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GEOMODELATOR - from static geologic models to structured grids for numerical simulations

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Motivation | Lack of flexible Open Source tool to convert complex geologic models into numerical simulation grids

- Conversion of static geologic models into numerical simulation grids required to undertake site-specific assessments of geologic subsurface utilisation.
- *GEOMODELATOR* [1] is a Python-based Open Source software package which enables modellers to translate static geologic models into regularly structured simulation grids with element partitions following complex model geometries.
- Geologic models generated by means of GIS, CAD or specific geologic modelling software packages are integrated in form of point cloud data.
- *GEOMODELATOR* maps geometric features such as lithologic horizons, faults and any kind of other geometric data by 3D Delaunay triangulation onto pre-defined grid element centres, and provides VTK data and Python numpy arrays for visual model inspection and their direct application in numerical simulations, respectively.
- The conceptual approach and its application to selected numerical simulation studies addressing fluid flow as well as transport of heat and chemical species in geological subsurface utilisation are presented here.

Methods | Workflow development for processing complex geometric input data and its interpolation onto pre-defined simulation grids

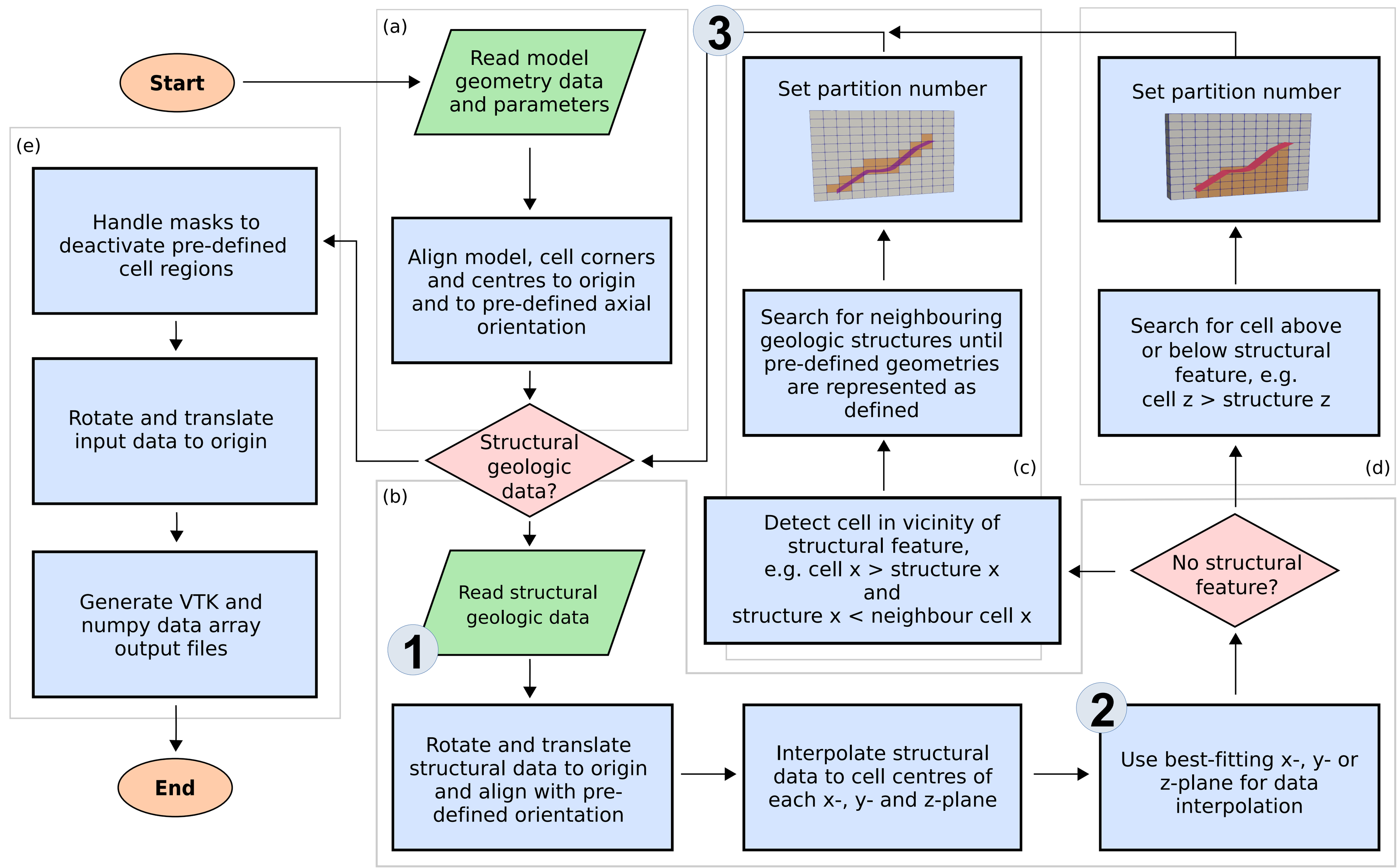
(a) 3D grid configuration, input and output file locations, spatial model data and grid discretisation

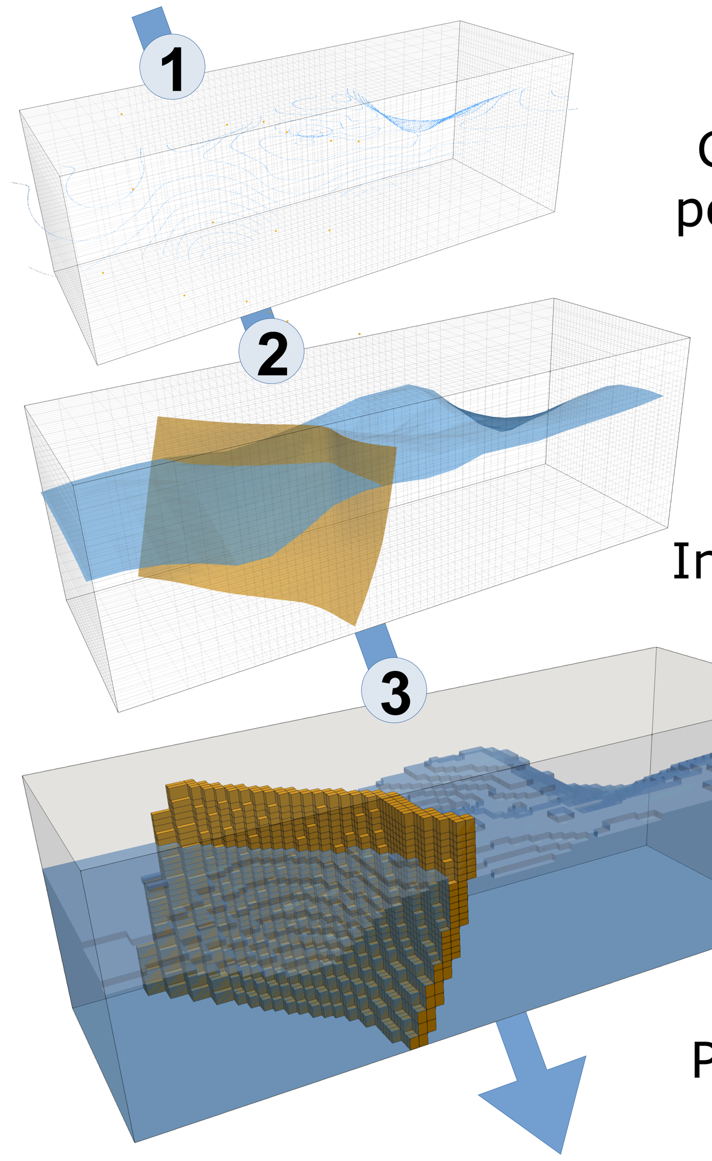
(b) Input data translation to origin and rotation (if required)

(c) Interpolation of horizon data to define lithologic partitions (cell groups)

(d) Processing of structural geologic data by surface interpolation to account for fault and other structural geologic partitions (cell groups), considering pre-defined geometric boundary conditions

(e) Generation of numpy arrays and VTK output files





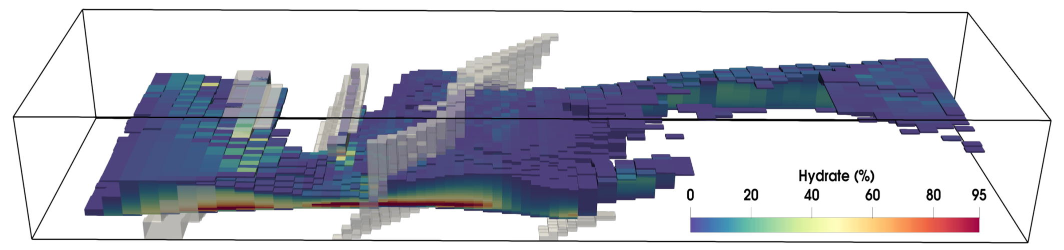
1 Geometric point clouds

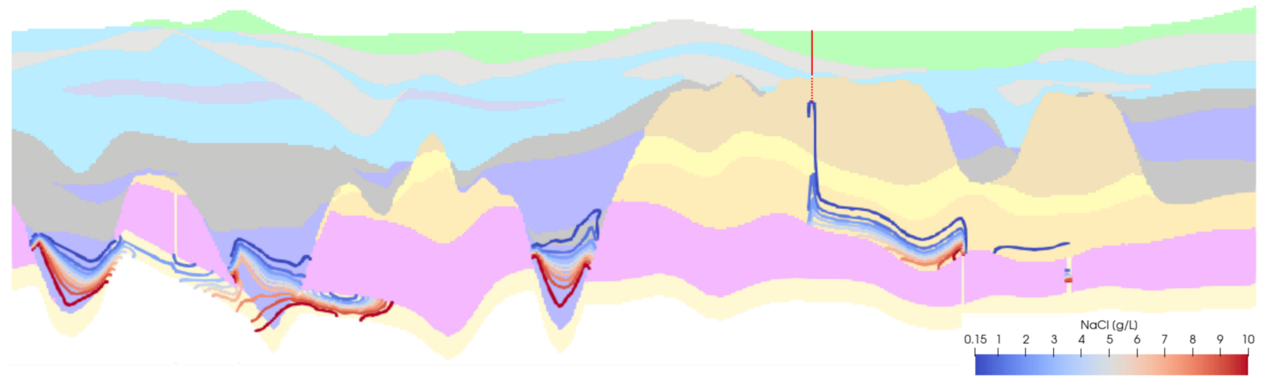
2 Interpolated surfaces

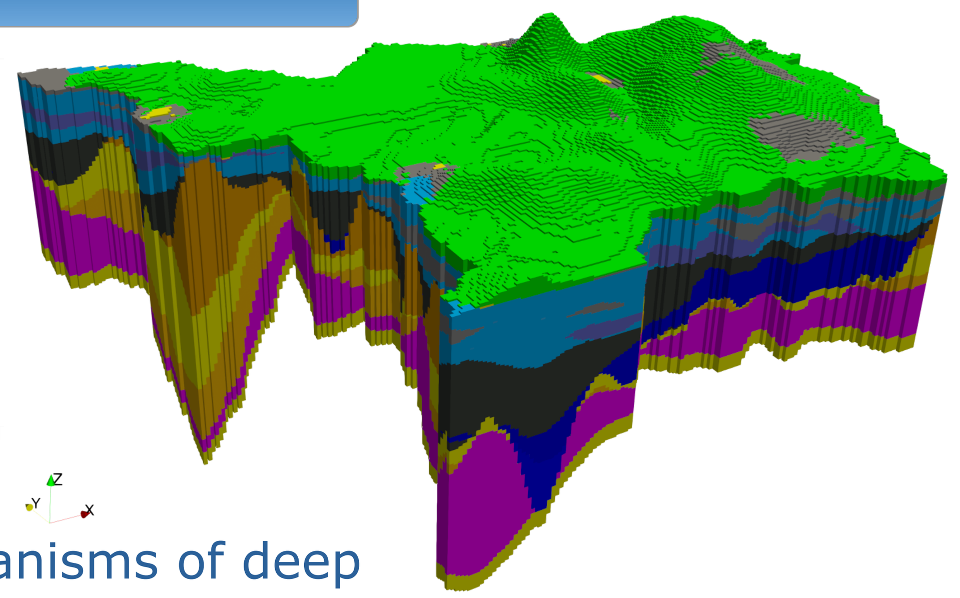
3 Partitioned model

Application examples | Complex structural 2D and 3D models derived from borehole and seismic data were converted into numerical flow and transport models

Validation of a hypothesis on an Arctic sub-permafrost gas hydrate formation mechanism, implying that CH_4-rich fluids were vertically transported from deep reservoirs via geologic fault systems and formed a present-day observed deposit [2].







Density-driven flow and transport modelling performed to investigate the upwelling mechanisms of deep saline waters across Quaternary window sediments in the Rupelian [3]. The initially applied 2D numerical flow and transport models were extended to 3D simulations by means of the *GEOMODELATOR* package [4].

Conclusions | Flexible workflow for complex geological model conversion available

- *GEOMODELATOR* is a Python-based Open Source converter for complex static geological models into structured grids
- Conceptual approach based on workflow combining best-fit planar interpolation following the required representation of the available geological structures
- Examples representative for other successful applications of *GEOMODELATOR* to complex geological models provided
- Further developments focus on interfaces for data integration from Open Source geological modelling programs, i.e. the import of GIS shapefiles

References

[1] https://git.gfz-potsdam.de/bnakaten/geomodelator
[2] Li, Z. et al. (2023): Geologic controls on the genesis of the Arctic permafrost and sub-permafrost methane hydrate-bearing system in the Beaufort–Mackenzie Delta. Frontiers in Earth Science, 11, 1148765. https://doi.org/10.3389/feart.2023.1148765.
[3] Chabab, E. et al. (2022): Upwelling mechanisms of deep saline waters via Quaternary erosion windows considering varying hydrogeological boundary conditions. Advances in Geosciences, 58, 47-54. https://doi.org/10.5194/adgeo-58-47-2022
[4] Chabab, E., et al. (2023): Saltwater upwelling quantified by density-driven 3D flow and transport simulations for a study area in Brandenburg, Germany, EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-12741, https://doi.org/10.5194/egusphere-egu23-12741

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