Using observations from the GPM core satellite to infer sources of error in HRRR precipitation forecasts

Janice L. Bytheway and Christian D. Kummerow

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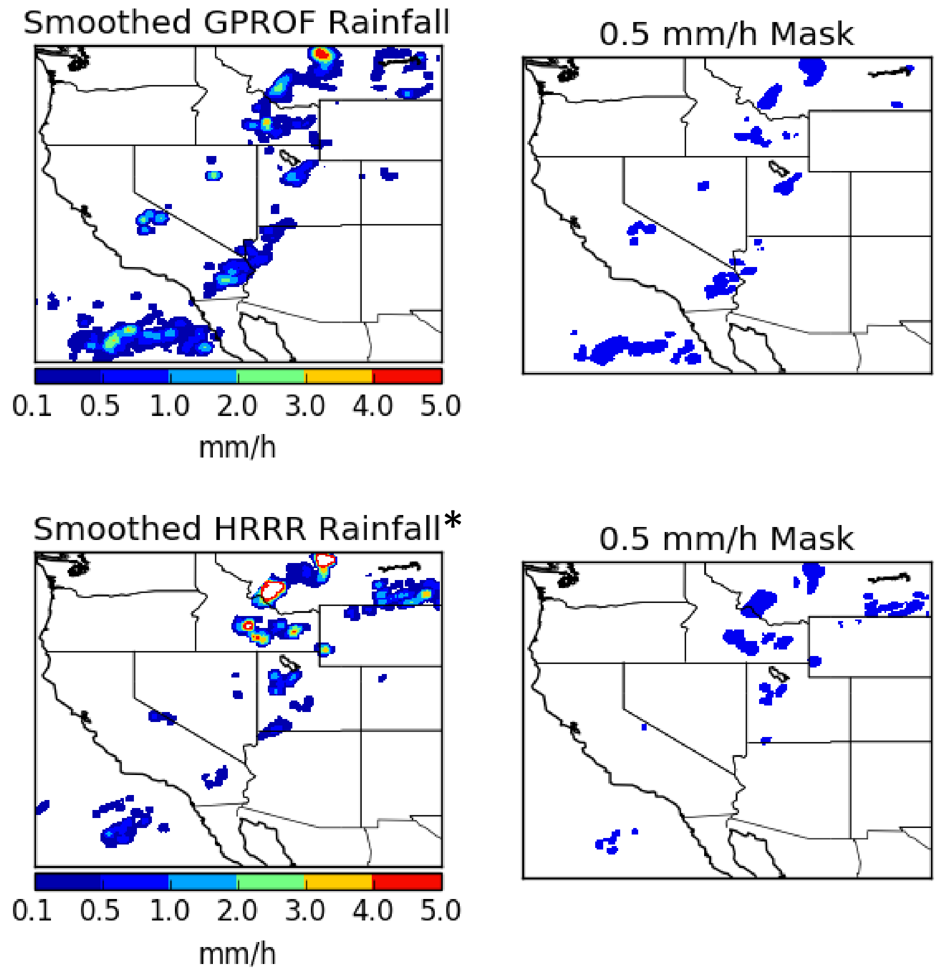
janice@atmos.colostate.edu

Introduction

- Many improvements to models in recent years
  - Increased resolution
  - Improved assimilation
  - Assimilation of cloudy and precipitation-affected observations
- High Resolution Rapid Refresh (HRRR)
  - High spatial and temporal resolution
  - Convection allowing
  - Radar reflectivity assimilation (diabatic initialization)
  - Transitioned to operational status in September 2014
- Still very difficult to forecast precipitation
  - Nonlinear relationship between observations and model variables
  - Difficulty expressing errors
  - Not typically validated
- Variety of products available from GPM core satellite ideal for assessment of precipitation forecasts (GPROF, 2AKu, GMI, 2BCMB)

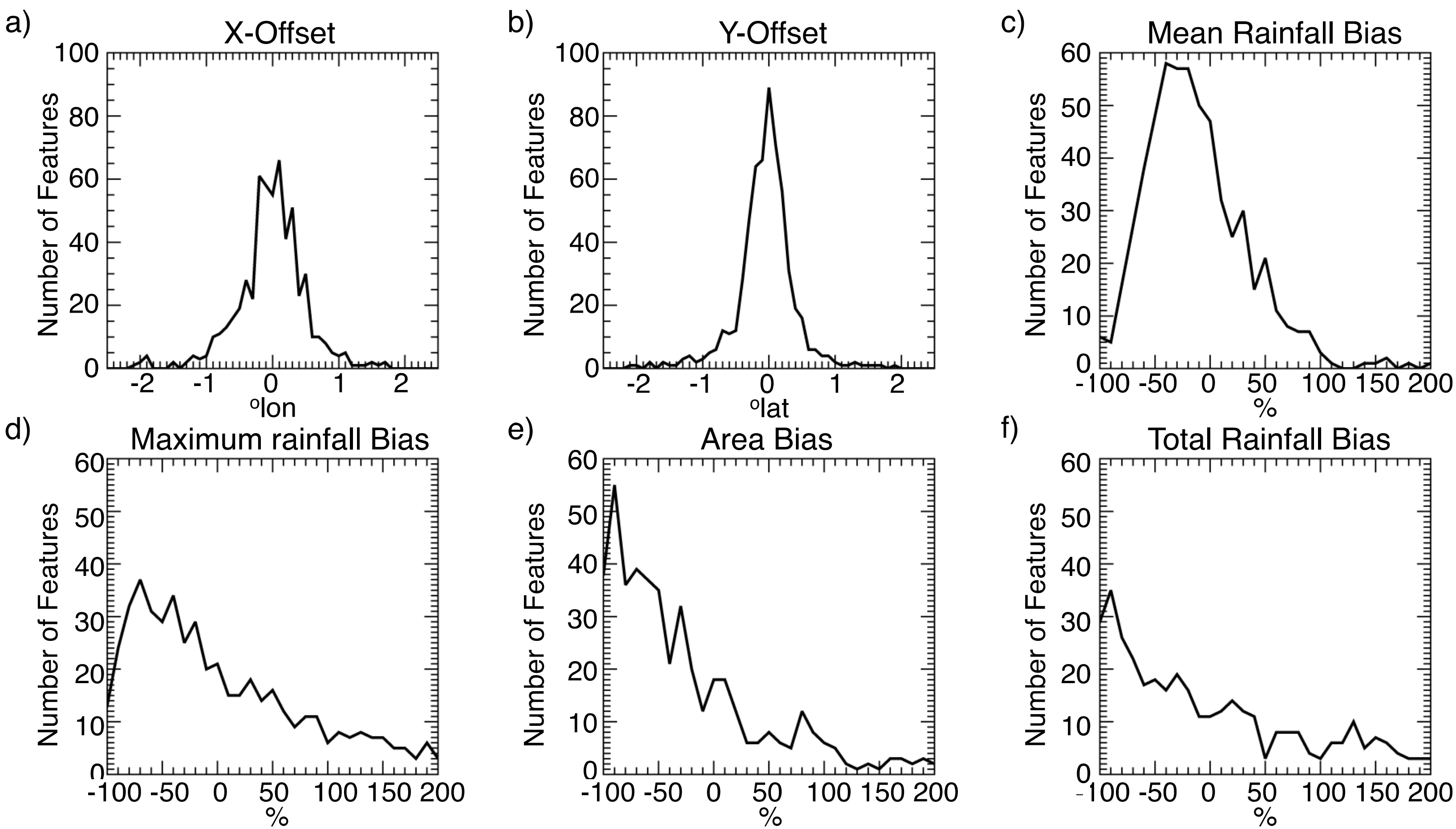
A Feature-based Assessment

- Based on the Method for Object-based Deterministic Evaluation (MODE) described in Davis et al. [2006; 2009]
- Identify likely convective precipitating features of interest in model and observations.
  - Apply 15km smoothing to rain field and identify areas where hourly accumulation exceeds a selected threshold (0.5 mm/h)
  - Maximum observed hourly rainfall exceeds 10 mm/h
  - Area within a selected isohyet exceeds 250 km^2 (obs only)
- Find observed/forecast feature pairs.
  - 585 identified over 2014-2015 warm season (JJA)
- Create a database of observed/forecast precipitating features and associated properties.



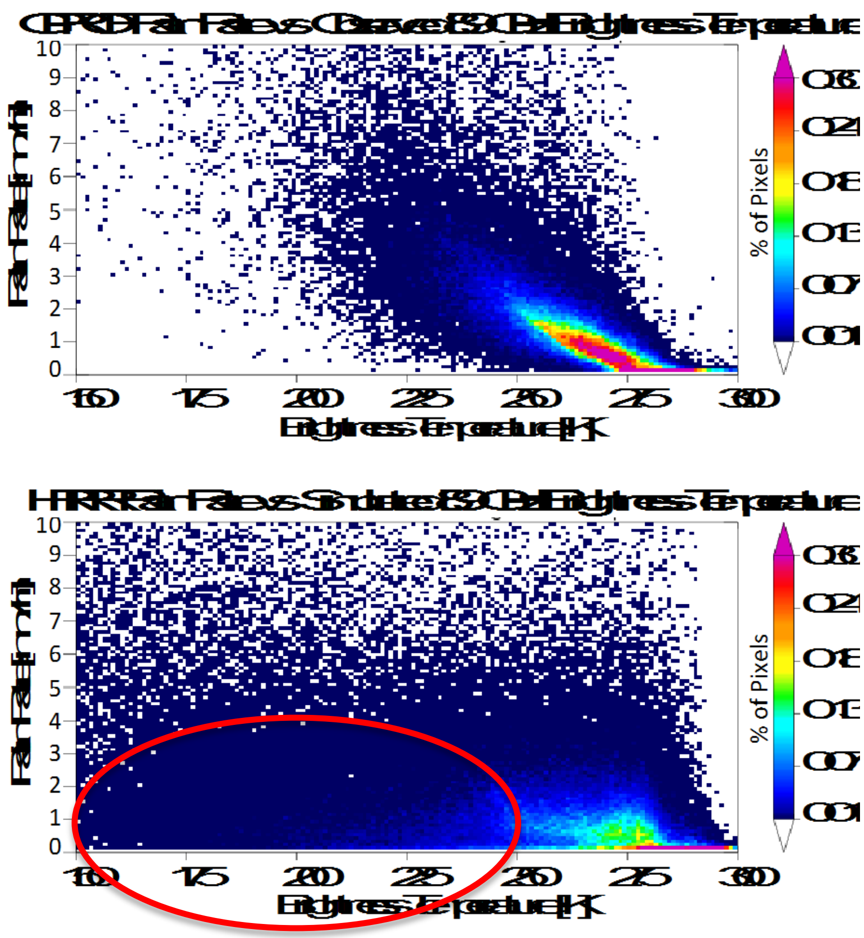
*Within GMI swath only

Validation Results (GPROF vs. HRRR)

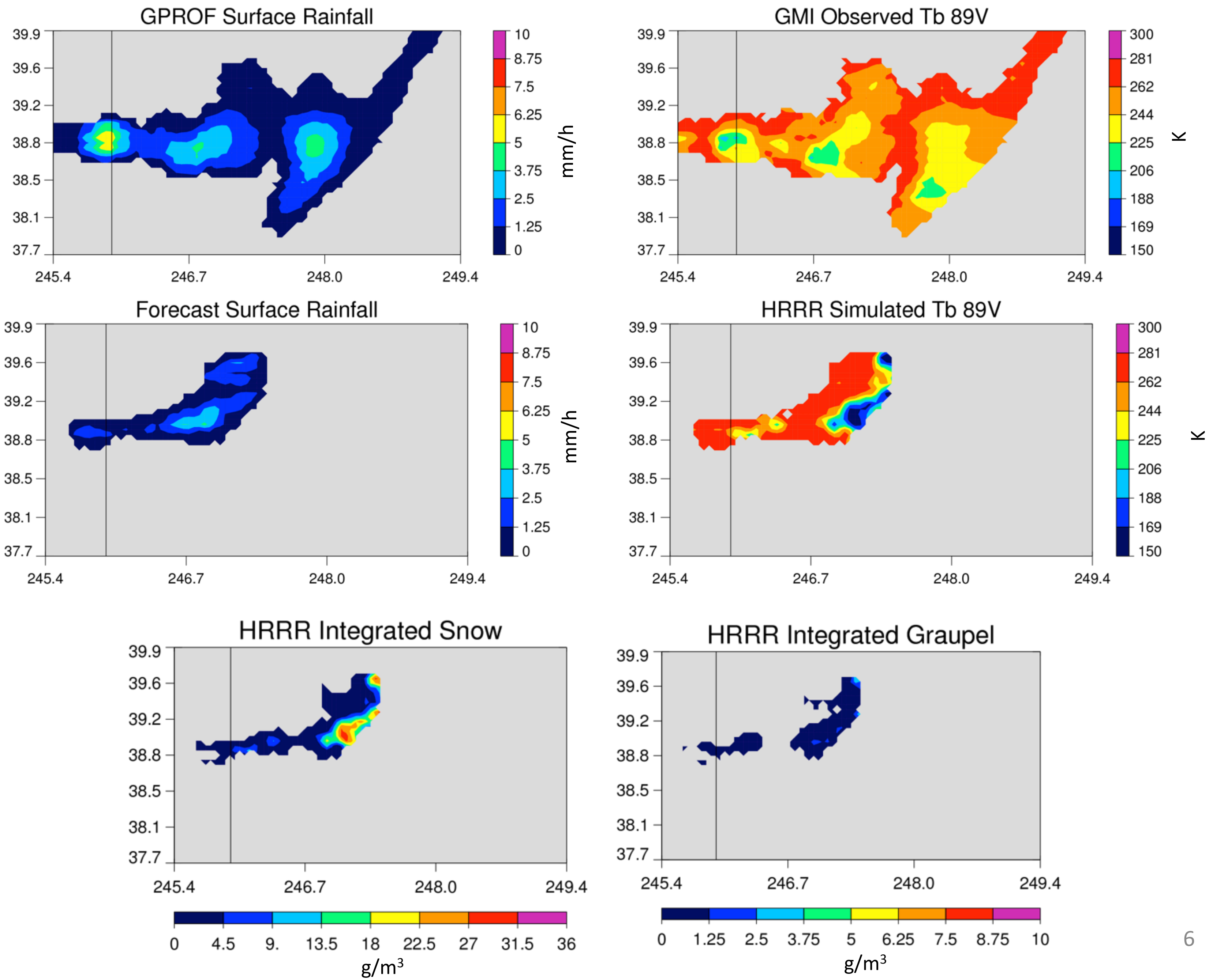


What can GPM observations tell us about WHY the low biases exist?

- Simulate radiances and reflectivities at GMI/Ku frequencies using HRRR atmospheric and hydrometeor output
  - Maintain particle density, and DSD slope and shape parameters from Thompson microphysics
  - Tbs: Eddington approximation
  - Reflectivity: QuickBeam (Haynes et al., 2007)



26 July 2014, 06 UTC



Is there anything that can be done in the simulation microphysics, while maintaining total overall water content, to bring simulated Tbs and reflectivities more in line with observed?

- “Melt” snow to rain when T > 270K
- **“Melt” snow to cloud**
  - **100% at T> 270K**
  - **50% at 260K < T < 270K**
- Transfer snow graupel
- Increase/**decrease snow density**
- Increase/decrease ice density
- Increase/**decrease graupel density**
- Increase/decrease intercept parameter (N_o) in rain
- Increase/decrease N_o snow
- **Increase**/decrease **N_o graupel**

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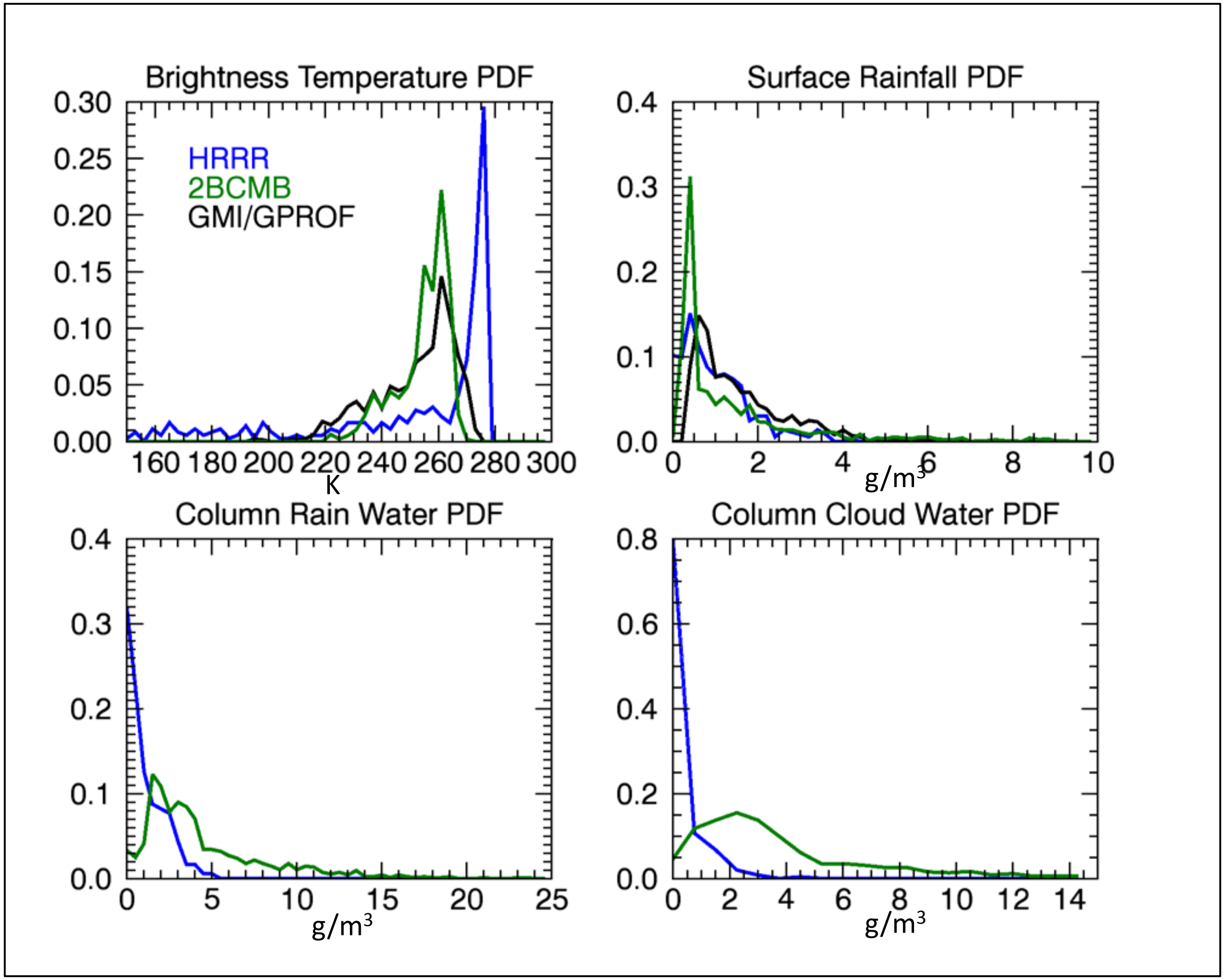
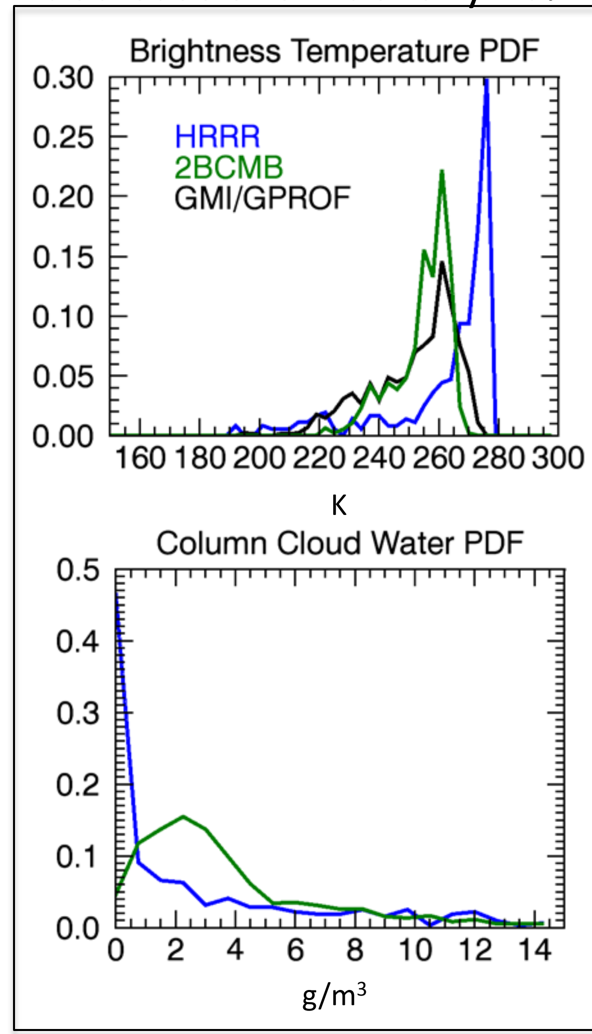
Combine and increase magnitude of changes to see if further improvement can be made

- Decrease snow density 75%
- "Melt" snow to cloud
  - 100% at T > 265K
  - 75% at 260K < T < 265
  - 40% at 255K < T < 255

Original

“Melt” snow to cloud
and
decrease snow density 40%





Why does there appear to be improper partitioning between ice and liquid hydrometeors?

Hypothesis: Model updrafts are too weak, and are therefore not lofting liquid hydrometeors very far above the freezing level

Reflectivity Profiles as a Proxy for Updraft Strength

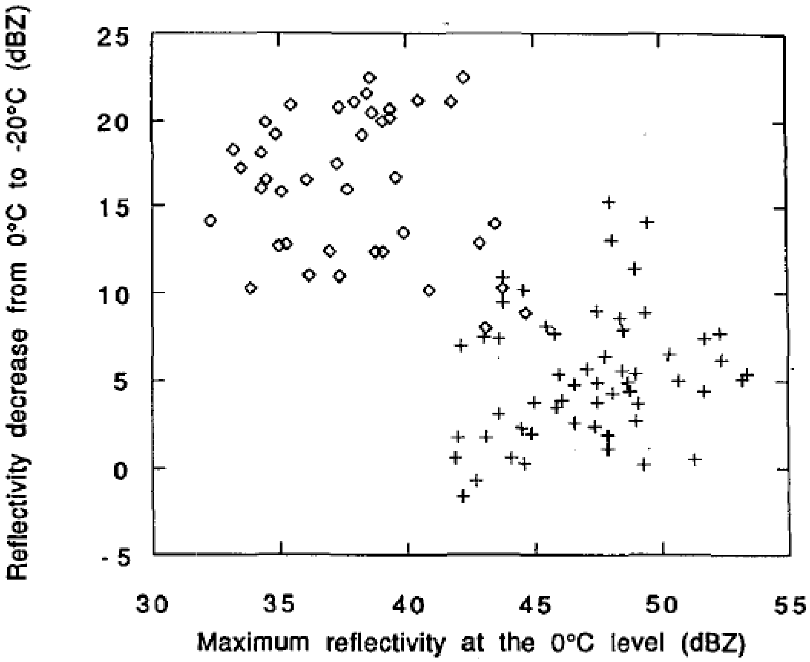
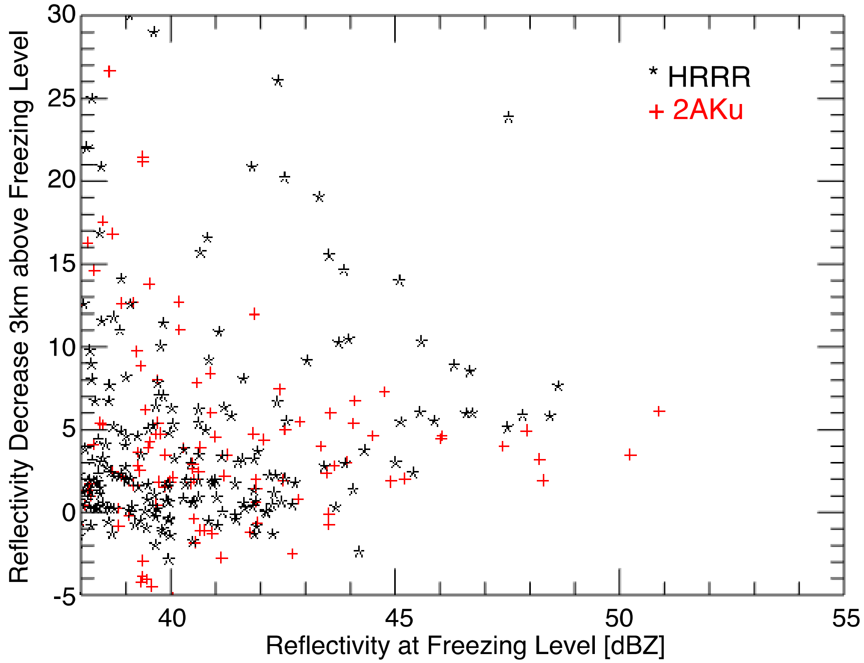


FIG. 5. Scatter diagram of the decrease in reflectivity with height over the lowest 3 km above the freezing level versus the maximum reflectivity at the freezing level for the tropical oceanic cells (diamonds) and the midlatitude continental cells (crosses).



Zipser and Lutz 1994

Conclusions

- Observations and products from the GPM core satellite can be compared to output and simulations from forecast models to validate and better understand model performance
- HRRR tends to under-forecast warm-season precipitation in the western US
- Forecast hydrometeor profiles from the HRRR appear to partition water incorrectly among species
- Weak updrafts potentially result in rapid freezing of lofted hydrometeors, resulting in lighter rain and colder brightness temperatures than observed.