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We disagree with the authors of the “white paper” on all major points. Here we will present only the highlights of our views. Please read our complete response at <http://www.emc.ncep.noaa.gov/mmb/papers/janjic/response2/response.html>.

I. SMOOTHING

The key issue in our misunderstandings appears to be the belief of Skamarock and Baldwin that we are removing the noise from our forecasts by heavy numerical filtering. That impression is incorrect. Following Arakawa, our modeling principle has been to prevent generation of computational noise through the use of sophisticated numerical schemes based on physical considerations rather than to continually remove it by numerical filters after it is generated. We certainly do not advocate “running high resolution forecasts using numerical filters that systematically remove the resolution gained by the refined grid.” Our experience at NCEP has been that the forecasts have been systematically improving with increasing resolution which would not have happened if we have been “systematically removing the resolution gained by the refined grid.” Apparent smoothness of NMM precipitation patterns is unrelated to the dynamics and can be varied as desired through the precipitation parameterization schemes.

Inspection of the amplification factors of the Mass Core (MC) advection schemes does not support the claim that the NMM is more damped than the MC. Even if there were too much damping in the NMM WRF, this damping is not hardwired and can be easily reduced if desired. In contrast, the dissipation in the MC is due to its high order filters and can be reduced only by increasing spatial resolution.

We view lateral diffusion as a legitimate physical process and not as a numerical filter. There is no physical justification for using diffusion operators higher than second order. The NMM’s lateral diffusion is not a second order filter because it is not linear. It is not obvious that the sixth and fourth order filters in the MC are more selective than the nonlinear lateral diffusion.

The forecasts produced by the Eta, the operational NMM, the WRF-NMM and the MC are shown at <http://www.emc.ncep.noaa.gov/mmb/mmbpll/nextpage/>. The WRF-NMM is run with very little lateral diffusion so that the impact of the diffusion in the operational NMM can be assessed by comparison with the forecasts by the WRF-NMM. As can be seen from the web site, the MC forecasts generally show a much higher level of computational noise than the forecasts by the two NMM’s.

NCAR has chosen a discretization approach based on higher-order formal accuracy as opposed to the physically based approach used in the NMM. The NCAR approach is not without problems. Experience with fitting higher-order polynomials to noisy data indicates that discretization based on higher order formal accuracy (i) may be locally very inaccurate in the case of large amplitudes of small scale motions; (ii) requires additional computational boundary conditions which also generate computational noise; (iii) does not guarantee accuracy of energy and enstrophy transport by nonlinear interactions leaving computational filtering as the only means for controlling the nonlinear cascade.

II. ENERGY SPECTRA

The NMM is very well qualified for investigating atmospheric spectra. Its energy and enstrophy conserving scheme restricts spurious energy transfer toward smaller scales by nonlinear interactions, and its explicit formulation of major dissipative processes allows precise “dosage” of dissipation as desired.

As demonstrated in our full response, contrary to the claims by Skamarock and Baldwin, the NMM dynamics can and do produce kinetic energy spectra that agree perfectly well with the observations. At the same time, none of the MC spectra shown by Skamarock and Baldwin resembles the observed Nastrom and Gage (1985) kinetic energy spectrum or the successfully simulated spectra by the NMM.

III. COMPARATIVE COMPUTATIONAL EFFICIENCY

NCAR claims that the MC is computationally more efficient than the NMM based on perceived forecast detail. With the same spatial resolution, the NMM is about *three times* faster than the MC. Further optimization may increase this factor to about *four*. On the other hand, as can be seen from the sharp drop-off of the MC spectra, the MC filters reduce nominal spatial resolution by roughly a factor of two (Figs. 9 and 10 in our full response). NCEP believes that the most important qualities of an operational model are its accuracy and computational efficiency. Comparison of verifying fits of forecasts run at NCEP to observations shows that the MC fits are consistently inferior to those of the Eta and the NMM for a large set of model produced geopotentials, temperatures, relative humidities and surface fields. Thus the MC has been producing forecasts that are inferior in important aspects but at three times the NMM’s computational cost.