Secondary microseism noise sources

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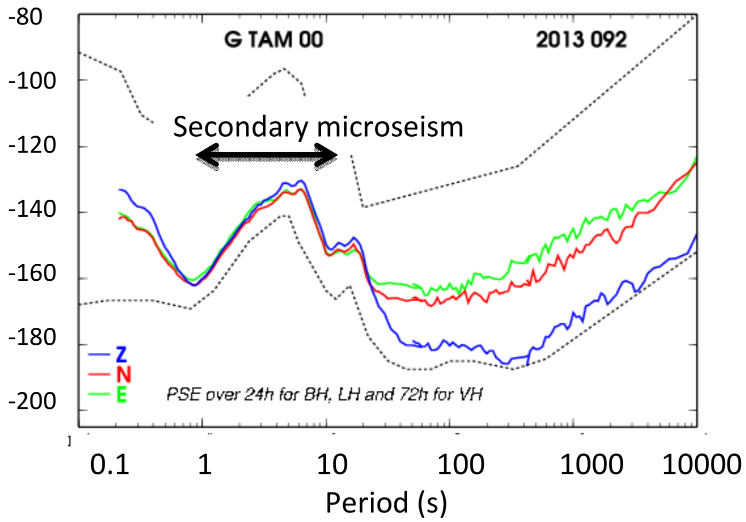
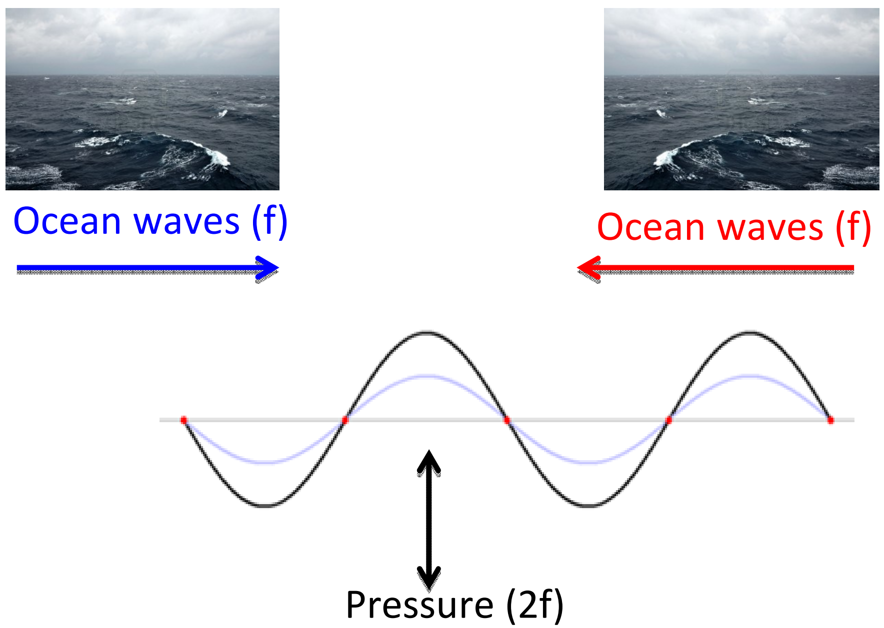
Secondary microseism sources

Seismic noise spectrum over one day



<u>Source of secondary microseism:</u>
The interaction of ocean waves of similar frequency and opposite directions generate pressure fluctuations that is not attenuated with depth and vary with twice the frequency of the ocean waves



Longuet Higgins, 1950; Hasselman, 1953

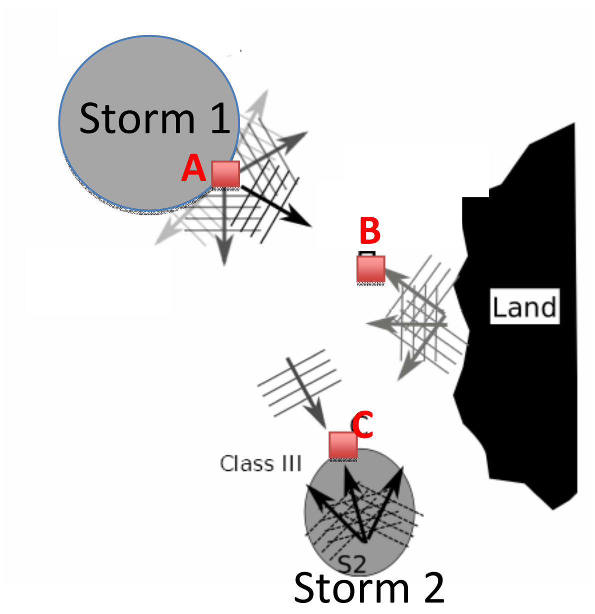
Ocean wave model

Noise sources are generated when there is interaction of ocean waves:

A.within a storm

B.by reflection at the coast

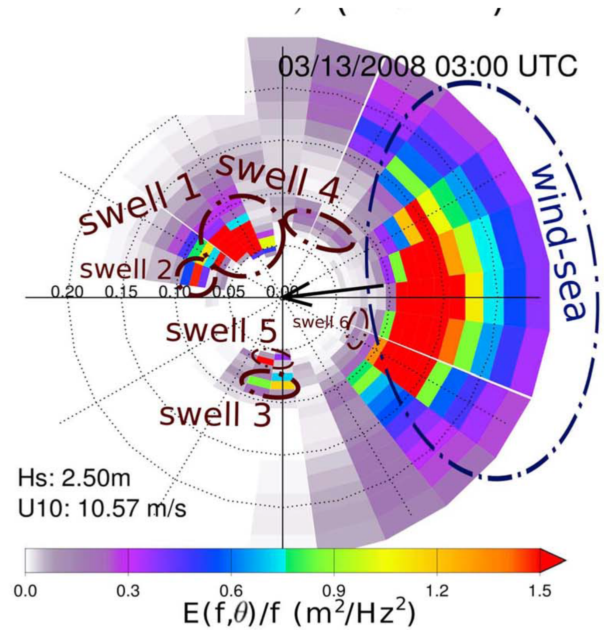
C.between storms



Ocean wave interactions are modelled every 6 hours

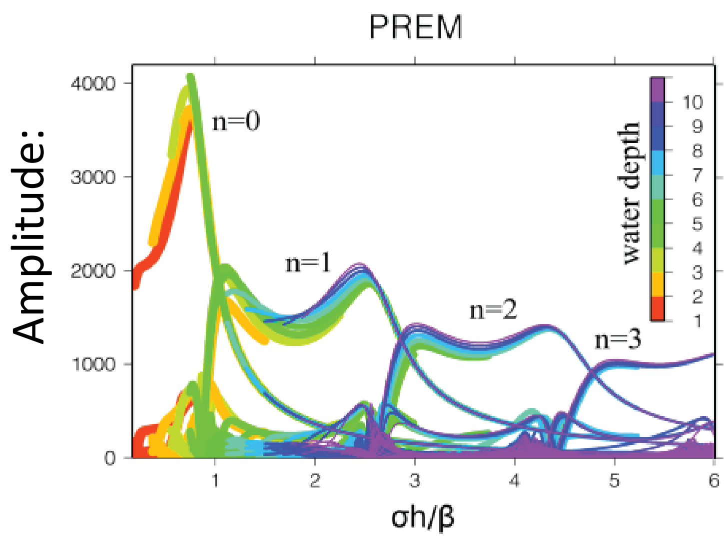
(code WAVEWATCH III, version 3.14, 6-hourly wind analysis from ECMWF).

(Ardhuin et al. 2011)

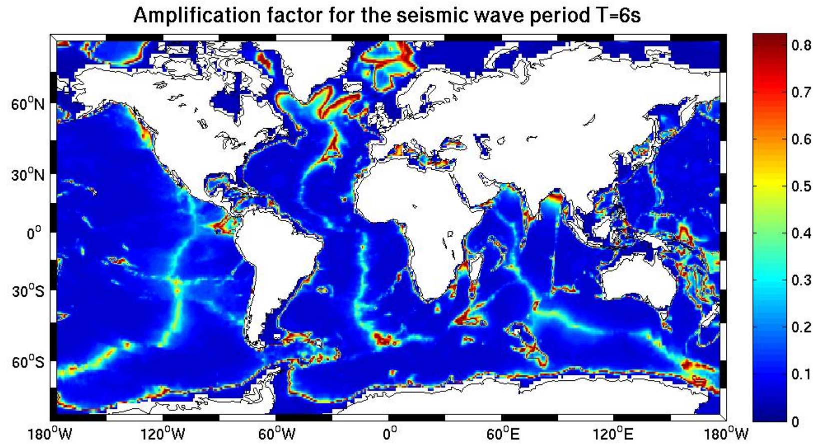


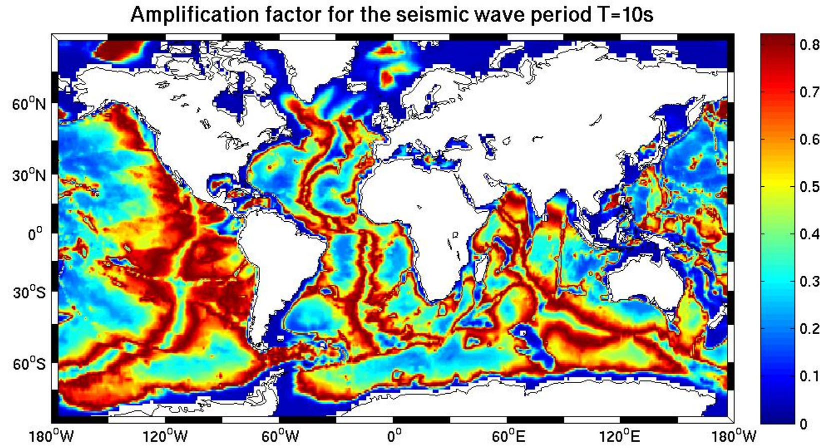
Rayleigh wave noise source

Rayleigh waves amplification:



Frequency dependent modulation of the source that depends on the local structure (bathymetry and crust)

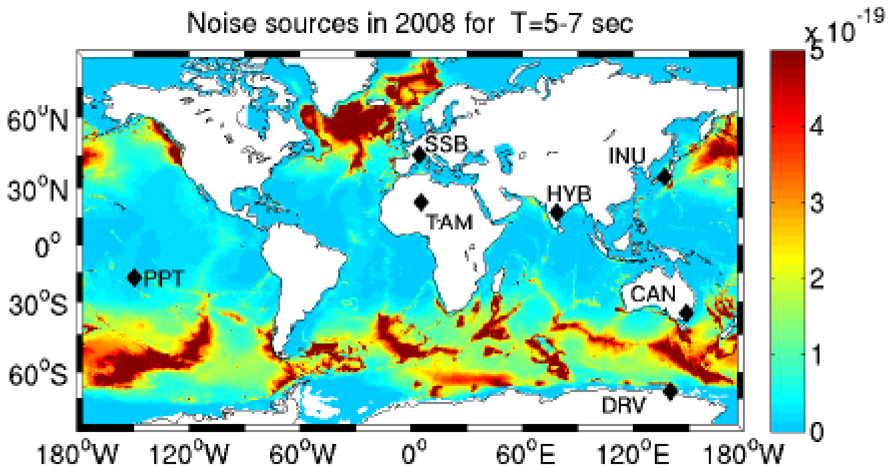




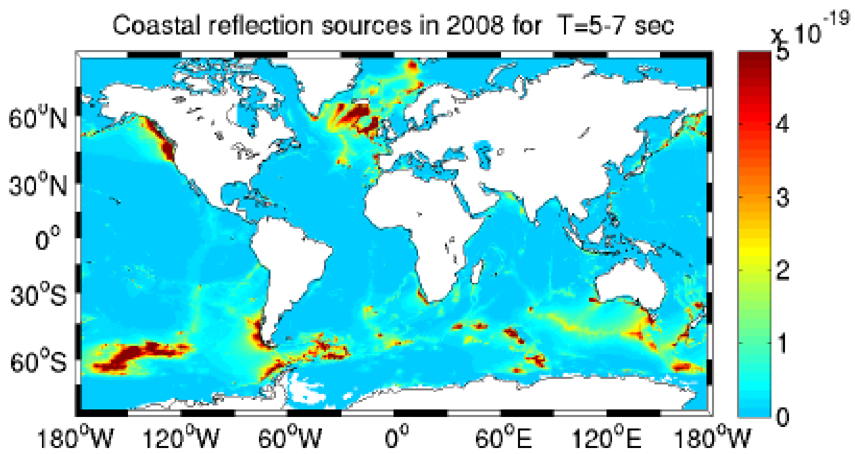
Longuet-Higgins 1950, …etc…, Stutzmann at al. 2012, Gualtieri et al., 2013

Rayleigh wave noise source

Rayleigh wave sources averaged over 2008



Coastal reflection Coefficient (R=5%)
to be adjusted!

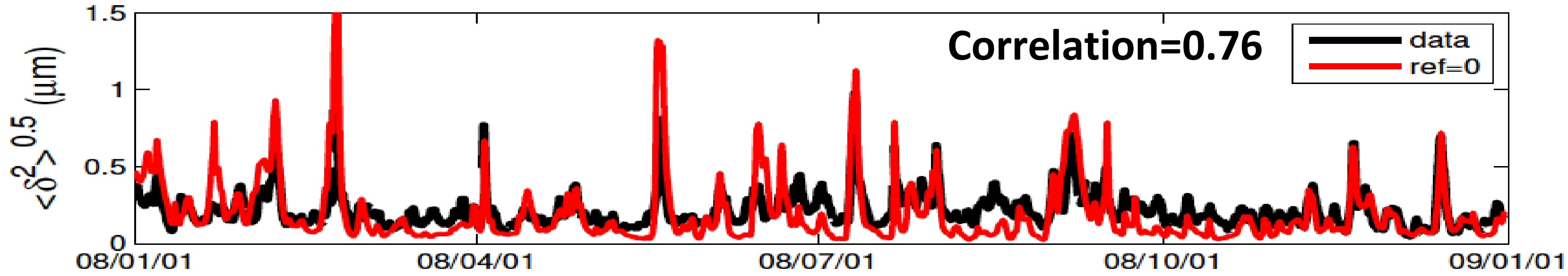


Stutzmann at al. 2012

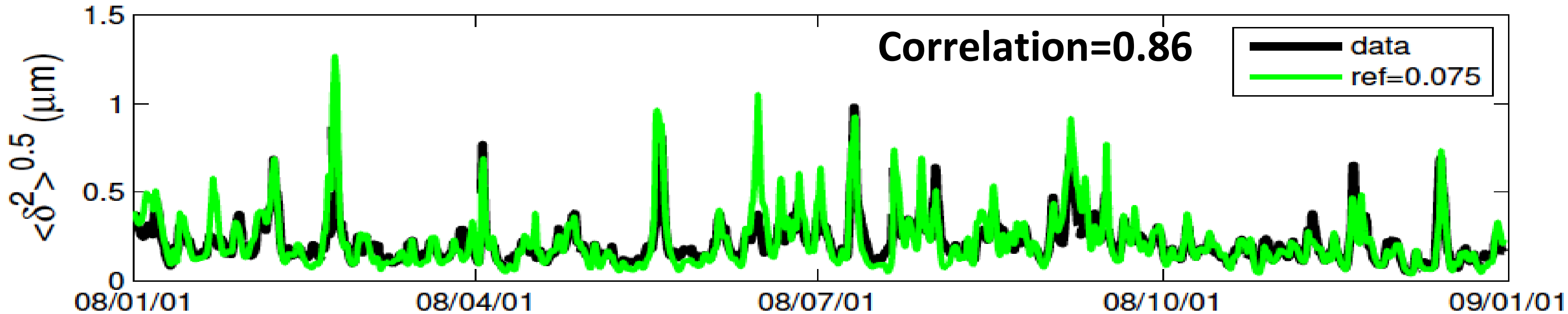
Modelling seismic spectra

Real and synthetic seismic spectra – Periods: 5-7sec

Without coastal reflection



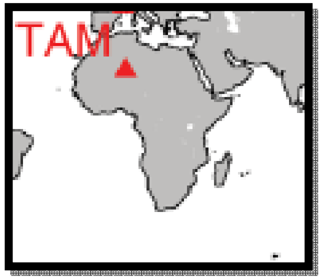
With coastal reflection

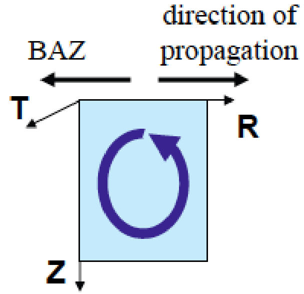


Strongest sources are related to the cyclonic activity
Smaller sources are generated by coastal reflection

Stutzmann at al. 2012

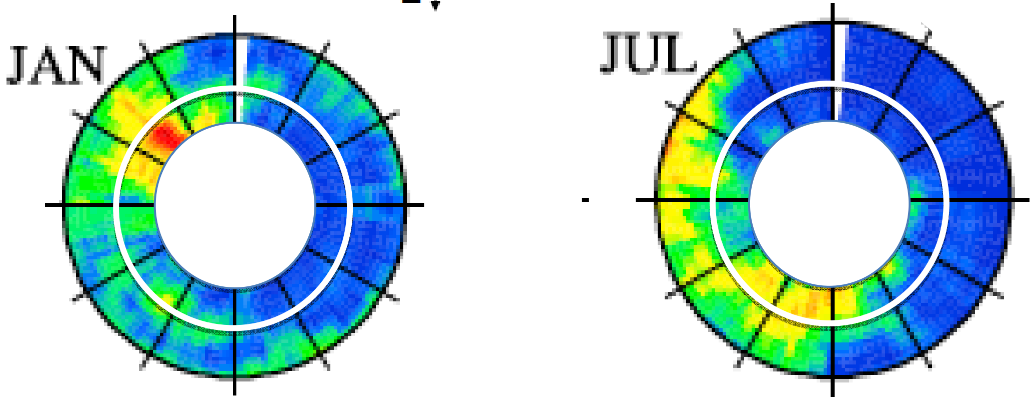
Rayleigh wave polarization

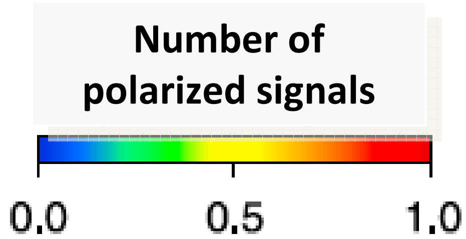




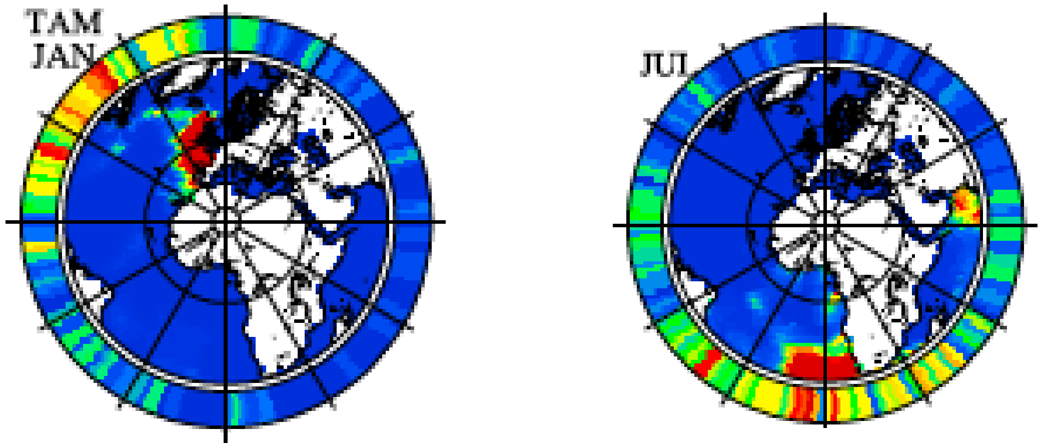
Statistical analysis of the polarization:
Schimmel et al., 2004

Frequency:
0.05-0.25 Hz



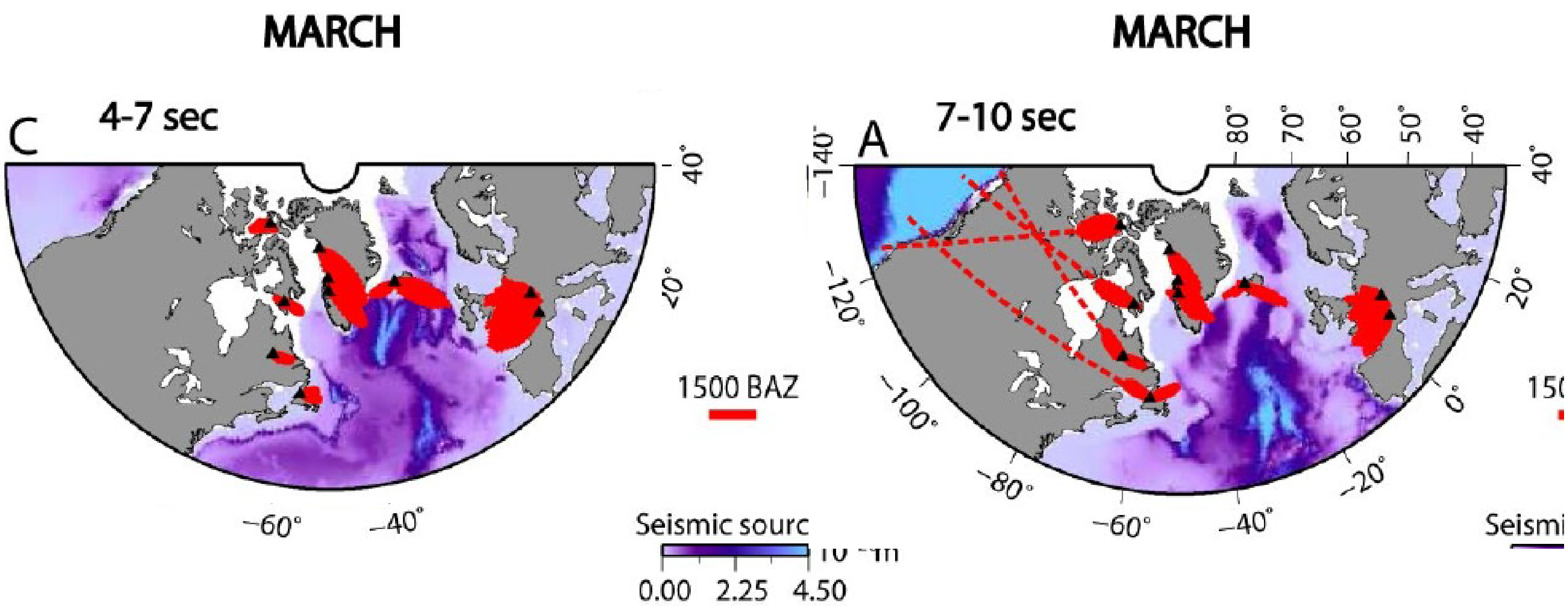


Frequency:
0.1-0.15 Hz



Schimmel et al., 2011

Rayleigh wave polarization



Frequency dependent noise polarization is well correlated with the corresponding sources

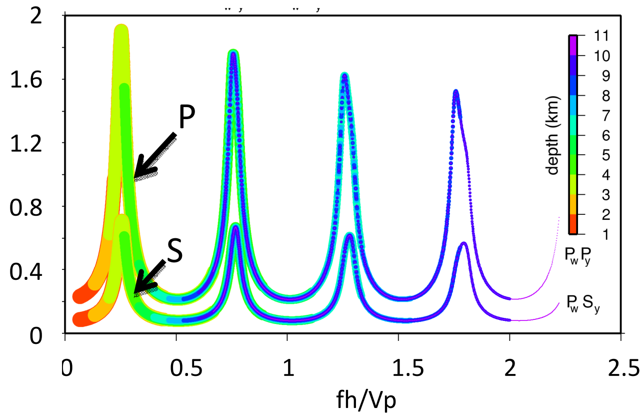
Sergeant-Boy et al, submitted

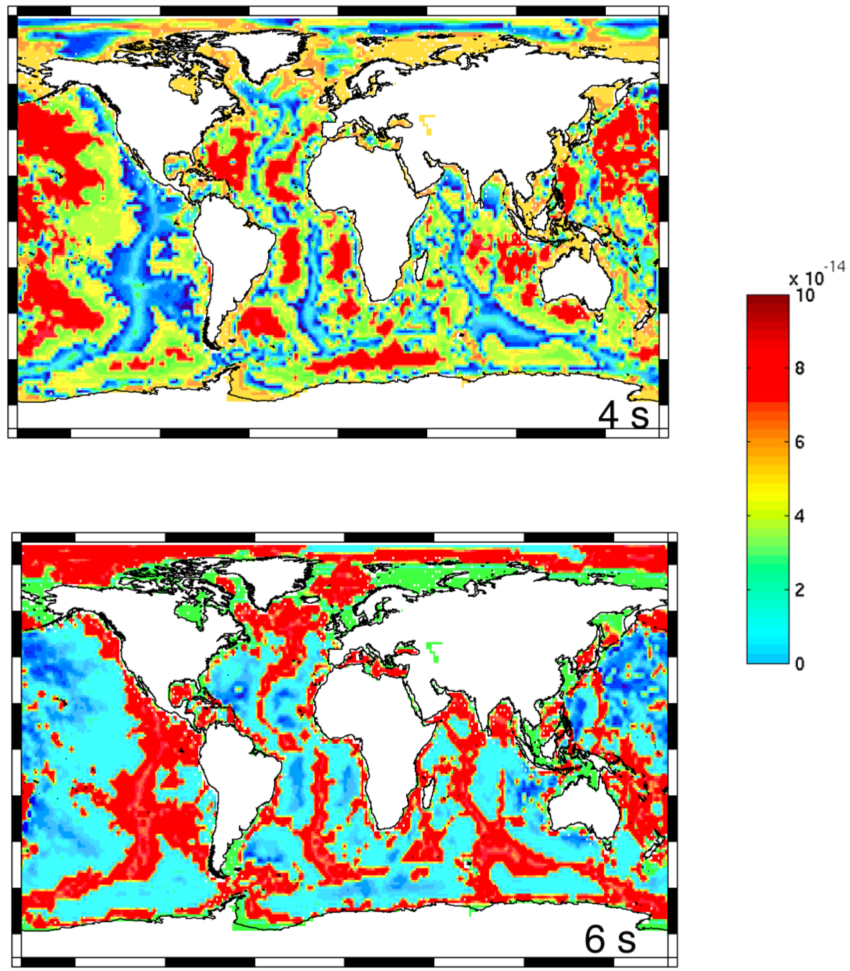
Body wave noise source

Source= ocean wave interactions

+

Body wave amplification due to bathymetry





- Stronger variability with frequency than for Rayleigh waves

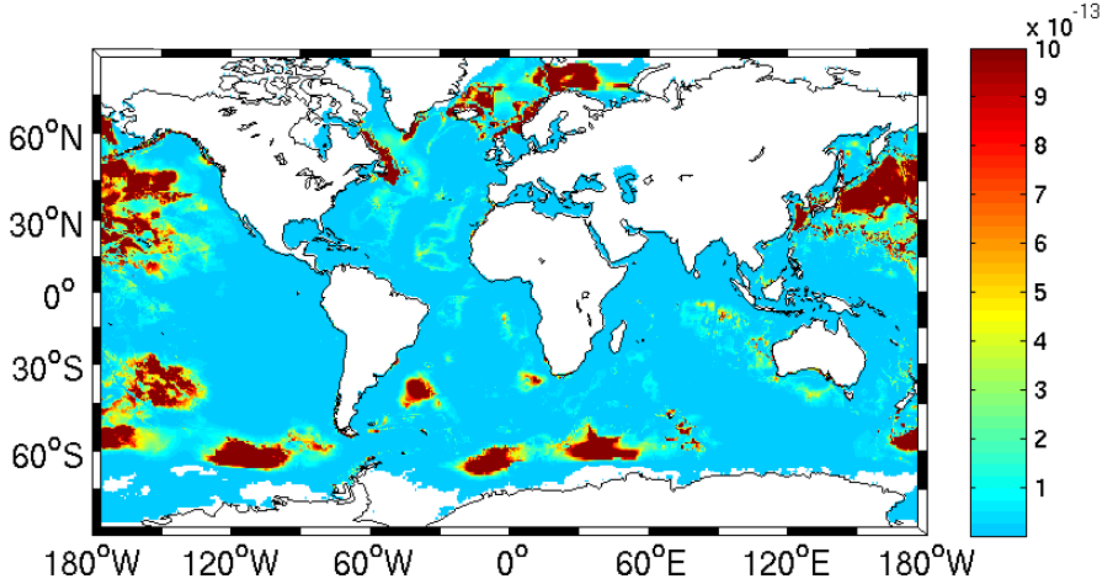
- Same source location for P and S waves

Ardhuin et al., 2013, Gualtieri et al.

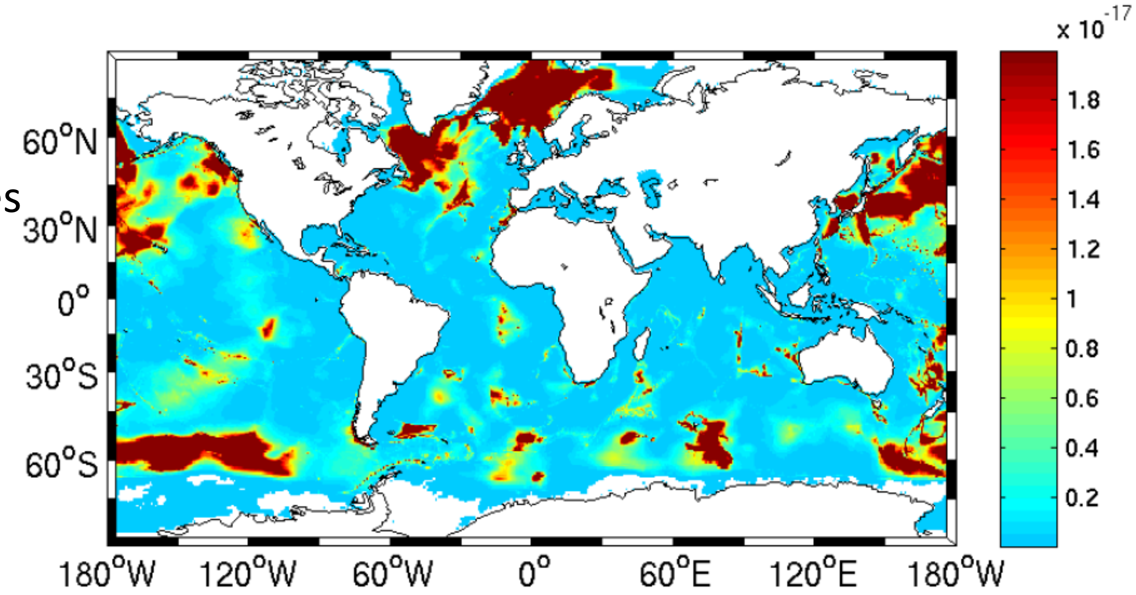
Body wave noise source

Period : 5sec

Body wave sources averaged over 2010

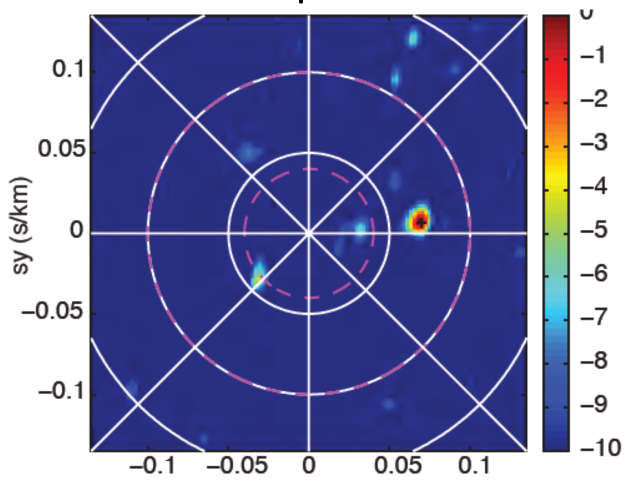


Rayleigh wave sources averaged over 2010

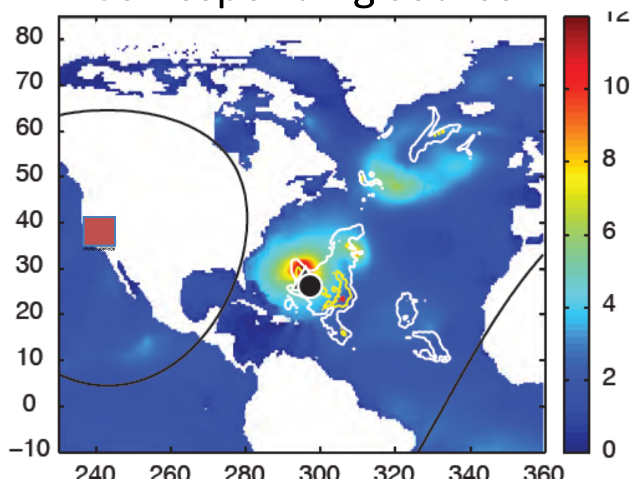


Body wave noise source

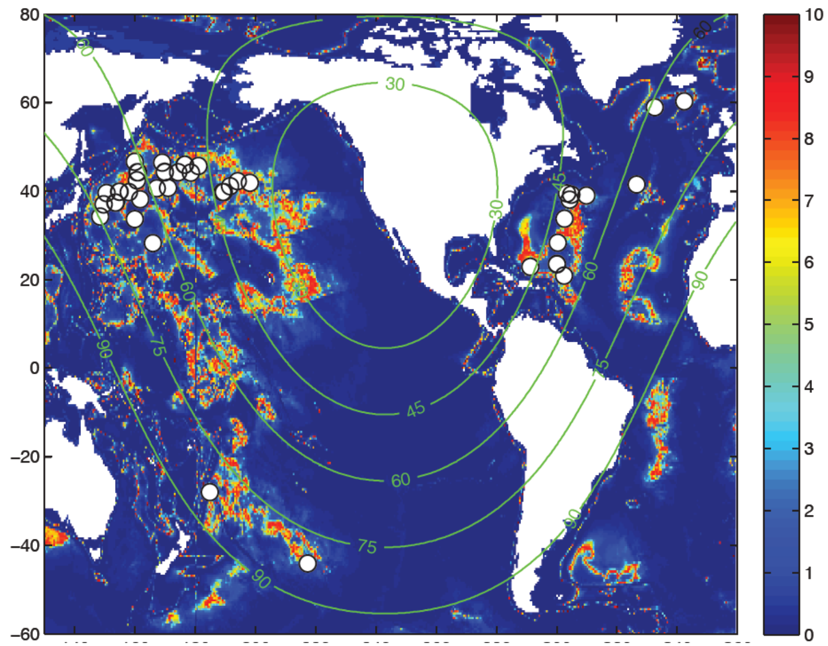
Beam power



Corresponding source



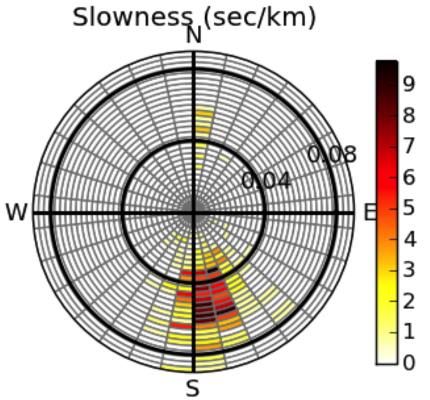
1) Extraction of the strongest source from the wave model (time & location)
2) Beamforming of seismic data

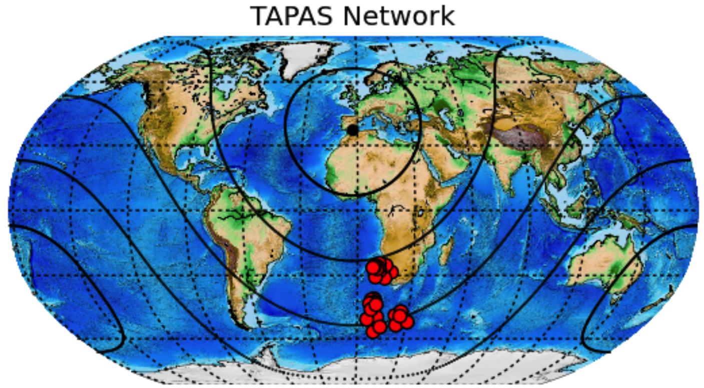


Most of the <u>strongest</u> sources recorded are in deep ocean and related to cyclonic activity

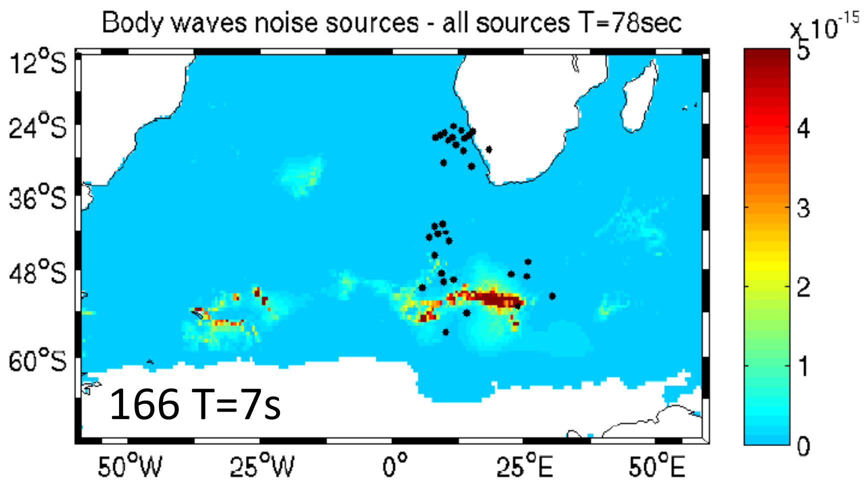
Obrebski et al. under review, JGR

P wave noise source

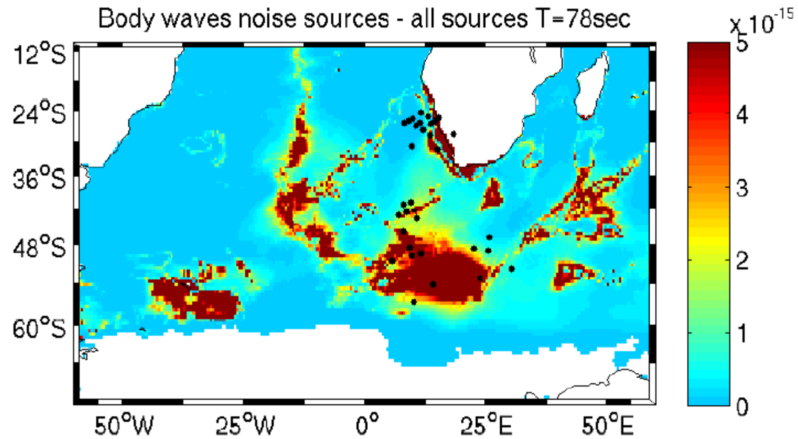




No coastal reflection

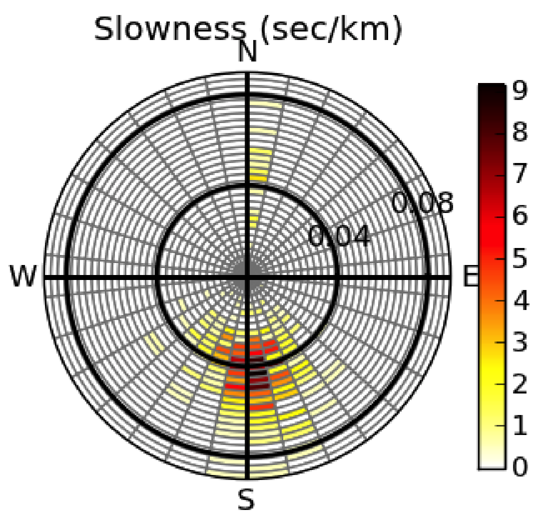


5% coastal reflection

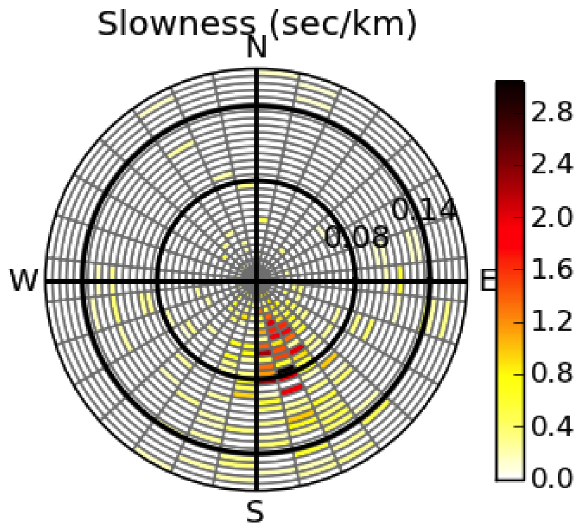


P and S wave noise source

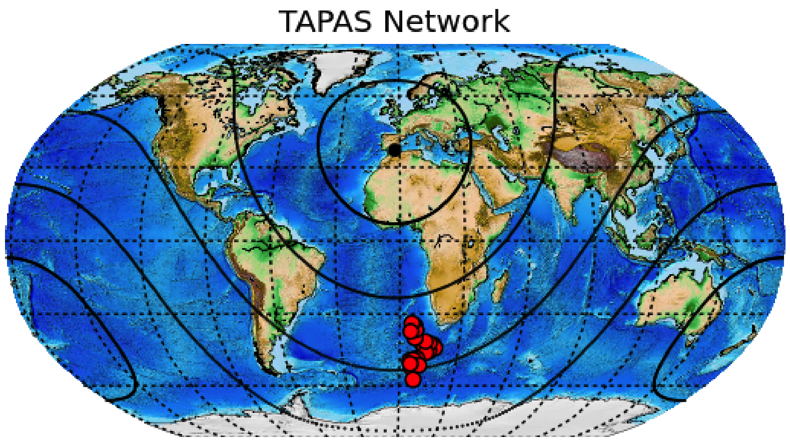
Z component: P wave detected

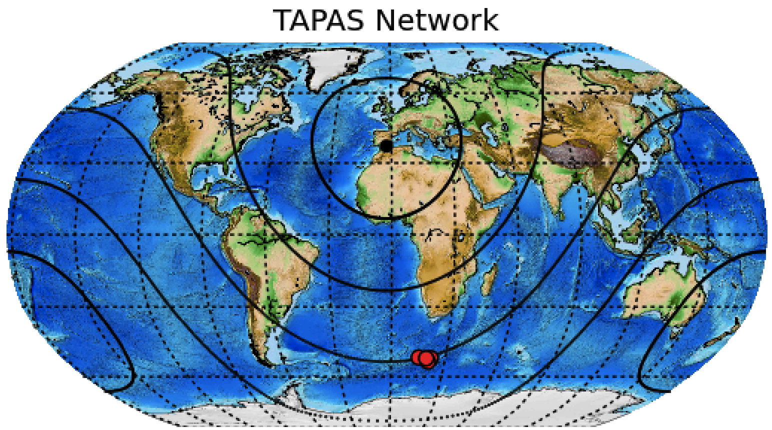


N-S component: S-wave detected



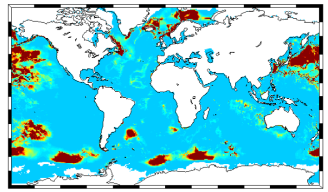
Day 177 - period 6sec





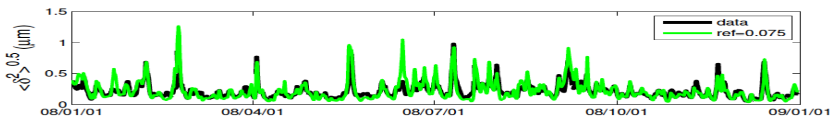
Conclusions

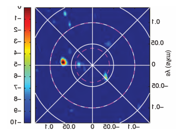
- Seismic noise sources are frequency dependent due to :
  - the ocean wave interaction location and frequencies
  - the modulation due to local bathymetry and structure



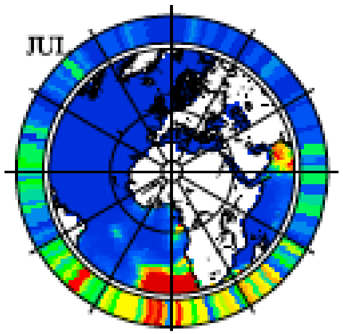
- Coastal and pelagic sources are needed to explain seismic noise recordings for both Rayleigh waves and body waves

- The strongest sources of both Rayleigh waves and boby waves are related to the cyclonic activity

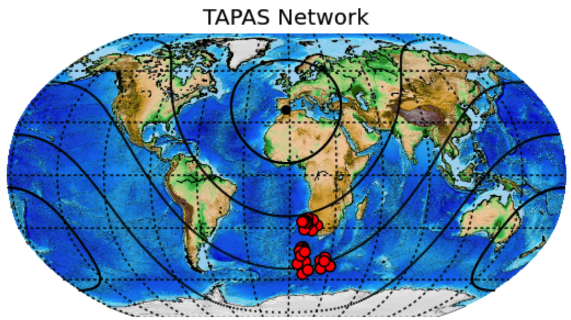




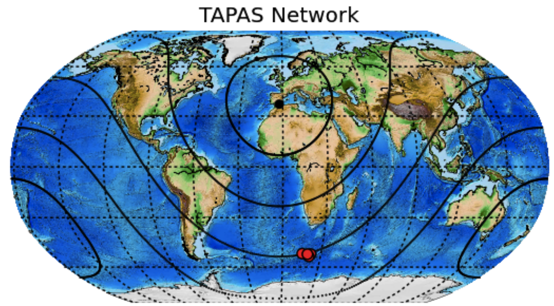
- P and S waves are generated in the same areas



Rayleigh waves



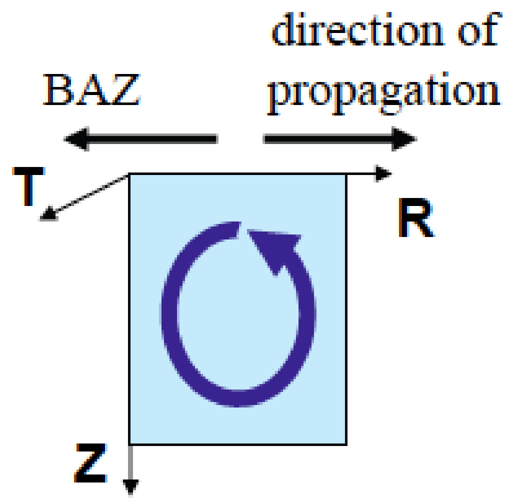
P-waves



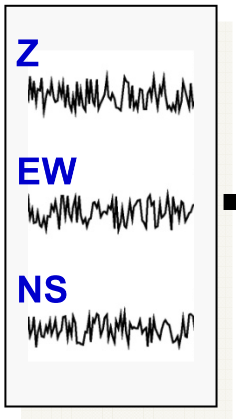
S-waves

Data processing

Search for Rayleigh waves in the noise
(period 3-20 sec)



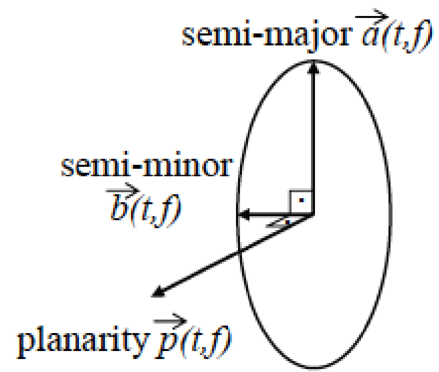
Search for elliptical polarized signal:



S-transform:
Time-frequency
matrices

For each (t,f)
Eigen analysis
of the covariance
matrices

Polarization attributes:



Schimmel and Gallart, 2004, 2005

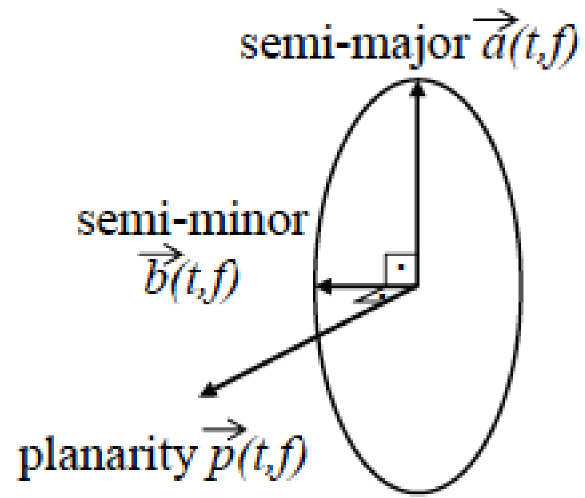
CSIC ICTJA

Data processing

CNRS INSU geoscope IPGP

Mean direction

$$\vec{m}(t,f) = \frac{1}{N(f)} \sum_{\tau=t-\frac{T(f)}{2}}^{t+\frac{T(f)}{2}} \frac{\vec{p}(\tau,f)}{|\vec{p}(\tau,f)|}$$



Degree of polarisation (DOP)

$$c(t,f) = \left(\frac{1}{N(f)} \sum_{\tau=t-\frac{T(f)}{2}}^{t+\frac{T(f)}{2}} \left| \frac{\vec{m}(t,f)}{|\vec{m}(t,f)|} \cdot \frac{\vec{p}(\tau,f)}{|\vec{p}(\tau,f)|} \right|^{\nu_1} \right)^{\nu_2}$$. sin(angle between **Z** and **p**)

DOP=1 Elliptical signal in the vertical plane

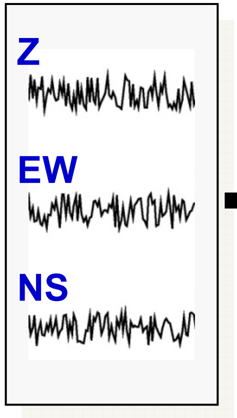
DOP=0 Linear signal

Extraction of robust polarization attributes: BACK AZIMUTH
DEGREE OF POLARIZATION

Schimmel and Gallart, 2004, 2005

Rayleigh wave polarization

Search for ellipticaly polarized signal:



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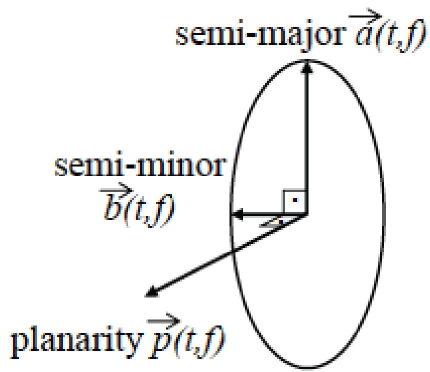

Statistical approach to extract robust:
- Degree of polarization (measure of the ellipticity in the vertical plane)
- Back azimuth

Schimmel and Gallart, 2004, 2005