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Meteorological tsunamis – generation mechanisms, propagation, coastal impact and warning systems

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Meteorological tsunamis (or meteotsunamis) are atmospherically generated tsunami-like waves which pose a severe threat for exposed coastlines. Although not as destructive as ordinary tsunamis, several meters high meteotsunami waves can bring destruction, cause loss of human lives and raise panic. An overview of meteotsunami research will be given: (i) meteotsunamis first appear in the middle age legends which attribute origin of these mysterious waves to supernatural forces; (ii) this is followed by the early 20 century scientific explanations of the phenomenon; (iii) and by several geographically limited short-term raises of meteotsunami research interest, commonly lasting for a few years after a particularly destructive event; (iv) starting in the early 2000s, and following realization that meteotsunamis are a worldwide phenomenon, there has been a boom of meteotsunami research, lasting till present days.

Atmospheric preconditioning for meteotsunami generation will be discussed. It will be shown that there are generally favorable (although not unique!) tsunamigenic synoptic conditions, which commonly include presence of strong mid-tropospheric jet stream. This is because dynamical instabilities, which can lead to tsunamigenic atmospheric pressure disturbances, often form at exit regions of jet streams. It will be shown that resonant transfer of energy between such atmospheric disturbances and long ocean waves is necessary for meteotsunamis to occur. Following resonant generation of open ocean waves, two different types of destructive meteotsunamis can occur: (i) harbor meteotsunamis – which commonly appear at very specific bays (so called meteotsunami hot spots), and which are characterized by strong currents, and prolonged ringing of sea surface, the latter lasting up to several hours; and (ii) beach meteotsunamis – which manifest as solitary waves at prolonged stretches of straight beaches. Examples of harbor meteotsunamis include events in Ciutadella Harbour, and Vela Luka and Nagasaki bays, which all have high amplification Q-factors, and marked resonant properties, and examples of straight beach meteotsunamis include Daytona Beach and Panamy City (both Florida) events, of 1992 and 2014, respectively; Odessa event of 2014, etc.

Presently, there are several on-going attempts for constructing meteotsunami warning systems. In order to be successful, these systems need to be based on combination of statistical evaluations, regional atmospheric modelling, high-resolution coastal modelling and real-time measurements. Feasibility of these systems will be discussed.