Seismo-acoustic studies at the Earth’s surface and in the atmosphere

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Content

• Brief review of infrasound
• Societal relevance of infrasound today
  - e.g nuclear and hazard monitoring
• Recent studies
  - Common ground with seismology
• Grand challenges
  - How cooperation with seismic community can help
Some Infrasound Sources
Sound Propagation

• Battle of Luca, September 19, 1862
The speed of sound is determined by temperature and wind speed. Propagation through unsteady atmosphere is known to be complex.
Infrasound and Seismic Event Catalogs

2000-2006 all network

IS bulletin (2000-2007)
4 874 events

1998-2005 EMSC

EMSC bulletin
Non-earthquakes reported events (1998-2005)
18 160 events

LRSPS Workshop
Denver, Sept 18, '08

Vergoz et al., 2007
Observed performances: Seasonal effects

Winter

- 75%
- 25%

Summer

- 15%
- 85%

Vergoz et al., 2007
Infrasound Detection

Wind noise key
IMS Infrasound Network
Societal relevance

• Societal relevance of infrasound today
  - Nuclear monitoring
  - Hazard monitoring
    • Volcanoes
    • Storms
    • Avalanches
    • Tsunamis
    • Wildfires
  - Tragic events - e.g. Columbia
  - Basic research
Some recent studies
Earthquake studies

Le Pichon, 2005
Infrasound measurements at I08BO, I09BR and I41PY

I08BO, 410 km

Dur = 26 min, Tmax = 5-10 s, Δθ = 43°

I41PY, 1420 km

Dur = 17 min, Tmax = 1-2 s, Δθ = 11°

I09BR, 2300 km

Dur = 52 min, Tmax = 3-5 s, Δθ = 25°

Le Pichon, 2008---M7.8 Northern Chile, June 13, 2005
Occidental Cordillera

Oriental Cordillera

Altiplano

Central Cordillera

North

Le Pichon, 2008
Amplitude of the simulated ground velocity

Le Pichon, 2008
Celerity model for I08BO

Le Pichon, 2008
Infrasound source regions from I08BO
410 km

Le Pichon, 2008
Infrasound source regions from I41PY
1420 km

Le Pichon, 2008
Infrasound source regions from I09BR
2300 km

Le Pichon, 2008
M7.0 East Coast of Honshu, Japan
May 26, 2003
Depth: 70 km

CHNAR: 1300 km

[Lee et al., 2004]
M7.0 East Coast of Honshu, Japan
May 26, 2003
Depth: 70 km

Duration: ~40 min
Radiating zone: ~1200 km

[Lee et al., 2004]
Monitoring and Studying Volcanoes

Acoustic Surveillance of Hazardous Eruptions (ASHE)
Operational Concept

4-element array

Analysis centre

VAAC

Bass et al., 2007
Tungurahua 2006

Garces et al., 2008

Low-level tremor (top), explosions and tremor (middle), Vulcanian-Plinian (bottom)
Studies of Atmospheric Events using the USAArray

Transportable Array Installation Plan
As of August 15, 2007.

Year
- Existing
  - 2004
  - 2005
  - 2006
  - 2007
  - 2008
  - 2009
  - 2010
  - 2011
  - 2012
  - 2013

Station removal follows in 24 months

Beginning 2014

LRSPS Workshop
Denver, Sept 18, '08
Atlantis
Propagation
Profile to NW of shuttle track

de Groot-Hedlin et al., 2008
The USArray and the Oregon bolide
Grand challenges (part 1)

- Test and refine our models of atmospheric structure
  - Increase station density
  - Ground-truth more sources
  - Co-locate atmospheric pressure sensors with seismic stations
  - Would help in many other areas (e.g. mechanical coupling between atmosphere and solid Earth, nature of acoustic noise, infrasound propagation modeling
More seismo-acoustic networks?

• e.g. SMU/IRIS effort underway
More seismo-acoustic networks?

- e.g. SMU/IRIS effort underway
- Can we do this on a larger scale?
  - Single sensors with interspersed arrays?
  - Begin at a “modest” scale?
  - Still time to begin with the USArray?
Grand challenges (pt. 2)

• Improve our ability to characterize near-surface and atmospheric processes using infrasound and infrasound with seismic
  - There is a rich interface between infrasound and seismic
    • e.g. the study and monitoring of volcanoes
AtmoScope - A. Muschinski

- GPS meteorology
- Atmospheric tides
- Free oscillations
- NWP
- Mesoscale meteorology and regional climate
- Limnology, hydrology, gravimetry and geodesy
- Adaptive seismometry
- Natural Hazards
- Meteor physics and CTBT monitoring
Concluding comments

• Information about seismic events can be carried by atmospheric signals and vice versa
  - Much common ground between the two disciplines

• Grand challenges
  - Many scientific issues could be addressed by increasing acoustic station density & co-locating these stns with seismic
    • e.g. atmospheric structure -> atmospheric propagation
    • e.g. hazard monitoring
    • e.g. mitigating seismic noise from atmosphere