THE CTBT NATIONAL DATA CENTRE: ROLES AND FUNCTIONS

PUSAT DATA KEBANGSAAN CTBT: PERANAN DAN FUNGSI

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Abstract

Following the signature of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) on 23 July 1998, Malaysian Nuclear Agency (Nuclear Malaysia) was designated as the CTBT National Authority in Malaysia. Subsequently, Malaysia ratified the treaty on 17 January 2008. Following the ratification, a CTBT National Data Centre (CTBT-NDC) was established at Nuclear Malaysia. The objective of this paper is to elaborate the unique roles and functions of CTBT-NDC which provide technical support to the CTBT National Authority in carrying out its roles under CTBT as well as promoting the uses of International Monitoring System (IMS) data and International Data Centre (IDC) products for civil and scientific applications. With regards to the verification of events suspected to be a nuclear weapon test, CTBT-NDC performs waveform data analysis using IMS data and IDC products produced by IDC in order to verify the nature of such event. The waveform data analysis could include seismic, hydroacoustic and infrasound data. In addition, an atmospheric transport modeling on possible release of radionuclide particles originated from the nuclear weapon test location is also performed to forecast the global dispersion of radionuclide smoke. The findings from these analyses will be used as technical advice to the CTBT National Authority. Apart from verification purposes, CTBT-NDC also promotes the benefits of IMS data and IDC products for civil and scientific applications such as earth studies, improvement of disaster management and etc. In summary, CTBT-NDC plays a unique role in supporting CTBT National Authority to carried out its functions under CTBT as well as promote the full use of IMS data and IDC products for civil and scientific applications.

Abstrak

Susulan daripada pemeteraian Triti Pengharaman Menyeluruh Ujian Senjata Nuklear (CTBT) pada 23 Julai 1998, Agensi Nuklear Malaysia (Nuklear Malaysia) telah dilantik sebagai Badan Kebangsaan CTBT di Malaysia. Kemudian, Malaysia telah meratifikasi Triti ini pada 17 Januari 2008. Lanjutan daripada ratifikasi tersebut, satu Pusat Data Kebangsaan CTBT (CTBT-NDC) telah ditubuhkan di Nuklear Malaysia. Objektif kertas ini adalah untuk menerangkan peranan dan fungsi unik CTBT-NDC yang mana ia menyediakan sokongan teknikal kepada Badan Kebangsaan CTBT dalam menjalankan peranannya dibawah CTBT serta mempromosi penggunaan data Sistem Pemantauan Antarabangsa (IMS) dan produk Pusat Data Antarabangsa (IDC) untuk tujuan awam dan saintifik. Berkaitan dengan verifikasi sesuatu kejadian mencurigakan yang mempunyai ciri-ciri ujian senjata nuklear, CTBT-NDC akan menjalankan analisa data gelombang menggunakan data IMS dan produk IDC dikeluarkan oleh IDC untuk tujuan verifikasi jenis kejadian tersebut. Analisis data gelombang melibatkan pengunaan data seismik, hidroakustik dan infra-bunyi. Di samping itu, model penyebaran partikel di udara mengenai kemungkinan pelepasan partikel radionuklid yang berasal dari lokasi ujian senjata nuklear juga akan dilakukan untuk meramal penyebaran partikel radionuklid tersebut di persekitaran global. Keputusan daripada analisis ini akan digunakan sebagai nasihat teknikal kepada Badan Kebangsaan CTBT. Selain daripada tujuan verifikasi, CTBT-NDC juga mempromosi faedah penggunaan data IMS dan produk IDC untuk tujuan awam dan saintifik seperti kajian mengenai bumi, penambahbaikan pengurusan bencana dan lain-lain. Kesimpulannya, CTBT-NDC memainkan peranan yang unik dalam membantu Badan Kebangsaan CTBT untuk menjalankankan peranannya di bawah CTBT serta berperanan mempromosi penggunaan data IMS dan produk IDC untuk tujuan awam dan saintifik.

Katakunci/keywords : CTBT, National Data Centre, CTBT-NDC, Nuclear weapon test

INTRODUCTION

Nuclear weapons are destructive and hence directly threatening to the global security as a whole [1]. The rapid advancement of nuclear weapon technology is mainly contributed by the non-universally acceptable nuclear weapon tests which provide critical information on the effectiveness, yield, and explosive capability of a nuclear weapon. Furthermore, the nuclear weapon test posed adverse effects on health and environment. Thus, being driven by the increased international pressure to have a world free of nuclear weapon as well as rising concern about radioactive fallout as a result of nuclear weapons testing, several international initiatives were undertaken to limit and to certain extend prohibit any nuclear weapon explosion. One of initiatives is the 1996 Comprehensive Nuclear-Test-Ban Treaty (CTBT) which bans all nuclear explosions by anyone in any environment [2]. Under the Treaty, the prerogative to make final judgement on the nature of a suspicious event which could be interpreted as nuclear weapon test is given to the Member States since it would be their responsibility to consider calling for an on-site inspection (OSI) – if data and data analysis pointed to a possible Treaty violation [3].

Under the Treaty, International Data Centre (IDC) was established which become the central element of CTBT verification regime with the purpose to collect, process and analyses monitoring data from the 337 worldwide facilities of the International Monitoring System (IMS). The IMS facilities comprise of 50 primary and 120 auxiliary seismic stations, 11 hydroacoustic stations, 60 infrasound stations, 80 radionuclide stations and 16 radionuclide laboratories. The result of the analysis will be made available to Member States in the forms of list of events, bulletins and reports. Based on this information, the States are facilitated to make judgements about an ambiguous event. However, during the period of negotiation of the Treaty, some Member States are requesting for indigenous capability to analyse monitoring data rather than solely depend on the analysis results from IDC to make the judgement. As a result, the CTBT National Data Centre (CTBT-NDC) was introduced to Member States which feel the necessity to have a national data centre. The CTBT-NDC could provide in-house analysis result on the monitoring data as the technical advice to the CTBT National Authority in the Member States. Prior to formation of CTBT, in most of the Member States, no dedicated national data centre has been established merely to monitor and verify the nuclear weapon test. In addition, under CTBT, the value of CTBT-NDC was further added by expanding its roles, which is not only to monitor the nuclear weapon test but also to promote the utilisation of monitoring data for civil and scientific applications.

METHOD

CTBT-NDC is supplied with NDC-in-box software package and equipped with computers, server and communication infrastructures. At the moment, the NDC-in-box software package is still under active development, and will be continuously updated and expanded in the future. Generally, the NDC-in-a-box software package consists of a number of software components which provide functionality for working with waveform data and atmospheric transport modelling (ATM). Currently, NDC-in-a- box comprises the below listed software as shown in Table 1:

Table 1. NDC-in-a-box softwares

No.	Software Name	Description
1	CD Tools	Tools for sending and receiving data in CD format
2	Geotool	Tool for interactive review and processing of waveform data
3	Web-Grape	Graphical User Interface (GUI) based tool for interactive analysis and visualization of ATM calculation

In terms of monitoring data, CTBT-NDC receives 4 types of monitoring data including seismic, hydroacoustic, infrasound and radionuclide data which are transmitted from IDC either via Virtual Private Network (VPN) or Very-Small-Aperture Terminal (VSAT). The seismic, hydroacoutic and infrasound data are classified as waveform data. The transmission of the monitoring data is shown in Fig. 1 as below:

Figure 1. Transmission of the monitoring data from IMS Stations to CTBT-NDC

These monitoring data received at CTBT-NDC were further analyse using the NDC-in-a box software to verify the nature of any suspicious event which may related to nuclear weapon test. The process flow to analyse these monitoring data is shown in Fig. 2 as below:

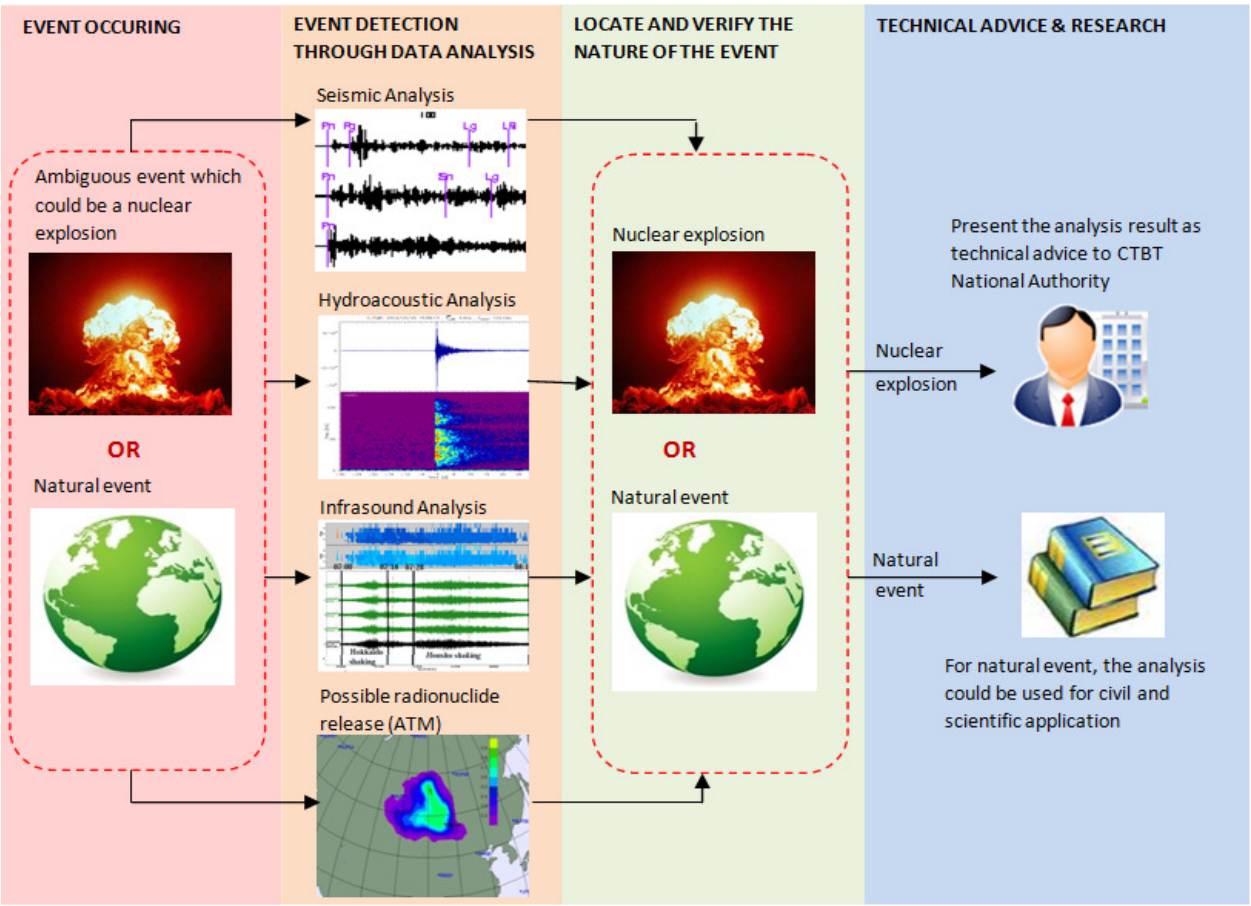

Figure 2. Process flow to analyse monitoring data for verification on the nature of an ambiguous event

In Fig.2, any event occurred could be a nuclear weapon test or natural event such as earthquake. Such event could trigger seismic wave, hydroacoustic wave, infrasound wave and possible release of radionuclide particle. These waves and radionuclide released will be detected by the IMS stations worldwide. Data from the IMS station will be transmitted to CTBT-NDC via IDC. Subsequently, these data will be analyse in detail at CTBT-NDC to identify the nature and the location of the event. If the nature of the event is confirmed as nuclear explosion, CTBT-NDC will present the analysis result to the CTBT National Authority for further measures. On the other hand, if the event is classified as natural event, the analysis will be kept in record and could also be used for civil and scientific application.

RESULTS

The analysis process performed at CTBT-NDC using the NDC-in-a-box software and the monitoring data proved to be reliable in providing critical information of any ambiguous event related to nuclear explosion. Such critical information could include the time and location of the suspicious event, the magnitude of the seismic wave, and sometime, it is possible to roughly estimate the magnitude of the explosion.

The waveform data (seismic, hydroacoustic and infrasound) could quickly and precisely locate the event as well as measuring the magnitude of the wave triggered by the nuclear explosion. The analysis result from seismic data alone could reliably locate the event with low area of uncertainty. Figure 3 below shows the analysis result of the seismic data which primarily identify the body wave (Pn, Pg, Sn) and surface wave (Lg, LR) for event location and wave magnitude estimation.

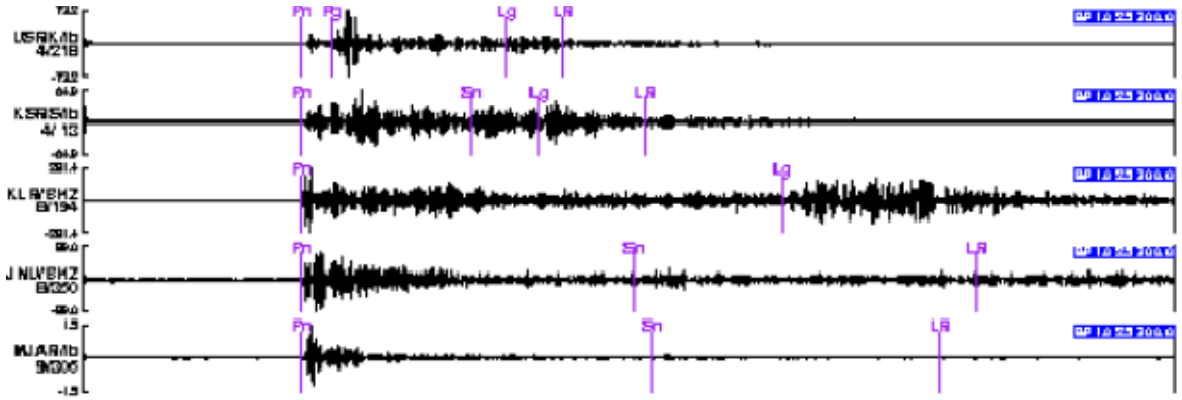

Figure 3. Analysis result on seismic data from a few seismic monitoring stations

The following Fig. 4 shows the typical detection of the event location using waveform data analysis. The size of uncertainty area is highly depends on the amount of waveform data available. With more waveform data available, the event location will be more precise and reliable. The left side picture in Fig.4 represents the detection of event location by the IMS waveform stations worldwide. The right side picture in Fig.4 is a zoom-in picture of the event location. The circles in the pictures represent the area of uncertainty. It can be seen that the circle size reduce significantly as more waveform data become available. From the analysis result it shows that the event is detected with uncertainty area less than 1000 km^2.

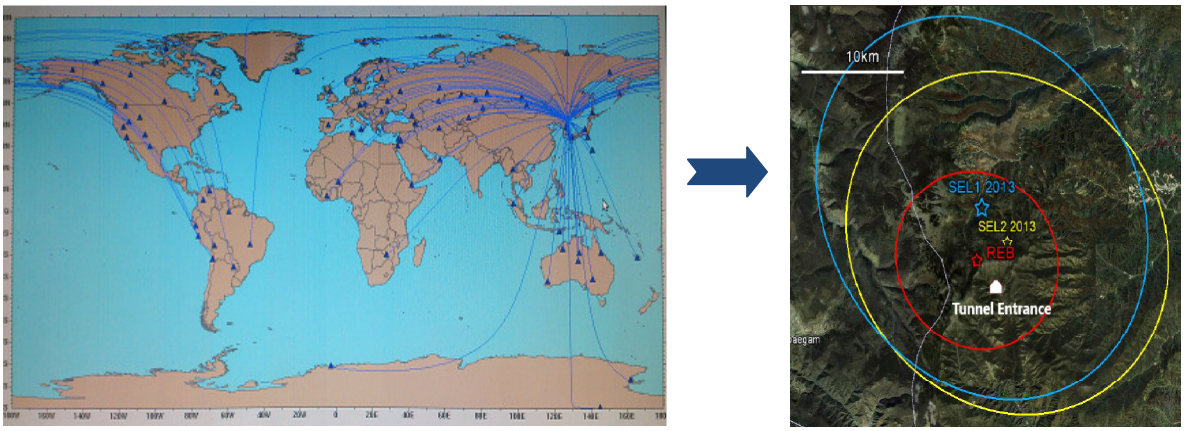

Figure 4. Typical detection of event location

Apart from waveform data analysis for detecting of event location, the atmospheric transport modelling (ATM) of possible radionuclide release was conducted to forecast the dispersion of radionuclide smoke originated from the event location. Figure 5 below shows the propagation of radionuclide smoke from the event location using the ATM model. The dispersion of radionuclide smoke is highly depends on the meteorological condition as well as the amount of radionuclide released.

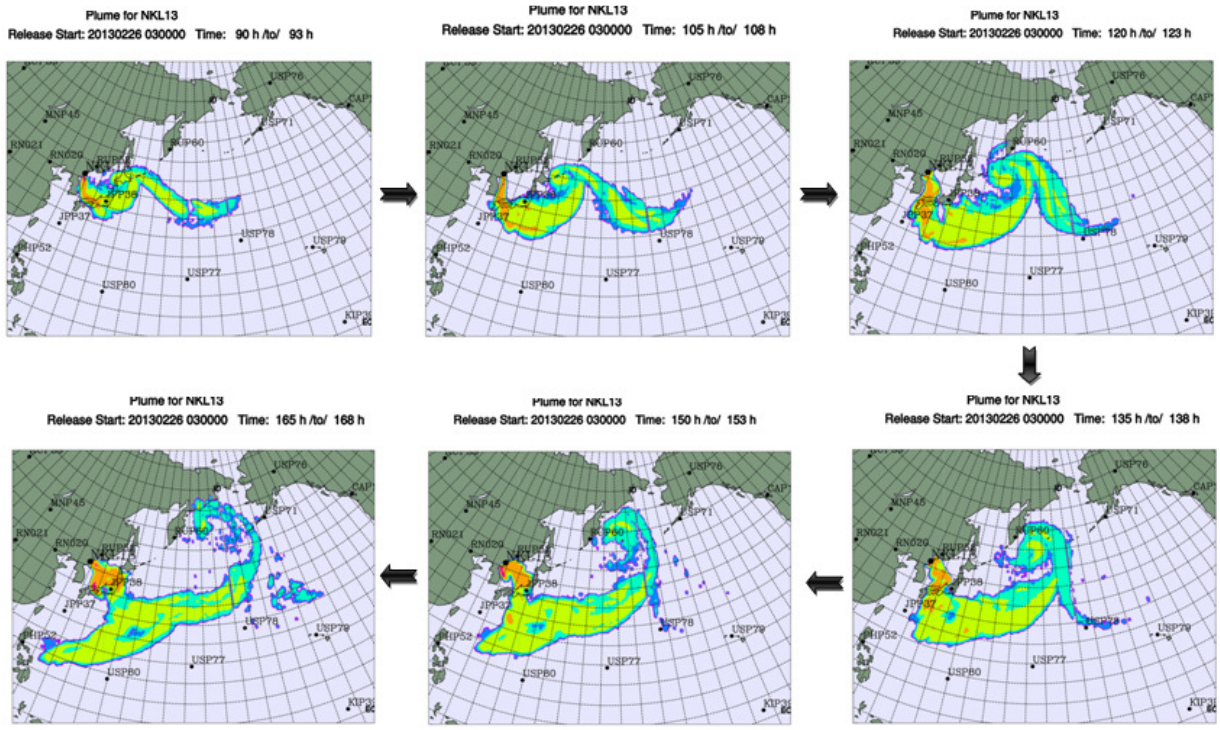

Figure 5. Atmospheric transport modelling (ATM) of radionuclide smoke from event location

Besides the use of monitoring data for nuclear weapon test verification, these data could also be used for civil and scientific purposes. Some of the results on the application of monitoring data for civil and scientific purposes are presented in the Fig.6 below. The left side picture represents the infrasound pattern from a group of whale at the sea whereas the right side picture shows the infrasound wave triggered by underwater volcanic eruption.

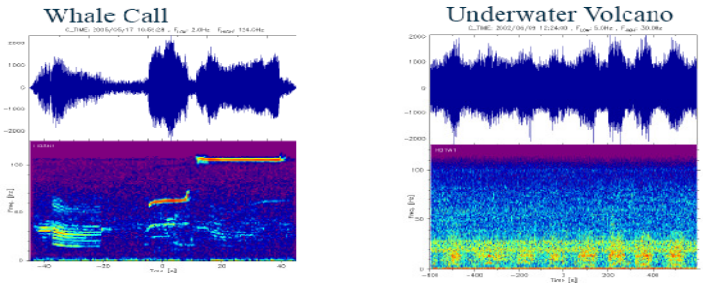

Figure 6. Application of monitoring data for civil and scientific purposes

The following Table 2 listed a few possible civil and scientific applications for each type of monitoring data.

Table 2. Possible application of monitoring data for civil and scientific purposes

Type of monitoring data	Possible civil and scientific applications
Seismic data	Civil application: i. Rapid acquisition and dissemination of data for disaster management and response effort due to the earthquake and tsunami ii. Improvement in reporting the location and magnitude of earthquake which could enhance estimation of earthquake hazard which lead to better construction and design standards Scientific application: i. Research on earth's structure
Hydroacoustic data	Civil application: i. Rapid acquisition and dissemination of tsunami data ii. Monitoring of underwater volcanic eruption which lead to the improvement of shipping safety iii. Storm monitoring and tracking iv. Monitoring of ice shelf break-up and creation of large icebergs Scientific application: i. Improved research on ocean studies which lead to better weather forecast and climate change studies ii. Marine life research
Infrasound data	Civil application: i. Detection of volcanic explosion for aviation safety ii. Detection of artificial and natural explosion in the earth's atmosphere such as meteors, storm, sprites and aurora iii. Improvement of storm monitoring and tracking Scientific application: i. Improved understanding and studies on microbaroms and mountain waves ii. Creation of valuable archive data for future research application
Radionuclide data	Civil application: i. Could be integrated with weather forecast ii. Provide critical information on nuclear related accidents, such as release of radionuclide smoke and dispersion model Scientific application: i. Research on mapping of worldwide background radiation ii. Studies on airborne pollutants and global air mass movement

DISCUSSION

The analysis results presented in the previous section obviously showed the capability of the monitoring data available to CTBT-NDC to reliably detect nuclear weapon test as well as provide critical information of the nuclear test. The information on the suspicious event is prove to be highly valuable to the CTBT National Authority to make informed judgement on the nature of the suspicious event as well as the consideration to exercise their right to call for OSI when the Treaty is in force if the event is truly a nuclear weapon test.

In addition, with more IMS become online which lead to more monitoring data available, it will significantly improve the accuracy of waveform analysis. In the current state where there are about 82 % of the IMS are online, the waveform analysis could consistently provide location of the ambiguous event with the area of uncertainty less than 1000 km^2. This limitation on the area of uncertainty is critical for the Member States to consider calling for on-site inspection (OSI) when the Treaty is fully in force due to the fact that OSI is only granted to be performed within the maximum area of 1000 km^2 [4].

On the other hand, CTBT-NDC is also able to perform atmospheric transport modeling to forecast the dispersion of radionuclide smoke originated from the nuclear weapon test. This forecast is important to assist the CTBT National Authority to take necessary measures such as informing the relevant authority and the public on the level of radionuclide release from the nuclear test as well as preparing precaution measures, if it deems necessary.

For the role of CTBT-NDC to promote the use of monitoring data for civil and scientific application, the justification is reasonable on the basis that the monitoring data could serve more than just for monitoring of nuclear weapon test. Since nuclear explosion and nuclear weapon test is now being see as a rare event, the utilisation of these monitoring data for civil and scientific application will highlight the value of these monitoring data whilst at the same time serving the good development of science and technology.

CONCLUSION

In the framework of the Treaty, the primary role of CTBT-NDC is to provide close support to the CTBT National Authority to check its compliance with the Treaty provisions. The close support could be in the form of giving technical advice on the suspicious event which could be related to nuclear weapon test. Thus, the in-house capability to analyse monitoring data is vital as it offers check-and-balance with the analysis result performed by the IDC. In addition, taking into consideration that the nuclear weapon test is not frequently occur, the function of CTBT-NDC was further expanded to include the promotion on the use of monitoring data for civil and scientific purposes. As such, the synergies between these functions have made the CTBT-NDC unique as if CTBT-NDC is fulfilling a dual-purpose functions-monitoring of nuclear weapon test and promote the full use of monitoring data for mankind benefits.

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