ATLAS

THE FASTEST GEOMECHANICAL SOLVER
FOR EXTREME-SIZE SIMULATIONS

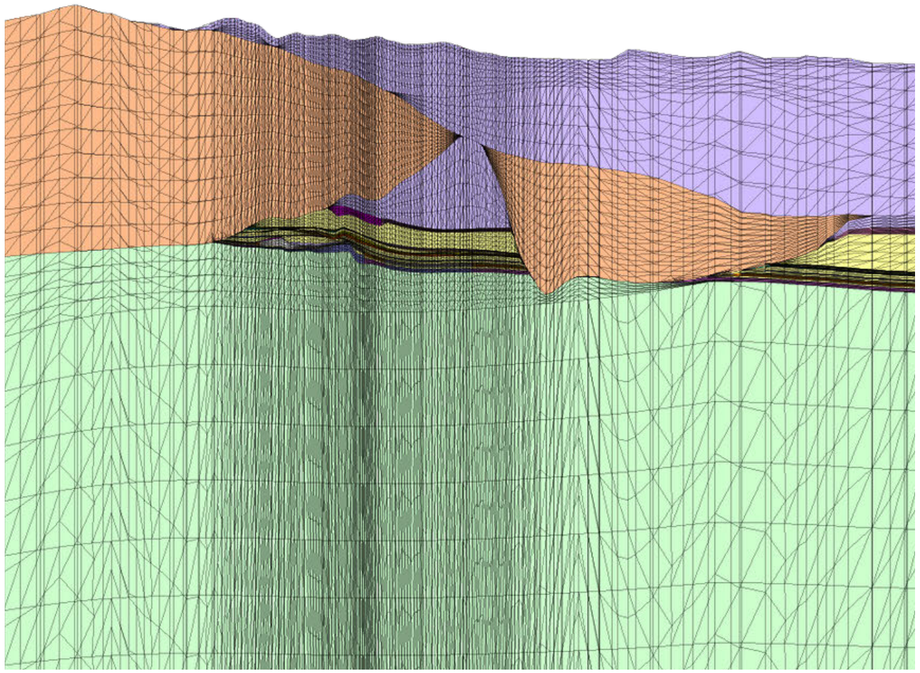
The product

ATLAS in a nutshell

ATLAS is a 3D Finite Element (FE) software, specifically tailored for **geomechanical simulations**. It is currently used for the simulation of land subsidence, rock integrity, fault activation, induced seismicity and many other relevant geomechanical processes related to the exploitation of subsurface resources.

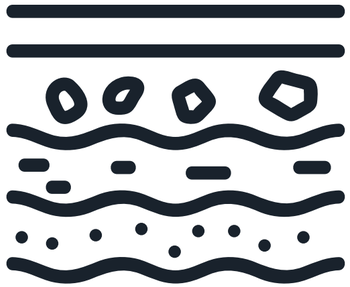
What makes ATLAS outstanding if compared to other available scientific software is its **speed and efficiency**: ATLAS is natively designed for **parallel supercomputers** and it takes advantage of **GPU-accelerated architectures**. Hence, it allows for easily simulating extreme-size domains with several hundreds of millions of elements.

ATLAS is designed and implemented as a computational kernel library (with API), without any preferred GUI. This makes ATLAS **compatible with every other existing computational workflow**. Its results can be visualized by any common Graphical Visualization tool, including opensource software such as Visit or Paraview.

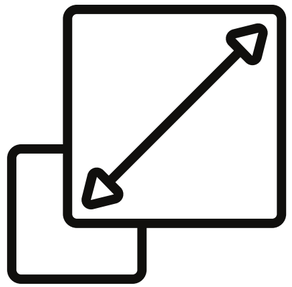


ATLAS AT A GLANCE

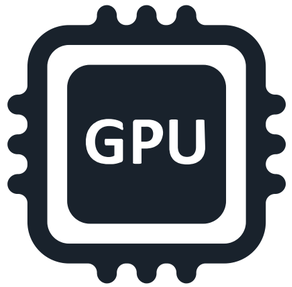
THE SECREAT SAUCE



Tailored for geomechanics



Scalable up to several milions of elements

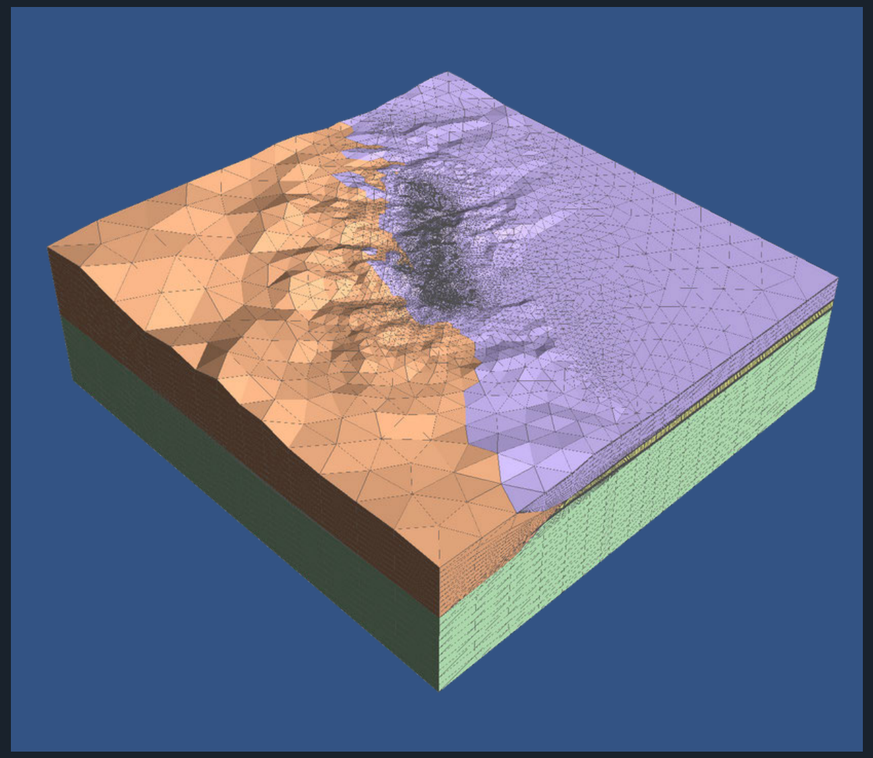


Natively GPU accelerated

Compatible with every workflow

GEOMECHANICS

The target of ATLAS

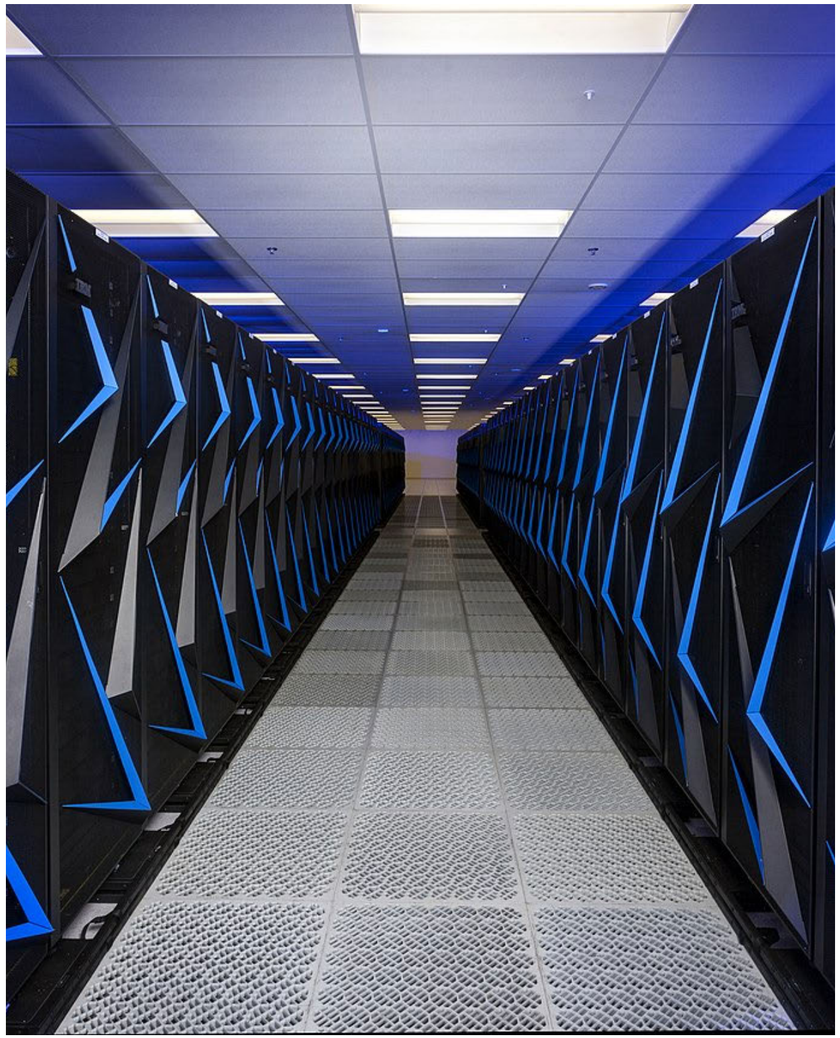


ATLAS is specifically tailored for **geomechanical simulations**. In particular, it is able to model every mechanical aspect related to the exploitation of subsurface resources, such as the withdrawal and injection of water, gas, oil, CO2 and so on.

ATLAS computes the most important geomechanical quantities associated with these operations: **surface displacements, stress and strain within the rock/soil layers, plastic and viscous deformations of the geomaterials, interface loads and sliding of faults.**

As far as geomechanical problems are concerned, the non-linear mechanical behavior of the material is a key aspect. ATLAS provides **several constitutive laws**: isotropic and anisotropic linear and non-linear elasticity, Drucker-Prager and Modified Cam Clay elastoplasticity, Vermeer-Neher viscoplasticity. Moreover, the modularity of the code allows for a quick implementation of other stress-strain relations.

Interface elements in ATLAS are modeled through a very robust formulation based on **Lagrange Multipliers**. These elements simulate the contact between the two side of the faults, assuming also **several non-linear friction laws** and allowing to take into account the accumulated stress due to an eventual fault sliding.



EXTREME-SIZE

Scalable up to hundreads milions of elements

ATLAS is specifically designed for the most modern **High Performance Computing** (**HPC**) and it is thought to be ready for the next generation **Exascale systems.**

At the heart of Finite Element (FE) software resides numerical linear algebra routines. When comes to the solution of extreme-size FE models, it is well known that, for large models, the most time consuming task (up to 95% of the total computational time) consists in the solution of the arising linear systems of equations.

ATLAS takes full advantage of Chronos, a proprietary collection of sparse linear algebra kernels designed for HPC. The library implements **best-in-class preconditioners** to incredibly accelerate the convergence, and is able to solve systems with hundreds of millions (or even billions) of unknowns.

Every innermost numerical kernels of ATLAS is highly optimized to increase the efficiency of the code.

FAST

A GPU-accelerated solver

ATLAS is natively implemented for **Graphical Processing Units** (**GPUs**).

GPUs have been originally used for gaming and 3D rendering. However, with properly designed algorithms, GPUs offer **incredible speed-up** also for scientific and numerical computations. This allows approximately a **10x speed-up** if compared with CPU-only based software.

Mainly written in Fortran and C++, ATLAS uses **openMP** directives for shared memory processing and **CUDA** to enable GPU accelerators. Interprocessor communication for distributed memory computation is accomplished through **MPI**. The library can be tailored and optimized for the specific computational architecture available, making ATLAS compatible with almost any modern HPC system.

Thanks to this dramatic reduction of simulation time, scientists and engineers can develop more accurate and reliable models, as well as investigate a broader range of scenarios.

COMPATIBILITY

Minimize the impact on the workflow

ATLAS is designed and implemented as a **computational kernel library** (**with API**), without any GUI. This allows ATLAS to be compatible with every other **existing computational workflow**, and its input/output can be fully adapted to the user requirements.

ATLAS has been currently connected to many other software solutions (ABAQUS, Eclipse, SKUA and so on). The results of ATLAS are available in standard format and can then be visualized through user-friendly visualization tools, including also opensource software such as **Paraview** or **Visit.**

For the above reasons, including ATLAS in new workflows requires a minimal effort and the results can be visualized and post-processed together with other existing simulation tools.

10 Billions

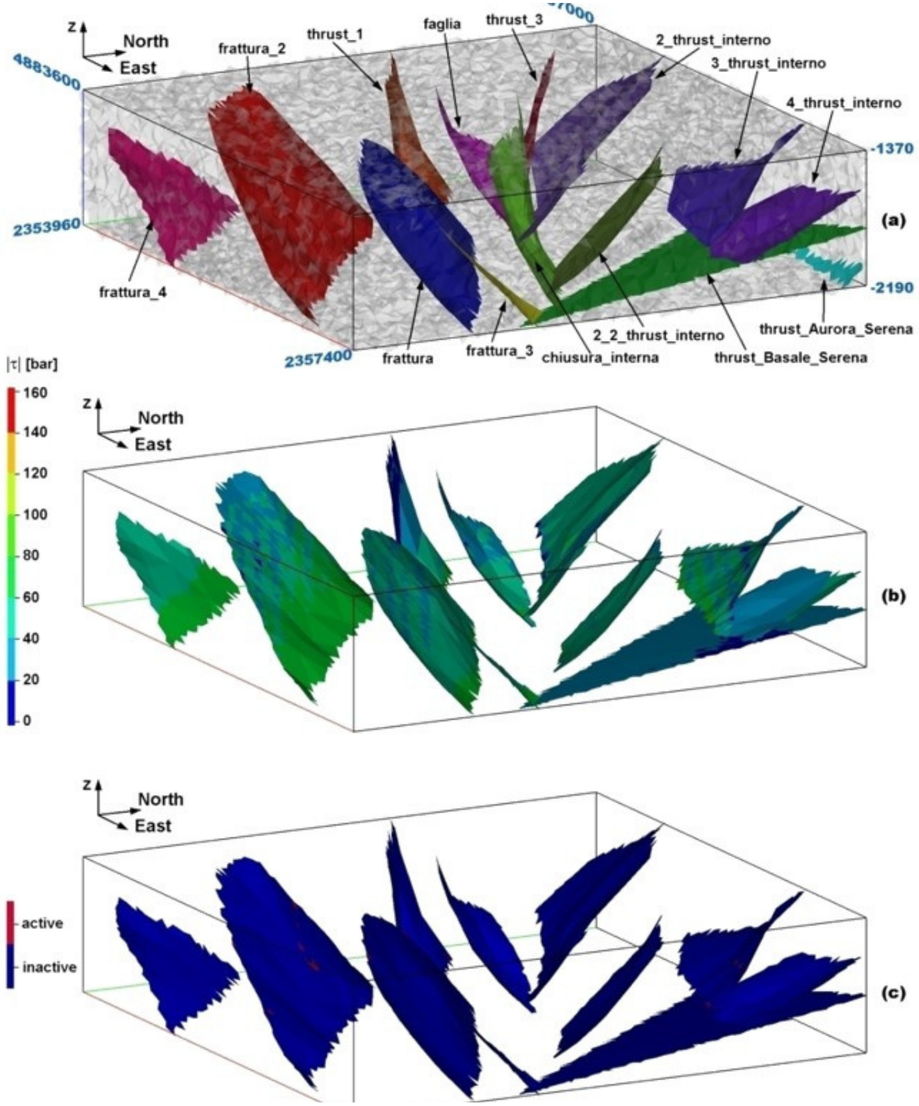
Number of elements that can be simualted

10x

Speed-up compared with CPU-only based software.

Selected test cases

APPLICATIONS AND PERFORMANCES



NORTH ADRIATIC BASIN

Fault activation due to CO2 storage

ATLAS has been used in several project to predict the geomechanical effects of CO2 storage.

The software computes the eventual activation of faults due to the variation of the stress condition within the soil layers. In particular, the active interface elements (those with a slip due to a stress variation) are identified.

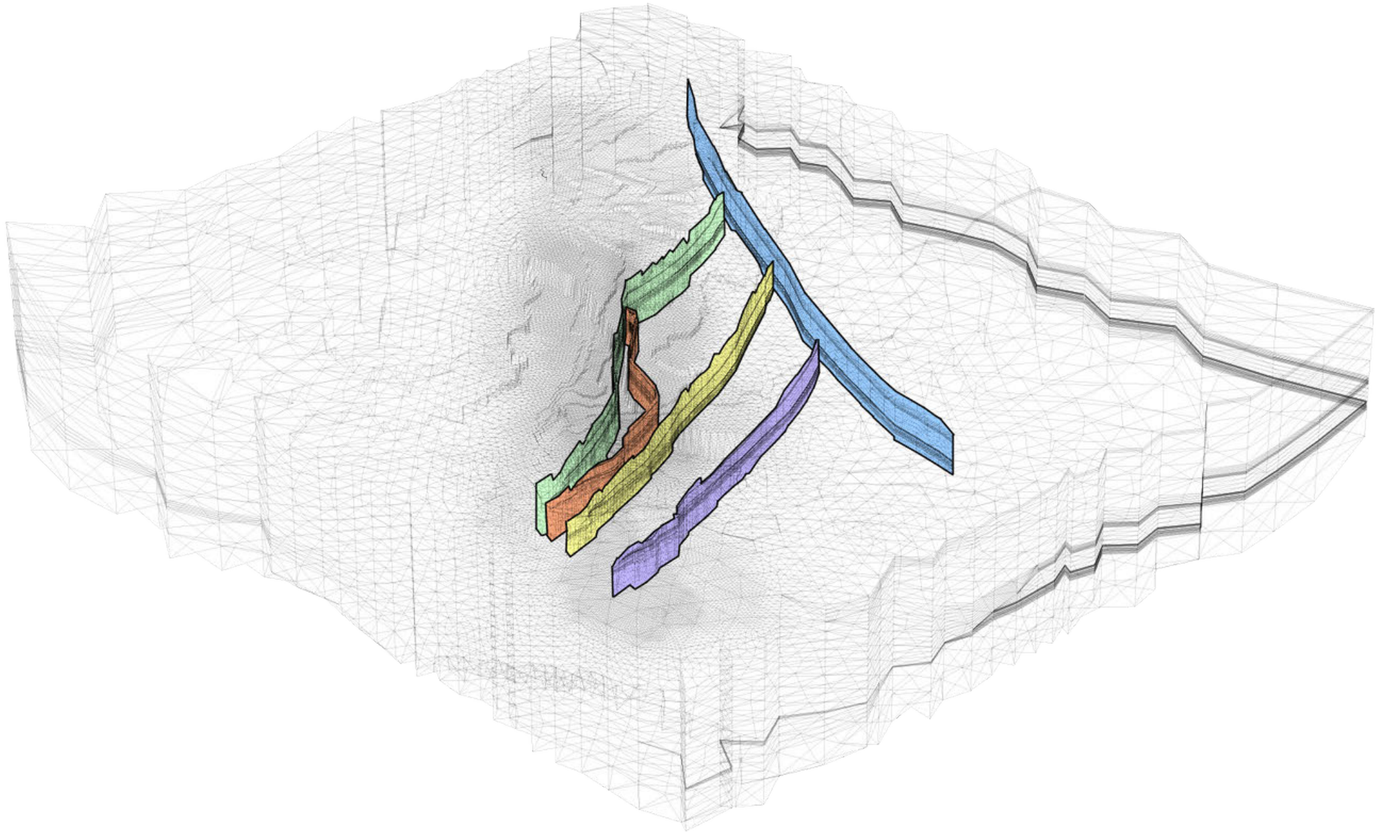
The software allows for investigating different scenarios and strategies of injection, in order to maximize the capacity and avoid any environmental impact.

OIL&GAS RESERVOIRS

Geomechanical effects of seasonal gas storage

ATLAS has been used in several projects to predict the geomechanical effects of seasonal gas storage on depleted reservoirs.

The software computes the subsidence, the stress increase in the reservoir rock, in the caprock and in sorrounding soil laye layer and the stability of the intersecting and surrounding faults.



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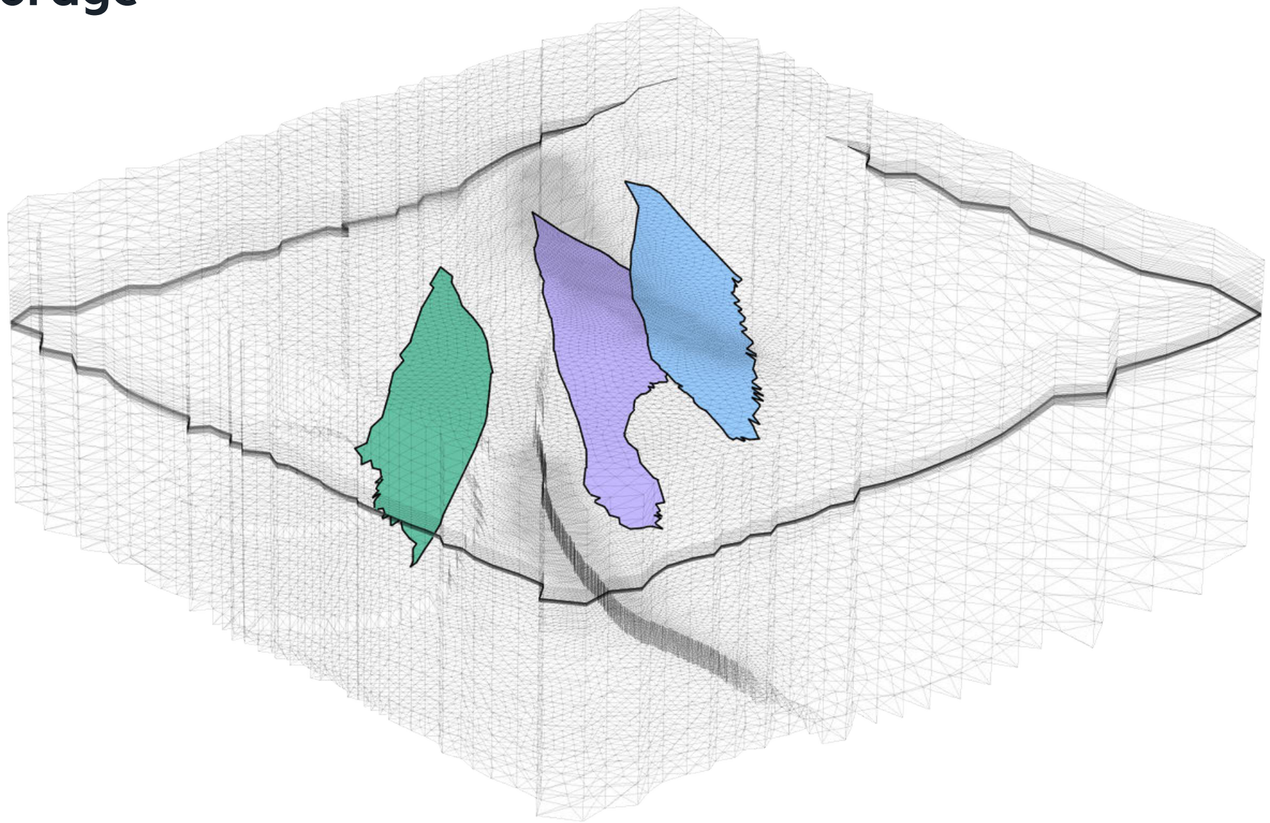
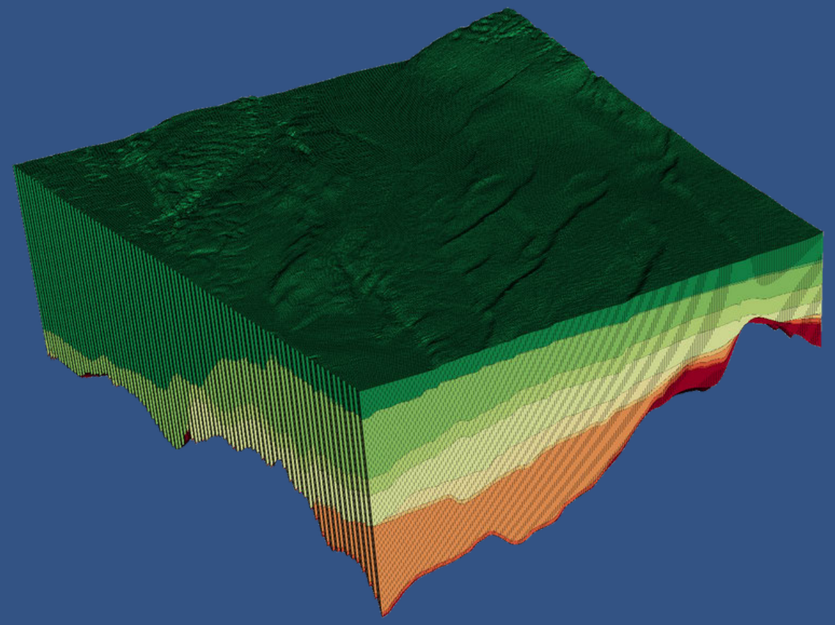
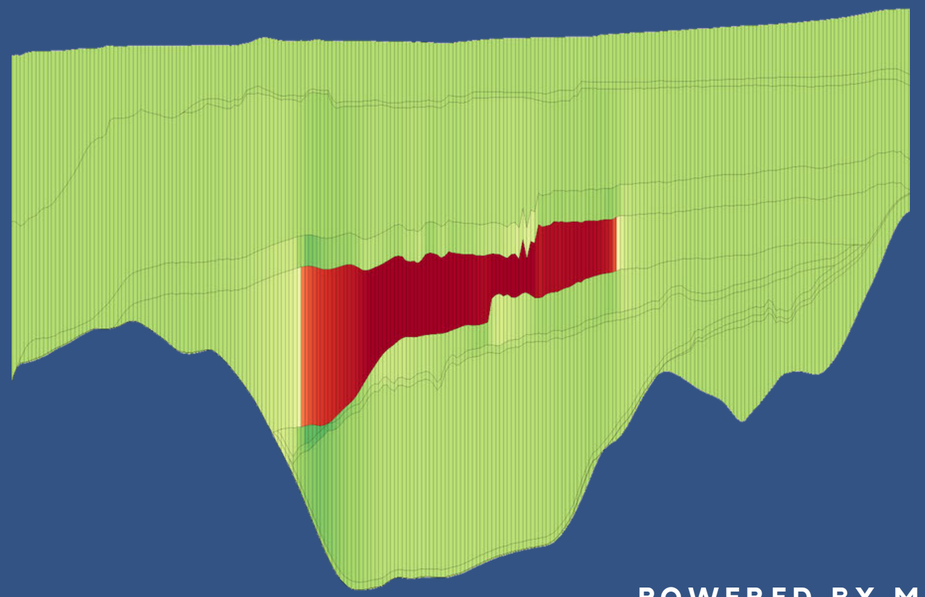


OIL&GAS RESERVOIRS

Complex geometry

ATLAS is able to simulate complex geometries, with several strata and layer intersections. The software con handle structured and non-structured computational grids, which is an essential feature to model real geological formations.





Company Profile

Who we are

MATHEMATICAL METHODS and MODELS for ENGINEERING

M3E is the acronym for **Mathematical Methods and Models for Engineering**. The company focuses on numerical modelling and algorithms development for the solution of challenging problems in several engineering sectors.

M3E combines high competences in mathematics and computer science together with an extensive knowledge in engineering, to provide support and consultancy to top engineering firms. In particular M3E is specialized in the development of software for the numerical discretization of partial differential equations, linear algebra, trials scheduling, optimization, data analysis, High Performance Computing and Machine Learning for several engineering applications.

Along with the software, M3E also offers consulting services for surface and underground environmental processes, management of water resources, transport and diffusion of contaminants in fresh water aquifers, exploitation of oil and gas reservoirs, subsidence and its possible mitigation, air pollution diffusion, simulation of industrial process. M3E is the ideal partner to develop unique models and algorithms to solve the most challenging problems.

CSQ IQNet CERTIFIED MANAGEMENT SYSTEM
azienda con sistema di gestione per la qualità certificato
ISO 9001:2015

Member of TechNetAlliance

ETP 4 HPC

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