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Meteorological tsunamis in the World Ocean: Overview

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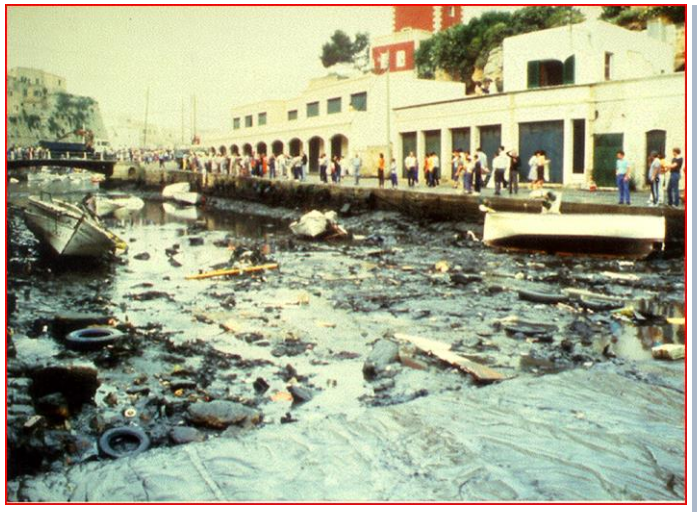
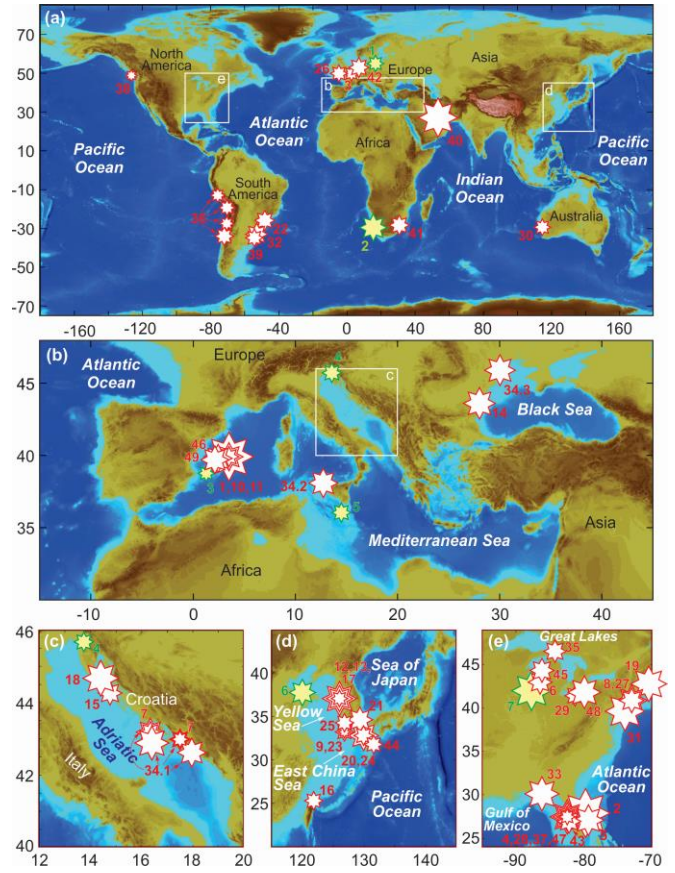


Summary Meteorological tsunamis" ("meteotsunamis") are long destructive oceanic waves that have the same temporal and spatial scales as ordinary tsunami waves and can affect coastal areas in a similar hazardous way, but which are generated by atmospheric forcing (atmospheric gravity waves, pressure jumps, frontal passages, squalls, etc.) rather than by seismic activity or submarine landslides. Meteotsunamis have long been considered a very rare and local phenomenon that occurs only in a few specific harbours, such as Ciutadella (Balearic Islands, Spain), Vela Luka and Stari Grad (Croatia), Mazaro dell Vallo (Sicily), Nagasaki Bay (Japan) and other locations, including the Great Lakes. However, observations from around the world over the past decade and the occurrences of several devastating events, including the 2017 meteotsunamis in the Netherlands, Durban (RSA) and Dayyer (Iran), and the 2018 meteotsunamis on the coast of Florida (USA), have demonstrated that meteotsunamis are much more common and widespread than was previously thought. There are two basic types of meteorological tsunamis associated with atmospheric activity: "*bad-weather*" meteotsunamis and "*good-weather*" meteotsunamis. Bad-weather waves fall into the "expected" category, as: they are normally associated with large-scale intense meteorological events, such as hurricanes, typhoons, derechos, and strong cyclones (i.e., with *storm weather*). Typical features of these events include: (1) Impacts of extensive coastal regions (of several hundred kilometers); (2) extreme, long lasting ("ringing") seiches; and (3) concurrence with other hazardous types of sea level oscillations, in particular, with storm surge, infragravity waves and wave setup. This type of meteotsunami is common on the Atlantic coasts of North America and northern Europe. Good-weather meteotsunamis are "mysterious" and "unexpected", frequently occur during beautiful calm weather and are normally generated by atmospheric pressure jumps and trains of atmospheric gravity waves. Such meteotsunamis are more localized, have shorter duration and are not typically concurrent with other long wave phenomena. Data analysis and numerical experiments have shown that "good-weather" meteotsunamis are a *resonant* phenomenon governed by the Froude number, *Fr*, which is the ratio of the atmospheric gravity wave speed (*U*) to the phase speed of long ocean waves (*c*). Resonance occurs when $Fr = U/c \sim 1.0$. Meteotsunamis can also be strongly amplified by topographic steering and resonance features. This leads to two subtypes of "good-weather" meteotsunamis: "*harbour meteotsunamis*" and "*beach meteotsunamis*". "*Harbour resonance*" and high *Q*-factor in specific bays, inlets and harbours play critical roles in harbour meteotsunamis. "Harbour meteotsunamis" are common destructive features in Mediterranean regions, in particular, in the Adriatic Sea, and on the coasts of the Balearic Islands, western Sicily and Malta. Several catastrophic events, including the 6-meter Vela Luka (Croatia) flood of 21 June 1978 and the 1984 and 2006 floods in Ciutadella Harbour (Spain), are spectacular examples of harbour meteotsunamis. Such meteotsunamis lead to steady monochromatic oscillations at the period of the fundamental mode of the corresponding basin. "Beach meteotsunamis" occur on straight beaches and have properties solitary waves ("solitons"). The most famous example of this kind is the "Daytona Beach" (Florida) event of 3 July 1992 when a 3.5-meter tsunami-like ocean wave injured 75 people. Recently, similar destructive events impacted Florida (2012, 2014, 2018), Odessa in the Black Sea (2014) and Dayyer in Iran (2017).



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