P2.1 The WRF Model's New Explicit Numerical Diffusion Scheme and Its Effects on Transport and Dispersion in the Planetary Boundary Layer

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1. Introduction

With the release of version 2.2, the Advanced Research core of the Weather Research and Forecasting (WRF) Model includes for the first time an explicit, sixth-order, numerical diffusion scheme (Knievel et al. 2007). This scheme's scale-selectivity preserves the model's high effective resolution. The scheme also can be made monotonic via a flux limiter, so extrema are not created nor amplified in a diffused field. The flux limiter compromises diffusion rate and scale-selectivity, however.

Recent research has shown that the explicit diffusion scheme can dramatically suppress noise within the daytime boundary layer. Because one manifestation of this noise is deep, alternating columns of ascent and descent (Knievel et al. 2007), we hypothesized that applying explicit diffusion and suppressing noise will affect the transport and dispersion of airborne material released into the boundary layer. This paper is a first look at whether there is any evidence of such an effect.

2. Data and methods

2.1 *WRF Model*

For the numerical simulations, we used the WRF Model (Advanced Research core version 2) with four domains, the three finest of which were placed over the U. S. Great Basin (Fig. 1). The domains' grid intervals respectively are 30.0, 10.0, 3.3, and 1.1 km. Other characteristics of the computational domains, in addition to the physical parameterizations and the initial and boundary conditions, are as described by Knievel et al. (2007).

2.2 *Simulations*

In the control simulation, explicit diffusion was not applied. In the test simulation, explicit diffusion was applied at a nominal rate of 24% per time step with the flux limiter turned on. For an explanation of the flux limiter's effect on diffusion rate, please see the commentary by Knievel et al. (2007).

2.3 *Passive tracer*

We modified the WRF Model's public code to include arrays of a scalar tracer field that were transported passively by two mechanisms: 1) advection by the model's predicted wind, and 2) parameterized turbulent transport by the Yonsei University (YSU) boundary layer scheme.

The tracer, specified in terms of a mixing ratio, was inserted into the control and test simulations in a single column of grid points over the lowest three model levels. The steady source was started after one hour of model time had elapsed and was maintained through the rest of the 48-h simulations. The location of insertion was one of the test ranges at Dugway Proving Ground (DPG), UT (Fig. 2). For the purposes of this study, the choice was somewhat arbitrary, and other sites will be tried in future work. The kinematical field over DPG is not particularly noisy compared to that in other parts of the domain, so any differences between the plumes in the control and the diffusive simulations probably represent a typical case and under-represents an extreme case.

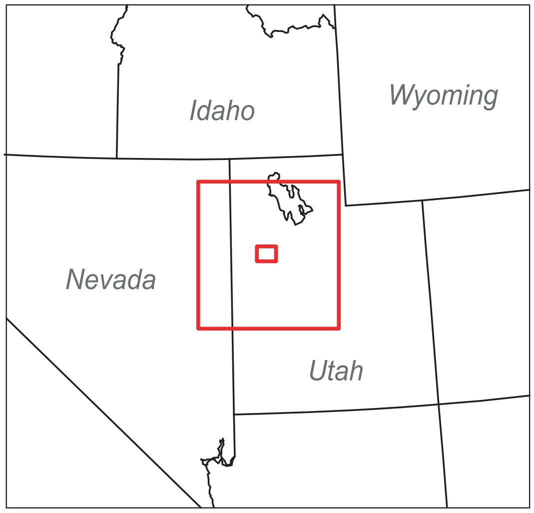

Figure 1: Setting for computational domains 3 and 4 (red). Results from domain 3 are used in subsequent figures.

3. Results

Compared with the control simulation, the diffusive simulation's distribution of the passive tracer is more broad and more shallow, and its maxima are less extreme (Figs. 3 and 4). This effect is consistent with our hypothesis, and is the intuitive result. The diffusive simulation lacks the grid-scale updrafts and downdrafts that are present in the control simulation (Knievel et al. 2007), which seems to prevent the tracer from being mixed as

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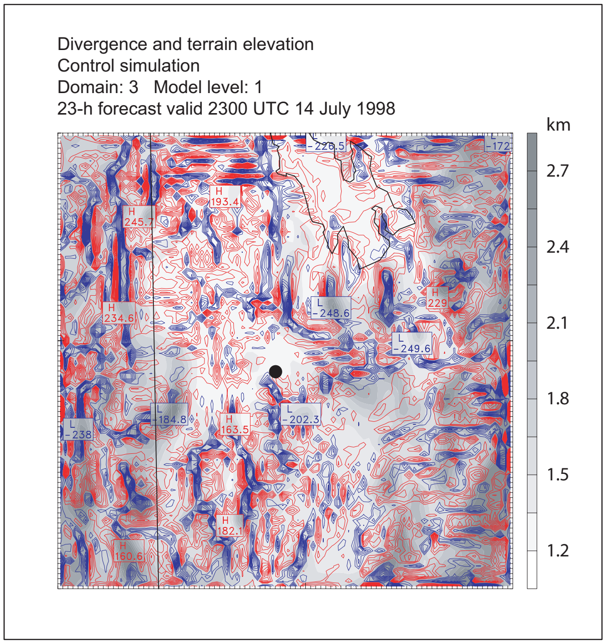

Figure 2: Quasi-horizontal cross section from the control simulation valid at 2300 UTC 14 July 1998. Horizontal divergence along the lowest model level is contoured every 2×10^{-4} s^{-1} (positive is red, negative is blue) and terrain elevation (m AMSL) is shaded. The black dot marks the location of the steady release of tracer.

deeply. The diffusion also smoothes the horizontal wind field and the distribution of the tracer, itself, which reduces the magnitude of the plume's extrema. The two plumes travel in similar directions (Fig. 3), but one might expect that, in cases with much higher vertical directional wind shear, differences in vertical mixing might produce differences in the directions that plumes travel.

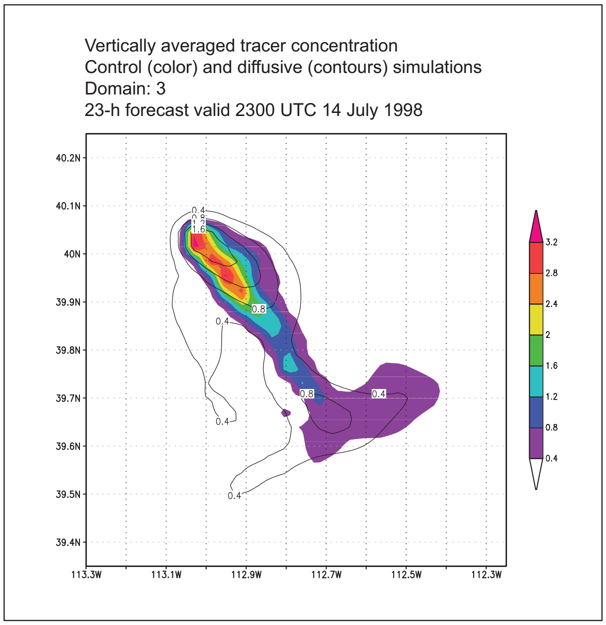

Figure 3: Horizontal cross section of tracer concentration (arbitrary values in g kg^{-1}) vertically averaged over domain 3 at 2300 UTC 14 July 1998. The control simulation is shaded, the diffusive is contoured.

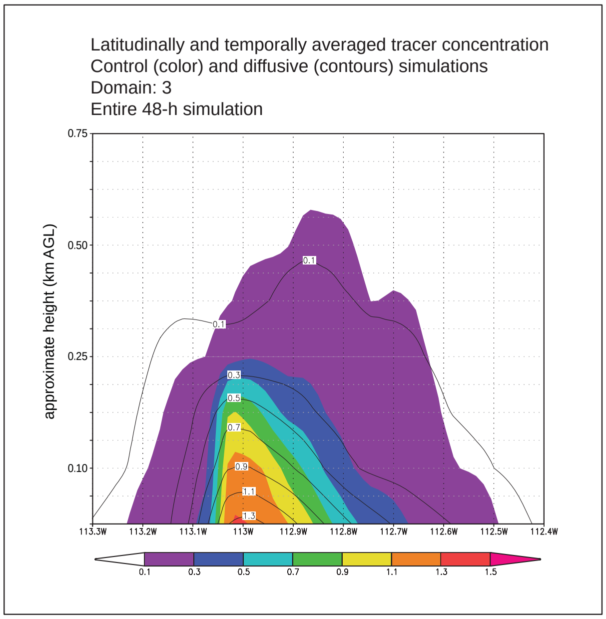

Figure 4: Vertical cross section of latitudinally and temporally averaged tracer concentration (arbitrary values in g kg^{-1}) over the entire 48-h simulation. The control simulation is shaded, the diffusive is contoured.

4. Future research

As mentioned, this paper is only a first, superficial look at the topic. We are still studying the generality of our results and their sensitivity to factors such as the characteristics (3-dimensional location, steadiness, etc.) of the tracer source. Many more tests need to be conducted before a picture of the relevant sensitivities begins to fully emerge. In the future we also propose to isolate the role of diffusion acting just on the tracer from the role of the diffusive wind field acting on the tracer.

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REFERENCES

Knievel, J. C., G. H. Bryan, and J. P. Hacker, 2007: Explicit numerical diffusion in the WRF Model. *Mon. Wea. Rev.*, **135**, 3808–3824.