SENSITIVITIES OF SPECTRAL NUDGING TOWARD MOISTURE

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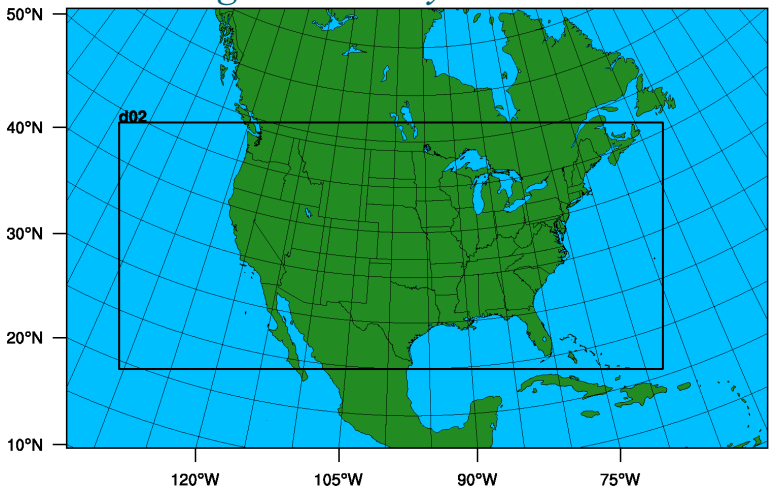
THREE 20-YEAR *HISTORICAL* RUNS IN REGIONAL CLIMATE MODE

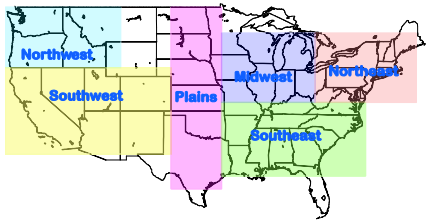
- WRFv3.2.1: 2 Dec 1987 – 1 Jan 2008, *continuous* run
  - Initialized from 2.5° × 2.5° NCEP/DOE Reanalysis II
  - 108-36-km, 2-way-nested
  - 34 layers, top at 50 hPa
  - WSM6 microphysics
  - Grell ensemble convection
  - RRTMG radiation
  - YSU PBL scheme
  - NOAH LSM

Figure courtesy J. Herwehe

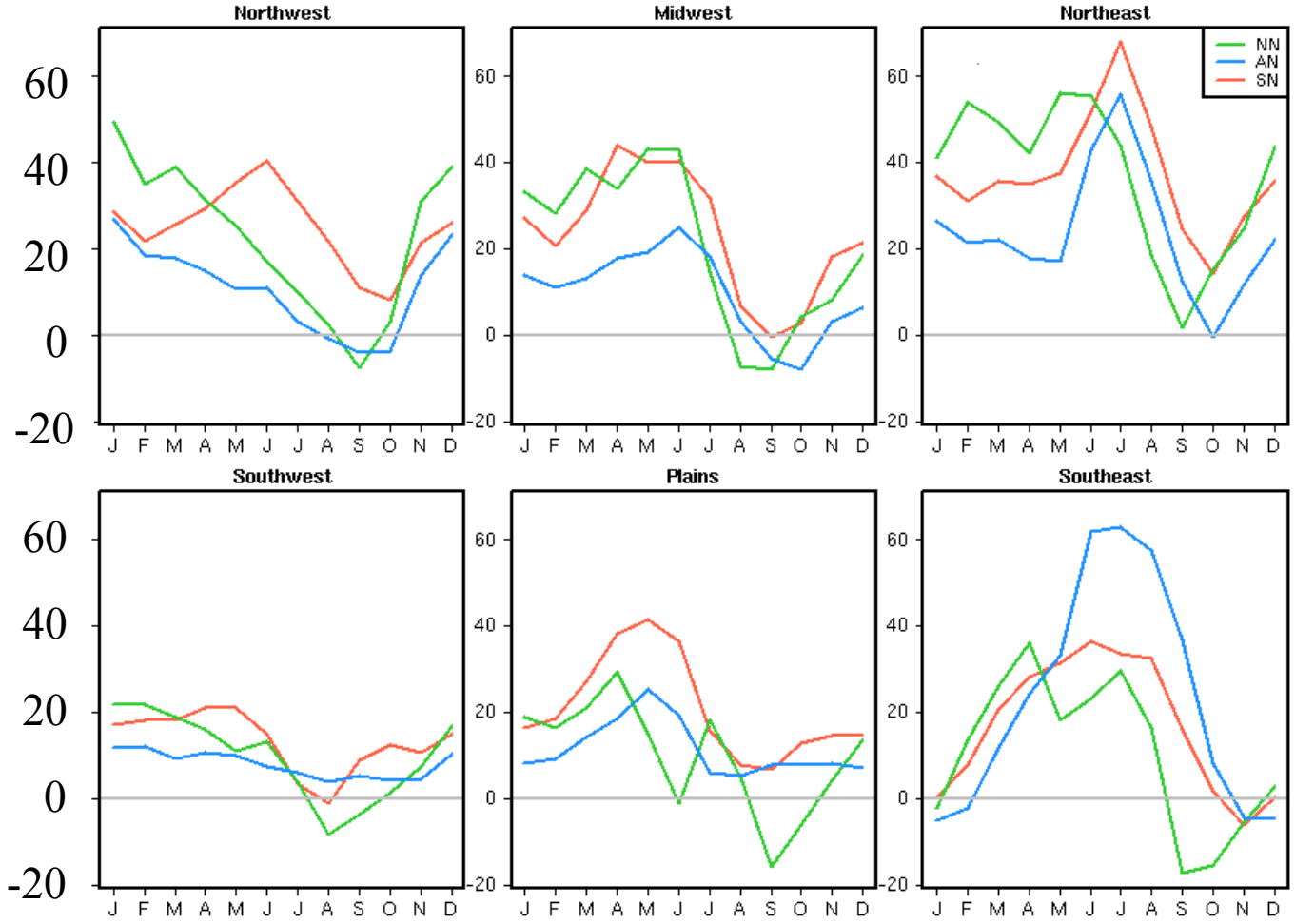


- Nudging: none (NN), analysis (AN), spectral (SN)
  - No nudging in PBL; some changes to coefficients
- Comparisons to NARR and CFSR on 36-km domain

PRECIPITATION DIFFERENCE FROM NARR (AVERAGED OVER 20-YEAR PERIOD)



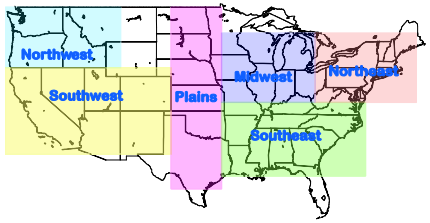
Compare to 3-h, 32-km NARR



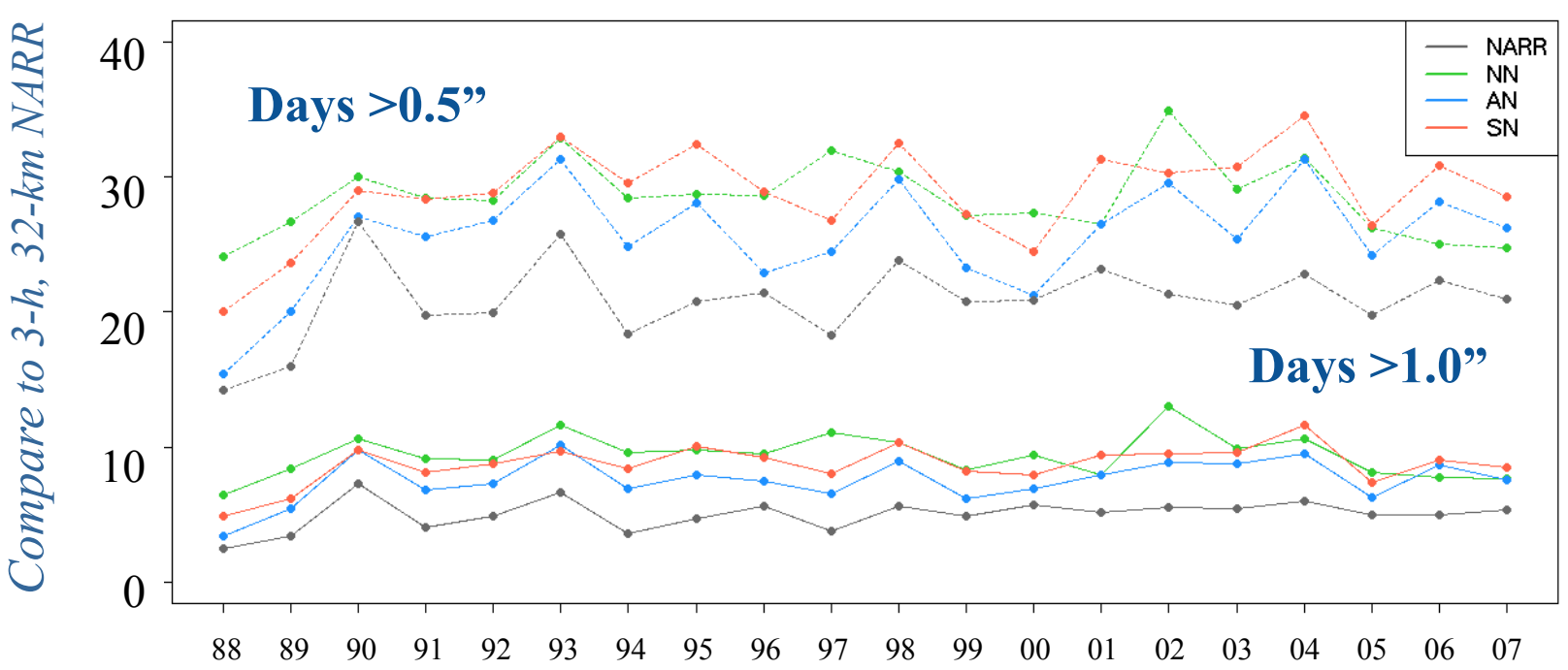
Otte et al., *J. Climate*, in press

SN is consistently wetter than AN in 5 of 6 regions.
SN wet bias is often as large as or larger than NN.

Effects of Nudging on Precipitation Extremes



Annual Area-Average Days Exceeding Threshold Precipitation



Otte et al., *J. Climate*, in press

AN closer to NARR than SN for extremes of precipitation.

WE PREFER TO USE SPECTRAL NUDGING FOR REGIONAL CLIMATE MODELING

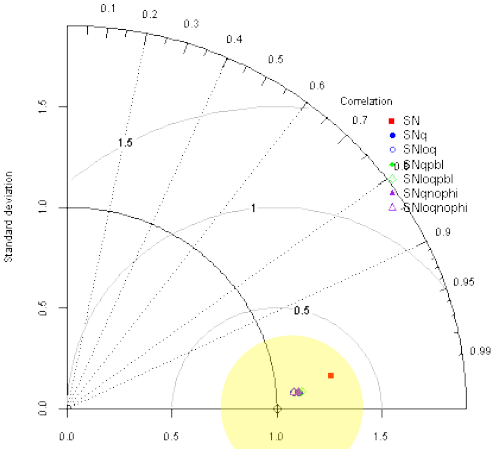
- SN is spatial-scale-selective whereas AN is not.
  - SN preserves spatial variability in the desirable range.
  - AN dampens variability, but produces comparable 2-m temperature to and better precipitation than SN.

- Motivating Science Question: Can SN precipitation be improved without compromising 2-m temperature?

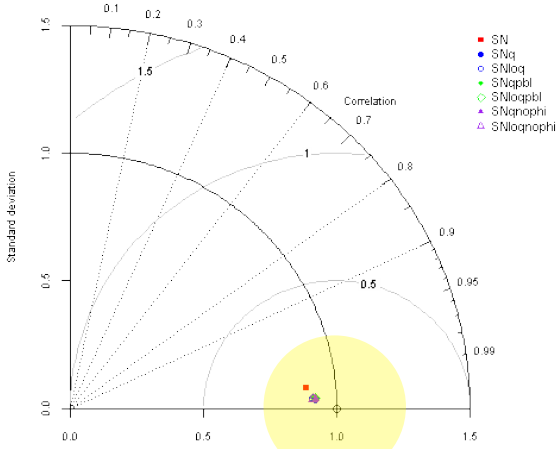
- Hypothesis: SN will predict precipitation better if also nudging toward moisture.

TAYLOR DIAGRAMS – PRECIPITABLE WATER ("SN SENSITIVITIES WITH NUDGING Q" VS. NARR, 3-YR)

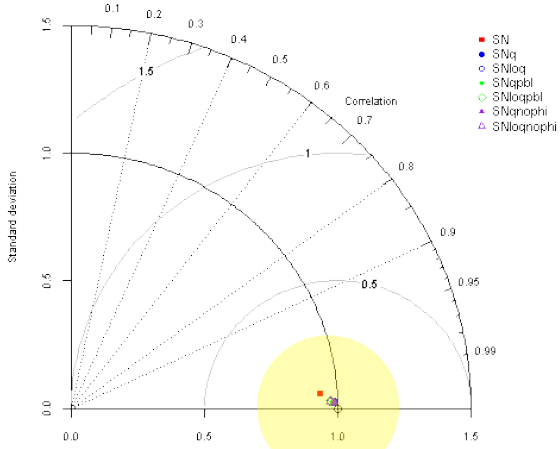
Northwest



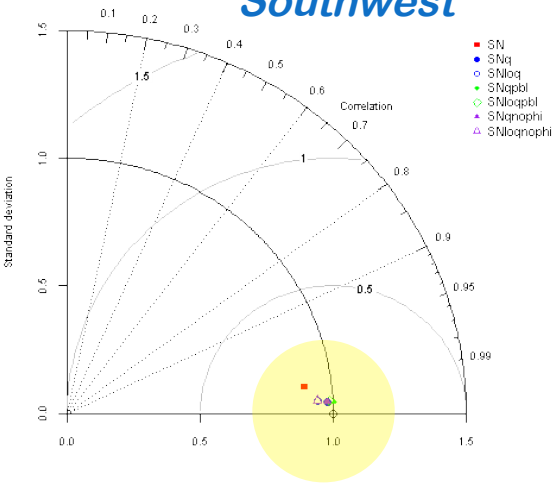
Midwest



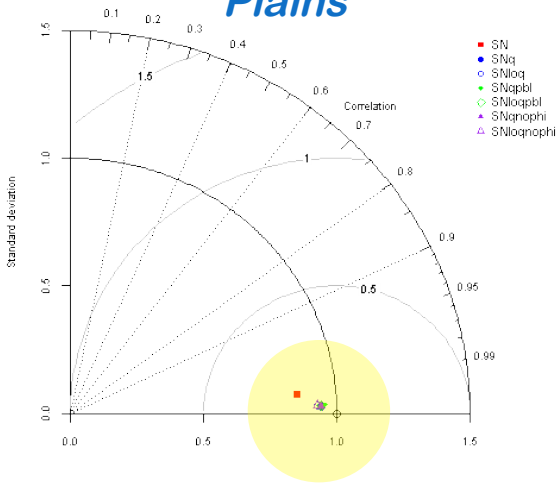
Northeast



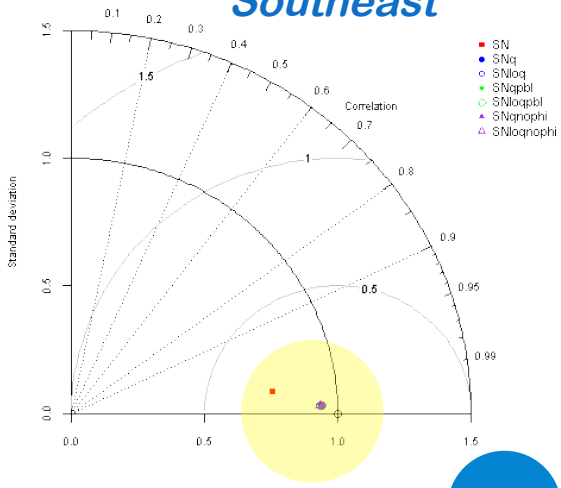
Southwest



Plains



Southeast



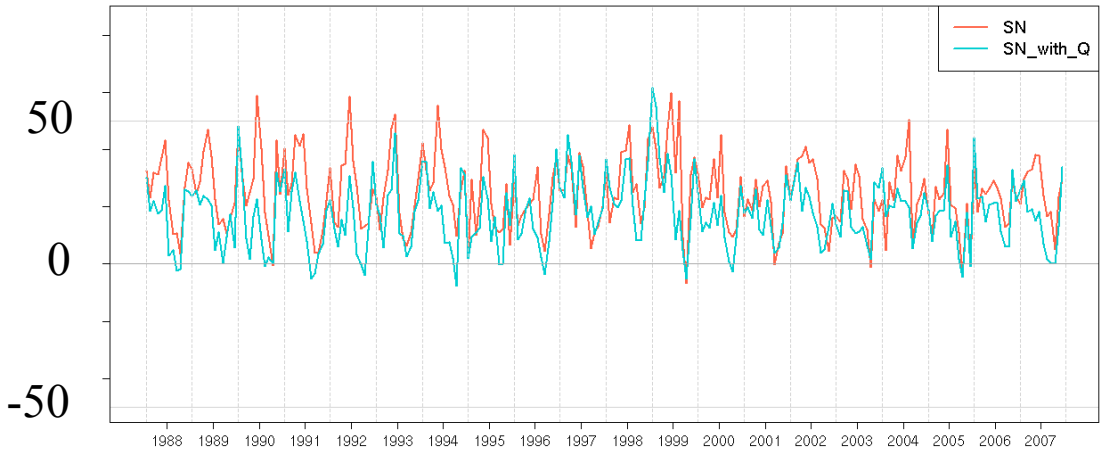
Adding SN toward moisture (all except ▪) improves PWAT comparison to NARR, *even in PBL*, and not always in same direction (SW vs. NW).

WE ITERATED ON STRATEGIES TO USE SPECTRAL NUDGING OF MOISTURE.

- "Default" coefficient (~1 h timescale) is too strong
  - Did not improve precipitation
  - Resulted in too many clouds
- Conservative coefficient (~6 h timescale) works well
  - Tracks consistently with AN (same coefficient)
- Both had too many high clouds and too low OLR!
- Implemented "reverse Zfac" to limit nudging above tropopause
- Restricted nudging of [illegible] above tropopause and lowered its coefficient to match Q
  - $G_{[illegible]} = 4.5 \times 10^{-5}$ s^{-1} and $G_Q = 4.5 \times 10^{-5}$ s^{-1} (time scale ~6 h)
  - Same coefficients used on both domains

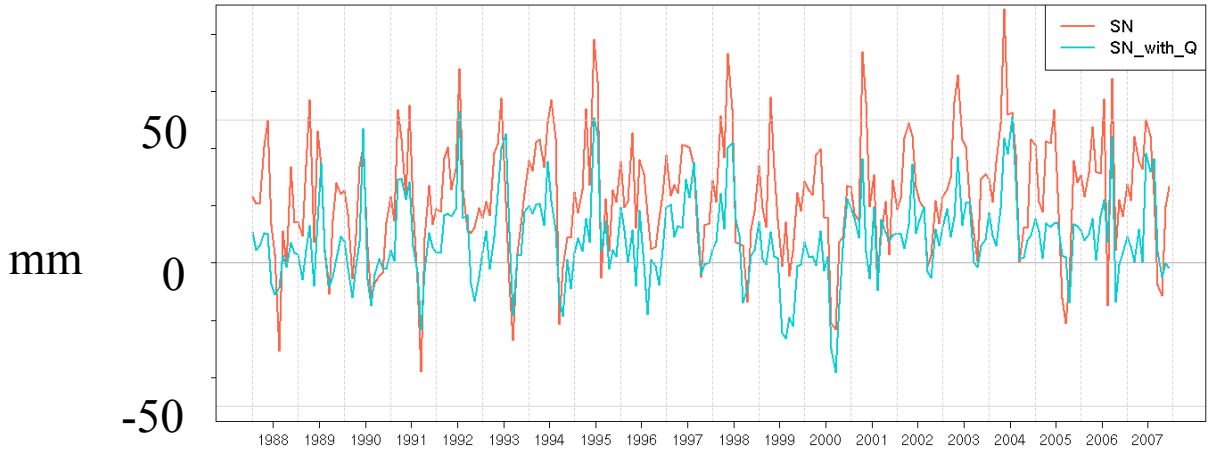
20-Year Monthly Precipitation Difference from NARR

Northwest



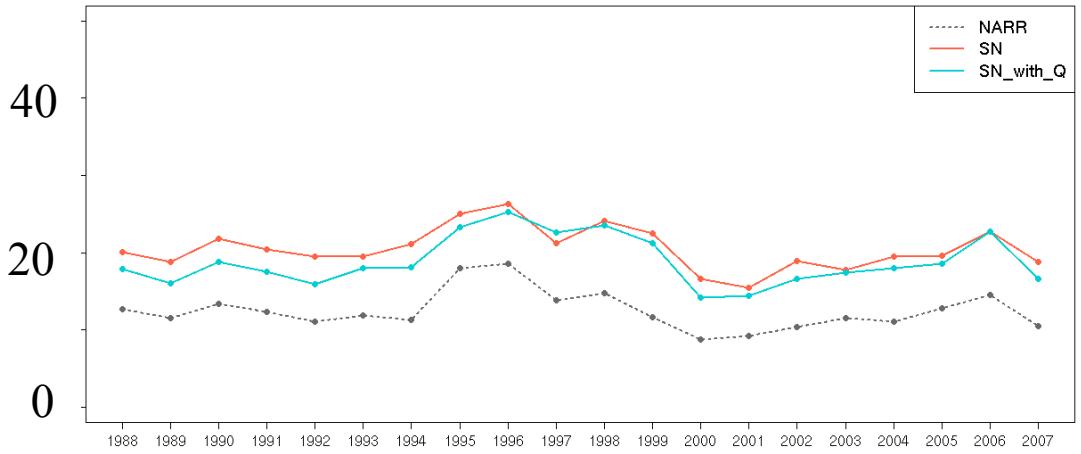
SN_with_Q reduces overprediction of monthly precipitation in SN.

Midwest



Annual Area-Average Days with Precipitation >0.5”

Northwest

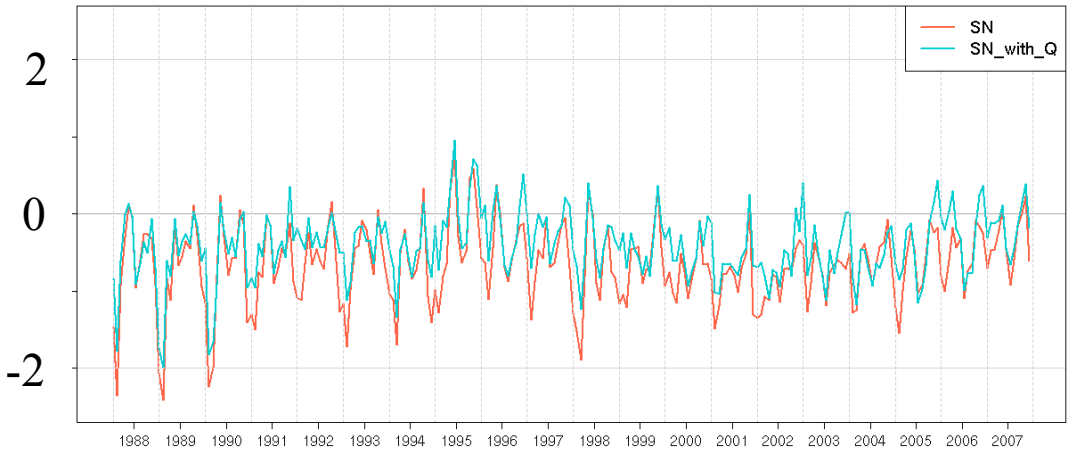


SN_with_Q improves prediction of extreme precipitation events.

Midwest

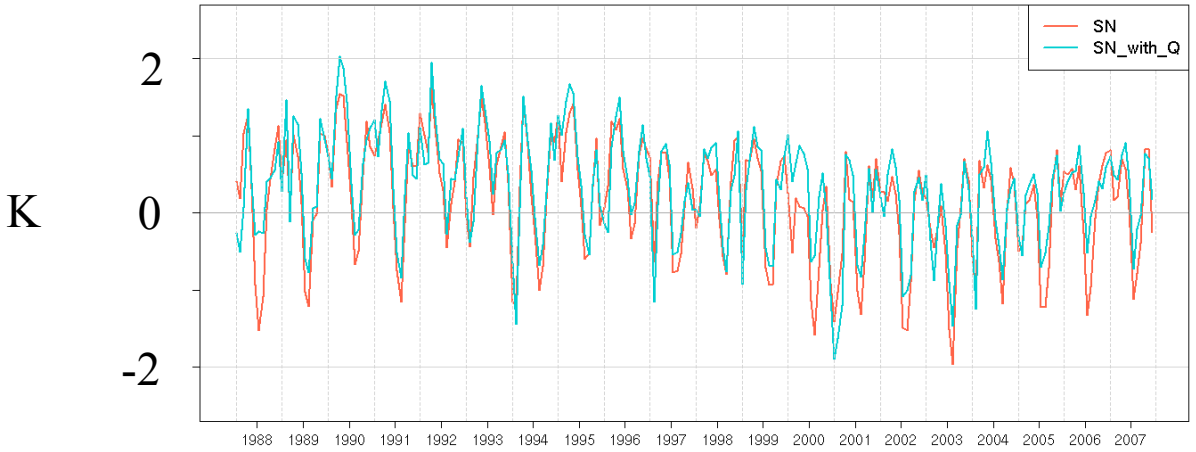
20-Year Monthly Temperature Difference from CFSR

Northwest



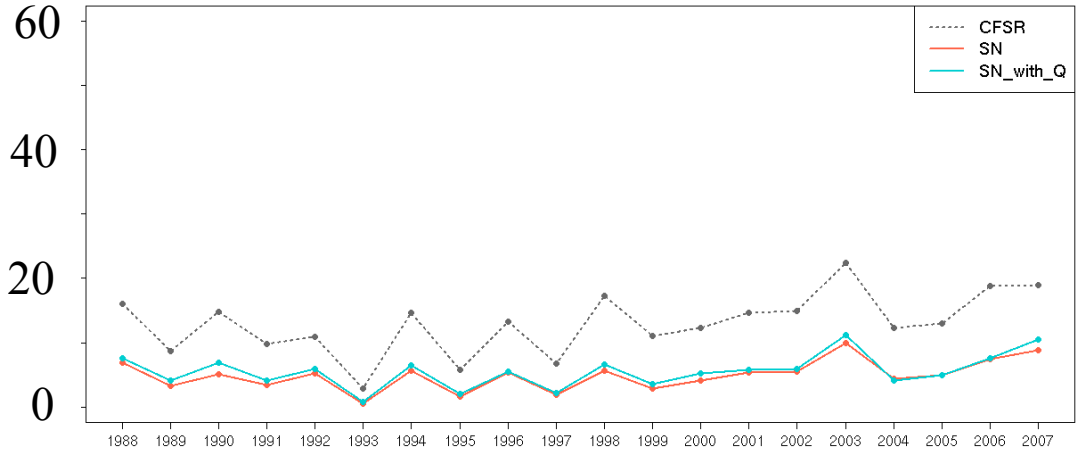
Overall, SN_with_Q improves 2-m temperatures compared with SN.

Midwest



Annual Area-Average Days with Temperature >90°F

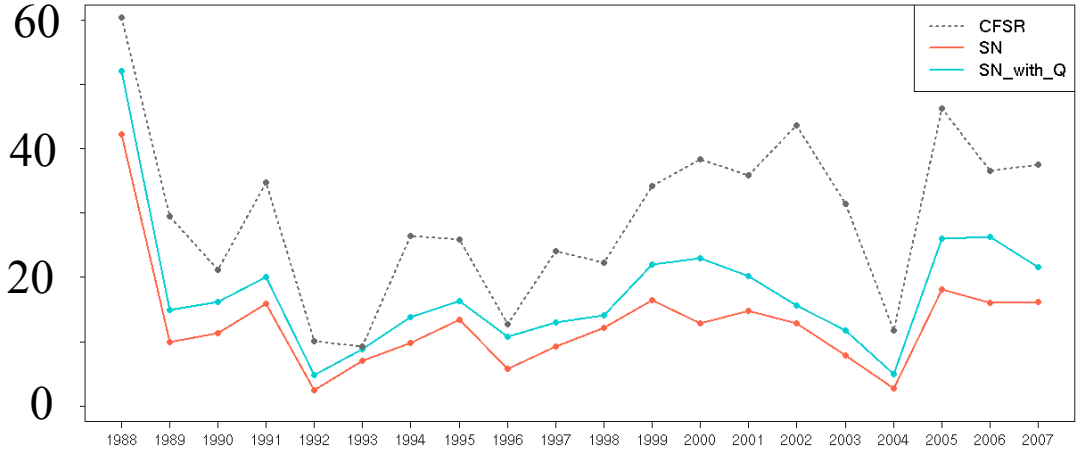
Northwest



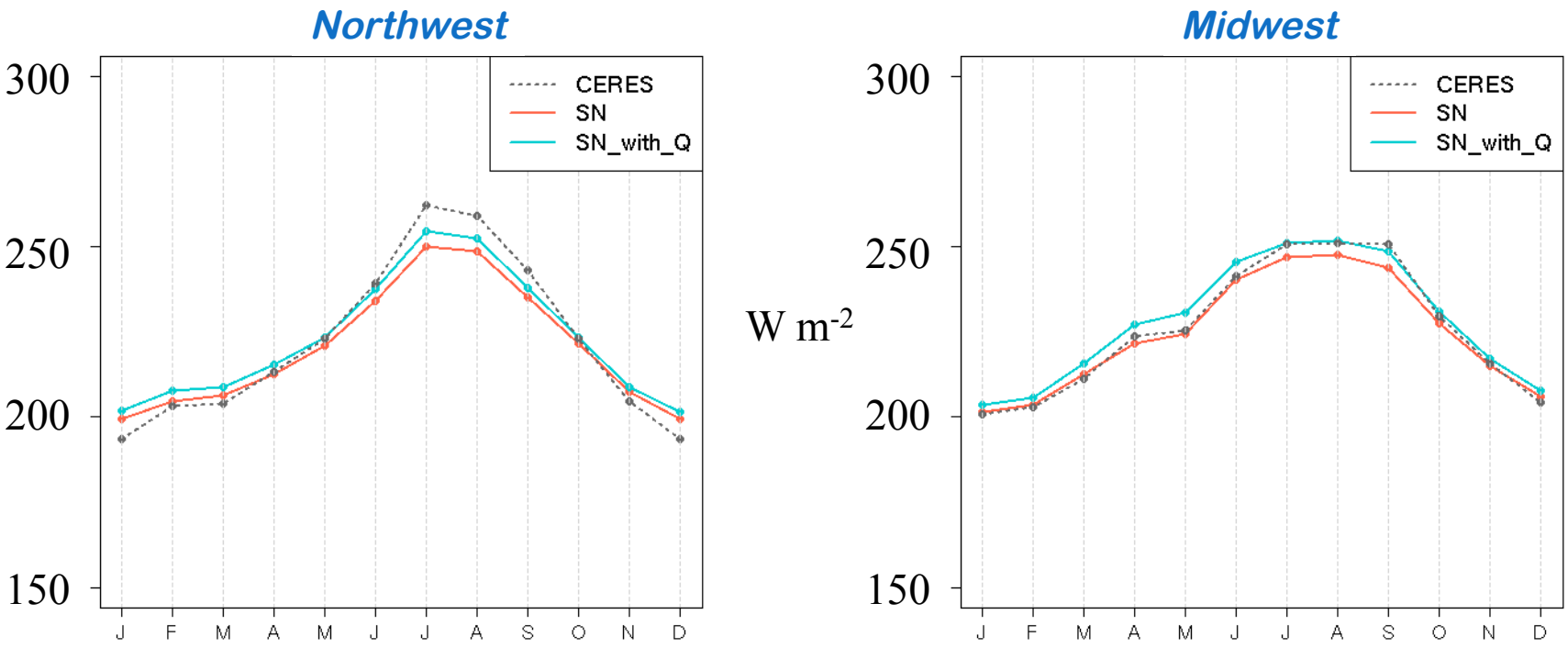
SN_with_Q creates slight to modest improvements in prediction of extreme warm temperatures.

Midwest

days



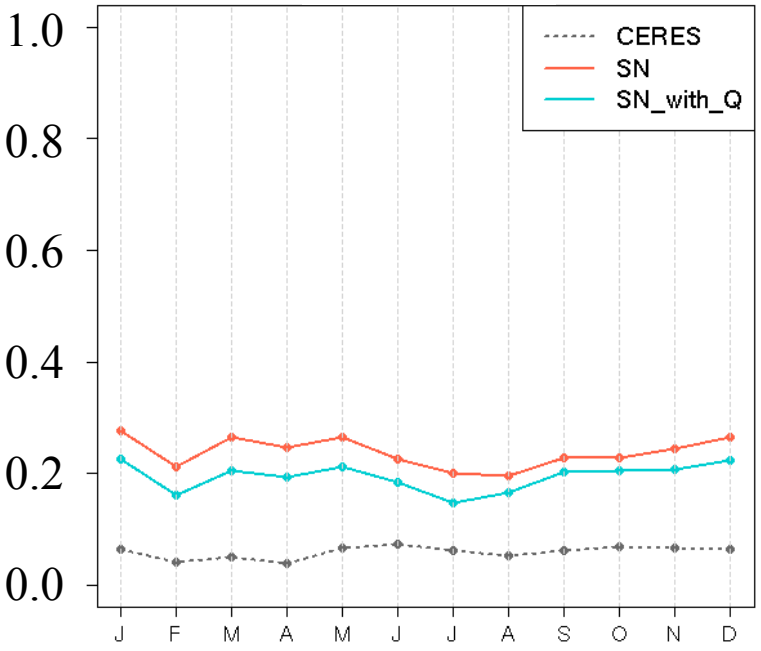
COMPARISON TO CERES: LW UPWARD RADIATION AT TOA



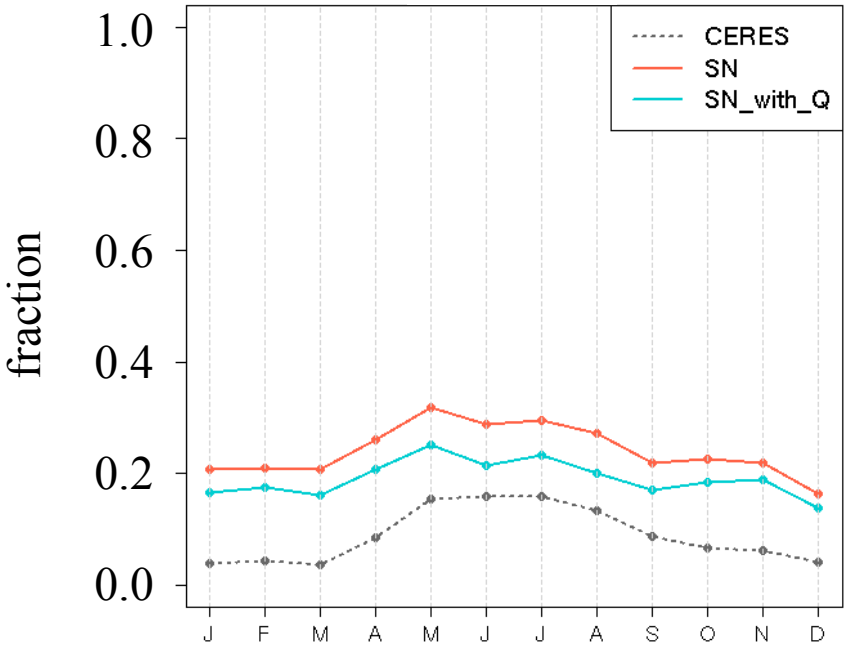
SN and SN_with_Q agree well with CERES outgoing longwave radiation.

COMPARISON TO CERES: VERY HIGH CLOUD FRACTION (ABOVE 300 HPA)

Northwest



Midwest



SN_with_Q reduces overprediction of very high clouds by ~4%.

SPECTRALLY NUDGING MOISTURE CAN IMPROVE PRECIPITATION IN WRF!

- Did not compromise 2-m temperature verification!
  - Improved extreme heat predictions!
- Must be **careful and conservative**!
  - Default coefficient ($G_Q = 3.0 \times 10^{-4}$ s^{-1}) is too high!
  - Fairly low coefficient ($G_Q = 1.0 \times 10^{-5}$ s^{-1}) is too low!
- Can be limited to below tropopause
  - High clouds and radiation more consistent with CERES
  - Little effect on 2-m temperature or precipitation
- Also restricting [illegible] nudging above tropopause and reducing $G_{[illegible]}$ improves simulation
  - Applying consistent nudging to thermodynamics

Contact me if you want to see more details!