Towards 3D multiscale adjoint waveform tomography of the crust and upper mantle beneath Southeast Asia

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Southeast Asia is one of the most complex tectonic regions on Earth. This is mainly a result of its location within the triple junction of the Australian, Eurasian and Philippine Sea plates which has created a complicated configuration of active plate tectonic boundaries. High plate velocities have generated thousands of kilometers of subducted material and ongoing subduction along the Sunda Arc represents a significant natural hazard (such as the 2004 Sumatra-Andaman earthquake, 2012 Indian Ocean earthquakes and 2018 Anak Krakatoa eruption). However, recent tectonic activity around Borneo may be related to postsubduction processes which could be the key to understanding how the tectonic subduction cycle terminates. Further east, the region is dominated by several minor tectonic plates and the spectacular 180-degree curvature of the Banda Arc. Our work aims to further improve the understanding of this area by providing detailed images of the upper mantle.

Adjoint waveform tomography is especially suitable for imaging such complex regions. By simulating the 3D wavefield, it is possible to directly compare observed and simulated seismograms, thereby taking into account both body and surface waves. The method can account for the effects of anisotropy, anelasticity, wavefront healing, interference and (de)focusing that can hamper other seismological methods, and is thus especially suitable for strongly heterogeneous areas such as Southeast Asia.

To date, sparse instrument coverage in the region has contributed to a heterogeneous path coverage. In this project, we make use of publicly available data as well as our recently deployed networks of broadband seismometers on Borneo and Sulawesi. This, in addition to access to national permanent networks promises a significant improvement in data coverage around the Banda Arc, Borneo and Sulawesi, thereby providing new opportunities to untangle the region's complexity.

We compiled a catalogue of well-constrained earthquakes, optimising for coverage, signal-to-noise ratio and data availability across a wide frequency band, and compared our observed data to synthetics generated from an initial model. In the first part of the inversion, we use long periods of 100 - 150 s to update our initial model using a gradient-based optimisation scheme. We use adjoint methods to obtain sensitivity kernels as the corresponding gradients and initial results will be documented in this presentation. In subsequent iterations, we permit increasingly shorter periods in order to progressively recover finer scales structure and avoid cycle skipping issues.