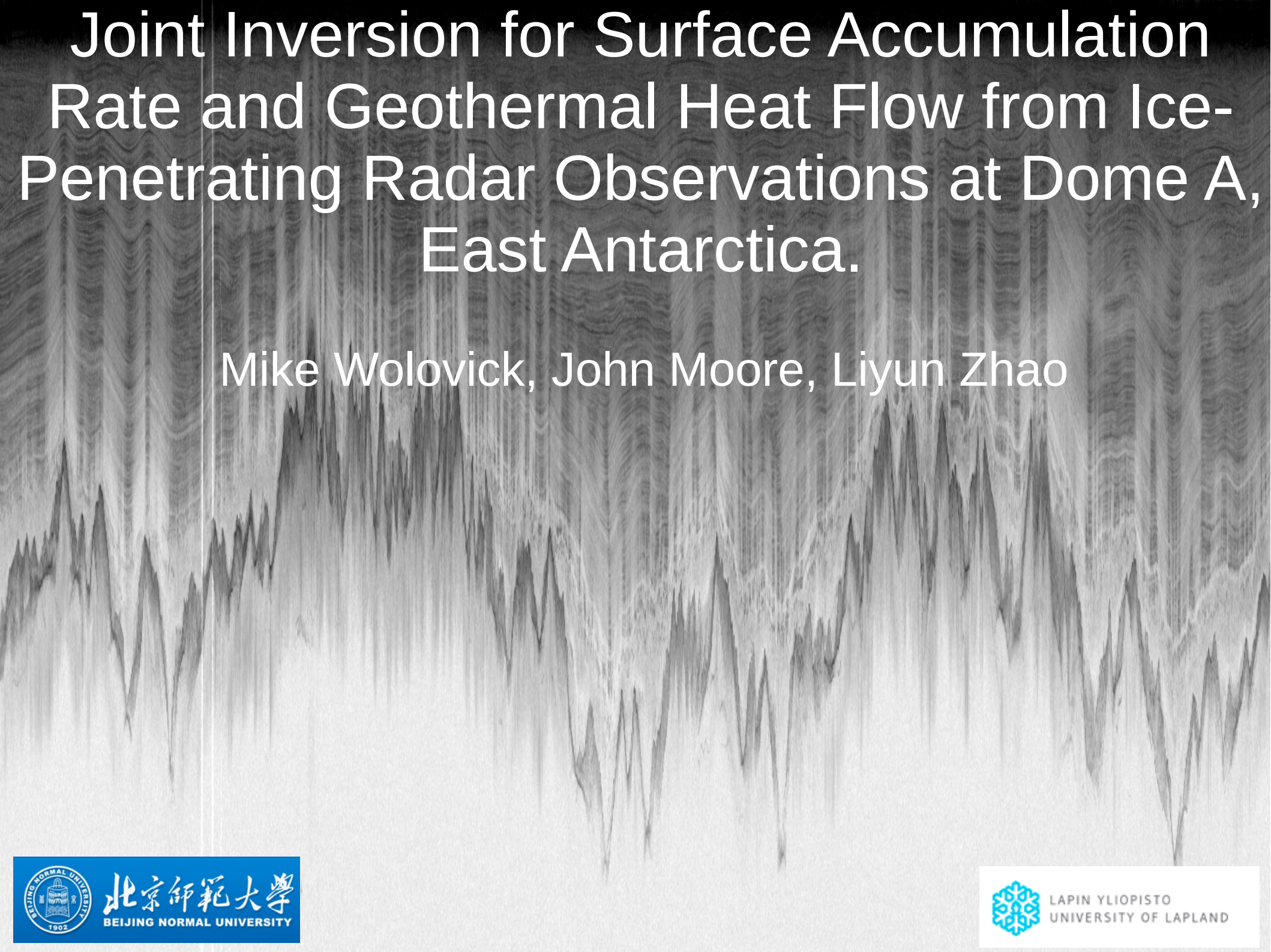
Joint Inversion for Surface Accumulation Rate and Geothermal Heat Flow from Ice-Penetrating Radar Observations at Dome A, East Antarctica.

Mike Wolovick, John Moore, Liyun Zhao



北京師範大學
BEIJING NORMAL UNIVERSITY

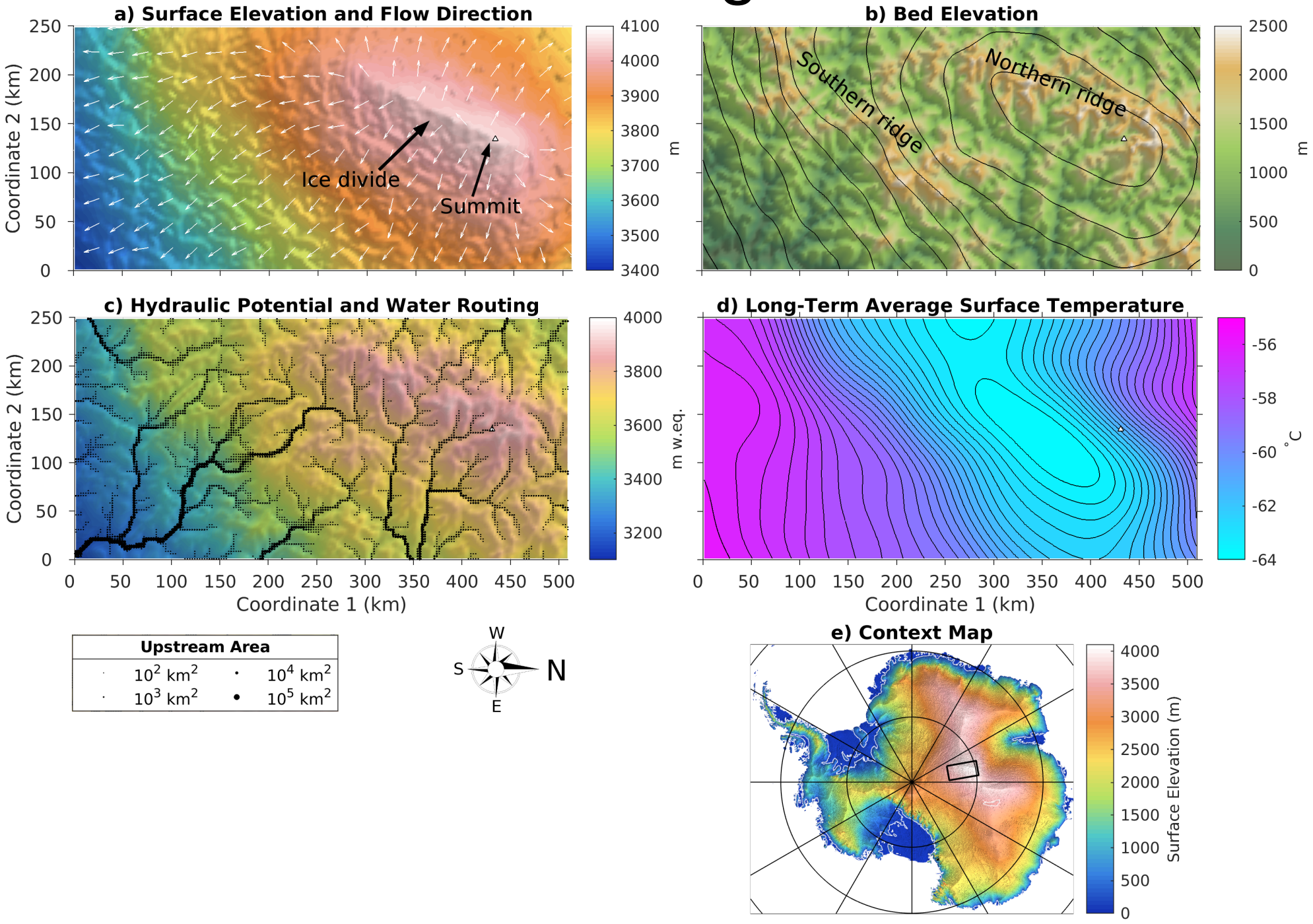
LAPIN YLIOPISTO
UNIVERSITY OF LAPLAND

Outline

1) Setting
2) Model overview
3) Inversion results
4) Details of best-fit model
5) Comparisons
6) Conclusions

These results in press at JGR: Earth Surface

Setting

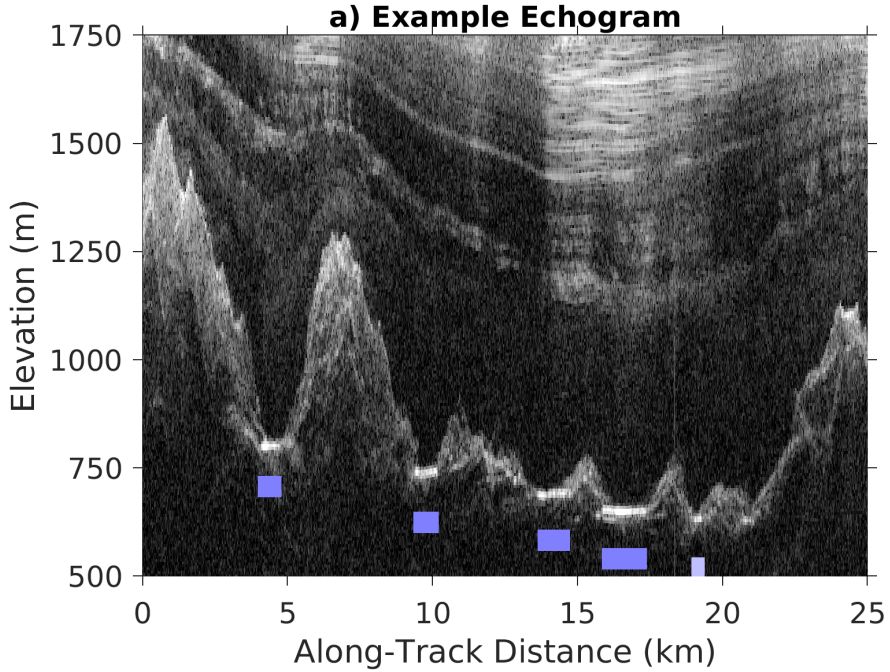

a) Surface Elevation and Flow Direction
Coordinate 2 (km)
Ice divide
Summit
m
b) Bed Elevation
Southern ridge
Northern ridge
m
c) Hydraulic Potential and Water Routing
Coordinate 2 (km)
Coordinate 1 (km)
m w.eq.
d) Long-Term Average Surface Temperature
Coordinate 1 (km)
°C
Upstream Area
10^2 km^2
10^3 km^2
10^4 km^2
10^5 km^2
W
S
N
E
e) Context Map
Surface Elevation (m)

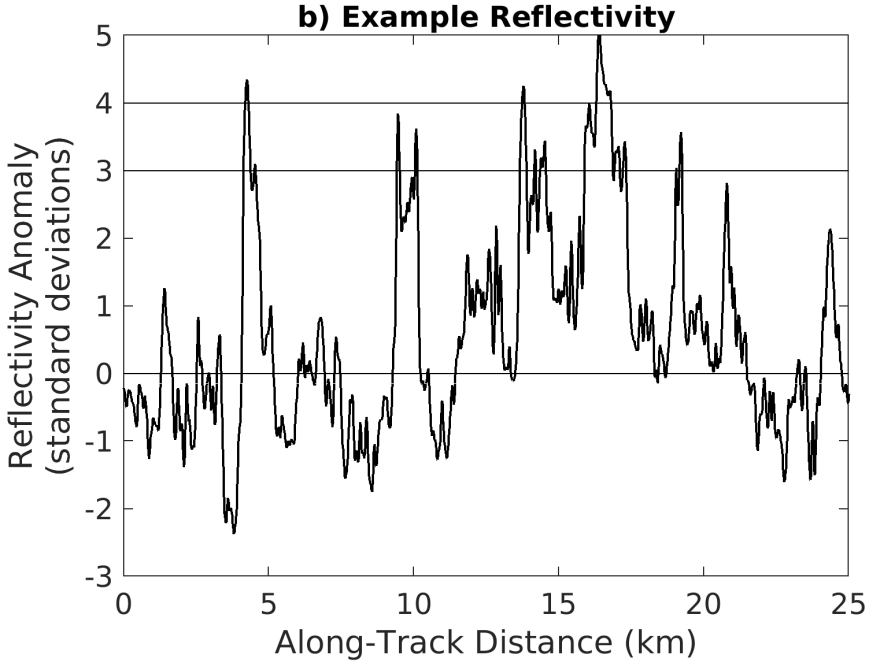
Forward Model Description

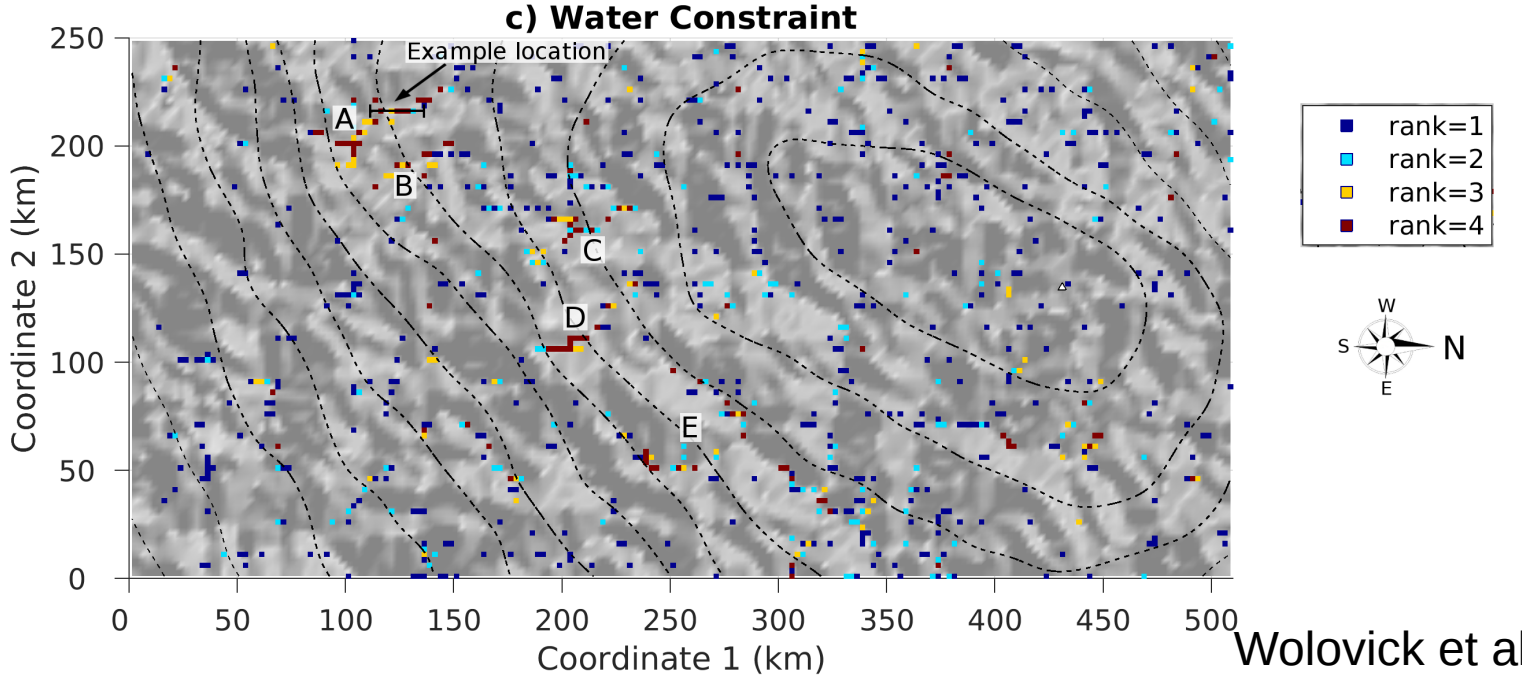
Large-scale shallow ice model in steady state

- Domain is 250x500 km AGAP-S grid
- Column-average velocity from mass balance
- Vertical distribution of velocity from rheology
- Temperature
  - Full horizontal & vertical advection
  - Only vertical diffusion
  - Both basal melt and freeze-on
- Basal hydrology
  - Balance water flux dictated by hydraulic potential
  - Delivers water from melting to freezing zones
  - Iterate for consistency with ice thermal field
- Computes age and freeze-on distribution after

Data Constraints: Water

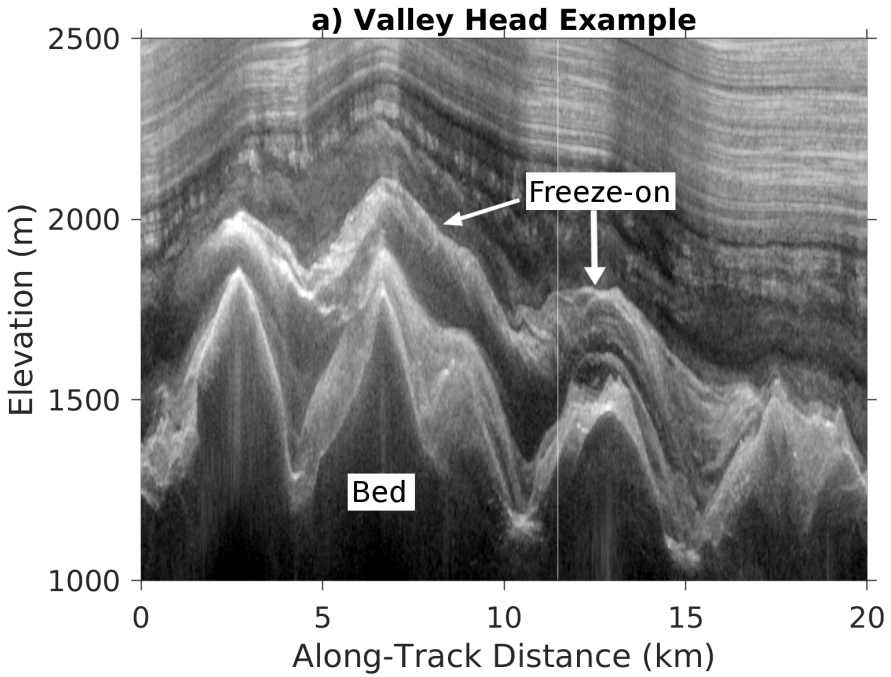


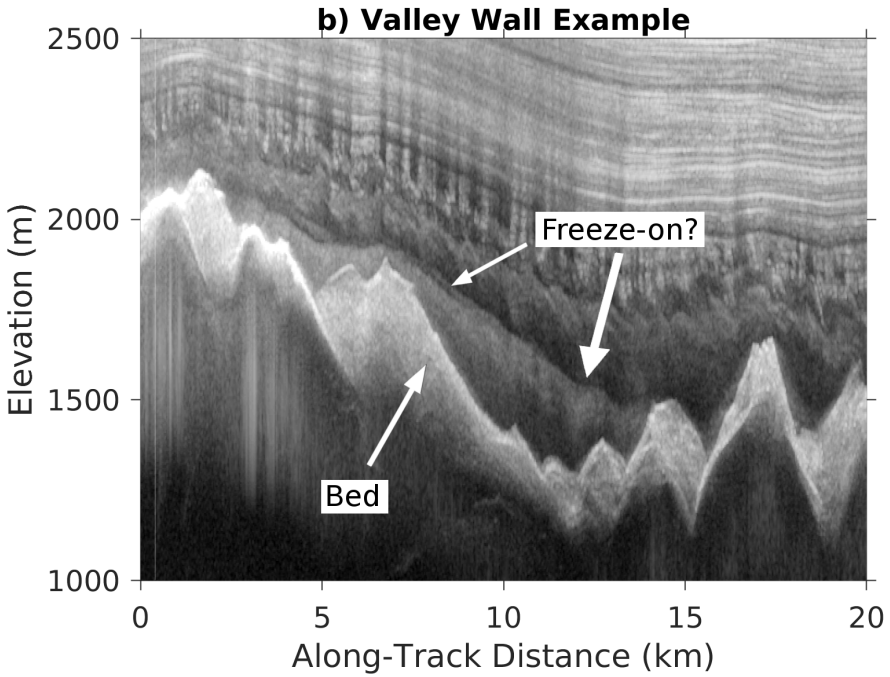


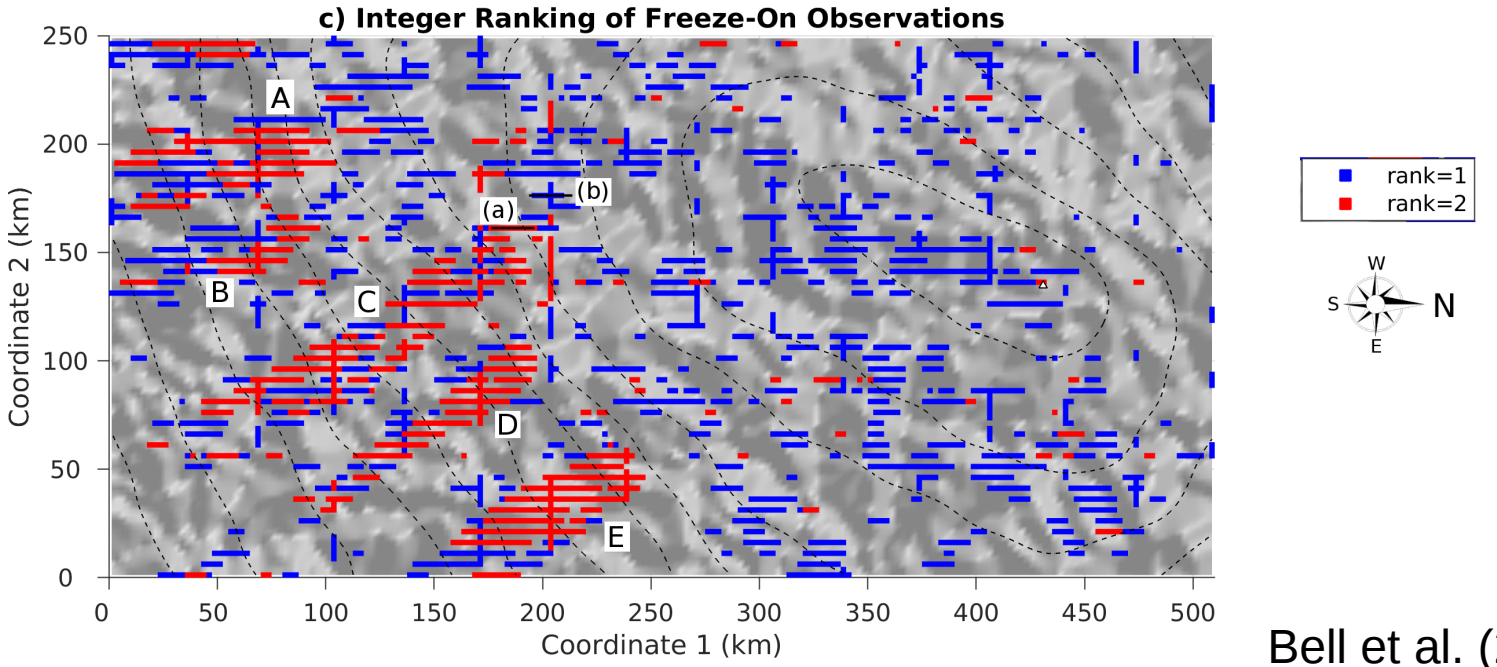


Wolovick et al. (2013)

Data Constraints: Freeze-On

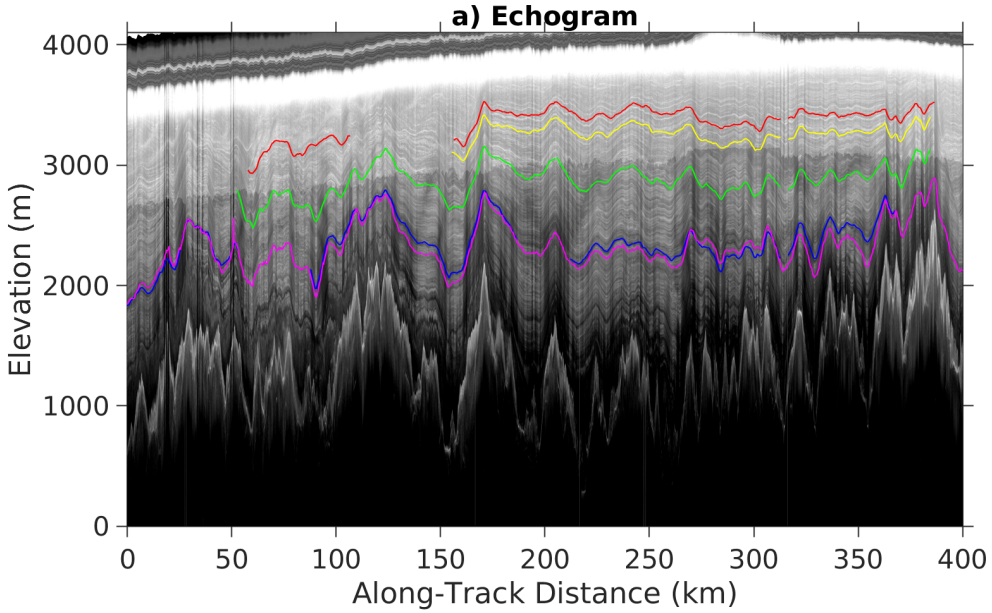


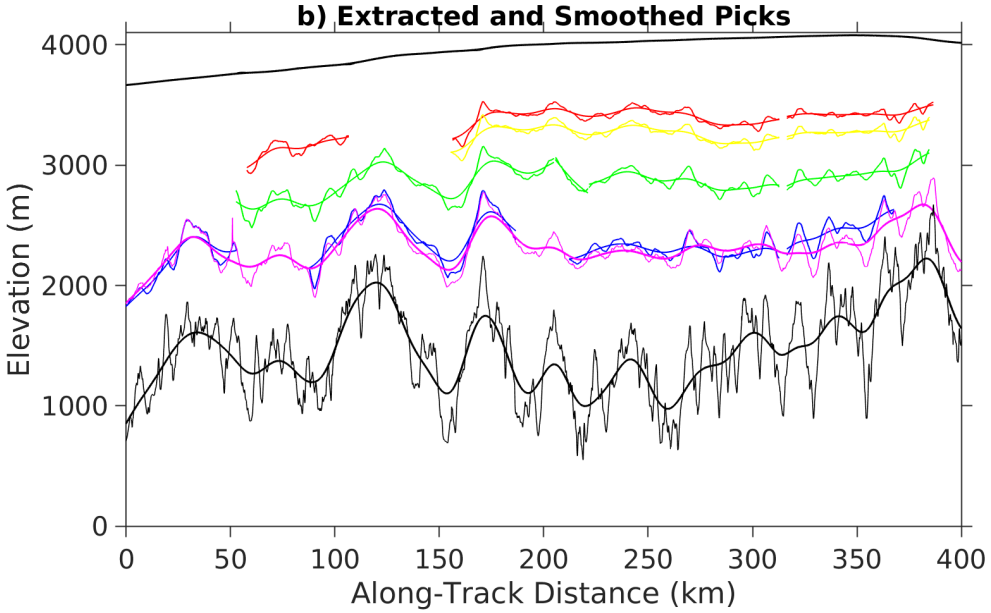


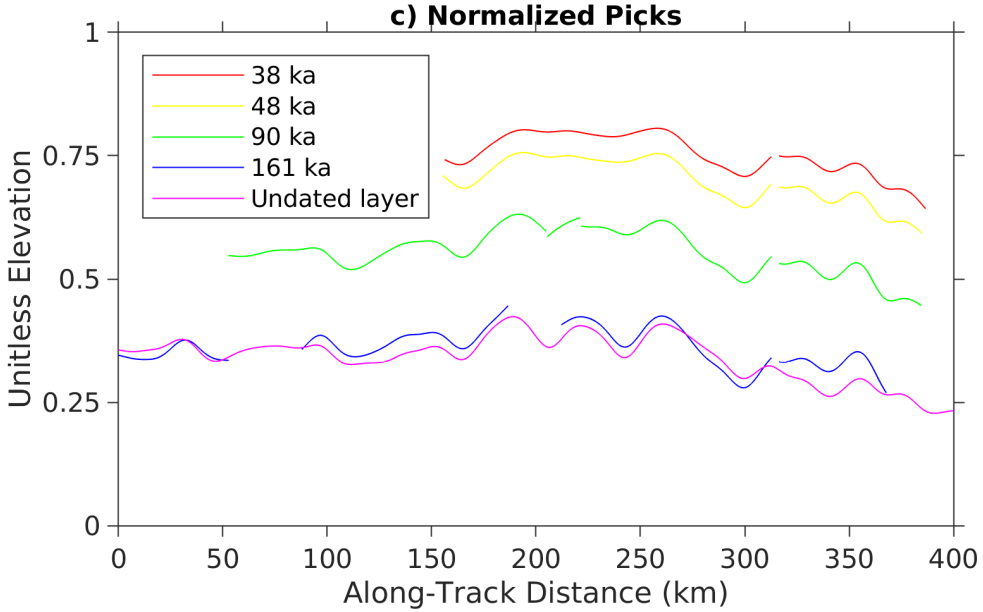


Bell et al. (2011)

Data Constraints: Internal Layers



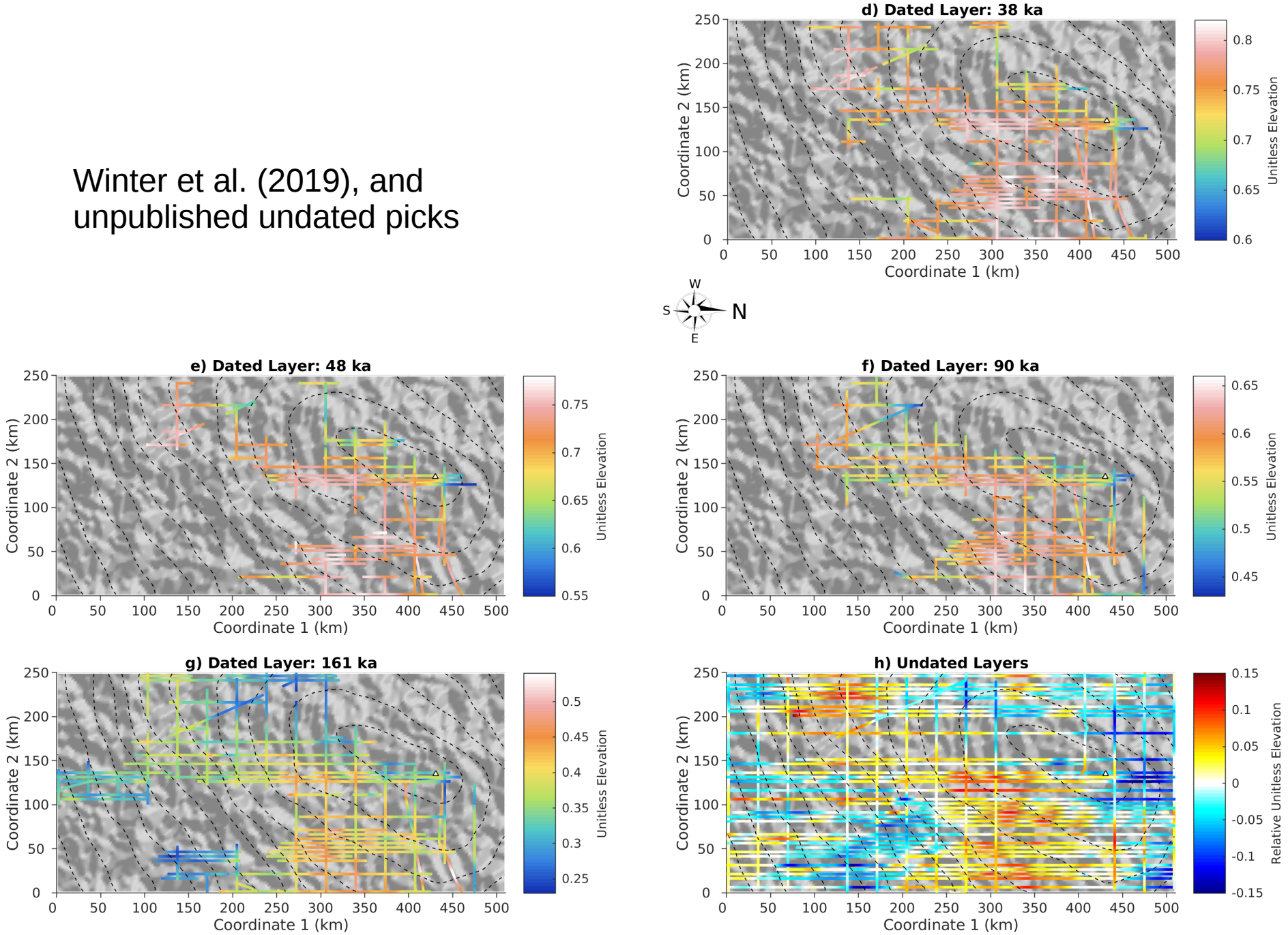




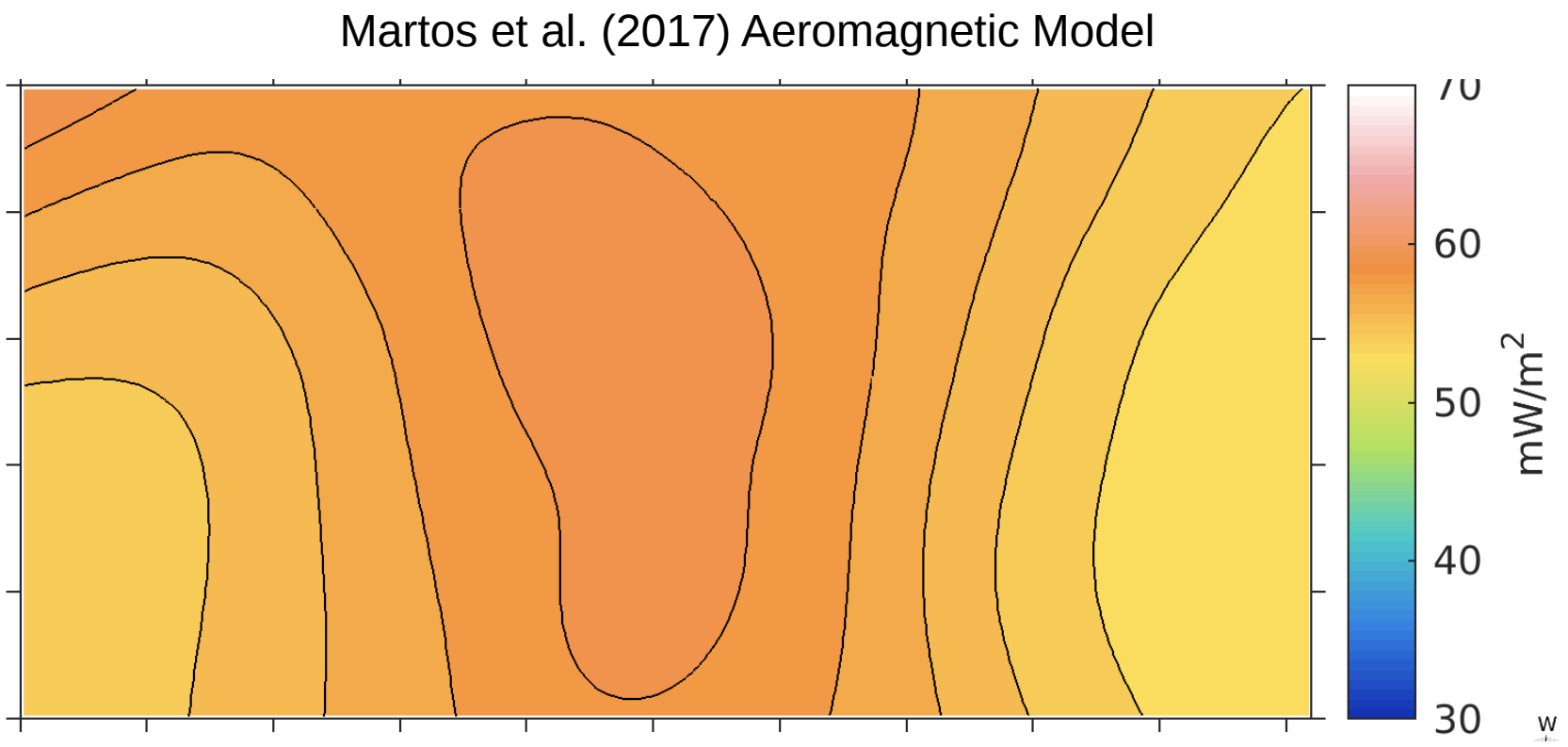
Winter et al. (2019), and unpublished undated picks

Data Constraints: Internal Layers

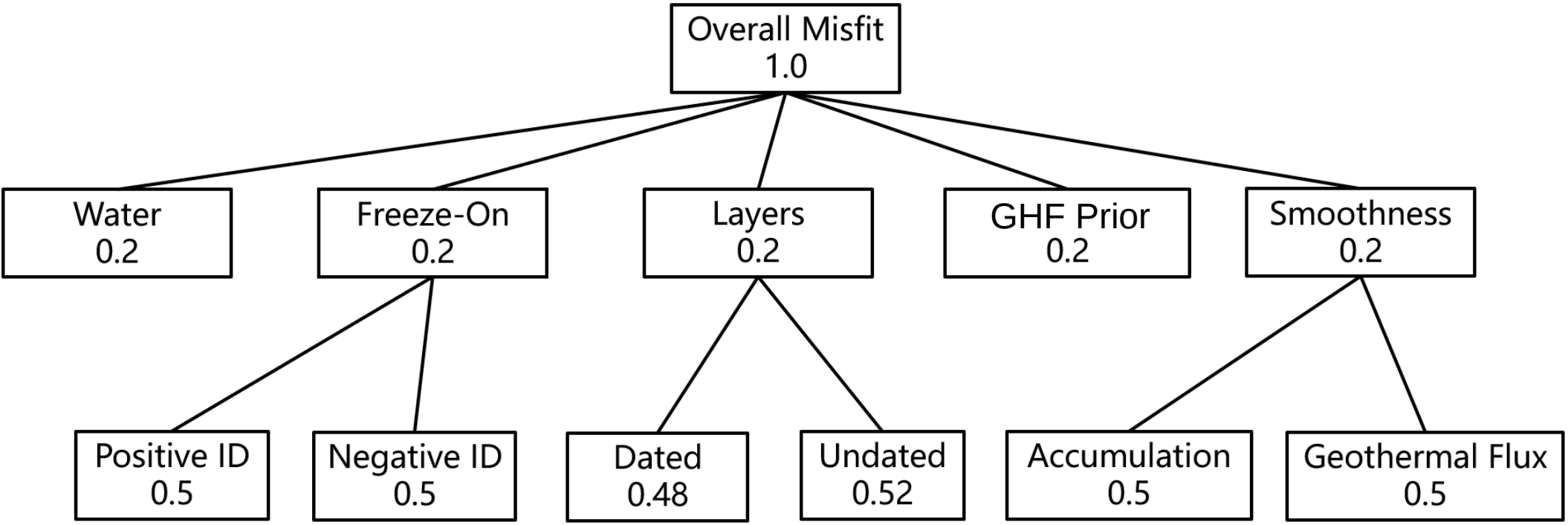
Winter et al. (2019), and unpublished undated picks



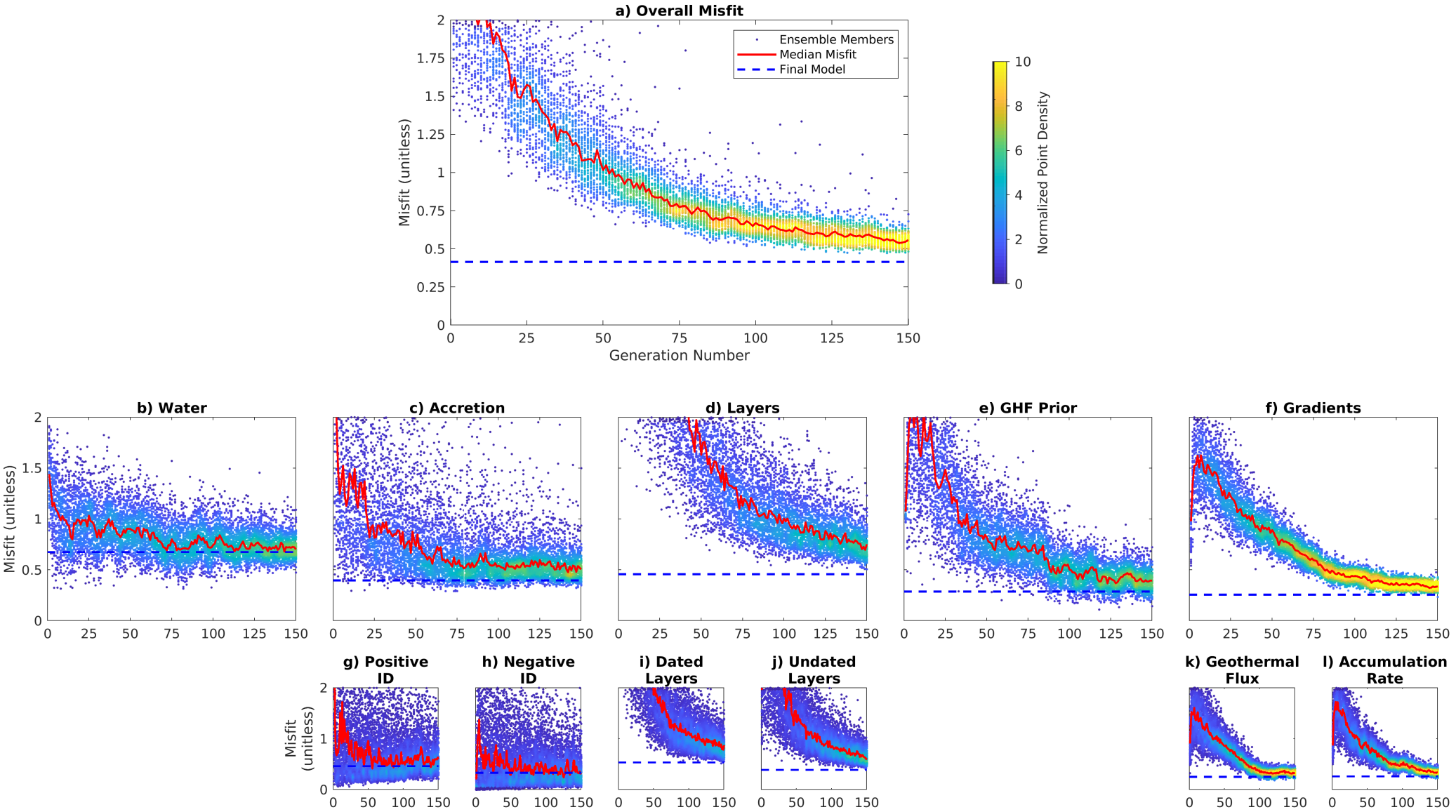
Data Constraints: GHF Prior



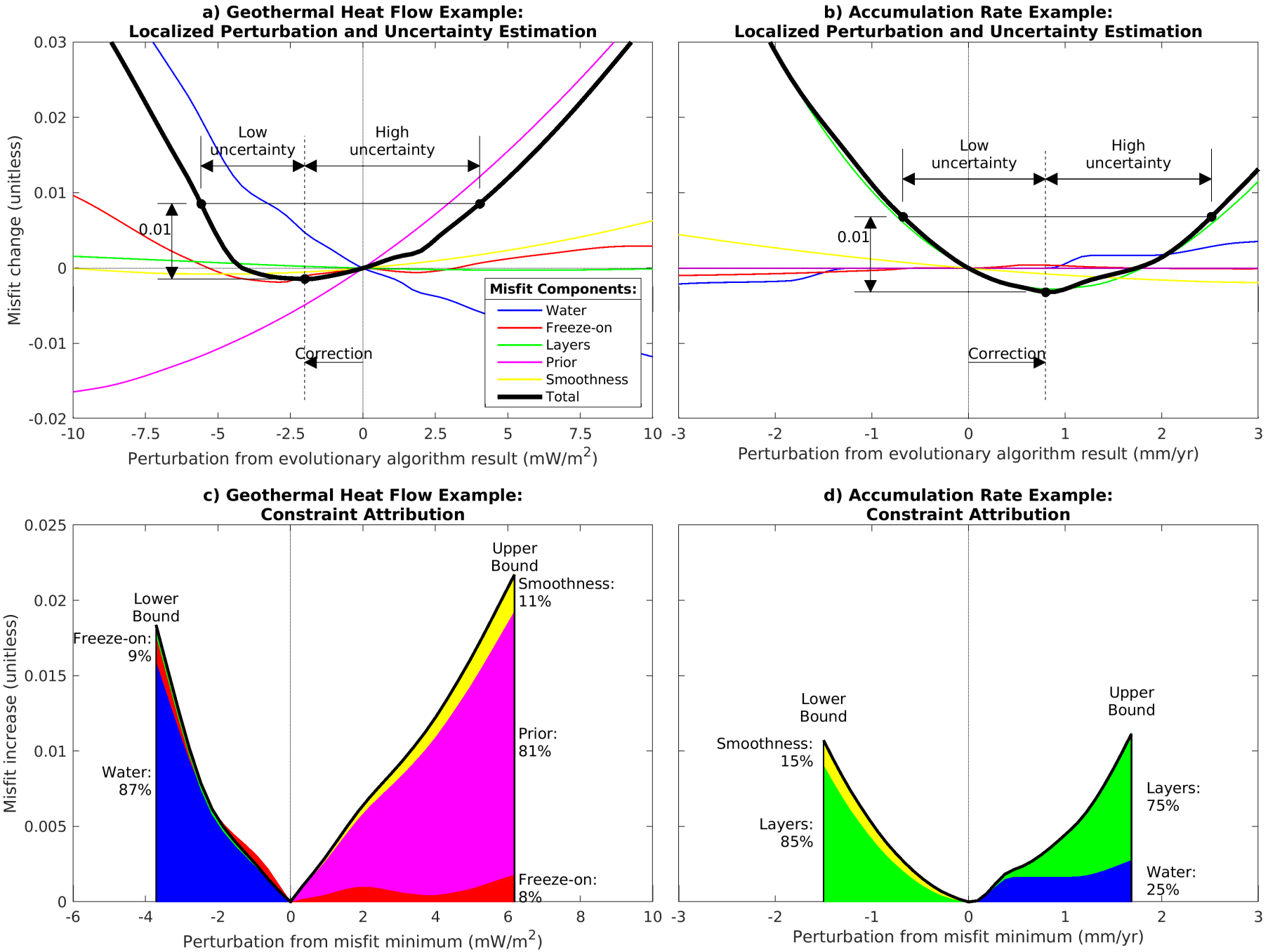
Combined Hierarchical Misfit Function



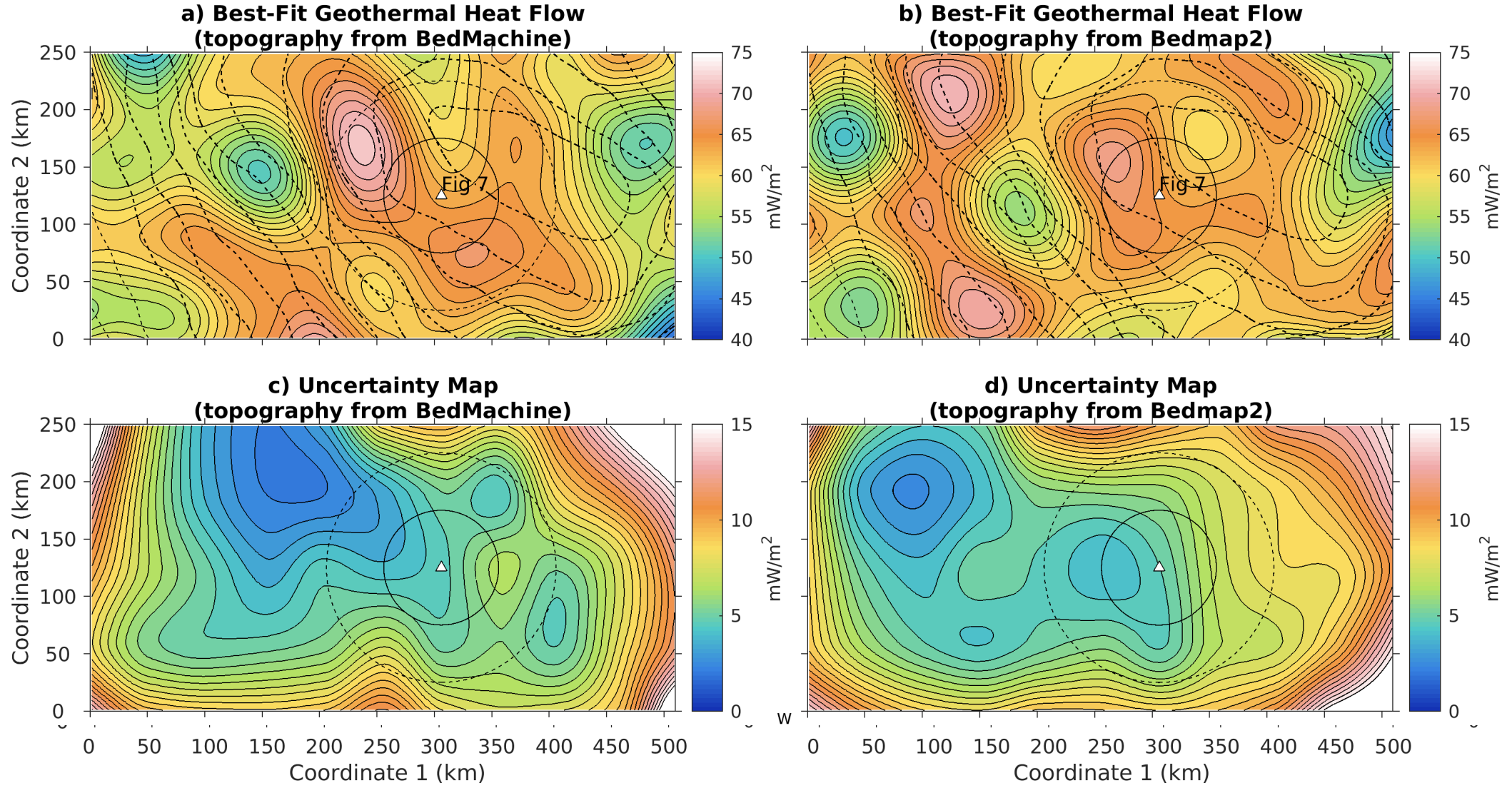
Evolutionary Algorithm



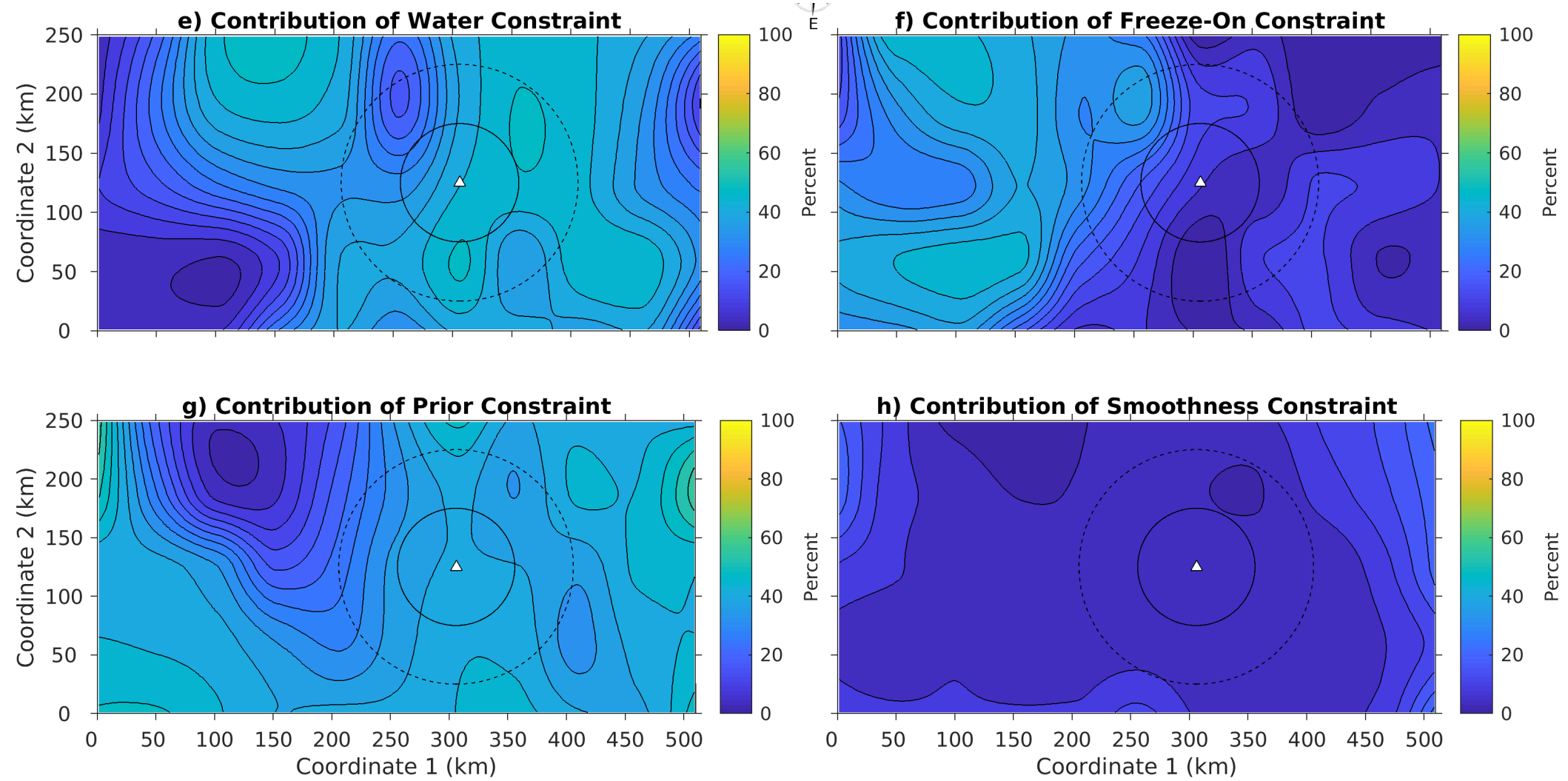
Localized Perturbation Tests



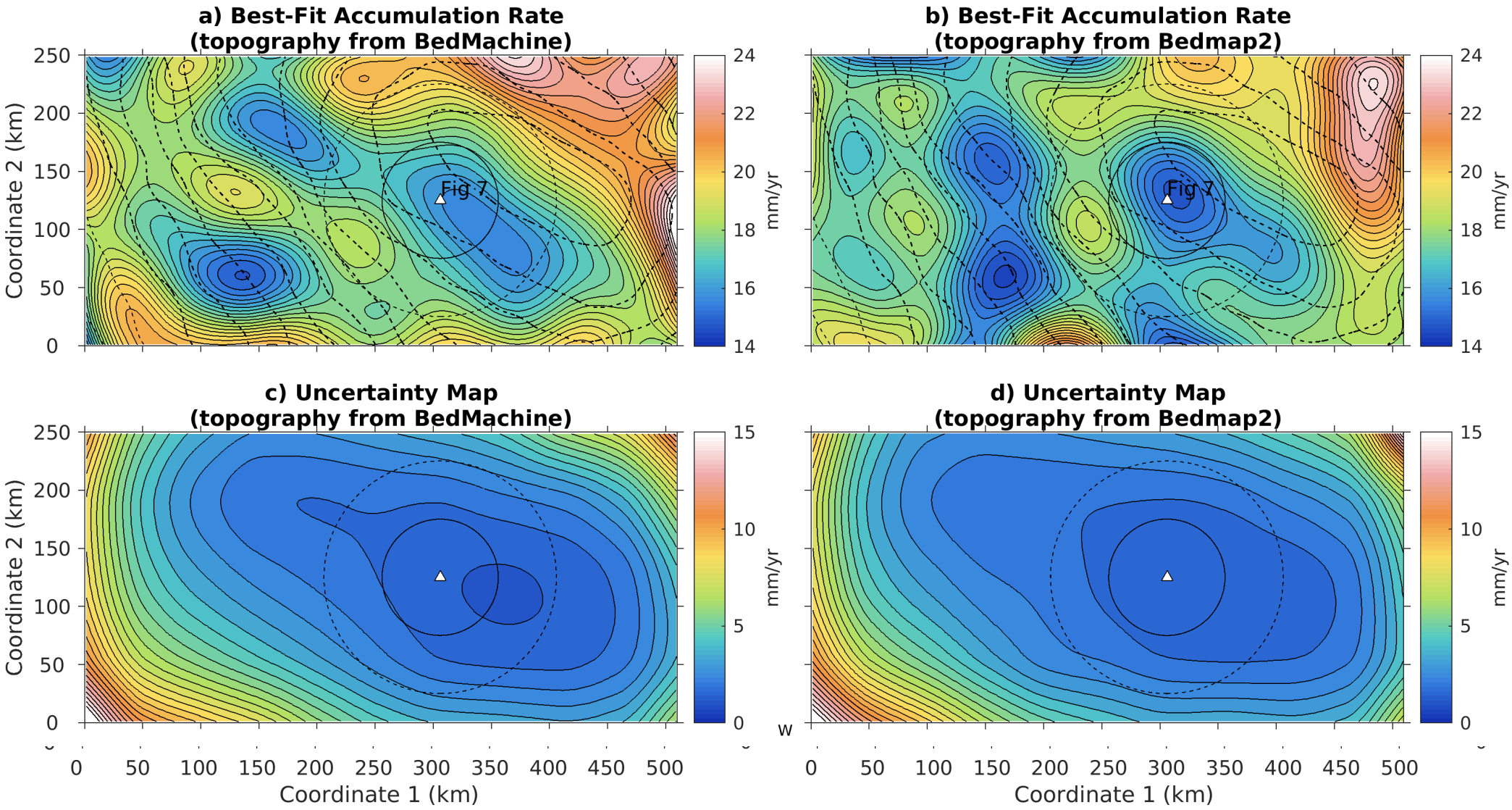
Results- GHF


a) Best-Fit Geothermal Heat Flow
(topography from BedMachine)
b) Best-Fit Geothermal Heat Flow
(topography from Bedmap2)
c) Uncertainty Map
(topography from BedMachine)
d) Uncertainty Map
(topography from Bedmap2)
Fig 7
Coordinate 1 (km)
Coordinate 2 (km)
mW/m2
0
50
100
150
200
250
300
350
400
450
500
40
45
50
55
60
65
70
75
5
10
15

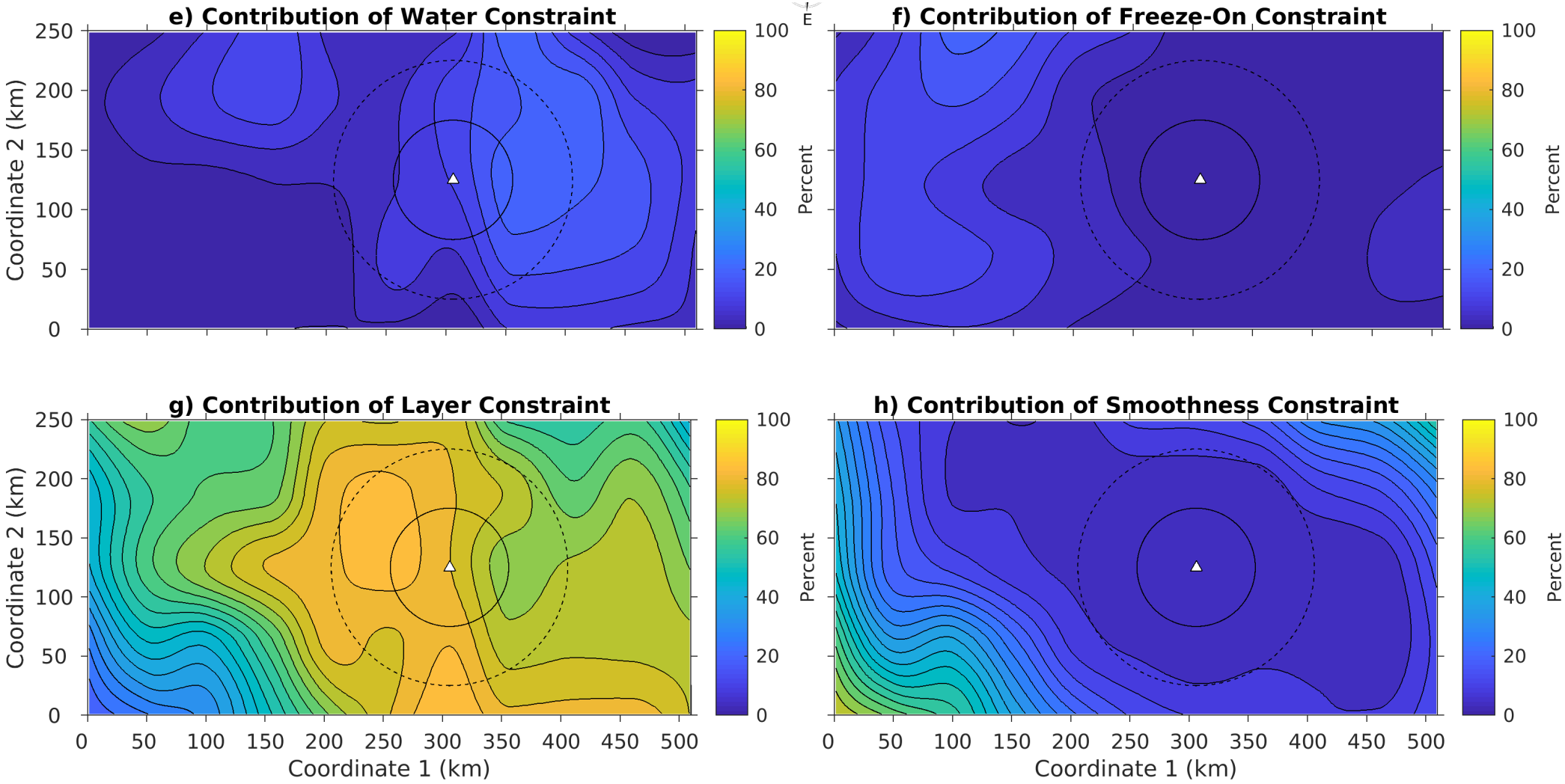
Results Attribution- GHF



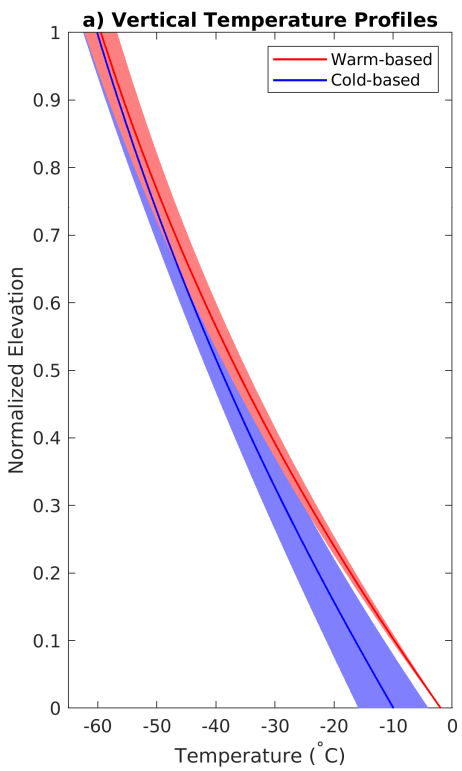
Results- Accumulation Rate

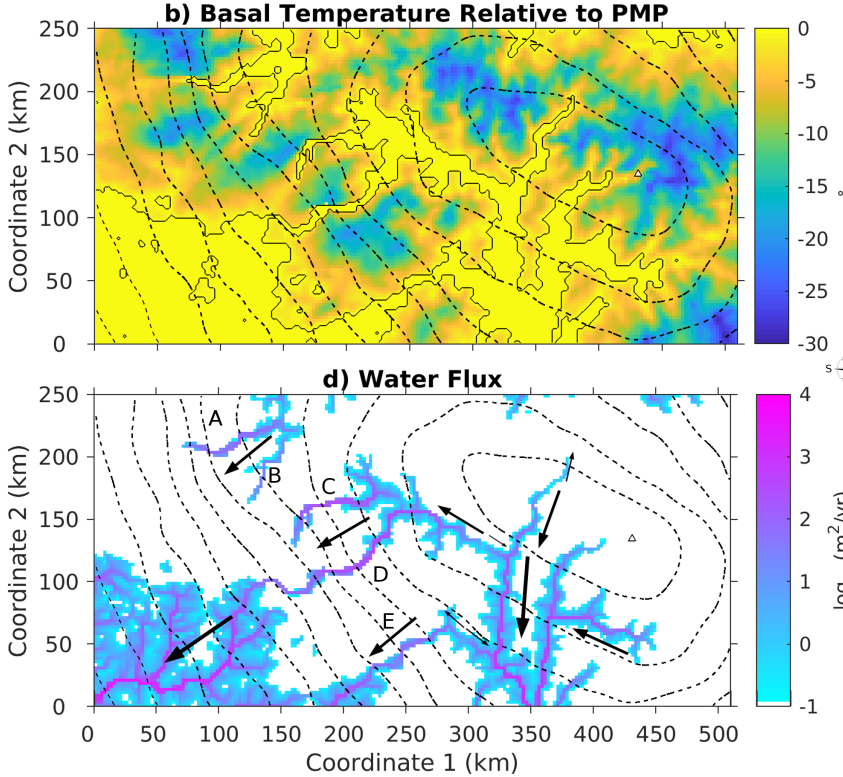


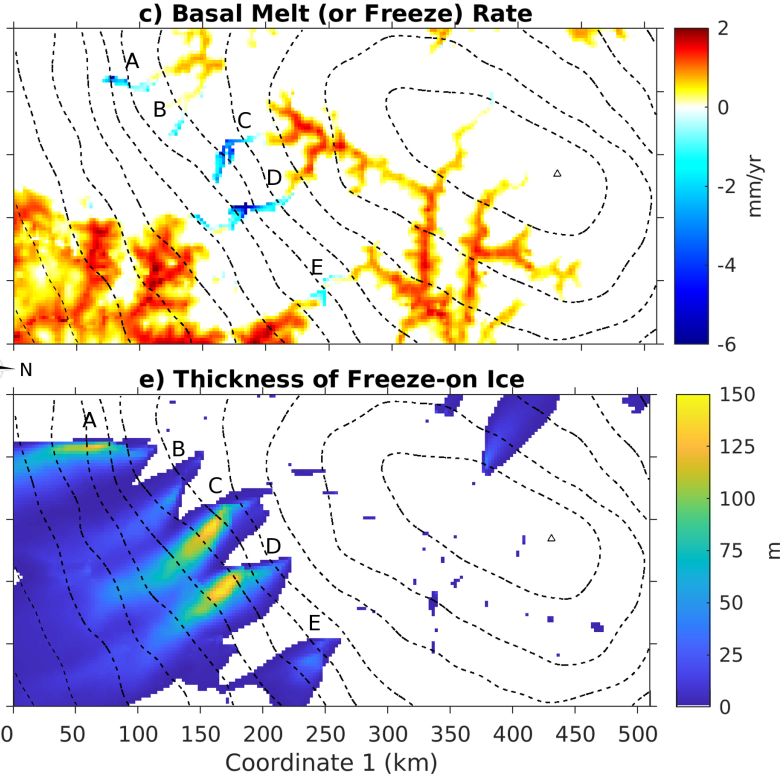
Results Attribution- Accumulation Rate



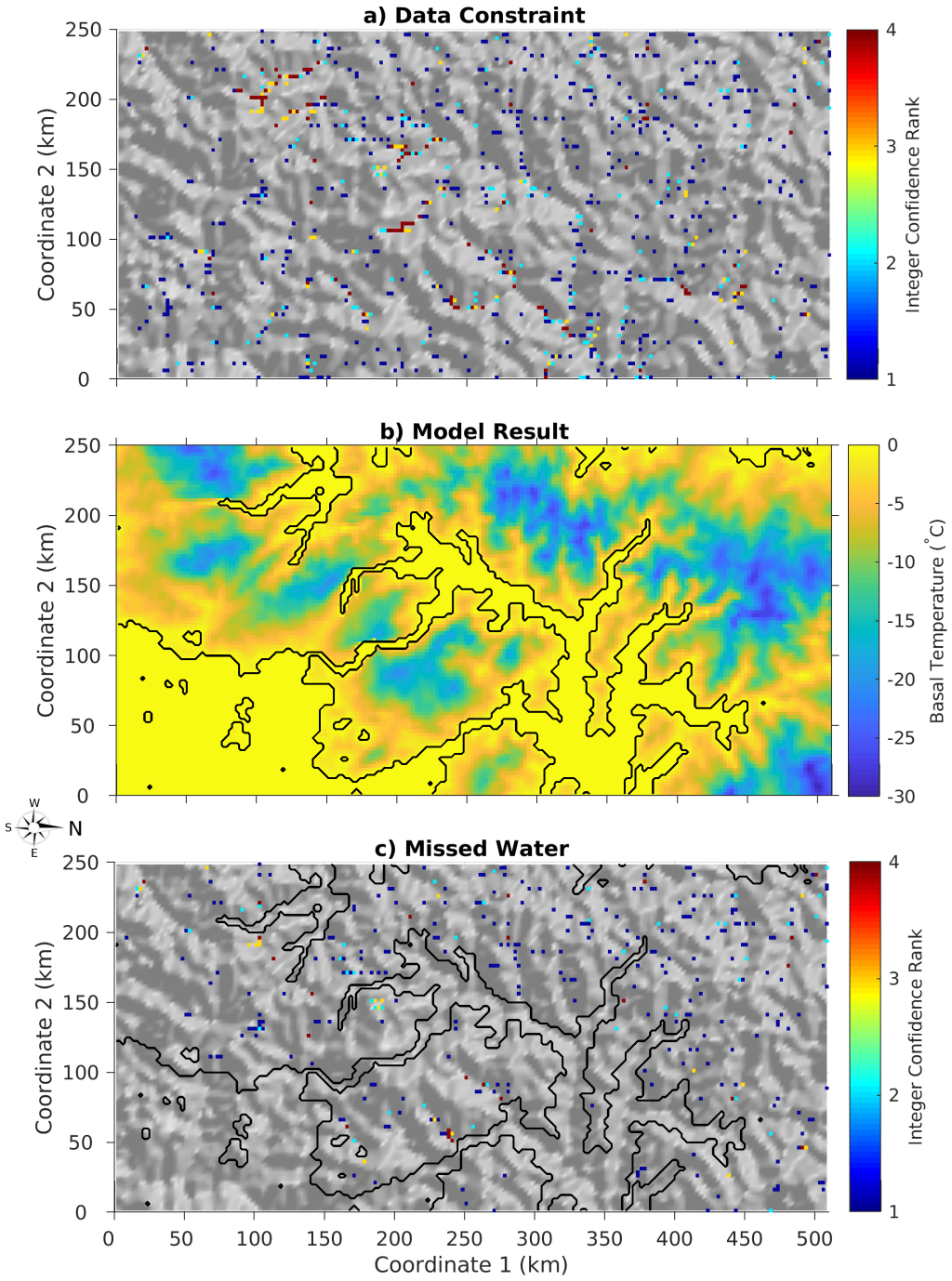
Best-Fit Model: Thermal Structure



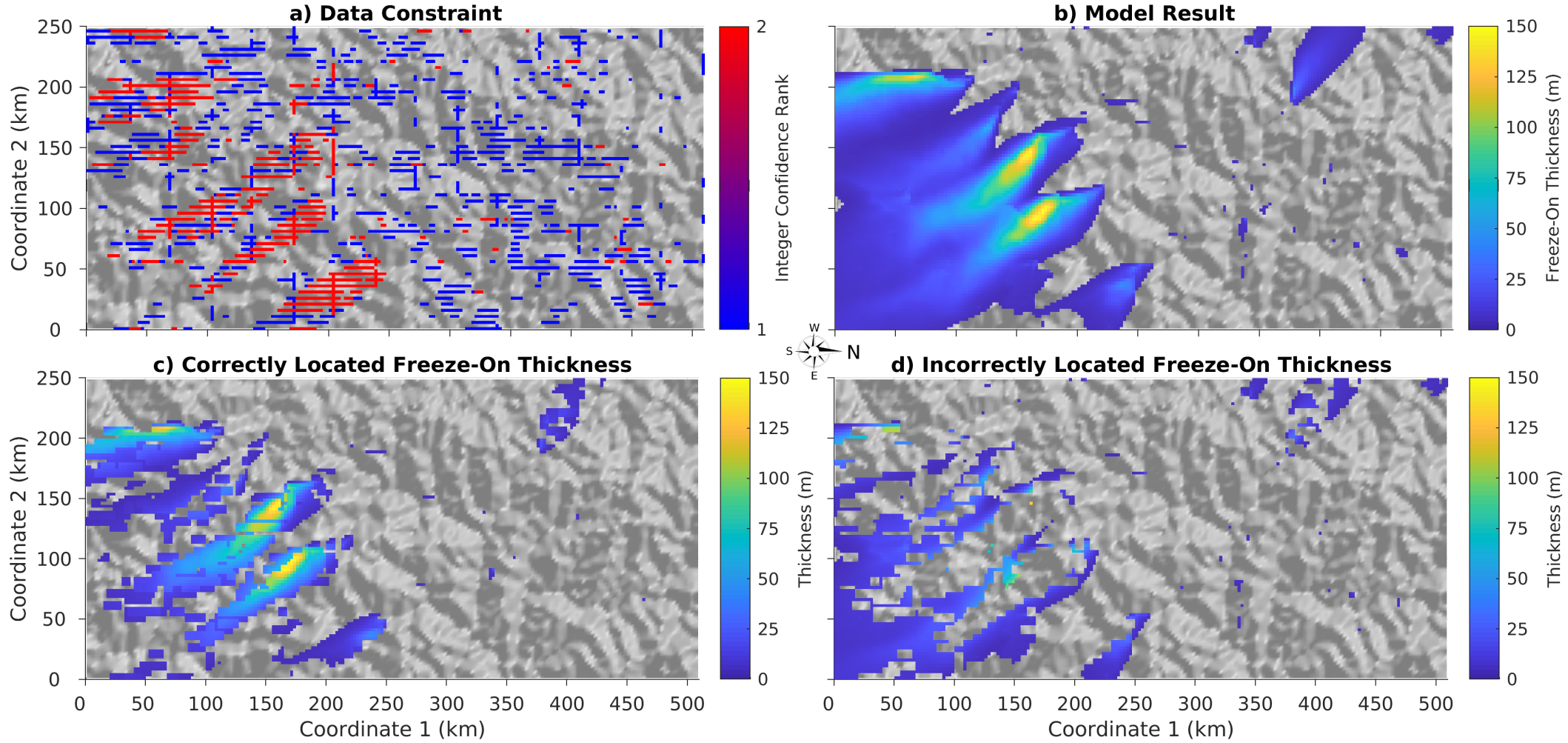




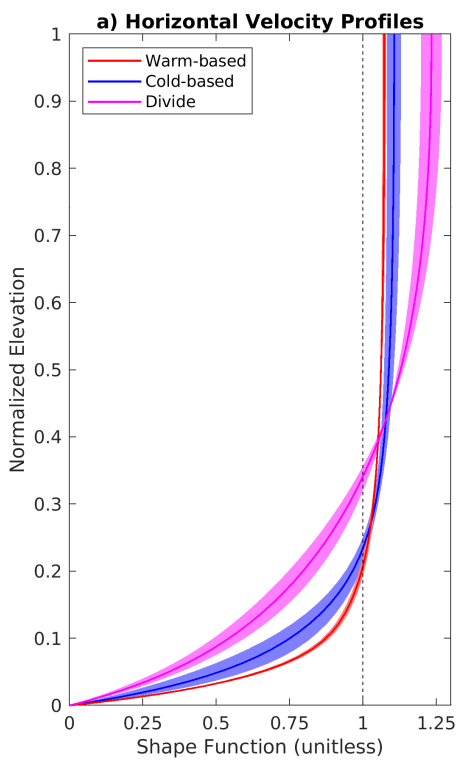
Fit to Data: Water Locations

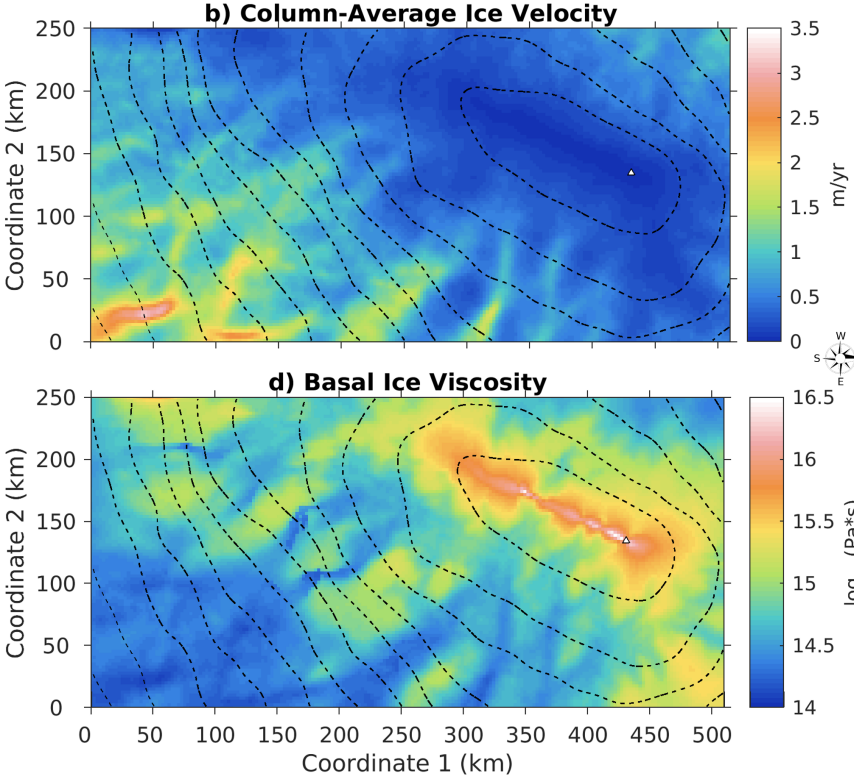


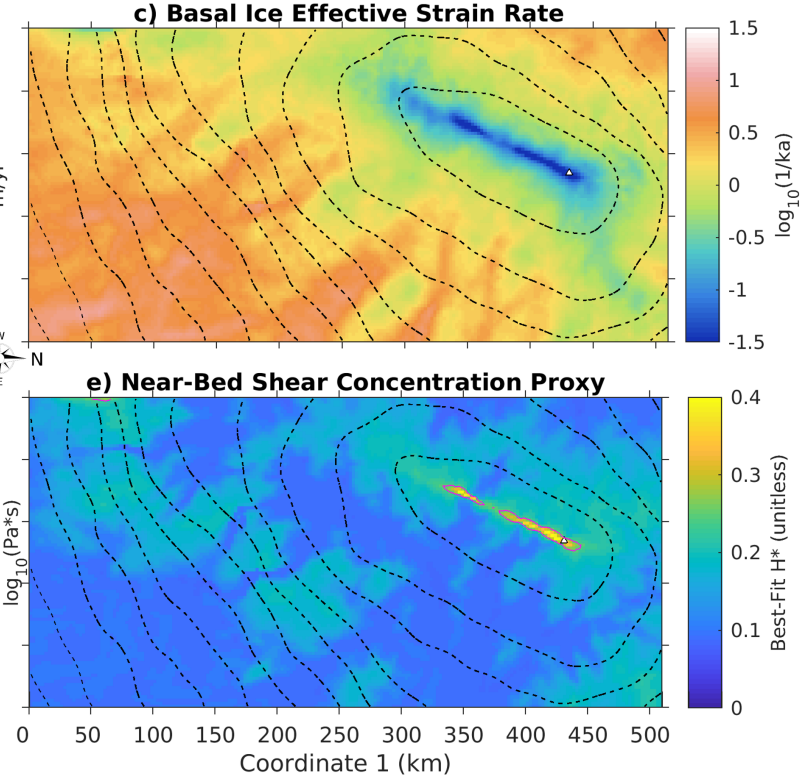
Fit to Data: Freeze-On Locations



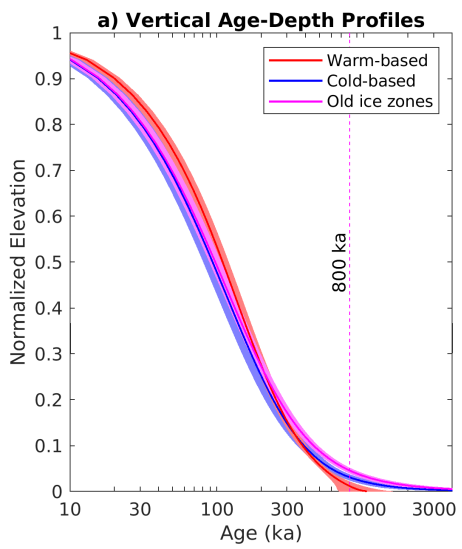
Best-Fit Model: Flow Structure

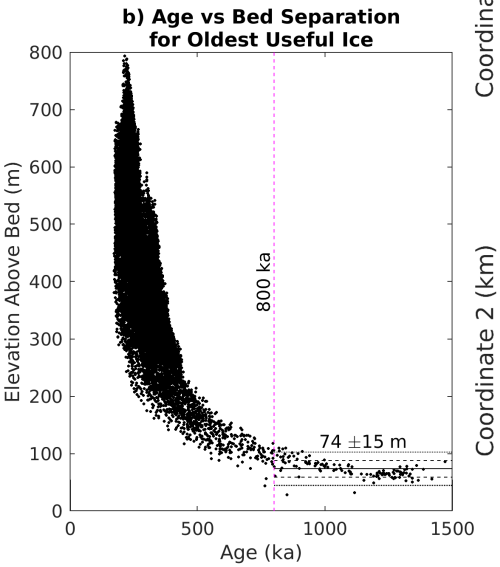


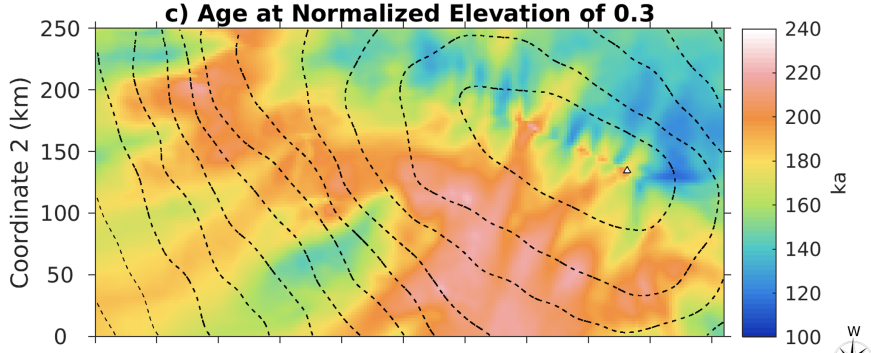


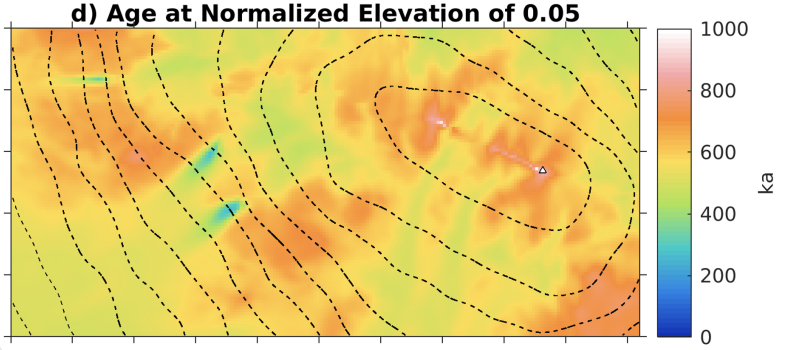


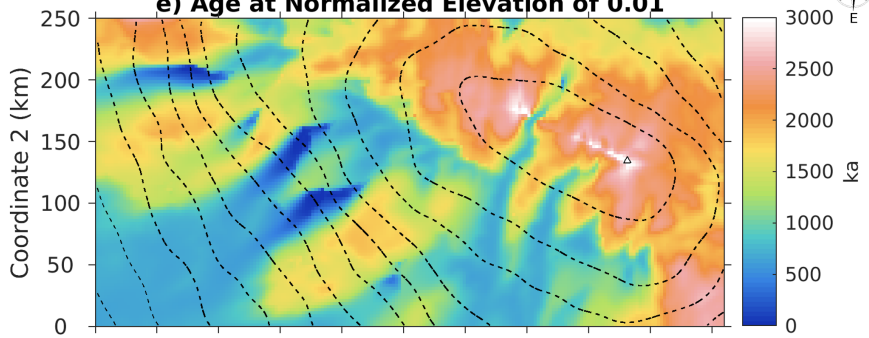
Best-Fit Model: Age Structure

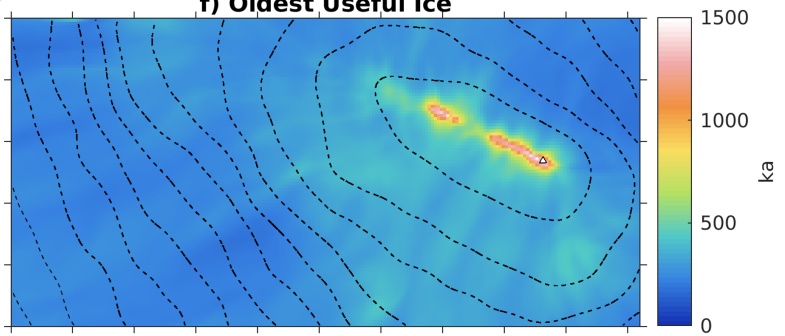


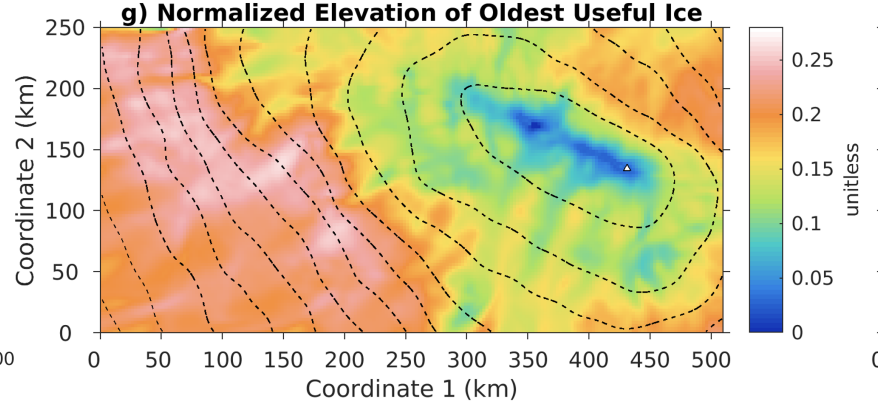


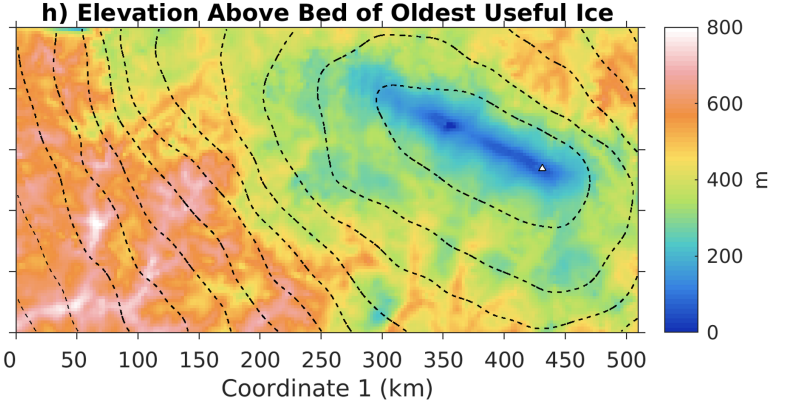




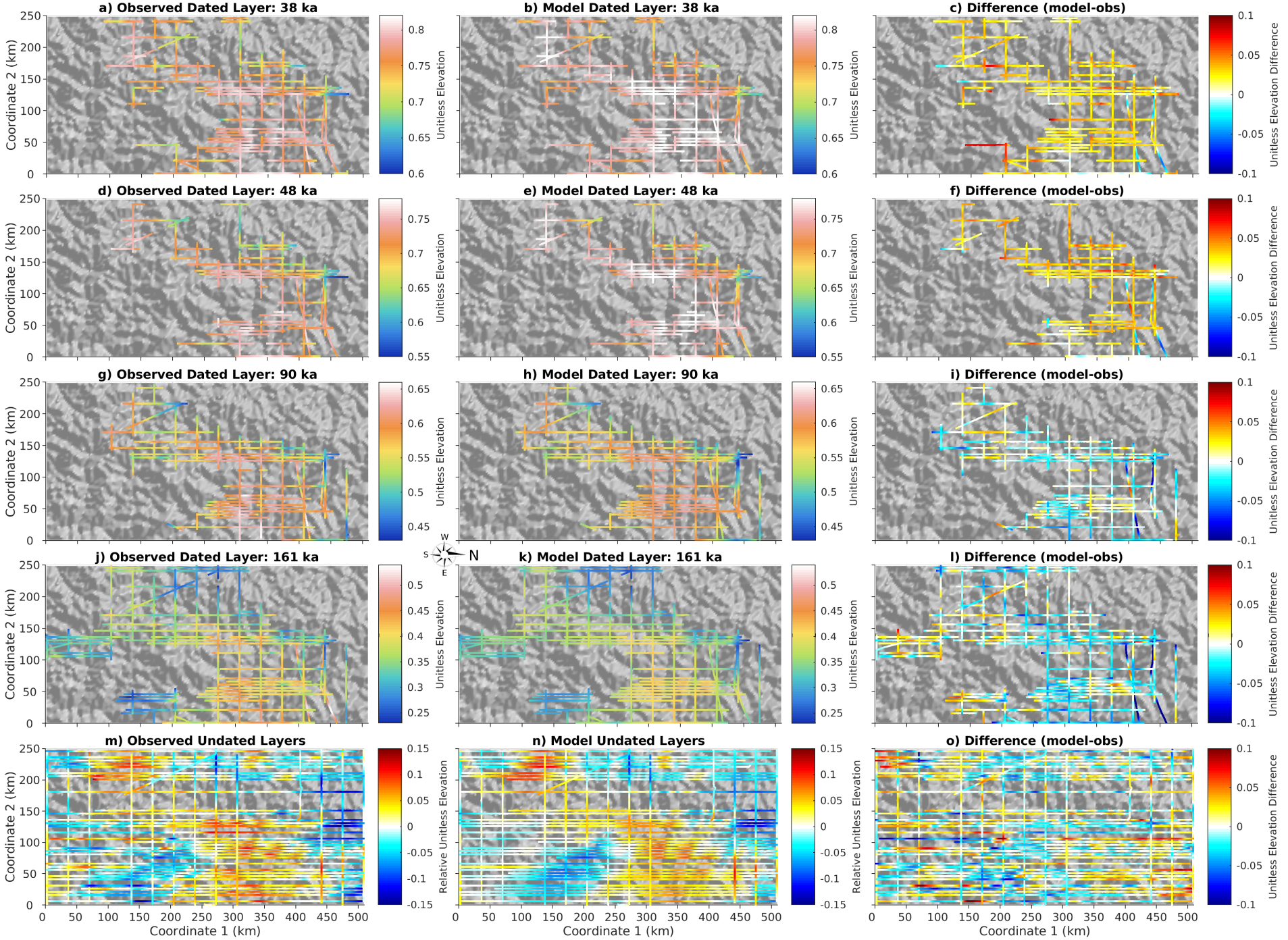




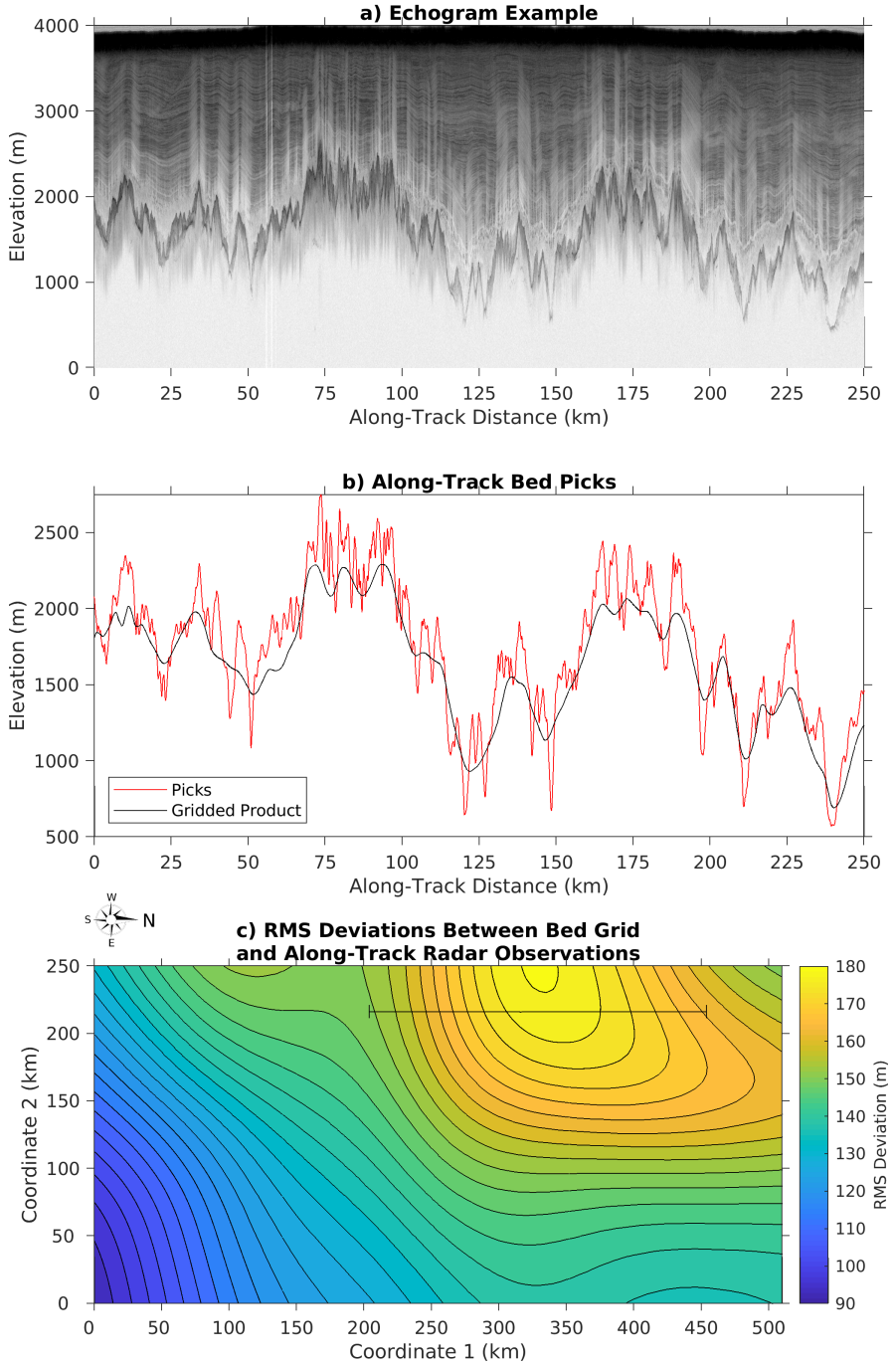




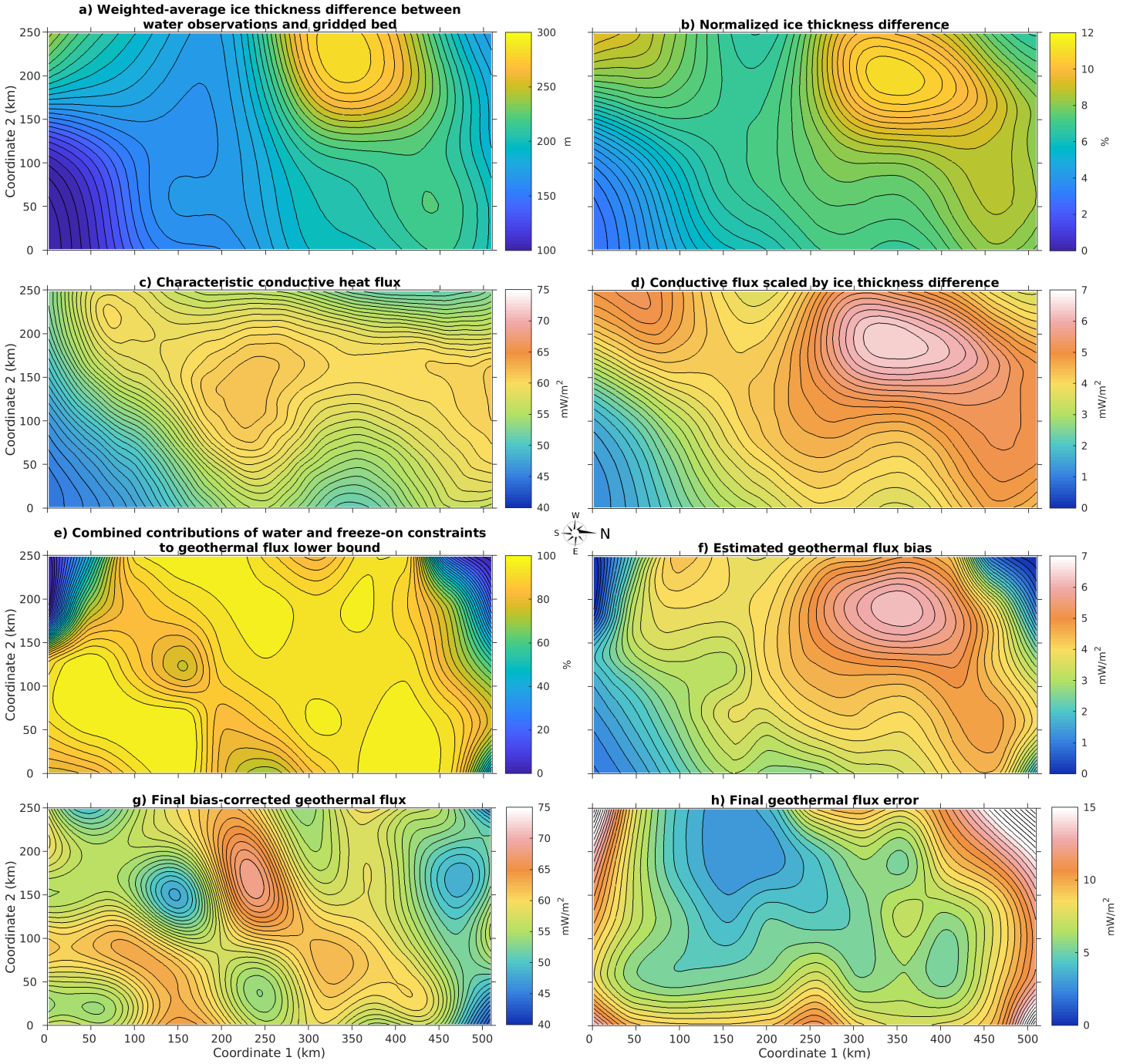
Fit to Data: Internal Layers



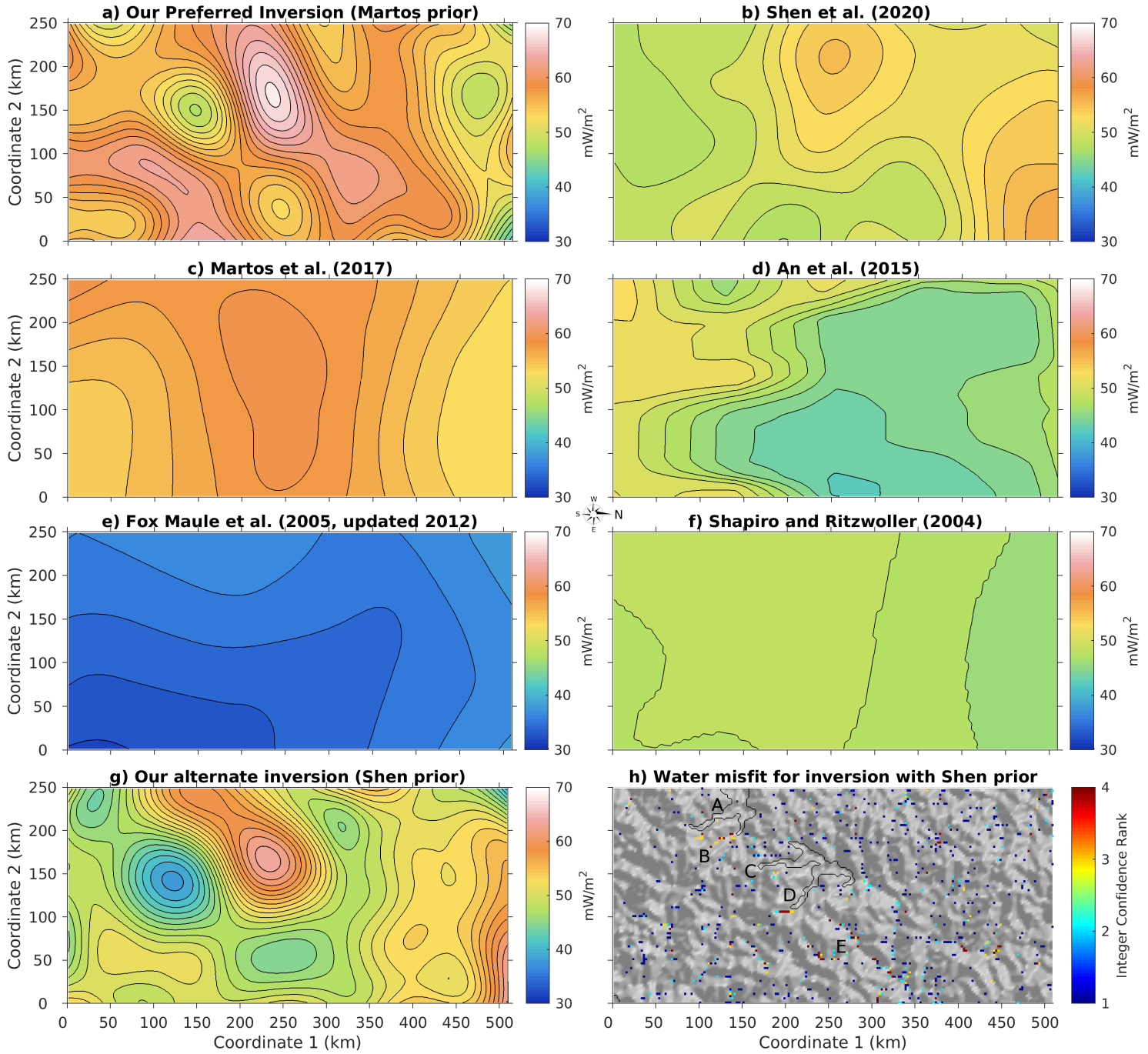
Unresolved Small-Scale Topography



Small-Scale Topography: GHF Bias



GHF Comparison with Other Results



Conclusions

- It is possible to invert glaciological observables to obtain difficult-to-constrain boundary conditions like GHF in a self-consistent model
  - Results are robust to bed grid used
  - Uncertainty can be constrained (but not skewness yet)
  - Results can be quantitatively attributed between the data inputs
- Locations of water and freeze-on are well fit, but our model also predicts new areas to look for water and suggests freeze-on volume lower than previous interpretation
- We predict stratigraphically intact ice up to 1.5 Ma located under the divide, assuming long-term divide stability
- Inversion results suggest divide stability in the last glacial cycle
- GHF generally higher than previous estimates, but consistent with crustal heat production
- Full story in pair of papers recently accepted at JGR: Earth Surface