EGU2013-5375

Variability of the Seismic Noise Sources in North

* Contact: sergeant@ipgp.fr, stutz@ipgp.fr

Amandine Sergeant[1] , Eléonore Stutzmann[1] , Alessia Maggi[2] , Martin Schimmel[3] , Fabrice Ardhuin[4] & Matthias Obrebski[4]

1: Seismology, IPGP, Paris, France - 2: Seismology, IPGS-EOST, Strasbourg, France - 3: ICTJA-CSIS, Barcelona, Spain - 4: IFREMER, Plouzané, France

Abstract

Seismic noise recorded in the frequency band 0.1 and 0.33 Hz is called secondary microseisms. It is dominantly Rayleigh waves which are generated by the interaction of ocean gravity waves. A statistical analysis of the noise polarization at broadband stations in Greenland (GLISN network), Canada and Europe shows that the detected noise sources are frequency dependent. Stations in Eastern Canada record low frequency noise generated in the North Atlantic and Pacific oceans and higher frequency noise only from the North Atlantic. Greenland stations do not detect the Pacific sources. Sea ice in the Labrador Sea in winter is well correlated with the decrease of high frequency seismic noise and with the change of the source azimuths. Indeed, in winter the sea ice prevents the generation of noise sources in that area. We model the seismic noise using an oceanographic model that takes into account ocean wave coastal reflections which enable to accurately model the noise spectrum temporal and frequency variations. The strongest sources are generated in deep ocean close to the ridge axis. Sources generated by coastal reflection are negligible along the Eastern Canada coast and more important along Greenland and European coasts. The strongest noise source locations are consistent with the back azimuths measured by polarization analysis and they depend on both frequency and bathymetry.

1. Rayleigh Waves Polarization

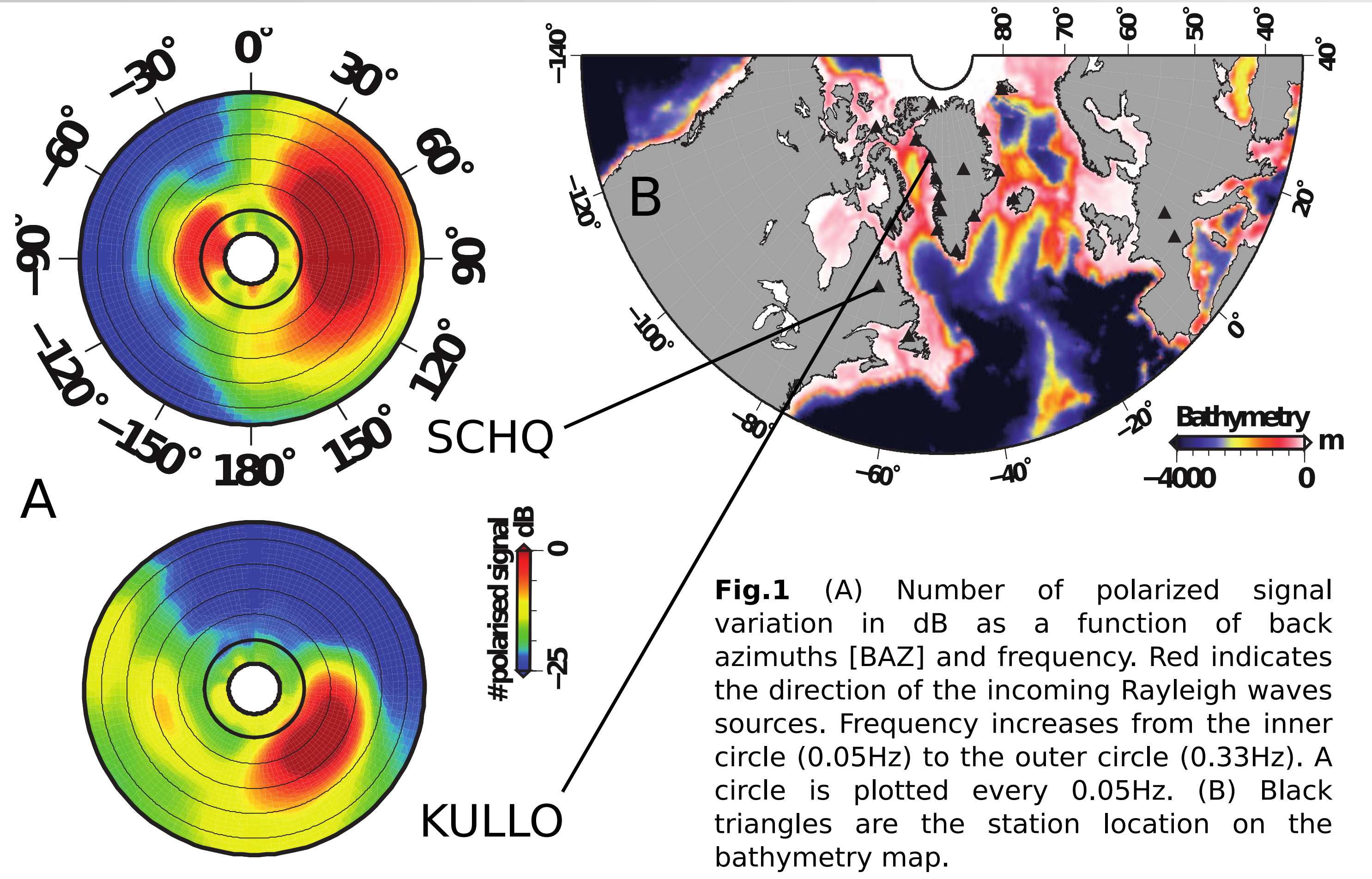


Fig.1 (A) Number of polarized signal variation in dB as a function of back azimuths [BAZ] and frequency. Red indicates the direction of the incoming Rayleigh waves sources. Frequency increases from the inner circle (0.05Hz) to the outer circle (0.33Hz). A circle is plotted every 0.05Hz. (B) Black triangles are the station location on the bathymetry map.

We analyse the noise elliptical polarization in time-frequency domain at 20 broadband stations located around the North Atlantic Ocean during the year 2010.

Station SCHQ:

¤ One direction toward the East, i.e. North Atlantic Ocean, in the frequency range 0.1-0.3 Hz.

¤ An other direction toward the West, i.e. Pacific Ocean, in the frequency range 0.05-0.15 Hz.

Station KULLO:

¤ One direction toward the South-East, i.e. North Atlantic Ocean, in the frequency range 0.1-0.25 Hz.

¤ Weaker sources toward the South and the West (0.2-0.3 Hz) and toward the South-West, i.e. Labrador Sea, (0.15-0.2 Hz).

Stations in Greenland and Canada record different noise source azimuths as a function of frequency.

2. Frequency-dependent Noise Sources

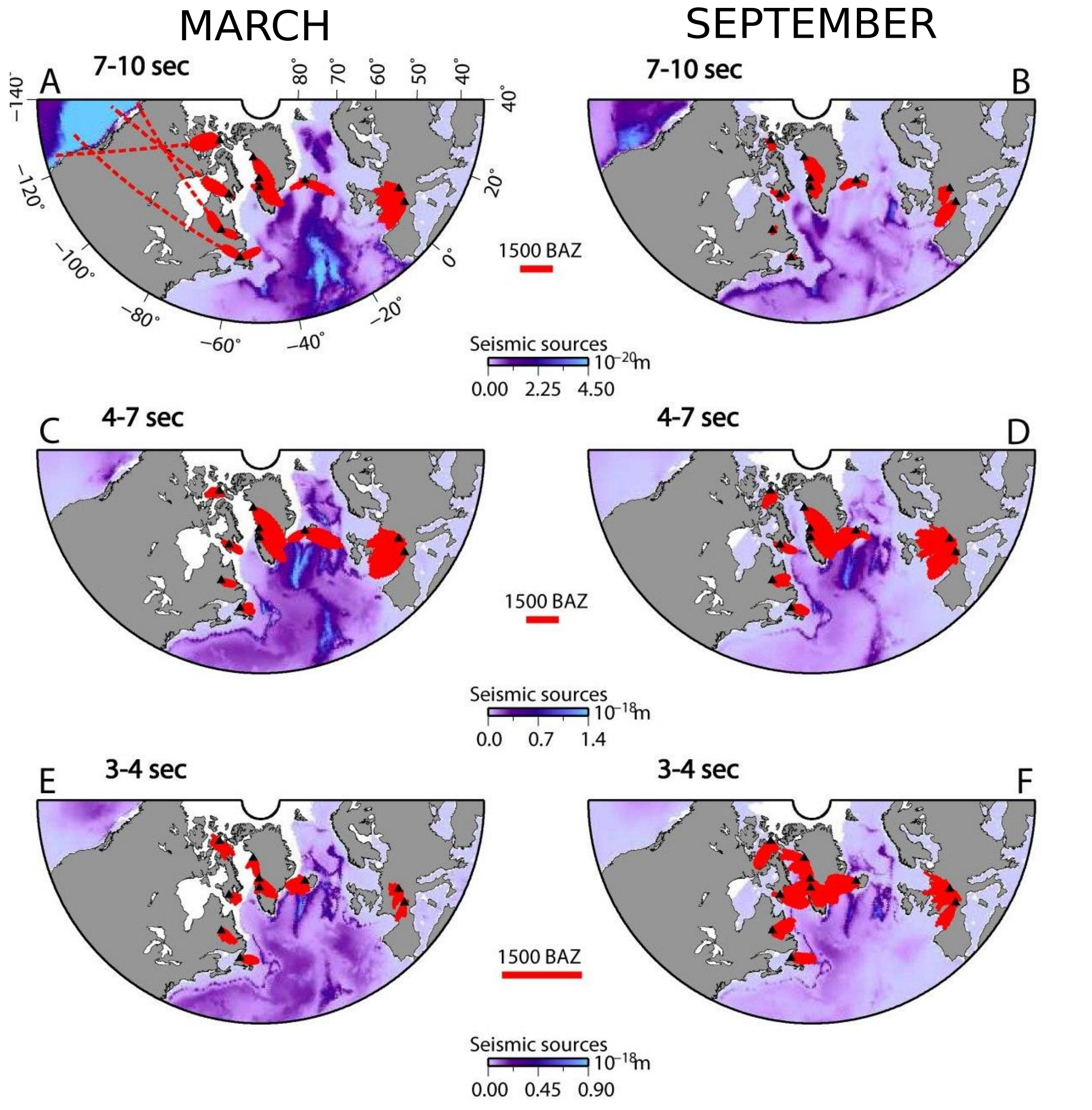


Fig.2
Modelled secondary microseim sources averaged in March and September for period bands: 7- 10 sec (A, B), 4-7 sec (C, D) and 3-4 sec (E, F). Angular histograms (red) show the source azimuths measured by polarization analysis.

¤ **Variability of SM source locations with period:**

7-10 sec	Sources are in the Pacific, mid-Atlantic and near the Canadian coast. The water depth at the source location is ~3500m (Fig.1B).
4-7 sec	Sources are in the vicinity of the Atlantic ridge axis and near the Canadian coast. The water depth at the source location is ~2000m.
3-4 sec	Sources are along the Atlantic ridge axis and close to the Canadian coast. The water depth at the source location is ~1000-1500m.

¤ **Constant source locations in the Atlantic with varying amplitudes as a function of season.**

Conclusion

We show that the variability of the noise polarization in North Atlantic is frequency-dependent and well correlated with the variability of noise sources. Noise source magnitude depends on the ocean wave interaction amplitude, the structure beneath the source (bathymetry and crust) and the frequency. In the Baffin Bay and Labrador Sea, short period seismic noise further depends on the sea-ice cover which impedes noise source generation.

3. Sea-ice Effects on the Seasonal Variations of the SM

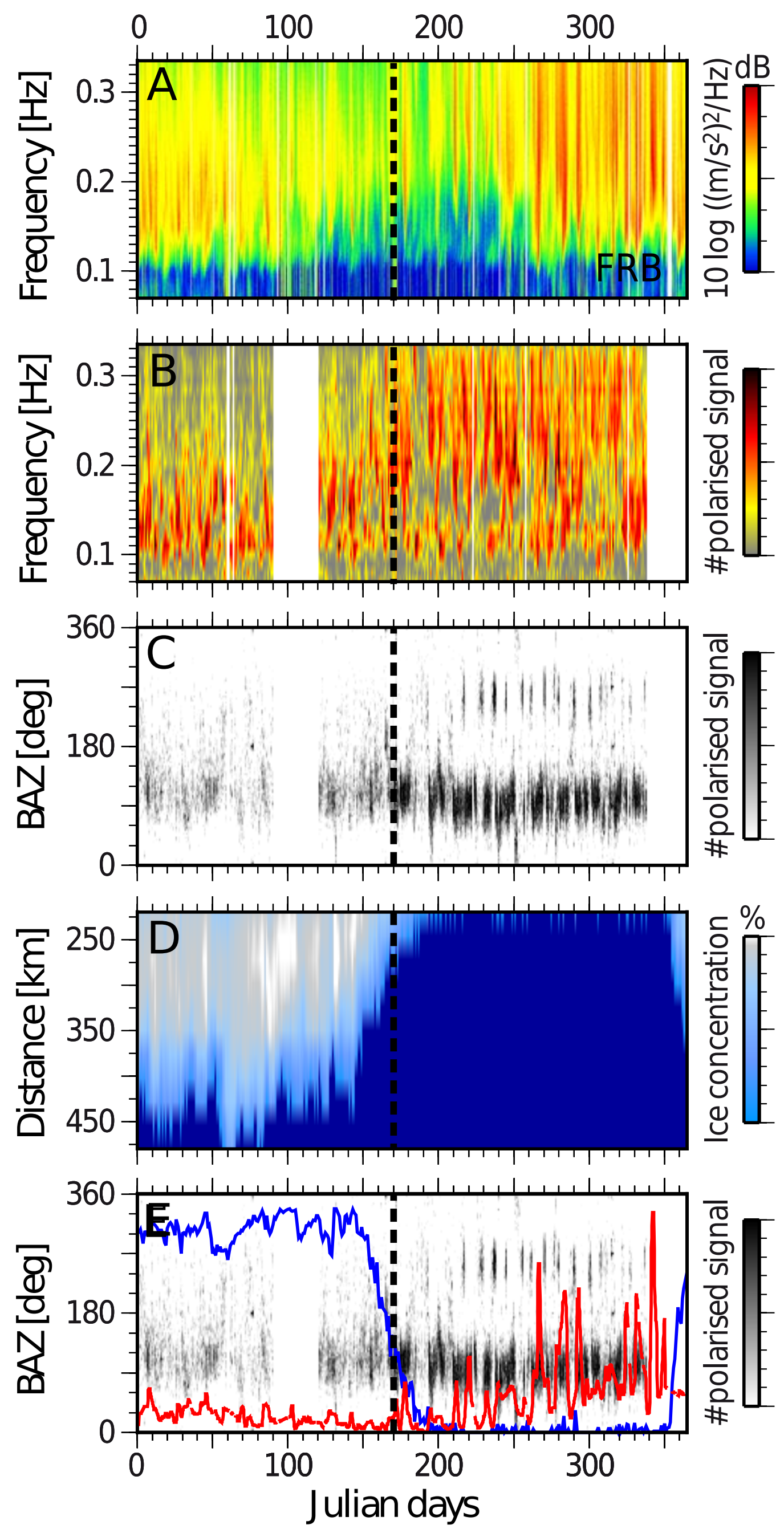


Fig.3 For station FRB, temporal variations of (A) microseismic power spectral density, (B) normalised number of polarized signal [NPS] with frequency, (C) NPS with BAZ in the frequency band 0.2-0.33 Hz, (D) ice concen-tration around the sta-tion. (E) Synthesis: effect of the sea-ice withdrawal on the 0.2-0.33 Hz noise recorded at FRB. The blue line represents averaged ice-concentration around FRB. The red line represents averaged 0.2-0.33 Hz noise amplitude.

¤ **Seasonal variations of the noise amplitude and the number of polarised signal (Fig.3A, 3B):** In the frequency band 0.1-0.2 Hz, the noise is stronger in winter than in summer. In the frequency band 0.2-0.33 Hz, the amplitude and polarization are higher the second part of the year.

¤ **Seasonal variations of 0.2-0.33 Hz Rayleigh waves polarization (Fig.3C):** constant BAZs throughout the year, new directions of incoming waves the second part of the year.

¤ **The noise variation in the frequency band 0.2-0.33 Hz at FRB is well correlated with the presence of sea-ice around the station (Fig.3D, 3E, Fig.4).**

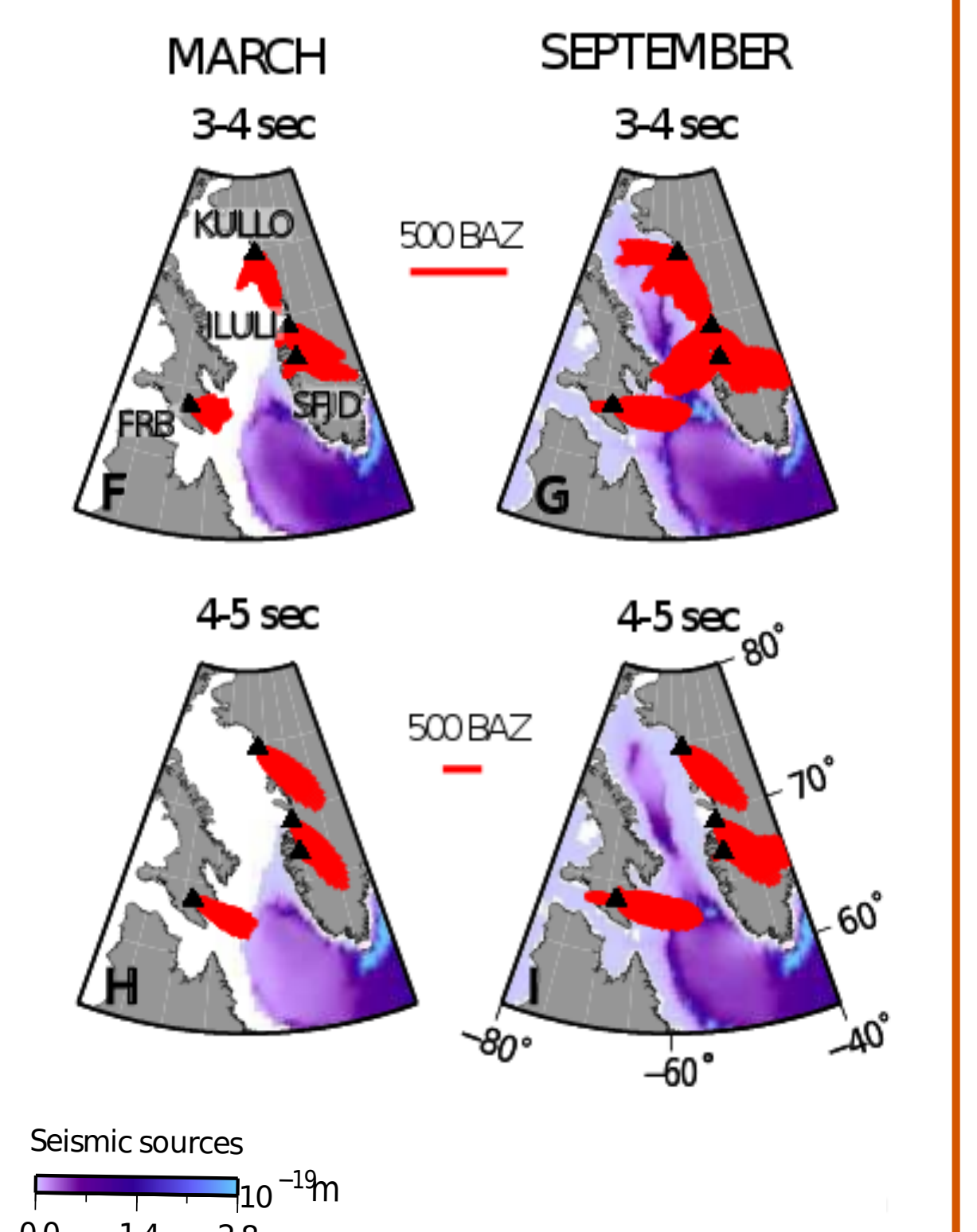


Fig.4
Modelled secondary microseim sources averaged in March and September for the period bands 3-4 sec (F,G) and 4-5 sec (H,I). Angular histograms (red) show the sources azimuts.

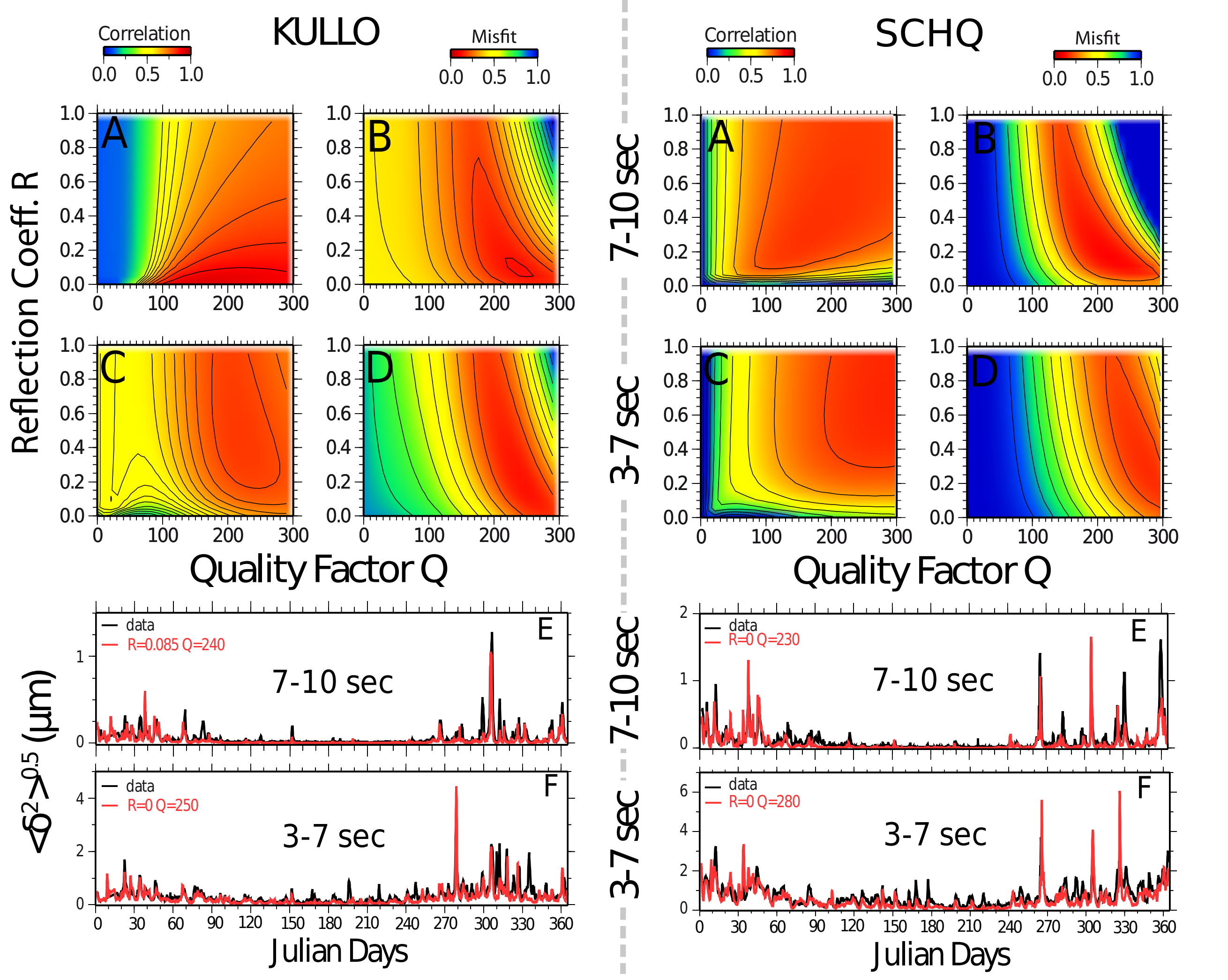
The presence of sea-ice is correlated with the variation of the source azimuth recorded at stations in Greenland in the period band 3-4 sec.

Parametrization of the Seismic Source Model

We model the secondary microseism sources using an ocean wave model (Ardhuin *et al*, 2011). The model is computed with and without spatially uniform coastal reflection of the ocean waves. We then construct a seismic source model with a specific coastal reflection coefficient by a simple linear combination of the two models.

To determine the reflection coefficient R adaptated to the area of interest, we model noise power spectra at each station for a wide range of R and seismic attenuation coefficient Q. The adjustement of (Q, R) is performed by minimizing the differences between modeled and observed noise (correlation and L1-misfit).

Fig.5 Seismic noise modelling for stations KULLO (Greenland) and SCHQ (Canada). Correlation (A,C) and misfit (B,D) between real and synthetic spectra as a function of seismic attenuation Q and ocean waves coastal reflection coefficient R, in two period bands 7-10 sec (A,B) and 3-7 sec (C,D). Real (black) and synthetic spectra (red) variations over one year in displacement averaged in the period bands 7-10 sec (E) and 3-7 sec (F). The synthetic spectra (red) are computed for Q and R values that minimize the misfit and compared to the real data (black).



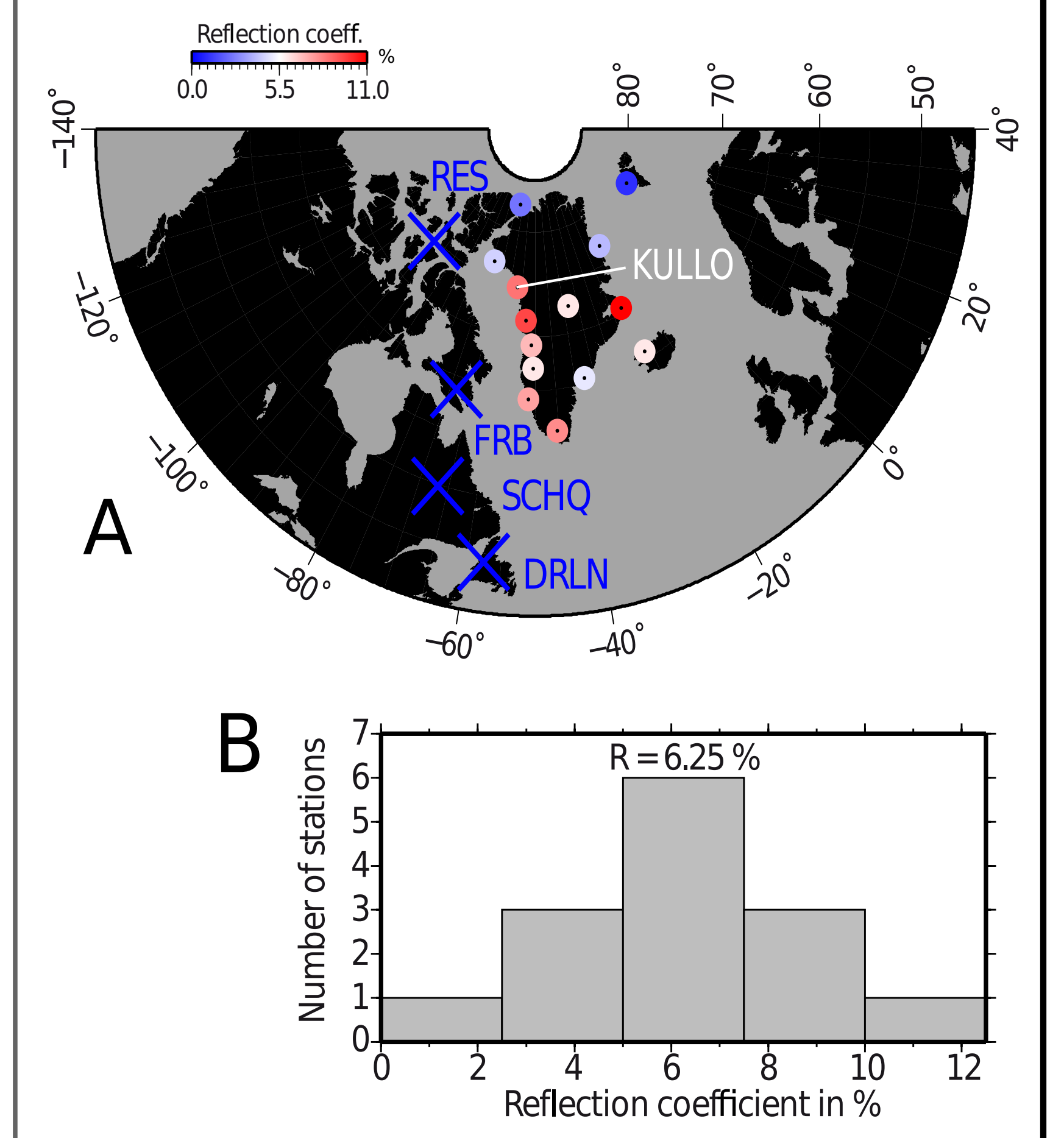


Fig.6 (A) Distribution of the ocean wave reflection coefficient R for the period band 7-10 sec. The blue crosses indicate stations for which the value of R have no effect. (B) Histogram of the number of stations in Greenland for each R value.

We construct seismic source maps using a spatially uniform reflection coefficient R=6.25% (Fig.6B) for the 7-10 sec period band and R=0 for shorter periods (3-7 sec).

References :

Ardhuin, F., E. Stutzmann, M. Schimmel, and A. Mangeney, 2011. Ocean wave sources of seismic noise, Journal of Geophysical Research, 116 (C9), C09,004.
Schimmel, M., Stutzmann, E., Ardhuin, F. and Gallart, J., 2011. Earth's ambient microseismic noise, Geochem. Geophys. Geosyst., 12, Q07014, doi:10.1029/2011GC003661.
Sergeant, A., Stutzmann, E., Maggi, A., Schimmel, M., Ardhuin F. and Obrebski, M. Frequency-dependent noise sources in the North Atlantic Ocean, *to be submitted*.
Stutzmann, E., Schimmel, M., Ardhuin, F., 2012. Modeling long-term seismic noise in various environments. Geophys. J. Int. 191, 707–722.