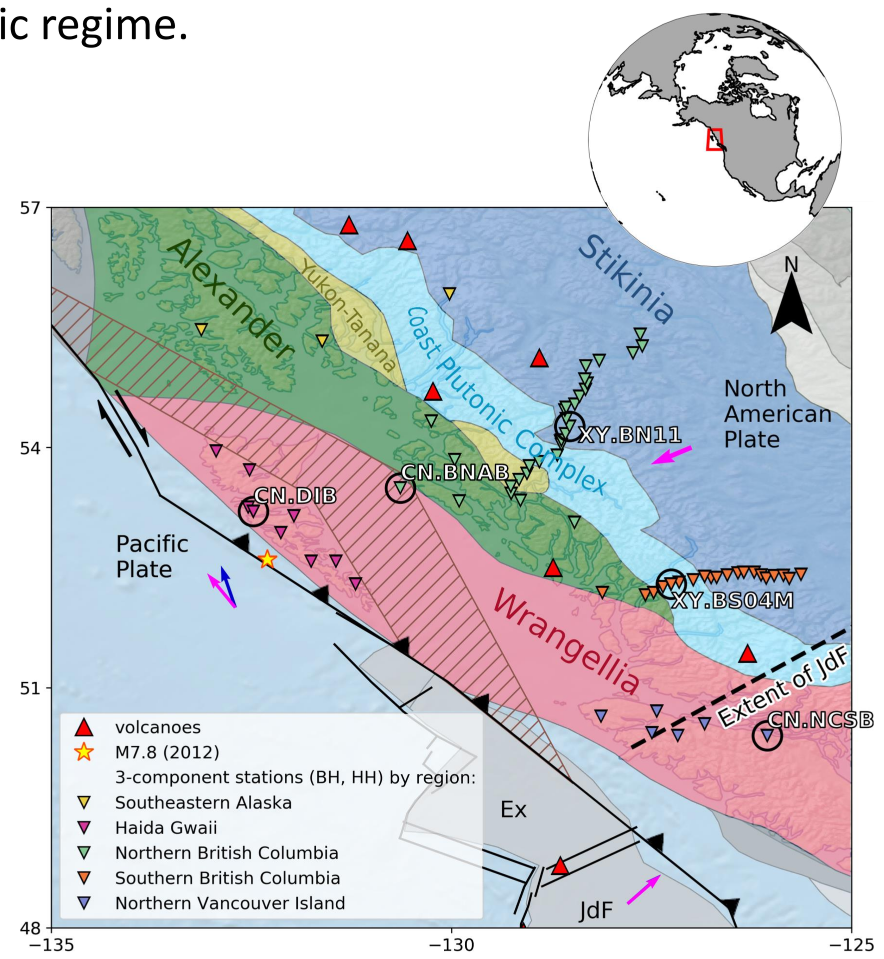
Tectonic fabric along the Haida Gwaii margin from receiver function analysis

Taylor Tracey Kyryliuk[1], Pascal Audet[1], Jeremy Gosselin[2], Andrew Schaeffer[3]
[1]Department of Earth and Environmental Sciences, University of Ottawa, Canada
[2]Department of Geosciences, University of Calgary, Canada
[3]Geological Survey of Canada, Natural Resources Canada, Canada

Introduction

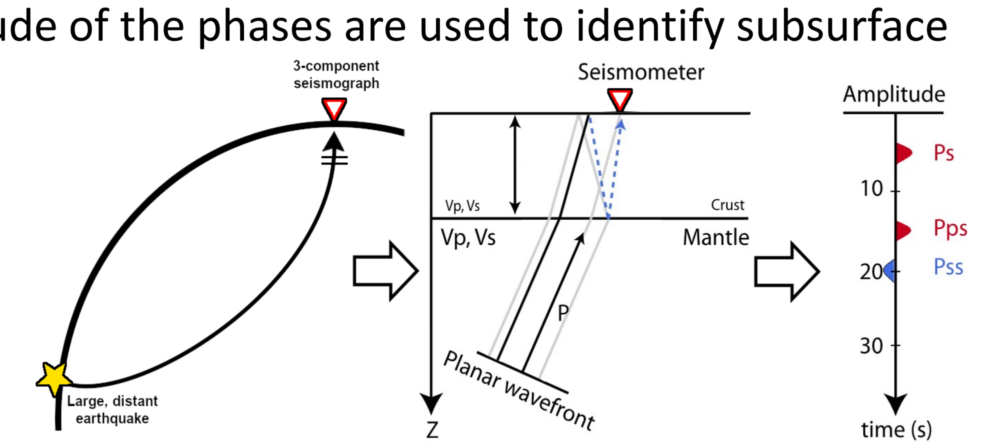
Coastal British Columbia is Canada's most seismically active region. Could it be the future epicentre of a tsunami triggering megathrust earthquake? The presence of two subducting plates in the region poses this risk. Our goal is to identify seismic anisotropy in the region to better constrain the subducting plates and understand the past and current tectonic regime.



The map above shows the study area, characterized by a collage of geomorphologically unique margin-parallel terranes. Terranes are colour coded and labelled. The Pacific (PA) plate subducts obliquely beneath North America (NA) and terminates in a triple junction in the south with the Explorer (EX) microplate. The brown hatched polygon indicates the range of the possible landward extent of the PA slab. Further south, the Juan de Fuca (JdF) plate subducts beneath NA. Arrows indicate the relative plate motions: relative to a global hotspot (pink), relative to NA (blue). The yellow star indicates the epicentre of the Haida Gwaii earthquake which had a thrust component.

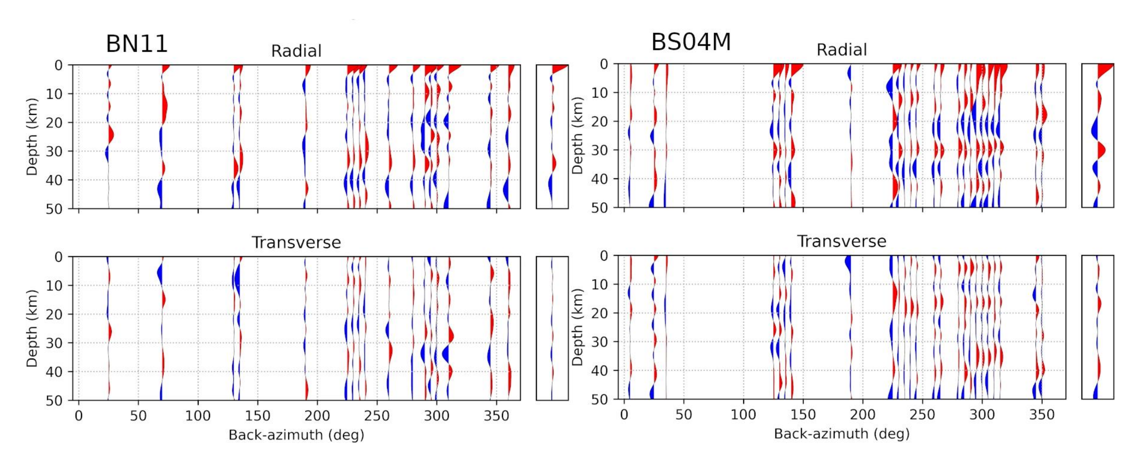
Methodology

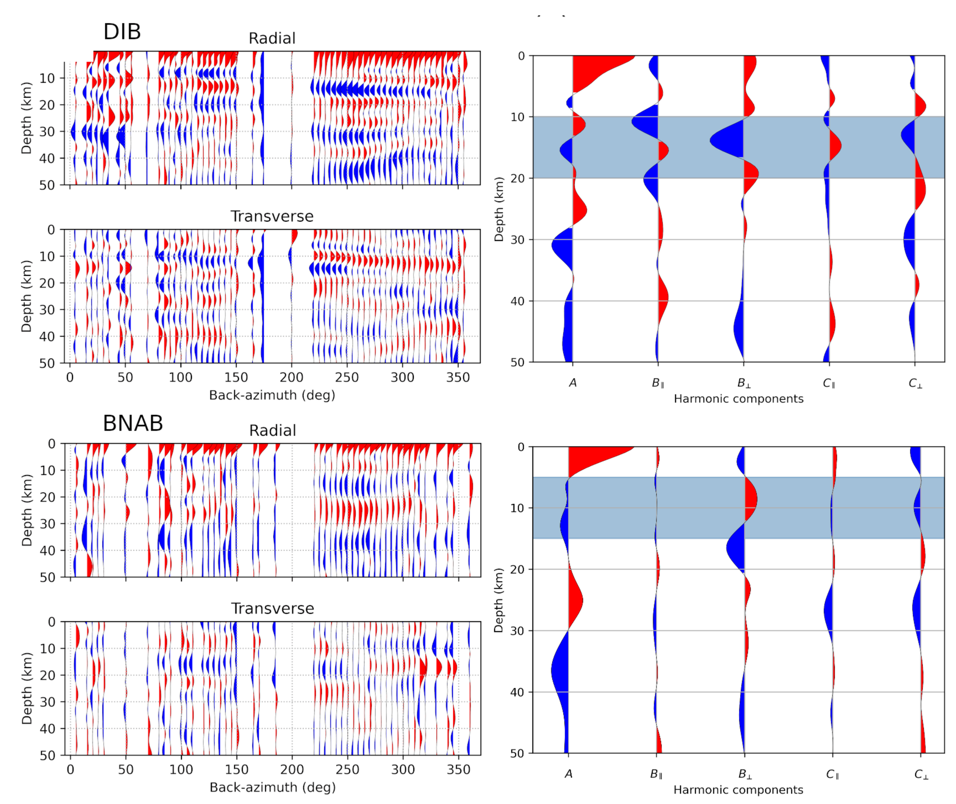
We use a network of 74 3-component broadband seismic stations. We calculate receiver functions (RF) using the P to S conversions of teleseismic body waves created by velocity contrasts beneath a station (as illustrated below). The timing and amplitude of the phases are used to identify subsurface structure.



Methodology

RFs are migrated from time to depth, binned by back-azimuth and plotted. The presence of energy on the transverse component of a RF indicates the presence of seismic anisotropy.





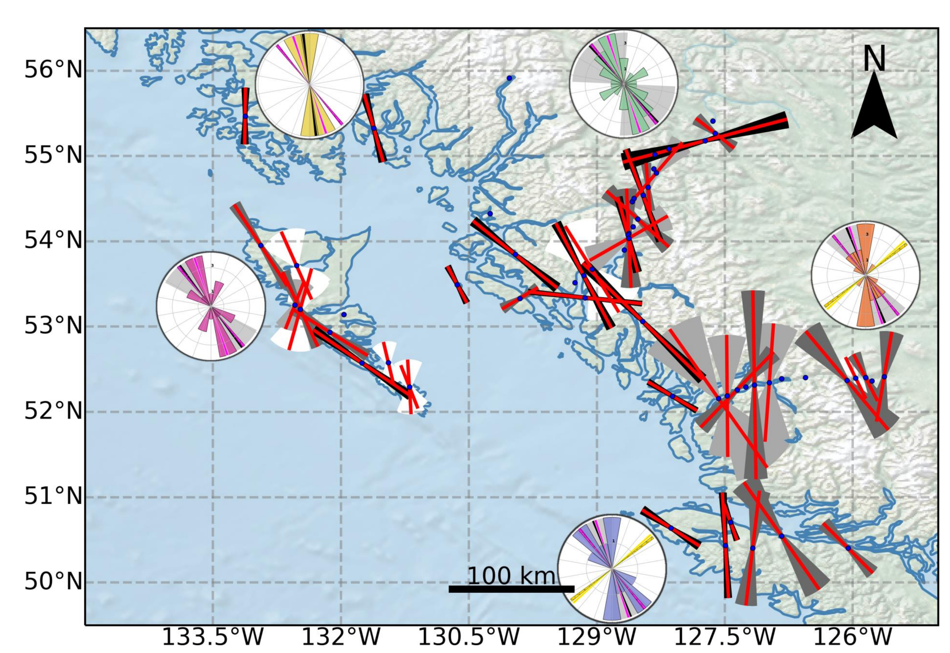
The surrounding figures show RF calculated for stations with both good (DIB, BNAB) and poor (BN11, BS04M) azimuthal coverage.
Evidence of seismic anisotropy was found beneath all stations in the study (see transverse components).

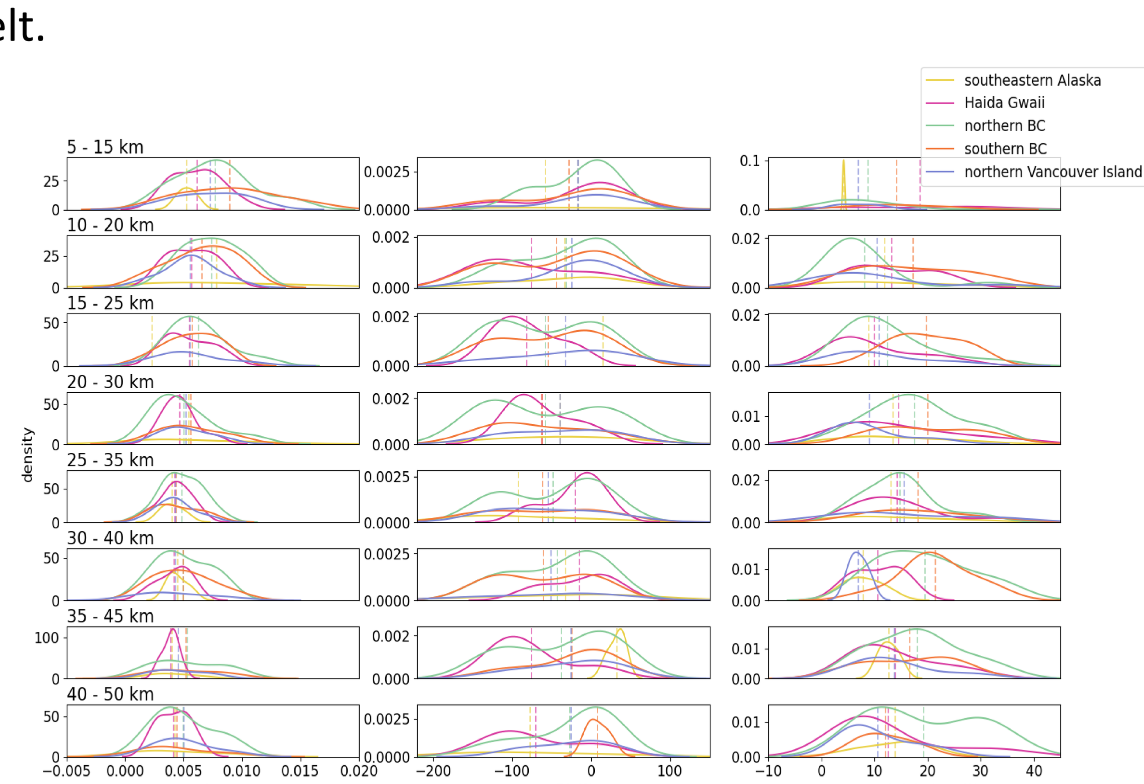
RFs are decomposed into back-azimuth harmonics. The first-order harmonic corresponds to seismic anisotropy arising from dipping structures and/or material anisotropy with a plunging axis of hexagonal symmetry.

Optimizing the first-order harmonic for a specified depth range yields the azimuth of the strike of a dipping interface or the trend of material anisotropy. Examples are shown on above figure (far right) for stations DIB and BNAB optimized for the highlighted depth ranges.

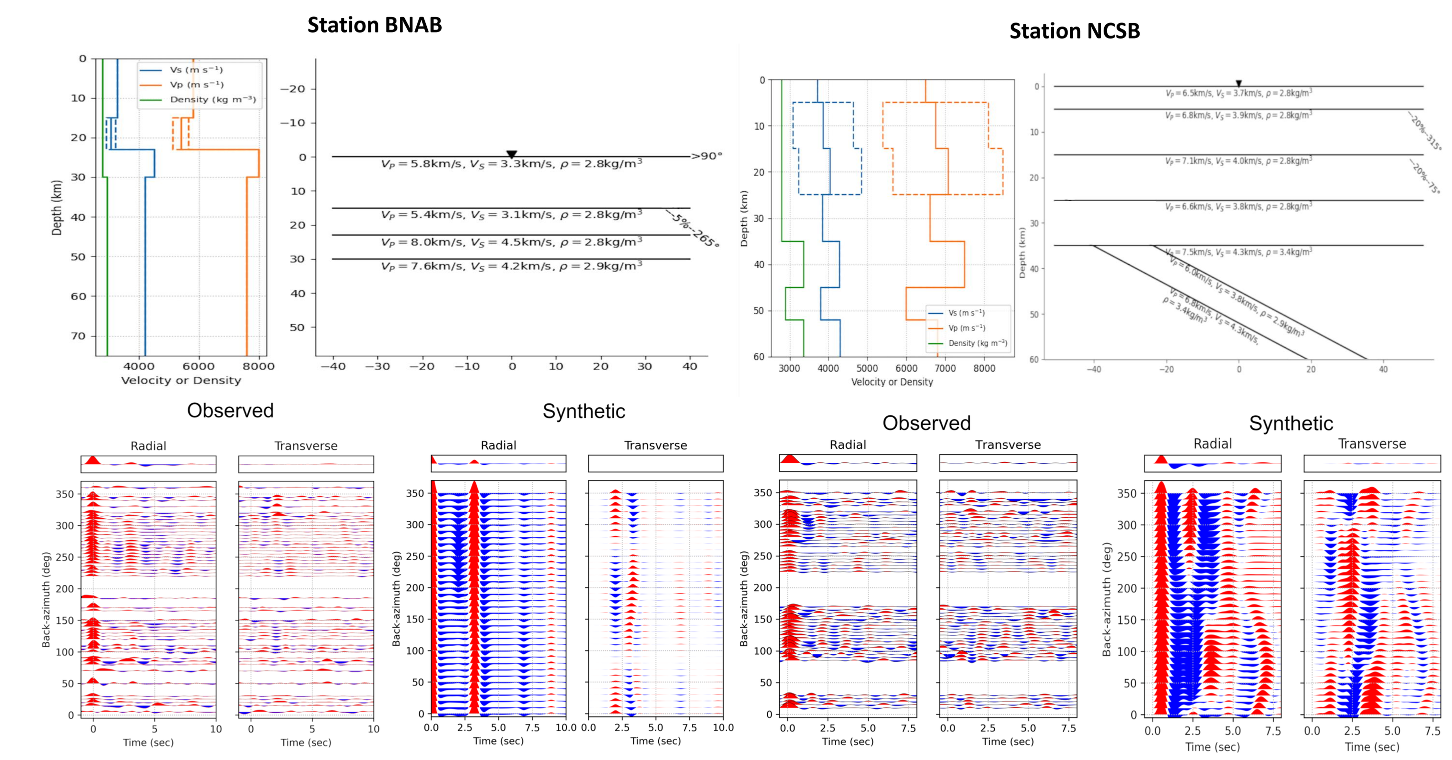
Discussion

Dominant RF orientations align with the strike of subduction zone margins below Haida Gwaii and in agreement with the extent of the JdF. Margin-parallel orientations along eastern Alexander terrane reach Moho depths in agreement with a historical thrust belt.





The above left figure shows the 5 – 15 km depth range. The average dominant RF orientations are coherent but rotate slightly from southeast to northwest. These patterns do not align with stress measurements, we attribute them to mineral alignment caused by the tectonic history and overprinted by the current tectonic regime.



The results from the harmonic decomposition are used to create seismic velocity models and produce synthetic RF. We compare these to our observations for stations BNAB and NCSB. The model for BNAB, with a low velocity layer of anisotropy in the mid-lower crust is a good fit to the observations. The model for station NCSB, which lies above the subducting JdF is more complex and also contains multiple layers of anisotropy. The fit of this model is close to the observations.

These models help to support our interpretation of our findings.

Conclusions

- There is a coherent pattern in dominant RF orientations at shallow depths
- We see evidence of dipping structures beneath Haida Gwaii and Vancouver Island, but not beneath the northernmost stations on Vancouver Island.
- Seismic anisotropy is widespread in the region and pays homage to the complex geological history of the region + the current tectonic regime.
- The observed RF can be explained by seismic velocity models with dipping interfaces and material anisotropy.

References

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