Magnetic field background variations can limit the sensitivity of seismic broad-band sensors

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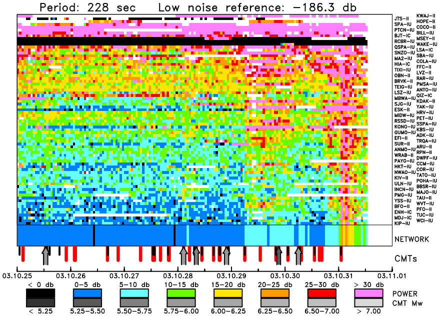
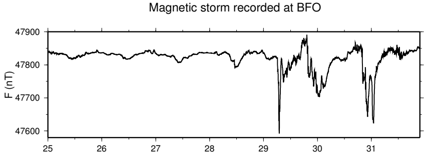
Response of the GSN to a magnetic storm



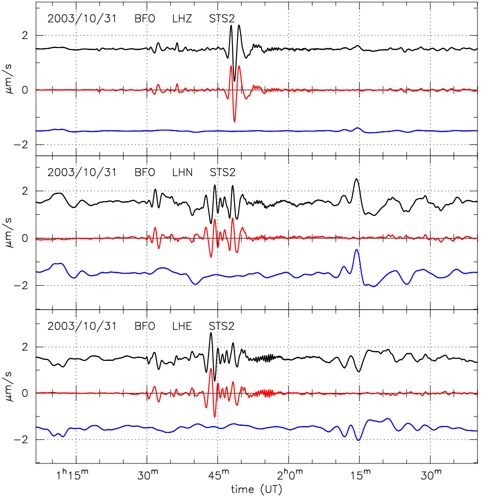


Signal power at 228 s period for stations of the Global Seismographic Network (GSN)

Courtesy of Göran Ekström (Signal Power at Digital Broadband Stations Derived from Near Real Time Data, LDEO Seismology Research: Seismic Noise) `http://www.ldeo.columbia.edu/~ekstrom/Research/Noise/RADB_hourly_rms.html`

Removing magnetic field noise from seismic recordings

velocity seismograms (100 s – 360 s)

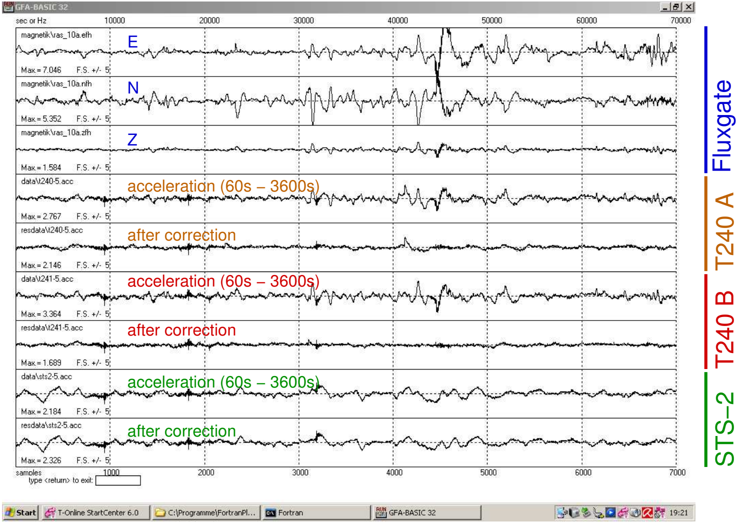


original recording

after correction

magnetic field contribution

Two Trillium T240 and one STS-2 in a huddle test at BFO



Sensitivity of vertical component to magnetic field

Trillium seismometers in the huddle test

Seismometer	$s_E\left(\frac{\mathrm{m}}{\mathrm{T\,s}^2}\right)$	$s_N\left(\frac{\mathrm{m}}{\mathrm{T\,s}^2}\right)$	$s_Z\left(\frac{\mathrm{m}}{\mathrm{T\,s}^2}\right)$	$\lvert\vec{S}\rvert\left(\frac{\mathrm{m}}{\mathrm{T\,s}^2}\right)$
T240 A	0.0633	0.0186	1.4840	1.485
T240 B	0.0890	-0.1409	1.3116	1.322

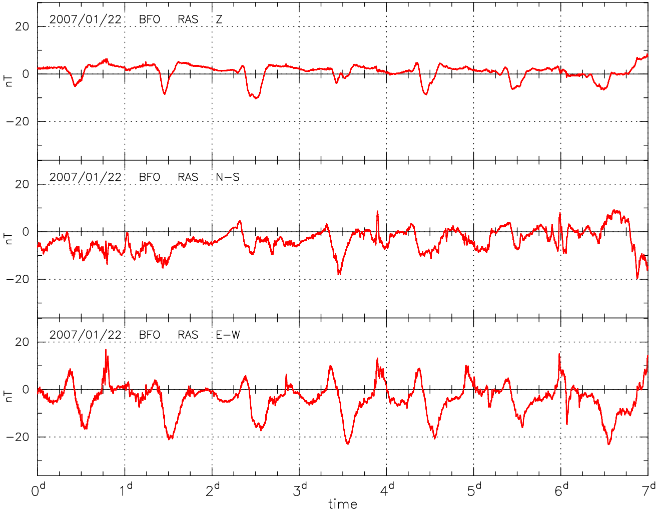
Sensitivity of vertical component to magnetic field

GRSN seismometers relative to magnetic field at BFO

Seismometer	$s_E\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$s_N\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$s_Z\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$\lvert\vec{S}\rvert\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$
T240 A	0.0633	0.0186	1.4840	1.485
T240 B	0.0890	-0.1409	1.3116	1.322
Station	$s_X\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$s_Y\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$s_Z\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$	$\lvert\vec{S}\rvert\ \left(\frac{\mathrm{m}}{\mathrm{T\,s^2}}\right)$
BFO (STS-1)	0.0035	0.0008	-0.0693	0.069
BFO (STS-2)	0.0242	0.0020	-0.0697	0.074
BRG (STS-2)	0.0155	0.0563	-0.0334	0.067
BUG (STS-2)	-0.1036	-0.0771	0.4533	0.49
CLL (STS-2)	-0.0072	-0.0283	0.0414	0.051
CLZ (STS-2)	0.0981	-0.2172	1.2001	1.2
FUR (STS-2)	0.1652	-0.0003	0.3676	0.40
MOX (STS-2)	-0.0418	-0.0695	-0.0598	0.11
TNS (STS-2)	0.1712	-0.1220	-0.1083	0.31

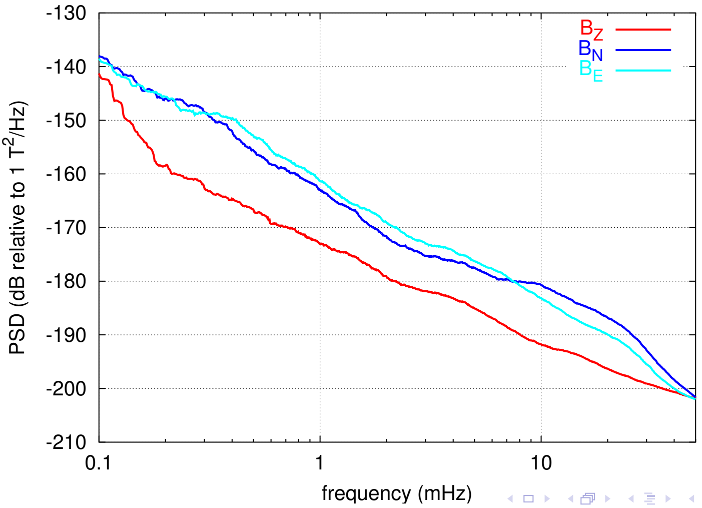
Contribution by magnetic field for 7 days in January 2007

Magnetic field recordings (periods > 50 s)



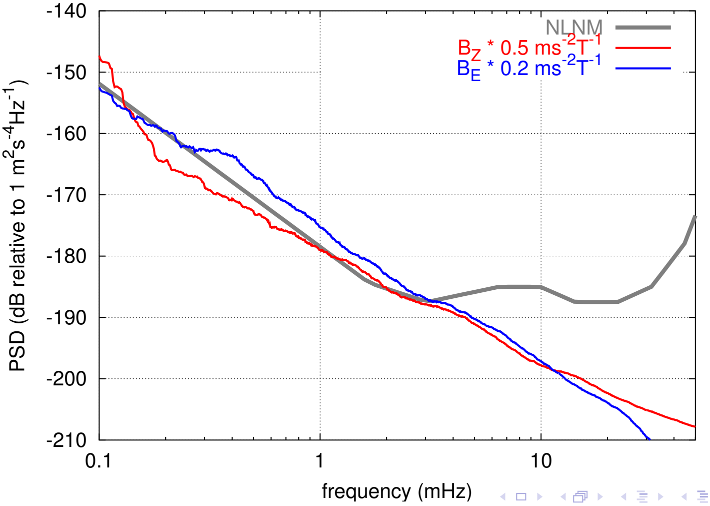
Contribution by magnetic field for 7 days in January 2007

Power spectral density



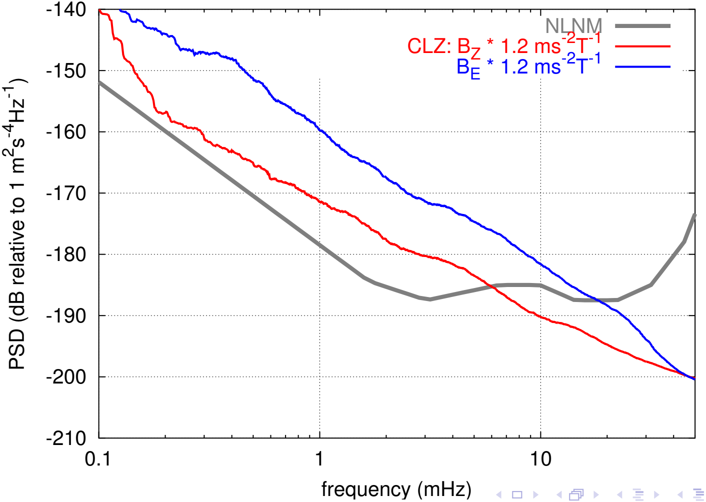
Contribution by magnetic field for 7 days in January 2007

Expected contribution to seismometer noise



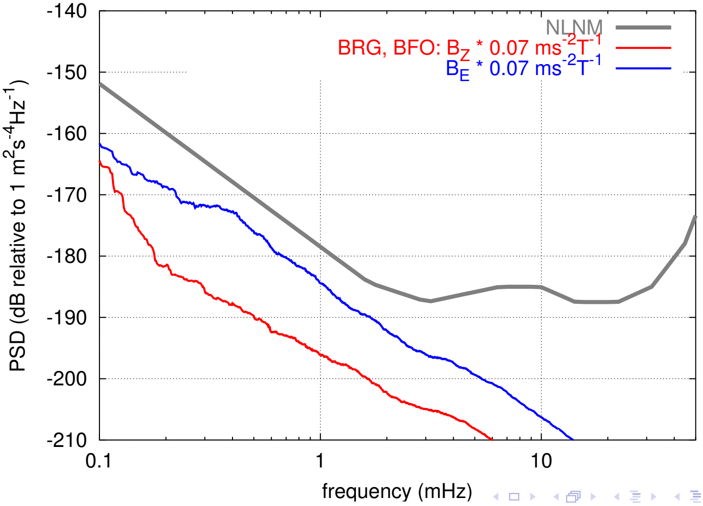
Contribution by magnetic field for 7 days in January 2007

Expected contribution to seismometer noise



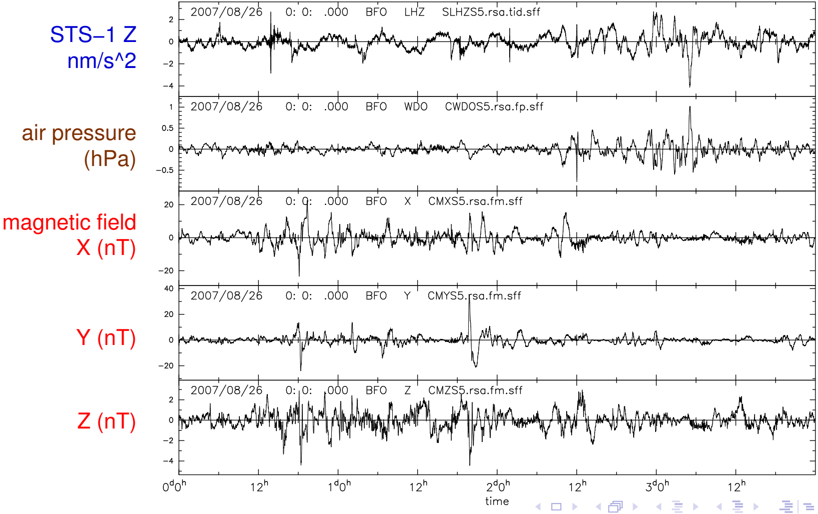
Contribution by magnetic field for 7 days in January 2007

Expected contribution to seismometer noise



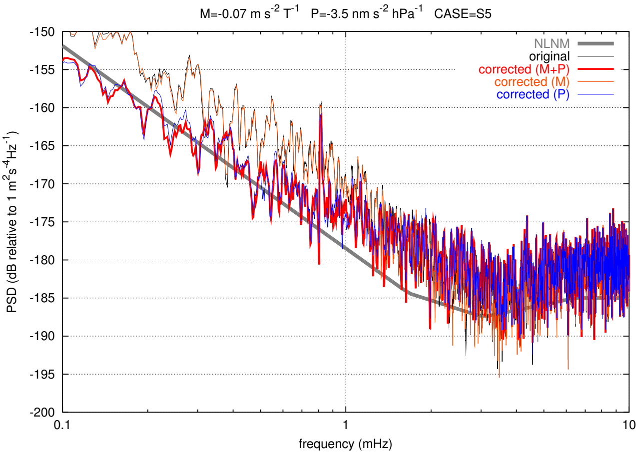
Simultaneous correction for air pressure and magnetic field

Recordings (band-pass: 100 s – 3 h)



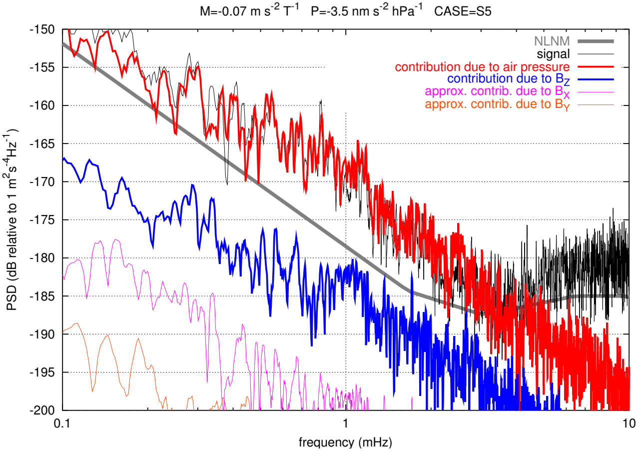
Simultaneous correction for air pressure and magnetic field

Effect of corrections



Simultaneous correction for air pressure and magnetic field

Potential contributions to recorded signal



Conclusions

- Noise induced by the magnetic field background variations can exceed the NLNM in the normal-mode band (between 0.5 mHz and 3 mHz) for instruments with sensitivity larger than 0.2 $\frac{\mathrm{m}}{\mathrm{T\,s}^2}$.
- It is crucial to find appropriate means to ensure a low sensitivity to magnetic fields when designing and installing high-sensitive broad-band seismometers for the observation of normal modes.
- The ineffectiveness of air-pressure corrections for the STS-1 at BFO cannot be explained by magnetic field induced noise.

Acknowledgements

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Noise power after correction