

**A Master's Thesis Submitted in Partial Fulfilment
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**Environmental Measurements and
Non-State Monitoring
of Nuclear Treaties
- A Case Study on North Korea -**

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I pledge that this Masters Thesis, entitled „Environmental Measurements and Non-State Monitoring of Nuclear Treaties” has not been submitted for academic credit in any other capacity, and that this Masters Thesis has not yet been published.

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Hamburg, den 15. Juli 2009

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List of Abbreviations

ACA	Arms Control Association
CD	United Nations Conference on Disarmament
CNS	James Martin Center for Nonproliferation Studies
CTBT	Comprehensive Nuclear-Test-Ban Treaty
CTBTO	CTBT Organization (at the moment „Preparatory Commission for the CTBTO”)
DPRK	Democratic People’s Republic of Korea (also: North Korea)
FMCT	Fissile Material Cut-off Treaty
IAEA	International Atomic Energy Agency (also: IAEO)
INFCIRC	Circular Information Letters from the IAEA
IDC	International Data Centre
IMS	International Monitoring System
NNWS	Non-Nuclear Weapons State
NPT	Non-Proliferation Treaty
NTM	National Technical Means
NWFZ	Nuclear Weapons Free Zone
NWS	Nuclear Weapons States
OSI	On-Site Inspection
PTBT	Partial Test Ban Treaty
ROK	Republic of Korea (also: South Korea)
WMD	Weapons of Mass Destruction

1 Introduction

Nowadays modern civilisation knows several forms of weapons of mass destruction. Besides various biological and chemical types, common language knows also a third variant, the nuclear weapon. The potential of nuclear weapons for vast destruction was experimentally demonstrated for the first time in the Manhattan project with the so-called Trinity bomb, the world's earliest functioning nuclear explosion device. Although it was only a test, project leader J. Robert Oppenheimer commented on the very first nuclear detonation on 16 July 1945 by citing an Hindu scripture:

„Now, I am become Death, the destroyer of worlds.”

About three weeks after being tested for the first time nuclear weapons were used twice in the Second World War by the United States of America. Up to today these were the only offensive uses of nuclear weapons. The bombings of Hiroshima and Nagasaki on 6 and 9 August 1945 are infamously known for the hundreds of thousands of perished and violated victims.

After the Second World War was over the United States, so far the only possessor of nuclear weapons, was facing new nuclear weapons states emerging from the international community. One after another of today's acknowledged nuclear weapon states conducted their first tests: 1949 Soviet Union, 1952 United Kingdom, 1960 France, 1964 China.

As early as in 1953 US president Eisenhower realised the danger arising from a growing number of nuclear weapons states. His „Atoms for Peace” speech in front of the United Nations on 08 December 1953 was a crucial step for the international community to recognise the importance of future nuclear treaties. In the following years treaties concerning various nuclear issues were established. One can distinguish between different kinds of treaties: Global, regional and bilateral treaties.

Global treaties are opened for every state to become a signatory. Important global nuclear treaties are listed in the following:

1963 PTBT The Partial Test Ban Treaty forbids all signatory states to test fire nuclear devices except underground. This prohibits nuclear explosions in the atmosphere,

1 Introduction

in space and underwater. The treaty was established to slow down the nuclear arms race as well as to avoid an increasing nuclear contamination of the environment. It was signed and ratified by most countries in the world¹; countries who have not sign it and have conducted nuclear tests (as is known) since then are China, France and North Korea. The combination of atmospheric, space and underwater was chosen, as the principal state authors (US, UK, USSR) were sure to be capable of proper verification of these areas by their own national technical means.

1967 Outer Space Treaty Originally the Outer Space Treaty was an agreement between the US, UK and USSR to ban weapons of mass destruction for military purposes from orbits around the earth and any other location in outer space. Now the treaty has 99 state parties, while another 26 countries have signed the treaty without ratification. No verification is foreseen in the treaty text, but national space-tracking systems, especially in the US, observe the traffic situation in space.

1968 NPT The Treaty on the Non-Proliferation of Nuclear Weapons is supposed to (1) prevent non-nuclear weapons states (NNWS) from acceding nuclear weapons, (2) in return support the civil usage of nuclear energy in all member states and (3) encourage nuclear weapons states to disarm their nuclear weapons. Today it has 189 member states, including five acknowledged, so-called *official* nuclear weapons states (NWS). Still, four states refuse to sign the treaty or have withdrawn from it; namely India, Israel, North Korea and Pakistan. These *de facto* NWS cannot join until dismantling their nuclear weapons. However, the treaty has a comprehensive verification and safeguards regime under the supervision of the International Atomic Energy Agency, an affiliate of the United Nations Organisation.

1996 CTBT The Comprehensive Test Ban Treaty prohibits all nuclear explosions in any environment and for any purpose. It can only enter into force, when the 44 states, who had own nuclear technology in 1995, have ratified the treaty. Today the CTBT was ratified by 148 states, further 32 states have signed it; but nine of the essential states are still reluctant. Once into force the CTBT Organisation will be responsible for verification, which includes seismic and radionuclide monitoring. The CTBTO will run the International Monitoring System (IMS) as well as the International Data Centre (IDC), which will collect and process the relevant data, and forward it to the member states. This process purposefully does not include an interpretation of the data, since this a voluntary task for each member state.

¹PTBT today: 133 states signed, 123 states ratified.

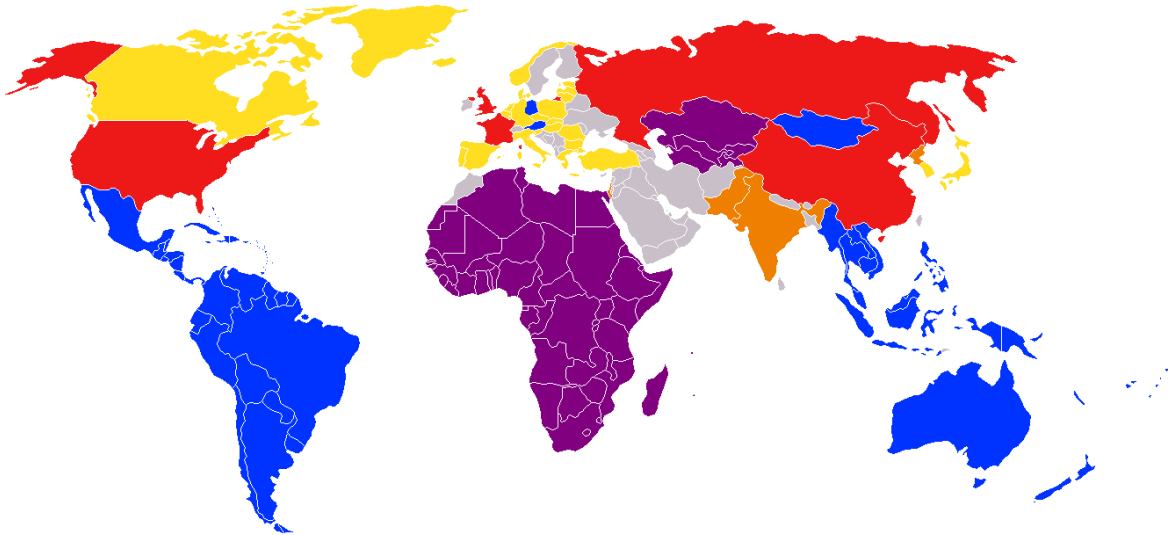


Figure 1.1: Global allocation of nuclear weapons in 2007 [Neu08]. Official NWS (red), de facto NWS (orange), under a nuclear umbrella (yellow), NWFZ with treaty in force (blue), NWFZ with treaty not in force (purple).

Regional treaties with nuclear aspects often deal with the establishment of a nuclear weapon free zone (NWFZ) within a certain community of states. Examples of this kind of treaty are (in brackets the region of effect):

NWFZs Antarctic Treaty (Antarctica), Treaty of Tlatelolco (Latin America and the Caribbean), Treaty of Bangkok (ASEAN² states), Treaty of Pelindaba (Africa), Treaty of Rarotonga (South Pacific).

Figure 1.1 gives an overview of nowadays allocation of nuclear weapons in the world. Some of those regional treaties also provide an agreement on verification, which is often implemented by regional institutions working in state cooperation, e.g. the verification of the Treaty of Tlatelolco is overseen by the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean in Mexico City.

Bilateral treaties are agreements between two state parties or international organisations respectively. Since the United States and the Soviet Union were and still are the biggest nuclear powers, bilateral nuclear treaties were often created to control the arms race between the two. Naturally, bilateral treaties were also created by other states.

²The Association of Southeast Asian Nations (ASEAN) is a political and economic organisation of ten Southeast Asian countries.

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Selected bilateral nuclear treaties/agreements are listed in the following:

SALT I & II The Strategic Arms Limitation Talks were held between the US and the USSR in two rounds³. In these agreements, both sides agreed to an upper limit of their strategic ballistic missile launchers, but no measures for verification were arranged.

INF The Intermediate-Range Nuclear Forces Treaty was signed by the US and the USSR in 1987 and prohibits all ground-launched ballistic and cruise missiles with intermediate ranges. All existing nuclear and conventional weapons of these types had to be eliminated by 1991, which was controlled by extensive bilateral inspections.

START I & II The first Strategic Arms Reduction Treaty was signed by the US and the USSR in 1991 to reduce their offensive arsenals. It limited the number of strategic nuclear delivery vehicles to 1,600 and the the number of warheads to 6,000 per country. Verification was only implemented on an unilateral national basis, e.g. satellite imagery of the decommissioning of hostile long range bombers. Subsequently START II was signed in 1993 and should have further reduce both side's offensive capacities. Although ratified by US and USSR, it has never entered into force.

ABACC⁴ The Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials was founded by Argentina and Brazil in 1991. It is a safeguards agency based on an bilateral agreement to mutually verify the peaceful use of nuclear materials that could be used for the manufacture of weapons of mass destruction.

When looking at the worldwide development of nuclear proliferation and disarmament in the past half century, several goals have been reached, but certain drawbacks still undermine peace and security. The list of achievements certainly includes the complete nuclear disarmament of four countries, namely South Africa, Kazakhstan, Ukraine, Belarus. As far as is known the commonly accepted ban of nuclear weapons in space has not been violated yet. The NPT was extended indefinitely in 1995. Nuclear tests have been more or less banned underground. Also, the absolute number of conducted nuclear tests drastically decreased since the end of the Cold War. All official NWS have stopped conducting tests by today; China and France were the last testers in 1996.

³SALT I: 1969-1972, SALT II: 1977-1979.

⁴Agencia Brasileño-Argentina de Contabilidad y Control de Materiales Nucleares

On the other hand there are still countries with unsolved nuclear issues. The uranium enrichment program of Iran is running in contradiction to an UN resolution. The case of the latest Iraq war showed that the mere suspicion of possessing WMD, expressed by a single state, is sufficient to legitimate a war. Furthermore, four countries acceded nuclear weapons after the NPT entered into force: Israel, India, Pakistan and North Korea. The latter three countries were the only ones conducting nuclear tests since the official NWS stopped doing so.

Nuclear weapons still exist and a Nuclear Weapons Convention, which would ban all nuclear weapons, has been only drafted, but is far from a common agreement.

As seen above, the verification regimes of nuclear treaties are basically relying on state actors or organizations of state actors. Along with this status, the world public has to rely on the results and conclusions given by state actors. Therewith the processes of decision and opinion making are also mainly in the hands of governments, or international organizations respectively.

Nowadays, an increasing potential of non-governmental actors in the field of monitoring treaties can be observed. The work of non-governmental, or *non-state*, actors can be done in different ways: Either supporting the governmental verification regime, or in an independently and self-contained manner. In any case the activity of non-state actors contributes to the public opinion making and therefore, acts as a counterbalance to the non-verifiable work of state actors.

The present thesis examines the role of non-state actors in the field of monitoring nuclear treaties with methods of environmental measurements. The use of environmental measurements for verification purposes plays a key role in the detection and confirmation of nuclear tests. Therefore, the case of the North Korean nuclear test in October 2006 seems appropriate to analyse the topic and is chosen as a case study.

The thesis is structured as follows:

- In Chapter 2 the research question and the methodology used to answer it are explained.
- In Chapter 3 significant methods of environmental measurements to detect nuclear tests are presented.
- In Chapter 4 the relevant actors are defined and the actual case study is compiled.
- In Chapter 5 the case study is analysed with regard to the roles of state and non-state actors within the conflict at hand.

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- In Chapter 6 the consequences for future treaties as well as for peace and security in general are discussed.
- In Chapter 7 the conclusion summarizes the presented work.

2 Methodology

The present chapter sets the scientific aim and focus of the thesis. Firstly, the main terms that are necessary to frame the topic are defined in section 2.1. Secondly, possible roles of non-state actors are introduced in section 2.2. The research question and the approach that is chosen to answer this question is derived in section 2.3.

2.1 Definitions

With regard to this thesis' title „Environmental Measurements and Non-State Monitoring of Nuclear Treaties” the main terms are defined in this section. The definition of environmental measurements is a rather technical issue. Within this thesis it stands mainly for techniques of radionuclide measurements, which are dealt with separately in chapter 3. However, the term „non-state monitoring” requires the explanation of „non-state” and „monitoring”.

At the time when nuclear treaties, such as the Nuclear Nonproliferation Treaty (NPT) or the Intermediate-Range Nuclear Forces Treaty (INF), were developed and accepted by the international community¹, the verification of those treaties was solely in the hands of state actors. On the other hand the general role of non-governmental organizations (NGOs) and international organizations is increasing in the field of the technical surveillance of international agreements. This means that the surveillance of treaties is not a solely state domain anymore. However, the term „non-state actor” includes various forms like private industry, non-governmental organizations, private citizens and media corporations. These actors are different from state actors: Since they are not elected, they are more independent and not responsible towards any constituency and therefore, can set their own agenda. In this regard the International Atomic Energy Agency (IAEA), amongst other things entrusted with the verification of the NPT, is accounted as a state or governmental actor, since it consists of member states. However, non-state actors can vary widely in terms of goals, size and budget.

¹In the case of the INF treaty only the US and Russia were concerned.

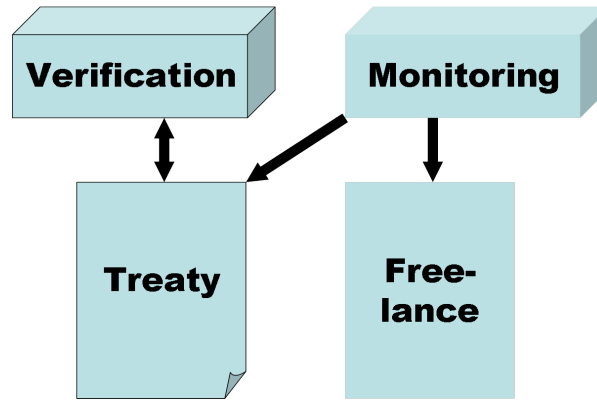


Figure 2.1: Discrimination of Verification and Monitoring. Verification is always anchored to a treaty and solely for this purpose. Monitoring is not specified and can be freely applied to treaty contents or other fields.

The terms verification and monitoring are often mixed up or accounted for the same meaning. Therefore, the differences between them have to be clarified:

Verification is meant here as the assignment to assure and control the compliance of member states with a treaty's obligations. Since arms control treaties are usually only accessible for state parties, verification has since then been solely in the hands of state actors. This means that verification is often a governmental domain and always related to a certain treaty/agreement. The measures that are necessary to fulfill this assignment are usually specified within the wording of a treaty. Verification can be accomplished with formally established mechanisms, which can also include national technical means (NTM). Verification only occurs in connection with a treaty (see also Figure 2.1).

Monitoring in general implies the collection and/or interpretation of data for surveillance purposes. In contrast to verification, monitoring is accomplished without mandate or legal framework. This means the process of monitoring is detached from official treaties, but still can refer to some treaty's content. Those activities may be accomplished by national technical means, but also by independent civil actors, since monitoring is not restricted to state actors.

Verification is still a necessary part of treaties, which has to be carried out by the state parties. However, the independence of non-state actors can create or add credibility, transparency and reliability in the monitoring field.

2.2 The Role of Non-State Actors

Non-state actors can be involved in the supervision of international agreements in different ways [Mei01]:

- Officially - as part of an established verification regime. This is not common in arms control agreements, but rather in multilateral environmental agreements.
- Quasi-officially - linked to official mechanisms. For instance the Center for Nonproliferation Studies, Monterey Institute of International Studies, which supports the IAEA with the maintenance of databases, compiled from open source information.
- Informally - outside of official verification mechanisms, i.e. doing monitoring. This is practicable through gathering own information as well as the usage of open source information.

The work of non-state actors in the fields of verification and monitoring have advantages and disadvantages compared to the work of state actors. In general non-state actors have a different access to information and different assessment capabilities, which enables them to see things from a different angle. Furthermore, they can usually act faster, are able to concentrate their focus on an area or country, and are political independent (see section 2.1). If they are not an integrated part of an official verification regime, they can also increase their scope beyond the content of a treaty.

On the other hand, *different* access to information could also mean *limited* access to information, which can decrease the completeness or the reliability of the work. Moreover, not being bounded to continuous monitoring can also lead to shorter attention spans, as non-state actors can switch topics as they wish. Their limited financial power can make them dependent from the donors and also restrict their technical possibilities. Their political independence is relative [Mei01]. These points increase the probability for inconsistencies and unreliability in the work of non-state actors.

2.3 Scientific Approach

As mentioned beforehand, the task of surveilling the compliance of treaties, in this case nuclear treaties, is no longer opened solely for governments, but also for non-state actors. It can be observed that the role of non-state actors in this field is increasing or at least have emerging potential. Their current and possible roles in the field of environmental

monitoring are to be examined in this thesis. Parallel to the presented work their roles in the field of satellite remote sensing are examined in another Master's thesis by Tim Buchholz [Buc09].

With regard to nuclear treaties environmental measurements play a role in the detection and confirmation of nuclear tests². All kinds of nuclear tests will be prohibited for the member states of the CTBT as soon as it enters into force. Nevertheless, the accordant monitoring system is under construction and partially already working. It had its first appraisal in October 2006, when the North Korean government conducted its first nuclear test. The actions and reactions of relevant actors after the nuclear test will be examined in this thesis. The focus will be especially on the spread of the knowledge about the nuclear character of the observed explosion. Within this case study the role of non-state actors with their regard to peace and security is analysed.

To answer these questions the following approach is taken:

1. The **sources of information** for the chosen case study are chosen and gathered. Only original documents are considered here, as the thesis aims to analyse the actual course of events. Furthermore, only publicly available documents are considered, since a comprehensive search for not publicly available documents, i.e. confidential or secret documents, would go beyond the scope and means of this thesis. This step also includes a clear **definition of actors** to sharpen the focus of the case study, i.e. who's publications and announcements are considered.
2. The second step analyses the contributions of each actor and the **correlations** between different publications and actions. Here it is important to look for **citation**, i.e. who cites whom, and **cross references**.
3. Subsequently the effects of the actor's knowledge and actions on the presented conflict situation is analysed. The focus here is on the **effects on peace in the actual case study**.
4. Then the lessons learned from the case study are examined with regard to their **consequences to international peace and security**. This also includes the possible impact on future treaties.
5. Finally, the results are shortly **compared** to the results from [Buc09]. If possible, a common conclusion is drawn.

²Another application is for example the detection of undeclared plutonium production via Krypton-85 measurements.

3 Detection and Confirmation of Nuclear Tests

Environmental sampling was already used as early as 1944 to look for Xenon-133 in the atmosphere in order to find evidence for a German operating reactor. Since 1951 the USA used environmental sampling of Krypton-85 to derive the amount of Russian weapons plutonium production. Environmental measurements for verification purposes of a treaty were first implemented in the PTBT in 1963. In this case the detection of Xenon-133 has been done by national technical means [Ric06].

Nowadays, environmental measurements play a distinguished role in the detection and confirmation of nuclear weapons tests. Hence, they are a fundamental tool in the verification regime of the CTBT. The reason why nuclear tests may be necessary for a country and the connection between nuclear tests and environmental measurements is explained in section 3.1, the role of radionuclide measurements in verification and monitoring activities is the content of section 3.2. Finally other relevant techniques for the detection of nuclear tests are summarized in section 3.3.

3.1 Nuclear Testing

From the first nuclear test in 1945 until today the design of nuclear weapons has evolved. The development spans from the crude gun design, over the implosion device, to the hydrogen bomb and the neutron bomb. If one wants to proceed on this stairs of nuclear weapons development, nuclear testing is essential [Lie09]. Thus, when a NNWS wants to become a NWS, it can either receive the accordant technology from an existing NWS (horizontal proliferation) or develop the technology by own scientific efforts (vertical proliferation). The former is a major goal of the NPT; for the latter it is likely that it conducts a nuclear test, which is the central theme of the CTBT.

Nuclear tests can be carried out in any place accessible to mankind, i.e. underground, underwater, in the atmosphere or in outer space. The international community, or the

CTBT & CTBTO

The Comprehensive Test Ban Treaty prohibits any kind of nuclear test for every member state and can only enter into force, if every state listed in Annex 2^a has ratified the treaty. Once into force the compliance will be monitored by the CTBT Organization, which until then is working under the name Preparatory Commission of the CTBTO. Its tasks embrace the preparation of the International Monitoring System (IMS), the International Data Centre (IDC) as well as the foreseen On-Site Inspections (OSI).

The IMS will consist of four worldwide measuring networks: A seismic network to measure waves propagating the earth and distinguish between earthquakes and explosions; hydroacoustic sensors to measure sound waves propagating the oceans; highly sensitive barometers to measure infrasound waves propagating the atmosphere; and radionuclide and noble gas stations to detect particles, which are generated in nuclear explosions and propagating in the atmosphere.

The IMS will take measurements on a continuous basis, while the IDC will process the data without prejudice and forward it to the member states. The actual verification will be done by the member states with their NTM.

^aI.e. the 44 states that owned nuclear reactors in 1995 accordant to the IAEA database.

CTBTO respectively, have different opportunities to detect and confirm such a test (see box on this page). The facts of interests are usually the time and location of the test as well as the yield of the explosion and the kind of nuclear device. However, the nuclear character of an explosion that is detected and located by waveform measurements, can only be confirmed from afar by radionuclide measurements.

3.2 Radionuclide Measurements

In a nuclear explosion various fission products are generated. In an underground test most of these products are sealed under the earth's surface. Only noble gases do not form chemical bonds with the surrounding rocks and minerals. Thus, it is likely that they will be released into the atmosphere by propagating through the earth's crust¹. Once dispersed into the atmosphere the gaseous particles follow prevailing winds, but their abundance can still be measured. Some of the generated isotopes are stable, but most are radioactive. Among the produced radioactive noble gases is Xenon. It is the aim of the CTBTO radionuclide monitoring network to detect those residual particles and enable the member states to confirm the nuclear character of an explosion.

The yield of an explosion can be estimated with the waveform measurements, which

¹Only well contained nuclear explosions do not release any radioactive particles into the atmosphere.

are also included in the IMS. Once the yield is known, the amount of fissile material used in the detonation can be estimated, e.g. the mass of used plutonium. Then the amount of generated Xenon that will seep through the earth's surface can be calculated. From there on atmospheric models help to follow the way and form of the radioactive cloud that spreads around the globe. When the cloud passes one of the radionuclide stations the measurements can be compared with the theoretical prediction.

On the other hand also civil sources of Xenon exist, which can complicate the detection of nuclear explosion signals, especially as those civil sources, e.g. nuclear reactors, can emit Xenon constantly as well as irregularly.

3.3 Other Techniques

Although the case study at hand is focused on the impacts of radionuclide measurements, other techniques are also relevant for the verification and monitoring of nuclear tests. The CTBT regime relies also on three waveform measurements. Each one of these three techniques represent a possible nuclear test area:

- Seismic stations to monitor the Earth for underground nuclear explosions.
- Hydroacoustic stations to monitor the oceans for underwater nuclear explosions.
- Infrasound stations to monitor the Earth mainly for atmospheric nuclear explosions.

These remote methods are meant to detect nuclear explosions, but on-site inspections (OSI) are the final verification measure in the CTBT. An OSI can only be conducted once the treaty has entered into force and then only upon request by a member state. Moreover, an OSI requires that the location of the suspected test site have been narrowed down to less than 1000 km². The inspectors of an OSI will use various methods for the verification process: Visual observations, gamma monitoring and environmental sampling.

Recently it has been shown that also SAR-interferometry is in principle capable of confirming underground explosions [Rie09].

4 Case Study North Korea

Selected methods of environmental measurements were presented in the previous chapter. These methods find their application in verification as well as in monitoring regimes. Within those they play an key role to detect undeclared nuclear activities. The case of the two North Korean nuclear tests on 09 October 2006 and 25 May 2009 is a prominent example for the significance of environmental measurements and their entanglement with political activity. Therefore, the first North Korean nuclear test is chosen as a case study to analyze the relevance of environmental measurements to international peace and security.

The present chapter will present the course of events of this chosen case study in a chronological order. It will begin with a historical overview of the nuclear (weapons) program prior to the nuclear test in 2006. Subsequently the actions and reactions following to the nuclear test of the affected actors will be presented with emphasis on the transfer and use of information from the civil society. Therefore, the actors will be clearly defined and classified. A summary of the current political situation of North Korea terminates this chapter.

Prior to the presentation of the actual case study some basic information about North Korea are summarized in the following [Aus08]:

The Democratic People's Republic of Korea¹, also known as North Korea, is a state in east Asia with a population of about 23 million. It is a socialistic, dictatorial reigned state, which covers the northern part of the Korean peninsula. Before the annexation by Japan in 1910 North and South Korea formed one Korean state. After the Second World War the former Korea has been occupied and divided by the USA and the Soviet Union. Since the end of the Korean War in 1953 it is separated by a 4 km wide buffer belt, the Korean Demilitarized Zone. The North Korean government is factually led by the potentate Kim Jong-il. His regime earned international criticism for misgovernment and major violations of human rights. Furthermore, it is held responsible for the proliferation of missile technology. The nuclear history of the DPRK is dealt with in the following.

¹From now on shortened to DPRK.

4.1 Nuclear History

The following section divides the history of the North Korean nuclear program before their first nuclear test in three parts. The roots of the program are found as early as in the 1960s and are described in the first subsection, 4.1.1. In 1985 the DPRK joined the Non-Proliferation Treaty. The events from that year until their final withdrawal in 2003 are summarized in 4.1.2. The section ends with an overview of the years between their withdrawal from the NPT in 2003 and their nuclear weapon test in 2006, see subsection 4.1.3.

4.1.1 Before joining the NPT

Although it is said that the DPRK has been pursuing a nuclear research program since the 1950s, verifiable facts can only be traced back to about 1962 [Pik05]. At this time the DPRK government started the process of „all-fortressization”, which persists until today. The foundation for DPRK’s nuclear research program has then been laid under an agreement with the Soviet Union [Pik05]:

- A large-scale nuclear research complex was built in Yongbyong, which persists to be the country’s center for nuclear related research today. A Soviet IRT-2M research reactor was assembled in 1965. The accordant fuel elements consisted of enriched uranium (10%) and were delivered from the Soviet Union between 1965 and 1973.
- The needed scientists and specialists have been recruited from Korean students who had studied in the Soviet Union.

During the 1970s the Korean research became more independent and got focused on the nuclear fuel cycle, i.e. refining, conversion and fabrication of nuclear fuel. In 1974 they modernized their research reactor after Soviet example, i.e. upgraded it to 8 MW(e) and switched to 80 % enriched uranium fuel. In 1977 the DPRK signed its first IAEA Safeguards Agreement² for two of their nuclear facilities [Iae09]. This Safeguards Agreement particularly allowed the IAEA to inspect the aforementioned research reactor. In 1979 they indigenously began to build a second research reactor³, also near the town of Yongbyon, which became operational in 1986. Parallel to the construction of this reactor an ore processing plant and a fuel rod fabrication plant were built. Nowadays it

²The DPRK Safeguards Agreement with the IAEA is of an INFCIRC/66 type and can be found in the IAEA INFCIRC/252.

³5 MW(e), natural uranium, graphite moderated

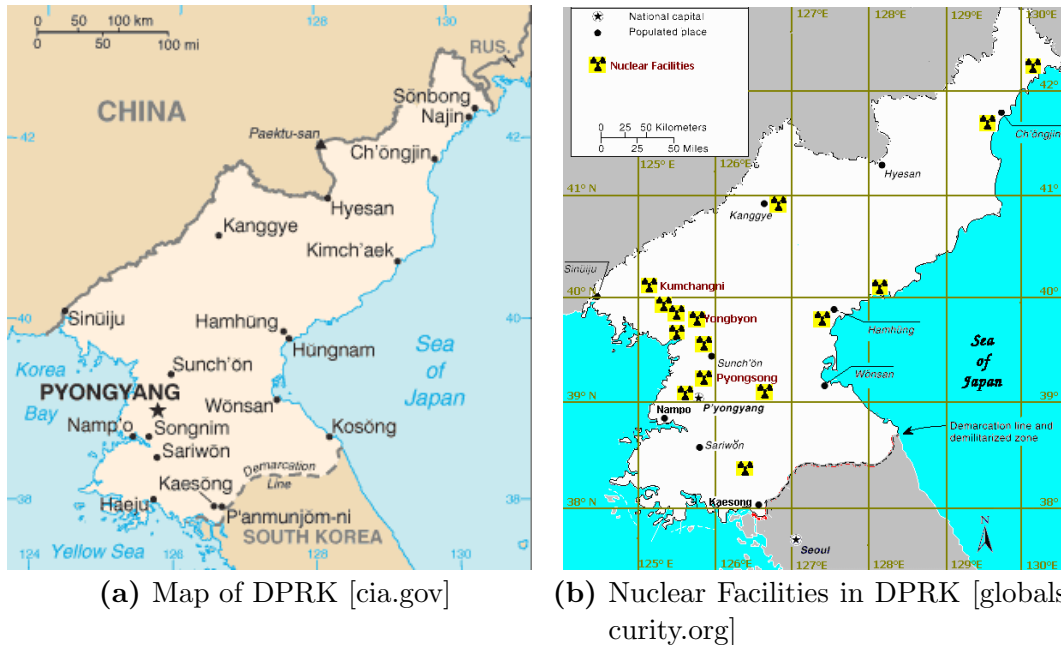


Figure 4.1: Maps of DPRK. (a) The Capital is Pyongyang. The country borders to China (north), Russia (northeast), the Sea of Japan (east), South Korea (south) and the Yellow Sea (west). (b) The main nuclear research facilities are located in Yongbyon, a city ca. 100 km north of Pyongyang.

is believed that the DPRK maintains uranium mines with access to four million tons of exploitable high-quality uranium [Pik05].

During the 1980s the DPRK not only pressed ahead with research on practical uses of nuclear energy, but also laid the cornerstone for their nuclear weapons program. Besides the commissioning of uranium fabrication and conversion facilities, the DPRK began the construction of another reactor of 200 MW(e) and a nuclear reprocessing facility in Taechon and Yongbyon. In 1985 secret construction works on a nuclear reactor near Yongbyon were reported from US officials, referring to own intelligence data [Pik05].

4.1.2 During membership in the NPT

Subsequently, the aforementioned accusations from the US government increased the international pressure on Pyongyang to join the NPT. Finally, on 12th December 1985 the DPRK became a member state of the NPT, but still refused to sign a safeguards agreement with the IAEA. The latter is in fact compulsory for parties of the NPT. In 1990 it was reported by the Washington Post that new satellite imagery showed the existence of a structure in Yongbyon possibly capable of plutonium separation. By the end of

December 1991 a Joint Declaration on the denuclearization of the Korean peninsula was initialed. In this agreement North and South Korea relinquished on tests, manufacturing, production, receiving, possession, storage, deployment, or usage of nuclear weapons and possession of nuclear reprocessing and uranium enrichment facilities. These declarations were meant to be verified through inter-Korean inspections by a joint commission⁴.

One month later, 30th January 1992, the DPRK also signed a nuclear safeguards agreement with the IAEA, accordant to the obligations of the NPT. This safeguards agreement between the DPRK and the IAEA entered into force in April 1992. In the following month it submitted its initial report under the new safeguards agreement, thus the first IAEA inspections could begin in June 1992.

However, shortly thereafter the inspections brought up inconsistencies between the original state declaration and the verification measurements. These contradictions resulted mainly from the North Korean plutonium and nuclear waste declarations and furthermore, hinted at the existence of undeclared plutonium. Further requests from the IAEA for additional inspections in two other facilities were refused by the DPRK. Thus, in February 1993, the Director General of the IAEA, at his time Hans Blix, started the procedure for a special inspection of the North Korean case, accordant to the Safeguards Agreement. The DPRK also refused this request from the IAEA and thereby giving the IAEA Board of Governors reason to conclude non-compliance of the DPRK with its Safeguards Agreement. Therefore, in line with Article XII.C of the IAEA Statute, the Board of Governors reported to the UN Security Council [Iae09], which in return, on 11 May 1993, called upon the DPRK to fulfill its obligations from the Safeguards Agreement.

During these events, on 12 March 1993, the DPRK announced its withdrawal from the NPT with the foreseen lead time of three months. However, in June 1993, only one day before the withdrawal would have taken effect, the DPRK suspended the effectuation of its withdrawal. Still, between 1993 and 1994, the DPRK allowed the IAEA to conduct basic safeguard activities focused on containment, surveillance and maintenance. These limited safeguards were neither in compliance with the full implementation of safeguards obliged by the IAEA nor did they deliver any assurance of solely peaceful nuclear activities in the DPRK. This led to another report from the IAEA Director General to the UN Security Council, which in return again called upon the DPRK on 31 March 1994 to allow the required inspections.

Then, on 13 June 1994, after being a member state for 30 years the DPRK withdrew

⁴The accordant Joint Nuclear Control Commission (JNCC) was established in March 1992, but then could not find an agreement for a bilateral inspection regime [Pik05].

its IAEA membership. However, this did not effect the obligations under its Safeguards Agreement, but the DPRK still refused further inspections. This situation was defused by negotiations between the US and the DPRK until 21 October 1994, when both committed to the Agreed Framework. The Agreed Framework stipulates that the US provides the DPRK with a light water reactor, whereas the DPRK in return freezes the activities in its heavy water reactor and facilities. The IAEA was meant to monitor the freeze and indeed maintained a continuous presence in Yongbyong.

The following years were determined by technical talks between the IAEA and the DPRK concerning the ongoing differences to the status of the Safeguards Agreement. However, in August 1998 the DPRK fired a multistage missile over Japan into the Pacific Ocean, demonstrating their striking capabilities against Japan. Naturally this increased the international pressure on the North Korean government and led to US-DPRK talks in Pyongyang in November 1998. There North Korea pledged to freeze its long-range missile tests and in return the US eased their economic sanctions against them. Nevertheless, the situation sharpened again between 2000 and 2002, due to allegedly US-caused delays in building North Korean power plants and the „axis of evil“-policy of the new US administration under President George W. Bush. The US government finally revealed that the DPRK had admitted having a secret nuclear weapons program, which it acknowledged after US officials confronted them with evidence [Cnn09]. Subsequently North Korea removed the IAEA monitoring tools and also expelled its inspectors in December 2002.

4.1.3 After withdrawal from the NPT

On 6 January 2003 the IAEA Board of Governors called upon North Korea to fully cooperate and act in compliance with its Safeguards Agreement. Five days later, one month after expelling the IAEA inspectors, the DPRK finally withdrew from the NPT and also started to reactivate its nuclear facilities. Although the NPT allows a state to withdraw, if it gives reason and notice of such withdrawal to all State Parties and the UN Security Council three months in advance, the DPRK ignored this official procedure. It reasoned, that it needed to give notice only one day in advance due to their first announcement of withdrawal in 1993.

The seriousness of these events and the ongoing reactivation of the North Korean nuclear program, including reactors, nuclear weapons research and further missile tests, induced the first round of the so-called six-party talks (see box on the next page) in August 2003. During this first round of talks no objectives were achieved, except the

Six-Party Talks

The participants of these talks are the three North Korean direct neighbours (namely South Korea, China, Russia), Japan, USA and the DPRK itself. The six-party talks aim to peacefully resolve the conflicts resulting from the North Korean nuclear weapons program. There has been a series of meetings until recently, on 14 April 2009, the DPRK left the negotiating table, due to the unanimous condemnation of the North Korean missile test on 5 April 2009 by the UN Security Council.

Agenda of the Six-Party Talks: The DPRK demands a security guarantee from the US administration and the completion of the promised two light-water reactors. Especially since it was labeled a part of the axis of evil by the Bush administration the DPRK also insisted on a normalization of their economic restrictions, i.e. sanctions and bank account freezes, and their diplomatic relations (the latter has been induced in 2009 by the new US administration under Obama).

On the other hand the USA and Japan demanded a complete and irreversible disarmament of the North Korean nuclear program (civil and military), whereas China, the ROK and Russia agreed on a possible step-by-step solution with certain rewards for the DPRK for each completed step.

agreement on a further round of talks. The following two rounds, in February and June 2004, brought likewise outcomes, e.g. the participating states could agree on general statements about their peaceful coexistence.

In February 2005 the North Korean government publicly admitted its possession of nuclear weapons for the first time. By June the country speaks of a stockpile of weapons and an ongoing production. The following fourth round of the Six-Party Talks were held between July and September 2005 and brought consensus on a Joint Statement of six articles. Within these the state parties agreed on a verifiable denuclearization of the Korean Peninsula, and most notably plans for a return of North Korea to the NPT, which included abandonment of its nuclear weapons program, but also its right to peaceful use of nuclear energy. On the other hand, the five states except North Korea promoted to increase economic aid and cooperation, e.g. in energy, trade and investment. Furthermore, South Korea and especially the USA promised the provision of security guarantees not to attack the DPRK, but the construction of a light-water reactor was neglected.

The fifth round of the Six-Party Talks was divided in two phases. During the first phase in November 2005 not much progress was made. The talks were suspended, when the DPRK argued about further US financial restrictions against banks and North Korean companies for their alleged involvement in illicit activities. However, in April 2006 North Korea offered to return to the negotiation table as soon as their bank accounts

were released from US freezings, but in opposition to the DPRK the US insisted to treat financial and nuclear issues separately. In response to this „hostile US policy” the DPRK test-fired six missiles in July 2006 to prove their striking capabilities. These tests included a long range Taepodong-2 rocket, which was supposed to be capable of reaching the US, but failed after 40 seconds. The US government spoke of provocative tests [Cnn09]; the United Nations Security Council condemned these missile tests unanimously in resolution 1695.

In October 2006 the situation escalated, when the DPRK announced and conducted their first nuclear test. This and the following reactions of the international community are the content of the next section.

4.2 Actions and Reactions after First Nuclear Testing

The present section describes the course of events unfolding from the first North Korean nuclear test on 9 October 2006. The first subsection deals with the clear definition of actors, who’s actions and reactions will be examined in the second subsection. The latter aims for an accurate narration of the case study accordant to public resources. The actual analysis of the case study is done in the subsequent chapter on page 43.

4.2.1 Definition of Actors

Prior to the analysis of the evolution of the events following the first North Korean nuclear test it is reasonable to define the considered actors. The chosen actors are classified in four groups of actors, namely (1) Supranational, (2) National, (3) Independent and (4) Media. A short explanation for each actor gives reason for the selection; also the source of information is given for each actor.

4.2.1.1 Supranational

The actors on the supranational level are superordinate with regard to national states. Supranational structures lift the competence of decision-making from single states on a common higher ground. The process of decision-making can vary; resolutions may require consensus or may be approved without consensus. Supranational actors are groups of associated single actors/states.

UNSC The United Nations Organization, and the United Nations Security Council respectively, plays a key role in the presented case study, as it is meant to help

resolving the conflict and also serves as a mouthpiece of the international community. [North Korea UN Documents, <http://www.securitycouncilreport.org/>]

CTBTO The Preparatory Commission of the Comprehensive Test Ban Treaty Organization is a relevant actor as it is entrusted with the supervision of the compliance of state actors with the CTBT and therefore also capable of seismic and radionuclide measurements. [Press Centre, <http://www.ctbto.org/>]

IAEA Besides of the still ongoing issues between the IAEA and the DPRK, the International Atomic Energy Agency has more than once sent nuclear inspectors into the DPRK and, therefore, has had insight into the North Korean nuclear program. [News Centre, In Focus: IAEA and DPRK, <http://www.iaea.org/>]

4.2.1.2 National

On the contrary to supranational actors, the actors on the national level, i.e. state actors, often act without obtaining approval from other states. Also, this is the level where most conflicts are carried out. The considered state actors are chosen due to their key role in the case study. However, the common source of information about certain state activities is the public media.

DPRK Obviously the Democratic People's Republic of Korea occupies a central position in this conflict, whose announcements and actions needs to be considered. [see UN and media actors]

USA The United States of America has always been a strict observer of the North Korean nuclear ambitions and was often the first to report previously unknown facts of the North Korean nuclear program. As a global power its decisions and actions can have a major impact on the situation in the case study. [www.dni.gov, see media actors]

Sweden The defense research institute of the Swedish government (Totalförsvarets forskningsinstitut, FOI) worked together with the South Korean government to obtain relevant air samples shortly after the nuclear test in 2006. These air samples were taken to confirm or disprove the execution of a nuclear explosion. [Press room, <http://www.foi.se/>]

ROK The Republic of Korea (South Korea) is one of the few state actors, who officially confirmed the nuclear character of the North Korean test, although their

information originate from the FOI. [see Sweden and media actors]

Six-Party Talks The Six-Party Talks are not an international organization, but rather a forum for the participating states. Thus, they are not considered on the supra-national level. The talks were continued after the nuclear test and are therefore taken into account. [see ACA and media actors]

Other Additional states will be considered, since their national technical means also yielded results about the nuclear test, e.g. Germany. [internal source from ZNF]

4.2.1.3 Independent

There are a number of actors in the field of international security, that are regarded as independent. This means, that they have goals and act to reach them, but are not restricted by national opinions, obligations etc. Where state actors often struggle for their own advantage, independent actors set and follow their own goals, e.g. prevent proliferation of nuclear material. This applies to NGOs, and in some regard also research institutes; the transition in reality is smooth.

ACA Representative for the group of arms control related NGOs the Arms Control Association is chosen as an actor, as it is a national nonpartisan membership organization, which researches effective arms control policies. It provides policy-makers, the press and the public with information, analysis and commentary on arms control issues. [Press room, <http://armscontrol.org/>]

ISIS The Institute for Science and International Security, founded and led by David Albright, is often able to release insider information about current security-related topics, e.g. satellite imagery and coordinates of nuclear facilities. [Country Assessments, <http://www.isis-online.org/>]

INESAP The Independent Network of Engineers and Scientists Against Proliferation is a non-profit, non-governmental network organization, which promotes non-proliferation and disarmament of weapons of mass destruction. With its technical expertise INESAP can independently analyse relevant data and publish its results. [<http://www.inesap.org/>]

Other There are independent research institutes as the Centre for Science and Peace Research (ZNF, <http://www.znf.uni-hamburg.de/>) at the University of Hamburg or the James Martin Center for Nonproliferation Studies (CNS, <http://cns.miis.edu/>),

which can do own analysis of published measuring data or otherwise contribute with their technical or political opinion.

4.2.1.4 Media

The actors in the field of (mass) media often release previously unknown facts, while they are not necessarily revealing their source of information. However, media actors are not inherent independent, as they can for instance be regulated by a government or have an own political view. In any case they are a key player in the process of opinion making for the population.

Western Media Certain actors of the US media are considered here, as they retrieve their information often from good ties to governments. Their publications are also often used by other media corporations. Therefore, they are important in the process of opinion making and revealing new information. These actors are for example the New York Times (NYT), CNN and the Washington Post; other non-US media actors may also be considered. [News archives on <http://www.nytimes.com/>, <http://edition.cnn.com/>, etc.]

KCNA The Korean Central News Agency is the North Korean state news agency, which, according to its website, "speaks for the Workers' Party of Korea and the DPRK government". On one hand the agency is controlled by its government, but on the other hand is still a media actor responsible for opinion making in- and outside of the DPRK. [Past news, <http://www.kcna.co.jp/>]

4.2.2 Course of Events

Since the main actors are defined, the detailed course of events is chronologically compiled in the following.

October 2006

- 03 *DPRK*: The North Korean government announced to conduct its first nuclear test, but no specific time was defined.
 KCNA: The website of KCNA did not release any statement about the governmental announcement or other nuclear issues.
- 04 *USA*: Warnings from the US (and Japan) that a nuclear test would lead to a sharp response and could undermine the security balance in Asia.

4.2 Actions and Reactions after First Nuclear Testing

China: A Chinese official urged North Korea to act calm and also warned other countries not to take actions that lead to escalation.

ACA: The Arms Control Association condemned the North Korean nuclear test threat and called for more effective, energetic U.S. diplomacy.

KCNA: An article on the website expressed the North Korean stand on its war deterrent: „The DPRK will make positive efforts to denuclearize the peninsula its own way without fail despite all challenges and difficulties.”

NYT: The New York Times reported that US officials assume the announcement of a nuclear test as a negotiating ploy.

06 *UNSC*: The United Nations Security Council unanimously warned North Korea against testing.

CTBTO: The Executive Secretary and the Chairman of the CTBTO Preparatory Commission each released a statement in which they call upon the DPRK to cancel the announced test and to sign and ratify the CTBT.

09 *DPRK*: The North Korean government announced that it had conducted an underground nuclear test.

IAEA: In a statement, Director General El Baradei said he deeply regrets, and expresses serious concern, about the reported nuclear test by the DPRK.

CTBTO: Over twenty seismic stations of the IMS detected signals originating from the event. Less than two hours later, States Signatories received the first preliminary information on time, location and magnitude of the event. Again the Executive Secretary and the Chairman of the CTBTO Preparatory Commission each released a statement in which they express their concern about the nuclear test, the DPRK and the future of the CTBT.

10 *ISIS*: On its website ISIS released satellite imagery showing the „suspected North Korean nuclear test site”.

CNS: The James Martin Center for Nonproliferation Studies analysed yield and location of the explosion and the reaction from major actors. It reports that „China had reportedly been given notice by North Korea about 20 minutes before the test”, but also that „so far Russian Defense Minister Sergei Ivanov is the only significant authority to insist the event was definitely a nuclear explosion” [Pin06].

KCNA: „[...] the DPRK successfully conducted an underground nuclear test under secure conditions on October 9, 2006 [...]. It has been confirmed that

there was no such danger as radioactive emission in the course of the nuclear test [...] It will contribute to defending the peace and stability on the Korean Peninsula and in the area around it.”

- 10-11 *USA*: The US Air Force dispatched planes with special radiation detectors into international airspace near North Korea (accordant to a NYT article from 14 Oct).
- 11 *DPRK*: Accordant to an ACA article, the North Korean government announced possible additional tests.
CTBTO: A detailed analysis of the event on 9 October 2006 was distributed to States Signatories.
- 11-14 *Sweden/ROK*: In cooperation with the South Korean government the Swedish defense research institute FOI sent an inspection team in order to do four days of ground-based air sampling on the east coast of South Korea.
- 13 *US*: Intelligence officials said that „analysis of air samples taken in the region on Wednesday (11 Oct) found radioactive material that is consistent with a North Korean nuclear test” (accordant to NYT, 14 Oct).
ACA: In an article the ACA executive director is cited speaking of an „apparent nuclear test explosion”.
- 14 *UNSC*: The Security Council adopted resolution 1718 calling upon North Korea to return to the Six-Party Talks, imposing sanctions on North Korea and setting up a Sanctions Committee.
NYT: In an article the NYT cited the US intelligence statement of 13 Oct hinting at a nuclear explosion, but also reported opinions of independent US scientist, who said that it was a sub-kiloton explosion and therefore, were not sure about the success as well as the nature of the explosion. It also stated that the DPRK had notified the Chinese government that the nuclear test would be in the range of four kilotons.
- 16 *USA*: In an official statement, the Office of the Director of National Intelligence said that analysis of air samples from 11 Oct 2006 detected radioactive debris, which confirms the nuclear test.
- 17 *ISIS*: On its website ISIS released satellite imagery speaking of a „North Korean site after nuclear test”.

4.2 Actions and Reactions after First Nuclear Testing

NYT: „American intelligence agencies have concluded that North Korea’s test explosion last week was powered by plutonium”, but no source of information is given.

21-25 *CTBTO*: The radionuclide station RN16, located in Yellowknife (Canada), was able to detect elevated amounts of the noble gas Xenon 133 in the atmosphere.

26 *Germany*: Together the two Federal Ministries for Geo-science (BGR) and Radiation Protection (BfS) released a statement about the North Korean Nuclear test, including independent seismic analyses concerning yield and location of the explosion. It is also stated that information about radionuclide measurements are only available from the US and Swedish airborne sample takings and that no radionuclide station had detected an elevated amount of Xenon yet [Bun06].

27 *CTBTO*: The International Data Centre dispatched the radionuclide measuring data from RN16 on 21 October to all member states [Sae09].

November 2006

01 *UNSC*: The Security Council adopted an addition to resolution 1718 from 14 October, including an updated list of sanctioned goods.

ACA: The Arms Control Association released a statement criticizing the effectiveness of UN resolution 1718 and also reports North Korea’s willingness to rejoin the six-party talks.

09 *ACA*: An article concentrated on three questions: „How powerful was the explosion? Was it a nuclear test? If nuclear, was the test successful?” However, only the yield of the explosion can be identified by seismic calculations for certain. The nature of the explosion stays scientifically unreproducible for the public until radionuclide measuring data is available.

December 2006

Dec *INESAP*: In December 2006 INESAP published their Bulletin No. 27, in which an article from the ZNF dealt with the explosion’s characteristics, the low yield and the radionuclide measurements. It argues that the nuclear

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character of the explosion has not been independently proven, but is likely. (A shorter article about this topic was also published in December 2006 by the German „Physik Journal“.)

- 01 *ACA*: An article reported that North Korean officials stated the use of plutonium as fissile material. It also mentioned still existing uncertainties about the test, i.e. why the yield was lower than expected ($<1 kt$).
- 18 *Six-Party Talks*: The actual fifth round of the talks were resumed until 22 Dec, but accordant to an *ACA* article from 01 January 2007 no consensus has been reached.
- 19 *FOI*: The Swedish defense research institute released a press statement about Xenon findings in the air samples from October, which „with a relatively high level of probability” originated from the test site. It is stated that due to these measurements the South Korean government confirmed the nuclear character of the test.

January - March 2007

- 11 Jan *UNSC*: In a meeting the Security Council further discussed and specified resolution 1718.
- 8-13 Feb *Six-Party Talks*: The fifth round of the talks commenced its third phase.
- 13 Feb *DPRK*: On its website the *ACA* reported progress at the latest six-party talks, when the *DPRK* agreed to freeze its plutonium-production complex within two months (deadline: 14 April 2007); in return it would receive aid and fuel.
- 20 Feb *ISIS*: David Albright assessed in a report the North Korean plutonium stock and also stated that „little is known about North Korea’s ability to make a nuclear weapon”.
- 01 Mar *NYT*: It is reported that the US intelligence softens its position by admitting doubts on the North Korean progress in their uranium enrichment program. The allegedly advanced enrichment program has been the key argument for the Bush administration to confront the *DPRK* in 2002.
- 19-22 Mar *Six-Party Talks*: The sixth round of the talks commenced.

April - December 2007

- 01 Apr *ACA*: It was reported that at the beginning of the sixth round of talks the DPRK have had taken first steps to shut down their 5 MW(e) reactor. In order to repay this the US announced to unfreeze the North Korean bank accounts, but due to a transaction delay the DPRK did not receive the money, refused to proceed and abandoned the talks early.
- 14 Apr - DEADLINE - for the DPRK to shutdown its plutonium producing complex.
- 06 May *ACA*: On its website the ACA published reports that a large part of the UN member states are missing to fulfill and report their sanctions against the DPRK. On the other hand it also reports that the DPRK missed its deadline to shutdown certain nuclear facilities, saying that it refuses to do so as long as their funds have not been transferred.
- 09 May *Sweden*: The Swedish defense research institute FOI released a report about their „Measurements of radioxenon in ground level air in South Korea following the claimed nuclear test in North Korea on October 9, 2006” [Rin07]. Within this it says: „The report focuses entirely on the analysis of the activity concentrations and gives no interpretation of the data, such as on the source of the observed activity.”
- 16 Jun *DPRK*: According to a KCNA report from 18 June 2007, the DPRK invited the IAEA in a June 16 letter.
- 18 Jun *KCNA*: The website reports that the DPRK invited a working-level delegation of the IAEA to visit the DPRK „as it is confirmed that the process of de-freezing the funds of the DPRK at the Banco Delta Asia in Macao has reached its final phase”.
- 30 Jun *ACA*: Due to the ongoing solving of the banking dispute, a progress in the North Korean reactor shutdown could be reported.
- 18 Jul *IAEA*: According to an ACA article from 24 July 2007 the IAEA confirmed on 18 July 2007 that North Korea has shut down five nuclear facilities at Yongbyon and therefore, ended its production of plutonium.
- 18-20 Jul *Six-Party Talks*: The first phase of the sixth round of talks was resumed. The six parties restated their commitment to the Joint Statement of 2005 (see

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page 30), including the DPRK, to close all nuclear programs and facilities, but no deadline was determined.

27-30 Sep *Six-Party Talks*: The second phase of the sixth round of talks took place. After hearings of working groups the participating states agreed on complete disablement and declaration of all North Korean nuclear facilities by 31 December 2007. In return the DPRK will receive economic, energy and humanitarian support.

Nov *DPRK*: As agreed on the DPRK issued a declaration of its nuclear inventory.
US: The US claimed that the list was incomplete and therefore, denied its shipment of aid. Thus the planned final meeting of the Six-Party Talks did not take place.

January - December 2008

May *DPRK*: The North Korean government delivered a documentation of its nuclear reactor.

27 Jun *DPRK*: After finally delivering a comprehensive declaration of their nuclear program to China, it was followed by worldwide media how the DPRK destroyed their cooling tower in Yongbyon.
US: In return the US government announced to reassess the data, lift the sanctions against the DPRK and also delete it from the list of state sponsors of terrorism.

03 Jul *DPRK*: In a letter to the UNSC the North Korean government outlined the importance of the US and other states to „fundamentally drop its hostile policy towards the DPRK”. Furthermore, it stated that „Only then can the denuclearization process make smooth progress”. It also reminded the six parties to fulfill their obligations.

11 Aug *DPRK*: In another letter to the UNSC the North Korean government heavily accused and criticized the US for manipulating the public and its long time deployment of nuclear weapons in ROK. Further the DPRK justified its nuclear weapons and military armament. Nevertheless it said that the only way to ensure peace on the Korean peninsula is a new peace agreement.

- 26 Aug *DPRK*: According to CNN the North Korean government declared a full stop of the nuclear dismantling process, since the US did not remove it from the list of state sponsors of terrorism.
- 11 Oct *US*: Finally the US executed the removal of the DPRK from the list of state sponsors of terrorism.

4.3 Current Status

Following the above described political course, the North Korean government continued with its politics and rhetoric of confrontation in 2009. In January 2009 it accused South Korea of hostile intentions and revoked all common military and political agreements [Cnn09]. The situation escalated again on 05 April 2009 when the DPRK conducted what it called a peaceful satellite launch, while the US State Department claims it was a provocative ballistic missile tests. On 13 April an UN declaration follows condemning the launch and demanding no more launches. On the following day the DPRK announces to abandon international talks concerning the decommissioning of their nuclear program and furthermore, asked the IAEA inspectors to leave, who departed on 16 April. It adds on 18 April that any sanctions or other kind of pressure against it will be considered a declaration of war.

On 25 May 2009 North Korea announced its second successfully conducted nuclear test. Due to seismic measurements the location, time and yield of the test could be determined on the same day. A fact sheet with preliminary results has been issued and distributed by Martin Kalinowski on 25 May and revised on 27 May [Kal09b]. The event has taken place close to the first nuclear test site with an estimated yield of 1.5-4.5 kt TNT. This second North Korean nuclear test also evoked an condemnation by the UN Security Council and by the broad international community. Until July 2009 the crisis evolved through further exchange of missile tests, threats of further nuclear tests and threats of war by North Korea on one side, and condemnations and sanctions against it by the UN on the other side.

5 Analysis of the Case Study

The analysis of the presented case study mainly centers on the question when the international community was convicted of the nuclear character of the North Korean explosion and when they could have been sure by evidence.

5.1 Correlations of Actions and Actors

Today the explosive character as well as the nuclear character of the seismic activity near the city of Kilchu in North Korea on 09 October 2006 is widely acknowledged. However, on 09 October the international community and the world public had only the North Korean national confirmation of the nuclear test.

Due to seismic monitoring the location and time of the event have been determined; furthermore, also tectonic activity could be excluded and the explosive character has been confirmed on the following day [Pin06]. Governmental and independent experts agreed on the unexpected low yield for an assumed nuclear explosion. Therefore, two possible scenarios have been presumed: Either the explosion was nuclear, but did not reach the desired yield, or it was not nuclear, but a conventional chemical one.

5.1.1 The Dispute over the Nuclear Character

The doubts on the nuclear character of the seismic event can be found in several publications following the event, e.g. from CNS, ACA, INESAP and even state actors like Germany [Bun06]. The ACA took the North Korean announcement on 11 Oct 2006 of further nuclear tests as a hint that the actual test did not reach the expectations - and therefore as a sign of the nuclear character of the explosion. As seen from the chronology, there have been three measurements accomplished that speak for the nuclear character:

1. The first action to resolve those doubts was taken by the **United States** by dispatching an US Air Force plane for air sampling. However, no official announcement about this has been made in the meantime.

2. Subsequently, one day after the US, the **Swedish** government sent a team to do four days of ground-based air sampling.
3. Two weeks after the North Korean test the **CTBT** radionuclide station in Yellowknife, Canada, detected Xenon consistent with the test.

Although these three measurements could have helped to clarify the character of the explosion, their publications were not taken for granted. The accordant, official statements about the data and the results were handled differently:

1. The **United States** National Intelligence confirmed on 16 Oct 2006 the nuclear test due to „detected radioactive debris”; no measuring data or any further information about the measuring process has been published.
2. (a) The **South Korean** government confirmed in mid-December 2006 the nuclear test due to Xenon findings in air samples that probably originated from the test site. The sampling has been done by the Swedish FOI, who also released a press statement.
(b) The **Swedish** FOI published their measurements in the so-called SAUNA report in May 2007. Although no interpretation is given, environmental sample experts were in principle enabled to draw conclusions and confirm the nuclear character. The interpretation „[...] will be discussed in a separate report, together with a presentation of background data recorded in ROK during November 2006 to February 2007.” [Rin07].
3. As foreseen in the **CTBT** text, the measuring data has been forwarded to the member states on 27 Oct 2006, since the CTBTO is not supposed to publish it.

As seen from this, the actual confirmation of the nuclear test has never been completely done by an independent, i.e. non-state, actor. The US government published only the conclusion without any underlying data. The reason for this retention of background information is unknown.

Since the South Korean government relied on external data that was analysed by the FOI, it is assumed that this is also the reason for giving only a conclusion, but no background information.

On the contrary to the US and ROK, the Swedish government published only the measurements, but no interpretation yet. The SAUNA report was the first possibility for the public to draw own conclusions, even though only from governmental data. However,

by the time the SAUNA report was published, the discussion about the nuclear character of the explosion has been over. Still, neither an independent nor a governmental analysis of the Swedish measurements has been published yet. An official interpretation by the FOI itself would make up for a complete and publicly analysis by one actor, which would clearly increase the transparency and consistency of the verification process. The reasons for the delays of publications of the SAUNA report (\approx seven months) and the interpretation (not published by July 2009) have been given by Anders Ringbohm (FOI):

”The main reason for the measurements was not to produce publications. The measurements were made for our customers, and they received reports very soon after the measurements were conducted. We realise the importance of peer-reviewed publications, both because of the general interest as well as for quality control, but they are written when we have the possibility. We are a small group with many duties, and sometimes it can take a long time. Furthermore, the first publication contained a new analysis method that I developed during the analysis.” [Rin09]

However, an official interpretation from the FOI is in preparation and „will soon appear in print” [Rin09].

As seen above, a public/independent and complete confirmation of the nuclear test through scientific analysis does not exist until today. Although, doubts have been expressed after the test, the international community did not wait for an independent confirmation. Some state actors, e.g. Germany, expressed doubts about the nuclear character; but on the other hand, some state actors acted on the assumption of a nuclear test from the beginning. The doubts vanished over time until today, when then international community is broadly convinced about the nuclear test.

5.1.2 The Decision about the Nuclear Character

Although the nuclear character of the North Korean explosion has never been publicly proven, certain states refer to their own national technical means and therefore claim to have confirmed the nuclear character. This is of special interest, since it must not necessarily be true, when two opposed state actors (US, DPRK) agree on the nuclear character of the test. These claims seem to have sufficed for the international community to act as if the nuclear character is proven. This would mean that state actors have had reason not to wait for an scientific proof, but act on the basis of assumption, perhaps even on the assumption of the worst case scenario. The first reaction from the international

community against North Korea due to the nuclear test came from the United Nations Security Council.

The UN resolution 1718, condemning the *nuclear* test and sanctioning North Korea, has been unanimously adopted five days after the North Korean test - two days before the first official confirmation by the US, but one day after unofficial confirmation from the US national intelligence has been published by the New York Times. However, the UN resolution 1718 justifies its adoption not by the existence of scientific proof, but by referring to the North Korean official claim of a nuclear test [Uni06]. Nevertheless, there are two possibilities on what reasoning the resolution has been built behind the scenes. Either the resolution is really based on the mere claim of the North Korean government to have tested a nuclear weapon, or the US government - so far the only possible possessor of relevant data - supported the Security Council with further evidence. In both cases the UN Security Council would have adopted the resolution without independent proof on hand and with existing public doubt from independent actors. Still, even doubts from state actors were released in public statements, e.g. Germany on 26 Oct 2006, but no actions on a presumption of innocence have been taken. If those early actions against North Korea were made on any basis of scientific evidence, these could have only come from the US government, since neither the Swedish results nor the CTBT radionuclide measurements were made available that early.

Strange enough, ISIS - usually having a leading role in the non-state monitoring of nuclear issues - only published the satellite imagery of the suspected test site. No contribution from ISIS to the clarification process of the nuclear character can be found on their web page. Moreover, not even the doubts about the nuclear test have been promoted. This suggests that the existing and close ties of David Albright to the US government provided ISIS with background information. On the other hand ISIS usually publishes even confidential material once they received it. Thus, the position of ISIS in this regard cannot be determined for sure.

No public statement about the usage of the CTBT data by member states was found during this research, although this would have been the only measuring data available in an equal way for every member state. The neglected public use of the Swedish and the CTBT data seems to be related to the duration of their publication. In critical situations the international community is enforced to act quick and cannot wait for public, independent proof. While the doubts on the nuclear character of the test vanished over time, the conviction of it spread through the international community without any independent foundation.

5.1.3 Effects of Environmental Measurements

The role of environmental measurements in the present case study is of special interest, because the explosion yield does not inherently speak for a nuclear explosion. Thus, the evidence from radionuclide measurements are a crucial method in this case, since they are the only remote sensing technology able to confirm the nuclear test.

The CTBT measurements could not have been accomplished faster in this case study, since it took the Xenon cloud almost two weeks to reach the first IMS station on its path and get detected. Therefore, these measurements could have only served as a retroactive confirmation of the actions taken. Once the IMS is completed, the reaction time will probably be shorter, due to the denser network of radionuclide stations. Although the detection of Xenon in Yellowknife by the IMS had no reconstructable impact on the considered case study, it demonstrated the functionality of the radionuclide network. Before that the environmental measuring component of the IMS was not considered as a crucial part of it. The successful detection of Xenon over a distance of 7500 km, after almost two weeks together with the accordant atmospheric simulations showed the capabilities of the network.

Once the CTBT will have entered into force, member states can request an On-Site Inspection (OSI), if the assumed nuclear test area has been narrowed down by waveform measurements to less than 1000 km². Supposed the CTBT would have entered into force, which means that also the DPRK would have ratified it, it had different effects on the presented case. Since the waveform measurements located the event on 09 Oct 2006 in an area less than 1000 km², an OSI would have been possible [Müt09]. The focus of an OSI is on speed, thus a hypothetical inspection would begin not later than ten days after the detection of the event. Hence, an OSI would have started at least three days before the radionuclide station in Yellowknife picked up the elevated amount of Xenon. But since an OSI can last several months, the radionuclide measurements would still have provided the verification regime with relevant data. The detection of Xenon that is consistence with a release from the North Korean nuclear test site and time clearly increased the acceptance of the environmental measurements on the political level and also inside the CTBTO [Sae09].

The Swedish FOI measurements have been conducted exemplarily: The mobile, ground-based radionuclide system has been dispatched quickly to South Korea and comprehensive air sampling has been done over four days. These measurements gain importance since the Swedish foreign policy is famous for its neutrality and could therefore, provide the public with likely unbiased results. The official interpretation was reserved for cer-

tain „customers” (see above, [Rin09]), among which the Swedish and the South Korean government can be reckoned. However, the official interpretation of the data was most likely faster than the public release of the measuring data in the SAUNA report. The public release of the measuring data, i.e. the SAUNA report, in May 2007 was too late to be of any relevance for any state actor, except for another retroactive justification.

According to the reasoning in the statement of Anders Ringbohm (see section 5.1.1), the analysis and publication process within the FOI is subject to restrictions in terms of the official scope of their work. If the FOI would be an independent actor, for instance a NGO, it would not undergo these kinds of restrictions. Its scope would not be to serve its customers, but for example to provide the public with independent information. The technical means and technical expertise that have been used for the FOI measurements and analysis in mid-October are also within the realms of possibility for an NGO. Then, the measurements could have been taken the same way it has been done, but the analysis and interpretation would probably have been published much faster.

As seen above, the actual non-state actors in the case study, as CNS, ACA and INESAP, were rather engaged in the promotion of eligible doubts, than in the clarification of these. Although no civil actor has been directly involved in the confirmation of the nuclear test, it would have been possible for such a non-state actor to play a investigative and informative role in the presented case with the FOI as a role-model.

5.2 Consequences from the Second Nuclear Test

Compared to the first nuclear test in October 2006 the second nuclear test in May 2009 was stronger in its yield, estimated 1.5-4.5 kt TNT compared to 0.5-0.8 kt TNT. Both tests were carried out in the same test area. However, unlike with the first test, the second test did not bring up any public discussion about the character of the explosion, i.e. chemical or nuclear. Although a chemical explosion of this magnitude is unlikely, it is still possible. Besides the North Korean claim of a nuclear test, it seems that the magnitude of the explosion yield and the use of the same test area suffice as an indication for a nuclear explosion. Still, no public discussion about the character of the explosion nor about the dispute over the first test occurred in the media. However, some military officials from South Korea expressed existing doubts [Kal09a].

In spite of the increased yield of the second test the radionuclide stations could not detect an elevated amount of Xenon that would be traceable back to the test site. About two weeks after the test, on 09 June 2009, the FOI released a press statement that it

has assessed North Korea's second nuclear test [Foi09]. It mentions the existence of the Xenon measuring devices, but no detection of the gas itself. Nor can any public statement from the CTBTO about a successful Xenon detection be found. The reason for the absence of Xenon findings may be for example an adequate containment of the fission products or a faked nuclear test. The consolidated opinion of the world public about the nuclear character of the 2006 explosion seems to rule out a discussion about the latter possibility of a faked test. This situation would clearly be different if North Korea would not publicly announce and promote their nuclear test, but deny it. Then the international community as well as independent actors would probably seek for evidence of the nuclear character. Nevertheless, the absence of Xenon findings in the atmosphere is perceived as a setback for the acceptance of environmental measurements.

5.3 Conclusion

In the analysis of the case of the first North Korean nuclear test it became clear that the international community could not wait for independent measurements to be published. The IMS measurements in Canada were taken when the process of opinion making has almost been settled. Only the national technical means of the US and Sweden could have contributed to well-founded decisions. The confession of the DPRK about the test seem to have taken away the burden of proof from the international community, although the possibility of a faked test was publicly discussed in the beginning. Non-state actors played only minor roles in the case study, where they could have supported the opinion making and add credibility and transparency to the decisions of state actors.

Therefore, the contribution of environmental measurements to peace in the presented case study is questionable or at least disputable: Civil environmental measurements did not occur; only national technical means were responsible for fast gathering of data. A relevant, timely interpretation by civil actors was prevented by delayed publication of measuring data, even though not on purpose. The role of the results from the national technical means behind the scenes of decision making cannot be determined, but it seems likely that the US results played a role for the UN resolution 1718 and that the Swedish results satisfied their customers in terms of an additional confirmation.

6 Relevance to Peace and Security

This chapter analyses the results from the case study in terms of the general and possible role of non-state actors in the field of monitoring nuclear treaties with environmental measurements, see section 6.1. Subsequently, the presented outcome is compared to the possibilities of non-state actors in the field of monitoring nuclear treaties with satellite remote sensing, see section 6.2. Finally, the possible effects on the future of nuclear treaties are assessed, see section 6.3.

6.1 Possibilities of Non-State Actors in Nuclear Treaties

It has been shown that scientific struggle for evidence and opinion making in the international community are not necessarily coupled. Obviously there are situations in international politics that require fast decisions and actions. Non-state actors can support this processes during different steps. In the following the capabilities of non-state actors are assessed in the field of environmental measurements for monitoring of nuclear treaties.

The first step in the monitoring process is the setting of the actor's SCOPE and FOCUS. A worldwide network of environmental measuring stations, like the IMS, is likely to be too expensive for an ordinary non-state actor. Therefore, it is more appropriate to assume that such an actor would participate in regional and continuous monitoring, or specialize in single measurements with worldwide application, where they are of special interest. The former option would make a network of non-state actors necessary to guarantee worldwide monitoring of a treaty; the latter option enables the actor to focus on certain hot-spots.

Another important parameter for the role of non-state actors is their ACCESS to information. If one wants to accomplish environmental measurements in certain places at the right time, i.e. hot-spots, the accordant information *where* and *when* must be known prior to the process. This trigger information can originate from different sources, e.g. public announcement (see nuclear test by DPRK), governmental sources (national in-

telligence), or an existing continuous monitoring network (e.g. seismic stations¹ for the detection of nuclear tests). Especially the latter makes a complete independent process is conceivable. Still, in some cases the non-state actor may be dependent on governmental sources and the leakage of trigger information.

When it comes to the ASSESSMENT of measuring data, whether published from someone else or self-accomplished, the capabilities of non-state actors are not much different from state actors. The necessary expertise in physics, geophysics, etc. is usually also available in civil society, especially non-governmental organisations. However, the collected data is not necessary unambiguous. When remote environmental measurements are applied, they have to be combined with atmospheric calculations; backward and forward models are applicable and can help to find correlations between the suspected origin and the place of measurements. Due to the existence of known and unknown civil and military sources, the combination of calculations and measurements usually leads to consistency with prior assumptions, but not unambiguity.

The RELIABILITY of environmental measurements is dependent on the proper and timely application of these, where they are needed. As mentioned above some trigger information is usually necessary to monitor an event of interest. Single measurements in hot-spots are not autonomous and need completion by other techniques.

As shown in the case study the SPEED of state actors in taking measurements is high, which is not necessarily true for to the publication of their data and results. To be comparable with state actors in the field of environmental monitoring, non-state actors must be able to react in a comparable or faster time frame. Their advantage becomes especially apparent when it comes to publishing the results in a fast and timely manner, since they are not bound by discretion or other treaty obligations.

On the other hand, the freedom of not being a member of a treaty decreases the CONSISTENCY of a non-state actor in the long run. Since the actor can change his own agenda, it is not guaranteed that his today's focus will still be covered by him in the future.

Considering the above parameters, non-state actors have the possibility and qualification to play a role in the field of monitoring nuclear treaties with environmental measurements, e.g. the CTBT. This could contribute to and/or improve current verification regimes in terms of transparency, reliability, credibility and quality. However, this role is not filled yet as seen in the presented case study.

¹Seismic stations can be found numerously throughout the world for earthquake observations and are often in the hands of independent actors as research institutes.

FMCT

The Fissile Material Cut-off Treaty is currently being negotiated in the United Nations Conference on Disarmament (CD) to prevent the production of weapons-grade uranium and plutonium. This would not restrain the production of fuel-grade uranium and plutonium. The accordant committee has been mandated in 1995 to begin negotiations on the treaty, which have been delayed for several years now. In the last nine years the CD was unable to agree on a common agenda and was unable to establish a committee for the beginning of negotiations. One of the contentious issues are for instance the existing stockpile of fissile material [<http://www.reachingcriticalwill.org/legal/fmct.html>].

However, the US opposes to include a verification mechanism in the treaty, because it were not verifiable, but would approve a treaty that allows states to use their own national technical means for monitoring purposes.

6.2 Comparison with Satellite Remote Sensing

Parallel to this work another thesis with focus on the role of non-state actors in the field of monitoring nuclear treaties with *satellite remote sensing* was written, see [Buc09]. While the trigger information that is needed for appropriate environmental measurements can origin from various sources, the field of satellite imagery usually relies on the leakage of information by human intelligence, i.e. governmental sources or whistle blowers. This is due to the vast amount of imagery that is potentially available through satellite remote sensing. However, once the region of interest is identified, both - state and non-state actors - have the same opportunities and comparable expertise to assess the imagery data. This is similar to the field of environmental measurements. Another similarity can be found in the ambiguity of the data; where a radionuclide measurement struggle with the correlation with its origin, satellite imagery is usually subject to interpretation and thus, often cannot clarify the situation without further information. Also, verification and monitoring regimes can be improved by the potential increase in speed resulting from the application of these techniques by non-state actors. The reason for this is the same for both techniques; they are not bound to treaty restrictions.

6.3 Impact on the Future of Nuclear Treaties

Although the detection of Xenon by the CTBTO in Yellowknife, Canada, on 21 Oct 2006 was too late to influence the first decisions of the international community, it may still have an impact on today's negotiations of treaties. Originally the radionuclide techniques were not considered as the most powerful tools in the CTBT verification

regime's toolbox. In terms of detecting nuclear tests the three waveform techniques were entrusted most. The radionuclide techniques were meant to confirm a detection, but were not essential, since nuclear explosions, especially country's first nuclear tests, usually have a yield that exceeds the yield of practicable conventional explosions. The role of radionuclide measurements in the first North Korean nuclear test increased their acceptance, which is expressed in an article of the ACA on 01 Nov 2006 [Smi06]:

„The power and versatility of nuclear forensics, particularly radio-chemical techniques, could not have been better demonstrated than by its application to the recent underground test in North Korea.”

A personal interview with Paul Saey, radionuclide officer in the CTBTO, supports this view. He confirmed that the acceptance of radionuclide techniques has been raised within in the CTBTO as well as on the political level of the international community by this successful crucial test in 2006 [Sae09]. The obtained reputation can be used to convince undecided countries of the verifiability of the CTBT. Furthermore, it can be used on the political level as an argument for the applicability of environmental measurements in future treaties, e.g. the Fissile Material Cut-off Treaty (FMCT, see box on the previous page). An assumed verification regime of the FMCT would rather concentrate on the detection of Krypton than Xenon. Although these gases are detected by different technologies, the success of the Xenon detection in 2006 may be used to convince political actors of the applicability of environmental measurements in general. However, the absent detection of anomalous Xenon amounts after the second North Korean nuclear test was a setback for the regime.

Moreover, not only the success of environmental measurements after the first North Korean nuclear test may have an impact on the future of nuclear treaties. Also the FOI can be seen as a role model for acting outside of verification regimes that can also be carried out by civil society. This is also imaginable for other treaties, e.g. the FMCT, where non-state actors could conduct the accordant air sampling. However, in the case of the FMCT the measurements would have to be carried out on a continuous basis, since no trigger information from continuous sources, e.g. through seismic activity, would be available.

7 Conclusion

The role of non-state actors in the field of monitoring arms control related treaties is a contemporary topic and their importance is subject of controversial discussion. The presented work examines the current and possible roles of non-state actors in the sub-field of monitoring arms control treaties with the usage of environmental measurements. For this purpose a case study has been chosen, in which the environmental measurements played a key role with regard to peace and security: The nuclear character of the first North Korean nuclear test in October 2006 was not self-evident and needed confirmation by environmental measurements, i.e. detection of Xenon originating from the test site. The following reactions of the involved actors have been contradictory; some actors promoted their eligible doubts about the nuclear character, while other actors acted on the assumption of a nuclear test. The discussion about the nuclear character of the seismically detected explosion could have been clarified by an public, independent and complete analysis of environmental measurements.

Three measurements that could have confirmed the nuclear test have been conducted: The United States and Sweden used national technical means to do air sampling close to the North Korean border shortly after the explosion; due to prevailing winds the radionuclide station of the IMS in Yellowknife, Canada, could detect an elevated amount of Xenon after about two weeks. However, no complete analysis was published until today. The United States published neither details nor analysis of their measurements. The CTBTO data is confidential to the member states. The Swedish measurements were published after seven months, but no interpretation was given. Anyway, the civil society could draw conclusions from these data. During the analysis of this case study it became clear that political decisions cannot always wait for an independent, scientific proof that legitimates actions against a country. Furthermore, it was shown that civil actors played no major role in the clarification process of the North Korean nuclear test. On the other hand, the acting of the Swedish defense research institute FOI showed that civil monitoring would be possible. The conducted measurements are feasible and conceivable to be carried out by a non-state actor.

7 Conclusion

From the analysis of the case study the advantages and disadvantages of non-state actors in the field of monitoring nuclear treaties became clearer. In terms of access to and assessment of information they have capabilities comparable to state actors, when taking the Swedish measurements as a role model. The critical characteristics of non-state actors in this field are speed and consistency of focus. These are the parameters in which they have to compete with state actors. The omnipresent disadvantage is the necessity of trigger information to tell the non-state actor to take measurements where and when. In total one can say that non-state actors have the possibility to contribute to peace and security by monitoring nuclear treaties with environmental measurements, although this role has not been filled yet. This would add transparency and credibility to the actions of the international community and possibly fill gaps where the official verification regime shows vacancies. A comparison with the work about satellite remote sensing and non-state monitoring of nuclear treaties confirmed these results.

The earned credibility of environmental measurements, although lowered after the second North Korean nuclear test, may still have an impact on today's and future treaties. The CTBT's verification regime gained international acceptance, which can contribute to signings and ratifications from the remaining states. However, as long as North Korea continues nuclear testing, it will not sign and ratify the CTBT, preventing it from entry into force. Today, a provisional entry into force of the CTBT is discussed, which means that even if the treaty did not enter into force, the state parties could agree to act like it did. Also other treaties, e.g. the FMCT, which verifiability is controversially discussed on the international level, could gain confidence through the successful measurements.

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