

# A low-velocity pipe-like structure at the base of the mantle beneath Hawaii

inferred from focussing of seismic waves

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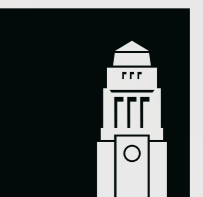


The Leverhulme Trust

**NERC**

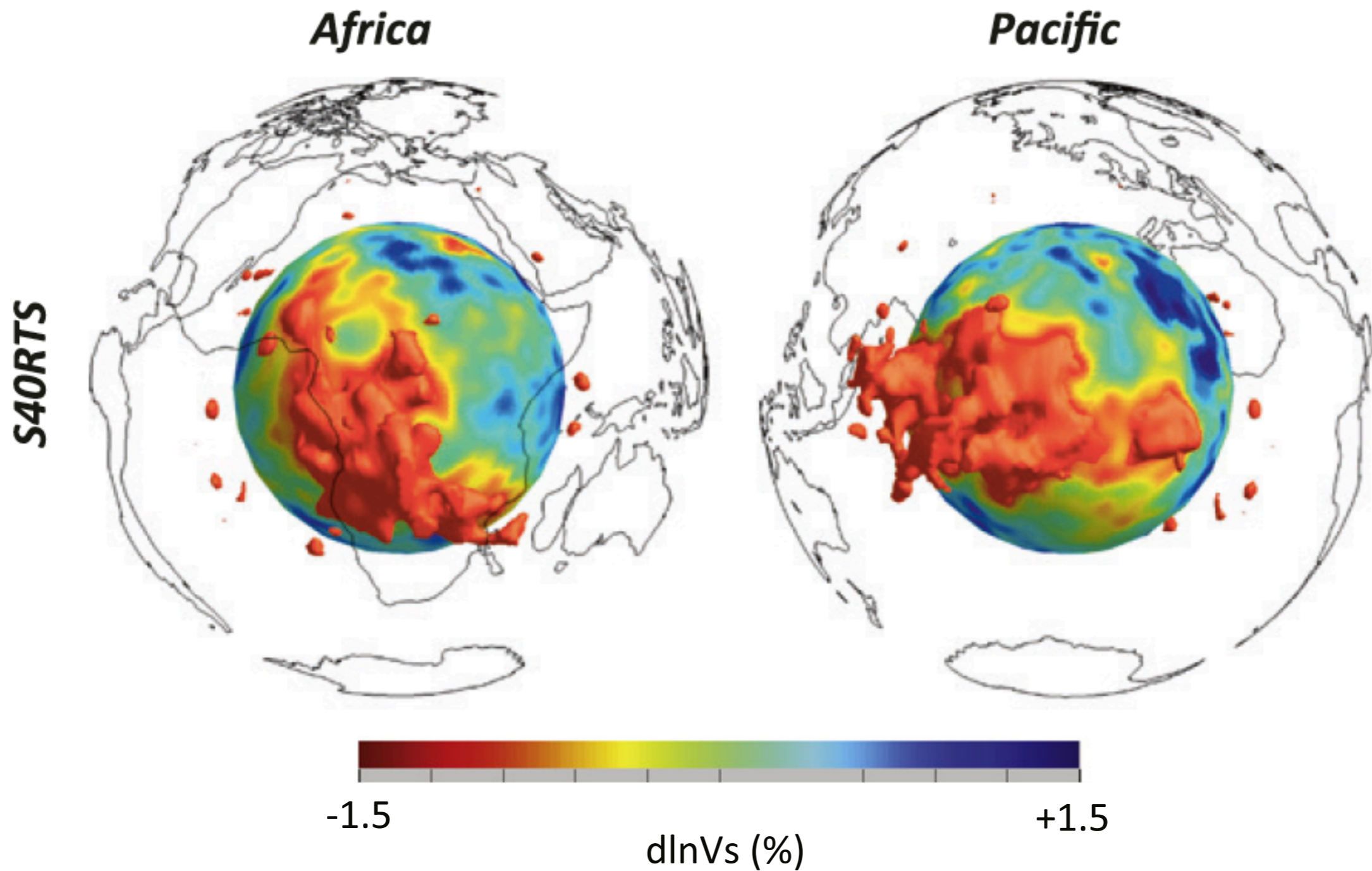
SCIENCE OF THE ENVIRONMENT

CMB



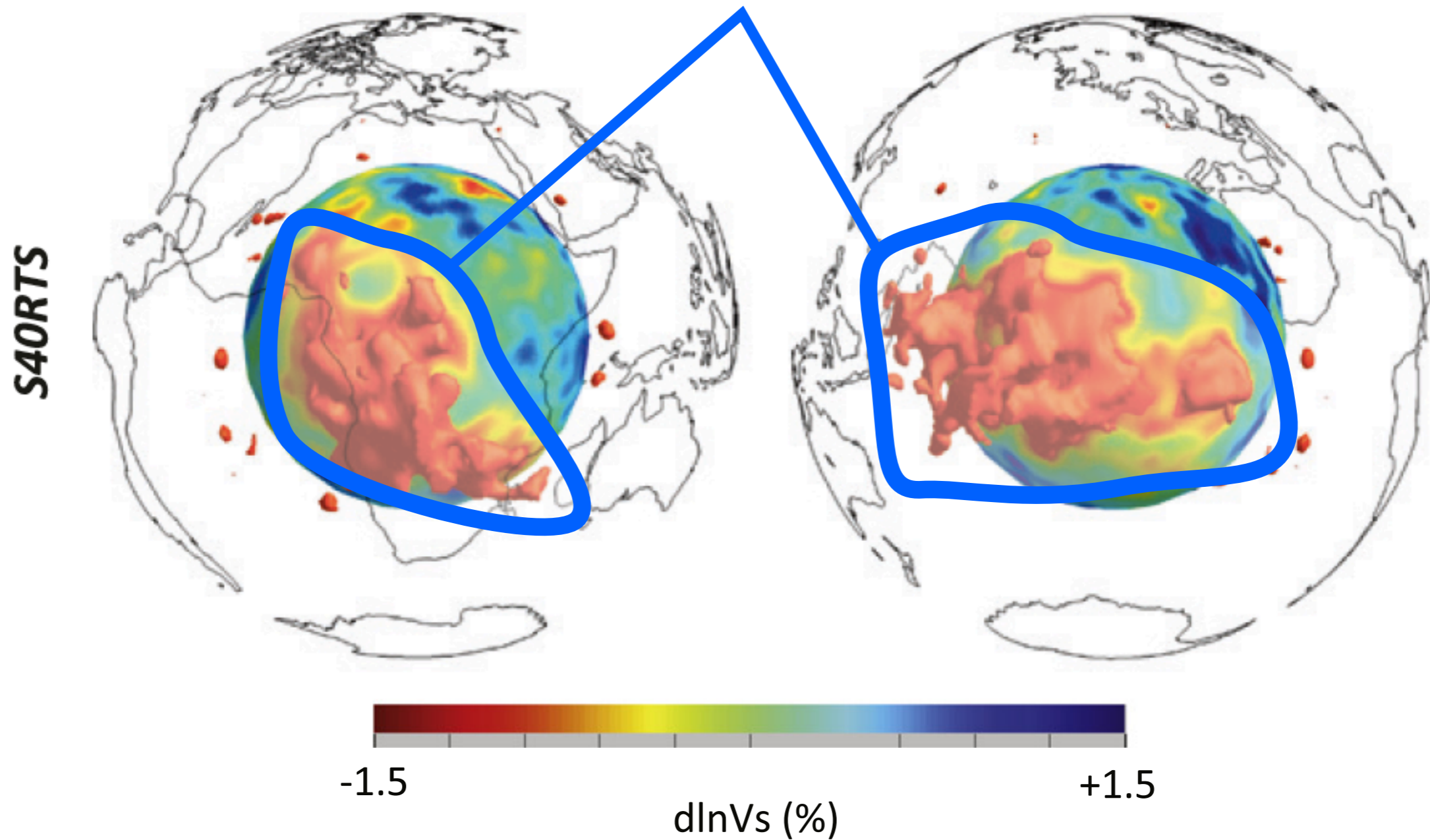
**UNIVERSITY OF LEEDS**

# Lower mantle tomography

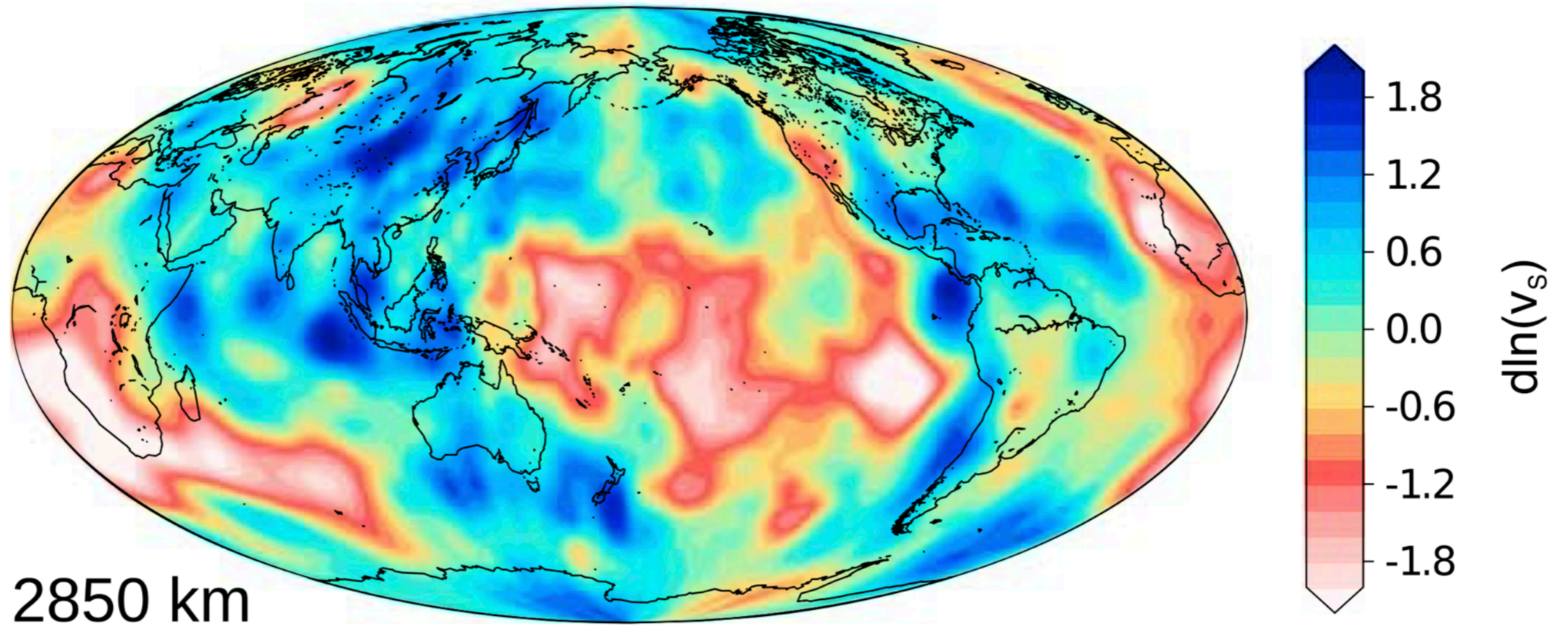


# Lower mantle tomography

## Large Low (Shear) Velocity Provinces

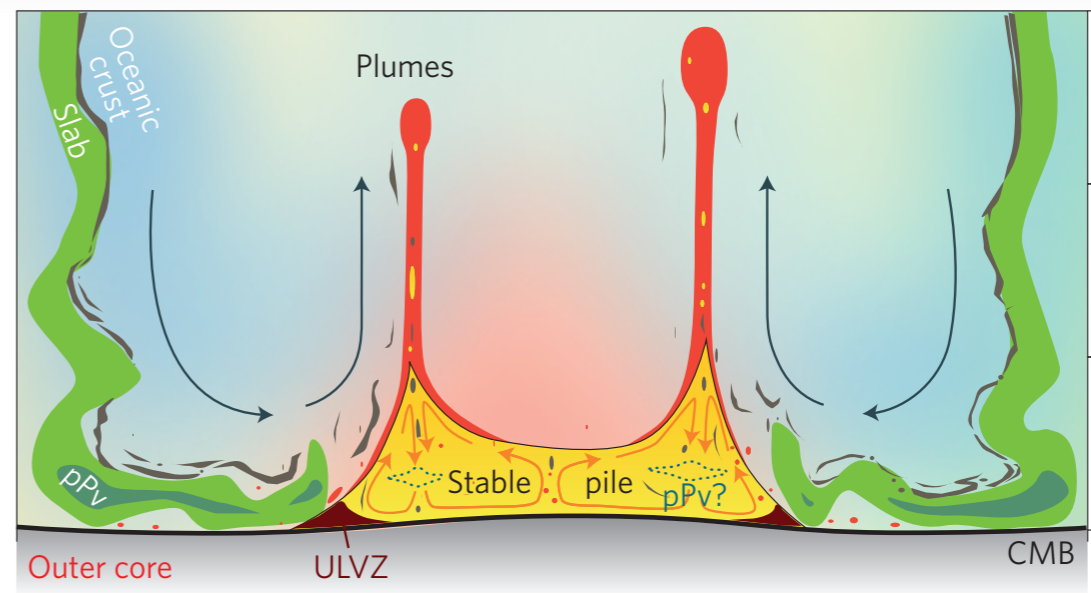
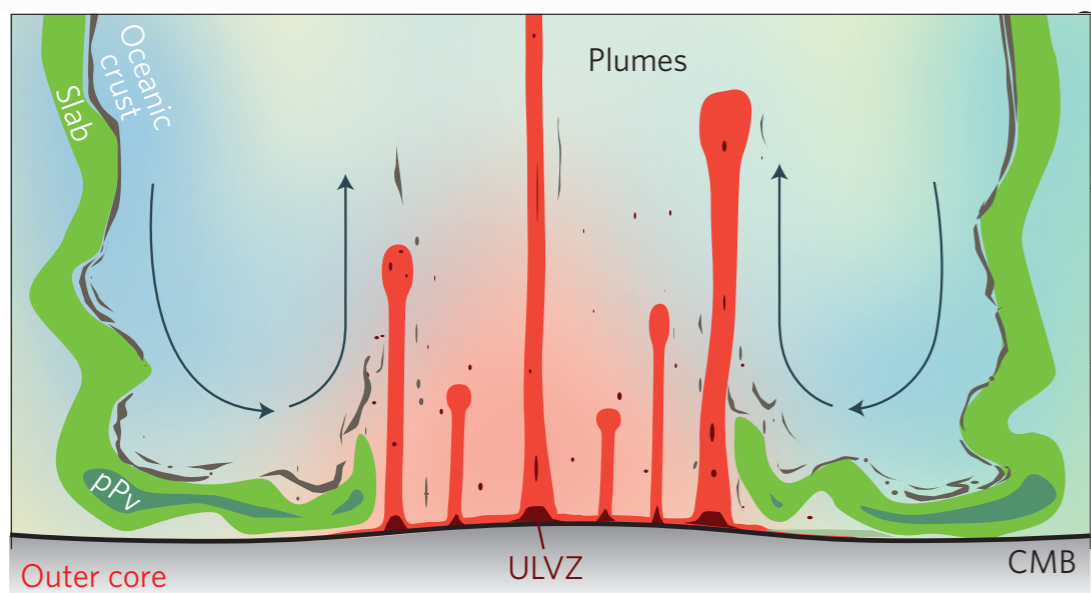
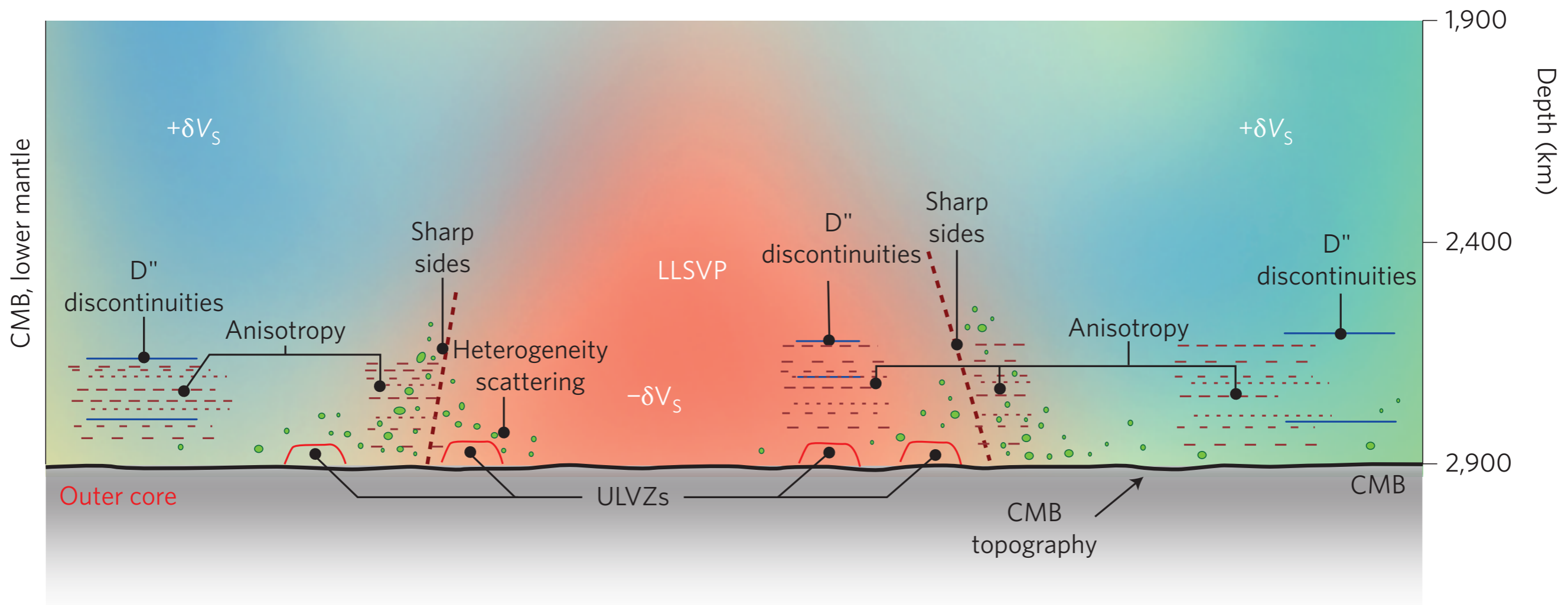


# Lower mantle tomography

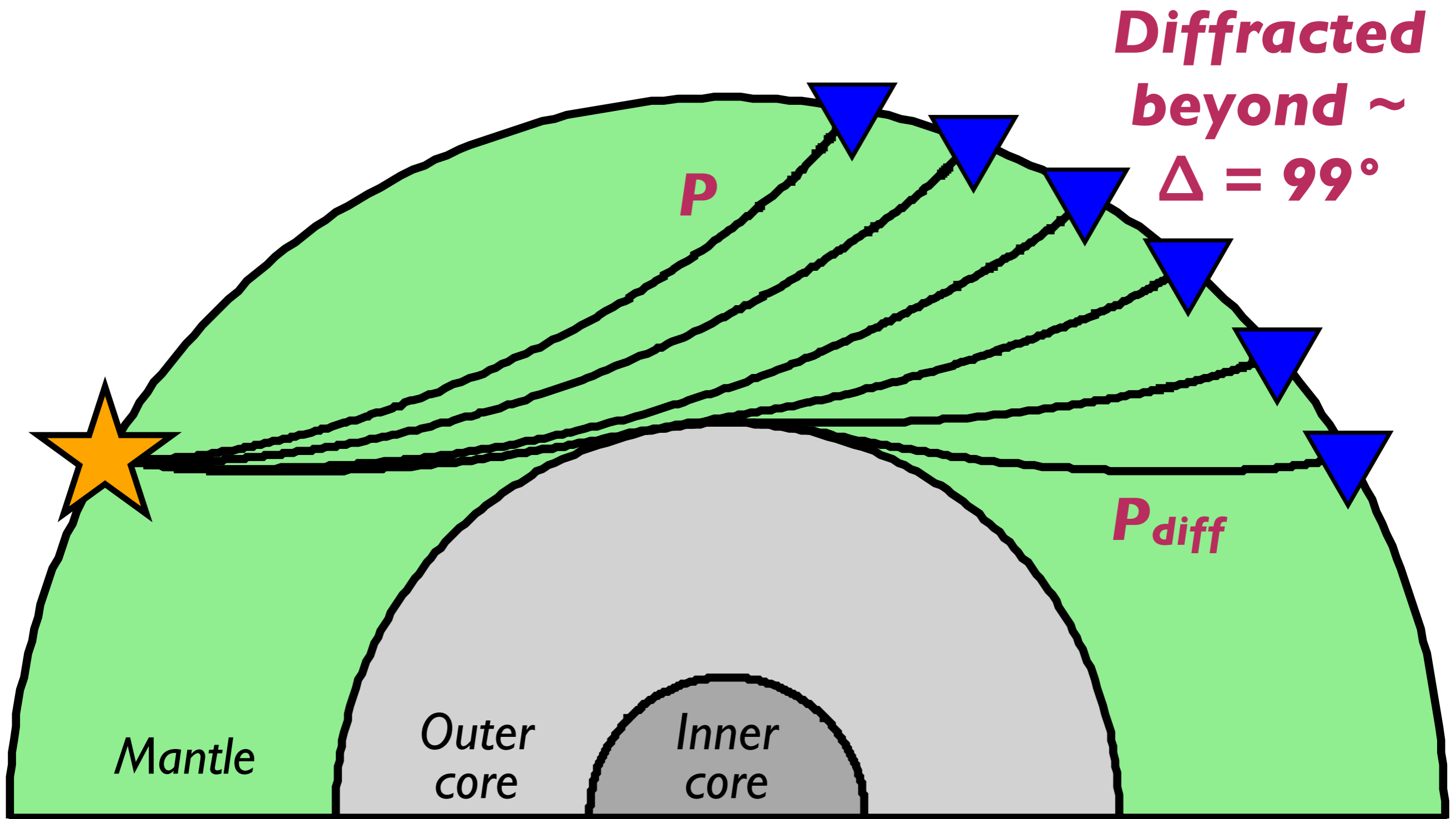


- LLSVPs: not uniform
- Small-scale (100s km) structures
- Tomography struggles to resolve

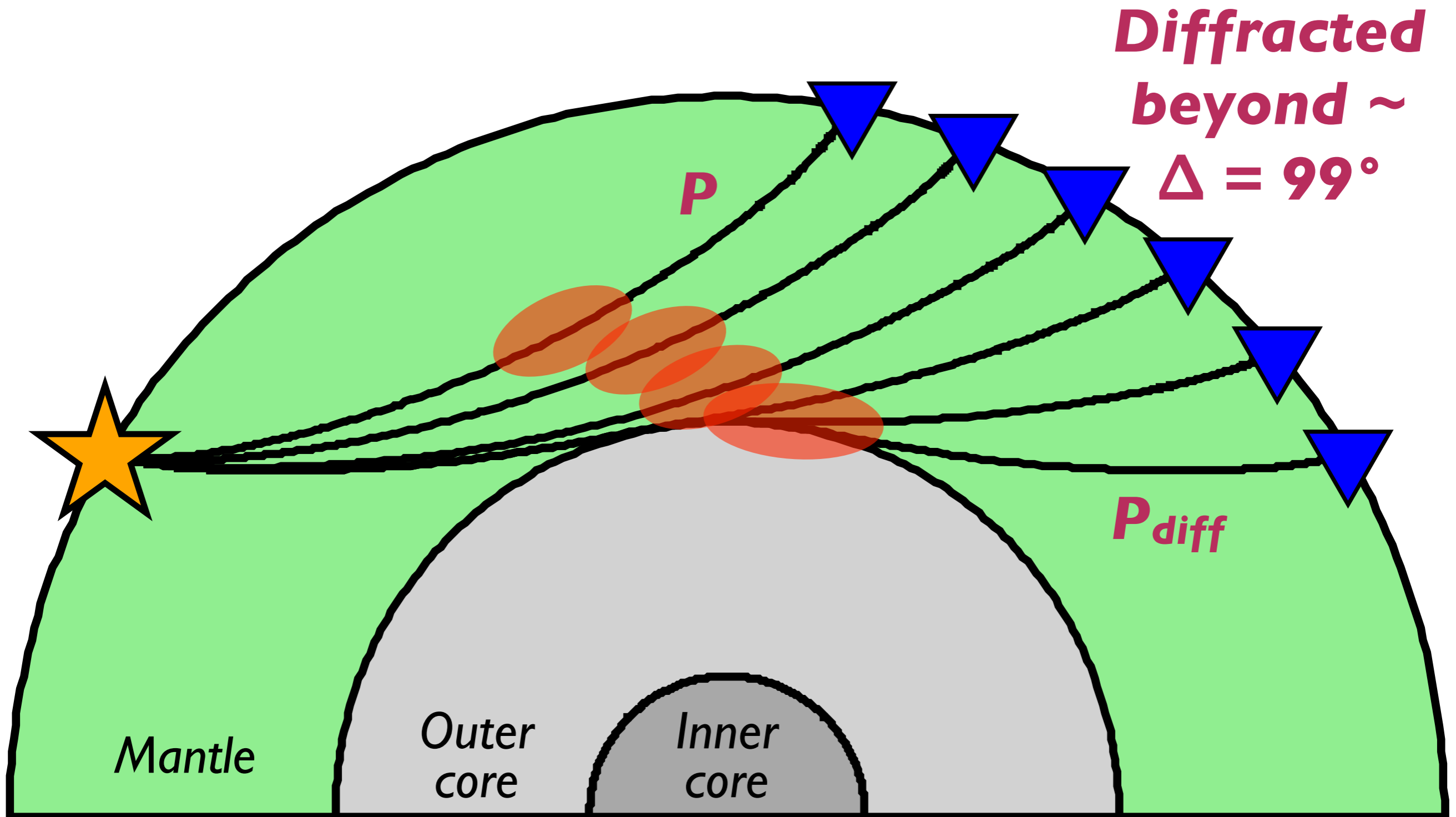
# Small-scale structure in lowermost mantle (D'')



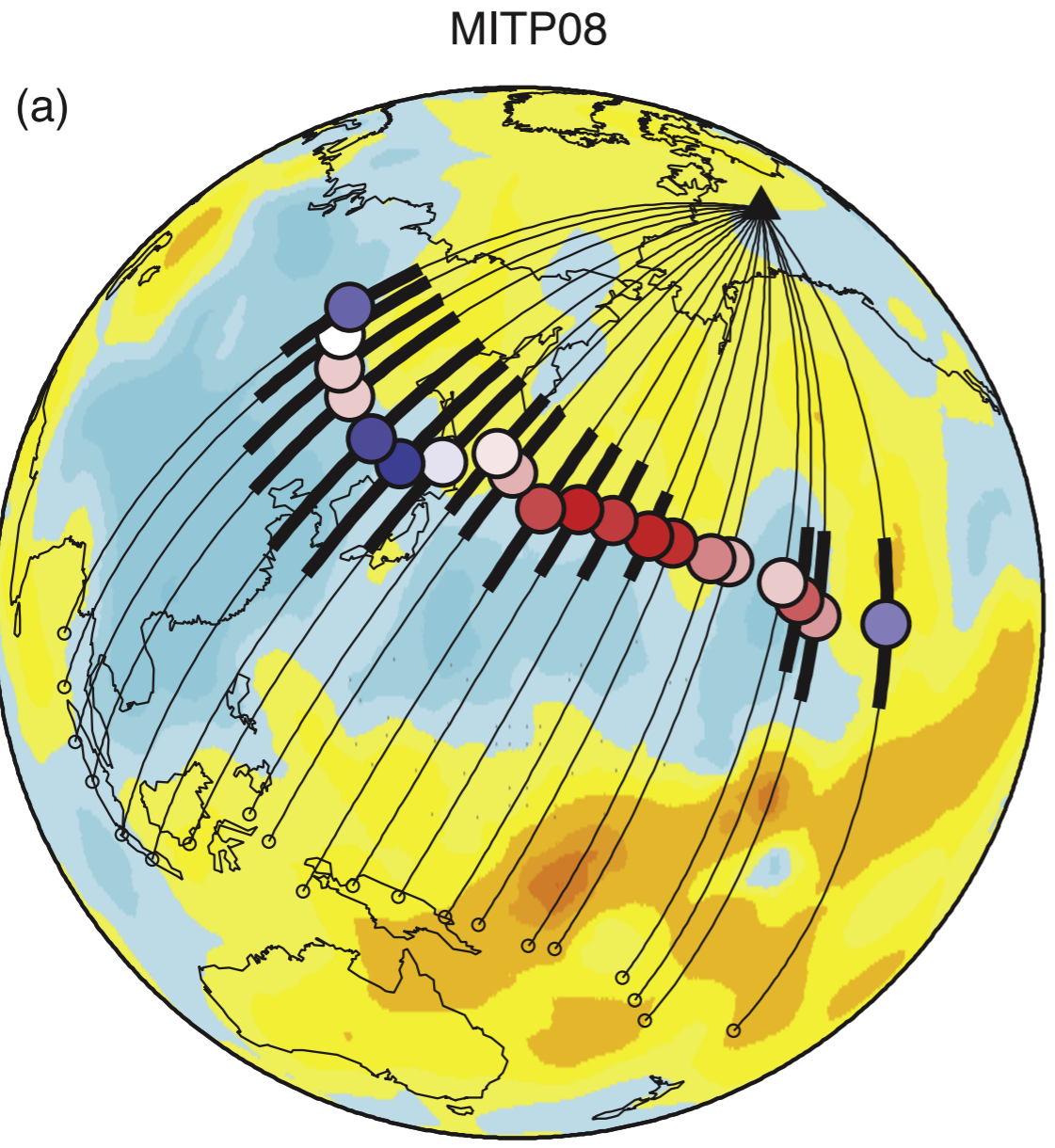
# How to investigate?



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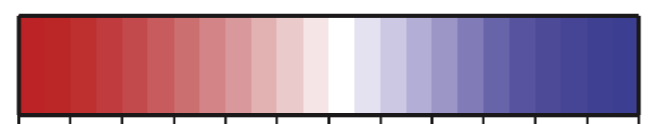


# Pacific LLSVP and lowermost mantle



-1.6 -0.8 -0.0 0.8 1.6

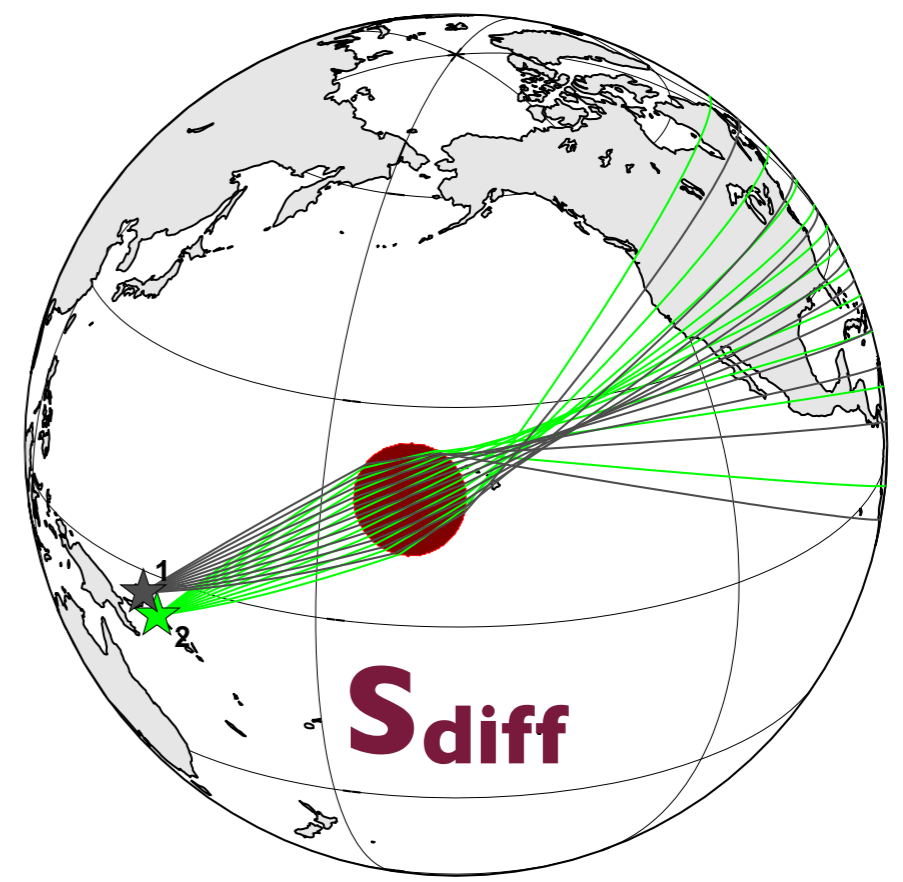
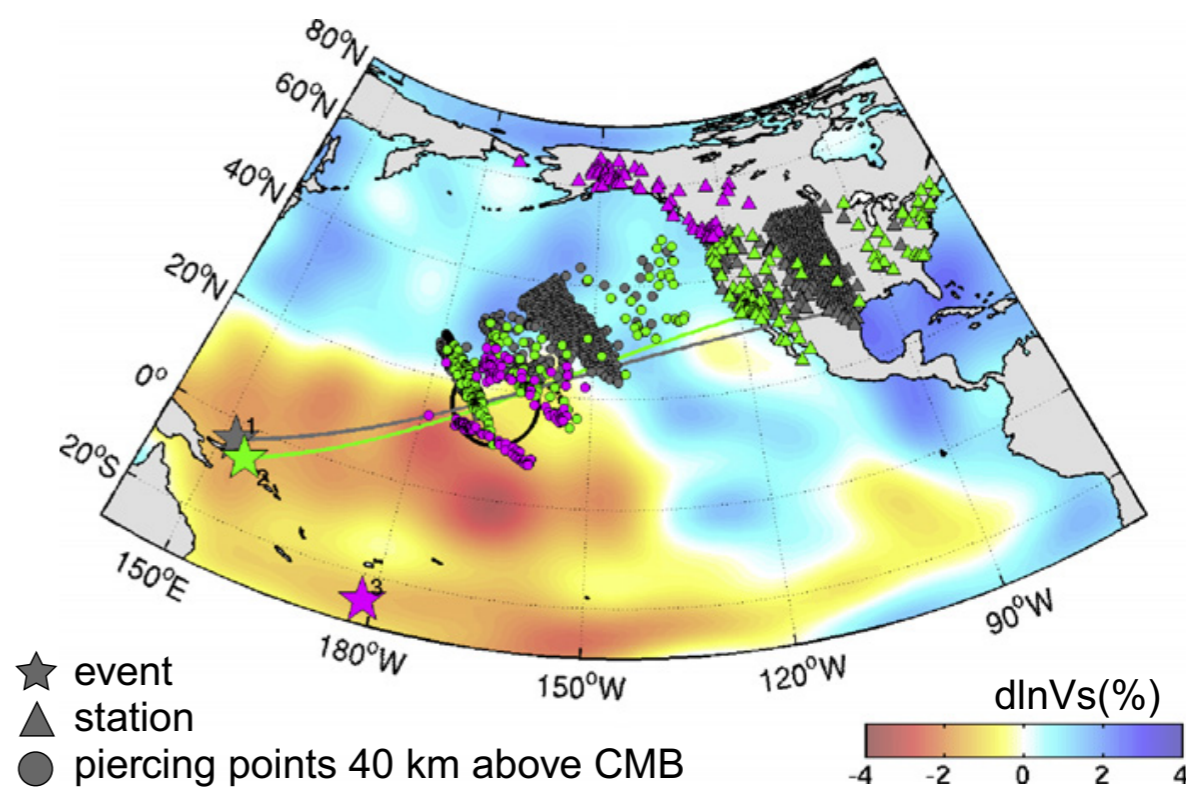
P velocity variation



-6 -4 -2 0 2 4 6

percent changes in  $V_p$

**P/ $P_{diff}$**

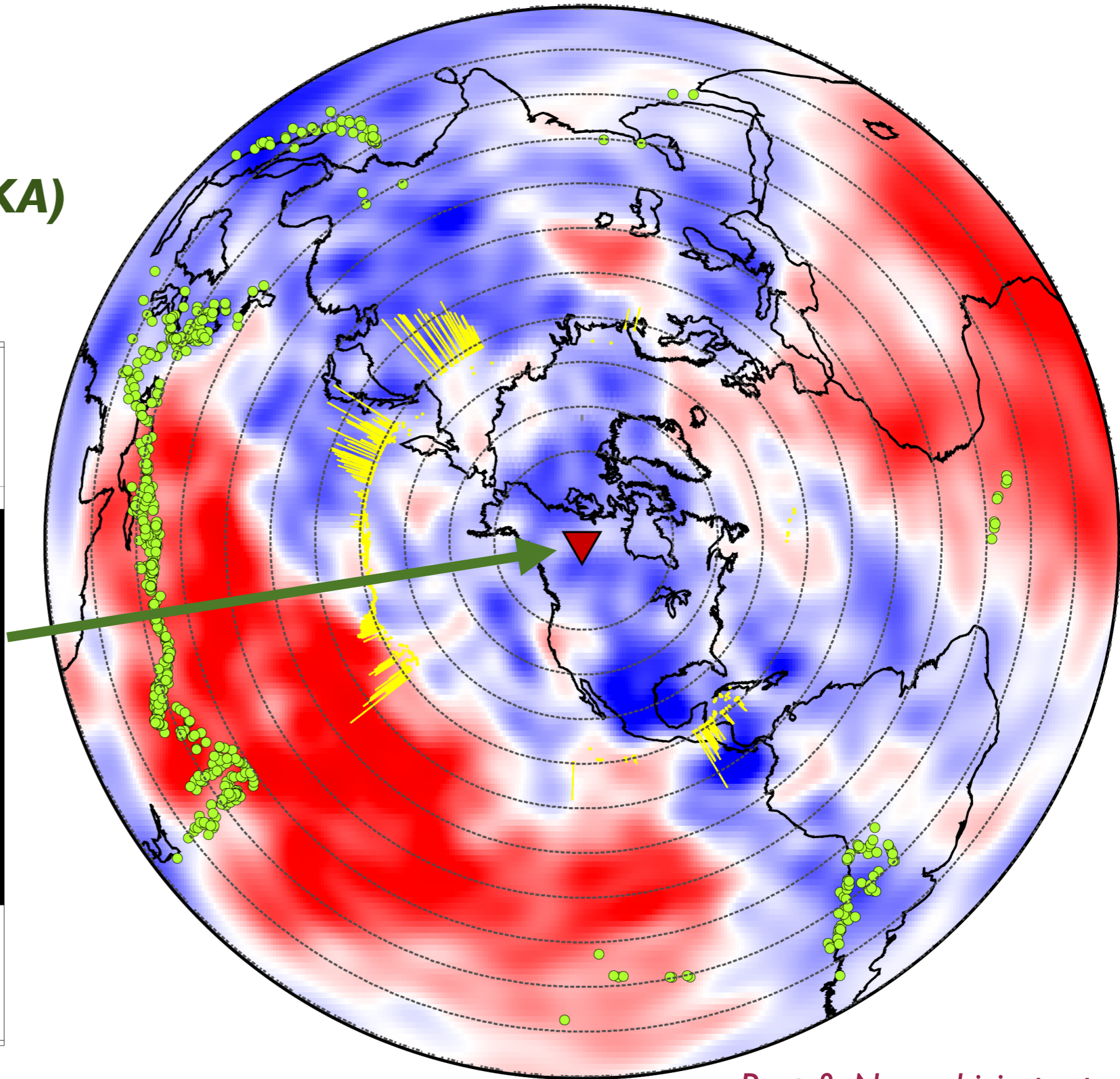
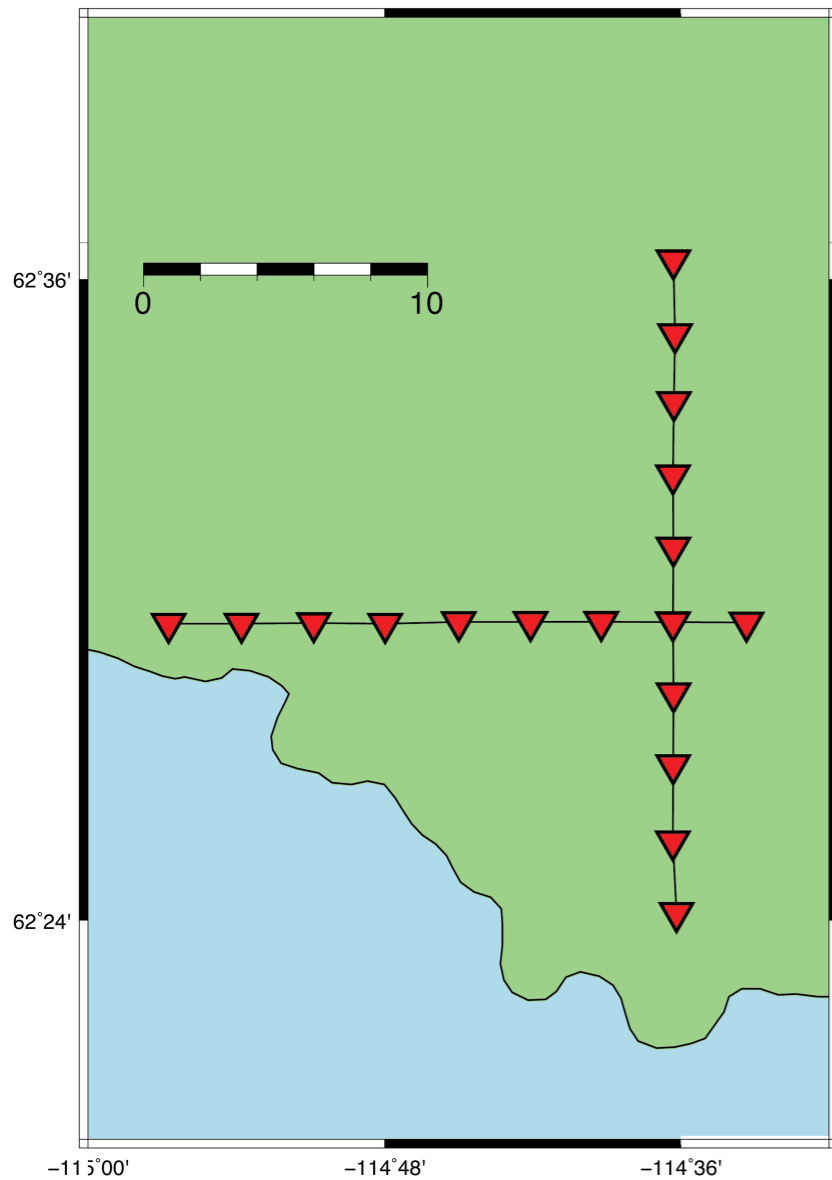


*Xu & Koper, GRL, 2009; Cottaar et al., EPSL, 2012*

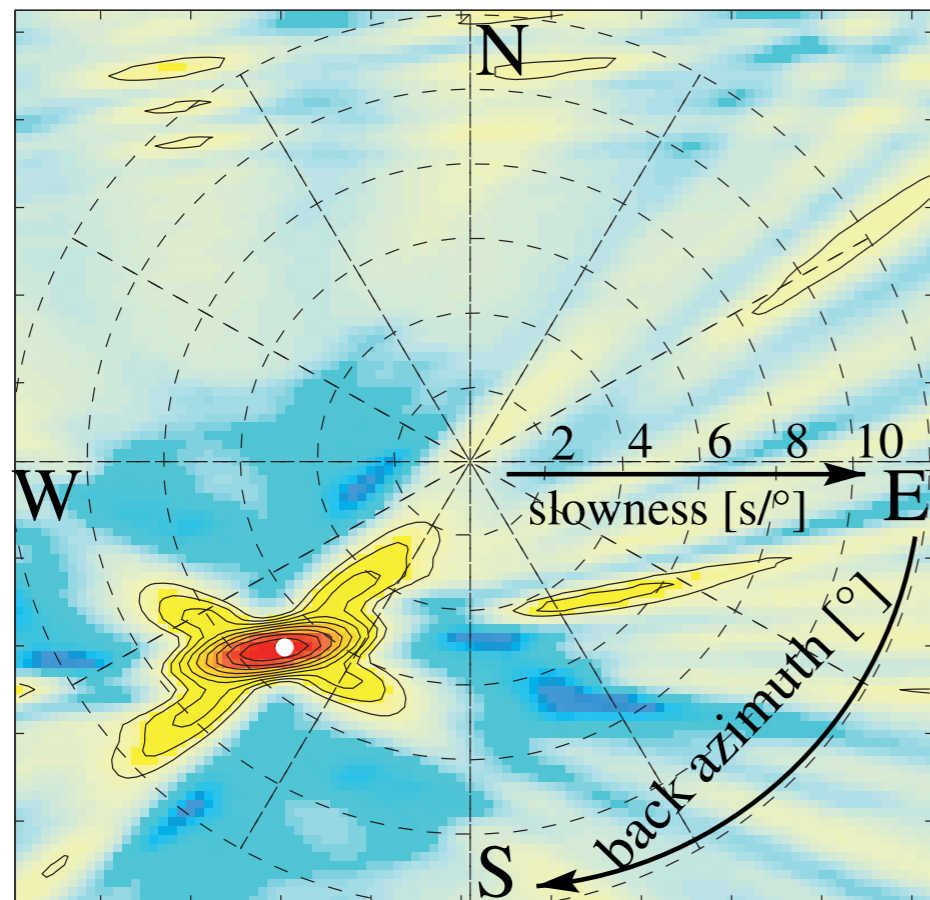
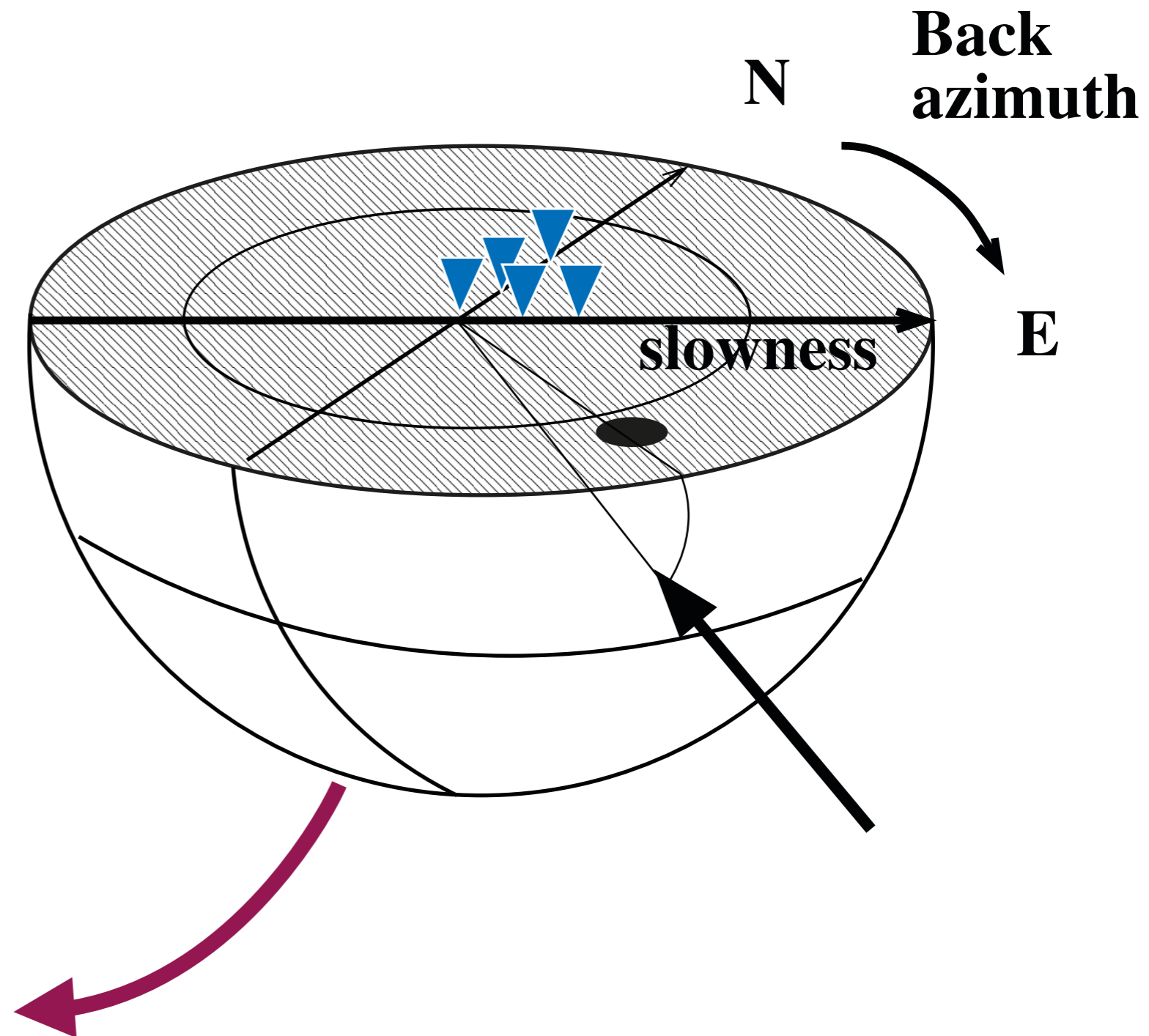
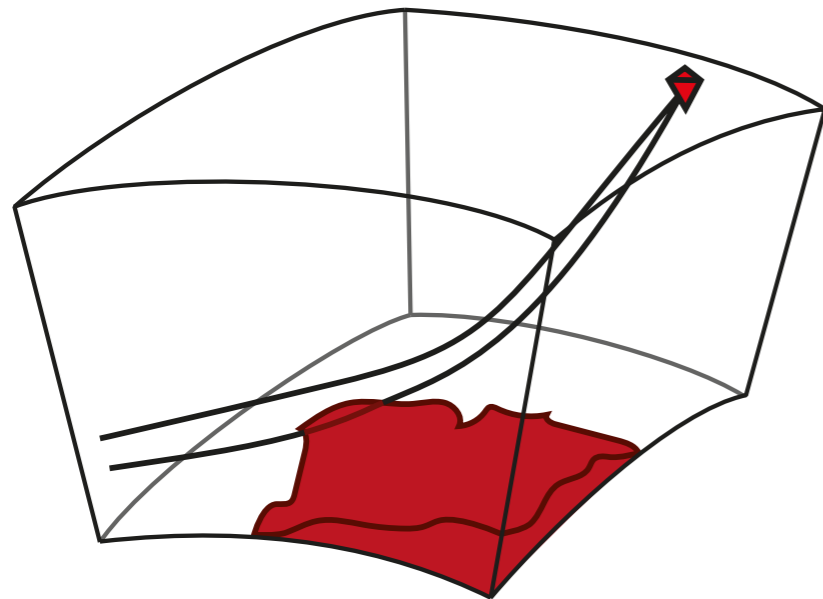


# Data

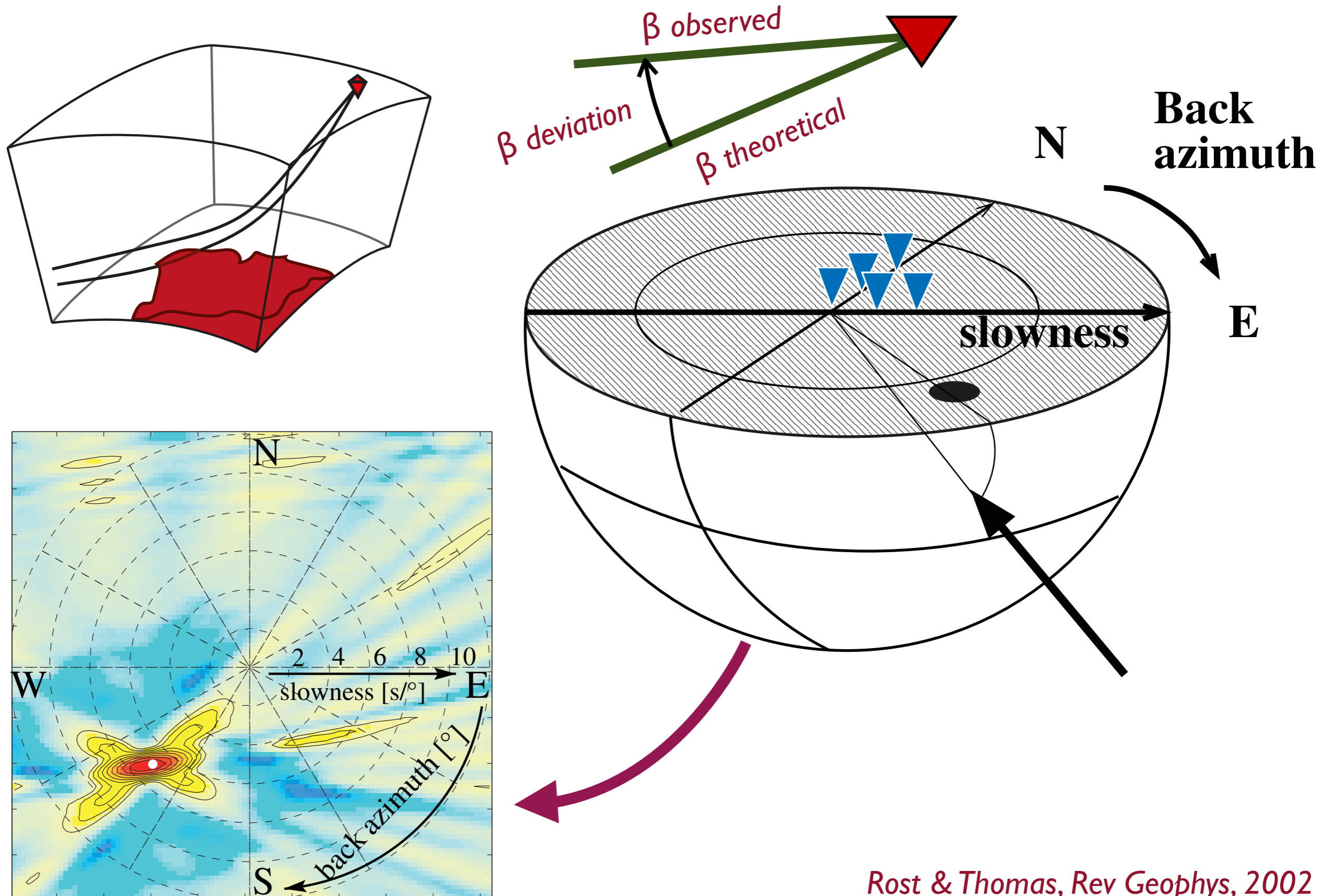
## Yellowknife array (YKA)



# Frequency-wavenumber ( $fk$ ) analysis

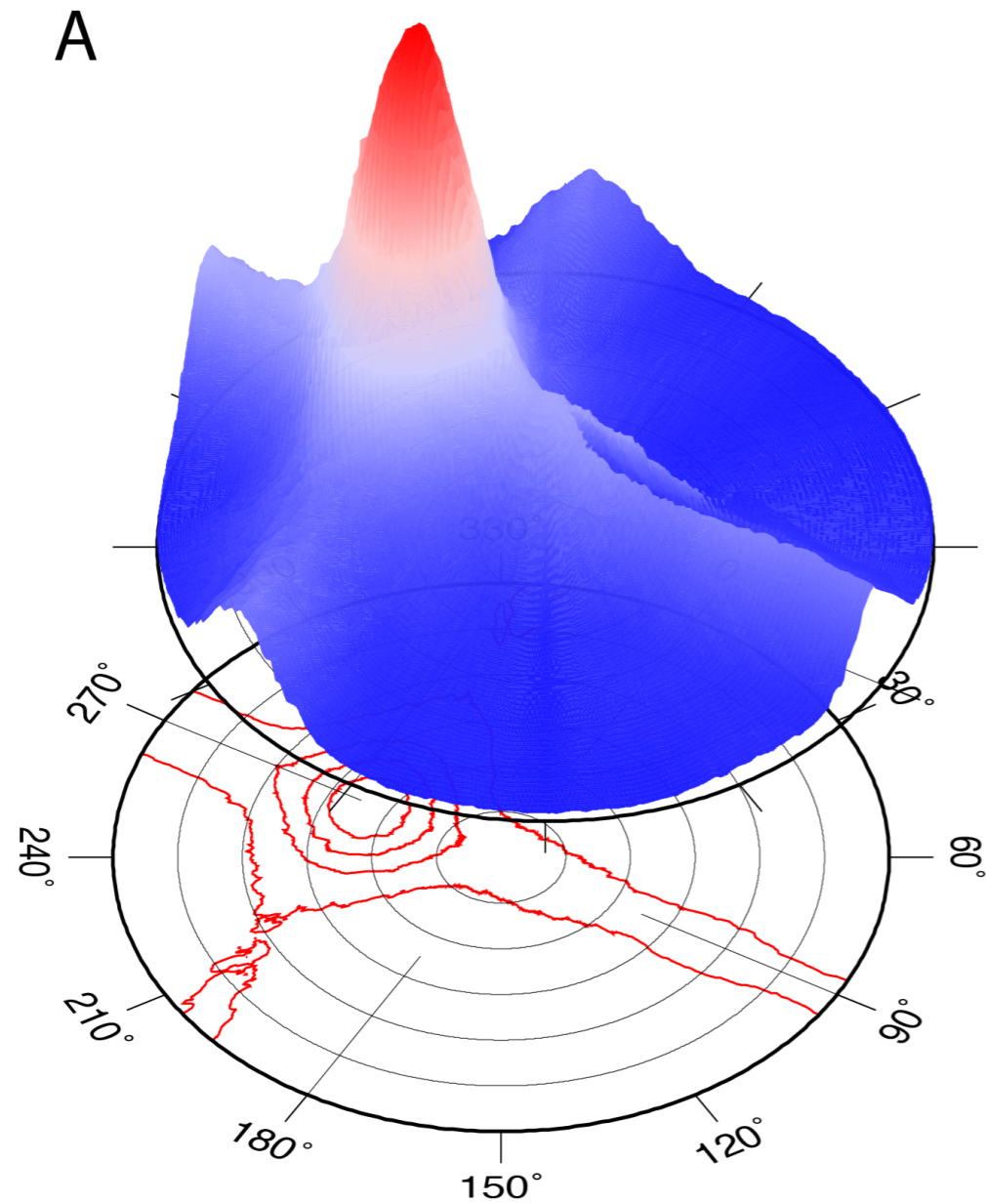


# Frequency-wavenumber ( $fk$ ) analysis

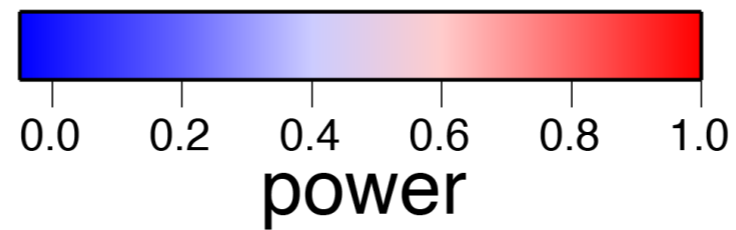
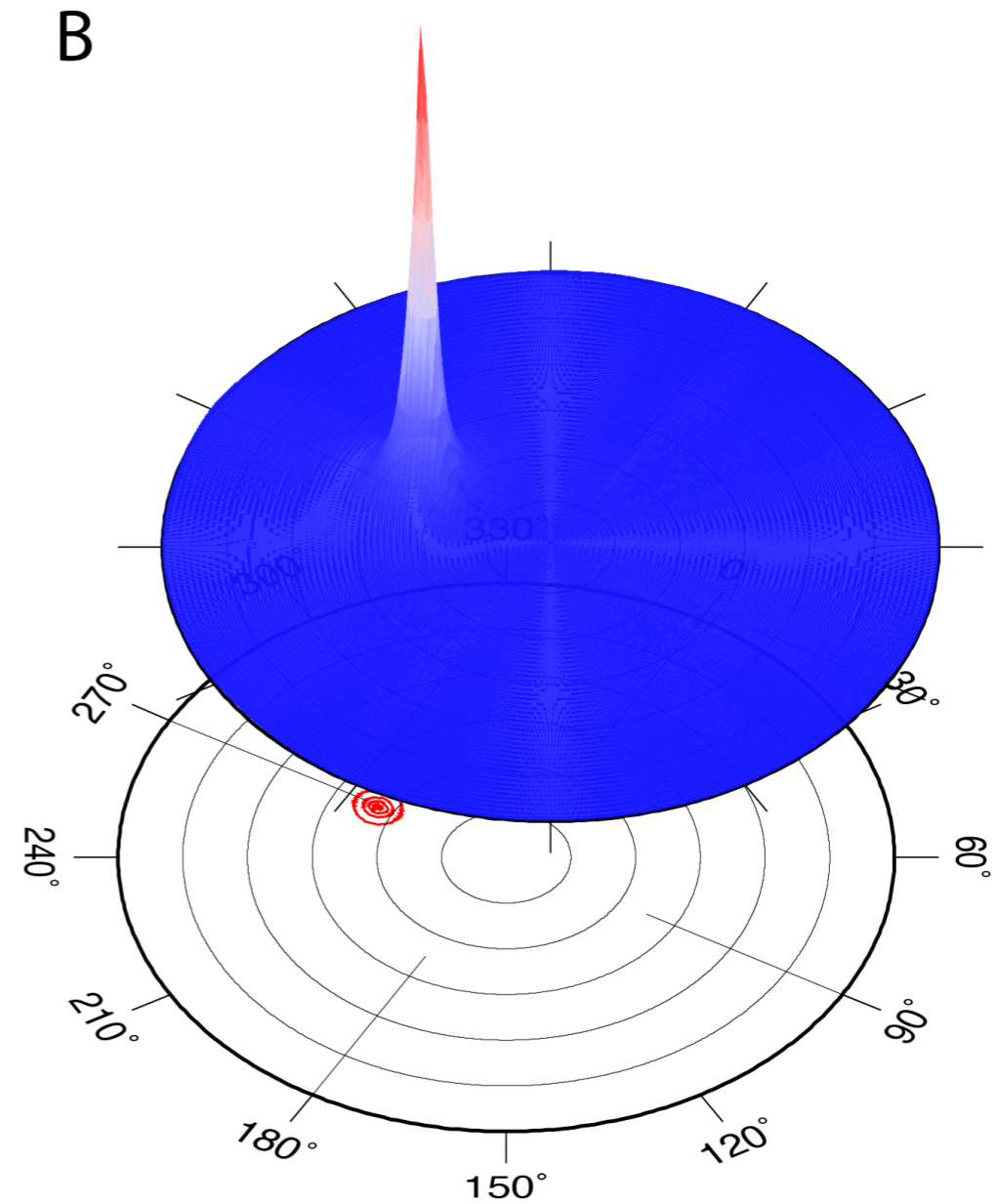


# F-stacking

**Standard beam**



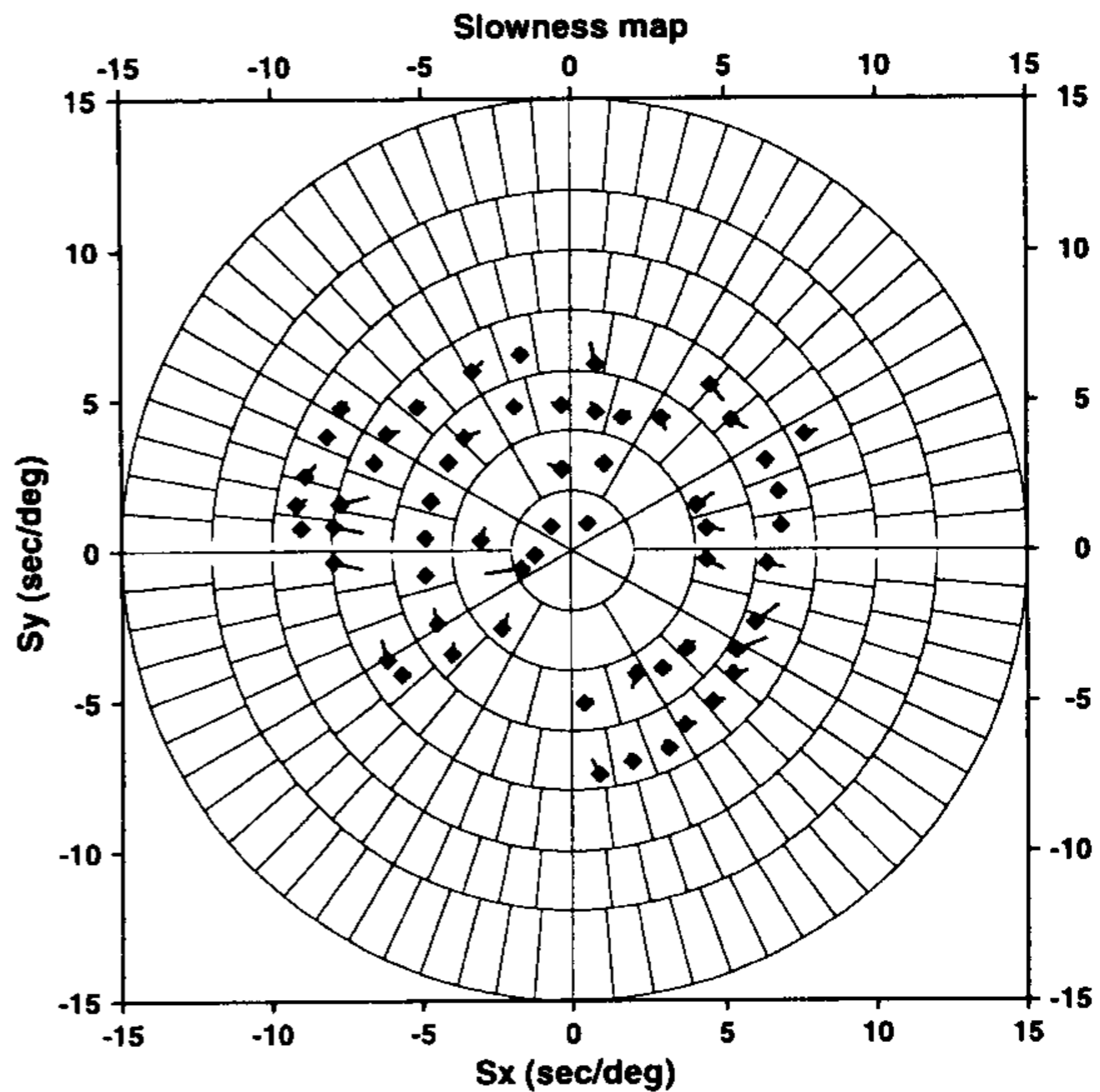
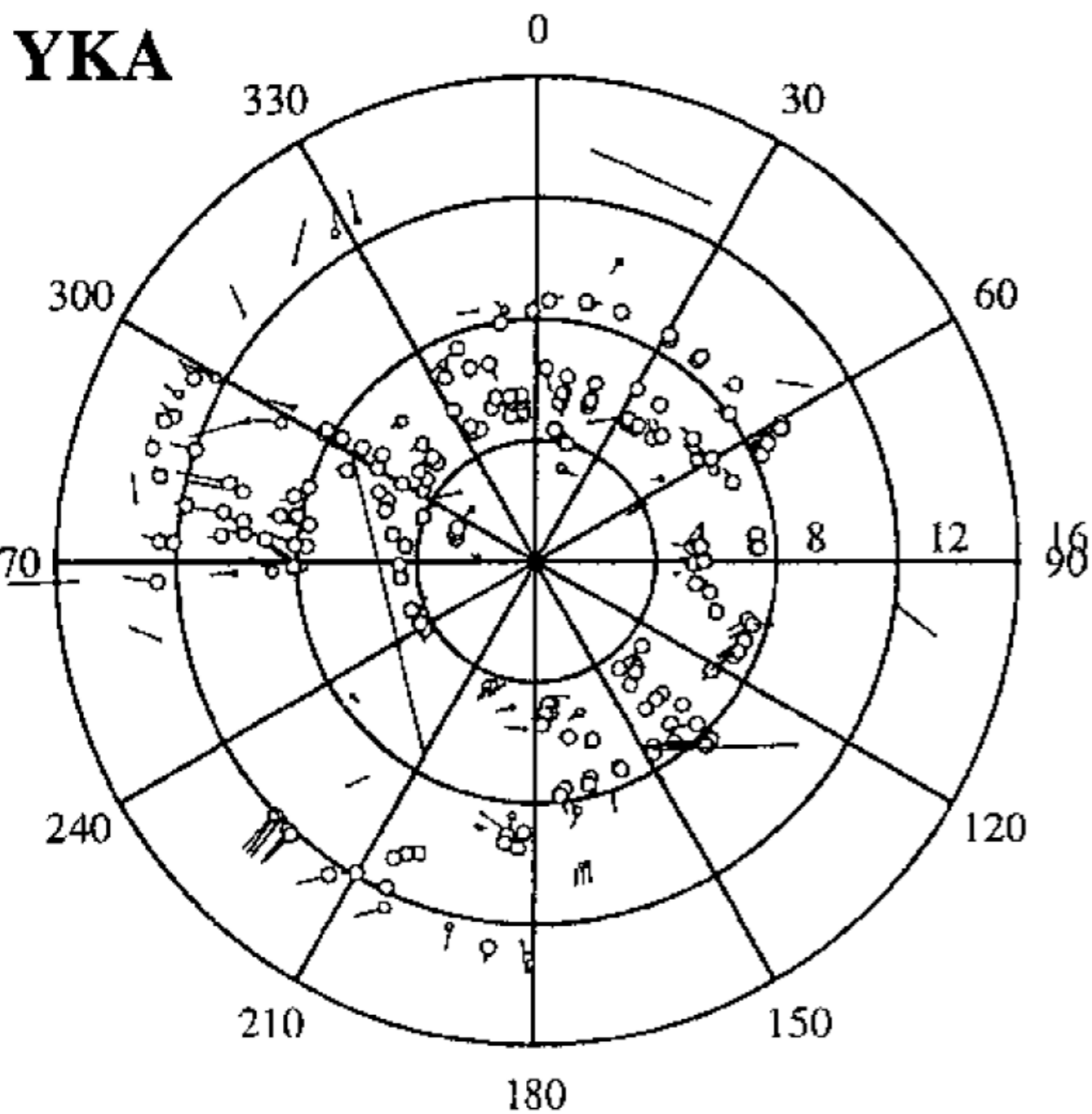
**F-beam**



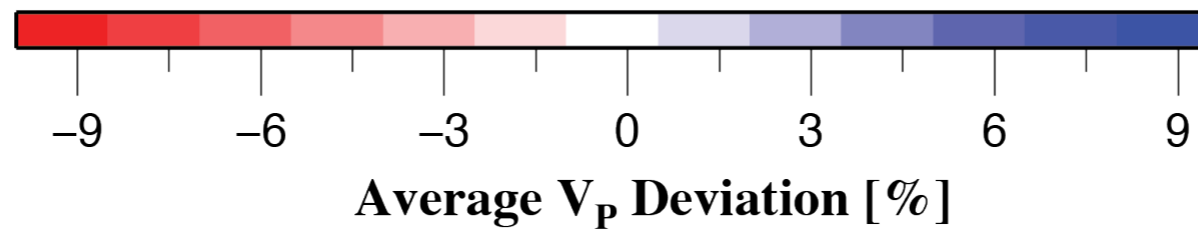
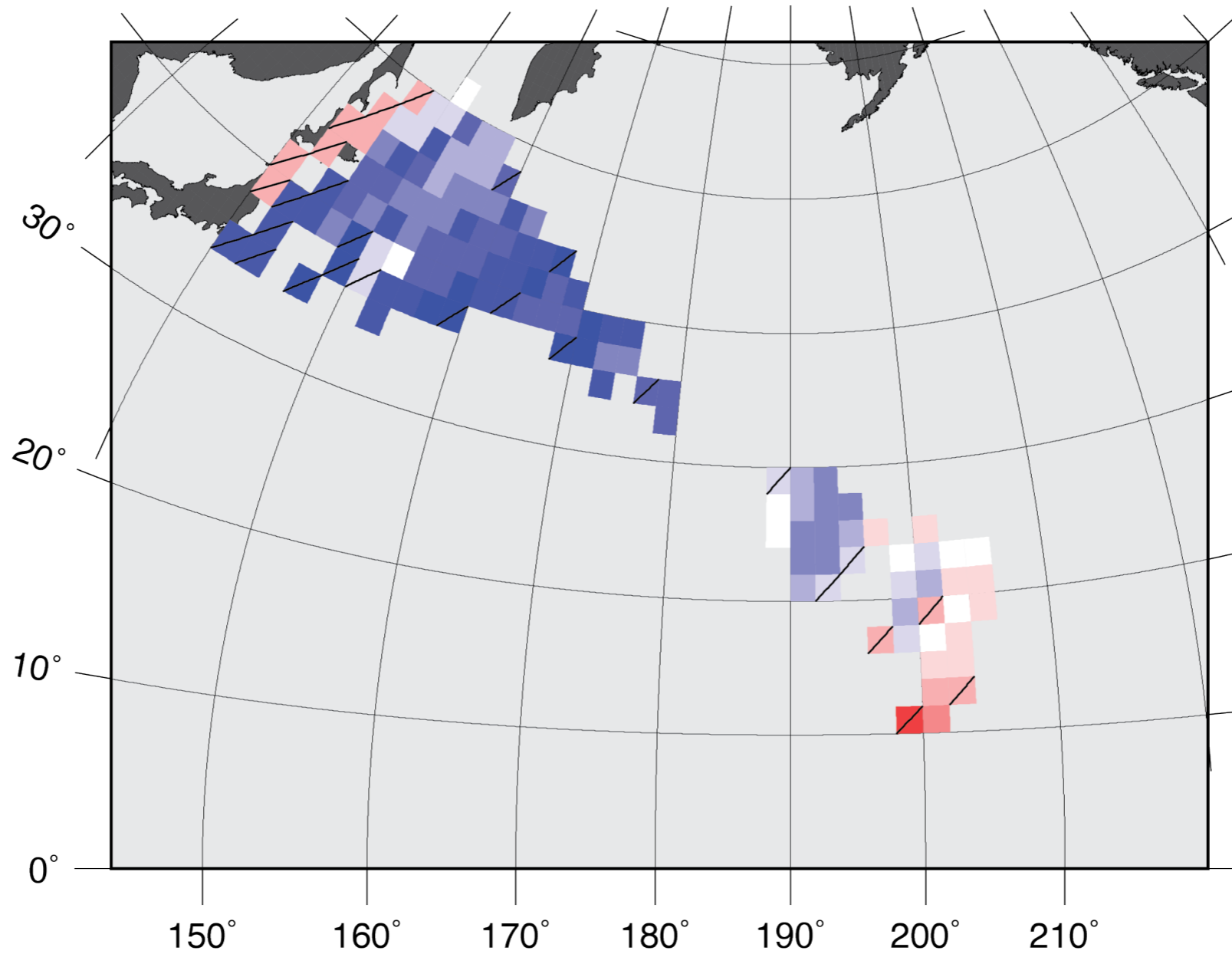
# Yellowknife mislocation

(a)

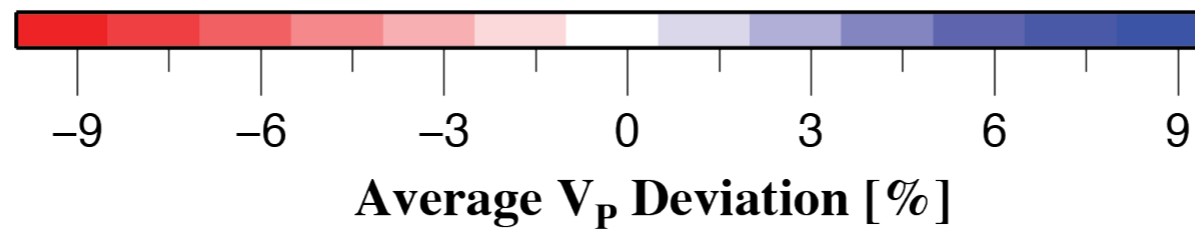
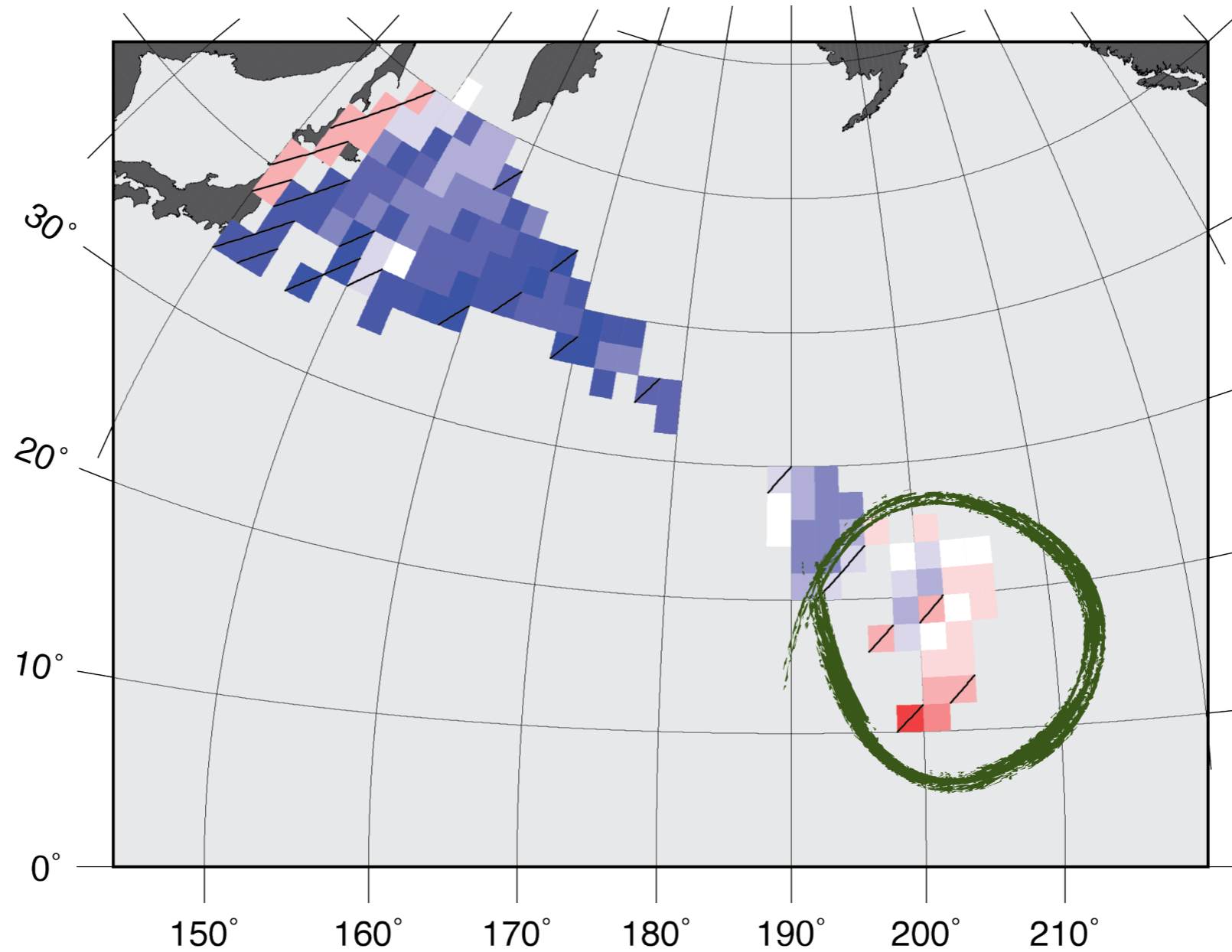
Slowness-azimuth corrections, YKA



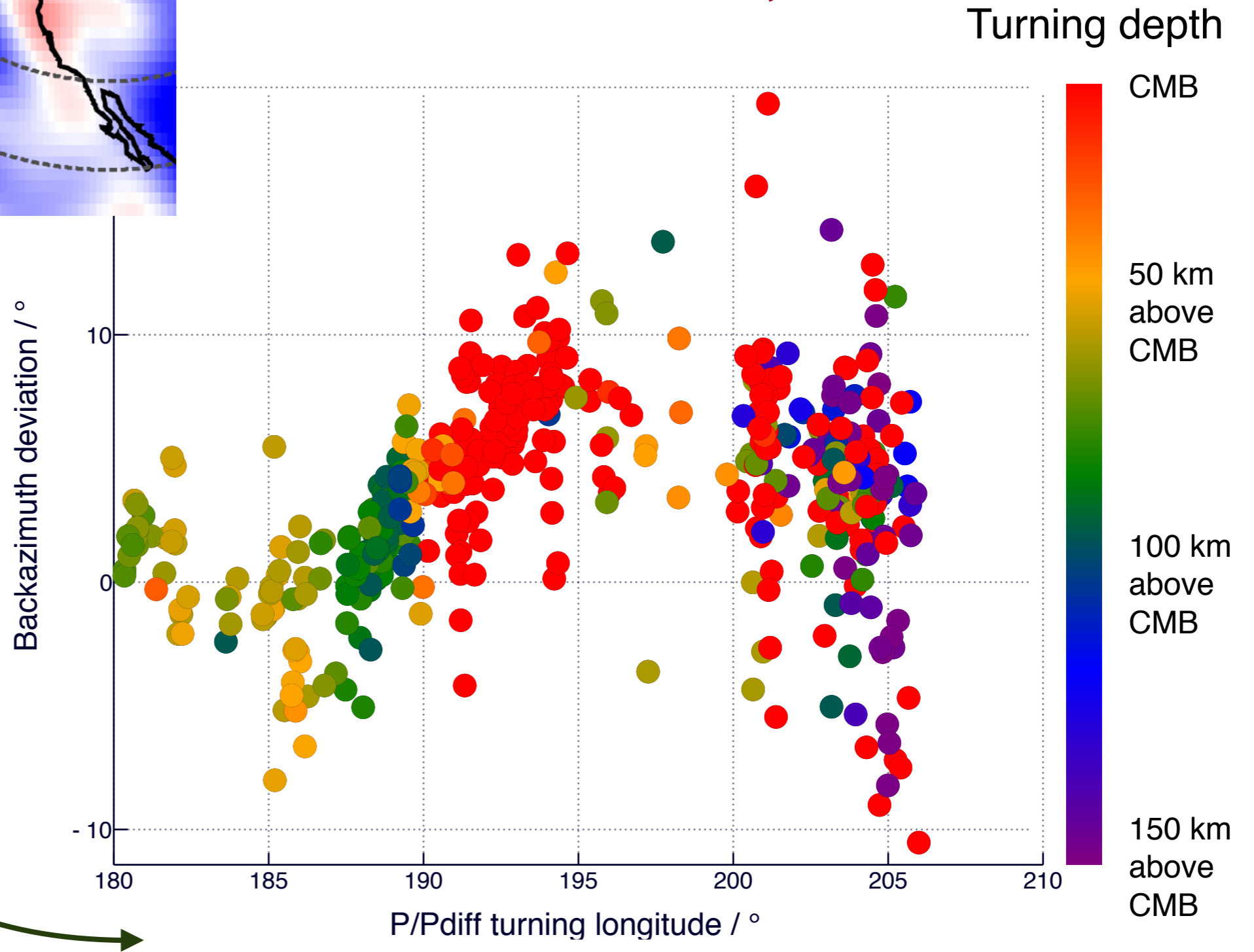
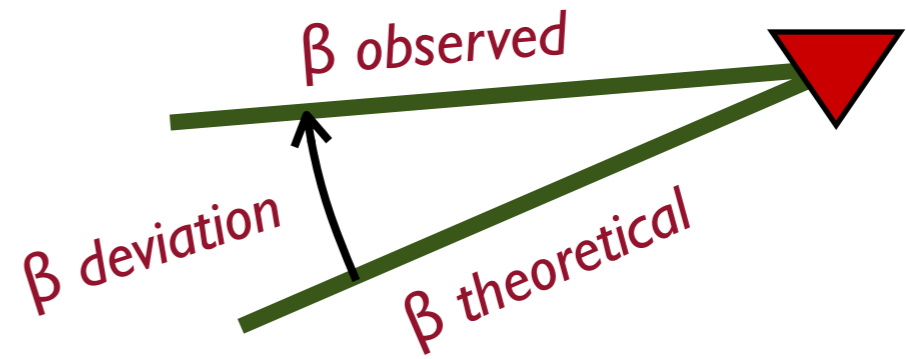
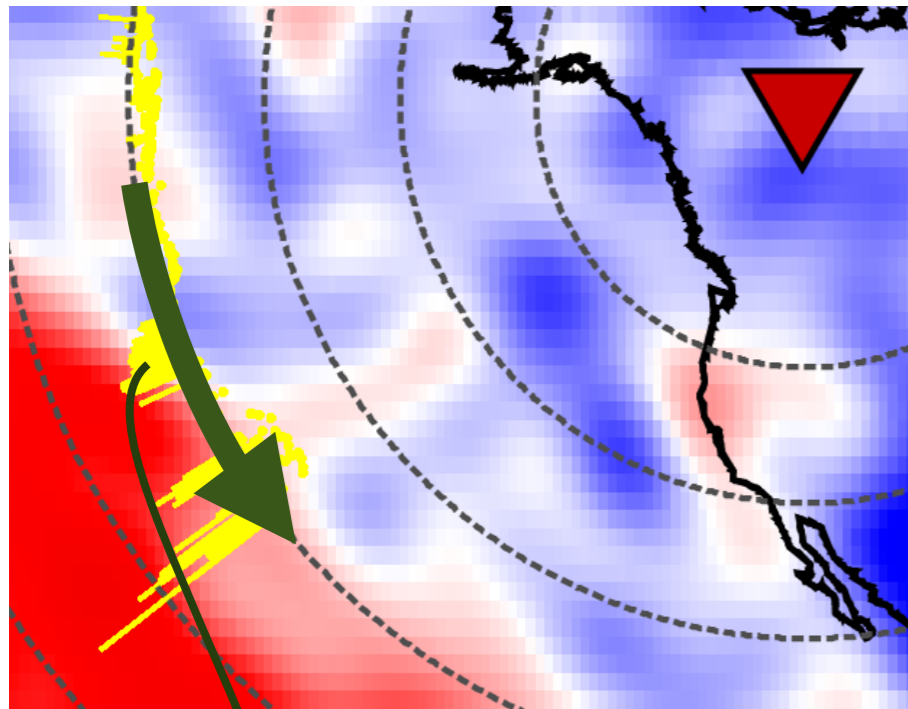
# Results



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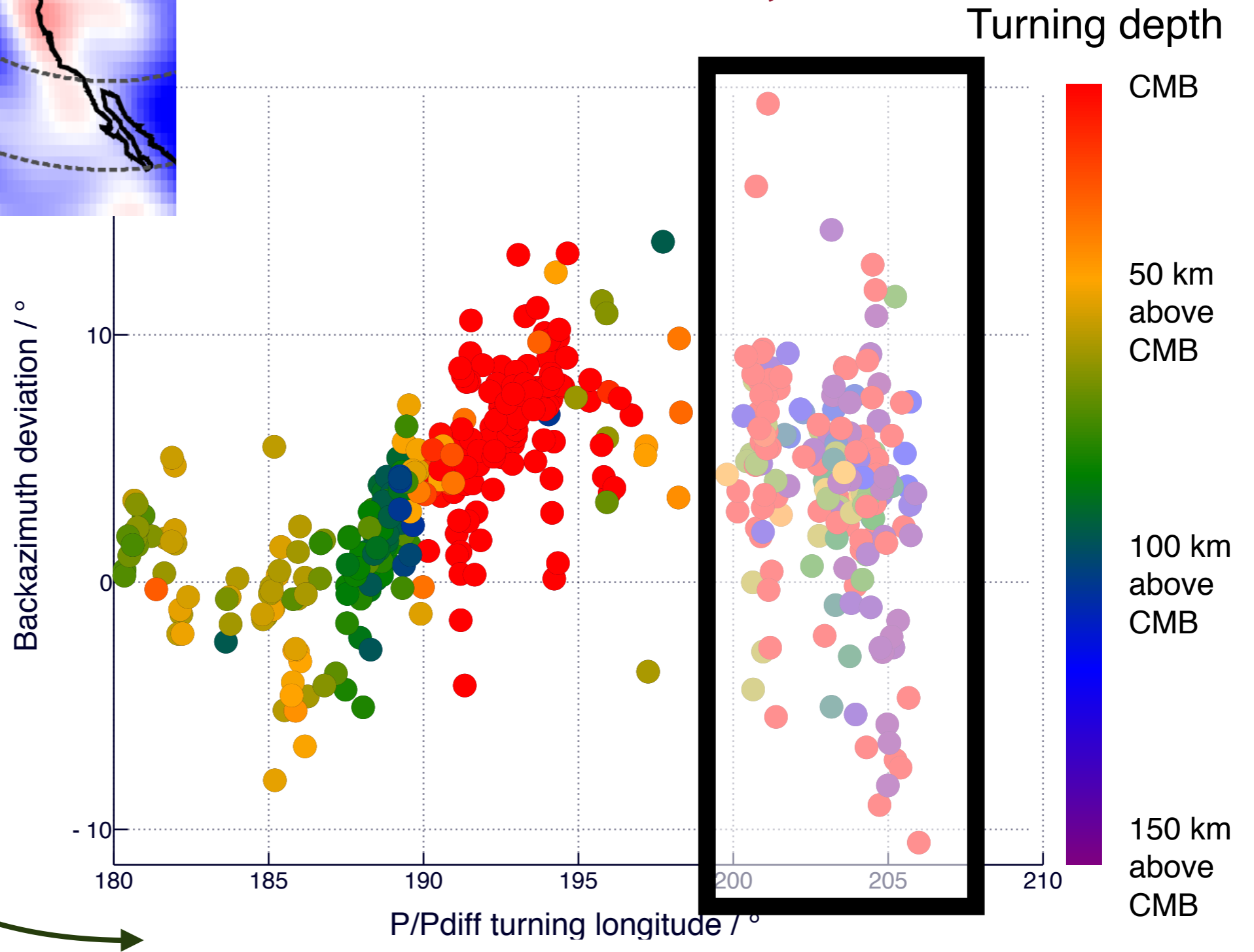
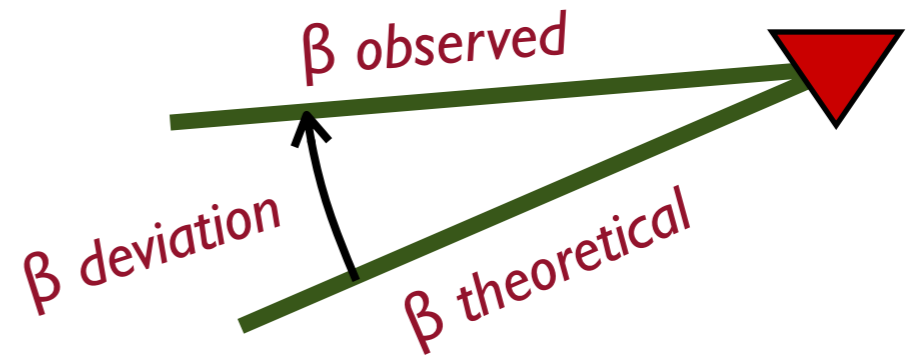
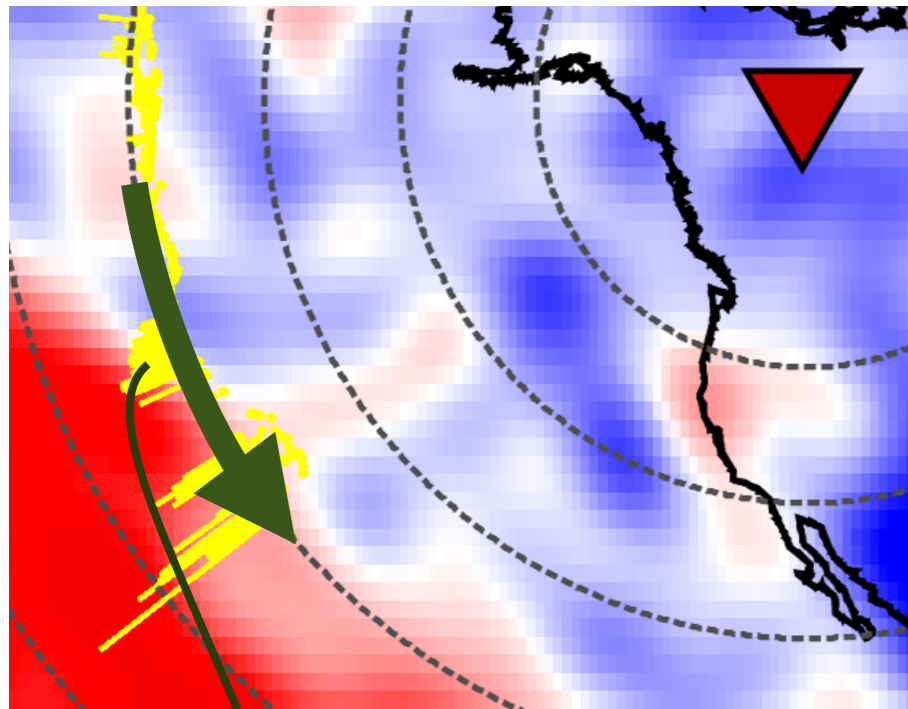


# Results

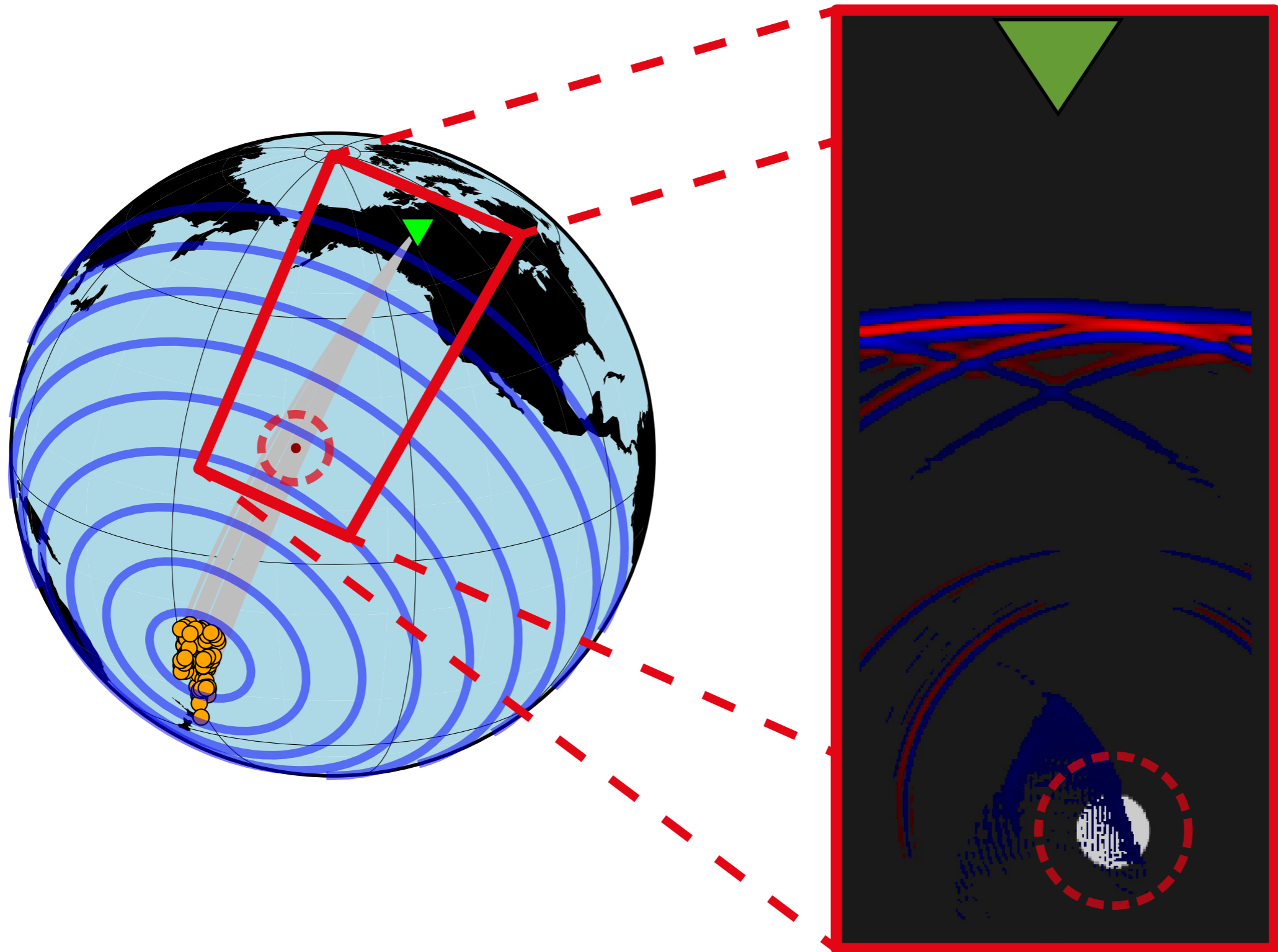




# Results



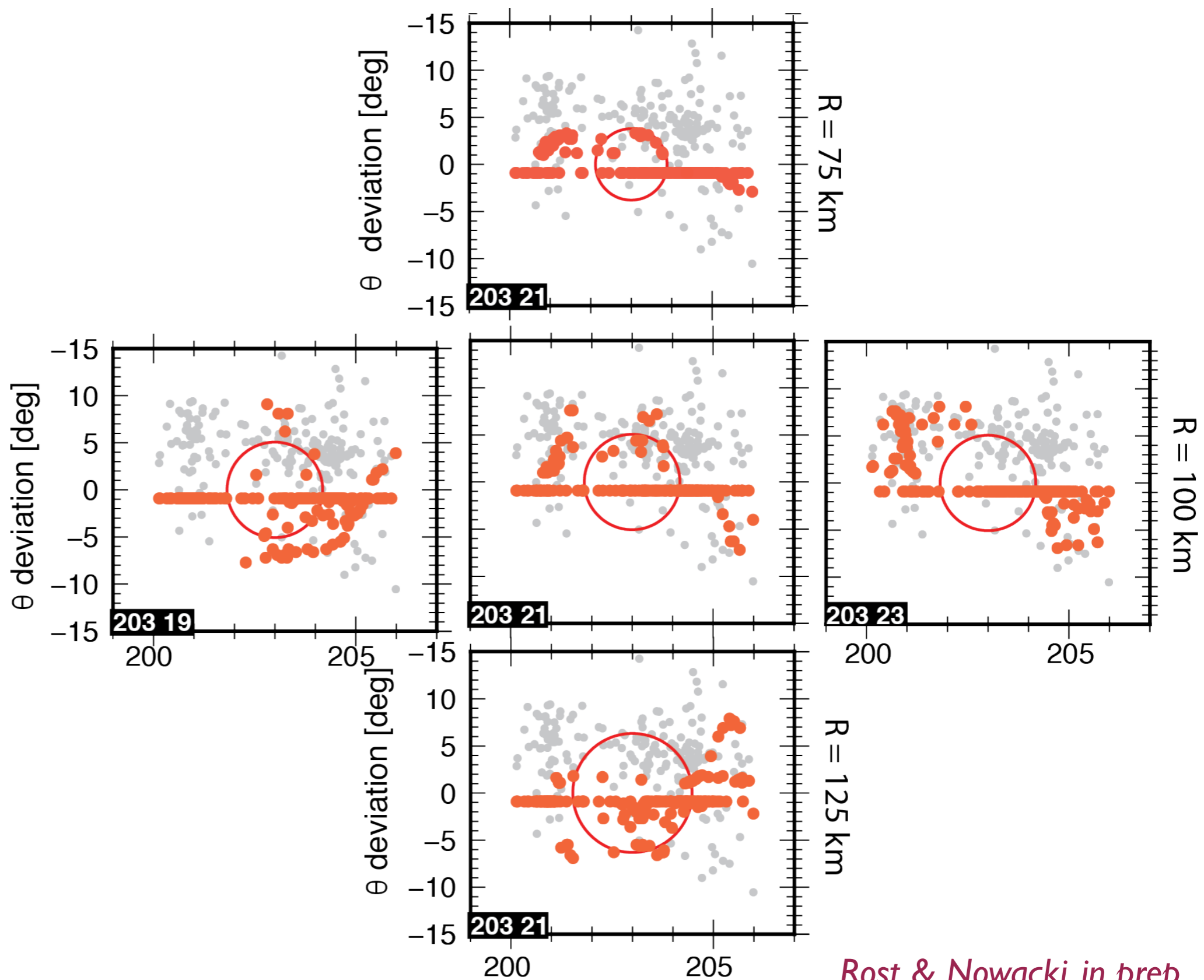
# Forward modelling



# Grid search

Vary:

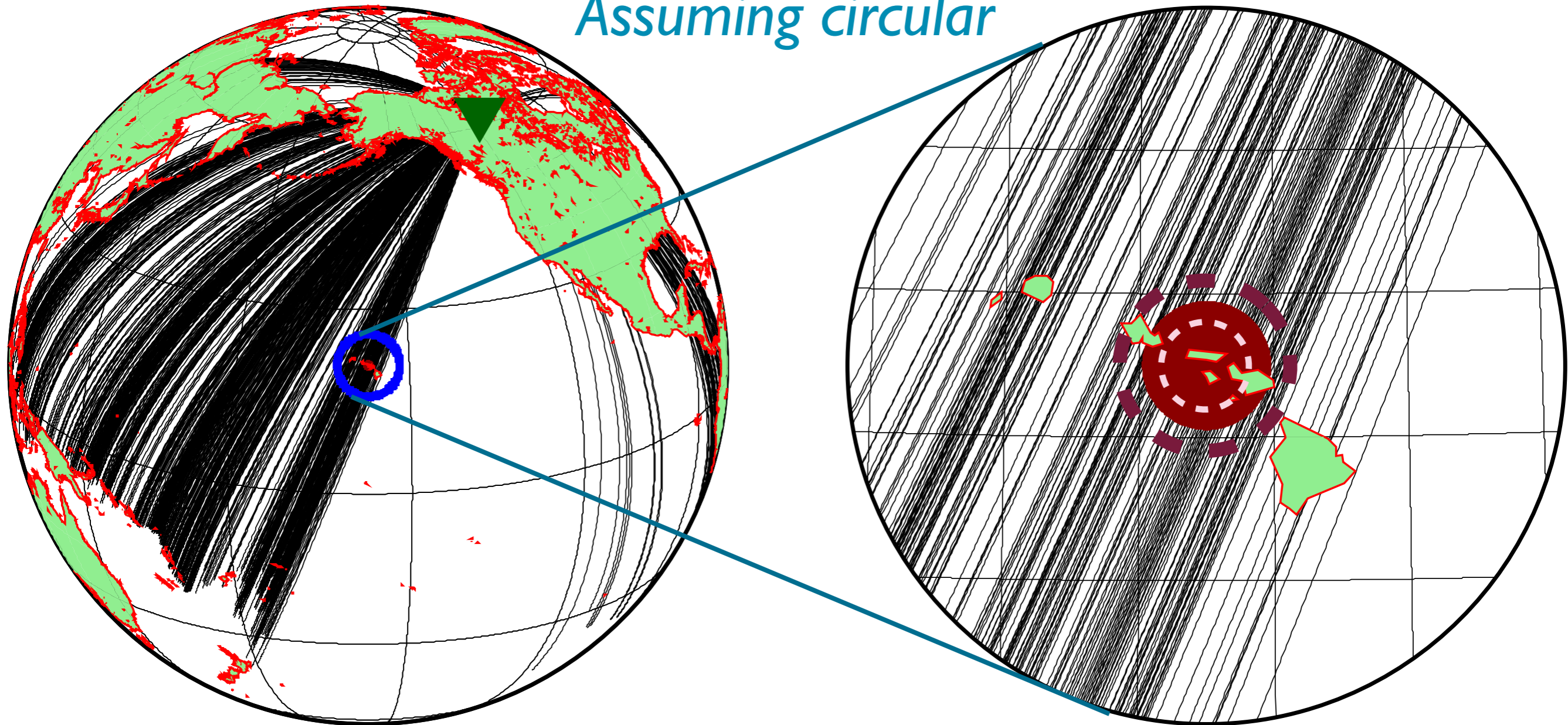
- Location
- Radius
- $V_P$
- $V_S$
- $\rho$



# Anomaly location and size

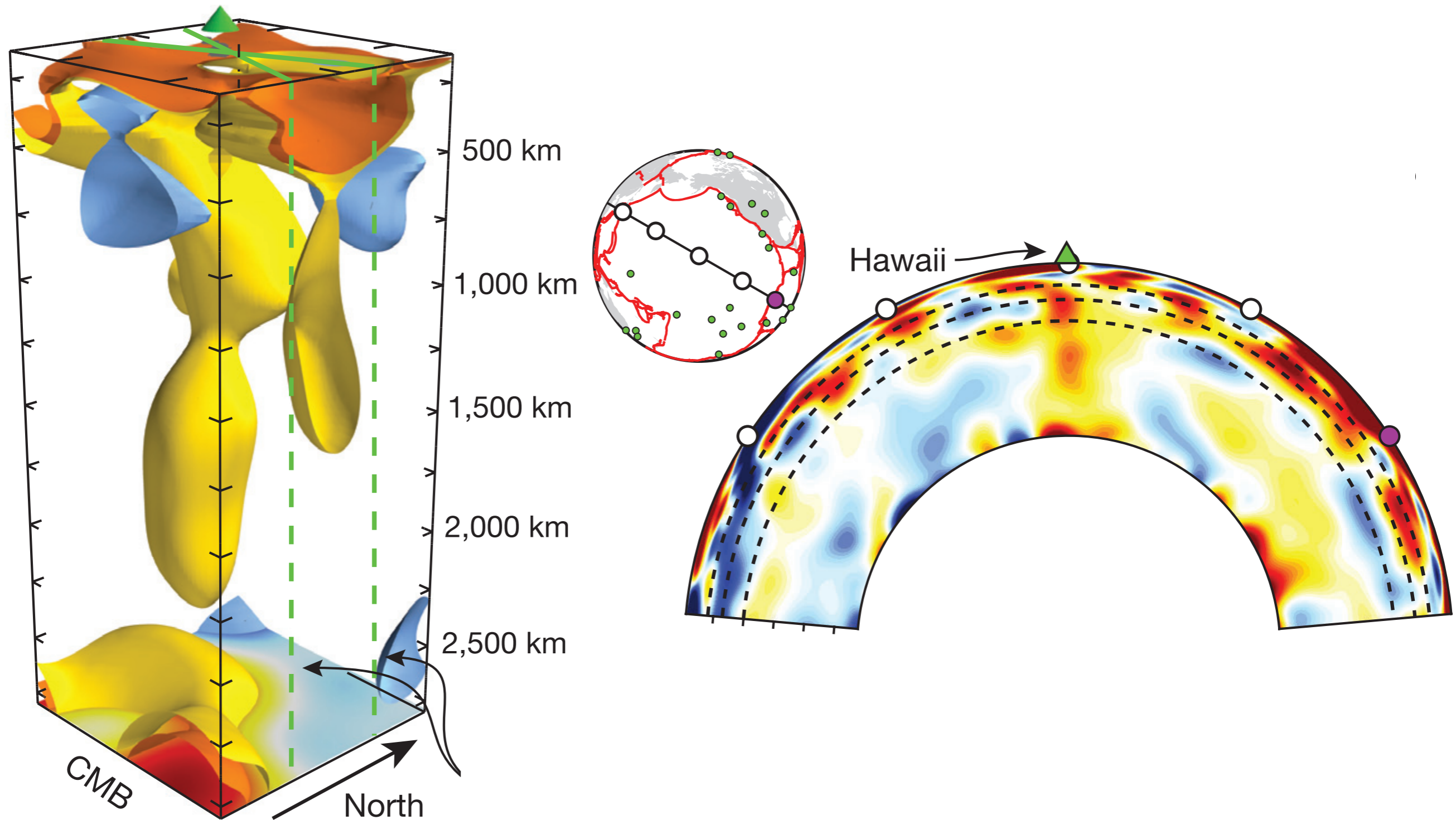
$$75 \text{ km} < r < 125 \text{ km} \quad -10 \% \geq \delta V_P > -5 \%$$

*Assuming circular*



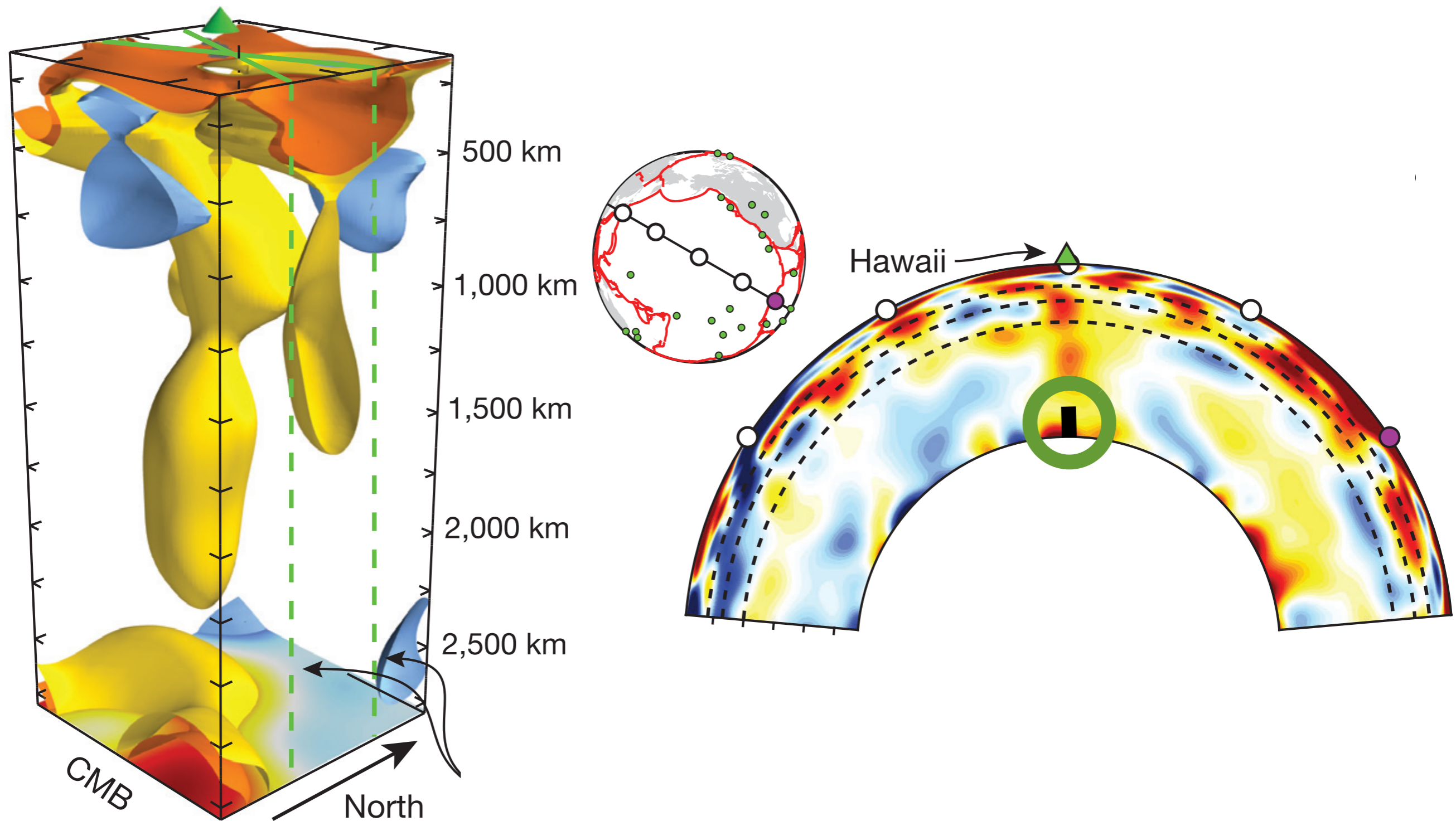
# Agreement with tomography

**a**



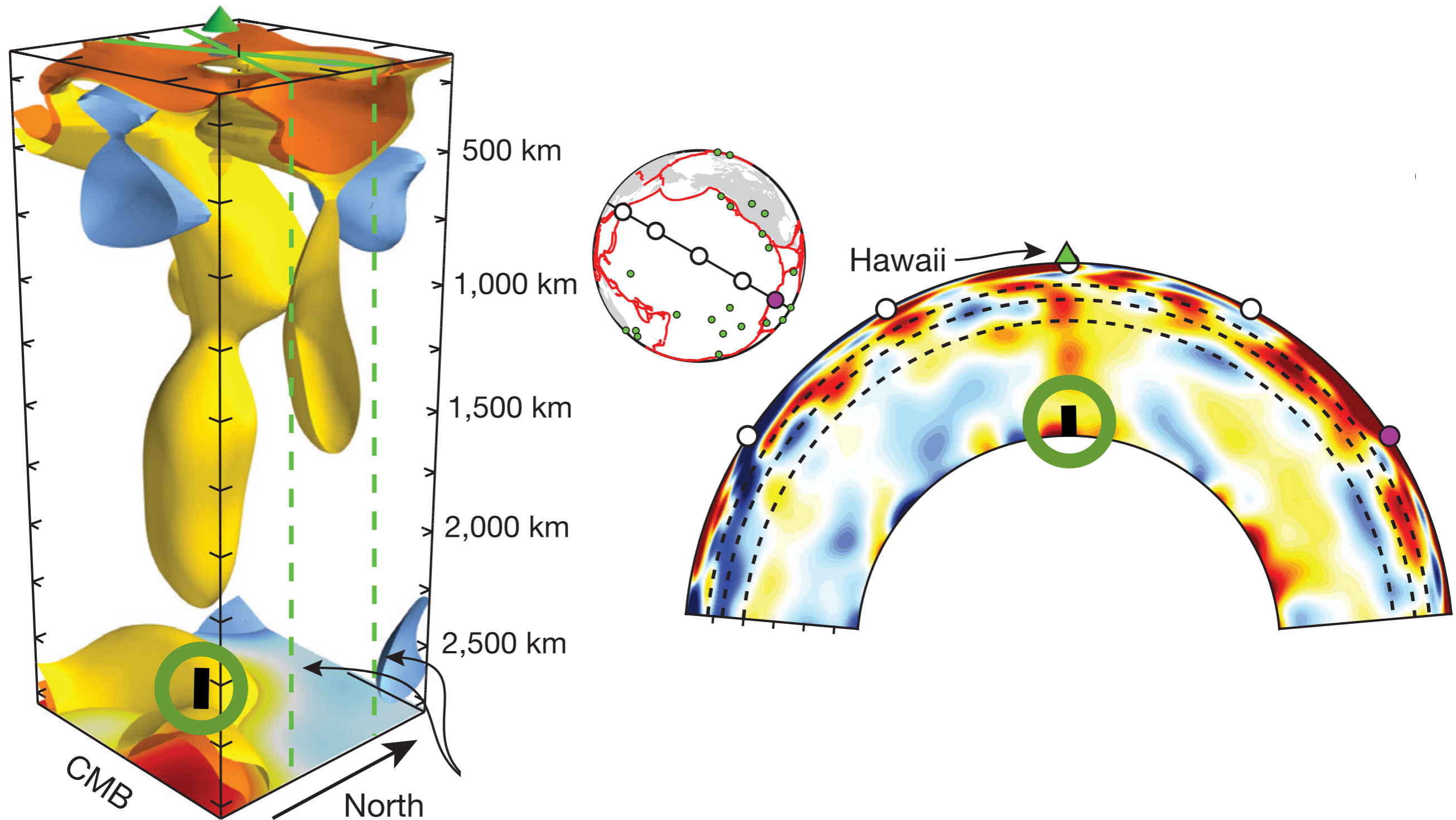
# Agreement with tomography

**a**

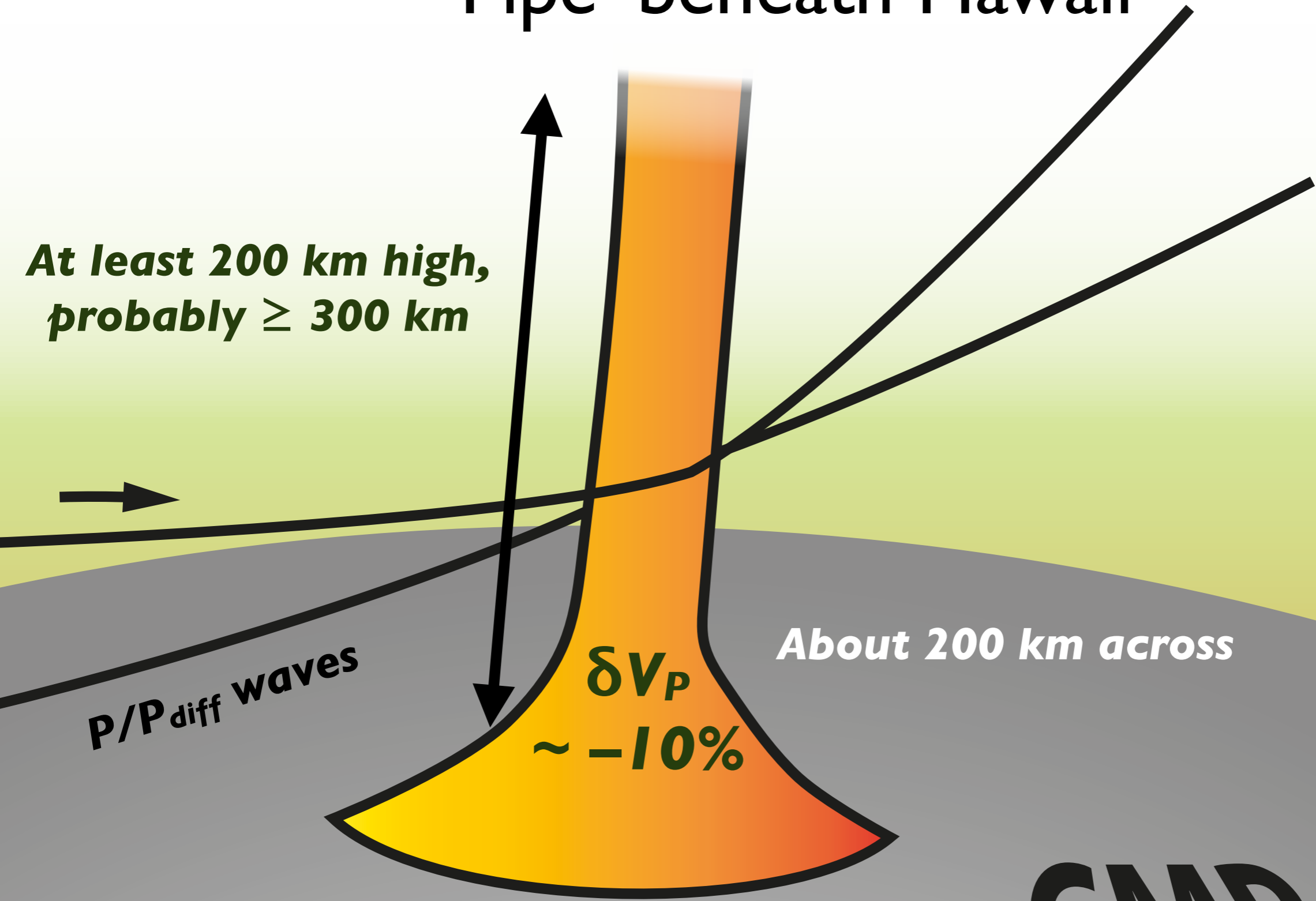


# Agreement with tomography

**a**



# 'Pipe' beneath Hawaii



At least 200 km high,  
probably  $\geq 300$  km

About 200 km across

P/P<sub>diff</sub> waves

$\delta V_P$   
 $\sim -10\%$

Shape at base?

**CMB**

Vertical exaggeration:  $\sim 3$



*finni*

# Cottaar 'unusually large ULVZ'

$r \approx 450 \text{ km}$     $\delta V_s \approx -20 \%$     $h \approx 50 \text{ km}$

*Assuming circular*

