energi SIMULATION

SUMMIT

Sep 30 – Oct 1

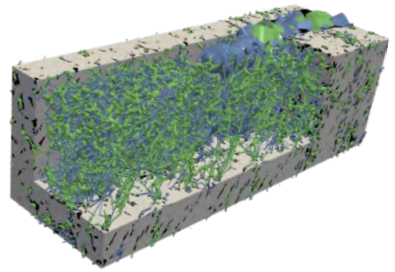
2021

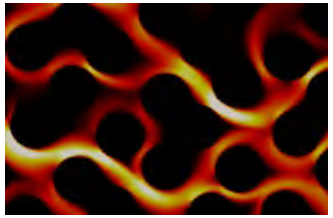
HERIOT WATT UNIVERSITY

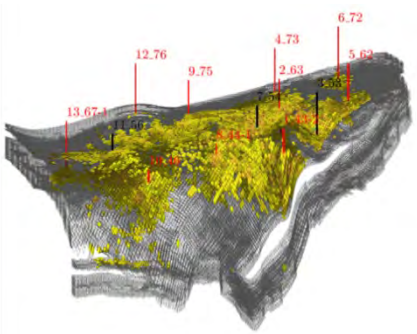
Sebastian Geiger

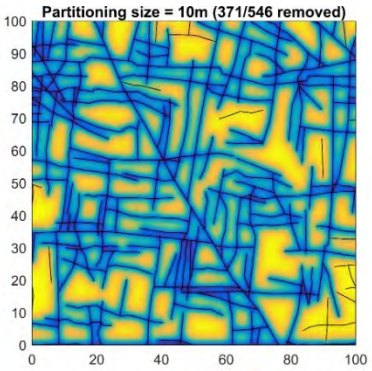
Energi Simulation Chair for Fractured and Geothermal Reservoirs

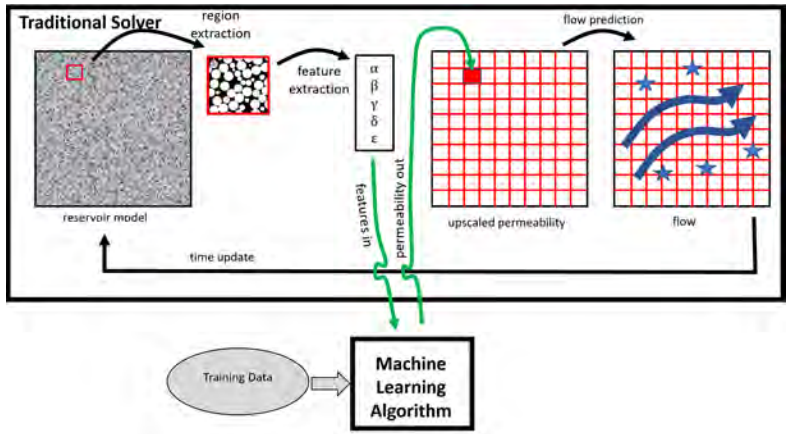
- Previously Energi Simulation Chair for Carbonate Reservoirs (2010 to 2021)
- Aim: Use long-standing expertise in modelling naturally fractured reservoirs to tackle wider low-carbon geoenergy challenges beyond oil and gas
- Key research themes:
  - *Ultra-fast static and dynamic modelling for (fractured) geological reservoirs*
  - *Characterising flow behaviours across scales (incl. machine learning and multi-scale imaging)*
  - *Testing technologies in real field applications*











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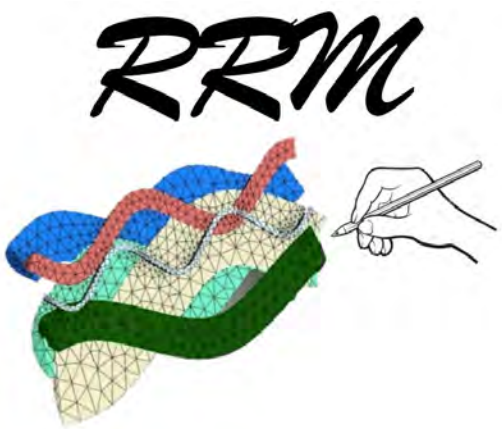


If you can't draw it, don't model it

Rapid Reservoir Modelling (RRM): Fast prototyping of reservoir models with dynamic feedback

Carl Jacquemyn, Gary Hampson, Matt Jackson – ICL
Julio Machado Silva, Sicilia Judice, Fazilatur Rahman, Mario Costa Sousa – UofC
Dmytro Petrovskyy, Sebastian Geiger – HWU

ExxonMobil equinor PETROBRAS PETRONAS

Persistent and ongoing problems with conventional workflows

- Efficient management of geoenergy reservoirs (geothermal, CCS, hydrogen, oil & gas) needs good reservoir models but current workflows face the following challenges:

  - *Slow turnaround time and linear workflows*
  - *Geological concepts are locked in early*
  - *Difficult (impossible?) to rapidly explore how range of concepts (engineering and geology) could impact on reservoir behaviour*
  - *Fixed and pre-defined grid resolutions limit the spatial complexity and resolution of reservoir architectures that can be captured*
  - *Integration across different disciplines difficult due to different software tools, grid types, and resolution*

What is Rapid Reservoir Modelling (RRM)?

- In a nutshell… the development of a new, open-source software tool for
  - *rapid creation of conceptual reservoir models*
  - *rapid modification of existing reservoir models*
  - *rapid calculation of key static and dynamic reservoir properties*
  - *prototyping of reservoir concepts and models and testing with quantitative data using a range of input data (e.g. seismic lines, outcrop analogues, blank screen…)*

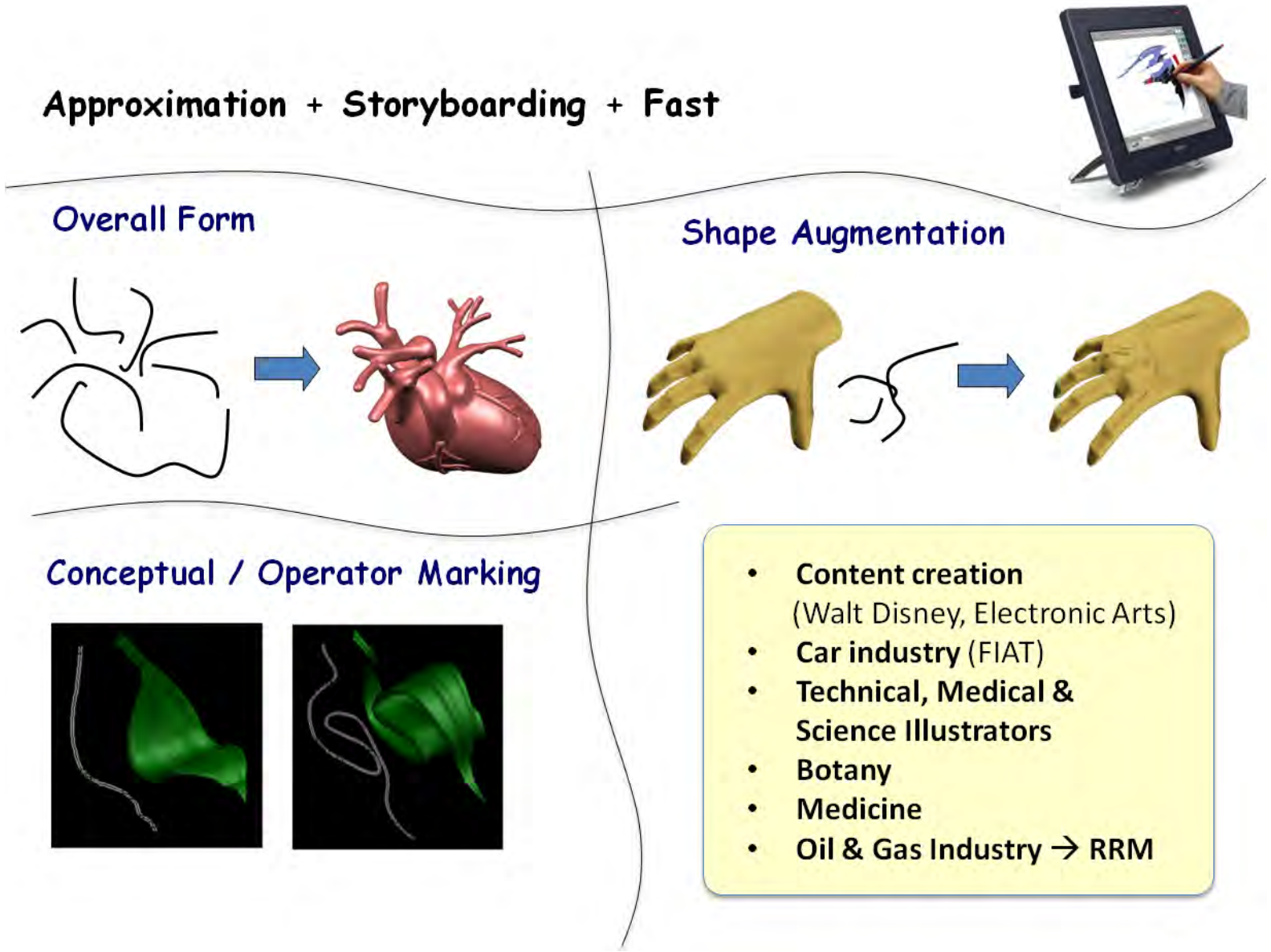
- RRM uses a simple, intuitive, and interactive interface
  - *to do things that are difficult using conventional geomodelling tools*

- Not a replacement, plugin, or competitor for existing tool and software packages

Key components of RRM

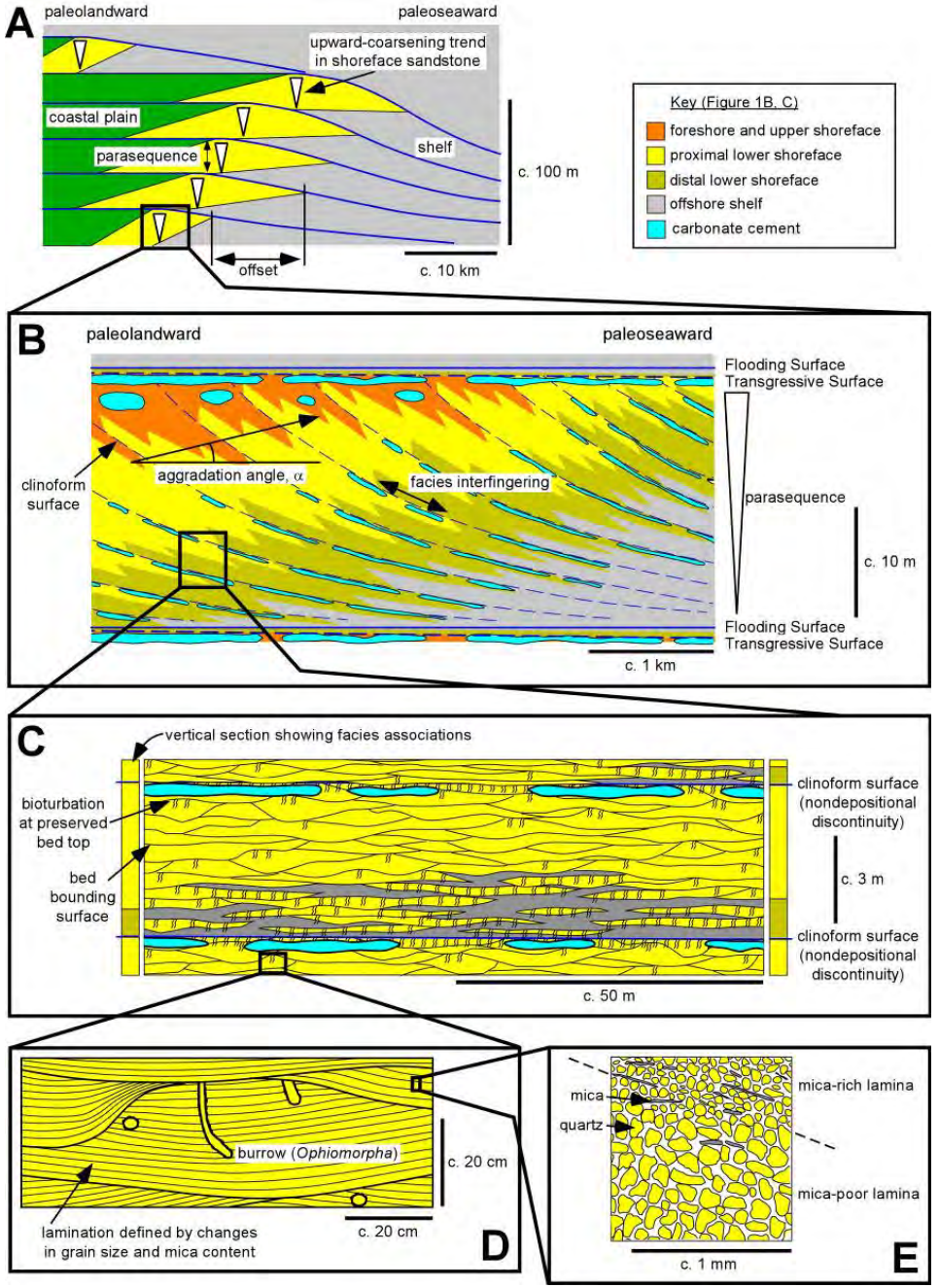
- Sketch-Based Interface and Modelling (SBIM)
  - *Intuitive and easy workflows*
  - *Anyone can use it, from undergraduates to professionals*
- From 2D sketches to 3D surfaces
  - *Cross-sections and map view are familiar for geoscientists*
  - *Surface-based representation*
- Geological operators
  - *Create geological consistent models in any order at any scale*
  - *Interpretations can evolve*
- Flow diagnostics
  - *Rapid calculation of relevant volumetric and fluid flow properties*

Sketch-based Interface and Modelling (SBIM)



SBIM and surface-based modelling

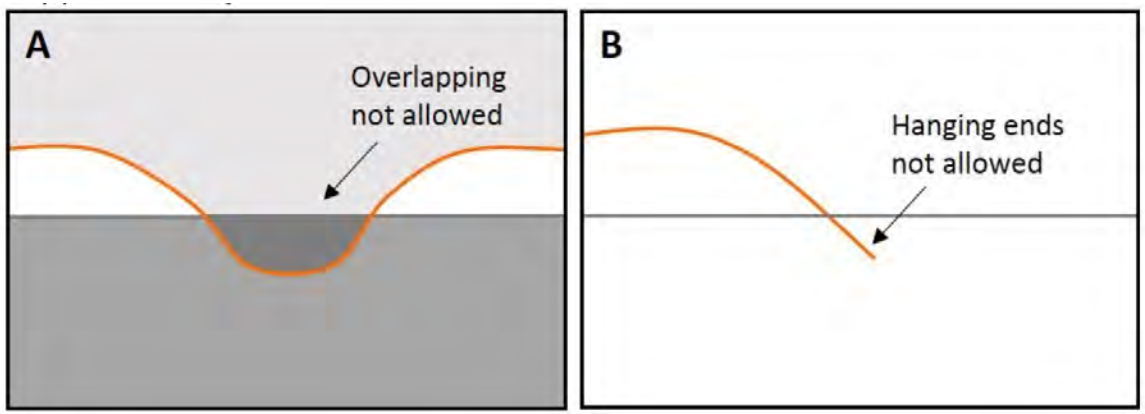
- All geological heterogeneity is modelled as one or more discrete rock volumes bounded by surfaces ("geological domains")
- Hierarchy of multi-scale surfaces (faults, stratigraphy, facies, diagenetic bodies…)
- Petrophysical properties within geological domains are constant
- Equivalent to a grid-based approach but petrophysical properties are constant within geologically meaningful domains
- Geological operators in RRM define how surfaces interact with each other in a consistent way

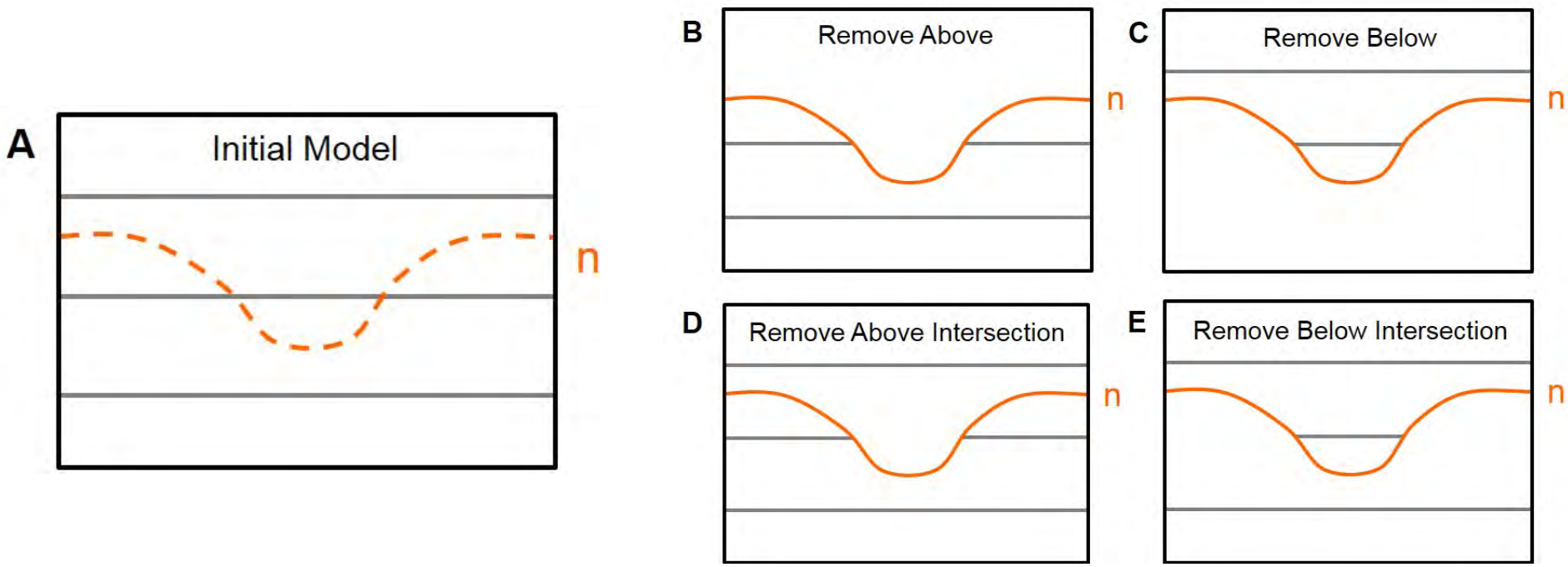


Surface-based modelling concepts after Jackson et al. (2013)

Example geological operators for existing surfaces

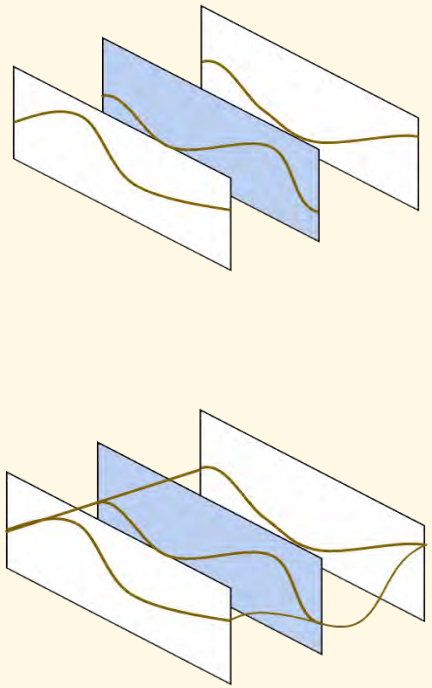
- Basic rules for stratigraphic surfaces
  - *Surface cannot cross*
  - *Surfaces cannot end within domain*



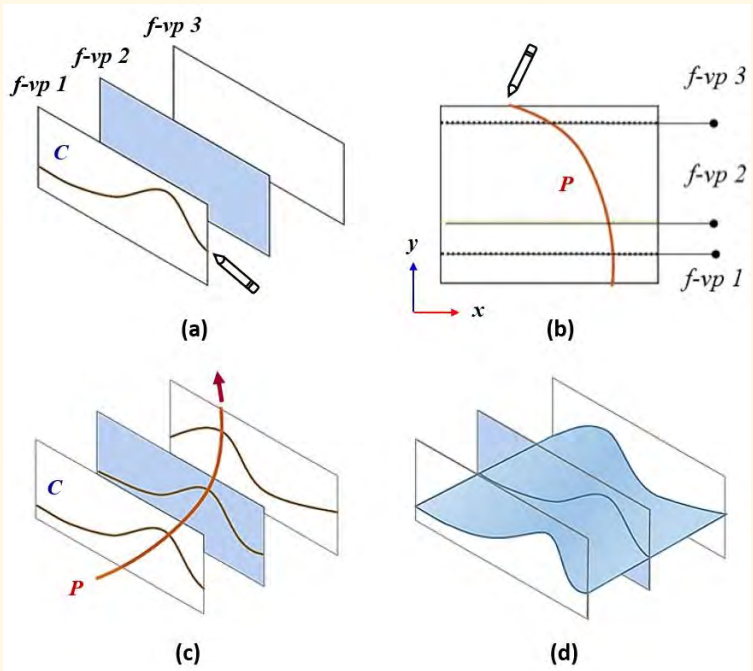


From 2D sketches to 3D surfaces

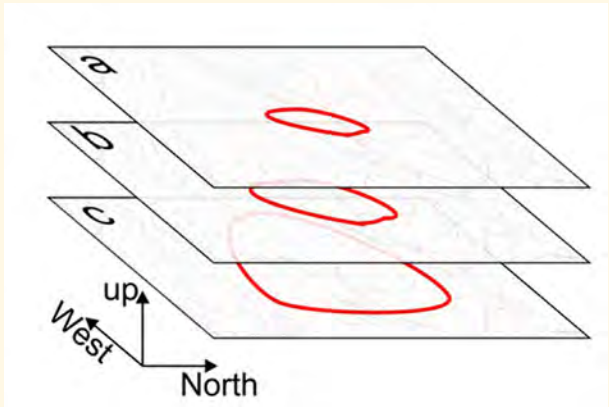
Interpolation



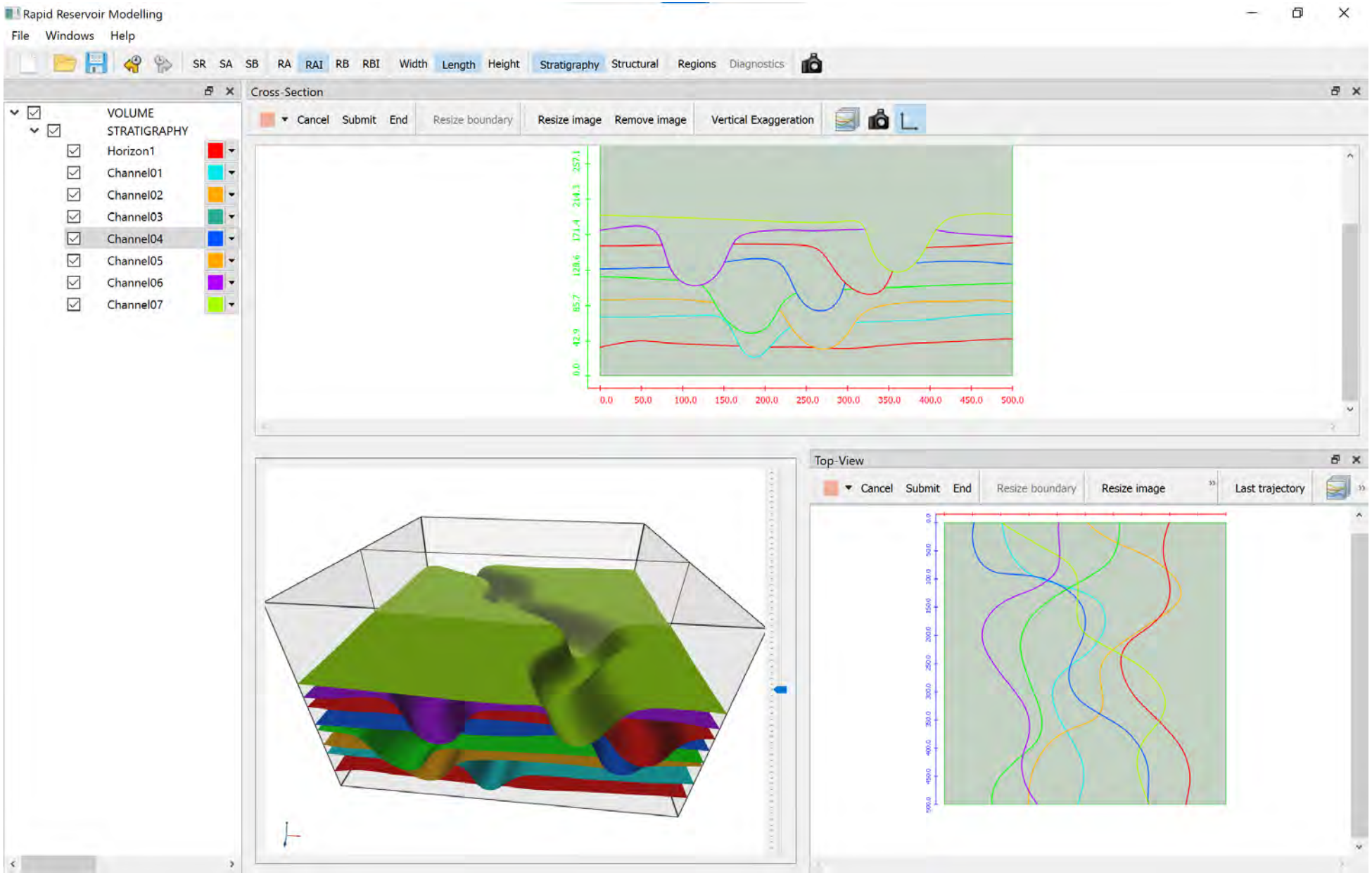
Extrusion along a path



Contour sketches

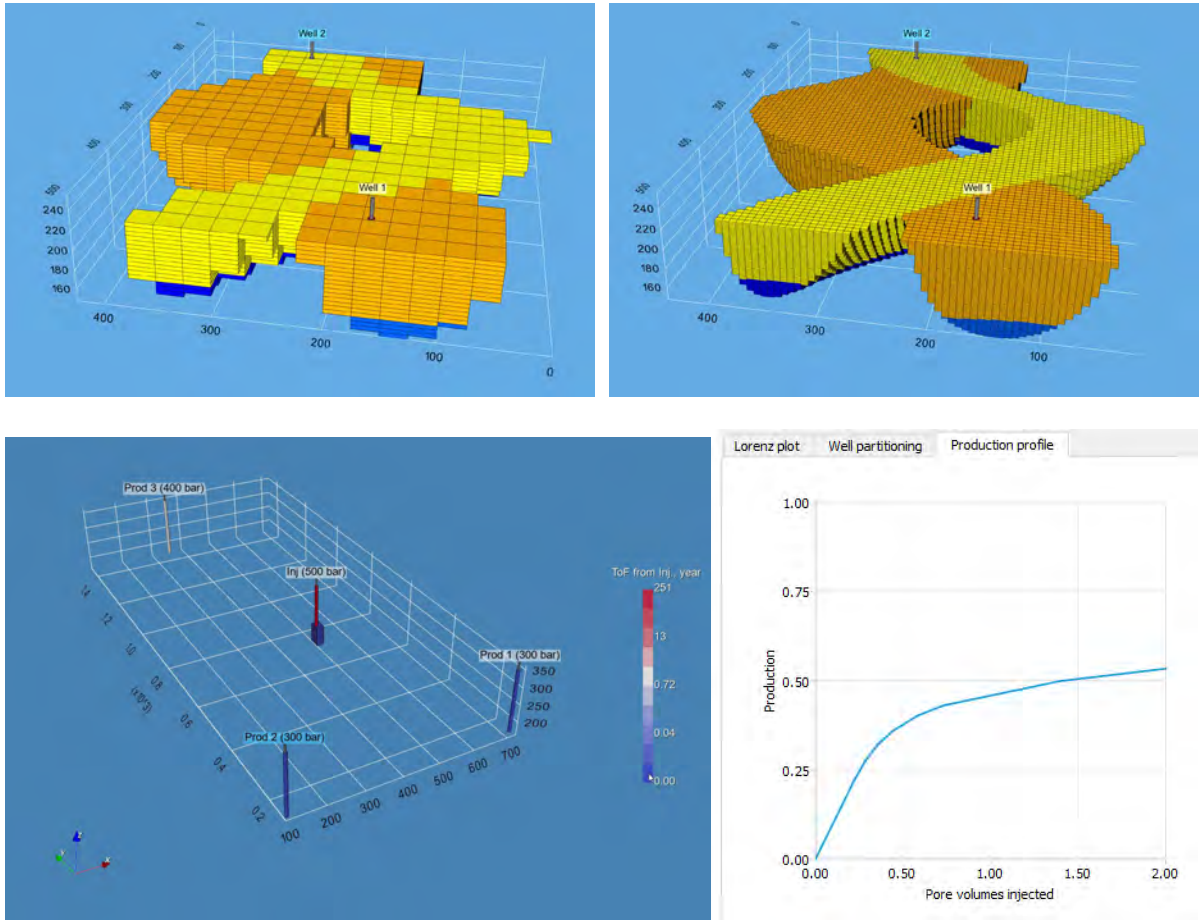


Creating 3D surfaces with simple GUI and interactive hardware



From static models to dynamic feedback

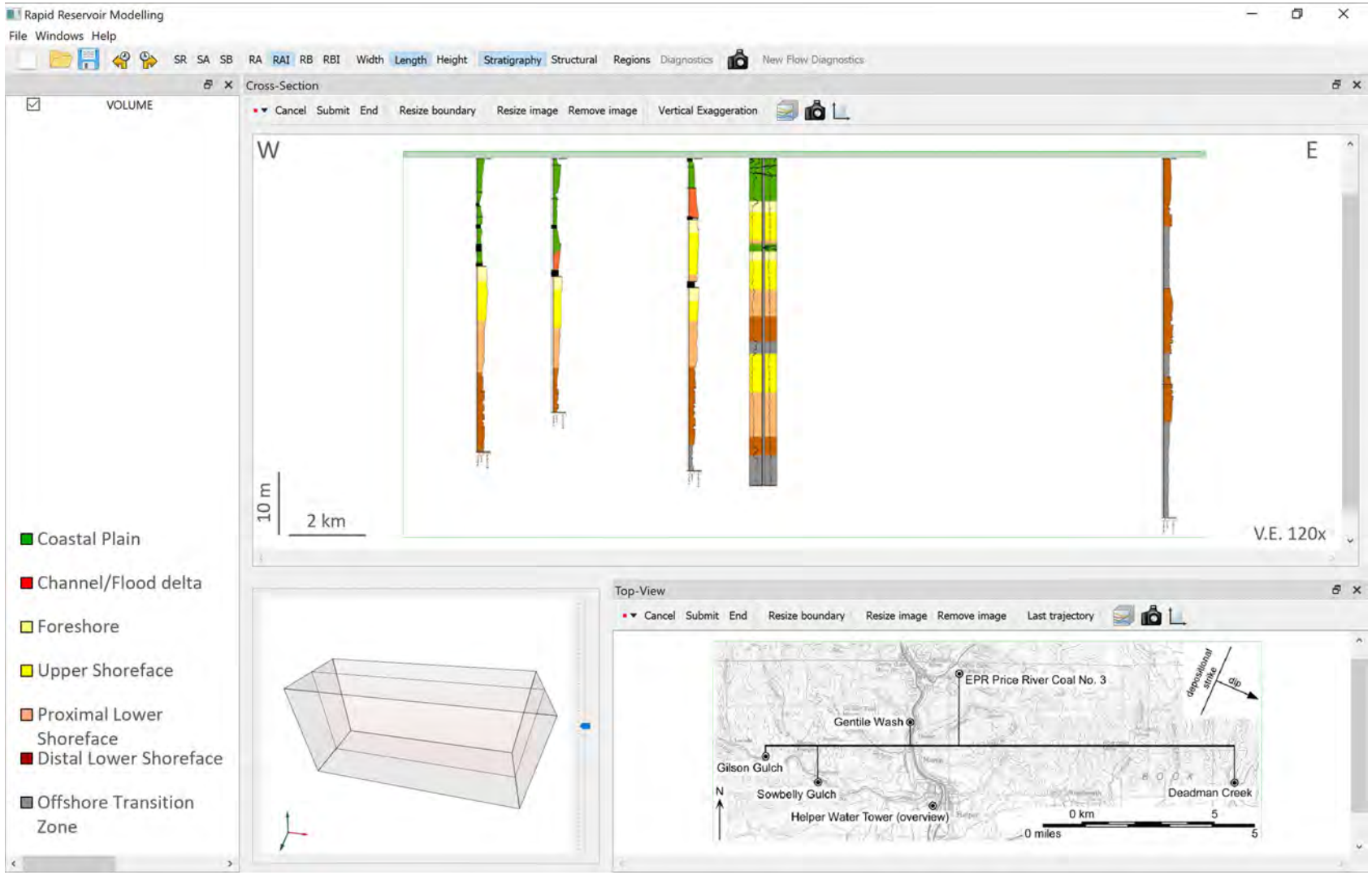
- Grid is disposable and generated on the fly only when needed for calculations
- Three equations (steady-state) are solved to provide visual and interactive information in real time on
  - *Reservoir pressure and time-of-flight*
  - *Reservoir partitioning, well allocations, and sweep efficiency*
  - *Effective permeabilities for upscaling*
- Compare and contrast scenarios and development options to select “good” models for further full-physics simulations using (commercial) simulators



Flow diagnostics concepts after Moyner et al. (2014)

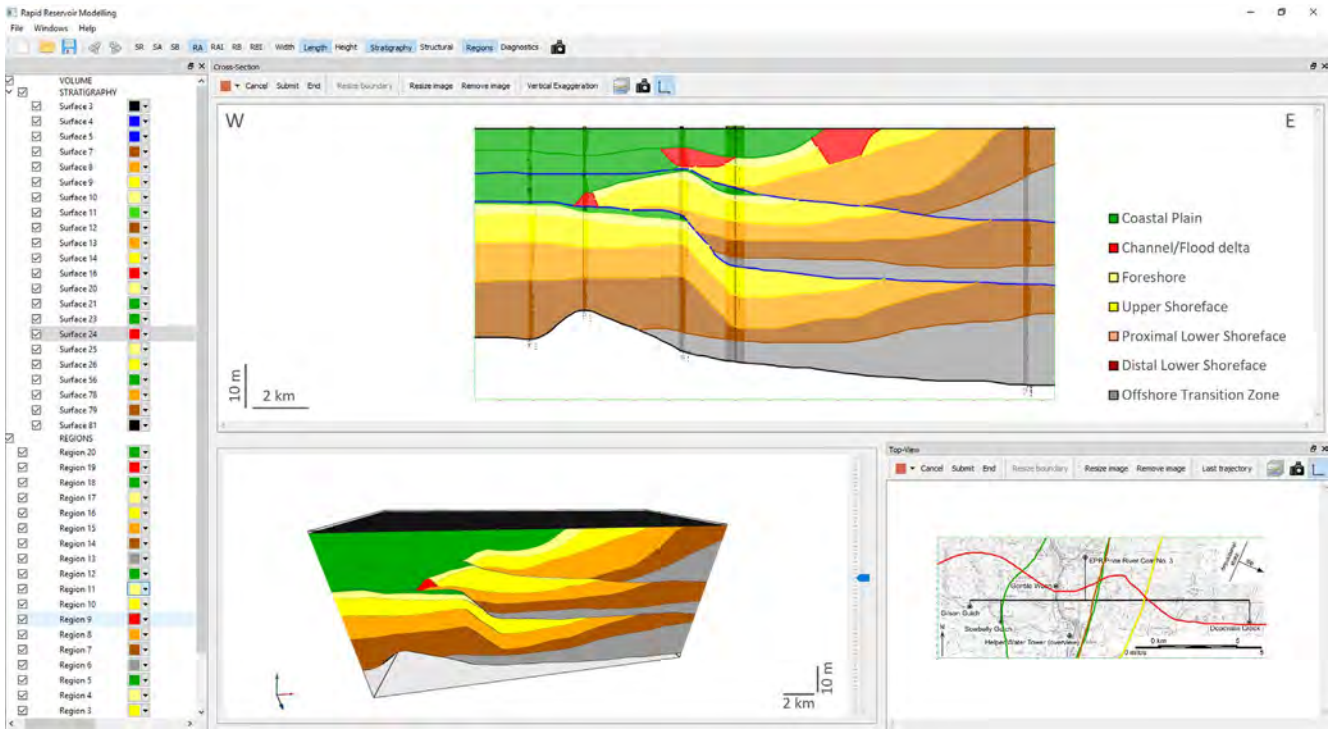
Example case study: Shallow marine correlation

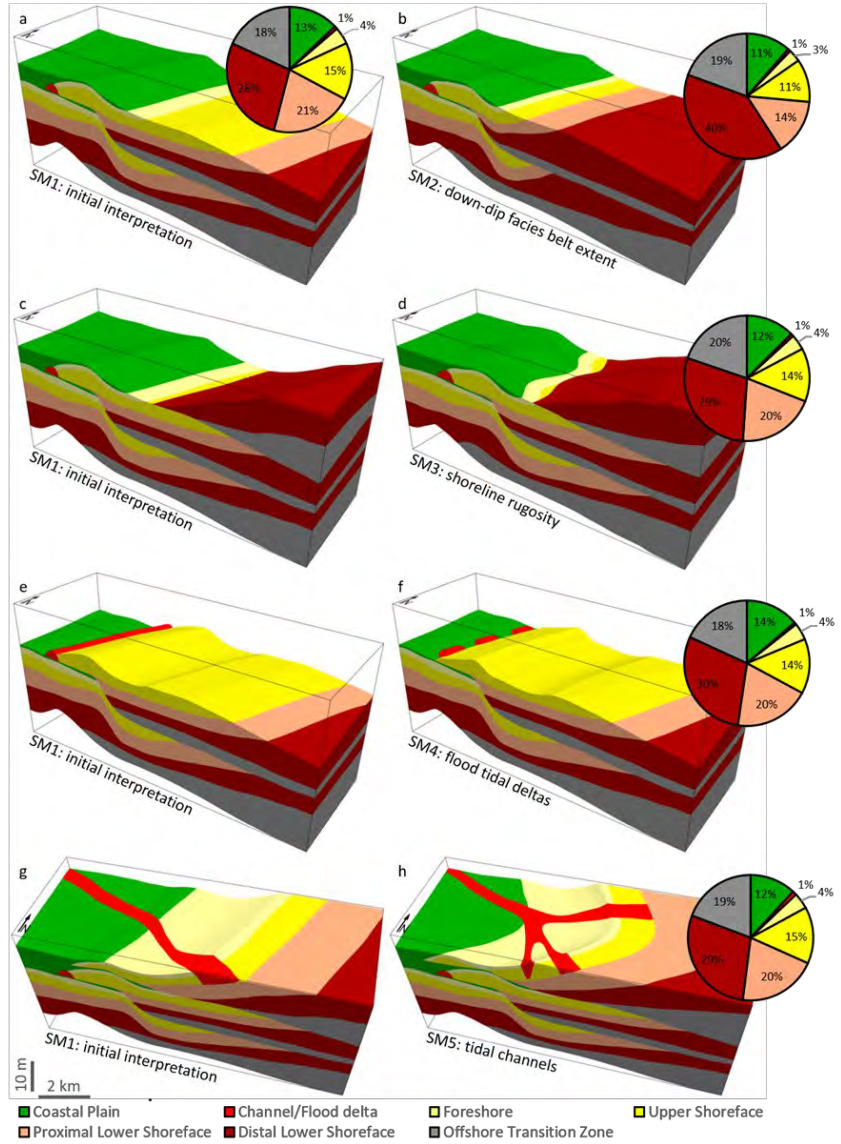
- Spring Canyon Mb., Book Cliffs, Utah
- Input data
  - *4 interpreted sedimentary logs*
  - *1 interpreted wireline log*
  - *Map with log locations*
- Average depositional strike and dip



Example case study: Shallow marine correlation

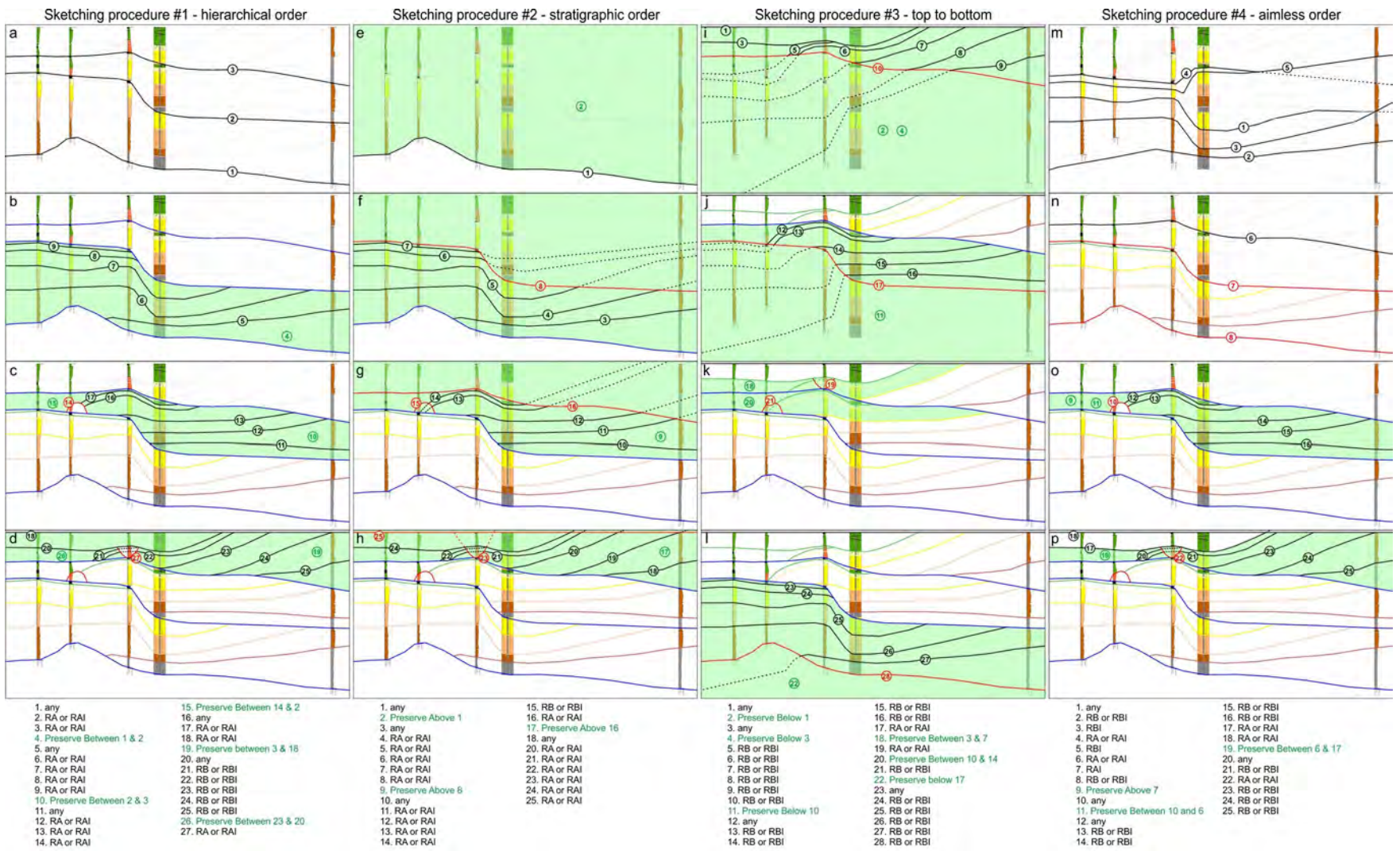
- Different correlations and interpretations are possible
- No complicated workflow – simple sketches allow to easily change the concept completely



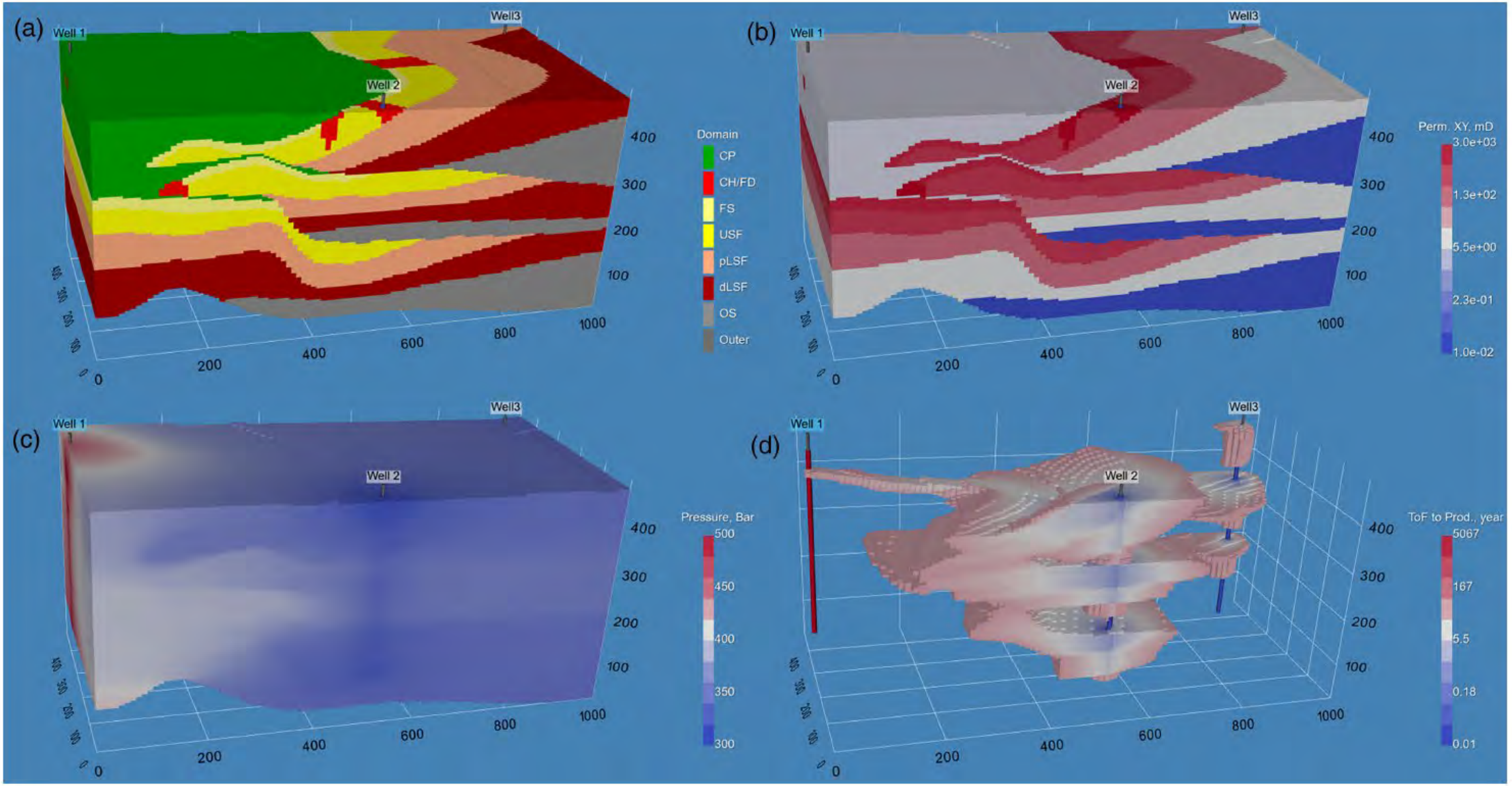


Example case study: Shallow marine correlation

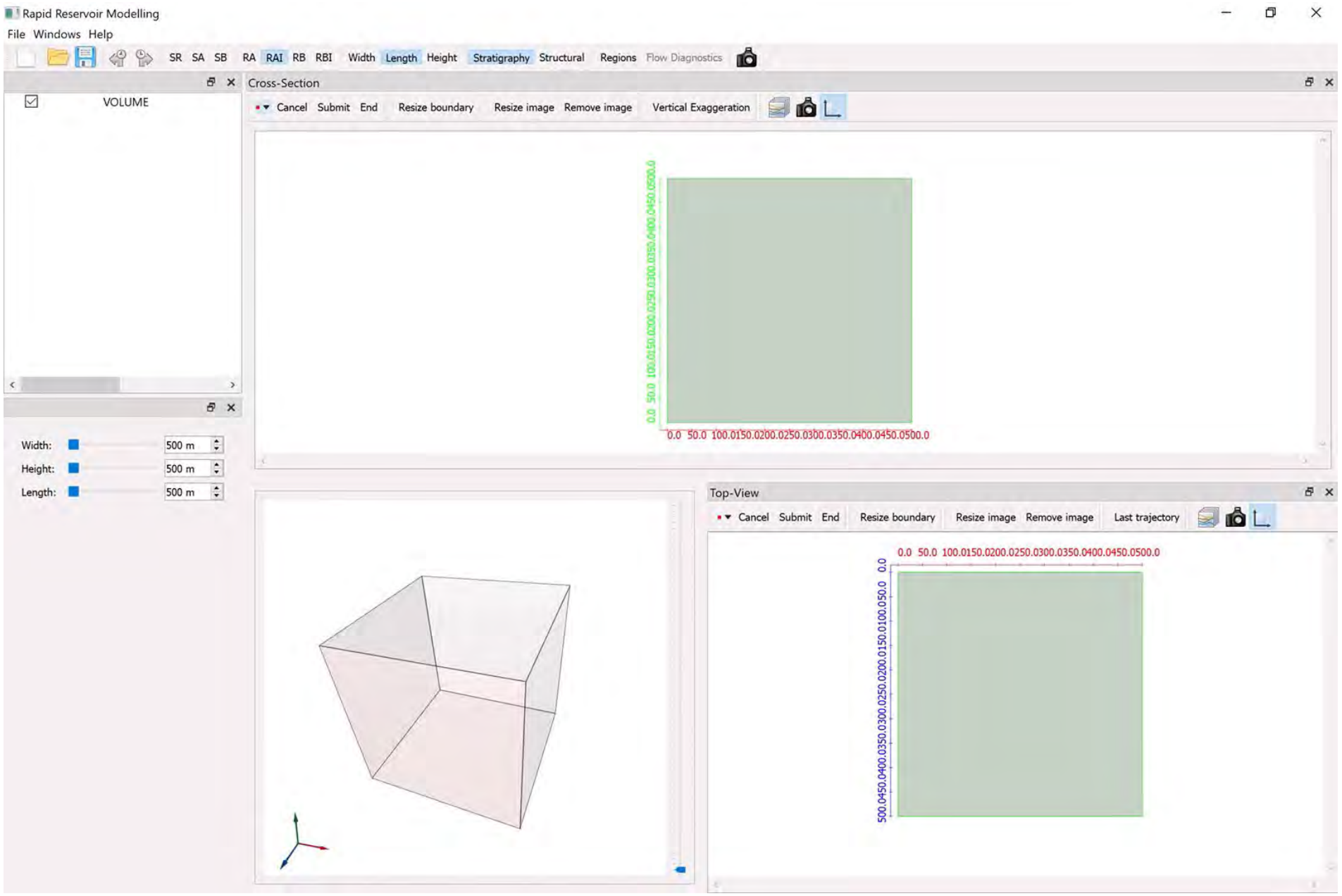
- Different correlations and interpretations are possible
  - *User experience and expertise*
- Different approach
  - *Top-down*
  - *Bottom-up*
  - *Flooding surfaces first*
  - *Obvious feature first*
  - *Hierarchically*
  - *…*
- Enabled by geological operators



Example case study: Shallow marine correlation

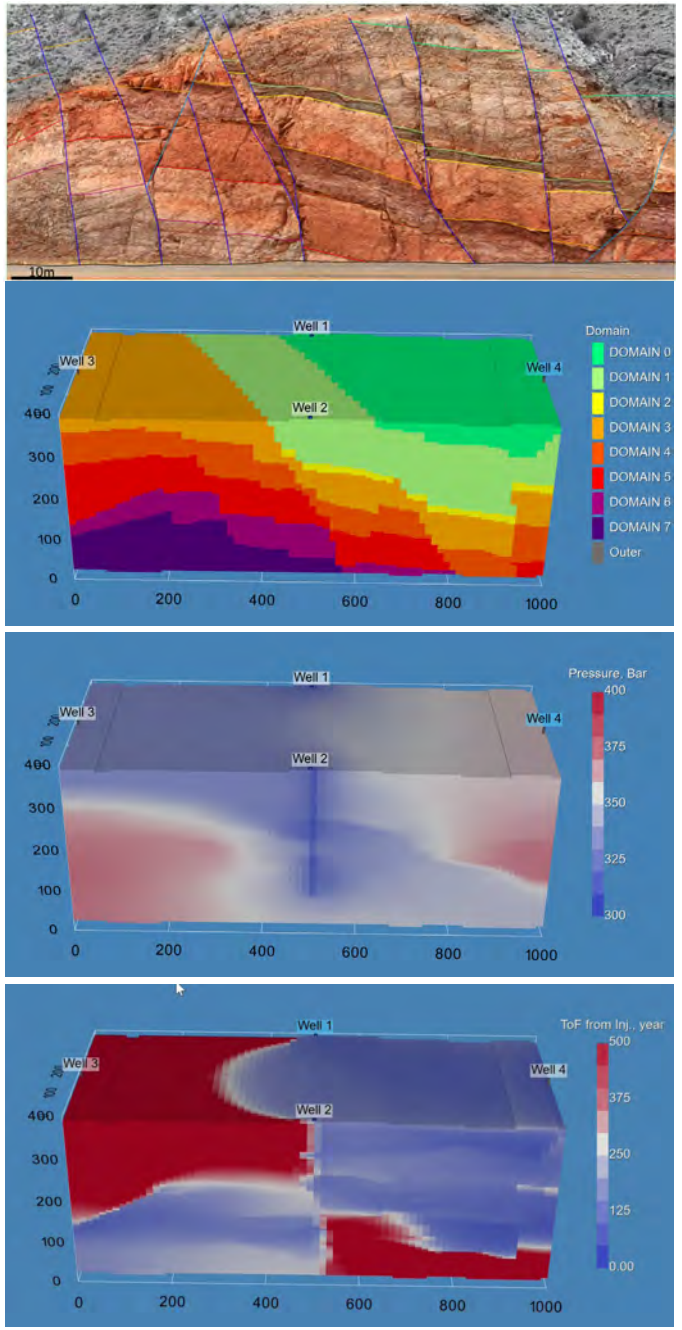


A real-time screen recording of RRM



Open source

- Rapid Reservoir Modelling has clear goals
  - *Model prototyping*
  - *Quantitative feedback on flow behaviour, e.g. for hydrocarbon, geothermal, CO_2 storage, or groundwater*
- Potential userbase is much larger
  - *Geoscience students discovering 3D relationships*
  - *During fieldtrips, directly interpret outcrops in 3D and understand impact on flow*
  - *Tool to communicate across disciplines with short turnaround times to link geology to fluid flow*
- Availability – please try it
  - *bitbucket.org/rapidreservoirmodelling/rrm*



Conclusions

- Prototyping tool for 3D geological modelling
  - *Intuitive sketch-based interface*
- Geological operators
  - *Flexibility of sketching in any order*
- On-the-fly application of operators
  - *Interpretation on the fly*
- Quantitative measures
  - *Facies proportions, volumes…*
  - *Flow diagnostics: real-time dynamic and quantitative feedback*