

# DEFINING THE NORTH AMERICAN - SOUTH AMERICAN PLATE BOUNDARY AT THE ANTILLES SUBDUCTION ZONE - FIRST GRAVIMETRY RESULTS

**Anna Czachor**

**Johanna Klein, Frauke Klingelhoefer,**

**Peter Haas, Janine Berndt**

**M2 Internship**



02.07.2025





# Plan for Today

No conclusions to show... yet! But science takes time, therefore:



Historical Views on the Plate Boundary Location



Revisiting the Boundary: Insights from the Demerara Plateau



Internship Goals



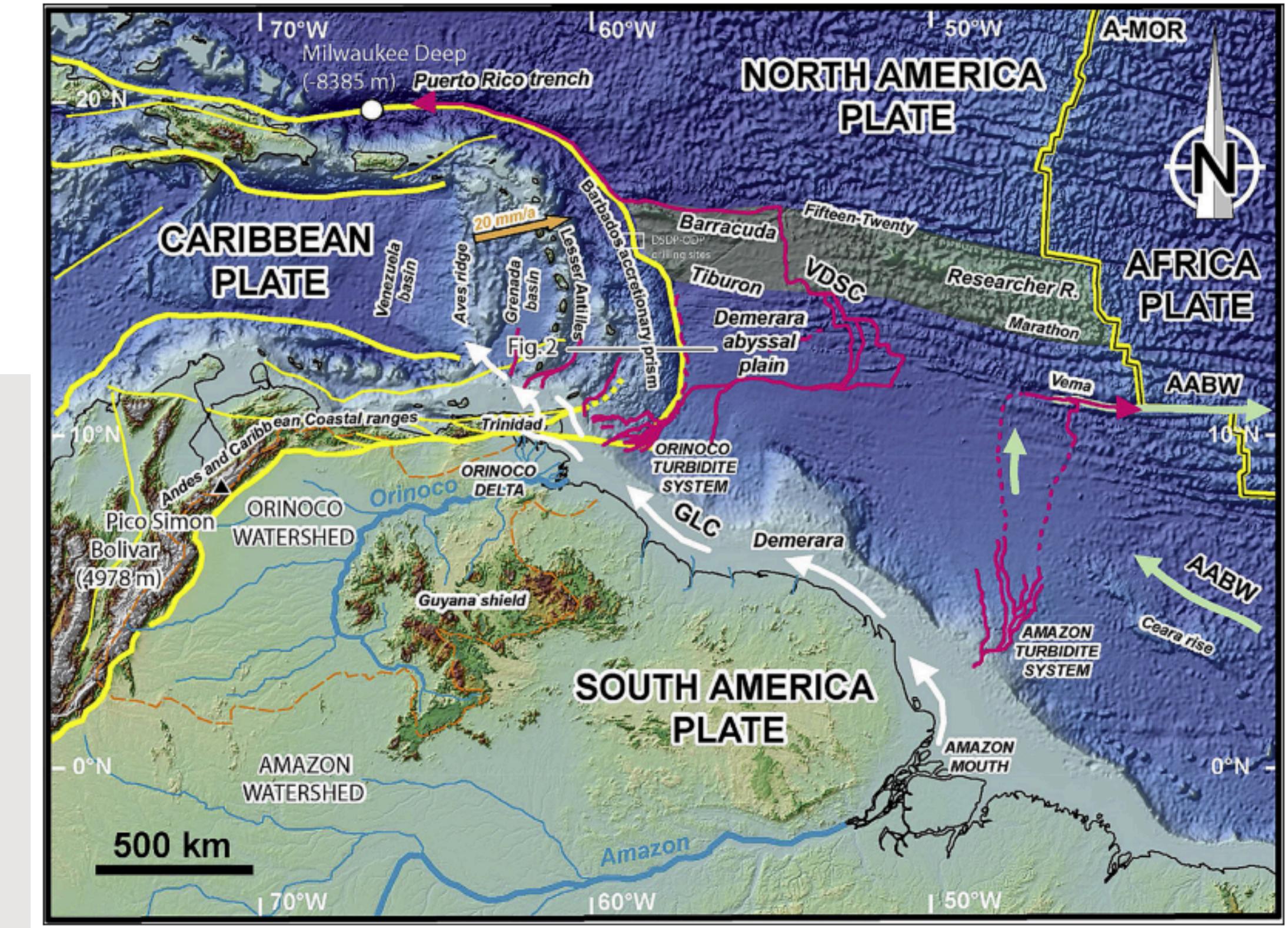
Processing steps and first results

# Historical Views on the Plate Boundary Location

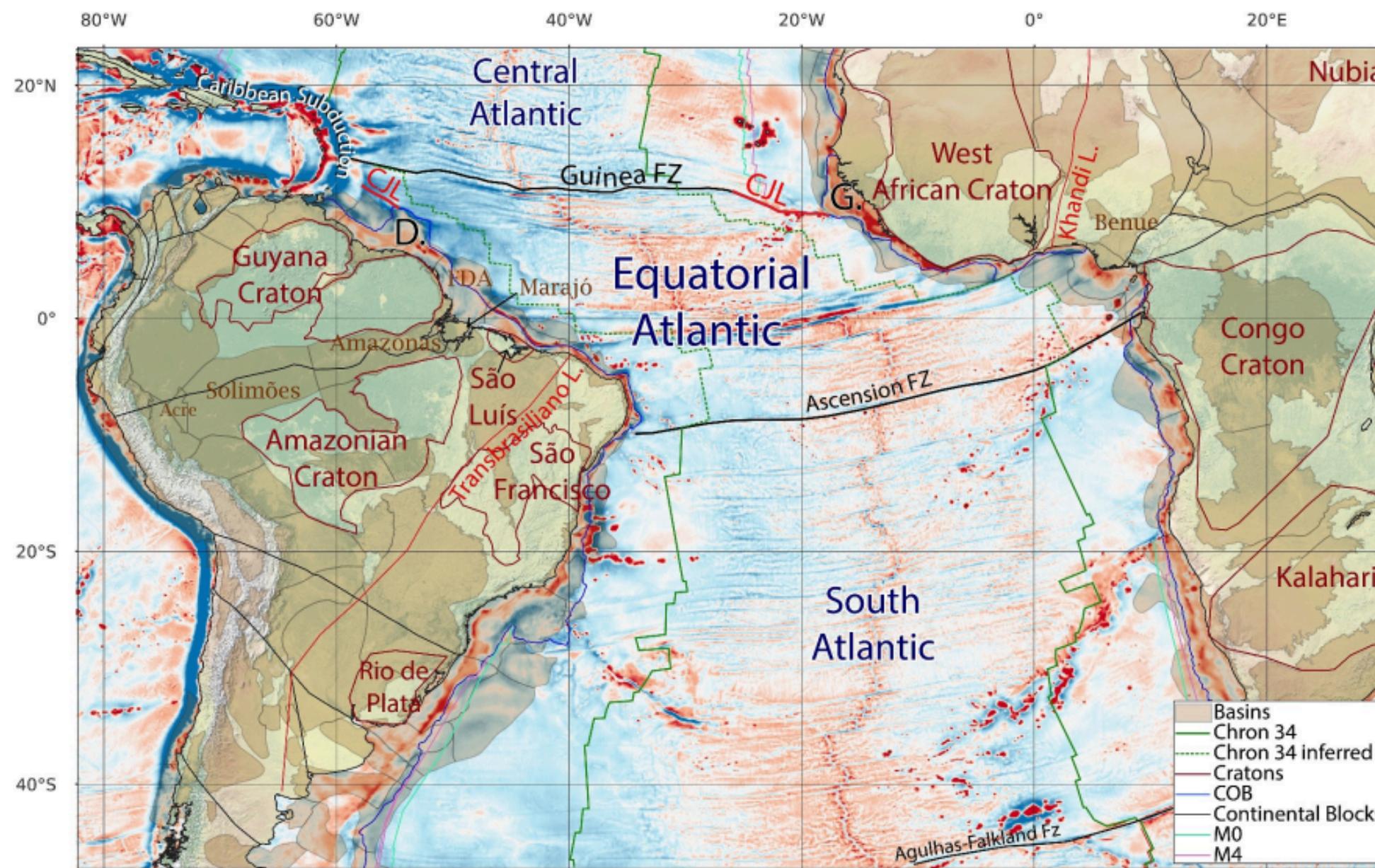


From Deville et al. (2015)

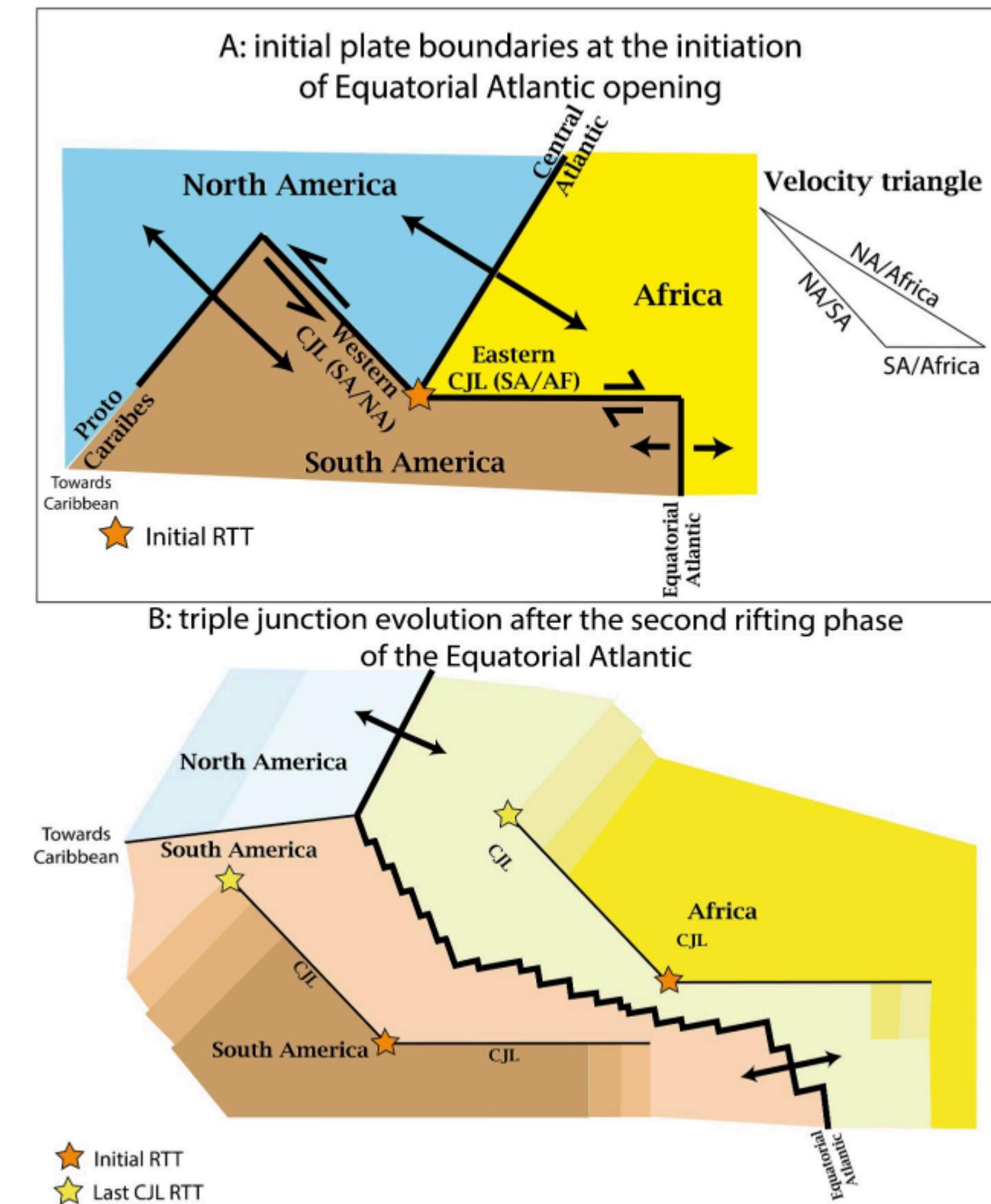
- Ball & Harrison (1970): Near 20°N
- Vogt & Perry (1981): Closer to 13°N
- Le Douaran & Francheteau (1981): Also near 13°N
- Roest & Collette (1986): Proposed northward migration from ~8°N to ~16°N (around 7 Ma)
- Patriat et al. (2011); Deville et al. (2015): Described the present-day boundary as a broad deformation zone, ~200 km wide, involving features like the Barracuda Ridge and Tiburon Rise

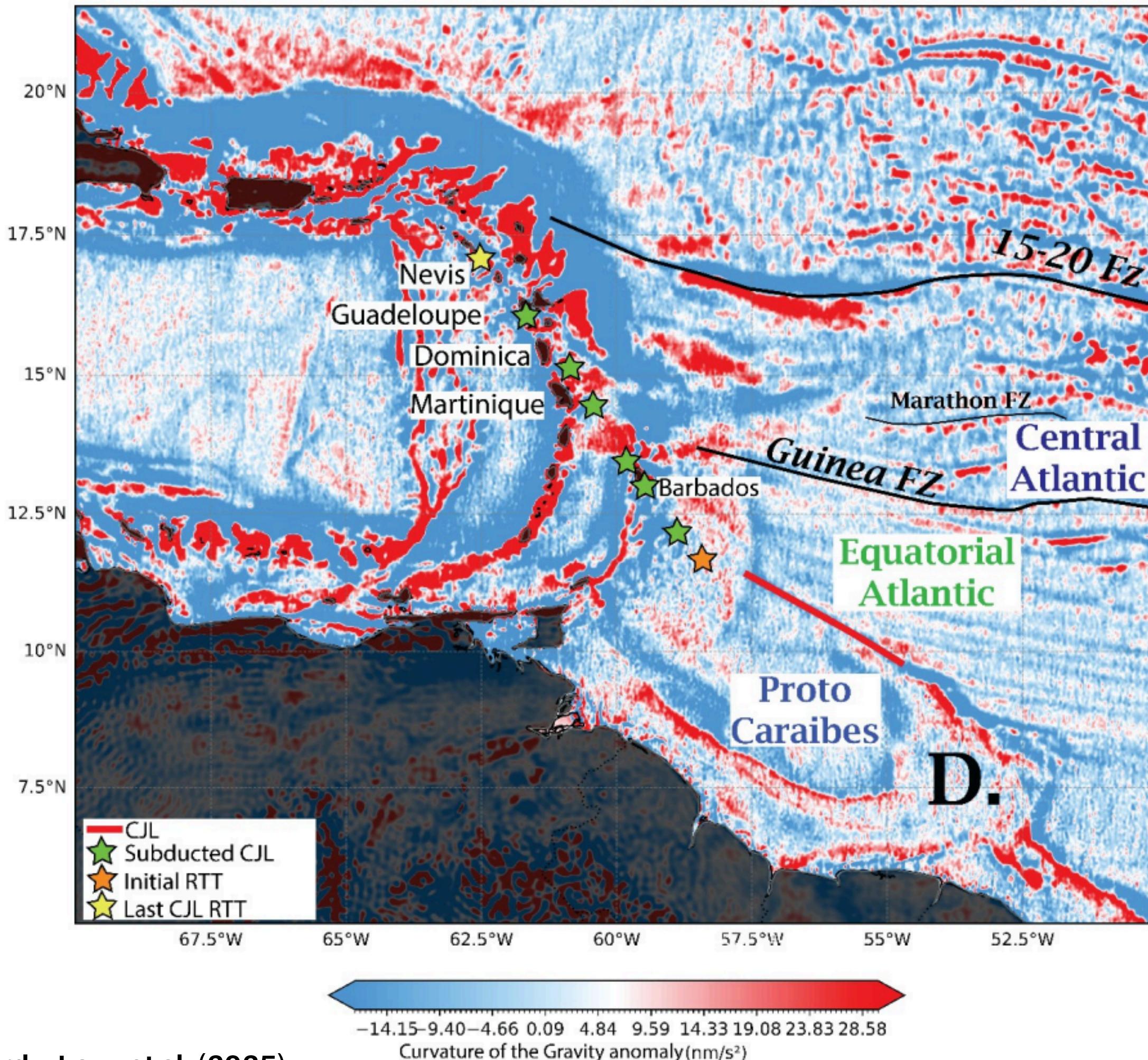


# Revisiting the Boundary: Insights from the Demerara Plateau



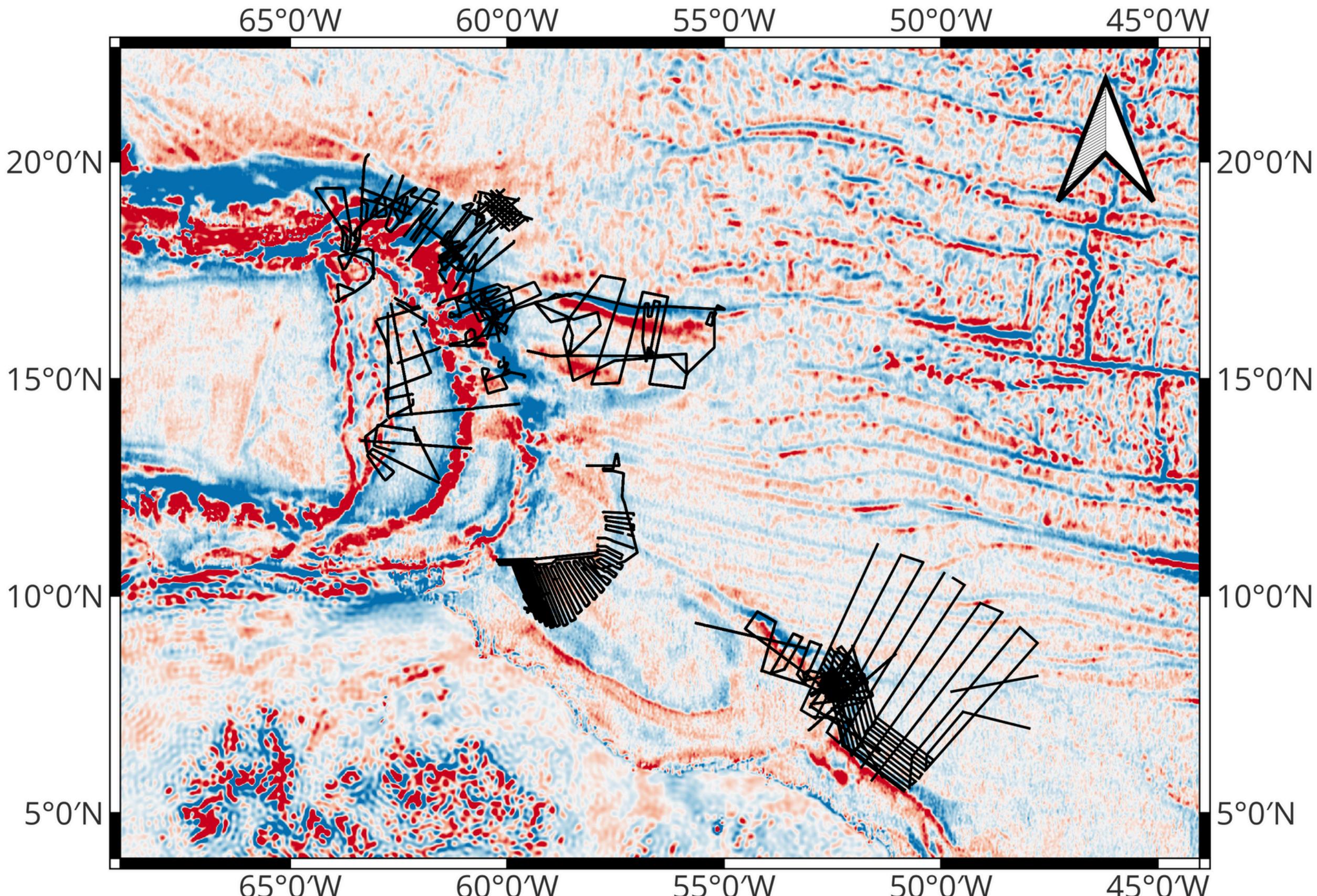
From Lesourd—Laux et al. (2025)



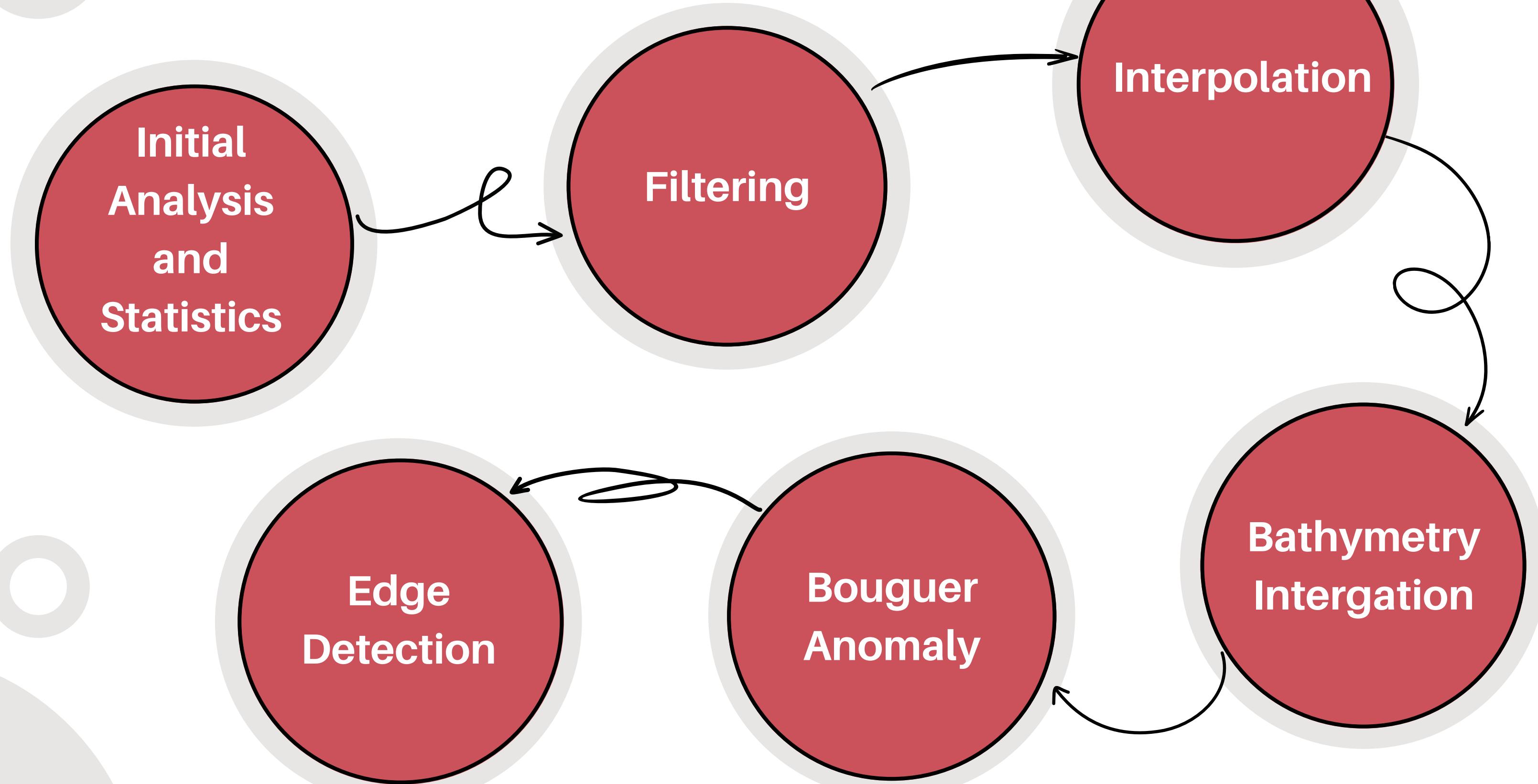


# Internship Goals

- 1) Calculate **Bouguer gravity anomalies**
- 2) Apply **edge detection** to identify structural boundaries
- 3) Machine learning project
- 4) Integrate **2D gravity model** with existing **seismic profiles** and **earthquake data**

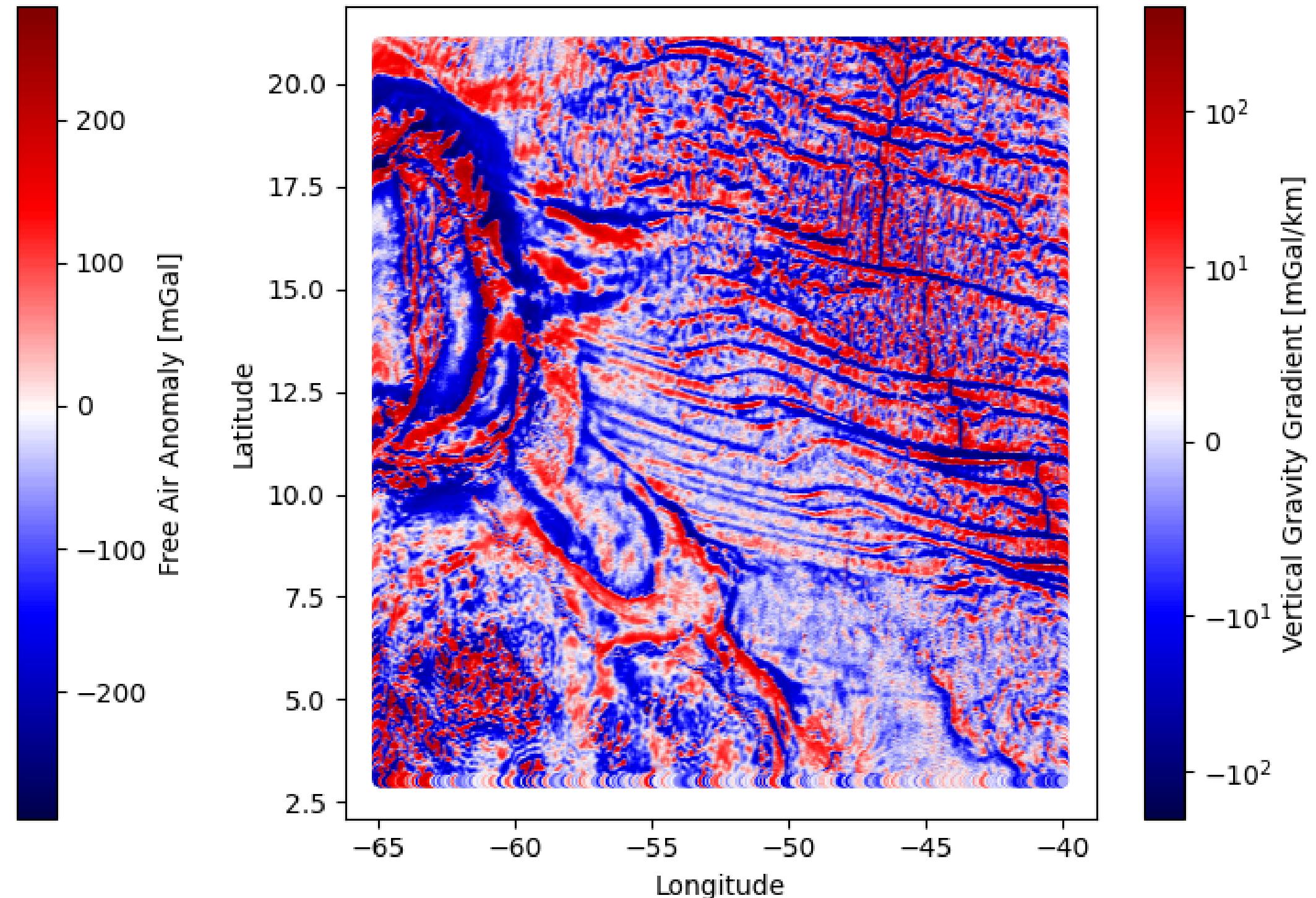
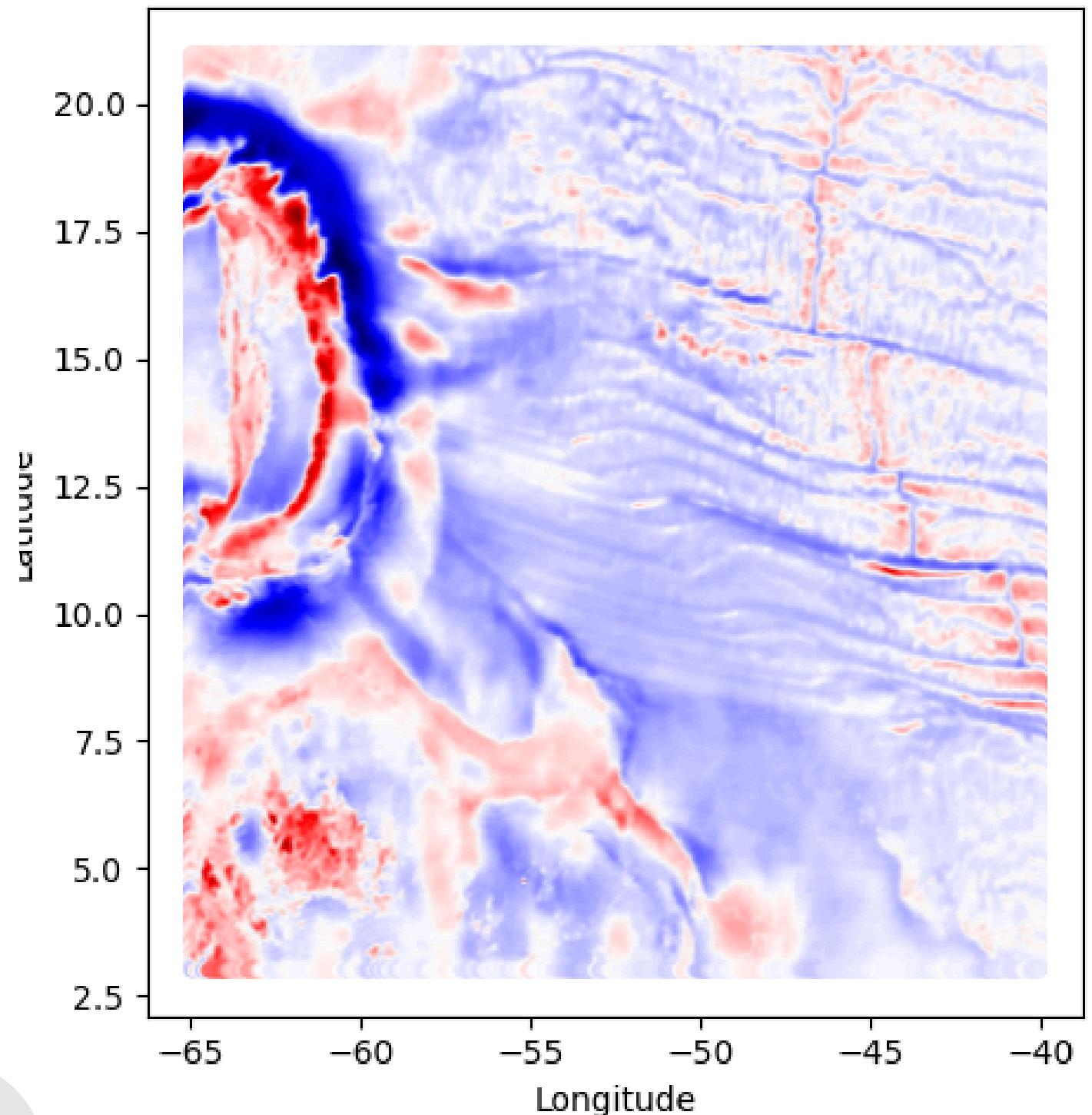


# Processing

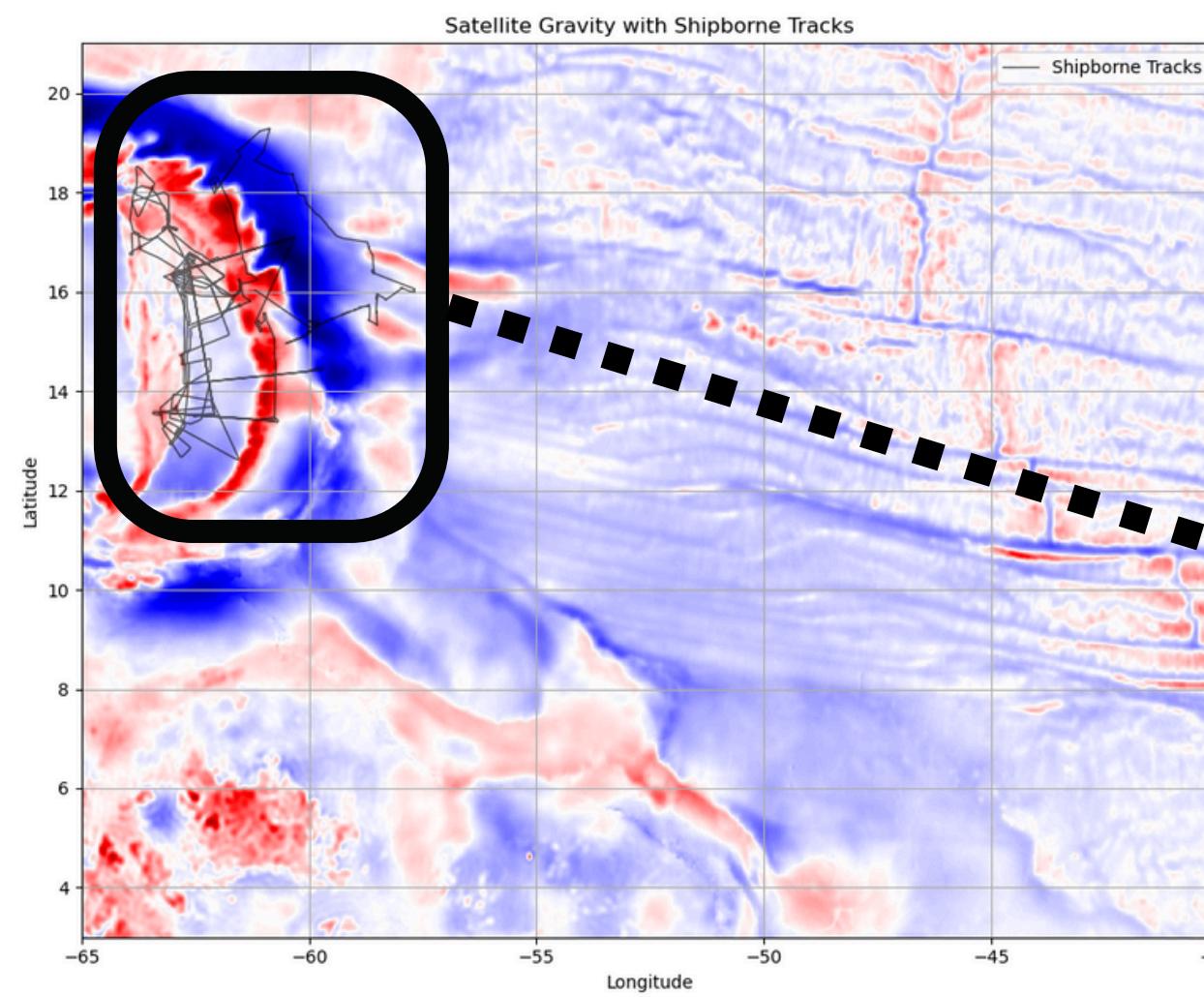


# Initial Analysis and Statistics

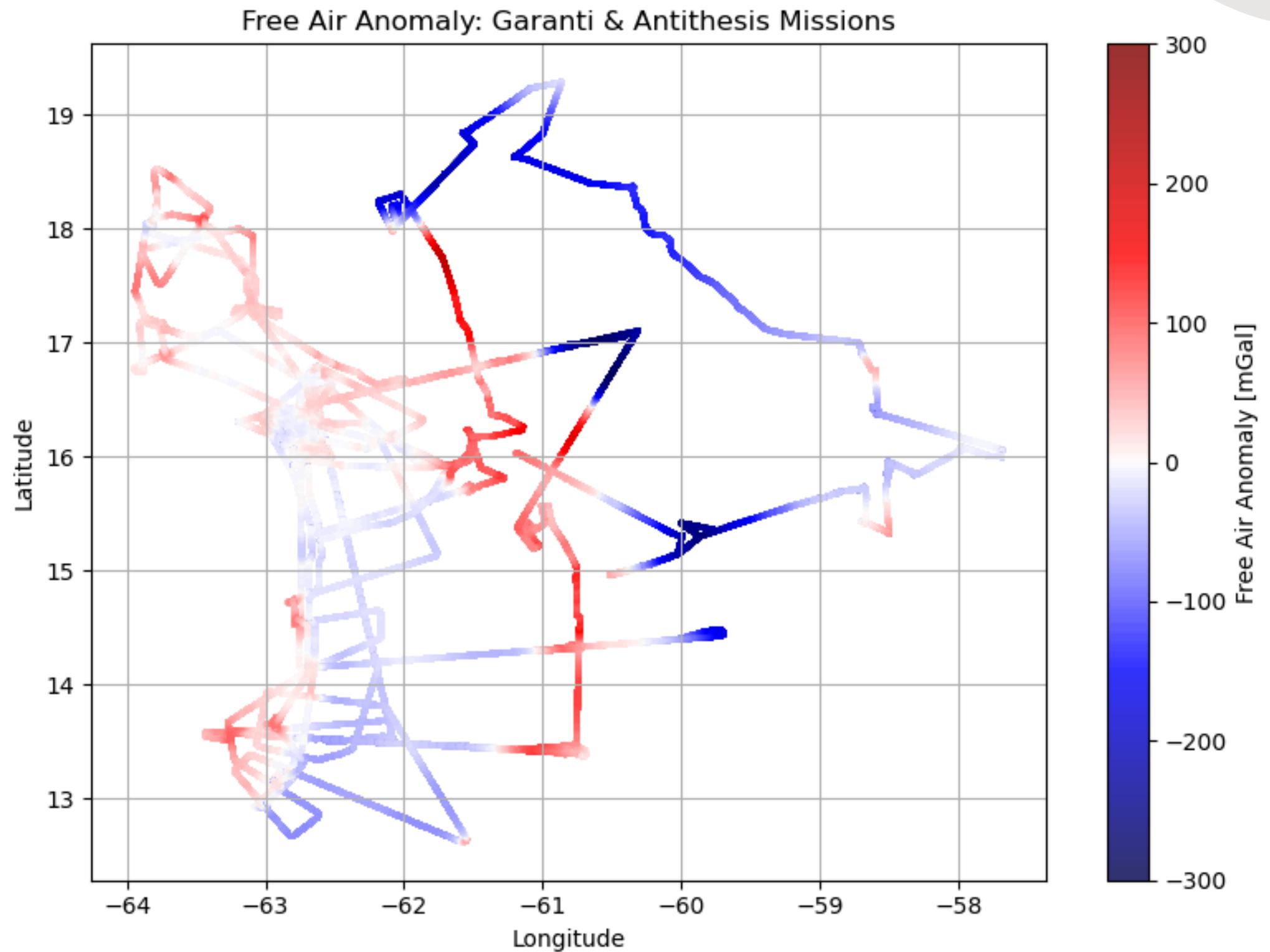
Satellite data from <https://topex.ucsd.edu> - SWOT 2024



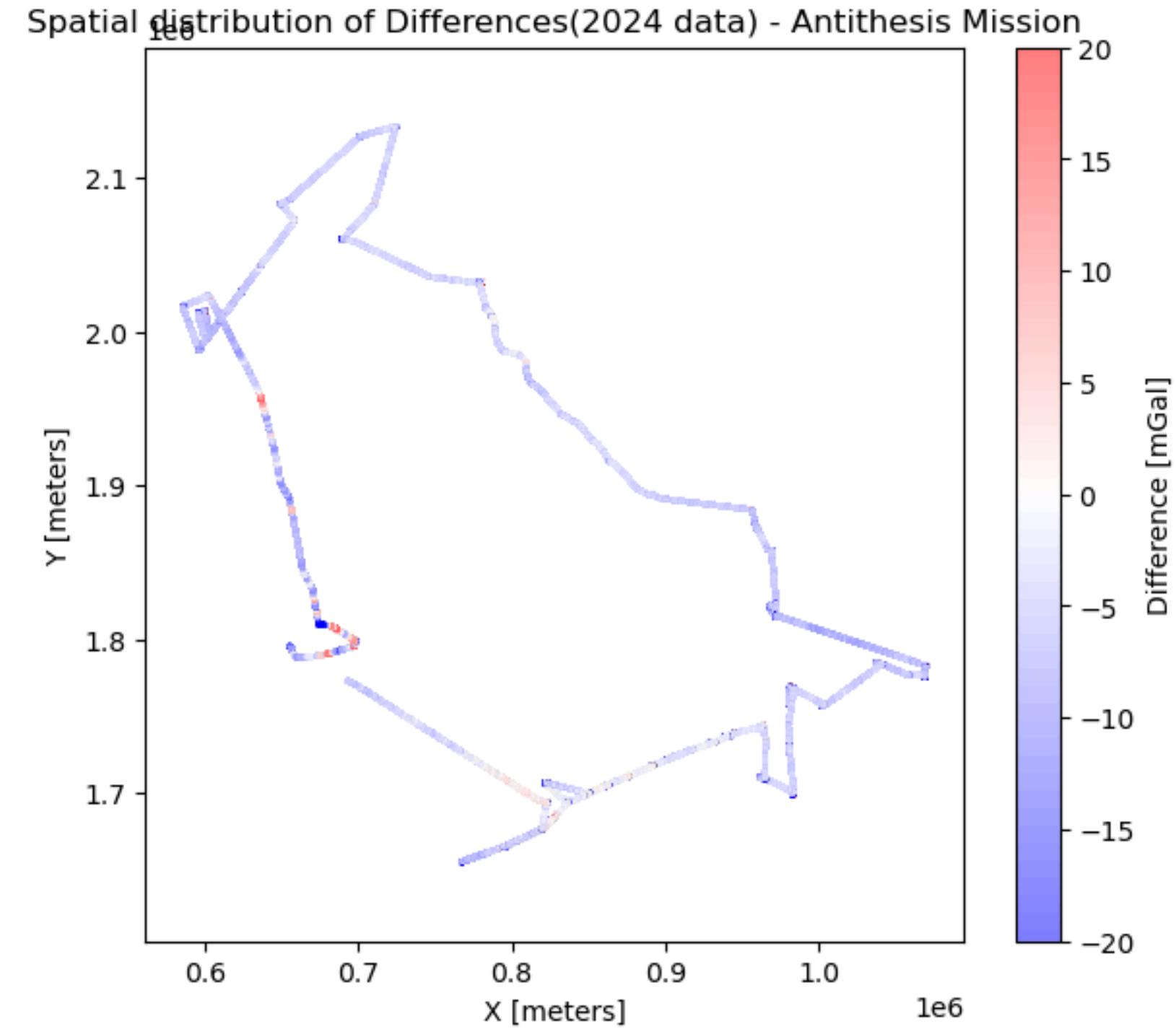
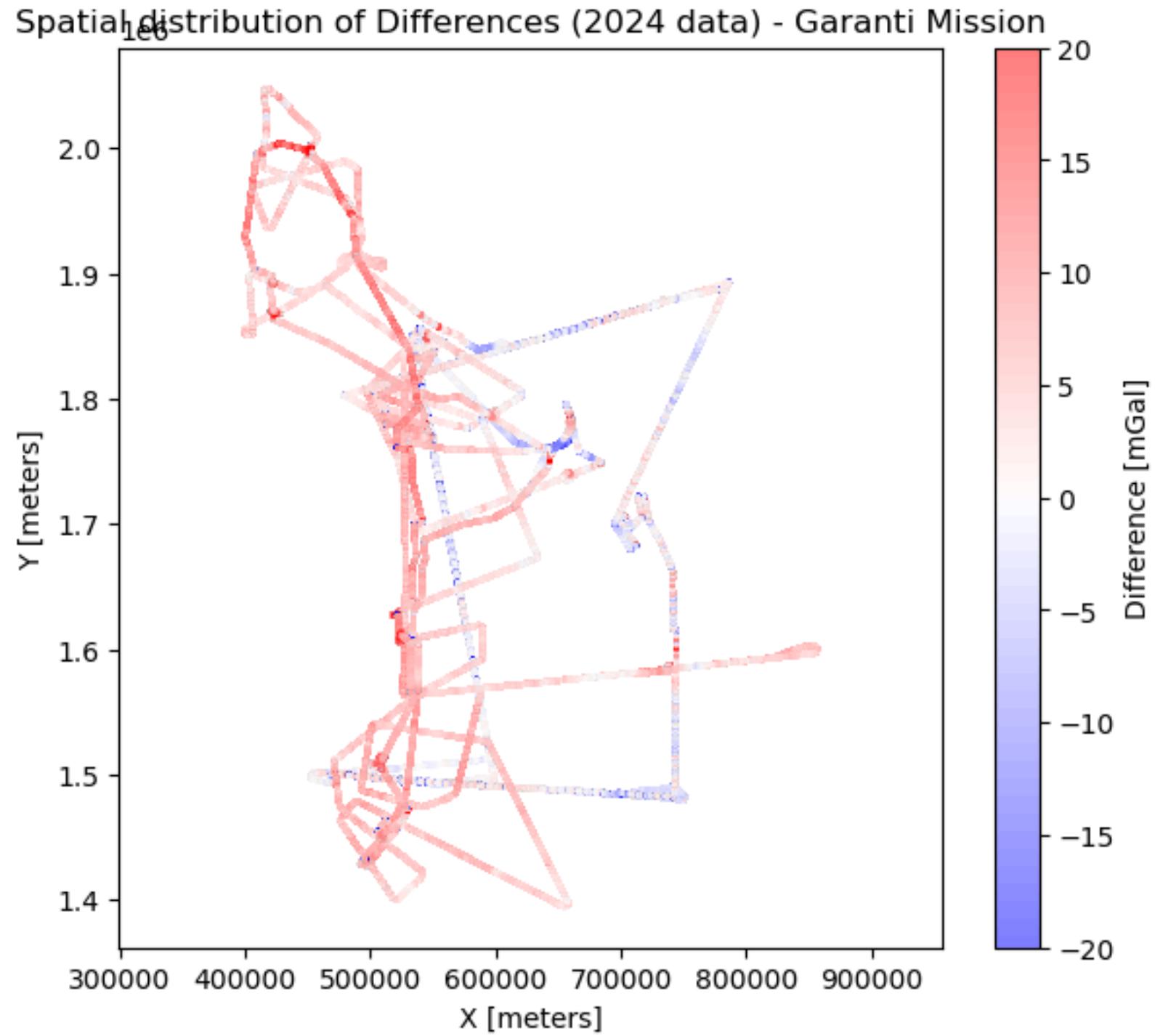
# Initial Analysis and Statistics



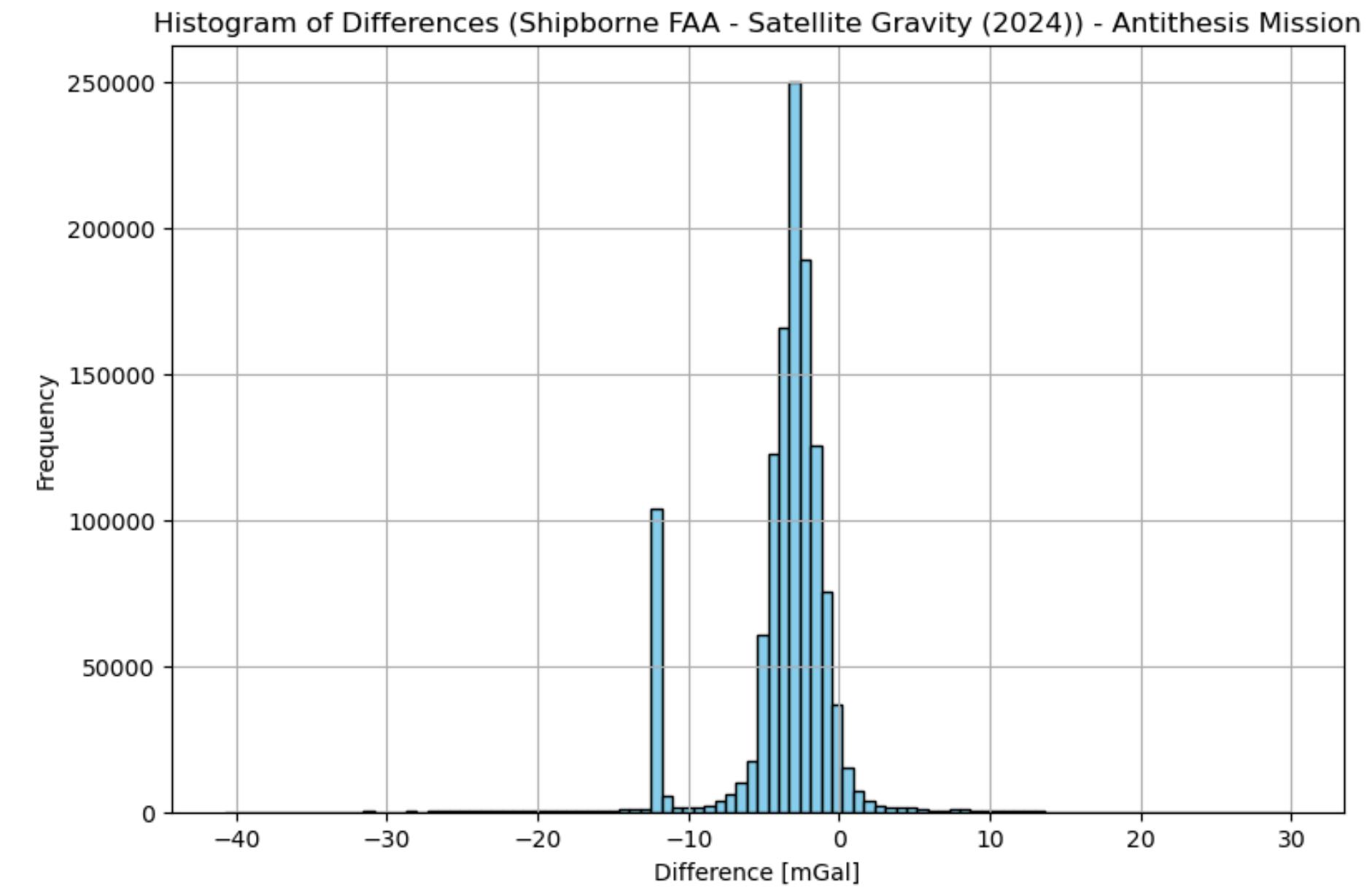
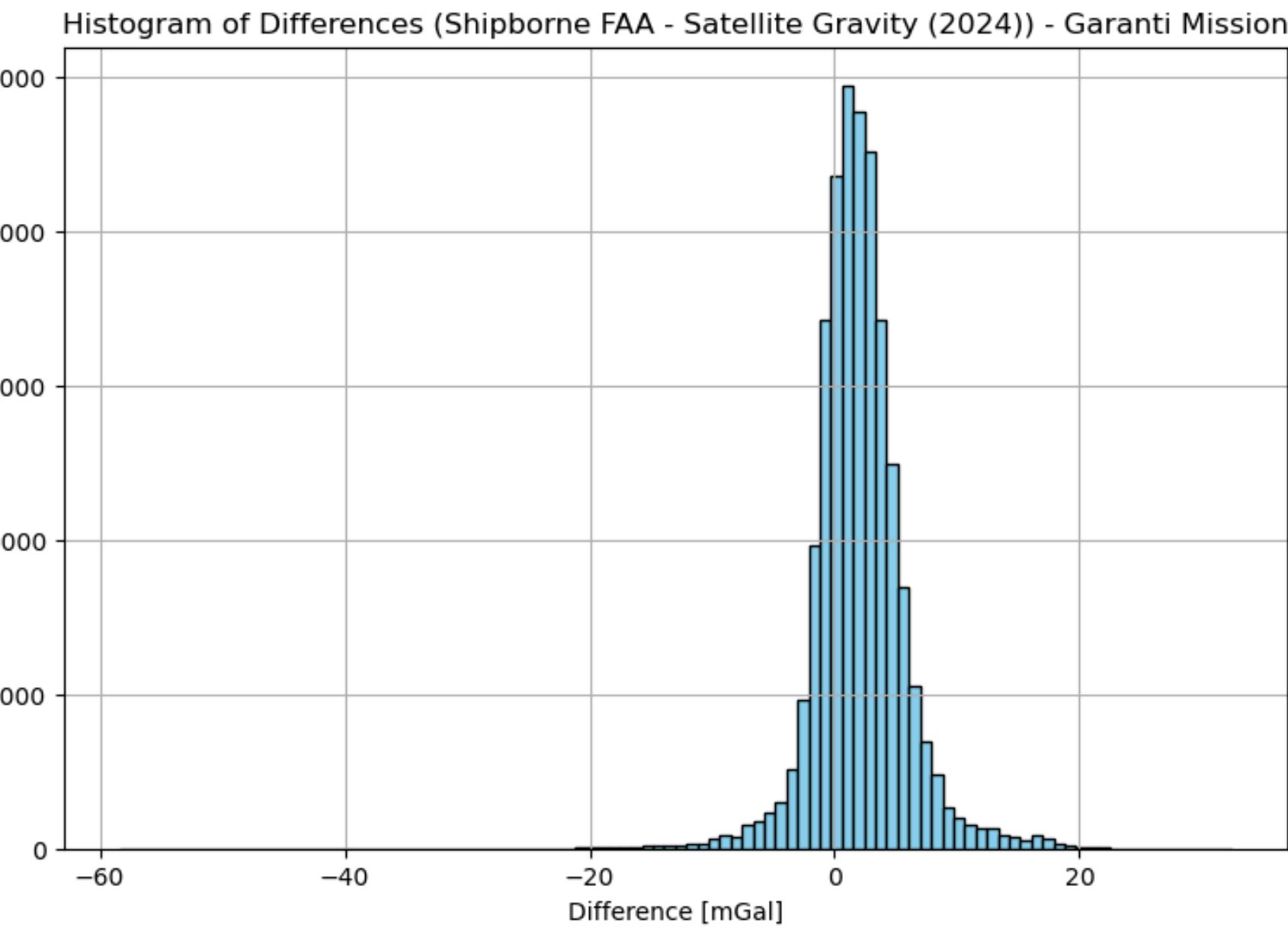
Shipborne data - 2016/2017 (Ifremer expeditions)



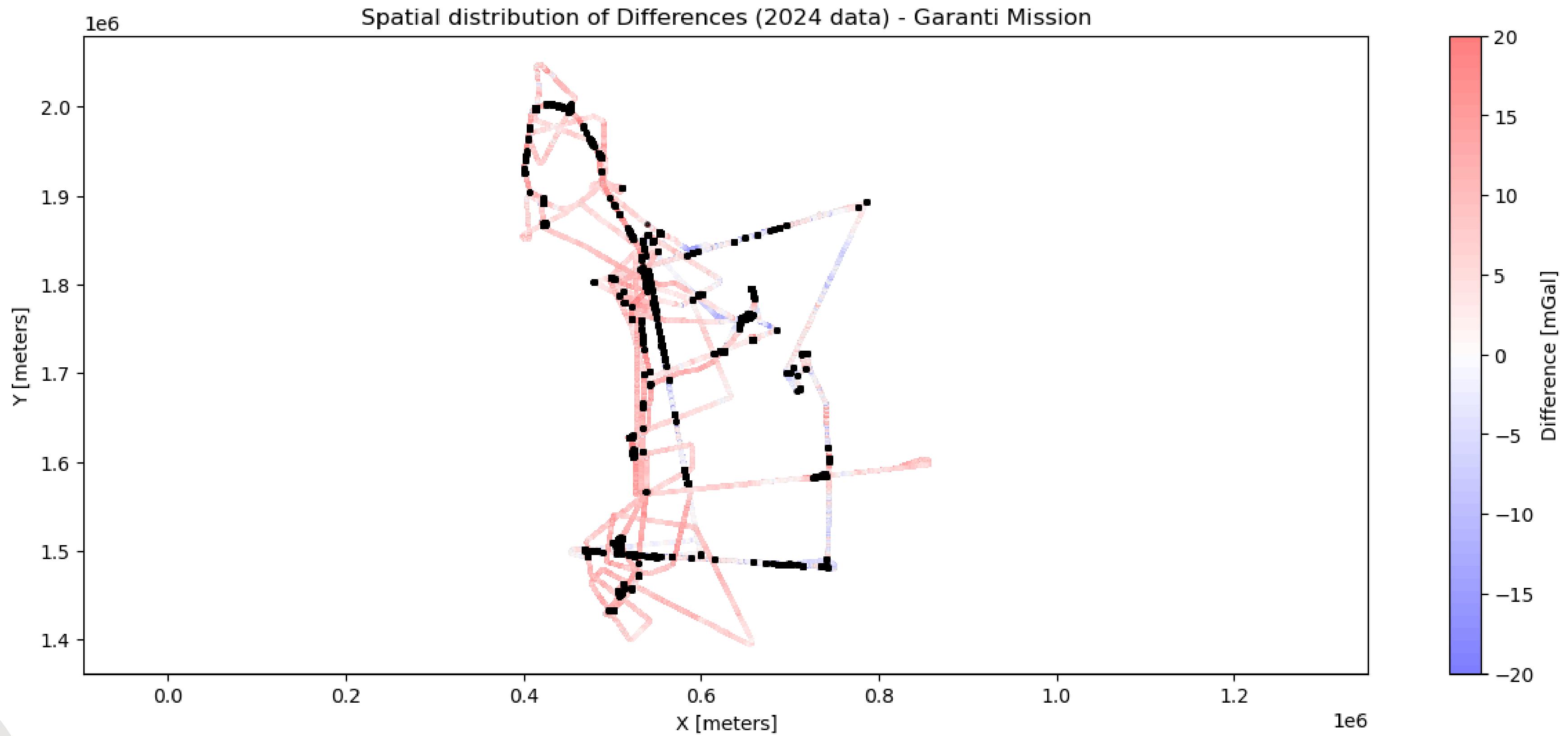
# Initial Analysis and Statistics



# Initial Analysis and Statistics

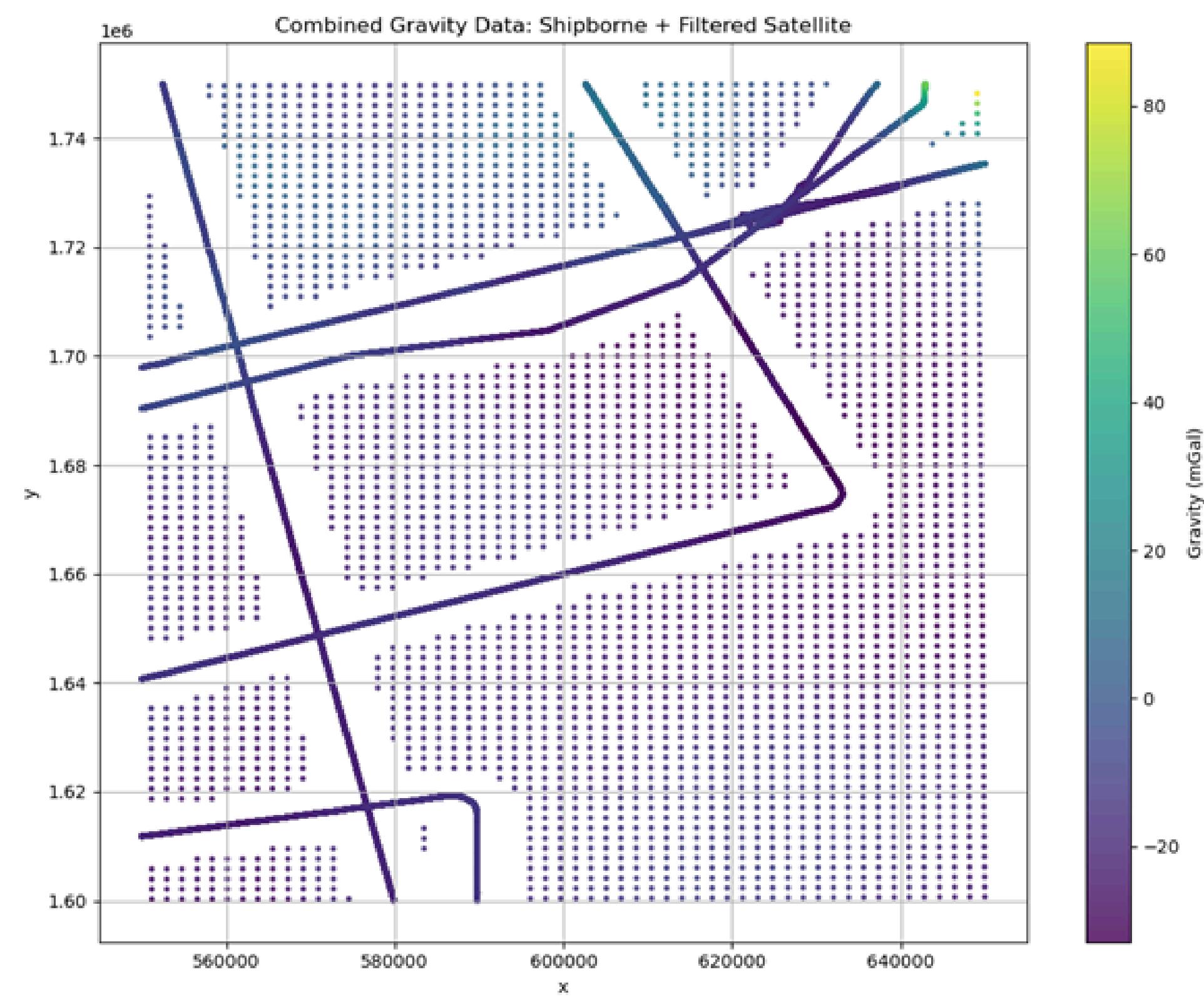
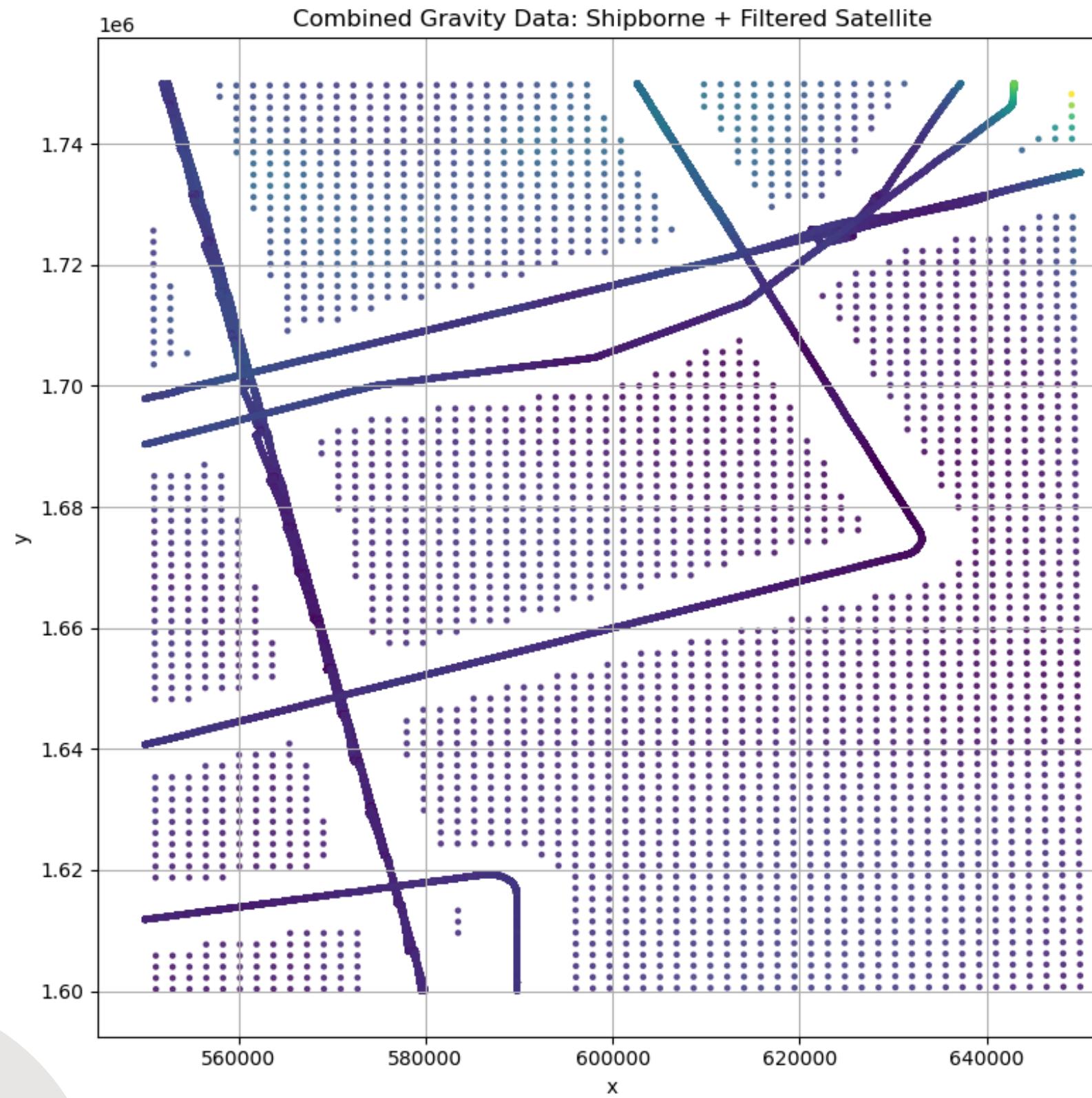


# Filtering



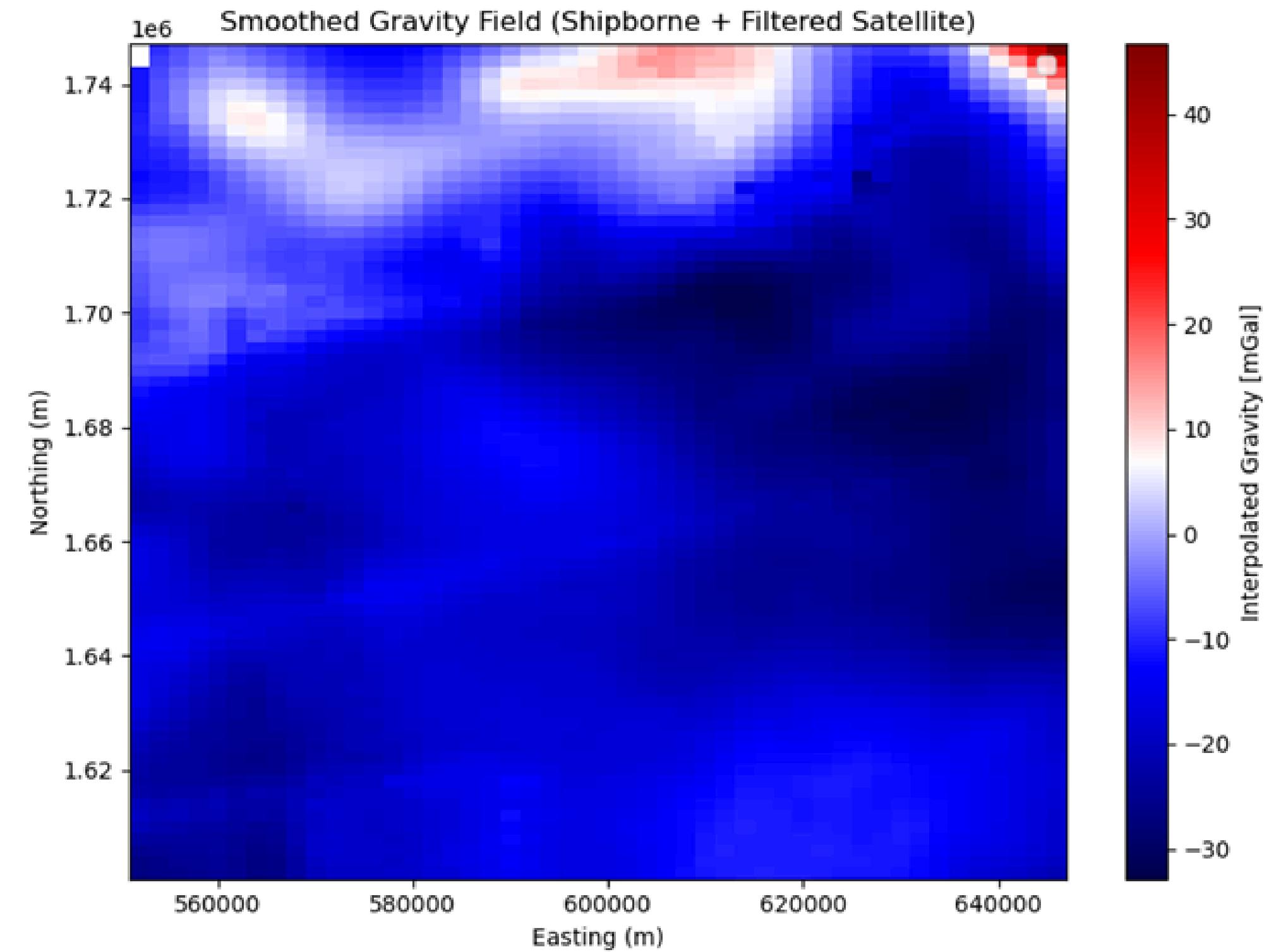
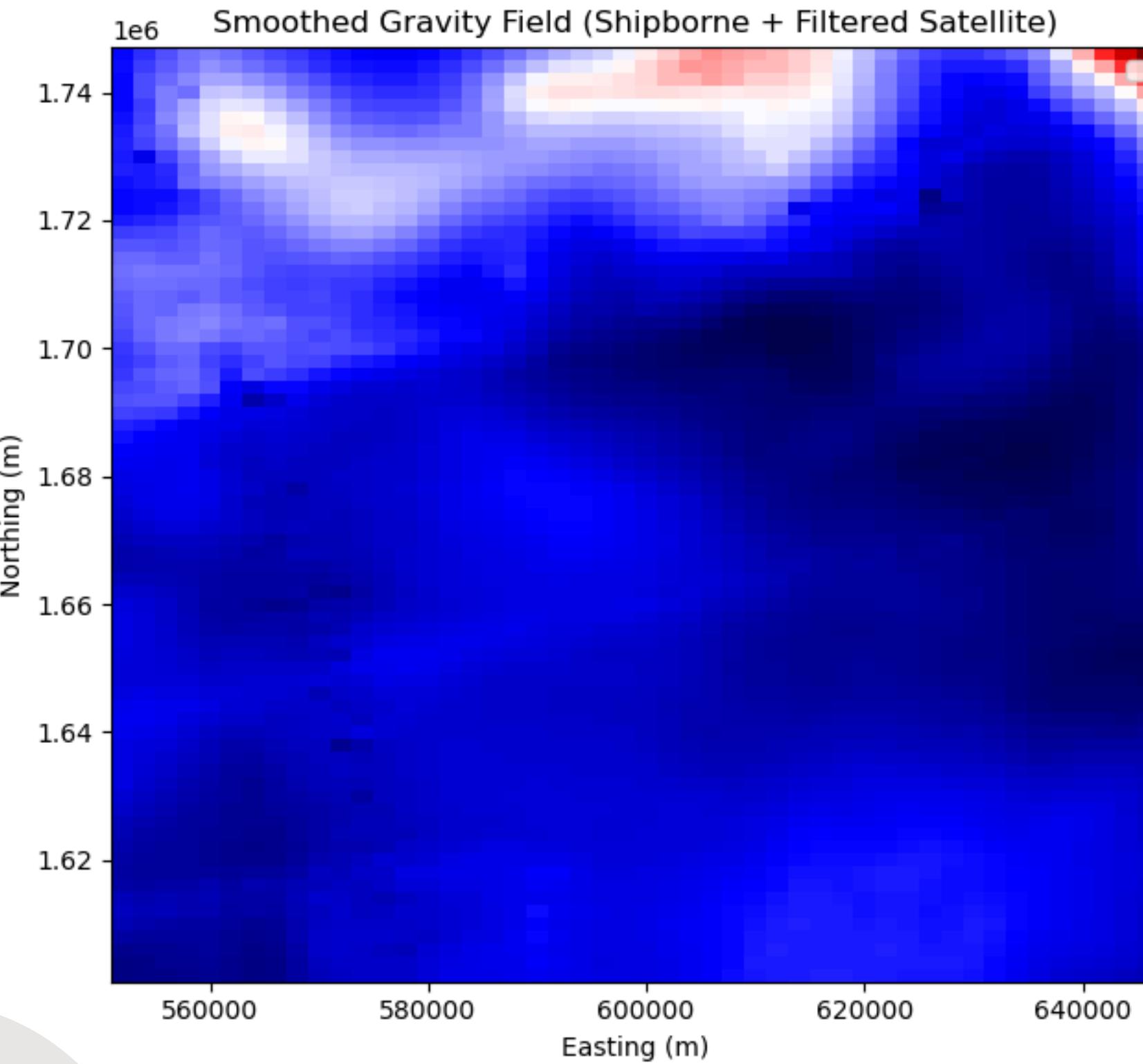
## 2

# Filtering

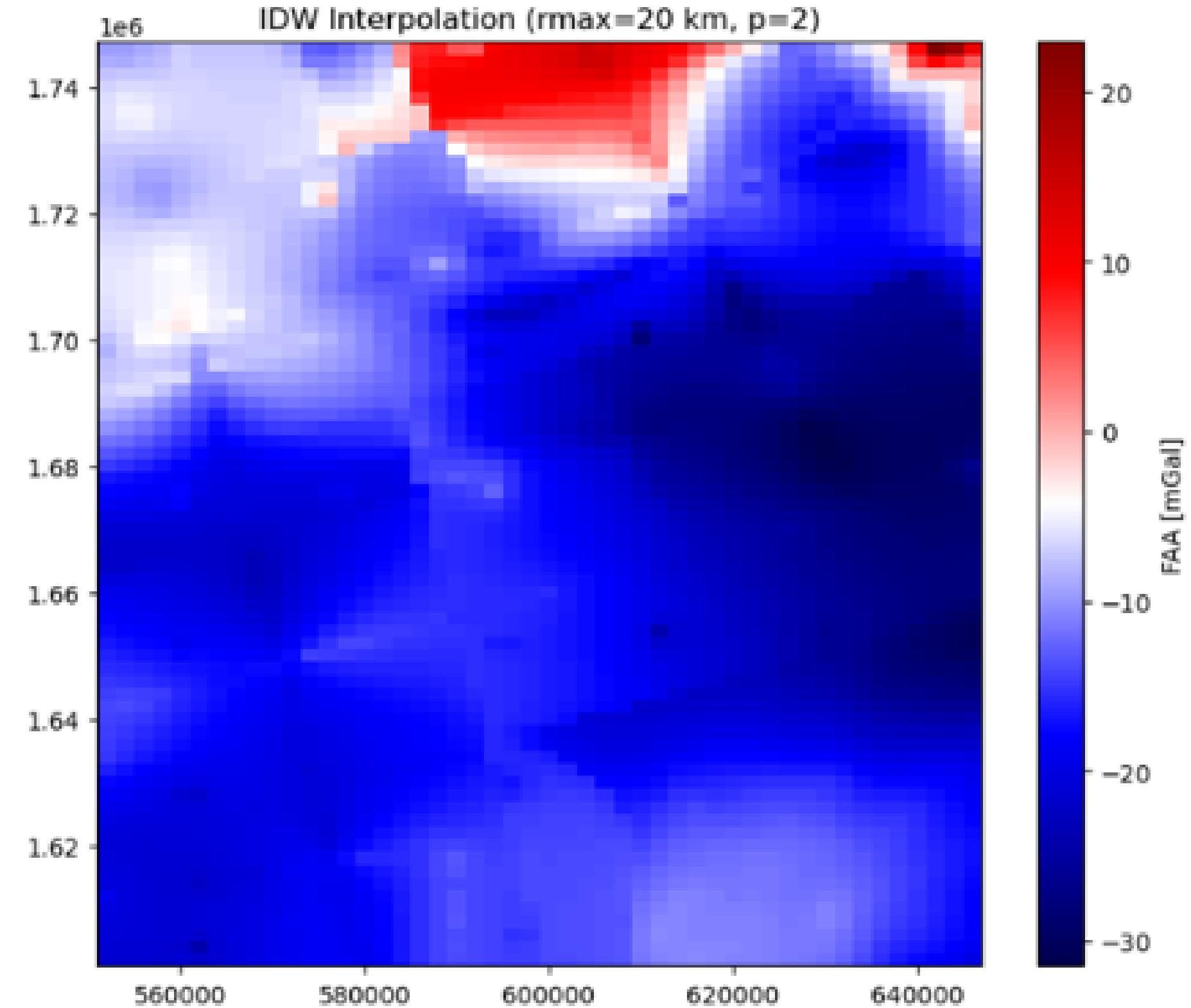
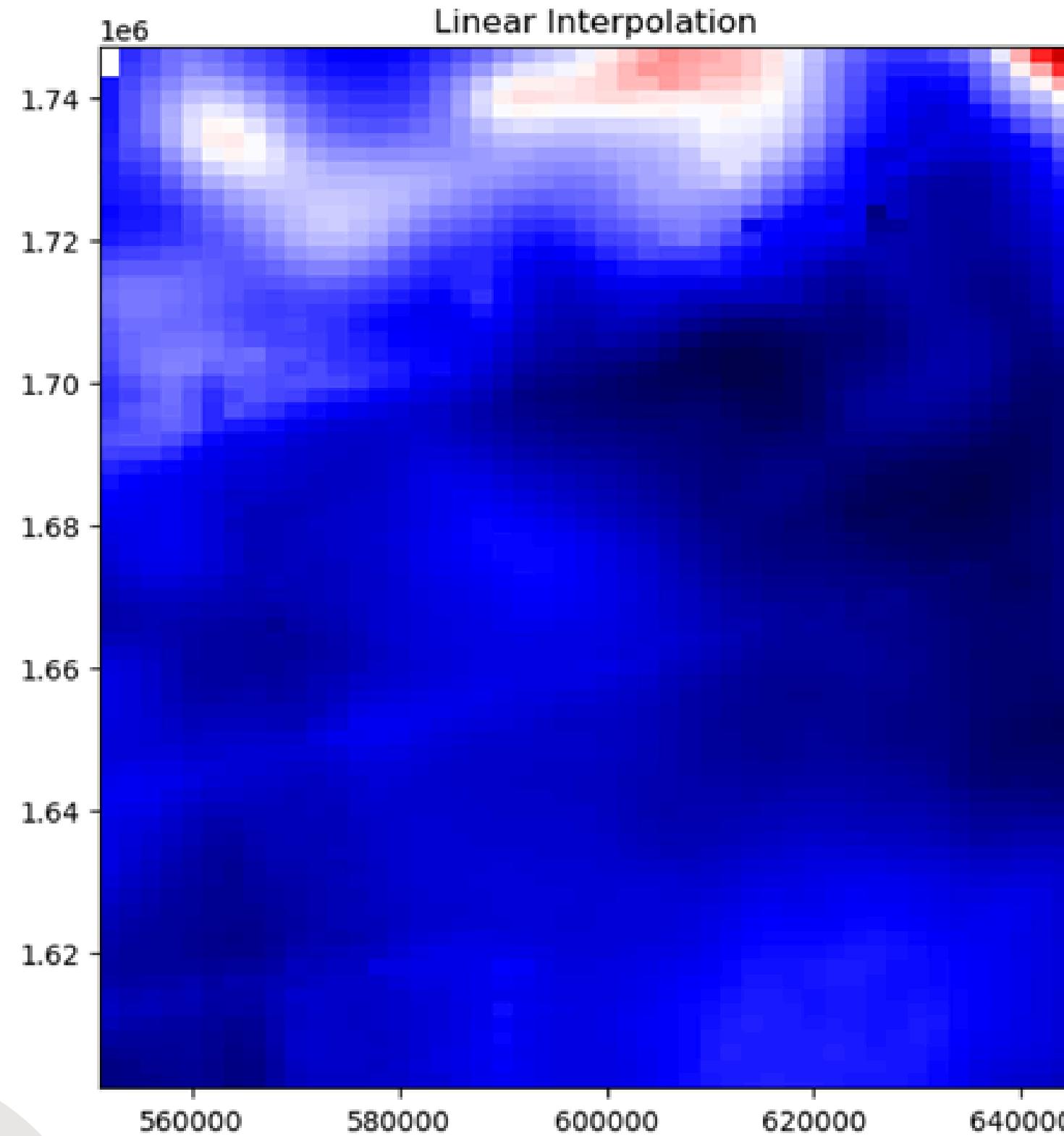


2

# Filtering

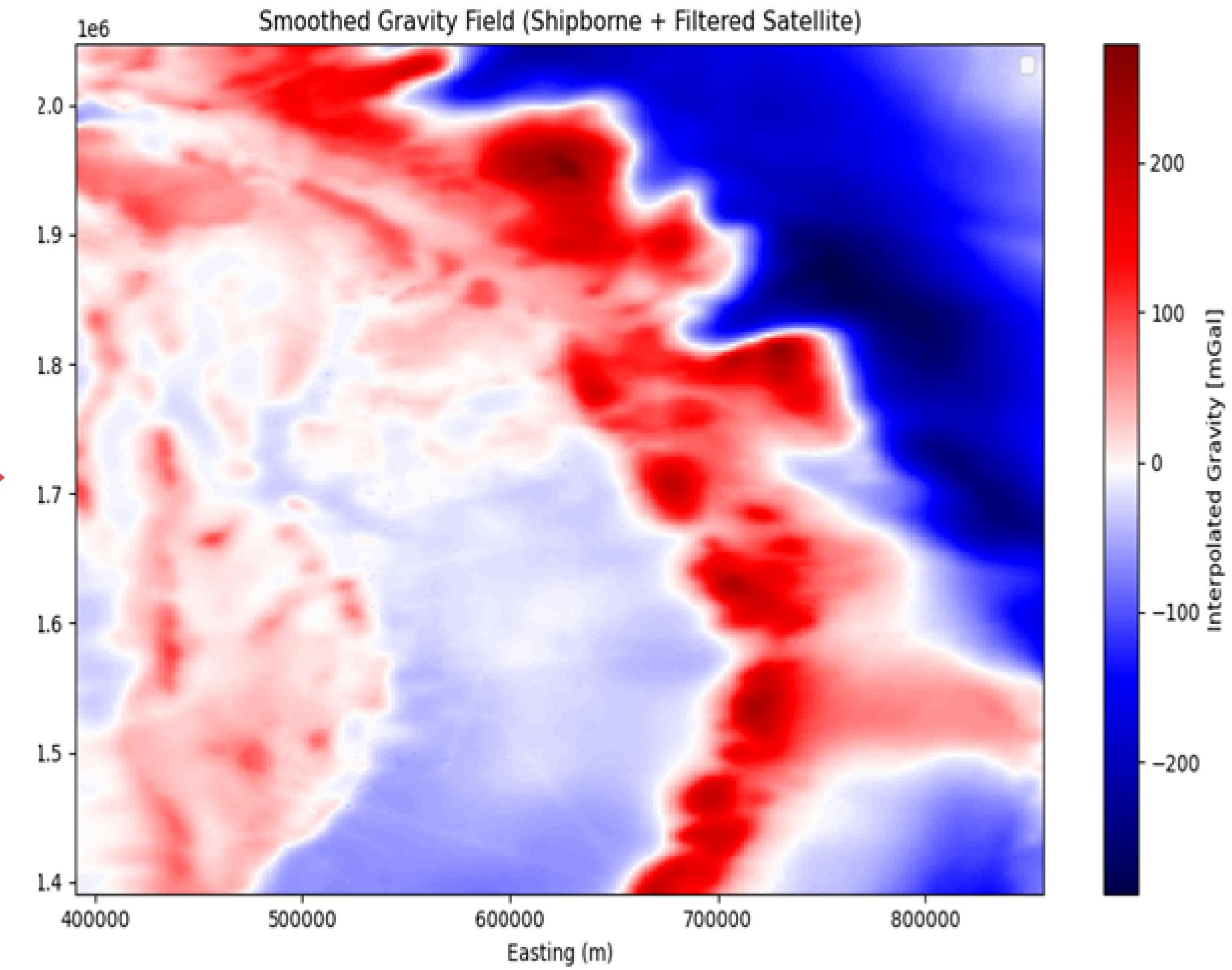
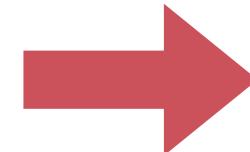
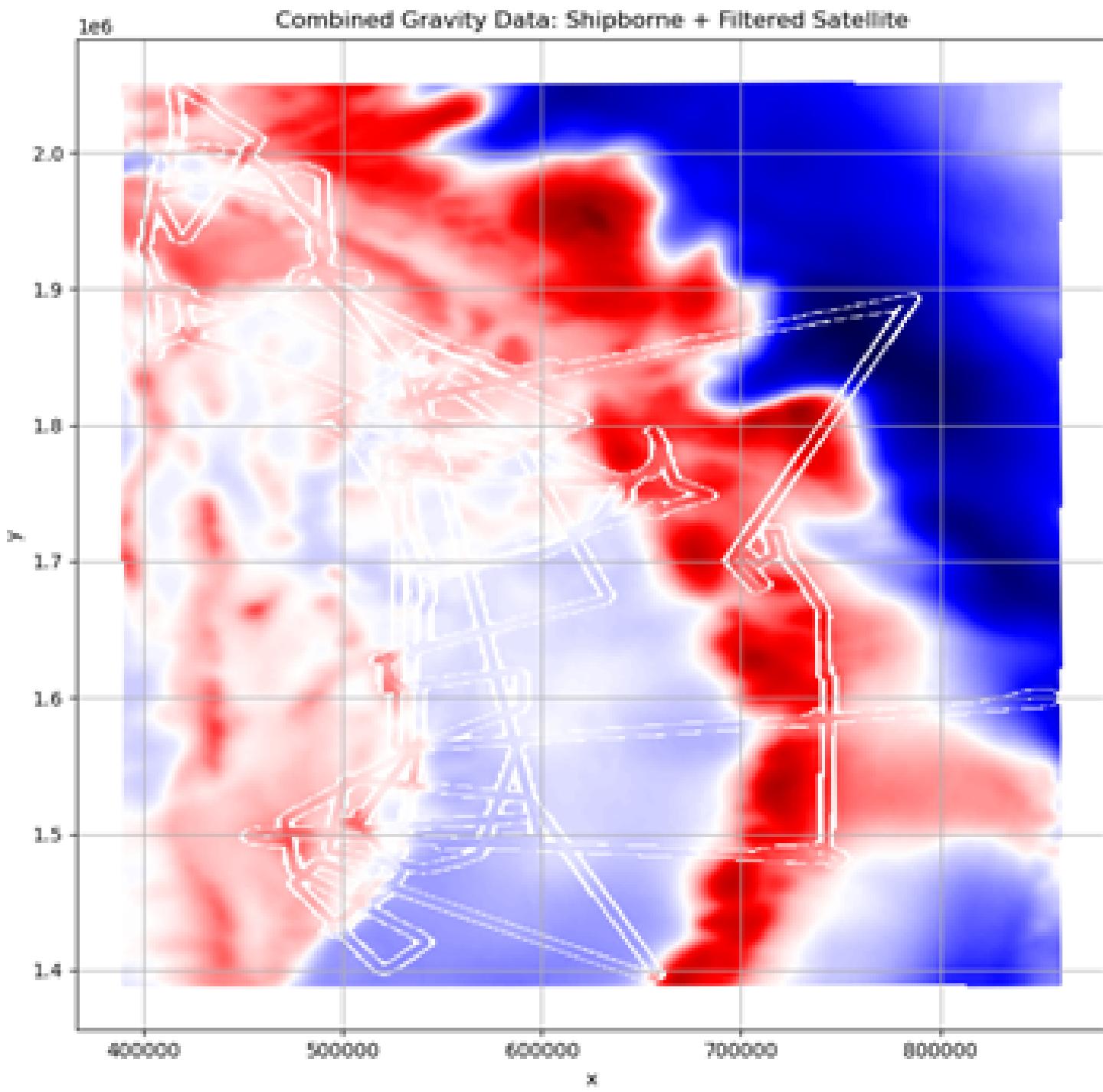


# Interpolation



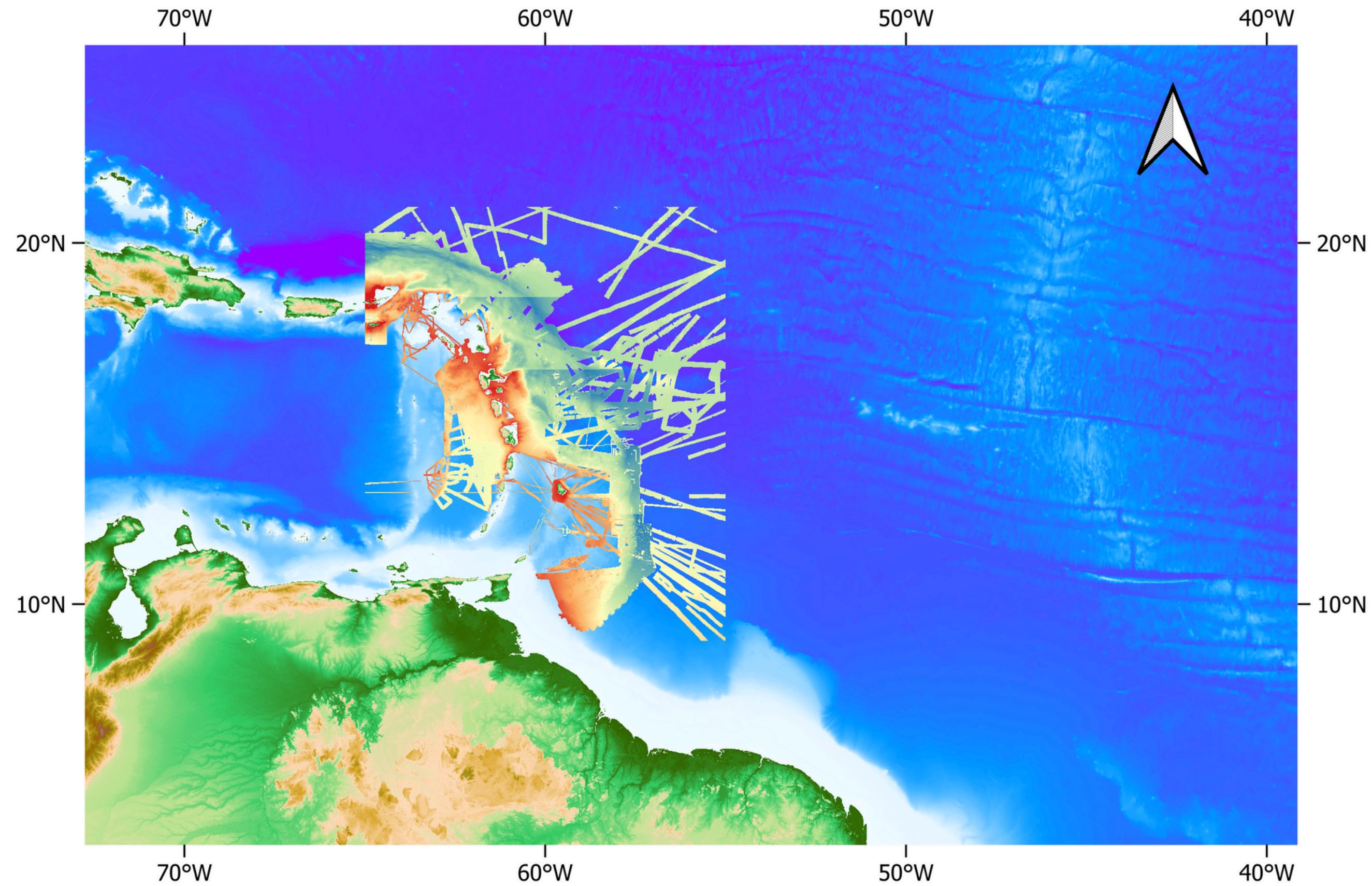
## 3

# Interpolation



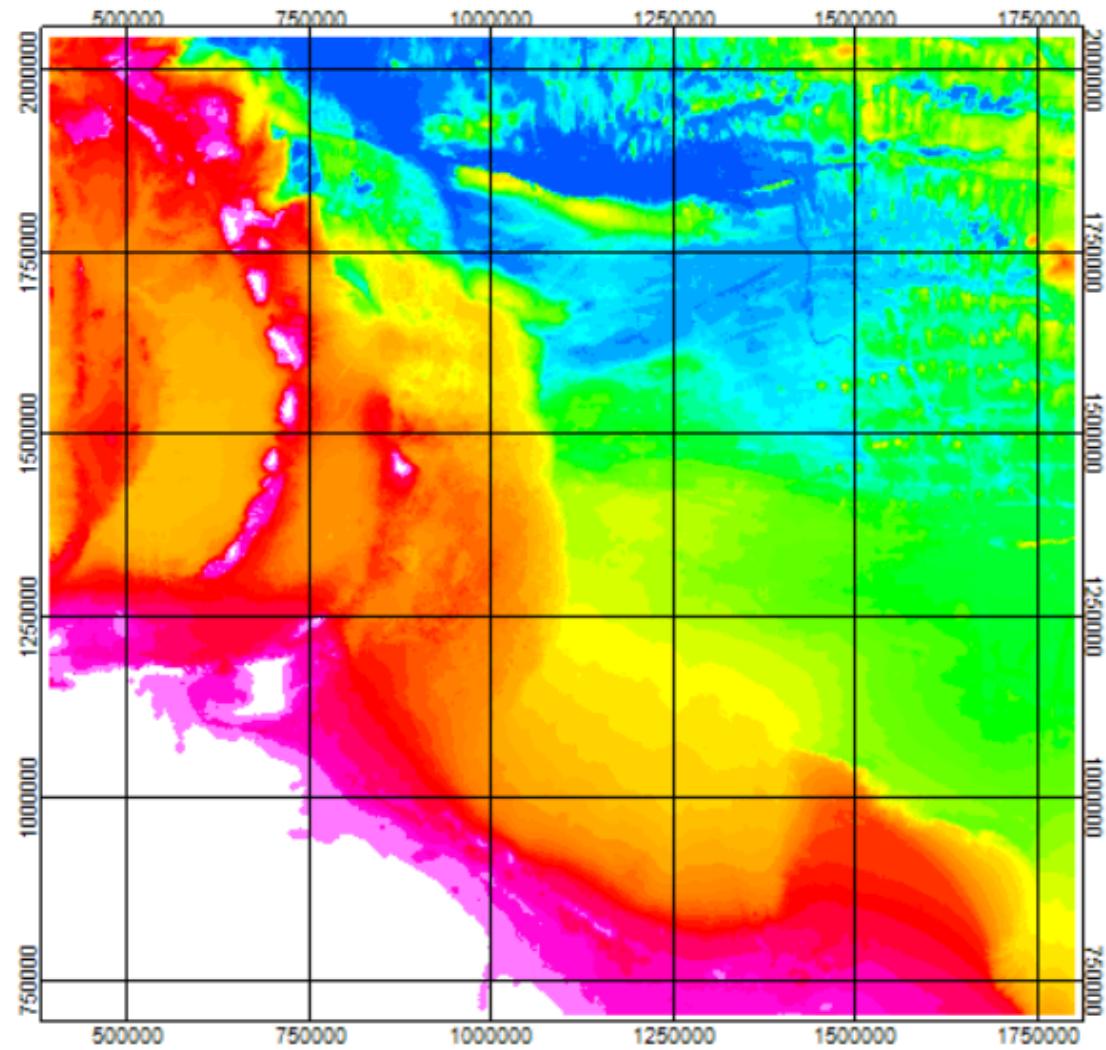
5

# Bathymetry Integration

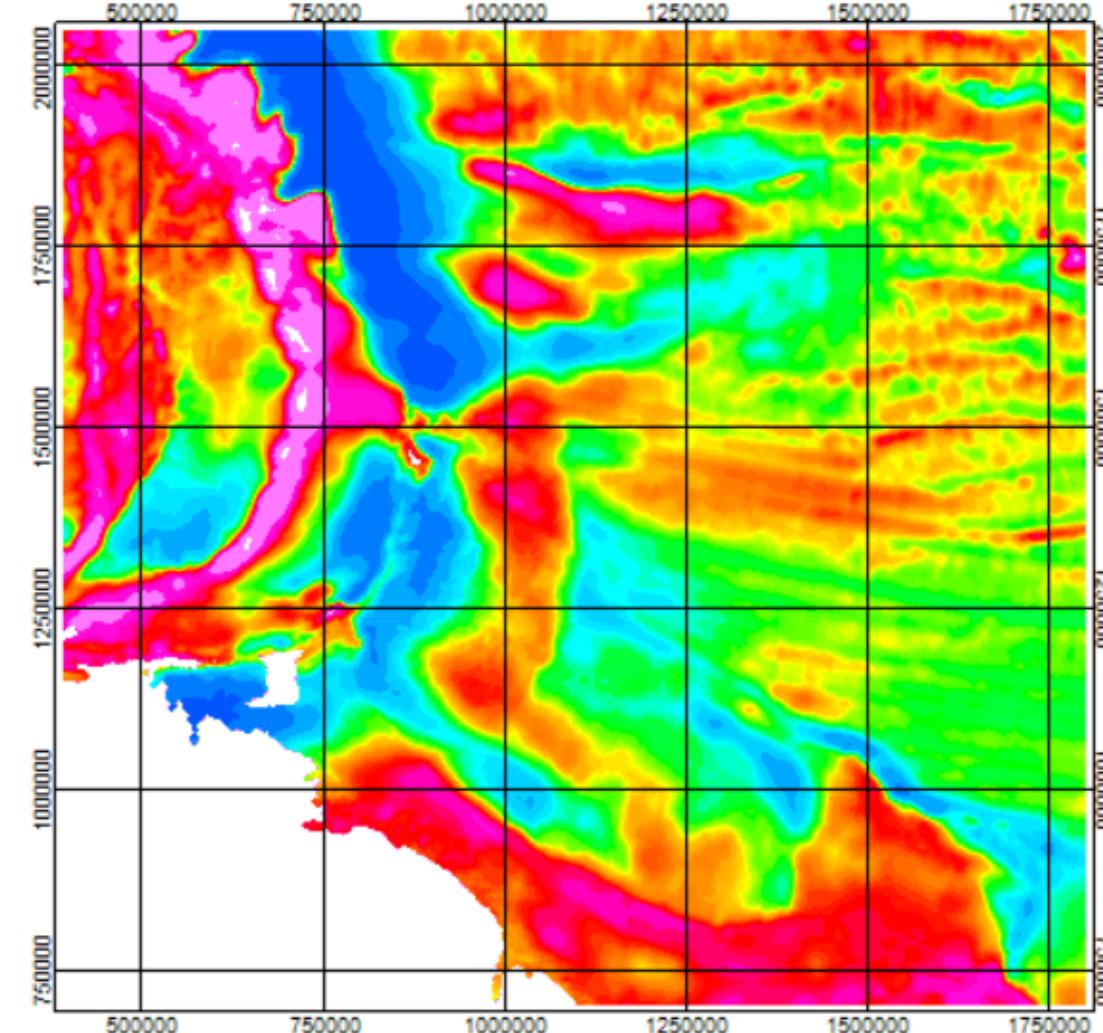


4

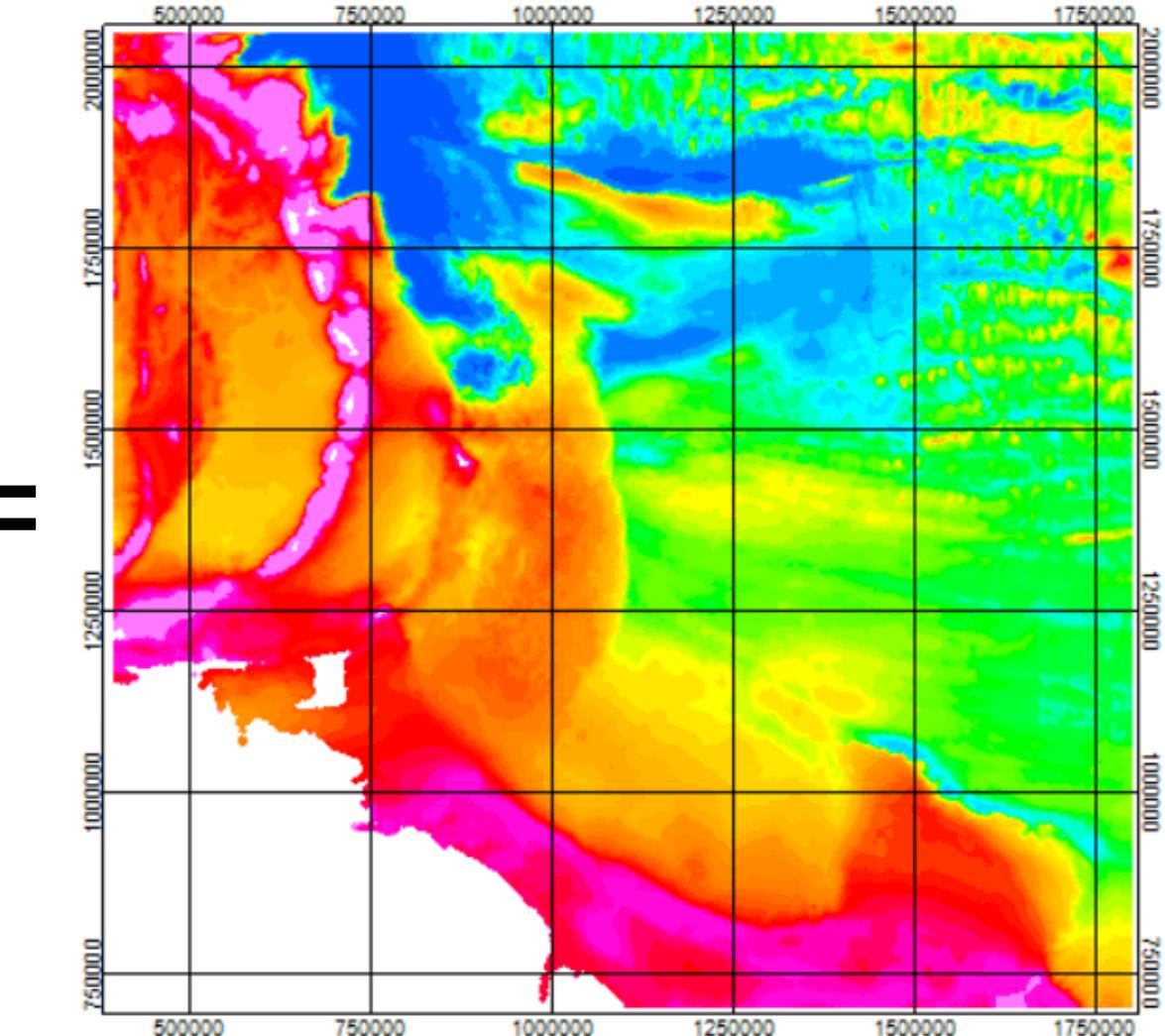
# Bouguer Anomaly



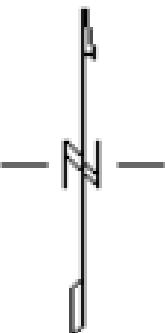
+



Bullard correction



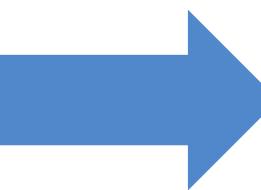
Terrain correction



## 5

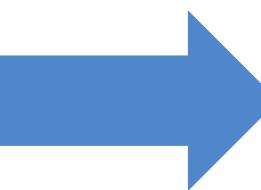
# Edge Detection

$$\text{HD}(g) = \sqrt{\left(\frac{\partial g}{\partial x}\right)^2 + \left(\frac{\partial g}{\partial y}\right)^2}$$



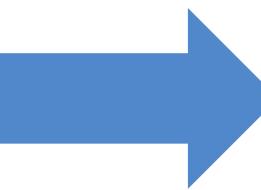
lateral changes in the field

$$\text{TD}(g) = \tan^{-1} \left( \frac{\frac{\partial g}{\partial z}}{\sqrt{\left(\frac{\partial g}{\partial x}\right)^2 + \left(\frac{\partial g}{\partial y}\right)^2}} \right)$$



emphasizes contacts and boundaries of gravity sources

$$\text{AS}(g) = \sqrt{\left(\frac{\partial g}{\partial x}\right)^2 + \left(\frac{\partial g}{\partial y}\right)^2 + \left(\frac{\partial g}{\partial z}\right)^2}$$

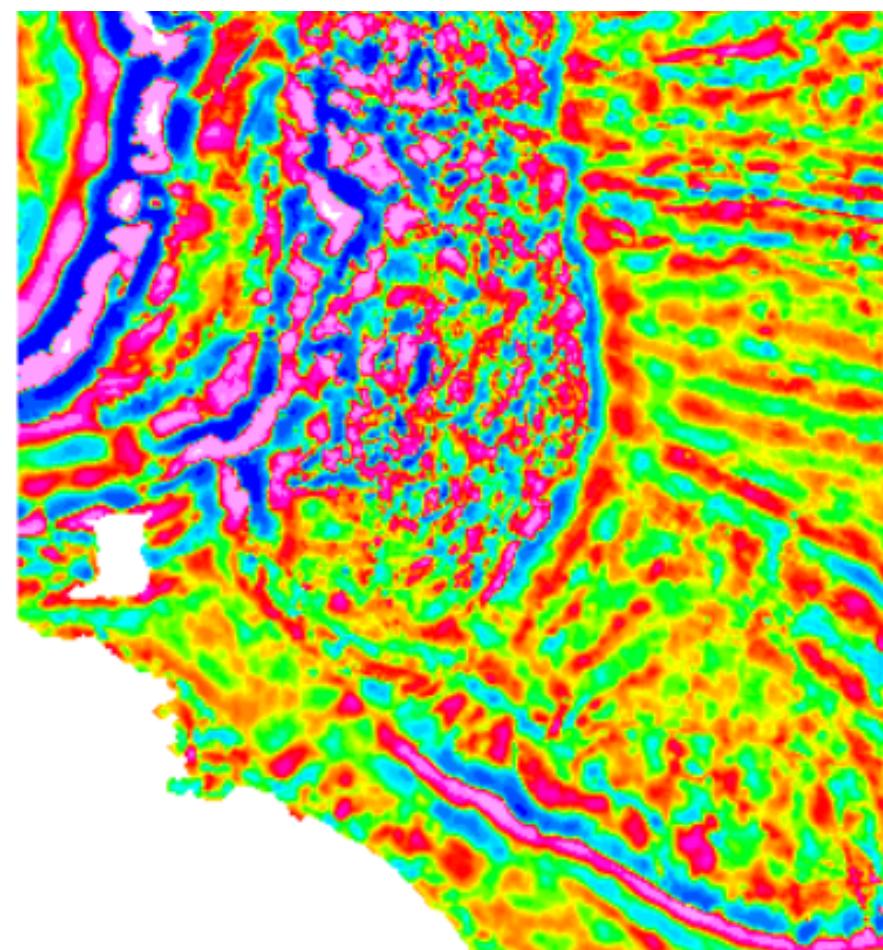
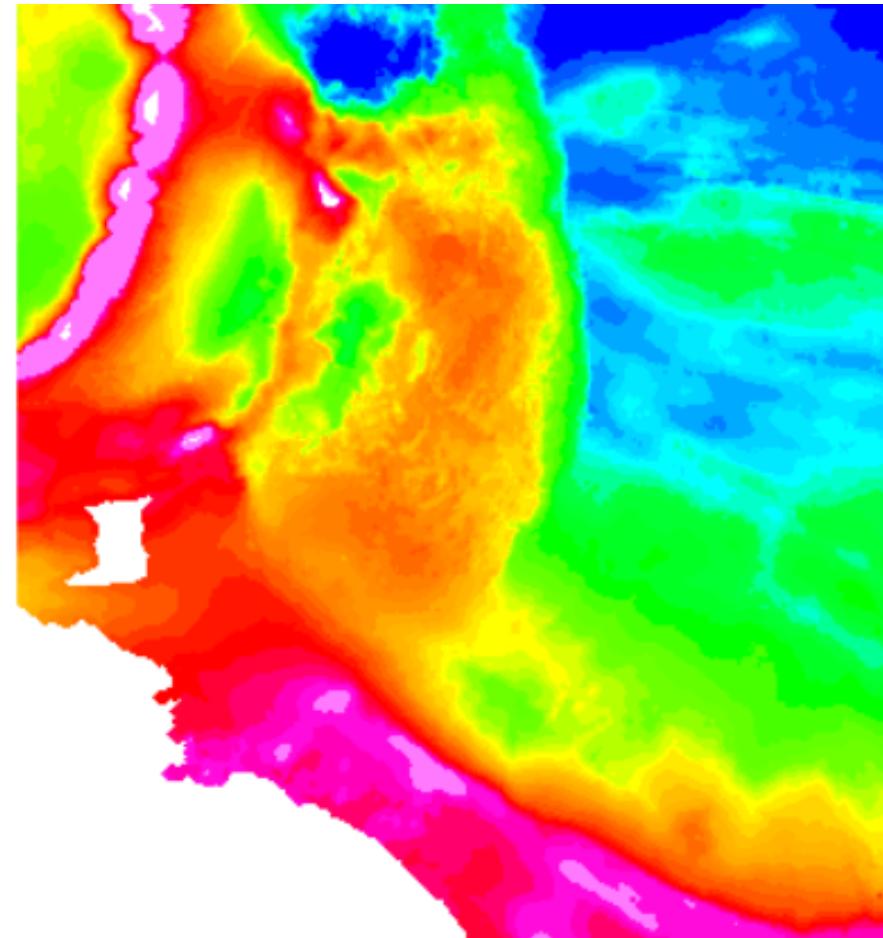
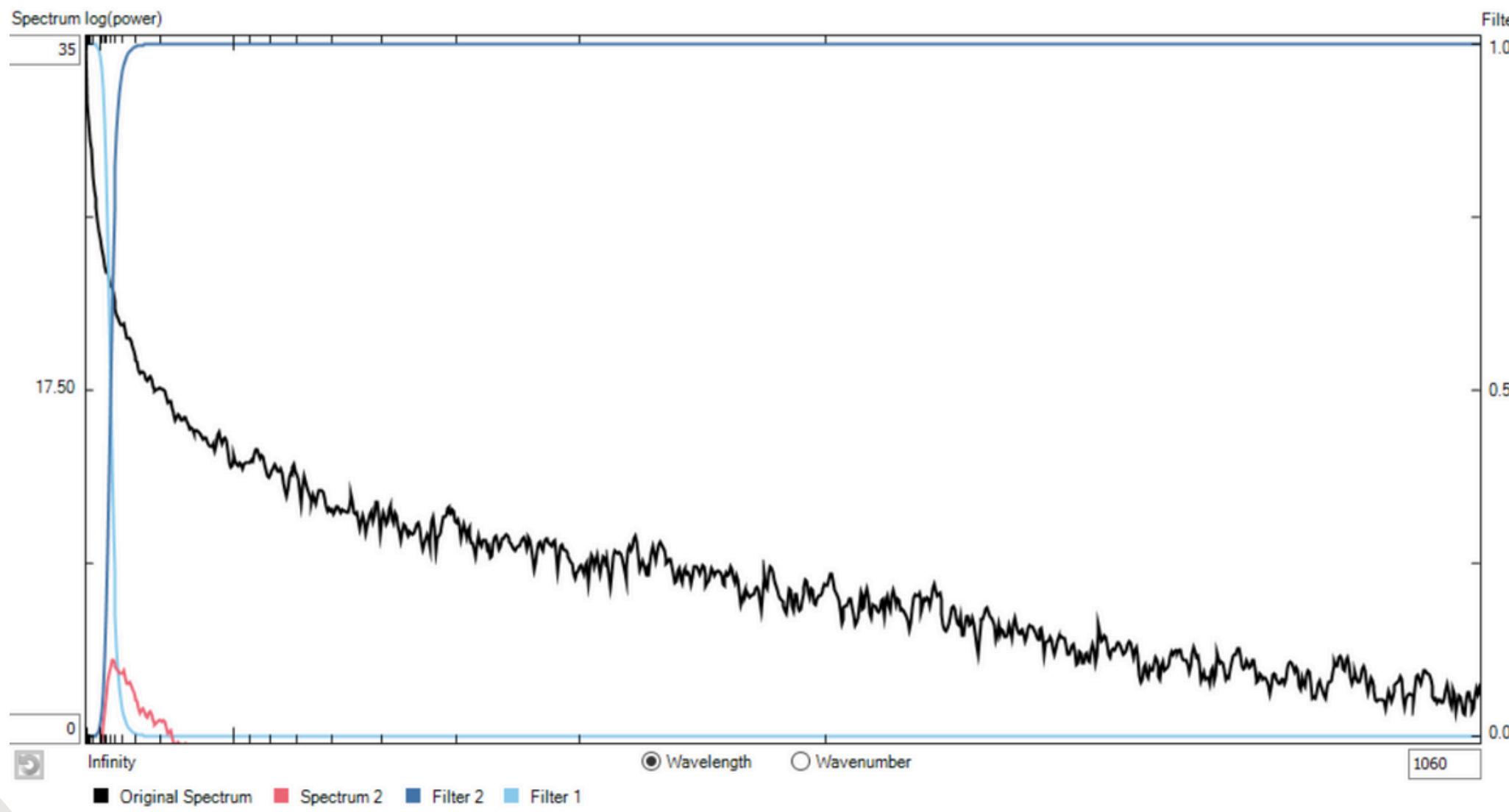


overall gradient structure, including contributions from depth

**a**

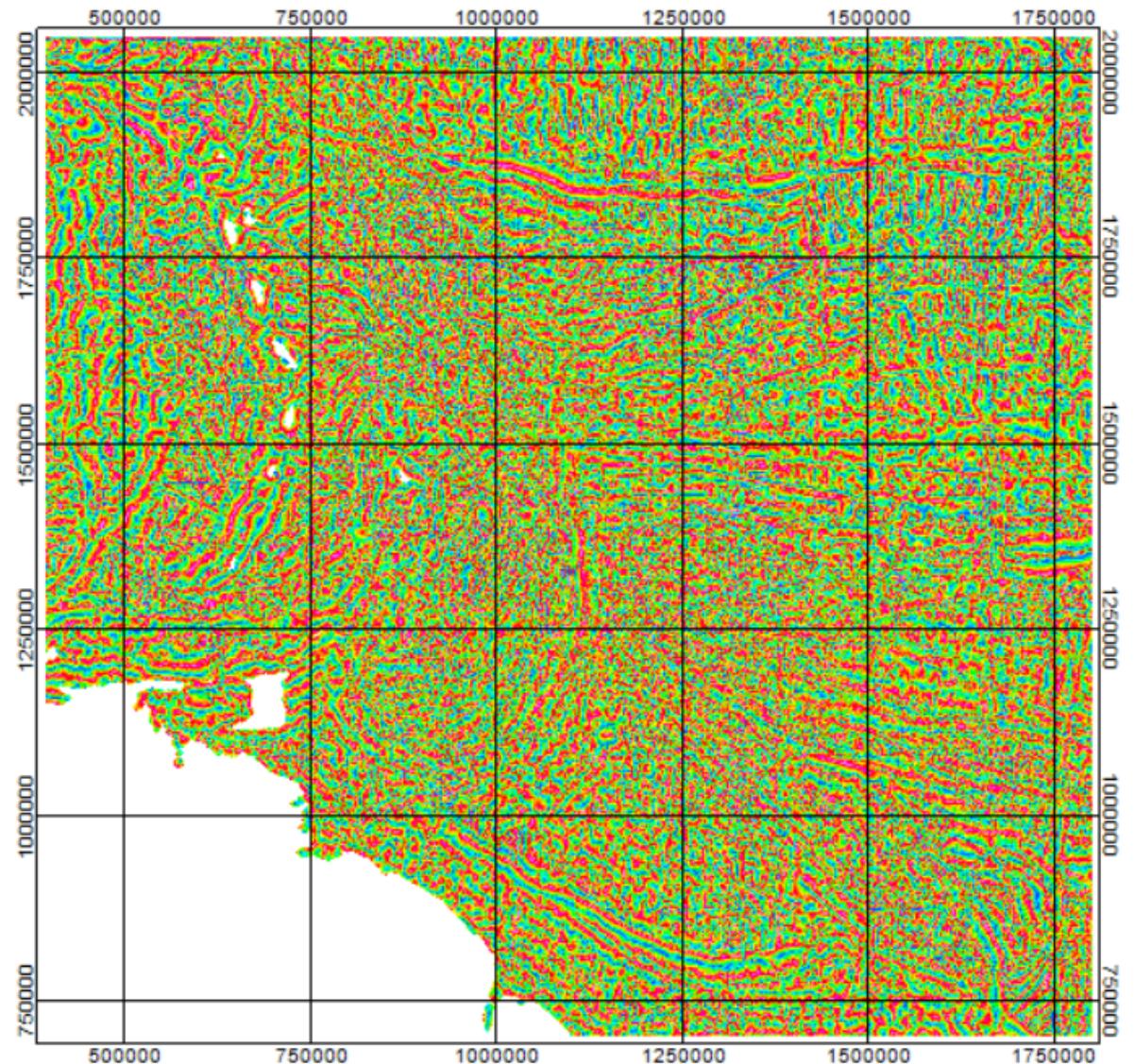
# Matched Filtering

- frequency-domain filtering technique used to enhance signal from a specific depth
- amplifies wavelengths corresponding to chosen depth and suppresses others

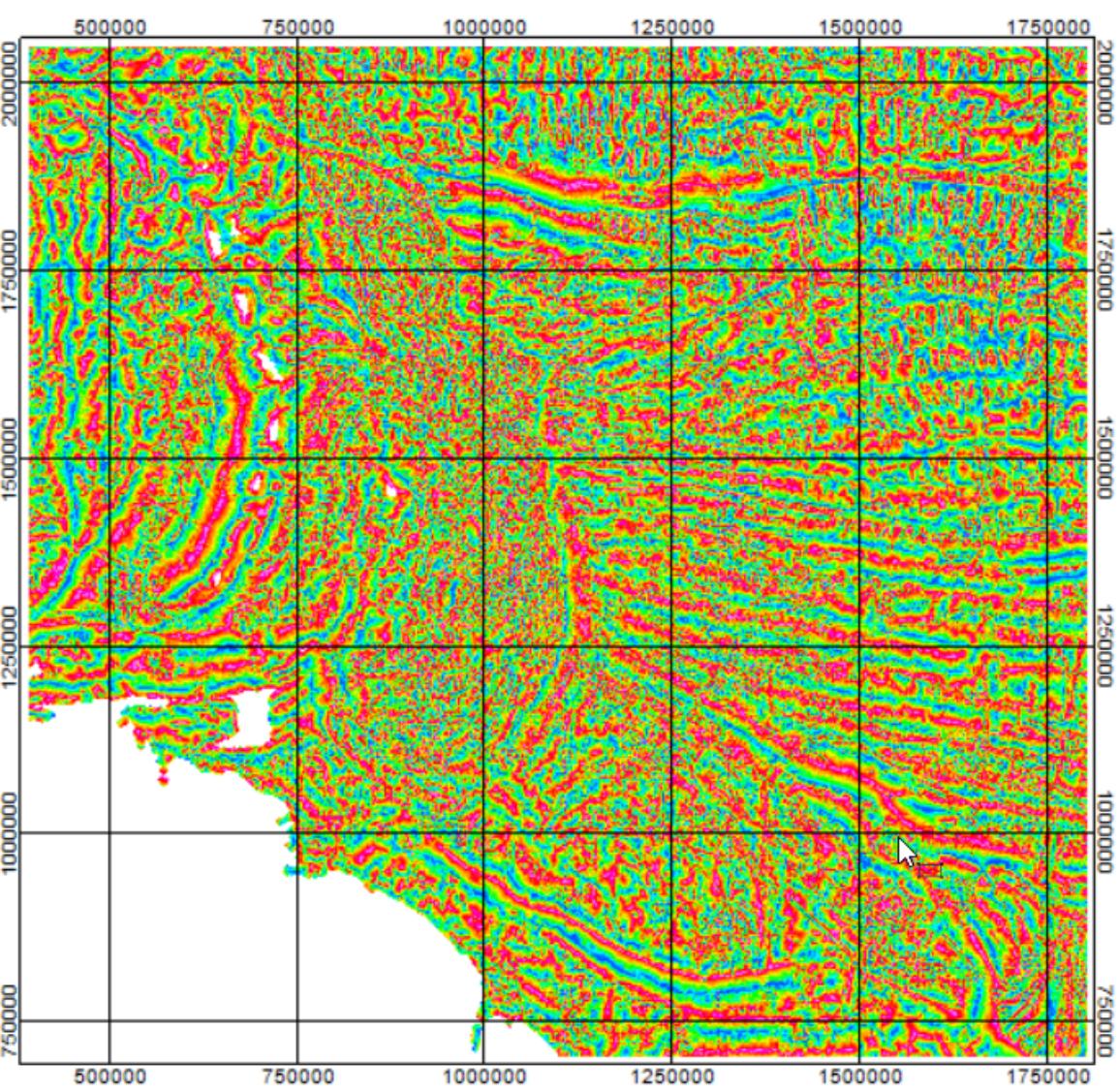


**b**

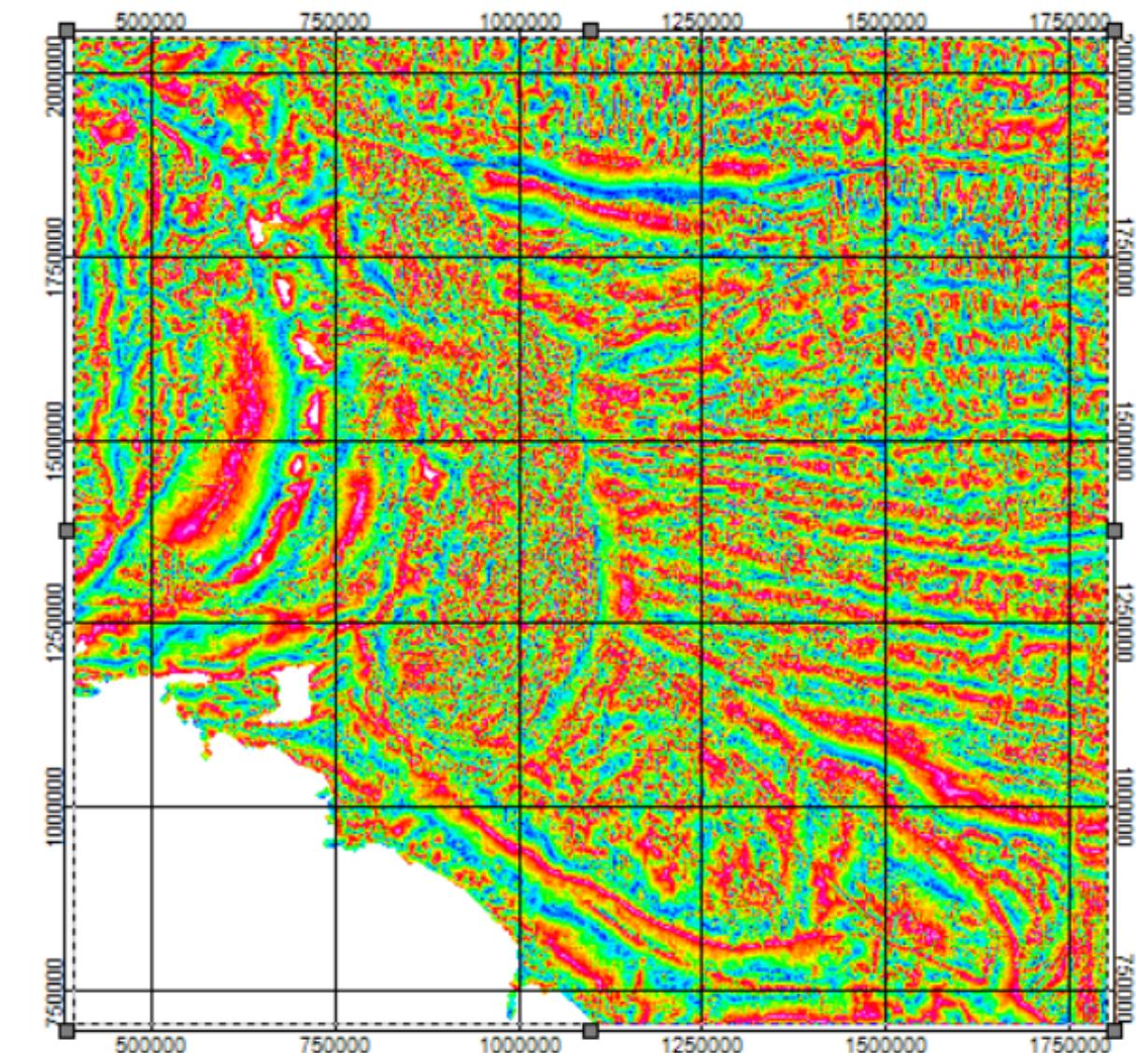
# Tilt Derivative (TD)



30 km



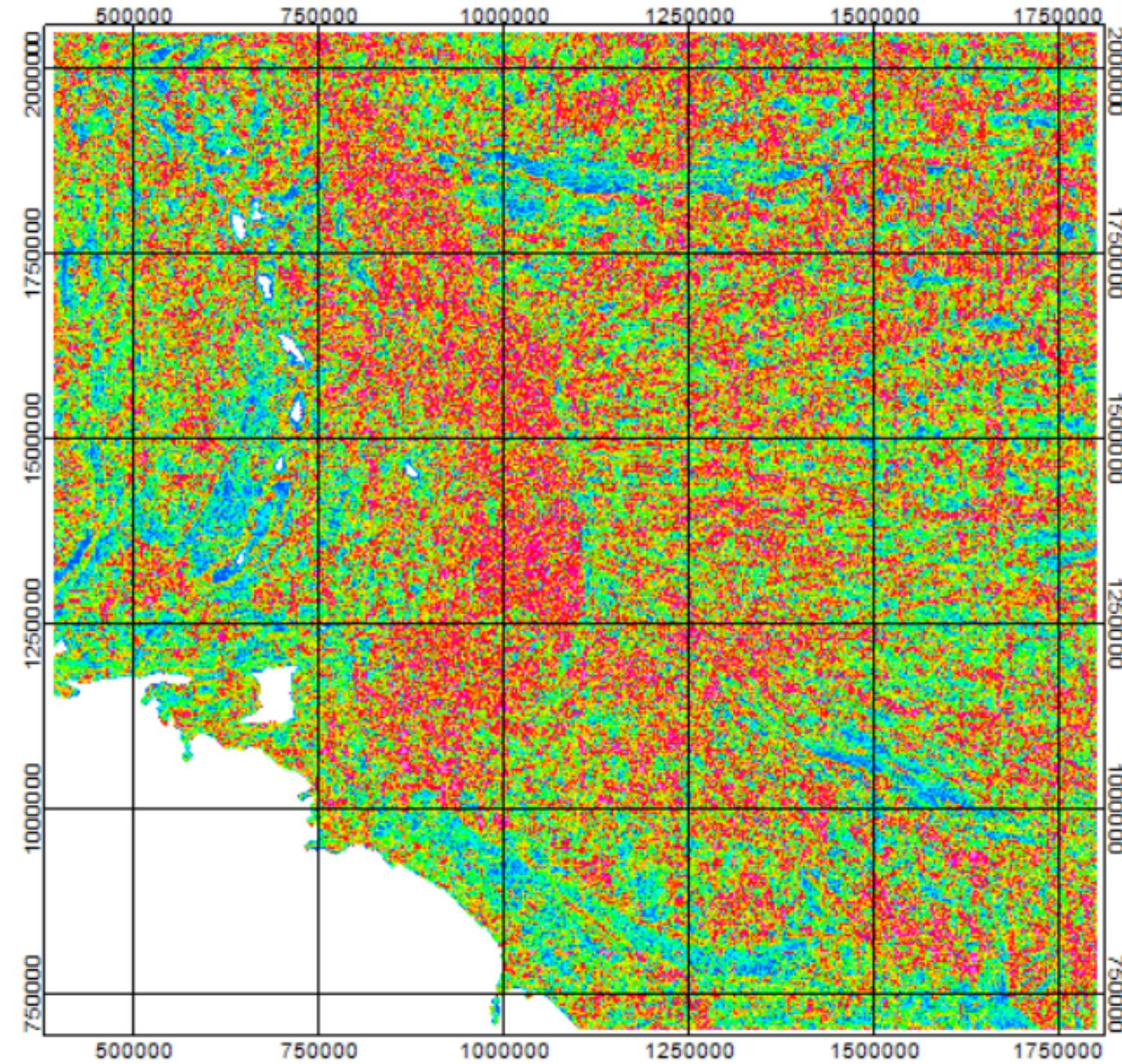
60 km



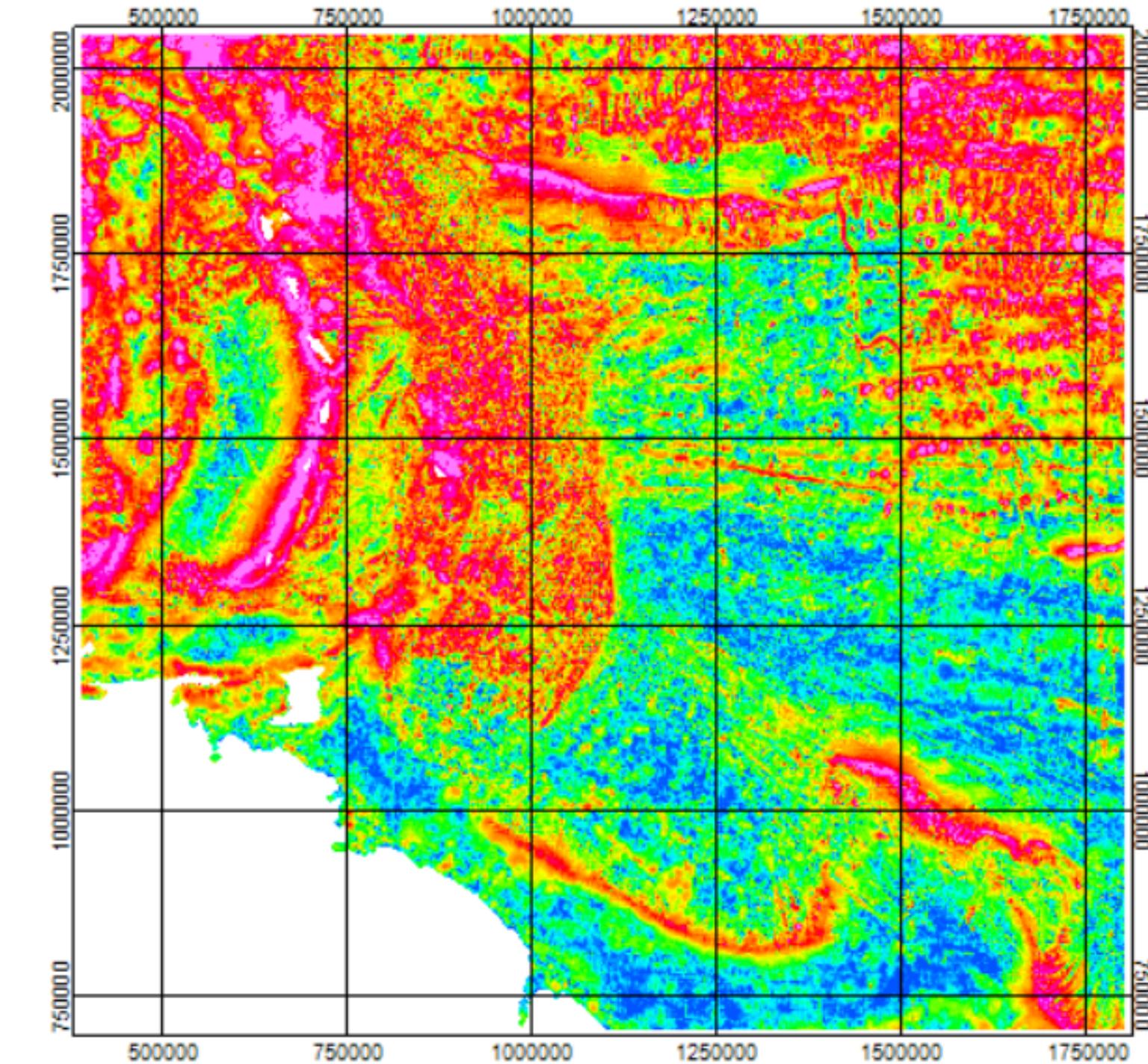
90 km

C

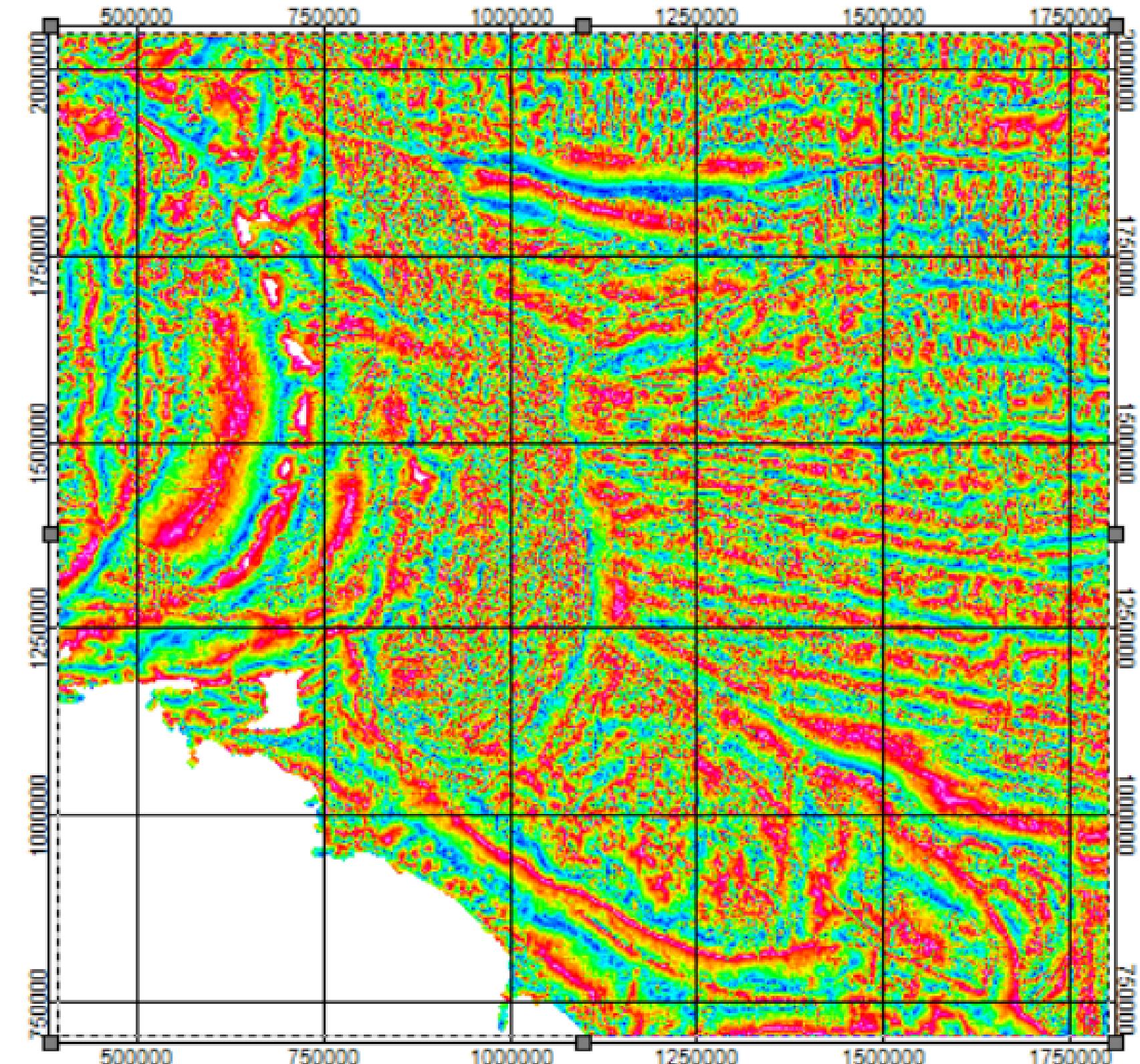
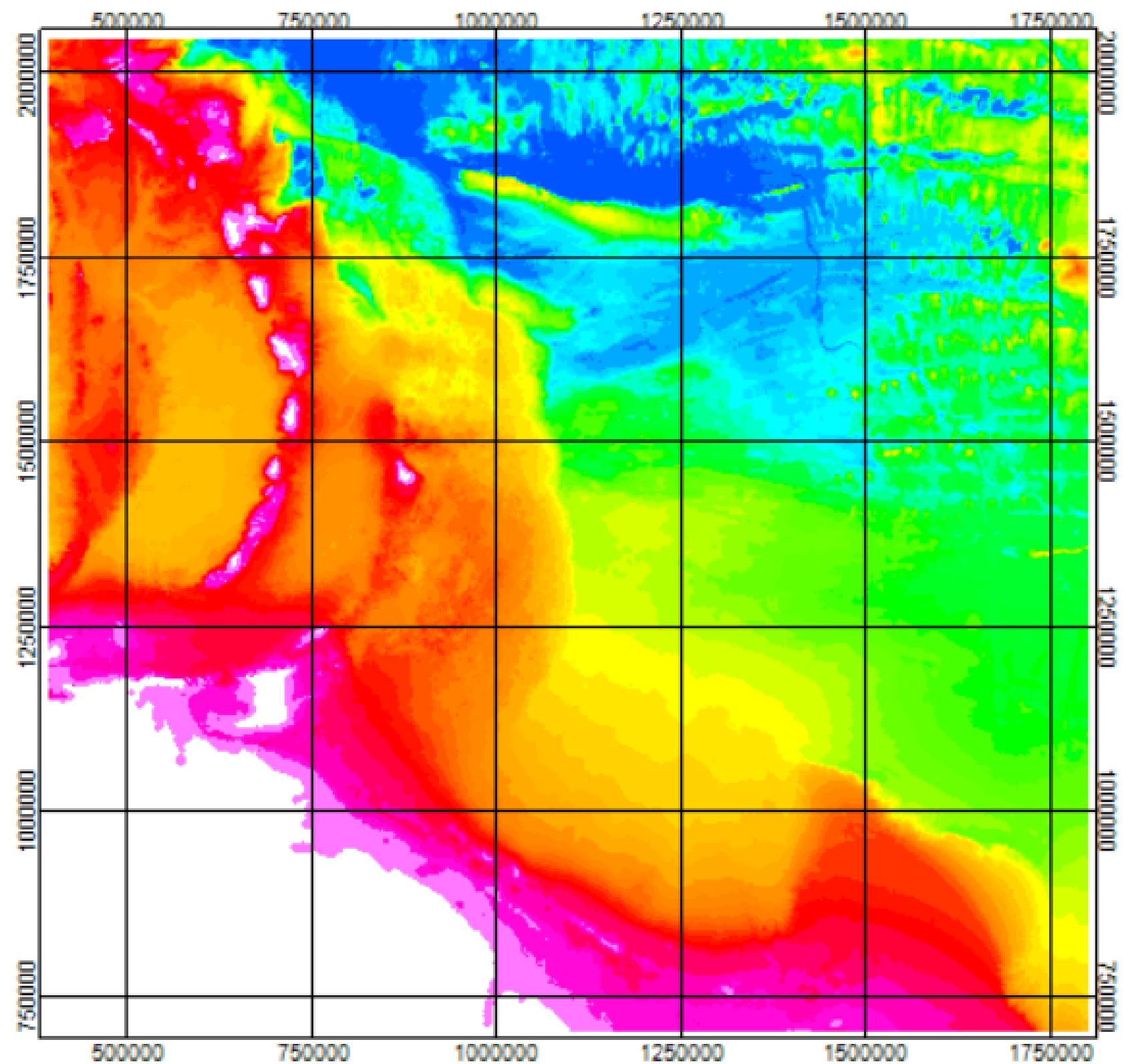
# Horizontal Derivative (HD) & Analytic Signal (AS)



HD for 90 km

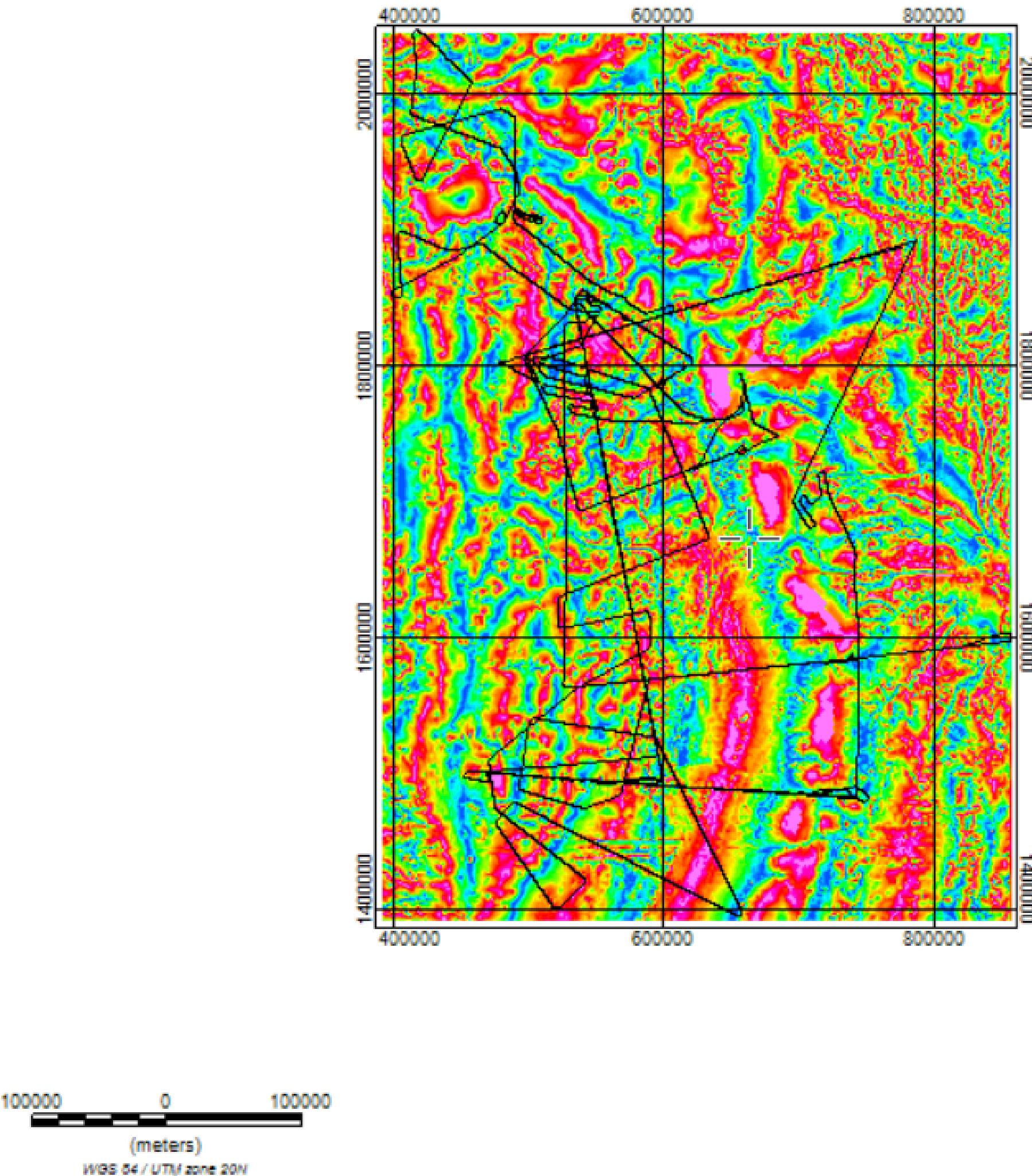


AS for 90 km



# What's next?

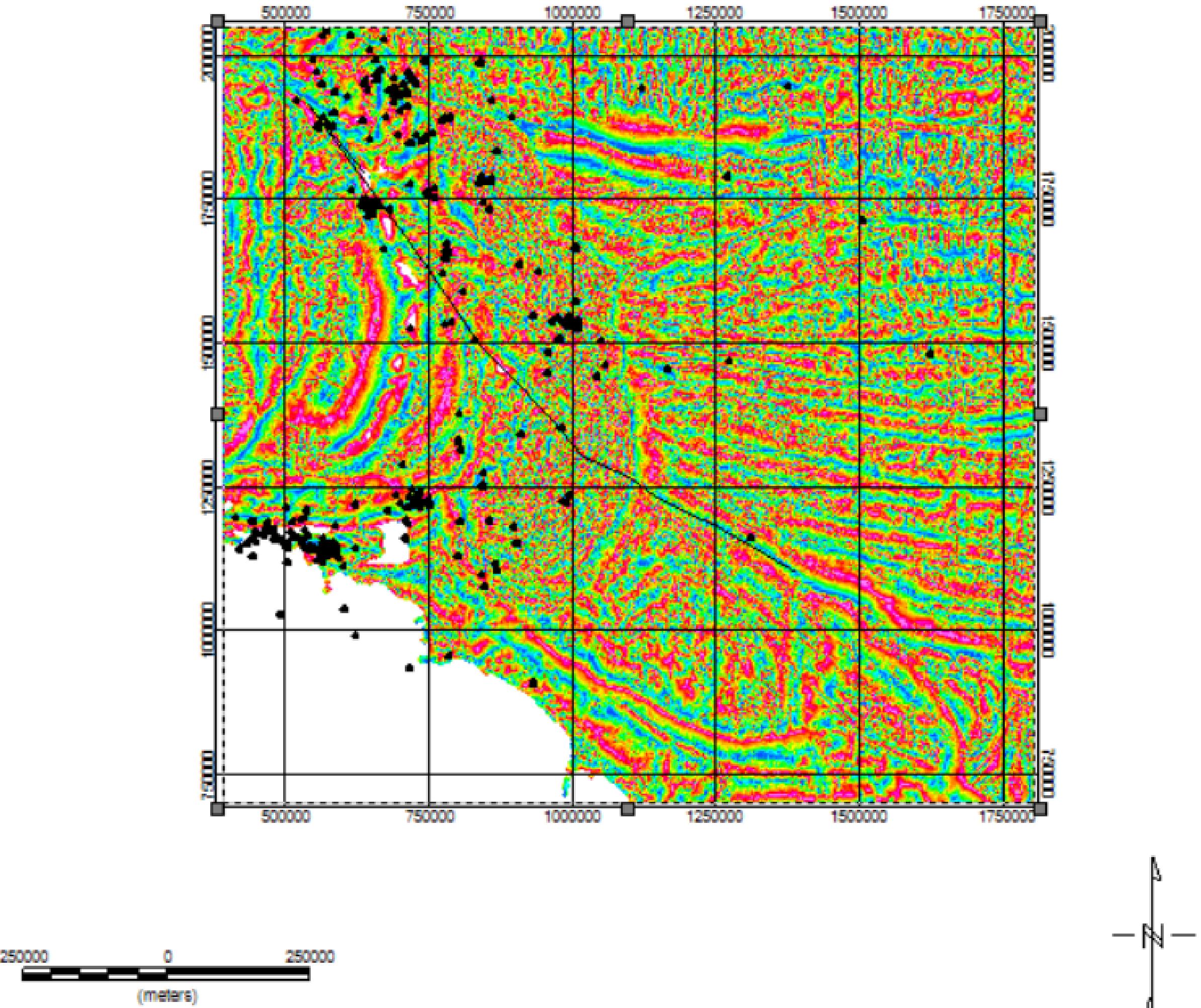
- Further filtering
- Integrating MBES data
- ML project for edge detection
- Comparison with available seismic data and literature

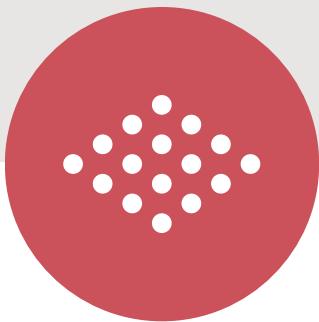


# What's next?

- Further filtering
- Integrating MBES data
- ML project for edge detection
- Comparison with available seismic data and literature

>>>





>>> **THANK  
YOU!** <<<

# References

- E. Deville et al. "Tectonics and sedimentation interactions in the east Caribbean subduction zone: An overview from the Orinoco delta and the Barbados accretionary prism". In: Marine and Petroleum Geology 64 (2015), pp. 76-103. doi: [10.1016/j.marpetgeo.2014.12.008](https://doi.org/10.1016/j.marpetgeo.2014.12.008).
- Lesourd—Laux, T., Basile, C., Roest, W., Klingelhoefer, F., Zahirovic, S., Wright, N. M., et al. (2025). New kinematic model of the early opening of the Equatorial Atlantic Realm. *Tectonics*, 44, e2024TC008713. <https://doi.org/10.1029/2024TC008713>

