Evaluation of the Relative Contribution of Observing Systems in Reanalyses: Aircraft Temperature Bias and Analysis Innovations

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Reanalyses and Observations

- Reanalyses assimilate a broad suite of observations, yielding a single consistent product
- The presence, or lack, of observations often determines the quality of reanalysis data
- Observation reports from the analysis are usually in observation-space format, or diverse binary or ascii data format
- Research studies do not usually indicate the presence of observations and their impact on reanalysis

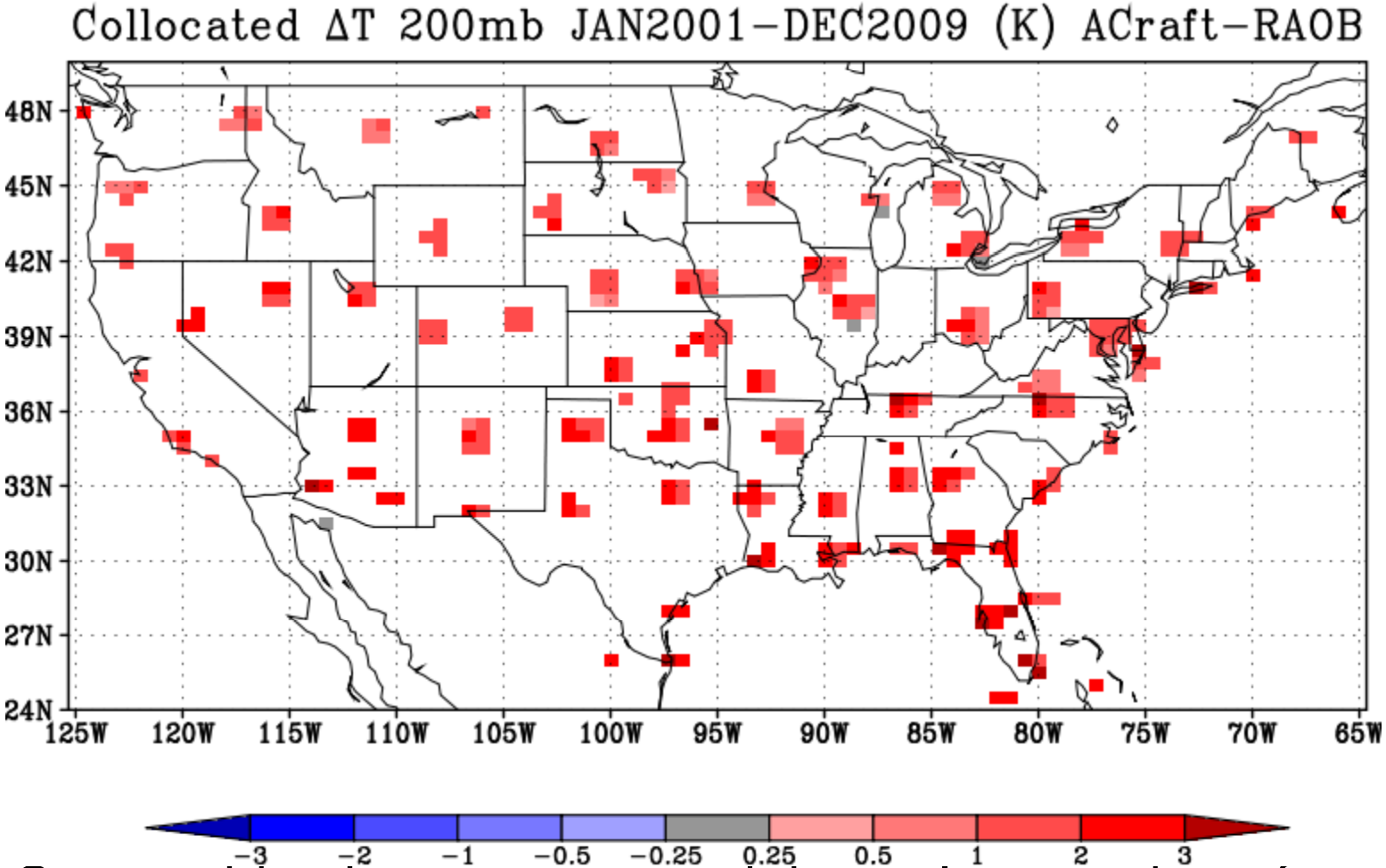
MERRA and GIO

- NASA's most recent reanalysis – Modern-Era Retrospective analysis for Research and Applications (MERRA) – Rienecker et al. (2011, J. Clim)
  - 1979 – present; more than 300 diagnostic variables
- Gridded Innovations and Observations (GIO)
  - Derived from GSI "diag" (feedback) files, and includes the observation, background forecast error (OmF) and analysis error (OmA)
  - Conventional obs (sonde, stn pressure, etc) and also Radiance data
  - Gridded to MERRA's native pressure coordinate – ½°×⅔°, 42 pressure levels for every 6 hour analysis time
- How deep can we dig into the analysis and observations with this kind of post processed observations?

Case Study: Aircraft Temperature Bias

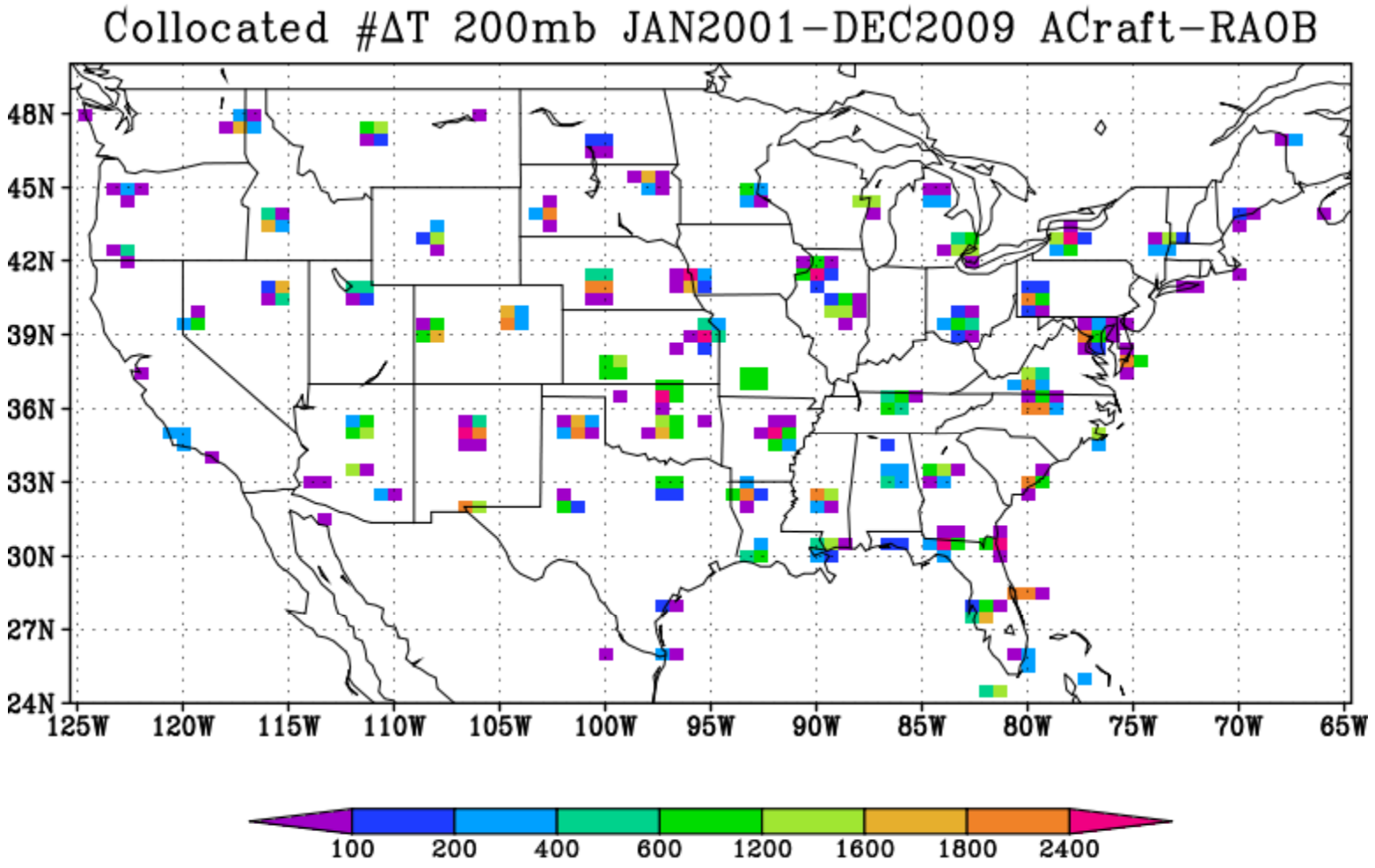
- **Warm biases** in commercial aircraft – Cardinali et al. (2003) and Ballish and Kumar (2008)
  - Use forecasts or increments to evaluate obs
  - Some limitations – few seasons, small regions
  - Recommend aircraft T bias corrections
- GIO Comparison
  - Develop **collocations** for a 31 year period over the continental US
  - Initially looking at 200mb – Cruise level, more collocations
  - Collocations are based on the 6 hourly analysis and MERRA analysis grid
  - **Can we use these collocations to derive the characteristics for bias corrections in reanalyses**?

9 Year Average Difference

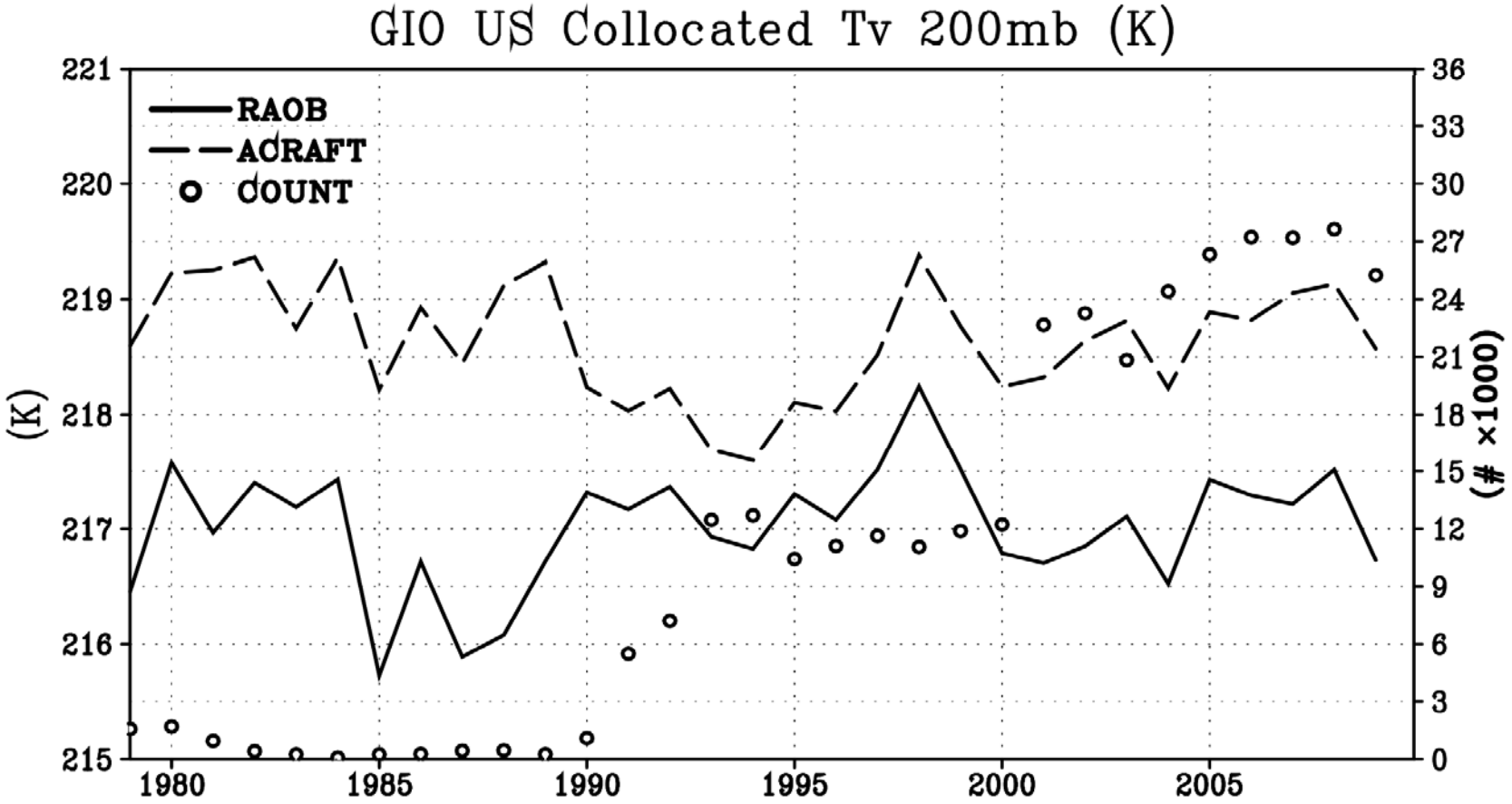


- Some grid points are screened due to low number of collocations

9 Year Collocation Count

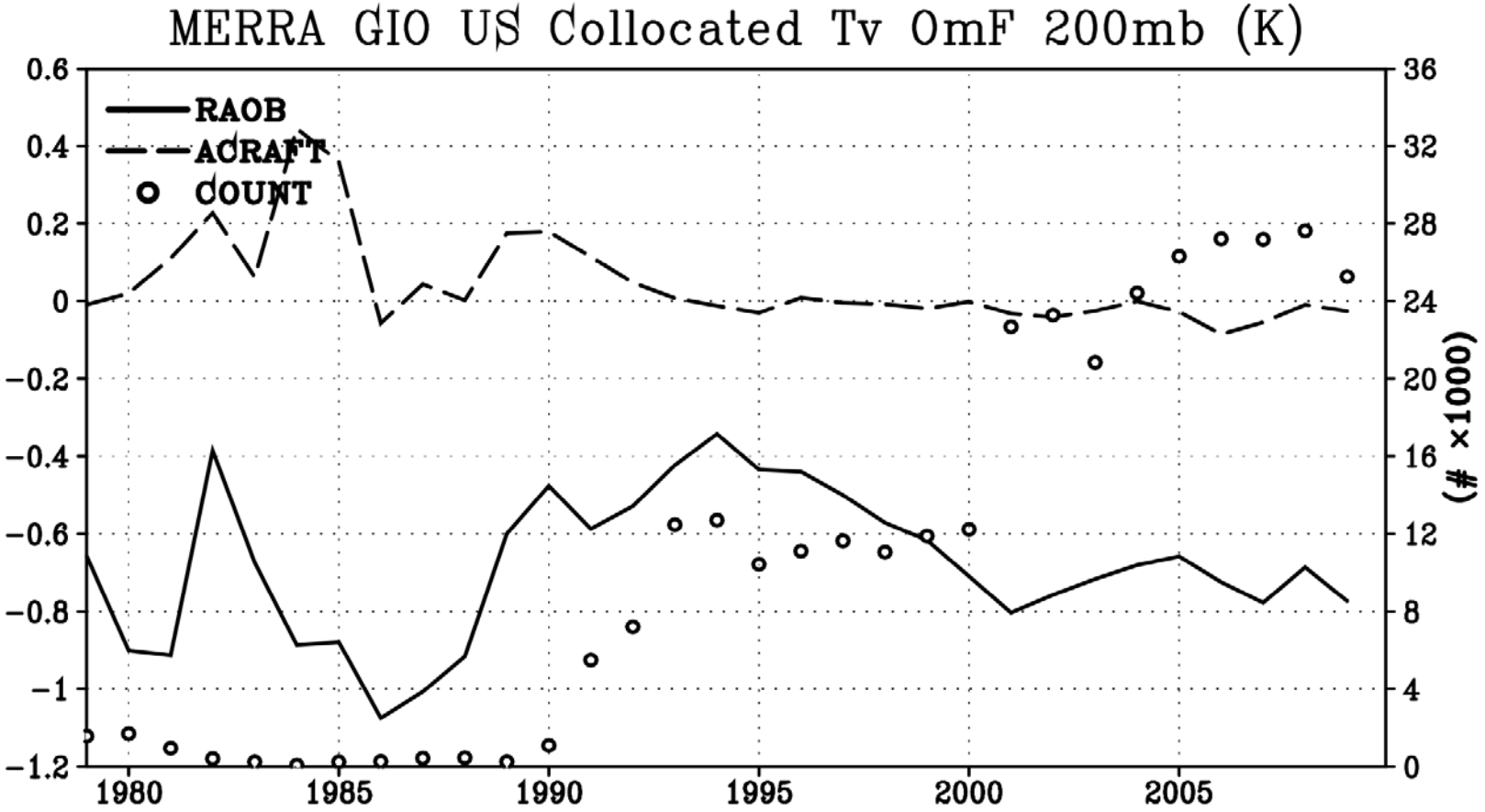


Annual Mean Time Series

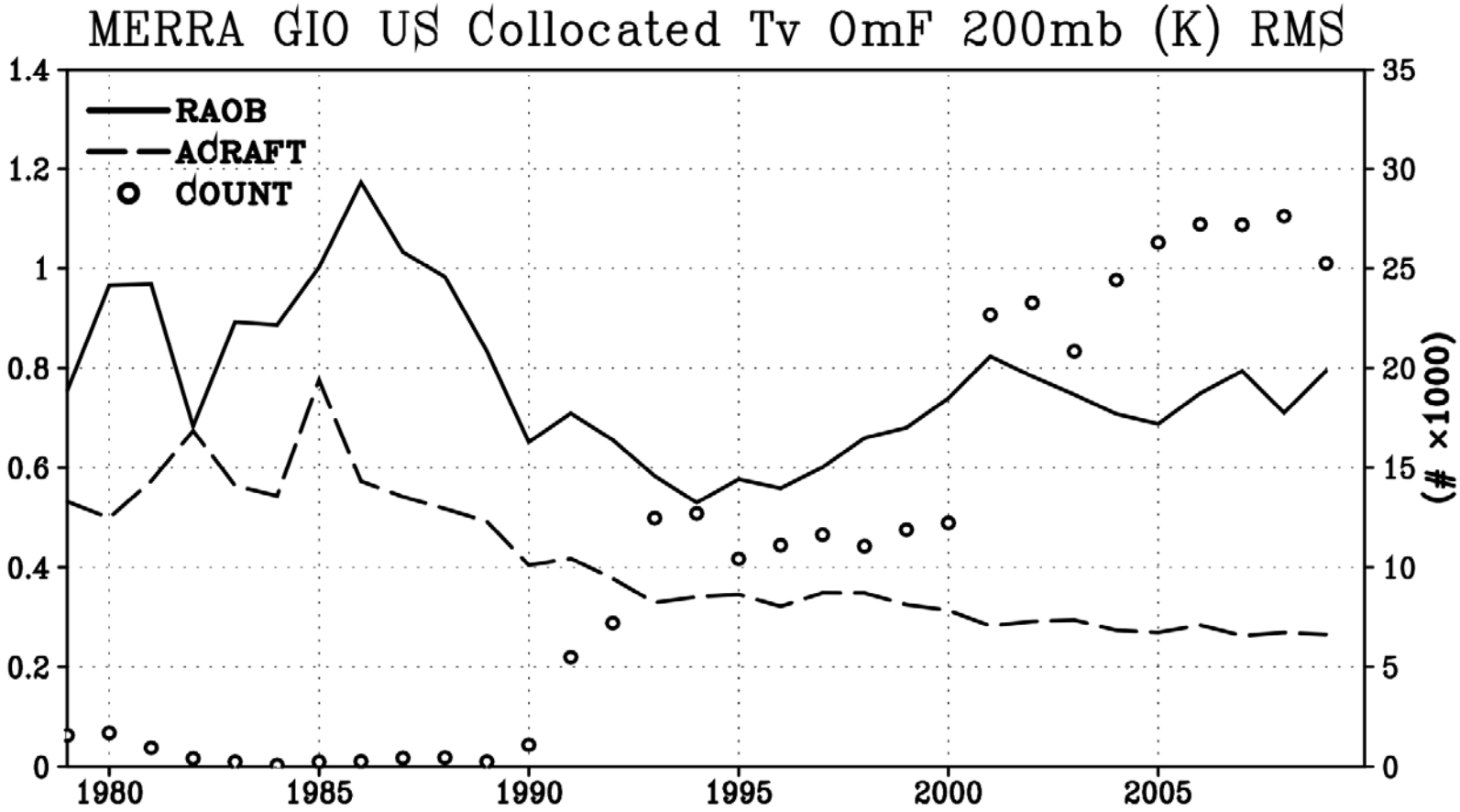


- Apr 1991 – MDCRS Start

Annual Mean Forecast Error (OmF)

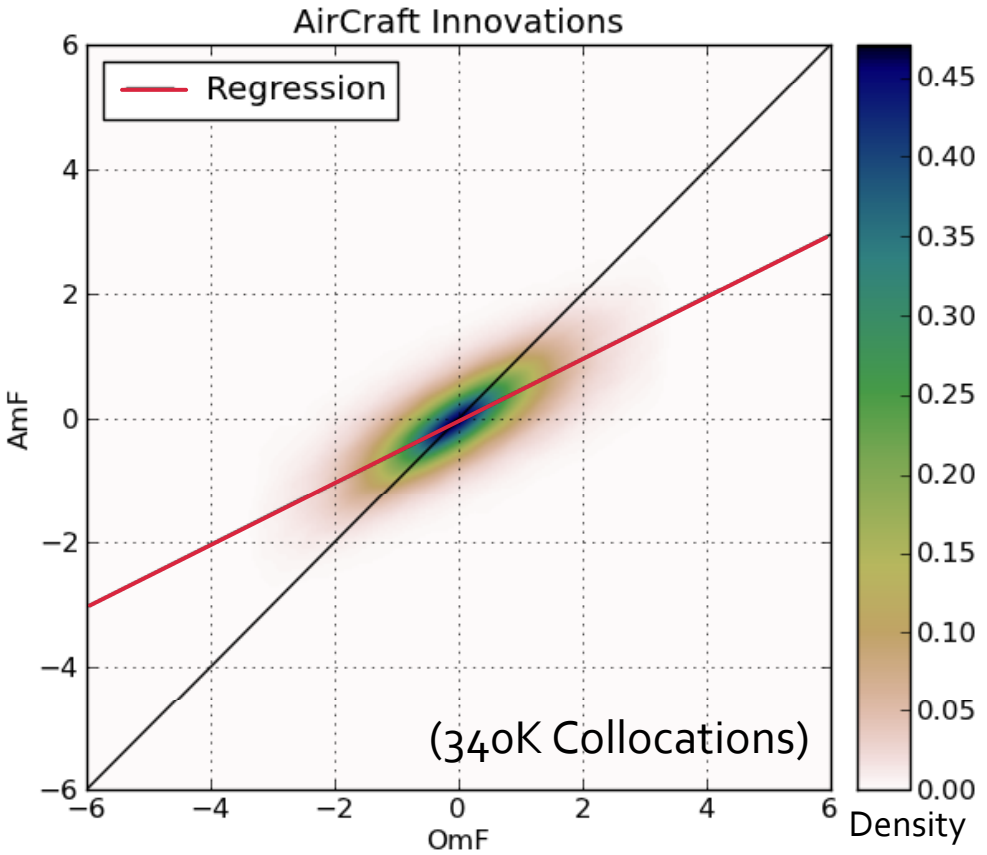


Annual Mean Forecast Error RMS



Quantifying Observation Influence

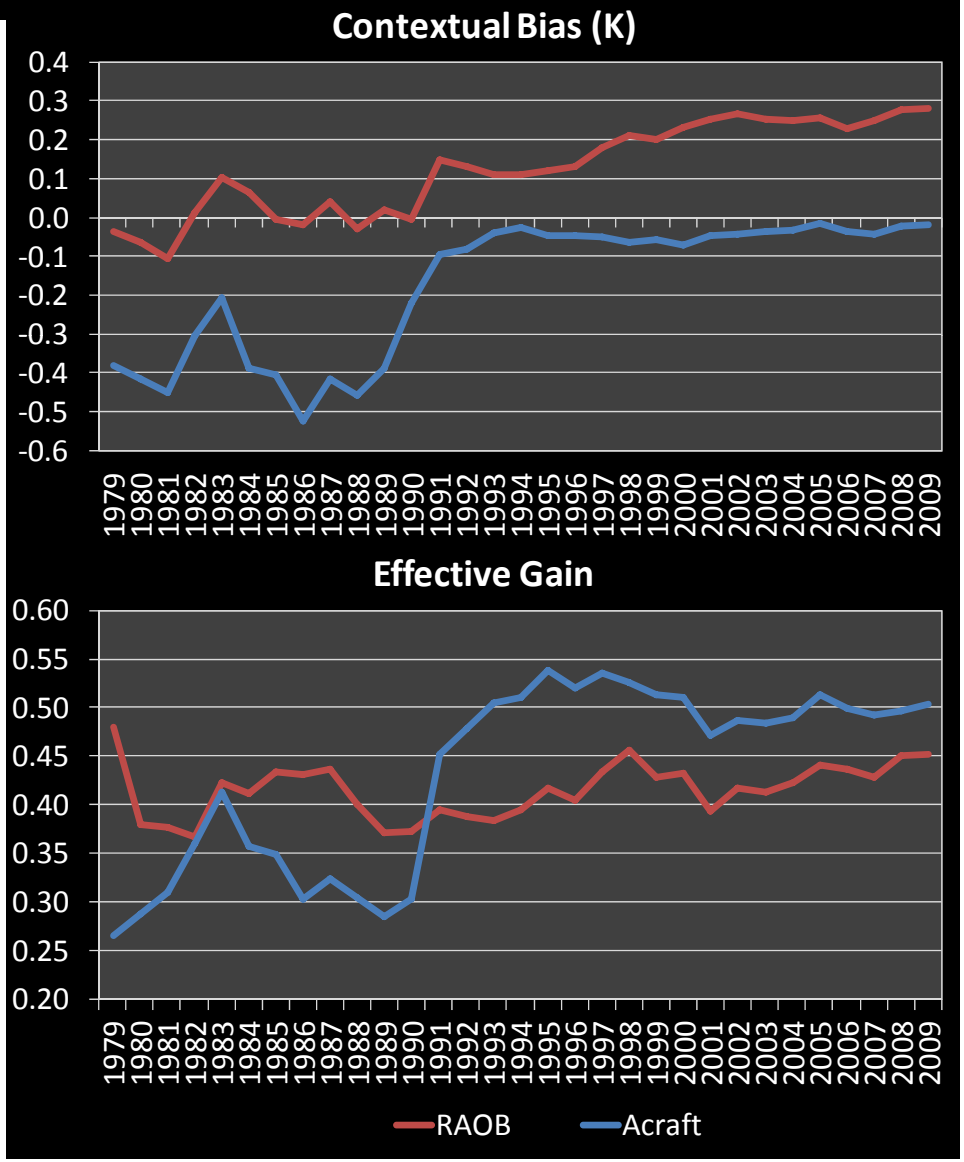
- **A-F ~ κ(O-F) + β**
- **κ - Effective Gain**: A measure of how much the analysis draws to an observing system
- **β – Contextual Bias**: a measure of bias of an observing system relative to other contributing observing systems



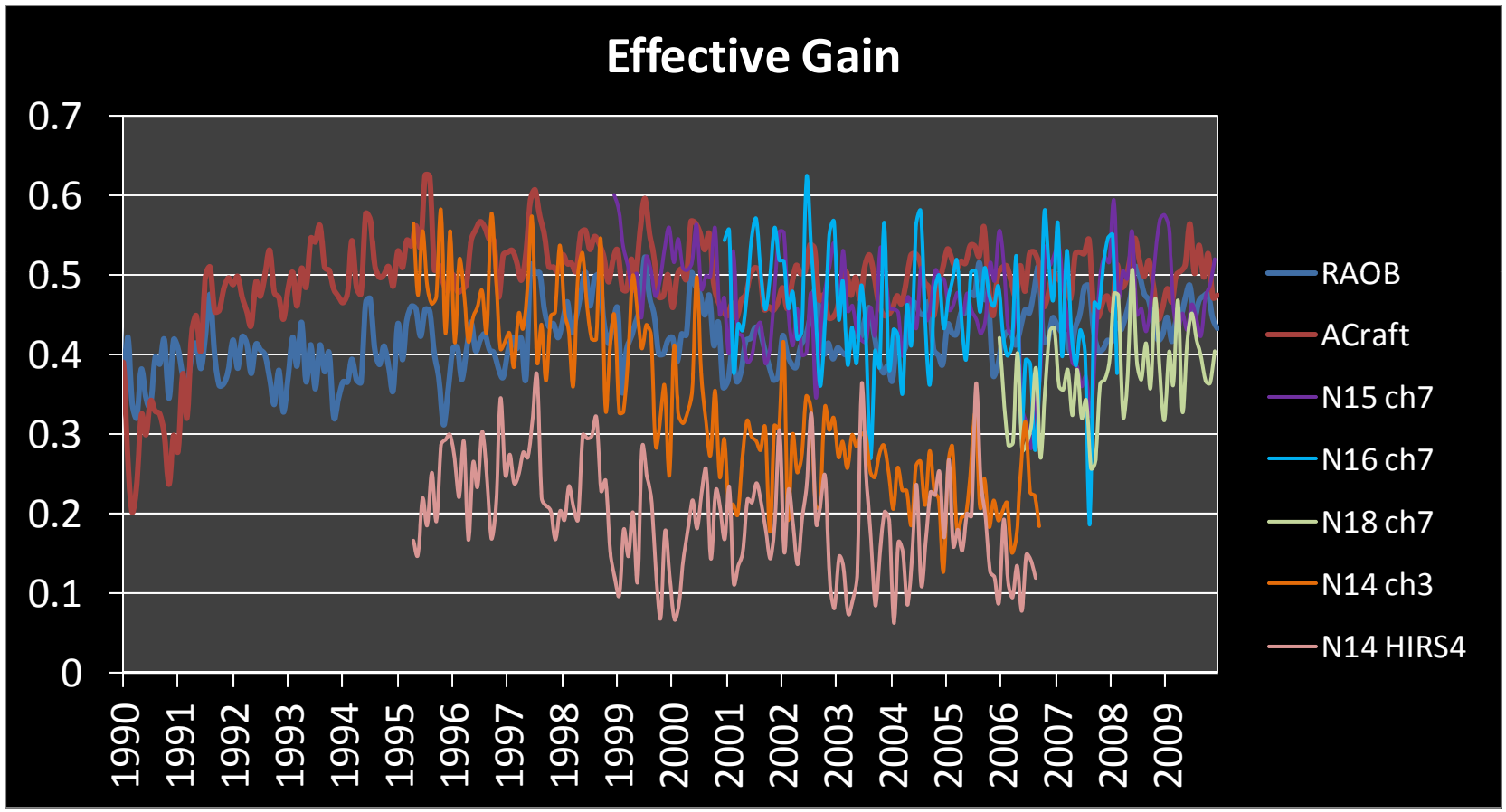
91-09 (200mb)	κ	β
AirCraft T	0.50	-0.04
RAOB T	0.41	0.21

Interannual Variations

- As Aircraft observations become prevalent their β is reduced and Gain increases
- RAOBs have somewhat continuous gain, but become biased
- Aircraft observations control the analysis at 200mb over the US after 1991

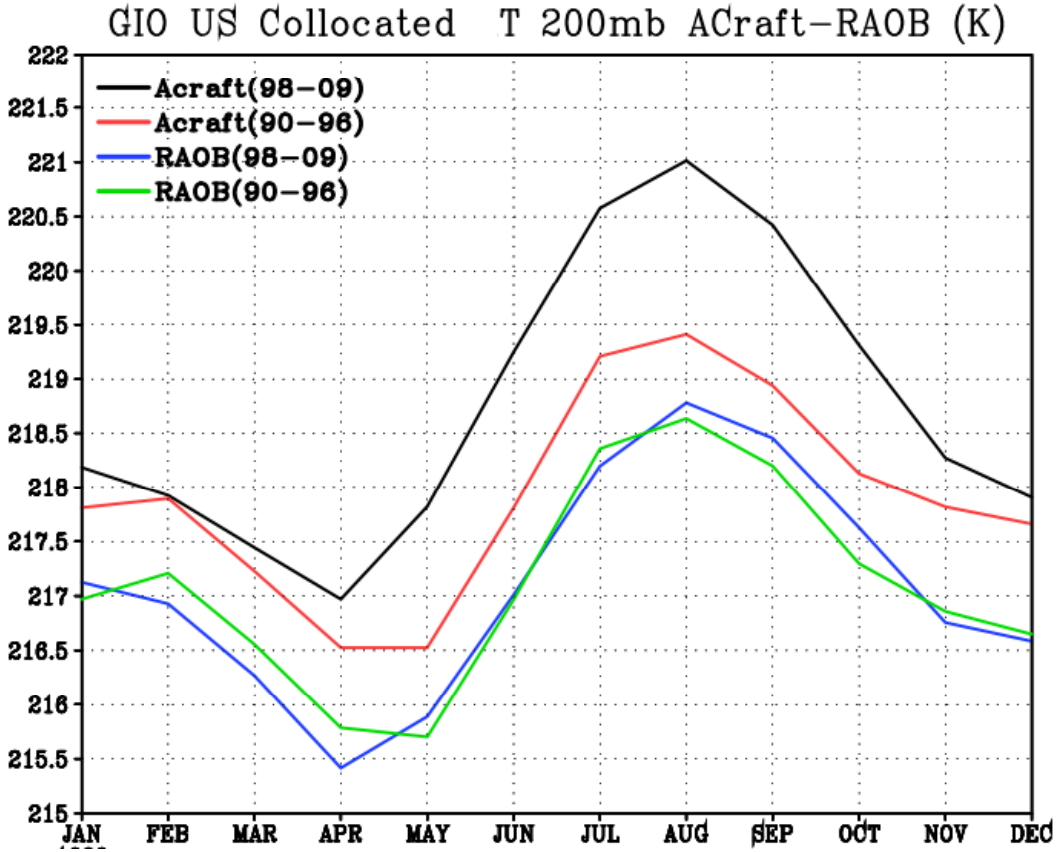


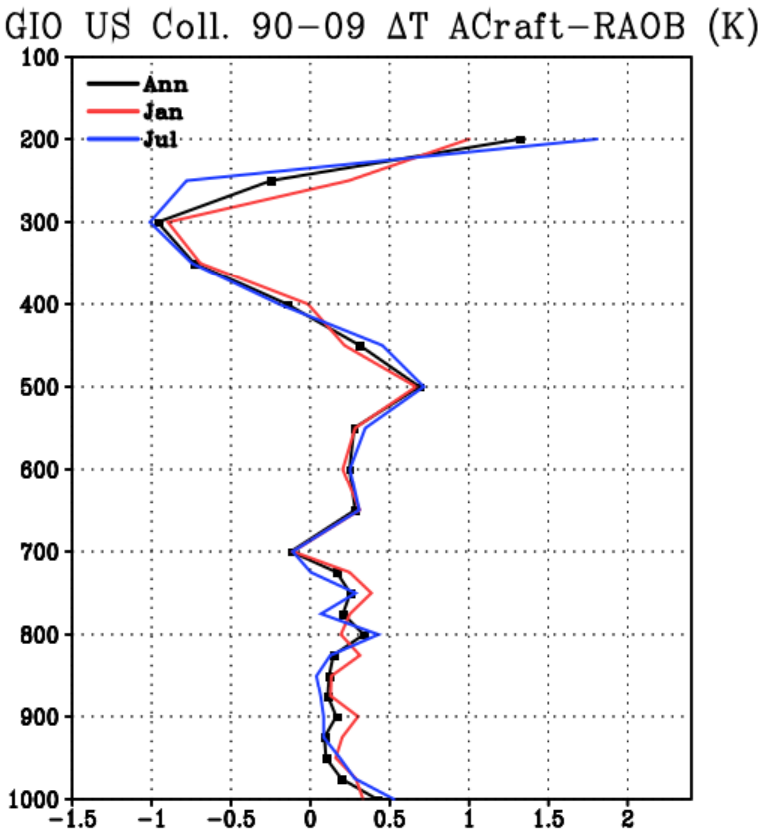
Incorporating Tb into Evaluation



- Near-200mb peaking channels from MSU, AMSU and HIRS

Further Considerations





- Radiosonde obs more consistent in time than aircraft
- Some vertical variations not yet accounted for

Future Considerations

- Process at higher resolution?
  - For example, better locate data near tropopause
- Integrate radiance and conventional observation comparisons
- Assuming Radiosonde output is accurate, aircraft bias correction needs to be developed, but will need to consider seasonality and altitude.
- Many uses in identifying observational influence on the reanalysis

Thanks for any comments

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