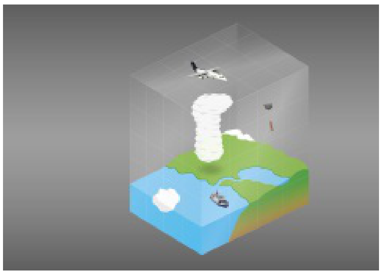

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Diagnosing Forecast Sensitivity for Field Campaigns using Adjoints

Tuesday, 11 June 2019 09:30 (30 minutes)

Adjoint models can provide valuable insight into the practical limitations of our ability to predict weather systems, such as extratropical and tropical cyclones, and their associated high-impact weather. An adjoint model can be used for the efficient and rigorous computation of numerical weather prediction forecast sensitivity to changes in the initial state or an earlier point in the forecast. The sensitivity calculations can help to unravel complex instabilities and influences on extratropical and tropical cyclone evolution that occur over a wide range of scales. Adjoints also can be used to explore the rapid growth of small perturbations that lead to large errors on multiple scales and limit the forecast accuracy of high-impact weather events.

In this presentation, we provide highlights from a number of field programs to illustrate the utility of adjoints to: i) inform field program observing strategies; ii) highlight key mesoscale moist instabilities and processes; and iii) diagnose initial condition sensitivities and processes that contribute to forecast errors. We will discuss examples from several fields programs in which we apply NRL's Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS) moist adjoint to diagnose forecast sensitivity including: i) tropical cyclone programs: NASA Hurricane and Severe Storm Sentinel (HS3), NOAA/NASA Sensing Hazards with Operational Unmanned Technology (SHOUT), Office of Naval Research (ONR) Tropical Cyclone Intensity (TCI) and ii) extratropical cyclone programs: North Atlantic Waveguide and Downstream Impact Experiment (NAWDEX) and Atmospheric Rivers Reconnaissance (ARRECON).

The adjoint, tangent linear, and nonlinear models for the nonhydrostatic COAMPS are applied with high-horizontal resolution (5 to 45 km). We show that the initial state sensitivity and forecast errors are well correlated based on results from several different field programs. We compare and contrast results from tropical and extratropical campaigns using several different response functions to explore various aspects of sensitivity and predictability including: i) kinetic energy, ii) accumulated rainfall, iii) integrated vapor transport, and iv) potential vorticity. The adjoint sensitivity results for the extratropical and tropical cyclones underscore the importance of the low- and mid-level moisture distribution and multi-scale interactions. We demonstrate that small perturbations of moisture, winds, and temperature in sensitive regions rapidly evolve into disturbances that impact the predictability of downstream high-impact weather. The forecast sensitivity to diabatic heating is also explored using the adjoint to provide insight into the implications of model error associated with microphysical parameterizations.

The results underscore the need for accurate moisture observations and data assimilation systems that can adequately assimilate these observations in order to reduce the forecast uncertainties for these high-impact events. However, given the nature of the sensitivities and the potential for rapid error growth, the intrinsic predictability for high-impact weather appear to be limited.

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