# Initialization with Rainfall defined Diabatic Heating

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## 1. Introduction

Many studies have indicated that the inclusion of rainfall data into numerical models can improve the accuracy of numerical weather prediction (e.g. Zou 1996, Pu 2002). In this paper, the assimilation of NRL (US Naval Research Laboratory) rainfall is implemented with the idea of adjustment of diabatic heating to improve the large-scale environment and mesoscale structures in initial conditions. Numerical experiments are performed to evaluate the impact of rainfall data on the prediction of rainfall and track of Tropical Cyclone Chris, which made landfall near Port Headland, Western Australia during 3-6th, Feb. 2002.

The NRL rainfall data, classified as three types (i.e. stratiform, convective and composite rainfall - combined by stratiform and convective rainfall) following Churchill and Houze (1984), is used to define the vertical profiles of diabatic heating (Johnson 1984). The rainfall region is considered as convective type if the rainfall rate exceeds 10 mm $h^{-1}$. Grid points with a surface rainfall rate twice as large as the averaged value taken over the four surrounding grid points are identified as the convective type. During the period of initialization (assimilation), the diabatic heating from the cumulus scheme is replaced by the heating profile given by Johnson (1984) and 6-h satellite-observed cloud-top temperatures.

## 2. Experiment design

The BMRC (Bureau of Meteorology Research Center, Australia) tropical limited-area model (Davidson 1992) is used for the experiments. It is a hydrostatic, primitive equation model, with a vertical sigma coordinate system and semi-implicit time differencing. Physical parameterizations include a stability-dependent boundary layer, diurnally varying radiation with diagnosed surface temperatures over land, shallow convection, large-scale precipitation and Kuo-type cumulus convection. The horizontal grid spacing of 15 km and 29 sigma levels has been used in this study. Boundary conditions are obtained from the BMRC global prediction system.

Several experiments were performed with respect to the options of “rainfall assimilation” and “dynamic nudging” (Table.1). For the experiments RA (with rainfall assimilation) and RAN (with rainfall assimilation and dynamic nudging), 6-h accumulated NRL rainfall data are ingested in the model within each of the 4*6h initial (assimilation) periods, valid respectively at 24h, 18h, 12h, 6h prior to the base time of the simulation (23UTC 3 Feb 2002) (Fig. 1). To help make the momentum field more consistent with the mass field during the initialization, dynamic nudging (using conventional observations) is also performed in RAN.

## 3. Results

### *a. Rainfall distribution*

Rainfall assimilation greatly improves the prediction of rainfall, with the RAN experiment the most obvious (Fig.2).

### *b. TC Track*

Inclusion of NRL rainfall data improves the track in all the experiments (Fig. 3), with the RAN experiment giving the most significant improvement.


**References**

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**Table.1 Design of numerical experiments**

| Numerical expt. | Rainfall assimilation? | Dynamic nudging? |
|---|---|---|
| CTRL | No | No |
| RA | Yes | No |
| RAN | Yes | Yes |

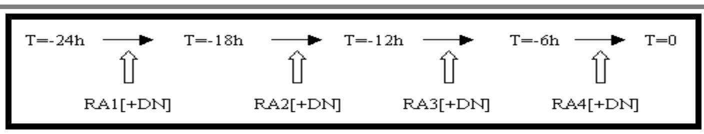


Fig.1 The cycle of rainfall assimilation

(RA1, RA2, RA3, RA4 denotes the assimilation with 6-h accumulated rainfall within each of the 4*6-h initialization periods, DN refers to the optional dynamic nudging)

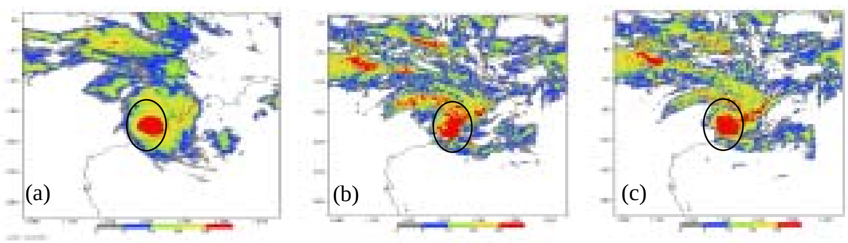


Fig. 2 (a) NRL accumulated rainfall and simulated rainfall in experiment (b) CTRL and (c) RA at 00UTC 3th – 00UTC 4th, Feb 2002. (the circle denotes the region of intensive rainfall)

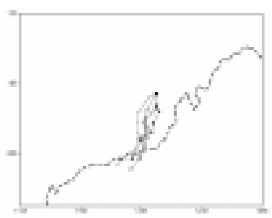

Fig.3 Observed and predicted tracks of Chris from 00UTC 3 Feb. 2002 at 6-h interval

The track with mark "open circle" denote the observation, "cross" - CTRL experiment, "open square" - RAN experiment, "closed circle" - RA experiment.