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7.2 Status and plans for implementing algorithms at the GSETT-3 IDC

Introduction

Research and development efforts at NORSAR have for quite some time focused on methods and procedures that could be useful in the data processing carried out at the GSETT-3 IDC. These efforts have given results in terms of new knowledge, ideas, advice and recommendations that have been communicated to the IDC, and also results in terms of products, like the prototype Threshold Monitoring system delivered to the IDC in October 1994, and a modified DFX for large array processing delivered in June 1996.

For our FY96 R&D effort for ARPA, we have focused on integration of NORSAR knowledge emerging from our research program into the Detection and Feature Extraction (DFX) software. Our ability to operate DFX, define problems and implement solutions came as a result of close cooperation with DFX developers at SAIC, San Diego. The study of the DFX software and its structure has continued, and we are now able to operate the IDC version at our data processing center, using on-line data from e.g. the large NORSAR teleseismic array.

NORSAR large array data at the IDC

As of September 1, 1996, NORSAR array data have been continuously transmitted to the IDC. Upon request from the IDC, we changed the naming of the NORSAR array on October 2, 1996. The naming convention is now:

NOA	Denotes the large-aperture NORSAR array. Will enter the IDC bulletin as station name for phase readings. Will be used for requests for data for all stations within the array.
NB200	Reference station name for NORSAR array beamforming. Center site of subarray NB2, which has stations NB200, NB201, NB202, NB203, NB204 and NB205. A request for NB2 will mean data from all stations in subarray NB2. A request for NB200 will mean data from station NB200 only. Station name NB2 has been used as reference for the entire NORSAR array from October 1, 1976 to October 2, 1996.
NAO00	Center site of subarray NAO, which has stations NAO00, NAO01, NAO02, NAO03, NAO04 and NAO05. A request for NAO will mean data from all stations in subarray NAO. A request for NAO00 will mean data from station NAO00 (center instrument) only. Station name NAO was used as reference for the entire NORSAR array up to October 1, 1976.

The complete list of station names for NORSAR are now:

NB200,	NB201,	NB202,	NB203,	NB204,	NB205,	subarray NB2.
NAO00,	NAO01,	NAO02,	NAO03,	NAO04,	NAO05,	subarray NAO.
NBO00,	NBO01,	NBO02,	NBO03,	NBO04,	NBO05,	subarray NBO.
NC200,	NC201,	NC202,	NC203,	NC204,	NC205,	subarray NC2.

NC300, NC301, NC302, NC303, NC304, NC305, subarray NC3.
NC400, NC401, NC402, NC403, NC404, NC405, subarray NC4.
NC600, NC601, NC602, NC603, NC604, NC605, subarray NC6.

The subarray names are registered ISC codes. The station NC602 is co-located with station NRA0 of the NORESS array.

The main components of SPV (Short Period Vault) sites are one Teledyne Browne 20171-0104 seismometer with sensitivity 650 Volts/meter/second, one Teledyne Browne Brick amplifier with gain 39.8, one Science Horizons AIM24-1 digitizer with gain 10, and one Trimbledone GPS receiver. The seismometers are emplaced in 132 mm boreholes of depth 3.5 meter for 22 sites and 6 - 12 m for 13 sites. (7 of the SP seismometers are in the subarray LPV(Long Period Vault)). Other electronic components include items such as 9600 baud synchronous modem, battery, battery charger and lightning protection. Communication to each subarray Central Terminal Vault, CTV, is achieved through buried cables. These buried cables also carry 60 Volts DC for providing power to the SPVs, and are up to 14 km in length.

The stations NAO01, NBO00, NB201, NC204, NC303, NC405 and NC602 have in addition to the short period vertical seismometer one three-component broadband seismometer installed in the Long Period Vault, LPV. The main components of the LPV are (in addition to one SPV system): one Teledyne Browne KS54000P-0105 "Posthole" seismometer with sensitivity 5000 Volts/meter/second, one Science Horizons AIM24BB-3 digitizer and one Trimbledone GPS receiver. In addition there are other electronics as within the SPVs. The LPV is situated close to a CTV which has lightning protection, modems and a Science Horizons CIM II which communicates with 7 AIM digitizers and the NORSAR Data Processing Center (NDPC) at Kjeller.

The array diameter is approximately 60 km, and each subarray diameter is in the range 7-10 km. The data are transmitted to the NDPC using 7 individual leased telephone lines. Some delay in data transmission may occur which means that parts of the array data might arrive at later times. "Later" means, in this context a delay from 10 seconds up to 2 hours after real-time.

The transmission of data to the IDC is achieved by use of the Science Horizons dl2alpha program and the IDC's AlphaSend program. An inspection of the operations data base at the IDC has shown that, occasionally, minor gaps in data are observed at the IDC even in cases when data are present at NDPC. The cause of this discrepancy is, however, not known at present.

NORSAR array processing at the IDC testbed

Following a period of intensive software development and testing, a new version of DFX was delivered to SAIC, San Diego, on 18 June 1996. This version accommodates the NORSAR large array processing as described in NORSAR Sci. Rep. 2-95/96.

Testbed operation of this version for NOA data was initiated on October 9, 1996.

The initial results from NOA processing demonstrated that a change in parameter setting needs to be done. Due to large beamforming time delays introduced for the large-aperture NOA array, the detection triggers for each signal will span much larger time intervals as compared to smaller arrays. The parameters controlling the triggering of signals by the DFX detection algorithm has been studied, and new parameters for station NOA will be suggested.

The general impression from the first week of DFX operation on NOA data, compared to local NDPC detection processing, is that all real signals are detected and that the slowness vector estimates are consistent with those resulting from the NDPC processing. The number of false triggers due to spikes and data gaps are significantly reduced as compared to the NDPC processing.

Although the DFX masking process effectively removes bad data, we still see a need for an operator-initiated masking process. We suggest that a database table is defined that contains:

sta	Station name
chan	Channel name
time	Start time for abnormal channel status
endtime	End time for abnormal channel status
status	Descriptive code for abnormal channel status. E.g. channel masked during processing.
commid	Comment id for description of status.

The table should be maintained by the IDC operator in cooperation with the NDC station operator. It would be a manageable effort to use this information within DFX for channel masking.

NORSAR processing algorithms

The new algorithm used for large array slowness vector estimation is the DFX function *"compute-beamform-fk"* which is described in Fyen (1996a, 1996b).

Future plans for NORSAR processing.

The current detection recipe for NOA has 180 beams. This number has been kept unchanged to minimize the need for computing power during testbed operation. As soon as the NOA station processing has proven to be working satisfactorily, we will supply a new beam set with a larger number of beams.

Experiments with individual subarray processing have been conducted, and initial results show that due to large amplitude differences across the array, improved detectability can be obtained compared to the full array beam. Within this framework, the NORESS array, which is located within the NOA array, could be processed as a subarray. The problem is how to reduce individual subarray detections to one detection representing the NOA array, and then make a decision on what array configuration and method to use for slowness vector estimation. The challenge is to submit high quality arrivals for the IDC phase association algorithm (GA) and not to confuse the GA process with several subarray detections for the same event. Efforts to solve this problem will continue.

Threshold Monitoring at the IDC testbed

During a visit to the IDC in the time period Aug. 20-23, the Threshold Monitoring (TM) system was installed on the testbed. The DFX program was configured to do the STA calculations for each of the available stations, using the extended functionality provided by NORSAR. The programs for subsequent calculations of network magnitude thresholds were installed in the so-called Delta-pipeline, operating with a time delay of 10-12 hours behind real-time. Since then, the processing has been running without technical problems, confirming the robustness of the TM system with respect to continuous operation. Initially a couple of bugs were detected in the configuration of DFX, but these were soon corrected.

A common baseline beam deployment was used for STA calculation of data from all available arrays. For details, see Fyen et al, 1996. In order to obtain more precise estimates of the magnitude thresholds, we have started an effort of tuning the beam deployments for each of the primary stations of the IMS network, see section 7.3 of this report.

During the next reporting period, we will complete the tuning of the IMS primary network. After this we will technically and seismologically verify the results for threshold monitoring using the full IMS primary network, assist in transferring the TM system into the operational system at the IDC, and develop adequate products with associated graphical displays for making the output from the TM system available to the international community.

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