Does nudging squelch the extremes in regional climate modeling?

Tanya L. Otte, Christopher G. Nolte, Martin J. Otte, and Jared H. Bowden

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Our Research Problem...Simplified

Constraint of RCM toward GCM

- Keeps RCM climate consistent with GCM
- Decreases variability

Freedom of RCM to develop smaller-scale processes

- Allows RCM climate to deviate from GCM
- Increases variability

More constraint toward GCM  Less constraint toward GCM
WRFv3.2.1 forced by 2.5° × 2.5° NCEP Reanalysis 2 (R2)...

Compare against 32-km North American Regional Reanalysis

Three 20-Year continuous WRF runs with hourly output; compare to 3-h NARR

Northwest (NW)
- 745 total
- 701 land

Midwest (MW)
- 735 total
- 657 land

Northeast (NE)
- 791 total
- 525 land

Southwest (SW)
- 1736 total
- 1460 land

Plains (PL)
- 1089 total
- 1068 land

Southeast (SE)
- 1435 total
- 1052 land
Both types of nudging consistently reduce error.
Monthly Area-Averaged Precipitation Total

Greater variability without nudging: Is it real?
Compared to NARR, WRF is too wet. Nudging reduces erroneous peaks.
Annual Days with Temperature Relative to Threshold

Southwest

Nudging adds variability for extreme cold. Nudging lowers extreme high temperatures…will this verify?
Annual Days with Precipitation Exceeding Threshold

Southwest

Area Average Days with Precip > Threshold

> 0.1 in
> 0.5 in
> 1.0 in


WRF is generally too wet compared to NARR. Nudging, especially AN, makes extremes more realistic.
Spectral Variance: 500-hPa Geopotential Height

Unrealistic longwave in NN. More variability with SN overall. WRF variability suppressed with AN – coefficients too strong.
AN has most overall variability, especially from long waves. Note that only AN nudges moisture.
Nudging Does Not Appear to Squelch the Extremes in RCM

• Both AN and SN improve means
  – 2-m temperature slightly warmer with AN than SN

• Precipitation totals simulated better with AN than SN
  – Precipitation overpredicted by WRF, especially without nudging

• SN has more variability than AN
  – Spectra suggest AN coefficients are too strong for RCM
  – Will weaker AN coefficients improve variability, retain value?
  – Need hourly observations to validate variability of SN surface fields

• Performance is consistent in most regions
  – Steep terrain qualitatively affects results
  – Can terrain mismatch be overcome in RCM?