Long-period Global Detection and Location of Earthquakes Using the GSN

Göran Ekström, Meredith Nettles • Harvard University

We use long-period data from the Global Seismographic Network in an array-processing mode to detect and locate shallow earthquakes globally. A global grid of target locations is monitored continuously for detections of sources of Rayleigh wave energy in the 35–150 s period band. The tuning of the array for each target location is accomplished by calculation of frequency-dependent path corrections using detailed global phase-velocity maps. The detection algorithm uses a matched filter to look for source pulses on reverse-dispersed and stacked seismograms. In addition to analyzing real-time data, we have applied the algorithm in a systematic fashion to continuous archived data from the IRIS GSN and other global networks for a period of 11 years, 1993–2003. For this period, we detect and locate approximately 25,000 earthquakes. The smallest earthquake detected has a magnitude $M = 4.6$. 1,860 of the events are not correlated with any earthquake reported by the NEIC, ISC, or the IDC (based on the REB bulletins). We believe that fewer than 1% of our new events are false detections, and that our analysis identifies around 150 new $M$~5 earthquakes per year. The map below shows the locations of the 1,860 previously unknown earthquakes. The quality of the detection is indicated by the color: red indicates the best quality, green is very good, and yellow is good. Nearly all of the events are located in seismically active areas. It is interesting to note that a great majority of the new events fall along ridges and transform faults, and relatively few in subduction zones; many events associated on the map with subduction zones are located in back-arc basins. More than 100 of the newly detected events are located in areas away from regions that are considered seismically active. In particular, a very large number of earthquakes can be seen along the coast of Greenland. These events, first described by Ekstrom, Nettles, and Abers (Science, 2003), belong to a new class of earthquakes associated with the sliding of glaciers. These glacial earthquakes are not detected by traditional methods owing to their very slow slip. The typical duration for an $M = 5$ glacial event is 30–60s. Other previously undetected events may also be unusually slow or may be associated with geophysical phenomena that generate elastic waves by processes other than standard fault motion. For example, several events in central Africa are associated with volcanic eruptions, and the events off the east coast of North America may be related to submarine sliding. Real-time results from our surface-wave detector can be seen at http://www.seismology.harvard.edu/~ekstrom/Research/SWD/.