



Body-Wave Magnitude of the Six Underground Nuclear Tests in North Korea

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Introduction and Motivation

Our goal is to stop nuclear weapon test by any nation.

- Since nuclear weapon testing is a crucial step in designing nuclear weapons systems,
 - if we can curb the nuclear weapons testing, then we can effectively stop building nuclear weapons.
- Our work supports the Comprehensive Test Ban Treaty (CTBT)

On September 1996, the General Assembly of the United Nations endorsed the treaty by a 158 to 3 vote.

The treaty bans all nuclear test explosions of any size.

- CTBT Organization is set up in Vienna, Austria and functioning in full capacity with the International Data Center (IDC), the IMS is also nearly complete.



Mission Relevance

- Ultimate goals of NNSA – nuclear weapons non-proliferation, and
- Our research objective – stop nuclear weapon testing,

Both have the same goal,

- But we work under the comprehensive nuclear test-ban treaty (CTBT) to achieve the goal.



Technical Appro

4 Major Technology used in IMS

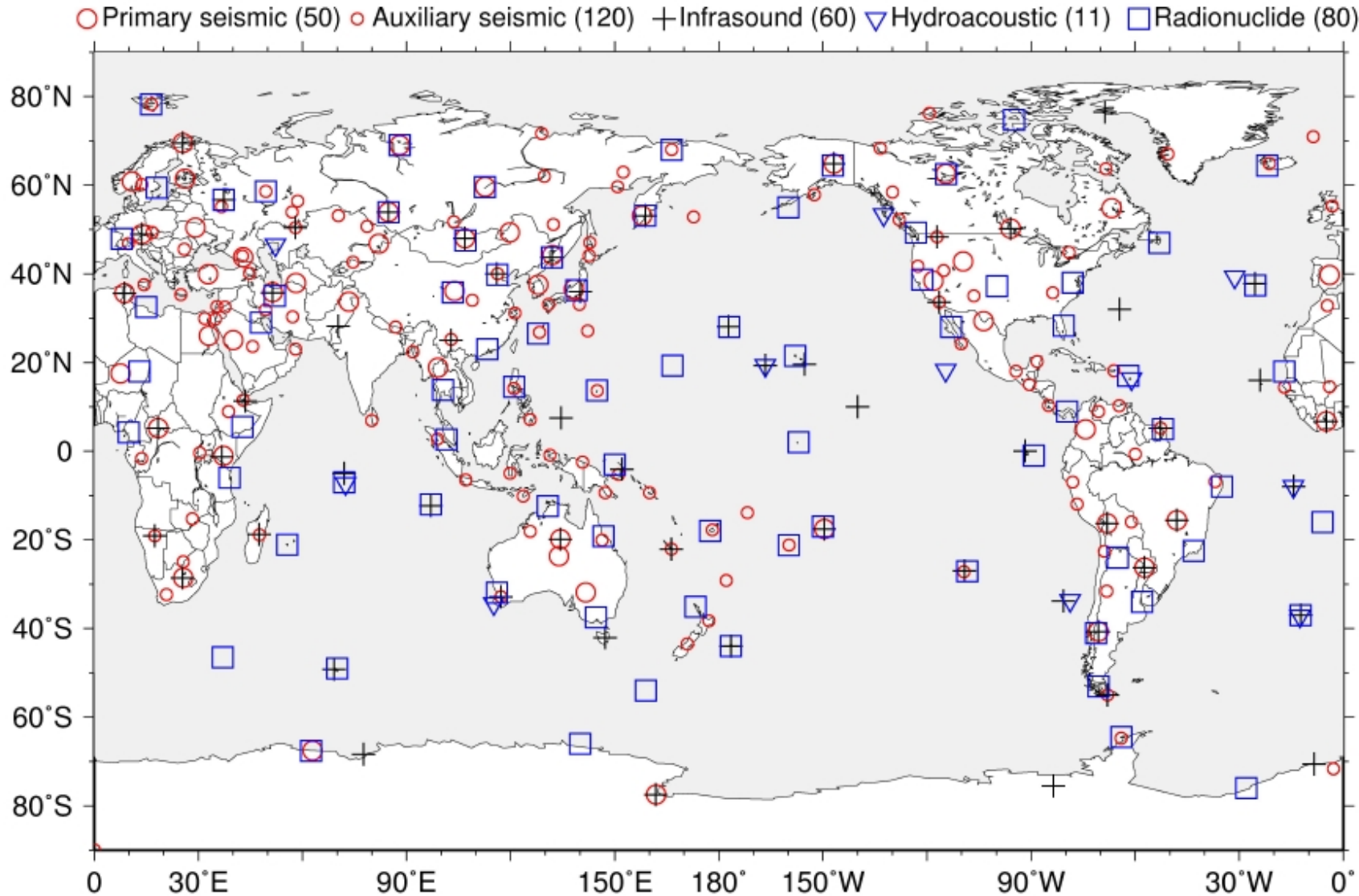
Key Technology	Test Environment		
	Under ground	Under water	Atmosphere
Seismic	P	P	S
Hydroacoustic	S	P	S
Radionuclide	P	P	P
Infrasound	S	S	P

P: **Primary** application

S: **Secondary**

Near Space Electromagnetic
& Satellite Imagery

International Monitoring System for the CTBT



Technical Approach

Body-wave magnitude, $mb(P)$, of a UNT at each station is given by,

$$mb(P) = \log_{10} (A/T)_{\max} + B (\Delta, h) + S + F$$

where

A = amplitude of P wave in nanometer,

$B (\Delta, h)$ = amplitude-distance correction curve,

S = station site effect,

F = regional wave path effect.

Event magnitude is obtained by an average of station magnitudes.



Technical Approach

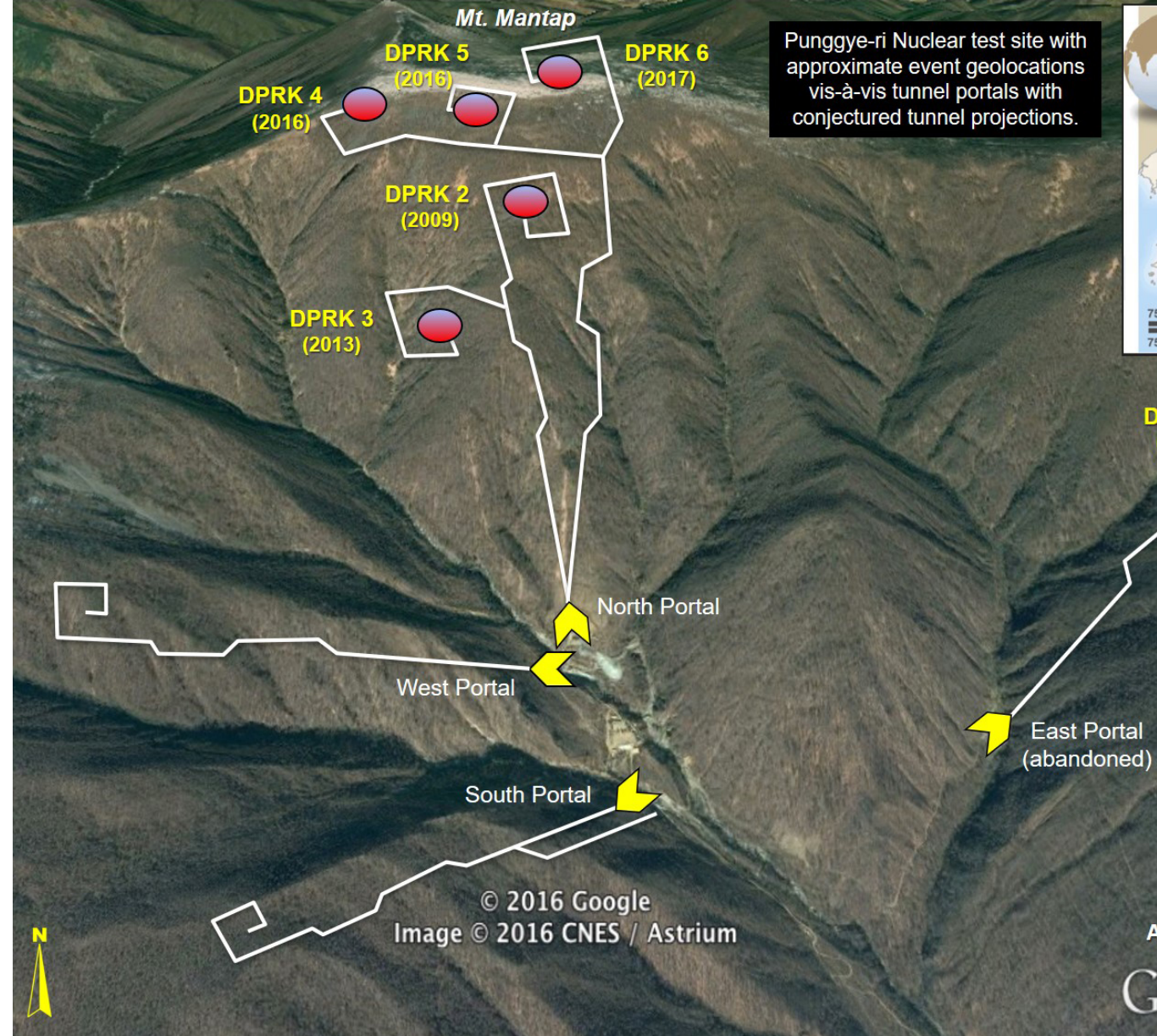
Yield of a UNT is estimated using a relation; yield - body-wave magnitude,

$$0.75 \text{ Log (Yield in kton)} = \text{mb}(P) - 4.45$$

Constant 4.45=EKTS, granite; 4.25=NZ;

Test site condition: Mt. Mantap, 2204 m

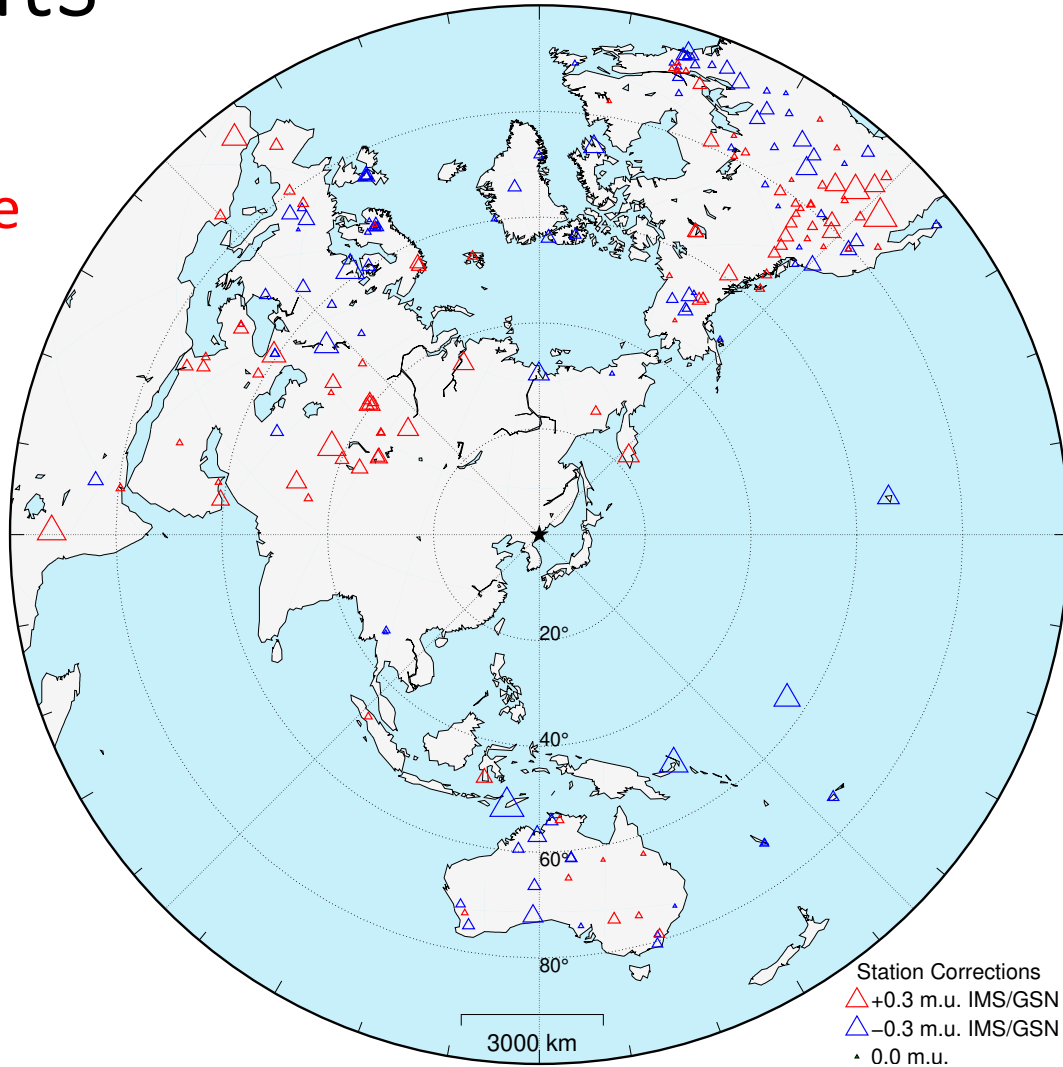
- Burial depth – overburden pressure
- Geology of test site
- Water table
- Coupling with medium



Results

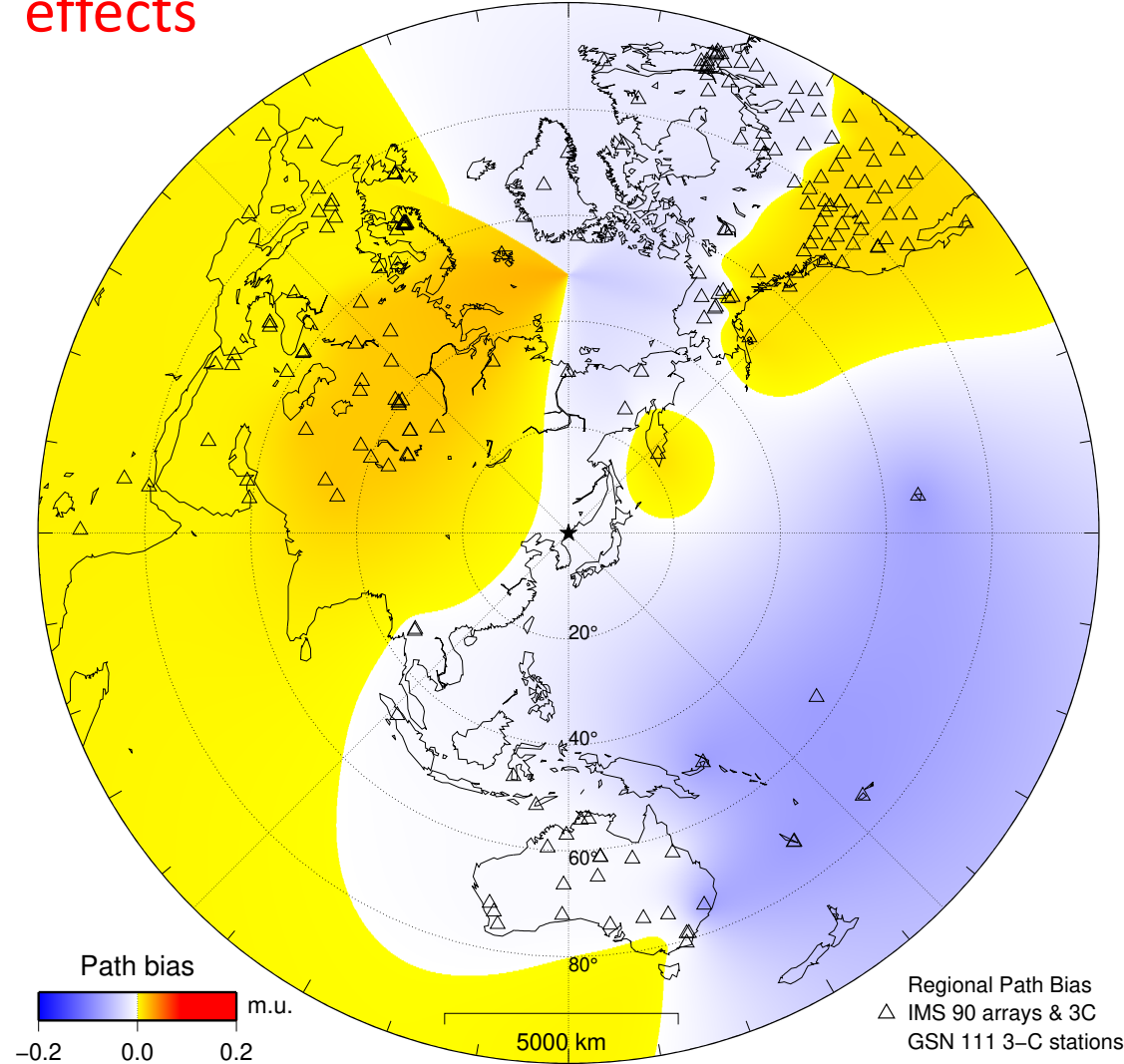
IMS, GSN & RSN Arrays and 3-C Stations, 201

Station site effect



Path effects

IMS, GSN & RSN Arrays & 3-C Stations



Expected Impact

- Reliable estimates of the yield for the six underground nuclear tests conducted by North Korean,
- Any future explosions.



MTV Impact

- What do you expect will be the impact of the MTV on your project development?

We had interaction with scientist at the national labs (LLNL, LANL) as well as the International Data Center (IDC) of CTBTO in Vienna, Austria.

- Technology transitions

- Who is interested or using your technology:

Appropriate offices in the US Department of State, and Department of Defense who deal with test ban monitoring.

- Who are you collaborating with on your technology

Opened a session on the “Nuclear Test Ban Monitoring” during 2020 AOGS (Asia Oceania Geosciences Society) Annual Meeting, but was canceled due to Covid-19. Researchers in Korea, and in the south and Far-east Asia.



Conclusion

- We obtained station site effects for 200 IMS and Global Seismic Network stations (Station magnitude adjustments are ± 0.4 magnitude units),
- Station site effects show systematic regional distribution.
 - Positive adjustments: Australia, western Europe and Eastern North America;
 - Negative adjustments: central Asia and western US.
- We obtained an average regional path effects that vary gradually from positive to negative effects, similar to the station site effect, but small values,
- These results will help us to establish a reliable magnitude – yield relation for the six North Korean UNTs.



Next Steps

- We are working on writing manuscript(s) for publication of our results,
- Expand the work for more detail analysis of test site conditions to estimate yield,
- and validate the regional scale path effects on the body-wave magnitude determination.



Acknowledgements



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