



Supplement of

Using a multi-criteria approach for a regional differentiation of the likelihood of future volcanic activity in Germany

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The background of the slide is a photograph of a volcanic eruption. A massive, billowing plume of white and grey ash and steam rises from a dark, rocky landscape. The sky is overcast with grey clouds, and a bright light source, likely the sun, is visible through a break in the clouds, creating a lens flare effect. The foreground shows a dark, rocky slope leading up to the base of the volcano.

Using a multi-criteria approach for a regional differentiation of the likelihood of future volcanic activity in Germany

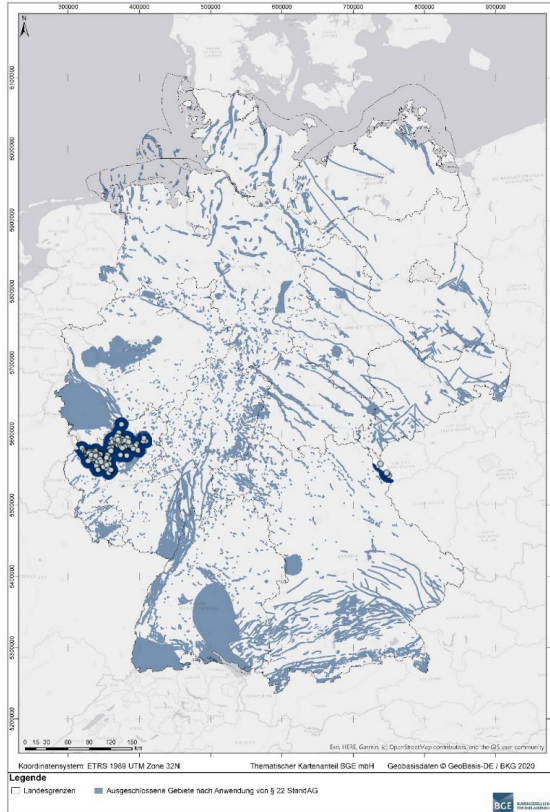
SafeND 2023

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Alexander Bartels, Franz May

14.09.2023

Motivation

Ausgeschlossene Gebiete nach Anwendung der Ausschlusskriterien gemäß § 22 Standortauswahlgesetz

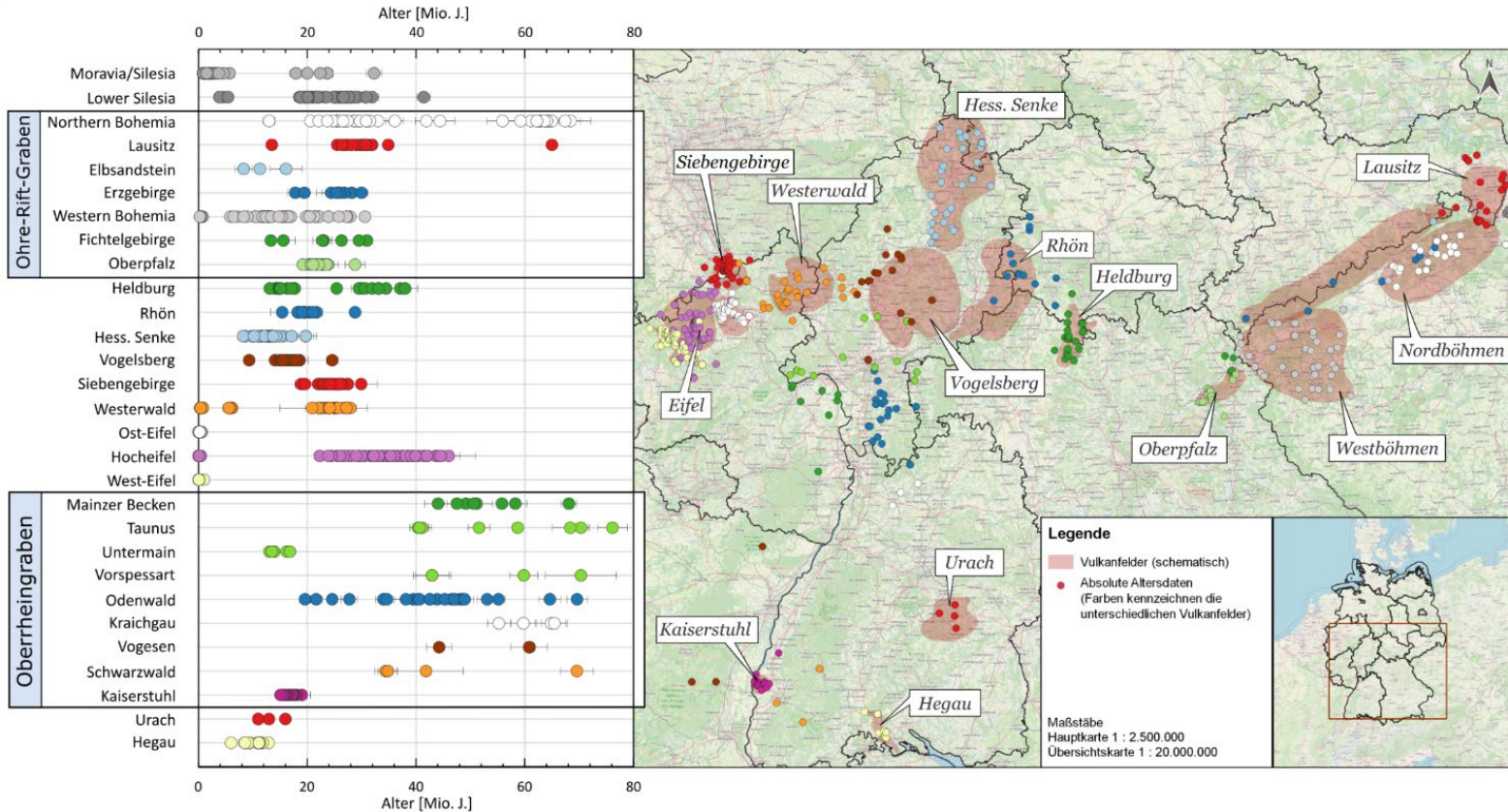


German Repository Site Selection Act (StandAG, 2017)

An area is not suitable as repository site for highly radioactive waste if Quaternary volcanism is present or future volcanic activity is expected (1 million years)

now: Considering Quaternary volcanoes, but not possible future scenarios for volcanism

Motivation



Objectives



- Development of a **Germany-wide** applicable **method** to differentiate areas of possible future volcanic activity
- Considering a variety of geoscientific **indicators** and related **parameters**, which may promote volcanism and/or show its long-term evolution
- **Combination** of all **parameters** to a semi-quantitative **index**, whose spatial value distribution can be used for the **hazard assessment** of future **volcanism**

Indicators

Expert surveys:

- Volcanism in Germany
- Possible indicators
- Quantification of indicators (parameters)

→ 30 indicators have been identified

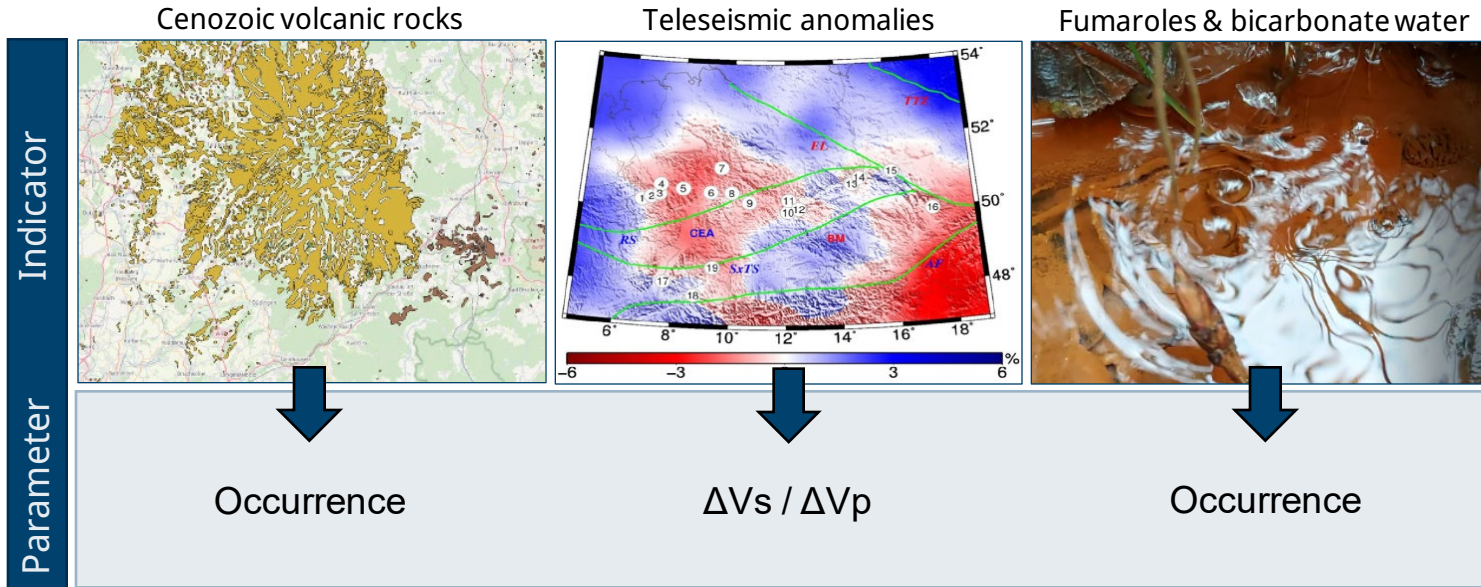
Top 10 (according to expert surveys)

- DLF-Earthquakes
- Geochronological data
- Geochemical and isotopic analysis of mantle fluids and gases
- Earthquake swarms
- Occurrence of Cenozoic volcanic rocks
- Teleseismic anomalies in the mantle
- Fumaroles and bicarbonate water
- Ground motion
- Neotectonic activity
- Faults and sutures

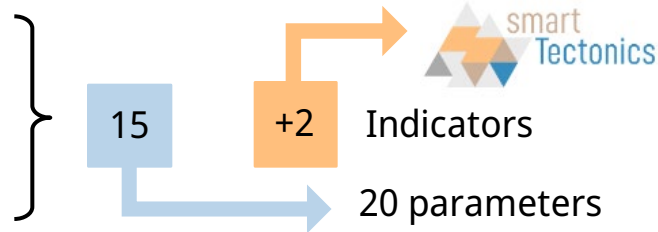


https://www.bgr.bund.de/DE/Themen/Endlagerung/Produkte/produkte_node.html?tab=Standortauswahl

Quantification of indicators



- Re-evaluation of indicators
- Evaluation of available data
- Resolution / uncertainties
- Defining threshold values



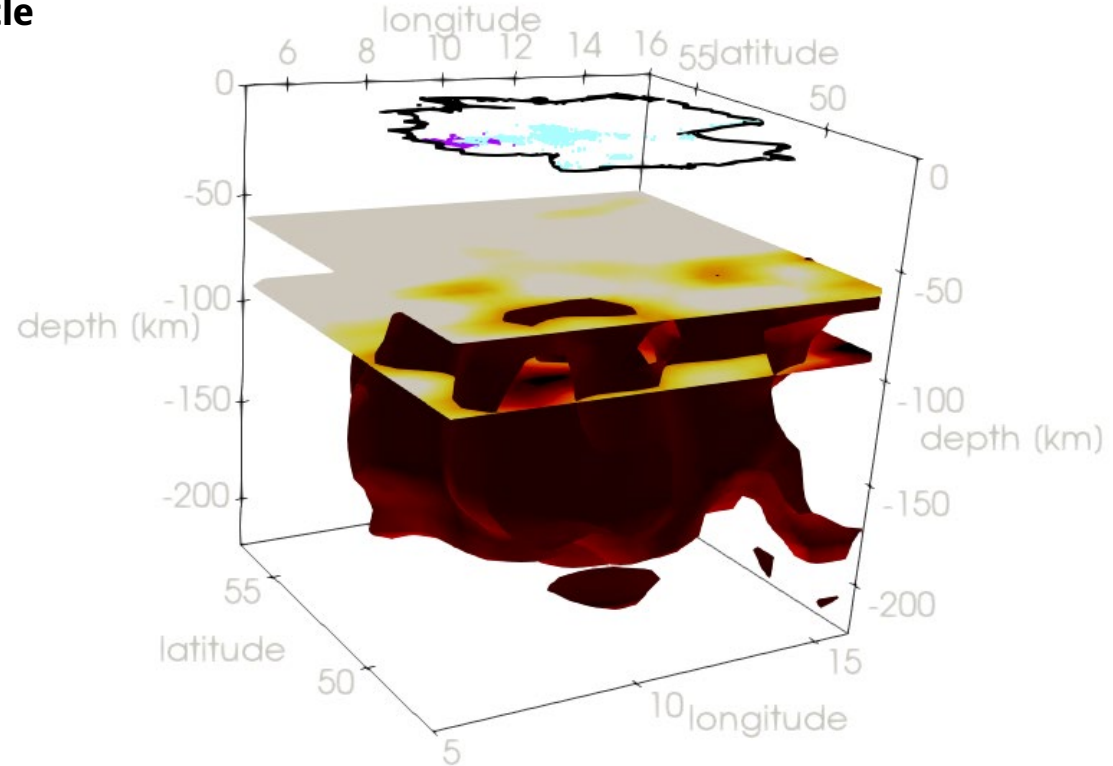
Quantification of indicators

Seismic anomalies in the earth's mantle

- Mineralogy
 - Temperature
 - Water content
 - Melt content
- Defining a quantifiable property

Parameter: ΔV_s

($\Delta V_{s_{\min}}$, 60 - 90 km depth)



Quantification of indicators

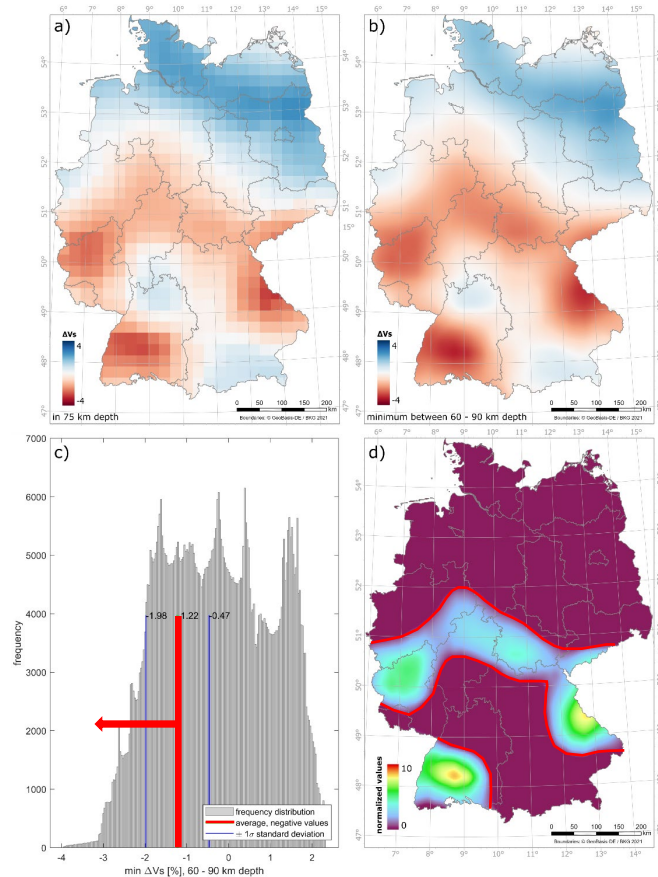
Seismic anomalies in the earth's mantle

- Mineralogy
- Temperature
- Water content
- Melt content

→ Defining a quantifiable property

Parameter: ΔV_s
($\Delta V_{s_{\min}}$, 60 - 90 km depth)

- Data processing
- Determination of relevant values by defined threshold values
- Standardization of values

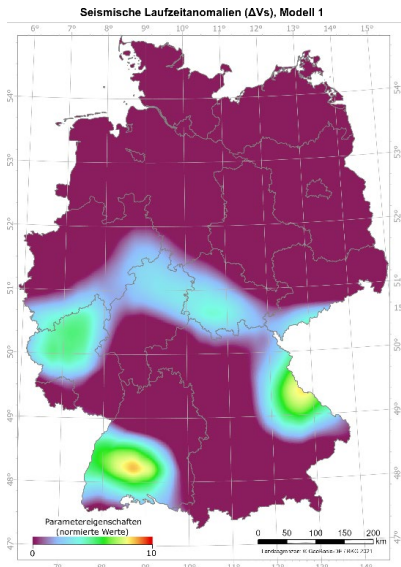


Quantification of indicators

Parameter: ΔV_s

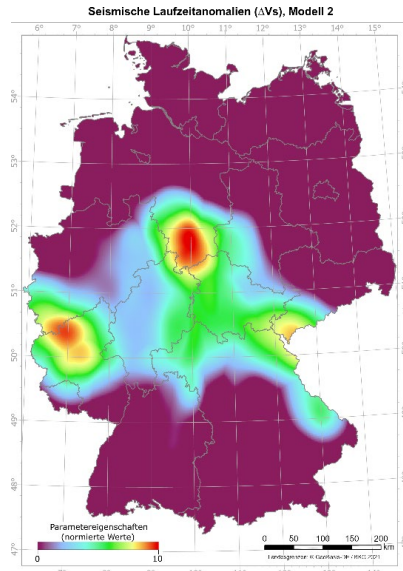
($\Delta V_{s_{\min}}$, 60 - 90 km depth)

- Combination of datasets



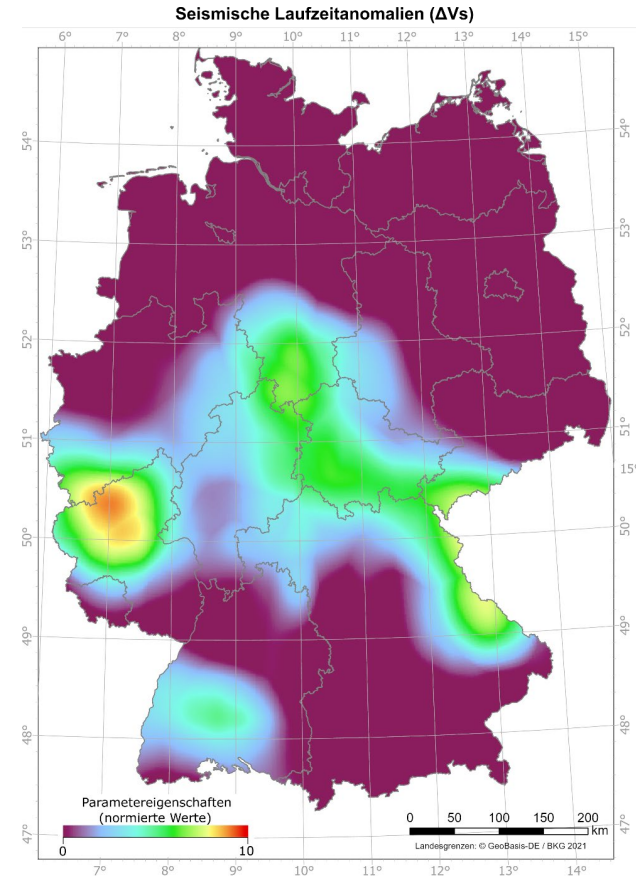
Fichtner et al., 2018

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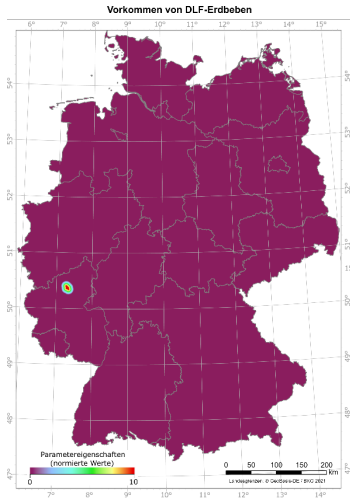


Zhu et al., 2015

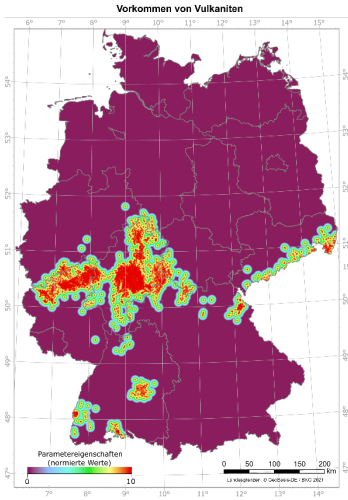
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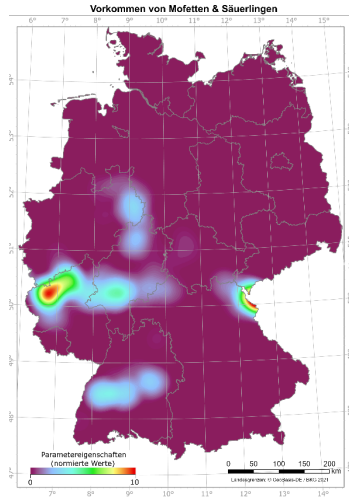
Quantification of indicators



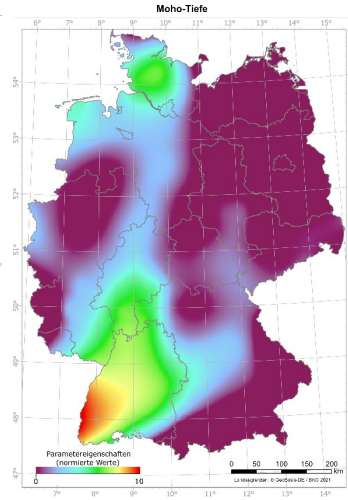
DLF-Earthquakes



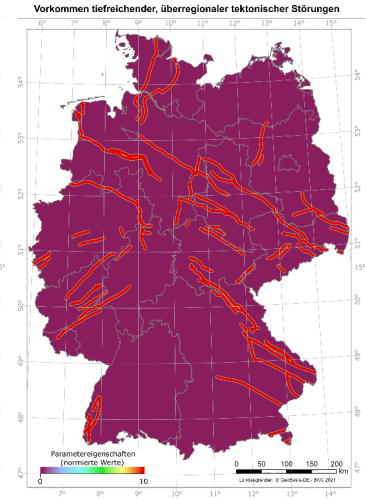
Cenozoic volcanic
rocks



Bicarbonate water
& fumaroles



Moho depth



Faults

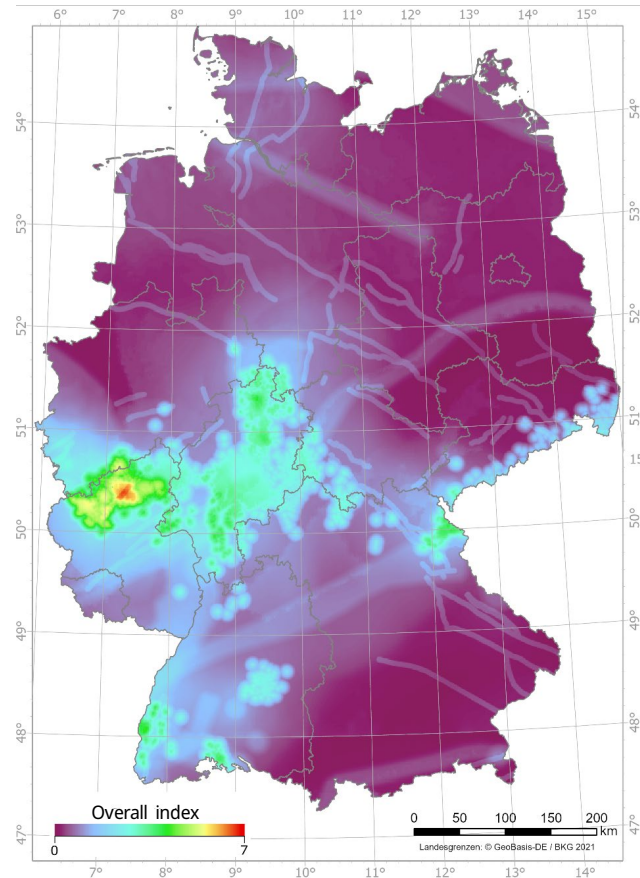
Quantification of indicators



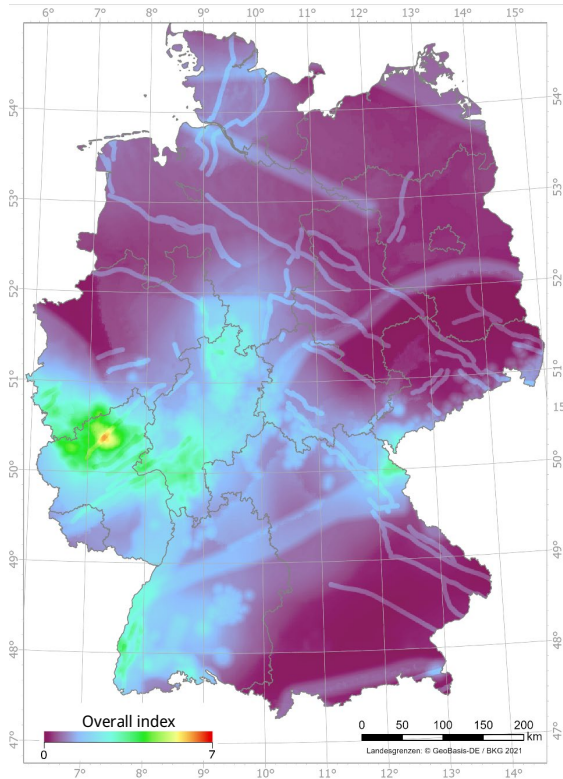
Combination of parameters

- Starting with a white map
- Germany-wide application of parameters
- Combination of parameters to an overall index

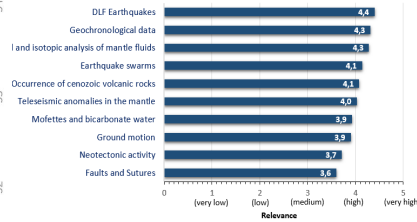
➔ Possible hazard map



Results



Weighted sum according to expert surveys

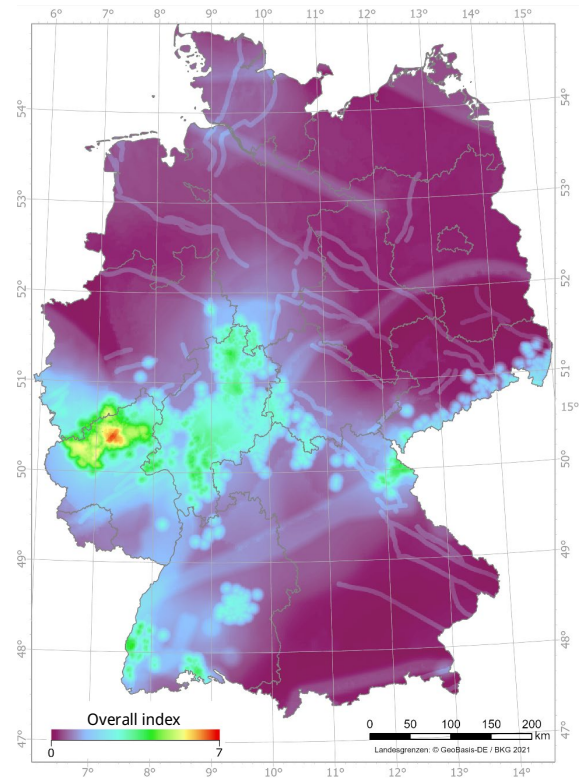


Weighted sum according to expert surveys

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Considering process categories

- 1) melt generation
- 2) pathways
- 3) volcanism

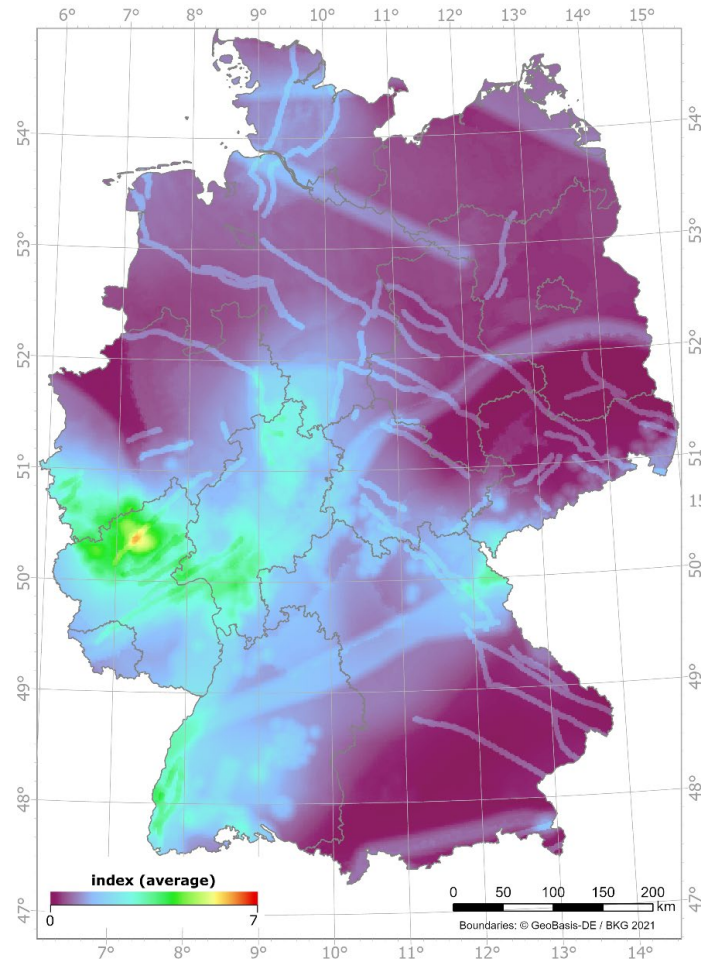


Results

Determining the degree of subjectivity of the results:

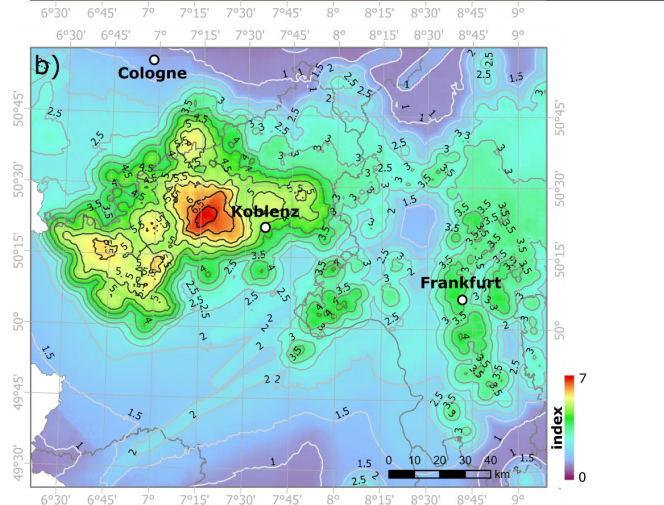
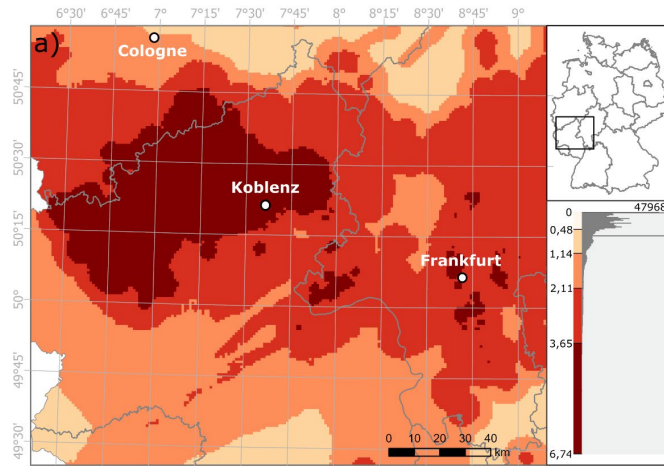
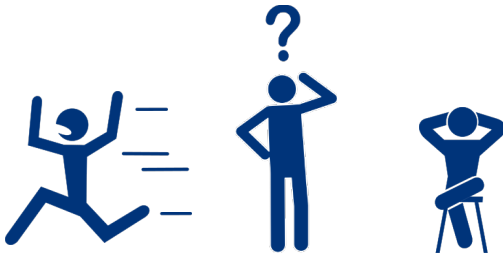
- Using random weighting factors
- Average of 1,000 index calculations

→ Results are comparable with those computed using the output of expert surveys



Differentiation of areas

- Spatial differentiation of the likelihood of future volcanism by evaluating the index values
- Fixed categories vs. continuous value distribution
- **When is a value critical?**



Summary



- Germany-wide collection of data that may provide information about future volcanism
- A multi-criteria approach to forecast most probable regions of future volcanic eruptions in Germany
- 20 parameters were quantified and evaluated using threshold values
- A calculated index is used to quantify the likelihood of possible future volcanic activity within certain areas in Germany
- Results show an elevated risk of future volcanic activity in regions beside the Quaternary volcanic fields

Thank you for your attention!