2.5 ANALYSIS OF THE IMPACT OF MIXING-LENGTH FORMULATIONS ON WIND AND TEMPERATURE PREDICTIONS IN TWO TKE PBL SCHEMES

Xia Feng*, Nelson Seaman, David Stauffer and Brian Reen
Department of Meteorology, The Pennsylvania State University, University Park

1. INTRODUCTION

Zhang et al (2004) evaluate five widely used PBL parameterization schemes in their reproduction of the diurnal cycles of surface wind (V_{sfc}) and surface temperature (T_{sfc}). Their results suggest that the Gayno-Seaman (G-S; Shafran et al. 2000) scheme reproduces better the observed time variation of T_{sfc} and vertical profile of potential temperature. However, it produces pronounced phase errors in the diurnal cycles of V_{sfc}. Another TKE-based scheme, the Meller-Yamada-Janjic (Eta; Janjic 1997, 2001) scheme, underestimates T_{sfc} and generates a colder and shallower mixed layer. The Eta scheme produces a good simulation of the daytime phase and amplitude of V_{sfc}. Their work motivates us to find out why V_{sfc} behaves differently using the similar TKE-based Eta and G-S schemes.

2. MODEL AND DATA

The 3-D nonhydrostatic MM5 model is used to compare two PBL schemes: G-S and Eta.

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* *Corresponding author address*: Xia Feng, Penn State Univ., Dept. of Meteorology, State College, PA; e-mail: fengx@psu.edu

In order to evaluate difference in the performance of these two schemes, we keep radiation, cloud and precipitation parameterization identical but surface flux calculations differ. The one layer slab model is used for G-S scheme and the 4-layer slab model is used for the Eta scheme. The innermost of these model domains has 160×175 points in the horizontal with spacing of 4km (Fig. 1). A total of 63 σ levels are used in the vertical direction. The lowest half model level is 30 m. The IHOP case 0000UTC 20 May 2002 is integrated for 24 hours with time step of 6 s. The standard observation data contains 91 surface observations stations and 4 sounding locations in our domain of interest.

FIG. 1. Nested grid domain for MM5 applied to IHOP case of 0000UTC, 20 May 2002. Results evaluated versus observations for the 4-km domain.

3. MM5 3-D MODEL RESUTS

3.1 Surface Temperature

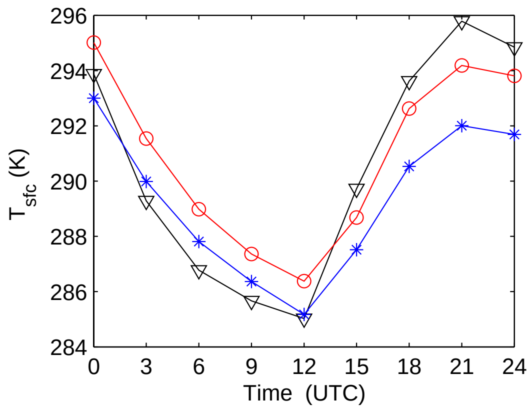

FIG. 2. Comparison of the averaged Tsfc (K) between the observations (triangle) and the model simulations using the G-S (circle) and Eta (star) PBL schemes during 1 day period of 0000UTC 20 May — 2400UTC 21 May 2002.

Diurnal variation of averaged Tsfc from G-S and Eta schemes are compared with observation (Fig. 2). Both schemes overestimate night-time Tsfc and underestimate the daytime Tsfc. The Eta scheme gives better performance during the late night stable situation and G-S scheme is more consistent with the observation for the daytime simulation. In addition, the Eta scheme (Fig. 3b) produces a colder and shallower mixed layer than that from the G-S scheme (Fig. 3a) which is similar to the results of Zhang. The superadiabatic lapse rate near the surface is stronger in the G-S scheme due to weaker upward heat flux transport which relies on the strength of eddy diffusivity (not shown).

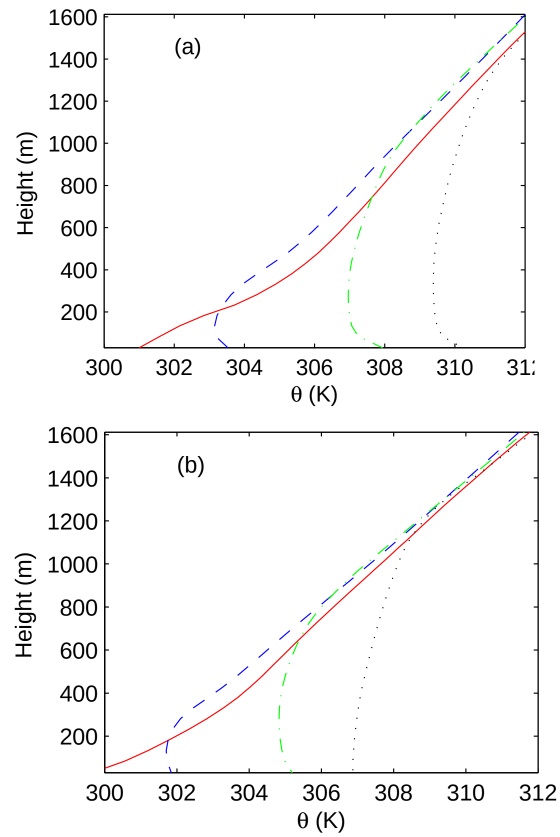

FIG. 3. Vertical profiles of the area-averaged potential temperature from (a) G-S and (b) Eta schemes at 1200 UTC (solid), 1500UTC(dash), 1800UTC(dash dot) and 21UTC (dot) 20 May 2002.

3.2 Surface Wind Speed

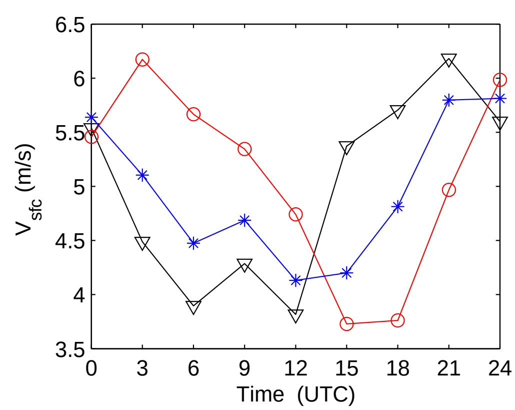

FIG. 4. As in Figure 2, but for the area-averaged Vsfc (ms^{-1}).

Overestimation of V_{sfc} during the night time by the G-S scheme and underestimation during the day are shown in Fig.4, even though T_{sfc} was simulated well by both PBL schemes. This further strengthens the point that good treatment of diurnal cycle of T_{sfc} does not ensure a reasonable diurnal cycle of V_{sfc}. In addition, the Eta scheme provides more realistic simulation of V_{sfc} variation, whereas G-S scheme exhibits a 6 h phase delay which is similar to Zhang's simulation. The simulated LLJ with Eta scheme (Fig. 5a) is in good agreement with the observation, but G-S scheme predicts a stronger LLJ at a slightly higher level. At the same time, the predicted V_{sfc} from Eta scheme (Fig. 4) shows a rapidly increasing speed from 1500UTC-2100UTC which is somewhat slow, but mostly consistence with the observation. But G-S scheme propones this increasing stage by six hours compared to the observation. After 24 hours integration, the wind profiles differ significantly (Fig. 5b). These differences may be attributed to the formulation of mixing length which decides eddy diffusivity and controls the vertical transport of momentum from LLJ.

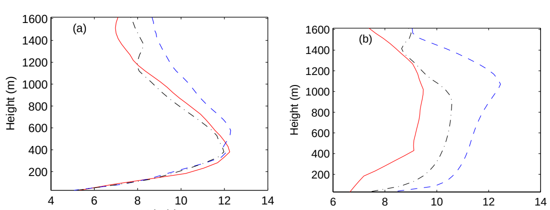

Fig. 5. Comparison of vertical profile of the averaged horizontal wind speed (ms^{-1}) between observation (solid) and model simulations using G-S (dash) and Eta scheme (dash dot) at a)1200UTC 20 May and b) 0000UTC 21 May 2002.

4. MM5 1-D RESULTS

In this experiment, we replace the formulation of mixing length in the G-S scheme with that from the Eta scheme using MM5-1D GUI model (Ricardo, 2002). The horizontal advection and pressure gradient terms for wind diagnosed from 3-D MM5 output are interpolated for 1-D model use. Since MM5-1D model using Eta scheme is not available, only the simulated surface wind velocity with the original and the modified G-S scheme are compared with the he observed for four chosen sounding locations (Table 1).

Table 1: *Chosen Sites for Simulation Experiments*.

Station ID	Site Number
72451	SI
72363	SII
KIAB	SIII
KAVK	SIV

Figure 6 shows the simulated V_{sfc} from original G-S and modified G-S schemes compared with observations. We can see the variation of V_{sfc} among sounding locations using MM5 1D model is different from the spatially averaged wind variations produced by the 3D MM5 model. Simulated phase lags appear in each site. With the modified G-S, somewhat better results are obtained at sites SIII and SIV than with the original G-S scheme. However, SI and SII show poor performance with the modified G-S scheme especially during the daytime.

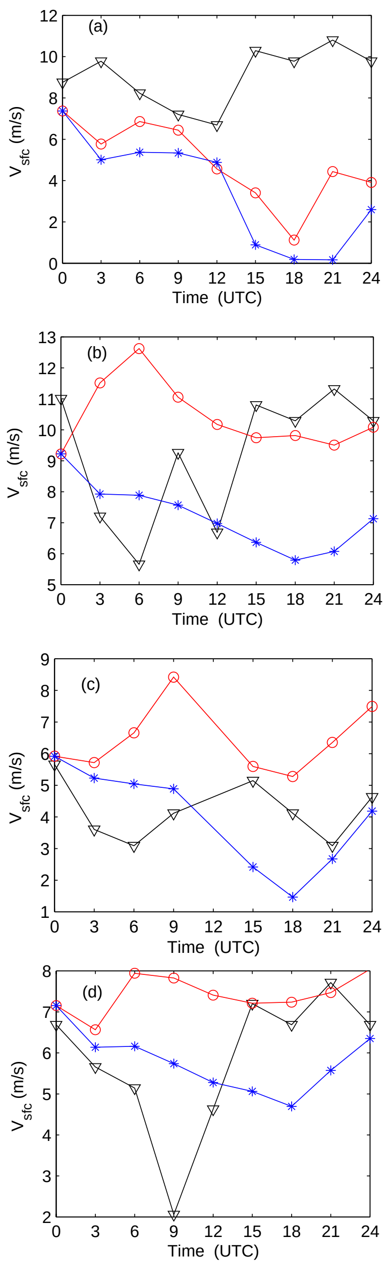

FIG. 6. Comparison of the observed surface wind velocity (triangle) with G-S (circular) and modified G-S (star) at site a) SI b) SII c) SIII and d) SIV.

5. CONCLUSIONS

Recent results from Zhang et al. (2004) show that the G-S scheme reproduces well the observed time variations of Tsfc and the vertical profile of potential temperature. However, it also produces pronounced phase errors in the diurnal cycle of Vsfc.

Comparisons between G-S and Eta schemes suggest that the different simulation of Vsfc may be generated by the different downward momentum transport which depends on the specification of mixing length.

In order to further investigate the role of mixing length on the simulated surface wind speed, we replace the formulation of mixing length in G-S scheme is with that from Eta scheme. The results show that the MM5 1-D GUI model produces a different cycle of Vsfc compared to the area averaged Vsfc using MM5 3-Dmodel. In addition, the modified G-S scheme gives better results for SIII and SIV and the poor simulations for S1 and SII. Further investigation is necessary to understand the causes of phase errors in the G-S diurnal variation of Vsfc.

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