Topic	Access to the CMR seismic/hydroacoustic/infrasonic data
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1 Introduction

After the signature of the Comprehensive Nuclear-Test-Ban- Treaty (CTBT) in New York in 1996, the International Data Centre (IDC) was established within the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in Vienna, Austria. The procedures developed through international co-operation during GSETT-3 (Group of Scientific Experts Technical Test 3) and originally implemented at the Prototype IDC (PIDC) in Arlington, USA, are now used and further developed at the IDC in Vienna. However, although it can be expected that more information on the IDC will be posted in future on www.ctbto.org, IDC data products are not yet openly available. In contrast, the Center for Monitoring Research (CMR; http://www.cmr.gov), an offspring of the PIDC, makes seismic, hydroacoustic, infrasonic (SHI) data products accessible. These data come from two sources, the PIDC and the RDSS (Research and Development Support System). The PIDC data products consist of continuous waveforms and bulletins accumulated during PIDC operations from January 1995 to September 2001 whereas collecting and archiving both historical and current data are ongoing for the RDSS data products and metadata. The RDSS data also include a subset of the PIDC data that are of interest. This document summarizes the CMR SHI data products and provides information on their open access.

The data products are managed through various Oracle databases (see http://www.oracle.com) using the CSS3.0/IMS1.0 schema (e.g., IDC Documentation 5.1.1, 2001). The RDSS databases are also documented individually. Waveform data are stored in a mass store system or disks, with indexes in the databases. For public access data are retrieved from inside the firewall based on user requests. For data exchange, GSE2.0/IMS1.0 formats (IDC Documentation 3.4.1, 2001) are used, and flat files of CSS (Center for Seismic Studies) tables facilitate easy integrations with Oracle databases. Many tools for data analysis and conversions are available at CMR and in other domains.

One type of data products is bulletin and metadata information. These can be openly accessed through web interfaces and/or AutoDRM (for PIDC data). Bulletins can be retrieved (both calendar retrieval and custom retrieval) at the CMR web site at http://www.cmr.gov. AutoDRM is a message system to which data requests may be sent in formatted messages. A front-end web interface is also available at the CMR web site for AutoDRM (event-based). The other type of data products is waveform data and related station/instrumentation information. Waveform data can be retrieved using AutoDRM (for PIDC data), web, or FTP. Related station/network information can be accessed via the CMR web.

In this document we describe each of the bulletin and waveform data products from the PIDC (Section 2) and the RDSS (Section 3), and their retrieval methods (Section 4). Tools available for data analysis are listed (Section 5). We also summarize the time lines of configuration changes that affect the data products (Section 6). More information on CMR data products and data access is described in the user's guide to the CMR data products (Yang et al., 2000b; http://www.cmr.gov/rdss/documents/user_guide/index.html).

Further documentation can be found at http://www.cmr.gov/pidc/librarybox/ccb.html, including IDC Documentation and the Configuration Control Board memos that document changes to the PIDC system. Users may also contact user_services@cmr.gov for questions/requests concerning CMR data products. As the success of data collection relies on cooperation among a wide range of sources, we strongly encourage users to contribute information to CMR.

2 PIDC Data Product

2.1 PIDC Bulletins

There are seven PIDC event bulletins generated from Oracle databases (Table 1). Each bulletin is a list of events and event parameters (origin and associated arrival information).

Table 1 PIDC event bulletins

Acronym	Description
REB	Reviewed Event Bulletin
SEB	Standard Event Bulletin
SSEB	Standard Screening Event Bulletin
SEL1	Standard Event List1
SEL2	Standard Event List2
SEL3	Standard Event List3
GAMMA	Supplementary Bulletin

2.1.1 Reviewed Event Bulletin (REB)

The Reviewed Event Bulletin (REB) is the analyst-reviewed final PIDC SHI bulletin. It includes only prototype and final International Monitoring System (IMS) stations, and only events formed using at least three primary stations (IDC Documentation 5.2.1, 1999).

The REB event locations were computed using PIDC software that allows for a hierarchy of corrections relevant to location improvement (Nagy, 1996). From the beginning of the PIDC operations on January 1, 1995, the IASPEI91 model (Kennett, 1991) has been used as the reference travel time set. Ellipticity and elevation corrections are made for each arrival. Slowness and azimuth are very critical when locating events with only a few stations. Tabulated Slowness and Azimuth Station Corrections (SASCs) for each station and array were used from January 1998 (Bondar, 1998) and updated in July 2000 (Wang and McLaughlin, 2000). Separate regional (distance less than 20°) travel time curves may be designated for Pn, Pg, Sn, and Lg for each IMS station. Regional 1-D travel-time tables were used in locating REB events in Fennoscandia between September 1997 and March 1999 (Bondar and Ryaboy, 1997). Since then these 1-D travel times have been only used in PIDC operations when producing the automatic bulletins (SELs). In the hierarchy of location calibration the PIDC software may also use tabulated path corrections, or Source Specific Station Corrections (SSSCs), to apply corrections relative to IASPEI91 as a function of source location for any station and phase. Regional SSSCs were used for Fennoscandian and high latitude IMS stations from April 1999 (Yang and McLaughlin, 1999). SSSCs for North

America were used from March 2000 (Yang and McLaughlin, 2000), and some were updated in April 2001 (Ryaboy et al., 2001). The SSSCs are model-based and SASCs were developed based on the REB data; the corrections are relative to the default IASPEI91 model.

Location uncertainties are represented by error ellipses at 90% confidence level. The *a priori* errors are separated as measurement and modeling errors, starting in September 1997 (Israelsson et al., 1997). The former represents errors in arrival time picks as a function of signal-to-noise ratio. Modeling errors, as a function of distance for each type of seismic phase, specify uncertainties in the model when representing the real Earth. The location software extracts the modeling errors from the travel-time tables (and SSSCs) for a given phase (and station), and extracts the measurement errors from the arrival table for given phase picks. The measurement errors were not retro-updated in the PIDC databases for data prior to the implementation, but were updated in the RDSS databases as described in their individual documentation.

The hierarchical corrections, for example, SASCs and SSSCs, and the measurement/modeling errors were developed and implemented incrementally. They have a considerable impact on event locations, error ellipses, and residuals. When using the CMR data products covering an extensive time period, users should be aware of when such files are were implemented/updated in the PIDC system, therefore affecting the bulletins (see Section 6). If users relocate events using the PIDC software/procedures, applying the latest corrections/errors is important.

Several magnitudes are computed for REB events, including mb, ML, Ms, mb_mle, ms_mle, mb1, mb1_mle, ms1, and ms1_mle (IDC Documentation 5.2.1, 1999; Israelsson et al., 2000). They may be different from those given by other organizations such as the NEIC or ISC. Also note that amplitudes are measured by the automatic system, and are not revised by the analysts.

The mb magnitude is calculated using the Veith-Clawson (1972) attenuation correction as a function of distance and depth over the distance range of 20°-90°:

$$mb = \log10(amp/per) + Q(distance, depth)$$

where the amplitude amp is peak-peak in nm and per is dominant period in seconds.

The calculation of the local magnitude ML (elsewhere in the Manual termed Ml) is more complicated as attenuation curves tailored to each station are being used. ML magnitudes are calculated from short term average amplitudes in the passband 2-4 Hz for Pn or P phase, if the distance is less than 20° and the estimated depth - depth error < 40 km.

The attenuation correction for ML is calculated from the formula:

$$a + b * r + c * \log10(r)$$

where r is the epicentral distance (in km) and the coefficients a, b, c have been tailored for each station that contributes to the REB to maximize agreement between ML and mb. Each station has its own a, b, and c values, and the values of these coefficients may change from time to time as part of tuning work to make more consistent magnitudes. The REB ML magnitude is obtained from:

$$ML = \log10(AMP/PER) + a + b * r + c * \log10(r)$$

where AMP is the short term average amplitude as it appears in the REB in nm (0-peak). It has been transformed from a short-term average value, corrected for long-term noise and measured in a 2-4 Hz bandpass. PER, period in the formula above, is always 1/3 sec (0.33 in the REB) for ML, as the amplitude is measured from a band pass filtered channel (between 2-4 Hz) with a center frequency of 3 Hz. Note that for stations with instrument calibration periods different from 1 sec, the instrument calibration period will enter the formula.

The Ms magnitude is computed for surface waves only at primary seismic stations. The amplitudes and periods are measured for Rayleigh waves (LR) on a beam for arrays or vertical channel at single stations. The Ms formula is:

$$Ms = \log(amp/per) + B(r)$$

where r is distance and B(r) is the attenuation correction.

The Maximum Likelihood Estimates of mb (mb_mle) and Ms (ms_mle) magnitudes are quite different from the standard average magnitudes. For a given event, these magnitude estimates are based not only on the amplitude/period ratios of P/LR (mb/ms) waves at detecting stations, but also on noise amplitudes at stations that did not detect the event. They are calculated using the maximum likelihood algorithm of Ringdal (1976). The reason for calculating mle type magnitudes is to reduce bias for event magnitudes based on a small number of stations.

The generalized mb (mb1, mb1_mle) and Ms (ms1, ms1_mle) are calculated to improve consistencies and robustness of IDC mb and Ms magnitude. Empirical *a priori* station corrections are applied, when available, in calculating these magnitudes. On average mb1 is about 0.2 magnitude higher than mb_ave (Israelsson et al., 2000).

(Note of caution for data users outside of the CTBTO community: (P)IDC magnitudes differ from IASPEI recommended standards for magnitude determination from body and surface waves (see IS 3.2). Their main aim is to use magnitude definitions that could be automated and also extend down to lower source sizes than traditional definitions. Earthquake seismology has to assure long-term continuity and stability of standard earthquake magnitudes according to their original definitions and thus to guarantee homogeneous earthquake catalogues for seismic hazard assessment, proper estimates of time-variable seismic energy release and other seismological and engineering applications up to the strongest seismic events possible (Mw up to about 10). Note that the catalogs commonly used for hazard assessments etc., such as NEIC and ISC, also do not yet fully conform to earlier IASPEI recommendations, and in fact combine individual magnitudes calculated according to myriad, largely undocumented, definitions whose mix has changed with time. The (p)IDC methods are documented and consistent, and the results may over time provide the most complete and stable catalogs for some purposes.

2.1.2 Standard Event Bulletin (SEB)

The Standard Event Bulletin (SEB) is similar in content and format to the REB, but also includes “event characterization” parameters and “event screening” results for each event.

2.1.3 Standard Screened Event Bulletin (SSEB)

The Standard Screened Event Bulletin (SSEB) is similar in content and format to the Standard Event Bulletin (SEB), but does not include events that were screened out by a standard set of event screening criteria.

2.1.4 Standard Event List 1 (SEL1)

The Standard Event List 1 (SEL1) is the initial automatic event list generated one hour after real time. Data from auxiliary stations were requested by the automatic system based on SEL1 locations in order to improve event locations in further processing (SEL2 and SEL3). SEL1, SEL2, and SEL3 are automatic processing results of IMS seismic/hydroacoustic/infrasonic data available at the PIDC. These events are generated using algorithms similar to those of the REB. Citation or research use of the automatic event lists is strongly discouraged.

2.1.5 Standard Event List 2 (SEL2)

The Standard Event List 2 (SEL2) is the second automated event list generated six hours after real time. Data requested from auxiliary stations are used in locating events. SEL2 results are generally improved compared to SEL1.

2.1.6 Standard Event List 3 (SEL3)

The Standard Event List 3 (SEL3) is the final automated event list generated 12 hours after real time. Data requested from auxiliary stations are used in locating events. SEL3 results are further improved compared to SEL1 and SEL2 since some late data may arrive after the first two bulletins are generated.

2.1.7 Supplementary (GAMMA) Bulletin

The Supplementary (also known as GAMMA) Bulletin contains supplementary event information during the PIDC operations. These events were located by national networks and contributed to the PIDC by National Data Centers (NDCs). About 30 NDCs have provided events to the Gamma Bulletin.

The GAMMA events are compared with the REB for event correlations (origin time within 60 seconds and epicenter within 3 degrees). Events are also grouped across the NDC bulletins, but no preferred origin is chosen from multiple solutions for an event. There are no arrivals or waveforms in the GAMMA Bulletin, but PIDC arrival and waveform data are available at CMR for a GAMMA event when it is also in the REB.

The GAMMA Bulletin represents a potential source of well-located events that might be usable as ground truth events. Comparisons between the GAMMA Bulletin and the REB for common events can reveal systematic biases in the IMS network solutions and lead to concentrated regional calibration effort. However, the quality of the GAMMA Bulletin varies

from region to region. Many NDCs provide locations far outside their networks. Very often the events are provided without quality information so that it is impossible to assess the accuracy of the event parameters.

2.2 PIDC waveform and related data

PIDC waveform data include those from the waveform archive and segment archive. They were processed by PIDC Operations, and stored in a mass store system for stations whose data were received by the PIDC since 1995.

2.2.1 Waveform archive

The waveform archive consists of four hours segments of data. Pointers to the waveform data (wfdisc records) as well as derived parameters are stored in the operational database.

2.2.2 Segment waveform archive

The segment archive consists of segments of a few minutes around the arrivals, resulting in much smaller data volumes. The following rules apply for selecting data segments to all stations with at least one phase associated in the REB, all primary stations within 30 degrees of the REB event, or all auxiliary stations with waveform data available (Coyne, 1996):

- For three-component station or reference stations of arrays at regional distance, raw waveforms for all components from one minute to a group velocity of 2.5 km/s plus one minute.
- For arrays at regional distance, incoherent beams over the same time window, as well as a five minute segment of the beam to the theoretical P-wave slowness and azimuth beginning one minute before the first arrival.
- For three-component stations or reference stations of arrays at teleseismic distance, three broadband or short period channels beginning one minute before the first arrival to a total of five minutes. To include surface waves three broadband or long-period channels are filtered and decimated to 1 sample/s from one minute prior to the first arrival through a group velocity of 2.5 km/s plus one minute.
- For arrays at teleseismic distance, a five minute segment of the beam to the theoretical P-wave slowness and azimuth beginning one minute before the first sample, from a group velocity of 4.5 to 2.8 km/s.
- For hydroacoustic stations, all channels two minutes before the T phase to four minutes after.

2.2.3 Related data

Other related data are useful in requesting/analyzing waveform data. Related data include station/network/threshold monitoring status, instrument response files, and station information. Station information and instrument response are important in processing the waveform data. The station/network/threshold monitoring status provides station availability information for a given time period.

3 RDSS data product

3.1 RDSS bulletins

RDSS bulletins are not direct results from PIDC operations; they are ground truth, supplementary, and/or calibration information useful to researches. The event bulletins are generated from a number of database accounts given in Table 2. Related metadata, e.g., data sources, are also stored and available in these databases.

Table 2 RDSS databases

Acronym	Account
REDB	Reference Event Database
EXPLOSION	Nuclear Explosion Database
SPECIAL_EVENT	Special Event Database
INFRASOUND	Infrasound Database
HYDROACOUSTIC	Hydroacoustic Database
GT	Ground Truth Database
LOPNOR	Lop Nor ACD Database
NOISE	Noise Database

3.1.1 Reference Event Database (former Calibration Event Bulletin)

The Reference Event Database (REDB, former Calibration Event Bulletin, CEB) contains selected REB events that are small to medium sized, well-located, and globally uniformly distributed during the PIDC Operations in 1995-2001. These events are potentially useful to produce global and region-dependent corrections for IMS stations, to verify regional travel-time curves proposed on the basis of tectonic structure, to test location procedures, and to refine error estimates.

REDB (former CEB) events were selected from the REB ('PIDC_REB'). Additional steps are undertaken after a REDB event is selected:

- All auxiliary data were requested and archived by the PIDC Operations. However, due to the limited life span of the station disk loops, many REDB events do not have additional waveforms because of delays in requesting auxiliary data.
- The REDB event was re-analyzed and relocated by analysts using additional waveforms if analyst resources were available ('PIDC_REV').
- NDC bulletin data were requested for events within or near their national territories. These bulletins were merged into the REDB database ('XXX_NDC').
- The REDB events were relocated using all arrivals, including those from NDCs and/or those from analysts' re-analysis ('PIDC_REDB').

The hierarchy for preferred solutions is as follows: PIDC_REB, PIDC_REV, PIDC_REDB, with increasing preference. A detailed description of the database is given in Yang et al. (2000e). The quality of REDB events is non-uniform due to limitations on obtaining NDC bulletins for all regions, on requesting auxiliary waveforms, and on human resources for re-analysis. Event locations have generally been improved in North and South America, Australia, Europe, and parts of Asia, but not in Africa and many other regions in Asia.

3.1 2 Nuclear Explosion Database

The Nuclear Explosion Database includes information (e.g., origin time, location, yield, seismic magnitude, and burial depth) on nuclear explosions worldwide in history. In the database there are 2041 events conducted by the United States, France, China, India, United Kingdom, the Soviet Union, and Pakistan during 1945-1998. Waveform data are available for about 1/3 of the events. Instrument responses and arrival picks are also collected. A detailed description of the database is given in Yang et al. (2000d). This database and related information are updated as corrections are made and as new information becomes available.

3.1.3 Special Event Database

The Special Event Database contains information on event parameters and waveform data for non-nuclear events of special interest. It consists of selected chemical explosions and earthquakes that occurred near former test sites and/or regions of interest. This also includes in- or near-water events and events of unknown character. Waveforms are obtained from the PIDC/CMR archive system, IRIS, NORSAR, and researchers. A detailed description of the database is given in Yang et al. (1998).

3.1.4 Infrasound Database

The Infrasound Database contains comprehensive information on infrasonic source locations, recorded waveforms, and related metadata. It includes Ground Truth (GT) events and waveforms, recordings of Soviet nuclear explosions in 1961, waveforms for events in the Antarctic and Alaska collected by the University of Alaska/ENSCO, synthetic waveform data for IMS stations, and other infrasound signals.

3.1.5 Hydroacoustic Database

The Hydroacoustic Database contains selected events of hydroacoustic interest, including earthquakes, nuclear explosions, and chemical explosions from various experiments. It also includes ground truth phase picks for training the neural networks that are used in hydroacoustic phase identification in the automatic processing. A detailed description of the database is given in Yang et al. (2000a).

3.1.6 Ground Truth Database (GT)

The Ground Truth (GT) database consists of explosions and earthquakes with known or estimated location accuracy, classified into separate categories. A GTX category includes events with location accuracy better than X km. The GT database contains subsets of events taken from the REB, REDB, Nuclear Explosion, Special Event, Hydroacoustic, and Infrasound databases. Other events are unique to the GT database. A description of the GT events is given in Yang et al. (2000c).

3.1.7 Lop Nor ACD Database

The Lop Nor Event Database contains the parameters, waveforms, and metadata developed during the CMR Lop Nor Advanced Concept Demonstration (ACD) project. It includes nuclear explosions and earthquakes, as well as some scaled/embedded events. There are 421 events between 5 May 1964 and 9 April 2002 in the Lop Nor ACD Box, 39°-44°N and 86°-92°E, with ~43,000 arrivals. For each event there are multiple data sources and a preferred origin is chosen based on the location accuracy. Data sources for bulletins include the ACD analysis results, IDC/PIDC REB, CMR Nuclear Explosion Database, CMR Ground Truth Database, International Seismological Centre, and the Annual Bulletin of Chinese Earthquakes. GT information is available for most of nuclear explosions and for the scaled/embedded events. A total of 205 events were thoroughly analyzed during the ACD work, including 25 out of all 45 nuclear explosions. Waveform data were obtained for these 205 events from the PIDC/CMR archive system, CMR Nuclear Explosion Database, IRIS, and Blacknest. There are also 10-day continuous waveforms in August 2-12, 2001.

3.1.8 Noise Database

The Noise Database contains background noise spectra for IMS stations since June 1997, except for a few day gaps (Bahavar and North, 2002). On average there are more than 600 background noise spectra available for each data day. The collection of noise samples is a routine automated process that requires limited human intervention. In the early days the calculation of spectra is based on 40-second and 10-second Hamming windows for the primary and auxiliary stations, respectively, with 10% tapering and 67% overlaps. Since January 1998 the windows have been changed to 100-second and 20-second for the primary and auxiliary IMS stations, respectively.

3.2 RDSS waveform and related data

RDSS waveform data are collections of historical waveform segments (as early as 1961) from various organizations. Some PIDC data are also included for events of interest. Data are stored on external disks with indexes in the RDSS databases. Related data include those such as instrument response files, noise spectra, ground truth phase picks, and station information.

3.3 Metadata

Metadata are data about data. They are useful in understanding and utilizing the information on bulletins and waveforms. Typical metadata in the RDSS databases include descriptions of data source, explosion type, and test site, and waveform and other plots.

4 CMR data retrieval

Both types of PIDC and RDSS data products (bulletins and waveforms) can be obtained from CMR. Bulletins may be obtained by calendar web retrieval, by custom web retrieval, by AutoDRM, and by FTP. Waveforms may be obtained by web, by AutoDRM, and by FTP. A

detailed summary of the databases and their retrieval methods is given in Table 3. In general users can retrieve PIDC data using AutoDRM and RDSS data using FTP. AutoDRM requires formatted messages for direct requests to obtain bulletin and waveform data. A web interface is available at CMR to form and submit event-based requests for waveform data. In both cases AutoDRM users receive information and data through E-mail/FTP.

The CMR web site is http://www.cmr.gov. The direct AutoDRM address is messages@cmr.gov and the web interface is available at the CMR web site. The CMR FTP site is ftp.cmr.gov or ftp://ftp.cmr.gov.

4.1 Calendar web retrieval (Bulletin)

Calendar web retrieval provides easy access to database information for a given event occurrence date. All the events in the REB, SEB, SSEB, SEL1, SEL2, SEL3, GAMMA (http://www.cmr.gov/pidc/dataprodbox/prodavail.html), and REDB (former CEB; http://www.cmr.gov/rdss/resources/index.html) since January 1995 can be accessed by calendar retrieval.

4.2 Custom web retrieval (bulletin/waveform)

Custom web retrieval allows users to specify selection criteria for events of interest. This function is provided for a group of the PIDC bulletins together (REB, SEL1, SEL2, SEL3, SEB, SSEB; http://www.cmr.gov/pidc/dataprodbox/cust.html) and for other PIDC/RDSS bulletins on their individual web pages (http://www.cmr.gov/pidc/dataprodbox/prodavail.html and http://www.cmr.gov/rdss/resources/index.html). Results may be sorted by such parameters as time and region.

4.3 Retrieval by AutoDRM (bulletin/waveform)

Data or subscription request for the REB, SEL1, SEL2, SEL3, and SEB can be made using AutoDRM. The available information includes bulletin, event, origin, arrival, detection, waveform, station, channel, and response. The retrieving results or error messages are sent back to users by E-mail and data can be picked up at the CMR FTP site.

4.4 Retrieval by FTP

Information on some RDSS databases can be retrieved by FTP at ftp.cmr.gov or ftp://ftp.cmr.gov.

Table 3 Retrieval methods for SHI bulletins and waveforms

Bulletin	Calendar retrieval	Custom retrieval	AutoDRM	FTP	Source
REB	bulletin	bulletin	both		PIDC data product
SEB	bulletin	bulletin	both		PIDC data product
SSEB	bulletin	bulletin	both		PIDC data product

SEL1	bulletin	bulletin	both		PIDC data product
SEL2	bulletin	bulletin	both		PIDC data product
SEL3	bulletin	bulletin	both		PIDC data product
GAMMA	bulletin	bulletin			PIDC data product
REDB (former CEB)	bulletin	bulletin			RDSS data product
EXPLOSION		both		both	RDSS data product
SPECIAL EVENT		both			RDSS data product
INFRASOUND		both			RDSS data product
HYDROACOUSTIC		both			RDSS data product
GT		both			RDSS data product
LOPNOR		both			RDSS data product
NOISE				both	RDSS data product

4.5 Format/Tools for data exchange/conversion

Bulletins are generally in the IMS1.0 format, except that GAMMA is in the GSE2.0 format. Waveform information is stored in a CSS3.0 table (wfdisc table) for indexes and in binary data files (.w files). These files can be read directly by waveform analysis tools, e.g., SAC, and Matseis. They can also be converted from CSS to other formats using some tools (see 5).

Flat files of CSS database tables other than wfdisc and Oracle export may also be used for data exchange for advanced users with direct access to Oracle databases. Table 4 lists the major relevant database tables and their brief descriptions. Schema for most of the tables are given in the IDC Documentation 5.1.1 (2001). New RDSS tables, particularly for metadata, are described in individual RDSS database documentation.

Table 4 CSS3.0/IMS1.0 and RDSS database tables

Table name	Description	Schema
affiliation	Network station information	IDC
amplitude	Arrival- and origin-based amplitude measurements	IDC
arrival	Summary information on an arrival	IDC
assoc	Data associating arrivals with origins	IDC
ceppks	Cepstral analysis results	IDC
complexity	Complexity event characterization parameter	IDC
detection	Summary information about detections	IDC
event	Event origin connection	IDC
explo	Event yield, medium, test site, explosion type	Adopted by IDC
glossary	Abbreviation descriptions	Adopted by IDC
hydro_features	Hydoracoustic signal features	IDC
infra_features	Infrasonic signal features	IDC
instrument	Calibration information for stations	IDC
location	Mine/test site information	Adopted by IDC
metadata	Metadata local residence	RDSS
netmag	Network magnitude	IDC
network	Network descriptions and identification	IDC
origaux	Additional information on origin	IDC
origerr	Errors in origin estimations	IDC

origin	Summary of hypocenter parameters	IDC
origintag	Origin-based metadata	RDSS
parrival	Predicted arrivals and associations for origin-based amplitude measurements	IDC
reference	Reference information	RDSS
remark	Comments on data	IDC
sensor	Calibration information for channels	IDC
site	Station location information	IDC
sitechan	Station-channel information	IDC
splp	Event characterization parameters for short-period/long-period energy ratios	IDC
spvar	Variance of detrended log spectrum	IDC
stamag	Station magnitude estimates	IDC
thridmom	Third moment of frequency	IDC
timefre	Time-frequency measurements for event characterization	IDC
wfdisc	Waveform index	IDC
wftag	Waveform mapping to event	IDC

5 Data analysis/conversion tools

A number of tools that aid data conversion and analysis are available at CMR or from other domains. Some most frequently used tools are summarized in Table 5.

Table 5 Tools available at CMR or other domains

Name	Description	Access
LocSAT	Off-line location program using flat files for inputs/outputs	ftp://ftp.cmr.gov/pub/rdtb/software/Loc-SAT
HLS	Hypocenter location server	Direct use at http://www.cmr.gov
SAC	Waveform data analysis	http://www-ep.es.llnl.gov/www-ep/esd/seismic/sac.html
MatSeis	Waveform data analysis	http://www.ctbt.rnd.doe.gov/ctbt/data/matseis/matseis.html
GMT	Graphic maps	http://www.soest.hawaii.edu/gmt
AutoDRM	Extract database data via internet	Direct use at http://www.cmr.gov
css2sac	Waveform data format conversion from CSS to SAC	http://orfeus.knmi.nl/other.services/conversion.shtml
sac2css	Waveform data format conversion from SAC to CSS	http://orfeus.knmi.nl/other.services/conversion.shtml
codeco3	Conversion between IMS1.0, SAC, and CSS formats	http://www.cmr.gov/rdss/resources/index.html

5.1 Event locations and magnitudes (LocSAT, HLS)

The event locations in the CMR bulletins are produced using application programs based on the “libloc” library. The program Global Association (GA) is used to generate locations for

automatic bulletins, SEL1, SEL2, and SEL3 (IDC Documentation 5.2.1, 1999). The program Analyst Review Station (ARS) is used to generate locations and magnitudes for the REB. Program EvLoc is used to generate the final locations and magnitudes in the REDB (former CEB).

A program, LocSAT, is similar to EvLoc except that it interfaces with flat files instead of databases, and it does not compute magnitudes. As an official release by the CMR R&D Test Bed, LocSAT is available for reproducing the REB/REDB locations.

A Hypocenter Location Server (HLS) has been developed to provide an interface for users to access EvLoc directly. HLS supports the full capabilities of EvLoc, including magnitude calculation. HLS uses the platform-independent XML format as the data exchange format (see http://www.fdsn.org/FDSNwgII.htm).

5.2 Seismic Analysis Code (SAC)

SAC (Seismic Analysis Code) is a general purpose interactive program designed for the study of sequential signals, especially time series data. Analysis capabilities include general arithmetic operations, Fourier transforms, three spectral estimation techniques, IIR and FIR filtering, signal stacking, decimation, interpolation, correlation, and seismic phase picking. SAC also contains an extensive graphics capability.

5.3 Matseis

Matseis is a MatLab-based data analysis tool with strong signal processing and graphic functions. It integrates origin, waveform, travel-time, and arrival data information, and provides graphical plot controls, data manipulation, and signal processing functions. Three data types are recognized, including CSS3.0 Oracle database accessed by SQL, CSS3.0 flat files, and local databases.

5.4 Generic Mapping Tools (GMT)

GMT (the Generic Mapping Tool) is a collection of UNIX tools that allow users to manipulate 2-D or 3-D data sets (including filtering, trend fitting, gridding, projecting, etc.) and produce plots ranging from simple x-y plots through contour maps to artificially illuminated surfaces and 3-D perspective views. GMT supports 25 common map projections plus linear, log, and power scaling, and comes with support data such as coastlines, rivers, and political boundaries.

5.5 Database access tools (AutoDRM)

AutoDRM provides automated E-mail message responses to requests for data in the databases. An AutoDRM web interface is available via the CMR web site. Users can select data request criteria, which are automatically translated into standard request messages. Data

requests are handled by the automated system at the PIDC and the results are sent back to the users by E-mail.

5.6 Data conversions (css2sac, sac2css, codeco3)

Programs css2sac and sac2css convert waveform data between the CSS3.0 format and the SAC formats. SAC can also read the CSS3.0 format directly, so the conversion is not necessary.

Program codeco3 converts many formats including IMS/GSE waveform (from AutoDRM) data to SAC or CSS.

6 Time lines of configuration changes

Configuration changes that affect the uniformity of the CMR products occurred very often during the PIDC Operations due to development and calibration efforts towards a better system. It is important to note the dates of configuration changes given in Table 6 when using the CMR data products. In general, the affected parameters include arrival picks, phase types, event locations, error ellipses, and magnitudes.

Table 6 Dates of configuration changes that affect CMR data products

Date	Changes to the system	Affected database/table/parameter	CCB Memo
New releases:			
12/1995	GA in SEL1	SEL1	CCB-PRO-95/29
12/1995	DFX	All	CCB-PRO-95/30
06/1996	new version of GA (128.1)	assoc, origin, origerr in SEL1, SEL2, SEL3	CCB-PRO-96/25
07/1996	new version of DFX (111.1)	arrival, assoc, detection in SEL1, SEL2, SEL3	CCB-PRO-96/28
08/1996	new release (PIDC4.0)	All	CCB-PRO-96/32
06/1997	new release (PIDC5.0)	All	CCB-PRO-97/19
03/1998	new release (PIDC6.0)	All	CCB-PRO-98/06
07/1999	new release (PIDC6.2)	All	CCB-PRO-99/13
07/2000	new release (PIDC7.0)	All	CCB-PRO-00/07
Surface waves/magnitudes:			
03/1995	ML	netmag, stamag in SEL1, SEL2, SEL3	CCB-PRO-95/05
07/1995	new maxsurf (1.2)	LP and LR phases in REB	CCB-PRO-95/14
10/1995	ML	netmag, stamag in SEL1, SEL2, SEL3	CCB-PRO-95/18

04/1996	improved dispersion curves	LP and LR phases in REB	CCB-PRO-96/13
11/1996	new maxsurf (2.2)	LP and LR phases in REB	CCB-PRO-96/40
06/1997	MS-mle	netmag, stamag in REB	CCB-PRO-97/18
04/1999	new station correction curves for ML	netmag, stamag in REB, SEL1, SEL2, SEL3	CCB-PRO-99/04
07/2000	mb1, Ms1	netmag, stamag in SEL1, SEL2, SEL3	CCB-PRO-00/06
Hydroacoustic/Infrasonic system:			
05/1996	Hydroacoustic stations included	PSUR and WAKE in REB, SEL1, SEL2, and SEL3	CCB-PRO-96/10 CCB-PRO-96/14
09/1997	StaPro for hydroacoustic stations	Arrivals in SEL1, SEL2, and SEL3	CCB-PRO-97/26
07/2000	Station specific 2D travel time tables	Assoc, origin, origerr in REB,	CCB-PRO-00/19
Event characterization:			
07/1996	routine estimation of event characterization parameters	originamp, splp in REB	CCB-PRO-96/27
08/1996	routine estimation of event characterization parameters	ceppks, complexity, and spvar in REB	CCB-PRO-96/30
07/2000	revised routine estimation of event characterization parameters	amplitude in REB, SEL1, SEL2, SEL3	CCB-PRO-00/08
Event location:			
09/1997	new measurement errors	arrival in REB, SEL1, SEL2, SEL3	CCB-PRO-97/18
09/1997	1D regional travel time tables for Fennoscandian stations	assoc, origin, origerr in REB, SEL1, SEL2, SEL3	CCB-PRO-97/22
01/1998	SASCs	assoc, origin, origerr in REB, SEL1, SEL2, SEL3	CCB-PRO-98/01
04/1999	SSSCs for Fennoscandian stations	assoc, origin, origerr in REB	CCB-PRO-99/03
03/2000	SSSCs for North American IMS stations	assoc, origin, origerr in REB	CCB-PRO-00/01
07/2000	updated SASCs	assoc, origin, origerr in REB, SEL1, SEL2, SEL3	CCB-PRO-00/20
04/2001	3D SSSCs for North American IMS stations	assoc, origin, origerr in REB	CCB-PRO-01/01

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