Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe

Technical review report for project 3DGEO-EU

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

INTRODUCTION

Technical review report is part of GeoERA's Monitoring and evaluation process for co-funded projects (*hereinafter: project*). The aim of a technical review is to assess the work carried out under the project over a certain period and provide recommendations. Such technical review evaluates the project reports and deliverables, the proper use of resources, the management of the project and the expected impact.

Technical review report consists of four sections, each representing one level of monitoring and/or evaluation of the project:

Level	Monitor / Reviewer	Input	Aim
1 – Monitoring of progress indicators	Monitoring and reporting officer (GeoZS)	MPPR* FPPR**	Monitoring of the effectiveness of implementation of selected projects with respect to finance, time and administration.
2 – Scientific review	Reviewers (GeoZS)	Submitted deliverables MPPR FPPR	Quality review of the deliverables and review of achieving scientific and professional goals.
3 – Review of the theme progress	Theme coordinators	MPPR FPPR	Review of achieving theme objectives.
4 – GeoERA Progress evaluation	Stakeholder Council member(s)	Sections 1 and 2 of this report Review meetings	Overall project progress and general recommendations.

*MPPR = Midterm Project Progress Report (see PI doc no 2)
**FPPR = Final Project Progress Report (see PI doc no 2)

Monitoring and evaluation process:

M0 = End of reporting period
M1 = Submitted (Final) Project progress Report (MPPR / FPPR)
M2 = 1 – Monitoring & 2 – Evaluation
M3 = 3 – Evaluation of the theme progress
M3 = (Final) Review Meeting & 4 – Progress evaluation

Each project will be reviewed twice: for first project period M1-M18 – Technical review report, and second project period M19-M36 – Final review report.
Technical review report is based on Horizon 2020 templates but adopted to GeoERA needs. Technical reviews of projects shall be carried out on a confidential basis.

GENERAL INFORMATION

ERA-NET Cofund Grant Agreement:	731166
ERA-NET Cofund acronym:	GeoERA
Call identifier:	H2020-LCE-2016-2017/H2020-LCE-2016-ERA
Project full title:	3D geomodeling for Europe
Project acronym:	3DGEO-EU
Project reference number:	GeoE.171.005
Project topic:	GeoEnergy
Project specific topic:	GE5-Advancements in developing and using 3D transnational geomodels
Lead partner:	BGR Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
Project website:	http://geoera.eu/projects/3dgeo-eu/

☐ Technical review report
☒ Final review report

Period covered	01/01/2020 – 31/10/2021
Review meeting date	29.11.2021

Contributor:	Role:	Approved on:
Barbara Simić	Monitoring and reporting officer	1.12.2021
Aleksandra Trenchovska	Monitoring and reporting officer	1.12.2021
Ana Novak	Scientific Reviewer	3.12.2021
Jasna Šinigoj	Scientific Reviewer	29.11.2021
Matija Krivic	Scientific Reviewer	29.11.2021
Serge van Gessel	Theme coordinator	24.12.2021
Elizabeth S. Cochran	GeoERA Stakeholder	22.12.2021
Harikrishnan Tulsidas	GeoERA Stakeholder	28.01.2022

1 LEVEL 1 – MONITORING OF PROGRESS INDICATORS

In this section the project is monitored "remotely" on the basis of the respective reports. This part is filled in by Monitoring and reporting officer with aim to monitor the effectiveness of implementation of the selected projects with respect to finance, time and administration, based on submited MPPR and FPPR.

	Yes	Partially (comment needed)	No
PROJECT MANAGEMENT			
Has the MPPR / FPPR report been submitted on time?	☒	See comment no. 1	☐
Have there been any changes in project partnership?	☒	See comment no. 2	☐
Has the project management been performed as required?	☒		☐
Has the collaboration between partners been effective?	☒		☐
Do you identify evidence of underperforming partners, lack of commitment or change of interest of any partners?	☐ (see comment)		☒
DELIVERABLES and MILESTONES			
Have the planned deliverables for the period been submitted on time according to timeline in Project Agreement?	☐	See comment no. 3	☒
Have the planned deliverables for the period been completed (from MPPR / FPPR, sheet 4)	☒		☐
Have any changes to deliverables occurred (type/ dissemination level)? (from MPPR / FPPR, sheet 4 and 5)	☒		☐
Have planned milestones been achieved for the reporting period? (from MPPR / FPPR, sheet 4)	☒		☐
Have the project partnership identify any difficulties achieving any of the deliverables / milestones?	☒		☐
DEVIATIONS (from MPPR / FPPR, sheet 5)			
Has the project partnership identify any deviations that will not affect projects outputs?	☒		☐
Have any deviations occur on the project, with impact on project outputs?	☐		☒
In case of deviations, have the project adopted corrective measures?	☒		☐

DISSEMINATION, COMMUNICATION			
Has the project adopted its dissemination plan?	☐		☒
Have the planned dissemination activities been completed for the reporting period? (from MPPR / FPPR, sheet 6)	☒		☐
Have the partners' disseminated project results and information adequately?	☒		☐
Is the project following dissemination plan?	☒		☐
Is the project interacting in a satisfactory manner with other GeoERA projects?	☒		☐
Is the project interacting in a satisfactory manner with national/international bodies?	☐	NA	☐

FINANCE			
To the best of your estimate, have the resources used been utilised for achieving the project? (according to MPPR / FPPR, sheet 9)	☒		☐
To the best of your estimate, have the resources used been in a manner consisted with the principle of economy, efficiency and effectiveness?*	☒		☐
Are there any major deviations in the budget consumptions from the financial plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒	See comment no. 4	☐
Are there any major deviations in the Person - Months consumptions from the plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒		☐
Are any budget modifications for the project needed? (from MPPR / FPPR, sheet 5)	☐		☒

***The principles of economy, efficiency and effectiveness**: refers to the standard of "good housekeeping" in spending public money effectively. Economy can be understood as minimising the costs of resources used for an activity (input), having regard to the appropriate quality and can be linked to efficiency, which is the relationship between the outputs and the resources used to produce them. Effectiveness is concerned with measuring the extent to which the objectives have been achieved and the relationship between the intended impact and the actual impact of an activity. Cost effectiveness means the relationship between project costs and outcomes, expressed as costs per unit of outcome achieved.

Comments (highlighting the project progress) / deviations / recommendations:

The 3DGEO-EU project was mainly concerned with methods for harmonizing geological data and 3D geomodels across international borders. The aim was to harmonize methods and workflows for cross-border harmonization. The main challenge that the project addressed is inconsistent geospatial data and 3D subsurface information across borders. The project consortia identified the reasons for the inconsistency and aimed to overcome the differences and develop the best methods and (optimized) workflows for cross-border harmonization and 3D geomodelling that can be applied in other regions and geological settings in Europe. The project established international transboundary pilot areas that served as showcases for the development and testing of methods for transboundary harmonization of 3D geological models. Accompanying the work in the pilot areas and supporting the cross-border harmonization, they have investigated selected geomodelling topics such as the visualization of uncertainties of 3D geological models, the modeling of geological faults or the optimization of 3D subsurface reconstructions. The project has achieved its main objective and made an important step towards the harmonization of data and methods for 3D modeling. Although there is still some work waiting for the 3DGEO-EU consortia with additional partners from more countries who will perfect the model in the future, this project is an important first step towards a common 3D mapping.

The Covid 19 epidemic had an impact on the progress of the 3DGEO-EU project. In December 2020, the project was extended by 4 months, from 30.6.2021 to 31.10.2021. The postponed project activities were appropriately communicated to the GeoERA Executive board, which has reviewed and approved the changes in terms of achieving the project outcomes. A detailed list of changes is part of the project documentation in the Project plan History of changes.

The project management structure was well defined and efficient. The pandemic situation required a high degree of flexibility on the part of the partnership and adaptability of its involvement in project activities, especially when lockdowns were introduced, and field work was prohibited. To ensure the achievement of the set objectives, partners increased their efforts, resulting in higher person-months and budget expenditures. Overall, the project consortia spent 15% more budget than planned. The project did not identify any underperforming partners that could affect the quality of the project outputs. Only one partner, GEOINFORM, ceased its activities in the second reporting period without any impact on the project work.

The dissemination and communication activities of the project are adequate. Activities were mainly focused on publications, e.g., posters, published abstracts and scientific publications, although the consortia also made efforts on newsletters and social media, the targeting of which is somewhat difficult to determine. The

Monitoring team requested an update of the CDA table, which could improve the overall assessment of these activities.

Comment no. 1: The Final Project Progress Report was submitted on time in draft form. Partners still have the opportunity to recalculate their financials by the end of the calendar year to include the final data, so minor deviations can be expected. The changes will not affect the content of the project.

Comment no. 2: During the implementation of the project, one partnership change occurred: IGME-Sp Geological Survey of Spain has been integrated into CSIC Agencia Estatal Consejo Superior de Investigaciones Científicas.

Comment no. 3: Due to the pandemic situation, some activities were delayed, and deliverables had to be submitted later than planned. The revised dates were communicated to the Monitoring team and the GeoERA Secretariat by amending the project plan.

The deliverable changes in the project implementation period are:

Reporting period 1:
D3.1 postponed from M6 (31.12.2018) → M12 (30.6.2019)
D3.2 postponed from M6 (31.12.2018) → M10 (30.4.2019)
D3.4 postponed from M18 (31.12.2019) → M23 (31.5.2019)
D4.2 postponed from M18 (31.12.2019) → M38 (31.8.2021)
D4.3 postponed from M18 (31.12.2019) → M39 (30.9.2021)
D8.3 postponed from M18 (31.12.2019) → M19 (31.1.2020)

Reporting period 2:
D1.2 is renamed to NLS3D: A harmonized 3D model of 10 main Cenozoic and Mesozoic horizons with a supporting report
D3.5 postponed from M24 (30.6.2020) → M29 (30.11.2020) and renamed to Harmonized seismic stratigraphic concepts - A base for consistent structural interpretations
D3.6 postponed from M 24 (30.6.2020) → M35 (31.5.2021)
D3.7 postponed from M 24 (30.6.2021) → M34 (30.4.2021)
D1.3 postponed from M30 (31.12.2020) → M33 (31.3.2021) and renamed to Harmonized distribution, depth and thickness maps of Cenozoic layers
D1.4 is deleted, D1.5 became new D1.4
D3.8 postponed from M30 (31.12.2020) → M39 (30.9.2021)
D5.1 is deleted
D6.2 from M30 (31.12.2020) → M40 (31.10.2021)
D2.2 postponed from M33 (31.3.2021) → M39 (30.9.2021)
D2.3b postponed from M 33 (31.3.2021) → M39 (30.9.2021)
D6.2b is deleted

D1.5 is deleted
D2.4 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D3.9 postponed from M36 (30.6.2021) → M29 (30.9.2021)
D4.4 postponed from M36 (30.6.2021) → M39 (30.9.2021)
D6.1 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D6.3 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D6.4 is deleted, D6.5 became new D6.4
D6.4 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D7. postponed from M36 (30.6.2021) → M40 (31.10.2021)
D8.1 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D8.4 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D8.5 postponed from M36 (30.6.2021) → M40 (31.10.2021)
D1.5 postponed from M36 (30.6.2021) → M40 (31.10.2021)

Comment no. 4: Some project partners spent 20% more than their planned budget, others spent less than 80%. The partners that have exceeded their budget are BGR, IGME-Sp, LBEG and LBGR. Partners that spent less than their planned budget are: CGS and GEOINFORM. The consumption of man-months followed the EUR consumption.

The project has coped well with the negative external factors and has overcome its challenges in such a way that it has achieved its planned objectives and project results. For this reason, the project is rated "excellent" at level 1 and thus receives a rating of 4 - Objectives and targets fully achieved.

Overall assessment of the project:

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)
☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)
☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)
☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)
☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Summary of dissemination activities:

	SCIENTIFIC COMMUNITY	GENERAL PUBLIC	POLICY MAKERS	EUROPEAN INSTITUTION	NATIONAL INSTITUTION	REGIONAL INSTITUTION	INTERNATIONAL INSTITUTION	LOCAL INSTITUTION	PRIVATE COMPANIES	OTHER	Total Target Group reach
MEETINGS	374										374
ONLINE_MEDIA		1600									1600
PUBLICATIONS	4329	1241									5570
Total	**4703**	**2841**									**7544**

	ABSTRACTS	INTERNAL PROJECT MEETING	LINKEDIN	MEETING WITH OTHER GEOERA PROJECTS	NEWSLETTER	POSTER	SCIENTIFIC PUBLICATION	Total
MEETINGS		26		6				32
ONLINE_MEDIA			2					2
PUBLICATIONS	11				5	5	6	27
Total	**11**	**26**	**2**	**6**	**5**	**5**	**6**	**61**

Are the dissemination activities adequate?

☐ 5 - **Overachieved** (the projects dissemination activities have exceeded expectations)
☐ 4 - **Excellent** (the projects dissemination activities have fully achieved its expectations)
☒ 3 - **Good** (the projects dissemination activities are adequate)
☐ 2 - **Acceptable** (the projects dissemination activities are acceptable)
☐ 1 - **Unsatisfactory** (the project has failed to disseminate)

Cummulative financial statement:

	Person months	Total eligible costs	Reimbursement rate	GeoERA contribution	In-kind contribution
Plan	**552,53**	**3.649.301,84**	**29,7 %**	**1.083.842,65**	**2.565.459,19**
1st period consumption	216,58	1.834.468,78	29,7 %	544.837,23	1.289.631,55
2nd period consumption	335,94	2.375.706,98	29,7 %	705.584,97	1.670.122,01
TOTAL	**552,52**	**4.210.175,76**	**29,7 %**	**1.250.422,20**	**2.959.753,56**

2 LEVEL 2 – SCIENTIFIC REVIEW

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by reviewer with aim to review the quality of the deliverables and review of achieving scientific and professional goals. Scientific review is based on submitted deliverables and reported Impact statement in MPPR/FPPR.

Impact statement (from MPPR / FPPR, sheet 8):

Will was presented at the Review meeting. The project has identified its scientific, economic and social impact, achieved through its activities.

Expected impact (from Project Agreement):

The cooperation of GSOs in this project to perform geomodeling work in well selected cross-border pilot areas and supported by work on method development issues will help to establish methods and workflows for cross-border harmonization of 3D geomodels, applicable to other border regions in Europe. The expected impacts can be specified as follows: • Establishment of consistent data and model base in cross-border regions improves the state of knowledge and thus will lift up subsurface resource assessments studies in cross-border regions to a new level. • Establishment of a set of cross-border consistent geomodels in the pilot areas that can be the nucleus for further transnational harmonization projects and the establishment of a pan-European harmonized geological knowledge base. • Harmonization of stratigraphic as well as structural modeling workflows in border areas allow for a better comparability of results of cross-border assessments in the future. • Development of methodologies for semantic and geometric harmonization of data and geomodels across borders. • Improved visualization methods for uncertainties and optimized reconstruction and restoration workflows to reduce uncertainty of geomodels will help to enhance the reliability of 3D geomodels for future cross-border resource assessments at the European scale. • Advanced mapping and 3D geomodeling strategies that allow for regional to pan-European cross-border consistency and integration, thus helping to adequately inform European stakeholders and decision makers on subsurface resources. • Development of common and accepted standards and disseminate best practices for crossborder harmonization, applicable to other European countries. • Existing links to other GeoERA projects like GE1-GARAH, GE4-HIKE, GE6-GeoConnect3D will demonstrate the application of the models.

Evaluation of deliverables

No.	Title	Status (Approve/ Reject)	Comments
D1.2	NLS3D: A harmonized 3D model of 10 main Cenozoic and Mesozoic horizons with a supporting report	Approve	See comment below
One of the "Learned lessons" states that harmonized raw data (and communication) is needed to create valid and robust cross-border models. This may perhaps be the strongest message of the project which is often repeated in the individual deliverables.			
D1.3	Harmonized distribution, depth and thickness maps of Cenozoic layers	Approve	See comment below
The names of the deliverable folders are a bit confusing as they differ only by the "_" symbol. Perhaps the names of the folders should clearly indicate whether they contain distribution + depth or distribution + thickness grids. Answer to comments: Deliverables were named by the name written in the last project amendment. We made little technical correction on SharePoint, thus in the folder now are files which indicate depth and thickness characteristics.			
D1.4	Harmonized map of hydraulic barrier between fresh groundwater and the deep salt groundwater system as a decision support tool for planners	Approve	See comment below
The base Rupelian grid in both deliverable folders differ only by a few cells, the metadata and the extent are the same. What is the difference between the two folders? Answer to comment: The base Rupelian grid was delivered in two formats: Once as an ASCII grid (according to the Data Delivery Plan by GIP-P) in one zip-folder, and in addition as a service for the users also as a Zmap grid (*.dat file) in another zip-folder. So it is the same grid, but in two different formats! We made little technical correction on SharePoint, thus in the folder now are files which indicate two different formats.			
D1.5	Final report incl. lessons learned	Approve	/
D2.2	Documentation methods, workflows and results	Approve	/
D2.3b	Harmonized 3D geomodel pilot area 2)	Approve	/
D2.4	Final report incl. lessons learned	Approve	See comment below
All points listed in the "Lessons learned" section are very relevant also for future cross-border harmonization projects.			

D3.4	Lithostratigraphic/ chronostratigraphic correlation profiles through the study area	Approve	See comment below
Perhaps “structural” or “geotectonic units” would be a more appropriate term. “Structural elements” is more commonly used to describe faults and not areas/units.			
D3.5	Harmonized seismic stratigraphic concepts - A base for consistent structural interpretations	Approve	/
D3.6	Summary of the harmonization work on time model for seismic interpreted main horizons incl. main fault planes	Approve	/
D3.7	Harmonized cross-border velocity model	Approve	/
D3.8	Harmonized structural 3D models	Approve	See comment below
Fig. 26: “Wide” should be “width”			
D3.9	Final report incl. lessons learned	Approve	See comment below
All points listed in the “Lessons learned” and “Recommendations” sections are very relevant and should be considered in future cross-border harmonization projects.			
D4.2	Sources of uncertainties in geomodels	Approve	/
D4.3	Documentation of requirements for the visualization of uncertainties in geomodels which can be used as input for EGDI	Approve	/
D4.4	Example data sets/geomodels containing uncertainty information	Approve	/
D5.1	Methods, bottlenecks, best practices and accompanying descriptions to faults in 3D models	Approve	See comment below
Deliverable marked as D5.1 in the Sharepoint folder			
D6.1	Report on a 3D model of the South western Pyrenees	Approve	See comment below
Compliments on the great work done by the WP team.			
D6.2	3D model of the South western Pyrenees; digital files		/
D6.3	Report on harmonization procedure with gravmag in East GER/ West Poland border	Approve	/

D6.4	Optimized 3D reconstructions workflows	Approve	/
D7.2	Data exchange report	Approve	/
D8.1	Minutes of meetings (M40)	Approve	/
D8.4	Final Project Progress Report	Approve	/
D8.5	Synthesis Report on final results	Approve	See comment below
The report provides important points regarding learned lessons and conclusions.			

Has the quality as a whole been achieved according to the objectives? Has the project as a whole been making satisfactory progress?

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Comments (highlighting the project progress) / deviations / recommendations:

The GeoERA 3DGEO-EU is a project focused on the harmonization of cross-border geological models in the European Union. The project used several case studies to, among other things, identify the most common discrepancies between models (and the reasons for them), to optimize workflows, to identify possible challenges in cross-border modeling, propose good practices in such efforts etc. Despite a delay due to the pandemic, the project was successful in achieving set objectives and provided all the agreed deliverables (some planned deliverables were deleted – see comments from Level 1 review). A case study in the Pyrenees was significantly affected by delays, however this was not affecting the rest of the project in a negative way. The delay is understandable considering the pandemic and the magnitude of the planned campaigns and workplan within the case study. The project members were active in dissemination activities related to the project, however they could be more present on social media. The project team had some scientific output with several publications in some of the highest ranking journals on the topics related to structural geology and tectonics. The submitted deliverables extensively covered their topics and they provide an important resource for future cross-border geomodel harmonization efforts in the European Union and worldwide.

3 LEVEL 3 – REVIEW OF THE THEME PROGRESS

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by Theme coordinator with aim to review the achieved scientific goals in accordance with theme objectives, on the basis of Sheet 3 in MPPR / FPPR – Project contribution to GeoERA project.

Project contribution to GeoERA project (from MPPR / FPPR, sheet 3):

The overall objectives of GeoERA “is to contribute to the optimal use and management of the subsurface. GeoERA will … aim to support 1) a more integrated and efficient management and 2) more responsible and publicly accepted, exploitation and use of the subsurface.”
3DGEO-EU aimed to contribute to these objectives as it tested and developed methods and workflows needed for generating harmonized cross-border 3D geomodels of the subsurface. The partners put a lot of effort into the project, following a path from the first project phase (Months 1 -18), where partners defined the areal extent of pilot/work areas, covered the state-of-the-art in the areas and for selected geomodeling topics, i.e. an inventory of existing geodata, 3D models, concepts and methods, then evaluated the state-of-the-art (e.g. differences across borders), and on this basis developed strategies for the modelling and harmonization work, which partly included field campaigns to acquire gravity data (south western Pyrenees), then to the second project phase (Months 19 – 40) with a focus on the actual harmonization work and the generation of harmonized 3D geomodels and maps. Altogether, the partners of 3DGEO-EU have accomplished many products, i.e. more than 20 technical/scientific reports and several digital data sets (e.g. harmonized 3D geomodels and 2D maps) for various work areas. The partners gained experience and increased their knowledge level on the tackled research issues, which enables the project partners to communicate valuable lessons learned.
Thus, 3DGEO-EU has contributed to the overall objectives of GeoERA, as the project results have increased the knowledge concerning ways and means to harmonize underlying geological base data, which is necessary for all kind of consistent and reliable subsurface assessments and thus eventually for planning of the optimal use and management of the subsurface.
The results of 3DGEO-EU mainly aim at experts from European Geological Survey Organizations and the scientific community, thereof especially the geomodeling community, who can build upon the results and carry on to create harmonized 3D geomodels in other areas of Europe as well. By this way, the 3DGEO-EU results can help to achieve the future goal of creating a consistent database for pan-European assessments of subsurface resources. Therefore, in the end stakeholders, decision makers, politics and the public will also have a benefit from those technical expert results of 3DGEO-EU.

This project relates to the GeoEnergy Specific Research Topic (SRT) GE5 “Advancements in developing and using 3D transnational geomodels”. The results of 3DGEO-EU contribute to some aspects of the SRT GE5 scope, for example:
- The gained knowledge on methods and workflows for the harmonization of geological data and 3D geomodels has advanced the state-of-the-art towards an integrated and applied 3D modeling.
- The gained knowledge on methods and workflows and the demonstration of cross-border harmonization can help to enhance the reliability of 3D geomodels for future cross-border resource assessments.
- The achieved workflows and solutions in the field of model harmonization are applicable to other countries, regions and organizations as well.
- The generated harmonized cross-border 3D geomodels in different European pilot areas can be used as examples and keystones for further transnational developments.

Theme objectives:

General Theme objectives: (Excellent)
The 3DGEO-EU project delivers an essential and state-of art foundation (harmonized 3D geological models) to assess resources across borders (WP1 – WP3 and WP6). The reported approaches, strategies and results are a guideline for mapping and 3D modelling of other regions in Europe. The resulting models and attributes of the WP3 region are deployed for analysis of hydrocarbon potential in the GARAH project. Insights/results from other pilot areas are also tested on other types of resources like geothermal, groundwater, storage and evaluation of potential conflicting uses. Although 3DGEO did not assess hazards and risks, the 3D modelling efforts resulted in updated harmonized fault models which have been embedded in the HIKE project Fault Database. The project provides an essential and generic basis to properly assess interactions between subsurface activities. Interfering subsurface uses have been discussed in pilot areas based on new 3D model data. Aspect of uncertainty visualization is linked with GeoConnect3D

Theme scope, approach and methods: (Excellent)
The 3DGEO-EU project primarily focuses on the development of harmonized 3D geological frameworks and attributes that can be used for various types of resources (e.g. hydrocarbons, geothermal, storage, groundwater, etc.). Examples of resource assessments have been done in several case study areas to demonstrate the applicability and added value (e.g. WP1). Some applications have been evaluated in the pilot areas and via the GARAH project (WP3). The methodologies also focus on the determination and visualization of uncertainties (WP4 and WP6). This is an important aspect for future work by the GSOs of Europe. Besides that, the 3D framework allowed analyses of potential overlaps/competitions/synergies between subsurface uses including the potential connections between geoenergy applications and

groundwater. The modelling approaches for faults (WP5) are share with the HIKE project.

3DGEO-EU has significantly contributed to the development and testing of common spatial geological frameworks (extent, depth, thickness, as well as essential properties of geological intervals containing relevant geo-energy resources and storage capacities). The core of the project focused on the development and demonstration of advanced 3D modelling and assessment activities that may be proposed for complex geological configurations typical for specific cross-border regions. Thereby the project revised and embedded national 3D models into cross-border harmonized and standardized models, allowing the integration of data sources with different origins and characteristics. Resulting fault data standards were exchanged with the HIKE project while the harmonized cross-border Entenschnabel model (D3.2) was used in GARAH. Recommendations and lessons learned for different settings which can be applied in other (new) areas. Methods applicable for GSOs in general.

The 3D modelling methods and correlation approaches have been developed and tested in cross-border pilot areas. The models are developed on the basis of heterogeneous datasets of different origin and quality. Different modelling strategies are presented for different geological and data settings. The 3DGEO-EU project did not have the objective to implementation 3D modelling across entire Europe or within larger transnational regions. The insights and results of the project however can be used by other surveys (national mapping) and future transnational studies. These insights form an important foundation for CSA-GSE and future mapping and modelling at the GSOs

Beyond state of art (Excellent)
The 3DGEO-EU project contributed to a novel state of art of

- Advanced mapping and 3D modelling strategies that allow for regional to pan-European cross-border consistency and integration;
- Advanced and harmonized resource estimation workflows addressing uncertainty and sensitivity;
- Basic framework for evaluation of synergies and conflicting uses

Project-2-Project:
The 3DGEO-EU project delivers results to GARAH (hydrocarbon assessment) and HIKE (fault modelling) and collaborated with GeoConnect3D on uncertainty visualization

Has the project as a whole achieved the objectives and expected impact of the theme?

☐ 5 - **Overachiever** (the project has achieved greater impact on project theme and/or other themes than expected)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals towards the theme as expected)

☐ 3 - **Good progress** (the project has achieved most of its impact towards the theme for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has minor impact)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or has no impact on the theme)

Comments / deviations / recommendations:

The project provides important stepping stones for future european 3D models that can be widely deployed in resource assessments and visualization of the subsurface for geologists and non-geologists. The strategies consider the fact that geology and geoscience data are characterized by many heterogeneities. 3D models will contribute to a better understanding and more reliable estimation of resources and subsurface interactions and processes. The results can be a guideline for national 3D modelling projects, thereby contributing to capacity building

Note: the results are not yet accessible in EGDI

4 LEVEL 4 – GEOERA PROGRESS EVALUATION

In this section the project is reviewed on the Review meetings, where projects present their overall progress and achievements. This section relates to particular project, broader impact of GeoERA as a whole on policies will be covered at the Final Review meeting with questionnaire and interview with Evaluator.

Based on technical review summaries provided by Sections 1 – 3 of this report, and project presentation on the (Final) Review meeting:

Has the project as a whole been making satisfactory progress according to your own understanding and expectations of the GeoERA project?

☐ 5 - **Overachiever** (the project has exceeded expectations)
☒ 4 - **Excellent progress** (as expected)
☐ 3 - **Good progress** (minor recommendations given below)
☐ 2 - **Acceptable progress** (below expectations)
☐ 1 - **Unsatisfactory progress** (the project did not meet expectations)

Overall comments for the project (overall recommendations, modifications, corrective actions, or re-tuning the objectives to optimize the impact or keep up with the State of the Art, re-focusing, or a simple praise)

Stakeholder one review:

The 3DGEO project of GeoERA had a range of work packages focused on development of cross-border 3D structural information. Several of the work packages focused in specific regions: Dutch-German, Polish-German, and North Sea (NL-DE-DK). Each of the case studies defined different structural targets of interest such as particular horizons that were of economic value. Overall, the 3DGEO project made excellent progress on their objectives.

The initial half of the project was focused on collection of available datasets, including working to access proprietary industry data. A key (perhaps unexpected) lesson from the project was the difficulty accessing datasets and how to navigate making derived datasets and not raw data available publicly. A significant effort was put into re-analyzing raw data to produce derived products (locations of horizons, faults) because of these restrictions. Despite these barriers, the progress made was impressive with new 3D cross border models now publicly available through the project web interface. There were also nice connections with the HIKE project in development of fault metadata for use by the larger effort.

The utility of 3D databases rests on the quality of the metadata, including uncertainty estimates. The project put considerable effort (work package 4) in devising ways of recording and displaying uncertainty estimates. I found this to be a real highlight of the project because uncertainties are sometimes treated as being of secondary importance. The efforts under work package 4 provided new methodology for displaying uncertainty in 3D structure that will undoubtedly be of value to a wide range of projects, unrelated to GeoERA.

In addition to accomplishing the primary objectives of the project, the project resulted in a clear set of lessons for future efforts. There was recognition that expansion of these high resolution 3D mapping projects would likely require concerted effort to collect new datasets (collaboratively). They also identified a need to expand the types of geophysical surveys conducted to include potential field methods because these improved the resulting models. And, most importantly, the need for open data standards across European is a pressing need and without such standards opportunities for improving 3D models would be limited. I hope to see progress in the future on such open data sharing standards.

Stakeholder two review:

3DGEO-EU project provides valuable inputs for the optimal utilisation of the European sub-surface. The presentation of data in 3D allows various stakeholders to visualize the data quickly and plan for the possible utilisation that can help tackle challenges such as climate change and progress towards a circular economy.

In Dutch-German, Polish-German, and North Sea (NL-DE-DK), the outputs from three pilot projects helped understand the cross-border issues in harmonizing the data. The studies have highlighted the data issues in cross border 3D modelling. Some of the data are in different resolutions, quality and details, so the project can have problems joining all the data, especially in the cross-border regions. The difference in data quality is due to data produced in different periods (some are from the seventies or eighties). The older the data is, acquisition technologies and resolution differ. Only limited data, such as gravity data, was available in some cases. Due to data ownership issues, the project had problems accruing some data from different stakeholders. Due to ownership issues, the project output can only provide processed data, not the raw data itself.

The project has developed three unique, innovative methodologies in 3D modelling. These models concern uncertainties, faults and optimization of data. There was an information interface. The project involved 11 partners from 7 countries. A total of 12 technical reports were developed by the project.

This work has also highlighted the potential for using the subsurface to address future challenges, e.g. green economy, deep geo-energy, hydrogen or CO2 storage. The synthesis of all this into one framework was a challenge, which the project team addressed very well through innovative methods.

The project has interacted with other projects such as GARAH, HIKE and GIP-P. Overall the project had performed exceptionally well, and all the project members were congratulated for the sincere and dedicated work.

The project has done an excellent job highlighting critical issues in cross border harmonizing of data. The use of gravity data in 3D modelling, where expensive seismic data was unavailable, is worth highlighting. It is recommended that projects like this have access to all the available data from all stakeholders, including governments and companies. As the outputs are highly valuable for strategic decision making in Europe, there should be no impediments for the projects in accessing all available data.

There is a requirement for high-level policy directives to make all data freely available for future projects, specifically the CSA project. The raw data need not be published. Only the processed data may be open to the public.

Synthesizing 3D methodology was a challenge, and the outputs are a productive contribution to the objectives of the project and science in general. The results should be published in reputed journals.

The methodologies developed by this project have highlighted the use of 3D models to support decision-making for the green economy. The project team is congratulated for their sincerity and dedication in developing the case studies and the new methodologies.

Annex 1: Review meeting list of participants

Name	Function	Beneficiary
Joop Hasselman	GeoERA coordinator	Netherlands Organisation for Applied Scientific Research
Harikrishnan Tulsidas	GeoERA Stakeholder	UN Economic Commission for Europe
Elisabeth S. Cochran	GeoERA Stakeholder	US Geological Survey
Barbara Simić	Monitoring and Reporting Officer	Geological Survey of Slovenia
Aleksandra Trenchovska	Monitoring and Reporting Officer	Geological Survey of Slovenia
Jasna Šinigoj	Scientific reviewer	Geological Survey of Slovenia
Matija Krivic	Scientific reviewer	Geological Survey of Slovenia
Ana Novak	Scientific reviewer	Geological Survey of Slovenia
Serge van Gessel	GeoEnergy Theme coordinator	Netherlands Organisation for Applied Scientific Research
Stefan Knopf	3DGEO-EU Project manager	Federal Institute for Geosciences and Natural Resources, Germany
Melanie Witthöft	Project member	State Office for Mining, Energy and Geology Lower Saxony
Karsten Obst	Project member	State Office for the Environment, Nature Conservation and Geology Mecklenburg-Vorpommern
Christoph Jahnke	Project member	State Office for Mining, Geology and Raw Materials Brandenburg/ State Office for the Environment, Nature Conservation and Geology Mecklenburg-Vorpommern
Ewa Szynkaruk	Project member	Polish Geological Insitute

Hans Doornenbal	Project member	The Netherlands Organisation for applied scientific research
Björn Zehner	Project member	Federal Institute for Geosciences and Natural Resources, Germany
Emilio L. Pueyo	Project member	Geological Survey of Spain