NORSAR Scientific Report No. 1-2003

Semiannual Technical Summary

1 July - 31 December 2002

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Kjeller, February 2003

4.4 NORSAR's Event Warning System (NEWS)

4.4.1 Introduction

Data from the highly sensitive regional arrays ARCES, FINES, HFS, SPITS, and NORES, and the teleseismic NORSAR array (NOA) are automatically processed in on-line mode. However, the routine data processing of single arrays can be delayed due to data transfer problems. Therefore, the full automatic regional and local event location process GBF (Ringdal and Kværna, 1989) can also be delayed by hours or even days because this process waits for the results of all arrays. In some cases of felt seismic events the GBF system is not fast enough to deliver event locations, which could be used to inform the public calling NORSAR directly after the events occur. In addition, GBF does not use automatic analysis results from the teleseismic NORSAR array although this may help to locate local or regional events. Therefore, during the last two years, a new extra event location system was developed to provide quick but reliable solutions for strong events: NORSAR's Event Warning System (NEWS).

4.4.2 Triggering NEWS

The whole NEWS system is based on high signal-to-noise ratio (SNR) detections, which usually correspond to large amplitudes. Whenever one of the regional arrays observes a P-type onset with an SNR larger than 50, the NEWS process is started. The SNR threshold of 50 is used to avoid too many false alarms by larger man-made events, which can easily reach SNR values of 20 or 30. Seismic events which are felt in Fennoscandia on the other hand usually have first-P onsets with SNR values of around 100 or larger for the closest array. In the case of larger teleseismic onsets at the small aperture arrays, the threshold of 50 gives for example, a trigger level for events in the Japanese area of station magnitudes between mb 4 and 5.

The automatic data processing of NOA also starts the NEWS process whenever the automatic NOA data analysis locates an event after detecting a teleseismic P-type onset (i.e., apparent velocity larger than 10 km/s), with an SNR larger than 8.5 for this onset, and an estimated event body-wave magnitude of larger than 4.9.

Once triggered, the NEWS process searches the automatic result lists of all other arrays for corresponding onsets. Corresponding in this context means that the other onsets have to come from a backazimuth, and with an apparent velocity, which is consistent with the triggering onset. For example, any triggering P onset reaching HFS from the south will not be associated with any P-type onset reaching ARCES from the North. To formulate robust rules for which onsets can eventually be associated with the same event took some time. As implemented today, these rules build on the travel-time differences between the onset times at the different stations, measured backazimuth and apparent velocity of the signals, and the SNR of the onset. If the triggering onset has a large SNR, all corresponding onsets at the other arrays should also have an SNR of greater than 8 apart from a higher SNR threshold of 30 for SPITS and a lower threshold of 6 for NOA. This was implemented to reduce spurious associations due to the numerous high SNR P-type onsets at SPITS from local events and because measured parameters on NOA onsets are reliable enough also with lower SNRs due to the larger aperture of this array. In the case of local or regional events, NEWS also searches for S-type onsets in the onset lists for the small aperture arrays. Corresponding S-type onsets must have at least an SNR of 10 to be accepted for NEWS.

4.4.3 Locating the event

After all available lists are searched; the NEWS process locates the seismic event. To make this automatic event location as robust as possible, only onsets times and apparent velocity values from first P and S arrivals are used. From all other onsets in compliance with the selection rules only measured backazimuth values are used to locate the event. Depending on the mean apparent velocity of the P onsets, the program defines the event as probably regional, or as near, far or very far teleseismic. Then, together with the mean backazimuth observation, an initial source region is chosen. Depending on this initial solution, either a regional or a global velocity model is used to locate the event. In the case of a far-regional or teleseismic event, all observed P amplitudes are used to calculate an event magnitude.

For the determination of the source parameters NORSAR's location program HYPOSAT (Schweitzer, 2001) is used. An automatic phase association and event location can only be a preliminary source parameter determination. With the limited amount of data available for localizing the event, the event's depth cannot be resolved and is therefore fixed. However, during the last two years, such preliminary locations have been sufficient for preliminary information to the public in the case of local / regional events.

Although the network of seismic arrays used has an aperture of ca. 18 deg in north-south direction, teleseismic events are usually observed over only a very small azimuth range. Therefore, the small number of available observations produces solutions with limited accuracy and large error bars. Some events are even not locatable and the inversion for an epicenter becomes unstable. This is in particular true for events in the South Pacific for which only PKP-type onsets can be observed.

4.4.4 NEWS results

The earliest versions of the NEWS system was implemented at NORSAR during winter / spring 2000 / 2001. In the following months the results were systematically followed up and the system tuned for more stable solutions and fewer false alarms. On average, NEWS solutions are available between a few and up to about 10 minutes after the first P onset with high SNR have been recorded at the seismic station. From 16 January 2001, a listing of the 30 most recent NEWS solutions has been available on the web (http://www.norsar.no/bulletins/alert/). For some events, NEWS reports more than one solution. This is due to the fact that in particular for stronger events several of the arrays have P onsets above the SNR threshold of 50. In addition, sometimes the data analysis of single arrays is significantly delayed. In all these cases, the NEWS system is constructed such that it only reports again events with significantly different epicenter solutions, more defining parameters and/or smaller error bars. In summer 2002, NORSAR started to send the NEWS solutions to interested data centers, which also work on quick epicenter solutions in Europe. Since 16 June 2002, the European data center for broadband data ORFEUS in De Bilt and, since16 July 2002, the European-Mediterranean Seismological Centre (EMSC/CSEM) in Paris have received NEWS solutions in IMS1.0 format. However, the solutions sent by E-mail are only subsets of the events published on NORSAR's web page since these data centers are not interested in all the small events in Fennoscandia or the European Arctic; only events located with at least three P-type onsets are reported.

In the case of teleseismic events, the NEWS reports are often listed together with only one or two of the many alert-messages from distributing institutes on the Real Time Seismicity Page

of the EMSC (http://www.emsc-csem.org/Welcome.html) and thereby help the EMSC to locate such events more accurate.

NEWS reported 1406 events in the period between 16 June and 31 December 2002, which is approximately 7 events per day. However, 186 of these reports were multiple events. Fig. 6.1.1 shows only the 1220 events without the 186 multiples as red dots. In addition, the global seismicity as seen by the REBs is shown as light gray dots. Obviously, the array network sees mainly seismic events from the Eurasian continent and the European Arctic. Other source regions in similar epicentral distance as the Mid-Atlantic Ridge System, the Caribbean Sea, or North and Central America do not produce sufficiently large P onsets at the arrays to trigger NEWS. It also seems that the array network is not very sensitive to the high seismicity in far-regional distances such as for example the whole Mediterranean Region.

4.4.5 The 8 September 2002 event - a case study

On 8 September 2002 the Russian authorities destroyed with an underwater explosion the last remains of the submarine Kursk. This event with a GBF network magnitude of 2.75 was strong enough to be observed at many seismic stations. The P onsets at ARCES and at FINES were recorded with an SNR large enough to trigger the NEWS system (ARCES 362.6, FINES 196.9). Five P onsets of the automatic data-processing lists at ARCES (3), FINES (1) and HFS (1) were retrieved and the event was located. The first P onset at ARCES was recorded at 17:17:32.4 and, 8 minutes later, at 17:25:31 NEWS had send out an alert E-mail. Fig. 6.1.2 shows a map of the different locations related to this event; the NEWS solution using only five P onsets from three stations, a single array solution using two P and two S onsets at ARCES (http://www.norsar.no/bulletins/dpep/2002/251/ARC/ARC02251.html), the GBF solution using ten P and S onsets from five arrays (http://www.norsar.no/bulletins/gbf/2002/GBF02251.html), the REB solution with 9 defining P and S onsets from 5 stations, and the known Kursk location (e.g., Schweitzer, 2002). NEWS reports and REB bulletins also contain error ellipses, which are plotted in addition on the map. The map clearly demonstrates how helpful the quick NEWS solutions can be in responding to public requests regarding large seismic events at local or regional distances; the distance between the know explosion site and the NEWS location is only about 79 km.

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References

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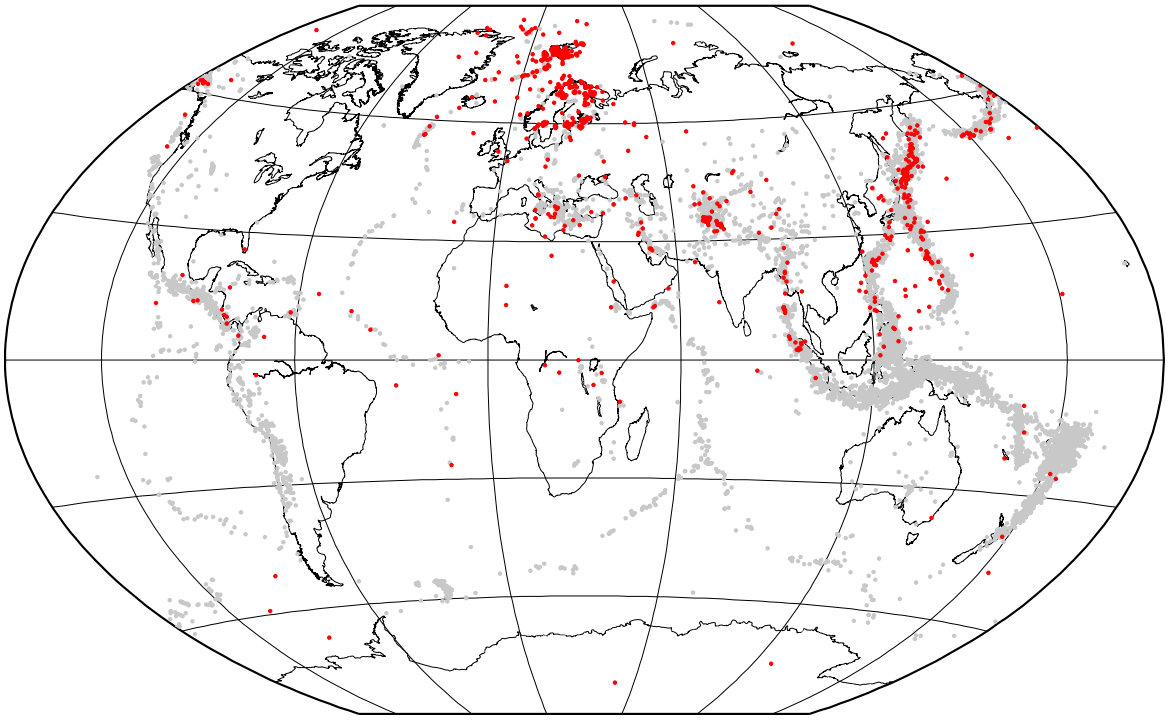

Fig. 4.4.1. Map with all 1220 NEWS locations (red) between 16 June and 31 December 2002 on top of all 10796 events (grey) as listed in the REBs of the same period.

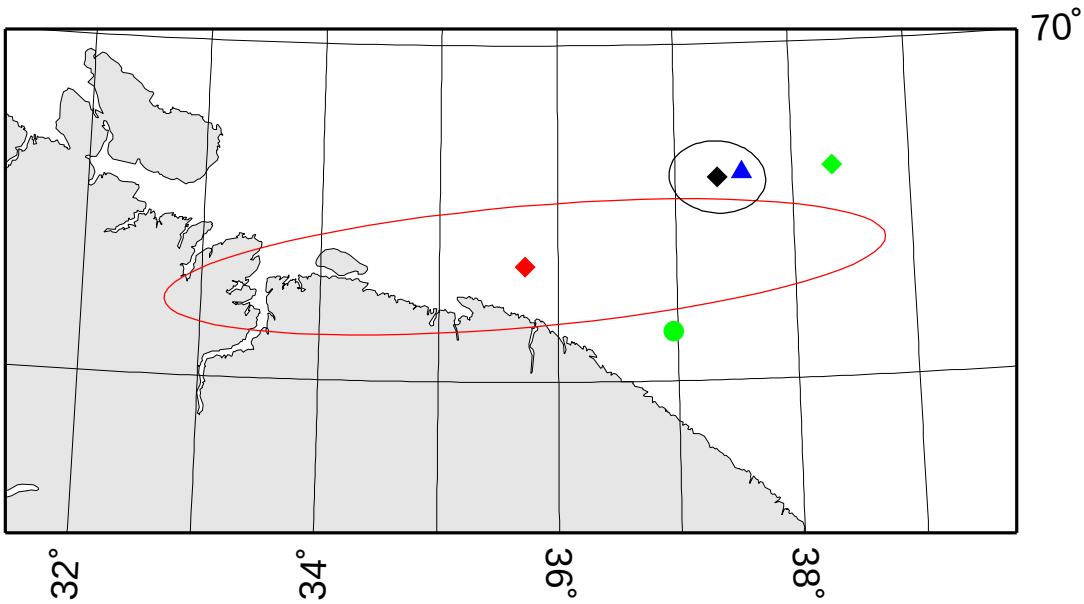

Fig. 4.4.2. Different locations of the Kursk explosion on 08 September 2002 as reported by; NEWS in red with 95% error ellipses, ARCES as a green circle, GBF as a green diamond, REB with 90% error ellipses in black, and the known Kursk position as blue triangle.