From cross-border harmonization of 3D geomodels to geo-energy resource assessments

3DGEO-EU

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GARAH

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166

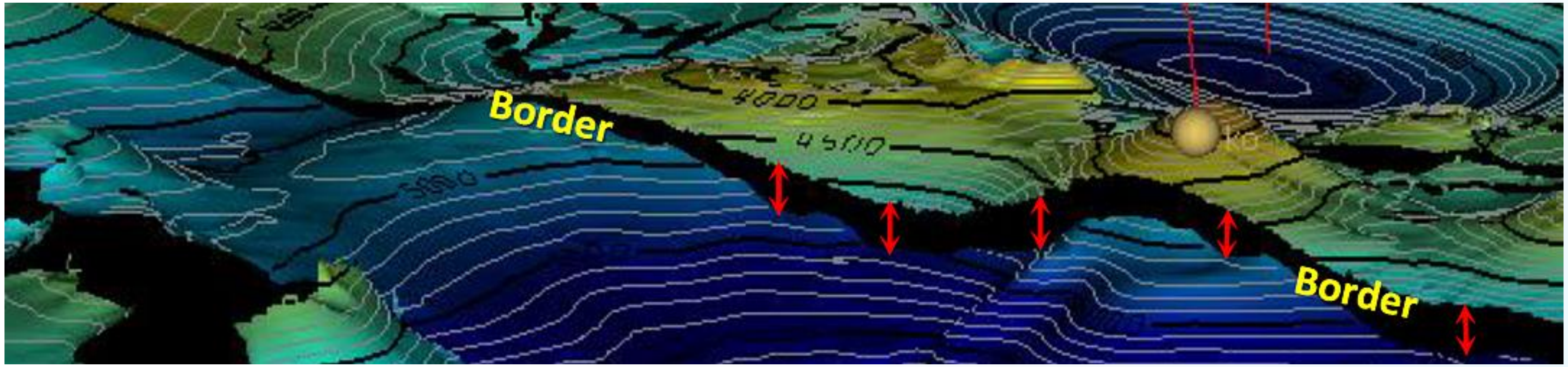
Cross-border harmonization of 3D geomodels

3DGEO-EU: "3D geomodeling for Europe"

<u>Context/problem (main focus of project):</u>

3D subsurface information is often inconsistent across borders, i.e. exhibit “border discontinuities”

→ hampers reliable cross-border assessments of subsurface geo-resources



In 3DGEO-EU, the partners have tested and optimized <u>methods and workflows</u> for the harmonization of cross-border 3D geomodels

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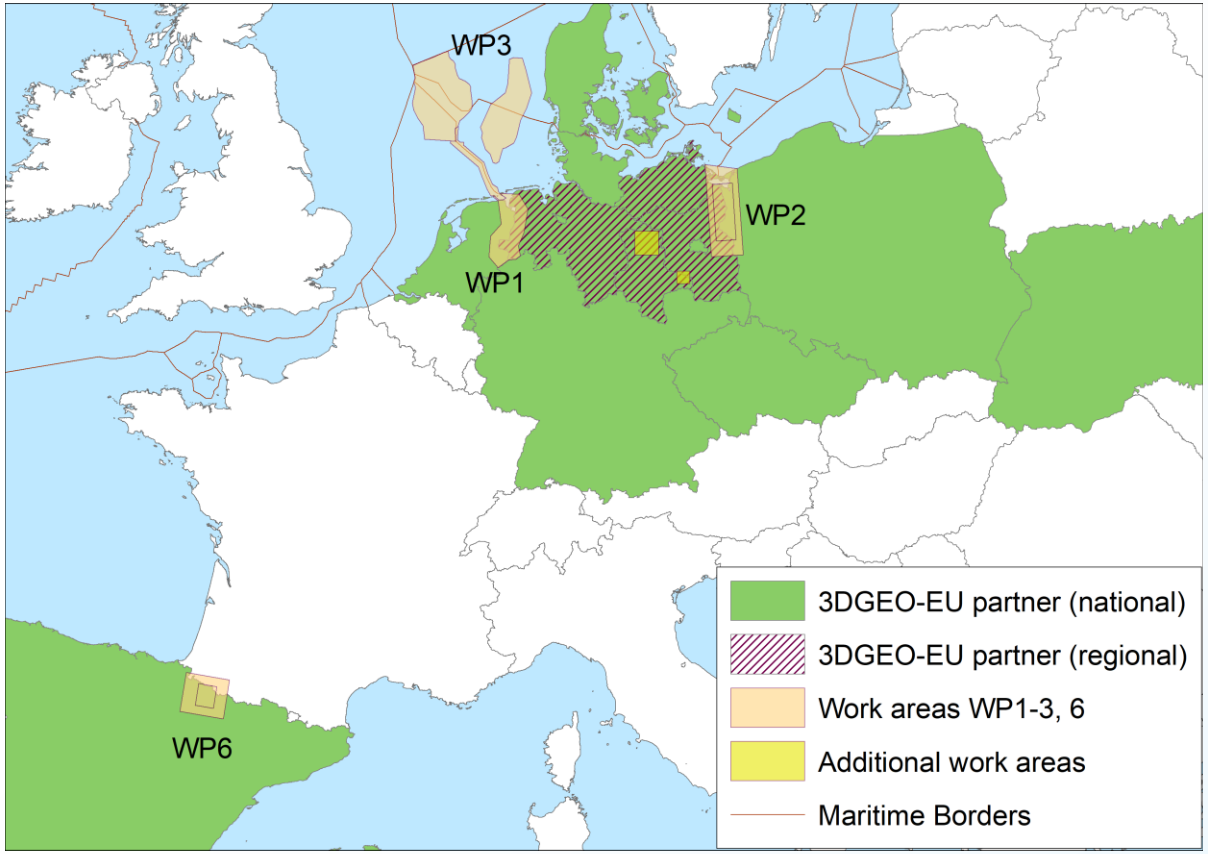
Cross-border harmonization of 3D geomodels

Work areas

Pilot areas for cross-border harmonization
(WP1-3)

In addition to cross-border harmonization, the partners investigated selected geomodeling topics, e.g. visualization of uncertainties, and potential field geophysical methods for 3D geomodeling approaches.

→ **Case study Pyrenees** (WP6)



<u>11 partners from 7 countries:</u>

BGR (Germany)
CGS (Czech Republic)
GEOINFORM (Ukraine)
GEUS (Denmark)
IGME (Spain)
LAGB (Germany)
LBEG (Germany)
LBGR (Germany)
LUNG (Germany)
PIG-PIB (Poland)
TNO (The Netherlands)

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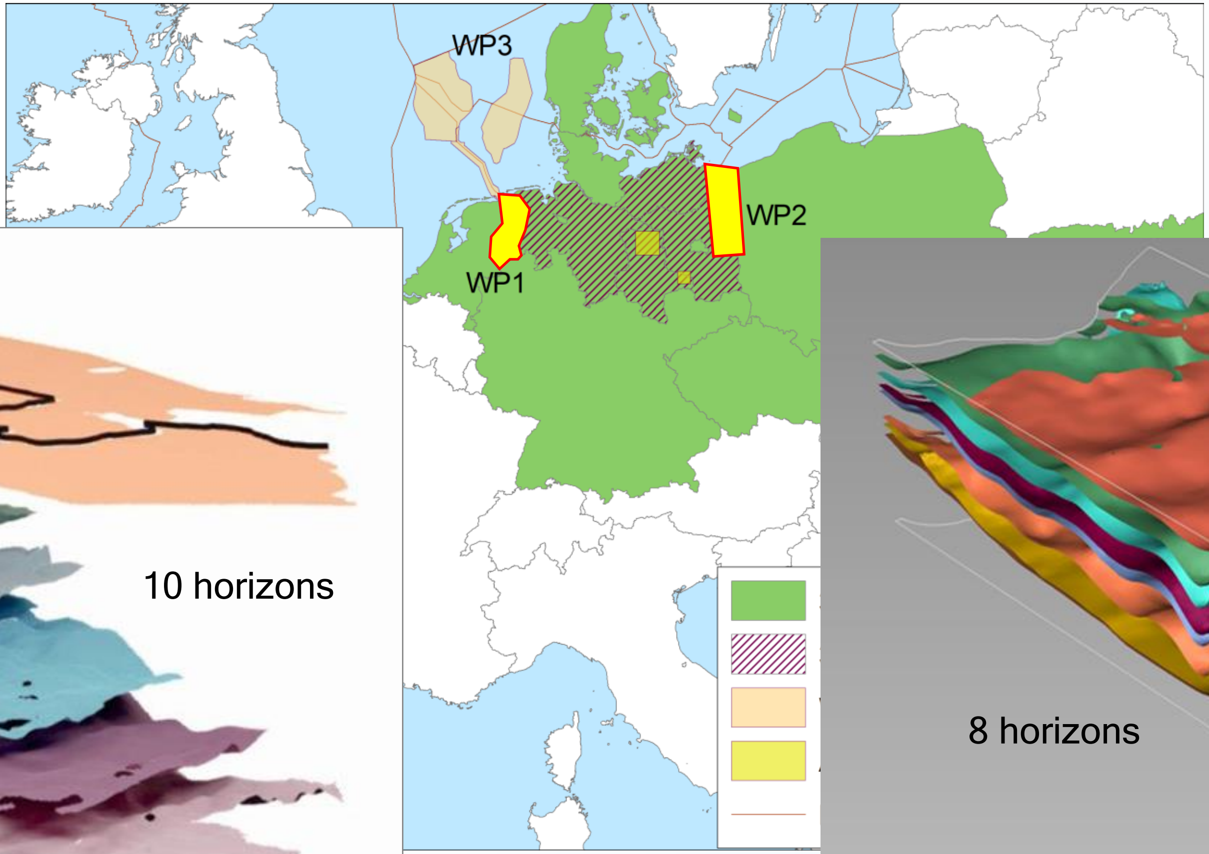
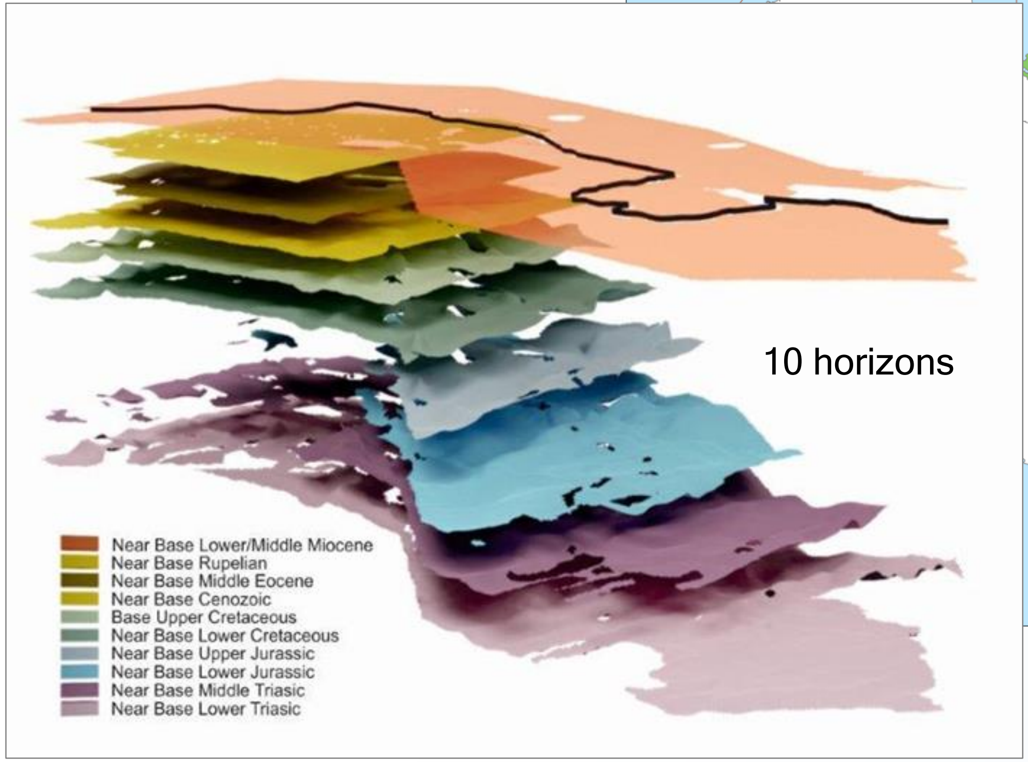
Cross-border harmonization of 3D geomodels

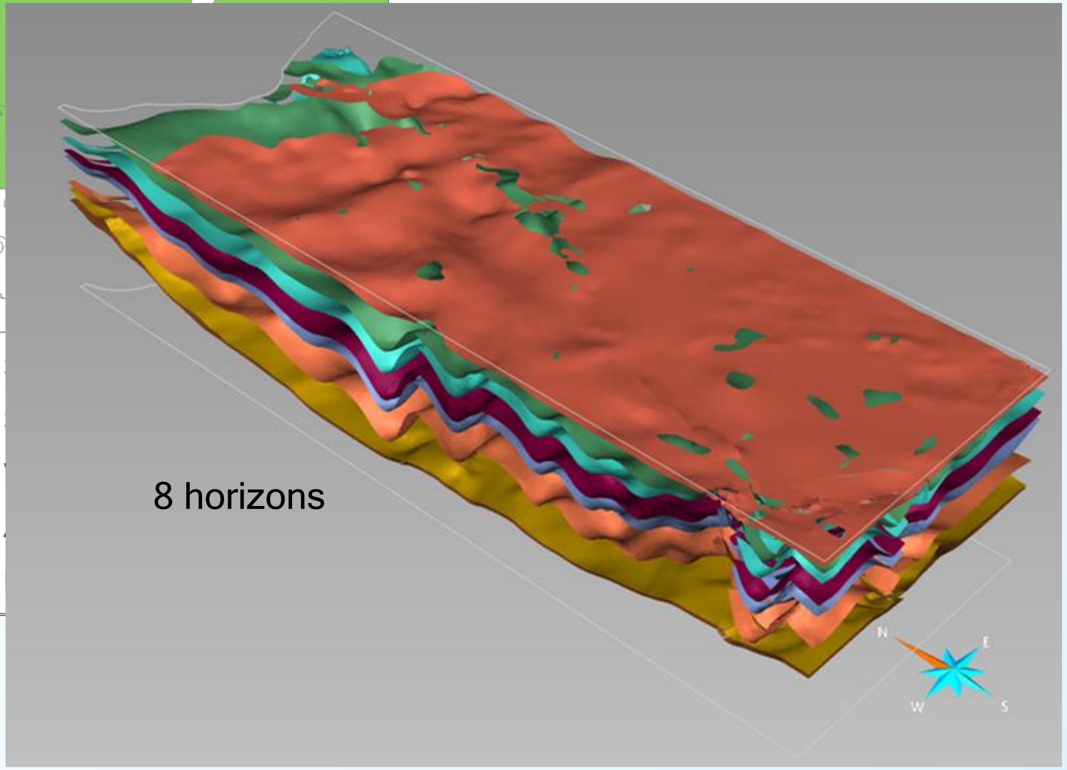
Created cross-border 3D geomodels

Consistent 3D model “NLS3D” of the cross-border region Between the Netherlands and Lower Saxony (Germany)





Harmonized 3D geomodel of the cross-border region between Poland and Brandenburg and Mecklenburg-Western Pomerania (Germany)



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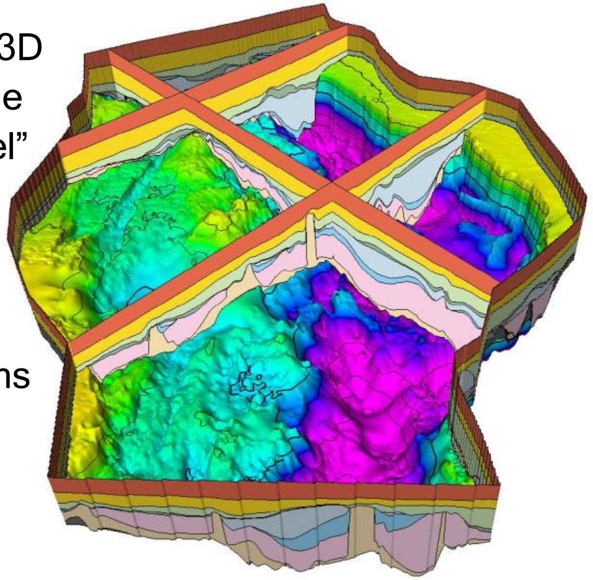
Cross-border harmonization of 3D geomodels

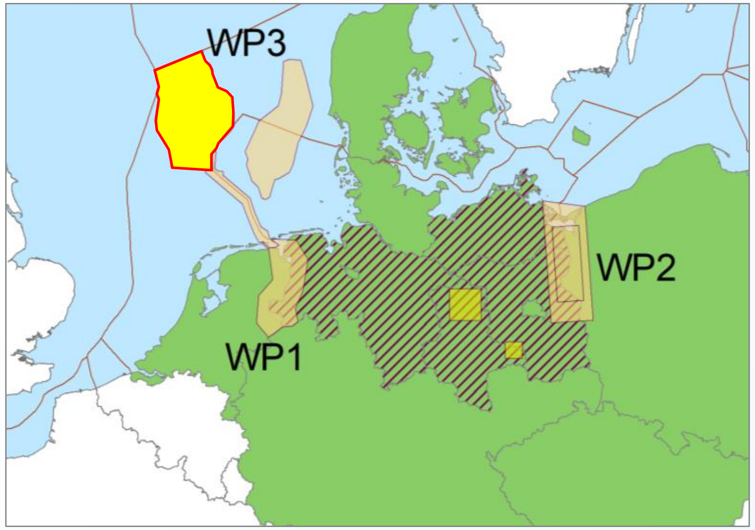
Created cross-border 3D geomodels

Results (North Sea area)
State of the Art Report
Generalized 3D depth model of the Entenschnabel region
Harmonized stratigraphic chart for the North Sea area NL-DE-DK
Lithostratigraphic/ chronostratigraphic correlation profiles through the study area
Harmonized seismic stratigraphic concepts - A base for consistent structural interpretations
Harmonized time model of the Entenschnabel region
A harmonized cross-border velocity model
Harmonized depth models and structural framework of the NL-GER-DK North Sea
Final report incl. Lessons learned

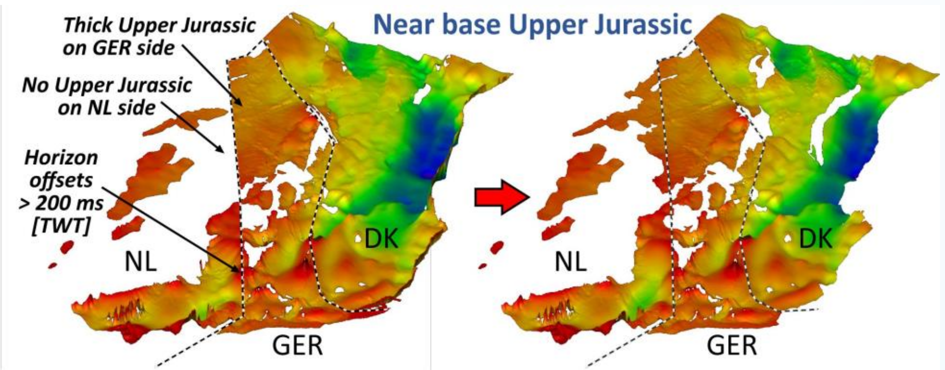
A harmonized 3D geomodel of the "Entenschnabel" region

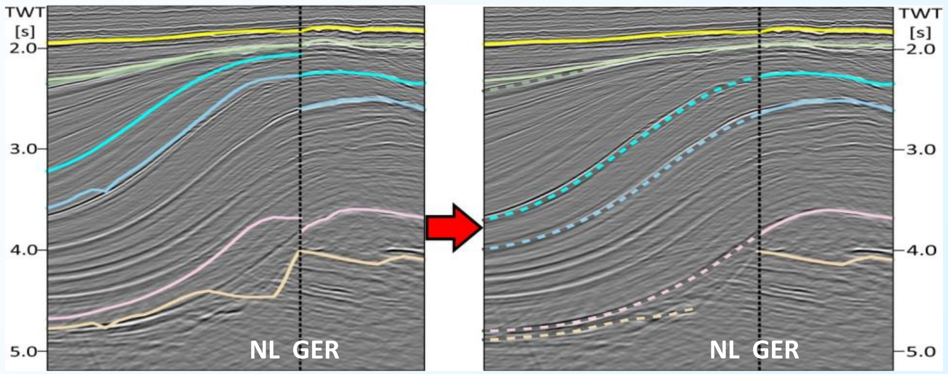


8 horizons



Dutch-German-Danish North Sea sectors





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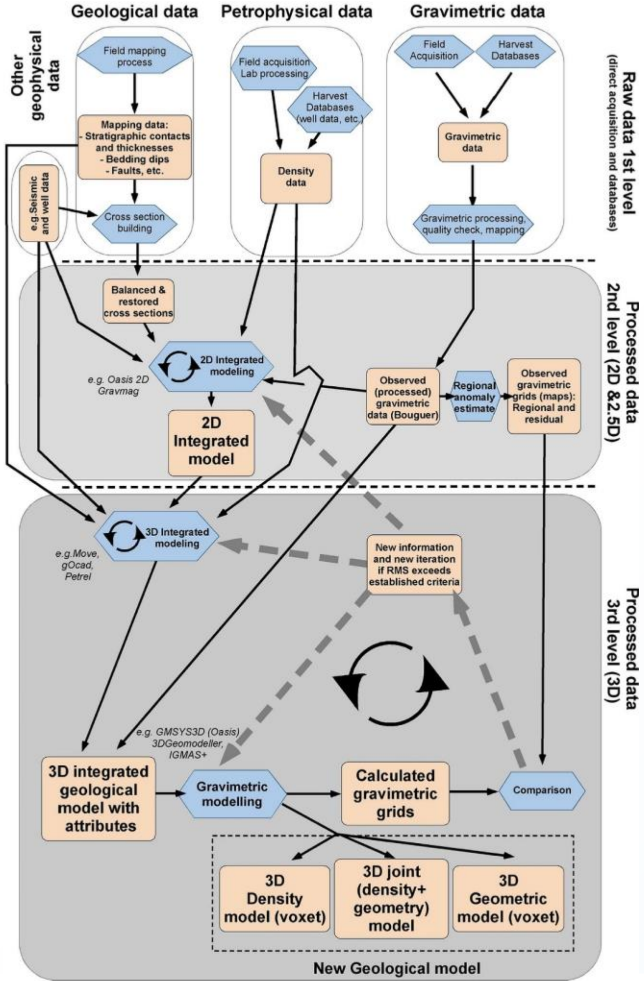
Cross-border harmonization of 3D geomodels

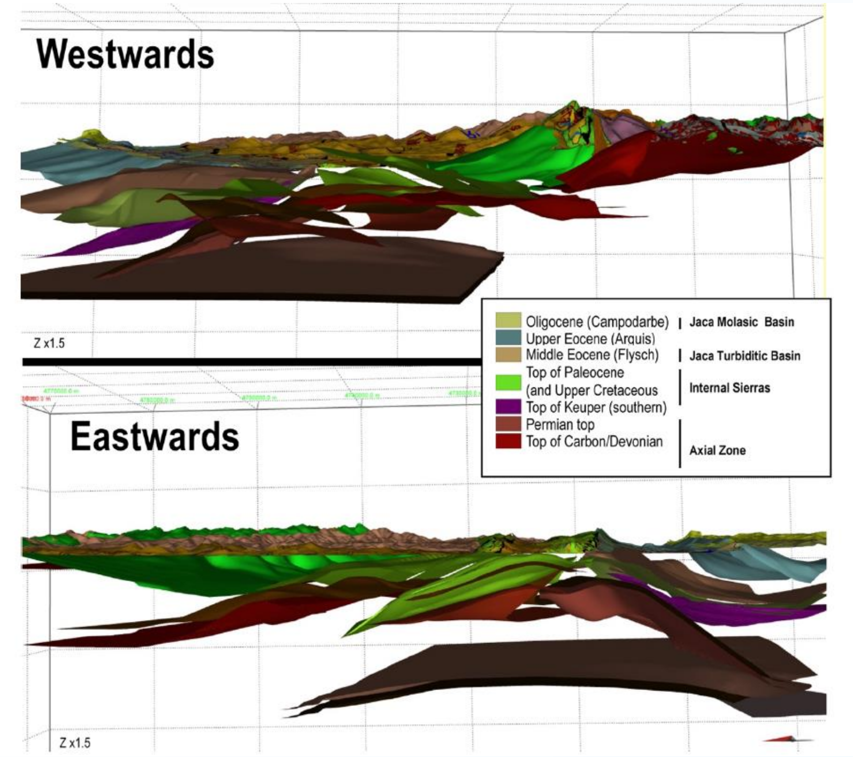
What about areas with scarce subsurface information (wells, seismics)?

Option: Use potential field geophysics (<u>particularly gravimetrics</u>) and classic structural geology techniques (like balanced cross sections) as <u>quick, cost-effective and efficient methods for 3D geomodeling</u>

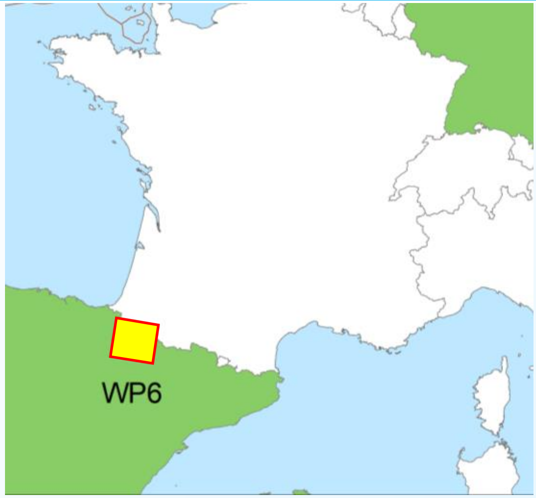
Developed and tested <u>workflow</u>



Created 3D geomodel (Western Pyrenees)



3D view of stratigraphic horizons



Gravimetric data acquisition in the field (Pyrenees)

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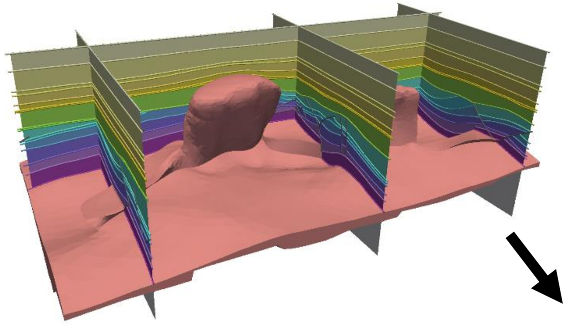
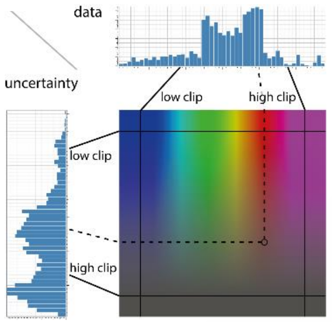
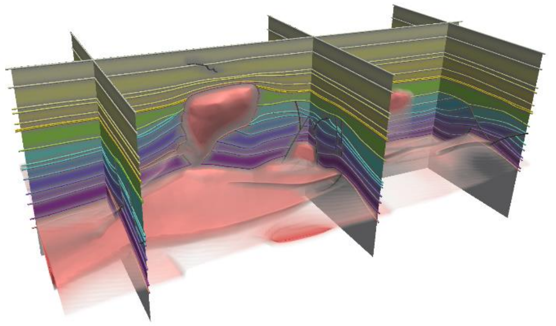
Cross-border harmonization of 3D geomodels

What about uncertainties of geomodels?





Literature research to cover the state of the art in uncertainty visualization



Compilation and discussion of sources of uncertainty in 3D geomodels

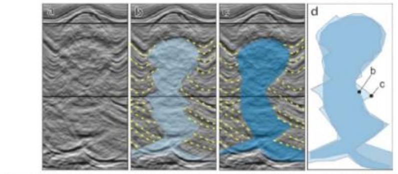


Figure 11: Seismic representation of a salt structure and possible interpretations of the salt structure (blue) and the surrounding sediments (yellow dashed lines) (b, c). d shows a comparison of the outer shapes of the structures in b and c. See Figure 10 for an overview of the seismic section.

Example 2: Crestal structures of diapirs

In Figure 12 the extract of the seismic section from Figure 10 shows the top part of a salt wall. In general, the crestal structure of a diapir is often very heavily deformed by forces accompanying the growth of the structure or act during salt withdrawal, as well as influenced by effects of subrosion. The segmentation into several small and often deeply dipping faulted blocks (e.g. Yin et al., 2009) decreases seismic imaging and complicates the differentiation in main salt body, cap rock and adjacent sediments. Presumably, the interpreters oversimplify the salt cap structures, especially if the cap rock material is thin or shows similar seismic characteristics like sediments of the flank. Well explored structures onshore give an impression of the partly given complexity in the top of salt structures (e.g. Best & Zirngast, 2002). Figure 12-b and Figure 12-c show two possible interpretations of the salt structure example (in time domain). Due to the only moderate image quality of the 2D seismic line, some properties of the salt structure cannot be interpreted with sufficient certainty. Question marks about the interpretation persist with regard to

Figure 12: Seismic image of a salt wall top in the German North Sea, illustrating the difficulties in differentiating between salt body, cap rock and adjacent sediments. See Figure 10 for a full view of the seismic section.

- the structure of the sediment-salt contact (antithetic faults or rollover on the main fault; imaged in an overview scale in Figure 10) (black dot)
- the extent/thickness of the possible caprock (red dot)
- the age of the sediments covering the salt structure (green dot).

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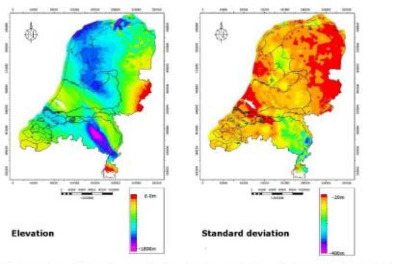

Elevation
Standard deviation

Figure 21: Exemplary side-by-side view for the elevation and its standard deviation (base of the North Sea Supergroup) within the Dutch DGMDeep model.

Executed 500 times

Figure 22: Overview of the workflow for uncertainty assessment of the regional geological model (DGMdeep) in the Netherlands, pictured as an event-driven process chain.

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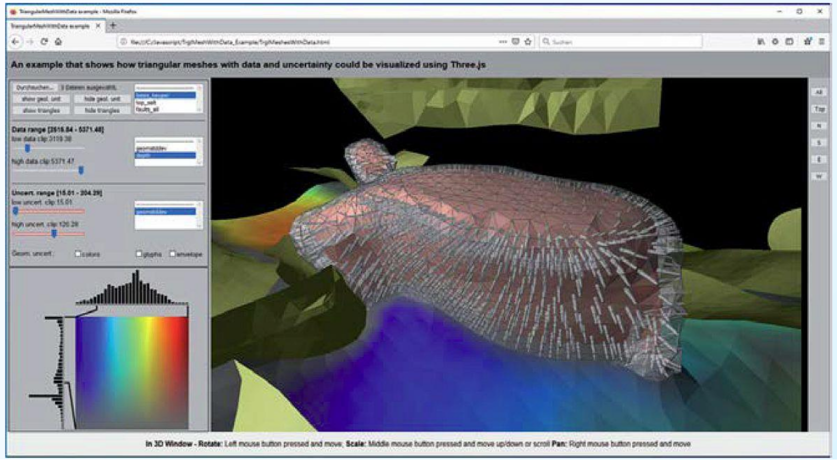
Example Data in EGDI Database (can be pulled from there and visualized with a developed software prototype)



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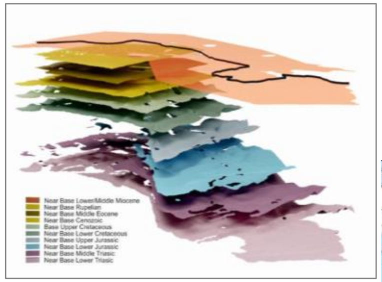
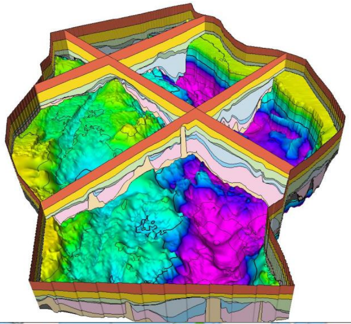
(EGDI: European Geological Data Infrastructure)

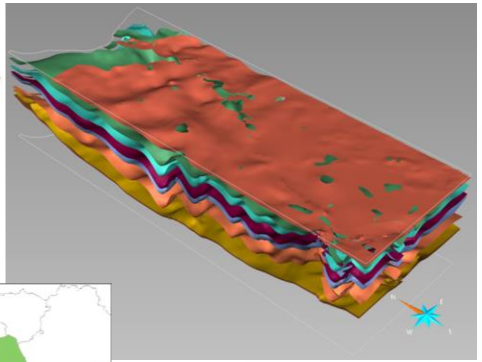
Cross-border harmonization of 3D geomodels

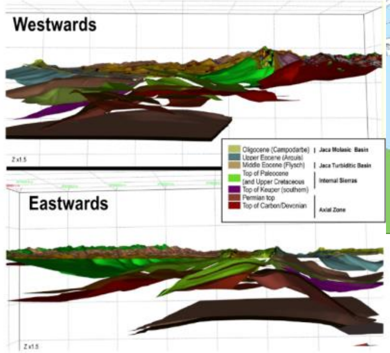
Project results are available on the GeoERA - 3DGEO-EU webpage: https://geoera.eu/projects/3dgeo-eu/

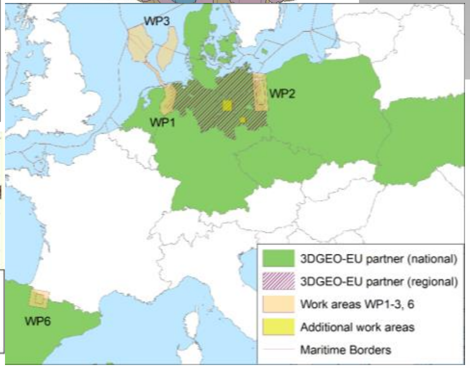
3D geomodels

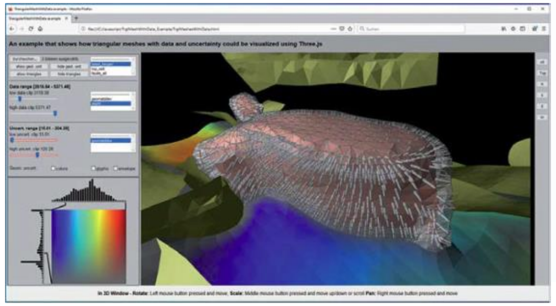




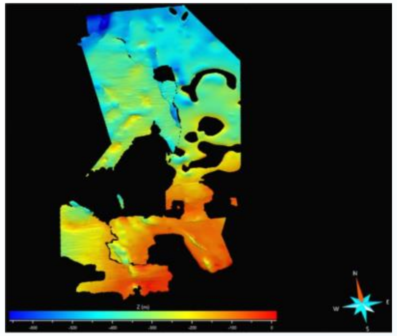




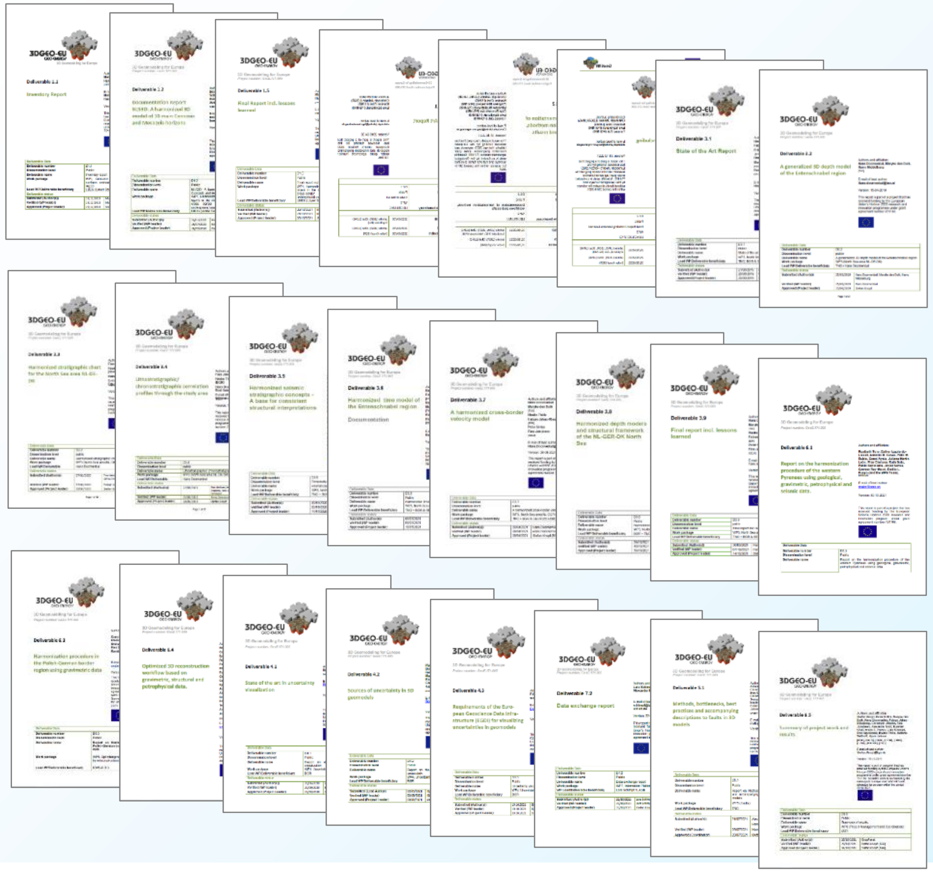




2D maps



Work and results are documented in more than 20 technical/scientific reports



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Cross-border harmonization of 3D geomodels

- The results and lessons learned from 3DGEO-EU provide advice on how (cross-border) geomodel harmonization could be done.
- The generated 3D geomodels in different European pilot areas can be used for e.g. assessments of subsurface resources or as examples and keystones for further transnational developments.
- The topic of cross-border harmonization should be further promoted in order to ultimately achieve the goal of a harmonized geological database across Europe.

How a 3D geomodel can be used for geo-energy resource assessments will be shown – among other things – in the following GARAH presentation.

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