Global Nuclear Explosion Monitoring

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Natural events occur worldwide

World Seismicity 1977-1992

From Columbia University website
Networks such as the International Monitoring System can detect events down to a threshold.
Example of a seismic station

From CTBTO website
Example of an Infrasound/Radionuclide Station

From CTBTO website
Example of a hydroacoustic station

From CTBTO website
As part of the overall nuclear non-proliferation program, the U.S. Government monitors for potential nuclear weapons testing

- Various Executive Branch agencies contribute to this mission:
  - Air Force Technical Applications Center
  - Air Force Geophysics Laboratory
  - Department of Energy’s National Nuclear Security Administration
  - Lawrence Livermore National Laboratory
  - Los Alamos, Sandia, and Pacific Northwest National Laboratories
U.S. sponsors satellite monitoring

From NNSA NEM Strategic Plan
The progression of test ban treaties is driving monitoring from teleseismic to regional distance

- Limited Test Ban Treaty (1963)
- Threshold Test Ban Treaty (1974)
- Comprehensive Test Ban Treaty (1996)
Why are regional monitoring and calibration difficult problems?

- the number of events increases exponentially with decreasing magnitude
- smaller events have to be observed on shorter paths confined to the upper mantle and crust
Event location is performed by triangulation of seismic wave arrival times.

Different seismic waves travel at different speeds.

The travel times of seismic waves increase with distance from their source, and...

...measured arrival times are used to estimate the source origin time and triangulate the source location.
Event discrimination is performed by measuring the relative amplitudes of different seismic waves.
The Knowledge Base is needed because wave propagation in the earth is not uniform

Seismic travel times from a point in the Middle East

Assumed Uniform World

The Actual Situation
End-to-end tests validate calibrations: earthquake aftershocks test location capability

1991 Aftershock Sequence
- 13 events with known locations
- sparse network relocation

Ground truth from a dense local network
Relocating the Racha earthquake sequence with and without corrections shows calibration value.
Path corrections significantly improve discrimination

Station NIL Kriged Correction Surface (1-2 Hz Pn/Lg)

Calibration improves discrimination

Comparison with nearest earthquake
Nuclear explosion monitoring is well developed across many technologies worldwide