Pre-Launch Assessment of the GOES-R Rainfall Rate Algorithm Using Current GOES

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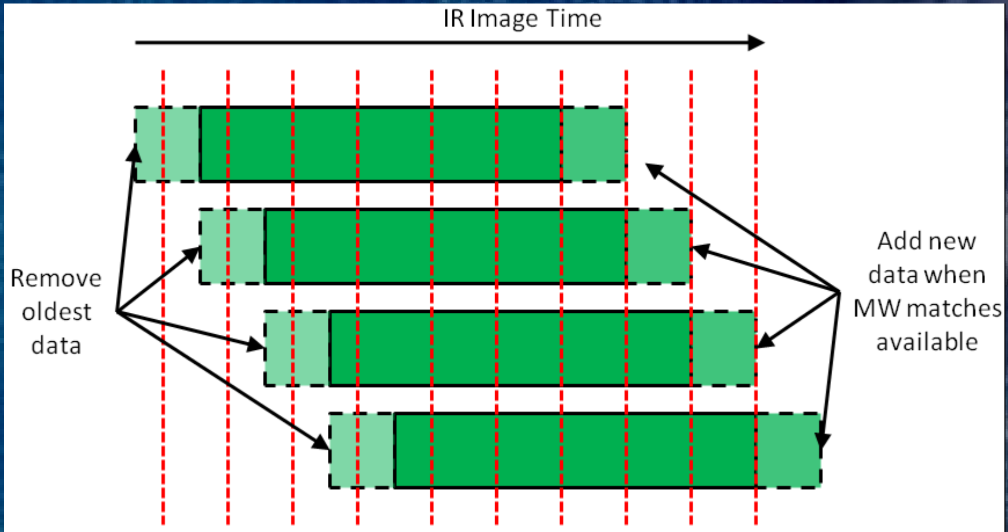
Algorithm Overview

- The GOES-R Rainfall Rate algorithm will produce estimates of instantaneous rain rate every 15 min on the ABI full disk at the IR pixel resolution (~ 2 km) with a latency of less than 5 min from image time.
  - Primary focus is operational flash flood forecast support
- The rain rates will be derived from the ABI IR bands, calibrated against rain rates from MW instruments.
- This will allow the rapid refresh and high spatial resolution of IR data from GEO while attempting to capture the accuracy of MW rain rates from LEO.
- A version of this algorithm modified for current GOES has been running in real time since August 2011 in support of GOES-R Proving Ground activities.

Calibration: Matched MW-IR Data

- Start with a rolling-value matched MW-IR dataset with 15,000 pixels with rates of at least 2.5 mm/h, which is updated whenever new MW rain rates become available.
  - MW rain rates are from the CPC combined MW (MWCOMB) dataset



Calibration: Cloud Types

- Divide pixels into ~~three~~ two types:
  - ~~Type 1 ("water cloud"): $T_{7.34}$<$T_{11.2}$ and $T_{8.5}$-$T_{11.2}$<-0.3~~
  - ~~Type 2 ("ice cloud"): $T_{7.34}$<$T_{11.2}$ and $T_{8.5}$-$T_{11.2}$≥-0.3~~
    - (No 8.5 µm on current GOES; combined into 1 type: $T_{6.7}$<$T_{11.0}$)
  - Type ~~3~~2 ("cold-top convective cloud"): ~~$T_{7.34}$~~$T_{6.7}$≥$T_{11.2}$
- Divide pixels by each latitude band (60-30ºS, 30ºS-EQ, EQ-30ºN, 30-60ºN).
- Maintain separate matched data sets for each class (~~3~~2 cloud types x 4 latitude bands = ~~12~~8 classes)

Calibration: GOES Predictors

- Use data from ~~5 ABI~~ 2 GOES bands (~~6.19~~, 6.7, ~~7.34,~~ ~~8.5~~, 11.2, ~~12.3~~ µm) to create a total of ~~8~~4 predictors:

~~$T_{6.19}$~~ $T_{6.7}$	~~$T_{8.5} - T_{7.34}$~~
$S = 0.568-(T_{min,11.2}-217\ K)$	~~$T_{11.2} - T_{7.34}$~~ $T_{11.2}-T_{6.7}$
$T_{avg,11.2} - T_{min,11.2} - S$	~~$T_{8.5} - T_{11.2}$~~
~~$T_{7.34} - T_{6.19}$~~	~~$T_{11.2} - T_{12.3}$~~

» (Note that these predictors were selected from a much larger initial set)

Calibration: Nonlinear Predictor Transformation

- Since the relationship between the IR predictors and rainfall rates are most likely nonlinear, regress all ~~8~~4 predictors against the rainfall rates in log-log space to produce ~~8~~4 additional nonlinear rain rate predictors; i.e.,

$$y = \alpha\left(x + \gamma\right)^{\beta}$$

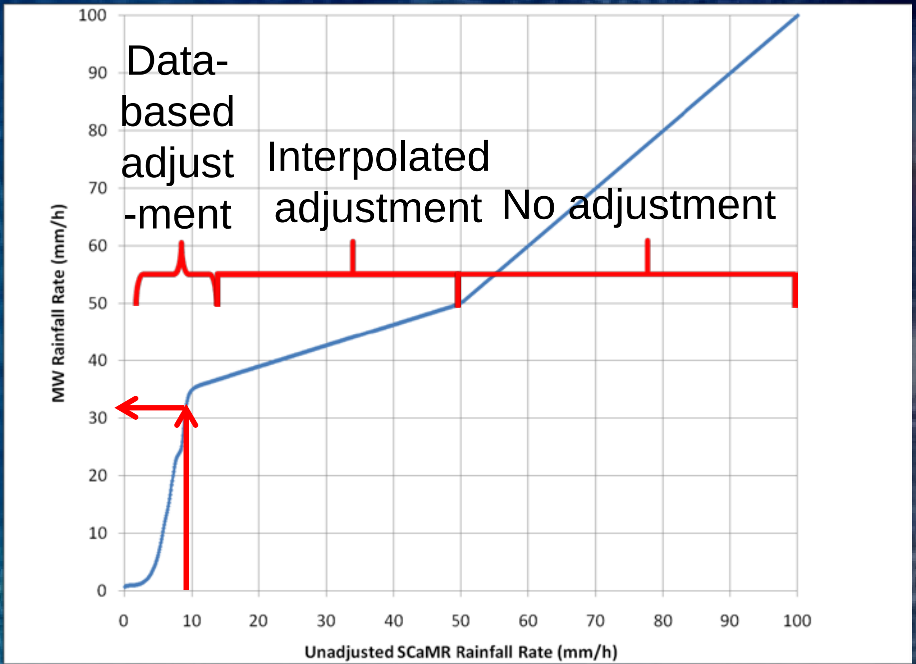
(the intercept γ is determined via “brute force”)

Two Calibration Steps

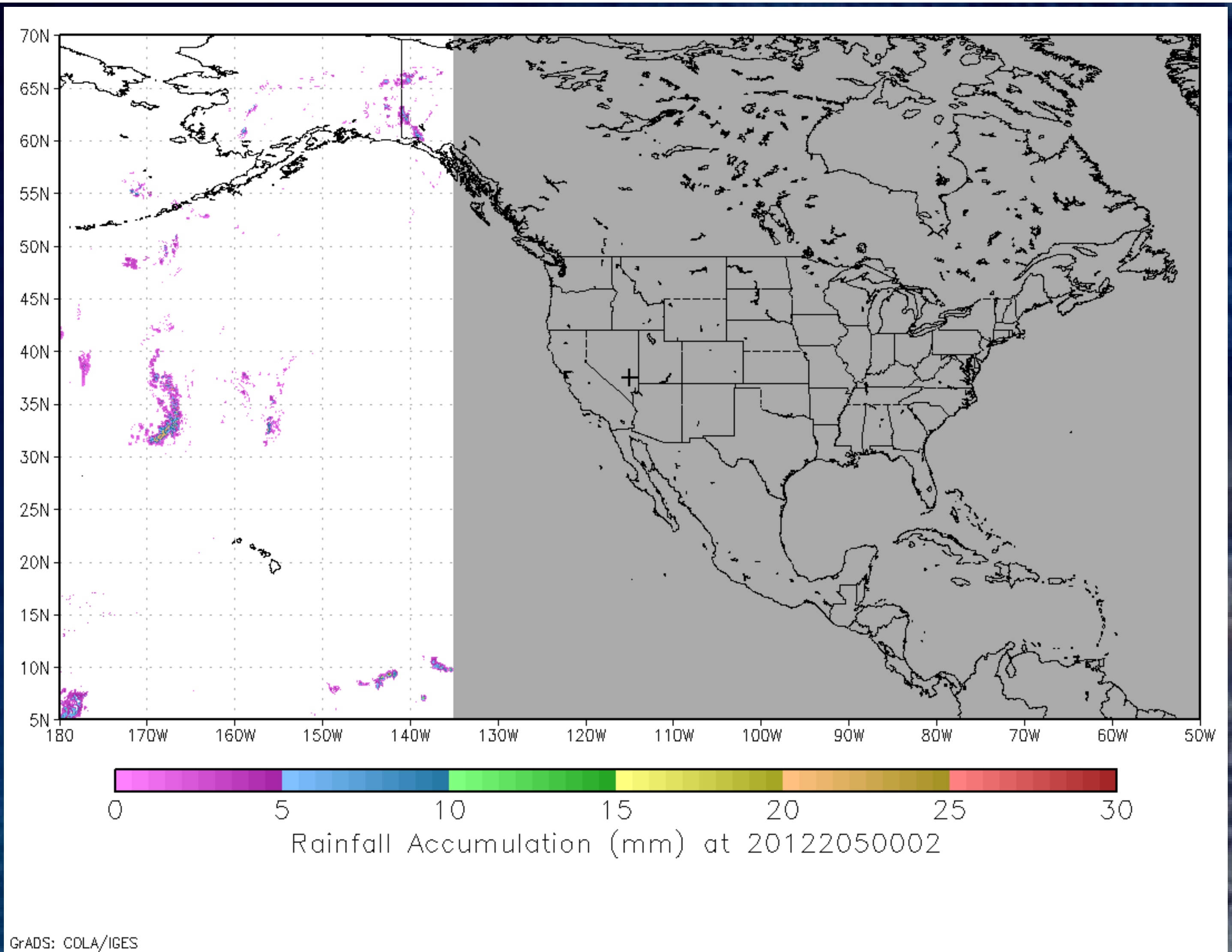
- Rain / no rain calibration using discriminant analysis and only linear predictors
  - » Optimize Heidke Skill Score for up to 2 predictors
- Rain rate calibration using stepwise forward linear regression on all predictors (raining MW pixels only)
  - » Optimize correlation coefficient for up to 2 predictors

Calibration: Distribution Adjustment

- After calibration, match the CDF of the retrieved rain rates against the CDF of the target MW rain rates
- Use the result to adjust the retrieved rain rates to match the target rain rate distribution.

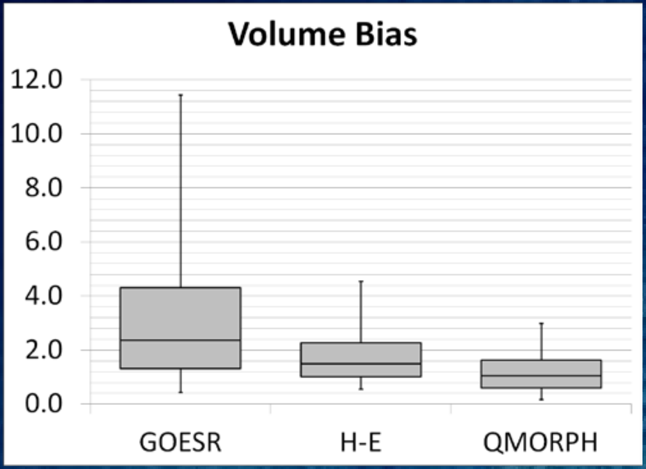


Example: 23 July 2012

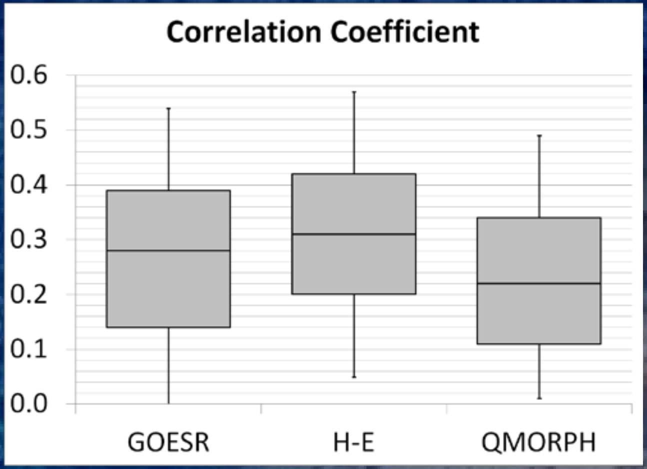


Algorithm Performance: CONUS Version

- Comparison of CONUS (2-band) algorithm run on current GOES with H-E, validated against Stage IV/MPE 1-h totals
- Validation for 22 August 2011 – 1 September 2012



Significantly stronger wet bias than H-E



Slightly worse correlation coefficient than H-E

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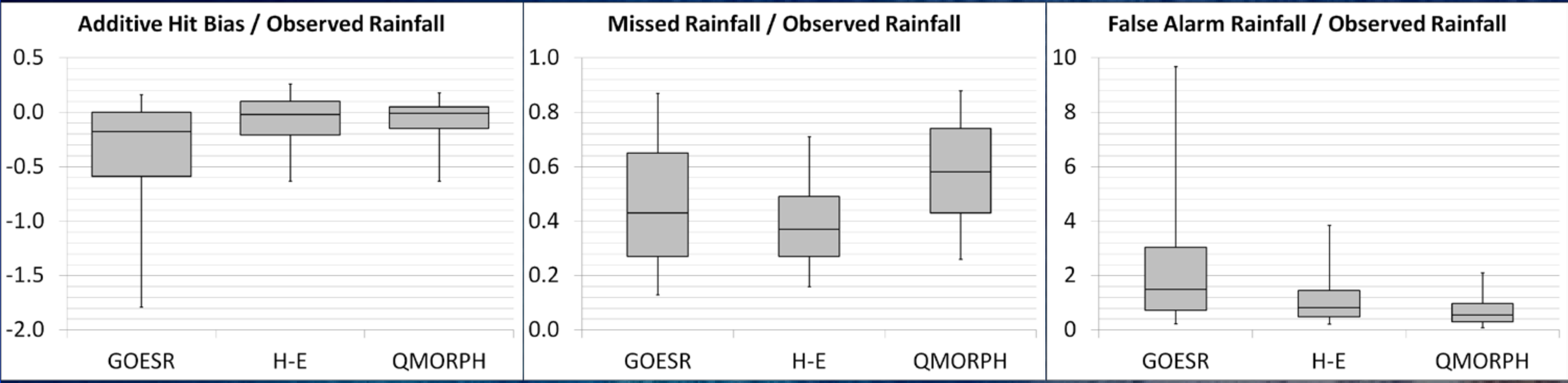
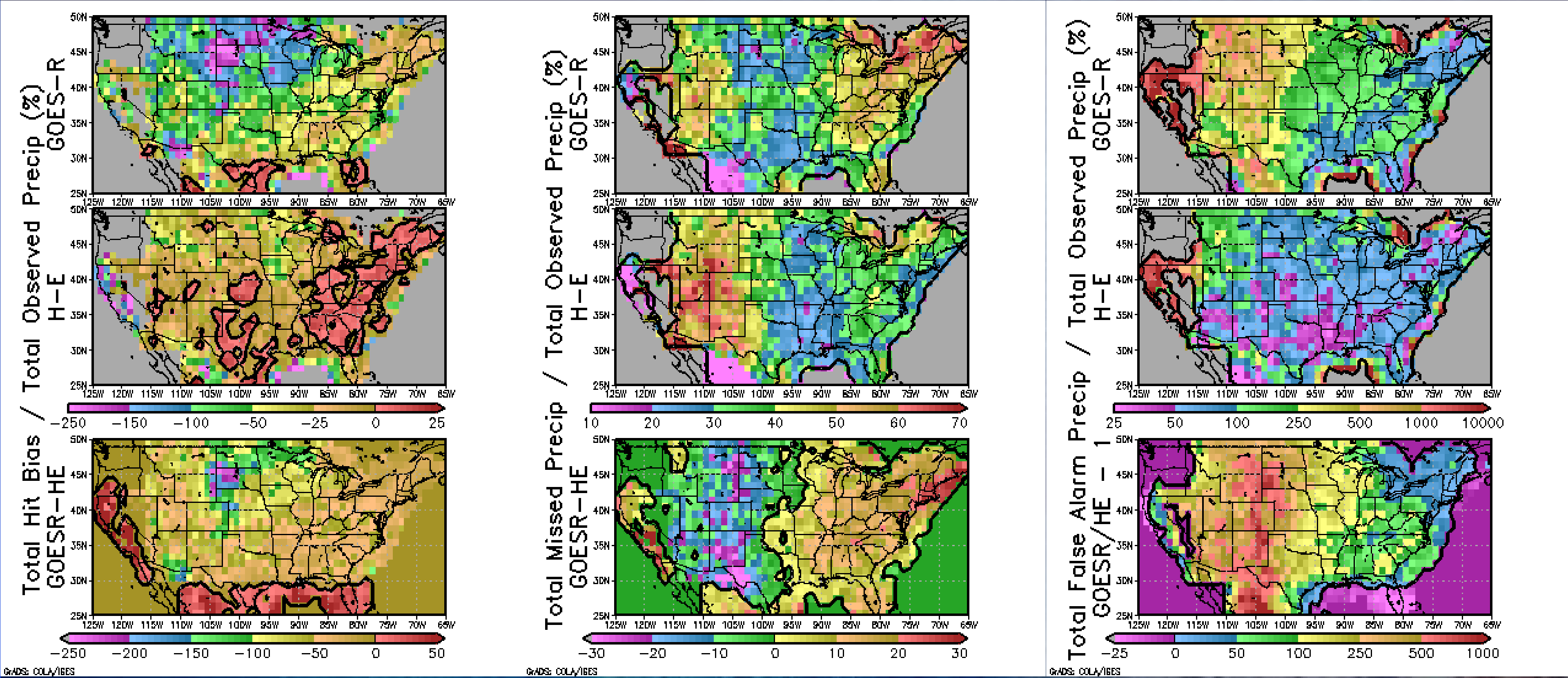


Stronger dry bias compared to H-E for "hit" pixels

Slightly more missed rainfall than H-E

Significantly more false alarm rainfall than H-E

Algorithm Performance: CONUS Version



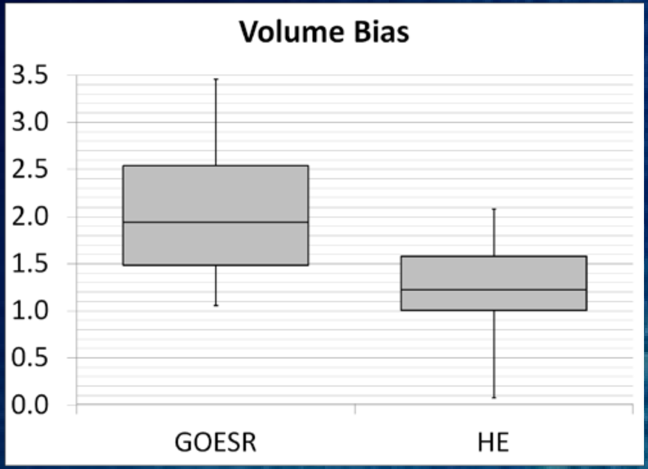
Much stronger dry bias for "hit" pixels than H-E over northern Plains

Less missed rain than H-E over western US; more missed rain over eastern US

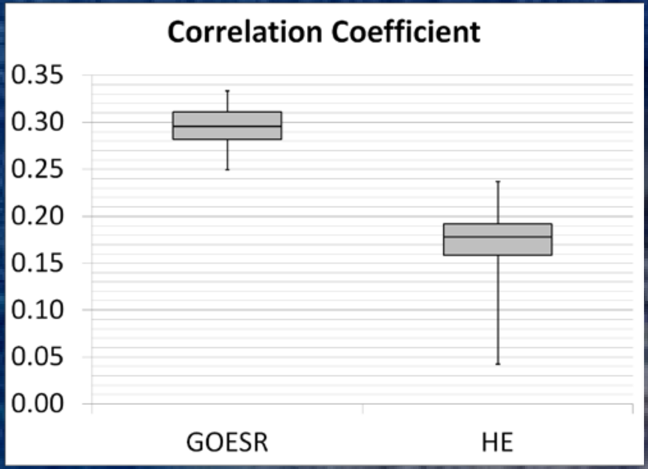
Much more false alarm precip than H-E over western US

Algorithm Performance: Full Version

- Comparison of full (5-band) algorithm run on SEVIRI with H-E, validated against TMI instantaneous rates
- Validation for 6-9 January, April, July, October 2005



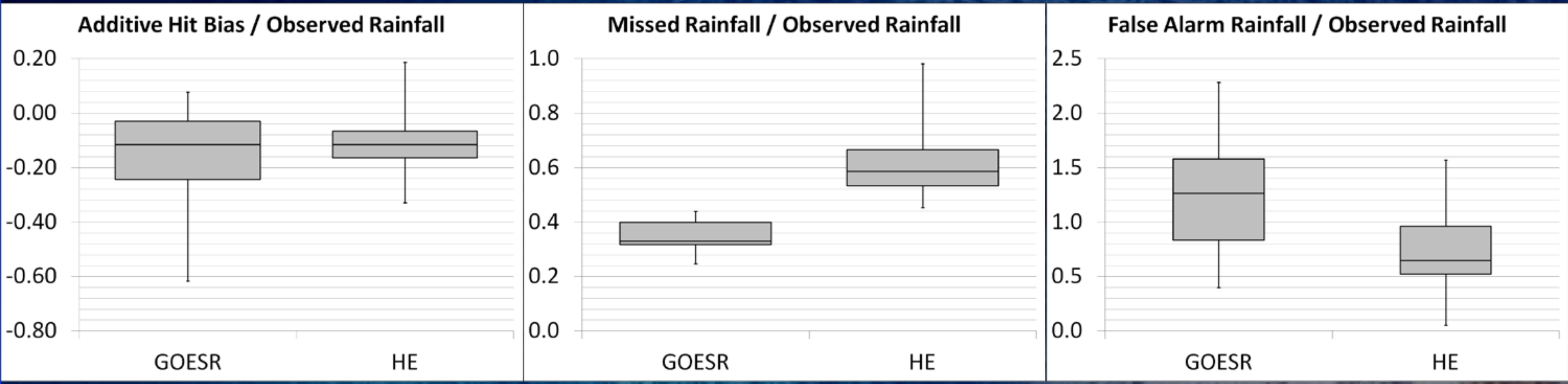
Stronger wet bias than H-E



Significantly better correlation than H-E

Algorithm Performance: Full Version

- Comparison of full (5-band) algorithm run on SEVIRI with H-E, validated against TMI instantaneous rates
- Validation for 6-9 January, April, July, October 2005



Similar slight dry bias to H-E for "hit" pixels

Significantly less missed rainfall than H-E

More false alarm rainfall than H-E

Future Plans

- Determine and address the causes of the false alarms
  - Use the texture parameter of the H-E as a predictor to improve cirrus screening?
- Experiment with a model PW / RH adjustment to rain rates to account for moisture availability and subcloud evaporation of hydrometeors.
- Apply calibration coefficients derived by Zhanqing Li (UMCP) et al. to real-time GOES cloud property information and evaluate impact on warm-cloud light rainfall which typically IR and MW have difficulty detecting.
- Continue experiments with orographic rainfall modulation.

Summary

- The GOES-R Rainfall Rate algorithm will estimates of instantaneous rainfall rate at the full ABI IR pixel resolution (~2 km) with a latency of less than 5 min from image time, using MW rain rates as a calibration standard.
- A simplified (2 bands instead of 5) version has been running in real time over the CONUS since August 2011.
- In general, this version does worse than the current operational algorithm, particularly in terms of false alarms…
- …but when comparing the full algorithm to the H-E using SEVIRI as a proxy, the comparisons are more favorable.
- Additional enhancements and tests are being performed.