USE OF NWP FOR NOWCASTING

Juanzhen Sun
National Center for Atmospheric Research, Boulder, CO 80303

Abstract
In this paper, a review on the use of numerical prediction models (NWP) for nowcastingis given. The review is mainly based on the WMO workshop on the use of NWP for nowcasting held in October, 2011 in Boulder(NWP-NWC2011) (http://wmo-workshop-on-the-use-of-nwp-for-nowcasting.wikispaces.com). In this workshop, practitioners, users and developers of high resolution models, data assimilation and nowcasting systems gathered to articulate and define requirements for NWP in nowcasting applications, identify existing gaps between the nowcasting and mesoscale NWP communities, and to explore ways to advance the nowcasting. The majorprogresses on the use of NWP for nowcastingare summarized and future challenges that face the NWP communityare discussed.

1. INTRODUCTION

In recent years, numerical weather prediction (NWP) models have demonstrated to possess improved capability in providing guidance for high-impact weather prediction at km-scale for forecast ranges up to 24-36 hours. In the nowcasting (or very-short-term of 0-6 hours) range, however, the usefulness of NWP is limited due to a number of scientific issues (e.g. spin-up, analyses of highly complex, nonlinear physical processes, initialization techniques, etc.) as well as limited awareness of the needs of nowcasting in the NWP community. As the demand to improve very-short-term forecasts of high-impact-weather have been increasing, research on the use of high-resolution NWP for nowcasting has also expanded rapidly.

Recently, advanced approaches to nowcastingthat depend on high-resolution NWP products to improve nowcastingbeyond the first hour have been developed. Blending of traditional extrapolation-based techniques with high-resolution NWP (the so-called heuristic approach) is gaining popularity in the nowcasting community. The increased need of NWP products in nowcasting applications poses great challenges to the NWP community because the nowcasting application of high-resolution NWP requires special considerations that are different from the longer range NWP. Among them are, e. g., limited predictability of convective high impact weather, convective scale data assimilation to deal with spin-up issues, NWP with model resolution less than a few km to adequately resolve the physical processes, physical parameterizations suitable for nowcasting applications, etc.

2. REVIEW OF PROGRESS

A basic requirement for NWPsthat are intended for the nowcasting purpose is that they need to produce products that have high spatial and temporal resolutions. Several operational centers are currently running NWP models at the convection-permitting resolutions of 1.5km-4km (see NWP-NWC2011 presentations by Wang, Lean, Steinle, Benjamin, Xu, and Auger). The high-resolution NWP systems are usually coupled with a high-resolution data assimilation system that is able to assimilate high-resolution observations, such as those from Doppler radars. Since a common problem with NWP models that are initialized from large-scale coarse-resolution analysis (often being referred to as “cold start”) is the initial spin-up, considerable efforts were devoted to the development of the high-resolution data assimilation methods in the last decades to mitigate the issue.

Numerous studies have shown that observations from Doppler radars are critical data that can be assimilated in NWP models through rapid update cycle (RUC) to reduce the spin-up problem. Methods that were developed for radar data assimilation vary in complexity. The simpler schemes are developed based on the concept of diabatic initialization in which estimated latent heat, in-cloud humidity, and/or vertical velocity from radar reflectivity observations are assimilated. Examples of these schemes are latent heat nudging (Schraff, NWP-NWC2011), cloud analysis (Lim, Xie, NWP-NWC2011), and digital filter initialization (Weygandt, NWP-NWC2011). More sophisticated schemes assimilate reflectivity as well as radial velocity, such as the 3-dimensional variational scheme (Sun, Xue, Ballard, Montmerle, NWP-NWC2011). The most sophisticated schemes are developed using the 4-dimensional variational (4D-Var) method and the ensemble Kalman filter (EnKF) technique. These schemes assimilate both radial velocity and reflectivity data with a full or reduced form of the NWP model as the constraint (Sun, Xue, Fillion, Ballard, NWP-NWC2011). Some of the schemes based on the diabatic initialization and 3D-Var have been implemented operationally with 1-3 hour RUCs. Encouraging results were shown that the precipitation forecasts could be improved typically up to 6-12 hours. Fig. 1 gives an example of the impact of radar reflectivity data assimilation through latent heat nudging using NCAR's nudging system RTFDDA (Real Time Four Dimensional Data Assimilation, Liu et al 1998).

3. FUTURE CHALLENGES

The model's predictability of atmospheric convection remains to be a challenge for improving the 0-6 h forecast of convective weather.

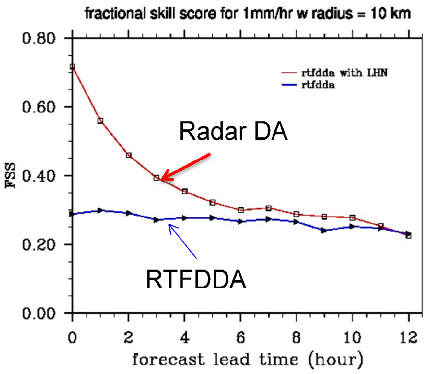

Fig. 1 Fractions Skill Score (FSS) for hourly-accumulated precipitation with the threshold of 1mm and a radius of influence of 10 km. Two runs over a period of 12 days during June 2010 in the Rocky Mountain Front Range region are compared for the standard RTFDDA withoutradar data and the upgraded version with radar reflectivity data assimilation though latent heat nudging (Courtesy of Mei Xu).

According to Zawatzki (NWP-NWC2011), convection below 100km has short life time and low predictability. Zawatzki also showed that the current NWP models also have difficulty in accurately forecasting the diurnal cycle. In addition, the short-term NWP often misses small-scale phenomena even when radar observations are used in the initialization. Sun (NWP-NWC2011) found that the impact of radar data assimilation varies depending on the model initialization time. Future researcheson model predictability, improvement of diurnal cycle forecast, improvement of initialization through data assimilation, and sensitivity of physical parameterization schemes to data assimilation and forecast are only a few among the msnychallenges for the effective use of NWP in the nowcasting range.

4. REFERENCES

Liu, Y., Warner, T. T., Bowers J. F., and Co-authors, 2008: The operational Mesogamma-scale analysis and forecast systems of the US Army Test and Evaluation Command. Part I: Overview of the modeling system, the forecast products, and how the products are used.