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RORIP1 – First field experiment of rip currents dynamics on the Black Sea coast

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Rip currents are powerful, shore-normal jet-like flows of water through the surf-zone, which are variable in space and time due to changes in incident wave conditions and nearshore morphology. Despite the low to moderate wave energy environment of the Black Sea, rip currents represent an important hazard on many of its beaches. Furthermore, there is a very low level of public's awareness related to rip currents associated dangers. Regardless of this context, to our knowledge, no field experiments aiming at measuring rip currents dynamics and behaviour were conducted so far on the Black Sea coasts.

We present the first results following the RORIP1 field experiment, which took place for 10 days (11 – 21 October 2021) on Eforie Nord beach, Romanian Black Sea coast. We monitored 3 individual rip currents from a total of 10, which pose a great hazard for a 1-km long beach, the most dangerous on the entire Romanian Black Sea coast (135 and 104 drowning rescues in 2019 and 2020; 22 and 4 casualties in 2017 and 2018). We employed a complex methodology for rip currents monitoring comprising video techniques (video camera and UAV), topographic and bathymetric surveys, sediment sampling, drifters and ecological dye deployments, offshore wind and waves (Spotter buoy) and nearshore hydrodynamic measurements (3D current meter, pressure sensor).

Rips form in the troughs of multiple crescentic bars, often keeping their same position for a longer time period, and are fed by water influx through wave motion and breaking on the bar crests. Drifters and ecological dye deployments, complemented by UAV surveys and video camera footage, highlighted both 'circulatory flow' and 'exit flow' circulation regimes. In some cases, alongshore feeding channels between adjacent rips developed in the proximity of the shoreline, enhancing the offshore flows.

A number of 7 individual surf-zone drifters were released in the vicinity of shoreline during 3 deployments. Despite the low-energy wave conditions (offshore average Hs between 0.35 and 0.55 m; average periods between 3.6 and 4.5 seconds; propagating from ENE), all drifters experienced

exit behaviour from the surf zone. Drifters registered average surface velocities between 0.34 and 0.43 m/s, with maximum instantaneous values exceeding 2 m/s. They travelled between 175 and 325 m during the periods of deployment ranging from 15 to 26 minutes, reaching cross-shore distances of 150 m from the shoreline. The above depicted surface dynamics is in good agreement with the preliminary modelling (Delft3D) employed for this area, which showed similar circulation patterns and surface flows for comparable hydrodynamic conditions.

Our results, backed by a suite of complex analysis, demonstrate the high potential of rip currents to generate strong offshore flows even during low-energy wave conditions along Eforie Nord beach (Black Sea). This poses a great danger for beach safety and awareness of their related hazards is an urgent task for beach managers in the near future.