Chapter 9

Conclusions

In this thesis, I present a wide range of studies in observational seismology. The results span interpretations of noise correlations in different environments, source parameters of intermediate to great earthquakes, and seismic velocity structure. Although the individual problems are relatively independent, the philosophy behind my approaches is to bring observational insights from seismic waveforms in critical and simple ways. The results can be summarized in the following.

In Part I, I first present two successful applications of the noise correlation method, in calibrating earthquake centroid and retrieving crustal body waves. I also present examples in which the noise correlations do not yield Green's functions, yet the results are still interesting and useful after case-by-case analyses. I use array technique to locate uneven distribution of noise sources and show their effects on weaker body-wave phases. I demonstrate that temporal variability of noise frequency content can cause spurious velocity changes when noise correlations are used to monitor velocity changes. For the Amery Ice Shelf, I find that the noise field is not diffuse, but dominated by energy trapped in a low velocity waveguide caused by the water layer below the ice. In summary, the noise correlation method, as a very useful tool in many cases, does not guarantee a correct or efficient interpretation of the noise data because it assumes a diffuse noise field. Thinking outside the box of retrieving Green's function from noise may be valuable for understanding ambient noise better.

In Part II, I present studies using earthquake waveforms to constrain earthquake source parameters and seismic velocity structure. This is the classical field of waveform seismology. By incorporating new dataset and improved methodologies, I am able to bring new information to the problems. I find that earthquakes in the Tohoku-Oki region have steeper dip angles than the previously imaged plate interface and explain this discrepancy as evidence for a complex plate interface. I obtain sub-event models for the two largest deep earthquakes, the Great 2013 Sea of Okhotsk earthquake and the Great 1994 Bolivia earthquake and attribute their differences to different slab thermal states. I model teleseismic waveforms from earthquakes in the Kuril subduction zone and obtain a ~5% velocity perturbation in the slab, significantly higher than most tomographic models. These results show the great vitality of the classical waveform modeling method.

Research usually brings forward more questions than answers. For example, what is next about ambient seismic noise? What can interplate earthquakes tell us about the plate boundaries and how are they related to great earthquakes? Can seismic waveforms finally resolve the problem of slab penetration into the lower mantle? What is the physical mechanism(s) of deep earthquakes? I do not have answers to these questions. However, I also have no doubt that seismograms will be a critical piece of the puzzle.