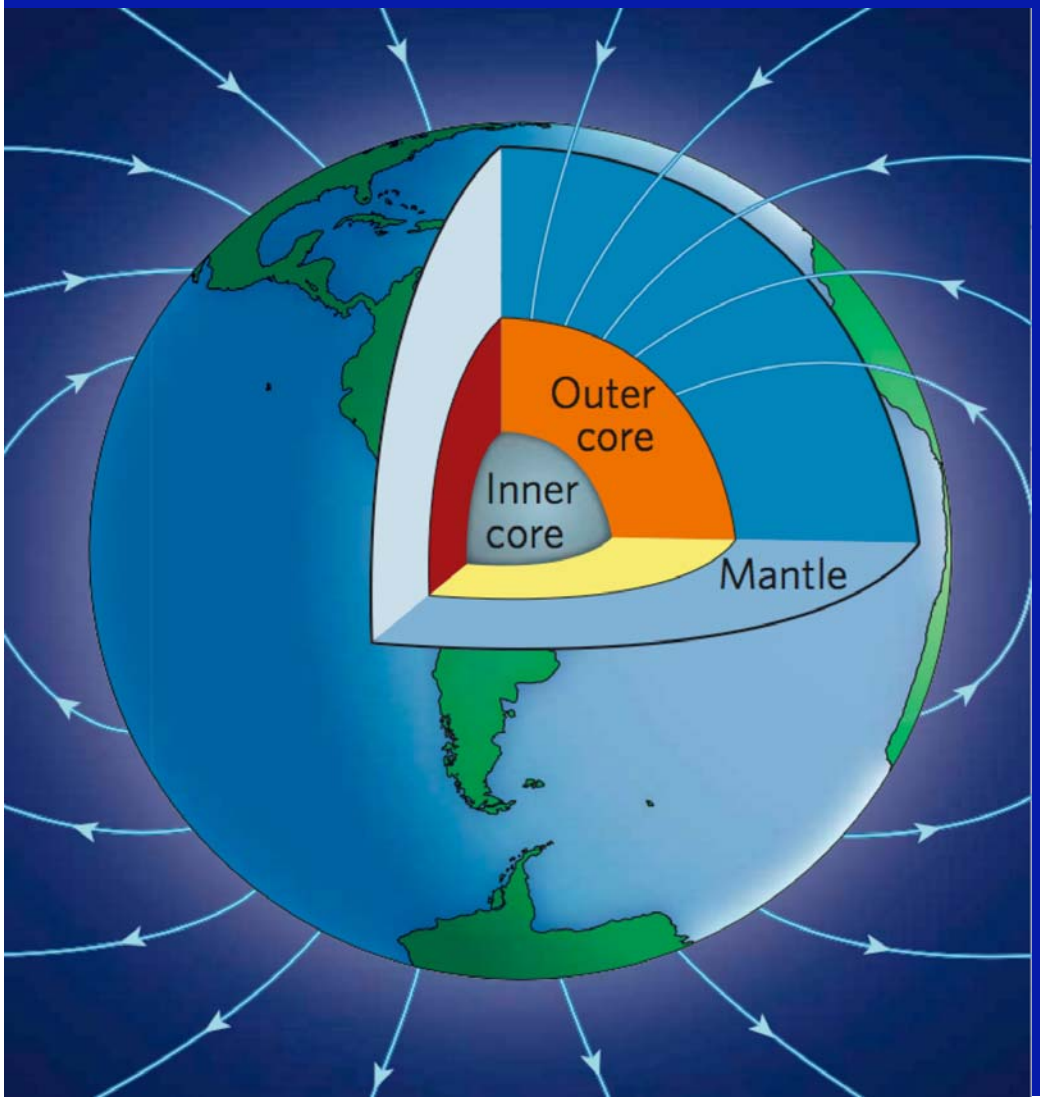
INFLUENCE OF INHOMOGENEOUS BOUNDARY CONDITIONS ON THE GEODYNAMO



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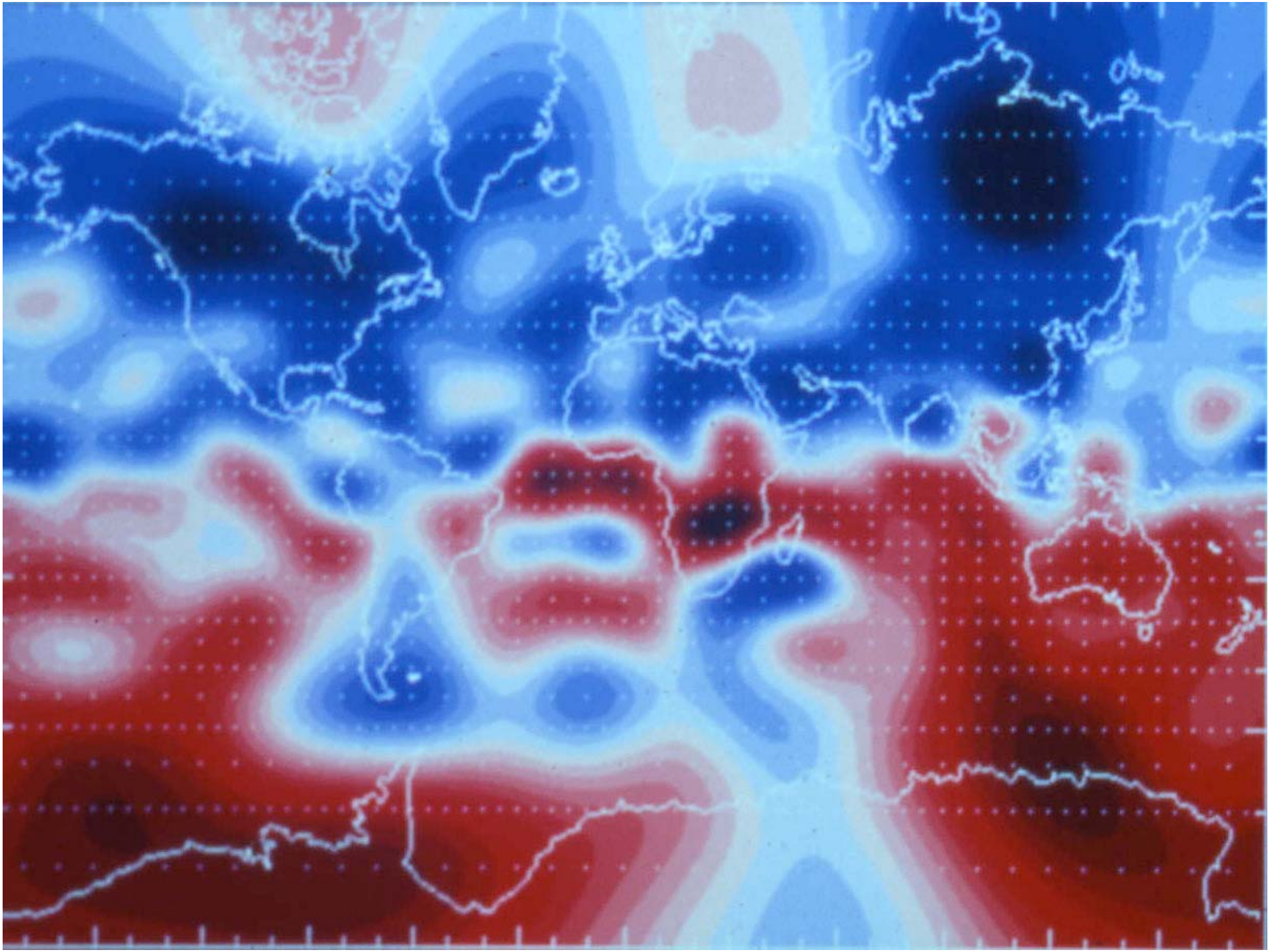
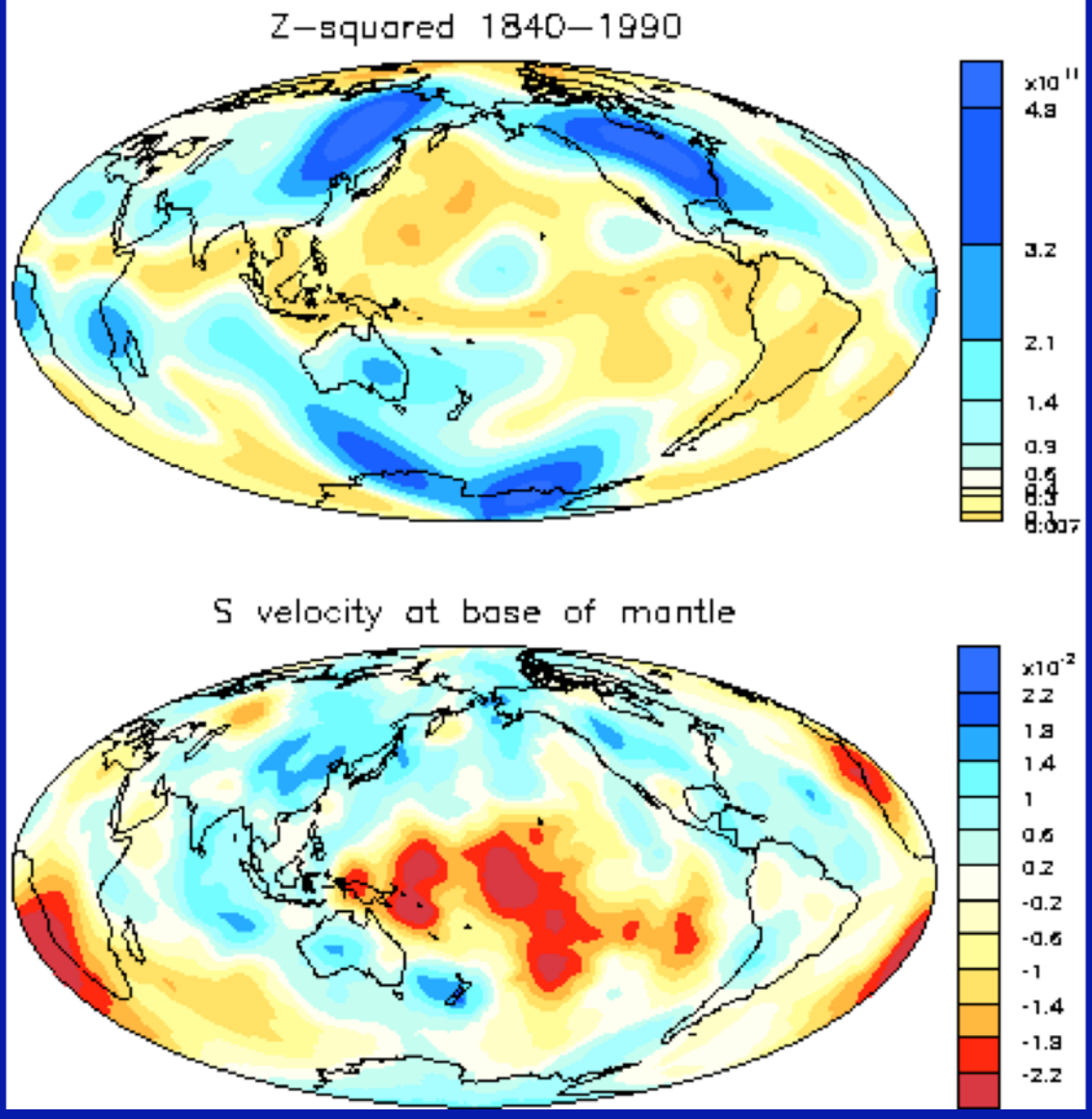
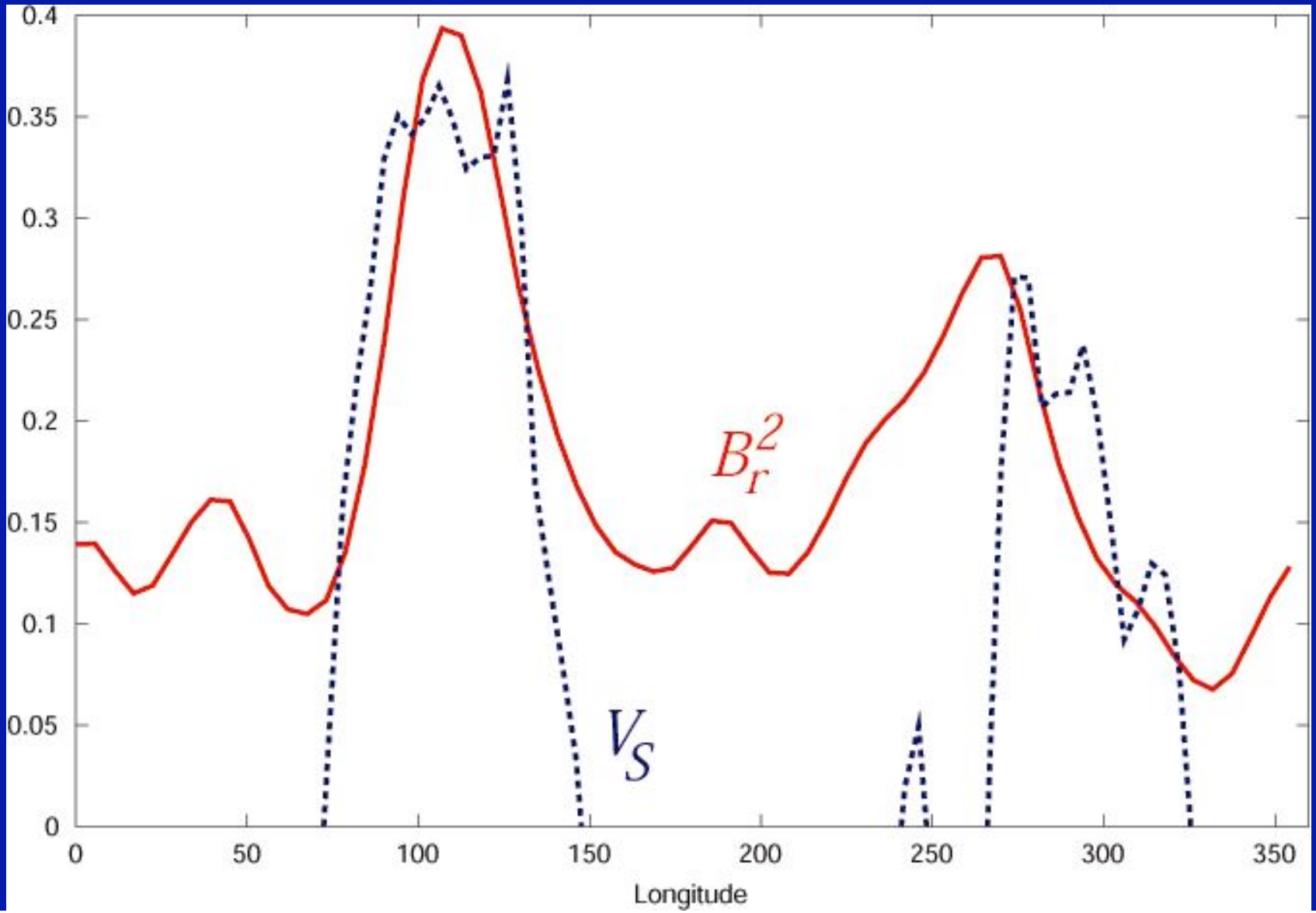


Comparison of Magnetic Field with Shear Velocity



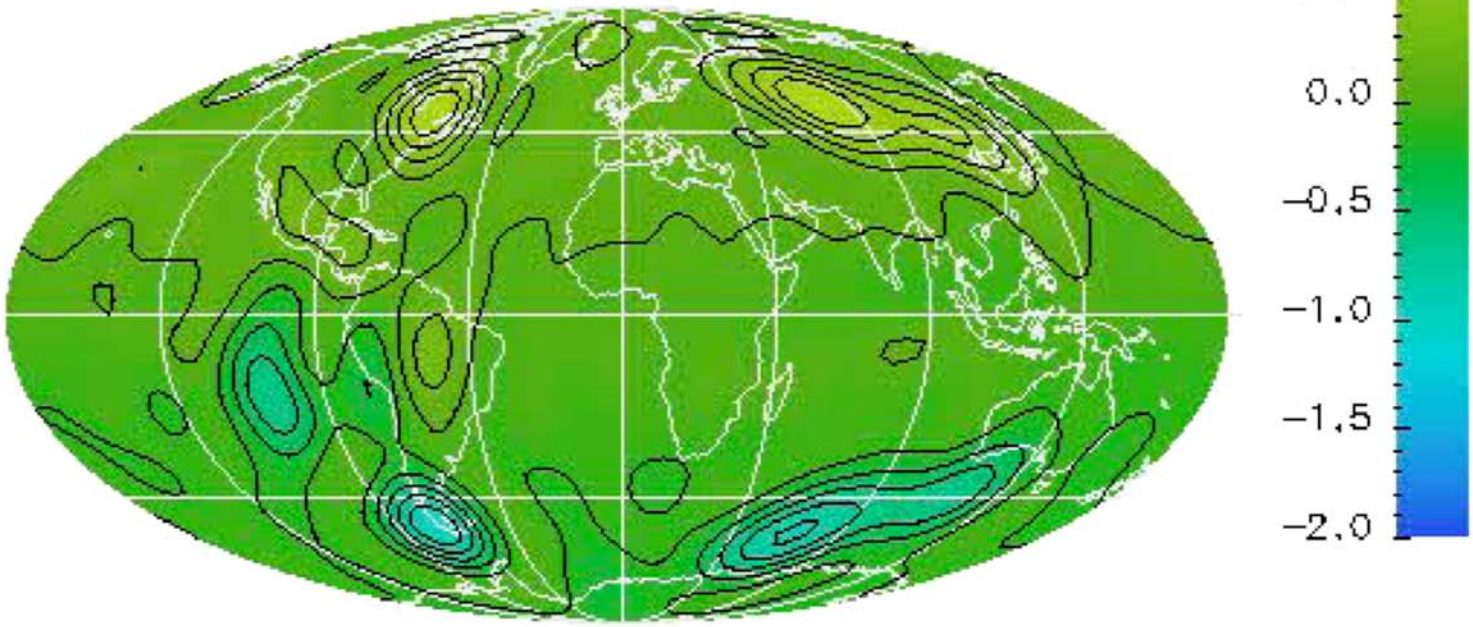
GEOMAGNETIC FIELD AND LOWER MANTLE V_S AS FUNCTIONS OF LONGITUDE



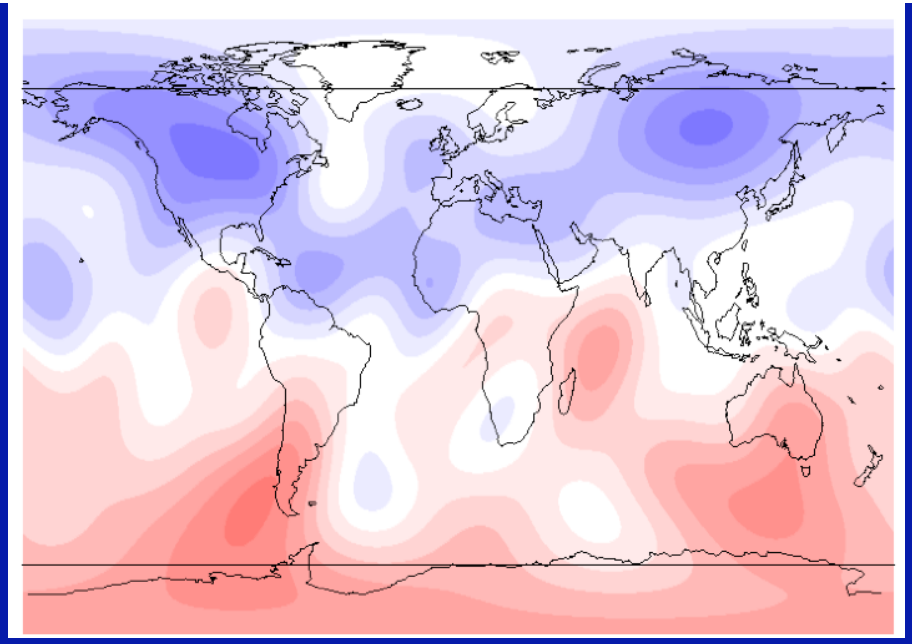
GEODYNAMO MODEL: PARAMETERS

- Ekman number (rotation/viscosity) $E = 1.2\ 10^{-4}$
  - Cannot be small enough
- Rayleigh number (vertical buoyancy) *Rv=1.4Rc:*
  - Close to critical or subcritical
- Prandtl number (viscosity/thermal) *Pr=1*
  - Should be large to remove inertia
- Roberts number (thermal/magnetic) *q=10*
  - Cannot be too small or dynamo will fail
- Horizontal buoyancy number *Rh*
  - Rh/Rv in range zero to 1 or more:
  - locks at 0.9, no dynamo >1.2

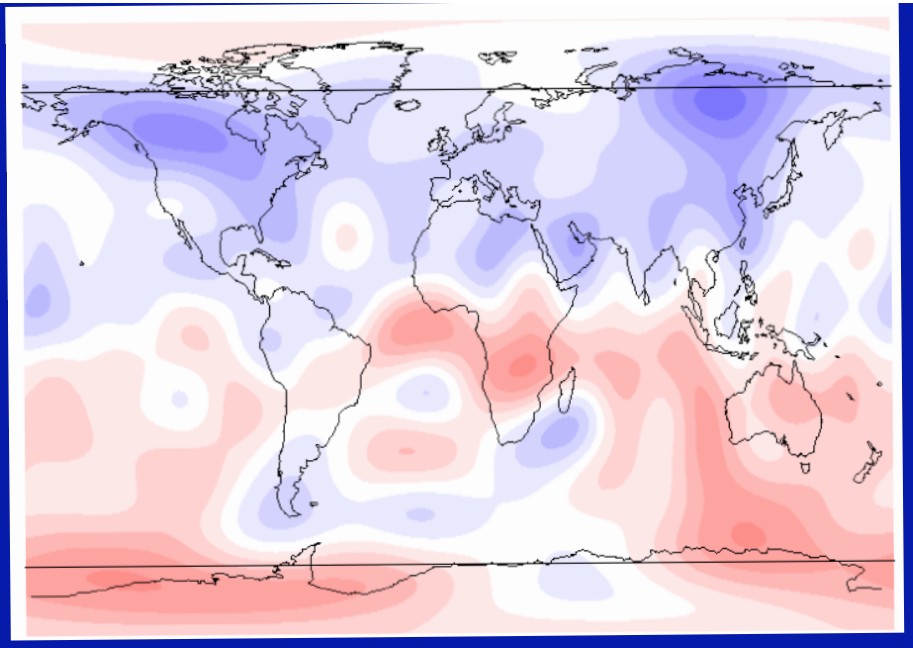
$E=2\ 10^{-4}$, $q=10$, $Ra=1.5Ra_c$



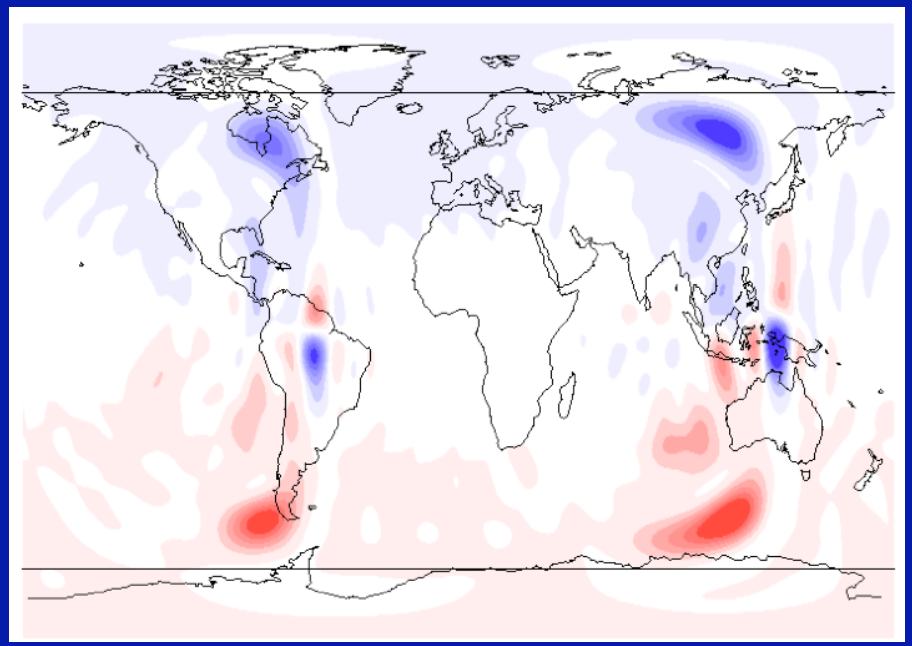
$Rh/Rv=0.9$



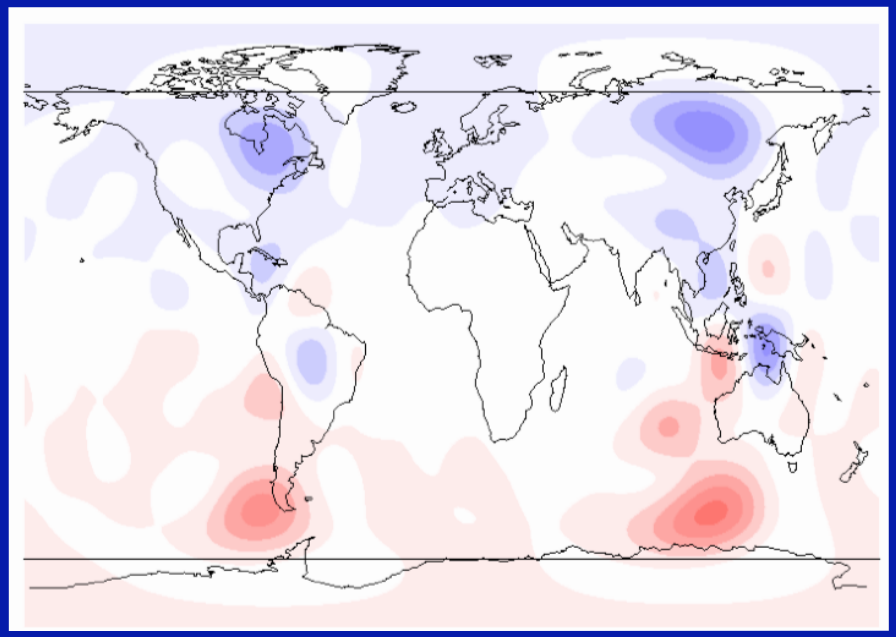
Earth 1750



Earth 1990



Model



Model truncated

LOCATION OF THE 4 LOBES

N CANADA

52N 110W

split in 2

55N 74W

EARTH

MODEL

SIBERIA

59N 108E

stable

55N 112E

W OF S. AMERICA

68S 109W

drifted west 25°

56S 74W

S OF AUSTRALIA

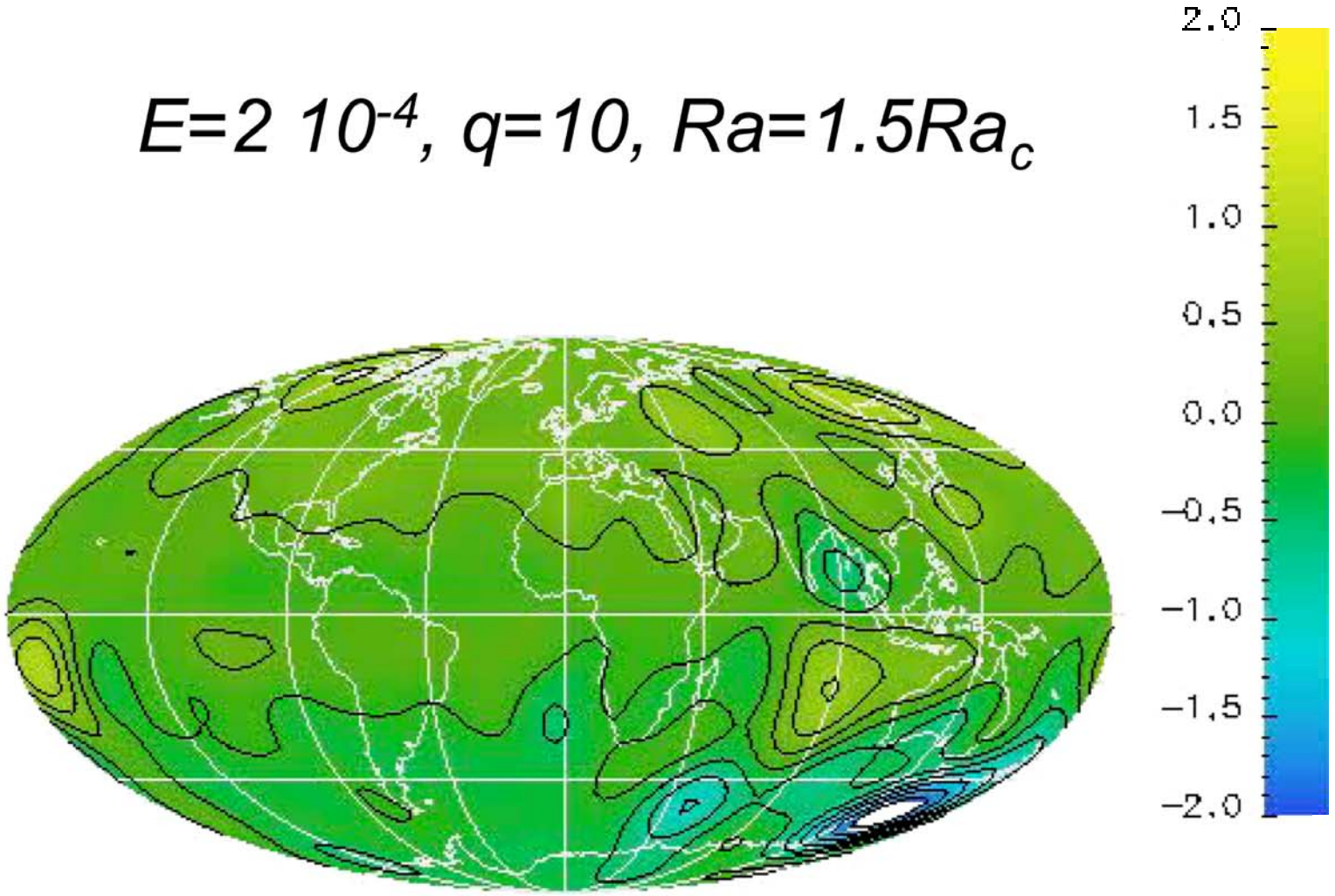
56S 117E

stable

56S 114E

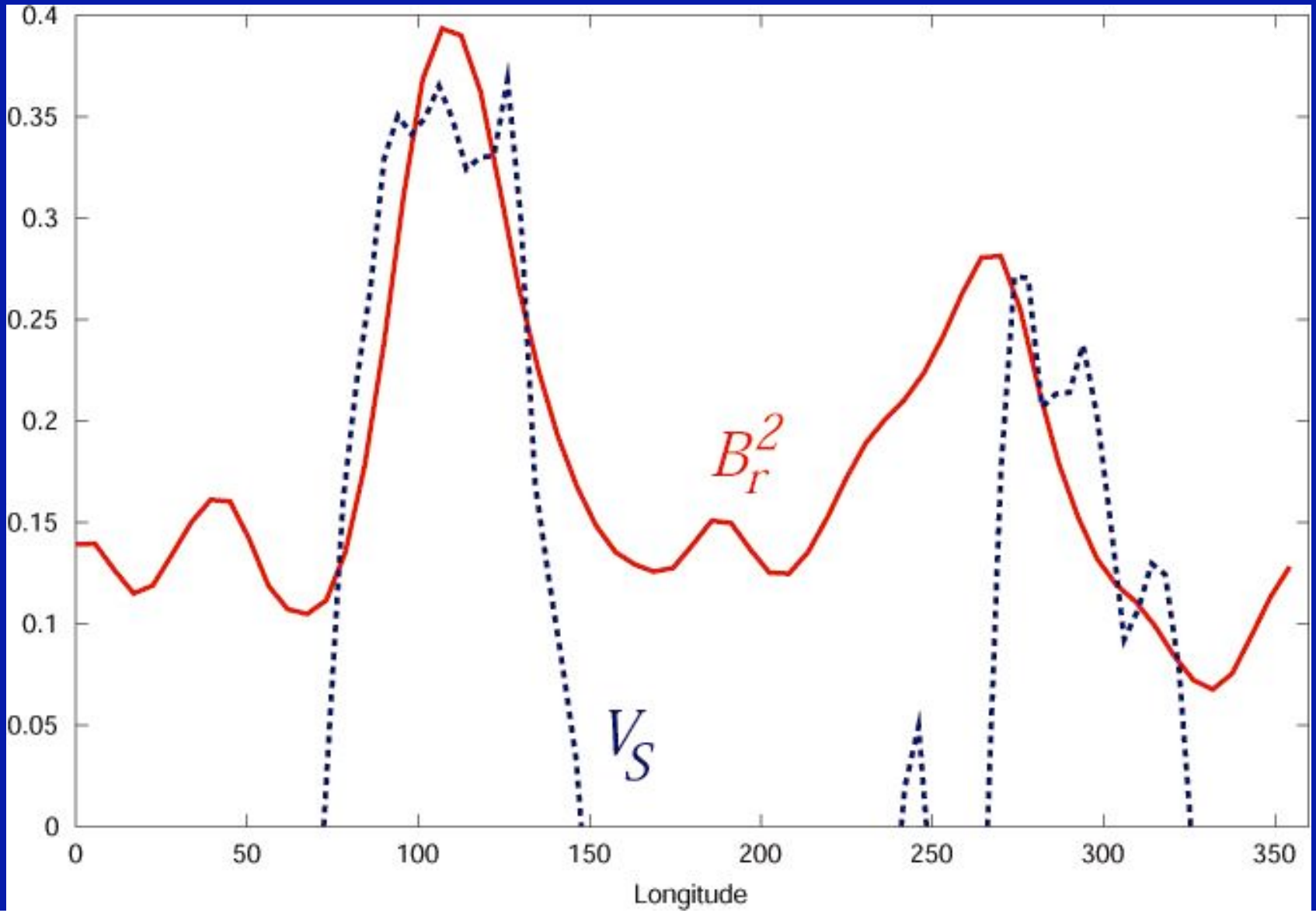
TANGENT CYLINDER 71°

$E=2\ 10^{-4}$, $q=10$, $Ra=1.5Ra_c$



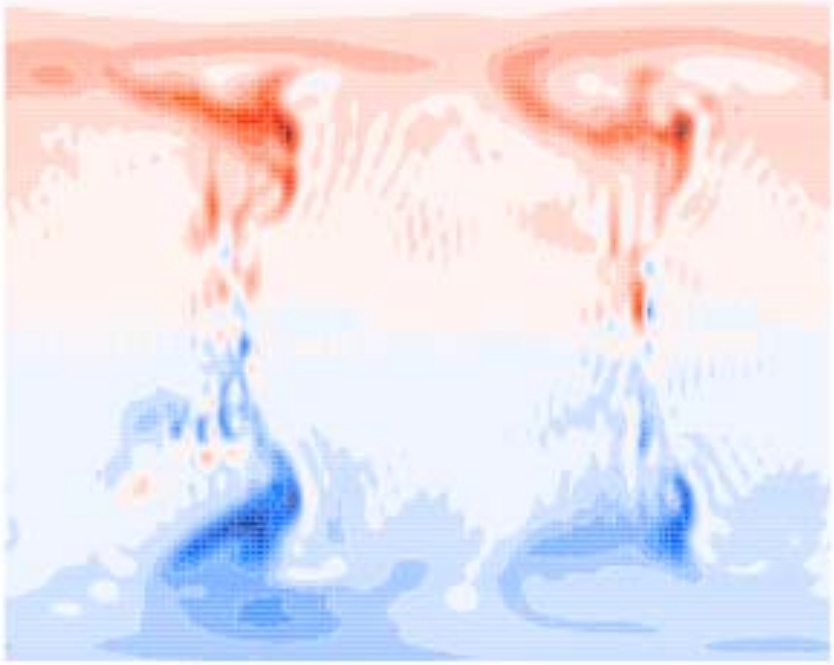
$Rh/Rv=0.6$

GEOMAGNETIC FIELD AND LOWER MANTLE V_S AS FUNCTIONS OF LONGITUDE

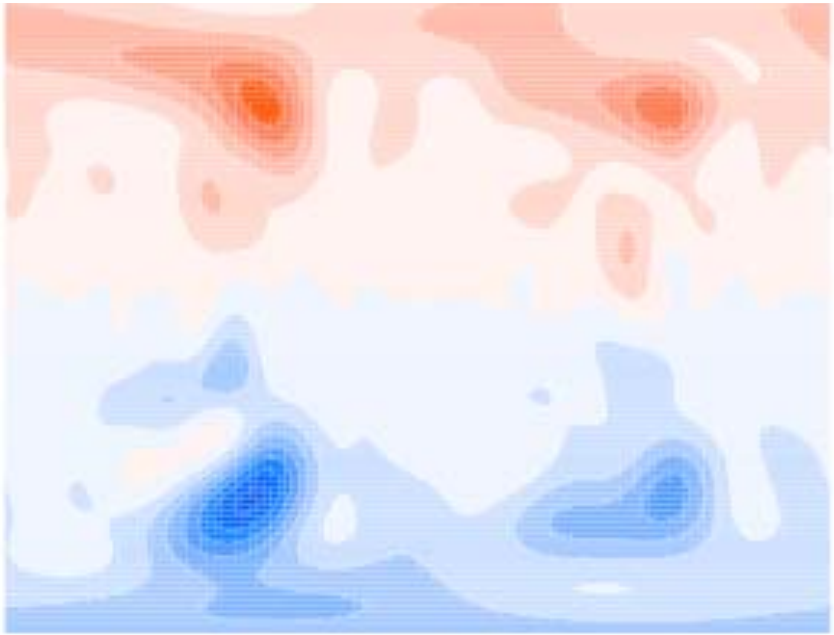


A LOCKED DYNAMO WITH *q=1*

- Rather than reducing electrical diffusivity, increase thermal diffusivity…
- Or reduce the convection (Peclet number) at the top
- Chemical buoyancy has sinks at the top
- As does thermal buoyancy because of the curvature of the adiabat in the core
  - Locking is then possible with a higher Rayleigh number because advection remains weak near the boundary



Surface field for $Ra_b=750$, $Ra_i=78$

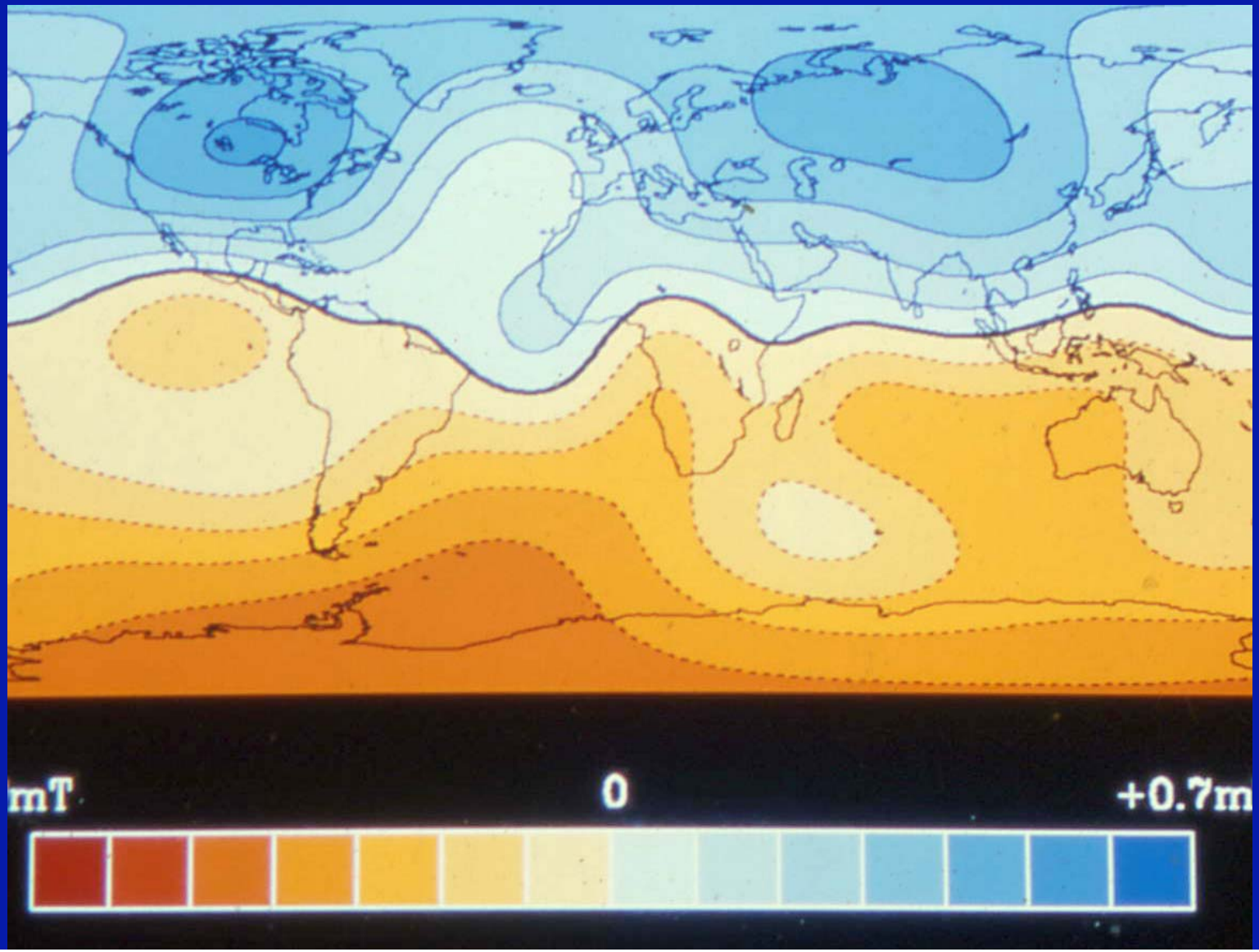


As above truncated to degree 14

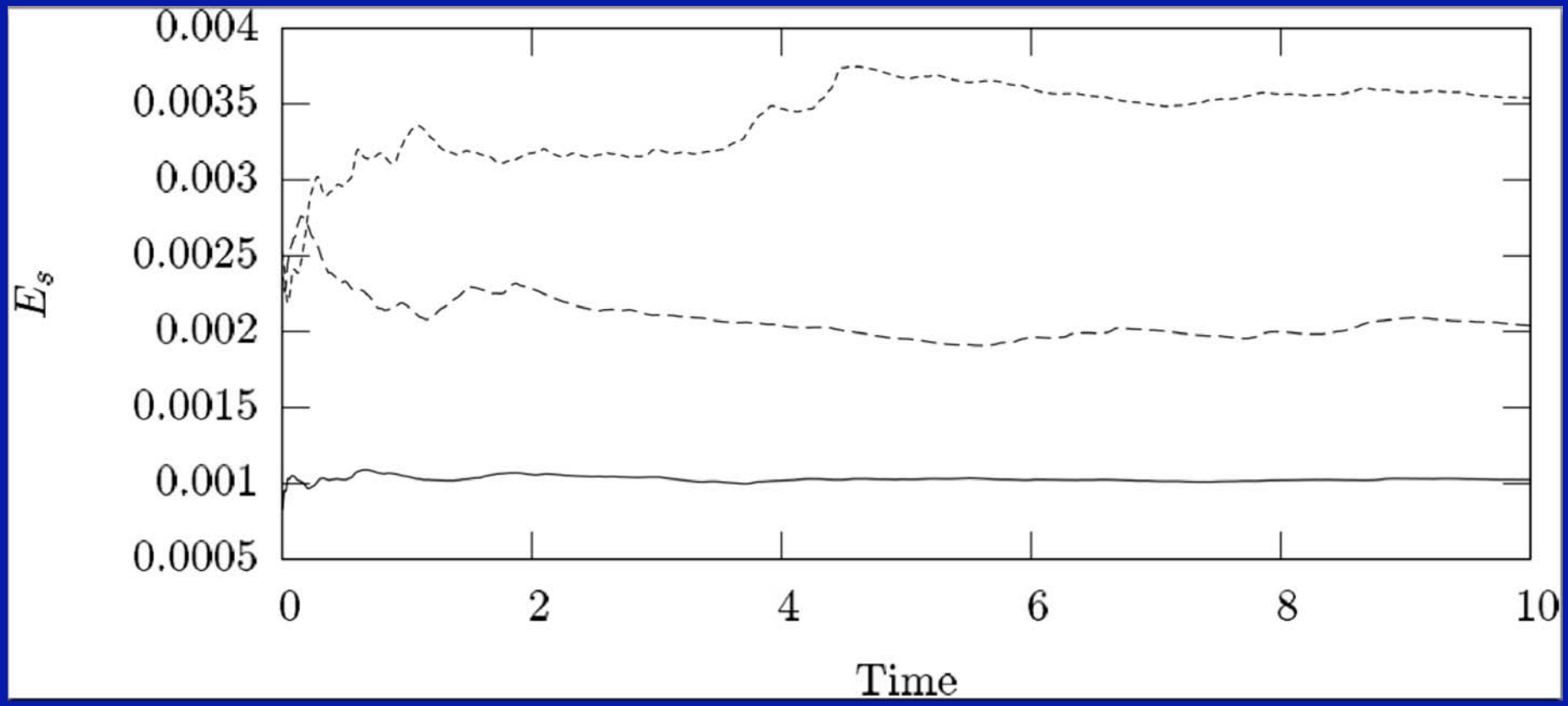
COMPARISON WITH PALEOMAGNETISM, 5 Myr

- Global models show some evidence of flux concentrations
- Can now compare dynamo predictions with data directly

THE TIME-AVERAGED PALEOMAGNETIC FIELD LAST 5Ma

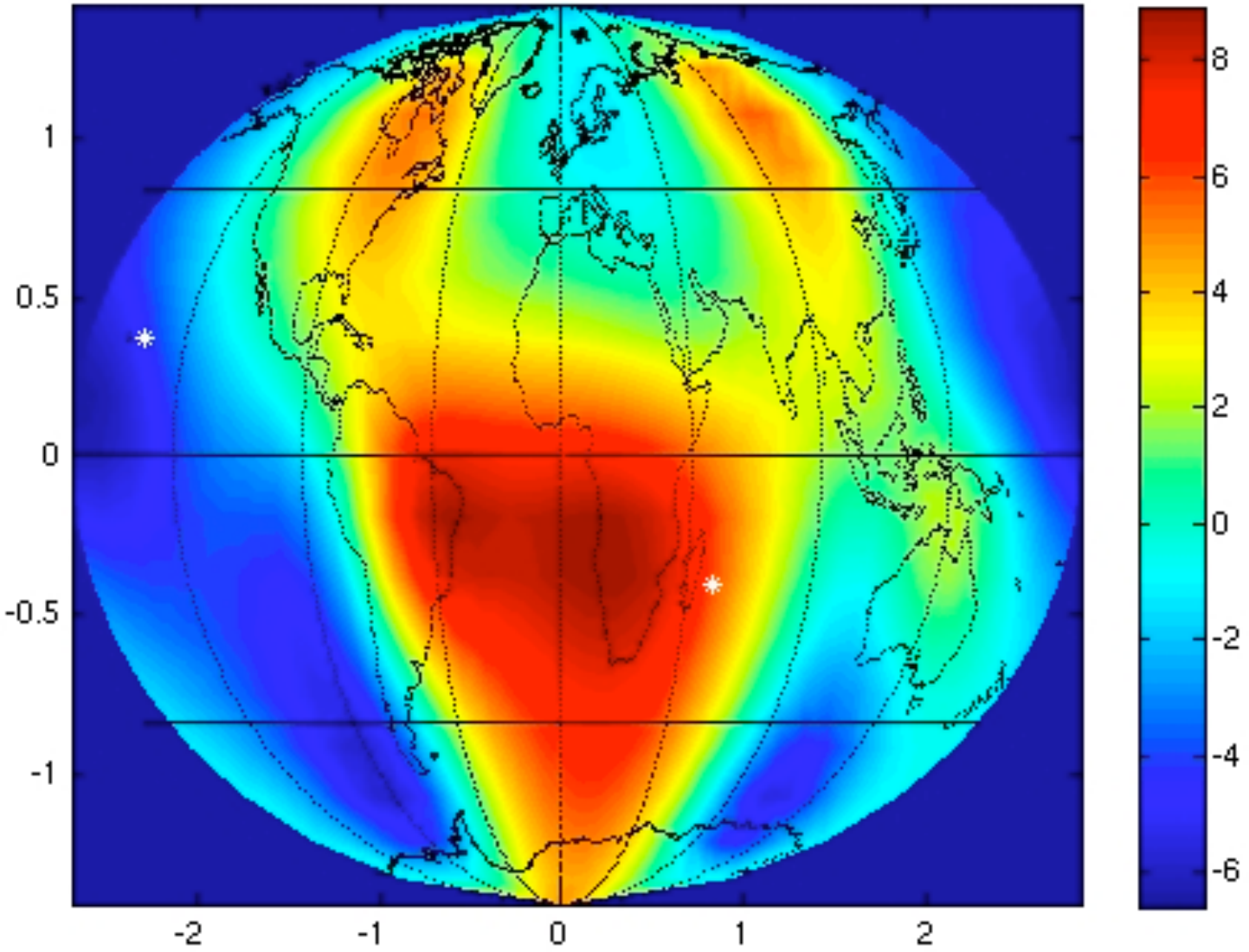


TIME FOR AVERAGING



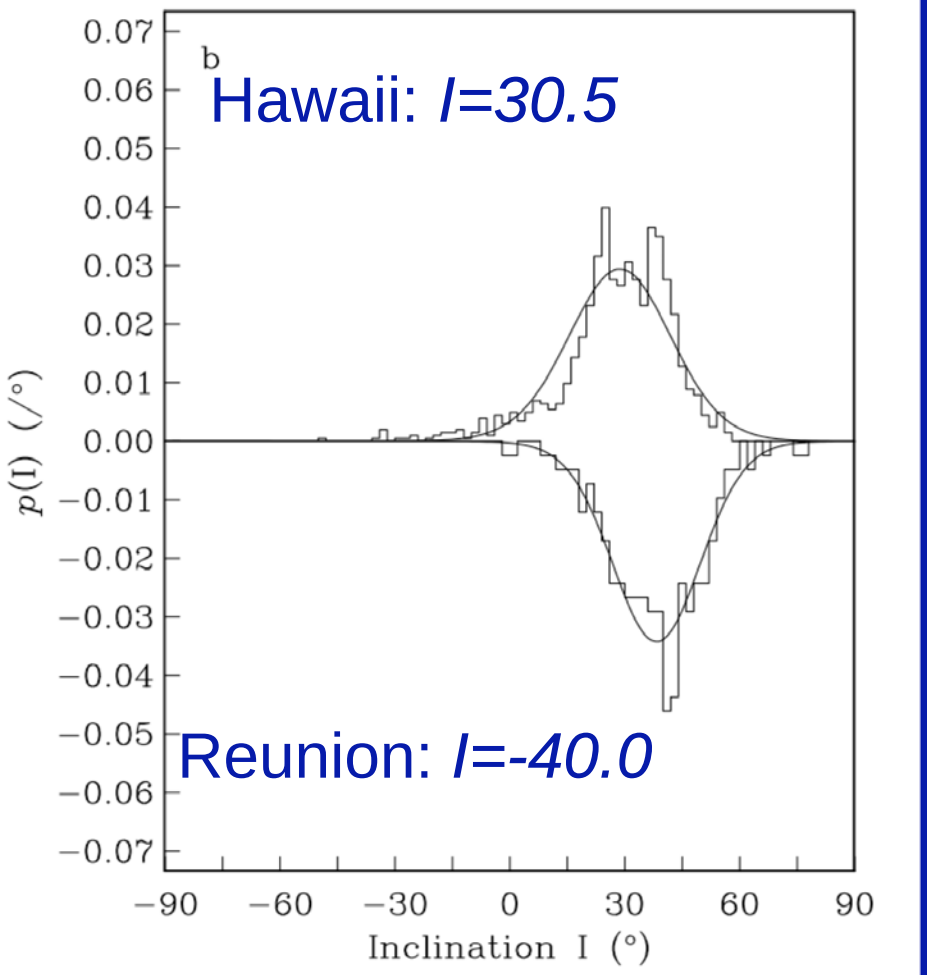
- 1 diffusion time = 200 kyr
- Field "hangs up" increasing averaging time required

INCLINATION ANOMALY

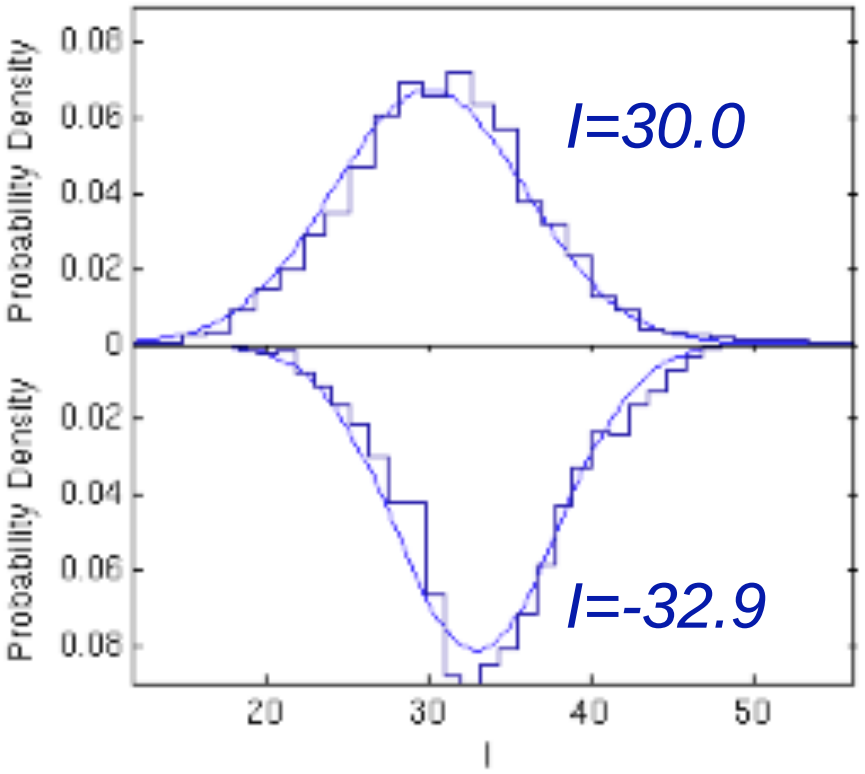


COMPARE HAWAII & REUNION

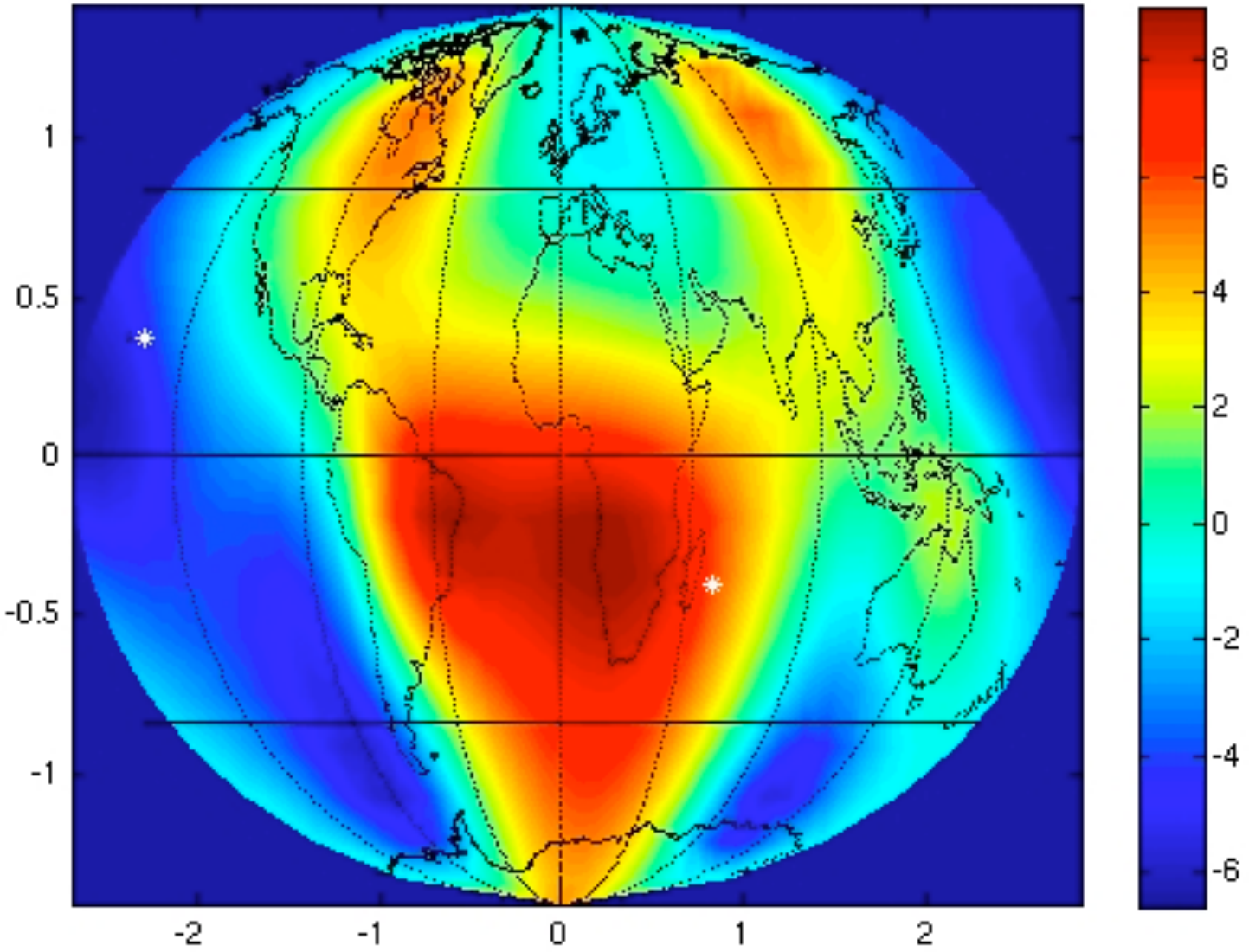
Love & Constable (2003)



Locked dynamo (this study)

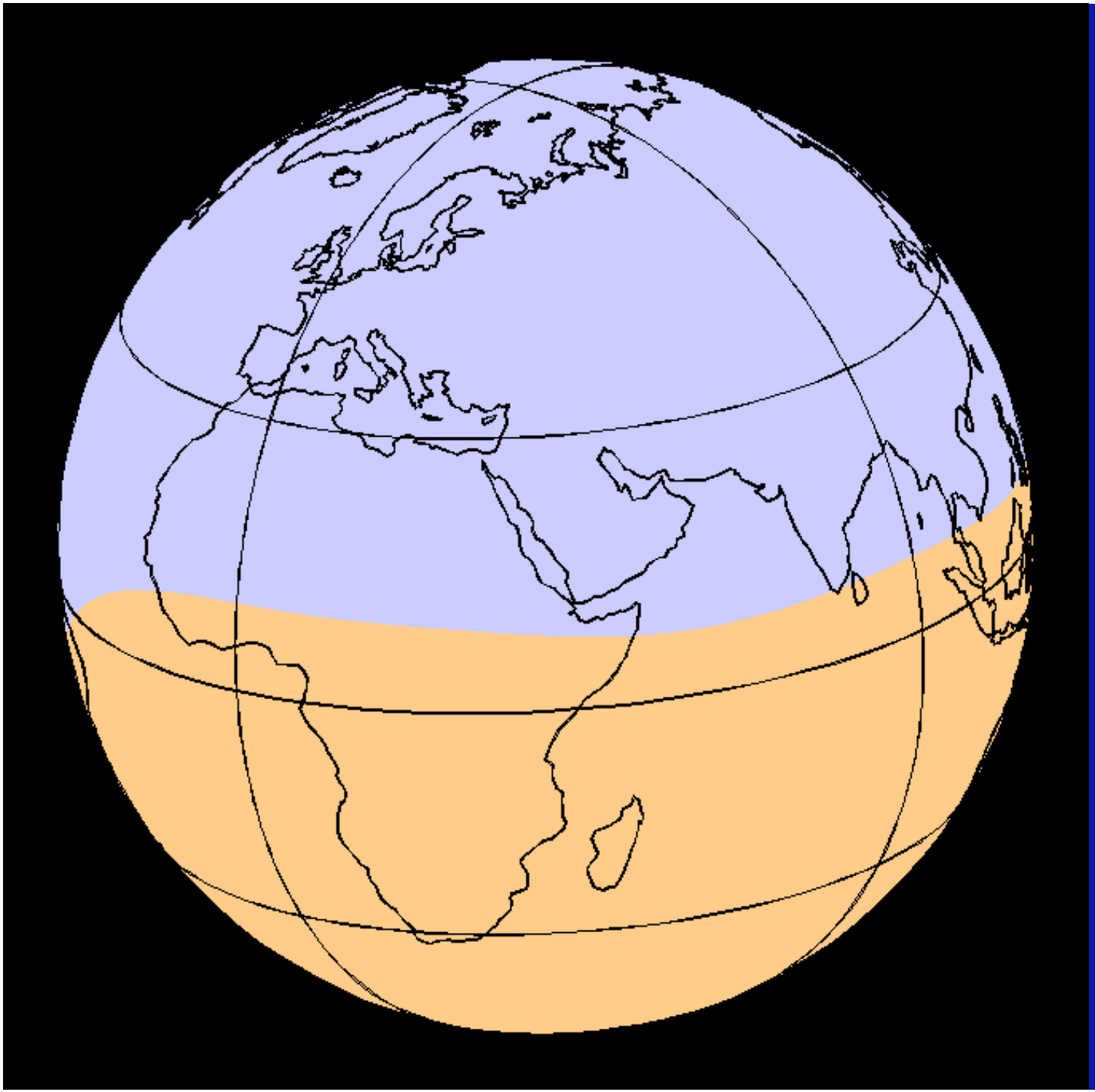


INCLINATION ANOMALY



CONCLUSIONS

- Thermal boundary effects are strong when upper core advection is weak
- The present geomagnetic field is correlated with Vs
- The bigger Siberian anomaly has a bigger effect on the magnetic field than the Canadian anomaly
- Departures from the dipole are dominated by variations in longitude not latitude
- The averaging time is not an indicator of how well the dynamo is locked

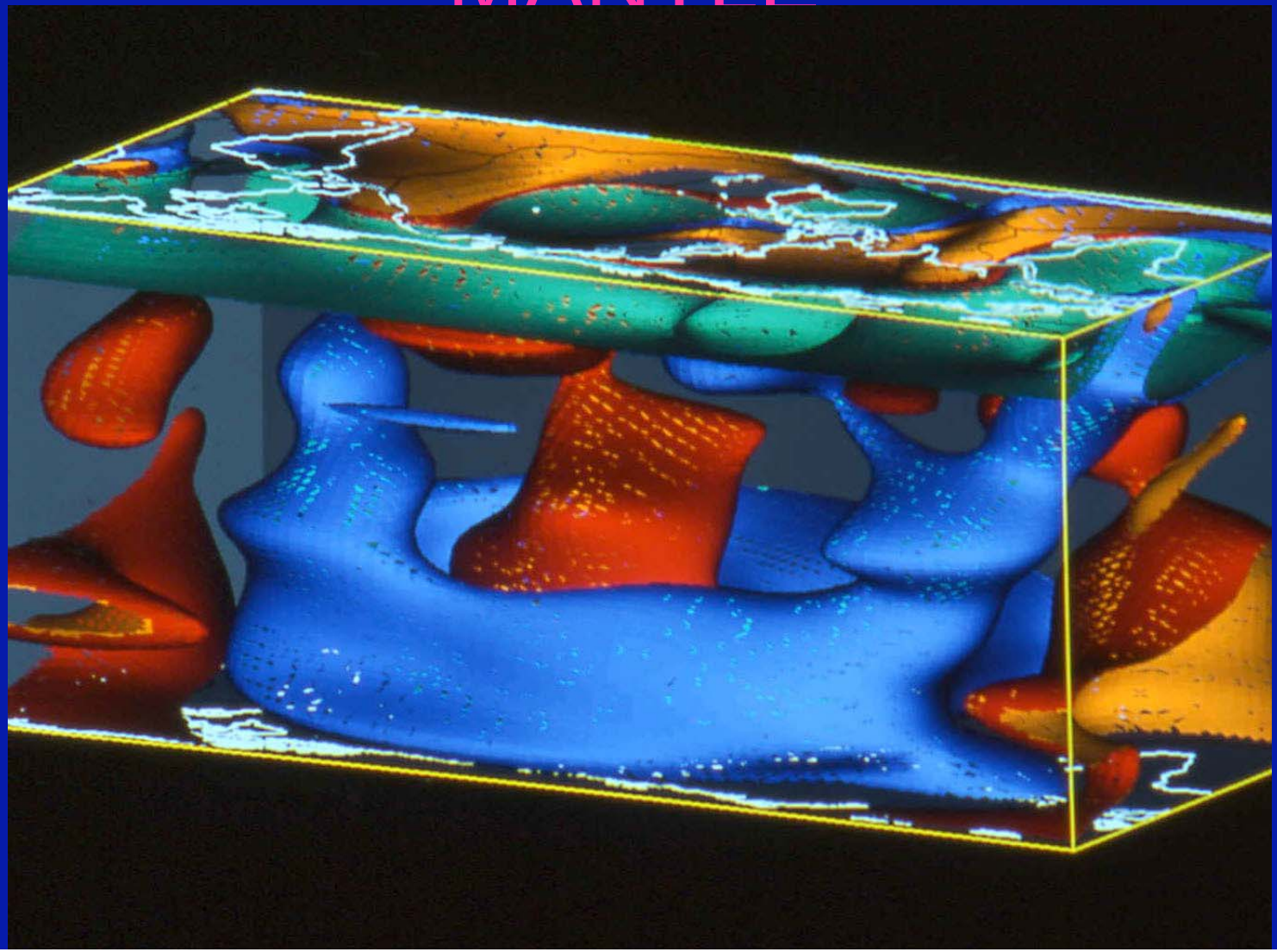


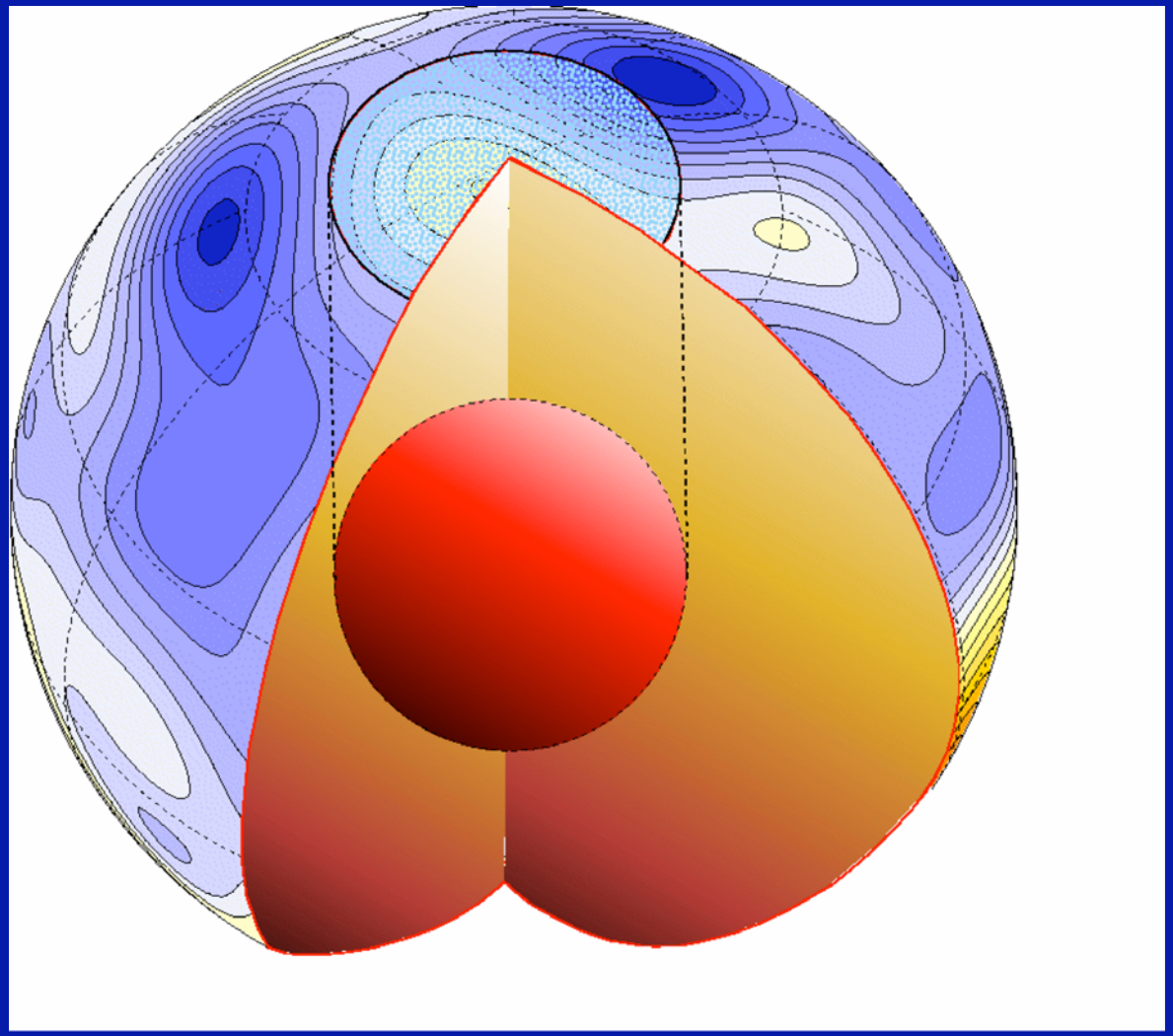
Radial component 1980

Downward continued

To core surface

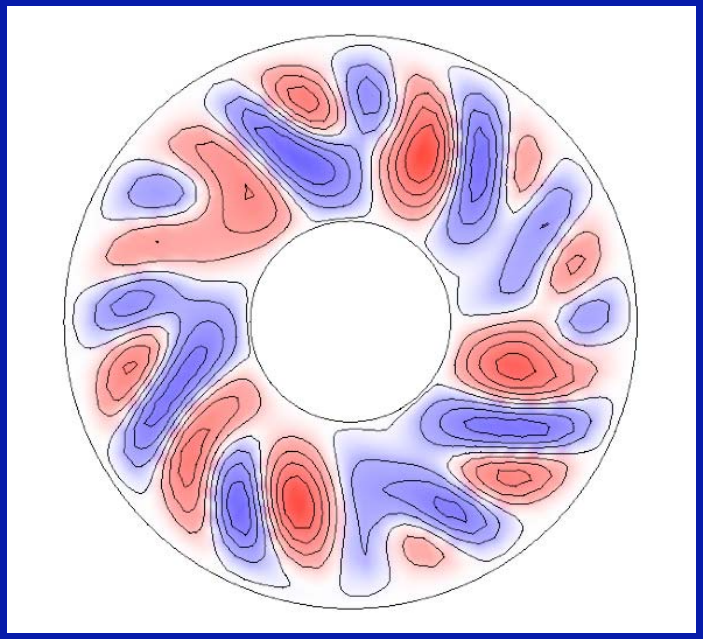
TEMPERATURE IN THE SOLID MANTLE





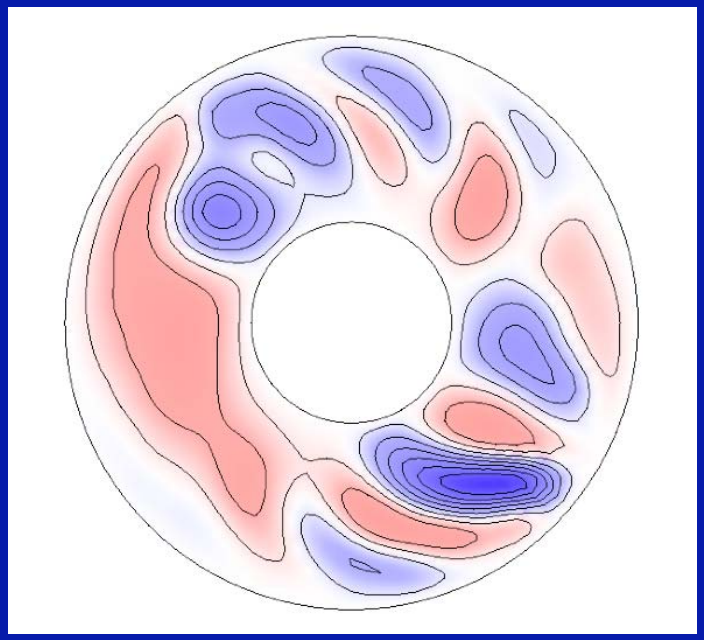
The Tangent Cylinder

RESONANCE NEEDS COMPARABLE SCALES: MAGNETIC FIELD PROVIDES THIS

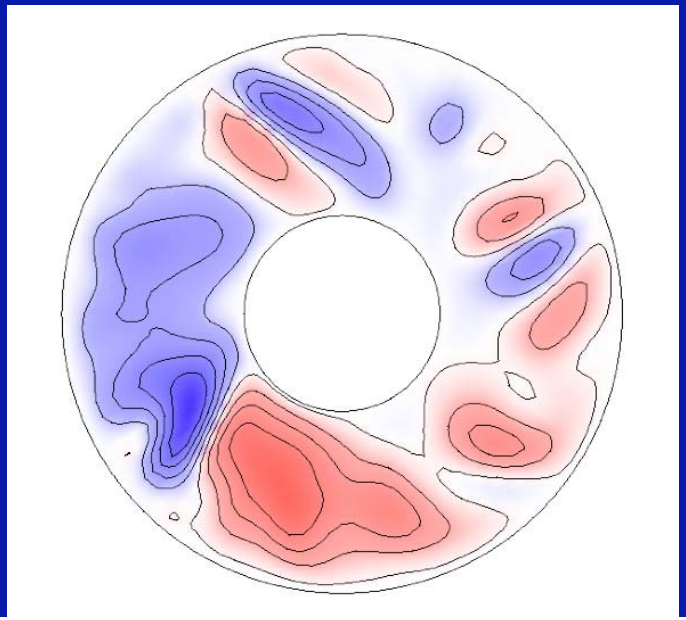


HOMOGENEOUS

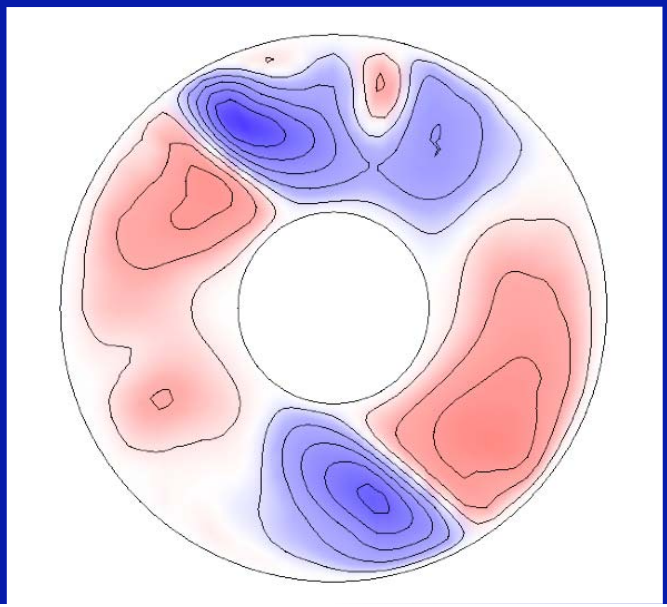
NON-MAGNETIC



INHOMOGENEOUS



DYNAMO



DYNAMO RESULTS

- Find a *simple* dynamo…
- with a field locked to boundary heat flux anomalies
- Compare it with the slowly varying component of the Earth's main field