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IDC/CTBTO

PUTTING AN END TO NUCLEAR EXPLOSIONS





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- Introduction
- Parameters for Configuration of non-IMS seismic stations
- □ Instrument file and nominal calibration factor
- □ Program developed for configuration of non-IMS seismic stations
- □ Testing on example event
- Discussion and conclusion





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Introduction

- NDC-in-a-Box is an independent software package developed, distributed, and supported by PTS, which is intended for NDCs to establish a verification regime with a number of functions including receiving, archiving, processing and analysing data from IMS stations. To simplify installation and configuration of NDC-in-a-Box package, most software tools and applications are provided via a distributed virtual machine SeisComP3, which has a large installed base, has been integrated into NDC-in-a-Box since 2016. Automatic data processing is now possible with SeisComp3 in addition to interactive data analysis.
- The standard way to configure non-IMS seismic stations is to use SeisComp3 scripts. Station parameters are imported into the OSDB database or saved as data files within the NDC-in-a-Box virtual machine. An alternative method is introduced here for configuration of non-IMS seismic stations. Based on basic parameters and instrument response file of non-IMS seismic stations, a program developed in Matlab is used to process stations parameters including calculation of instrument response parameters and export them into the database. Standard data files of non-IMS seismic stations can be accessed by NDC-in-a-Box via the shared folder of virtual machines, which simplifies the management of parameters for non-IMS seismic stations parameters and data exchange.





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□ Parameters for Configuration of non-IMS seismic stations

- In order to analyse data from non-IMS seismic stations, basic parameters of stations should be configured in Geotool. Those parameters include station code, station location of latitude and longitude and response file, etc. Response file of station are saved in specific directory and will be loaded as required for data processing.
- Basic parameters of stations are exported in five different database tables of SITE. SENSOR. SITECHAN. INSTRUMENT and AFFILIATION. Relationship between these tables is shown in Figure 1.

Basic parameters of stations can be saved in databases integrated in Geotool, which can also be saved as data files.

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Figure 1 Database tables used for configuration of non-IMS seismic stations





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- □ Instrument file and nominal calibration factor
- Generally, the overall response associated with a seismometer can be described in five different stages. Particle motion detected by seismometer will be transferred to electricity signal, amplified from analog signal to digital signal with units of counts.



Figure 2 Stages description of overall response associated with a seismometer

- Response file and nominal calibration factor(simplified as NCALIB) are two key parameters used in IDC system. There are
 three different format of response file: the Poles and Zeros Block Format(PAZ), the Frequency, Amplitude and Phase Block
 Format(FAP), and the Finite impulse Response Block Format(FIR), in which format of PAZ is used mostly in IDC system.
- Nominal calibration factor is saved in database table of instrument, related tables include SENSOR and WFDISC. Data from stations transferred to IDC in protocol of CD1.0/CD1.1 will be saved in format of CSS for each couple of hours, basic parameters of stations will be saved in database table of WFDISC. Nominal calibration factor and related calibration period are included in WFDISC. If parameters of sensitivity is changed, many more data segments saved in format of CSS would be updated.



Instrument file and nominal calibration factor

 To simplify the update procedure on sensitivity in the IDC system, the nominal calibration factor NCALIB is saved in table of INSTRUMENT, the ration of CALRATIO based on change of NCALIB is saved in table of sensor. If there is a sensitivity change on the seismometer, CALRATIO in the sensor table will be update, which would be applied on all related data segments in format of CSS. The INSTRUMENT and SENSOR database tables are connected via the INID key (Figure 3).

	INSTRUMENT
Column	Description
inid	instrument identifier 🦟
insname	instrument name
instype	instrument type
band	frequency band
digital	data type,digital(d),or analog(a)
samprate	sampling rate in samples/second
ncalib	nominal calibration(nanometers/digital count)
ncalper	nominal calibration period(seconds)
dir	directory
dfile	data file
resptype	response type
Iddate	load date

	SENSOR												
	Column	Description											
	sta	station code											
	chan	channel code											
	time	epoch time of start of recording period											
	endtime	epoch time of end of recording period											
4	inid	instrument identifier											
	chanid	channel identifier											
	jdate	Julian date											
	calratio	calibration											
	calper	calibration period											
	tshift	correction of data processing time											
	instant	(y,n) discrete/continuing snapshot											
	Iddate	load date											

Figure 3 Data segments and application for response parameters



- □ Instrument file and nominal calibration factor
- Pole-Zero Representation for Analog Stages of velocity seismometer
- Transfer function of seismometer in form of velocity is shown below. S_d is sensitivity, A₀ is normalization factor. Transfer function
 of velocity seismometer can be converted to format of displacement or accelerator; NCALIB is nominal calibration factor. There is
 a little bit different for format of response file in terms of velocity, acceleration and displacement.

$$G(f) = S_d A_0 \frac{\prod_{n=1}^N (s - r_n)}{\prod_{m=1}^M (s - p_m)} = S_d A_0 H_p(s)$$

 $ncalib = \frac{1 \times 10^9}{(S_d \times 2\pi f)}$ for velocity seismometer $ncalib = \frac{1 \times 10^9}{(S_d \times 4\pi^2 f)}$ for accelerator seismometer $ncalib = \frac{1 \times 10^9}{(S_d \times f)}$ for displacement seismometer

Where

- $s = i2\pi f$ if the reference frequency is 1 radian/second;
- S_d is the sensitivity;

 $A_0 = \frac{1}{|H_p(s)|}$ is normalizing constant.





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- □ Instrument file and nominal calibration factor
- For instance, if the response file is in terms of PAZ.
- As shown in Figure 4. Response file used in IDC system is in terms of displacement. One zero would be added in response file for velocity seismometer, two zeros would be added for acceleration seismometer.
- To be consistent to original stations, the normalization factor A₀ is same as original value, but the real normalization factor would be calculated at calibration period in data processing.

Line #	Position	Field	Format	Description
Comments				
1 to L	1–80	-	a80	General comments preceded by a "#"
L+1	1	1	a1	#
	3–80	2	a78	instrument type/description (KS36000, GS- 13, and so on)
Instrument	Response	Group U	sing Poles	and Zeros (paz)
L+2 to K	1–80	1	a80	comments (preceded by a "#")
K+1	1–12	1	a12	response source (theoretical or measured)
	14–15	2	i2	sequence number
	17–28	3	a12	description (instrument, anti-alias, and so on)
	30–35	4	a6	response type (fir, paz, fap)
	37–80	5	a44	author or source of information
Line #	Position	Field	Format	Description
K+2	-	1	f or e	normalization factor (Ao)
K+3	1–8	1	i8	number of poles
K+4 to N	-	1–4	4(f or e)	complex pole and complex error
N+1	1–8	1	i8	number of zeros
N+2 to M	-	1–4	4(f or e)	complex zero and complex error

Figure 4 Format of response file (part content)



□ Program developed for configuration of non-IMS seismic stations

 Figure 5 The procedure of reading and formatting parameters for non-IMS seismic stations





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Program developed for configuration of non-IMS seismic stations

 Data files and directory needed for configuration of non-IMS seismic stations is shown in Figure 6. Basic parameters of IMS stations are saved in data files of affiliationTable, instrumentTable, sensorTable, siteTable, sitechanTable; parameters for non-IMS seismic stations are saved in data files of affiliationTable2, instrumentTable2, sensorTable2, siteTable2, sitechanTable2.

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recipeDir2									
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blockageDir	/opt/ctbto/idc/config/tables/data/BLK_OSO								
magDescripFile	/opt/ctbto/idc/config/tables/mag/mdf/idc_mdf_ars.defs								
mapDir	/opt/ctbto/idc/config/tables/map								
affiliationTable	/opt/ctbto/idc/config/tables/static/global.affiliation								
affiliationTable2	/media/sf_NonIMS_stations/tables/nonims.affiliation								
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instrumentTable	/opt/ctbto/idc/config/tables/static/global.instrument								
instrumentTable2	/media/sf_NonIMS_stations/tables/nonims.instrument								
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sensorTable	/opt/ctbto/idc/config/tables/static/global.sensor								
sensorTable2	/media/sf_NonIMS_stations/tables/nonims.sensor								
siteTable	/opt/ctbto/idc/config/tables/static/global.site								
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Figure 6 Data files and path for configuration of non-IMS stations

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

 Database for management of non-IMS seismic stations was developed in MySQL (Figure 7), application interface was developed in Matlab, which can be used to load station parameters into database of MySQL.

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Figure 7 Database developed for management of non-IMS stations in MySQL





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Testing on example event

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orid	Date	Time	Latitude	Longitude	mb	Ms
11897223	4/16/2015	18:07:44	35.29	26.82	5.6	5.9

Figure 8 Example event from IDC REB

		_			
Ш	MSEY	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	MSVF	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	NIL	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	NNA	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	NRIL	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	NVS	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	OBN	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	PALK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	PFO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	RAYN	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	RPN	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	SACV	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	SHEL	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
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Ш	SUR	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	TAU	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
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Ш	XBFO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	XPF	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
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Figure 9 Station list from IRIS for example event

Ш	AAK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
11	ABKT	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ABPO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ALE	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ARTI	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ARU	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ASCN	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	BFO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	BORG	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	BORK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	BRVK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	CMLA	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	COCO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
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Ш	EFI	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ERM	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	ESK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	FFC	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	GAR	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	HOPE	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
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Ш	IBFO	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	JTS	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	KAPI	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	KDAK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	KIV	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	KURK	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
П	KWAJ	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	KWJN	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	LVZ	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00
Ш	MBAR	10	BH?	2015-04-16T18:00:00	2015-04-16T19:00:00





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Testing on example event

- Data of 35 seismic stations from IRIS were downloaded and formatted to five different data files, response file of each station was saved in specific directory.
- Once configuration of station parameters was finished, detail information of those stations could be viewed in Geotool. Part of information in data files of *SITE*, *SITECHAN* and *INSTRUMENT* is shown in Figure 10.

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ALE.	2014140	-1	92 5033	-62 3500	0.0600	Alext NU Capada		ALE.	0,0000	0.0000	2014-Maure	1		
RSCN	2013250	-1	-7.9327	-14.3601	0.1730	Butt Crater, Asception Island		OSCN	0.0000	0.0000	2013-Sen-			
BORG	2012172	-1	64.7474	-21.3268	0.1100	Borgarf Jordur, Ashiarnarstadir, Iceland	88	RORG	0.0000	0.0000	2012-Jun-	-		
BRVK	2011149	-1	53,0581	70.2828	0.3300	Borovoue, Kazakhstan	0.0	BRVK	0.0000	0.0000	2011-Mau-	1 -		
CHLA	2011315	-1	37,7637	-25,5243	0.4290	Cha de Macela, Sao Miguel Island, Azores	0.0	CMLA	0.0000	0.0000	2011-Nov-	-		
0.000	201412	-1	-12,1901	96.8349	0.0010	West Island, Cocos (Keeling) Islands	5.5	0000	0.0000	0.0000	2014-Jan-	1		
DGAR	201277	-1	-7,4121	72,4525	0.0010	Diego Garcia, Chagos Islands, Indian Ocean	88	DGAR	0,0000	0,0000	2012-Mar-			
EFI	2014363	-1	-51,6753	-58,0637	0,1100	Mount Kent, East Falkland Island	9.9	EFI	0,0000	0,0000	2014-Dec-			
ERM	2012310	-1	42,0150	143,1572	0,0400	Erimo, Hokkaido Island, Japan	99	ERM	0,0000	0,0000	2012-Nov-	1		
ESK	201056	-1	55.3167	-3.2050	0.2420	Eskdalemuir, Scotland, UK	55	ESK	0.0000	0.0000	2010-Feb-	1		
FFC	201598	-1	54,7250	-101,9780	0,3380	Flin Flon, Canada	8.8	FFC	0,0000	0,0000	2015-Apr-	11		
HOPE	20158	-1	-54,2836	-36,4879	0.0200	Hope Point, South Georgia Island	8.8	HOPE	0,0000	0,0000	2015-Jan-	-		
JTS	201513	-1	10,2908	-84,9525	0,3400	Las Juntas de Abangares, Costa Rica	99	JTS	0,0000	0,0000	2015-Jan-			
KAPI	201361	-1	-5,0142	119,7517	0,3000	Kappang, Sulawesi, Indonesia	0.0	KAPI	0,0000	0,0000	2013-Mar-	1		
KDAK	2014281	-1	57,7828	-152,5830	0,1520	Kodiak Island, Alaska, USA	8.8	KDAK	0,0000	0,0000	2014-Oct-	13		
KIV	201371	-1	43,9553	42,6863	1.0540	Kislovodsk, Russia	8.8	KIV	0,0000	0,0000	2013-Mar-	11		
KURK	2011158	-1	50,7154	78,6202	0,1840	Kurchatov, Kazakhstan	0.0	KURK	0,0000	0,0000	2011-Jun-	14		
KUAJ	2014158	-1	8,8019	167.6130	0,0000	Kwajalein Atoll, Pacific Ocean	66	KWAJ	0,0000	0,0000	2014-Jun-	2		
MBAR	2014216	-1	-0,6019	30,7382	1,3900	Mbarara, Uganda	88	MBAR	0,0000	0,0000	2014-Aug-	21		
NIL	201371	-1	33,6506	73,2686	0,6290	Nilore, Pakistan	8.8	NIL	0,0000	0,0000	2013-Mar-	23		
NNA	201162	-1	-11,9875	-76.8422	0,5750	Nana, Peru	99	NNA	0,0000	0,0000	2011-Mar-	23		
OBN	2013193	-1	55,1146	36,5674	0,1600	Obninsk, Russia	0.0	OBN	0,0000	0,0000	2013-Jul-	24		
PALK	2014185	-1	7.2728	80,7022	0.4600	Pallekele, Sri Lanka	6.6	PALK	0.0000	0.0000	2014-Jul-	21		
PFO	2013304	-1	33,6107	-116,4550	1,2800	Pinon Flat, California, USA	8.8	PFO	0,0000	0,0000	2013-Oct-	24		
RAYN	201020	-1	23,5225	45,5032	0,6310	Ar Rayn, Saudi Arabia	9.9	RAYN	0,0000	0,0000	2010-Jan-	23		
RPN	2014190	-1	-27,1267	-109.3340	0,1100	Rapanui, Easter Island, Chile	00	RPN	0,0000	0,0000	2014-Jul-	21		
SACV	201438	-1	14.9702	-23,6085	0,3870	Santiago Island, Cape Verde	55	SACV	0,0000	0,0000	2014-Feb-	25		
SHEL	2013233	-1	-15,9594	-5,7455	0,5370	Horse Pasture, St. Helena Island	8.8	SHEL	0,0000	0,0000	2013-Aug-	7/		
SUR	2012156	-1	-32,3797	20,8117	1,7700	Sutherland, South Africa	22	SUR	0,0000	0,0000	2012-Jun-	ored tows		
TAU	201521	-1	-42,9099	147.3204	0.1320	Hobart, Tasmania, Australia	99	TAU	0.0000	0.0000	2015-Jan-	21		
UOSS	2013276	-1	24.9453	56.2042	0.2844	Univ. of Sharjah, Sharjah, United Arab Emirates	65	UOSS	0.0000	0.0000	2013-Oct-	03		
WRAB	2013308	-1	-19.9336	134.3600	0.3660	Tennant Creek, NT, Australia	8.8	WRAB	0.0000	0.0000	2013-Nov-	04		
XPFO	201479	-1	33,6107	-116.4550	1,2800	Pinon Flat, California, USA	9.9	XPFO	0,0000	0,0000	2014-Mar-	20 7		
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Figure 10 Station parameters in different data files viewed in Geotool



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□ Testing on example event

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 Data of those stations could be loaded in Geotool for data analysis. Data waveforms, location results, map and magnitude for example event is shown in Figure 11.

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Figure 11 Data waveform and event location for example event

Locate Event

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105,53

- phase, T - timedef, A - azdef, S - slodef





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Testing on example event



Figure 12 Response curve of station AAK in Geotool.

Figure 13 Comparison of response parameters for station AAK from IRIS to that from IDC system.





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Discussion and Conclusion

- Programs used for configuration of non-IMS seismic stations were developed in Matlab, which could be used to read
 parameters of seismic station from IRIS and format in data files as required in Geotool. A separate database was developed
 in MySQL for management of parameters of non-IMS seismic stations.
- Data files and data for non-IMS seismic stations are saved in local directory of host computer, which is connected to VM by shared folder. Path of datafiles used in Geotool is pointed to shared folder to ensure data from non-IMS seismic stations would be analysed properly in Geotool.
- The idea of analysing data in Geotool through the use of a shared folder would benefit for data management, even when the VM is not stable, there is no impact on data in shared folder. Also, the disk space available on the VM may be limited, whereas the host computer may have much more capacity.
- One example event was selected from IDC REB, available station data and parameters were request from IRIS. Testing
 results showed that data from non-IMS seismic stations can be loaded into Geotool properly for normal data analysis, which
 include adding phase, event location and magnitude calculation, etc. Location results is consistent to that of IDC REB except
 magnitude.
- It is quite easy to implement the application for non-IMS seismic stations. If stations parameters were request from IRIS by script of irisFetch, all parameters in different time periods is mixed in one struct file, which would be pro-processed by programs developed here and exported to specific directory in host computer. The method proposed would be convenient for data analysis for multiple non-IMS seismic stations.