A new Tropical Cyclone Model

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LRZ-Account: uh21501,uh21301

Abstract

A new numerical three-level model has been developed to study the role of the convection parameterization in the intensification of tropical cyclones. The novel feature is a new convection parameterization and the coupling of a mixed-layer ocean.

Keywords: convection; tropical cyclones

1 Introduction

Operational weather forecast models, which have a horizontal resolution of about 50km (partly over the whole globe) show good skill in the prediction of the track of tropical cyclones, but the intensification of these storms is not well captured [2]. Some simple one-layer models of tropical cyclones (vortices) which do contain neither clouds nor precipitation predict the track of tropical cyclones surprisingly well but the intensity cannot change significantly. A common method to obtain a good initial guess for the wind field of a tropical cyclone is to erase it from the initial data and implant a 'bogus' vortex instead. This 'bogus–ing' has also some beneficial effect on the track forecast of more complete forecast models, but not as much on the intensification forecast. The key for a more successful intensification prediction is a better understanding of the convection parameterizations used see [3]. Convection has to be parameterized for horizontal resolutions down to approximately one kilometer. As a research tool we have created a simple three-layer model of the tropical atmosphere and the coupling of a simple one (and a half) layer ocean is under way.

2 The new model

The atmospheric model has three layers in the vertical, these are the boundary layer (BL) the middle troposphere (MT) and the upper troposphere (UT). The vertical coordinate is a so-called σ–coordinate [1] which is given by $\sigma = (p - p_{top})/(p_{surface} - p_{top})$, where p is pressure. The ocean surface is flat and corresponds with $\sigma = 1$. The top of the model is at $\sigma = 0$. Only one layer of the ocean, the mixed layer (OCML) is active. We initialize the model with a weak vortex with an analytical profile. Initially there is no convection, but during the time integration the convection sets in and acts to spin up the vortex. The processes involved are: Friction which induces a radial inward flow. Surface stress that drives the mixed layer of the ocean and causes (cold) up-welling. Shallow convection (sc) that redistributes (potential) temperature and moisture in the vertical. Resolved large scale rain (lsr) due to supersaturation. Our main focus is on deep convection (dc) which is assumed to take place within a vertical column (dashed). Besides a mass transport from the BL upwards, downdraughts (Md) and lateral entrainment (Me) and convective rain (cr) are included.

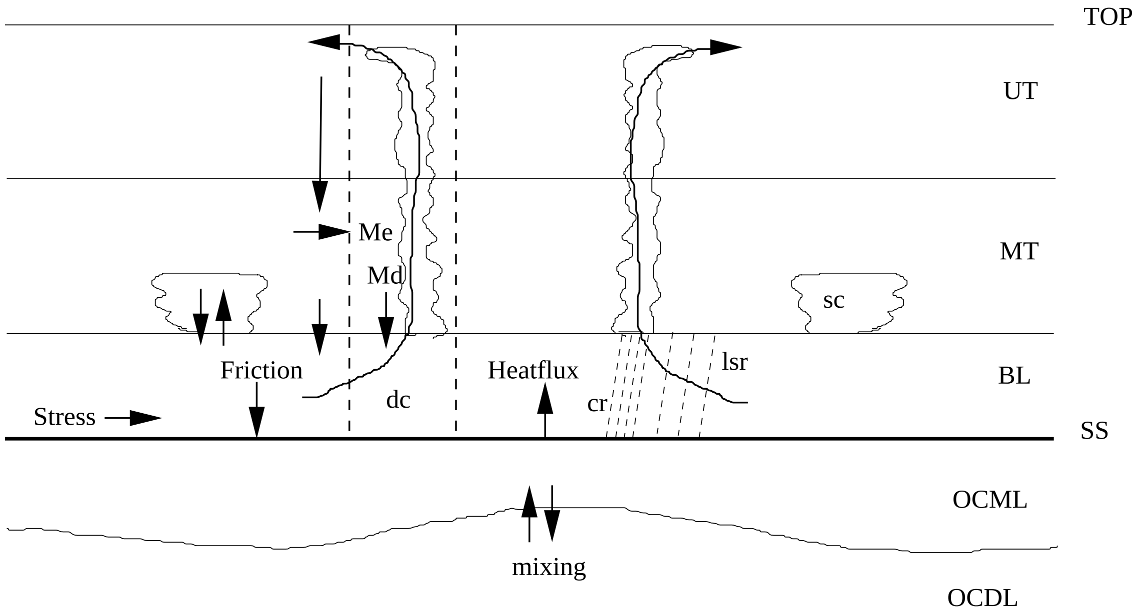

Figure 1: Physical processes contained in the numerical model.

3 Vectorization and Coding

The atmospheric Sigma-model is not a novelty. Because older codes are difficult to maintain, and do not make use of proper numerical techniques for our investigation, we have created a new Fortran 90/95 model code with highest priority on portability. The code makes extensive use of the novel features of the new language standard, mainly array operations. Because of the patchy occurance of convection these are coded by Fortan90 WHERE Blocks. On the Cray T90 the use of the flowtrace timing tool revealed shorter execution times than with conventional loop coding. No attempt was made to prepare the code for massive parallel computing. With a reduced number of 201 $\times$ 201 grid points in the horizontal the execution time on a DEC Alpha (433Mhz) is on the order of 1 day (approximately 1 hour on a Cray T90).

4 Results

A paper with the title: A Minimal Three-Dimensional Tropical Cyclone Model by Smith, R.K, Hongyan, Z., Ulrich, W. is submitted for the 24th Conference on Hurricanes and Tropical Meteorology
http://www.ametsoc.org/ams/meet/index.html

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