Open-ocean and coastal sources of microseisms

Speaker： Tzu-Chuan Lee

2012.12.13

References

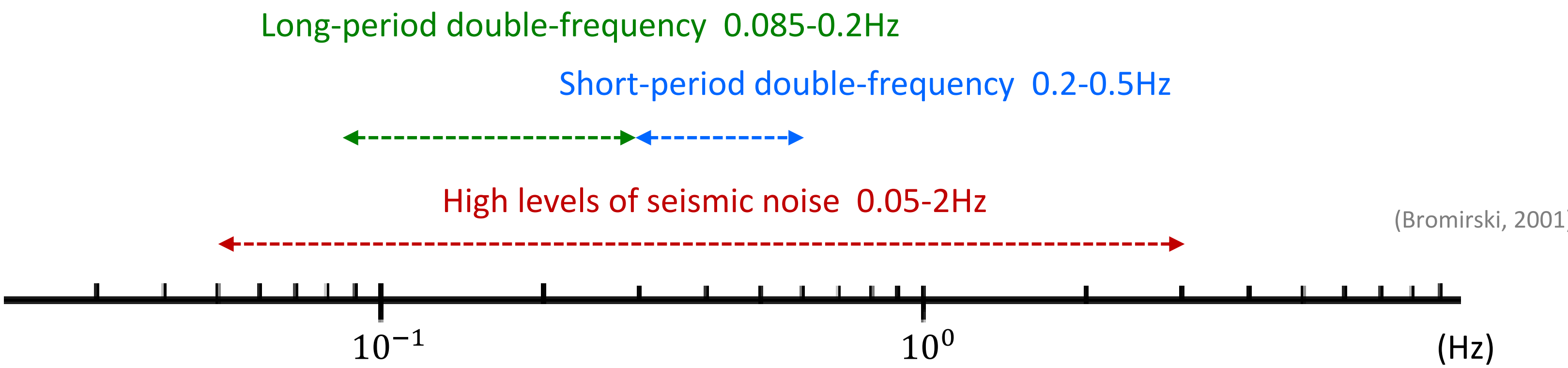
① Bromirski, P. D., F. K. Duennebier, and R. A. Stephen (2005), **Mid-ocean microseisms**, *Geochem. Geophys. Geosyst.*, *6*, Q04009, doi:10.1029/2004GC000768.

② Zhang, J., Gerstoft, P., Bromirski, P.D. (2010), **Pelagic and coastal sources of P-wave microseisms: Generation under tropical cyclones**, *GRL*, Vol. 37, L15301, doi:10.1029/2010GL044288

Outline

1. Introduction
2. Data
3. SPDF Microseism
4. LPDF Microseism
5. Discussion
6. Conclusions

1. Introduction



- The peak in this portion of the seismic noise spectrum, called the **microseism peak**, is caused by ocean wave energy coupling into motion of the earth.

- The microseisms are observed at twice the frequency of the ocean waves and thus are termed **double-frequency** microseisms.

Questions

Concerning the origin and propagation of these microseisms:

1) Can storms at sea generate **both LPDF and SPDF** microseisms that are observed at distant seismic stations?

2) How far do SPDF microseisms **propagate** across the ocean floor?

3) Are SPDF and LPDF microseisms generated near distant shorelines observed at mid-ocean **seafloor stations**?

Stations

NOAA buoy

Land seismic station

OBS

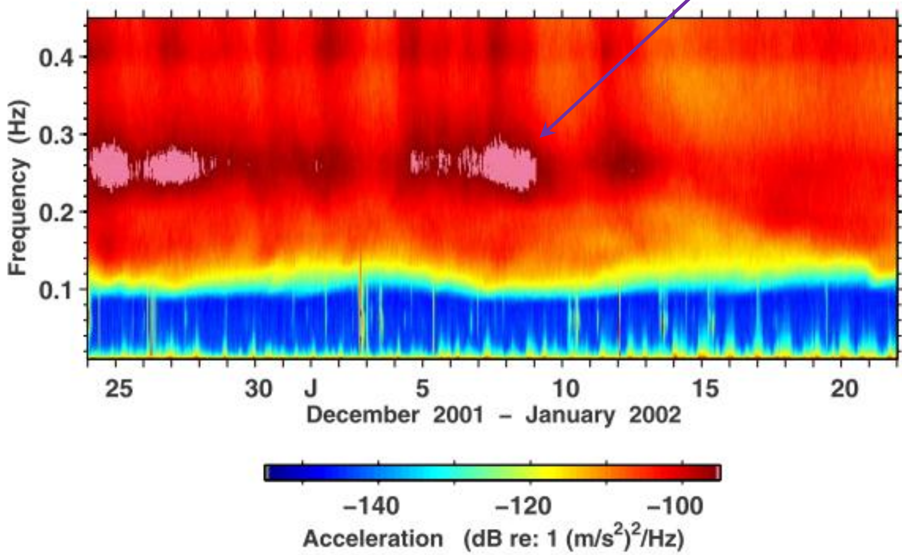
- The distance from shorelines allows coastal and open ocean microseism generation to be **distinguished**.

2. Data

Short-period double-frequency 0.2-0.5Hz

Long-period double-frequency 0.085-0.2Hz

Microseism peak is generally between 0.2-0.3Hz



A sharp drop in energy at about 0.085Hz

Tidal currents at 24 hour intervals

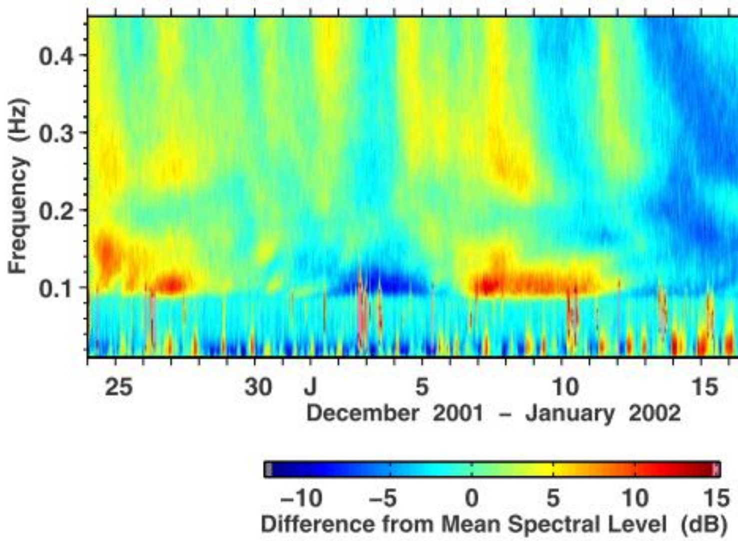
- Removing the mean spectral amplitude at each frequency emphasizes relative **temporal changes** while discarding absolute amplitudes and the effects of stationary system and environmental responses.

2. Data

Short-period double-frequency 0.2-0.5Hz

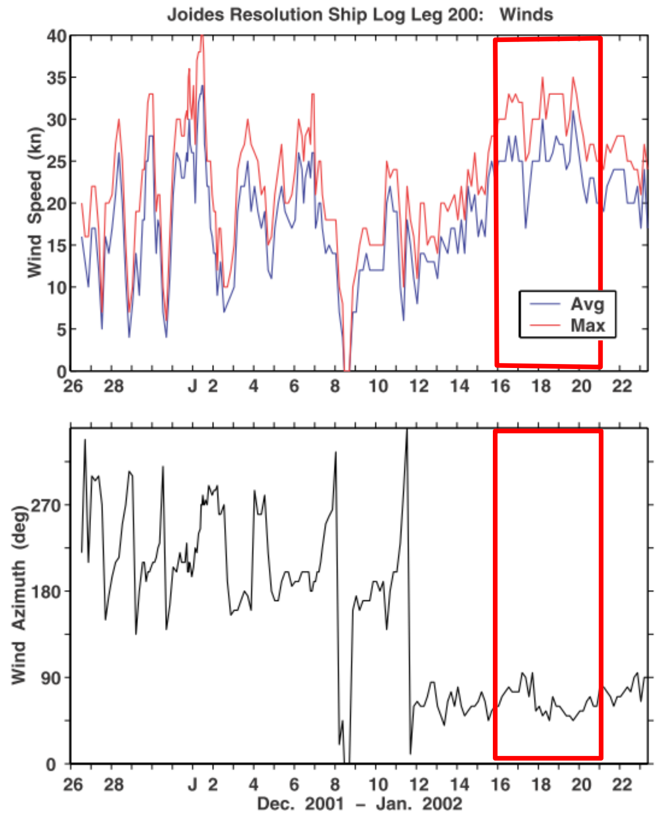
Long-period double-frequency 0.085-0.2Hz

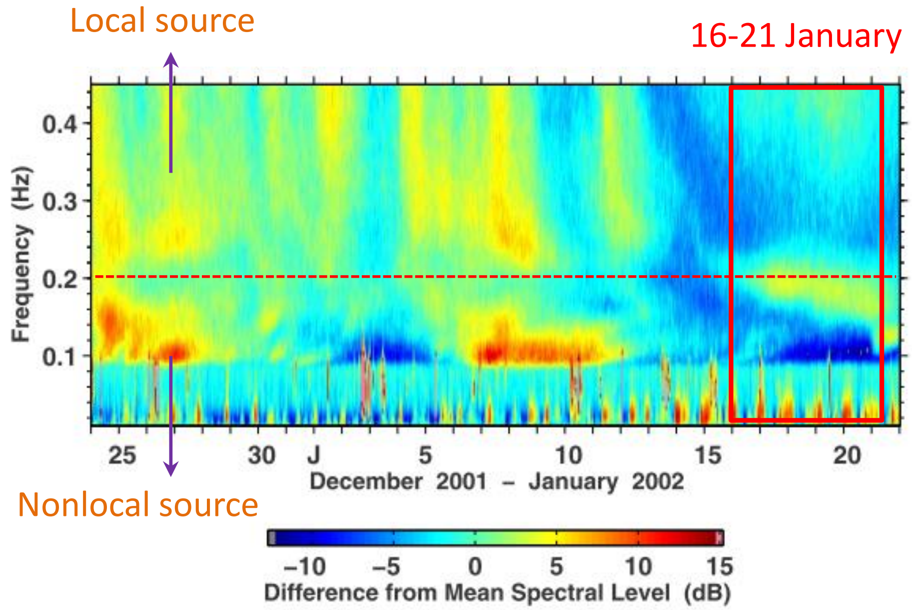
The PSD is divided by the mean



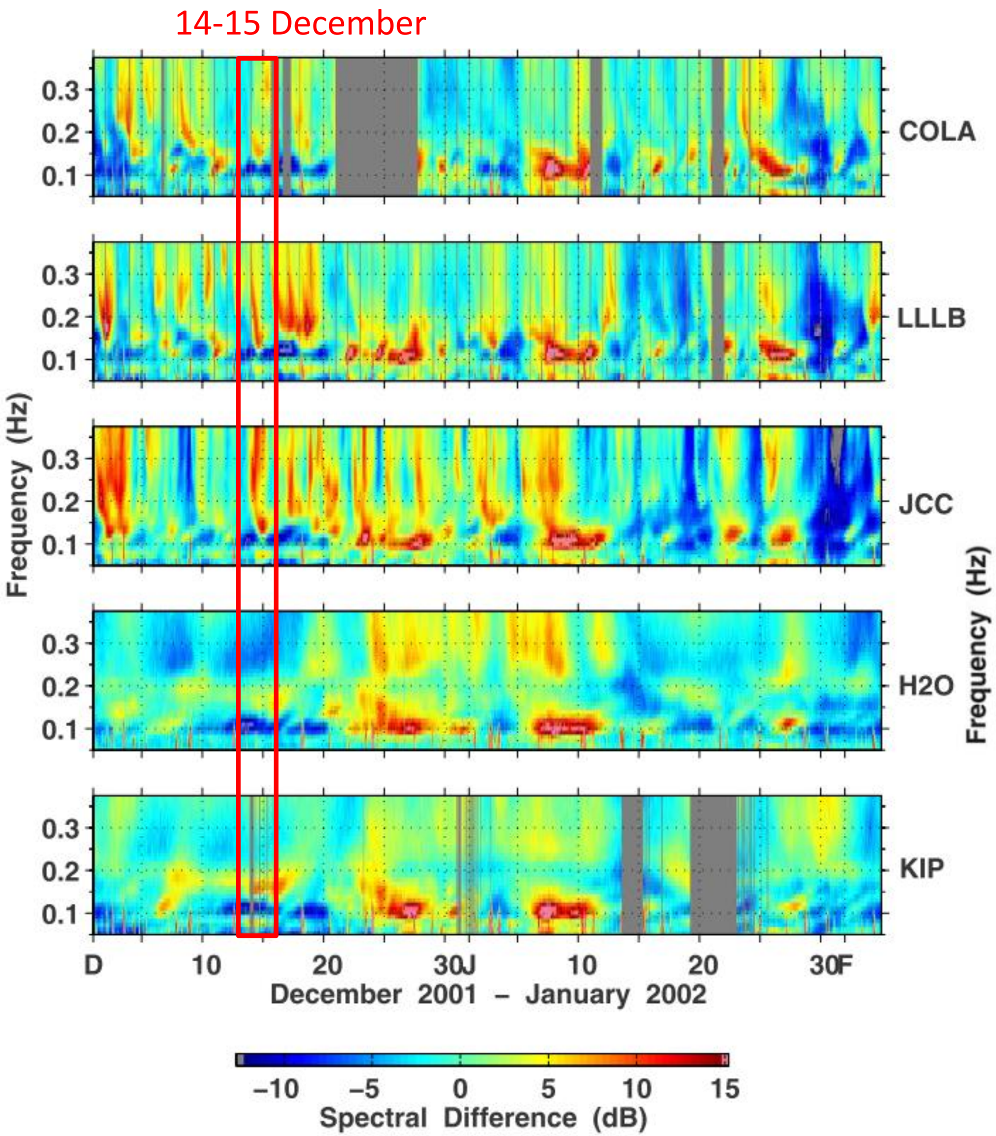
- Removing the mean spectral amplitude at each frequency emphasizes relative **temporal changes** while discarding absolute amplitudes and the effects of stationary system and environmental responses.

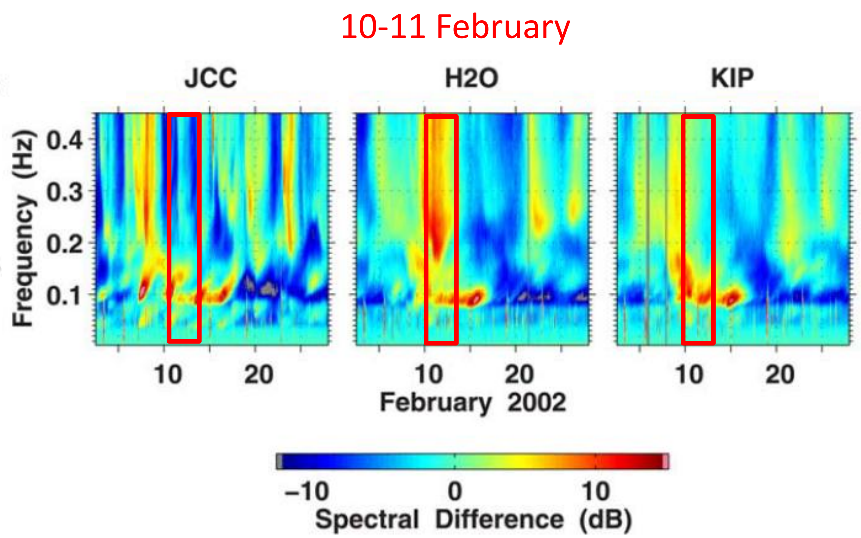
3. SPDF Microseism





- SPDF microseism levels remain relatively low for about 6–18 hours after wind speed increases, generally rising sharply when the **wind direction changes**.



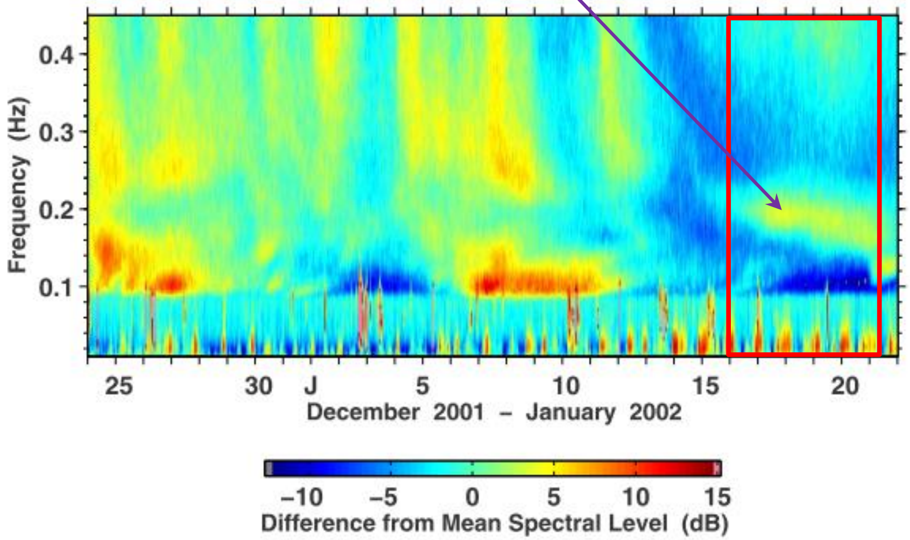


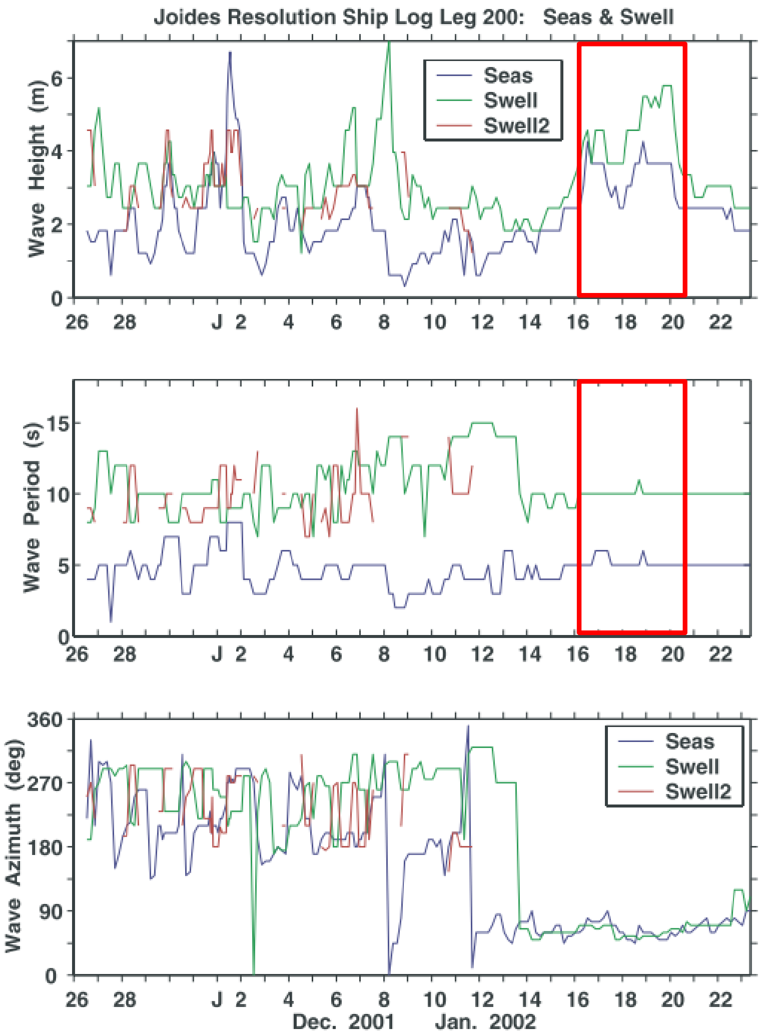
- SPDF microseisms do not **propagate well** from shorelines to ocean basins or ocean basins to shorelines.

Exception

Locally generated DF microseisms

16-21 January

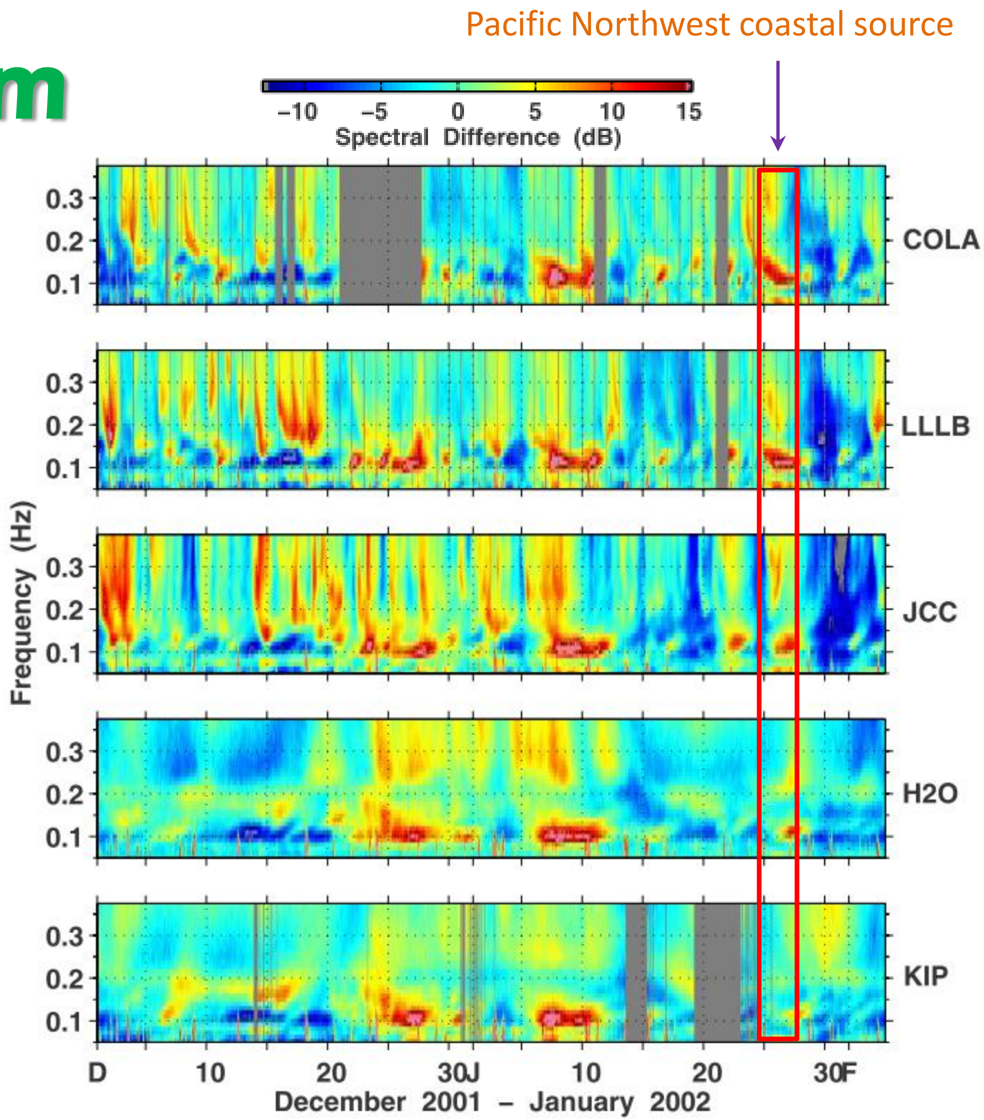




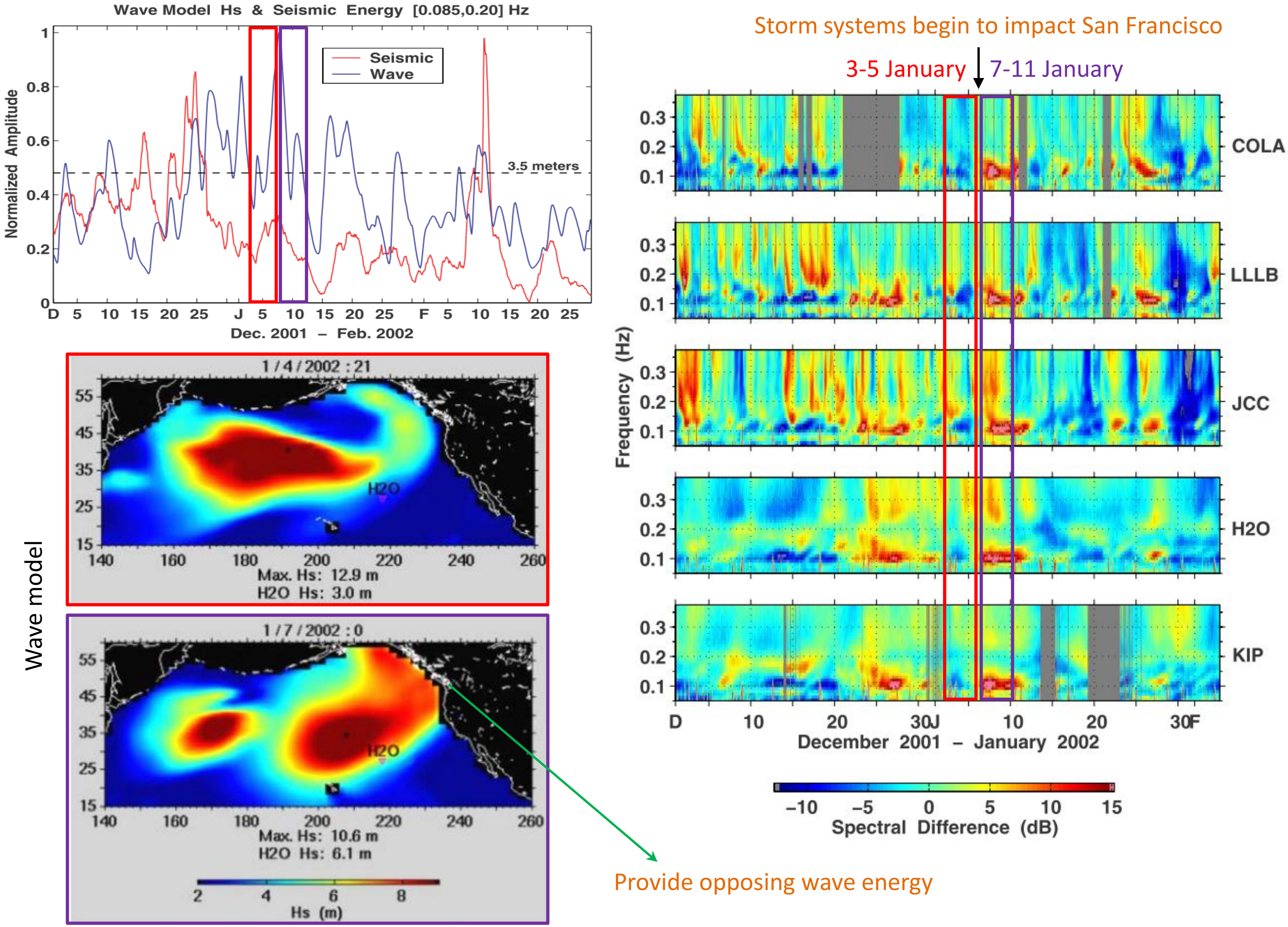
- A large storm or a large swell will not generate high-amplitude DF microseisms in the open ocean that can be observed at continental stations.

4. LPDF Microseism

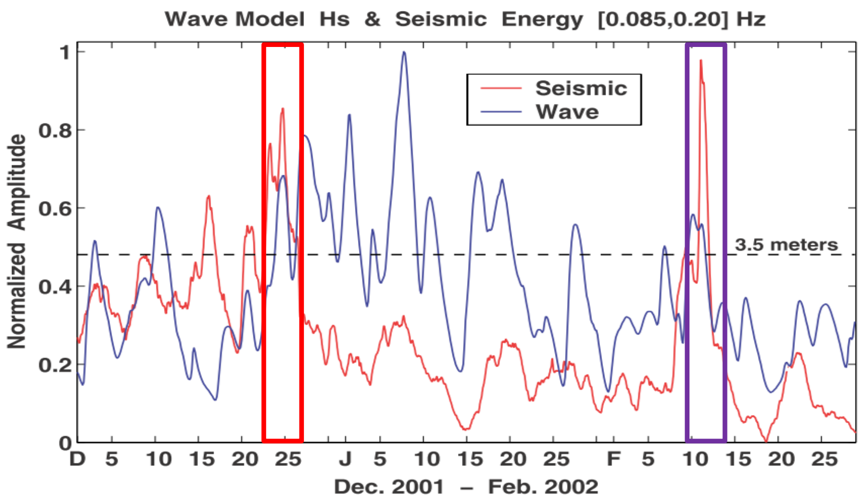
- The levels of microseism peaks
  1) The amplitudes of the opposing wave components in the generation region
  2) The area of wave-wave interactions
  3) The distance from the generation area



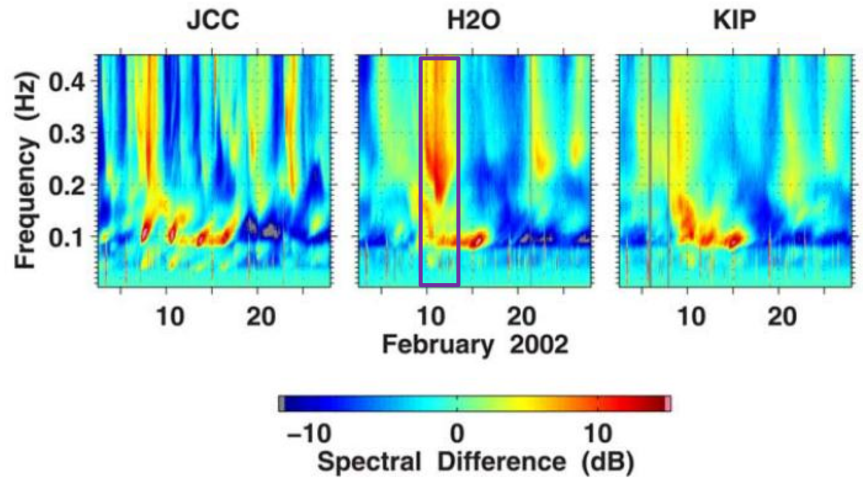
- Comparison of relative amplitudes gives an indication of the **source region**.



Wave Model Hs & Seismic Energy [0.085,0.20] Hz
Seismic
Wave
3.5 meters
Normalized Amplitude
Dec. 2001 – Feb. 2002
1 / 4 / 2002 : 21
Max. Hs: 12.9 m
H2O Hs: 3.0 m
1 / 7 / 2002 : 0
Max. Hs: 10.6 m
H2O Hs: 6.1 m
Hs (m)
Wave model
Storm systems begin to impact San Francisco
3-5 January
7-11 January
COLA
LLLB
JCC
H2O
KIP
Frequency (Hz)
December 2001 – January 2002
Spectral Difference (dB)
Provide opposing wave energy

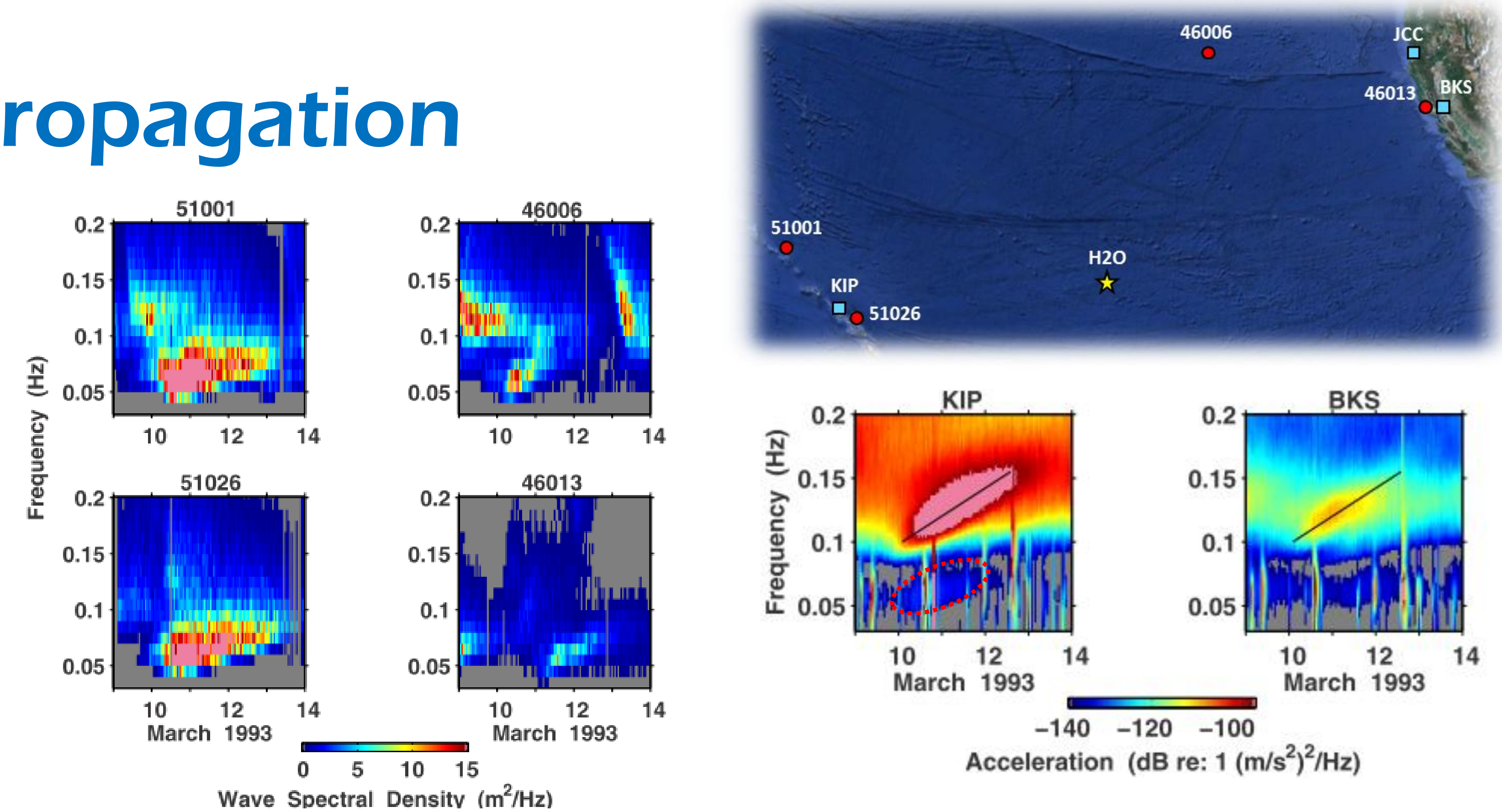


14-16 December 10-11 February



- The two highest peaks that occurred at H2O are not associated with the highest **wave height** over H2O.
- The elevated microseism levels result from the interaction of waves from **concurrent storm systems** can produce high-energy microseisms at the upper end of the LPDF band.

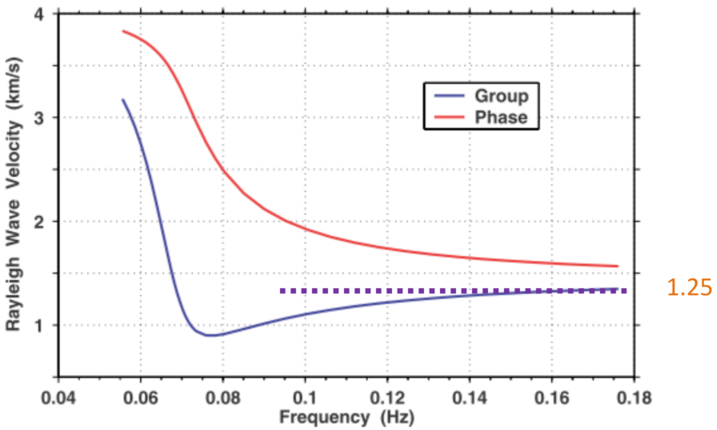
Propagation



- A lower amplitude **primary microseism** peak is also seen at KIP at the same frequency as the waves.
- Strongly implying that the LPDF microseism is generated at Hawaii shorelines and **traveled** to California as Rayleigh waves.

5. Discussion

Isotropic PREM model
with oceanic crust and a 5.4 km water layer

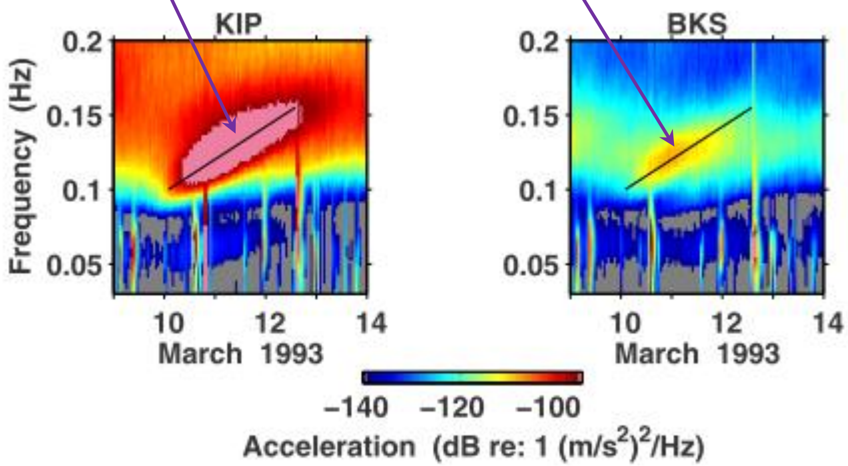


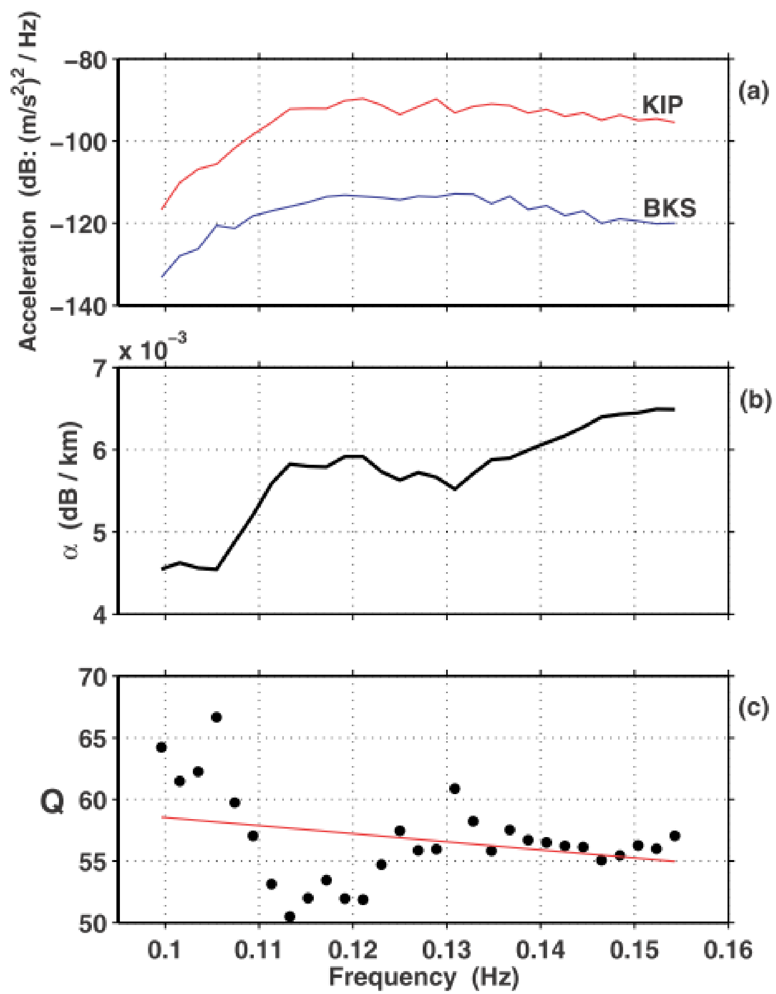
- An estimate of open-ocean SPDF microseism **effective Q** that includes intrinsic and scattering losses.

Effective attenuation α=10/500=0.02 dB/km
An average Rayleigh wave group velocity V=1.25 km/s
Effective Q=πf/ αV
When f=0.3 Hz ∴**Q= π * 0.3 / 0.02 / 1.25 ≈ 40**

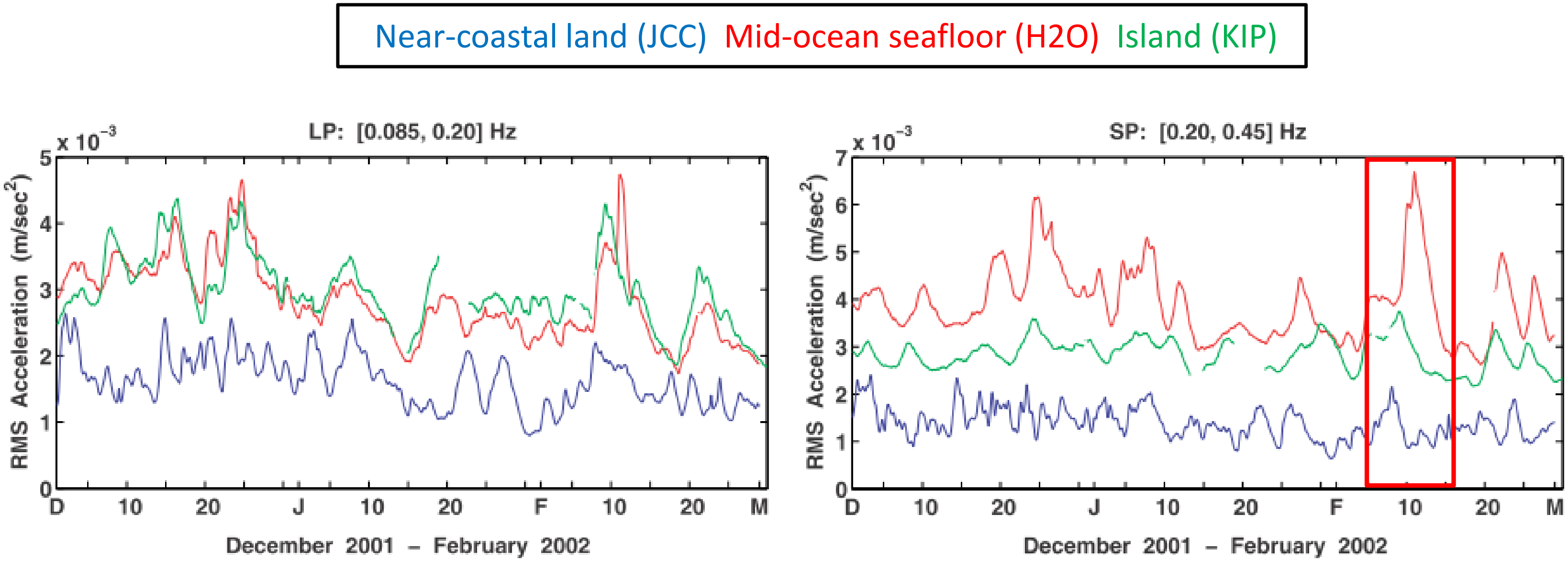
- This low Q estimate is consistent with **poor propagation** of SPDF signals.

A relatively uniform reduction of spectral levels





- The low DF microseism effective Q suggests that most DF microseism energy is not **coupled into** the deeper crust and likely loses from **scattering** in the upper crustal layers.

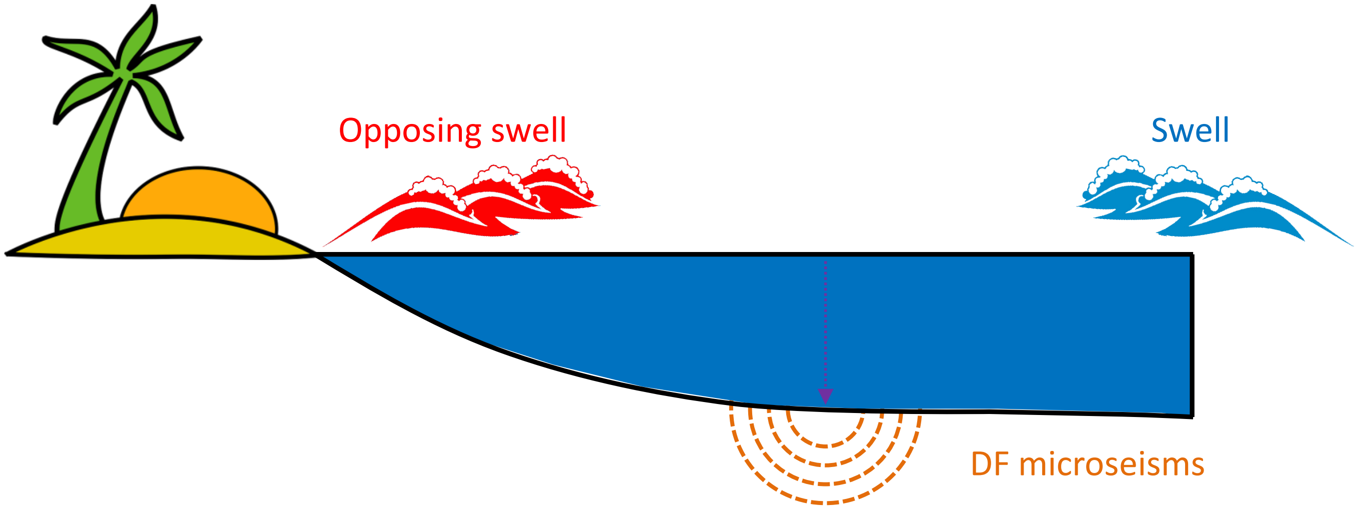


- JCC compared with other stations is consistent with the absence of **sediment mode** and DF energy that does not **propagate well**.
- The LPDF levels at JCC and KIP are higher than their SPDF levels, indicative of **differences** between ocean bottom and land-based sites.

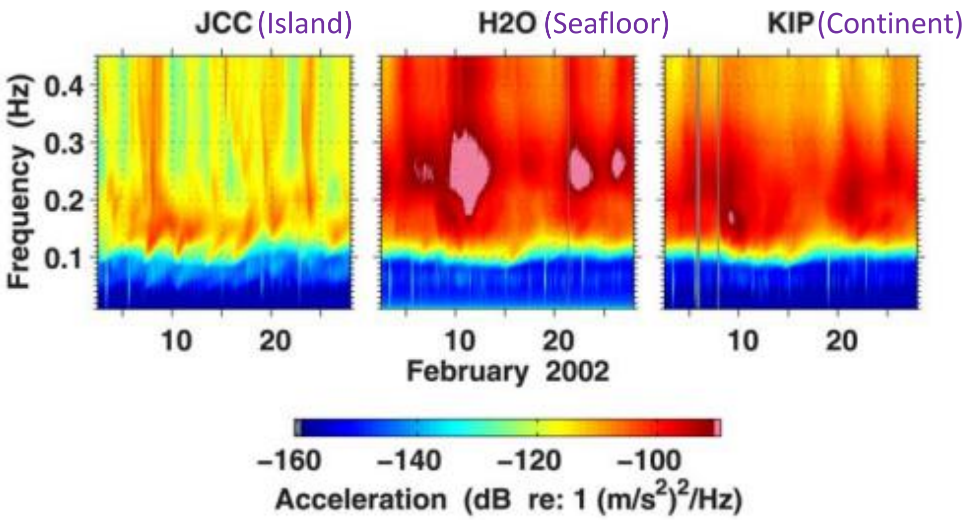
6. Conclusions

1) The results indicate that much of the LPDF is excited in near-coastal areas and propagates as **Rayleigh wave** modes throughout the ocean basin.

   LPDFs are generated in the open ocean only when **favorable weather** conditions produce opposing swell.



2) The duration of elevated SPDF levels at land-based sites is generally less than at ocean bottom, likely resulting from the **lack of SPDF generation** from receding storms.



3) These observations show that wave-wave interactions under storm maybe we can **track** using seismic arrays.

Thanks for your attention