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Relocating Seismicity on the Arctic Plate Boundary Using Teleseismic and Regional Phases and a Bayesian Multiple Event Locator

Steven J. Gibbons (1), Trine Dahl-Jensen (2), Tormod Kværna (1), Tine B. Larsen (2), Berit Paulsen (1), and Peter Voss (2)

(1) NORSAR, Kjeller, Norway (steven@norsar.no), (2) The Geological Survey of Denmark and Greenland, Copenhagen, Denmark

The tectonophysics of plate boundaries are illuminated by the pattern of seismicity - and the ability to locate seismic events accurately depends upon the number and quality of observations, the distribution of recording stations, and how well the traveltimes of seismic phases are modelled. The boundary between the Eurasian and North American plates between 70 and 84 degrees North hosts large seismic events which are well recorded teleseismically and many more events at far lower magnitudes that are well recorded only at regional distances. Existing seismic bulletins have considerable spread and bias resulting from limited station coverage and deficiencies in the velocity models applied; this is particularly acute for the lower magnitude events which may only be constrained by a small number of Pn and Sn arrivals. Over the past 15 years, there has been a significant improvement in the seismic network in the Arctic – a difficult region to instrument due to the harsh climate, a sparsity of quiet and accessible sites, and the expense and difficult logistics of deploying and maintaining stations. New deployments and upgrades to stations on Greenland, Svalbard, and the islands Jan Mayen, Hopen, and Bjørnøya have resulted in a sparse but stable regional seismic network which results in events down to magnitudes below 3 generating high quality Pn and Sn signals on multiple stations. A catalog of over 1000 events in the region since 1998 has been generated using many new phase readings on stations on both sides of the spreading ridge in addition to teleseismic P phases. The Bayesloc program, a Bayesian hierarchical multiple event location algorithm, has been used to relocate the full set of events iteratively and this has resulted in a significant reduction in the spread in hypocenter estimates for both large and small events. Whereas single event location algorithms minimize the vector of time residuals on an event-by-event basis, Bayesloc favours the hypocenters which result in time residuals which are most consistent over a given source region. The relocations have been performed with different 1-D velocity models for the Arctic region and hypocenters obtained using Bayesloc have been shown to be relatively insensitive to the specified velocity structure in the crust and upper mantle, even for events only constrained by regional phases. The patterns of time residuals resulting from the multiple-event location process provide well-constrained time correction surfaces for single-event location estimates and are sufficiently stable to identify a number of picking errors and instrumental timing anomalies. This allows for subsequent quality control of the input data and further improvement in the location estimates.