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Simulation of a tropical cyclones using the GFDL TC model with bulk-parameterization and spectral microphysics

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1. INTRODUCTION

The evolution of tropical cyclones (TC), especially their intensity and structure depend on the magnitude and spatial distribution of convective heating within a TC. The associated precipitation rate and amount depend on microphysical structure of clouds, of size of drops and type and size of cloud ice. Convective parameterization schemes traditionally used for TC simulation were designed for models with comparatively crude resolution unable to resolve individual cumulus clouds. These schemes are based on some semi-empirical or semi-intuitive assumptions, concerning convection response to large-scale forcing. These schemes lead, as a rule, to different TC intensities, structure and, sometimes, to substantially different tracks. In addition, these schemes which do not include microphysical processes often result in significant variations in precipitation forecasts. At the same time, the increased resolution of many advanced TC models allows convection to be explicitly resolved in the vicinity of TC center, where convection is concentrated. This is especially true in the zone of the eye wall, where clouds are large, having diameters up to several kilometers.

2. EXPERIMENTAL DESIGN

Two convective schemes have been recently implemented into the GFDL tropical cyclone model. The first one is a bulk-parameterization scheme based mainly on study by Lin et al. (1983). This scheme has been successfully used in simulations of ensembles convective clouds, of tropical squall lines in the Goddard Cloud ensemble model (Tao et al, 2001), as well as in other high resolution mesoscale models for simulation of storms. It describes the formation and transport of cloud hydrometers of five types: cloud water (small cloud droplets), raindrops, ice crystals, snowflakes (aggregates), and graupel.

The second scheme developed at the Hebrew University of Jerusalem (Khain et al, 2000; 2001) is based on solving equation system for size distribution functions for liquid water, plate-, columnar,- and branch-type ice crystals, aggregates, graupel, of droplet and ice size spectra and precipitation.The evolution and structure of tropical cyclones obtained using current parameterization scheme (Kurihara and Tuleya, 1974), bulk-parameterization and spectral microphysics will be compared in both axisymmetric and three dimensional domain configurations. Special attention will be paid to differences in intensity, structure, precipitation rate and profiles of convective heating

3. RESULTS

Preliminary results are now being obtained from the integration of an idealized experiments using the Lin et al. (1983) scheme. Cross sections of the distribution of ice, graupel and rainwater are shown in Figure 1 during the early stages of the integration. More complete results will be shown later. The initial experiments were run with relatively coarse vertical (18 levels) and horizontal(1/6deg) resolution. More extensive testing will be done with a higher resolution nested grid model with 42 levels and the inner mesh having 1/12 degree resolution or finer. Compared to the control run using convective adjustment, the integration with explicit cloud resolving microphysics was much less cyclogenic with very little observed development. As mentioned, finer scale experiments are now being run at a resolution more suitable for cloud-resolving simulations. The role of the environmental flow in controlling the intensity and structure will also be studied. Results will be shown later.

Figure 1 (next page). Cross section of cloud micro0physical variables ice crystal, graupel and rainwater in the early stages of a simulation using the GFDL three-nested model with 1^o, $1/3^{o,}$ and 1^o horizontal resolution with 18 levels in the vertical.

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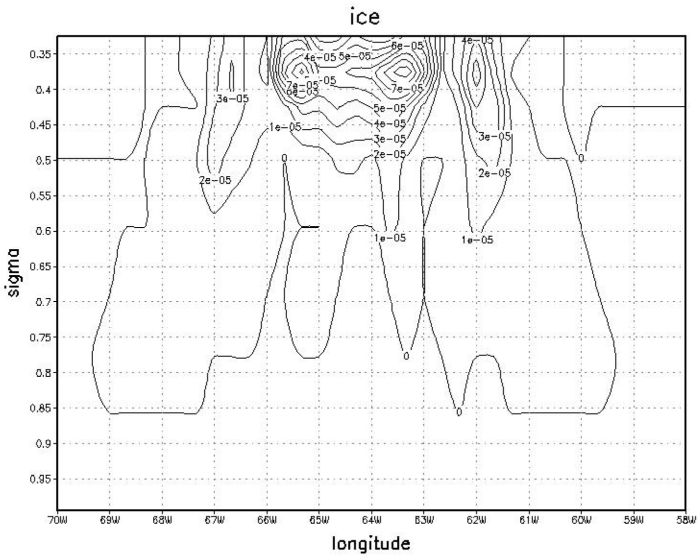
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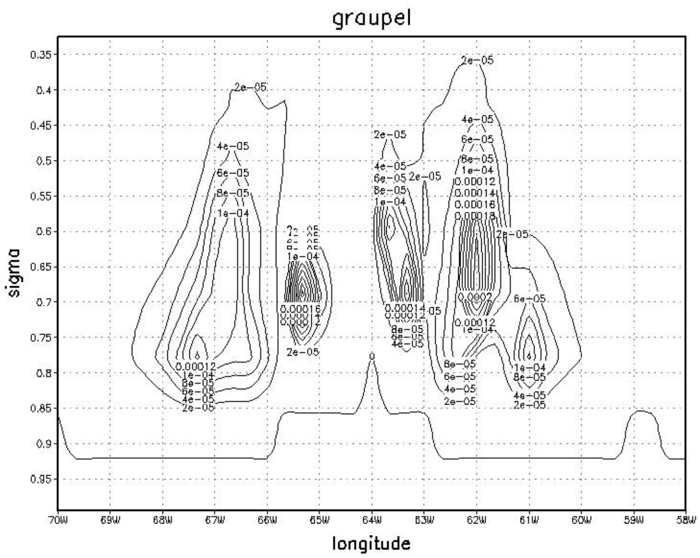
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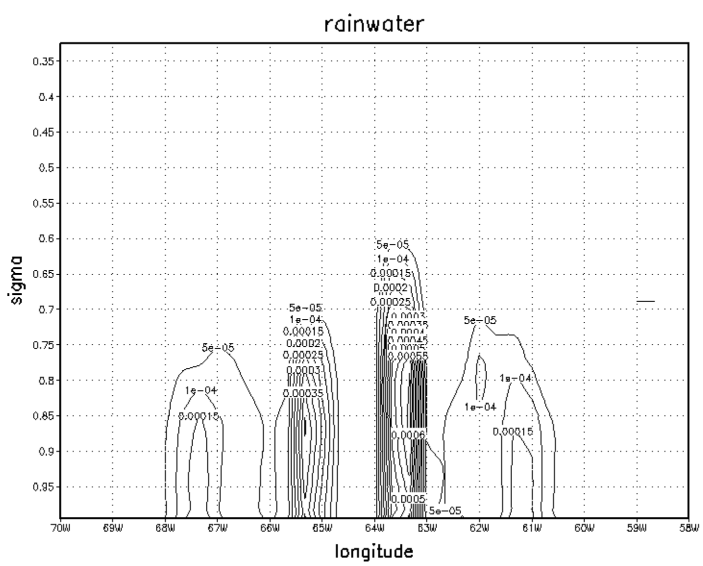
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