UiO : Department of Geosciences
University of Oslo

Presentation of MSc thesis in geophysics

Strategy for CSEM data inversion – Sleipner CO_2 storage project

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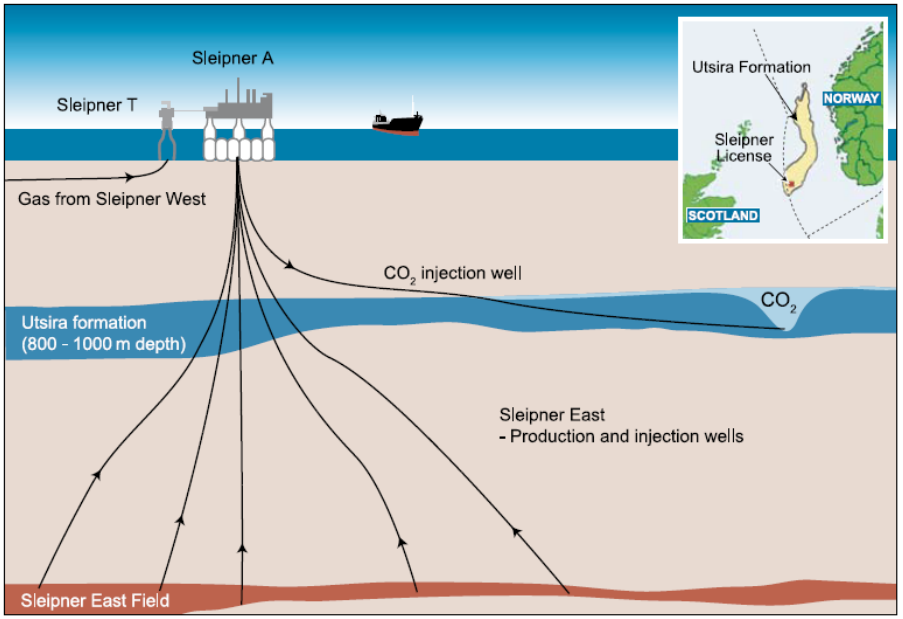
SUbsurface CO2 storage- Critical Elements and Superior Strategy

Introduction

- Motivation, background, objective
- Marine CSEM (controlled source electromagnetic) method
- Available data
- Data visualization and filtering
- Inversion results – effect of filtering
- Further work

Motivation and background

- Since 1996 nearly 1 million tons of CO_2 have been injected into the Utsira formation in the Sleipner field area every year
- In 2008 a CSEM dataset was acquired by EMGS over the area
- Studied by NGI to validate the feasibility of using marine CSEM for CO_2 injection monitoring in the offshore environment
- Challenges related to inverting the dataset to get an image of the subsurface



From: IPCC (2005)

Objective

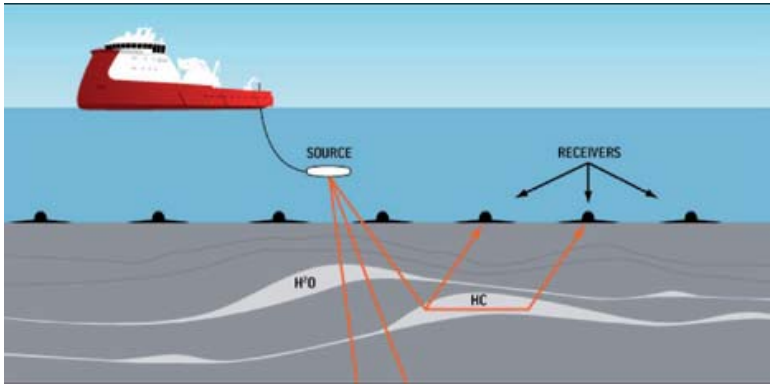
Establish an inversion strategy to resolve some of the challenges related to inverting the CSEM dataset from the Sleipner CO_2 storage project

Focus on challenge related to the influence from pipeline network on seabed;

- Interfering with CSEM signal → artefacts in image of subsurface

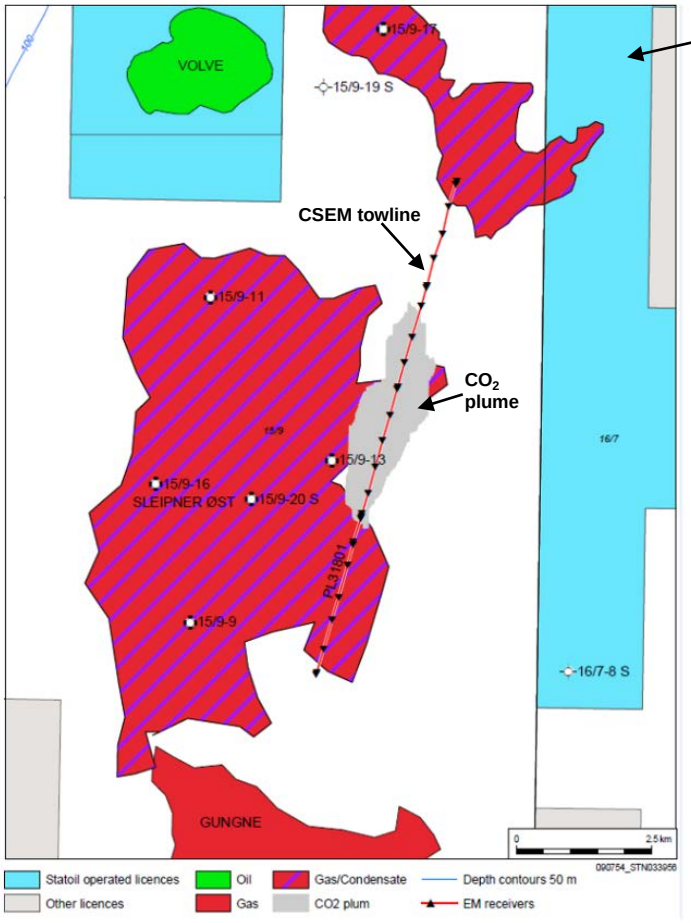
The marine CSEM method

- Maps the resistivity of the subsurface (materials ability to oppose the flow of electric current)
  - Low frequency EM source (HED) towed close to seabed where receivers are deployed
  - Measures the electromagnetic field components
- Hydrocarbons characterized by high resistivity
- In resistive layers EM waves attenuate very little compared to surroundings, and guided waves travelling in the layer leaks energy up, measured by receivers.
- Measurements used to generate resistivity image of the subsurface



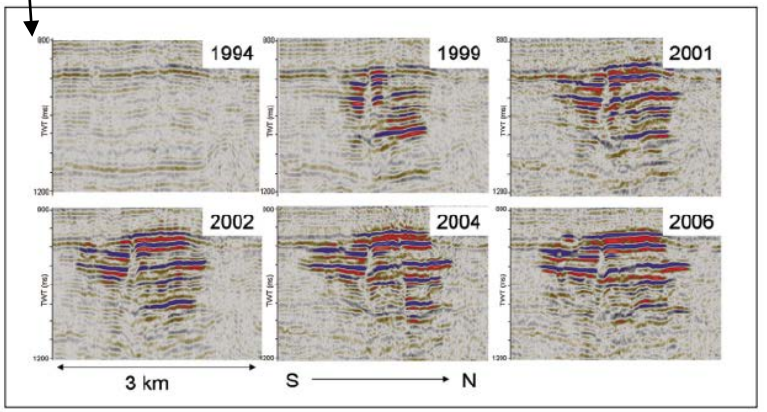
From: GEO ExPro (2017)

Sleipner CO_2 storage project – available data



From: Park et al. (2013)

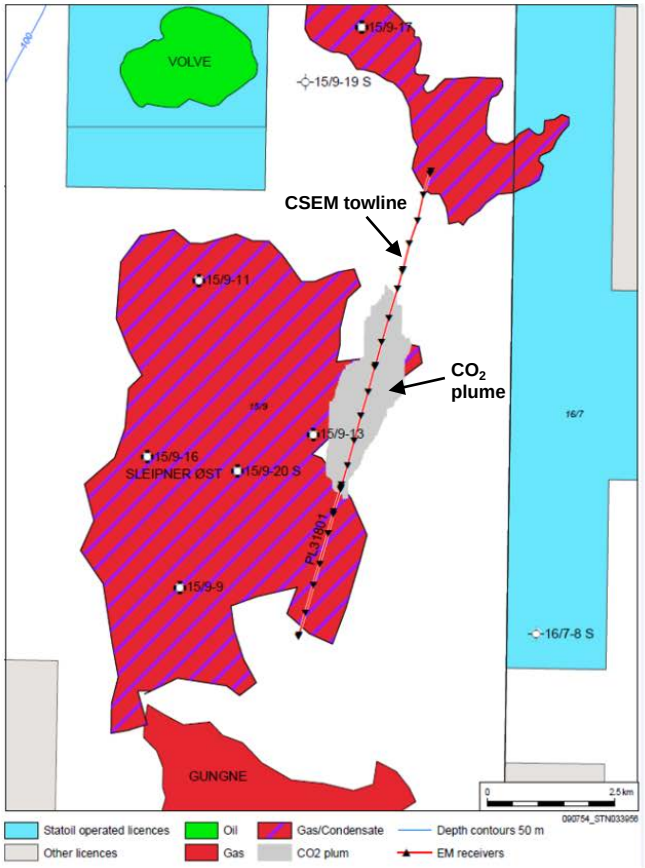
- CSEM survey (EMGS, 2008)
  - 27 receivers covering about 9.5 km
  - Inline electric field and broadside magnetic field
  - 0.5, 1, 1.5, 2, 2.5 and 7 Hz
- Well logs (NPD)
- 4D seismic survey (Arts et al. 2008)
  - Depth converted seismic used to locate the CO_2 and evaluate the CSEM inversion results

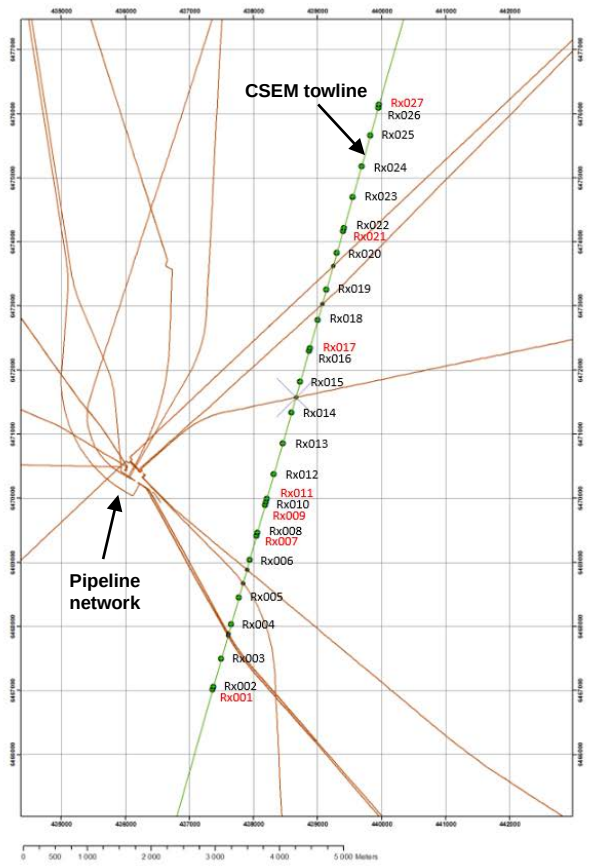


From: Arts et al. (2008)

CSEM data filtering

- Remove closely spaced receivers
- Improve inversion result by identifying and filtering out data strongly influenced by pipelines

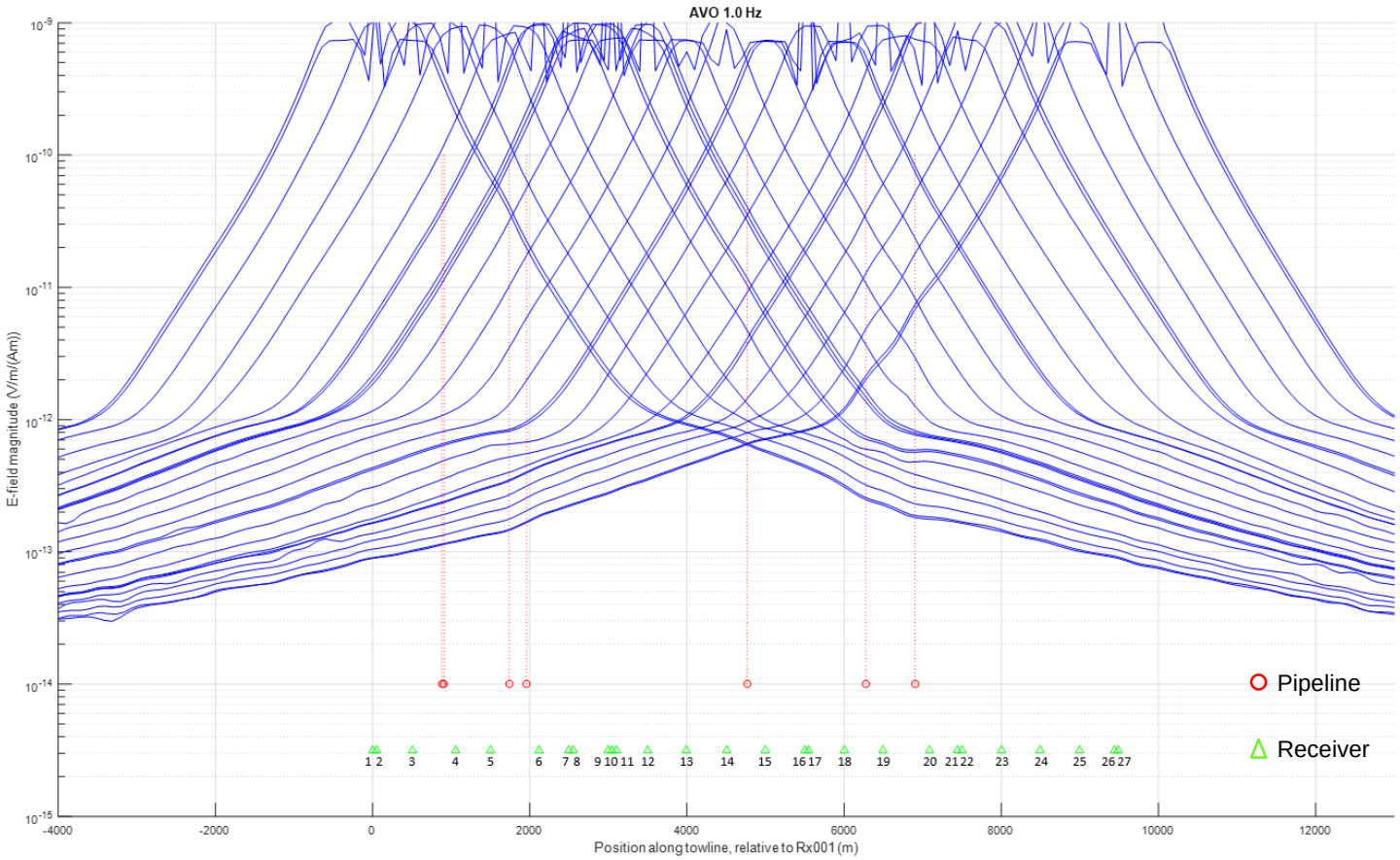




Modified from: Park et al. (2013)

CSEM data filtering – identifying data

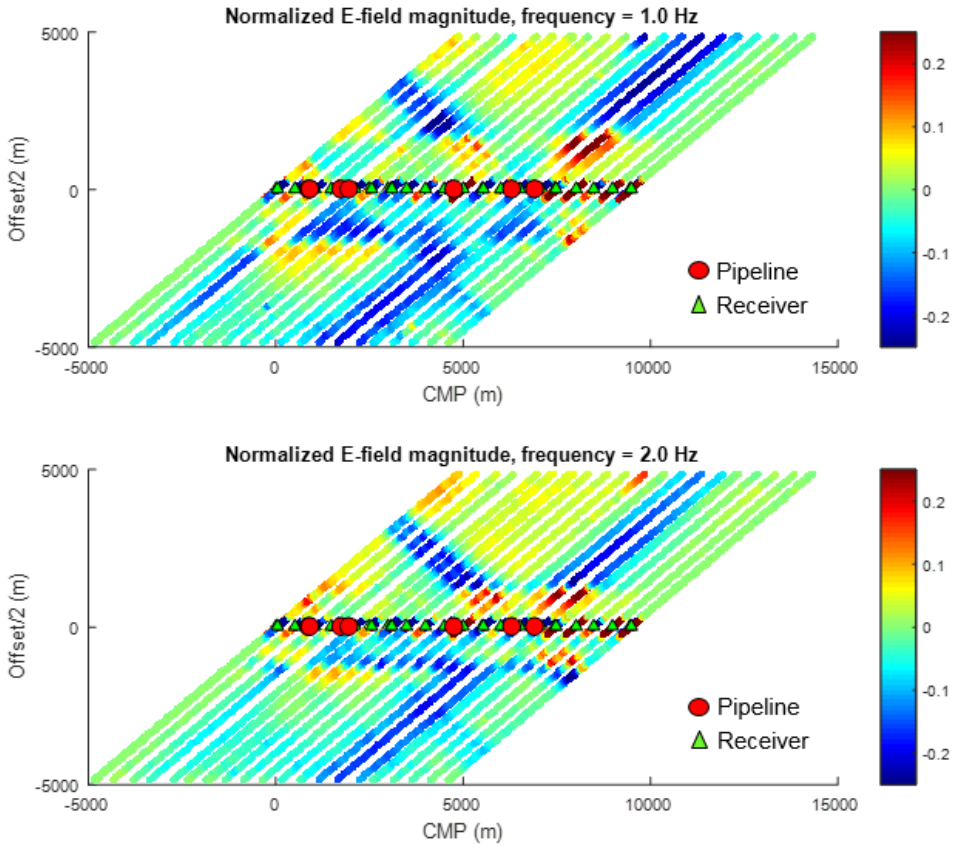
AVO (amplitude versus offset) along towline – effect of pipelines?



CSEM data filtering – identifying data

Normalized AVO – effect of pipelines

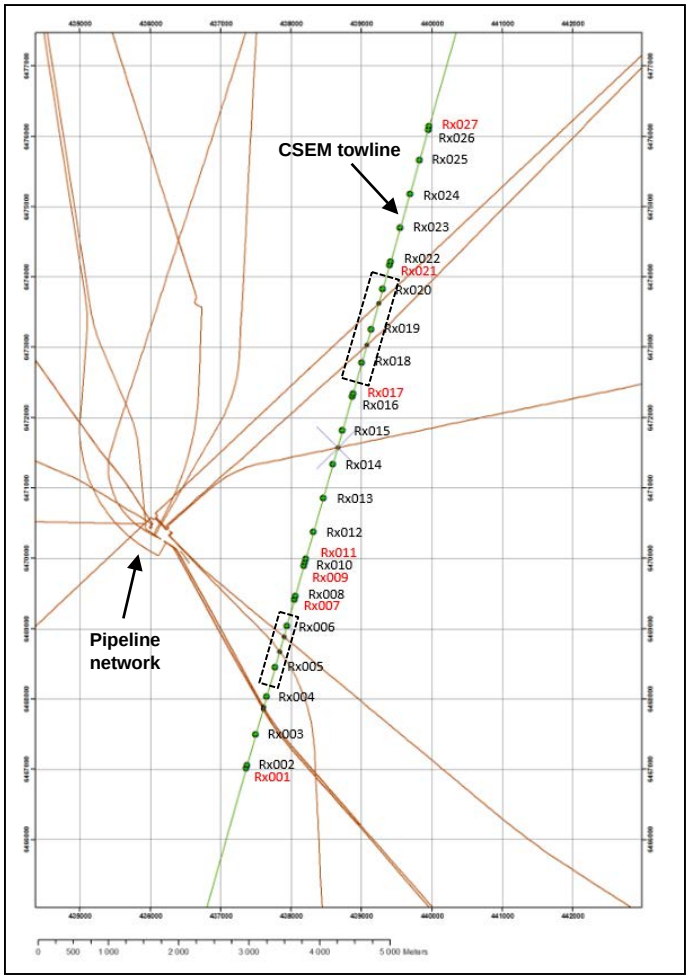
- Visualize nAVO plotted by common midpoint (CMP) between source and receiver (x) and half offset (y)
- Normalize by background response to enhance anomalies
- No baseline CSEM - normalized by average between two end receivers
- Two distinct negative anomalies
  - Can approximate location
  - Generated by seabed pipelines



CSEM data filtering

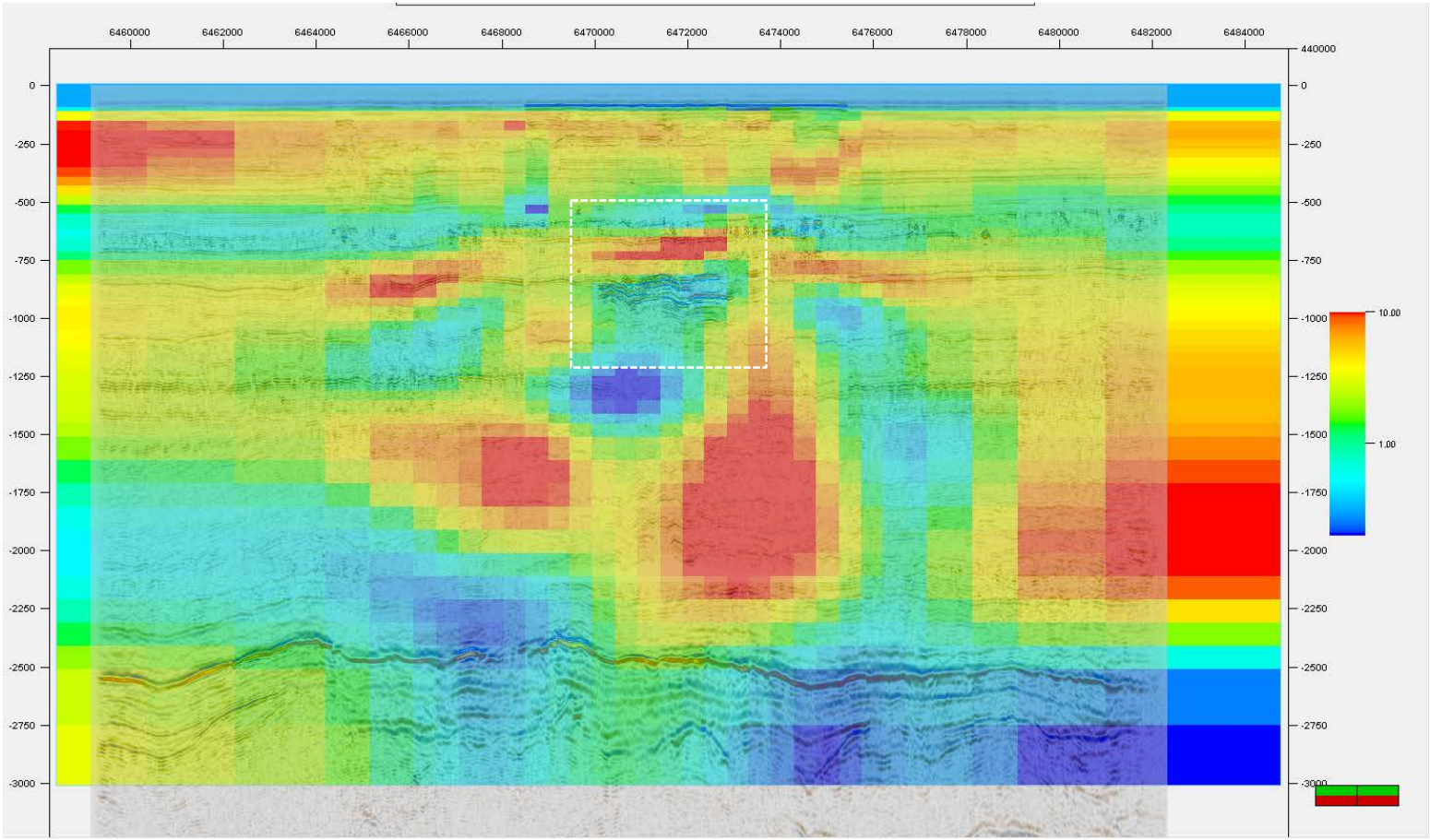
Strongly influenced data

- Rx005, Rx006, Rx018, Rx019, Rx020 strongest negative anomalies
  - ➢ Pipelines crossing between these seem to have largest influence on the data
- May be due to:
  - Crossing angle
  - Pipeline diameter
- Filter out data from these receivers, and source points from same areas



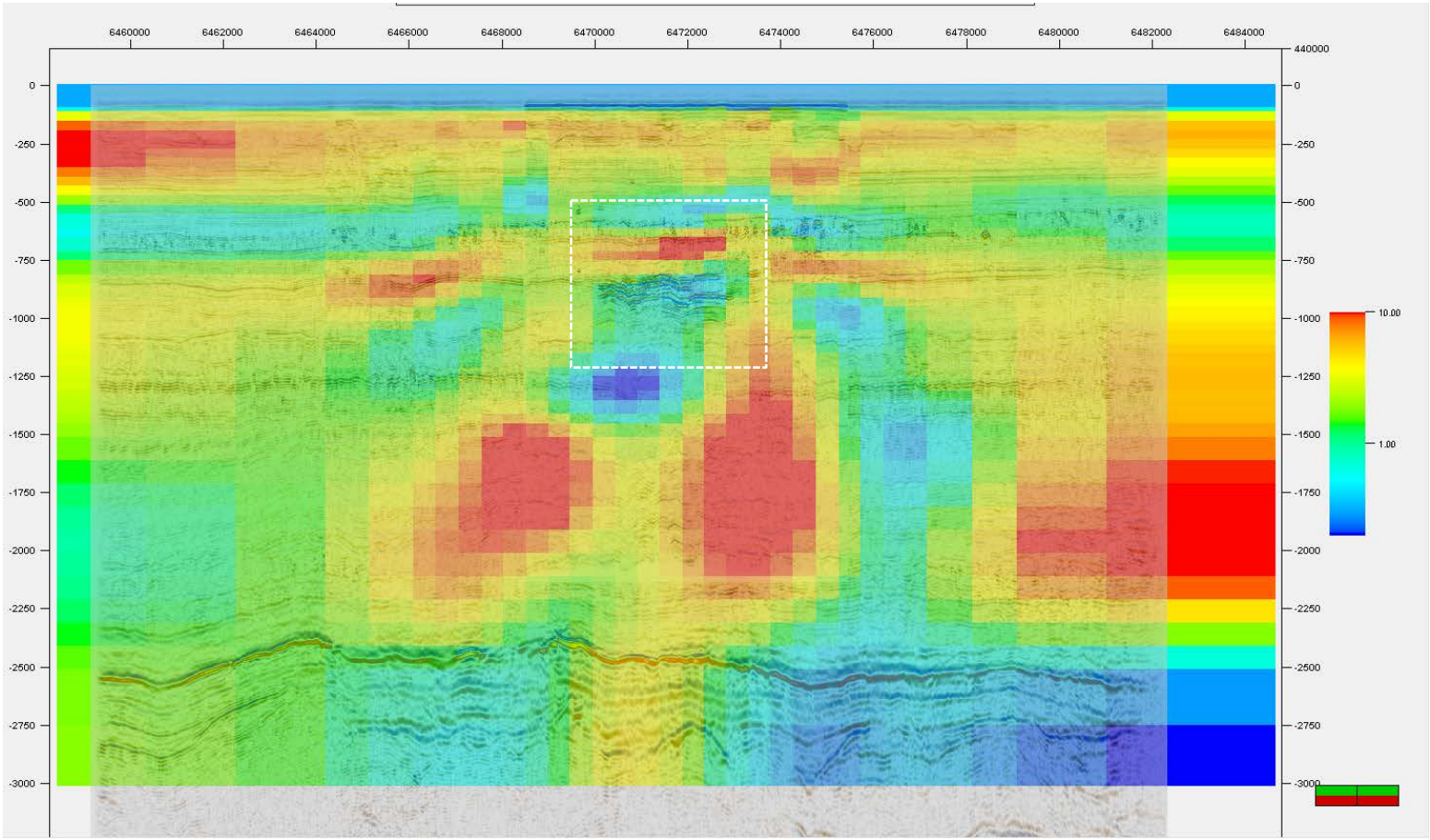
Inversion of the Sleipner 2008 CSEM dataset

Initial inversion result (superimposed on depth converted seismic)



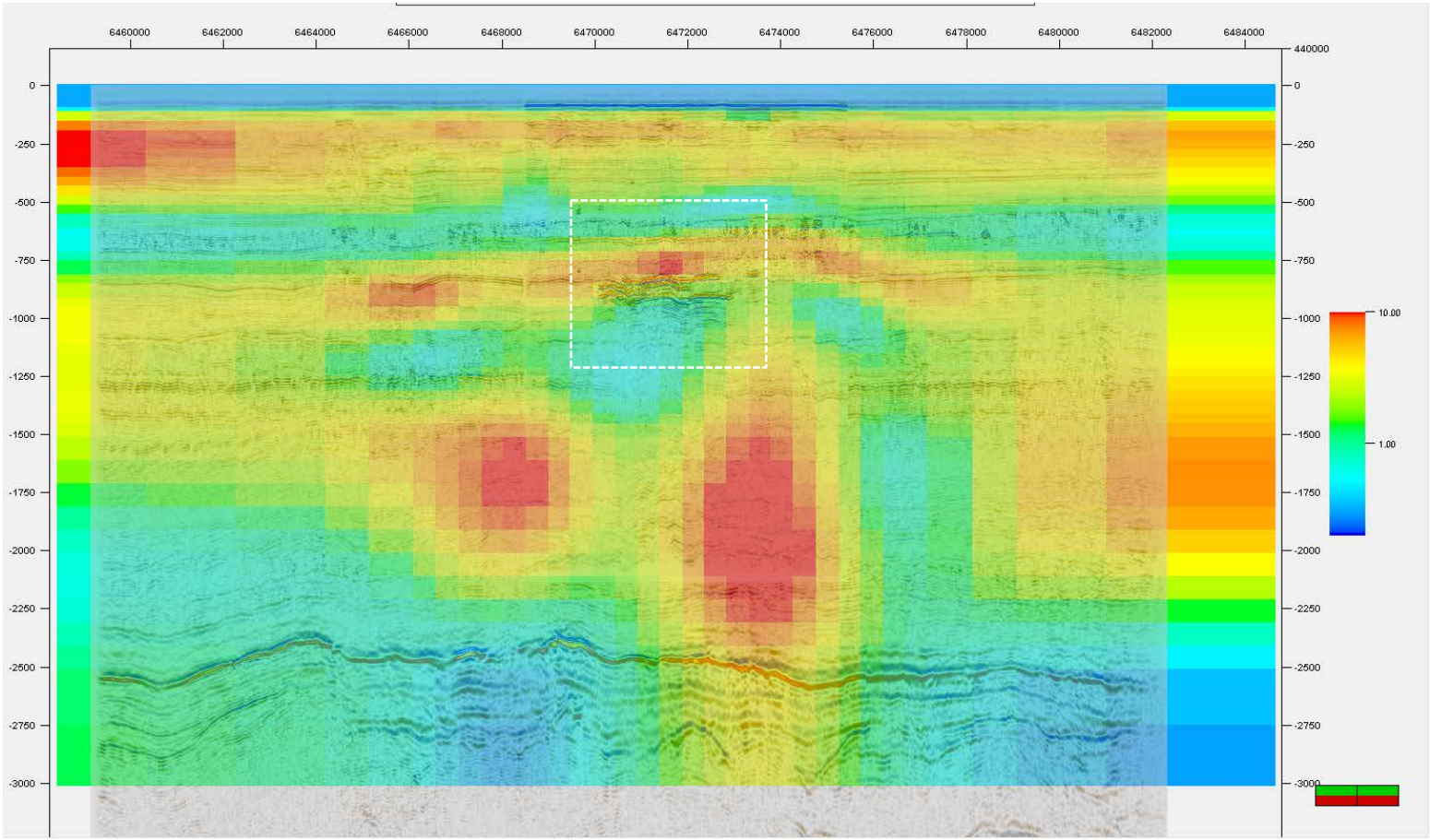
Inversion of the Sleipner 2008 CSEM dataset

Inversion result after filtering out closely spaced receiver data (superimposed on depth converted seismic)



Inversion of the Sleipner 2008 CSEM dataset

Inversion result after removing data strongly influenced by pipelines (superimposed on depth converted seismic)



→ Location of CO_2 better, and pipeline influence reduced

Further work

- Use inversion results and seismic to do more constrained inversions to improve the result
- Analyze the data to try to develop a more generalized strategy for filtering the data
- Other inversion setups

References

Arts, R., Chadwick, A., Eiken, O., Thibeau, S., & Nooner, S. (2008). Ten years' experience of monitoring CO2 injection in the Utsira Sand at Sleipner, offshore Norway. *First break, 26*(1).

GEO ExPro. (2017). Available at: *http://www.geoexpro.com/articles/2009/01/technology-changing-exploration-using-non-seismic-technology.* Retrieved 13.03.2017.

IPCC. (2005). *IPCC special report on carbon dioxide capture and storage.* Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, 442 pp.

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