Analyzing Tropical Waves Using the Parallel Ensemble Empirical Model Decomposition Method: Preliminary Results from Hurricane Sandy

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Among Decadal Survey Missions, "*Extreme Event Warning*" and "*Climate Projections*" have been identified as top-priority scenarios by the advanced data processing group at the ESTO AIST PI workshop (AIST, 2010). In the coming years, *the Global Precipitation Measurement (GPM), the Cyclone Global Navigation Satellite System* (*CYGNSS*) *will provide measured wind fields and precipitation fields for improving the understanding of physical processes for the genesis and intensification of hurricanes.* Our research team has contributed to this objective by developing the NASA Coupled Advanced global multiscale Modeling (Shen et al., 2006a,b; Tao et al., 2008, 2009) and Visualization system (CAMVis) and integrating it with the Multiscale Analysis Packages (MAP) and satellite data modules (e.g., for TRMM data). We have successfully demonstrated that an integrated system, with the capability in revealing sophisticated hierarchical multiscale processes, can improve our understanding of the predictability of mesoscale processes, such as tropical cyclones (TCs) (Shen et al., 2010a,b; 2011; 2012a; 2013a-c). Selected cases in our recent studies include the relationship between (i) TC Nargis (2008) and an Equatorial Rossby (ER) wave; (ii) Hurricane Helene (2006) and an intensifying African Easterly Wave (AEW); (iii) Twin TCs (2002) and a mixed Rossby-gravity wave (MRG) during an active phase of the Madden Julian Oscillation (MJO; Madden and Julian, 1971); (vi) Hurricane Sandy (2012) and upper-level tropical waves associated with an MJO (e.g., Blake et al., 2013; Shen et al., 2013c).

The MAP includes a parallel version of the ensemble empirical model decomposition (EEMD, Wu and Huang, 2009; Wu et al., 2009) and the stability analysis tool (SAT) with a calculation of the ensemble Lyapunov Exponent (eLE, e.g., Shen et al., 2014a). In this study, we discuss the performance of the parallel ensemble empirical mode decomposition (PEEMD) in the analysis of tropical waves that are associated with tropical cyclone (TC) formation. To efficiently analyze high-resolution, global, multiple-dimensional data sets, we first implement multi-level parallelism into the EEMD and obtain a parallel speedup of 720 using 200 eight-core processors. We then apply the PEEMD to extract the intrinsic mode functions (IMFs) from preselected data sets that represent (1) idealized tropical waves and (2) large-scale environmental flows associated with Hurricane Sandy (2012). Results indicate that the PEEMD is efficient and effective in revealing the major wave characteristics of the data, such as wavelengths and periods, by sifting out the dominant (wave) components. This approach has a potential for hurricane climate study by examining the statistical relationship between tropical waves and TC formation. As of July 2014, the PEEMD can scale up to 5000 CPUs using a high resolution MRG wave case study with 1000x1000 grid points, suggesting that it can efficiently process high-resolution global data at a resolution of 0.25 degrees or higher. It is being applied to perform tropical wave analysis for multi-year data.

References:

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