Geostatistical Gravity Inversion for Estimating Sub-Ice-Bathymetry

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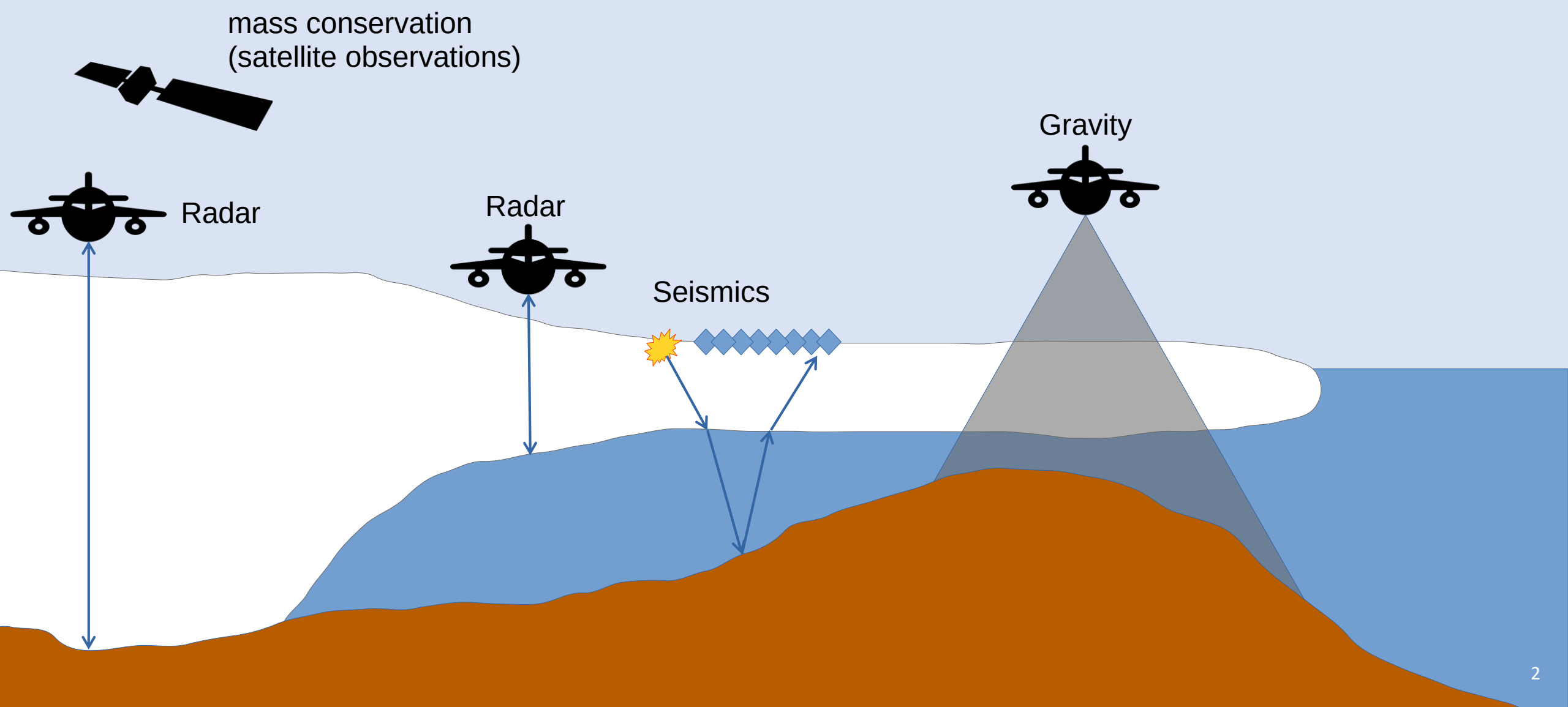
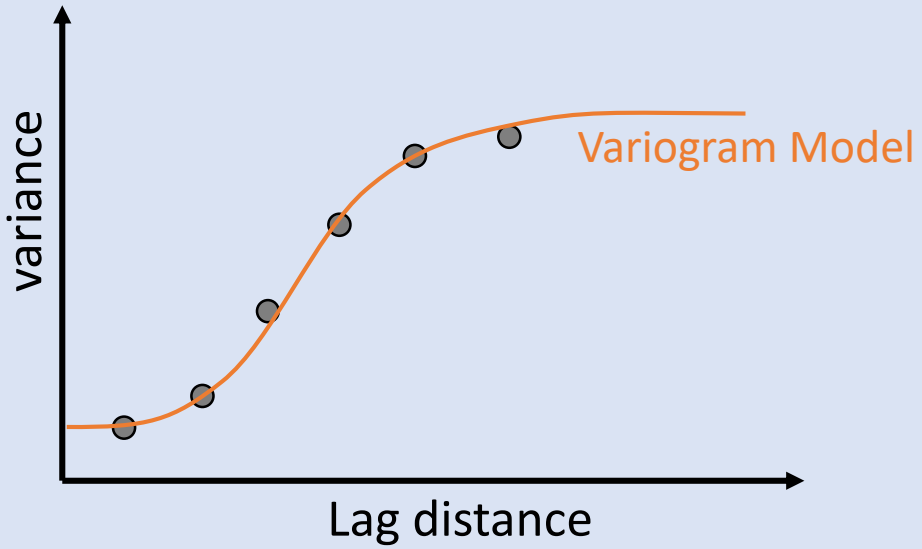
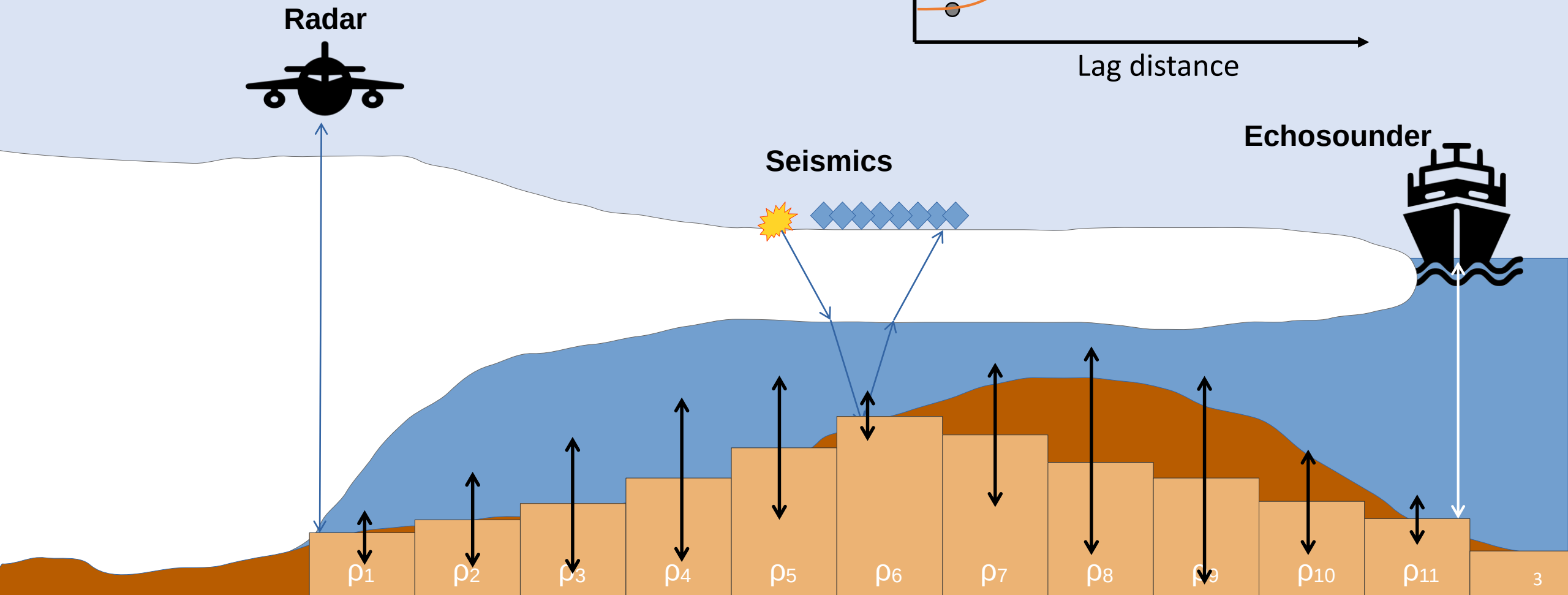
Motivation


mass conservation
(satellite observations)
Radar
Radar
Seismics
Gravity

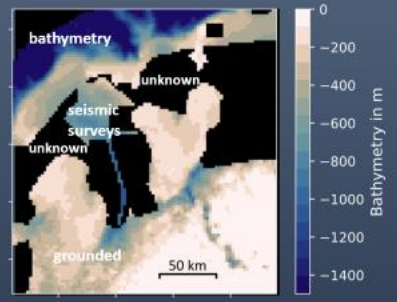
Constraints



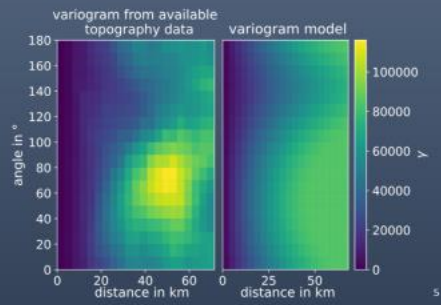


A-Priori Information

Existing bathymetry/ topography measurements
(e.g. seismics, hydroacoustics, radar)

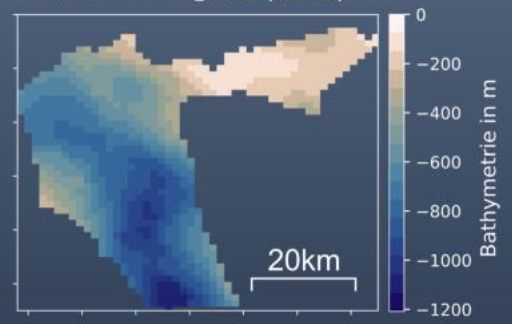


Modelling a Variogram from Topography data



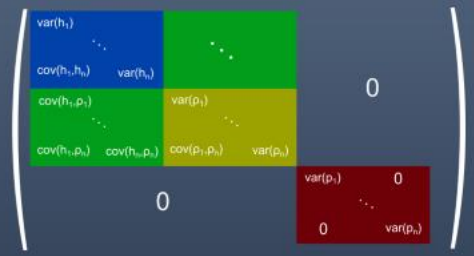
A-Priori Model and Inversion Initialization

Kriging
of the existing bathymetry



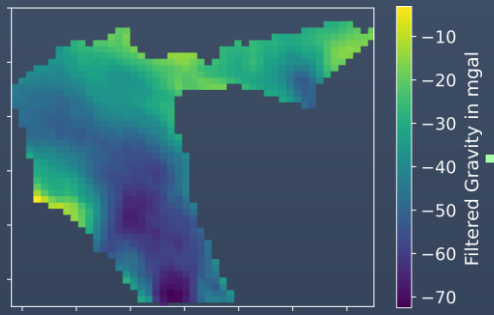
A-Priori probability density

A-priori probability (Covariance Matrix M)



- Variance and spatial continuity of:
  - Bathymetry
  - Density
- Correlation of Bathymetry and Density (stabilization of the inversion)
- Variance of an additional linear trend correction

Gravity measurements



Quasi-Newton Optimization

Error Function:

$$\| \mathbf{G}\,\mathbf{m} - \mathbf{d}_{obs} \|_{\mathbf{D}}^2 + \| \mathbf{m} - \mathbf{m}_{prior} \|_{\mathbf{M}}^2$$

gravity error

regularization/ model likelihood

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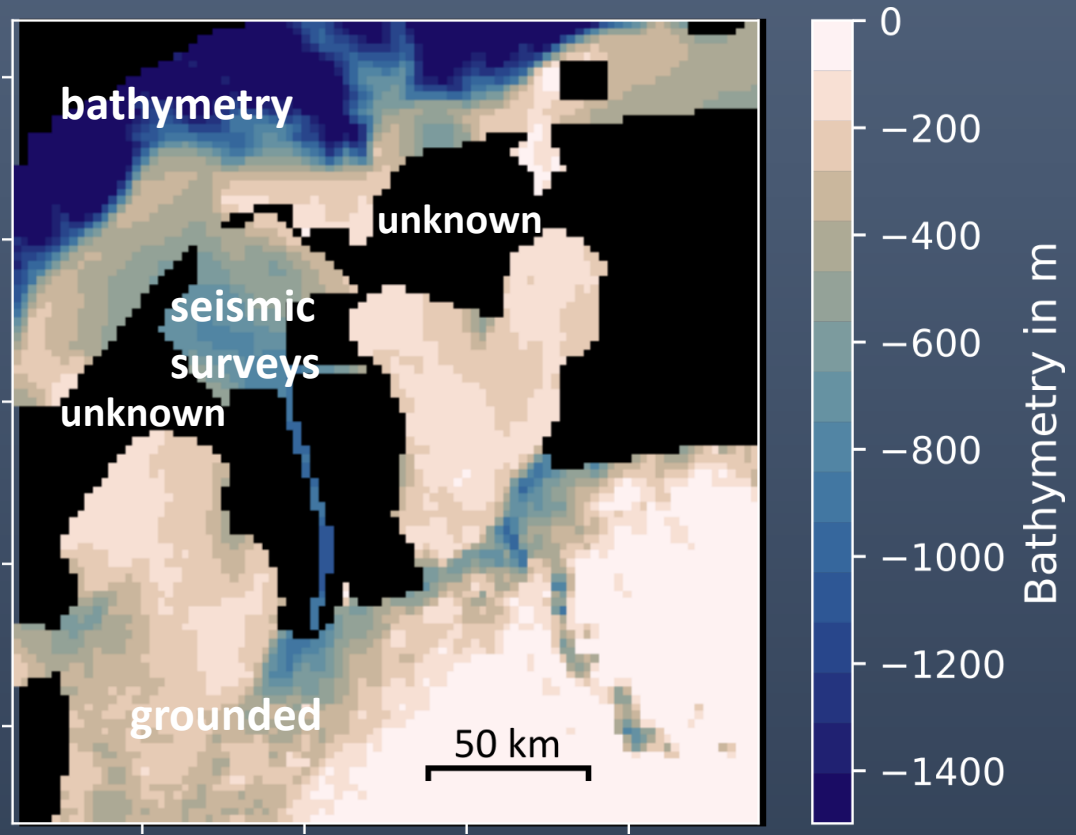
(e.g. seismics, hydroacoustics, radar)



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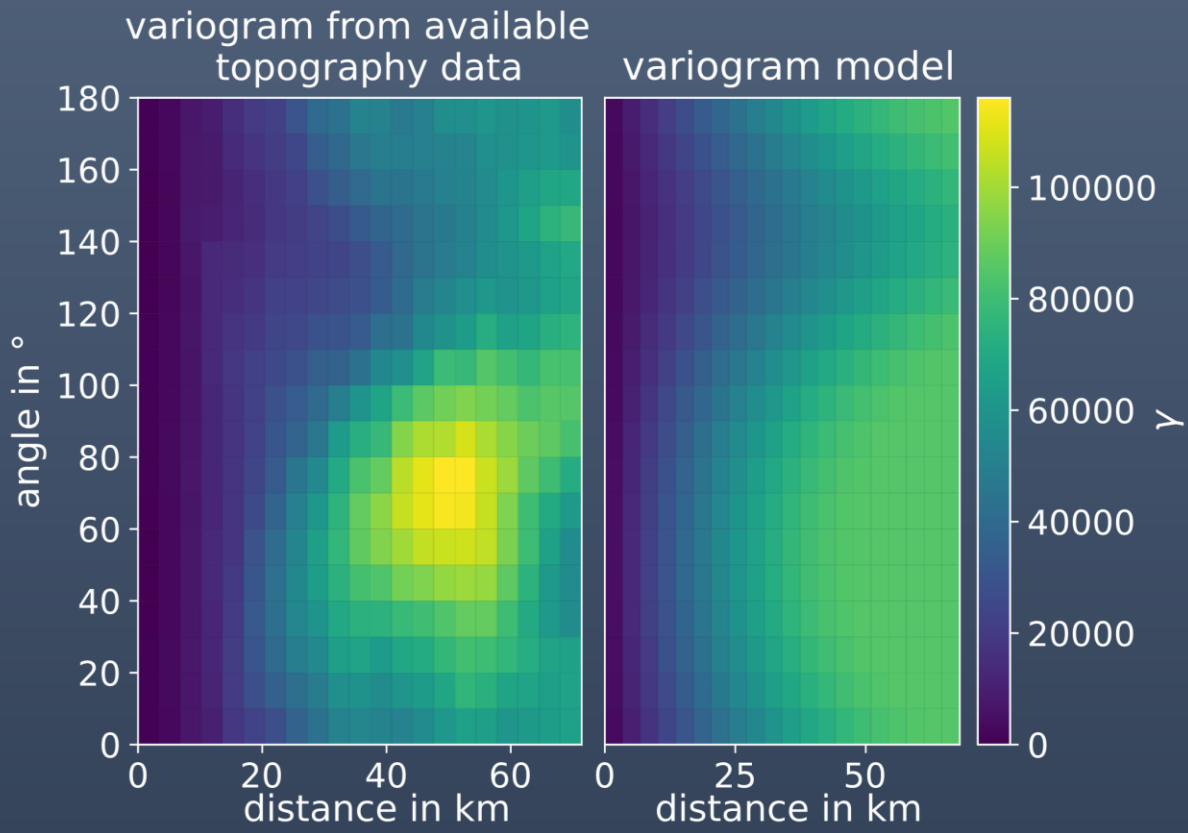

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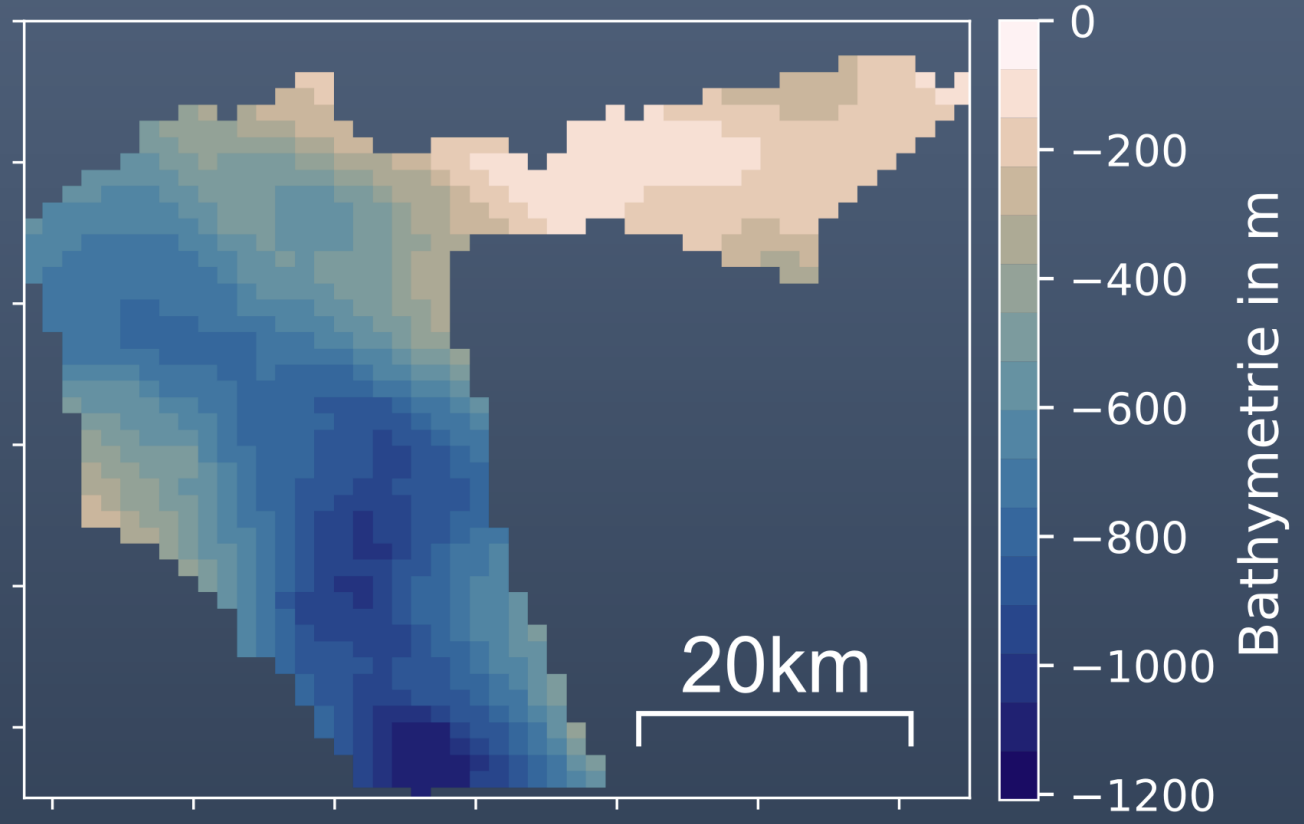
Kriging

of the existing bathymetry



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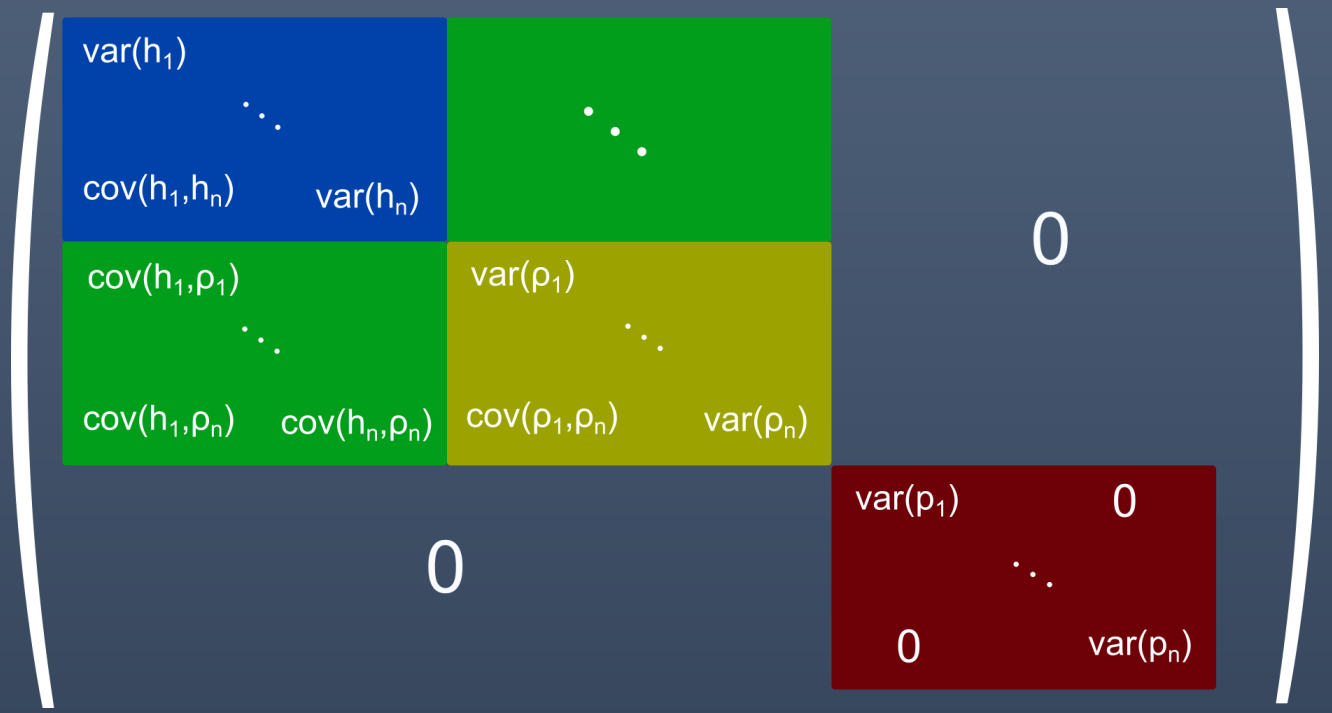

- Variance and spatial continuity of:
  - Bathymetry
  - Density
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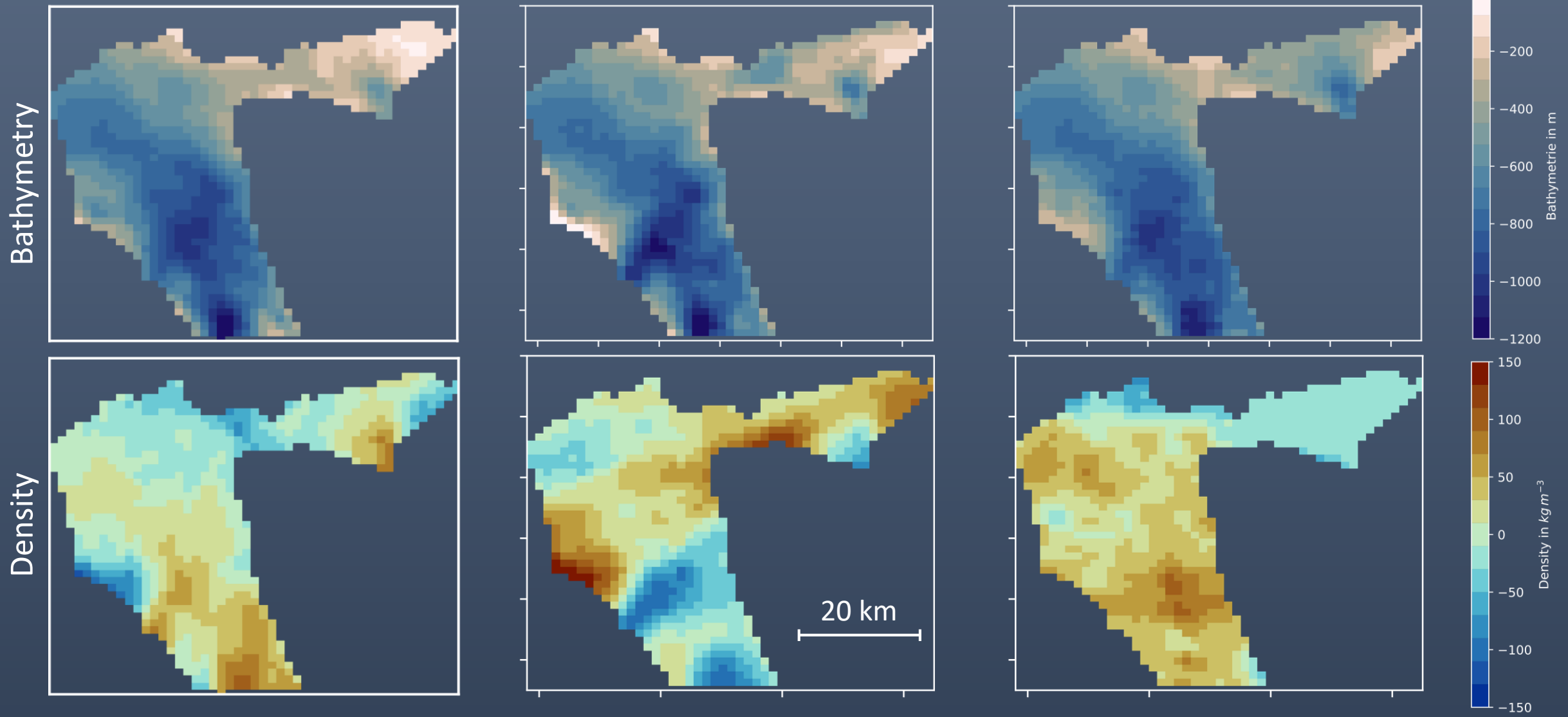
- Variance of an additional linear trend correction

Results - Sub-ice-bathymetry

Result for data with directional Filter

without directional Filter

Eisermann et al. 2020



Results - Sub-ice-bathymetry

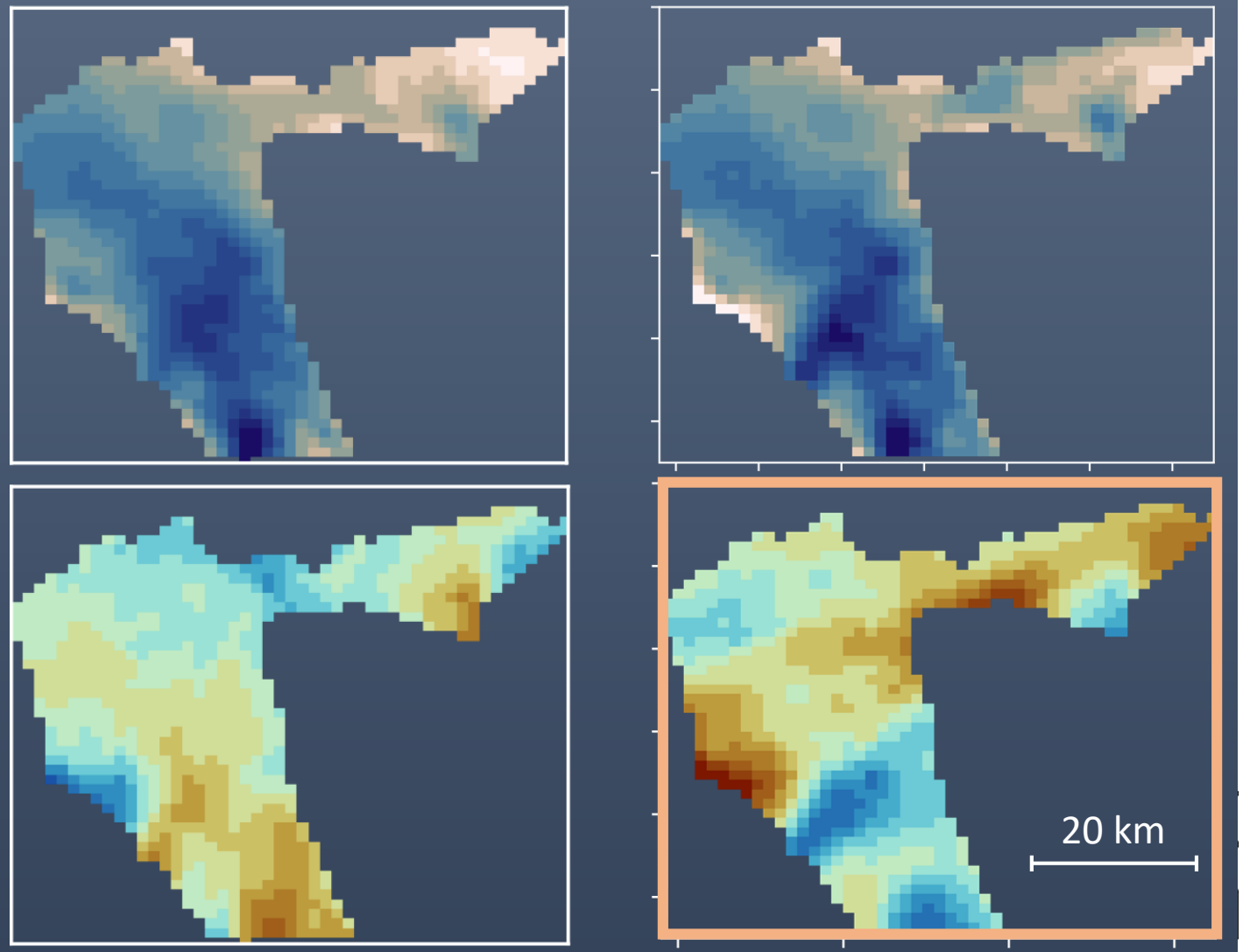
Result for data with directional Filter

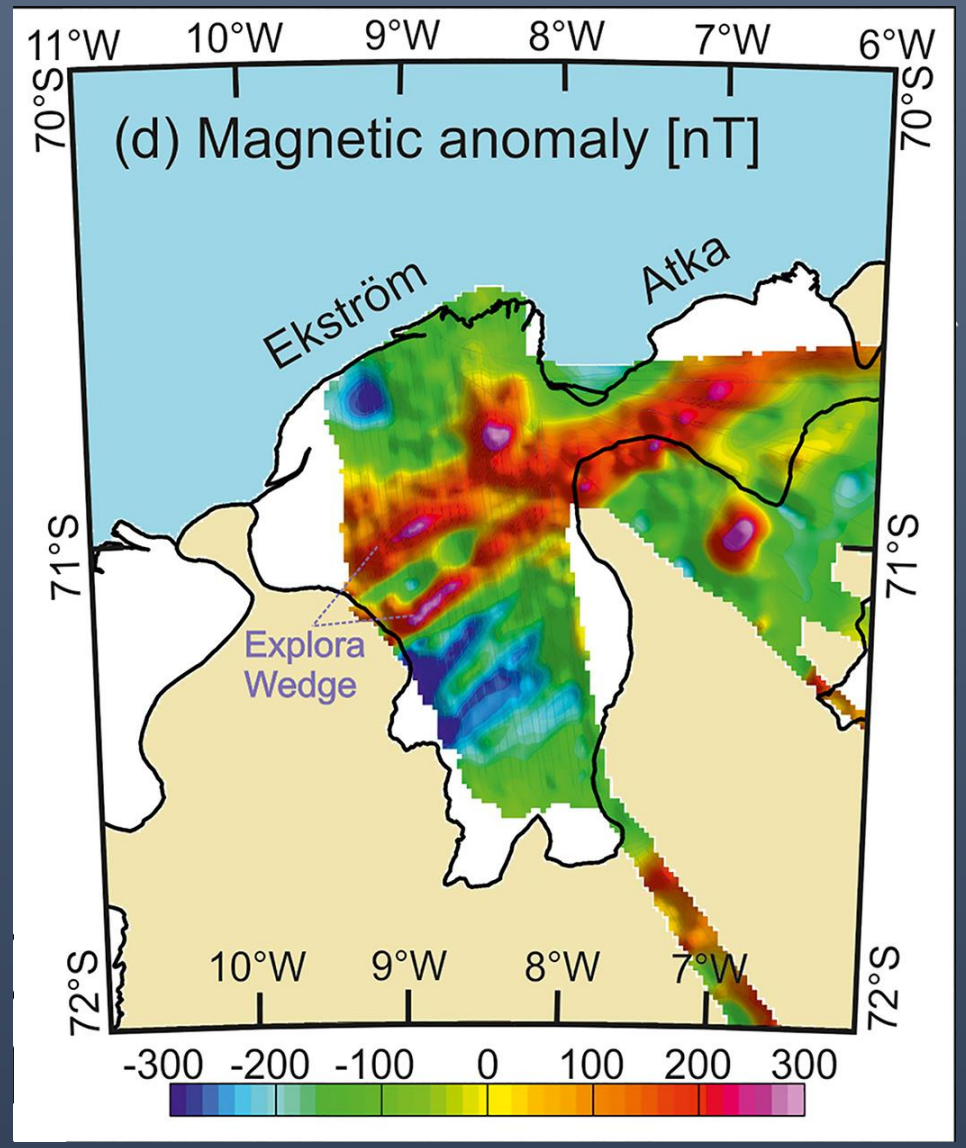
without directional Filter

Eisermann et al. 2020

Bathymetry

Density





Take home message

- Geostatistics have the potential to further constrain a highly ambiguous problem
- A simultaneous inversion for density, morphology and an additional trend is feasible for a well constrained investigation area

Outlook

Are there better ways to constrain spatial continuity?

→convolutional neural networks

OSPP