High Performance Computing Oil and Gas Industry

The way to open new opportunities

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Upstream Technology Unit

Introduction- Repsol Organization

LNG

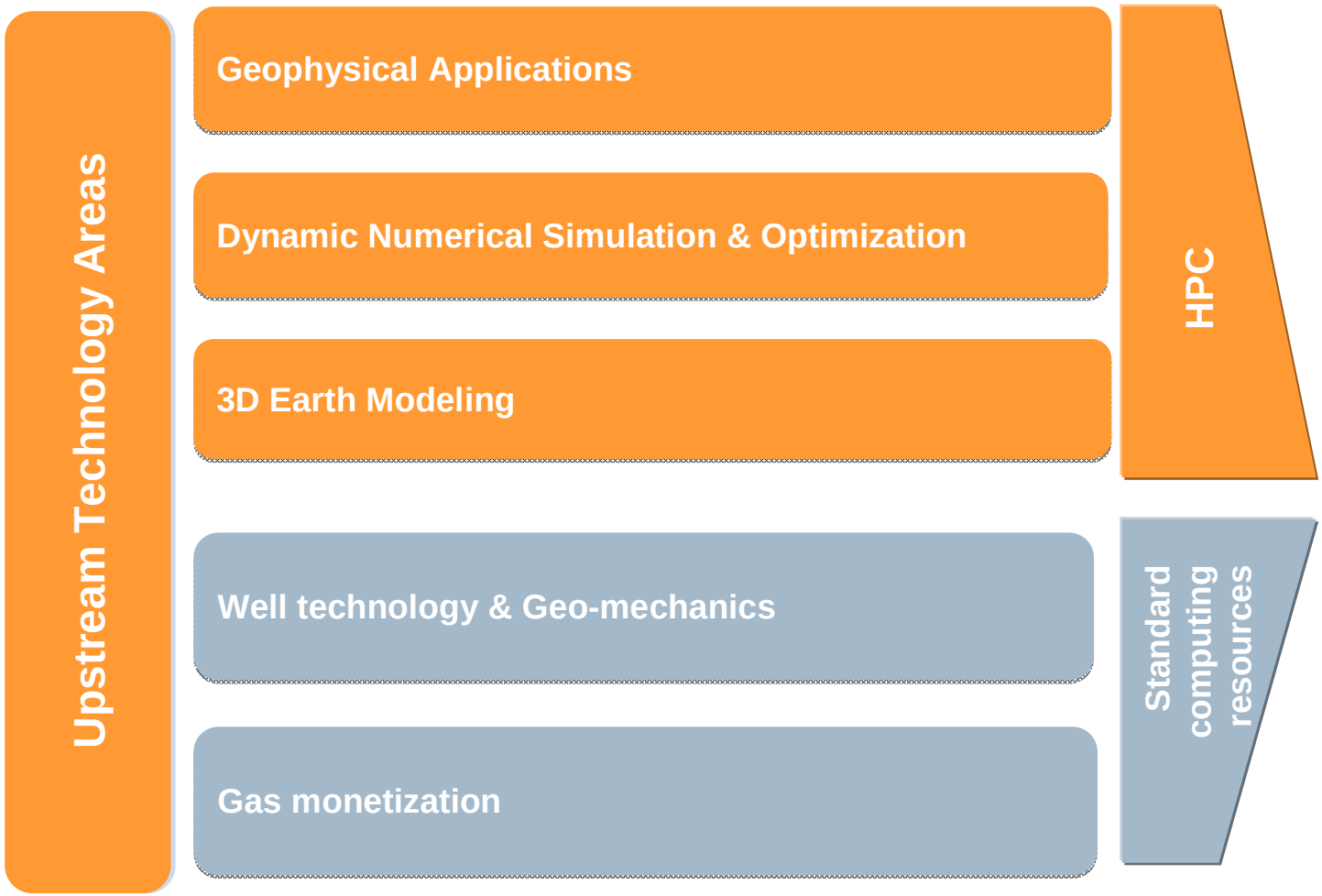
Exploration and Production

Refining

Enviroments

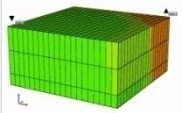
New energy

Introduction

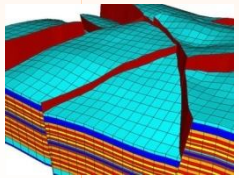


Modeling Evolution

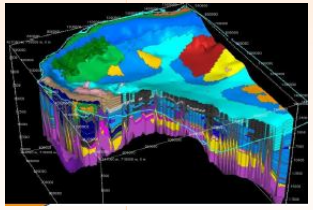
Homogeneous models
Tank Model, Black Oil, cartesian



Numerical models-
Unstructured grids
(PEBI)



Parallel simulations that allow to capture detailed geological heterogeneity at relatively fine resolution



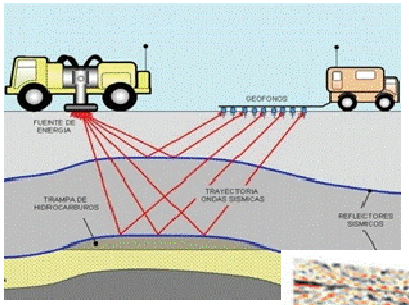
The size and complexity of reservoirs push at the limits of computer technology

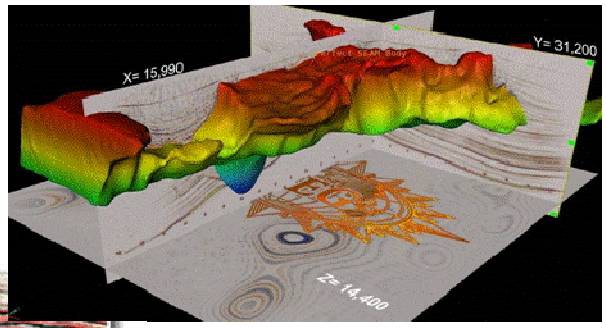
1980 1990 2000 2010 2020

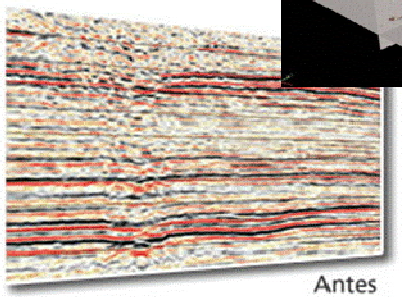
High Performance Implementations of Geophysical Applications

- HPC/Modeling seismic
  - Provide datasets to test algorithms for imaging and inversion

    i.e., datasets for models that represents complex earth structures and physical parameters, where the true inversion results is known
  - Modeling seismic exploration at full scale
  - Better understands features and artifacts in resulting images





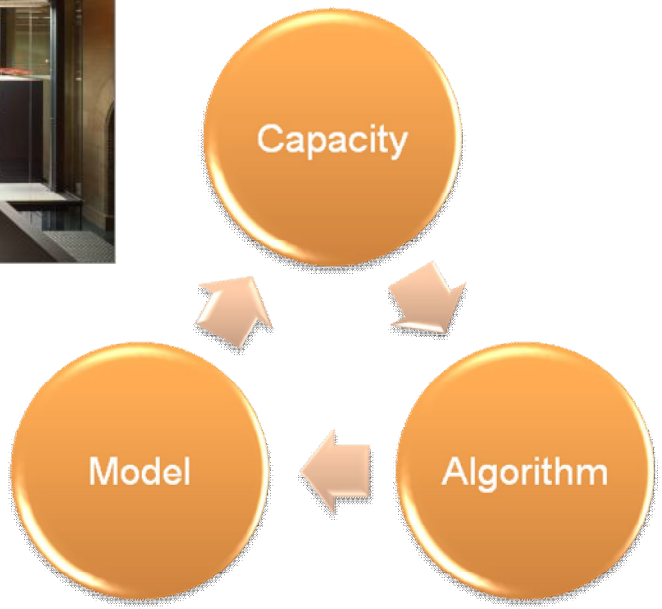


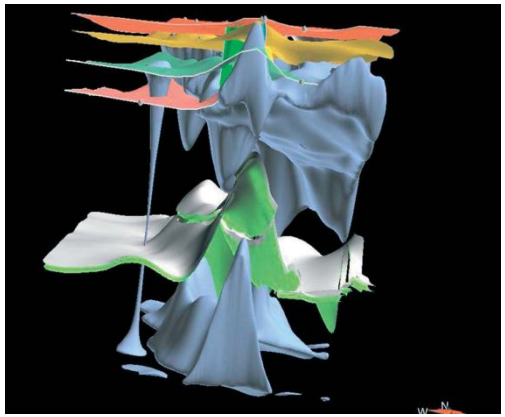
Seismic Interpretation

Caleidoscopio Project

- Caleidoscopio project:
  - Goal: To develop new tools able to process seismic images 15 times faster than other companies in the sector in order to develop new fields in a Gulf of Mexico. (57.000 MMBls)
  - Constrains
    - The algorithms for seismic modeling are not universal depend on the production area.
    - The seismic dataset of data acquisition are around 15 Terabytes.
    - Difficult scenario: deep water and HCs trapped salt.

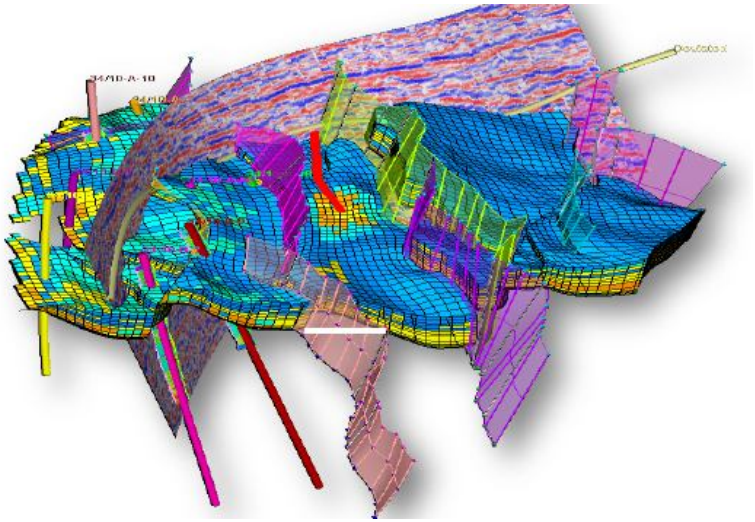
Caleidoscopio Project





Challenge for Seismic Modelling

- A grand Challenge for Seismic Modeling
  - Produce a code and hardware that computes a modern 3D seismic dataset in less time than it takes to collect a 3D seismic dataset.
  - The earth is heterogeneous on all scales. The main limitation to explore and to exploit underground resources in a sustainable way



Dynamic Numerical Simulation & Optimization

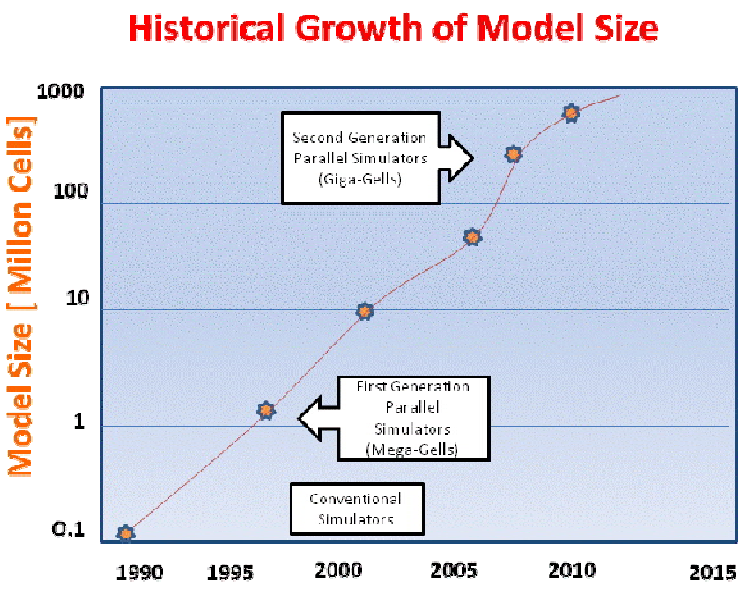
Dynamic model integrate geological data and seismic attributes which allow to optimize well locations and field production plan.

- Based on Darcy's equation:

  Multiphase flow through porous media and discrete flow equations for fluid pressure field and phase saturations

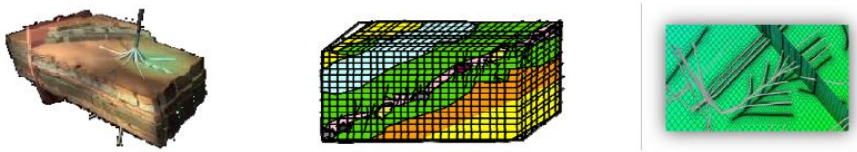
- Solve the PDEs by IMPES schemes

- Simulation with a large number of cells:
  - Industry is moving toward billion cell models
  - Requires very large supercomputer installation
  - Up-scaling can reduce the computational



Giant Field of Saudi Arabia

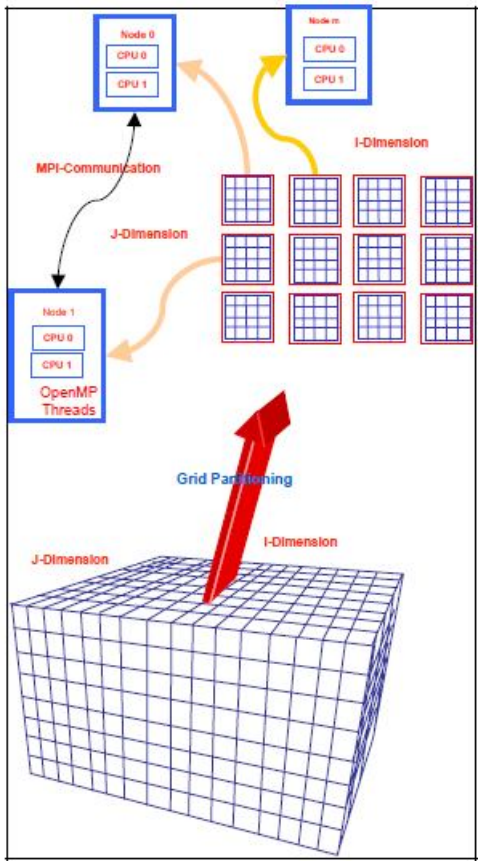
- Giant Field of Saudi Arabia
  - Goal: To develop a tool to capture important features of geologic description with minimal affect of upscaling.
  - Constrains
    - There are typically multimillion cells in an average reservoir model due to the size of the reservoir.
    - The simulation model contain features, such as fractures, maximum reservoir contact wells (600 wells) etc.

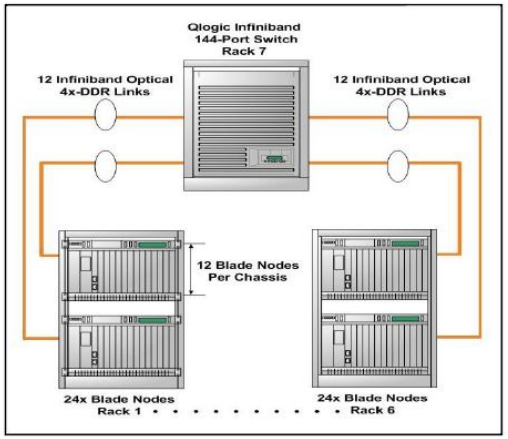


(a) Physical model (b) Simulation model (c) Details of simulation model

Giant Field of Saudi Arabia

- Alternative based on HPC

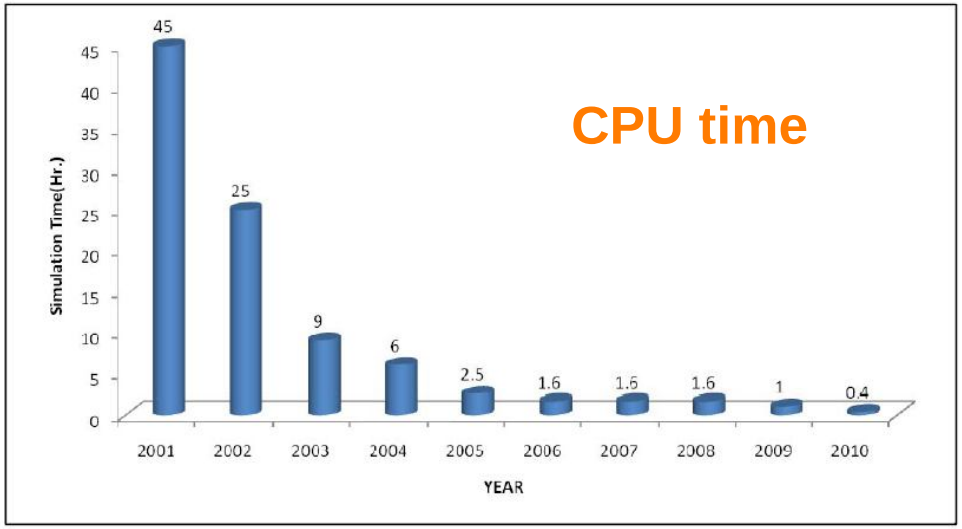




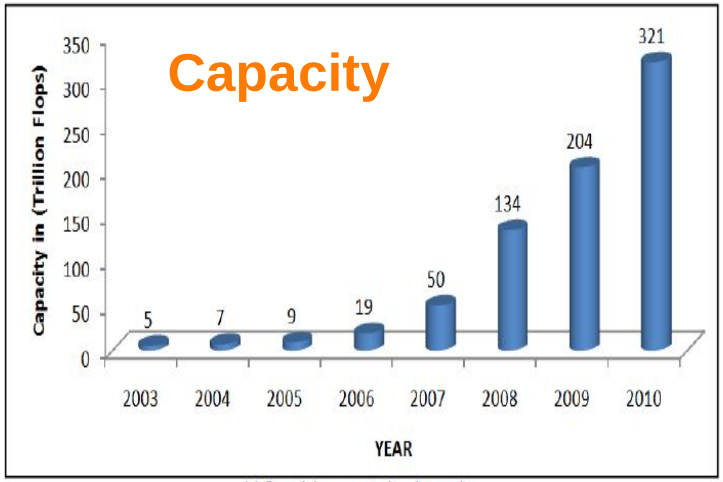
Source SPE 141402

- The cluster consists of 3,200 compute nodes with dual sockets and Intel Quad Core X5570 2.93Ghz processors.
- Each node has 12 GB DDR3 1.333 Mhz of Memory (Total of 1.5 TB)

Evolution of Simulation



Simulation time for a 10 million cell reservoir model.

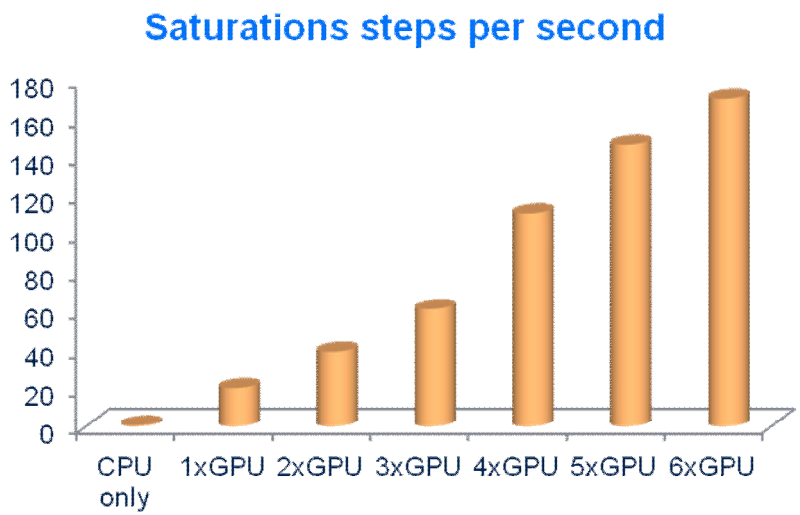


(a) Growth in computational capacity.

(b) Growth in storage capacity.

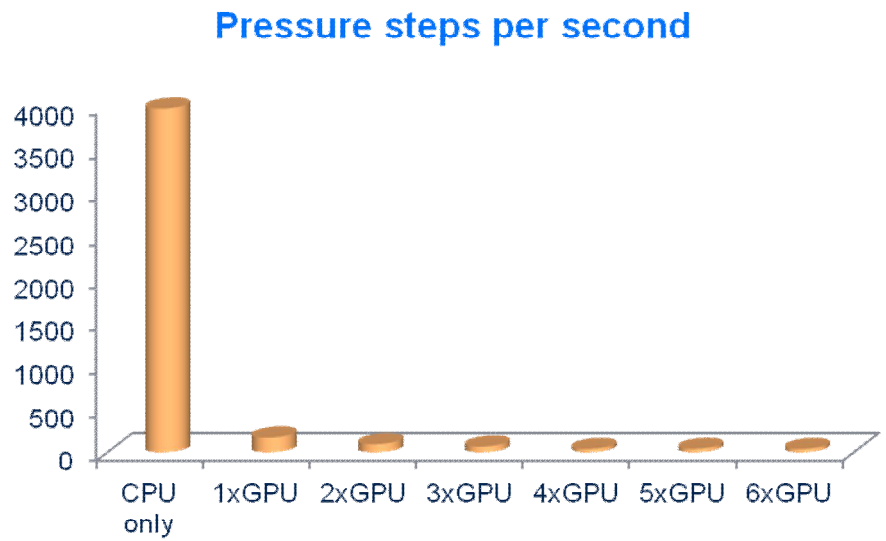
Source SPE 141402

Reservoir Simulation with GPUs



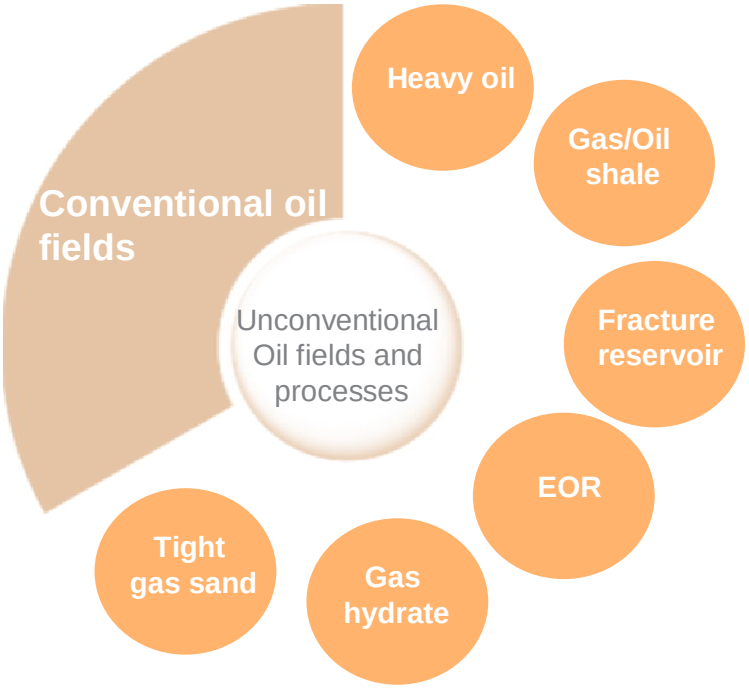
In CPU code, saturation steps are the bottleneck

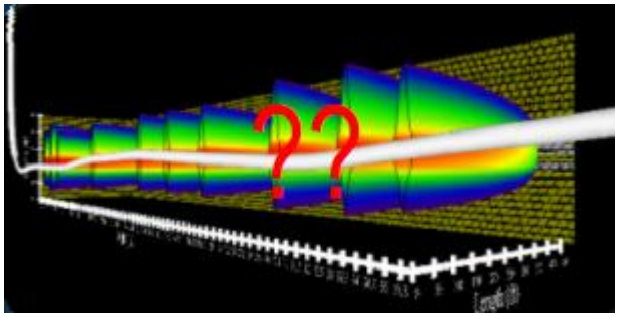
Pressure solves take much longer than saturation updates



If done properly, saturation updates are a very good fit for GPU acceleration

Unconventional Oil Fields and Processes





- Orders of magnitude reduction in perm require orders of magnitude increase in reservoir contact.
- New High Performance Computing Techniques are required to develop these reservoirs such as dual porosity etc.

Others Critical Areas that Required HPC

1. Field development plan Optimization

Develop a new technique that Optimize Production Scheme Planning avoiding risk and performing decision making under a uncertainty range (achieving the objective function the global minimum)

2. The "All in one" integrated Smart Dynamic Model

Integration in one model all data from G&G and Reservoir Engineering using differents tools and methodology, and flexible and adaptable to changes and variations (Not anymore Static but time variant). Optimization and event solution concepts. Grid concept Optimization and automatic upgrade of earth model with new wells information.

3. Surface/sub-surface integration (S-SS modeling)

Integrate a complete interactive Near wellbore, 3D Field & Surface facilities models in order to provide a powerful support to make assertive decisions

Conclusions

- Complexity of reservoirs push at the limits of computer technology.
- Seismic modeling is invaluable tool to characterize complex reservoirs, and its future is intimately associated with HPC.
- Supercomputers are increasingly necessary to model Unconventional Oil fields and processes.
- Futures critical areas in dynamic numerical simulation requires HPC
- HPCs in the oil and gas industry have become a must.
- Challenges in Algorithms, Accelerators, Programming models, tools, power consumption, memory managements, etc
- The way to open new research opportunities at the CTR

REPSOL

Inventemos el futuro