OPERATION AND RECENT DEVELOPMENT OF THE PROTOTYPE INTERNATIONAL DATA CENTRE

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ABSTRACT

The Prototype International Data Center (PIDC) in Arlington, Virginia is now in its fifth year of full-scale operation. It continues to evolve through a series of software 'releases' that incorporate advanced physical and computer science technologies. After testing on the operational system at the PIDC, the software is delivered to the CTBT Organization in Vienna. The second release of software to the IDC was installed in May 1999, and provides that facility with a capability for data acquisition, automatic processing, analysis and product dissemination that is essentially identical to that of the PIDC.

The network currently used by the PIDC consists of 36 primary and 37 auxiliary seismic stations; 4 hydroacoustic stations. 6 infrasonic and 20 radionuclide stations that together yield on average 4.2 Gb of data per day. These data are forwarded to the Vienna IDC which at present (May 1999) does not have any independent data sources. The PIDC continues to publish multiple automated event listings and a Reviewed Event Bulletin (REB) for every day of the year. Over the past year, enhancements of the application software, data services and system utilities have refined the ability to detect and locate events. In the latest version of the software these include:

- routine automatic and interactive processing of infrasound data
- seasonally varying hydroacousitc travel times and improved hydroacoustic analysis tools
- 'Filed of Regard" images for radionuclide measurements
- source specify station corrections (SSSC's) for northwestern Eurasia
- improved coefficients for M_L determinations, to closer match m_b
- new M_s computation, including regional-distances
- Threshold monitoring, assessing seismic station and network detection capability
- expanded bulletin formats that include maximum-likelihood and upper-bound magnitudes.

In addition to this new functionality, there have been many improvements in such areas as the stability of the distributed application and control processing system, and better error-handling capabilities. Data and products from the PIDC continue to be made available by subscription (regular mail messages), on demand through an 'AutoDRM' service, and via the PIDC Web page (www.pidc.org)l

Key Words; International Data Centre, bulletin

ENHANCEMENTS IN AUTOMATED PROCESSING SYSTEMS

The operability of IMS systems was significantly enhanced with the replacement of ISIS, a distributed application control processing system (DACS), by Tuxedo, a more robust queue-based DACS. Tuxedo 'middle-ware' has been in use for several years, for example, by the banking industry in Automated Teller Machines (ATM's). Operability of the system was also improved with the new DACS controller GUI '*Tuxpad*'. *Tuxpad* was developed to enable an IMS system operator the ability to monitor and control the entire automated processing system via a handy GUI interface. *Tuxpad* features include online modifications to the timely execution individual process or entire groups of processes, re-distribution of processing load, etc. A similar advancement incorporated within the WorkFlow GUI enables an operator to examine in detail the status of a individual process within the 'pipeline', identify problems that may exist, and if necessary re-process the interval via a simple mouse command. Although such modifications may appear subtle, they have enhanced the error handling capability and significantly improved the operability of the automated processing system.

INFRASONIC SIGNAL PROCESSING

Infrasonic signal processing is a routine part of interactive analysis at the PIDC. Infrasonic waves can originate in the atmosphere or as seismic waves that couple with the atmosphere. The signals typically have a duration from 10-100 seconds, in general a dominant frequency from 0.01-3.0 Hz and can display a strong coherence across an array of sensors. An infrasonic 'detection' is declared by the automated system when the spatial coherence of the waveforms exceeds a pre-determined threshold, where the spacial coherence of the waveforms is calculated in a two-dimensional slowness plane for a set of frequency bands. Although 60 IMS infrasonic stations are scheduled to be deployed, 6 are currently available at the PIDC. For the tuning of existing and the testing of new algorithms and parameter configurations an interactive GUI analysis tool has been developed (Wang, 1999). Improvements pertaining to the kinds of features of a detection that should be extracted as well as the methodology of extraction are active research topics.

HYDROACOUSTIC INTERACTIVE ANALYSIS TOOLS

Hydoacousitc processing includes signal detection, feature measurement, phase identification and association. Among the many new features introduced into the Analyst Review Subsystem (ARS) several of these features that specifically address processing and displaying hydroacoustic data are in standard use. Hydroacoustic functionality includes and allows users to:

- select whether to display the peak or probability weighted arrival time;
- display the onset/termination times for a hydro arrival;
- modify the onset/termination times;
- send the modifications to DFX (Detection and Feature Extraction) for processing;
- display the new onset/termination and arrival times and;
- save these new parameters to the database.

The addition of hydroacoustic as well as atmospheric infrasound data as input has extended ARS' processing requirements. Previously ARS could safely assume all seismic arrivals occurred within 40 minutes of an event, however, acoustic phases may arrive hours later. ARS' has been modified to handle time-extension waveform loading for a given analysts' allocation.

FIELD OF REGARD IMAGERY

The PIDC generates products to support radionuclide monitoring operations and to support the location of radionuclide sources using atmospheric transport modeling (Zuzola et al., 1998). One such product, the field of regard (FOR) identifies an area within which air has a non-zero probability of moving forward over a specific time interval and arriving at a site or a point location. The area identified is based on the release of air parcels at grid point locations from which the air parcels grow by diffusion/dispersion and move with the atmospheric flow. If the parcels grow in size and move over the site or point location, and have grown large enough to impact the site at a user defined minimum concentration (minimum detection level), then that particular parcel contributes to the probability distribution. The area enclosing the union of all parcels over a period of time which impact the site defines the FOR. The ratio of the parcels from any particular grid point that arrive/impact at a station to the total number of air parcels released from all grid points that arrive/impact at that station taken from all releases for all the grid points in the region of interest determines the probability distribution needed to define the most likely source area, or the FOR. The time specified for the field of regard is the initial time of release of air parcels from any of the grid points. If the FOR is a 48-hour FOR, air parcels require 48 hours or less travel time from any grid point to arrive at (or pass through) the site or point location. Detailed sample information, measurement categorizations, processing results and FOR images are available for 48- and 72-hour timesteps via the PIDC website.

SOURCE SPECIFIC STATION CORRECTIONS

It is well known that IASPEI91 global travel time curves deviate from observed travel times in shields and platforms at regional distances. One of the objectives of the PIDC is to improve event locations using regional travel time corrections for IMS stations relative to IASPEI91. The PIDC incorporated source specific station corrections (SSSC's) into the IMS during the spring of 1999 for the Fennoscandian region. In addition, SSSC's are under testing for more than 20 seismic stations in the US and Canada (Yang and McLaughlin, 1999b). Preliminary results presented in Yang et al., (1999b) show event locations are improved and error ellipses are reduced when such corrections are utilized.

IMPROVED ML DETERMINATION OF IMS STATIONS

In the spring of 1999, station-specific correction curves for M_L estimation were installed into the PIDC operational system. This was the first significant upgrade since 1995 (Israelsson, 1995) to reduce the discrepancy between M_L and m_b on a station by station basis. Better station M_L magnitude estimates result in better network M_L. Improved curves were determined from two years (1997-1998) data recorded at 85 stations or about 13,000 arrivals. Comparisons and results discussed in detail in (Yang et al., 1999) show a significant reduction in biases and scatter for many of the IMS stations.

MS COMPUTATION INCLUDING REGIONAL-DISTANCES

Computation of M_s was modified by replacement of the Prague distance formula with the formula of Rezapour and Pierce (1998) and Stevens and McLaughlin (1997) in order to increase accuracy, reduce uncertainty and decrease M_s thresholds. Since the beginning of GSETT-3 surface wave processing was limited to the range of 20-100 degrees, primarily because M_s calculated at distances less than 20 degrees is consistently lower than M_s at greater distances. Modifications discussed in McLaughlin and Stevens (1999) show this is no longer the case, hence, the distance range for measuring surface waves was extended to 2-100 degrees. These enhancements significantly improve the PIDC's ability to estimate M_s.

THRESHOLD MONITORING

Threshold Monitoring (TM) provides an ability to assess the detection performance of the primary IMS seismic network using hourly summaries of each station's data availability, noise levels and average and worst-case global detection capability. Graphical results in the form of PostScript files are accessible via the PIDC website and via pointers in the fileproduct table which provides a framework for distributing TM results through the Subscription system. TM has been included within the SEL3 pipeline which runs approximately 12 hours behind real time. Several applications comprise TM (Kvaerna, 1998) and include: TMthreshold, which calculates global detection thresholds using DFX, and TMprod which creates hourly summary plots and updates the fileproduct table. The three kinds of TM plots available are:

- 'detplot' provides average and worst-case network detection capability by the hour;
- 'status' provides the noise level, signal, and data gaps for primary seismic stations;

- 'uptime' displays a world map with information on station availability.

IMS1.0, MAXIMUM-LIKELIHOOD AND UPPER-BOUND MAGNITUDES

The Reviewed Event Bulletin (REB) is a list of events and event parameters obtained by analyst review of automated processing results of data from Primary and Auxiliary SHI stations. IMS1.0 format is now the standard publication format for PIDC products. Perhaps the most significant new feature of IMS1.0 is the inclusion of maximum likelihood magnitude measurements.

The PIDC has routinely estimated maximum likelihood m_b and M_s magnitudes and stored the values as mb_mle and ms_mle in the REB netmag tables since April 1998. These magnitudes are published as mbmle and msmle in the IMS1.0-format REB and represent the maximum likelihood estimate for m_b and M_s, based on associated P-wave and LR measured at primary stations plus the noise amplitudes measured at primary stations at the predicted times for P- waves and LR. In general, the maximum likelihood values will be slightly less than the network average magnitudes published as m_b and M_s. Because large events have few stations that do not have detections, the maximum likelihood values will be nearly the same. In the case that there are no associated P-waves in the epicentral distance range 20 to 100 degrees or LR detections in the epicentral distance range 2 to 100 degrees, 95% confidence upper bounds are estimated for m_b and M_s respectively, based on the measured noise values at respective predicted times at primary stations. These 95% confidence upper bounds are published as mbub and msub in the IMS1.0-format REB and represent the magnitude which 95% probability no station would detect given the observed noise levels. Recent results are discussed in Israelsson (1999).

This is the first application of routine publication of automated maximum likelihood and upper bound magnitudes. While all possible P-waveforms are reviewed by analysts, M_s and M_s noise estimates are detected, associated, and measured automatically without analyst review. M_s upper bounds reflect the results of the automated detection of LR amplitudes. Note, some legitimate LR measurements may not have been associated by the automated system and are treated as noise.

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