Meteorological tsunami

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

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 Vilbic)
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

Central Kuril earthquake ($M_w = 8.3$) and tsunami of 15.11.2006

Tsunami record at Crescent City (CA)

Port of Crescent City (CA)
“Rissaga” waves in Ciutadella Harbour, Menorca Island, Baleares (July 1989)

Wave height > 2 m
Period 10.6 min
Times (UTC) of the first air-pressure maximum

Air pressure

Atm. Pressure (hPa)

Sea level (cm)

Wind (m/s)

27 June 2003, Croatia

(From Ivica Vilibic)
Malta Island

"Milghuba" waves (1996)

Qawra Station (open sea)

Mellieha Bay

Air pressure

Atm. pressure/10 (mbar)  Sea level (m)

18 September 1996

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

Algerian tsunami
21 May 2003 (M = 6.8)

(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 \( \rightarrow \) from 1-2 min to \( \sim \) 2.5 hrs

✓ Same spatial scales \( \rightarrow \) 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

(Monserrat, Rabinovich and Casas, 1998)
Meteorological tsunami
Proudman resonance

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

Formation of “abiki” waves
(period of 35 min)

Monserrat, Vilibic, Rabinovich (2006)
Meteotsunamis on the coast of British Columbia
British Columbia
Southern Vancouver Island

2007
British Columbia and Washington State records

Sea level

Atmospheric pressure
Sea level and atmospheric pressure wavelet analysis of the 2007 event
Inverse celerity vectors for the 2007 meteotsunami
British Columbia and Washington State records

Sea level

Atmospheric pressure

2008
Inverse celerity vectors for the 2008 meteotsunami
High-altitude (500 hPa) atmospheric pressure maps for the 2005, 2007 and 2008 events
26 December 2004: North Atlantic

Tsunami’s passage through Atlantic
Scientists uncovered evidence Thursday that last week’s tsunami was felt along the East Coast 28-30 hours after the earthquake. The new data is being used to model the tsunami movement through the Atlantic Ocean.

(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

Cutler Naval Base (ME)

Duck (NC)

Wrightsville Beach (NC)

Trident Pier (FL)

December 2004

Frequency (cph)

Period (min)

-12 -10 -8 -6 -4 -2 0 (dB)