Topics:

1. Moment-tensor analysis using global data
2. The Harvard CMT Catalog
3. Using calibration information in waveform analysis
4. Quality control using noise
5. Finding interesting things in the noise

Moment-tensor analysis by waveform fitting

(Observed seismogram)/(Instrument response) x Filter = Observed waveform

(Synthetic displacement seismogram) x Filter = Model waveform

Model waveform depends on:
1. Earthquake parameters
2. Earth structure

If the Earth structure and the earthquake location are known, the

Model waveform depends only on the six elements of the moment tensor,

M_{xx}, M_{yy}, M_{zz}, M_{xy}, M_{xz}, and M_{yz}

Minimize the difference $[\text{Observed waveform - Model waveform}]^2$

with respect to the moment tensor elements.

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The Harvard CMT Catalog

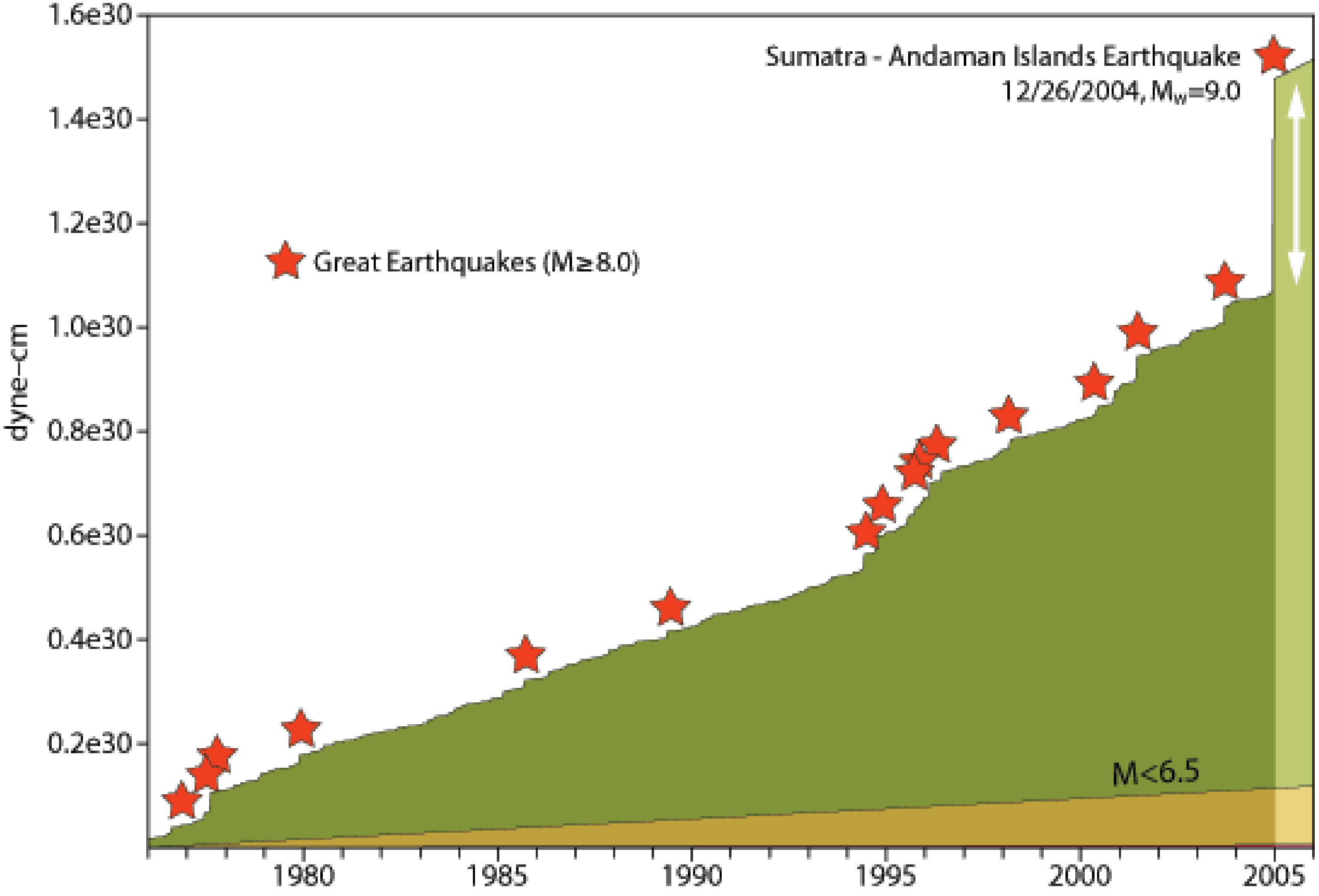
The CMT catalog contains about 21,000 centroid-moment tensor (CMT) solutions for earthquakes since 1976.

The CMT catalog is nearly complete for earthquakes with M=5.5 and larger.

The CMT catalog and additional information can be accessed from `http://www.seismology.harvard.edu`

If you want to receive ‘quick CMTs’, email `eq@seismology.harvard.edu`

Cumulative moment release since 1976



Topics:

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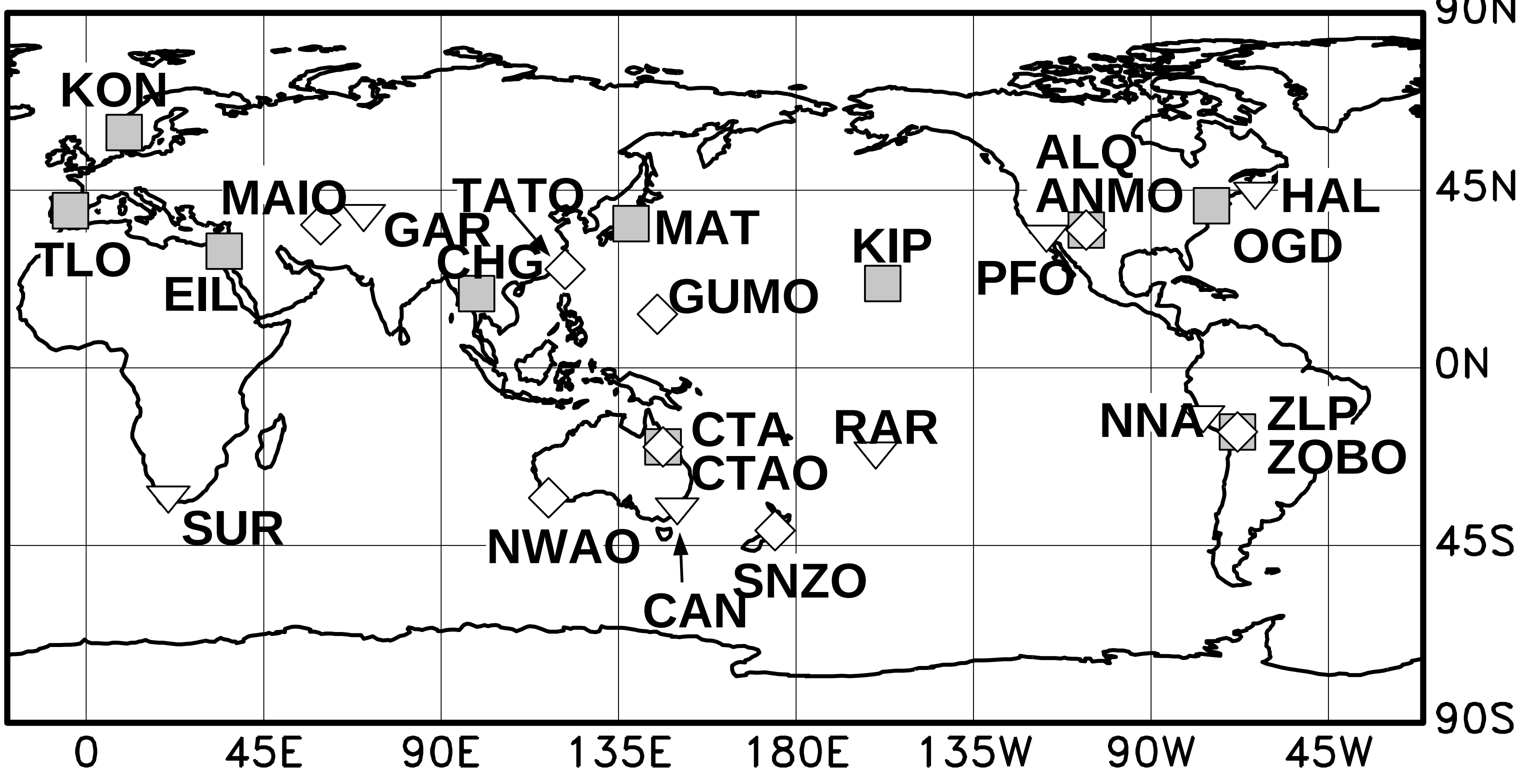
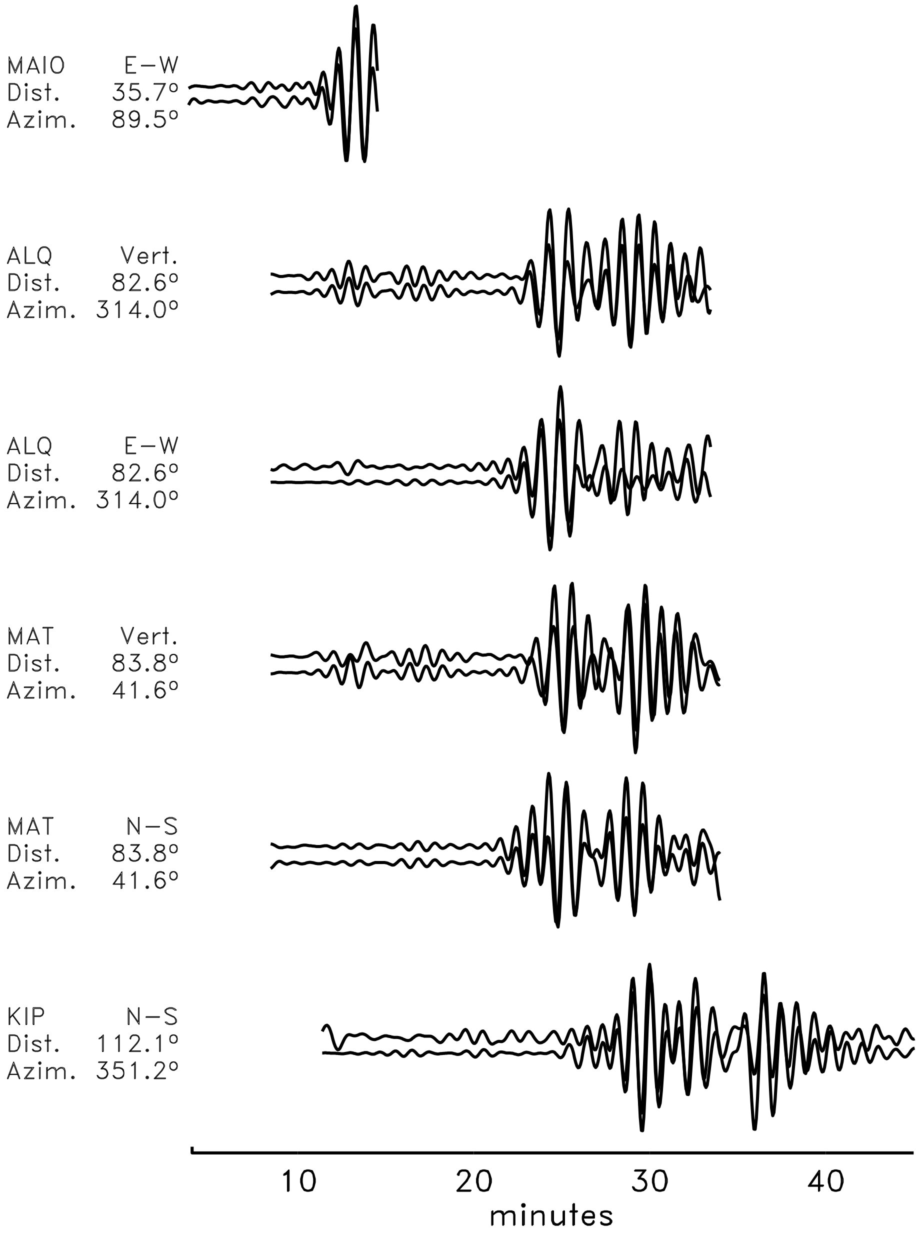
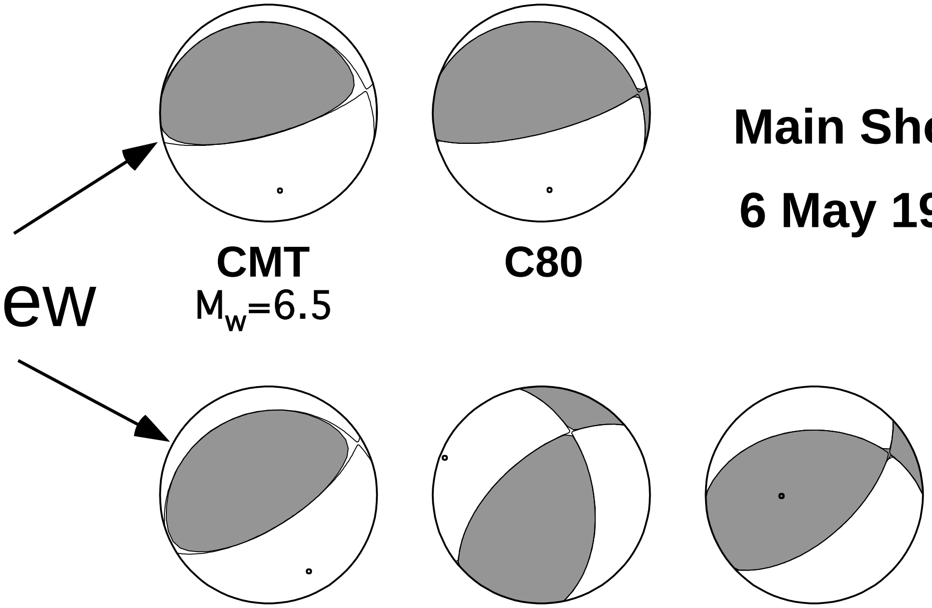
Digital stations in 1976



1976 Friuli earthquake, waveform fits



Friuli Events



new

CMT
M_w=6.5

C80

Main Shock

6 May 1976

CMT
M_w=6.0

C80

A&J

Aftershock

15 Sept. 1976

Ekstrom and Nettles, 1997

Topics:

4. Quality control using noise
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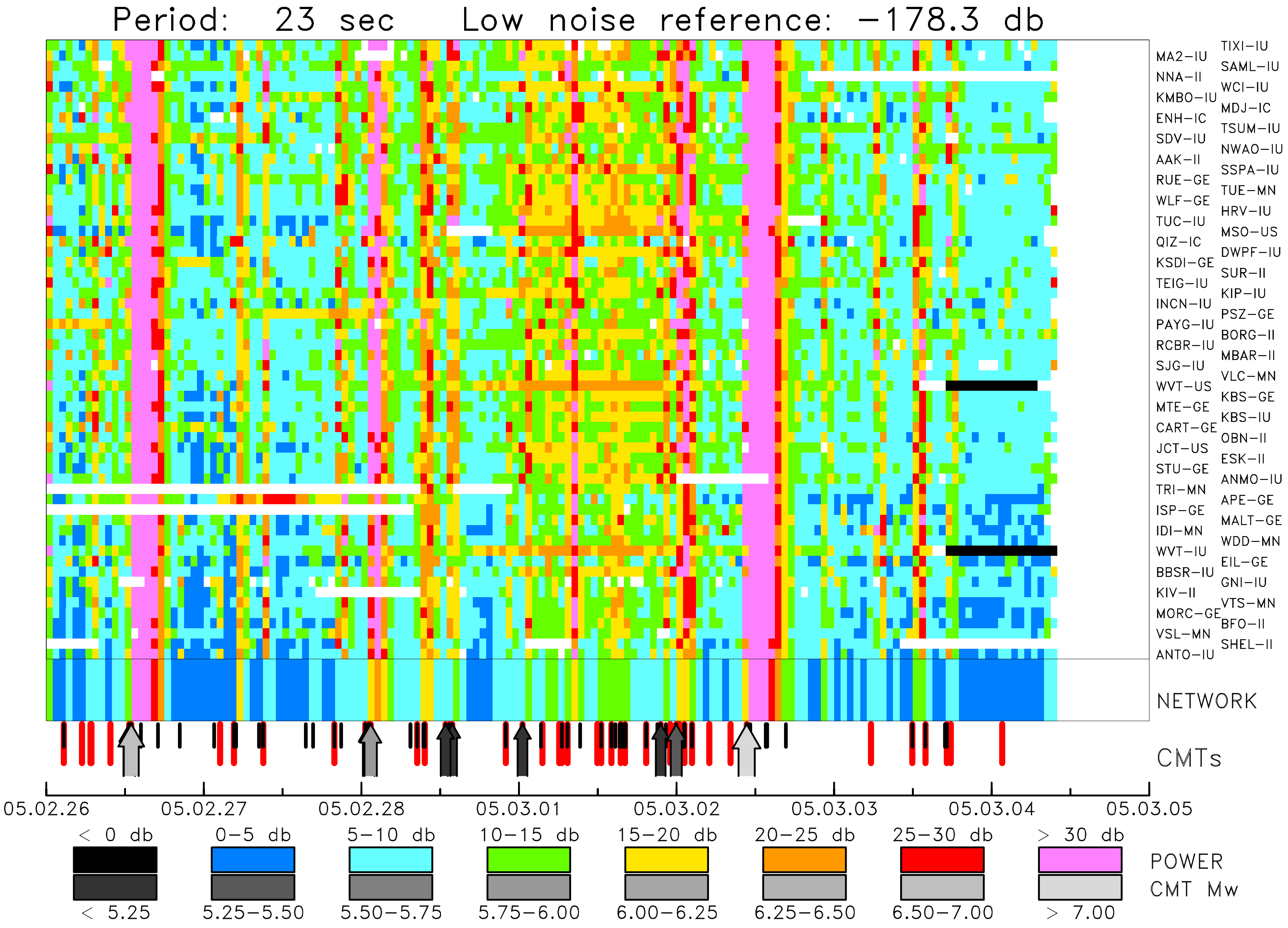
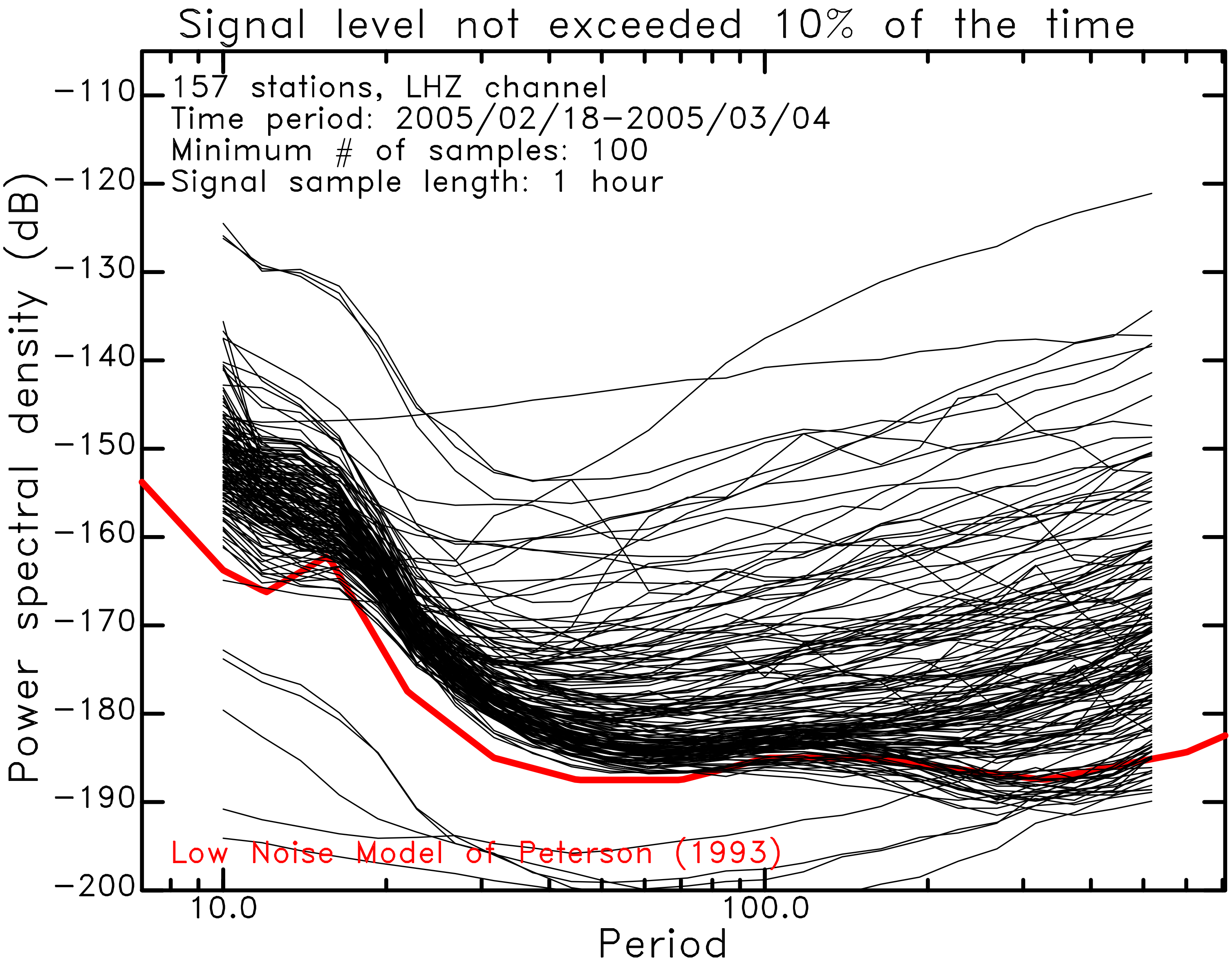
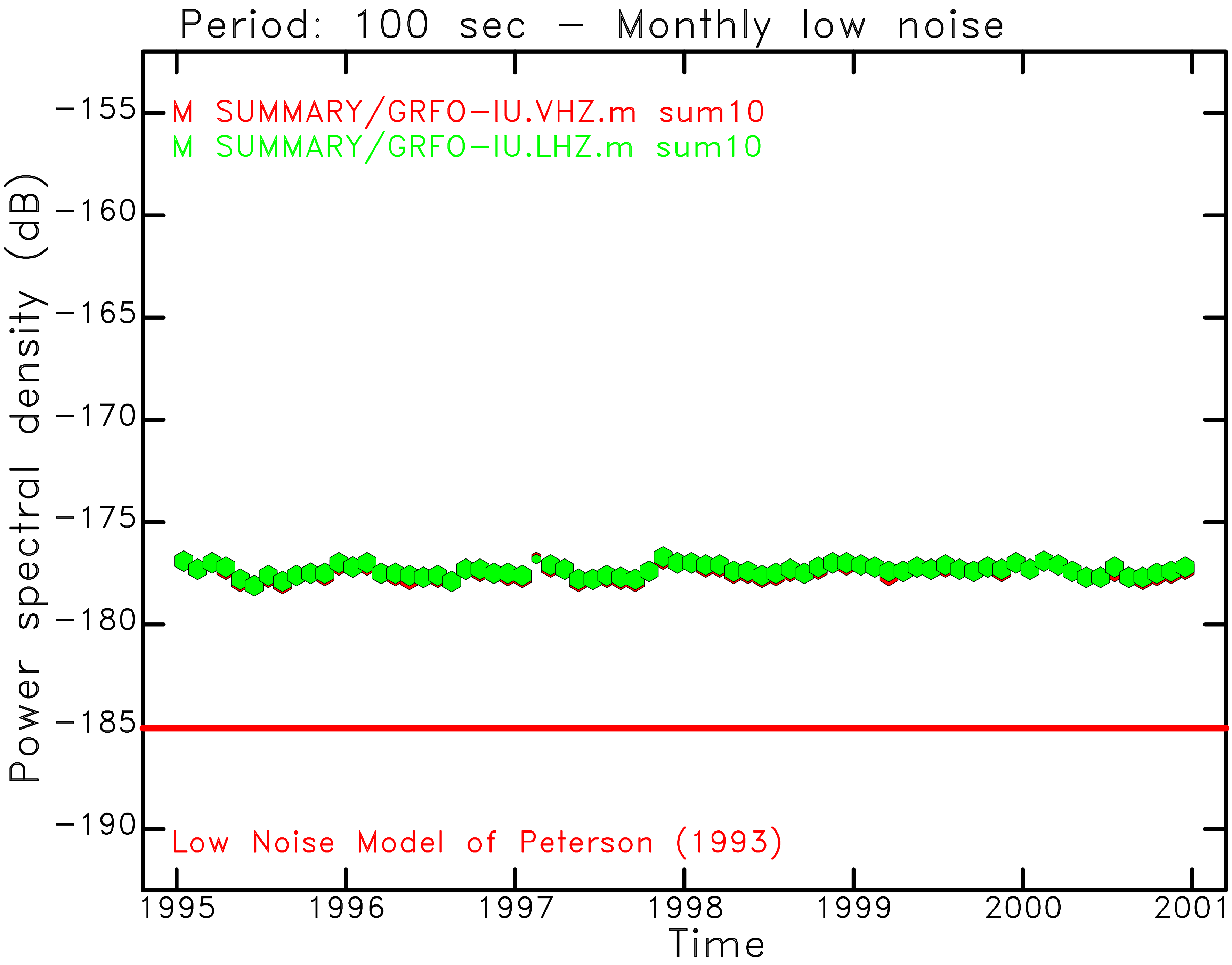
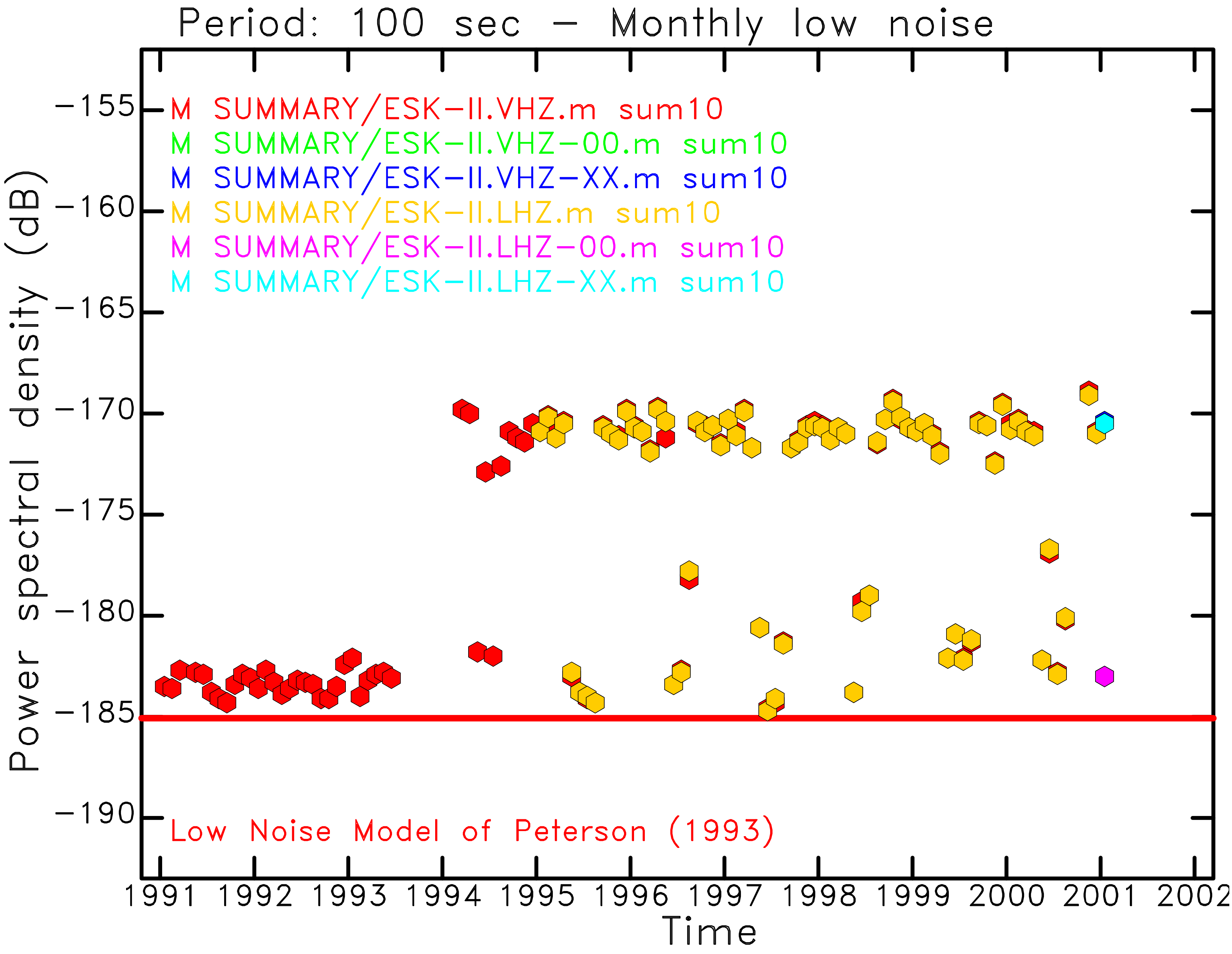

Period: 23 sec Low noise reference: −178.3 db
TIXI−IU
MA2−IU
SAML−IU
NNA−II
WCI−IU
KMBO−IU
MDJ−IC
ENH−IC
TSUM−IU
SDV−IU
NWAO−IU
AAK−II
SSPA−IU
RUE−GE
TUE−MN
WLF−GE
HRV−IU
TUC−IU
MSO−US
QIZ−IC
DWPF−IU
KSDI−GE
SUR−II
TEIG−IU
KIP−IU
INCN−IU
PSZ−GE
PAYG−IU
BORG−II
RCBR−IU
MBAR−II
SJG−IU
VLC−MN
WVT−US
KBS−GE
MTE−GE
KBS−IU
CART−GE
OBN−II
JCT−US
ESK−II
STU−GE
ANMO−IU
TRI−MN
APE−GE
ISP−GE
MALT−GE
IDI−MN
WDD−MN
WVT−IU
EIL−GE
BBSR−IU
GNI−IU
KIV−II
VTS−MN
MORC−GE
BFO−II
VSL−MN
SHEL−II
ANTO−IU
NETWORK
CMTs
05.02.26
05.02.27
05.02.28
05.03.01
05.03.02
05.03.03
05.03.04
05.03.05
< 0 db
0−5 db
5−10 db
10−15 db
15−20 db
20−25 db
25−30 db
> 30 db
POWER
CMT Mw
< 5.25
5.25−5.50
5.50−5.75
5.75−6.00
6.00−6.25
6.25−6.50
6.50−7.00
> 7.00


Signal level not exceeded 10% of the time


Period: 100 sec – Monthly low noise
M SUMMARY/GRFO–IU.VHZ.m sum10
M SUMMARY/GRFO–IU.LHZ.m sum10
Power spectral density (dB)
–155
–160
–165
–170
–175
–180
–185
–190
Low Noise Model of Peterson (1993)
1995
1996
1997
1998
1999
2000
2001
Time


Period: 100 sec – Monthly low noise
M SUMMARY/ESK-II.VHZ.m sum10
M SUMMARY/ESK-II.VHZ-00.m sum10
M SUMMARY/ESK-II.VHZ-XX.m sum10
M SUMMARY/ESK-II.LHZ.m sum10
M SUMMARY/ESK-II.LHZ-00.m sum10
M SUMMARY/ESK-II.LHZ-XX.m sum10
Low Noise Model of Peterson (1993)
Power spectral density (dB)
−155
−160
−165
−170
−175
−180
−185
−190
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Time

Topics:

5. Finding interesting things in the noise

Surface-wave dispersion

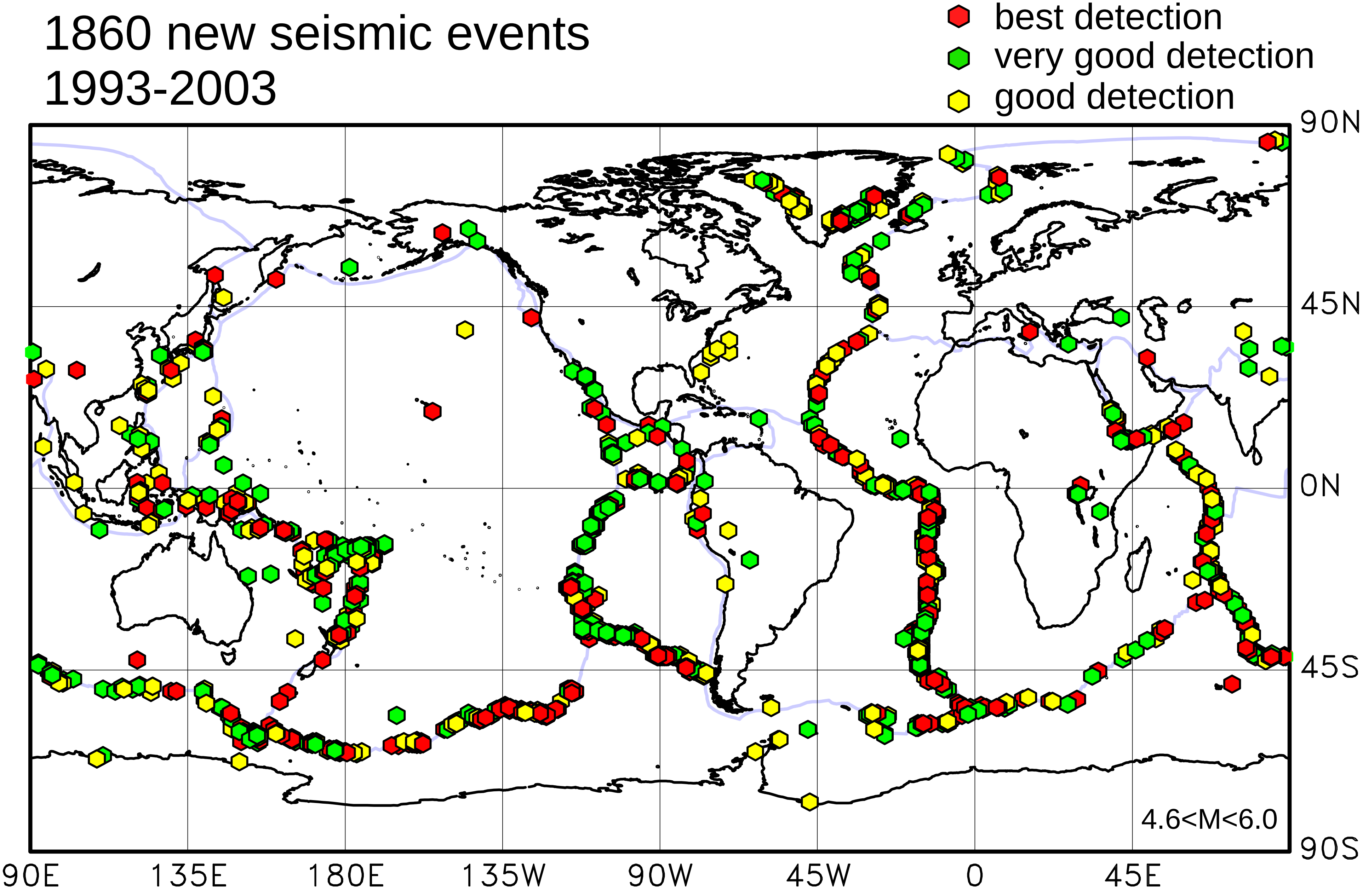
Seismic surface waves are *dispersive*, $c = c(\omega)$, where c is the velocity, $\omega = \frac{2\pi}{T}$ and T is the period of the wave.

Travel time τ is therefore dependent on frequency, $\tau(\omega)$.

For the travel time from point (θ_A, φ_A) to point (θ_B, φ_B) we write,

$$\tau(\omega) = \int_A^B \frac{ds}{c(\theta, \varphi; \omega)}$$

with velocity depending on position, $c(\theta, \varphi)$.


1860 new seismic events
1993-2003
best detection
very good detection
good detection
90N
45N
0N
45S
90S
90E
135E
180E
135W
90W
45W
0
45E
4.6<M<6.0

Web pages for earthquake locations and QC

`www.seismology.harvard.edu/˜ekstrom/Projects/RTDH.html`

`www.seismology.harvard.edu/˜ekstrom/Projects/WQC.html`