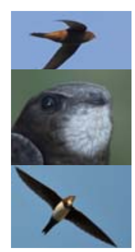
SWIFT: Upgridding & Upscaling Training Session

Krishna Nunna

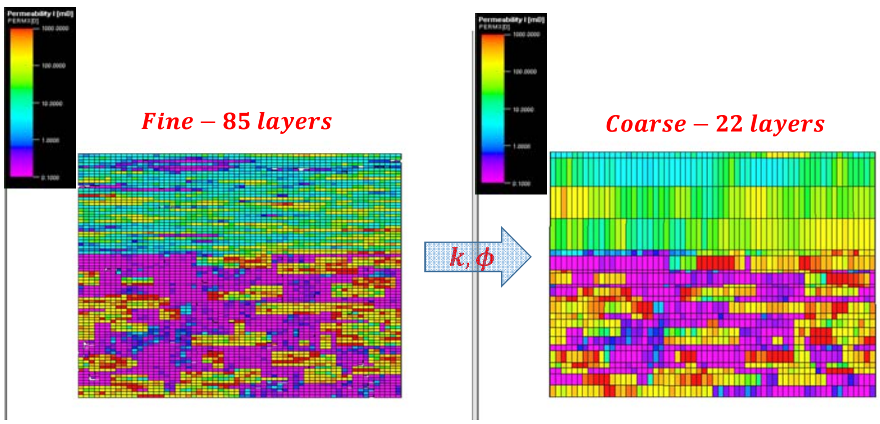
April 28, 2017

Outline



- Introduction
- SWIFT Technology
- SWIFT Workflows
- SWIFT Output
- Training

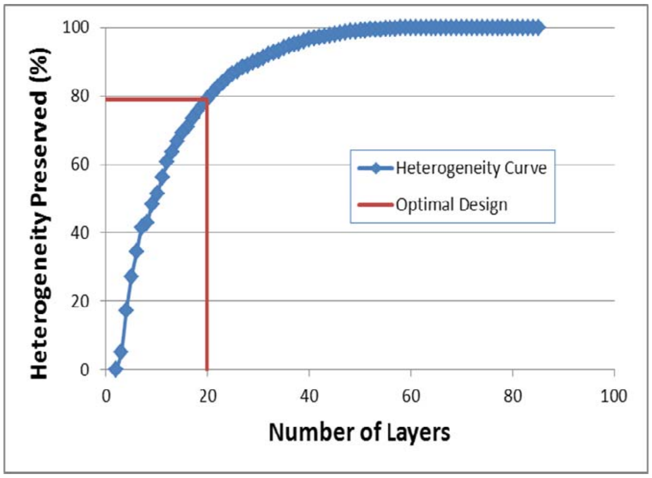
Upgridding & Upscaling



SWIFT Technology

Upgridding	Upscaling
Layer design based on an error analysis • How coarse a grid is optimal? • Have explored different error measures	Well index upscaling provides upscaled cell permeabilities • Suitable for visualization • Preserves continuity • Does not capture flow barriers
Areal grid coarsening usually depends on well spacing or CPU requirements	Transmissibility upscaling preserves the flow connectivity and barriers • Local flow calculation imposes planar pressure boundary conditions • Transmissibility multipliers may be used to visualize barriers

SWIFT Technology: Upgridding



- Recursive analysis used to design and identity optimal layering

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Static Property Upscaling

Weights come from the previous equation in the hierarchy

Conserved Volume	Summation	Expressed as an Averaged
Bulk Rock Volume	$MULTBV.BRV = \sum_i BRV_i$	$MULTBV = \frac{\sum_i BRV_i}{BRV}$
Net Rock Volume	$NTG.MULTBV.BRV = \sum_i NTG_i.BRV_i$	$NTG = \frac{\sum_i NTG_i.BRV_i}{\sum_i BRV_i}$
Pore Volume	$\phi.NTG.MULTBV.BRV = \sum_i \phi_i.NTG_i.BRV_i$	$\phi = \frac{\sum_i \phi_i.NTG_i.BRV_i}{\sum_i NTG_i.BRV_i}$

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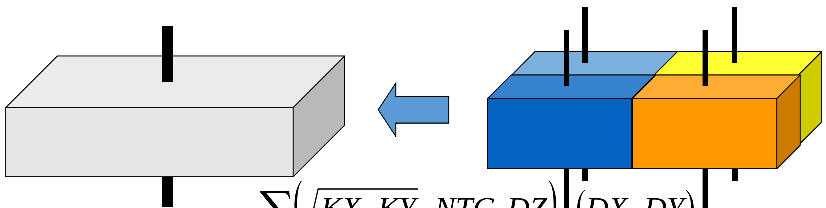
Well Index Upscaling

- Preserve flow between wells and the reservoir
  - Three hypothetical directional wells (X, Y & Z) for each coarse cell
  - Algebraic upscaling preserves reservoir quality & continuity of pay



$$\left(\sqrt{KX \cdot KY}\right)^{Effective} = \frac{\sum_{ijk}\left(\sqrt{KX \cdot KY} \cdot NTG \cdot DZ\right)_{ijk}\left(DX \cdot DY\right)_{ijk}}{\sum_{ijk}\left(NTG \cdot DX \cdot DY \cdot DZ\right)_{ijk}}$$

- Use well index upscaling to define cell permeability in the simulator
  - Ensures that fluids correctly enter and leave the reservoir

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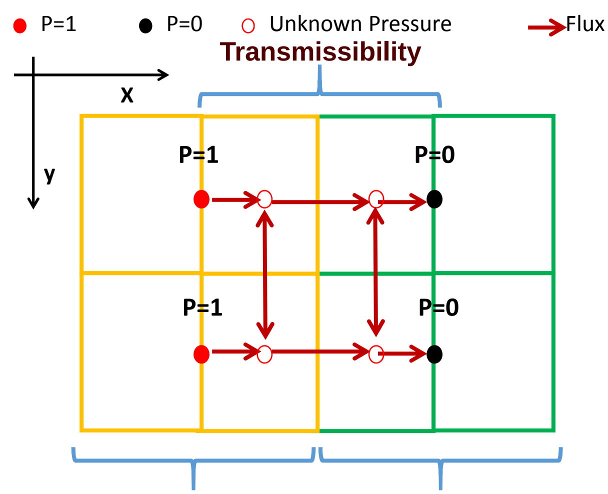
Transmissibility Upscaling

- Planar pressure boundary condition imposed to get the upscaled transmissibility
- 2x2 flow calculation shown



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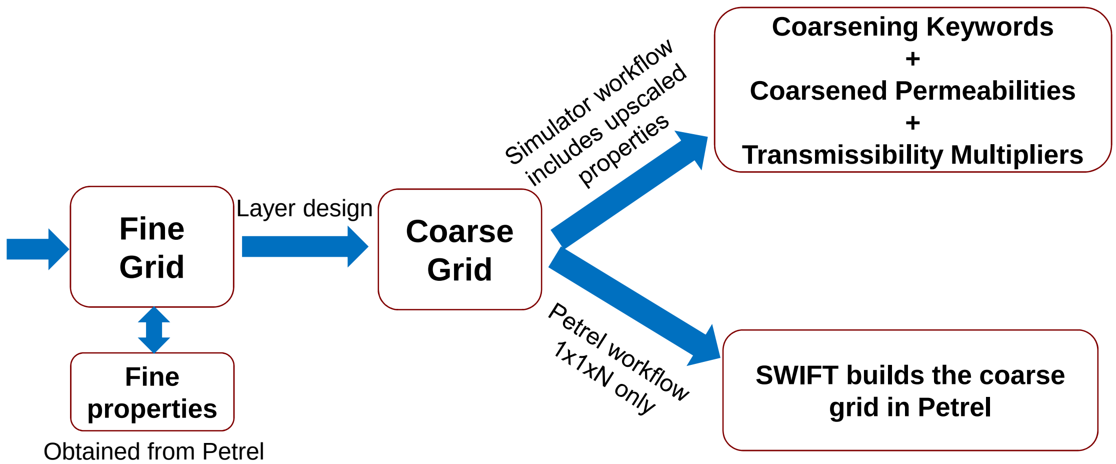
SWIFT Workflows



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SWIFT Workflows

	Simulator	Geologic model
Input	Fine scale model	Fine scale model into Petrel
Upgridding	COARSEN keyword	SWIFT builds coarse grid
Upscaling	Calibrated fine cell permeabilities and transmissibility multipliers supplied	Property upscaling can be performed by Petrel

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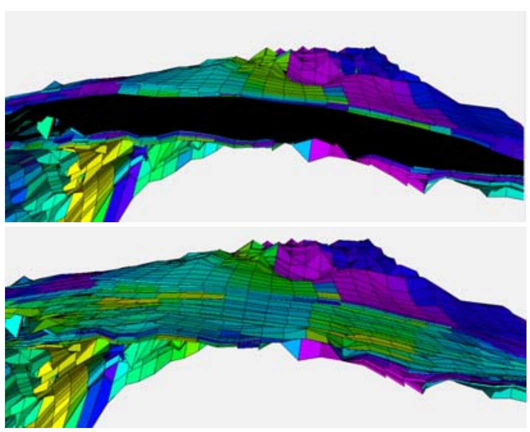
SWIFT: Output Files

File(s)	Function
COARSEN	Simulation grid coarsening as per SWIFT layer design algorithm
COARSE_PERMX, COARSE_PERMY, COARSE_PERMZ COARSE_PORO, COARSE_NTG	Replaces the fine scale cell properties with the coarse average properties (Replaces the original fine scale data)
MULTX, MULTY, MULTZ	Transmissibility multipliers to get the effective coarse transmissibility using SWIFT upscaling algorithm
SWIFT_SUMMARY	Summary of keywords to be included in the GRID section

SWIFT : Follows Horizons

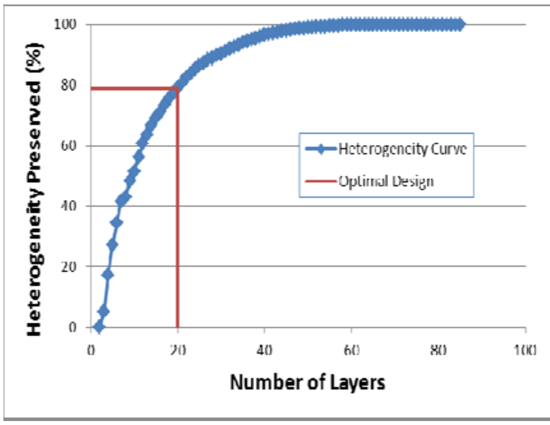


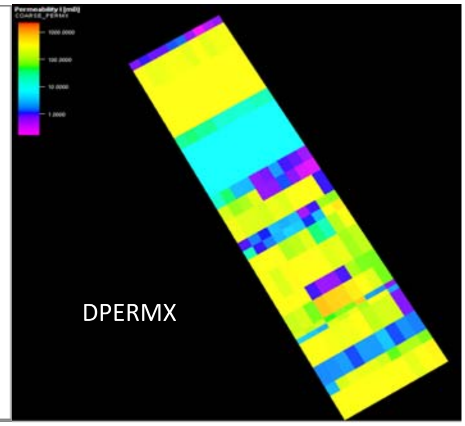
Hard to visualize this many layers!

DWGOM Field Model 420 → 13 layer

14 Horizons are shared between the fine and coarse models

SWIFT: Diagnostics





1D Diagnostic plot

3D Diagnostic

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SWIFT

- Live demonstration
- Questions?

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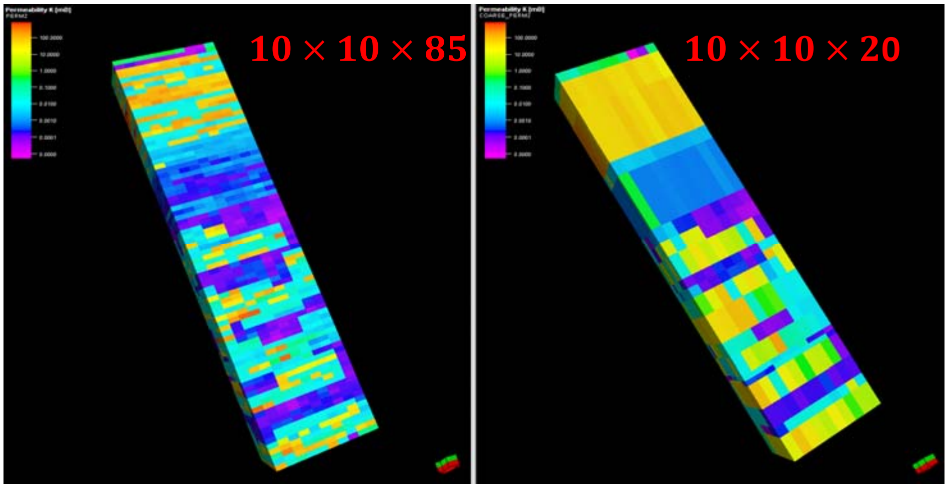
SWIFT Example: SPE 10 Sector



Well Index Upscaling

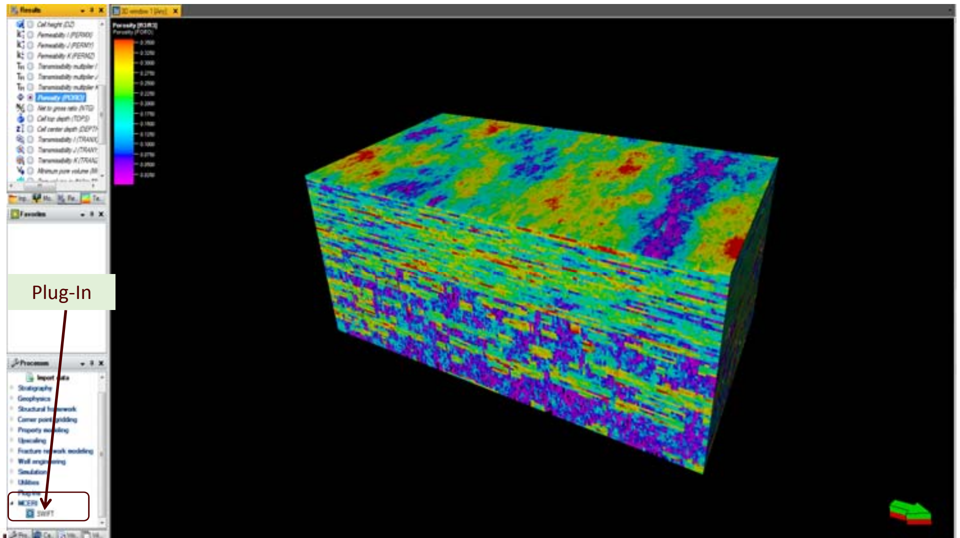
$$\left(\sqrt{KX \cdot KY}\right)^{Effective} = \frac{\sum_{ijk}\left(\sqrt{KX \cdot KY} \cdot NTG \cdot DZ\right)_{ijk}\left(DX \cdot DY\right)_{ijk}}{\sum_{ijk}\left(NTG \cdot DX \cdot DY \cdot DZ\right)_{ijk}}$$

$$KX^{Effective} = \frac{\left(\sqrt{KX \cdot KY}\right)^{Effective} \cdot \left(\sqrt{KX \cdot KZ}\right)^{Effective}}{\left(\sqrt{KY \cdot KZ}\right)^{Effective}}$$

$$KY^{Effective} = \frac{\left(\sqrt{KX \cdot KY}\right)^{Effective} \cdot \left(\sqrt{KY \cdot KZ}\right)^{Effective}}{\left(\sqrt{KX \cdot KZ}\right)^{Effective}}$$

$$KZ^{Effective} = \frac{\left(\sqrt{KX \cdot KZ}\right)^{Effective} \cdot \left(\sqrt{KY \cdot KZ}\right)^{Effective}}{\left(\sqrt{KX \cdot KY}\right)^{Effective}}$$

Petrel Plug-In: SWIFT



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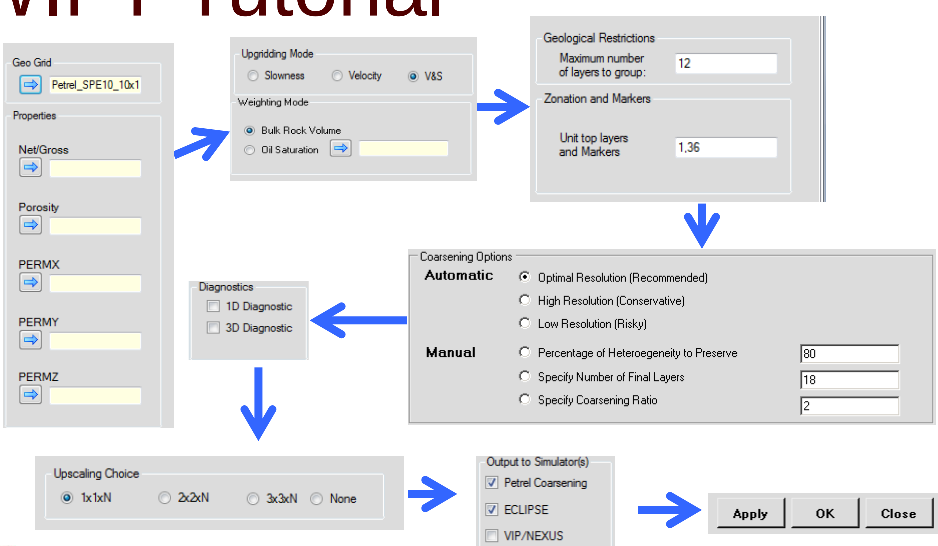
SWIFT Tutorial



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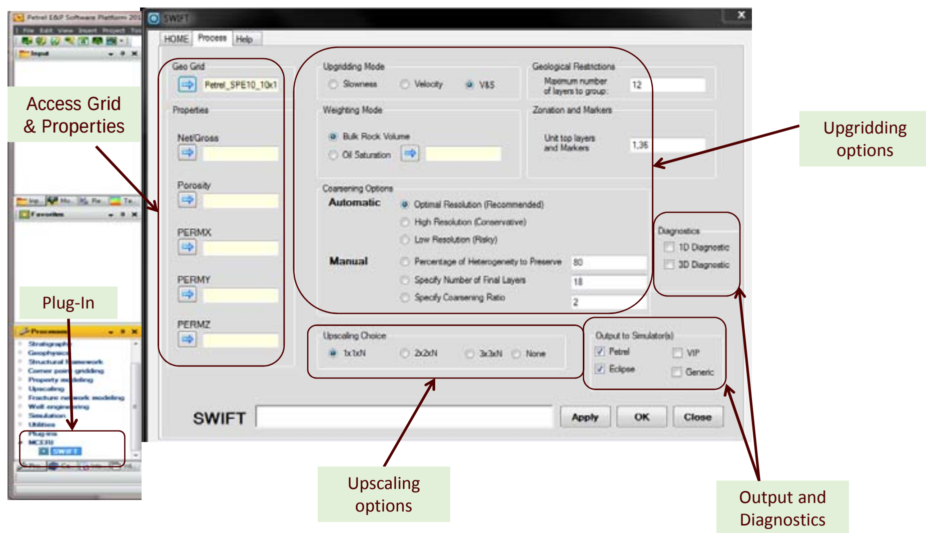
SWIFT GUI



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Complete Simulator Workflow

SWIFT.sip input file

```
OPTIMAL_LAYER_CHOICE
--   Choices for layering design:
--1- Keyword: LAYER & followed by target value.
--2- Keyword: OPT & followed by total number of layers.
--3- Keyword: PERCENTAGE & followed by  followed by target value (30, 80...DO NOT use %).
--4- Keyword: LOW_RES.
--5- Keyword: HIGH_RES.
--6- Keyword: UNIFORM & followed by number of fine layers to be combined uniformly.
OPT

UPGRIDDING ALGORITHM
--VELOCITY or SLOWNESS
VS

UPSCALING CHOICE
--1x1xN, 2x2xN, 3x3xN, None
2x2xN

MARKER
-- marker locations
1/
1/

--Diagnostics
1DDiagnostics
output

3DDiagnostics
no_output

UNIT_MAX
-- Maximum number of fine layers which are allowed to be combined.
12

OUTPUT
-- Outputs are generated in one of these formats->(ECLIPSE==ECLIPSE OR VIP/NEXUS==VIP)
ECLIPSE

PHASE
SINGLE

GRID_FILE
DELMI.GRID

INIT_FILE
DELMI.INIT
```

GRID/INIT for reservoir model

```
--      THIS IS THE SUMMARY FILE OF SWIFT OUPUTS

--      FOR 2X2XN,3X3XN, PLEASE DELETE THE ORIGINAL PERMX, PERMY, PERMZ

--      PLEASE COPY AND PASTE THE FOLLOWING TEXT TO THE GRID SECTION

--PERMX FILE
INCLUDE PERMX.inc

--PERMY FILE
INCLUDE PERMY.inc

--PERMZ FILE
INCLUDE PERMZ.inc

--TRANSMISSIBILITY MULTIPLIERS IN X DIRECTION
INCLUDE MULTX.dat

--TRANSMISSIBILITY MULTIPLIERS IN Y DIRECTION
INCLUDE MULTY.dat

--TRANSMISSIBILITY MULTIPLIERS IN Z DIRECTION
INCLUDE MULTZ.dat

--COARSEN FILE
INCLUDE ECL_COARSEN.dat
```

SWIFT-SUMMARY FILE

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