Short report on compound coastal flooding assessment in Marin County (AGU TEX project)

Compound flooding refers to the events that coincidence/consequence of two (or more) flood drivers, which might be themselves at the moderate level, yield significantly high flooding hazard that each of these drivers may not produce individually (in isolation). In such occasions the nonlinear interactions of underlying mechanisms may significantly enhance the risk of flooding. Compound flooding has been studied and reported in many freshwater influenced systems, e.g. San Francisco Bay (Moftakhari et al., 2017). In these systems a number of physical processes (i.e. atmospheric pressure variation) at different time-scales may interact to produce conditions resulting in compound flooding.

The statistical dependence between drivers in compound coastal flooding makes the accurate frequency analysis of compound events complicated, as the exceedance probability of these events may no longer be equal to the product of individual probabilities. In fact, the joint probability in this case should account for the correlation structure between variables and so the appropriate statistical tools (e.g. multivariate frequency analysis tools) are required for appropriate characterization of risk.

West of Marin County is continuously threatened by direct oceanic surge tides (surge + astronomic tides) and precipitation-driven (pluvial/fluvial) flooding. In this study we test the hypothesis that if there is a significant correlation structure between these two sources of flooding. If the hypothesis "*there is no significant correlation structure between extreme precipitation and coastal ocean water level in this coastal watershed*" is rejected we need to employ sophisticated concepts of multivariate frequency analysis, otherwise the common practices recommended by federal agencies (FEMA, 2015) reasonably well represent the dynamics of flooding.

To test the above hypothesis we analyzed the joint probability of *i*) water level observed at tide gauge located in Point Reyes, CA (NOAA Station ID: 9415020)[1] and *ii*) hourly precipitation observed at Mount Tamalpais (GHCND:USC00045995)[2]. Both time-series are relatively complete over the last 38 years. We used both the two-sided *i*) peak-over-threshold and *ii*) block-maxima sampling techniques (Wahl et al., 2015) to sample the data sets for different combinations of *i*) Surge tide and *ii*) Surge only from the coastal ocean water level, and *i*) hourly, *ii*) total 2-hour and *iii*) total 6-hour precipitation from the pluvial component, a total combination of twelve scenarios. The table below is a sample report of the significance of correlation structure from different metrics.

Correlation type	Correlation Coefficient	p value	Significant at 5%?
Kendall rank	-0.1878	0.1373	No
Spearman's rank-order	-0.2359	0.1538	No
Pearson product-moment	-0.3056	0.0621	No

Based on these statistics, no significant correlation structure has been detected between coastal and terrestrial flood drivers in the studied system and so independence among flood drivers will be a valid assumption that is compatible with the FEMA's approach in flood risk mapping under compound flooding situations (FEMA, 2015).

References

FEMA. (2015). *Guidance for flood risk analysis and mapping; combined coastal and riverine floodplain* (No. Guidance Document 32). FEMA.

Moftakhari, H., Salvadori, G., AghaKouchak, A., Sanders, B. F., & Matthew, R. A. (2017). Compounding effects of sea level rise and fluvial flooding. *Proceedings of the National Academy of Sciences*, *114*(37), 9785–9790. https://doi.org/10.1073/pnas.1620325114

Wahl, T., Jain, S., Bender, J., Meyers, S. D., & Luther, M. E. (2015). Increasing risk of compound flooding from storm surge and rainfall for major US cities. *Nature Climate Change*, *5*(12), 1093–1097. https://doi.org/10.1038/nclimate2736

[1] https://tidesandcurrents.noaa.gov/stationhome.html?id=9415020

[2] https://www.ncdc.noaa.gov/cdo-web/datasets/GHCND/stations/GHCND:USC00045995/detail