Overview IOR Centre

Aksel Hiorth (UiS-IRIS)

FORCE, NPD, 19. April 2018

The National IOR Centre of Norway

Acknowledgement

The National IOR Centre of Norway

The organization

Chairman: Kåre Vagle

The Board

Head of Committee: Niels Lindeloff

The Technical Committee

Centre Director: Merete Vadla Madland

The Management Team

Director of Field Implementation: Sissel Opsahl Viig

Theme leader: Aksel Hiorth

Theme 1 Mobile and immobile oil And EOR methods

Theme leader: Randi Valestrand

Theme 2 Mobile oil – reservoir Characterisation to improve volumetric sweep

Director of Academia: Svein M. Skjæveland

Task leader: Arne Stavland

Task 1Core scale

Task leader: Udo Zimmermann

Task 2 Mineral fluid reactions at nano/submicron scale

Task leader: Espen Jettestuen

Task 3 Pore scale

Task leader: Aksel Hiorth

Task 4 Upscaling & environmental impact

Task leader: Tor Bjørnstad

Task 5 Tracer technology

Task leader: Robert Klöfkorn

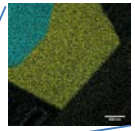
Task 6 Reservoir simulation tools

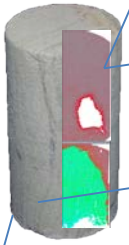
Task leader: Geir Nævdal

Task 7 Field scale evaluation & history matching

IFE IRIS University of Stavanger

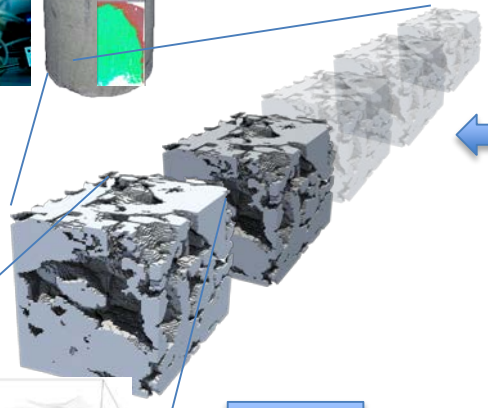
Lab

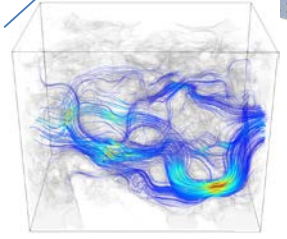




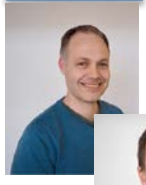
Task 2

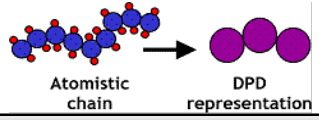
Task 1

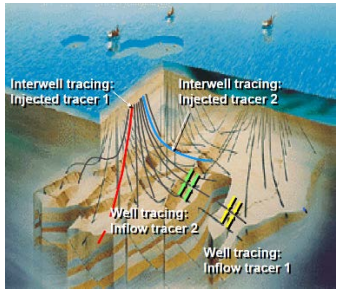




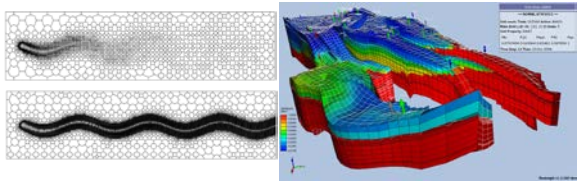
Task 3







Task5



Task6

IORSim
advect components
Modular interface

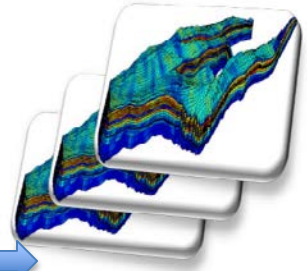
Geo-chemistry

Silicate

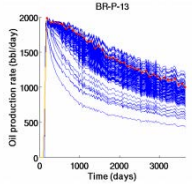
Yard Test

Task4

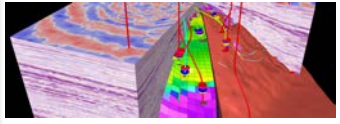
Field evaluation



Task7



4D Seismic HM



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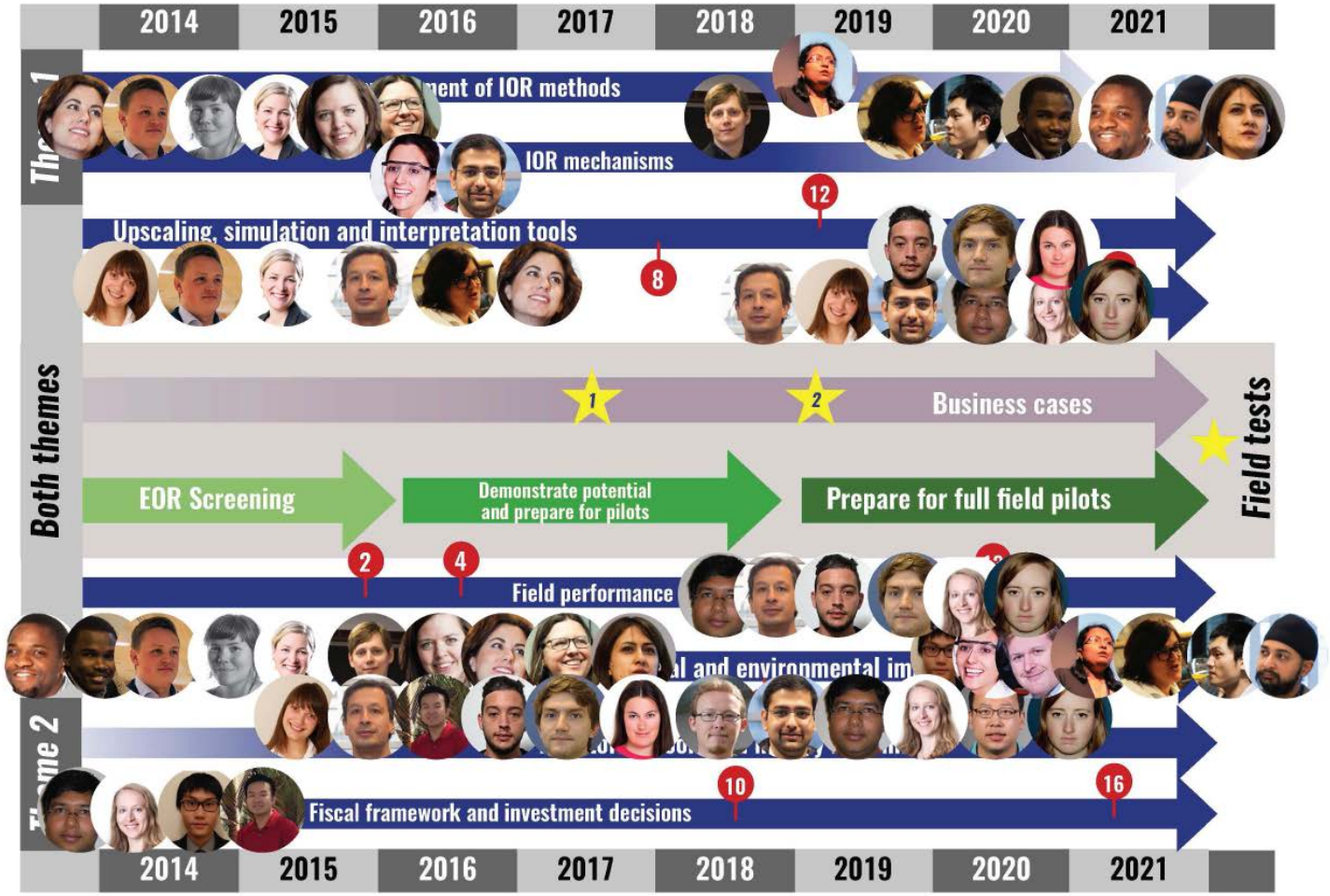


on and tracer data, 4D
/geomechanical model)

ore, sub-micron experi-

n test

tection), tracer data (resi-

(e.g. Eclipse, Visage), tra-

smic and tracer data

k and taxation)

R methods

sts

veep/injection and produ-
economic potential)

and full-field tests

at NCS

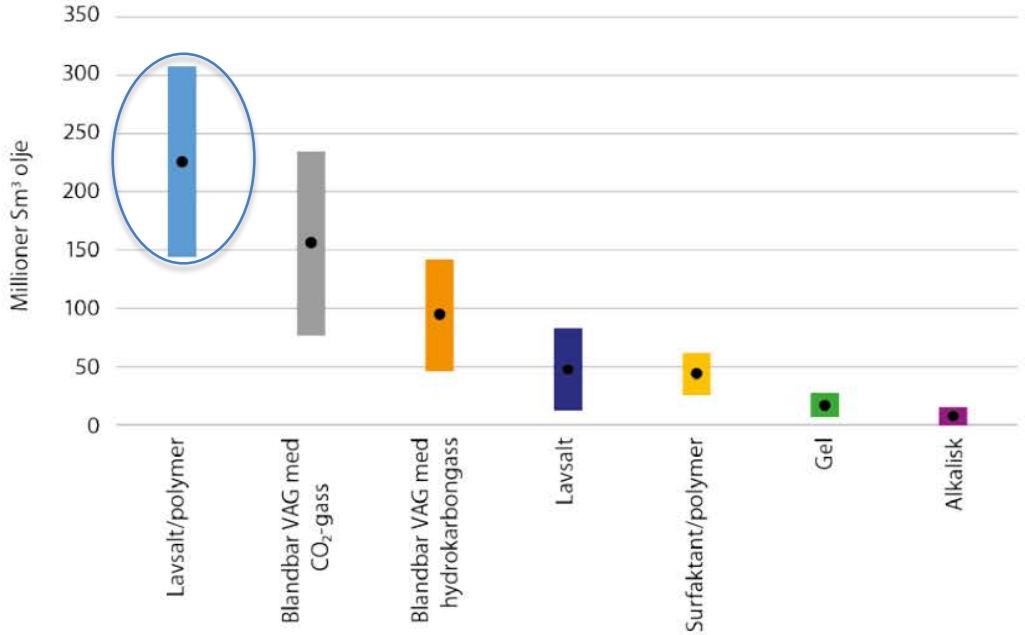
-well tests (access to field data)

EOR-METODER

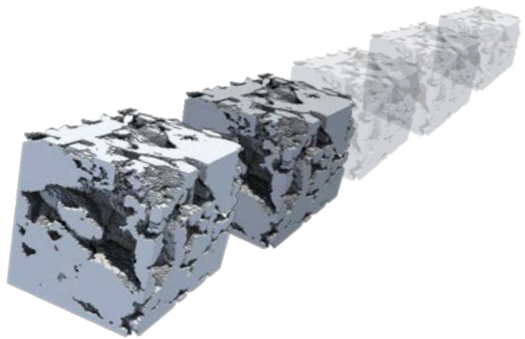
27 felt, 7 metoder:

Resource Report, NPD, 15. June 2017

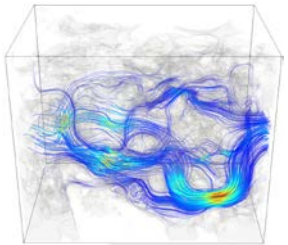
Polymer & low Sal



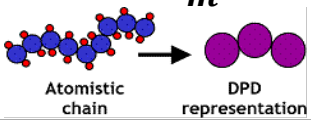
Upscaling



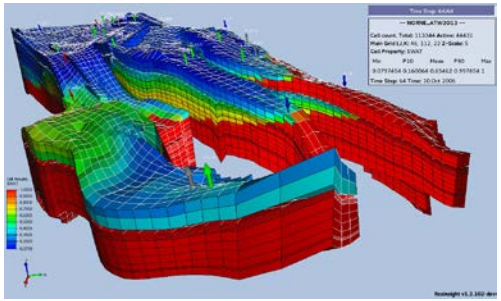
$$\boldsymbol{u_t} - \nabla \cdot \boldsymbol{S}(\boldsymbol{Du}) + (\nabla \boldsymbol{u})\boldsymbol{u} + \nabla \boldsymbol{P} = \boldsymbol{f}$$



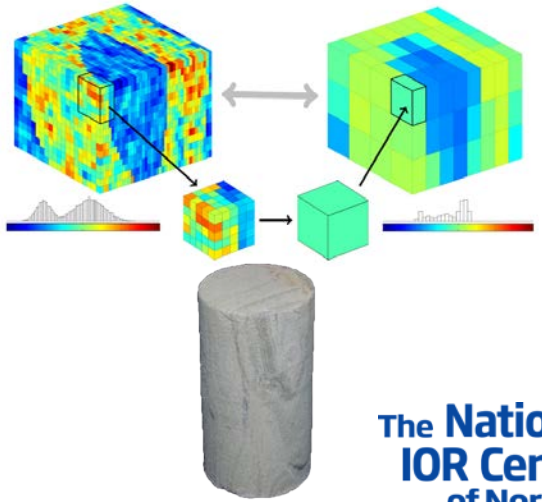
$\overrightarrow{\boldsymbol{F_m}}$



Integrate degrees of freedom



$$k_{rw} = f(r_p, \overrightarrow{\boldsymbol{F_m}}, k_{frac}, q, ..)$$



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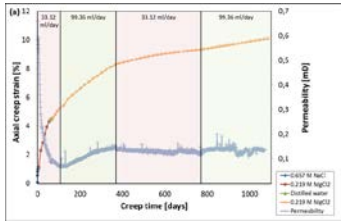
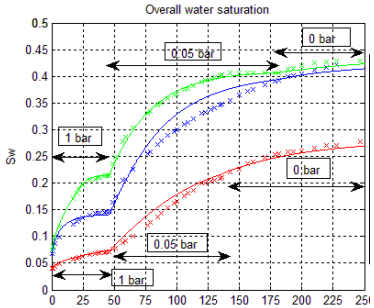
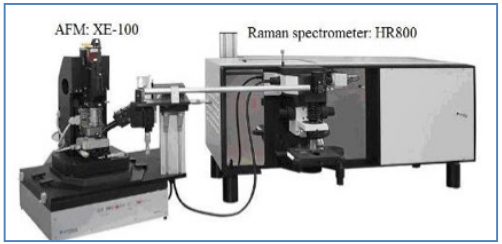
Understanding Smart Water/Low Sal

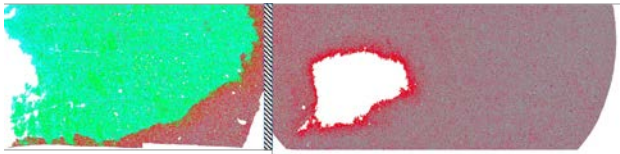
Core

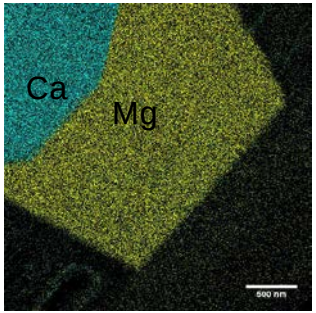




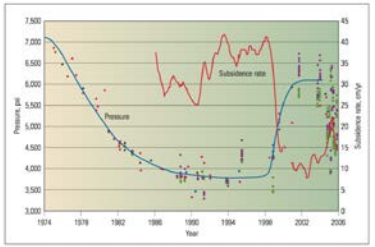
Nano-scale



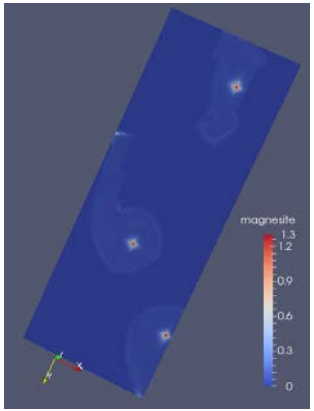




Tying to field



^ Subsidence and pressures in the Ekofisk field crestal area. Pressure measurements in wells in the crestal area follow a trend (blue) with a rapid increase in mid-1998 that corresponds closely to the slowing of the subsidence rate (red).



Key-words: multi scale, scientific publications, robust upscaling

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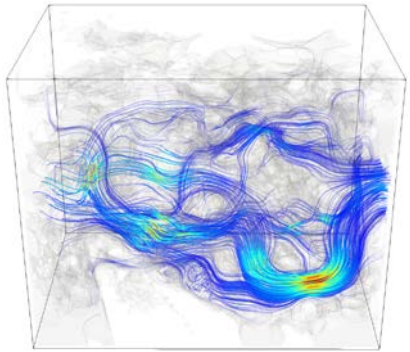
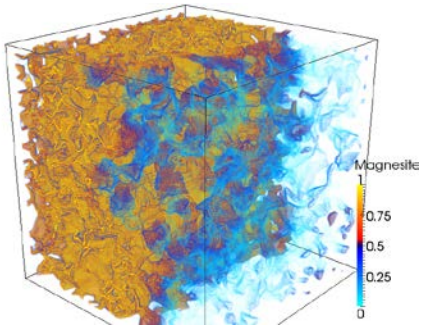
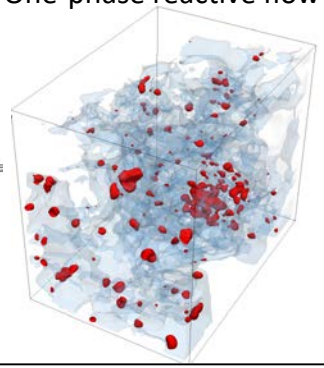
A glimpse into our pore scale simulation toolbox

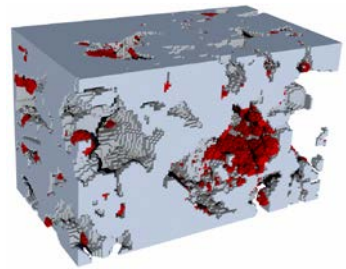
One-phase flow (streamlines)



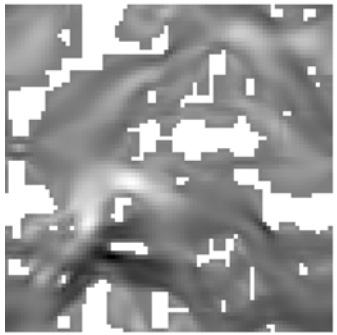
One-phase reactive flow (mineral precipitation)

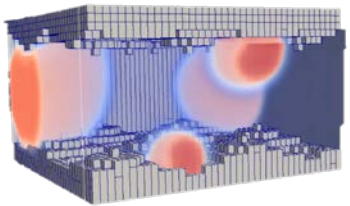




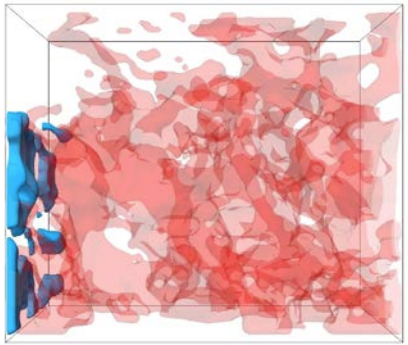


Non-Newtonian flow

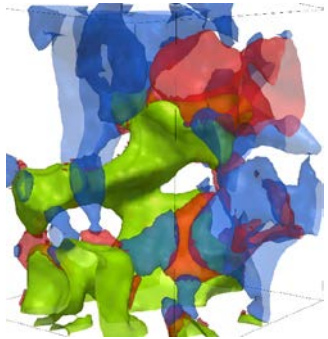




Two-phase flow



Three-phase capillary flow



Key-words: generic tools, process understanding, scientific publications

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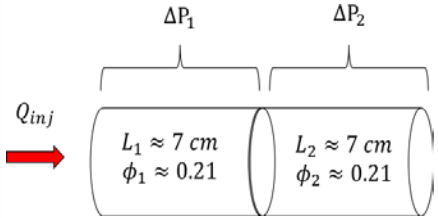
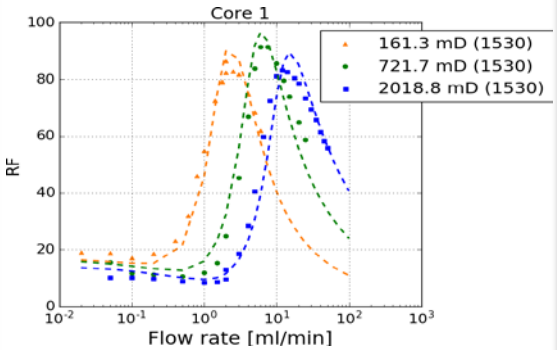
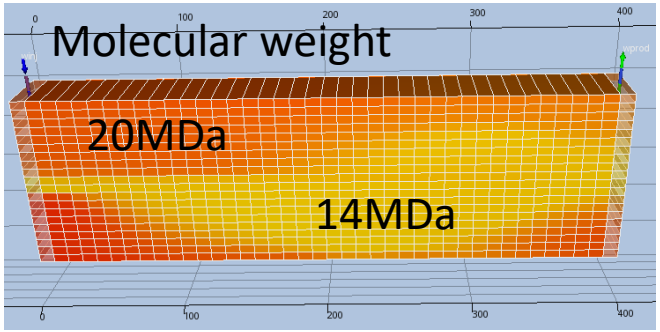
IORCoreSim – Polymer from core to field

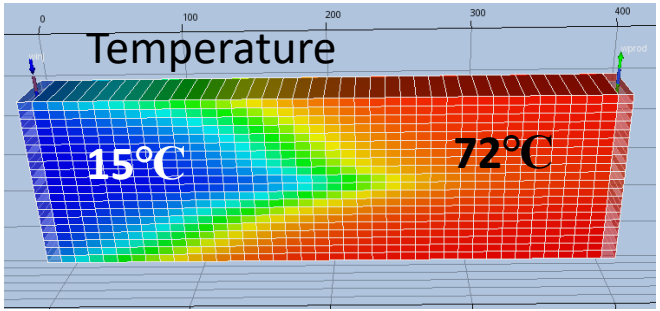
Core Scale Polymer





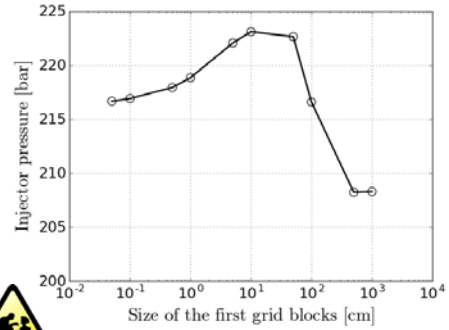
Larger scale





Upscaling to grid block

- Improve well model
- Outside well block:
  - «no» degradation
  - Shear thinning



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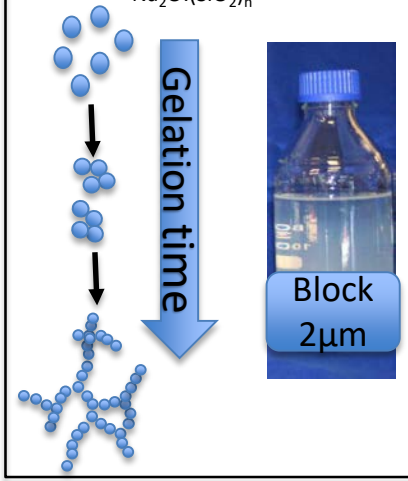
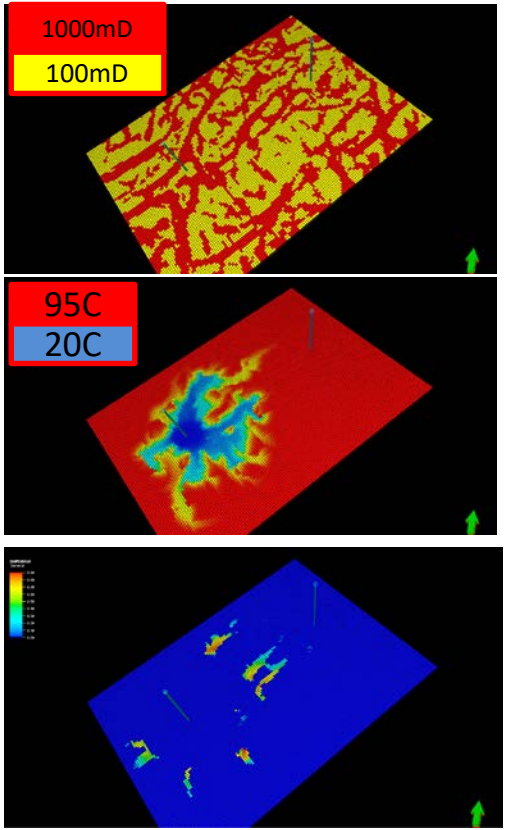
IORSim - Adding Advanced Chemistry to Reservoir Simulators

LAB

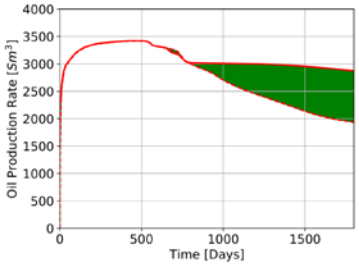
$Na_2O:(SiO_2)_n$



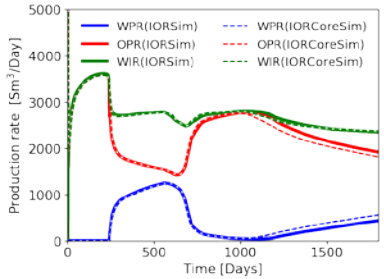
Field



Response



Benchmarking



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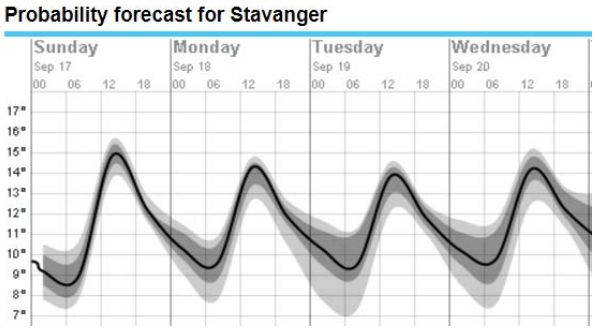
4D seismic History Matching Work-Flow

EnKF: Ensemble Kalman Filter

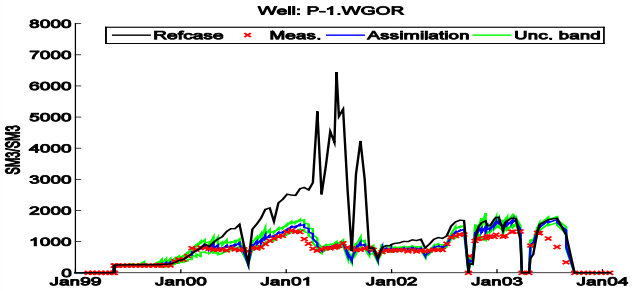
EnKF published in 1994 (NERSC, Bergen, Norway)



EnKF for reservoir characterization:

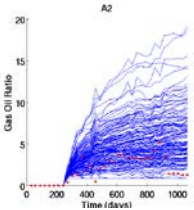
2002: First publication (Nævdal et al., IRIS)

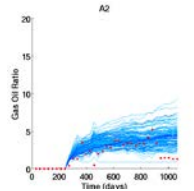
2004- : Work on field cases & Research



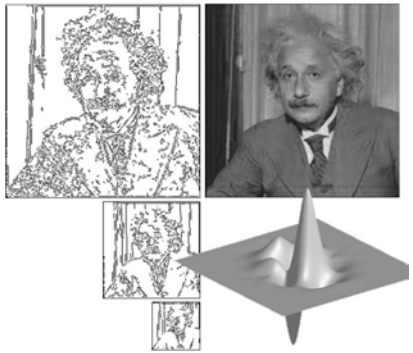
Data:
Production data
Well logs
Cores (lab)
Tracer data
Gravity data
Seismic
…

Parameters updated:
Grid based (poro, perm)
Rel. Perm
Transmissibility multiplyers
Faults
Fractures
Overburden
…



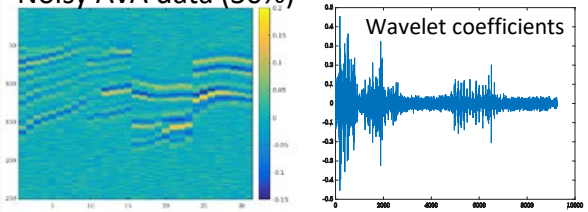


Proposed framework: Wavelet-based sparse representation

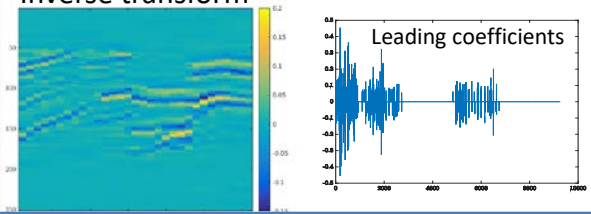


Starck, Jean-Luc, Fionn Murtagh, and Jalal Fadili. Sparse image and Signal Processing: Wavelets and Related Geometric Multiscale Analysis. Cambridge University Press, 2015

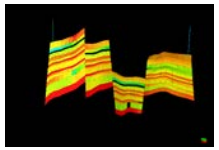
Noisy AVA data (30%)



Inverse transform

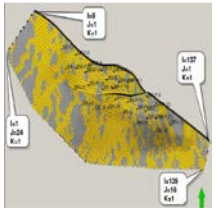


Benchmarking:
2D Norne



Keep 6 % -> Works!

3D Brugge:



Keep:
1) 3 %
2) 0.02 %
->Works!

Now: Real field!

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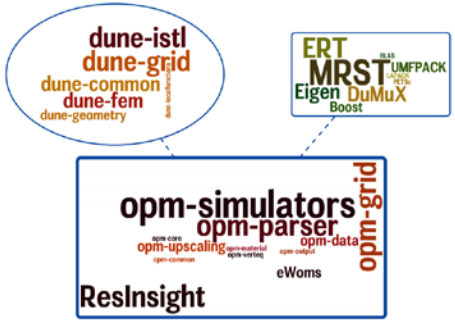
Open Porous Media -OPM

Huge initiative:



- OPM makes use of state-of-the-art software components from other projects
- OPM focuses on porous media applications
- OPM embraces collaboration through open source

Current OPM-Flow activities:

- CLIMIT-DEMO
- National IOR Centre of Norway
- EU: MSO4SC
- Statoil

CLIMIT

MSO4SC

Statoil

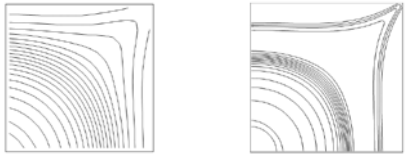
The National IOR Centre of Norway

➢ Currently benchmarked on several North Sea Fields

Centre activities:

➢ Developing higher order methods for realistic field cases (reservoir grid/corner-point grid).

➢ Developing fully-implicit higher order methods applicable in black-oil simulators.



➢ Releases twice a year
➢ Tracer
➢ Near well
➢ Numerical computation

Essential Keywords: Long term & Education & Cooperation & Generic

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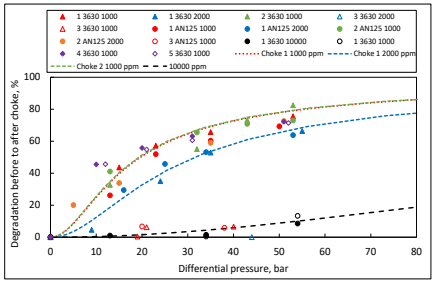
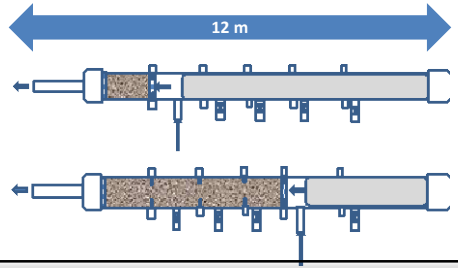
Plans for three years and beyond

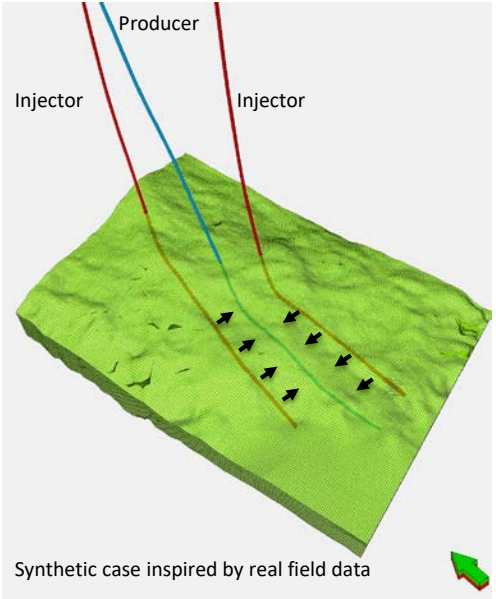
- **STEP programme** (**ST**ud**E**nts&**P**artners)
- All PhD and post docs:
  - Contribution to use cases
  - Actively discuss potential synergies between ongoing projects
- Plan to educate at least six more PhD students and four more post docs
  - Cross discipline projects
  - Cross discipline advisers
- Become even more visible, attract even more cooperation, and increase funding even more!





Generic Use Cases

- Demonstrate methodology



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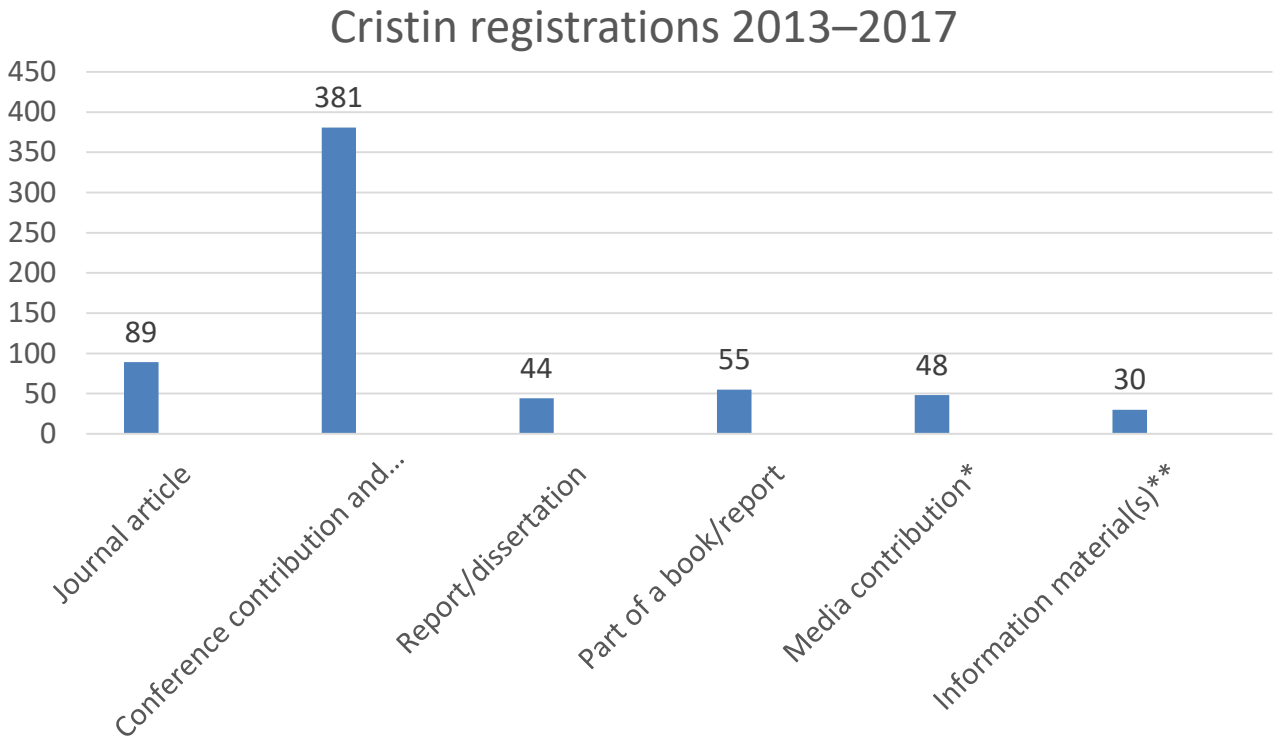

*134 media contributions in 2014 not registered in Cristin

**Not registered in Cristin

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24.-25. April

IOR NORWAY 2018

SMART SOLUTIONS FOR FUTURE IOR

"A UNIQUE OPPORTUNITY TO ENGAGE WITH IOR PROFESSIONALS AND RESEARCHERS FROM NORWAY AS WELL AS EUROPE AND FURTHER AFIELD"

WELCOME!

NFiP PETROLEUM RESEARCH SCHOOL OF NORWAY

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Norway Pumps & Pipes – Cross-industry collaboration

3rd Joining Forces Seminar – NPD, Stavanger, 19th – 20th April 2018

Thor Ole Gulsrud, PhD, Research Director – Medtech, IRIS

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Pumps & Pipes – the story

The solution to your problem may very well be in «The Other Guy's Toolkit»

HOUSTON Methodist LEADING MEDICINE

ExxonMobil

UNIVERSITY of HOUSTON

NASA

Similar challenges – different approaches

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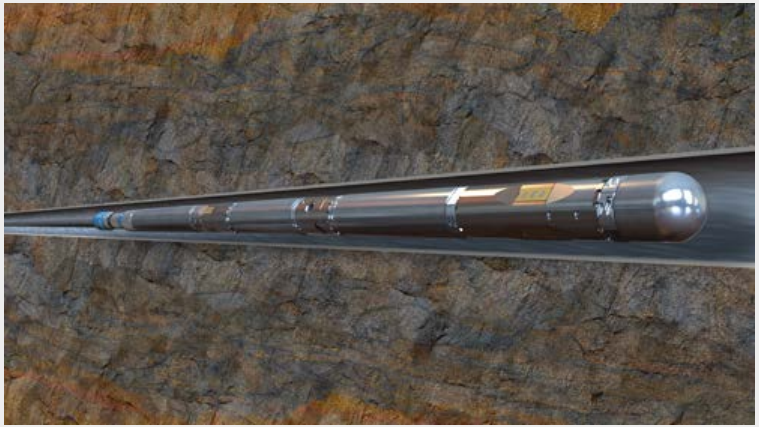
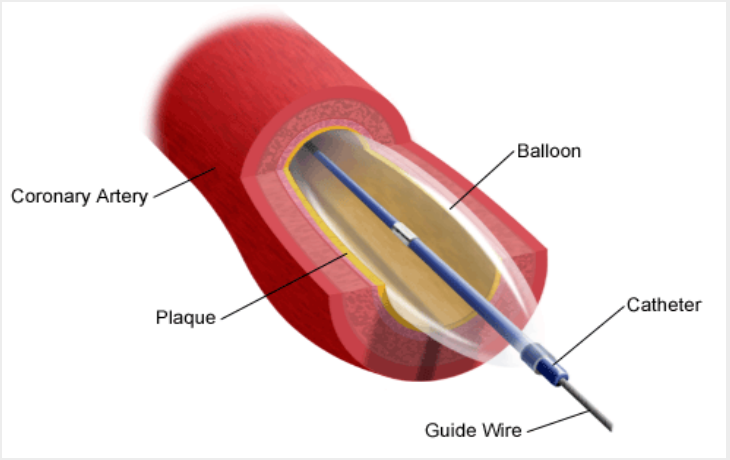


Schlumberger ACTive DFLO CT real-time flow measurement tool

Well intervention



Hackensack University Medical Center

Cardiac intervention

Norway Pumps & Pipes

Inspiration from Houston

www.pumpsandpipes.com

MNOK 5 from NMHCS*

*Norwegian Ministry of Health and Care Services

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NP&P February 2016

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Main activities:

- Regular lunch-seminars.
- Workshops on different topics.
- Promote cross-industry collaboration to solve challenging problems.
- Seed funding of projects (in 2016 and 2017).
- First conference will be organized in 2018.

Project example 1: **Non-invasive FFR-measurement**

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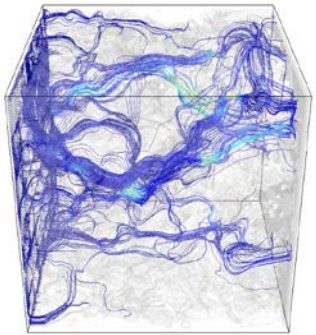
Challenge from the cardiologists:

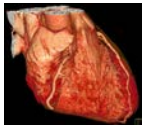
- Calculate how much a given stenosis affects the supply of oxygen to the heart.

Project:

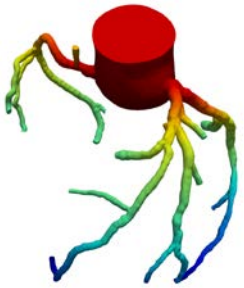
- Non-invasive assessment of the coronary arteries based on data modelling and medical imaging.

Flow model for Enhanced Oil Recovery





Non-invasive FFR-measurement



$$\overbrace{\rho\Big(\underbrace{\frac{\partial \mathbf{v}}{\partial t}}_{\text{Unsteady acceleration}} + \underbrace{(\mathbf{v}\cdot\nabla)\,\mathbf{v}}_{\text{Convective acceleration}}\Big)}^{\text{Inertia}} = \underbrace{-\nabla p}_{\text{Pressure gradient}} + \underbrace{\mu\nabla^2\mathbf{v}}_{\text{Viscosity}} + \underbrace{\mathbf{f}}_{\text{Other forces}}$$

Project example 2:
Resuscitative Endovascular Balloon Occlusion of Aorta (REBOA)

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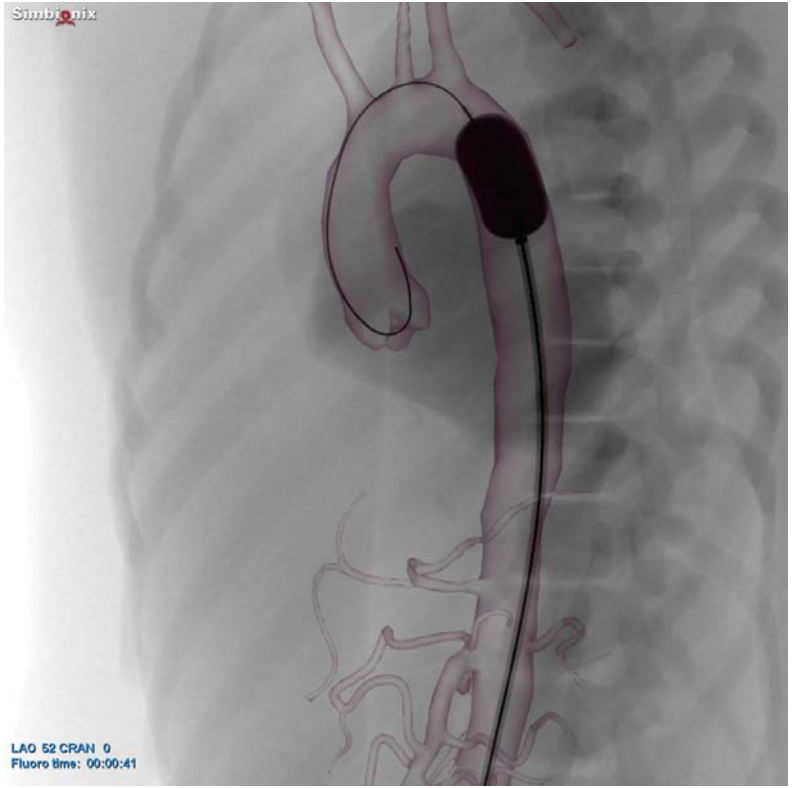
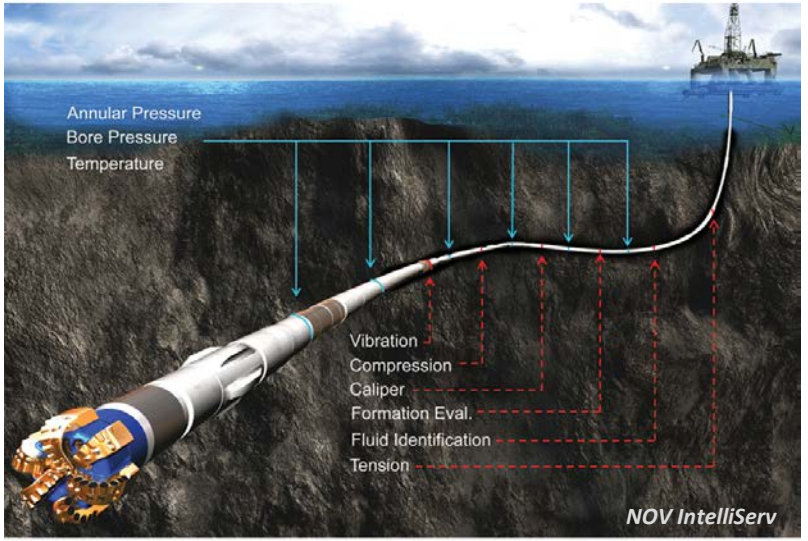


- REBOA is a technique that stops the internal bleeding by inflating a balloon inside the aorta.
- Can the catheter be equipped with sensors that register different vital parameters such as blood pressure and oxygen content?



IRIS

From “Ullrigg” to “Ullrik”

Norway Pumps & Pipes 1st Annual Conference, Stavanger 17.-18th of October 2018

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1ST NORWAY PUMPS & PIPES CONFERENCE

OCTOBER 17-18, 2018, SOLA STRAND HOTEL, SOLA, NORWAY

We are delighted to invite you to attend this very first Norway Pumps & Pipes Conference.

Read more here!

Conference theme: Cross-industry Collaborations

- Call for abstracts - deadline June 20th
- Explore and promote unique innovation possibilities between oil & gas and medicine.
- Share competence and challenges.
- Highlight new solutions and innovations.

Alan B. Lumsden, MD

Walter W. Fondren III Distinguished Endowed Chair, DeBakey Heart & Vascular Center
Chair, Department of Cardiovascular Surgery
Professor of Cardiovascular Surgery, Institute for Academic Medicine
Full Clinical Member, Research Institute
Houston Methodist
Weill Cornell Medical College

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Thank you for your attention!

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