# 7B.2 TOPOGRAPHIC EFFETCS ON TYPHOON NARI (2001): VERIFICATION AND SENSITIVITY EXPERIMENTS

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## 1. Introduction

Typhoon Nari struck Taiwan on September 16, 2001; it brought heavy rainfall, fresh flood, and caused tremendous economical loss, including 92 human lives. The record-breaking 24-48 hour accumulated rainfalls more than 2000 mm in some parts of Taiwan caused widespread flooding and severe property damage. Nari's heavy rainfalls on Taiwan were due to warm sea surface temperature, Nari's unique track and very slow moving speed, and the steep terrain of Taiwan (Sui et al. 2002). The objective of this study is to investigate the topographic effects responsible for heavy rainfalls of Typhoon Nari (2001).

## 2. Methodology

The PSU-NCAR MM5 model (Grell et al. 1995) is used to investigate the precipitation structure and processes associated with Typhoon Nari. The MM5 model configuration includes four nested grids with horizontal grid size of 54, 18, 6, and 2 km, respectively, and 31 sigma levels in the vertical. Model top is at 50 hPa. The simulation is integrated for 108 h, starting from 1200 UTC 15 September 2001. The initial and boundary conditions are taken from the ECMWF advanced global analysis with $1.125^o \times 1.125^o$ horizontal resolution. Sea surface temperature is kept constant during the period of integration. The full-physics control simulation uses the following physics options: 1) the Grell (1993) cumulus parameterization scheme, 2) the Reisner microphysics scheme with graupel (Reisner et al. 1998), 3) the MRF PBL scheme (Hong and Pan 1996), and 4) the atmospheric radiation scheme of Dudhia (1989). Note that no cumulus parameterization scheme is used on the 6-km and 2-km grids.

We follow the method of Davis and Low-Nam (2001) to perform typhoon initialization. First the erroneously large vortex in the large-scale analysis is removed. Then an axis-symmetric Rankine vortex is inserted into the wind field, with the storm characteristics estimated from the JTWC best-track analysis. When constructing the three-dimensional bogus wind, the axis-symmetric wind is vertically weighted. The vertical weighting function is specified to be unity from the surface through 900 hPa, 0.96 at 850 hPa, 0.99 at 700 hPa, 0.97 at 500 hPa, 0.85 at 300 hPa, 0.6 at 200 hPa, 0.3 at 100 hPa, and 0.1 at 50 hPa. Then the nonlinear balance equation is used to solve the corresponding geopotential height perturbation, and the hydrostatic equation is used to obtain the temperature perturbation. Moisture is assumed to be saturated within the typhoon vortex.

## 3. Results

The simulated Nari makes landfall over Kee-Lung (22 hours after initialization), only 20 km off the actual landfalling position of I-Lan. Basically, The MM5 can simulate the precipitation distribution and amount reasonably well. For example, the MM5 on the 2-km grid can simulate maximum 24-h rainfall of 1183 mm near Mount Snow on September 17th, in close agreement with observed maximum of 1188 mm (figure not shown).

We compare the simulated radar reflectivity versus the observation from the NEXRAD Doppler radar located over the WuFeng Mountain (RCWF). Note that because of the landfall timing error (roughly three hours earlier) of the simulated Nari, both radar reflectivity fields are adjusted in time so that both typhoon centers are at relatively the same position with respect to Taiwan's northern coast. Also note that both simulation and observation data are analyzed in the same horizontal resolution (6 km) and the same height (3 km AGL), and both are displayed in the same color scale. The observed radar reflectivity showed heavy precipitation around the eyewall, a clear typhoon eye, and several spiral rainbands; these features are well simulated by the MM5 model.

We also compare the simulated versus observed radar radial wind field from the RCWF radar. Again, both fields are adjusted in time so that both typhoon centers are at relatively the same position

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with respect to Taiwan's northern coast. Also both data are analyzed in the same horizontal resolution (6 km) and the same height (3 km AGL), and are displayed in the same color scale. This comparison indicates that the counterclockwise tangential wind circulation around Nari is well captured by the MM5 model, although the simulated wind (of maximum radar wind of 40 m/s) is slightly stronger than the observed wind (of the maximum radar wind of 35 m/s).

The good agreement between our MM5 control simulation and observation for Typhoon Nari gives us confidence to perform further model diagnostics and sensitivity experiments, similar to the case of Typhoon Toraji ((Yang and Ching 2005). The issue of precipitation efficiency for Nari while she was still over open ocean is discussed in Sui et al. (2005), and the simulation of Nari-induced flooding is reported in Li et al. (2005). Two sensitivity experiments on topographic effects are conducted: one with half of the actual terrain height and the other with topography totally removed. In the half-terrain experiment, the simulated typhoon track followed closely the observed track for the first two days and then started to have a noticeable deviation on the third day; the simulated rainfall total is about 60% of the observed during the landfall period. If Taiwan's topography is completely removed, it shows a substantial change on typhoon track, and the simulated rainfall total over Taiwan is only about 40% of the observed during the landfall period (Fig. 1). More diagnostics are in progress to investigate the complex interactions between the microphysical and topographic processes.

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a) Control

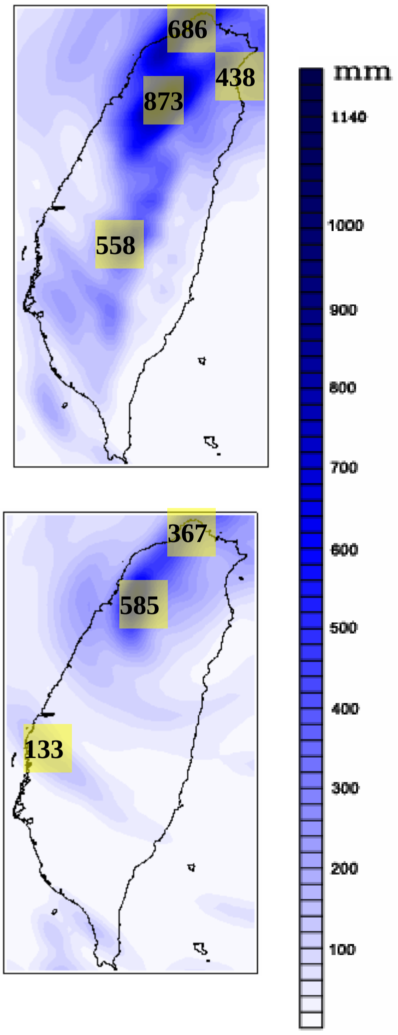

Figure 1: The simulated 24-h rainfall (in units of mm) for 16 September 2001 on the 2-km grid: (a) Control and (b) No-Terrain experiments.