Multi-scale predictability aspects of a severe European winter storm

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A severe winter storm, referred to in the media as Xynthia, crossed Western Europe on 26–28 February 2010 and has been described as the most intense in this region in more than a decade. The violent storm claimed the lives of more than 50 people with many of the deaths in France related to strong winds and a storm surge that caused a rapid rise in water. Hurricane force winds were reported along the Atlantic Coast of France flooding low-lying coastal areas. The storm produced heavy rains, and strong winds, which caused widespread power failures and severely impacted the transportation system including numerous airport closures and delays in rail traffic. The insured losses from the storm are projected to be $2 to $4.1 billion (AIR Worldwide).

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 mesoscale sensitivity and predictability characteristics associated with the severe extratropical cyclone. Unique aspects of the adjoint modeling system include a full adjoint to the microphysics and a nested grid capability that allows for multi-scale sensitivity calculations. The adjoint is applied using the nesting option with 45 and 15 km meshes for a series of forecasts initialized during the 27-28 February time period. Results indicate that 12 h and 24 h forecasts of intensification of the extratropical cyclone in Western Europe are very sensitive to the initial state. The adjoint-based sensitivity fields indicate highly structured patterns in the wind, thermal, and microphysical fields that project on to the model simulated deep convection, which ultimately influences the intensification rate. Relatively small basic state perturbations based on the adjoint calculations on the order of observational errors (1 m s⁻¹, 1 K) lead to rapid growth rates in the near-surface horizontal velocity and deepening rate of the central pressure. The sensitivity of the adjoint results to the horizontal resolution and microphysical parameterization will be discussed. Implications of the
adjoint-based sensitivity fields for the predictability of mesoscale aspects of Xynthia will be addressed.