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Mapping the impact of hurricane-induced storm surge and river flooding in the US

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The 2017 Atlantic hurricane season was a record breaker; this extremely active year has been classified as the most expensive in US history. Between August 25th and September 20th, hurricanes Harvey, Irma and Maria made landfall on the Atlantic coast in quick succession. The trio of major hurricanes that hit this coastline cost the country USD $265 billion, which surpasses the previous record set in 2005 by Katrina, Rita and Wilma. Much of these costs can be attributed to flood damage so there is a clear need for high-quality, reliable flood maps in these vulnerable regions.

After comparing preliminary hydraulic model outputs for Florida to the flood extent of Hurricane Irma, we found that many areas known to have flooded during the hurricane event were not represented as having a flood hazard in the modelled inundation. Analysis of saline gauges along the St John River, Florida, found that salinity within the river peaked six hours prior to the maximum water level being reached. The significant flooding experienced around the St John River was therefore attributed to a combination of both storm surge and rainfall runoff; however, the interaction between the two flood hazards is not well studied or understood.

A hurricane storm event often brings significant levels of heavy rainfall and high river flows as well as causing a hurricane-induced storm surge within tidal rivers. If both risks occur at the same time or in close succession, the downstream boundary water level can be heightened by the storm surge, which in turn causes a backwater effect upstream. The interaction between hurricane-induced storm surge and high river flows as a result of heavy precipitation has the ability to exacerbate flooding in coastal areas. A compound flood event has the potential to cause significant damages and loss of human life due to the risk of increased flood hazard; this has been seen in flood events across the world.

To capture this increased flood hazard, we developed a method to adjust our fluvial models to incorporate the processes of a compound flood event. We implemented this methodology for any fluvial model with a hydrograph that peaked in 24hrs or less, as it is unlikely that a slow-response hydrograph would have a peak concurrent with storm surge. The resulting flood map was then validated against the flood extents experienced during Hurricane Irma. This compound flood map captured a greater number of flooded locations from the Irma event. This work highlights the importance of considering and modelling compound flood events and exploring the probability that hydrograph peaks coincide with storm surges.