Most of the seismic arrays in the International Monitoring System (IMS) have only vertical sensors at all sites. Many have 3-component seismometers at only a single site. Several arrays have a number of 3-component sensors at a limited number of sites, although often not enough to fully exploit array processing on the horizontal components. The detection of regional S phases is crucial in the detection and location of low magnitude seismic events that are only recorded at regional distances. This is especially the case where station coverage is sparse and the azimuthal gap is significant. The European Arctic is such a region. Mainly ocean, there are few land sites - and the few suitable locations for seismic stations are quite inaccessible.

In 2004, the SPLIT array on Svalbard was upgraded to comprise 3-component sensors at 6 of 11 sites. As the number of automatic detections increased, this led to an enormous improvement in the detectability of regional S phases on this array, and a far better seismic monitoring capability for the European Arctic.

The ARCES array was upgraded in 2014 and it was decided that 3-component sensors would be installed at all 25 sites, making it the first entirely 3-component seismic array of the IMS. (The old ARCES configuration consisted of 5-component sensors at 8 sites, indicated by blue triangles in the figure below.)

In the left panel we display the frequency–amplitude (F–A) spectra for the Sn phase, measured in the time-windows indicated above in both the vertical component traces and on the rotated horizontal component traces. The relative power, or coherence, is far higher on the horizontal component than on the vertical component. This increases the likelihood of obtaining robust slowness estimates and also increases the likelihood that the coherence-based detectors (such as the F-detector) would perform better than they would on a vertical-only array.

Consequences for Automatic Event Bulletins

The improved detection of Sn phases leads to better constrained automatic event locations. Here we see several events in the western Barents Sea for which no Sn phase was detected at ARCES under the detection criteria for the old array configuration.

While the new detection criteria are applied for the fully 3-component array, many more Sn phase detections are made and this results in far more robust automatic event hypocenters.

In September 2014, the 25-site ARCES array in northern Norway was upgraded to have 3-component sensors at all sites making it the first fully 3-component IMS seismic array. The detection and correct identification of regional S phases is crucial for detecting and locating seismic events at regional distances, especially where station coverage is relatively poor.

Sn phases at ARCES are recorded with a higher signal-to-noise ratio (SNR) on the rotated horizontal component seismograms than on the vertical component seismograms. Significantly, the coherence of the Sn phases is almost always higher on the horizontal components than on the vertical components, allowing for more stable slowness estimates.

While the improvement in SNR is modest, the 3-component processing results in significantly more Sn phase detections. The improved quality of the detection lists results in better defined automatic event location estimates.

We advocate the installation of 3-component sensors at many more sites of IMS seismic arrays.