Modeling Regional Depth Phases for Eastern Austria

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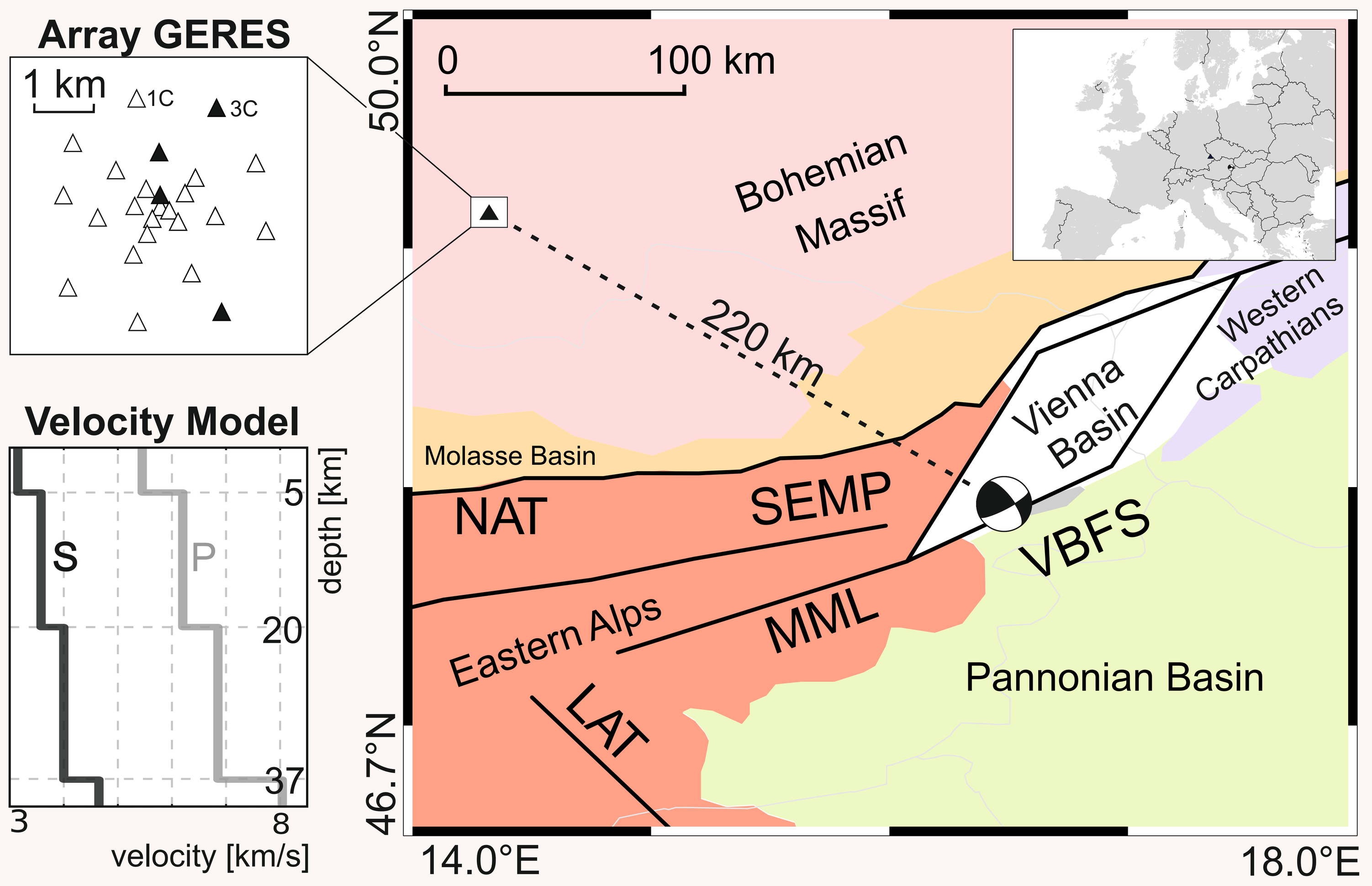
Introduction

- The Vienna Basin in Eastern Austria is a region of low to moderate seismicity, and hence the seismological network coverage is relatively sparse
- However, earthquake depth estimation needs a dense seismic network around the anticipated epicenter
- Regional Depth Phases (RDP) like sPg, sPmP and sPn can be used to determine depth even if observable on a single station
- Seismic arrays together with appropriate processing can help to detect and identify phases

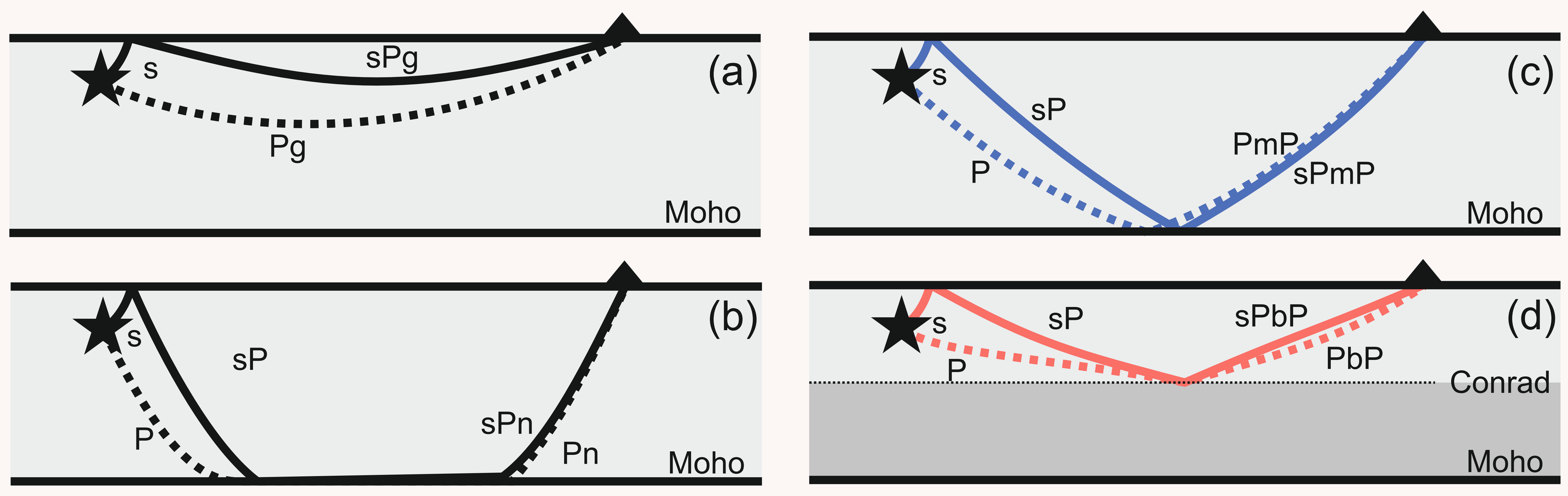
Tectonic Setting and Dataset

Right panel: schematic map of the Vienna Basin with surrounding tectonic units and main faults shown together with focal mechanism of the *Ml* 4.2 earthquake from 20/09/2013 in Ebreichsdorf by Hausmann et al. (2014). *Top left panel:* layout of seismic Array GERES with 1-component stations (white triangles) and 3-component stations (black triangles) *Bottom left panel*: P and S velocity model for the area by Hausmann et al. (2010)

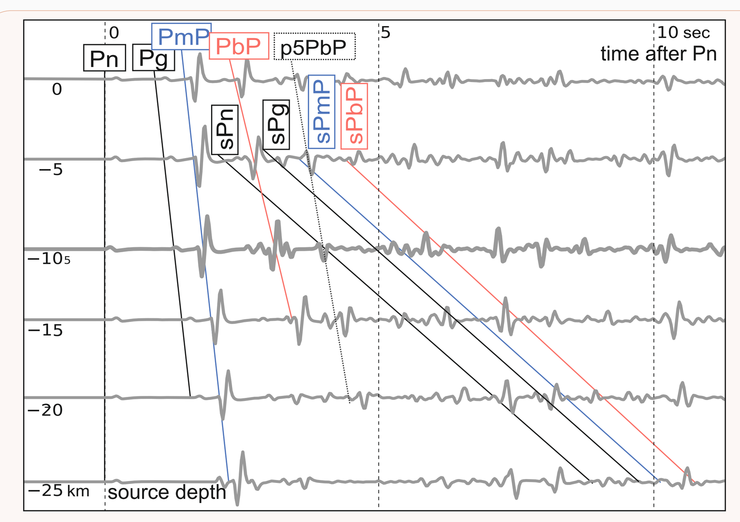


Wavepaths of Regional Depth Phases

Regional Depth Phases (RDP) like sPg, sPmP and sPn are P phases converted to S at the surface. They develop at different regional distance ranges (Ma and Atkinson, 2006) and the time difference between direct and reflected phase is sensitive to epicentral depth. This property already has been successfully used for calculating depth if an RDP is observed at only one station. Wavepaths shown in the figure below are adapted from Ma and Eaton (2011): (a) Pg and sPg, (b) Pn and sPn, (c) PmP and sPmP, (d) PbP and sPbP.



Waveform Modeling for GERES



In the first part we model RDP propagation for the tectonic setting and seismic data in our area of interest. The source time function was estimated for both *Ml* 4.2 earthquakes with empirical Green functions and is approximated by a 0.2 second parabolic pulse. With the given focal mechanism and velocity model synthetic seismograms were calculated using the wavenumber integration implemented by Herrmann (2013) for all stations of the array and for depths ranging from 0 to 25 *km*.

Acknowledgements

We thank the Zentralanstalt für Meteorologie und Geodynamik (ZAMG) and the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) for making available seismic data for this study. Plots were created with ObsPy (Beyreuther et al., 2010) and maps with QGIS (QGIS, 2009). Synthetics were generated with Computer Programs in Seismology by Herrmann (2013). Travel Times were calculated with TauP (Crotwell and Owens, 2011).

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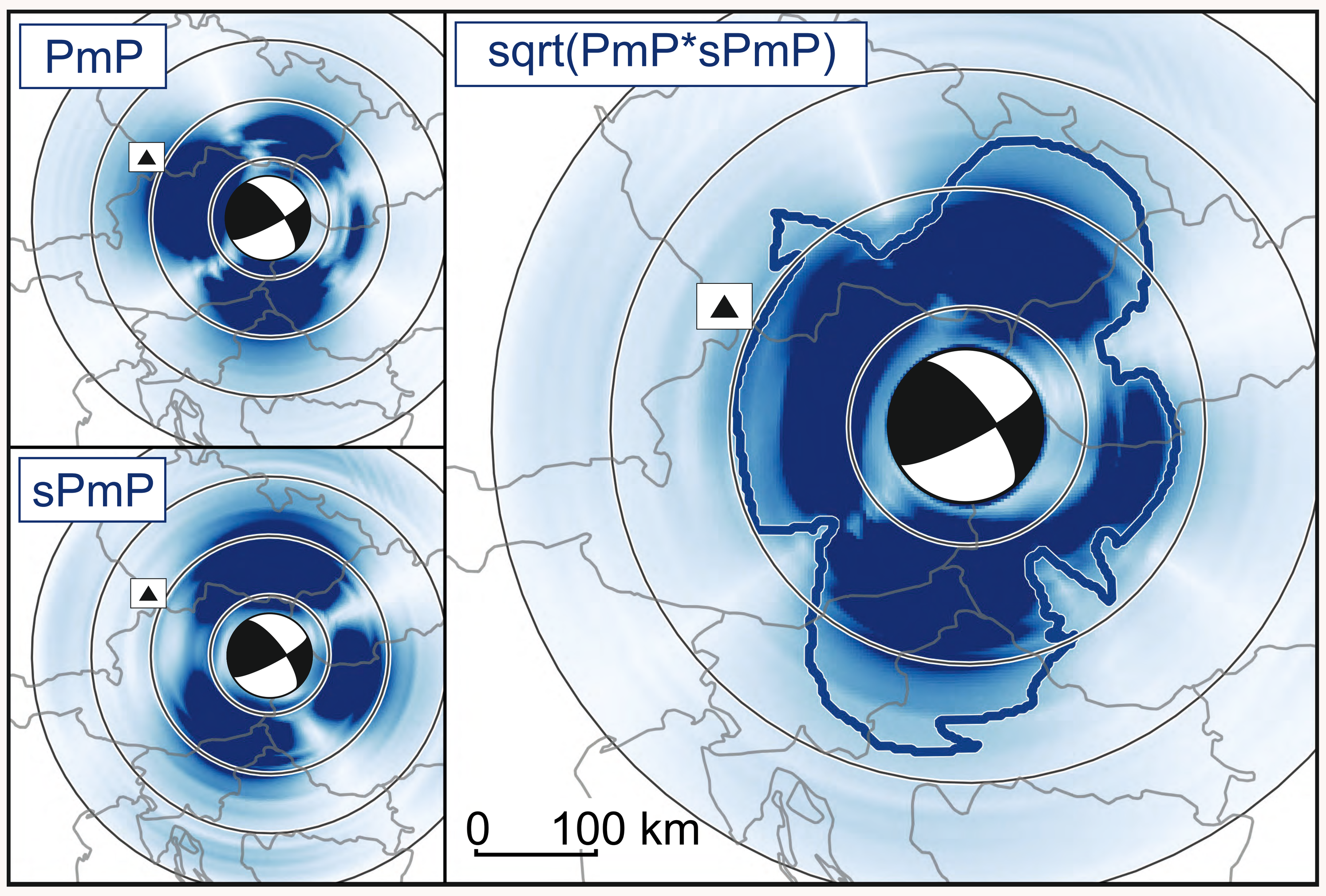
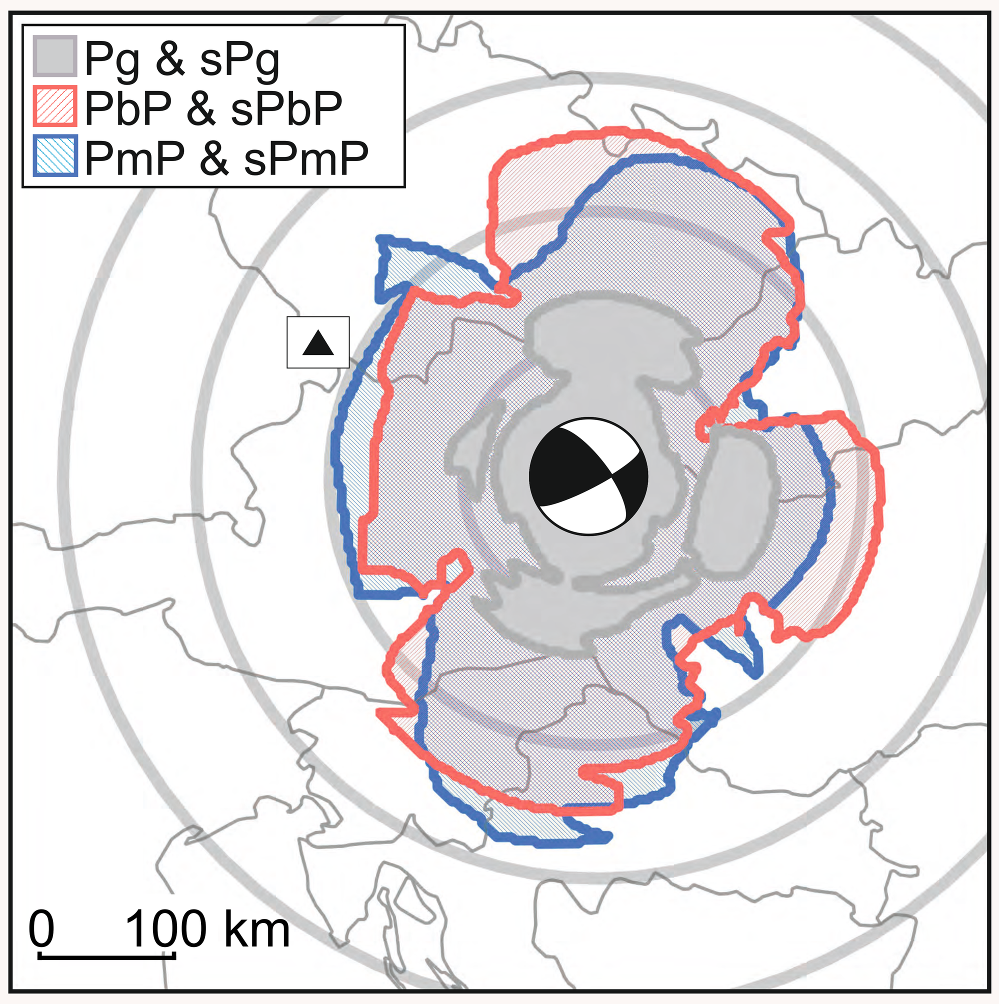
Lateral Propagation of RDP

Processing: To get an overview on lateral propagation behavior of RDP, we additionally calculated synthetic seismograms in a regular spaced grid around Ebreichsdorf up to 400 *km* distance. We processed the synthetic data as follows: we measure the maximum amplitude of arriving RDPs on the horizontal component velocity record (PmP and sPmP on left panels). Afterwards, we multiply these values for each phase pair at each point and extract the root to be able to use similar scaling (right panel). Additionaly we mark the area of minimal visible amplitude for both phases (blue contour line) .

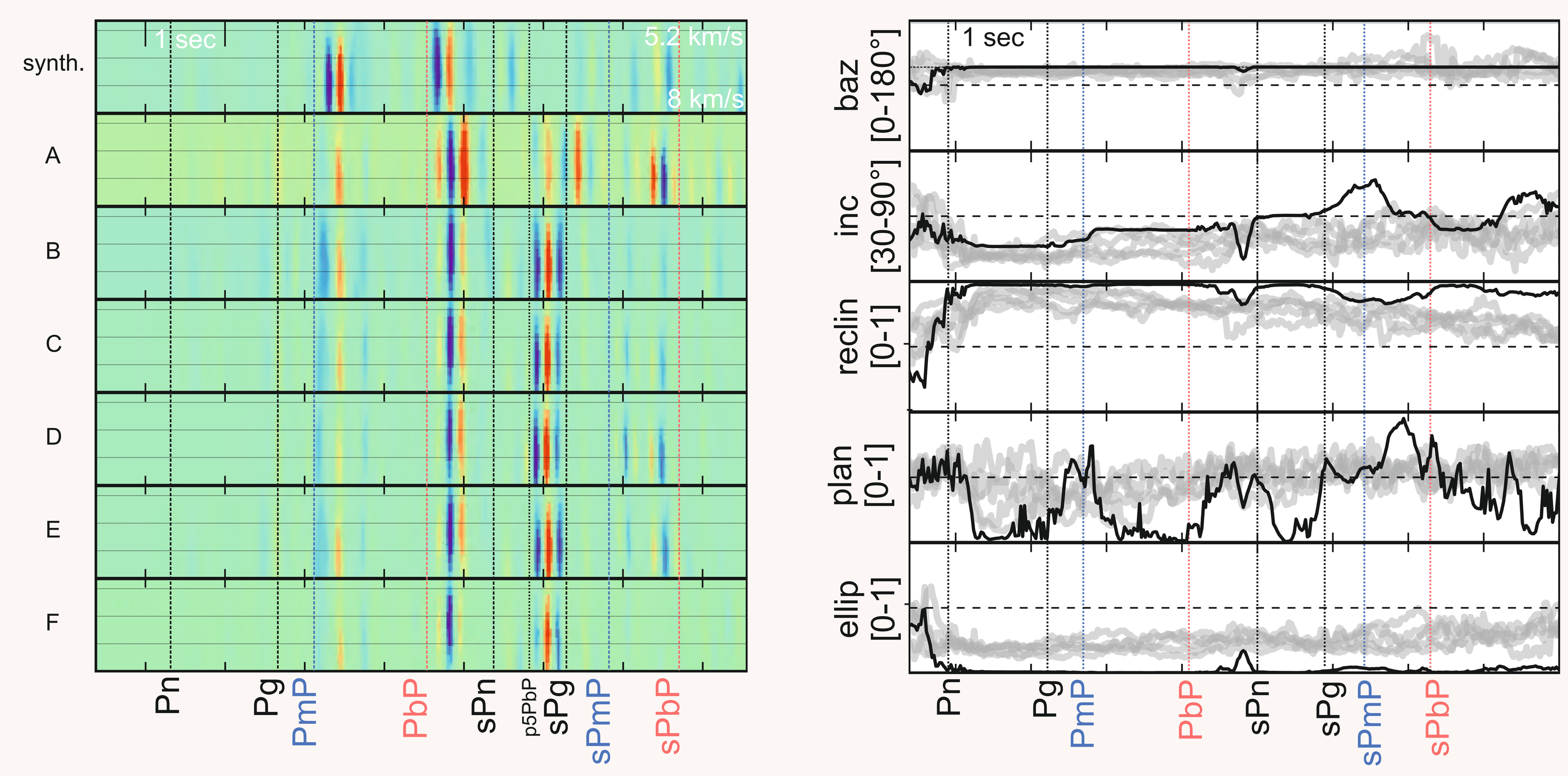


Results: Areas of depth phase pairs with minimal visible amplitude for pairs of RDP are shown in the following Figure. Wave propagation for our dataset with a four layer model and a strike-slip mechanism is complex. Depending on the azimuth RDP have strong amplitudes at distances between 50 and 250 *km* .



Vespagram and Polarization Analysis

Vespagrams (left) for synthetic data for the first earthquake at GERES and real data for all earthquakes with $Ml > 2.0$ from Apoloner and Bokelmann (2015) . Vespagrams are aligned on PmP arrival and phases were calculated with TauP by Crotwell and Owens (2011). Strong PbP indicates that earthquakes are above the Conrad discontinuity.



Polarization analysis (right) for synthetic data (black) and earthquakes (grey) calculated with Vidale (1986). From top to bottom: backazimuth, incidence angle, rectilinearity, planarity and ellipticity. Although Pn is not visible in the seismograms, polarization analysis gives a clear Pn onset for all earthquakes with $Ml > 2.5$.

Conclusions

- Regional depth phase amplitudes are strongly influenced by strike-slip sources
- Additional layers in the underground produce strong reflections like PbP, which constrain depth
- Vespagrams help to identify phases in the P-coda by their slowness
- Polarization analysis robustly detects Pn for $Ml > 2.5$