EPA
United States
Environmental Protection
Agency

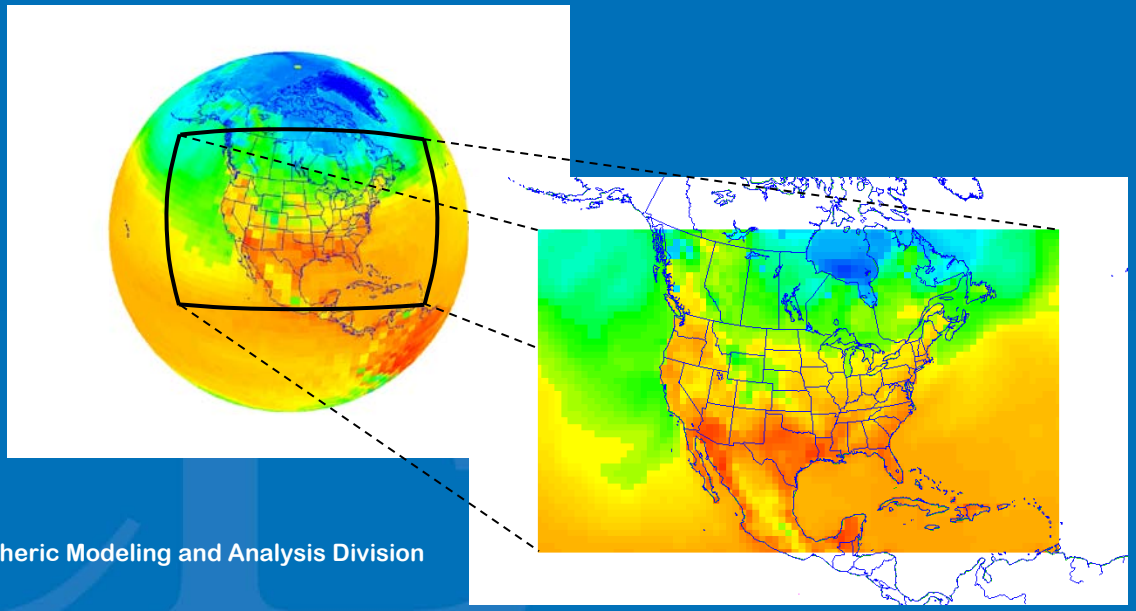
Does nudging squelch the extremes in regional climate modeling?

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

12th WRF Users' Workshop

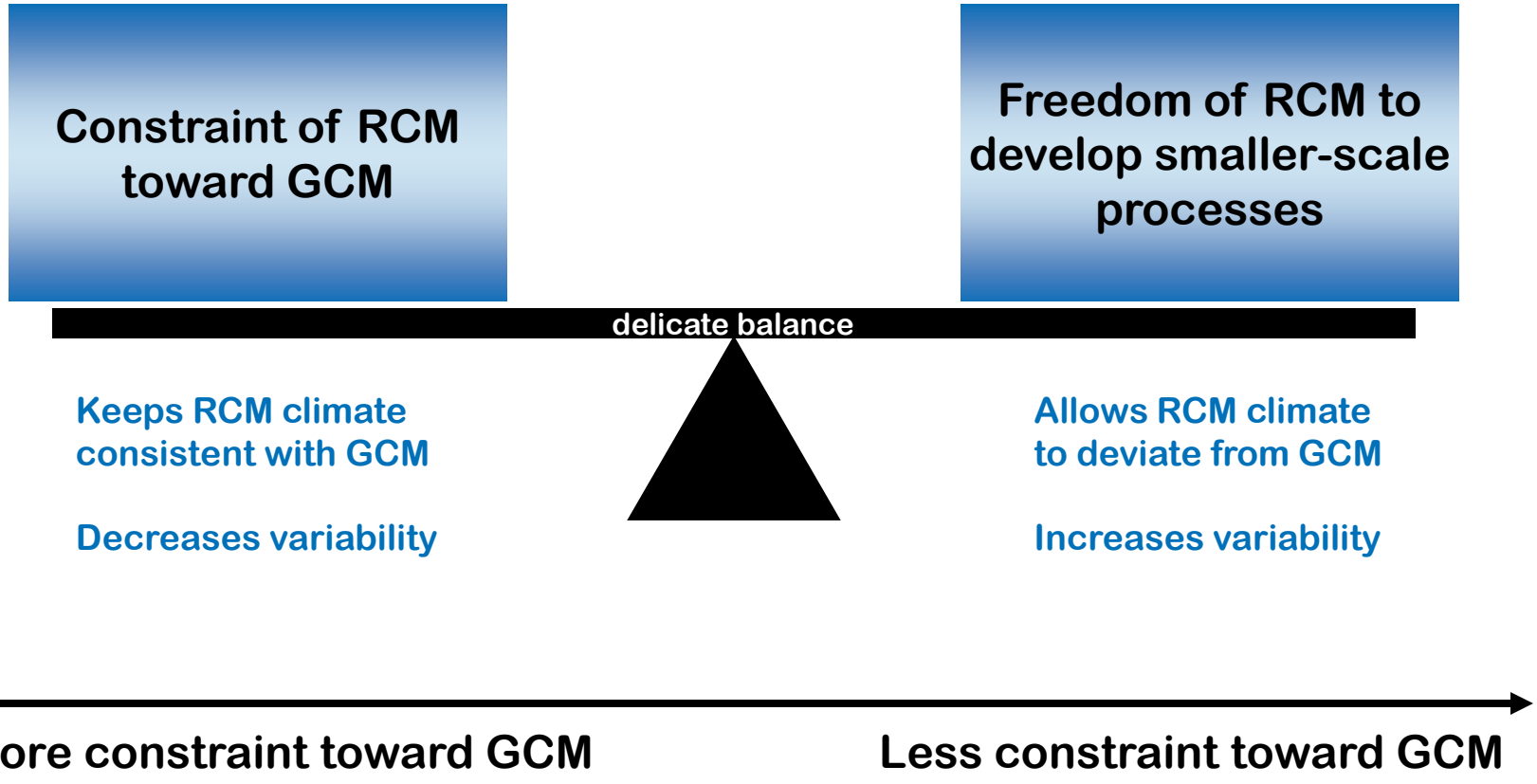
Boulder, Colorado

23 June 2011



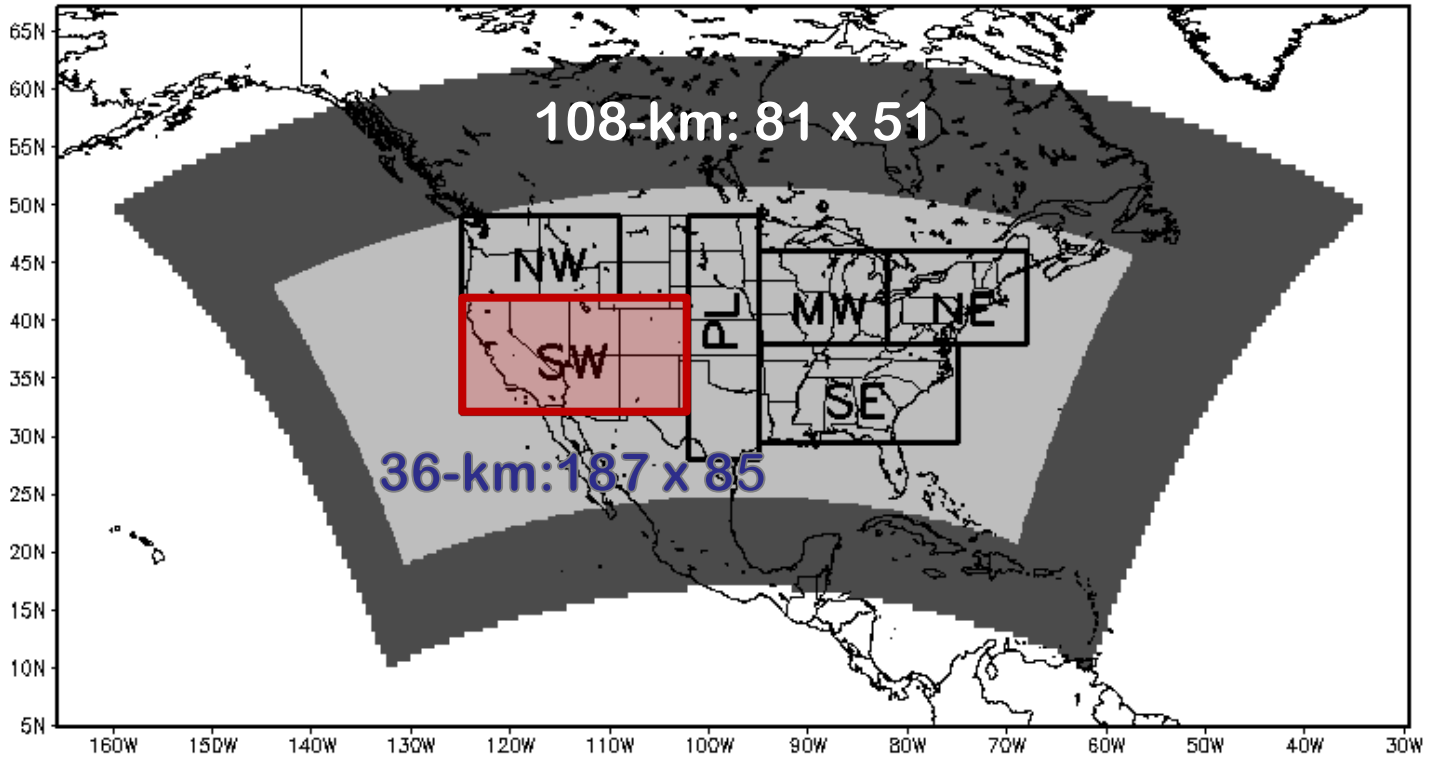
Office of Research and Development
National Exposure Research Laboratory, Atmospheric Modeling and Analysis Division

Our Research Problem…Simplified



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

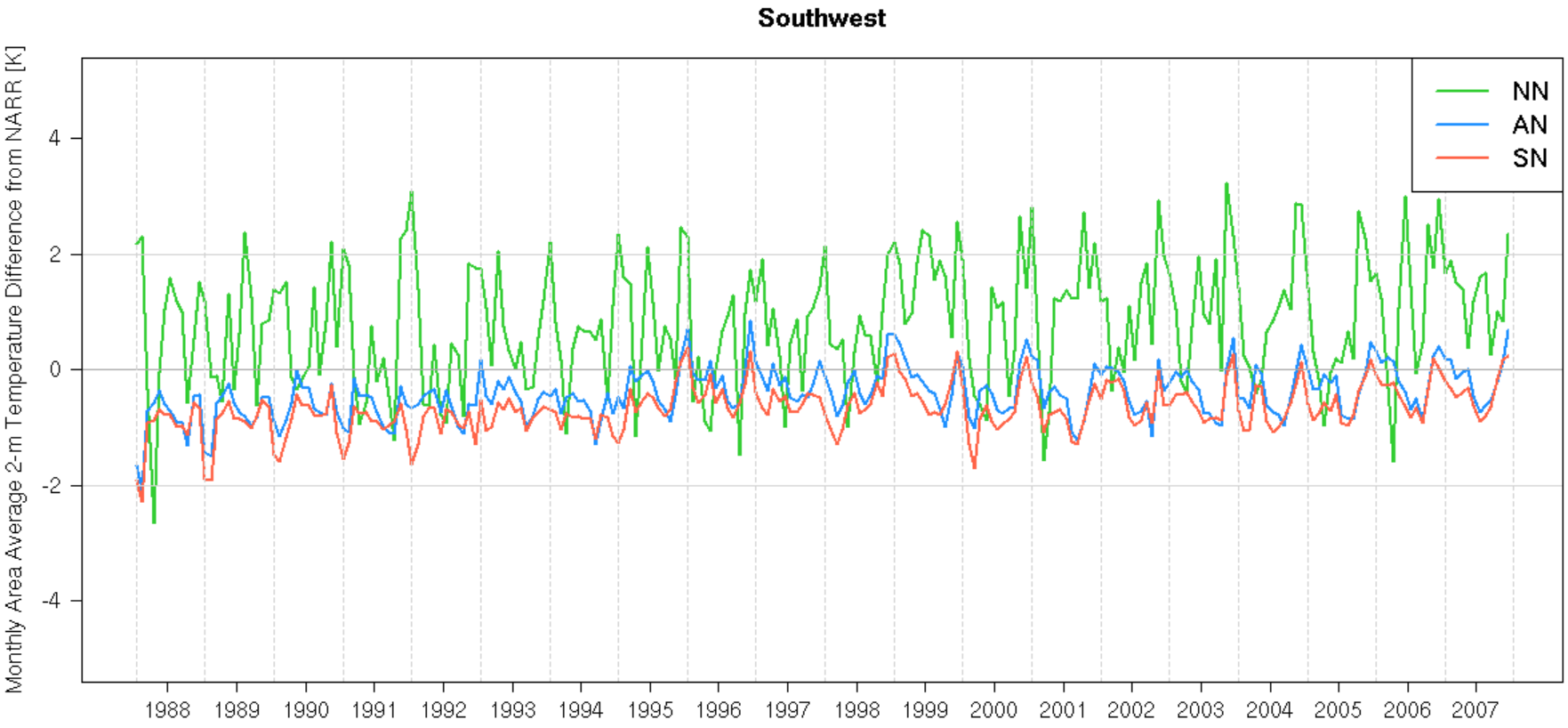


36-km cells per region:

Northwest (NW)	Midwest (MW)	Northeast (NE)
745 total	735 total	791 total
701 land	657 land	525 land

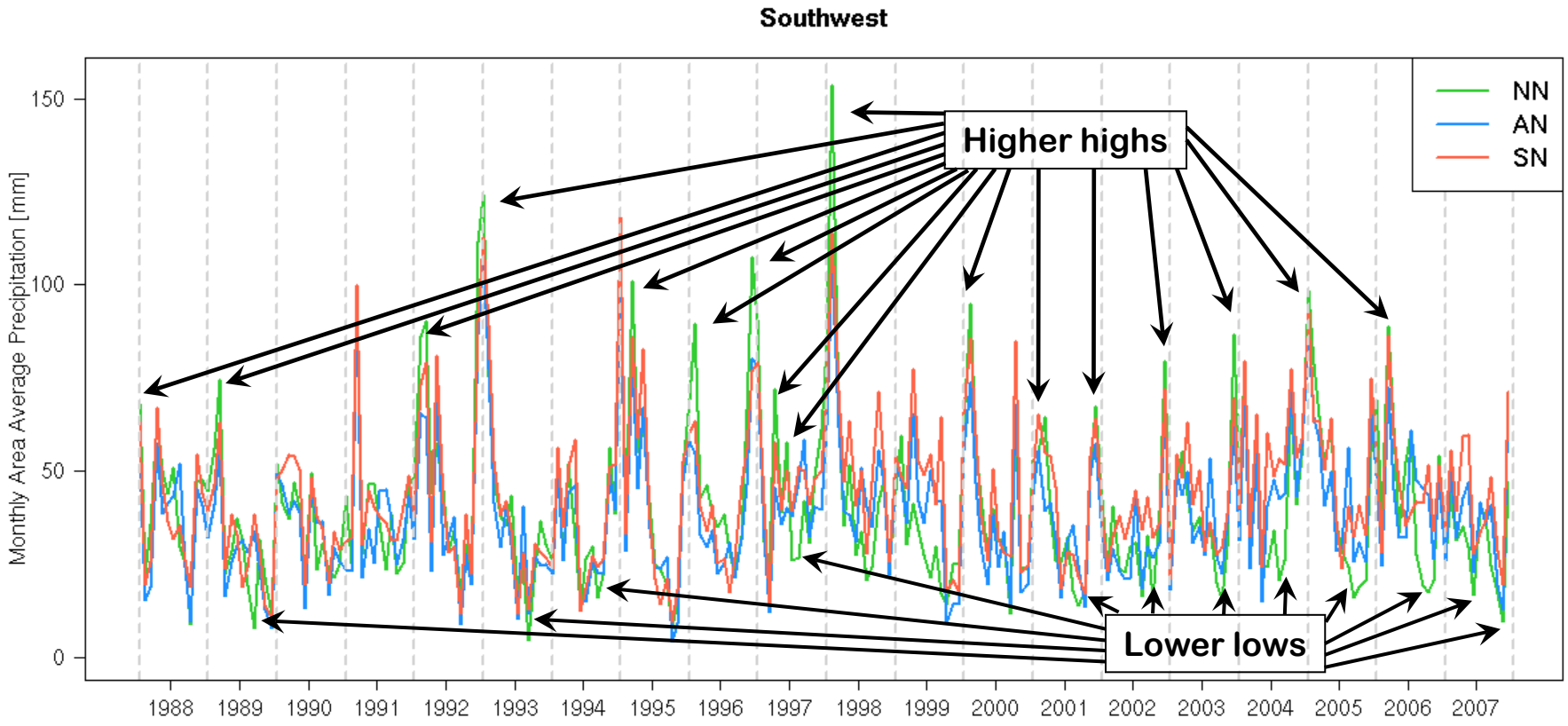
Southwest (SW)	Plains (PL)	Southeast (SE)
1736 total	1089 total	1435 total
1460 land	1068 land	1052 land

Monthly Area-Average Temperature Difference from NARR



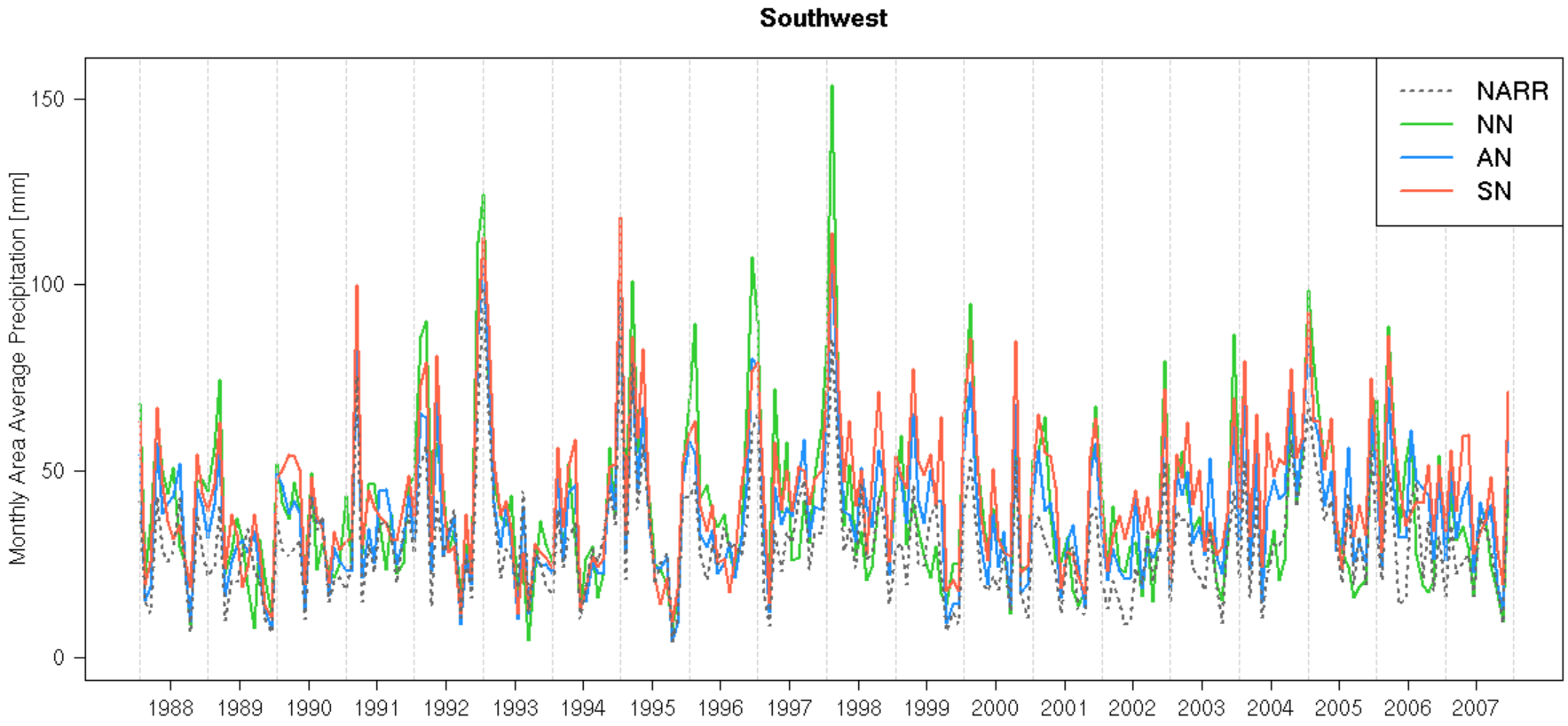
Both types of nudging consistently reduce error.

Monthly Area-Averaged Precipitation Total



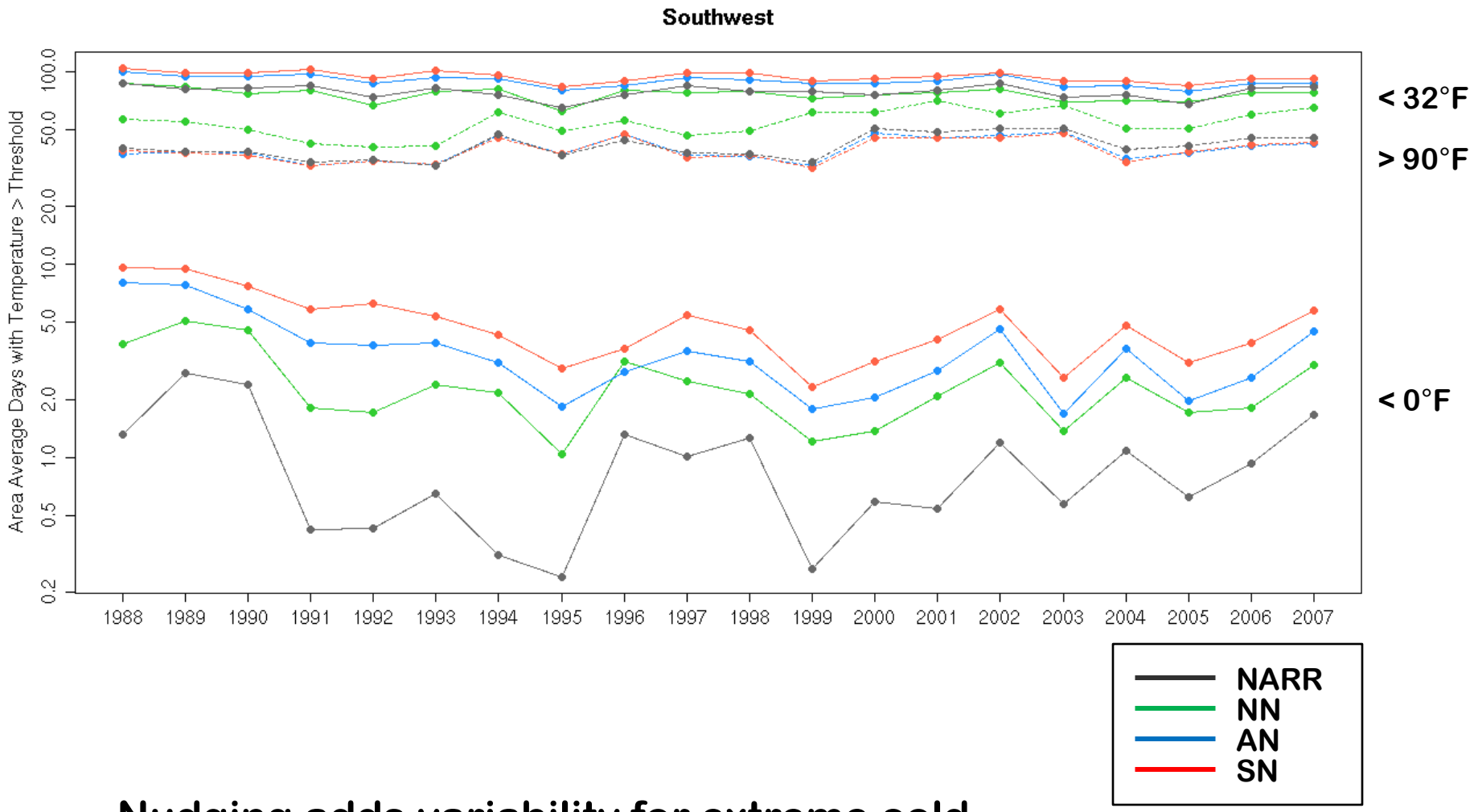
Greater variability without nudging: Is it real?

Monthly Area-Averaged Precipitation Total



Compared to NARR, WRF is too wet.
Nudging reduces erroneous peaks.

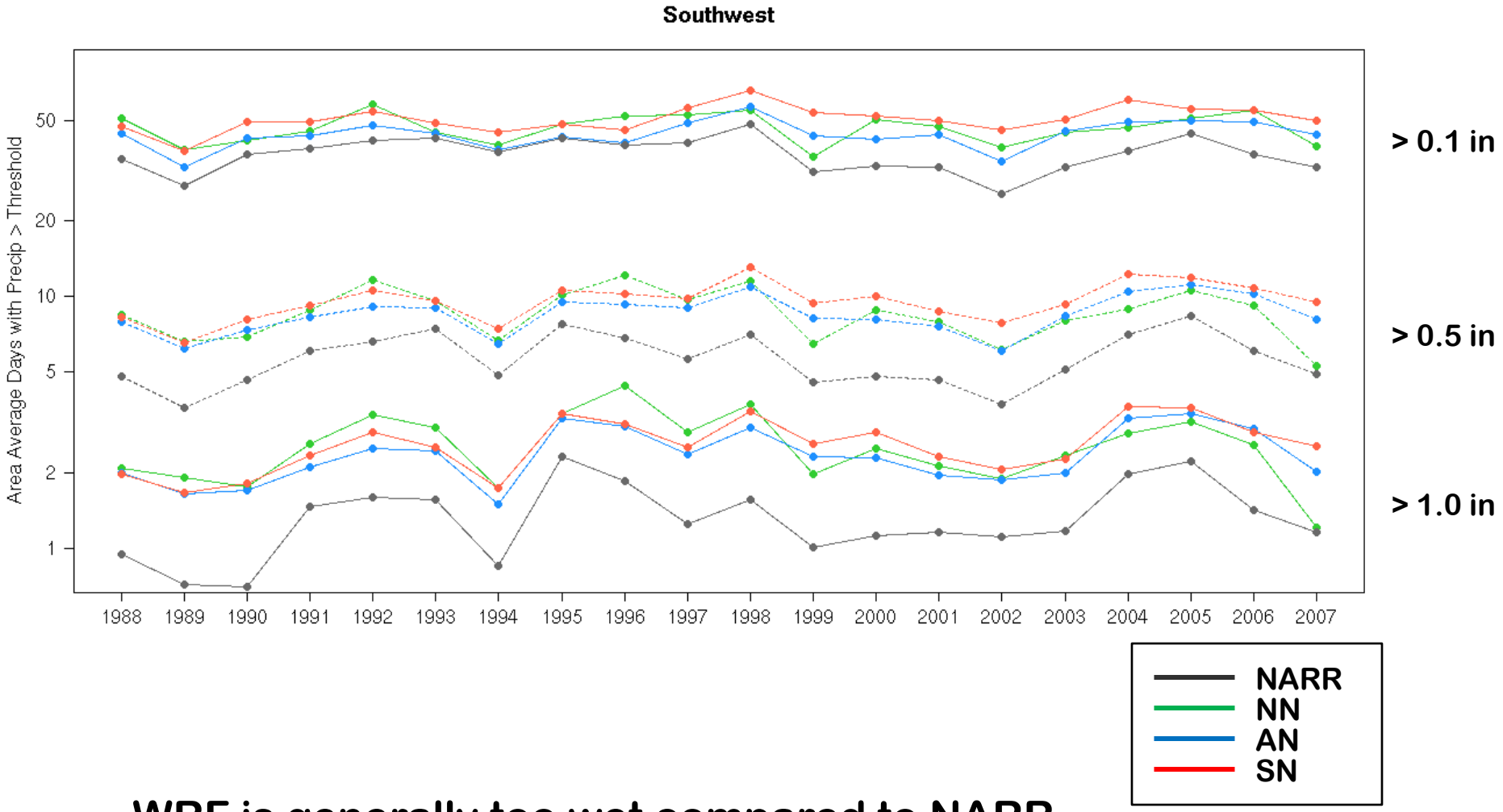
Annual Days with Temperature Relative to Threshold



Nudging adds variability for extreme cold.

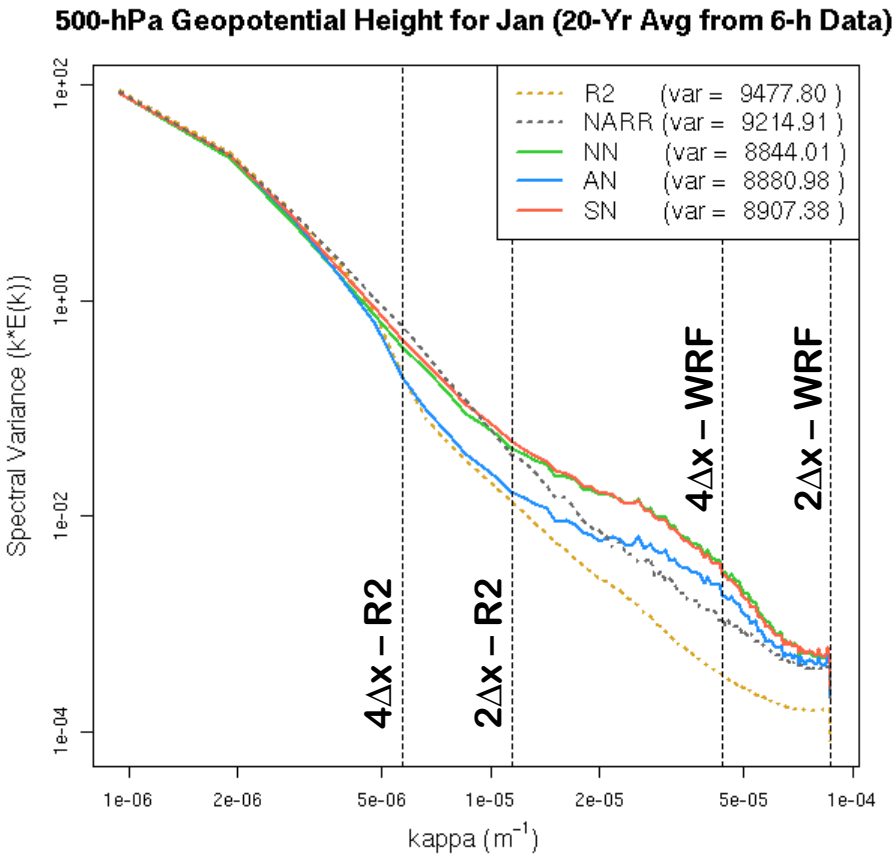
Nudging lowers extreme high temperatures…will this verify?

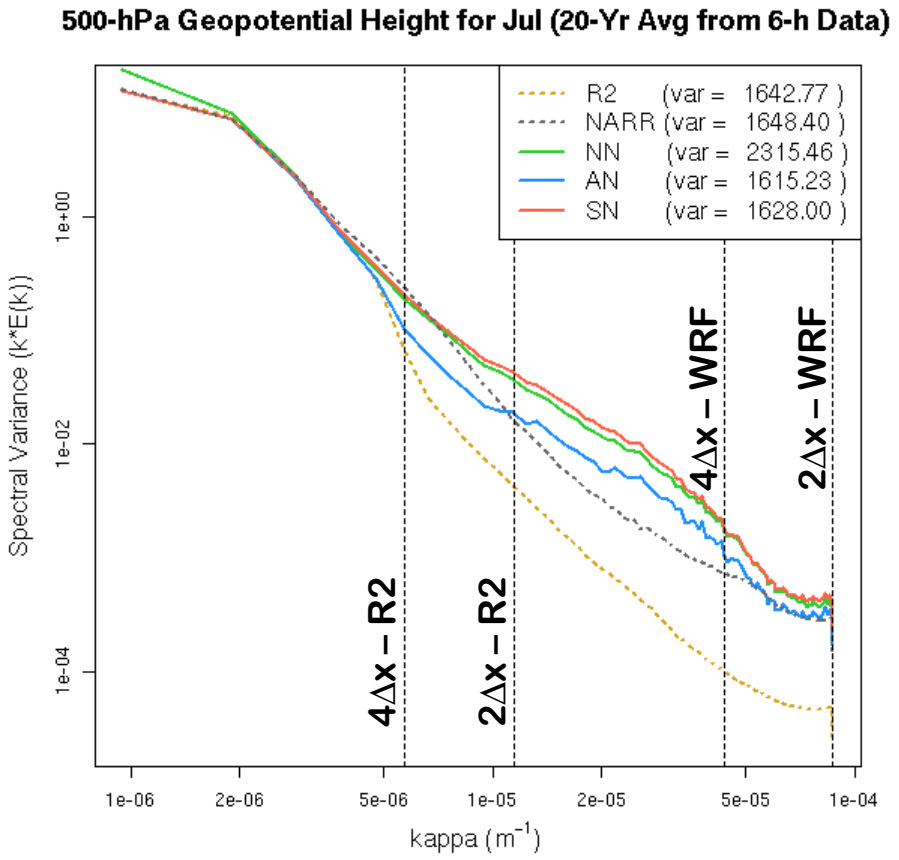
Annual Days with Precipitation Exceeding Threshold



WRF is generally too wet compared to NARR.
Nudging, especially AN, makes extremes more realistic.

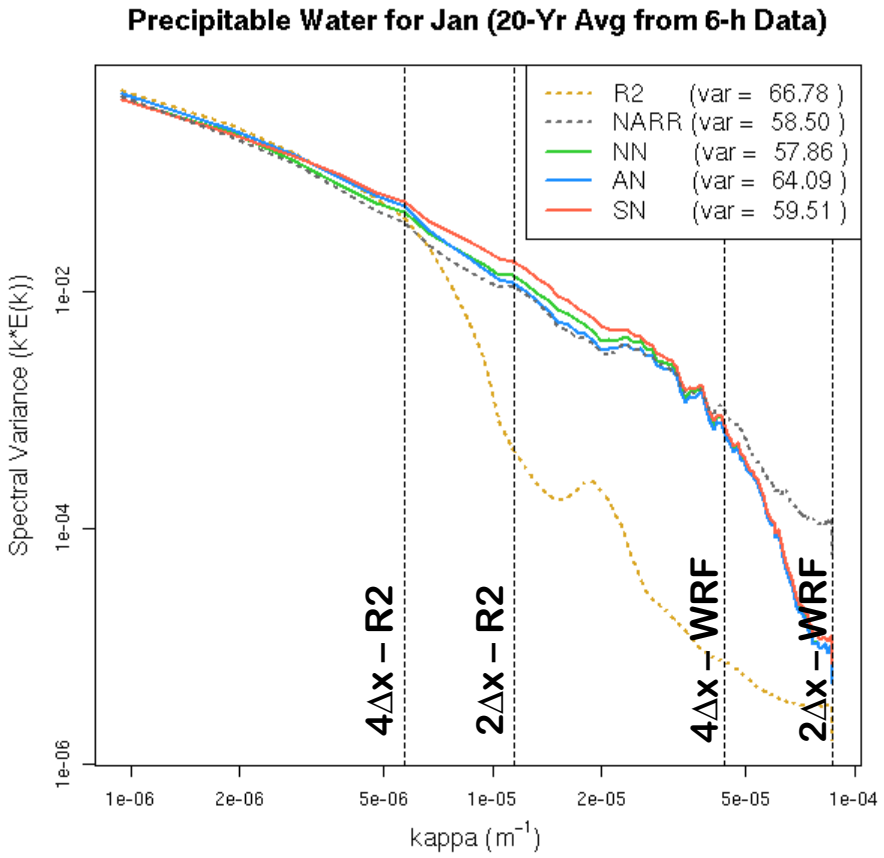
Spectral Variance: 500-hPa Geopotential Height

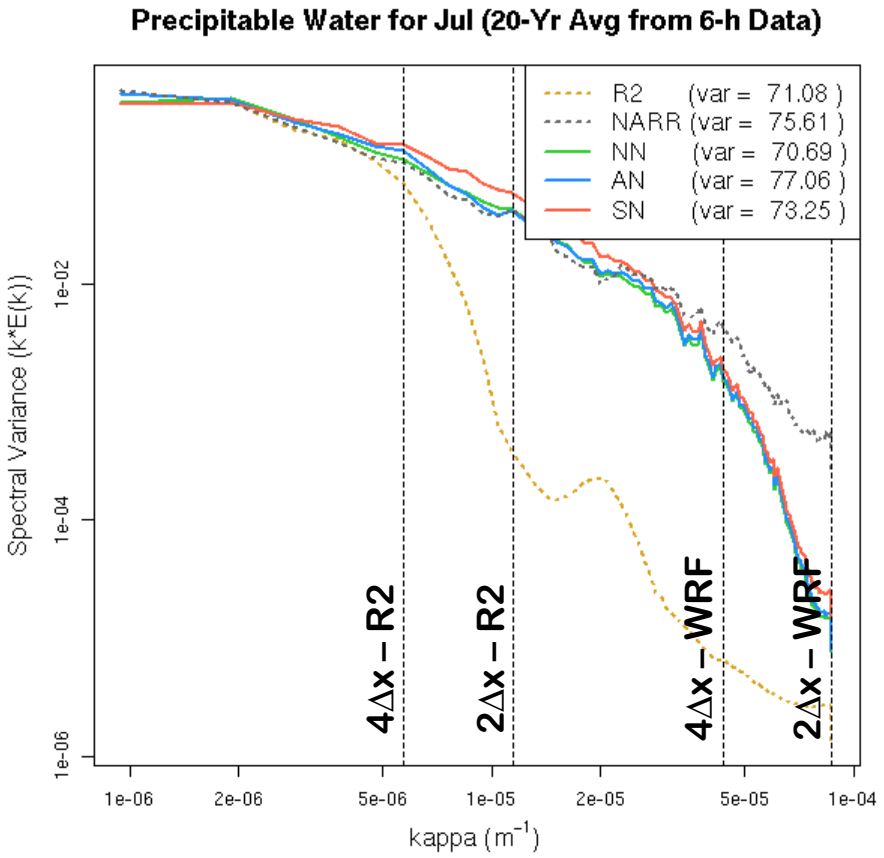




Unrealistic longwave in NN. More variability with SN overall. WRF variability suppressed with AN – coefficients too strong.

Spectral Variance: Precipitable Water





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?