Integrating Local Grid Refinement (LGR) into the Simulation Workflow

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Summary

- Overview
- LGR OPM Team
- Integrating LGR into Visualization Output
- Integrating LGR into Simple Well Models
- Conclusions & Next Steps

Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Overview

Purpose of This Work:

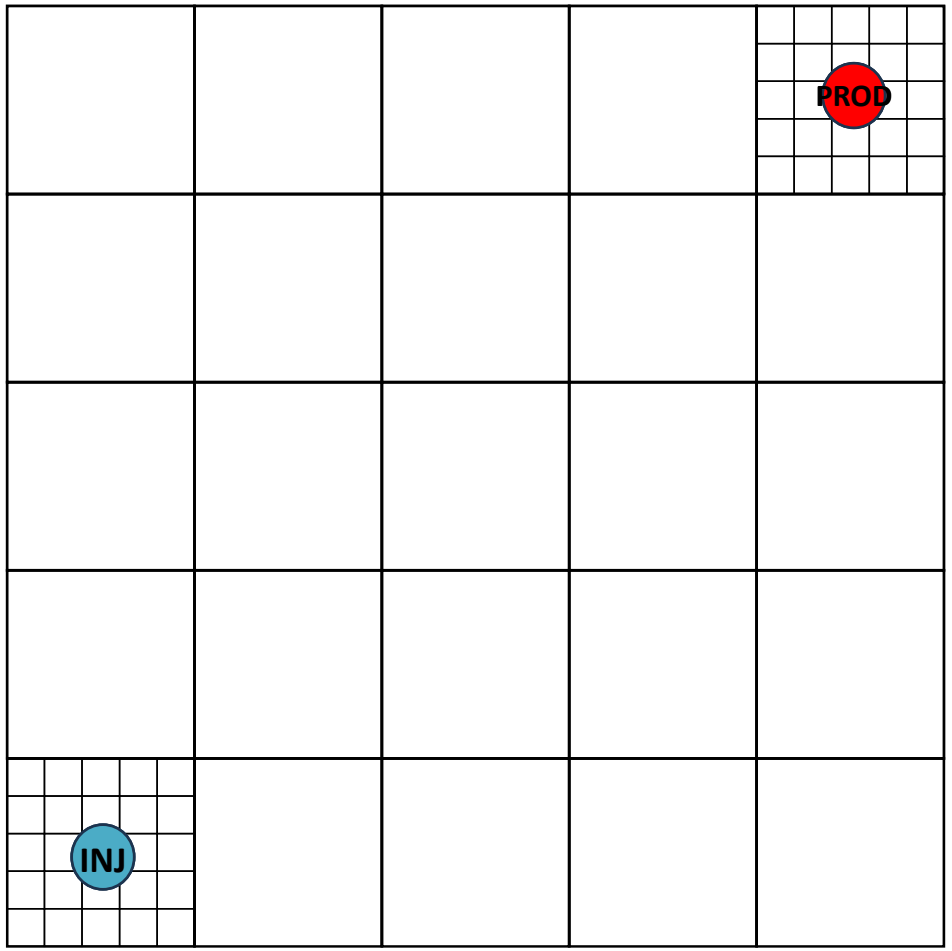
- Integrate the **Local Grid Refinement (LGR)** framework into the OPM simulation and visualization workflow.

Main Objectives:

- **LGR Well Model**: Achieve high resolution in the near-well region without refining the global grid.
- **LGR ResInsight Compatible Output**: Extend output routines to support LGR structures and enable seamless visualization in ResInsight

History:

- LGR simulation only possible without LGR wells.
- Outputs exclusively in VTK



Integrating Local Grid Refinement (LGR) into the Simulation Workflow

LGR OPM Team

TNO Team – LGR Integration:

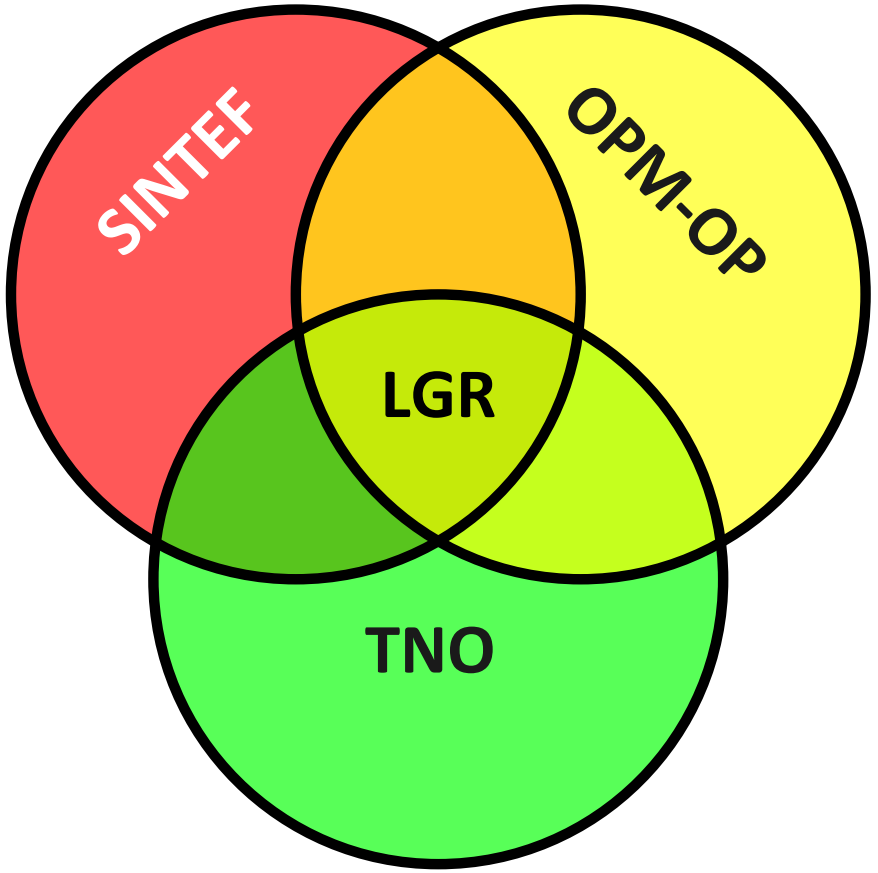
- Negar Khoshnevis
- Artur Castiel
- Eduardo Barros

OPM-OP – LGR Core:

- Blatt, Markus
- Ritorto, Antonella

SINTEFF – Senior Developer:

- Bård Skaflestad

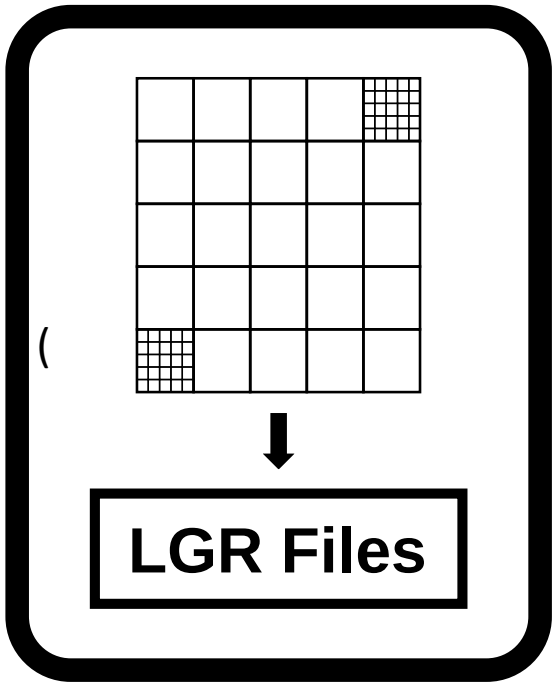


Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Visualization Output

What is Needed for OPM to Produce Visualization for LGR compatible with Reference Simulator?

- **EGRID:** Geometry description of the grid structure including the LGR blocks
- **INIT:** Initial state with LGR-aware indexing.
- **UNRST:** Restart file for visualization purposes (outputting) including LGR state*
- **(OPTIONAL)**: LGR Summary files and others



*Implementation of UNRST has not yet started.

Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Visualization Output

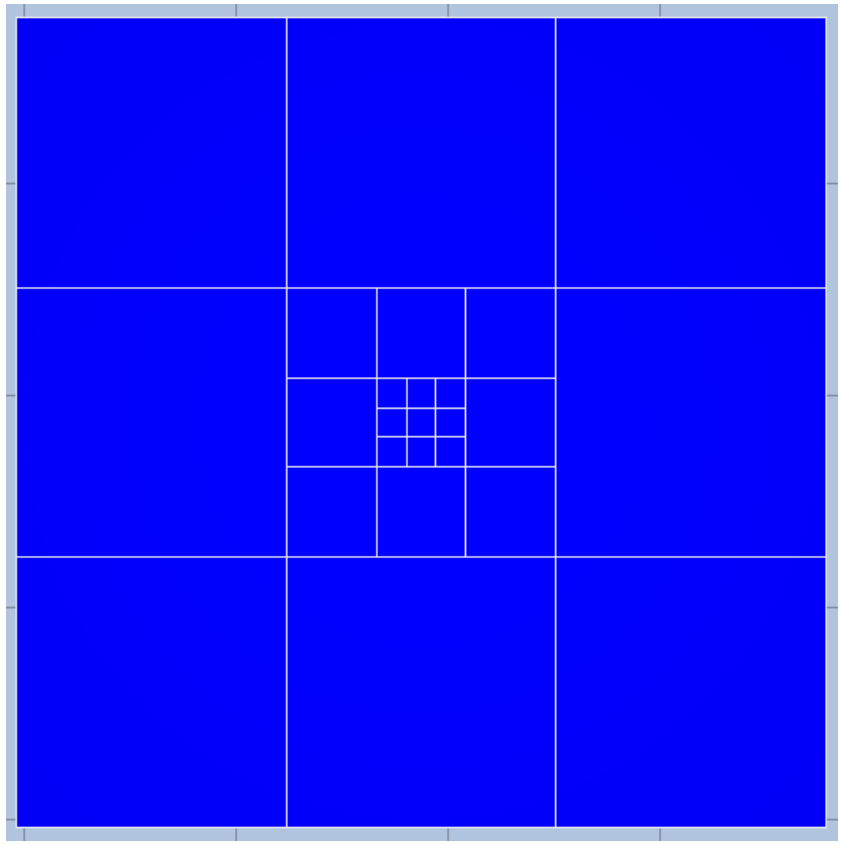
Extending EGRID to support LGR

Describes LGR grid geometry and topology, LGR hierarchy.

Brief Overview of Modifications Implemented:

- *EclGridLGR* inherits from *EclGrid*.
- *EclGrid* and *EclGridLGR* objects create a tree that represent grids with LGR.
- Save method in *EclGrid* is adapted and recurrently calls children *EclGridLGR* cells creating the EGRID files.

Progress: 98% Done



Nested EGRID generated by OPM visualized at ResInsight

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Integrating LGR into Visualization Output

Generalizing INIT files to support LGR

Store static and initial simulation data.

Modify EclIO routines to account for LGR in INIT File:

Added dedicated methods to write LGR-specific sections of INIT File:

- LGR File headers
- LGR Static Properties
- LGR Simulation Properties

We currently assume properties of LGR refined cells are inherited from the topmost host father. For a more general approach, a LGR *FieldProperty* Manager is required.

Progress: 80% Done

```
'LGR     '           1 'CHAR'
'LGR1    '
'LGRHEADI'          45 'INTE'
         1         100           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0           0           0           0
         0           0           0
'LGRHEADQ'           5 'LOGI'
 F  F  F  F  F
'LGRHEADD'           5 'DOUB'
  0.00000000000000D+00  -0.10000000000000D+21  -0.10000000000000D+21
 -0.10000000000000D+21  -0.10000000000000D+21
'INTEHEAD'         411 'INTE'
         0      201802           2           0           0           0
         0           0           3           3           1           9
         0           0           7           0           0           1
         0           2           2           0           0           0
       155         122         130           3           0           0
         1           0          25          41          58           0
        99         112         180           5           0           0
        18          24          10           7           2           4
         0           1           1           0           0           0
         0           0           0           0           0           0
         0           0           0           0           1           1
      2015           0           0           0           0           0
         0           0           0           0           5          10
         0           0          12           1          25           1
         0           0           8           8           0           1
         0           0           0           0         100           0
         0           0           0           1           0           1
```

Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Simple Well Models

Implementing Support for LGR wells

Integration of basic well model with the LGR framework.

WELSPECL Keyword Support

- Enables defining wells within LGR regions
- Parsing and tagging logic added

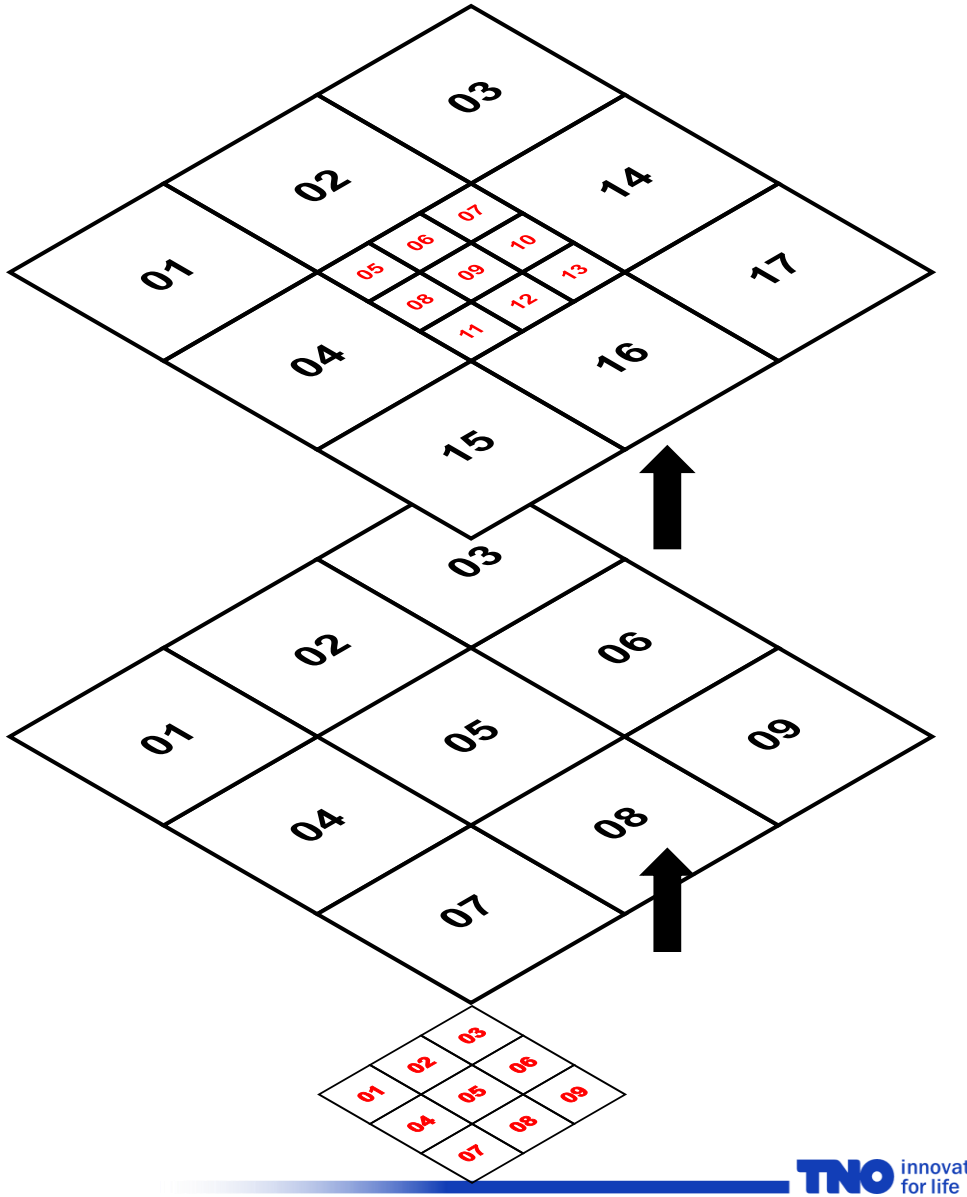
opm-common updates

- *EclGrid*, *Schedule*, *ScheduleGrid*, and *CompletedCells* and other classes now LGR-aware.
- Support for:
    i. Retrieving LGR cell depths and dimensions
    ii. Calculating LGR cell subdivision ratios.

opm-simulators enhancements.

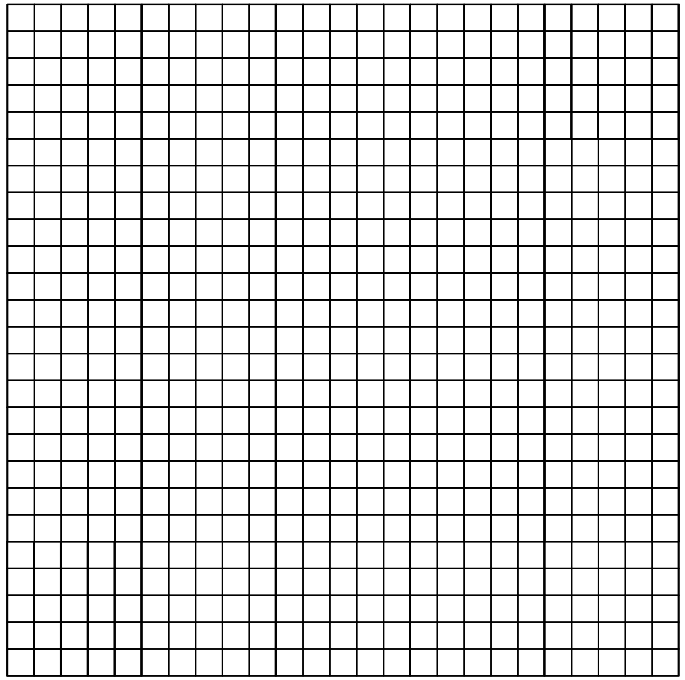
- Grid index mapping integrated with opm-grid to handle global-to-local cell translation

Progress: 85% Done



Integrating Local Grid Refinement (LGR) into the Simulation Workflow

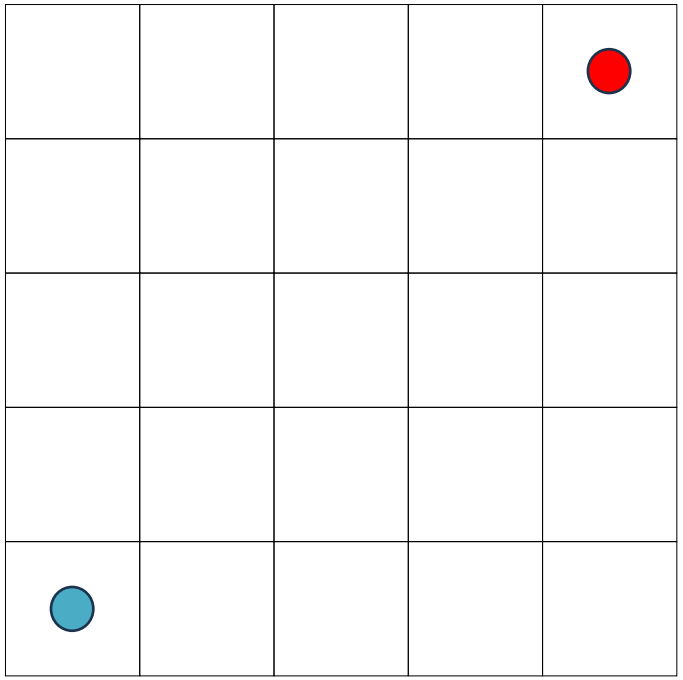
Integrating LGR into Simple Well Models



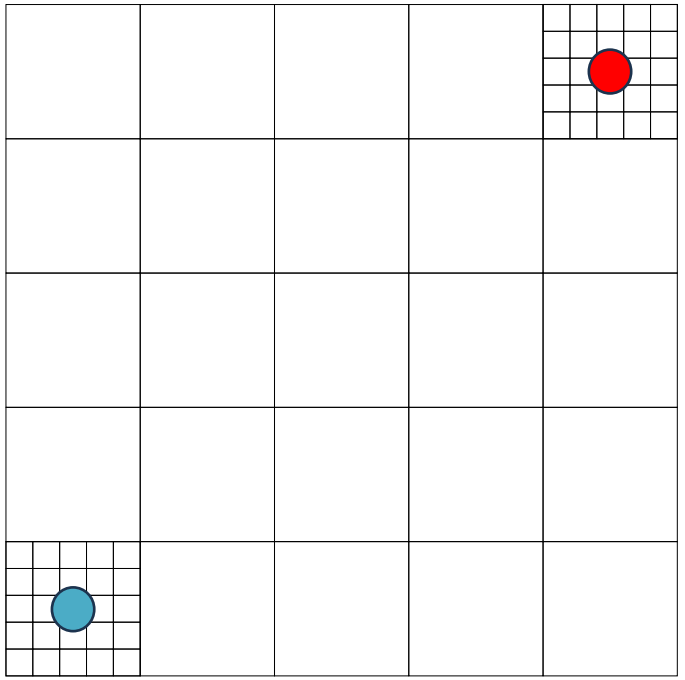
Fine-Scale
25 x 25

Integrating Local Grid Refinement (LGR) into the Simulation Workflow

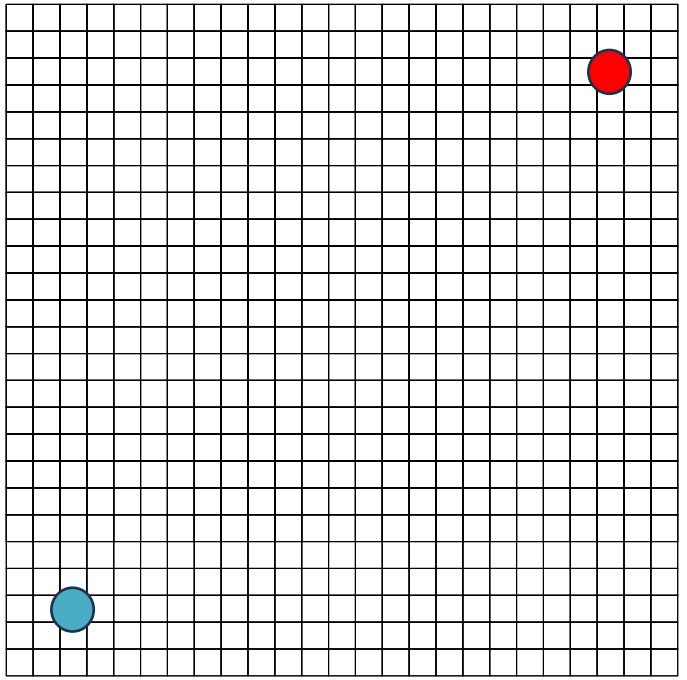
Integrating LGR into Simple Well Models



Coarse-Scale
5 x 5 = 25



LGR
5 x 5 + 2 (5 x 5) - 2 = 73

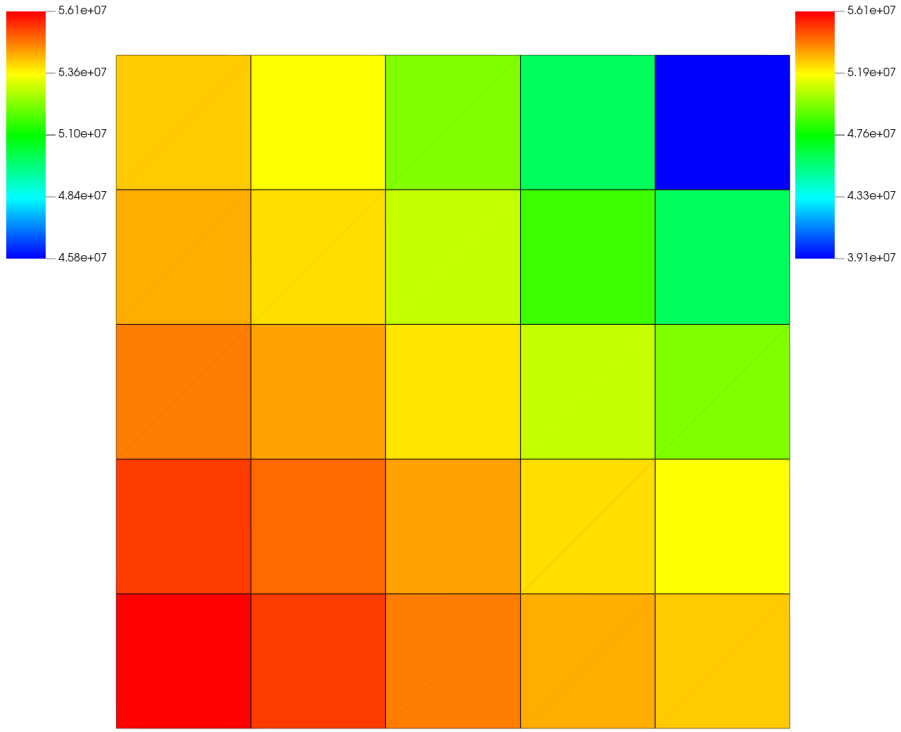


Fine-Scale
25 x 25 = 625

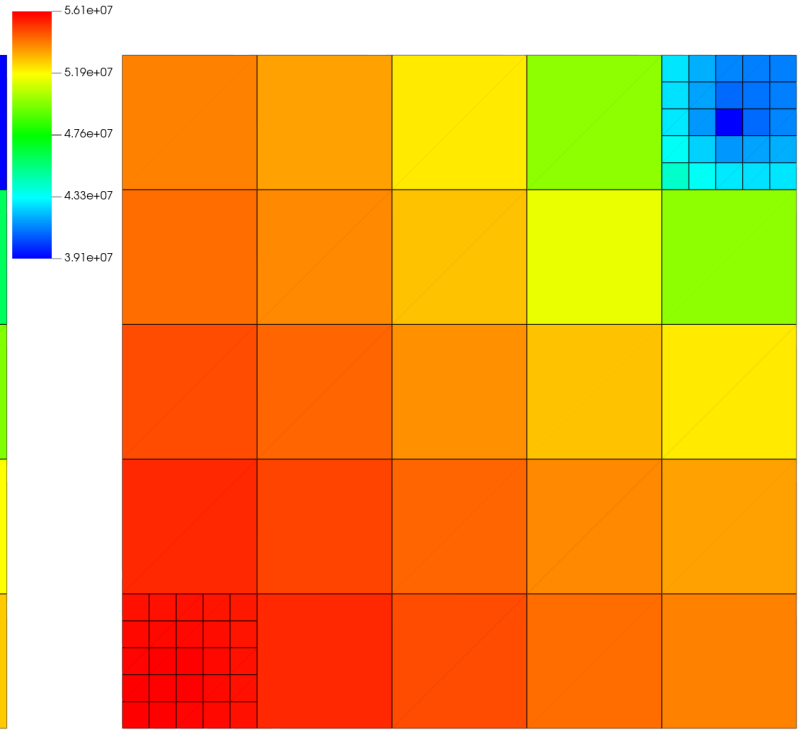
Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Simple Well Models

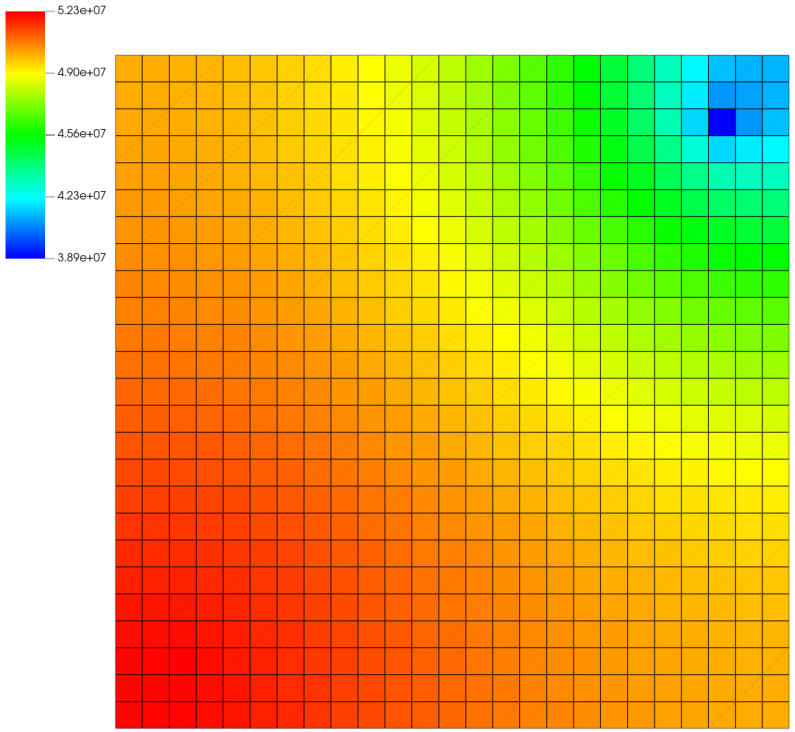
Gas Pressure Field: Black Oil Homogeneous ¼ Five Spot



Coarse-Scale
25



LGR
73



Fine-Scale
625

Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Simple Well Models

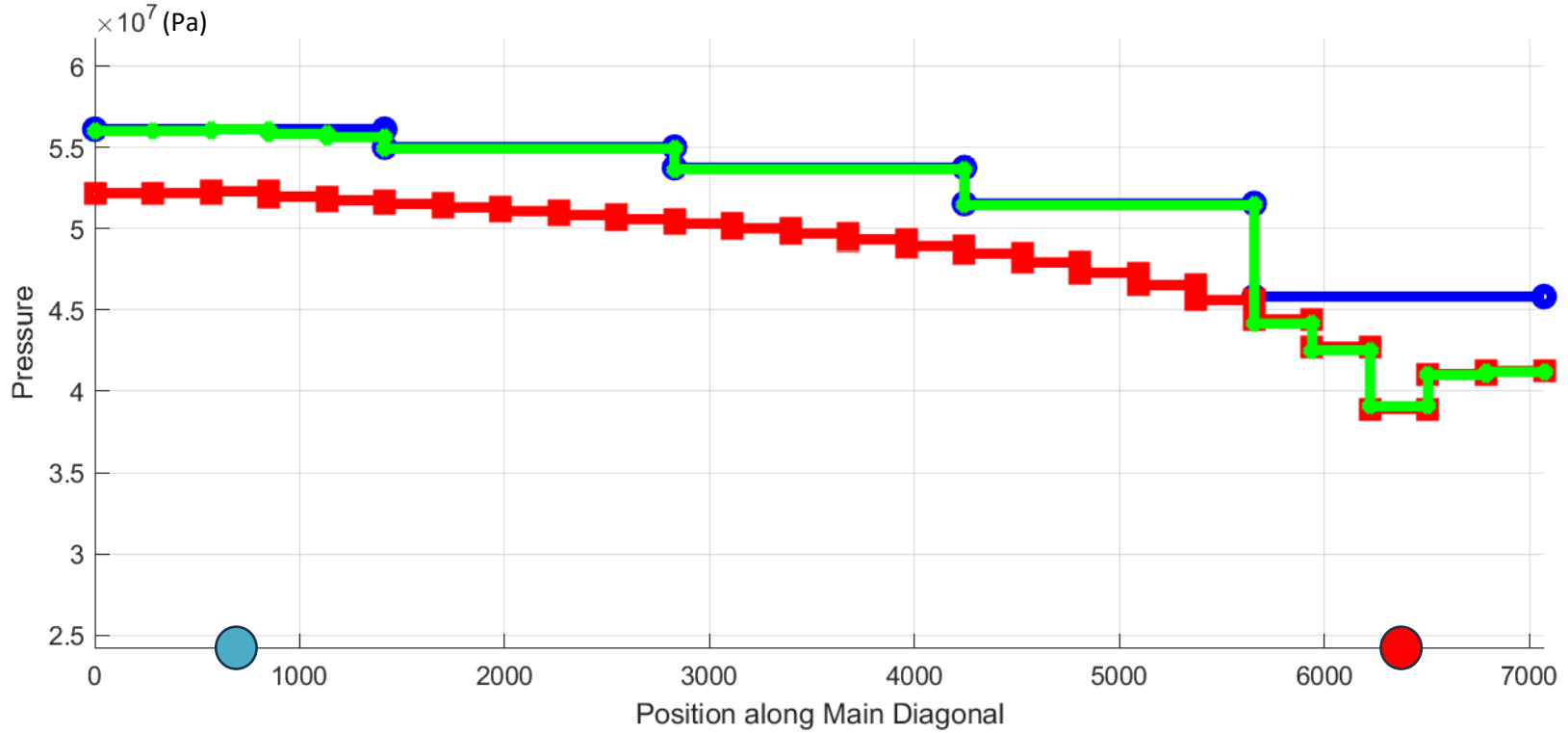
Gas Pressure Field: Black Oil Homogeneous ¼ Five Spot

Coarse

LGR

Fine

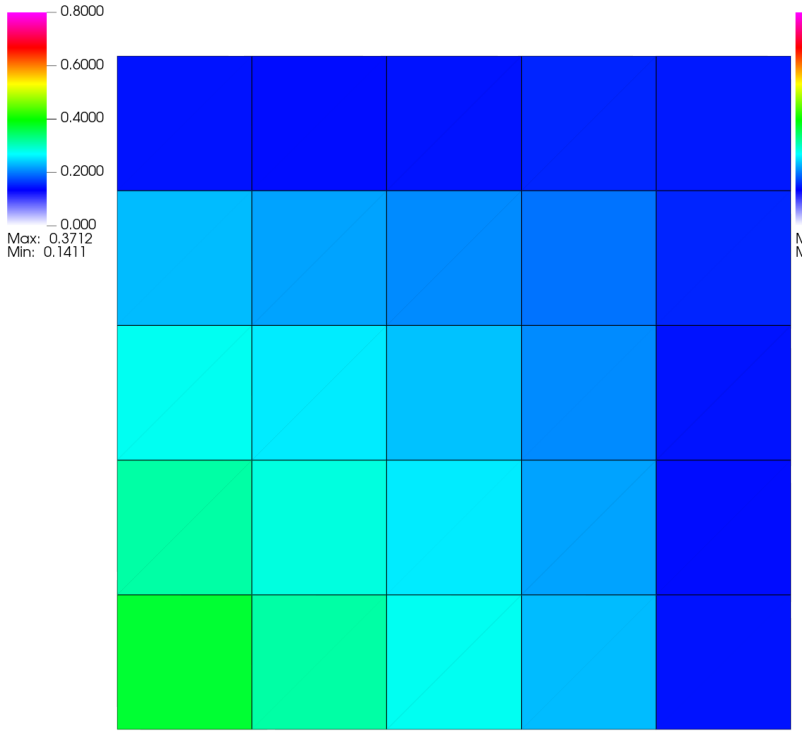
(bar)



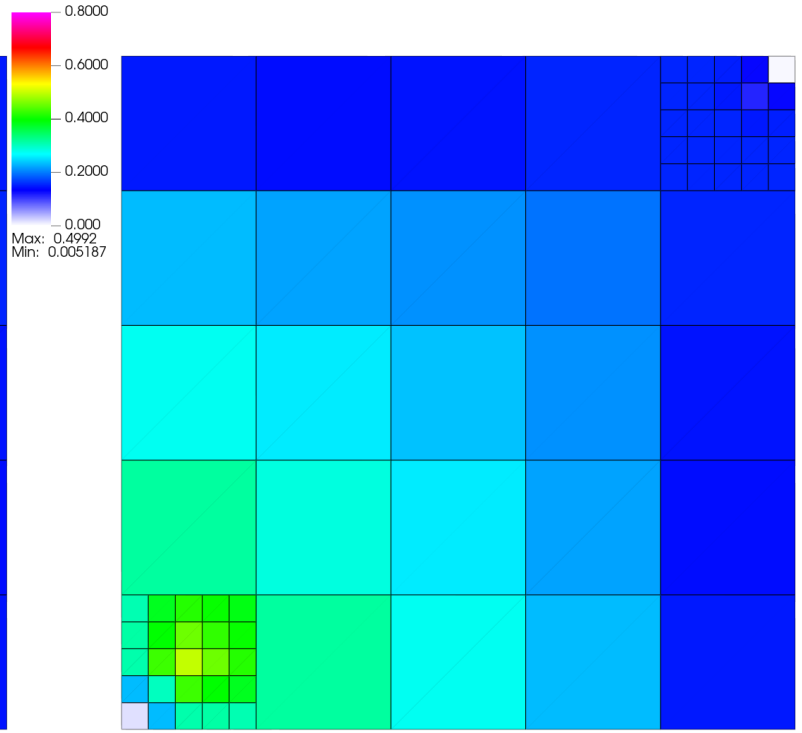
Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Integrating LGR into Simple Well Models

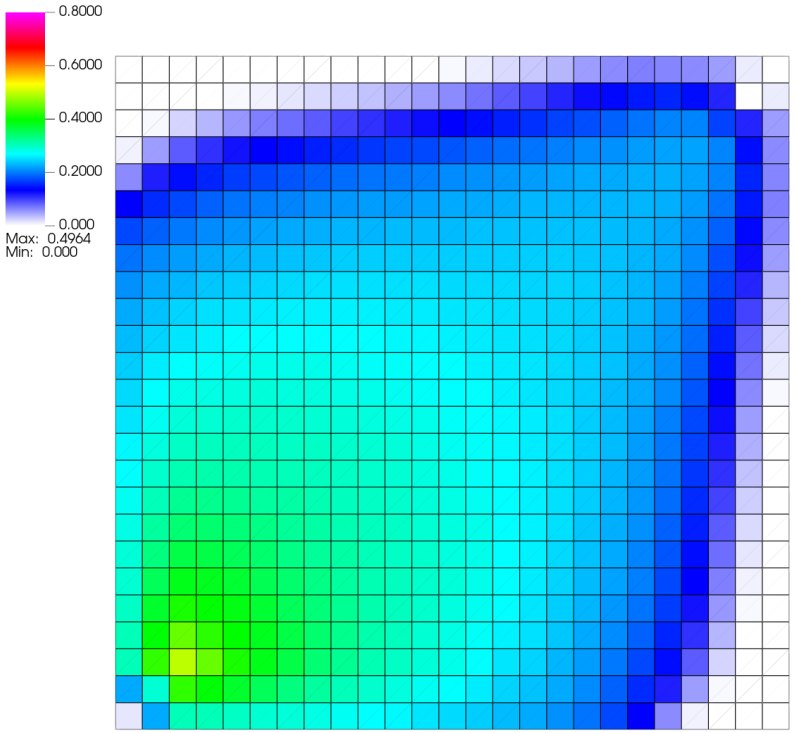
Gas Saturation Field: Black Oil Homogeneous ¼ Five Spot



Coarse-Scale
25



LGR
73



Fine-Scale
625

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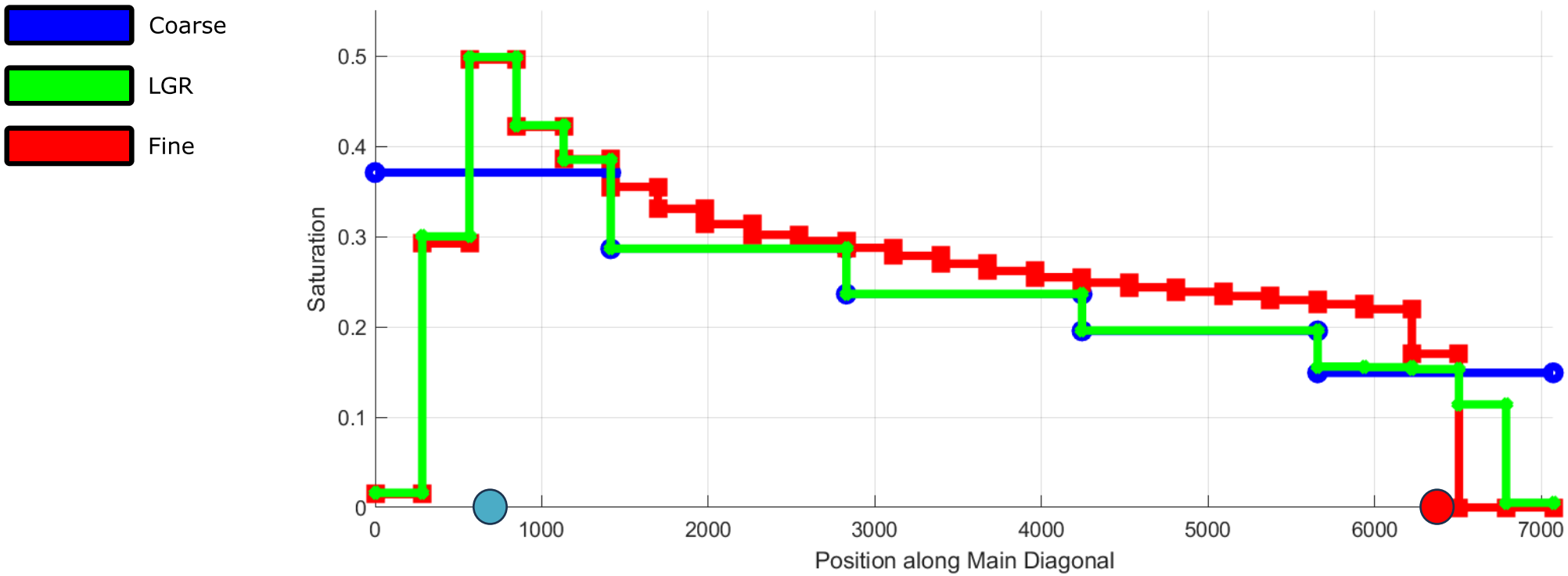
Integrating LGR into Simple Well Models

Gas Saturation Field: Black Oil Homogeneous ¼ Five Spot



Integrating Local Grid Refinement (LGR) into the Simulation Workflow

Conclusions & Next Steps

- Early results confirm successful integration of the LGR framework into OPM.
- Core components function as intended.
- Further work is needed to reach production-level maturity. They include:

UNRST Support
Enable output of LGR-related results for post-processing and visualization
INIT File Completion
Finalize the INIT file generation pipeline for LGR grids
LGR FieldPropertyManager
Design and implement field-level property management within LGR contexts
Testing & Validation
Expand test coverage to ensure robustness across realistic scenarios

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