Framework combining Prototype Spatial Decision Support System with Remote Sensing analysis

Case of Study – Southern Ruhr Area

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Risk Assesment approach for Long-term Monitoring of Abandoned Coal Mines

An Application Programming Interface (API) is being developed to integrate multi-risk factors related to post-mining sites, the approach presented in this project incorporates long-term monitoring of resulting low-risk areas. Hotspots were studied using SBAS-InSAR for ground displacement detection and Sentinel-2-derived indices to distinct environmental changes.
Keywords: Post-Mining; Monitoring; Multi-Hazard; Spatial Decision Support System; Remote Sensing

Introduction

Despite the cessation of mining operations, the remains of exploitation poses significant hazards in the Ruhr area. Understanding the impacts and interactions of these hazards is a critical issue for local authorities, guiding them towards informed decisions to safeguard their citizens

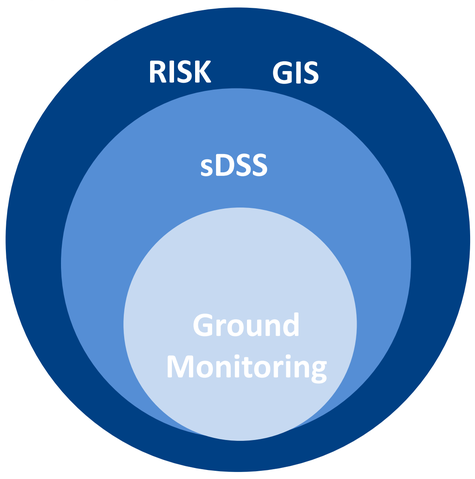

Figure 1. Holistic Framework Perspective

Risk Monitoring with Remote Sensing

- Analyze and detect changes over time.
- Measuring the displacement and its variation in time possible by time-series analysis
- Monitoring ground movement events in large areas where coal mining took place.

Spatial Decision Support Systems(sDSS)

Compute-based tool that integrates conventional data, spatially referenced information, and decision logic to aid human decision-makers. Components serves as a solution for the fusion between models and GIS with an User Interface component for stakeholders.

Methodology

Workflow for the combination of Ground Movement Monitoring with sDSS API

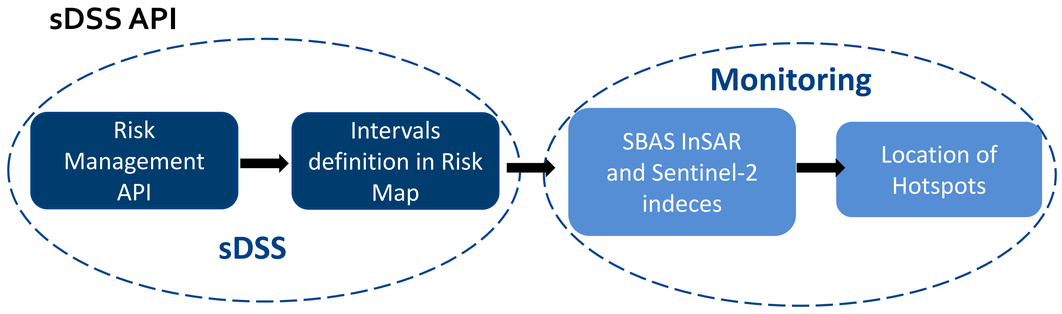

Figure 2. Methodology for Monitoring Low risk zones of Southern Ruhr

Model definition of Risk factors

- Multi-hazard Index based on Significance and Interaction matrix (Multi-Criteria Decision Methods)
- Vulnerability based on Social Vulnerability Indicators (SoVI): Gross Domestic Product, Population Density, Traffic area and Settlement
- Expose element at risk based on Sentinel-2 Land Cover/Land Use data

Ground Movement Monitoring

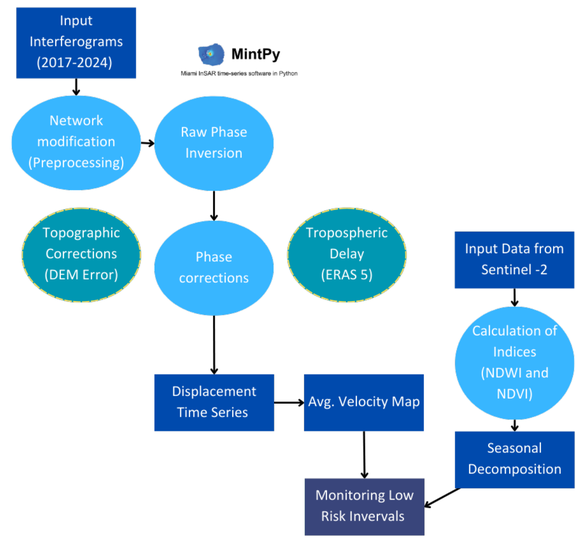

Figure 3. Framework for SBAS InSAR and Sesonal Change analysis

Results

Definition of Point of Interest based on Risk and SBAS-InSAR

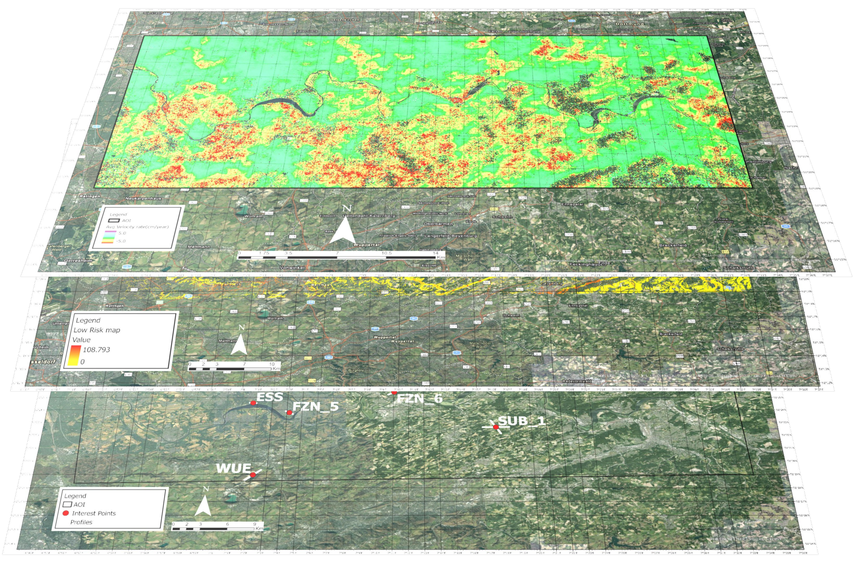

Figure 4. Top: Avg. Velocity map from 2017-2024 (SBAS-InSAR). Middle: Low Risk Map from Risk Management API. Bottom:Profiles in interest point to understand the ground movement

Interest Point(ESS) – Reported event in Essen

- Reported in September of 2023 by Municipality of Essen
- Event located near High risk area of the Low interval map

Interest Point(FZN_6) – Reported event in Bochum

- Reported in September of 2018, register by the FZN
- Located in Bochum at 300m from an open shaft.
- Risk map predicted the area as a high risk location

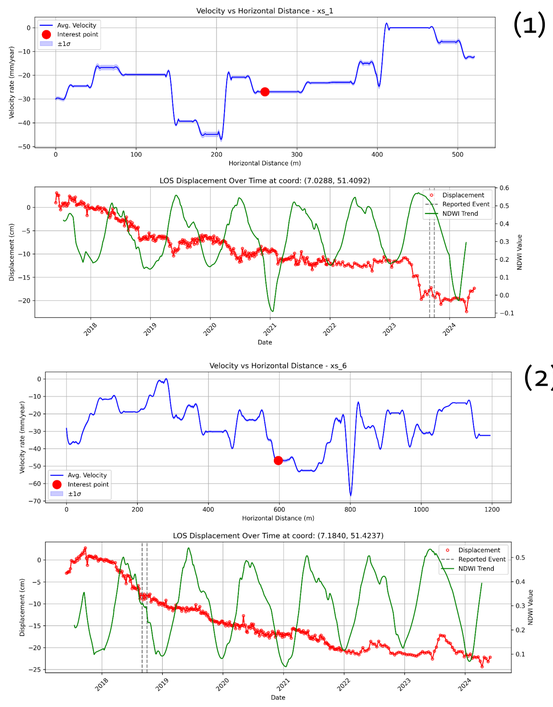

Figure 5. (1) LOS displacement at ESS point with Seasonal Decomposition of NDWI. . (2) LOS displacement at FZN_6 point with Seasonal Decomposition of NDWI.

Conclusion

- InSAR-SBAS method perfomed with the MintPy routine has demonstrated significant potential for effectively monitoring low displacements and assessing risk areas in post-mining sites.
- By integration the three factors risk in the API, the expert could evaluate the risk intervals in each post-mining location using only the sDSS for the assessment.
- The risk map was able to predict multiple post-mining events with information supported by the Research Center of Post-mining THGA
- The methodology presented could be applied to new projects like SIRIMA, where its focus relates to sinkhole detection and hazard management.

References:

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[3] Yunjun, Z., Fattahi, H., and Amelung, F. (2019), Small baseline InSAR time series analysis: Unwrapping error correction and noise reduction, Computers & Geosciences, 133, 104331

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