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On the LOTEM and semi-airborne CSEM 2D joint inversion

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DESMEX

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- Limitation of 1D joint inversion

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- Synthetic data
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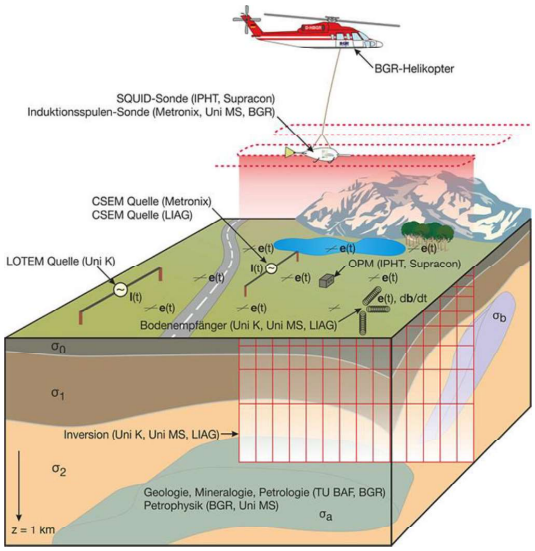
Introduction & Motivation

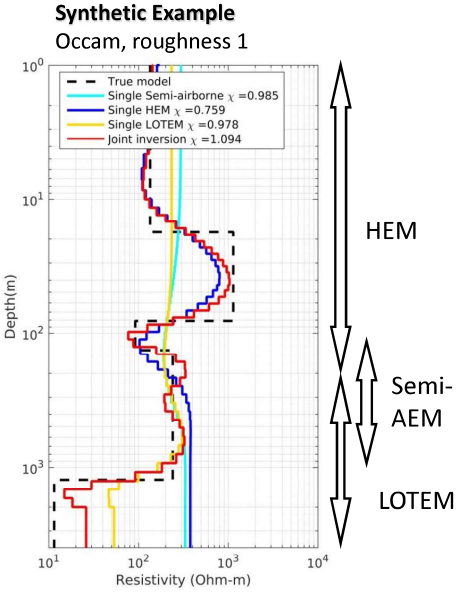
- Single EM method
  → advantage & weak points
  - Ground based EM (e.g. LOTEM):
    larger offset sparser stations
  - Air-borne EM (e.g. Semi-airborne):
    denser data coverage
    fast & convenient smaller offset
  - Helicopter EM (HEM):
    limited depth of investigation
    high resolution for shallow layers

- Joint inversion
  - ➔ combine the advantages.
  - ➔ See deeper and more accurately.



1D joint inversion for HEM, LOTEM and Semi-AEM

- HEM (Blue)
  - improve resolution of shallow layers.
- LOTEM (Yellow)
  - recover deep structures.
- Semi-airborne EM (Semi-AEM) (Cyan)
  - high spatial data density.
- Joint inversion (red)
  - combine resolution advantages of all three EM methods.
  - reveals true model perfectly.



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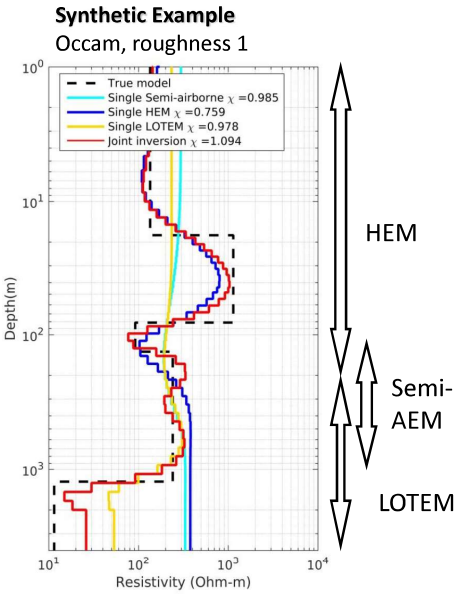
- Joint inversion (red)
  - combine resolution advantages of all three EM methods.
  - reveals true model perfectly.

But, NOT perfect for field data !



Convergence Problem

- Problem :

→ Each **single EM method** (Semi-AEM or LOTEM) 1D inversion show a **good convergence** and a good data fitting.

→ **However**, 1D **joint inversions** of field data often do **not converge**.

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- **What limits 1D joint inversion ?**

2D effects?

Anisotropy?

IP?

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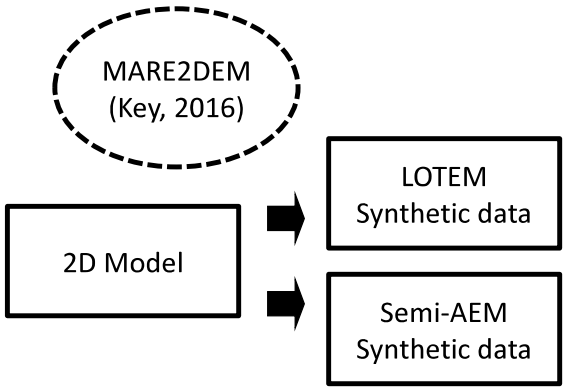
IP?

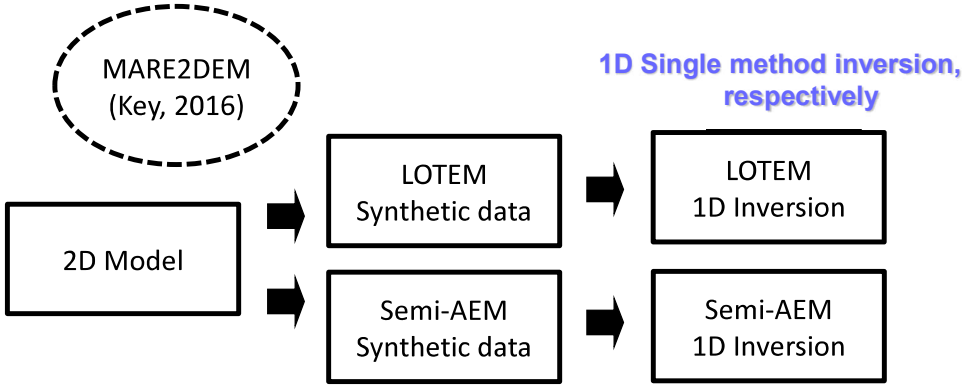
2D effects in 1D joint inversion ?

- Problem :
- **2D effects limit 1D joint inversion ?**



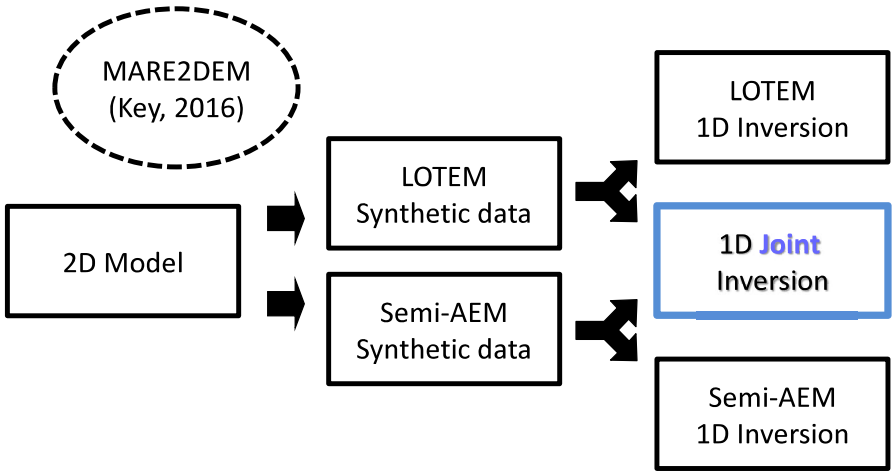
2D effects in 1D joint inversion ?

- Problem :
- **2D effects limit 1D joint inversion ?**

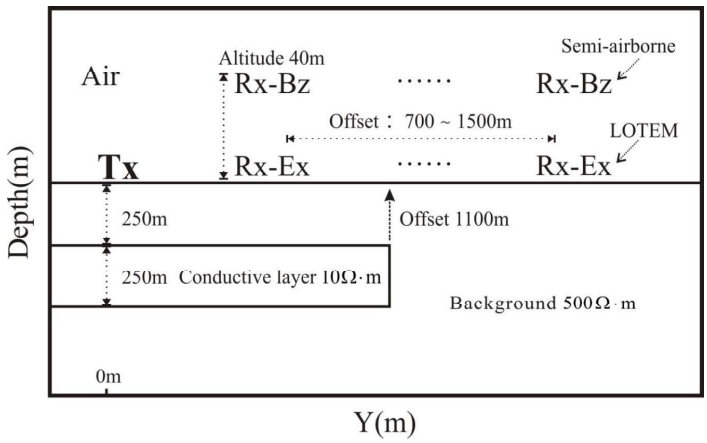


2D effects in 1D joint inversion ?

- Problem :
- **2D effects limit 1D joint inversion ?**



2D effects in 1D inversion – 2D model



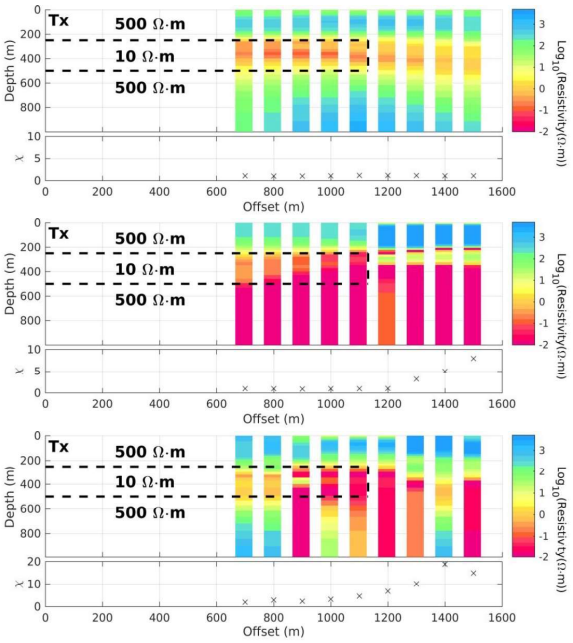
- **Investigate 2D effects for Rx locates at different positions**

2D effects in 1D inversion – results

LOTEM

Semi-AEM

1D Joint



2D effects: Rx locates above conductive layer

LOTEM

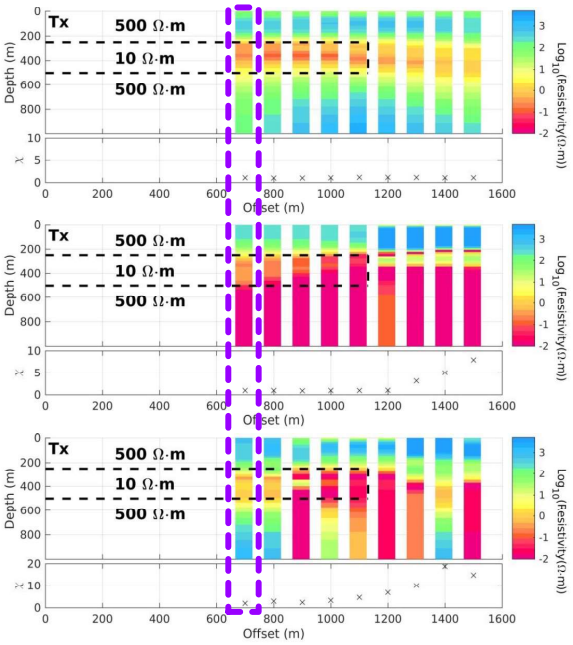
- Good data fitting
- Reveal target

Semi-AEM

- Good data fitting
- Reveal target

1D Joint

- Good data fitting
- Reveal target



2D effects: Rx locates above 2D boundary

LOTEM

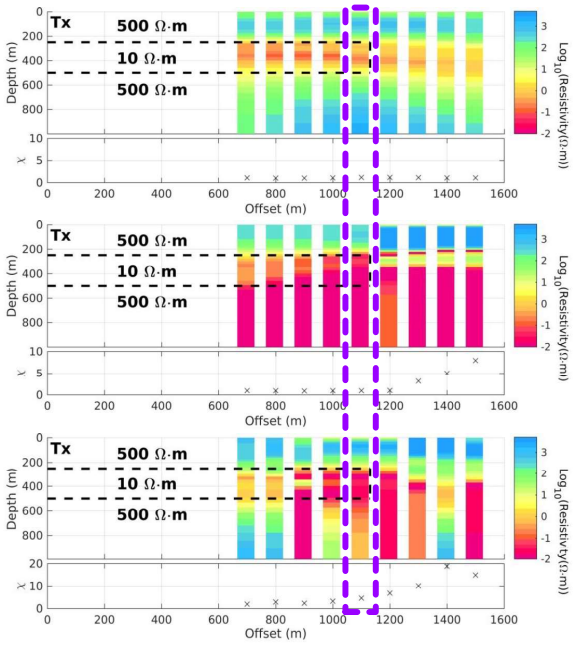
- Good data fitting
- Reveal target

Semi-AEM

- Good data fitting
- Wrong resistivity

1D Joint

- Poor data fitting
- Wrong resistivity



2D effects: Rx locates above background rocks

LOTEM

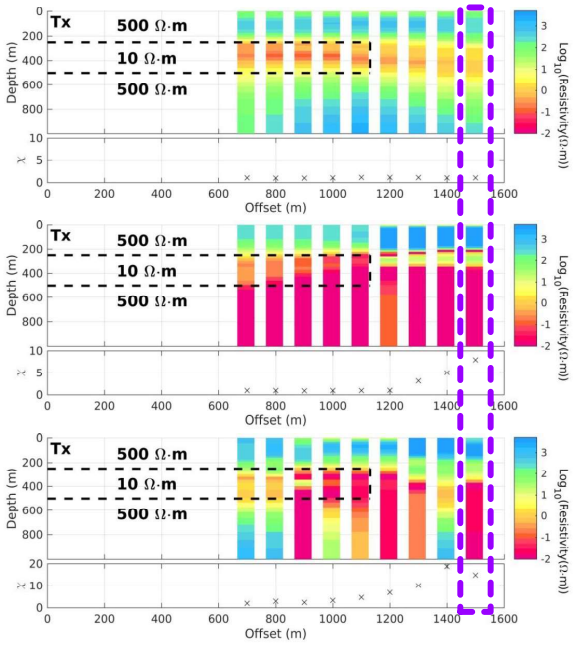
- Good data fitting
- Artificial layer

Semi-AEM

- Poor data fitting
- Artificial layers

1D Joint

- Very bad data fitting
- Artificial layers



2D effects in 1D joint inversion

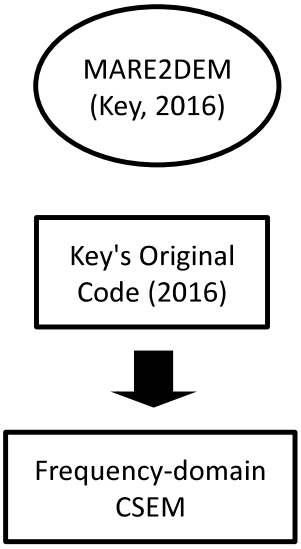
- When 2D effects are strong:

→ Lead to **different artifacts** in different **single EM method** inversion.

→ 1D **joint** inversions can **not converge**.

→ **2D Inversion is needed !**

Develop 2D Joint inversion algorithm



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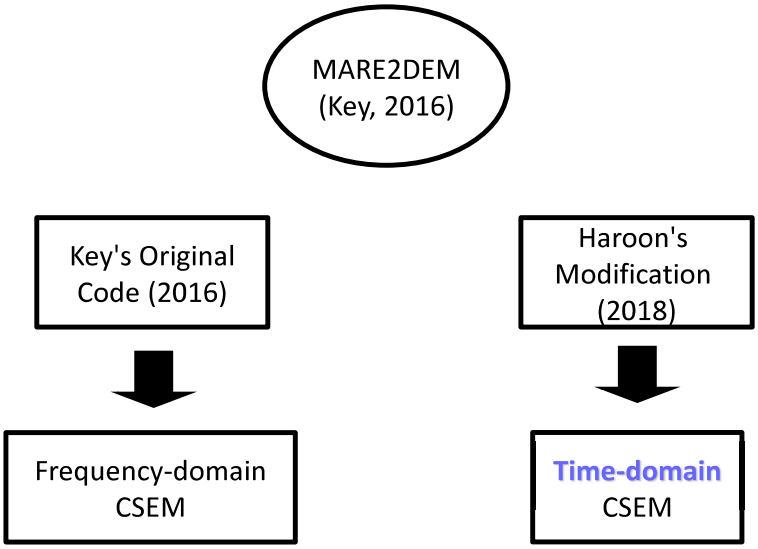

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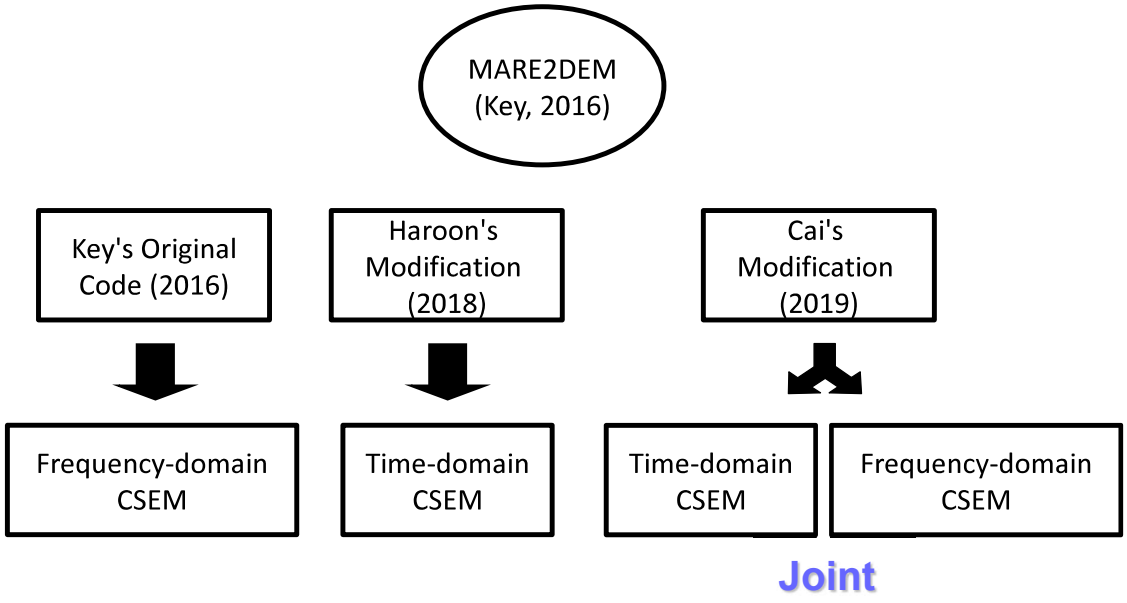
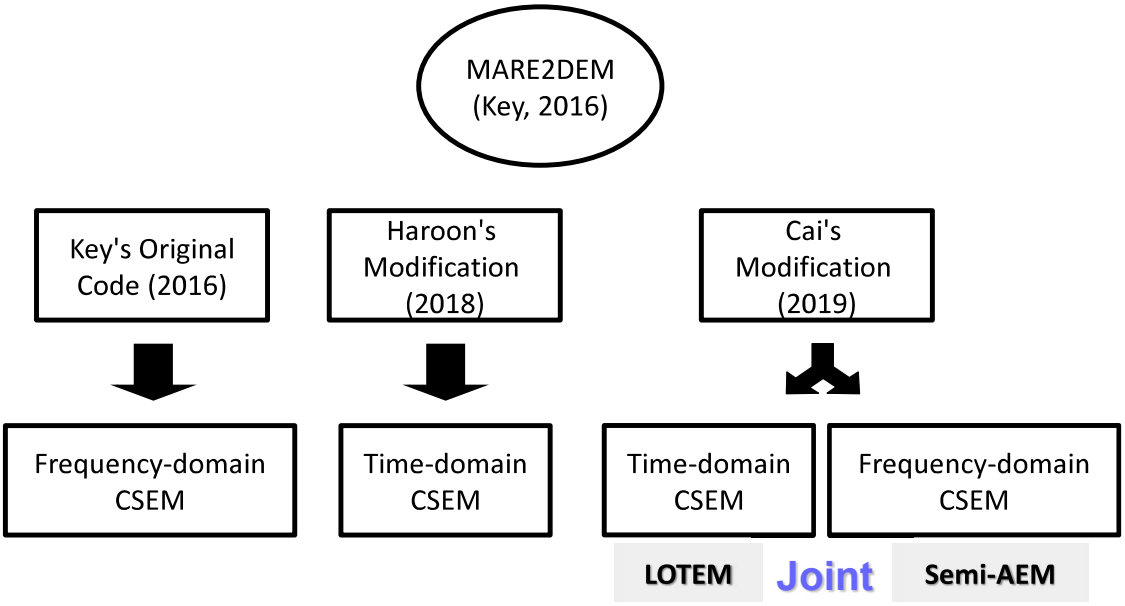
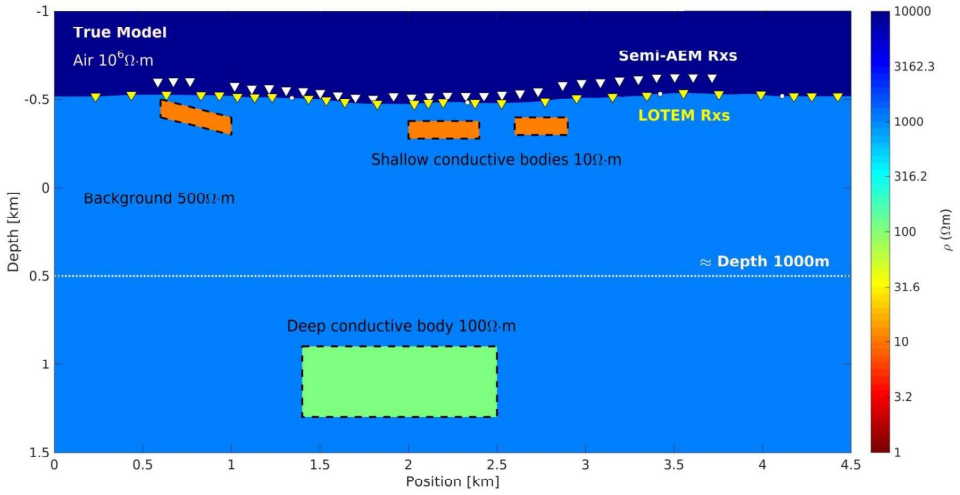


Develop 2D Joint inversion algorithm

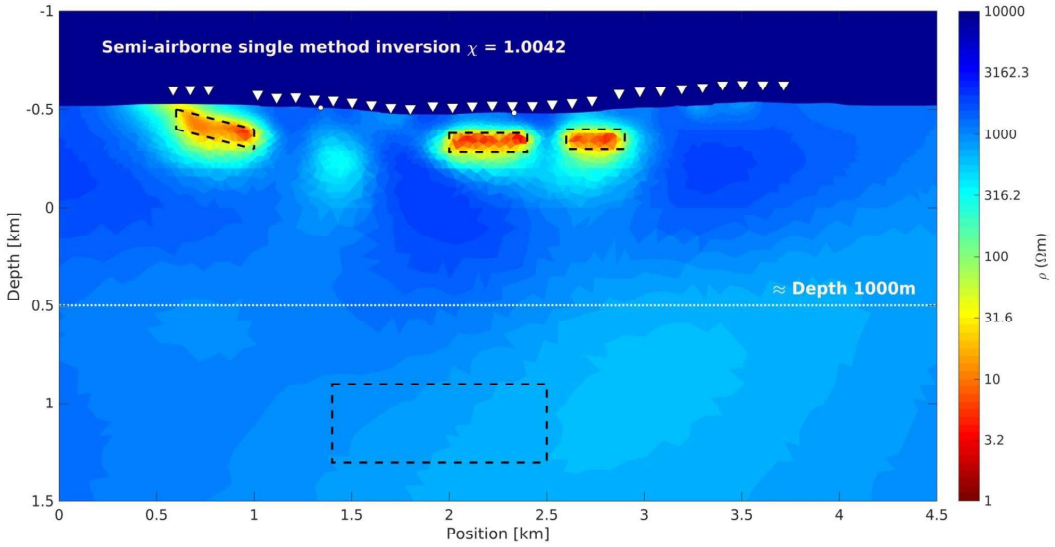


Synthetic model

- Real topography + **field configuration** (Schleiz, 2016)
- 2D resistivity model – based on 2D inversion results
- **Advantage** of joint inversion :
  better resolution & more flexible configuration

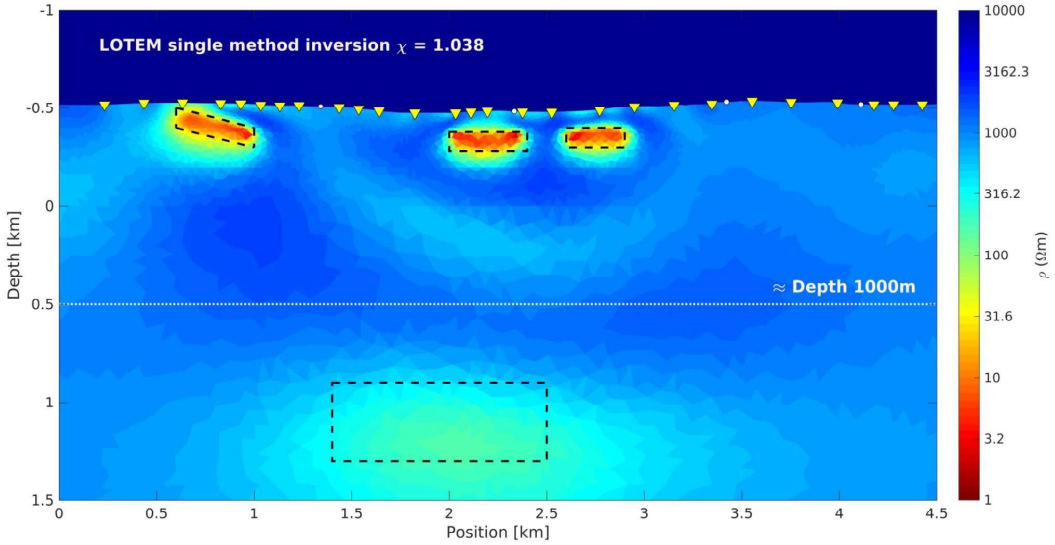


Synthetic model – Semi-AEM inversion



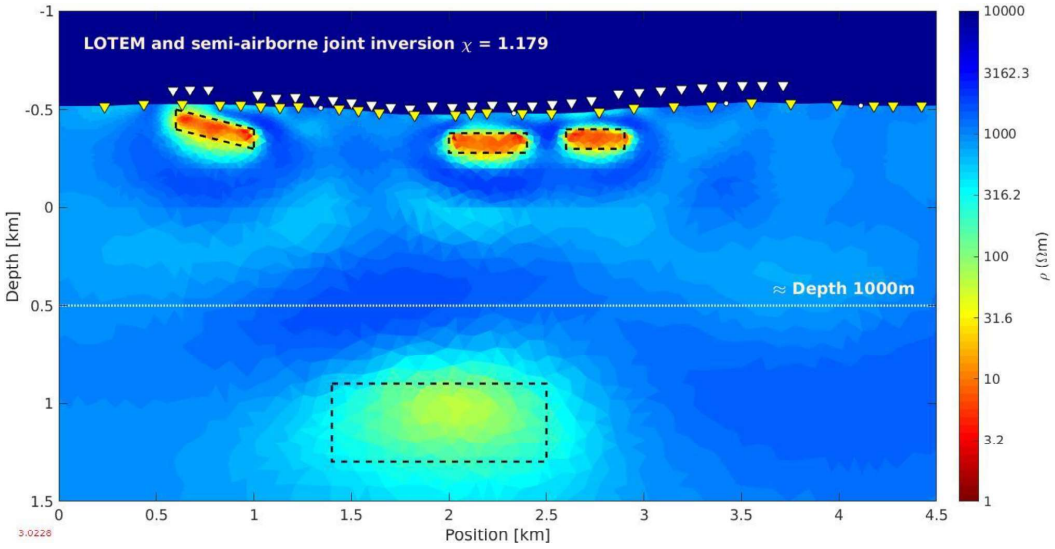
- Deep structure – not revealed – Largest offset around 1500m

Synthetic model – LOTEM inversion



- All structures are revealed – Largest offset around 4000m

Synthetic model – 2D joint inversion



- All structures are revealed in higher resolution – **Resolution advantage**

Too much LOTEM stations?

- Semi-airborne :
  fast & convenient offset <= 2000m

- LOTEM :
  more work for each Rx offset → 4000m

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- Semi-airborne :
  fast & convenient offset <= 2000m
  - **Reliable for depth down to roughly 1000m**
- LOTEM :
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  - **Advantage for deeper structure detection (> 1000m)**

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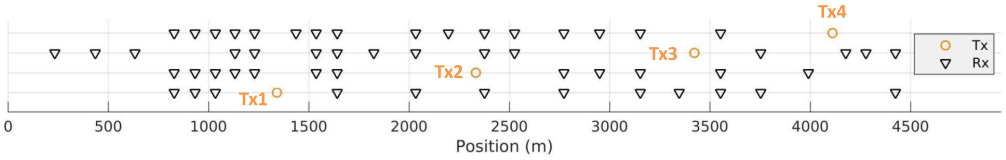
- Semi-airborne :
  fast & convenient offset <= 2000m
  - **Reliable for depth down to roughly 1000m**
- LOTEM :
  more work for each Rx offset → 4000m
  - **Advantage for deeper structure detection (> 1000m)**

- **Reduce the number of LOTEM stations with small offsets ?**

Reduce the number of LOTEM stations

- Former LOTEM configuration, **offset from 500 to 4000m**, 1650 data points



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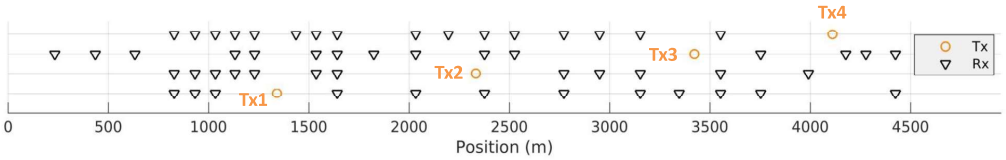
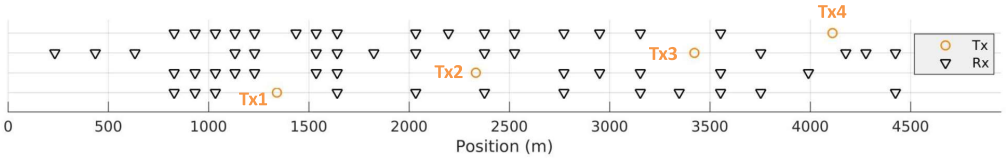


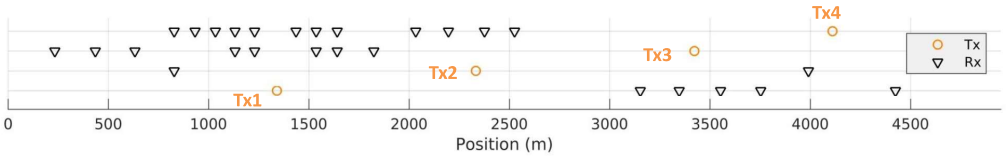
- **Remove Rxs with offset < 1500m**

Reduce the number of LOTEM stations

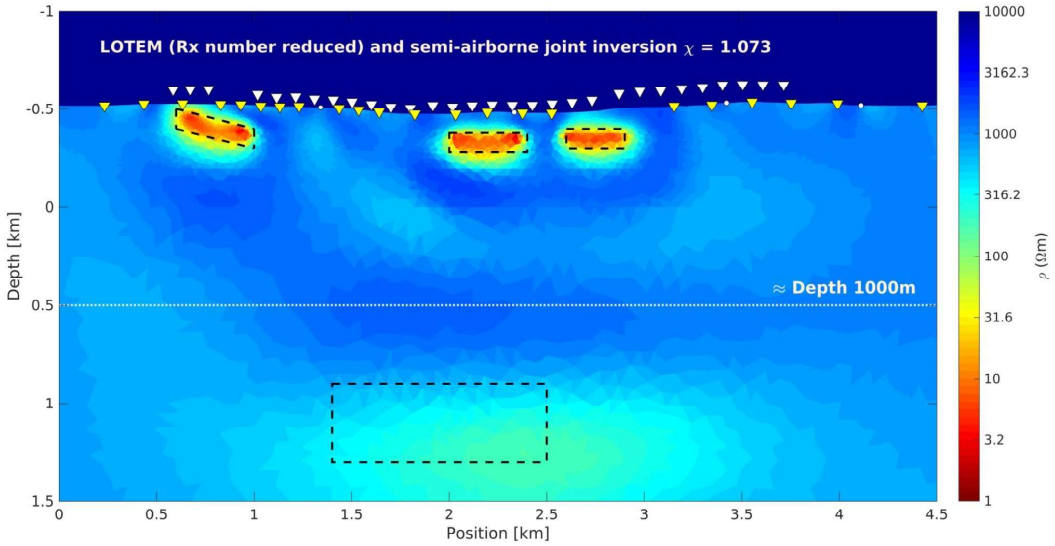
- Former LOTEM configuration, **offset from 500 to 4000m**, 1650 data points



- LOTEM configuration with less Rxs, **offset from 1500 to 4000m**, 810 data points

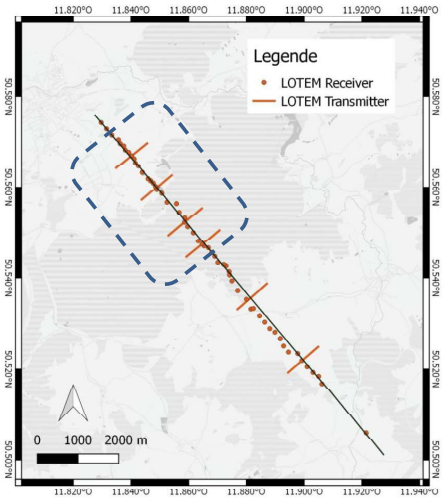


Synthetic model – 2D Joint inversion with less LOTEM receivers



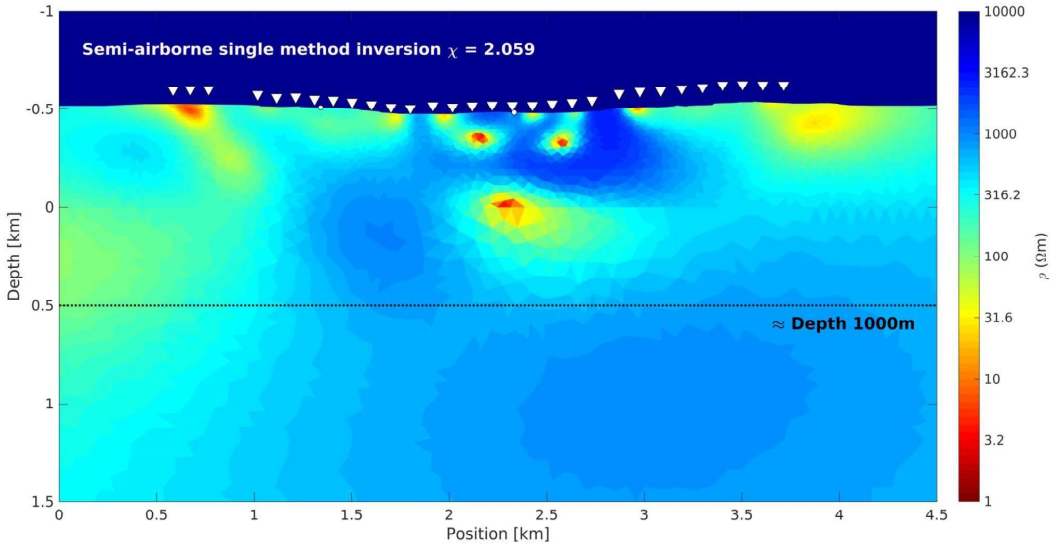
- Deep structure is still revealed – with reduced resolution
- **more flexible configuration possible**

2D inversion of field data from Schleiz, 2016

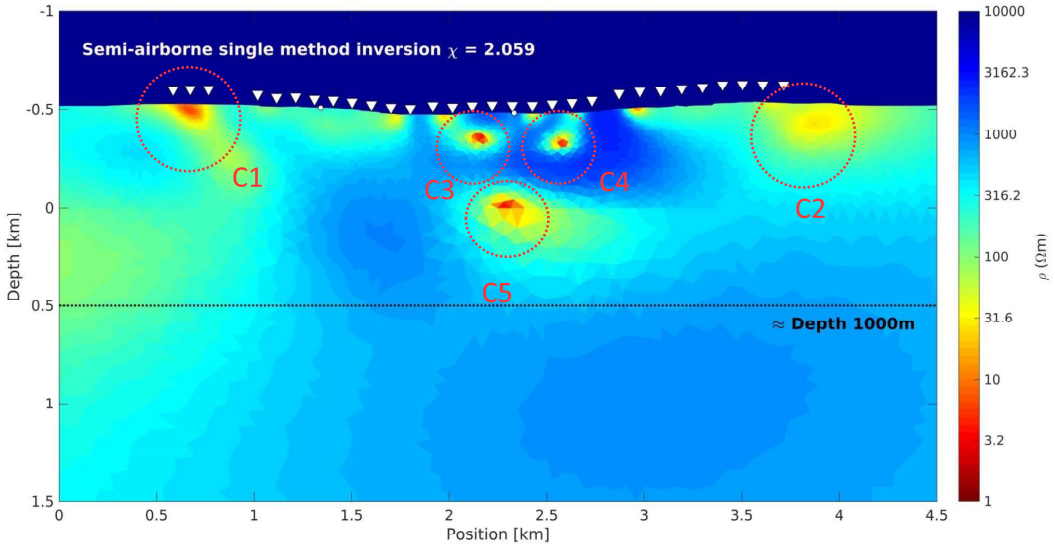


- Red dots & lines
  - LOTEM profile
- Blue dash
  - Semi-AEM region
- Part of the profile for 2D joint inversion

2D inversion of field data – Semi-AEM

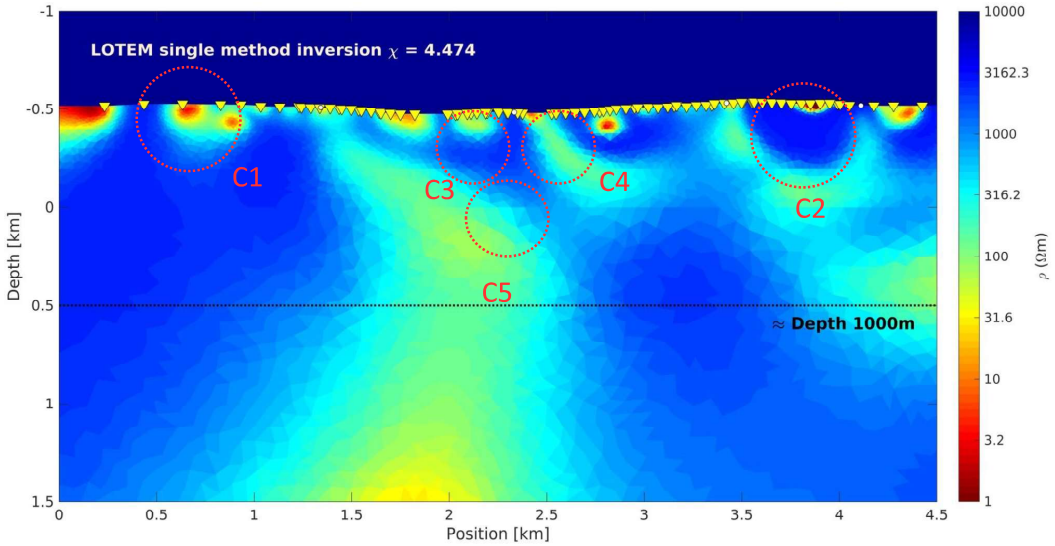


2D inversion of field data – Semi-AEM

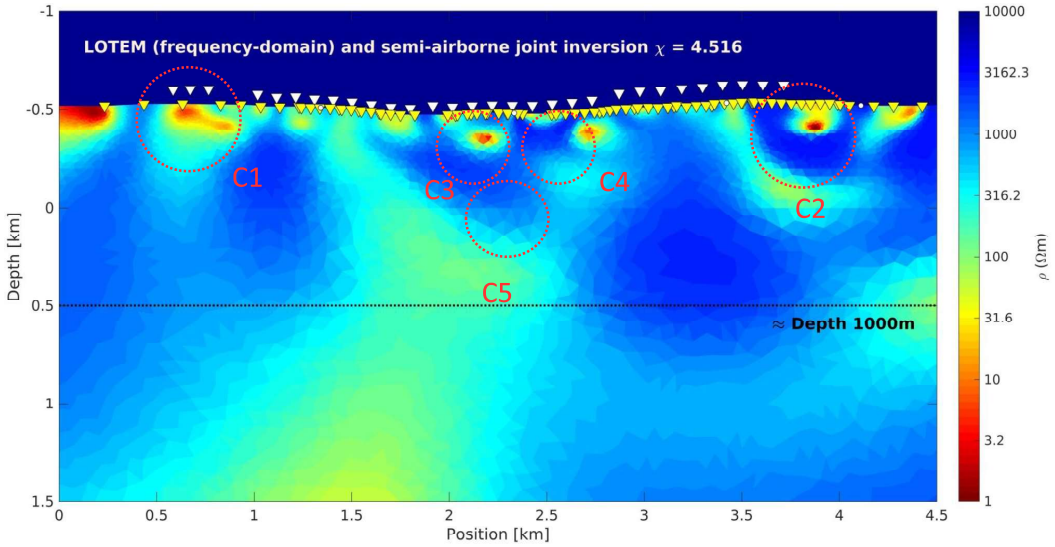


- Five conductive bodies in result are marked by red circles.

2D inversion of field data – LOTEM



2D inversion of field data – 2D joint inversion



- Joint inversion combines the characteristics of single method inversion results of LOTEM and semi-airborne.

Summary

- Strong 2D effects in data lead to the 1D inversion converge to different models for LOTEM and semi-airborne methods.
- 2D joint inversion of LOTEM and semi-airborne data is realized
  - – Advantage: resolution & configuration possibility
  - – Combines the characteristics of single inversion results of LOTEM and semi-airborne.

Thank you for attention !