23.2 An Investigation of the Mesoscale Predictability over the Northeast U.S.

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1. INTRODUCTION

The mesoscale prediction of winds, temperatures, and precipitation over the Northeast U.S. is complicated by the Appalachians, coastline curvature, and urban centers. Through a collaborative effort between Stony Brook University (SBU) and the local National Weather Service (NWS), the Penn State-NCAR Mesoscale Model (MM5) has been running in real-time during the past four years down to 4-km grid spacing for the southern New England and New York City metropolitan regions (Fig. 1).

This effort has improved our understanding of the model skill at high resolution and the impact air-sea interactions on the forecasts (Colle et al 2003a,b). Several model biases have been documented such as the warm bias over water during the cool season, an urban cool, moist, and weak wind bias during the day, and a dry bias during the warm season. These biases impact the coastal mesoscale flows. For example, 4-km sea breezes are 1-2 hours early on average, and there is generally too little warm season explicit precipitation in the 12- and 4-km nests.

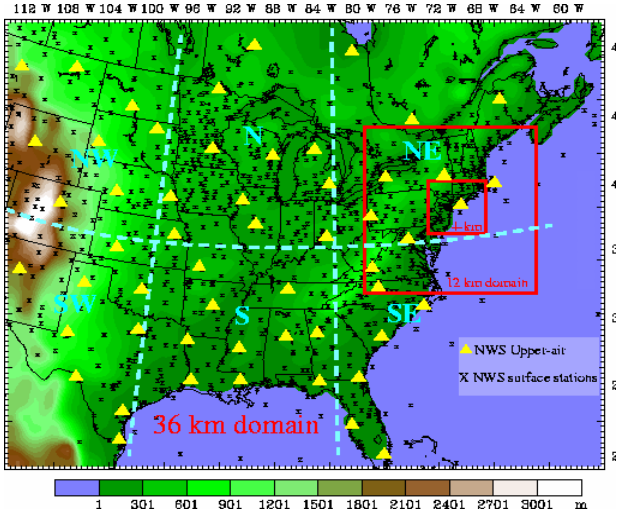

Figure 1: The MM5 domains used in the SBU modeling system. The surface and upper-air stations used for verification are also shown.

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More recently, the SBU MM5 forecasts have been verified using an instrumented ferry over Long Island Sound between Port Jefferson, NY and Bridgeport, CT. These observations help validate the MM5 temperatures, winds, and fluxes over water.

To address some of the uncertainties in physics and initial conditions, the SBU modeling system has been expanded to include an 18-member MM5 ensemble down to 12-km grid spacing over the Northeast (Fig. 1), and the project now involves other NWS offices (Mt. Holly, NJ and Taunton, MA), as well as the NWS Northeast River Forecast Center and the NWS Eastern Region Headquarters. The purpose of this collaborative project is to investigate the strengths and weaknesses of ensembles through verification and operational implementation.

2. ENSEMBLE SETUP

Since the spring of 2003, SBU has been running an 18-member MM5 ensemble at 36- and 12-km grid spacing. There are 12 physics-based members consisting of three boundary layer and four convective parameterizations (Table 1), which use the National Center for Environmental Prediction (NCEP) Eta grids for initial and boundary conditions. The remaining six (6) members are run with the same physics, but use different model initializations from the 2100 UTC NCEP's Short-Range Ensemble Forecast System and the 0000 UTC Global Forecast System (Table 2). Each member is run out 48 hours for the 0000 UTC cycle.

Table 1: MM5 members used in the physics-based ensemble. The parameterizations used in member 4 (in bold) are applied in all initial-condition members.

Member	*Convective Scheme*	*PBL scheme*
1	Kain-Fritsch 2	MRF
2	Kain-Fritsch 2	Blackadar
3	Kain-Fritsch 2	ETA
4	**Grell**	**MRF**
5	Grell	Blackadar
6	Grell	ETA
7	Betts-Miller	MRF
8	Betts-Miller	Blackadar
9	Betts-Miller	ETA
10	Kain-Fritsch	MRF
11	Kain-Fritsch	Blackadar
12	Kain-Fritsch	ETA

Table 2: The MM5 members used in the initial condition ensemble. Members 1-5 use initial and boundary conditions generated by the 2100 UTC NCEP Eta bred forecasts.

Member	*IC Perturbation set*
1	ETA -1 (21z)
2	ETA -2 (21z)
3	ETA +1 (21z)
4	ETA +2 (21z)
5	ETA ctrl (21z)
6	ETA (00z)
7	GFS (00z)

3. ENSEMBLE POST-PROCESSING

One goal has been to improve probabilistic quantitative precipitation forecasting. Several statistical products have been developed for operational forecasters. For example, Fig. 2 shows a confidence-based most probable category (0-7) for the 24-48-h precipitation from Isabel using the 12 physics members ending at 0000 UTC 19 September 2003, which is constructed as follows. Each member's accumulated precipitation forecast at every model grid point is first sorted into seven bins: 0= < 0.01 inches, 1= 0.01-0.09", 2= 0.10=0.24", 3= 0.25-0.49", 4= 0.50-0.99", 5= 1.00-1.99", 6= 2.00-4.99", 7 >= 5.00". At a point there may be a distribution of ensemble members that fall within several bins (e.g., 5 members in bin-1, 9 members in bin-2, 3 members in bin-3, 1 member in bin-4, and 0 members in bin-5). The probability of each member in a specific bin is then calculated, with the highest probability bin defined as the most probably category (MPC). A confidence-based category (CBC) is defined:

$$CBC = \beta + MPC, \qquad (1)$$

where $\beta = \gamma * 0.5 * \{1+[1-(PROB1-PROB2)]\}$, and $\gamma = (MPC2-MPC1) / |(MPC2-MPC1)|$. In equation 1, MPC is the most probable category, β is a confidence factor, γ is a directional factor, and PROB1 (PROB2) is the probability of the most (second-most) probable category, MPC1 (MPC2). Thus, the greater the difference between PROB1 and PROB2, the farther CBC is from MPC1 + 0.5. For example, a value of CBC = 2.5 is the highest confidence category-2 forecast. Thus, a value of CBC = 2.3 indicates the second-most probable category is lower than category-2, but the confidence for a category-2 is still larger than a neighboring point having a CBC = 2.1. A higher confidence forecast for a given category is darker shaded for a given color in Fig. 2. During Isabel, there was high confidence for more than 5.00 inches (126 mm) to fall during landfall.

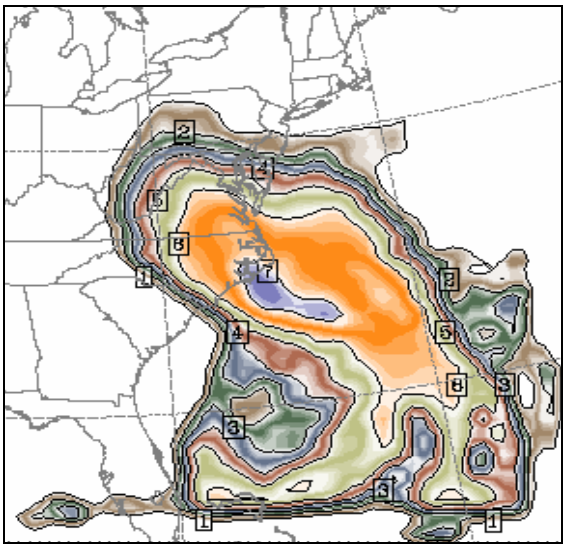

Figure 2. A confidence-based most probable category (CBC) for the 24-48 h precipitation from the 12 physics members ending at 0000 UTC 19 September 2003. See text for details and interpretation.

4. SUMMARY AND FUTURE WORK

During the past four years a long-term MM5 verification dataset has been obtained over the Northeast U.S. This work has been extended to include additional observations (e.g. ferry observations) and the development of a 18-member MM5 ensemble forecast system using different physics and initial conditions. These forecasts are available at: http://fractus.msrc.sunysb.edu/mm5rte, and the ensemble statistical data is being sent to our NWS forecast partners. During the next year the individual members and ensemble means/categories will be verified and implemented into operations, and additional members will likely be added.

5. AKNOWLEDGEMENTS

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6. REFERENCES

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