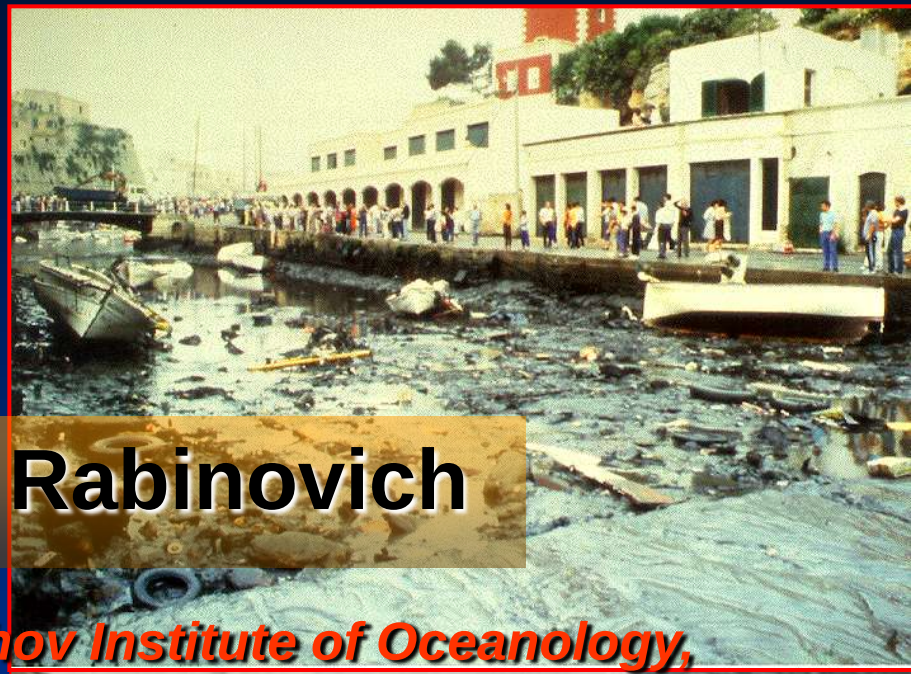
Tsunamis and Meteotsunamis:
Similarities and differences



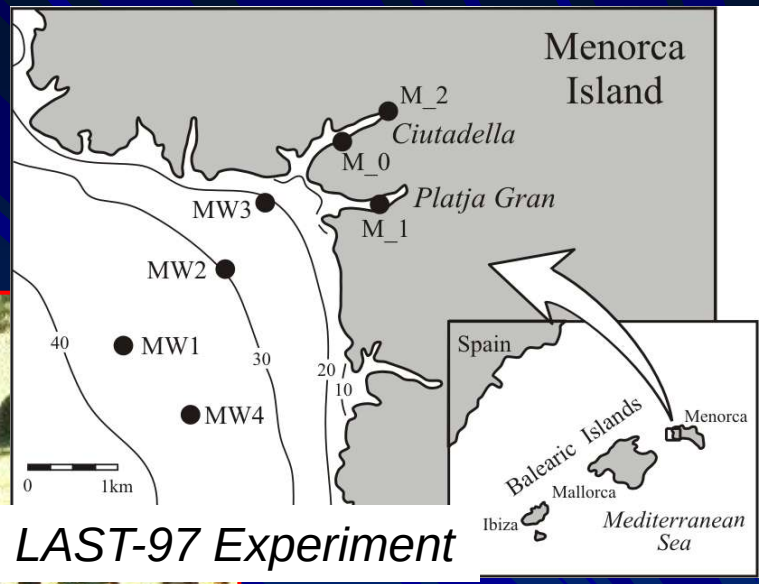
Alexander B. Rabinovich

Tsunami Laboratory, P.P. Shirshov Institute of Oceanology, Moscow, RUSSIA

Institute of Ocean Sciences, Sidney, BC, CANADA

Meteorological tsunami

«Rissaga»: Ciutadella Harbour, Menorca Island, Baleares, Spain



LAST-97 Experiment

21 June 1984

Monserrat et al., 1991, 1998
Rabinovich and Monserrat, 1996, 1998

Meteorological tsunami

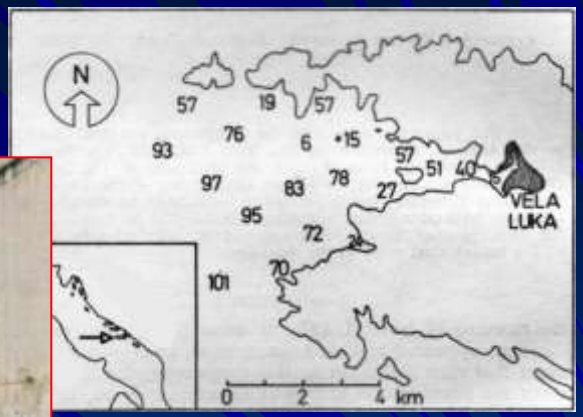
"Rissaga" waves in Ciutadella Harbour (Menorca I.) 15 June 2006

More than 40 damaged boats. Total loss: ~ 30 mln euros.

(Monserrat, Vilibic, and Rabinovich, 2006)

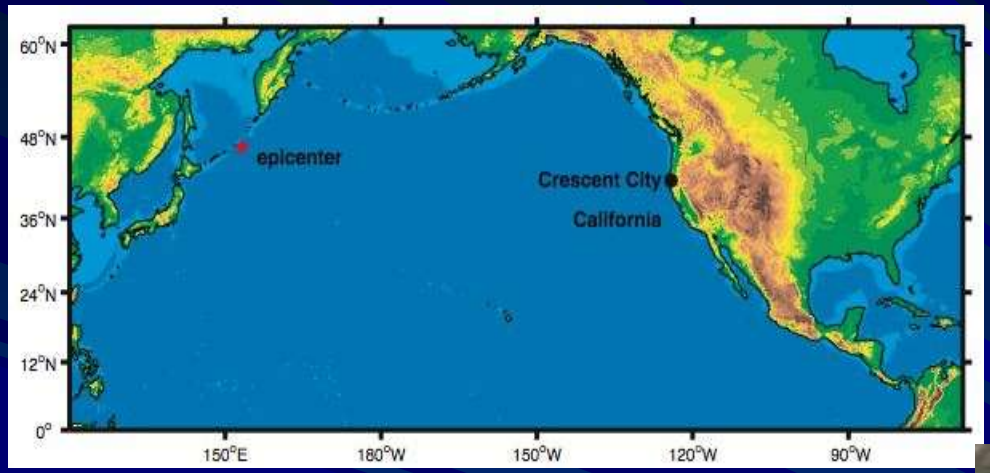
Meteorological tsunami

Vela Luka, Croatia, 21 June 1978



(From Ivica Vilibic)

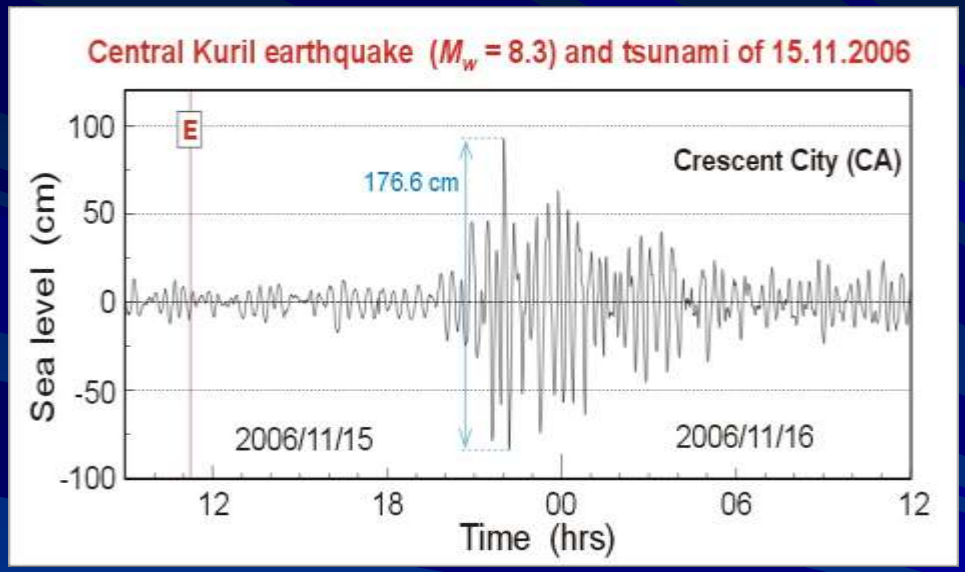
Crescent City (California)



Significant destructions in the harbour of Crescent City (Northern California) produced by the 2006 Kuril Islands tsunami (the source area on the opposite side of the Pacific Ocean).

Crescent City (California)

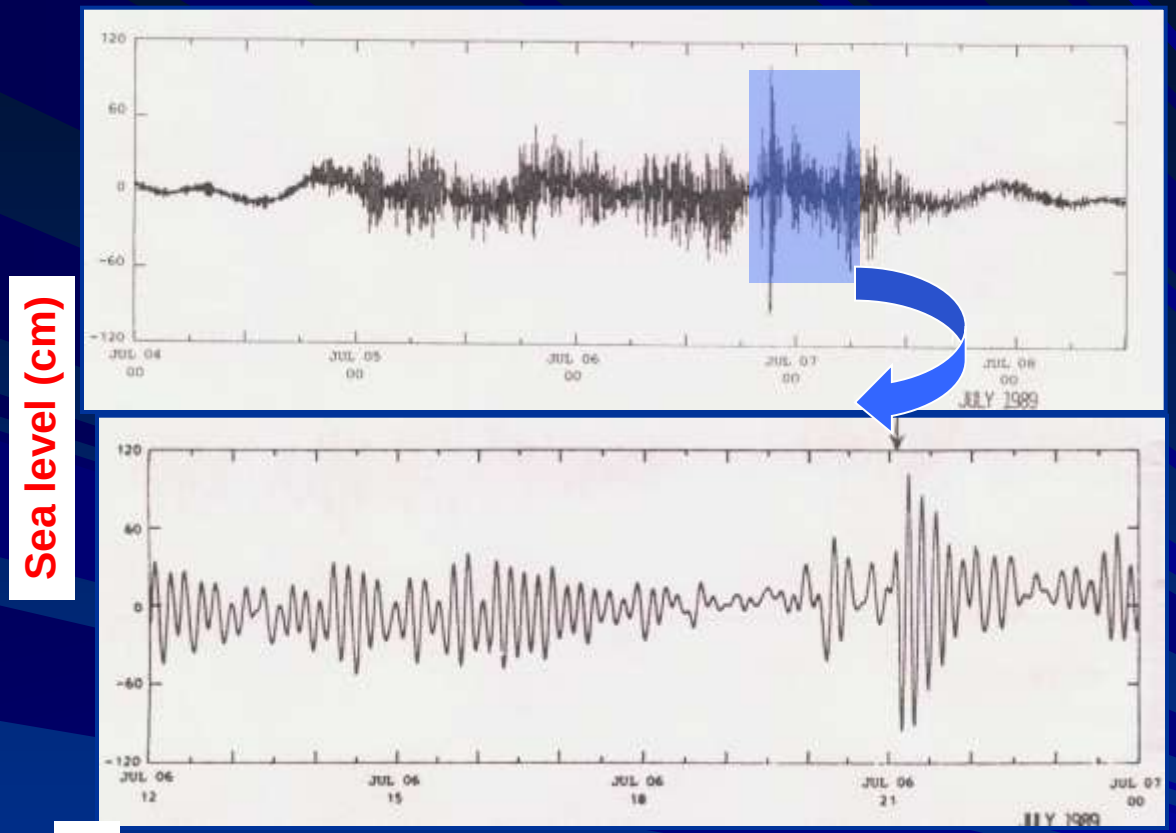
Kuril Islands tsunami of 15 November 2006



Tsunami record at Crescent City (CA)

Port of Crescent City (CA)

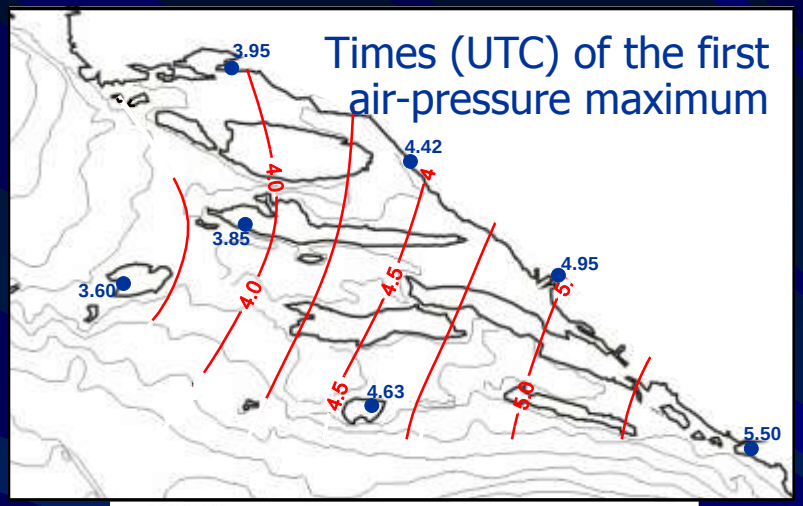
Meteorological tsunami



“Rissaga” waves in Ciutadella Harbour, Menorca Island, Baleares (July 1989)

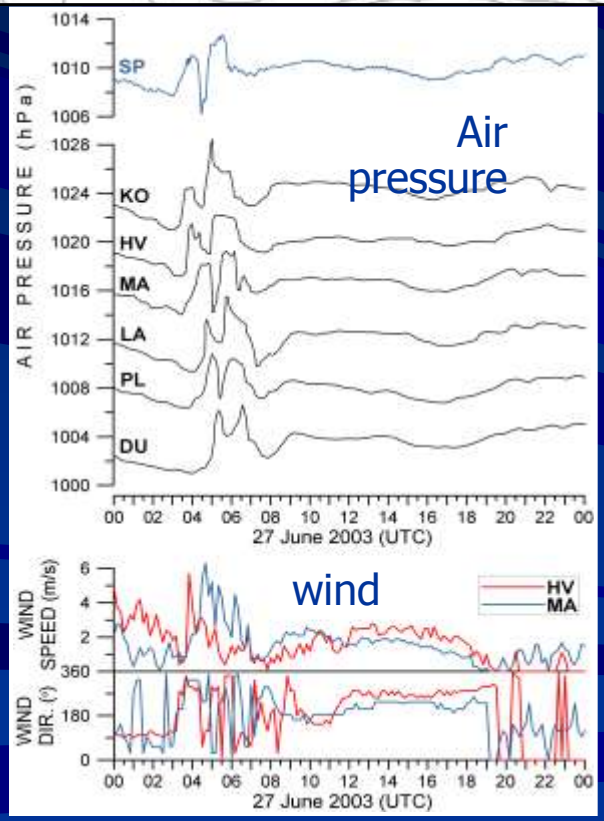
Wave height > 2 m
Period 10.6 min

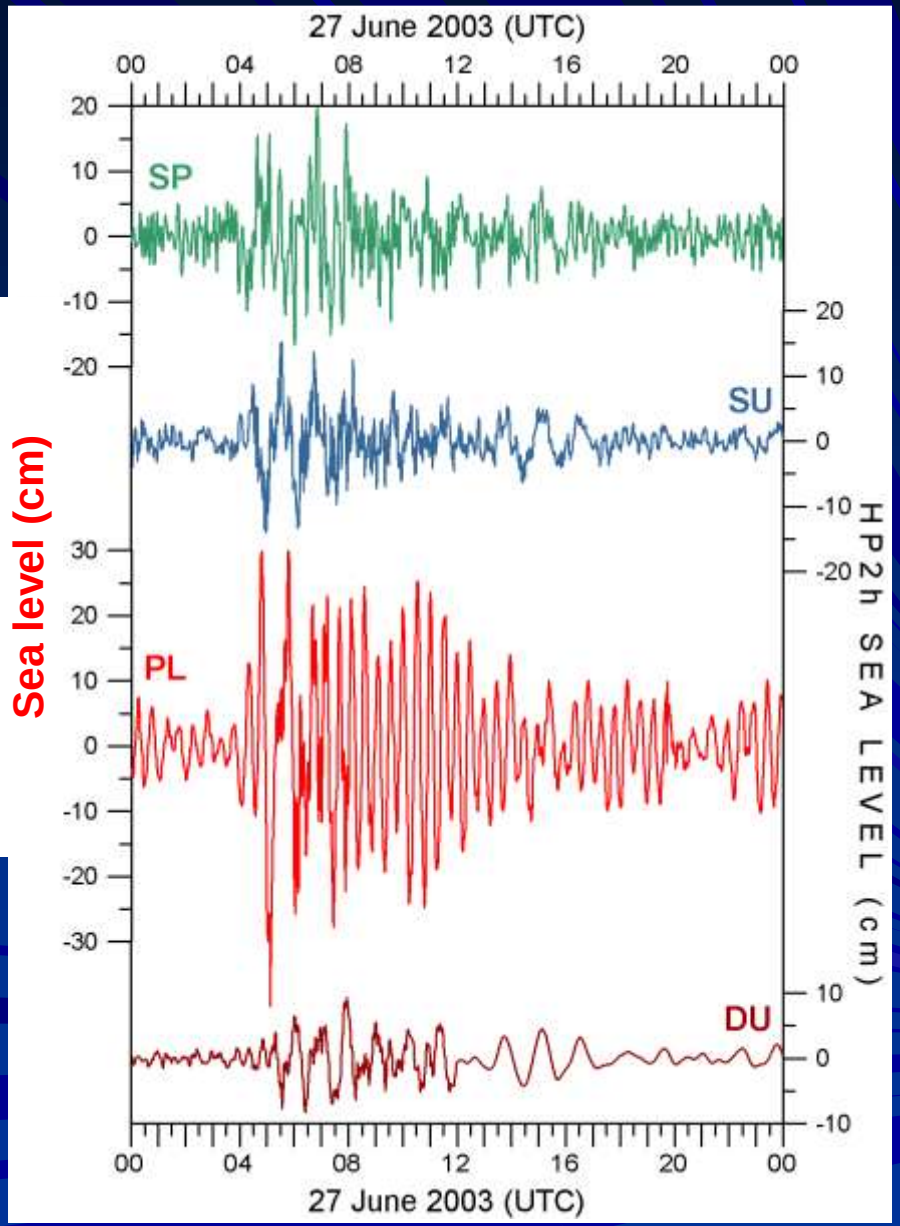
27 June 2003, Croatia



Atm. Pressure (hPa)

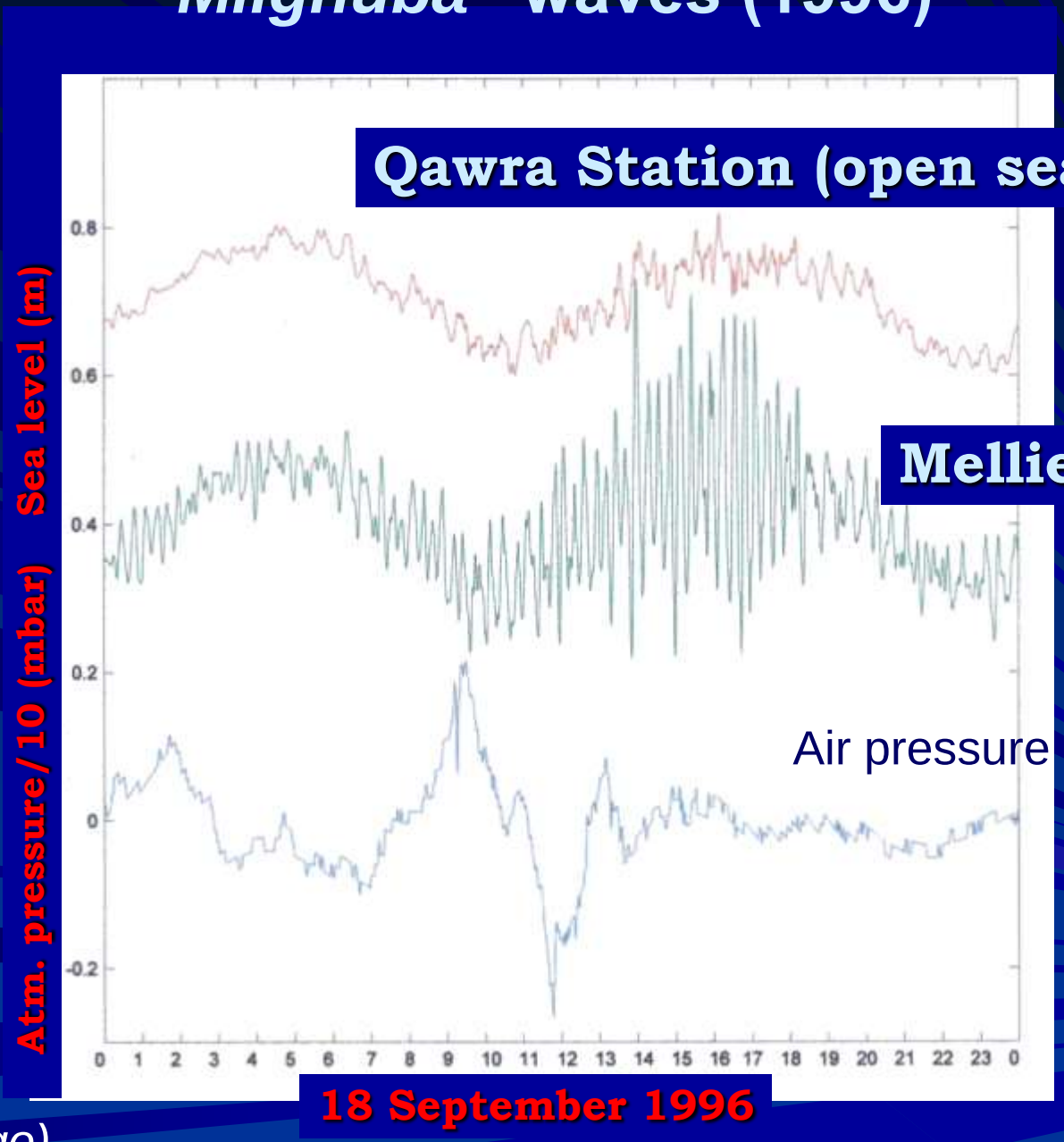
Wind (m/s)





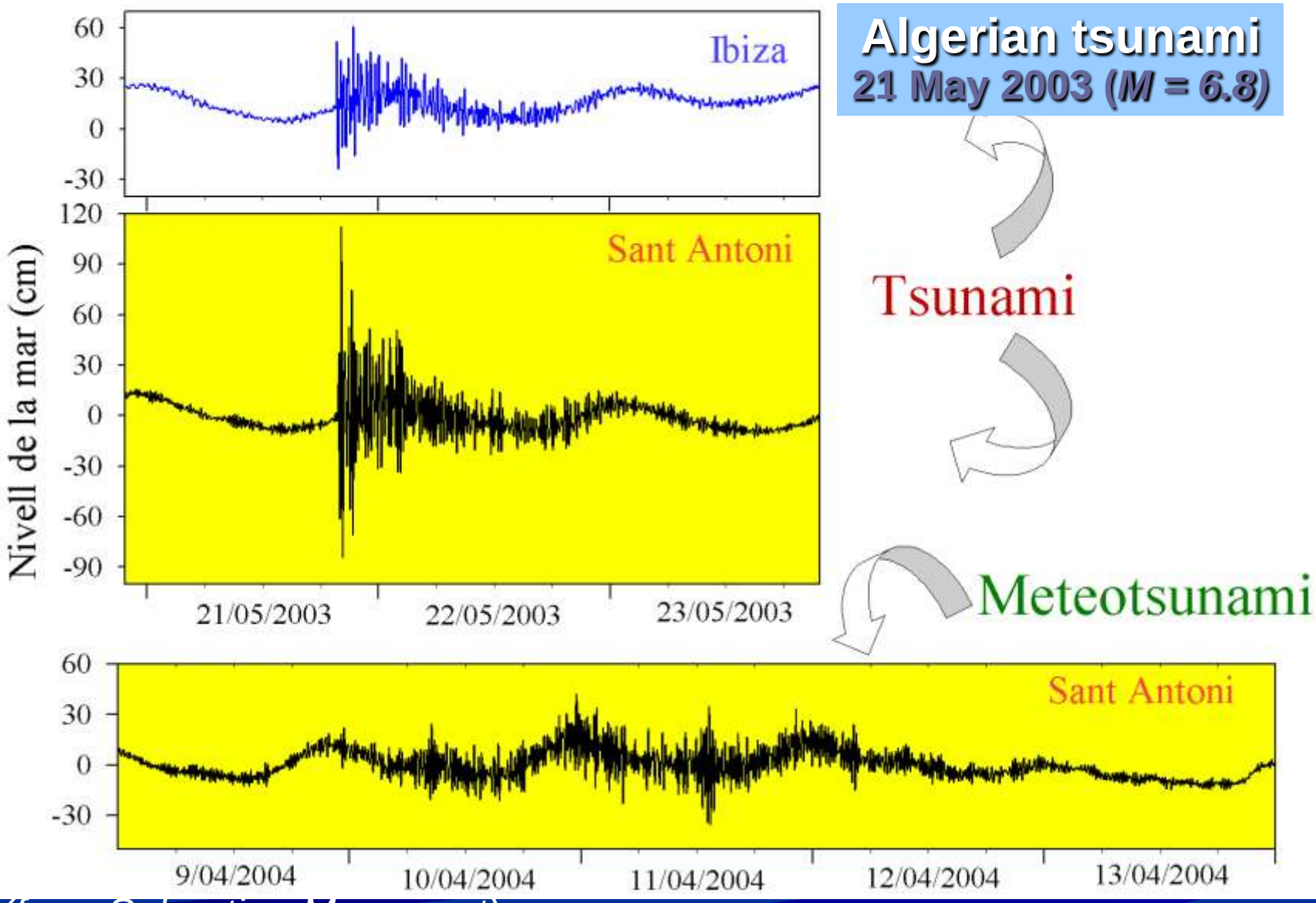
(From Ivica Vilibic)

Malta Island "*Milghuba*" waves (1996)



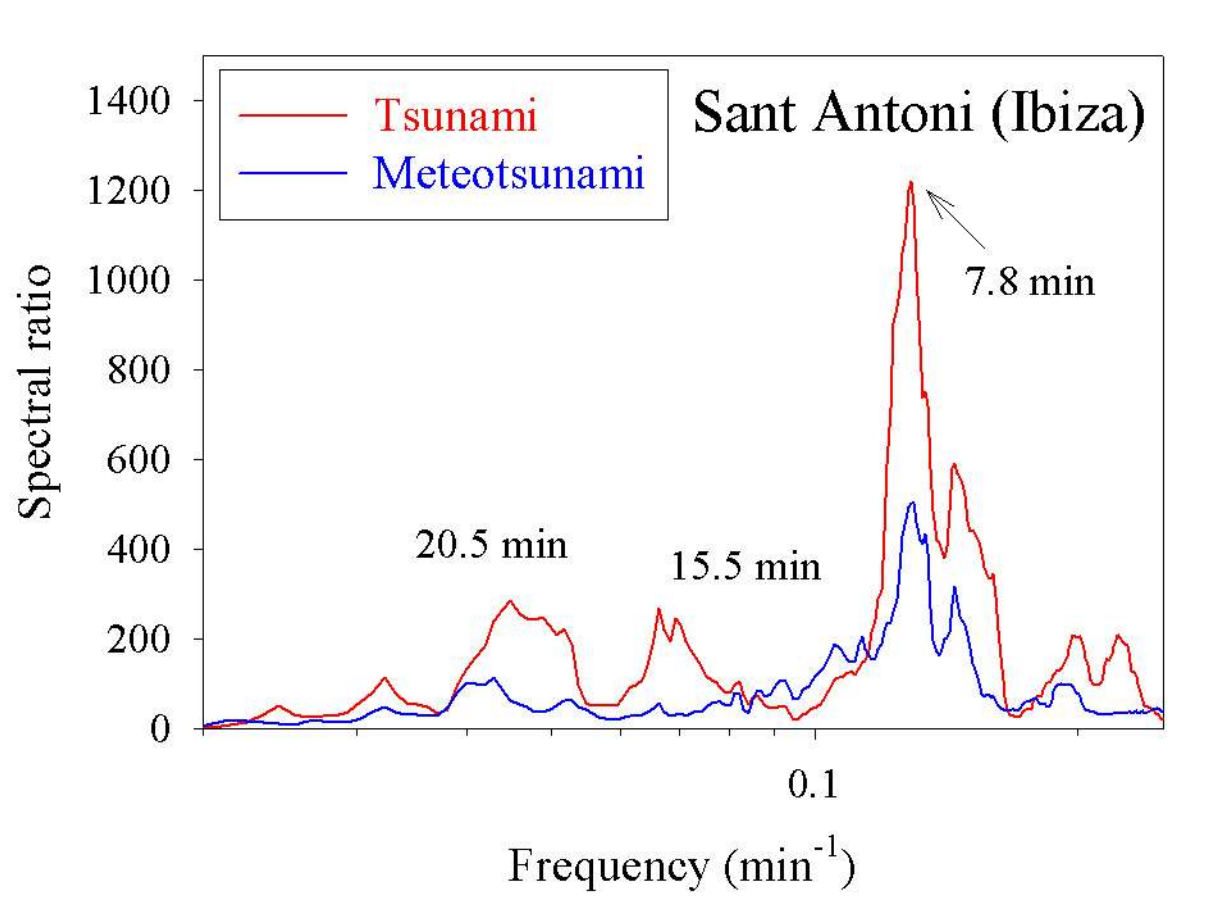
(From Aldo Drago)

Tsunami and Meteotsunami recorded at the same site (Ibiza Island)



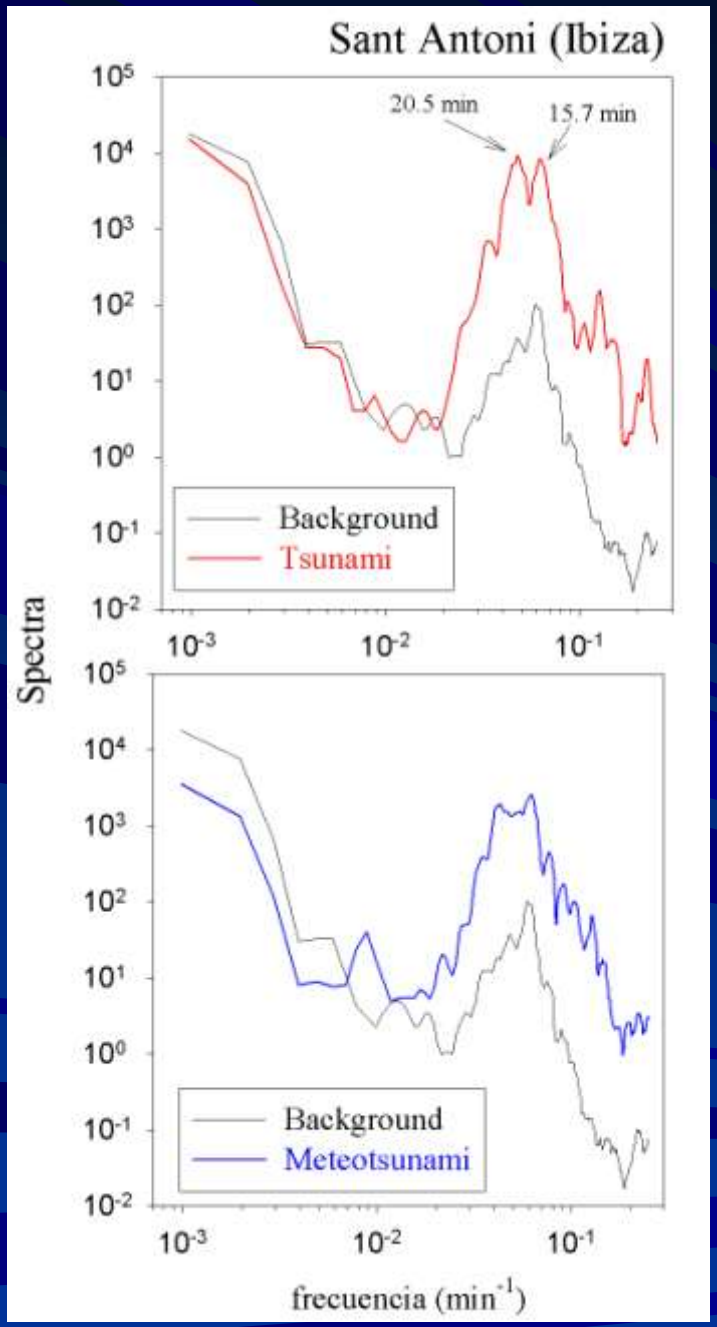
(from Sebastian Monserrat)

Source functions of tsunami and meteotsunami recorded at the same site (Ibiza Island)



Two peaks **(20.5** and **15.5 min)** are definitely related to the **tsunami source,** while **7.8 min** to the common propagation path of both types of waves

(from Sebastian Monserrat)



Spectra
of tsunami and meteotsunami
recorded at the same site

Ibiza Island
(Balearic Islands)

(from Sebastian Monserrat)

Similarities:

- ✓ **Same time scales → from 1-2 min to ~ 2.5 hrs**
- ✓ **Same spatial scales → from 1-2 km to hundreds of kilometers**
- ✓ **Similar destructive effects on the coast**

Significant harbour oscillations, accompanied by devastating currents;

Accumulating the energy (“swing effect”);

Similar spectra (matching the spectra of background oscillations)

Differences:

✓ Generation mechanism:

Seismic sources ←→ Atmospheric disturbances

Impulse source ←→ Prolonged source

Direct forcing ←→ Resonance

✓ Manifestation:

Global effect ←→ Regional (local) effect

More differences…

✓ **Wave dynamics:**

Free waves ←→ Forced waves

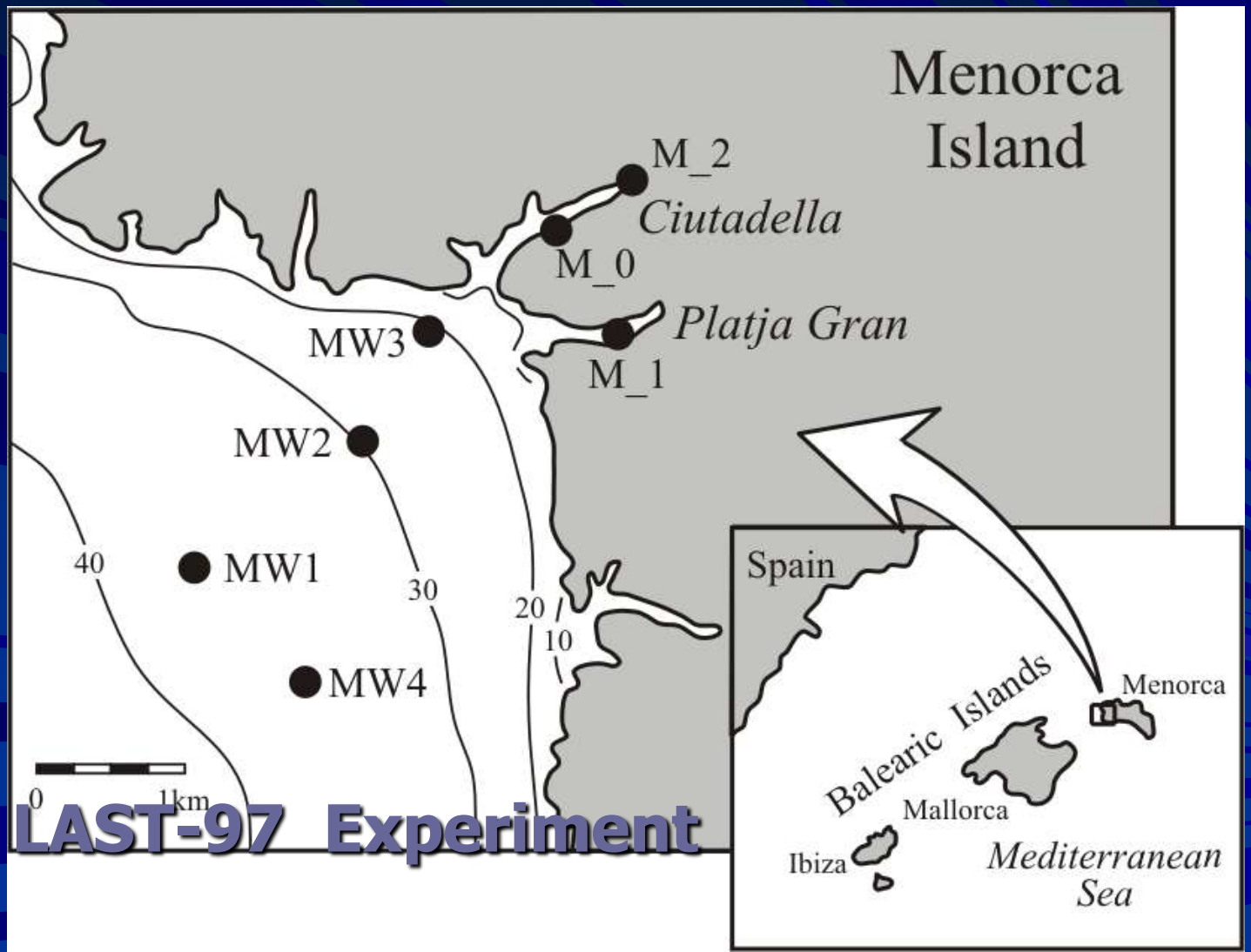
✓ **Generation region:**

Open (deep) ocean ←→ Coastal (shallow-water) area

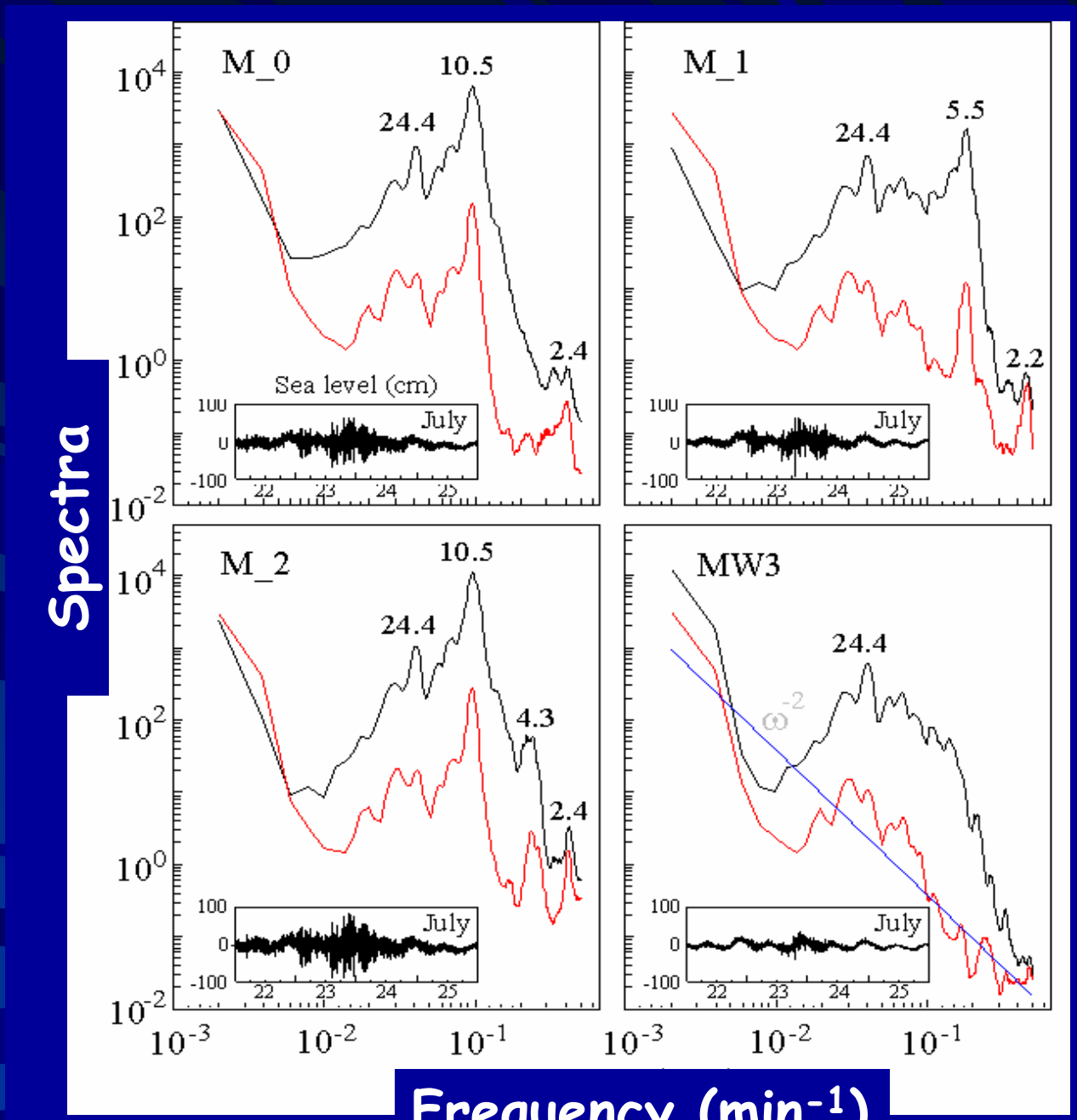
There is a definite physical similarity between meteorological tsunamis and landslide generated tsunamis…

Special hydrophysical experiment to study the generation of meteorological tsunamis LAST-97

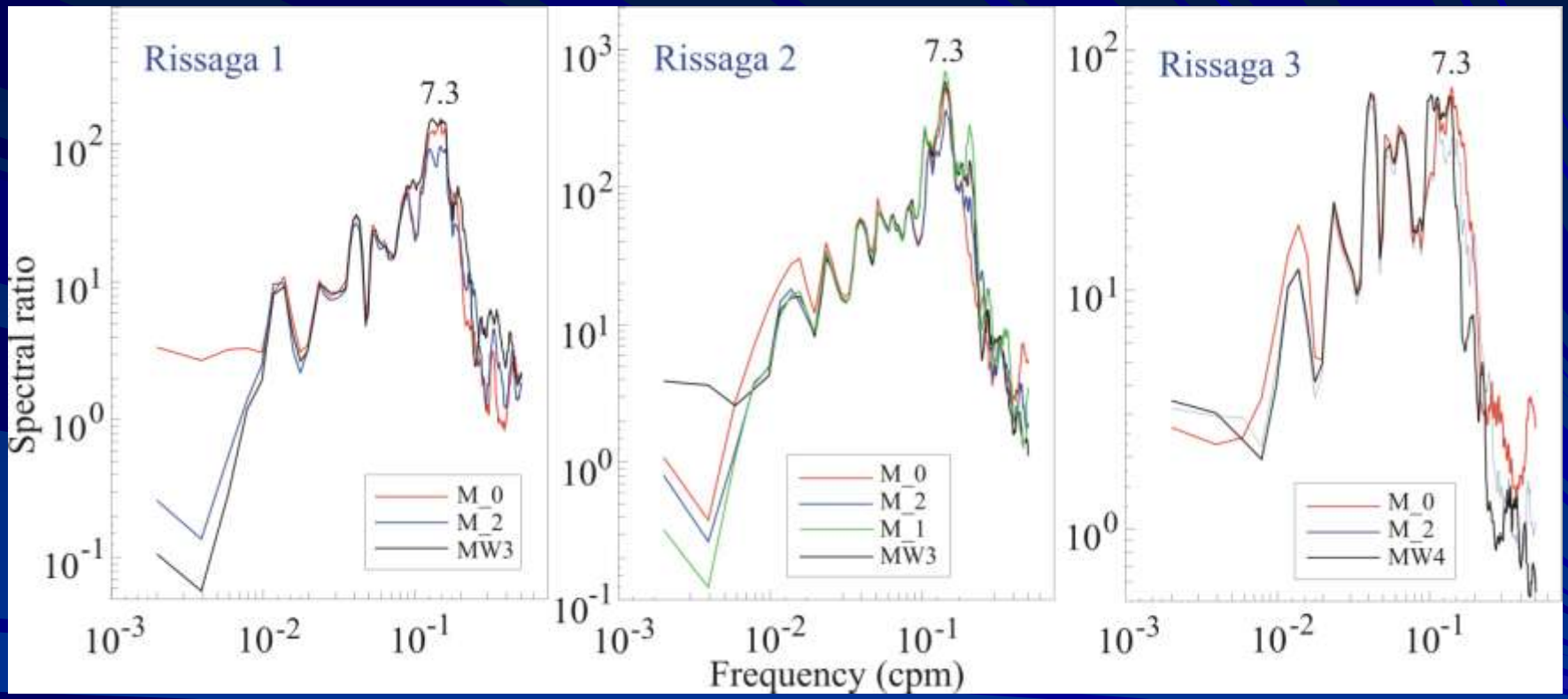
Balearic Islands, Spain



Spectra of the July 2007 rissaga and background oscillations



Source functions of different rissaga events recorded at the same sites

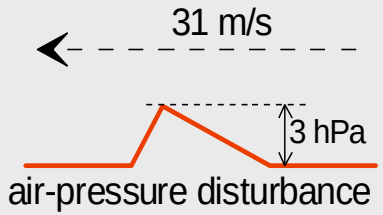


Separation of source and topography effects

(Monserrat, Rabinovich and Casas, 1998)

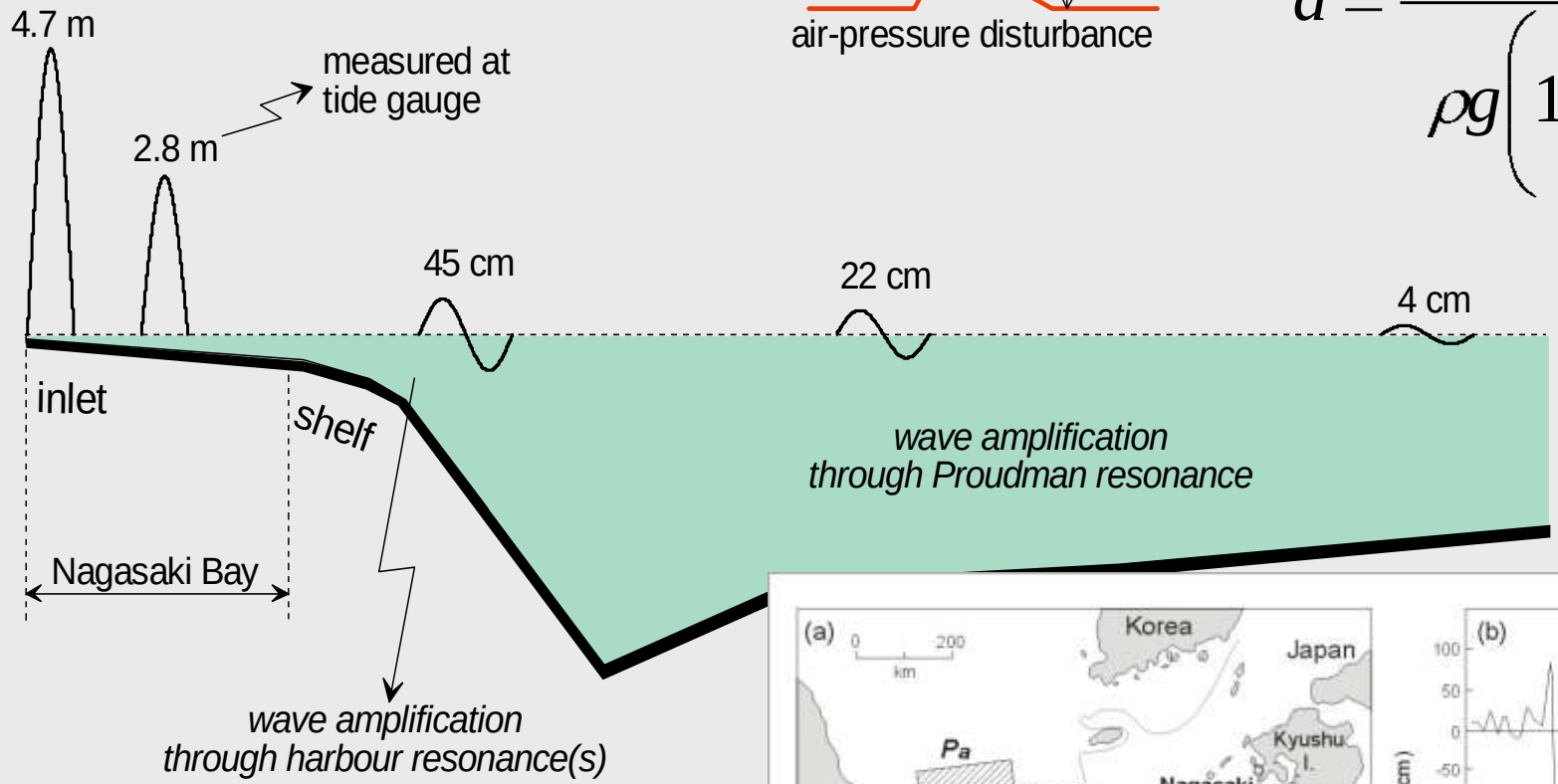
Meteorological tsunami

Proudman resonance



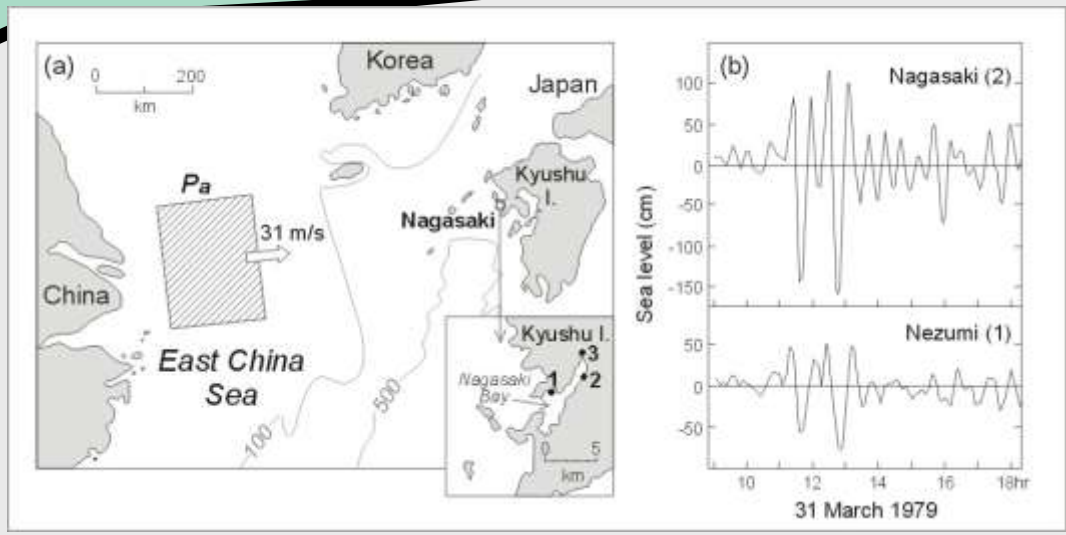
Wave amplitude

$$a = \frac{-\Delta P_a (x - Ut)}{\rho g \left(1 - \frac{U^2}{c^2}\right)}$$

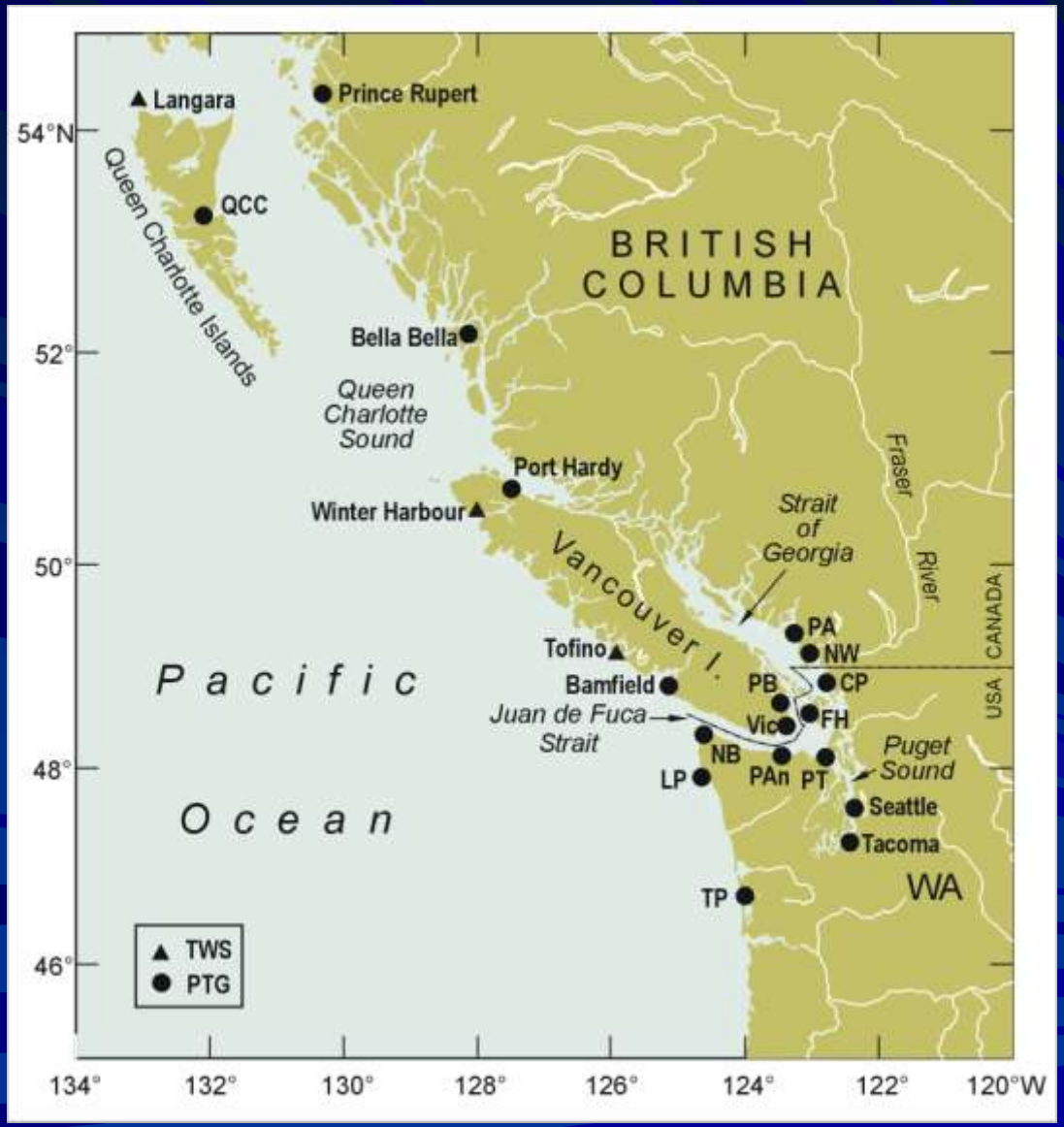


Formation of "abiki" waves
(period of 35 min)

Monserrat, Vilibic, Rabinovich (2006)

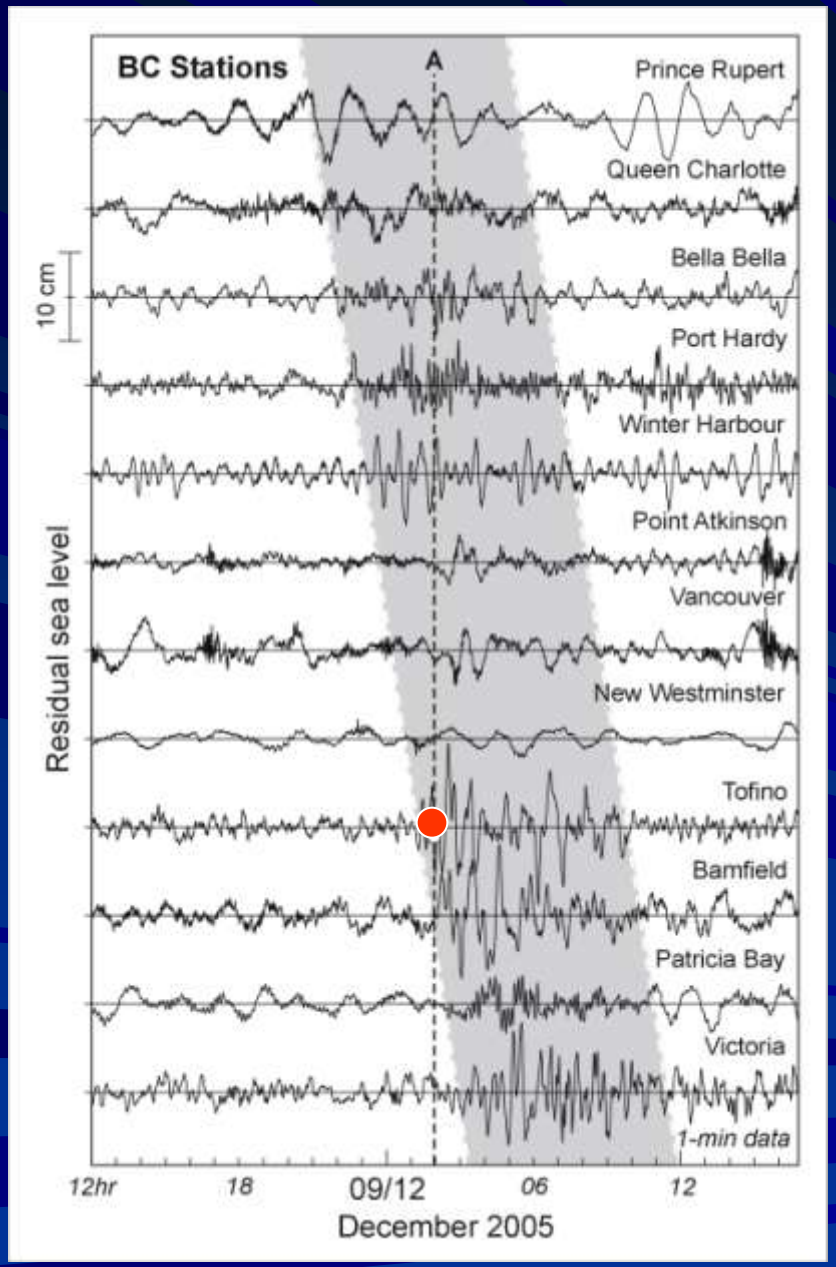


Meteotsunamis on the coast of British Columbia



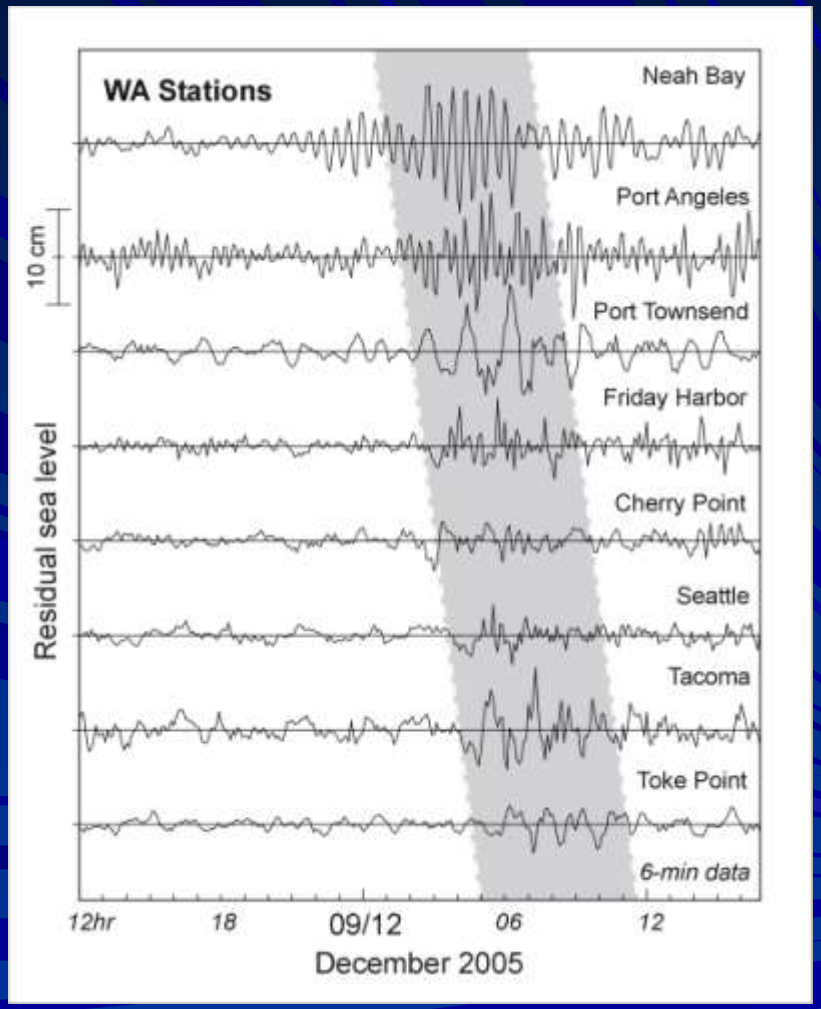
Tide gauge records

British Columbia

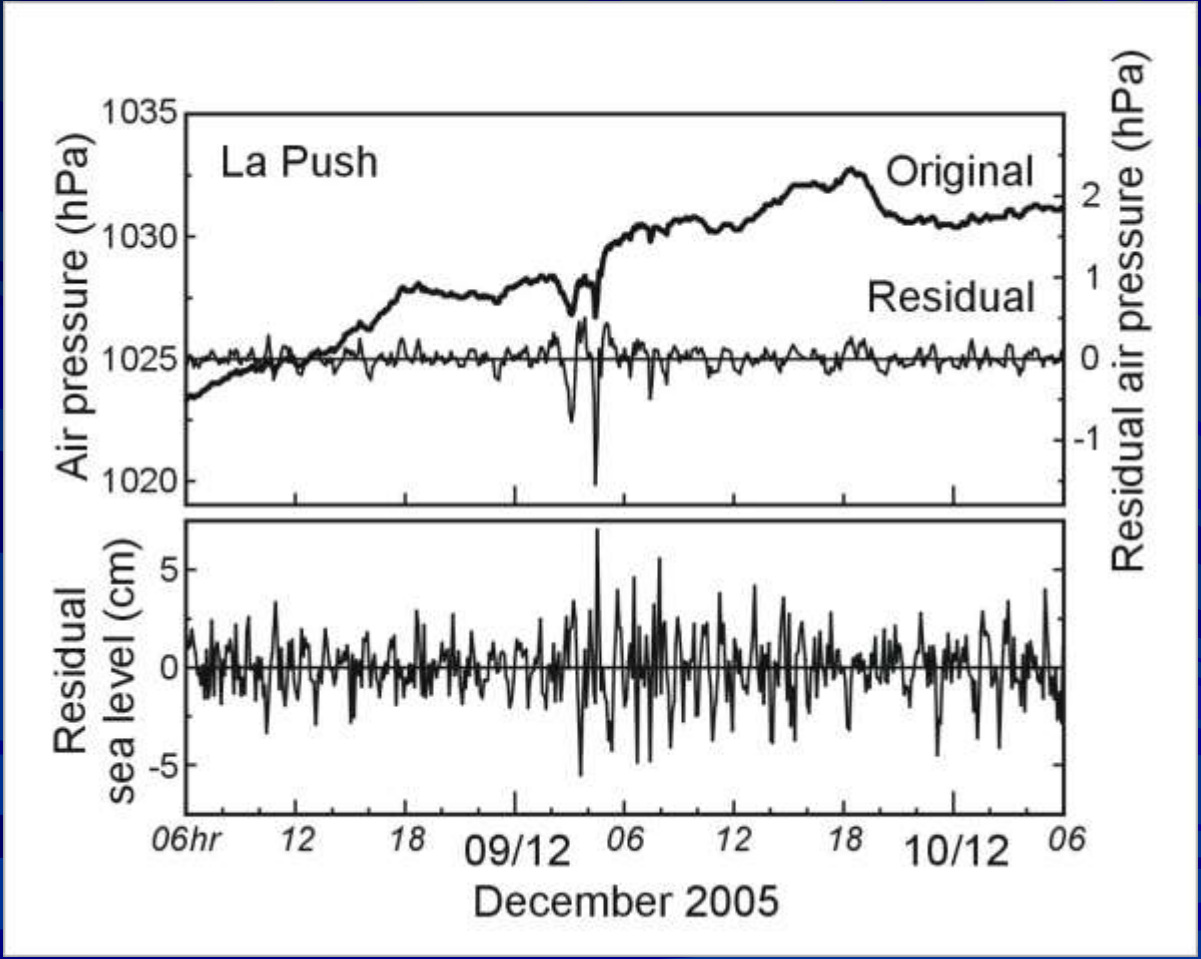


2005

Washington State

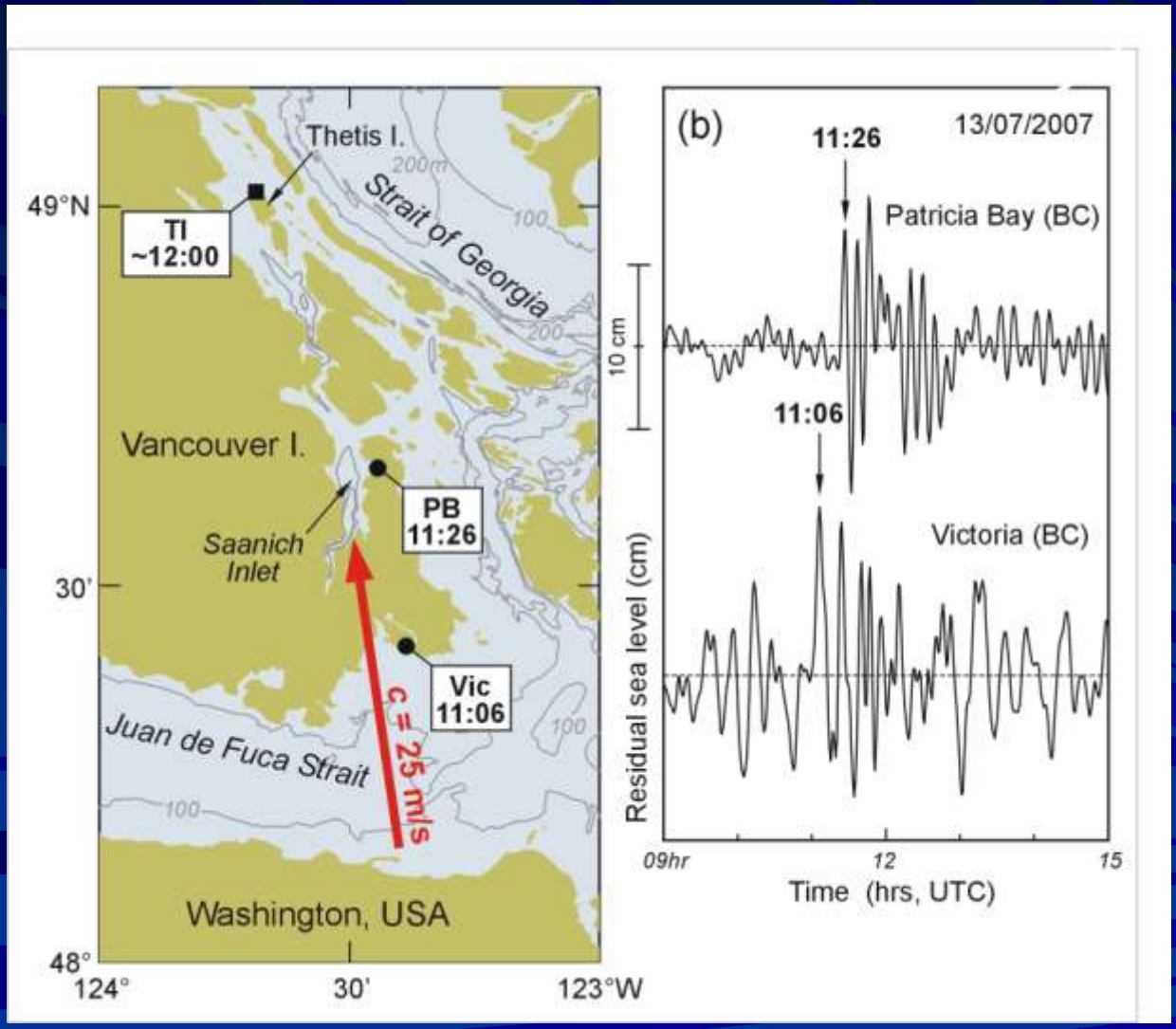


Washington State
La Push
2005



British Columbia
Southern Vancouver Island

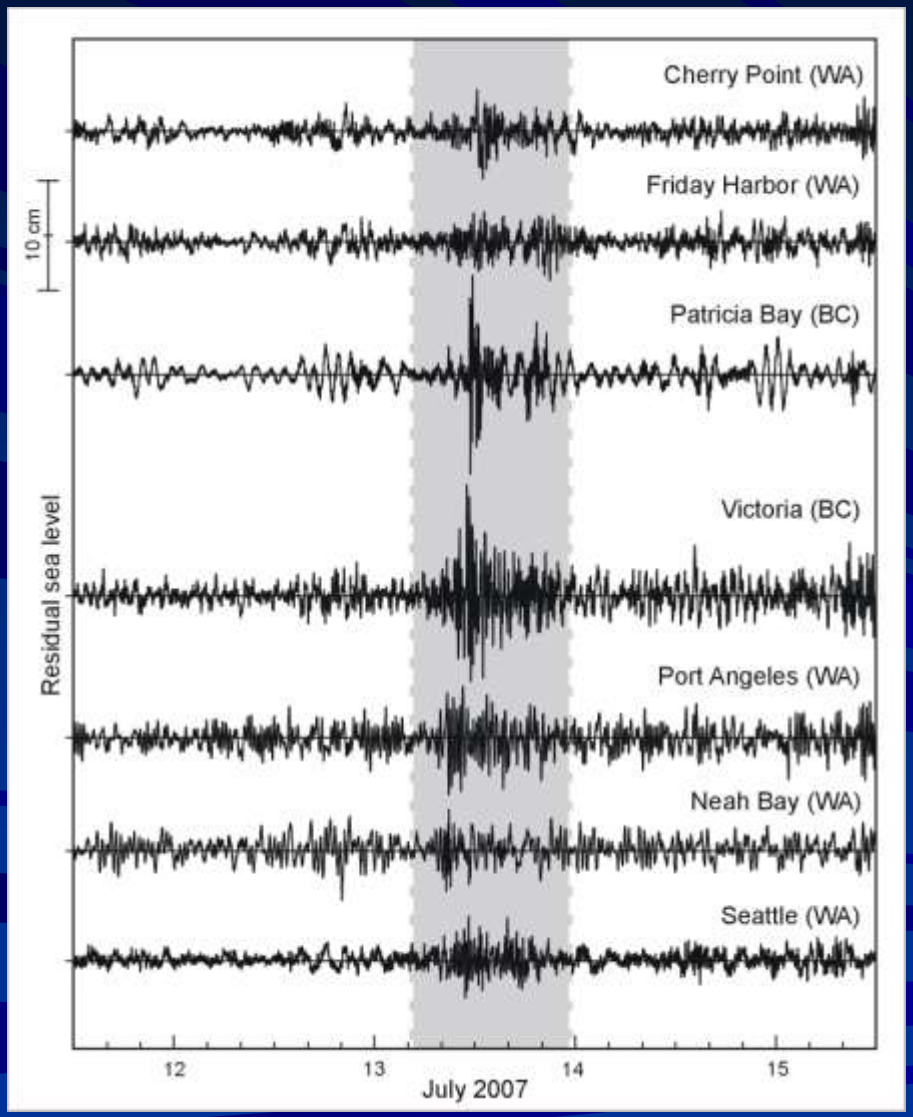
2007



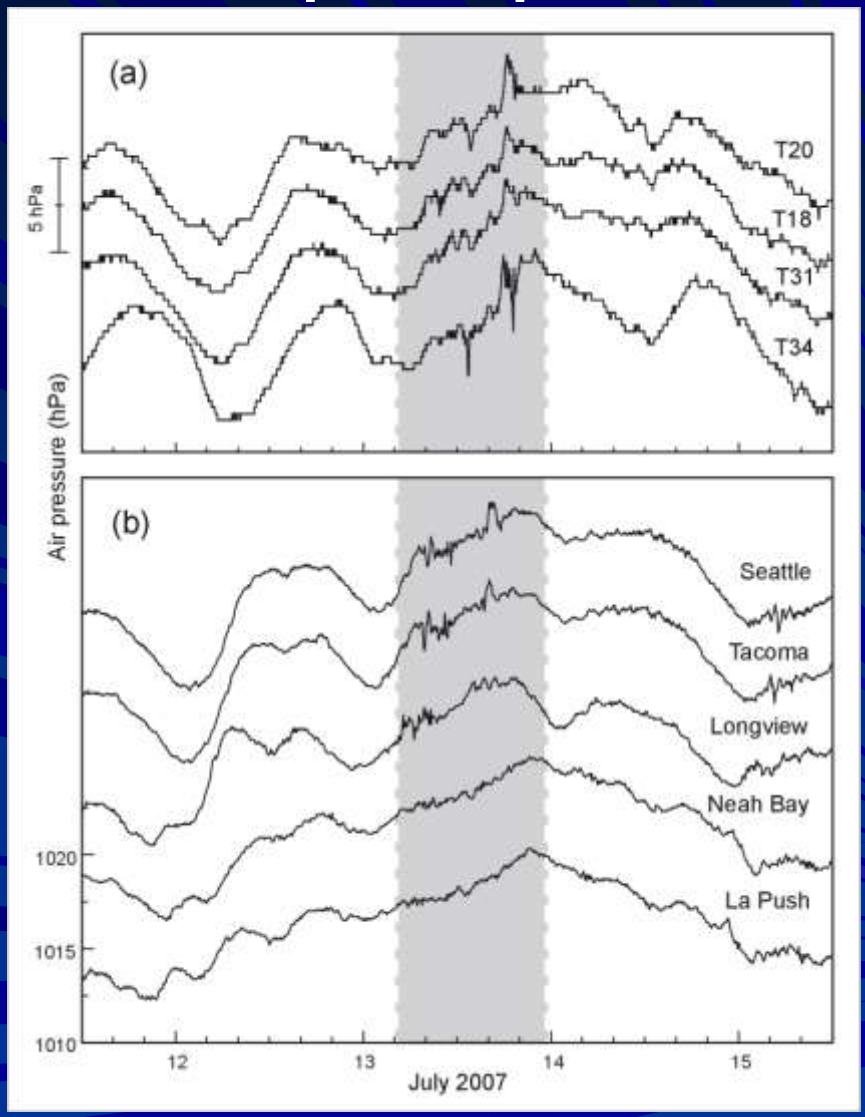
2007

British Columbia and Washington State records

Sea level

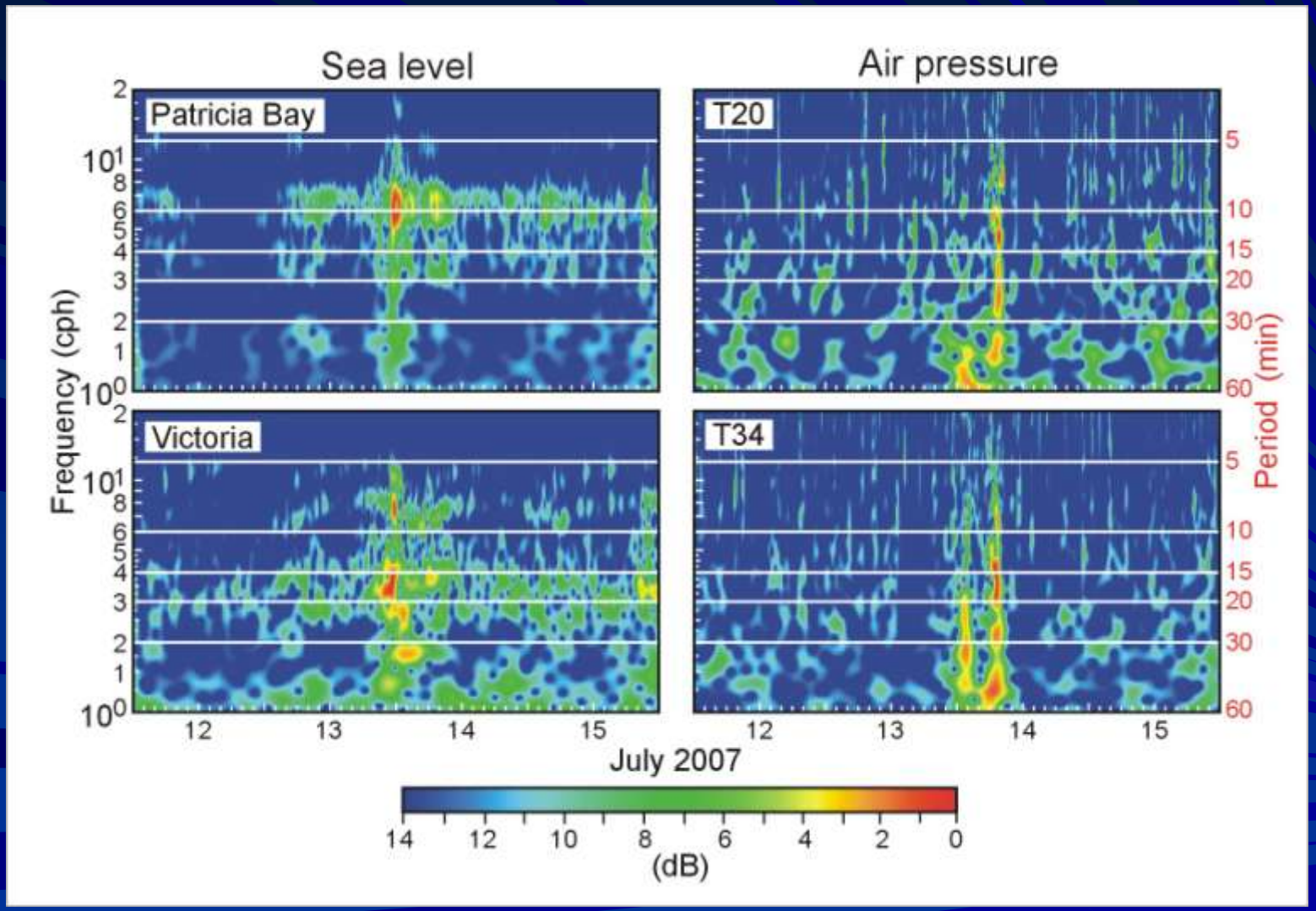


Atmospheric pressure



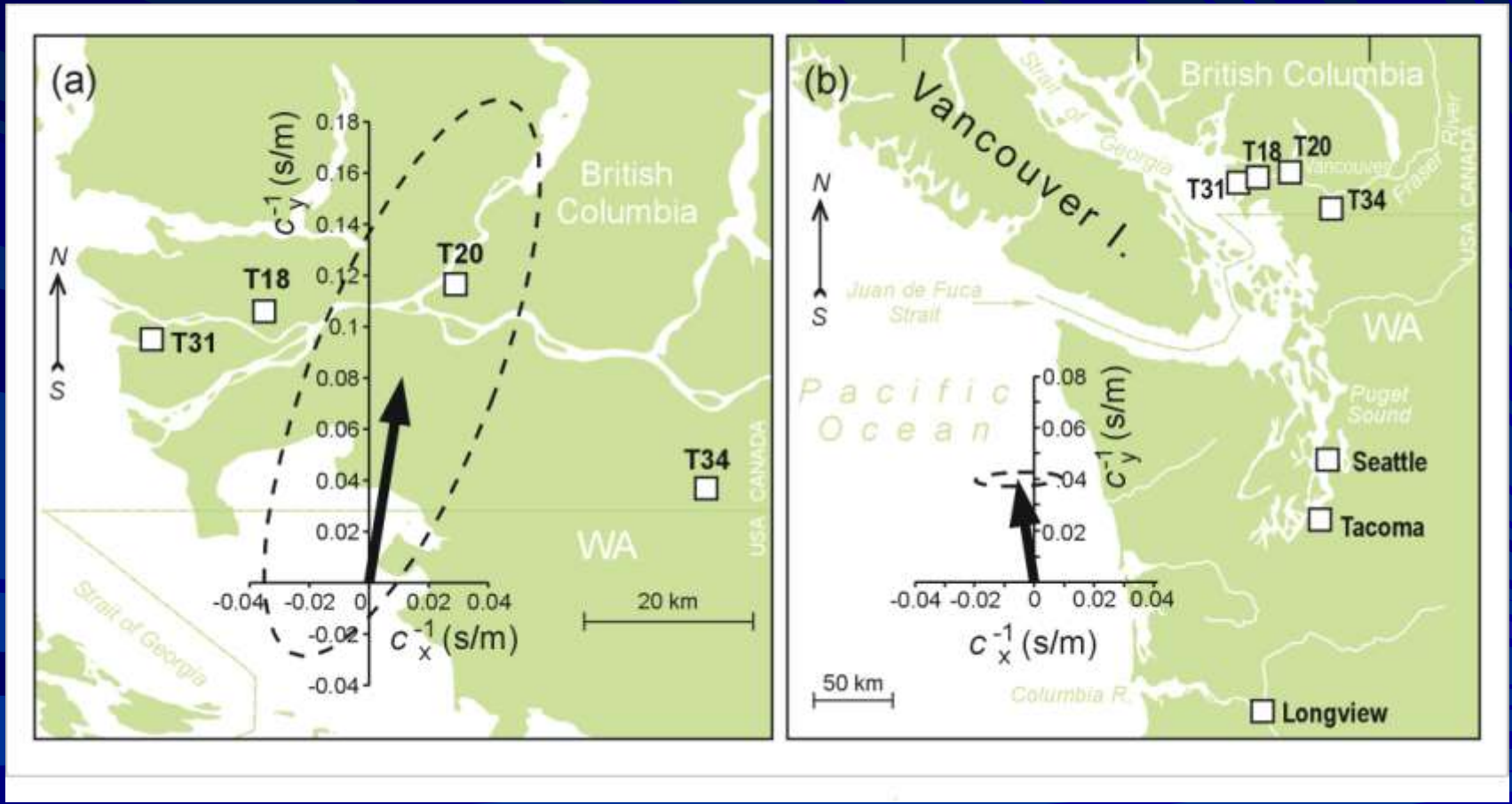
Sea level and atmospheric pressure wavelet analysis of the 2007 event

2007



Inverse celerity vectors for the 2007 meteotsunami

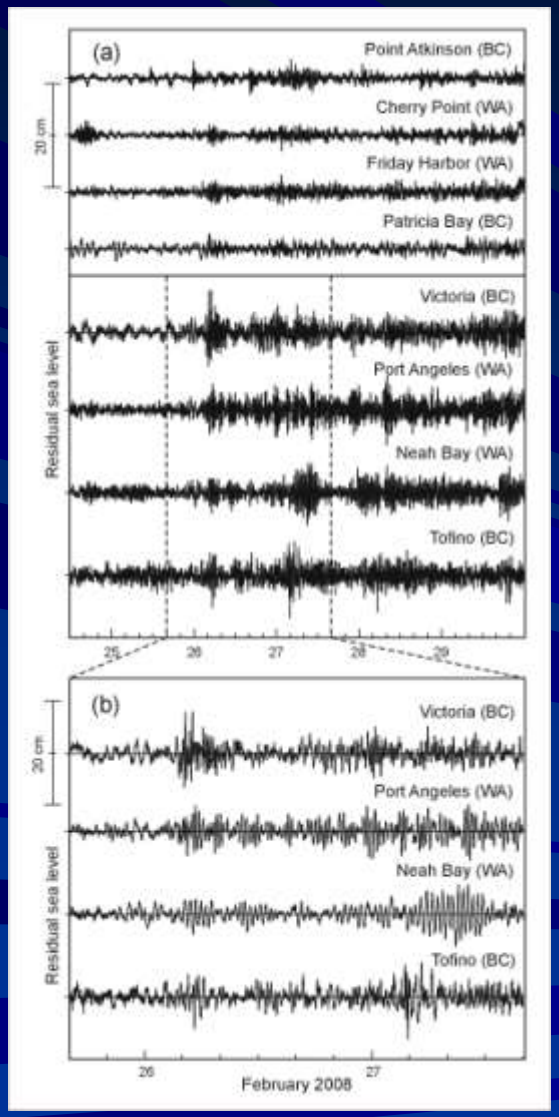
2007



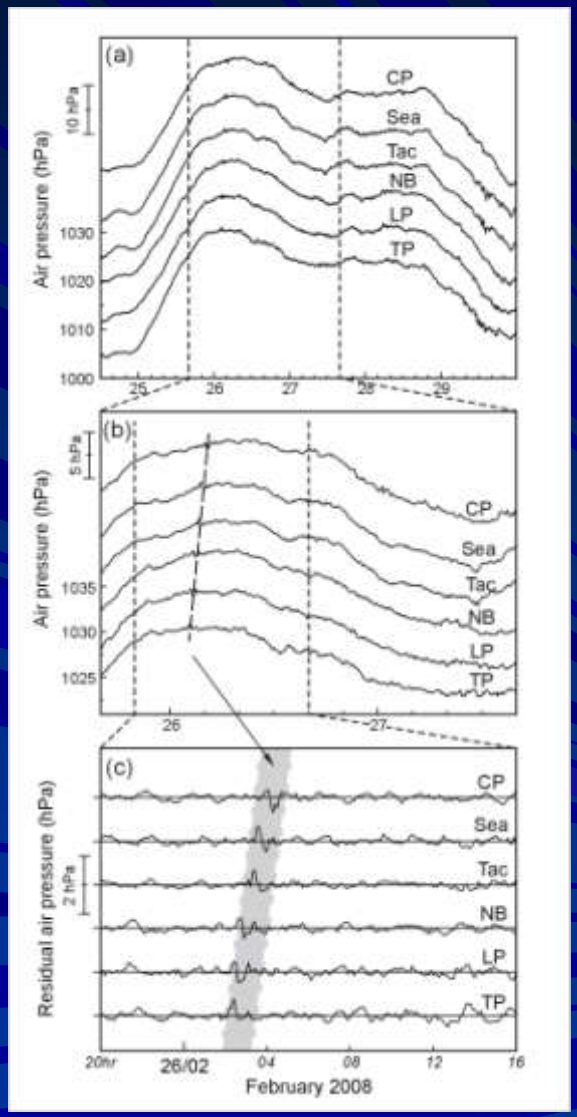
2008

British Columbia and Washington State records

Sea level

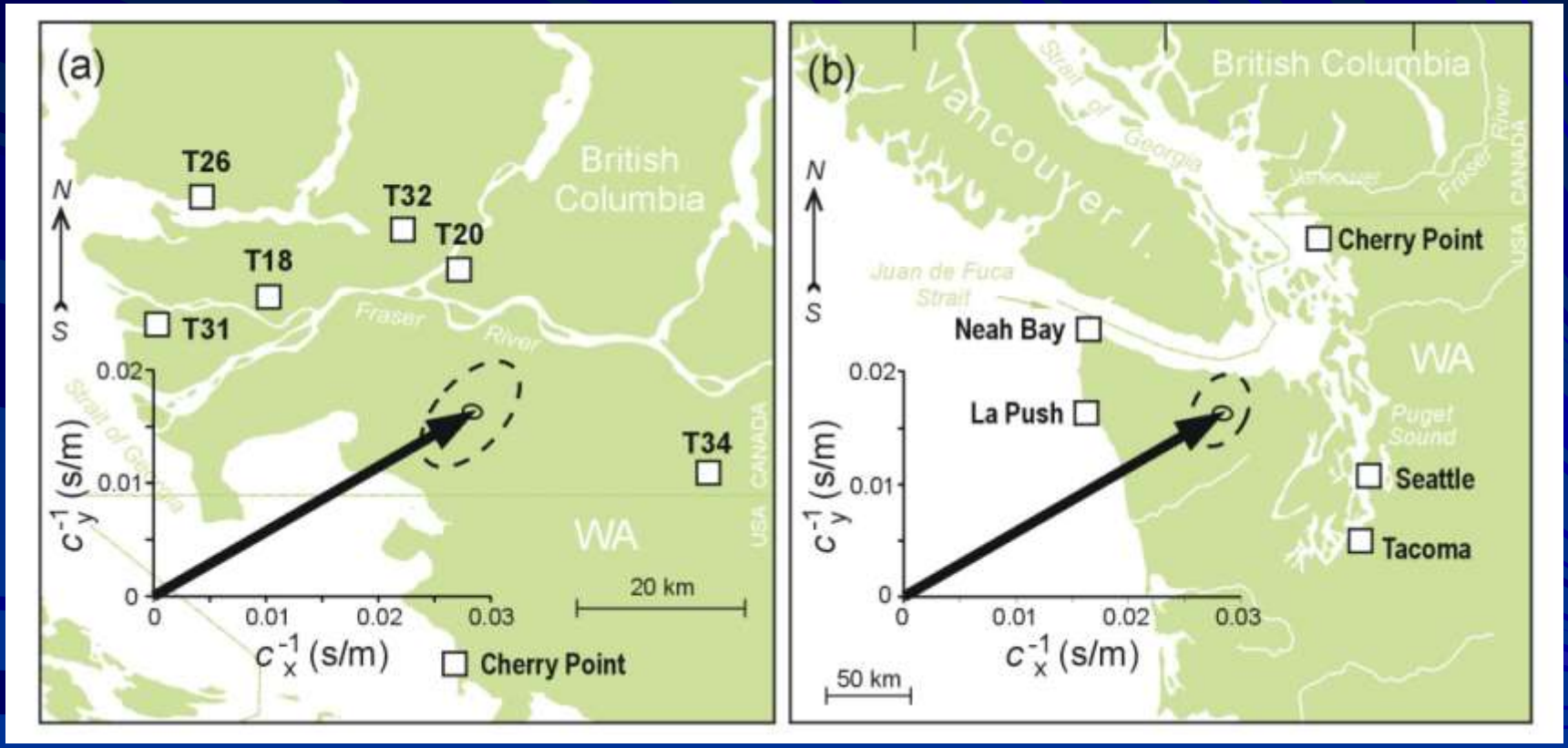


Atmospheric pressure

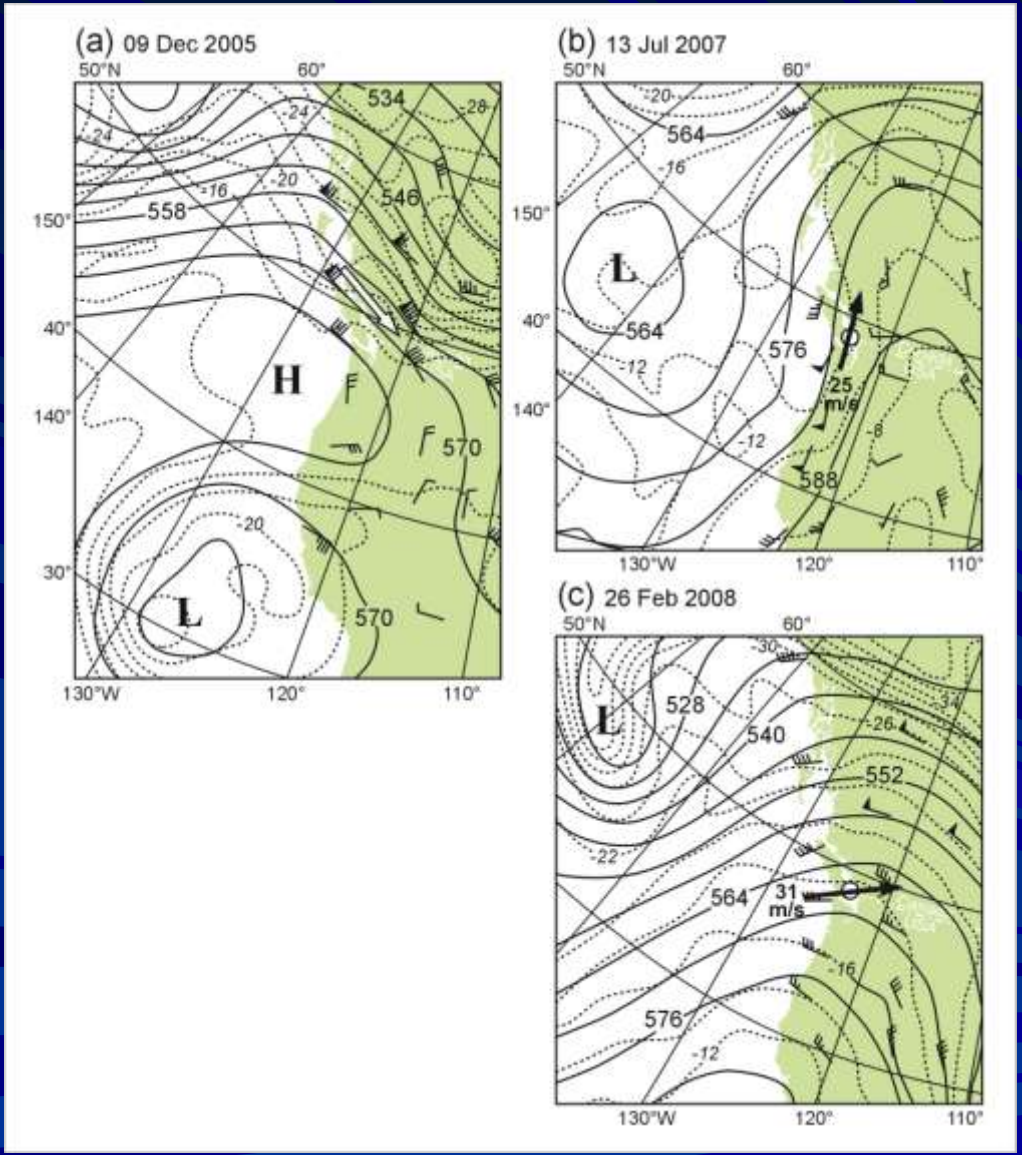


Inverse celerity vectors for the 2008 meteotsunami

2008



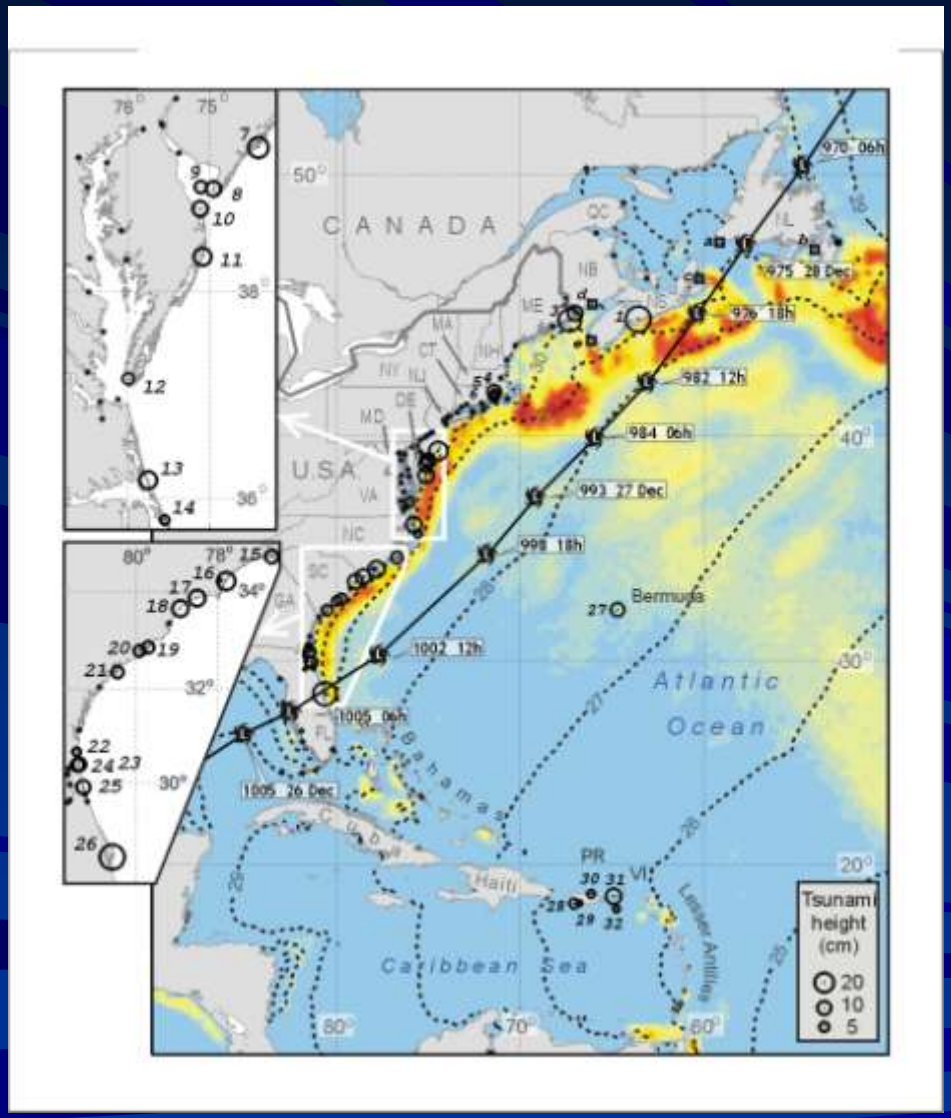
High-altitude (500 hPa) atmospheric pressure maps for the 2005, 2007 and 2008 events

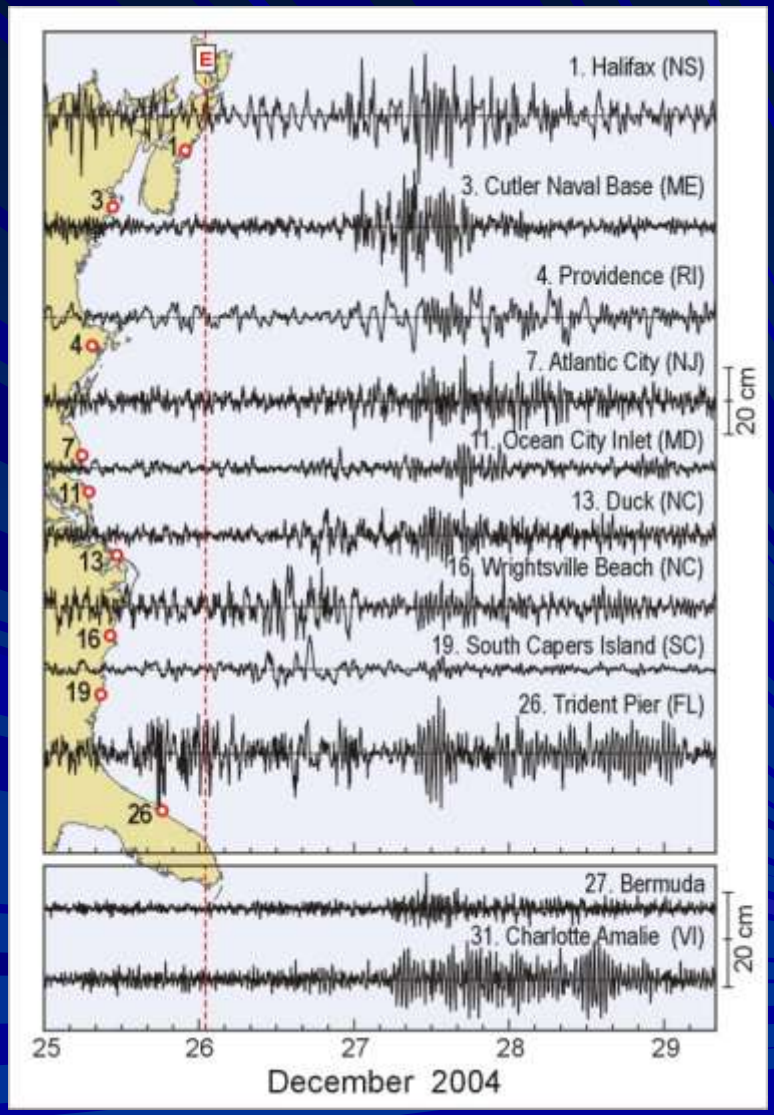


26 December 2004: North Atlantic

(in 10 days after the event)

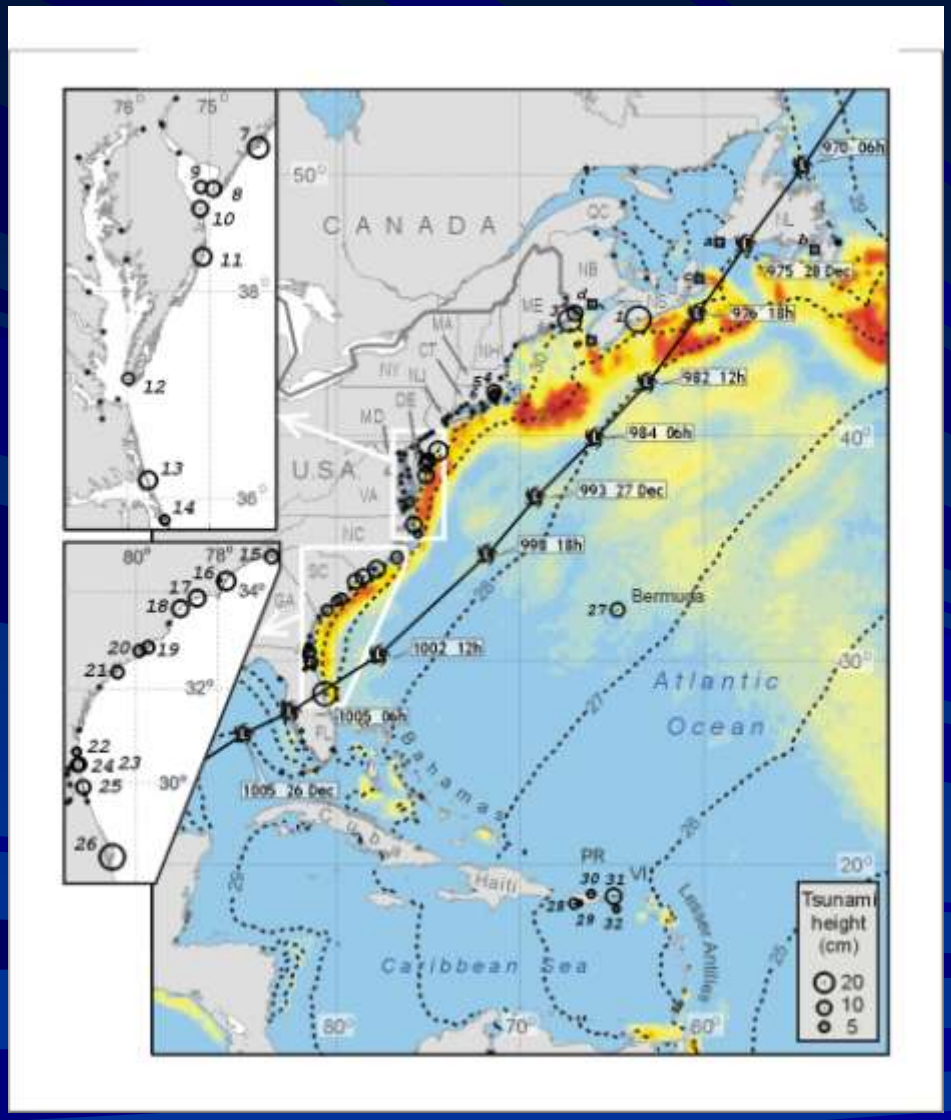
NW Atlantic Ocean. Double jeopardy: Concurrent arrival of the 2004 tsunami and storm-generated waves

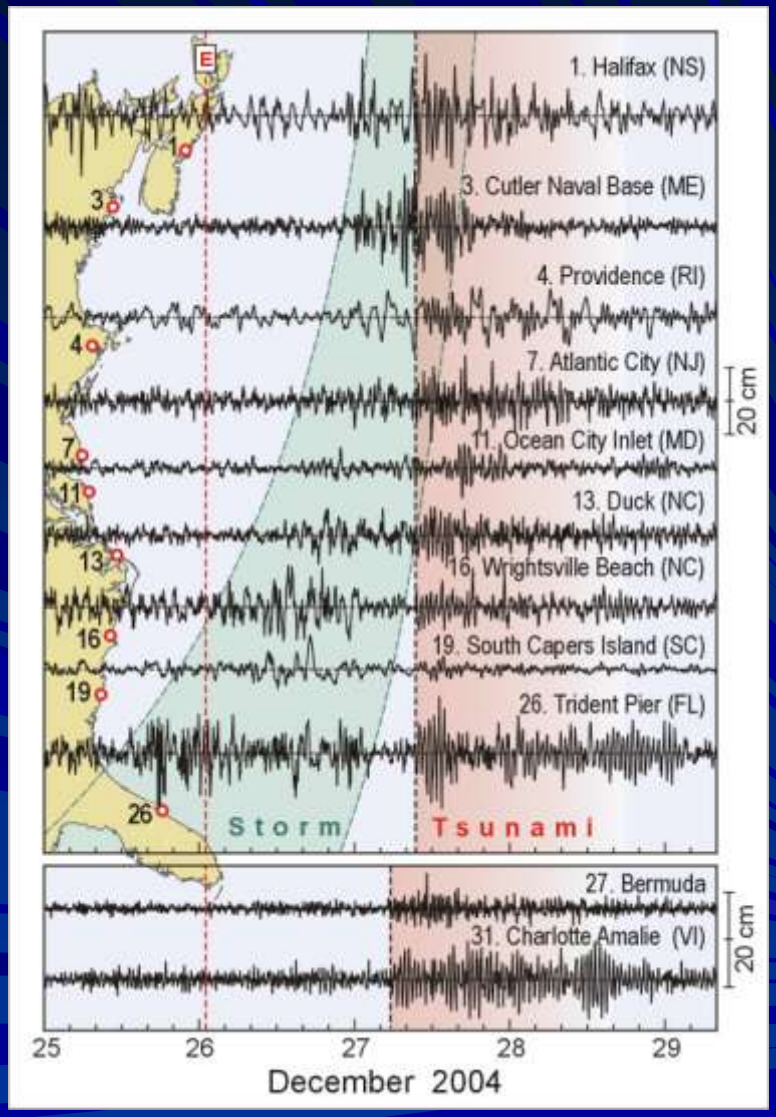




Thomson, Rabinovich, and Krassovski (GRL, 2007)

NW Atlantic Ocean. Double jeopardy: Concurrent arrival of the 2004 tsunami and storm-generated waves





Thomson, Rabinovich, and Krassovski (GRL, 2007)

NW Atlantic Ocean: Wavelet analysis

Storm-generated waves

Tsunami