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A Unified Data Assimilation Strategy for Regional Coupled Atmosphere-Ocean Prediction Systems

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Improving tropical cyclone (TC) forecasts is a top priority in weather forecasting. Assimilating various observational data to produce better initial conditions for numerical models using advanced data assimilation techniques has been shown to benefit TC intensity forecasts, whereas assimilating large-scale environmental circulation into regional models by spectral nudging or Scale-Selective Data Assimilation (SSDA) has been demonstrated to improve TC track forecasts. Meanwhile, taking into account various air-sea interaction processes by high-resolution coupled air-sea modelling systems has also been shown to improve TC intensity forecasts. Despite the advances in data assimilation and air-sea coupled models, large errors in TC intensity and track forecasting remain. For example, Hurricane Nate (2011) has brought considerable challenge for the TC operational forecasting community, with very large intensity forecast errors (27, 25, and 40 kts for 48, 72, and 96 h, respectively) for the official forecasts. Considering the slow-moving nature of Hurricane Nate, it is reasonable to hypothesize that air-sea interaction processes played a critical role in the intensity change of the storm, and accurate representation of the upper ocean dynamics and thermodynamics is necessary to quantitatively describe the air-sea interaction processes. Currently, data assimilation techniques are generally only applied to hurricane forecasting in stand-alone atmospheric or oceanic model. In fact, most of the regional hurricane forecasting models only included data assimilation techniques for improving the initial condition of the atmospheric model. In such a situation, the benefit of adjustments in one model (atmospheric or oceanic) by assimilating observational data can be compromised by errors from the other model. Thus, unified data assimilation techniques for coupled air-sea modelling systems, which not only simultaneously assimilate atmospheric and oceanic observations into the coupled air-sea modelling system, but also nudging the large-scale environmental flow in the regional model towards global model forecasts are of increasing necessity. In this presentation, we will outline a strategy for an integrated approach in air-sea coupled data assimilation and discuss its benefits and feasibility from incremental results for select historical hurricane cases.