The Influences of Differing Temperature and Moisture Roughness Length Parameterizations on Height Adjustment and Turbulent Surface Fluxes

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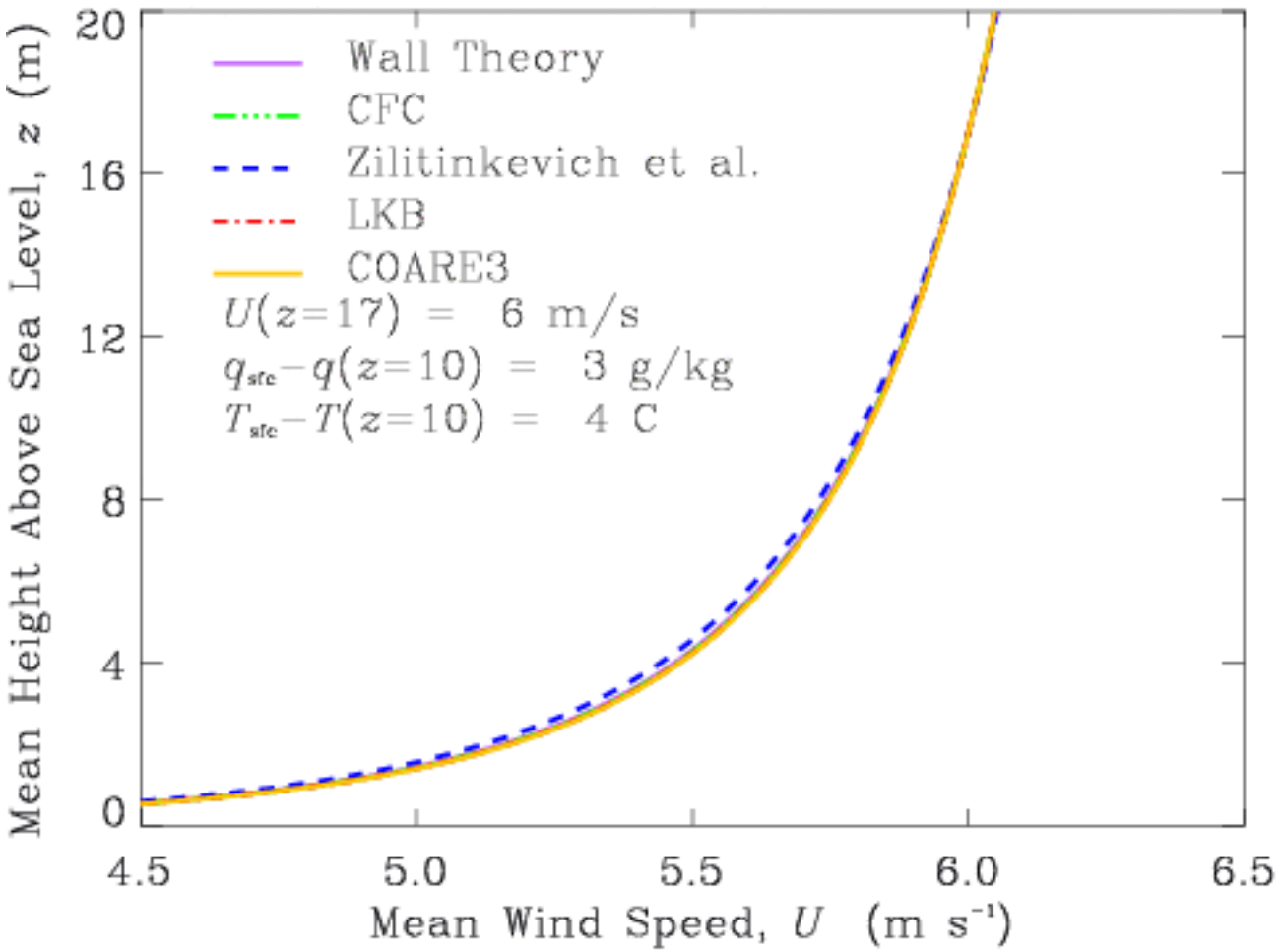
Who Is Interested?

- Historically, we have not worried too much about how we height adjust, provided that a 'reasonable' parameterization.
- Where might there be some concern?
  - Turbulent energy and mass fluxes.
    - These difference are presumably not large, but could be important on the time scale of several years.
  - Height adjustment of temperature and atmospheric moisture
    - Climatologies of these variables are of interest in studies of decadal change, global warming, and hurricane activity.
    - Particularly a problem if the bias is a function of observation height, resulting in a spurious trend.
    - Bias corrected and height adjusted data are valuable for satellite calibration.
- This height adjustment should be applied after instrument-related biases are removed .

Methodology

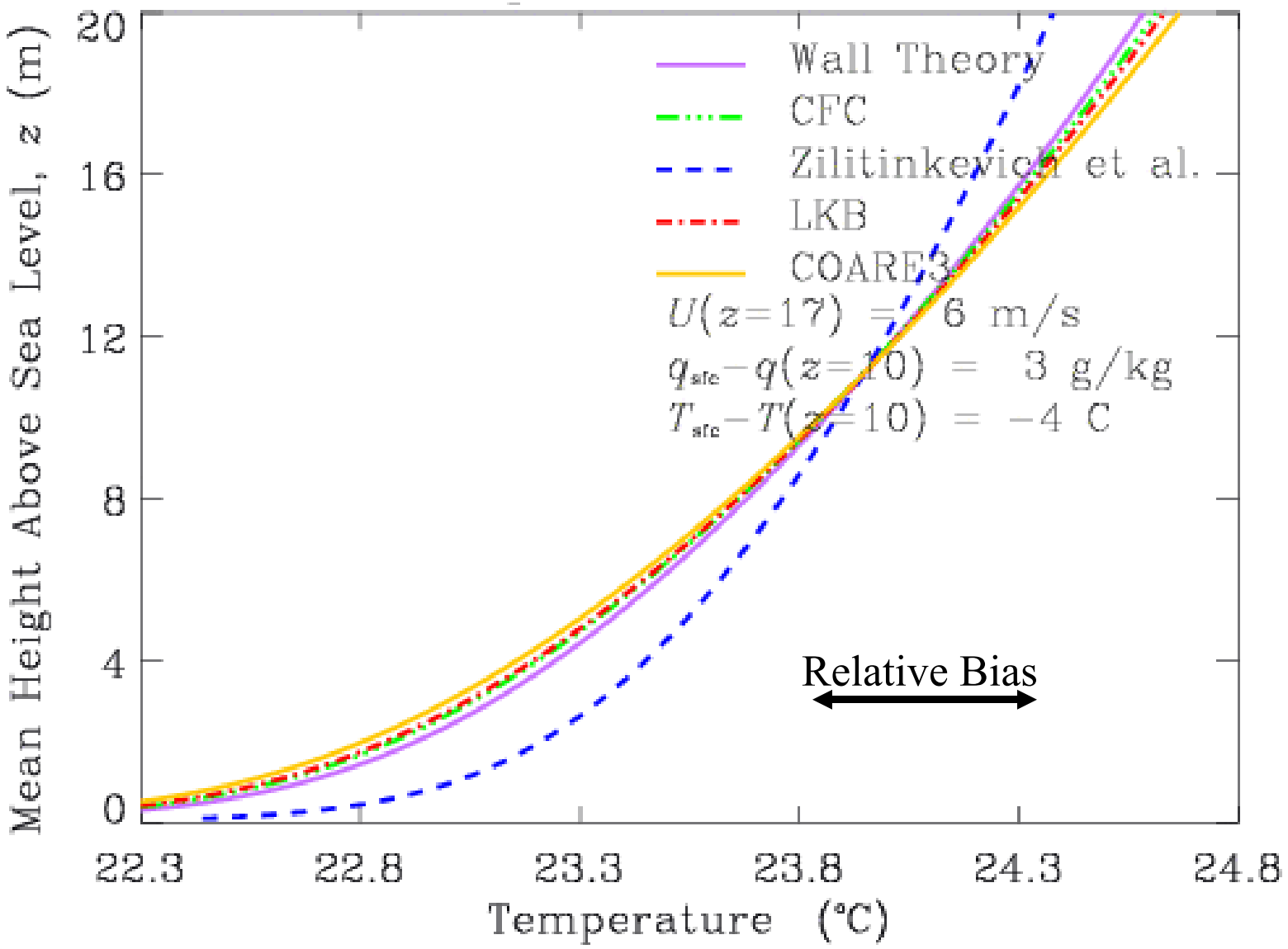
- Five parameterizations of roughness lengths for temperature and moisture are examined:
  - Wall theory (BVW; Bourassa et al. 1999)
  - Clayson, Fairall, and Curry (CFC, 1996)
  - Liu, Katsaros, and Businger (LKB, 1979)
  - Zilitinkevich et al. (2001)
  - COARE3.0 (Fairall et al.)
- All the above parameterizations are coupled with
  - Momentum roughness length (Bourassa 2006)
  - Atmospheric Stability
    - Stable: Beljaars and Holtslag (1991)
    - Unstable: Benoit's (1977)

Example: Wind Profile

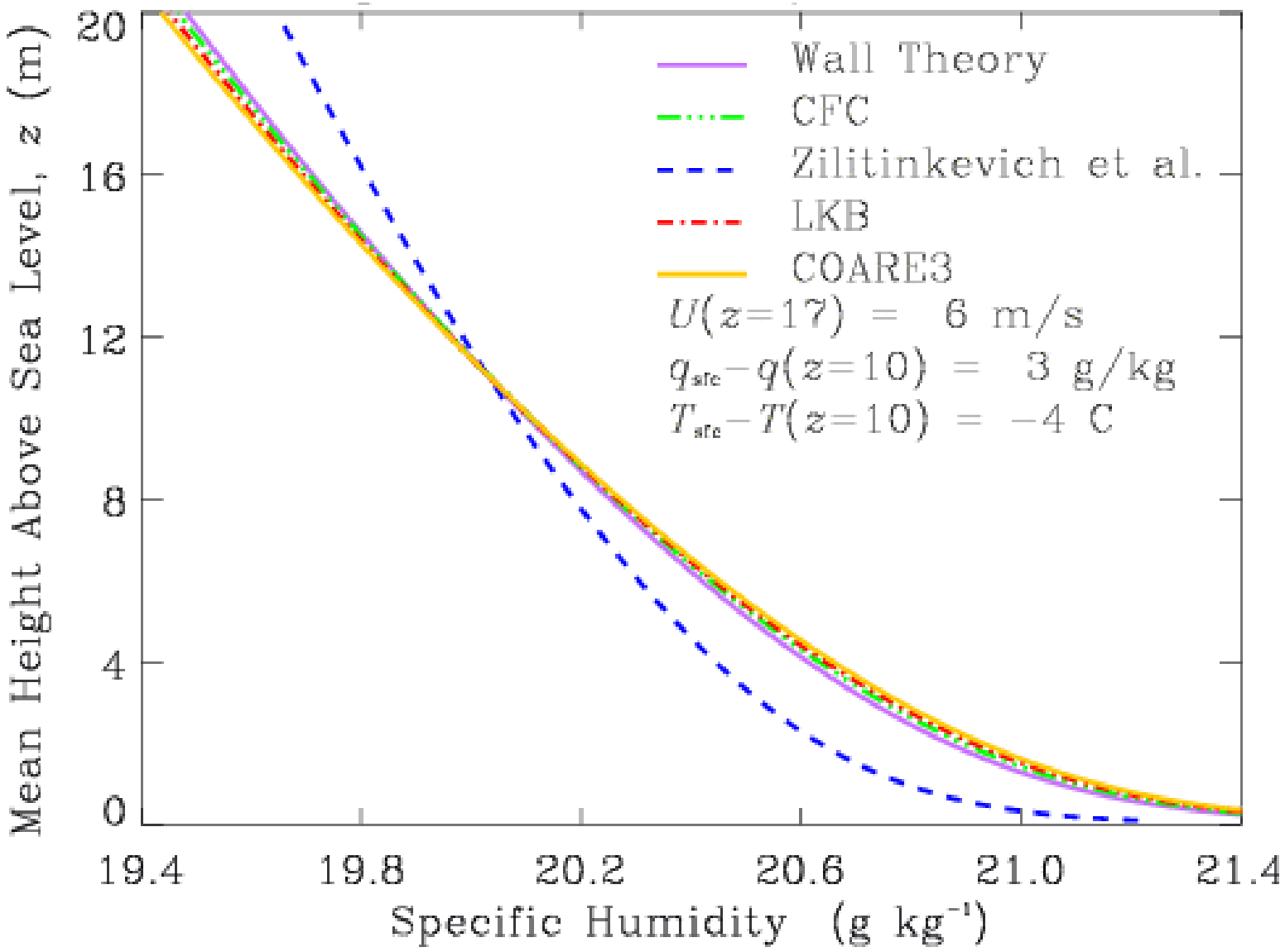


- Wind speeds are measured at a fixed height, and assumed to be relative to the surface.
- Temperatures are measured at a different lower height.
- In this case (unstable stratification), there is little dependence of the wind profile on the heat and moisture roughness length parameterizations.

Example: Temperature Profile (Stable)

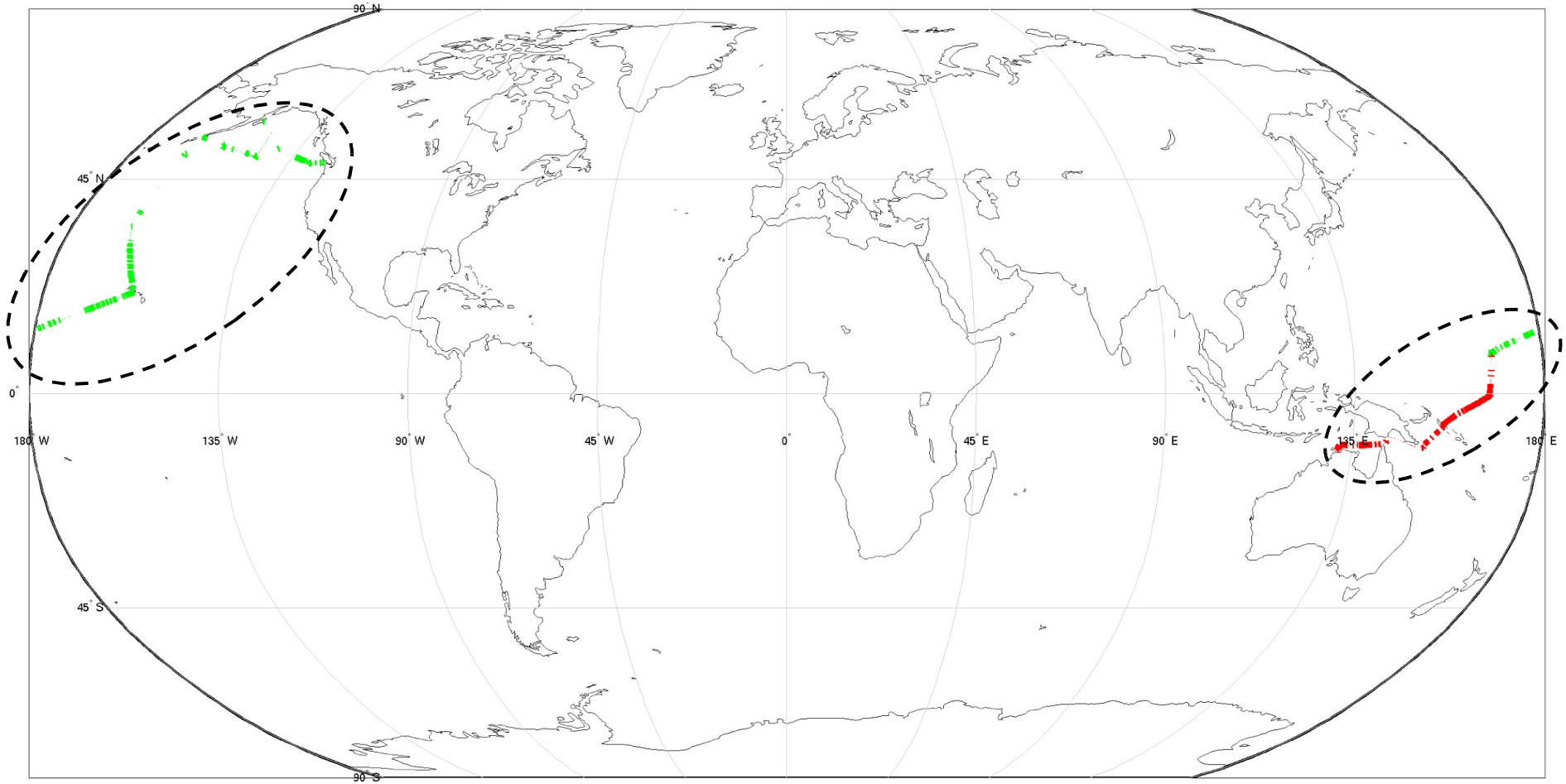


Example: Humidity Profile (Unstable)

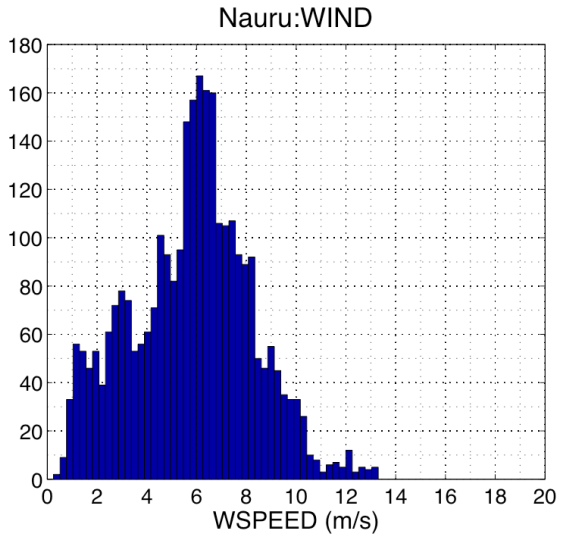


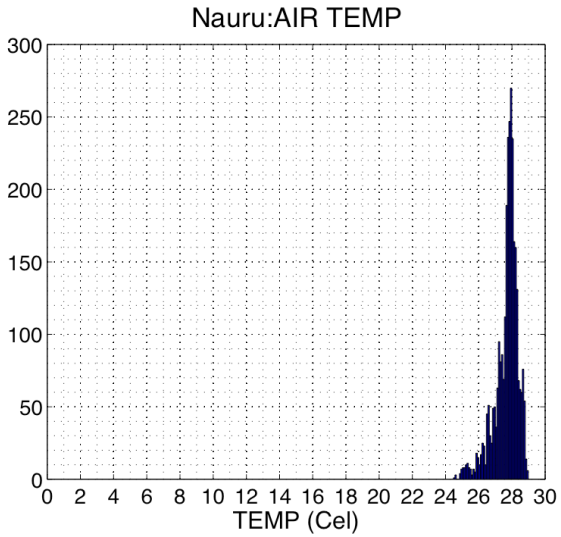
Data Used: Nauru99 & Moorings

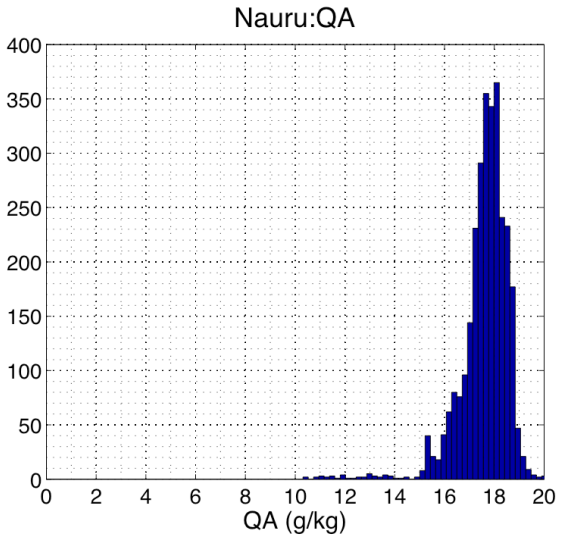
Red: NAURU99 ship track
Greed: MOORINGS

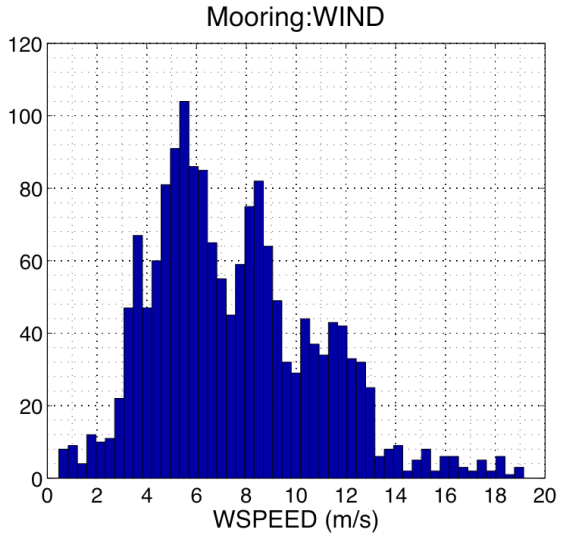


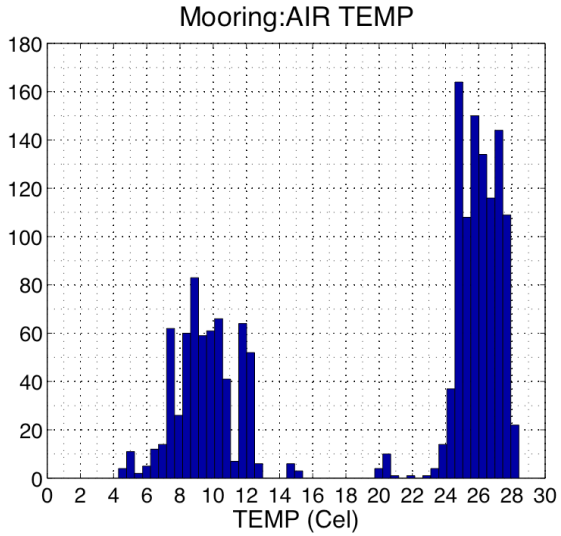
Ship Environments

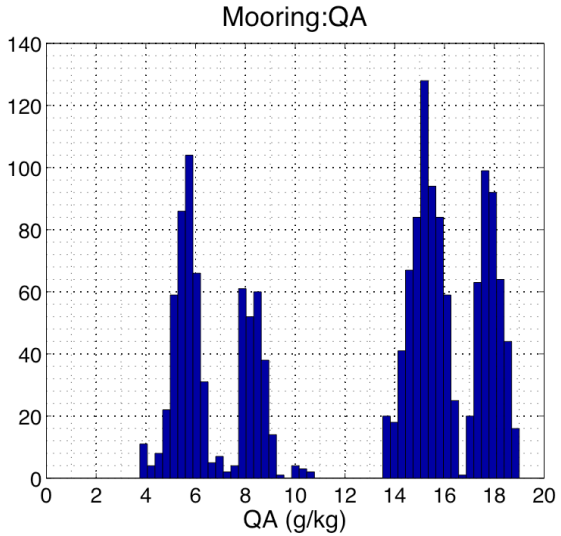




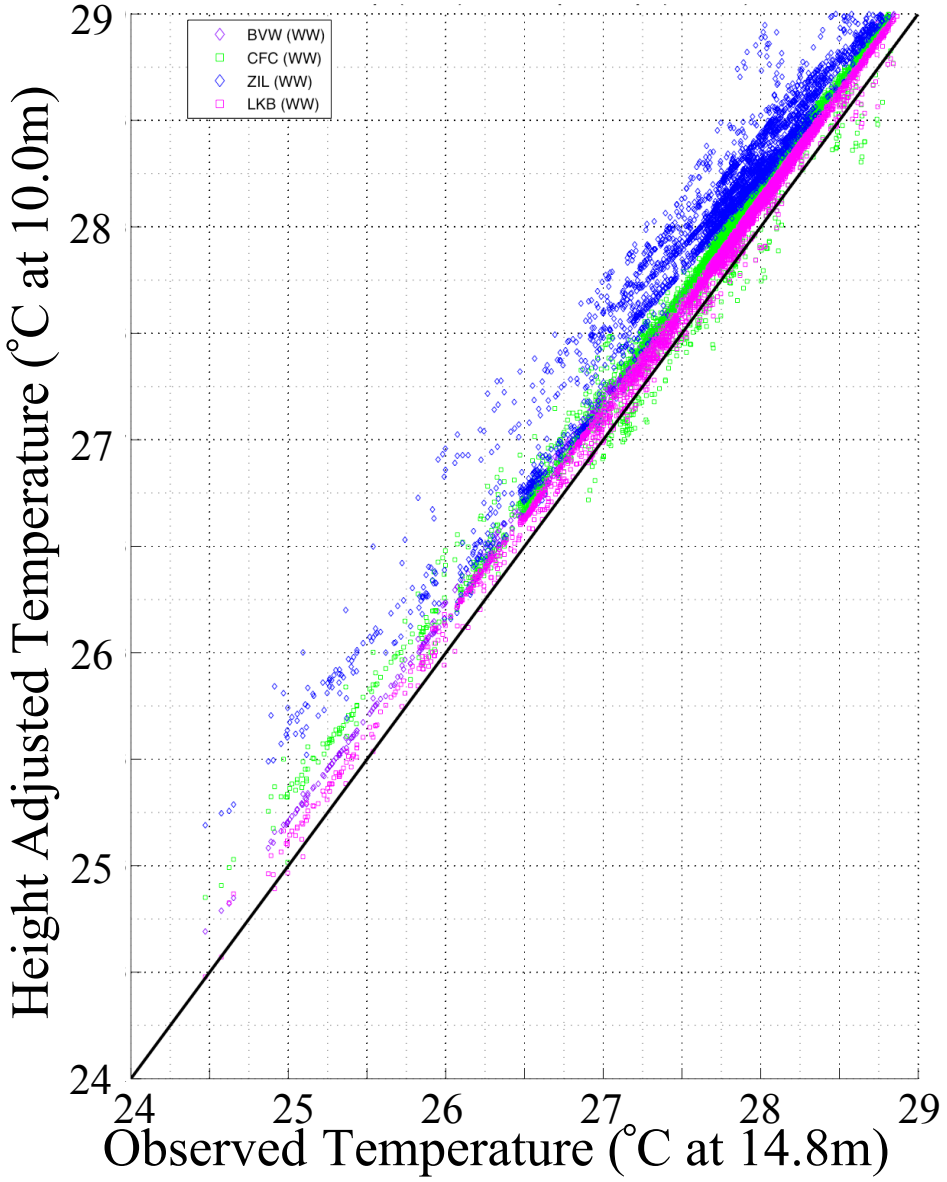






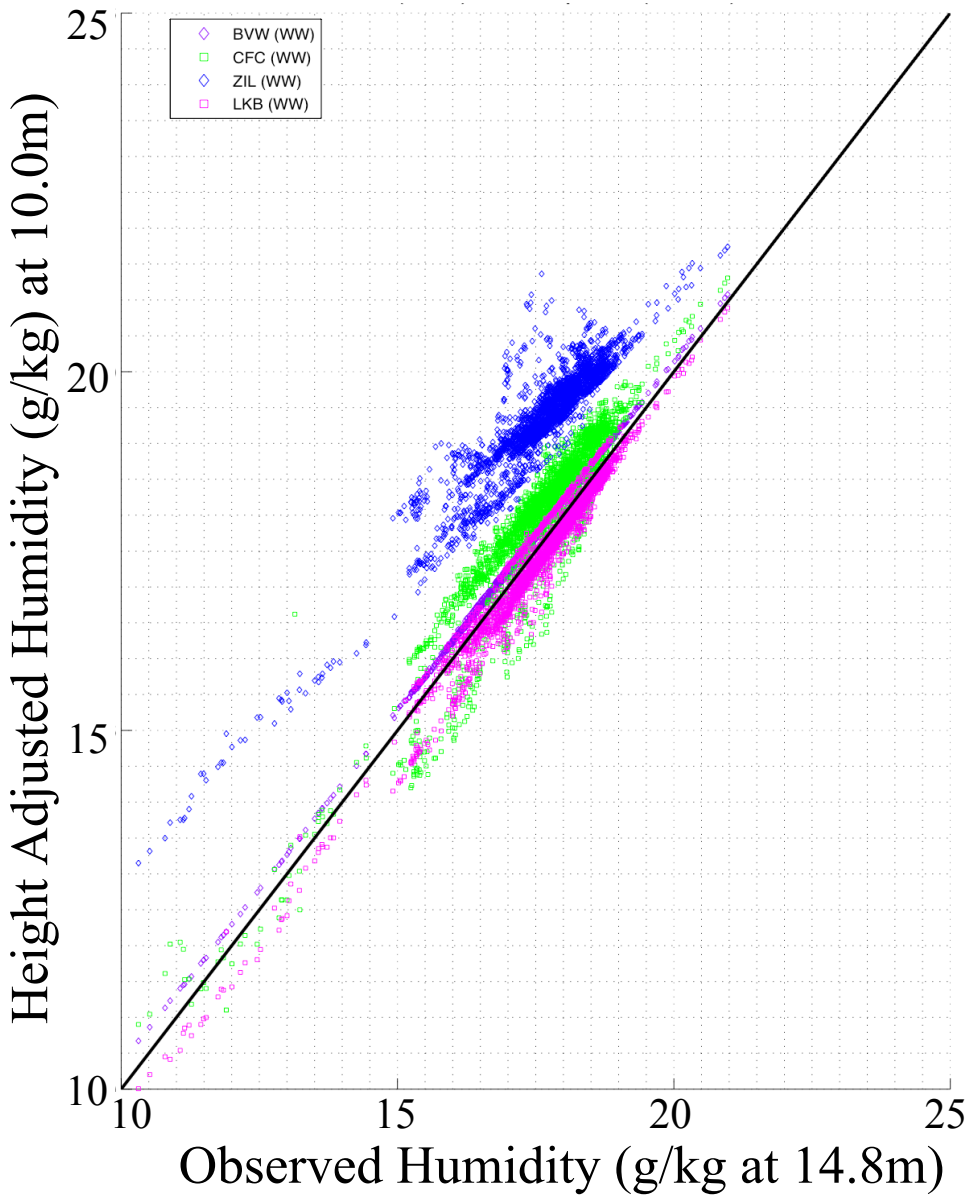


Temperature Impacts of Height Adjustments - NAURU



- Wall Theory
- CFC
- Zilitenkevich et al.
- LKB

Humidity Impacts of Height Adjustments - NAURU



- Wall Theory
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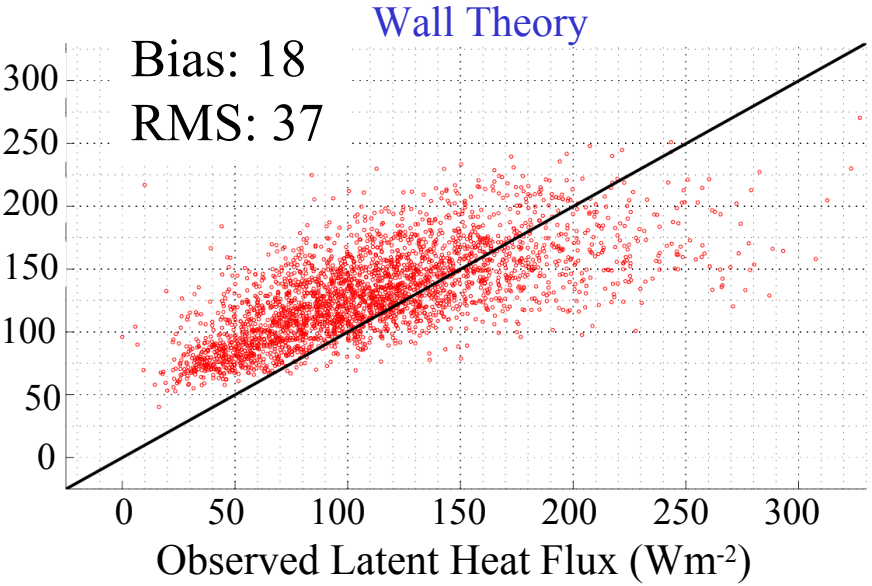
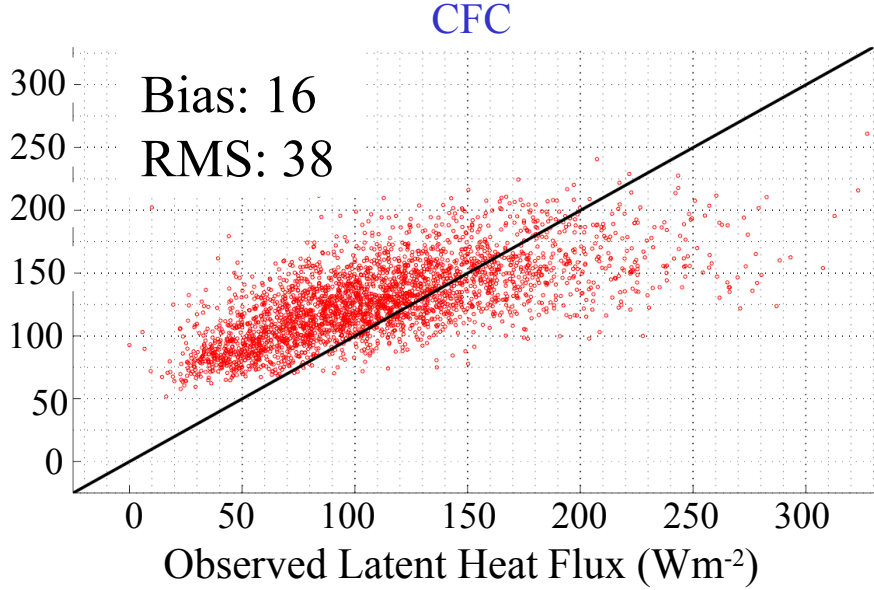
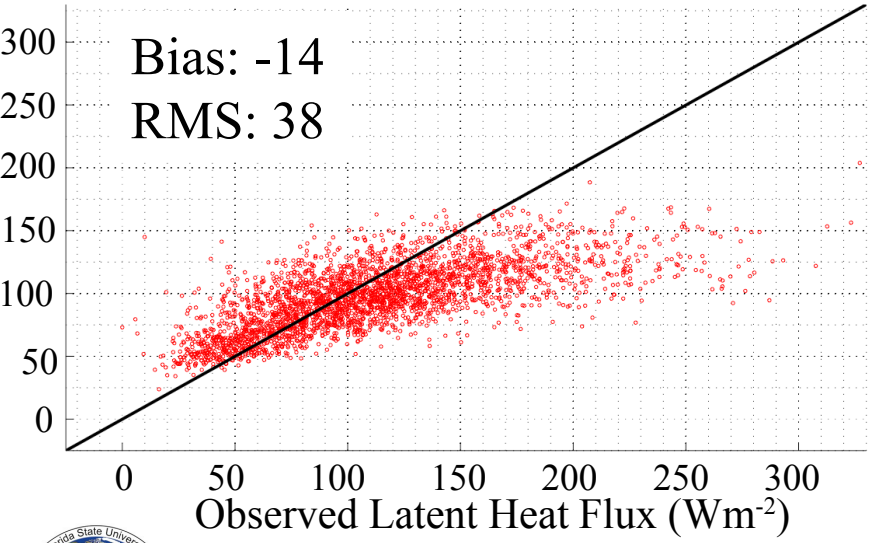
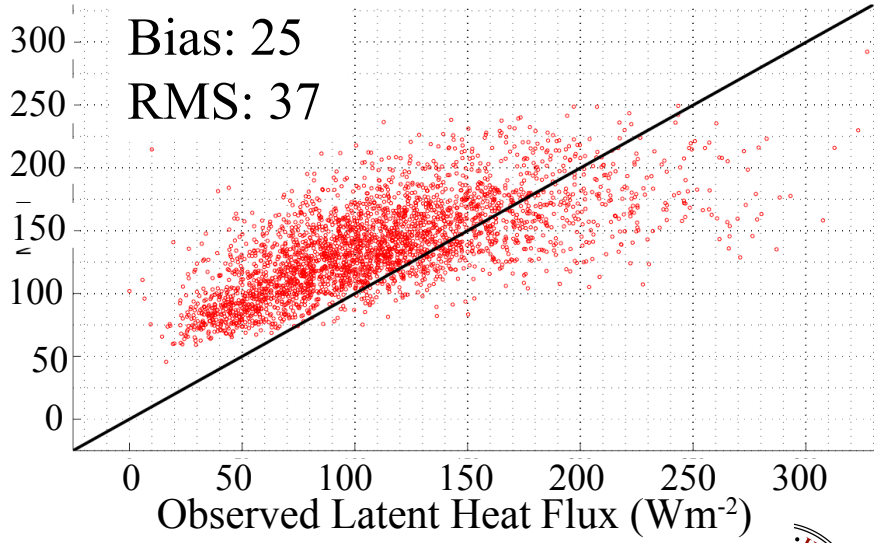
Impact on Latent Heat Flux - NAURU





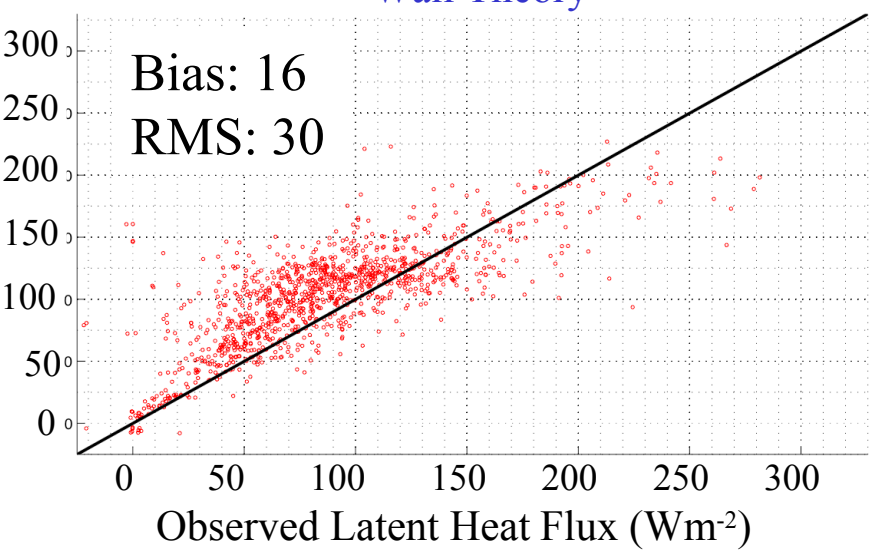
Modeled Latent Heat Flux (Wm^{-2})

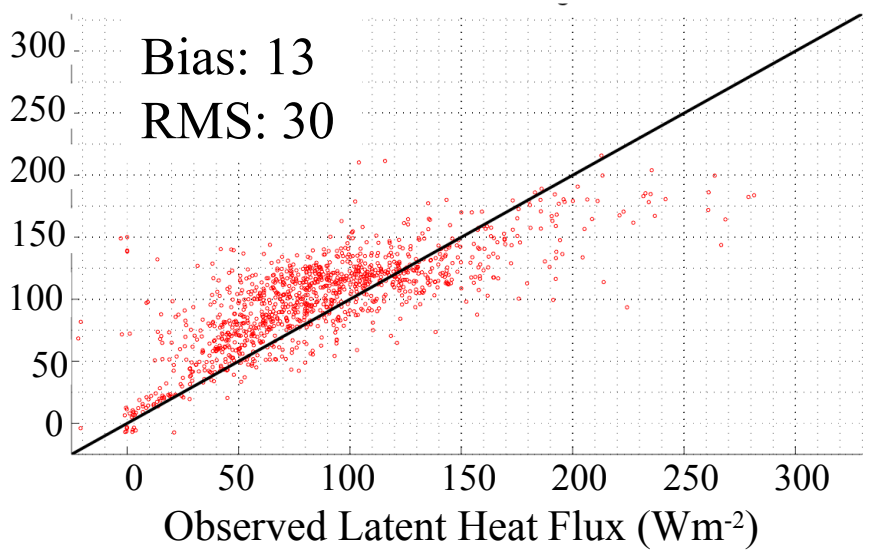


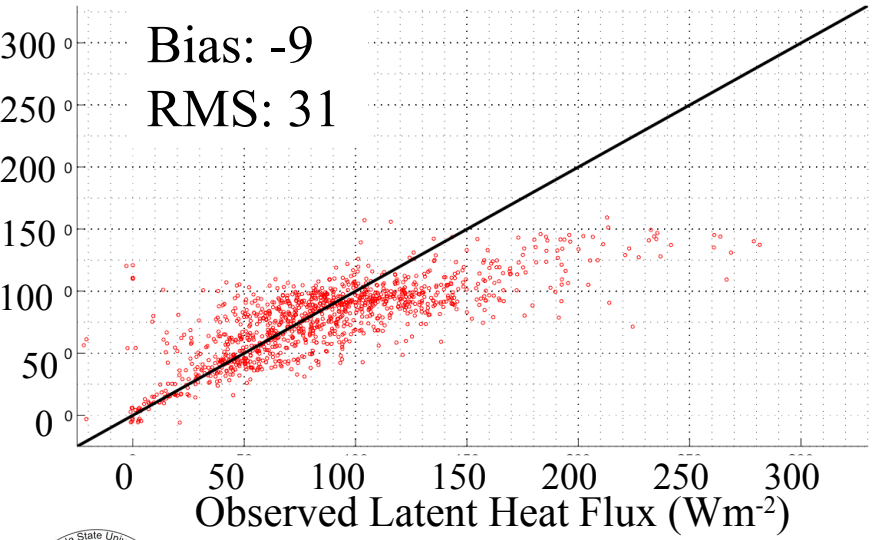


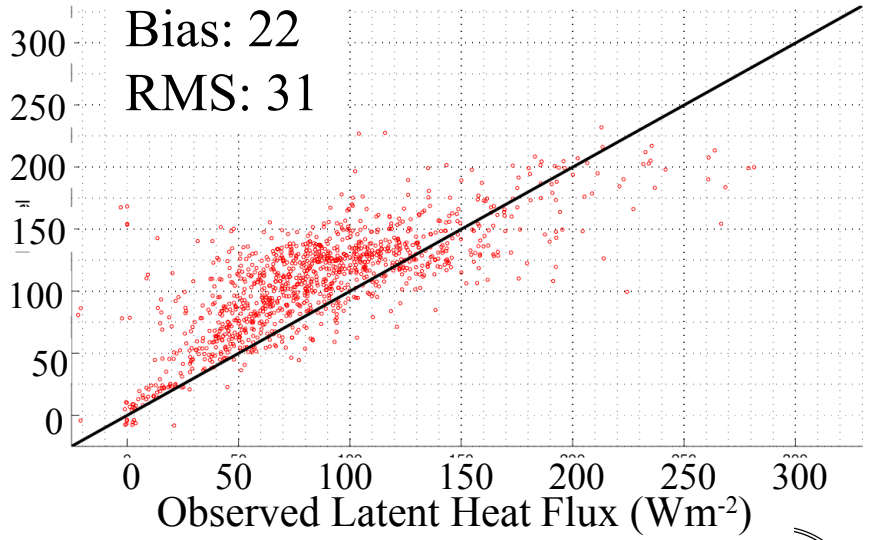
Comparison between modeled and Observed fluxes.

Impact on Latent Heat Fluxes - Moorings





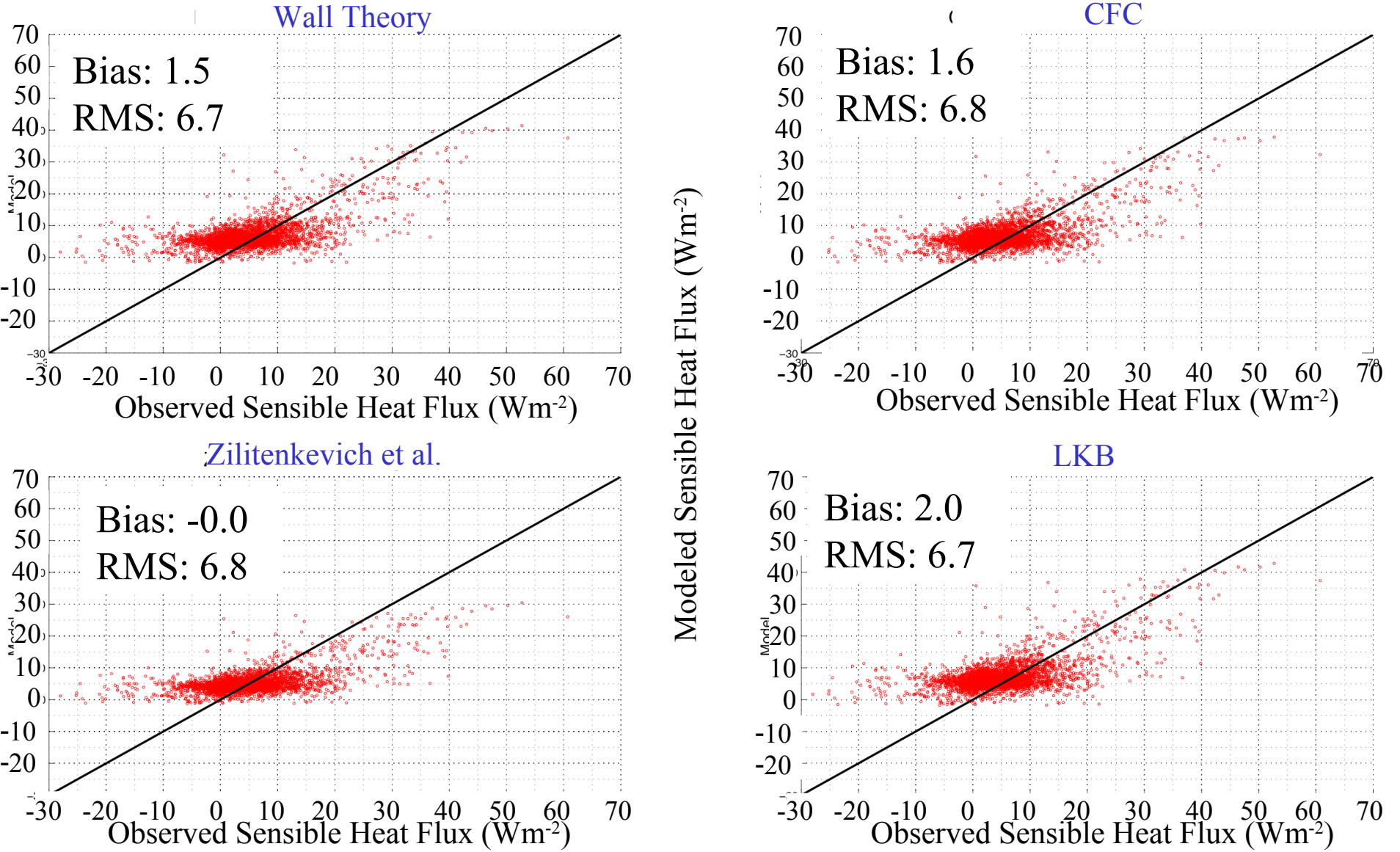




Modeled Latent Heat Flux (Wm^{-2})

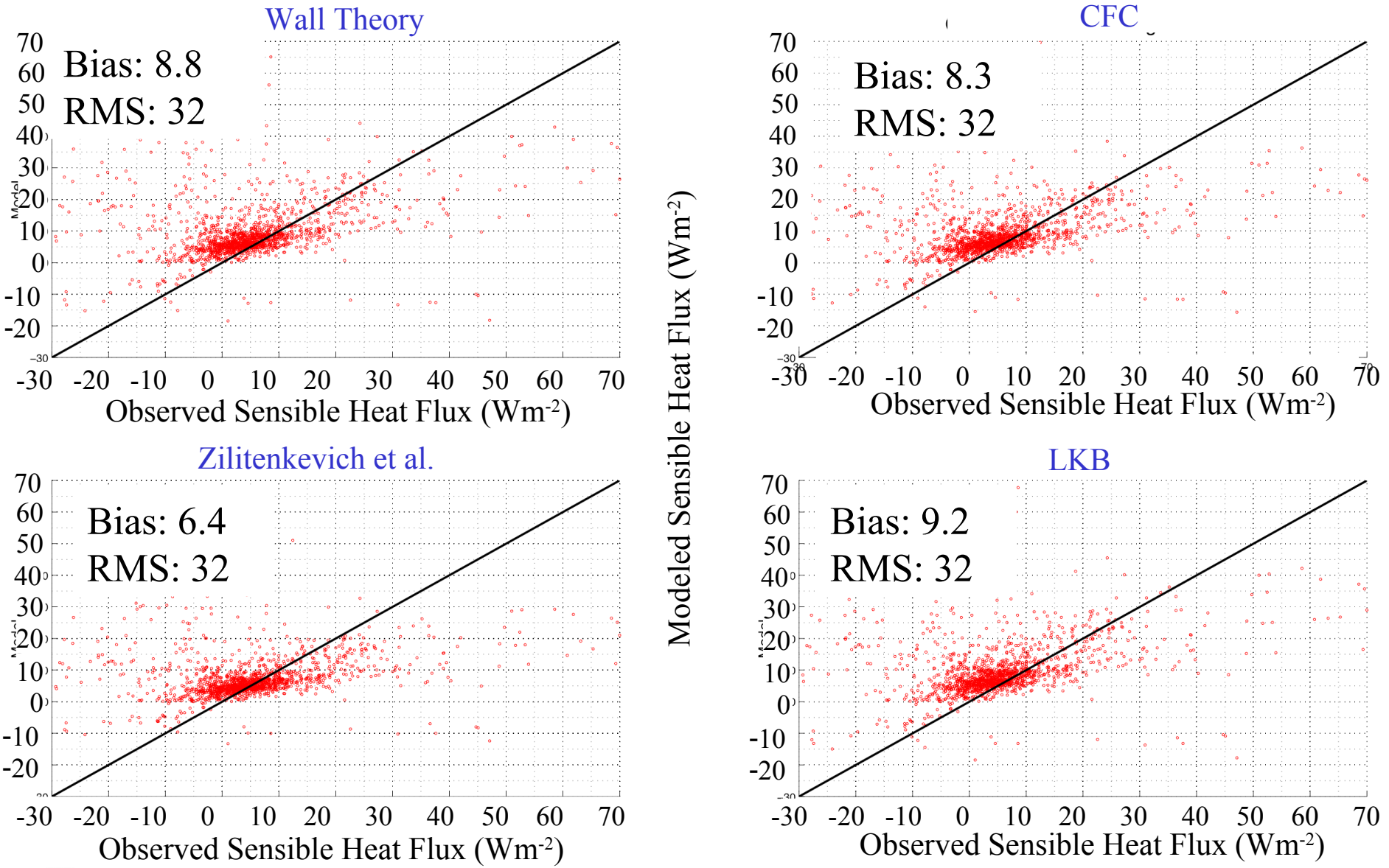
Comparison between modeled and Observed fluxes.

Impact on Sensible Heat Fluxes - NAURU



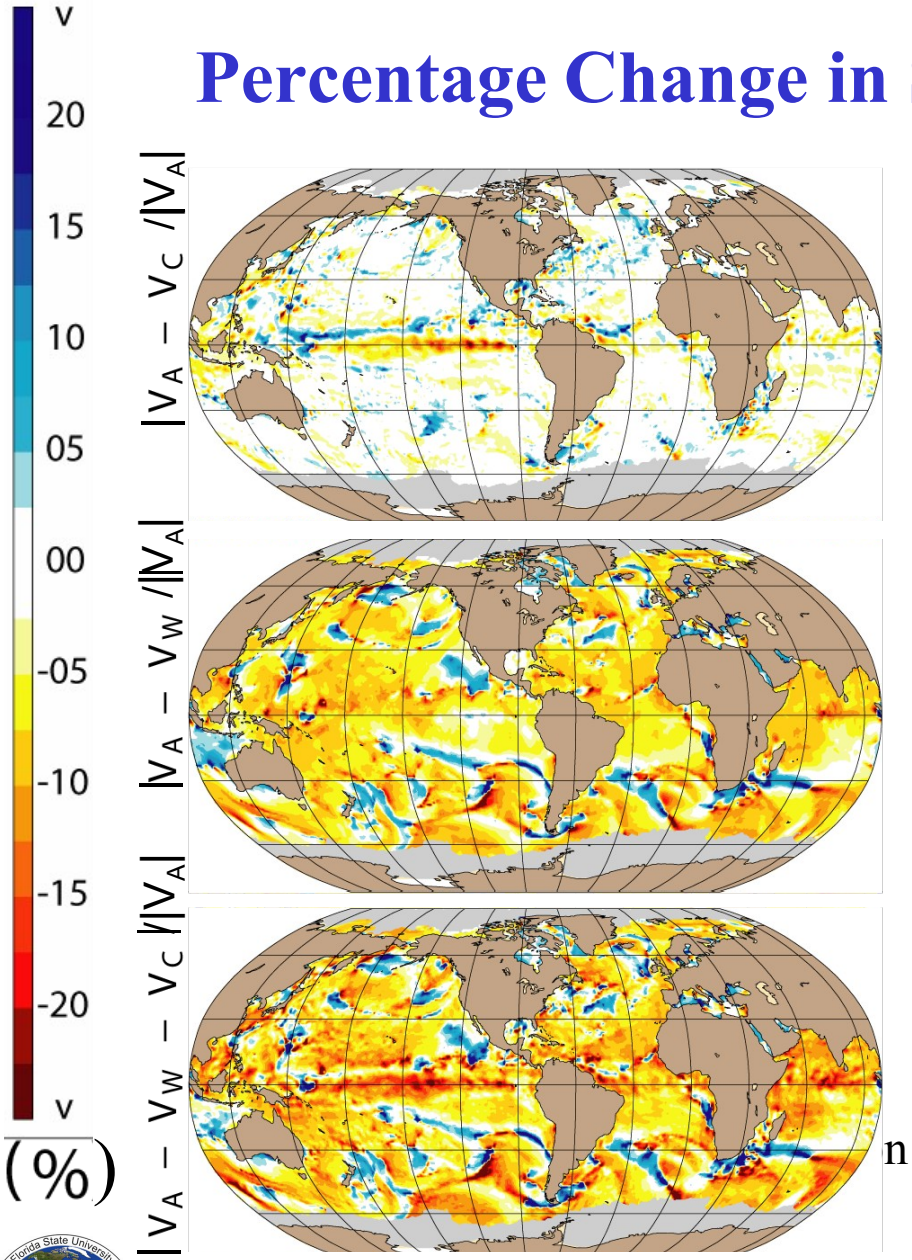
Comparison between modeled and Observed fluxes.

Impact on Sensible Heat Fluxes - Moorings



Comparison between modeled and Observed fluxes.

Percentage Change in Surface Relative Winds



- The percentage change in surface relative winds is roughly proportional to the change in energy fluxes.
- The percentage change squared is roughly proportional to changes in stress.
- The drag coefficient also changes by about half this percentage.
  - >50% changes in stress associated with strong storms!
  - Can have opposite change nearby.
  - Huge change in the curl of the stress!
  - Caveat: models uncoupled!

From *Kara et al.*, GRL, 2007

Conclusions

- Height adjustment could result in parameterization-related
  - Biases in 10m air temperature and humidity
  - Biases in latent and sensible heat fluxes
  - Artificial trends due to influence of observation height on the bias
- Biases could be inconsistent between upward adjustments (buoys) and downward adjustments (ships).
- It would be useful to provide these ICOADS users (and people working on reanalyses) with bias adjustments for observation height, but ONLY AFTER other instrument-related biases are considered.

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On the Order of Things