The crucial role of monitoring and forecasting the small-scale meteorological processes in the Venice Lagoon

Sea storms represent a major threat to many coastal areas. This is particularly Yes for the Venice Lagoon, North Adriatic Sea, Italy, where sea level forecast is of paramount importance for the safeguard of its historical settlements. This requires an integrative approach which combines monitoring, large-scale and small-scale forecasting models, early warning systems, and coastal management and planning. Although the forecast capability has improved significantly in the last decades, allowing reliable descriptions of meteorological patterns in the North Adriatic Sea a few days in advance, it is still very complex, even a few hours in advance, to identify and predict magnitude, trajectory, and effects of the small-scale local depressions traveling alongshore the lagoon, in terms of raising local water levels. In such cases, the inverse barometric effect (i.e., sea level rising in areas with lower atmospheric pressure) provides limited consequences because of their short timescale combined with the shallow water depth of the lagoon. The main sources of uncertainty studying the effect of these local processes are: i) the strong and short-lived winds that may be triggered by the transition of the local minimum of pressure, extremely effective in raising sea levels when blowing over the lagoon, as it happened on 12 November 2019; ii) the sudden and violent rain directly falling into the lagoon, which, if combined with the peak of the tide, can raise the local sea level by the total rainfall amount, as it happened on 16 May 2024. The Italian Institute for Environmental Protection and Research manages a dense network of meteorological and oceanographic stations located within the lagoon and offshore. These data, coupled with detailed numerical simulations, allowed a keen analysis of the local physical processes driven by the storms. Insights from the above mentioned, recent storm events, show that, under peculiar meteorological conditions, the sea level forecast may be very sensitive to small scale details of the three-dimensional meteorological fields, which are not always available or properly represented in the present resolution of the main meteorological models and that are intrinsically less predictable.

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