CTBTO | preparatory commission for the comprehensive nuclear-test-ban treaty organization

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CTBTO Spectrum

2007 Article XIV Conference Special Edition

United Nations Secretary-General Ban Ki-moon

Why ratify? The UNSG's views on the CTBT

Dr Hans Blix

CTBT:going the last mile to banish nuclear weapons testing

Ambassador Jaap Ramaker

2007Article XIV Conference: sending powerful signals for CTBT's entry into force

Dr Rebecca Johnson

Renewed opportunities to bring the CTBT into force

Inside this issue

Who we are

The Comprehensive Nuclear-Test-Ban Treaty bans all nuclear weapon test explosions. It opened for signature on 24 September 1996 in New York.

The CTBTO Preparatory Commission consists of the States Signatories and of the Provisional Technical Secretariat. The main task of the CTBTO Preparatory Commission is to establish a global verification regime capable of detecting nuclear explosions underground, underwater and in the atmosphere. The regime must be operational when the Treaty enters into force. It consists of 337 monitoring facilities supported by an International Data Centre and on-site inspection measures.

Editorial

When Ratifying States and supporters of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) gather this September in Vienna for the fifth Article XIV Conference, they will examine ways and means to accelerate the entry into force of the CTBT.

Why is it so important to join this steadily growing community of like-minded countries? Each and every signature or ratification strengthens the political value of the Treaty. Even without having entered into force, the CTBT helped to create a strong international norm against nuclear testing. The CTBT's raison d'être is to transform this norm into binding international law, thus helping to prevent unimaginable suffering to human beings and to the global environment. To achieve this, the ten remaining States whose ratification is imperative for entry into force need to join those who have already ratified the Treaty, recognizing its genuine non-proliferation and disarmament value, its verifiability and its contribution to international and regional peace and security.

In the past 11 years, the CTBTO Preparatory Commission has set up an elaborate verification system with global coverage that will verify compliance with the Treaty once it has entered into force. The system has already proven its relevance and maturity in the context of the nuclear test announced by the Democratic People's Republic of Korea (DPRK) in October 2006. With less than 60% of the stations in test mode operation, the event was – despite its low yield – well recorded by the system. A large number of seismic stations and the noble gas network, in combination with the atmospheric transport modelling, provided important data and data products, which were sent on time and in high quality to Member States.

The global reach of our verification system was underlined by the fact that noble gas readings were picked up by a station in Canada, more than 7500 kilometres away from the DPRK. While the North Korean event validated the internal procedures and technical capabilities of the system, it also underlined the urgent need for completing it. As of today, 210 monitoring facilities have been certified, meeting the stringent technical requirements of the CTBTO. Another 120 are in various stages of construction, many of them in remote locations, or remain to be built.

Due to the outstanding financial contributions of several Member States, the budgetary situation of the organization has dramatically worsened, thus endangering the completion of the verification regime. Today, our estimate is that US$ 24 million or more of the 2007 total annual budget of US$ 110 million, will be in arrears by the end of the year. In response to this serious situation and in order to achieve a balanced budget, I had to introduce stringent austerity measures, which will have a serious negative impact on programme activities, including the build-up, operation and maintenance of the monitoring stations. In the last nine months alone, we certified 33 new stations and installed a new global communications infrastructure and a new operations centre. This shows that with the necessary resources the system will grow as planned. I call on all Members of the Commission to redouble their efforts and encourage States Signatories to meet their payment obligations.

This special issue of CTBTO Spectrum focuses on the political importance of early entry into force leading up to the Article XIV Conference and the many challenges arising when building a global verification system. World-renowned personalities, such as United Nations Secretary-General Mr Ban Ki-moon and Dr Hans Blix, former Chairman of the Weapons of Mass Destruction Commission, give their views on the significance of the CTBT. Their contributions are complemented by a special feature analysis by Dr Rebecca Johnson, Director of the Acronym Institute, and a respected voice from the non-governmental community.

Other internationally acclaimed figures and scientists writing in this tenth issue of CTBTO Spectrum are Ambassador Jaap Ramaker, Special Representative for the CTBT, on the upcoming Article XIV Conference, Professor Helga Kromp-Kolb, on the potential value of International Monitoring System data for global climate change and Dr Douglas Christie, on the latest findings in infrasound research.

This issue also provides insights into the often challenging work of the Provisional Technical Secretariat (PTS). It reports on climatic and environmental hardship that PTS staff members experienced when carrying out certification tests at an infrasound station in Cape Verde. It gives a vivid example of PTS maintenance activities by following a remote operating vehicle checking the cable of a hydroacoustic station in Australia, and it reports on newly established scientific exchange platforms. Finally, three PTS staff members describe the correlation between atmospheric transport modelling and noble gas findings in the context of the DPRK event.

There is no other monitoring system comparable to the one built by the CTBTO. Its uniqueness in terms of global reach, state-of-the-art detection technologies and participatory approach to the verification results is unmatched. I hope that the successful handling of the DPRK event by the PTS has convinced Member States that their significant investments in the verification regime were justified. Ultimately, the monitoring system's worth will only become fully realized once the Treaty enters into force. I therefore urge all States to use the upcoming Article XIV Conference as an opportunity to recommit themselves to achieving this goal.

Tibor Tóth
Executive Secretary
Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

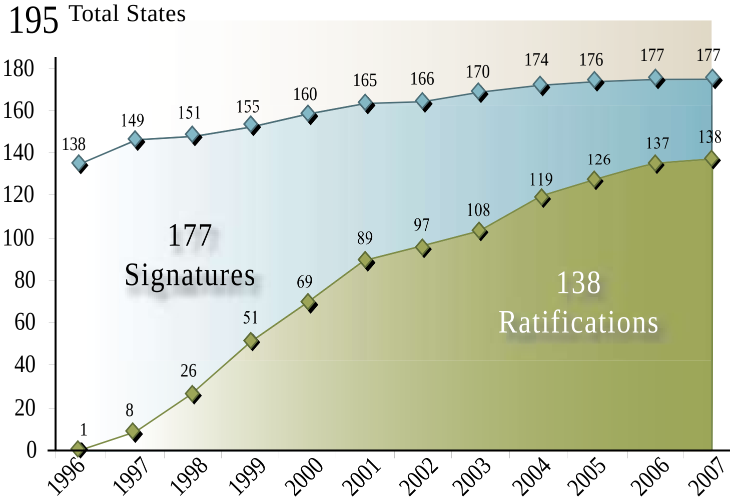
Treaty signatures and ratifications

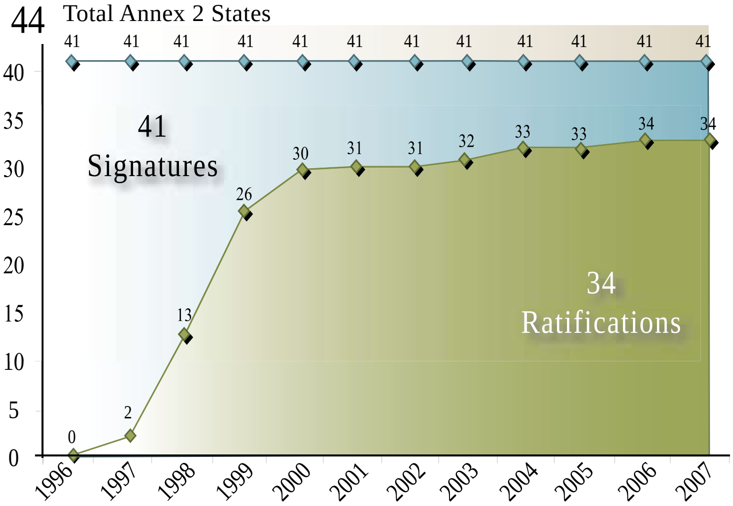
CTBT signatures and ratifications as of 2 July 2007

	Signatory States	Ratifying States	Non-Signatory States
Total States: 195	**177**	**138**	**18**
Annex 2 States: 44	**41**	**34**	**3**

Devolopment of CTBT signatures and ratifications 1996 - 2007

AS OF 2 JULY 2007





In the spotlight

Why ratify?
United Nations Secretary-General Ban Ki-moon's views on the CTBT

Q: *One of the key objectives of the United Nations is to establish and maintain international peace and security. In the first resolution adopted by the General Assembly in January 1946, Member States agreed unanimously that specific proposals should be made "for the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction."*

How do you as the United Nations Secretary-General intend to further this goal and to counter the serious threat that nuclear weapons pose to mankind and to international peace and security?

> "I urge those States that have not yet signed to sign and ratify the Treaty as soon as possible, in particular those States whose ratification is essential for the Treaty to enter into force."

A: I am personally concerned about this issue because nuclear weapons pose a number of threats to international peace and security. Some threats arise from existing arsenals, while others stem from the proliferation or terrorist acquisition of such weapons. I am convinced that these threats are best addressed by multilateral action, emphasizing in particular the goals of disarmament, non-proliferation and collective action against nuclear terrorism.

What is needed most is the entry into force of the Comprehensive Nuclear-Test-Ban Treaty and agreement on a fissile materials treaty. Venerable components of the multilateral disarmament machinery – notably the Conference on Disarmament, the Disarmament Commission and the General Assembly's First Committee – need to fulfill their role as crucibles for uniting all nations in this common cause.

While I cannot alone solve all these problems, I can and will use my voice as Secretary-General to underscore the concerns and expectations of the peoples of the United Nations. I specifically intend to strengthen the contributions of the United Nations Secretariat in meeting this challenge. I have established an independent Office for Disarmament Affairs, building on the work of the former Department, which will be headed by a High Representative who will report directly to me.

Q: *With the conclusion of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) more than ten years ago, the political objective to end all nuclear tests had been achieved and the legal framework established. But today, despite nearly universal adherence, the Treaty has yet to enter into force.*

What will you do, as Secretary-General of the United Nations and Depository of the Treaty, to forward the entry into force of the CTBT? What steps do you envisage that the international community, and in particular those States whose ratification is necessary for entry into force, must take?

A: On 17 and 18 September 2007, in my capacity as Depository of the Treaty, I am convening the fifth Conference on Facilitating the Entry into Force of the CTBT in Vienna, at the request of a majority of States that have ratified the CTBT. I support plans for this Conference that would create maximum visibility and encourage high-level representation by all States that have ratified it. Those seeking entry into force of the CTBT should encourage all signatories to ratify as soon as possible.

While the Conference will review a range of important technical issues, the most urgent task would be to reaffirm the States' commitment to the Treaty and to resolve to work for its prompt entry into force.
I urge those States that have not yet signed to sign and ratify the Treaty as soon as possible, in particular those States whose ratification is essential for the Treaty to enter into force. I urge participants in the forthcoming Conference to reaffirm the importance of a universal, internationally and effectively verifiable Comprehensive Nuclear-Test-Ban Treaty and to refrain from acts that would defeat the object and purpose of the CTBT pending its entry

> "I see emerging in the world today a 'zero tolerance' of any further tests of nuclear explosive devices. I hope to see the day when this expectation is made legally binding and remain convinced that the CTBT is the way that this goal will ultimately be achieved."

into force. I see emerging in the world today a 'zero tolerance' of any further tests of nuclear explosive devices. I hope to see the day when this expectation is made legally binding and remain convinced that the CTBT is the way that this goal will ultimately be achieved.

> "I will continue to do all I can to bring this historic Treaty into force."

Q: *The global verification regime that the CTBTO Preparatory Commission establishes to monitor compliance with the CTBT must be operational once the Treaty enters into force. On 9 October 2006, the Democratic People's Republic of Korea (DPRK) announced its test of a nuclear explosive device. With less than 60% of the monitoring stations in operation and working in test-mode only, the verification system provided States Signatories with reliable and high quality data, assisting them to make their own judgments.*

As a former Chairperson of the CTBTO Preparatory Commission, how do you view the work of the PrepCom and its Technical Secretariat, in particular the build up of the verification regime in the wake of the DPRK event?

A: I have a very high regard indeed for the work of the CTBTO Preparatory Commission, based not only on its formal goals, but also on my own personal experience in promoting them. I will continue to do all I can to bring this historic Treaty into force.

The global verification regime is the key for the successful implementation of the Treaty and should be strong enough to detect any nuclear test explosion in a way that would leave no chance that such a test could occur undetected. The verification regime is indispensable in constraining the proliferation of nuclear weapons and the development of new weapons. ■

Biographical note

Mr Ban Ki-moon, a South Korean national, began his five-year term as the eighth United Nations Secretary-General in January 2007. He is a career diplomat with 37 years of service in his Government and on the global stage, including as Ambassador to Austria and the International Organizations in Vienna (1998-2000), Chef-de-Cabinet to the President of the UN General Assembly (2001-2002) and Minister of Foreign Affairs and Trade (2004-2006). As Foreign Minister he played a leading role in bringing about a landmark agreement aimed at promoting peace and stability on the Korean peninsula.

In 1999, during his assignment to Vienna, he served as Chairman of the CTBTO Preparatory Commission. ■

Notes & quotes

"We need to press on with both the Comprehensive Test Ban Treaty and with the Fissile Material Cut-Off Treaty. Both limit - in real and practical ways - the ability of states party to develop new weapons and to expand their nuclear capabilities. And as such they therefore both play a very powerful symbolic role too - they signal to the rest of the world that the race for more and bigger weapons is over, and that the direction from now on will be down not up. That's why we are so keen for those countries that have not yet done so to ratify the CTBT. The moratorium observed by all the nuclear weapon states is a great step forward; but by allowing the CTBT to enter into force - and, of course, US ratification would provide a great deal of impetus - we would be showing that this is a permanent decision, a permanent change in the right direction."

Margaret Beckett, Secretary of State for Foreign and Commonwealth Affairs of the United Kingdom (2006 – 2007) at the Carnegie International Nonproliferation Conference, Washington D.C., 25 June 2007

CTBT: going the last mile to banish nuclear weapons testing

by Dr Hans Blix

Over a decade has passed since our leaders came together and promised us, and generations to come, that the testing of nuclear weapons would finally be banished to the realms of history. US President Clinton at the time called the Comprehensive Nuclear-Test-Ban-Treaty (CTBT) the “longest-sought, hardest-fought prize in the history of arms control”.

As it turned out, after the rejection of the Treaty by the United States Senate, and the refusal by other key States to ratify it, the prize was not yet won. The process, already initiated by American Presidents Eisenhower and Kennedy in the 1950s and 1960s, has yet to be pushed that last mile to completion.

It is truly worrying that, while new threats to global and human security are rapidly emerging, the old threats and challenges still linger. One of the main challenges of our time is how to deal with the astounding capacity that mankind has gained for war and destruction – manifested in its worst form by nuclear weapons. It is therefore absolutely necessary to revive disarmament and redouble our efforts to prevent further proliferation of such weapons. No single issue is more urgent, important in substance and in order to provide a new impetus to the general disarmament and non-proliferation agenda, than the entry into force of the CTBT. I believe that the time has come for a renewed serious debate on CTBT, and I do believe that the outlook for success is brighter now than it has been in a long time.

The importance of the CTBT needs no lengthy explanation. The Treaty is vital for efforts to prevent the development of a new generation of nuclear weapons, and to help reduce the reliance on nuclear deterrence in security policies. However, the CTBT also holds great potential as a signal to the world that our leaders, once again, stand firm behind their commitment to disarmament. The entry into force of the CTBT would reset the stage for global nuclear disarmament.

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Despite the reluctance of some key States to ratify the Comprehensive Test Ban, there seems to be an almost global consensus on the duty to abstain from testing. Since the conclusion of the CTBT in 1996, only India, Pakistan and, recently, the Democratic People’s Republic of Korea (DPRK) have conducted tests. The reaction from the international community has been concerted condemnation. Last year, the testing of a plutonium bomb by the DPRK was unanimously condemned by the Security Council – as were the nuclear tests by India and Pakistan in 1998. The North Korean test was explicitly deemed to constitute a threat to international peace and security, and sanctions were imposed.

In view of the Chinese and US support for these condemnations in the Security Council, it seems peculiar that neither the US nor China have ratified the CTBT. Dare we conclude that it is now the unanimous view of the Security Council that even in the absence of an operative Comprehensive Test Ban Treaty no State may undertake nuclear weapons tests? How could the Council otherwise condemn the DPRK? Whatever the answer, the time seems ripe for renewed efforts to get the Treaty ratified.

On 1 June 2006, the Weapons of Mass Destruction Commission, which I had the honour to chair, presented its Final Report: “Weapons of Terror: Freeing the World of Nuclear, Biological and Chemical Arms.” We highlighted the ratification by the United States as a key factor to facilitate the entry into force of the Treaty. A ratification by the United States would send a powerful positive signal and give several other States an incentive to join. After a US ratification, pressure would build up for other ratifications required. For example, signatures and ratifications by India and Pakistan might well follow ratification by China. A Chinese ratification would also be important in efforts to influence the DPRK. In the Middle East, ratifications might follow by Israel, Egypt and Iran. The remaining two, Colombia and Indonesia, would also be likely to join – they would surely not want to run the risk of appearing to block the Treaty’s entry into force. The active engagement of the United States would undoubtedly be central in this process.

The major transformation of the international scene during the last decades,

not least the development towards increasing global interdependence and the revolutionary technological progress in the fields of information and transportation, has fundamentally changed the threats to our security and the means needed for defence against these threats. Nuclear weapons have no meaningful role in the fight against international terrorism or in efforts to stop atrocities in ethnic conflicts. There is no conceivable use for nuclear weapons and their deterrent effect is becoming increasingly ineffective. In regions where deterrence might be a real basis for security, other measures, such as integration into the fabric of the international community, is likely to be more effective.

Recently, former US Secretaries of State Henry Kissinger and George Schultz, together with former US Secretary of Defense William Perry and former US Senator Sam Nunn, published an article in the *Wall Street Journal*, in which they proposed the initiation of a bipartisan process with the Senate in order to achieve US ratification of the CTBT and to work towards securing ratification by other key States. The article also deemed the reliance on nuclear deterrence to be obsolete. It would be interesting to hear this issue debated in the upcoming presidential elections. The next president of the United States will have an unprecedented opportunity to gain congressional support for an American ratification of the CTBT – and for a return to the driver's seat of international efforts in arms control and disarmament. Is this something that Democrats Hillary Clinton, Barack Obama or John Edwards, or Republicans John McCain or Rudy Giuliani would be ready to endorse? The world is looking to the United States for leadership – ready to follow. ■

Biographical note

Dr Hans Blix is a former Swedish Minister for Foreign Affairs. He served as Director General of the International Atomic Energy Agency from 1981 to 1997 and as Executive Chairman of the United Nations Monitoring, Verification and Inspection Commission from 2000 to 2003. Between 2004 and 2006, Dr Blix chaired the independent international Weapons of Mass Destruction Commission. He is the President of the World Federation of United Nations Associations. ■

"THE CTBT IS AS ESSENTIAL TO NUCLEAR DISARMAMENT AS IT IS TO NON-PROLIFERATION. THE EU BELIEVES THAT A LEGALLY BINDING PROHIBITION OF NUCLEAR WEAPONS TEST EXPLOSIONS AND ALL OTHER NUCLEAR EXPLOSIONS AS WELL AS A CREDIBLE VERIFICATION REGIME ARE VITAL. THE OCCURRENCE OF NUCLEAR TESTS AFTER THE OPENING OF THE CTBT FOR SIGNATURE UNDERLINES THE NEED FOR AS EARLY ENTRY INTO FORCE OF THE TREATY AS POSSIBLE.

THE EU REITERATES ITS CALL ON STATES, PARTICULARLY THOSE LISTED IN ANNEX 2, TO SIGN AND RATIFY THE SAID TREATY WITHOUT DELAY AND WITHOUT CONDITIONS AND, PENDING ITS ENTRY INTO FORCE, TO ABIDE BY A MORATORIUM ON NUCLEAR TESTING AND TO REFRAIN FROM ANY ACTION CONTRARY TO THE OBLIGATIONS AND PROVISIONS OF THE CTBT."

Statement by the European Union at the first session of the Preparatory Committee for the 2010 NPT Review Conference, 30 April-11 May 2007, Vienna, Austria

Notes & quotes

2007 Article XIV Conference: sending powerful signals for CTBT's entry into force

by Ambassador Jaap Ramaker

In this year's report "Global Risks 2007: A Global Risk Network Report", the World Economic Forum identified 23 core global risks to the international community over the next ten years. The risk posed by the proliferation of weapons of mass destruction ranked second after international terrorism, while nuclear weapons dominated the report's general proliferation concerns. In its analysis, the Forum left no doubt that nuclear weapons are unique amongst weapons of mass destruction in their undescribable potential for devastation and destruction.

"The necessary boost to the nuclear non-proliferation regime would, in my view, consist of bringing the CTBT into force. This would restore confidence in the regime and provide it with the 'blood transfusion' it so badly needs."

The 1968 Nuclear Non-Proliferation Treaty (NPT) remains the cornerstone of the nuclear non-proliferation and disarmament regime and the main tool by which the international community keeps the dangers posed by nuclear weapons in check. As we approach the fifth Conference on Facilitating the Entry into Force of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), widely known as the Article XIV Conference, it seems important to remember that these two treaties are closely connected, both conceptually and politically.

The preamble of the NPT recalled the determination of all parties "to seek to achieve the discontinuance of all test explosions of nuclear weapons for all time..." The conclusion of the negotiations on the CTBT in 1996 was a significant step forward. A 40 year old vision had come closer to realization. By the same token, the conclusion of the CTBT made good on the commitment that the States Parties to the NPT had made the year before, as part of a package of measures allowing for the indefinite extension of the treaty.

A decade later, not a day goes by without issues relating to nuclear weapons proliferation appearing in the headlines of the world press. In fact, the nuclear non-proliferation regime – under painstaking construction for many decades but still not completed – seems momentarily to move from crisis to crisis. In the view of many, the NPT has become a treaty under siege.

One of the most recent and perhaps clearest illustrations of this unfortunate state of affairs is the underground nuclear detonation conducted by the Democratic People's Republic of Korea in early October 2006. It was met with world-wide condemnation, which showed that the international community no longer accepts a world in which nuclear weapon tests can take place with impunity. On the positive side, if you wish, it should serve as a wake-up call that the issue of nuclear weapons tests needs far more attention then it has received in the last few years.

The necessary boost to the nuclear non-proliferation regime would, in my view, consist of bringing the CTBT into force. This would restore confidence in the regime and provide it with the 'blood transfusion' it so badly needs.

I believe we are on the right track. With a total of 177 signatures the Treaty could be considered universal already. The number of Ratifying States is steadily growing, standing at the moment at a respectable 138. Of those 44 States whose ratification is required for the Treaty to enter into force, 41 have signed and 34 have ratified it. Since the Treaty opened for signature in 1996, none of the five nuclear weapons States have conducted a nuclear test explosion. In addition, a robust system that will have to monitor the absence of nuclear test explosions once the CTBT has entered into force is in an advanced stage of development.

I understand the feelings of frustration many have when looking at the slow pace of our efforts to bring the CTBT into effect. But let us not forget: we all knew at the time of the negotiations that bringing a test ban into force, with the ambitious objective to bind all those in a position to test nuclear weapons, would by no means be an easy job. We all knew that this would take time.

It is precisely for this reason that, after some years, the negotiators of the Treaty decided to convene periodic conferences to take stock of the progress made in bringing the Treaty into effect. These conferences would also give Ratifying States the possibility to discuss ways and means to promote the ratification process of the CTBT.

The 2007 Article XIV Conference will provide an opportunity to send a powerful signal to the world to bring the Treaty into effect. We trust that the Conference's call to end at long last the era of nuclear test explosions and strengthen the nuclear non-proliferation regime will be echoed worldwide.

Obviously, the countries participating in this year's Conference in Vienna cannot help bringing the Treaty into force alone. Each and every member of the international community, with or without a nuclear

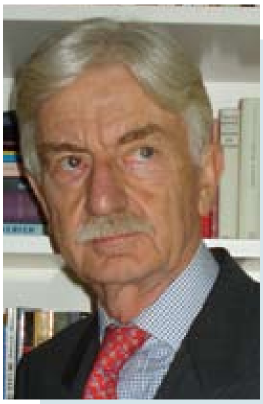
weapons programme, big or small, has to be aware of the consequences if the door to nuclear testing remains open. In particular, each and every country that has yet to sign or ratify the Comprehensive Nuclear-Test-Ban Treaty should realize that each additional signature or ratification adds to the Treaty becoming an international norm, strengthens the nuclear non-proliferation regime and contributes to a safer and more secure world. The 2007 Conference should call upon these States to shoulder their responsibility and take the next step.

Let me conclude with a quote from the report "Weapons of Terror, Freeing the World of Nuclear, Biological and Chemical Arms" from the Weapons of Mass Destruction Commission chaired by Hans Blix:

"The single most hopeful step to revitalize non-proliferation and disarmament today would be ratification of the CTBT by all states that have nuclear weapons."

I could not agree more. ■

Biographical note



Following the 2003 Article XIV Conference, Ambassador Jaap Ramaker was appointed Special Representative of the Ratifying States to promote the entry into force of the CTBT.

Between 1994 and 1997, he was Permanent Representative of the Netherlands to the Conference on Disarmament in Geneva. In this capacity, he chaired the CTBT negotiations and led them to a successful conclusion. ■

History and mechanism of the Article XIV Conferences

by Dr Andrea Wurm

The fifth Conference on Facilitating the Entry into Force of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) will be held 17-18 September 2007 at the Hofburg in Vienna. High level representatives of States that have already ratified the Treaty will examine how the ratification process can be accelerated and decide which measures may be undertaken to facilitate the early entry into force of the CTBT.

The Conference, widely known as the Article XIV Conference, is named after Article XIV of the CTBT that specifies the conditions for the Treaty's entry into force. Entry into force of the Treaty will take place 180 days after the 44 States that possessed nuclear reactors or research reactors at the time of the negotiations have ratified it. The negotiators of the CTBT also included a mechanism under Article XIV whereby regular conferences were to be convened if entry into force had not taken place three years after the anniversary of the Treaty's opening for signature.

So far, this mechanism has resulted in four Article XIV Conferences. The United Nations Secretary-General, in his capacity as Depository of the Treaty, convened them at the request of a majority of Ratifying States. Signatory States, non-signatory States, international organizations and non-governmental organizations were invited to attend as observers.

The first Article XIV Conference was held 6-8 October 1999 in Vienna. Ninety-two Ratifying States and States Signatories adopted a Final Declaration calling upon all States which had not yet done so to sign and ratify the Treaty. Japan was selected "to promote cooperation to facilitate the early entry into force of the Treaty, through informal consultations with all interested countries."

A second such Conference took place 25-27 September 2001 in New York, with 109 States participating. The Final Declaration was formulated in the same fashion as in 1999 and Mexico was selected as the coordinating State.

The third conference took place 3-5 September 2003 in Vienna, with 102 States attending. The Final Declaration stressed the importance of a universal and effectively verifiable comprehensive Treaty as a major instrument in all aspects of nuclear disarmament and non-proliferation. For the first time, the Conference adopted twelve specific measures, appended to its Final Declaration. One of them was the decision to appoint Ambassador Jaap Ramaker as a Special Representative to assist the co-ordinating State Finland in promoting the early entry into force of the Treaty.

One hundred and seventeen States participated in the 2005 Conference, held 21-23 September at the United Nations Headquarters in New York. Nearly 40 States were represented by their Ministers or Deputy Ministers of Foreign Affairs. The States Parties agreed that they would spare no efforts and use all avenues open to them to encourage further signature and ratification of the Treaty. The Conference reconfirmed the measures adopted at the 2003 Conference and decided that the Special Representative would continue to assist the coordinating State – Australia – in promoting the Treaty's entry into force.

The upcoming Article XIV Conference will be co-chaired by Austria and Costa Rica. It will provide another opportunity to move the issue of early entry into force of the CTBT to the forefront of Governments' agendas. The rising number of signatures and ratifications in the period before and after each Conference has previously shown how effective the Article XIV mechanism is. It is to be hoped that the momentum generated by the fifth Conference on Facilitating the Entry into Force of the CTBT once again translates into further signatures and ratifications, thus strengthening the norm against nuclear test explosions. ■

Dr Andrea Wurm is a political scientist working as a Public Information consultant. She has conceptualized, coordinated and edited CTBTO Spectrum *since its inception.*

Perspectives

Renewed opportunities to bring the CTBT into force

by Dr Rebecca Johnson

Eleven years after it was opened for signature, ten countries still have to ratify the Comprehensive Nuclear-Test-Ban Treaty (CTBT) before it can take full legal effect. For a treaty that has been signed by 177 countries and ratified by nearly 140, this is a ridiculous – and potentially dangerous – situation.

The CTBT in limbo

The CTBT's limbo is affecting the nonproliferation regime as a whole. Called for in the preamble of the 1968 Nuclear Non-Proliferation Treaty (NPT) and finally negotiated in the multilateral Conference on Disarmament and concluded in 1996, the CTBT has become hostage to its unnecessarily stringent entry-into-force provision. Instead of lamenting its fate, however, it behooves the international community to redouble efforts to bring the ten remaining States into the Treaty so that it can enter into full effect. This was the message coming from the 2007 NPT Preparatory Committee meeting.

The key to entry into force

The key to getting CTBT entry into force back on the practical agenda is undoubtedly the United States. In 1999, US ratification was sacrificed in a poisonous climate where Republicans – including test ban supporters – put their hostility towards President Bill Clinton above US security and nonproliferation interests. In 2007-2008, the United States is a different place. The Democrats became the majority party in the US Congress in 2006, and there is growing understanding that the United States needs to uphold the rule of law and engage more constructively in collective efforts to strengthen international security agreements. The significance of the 4 January 2007 editorial in the *Wall Street Journal* by Henry Kissinger, George Shultz, William Perry and Sam Nunn should not be underestimated. These former defence and foreign policy leaders stated as one of the priorities for US security "Initiating a bipartisan process with the Senate, including understandings to increase confidence and provide for periodic review, to achieve ratification of the Comprehensive Test Ban Treaty, taking advantage of recent technical advances, and working to secure ratification by other key states."

After the ratification debacle in 1999, President Clinton commissioned General John Shalikashvili to consult with Senators and "lay the groundwork for future ratification of the treaty". Shalikashvili's report argued that the CTBT enhances US security interests and noted "the value of a verification system extends well past the range where a monitor has high confidence of detecting, identifying, locating and attributing a violation, and down into the gray area where a potential evader lacks certainty about the likelihood of discovery". Shalikashvili emphasized how the CTBT's verification regime would be able to provide global coverage below 500 tons and much lower at all known test sites. A high level, bipartisan initiative is now needed to build on this assessment and convince American decision makers that continuing to block the CTBT is against US interests.

Indeed, there is much new data to bring Shalikashvili's assessment up to date and strengthen the case for American accession to the CTBT even more. In particular, the effectiveness of the sophisticated technologies that already feed into the CTBT's verification regime were vividly demonstrated when they detected and identified the low yield North Korean nuclear test of 9 October 2006.

The nuclear event in North Korea

North Korea's nuclear test came as a shock to the NPT regime, but may be turned to positive purpose. Firstly it reminded the world that nuclear testing remains a technology-proving rite of passage for would-be nuclear proliferators. It also forced the United States and China to join forces more effectively to bring about the North Korean Denuclearization Agreement in January 2007. It ought to be obvious to everyone that North Korea's signature and ratification of the CTBT should be made a requirement under the Denuclearization Action Plan, but for that to happen, the United States needs to stop repudiating the Treaty itself.

The importance of China's ratification

China's failure to ratify also weakens efforts to bring others on board. In addition to the United States, North Korea and China, the hold-out countries are: four non-nuclear-weapon NPT parties that have signed but not yet ratified: Colombia, Egypt, Indonesia and Iran; Israel, which is a non-NPT party that signed the CTBT in 1996 and participates in the CTBTO; and two further non-NPT parties that have not yet even signed: India and Pakistan.

For the past nine years, Chinese diplomats have assured NPT meetings that Beijing supports the CTBT, but that the National People's Congress is still deliberating over its ratification. This excuse merely gives the impression that China is waiting for the United States (and possibly India?), which leaves China looking as if it hasn't yet managed to overcome a sense of inferiority vis-à-vis the United States. To ratify now would be in China's regional security interests. It would demonstrate its international status as a leader, not a follower. It would set a positive example to North Korea and non-aligned countries like Indonesia, Egypt and Iran, and help governments and civil society put greater political pressure on Washington and New Delhi – a win-win strategic move for Beijing.

Indonesia should have no excuse not to ratify the CTBT. It was a significant player during the CTBT negotiations, and stands to lose credibility as a disarmament advocate and

leader among the Non-Aligned Movement and civil society if it continues to delay.

Incentives for the Middle East

By contrast, the Middle East triumvirate of Egypt, Iran and Israel will be tough to bring on board. In view of concerns about Iran's nuclear programme, its neighbours should have a clear incentive to get the CTBT locked down, but they don't seem to grasp that fact. Israel's problem is not the test ban per se: while there may be some remaining concerns about intrusive inspections at sensitive sites like Dimona, the main barrier to Israeli ratification is its close alliance with the United States. Israel has more to gain by ratifying than by continuing to stall, so a more positive sign from Washington is needed.

If Iran wishes to reassure the world that it really does want nuclear energy only for peaceful purposes, ratifying the CTBT would be a very important way to demonstrate that Tehran is not – as many fear – planning to emulate North Korea in the future by withdrawing from the NPT and testing a nuclear weapon. The international community should insist that Iran demonstrate its good faith by ratifying the CTBT, but at present the non-ratification of Egypt, Israel – and, of course, the United States – is providing Iran with a degree of cover. During the CTBT, Iran negotiated fully and constructively, including providing a Friend of the Chair on Inspections. Ratification by Iran would go some way towards alleviating international suspicions. If, on the other hand, Iran wants to pursue nuclear weapons under the guise of a nuclear energy programme, then ratification of the CTBT by the remaining countries, particularly Egypt, Israel and the United States, could more clearly expose such intentions.

Egypt is perceived to be waiting for Israel and perhaps also for Iran. This may be understandable, but in the case of the CTBT, such a policy is not in Egypt's interests. It stands to gain far more by ratifying now, and using that position to work with other major players to exert greater political pressure on Israel and Iran.

The special case of Colombia

Colombia's position is different. While saying that it strongly supports the CTBT, Colombia has a 'constitutional difficulty' and wants to be assured that when it deposits its ratification it will not be forced to pay backdated contributions, which it maintains would contravene its domestic law. Negotiations are continuing to find a way to resolve this legal conundrum.

India, Pakistan and the CTBT

This brings us to India and Pakistan, which hold rather different attitudes to the test ban. In September 1996, India declared that the CTBT was discriminatory and voted against its adoption by the General Assembly. Pakistan has always voted in favour of the CTBT but makes clear that it won't sign without India.

That was then and much has now changed. Nine years after India (followed by Pakistan) shocked the world with a series of nuclear tests, New Delhi is desperate to be accepted by the international community as a nuclear power, and there are those willing to accommodate this ambition, as exemplified by the US-India nuclear deal. As with the North Korean test, India's nuclear ambitions are a problem for international security. However, its desire to be perceived as a responsible nuclear weapon possessor also presents an opportunity to bring India into the CTBT. And if India joins, so will Pakistan – or at least that is the implication in all Pakistan's statements about the CTBT.

The role of the United States

None of this is likely without a change of policy in the United States. Whenever the Bush administration speaks or votes against the CTBT, it lets Iran, North Korea, China, India and the others off the hook. The US is thus undermining its own security objectives by repeatedly ignoring opportunities to make CTBT signature and ratification a condition of resolutions or negotiations intended to curb nuclear threats or programmes. Most recently, persistent US arrears in making their payments to the CTBTO are calling into question US commitment to nonproliferation, and risk undermining the Treaty's highly-effective monitoring system.

Though a successful Senate vote on ratification is still some way in the future, work needs to begin now on a bipartisan strategy to build greater understanding and support for the CTBT, especially among Republicans. While a first step needs to be payment of the US arrears, so that Americans can participate fully in the verification regime and decision-making, the overall aim must be to persuade 66 Senators to vote to ratify this international Treaty. After all, opinion polls show that 80 percent of Americans regard the CTBT as a desirable and necessary security step, not just for their country, but for the whole world. ■

Biographical note

Dr Rebecca Johnson is Executive Director of the Acronym Institute for Disarmament Diplomacy and author of a series of monographs on multilateral diplomacy. Her book on the history and contemporary importance of the CTBT is due to be published in early 2008. ■

Verification highlights

The main activity of the CTBTO Preparatory Commission is the establishment of a global verification regime capable of detecting nuclear explosions underground, underwater and in the atmosphere. As defined by the Treaty, this regime consists of an International Monitoring System supported by an International Data Centre, consultation and clarification mechanisms, on-site inspections and confidence-building measures, all of which must be operational at the Treaty's entry into force.

IMS network status

The establishment of the International Monitoring System (IMS) network has continued in all four technologies – seismic, hydroacoustic, infrasound and radionuclide. The complete network includes 321 stations and 16 laboratories in 89 countries.

As of 29 June 2007, 208 facilities, including 9 radionuclide laboratories had been certified (i.e. they meet the stringent technical requirements of the CTBTO PrepCom). Of the 321 stations, 248 had been installed and substantially met specifications. A total of 37 stations were either under construction or under contract negotiation, and 108 stations and five radionuclide laboratories had contracts for operation and maintenance.

During the last six months, 17 additional facilities, including five radionuclide laboratories, were certified. Altogether 215 facilities including nine radionuclide laboratories were configured in the International Data Centre (IDC) operational system. Out of these, 191 stations are sending data to the IDC.

By the end of 2008, the Provisional Technical Secretariat expects 90% of the IMS network to be installed. ■

Infrasound station IS11 in Cape Verde: a unique system in a challenging environment

by Dr Andrea Wurm

DIGGING THE TRENCHES FOR THE INFRASOUND ELEMENTS OF IS11, CAPE VERDE, DECEMBER 2006

The monitoring stations of the CTBTO verification regime employ the world's most advanced acoustic, seismic and radionuclide technologies. The 60-station infrasound network that monitors the atmosphere for low frequency sound waves produced by natural or man-made events is the only global monitoring network of its kind.

The stations are often located in remote and inhospitable environments. When installing stations or performing certification tests in such areas, staff members of the Provisional Technical Secretariat (PTS) need to have excellent engineering qualifications and be in good physical condition. This was also true for two PTS infrasound officers, Stefka Stefanova and Alfred Kramer, who had to deal with harsh climatic conditions and challenging technological issues related to the installation and certification of infrasound station IS11 in Cape Verde.

Spread out in the Atlantic Ocean like a jeweled necklace, the ten volcanic islands and five islets comprising Cape Verde were uninhabited when Portuguese mariners discovered the archipelago in 1456. Due to the islands' remote yet strategic position 500 kilometers off the West African coast, Cape Verde became an important hub for the transatlantic slave trade.

With the abolition of the slave trade, Cape Verde's primary source of income vanished. Changing weather patterns, aggravated by deforestation and overgrazing, led over the centuries to severe droughts. In the 20th century alone, repeated droughts caused the deaths of

SALT MARSHES ON MAIO ISLAND

200 000 people and prompted heavy emigration. As a result, Cape Verde's expatriate population is greater than its domestic one, numbering 480 000 people in 2007.

Cape Verde became independent in 1975. By 2007, remittances from emigrants play an important role in the country's service oriented economy, accounting for as much as 20% of GDP. Despite a lack of natural resources (mainly salt and limestone) and the periodic droughts, the country remains prosperous by West African standards. Tourism is the nation's main growth industry.

Cape Verde offers a lot to the interested visitor: a tropical climate with average temperatures ranging from 24°C to 29°C throughout the seasons, spectacular mountain scenery, beautiful extensive beaches, towns with intact colonial architecture and a vibrant Creole culture with breathtaking rhythms – some top world musicians such as Cesaria Evora come from Cape Verde. Every island has its own distinct character, from the lush and lively Santiago to the sandy and dry Maio, and from the volcanic Fogo to the diving paradise of Boa Vista, to name only a few.

The irregular rainfall, resulting in frequent water shortages, also differs greatly from island to island. Sand and dust carried by high winds from the Sahara sometimes cloud the sky and make any activity difficult. This phenomenon is called 'bruma seca' or 'dry fog'. It is particularly intense in the leeward island group which includes Maio, where infrasound station IS11is located.

Maio has an area of roughly 300 square kilometers and is one of the smallest islands of the archipelago. About 5500 people live there. It is a flat island with mainly white sand beaches and desert like-landscapes with almost no vegetation. The only exception to the arid and barren appearance of the island is a large area of artificially planted acacia trees. This plantation was identified during the January 1999 site survey as an ideal place to build the eight-element infrasound station IS11. The trees and bushes offer good wind protection to the

SATALLITE IMAGES OF CAPE VERDE WITHOUT (LEFT) AND WITH DUST CLOUDS IN THE ATMOSPHERE

TYPICAL SCENARY ON MAIO ISLAND

LUSH GREEN VEGATION ON SANTIAGO ISLAND

sensitive infrasound equipment and allow the collection of high quality data.

The CTBTO Preparatory Commission concluded a contract for civil work and equipment installation with the University of Mississippi, which subcontracted infrasound experts from the University of California, San Diego (UCSD), for the implementation.

A heatwave swept across Maio when the installation works started in October 2006. Temperatures of 35°C and more in the shade, plus winds blowing dust from the ground, made the digging for the grounding of the infrasound elements a nightmarish experience. The workers, who had to dig four 12 meter trenches at each of the eight sites, were covered with layers of dust and had difficulty breathing. Dust was everywhere: in the sky, on the ground, on the roads and on their clothes.

The two PTS infrasound officers visited Maio to control the quality of the installation and to perform certification measurements. A pre-installation and a certification visit took place in October and December 2006, respectively. A second certification visit was necessary in April 2007 in order to finalize the work. In a series of tests, the officers assessed the performance of the installed equipment and confirmed that it met the stringent requirements of the CTBTO Preparatory Commission.

During these missions, storms frequently carried sand and dust from the Sahara. The dust descended like fog on the island. Even the sun's rays were obscured by clouds of dust. For several days, everyday life and all outdoor activities on Maio were reduced to a minimum, including the installations at IS11. Flights between the islands were stopped. The tourists and

WORKERS PUTTING THE GRAVEL ON THE INLET PORTS, IS11, CAPE VERDE

WHITE BEACHES ON MAIO ISLAND

the local population were asked to remain indoors because the inhalation of fine dust particles causes stomachache and diarrhea. At IS11, special measures were taken to close and insulate all openings and doors, in order to protect the intrusion of sand and dust inside the equipment vaults and the Central Recording Facility. The solar panels, supplying power to the infrasound elements, needed to be cleaned regularly in order to insure their efficiency.

IS11 has been sending data to Vienna since January 2007. The certification of the station was planned for June. However, due to unexpected interruptions of the data flow, the certification had to be postponed.

Once certified, IS11 will not only provide data to the CTBTO global monitoring network, but may also contribute to a local volcano warning system. The almost 3000 meter high Mount Fogo on nearby Fogo Island is an active volcano that last erupted in 1995. The monitoring of its activities, coordinated by the Civil Engineering Laboratory of Cape Verde (Laboratório de Engenharia Civil de Cabo Verde), will benefit from the high quality infrasound data recorded at IS11. ■

Dr Andrea Wurm is a political scientist working as a Public Information consultant. She has conceptualized, coordinated and edited CTBTO Spectrum *since its inception.*

Infrasound is produced by a variety of natural and man-made sources. Exploding volcanoes, earthquakes, meteors, storms and auroras are among the strongest natural sources. Man-made sources of infrasound include nuclear, mine and large chemical explosions, as well as aircraft and rocket launches.

An infrasound station consists of four to eight array elements, arranged in different geometric patterns. Stations located in high wind areas or on isolated islands require more array elements to improve detection. At each array element sensors are used to measure the pressure changes produced by infrasonic waves. IMS infrasound stations are designed to cover the frequency band from 0.02 Hz to 4 Hz.

INFRASOUND OFFICER PERFORMING MICROBAROMETER COMPARISON TEST (PART OF THE CERTIFICATION MEASUREMENTS)

ARRAY ELEMENT L5 AT IS11, CAPE VERDE

Verification highlights

The importance of maintenance: inspecting hydroacoustic station HA01 at Cape Leeuwin, Australia

by Dr Andrea Wurm

With more than 200 monitoring facilities certified and plans to have 90% of the International Monitoring System (IMS) installed by the end of 2008, the focus has increasingly begun to shift from station installation to maintenance and network sustainability. Strategies are being developed on how to best support operation and maintenance of the stations in order to ensure an uninterrupted flow of data.

There are two types of maintenance activities: preventive maintenance includes regular inspection and service of station equipment; corrective maintenance is required whenever a station fails to perform, either due to equipment failure or to infrastructure damage. Whenever a problem at a station cannot be resolved at the operational level, the problem is re-assigned to the Maintenance Unit which then evaluates it and ensures that adequate measures are taken with support from the station operator.

With 11 stations, the hydroacoustic network is the smallest of the four sub-networks that form the IMS; the other networks are seismic, infrasound and radionuclide. Due to the efficient propagation of sound through water, six hydrophone stations and five T-phase stations are sufficient to cover the world's oceans.

IMS hydrophone stations are composed of triplets of hydrophones which are floated off the sea floor up to the depth of about 1000 metres where the sound propagates most efficiently. T-phase stations on small islands employ seismometers, which detect acoustic waves in the ocean after they are converted to seismic energy at the island's shore.

The highly sensitive hydrophones pick up acoustic signals, which are sent via an underwater fibre-optic cable to a shore station. The length of a cable to an IMS hydrophone station varies considerably, from 30 to 135 kilometres. The cable section nearest to the shore is usually the most vulnerable to damage from anchoring, fishing or strong waves and currents. To deploy or repair such a cable is a very costly operation, so the CTBTO Preparatory Commission has a vested interest in maintaining the cables in the best possible condition. Periodically, the Provisional Technical Secretariat (PTS) conducts preventive maintenance inspections to determine signs of instability or movement of IMS hydroacoustic cables, such as loops, kinks, bends, wear or abrasion that could lead to a malfunction.

CAPE LEEUWIN, THE SOUTHWESTERNMOST POINT OF AUSTRALIA WHERE THE SOUTHERN AND THE INDIAN OCEAN MEET

Hydroacoustic station HA01 at Cape Leeuwin, located at the most south-westerly point of Australia, was installed in 2001. The hydrophones are deployed about 100 kilometres from the shore at a depth of 1000 metres. A cable inspection was conducted immediately after installation and key areas for periodic surveys were identified along a stretch of about 20 kilometres near the shore where the cable was lying in shallow water. The first post-lay inspection took place in early 2003.

In early March 2007, José Pereira, PTS Hydroacoustic Officer, supervised the most recent inspection mission to HA01. The team consisted of two engineers from the installation contractor and a survey vessel. Despite having been classified as a routine maintenance trip, the inspection survey encountered several challenges.

The cable was covered by sand or overgrown by algae and other marine organisms and was, to a large extent, perfectly camouflaged. The first challenge was to identify the cable in the open sea at a depth of up to 50 meters on the ocean floor. This was done with the help of GPS navigation and a remotely operated vehicle (ROV). The ROV is an underwater robot equipped with a video camera linked to

PREPARING FOR THE CABLE INSPECTION

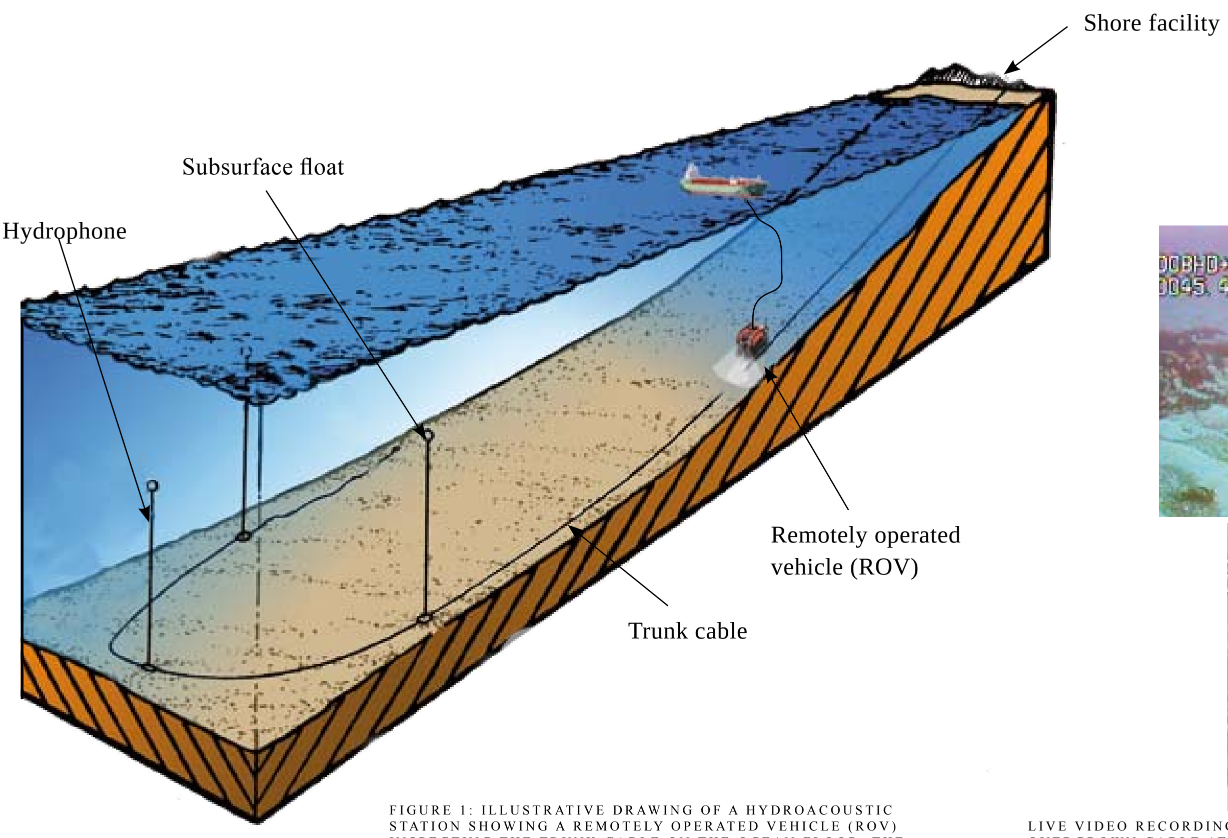


FIGURE 1: ILLUSTRATIVE DRAWING OF A HYDROACOUSTIC STATION SHOWING A REMOTELY OPERATED VEHICLE (ROV) INSPECTING THE TRUNK CABLE ON THE OCEAN FLOOR. THE OPERATION IS STEERED BY ENGINEERS ON BOARD THE VESSEL.

LIVE VIDEO RECORDINGS SHOWING PARTIALLY OVERGROWN CABLE AT HYDROACOUSTIC STATION HA01, CAPE LEEUWIN, AUSTRALIA.

REMOTELY OPERATED UNDERWATER ROBOT

UNDERWATER ROBOT WITH 'UMBILICAL' CABLE, READY FOR INSPECTION DIVE

a monitor by an 'umbilical' cable. This enables real-time inspection and recording for later image analysis. A GPS antenna was connected to a laptop computer for logging geographic co-ordinates. Utilizing the digital map created at the last inspection, the vessel needed to navigate to its correct position. The next challenge was to manoeuvre the ROV along previously defined sections of the cable. Losing track of the cable can happen easily when it is buried in sand or when the rolling of the vessel prevents the skipper from holding the position. To follow the cable required perfect coordination between the skipper, who had to continuously adjust the vessel's position, the engineer, who controlled the 'umbilical' cord that connected the computer with the ROV, and the engineer who checked the live images for signs of cable movement or damage.

Since the 20 kilometre stretch of the cable surveyed at Cape Leeuwin was partitioned into several sections, a new section had to be located every few hours. The heat wave that hit Western Australia in early March 2007 also made the work, which demanded a high degree of concentration for long periods of time, even more challenging for the inspection team. Temperatures of more than 45°C and an increasingly strong ocean current on the second day added to the challenge.

Altogether, the inspection team recorded nearly 20 hours of video material, spending roughly ten hours per day on the boat tracking the cable and analyzing the video recordings. No additional kinks or loops were found. Thus, the near-shore section of the cable of HA01 has remained stable since 2003. If any irregularity or damage, which could have led to a future cable break, had been identified during the inspection, an early repair would have minimized interruption to continuous data flow and would have saved the CTBTO considerable costs of a later major repair. ■

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Recent developments in infrasound monitoring technology: application to CTBT verification

by Dr Douglas R. Christie

The signing of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) on 24 September 1996 and the establishment of the International Monitoring System (IMS) for Treaty verification has led to a rapid development in infrasound monitoring technology. The IMS 60-station infrasound network has been designed to detect and locate atmospheric nuclear explosions with a yield of one-kiloton[1] reliably. While the stations in this network have been located as uniformly as possible all over the globe, the distances between stations vary and the monitoring capability for explosions over the continental land mass areas is generally better than the monitoring capability over the vast open ocean areas in the Pacific and South Indian Oceans. At the present time, the infrasound network is limited to two-station detection for one-kiloton explosions that occur over most of the ocean regions. Global three-station detection capability is desirable since this would greatly enhance the reliability of the network, lower the global detection threshold and significantly reduce location errors. Recent developments in infrasound technology suggest that the monitoring performance and reliability of the IMS infrasound network can be improved substantially.

Infrasound stations in the IMS network are located in a wide variety of environments ranging from equatorial rainforests to remote wind-swept islands and the ice-covered wastes of the polar regions. As a result, wind conditions at these stations vary widely. Wherever possible, IMS infrasound stations have been located in dense forests in order to shield the station from wind-generated noise. However, shelter from the winds is not always available and it has been necessary in some cases to establish stations in areas with little, if any, protection from the ambient wind. The level of background noise due to wind-generated turbulence is often very low at night when the upper winds are decoupled from the surface by a nocturnal boundary layer. The onset of daytime convection usually leads to a rapid increase in wind noise as the upper level winds are reconnected to the surface layer. Wind-generated noise may prevent the detection of signals from distant explosions. Here, we describe a technique developed at the Australian National University (ANU) that can substantially reduce and often eliminate wind-generated noise at IMS infrasound stations.

Historically, almost all wind-noise-reducing systems have been based on a spatial averaging technique developed by Fred Daniels in 1959 in which the micropressure fluctuations at a series of inlets along a tapered pipe are summed at the microbarometer sensor. If the wind-generated noise is incoherent between inlet ports and if the signal is perfectly coherent, then this procedure results in an increase in the signal-to-noise ratio equal to the square root of the number of inlets. During the last decade, refined noise-reducing pipe array systems

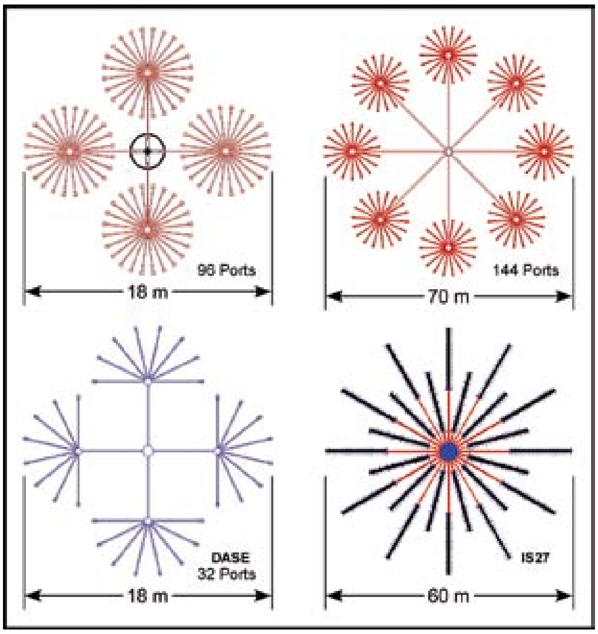

FIGURE 1: WIND-NOISE-REDUCING PIPE ARRAYS USED AT STATIONS IN THE IMS INFRASOUND NETWORK

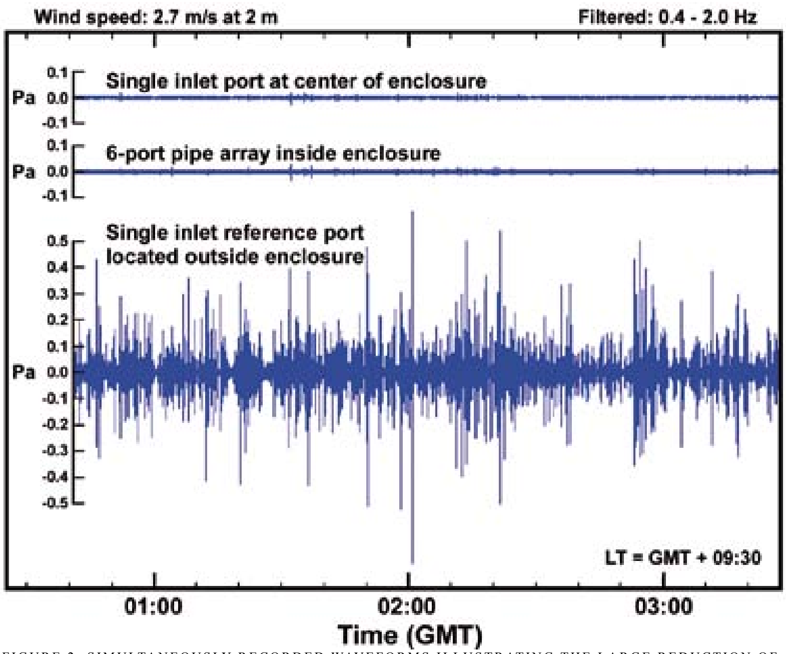

FIGURE 2: SIMULTANEOUSLY RECORDED WAVEFORMS ILLUSTRATING THE LARGE REDUCTION OF BACKGROUND NOISE IN THE PRIMARY MONITORING PASSBAND BY THE TURBULENCE-REDUCING ENCLOSURE DURING TYPICAL DAYTIME CONDITIONS

[1] The CTBT is a comprehensive treaty. No lower limit on yield is defined in the Treaty. For practical purposes, it was decided in the negotiations of the Treaty that the design of the global IMS infrasound network was to be based on the requirement that a one-kiloton nuclear explosion located anywhere on the globe should be detected reliably at a minimum of two monitoring stations. The global threshold for single-station detection is much less than one-kiloton. Two-station detection capability is required to determine the location of the explosion.

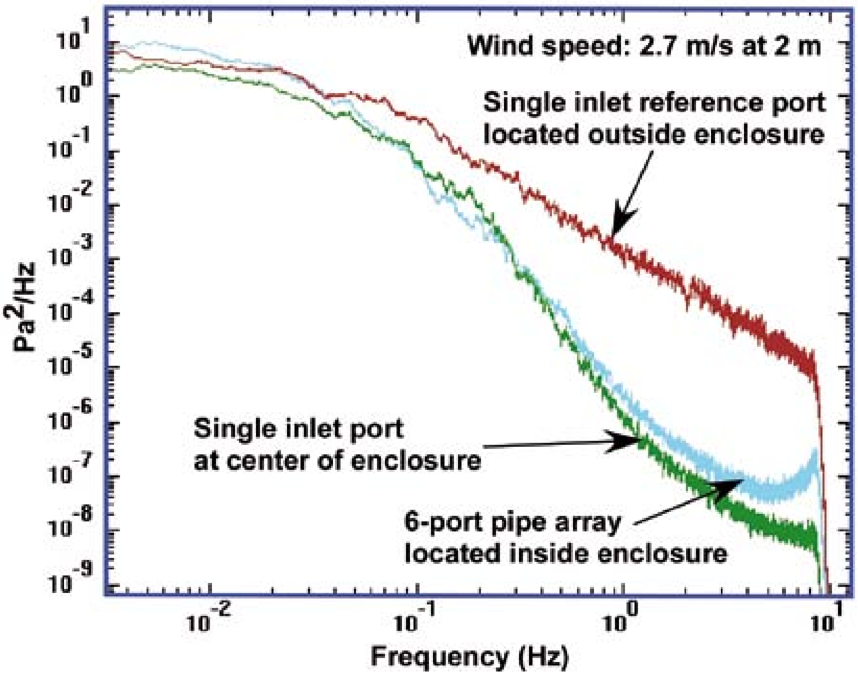

FIGURE 3: POWER SPECTRAL DENSITY OF BACKGROUND NOISE DATA RECORDED SIMULTANEOUSLY INSIDE AND OUTSIDE THE TURBULENCE-REDUCING ENCLOSURE DURING TYPICAL DAYTIME CONDITIONS

have been developed that are currently in use at IMS infrasound stations (see Fig. 1). These pipe arrays provide a very substantial reduction in wind noise, but the degree of noise reduction may not be sufficient when the station is located in an unsheltered area and winds are high. Wind noise reducing pipe array systems also have some disadvantages. The response of these systems is not always well known. In addition, they may be subject to unwanted resonances and may distort and attenuate higher frequency signals.

It seems clear that further refinements to existing pipe array designs will not lead to a significant improvement in wind noise reduction capability. The number of inlet ports and the size of existing pipe arrays has reached practical limits. A different approach to the problem of wind-generated noise is required. This new approach should result in a system that can reduce noise levels by at least a factor of ten over that obtained with existing systems. Research at the ANU during the past year has focussed on techniques which reduce wind noise levels by degrading turbulent eddies that generate noise in the primary monitoring passband (0.4 to 2.0 Hz).

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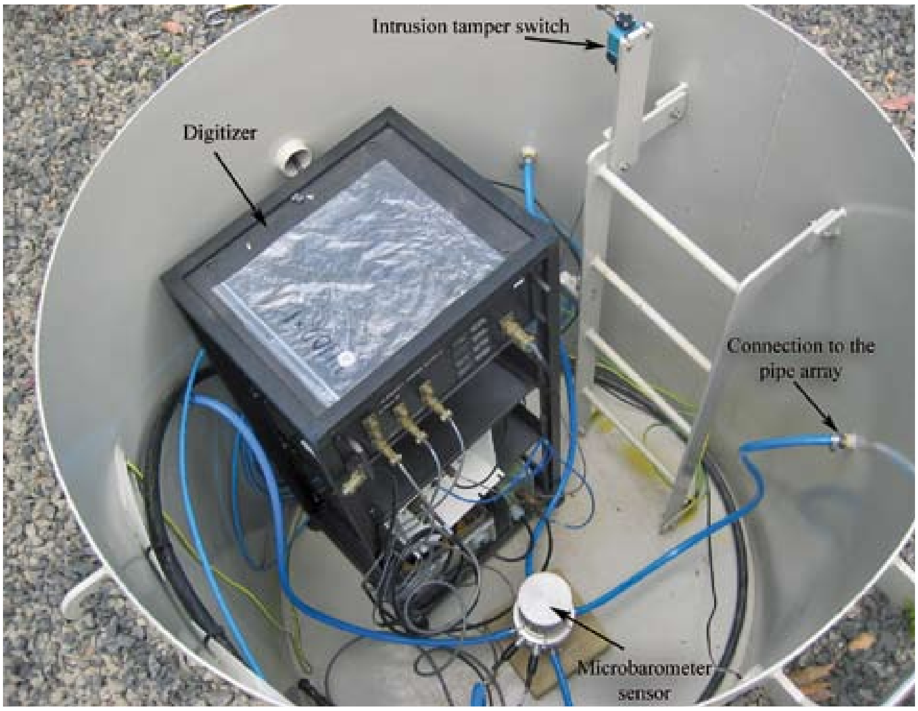


INSIDE OF AN INFRASOUND EQUIPMENT VAULT, INFRASOUND STATION IS04, SHANNON, AUSTRALIA

Glossary of terms

Nocturnal boundary layer
The nocturnal boundary layer is a thin layer of cooler air that forms at the surface over land during the night. This stable layer effectively prevents the ambient winds above this layer from reaching the surface.

Daytime convection
Daytime convection is a term used to describe the generation of thermal plumes induced by solar heating of the earth's surface during the day. The onset of thermal activity during the early daylight hours destroys the stable nocturnal boundary layer, thus reconnecting the ambient winds to the surface.

Pipe array system
Modern pipe array systems (see Figure 1) consist of a series of pipes that connect a large number of uniformly distributed inlet ports to a summing chamber at the inlet to the microbarometer infrasonic sensor. Samples of coherent infrasound and incoherent noise from all inlet ports are averaged at the sensor to give a large increase in signal-to-noise ratio.

Primary monitoring passband
This term is used to describe the range of frequencies (0.4 to 2.0 Hz) where infrasonic signals from distant explosions can be detected with optimum signal-to-noise ratio.

Verification science

North Korea: a real test for the CTBT verification system? Part II: noble gas observations

by MSc Paul R.J. Saey, Dr Andreas Becker and Dr Gerhard Wotawa

Part I of this article in *CTBTO Spectrum* 9 described the analysis method and results obtained from waveform data for the event that took place in the Democratic People's Republic of Korea (DPRK) on 9 October 2006. The Provisional Technical Secretariat (PTS) made a location and time determination of the event in the Reviewed Event Bulletin (REB), which is sent out to all States Signatories. While waveform data are utilized for event location and could be used to differentiate between an earthquake and an explosion, detections of relevant radionuclides or noble gases are the prerequisite to identify the nuclear origin of an event unambiguously. But only a detection of them at one of the International Monitoring System (IMS) radionuclide or noble gas stations could provide the PTS with the input to assist the State Signatories in identifying the DPRK event as having a nuclear origin.

In order to spot the potentially relevant IMS radionuclide stations, PTS utilized its atmospheric transport modelling (ATM) expertise. ATM provides updated information on the propagation of a possible release of radioactivity into the atmosphere based on the most accurate weather analysis globally available.

Radioactive release and the significance of noble gas

If a nuclear explosion took place in the atmosphere, above ground or insufficiently contained below ground, a large amount of debris would be ejected and transported by the wind. Once these particles passed an IMS radionuclide station, they would be measured and a signal identifying the origin of these radioactive particles would be found. In the case of the DPRK event, the closest IMS radionuclide particulate stations that could capture the signal were located at Takasaki and Okinawa in Japan and at Sand Point in Alaska. They did not measure any relevant radionuclides after the event. Even a re-measurement of the filters in CTBT-certified laboratories did not reveal any traces of a nuclear test.

However, a well contained underground explosion is not expected to release any particulates into the atmosphere. Noble gases created by the explosion may nevertheless leak out, and IMS noble gas stations would alone be capable of indicating that the event was nuclear. The time the gas needs to reach the surface is dependent on its diffusivity, upon the power of the explosion and upon the underground environment. It is reasonable to assume that a more immediate venting would eject a substantially larger fraction of the available noble gas than a later seepage.

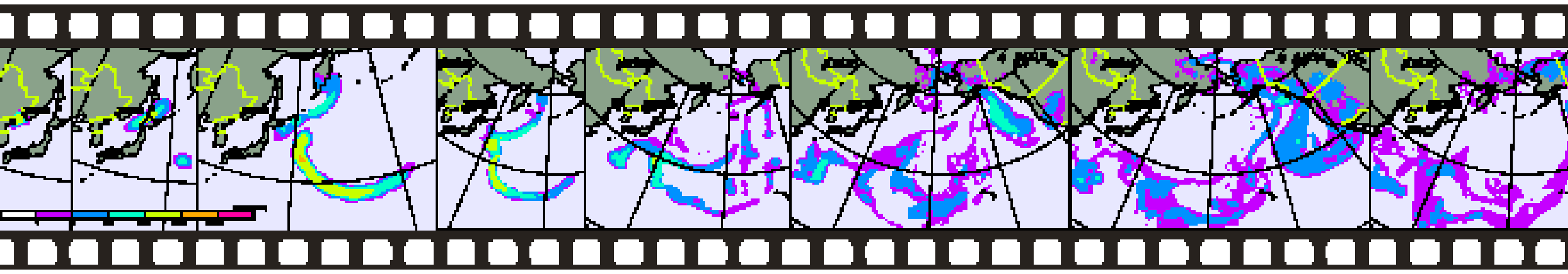
The build-up of the noble gas system

When the PTS was established in 1997, no noble gas monitoring systems were commercially available that fulfilled the IMS minimum requirements. Therefore, the International Noble Gas Experiment (INGE) was established to design, develop, build, install and test such machines (see also *CTBTO Spectrum* 1 and 8). By October 2006, ten of the planned forty experimental noble gas stations had been installed. No station was close to the DPRK. At the time of the event it was thus an open question whether the amount of release would allow for a detection at an operating station, located in the direction of the plume and requiring intercontinental transport of air over thousands of kilometres.

Xenon-133 detections at Yellowknife, Canada

According to ATM calculations, the debris would reach the nearest operating noble gas station in Yellowknife, Northern Canada, on 22 October 2006 with two peaks on the 23rd and 27th. Interestingly, alternative forward ATM calculations with up to two days delay in release times predicted the same double peak signal. This indicates that the peak pattern at Yellowknife was rather shaped by the geographical conditions (i.e. mountain ranges in Alaska and Northern Canada) than by the release time of the device.

The station in Yellowknife detected, as predicted, above-background levels of xenon-133 on 21 and 25 October with somewhat lower



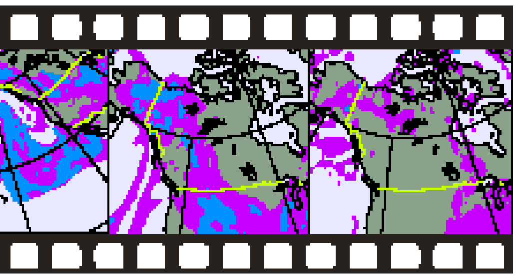
THE ABOVE FILMSTRIP SHOWS FROM LEFT TO RIGHT THE MOVEMENT OF THE XENON-133 PLUME IN TERMS OF CALCULATED GROUND LEVEL CONCENTRATIONS ASSUMING A SURFACE EMISSION OF 1015 BECQUEREL AT THE TIME AND COORDINATES OF THE 9 OCTOBER EVENT. THE SCENE ON THE FAR LEFT ILLUSTRATES HOW THE PLUME STARTS TRAVELLING TO THE EAST, WHILE THE SHOTS ON THE FAR RIGHT SHOW THE PLUME ARRIVING AT THE YELLOWKNIFE STATION (CAX16).

values between 22 and 24 October, thus resembling the calculated double peak pattern. Backtracking calculations were evaluated to exclude other known sources of noble gas from facilities closer to the station. Consequently, the ejection of xenon-133 characteristic for a one-kiloton nuclear explosion on the Korean peninsula at the time of the REB event was the most realistic source scenario to explain the observed concentration pattern in Yellowknife.

Conclusion

The Yellowknife detection of the DPRK test demonstrated that noble gas stations are capable of providing evidence of the nuclear character of an event, even though the network is not complete. Once the complete verification system is in place, the fusion of data from the radionuclide and waveform networks in conjunction with state of the art atmospheric modelling will provide an unprecedented system for locating and identifying nuclear events. ■

MSc Paul R.J. Saey is a nuclear physicist working as a PTS Radionuclide Officer, Dr Andreas Becker and Dr Gerhard Wotawa are meteorologists, both working as PTS Atmospheric Sciences Officers. The three were involved in the set-up and operation of the PTS noble gas and atmospheric transport systems utilized for the characterization of the DPRK event.



Secretariat snapshots

A new platform for exchange with the scientific community

by Dr Andreas Becker and Dr Frank Graeber

"The success and efficiency of our verification regime relies on a permanent dialogue with scientific institutions about the latest developments in their areas of expertise and their adaptation to our needs".

These words by the CTBTO Executive Secretary, Tibor Tóth, in his opening address to the CTBTO scientific symposium held in Vienna in 2006 encouraged staff members of the Secretariat to initiate a new scientific session on "Research and Development in Nuclear Explosion Monitoring" at the General Assembly of the European Geosciences Union (EGU). The event, with more than 8000 participants, was held in April 2007 in Vienna.

42 contributions underline importance of meeting

The session was designed to provide a forum for all verification technologies. Forty-two papers were submitted that covered all relevant fields, including seismology, infrasound, hydroacoustics, nuclear physics and atmospheric backtracking. A variety of topics critical for detection, location and characterization of nuclear explosions, including case studies based on natural and man-made events were presented.

PTS contributed 17 papers

By contributing 17 papers, the Provisional Technical Secretariat (PTS) increased the visibility of the CTBTO, thus contributing to enhanced public awareness of the Preparatory Commission's work. Lassina Zerbo, Director of the International Data Centre Division, presented an overview of the CTBTO monitoring system and four other papers described the system in more detail. Many fruitful discussions were initiated among PTS staff members and the Conference participants that may serve as a basis for enhanced activities with the scientific community.

How to detect and localize an event?

Accurate event characterization was one of the main topics of the session as this constitutes a key challenge for each of the CTBT verification technologies. Natural and man made sources, particularly smaller events, may generate signals, which to a certain extent display properties similar to those originating from Treaty-relevant sources. The correct discrimination of such signals poses a significant challenge to the monitoring system and to the automatic and interactive processing software. This requires research and development in quite different fields, depending on the technology in question.

Infrasound

A better understanding of infrasound propagation in a dynamic atmosphere greatly improves the association of signals and the location of events. However, experimental verification of propagation predictions for high altitude infrasound sources recorded at long ranges is difficult to perform due to the rarity of upper air explosion events. Henry Bass, Director of the National Center for Physical Acoustics at the University of Mississippi, presented a paper on an experiment involving moderately sized high altitude explosions. Six other external and two PTS papers presented case studies (e.g. the Buncefield fuel depot explosion in December 2005 near London, United Kingdom) and studies on the capabilities of certain infrasound arrays with regard to event characterization and monitoring of upper atmospheric dynamics.

Hydroacoustic

One of the two hydroacoustic papers presented initial results from a controlled source experiment in the southern ocean, which was designed to study errors in predicted estimates of transmission loss and source location. A PTS paper described a method for identifying seismic waves at IMS hydrophone triads, which represents a good example for positive synergy effects between waveform technologies.

continues on page 24

Potential civil and scientific applications

The importance of IMS data for global climate change research

by Professor Dr Helga Kromp-Kolb

Climate research deals with the analysis and projection of weather patterns over long periods of time. While the CTBTO Preparatory Commission is building the International Monitoring System (IMS) to monitor the earth for signs of a nuclear explosion, data from its 337 IMS facilities could also be of relevance for climate and climate change research, if made available to the scientific community. This is particularly true for the 60 station-infrasound network and the 80 station-radionuclide network, which are the only global monitoring networks of their kind.

Former US Vice-President Al Gore's highly recommended movie on global warming, "An Inconvenient Truth", pays tribute to Roger Revelle and Charles David Keeling, pioneers in monitoring the atmosphere for carbon dioxide at the Mauna Loa Observatory in Hawaii. In the mid-1960s, observations had only been carried out for about half a decade when Roger Revelle warned his students – Al Gore among them – that climate change would be the result of the observed change in the composition of the atmosphere (Fig.1).

This example demonstrates a number of important points. Our understanding of global climate is based on observations. Data collected in remote areas can give a clearer picture than data influenced by nearby disturbances. Some of the observed variables, like temperature or precipitation, are obvious climate indicators and are being monitored with the explicit purpose of climate (or weather) research. Others, initially not monitored for climate research, can prove extremely helpful in understanding the global atmospheric system. Unless trends are very strong, a period of a few years or even decades of observation will not be a proof of systematic climate change. Observed changes can, however, stimulate creative people to come up with interesting thoughts and hypotheses, as in the case of the CO^2-concentrations measured on Mauna Loa.

Several of these points demonstrate the relevance of IMS data. Although the worldwide national meteorological services operate a network of some 5000 ground stations, more than 600 upper air sounding stations, thousands of climate stations, as well as satellites, they were built primarily to serve national monitoring interests. The IMS network, however, was built to ensure global monitoring. Therefore, the IMS includes remote and inaccessible sites, whereas the vast majority of meteorological monitoring stations are situated in populated areas. Thus, IMS data can help to fill geographical gaps and IMS stations in remote locations could support additional meteorological monitoring efforts.

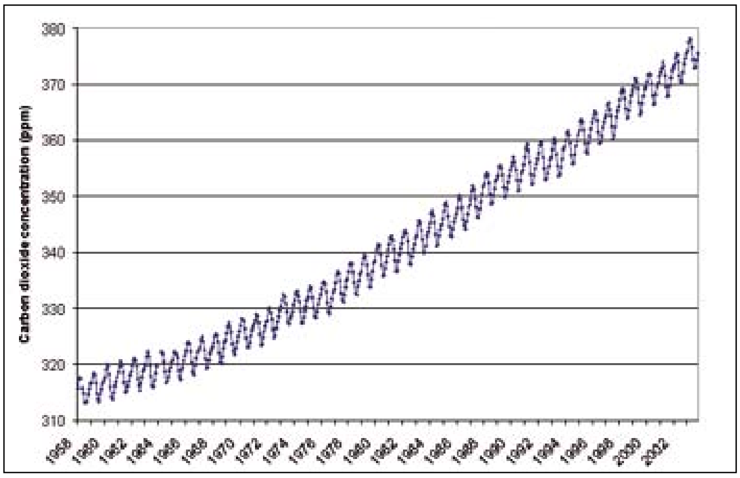


FIGURE 1: ATMOSPHERIC CO^2 CONCENTRATIONS (PPMV) DERIVED FROM AIR SAMPLES COLLECTED AT MAUNA LOA OBSERVATORY, HAWAII, STARTING 1958. ANNUAL CYCLES REFLECT THE INCREASED CARBON DIOXIDE INTAKE BY PLANTS IN THE SUMMER.

Mauna Loa data and others clearly demonstrate the value of data from remote sites.

It might be felt that IMS data are of little value for climate research, as they are only available for a few years and many climate processes can only be understood by looking at observations over long time periods. However, some processes such as volcanic eruptions and the ensuing cooling can be documented within a few years. In some cases, even shorter time scales, in the order of days or hours, can enhance the understanding of processes or evaluate different hypotheses. For example, the ban on aviation in the United States following the 9/11 attacks proved to be a valuable full scale experiment to analyze the influence of aircraft exhaust emissions (so-called 'contrails') on solar radiation. Another example are the measurements tracing the first arrival of the Chernobyl radioactive cloud in Austria (Fig. 2) or its propagation over Europe. These data sets continue to be used to test dispersion models. There are also some processes that elude systematic and direct monitoring due to the long time scales involved, such as the

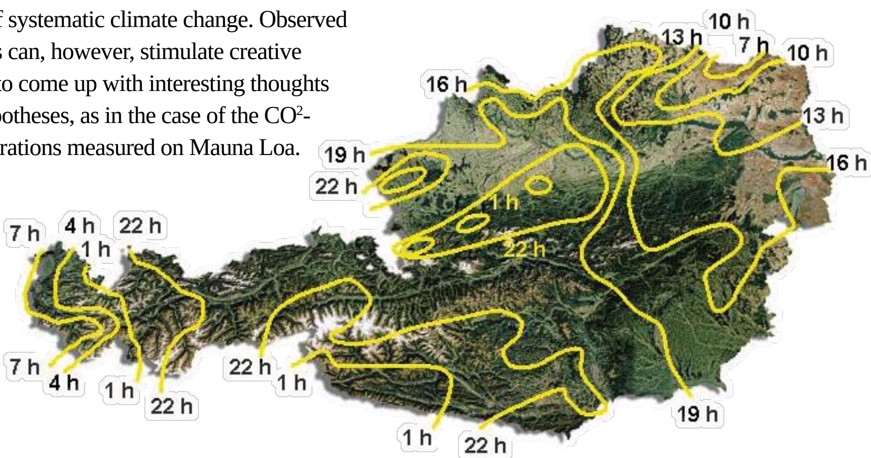


FIGURE 2: FIRST ARRIVAL OF THE RADIOACTIVE CLOUD IN AUSTRIA, FOLLOWING THE CATASTROPHE AT THE CHERNOBYL NUCLEAR POWER PLANT IN APRIL 1986. THE CLOUD ARRIVED AT THE NORTH EASTERN BORDER OF AUSTRIA ON APRIL 29TH AT 7 GMT IN THE MORNING AND REACHED THE WESTERN BORDER ABOUT 24 HOURS LATER. THE DATA SET GATHERED BY THE 336 ONLINE STATIONS OF THE AUSTRIAN EARLY WARNING SYSTEM THAT MONITORED THE GAMMA DOSES, CONTINUES TO SERVE METEOROLOGISTS IN VALIDATING ATMOSPHERIC TRANSPORT MODELS IN COMPLEX TERRAIN. [SOURCE: KOLB 1986]

100 000 year ice-age cycles. These can only be reconstructed based on indicators of a different nature such as the composition of air trapped in ice cores. Coupled with modern monitoring results, however, these records show the dramatic man-made impact on the composition of the atmosphere (Fig 3). Thus, even now, IMS data could be helpful in climate research.

In addition, IMS stations focus on parameters not monitored by meteorological networks, such as infrasound and radionuclides. These data are collected for IMS purposes, but contain additional information of no immediate use to the Preparatory Commission. A range of meteorological events can emit infrasound, such as severe storm systems, air and ocean waves, meteorites entering the atmosphere, auroras, volcano eruptions and earthquakes. What is considered a 'disturbance' or 'noise' in the data when monitoring Treaty compliance, may be of relevance to the climate science community. Thus, IMS data could become an important archive for the research of the atmosphere, severe storm systems, mountain waves, etc. – phenomena that can undergo significant changes as a consequence of climate change.

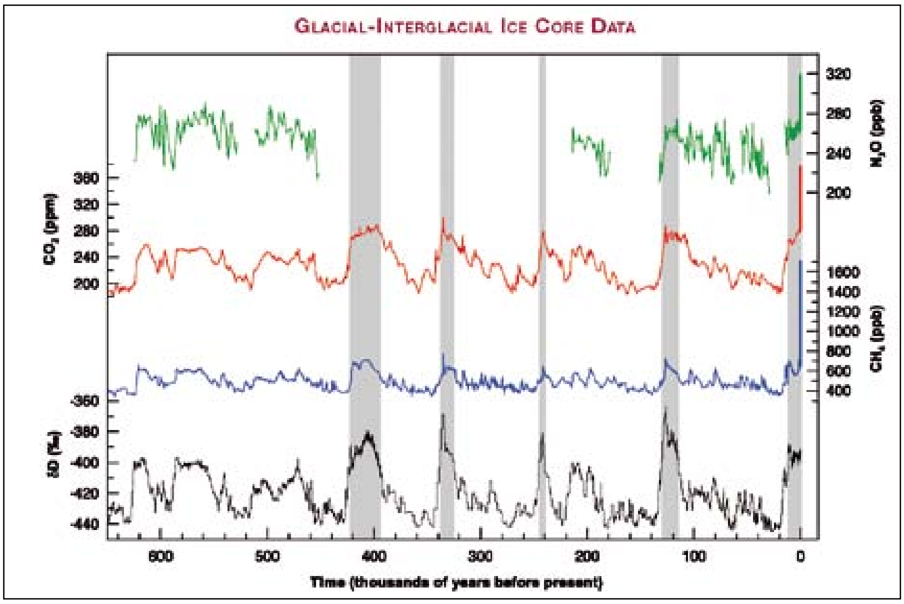


FIGURE 3: CARBON DIOXIDE CONCENTRATIONS IN THE ATMOSPHERE OVER THE LAST 600 000 YEARS, AS RECONSTRUCTED FROM THE AIR BUBBLES ENCLOSED IN ICE CORES. THE DRAMATIC INCREASE IN CONCENTRATION AS A RESULT OF BURNING OF FOSSIL FUELS DURING THE LAST 200 YEARS IS CONFIRMED BY THE MONITORING DATA OF THE MAUNA LOA OBSERVATORY. [SOURCE: IPCC 2007, FOURTH ASSESSMENT REPORT WGI, TS]

FILM POSTER OF AL GORE'S "AN INCONVENIENT TRUTH"

Natural radionuclide data also registered by the monitoring system can be used to validate and calibrate weather prediction and climate models. Very likely, IMS data sets will reveal useful and unexpected information, once they become available to the scientific community.

In his film, Al Gore shows how data on the thickness and extent of the Arctic ice cap, collected over the years, facilitated United States military submarine movements. When declassified, the data revealed a startling record of climate change. The extent and thickness of the Arctic ice cap had diminished by 40% since the 1970s. Although other data and models had shown that the effects of global warming were especially severe in higher latitudes of the northern hemisphere, it was the extent of ice melting in the Arctic and in Greenland that came as one of the biggest surprises to climate researchers. The arctic ice data were originally not released due to national security considerations.

Today it has become clear that it is the processes behind the data – not their release – that could threaten national security. Due to the melting of significant parts of the Greenland ice sheet, the sea level could rise considerably faster and higher than originally expected and cause flooding in densely populated coastal areas around the world. Millions of people would lose their homes. The ensuing global refugee crisis would further destabilize a world in which climate change already contributes to a widening of the gap between rich and poor.

Scientists need all available information to help society cope with the challenges associated with climate change. Here the CTBTO Preparatory Commission and IMS data can make a valuable contribution. ■

Biographical note

Dr Helga Kromp-Kolb is Professor at the University of Natural Resources and Applied Life Sciences in Vienna. Her research focuses on environmental meteorology, especially air pollution dispersion and climate change. She is a member of a number of scientific boards, as well as advisory committees to the Austrian Government. ■

Recent developments in infrasound monitoring technology: application to CTBT verification

continued from page 19

This has proven to be quite effective and the results are very promising. The technique is based on the use of turbulence-reducing structures constructed from robust screens stretched over a rigid framework. A wide variety of such turbulence-reducing enclosures have been tested and this has led to a highly efficient design consisting of a number of chambers and baffles with excellent noise-reducing performance characteristics. An example of the results obtained using the latest version of the noise-reducing enclosure in typical daytime wind conditions is shown in Fig. 2 for waveform data in the primary monitoring passband. As can be seen from this diagram, wind-generated noise levels are very substantially reduced by the porous enclosure, even in the case where the pipe array is replaced by a single inlet port. It is worth noting that the porous enclosure has virtually no influence on the amplitude of infrasonic signals. The power spectral density plots shown in Fig. 3 provide a better illustration of the high degree of wind noise reduction provided by the turbulence-reducing enclosure at all frequencies. The results presented in this diagram show that the turbulence-reducing enclosure provides a very effective means for reducing wind noise in the primary monitoring passband for CTBT verification. In addition, the results show that a single inlet port system located at the centre of the enclosure is more effective than the distributed six-port pipe array that is also located inside the enclosure.

In summary, recent research at the ANU has shown that turbulence-reducing enclosures can be used to reduce or eliminate wind noise at IMS infrasound stations. These systems can therefore be used to enhance the performance of existing pipe arrays or, in some cases, as effective stand alone noise-reducing systems that do not require a pipe array. ■

Biographical note

Dr Douglas Christie was born in Canada and joined the Australian National University (ANU) in 1975, where he carried out research on nonlinear waves and infrasound. He assisted the Australian Government as an infrasound expert during the CTBT negotiations 1994-96. In 1997 he joined the IMS Division at the CTBTO and helped to establish the global infrasound network. He returned to the ANU in 2003. ■

A new platform for exchange with the scientific community

continued from page 21

Seismic

Eight external and five PTS contributions on seismic data processing dealt with various topics, such as enhancements of the automated processing at the PTS, decoupling experiments in Israel, improvements in local and regional earthquake monitoring, improvements in event discrimination and low magnitude event detection. The October 2006 DPRK event provided seismic data, which was utilized by several studies on the performance of the CTBT verification regime.

Radionuclide, noble gas and atmospheric transport

The DPRK event demonstrated also the crucial role of the radionuclide technology for the nuclear event classification. Moreover, the typical radioactivity release characteristics of underground events have shed a spotlight on the radio-xenon technology and the corresponding atmospheric backtracking methodologies (see also article on page 20). Seven external and six PTS papers elaborated on related topics, such as high-resolution monitoring and atmospheric backtracking studies, enhanced global modelling and data mining to improve global emission inventories, and machine learning algorithms utilizing pattern recognition techniques for radio-xenon event classification.

Conclusion

With this session, a platform of know-how exchange in the much debated field of nuclear explosion monitoring could be established. The 2008 EGU General Assembly will again take place in Vienna offering PTS the opportunity to sustain a scientific dialogue that is tailored to its need to stay abreast of the latest developments in the field and to provide its input to it.

Abstracts of all 42 contributions are available on a CD-ROM (Geophysical Research Abstracts, Volume 9, 2007) and on the 2007 EGU General Assembly web-page[1]. ■

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[1] http://www.cosis.net/members/meetings/sessions/accepted_contributions.php?p_id=251&s_id=4563

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