



Evaluation of Intersect for polymer flood full field simulations

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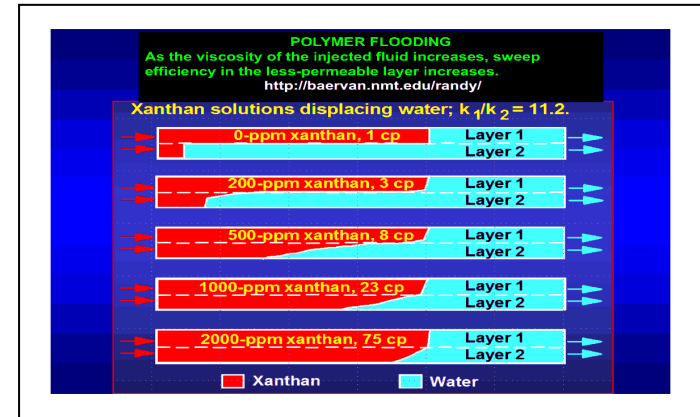
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Presentation overview

- Information about the oil field
- Business case of early polymer injection
- Reservoir simulation challenge
- Setup of INTERSECT evaluation
- Results of INTERSECT evaluation
- Way forward
- Q&A

Polymer injection from day one

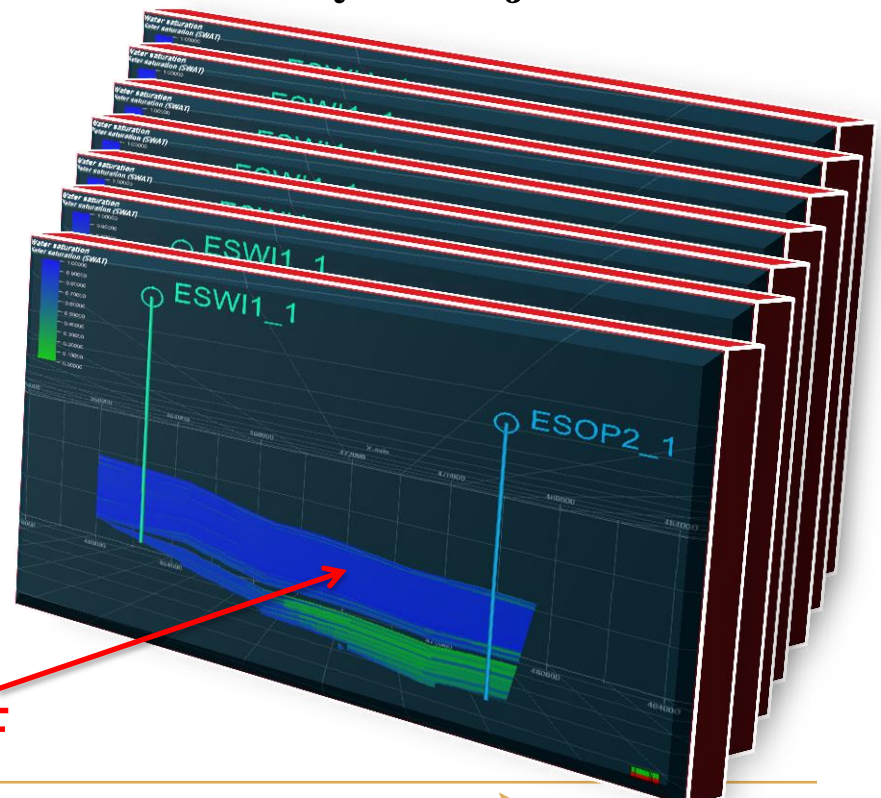
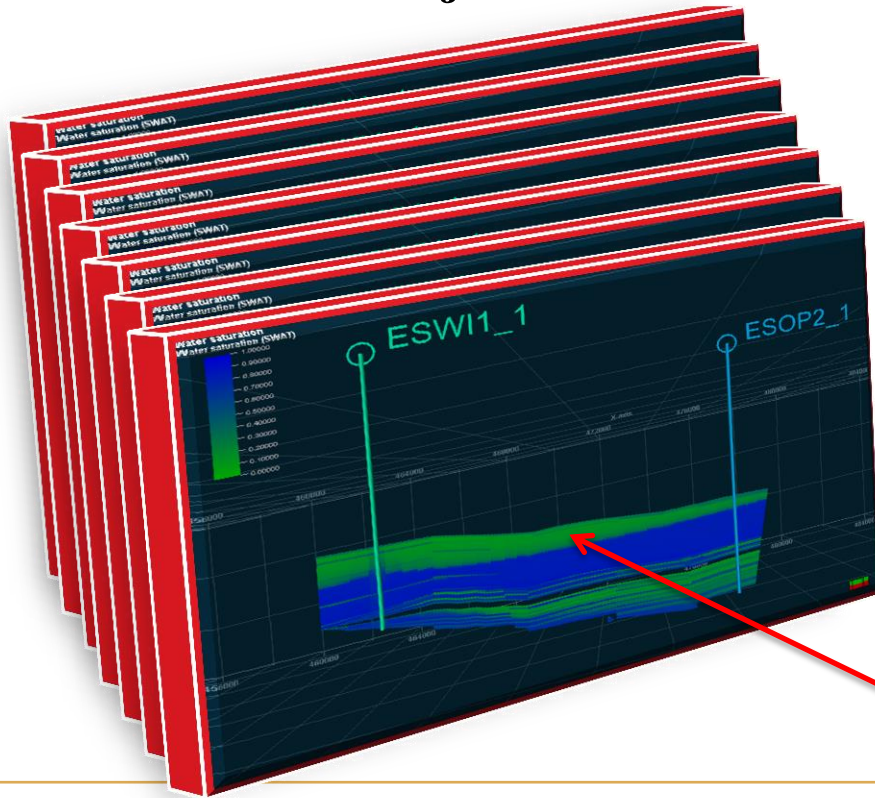
- Green field
- 2 main formations –
 - High perm upper and low perm lower
 - Most of STOIIP in upper formation
- Permeability contrast
 - 10-15 fold
- Pressure support
 - Weak to non present aquifer
 - Undersaturated oil with low GOR
- Unfavorable mobility ratio = 5
- Development concept
 - Mixed, platform plus subsea
- Polymer injection is new method for NCS
- EOR – how to get optimum well pattern?
- Costs of implementation are high
 - Need to have a strong business case
 - Implementation is time critical



Targeting remaining oil in the field

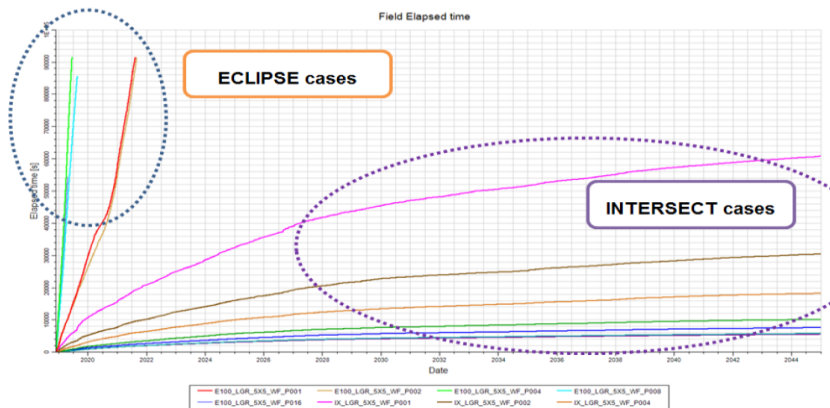
Water injection

Polymer injection



RF

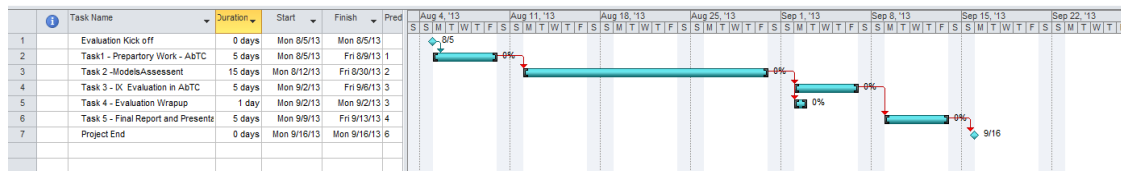
Detailed full field simulation is a key



Elapsed model run time with
different grid resolution

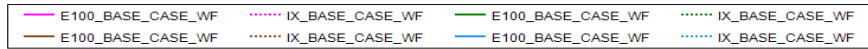
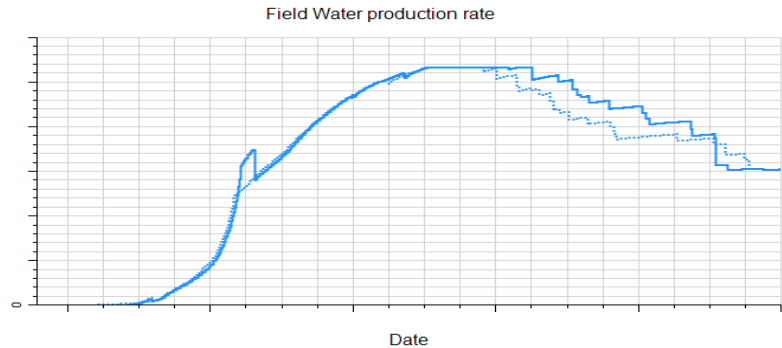
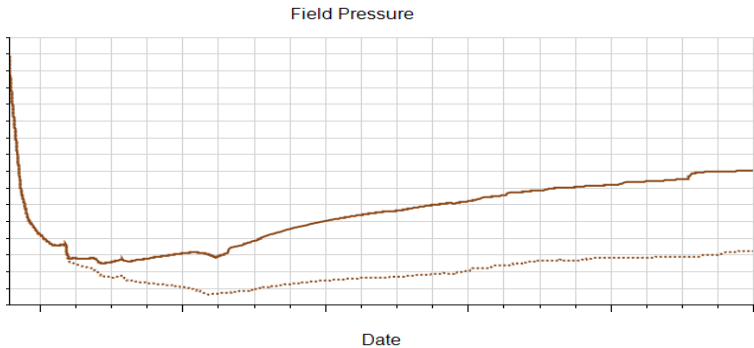
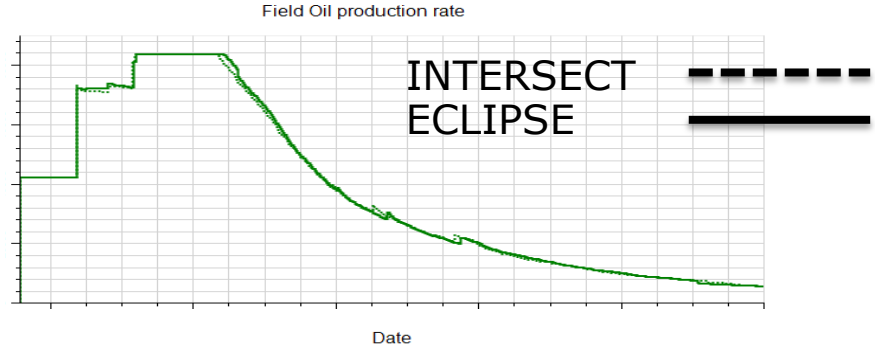
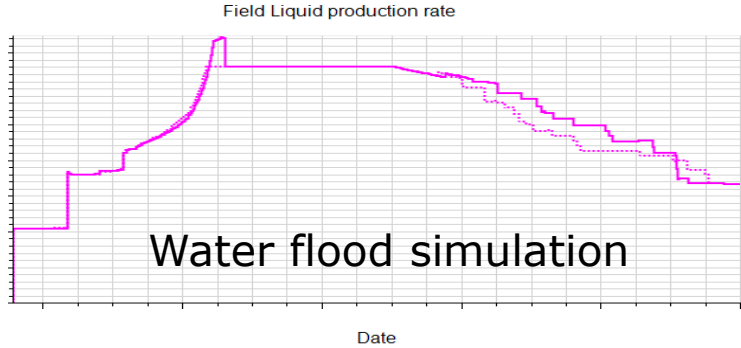
- Run times > 1 week for desired resolution
- ECLIPSE Parallel or Multiple Realisation runs or LGRs won't help!
- Sector model or coarse model?
- Risk of decision delay
 - Decision based on «simplified problem study»

New simulation technology for new oil field

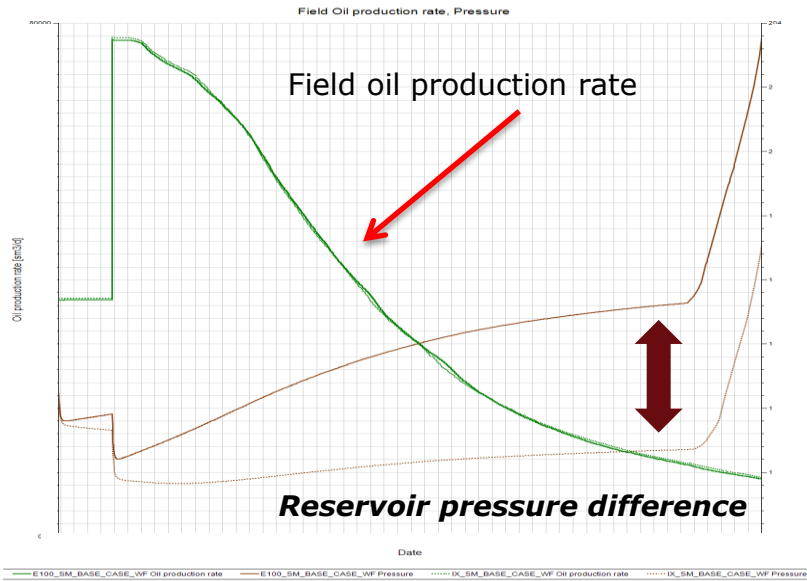


Task	Task 1 - Activities	Preparatory work (Abingdon Technology Center (AbTC) Team	Start date	End Date	Progress Status
1	1.1	Project Kick-off - height Models for the evaluation purpose will be sent by PETORO to SIS	Aug., 5th	Aug., 9th	100%
	1.2	AbTC IT environment set up			
	1.3	INTERSECT* installations and verification			
2	Tasks 2 - Activities		Start date	End Date	Status
	2.1	Review Eight Eclipse Model Analysis	Aug., 12th	Aug., 30th	100%
	2.2	Raw Migration of Eight Model			
	2.3	Training Contents preparation including Polumer options			
Task 3 - Activities		Start date			
3	IX Evaluation in AbTC		Sep., 2nd	Sep., 6th	Running
	3.1	Definition and agreement of Success Metrics & Scope of Work (SOW)			
	3.2	Review of the Eight Eclipse models			
	3.3	Training and Models Migration			
	3.4	Workflow definition and model features selection for testing INTERSECT*			
	3.5	Model Migration to INTERSECT*			
	3.6	Polymer Feature implementation in INTERSECT			
	3.7	Production Scenario definition and execution (Eclipse/INTERSECT*)			
3.8	Presentation of the Main Finding				
4	Task 4 - Activities		Start date	End Date	Status
	4.1	Result analysis and comparison against success metrics	Sep., 9th	Sep., 9th	
	4.3	Data and results will be frozen and sent by SIS to PETORO RE team			
Task 5 - Activities		Start date			
5	Final Report		Sep., 9th	Sep., 16th	
	5.1	Overall results analysis			
	5.2	Report and Final presentation			
	5.3	Final Meeting between PETORO and SIS Team in STAVANGER			

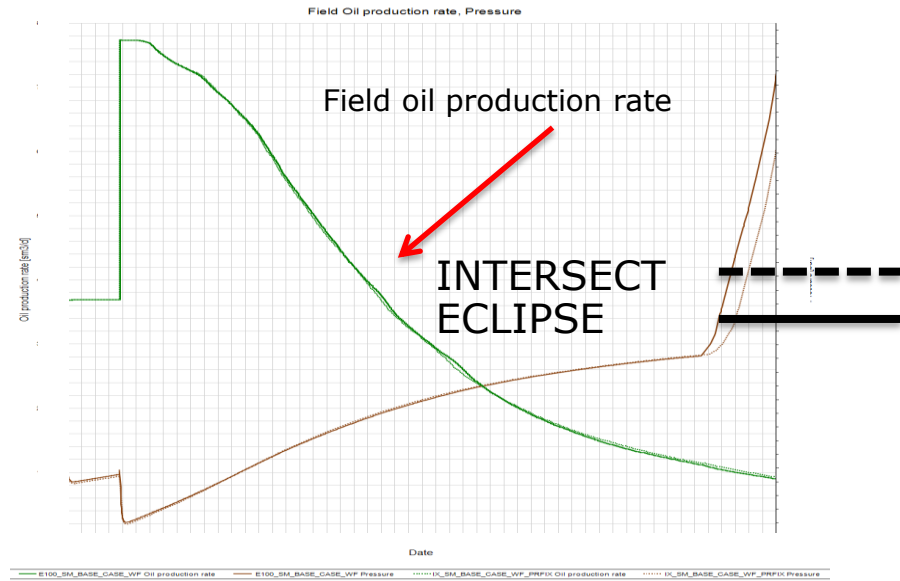
ECLIPSE and INTERSECT give similar results



Addressing behavior difference



IX has E300 defaults



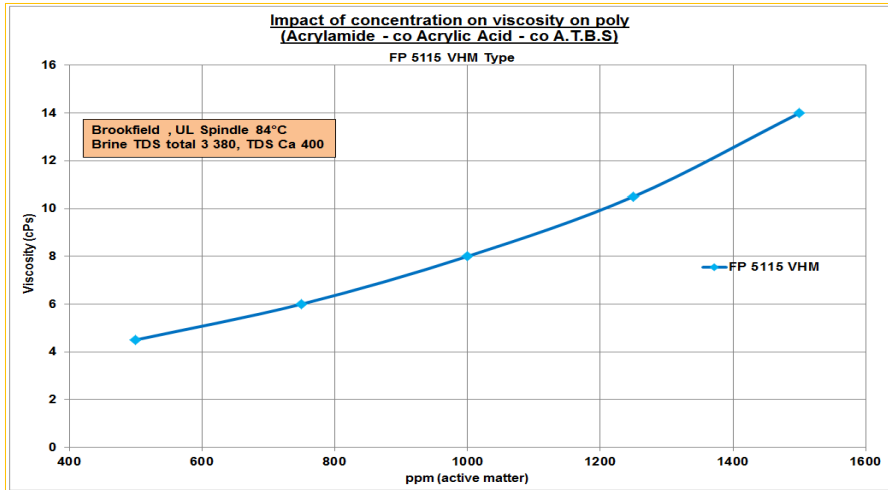
IX with E100 switch (new feature*)

Polymer injection in INTERSECT

ECLIPSE

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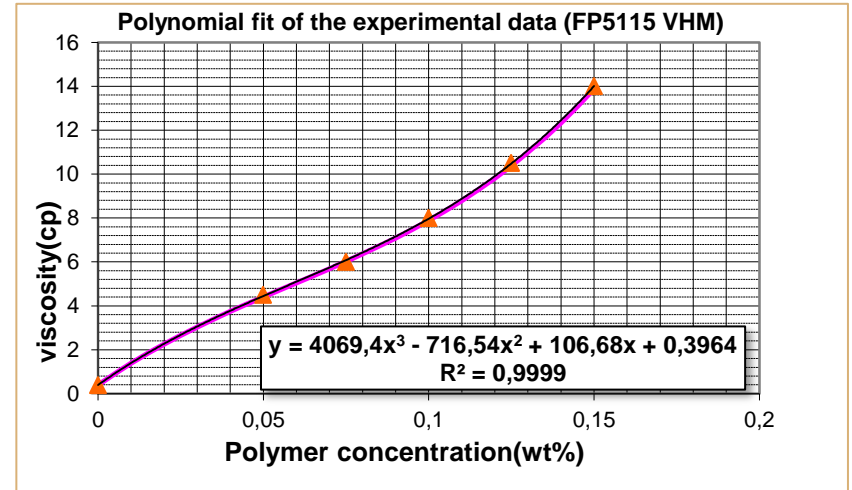
PLYVISC
-- Column 1: Polymer concentration in kg/Sm3 ( NB! 1.5 kg/Sm3 = 1500 ppm )
-- Column 2: Multiplication factor by which water viscosity has to be multiplied to g
-- Polymer with LOSAL water injection
0.00  1.0
0.50  11.5
0.75  15.4
1.00  20.5
1.25  26.9
1.50  35.9
/
    
```



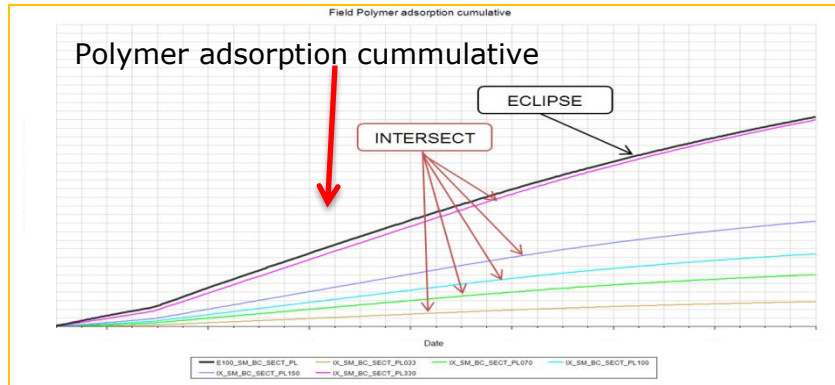
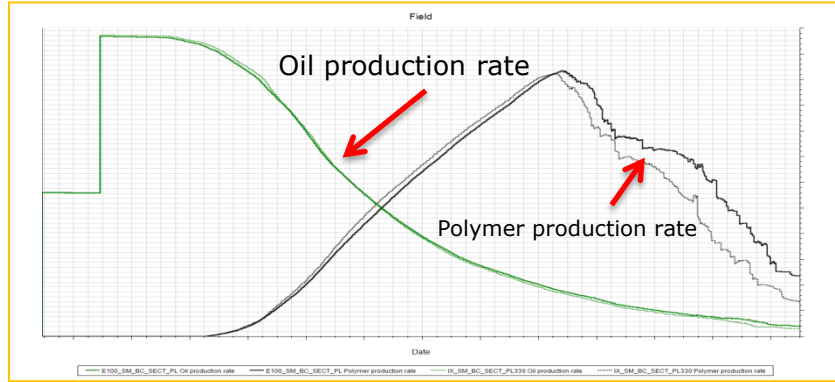
INTERSECT

$$\mu_p^0 = \mu_{H_2O,W}$$

$$\left(1 + \left[A_{p1} \left(\frac{m_{p,W}}{m_{H_2O,W}} \cdot 100\% \right) + A_{p2} \left(\frac{m_{p,W}}{m_{H_2O,W}} \cdot 100\% \right)^2 + A_{p3} \left(\frac{m_{p,W}}{m_{H_2O,W}} \cdot 100\% \right)^3 \right] \cdot [\bar{C}_{SEP}]^{E_p} \right)^{2.475}$$



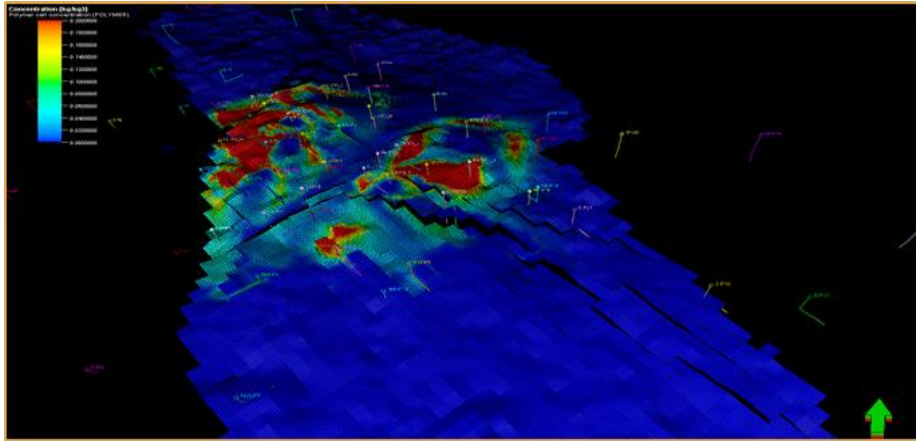
Agreement of results for polymer injection



- Good agreement between ECLIPSE and INTERSECT
- Different formulation for polymer adsorption in INTERSECT
 - ECLIPSE vs rock mass
 - INTERSECT vs water mass
- Good agreement for polymer adsorption using some tuning
 - Adequate results with different adsorption rates

New technology saves run time

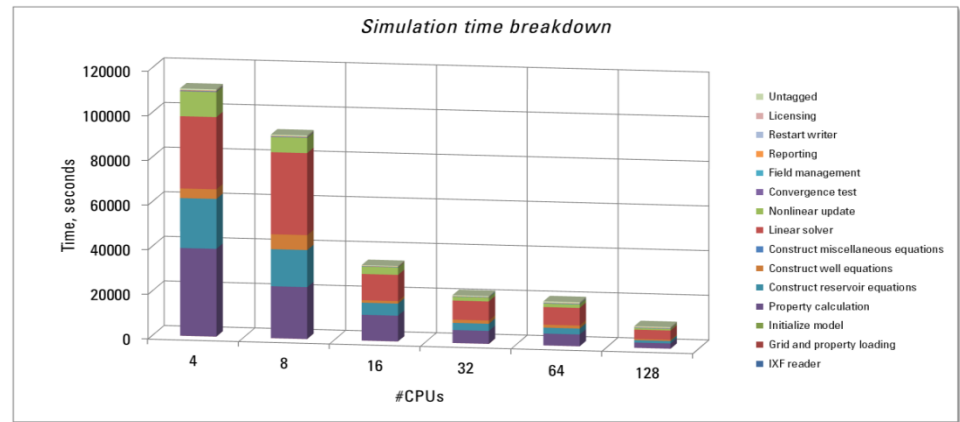
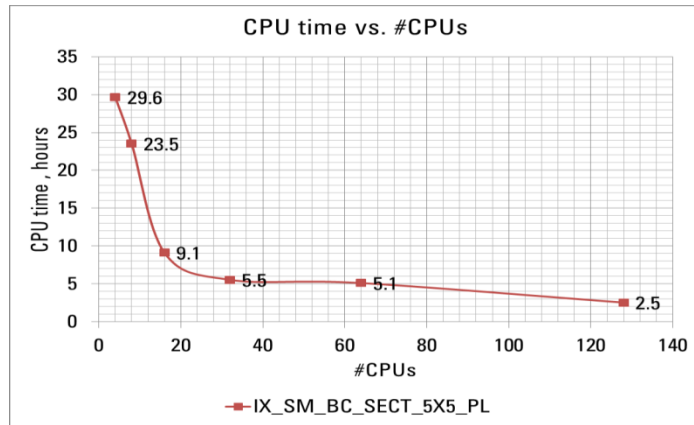
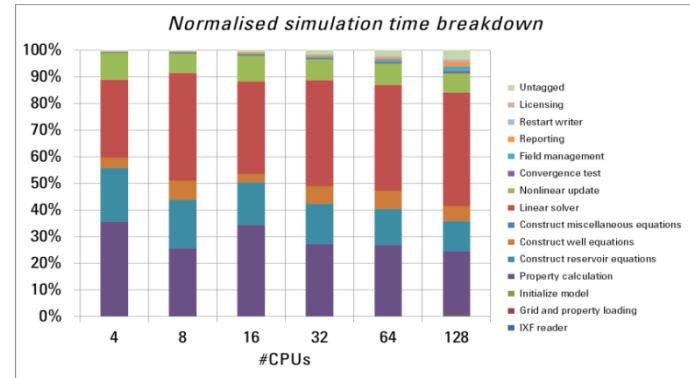
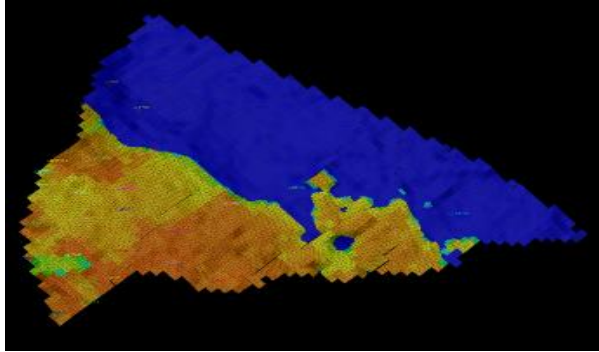
Polymer concentration in detailed FFM



- Coarse model with polymer:
 - 9h vs 15h serial
 - 0,5h vs 2h @ max parallel
- Detailed model with polymer:
 - 6.1 M cells, 30x30m grid
 - 5.5h vs > 1 week @ max parallel
- Effective handling of LGRs

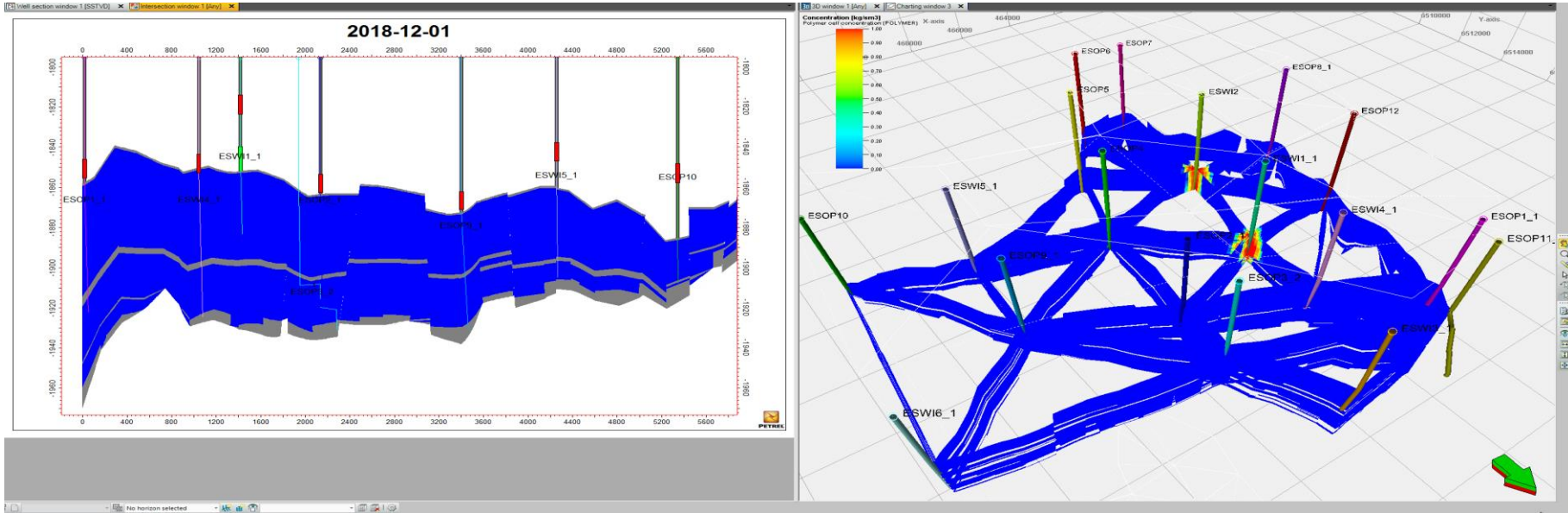
INTERSECT shows better scalability

refined 5x5 sector model with polymer injection



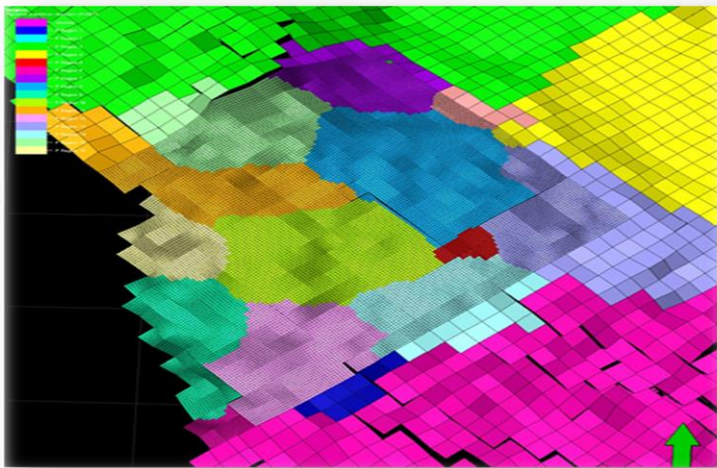
Great potential for business case optimisation

Polymer concentration development in detailed and coarse gridded regions



Way forward and recommendations

INTERSECT parallel run domains
...inside 7X7 LGR



- INTERSECT is mature reservoir modeling technology
- Petoro is considering use of INTERSECT for future studies where speed and scalability of INTERSECT will be critical:
 - EOR studies
 - Geological scale simulation
 - Replacement of «reservoir coupling» model with full field grid
- INTERSECT is not a «silver bullet»
 - it is tool for complex problems:
 - ECLIPSE is still a tool of choice for conventional models!

Questions

Valuable contributors to the project

- Adolfo Henriquez (project owner – Petoro)
- Hamid Nasiri (EOR expert – Petoro)
- Taoufik Manai (Schlumberger)
- Alexander Shadchnev (Schlumberger)
- Alan Thompson (Schlumberger)