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HURRICANES AND THE GULF STREAM

A Double Whammy Impact on Coastal Flooding

By Tal Ezer

Long-time residents of Norfolk and the Hampton Roads area remember the flooding caused by Hurricane Isabel (2003) which had the second highest storm surge on record.

Fewer people are alive to remember the largest storm surge ever recorded in Norfolk over 90 years of tide gauge measurement—this was the Chesapeake-Potomac Hurricane of 1933. Sea level rise (SLR) accelerates the frequency of minor tidal flooding (Ezer and Atkinson, 2014) and increases the number and intensity of storm surges (Fig. 1). Weaker storms that could be ignored in the past now cause major flooding with the additional SLR. If a hurricane with the same track and intensity as the hurricane of 1933 happened today, storm surge could reach ~2 m (~6 feet) over the highest tide level, with potential floods far exceeding any past storms.

In September 2018, ODU was spared the wrath of Hurricane Florence which was headed our way before making a left turn toward the Carolinas (nevertheless, as a cautious measure ODU closed and partly evacuated). But something unexpected did happen here—while Florence moved away from Virginia, the Hampton Roads area nevertheless experienced 2-3 weeks of minor tidal flooding (Fig. 2, page 2) even though the storm was nowhere in sight. New research at CCPO on the interaction between storms and the Gulf Stream (Ezer, 2018) may be able to shed light on this previously unexplained phenomenon.

Research at CCPO by Ezer, Atkinson and collaborators focused on the impact of ocean dynamics on coastal sea level and flooding. Ezer and Corlett (2012), Ezer et al. (2013) and Ezer (2013) were ODU's first publications on the subject after the establishment of the Climate Change and Sea Level Rise Initiative (initially led by L. Atkinson; now the new Institute for Coastal Adaptation and Resilience, ICAR). The early studies found a clear connection between long-term variability in the Gulf

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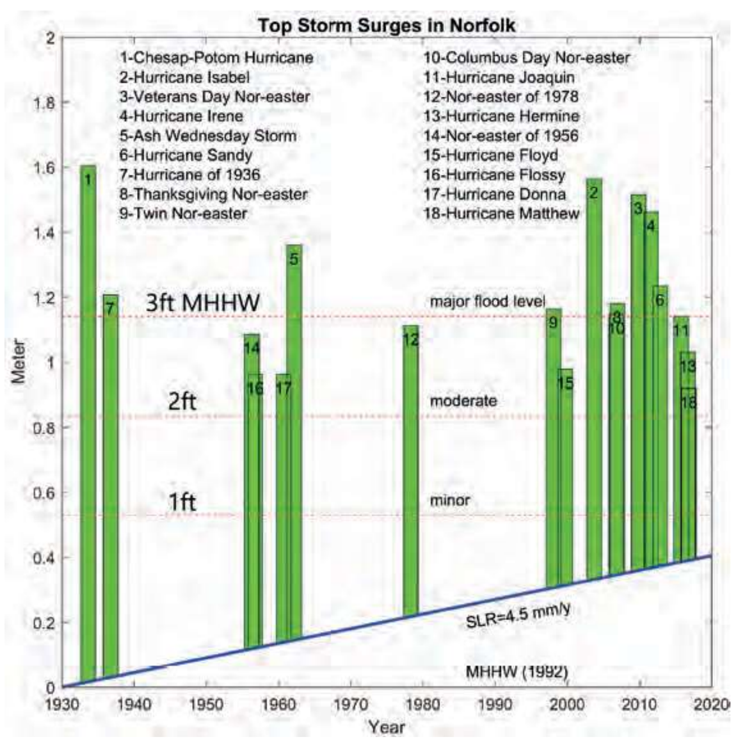

Fig. 1. The water level (relative to Mean Higher High Water [MHHW] in 1992) for the top storm surges as recorded by the Norfolk tide gauge (at Sewells Point). Note that over 60% of these storm surges occurred during the past 20 years while less than 40% occurred during the previous 70 years.

Inside

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Figure 2: Car drives through flooded Botetourt Street in Norfolk, Virginia in September 2018 (hurricane Florence was over North Carolina at that time). Picture taken by T. Ezer.

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Stream (GS), the Atlantic Meridional Overturning Circulation, AMOC (Ezer, 2015) and coastal sea level. Coastal sea level is elevated during periods of weakening GS, associated with a decrease in the sea level slope across the GS or a shift in its position. These studies have implications for how future climatic changes in ocean circulation and potential slowdown of AMOC may impact our coasts.

However, the early studies did not explain short-term minor tidal flooding (often called "nuisance" or "clear day" floods) that are now commonplace in Norfolk. These floods are unpredictable and cause significant disturbances to transportation and damage to cars parked in or driven into salt waters (e.g., Fig. 2). Recent studies (Ezer, 2016; Ezer and Atkinson, 2017; Ezer et al., 2017; Ezer, 2018) tried to understand this phenomenon using numerical models, tide gauges, GS flow measurements and satellite altimeter data. The studies found that sudden weakening in the GS transport (measured by a cable across the Florida Strait) can predict minor flooding in Norfolk a few days in advance. The signal is propagated along the GS by fast-moving barotropic waves that trigger coastal trapped waves, so there is only a short lag between the detection of a change in the GS near Florida and elevated sea level on the U.S. East Coast downstream along the GS. These short-term variations can be due to natural oscillations associated with mesoscale activity or variations in the offshore wind, but also due to offshore tropical storms and hurricanes which disrupt the flow of the GS. The impact on the GS and flooding in Norfolk from hurricanes that did not make landfall in Virginia were seen during Hurricanes Sandy (2012), Joaquin (2015), Matthew (2016) and Florence (2018). Fig. 3, for example, shows the slowing down of the GS and elevated sea level in Norfolk during a period of three weeks after hurricane Florence hit the Carolinas' coasts.

The recent studies explained this "double whammy" impact of hurricanes: first comes the storm surge, and then the indirect impact of the hurricane on ocean dynamics, where a disruption of the flow of the GS by the hurricane can cause a period of minor flooding long after the hurricane disappeared. The studies show that it may take a few weeks for this mighty current to fully recover from the hurricane's impact. This research can help improve predictions of storm surge models and prepare for the impact of future sea level rise.

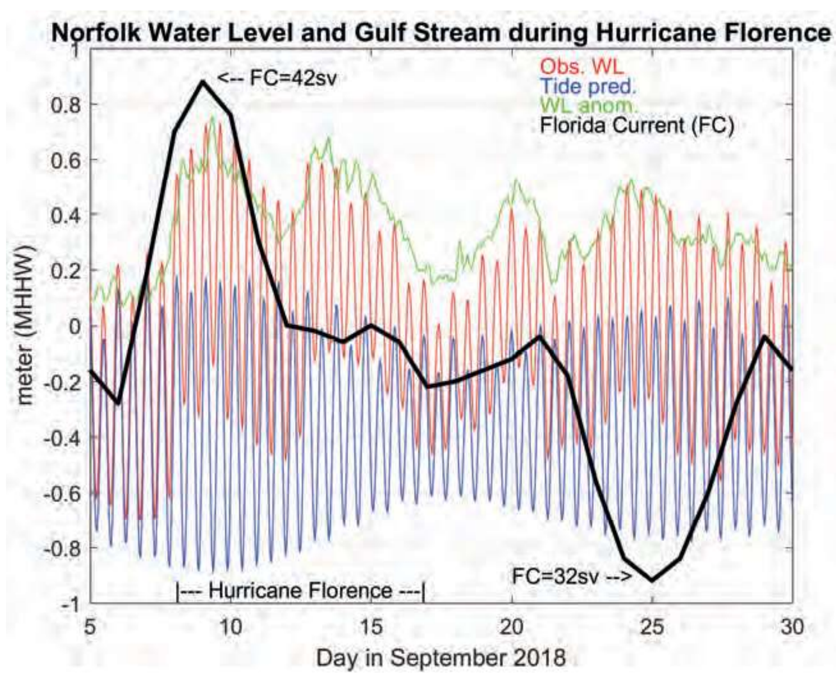

Figure 3: Hourly observed water level in Norfolk (red line) was well above the predicted tide level (blue line) following hurricane Florence. Measurement of the Florida Current shows a decline of ~30% (~10sv, 1sv=million cubic meter per second) in the transport that lasts for at least 2 weeks after the passage of the hurricane.

References

Ezer, T. and W. B. Corlett (2012), Geophys. Res. Lett., 39, L19605.

Ezer, T., L. P. Atkinson, W. B. Corlett and J. L. Blanco (2013), J. Geophys. Res., 118(2), 685-697.

Ezer, T. (2013), Geophys. Res. Lett., 40(20), 5439-5444..

Ezer, T. and L. P. Atkinson (2014), Earth's Future, 2(8), 362-382.

Ezer, T. (2015), Global and Planetary Change, 129, 23-36.

Ezer, T., (2016), Ocean Dynamics, 66(2), 207-220.

Ezer, T. and L. P. Atkinson (2017), Ocean Dynamics, 67(6), 751-766.

Ezer, T., L. P. Atkinson and R. Tuleya (2017), Dynamics of Atmospheres & Oceans, 80, 124-138.

Ezer, T., (2018), Ocean Dynamics, 68, 1259-1272.