

So: How Many Grid Blocks Do I Need?*

Edmund Stephens¹ and Mark Bentley¹

Search and Discovery Article #40417 (2009)

Posted May 12, 2009

*Adapted from oral presentation at AAPG International Conference and Exhibition, Cape Town, South Africa, October 26-29, 2008.

¹Reservoir Engineering, TRACS International, Aberdeen, United Kingdom (ed@tracsint.com)

Abstract

This paper presents a practical methodology for selecting an optimal grid resolution in dynamic modelling, by the use of representative 2D sections. The workflow is illustrated in a model of a deepwater isolated channel based on an outcrop in the Tabernas Basin, SE Spain.

Empirical indicators are presented to help grid selection in advance of model building. An indicator is developed to identify bypass ‘thief’ zones, which combines geological heterogeneity with fluid type and displacement process into a single number. The result indicates if zones should be retained explicitly in the grid or merged into an effective layer.

The key outcome of this work is a quantified illustration that the geological detail which needs to be carried in a reservoir model depends as much on fluid type and the planned recovery mechanism as it does on the geological heterogeneity itself.

A methodology is presented for grid selection using representative 2D areal and vertical sections. The approach is advantageous in building insight into fluid flow behaviours in the reservoir and prompts selection of a minimal model size leading to short modelling cycle times. The workflow is applied to the Tabernas model and demonstrates different gridding requirements for oil, gas and oil rim realisations.



So: How many grid blocks do I need?

AAPG, Cape Town

October 2008

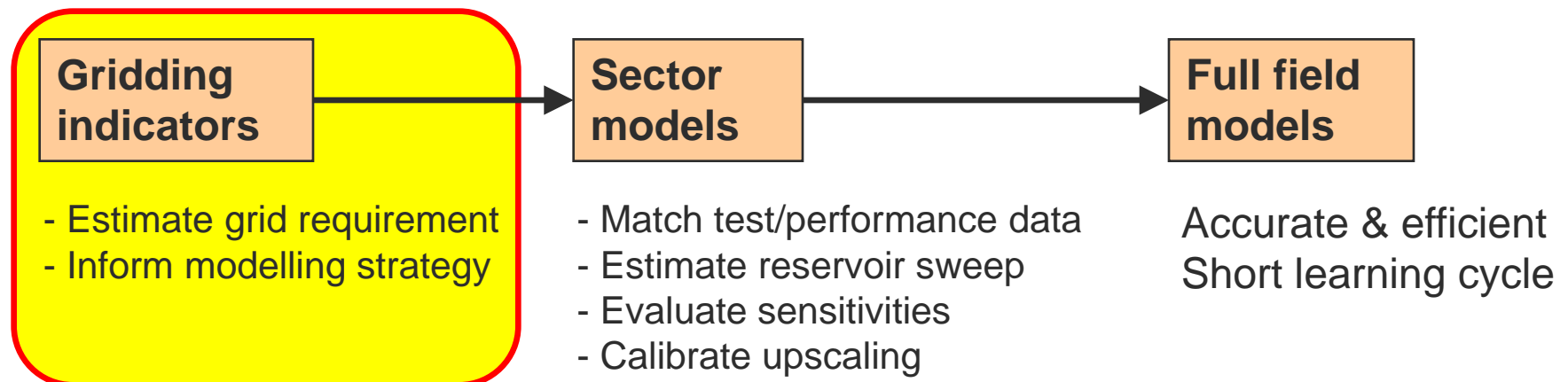
Dr Edmund Stephens, Consultant staff reservoir engineer

Dr Mark Bentley, Consultant staff geologist

Summary of presentation

- Grid depends on **fluid type**, **displacement process**
- Representative **scale of interest** (length, time)
- Example in deep water turbidite outcrop model
- Excessive grid resolution → threat to project delivery
- Worse, engineer may be unaware of needing a finer grid

So: Modelling strategy



Comparing static vs. dynamic gridding

Geocellular model

Structure
Stratigraphy
Facies
Properties

Flow model

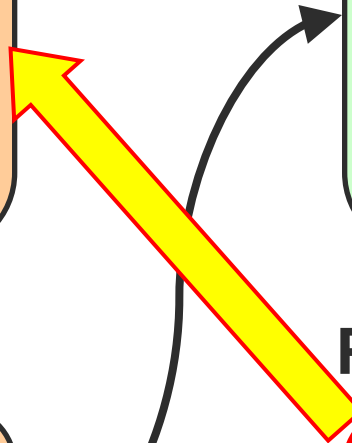
Pressure
Saturation
(Composition)
(Temperature)

Objectives

Volume in place
Connectivity
Heterogeneity

Predictions

Well productivity
Well decline
Recovery factor



Gridding outlook

- **‘Advice’ from text books**

- “Grid blocks should not be larger than relevant geological features”
- “Allow one or more grid blocks (preferably at least three) between wells”
- “Separate injectors/producers and contacts by at least three grid blocks”

- **Traditional results check**

- Compare results using finer scale model
- Tune grid until you get a consistent result
- ... but changing the grid can be hard
- ... and inputs can be scale dependent



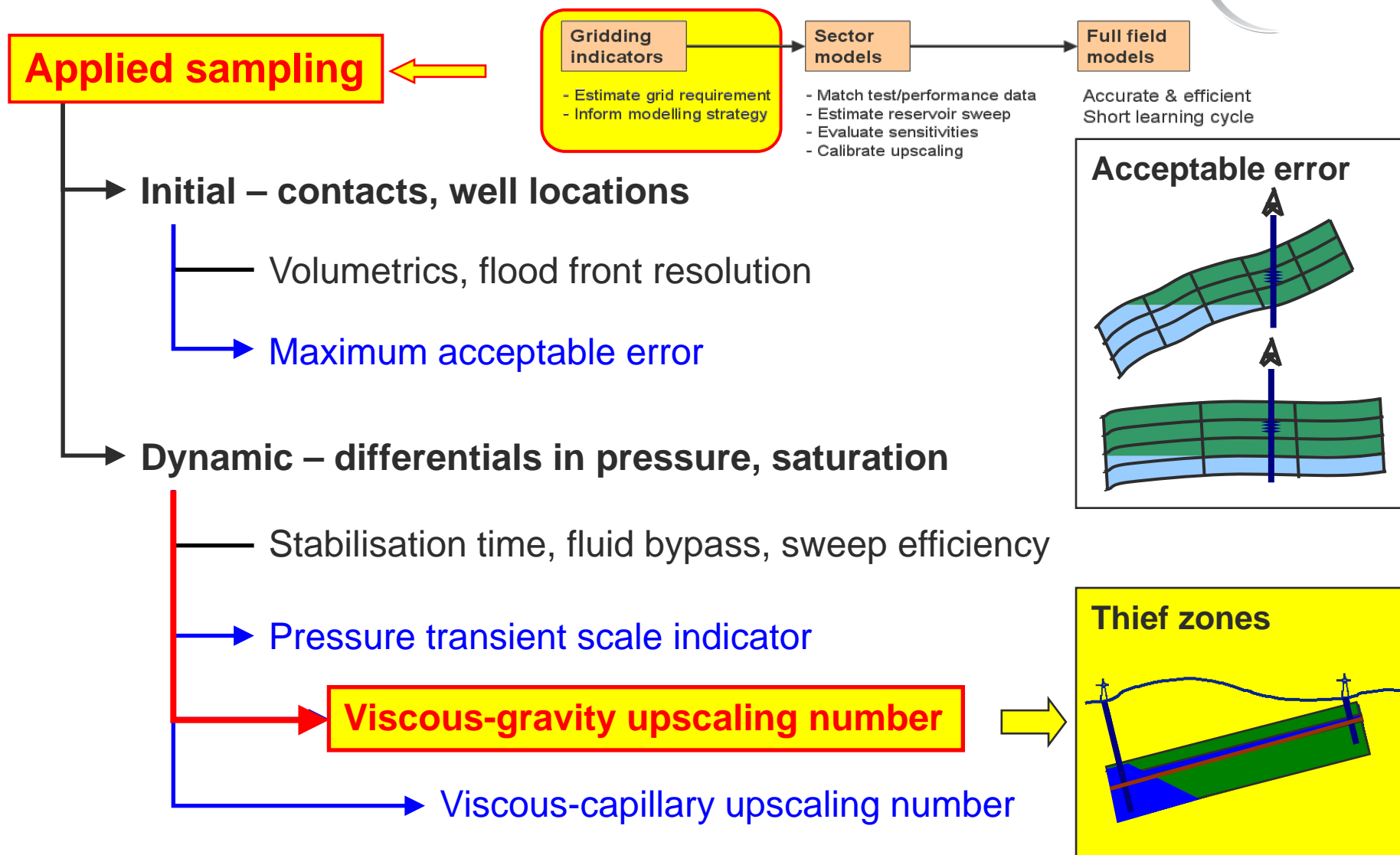
Too Vague !!



Too Busy !!

First casualty of early deadline

Alternative: Gridding Indicators



Viscous-gravity upscaling index

Indicator for bypass

$$U_{v/g} = \frac{1}{2} \left(1 + \left(1 + M_{sf} \right) \frac{k'_v}{k_v^{\text{eff}}} \right) \frac{k'_h}{k'_v} \frac{H'}{L} \cdot \frac{\Delta P / L_s}{\Delta \rho \cdot g}$$

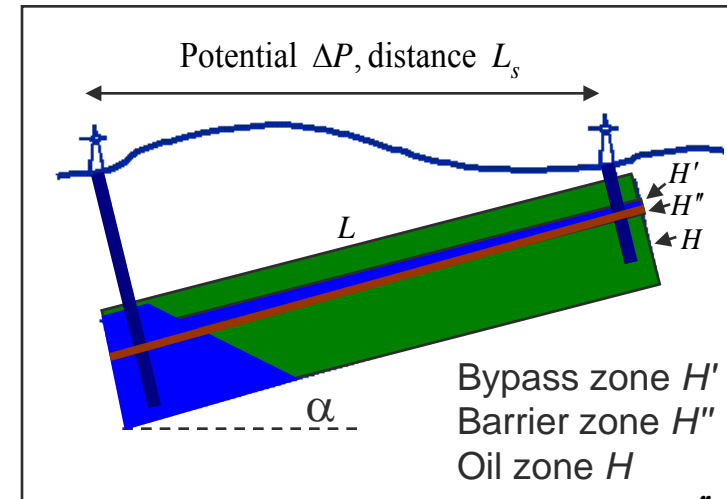
Permeabilities, thickness, length, force term

M_{sf} is the *shock front* mobility ratio

Dimensionless expression

$U_{v/g} \gg 1$ Bypass zone develops

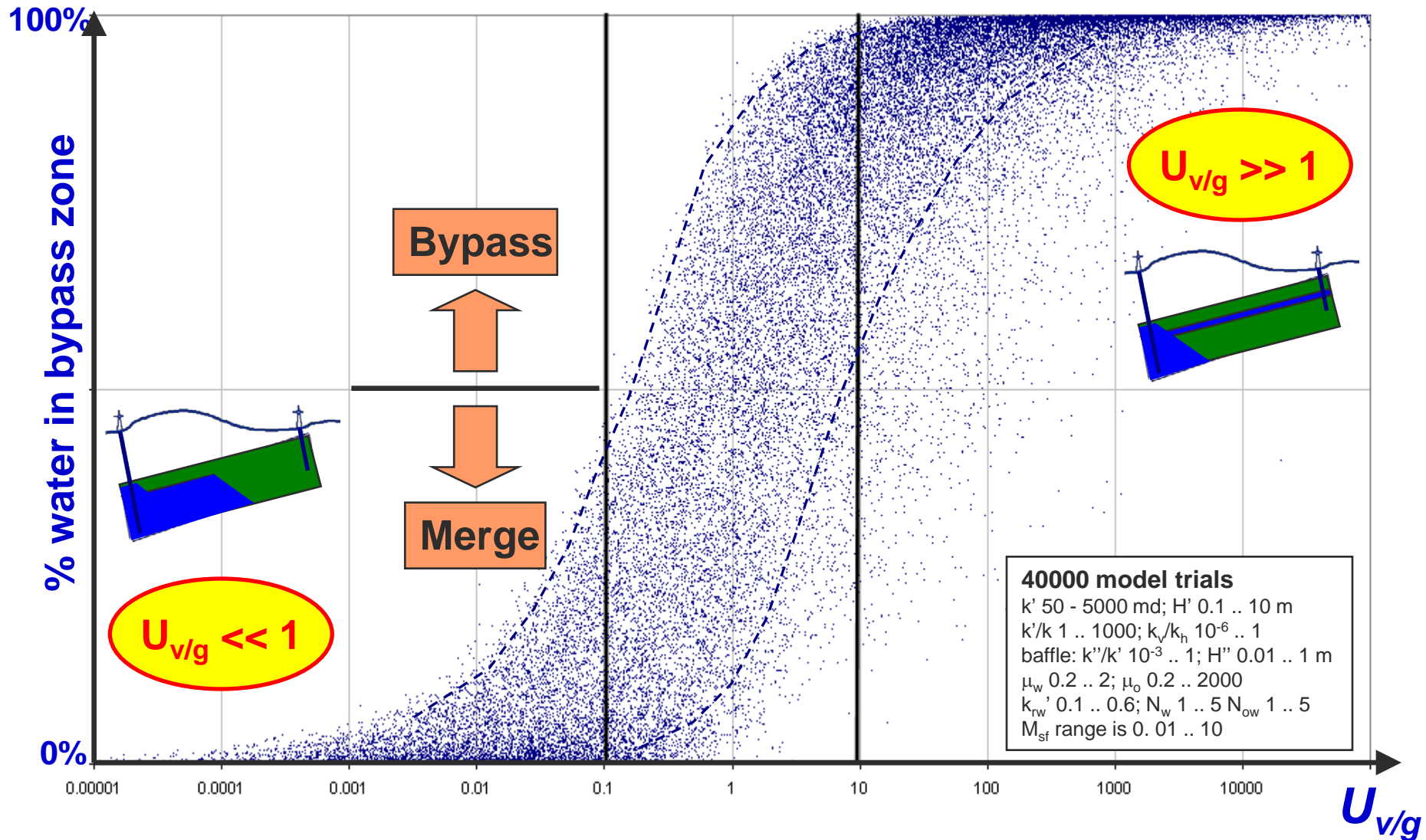
$U_{v/g} \ll 1$ Zone merges by gravity



$$\frac{1}{k_v^{\text{eff}}} = \frac{1}{k_v} + \frac{1}{k_v''} \frac{H''}{H'}$$

Layer bypass does not only depend on rock properties
Also: fluid type, displacement potential, scale of interest

Model trials for viscous-gravity index $U_{v/g}$

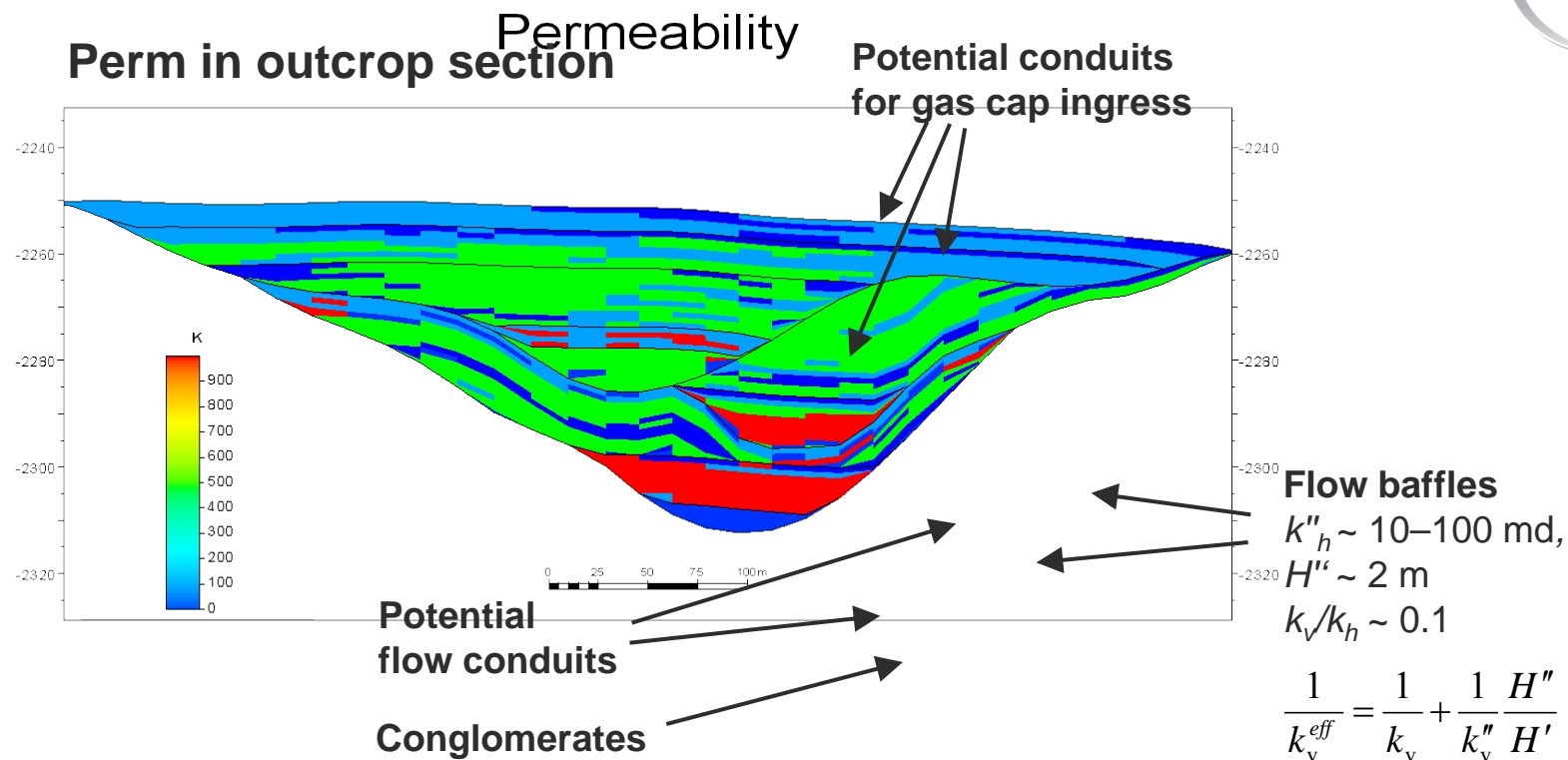


Isolated channel, Tabernas basin

- Narrow channel complex encased in mudstones and with a heterogeneous clastic fill; typical width 200m, thickness of 40m.
- Channel scour, stacked sequence of debrites and high density turbidites [Haughton, 2001].
- High permeability sands (500-1000 md) with thin beds and mudstone layers (5 – 50 md) forming vertical flow baffles in the reservoir.



Application of upscaling index

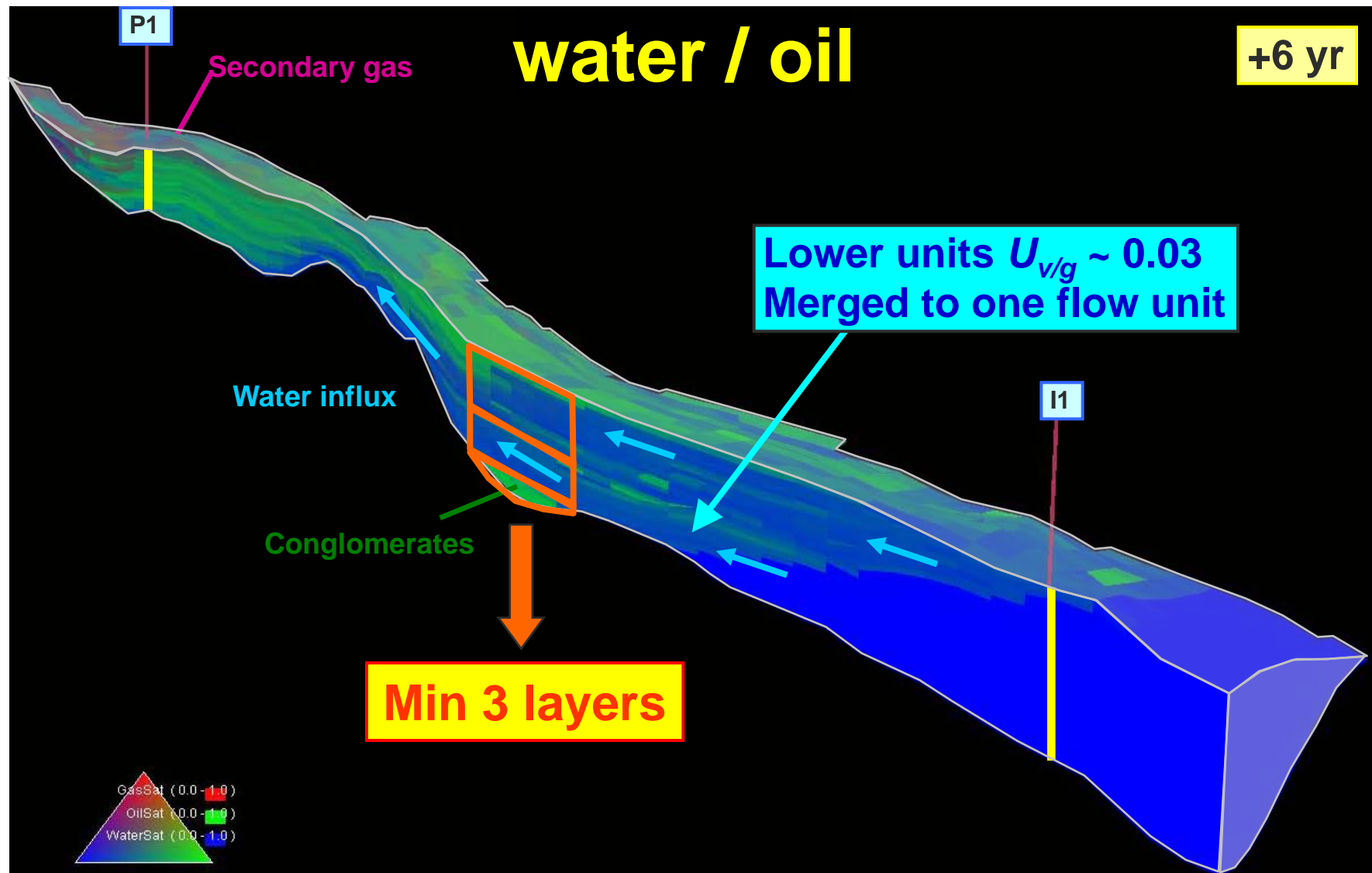


Viscous-gravity index			Static inputs				Dynamic inputs				Result
Fluid fill	Displacement process	Sand unit	k_h' md	H' m	k_v' md	k_v^{eff} md	M_{sf} frac	ΔP psi	L m	$\Delta \rho \cdot g$ psi/ft	$U_{v/g}$ index
Light oil	water/oil	Lower units	1000	10	100	10	0.5	500	5000	0.15	0.03
	water/oil	Conglomerates	1000	10	100	1	0.5	500	5000	0.15	0.3
Oil rim	water/oil	Lower units	1000	10	100	10	0.5	50	500	0.15	0.3
	gas/oil	Upper units	1000	5	100	10	10	50	500	0.15	1.1

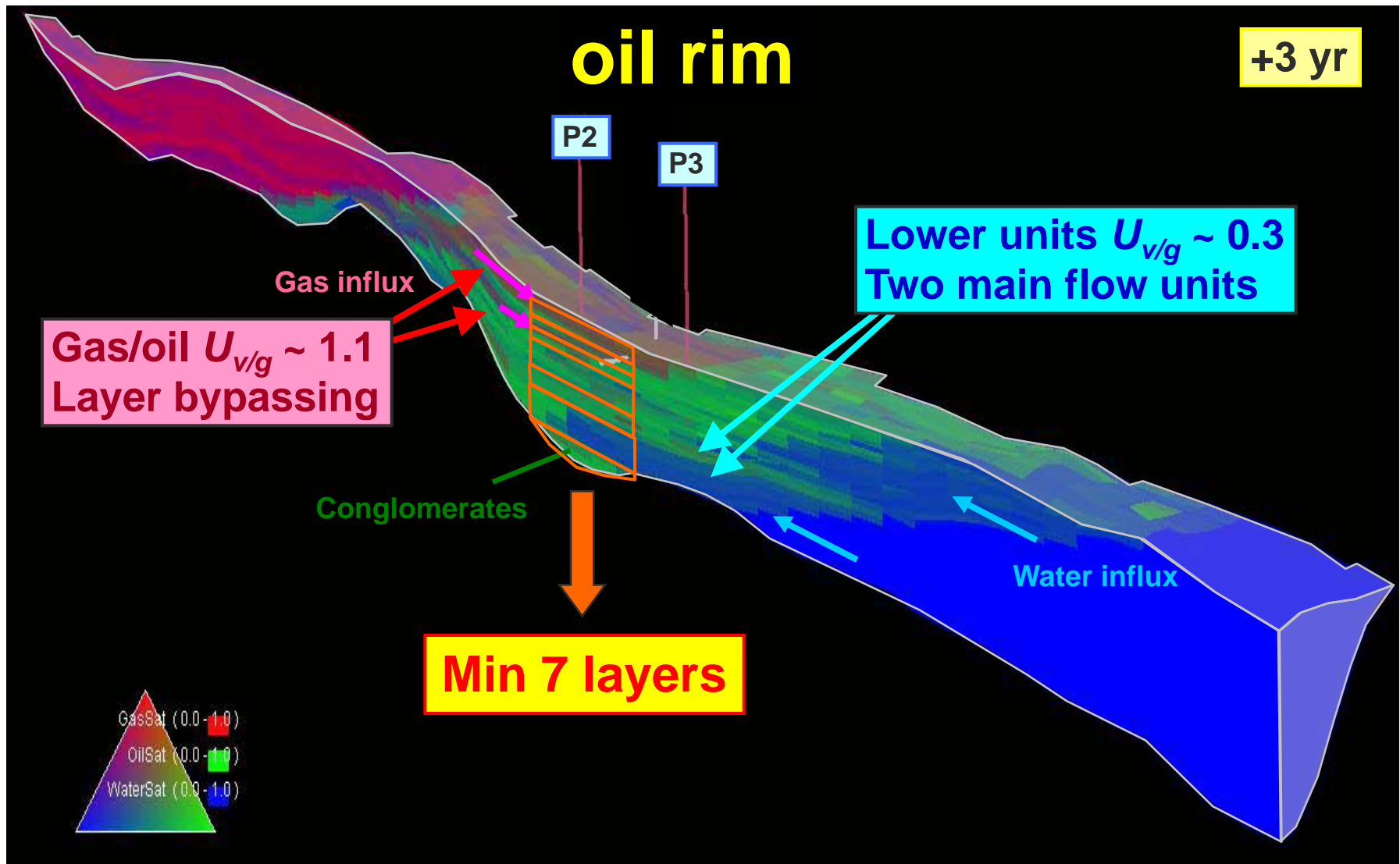
Merge

Bypass?

Light oil realisation



Oil rim realisation

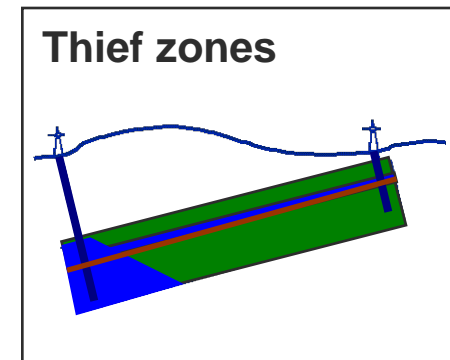


Conclusions

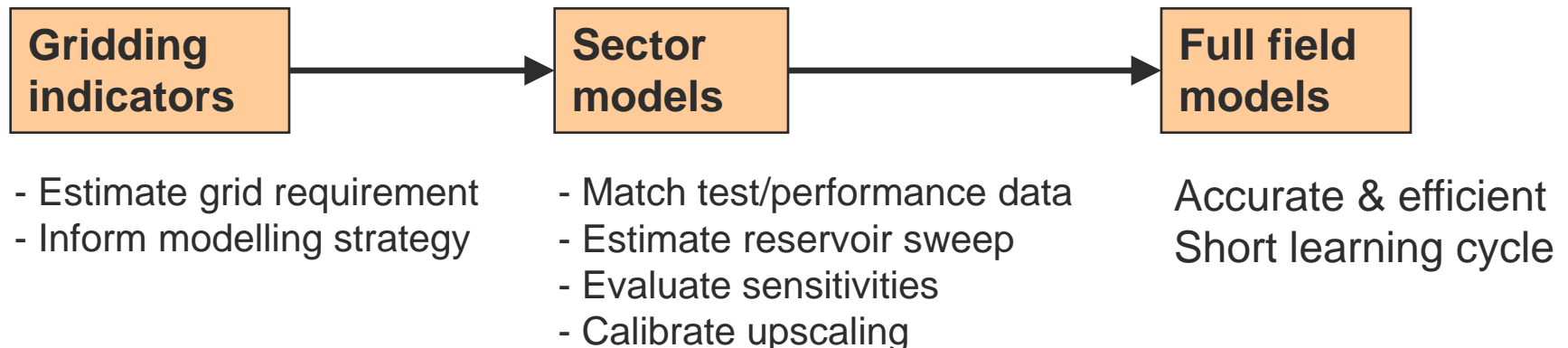
- Bypassing: **fluid type**, **displacement process**, **scale of interest**
- Upscaling indices for quantitative assessment
- Sector models to calibrate upscaling

Viscous-gravity upscaling index

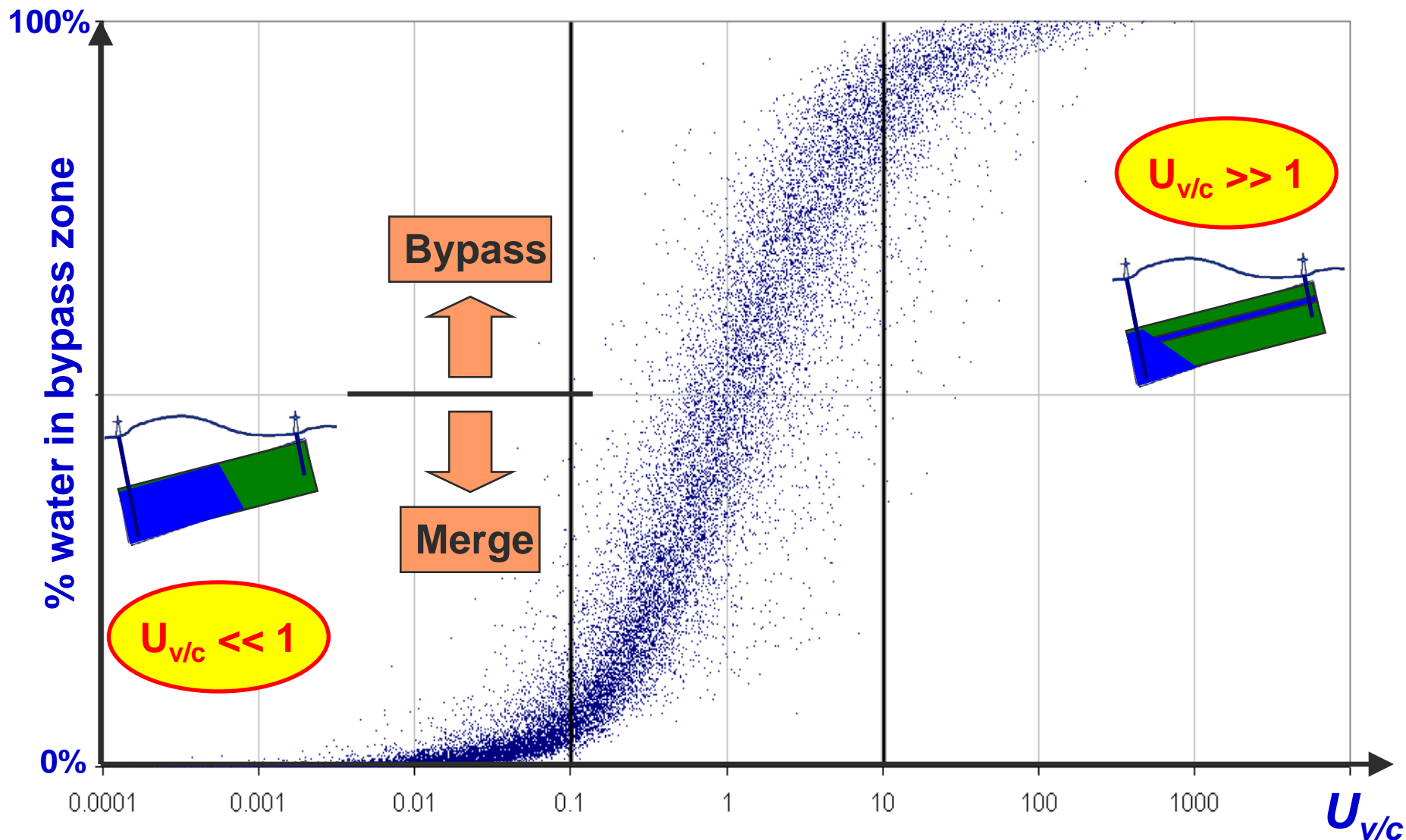
$$U_{v/g} = \frac{1}{2} \left(1 + \left(1 + M_{sf} \right) \frac{k'_v}{k_v^{\text{eff}}} \right) \frac{k'_h}{k'_v} \frac{H'}{L} \cdot \frac{\Delta P / L_s}{\Delta \rho \cdot g}$$



So: How many grid blocks do I need?



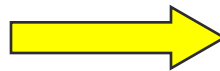
Model trials for viscous-capillary index $U_{v/c}$



Empirical solution for capillary transient

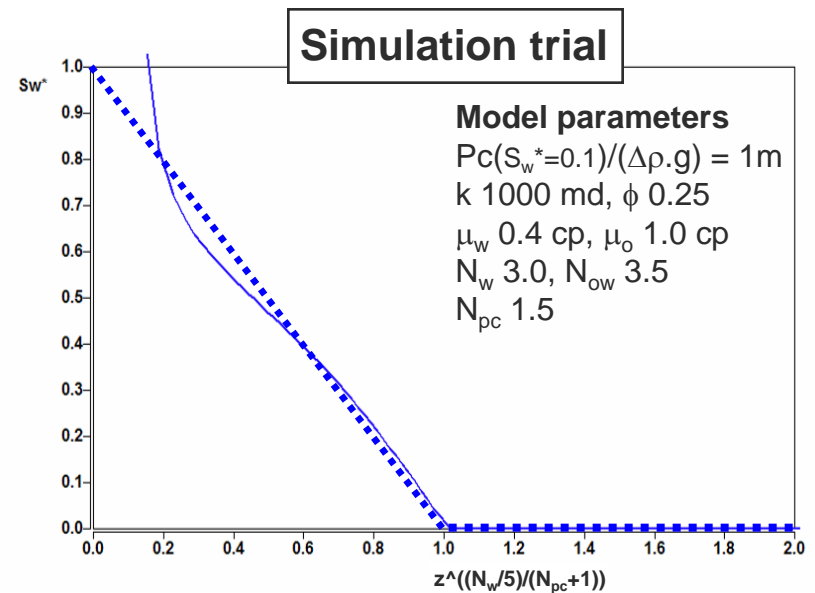
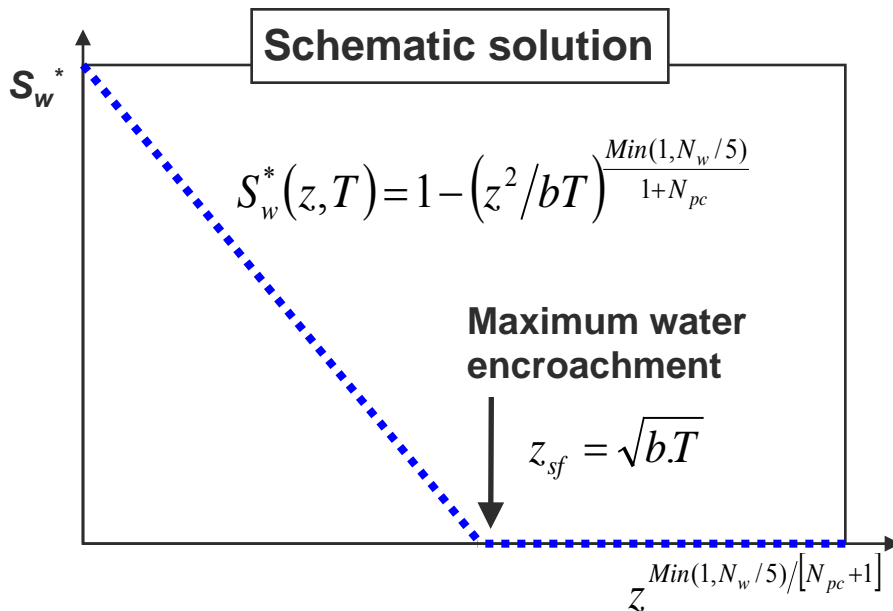
- Depends on perm, porosity, viscosity, Pc and Kr shape exponents
- Empirical solution for **shock front velocity** parameter (b)

$$b = Pc_e \cdot \frac{4N_{pc}^2}{N_w^4} \cdot \frac{k}{\phi} \cdot \frac{k_{rw}/\mu_w}{1 + M_{sf}}$$

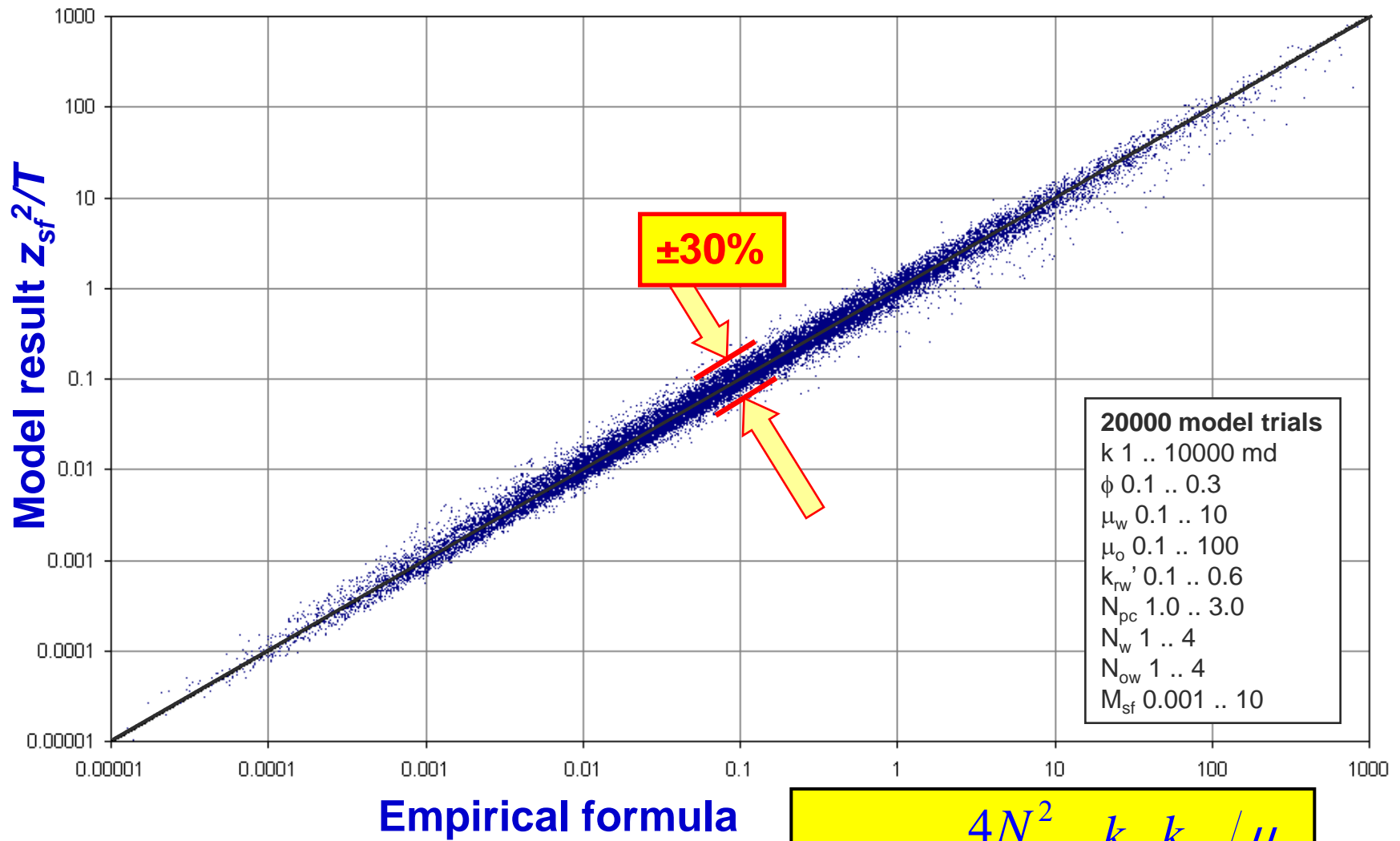


**Minimum layer thickness
Yield of tight zone**

Capillary transient function



Model trials for capillary shock front parameter



$$b = Pc_e \cdot \frac{4N_{pc}^2}{N_w^4} \cdot \frac{k}{\phi} \cdot \frac{k_{rw}/\mu_w}{1 + M_{sf}}$$