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Understanding the interaction between inland waters and the coastal zone during extreme events over the Po Delta from space

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The alternation of extreme events is a source of great stress on the territory and forces us to adopt solutions to help mitigate their consequences. In this study, an attempt is made to exploit Earth Observation from space as a means to point out the interaction of inland waters and the coastal areas during hydrological extreme events, i.e. floods and droughts. During a flood event, large volume of water from the river reaches the coast, adding a considerable volume of freshwater. Conversely, during a drought event salt water from the sea enters inland causing severe damage to agriculture and the local population. With this study we attempt to investigate how the systems of sea and river interact during particularly intense events using satellite optical (Sentinel-2 and Sentinel-3) and altimeter (Sentinel-3, Cryosat-2, Icesat-2) sensor data. The area selected is the Po River delta (up to 200 km from the mouth), which in recent years has been exposed to severe events: in November 2019, the Po River was subject to a copious flood that had not occurred since 2000, while in the summer of 2022, it experienced the worst drought in the last 70 years.

The analysis aims at evaluating three fundamental aspects: 1) the ability of satellite altimetry to identify extreme events in the river; 2) the potential of satellite altimetry to detect salt wedge intrusion in the Po River delta; and 3) the potential correlation between the altimetry observations and optical imagery of the river's plume along the Adriatic coast.

The analysis was conducted by analysing long time series (of about 10 years) for the first objective and by focusing on the drought event of 2022 and the flood events that occurred in the last 5 years for the other two objectives.

The results of the analysis confirm that the satellite observed the significant increase and decrease in water levels in correspondence of the extreme events. In addition, the analysis of the data at the virtual stations in the downstream part of the Po River, together with the data along the tracks crossing the plume closer to the mouth of the river, showed the interaction between the sea and the river. In particular, the temporal series of the river clearly highlight the influence of the sea water several km upstream the river (more than 40 km as reported in the news), probably related

to the salt wedge intrusion, which has caused significant damage to agriculture and drinking water aquifers for a long time after the event. The study qualitatively shows that extreme hydrological events can also be captured in the open sea in this region.

The analysis illustrates the great potential of satellite sensors to monitor extreme events and the interaction of inland and coastal waters.