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From block-shaped to flexible LGRs

Antonella Ritorto

May 27, 2025

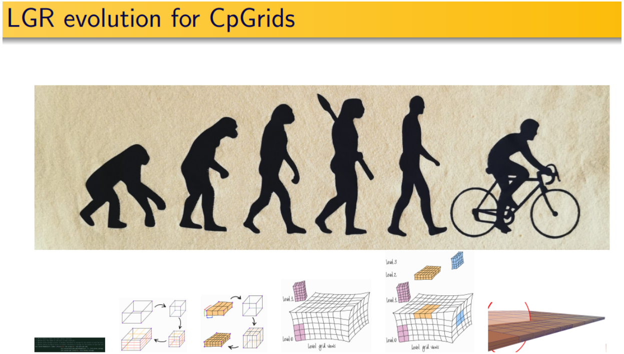
Local Grid Refinement (LGR)

Cooperation between

- **OPM-OP**
  - Blatt, Markus
  - Ritorto, Antonella
- **SINTEF**
  - Skaflestad, Bård
- **TNO**
  - Barros, Eduardo
  - Castiel, Artur
  - Khoshnevis, Negar

Flashback

Last OPM Summit - April 2024



LGR evolution for CpGrids

- Parent cells sets
  - block-shaped

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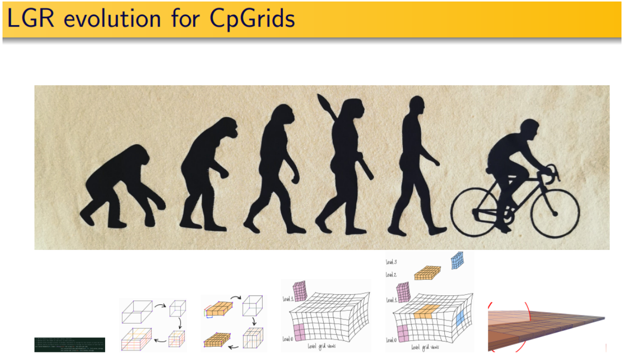

LGR evolution for CpGrids

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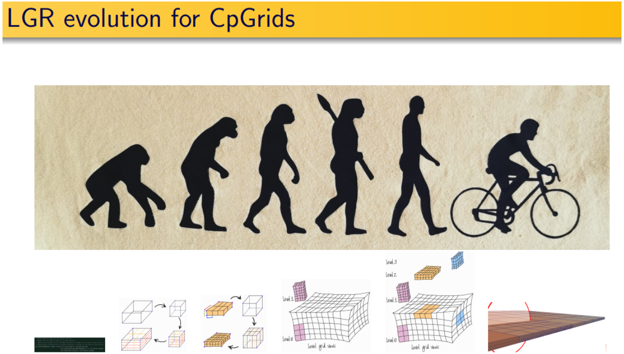

LGR evolution for CpGrids

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  - fully disjoint LGRs

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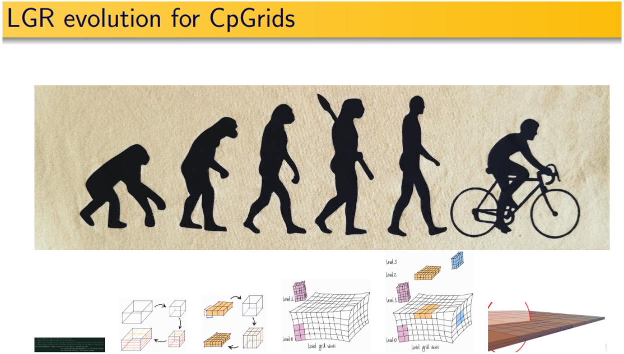

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  - single-cell refinement for irregular CpGrid

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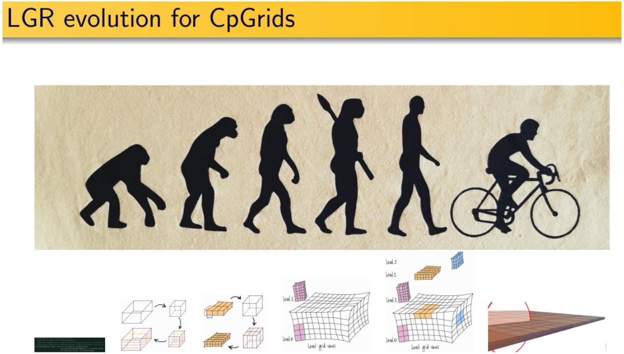

LGR evolution for CpGrids

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  - single-cell refinement for irregular CpGrid
- Simulation
  - serial

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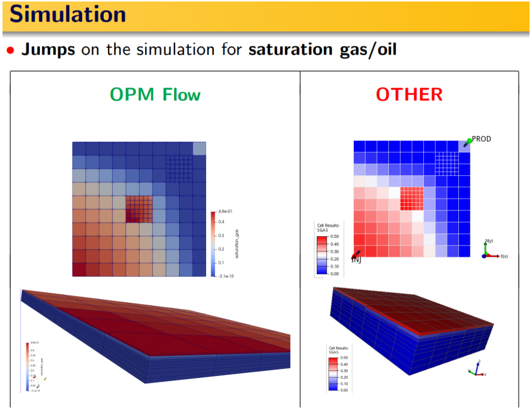

Simulation

- **Jumps** on the simulation for **saturation gas/oil**

- Parent cells sets
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- Simulation
  - serial
  - discontinuities in saturation oil/gas

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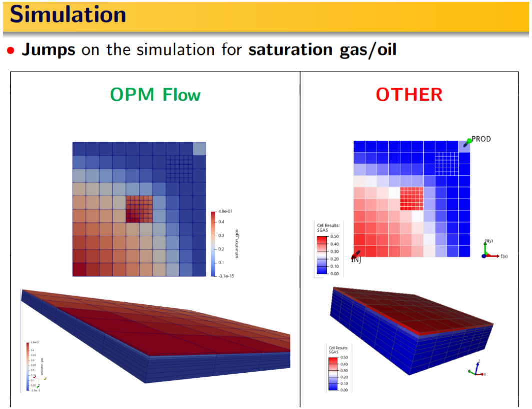

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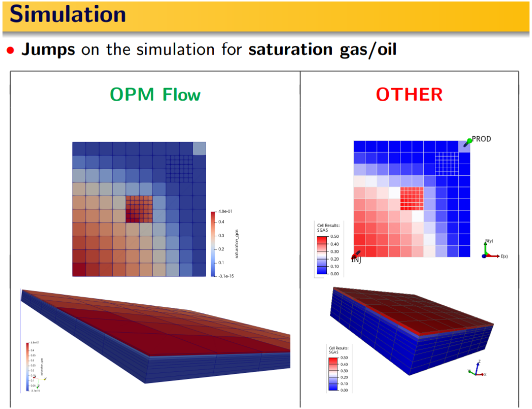
  - no wells

Last OPM Summit - April 2024



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OPM Flow

OTHER

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  - no wells
  - no output files

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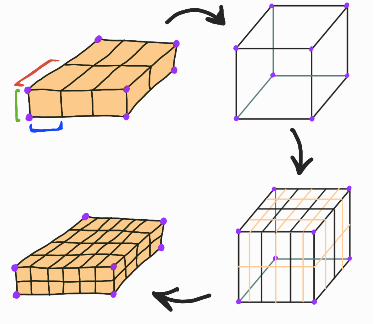
What has happened since then?

From block-shaped to arbitrary parent cells set

Before: fake-huge-cell-refinement



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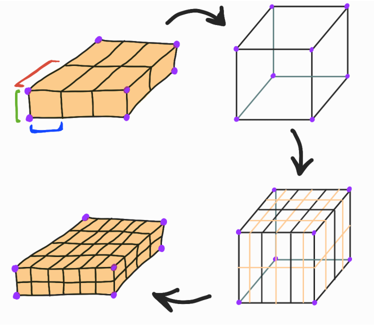
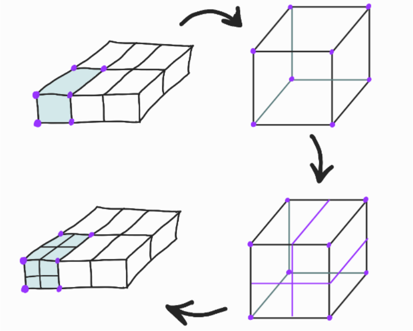


Now: single-cell-refinement



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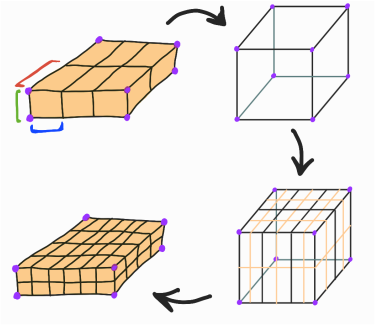

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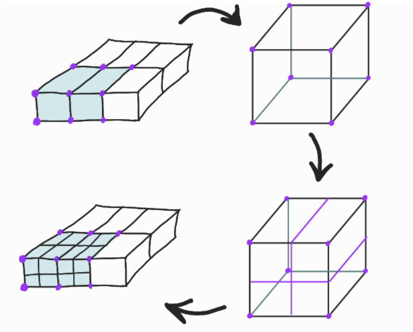

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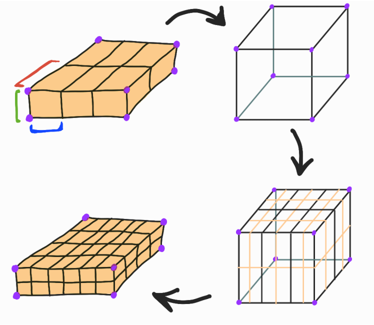

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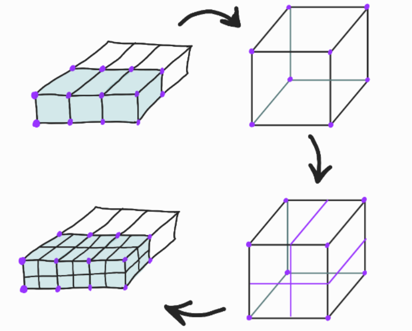

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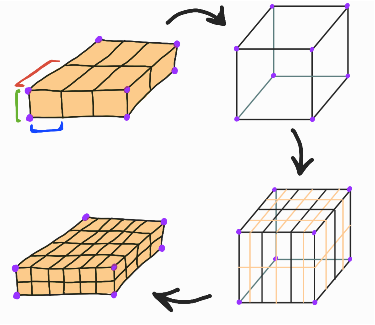

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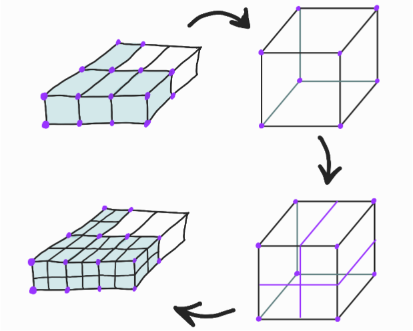

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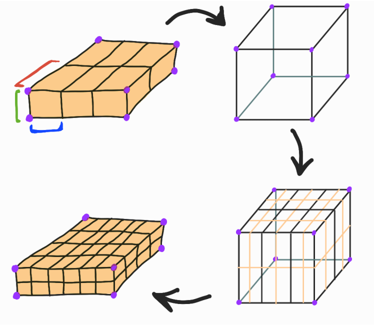

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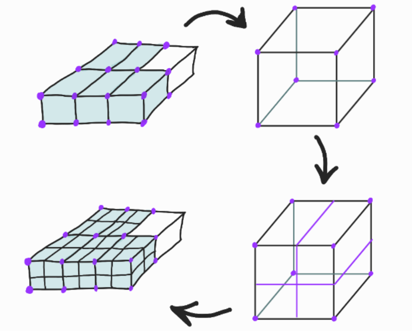

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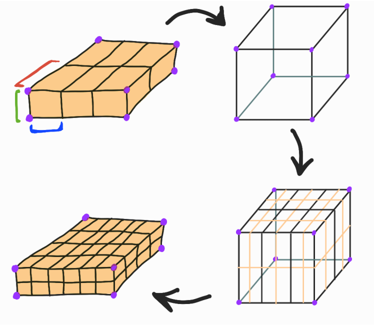

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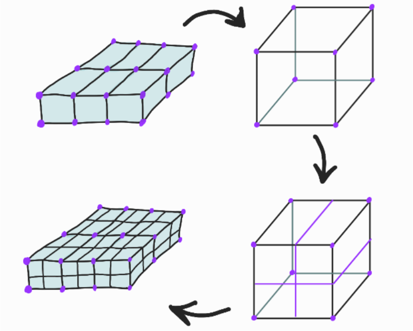

Main challenges

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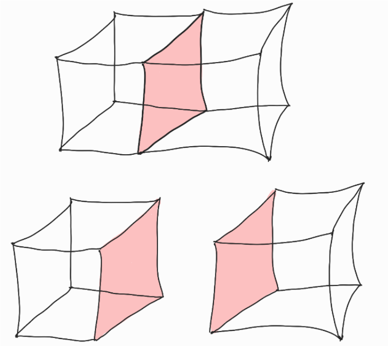

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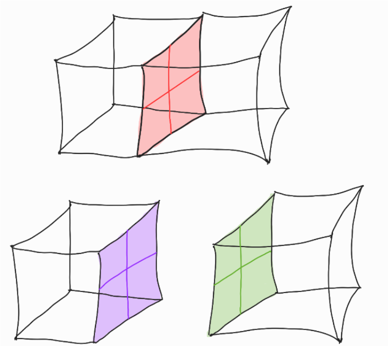

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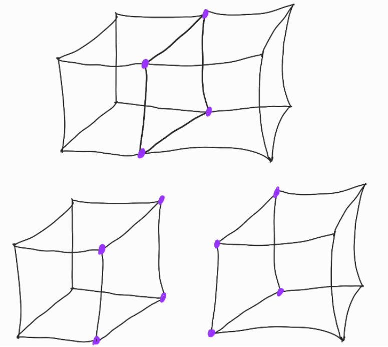

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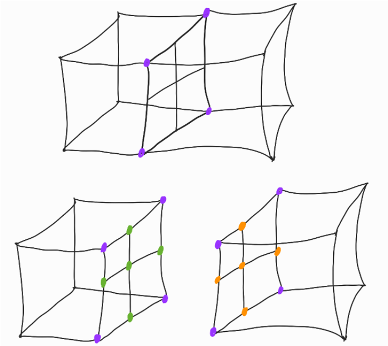

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A few methods to avoid repeating entities

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Don't worry, there is always room from improvement :)

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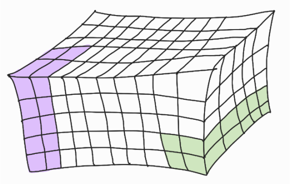
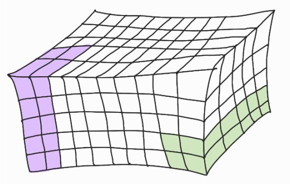
Before: addLgrsUpdateLeafView(...)



Now: addLgrsUpdateLeafView(...)



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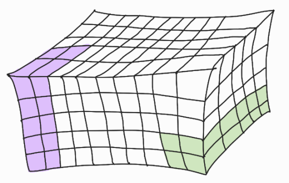
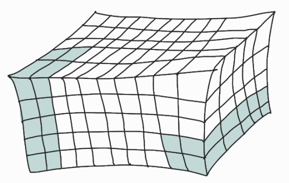


Now: adapt()



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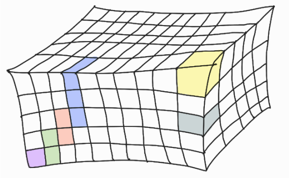

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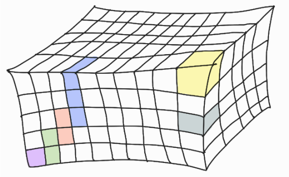

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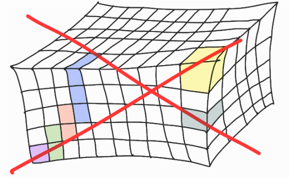

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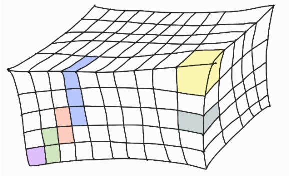

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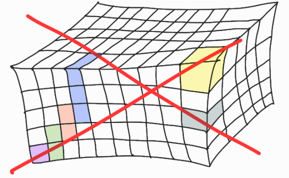

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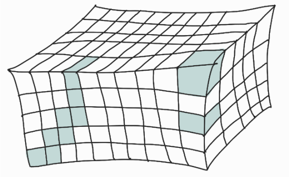

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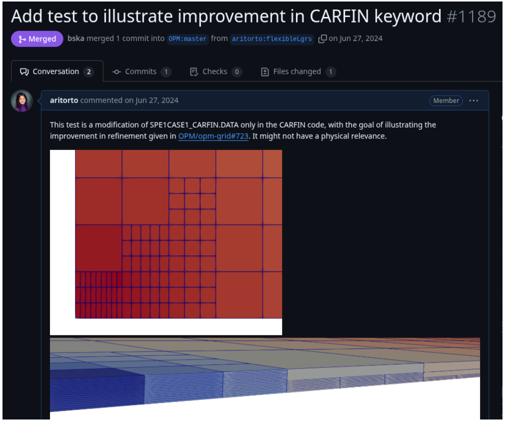

Add test to illustrate improvement in CARFIN keyword #1189

Merged bska merged 1 commit into `OPM:master` from `aritorto:flexibleLgrs` on Jun 27, 2024

aritorto commented on Jun 27, 2024

This test is a modification of SPE1CASE1_CARFIN.DATA only in the CARFIN code, with the goal of illustrating the improvement in refinement given in OPM/opm-grid#723. It might not have a physical relevance.

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  - block-shaped
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- **Define topology aspects of the refined and leaf grid views**

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- ...

What a summer!

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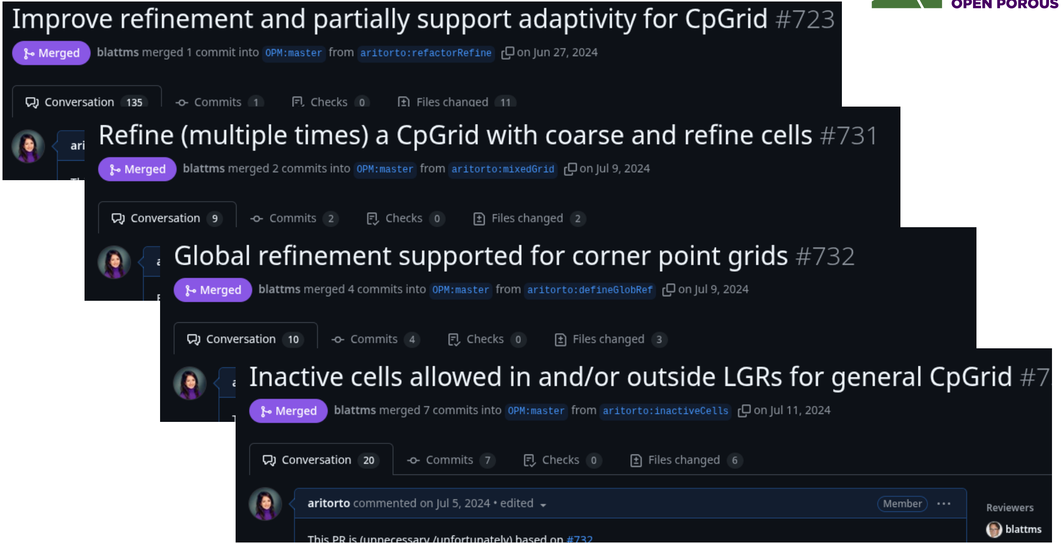


Improve refinement and partially support adaptivity for CpGrid #723

Merged blattms merged 1 commit into OPM:master from aritorto:refactorRefine on Jun 27, 2024

Refine (multiple times) a CpGrid with coarse and refine cells #731

Merged blattms merged 2 commits into OPM:master from aritorto:mixedGrid on Jul 9, 2024

Global refinement supported for corner point grids #732

Merged blattms merged 4 commits into OPM:master from aritorto:defineGlobRef on Jul 9, 2024

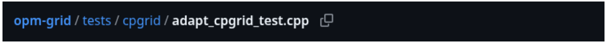
Inactive cells allowed in and/or outside LGRs for general CpGrid #7

Merged blattms merged 7 commits into OPM:master from aritorto:inactiveCells on Jul 11, 2024

aritorto commented on Jul 5, 2024 • edited Member

This PR is (unnecessary/unfortunately) based on #732

A few highlights



opm-grid / tests / cpgrid / adapt_cpgrid_test.cpp

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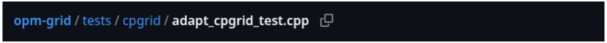

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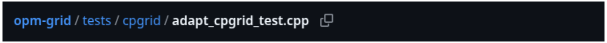
- *more flexible* parent cell sets

A few highlights



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- *more flexible* parent cell sets
- call **adapt()** multiple times as long as marked elements are *far from LGR boundaries*

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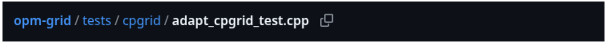

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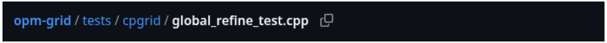

opm-grid / tests / cpgrid / global_refine_test.cpp

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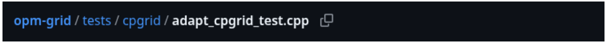

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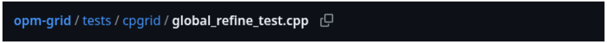

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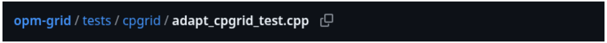

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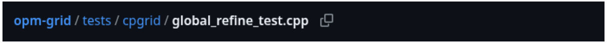

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- call **globalRefine(n)** is equivalent to call **globalRefine(t_i)** with $\sum_{i\in I} t_i = n$
- call **adapt()** on a globally refined CpGrid

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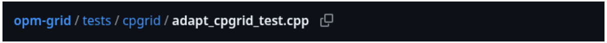

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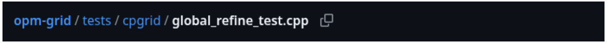
- call **adapt()** multiple times as long as marked elements are *far from LGR boundaries*



opm-grid / tests / cpgrid / global_refine_test.cpp

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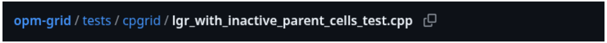

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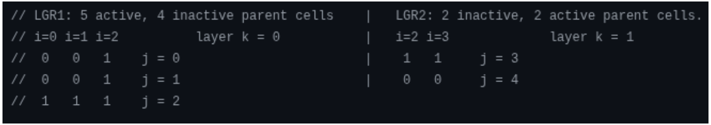

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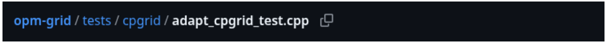
A few highlights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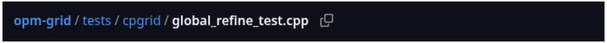
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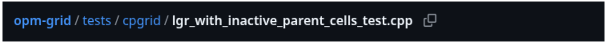
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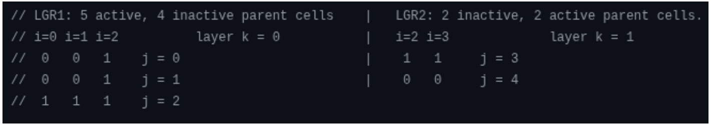

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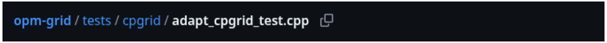
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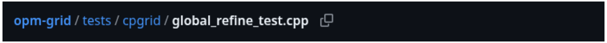
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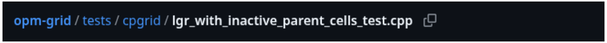
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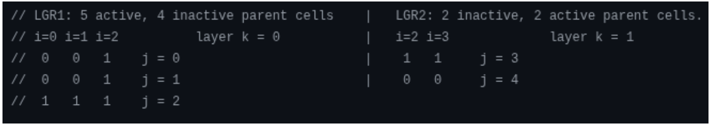
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- serial
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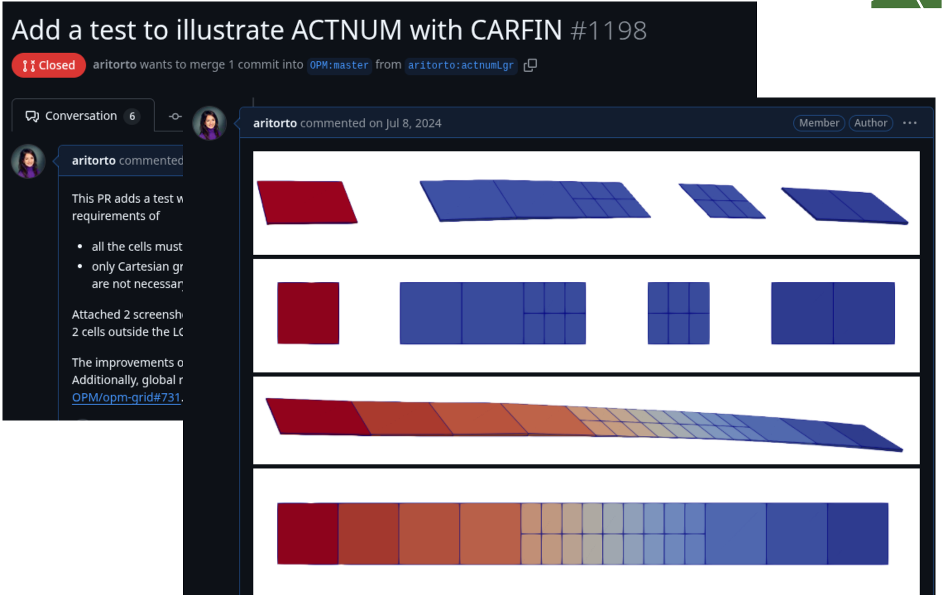
From all-active to active/inactive parent cells



Add a test to illustrate ACTNUM with CARFIN #1198

Closed aritorto wants to merge 1 commit into OPM:master from aritorto:actnumLgr

aritorto commented

This PR adds a test w
requirements of

- all the cells must
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Attached 2 screensh
2 cells outside the LG

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aritorto commented on Jul 8, 2024

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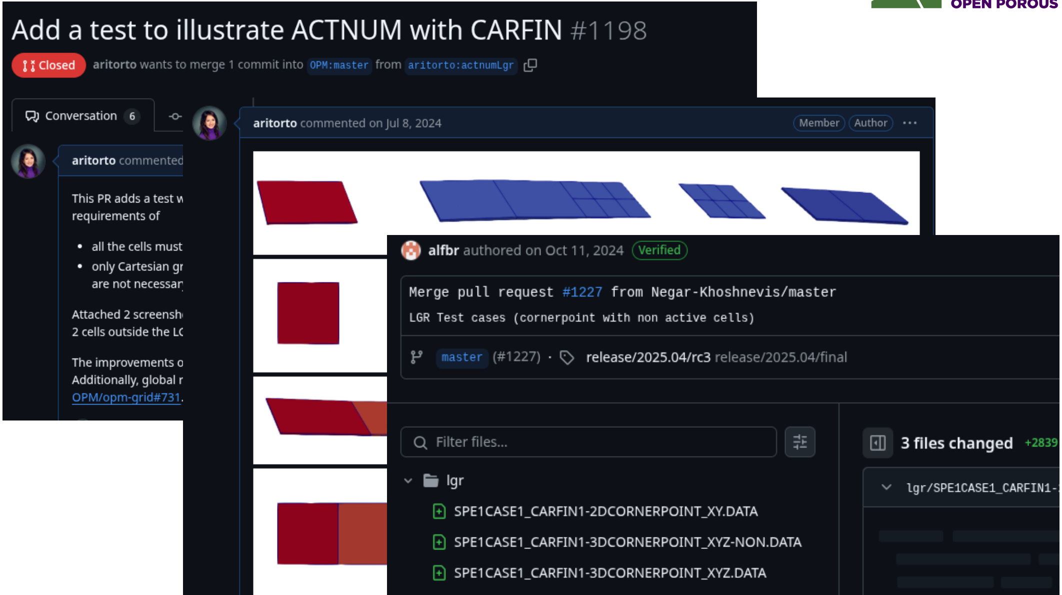

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aritorto commented on Jul 8, 2024 Member Author ···

alfbr authored on Oct 11, 2024 Verified

```
Merge pull request #1227 from Negar-Khoshnevis/master
LGR Test cases (cornerpoint with non active cells)
```

`master` (#1227) · release/2025.04/rc3 release/2025.04/final

- lgr
  - SPE1CASE1_CARFIN1-2DCORNERPOINT_XY.DATA
  - SPE1CASE1_CARFIN1-3DCORNERPOINT_XYZ-NON.DATA
  - SPE1CASE1_CARFIN1-3DCORNERPOINT_XYZ.DATA

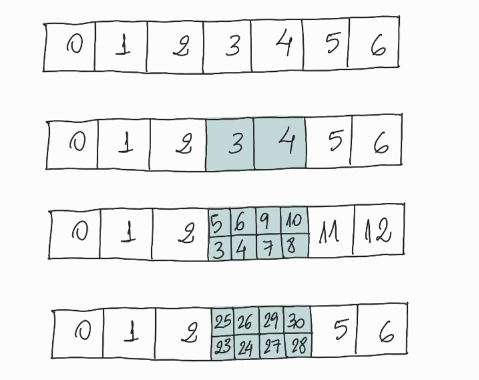
3 files changed +2839

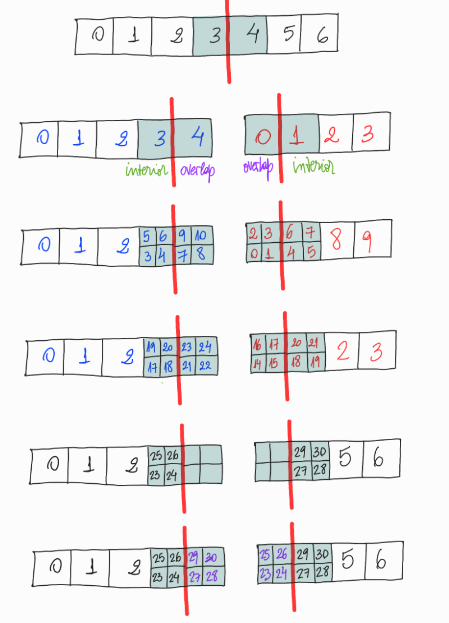
lgr/SPE1CASE1_CARFIN1-

Parallel 😱 simulation for CpGrid with LGRs!?

Parallel simulation, how far?

Local indices vs. **Ids**





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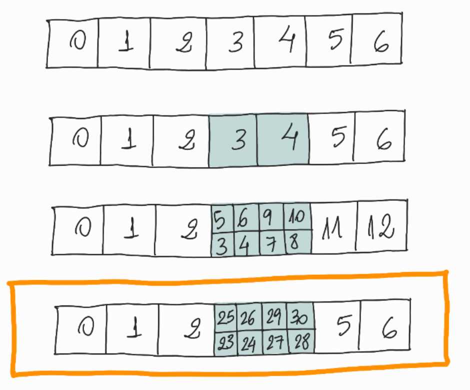

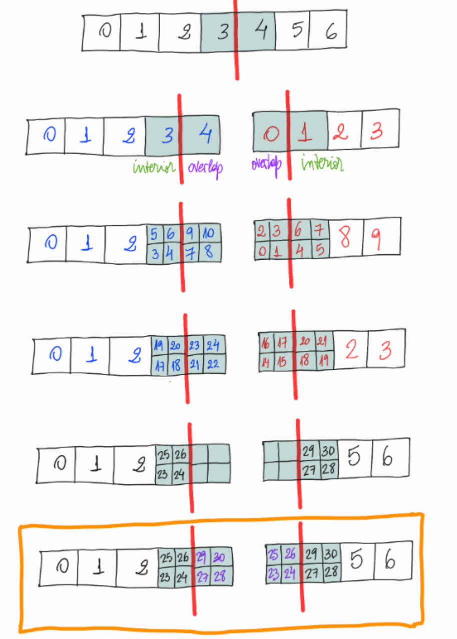

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Partition method: **ZoltanWell** (see **Michal's talk!**)

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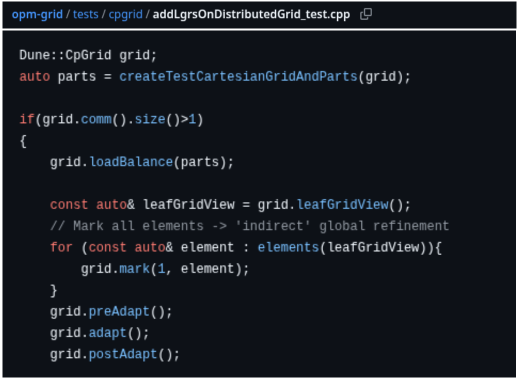

opm-grid / tests / cpgrid / addLgrsOnDistributedGrid_test.cpp

```
Dune::CpGrid grid;
auto parts = createTestCartesianGridAndParts(grid);

if(grid.comm().size()>1)
{
    grid.loadBalance(parts);

    const auto& leafGridView = grid.leafGridView();
    // Mark all elements -> 'indirect' global refinement
    for (const auto& element : elements(leafGridView)){
        grid.mark(1, element);
    }
    grid.preAdapt();
    grid.adapt();
    grid.postAdapt();
```

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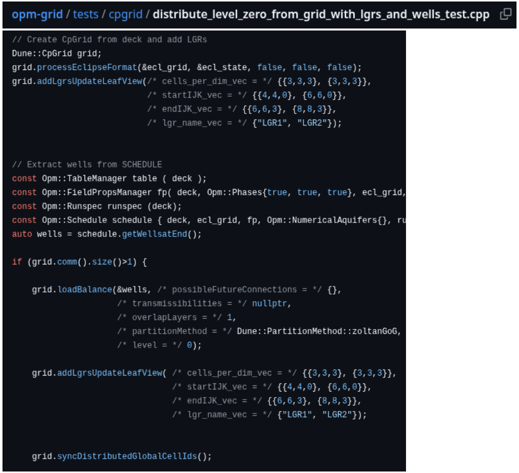

opm-grid / tests / cpgrid / distribute_level_zero_from_grid_with_lgrs_and_wells_test.cpp

```
// Create CpGrid from deck and add LGRs
Dune::CpGrid grid;
grid.processEclipseFormat(&ecl_grid, &ecl_state, false, false, false);
grid.addLgrsUpdateLeafView(/* cells_per_dim_vec = */ {{3,3,3}, {3,3,3}},
                           /* startIJK_vec = */ {{4,4,0}, {6,6,0}},
                           /* endIJK_vec = */ {{6,6,3}, {8,8,3}},
                           /* lgr_name_vec = */ {"LGR1", "LGR2"});


// Extract wells from SCHEDULE
const Opm::TableManager table ( deck );
const Opm::FieldPropsManager fp( deck, Opm::Phases{true, true, true}, ecl_grid,
const Opm::Runspec runspec (deck);
const Opm::Schedule schedule { deck, ecl_grid, fp, Opm::NumericalAquifers{}, ru
auto wells = schedule.getWellsatEnd();

if (grid.comm().size()>1) {

    grid.loadBalance(&wells, /* possibleFutureConnections = */ {},
                     /* transmissibilities = */ nullptr,
                     /* overlapLayers = */ 1,
                     /* partitionMethod = */ Dune::PartitionMethod::zoltanGoG,
                     /* level = */ 0);

    grid.addLgrsUpdateLeafView( /* cells_per_dim_vec = */ {{3,3,3}, {3,3,3}},
                                /* startIJK_vec = */ {{4,4,0}, {6,6,0}},
                                /* endIJK_vec = */ {{6,6,3}, {8,8,3}},
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    grid.syncDistributedGlobalCellIds();
```

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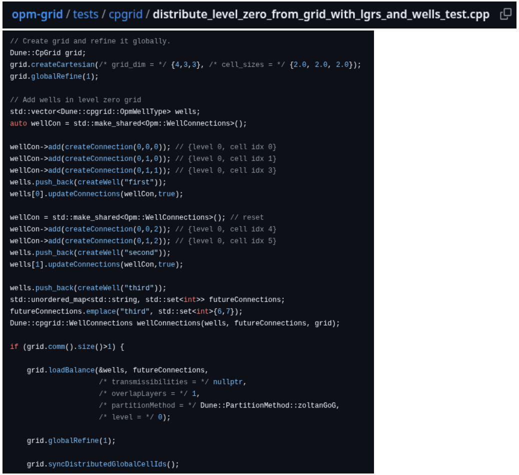
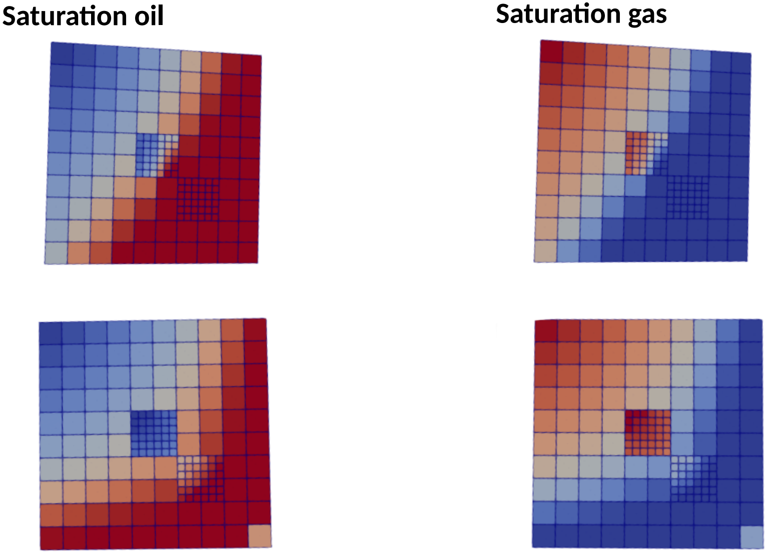


opm-grid / tests / cpgrid / distribute_level_zero_from_grid_with_lgrs_and_wells_test.cpp

```
// Create grid and refine it globally.
Dune::CpGrid grid;
grid.createCartesian(/* grid_dim = */ {4,3,3}, /* cell_sizes = */ {2.0, 2.0, 2.0});
grid.globalRefine(1);

// Add wells in level zero grid
std::vector<Dune::cpgrid::OpmWellType> wells;
auto wellCon = std::make_shared<Opm::WellConnections>();

wellCon->add(createConnection(0,0,0)); // {level 0, cell idx 0}
wellCon->add(createConnection(0,1,0)); // {level 0, cell idx 1}
wellCon->add(createConnection(0,1,1)); // {level 0, cell idx 3}
wells.push_back(createWell("first"));
wells[0].updateConnections(wellCon,true);

wellCon = std::make_shared<Opm::WellConnections>(); // reset
wellCon->add(createConnection(0,0,2)); // {level 0, cell idx 4}
wellCon->add(createConnection(0,1,2)); // {level 0, cell idx 5}
wells.push_back(createWell("second"));
wells[1].updateConnections(wellCon,true);

wells.push_back(createWell("third"));
std::unordered_map<std::string, std::set<int>> futureConnections;
futureConnections.emplace("third", std::set<int>{6,7});
Dune::cpgrid::WellConnections wellConnections(wells, futureConnections, grid);

if (grid.comm().size()>1) {

    grid.loadBalance(&wells, futureConnections,
                     /* transmissibilities = */ nullptr,
                     /* overlapLayers = */ 1,
                     /* partitionMethod = */ Dune::PartitionMethod::zoltanGoG,
                     /* level = */ 0);

    grid.globalRefine(1);

    grid.syncDistributedGlobalCellIds();
```

Smoother discontinuities in saturation oil/gas (PR6235)



Saturation oil

Saturation gas

top: PR6235, **bottom**: before PR6235

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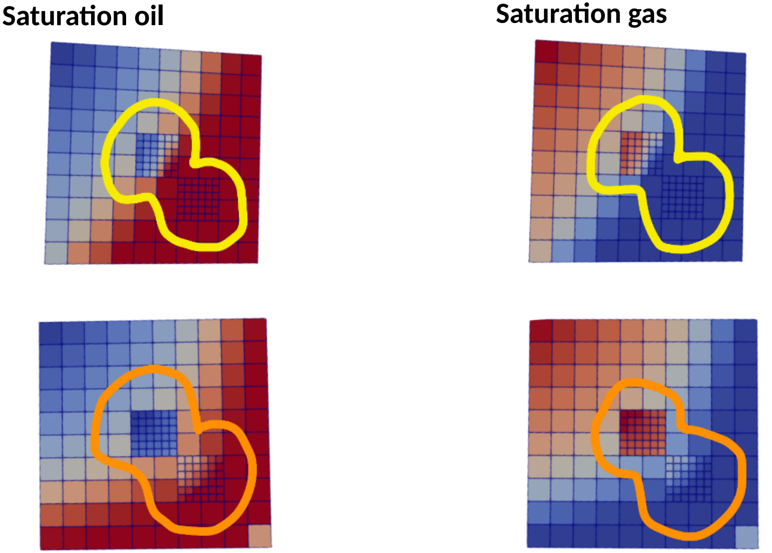

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Wells & output files from opm-grid

- **Wells** (PR862)

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  - small modification in **WellConnections** constructor
    Use **logicalCartesianSize()** and **globalCell()** from **level zero** if the CpGrid has LGRs.

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Last OPM Summit - April 2024

- Parent cells sets
  - block-shaped
  - all active
  - fully disjoint LGRs
  - single-cell refinement for irregular CpGrid

- Simulation
  - serial
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Thank you for your attention!

To be continued…