P1.34 Sensitivities of Modeled Tropical Cyclones to Surface Friction and the Coriolis Parameter

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1. INTRODUCTION

In this investigation the sensitivities of a 2-D tropical cyclone (TC) model to surface frictional coefficient and the Coriolis parameter are studied and their implication is discussed. The model used is an axisymmetric version of the latest version of the Goddard cloud ensemble model (Tao et al. 2002). The model has stretched vertical grids with 33 levels varying from 30 m near the bottom to 1140 m near the top. The vertical domain is about 21 km. The horizontal domain covers a radius of 962 km (770 grids) with a grid size of 1.25 km. The time step is 10 seconds. An open lateral boundary condition is used. The sea surface temperature is specified at 29°C. Unless specified otherwise, the Coriolis parameter is set at its value at 15N. The Newtonian cooling is used with a time scale of 12 hours. The reference vertical temperature profile used in the Newtonian cooling is that of Jordan (1958). The Newtonian cooling models not only the effect of radiative processes but also the effect of processes with scale larger than that of TC. Our experiments showed that if the Newtonian cooling is replaced by a radiation package, the simulated TC is much weaker.

The initial condition has a temperature uniform in the radial direction and its vertical profile is that of Jordan (1958). The initial winds are a weak Rankin vortex in the tangential winds superimposed on a resting atmosphere. The initial sea level pressure is set at 1015 hPa everywhere. Since there is no surface pressure perturbation, the initial condition is not in gradient balance. This initial condition is enough to lead to cyclogenesis, but the initial stage (say, the first 24 hrs) is not considered to resemble anything observed.

The control experiment reaches quasi-equilibration after about 10 days with an eye wall extending from 15 to 25 km radius, reasonable comparing with the observations. The maximum surface wind of more than 70 m/s is located at about 18 km radius. The minimum sea level pressure on day 10 is about 886 hPa. Thus the overall simulation is considered successful and the model is considered adequate for our investigation.

2. EXPERIMENTS

Three other experiments with zero, half, and double surface drag coefficient were made. The experiment without surface friction has also yielded the cyclogenesis process. Fig. 1 shows the tangential wind at day 10 hr 0. Thus, surface friction is not a necessary condition for cyclogenesis or for the mature TC. The eye-wall in this case is quite far (about 60 km) from the center; the low-level converging air toward the eyewall obviously can exist without the presence of surface friction. Without surface friction to reduce wind speed the converging air cannot reach very close to the center resulting in an eyewall with a large radius. This is due to the fact that the converging low-level air, in the absence of surface friction, gains high enough tangential wind to pick up enough moisture to make itself convectively unstable, when it is still quite far from the center. Outside the large radius eye-wall the increase of angular momentum due to converging air in the boundary layer is balanced by the decrease due to internal friction and horizontal diffusion, instead of surface friction.

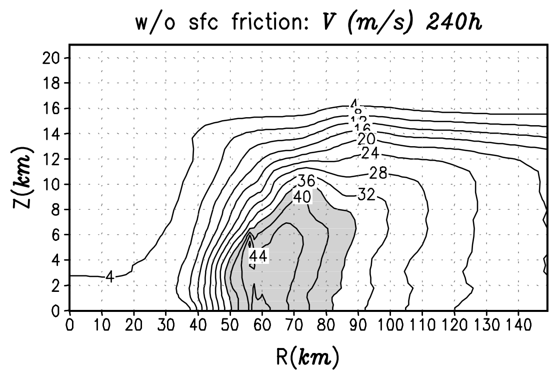

Fig. 1

In the experiments with half and double surface friction coefficient, the results show that higher surface friction renders a smaller and weaker TC but with earlier and more intense cyclogenesis process in terms of minimal sea level pressure.

To further study the role of surface friction, we need more experiments. In another two sets of experiments, the results of the control run at hr 96 (in the growing phase) and hr 240 (in the mature phase) are used as the initial conditions for runs of one day duration with half and double surface drag coefficient. Fig. 2 shows the total kinetic energy averaged over the model domain area of these runs. Fig. 3 shows the 24 hr averaged precipitation of these runs and Fig. 4 shows the 24 hr averaged inward radial mass flux in the lowest 1 km. These results show that increasing surface friction has

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helped low-level convergence and the eye-wall precipitation, but it has also reduced the total kinetic energy as comparing with the control. Further analysis has revealed that the increased low-level convergence leads to stronger vertical motion in the eye-wall and a cooler eye-wall, the combination of which gives a greater conversion rate from available potential energy to kinetic energy. However, this increase is met with a greater increase in frictional damping.

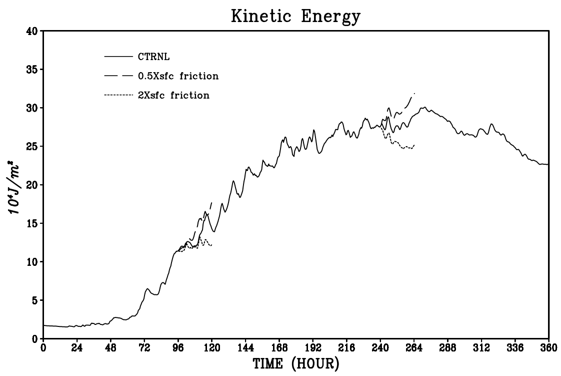

Fig. 2

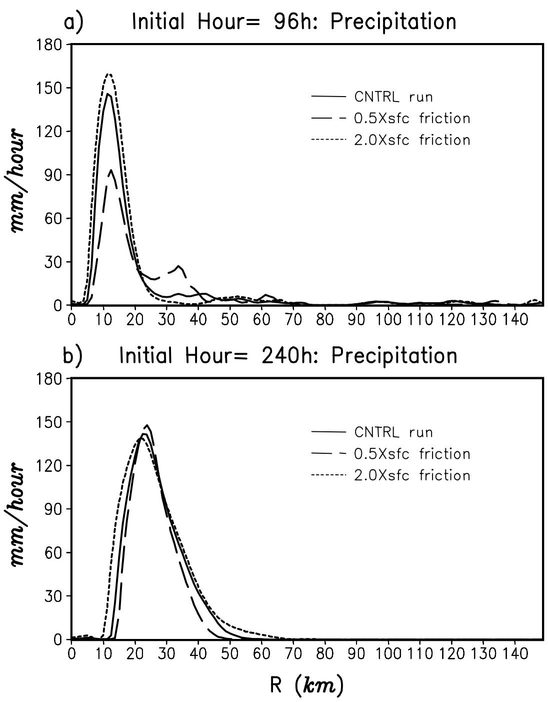

Fig. 3

Fig. 5 shows the area-averaged total kinetic energy as functions of time for experiments with various values of the Coriolis parameter (while keeping everything else the same.) It shows that the pole is not the most favored latitude. These results are different from the expectation of the Ekman pumping efficiency idea.

Further discussion will be provided at the conference.

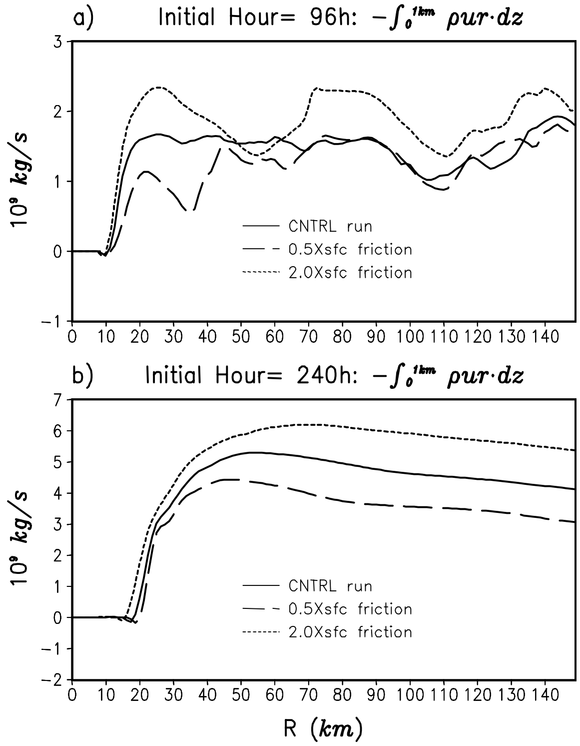

Fig. 4

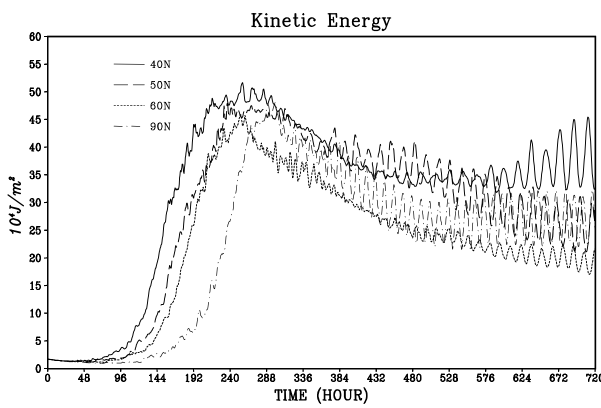

Fig. 5

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