Potential Improvement in North American Monsoon Forecasts Using Dynamically Downscaled Data

Hsin-I Chang¹, Christopher L. Castro¹, Francina Dominguez¹,², Brittany Ciancarelli¹, and Carlos Carrillo¹

¹Department of Atmospheric Sciences
²Department of Hydrology and Water Resources
University of Arizona
Tucson, Arizona, USA

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Presentation Outline

- Motivation:
  - Background on the North American Monsoon System
  - Importance in the Southwest U.S. and northwest Mexico
- Current NCEP monsoon seasonal projections
- Dynamical downscaled WRF-CFS reforecasts
- Improvements in climatology and interannual variability in WRF simulations
- Conclusions

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North American monsoon characteristics:

- Monsoon is a seasonal maximum in precipitation in northwest Mexico that progresses into Southwest U.S.
- Characterized by a rapid increase in thunderstorm activity in early summer.
- Thunderstorms largely driven by terrain forcing.
- Synoptic-scale forcing required for intense, organized convection.

Average rainfall in western Mexico during summer monsoon (Douglas et al. 1993)
Societal importance of the NAM:

Severe weather hazard
- Microburst
- Flash flood
- Landslide
- Lightning
- Dust storm
- Wildfire

Climate Impacts
- Agriculture
- Ecosystems
- Water supply
- Water demand
- Power use
- Extreme heat
Current issue:
Most global climate models cannot resolve the North American monsoon well—including CFS

Southern Arizona and northern Sonora
GCM forecast: CFS Component of NCEP Seasonal Forecasts

- Uses results from Climate Forecast System (CFS) AOGCM at T62 resolution
- 15 ensemble members initialized in late spring from NCEP Reanalysis II
- Results indicate very marginal performance for precipitation forecast skill in the Southwest U.S. region

Spatial distribution of retrospective CFS model forecast skill (% anomaly correlation) of the 15 member ensemble forecasts of JJA. (Saha et al. 2006)
Downscaling of CFS Reforecasts (1982-2000) with WRF:

- Use WRF configuration for UA operational forecasting at 32 km grid spacing over contiguous U.S. and Mexico
- 9 CFS ensemble members per season

**Dynamic core**
- Conservation Equations and diffusion
- Boundary layer MJY Scheme

**Microphysics**
- Single moment 3-class

**Land surface**
- NOAH

**Boundary Forcing**
- Lateral boundary and spectral nudging

**Coarse resolution driving data**
- NCEP-NCAR Reanalysis
- CFS Warm Season Reforecasts (April through June initializations)

**Convection**
- Kain-Fritsch

**Radiation**
- Goddard SW
- RRTM LW
Dramatic improvement in the climatology of monsoon precipitation accounted for by a much better representation of the diurnal cycle of convection.
Dominant mode of precipitation variability in early summer and relationship to Pacific SST:

Climatology delayed

Climatology accelerated

Fig. 14. Idealized relationship of monsoon ridge position and moisture transport to Pacific SSTs at monsoon onset.

(Castro et al. 2001)
Dominant REOF Mode of Early Summer (JJ): Standardized Precipitation Index (SPI) vs SSTA
Anomaly Correlation for NAME Regions: Standardized Precipitation Index Global and regional model data vs. CPC obs.

- Dynamical downscaling only leads to marginal improvements in seasonal forecast SPI for core regions (1,2), but does much better for westernmost regions (6,7).
- Discrepancies in reanalysis downscaled SPI anomaly correlations between adjacent U.S. and Mexican core regions (1,2). **Maybe indicative of a problem with CPC observed data??**
JJ SPI Anomaly Correlation: using new NOAA precipitation data product (similar to PRISM)
JJ SPI Anomaly Correlation: for WRF-CFS
CPC vs. NOAA observed precipitation data

Use of new LDEO precipitation dramatically increases the precipitation anomaly correlation in Mexico—means the difference in concluding whether or not a RCM can really improve monsoon seasonal forecasts in Mexico!
JJ Temperature Anomaly Correlation: with U. DEL data

NCEP Reanalysis

CFS model

WRF Downscaled NCEP Reanalysis

WRF Downscaled CFS model
Conclusions:

- **NEED FOR IMPROVEMENT IN MONSOON FORECASTS:** NCEP CFS cannot resolve the North American Monsoon as a salient climatological feature. This is mainly due to the inability of the global model to simulate convective precipitation.

- **PRESENCE OF LARGE-SCALE FORCING IN DRIVING GLOBAL MODEL:** CFS performs reasonably well in capturing the dominant large-scale teleconnections in the warm season related to Pacific SST forcing. Thus it provides reasonable boundary forcing to a finer resolution regional model.

- **REGIONAL MODEL DYNAMICAL DOWSCALING ADDS VALUE:** A model with a grid spacing of 10s of km is necessary to resolve the monsoon as a climatological feature and improves its representation of interannual variability, at least in areas of complex terrain. The choice of observed precipitation for validation matters a lot for Mexico!

- **INCORPORATION OF RCM DATA IN OPERATIONAL FORECASTS:** More work is needed to formally demonstrate the utility of these regional model data for official operational forecast purposes through the NAME forecast forum and NCEP. Current effort of MRED group.
Thank you

hchang@atmo.arizona.edu