We use 7823 regional waveforms from 2520 earthquakes (M > 4.0) recorded at 244 stations, located on the Indian subcontinent and Tibet, to compute fundamental mode Rayleigh wave group velocity dispersion curves between 10 and 120 s. The Rayleigh waveforms for all these traces had a signal-to-noise ratio above two for the periods of our interest. The latest provide a dense sampling of the Bay of Bengal and the Arabian Sea, the Indian subcontinent, the Himalayan foreland basin, the Himalaya, and the Tibetan Plateaus, between latitudes 8° to 40° and longitudes 60° to 100°. These 1-D path average group velocity curves were linearly combined through a ray theory based tomography formulation to obtain 2-D maps of lateral variation of group velocities at discrete periods. For the tomography the region is parametrised as 1° triangular elements with slowness defined at the apex of each triangle (node point). The coverage and resolution of the tomography maps are explored by computing ray density map, raypath orientation map and a standard checker board resolution test. The best resolved features in the tomography maps are at periods between 15 s and 45 s and in the range of ray density and orientation raypath orientation. To optimise the choice of the apriori slowness vector the sharpness of the observed anomalies in the tomography inversion, we performed apriori slowness test. We used a number of fixed apriori slowness values and computed the tomography images for every period. A plot of the apriori slowness versus sum of square(residuals) provides the choice for the optimal value for every period. We observe that for most periods this is marked by a minimum in the misfit curve. The regions with low velocities depict the basin areas with high sediment cover whereas the high velocity regions are indicative of the cratons and shield areas. Finally, we model the group velocity curve at each node point using a quasi-linear least squares inversion scheme of Ammon and Hermann (2004) to obtain 1-D shear wave velocity structure beneath the node point. We use cubic spline interpolation through these 1-D models to obtain 3-D shear wave velocity structure across the region of interest.

Data and Methodology

A new 3-D grid is generated through Delaunay triangulation (figures 1a, 1b) and the grid is refined in the regions of interest (figures 1c, 1d). The triangular mesh (shown below) is described by a position vector from the centre of the Earth. The group slowness is calculated at the nodes of these triangles from intersecting propagation paths for which group velocity dispersion measurements were made. A three-point linear interpolation was used to evaluate the model within each triangular element in the gridded region.

\[
\frac{1}{2} \sum_{i} \sum_{j} \sum_{k} (f_{ij} - f_{ik} - f_{jk})^2
\]

where \( f \) is the observed value at a node point where the slowness estimate lies in the triangular region. We solve this trilinear system of equations, where the solution vector \( f \) is the observed values at the node point, the matrix \( A \) is the Jacobian, and the vector \( b \) is the right-hand side of the linear system. The solution is then used to determine the gradient of the misfit at the node point. A steepest descent optimization is then applied to the node point to determine the optimal time slowness at the node point. The optimal time slowness is then used to determine the optimal time of travel at that point. The optimal time of travel is then used to determine the optimal time of travel at the next node point.

A simplified geometric setting showing surface ray paths of India and surrounding regions (taken from Muyra et al., 2006). Group velocity tomography maps at 256 s (figure 4a), 512 s (figure 4c), and 768 s (figure 4b). Wave phase tomography provides better constraints on the lateral velocity structure of the crust and continental lithosphere than mantle cores, subduction zones and island arcs. High velocity anomalies reflect the thicker crust beneath India plateaus and upturned portions of the subducting slabs in the Palaeo-Pacific.

The region of interest is parameterised by 1° triangular elements where the slowness values are calculated at the node point (figure 2a). Triangular coverage between apriori slowness values and four corresponding apriori nodes normalised at three different periods (figure 2b). The optimum value indicates a rise in the variation of dispersion with respect to the optimum value. This rise in dispersion and variance lies in the range of 0.035 and 0.05 for most of the periods in the tomography.

Conclusions

The results of regional tomography map is parameterised as 1° triangular elements, where the slowness values are calculated at the node point (figure 2a). The triangular coverage between apriori slowness values and four corresponding apriori nodes normalised at three different periods (figure 2b). The optimum value indicates a rise in the variation of dispersion with respect to the optimum value. This rise in dispersion and variance lies in the range of 0.035 and 0.05 for most of the periods in the tomography.

Reference
