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Local and large-scale controls of the exceptional Venice floods of November 2019

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On 12 November 2019, an exceptional flood event occurred in Venice, second only to the one that occurred on 4 November 1966. The maximum recorded sea level value of 189 cm above local datum resulted in the flooding of more than 85% of the pedestrian surface of the historical city. Moreover, with four extremely high tides since 11 November 2019, this has been the worst week for flooding in Venice ever since 1872, when official statistics were first produced. The event that struck Venice and the northern Adriatic Sea on 12 November 2019, although having certain conditions seemingly typical of the events that cause exceptional high waters, also had some peculiar characteristics not observed before and therefore it requires an in-depth analysis. Several factors made this event exceptional: an in-phase timing of the peak of the storm surge and the astronomical tide; an anomalously high monthly mean sea level in the Adriatic Sea induced by a steady low-pressure and wind systems over the Mediterranean Sea associated with large-scale low-frequency atmospheric dynamics; a deep low-pressure system over the central-southern Tyrrhenian Sea that generated strong sirocco (south-easterly) winds along the main axis of the Adriatic Sea pushing the waters towards north; a fast-moving local depression - and the associated wind perturbation - travelling in the north-westward direction along the Italian coast that may have forced long ocean waves (e.g., edge wave); and very strong winds (100 km h^{-1} on average, with gusts reaching 110 km h^{-1}) over the Lagoon of Venice which led to a further rise in water levels and damage to the historic city. In this study, a large set of available observations and the high-resolution numerical simulations are used to quantify the influence of these drivers on the peak flood event and to investigate the peculiar weather and sea conditions over the Mediterranean Sea during the Venice floods of November 2019.