LCS-1: First lithospheric magnetic field model from CHAMP and Swarm satellites **magnetic gradient observations** and implications for magnetic anomaly interpretation

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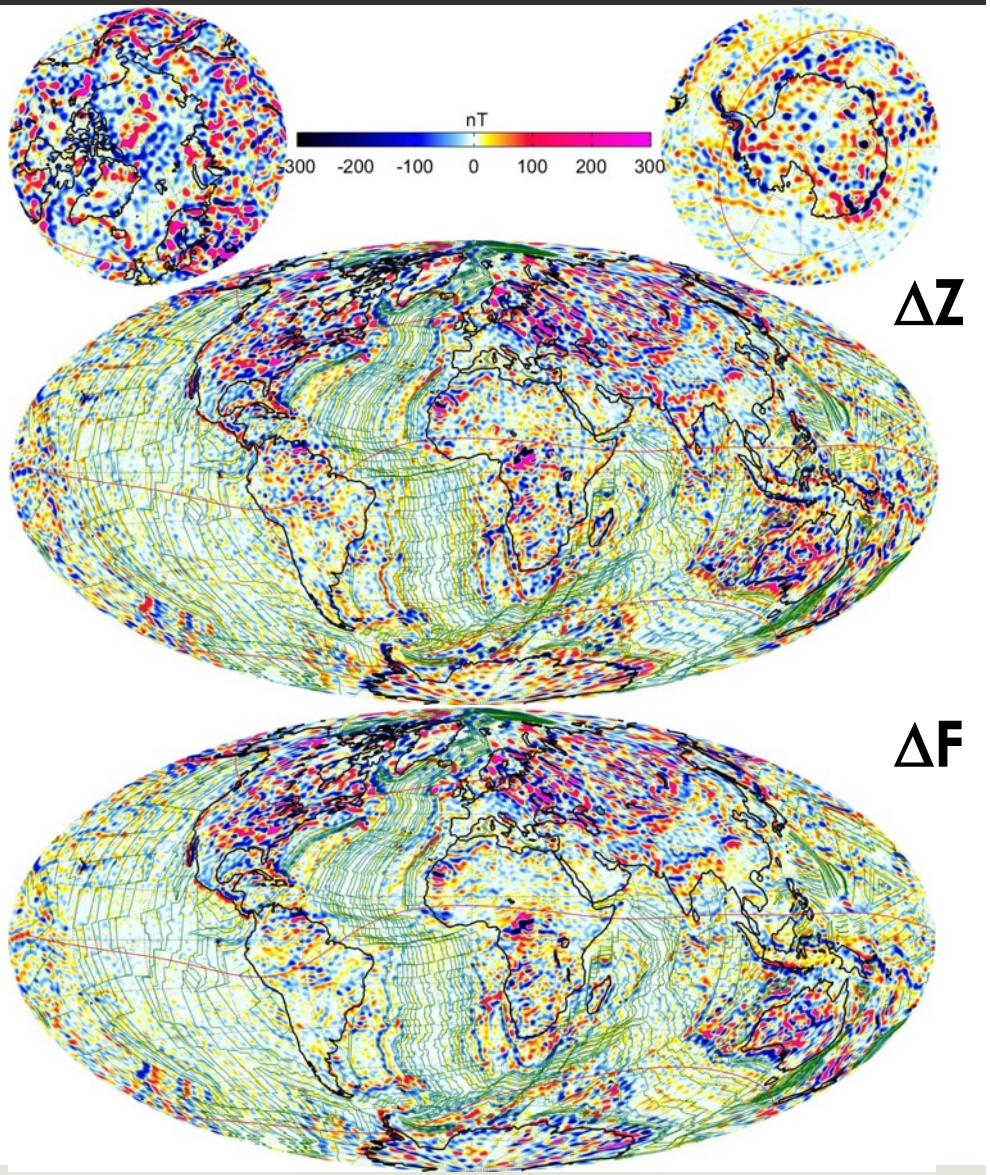
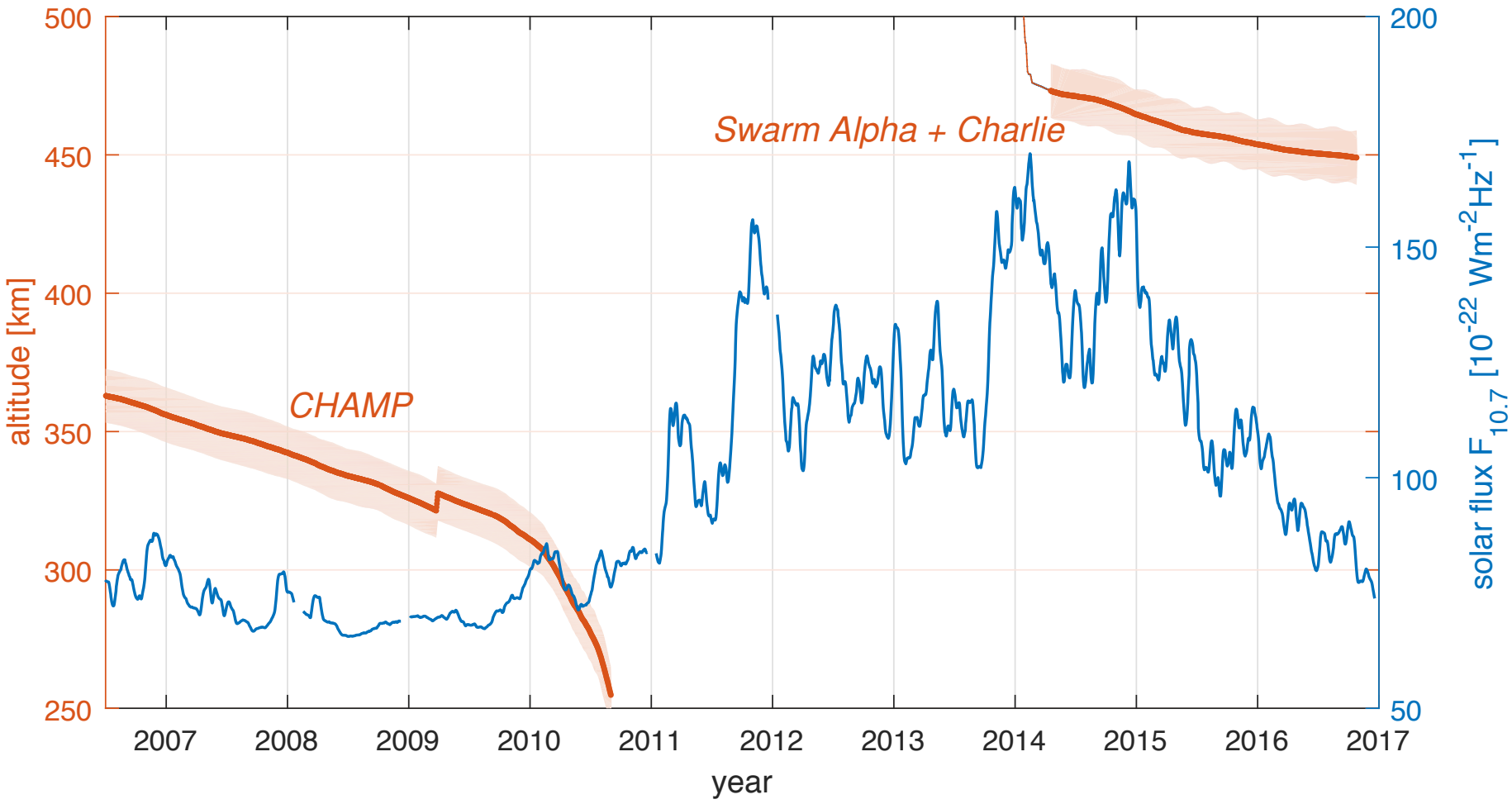
LCS-1Development: Key points

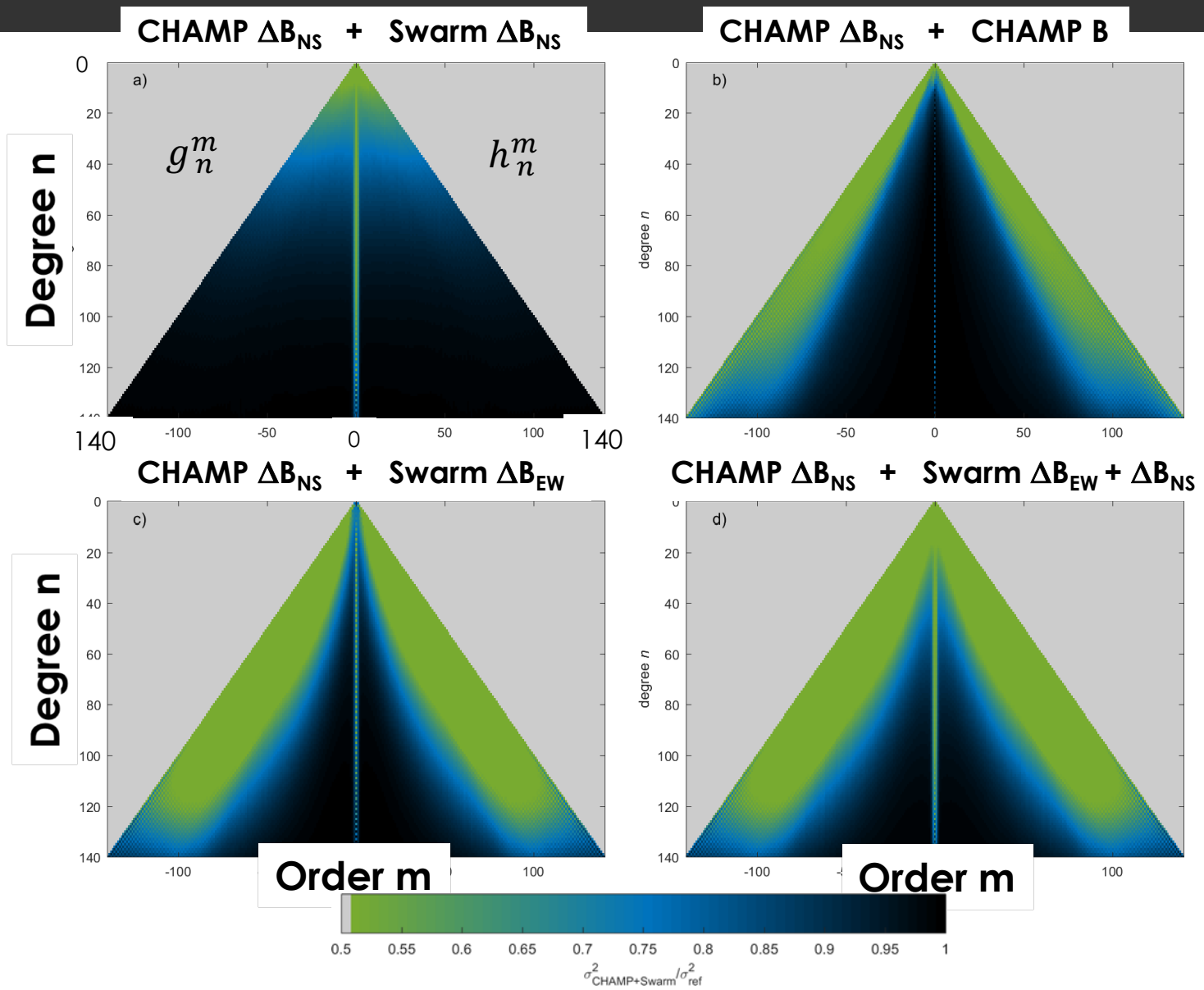
- Anomalies based only on CHAMP N-S and Swarm N-S and E-W gradients (6.2 million vector and scalar gradients)
  - Advantages
- 35000 equivalent sources (~1° spacing) at 100 km depth
- Minimization of misfit to gradients and minimization of |Br| at the earth's surface
- LCS-1 Spherical harmonic degrees 16-185
  - MF7 was degree 16-133



Altitude Coverage of Data



Improvement from Swarm gradients



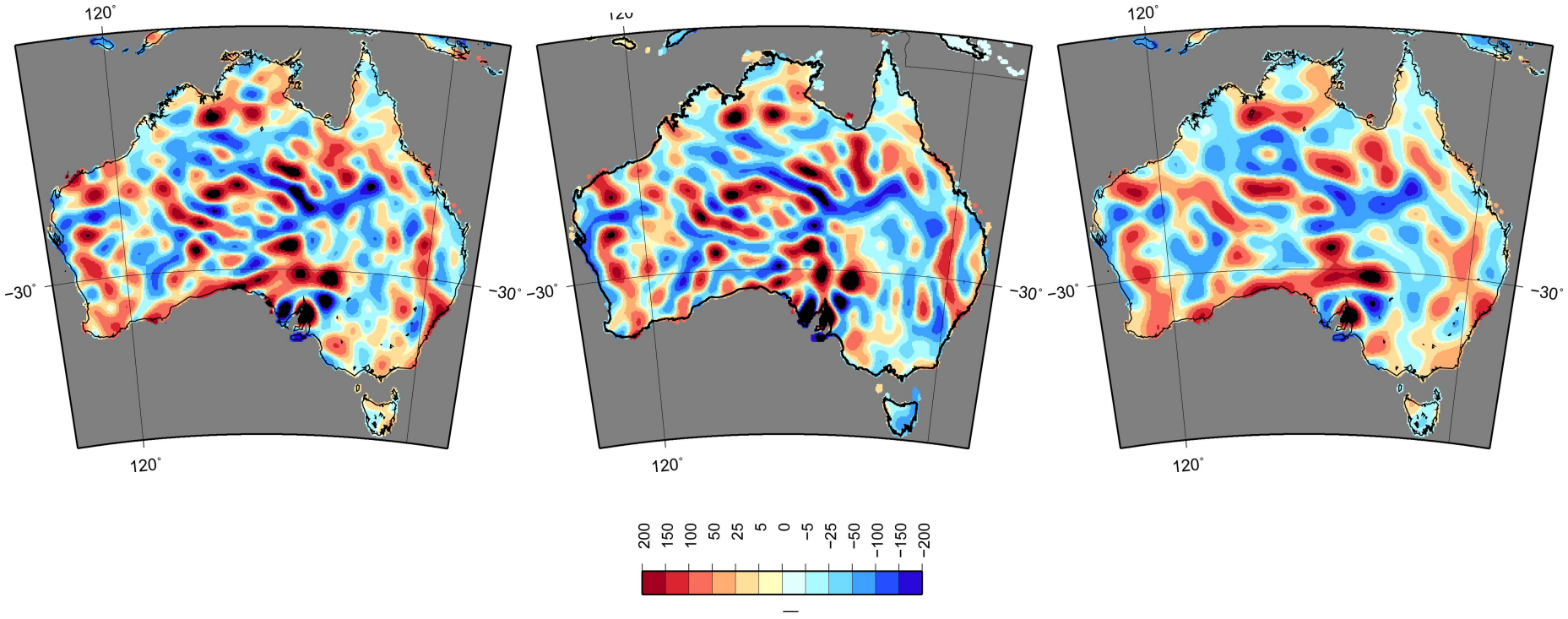
LCS-1 Validation - Visual

- **Comparison with Australian aeromagnetic data**

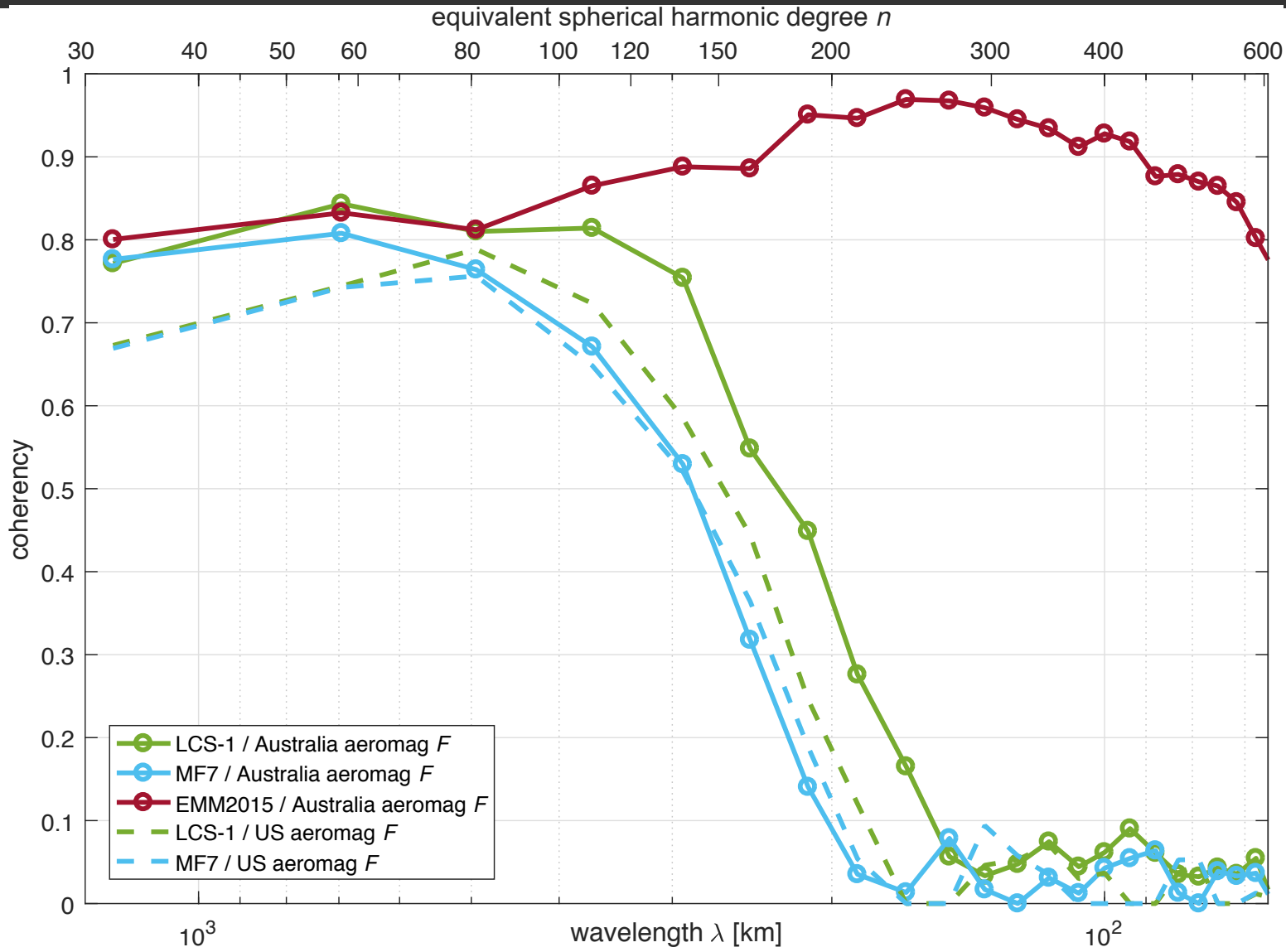
LCS-1

Aeromagnetic (5th ed)
225 km LP filtered

MF7

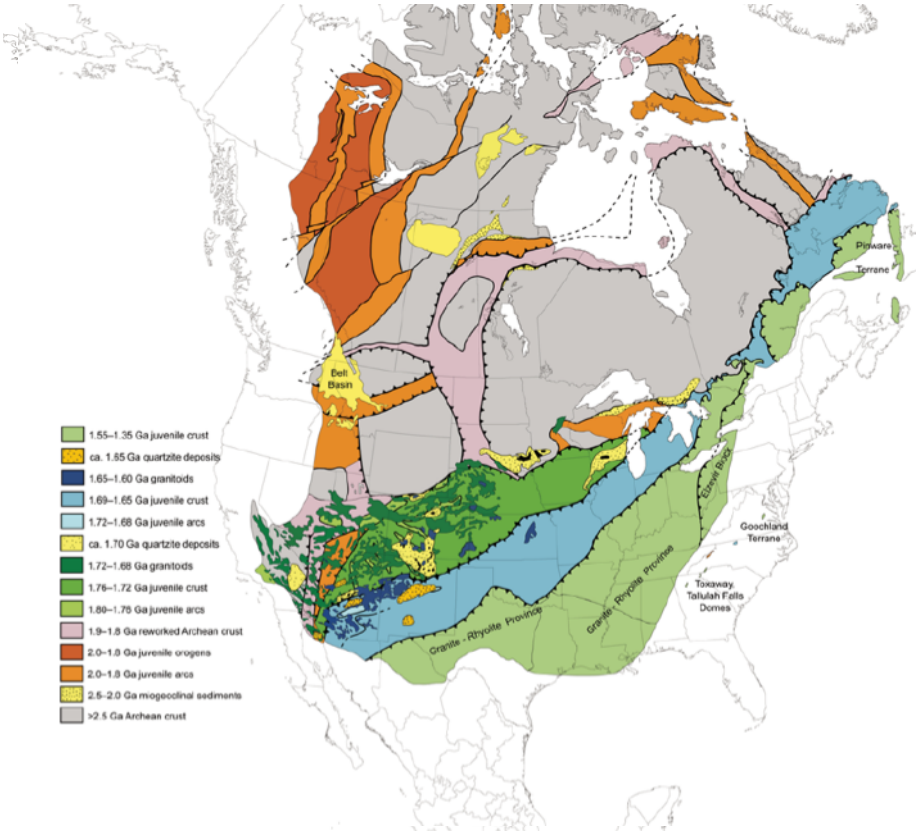


LCS-1 Validation - Coherency

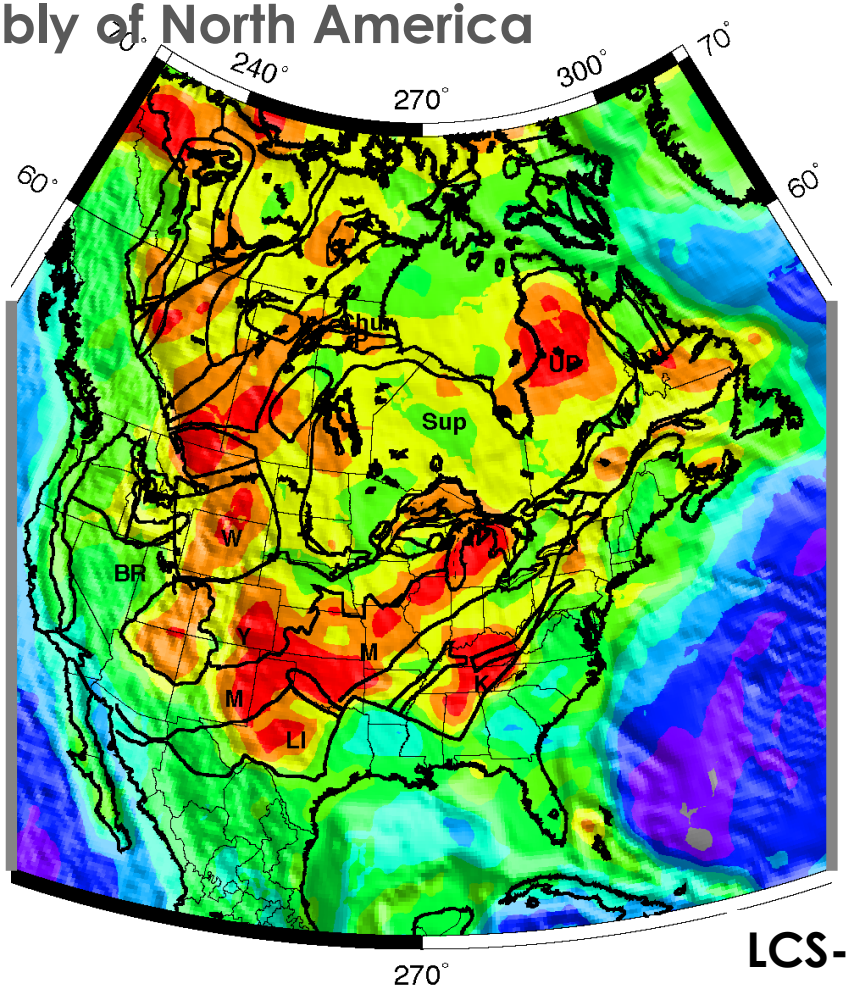


Interpretation – Paleoproterozoic and Mesoproterozoic provinces in the central U.S.

- **Laurentian Tectonic Assembly of North America**

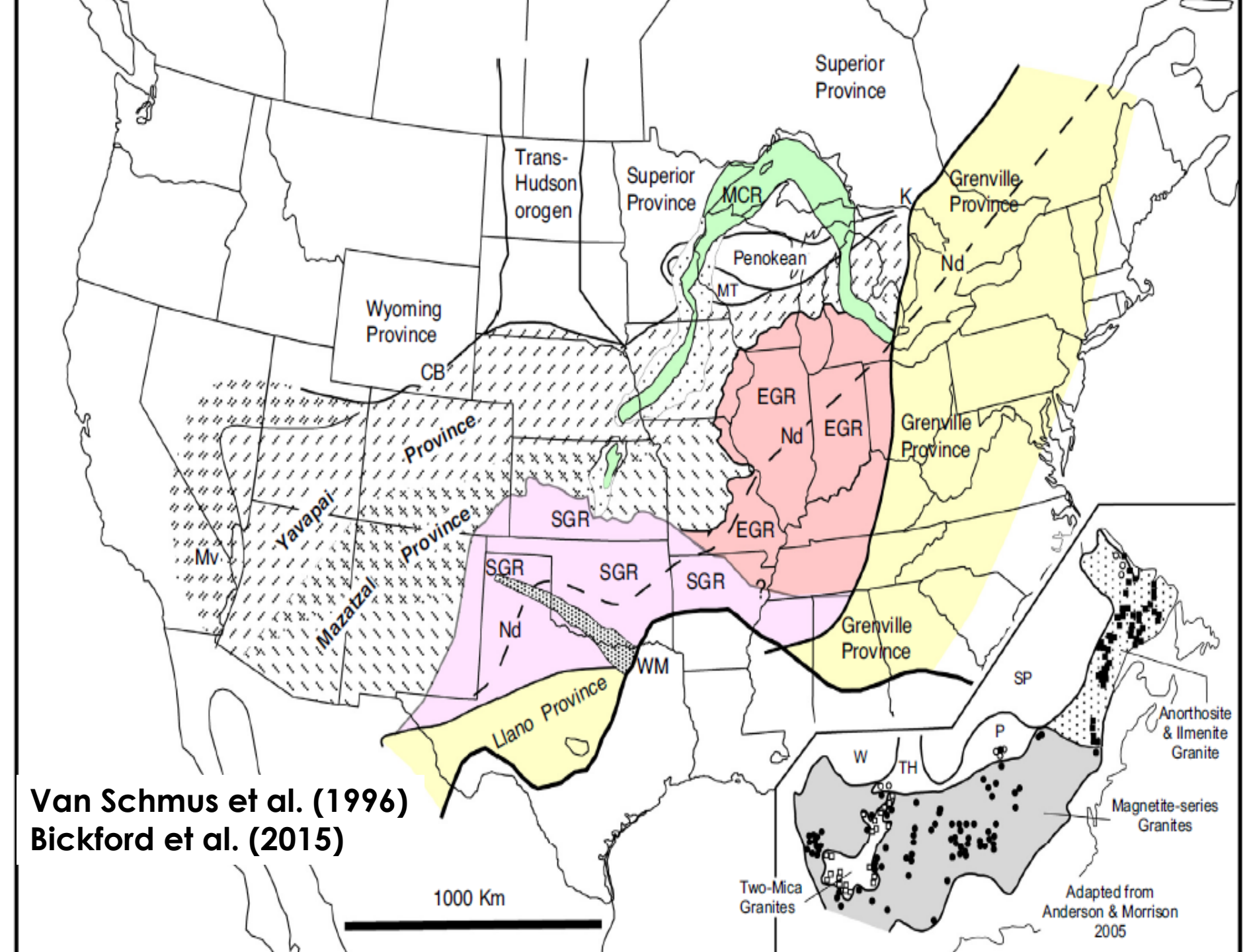


Archean and Proterozoic Provinces in North America (Whitmeyer and Karlstrom, 2007)



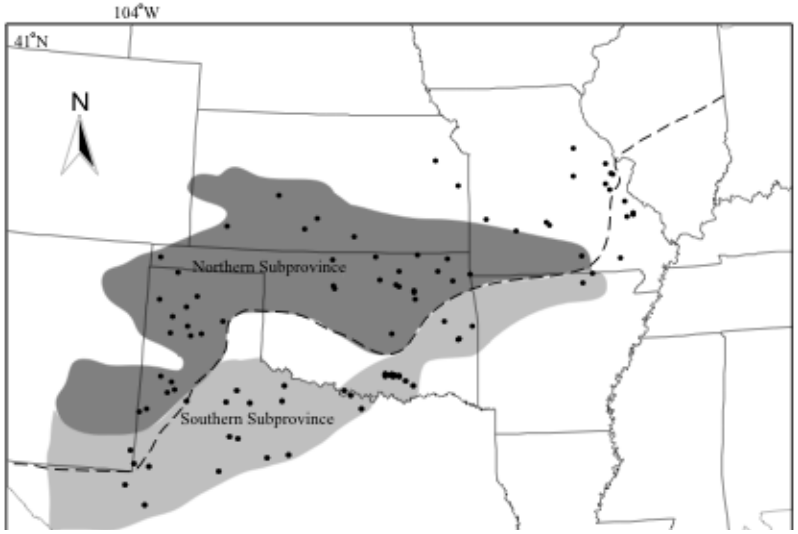
LCS-1

Depth-Integrated Susceptibility Variation



Van Schmus et al. (1996)
Bickford et al. (2015)

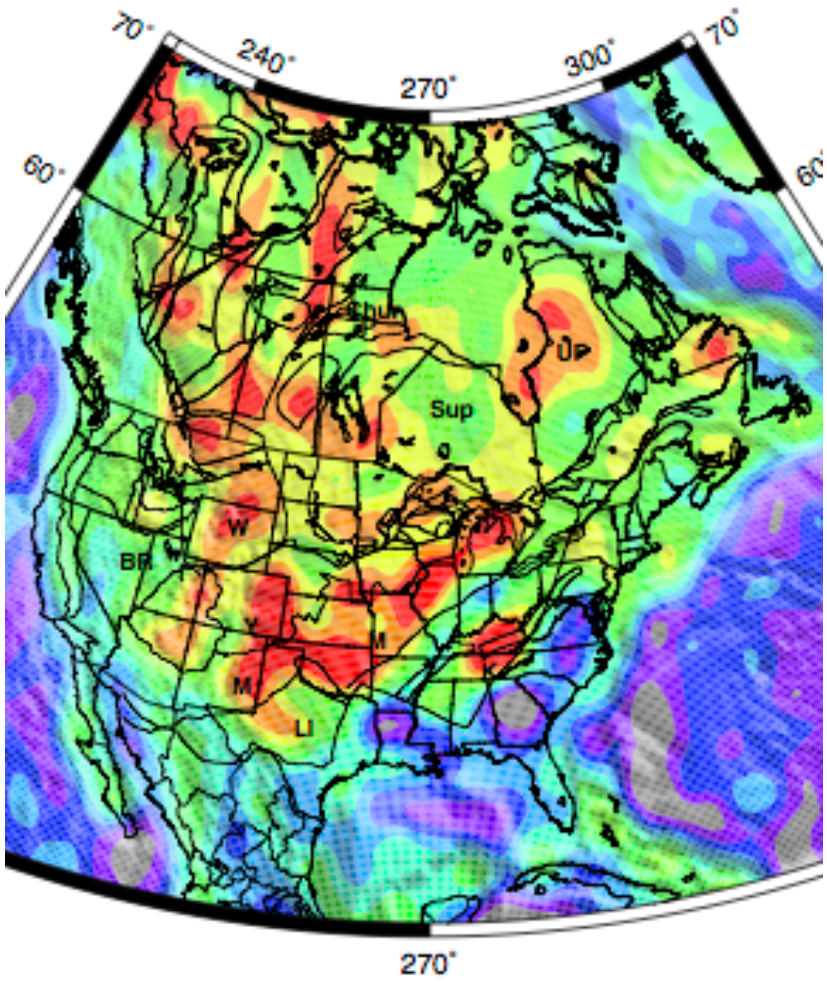
Subdivisions of Southern Granite-Rhyolite Province based on additional Nd model age data



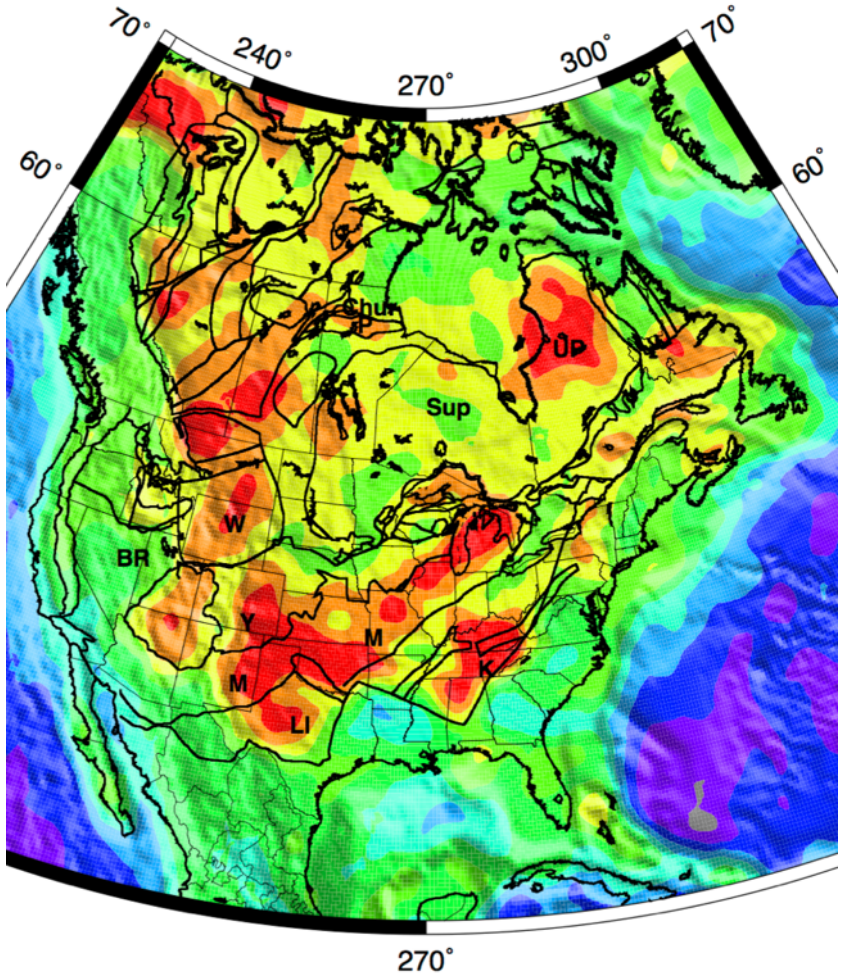
Rohs (2001) Univ. of Kansas, Ph.D. Thesis
Rohs and Van Schmus (2007)

Magnetization Resolution Improvement from Magsat, MF3, MF5, MF6, MF7 to LCS-1

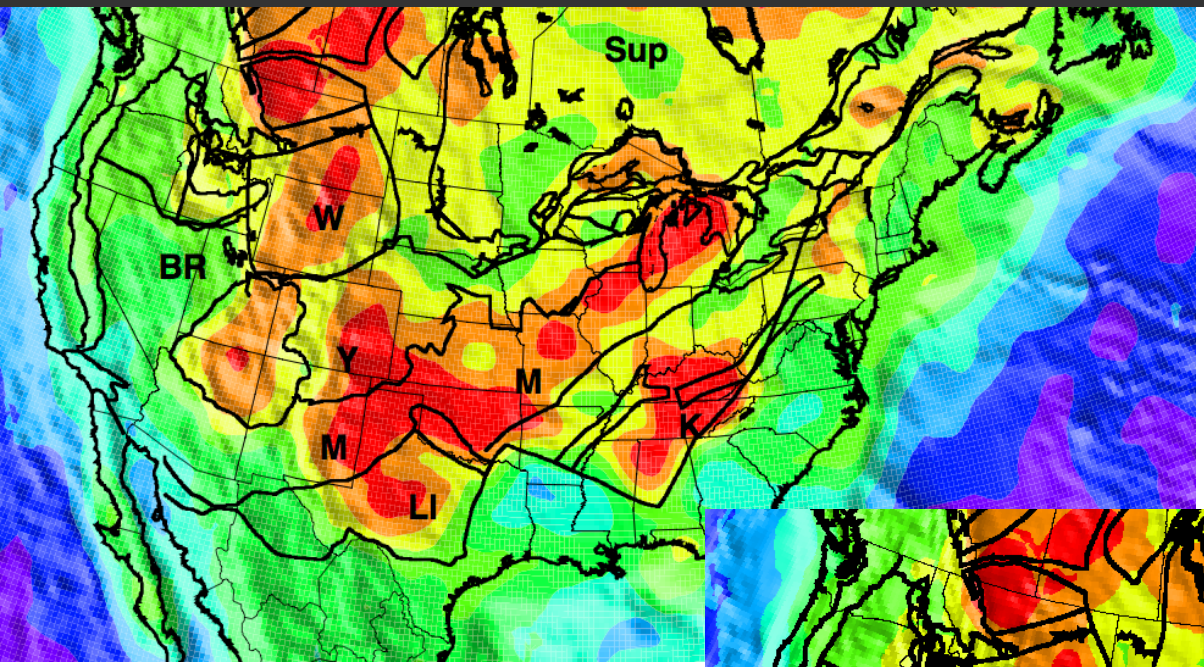
MF3



MF7



U.S. Magnetization Variation Features Resolution Improvement from MF3, MF5, MF6, MF7 to LCS-1

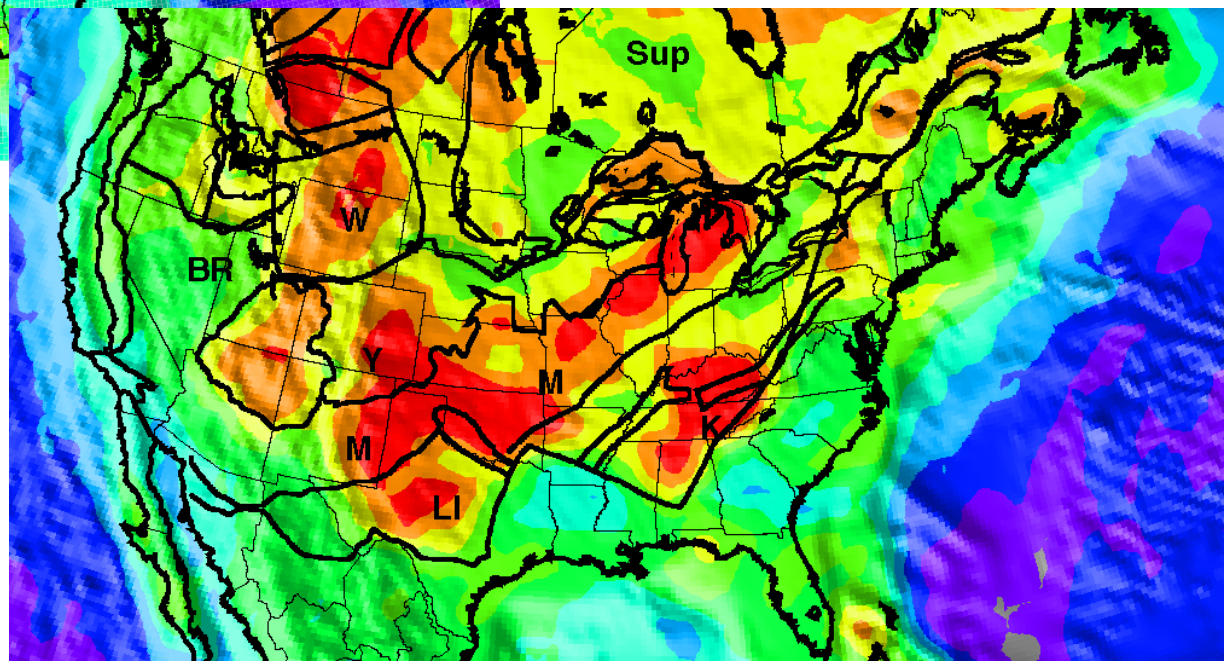


MF7

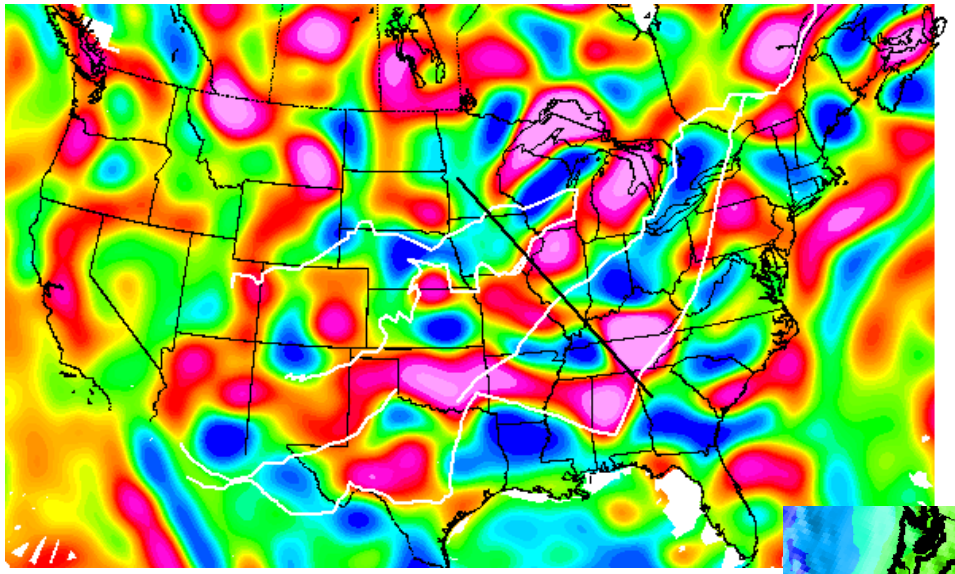
Ave. shortest λ ~ 300 km

LCS-1

Ave. shortest λ ~ 250 km

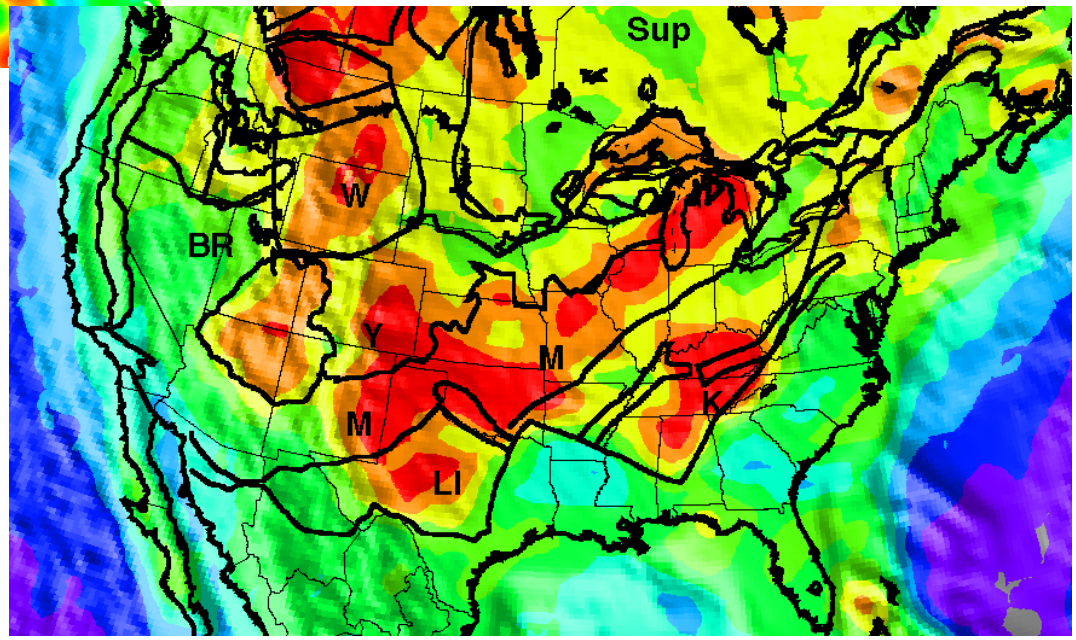


U.S. Aeromagnetic Features and LCS-1 Magnetization Variation

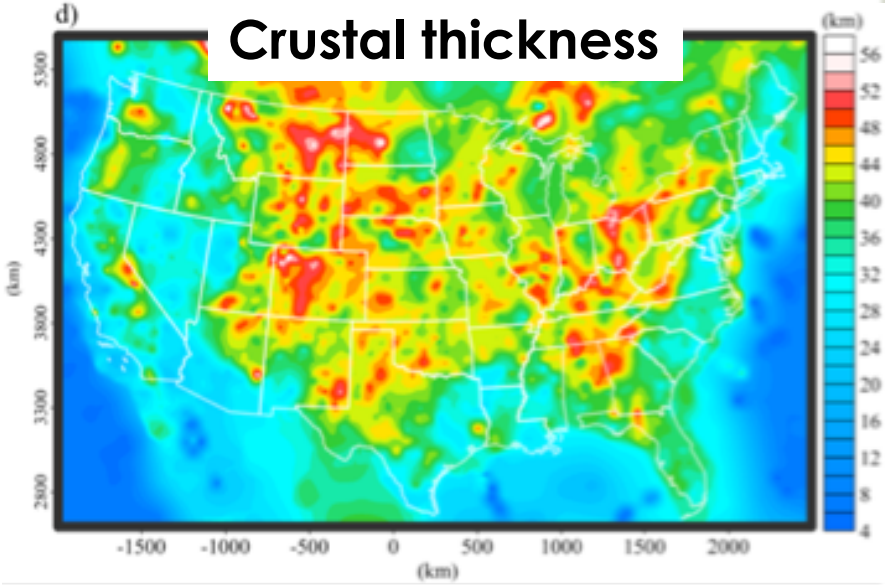


300 km Low Pass Full Spectrum US Magnetic Anomaly Map (NURE_NAMAM2008, Ravat et al., 2009)

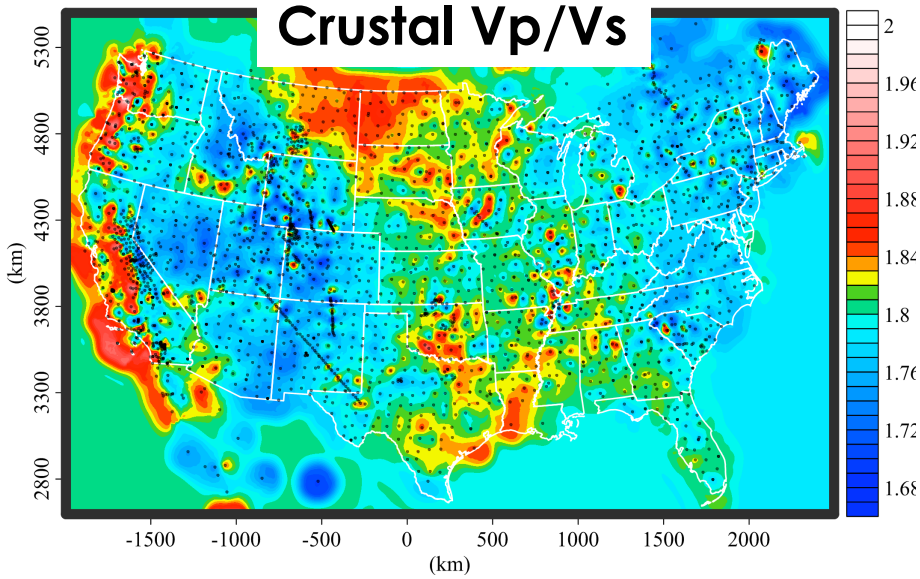
LCS-1



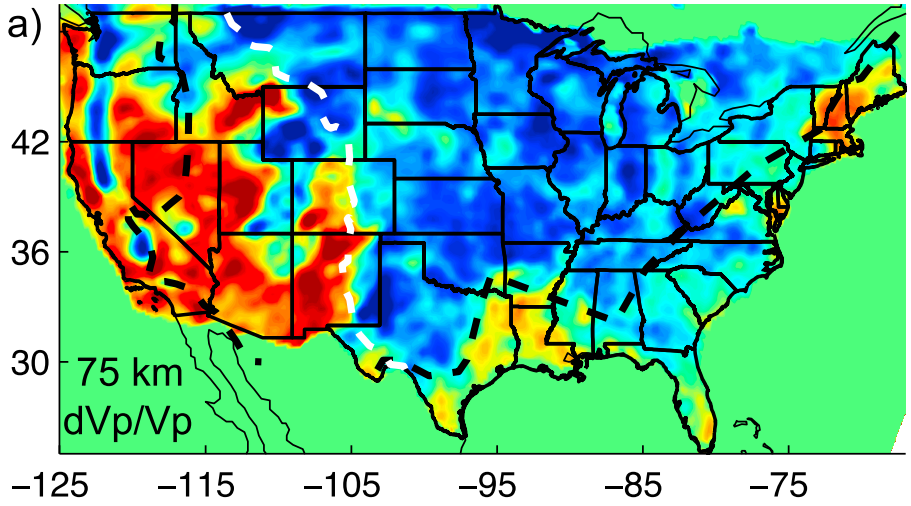
Crustal thickness



Crustal Vp/Vs



Seismic uppermost mantle dVp/Vp



Isostatic residual gravity anomaly from intracrustal density variations

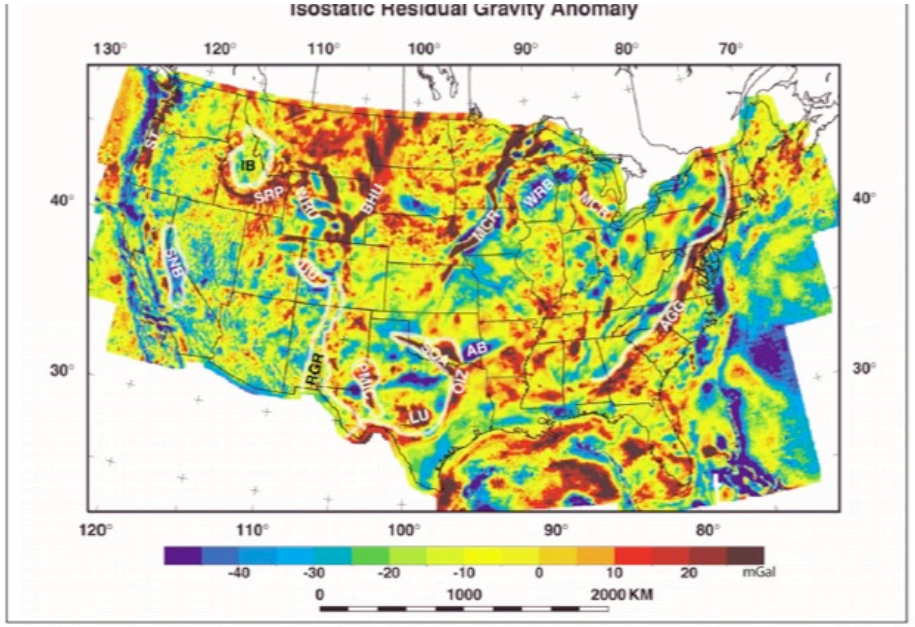
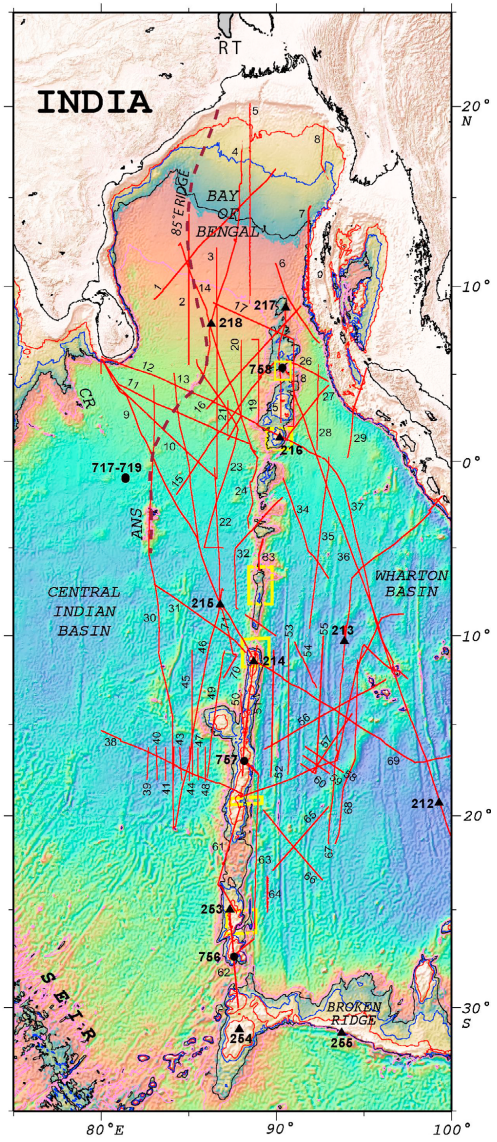
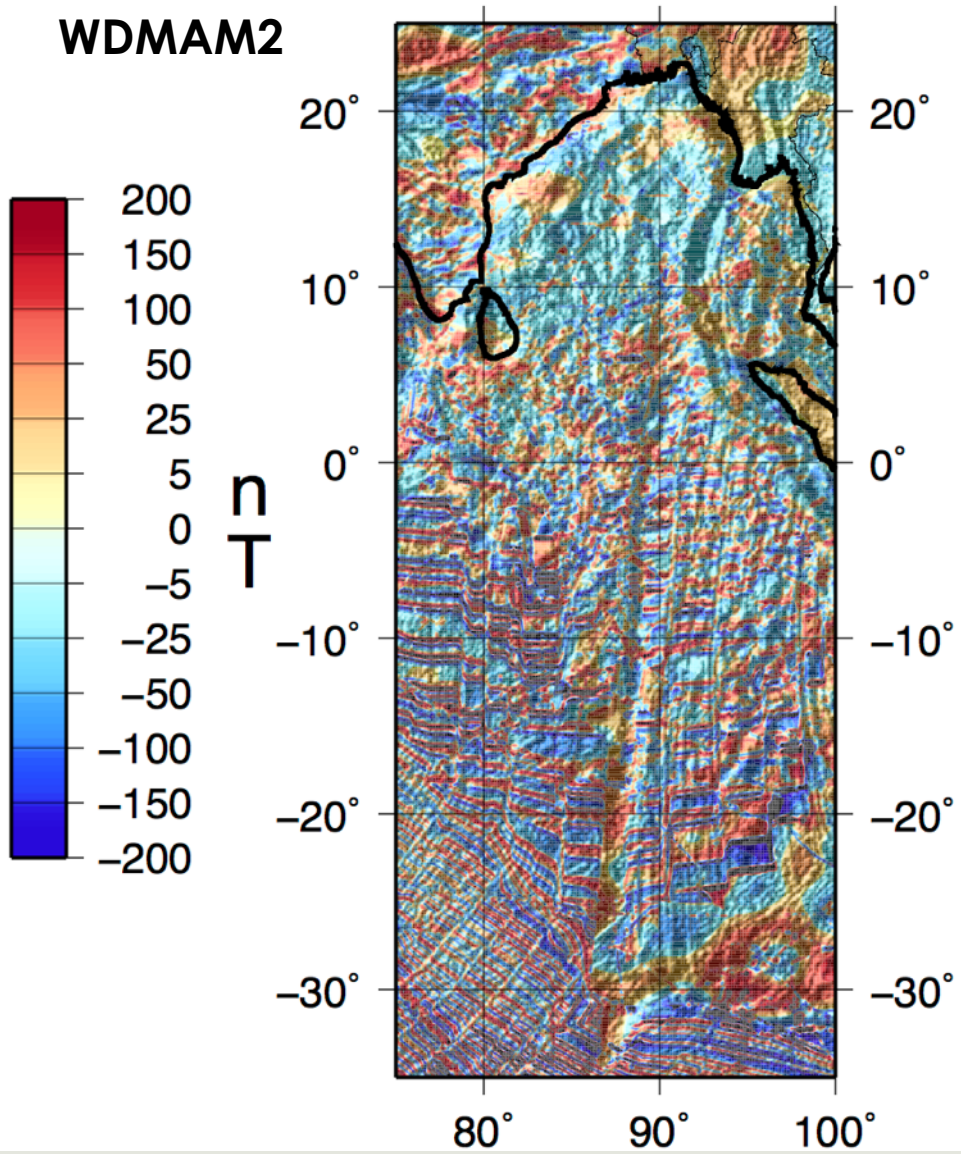


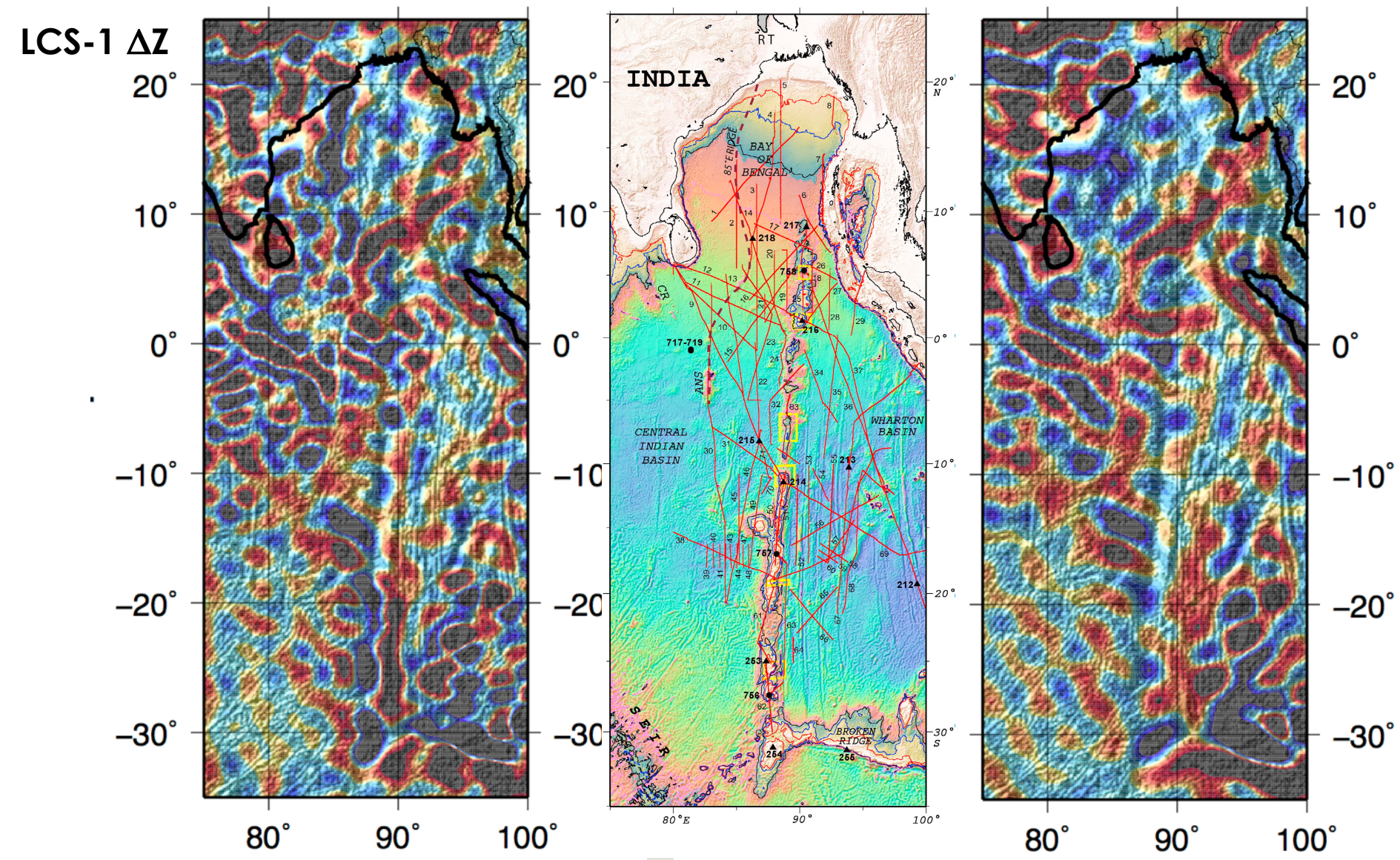
Figure 1. Isostatic residual gravity anomaly map of the conterminous United States (after Simpson et al., 1986). A few major gravity features are highlighted, such as the highs related to the Snake River plain (SRP), Siletz terrane (ST),

Interpretation Improvement: 90°E & 85°E Ridges in the Indian Ocean

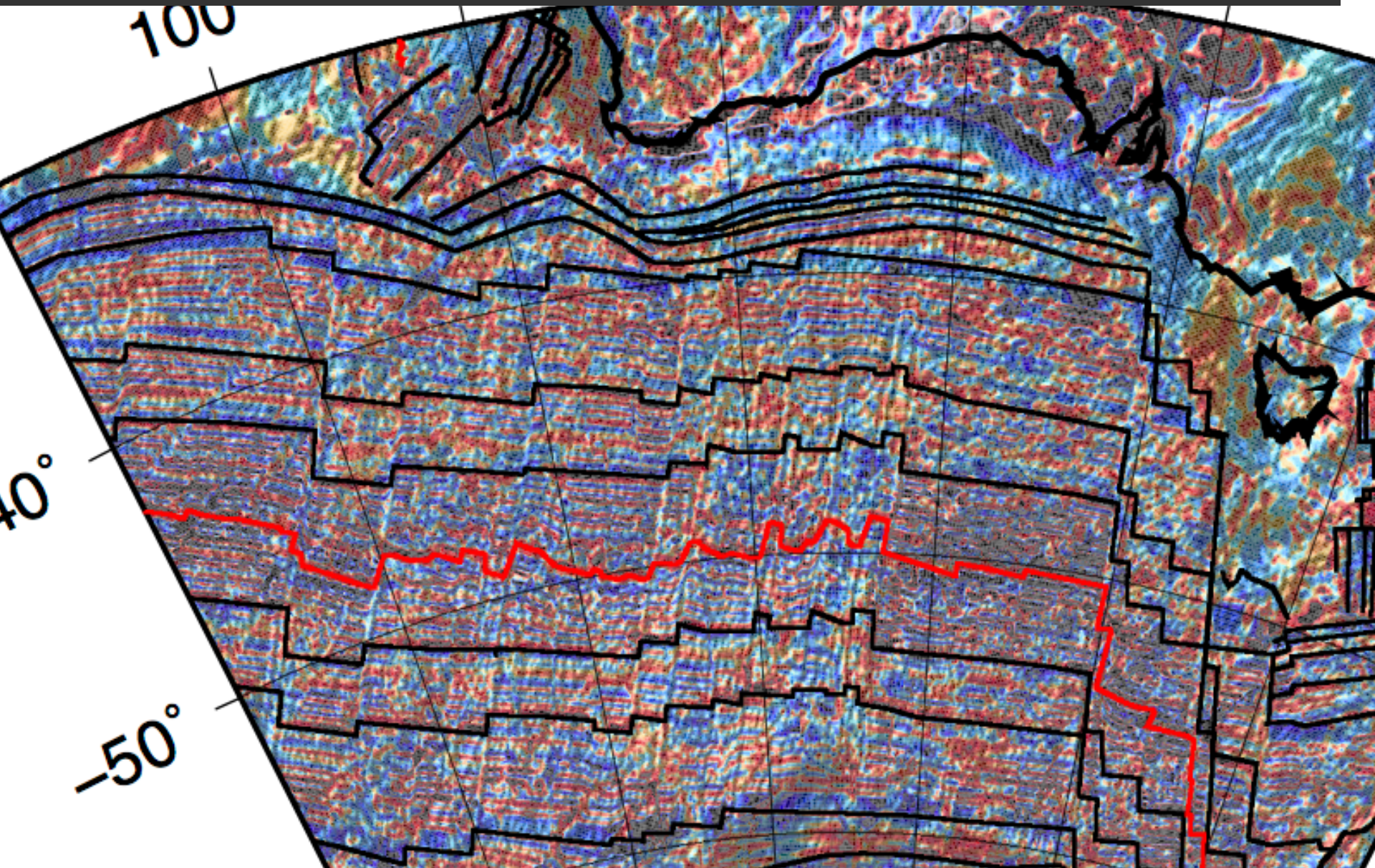




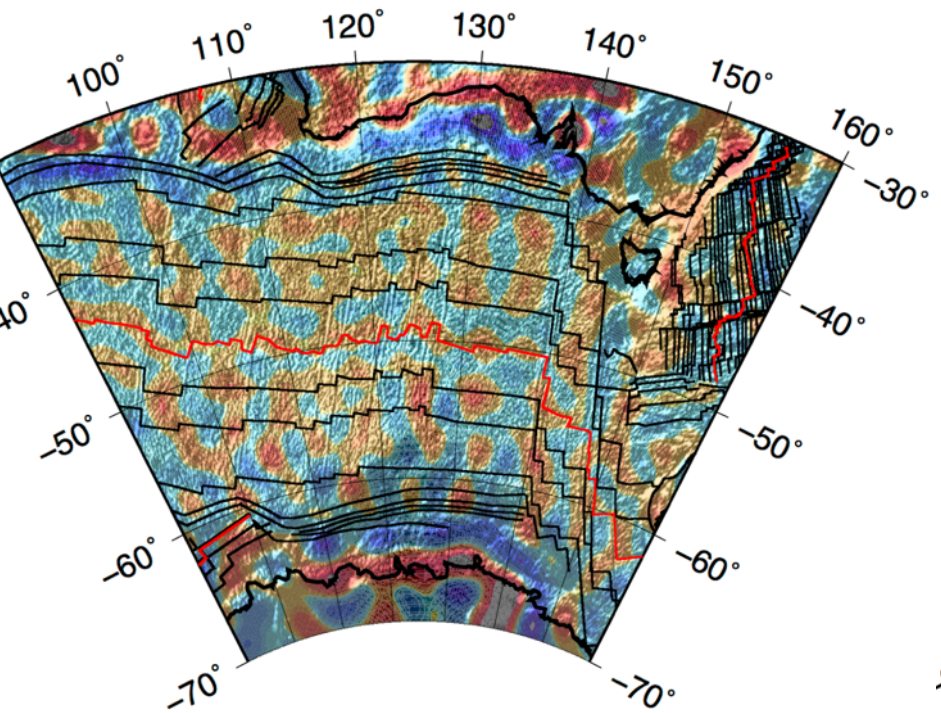
90°E & 85°E Ridges in the Indian Ocean



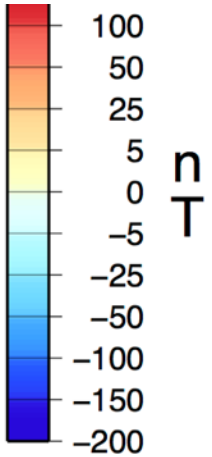
WDMAM2 - Seafloor spreading features between Australia-Antarctica



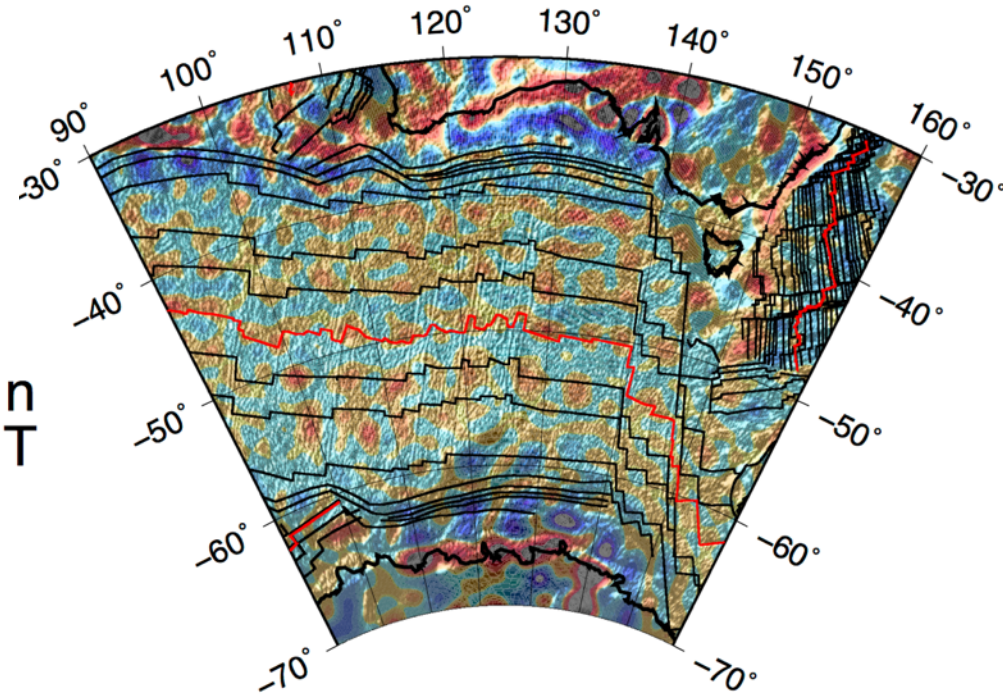
MF7 and LCS-1 (ΔF) Australia-Antarctica



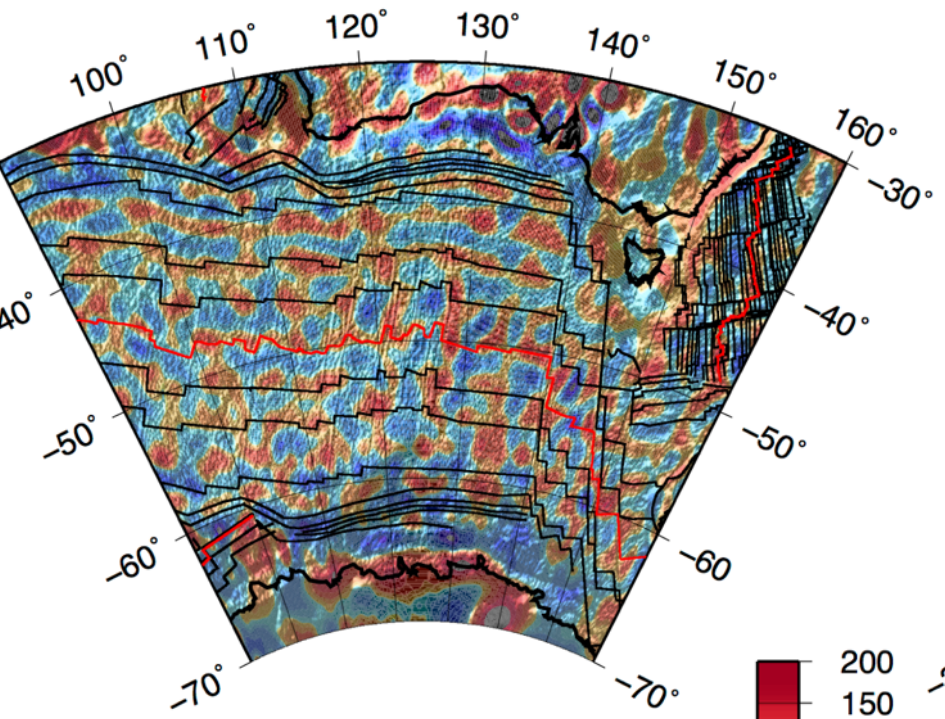
MF7 on sealevel ellipsoid



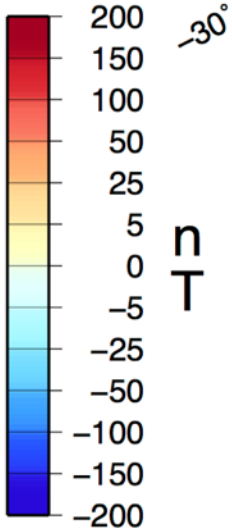
LCS-1 on sealevel ellipsoid



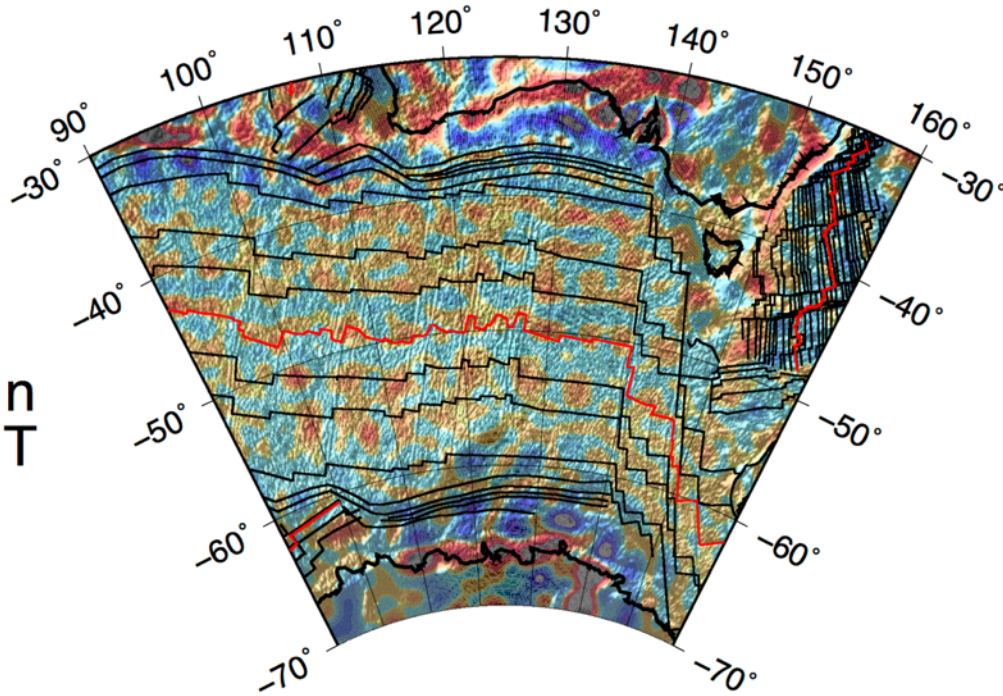
Filtered WDMAM2 and LCS-1 (ΔF) Seafloor spreading features between Australia-Antarctica



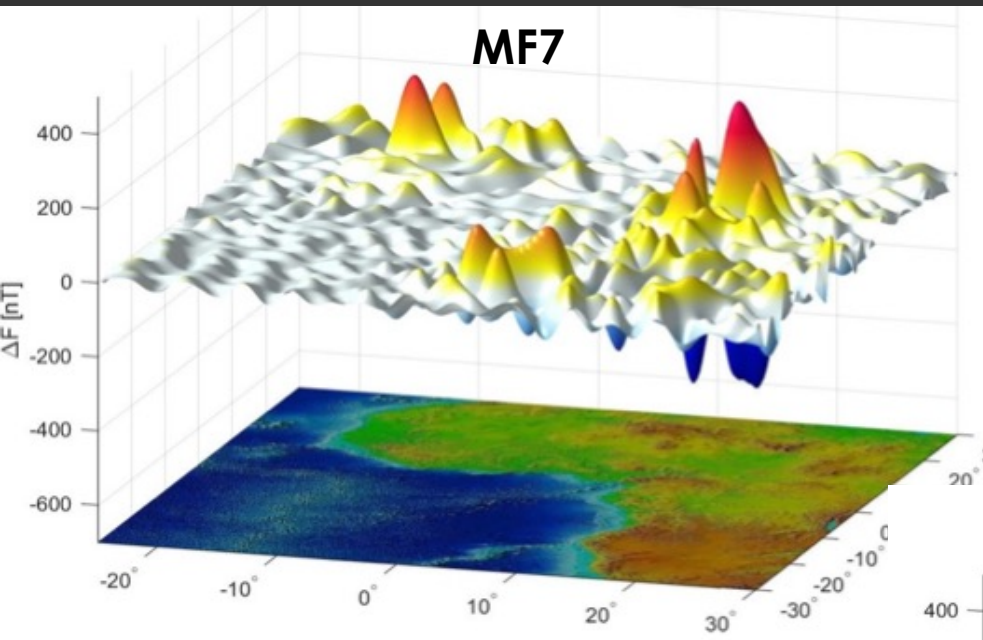
WDMAM2 λ > 250 km

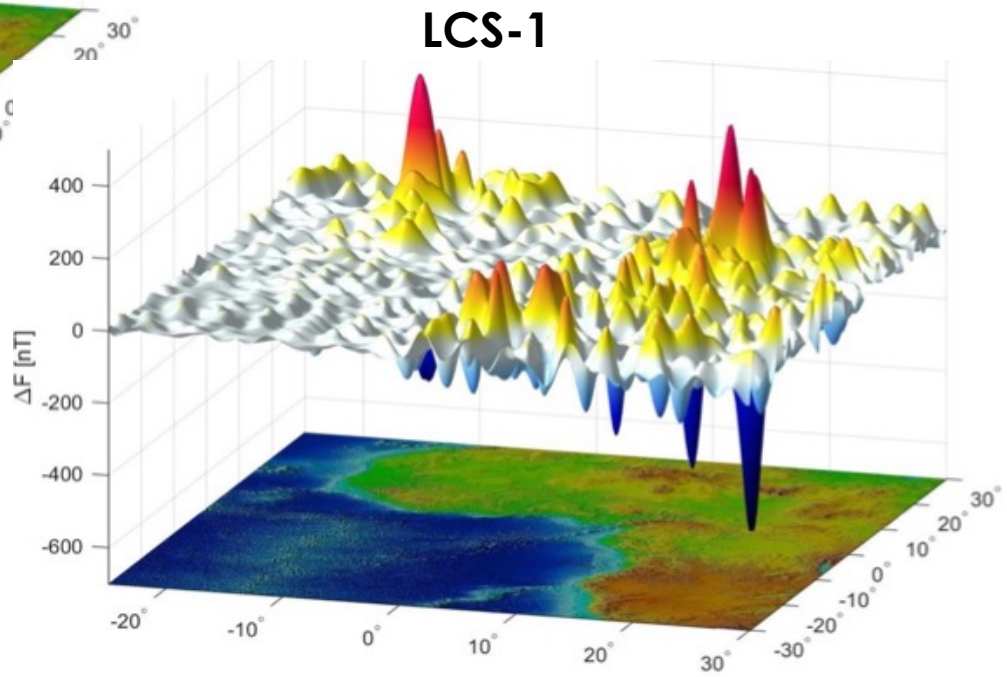


LCS-1 on sealevel ellipsoid

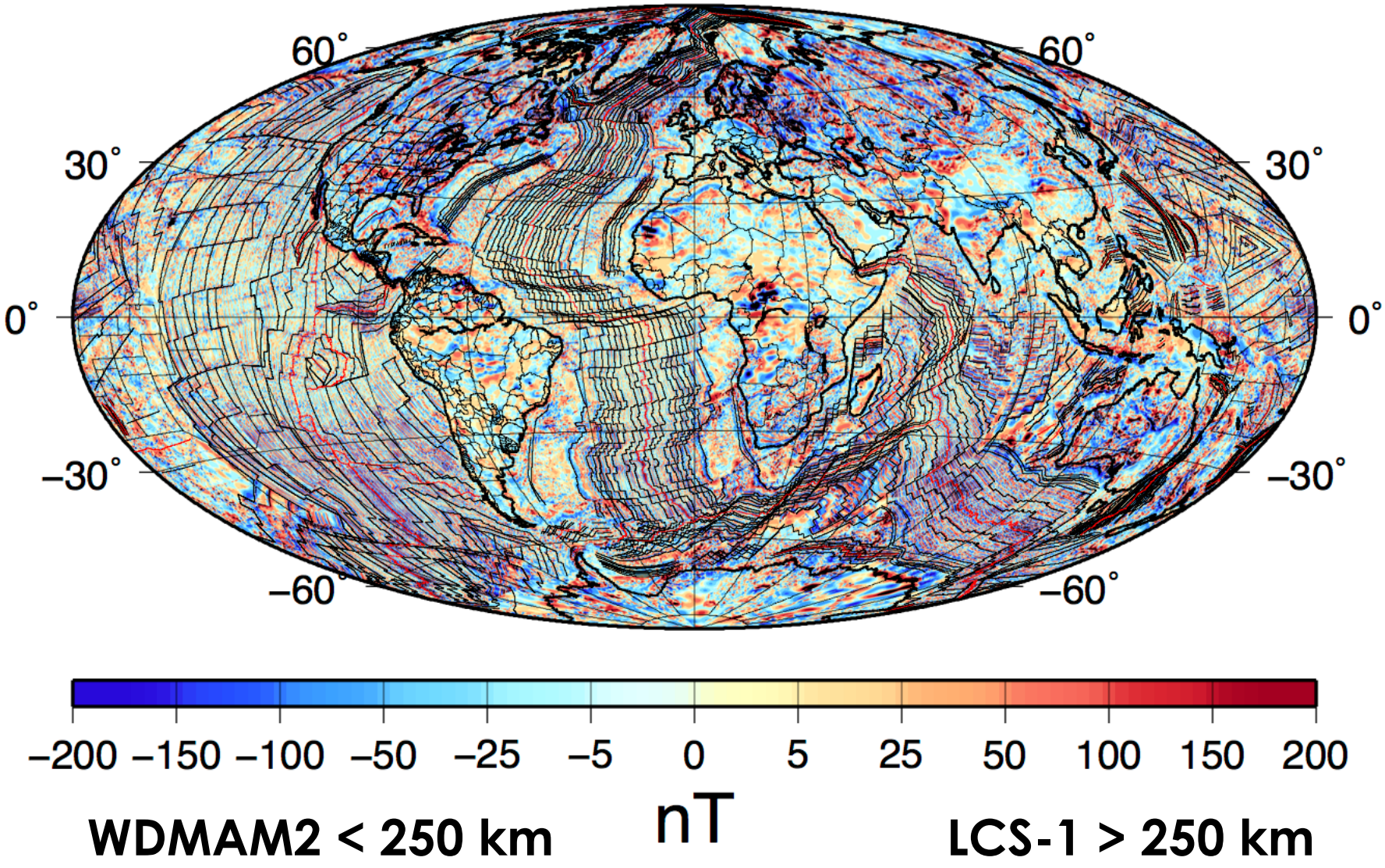


Bangui Anomaly – Central African Republic and surrounding areas





WDMAM2 with LCS-1

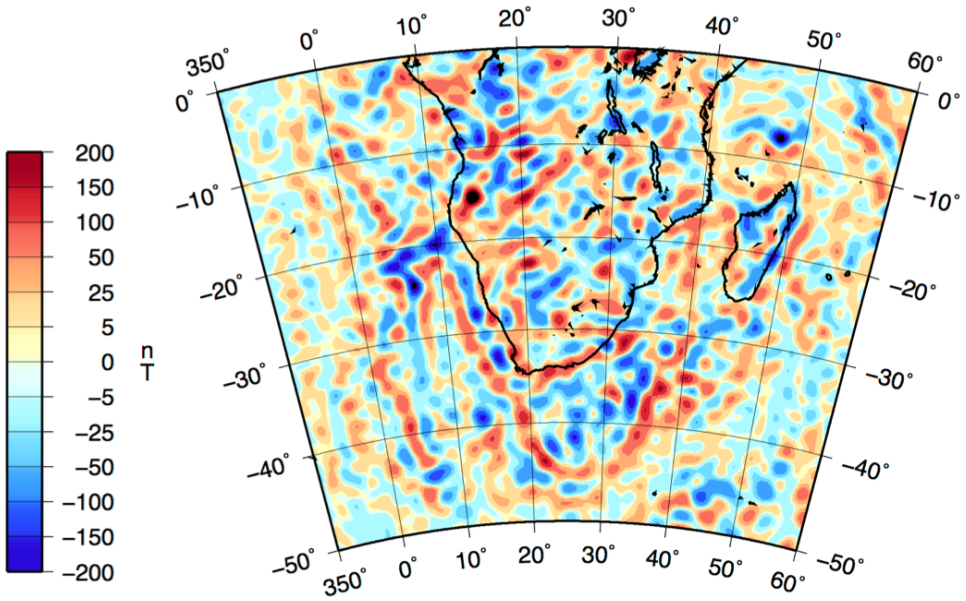


Conclusions

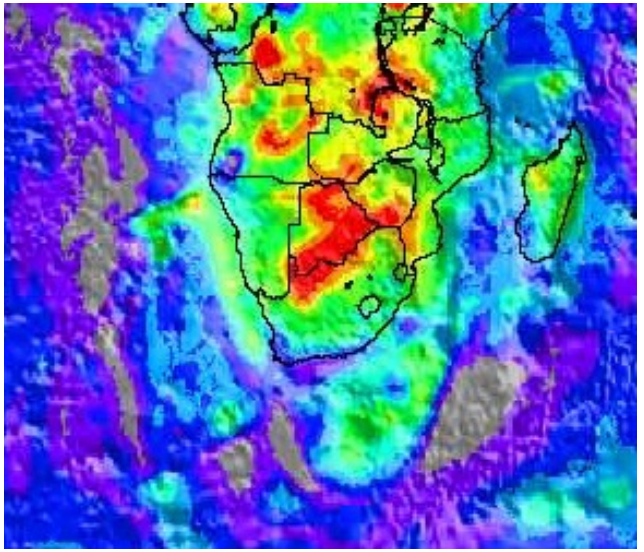
- Swarm gradient data contribute toward the improved lithospheric field model despite present high altitude
- Australian and North American spectral and visual comparisons show that shortest λ of 225 - 250 km is possible from satellites
- Improvement of λ 250-300 km over MF7 contributes towards details of geologic interpretation in North America
- 85E ridge in Bay of Bengal observable in the Z-component LCS-1 anomalies as opposed to MF7 or WDMAM2 (ΔF)
- Oceanic region between Australia and Antarctica and continent/ocean boundaries better resolved in LCS-1
- WDMAM and other regional compilation anomaly map projects could improve the long-wavelengths of > 250 km currently and suggests significant improvements expected in the future with more data and lower observation altitude

Southern Africa

Z component anomalies at the Earth's surface

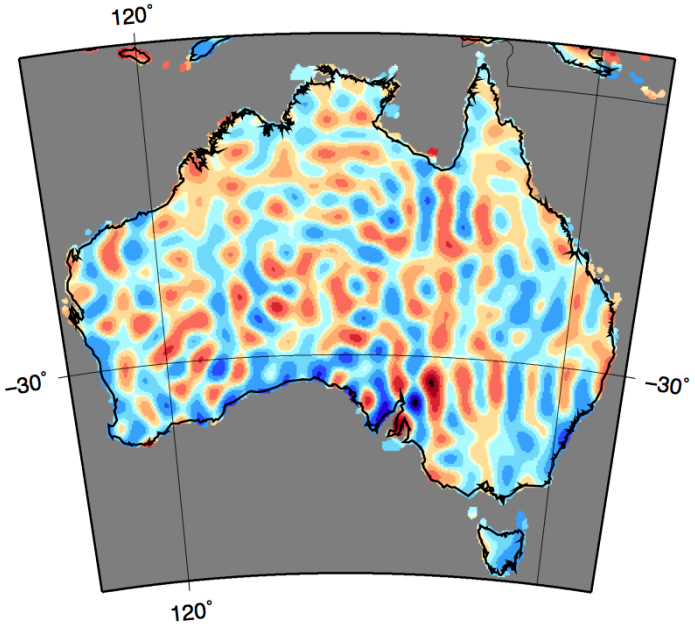


Depth-integrated magnetic susceptibility variation



Differences w.r.t. Aeromagnetic Data

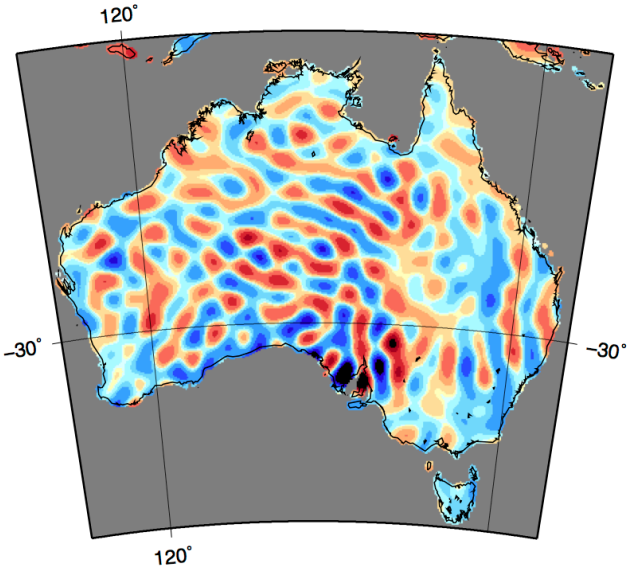
Aeromagnetic – LCS1

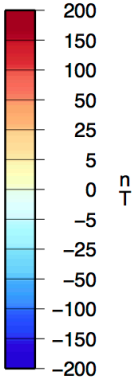


RMS ~ 42 nT

DR: I think the larger differences along the southcentral coast arise from the prominent electromagnetic induction effects in the Australian aeromagnetic data from the Olympic Dam metallic ore deposits

Aeromagnetic – MF7





RMS ~ 54.5 nT