3D MT Modelling in West Greenland Considering the Influence of Fjord Systems and Ocean.

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Introduction

Collecting magnetotelluric data in Greenland give rise to different challenges. Here we investigate one of the challenges, how a fjord system connected to the ocean can affect induction arrows around the fjord, by numerical simulations for periods of 1s, 10s and 100s. The results are induction arrows from a magnetotelluric data set collected in West Greenland in the summer 2013, with stations along the shoreline of the fjords between the towns of Kangerlussuaq and Aasiaat, see Figure 1. The setup consisted of 10 LMT stations on a 100 km profile with equipment kindly supplied by the GIPP at GFZ Potsdam (2015).

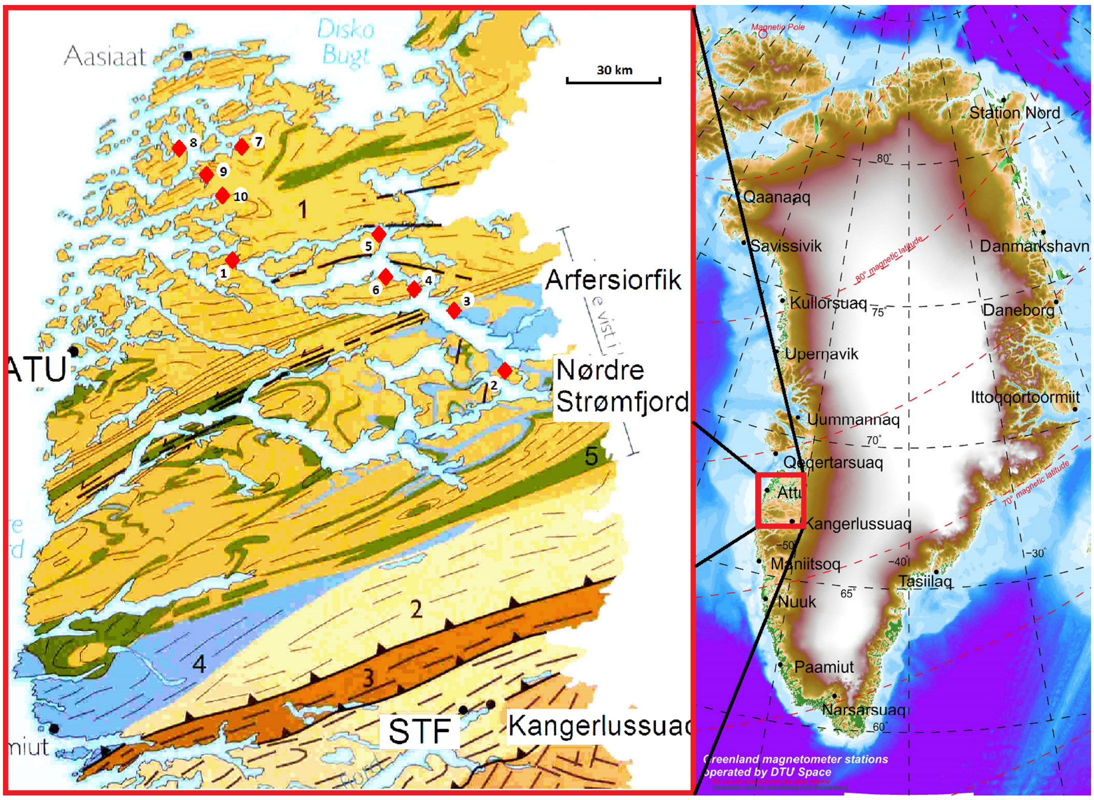

Figure 1: Left Red diamonds indicate the locations of the 10 stations at Arfersiorfik fjord. Geological map from van Gool in Henriksen (2008). **Right** Red square indicates the left-side maps location together with permanent DTU Space magnetometer stations.

Model study: the impact of fjords on MT transfer functions

We have conducted a model study with a simplified bended fjord, with or without connection to the ocean, to investigate how seawater of the fjord affects the induction arrows along the shoreline. The COMSOL Multiphysics v. 5.2 (2015) software is used to perform the modeling. The cross section of the fjord is set to a rectangle, 2 km width and 200 m depth.
Figure 2, left column, illustrates a fjord with no connection to the ocean, with the three panels presenting induction arrows for periods of 1s, 10s or 100s. The background color displays the magnitude of the induction, with the highest induction concentrated along the shoreline, but especially on the inside of the bend of the fjord. The real part of the induction arrows, illustrated as red arrows in Figure 2, will point away from conductive material (Wiese convention). Focusing first on the period of 1s, it is clear that the arrows along the shoreline (not towards the ends) are larger than 1, which is the maximum limit we normally expect from geology. For longer periods, 10s and 100s, the magnitude decreases fast and is negligible at long periods. Therefore, the induction caused by the fjord is most distinct for short periods, when the station is located very close to the shoreline.

The induction arrows change if the fjord is connected to the ocean. Figure 2, right column, illustrates thisfor periods 1s, 10s and 100s. Focusing on the period of 1s, the largest magnitude of the induction has shifted closer to the ocean, however the highest value is twice as large as in the bend. The magnitude in the bend is approximately the same value as in the situation without the ocean, but the difference is along the shoreline. The magnitude and the real induction arrows are very large all along the shoreline, whereas for the fjord without an ocean it decreases when moving away from the bend.
For the period of 10s, the magnitude is approximately the same in the bend, but the real induction arrows are larger. Induction from the fjord is completely disguised in the induction originating from the ocean, for the period of 100s,.
The induction from a fjord is therefore very high in low and medium periods and it can transverse further into a big fjord system when connected to the ocean, because of currents channeling.

Comparison with observations

The results of the model study illustrates the importance of modeling fjords in the vicinity of stations. The area of the magnetotelluric survey from West Greenland is traversed with a complex fjord system, see Figure 1. We have therefore tried to model the fjord system to account for the effect. As the bathymetry of the fjord system is not currently known different depths were tested and an average value of 100 m was selected.
Additionally, the model also consists of a model of the ocean created with the bathymetry from GEBCO world map (2014).
Figure 3 illustrates the model with a background resistivity of 100Ωm and a resistivity of the water (fjord and ocean) of 0.25Ωm. The induction arrows from this model are illustrated in Figure 4 together with the data response for three stations, station 8, 9 and 10 in the survey, see location in Figure 1.

Both station 9 and 10 illustrate a transition between conductive and resistive material to the north west of their location, which in the long periods is boundary to the ocean and for shorter periods is boundary to the fjord. The model responses agree with the data, the arrows

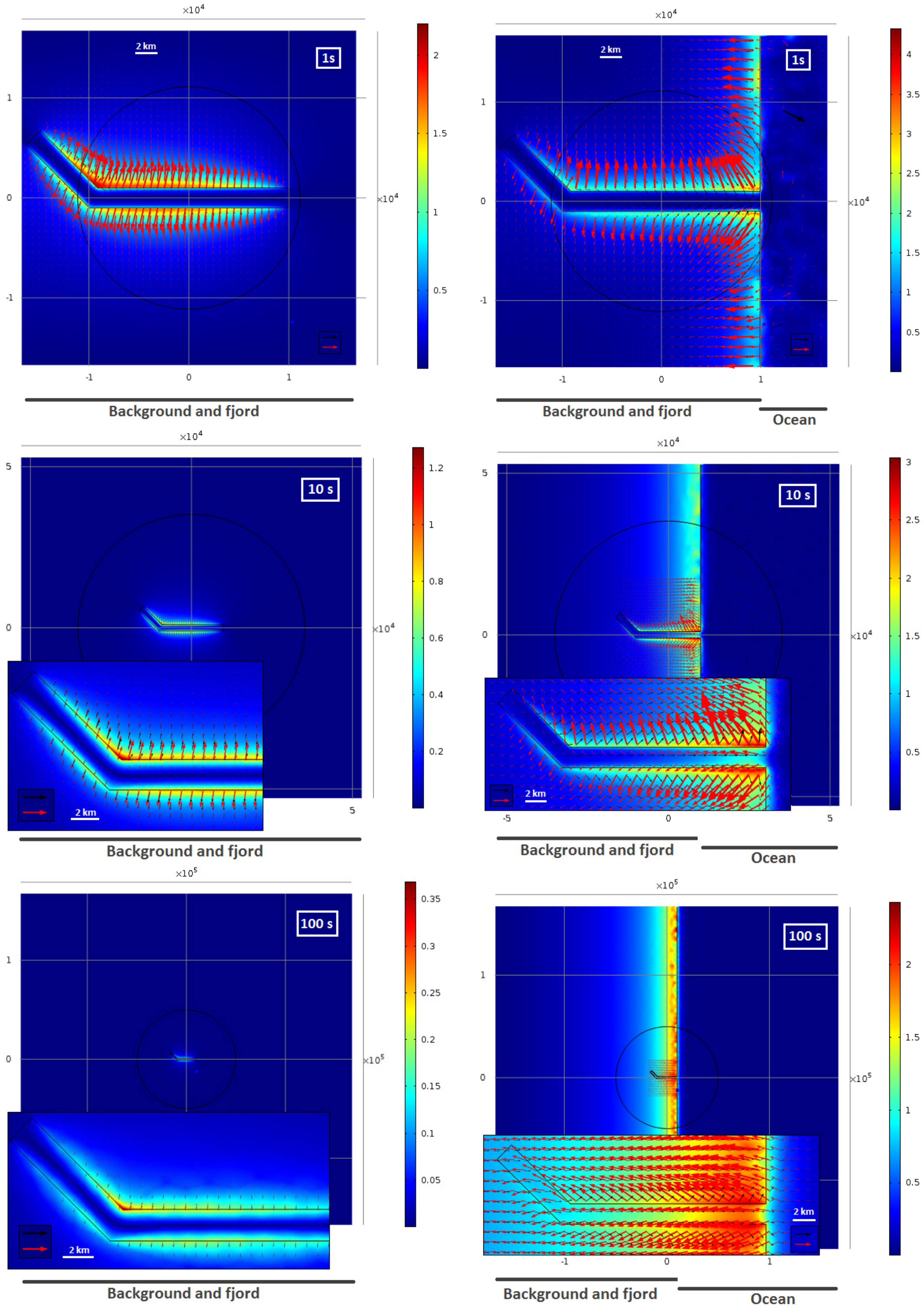

Figure 2: Left Models of a closed fjord, and **Right** model of a fjord connected to an ocean, for three different periods 1s, 10s and 100s. The color represents the magnitude of the total magnetic field and the red (black) arrows represents the real (imaginary) induction arrow. The four bottom figures display a zoom in of the fjord. Scale shown by unit arrows in each figure.

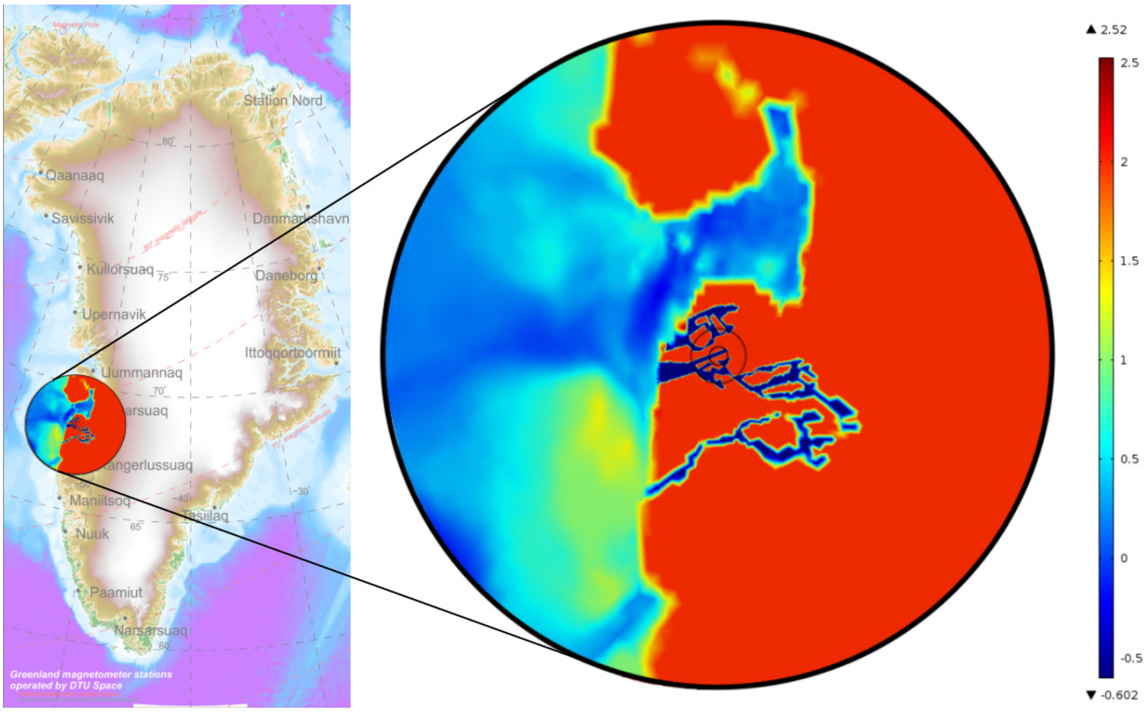

Figure 3: Left The resistivity distribution of the model located in its geographical surroundings. **Right** A close-up of the resistivity of the model, with a background resistivity of 100Ωm.

have the same direction in the real part, although not the same magnitude. Station 8 behaves differently, it illustrates a boundary between conductive and resistive material to the east in short periods and to the north west in long periods, with a smooth transition in between. This is present both in the data and the model. This can be explained by the location of station 8, which is on a small island within the fjord. There is a larger water area to the east and a large island to the west, which explains the rotation of the arrows with period.
Even though the model and data differ from each other with respect to the direction, they reveal the same pattern.

The model consists only of a homogeneous background, ocean and fjords and does not include any geological bodies. The considerable contribution originating from the ocean and fjords has to be considered definitely when explaining the observed data by conductivity models. To achieve a reasonable data fit shaping the fjord in the model as truly as possible is important.

References

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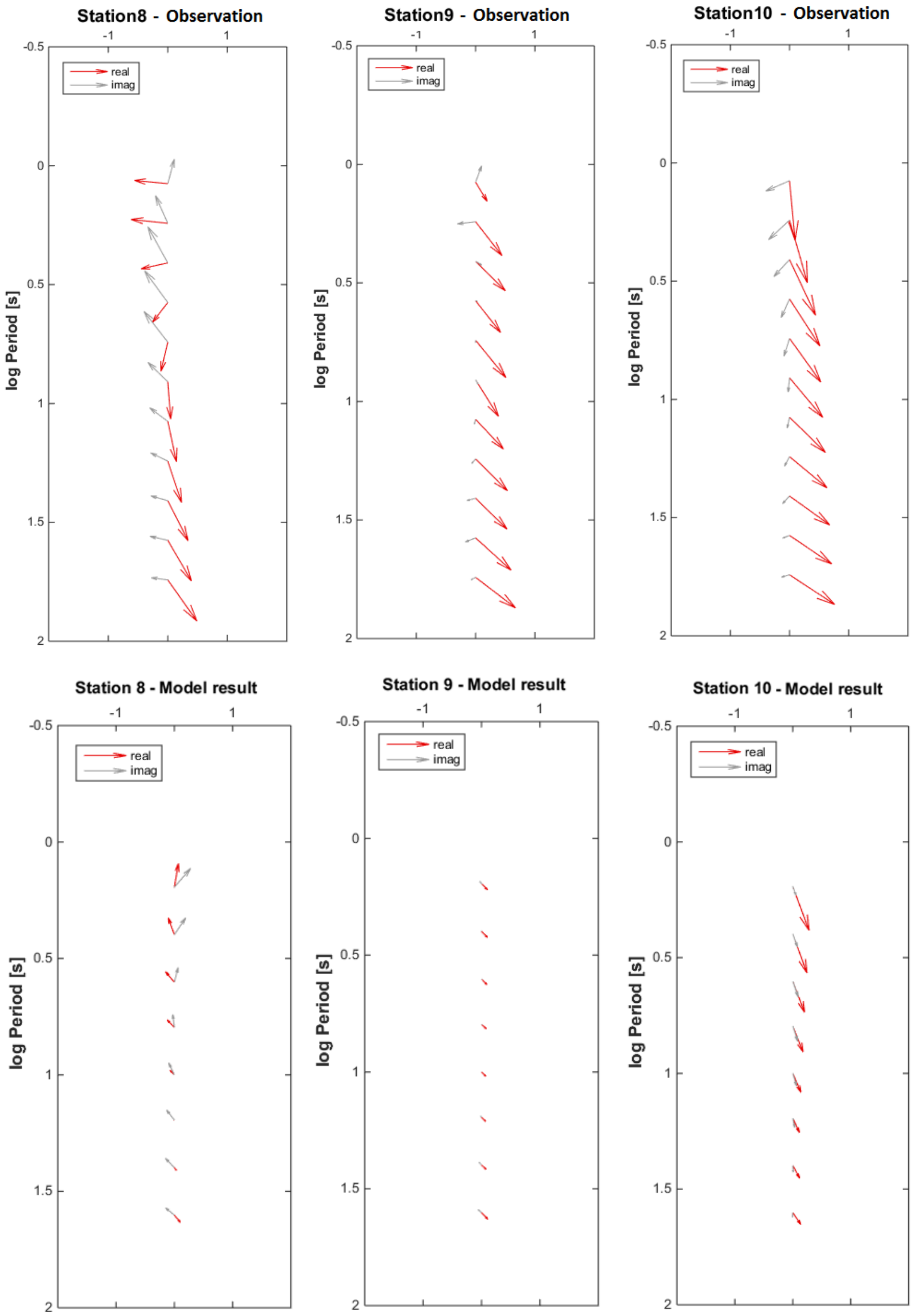

Figure 4: Observed (Top) and model (Bottom) induction arrows of station 8, 9 and 10.

instrument-pool-potsdam-gipp/instruments/gipp-mt/. ([Online; accessed 08-December-2015])

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