Modeling Intra-Seasonal Features of 2004 North American Monsoon Precipitation

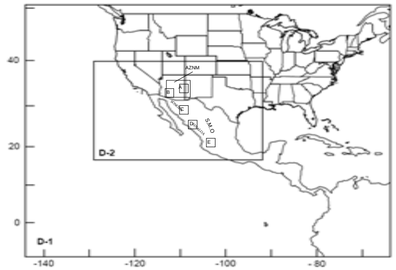
Xiaogang Gao, Jialun Li, and Soroosh Sorooshian

Department of Civil and Environmental Engineering, University of California, Irvine

ABSTRACT

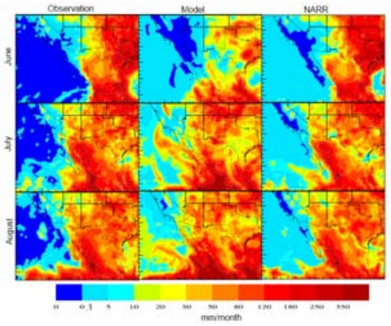
This study examines the capabilities and limitations of the MM5 regional climate model in predicting the precipitation and circulation features that accompanied the 2004 North American Monsoon (NAM). The modeling time period is from 1 June to 1 September, which overlaps with the NAME 2004 Enhanced Observation Period. When the model is reinitialized every five days to restrain the growth of modeling errors, its results for precipitation checked at sub-seasonal timescales become comparable with ground- and satellite-based observations as well as with the NAM's diagnostic characteristics.

STUDY DOMAIN

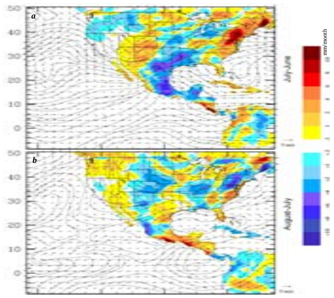


D-1 — a 75-km horizontal grid. D-2 — a 25-km grid with 28 vertical layers.
Boundary/initialization: ECMWF Global TOGA 2.5° Analysis, MODIS/AQUA SST.
Observations:
NCEP 0.25° grid rainfall data, NAME Event Rain Gauge Network (NERN),
Precip Est. from Remotely Sensed Inform. using ANN (PERSIANN), and
NCEP/NCAR Regional Reanalysis (NARR).

EVOLUTION

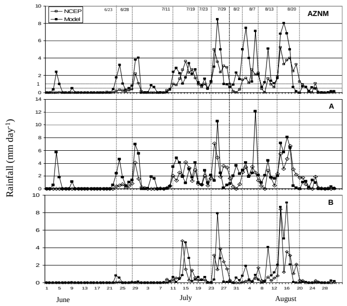


The NARR reanalysis and observed monthly rainfall are highly correlated. Model monthly precipitation over land described the evolution of 2004 NAM which matches the observation and is consistent with the diagnostic analyses. However, the model underestimated the monthly rainfall quantity and coverage areas.



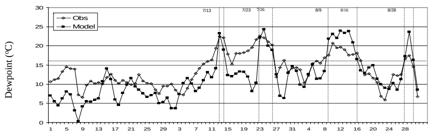
"Tripole" interactive relationships of summer precipitation: from June to July, an increase over the NAM region, an out-of-phase decrease over the Great Plains/Northern Tier, and an in-phase increase over the eastern US and from July to August, the inverse variations.

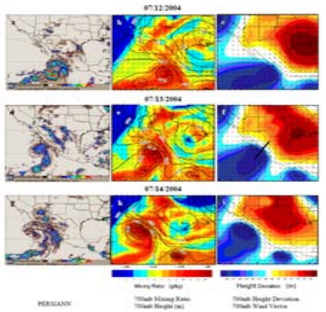
ONSET & DRY-WET EPISODES



Model over-predicted 2 rain events in June (>0.5 mm/day for 3 days). If excluding these events, the model and observation agree upon July 11 as the onset day. After onset, the AZNM region experienced a "wet episode" that included four heavy rain intervals. The model time series shows the same transition and the heavy rain intervals.
Over the Mogollon Rim (Box A), the model generated 3 unrealistic heavy rainfall events in June which could lead to misidentification of the monsoon onset date. Box B is the Sonora desert.

SURGES

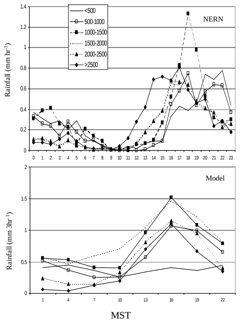


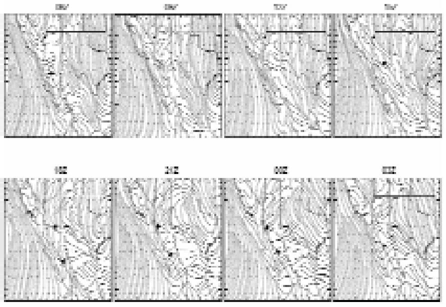


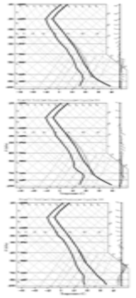
The ground observation enables the identification of four surges: Surge #1: July 11-15; Surge #2: July 17-26; Surge #3: August 8-16; and Surge #4: August 28-30. Correspondingly, the surges determined from the model were: July 13-14; July 23-26; August 9-16; and August 28-29. Surge #1 was a tropical cyclone surge. On July 12, Tropical Storm "Blas" was moving northward near the mouth of the Gulf of California, and Surge #1 started on July 13. The isobars of 700-mb height (middle column) delineates the movements of the cyclone Blas and the monsoon anticyclone.

DIURNAL VARIALITY

Modeled rainfalls in July at 6 elevation bands along the western slope of SMO are compared with the NERN observations. The model results demonstrate pronounced diurnal cycles, but two major errors: 1) the model diurnal cycles at all elevations shared a similar diurnal phase variability (peak at around 17 MST). The observed ones showed a shift in diurnal peak from ~17 MST over the highest elevation to ~23 MST over the lowest, and 2) the model underestimated the diurnal peak intensity over all elevation bands. In particular, little rainfall over the coastal band. Diurnal patterns of low Level flow show the shift of convective activity from the high elevation to the low elevation. Model soundings over the coastal area in the afternoon and evening show the convective inhibition.







CONCLUSIONS

* Model monthly precipitation describes the evolution of 2004 NAM that matches the observation, but underestimates rainfall amounts and coverage areas.
* Model daily precipitation at local areas (Boxes AZNM, A, and B) shows NAM's onset and subsequent transitions of dry-wet episodes that agree with the observations. * Precipitation is overestimated over the Mogollon Rim (A), but underestimated over the western slope of the SMO, northwestern Mexico.
* The predicted four gulf surges in July and August shows the model capability of reproducing the surge progression stimulated by strong forcing (Tropical Storm "Blas") acting at the mouth of the Gulf of California.
* Model diurnal patterns of low-level flows indicate that sustaining sea breezes are the source of afternoon to later night rainfall over the western slopes of the SMO. The model displays migration of convection from the mountain peak to the coast during the afternoon to late night but misses the observed shift in the diurnal rain peak. The model also fails to produce rainfall over the coastal band. The afternoon and night soundings show the existence of a negative energy layer (CIN) over the costal areas which blocks the development of convective rainfall. In high-resolution (3 km) simulations, the CIN can be diminished by outflows from the preceding convection over the upper slopes.

Acknowledgements

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Center for Hydrometeorology and Remote Sensing, University of California, Irvine