SpannEnD

Modelling the 3D stress state of Germany

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The SpannEnD Project

SpannEnD is an acronym for “**Spann**ungsmodell **En**dlagerung **D**eutschland”. It is a collaborative research project of three German research institutions (TU Darmstadt, Karlsruher Institut für Technologie & Deutsches Geoforschungszentrum Potsdam), funded by the Federal Ministry for Economic Affairs and Energy. It aims at the spatially continuous prediction of the 3-D stress tensor in Germany by means of a geomechanical numerical model. Independent on future host rock decisions, the model will focus on the basement structures as well as the sedimentary cover.

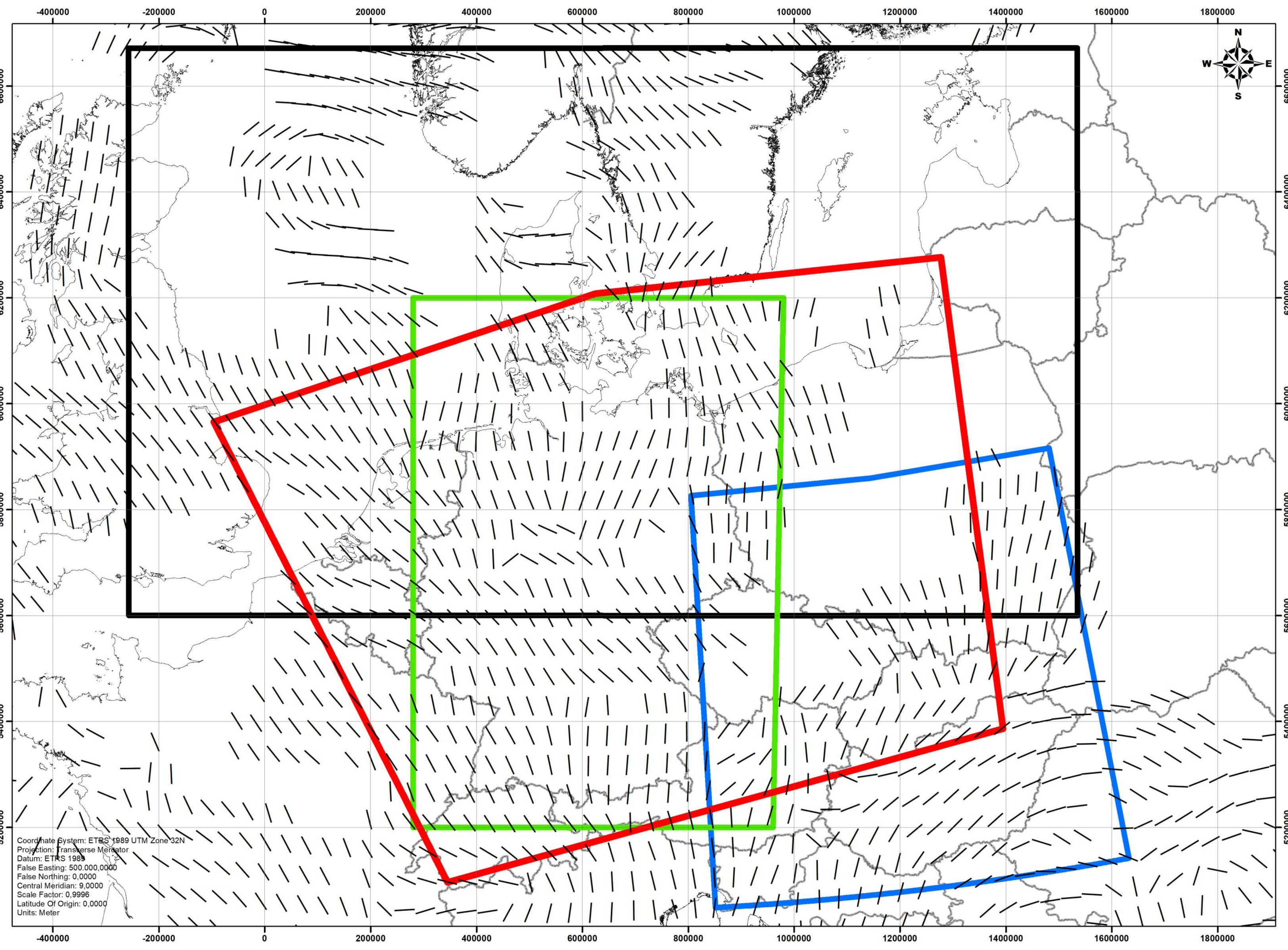

Figure 1: Mean S_{Hmax} orientations derived from the World Stress Map (WSM) (Heidbach, 2016) with model outlines used for the SpannEnD model. Outlines: Red = SpannEnD; Black = Central European Basin Model (Maystrenko & Scheck-Wenderoth, 2013); Blue = Tasarova et al., 2016; Green = 3D Deutschland (Anikiev et al., 2019).

The model area has been chosen perpendicular or parallel to stress orientations of S_{Hmax} and major tectonic structures as shown in Figure 1. As the base of our modelling work pre-existing models have been used. The main part is derived from the 3D Deutschland model (red outline), by Anikiev et al. (2019). Two other important models used are the Central European Basin Model (black outline, Maystrenko & Scheck-Wenderoth, 2013) and the model of Tasarova et al. (2016) of Central Europe (blue outline). Remaining gaps are filled with additional data and some smaller-scale models.
A major challenge is the lack of faults in all models used. Therefore, data of prominent faults within the model area have been compiled (Fig 2), which will be used for the selection of faults for later implementation in the model.

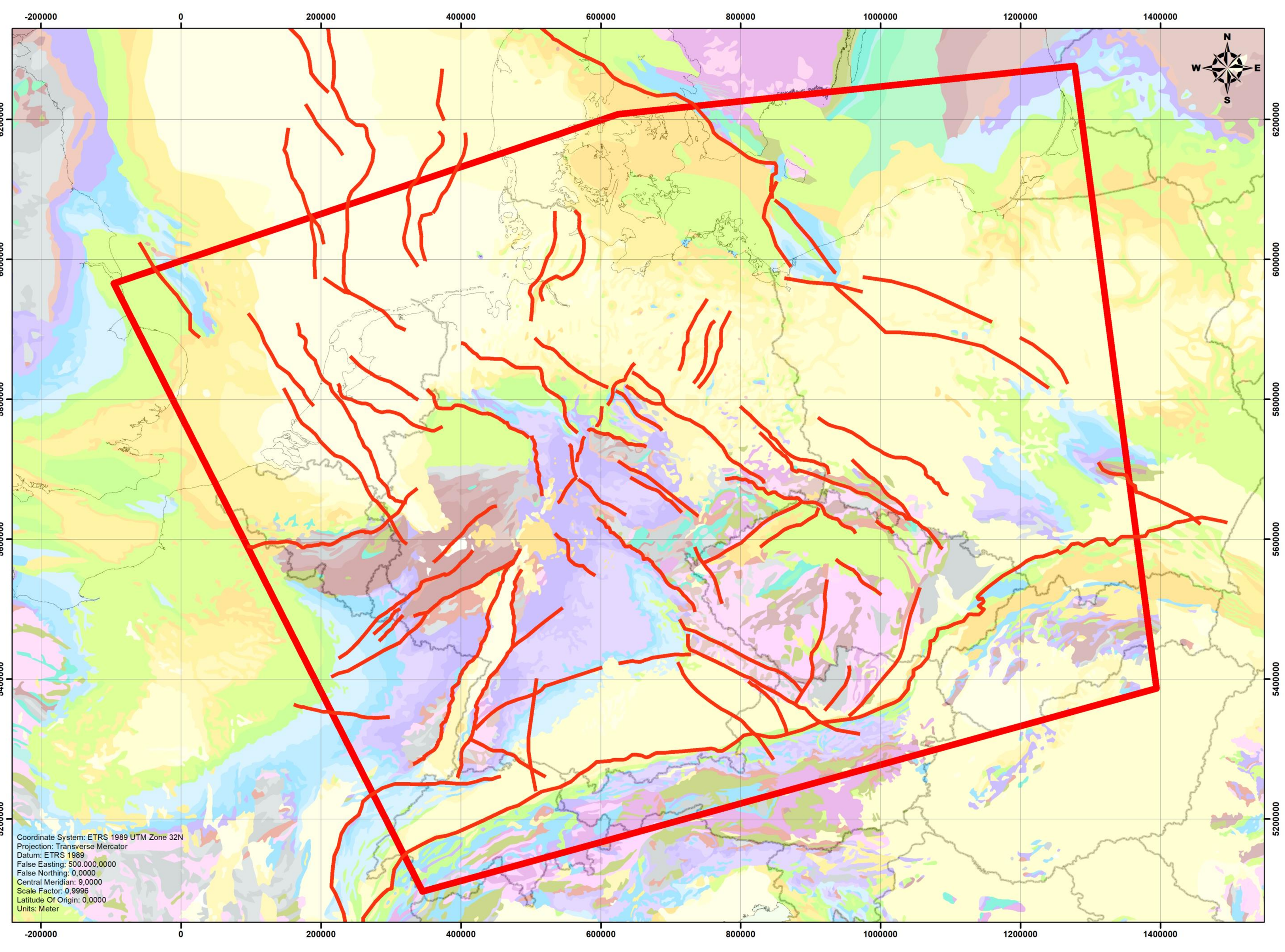

Figure 2: Geological overview based on the International Geological Map of Europe and Adjacent Areas (Asch, 2005) with major faults within the model area based on our data collection.

Current Model

The current model consists of four units. A sediment layer, the crystalline basement, the lower crust and the lithospheric mantle. The overall dimensions of our model are 1000 km x 1400 km x 100 km. The mesh comprises about 1.500.000 hexahedral elements with a lateral resolution of approximately 6 km x 6 km. The vertical resolution decreases with depths from ~600 m near the surface up to 7500 m at the models’ bottom. Due to the complex geometry of or model especially in the upper units we decided to use the ApplePy Script (Ziegler et al., 2019) for the discretization. In contrast to the traditional approach, in which each unit is meshed individually, the whole model is meshed with a regular grid and then ApplePy assigns each element to a unit. The workflow is sketched in Fig. 3. The equilibrium of forces between body and surface forces is solved in an inhomogeneous medium with finite element method. Important input variables are density and elastic material properties (Young’s modulus and Poisson’s ratio), which are different for each unit, and displacement boundary conditions to introduce the tectonic stresses.

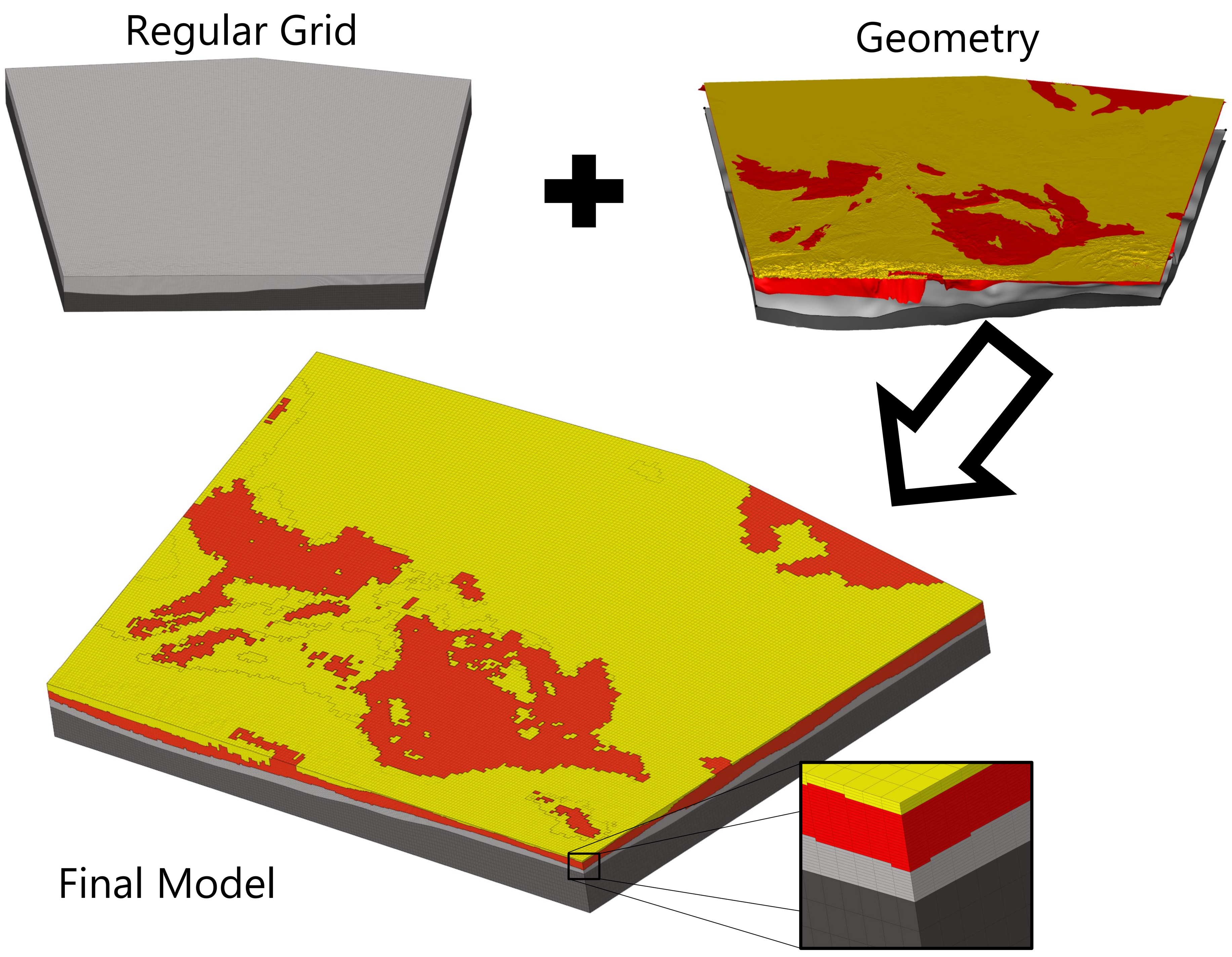

Figure 3: Workflow of model discretization using the ApplePy script (Ziegler et al., 2019). First, a grid is generated for a highly simplified model, in our case consisting of two layers (crust and mantle). Then the ApplePy script combines this grid with the more complex geometry to a model with a simple grid geometry but a complex structure.

First Results

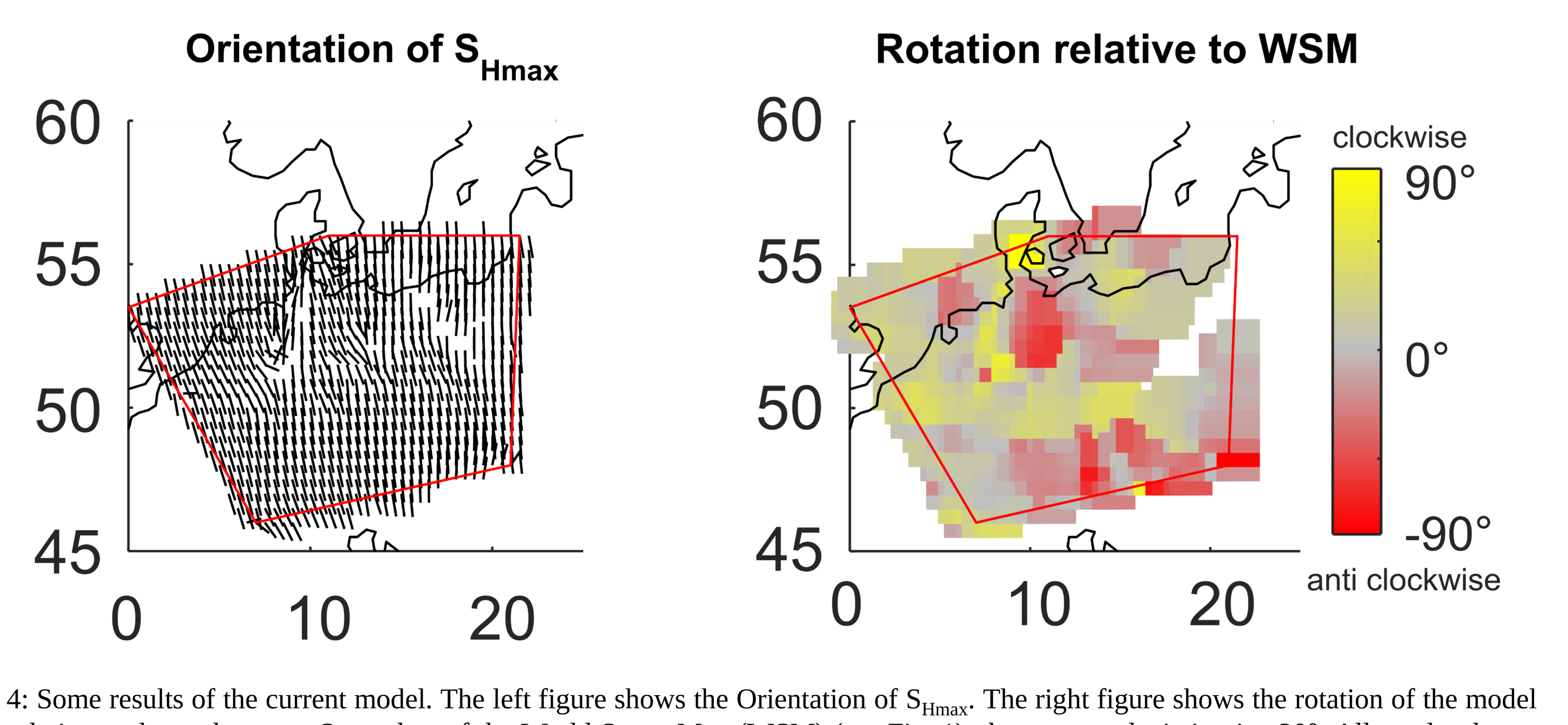

Figure 4: Some results of the current model. The left figure shows the Orientation of S_{Hmax}. The right figure shows the rotation of the model results relative to the to the mean S_{Hmax} data of the World Stress Map (WSM) (see Fig. 1), the average deviation is ~20°. All results shown are at a depth of 1000 m.

Next Steps

- Increase complexity of current model (e.g. different lateral crustal segments, finer resolution of the sediment layer)
- Selection and implementation of major faults
- Calibration with stress magnitude data

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