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High storm surge events in Venice and the 11-yr solar cycle

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In the last years the Venice lagoon has received much attention as a case of coastal vulnerability, mainly because of relative sea level rise and increase frequency of storm surge events, the so-called "aqua alta", which, particularly during autumn, cause the flooding of the Venice historical city center. Long-term fluctuations in solar activity and large-scale climate patterns have been suggested as feasible factors of flooding variability. This study explores the long-term frequency variability of High Surge Events (HSE) in Venice for the period 1948-2008 and its modulation by the 11-yr solar cycle.

A significant decadal variability in the frequency of HSE is found in good correspondence with the 11-yr cycle, solar maxima being associated to a significant increase of the October-November-December HSE frequency. A Storm Surge Pattern (SSP), i.e. the seasonal 1000 hPa height pattern associated to increased frequency of HSE, is identified and found similar to the positive phase of the main variability mode of the regional atmospheric circulation (EOF1). However, further analyses indicate that the increase of HSE in solar maxima cannot be simply explained by a higher recurrence of positive EOF1 phases during high solar years. It rather seems that solar activity modulates the spatial patterns of the atmospheric circulation (EOF) and the favorable conditions for HSE occurrence (SSP). Thus, under solar maxima, the occurrence of HSE is enhanced by the EOF1, namely a large-scale wave train pattern that is symptomatic of storm track paths over northern Europe. Solar minima reveal a substantially different and less robust SSP, consisting of a meridionally oriented dipole with a preferred southward path of storm track activity, which is not associated to any EOF during low solar periods. It is concluded that solar activity plays an indirect role in the frequency of HSE by modulating the spatial patterns of the main modes of atmospheric regional variability, the favorable patterns for HSE occurrence and their mutual relationships, so that constructive interaction between them is enhanced during solar maxima and inhibited in solar minima.