Activity report on postprocessing and evaluation of data model in pilot area Ljubljana

Deliverable D.T3.4.1 09 2019

D. Šram[1], M. Janža[1] & the GeoPLASMA-CE team.

[1] Geological Survey of Slovenia

Contact details of author: dejan.sram@geo-zs.si

The involved GeoPLASMA-CE team

GeoZS	Dejan Šram Mitja Janža

Content

Interreg CENTRAL EUROPE GeoPLASMA-CE European Union European Regional Development Fund

1. Executive summary in English language

This report provides an overview of the post processing steps of the geological and numerical models in the pilot area Ljubljana. We elaborated our models with special software systems, JewelSuite for geological modelling and FEFLOW for numerical modelling. Furthermore, we used more commonly applied software systems such as e.g. ArcGIS and MS Excel for post processing. Post processing of exported data from the models was necessary to derive secondary maps, such as resource maps, and to provide the data in the harmonized GeoPLASMA-CE standard for uploading to the GeoPLASMA-CE webportal. This mainly involved adapting and changing the file structure. Furthermore, post processing also included visualization of modelling results, which we achieved with ArcGIS.

We were able to finalize all post processing steps for both models as planned within the project runtime of GeoPLASMA-CE.

Detailed information about all post processing steps, model uncertainties and error estimations are included in D.T3.3.1 – Activity report on 3D modelling – Part 1 and Part 2.

2. Povzetek v slovenskem jeziku

V poročilu je podan pregled po korakih, ki smo jih napravili po 3D geološkem in numeričnem modeluiranju za pilotno območje Ljubljana. Pri izdelavi modelov smo uporabili specifično programsko opremo in sicer JewelSuite za geološki in FEFLOW za numerični model. Uporabili smo tudi bolj splošne programe kot so ArcGIS in MS Excel za nadaljno obdelavo. Nadaljna obdelava podatkov je bila nujna za izdelavo različnih tematskih kart, ki so bile usklajene po standardu GeoPLASMA-CE za objavo na GeoPLASMA-CE portal. V večini primerov se je spremenila oblika datoteke. Prav tako se je v ArcGIS-u opravila vizualizacija rezultatov.

Uspešno in v časovnem okvirju smo dokončali in predstavili rezultate v sklopu projekta GeoPLASMA-CE, kot je bilo načrtovano.

Bolj podroben opis in več informacij o sami izdelavi geološkega in numeričnega modela, negotovosti in ocena napake so na voljo v poročilu (angleška različica) - D.T3.3.1 – Activity report on 3D modelling – Part 1 and Part 2.

3. Introduction

3.1. Aim and scope of this report

This report describes post processing steps performed on the model of the pilot area Ljubljana, which have been created within the frame of Activity A.T3.3. These reports summarize activities on post processing and evaluation of 3D model of the pilot areas. It identifies strong and problematic points of preparation of the model.

This report describes the following post processing steps:

General post processing steps

- Harmonization of attributes
- Transformation of the reference system and parameter units to GeoPLASMA-CE standards

Geological 3D modelling

- Change the model representation (e.g. 3D/2D, unit tops)
- Change data structure (e.g. grids, triangulated surface)
- Quality control, validation and error estimation
- Visualisation of modelling results and derivation of secondary maps

Numerical modelling

- Quality control, Validation and error estimation
- Changes of the file structure (e.g. ESRI database, shapefile)
- Visualisation of modelling results and derivation of secondary maps (e.g. calculation of resource maps for open loop systems)

4. General postprocessing steps

4.1. Harmonisation of attributes linked to modelling

We applied all joint data standards defined in GeoPLASMA-CE to the output parameters. The common reference system chosen is ETRS-UTM33N for the pilot area Ljubljana. The harmonized standards for all output parameters can be found in the annexes of D.T2.3.1 – Set-up of harmonized data management infrastructure (for GeoPLASMA-CE).

See Table 1 for all output parameters related to modelling in the pilot area Ljubljana. Geological modelling was used to derive the tops of geological units. Bulk thermal conductivity and Subsurface temperature were calculated based on data values gathered on filed and output 3D geological model and are resource parameter for closed loop. The remaining three output parameters related to modelling were based on the numerical model and they are all resource parameters for open loop systems.

Table 1. Output parameters related to modelling in the pilot area Ljubljana.

Output-ID	Parameter	Relation to modelling
1	Top of geological unit	Derived directly from geological model
2	Bulk thermal conductivity	Calculated in ArcGIS based on field measurements and on outcomes of geological model
6	Subsurface temperature	Calculated in ArcGIS based on field measurements and on outcomes of geological model
7	Thermal capacity at peak load	Calculated in ArcGIS and MS Excel based on outcomes of numerical model
9	Energy content (for cooling, heating and balanced use)	Calculated in ArcGIS and MS Excel based on outcomes of numerical model
10	Hydraulic productivity at peak load	Calculated in ArcGIS and MS Excel based on outcomes of numerical model

4.2. Transformation of the reference system and parameter units to GeoPLASMA-CE standards

We used simultaneously local D48_Slovenia_TM coordinate system and the GeoPLASMA-CE coordinate system in the ArcMAP software. When data were transformed into JewelSuite and FEFLOW software for finalization of 3D modeling the GeoPLASMA-CE coordinate system was applied.

5. Geological modelling

5.1. Overview of applied products

Table 2 lists the software products, which we applied for geological 3D modelling.

Table 2. Applied software products for geological 3D modelling.

Version	Software	Activities related to numerical model
2018.3	JewelSuite	3D geological modelling
10.6.0.8321	ArcGIS	Geodata preparation and georeferencing

5.2. Changes of the model representation

No transformations were carried out regarding the 3D geological model prior to the implementation into the GeoPLASMA-CE portal. At the GeoPLASMA-CE webportal (https://portal.geoplasma-ce.eu/) virtual boreholes are automatically generate for location specific queries, which extract depth information for respective stratigraphic horizons from the 3D model, and the webportal also links to the interactive 3D GST Web Viewer developed by GiGa (PP10), where the model can be explored in full detail.

5.3. Changes of the data structure

The 3D model was created in ArcGIS as raster with cell size 100 * 100 m and transformed from grid to triangulated surfaces in JewelSuite. No transformation from surfaces to voxels or grids was performed for the implementation into the GeoPLASMA-CE portal.

5.4. Quality control, validation and errror estimation

Geostatistical methods have not been applied for quality control of the 3D Model. Geological layers used in 3D model where constructed based on available data. The most important layer is bedrock of alluvial aquifers of Ljubljansko polje and barje. It is derived from borehole data and the uncertainty is relative small which is confirmed with new boreholes which are drilled on the area. Other layers are created based on surface geological map, 2D cross-sections and expert knowledge of the area. Here the error and uncertainty increase with depth.

5.5. Visualisation of modelling results and derivation of secondary maps

The 3D model can be explored interactively via a Web 3D Viewer, which can be accessed on the GeoPLASMA-CE portal. The Web 3D Viewer is operated by GIGA Infosystems. Thickness maps or structural maps have not been calculated based on the modelled horizons.

6. Numerical modelling

6.1. Overview of applied products

Table 3 lists the software products applied for numerical modelling.

Table 3. Applied software products for numerical modelling.

Version	Software	Activities related to numerical model
7.1.4.17181	FEFLOW	Numerical modelling
7.1.4.17181	FEFLOW Parameter Estimation (FePEST)	Calibration of numerical model
10.6.0.8321	ArcGIS	Pre and post processing of numerical model
Office 365	MS Office (Access, Excel)	Pre and post processing of numerical model

6.2. Changes of the file structure

In the post processing phase, we calculated the above-mentioned output parameters for open loop systems. ArcGIS and MS Excel provided useful tools for the potential calculations. Application of these software programs only required one little change of data exported from FEFLOW. The exported shapefiles do not have a coordinate system assigned and this has to be adjusted in ArcGIS. Other than that, the results from FEFLOW could be used directly in ArcGIS for further post processing steps, which are explained briefly in chapter 6.4. and in more detail in D.T2.3.4 – Evaluated guidelines on harmonized workflows and methods for urban and non-urban areas.

6.3. Quality control, validation and errror estimation

We performed the following quality checks for the numerical model of the pilot area Ljubljana:

1. In the early stages of numerical modelling, we calibrated the hydraulic model. FePEST automatically adapted the hydraulic conductivities of the model to reach a good fit of the measured groundwater levels and the modelled hydraulic heads. FePEST also automatically provides an error estimation for the best fit of the calibration.
2. Within the process of modelling the groundwater temperatures, we compared time series of measured groundwater temperatures at certain observation wells and simulated groundwater temperatures at the same locations. This was a plausibility check to see if the temperatures are in a reasonable range and more importantly in doing so we were able to adapt thermal properties (thermal conductivity and thermal capacity) of the model.

6.4. Visualisation of modelling results and derivation of secondary maps

D.T3.3.1 – Activity report on 3D modelling - Part 2 describes all results of the numerical model in detail. Results of the numerical model were visualized in ArcGIS and these maps are part of D.T3.4.2 – Thematic maps showing potentials and conflicts at the pilot areas. Technically, the potential calculations could have been performed in FEFLOW, however we decided to use a combination of MS Excel and ArcGIS to derive the maps. This workflow does not depend on the software FEFLOW, which is a very specific modelling program, instead, to reach as many potential users as possible, we decided to prepare the workflow for more commonly used software systems.

We derived the maps using the outputs from the numerical model and joined them with additional input data in ArcGIS into one table. We exported this table into a text file and calculated the potential parameters in MS Excel. Annex 15 of D.T2.3.4 – Evaluated guidelines on harmonized workflows and methods for urban and non-urban areas, describes these steps and mathematical equations in more detail. It also provides an MS Excel template for all potential calculations for open loop systems. We imported the data from the text file into this template, which calculates the output parameters automatically, and transformed the data into maps with ArcGIS.

7. Conclusions and outlook

The workflow for geological 3D modelling was very efficient and we could apply it without problems in the pilot area Ljubljana. For numerical modelling, the GeoPLASMA-CE team did not elaborate a workflow. Instead, we discussed specific modelling issues of the different pilot areas in numerous meetings and telephone conferences.

There are no additional post processing activities scheduled for the geological or the numerical model after GeoPLASMA-CE. However, there are ideas to refine the models further. Now the hydraulic model is static while we have noticed that it is recommended to be transient due to high recharge of river Sava to aquifer which plays important role in temperature distribution.