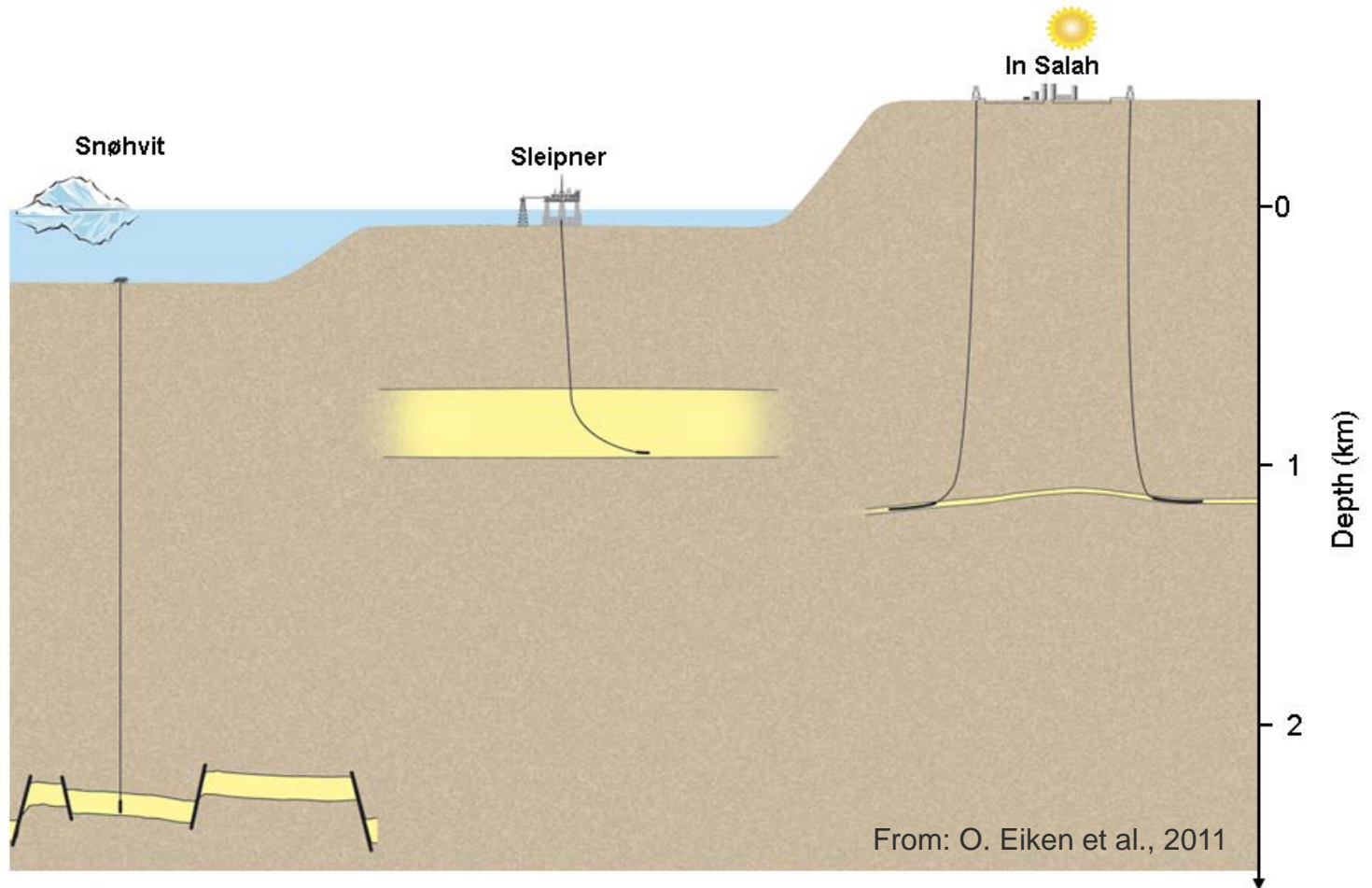


Swing Injection Technique for CO₂ Storage and EOR

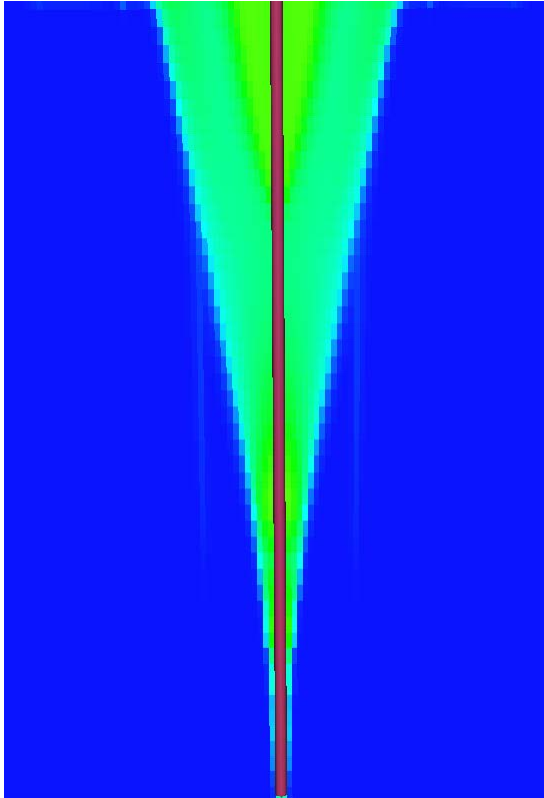
2nd Biennial CO₂ for EOR as CCUS Conference
Houston, Texas, Oct. 4-6, 2015

B. Nazarian, A. Cavanagh, P.S. Ringrose, and B. Paasch
Statoil Research Center, Trondheim, Norway

Background



Active plume management techniques

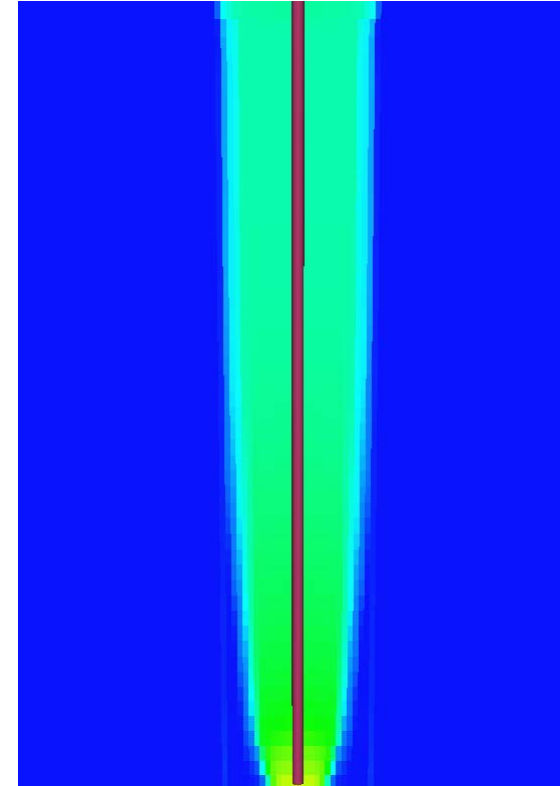


$$N_{gv} = \frac{k_v \Delta\rho g \cos\alpha}{\mu u_{inj}}$$

█ We cannot change

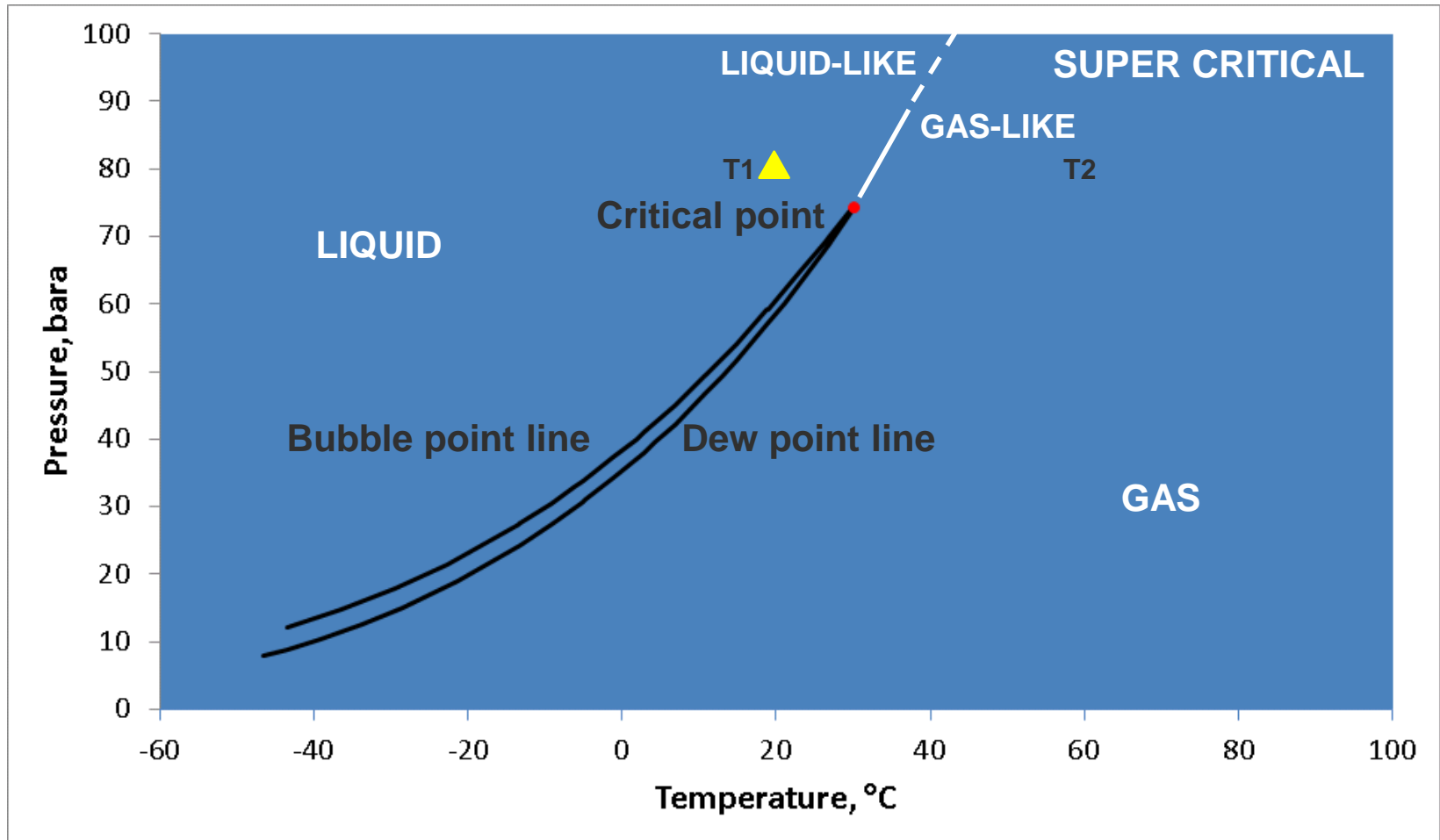
█ We do not want to change

- Poor sweep
- Considerable CO₂ at top seal

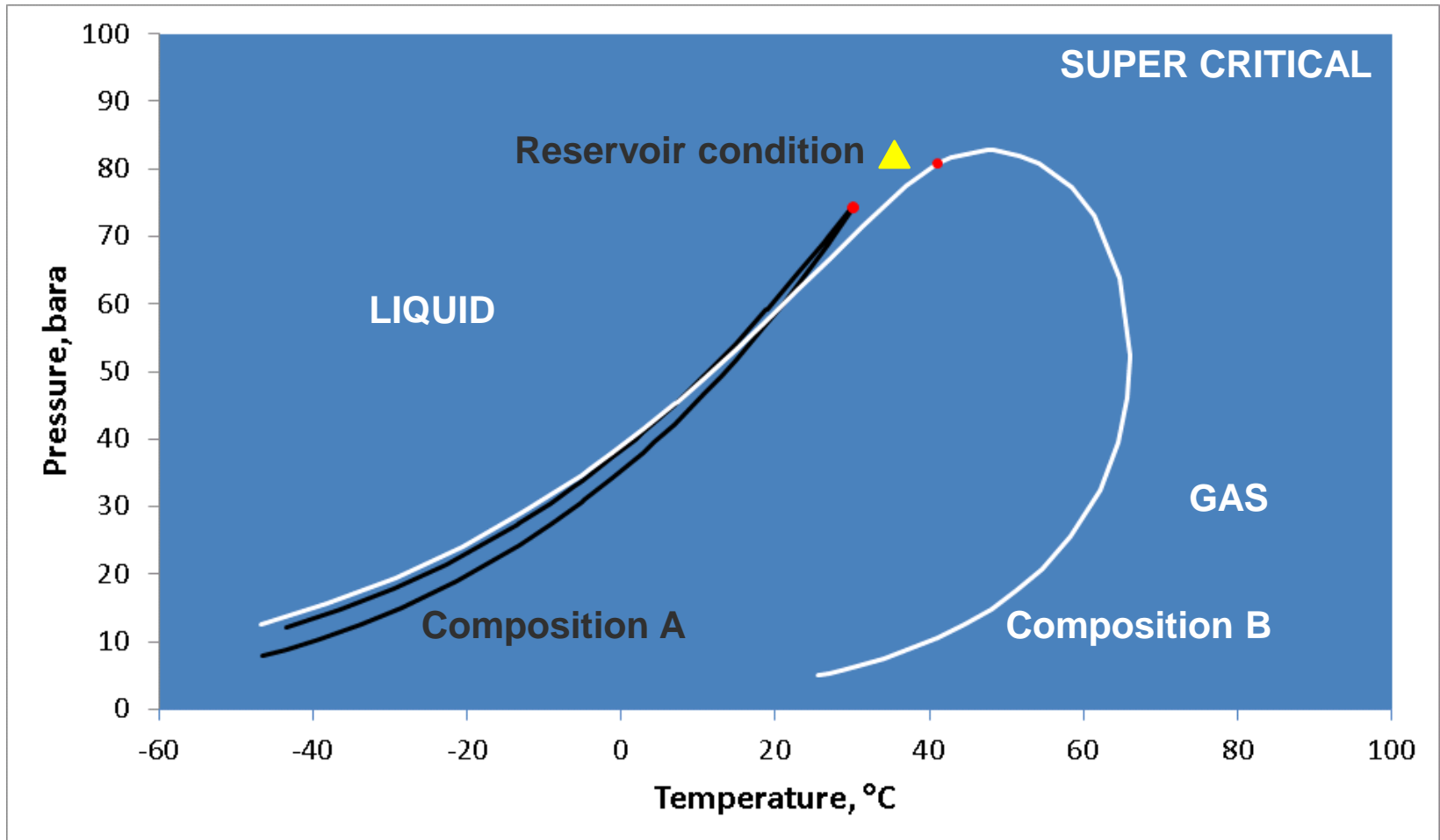


- Improved sweep
- Less CO₂ at top seal

CO₂ Temperature Swing Injection (TSI) technique

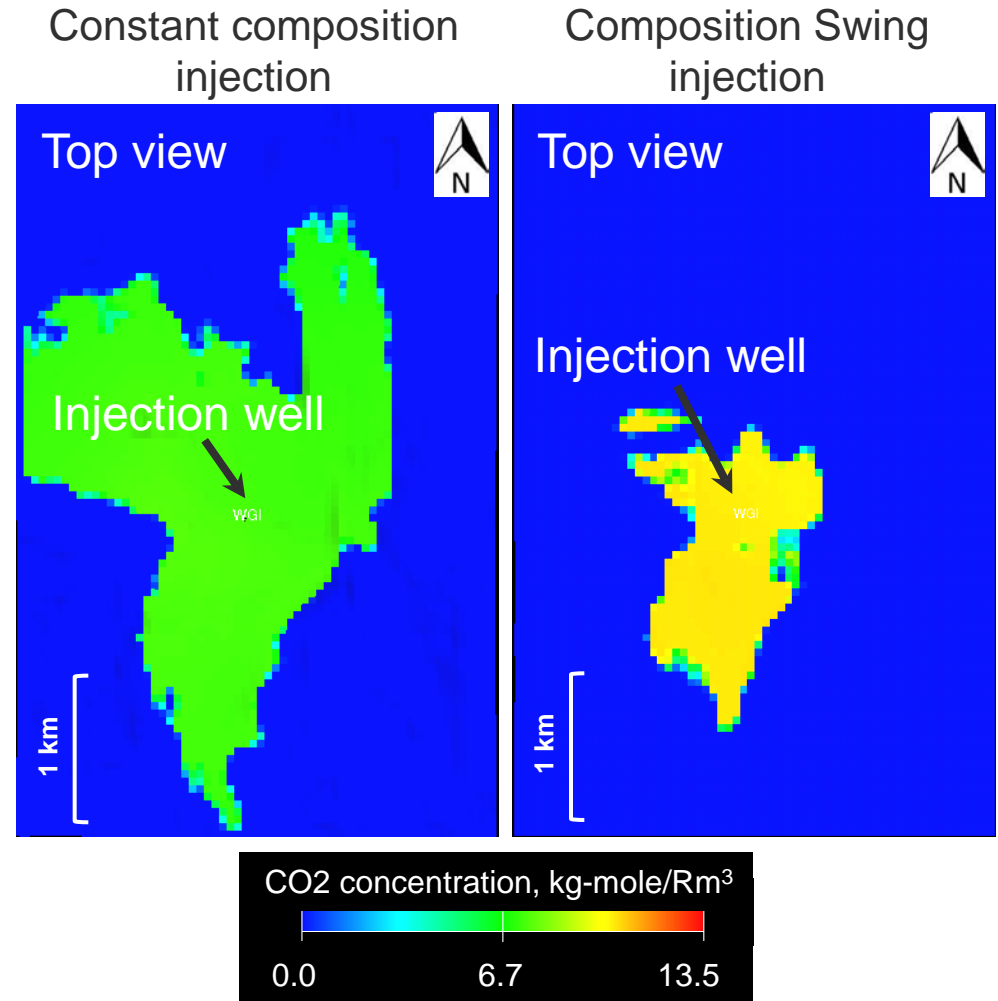


CO₂ Composition Swing Injection (CSI) technique





Effect of CSI injection on plume size

- Swing Injection for storage
- Sleipner/Utsira analogue
- Injection rate: 1Mtpa
- Injection period: 30 years
- CSI cycle: 6 months
- 61% reduction in plume volume when CSI is used

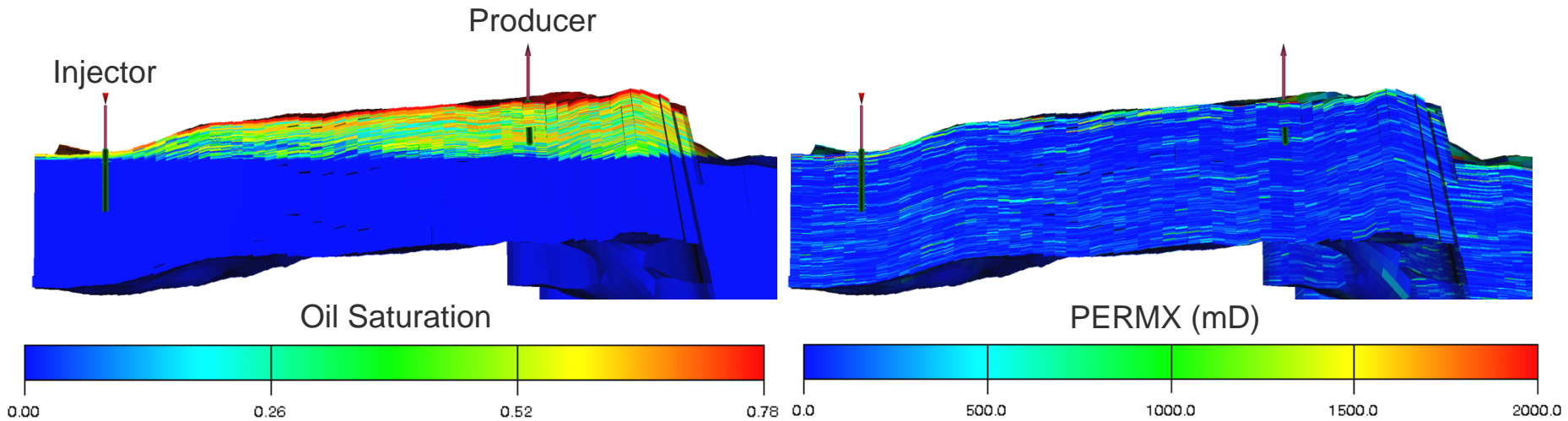


Quantitative effect of active plume management

- Gravity number is reduced by more than 30% using CSI and TSI techniques
- CSI results in reduction of plume volume by around 61%
- At moderate low temperatures, heat dissipation reduces the effect of TSI in CO₂ storage

Case	Gravity number, N_{gv}	Plume volume, Rm^3
Constant composition injection	8.43×10^{-3}	9.52×10^{10}
CSI technique	5.64×10^{-3}	3.51×10^{10}
Percent difference	 33.1	 61.5
Constant temperature injection	7.21×10^{-3}	2.02×10^{10}
TSI technique	4.67×10^{-3}	1.92×10^{10}
Percent difference	35.2	5.0

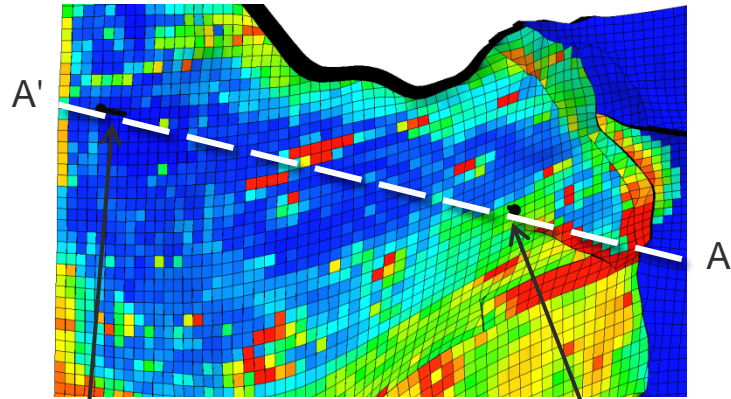
Swing Injection for EOR



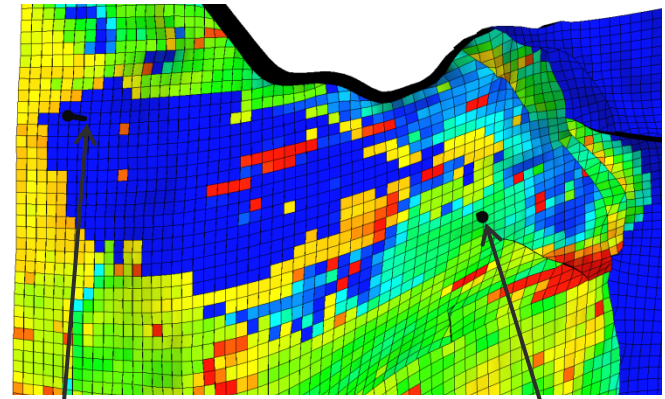
- North sea oil reservoir
- No initial gas-cap. The whole oil column is a transition zone
- Static properties improve at the top of the reservoir
- Challenging case for CO₂ due to segregation and early breakthrough
- Injection rate: 1 Mtpa
- Injection period: 38 years

Increased sweep efficiency by applying CSI

Pure CO₂ injection



Composition Swing Injection

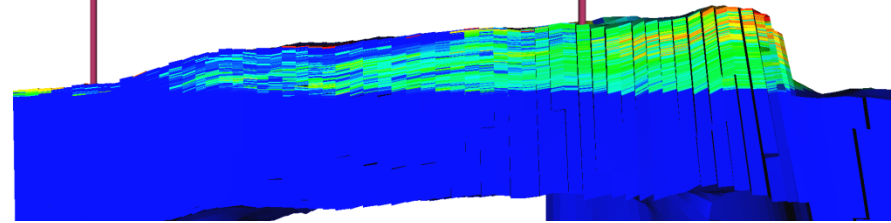
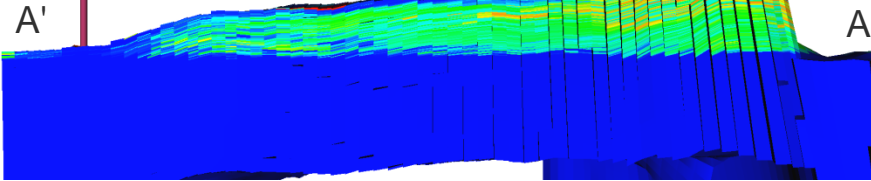


Injector

Producer

Injector

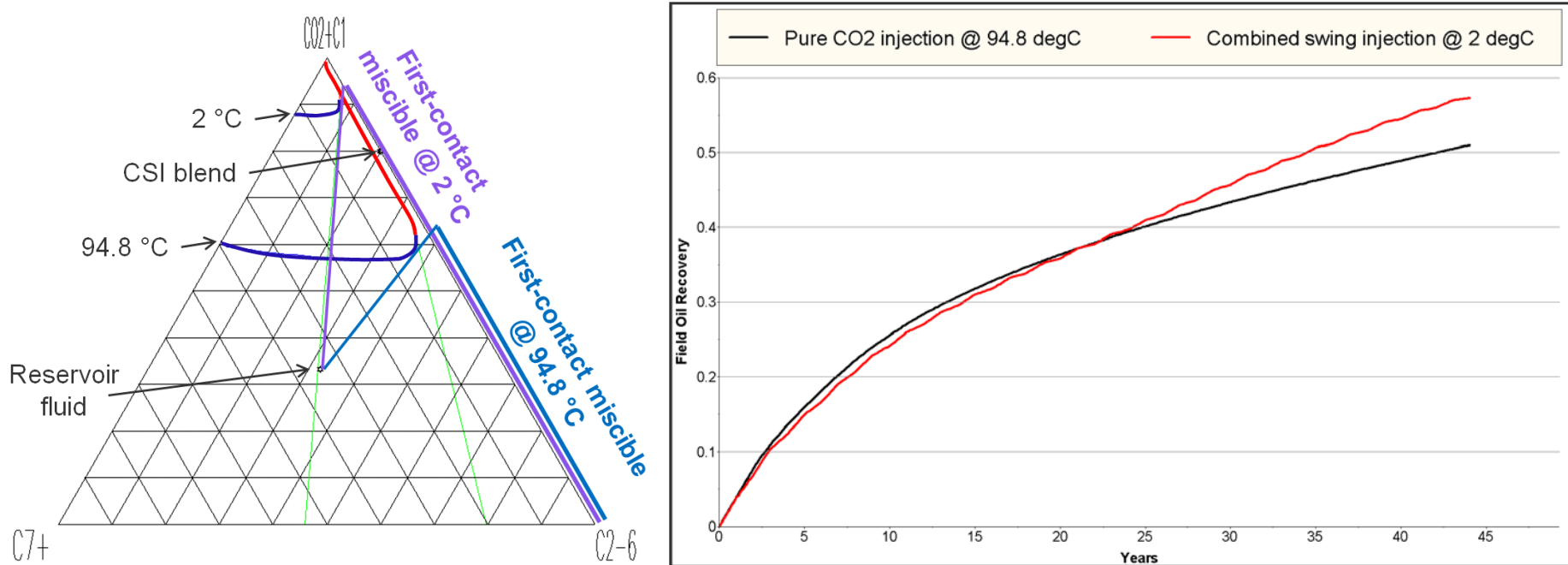
Producer



Oil Saturation

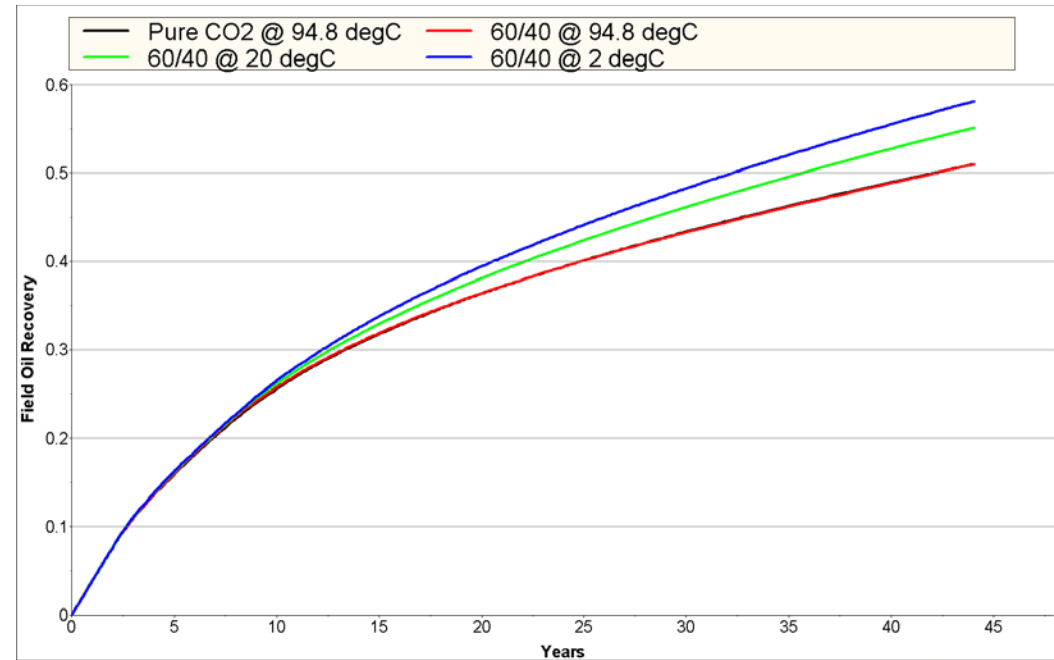
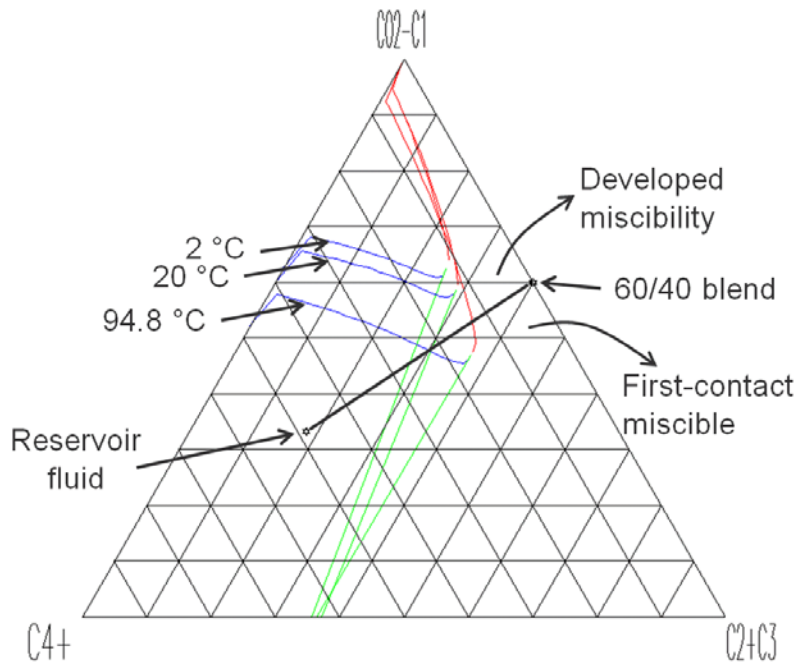


Combined CSI and TSI for EOR using CO₂ – intermediates blend



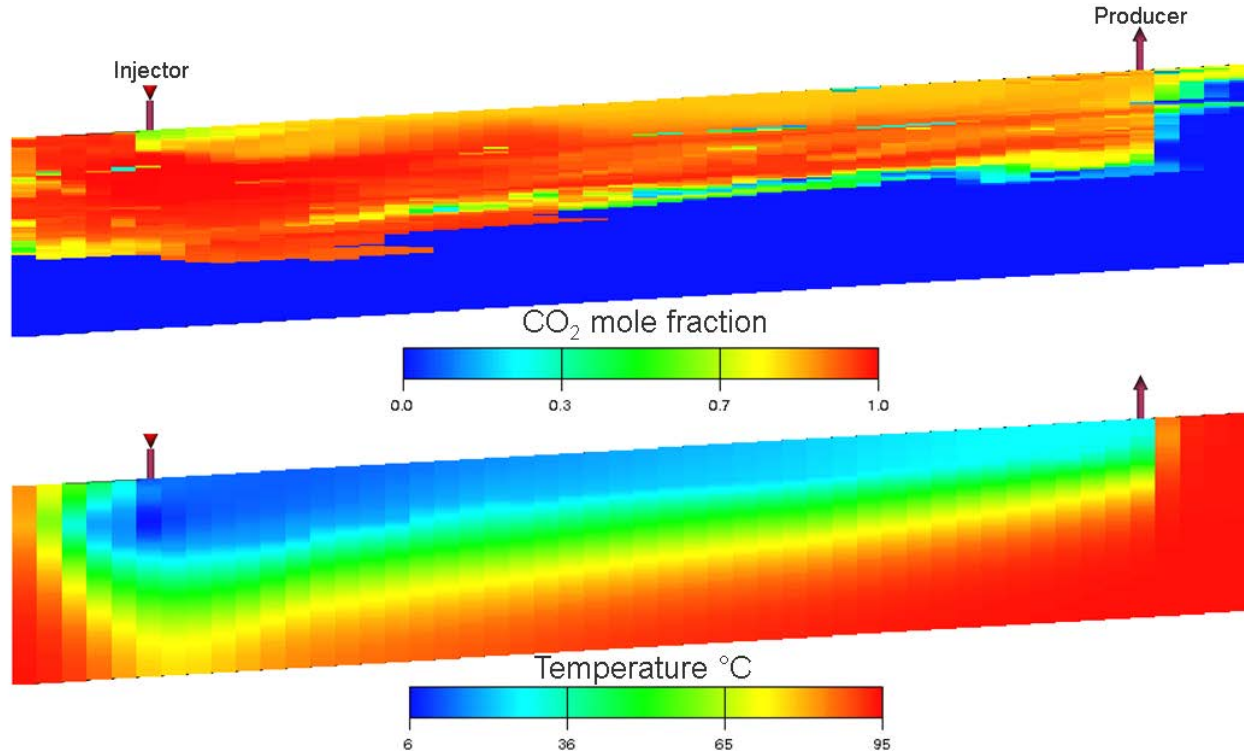
- Composition and Temperature swing injection can be combined
- Low temperature improves miscibility and enhances properties
- Recovery from the combined CSI and TSI is around 10% more than common CO₂ EOR

Combined CSI and TSI for EOR using CO₂ – light HC blend



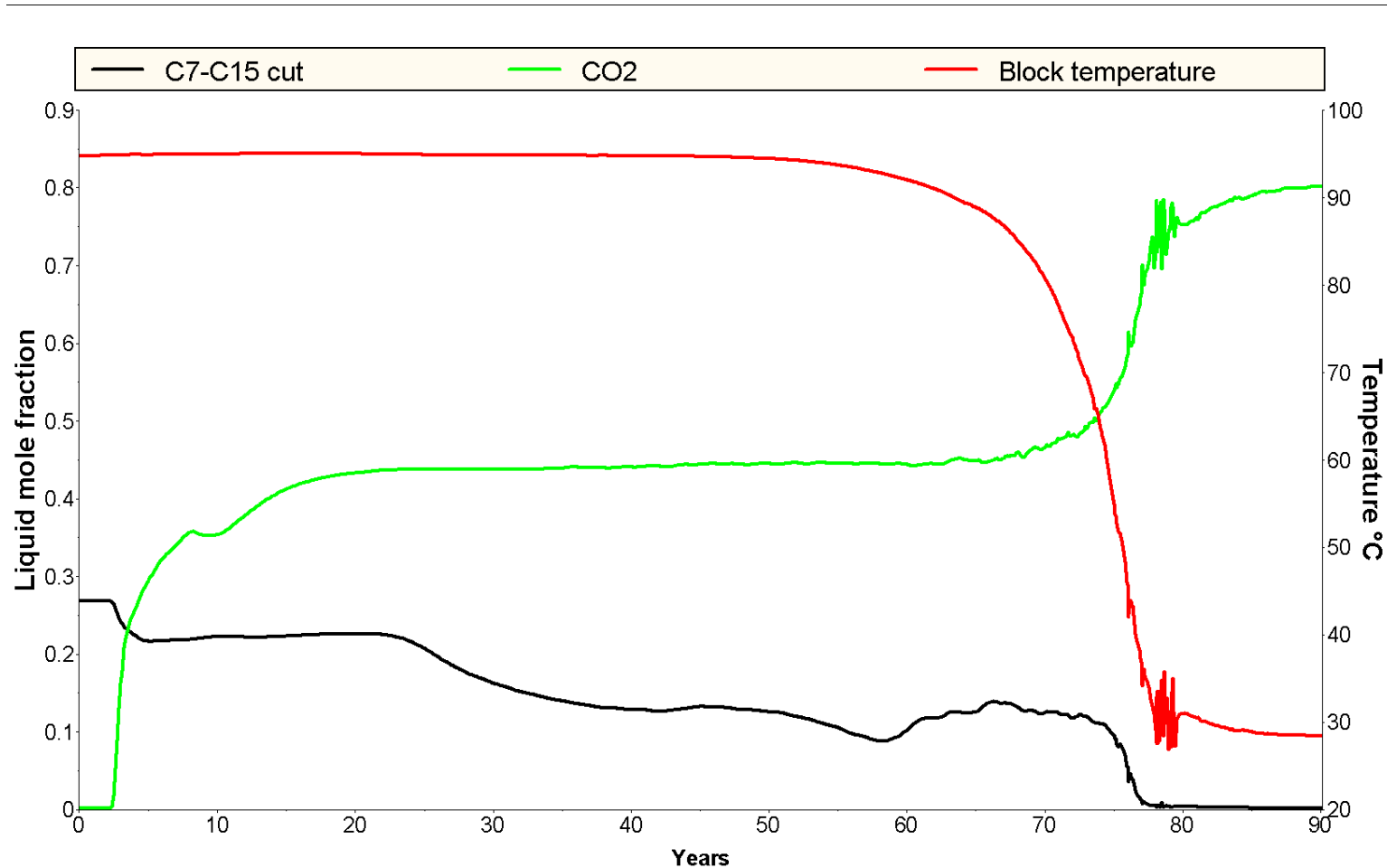
- Reduced temperature improves miscibility of CO₂ and light hydrocarbon blends
- 7% extra recovery @ 20 degC compared to common CO₂ EOR

Comparing saturation and temperature front movement



- Distance between the wells is 4000 m
- CO₂ breakthrough after around 2 years
- Temperature breakthrough after around 60 years

Effect of temperature on attic recovery near the producer



Conclusions

- The concept of Active Plume Management is applicable to both CO₂ storage and CO₂ EOR
- Swing injection techniques
 - CO₂ storage: Increased storage capacity by 60%
 - CO₂ EOR: Extra oil recovery by 10%
- In CO₂ storage Swing Injection controls the plume by density modification
- In CO₂ EOR Swing Injection works through viscosity modification and improved miscibility

There's never been a better
time for **good ideas**

Thank you for your attention

Swing Injection for CCS and CO₂ EOR

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