A nonparametric Bayesian spatial modeling framework for hurricane surface wind fields

Montserrat Fuentes*

Statistics Department

North Carolina State University

Storm surge is the onshore rush of sea water caused by the high winds and to a lesser extent the low pressure associated with a hurricane. Storm surge can compound the effects of inland flooding caused by rainfall, leading to loss of property and loss of life for residents of coastal areas. Numerical ocean models are essential for creating nowcast estimates as well as forecasts for coastal areas that are likely to be impacted by the storm surge. These models are driven primarily by the surface wind forcings. Currently, gridded wind fields used to spin up and force ocean models are specified by deterministic formulas that provide an idealized form of the wind profile based on th central pressure and location of the storm center. While these equations incorporate important physical knowledge about the structure of hurricane surface wind fields they cannot always capture the asymmetric and dynamic nature of a hurricane. A new Bayesian multivariate spatial statistical modeling framework is introduced to improve the estimation of the wind field inputs. A nonparametric spatial model is developed and applied to explain the spatial variability in the wind vectors (u and v as well as the cross-dependency between these two components. This Bayesian framework allows for estimation of the parameters of the multivariate spatial model and the physically based wind model while accounting for potential additive and multiplicative bias in the observed wind data from buoys, ships, aircraft and satellite data. We find that this multivariate spatial model consistently improves parameter estimation and prediction for surface wind data for case studies of Hurricane Charley (2004) and Ivan (2004) when compared to the original physical model.

*In collaboration with Kristen Foley (Stat., NCSU) and the Coastal Fluid Dynamics Laboratory headed by Dr. Lian Xie at North Carolina State University.