

On Building Large-Scale 3D Geological Models without Using Map Projections

Björn Zehner

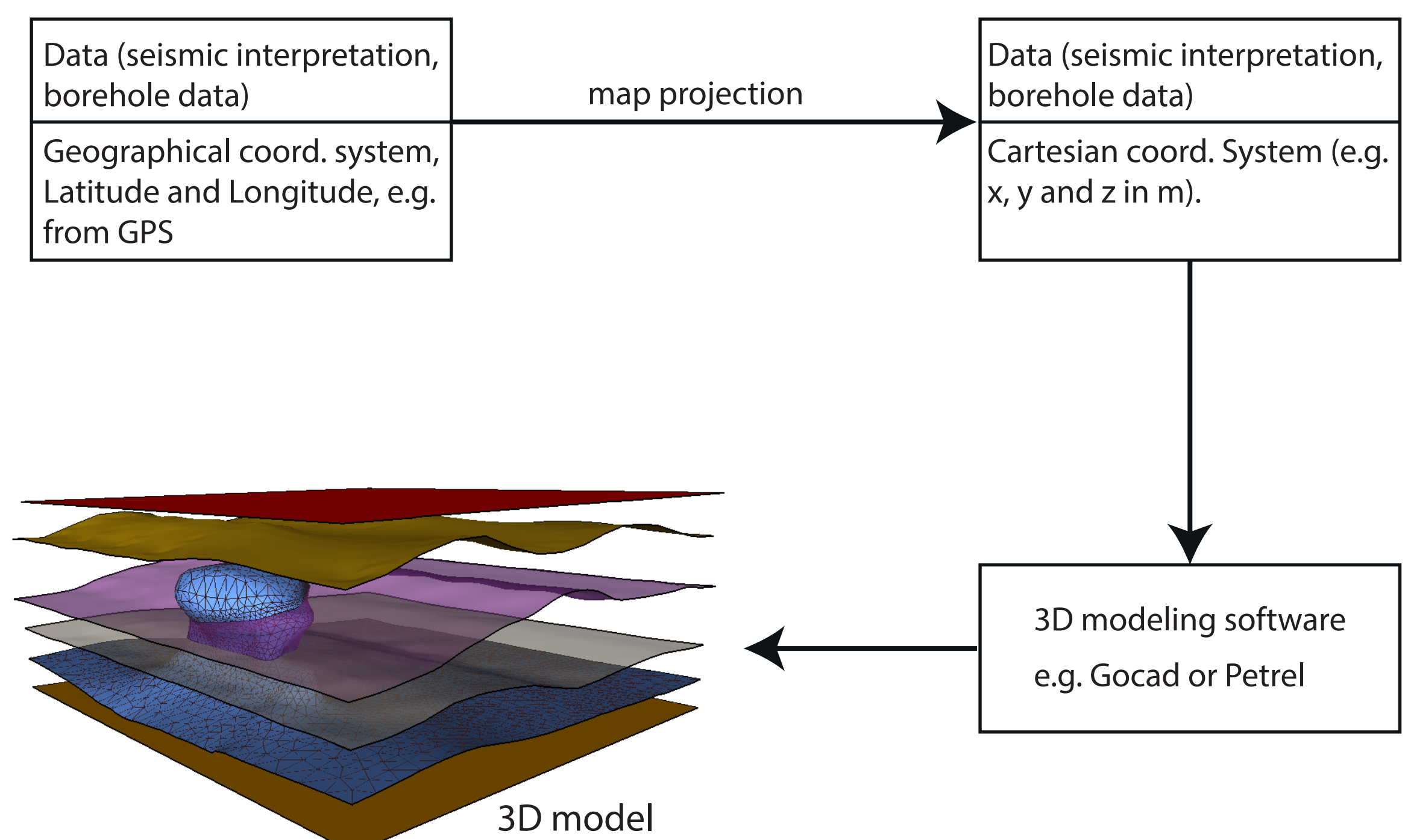
Federal Institute for Geosciences and Natural Resources (BGR) - Berlin Office, Wilhelmstrasse 25-30, 13593 Berlin, Germany; bjoern.zehner@bgr.de

Motivation - usual Approach

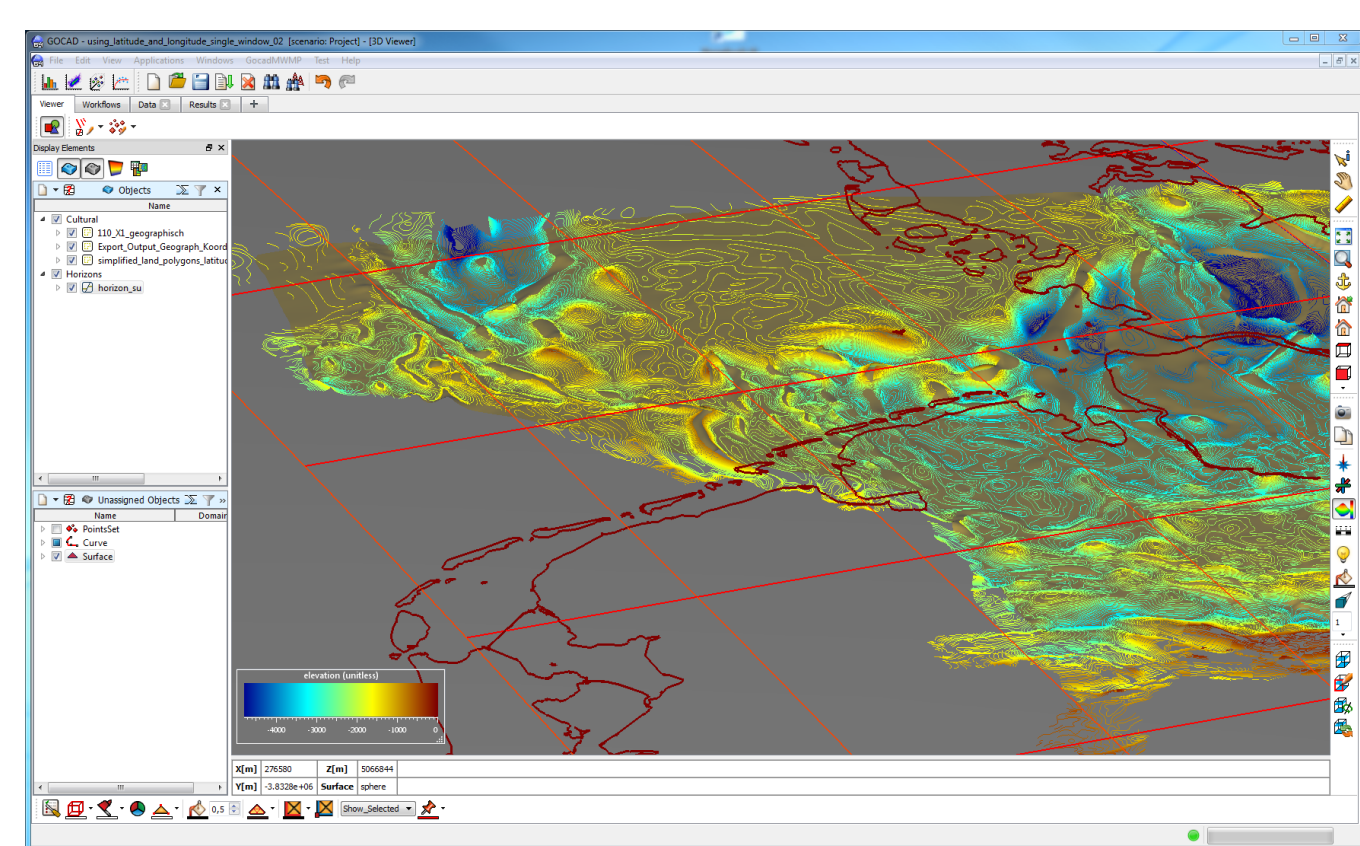
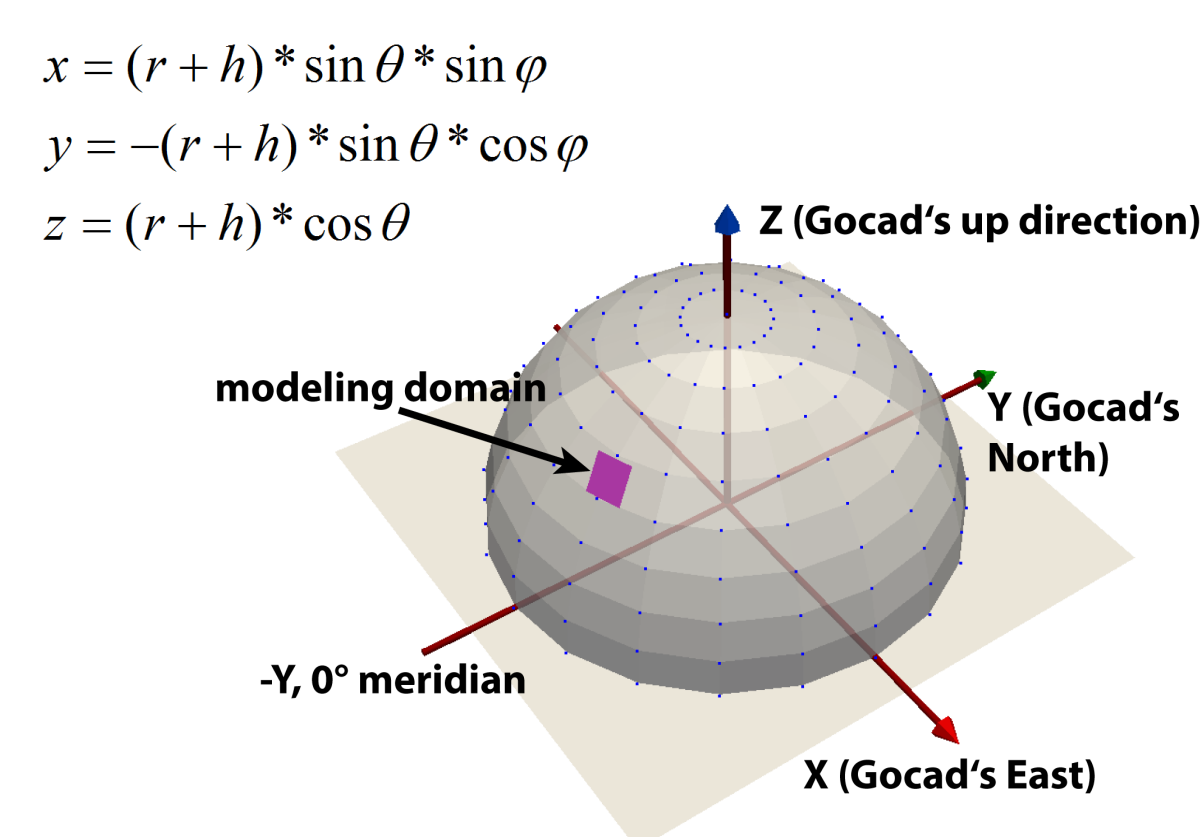
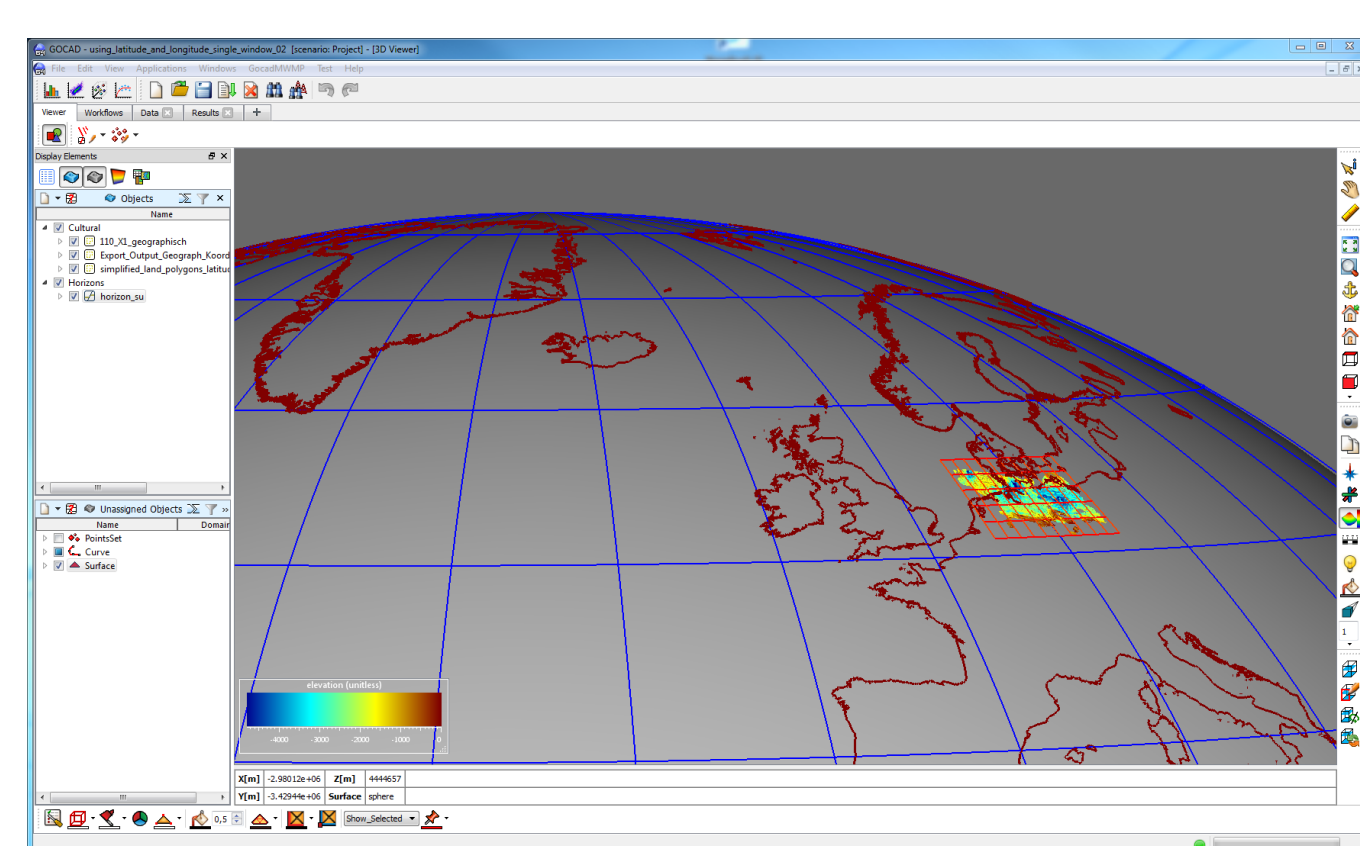
3D modelling is applied with increasing frequency to large-scale regional models, sometimes spanning whole countries. Further more and more transnational projects are emerging that involve large regions and several Geological Surveys (e.g. TUNB, GeoMol).

Currently, data storage and 3D modelling mostly takes place with reference to coordinate systems that are based on map projections, e.g. the UTM (Universal Transverse Mercator) projection.

This leads to several problems. If the data need to be shared across borders, they need to be projected back and forth and/or stored twice which leads to redundancies and may cause data inconsistencies. If the individual 3D models are to be connected, in order to generate a single model spanning a larger region, they will not fit together and may appear distorted.



Snapshot how data coordinate systems are usually handled.



Above: Gocad's coordinate system and the transformations from geographical coordinates onto the virtual earth's surface we use. Left: two screenshots of data and a modeled horizon in Gocad viewed from far away and more close. Blue lines indicate parallels and meridians in 10° steps, red lines indicate the same in 1° steps within the region of interest.

Alternative Approach

Theoretically, it would be preferable to model directly on the shell of the geoid. The data and the generated 3D models could then be managed using geographical coordinates which are valid worldwide (latitude, longitude and elevation, which is the height from the geoid). We have tested, if it is possible to use the commercial software Gocad for this approach, by following these steps:

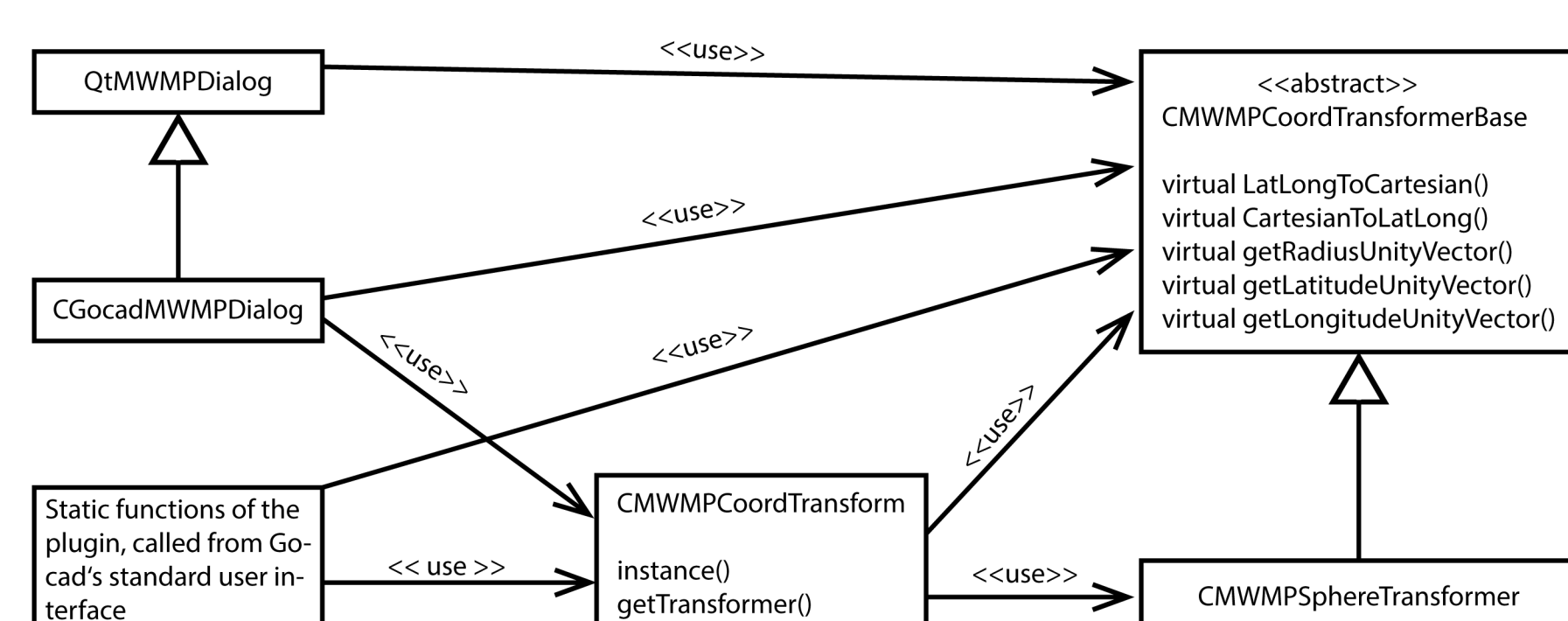
1. Preparing all the data using geographical coordinates and elevation instead of an x-, y- and z-based representation.
2. Loading the data, such as the contours above, using geographical coordinates and elevation.
3. Transforming the data onto a sphere or geoid in Gocad's Cartesian world coordinate system as it is shown to the left. The data would then spread along the geoid's surface.
4. Constructing the geological model as usual, using the standard Gocad functionality.
5. Finally, if needed, transforming the resulting model back from the Cartesian into the geographical coordinate system, describing the position of each vertex by latitude, longitude and elevation.

Implementation and Experiences

As a proof of concept, we have implemented a Gocad plugin which supports the user during the modeling process by providing some adapted versions of Gocad's standard functionality, such as the „view from top“ and „view from east“ commands, and the necessary transformation between the geographical coordinate system and Gocad's Cartesian coordinate system. Further we provide a widget for determining the unity vector in Gocad's coordinate system in dependency of the latitude and longitude and of the azimuth and dip relative to the virtual earth's surface.

For our impression the system could be used easily for the standard modeling tasks. However, for some functionality, such as creation and alignment of SGrids, it turned out to be preferable to temporarily rotate the used parts of the model, so that they are lying nearly horizontal.

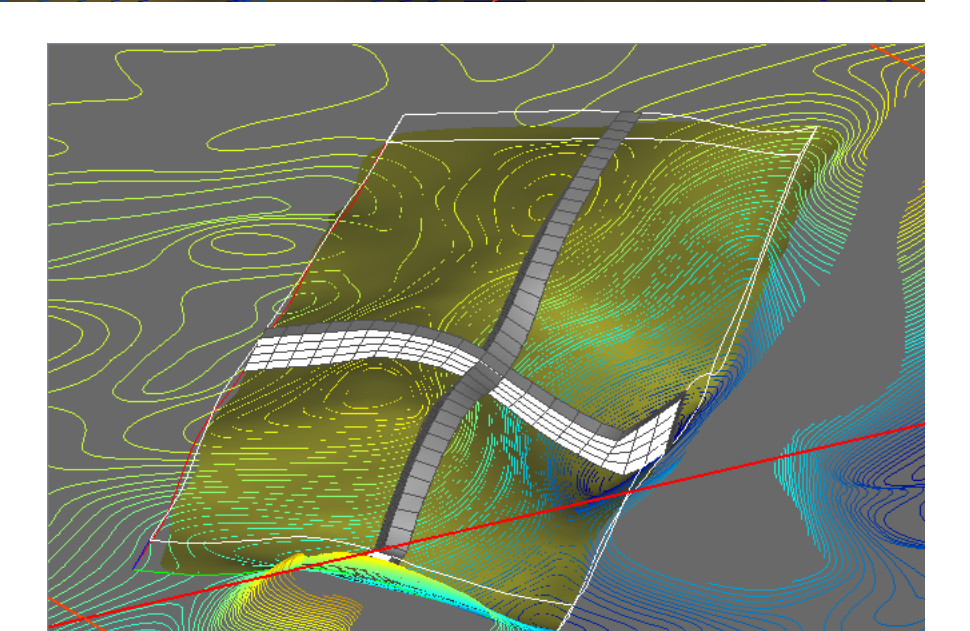
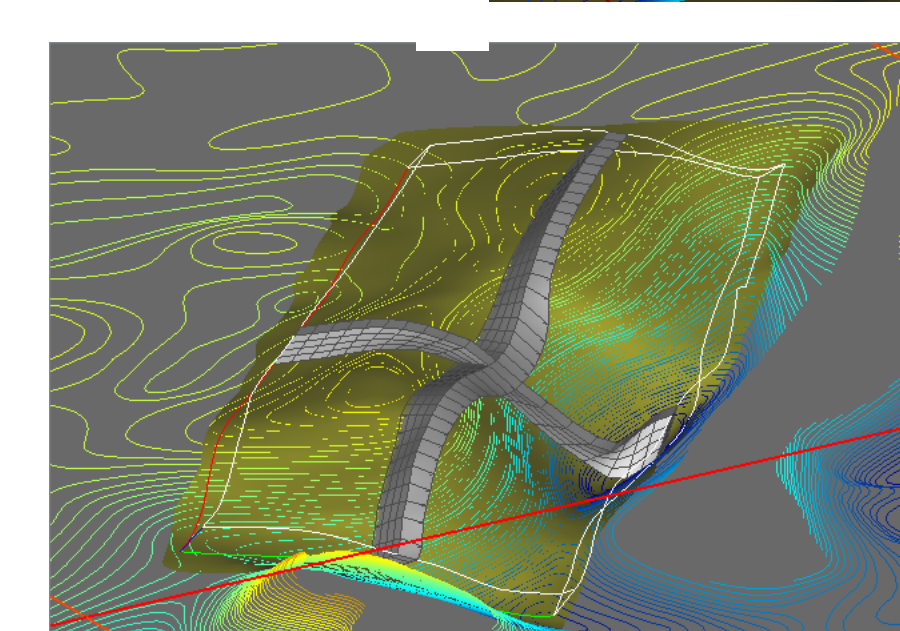
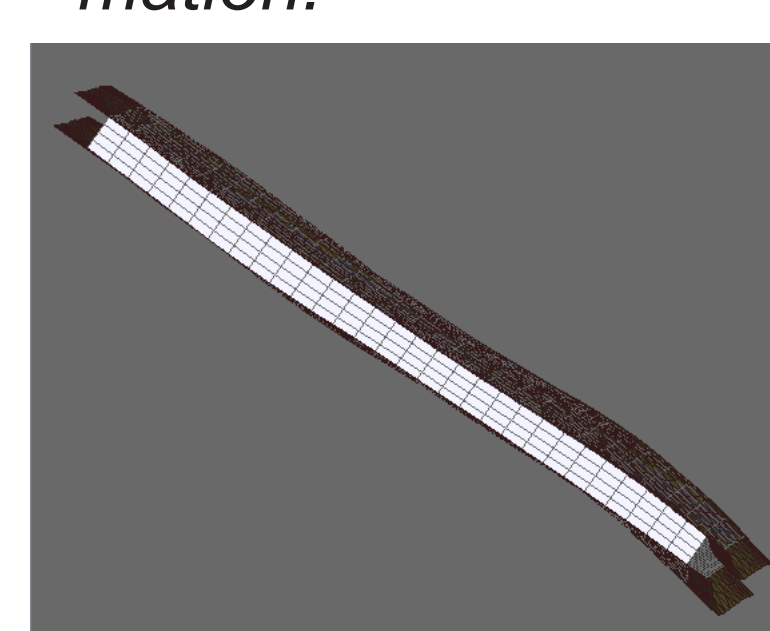
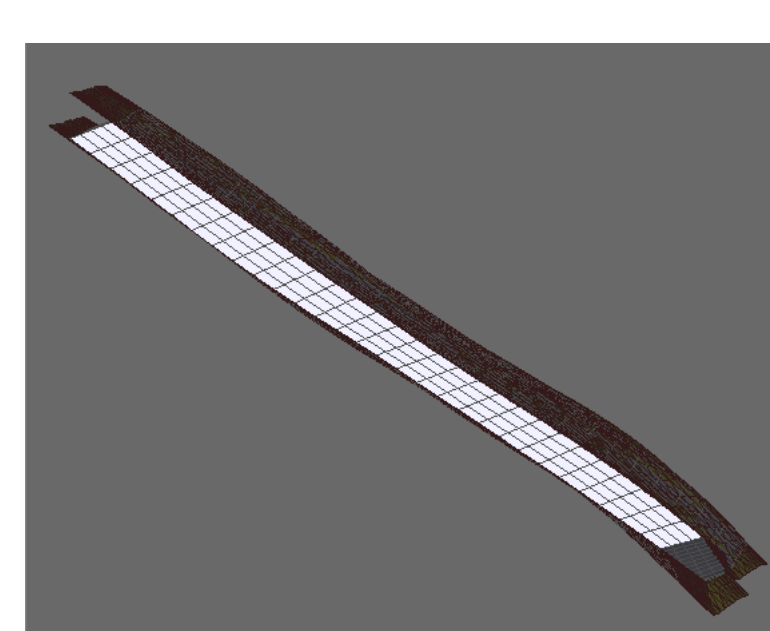
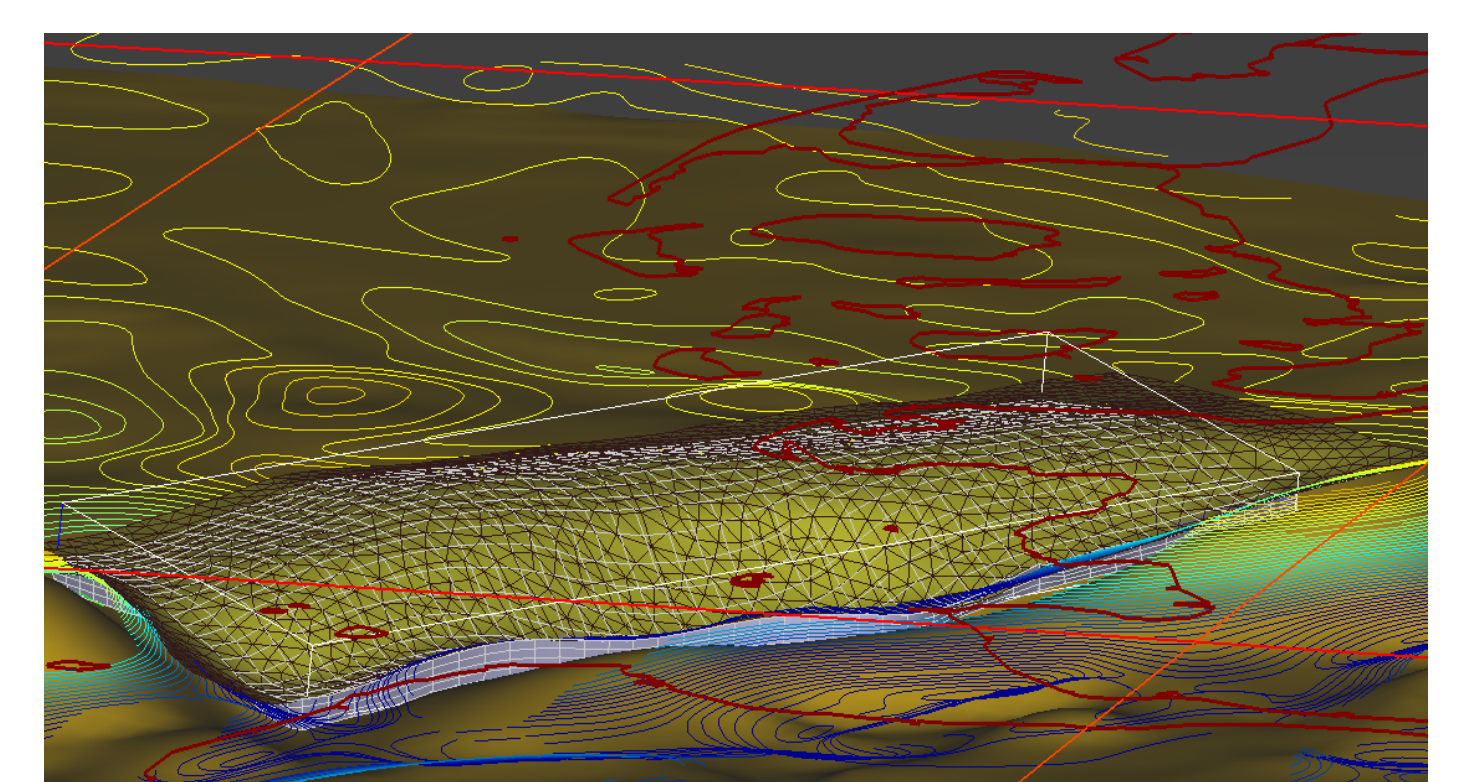
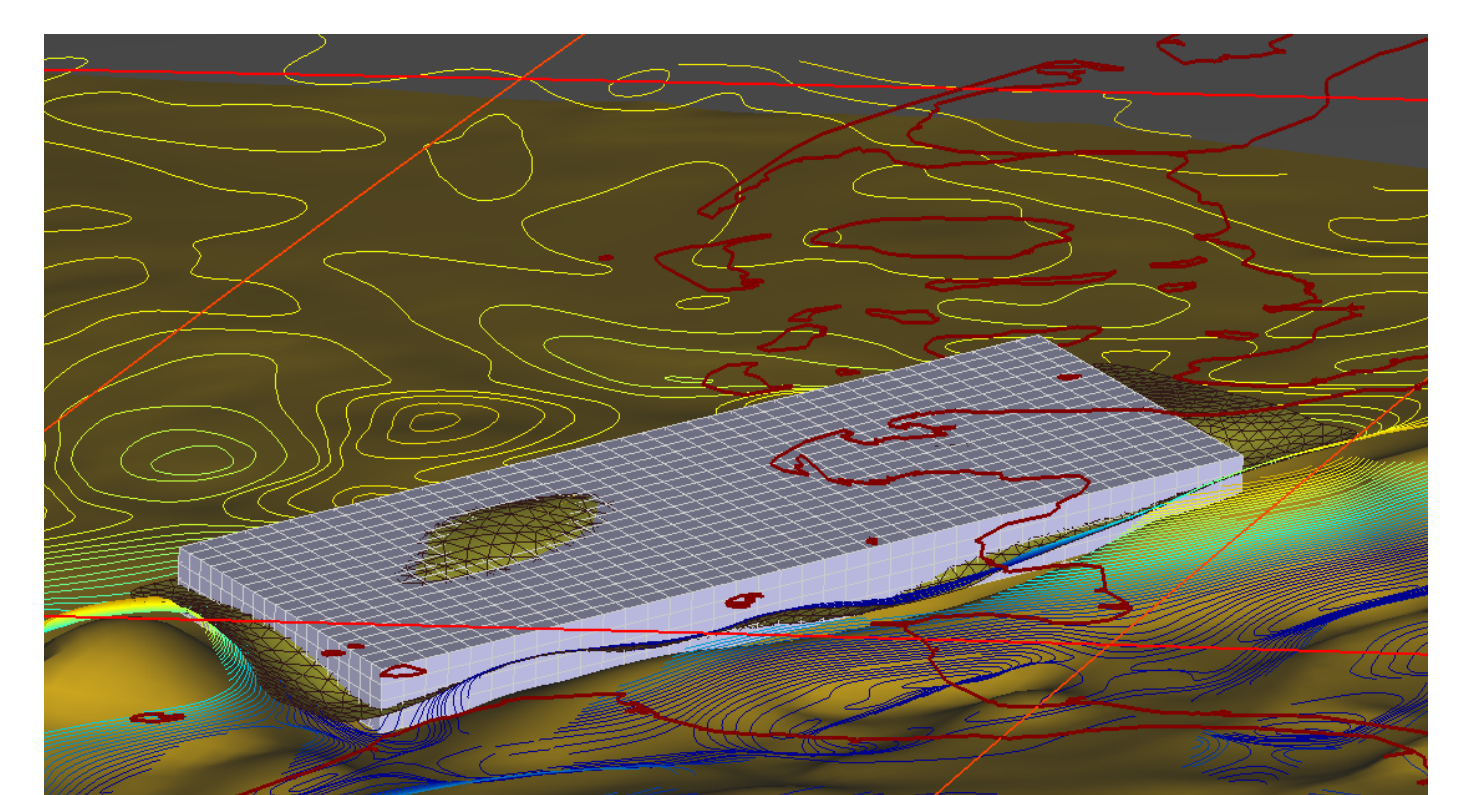
All the functionality is based on five basic functions (see class diagram below) that we have implemented, for our test, with the assumption that the earth is a sphere. Incorporating a better assumption, such as an ellipsoid or even a geoid, can be easily done.



Class diagram for our extension of Gocad.

Right: Process to create an SGrid and then fitting it between two surfaces.

Below: different screenshots showing the problematic that appears when creating an SGrid and delineating it to the surfaces below and above. The creation does work without any problems. When fitting it between two surfaces, the SGrid seems to lean towards the (geographic) South. Temporarily rotating the delineating surfaces, so that they are lying nearly horizontal, and fitting the SGrid inbetween them there, solves the problem. Each time left: created in place, right: created after transformation.



References

- GeoMol (2015): Assessing subsurface potentials of the Alpine Foreland Basins for sustainable planning and use of natural resources. www.geomol.eu, last visited February 2015.
- Müller, C., von Goerne, G., Zehner, B., Steuer, S., Jähne-Klingberg, F., Knopf, S., Kuhlmann, G. and Project Group (2015): A 3D Model of the North German Basin – Challenges and Approaches. Proceedings of the 8th Euregeo Conference in Barcelona, June 15th -17th, Barcelona, Spain, Online.