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How well can we model surface wave velocities in Europe?

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Seismic surface waves are an important observable for deriving information on earthquake sources (magnitude, seismic moment, geometry) and on earth's structure. Modeling their propagation, strongly affected by earth's heterogeneity, is crucial. We report on the statistics of group velocity measurements, taken in the European region, and on the ability to model velocities with ray theory, great-circle path propagation and laterally heterogeneous, isotropic maps. Our data set consists of fundamental mode Love and Rayleigh wave group speed measurements, taken by multi-filter analysis on wave groups isolated by phase matched filtering on seismograms recorded in the European and Mediterranean region. About 1500 Rayleigh and 800 Love wave groups are analyzed for periods between 20 and 160 s. Epicentral distance is between 500 and 7000 km. Consistency of measurements is evaluated by comparing ray clusters from sample earthquakes to stations within a radius of $\sim$ 100 km of a broad-band array in the Northern Apennines (RETREAT). In the whole data set, measurement errors in group speed decrease with distance, and show to be caused by inaccuracy in the estimate of group arrival time. We calculate maps of Love and Rayleigh group velocity at selected periods by linear tomographic inversion, using an *a priori* smooth reference model. We explore the null space of the inversion, by analyzing the effects of different regularization conditions on models that reproduce the data equally well – such as model norm, smoothness, curvature. We show that larger-scale features are generally robust and stable, whereas care must be taken in the interpretation of finer details.