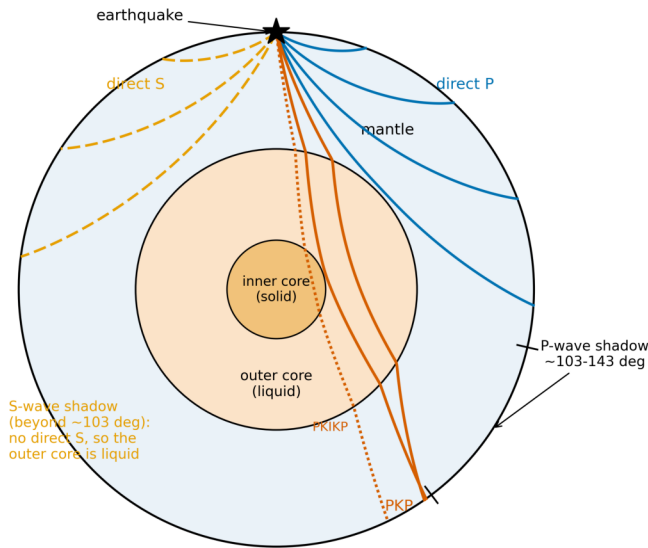


Group 1 - The Whole Planet

planetary interior | ~10,000 km

Group 1 - The Whole Planet:
the seismic shadow that proves Earth's outer core is liquid



Rays bend by Snell's law ($p = r \sin i / v$ constant). The velocity drop at the core-mantle boundary refracts P into the core (PKP) and opens the shadow zone; S has no path through the liquid outer core, so it simply disappears beyond ~103 deg.

- P (turns in mantle) - - - PKIKP (through inner core)
- PKP (through outer core) - - - S (cannot cross liquid core)

Question

How do we know Earth's outer core is liquid iron - and how would you find the core of Mars with a single seismometer?

Methods on the table

S-wave shadow and teleseismic body waves; normal modes and PKIKP; mean density and moment of inertia; the geodynamo.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

5. One number (an order-of-magnitude estimate)

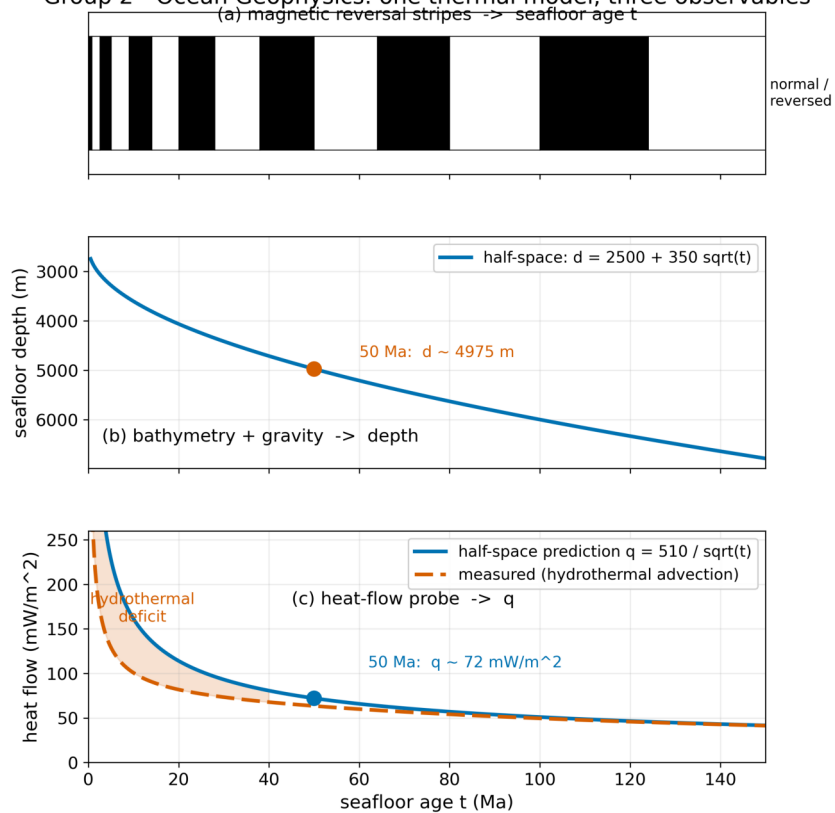
6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.

Group 2 - Ocean Geophysics: The Spreading Seafloor

ridge to abyssal plain | ~1,000 km

Group 2 - Ocean Geophysics: one thermal model, three observables



Question

For one patch of seafloor - how old is it, how deep should it be, and how much heat should it give off?

Methods on the table

Magnetic reversal stripes (age); bathymetry and gravity (depth); heat-flow probe with the half-space cooling model.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

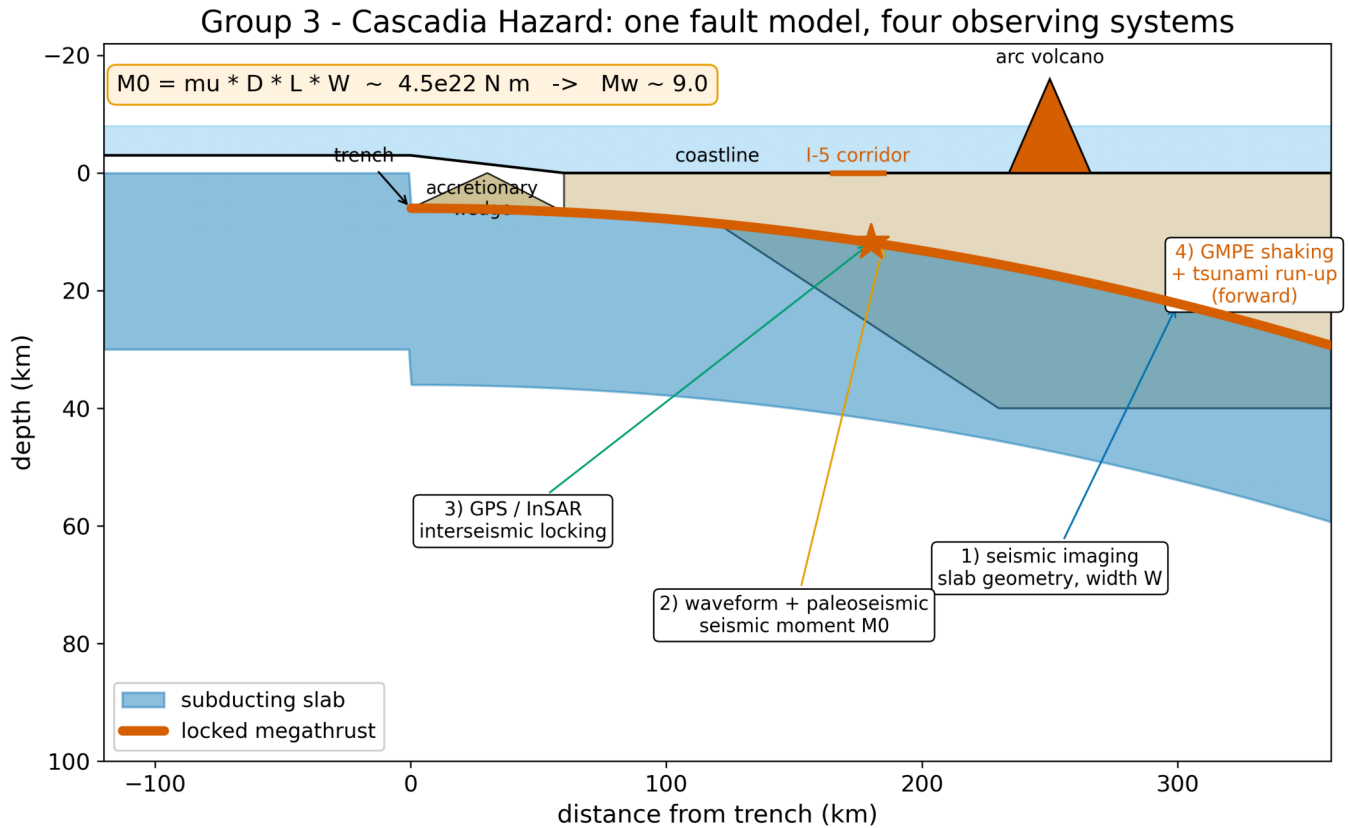
5. One number (an order-of-magnitude estimate)

6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.

Group 3 - Cascadia Earthquake & Tsunami Hazard

subduction margin | regional



Question

What will the next Cascadia megathrust do to Seattle and the coast?

Methods on the table

Seismic imaging of slab geometry and width W; waveform and paleoseismic moment M_0 ; geodetic (GPS/InSAR) locking; ground-motion and tsunami forward models.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

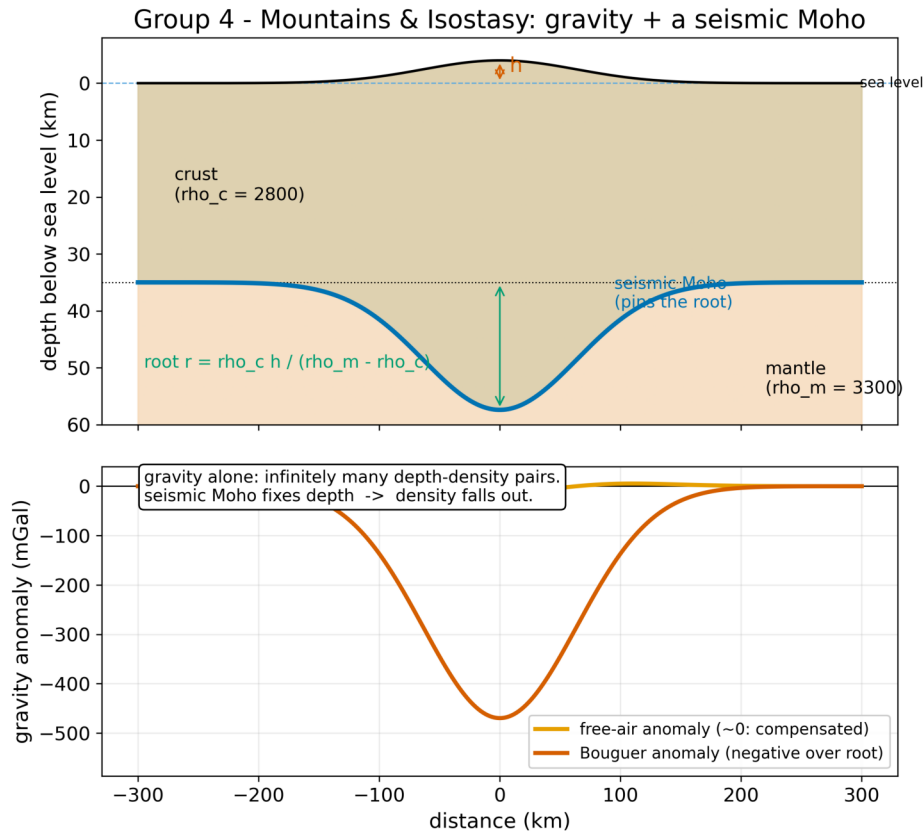
5. One number (an order-of-magnitude estimate)

6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.

Group 4 - Mountains, Basins & the Continents

lithosphere | 10-500 km



Question

Why is the Tibetan Plateau (or the Cascades) high - and what holds it up?

Methods on the table

Free-air versus Bouguer gravity; Airy and Pratt isostasy; crustal refraction for Moho depth; the Nafe-Drake bridge.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

5. One number (an order-of-magnitude estimate)

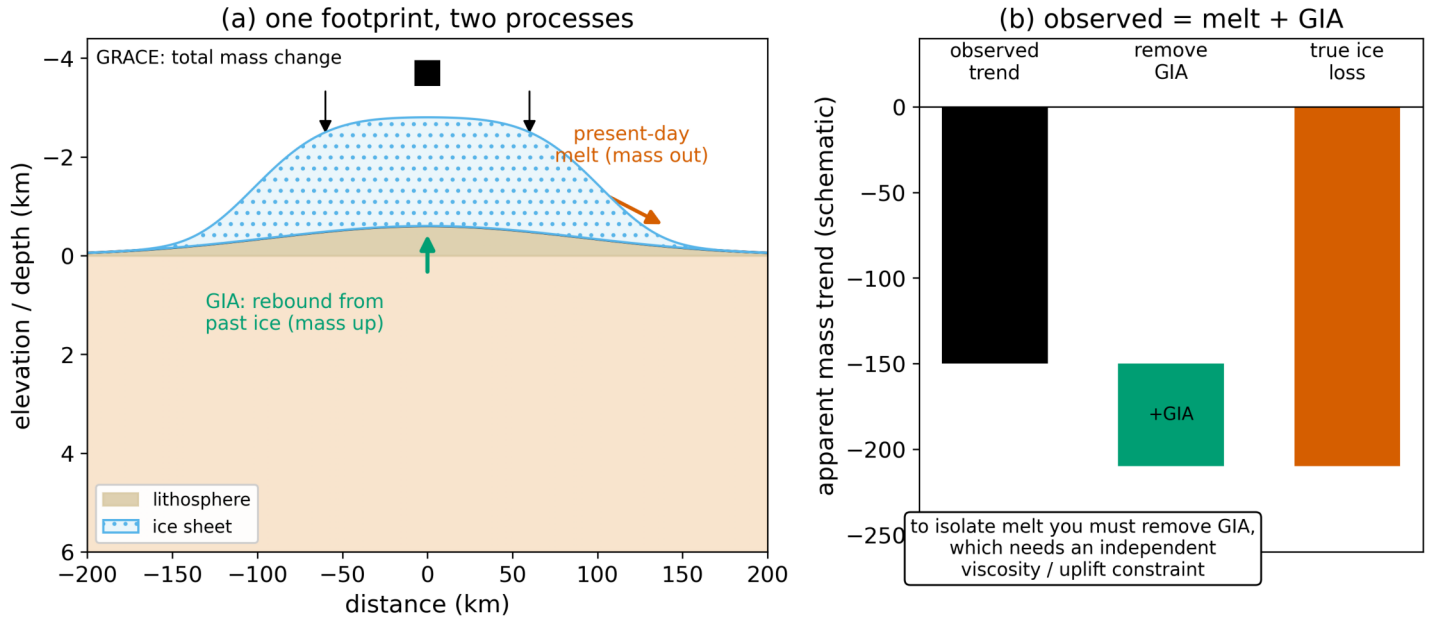
6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.

Group 5 - The Cryosphere & Climate-Solid Earth Coupling

ice sheet to mantle | regional-global

Group 5 - Cryosphere & Climate-Solid Earth Coupling



Question

How do we weigh an ice sheet and watch it melt - and why does the solid Earth bounce back?

Methods on the table

Time-lapse and satellite gravity (mass change); glacial isostatic adjustment (rebound, mantle viscosity); cryoseismology; distributed acoustic sensing on ice.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

5. One number (an order-of-magnitude estimate)

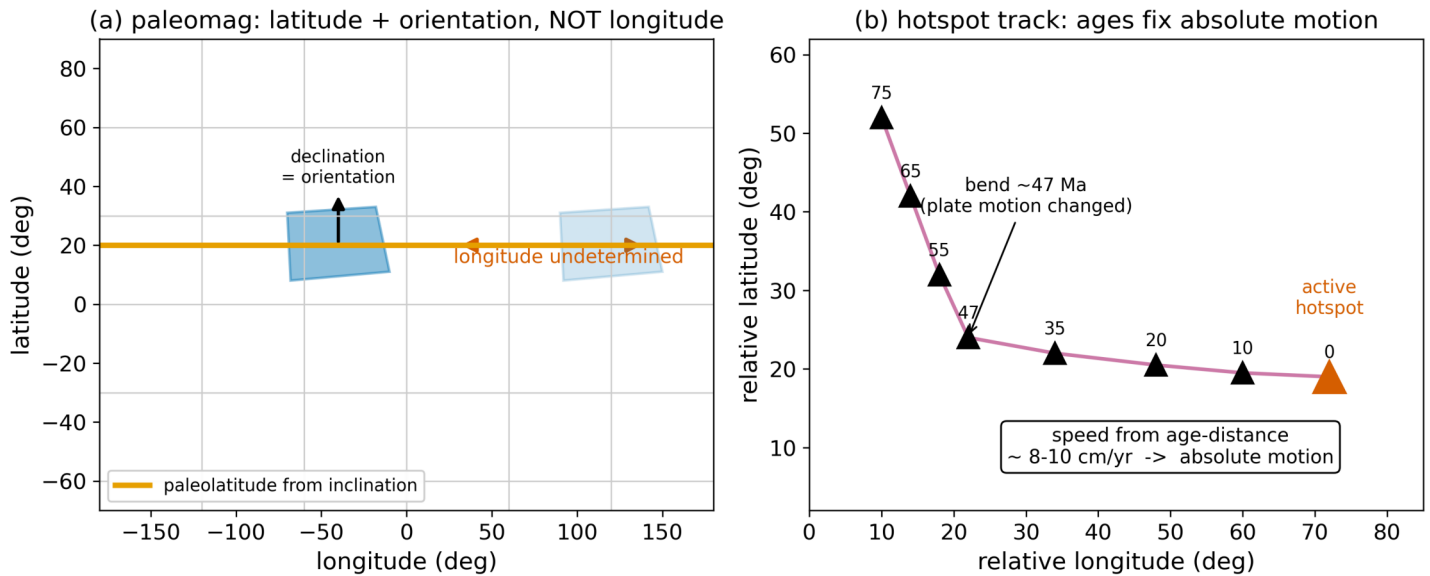
6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.

Group 6 - The Reconstructed Past: Plate Kinematics

whole planet | deep time

Group 6 - The Reconstructed Past: Plate Kinematics



Question

How do we rewind the plates 100 million years - and why isn't the hotspot frame fixed?

Methods on the table

Paleomagnetism (paleolatitude, apparent polar wander); seafloor magnetic isochrons; hotspot tracks; plate reconstructions.

Synthesis Card

1. Methods (2-4 course methods)

2. Observable -> property (what you measure; what it senses)

3. The null space (what one method alone cannot tell you)

4. The joint move (method A + B removes which ambiguity?)

5. One number (an order-of-magnitude estimate)

6. The one-method trap (the hidden single-method assumption)

The one rule: name at least two methods, and one ambiguity their combination resolves.