Examining Tropical Cyclone Predictability using a Mesoscale-model Adjoint

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Adjoint models can provide valuable insight into the practical limitations of our ability to predict the path of tropical cyclones and their strength. An adjoint model can be used for the efficient and rigorous computation of numerical weather forecast sensitivity to changes in the initial state. The sensitivity calculations illustrate complex influences on tropical cyclone evolution that occur over a wide range of scales from convective clusters to larger-scale weather systems. Rapid growth of small perturbations can lead to errors on multiple scales that conspire to limit the forecast accuracy of the path and intensity of tropical cyclones. In this study, the recently developed adjoint and tangent linear models for the atmospheric portion of the nonhydrostatic Coupled Atmosphere/Ocean Mesoscale Prediction System (COAMPS) are used to explore the sensitivity and predictability characteristics associated with tropical cyclones.

We focus primarily on the Northwestern Pacific Super Typhoon Lupit, which was erroneously forecasted by a number of numerical models to landfall in Philippines, as the forecast models failed to capture a critical and dramatic directional shift of the storm motion from westward to the northeast. The characteristics of the sensitivity of the Lupit forecasts vary significantly over the lifecycle of the storm. During the intensification time period, local temperature and moisture sensitivity results indicate that further strengthening of Lupit would be most efficiently achieved through warming and moistening in the mid-levels of the developing system. During the period just prior to the recurvature, the sensitivity calculations highlight a high pressure system to the east and two shortwave low-pressure troughs to the northwest that influence the track of Lupit. The implications of the sensitivity results (for both Lupit and other storms) for tropical cyclone predictability will be discussed.