Detection and classification of large-scale ground motion from remote sensing data

A case study in Hesse, Germany

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Motivation

Landslide activity and surface deformation in Hesse, Germany

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Image: hlnug.de

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Landslide activity and surface deformation in Hesse, Germany

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- Detect regions affected by ground movement using geodetic data
  - Subsidence, uplift, soil flow, landslides

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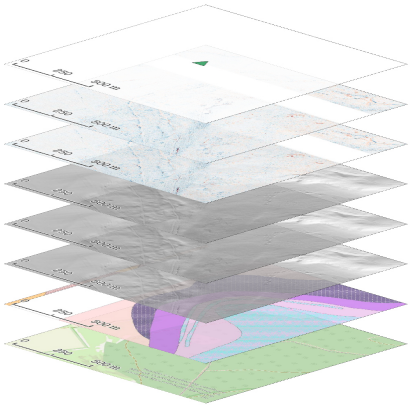


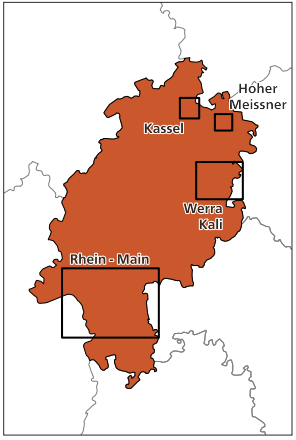
- Detect regions affected by ground movement using geodetic data
  - Subsidence, uplift, soil flow, landslides
- Various datasets:
  - Topographical (HVBG)
  - Geological (HLNUG)
  - Lidar scans in ’14, ’19, ’21 (HVBG)
    - 1m DEMs, DTMs and differences
  - InSAR persistent scatterer (BGR)
    - L2 and L3 data, continous timeseries
  - Other (climate, hydrological, mining, hydrocarbons, …)

HLNUG

Workflow


FOEN / Swiss Parks Network, swisstopo, Esri,
Garmin, FAO, NOAA, USGS

Workflow



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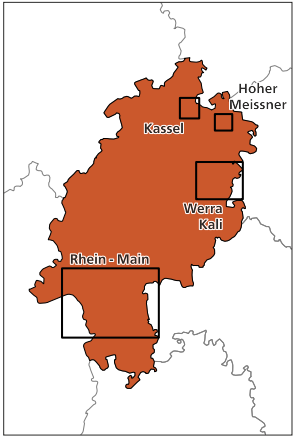

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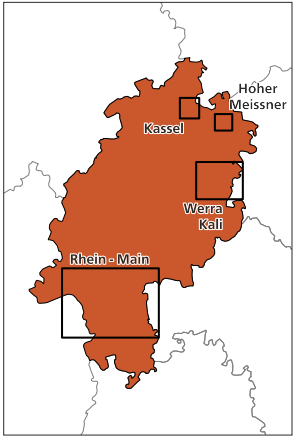
Workflow



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2. Plausibility check

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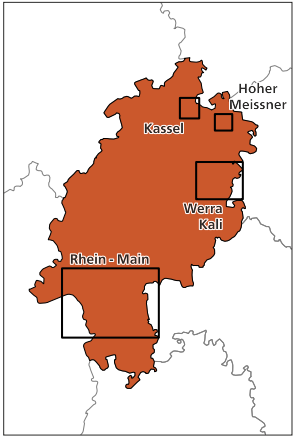

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3. Apply processing:
   - Reclassify Lidar differences
   - Detect large scale ground motion in PSI data (GroundMotionAnalyzer, Krzepek et al. (in press))
   - Invert timeseries for linear and seasonal components (GrAtSiD, Bedford and Bevis (2018))

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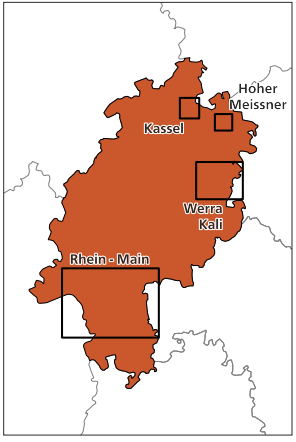

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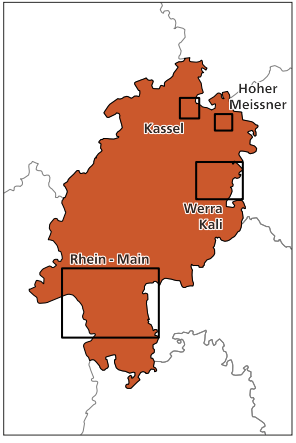

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5. Atlas of ground motions in Hesse

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Ground Motion Analyzer

Towards a suitable representation and detection of hotspots

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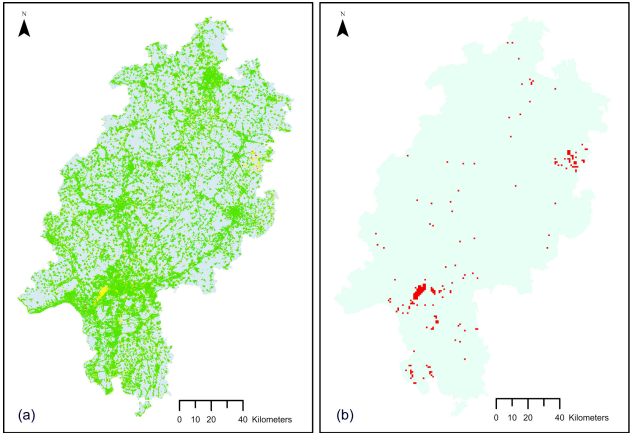


- Variable cell size
- Variance based filter
- Threshold of *n* PS that show subsidence or uplift

→ Selection of regions of interest for detailed studies

Mean Velocity Vertical [mm/a]

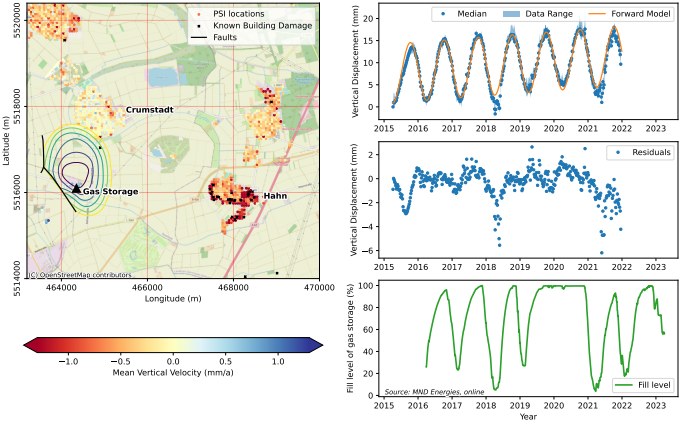
- min - -10
- > -10 - -2
- > -2 - 2
- > 2 - 10
- > 10 - max

State of Hessen

Ground Deformation Hot Spots

Detailed case studies

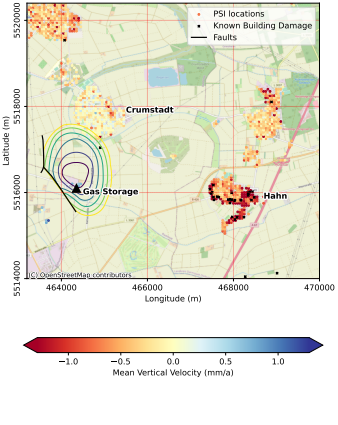
Gas reservoir characterization

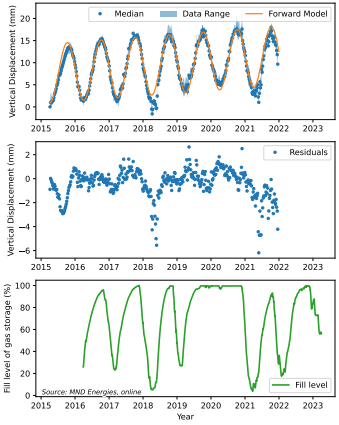


- Influence of subsurface on seasonal motion

Detailed case studies

Gas reservoir characterization





- Influence of subsurface on seasonal motion
- Reservoir characterization

Challenges

Processing artifacts and anthropogenic activity

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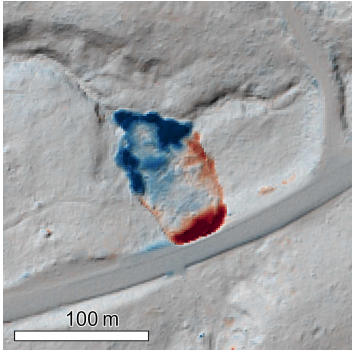
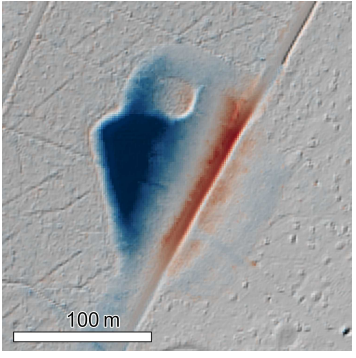
Landslide along road



Wind turbine



- Regions with activity are often close to important infrastructure

Challenges

Processing artifacts and anthropogenic activity

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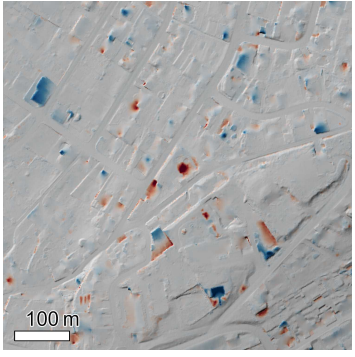
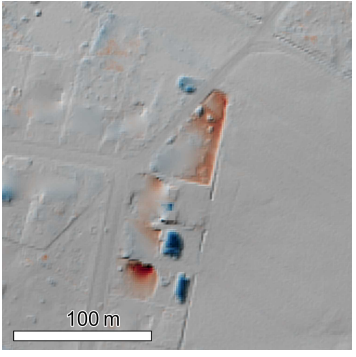
DEM artifacts



Unstable or artifact?



- Regions with activity are often close to important infrastructure
- Artifacts in densely populated areas
  - Reprocessing of datasets
  - Merging of DEMs and DTMs

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Manual classification

Preliminary classification of ground motions in pilot regions

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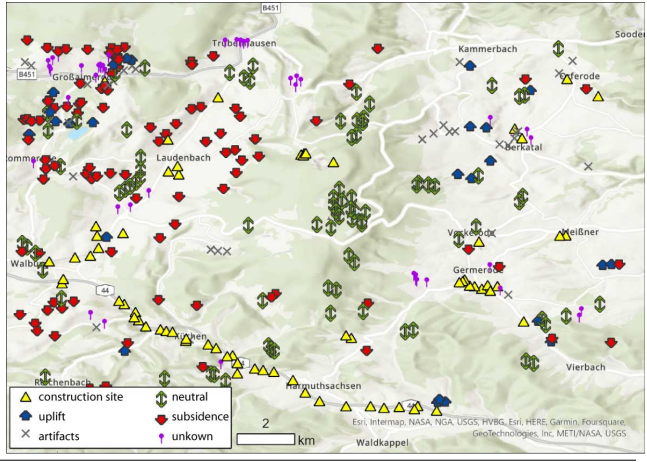
- Wide spectrum of surface motion



Manual classification

Preliminary classification of ground motions in pilot regions

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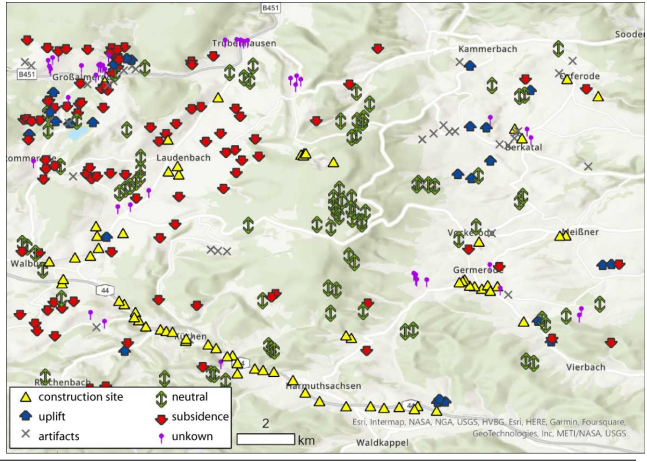
- Wide spectrum of surface motion
- Regions of uplift and subsidence cluster



Manual classification

Preliminary classification of ground motions in pilot regions

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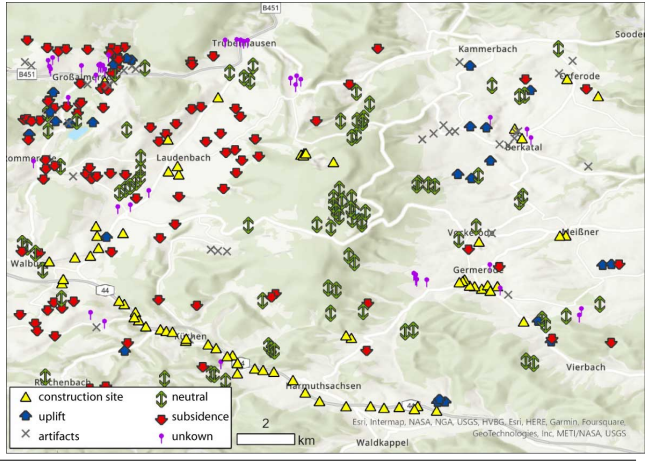
- Wide spectrum of surface motion
- Regions of uplift and subsidence cluster
- Some are clearly identified as anthropogenic
  - Exact source in many cases unknown



Conlusions and Outlook

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- Successful verification and integration of several unrelated datasets
- Manual detection → transition to automatic detection (including new data)
  - ML-enhanced detection workflow
  - Mapping of potential risks
  - Integration of processing results in classification scheme
- Adequate communication to the general public
- Influence of climate change on ground motion related hazard

Ideas for processing or detection methods? → rudolf@geo.tu-darmstadt.de

References

Bedford, J., Bevis, M., 2018. Greedy automatic signal decomposition and its application to daily GPS time series. Journal of Geophysical Research: Solid Earth doi:10.1029/2017jb014765.

Krzepek, K., Rudolf, M., Homuth, B., Henk, A., Iwaszczuk, D., in press. Raster representation of ground motion service data and automated hot-spot detection, in: 2023 Joint Urban Remote Sensing Event (JURSE), IEEE.