An Intercomparison of Temperature Trends in the U.S. Historical Climatology Network and Recent Atmospheric Renalyses

Russell Vose
Scott Applequist
Matthew Menne
Claude Williams
Peter Thorne

NOAA's National Climatic Data Center

Climate Monitoring

- **NOAA/NCDC *State of the Climate* Reports**
  - Monthly on-line publications
  - Generate numerous media inquiries

- **U.S. Historical Climatology Network (HCN)**
  - National-scale temperature time series
  - 1895-present, 1218 stations, bias-adjusted records

- **A role for reanalyses? (Dee et al., 2011)**
  - Near-surface air temperature not ingested in atmospheric analyses
 - Serve as a counterpart to the purely instrumental record

Purpose of Research

- **Compare HCN and reanalysis trends**
  - Use six reanalyses to bracket range of plausible trends
  - Note relative position of HCN in the reanalysis context

- **Two-part comparison**
  - Trends in area-averaged time series (mean, max, min)
  - Spatial patterns in trends (mean only)

- **Compare over 1979-2008**
  - Era common to HCN and all of the reanalyses
  - But most reanalyses are available in near-real time

HCN Is a Subset of COOP

HCN ▼
COOP ●
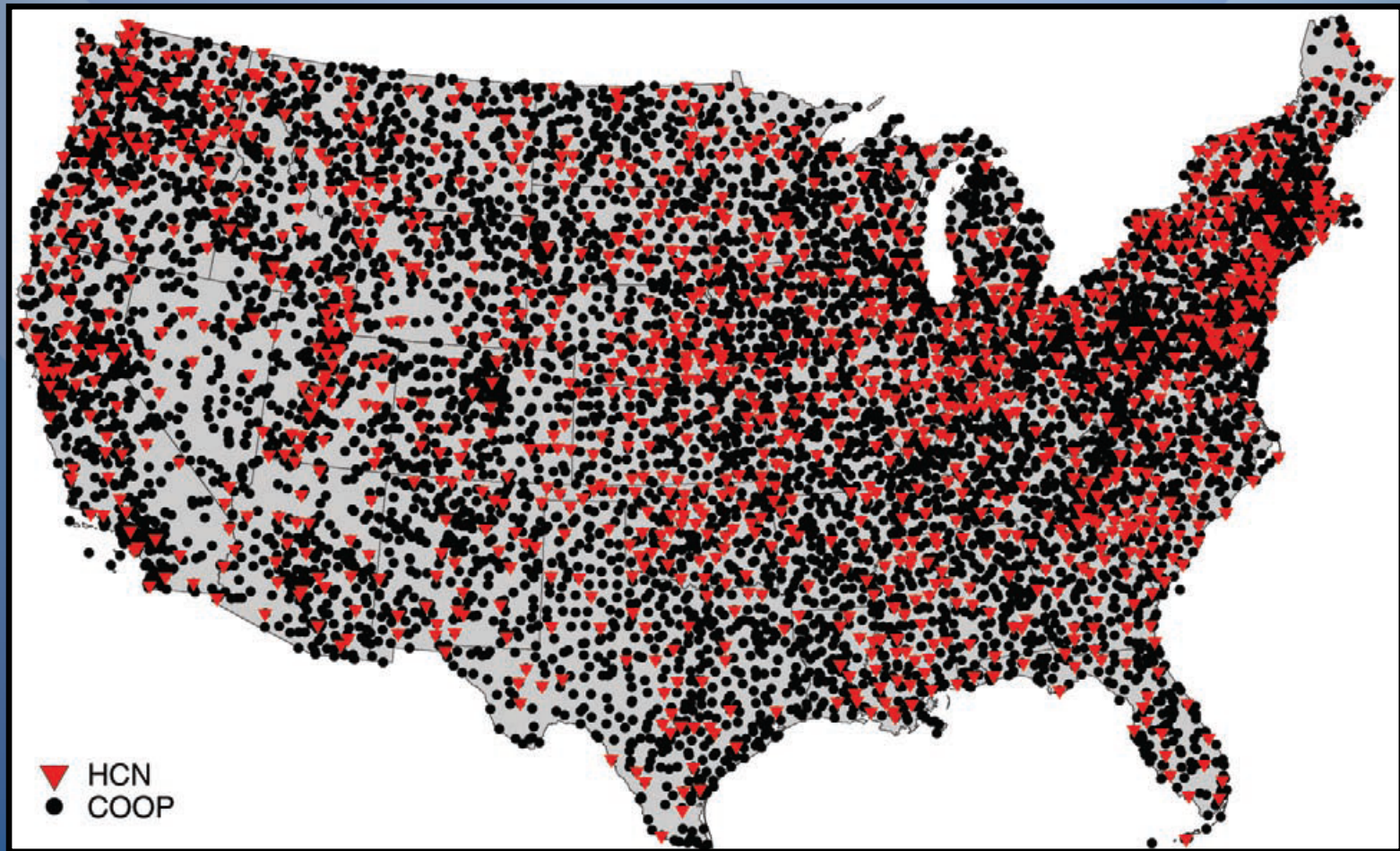
HCN Has Bias Adjustments

- **Account for historical changes in:**
  - Observation time, instrumentation, location
  - Documented in Karl et al. (1986), Vose et al. (2003), Vose and Menne (2004), Menne et al. (2009), Williams et al. (2012)

- **Address multiple changes from 1979-2008:**
  - Two net cold biases in maximum temperature
  - Offsetting cold/warm biases in minimum temperature

- **Also minimize bias from suboptimal siting:**
  - Poor- and good-exposure sites have comparable U.S. series
  - Adjusted series agrees well with Climate Reference Network
  - Explored further in Menne et al. (2010), Fall et al. (2011) – some debate on this point

Bias Adjustments: Reno, NV
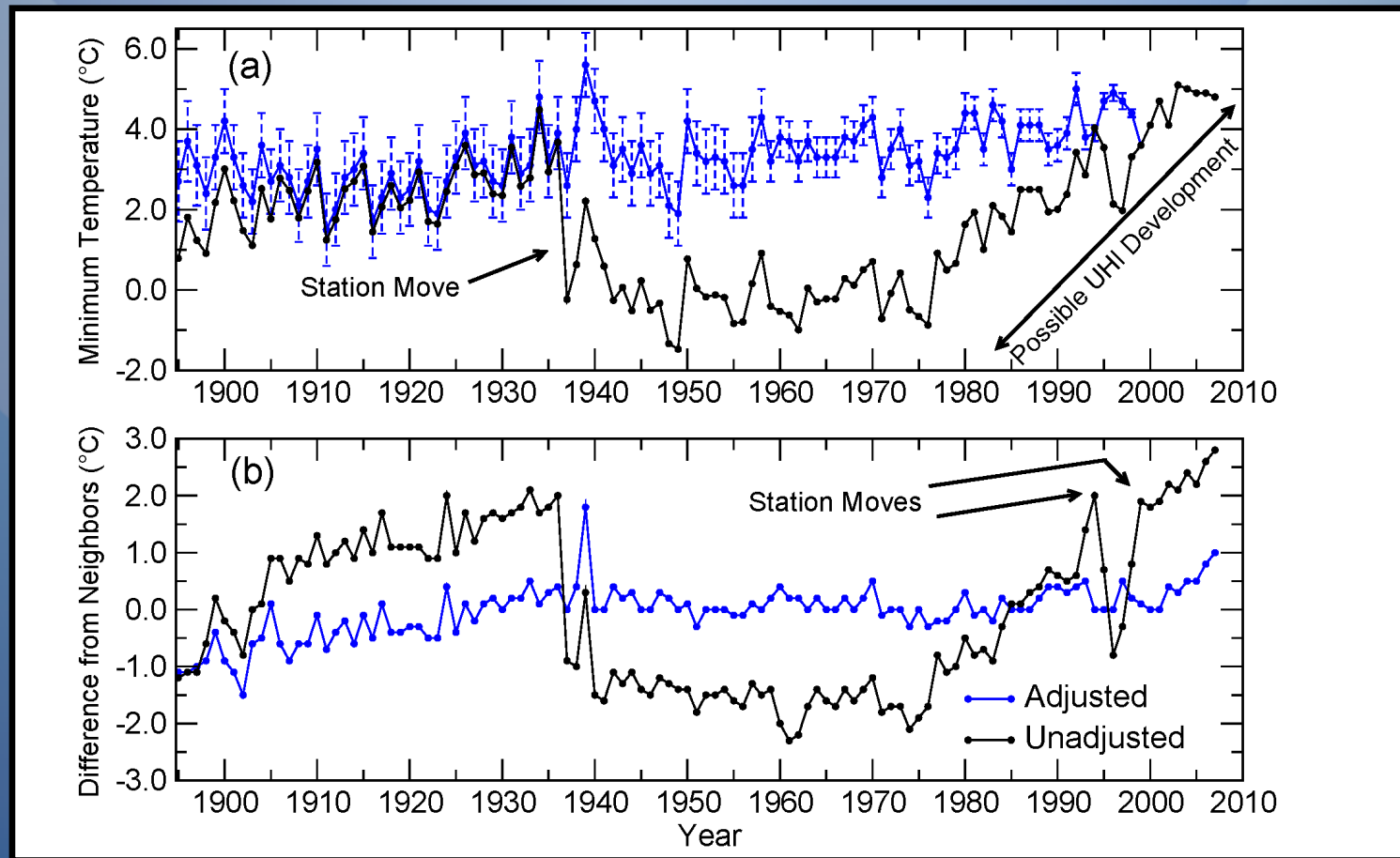
Compare HCN with 6 Reanalyses

- **Near-surface air temperature from:**
  - 20CR (Compo et al., 2010)
  - CFSR (Saha et al., 2010)
  - ERA-INT (Dee et al., 2011)
  - JRA-25 (Onogi et al., 2007)
  - MERRA (Rienecker et al., 2011)
  - NARR (Mesinger et al., 2006)

- **Substantial differences across the suite:**
  - Temporal resolution (2 are 1-hr, 3 are 3-hr, 1 is 6-hr)
  - Spatial resolution (half < 50 km and half > 125 km)
  - Distinct data assimilation schemes and input datasets

Why Use Multiple Reanalyses?

- **Makes no a priori assumptions**
  - Except that trends are generally credible
  - Reasonable for North America (e.g., Simmons et al., 2011)

- **Quantifies structural uncertainty**
  - From differences in data assimilation and input datasets
  - Manifest as an array of possible trend values

- **Helps avoid pitfalls**
  - Systematic biases across the reanalyses (Bosilovich et al., 2009)
 - Observing system changes (Bosilovich et al., 2011)

Computing U.S. Time Series

- **HCN**
  - Long-term (1979-2008) mean computed at each station
  - Annual values converted to anomalies by subtracting long-term mean
  - Anomalies gridded (Willmott et al., 1985), then area-averaged

- **Reanalyses**
  - Long-term mean computed at each U.S. grid box using all hours
  - Annual values converted to anomalies by subtracting long-term mean
  - Anomalies area-averaged
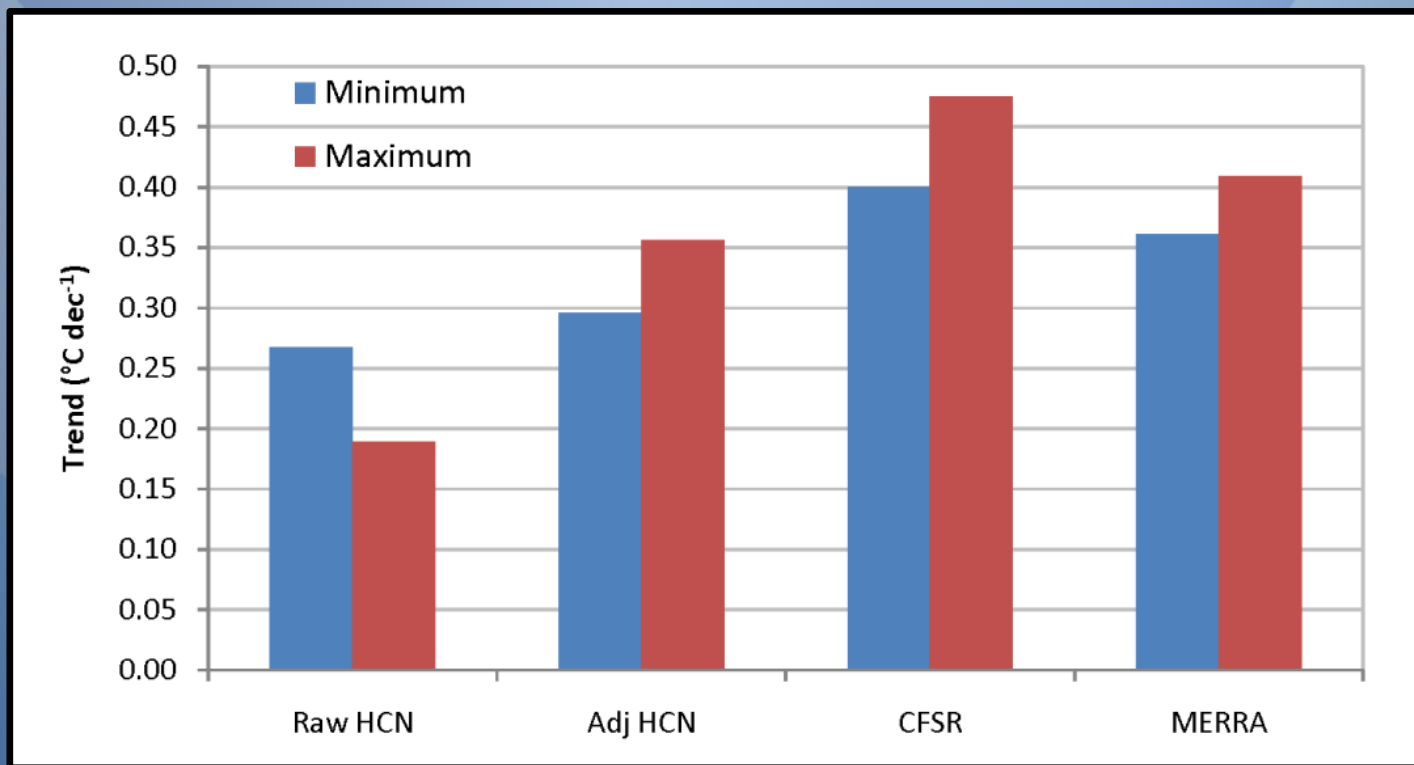
Mean Temperature
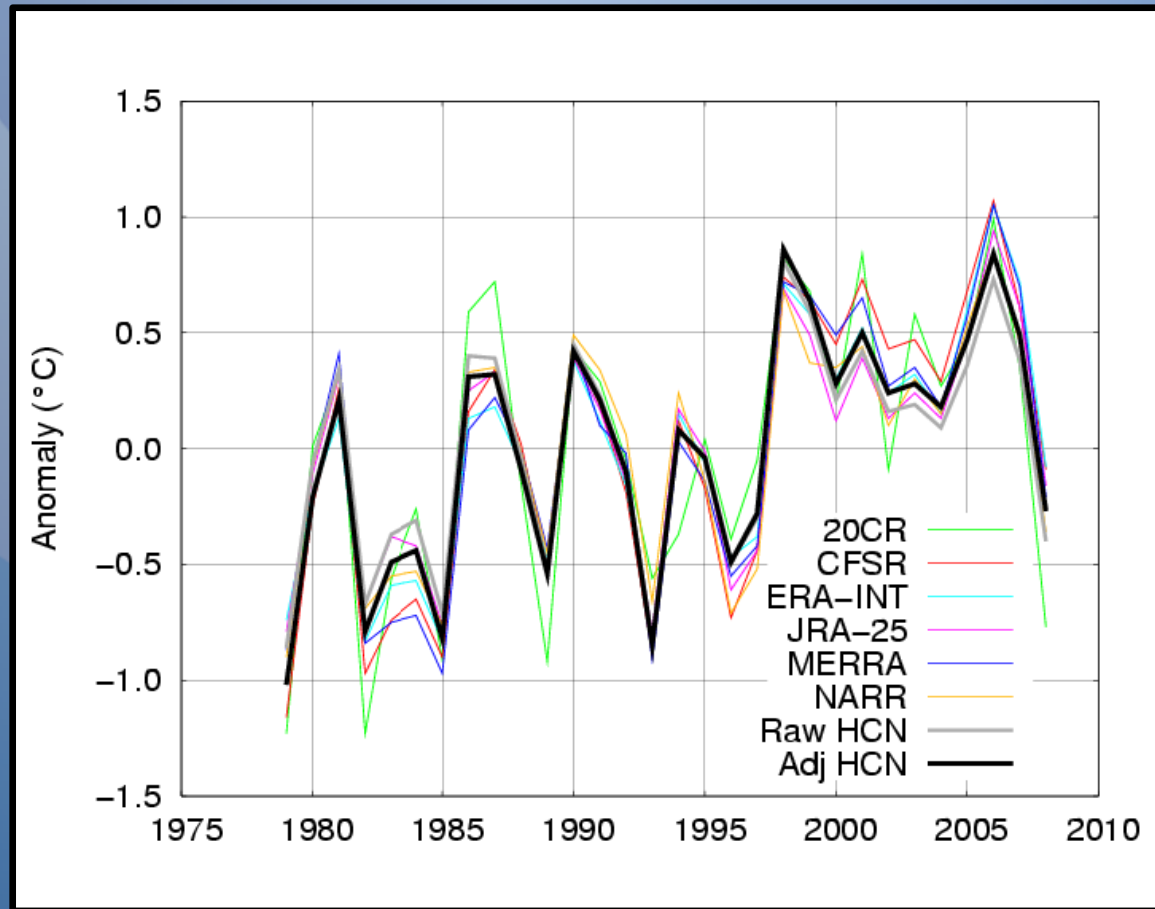
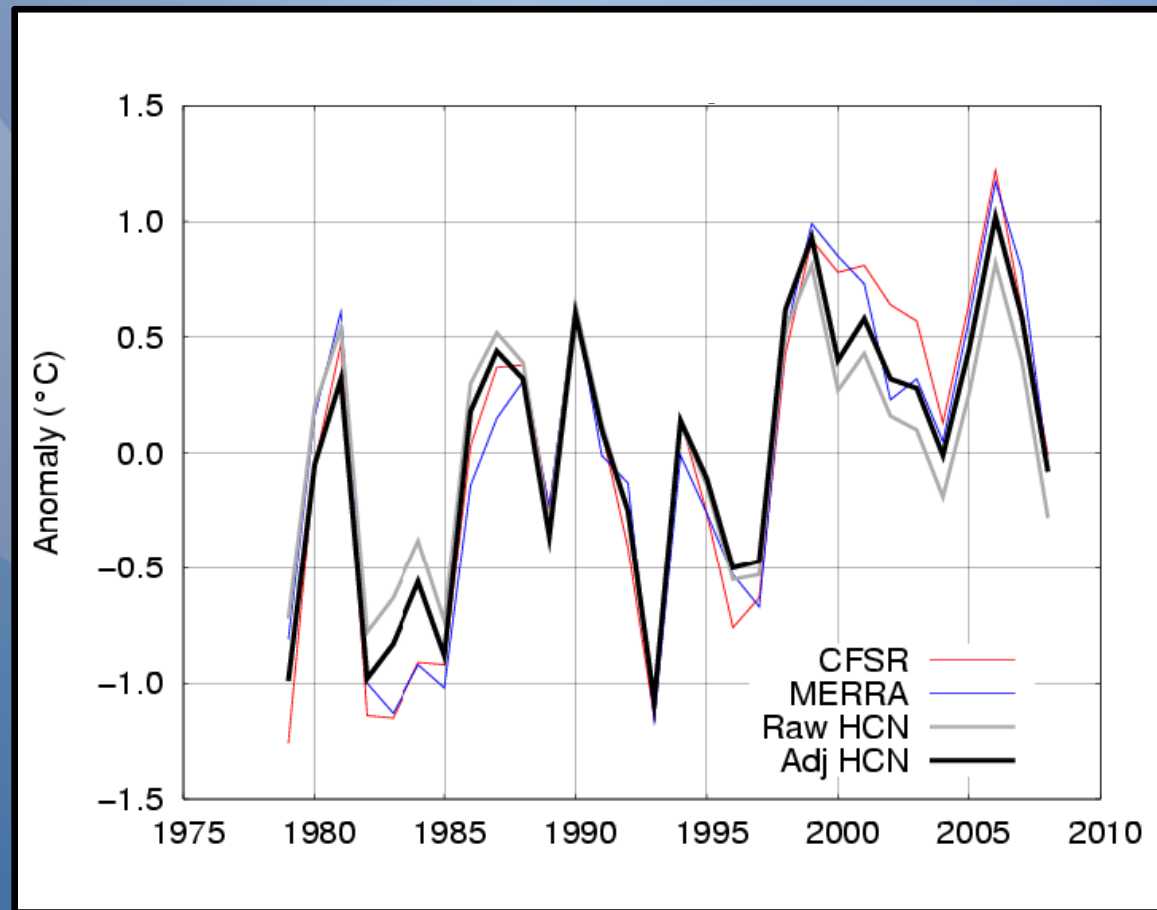# Mean Temperature Trends
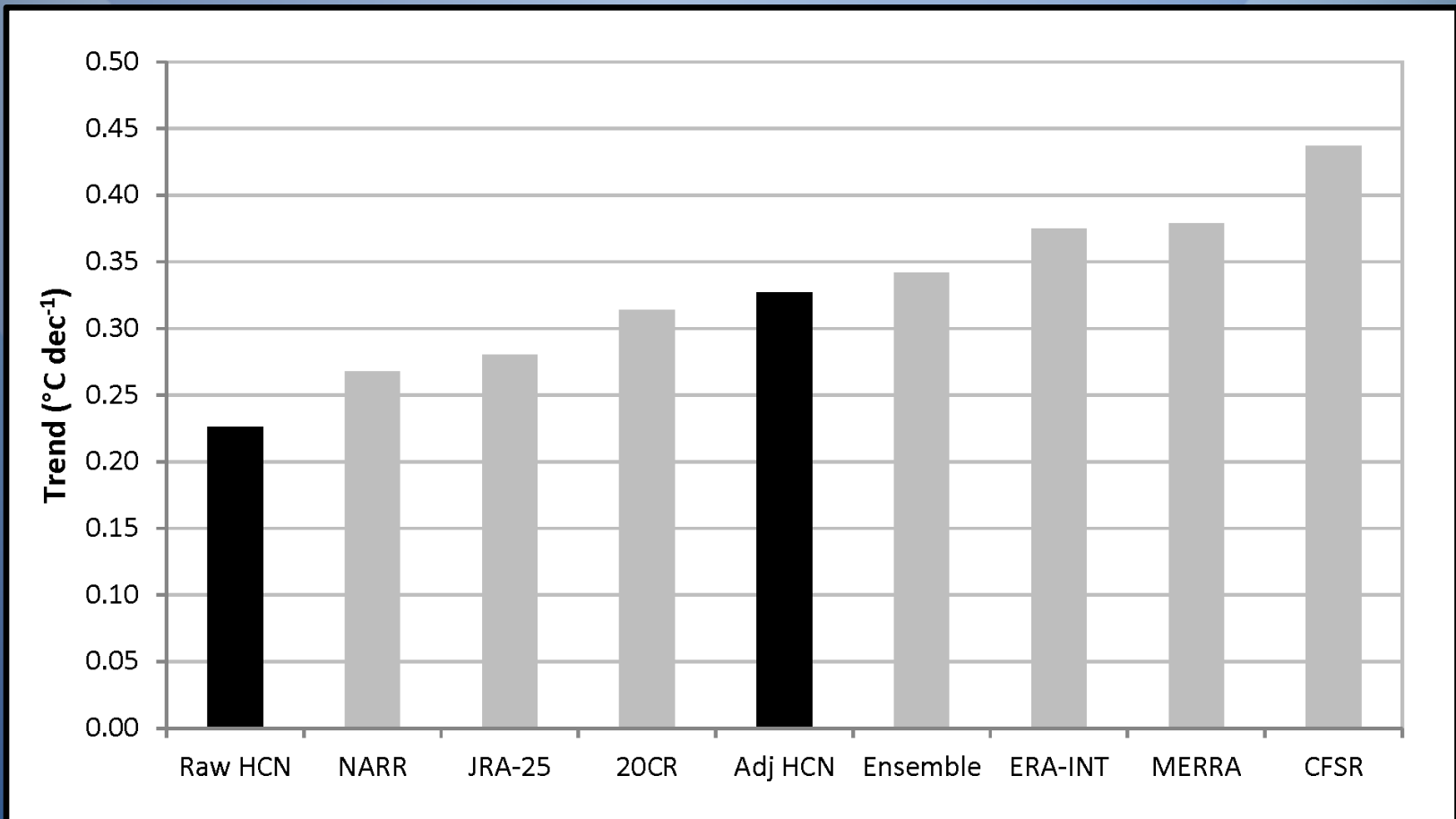
Mean Temperature Recap

- All trends are positive and statistically significant (in both HCN and the reanalyses)
- The trend in the adjusted HCN is roughly comparable to the ensemble mean of the reanalyses
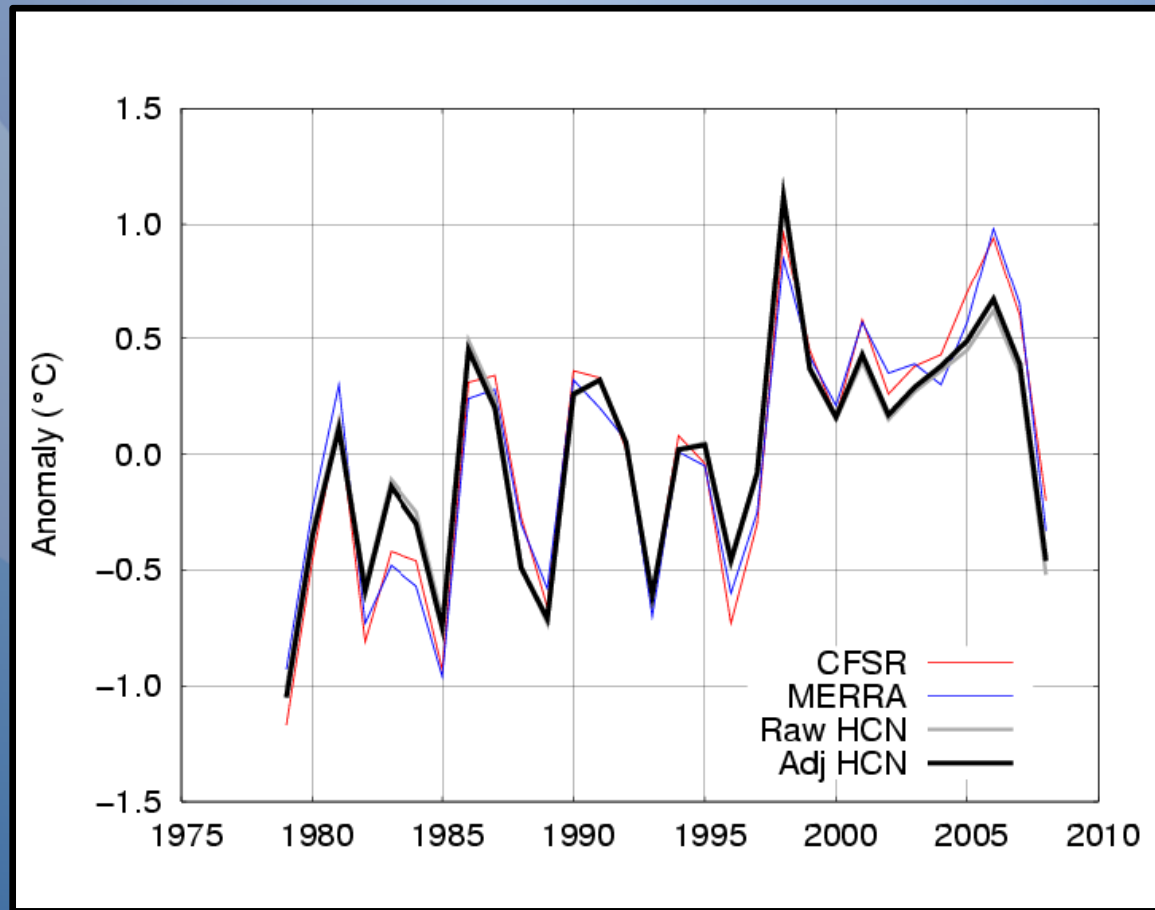- The HCN adjustments improve consistency with the reanalysis suite

Maximum/Minimum Trends

Maximum Temperature

Minimum Temperature

Maximum/Minimum Recap

- All trends are positive and statistically significant (in both HCN and the reanalyses)
- The HCN adjustments improve consistency with the reanalyses (more warming in maximum temperature)
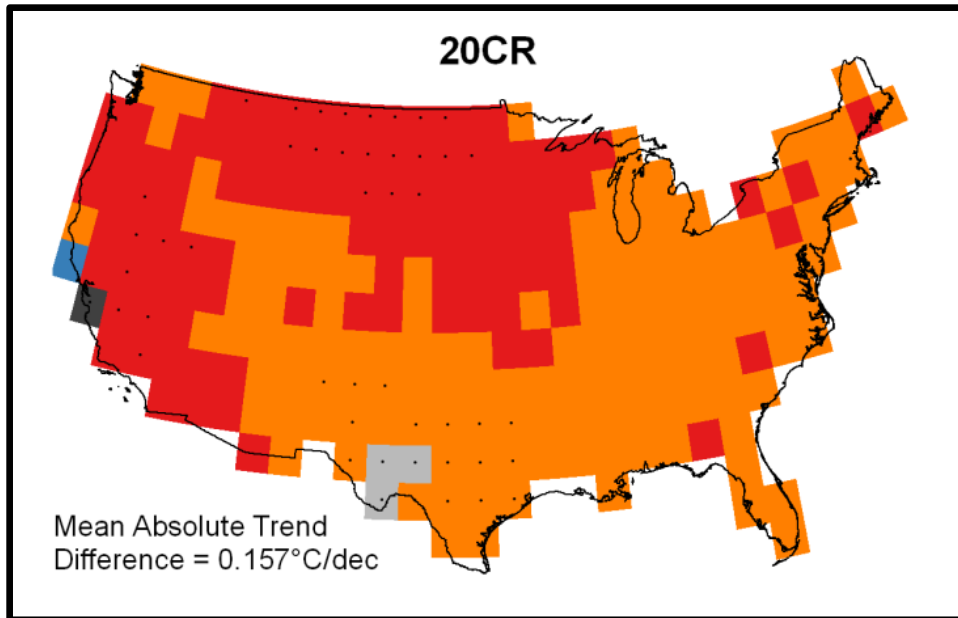- The HCN adjustments may not fully compensate for some recent changes (HCN trends too small?)
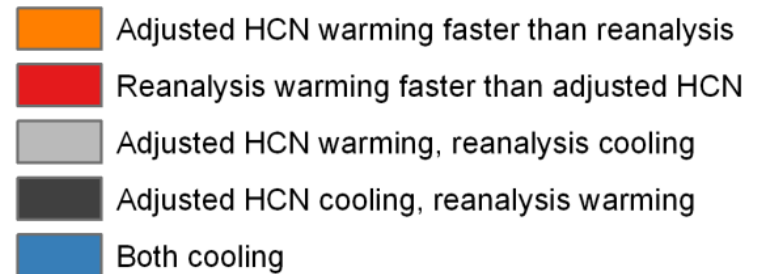
Grid-Box Trends

20CR
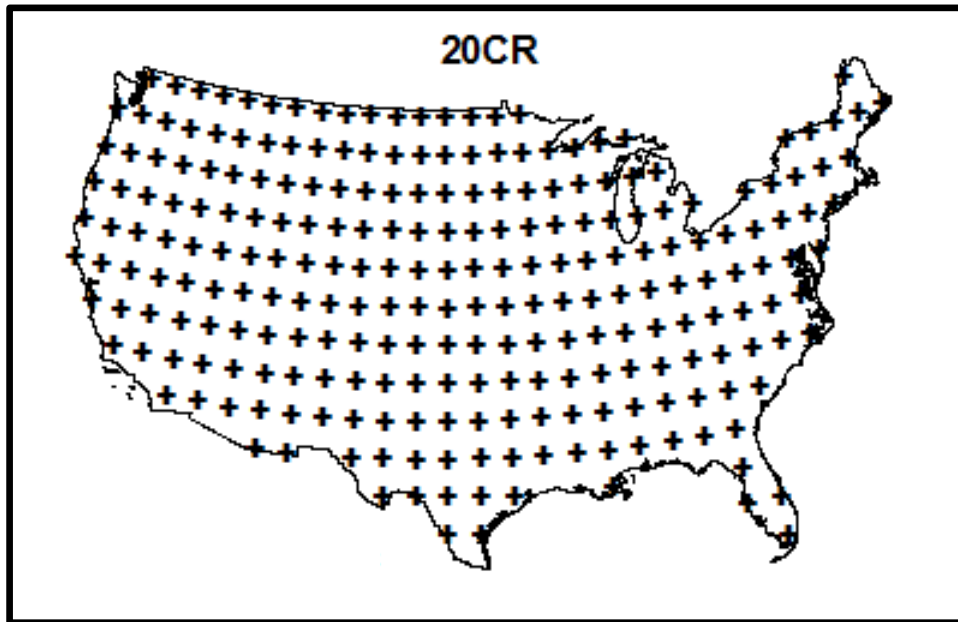
- Mean temperature only

- Compute reanalysis trend by box

- Compute HCN trend by box

  - Interpolate HCN anomalies to reanalysis grid
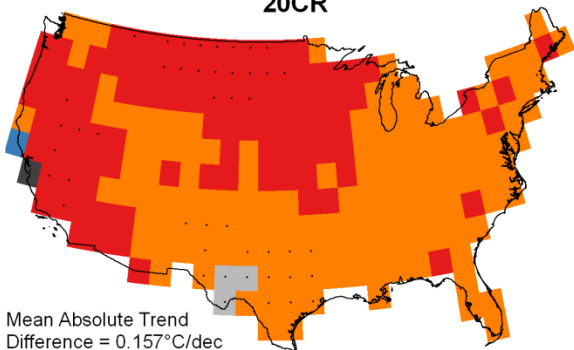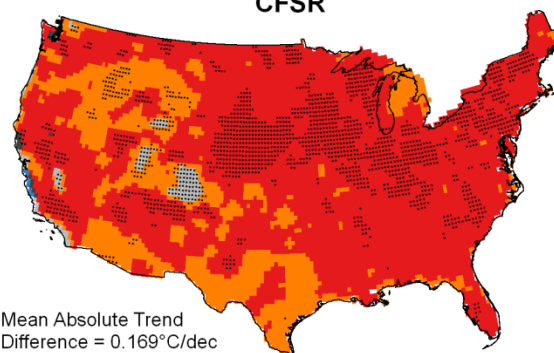 - Makes sense because HCN denser than half the reanalyses

Grid-Box Trends

20CR

Mean Absolute Trend
Difference = 0.157°C/dec

- Assign each box to one of five categories based on its reanalysis and HCN trends
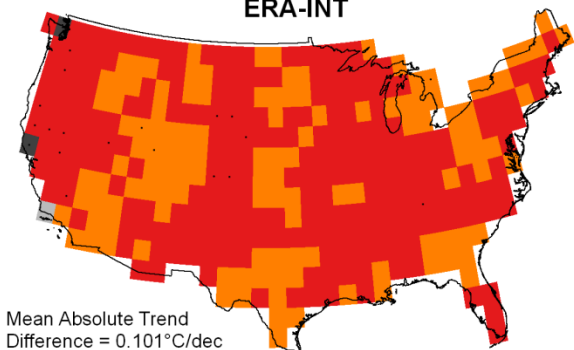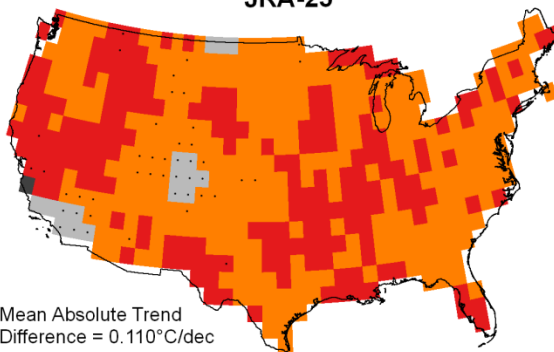
Adjusted HCN warming faster than reanalysis

Reanalysis warming faster than adjusted HCN

Adjusted HCN warming, reanalysis cooling

Adjusted HCN cooling, reanalysis warming

Both cooling

20CR

Mean Absolute Trend
Difference = 0.157°C/dec

CFSR

Mean Absolute Trend
Difference = 0.169°C/dec

ERA-INT

Mean Absolute Trend
Difference = 0.101°C/dec

JRA-25

Mean Absolute Trend
Difference = 0.110°C/dec

MERRA

Mean Absolute Trend
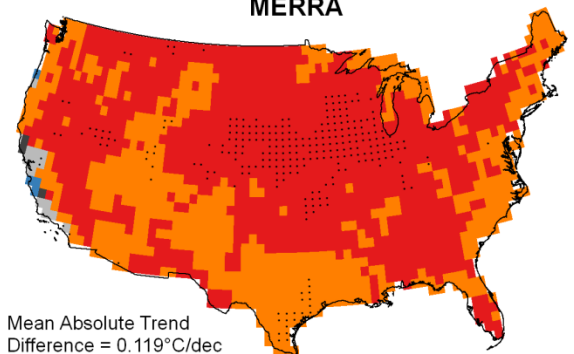Difference = 0.119°C/dec
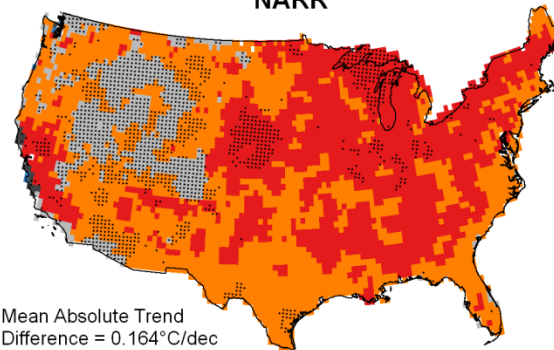
NARR

Mean Absolute Trend
Difference = 0.164°C/dec

	Adjusted HCN warming faster than reanalysis
	Reanalysis warming faster than adjusted HCN
	Adjusted HCN warming, reanalysis cooling
	Adjusted HCN cooling, reanalysis warming
	Both cooling

Grid-Box Trend Recap

- The adjusted HCN and the reanalyses agree in their depiction of widespread warming
- It is hard to verify the subtleties in the HCN pattern given the lack of consistency in the reanalyses

Final Messages

- There is broad agreement between the adjusted HCN and the reanalyses

- The HCN adjustments improve consistency with the reanalyses but may not address some recent changes

- It's probably unwise to use a single reanalysis to scrutinize small-scale trends in surface temperature