Inner core anisotropy measured using new ultra-polar PKIKP data and corrected for Mantle structure.

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Introduction

The inner core is one of the most challenging regions of the Earth to study: high seismic attenuation, mantle structure and poor data sampling all influence seismic interpretations of inner core structure. Despite this we are still able to observe variations in seismic velocity in the inner core and can relate this to structure in the deepest region of our planet.

When the velocity of a seismic wave differs depending on the direction of wave propagation through a medium this is called anisotropy. Cylindrical anisotropy, where the fast direction is parallel to Earth's axis of rotation, was first observed in the inner core by Poupinet et al. (1983) and is thought to be caused by the orientation and shape of HCP or BCC iron in the inner core. This is related to how the inner core grew and formed.

The main difficulty with measuring the anisotropy in the inner core is the poor spatial sampling, It is difficult to measure anisotropy reliably due to a lack of polar paths (phases that travel nearly parallel to Earth's axis of rotation). To overcome this poor sampling we have collected the largest known data set of ultra-polar paths to better resolve the fast direction of Anisotropy in the inner core.

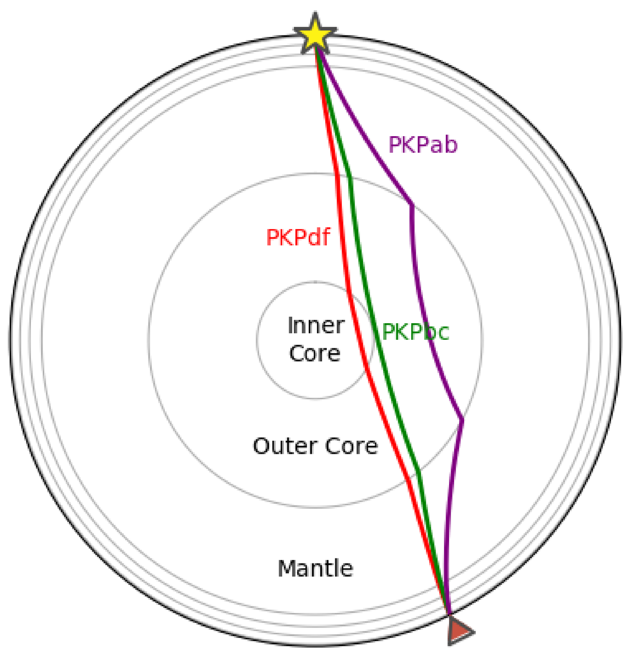
Conclusions

- ◆Overall inner core anisotropy is 1.9-2.2%.
- ◆There are longitudinal variations with a western hemisphere with 2-4% Anisotropy and an eastern hemisphere with little or no anisotropy.
- ◆Mantle corrections and raypath corrections are essential for removing small scale mantle heterogeneity
- ◆There is a clear inner most inner core with 3% Anisotropy and a radius between 690-750km

Future Steps

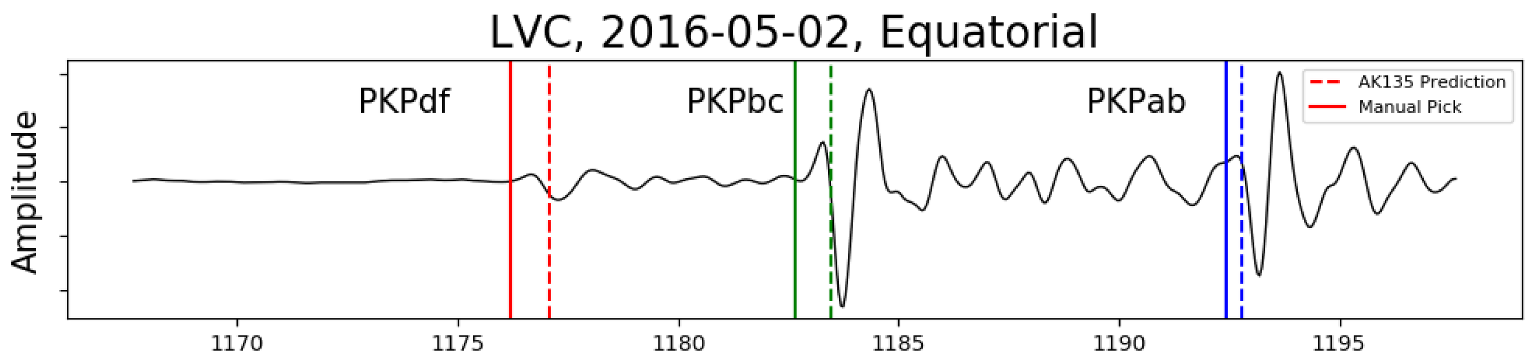
- ◆I want to measure inner core anisotropy from normal modes (whole Earth oscillations) providing a further observation type to constrain my models
- ◆Full waveform analysis of raypaths to further investigate mantle effects on these paths.
- ◆I will do a transdimensional inversion so that the data can parameterize my model

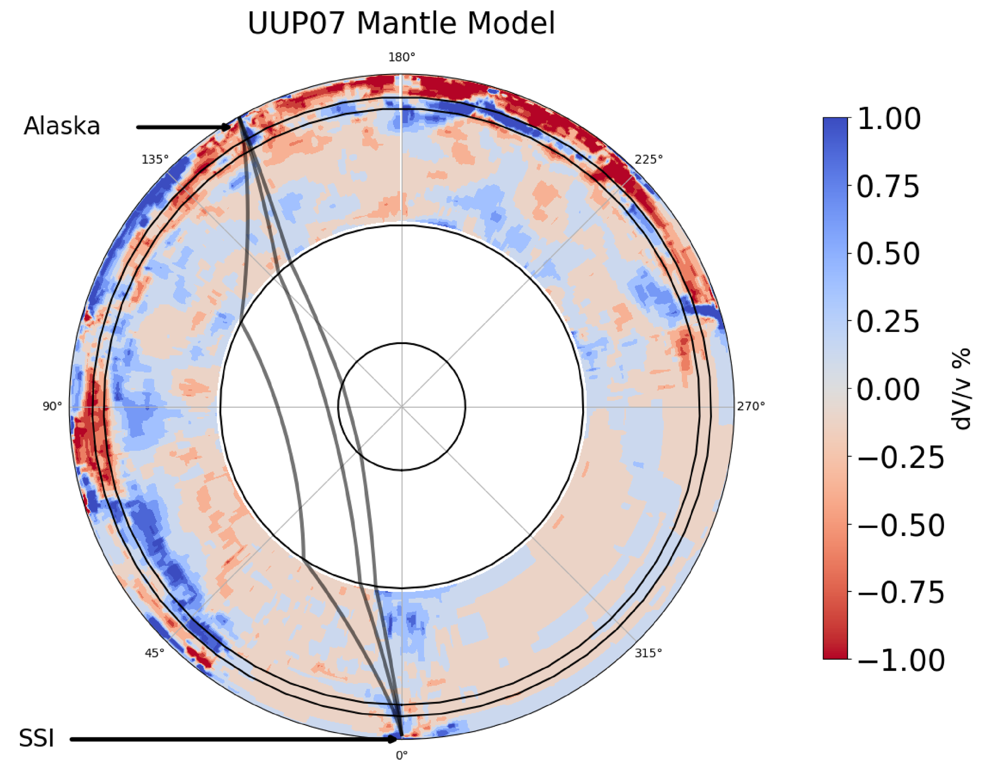
Methodology & Results



Raypaths and Arrival Times

- ◆We use differential arrival times to measure the fractional velocity of the inner core
- ◆I have collected a high quality data set of 2183 event station pairs providing measurements of the arrival times of PKPdf, PKPab and PKPbc phases
- ◆We can then calculate the differential arrival time between the PKPdf phase, which samples the inner core, and the PKPab and PKPbc phases which sample the outer core and mantle, giving an estimate of inner core velocity for that path



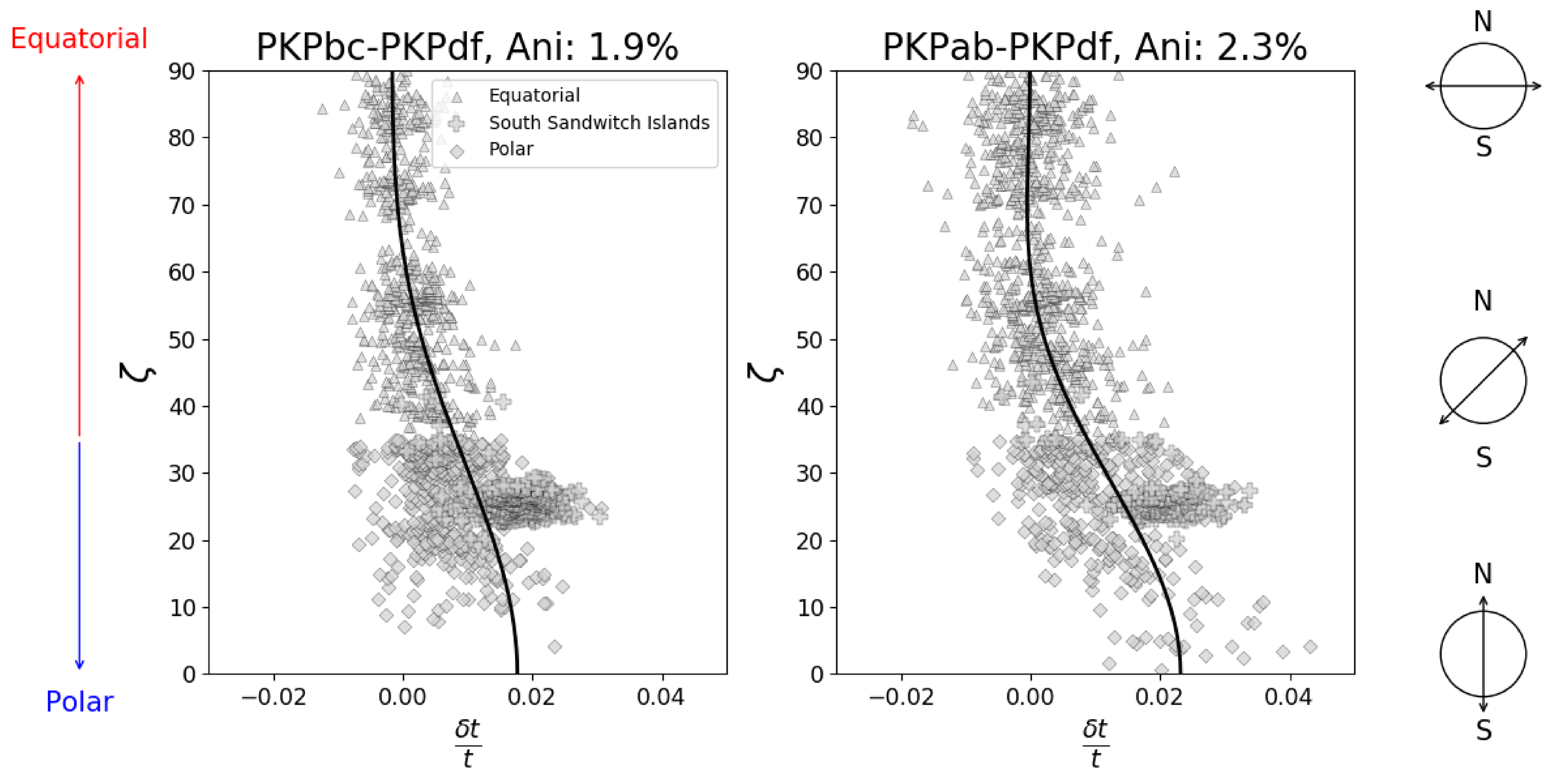


Mantle & Raypath Corrections

- ◆Eqn. 1 (Creager 1999) shows how we can calculate fractional travel time from differential arrivals.

$$\frac{\delta t}{t} = \frac{(\mathrm{PKP_{bc}} - \mathrm{PKP_{df}})_{\mathrm{data}} - (\mathrm{PKP_{bc}} - \mathrm{PKP_{df}})_{\mathrm{AK135}}}{t} \quad (1)$$

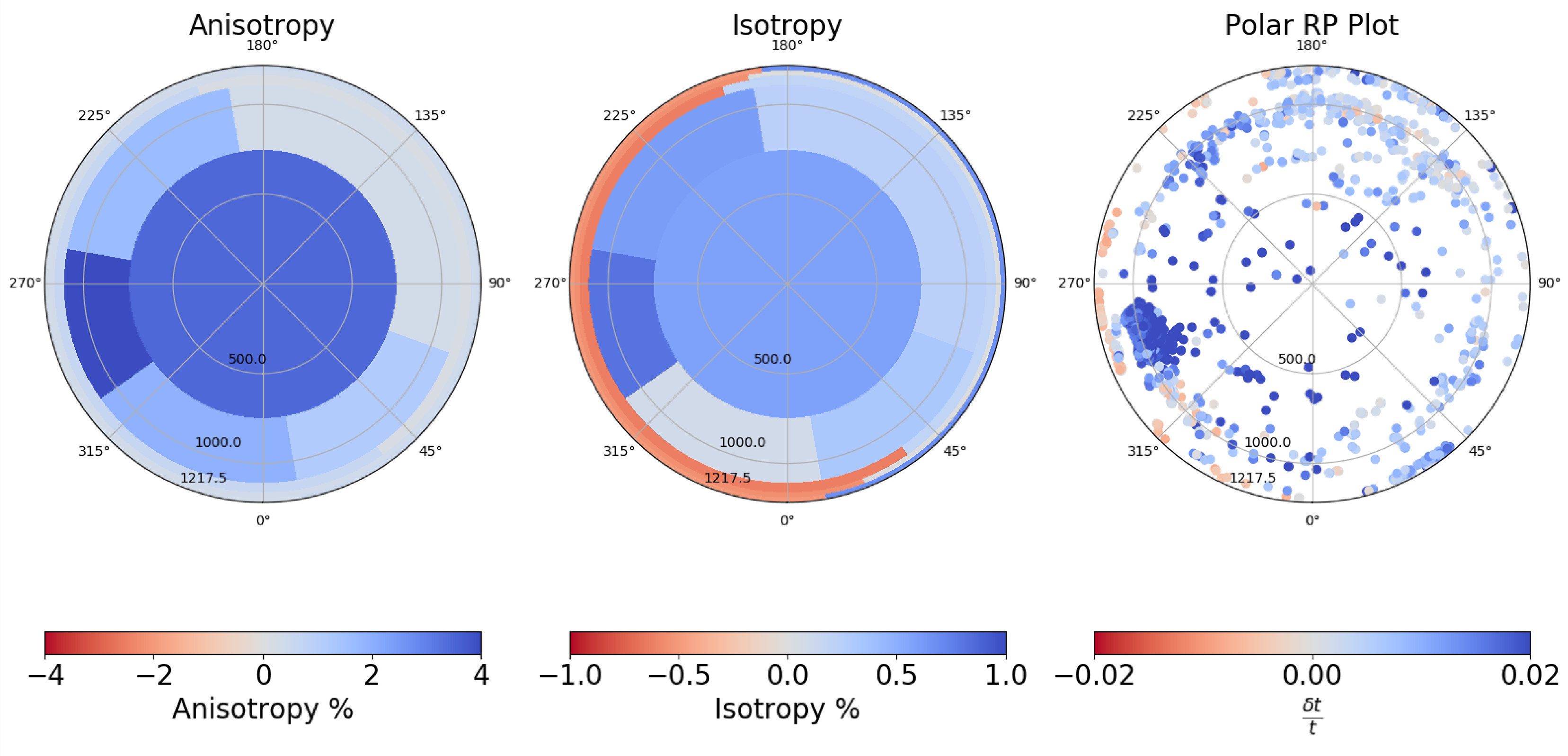
- ◆While the differential arrival times remove most of the error associated with source location and mantle structure, fine scale mantle structure can still affect the PKPbc, PKPab and PKPdf phases heterogeneously
- ◆This results in mantle structure being misinterpreted as inner core structure
- ◆To solve for this we use the UUP07 P-wave tomographic model to further correct for mantle structure resulting in more accurate differential travel time measurements
- ◆We also correct for changes in the raypath within in the inner core which can amplify both positive and negative anomalies
- ◆This reduces the misfit in our data and decreases the large positive anomaly of the data from the South Sandwich Islands to Alaska ray paths



Measuring Anisotropy

- ◆ζ is the angle between the PKPdf raypath in the inner core and Earth's axis of rotation
- ◆Paths with a ζ = 90 are equatorial and paths with ζ = 0 are polar (traveling parallel to the Earth's rotation axis).
- ◆Comparing δt/t with ζ it can be seen that velocities increase as ζ decreases.
- ◆By fitting Eqn 2 to our data we can solve for the love parameters which describe cylindrical anisotropy
- ◆Our measurement of inner core anisotropy is better than previous measurements due to our high numbers of ultra polar data (ζ<20)

$$\frac{\delta t}{t} = \frac{\delta v}{v} = a + b\cos^2(\zeta) + c\cos^4(\zeta) \quad (2)$$



Inverting for Inner Core Structure

- ◆We use a damped least squares inversion to solve for the a, b and c parameters for manually defined volumes of the inner core.
- ◆The figures on the left are slices through the equatorial plane of our models
- ◆There is structural variations with longitude and depth: we find that there are hemispheres in the inner core with high anisotropy (2%-4%) in the west and low or no anisotropy in the east
- ◆We also find that there is an inner-most-inner core with 3% anisotropy and a radius of 750-690 km..

References
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