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3D Geological Model for Germany and Adjacent Areas

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Abstract

3D geological models are an essential source of information for research as well as for the safe and efficient use of the underground. They provide not only a visualization of the subsurface structures, but also serve as geometry input for geophysical and numerical models, e.g., gravimetric, mechanical or thermal models. The set-up of a geological model for a numerical simulation is often a time-consuming task. During the last two decades several 3D geological models have been created for specific regions in Germany. However, up to now only one attempt has been made to combine several of them to a Germany-wide model. We present a new Germany-wide 3D geological model combining information of 27 individual models. The model has a resolution of 1 x 1 km2 and is vertically and horizontally subdivided into 146 units. Where possible, the model has been extended to neighbouring states, e.g., Netherlands, Belgium, France, Switzerland or Austria. In order to combine all models with their different sizes, resolutions and stratigraphic subdivisions, a point-set approach was chosen which has a number of advantages with regard to the flexibility and usability. To demonstrate the usability, the set-up of a FE model is shown as a possible application.

1 Introduction

3D subsurface models showing lithostratigraphic horizons are fundamental for both research as well as various applications and are essential for any safe and efficient use of the underground. Such structural models help not only to visualize the often complex geology but also provide the input geometry for numerical models, e.g., thermal, hydraulic and geomechanical models (Ahlers et al., 2021; 2022a; Anikiev et al., 2019; Arfai and Lutz, 2018; Balling et al., 2013; Koltzer et al., 2022). Such numerical simulations can then be used to provide predictions regarding the undisturbed temperature, pore pressure and stress state, among others, and how these conditions are potentially be disturbed by subsurface operations. Thus, 3D subsurface models are indispensable if it comes to the assessment of the geothermal potential of a region, the minimization of induced seismicity, or the search for a high-level nuclear waste repository and its long-term safety, to name just a few of the wide range of possible applications.

3D subsurface models can have very different scales ranging from meters to hundreds, or even thousands of kilometres. In the following, we focus on the scale of Germany and how various, mainly regional models can be combined. Regional 3D

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

models already exist for several individual federal states, e.g., North Rhine-Westphalia (Geologischer Dienst NRW, 2022), Hesse (Weinert et al., 2022), Baden-Wuerttemberg (Rupf and Nitsch, 2008) as well as across several federal states or including neighbouring countries, e.g., TUNB (BGR et al., 2022), GeoMol (GeoMol Team, 2015a), GeORG (GeORG-Projektteam, 2013), Erzgebirge (Kirsch et al., 2017). In addition, models for larger regions, e.g., MOLA (Przybycin et al., 2015), CEBS (Maystrenko and Scheck-Wenderoth, 2013), of the Upper Rhine Graben region (Freymark et al., 2017) exist and a Germany-wide model that combines these three models by Anikiev et al. (2019). However, a 3D structural model that combines all models - of a regional scale - currently available for Germany and neighbouring countries as the Netherlands, Belgium, Switzerland and Austria is missing. The challenge in setting up such a model is to integrate the different models not only regarding resolution and depths of horizons, but also with respect to the stratigraphic subdivisions.

In the following we first present the existing models which were combined to form a consistent 3D subsurface model of Germany including some neighbouring countries (Ahlers, 2025). The correlations made and additional raw data used are outlined but are also documented in detail for each model surface in the supplement. The resulting model can be used to extract further geological information like depth and thickness maps or to generate individual 3D (sub)models for any region desired. In addition, a workflow is shown which allows to create arbitrary finite element meshes based on the 3D structural model. Such discretized models can then be parameterized accordingly and used for thermal, hydraulic, mechanical or coupled simulations.

2 Model set up

2.1 Data base

27 individual models of different size and stratigraphic resolution were used to set up a unified 3D structural model for Germany (Fig. 1). As this model has been set up initially for the prediction of the recent crustal stress state of Germany by geomechanical-numerical modelling, it covers the same area as the models of (Ahlers et al., 2021; Ahlers et al., 2022a). Therefore, some neighbouring countries have also been included. Almost all surfaces defined in each of the 27 input models have been used for the unified model, with a few exceptions, e.g., tectonic units from the Erzgebirge model (Kirsch et al., 2017; **13**), whose stratigraphic correlation with other horizons is difficult. The succession between the earth's surface and the top of the crystalline basement has been subdivided into 3 to 24 units, depending on the input model. A special case is the integration of the relatively small (70 x 50 km^2) Ingolstadt model (Ringseis et al., 2020; **17**) with a highly resolved stratigraphy with 23 units. This data set was included to prove the possibility of integrating models of different scales and resolutions in one model and to show benefits and limits of the chosen point set approach (Sect. 2.3). If not already contained in the input models, the top of the crystalline basement - an import boundary for all kind of numerical simulations - has been created as a surface with additional data, e.g., well data, seismic sections or other geophysical data. Likewise, the top of the lower crust and the Mohorovičić discontinuity as base of the crust have been created from geophysical data in addition to the existing surfaces of the implemented models. The resulting unified model has a lateral resolution of 1 x 1 km^2, which is a

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

compromise between information loss from high resolution models and a suitable resolution for a large-scale model. The same lateral resolution has been previously used for gravity and thermal modelling by Freymark et al. (2017) and Anikiev et al. (2019) for their German-wide model.

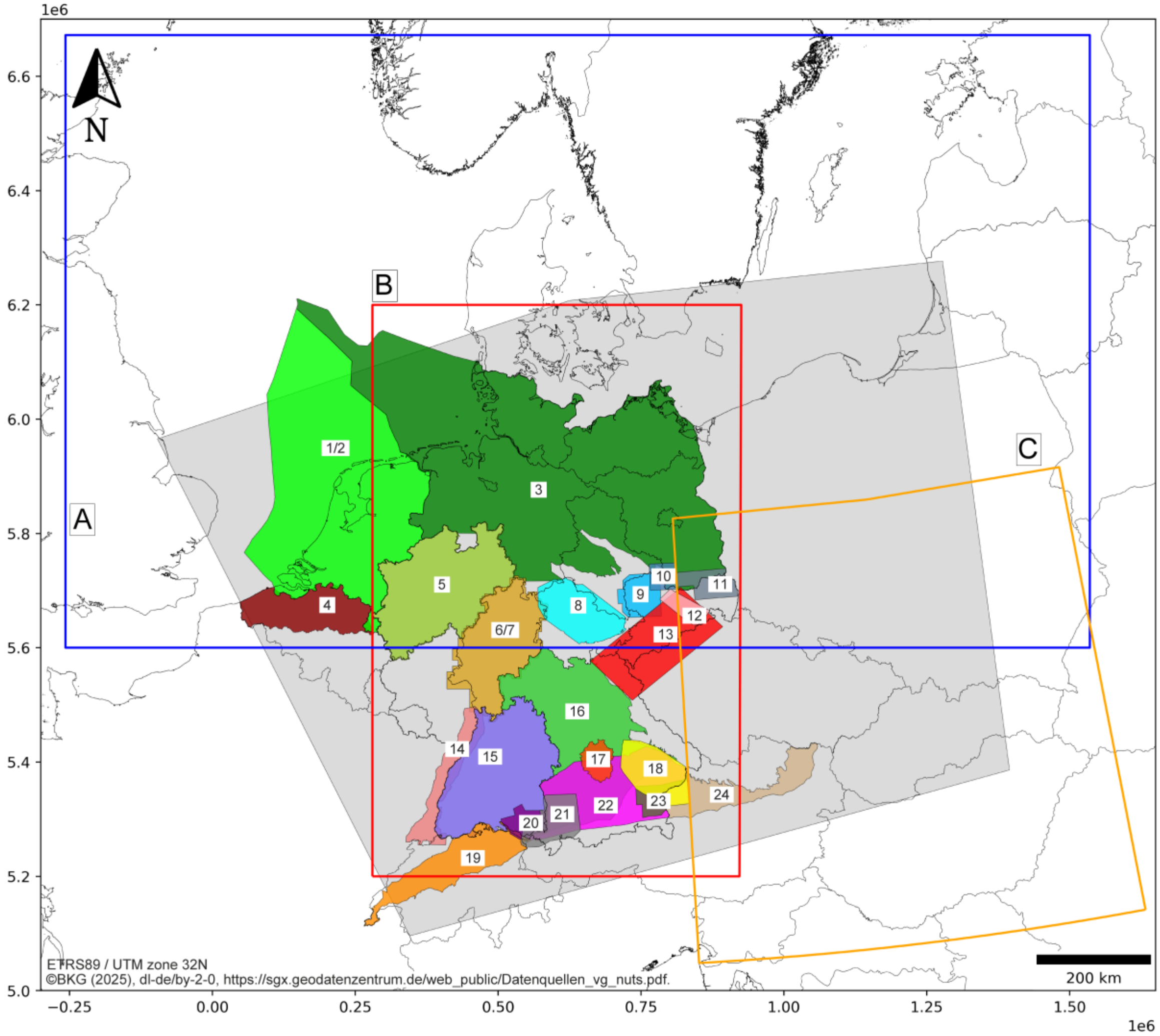

Figure 1: Overview of model area and 3D geological models used: Grey area: Model area. A: CEBS (Maystrenko and Scheck-Wenderoth, 2013), B: 3DD (Anikiev et al., 2019), C: LSCE (Tašárová et al., 2016); 1/2: Netherlands (TNO, 2019a; 2019b), 3: TUNB (BGR et al., 2022), 4: Vlaandern (Deckers et al., 2019), 5: Landesmodell NRW (Geologischer Dienst NRW, 2022), 6/7: Hessen (Bär et al., 2021; Weinert et al., 2022), 8: Thueringer Becken (TLUBN, 2014), 9: NW-Sachsen (Görne, 2011), 10: SN Zwischengebiet (Görne, 2012b), 11: Niederlausitz (Görne and Geißler, 2015), 12: Elbtalzone (Görne, 2012a), 13: Erzgebirge (Kirsch et al., 2017), 14: GeORG (GeORG-Projektteam, 2013), 15: Landesmodell BW (Rupf and Nitsch, 2008), 16: Geothermieatlas BY (LfU, 2022), 17: Ingolstadt (Ringseis et al., 2020), 18: Niederbayern (Donner, 2020), 19: GeoMol Swiss (Swisstopo, 2019), 20: GeoMol LCA BW (GeoMol LCA-Projectteam, 2015a), 21: GeoMol LCA BY (GeoMol LCA-Projectteam, 2015b), 22: GeoMol FWM BY (GeoMol Team, 2015b), 23: GeoMol UA-UB BY (GeoMol UA-UB-Projectteam, 2015), 24: GeoMol Austria (Pfleiderer, S. et al., 2016). The original model names are listed in Table S3, here short names are used. Coastlines and borders used in this figure are based on the Global Self-consistent Hierarchical High-resolution Geography (GSHHG) of Wessel and Smith (1996).

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

2.2 Model correlation

The first step in creating a unified model that covers an area with a complex geological history (e.g., Plant et al., 2005; McCann, 2008; Meschede and Warr, 2019) and combines many different models is the stratigraphic correlation of all model surfaces. Main challenges are the correlation of models from different countries, e.g., Netherlands and Germany, from different sedimentary basins, e.g., North German Basin, Upper Rhine Graben or Molasse Basin and from regions with different local stratigraphic terms. Another challenge is the combination of models which are based on different input data, e.g., mainly well-based models like Landesmodell BW (Rupf and Nitsch, 2008; **15**) and mainly seismic-based models like GeORG (GeORG-Projektteam, 2013; **14**). Finally, the variable stratigraphic resolution used in different input models must be considered. Some models provide only the major stratigraphic boundaries whereas others also provide subunits. An example is shown in Fig. 2. Model A contains four surfaces: top of the Jurassic, top of the Middle Jurassic, top of the Lower Jurassic and base of the Jurassic, whereas model B contains only two of these four surfaces: top and base of the Jurassic. In this example - for an accurate implementation – 4 units have to be considered, e.g., to define proper material properties for a numerical simulation: Upper Jurassic, Middle Jurassic, Lower Jurassic and, in addition, an undifferentiated Jurassic unit.

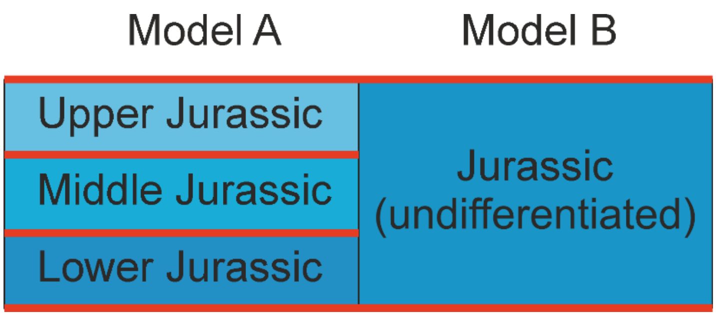

Figure 2: Sketch illustrating challenge of unit definition of models with different vertical (stratigraphic) resolution. Four units (blue boxes) are defined by four formation interfaces (red lines) of two models. Detailed description see text. (Reiter et al., 2023)

2.3 Point set approach

In order to combine models of different scales, stratigraphic and numerical resolution and often unknown raw data, we decided not to create new model surfaces. Instead, we use points sets which are projected onto input data. The basic modelling concept is shown in Fig. 3. First, a point set with a resolution of 1 x 1 km^2 is created. This point set is then projected onto a surface, in this case, the topography (Fig. 3a, green line). Next, the projected point set is duplicated and the duplicated one is projected onto the next underlying surface (Fig. 3b, yellow line). In contrast to the first projection shown the projected point set is additionally shifted down by 0.1 m. This step avoids ambiguous information of different surfaces at a single coordinate, e.g., for a surface pinching-out like the orange one (Fig. 3b). This step would be not necessary if a surface lies entirely below the overlying surface (yellow and green line). However, this is not the case for almost all surfaces in our model. The distance of 0.1 m is chosen as a compromise between usability during the model set-up and loss of information. A similar distance for non-existing units, e.g., due to erosional gaps, is used, e.g., by Anikiev et al. (2019).

Considering the 147 surfaces this minimum distance leads to a shift of up to ~15 m for the lower most model surface (Moho) which is tolerable for the model scale and resolution. The major advantages of the point set model approach are visualized by Fig. 3c-f. If two overlapping surfaces exist (Fig. 3c, purple and pink line) it is not necessary to cut these or to generate a new surface, which can take several hours per surface depending on size and resolution. In such a case, the projection is staggered (Fig. 3c-d). First, the duplicated and down shifted point set is projected onto the surface with the lowest reliability, in this case the purple one, then the projection is done onto the more reliable surface, in this case the pink one (Fig. 3d). The order of projection is determined according to various criteria, e.g., year of publication, model resolution, etc. An example is the German part of the Northern Alpine Molasse basin where seven partly overlapping models (Fig. 1, models **15, 17,18,20,21,22,23**) have been prioritized as follows: 1 Ingolstadt (Ringseis et al., 2020; **17**), Niederbayern (Donner, 2020; **18**), 2 GeoMol LCA BW (GeoMol LCA-Projectteam, 2015a; **20**), GeoMol LCA BY (GeoMol LCA-Projectteam, 2015b; **21**), GeoMol UA-UB BY (GeoMol UA-UB-Projectteam, 2015; **23**), 3 GeoMol FWM BY (GeoMol Team, 2015b; **22**), 4 Landesmodell BW (Rupf and Nitsch, 2008; **15**). Ingolstadt (Ringseis et al., 2020; **17**) is the most recent model (2020) with the highest resolution in this area. Niederbayern (Donner, 2020; **18**) was also published in 2020 and has a coarser resolution, however, they don't overlap. The GeoMol models are subdivided into the coarser framework model (GeoMol Team, 2015b; **22**) and three pilot region models (GeoMol LCA-Projectteam, 2015a; **20**, GeoMol LCA-Projectteam, 2015b; **21**, GeoMol UA-UB-Projectteam, 2015; **23**) all published 2015. Landesmodell BW (Rupf and Nitsch, 2008; **15**) is the oldest model in this area. Another advantage of the point set approach is the integration of model surfaces which occur only locally, e.g., in one model (Fig. 3e, red line) or to take into account the precise definition of stratigraphic unit (Fig. 2). The biggest advantage of the point set model, however, is the possibility to effectively integrating new or updated data in the existing model. For example, if an adapted surface (Fig. 3f, dashed orange line) should be integrated, the existing point set can be updated quickly.

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

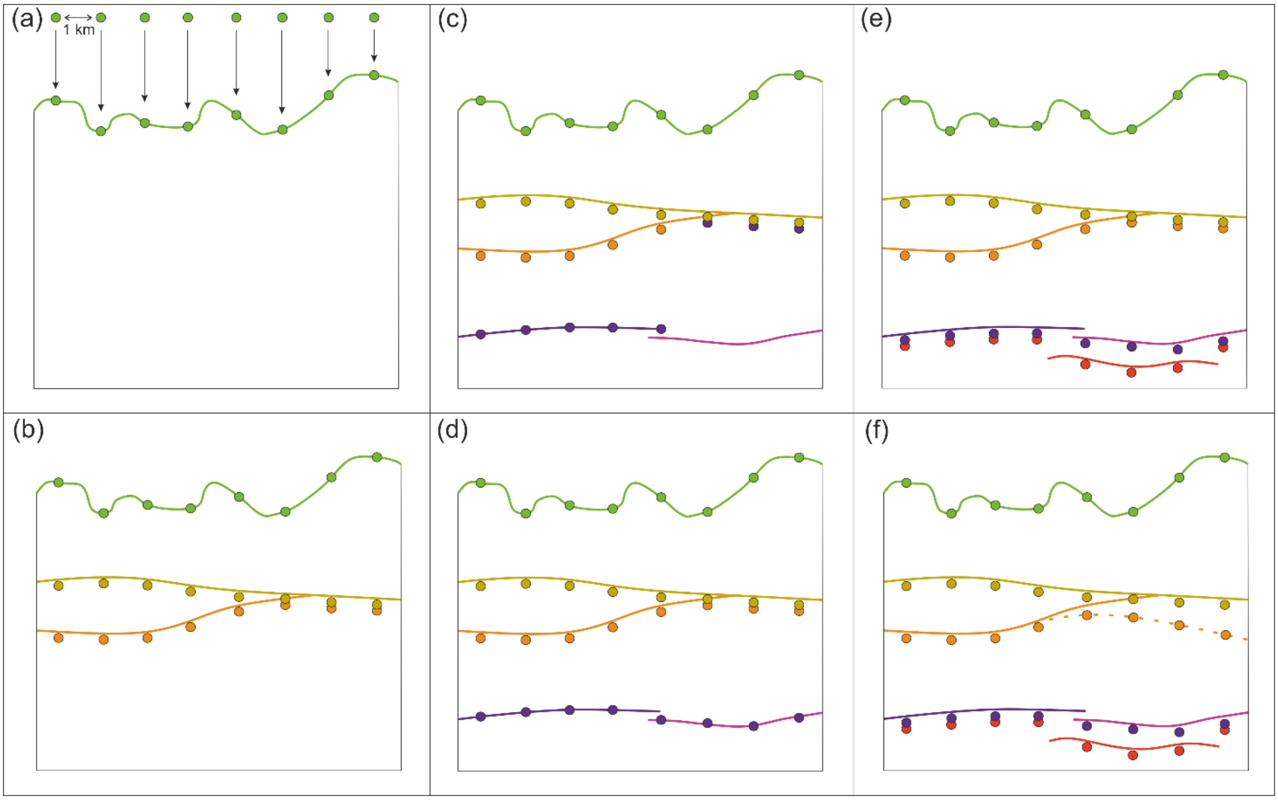

Figure 3: Sketch of the point set modelling approach used. Details are described in the text. (Reiter et al., 2023)

3 Results

3.1 Stratigraphic correlation

130 Based on 27 models (Fig. 1), 89 different surfaces could be defined. The result of the stratigraphic correlation is summarized in Table S1, a small excerpt is shown in Table 1. Each individual surface is listed in one row and is labelled with its id and surface name. The id's are categorized as follow: 00xx stratigraphic independent surfaces, 01xx Quaternary, 02xx Cenozoic, 03xx Cretaceous, 03xx Jurassic, 03xx Triassic, 06xx Permian, 07xx Carboniferous, 08xx Devonian, 09xx Variscan nappes, 10xx top basement. In the columns to the right of the surface name, all models used are listed. If a model contributes data to
135 a surface it is documented in the corresponding row. Information is given as follow: original file name – surface name (additional information). The rightmost column 'Literature' lists if literature has been used for the stratigraphic correlation, in addition, to the model descriptions and the stratigraphic table of Germany (DSK, 2016).

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

Table 1: Excerpt from the table ‚stratigraphic correlation' attached to this paper (Table S1).

id	surface name	Netherlands	TUNB	GMTED	…	Literature
0001	Topography			mn30_grd	…	(Danielson and Gesch, 2011)
…	…			…	…	…
0222	Base Selandian	2_NLNM_tvd_on_offshore_merge_DGM50_ED50_UTM31–Base North Sea Super Group (Top Dan, Basis Selandian)	t - Basis Tertiär (Top Dan, Basis Selandian)		…	(Doornenbal and Stevenson, 2010)
….	…	…	…	…	…	…

3.2 Model units

Based on these correlation results the final model units could be defined. The results are summarized in a second table (Table S2), an excerpt is again shown in Table 2. The structure is similar to Table S1 and the excerpt shows the same simple example as shown in Fig. 2. Within the TUNB model (BGR et al., 2022; **3**) the Jurassic is subdivided into three subunits Lias, Dogger, Malm (Lower, Middle and Upper Jurassic) while in the 3DD (Anikiev et al., 2019; **B**) only one Jurassic unit exists. Therefore, four individual units have been defined. In addition to Table S1 the geological categorization of the id's has been extended by: 11xx top crystalline basement, 12xx base Upper Crust, 13xx base Lower Crust. Furthermore, the categorization of id's 00xx to 10xx has been extended to take into account if several units are defined by one surface (Fig. 2). The final model contains 147 surfaces, i.e, 146 units: 131 sedimentary units, 8 upper crustal units and 7 lower crustal units.

Table 2: Excerpt from the table ‚units_overview' attached to this paper (Table S2).

id	unit name	…	TUNB		3DD	…
…	…	…	…		…	…
0404	Malm	…	05_ST_jo			…
0413	Dogger	…	06_jm			…
0416	Lias	…	07_ju			…
0418	Jurassic	…	…		10_Mesozoic_Triassic	…
…	…	…	…		…	…

3.3 Presentation of results

In addition to the point data sets Ahlers (2025) provides plots for each model unit, in total 146. In addition, 11 plots of combined model units are presented: Cenozoic, Cretaceous, Jurassic, Triassic, Zechstein, Rotliegend, PrePerm, Carboniferous, Devonian, Upper Crust, Lower Crust. As an example, the plot combining the Cenozoic model units (0102-

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

0106, 0201-0244, 0307, 0417) is shown in Fig. 4. It was chosen since 20 of the 27 models used contribute to these Cenozoic units. In general, all the plots are subdivided into four subfigures: the upper left subfigure shows the depth of the unit base, the lower left the thickness of the unit, which is also displayed as histogram in the lower right subfigure. In addition, the total area of the unit extend is given above the histogram. The upper right subfigure shows the input data used color-coded regarding the input models. The references of models used are displayed to the right of the histogram in the same order as in the legend of the upper-right subfigure. To account for outliers in the plots, the most extreme 1 % of depth and thickness values are not considered for the colour bars. The entire model area is indicated by a red rectangle. The hatched area indicate the parts without high stratigraphic resolution models (Fig. 1).

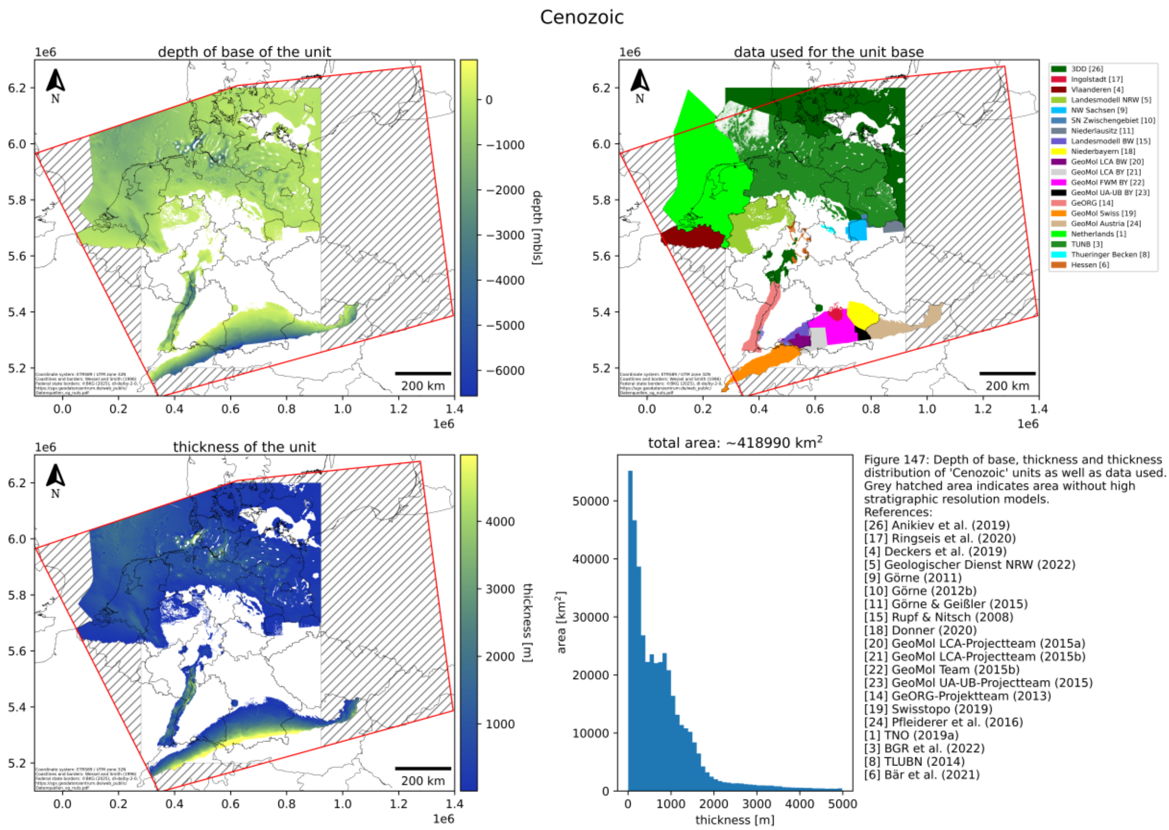

Figure 4: Depth of base (upper left), thickness (lower left) and thickness distribution (lower right) of combined Cenozoic units (id's: 0102-0106, 0201-0244, 0307, 0417) as well as data used (upper right) as an example of the figures published with the model (Ahlers, 2025). A detailed description is given in the text. Coastlines and borders used in this figure are based on the Global Self-consistent Hierarchical High-resolution Geography (GSHHG) of Wessel and Smith (1996).

3.4 Generation of a discretized model

The following example shows how a discretized 3D model - ready for parameterization - can be created from the structural model outlined above. For this workflow ApplePY v1.3 (Ziegler et al., 2020b) is used, a tool automating the process of

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

Earth System Science Data
Open Access Discussions

discretization (Fig. 5). In addition to a mesh (Fig. 5a) a structural model provided as point data set (Fig. 5b) is required. The creation of the mesh is not restricted to any specific software, however, must be provided as an Abaqus *.inp file. However, the Abaqus *.inp file is common and a structured text-file. The mesh and structural model are combined in ApplePY (Fig. 5c). ApplePY assigns each element to a model unit based on the geological information provided by the point data set (Fig. 5d). A detailed description of this tool is given by Ziegler et al. (2020a).

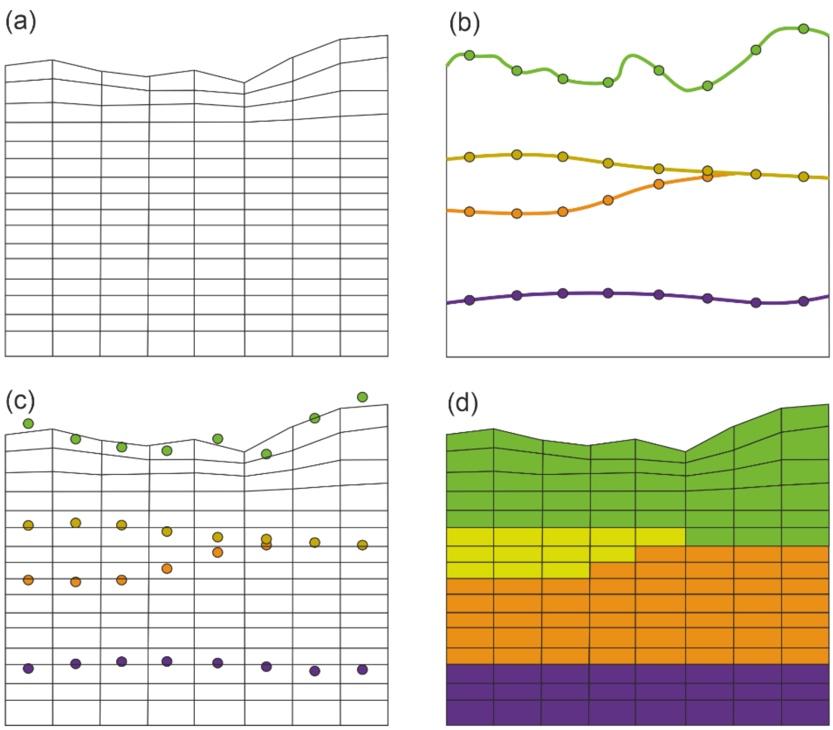

Figure 5: Sketch of the ApplePY approach (Ziegler et al., 2020b) based on Ziegler et al. (2020a) combining a mesh (a) with a structural model provided as point set data (b-c) to define model units (d). Details are described in the text.

3.4.1 Worked example

As an example, to illustrate the working steps, a region of 200 x 200 km^2 area covering parts of Belgium, Germany and Netherlands is chosen. In this area five different 3D models have to be considered (TNO, 2019a, 2019b; Deckers et al., 2019; BGR et al., 2022; Geologischer Dienst NRW, 2022; Fig. 1). The Coordinates (in ETRS89 UTM32N) of the area are: y (min) = 5650000, y (max) = 5850000, x (min) = 200000, x (max) = 400000, z (min) = -20000 m, z (max) = 1000 m. The resolution of the mesh is 100 x 100 x 50 elements, whereby the element thickness increases with depth. To choose reasonable layers, a look at the stratigraphic correlation outlined in Table S1 is helpful. In our example, base Cenozoic (in this region defined as base Zealandian), base Cretaceous, base Jurassic and top crystalline Crust are used. Once the desired surfaces have been selected, the respective data sets containing the lowest relevant data can be selected in Table S2. In case of base Jurassic 'gg_j_b' from 'Landesmodell NRW' is included in dataset 0416, the same applies to ‘Vlaanderen’. The corresponding data

https://doi.org/10.5194/essd-2025-320
Preprint. Discussion started: 25 June 2025

from 'Netherlands' and 'TUNB' have been included into datasets 0413 and 0414, i.e., dataset 0416 contains the base Jurassic of all relevant models in the region and is used accordingly as base Jurassic. An overview of all datasets used in the example is given in Table 3.

Table 3: Overview of surfaces and corresponding datasets used in the example.

Surface	Data set
Topography	Ahlers_2025_surface_id_0001
Base Cenozoic, i.e., base Seelandian	Ahlers_2025_surface_id_0236
Base Cretaceous	Ahlers_2025_surface_id_0303
Base Jurassic	Ahlers_2025_surface_id_0416
Top crystalline Crust	Ahlers_2025_surface_id_1103

Once the relevant datasets have been selected, ApplePY (Ziegler et al., 2020b) can be used. ApplePY includes two python files: ‘create_horizon_file.py’ and ‘apple.py’ which have to be updated with respect to the specific application. First, add chosen data sets to the ApplePY folder, open ‘create_horizon_file.py’ and add file names to line 12:

```
Line 12
files=['Ahlers_2025_surface_id_0001.txt','Ahlers_2025_surface_id_0236.txt','Ahlers_2025_surface_id_0303.txt','Ahlers_2025_surface_id_0416.txt', 'Ahlers_2025_surface_id_1103.txt']
```

In addition, adjust the separator to ‘;’ by editing line 28 and 57 from:

```
Line 28/57        line = str.split(line)
```

to:

```
Line 28/57        line = str.split(line,';')
```

Then run ‘create_horizon_file.py’ and open ‘apple.py’. Add name of the mesh - as Abaqus *.inp file format- in line 12, define name of the exported file of ‘create_horizon_file.py’ in line 13 and add unit names in line 14.

```
Line 12        geometry = 'example.inp'
Line 13        horizons = ['horizons.txt']
Line 14        strata = [‘Relicts’,'Cenozoic','Cretaceous','Jurassic','PreJurassic','Crystalline Crust']
```

‘Relicts’ is a model unit of element which occur due to differences between the topography, i.e., data set 0001 and surface of the mesh used. If elements - defined in the mesh - lie above the topography defined by 0001 such relictic elements occur.

Therefore, it is also possible to create a mesh without topography and remove the relict unit later on as it was done with the example here. Finally, run the ‘apple.py‘ script. The final model is shown in Fig. 6.

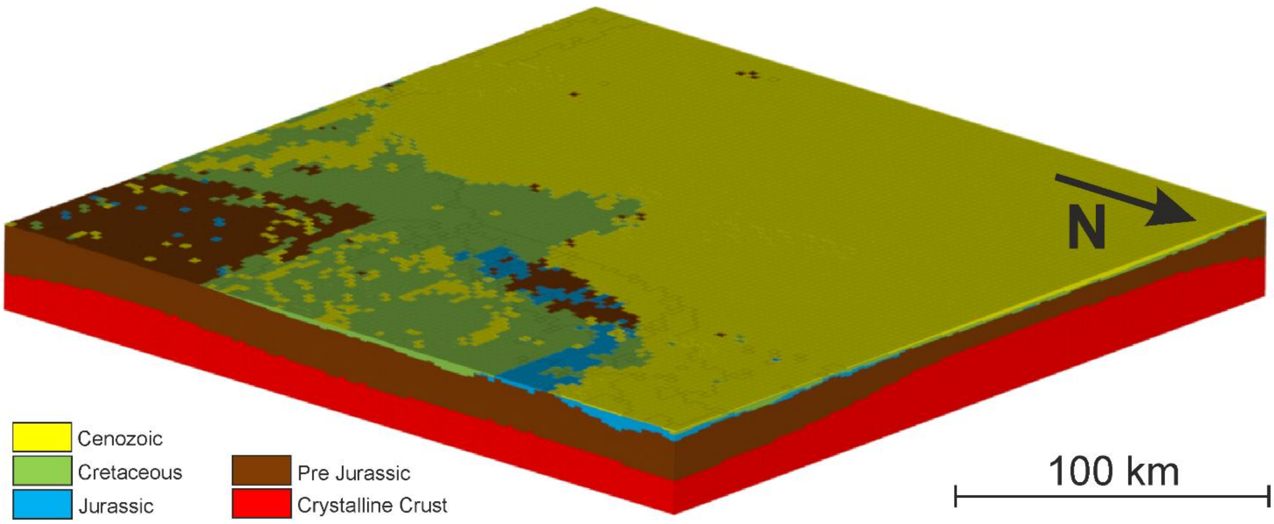

Figure 6: Discretized model created with data set of Ahlers (2025) and ApplePY (Ziegler et al., 2020b). The uppermost unit ‘Relicts’ has been removed. The model area is located at the triangle of countries of Belgium, Germany and Netherlands: y (min) = 5650000, y (max) = 5850000, x (min) = 200000, x (max) = 400000. The base of the model is at a depth of 20000 m.

4. Discussion

Due to the diversity and the lack of the raw data originally used to define the surfaces in the various input models as well as the very heterogeneous distribution of input data, we decided to use a point set modelling approach with a lateral resolution of 1 x 1 km^2. The lateral resolution is a compromise between loss of information, pretending a higher resolution in regions where only low-resolution data is available and the manageability of the final model. The largest loss of information occurs in regions with highly variable geology in lateral direction, e.g., areas influenced by volcanic activities or halokinetic structures. The vertical resolution depends mainly on the input data, however, since for technical reasons (Sect. 2) each model unit has a thickness of at least 0.1 m, an error of up to 14.6 m can occur on the deepest units. However, in relation to the overall size of the model, the thicknesses of the units and the uncertainties of the input data, these vertical errors can be considered as small. Overall, the loss of information and vertical uncertainties are acceptable, especially considering the size and purpose of the model.

The choice of point sets as publication format has several reasons. In general, point sets are a common publication form of numerical models, e.g., (Maystrenko and Scheck-Wenderoth, 2013; Anikiev et al., 2019; Deckers et al., 2019; Ahlers et al., 2022b). A major advantage is, that the point sets can be used directly for the fast creation of discretized models with ApplePY (Ahlers et al. 2022; Ziegler et al. 2019) as shown in Sect. 3.4 and no specific software is necessary for use.

Furthermore, the point set modelling approach has several advantages in contrast to common geological 'surface' models. An implementation of new or updated data can be done much faster, overlapping models do not have to be cut and models with different stratigraphic and lateral resolutions can be combined in one model. However, the integration of rather small and high-resolution models has some limits, e.g., some surfaces of the Ingolstadt models (Ringseis et al., 2020; **17**) have a smaller extent then the point set resolution of 1 x 1 km^2.

Some result figures show minor deviations between the 'depth' and 'thickness' and the 'data used' subfigures, as the original nodes of the input models are shown in the 'data used' subfigure and its resolution sometimes deviates from the model resolution of 1x1 km^2 shown in the other subfigures, e.g., unit 0228: the input data of the TUNB model (BGR et al., 2022; **3**) in the North Sea has a very low resolution, therefore, it appears that there are gaps in the model. No adjustment of these subfigures has been done since this would pretend a higher resolution of the input data. Another example of minor deviations between the subfigures is indicated for unit 0237, where the area of the 'data used' is larger than the depth and thickness of unit 0237. This, on the one hand, is due to very low thicknesses not resolved in the model (<4.4 m) and on the other hand results from very small extents not covered by the 1x1 km^2 grid. Deviations between 'data used' subfigure and 'thickness' and 'depth' subfigures occur for several units in northern Bavaria, e.g., 0416. Since there is no 3D geological model available for this area, only an atlas with isolines (LfU, 2022; **16**) could be used. In addition, there are results of a recent 2D seismic campaign of Fazlikhani et al. (2022). Based on this seismic survey and some deep boreholes located further to the south (Reinhold, 2005) surfaces were generated. These surfaces were not created using the data from the atlas (LfU, 2022; **16**), as the raw data used are not available. Therefore, for some units, e.g., 0526 show significant deviations between the seismic data and the atlas (LfU, 2022; **16**).

The Zechstein consists of two units (0601, 0602), a salinar and a non-salinar. Since only the 3DD model (Anikiev et al., 2019, **B**) distinguishes between these, this subdivision was extended using (Grabert, 1998; Seidel, 2003; LGB-RLP, 2005; Wong et al., 2007; Bachmann et al., 2008; Reinhold et al., 2014; DSK et al., 2020; Becker et al., 2021). The so called PrePerm units (1103-1108) are 'gap fillers' between the top crystalline basement and the deepest units resolved in the models. This unit is therefore sometimes only found in fragments (1107, 1108) and in some cases it is probably only a modelling relict and can therefore be equated with the crystalline basement, e.g., for the Mid German Crystalline High (1105). The unit 1301 show large areas with small thicknesses, which are also modelling relicts and show the deviation between original data of 3DD (Anikiev et al., 2019, **B**) used for surface 1301 and the new surface top Upper Crust (1203-1208) created for the entire model area. Since, the resolution of the top of the Upper Crust is lower than the original 3DD model, these relicts occur, similar effects occur for unit 1307.

5. Conclusions

The presented geological model of Germany and adjacent areas combines 27 models of different sizes from Germany and neighbouring countries, e.g., Switzerland, Austria or the Netherlands. It contains 147 surfaces, i.e., 146 units and is provided

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as a point data set with a resolution of 1x1 km^2. A comprehensive supplement documents the assumptions made. 157 figures of each individual unit and some combined units visualize the results. Creating a geological model as geometry input for numerical models often takes a significant amount of time, especially if different data sets have to be combined. The model presented is intended to replace this labour-intensive work step as far as possible, especially for large-scale models, or at least to simplify this work step by providing the correlation between models and regions. Especially, if ApplePY (Ziegler et al., 2020b) is used, it is possible to create a discretized 3D finite element model within a very short time, which can then be parameterized with mechanical, thermal or hydraulic material properties as required. Due to inhomogeneous input models and the overall size of our model, we used a point set approach, i.e., almost no new surfaces have been created. This approach provides the opportunity to integrate new or updated data quickly. The final model resolution of 1x1 km^2 is reasonable for large scale models, for studies focusing on small-scale structures the original data sets should be used. As far as we know, this model includes all available models with a reasonable size and is therefore, the most detailed geological model of Germany currently available.

Data availability:
The model is published as Ahlers (2025) and is available under https://doi.org/10.48328/tudatalib-1791 (The DOI will be activated after review, since no changes are possible after activation. Until then this URL is valid: https://tudatalib.ulb.tu-darmstadt.de/handle/tudatalib/4615)

Supplement:
Table S1
Table S2
Table S3

Author contribution:
SA: Conceptualization, data curation, investigation, methodology, validation, visualization, writing (original draft preparation, review and editing)
AH: Conceptualization, funding acquisition, project administration, supervision, validation, writing (original draft preparation, review and editing)

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The authors declare that they have no conflict of interest.

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