Heterogenous geological boundary conditions and geothermal heat flux revealed beneath Antarctica's subglacial lake districts

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Antarctic Geothermal Heat Flux

Antarctic geothermal heat flow and its implications for tectonics and ice sheets

Anya M. Reading, Tobias Stål, Jacqueline A. Halpin, Mareen Lösing, Jörg Ebbing, Weisen Shen, Felicity S. McCormack, Christine S. Siddoway & Derrick Hasterok

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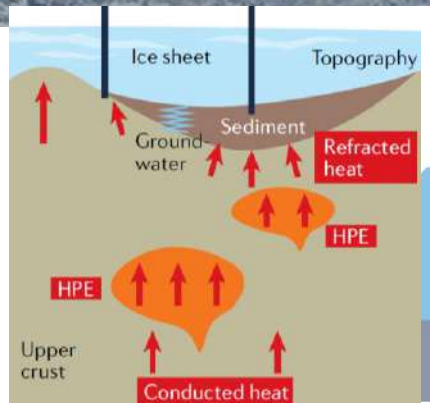
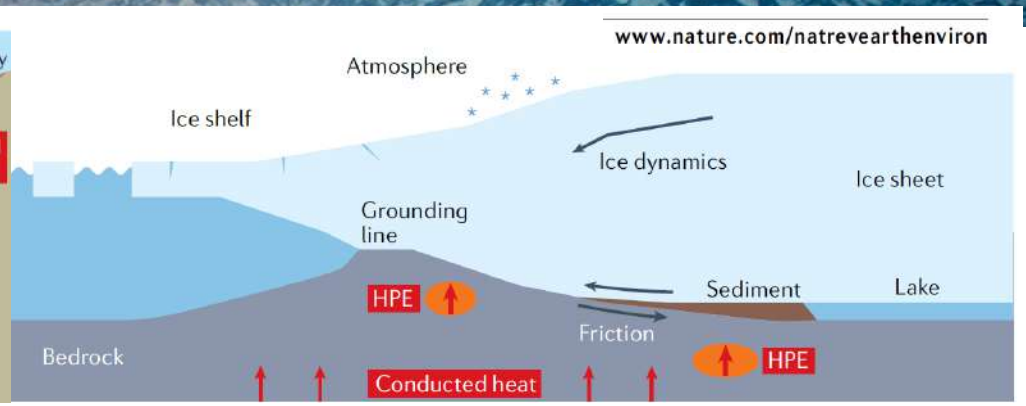
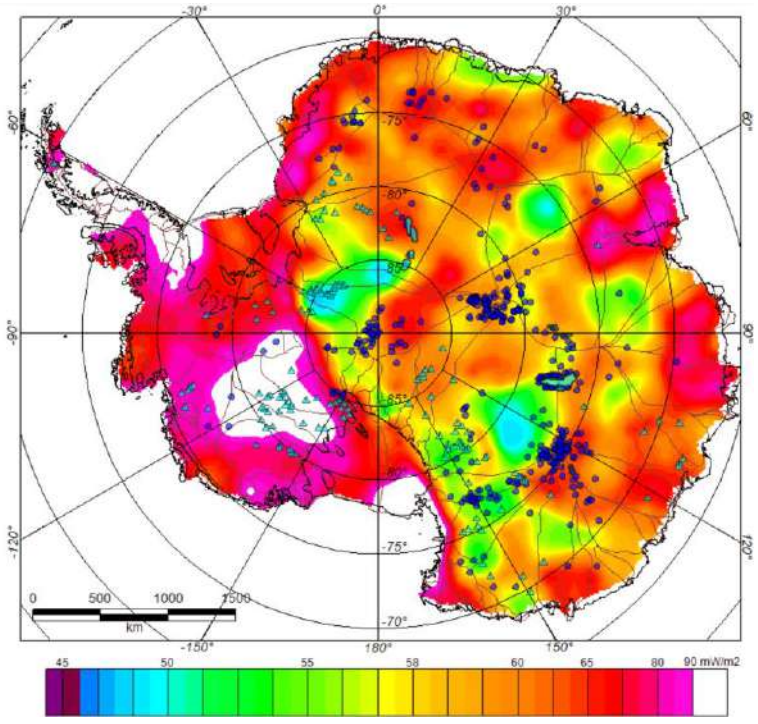
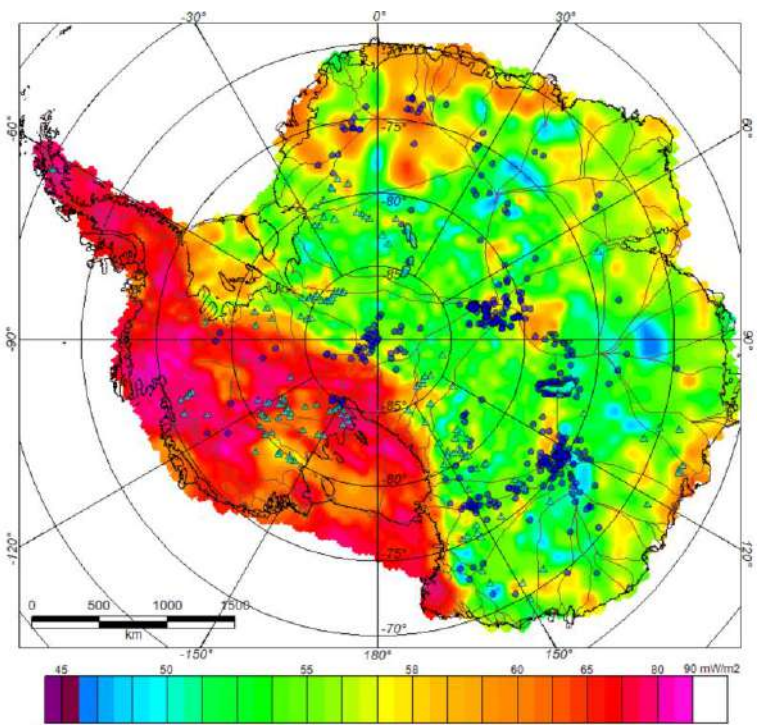


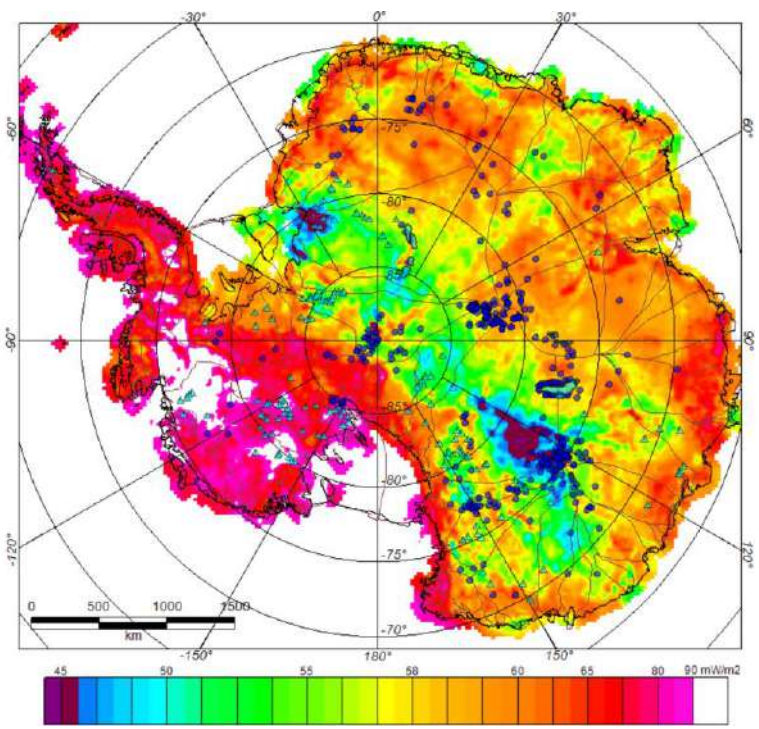




Magnetic GHF Estimate- *Martos et al., 2017, GRL*

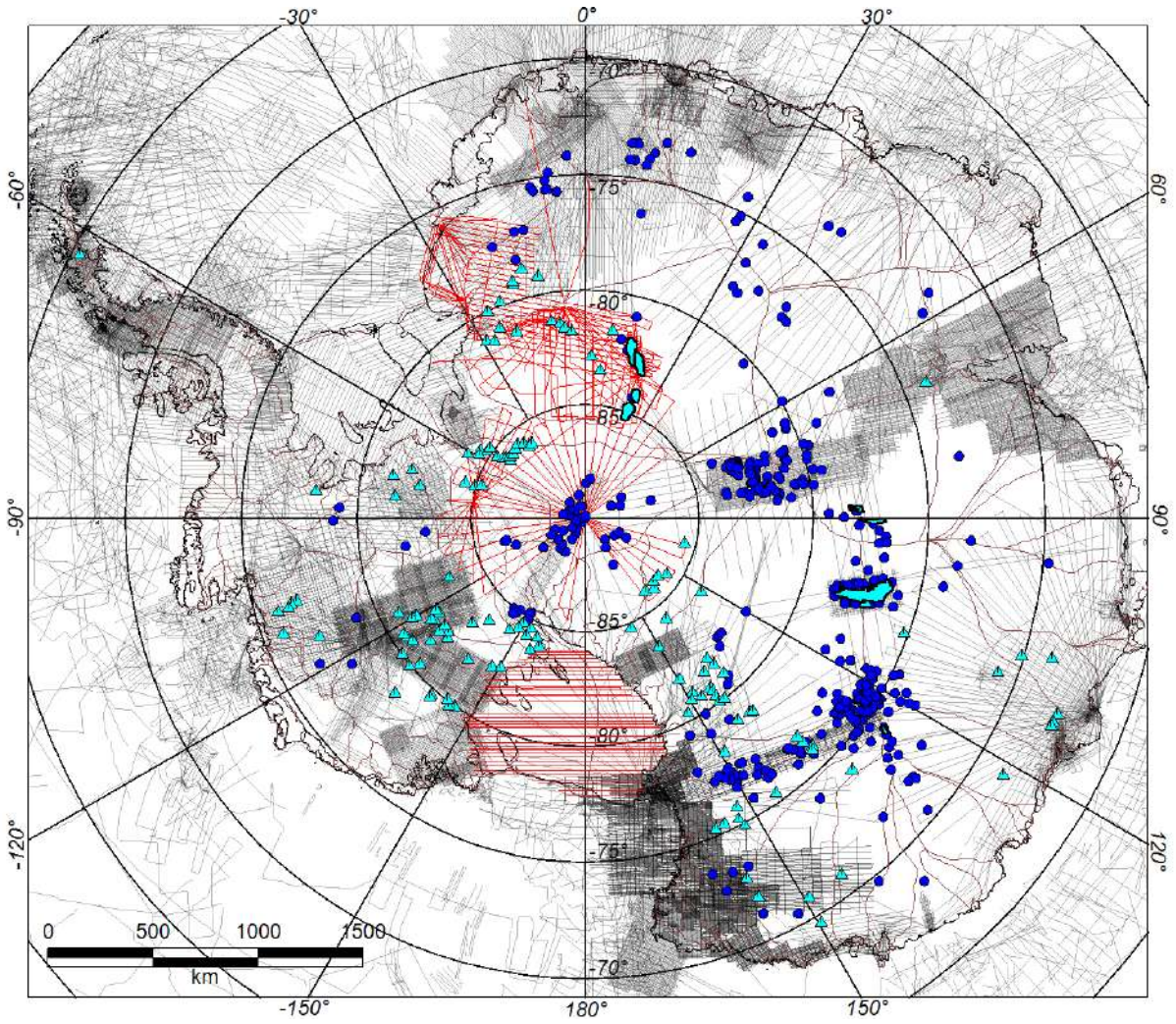


Seismological GHF Estimate- *Shen et al., 2020, GRL*

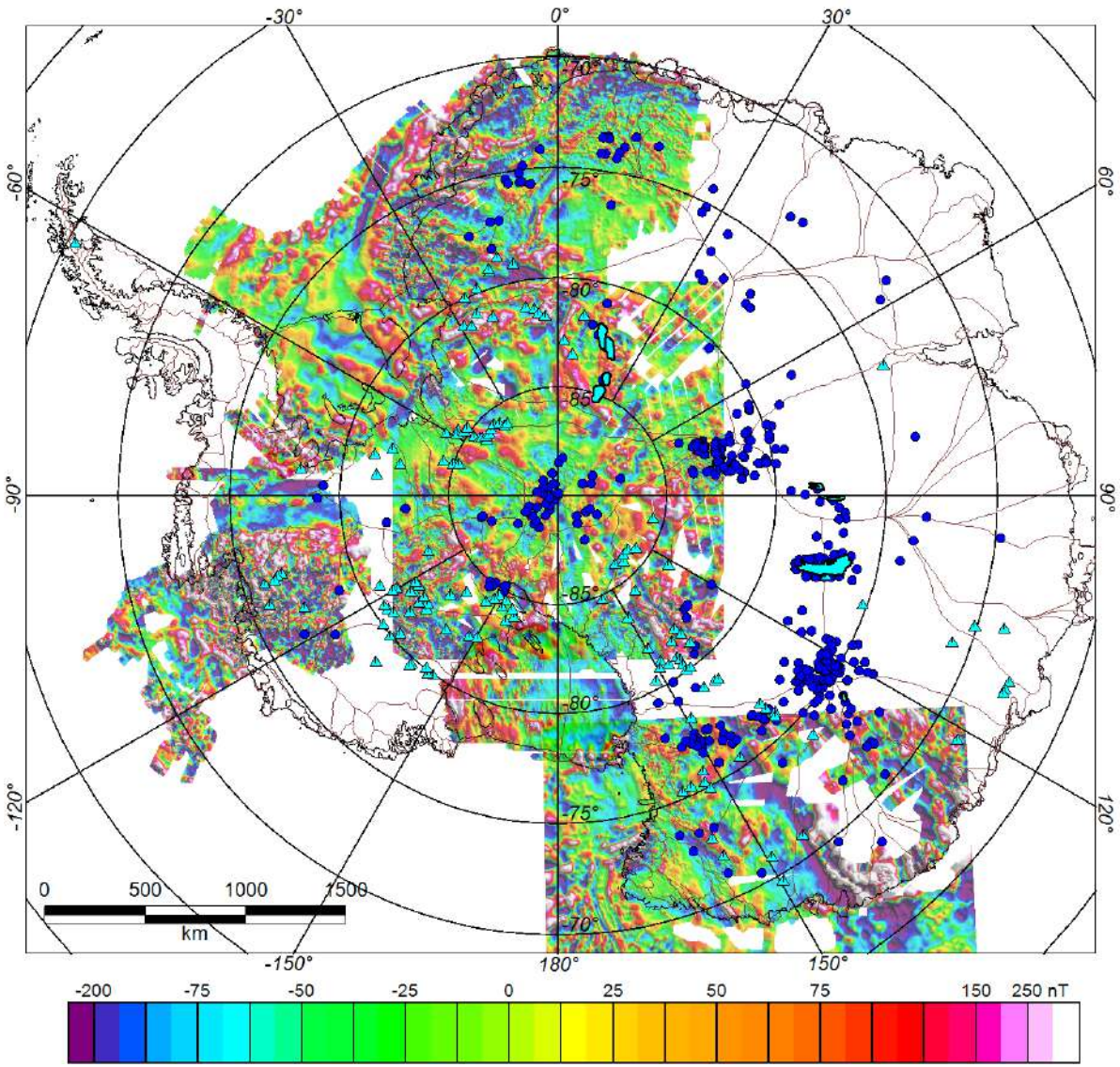


Multivariate GHF Estimate- *Stål et al., 2021, G-cubed*

ADMAP 2.0+ new aeromagnetic data as a tool for refined GHF estimation

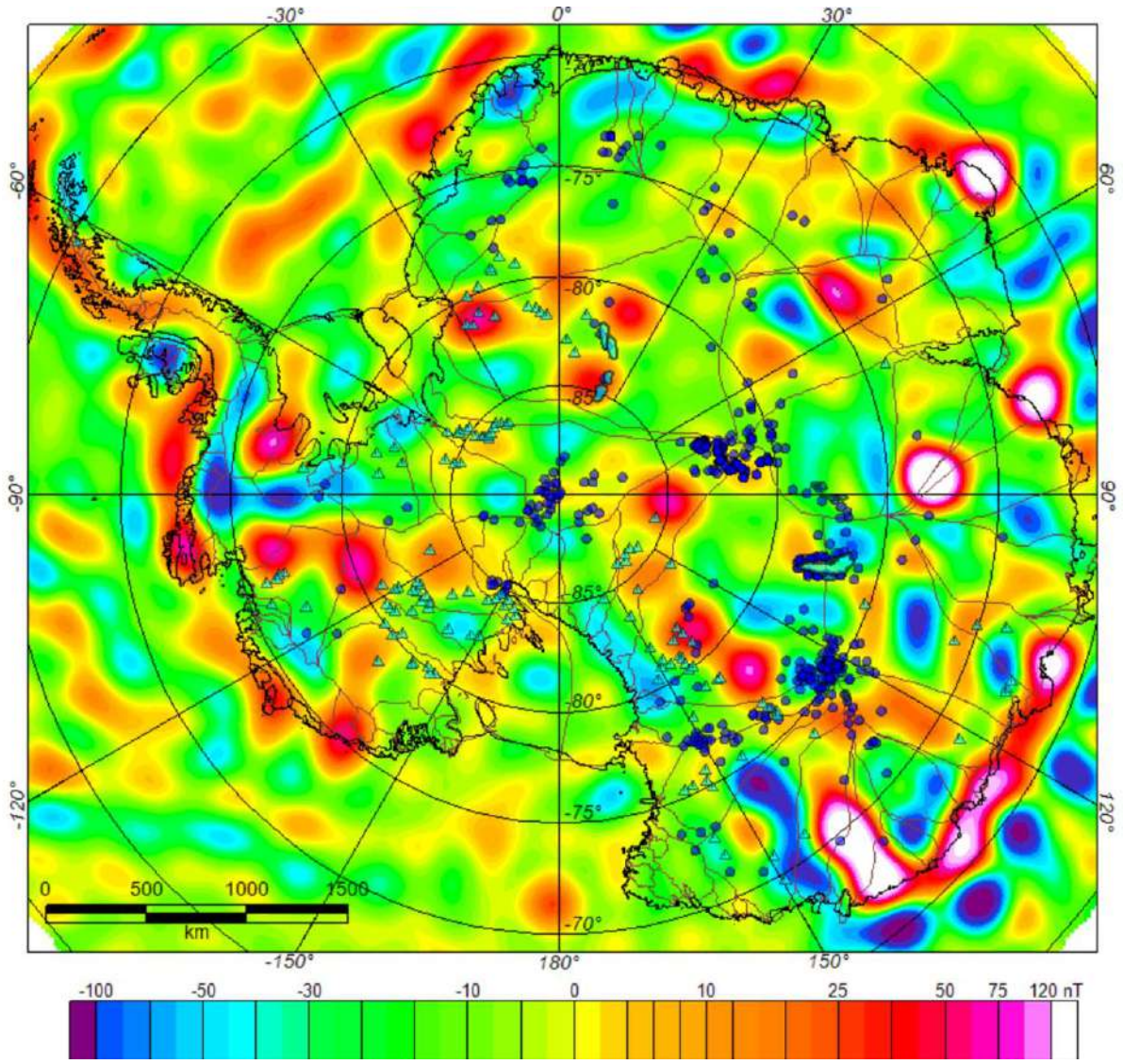


New aeromagnetic data for GHF Estimation- *Ferraccioli et al., 2024, Sci. Advances in prep.*

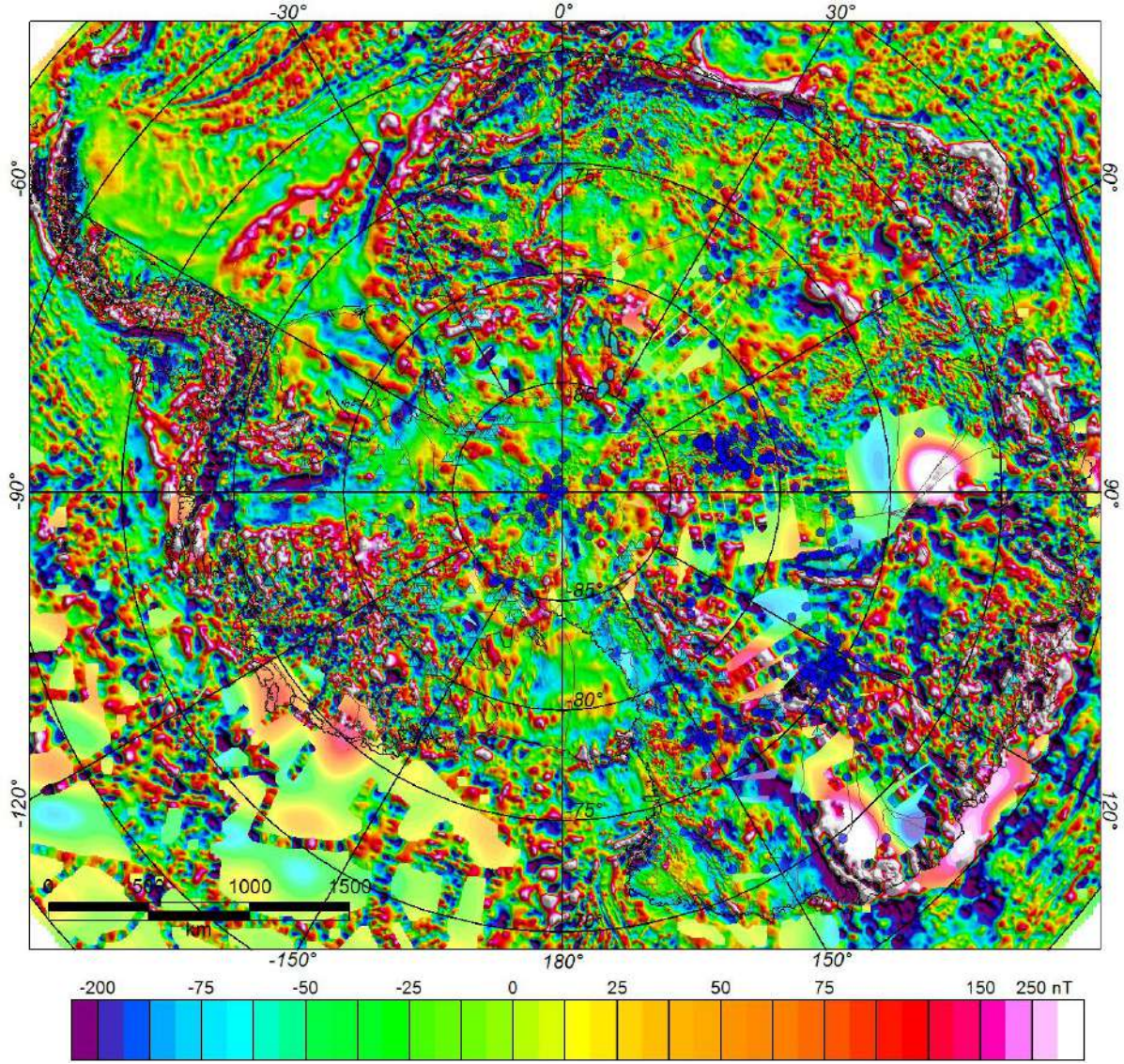


Set of new aeromagnetic data compilations- *Ferraccioli et al., 2024, Sci. Advances in prep.*

ADMAP 2.0+ conformed to SWARM

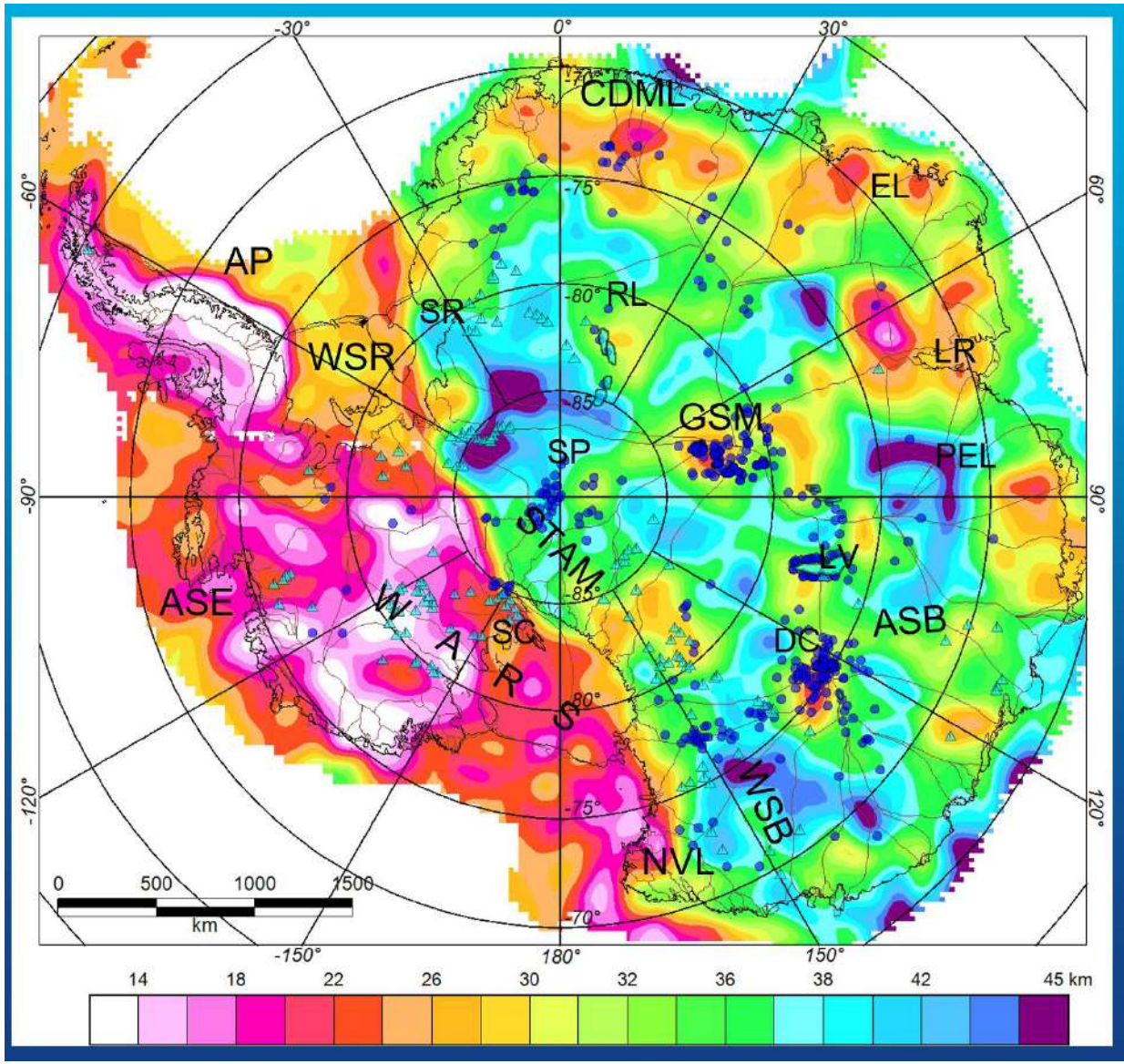


SWARM satellite magnetic data- *Ferraccioli et al., 2024, Sci. Advances in prep.*

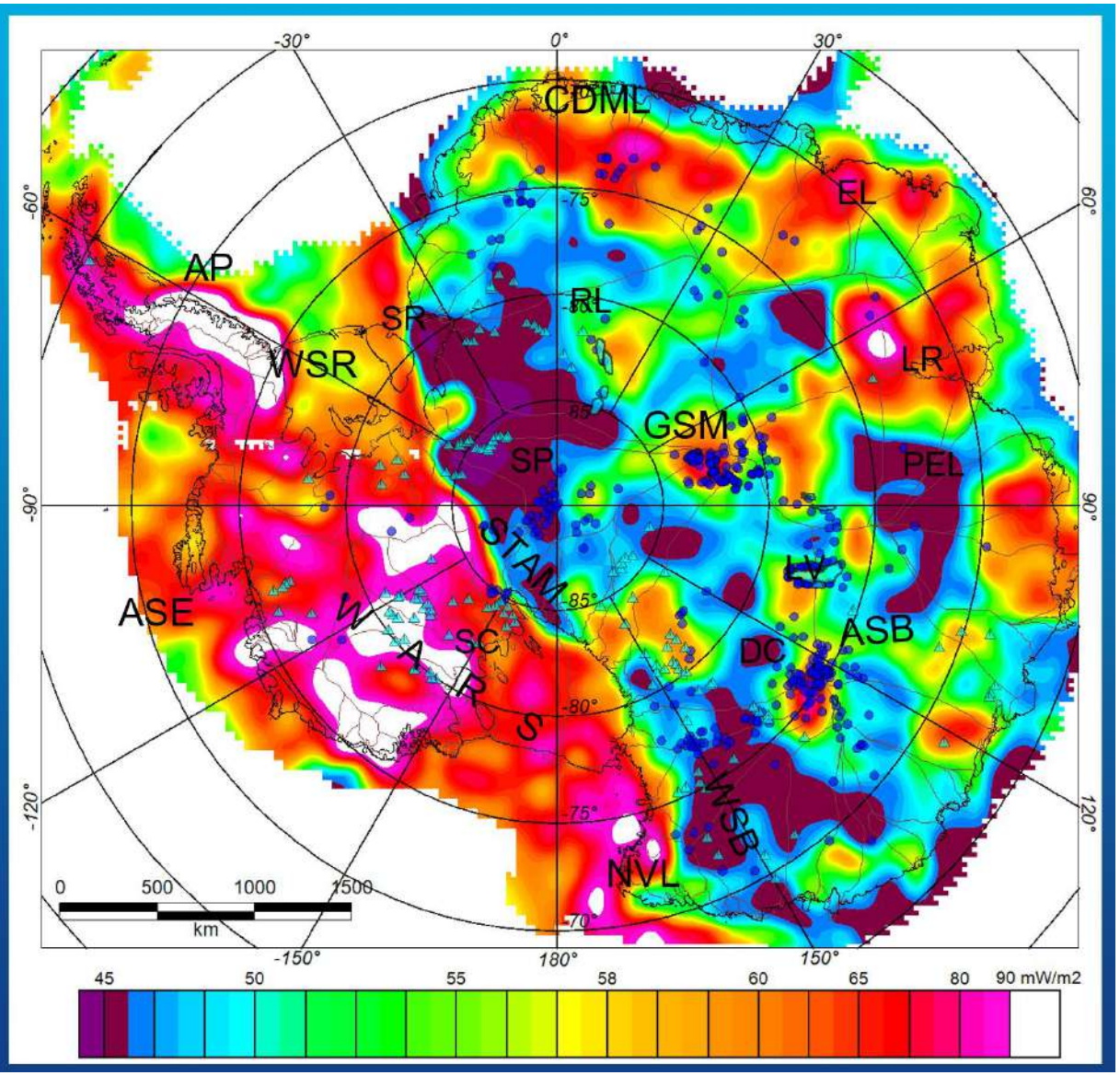


ADMAP 2.0+ compilation - *Ferraccioli et al., 2024, Sci. Advances in prep.*

New Curie Depth & GHF Estimates

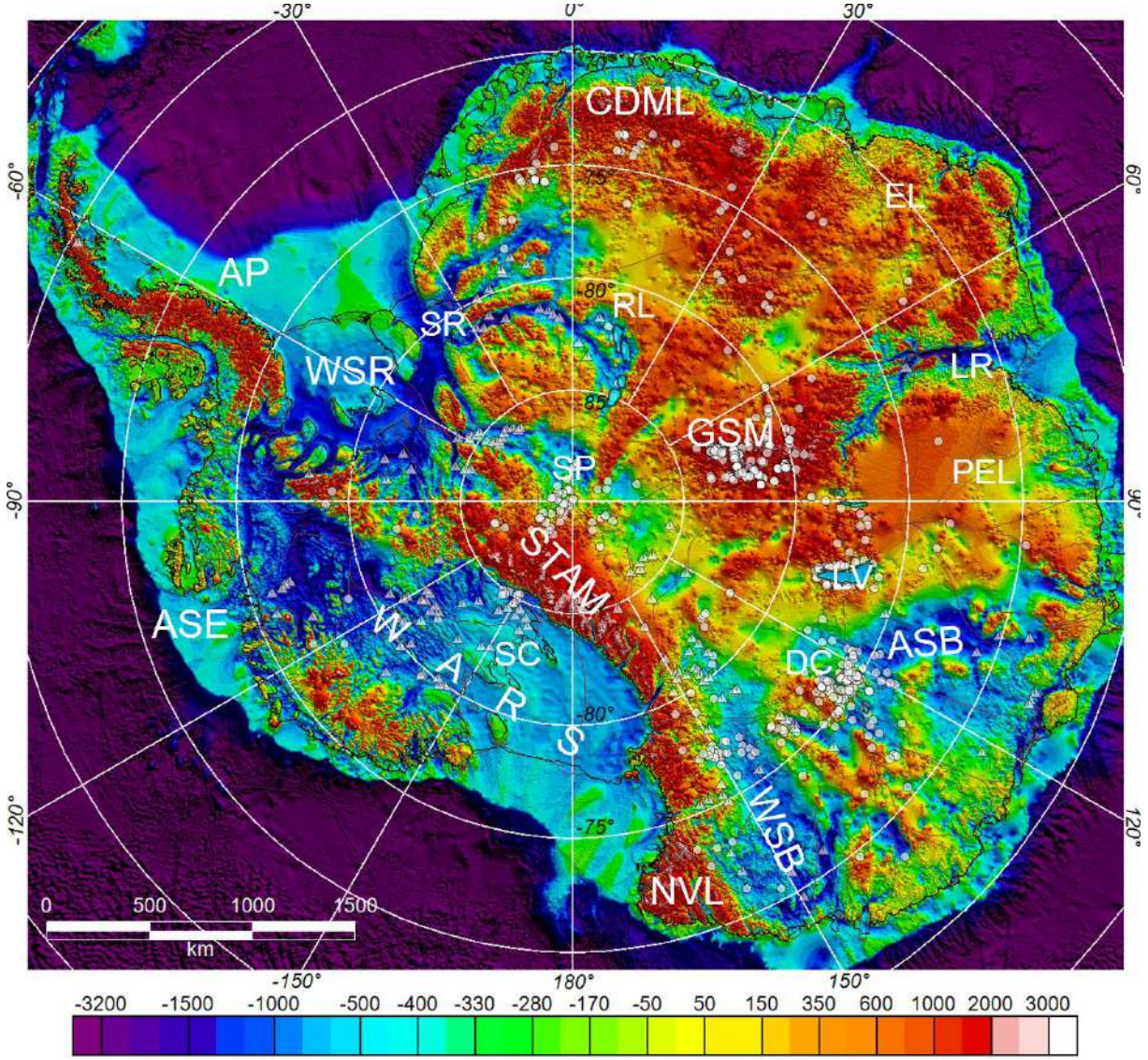


Curie Depth- *Ferraccioli et al., 2024, Sci. Advances in prep.*

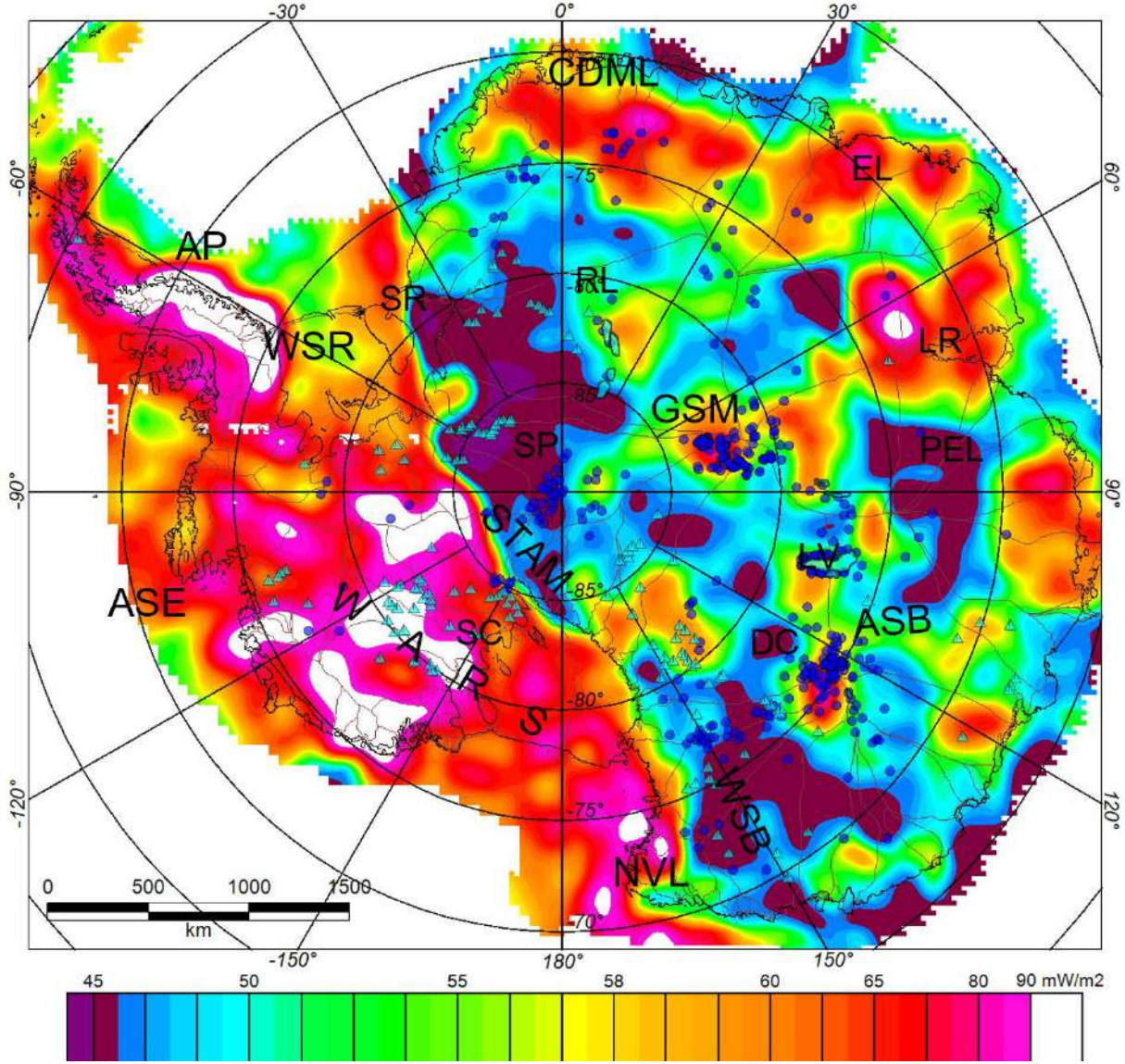


Geothermal Heat Flux - *Ferraccioli et al., 2024, Sci. Advances in prep.*

GHF estimate, bed & subglacial lakes

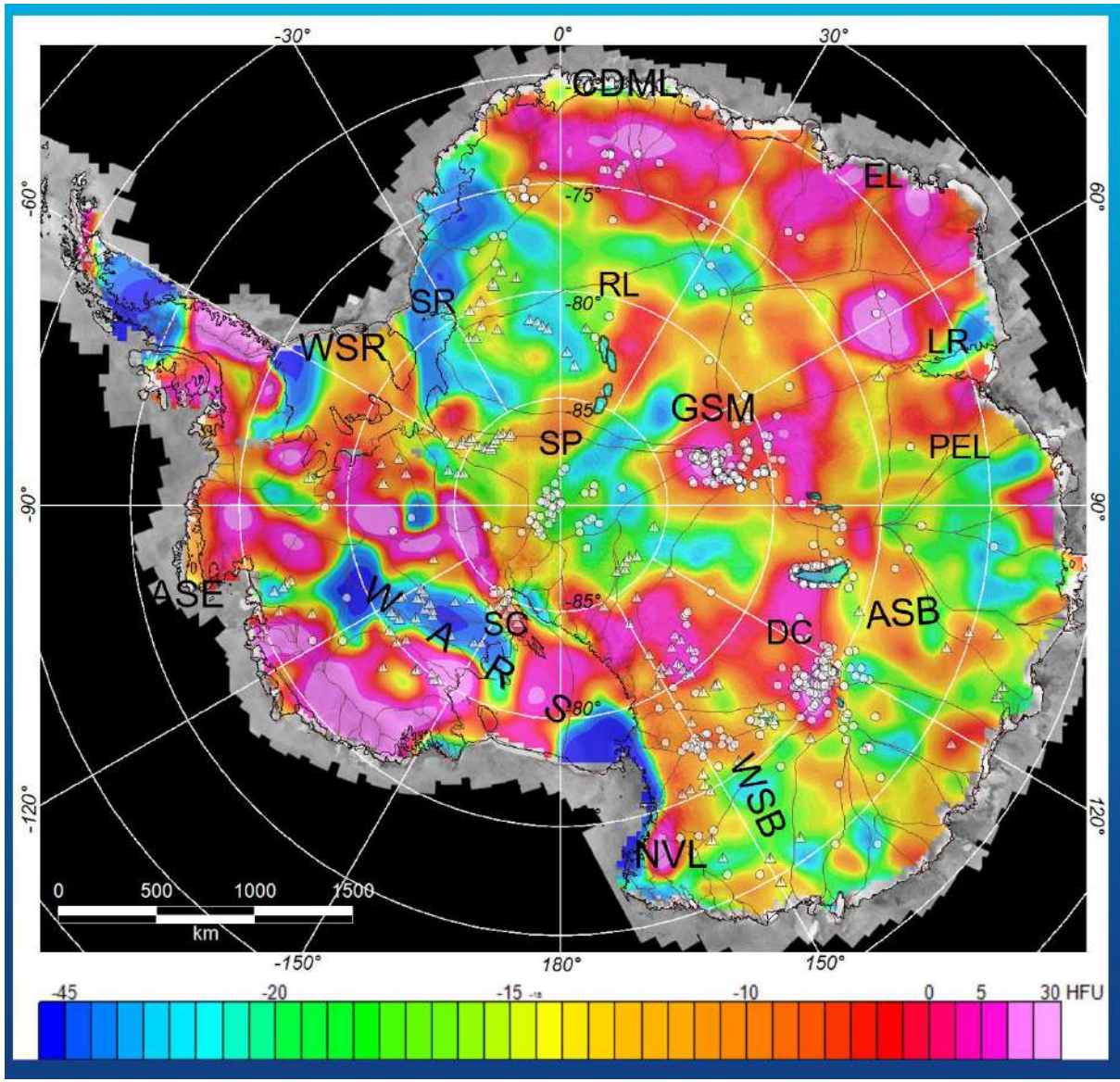


BedMachine- *Morlighem et al., 2020, Nature Geoscience*

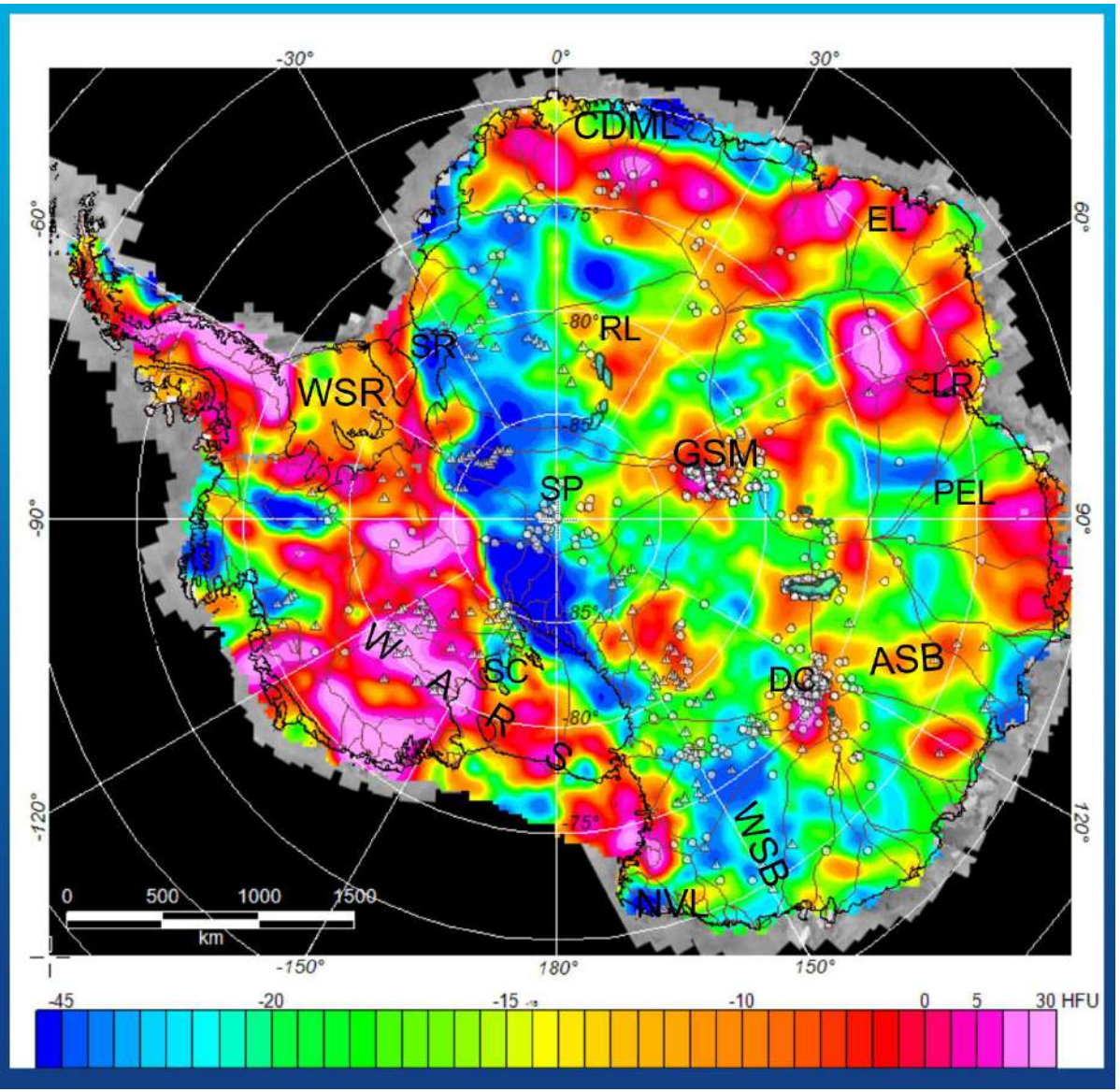


Geothermal Heat Flux - *Ferraccioli et al., 2024, Sci. Advances in prep.*

Differences wrt previous GHF Estimates



Differences wrt to previous mag estimate- *Ferraccioli et al., 2024, Sci. Adv. in prep.*

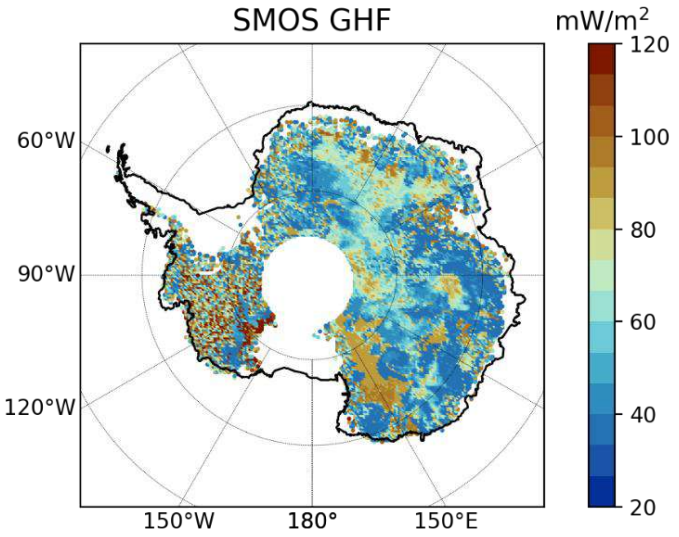


Differences wrt to previous seismological estimate - *Ferraccioli et al., 2024, Sci. Adv. in prep.*

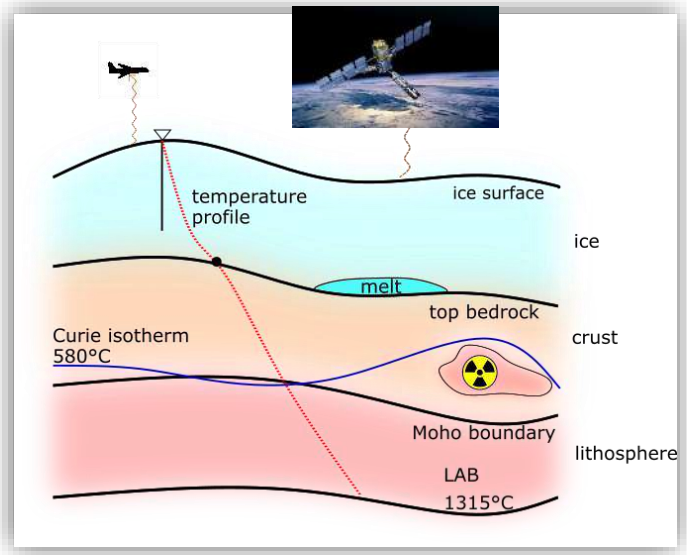
New research priorities & challenges

1. **To derive more fully integrated continental-scale views of GHF by combining disparate seismological, potential field, SMOS & geological/glaciological datasets & thermal models**

Requires e.g. Integrated Bayesian Inversion, Multivariate approaches, machine-learning & AI



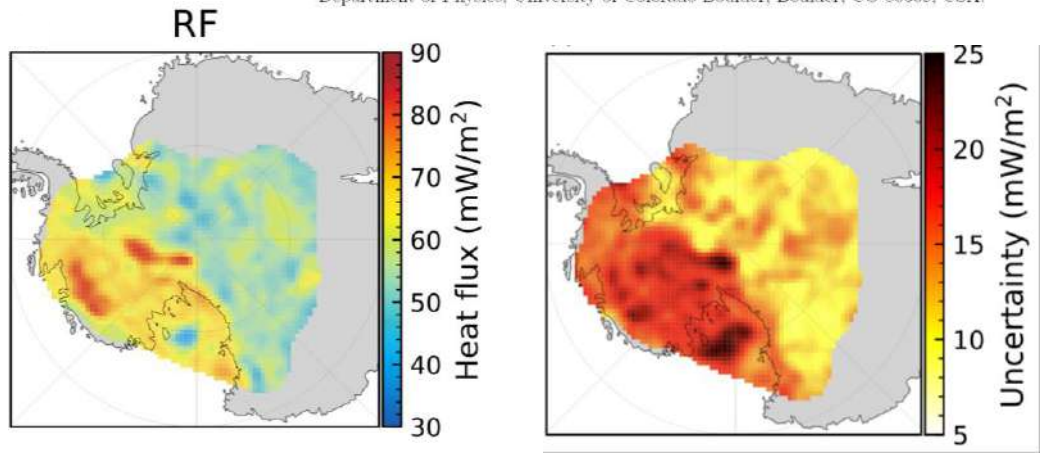
SMOS + multigaussian approach
Leduc-Leballeur et al., in prep



Applying Machine Learning to Characterize and Transport the Relationship Between Seismic Structure and Surface Heat Flux

Shane Zhang[*1] and *Michael H. Ritzwoller*[1]

[1] Department of Physics, University of Colorado Boulder, Boulder, CO 80309, USA.



SMOS satellite mission data
can be combined with glaciological/emission models
to **infer ice sheet temperature**

GHF from geophysical models & their uncertainty can be used as inputs

New research priorities & challenges

2. Bring the crust into the equation;

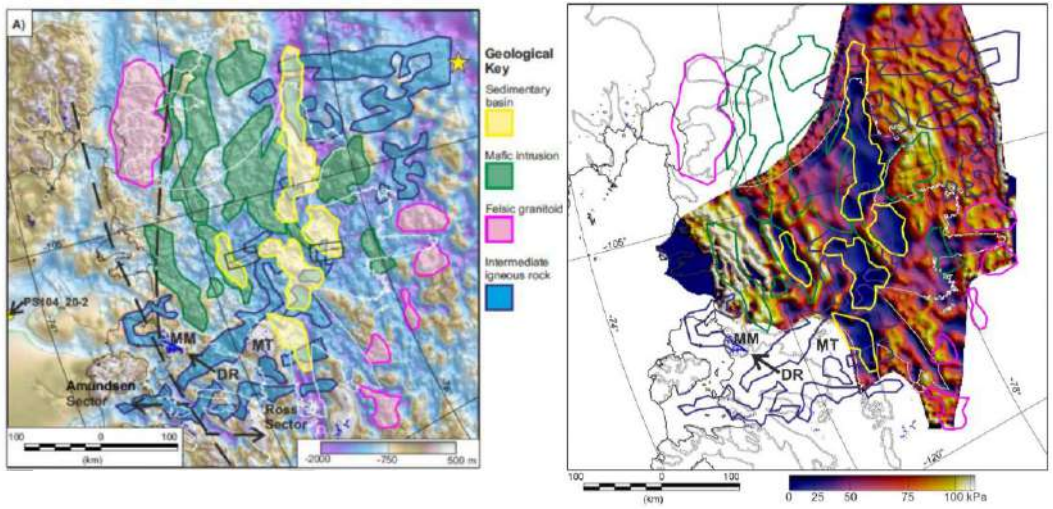
particularly radiogenic heat production & sedimentary basins to help upscale GHF estimates from continental to regional & local scales beneath subglacial hydrological networks

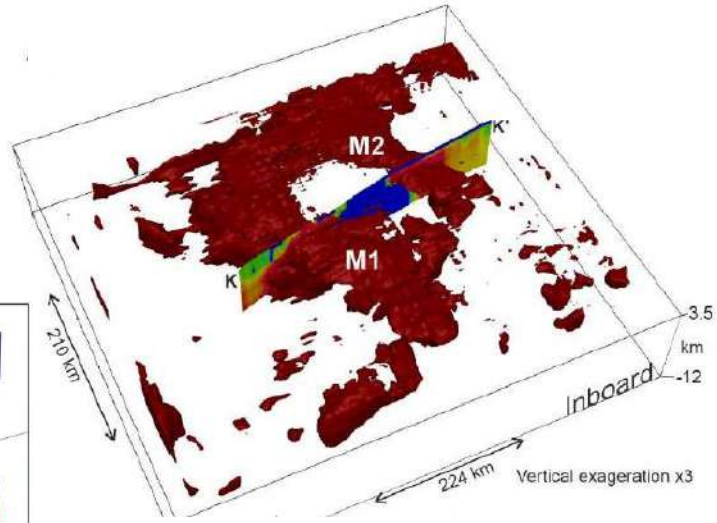
SCIENCE ADVANCES | RESEARCH ARTICLE

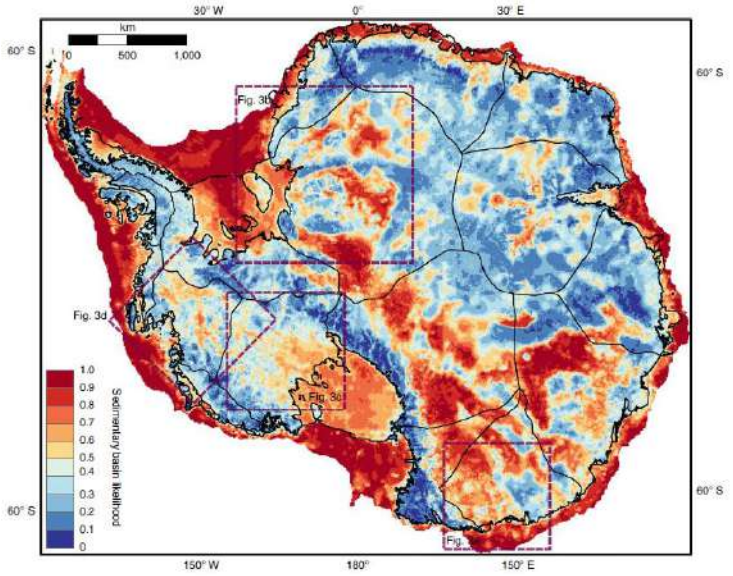
GEOPHYSICS

Geological sketch map and implications for ice flow of Thwaites Glacier, West Antarctica, from integrated aerogeophysical observations

Tom A. Jordan[1]*, Sarah Thompson[2], Bernd Kulessa[3,4], Fausto Ferraccioli[1,5]







nature geoscience

ARTICLES

https://doi.org/10.1038/s41561-022-00992-5

Sedimentary basins reduce stability of Antarctic ice streams through groundwater feedbacks

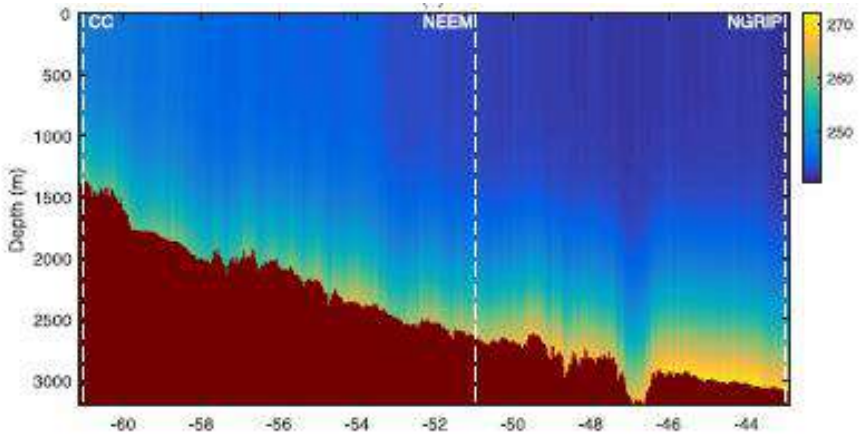
Lu Li[1], Alan R. A. Aitken[1,2], Mark D. Lindsay[1,3,4] and Bernd Kulessa[5,6]

New research priorities & challenges

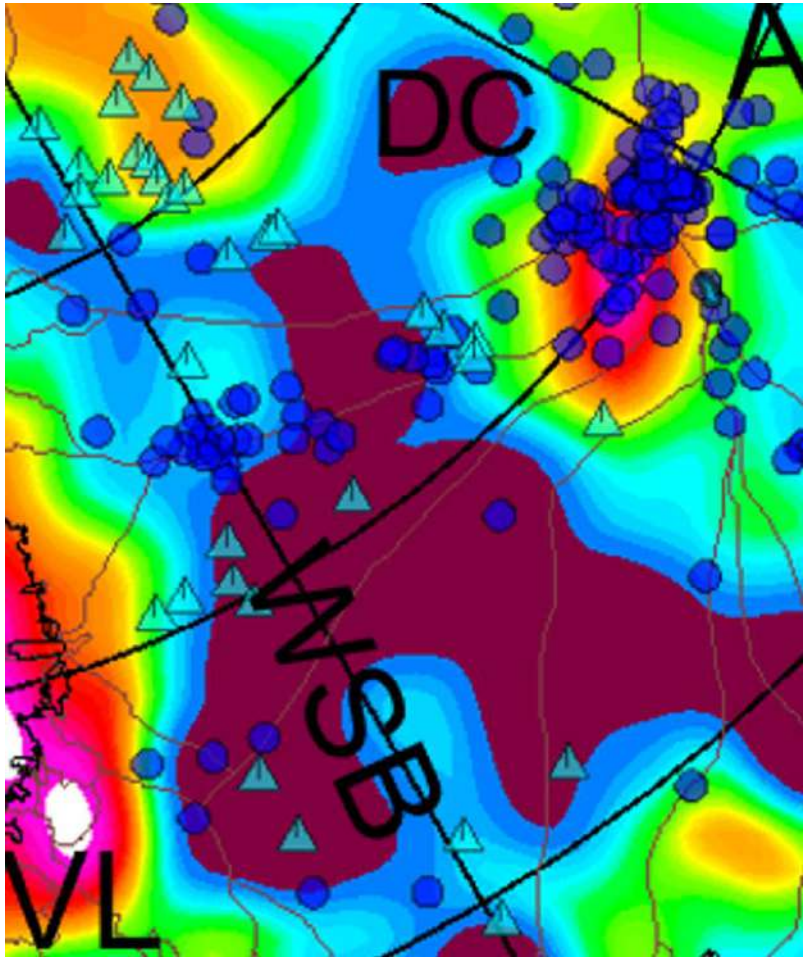
3. Validate & augment geophysical models with new seismological, MT & airborne surveys

CryoRAd precursor – UWBRAD airborne instruments

Ultrawideband microwave radiometer to image ice sheet internal temperature (e.g. Yardim et al. 2021)



Dome C and Wilkes Subglacial Basin regions provide ideal candidate sites for such new airborne & ground-based exploration campaigns



Summary

- A new satellite conformed aeromagnetic anomaly compilation that contains major new datasets (ADMAP 2.0+) provides a new tool to study Antarctic GHF heterogeneity

- Prominent GHF anomalies underlie parts of the West Antarctic Ice Sheet & are related to the WARS. Lower amplitude but intriguing GHF anomalies are imaged beneath the East Antarctic Ice Sheet, particularly beneath the Dome C, GSM & DML subglacial lake districts

- The next challenges are to integrate different geophysical observations/models & develop thermal models that incorporate both intra-crustal heat production and sedimentary basins

- Novel airborne UWBRAD surveys could help “take the temperature” of Antarctic ice sheets at unprecedented resolution (suggested survey priorities in the Dome C & WSB subglacial lake districts)