Eastern Pacific Tropical Cyclone Development and the North American Monsoon System

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Introduction:

Much of Southwest North America receives half or more of annual precipitation in the warm season months between July and September (Douglas et al. 1993). The domain encompassed by the North American Monsoon System (NAMS) is, by definition, continental. However, the core monsoon region in northern Mexico is sufficiently narrow that it is affected by both the subtropical Pacific Ocean and the Gulf of Mexico. Tropical cyclones[1] (TCs) develop and propagate in both regions and the influence of landfalling TCs extends throughout the NAMS domain, dropping copious amounts of precipitation on semiarid lands even while still at depression stage. In recent years more storm damage and loss of life in the Americas can be attributed to the extreme precipitation and associated fresh-water flooding of near-approaching or landfalling TCs than to their high winds (NHC Tropical Cyclone Reports (1995-2005). In addition, there is considerable intra- and inter-seasonal variability of both the development and the landfall of TCs in the Americas, and little work has been done to understand the impact that this variability has on warm season precipitation amounts.

In this poster we describe preliminary results of a study of the role of eastern Pacific tropical cyclone activity in the NAMS. The overall goals of this project are to
1) assess the capabilities of a high-resolution regional model (MM5) for simulating convective precipitation and tropical cyclones in the context of the monsoon circulation;
(2) assess the interannual variability of eastern Pacific tropical cyclones and their tracks in the observational record; and
(3) use the model to examine sources of potential predictability of cyclone activity on seasonal/interannual time scales.

[1]Generic term for tropical storms, hurricanes, and typhoons

MM5 Model Description:

A series of 16 simulations have been run using the PSU/NCAR mesoscale model (MM5)[2] to examine the variability in modeled precipitation, both oceanic and continental, to model parameterizations. The model has been configured to run with a 45-km resolution coarse mesh and a nested mesh of 15-km resolution over the continent to better resolve land processes. There are 23 vertical sigma-p levels with at least 7 levels below 850 mb to resolve boundary-layer processes.

The model top is set at 50 mb and a radiative boundary condition is used at the top of the model. Boundary layer processes are determined using the MRF scheme coupled with a simple 5-layer soil model that resolves diurnal temperature variation. A radiation scheme is implemented that accounts for longwave and shortwave interactions with model-predicted cloud and clear air. Sensitivity of model-predicted precipitation to different convective and explicit precipitation schemes are tested.

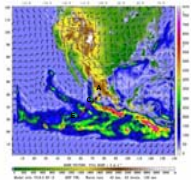
Initial and boundary conditions are specified using the NCEP final analysis (1°x1°, updated twice daily) for September 2000. We tested updating boundary conditions every 6 hours since they were available and found little difference in the results.

The model was run for the month of September 2000. We present results calculated for the first 10 days of September below.

[2]Anthes, R.A., E.-Y. Hsie and Y.-H. Kuo, 1987: Description of the PSU/NCAR mesoscale model version 4 (MM4). NCAR Technical Note, NCAR/tn-282+STR, 66 pp.

Here we report on two tests of model simulated precipitation. The left side of the poster illustrates overall coastal and oceanic precipitation and diurnal propagation of deep convection off the west coast of the Americas, as simulated by MM5. The right side of the poster shows an initial examination of simulated tropical cyclones during an active cyclone year.

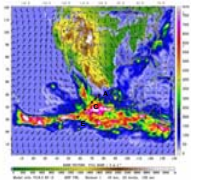
Representation of Continental and Oceanic Precipitation Across the Pacific Coast



45/15 km Kain-Fritsch simulations
10-day precipitation totals

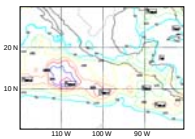
← Warm Rain resolved

Mixed Phase → resolved



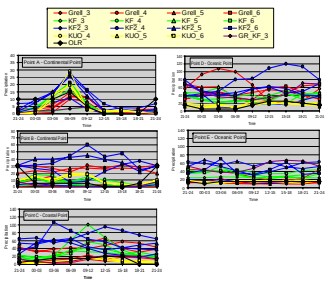
IR-derived 10-day total precipitation

(Courtesy of the Goddard Laboratory for Atmospheres)



Total 10-day precipitation for two of the simulations using the Kain-Fritsch convective parameterization scheme. On the left is a simulation in which a warm-rain specification of resolved microphysics is employed. On the right is a simulation in which mixed-phase specifications are used. Although the mean structure of the ITCZ appears to be well represented in both simulations compared with the OLR-derived precipitation on the right, the total amount in the mixed-phase simulation over the ocean is about 3-4 times too high. Continental amounts appear to be better represented in both simulations.

Diurnal Variation of Precipitation Across the Pacific Coast



Point values of the mean 3-hourly precipitation for the first 10 days of September 2000 along the line A-C-E indicated in the figures above for all sensitivity simulations.

IR-based observations for this period were obtained from Goddard Laboratory for Atmospheres (shown in thick black solid diamonds).

- Note that the observed maximum in precipitation moves off the coast as the day progresses.

- Most of the model simulations tend to over-predict the actual amount of precip and nominally predict the migration off the coast.

Summer 2000: An active year for eastern Pacific tropical cyclones

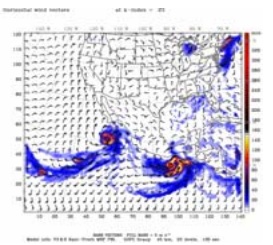
Observations

8 storms May - mid August
most tracks directed far offshore

17 named storms

9 storms mid Aug - Nov
most tracks remain near coast; several landfalls

Simulations: September 2000



12-hr accumulated precip 1200Z 04 Sept 2000
45/15 km resolution, Kain-Fritsch parameterization
(note presence of 2 tropical storms)

Model Resolution	Convection Scheme	# EP storms SLP < 1001 hPa	# total storms SLP < 1001 hPa
Observations		5 named	
45 km	Betts-Miller	10	26
45 km	Grell	7	16
45 km	Kain-Fritsch	8	16
28 km	Kain-Fritsch	7	11

Initial findings:

- **Each of these convective schemes supports tropical cyclogenesis in this model**
- **Increasing horizontal resolution (45 → 28 km) decreases cyclogenesis**
- **Simulations are generally overly active in spinning up tropical depressions**
  ... especially in the first 10 days after initialization (cyclogenesis decreases markedly in the second half of these month-long simulations)
- **Thus the model seems very sensitive to initial forcing within the computational domain (a model spin up problem)**

Research in Progress:

As in the NAMAP run, the model produces too much precipitation (much of it resolved rather than convective, though typically starting as convective). We will examine the sensitivity of model cyclogenesis to initial conditions within the computational domain, and to the longitude of the eastern model domain boundary (through which easterly waves propagate in from the imposed lateral boundary condtions). We will explore the model's ability to simulate the difference in cyclone tracks observed early and late in the 2000 TC season (see track maps above), and then examine interannual variability.