



Seismic Monitor with low false alarm rate

Natalia Zotov

Louisiana Tech University

LSC Meeting, LLO

March 22, 2002



Seismic Monitor with low false alarm rate

- Algorithm from US Geological Survey
- Characteristics
 - Low false alarm rate:
 - 1 per day at 'easy' sites
 - 1-2 per hour at 'difficult' sites
 - Fast: In 1991, using 16 MHz Sun,
 - 147 x real time, 17th order FIR
 - 7 x real time, 2nd order IIR
 - estimated improvement with functions inline:20-30%
- International standard in geology



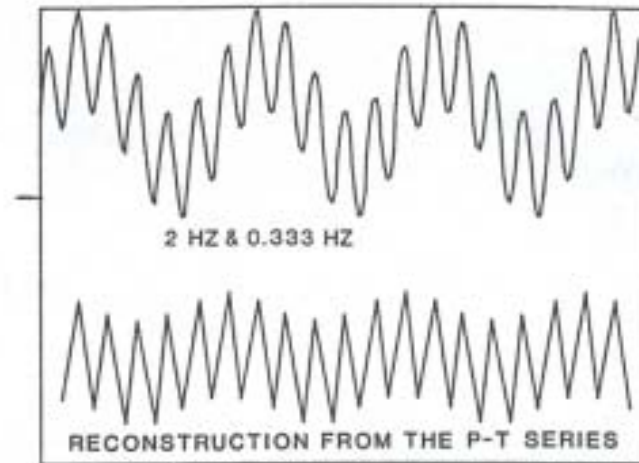
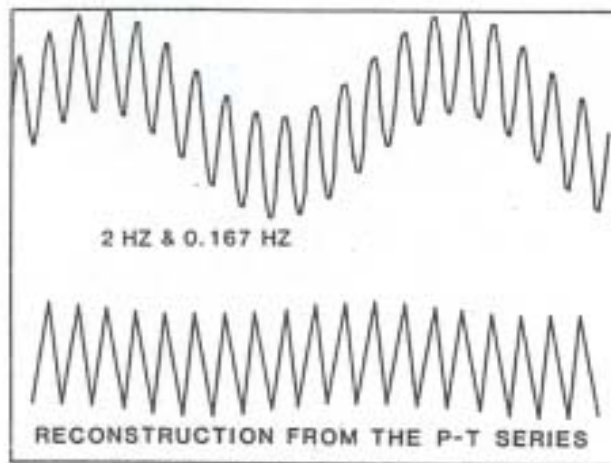
Seismic Monitor with low false alarm rate

- Data Management or Conditioning
 - Remove sampling frequency noise
FIR: running mean, broadband, downsample, resample, ...
 - Convert floating point data to integers
Critical to speed
 - 16-bit fp → 32-bit integer, geologists
 - 32-bit fp → 64-bit integer, IEEE/LIGO

All subsequent calculations done in terms of integer addition and subtraction, and bit shifting
- Frequency band filtering
e.g. remove frequencies < 1 Hz

Seismic Monitor with low false alarm rate

Basic algorithm



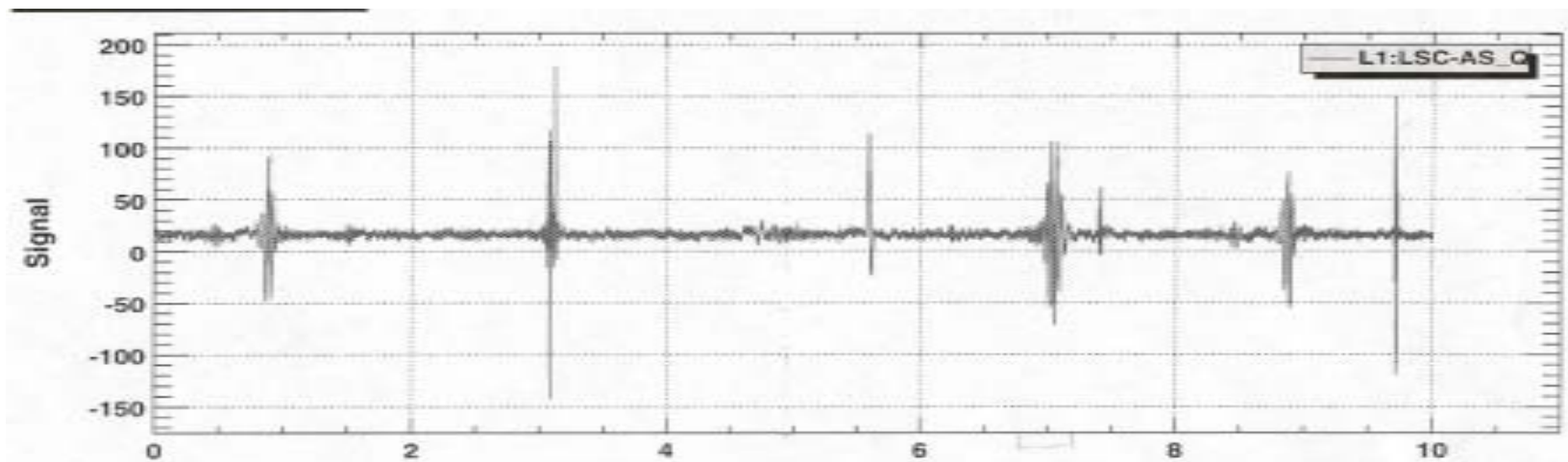
Form Peak-to-Trough series

- use standard deviation to form set of thresholds

Seismic Monitor with low false alarm rate

Background estimation

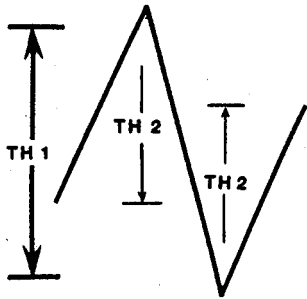
Use *estimator* of standard deviation - differencing
Estimate on continuous basis
until flag for possible event is set



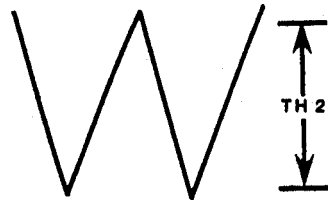
Definition of an Event

Set of thresholds, approximately 2, 3, 4 σ

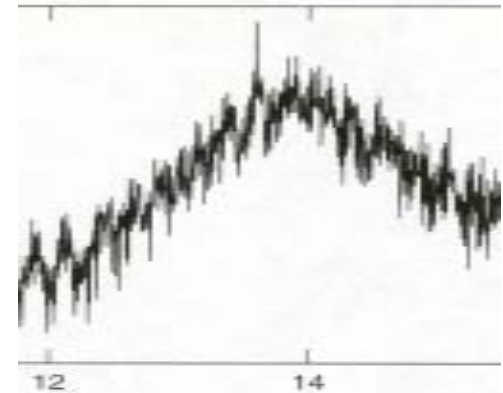
Minimum requirements



(a) One P-T $> 4 \sigma$
Two P-T $> 3 \sigma$



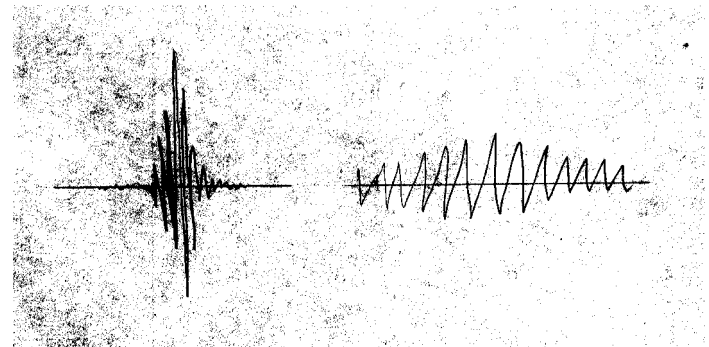
(b) Four P-T $> 3 \sigma$



Not an event

Descriptive parameters of event

- Onset time - earlier than time flag is set
- Impulsive or emergent?



- Maximum amplitude (in window)
- Average period

After event

- Deactivate monitor, at least briefly
- Double thresholds



Seismic Monitor with low false alarm rate

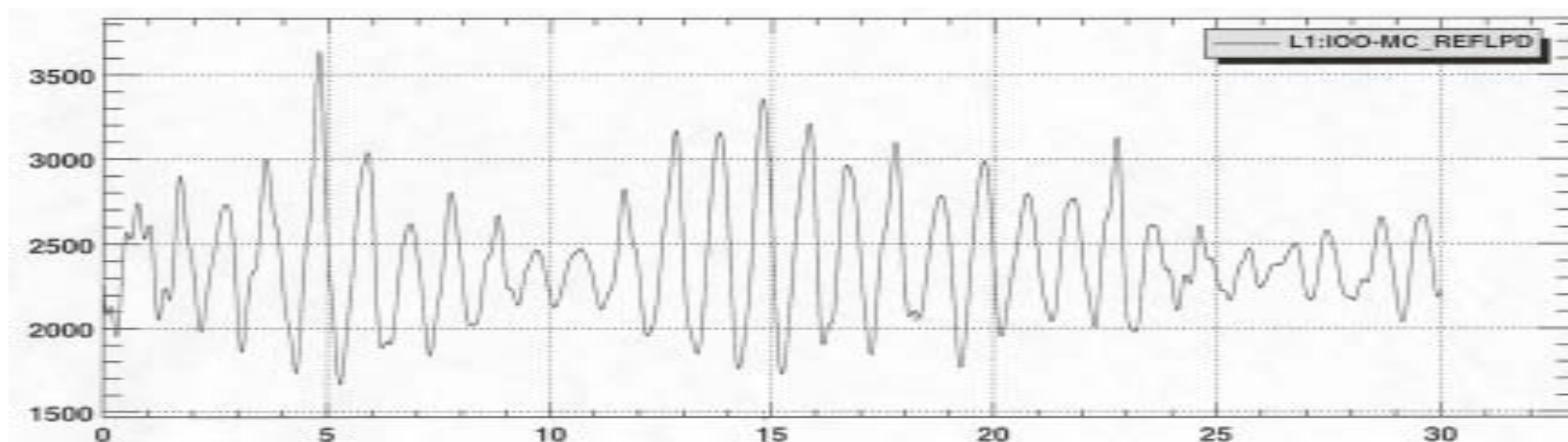
Tuning monitor

- Take **one** set of data
- Vary each parameter, one at a time, over a plausible interval until
 - observable glitches are detected
 - false alarms are minimal
- Needs to be done for **each site**
 - parameters depend on cultural noise
 - geological character of site

Driver has two input files:

- Site specific parameters
- User configuration files: site and channels

Next extension: Mode cleaner



Typical mode cleaner signal, with 'glitch'
(MC_F very similar)

Peak-Trough analysis

- Insert extra call to filter to take out low frequencies (< 1 Hz)



Seismic Monitor with low false alarm rate

- Future work

 - Finish driver - make LAL compliant

- Statistical analyses

 - e.g. factor analysis giving probabilities of propagation of glitches from one channel to next

 - e.g. LVEA_SEISZ → MC_F → AS_Q



Seismic Monitor with low false alarm rate

Descriptive parameters of event

- Onset time - earlier than time flag is set
- Impulsive or emergent?

- Maximum amplitude (in window)
- Average period

After event

- Deactivate monitor, at least briefly
- Double thresholds