

High Resolution Seismic Velocity Model beneath North Chile from Full Waveforms Inversion

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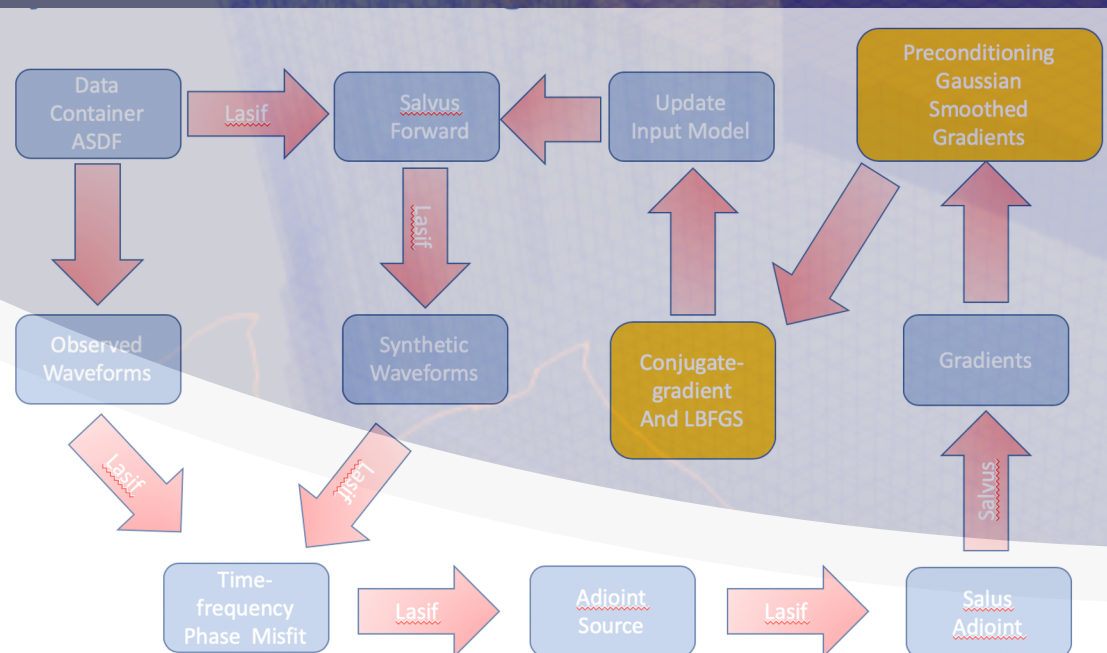
Freie Universität Berlin

Package introduction

Salvus: Salvus is a suite of spectral element method software performing full waveform modelling and inversion, developed by *Seismology and Wave Physics* group, ETH Zürich

Lasif: Lasif (Large-scale Seismic Inversion Framework) is a data-driven workflow tool to perform full waveform inversions, developed by *Seismology and Wave Physics* group, ETH Zürich

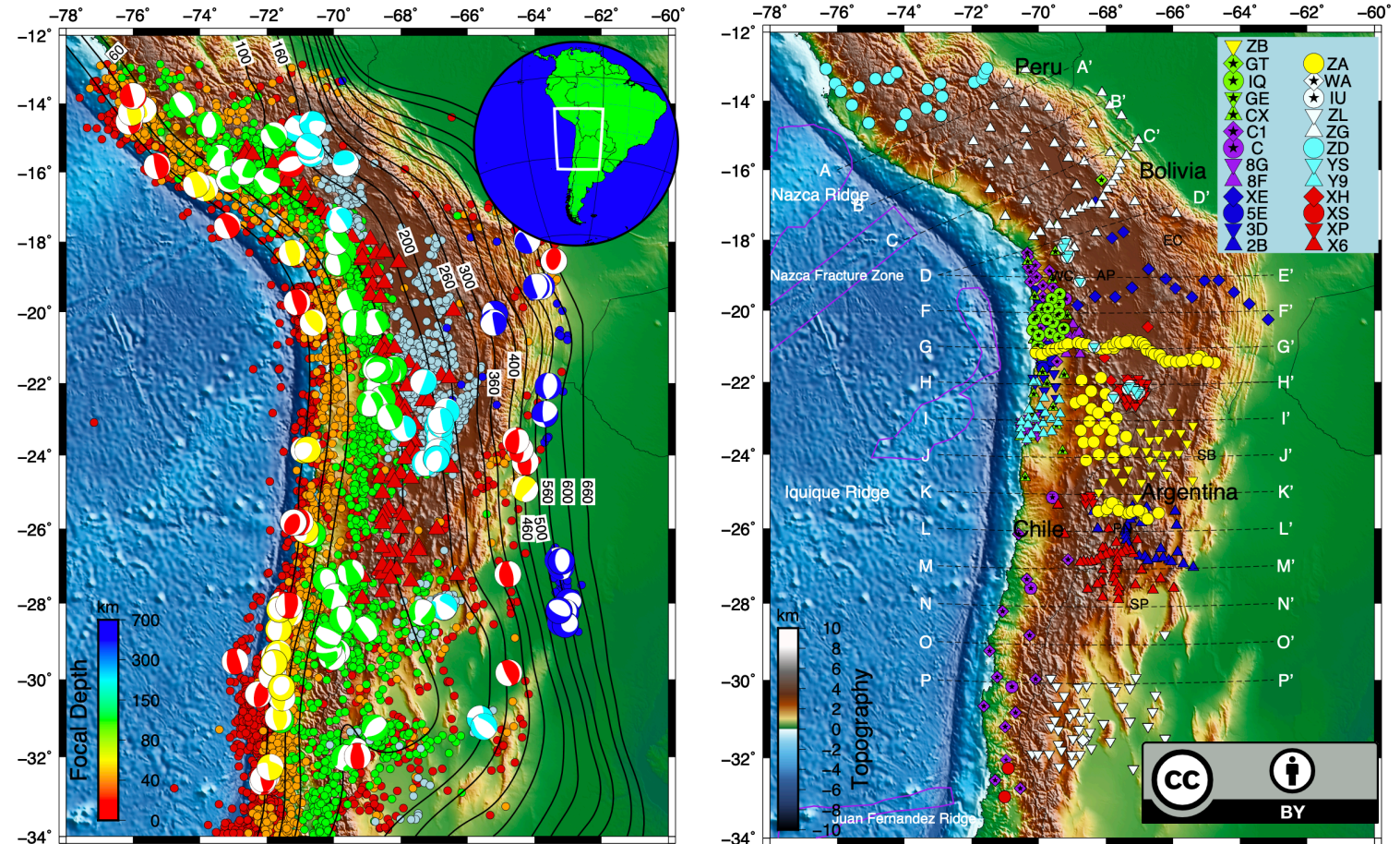
Pyflow: python scripts and notebooks for model updates and gradients processing (to be improved and adapted to new Salvus)



DATA

- Seismic displacement waveforms excited by 117 earthquake events ($5.0 < M_w < 7.0$) and 30 events for validation of model

All the data are retrieved from Geofon and IRISDMC data center through FDSN

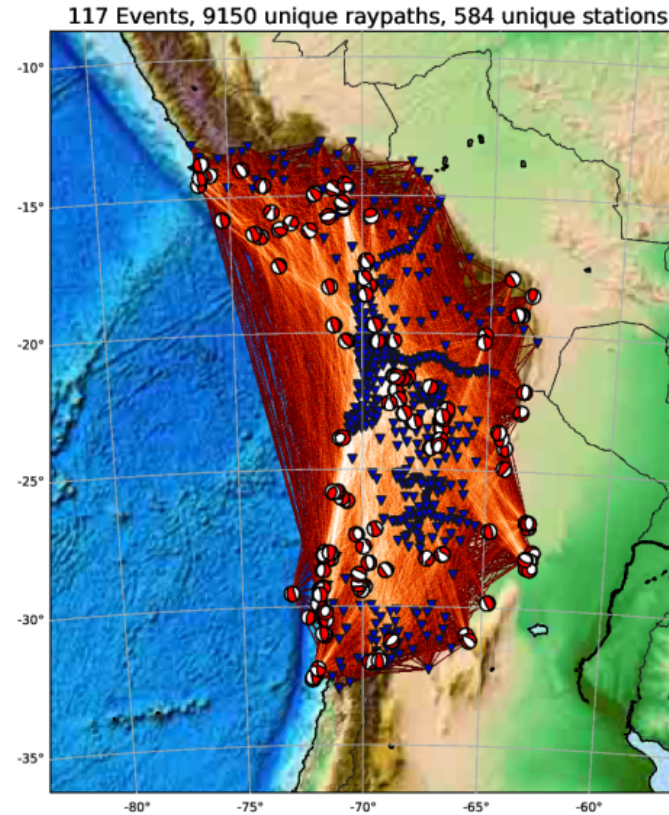


(a) Map showing seismicity (Magnitude > 2.5) and Nazca slab depth contours. The background is the topography of Central Andes. Slab contours are retrieved from the Slab2.0 global subduction zone model (Hayes et al., 2018), seismicity data are retrieved from 1991 to 2019, U.S. Geological Survey-National Earthquake Information Center (NEIC) catalogue (<https://earthquake.usgs.gov/earthquakes/search/>). The red, yellow, green, blue and purple dots represent 0-40 km, 40-80 km, 80-150 km, 150-300 km and over 300 km depth earthquakes, respectively. The Beachballs indicates the earthquakes for the full waveform inversion in this study. (b) Map showing seismic station locations for individual networks used in the study

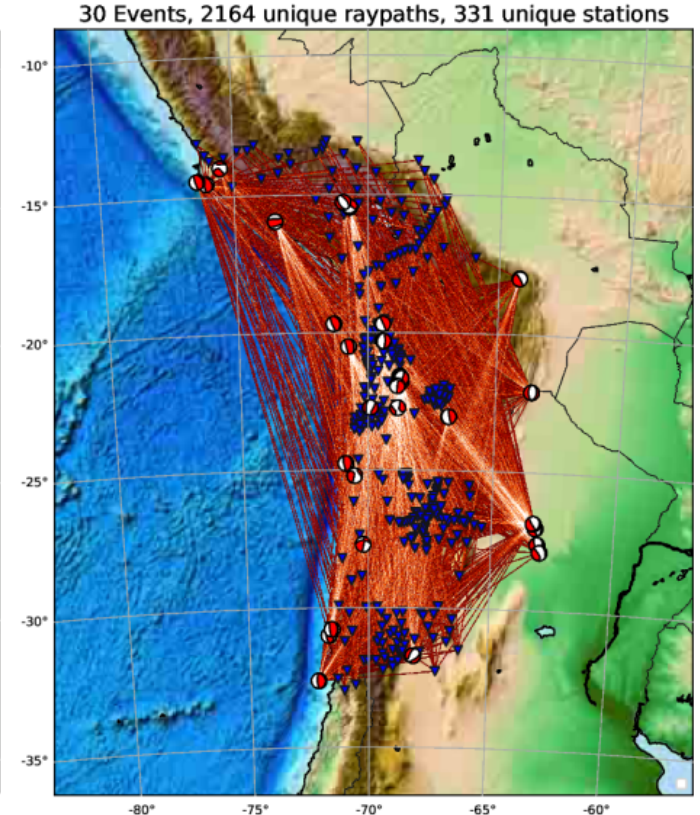
Ray Path Deployment

- The inversion data is applied to image the structure beneath our study domain.
- The validation dataset is also simulated to guarantee the correct misfits evolution.

Inversion



Validation

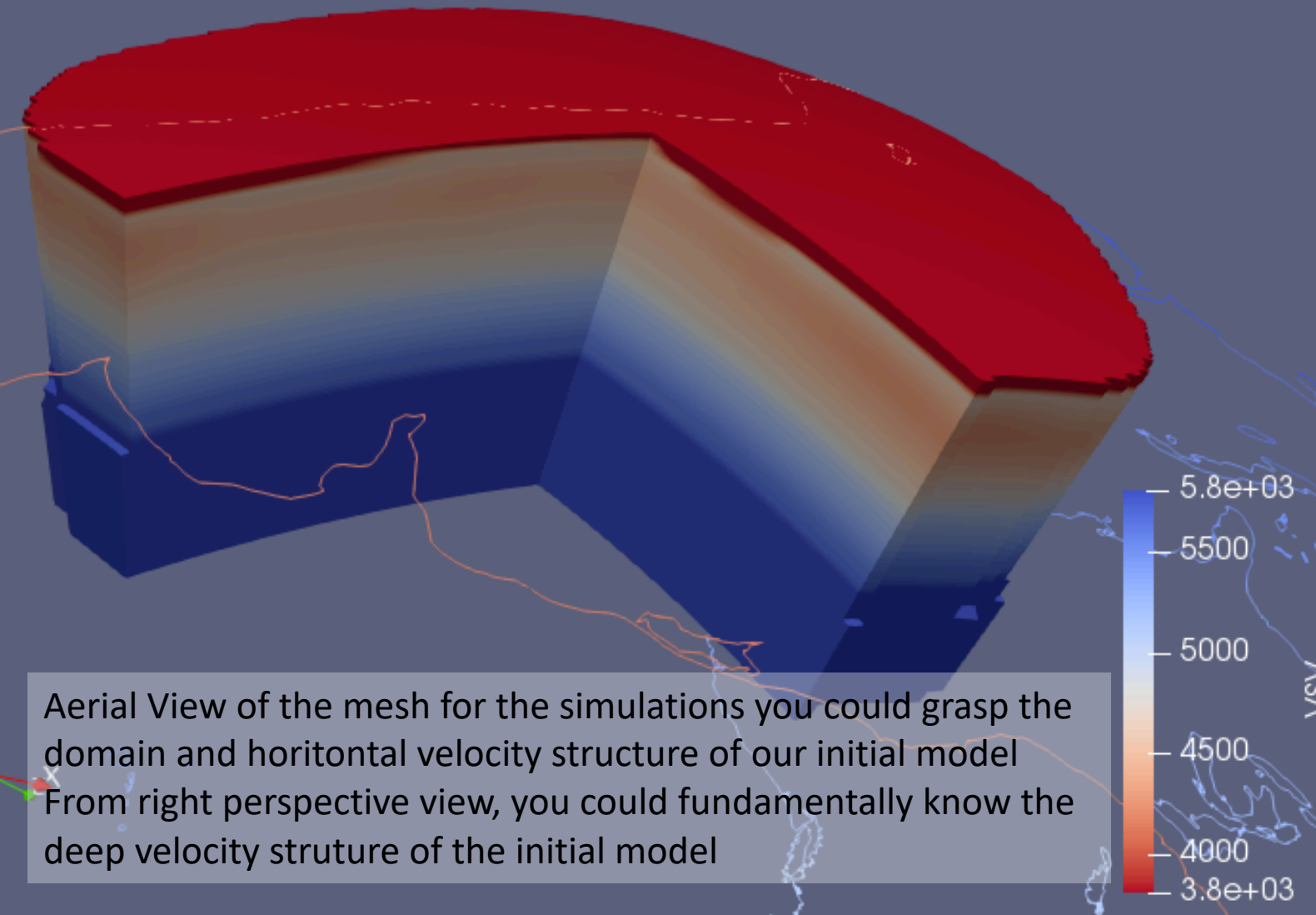
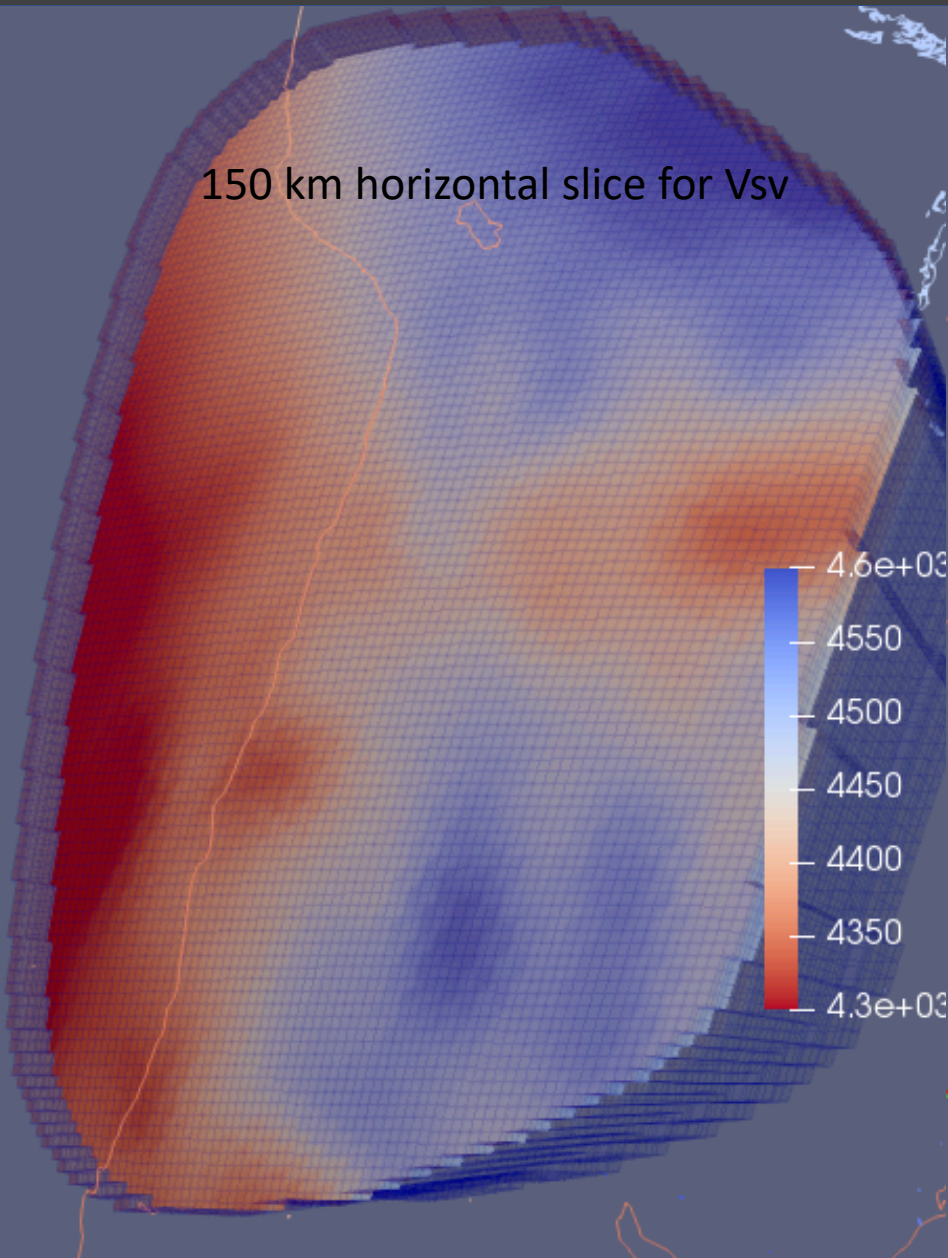


Finite Element Mesh



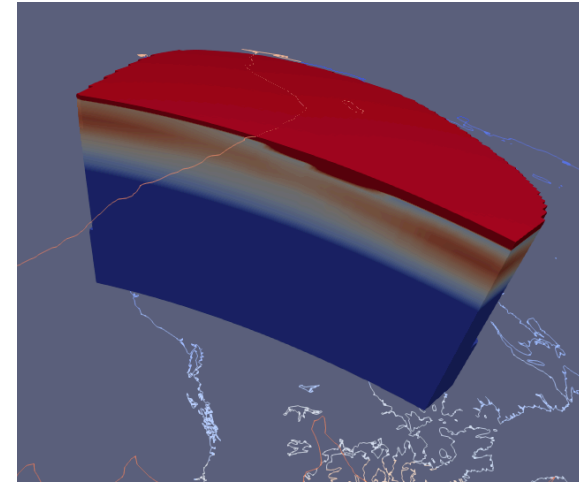
24° S and 70° W cross section clip for Vsv

150 km horizontal slice for Vsv

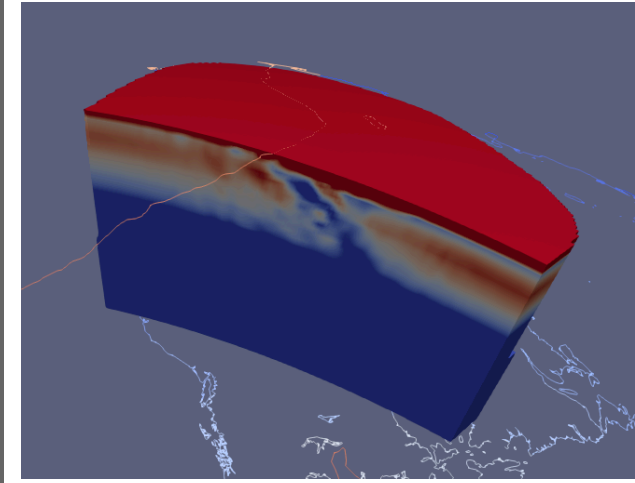


Aerial View of the mesh for the simulations you could grasp the domain and horizontal velocity structure of our initial model
From right perspective view, you could fundamentally know the deep velocity structure of the initial model

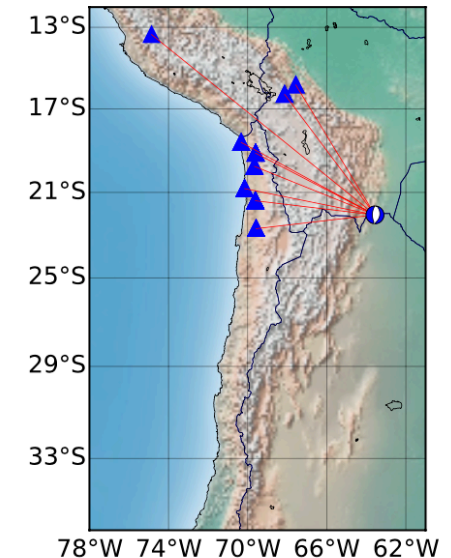
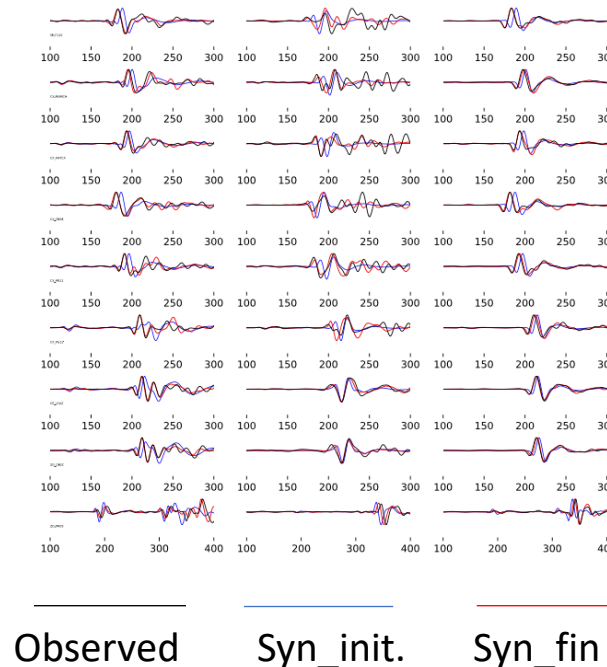
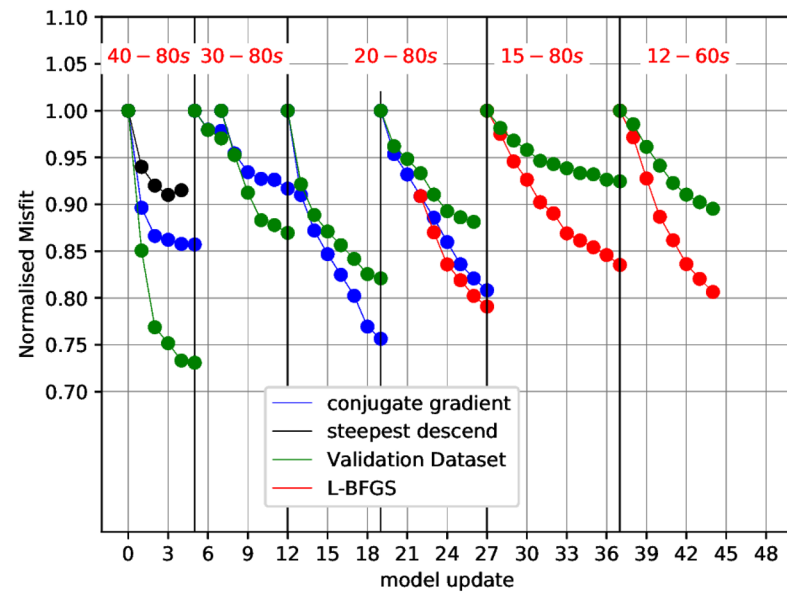
- For the 40-80s, 30-80s, 20-80s and 15-80s branches, the waveforms misfits with adjoint sources defined by time-frequency phase shift (Fichtner, 2010) .
- For the 12-60s branch, none shift cross-correlation coefficient is applied for misfits and adjoint sources calculations(Tao et al., 2017)

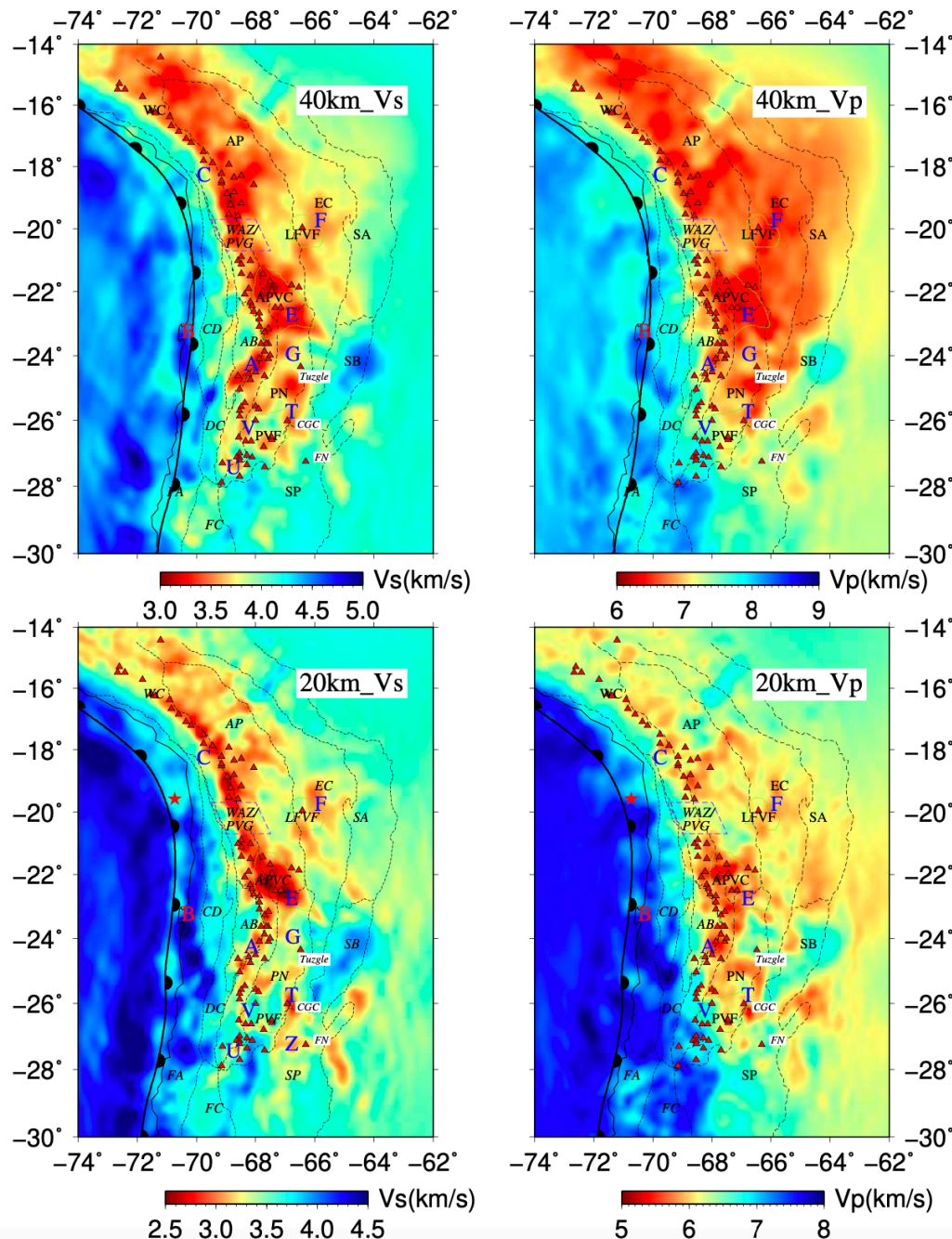


Initial model preview



Final model preview





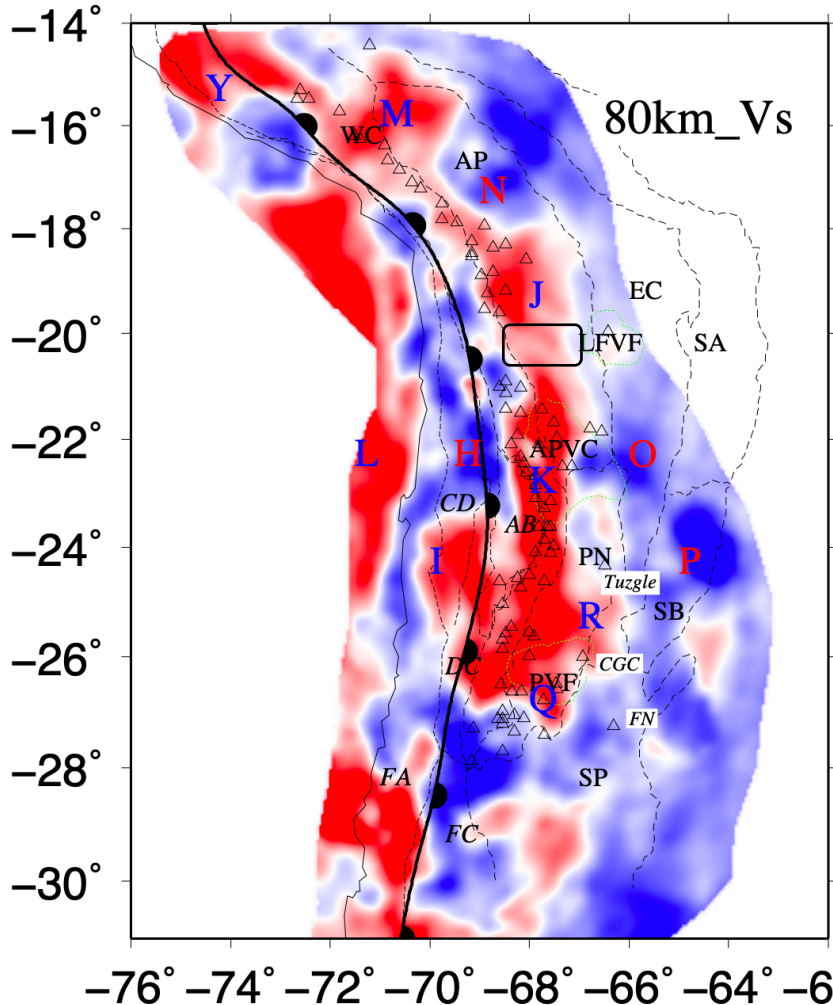
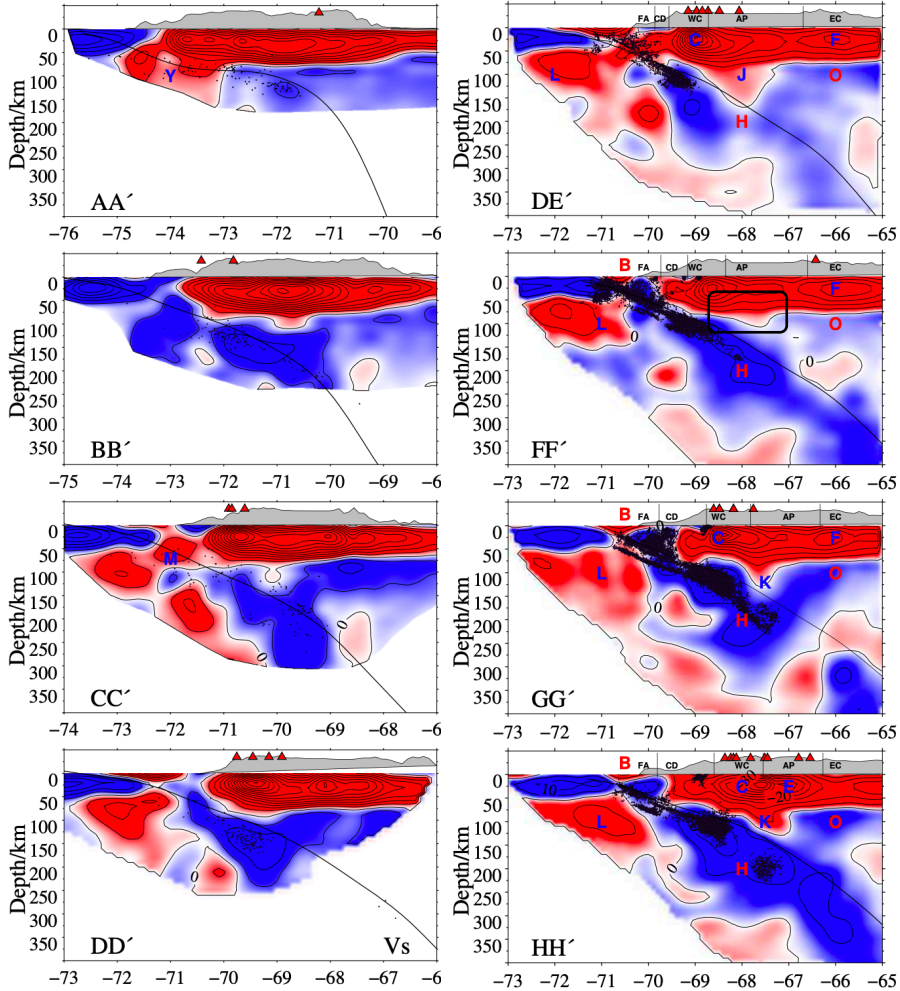
A striking low velocity band extending from South Peru along the Central Andes to Central Chile and Argentina, basically along the track of the volcanic arc, representing the partial melting of the middle crust and reaching the extreme beneath the Altiplano-Puna Volcanic Complex (APVC) and escaped from the Atacama Basin(AB). Also, there is a relatively weak zone from 20° S-21° S we marked as WAZ, which collocate with the Pica Volcanic Gap (PVG).

Weak but complicated low velocity anomalies beneath South Puna accompanied by volcanoes, such as Tuzgle, Cerro Galan Caldera (CGC) and Farallon Negro (FN)

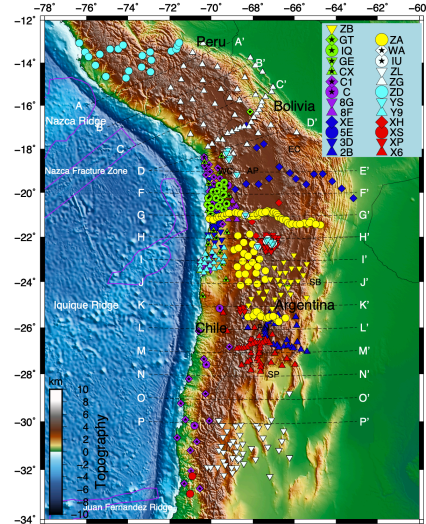
Horizontal sections from the tomography model for depth 20 km and 40 km. The black dots represent the crustal seismicity relocated from (Sippl et al., 2018), the red triangles indicate the modern volcanoes. The thin dashed lines divide our study region into several tectonic units, including Forearc (FA), Central Depression (CD), Domeyko Cordillera(DC), Atacama Basin(AB), Frontal Cordillera (FC), Western Cordillera (WC), Altiplano(AP), Eastern Cordillera (EC), Puna(PN), Subandean Zone(SA), Santa Barbara system(SB) and Sierras Pampeans(SP), the green outlines mark the locations of Los Frailes volcanic Arc Field(LFVF), Altiplano-puna volcanic complex(APVC) and Puna Volcanic Field(PVF). PVG (Pica Volcanic Gap) volcanoes, such as Tuzgle, Cerro Galan Caldera (CGC) and Farallon Negro (FN)

The boundaries of tectonic units are modified from (Scire, Biryol, et al., 2015), the red and blue alphabet indicate the positive and negative velocity perturbations in the image. The black solid lines denote the slab contour at the corresponding depth from Slab2.0

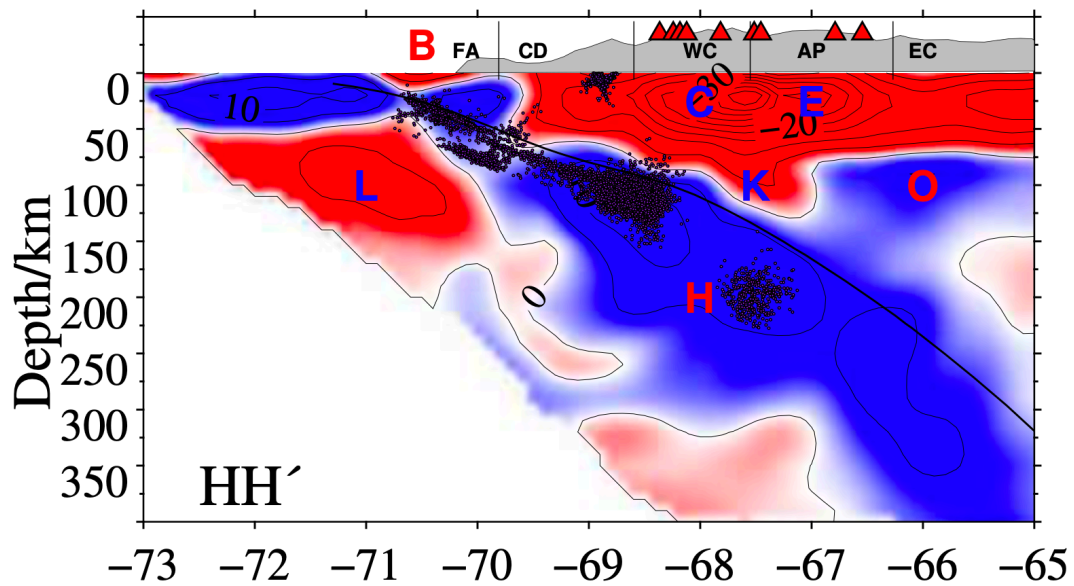
Vs perturbation



Isotropic Vs perturbation cross sections from the tomography model, the black dots denote the seismicity results from (Sippl et al., 2018)

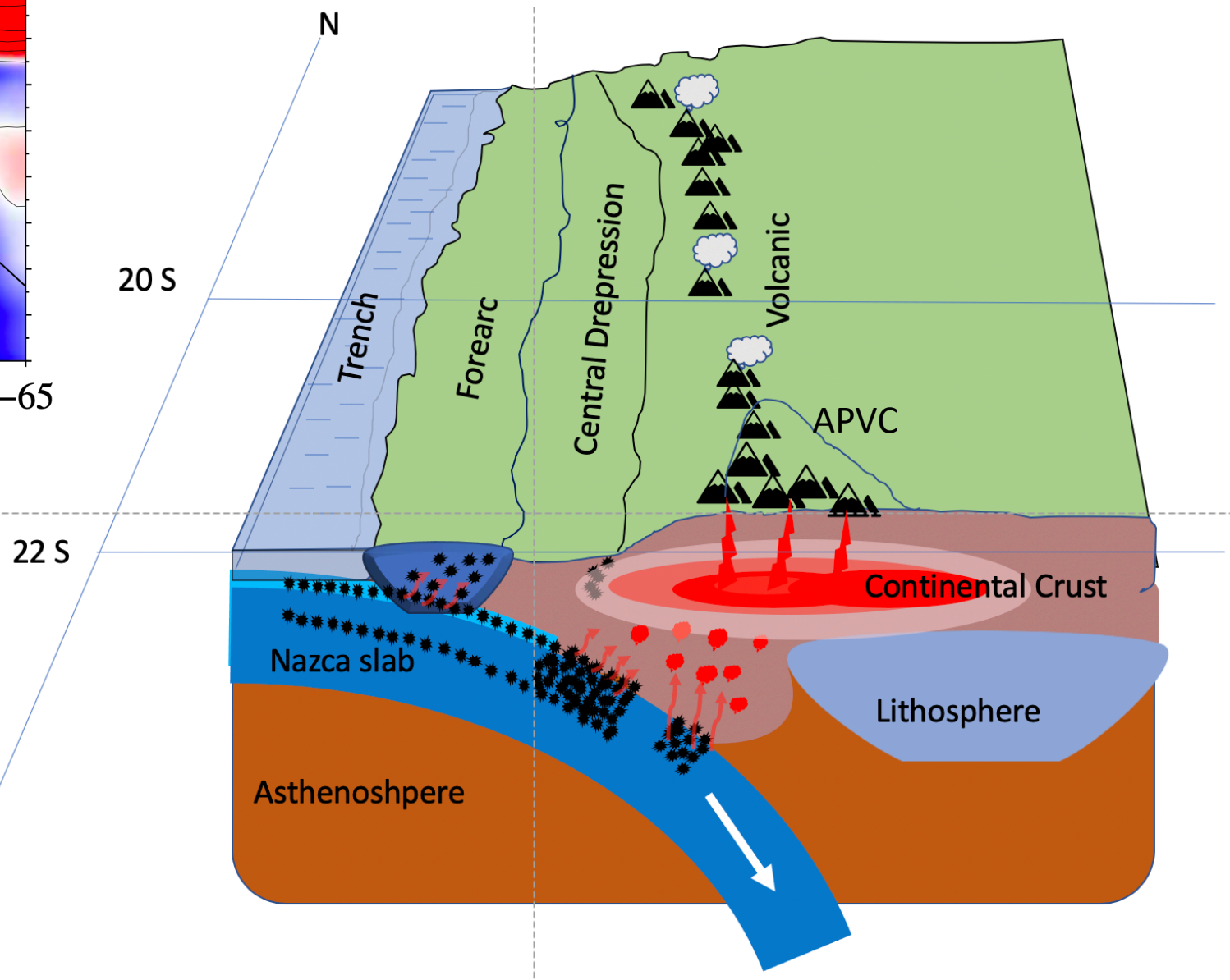


Atop of the subducted Nazca slab, low velocity anomaly marks the location of mantle wedge hydrated by the fluids expelled from the oceanic lithosphere (Anomaly J K) and coincident with the location of volcanic arc and the low velocity anomaly in the crust. There is also a gap of low velocity in the uppermost mantle, coincide with the location of the gap of volcanic arc.

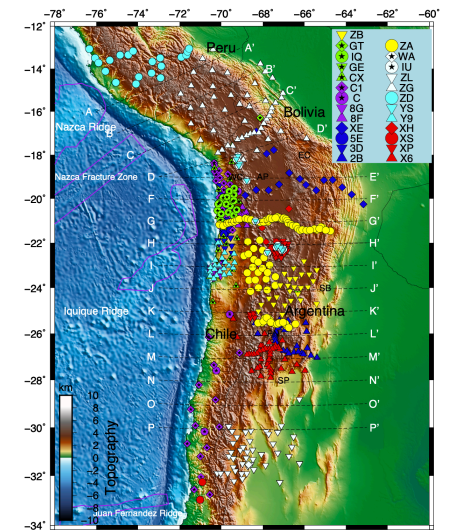
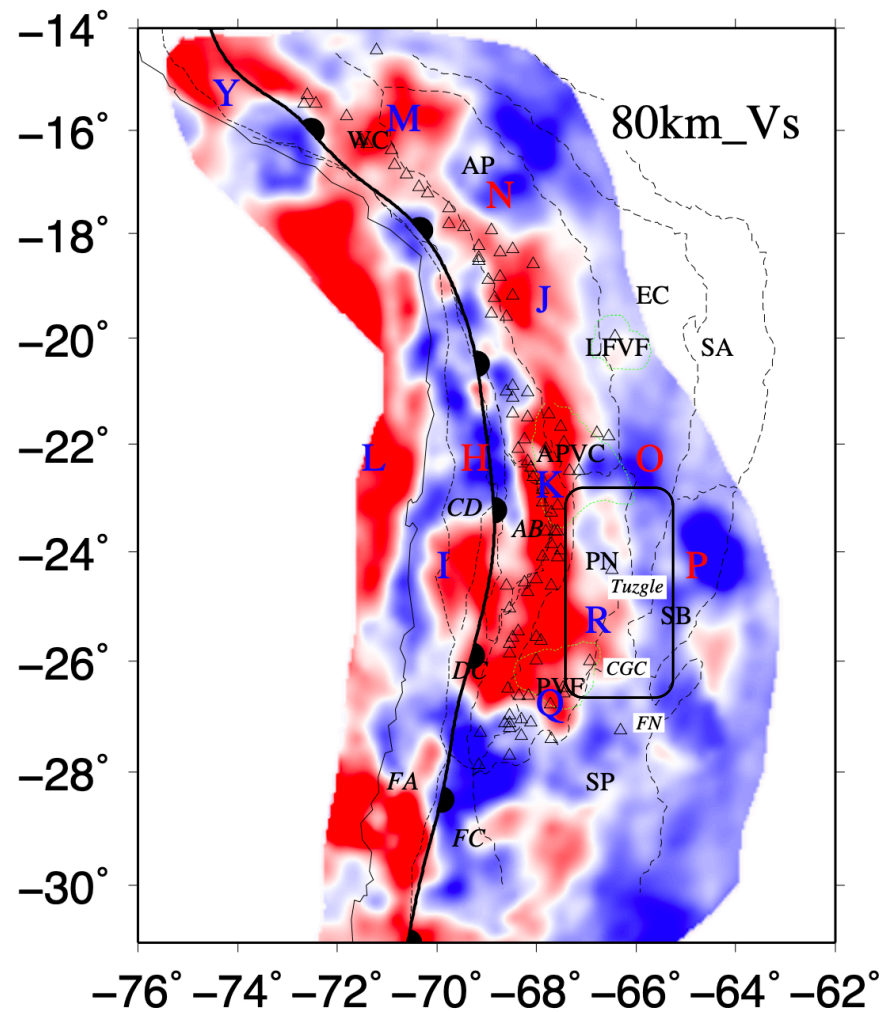
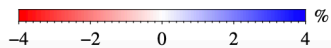
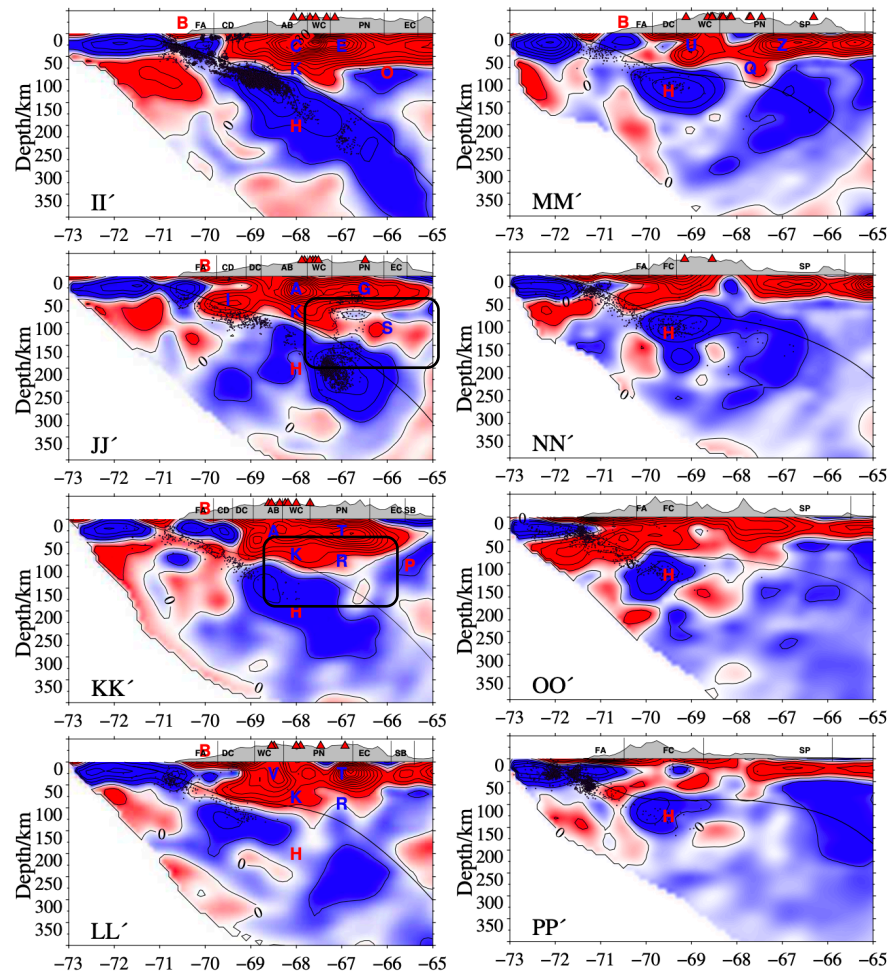


Isotropic Vs perturbation cross sections from the tomography model, the black dots denote the seismicity results from (Sippl et al., 2018)

Upper plane of Double Seismic Zone (DSZ) situated in the oceanic crust reflects the crustal dehydration reactions, possibly by lawsonite breakdown, while lower plane of DSZ and seismicity cluster at intermediate depth in the oceanic lithosphere appear to represent multi-stage dehydration of Serpentine, taking the responsibility for the hydrated mantle wedge and partial melting of continental crust.



Vs perturbation



Beneath the South Puna, conspicuous lithosphere detachment (S and R) could also be found in the uppermost mantle image and also connect with the formation of volcanoes of Tuzgle and CGC



Thanks for your time
and expect your
comments