Some Practical Considerations on Scaling

by

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Outline

1. ***Small-scale Features:***

    Conserving or losing information

2. ***Property contrasts – Fluvial sands***
3. ***Tensor Permeability?***
4. ***Rescaling – what should be conserved?***
5. ***What about Physics?***

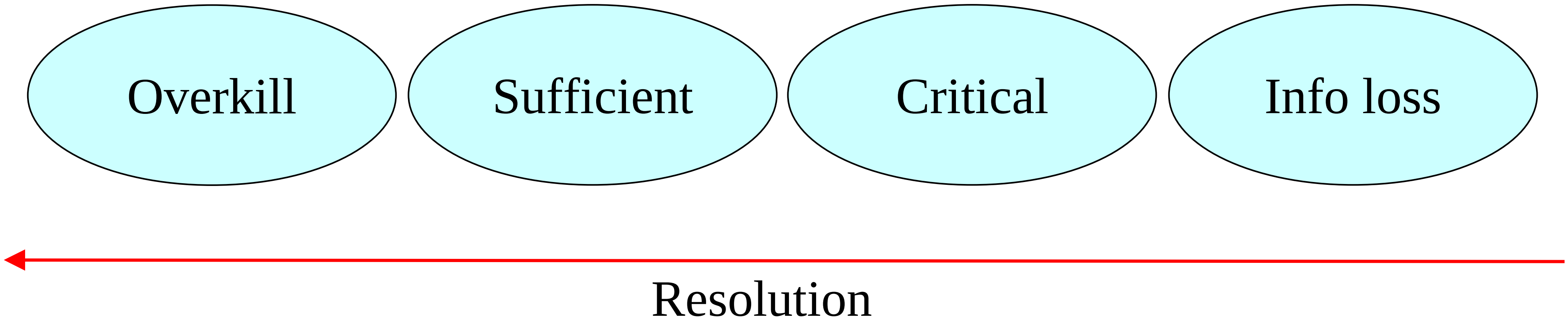
Questions – No Answers!


128 dpi
64 dpi
48 dpi
32 dpi
24 dpi
16 dpi

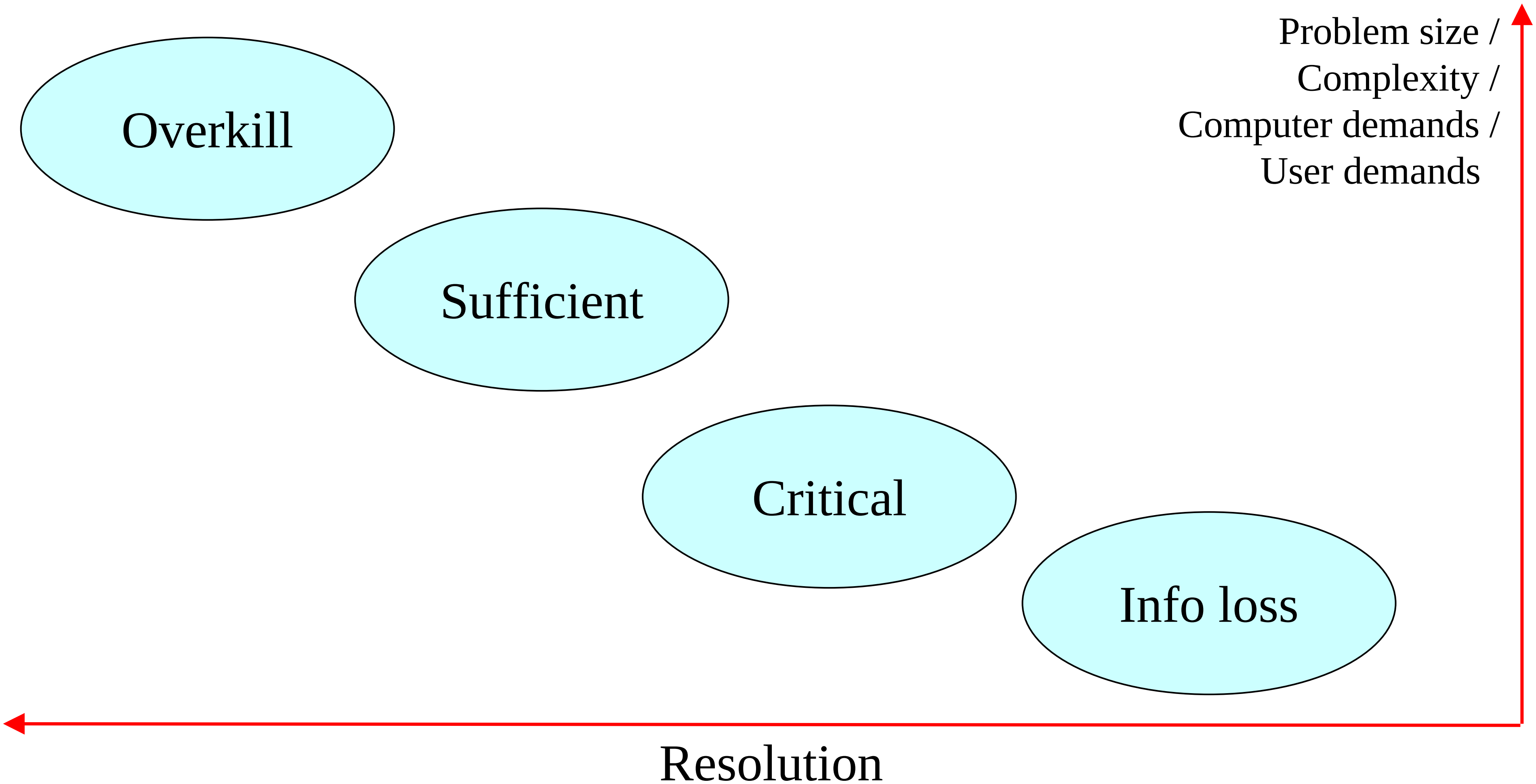

12 dpi
8 dpi
6 dpi
4 dpi
2 dpi
1 dpi

Observation

Along the upscale line, some critical resolution will always exist, such that beyond that resolution, information is lost, whatever we do.



Scale vs. effort



Choosing the “right” scale

What is vital?

What if we were allowed to use max resolution ...

Could we handle it?

"Subtle is the Lord, but malicious He is not" (?)

Given a set of field observations, there will always be some observations that cannot be explained or understood.

A) The action is on a too fine scale
B) Inadequate understanding of the physics
C) Inadequate model
D) The reservoir never intended that we were meant to understand...

Our observation base is a very small subset of actual behaviour in the reservoir $\rightarrow$
It's probably best not to even attempt to explain/account for these.

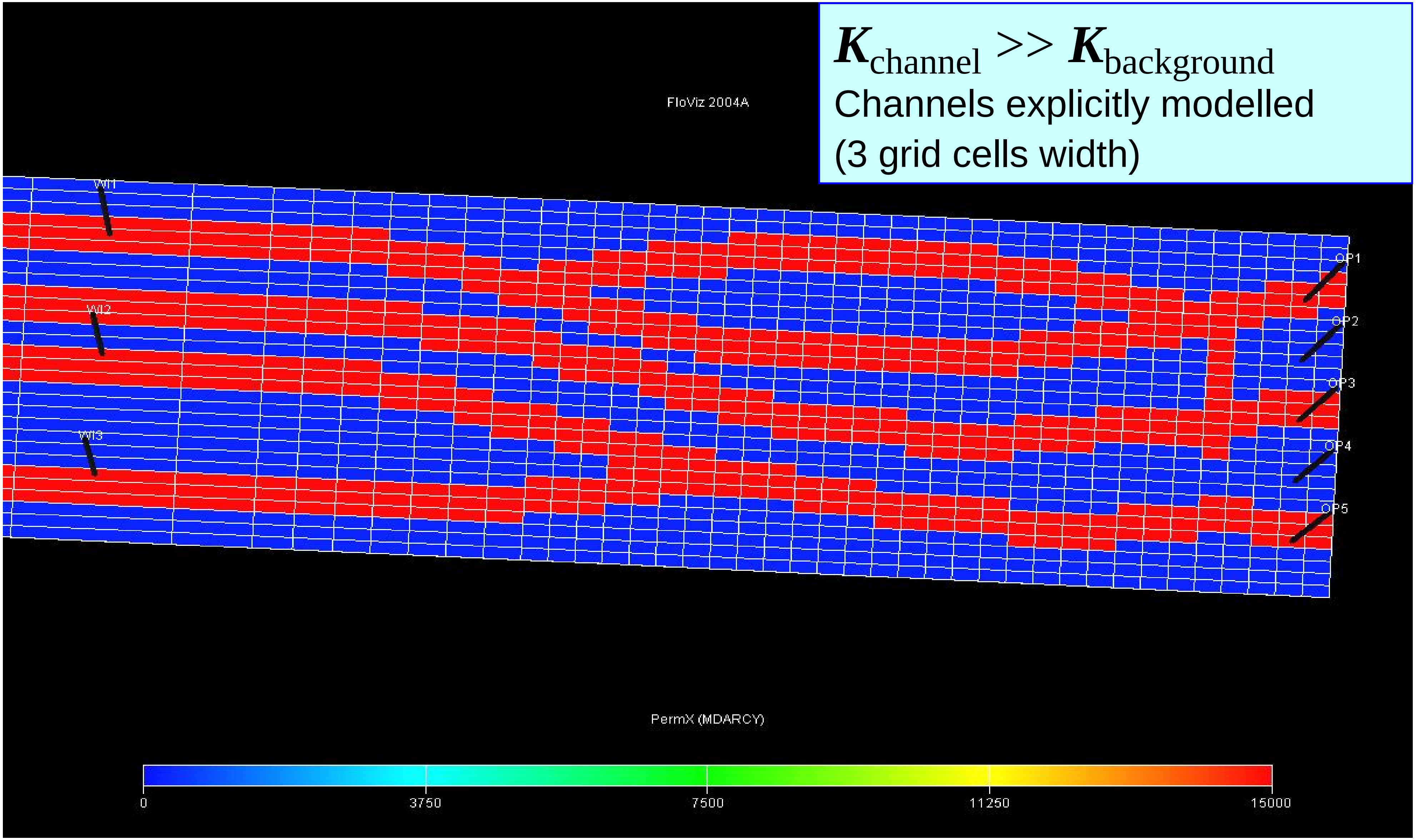
$\rightarrow$ History matching exceptional well production behaviour?

Channels – Large Permeability Contrasts

$K_{\text{channel}} >> K_{\text{background}}$

Channels explicitly modelled

(3 grid cells width)

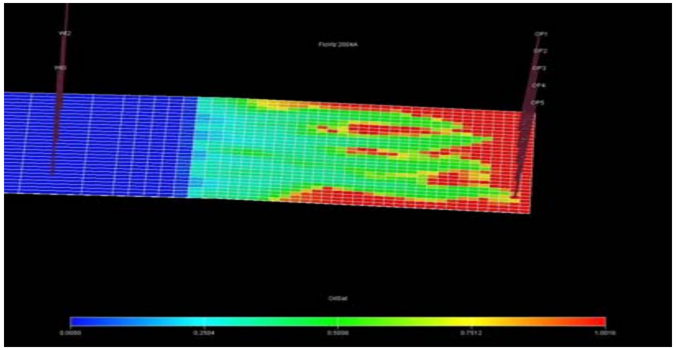


Channels – Large Permeability Contrasts

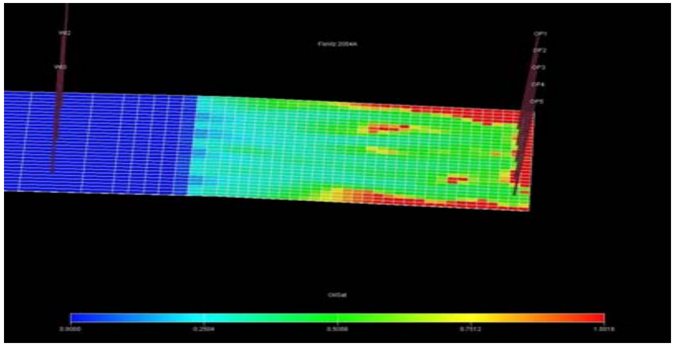
Intuitively we would expect water shoot-through
in the channels,
and water cycling during continued injection.

Our intuition agrees with field observations

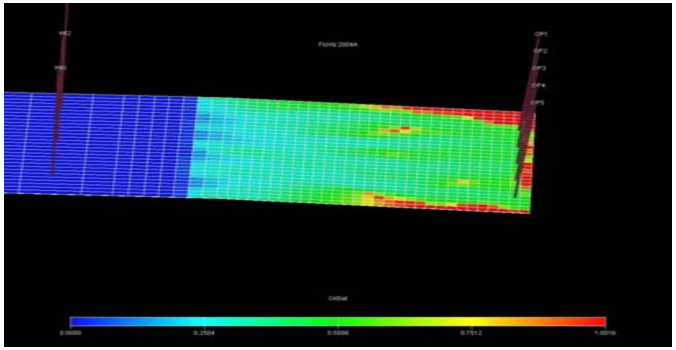
Channels – Large Permeability Contrasts



t_1



t_2

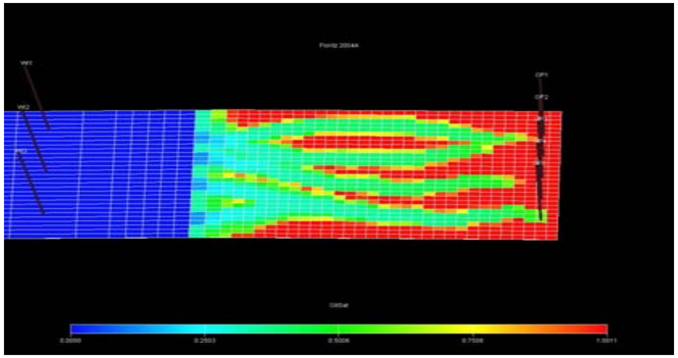


t_3

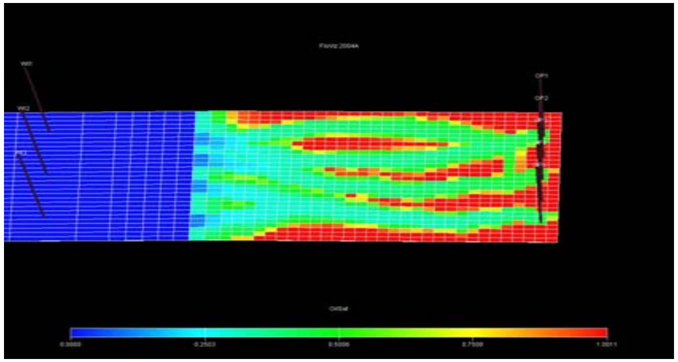
$K_{\text{channel}} = 10 * K_{\text{background}}$
(750mD – 75mD)

Far too much diffusion
Unrealisticly efficient sweep.

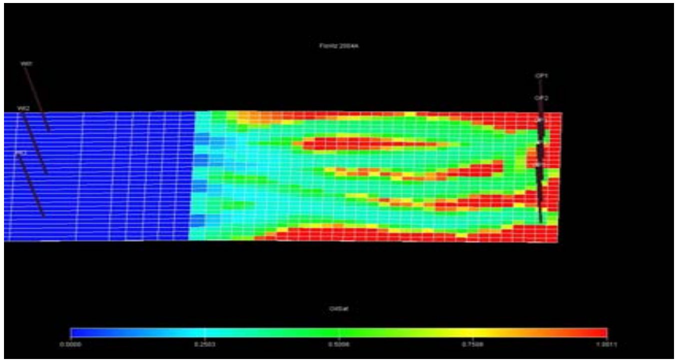
Channels – Large Permeability Contrasts



t_1



t_2



t_3

$\boldsymbol{K}_{\text{channel}} = 60*\boldsymbol{K}_{\text{background}}$
(15000mD – 60mD)

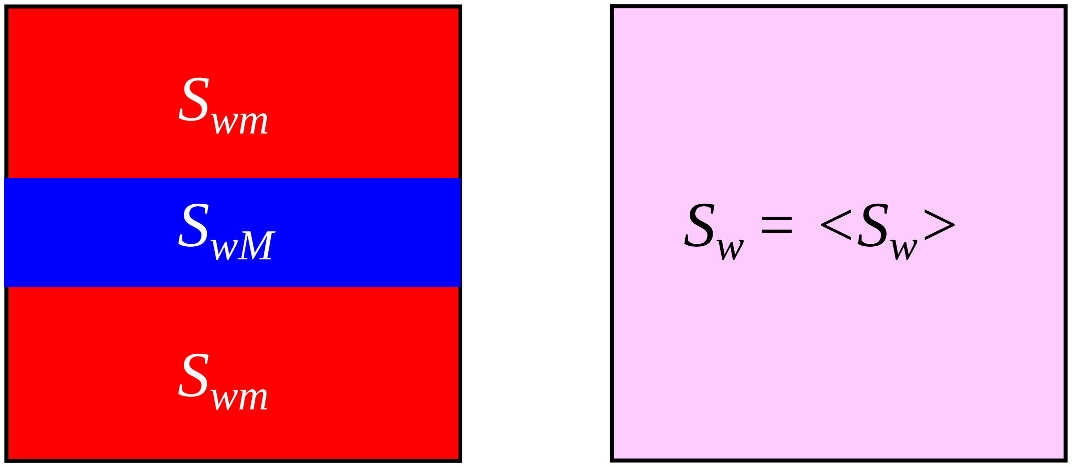
Still far too much diffusion

Channels – Large Permeability Contrasts

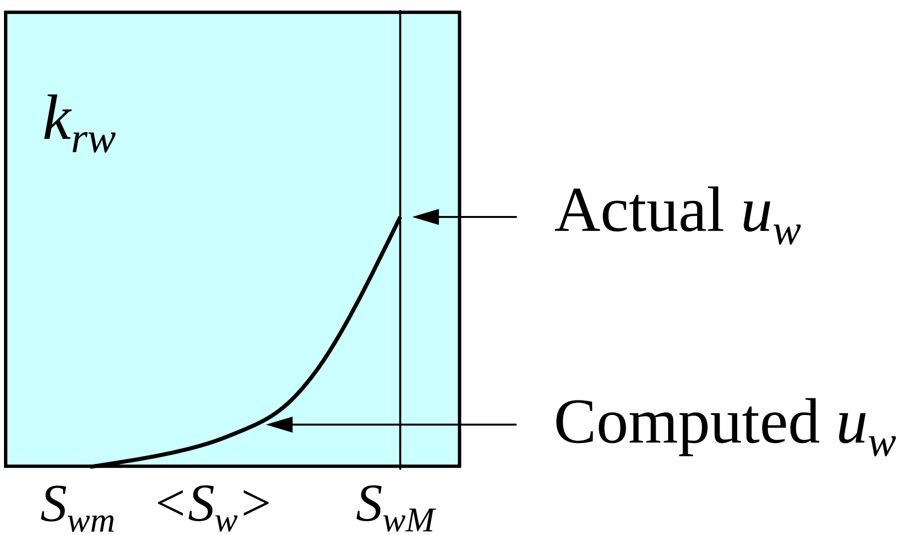
If the simulator (ECLIPSE) can't handle fluvial sands correctly when explicitly modelled with high resolution, how can we expect to upscale this problem?

(E.g. with a typical channel width of 5-15m, and grid cell dimensions of 50-200m.)

Tracking of low concentration, high velocity fluids



Actual Upscaled



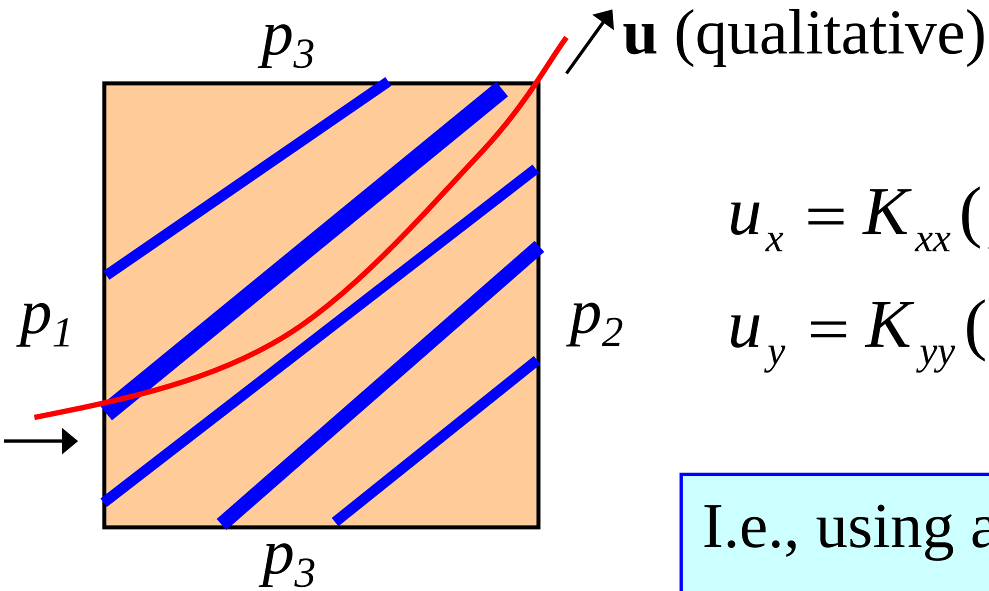
How to compute small volumes of fluid moving with high velocity? Esp. relevant for tracer tracking.

Tensor permeability

Darcy: $\mathbf{u} = \vec{\mathbf{K}} \cdot \nabla p$

One may argue that **K** is diagonal, but this is true only on the actual physics. Upscaling changes the physics, and thereby our model.

Assume a configuration,



Blue: Low-perm

$$u_x = K_{xx}(p_2 - p_1) + K_{xy}(p_3 - p_3) = K_{xx}(\Delta_x p)$$

$$u_y = K_{yy}(p_3 - p_3) + K_{yx}(p_2 - p_1) = K_{yx}(\Delta_x p)$$

I.e., using a diagonal permeability tensor the y-component of **u** is lost.

Tensor permeability – what's the catch?

If we are convinced that we need tensor permeability, why don't we simply use it?
There is a lot of software out there which can handle full tensors correctly.

The catch:
At least 60% of the user base runs ECLIPSE, which doesn't handle tensors correctly.

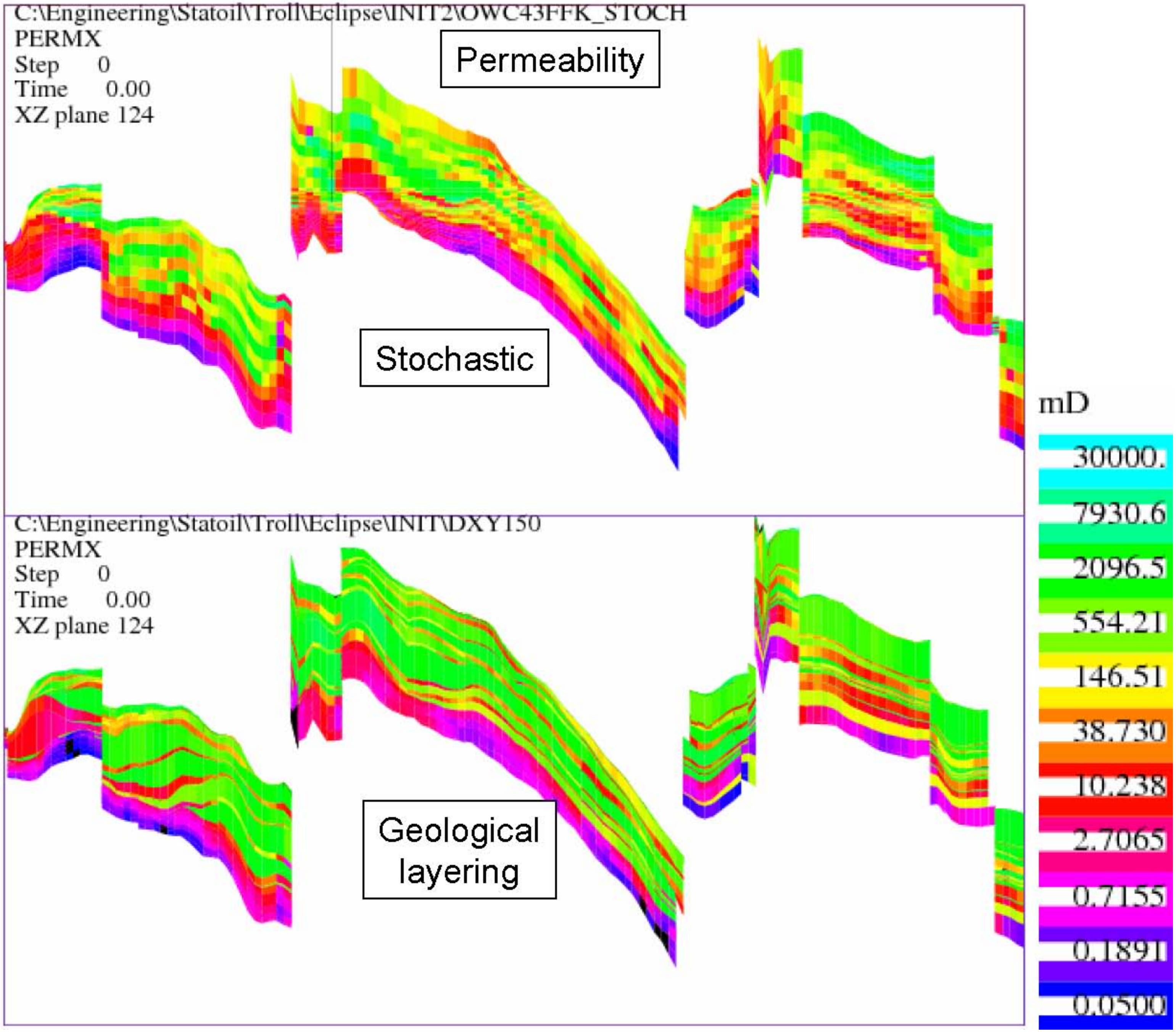
So how can we do the best possible job, accepting this constraint?

Example Rescaling

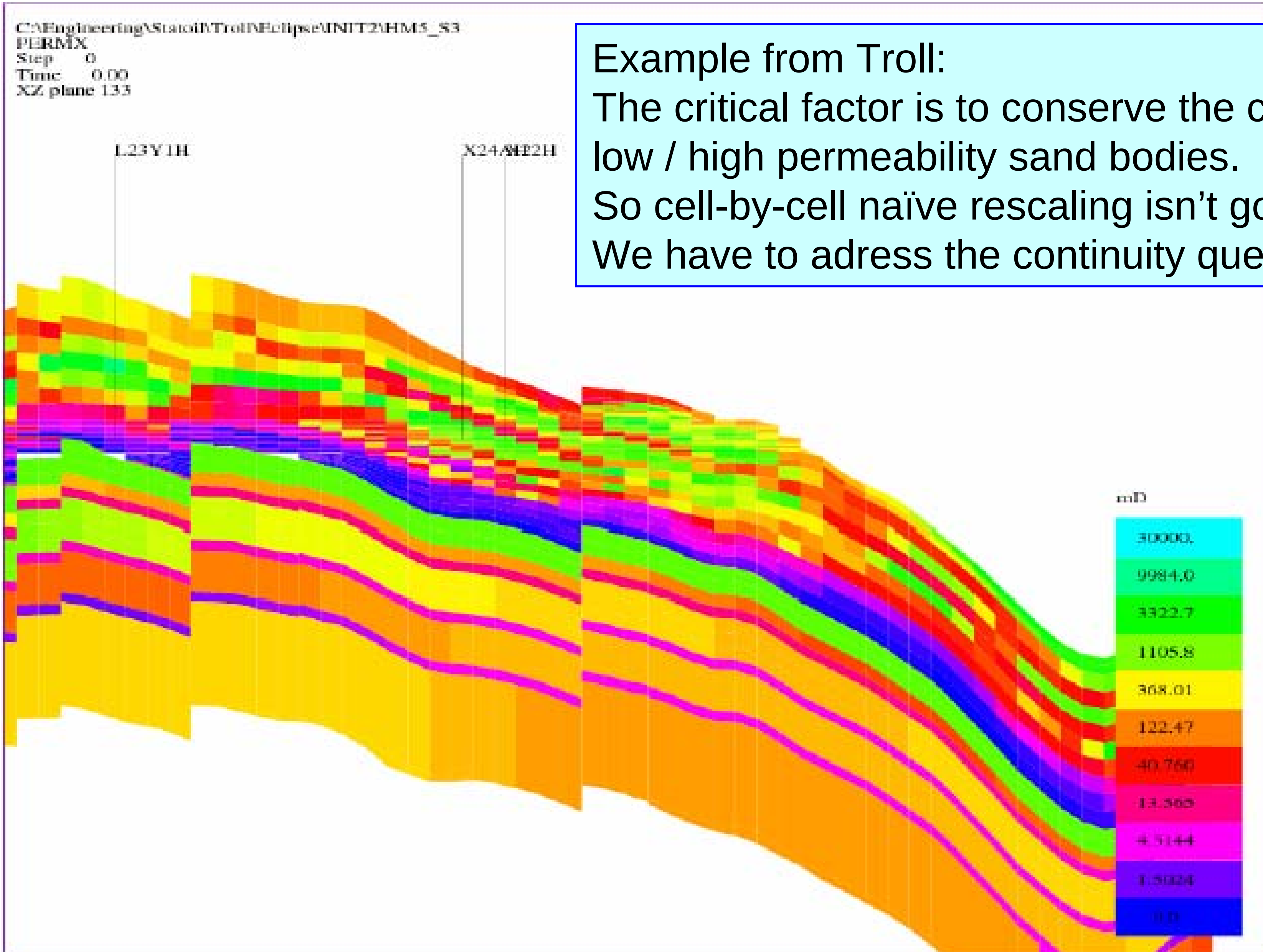
Challenge: Optimal grid for simulating a thin oil zone

- Intuitively, a horizontal grid will honour fluid movement best, but the surface description will be poorer
- A ”geo-grid” honours geology, but has significant drawbacks with respect to fluid flow tracking
- Either way, the final model is an upscaled one
- Since e.g. fluid contact movement is the critical factor in these kinds of problems, it is worhwhile to consider whether the gain in using a horizontal model is larger than the loss.

Example Rescaling – Geo vs. Horiz. model



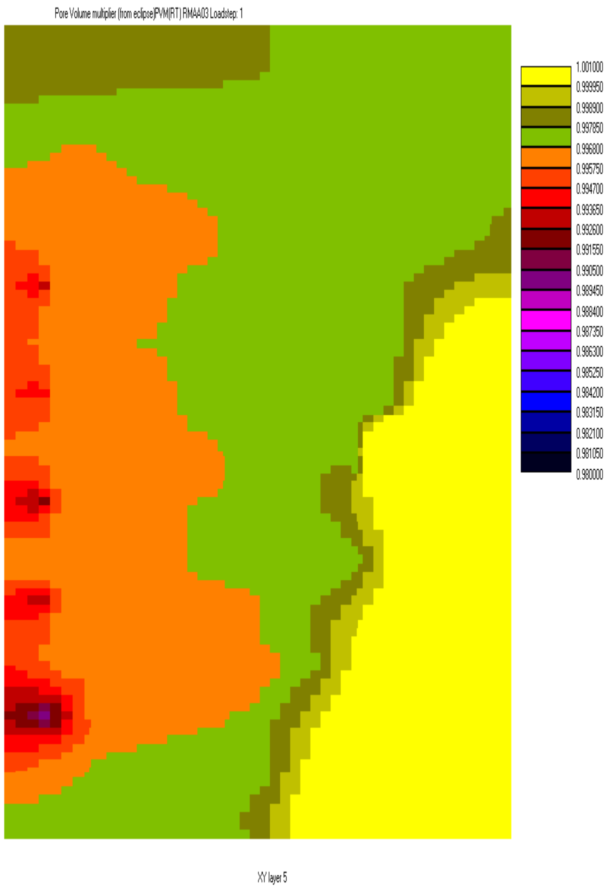
Example Rescaling



Example from Troll:
The critical factor is to conserve the continuity in the low / high permeability sand bodies.
So cell-by-cell naïve rescaling isn't good enough.
We have to adress the continuity question directly.

Honouring physics (hobbyhorse)

The world's best upscaling procedures are not going to help us if essential physics has been neglected from the outset.



Spatial Variation of porosity due to compaction
(Or permeability modifiers)

Left: Standard flow simulator approach.

Right: Correct.