ECHELON

CASE STUDY // KABOSU

FEBRUARY 28, 2022

BREAKTHROUGH IN RESERVOIR SIMULATION: ECHELON TACKLES AN EXTREMELY DIFFICULT COMPOSITIONAL MODEL

250

WELLS

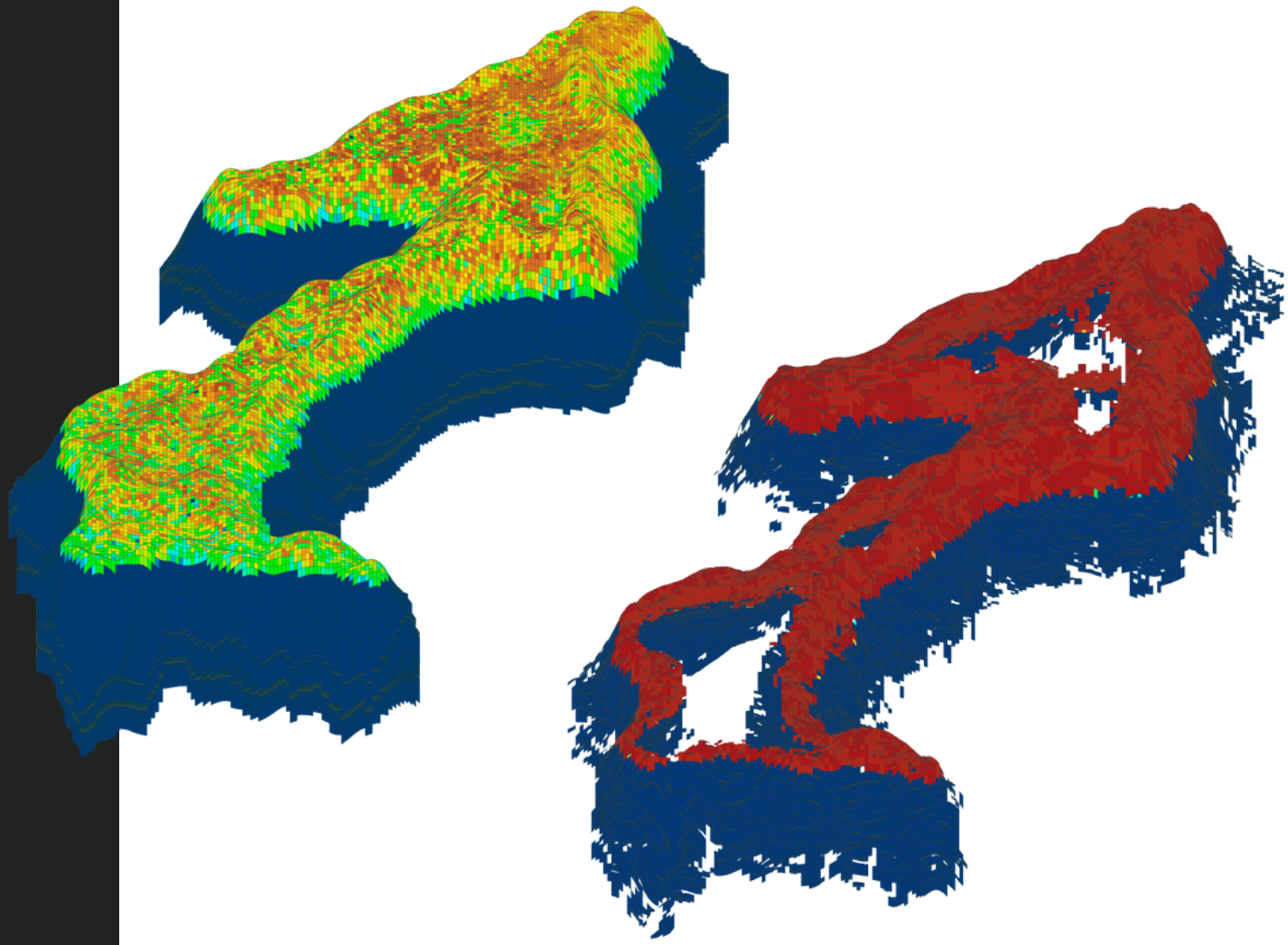
130

YEARS OF FORECAST

9

COMPONENTS

ECHELON CASE STUDY 04: KABOSU

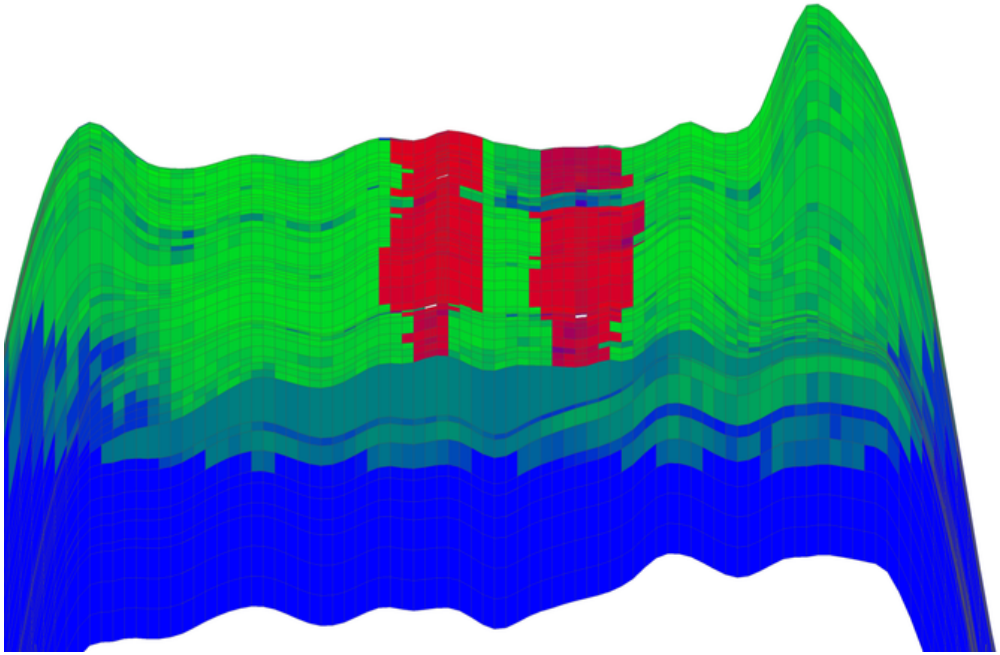


Initial water saturation in the matrix (left) and fracture media (right). Blue:1; Red:0. Note: The model presented is derived from the one presented by Panfili et. (2012).

This case study has been prepared from the material of "A Graphics Processing Unit–Based, Industrial Grade Compositional Reservoir Simulator, SPE-203929-PA, SPE J. (2021)"

CHALLENGE

The Kabosu field is as complex as it gets to simulate, combining advanced physics, challenging geology and complex field management strategies.



Ternary saturation profile of a field cross-section (Red: gas; green: oil; blue: water). Local grid refinements around two gas injectors can be noticed.

The challenge is to simulate Kabosu in the shortest possible time and limited hardware resources, without sacrificing results or accuracy. In particular, the end-goal is to perform iterative sensitivity studies requiring ensembles of model realizations within the same working day.

THE PHYSICS

Kabosu is a highly undersaturated oil asset, but a full compositional description is required to account for partial reinjection of produced sour gas under first-contact miscible conditions, and to treat the full 130 years of forecast where the bubble point is reached.

THE GEOLOGICAL MODEL

The field is a carbonate platform surrounded by a naturally fractured rim, represented by a dual porosity and dual permeability grid with 1.4M active cells, including local grid refinements around two gas injectors (not shown) noted by the fine gridding in the high gas saturated areas.

THE FIELD MANAGEMENT

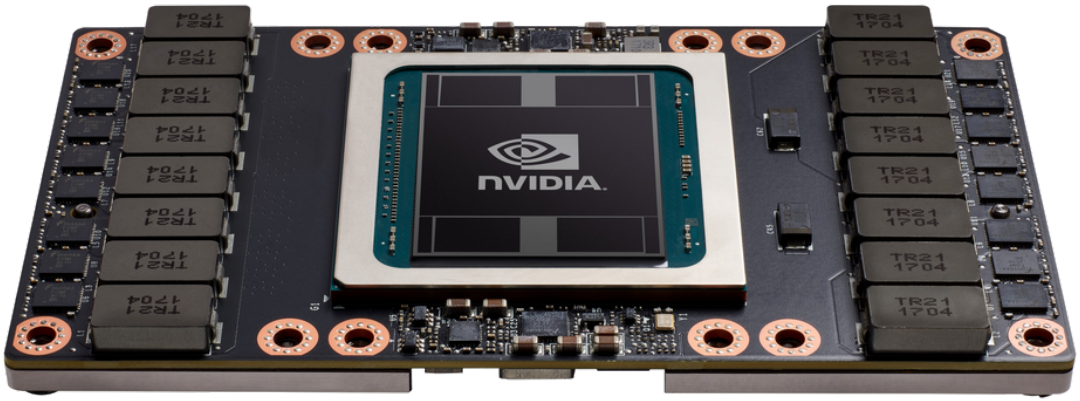
There are an aggregate of 250 producers and gas injectors; oil production is dynamically limited by the amount of available gas (production minus sales) that can be reinjected.

SOLUTION

The solution is to use the recently released ECHELON 2.0 reservoir simulation software. One of its key features is a compositional formulation which was planned, designed, implemented and rigorously tested over the last several years by the teams at SRT and Eni. As with its black-oil formulation, which has set the bar for industry performance, ECHELON's compositional formulation was created from inception to make full use of the GPU's capabilities and resources, optimizing for memory bandwidth, storage and FLOPS.

ECHELON 2.0. is commercialized with fully implicit (FIM) and adaptive implicit (AIM) formulations. It supports most reservoir and field management options available in legacy reservoir simulators, with the exceptional performance you expect from ECHELON. The software uses industry-standard input and output formats, and is therefore compatible with well-known pre and post-processing tools; adoption is a seamless task.

ECHELON 2.0 also has the unique feature of natively switching between injectivity-limited production and productivity-limited injection, whichever is more constraining, specifically developed by Stone Ridge Technology and Eni S.p.A. for this reservoir model.

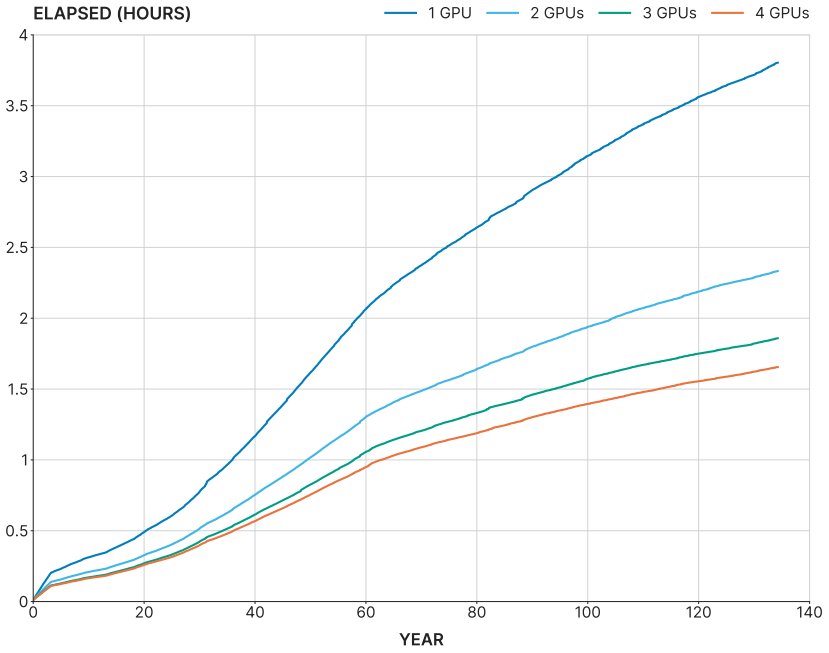


The NVIDIA V100 used by ECHELON to run the Kabosu compositional simulation model.

RESULTS

The Kabosu model was run on one of SRT's compute nodes with 4x V100 GPUs and 2x Intel 4114 silver CPUs (10 cores each). Results using 1, 2, 3, and 4 GPUs are presented below and on the following page. Model turn-around in around 2 hours allows multiple engineering iterations within a workday, enhancing productivity.

The results further demonstrate that full ensemble workflows are practical even for highly complex models such as Kabosu. Engineers are now at liberty to consider adopting an even higher-resolution model, especially with the latest Ampere GPUs which further boost performance.



Elapsed time vs. simulated time for the Kabosu model ran with ECHELON on 1, 2, 3, and 4 NVIDIA V100 GPUs.

OUTSTANDING PERFORMANCE

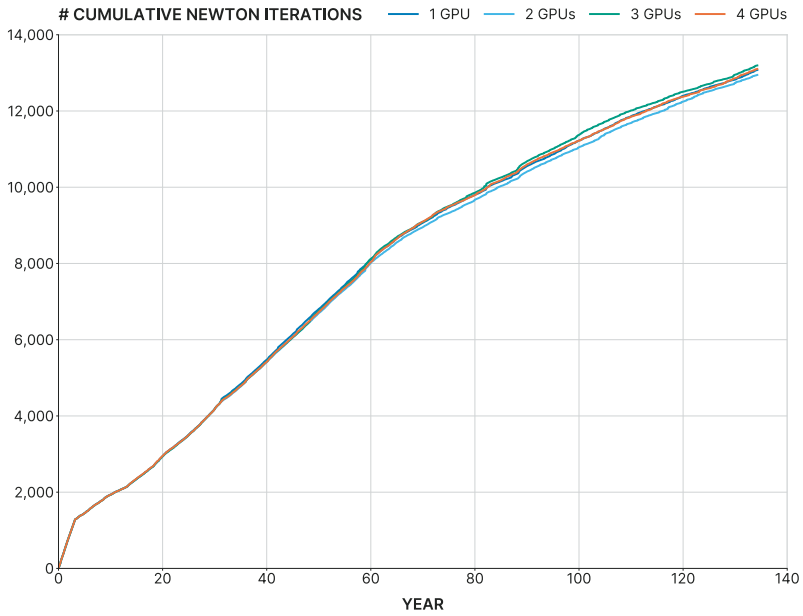
Strong scaling from 1 to 2 GPUs is 1.7x, and from 2 to 4 GPUs is 1.4x

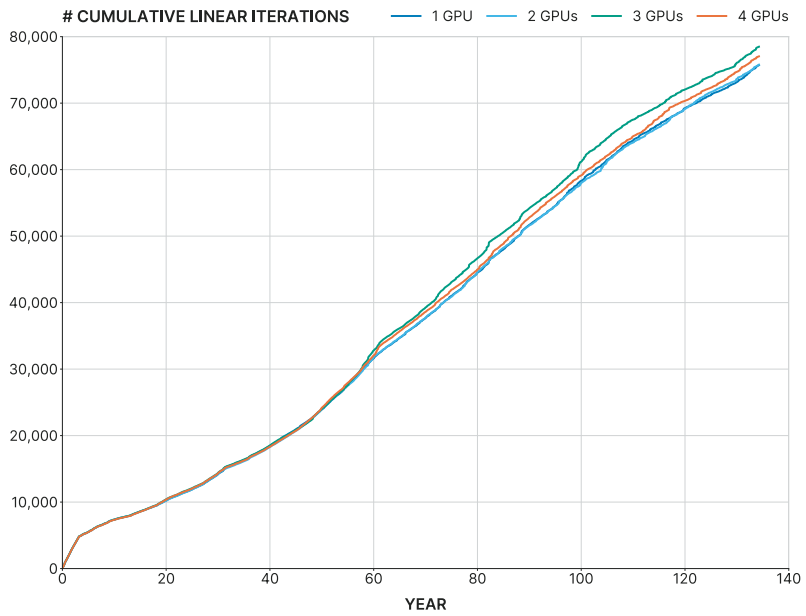
ROBUST NUMERICAL STABILITY

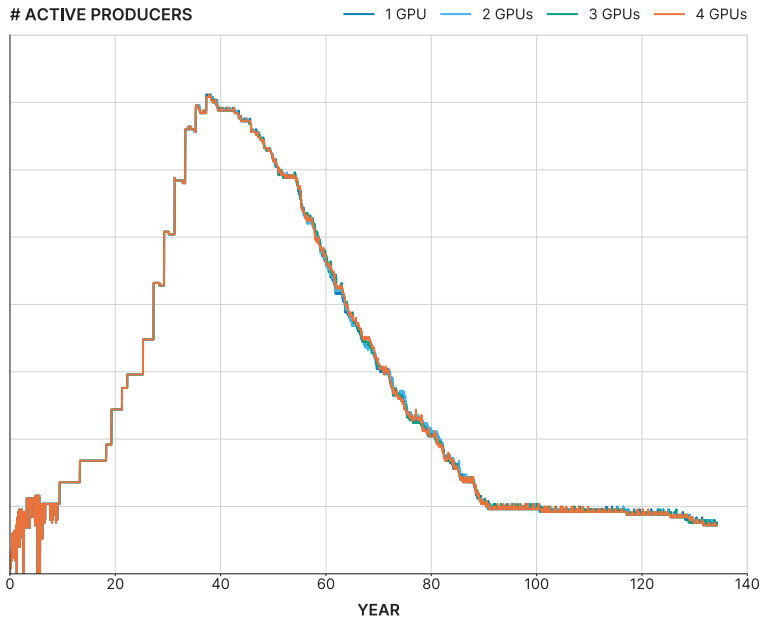
The cumulative number of Newton and linear iterations is almost unaffected by the GPU count, demonstrating the robustness of our formulation, the scaling properties of multigrid preconditioners, and the reliability of our heuristics for time-step selection and convergence criteria.

COMPLEX FIELD OPERATIONS

The number of wells producing at a given point in time, particularly in the tail, is essentially unaffected by the GPU count. The tail period is the most challenging part of the forecast as most wells are on THP control and producing below the bubble-point. This further confirms the robustness of ECHELON 2.0 software.







Cumulative number of Newton and linear iterations, and number of flowing producer wells vs. simulated time, for the Kabosu model ran with ECHELON on 1, 2, 3, and 4 NVIDIA V100 GPUs.

Panfili, P., Cominelli, A., Calabrese, M., Albertini, C., Savitskiy, A., and Leoni, G. (2012). Advanced upscaling for Kabosu reservoir modeling. SPE Reservoir Evaluation and Engineering, 15(02):150–164. SPE-146508-PA.

We thank Eni S.p.a for the permission to publish the data contained in this case study.

STONERIDGETECHNOLOGY.COM