

A Practical Workflow for Optimal Simulation Grid Design

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Summary

In this presentation, a practical workflow for optimal simulation grid design is illustrated. The algorithm is modified from SPE 95759 (King, *et al.*). The algorithm uses the local dynamic information, local velocity, as a scaling parameter, which quantifies the reservoir heterogeneity. A workflow is provided to demonstrate how to create a simulation grid, which is irregular in both I, J, and K directions.

Introduction

The presentation is the follow-up of my 2009 CSPG CSEG CWLS Convention talk, “*Introduction to Simulation Grid Design and Upscaling*”. Many people tried the optimism algorithm on layer coarsening after the talk, but they got troubles on creating the irregular grid. In this presentation, a practical workflow is provided and it will guide the user through on how to create an irregular grid in RMS 2009. The simulation grid will be irregular in both I, J, and K directions. How much information can be kept from the geological grid to the simulation grid can also be quantified.

Optimization Algorithm

The optimal layer coarsening algorithm will be illustrated here. The algorithms for optimal column coarsening and row coarsening are the same as layer coarsening.

In this algorithm, the local velocity, P , is chosen as the upscaling parameter.

$$P = f' \cdot k / \phi \quad (1)$$

where f' is the Buckley-Leverett speed, which includes the facies and saturation dependent relative permeability terms; k / ϕ is the interstitial velocity.

The total heterogeneity over the entire reservoir can be expressed as:

$$H = \sum_{i,j,k=1}^{NX,NY,NZ} n_{i,j,k} (P_{i,j,k} - \bar{P}_{i,j})^2 \quad (2)$$

where $n_{i,j,k}$ is the bulk volume of the cell (i, j, k) ; P is the local velocity shown in equation (1); the average property $\bar{P}_{i,j}$ is the weighted average of the properties in its column; and NX, NY, NZ are the number of columns, rows and layers of the grid.

$$\bar{P}_{i,j} = \sum_{k=1}^{NZ} n_{i,j,k} \cdot P_{i,j,k} / \sum_{k=1}^{NZ} n_{i,j,k} \quad (3)$$

After merging two cells (i, j, k) and $(i, j, k + 1)$, the variation change is:

$$\delta W_{i,j,k} = \frac{n_{i,j,k} \cdot n_{i,j,k+1}}{n_{i,j,k} + n_{i,j,k+1}} (P_{i,j,k} - P_{i,j,k+1})^2 \quad (4)$$

So the total variation change caused by merging two adjacent layers k and $k + 1$ is:

$$\delta W_k = \sum_{i,j=1}^{NX,NY} \delta W_{i,j,k}, k = 1, \dots, NZ - 1 \quad (5)$$

The total heterogeneity after merging layer k and $k + 1$ is:

$$H_{new} = H_{original} - \delta W_k \quad (6)$$

For a NZ layer grid, there are $NZ - 1$ layer pairs. So which two layers should be merged? Apparently, H_{new} is the maximum when $\delta W_k, k = 1, \dots, NZ - 1$ is the minimum in all possible $NZ - 1$ combinations.

The recursive algorithm works by merging two adjacent layers with the minimum variation change, until a single layer model is generated.

The heterogeneity versus model layers can be plotted; and the point of inflexion is the optimal point (Figure 1).

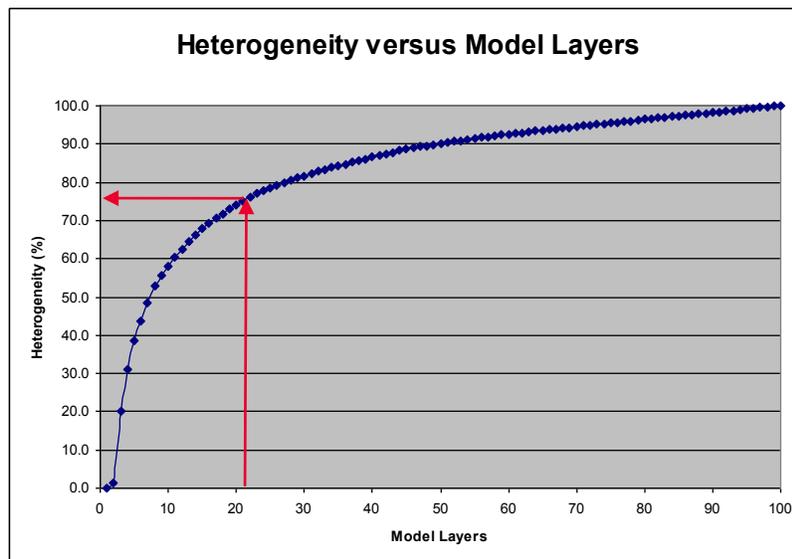


Figure 1 The plot of heterogeneity versus model layers showing the reservoir heterogeneity evolution history.

The Irregular Simulation Grid Building Workflow

The workflow shown here is based on RMS 2009 (Figure 2). It might be different if another reservoir modeling package is used because of the different grid building technologies.

Several RMSipl scripts are designed to fulfill the column, row and layer coarsening algorithms. There are also several utility scripts to aid for the simulation grid design, *e.g.*, generating the column and row control lines.

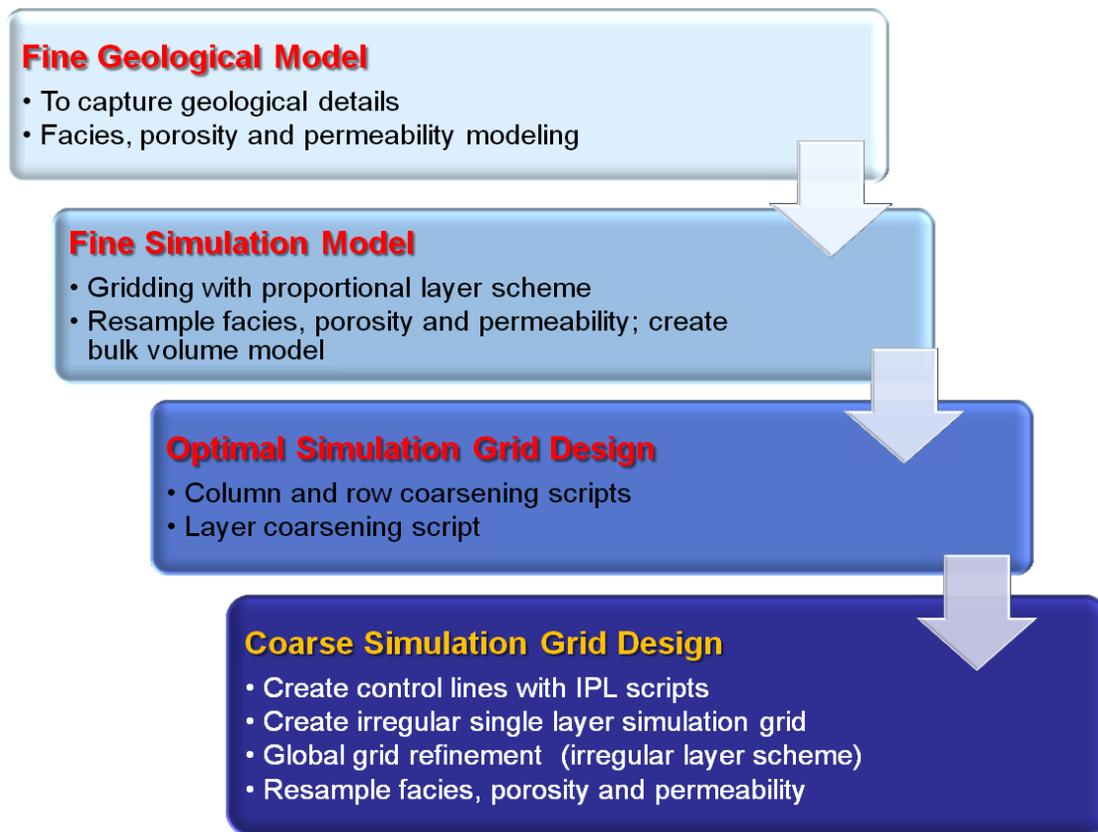


Figure 2 The workflow to create optimal irregular simulation grid in RMS 2009.

A Synthetic Example

The synthetic example is based on the demo project in RMS, the Emerald project, to illustrate the proposed workflow (Figure 3 and 4).

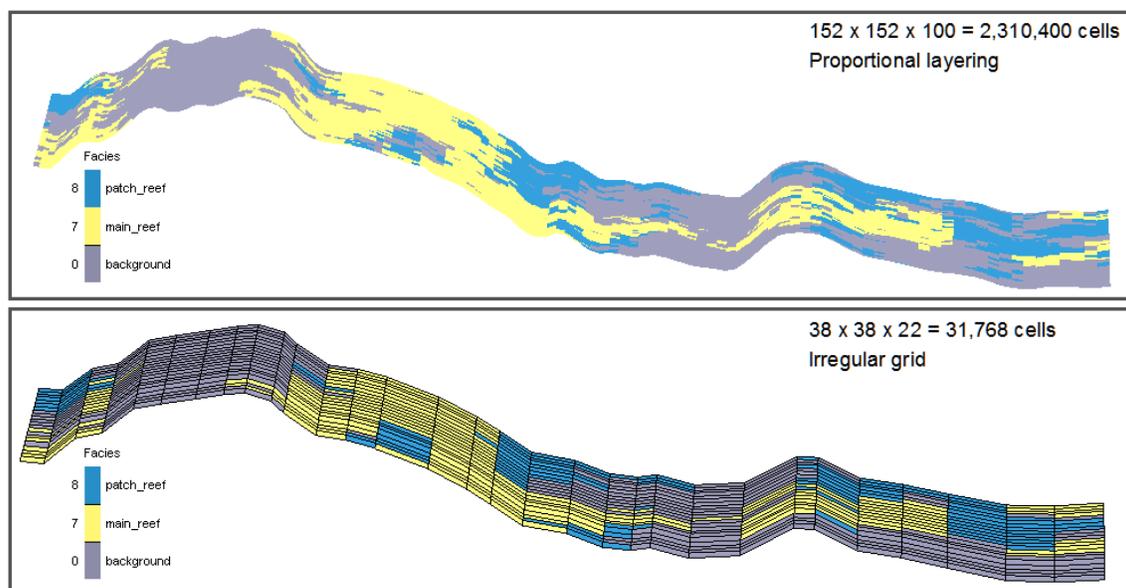


Figure 3 The comparison of the fine geological grid and the designed simulation grid (cross section). The remaining heterogeneity is 70%, 70% and 80% in I, J, K directions, respectively.

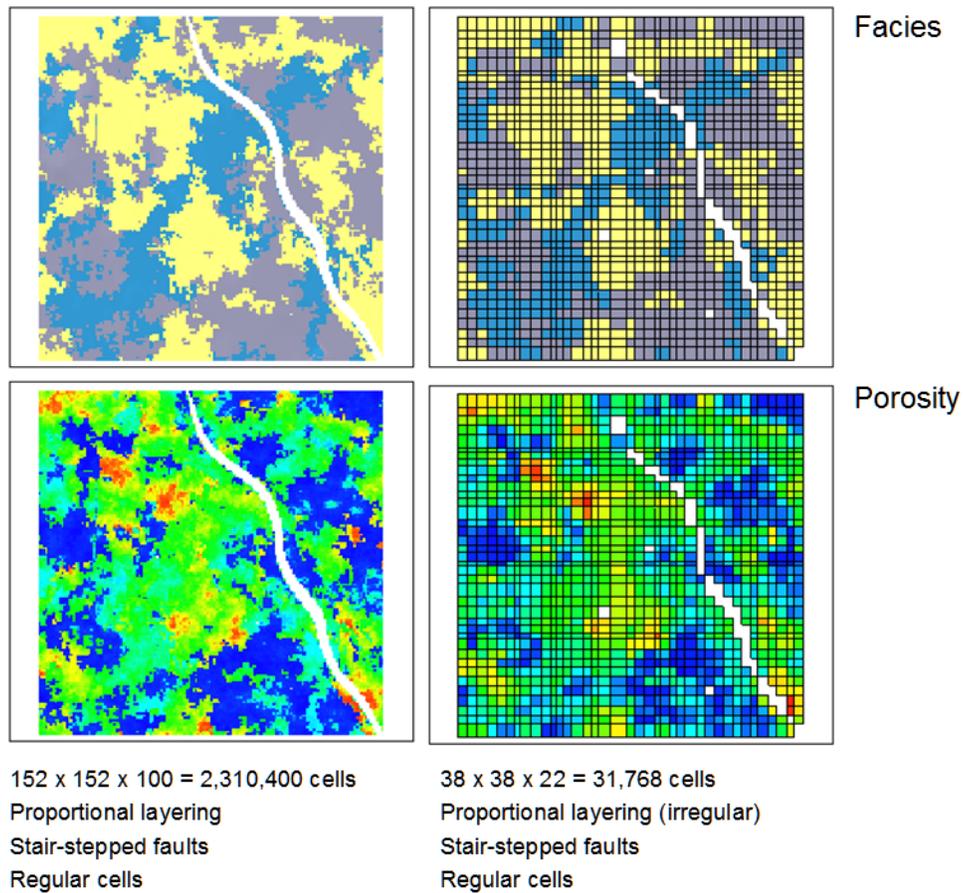


Figure 4 The comparison of the fine geological grid and the designed simulation grid (Horizontal). The remaining heterogeneity is 70%, 70% and 80% in I, J, K directions, respectively.

Conclusions

In this presentation, a practical workflow is provided to demonstrate how to create an irregular simulation grid. The simulation grid meets all the design rules (Zhang, *et al.*, 2009) and remaining reservoir heterogeneity can be quantified. The optimal number of columns, rows and layers can be picked from the plots of heterogeneity versus model columns, rows, and layers, respectively.

In practice, the desired maximum number of defined cells of the simulation grid should also be considered when choosing the optimal number of columns, rows and layers of the designed simulation grid.

References

- King, M.J., et al., 2005, Optimal coarsening of 3D reservoir models for flow simulation, 2005 SPE Annual Technical Conference and Exhibition, Dallas, USA. SPE 95759.
- Zhang, X., Ghanbari, S., and Chelak, R., 2009, Introduction to simulation grid design and upscaling, 2009 CSPG CSEG CWLS Convention, Calgary, Canada.