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TRENDS IN NUCLEAR EXPLOSION MONITORING RESEARCH & DEVELOPMENT
- A Physics Perspective -

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Outline

- WHAT is this document?
- WHY do you want to read it?
- WHERE can you find it?

WHAT is it?

- Review of technical literature related to nuclear explosion monitoring research and the CTBT
- Over 40 research trends
  - highlight the value and benefit to the monitoring mission
  - cite key papers that have advanced the science
  - summarize promising future research and development

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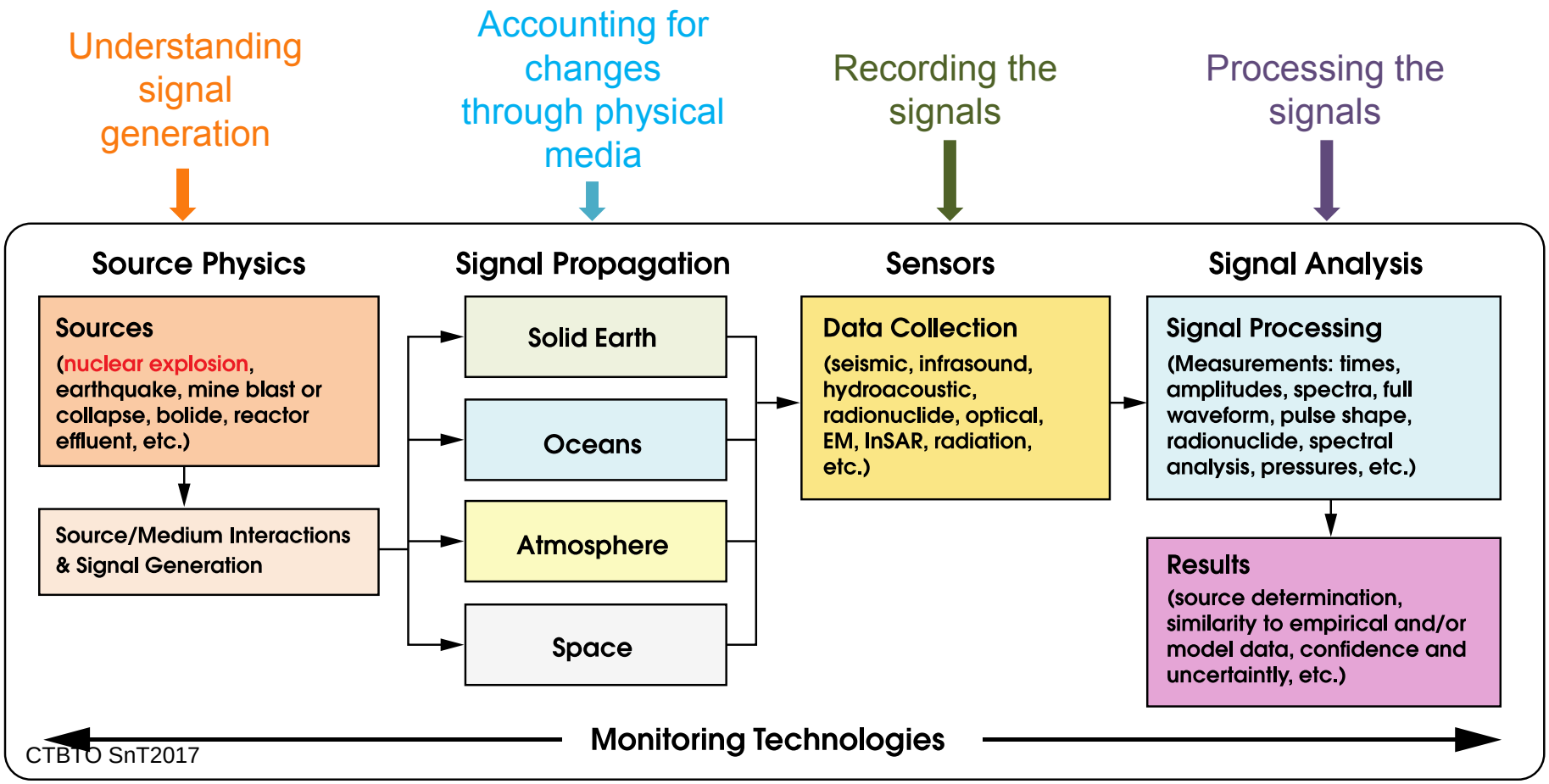
A Physics Perspective

Physics perspective provides a useful framework for research



WHY do you want to read it?

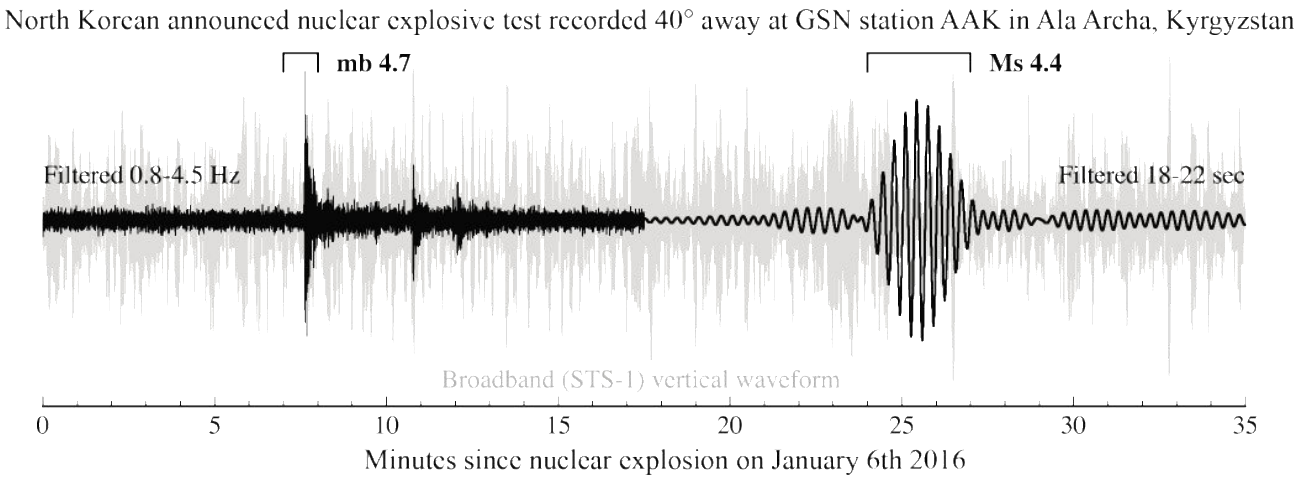
Unique features

- For subject matter experts:
  - Provides insight into other disciplines
  - Encourages multi-disciplinary research
  - Renews readership of previously published papers
- For next generation researchers and students:
  - Provides an introduction to the technical literature
  - Avoids future research duplication
- References are linked directly to the source papers
- Links, both internal and external, enhance the reader's experience

Tutorials

Tutorials provide basic background information

Tutorial: Measurements for Event Screening



The relative amplitudes of compressional and surface waves gives insight into the type of source event, which is used in event screening. Explosions direct energy into compressional P-waves, thus the amplitude of the P-waves is high relative to the amplitude of the surface waves. Two magnitudes are commonly applied to distant events: mb is measured using the first few seconds of a teleseismic P-wave and Ms is derived from the maximum amplitude Rayleigh wave. Shown above is a recording of an announced North Korean nuclear explosive test withn sectios of the w aveform bracketed that are used to calculate the mb and Ms. The raw waveform is shown in the background in gray. The waveform amplitudes are measured to obtain an mb of 4.7 and Ms of 4.4.

Future R&D is highlighted
- radionuclide example -

Significant improvements in monitoring can be achieved with further research in:

- Additional discrimination techniques for anthropogenic radiological backgrounds to understand signals for monitoring purposes

Future R&D

Discrimination techniques for anthropogenic sources are an important step in furthering our ability to monitor for nuclear explosions. Additional means of accounting for anthropogenic radiological backgrounds will be required to understand signals for monitoring purposes.

Future R&D is highlighted
- seismic example -

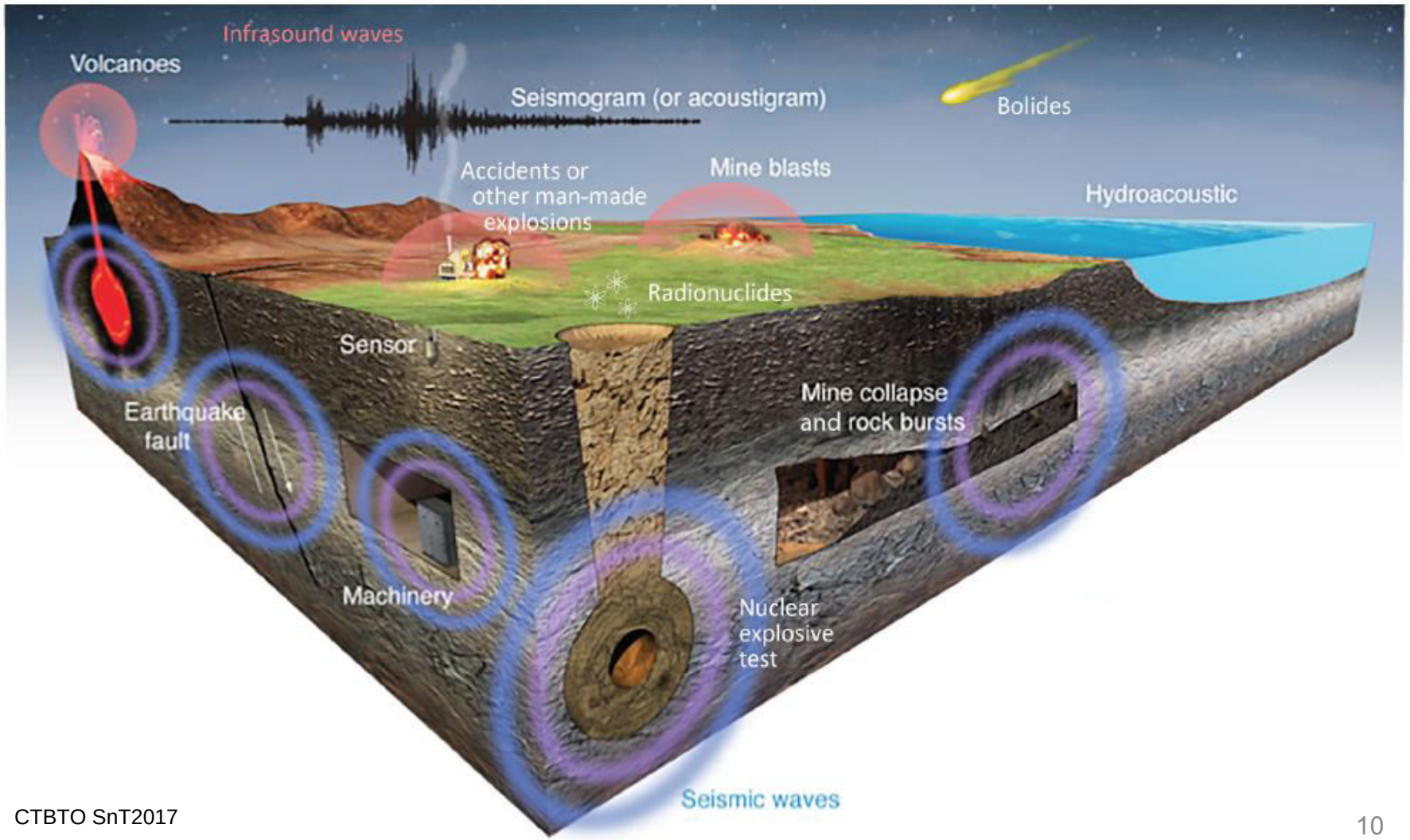
Significant improvements in monitoring can be achieved with further research in:

- Exploring the suitability of ambient noise for retrieval of amplitude information

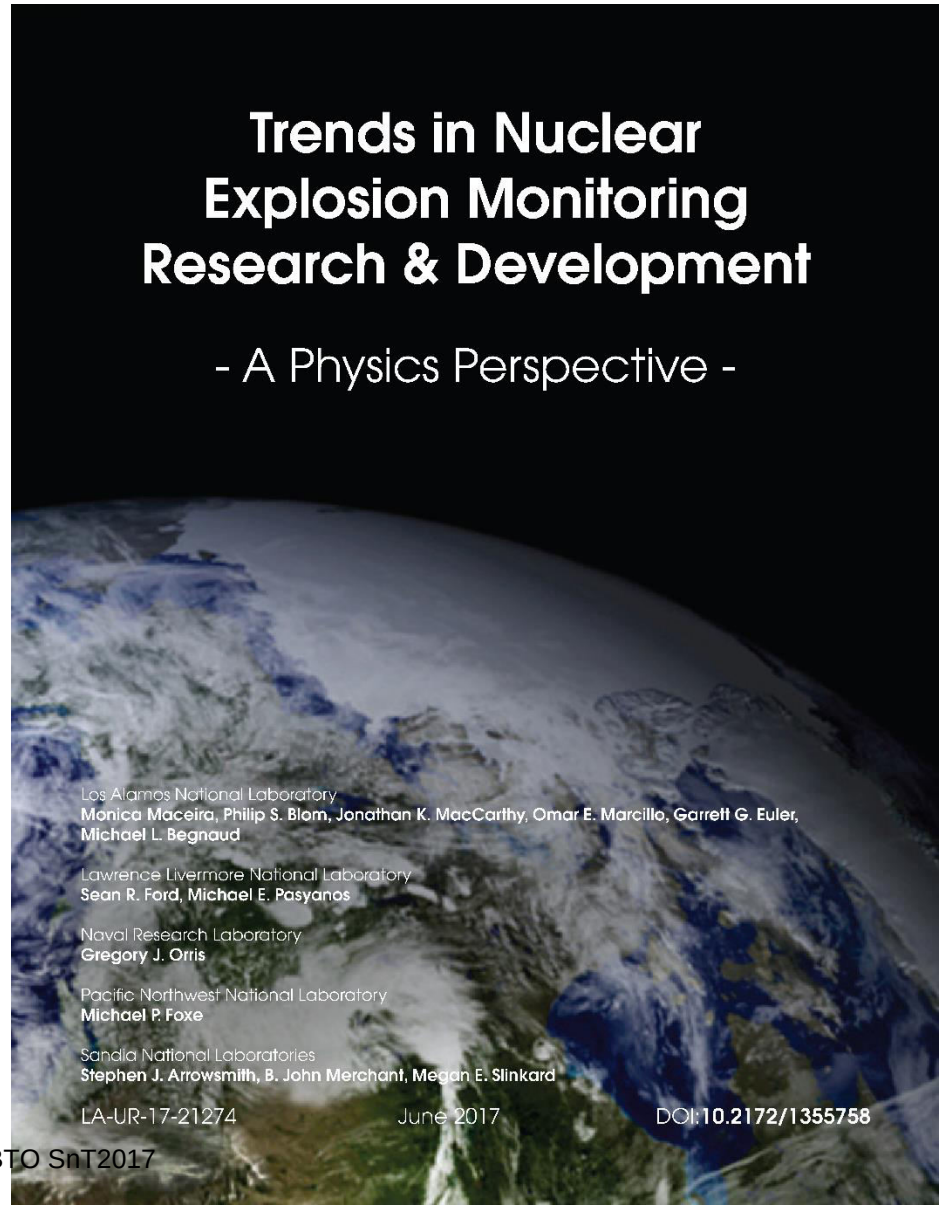
Future R&D

The suitability of the ambient noise field for retrieval of amplitude information continues to be explored numerically and theoretically, and is a future growth area for research using seismic noise.

Monitoring challenges of the physical environment



Disclaimer
The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO



Take a look inside!

Contents of Trends monograph

Trends in Nuclear Explosion Monitoring Research and Development - A Physics Perspective

- **Abstract**
- **Preface**
- **Acknowledgements**
- **Acronyms and Abbreviations**
- **Introduction**
- **Contextual Trends**
  - From large atmospheric to small underground explosions
  - From large signals to those hidden in the noise
  - From paper to high performance computing

Source Physics Trends

- **Source Physics – Understanding Signal Generation**
  - From natural to anthropogenic radioxenon background sources
  - From detection of single to multiple isotopes
  - From simple source analytical models to phenomenological numerical calculations for radionuclides
  - From narrow-band magnitude estimates to full spectral estimates of the seismic source
  - From surface-to-body-wave magnitude ratios to corrected regional phase amplitude ratios
  - From narrow-band teleseismic explosion size estimates to full-spectral estimates of coupled explosion size and depth
  - From simple explosion source analytical models to physics-based numerical seismic calculations
  - From simple analytical models to physics-based numerical infrasound and overpressure calculations
  - From separate treatment of mechanical waves in different media to combined analyses
  - From expert system to model-based event discrimination

Signal Propagation Trends

- **Signal Propagation - Accounting for Changes through Physical Media**
  - From global to local seismic models
  - From limited to broadband, multi-parameter surface-wave dispersion and attenuation models
  - From low-resolution *a priori* crustal models to high-resolution data driven crustal models
  - From adapted to infrasound-specific propagation tools
  - From generalized climatology-based models to statistical infrasound propagation models
  - From seismic noise to seismic signal
  - From 1D to 3D earth models
  - From ray theory to full waveform
  - From regular to irregular parameterization
  - From phase amplitudes to envelope amplitudes
  - From 1D hydroacoustic propagation to 3D models with uncertainty
  - From dilution estimates to probability distribution functions

Sensors Trends

- **Sensors– Recording the Signals**
  - From limited dynamic range sensor stations to high-resolution broad-band seismic arrays
  - From sparse monitoring stations to a dense network
  - From simple to complex sensor deployment planning
  - From dedicated calibration facilities to on-sensor calibrations
  - From uncertainty to traceability in measurements
  - From noble gas experiment to network demonstration
  - From a single spectrum to coincidence detection
  - From longer to shorter integration periods for in-field analysis
  - From plastic scintillators to solid-state detectors
  - From simple to intelligent radioxenon processing
  - From passive to active particulate collection
  - From manual to robust automated systems
  - From fission to combined fission/activation signatures for on-site inspection
  - From gamma spectroscopy to measurement restrictions

Signal Analysis Trends

- **Signal Analysis– Processing the Signals**
  - From single to multi-phenomenology integrated analysis
  - From idealized to adaptive infrasound signal detection algorithms
  - From time-or-frequency analysis to time-and-frequency analysis
  - From simple, statistical location algorithms to physics-informed algorithms for infrasonic analysis
  - From pick-based seismic event processing to full-waveform processing
  - From simple to sophisticated radionuclide spectral analysis
  - From radionuclide detection to source discrimination

Noteworthy features

- **Research Potential for Further Performance Improvements**
  - Summarizes trends in bullets & links to Future R&D boxes
- **R&D Themes from the GNDD Technology Roadmap**
  - Keyes trends to research performance metrics
- **Guide to Seismic Waves and Phases**
  - Provides tutorial for non-seismologists
- **References (with links)**
  - Capitalizes on digital revolution in information technology to facilitate reader access to the source papers

WHERE can you find it?

"Trends in Nuclear Explosion Monitoring Research & Development - A Physics Perspective"

http://www.osti.gov/scitech/10.2172/1355758

This electronic version of the document is recommended to the reader to take advantage of the internal and external links to references and other information sources.

http://www.dx.doi.org/10.2172/1355758