

Metal Earth Magnetotelluric Survey

Analysis and Preliminary Results



A new Canadian research initiative funded
by Canada First Research Excellence Fund.



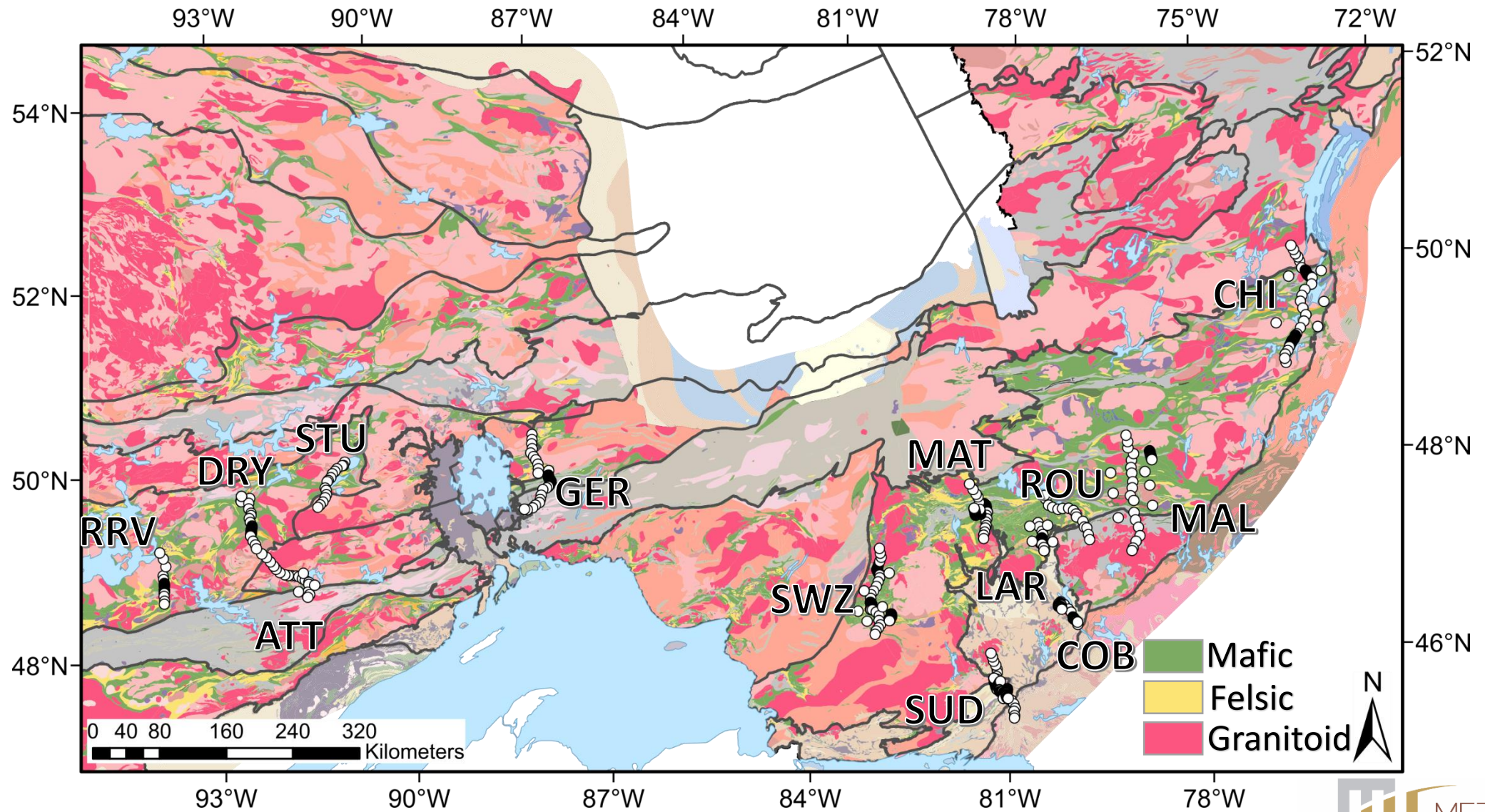
Canada



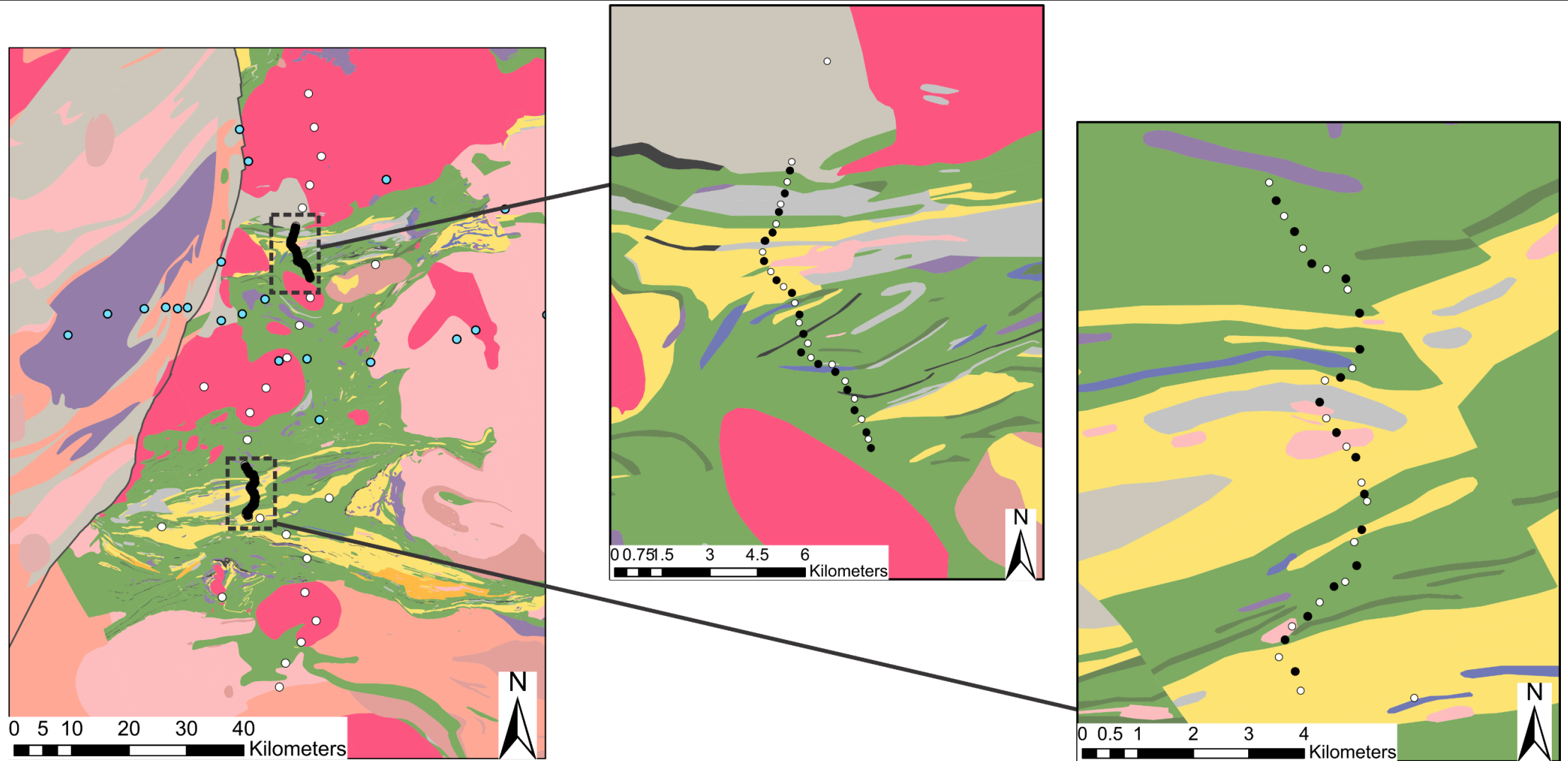
HARQUAIL SCHOOL OF EARTH SCIENCES
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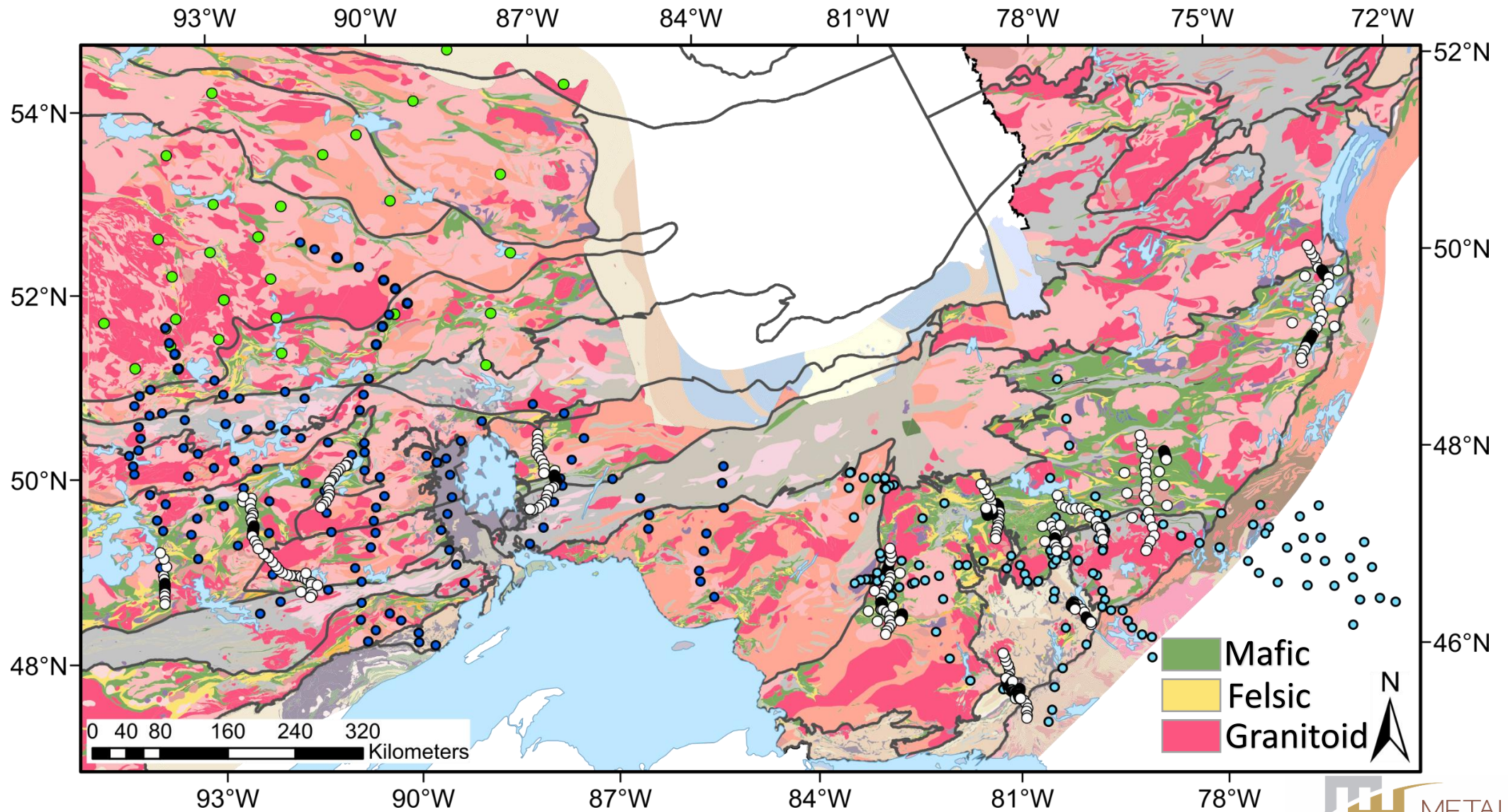
MT Survey



MT Survey - Swayze

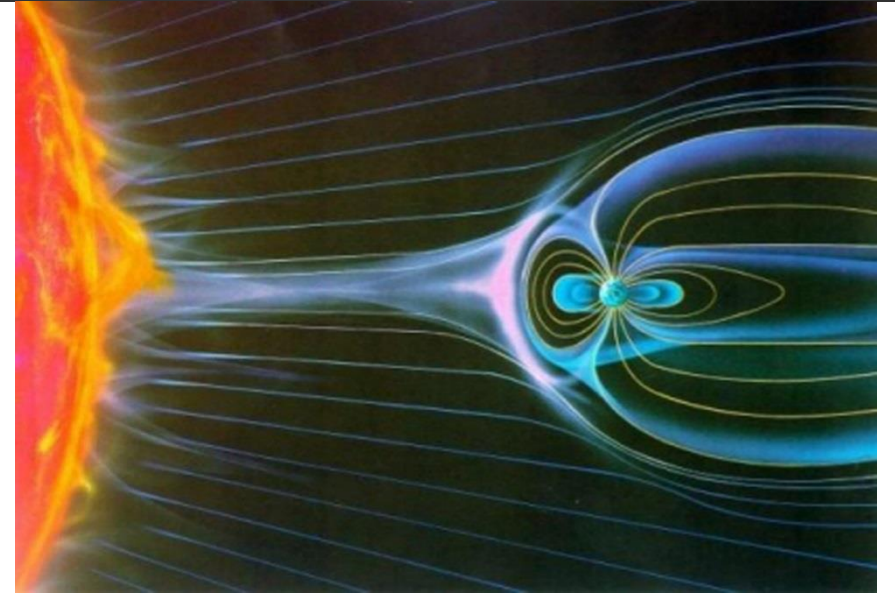


MT Survey

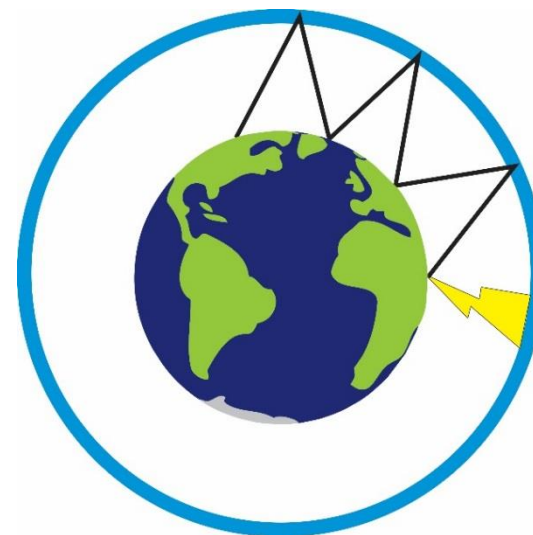


Magnetotellurics

- Natural source EM induction method
- Broad range of source frequencies
 - 10000 – 0.0001 Hz / 0.0001 s – 10000 s
 - → Depths of investigation from hundreds of meters to hundreds of kilometers
- For $f > 1$ Hz:
 - Global lightning activity
- For $f < 1$ Hz
 - Interactions between solar wind and magnetosphere



https://www.nasa.gov/mission_pages/sunearth/spaceweather/index.html

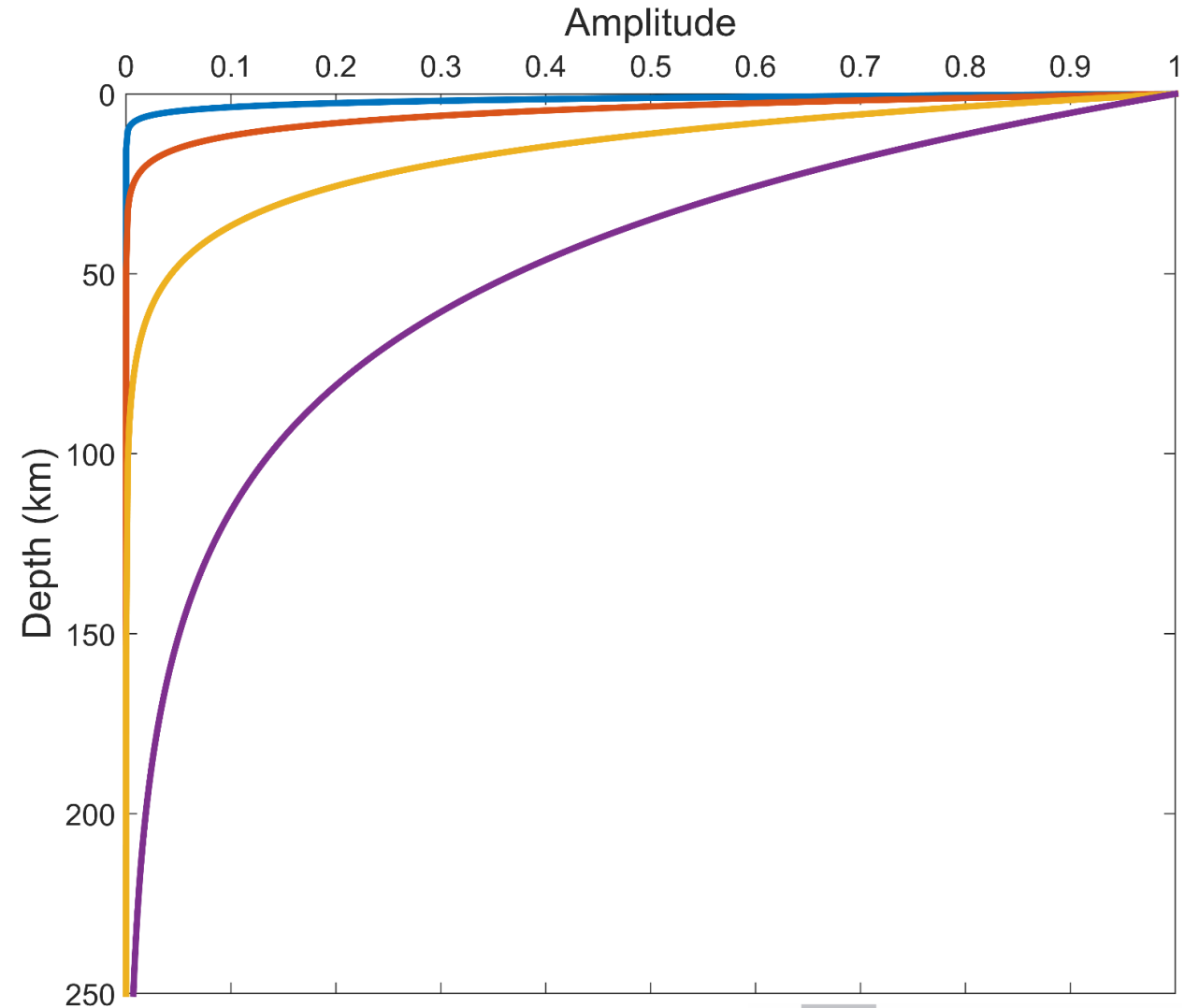


Magnetotellurics – Skin Depth

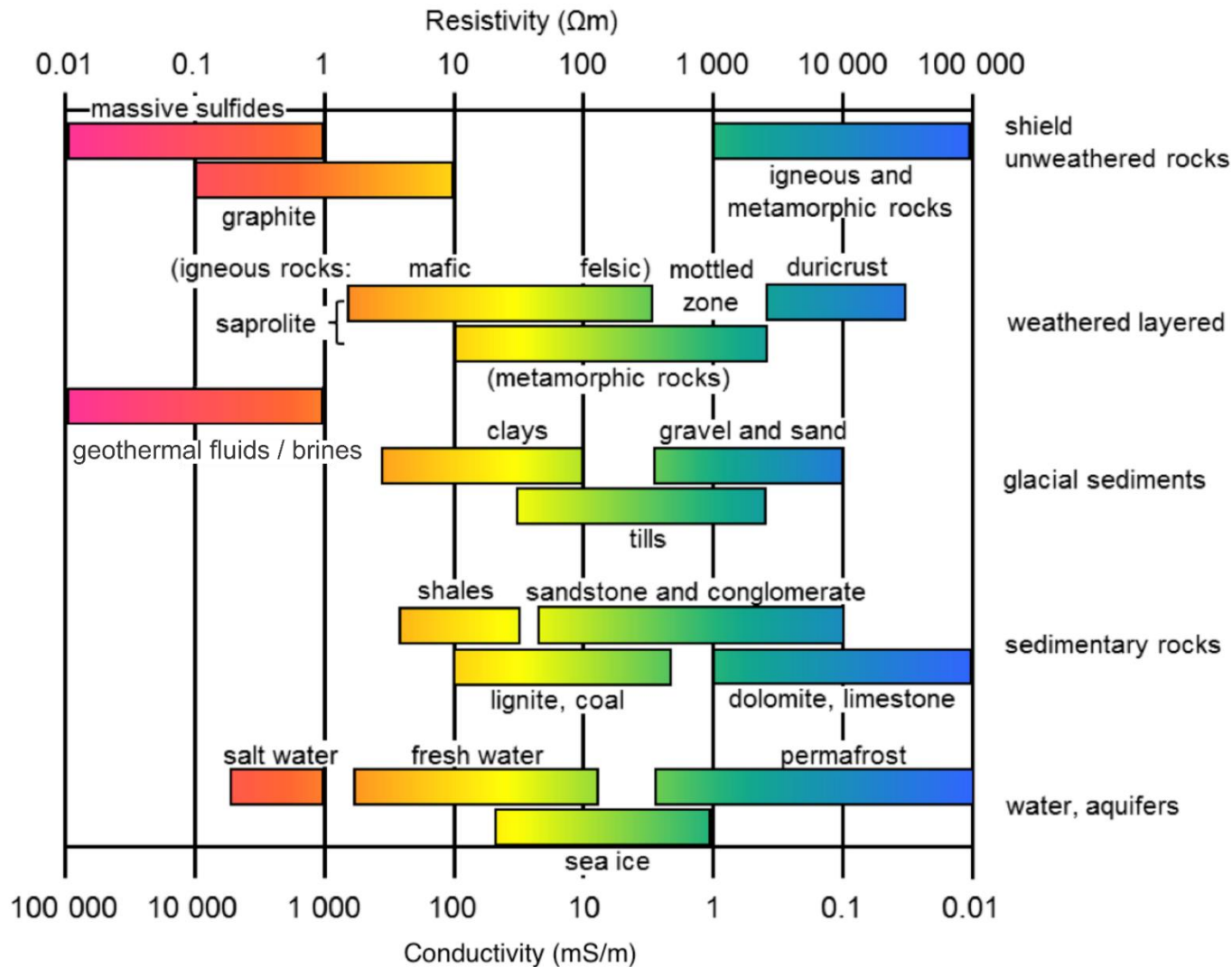
- Skin Depth:
- The depth at which EM waves are attenuated to $1/e$ of their surface values

- $$\delta(f) \approx 500 \sqrt{\frac{1}{\sigma f}} = 500 \sqrt{\rho T}$$

- f : frequency
- σ : conductivity
- T : period
- ρ : resistivity



Magnetotellurics – Physical Properties

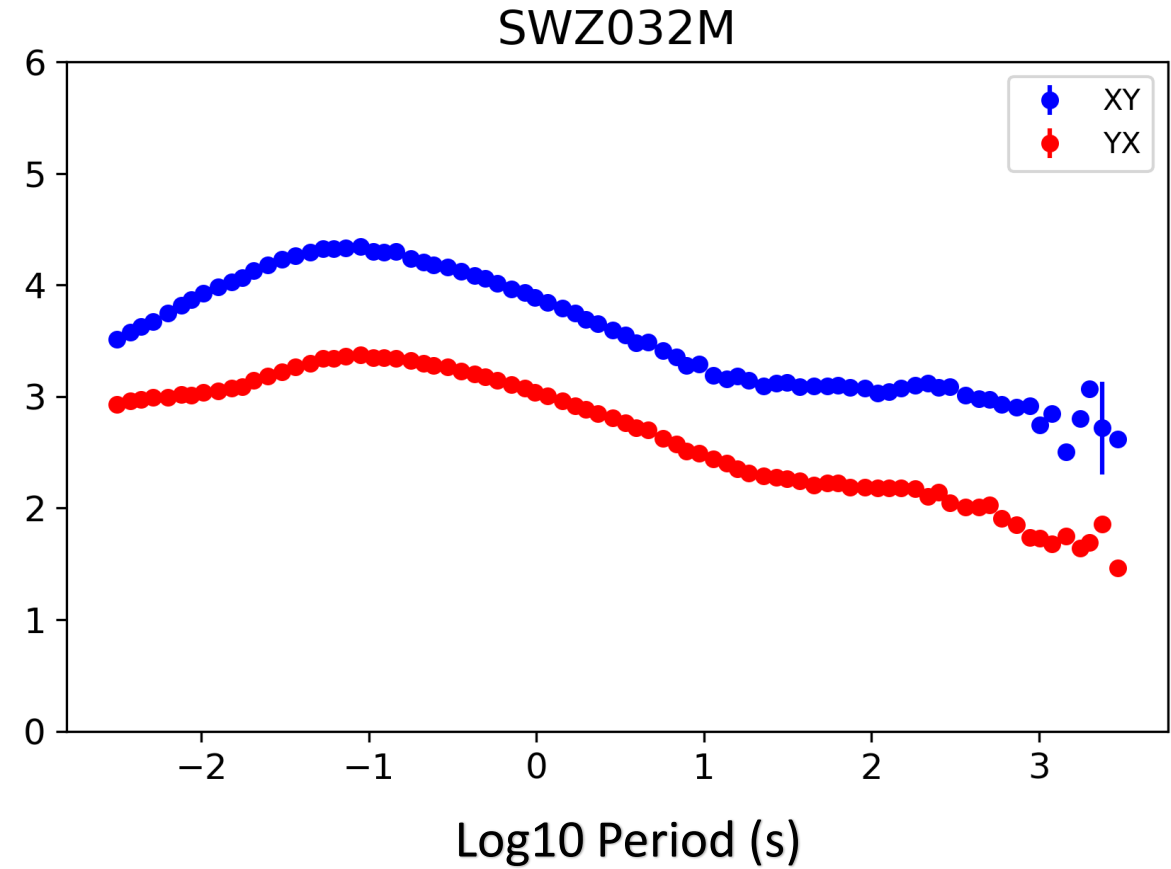
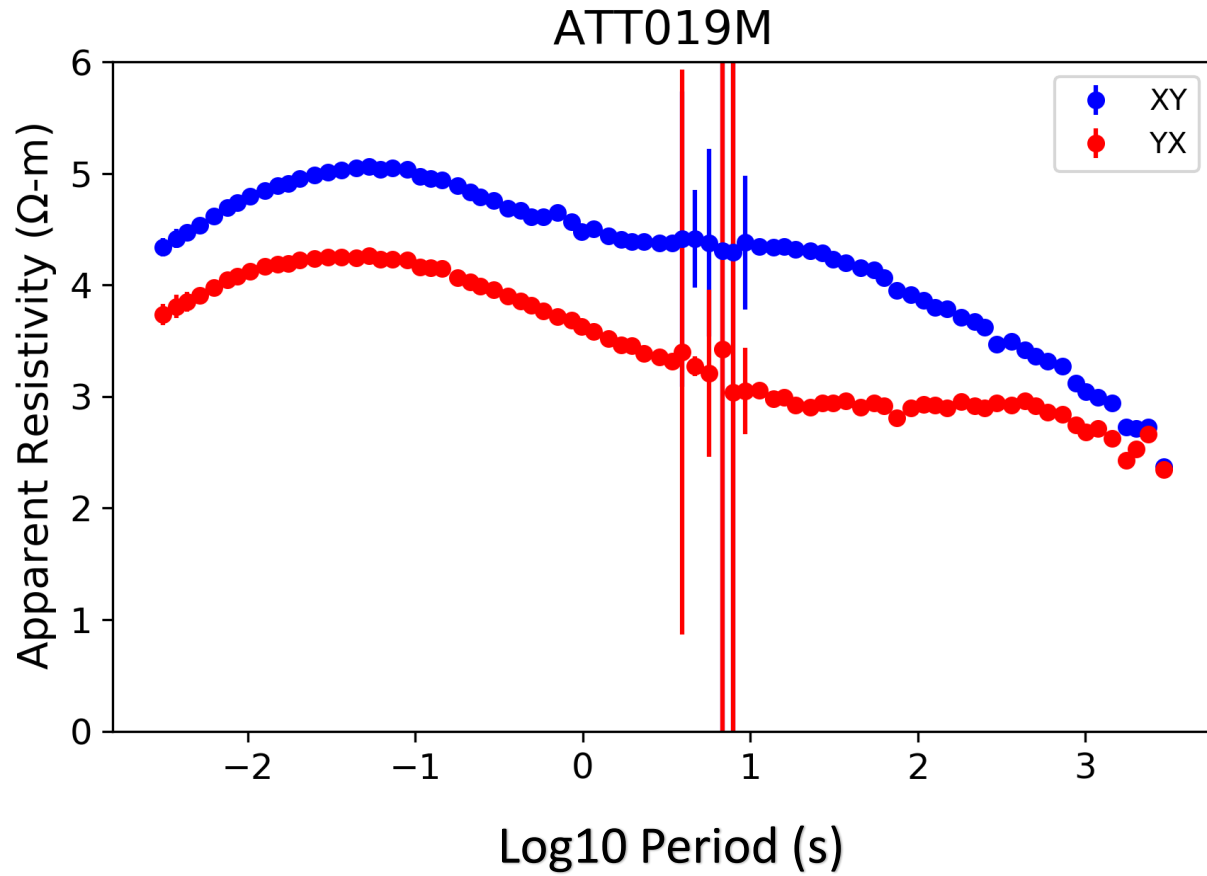


Varies with:

- Rock type
- Temperature
- Porosity
- Pore fluid

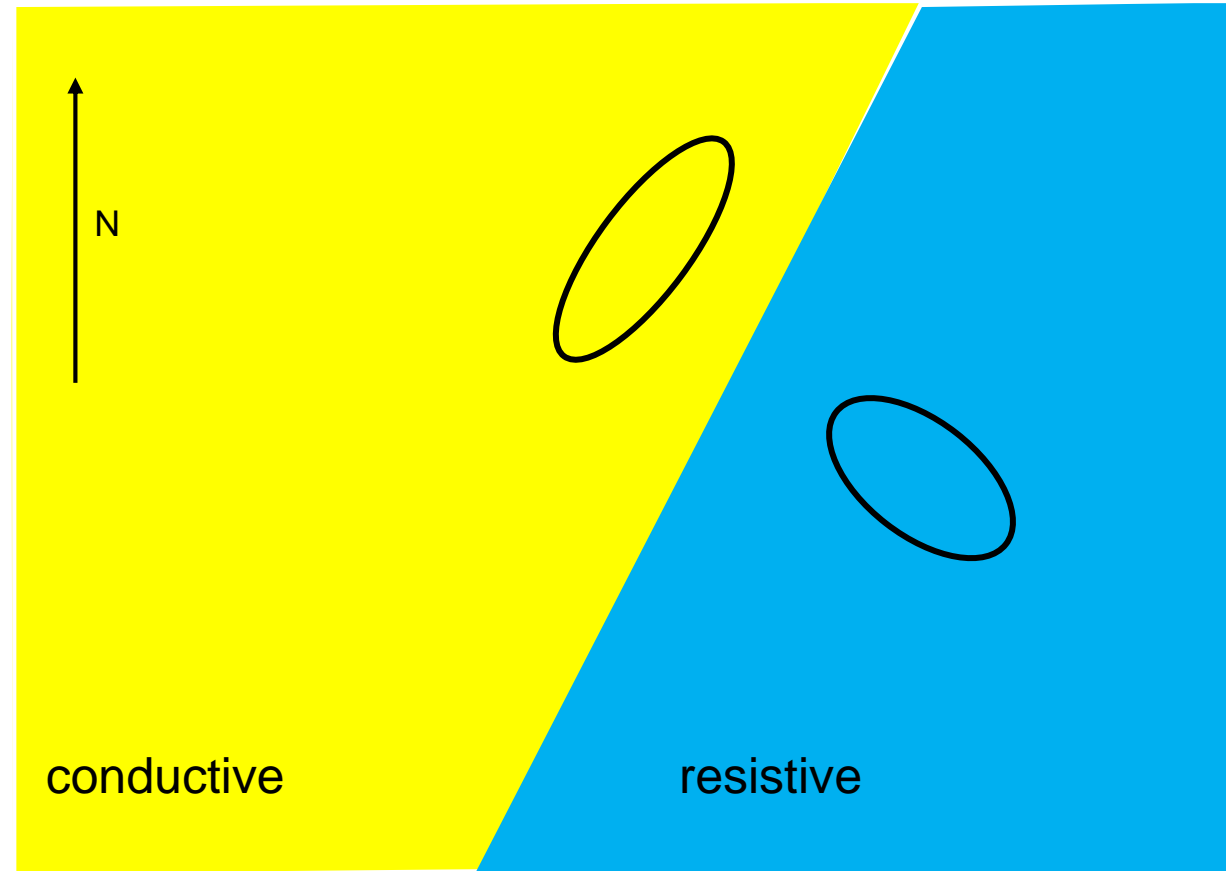
Modified from <https://em.geosci.xyz>

Magnetotellurics – Data Example



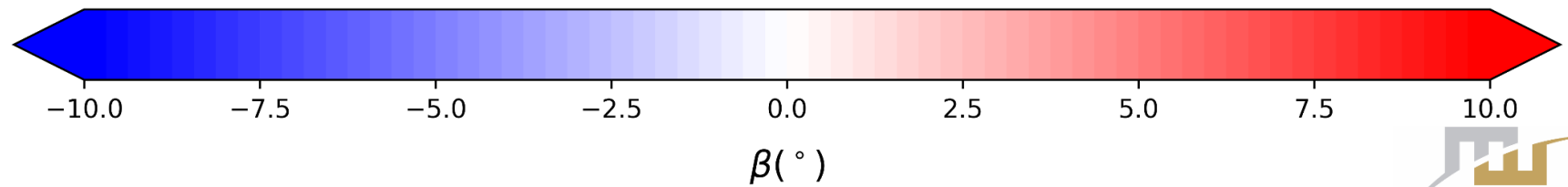
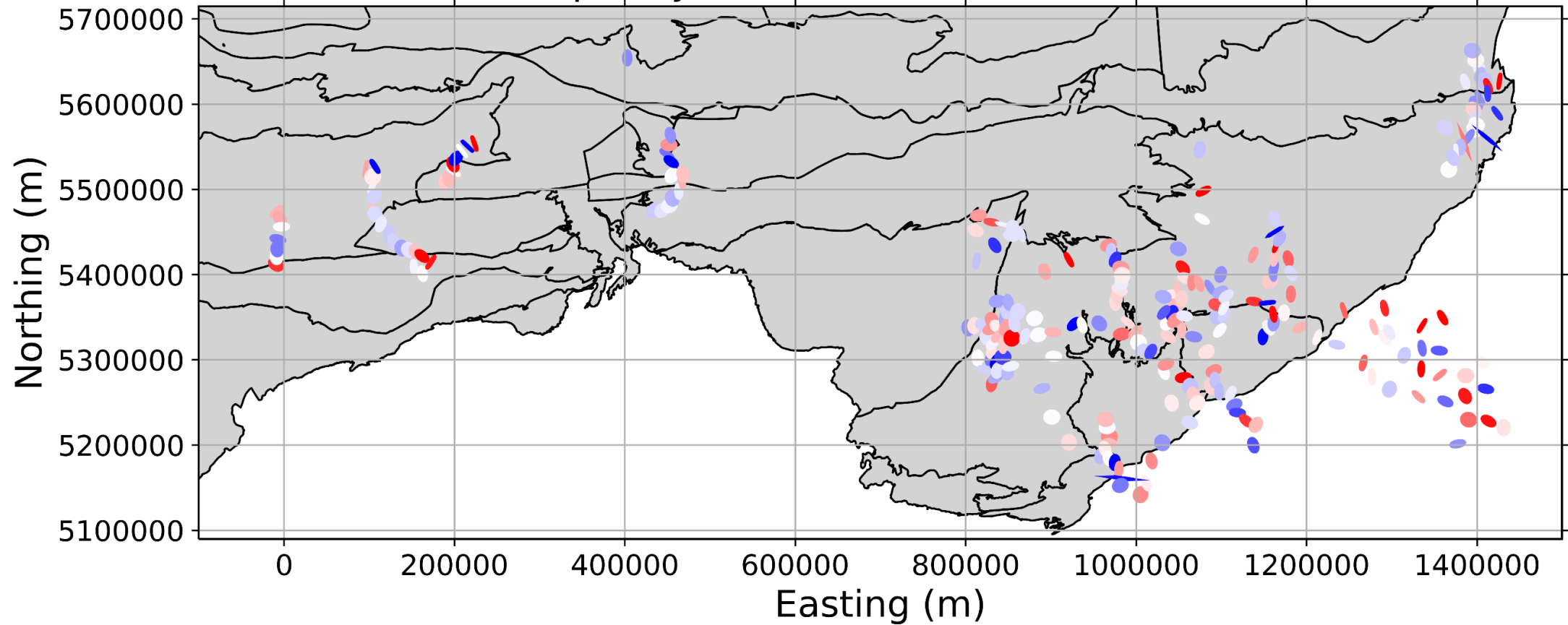
Phase Tensors

- Plotted as ellipses
- Direction of major axis points in direction of current flow
- For 2-D structure, will point to strike direction (or 90° to it)
- Ellipses become circles for 1-D structure
- Deviation from 1-D/2-D structure is characterized by the parameter β
 - $|\beta| > 3^\circ \rightarrow$ 3-D structure

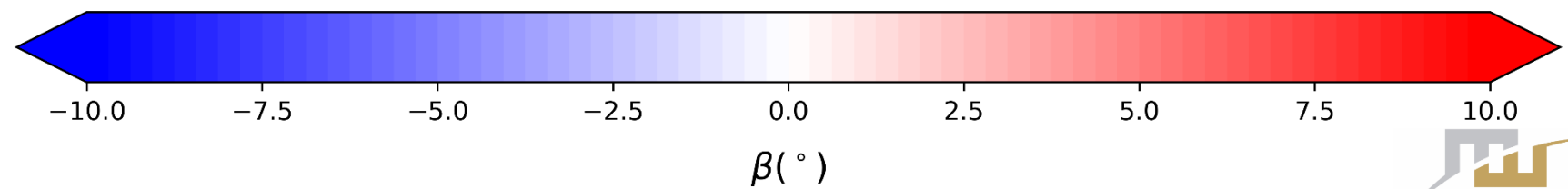
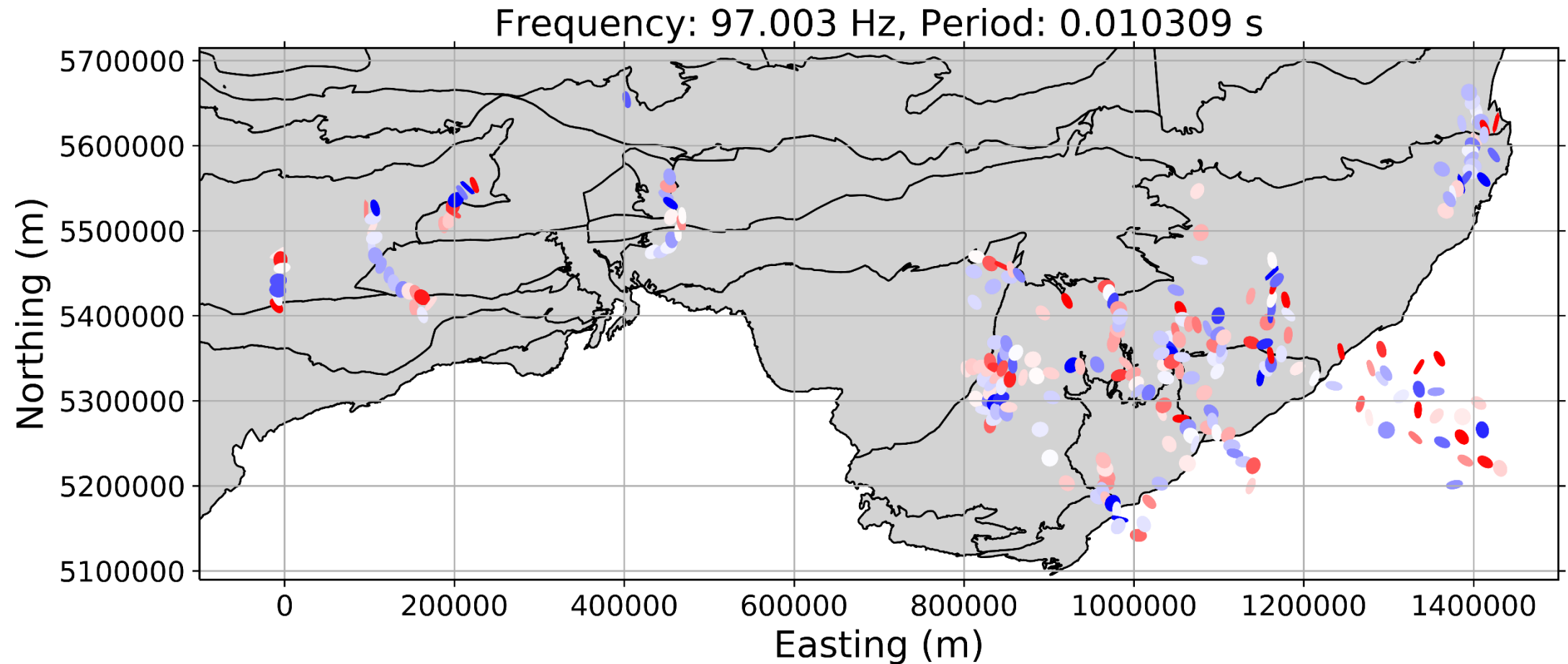


Phase Tensors

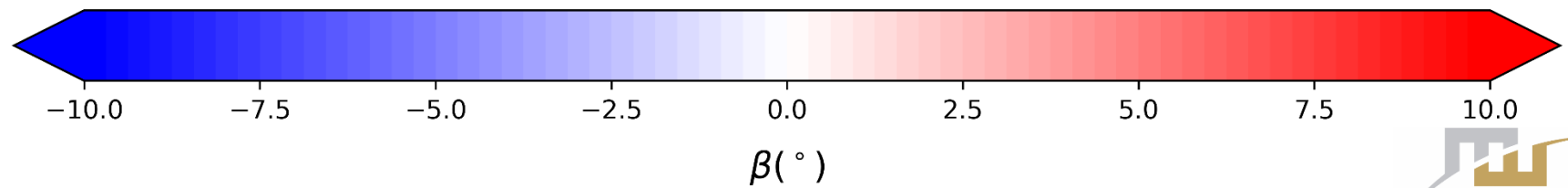
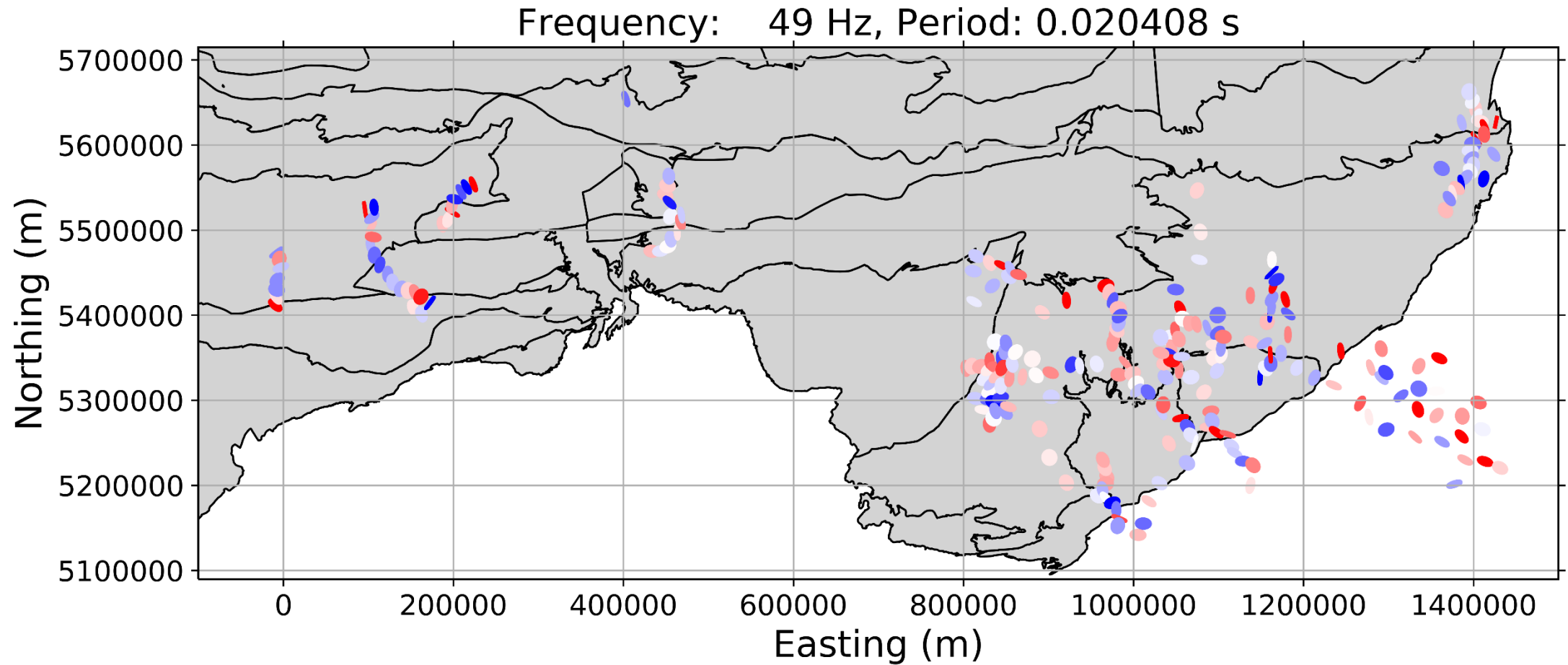
Frequency: 194 Hz, Period: 0.0051546 s



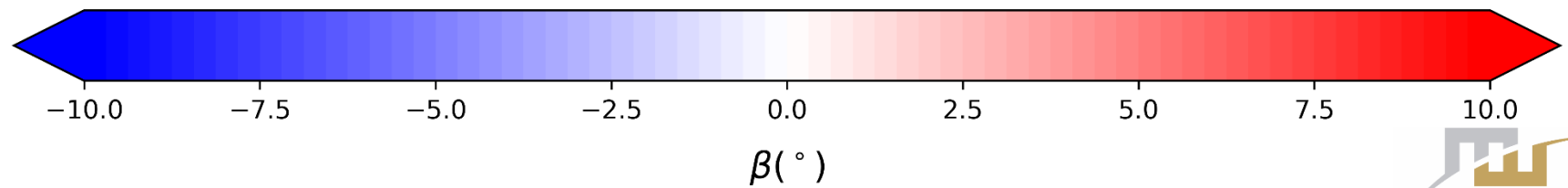
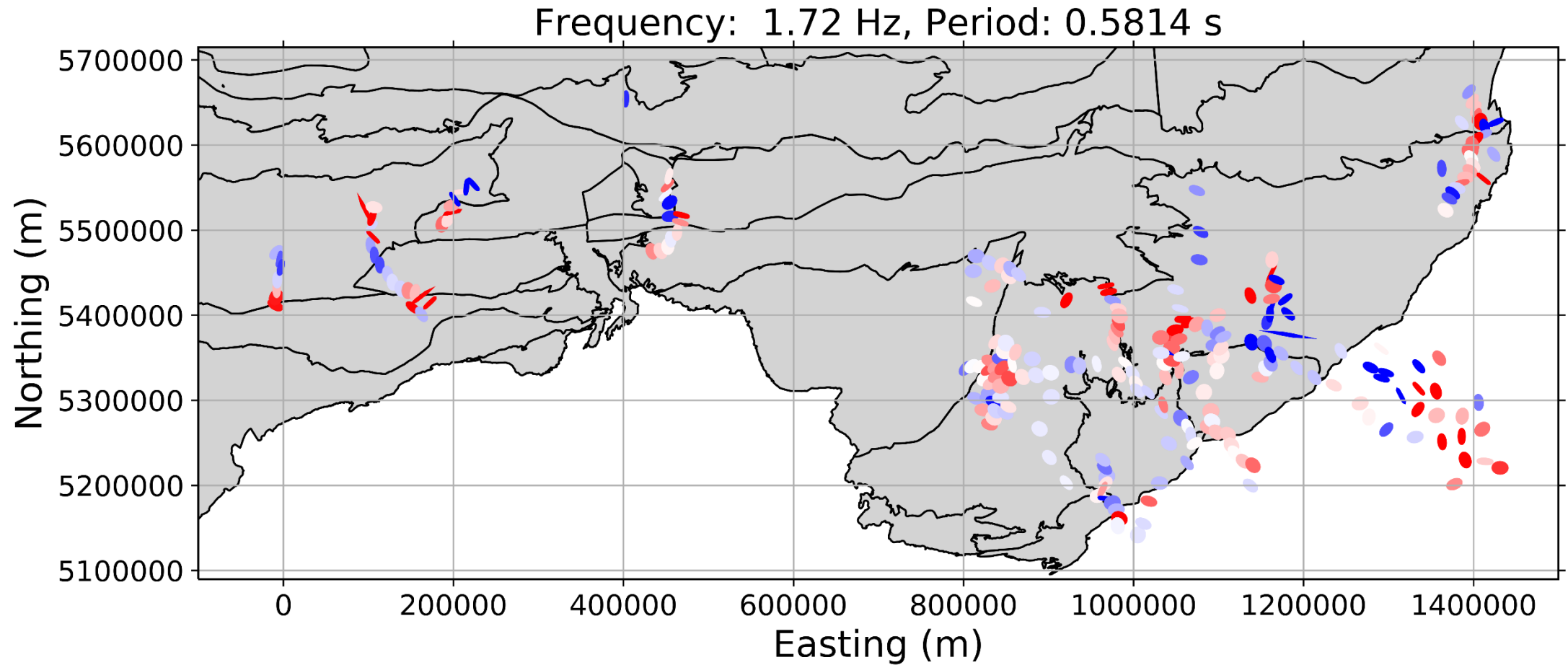
Phase Tensors



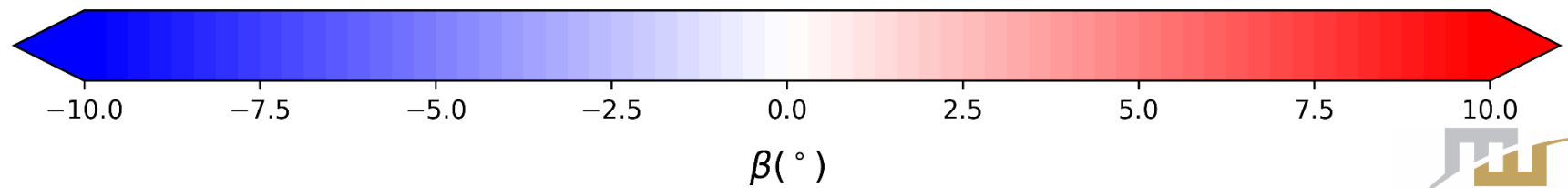
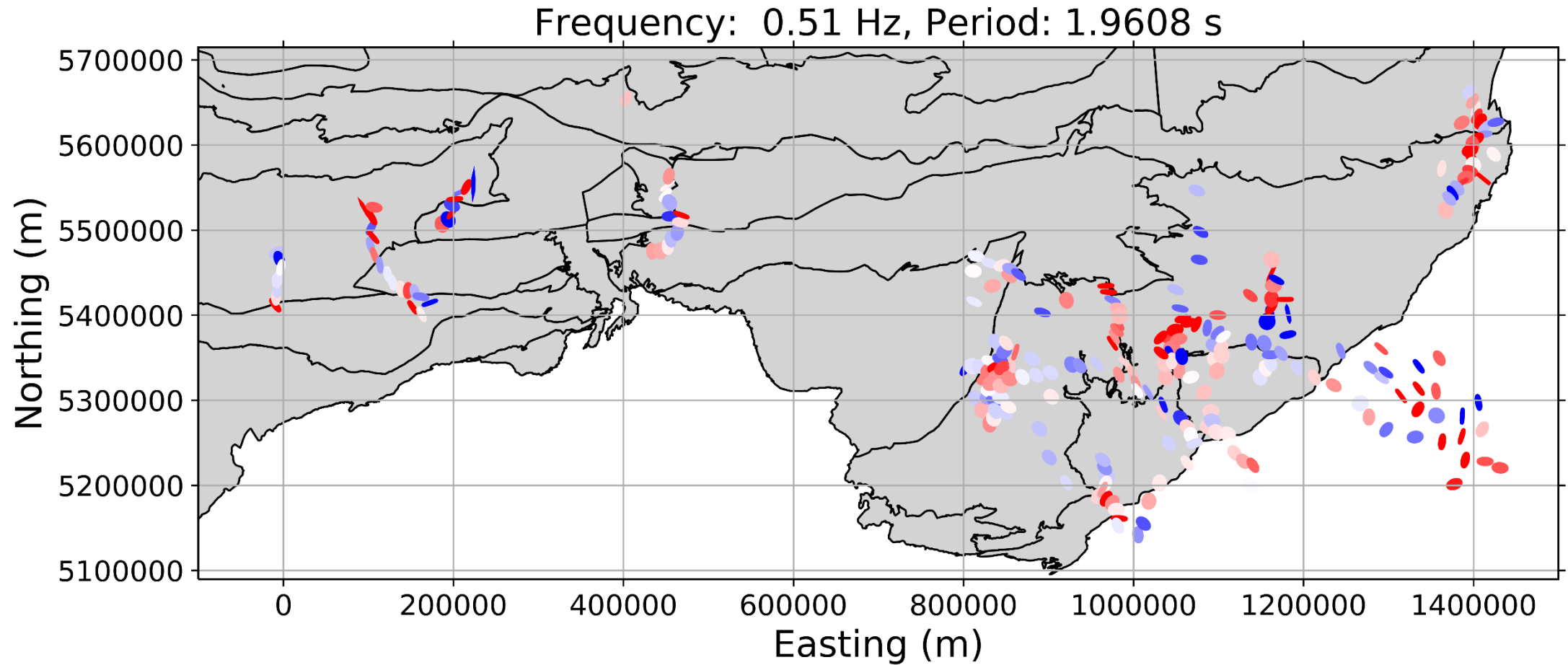
Phase Tensors



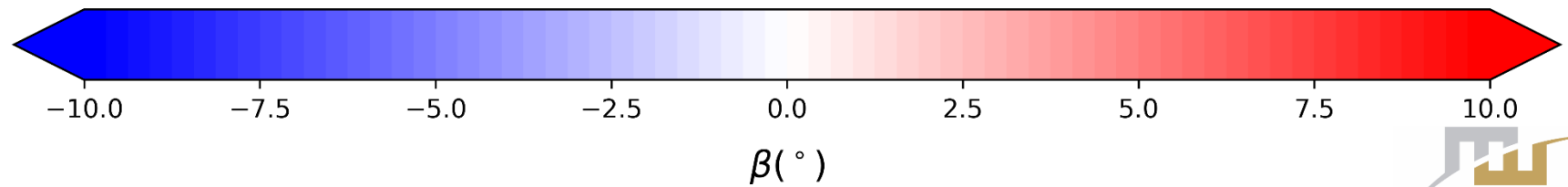
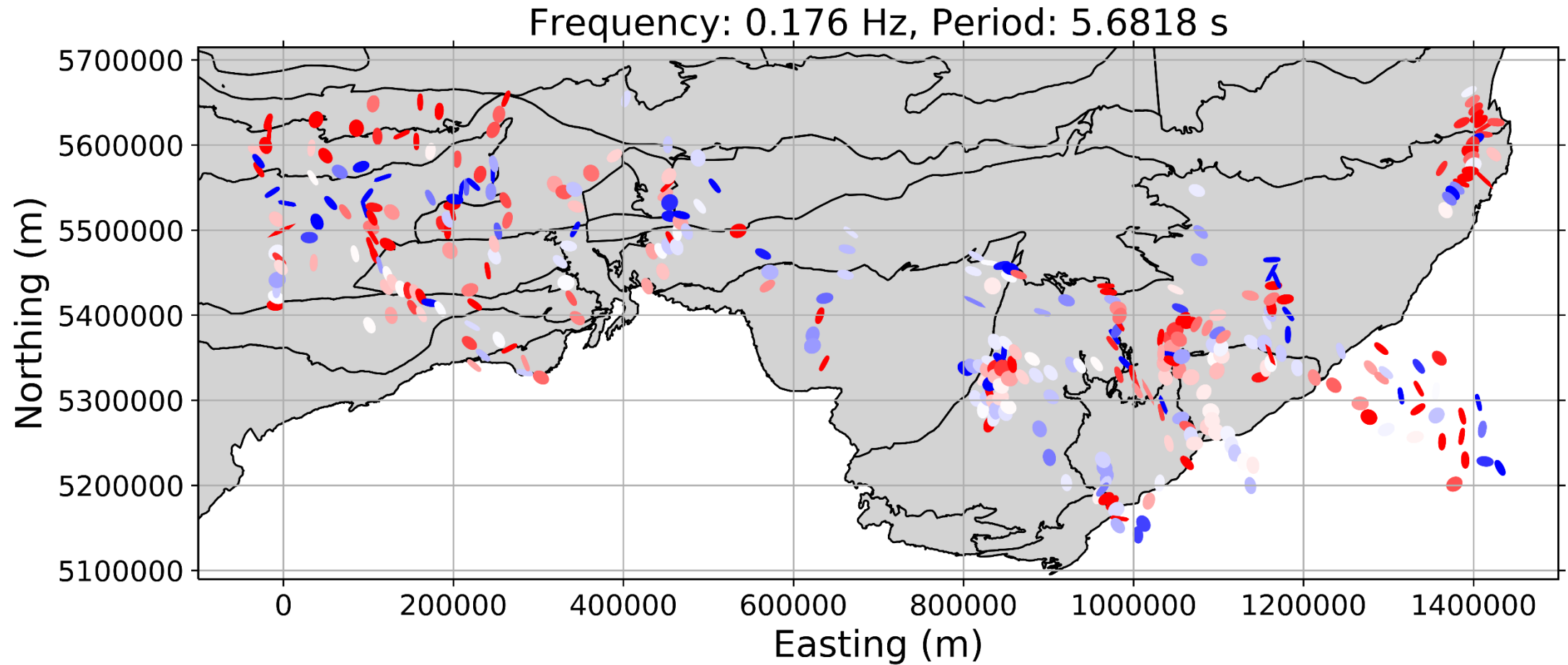
Phase Tensors



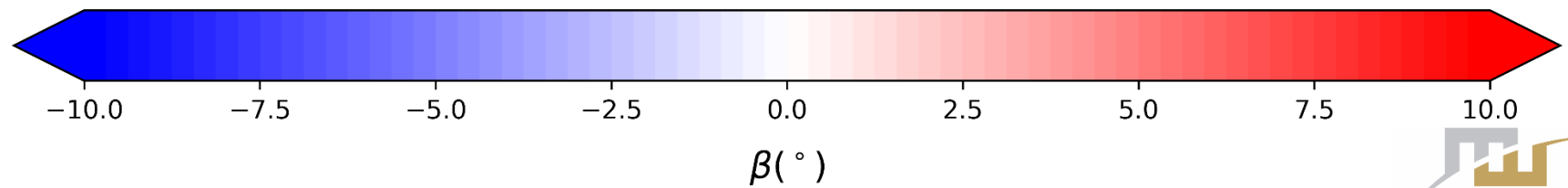
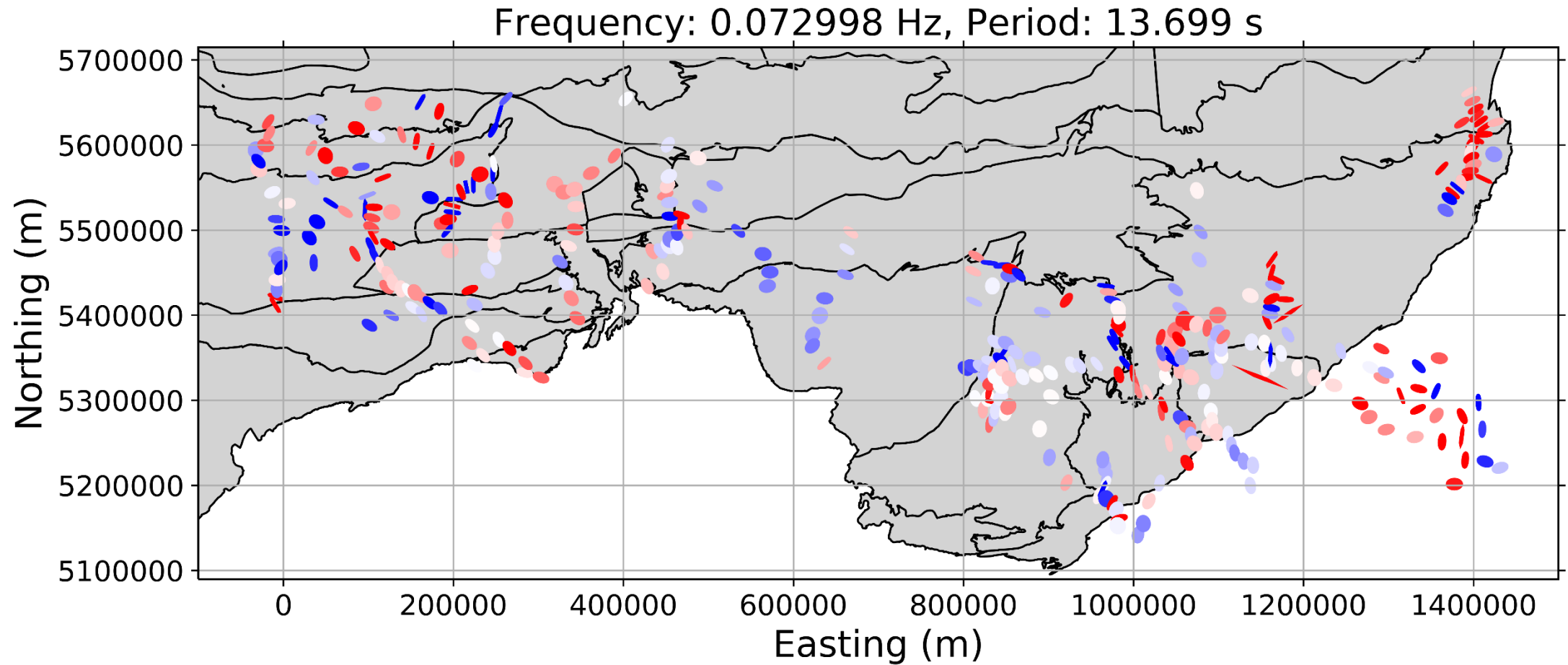
Phase Tensors



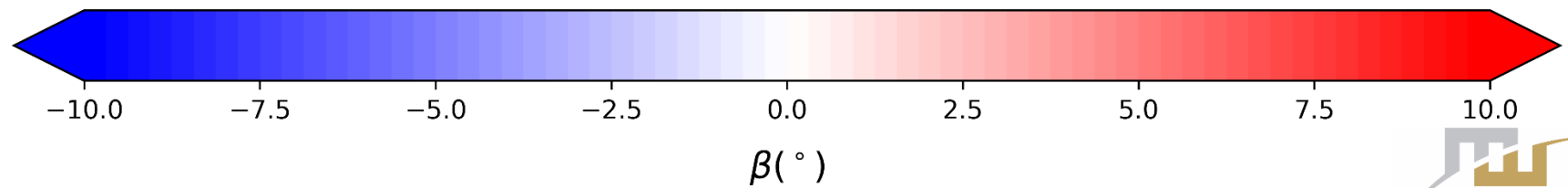
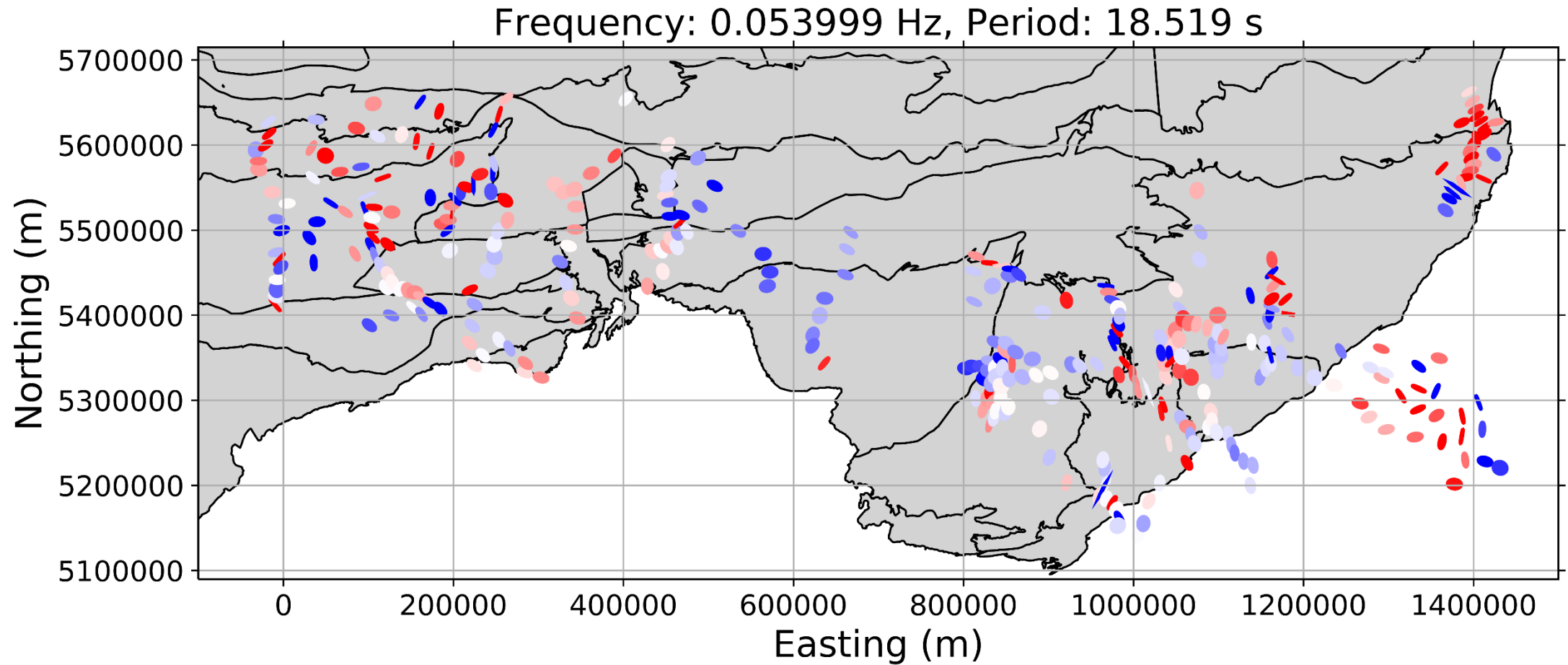
Phase Tensors



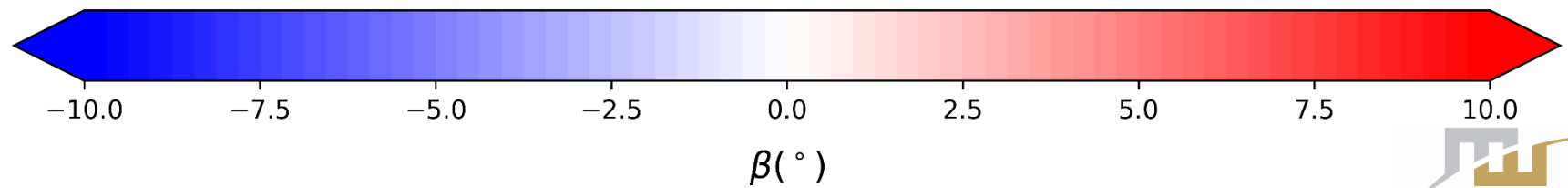
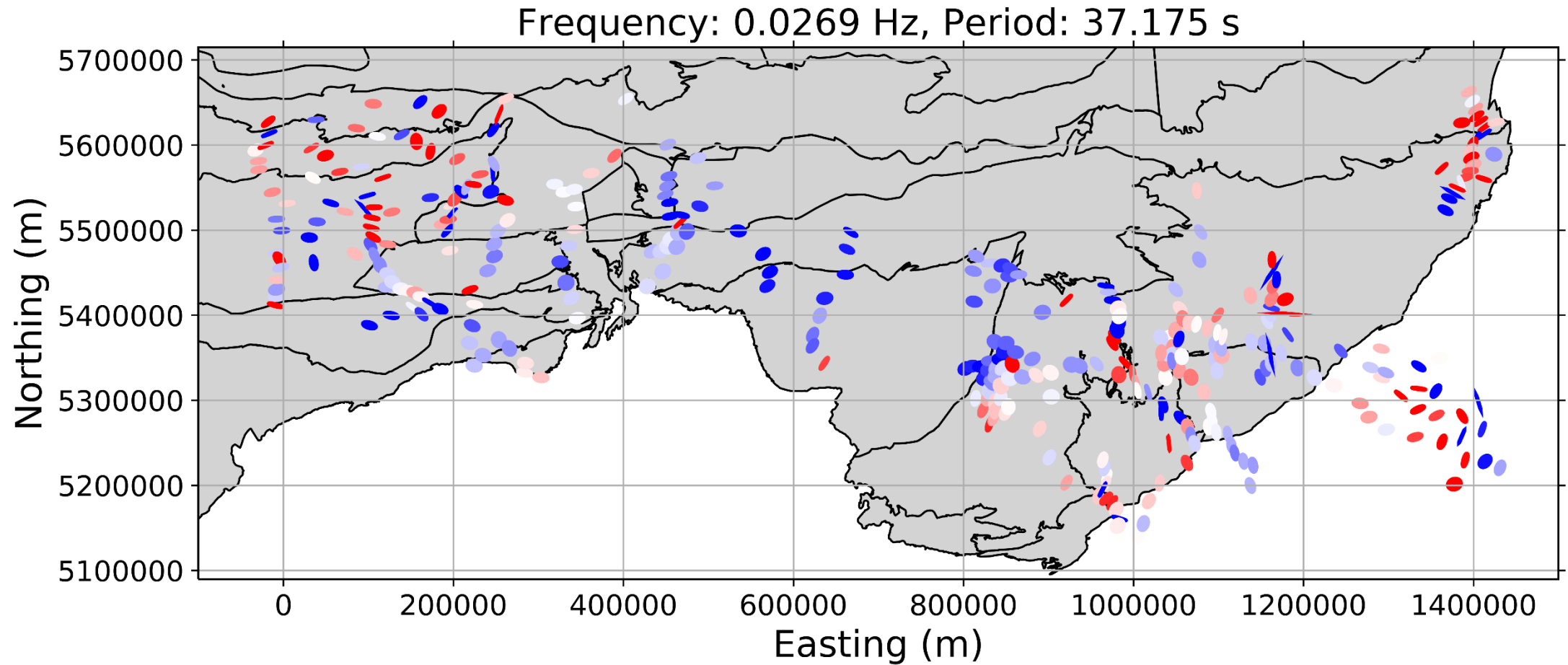
Phase Tensors



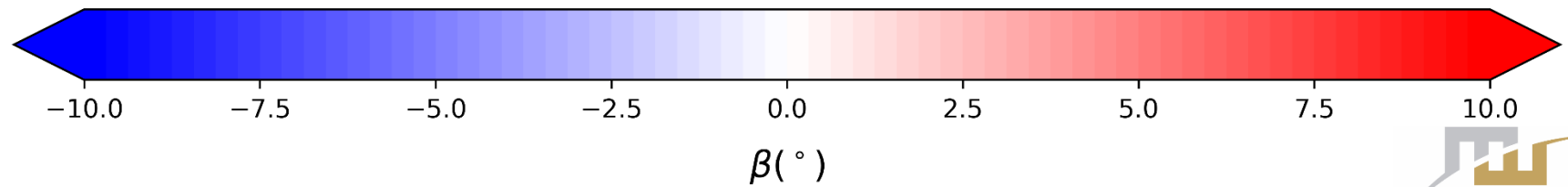
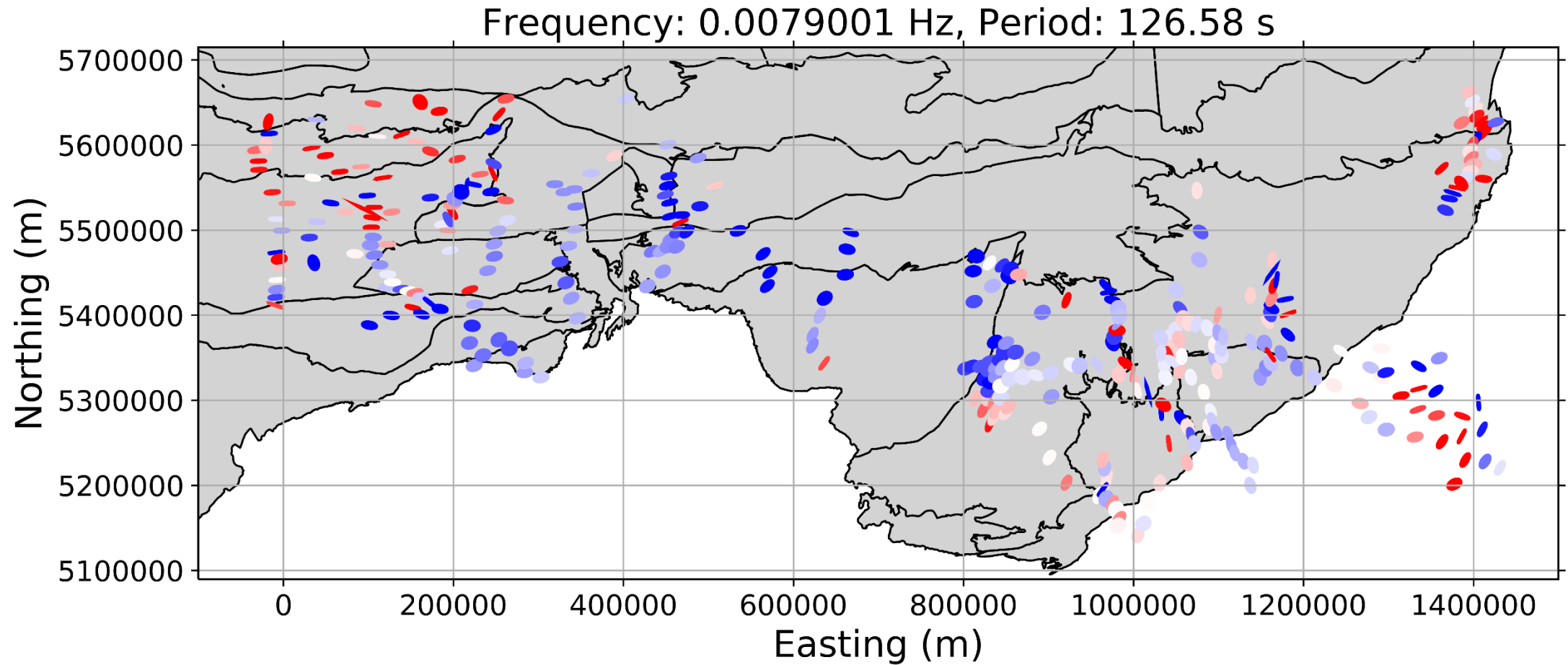
Phase Tensors



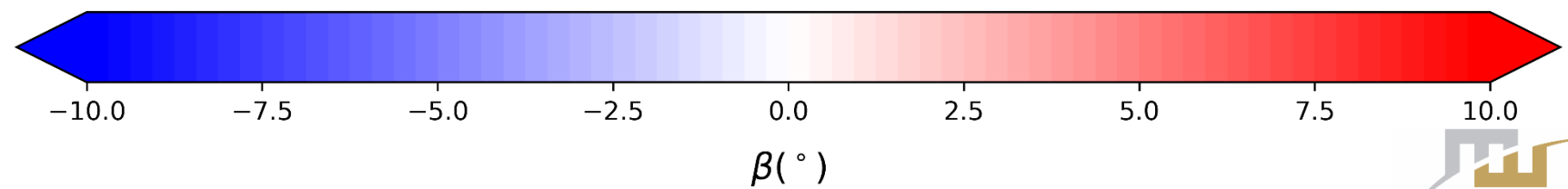
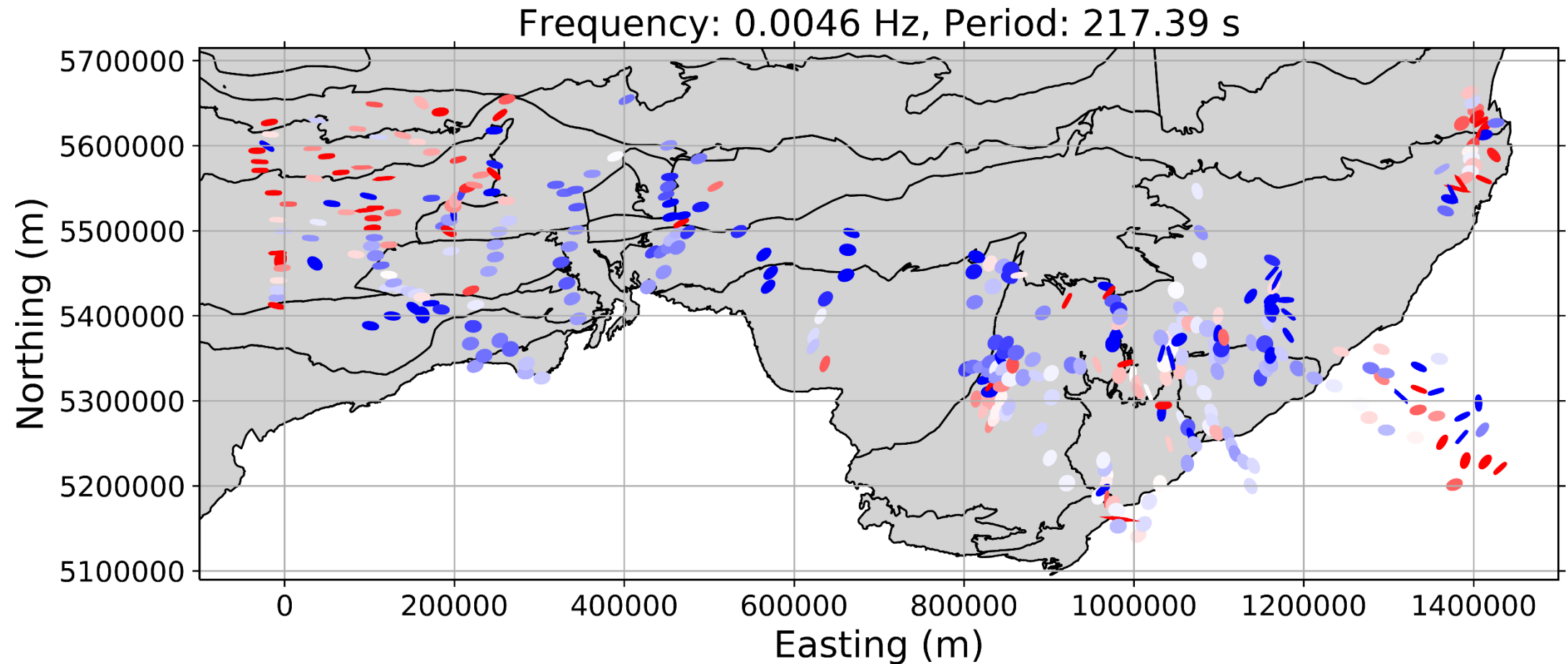
Phase Tensors



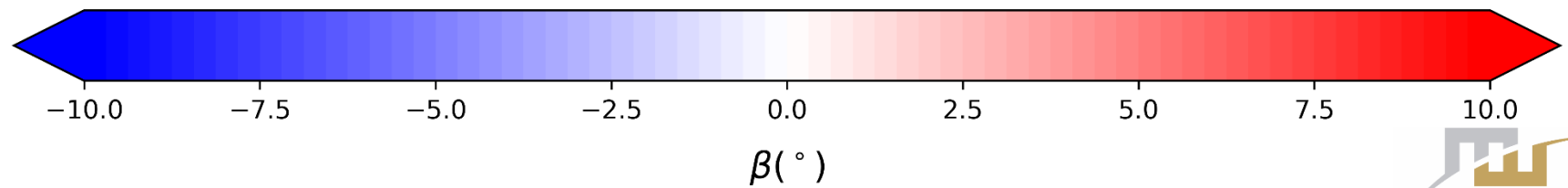
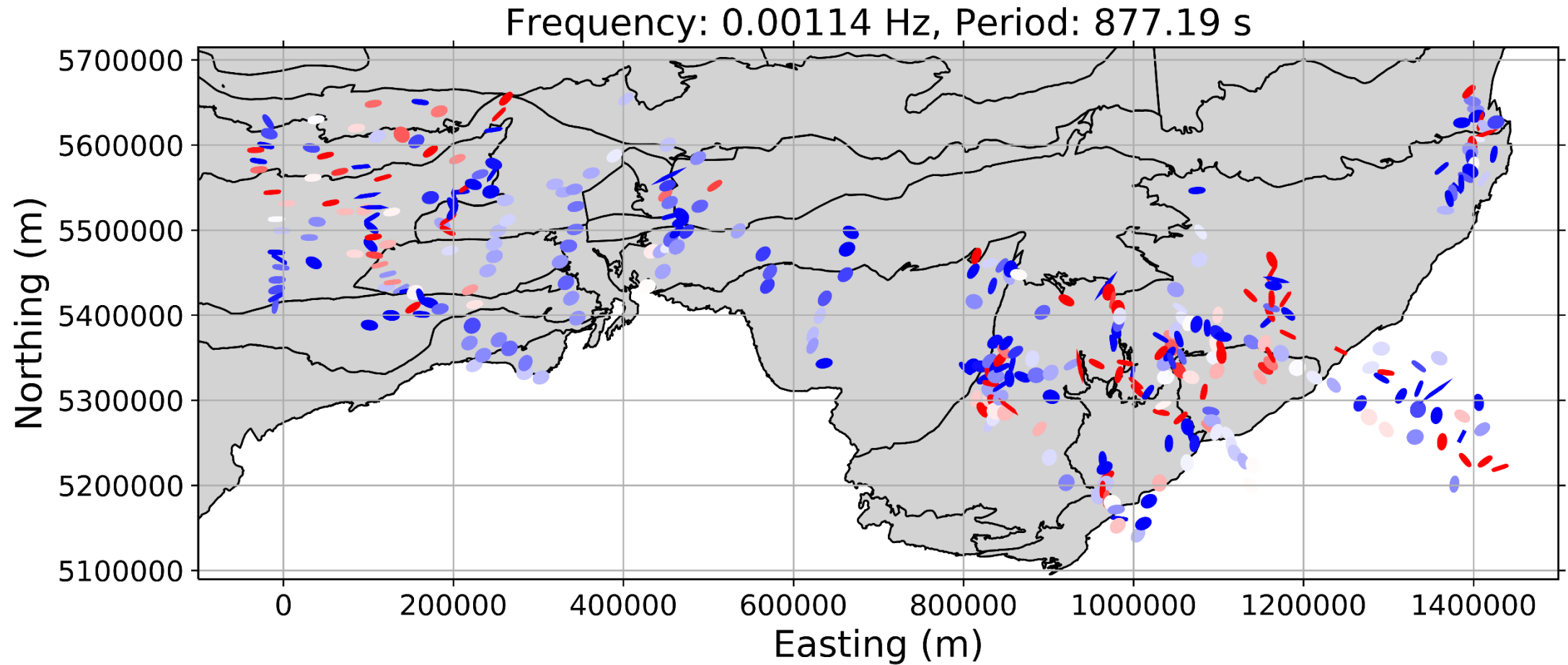
Phase Tensors



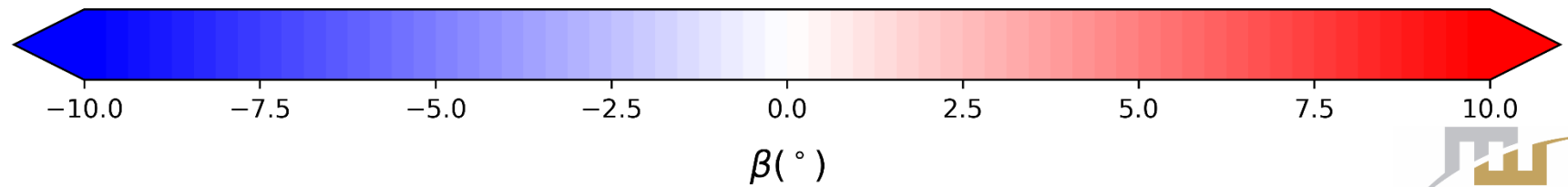
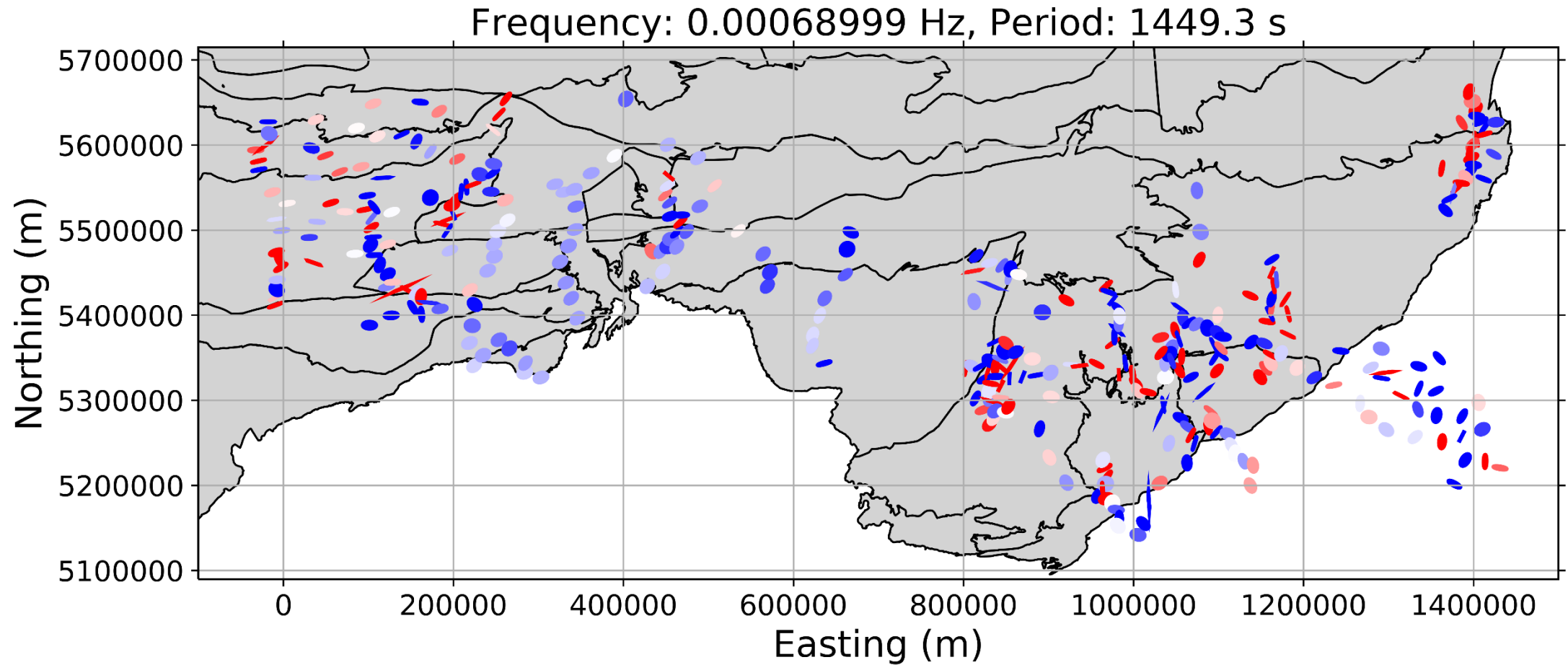
Phase Tensors



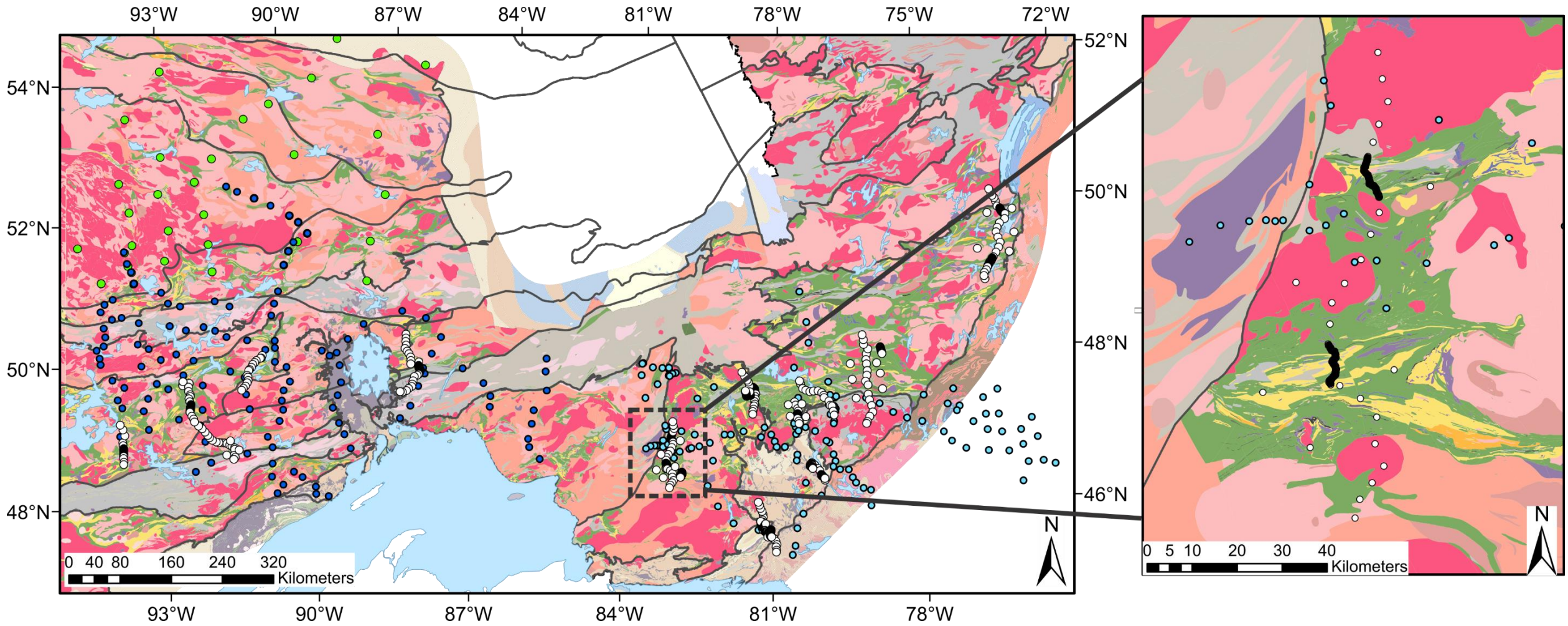
Phase Tensors



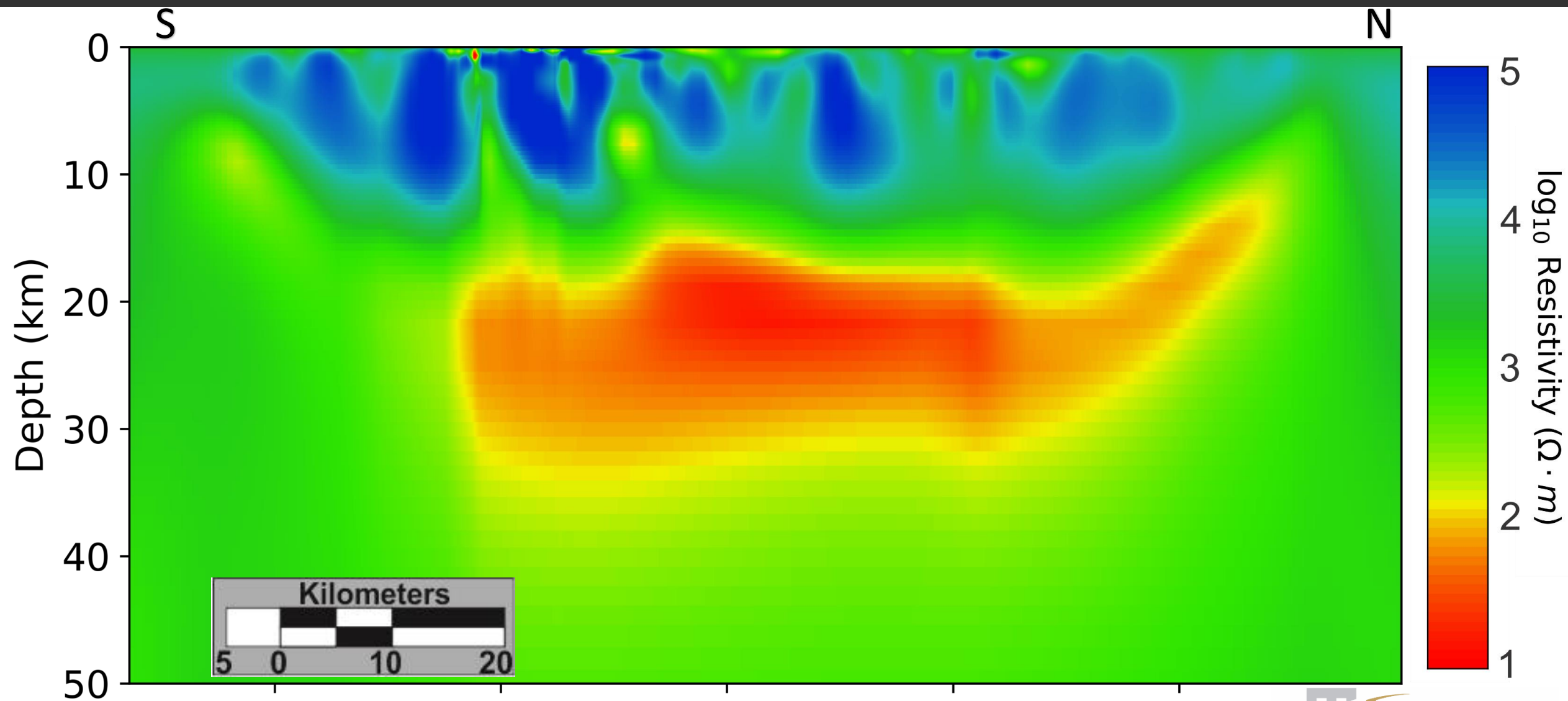
Phase Tensors



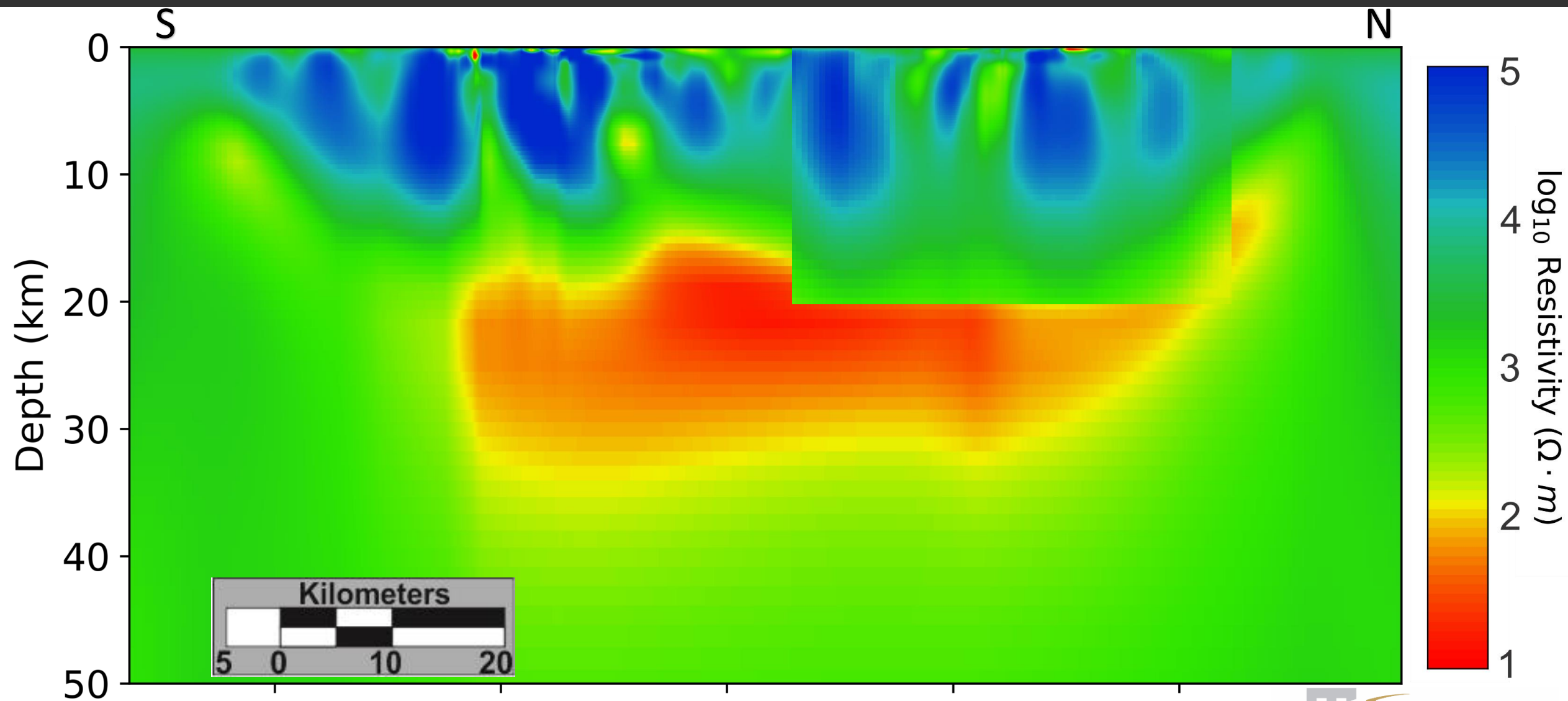
Results - Swayze



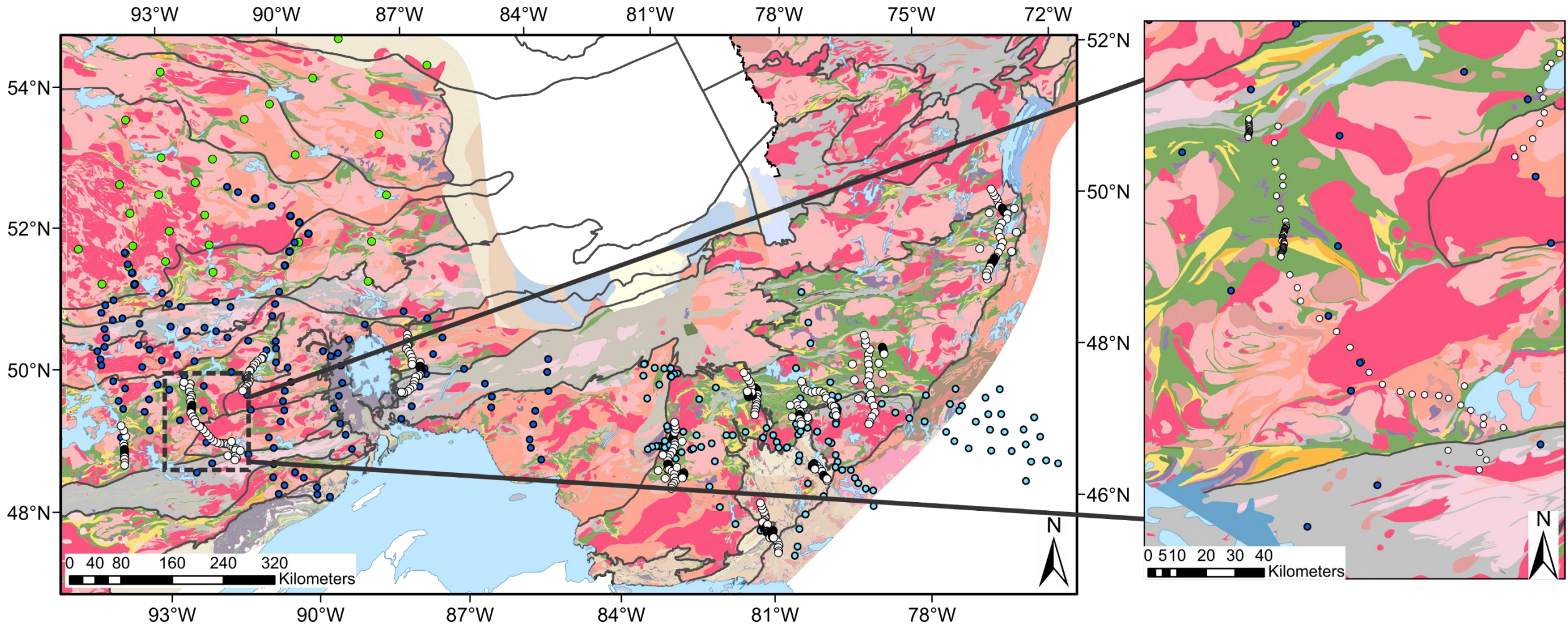
Results - Swayze



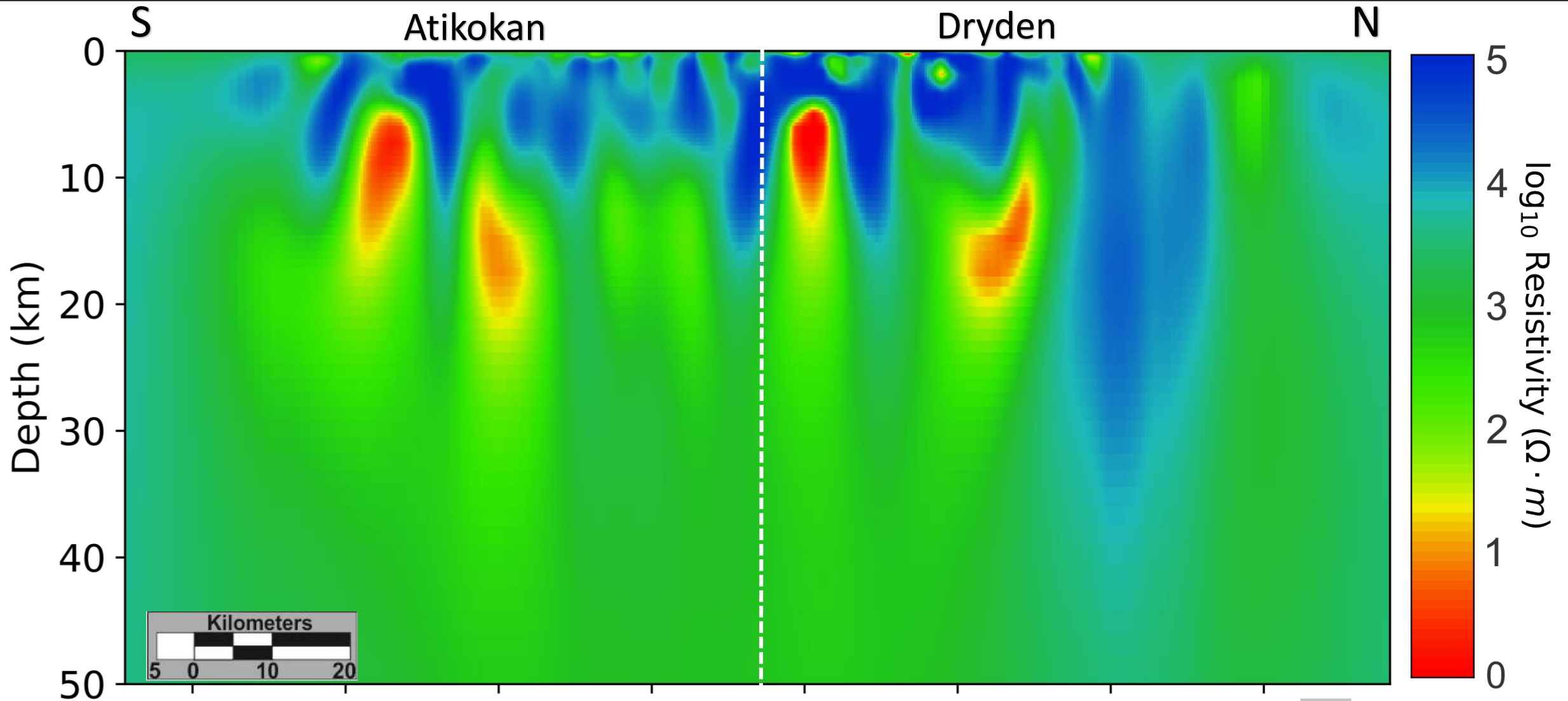
Results - Swayze



Results – Dryden / Atikokan



Results – Dryden / Atikokan



Summary

- 750 stations collected + ~300 legacy stations
 - Coverage across the Superior with depths of investigation from upper crust to upper mantle
- 1st-order analysis of the data indicates a fairly resistive upper to mid crust and less resistive lower crust / upper mantle
- MT data is 3-D, necessitating the use of 3-D analysis and inversion techniques
- Early inversion results from the Swayze and Dryden-Atikokan transects show differing geo-electric structure between the east and west Superior
 - Swayze: Sub-horizontal conductor in the mid to lower crust spanning the transect
 - Dryden-Atikokan: Set of discrete vertical conductors in the mid crust

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