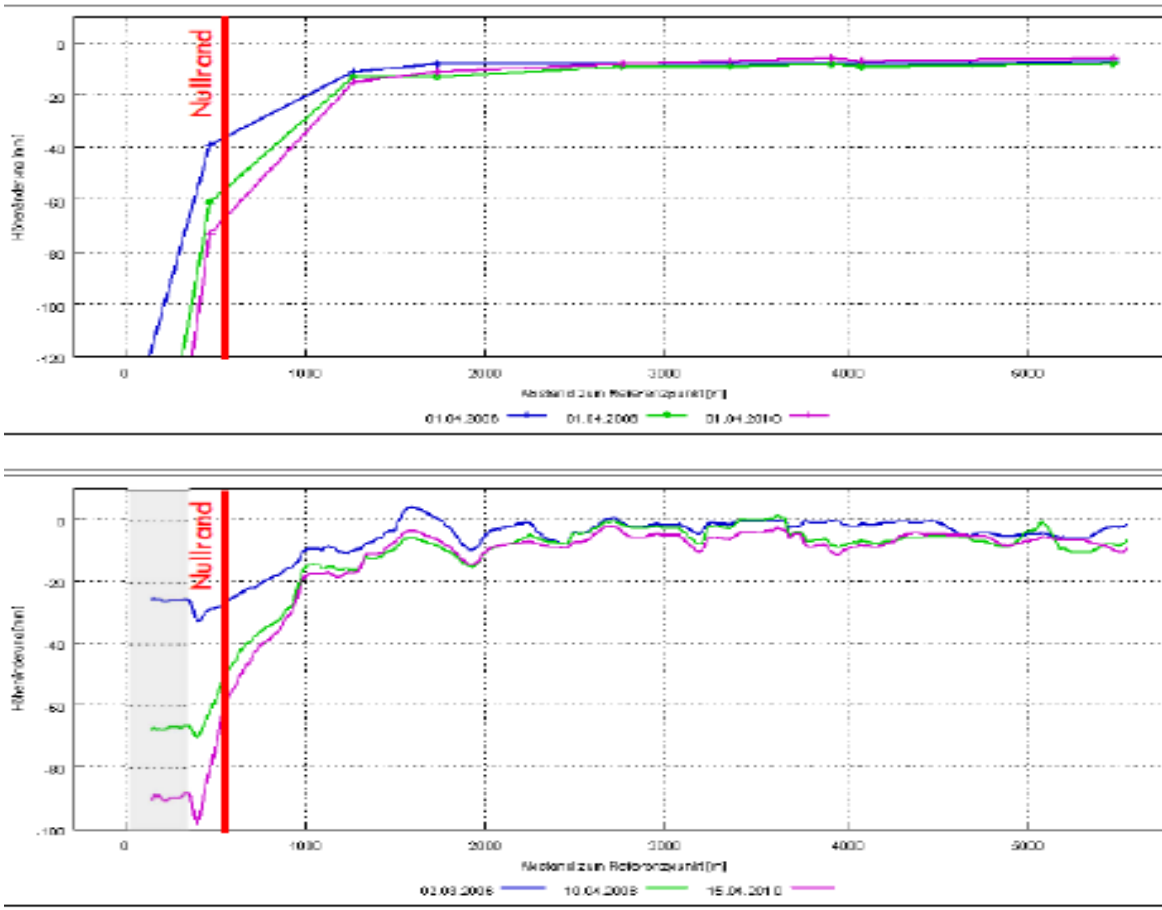
- Underground coal mine is obliged to monitor the outer border of surface subsidence (“zero-line”) by
  - Levelling of some lines with marked points once a year
  - GPS measurements of marked points once a year
- Subsidence outside the expected area has been measured in 2011/2012
- Independent expert opinion has been mandated by the Mining Authority
- Within this expert opinion satellite radarinterferometry was used for the first time by German Mining Authority to investigate subsidence from mining within a legal dispute

Source: http://www.bezreg-arnsberg.nrw.de/presse/2012/09/160_12/praesentation.pdf

Example: Monitoring of surface movements caused by mining Current example from German mining reality

- Comparison of radar-interferometry (new method) and levelling (proven method)





Source: http://www.bezreg-arnsberg.nrw.de/presse/2012/09/160_12/praesentation.pdf

Example: Monitoring of surface movements caused by mining Current example from German mining reality

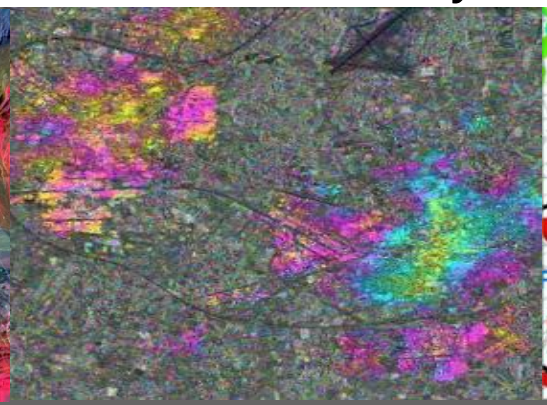
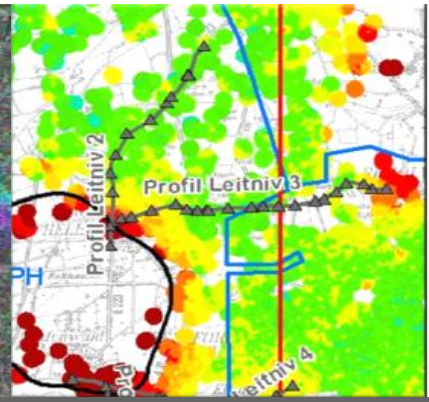
- In the urban part of the influenced surface area, radarinterferometry was able to identify significantly subsidence rates of approx. 3 mm/a
- However, the method failed in agricultural and wooden part of the influenced surface area (no good coherence)
- Due to the expert opinion the Mining Authority came to conclusions and requests now a new concept for future monitoring of the area by:
  - Extension of levelling lines in length, number and frequency
  - Extension of GPS measurements in number, frequency and accuracy (by changing the measurement approach)
  - Regular use of satellite radarinterferometry with annual data evaluation of all additionally acquired data sets (approx. 15 data sets from Radarsat-2)

Source: http://www.bezreg-arnsberg.nrw.de/presse/2012/09/160_12/praesentation.pdf

First Conclusions

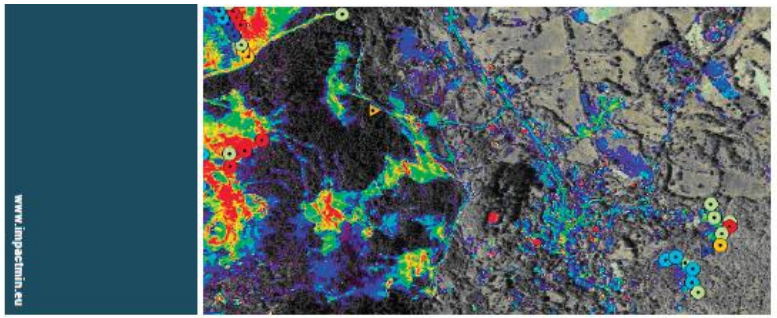
- Impacts from mining activities have been presented by examples from practice
- Monitoring of mining impacts is mandatory by legal regulations
- Cost-effective concepts for online monitoring and for large area monitoring with high point density and high monitoring frequency are needed
- New technologies have achieved a promising stage of development
- However, the applicability for monitoring of mining areas under the restrictions of mining law and permissions have to been evidenced
- R&D Projects are under progress to demonstrate the applicability
- First implementations into (legal) practice are under way



Second Conclusions
linked to ImpactMin

- This presentation has hopefully increased the sensitivity
  - for the demand of monitoring mining areas
  - for the requirements (by mining authorities, communities and mining companies) concerning this monitoring
- From the available documents of **ImpactMin** I have already learned that the project outcome is
  - definitely a milestone on the way to a more sufficient monitoring of mining areas
  - in particular by using the latest advances in remote sensing science
- Thanks to the entire **ImpactMin** team and congratulations for your work
- I'm looking forward to really interesting presentations



ImpactMin project is co-funded by the Seventh Framework Programme of the European Union.

Perfect Opportunity to Present ImpactMin Results to the International Mining Community

XV Congress

International Society of Mine Surveying (ISM)

16 to 20 September 2013 in Aachen / Germany

Over 500 participants from all major mining regions

Call for papers is already open

More information available: **www.ism-germany-2013.de**

Thank you for your attention!

To the team of ImpactMin:
All the best for this symposium and for your future activities!

Glückauf!

DMT GmbH & Co. KG
Exploration & Geosurvey
Contact: Norbert Benecke
Am Technologiepark 1
D-45307 Essen, Germany
Phone: +49 201 172 2012
Fax: +49 201 172 1971
E-mail: norbert.benecke@dmt.de
Internet: www.dmt.de