

# Magnetotellurics with magnetic observatory data affected by the ocean effect: Methodology and Results

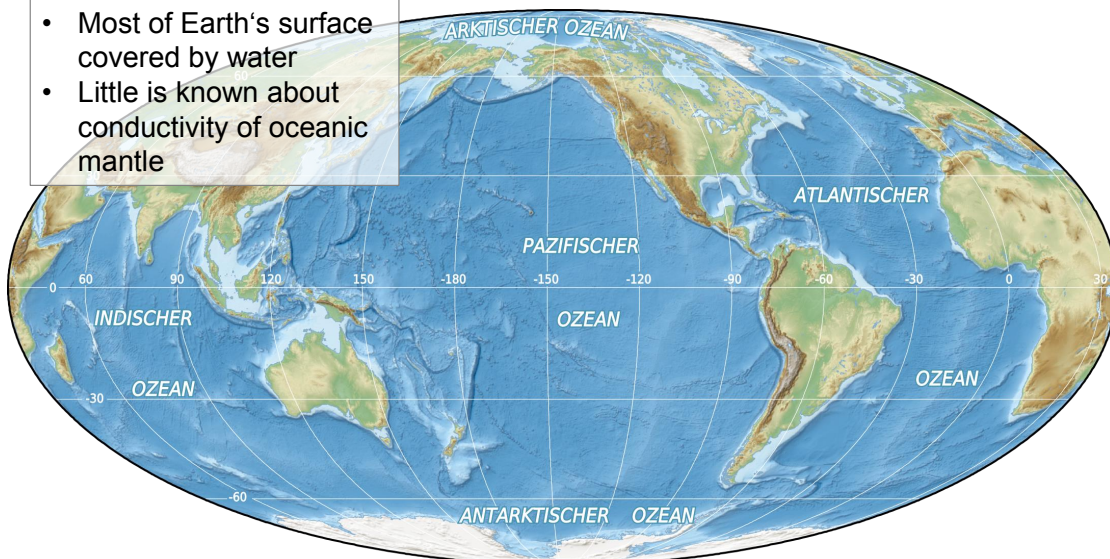
Schmucker-Weidelt Kolloquium 2017  
Breklum

A. Morschhauser, A. Grayver, A. Kuvshinov, F.  
Samrock, J. Matzka

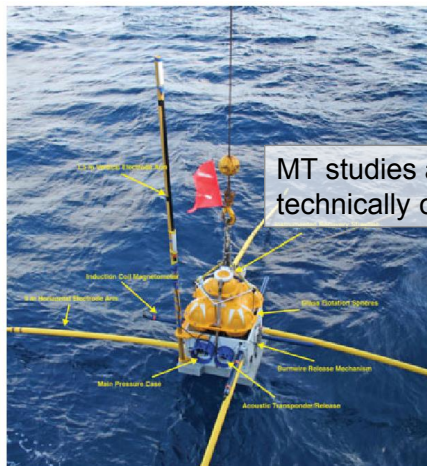
ETH Zürich, Department of Earth Sciences  
GFZ German Research Centre for Geosciences  
Adolf-Schmidt-Observatory for Geomagnetism, Niemegek

## Electrical conductivity of oceanic mantle

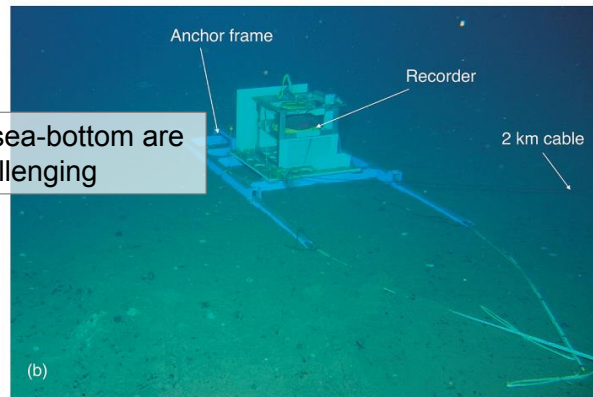
- Most of Earth's surface covered by water
- Little is known about conductivity of oceanic mantle



## Electrical conductivity of oceanic mantle



MT studies at sea-bottom are technically challenging

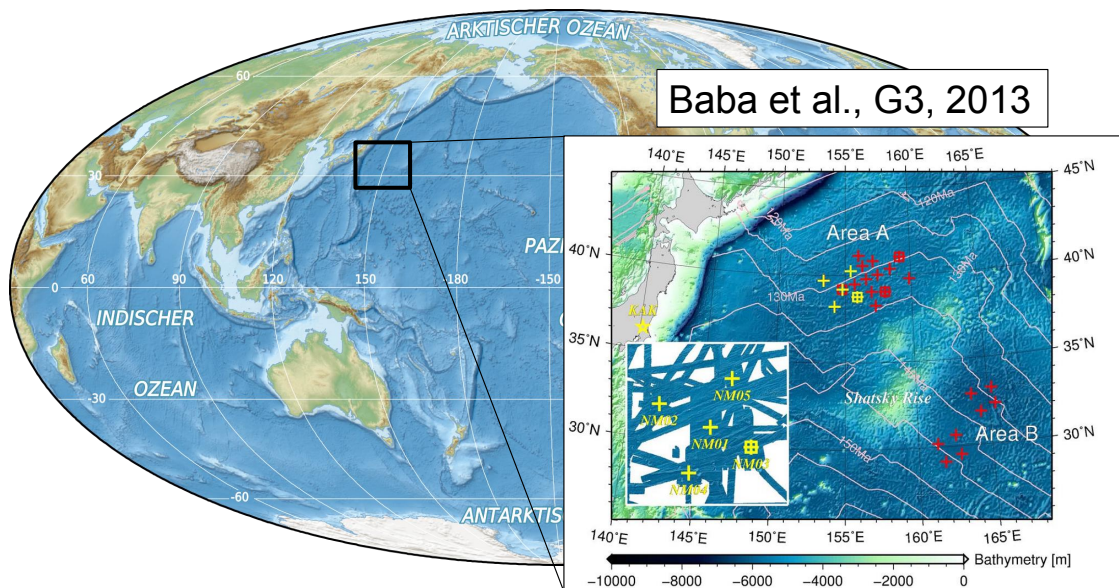


H. Utada, Proc. Jpn. Acad. B, 2015

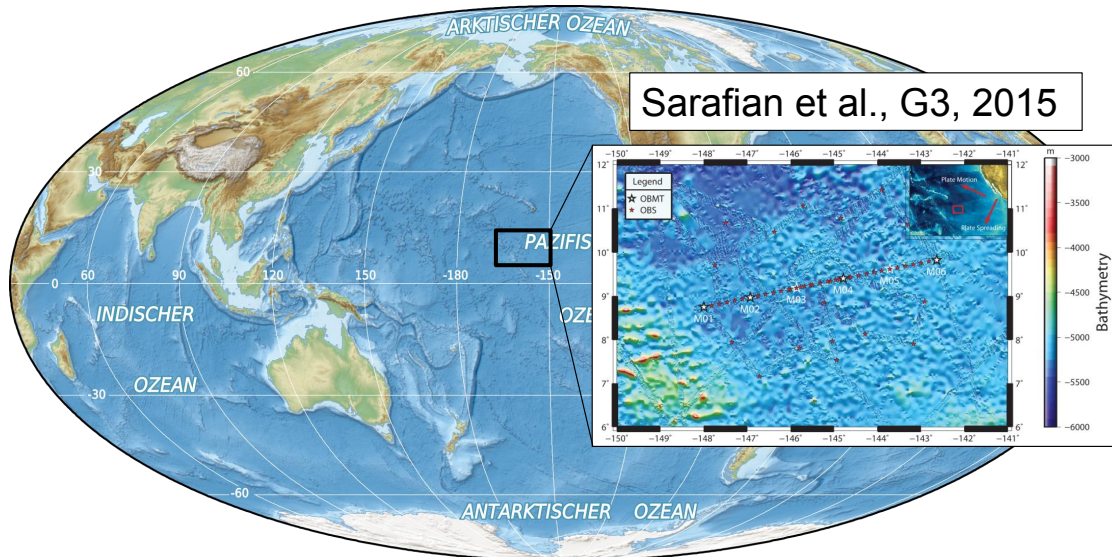
Figure 10 Scripps sea-floor EM recorder being deployed.

S. Constable, Geophys. Prosp., 2013

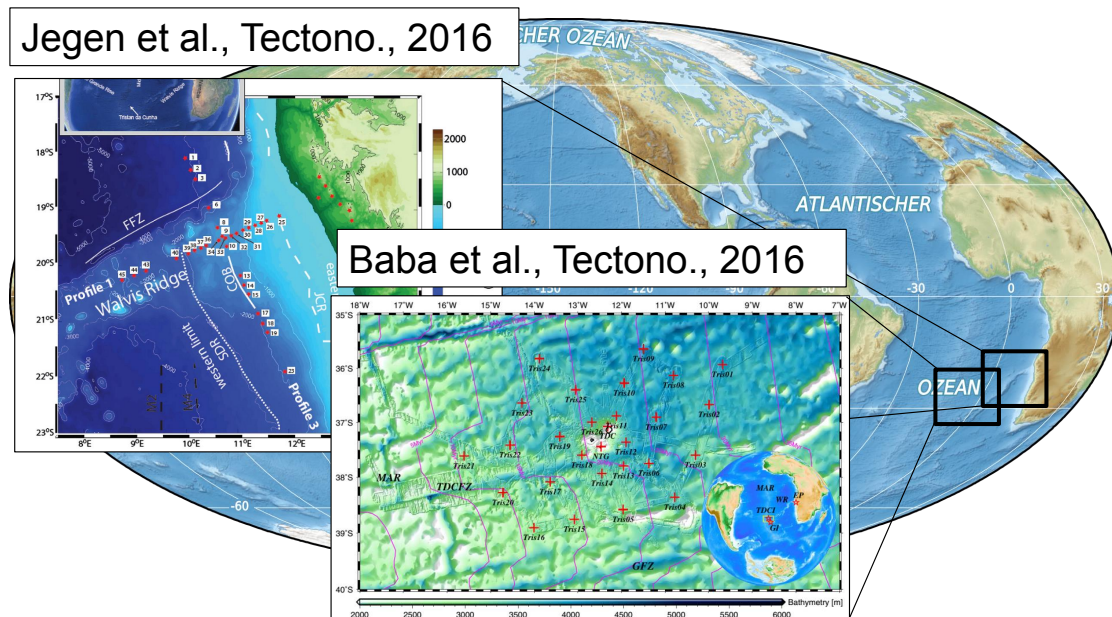
## Electrical conductivity of oceanic mantle



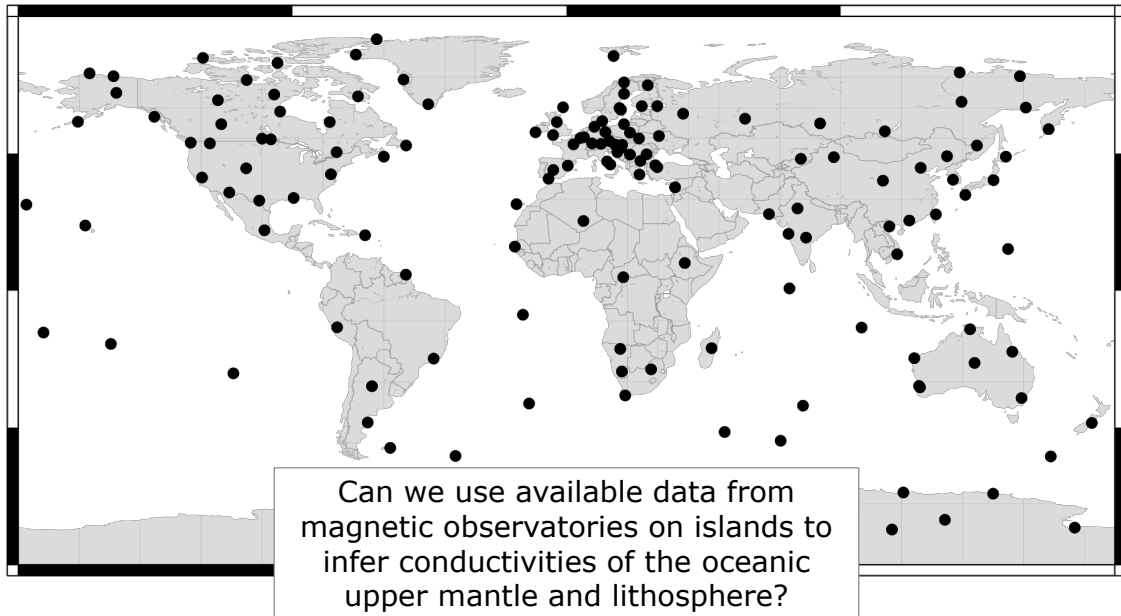
## Electrical conductivity of oceanic mantle



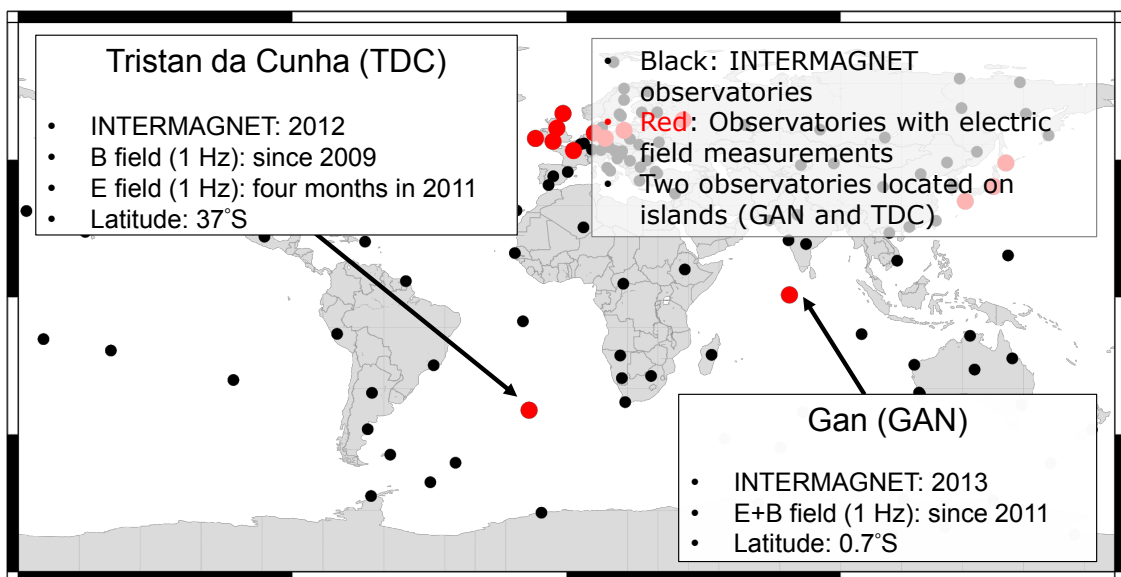
## Electrical conductivity of oceanic mantle



## INTERMAGNET Observatory Network

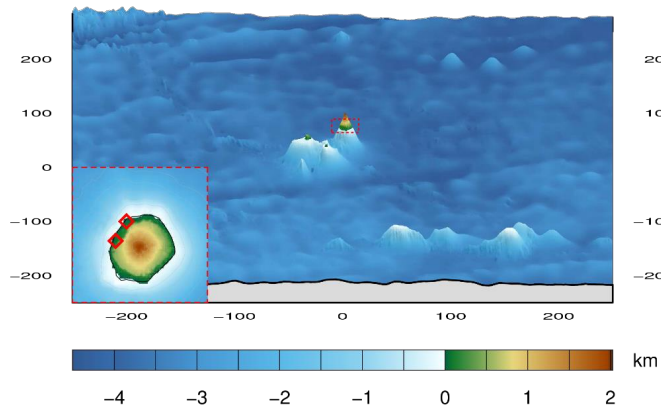


## INTERMAGNET Observatory Network



## Forward modeling setup

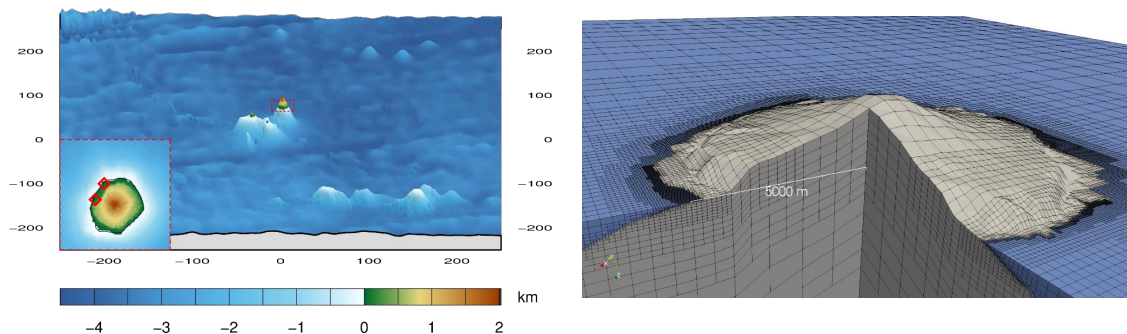
Tristan da Cunha (TDC)



- Conductivity of seawater needs to be accounted for: **Bathymetry model**
- Bathymetry and topography from GEBCO database (30''  $\approx$  1 km)
- Higher resolution ASTER data (1'') for topography of TDC

## Forward modeling setup

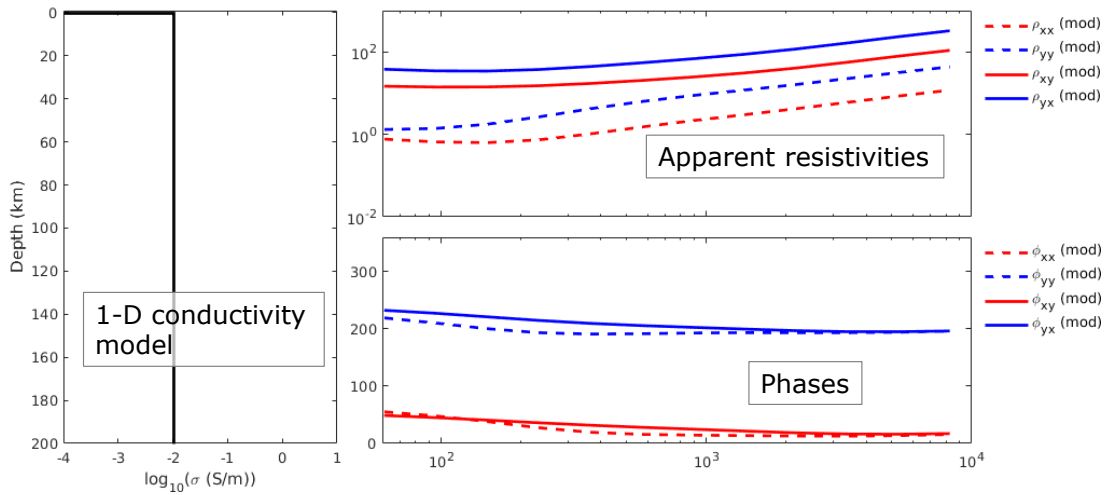
Tristan da Cunha (TDC)



Adaptive FEM code (Grayver and Kolev, 2015)

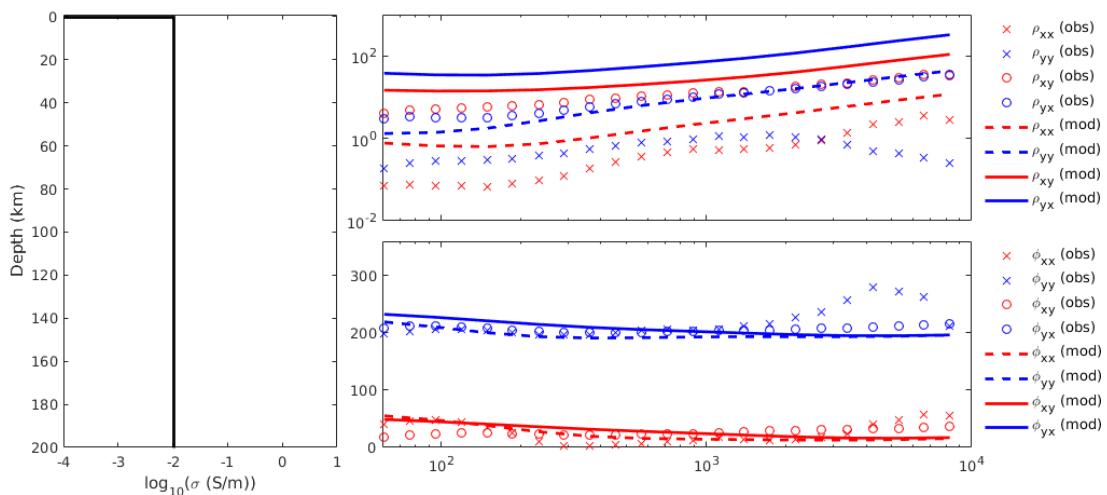
- Mesh is refined at seafloor, coastline, and observatory

## Forward modeling result: TDC



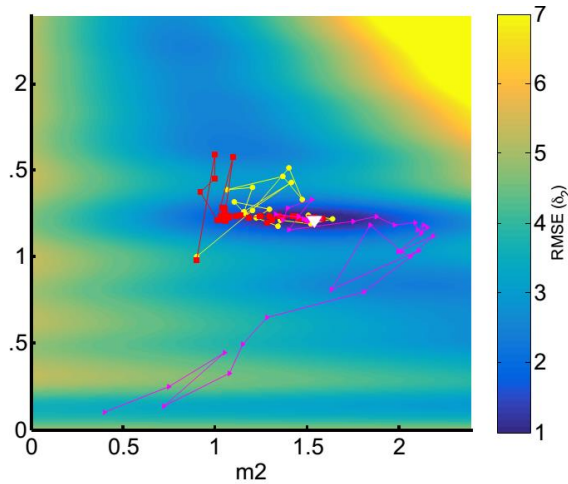
- Forward modelling with half-space model and ocean effect:
- 3-D response due to ocean effect

## Forward modeling result: TDC



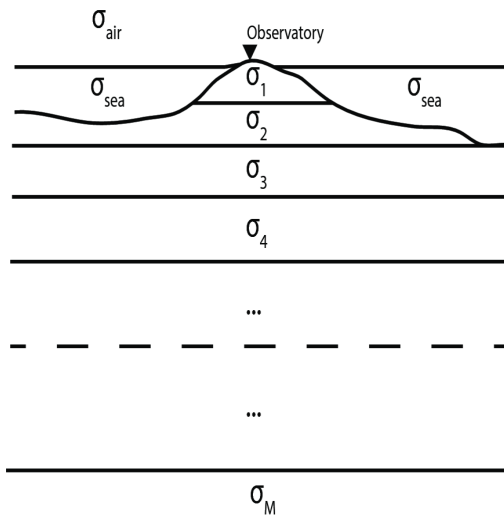
- Forward modelling with half-space model and ocean effect:
- Comparison to observed responses

## Inversion



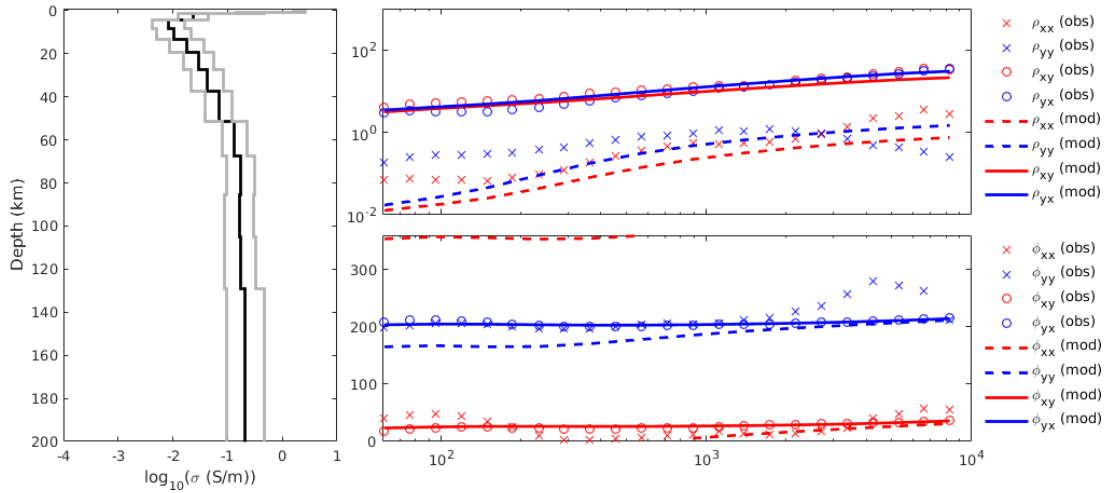
- Stochastic inversion (CMAES, Grayver and Kuvshinov, GJI, 2016)
  - Different norms possible (misfit and regularization terms)
  - Finds global minimum

## Inversion



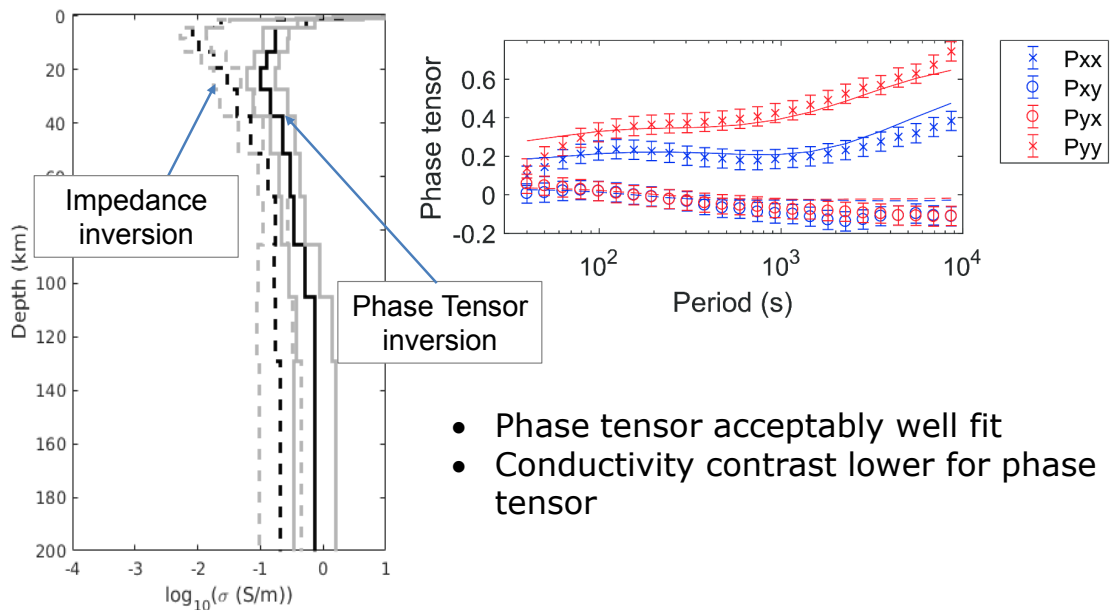
- Invert for
  - 1-D conductivity in presence of non-uniform ocean (3-D)
- Invert
  - Impedances
  - Phase tensor

## Inversion: Impedances TDC



Result of inversion (thick lines) in comparison to observed responses (symbols)

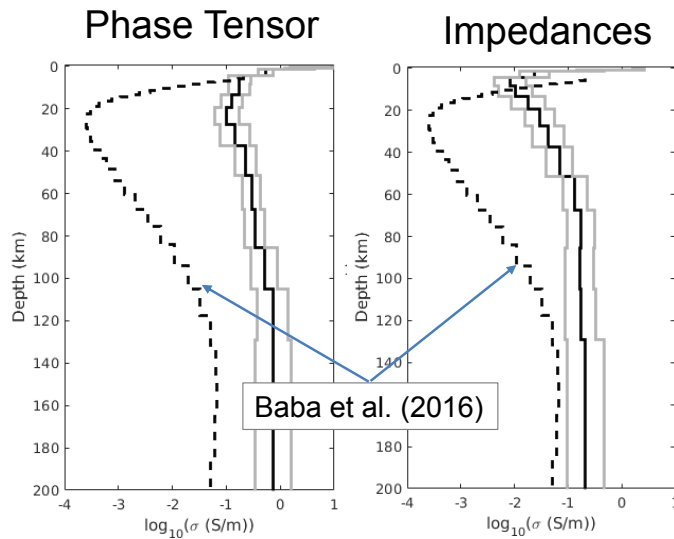
## Inversion: Phase tensor TDC



- Phase tensor acceptably well fit
- Conductivity contrast lower for phase tensor

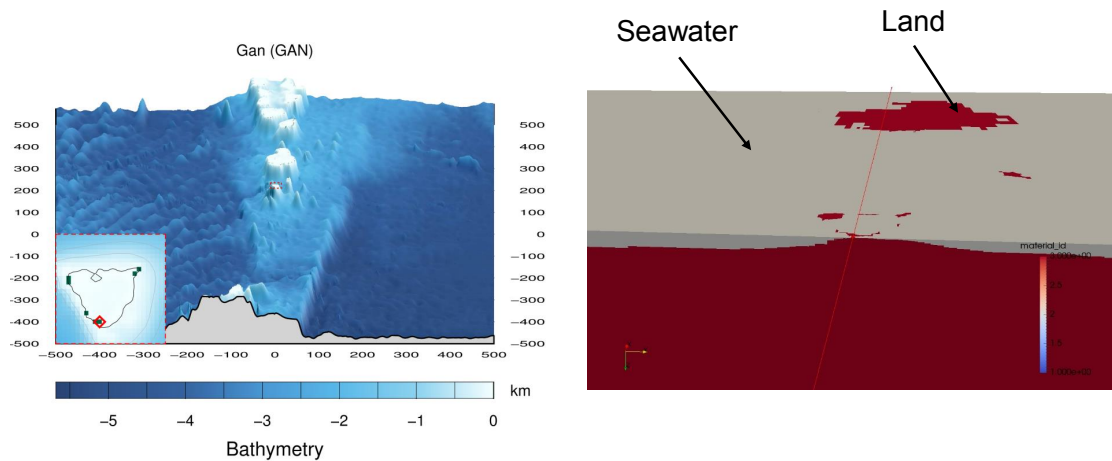


## Comparison to MT seabottom survey (Baba et al, 2016)



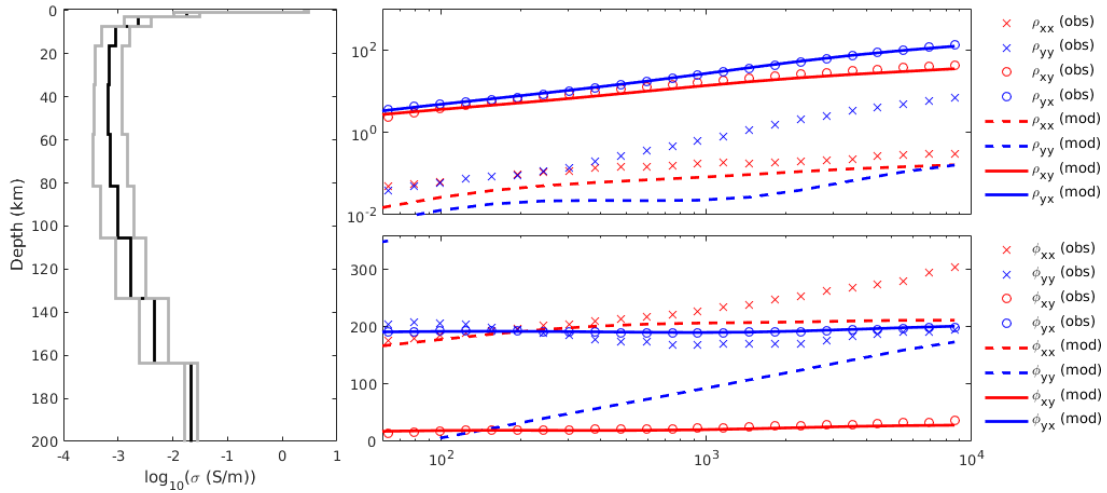
- More conductive than OBMT study
  - Galvanic distortions ??
- OBMT study: No station on island
  - Melt below the island ??

## Inversion of GAN data



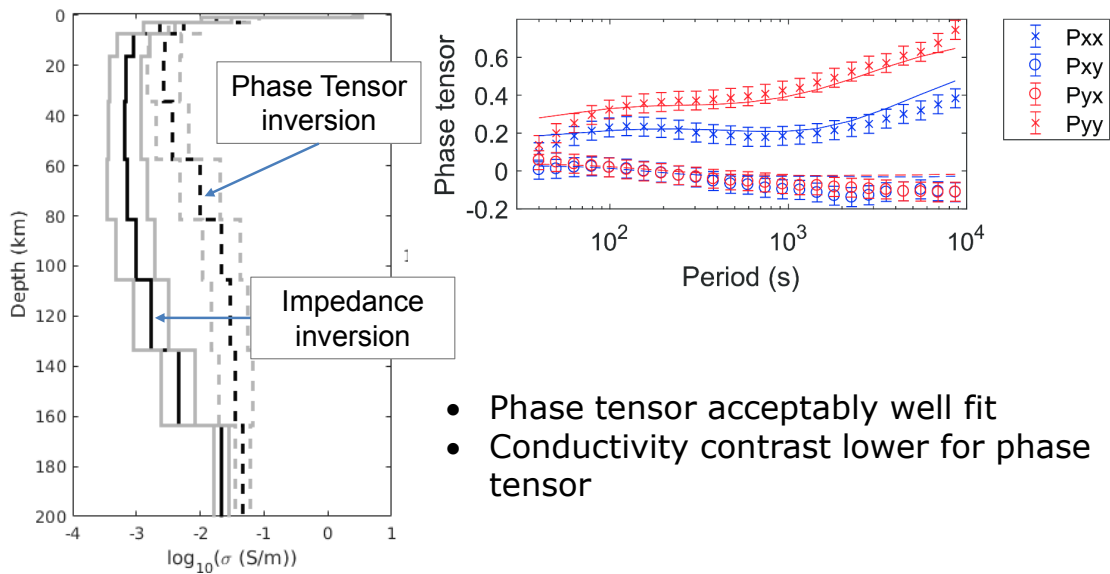
GAN observatory is located on southeast island of Maldives chain

## Inversion: Impedances GAN



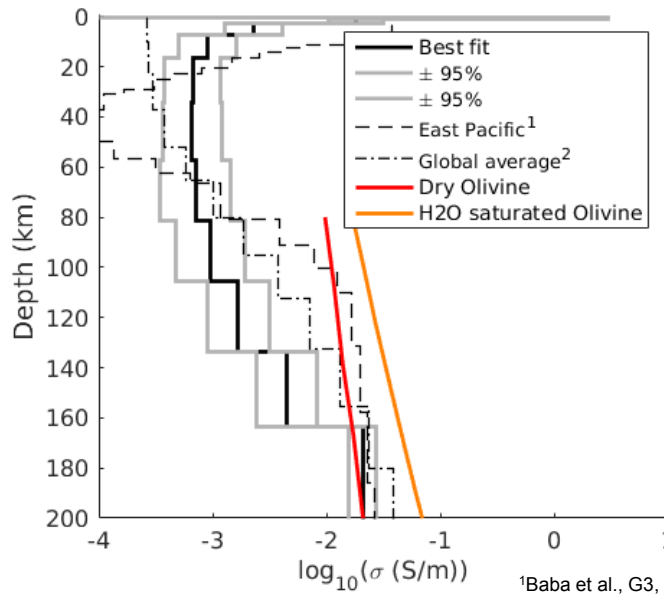
Result of inversion (thick lines) in comparison to observed responses (symbols)

## Inversion: Phase tensor GAN



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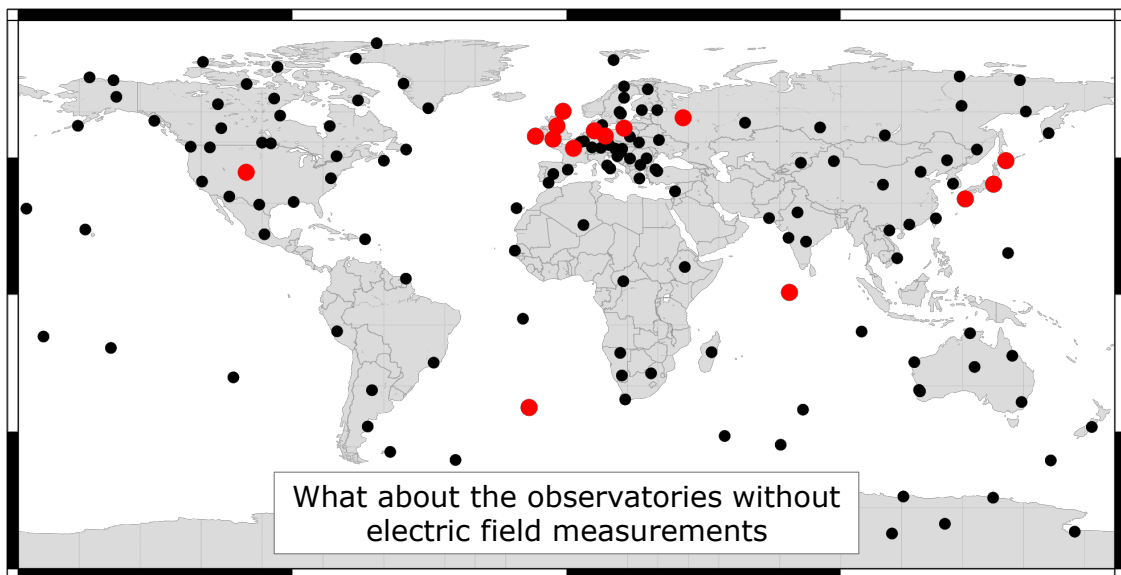
## GAN: Normal oceanic mantle



Inversion of GAN observatory data results in conductivity model similar to "normal oceanic mantle"

<sup>1</sup>Baba et al., G3, 2013  
<sup>2</sup>Grayver et al., S.A., 2016

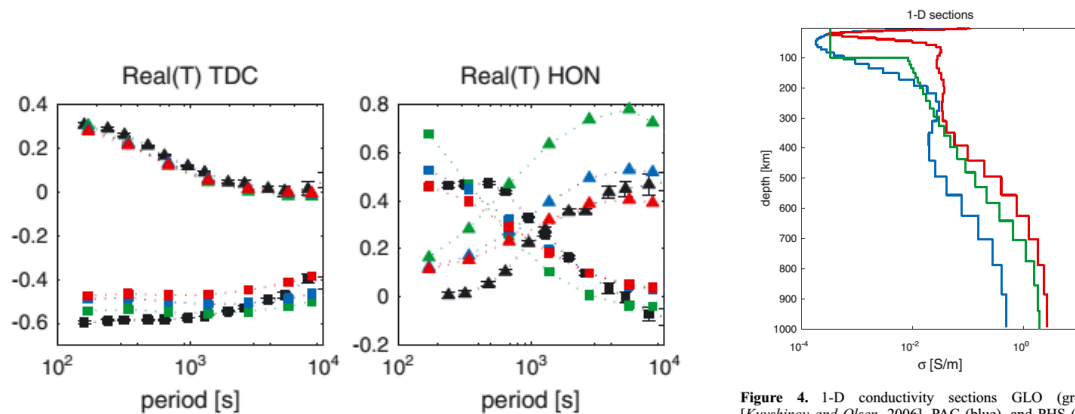
## INTERMAGNET Observatory Network



## Tippers at island observatories: Can we use them to probe electrical conductivity of the Earth's crust and upper mantle?

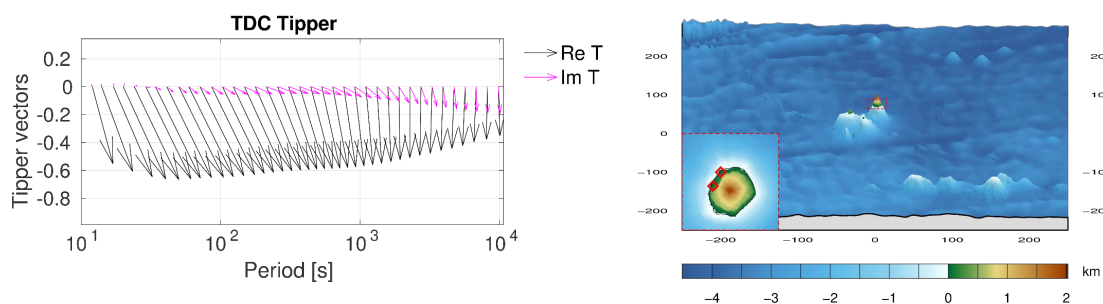
F. Samrock<sup>1</sup> and A. Kuvshinov<sup>1</sup>

GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 824–828, doi:10.1002/grl.50218, 2013



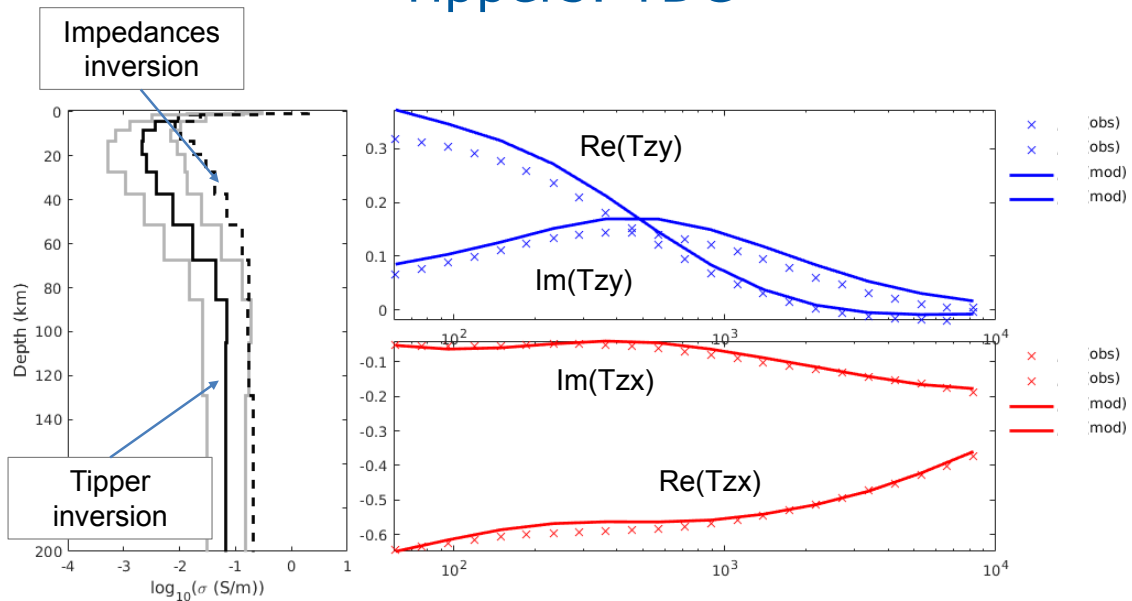
**Figure 4.** 1-D conductivity sections GLO (green) [Kuvshinov and Olsen, 2006], PAC (blue), and PHS (red) [Baba *et al.*, 2010], which are used in 3-D modeling; see details in the text.

## Tippers at TDC



- Observed tippers in Wiese convention point to less conductive island

## Tipplers: TDC



## Summary and Conclusions

- Framework for inverting observatory data affected by the ocean effect
- 1-D electrical conductivity for TDC and GAN
- More observatories can be used by inverting tippers
- Paper in preparation for submission to EPSL