A multi-instrument cross-validation of infrared thermodynamic profilers

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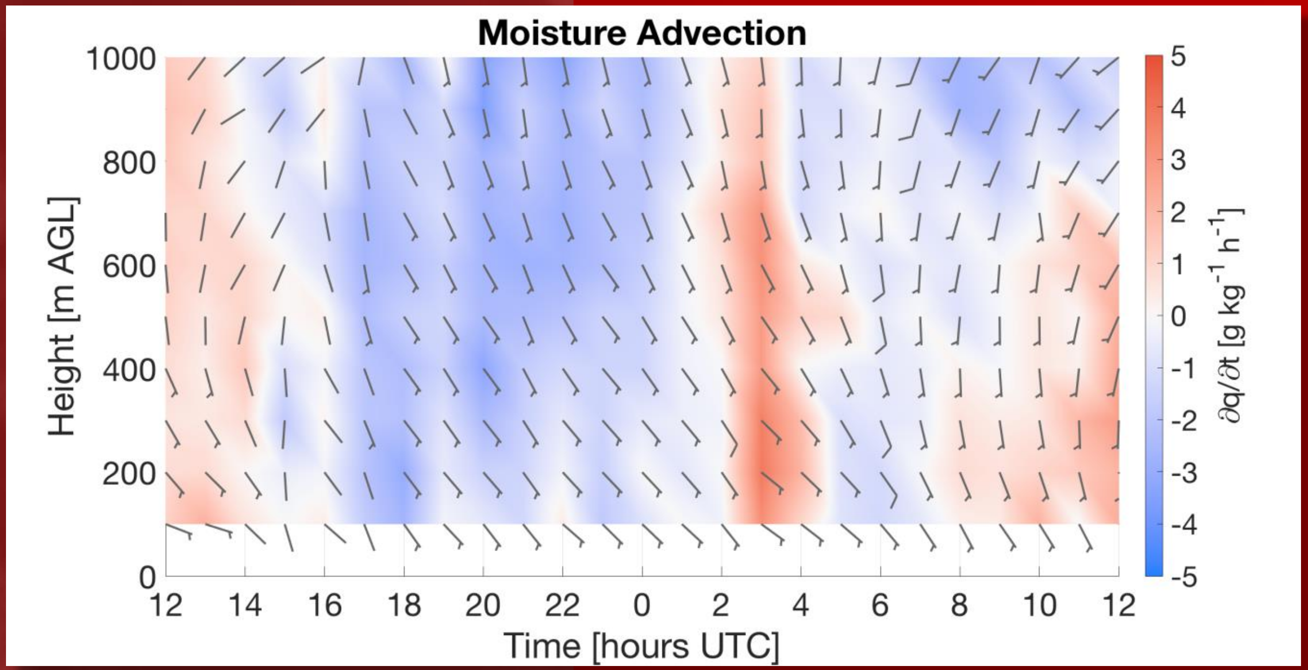
Operational Networks Need Repeatability



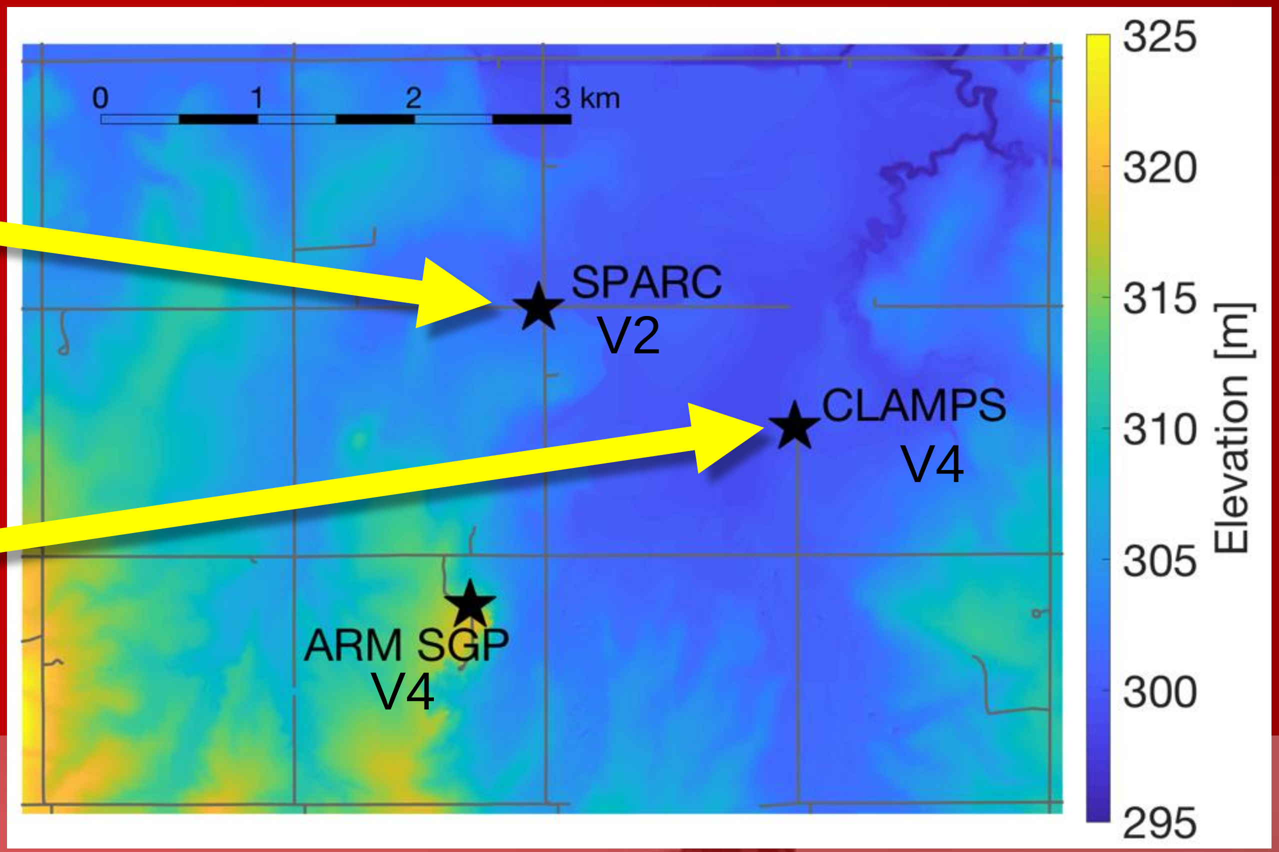
Why do two identical instruments in different locations produce different observations?

- Atmospheric conditions are different
- But what about instrument variablity?

For in situ instruments, this is easy to test: put them in a calibration lab.

LAFE gave us a rare opportunity: three AERIs in basically the same location… with 4x daily sonde launches!

Our Three AERIs



All three AERIs within 2 km horizontally and 15 m vertically.

Balloons launched next to ARM AERI.

AERIoe: AERI optimal estimation retrieval

AERIoe (Turner and Löhnert 2014, Turner and Blumberg 2018):

- Modified optimal estimation retrieval
  - includes uncertainties and information content
  - includes γ factor to increase convergence rate
- Retrieves profiles of temperature and moisture
  - most information content below 3 km
- A priori information comes from 10+ year climatology of radiosondes
- Uses LBLRTM as its forward model
- Capable of retrieving profiles below cloud base
- Also retrieves cloud properties
  - Liquid water path
  - Droplet effective radius

Making the comparisons

Retrievals need to be as consistent as possible

- Same configuration file for AERIoe
- Same version of LBLRTM (12.1)
- Same external cloud base height observations

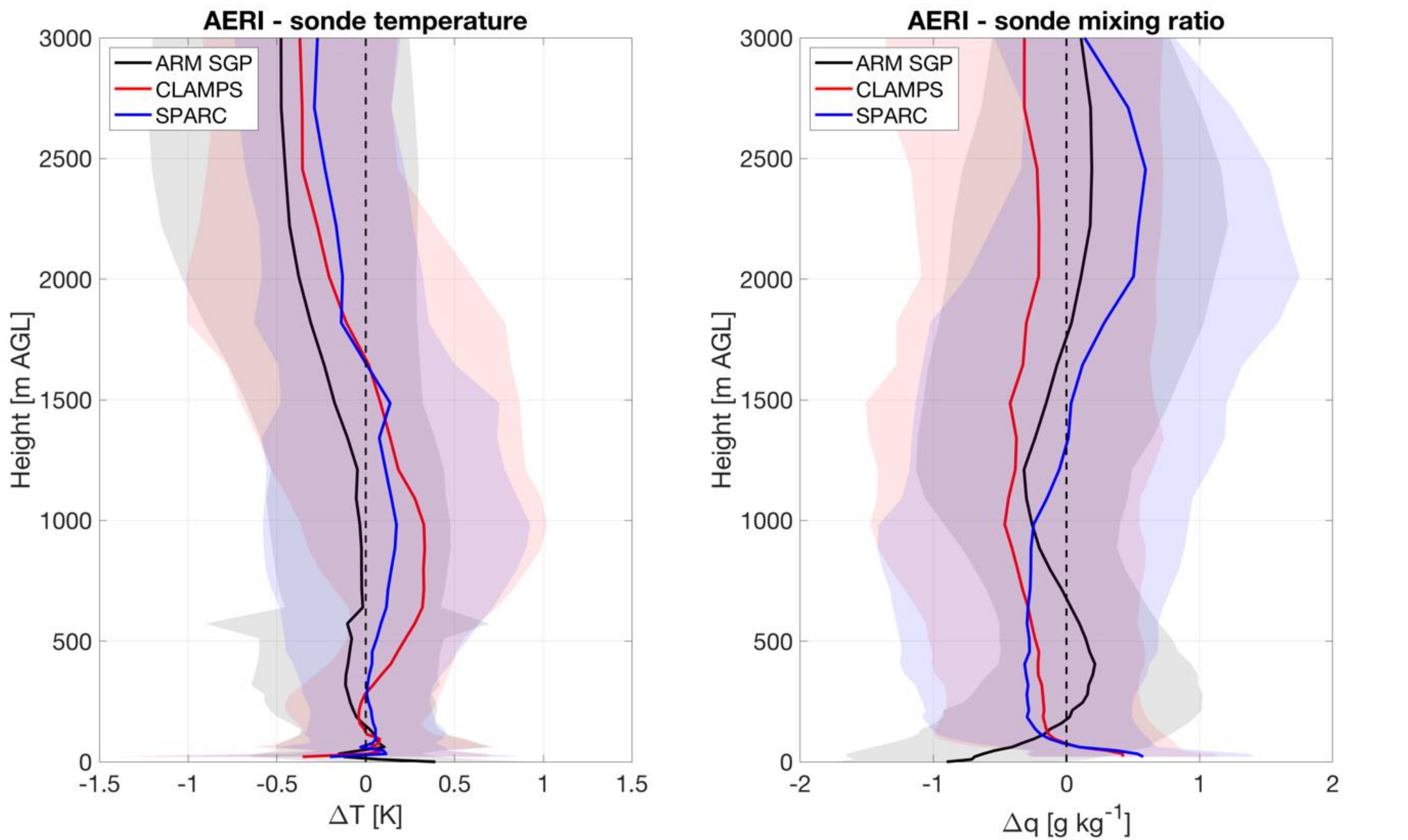
Cloud impacts minimized by cutting off retrievals at ½ vertical resolution below observed cloud base

AERI profile heights adjusted to be at same height relative to MSL for all 3 instruments.

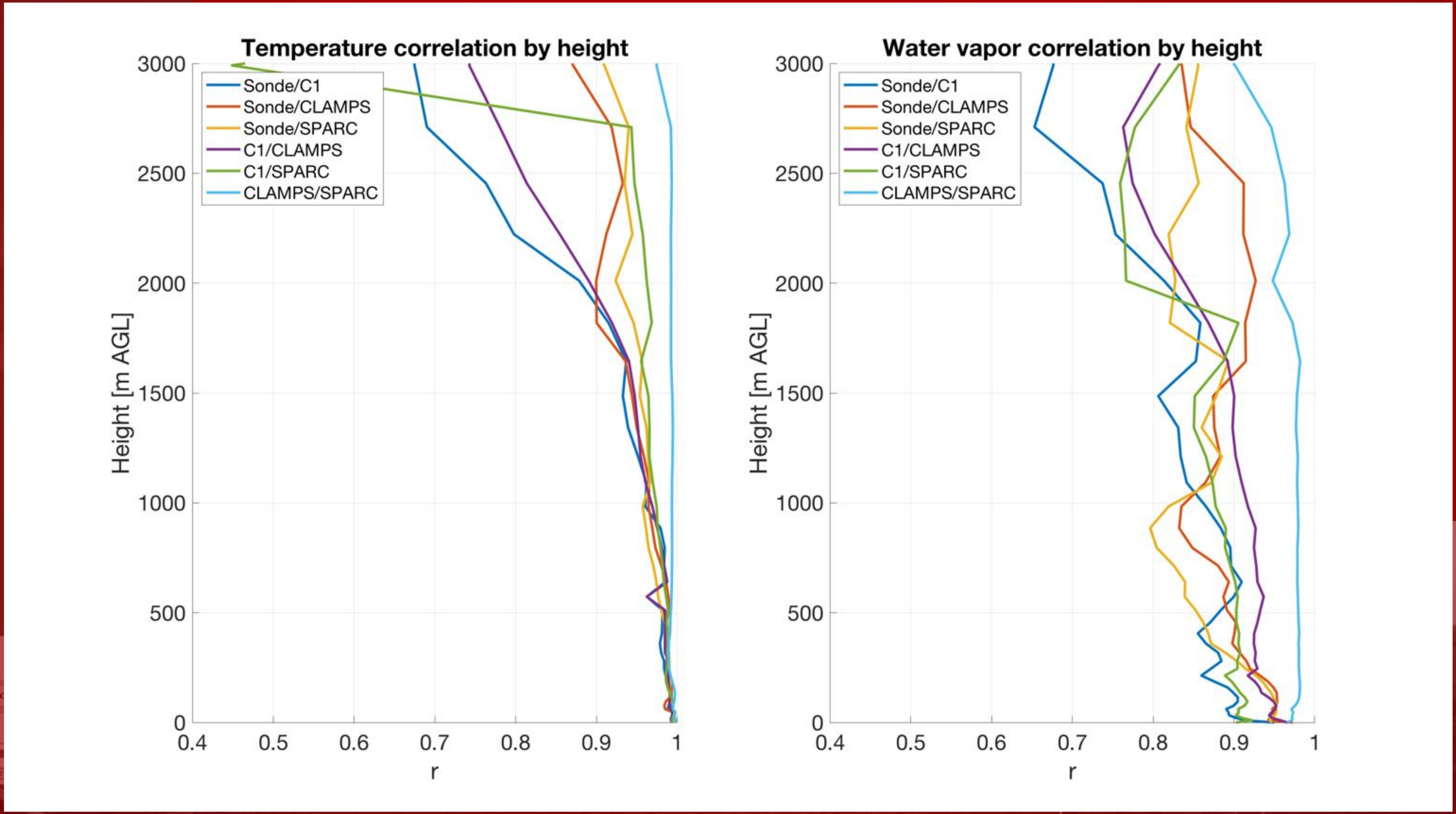
Sondes smoothed according to:

$$\mathbf{x}_{\text{sonde}}^{\text{smoothed}} = \mathbf{A}\left(\mathbf{x}_{\text{sonde}} - \mathbf{x}_{\text{a}}\right) + \mathbf{x}_{\text{a}}$$

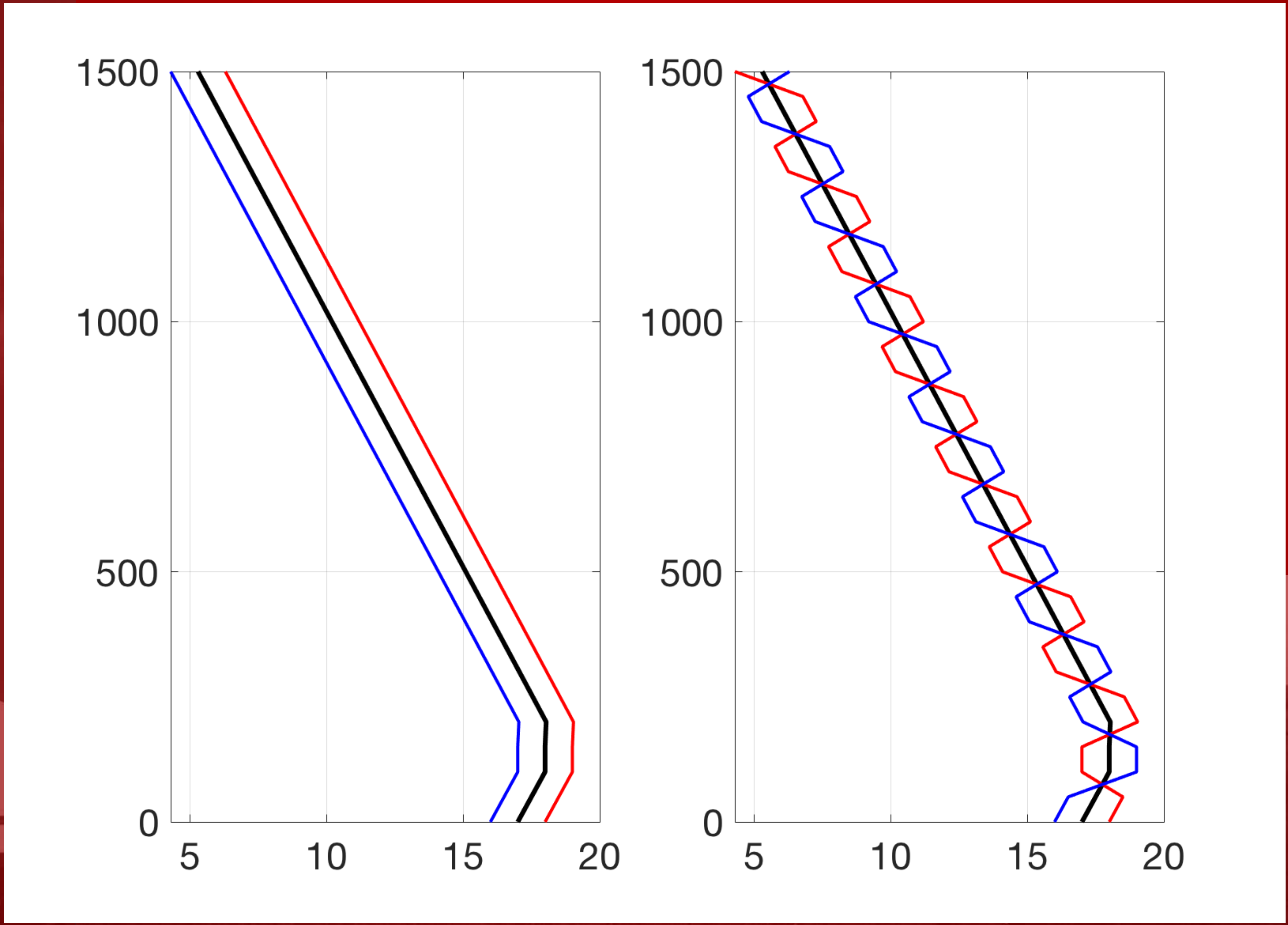
AERI vs. Radiosondes



AERI vs. Radiosondes



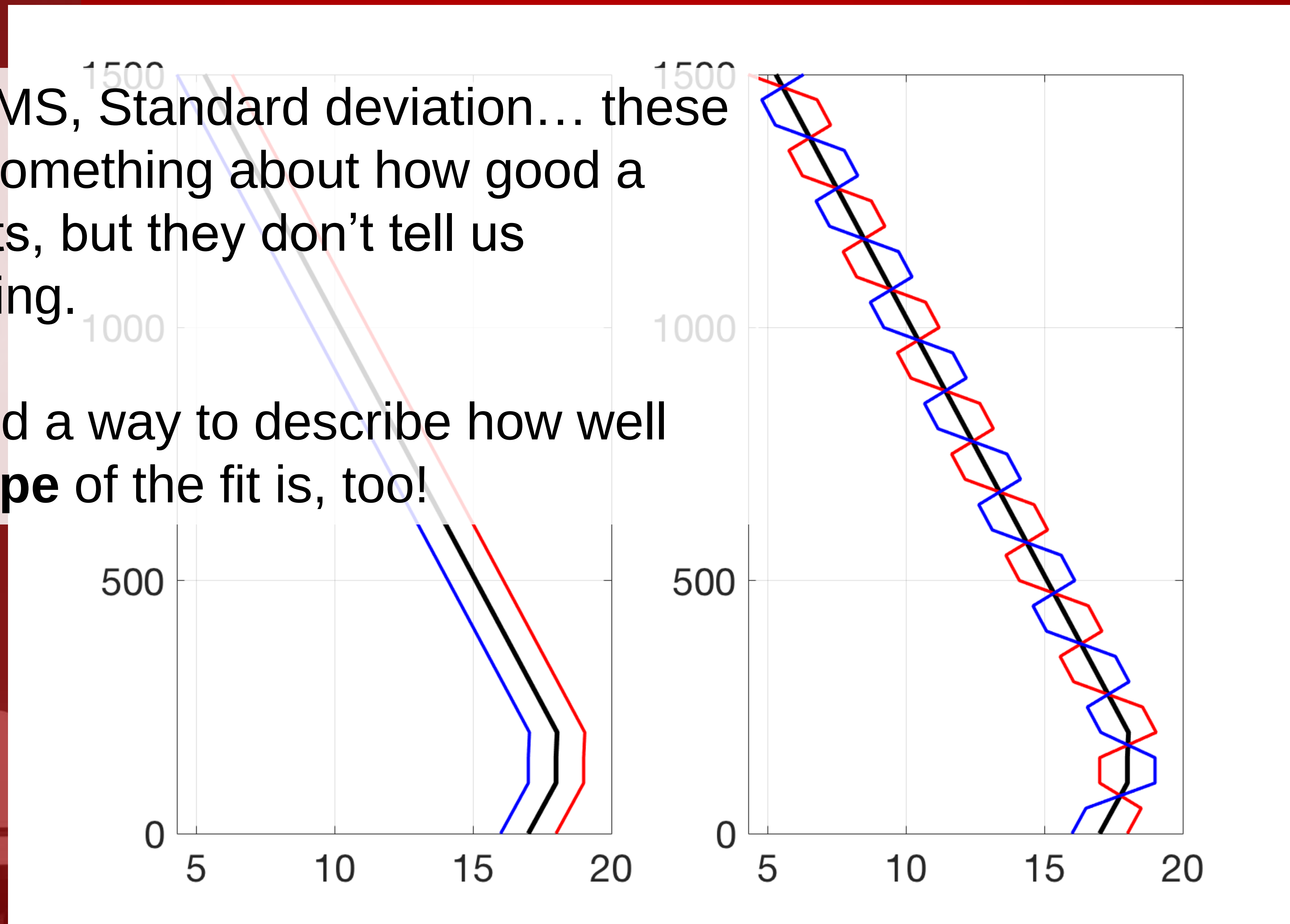
Judging the Fit



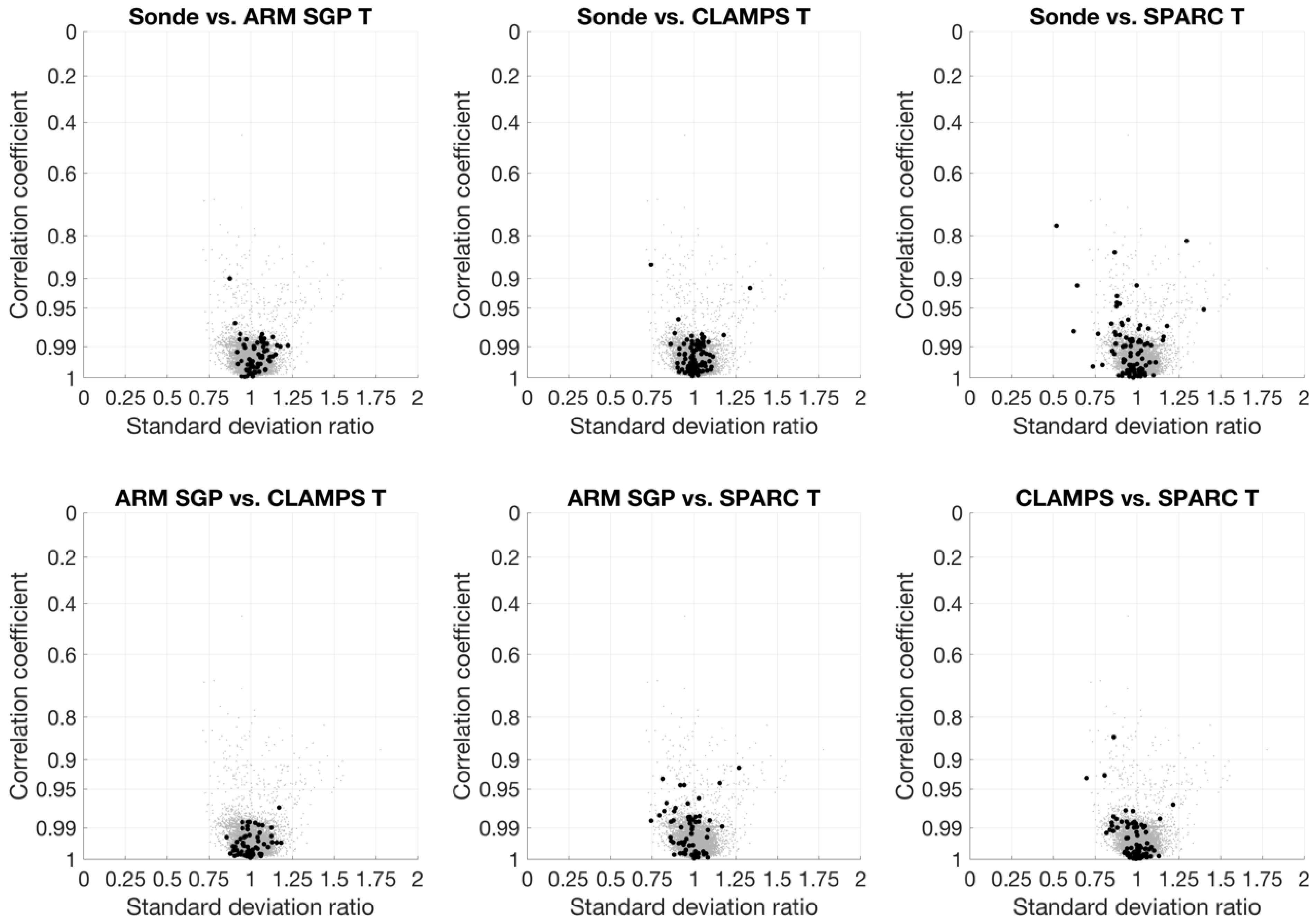
Judging the Fit

Bias, RMS, Standard deviation… these tell us something about how good a curve fits, but they don't tell us everything.

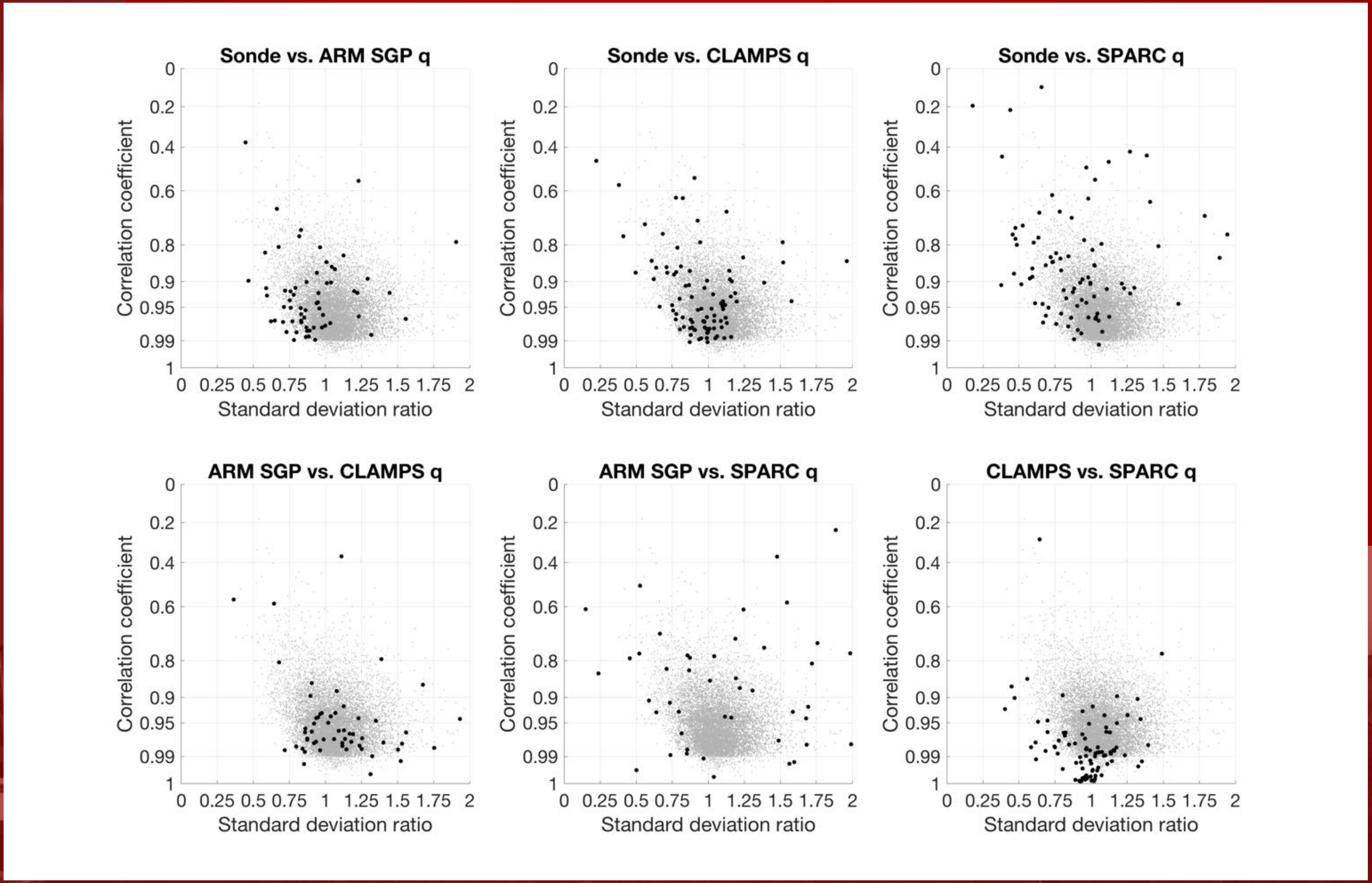
We need a way to describe how well the **shape** of the fit is, too!



Taylor Plots: Temperature



Taylor Plots: Mixing Ratio



- AERIs show excellent agreement with sondes
  - Mean bias for T < 0.5 K at all heights below 3 km
  - Mean bias for q 0.8 < g/kg at all heights below 3 km
  - These are within the uncertainty of the sonde itself

- AERIs show excellent agreement with each other
  - Profiles of pearson's correlation coefficient r is great!
    - Better than 0.9 for T below 2 km
    - Better than 0.8 for q below 2 km
      - We'd expect q to be less correlated

Taylor Analysis shows that instruments tend to retrieve the same shape as well.

Thank you!

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