Modelling for Understanding

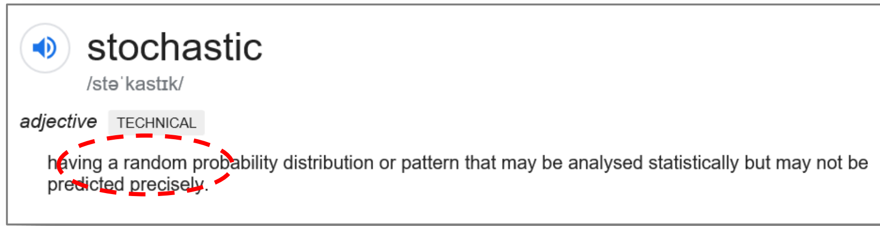
Mark Bentley

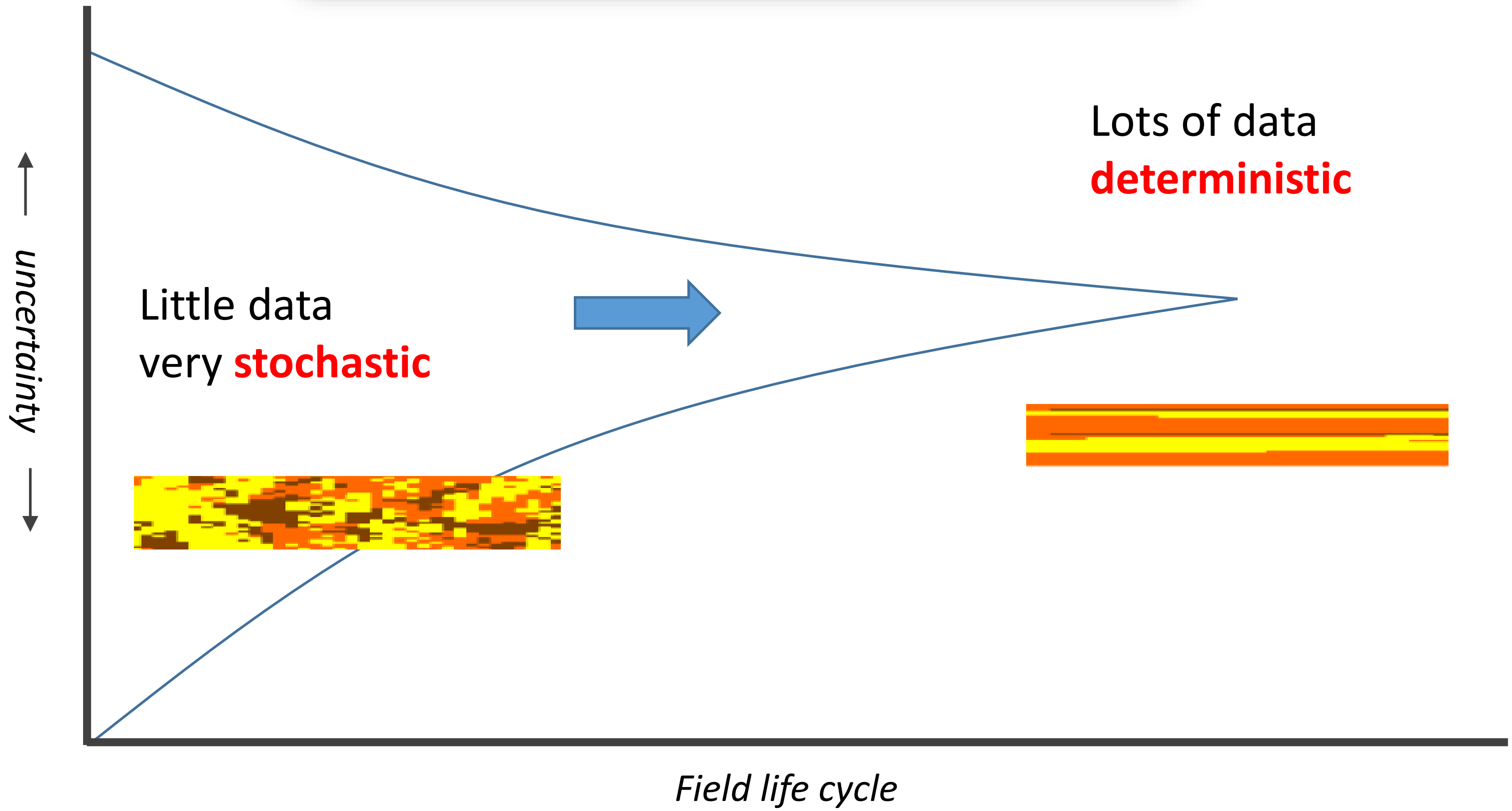
Heriot-Watt University & TRACS Training

… with contributions from Ed Stephens, Tom Buckle & Rona Hutton

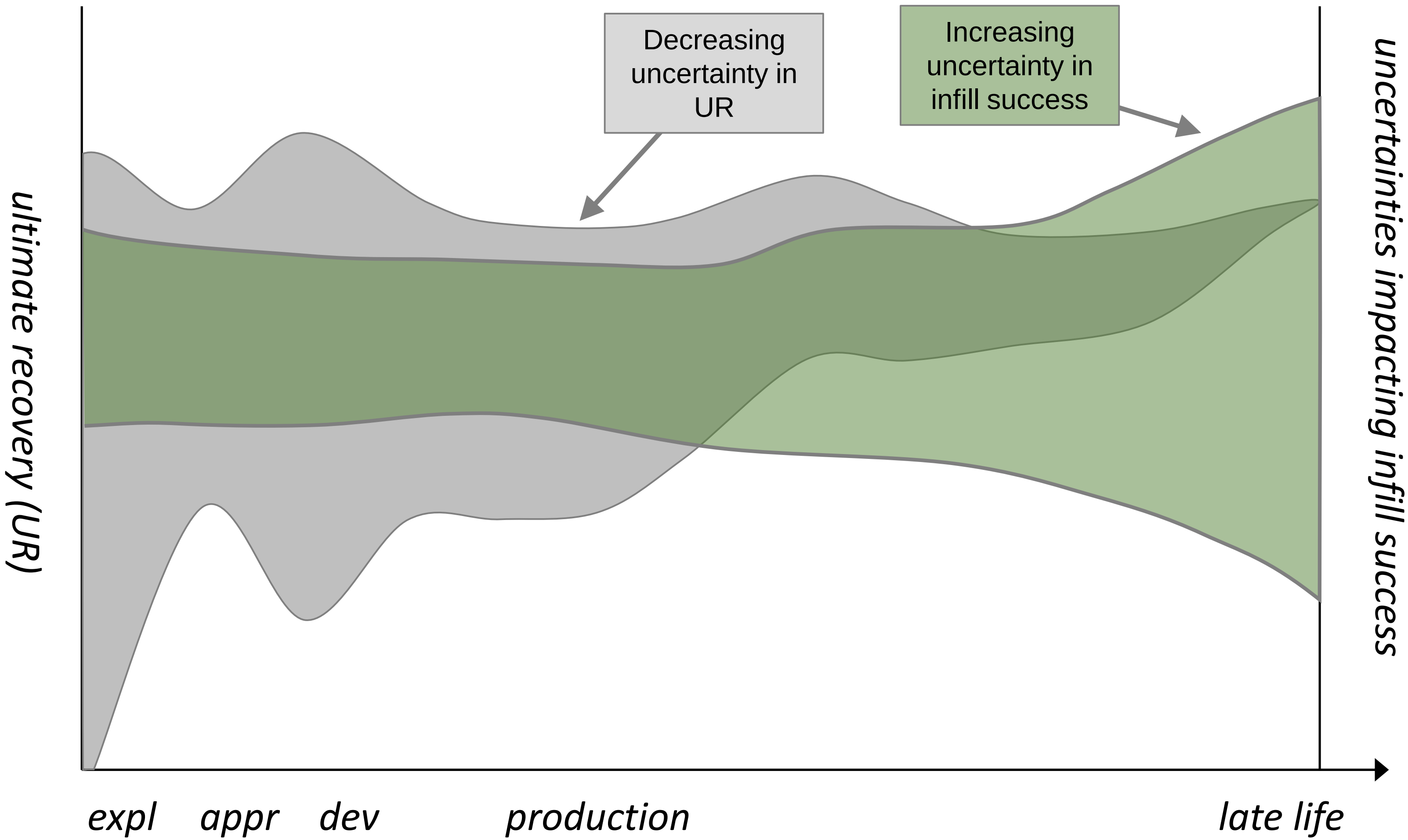

Outcrop-based stochastic modelling of turbidite amalgamation and its effects on hydrocarbon recovery

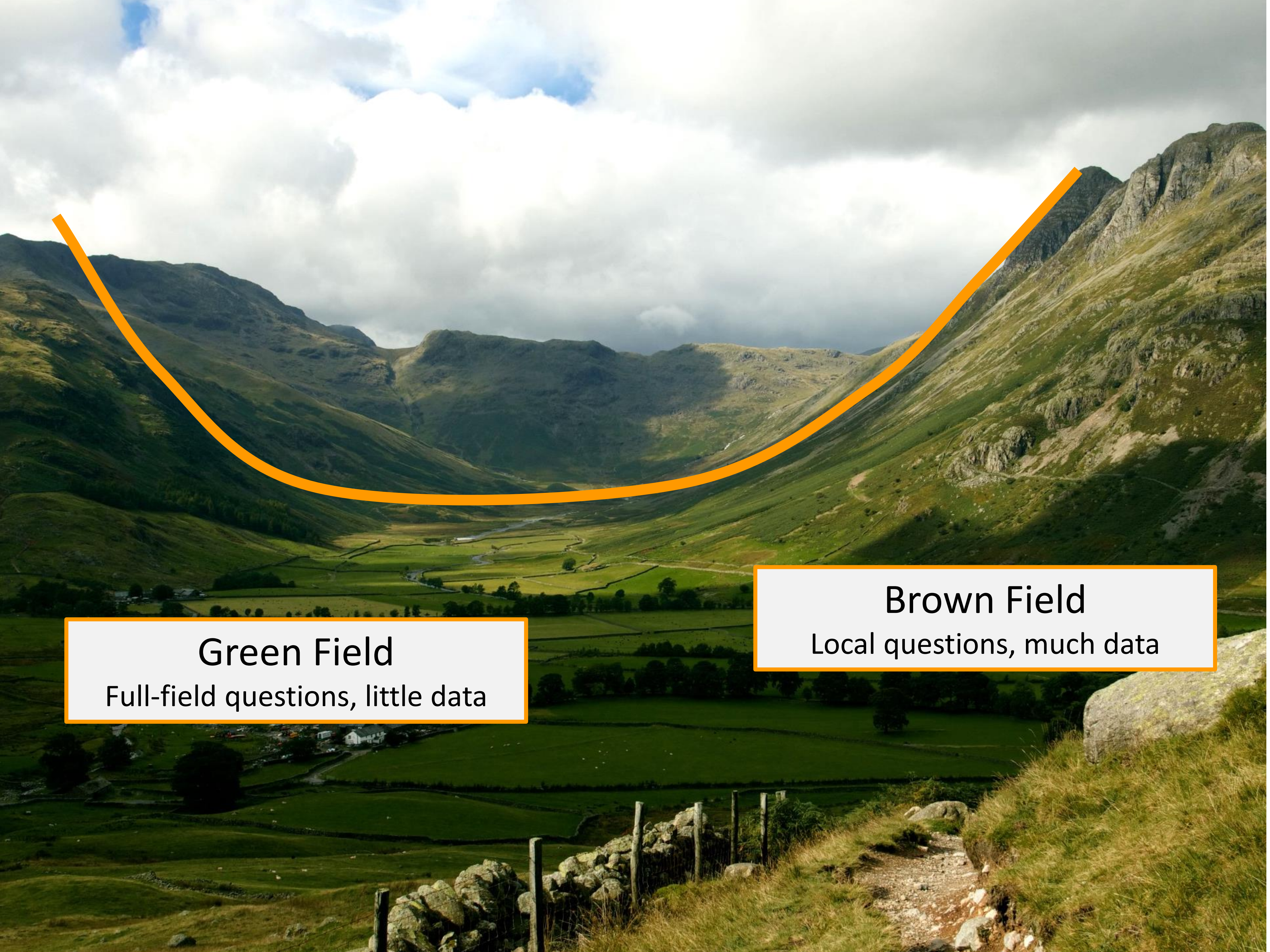
One view


stochastic
/stəˈkastɪk/
adjective TECHNICAL
having a random probability distribution or pattern that may be analysed statistically but may not be predicted precisely.


Lots of data
deterministic
Little data
very stochastic
uncertainty
Field life cycle

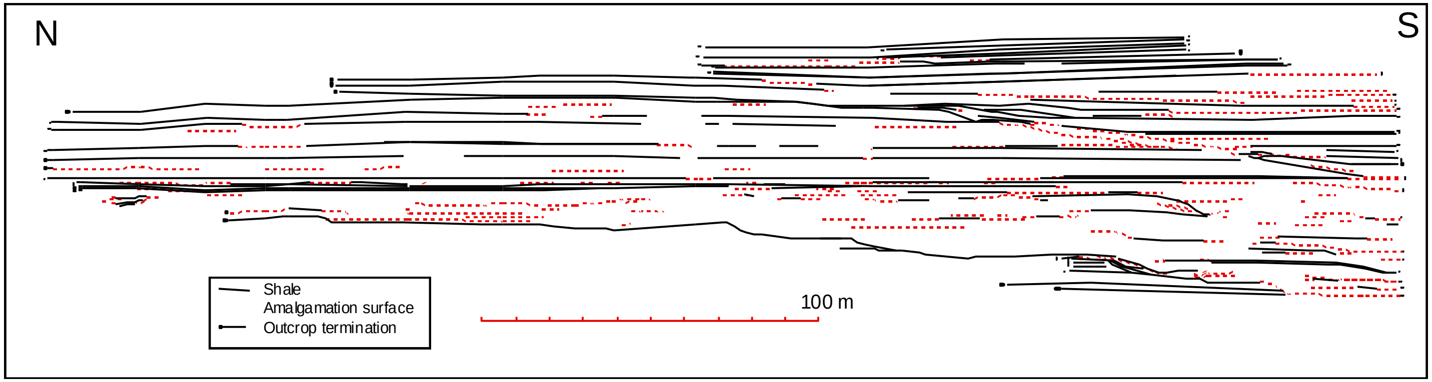
Life cycle uncertainty



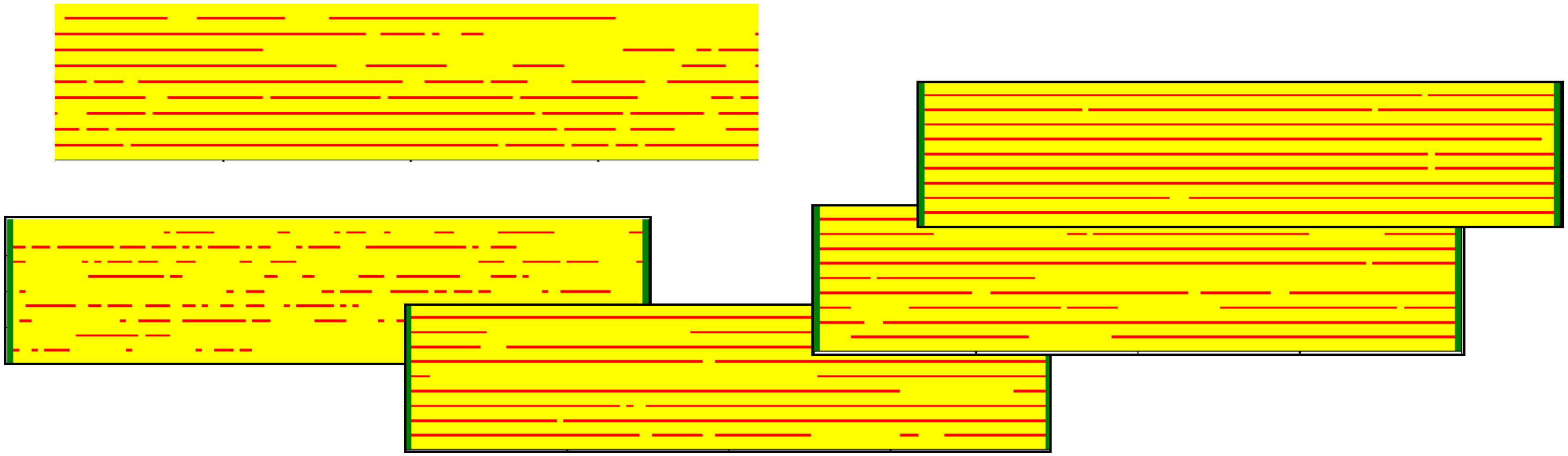

Brown Field
Local questions, much data
Green Field
Full-field questions, little data

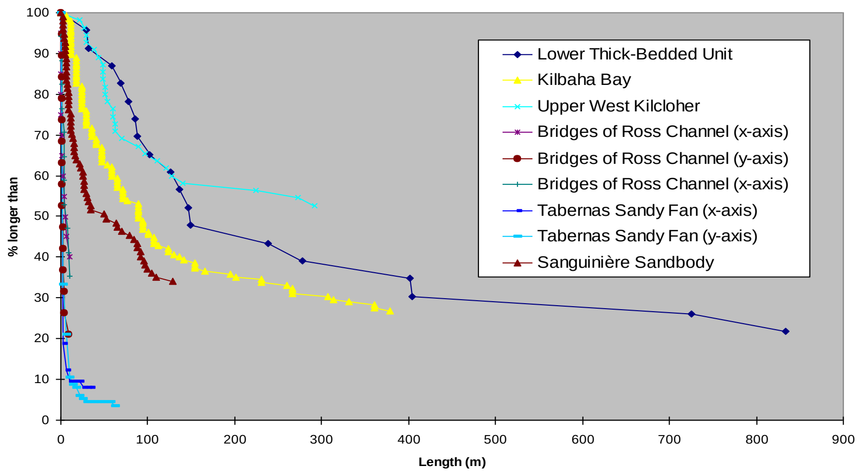
Heterogeneity – Col de la Cayolle

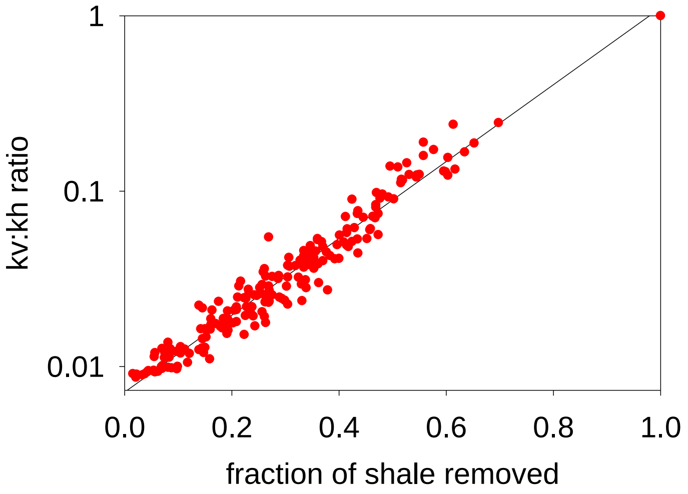
Heterogeneity – Col de la Cayolle



Heterogeneity – we've been here before

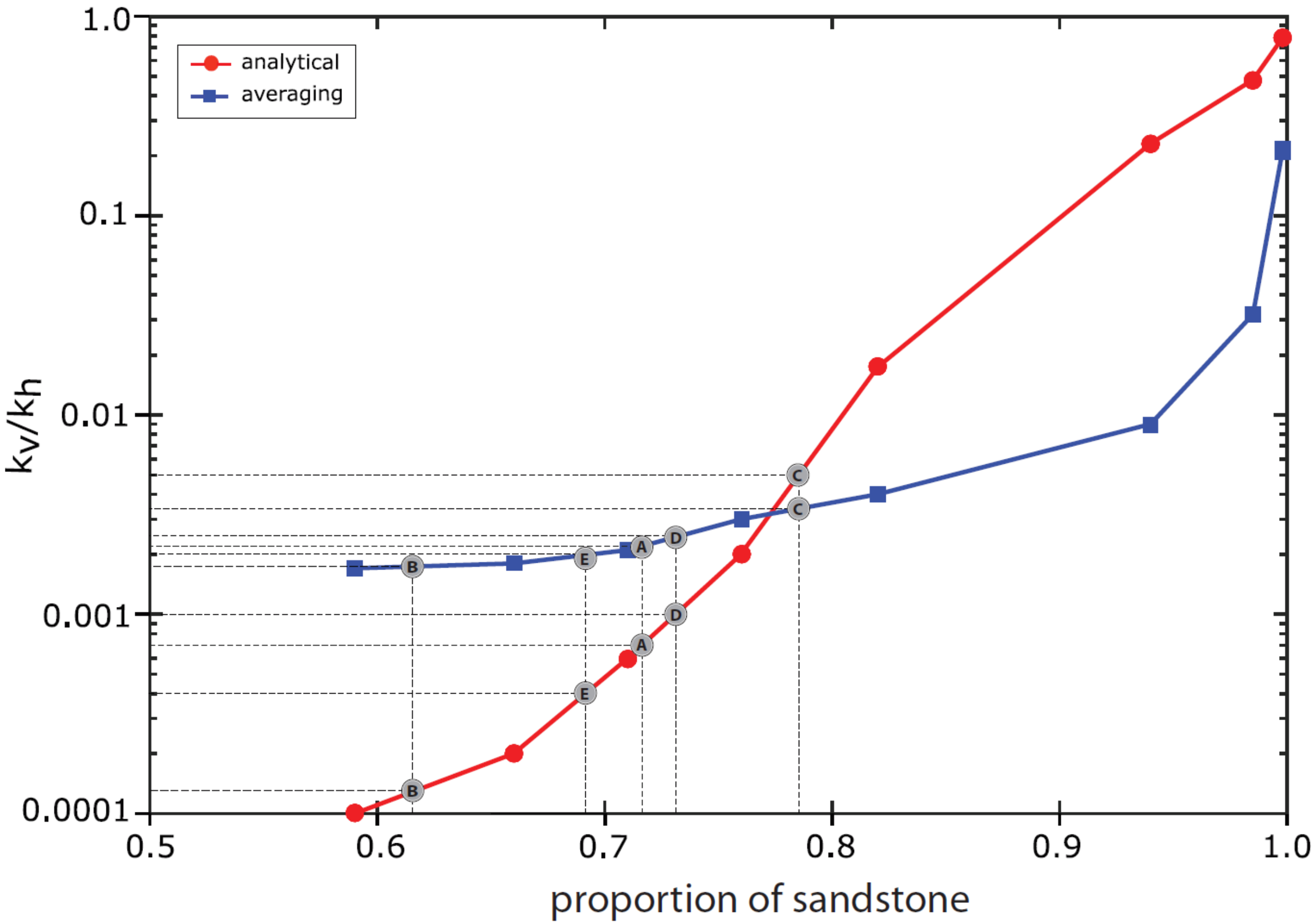






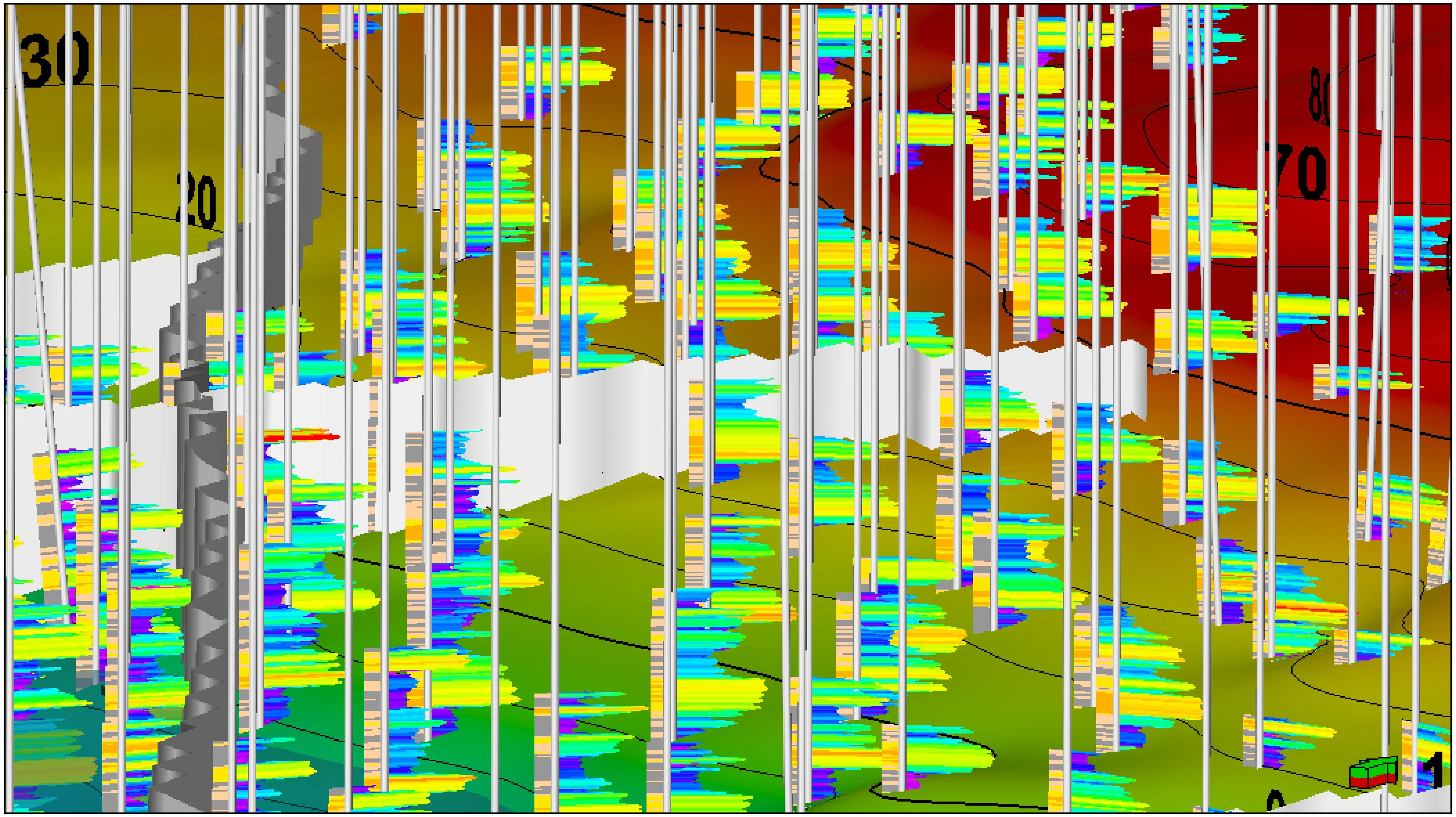
Stephen, Clarke & Gardiner 2001

Heterogeneity – and the work goes on



Onyenanu, Hampson, Fitch, Jackson, 2019

We tend to build big full-field models



Why?

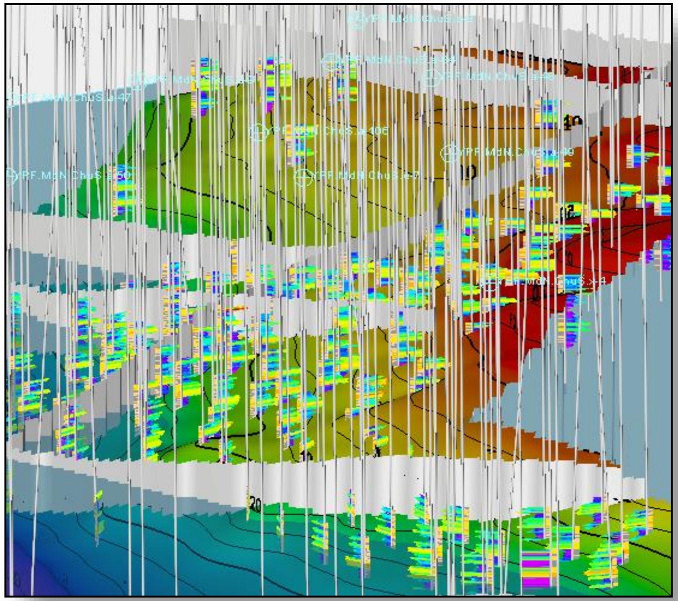
We have a complex problem

We had one thing we didn't understand

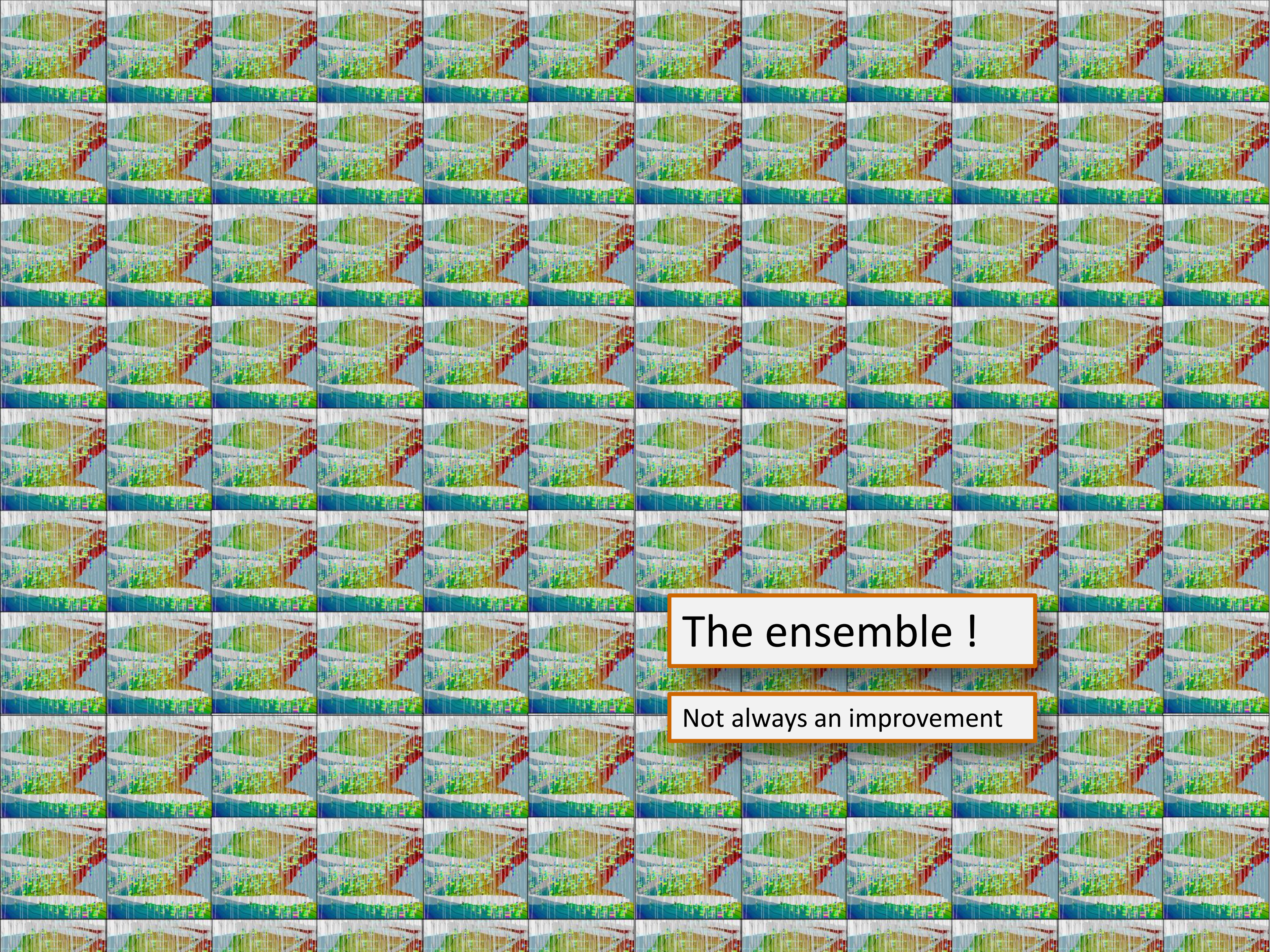
so …

Now we have two

We build a complex model



… with a thank you to Phil England



The ensemble !

Not always an improvement

Model choices

A base-case history-matched static-dynamic 3D model pair ★

Analytical models only (type wells, decline curves)

Low-mid-high versions of the above ★

Multiple models – statistical (more stochastic) – *the ensemble* ★

Multiple models – conceptual (more deterministic) - *scenarios*

2D maps and Monte-Carlo models

Full field models ★

Sector models

Well models

Mechanistic 'box models'

REV models (multi-scale)

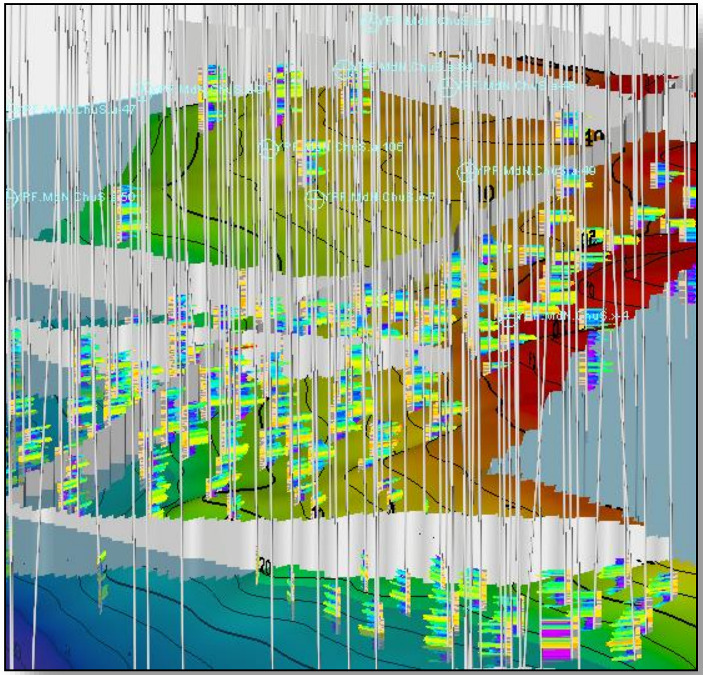
Spreadsheet

2D cross-sectional models

No model

How did this happen?

Because in the face of choice, we tend to default to the standard workflow



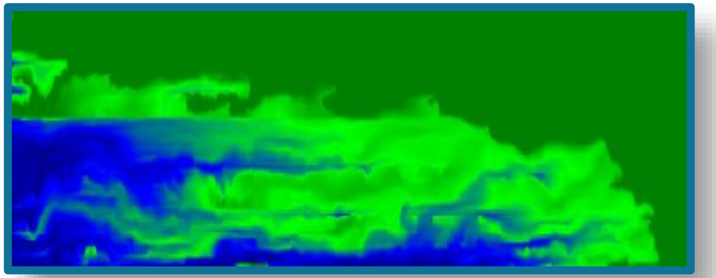
This talk …. question the workflow

A refinement

'Truth Models'

A different approach

'Modelling for Understanding'



The scale gap

Core Plug

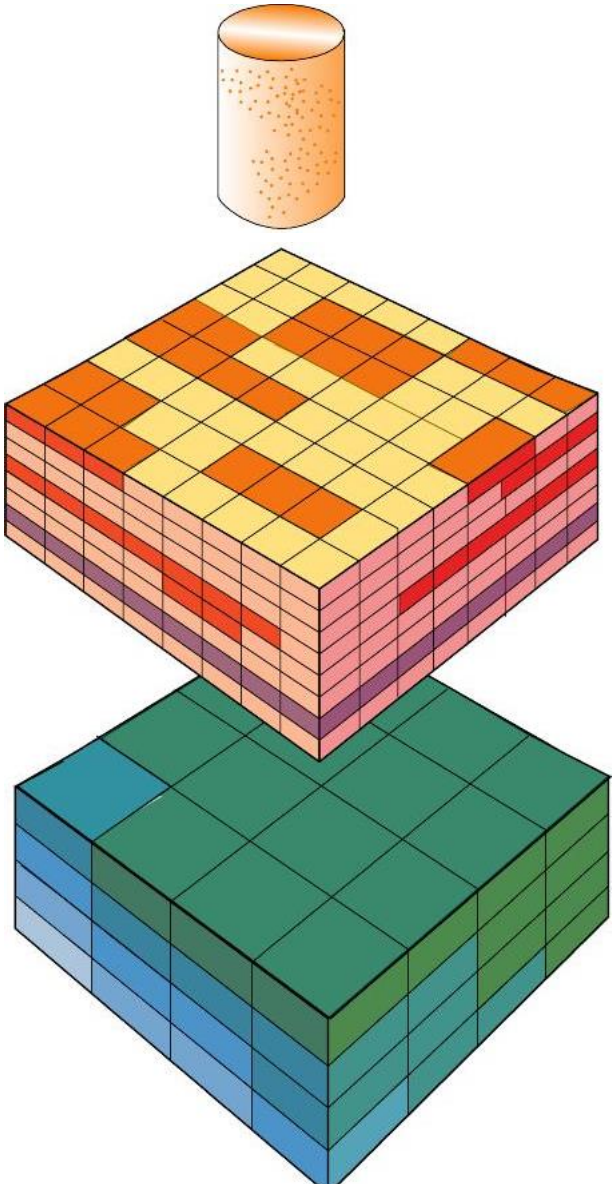
0.03m x 0.012m radius

Static Model

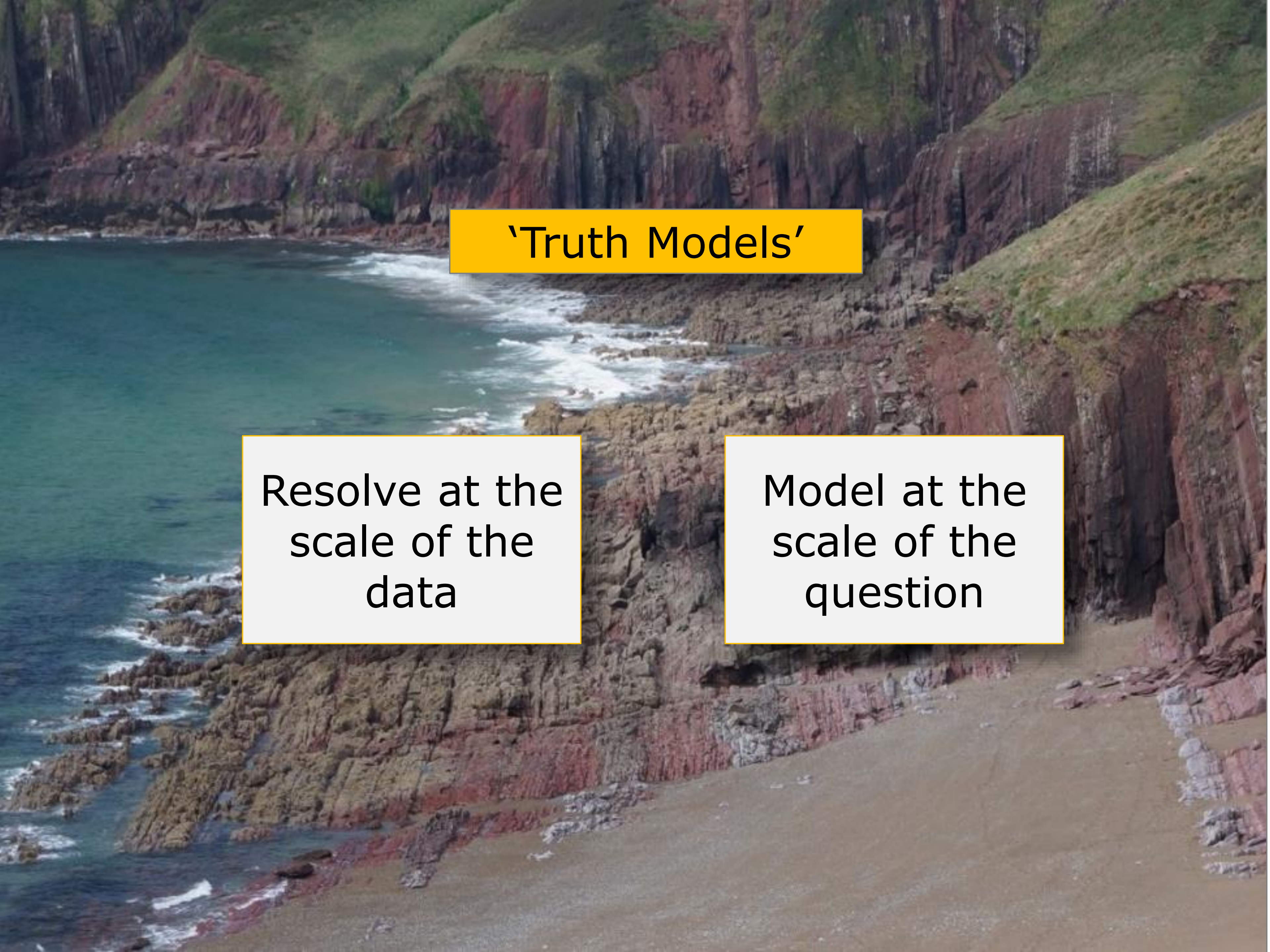
25m x 25m x 0.5m
Cell size

Dynamic Model

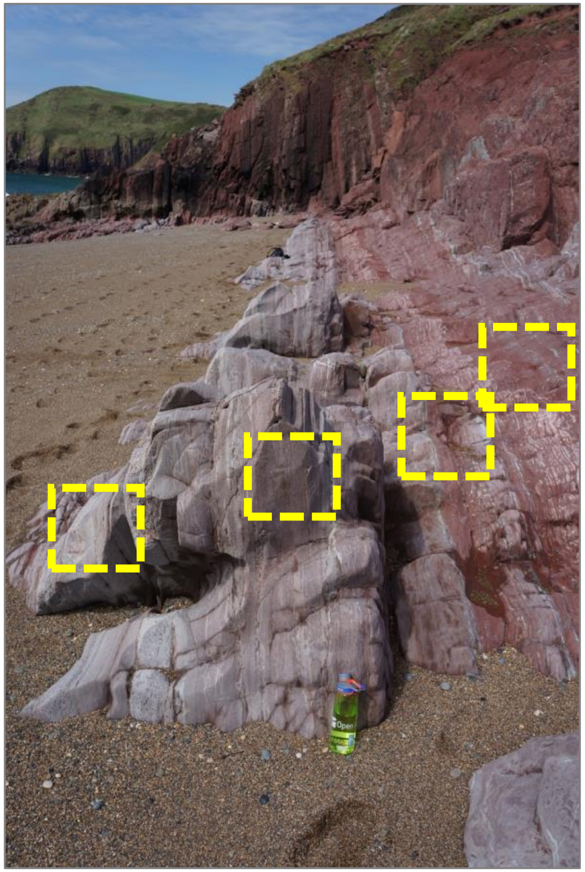
50m x 50m x 2m
Cell size

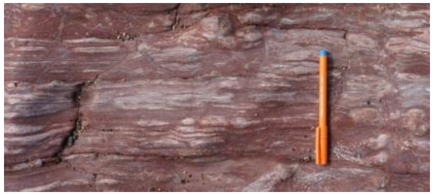


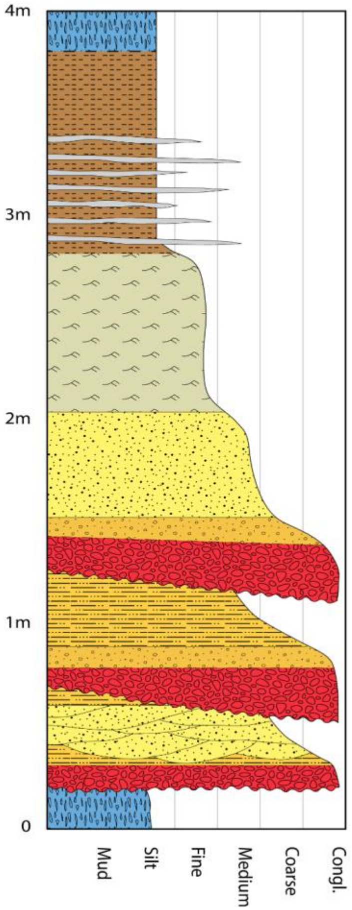
My, what a big simulator you've got…


‘Truth Models’
Resolve at the scale of the data
Model at the scale of the question

Understand one heterogeneous bed





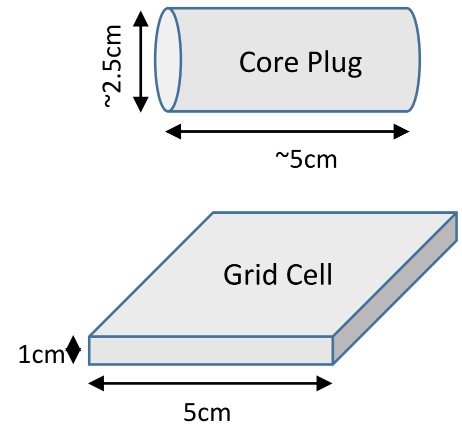


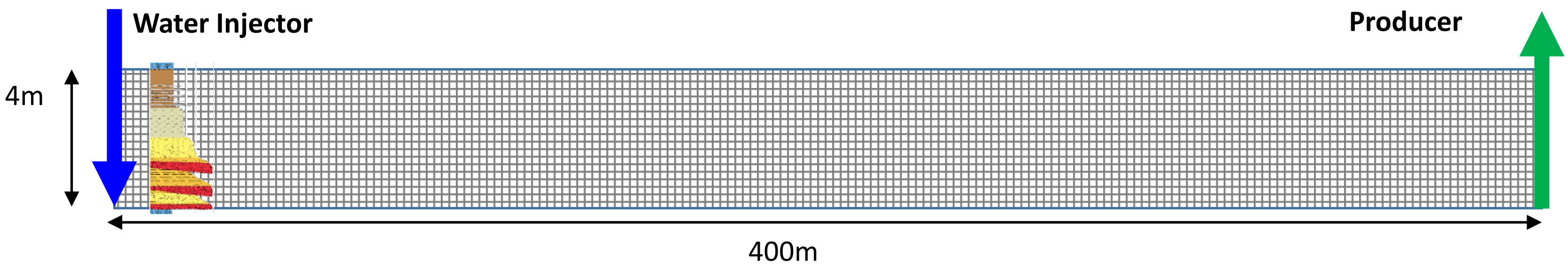
‘Truth modelling’

2D cross-sectional model

Typical offshore well spacing

Cell resolution close to the scale of the input data (SCAL)



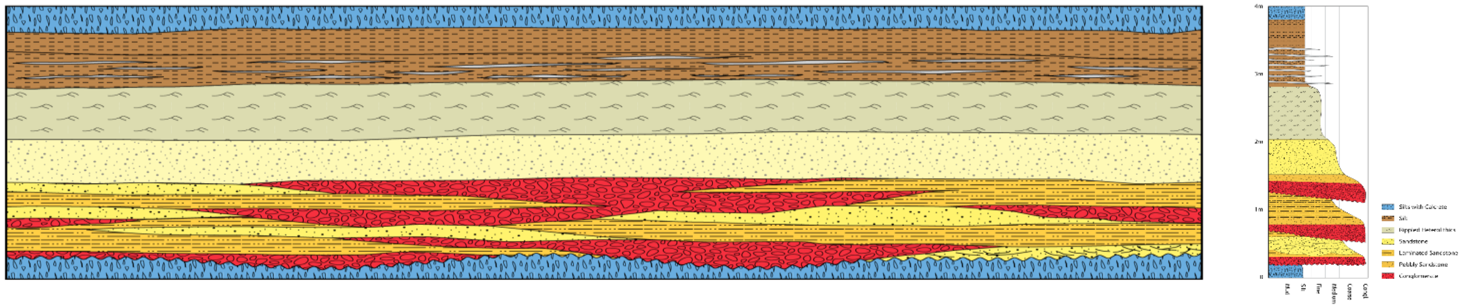


3.2 million cells

(the full field equivalent would be a few trillion cells)

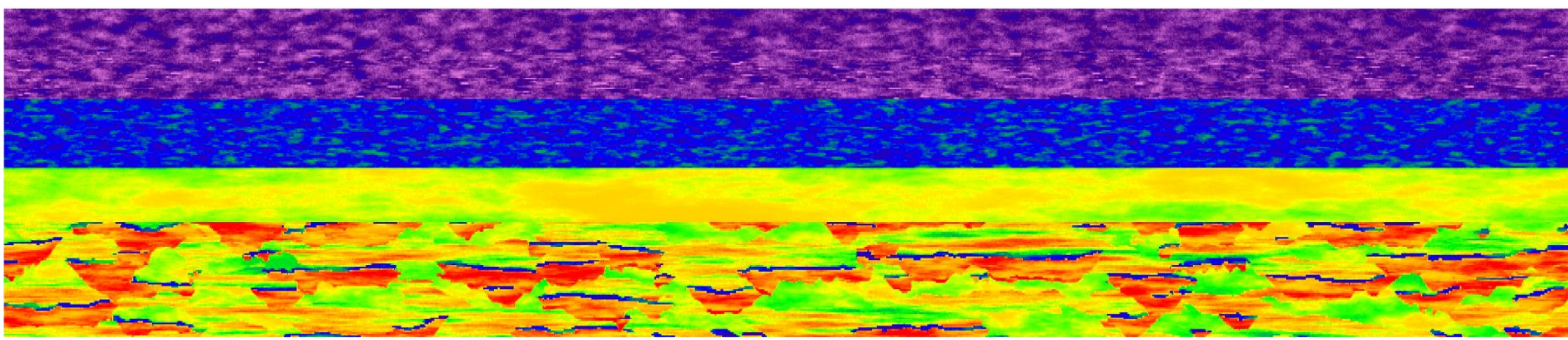
Heterogeneity – *if you can sketch it …*

Training image



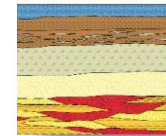
50m

MPS realisation (internal channel character added)

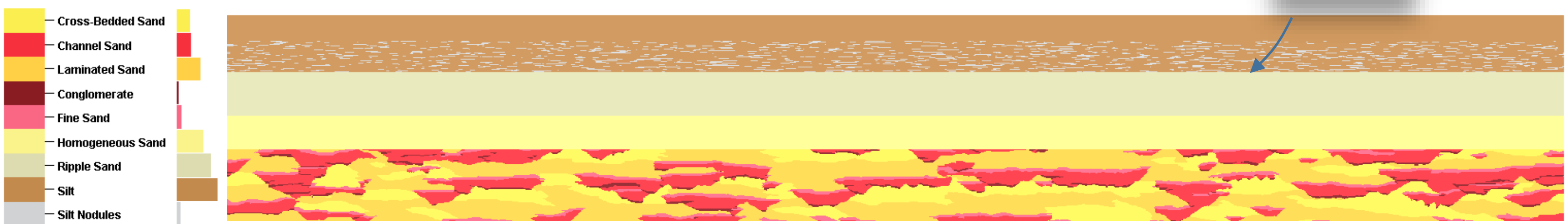


400m

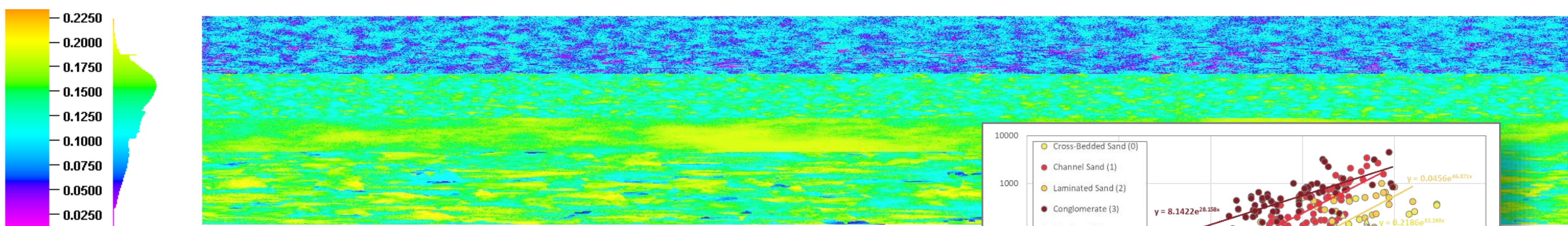
If you can sketch it ….

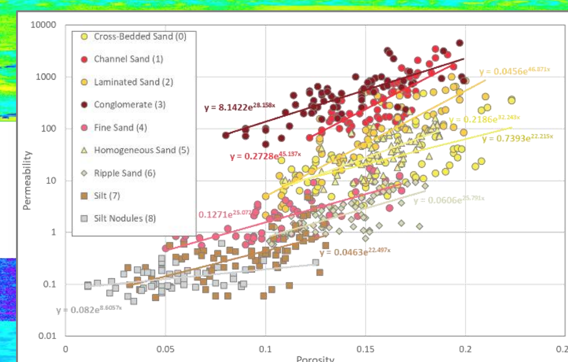


Model elements from multi-point statistics (MPS)

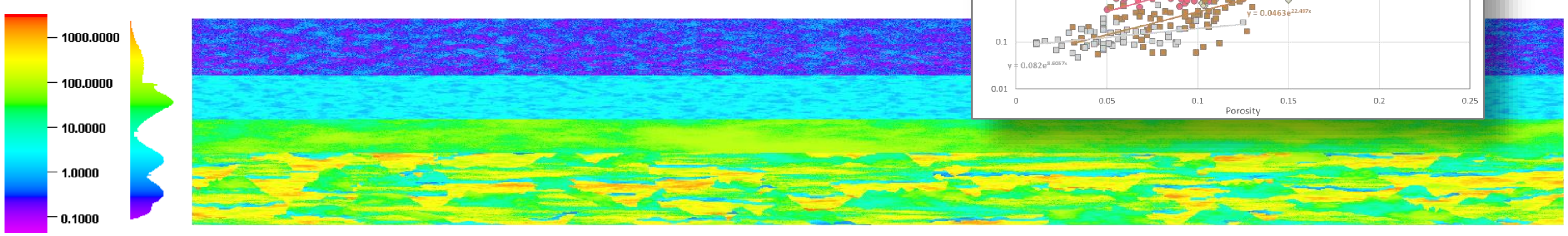


Porosity (frac)

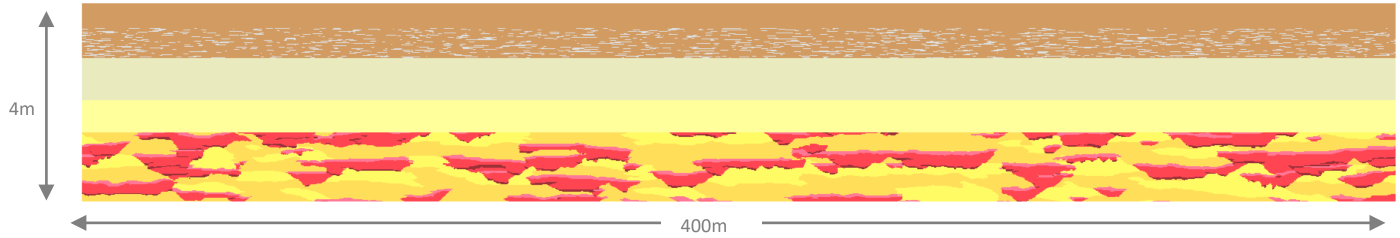


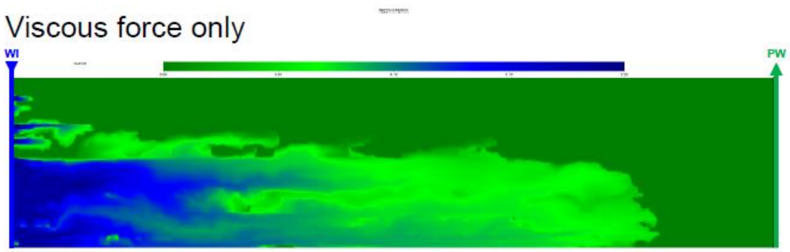


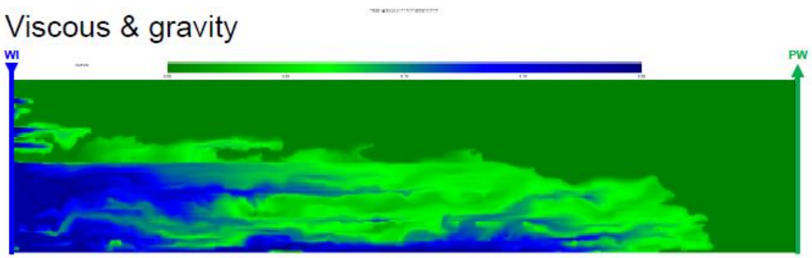
Permeability (mD)

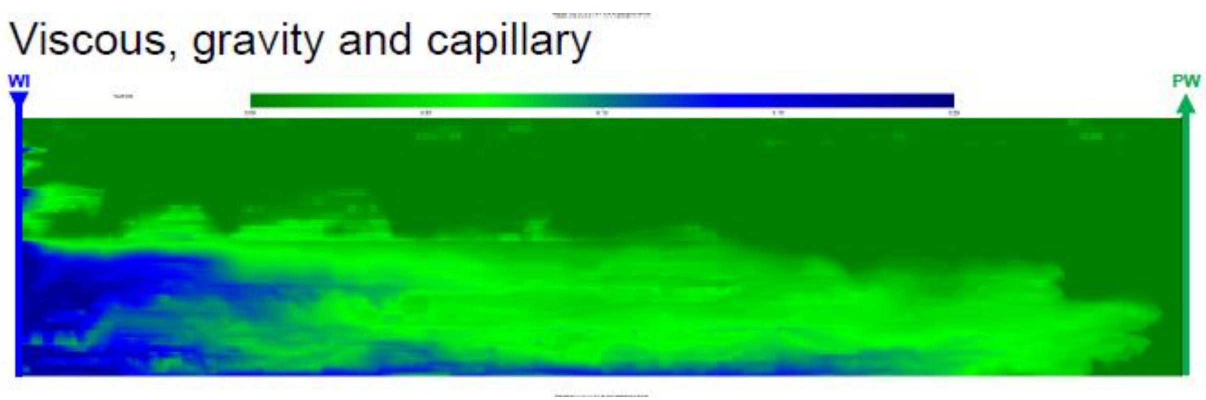


Truth models – building understanding





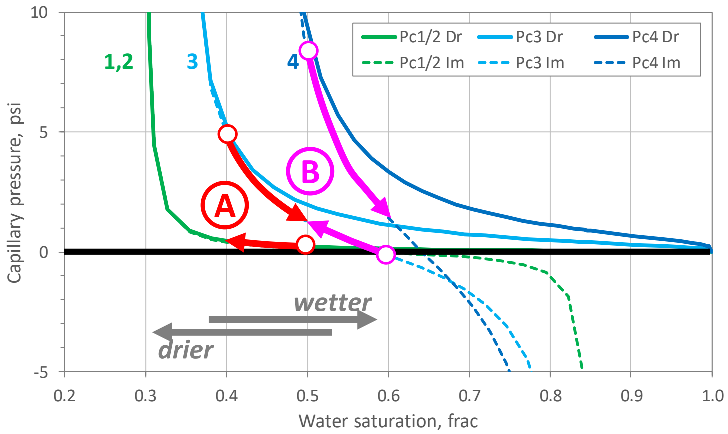


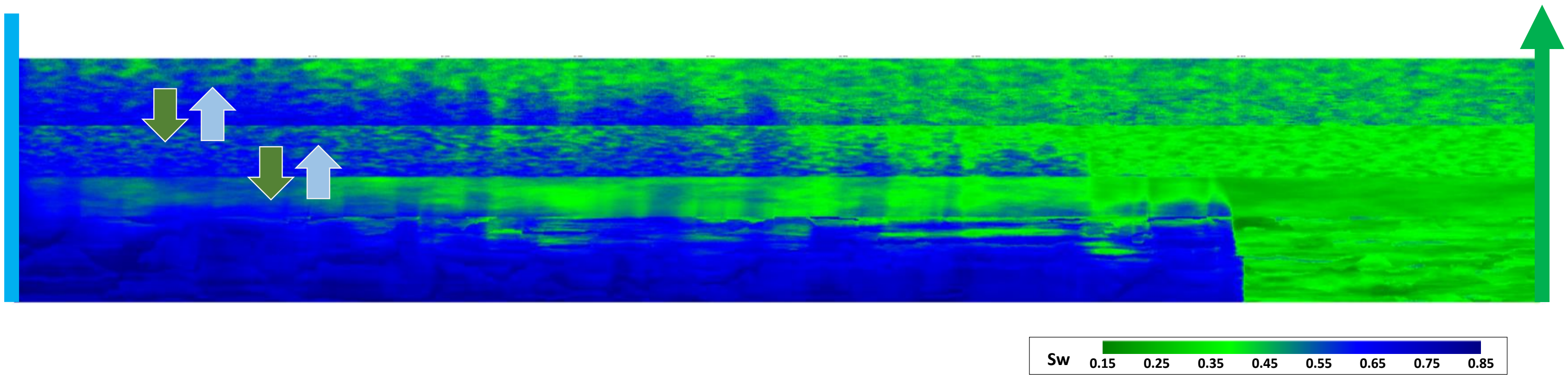


Understanding 1– impact of capillary forces

Water drawn up displaces oil down

Additional recovery from nominally ‘non-net’ material

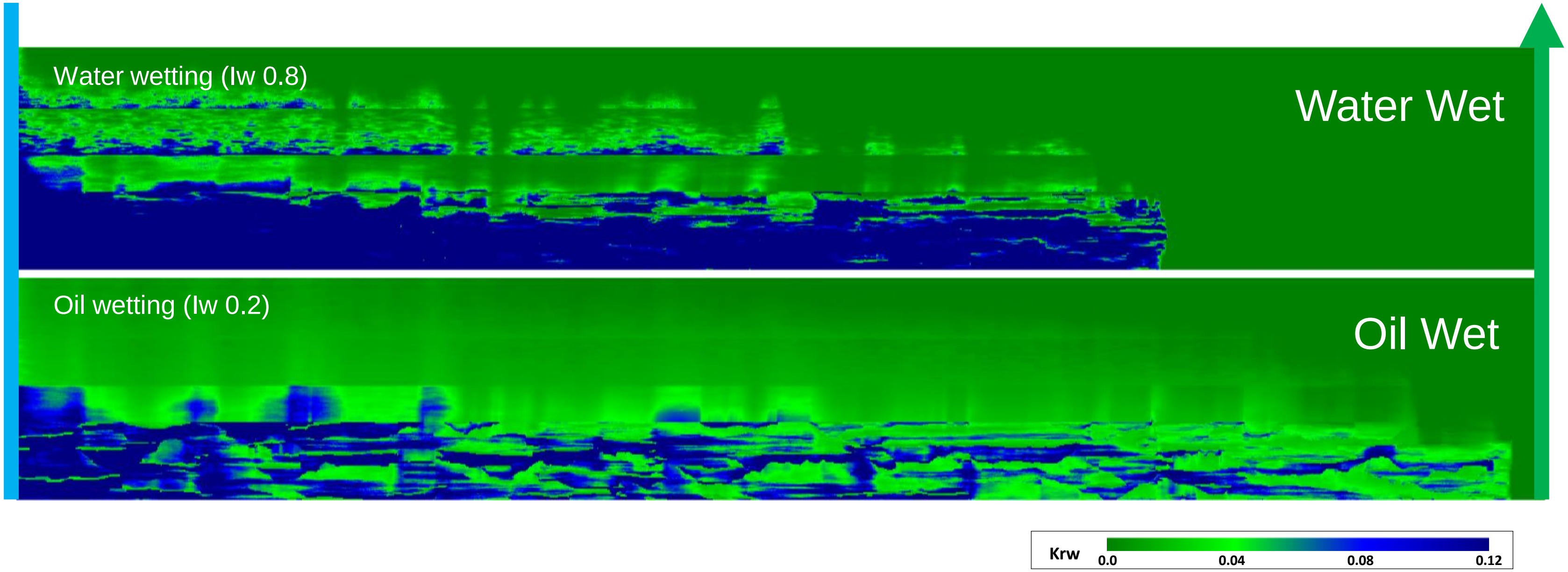




Understanding 2 – value of knowing wettability

WW: WBT later by ~ 10%,
RF higher by ~ 3%
Stronger spontaneous imbibition into upper units

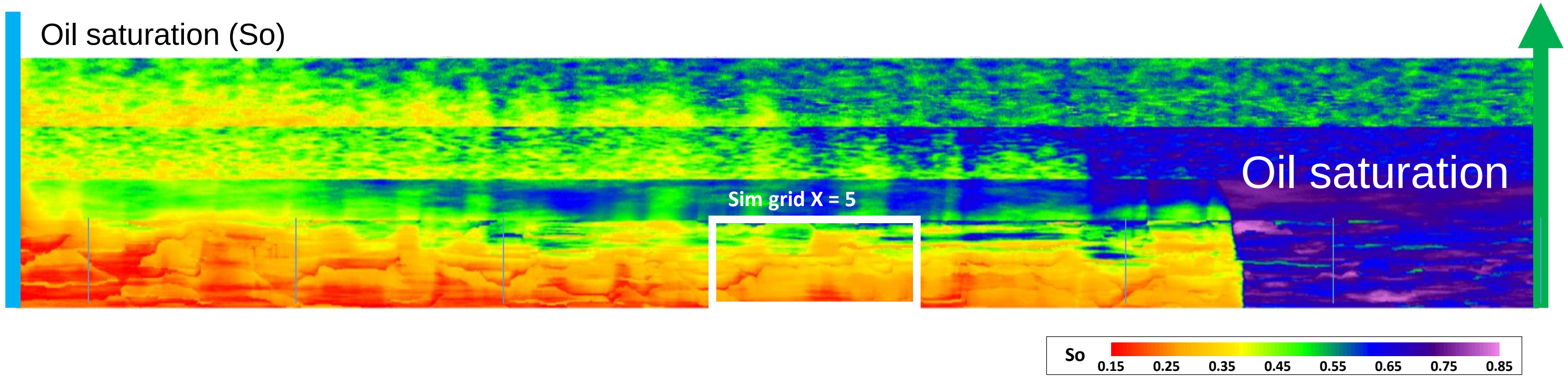
OW: WBT earlier by ~ 20%,
RF lower by ~ 10%
Bypass of lower perm material within lower unit



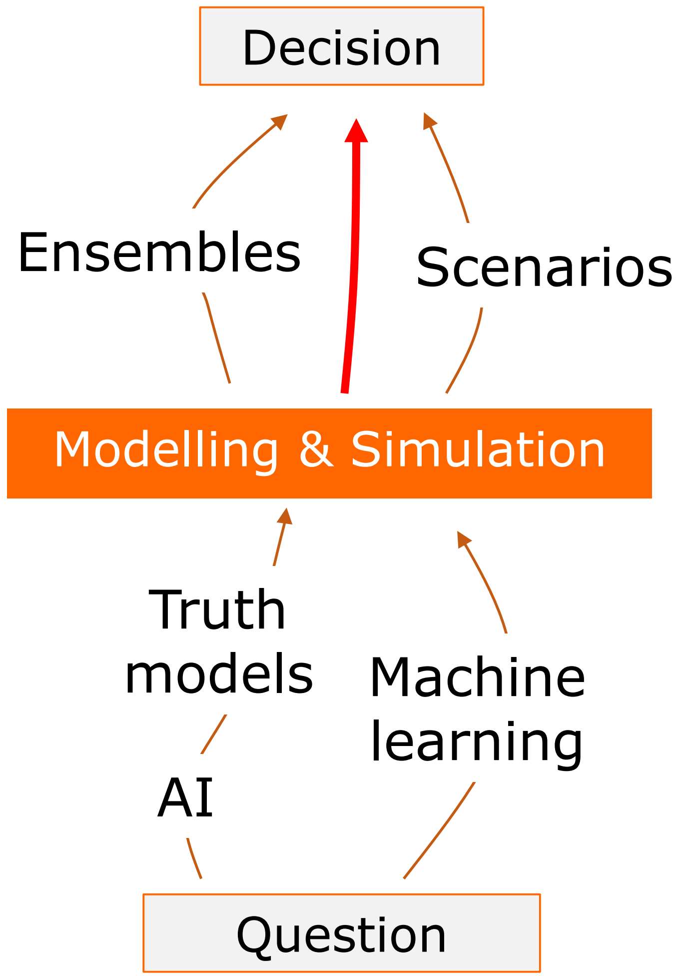
Understanding 3 – locating remaining oil

Saturation behind the flood front
Explore sim grid cell X=5 flowing ~90% water-cut

Model	Swi	W/cut	Krw	Kro	Soil
Ultra fine grid	30.7%	87%	**0.1305**	**0.0188**	**34%**
Sim grid X=5	30.6%	93%	**0.0992**	**0.0076**	**34%**

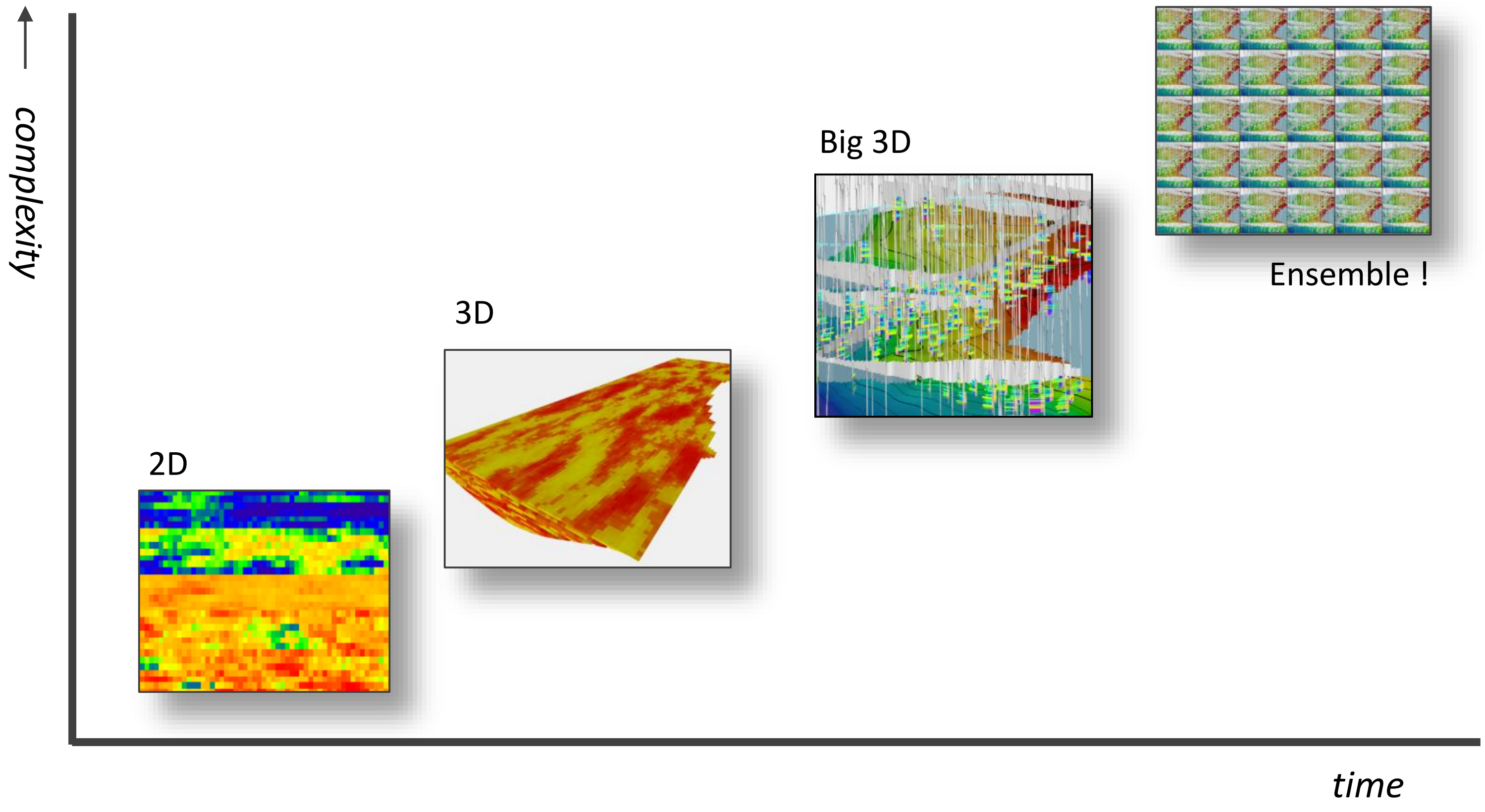


Questions and decisions …

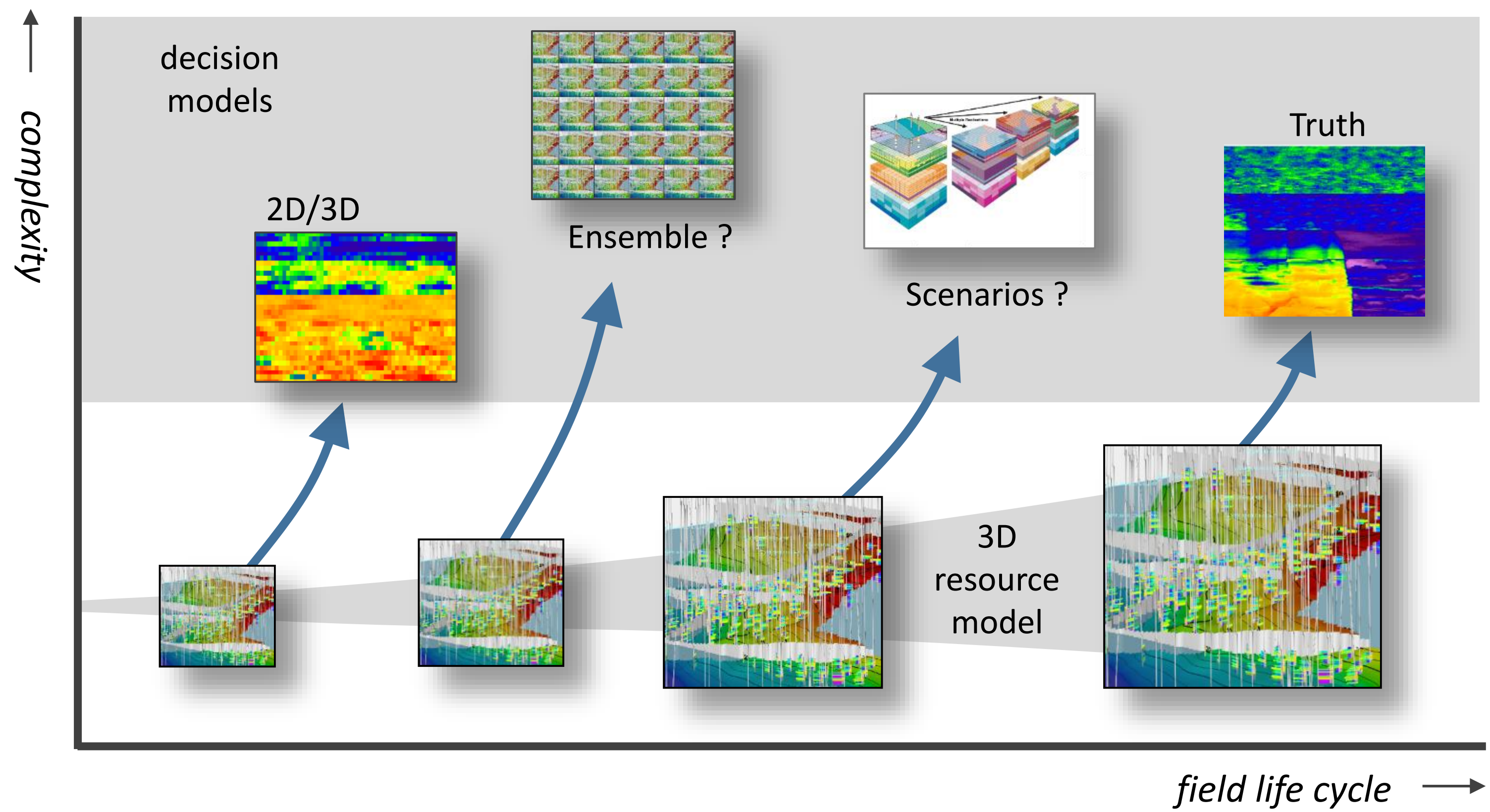


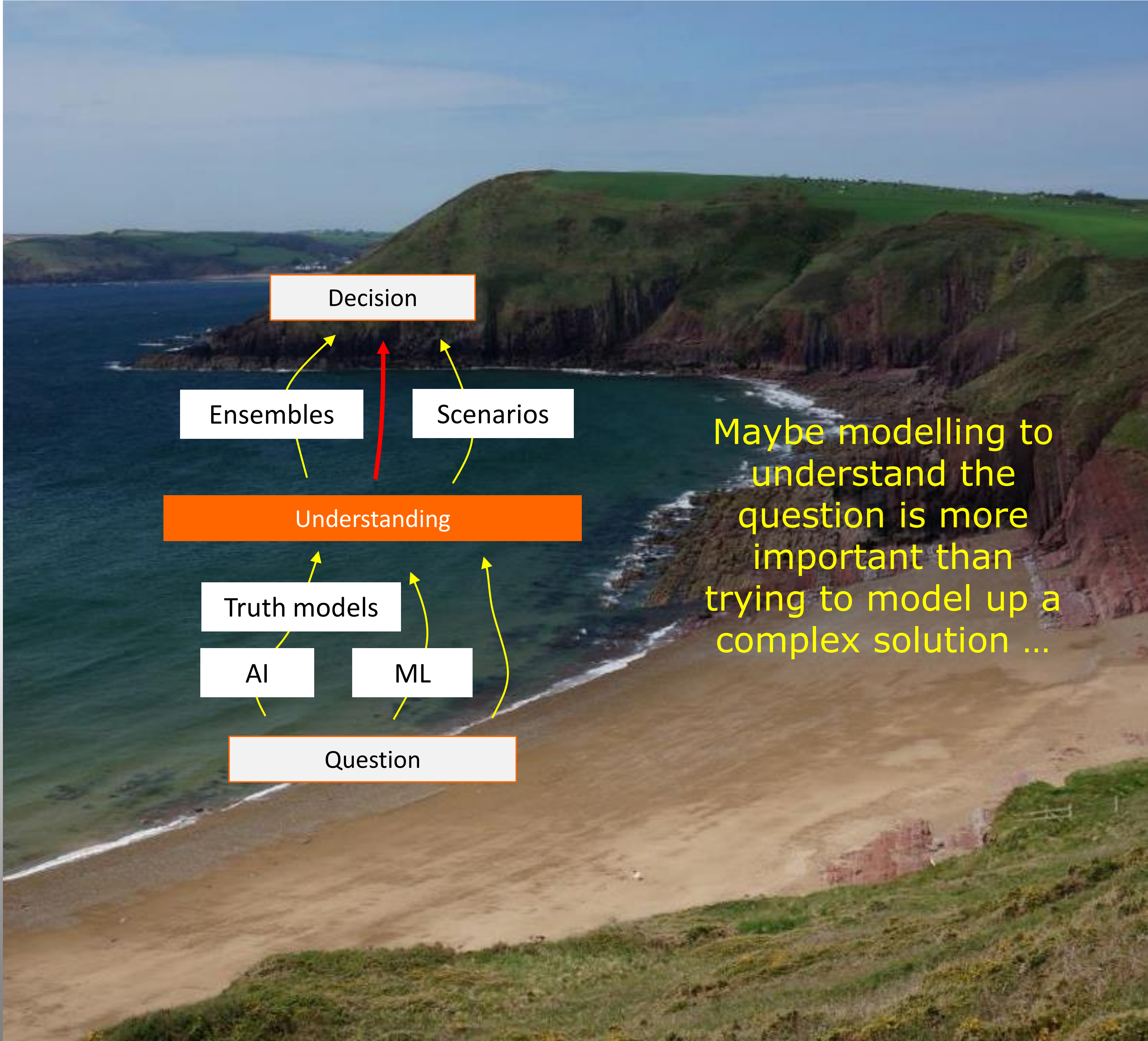

GAIA, Dan Arnold, Heriot-Watt

Modelling through time – not nimble



Modelling through time - less complex, more efficient





Maybe modelling to understand the question is more important than trying to model up a complex solution …