SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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Artificial Intelligence and the CTBT: Enhancing verification, building trust, and advancing science diplomacy.

Jean Yves Ndzana Ndzana, Ph.D.

Leiden University, Netherlands

The **Comprehensive Nuclear-Test-Ban Treaty (CTBT)** is one of the cornerstones of the global nuclear non-proliferation and disarmament architecture. With a robust **verification regime** comprising the **International Monitoring System (IMS)**, **the International Data Centre (IDC), and provisions for On-Site Inspections (OSIs), CTBT aims to detect and deter any nuclear explosion worldwide**. However, in a geopolitical climate characterised by mistrust and evolving technological landscapes, the Treaty's full potential remains unrealised. Most critically, it has **yet to enter into force** due to pending ratifications by key States listed Annex 2.

To navigate this impasse, a growing consensus is emerging on the need for **innovation** — not only in **political will** but also in **technical capability**. **Artificial Intelligence (AI)** offers a compelling frontier in this regard. It can enhance the sensitivity, accuracy, and responsiveness of the CTBT's verification regime, while simultaneously serving as a **science diplomacy tool to foster trust and cooperation among States Parties**. This presentation examines how AI can enhance the CTBT regime through three interrelated vectors: **verification performance, confidence-building measures**, and **science diplomacy**.

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I- The Role of AI in treaty verification

A- AI and the verification ecosystem

AI can be embedded across the **technical pillars** of the CTBT's verification regime. Applications include:

Machine learning (ML) and **deep learning (DL)** for signal classification. (Scientific advances in CTBT monitoring and verification., p.42)

Natural Language Processing (NLP) for rapid document analysis.

Predictive analytics for anomaly detection in large datasets.

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B. IMS and OSI Applications

a. Seismic monitoring:

- AI can improve the differentiation between natural earthquakes and anthropogenic seismic events.
- ML models trained in historical seismic data (e.g., from global catalogues) can help improve event discrimination and reduce **false positives**.

b. Hydroacoustic & infrasound monitoring :

- Neural networks can improve the classification of signals in noisy environments.
- AI allows a better identification of low-yield underwater or atmospheric events, previously masked by environmental interference.

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c- Radionuclide monitoring :

- AI enhances isotope pattern recognition.
- It facilitates rapid filtering of benign isotopic releases (e.g., from civil sources) from suspect nuclear activities.

d- On-Site Inspections (OSIs):

- AI supports autonomous drone navigation and sensor deployment.
- It assists in real-time data fusion from multi-modal sensors (e.g., infrared, geophysical).

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C- Cross-Field Case Studies

- In climate science, AI models could help predict complex atmospheric flows —technologies transferable to radionuclide plume analysis.

- Satellite imagery analysis in arms control (e.g., States, IAEA and commercial platforms) demonstrates the feasibility of AI for large-scale pattern detection. (Nuclear weapons and Artificial Intelligence: technological promises and practical realities, SIPRI Background Paper, Vladislav Chernavskikh, September 2024, p.5)

- AI applications in geohazard detection (In the nuclear context, *geohazard detection* means both identifying seismic/geological signals to verify and discriminate nuclear explosions from natural events and monitoring the secondary geological hazards that a nuclear blast itself may trigger) have demonstrated promise for interpreting infrasound anomalies. (https://www.sciencedirect.com/special-issue/318299/ai-powered-geological-hazard-mapping-monitoring-and-prediction).

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II- AI for Confidence Building

A- Increasing accuracy and transparency

AI systems, especially those that are **open-source or verifiable**, offer greater analytical consistency than subjective human assessments.
By enabling:

- **Real-time event verification**
- **Multisource correlation**
- **Automated classification and peer review**

AI can also **lower the risk of politicisation** of technical data.

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II- AI for Confidence Building

B- Addressing Technical Challenges

AI algorithms can be trained to:

Reduce the **impact of background noise** in seismic and hydroacoustic data.

Flag **anomalous data spikes** that warrant further expert scrutiny.

Identify and filter **signal interference** from mining or industrial activities.

These tools improve overall system resilience and lower the probability of **false alarms**, which have historically undermined treaty confidence.

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II- AI for Confidence Building

C- Real-Time Data Sharing and Trust

AI systems can process and disseminate verified alerts more rapidly, improving transparency and stakeholder inclusion. This supports:

Multilateral monitoring initiatives

Regional trust-building mechanisms

Shared early-warning platforms among States Parties

Such features help establish a confidence-building loop among the CTBTO, technical experts, and political stakeholders.

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III- Science diplomacy and political dimensions

A- AI as a neutral tool for security cooperation

AI, by virtue of its algorithmic logic and reproducibility, can **transcend national biases**. It serves as a "**technical lingua franca"** that unites scientists across borders, particularly within CTBTO's **Science and Technology (SnT)** community.

AI-enhanced data interpretation can be:

Peer-reviewed by international teams
Integrated into **joint verification experiments**
Embedded into **capacity-building programs** (e.g., for Global South States)
This fosters an inclusive, **multilateral epistemic community**—the heart of science diplomacy.

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III- **Science diplomacy and political dimensions**

AI as a neutral tool for security cooperation

Mitigating disputes through technical legitimacy
Verification disputes often stem from diverging interpretations of ambiguous data. AI's role as an **"evidentiary enhancer"** offers:
Common reference points for adjudicating claims.
Lowering the potential for **accusation-based escalation**.
Increased reliance on **technical validation** over political assertion.

Integrating AI without heightening tensions
Geopolitical sensitivities around AI must be addressed. Some States may:
Perceive AI tools as **intelligence-gathering proxies**.
Resist externally developed algorithms due to **sovereignty concerns**.

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III- **Science diplomacy and political dimensions**

AI models reflect the **biases of the data they are trained on**.

If not globally representative, models may systematically favor or exclude certain regional characteristics—reducing credibility.

Solutions:

Develop **global training datasets**.

Institutionalize **bias audits**.

Establish an **Ethics Review Board** for AI tools used in verification.

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III- **Science diplomacy and political dimensions**

B- Challenges and limitations

Ethical and Privacy Concerns

AI-based surveillance or pattern detection may raise concerns about **dual-use applications**.
On-Site Inspections using autonomous AI-driven tools could blur the line between **verification and intrusion**.

Risks of Misuse

States could **weaponize AI models** to generate misleading verification narratives.
Non-state actors may **tamper with AI systems** or exploit weaknesses in training datasets.
Algorithmic Bias and Impartiality

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III- **Science diplomacy and political dimensions**

C- Pathways to Implementation

Policy Recommendations

Include AI in the **next CTBT verification technology roadmap**.
Propose **pilot programs** within existing CTBTO Working Groups.
Establish a **CTBTO AI Task Force** comprised of scientists, diplomats, and ethicists.

Science Diplomacy as a Driver
Leverage the CTBTO's **Science Diplomacy Symposiums** to foster cooperation on AI models.
Use AI projects as a platform to **re-engage Annex 2 States**, framing participation as a contribution to global scientific advancement.

Encourage partnerships with **regional centers of excellence** in Africa, Asia, and Latin America.

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III- Science diplomacy and political dimensions

D- Policy Recommendations

Funding and Capacity-Building

Partner with **UN bodies**, **EU Horizon**, and **AI4Good** for financing.

Offer **technical training programs** to ensure equitable participation in AI development.

Create an **AI Verification Fellowship Program** under CTBTO's capacity-building initiatives.

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Conclusion

Artificial Intelligence holds transformative potential for the **CTBT verification regime**. Technically, it can enhance data accuracy, reduce ambiguity, and provide tools for real-time response. Politically, it can be a **trust multiplier**, helping States Parties reach consensus grounded in transparent, verifiable science. Diplomatically, AI aligns with the CTBT's tradition of **science-driven engagement**, offering a compelling pathway toward **universalisation and entry into force**.

However, its promise is not automatic. Success will depend on **inclusive governance**, **ethical safeguards**, and a deliberate effort to use AI not as a wedge, but as a **bridge**—between science and policy, between verification and diplomacy, between division and consensus.

The CTBT was born from scientific consensus and political courage. AI offers the next frontier, where innovation meets commitment, for a world free from nuclear testing.

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THANK YOU !!!