How can heat flow heat up geoneutrino science?

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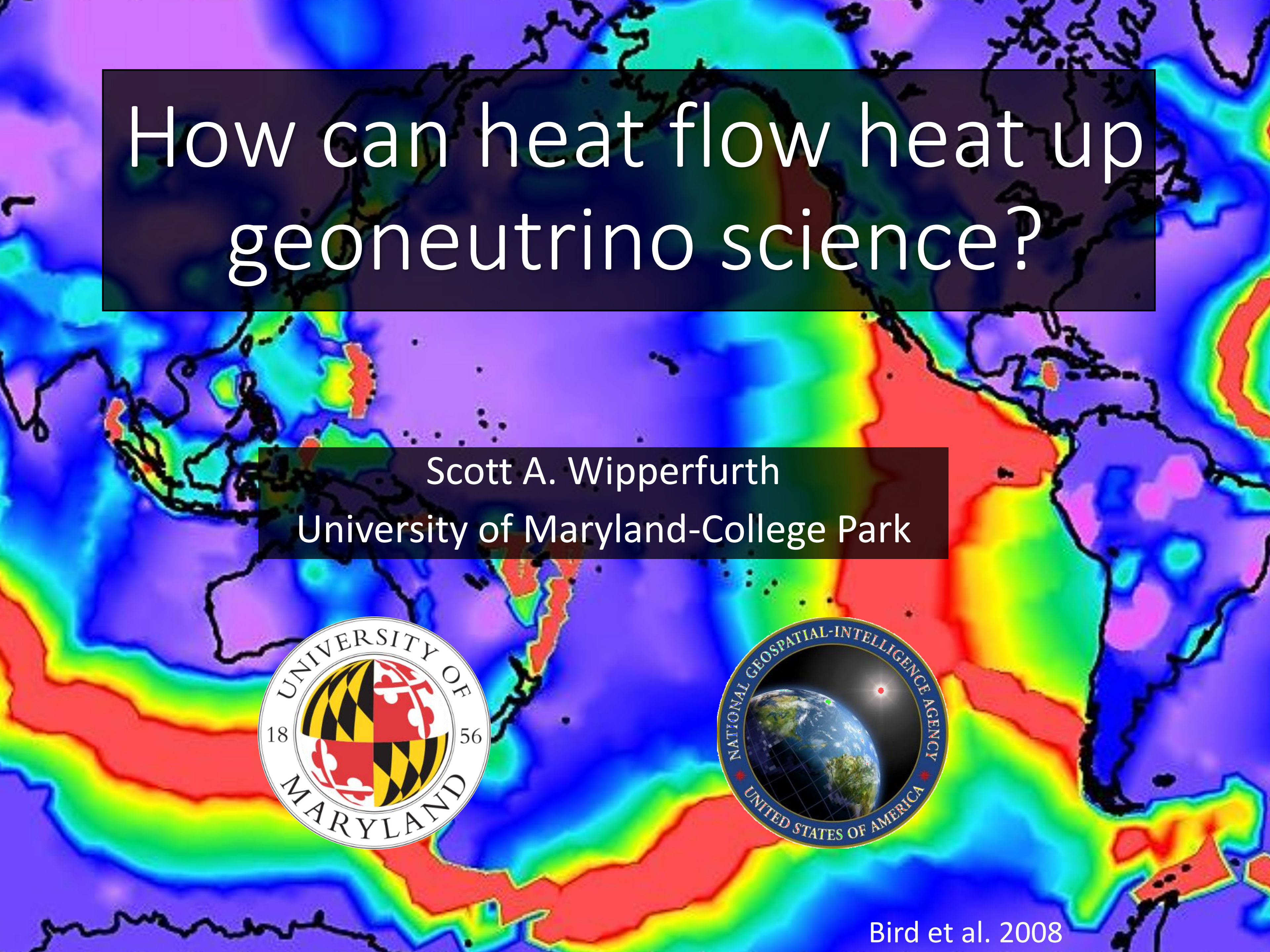
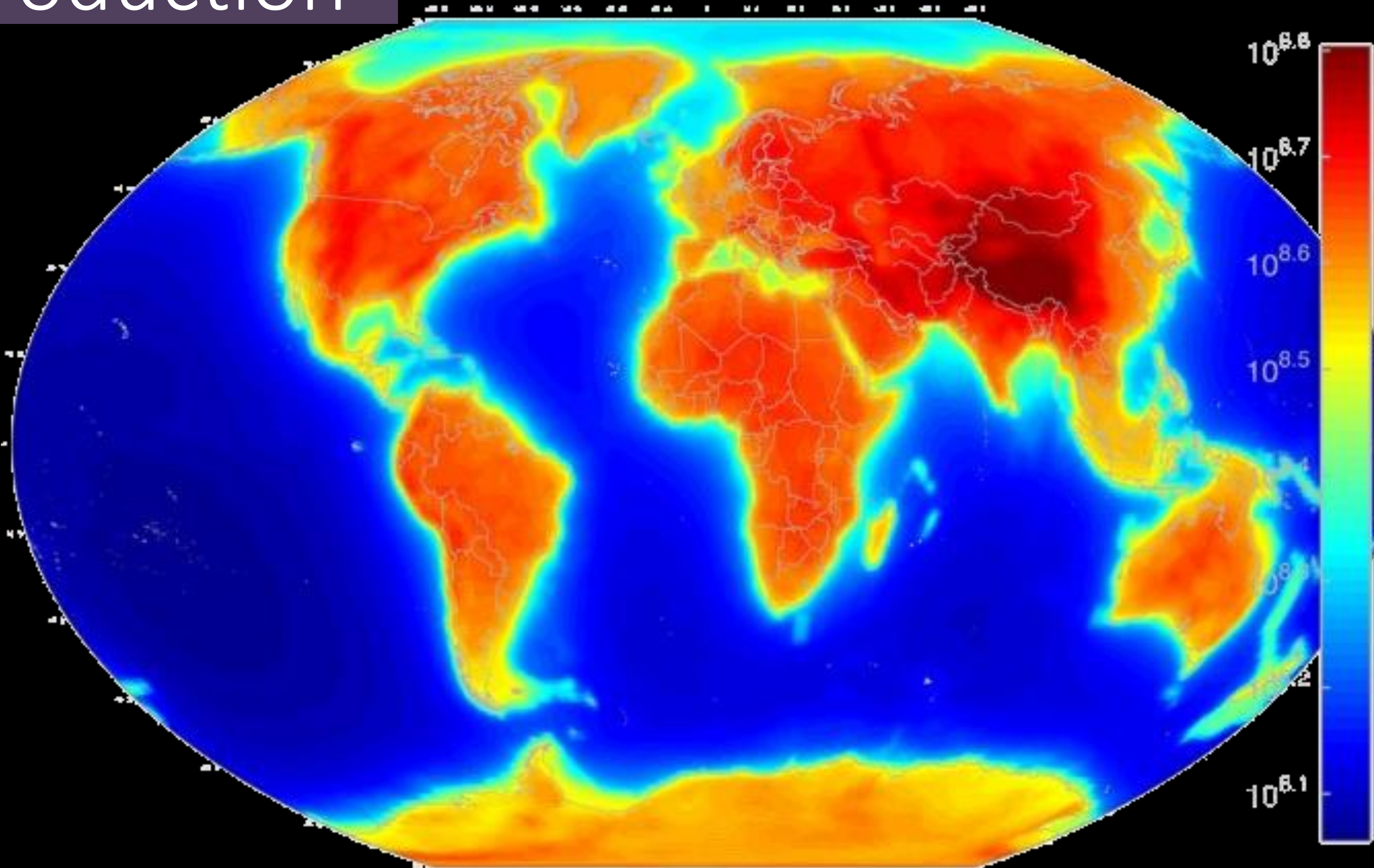


Bird et al. 2008

Introduction

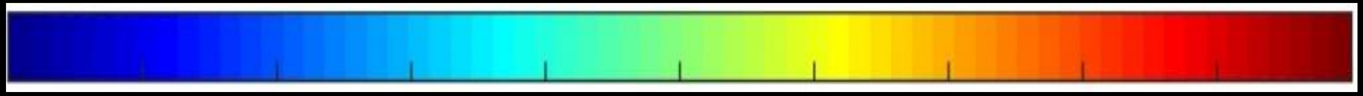
Antineutrino Global Map (AGM15)



Usman et al., 2015

Less $\frac{\bar{\nu}_e}{cm^2}/s$

More $\frac{\bar{\nu}_e}{cm^2}/s$



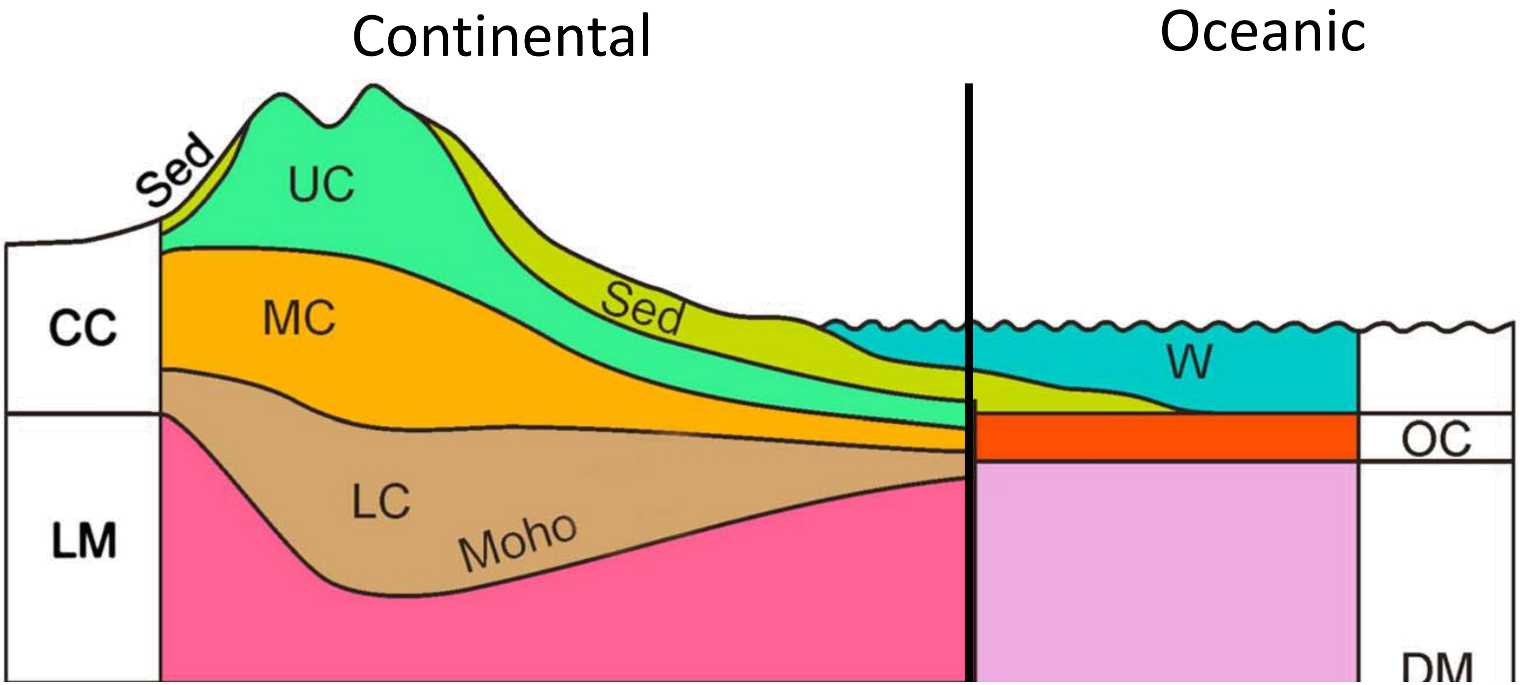
~ Less U, Th, K atoms

~ More U, Th, K atoms

Global Reference Model

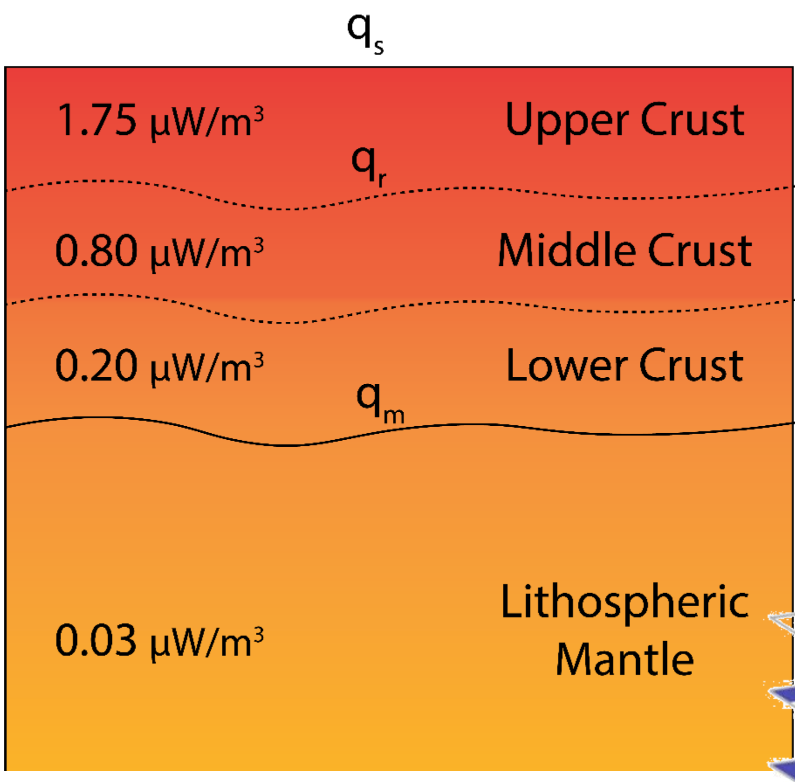
Continental Crust (CC)

Lithospheric Mantle (LM)



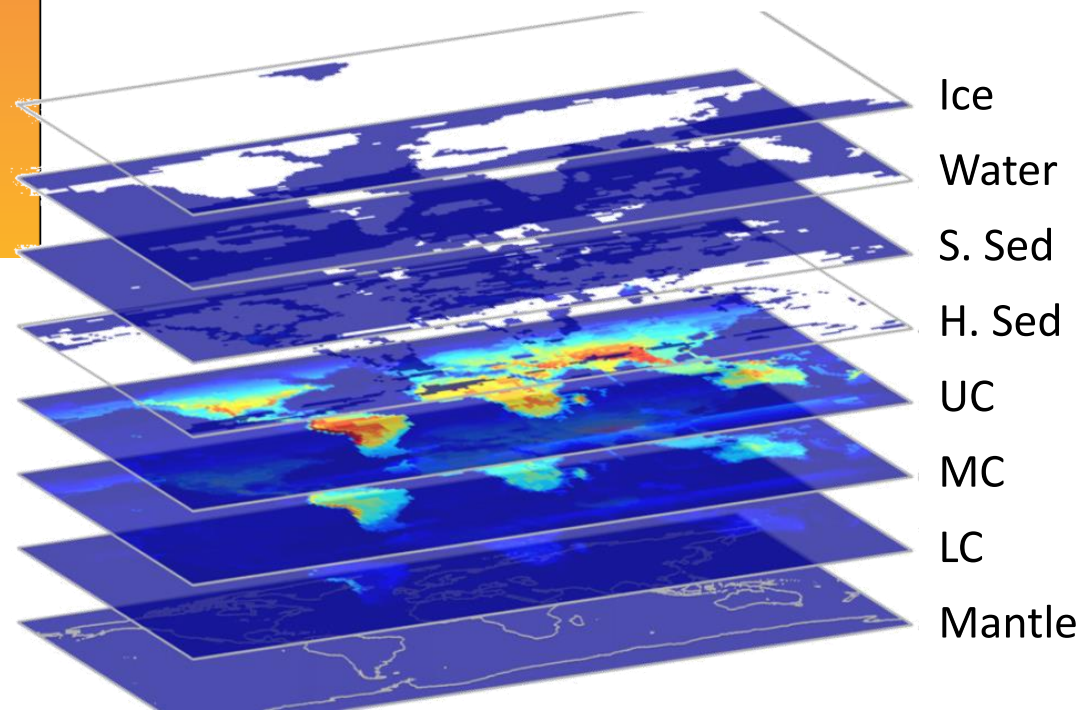
Huang et al., 2013

Global Reference Model



Huang et al., 2013

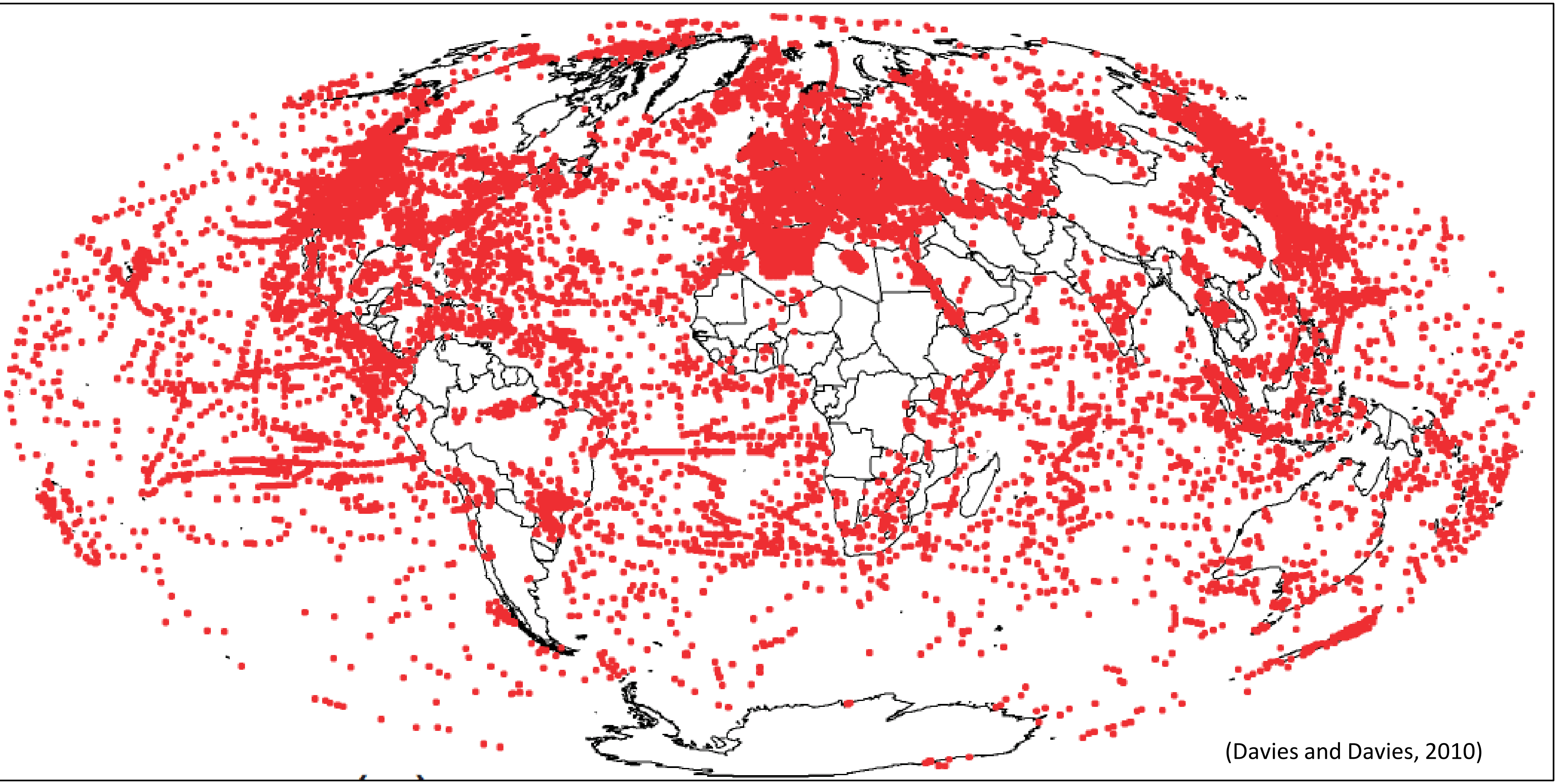
	U (ppm)	Th (ppm)	K (wt%)
UC	2.32	10.5	2.70
MC	1.52	4.86	0.97
LC	0.65	0.96	0.16



Jocher et al., 2013

Heat Flow

Earth surface heat flow = 46 ±2 TW (Davies and Davies, 2010)



(Davies and Davies, 2010)

~ 60,000 measurements (35,000 continental & 25,000 Oceanic)

Heat Flow

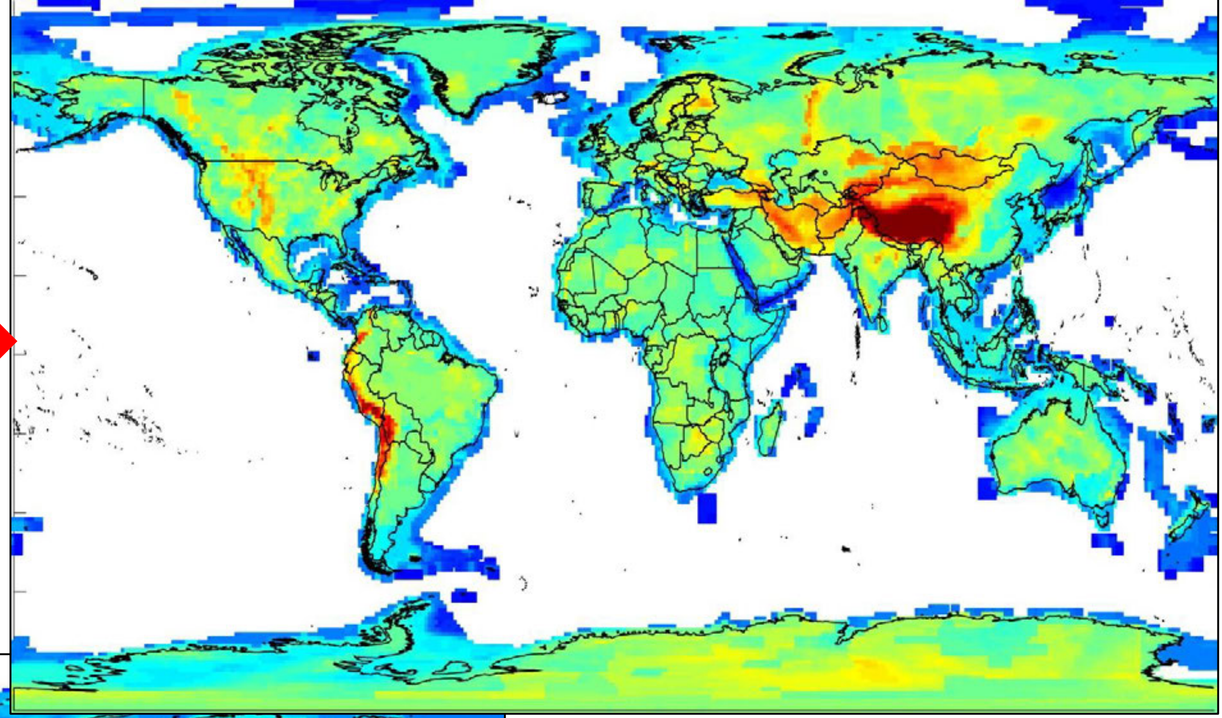
(CRUST 1.0)

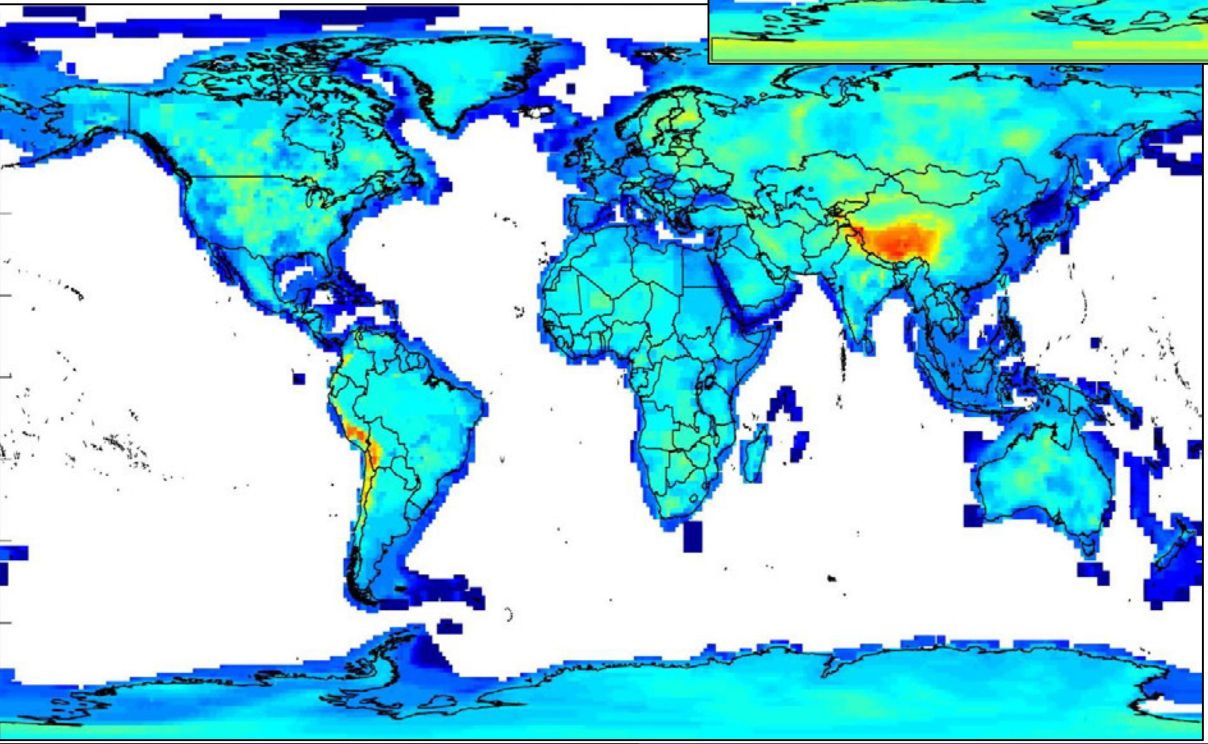
Scale

Red = 90 mW/m^2

Green = 55 mW/m^2

Blue = 25 mW/m^2





Crust Thickness

(CRUST 1.0)

Scale

Red = 80 km

Green = 50 km

Blue = 20 km

Heat Flow

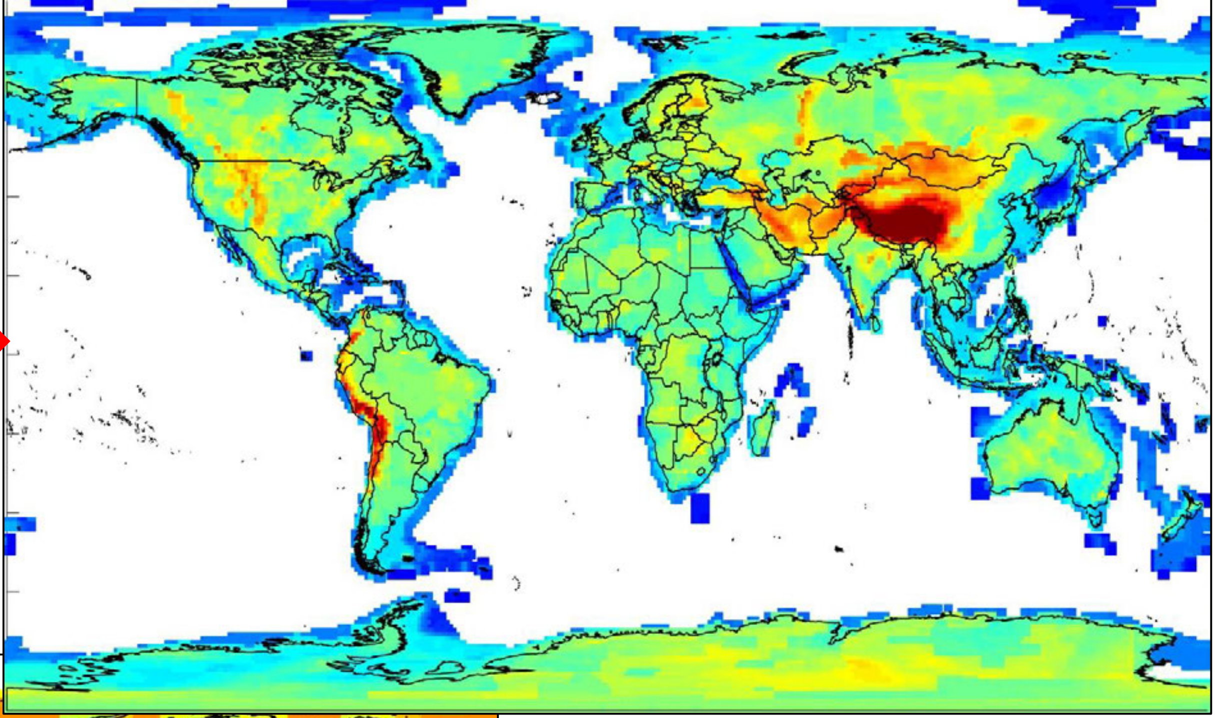
(CRUST 1.0)

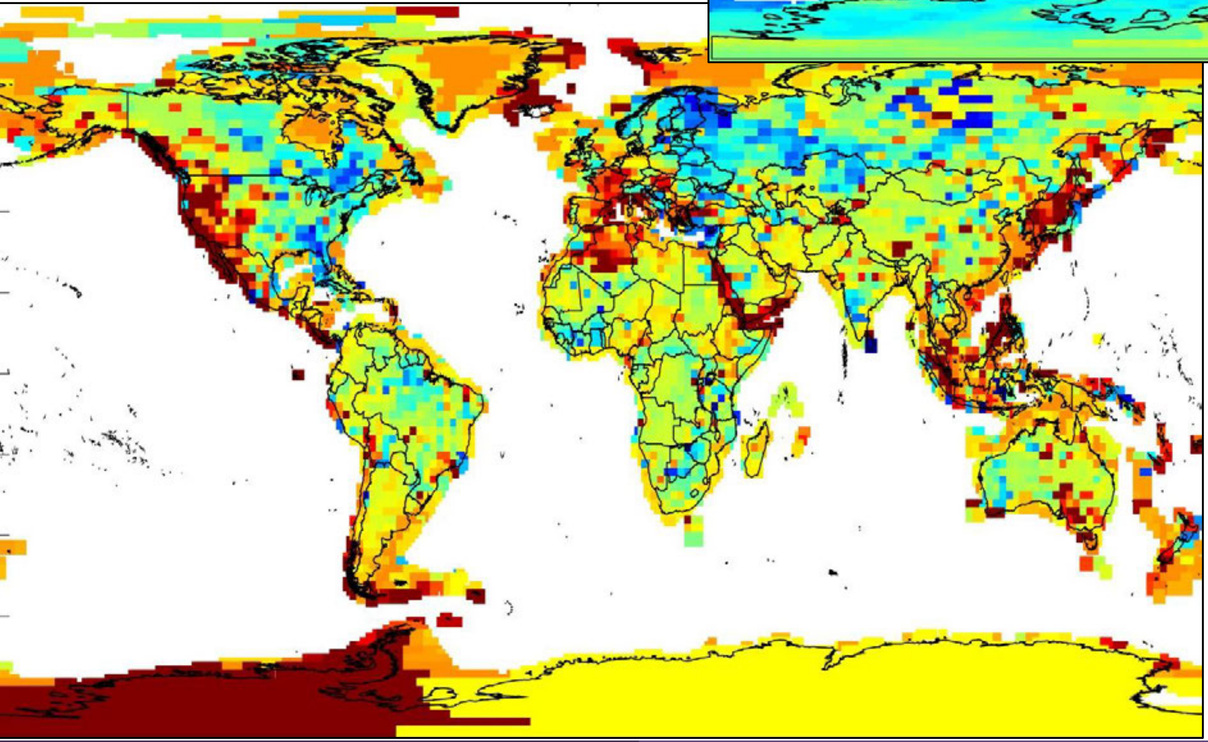
Scale

Red = 90 mW/m^2

Green = 55 mW/m^2

Blue = 25 mW/m^2





Heat Flow

(Davies 2013)

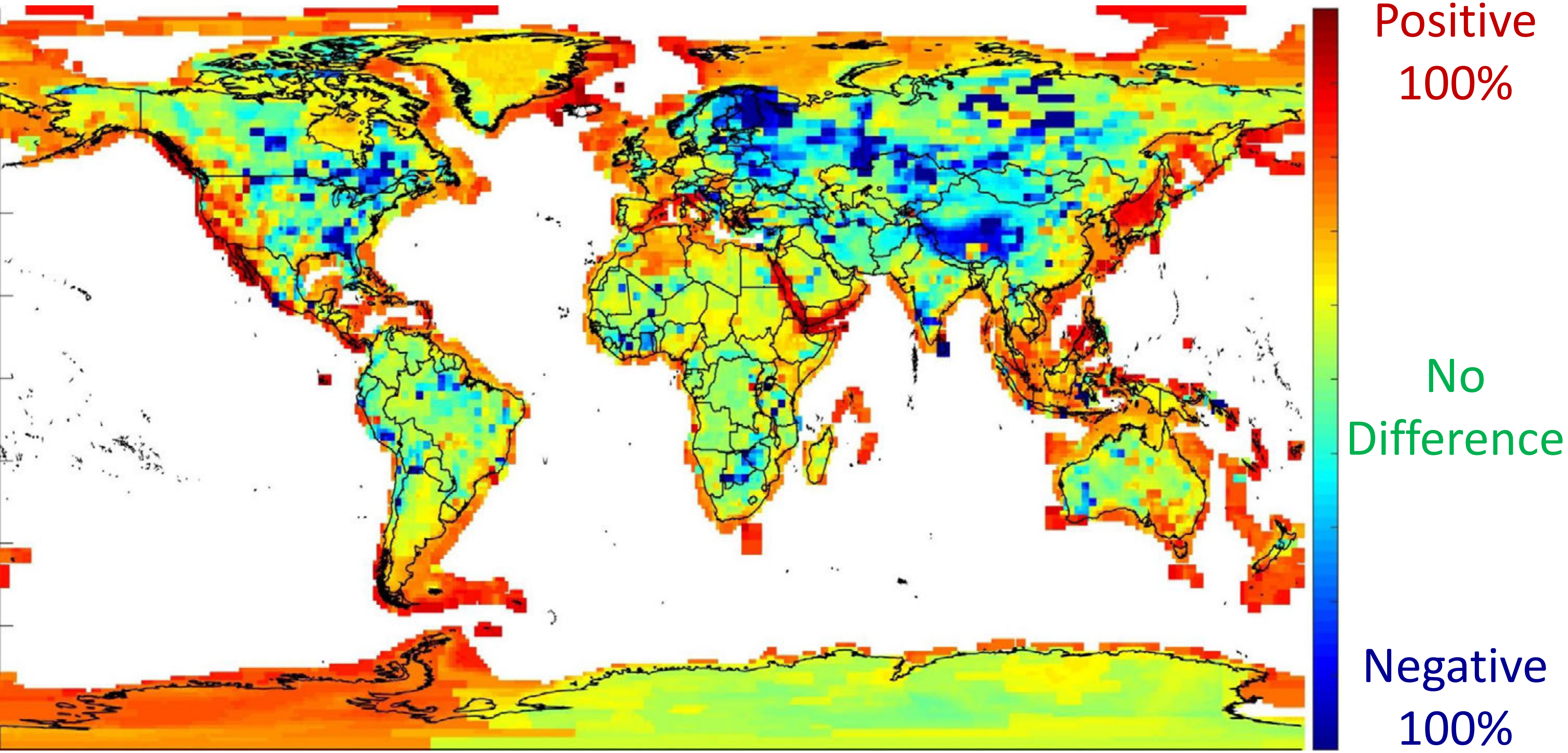
Scale

Red = 90 mW/m^2

Green = 55 mW/m^2

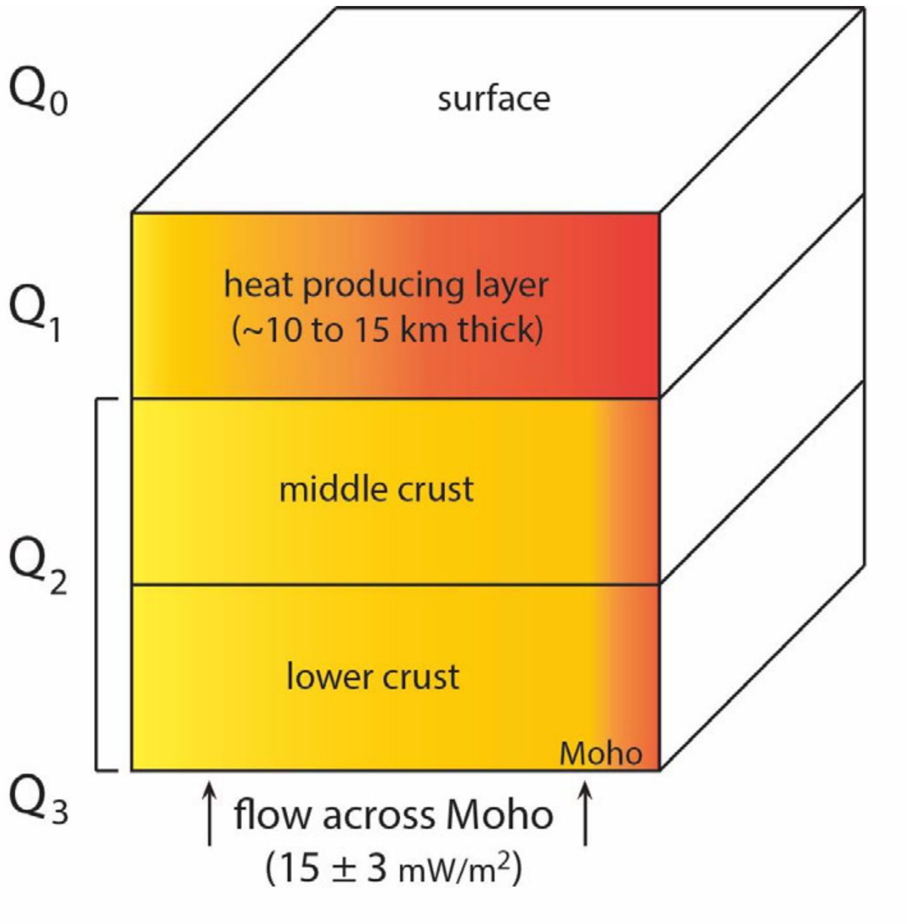
Blue = 25mW/m^2

Delta Map



Negative = Overestimating heat flow with Reference Model

Model Architecture



Q_0 = Surface heat flow

Q_1 = Heat flow from UC

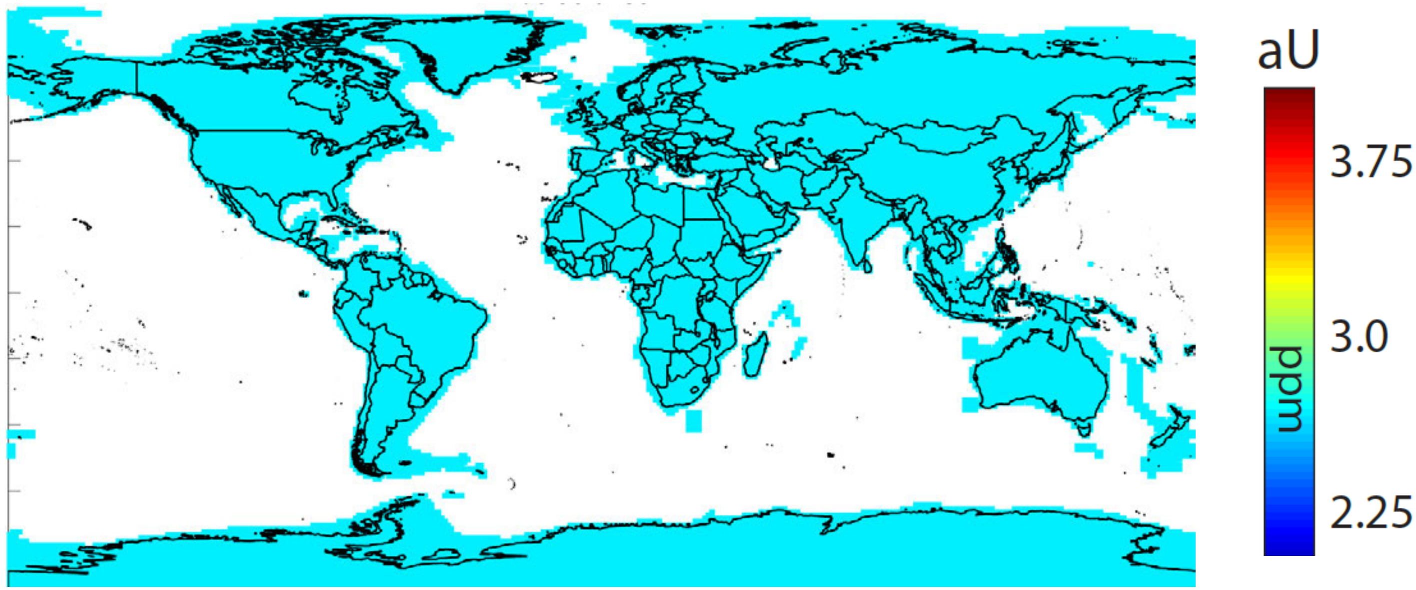
Q_2 = Heat flow from MC + LC

Q_3 = Heat flow across Moho

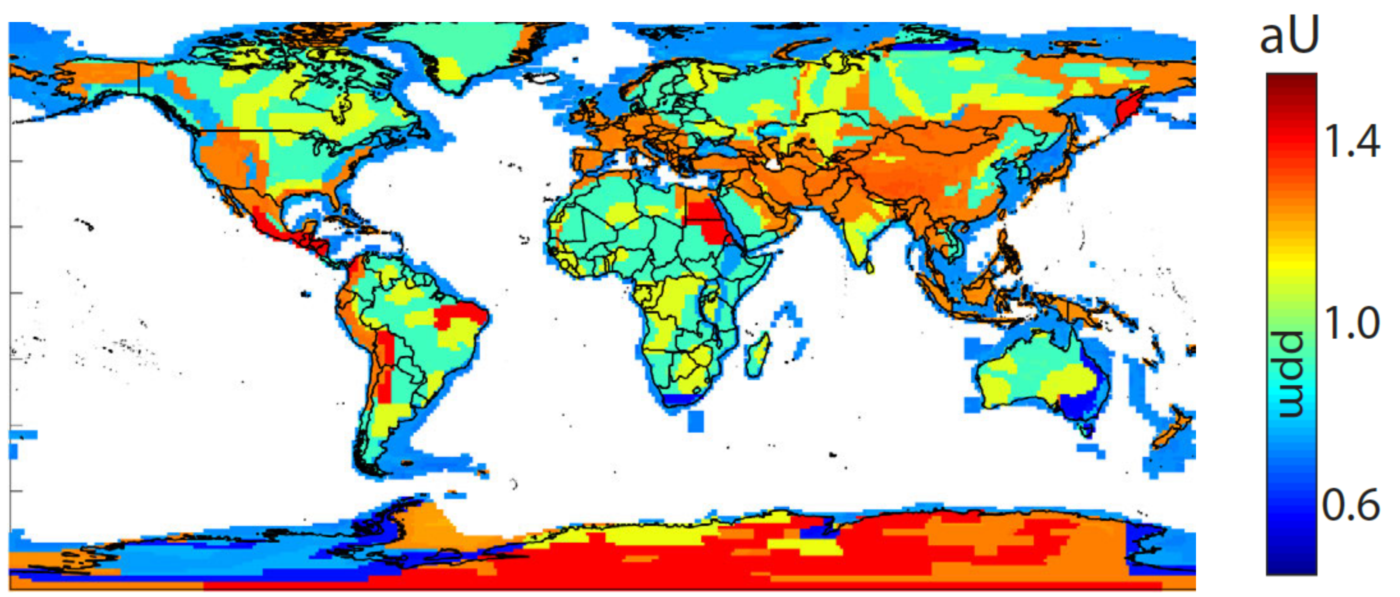
$$Q_1 = Q_0 - Q_2 - Q_3$$

Spatial Heterogeneity of Models

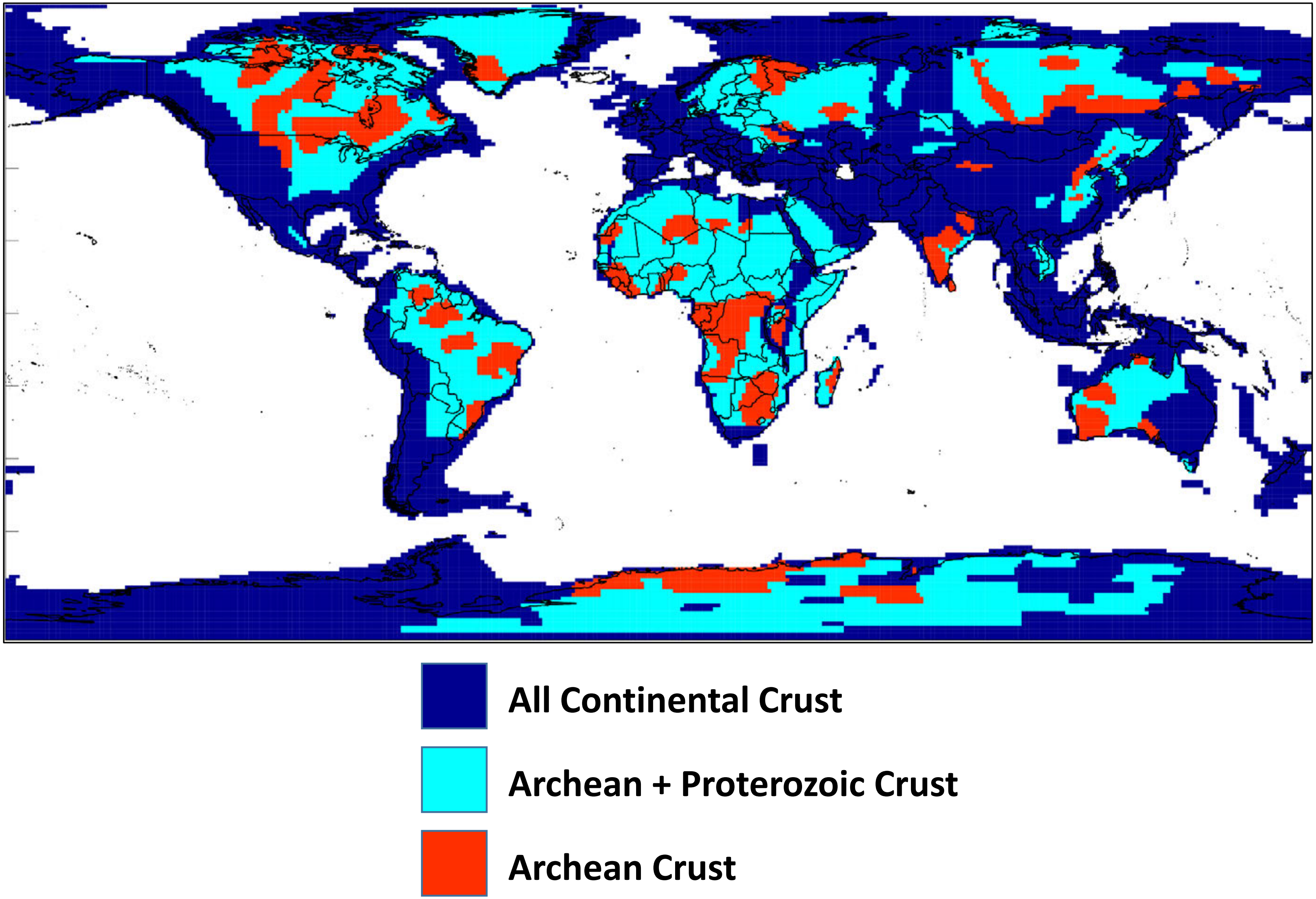
Upper Crust



Middle Crust



Model Architecture

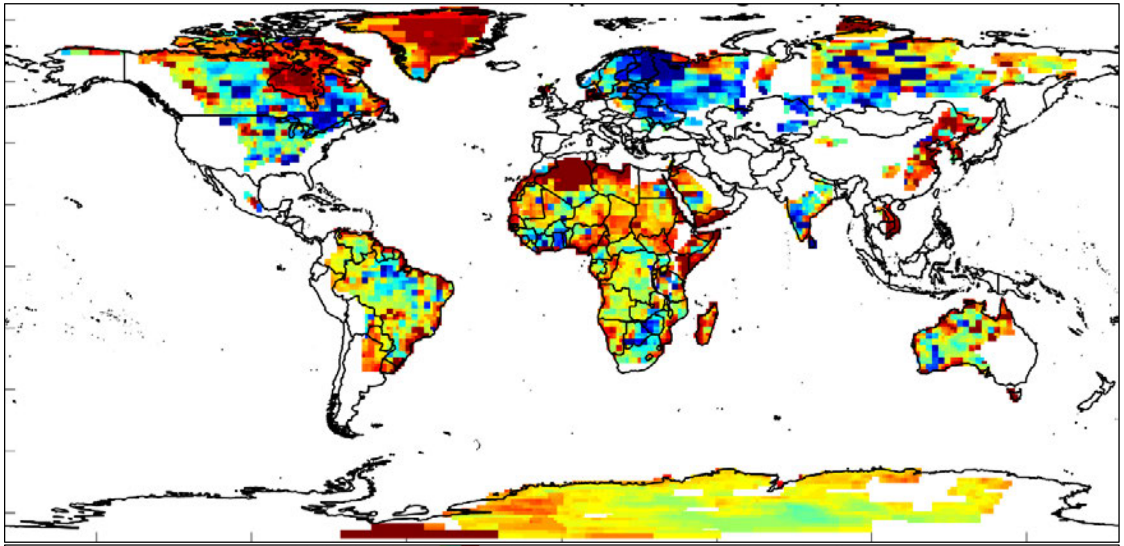


Results: Archean + Proterozoic

Uranium Concentration in UC

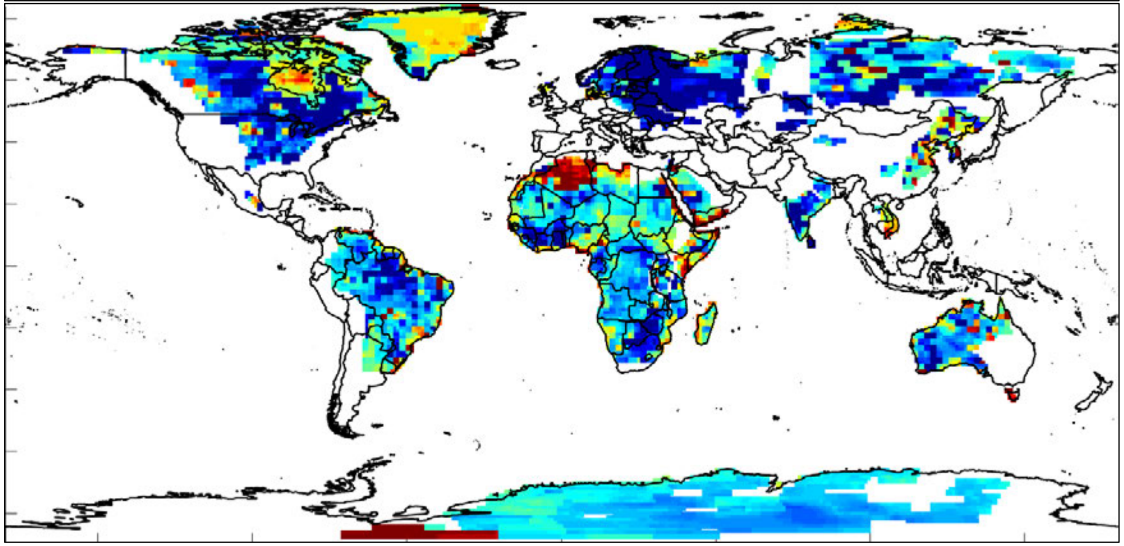
Moho Q_3 = 15 mW/m^2

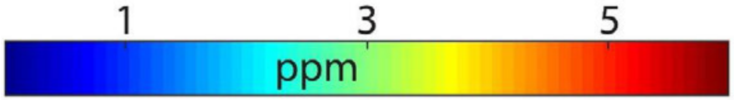
Avg. U = 3.66 ppm



Moho Q_3 = 30 mW/m^2

Avg. U = 2.00 ppm





Results: Archean Only

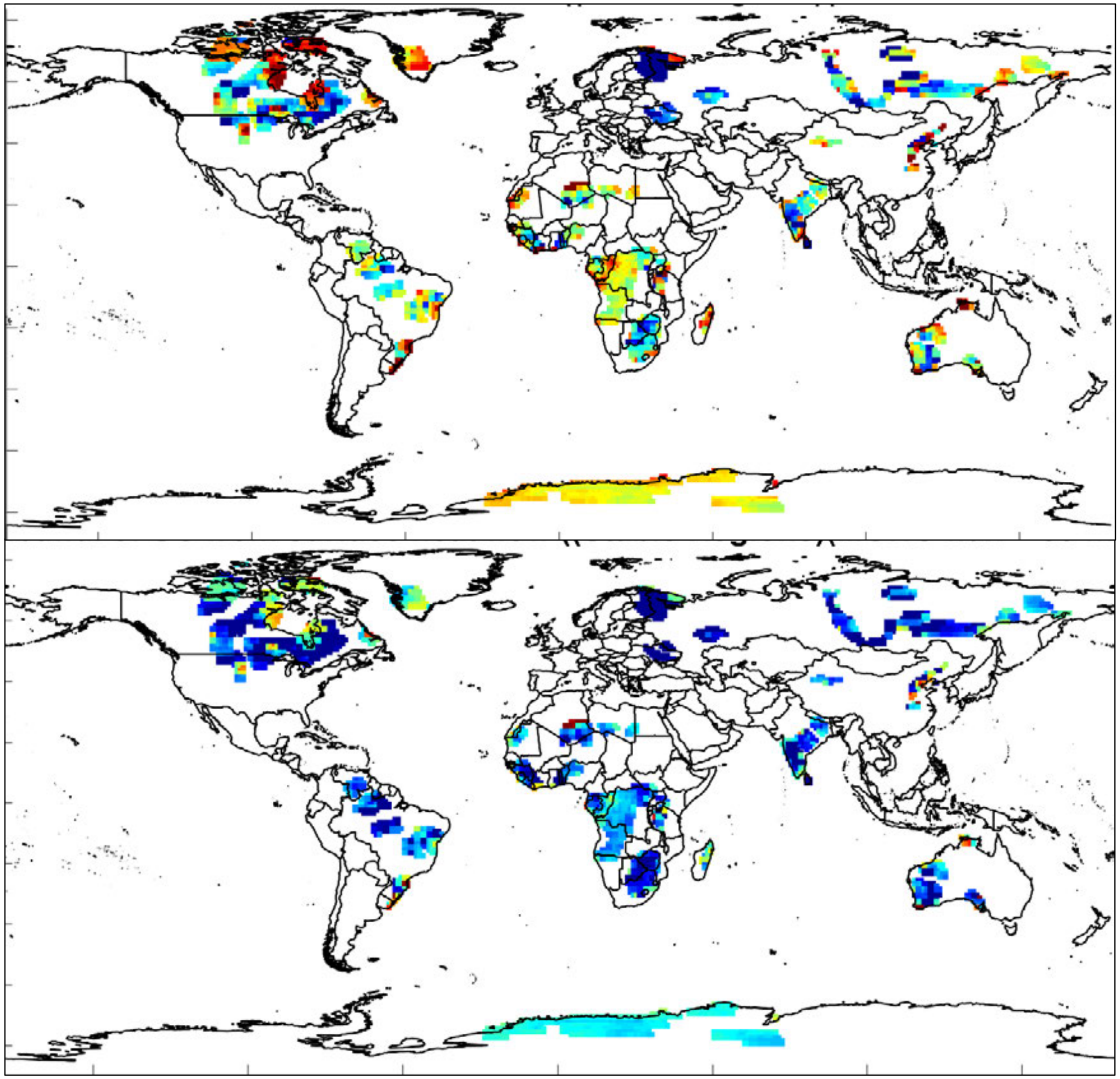
Uranium Concentration in UC

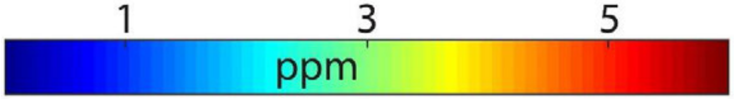
Moho Q_3 = 15 mW/m^2

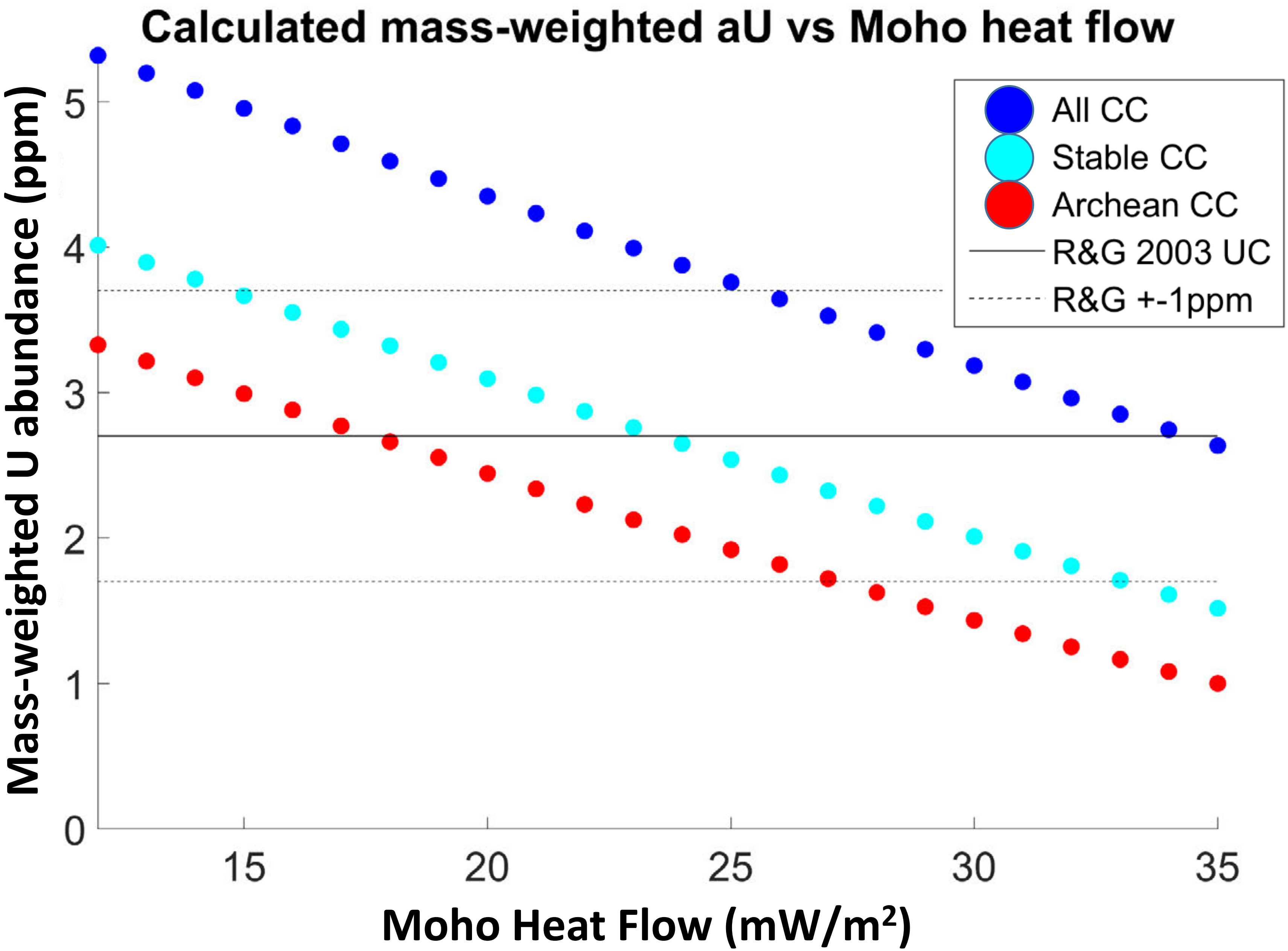
Avg. U = 2.99 ppm

Moho Q_3 = 30 mW/m^2

Avg. U = 1.43 ppm

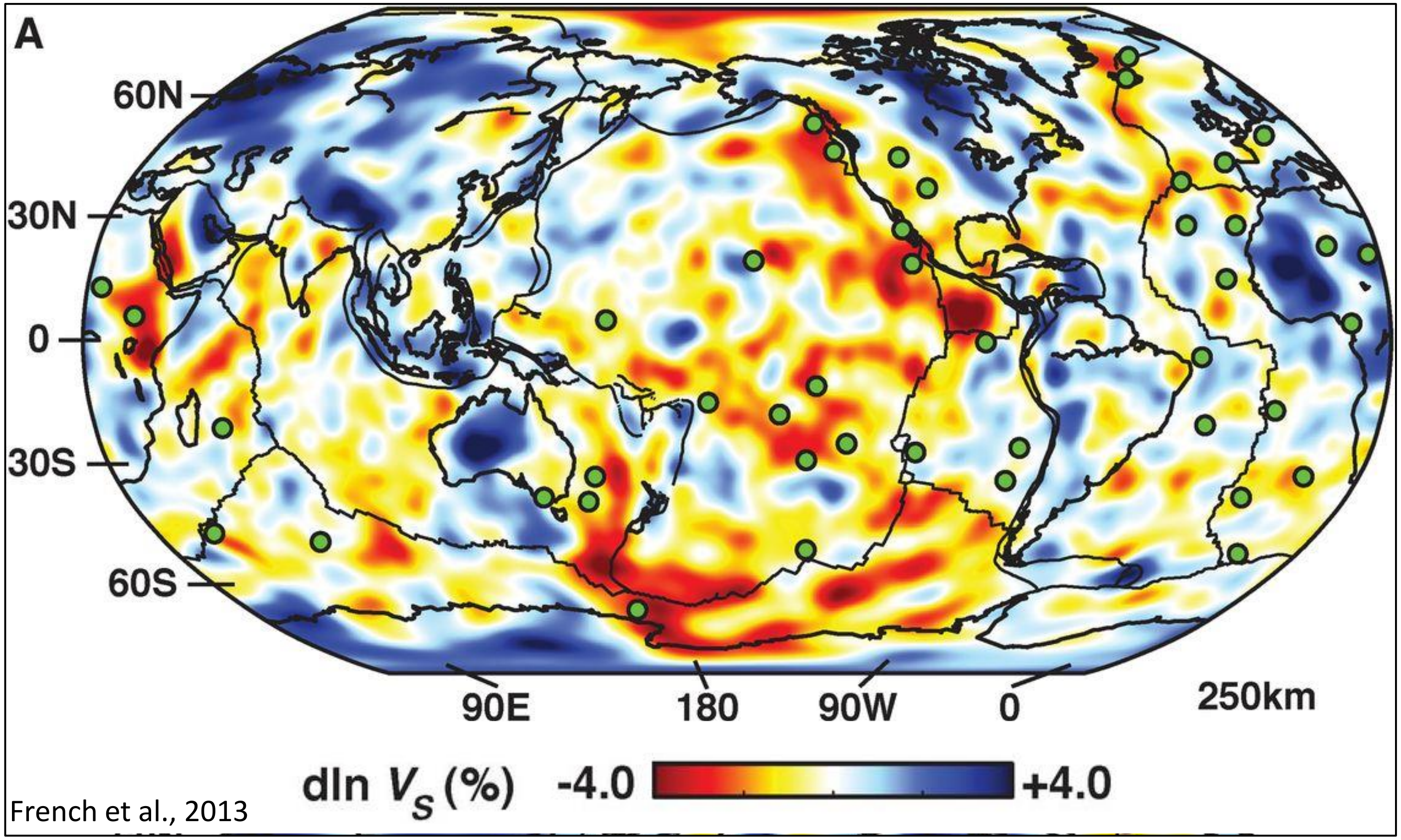





Calculated mass-weighted aU vs Moho heat flow
Mass-weighted U abundance (ppm)
0
1
2
3
4
5
15
20
25
30
35
Moho Heat Flow (mW/m²)
All CC
Stable CC
Archean CC
R&G 2003 UC
R&G +-1ppm

Calculate Q_3 directly?

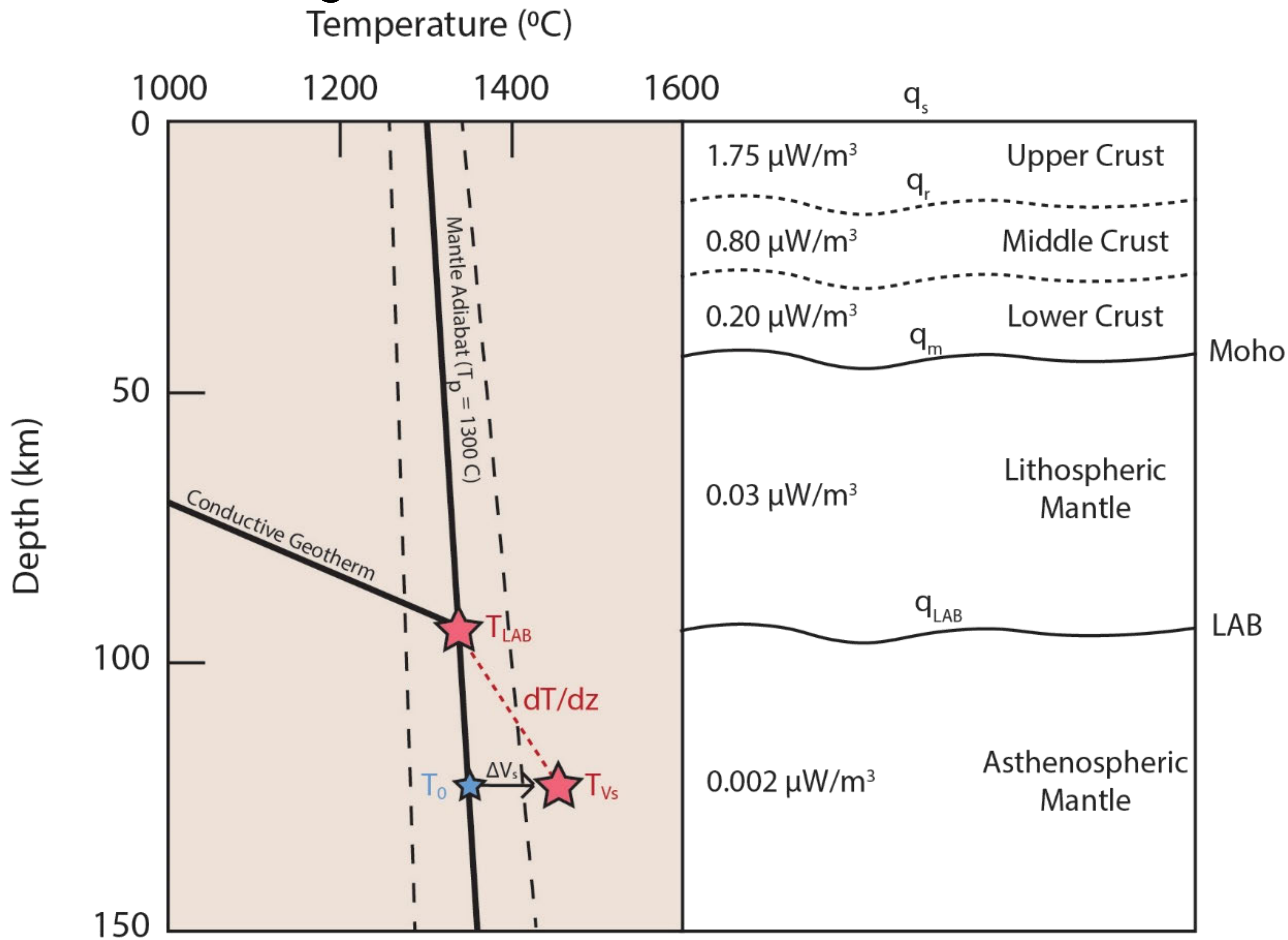
Seismic shear wave velocity variation at 250km depth



French et al., 2013

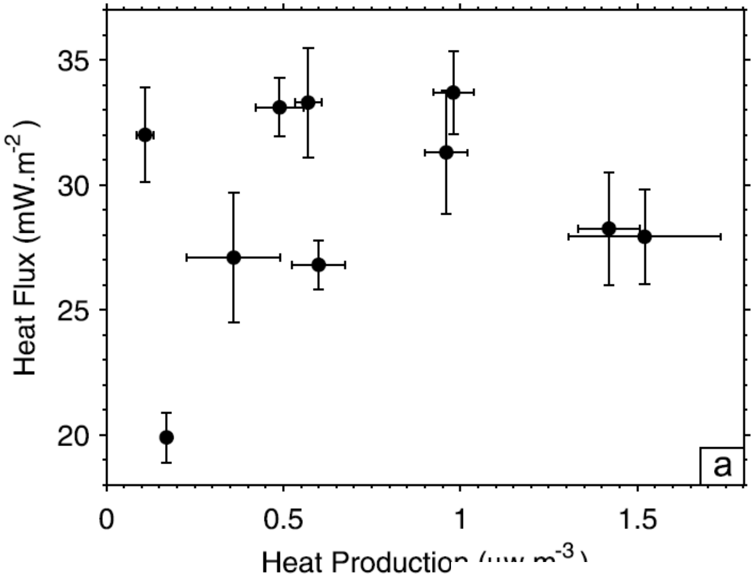
$$V_s = \sqrt{\frac{\mu}{\rho}}$$

Calculate Q_3 directly?

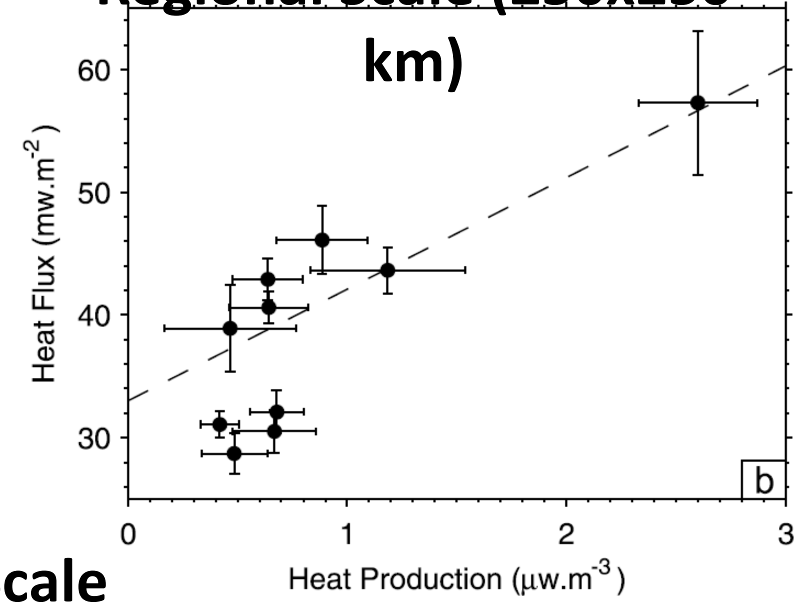


Exploit Q/A relationships?

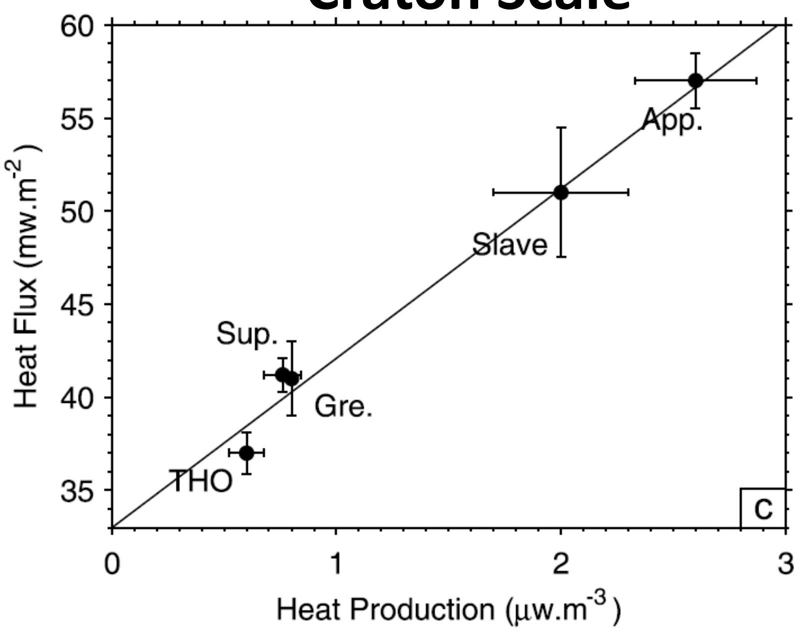
Local Scale



Regional Scale (250x250 km)

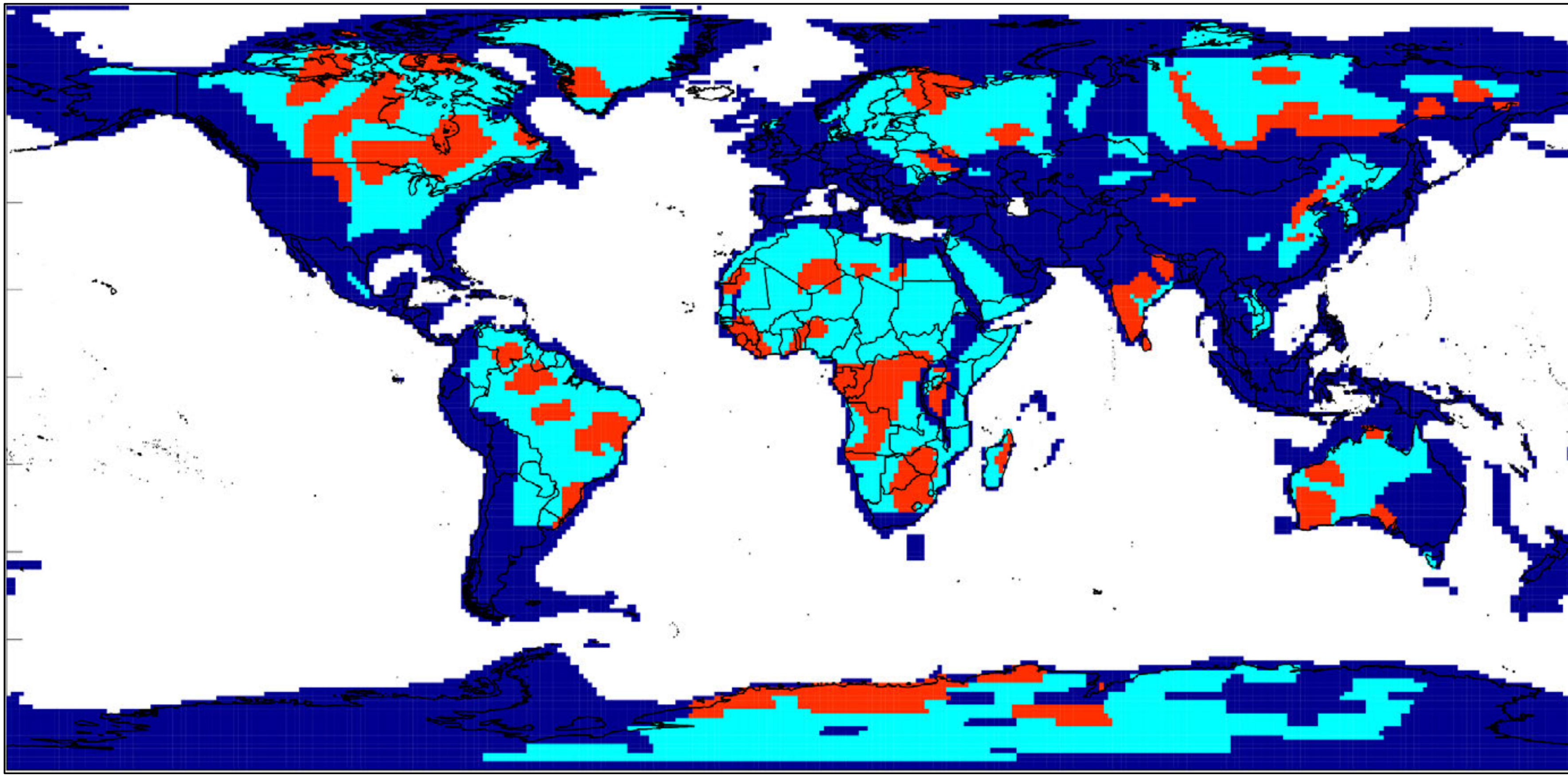


Craton Scale



Lévy et al., 2010

Exploit Q/A relationships?

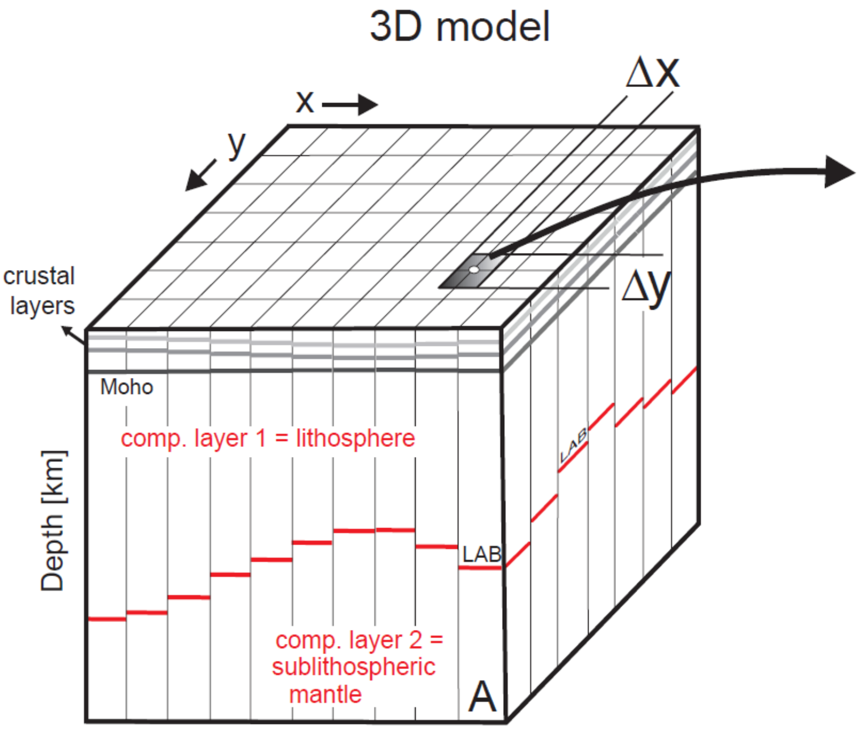


All Continental Crust

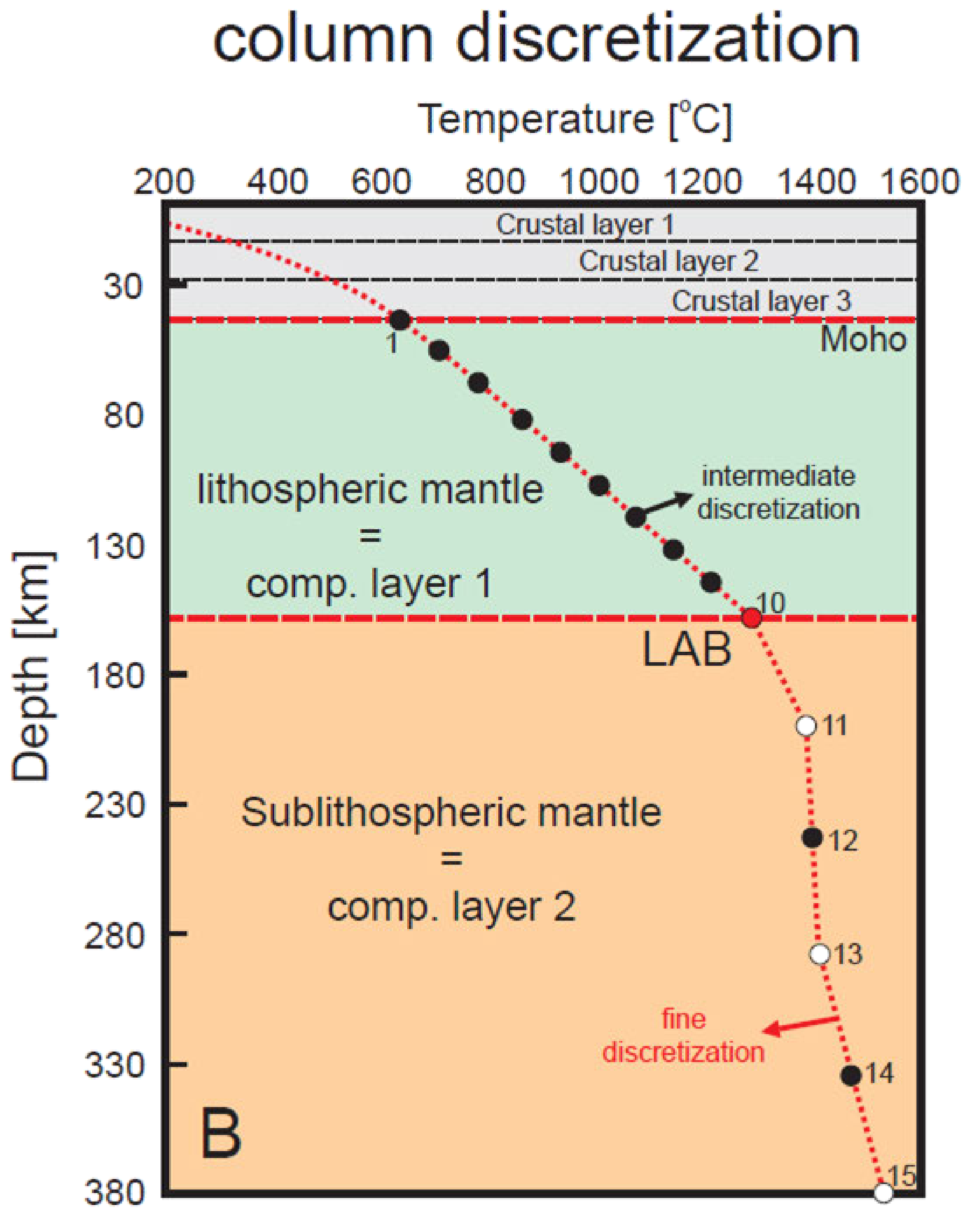
Archean + Proterozoic Crust

Archean Crust

Heat Flow with other data



Join inversion of P & S wave travel times, surface waves, geoid height, gravity anomalies, **surface heat flow**, and elevation



Afonso et al. 2016

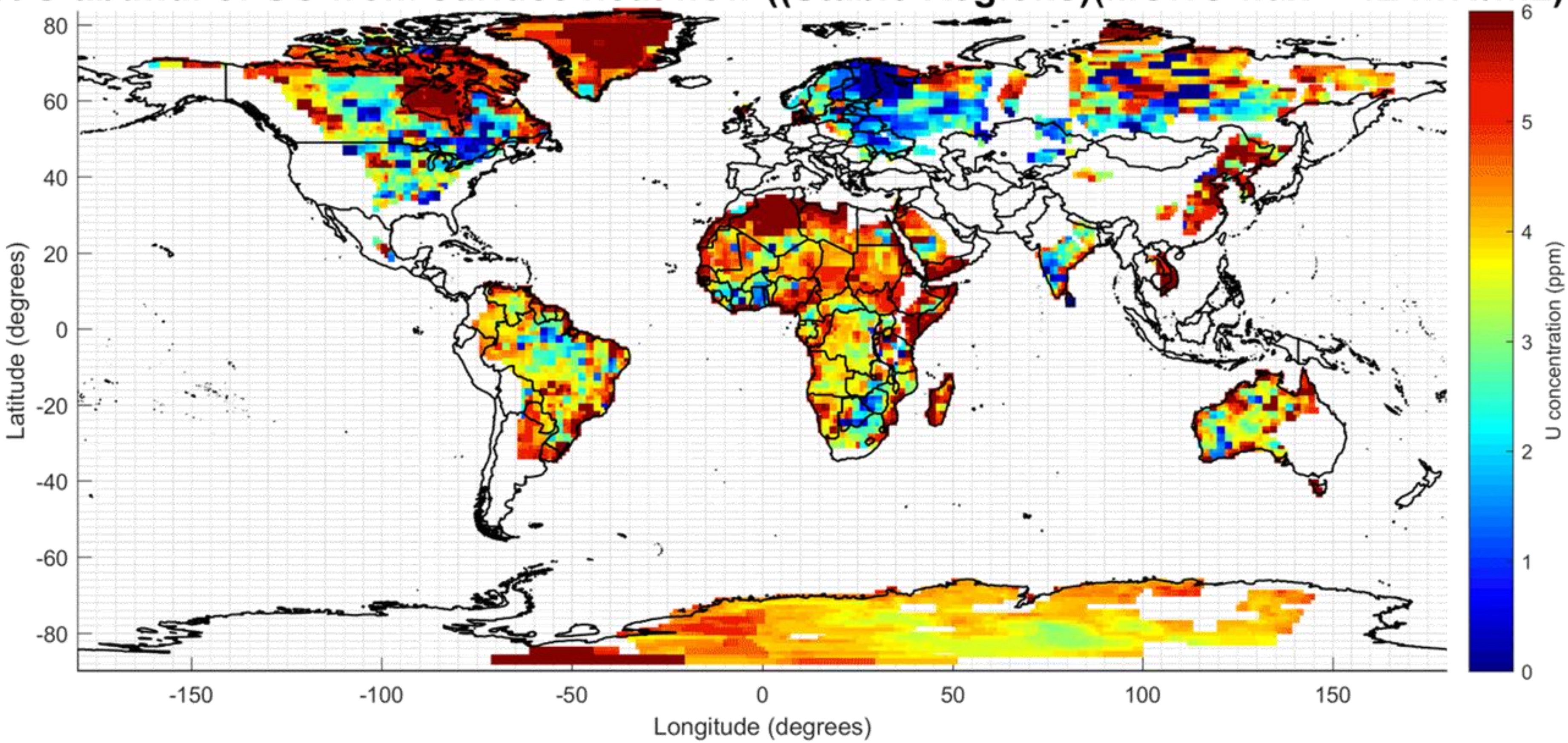
Conclusions

1. **Magnitude of surface heat flow significantly controlled by UC heat production**
    - Theoretically we can inverse-model surface heat flow for crustal heat production

2. **Heat flow modeling has many unknowns leading to large assumptions**
    - How does heat production change with depth?
    - What is the heat flow across the Moho?
    - What is the extent of horizontal heat flow?
    - On what scales can we model accurately?

3. **Heat flow inverse modeling has great potential, but the road will be bumpy…**
    - Possibility to provide knowledge on the distribution of U, Th, and K in the continental crust
      = better geoneutrino prediction

Est U abund. of UC from surface heat flow ((Stable Regions)(MOHO flux = 12 mW/m2)



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