

**Evaluation of Actual Evapotranspiration (ET_a) Rates from
the Operational Simplified Surface Energy Balance
Method (SSEBop) in Florida and
parts of Georgia and Alabama**

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WHY DO WE NEED ACTUAL EVAPOTRANSPIRATION (ET_a) RATES?

- **Actual evapotranspiration (ET_a) is one of the largest components in the water budget**
 1. **It can exceed rainfall in dry years.**
 2. **ET averages ranged from 55 to 75 percent of rainfall in Florida from 2000 to 2017.**
- **Actual evapotranspiration (ET_a) leads to more accurate hydrologic budget calculations.**
- **ET_a should be used as calibration target in hydrologic studies.**
- **Spatially and temporally distributed ET_a rates – via remote sensing.**

HOW DO WE GET ET_a EVERYWHERE AND FOR ALL TIMES?

- Simplified Surface Energy Balance – operational (USGS SSEBop) method
- A remote sensing USGS product (MODIS satellite data began in 2000)
- SSEBop method calculates actual evapotranspiration (ET_a) rates using:

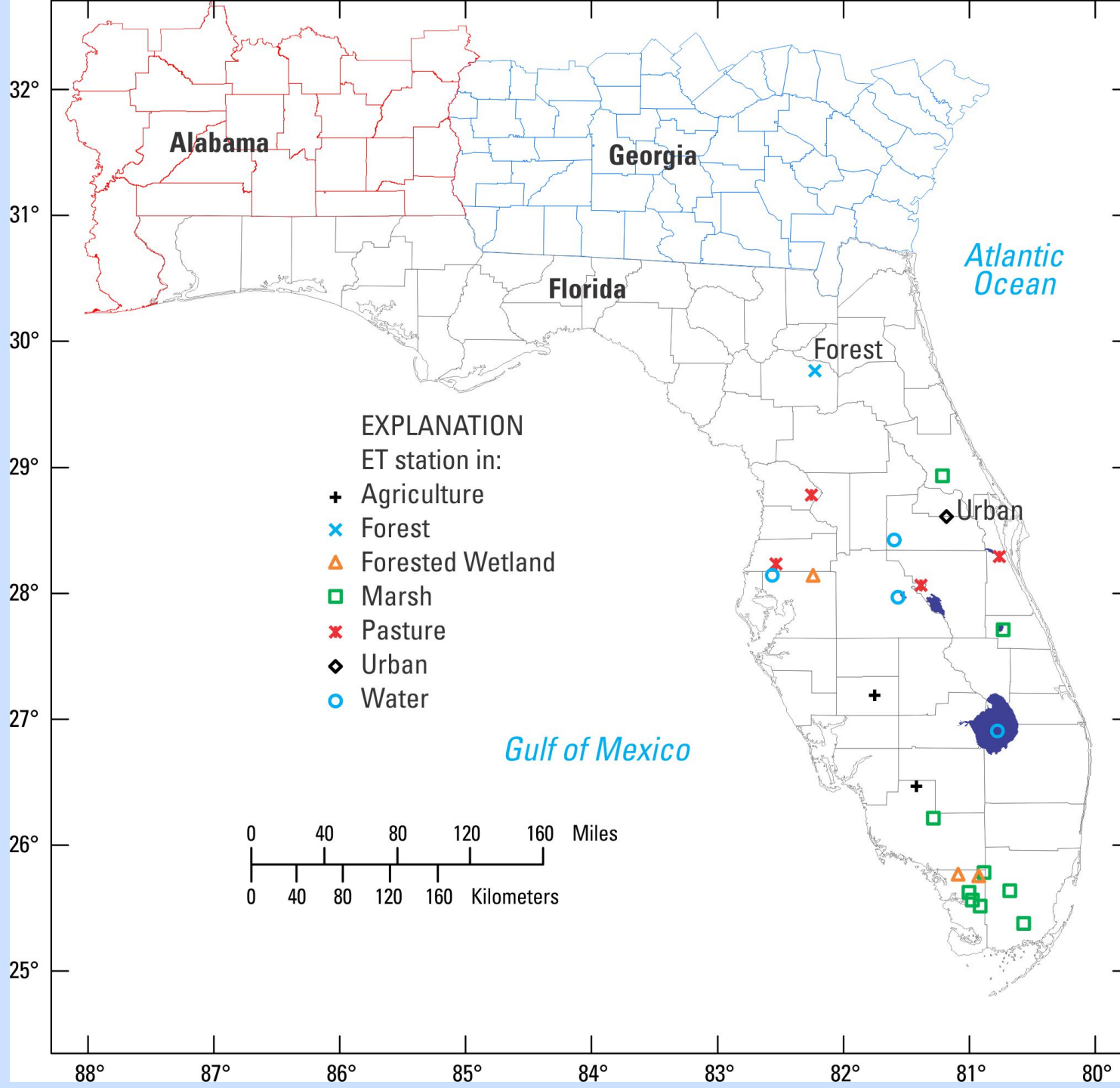
1. grass reference ET_r (NOAA),
2. air temperature (PRISM) and land-surface temperature (MODIS),
3. $ET_a = EF \times ET_r$ (EF is evapotranspiration fraction)

EF=1, wet and cool surface, difference between air and land-surface temperature is small

EF=0, dry and hot surface, difference between air and land-surface temperature is large

- SSEBop rates are generated for every square kilometer, every 8 days.
- Objective of study is to evaluate utility of SSEBop rates and improve these rates.

Measured ETa stations in Florida.





Starkey Pasture,
Pasco County



Lake Starr, Polk County

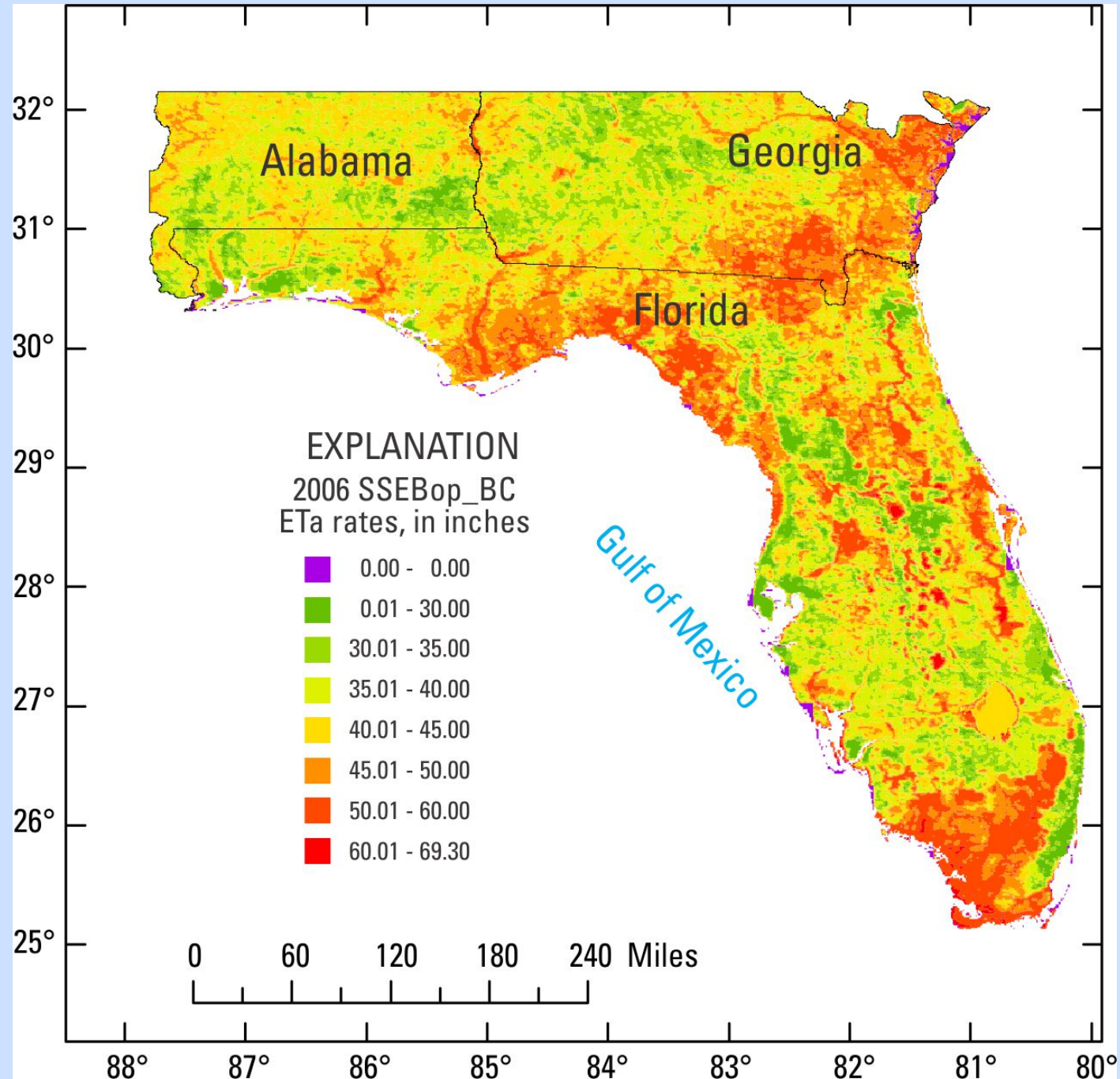


Forested Wetland, Collier County

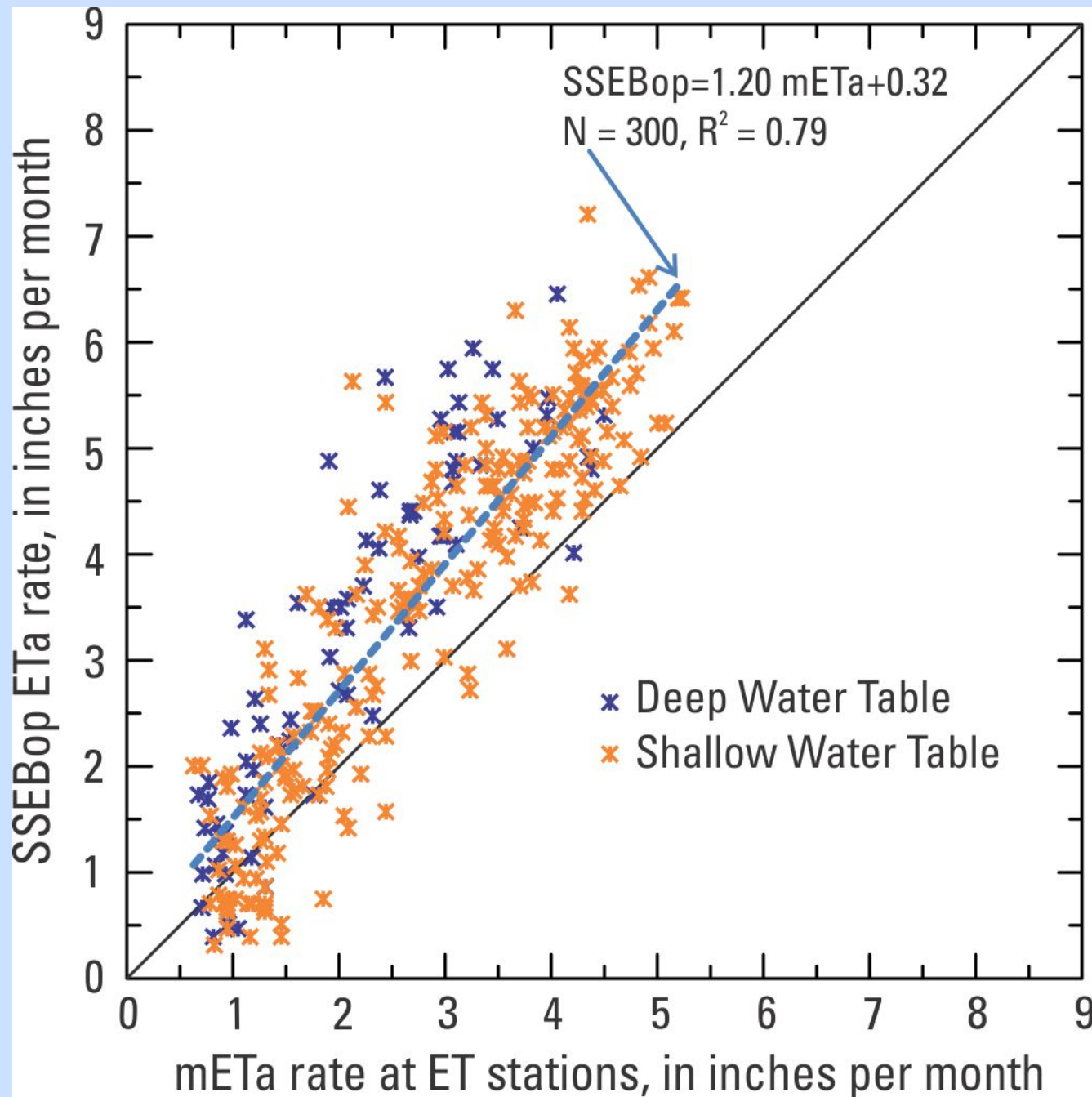
APPROACH

- Evaluate efficacy of SSEBop rates using mETa data from ET stations:
 - A. obtain SSEBop ETa rates from <https://edcftp.cr.usgs.gov/project/SSEBop/MODIS/>
 - B. compare MODIS ETa rates with mETa data at each ET station
 - C. correct bias in ETa for each land use, for each season
 - D. map bias-corrected SSEBop ETa rates
- Evaluate bias-corrected SSEBop ETa rates with independently calculated ETa
 - A. calculate WBETa at selected basins using hydrologic budget
 - B. calculate residuals (WBETa – SSEBop) at the basin level

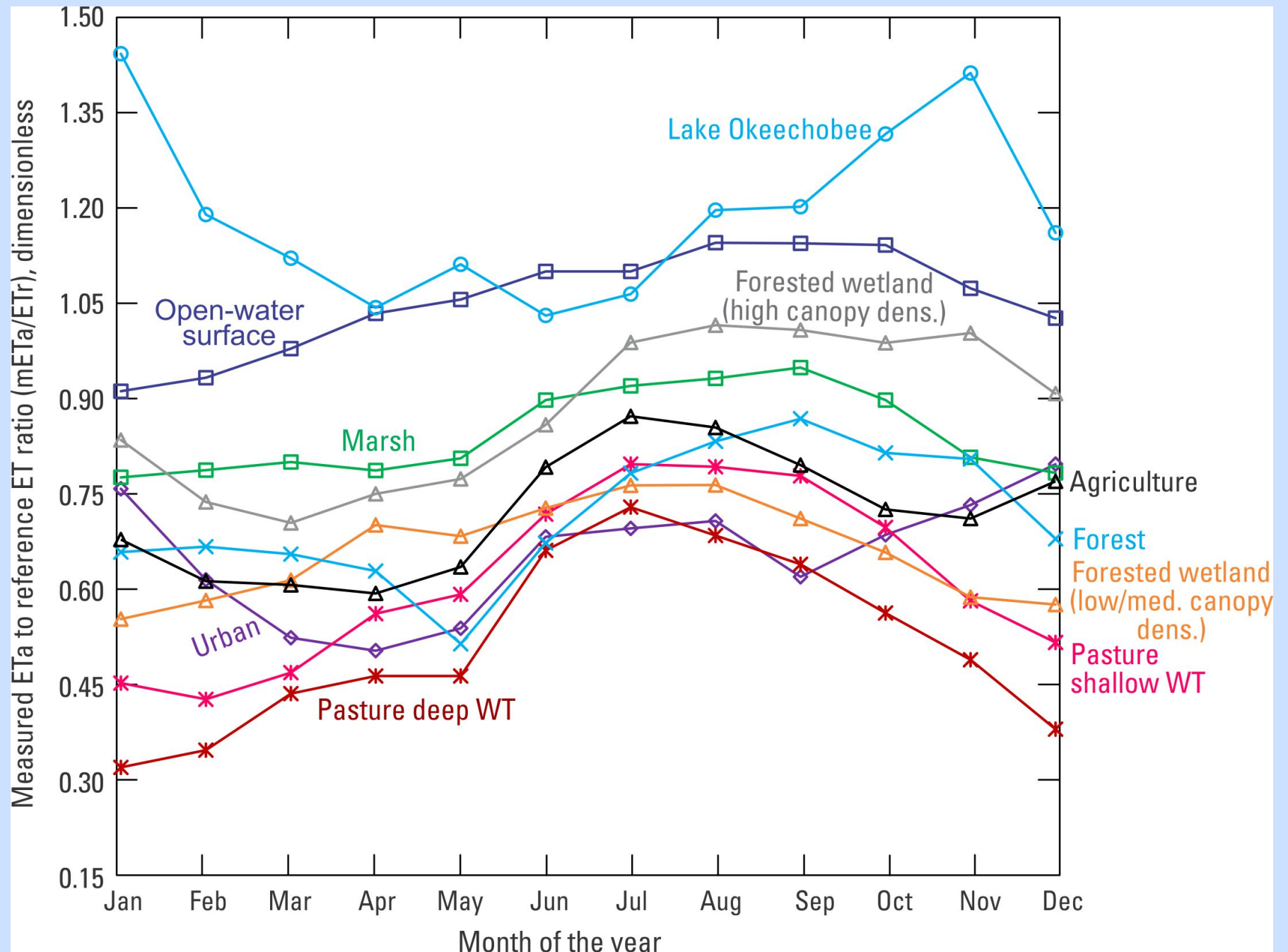
SSEBop 2006 ETa rates in and near Florida Before Bias Corrections



Monthly SSEBop ETa rates vs. mETa at Pasture Stations

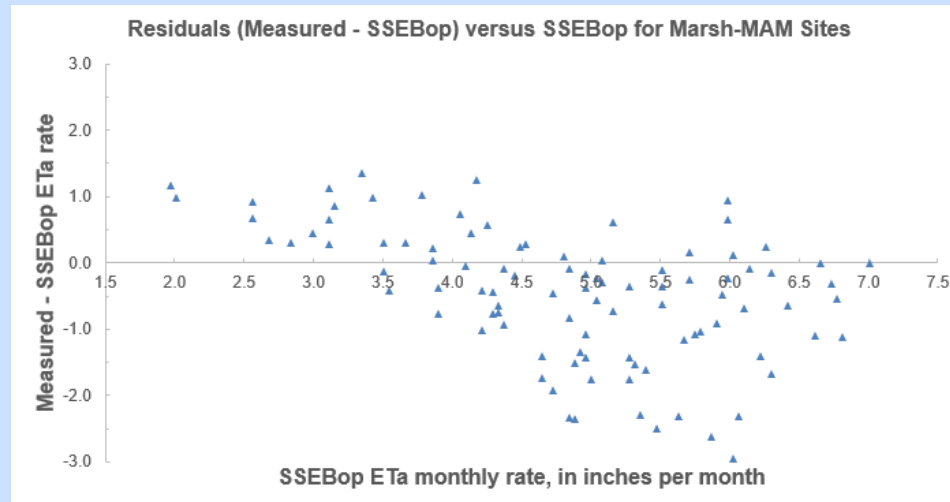


Average monthly ratios mETa/ETr for all land-use categories

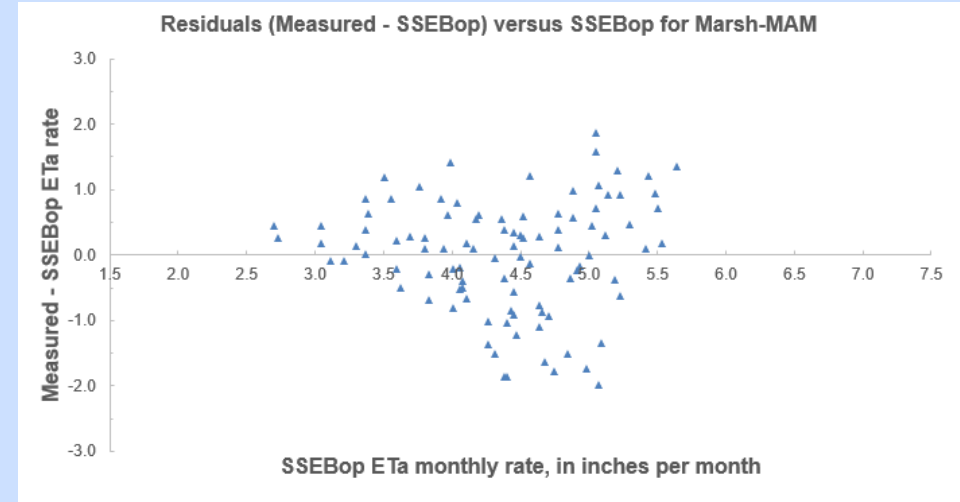


Bias Corrected Residuals mETa - SSEBop by Season at ET Marsh Stations

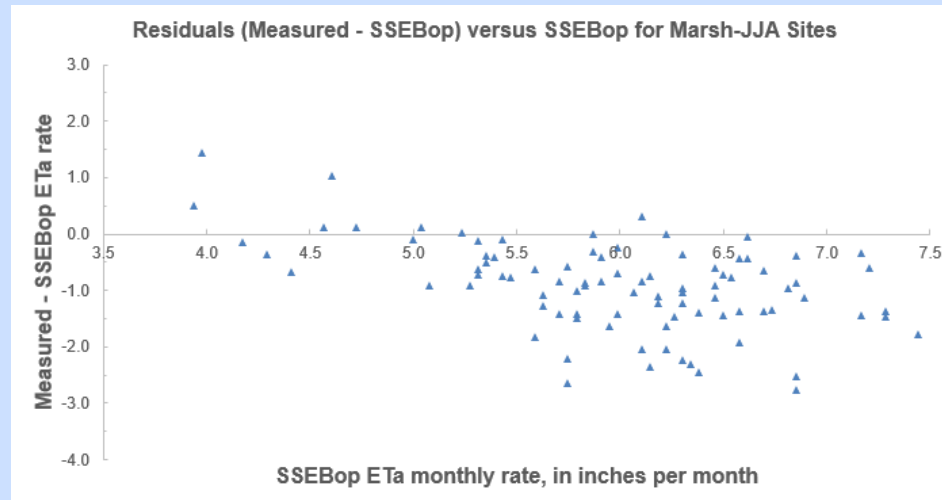
Spring – before bias corrections



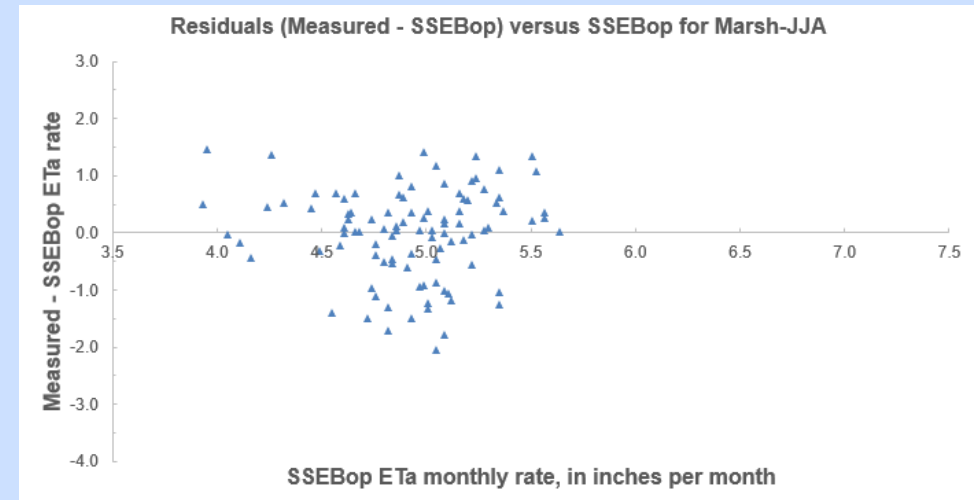
Spring – after bias corrections



Summer – before bias corrections

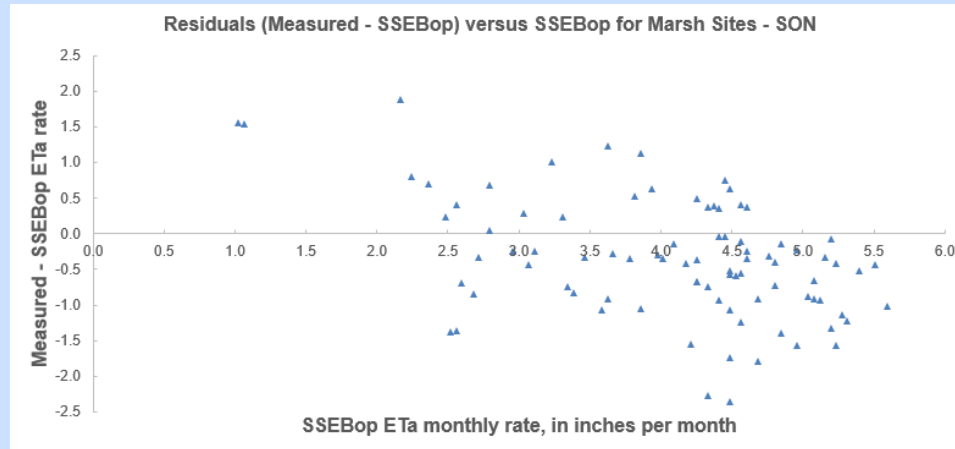


Summer – after bias corrections

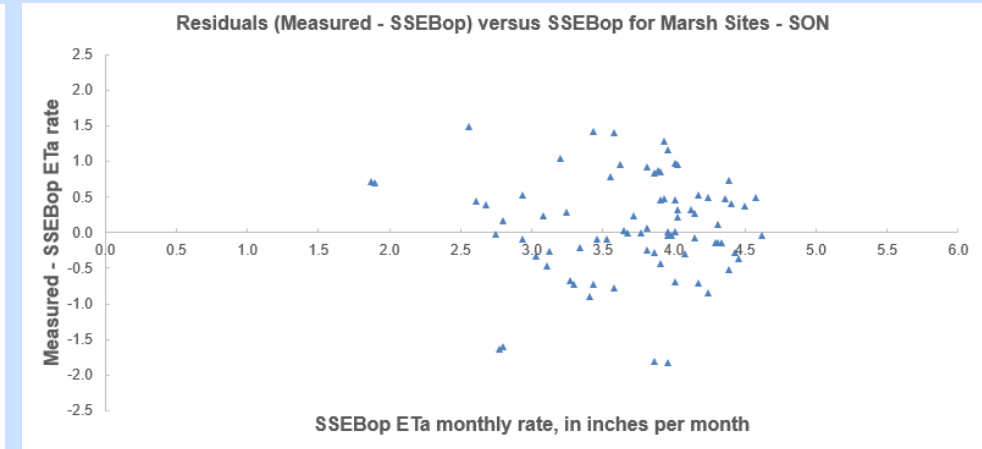


Bias Corrected Residuals mETa - SSEBop by Season at ET Marsh Stations

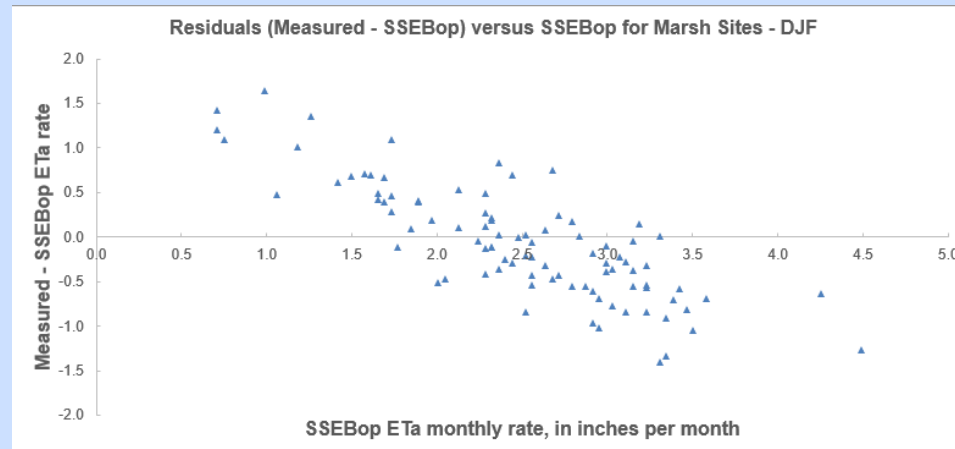
Fall – before bias corrections



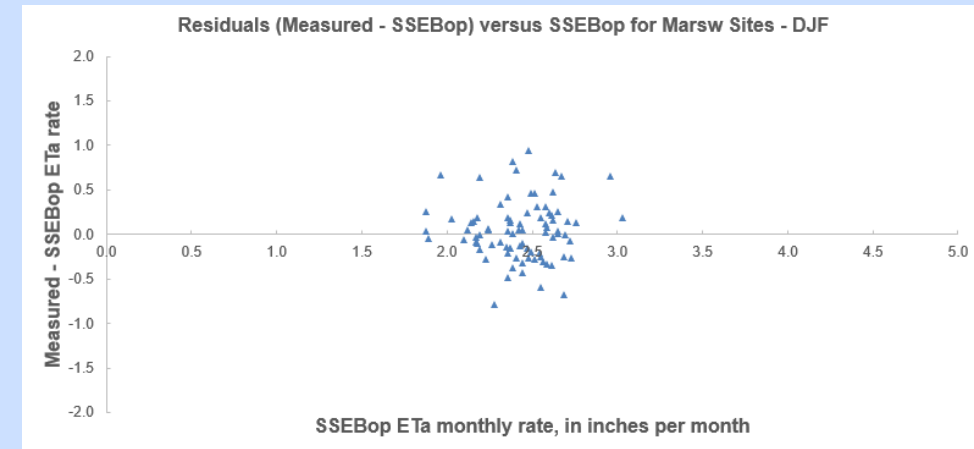
Fall – after bias corrections



Winter – before bias corrections



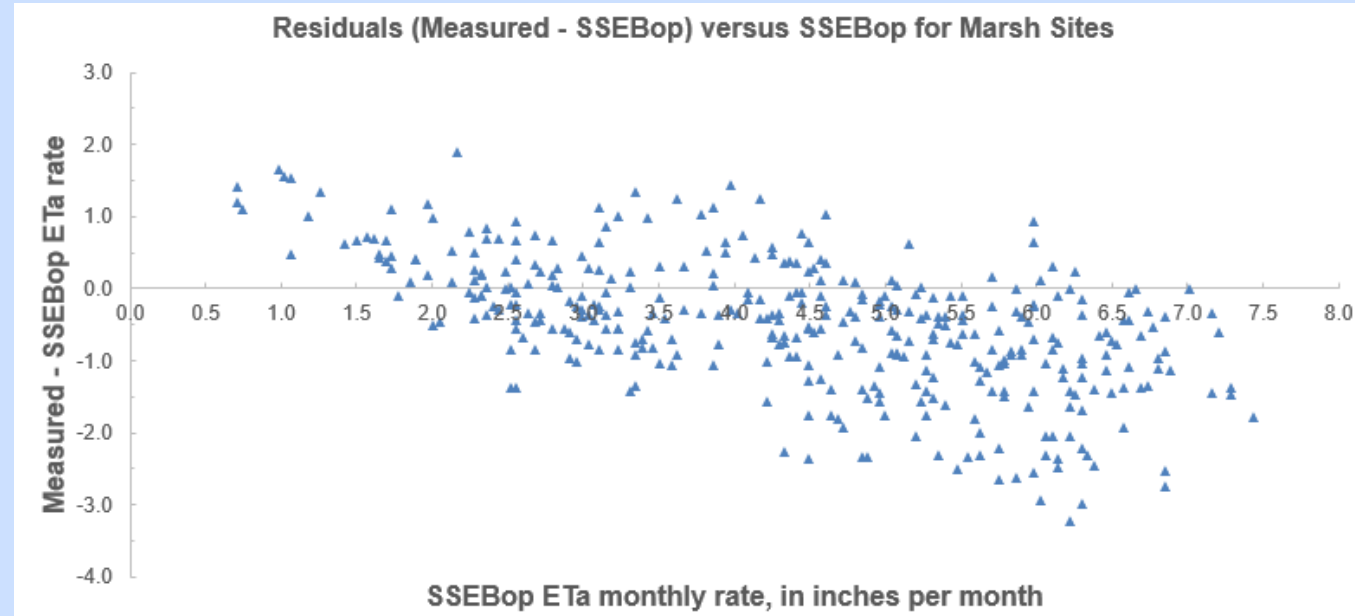
Winter – after bias corrections



$$mETa - SSEBop = m * SSEBop + b \rightarrow SSEBop_{corrected} = (1 + m)SSEBop + b$$

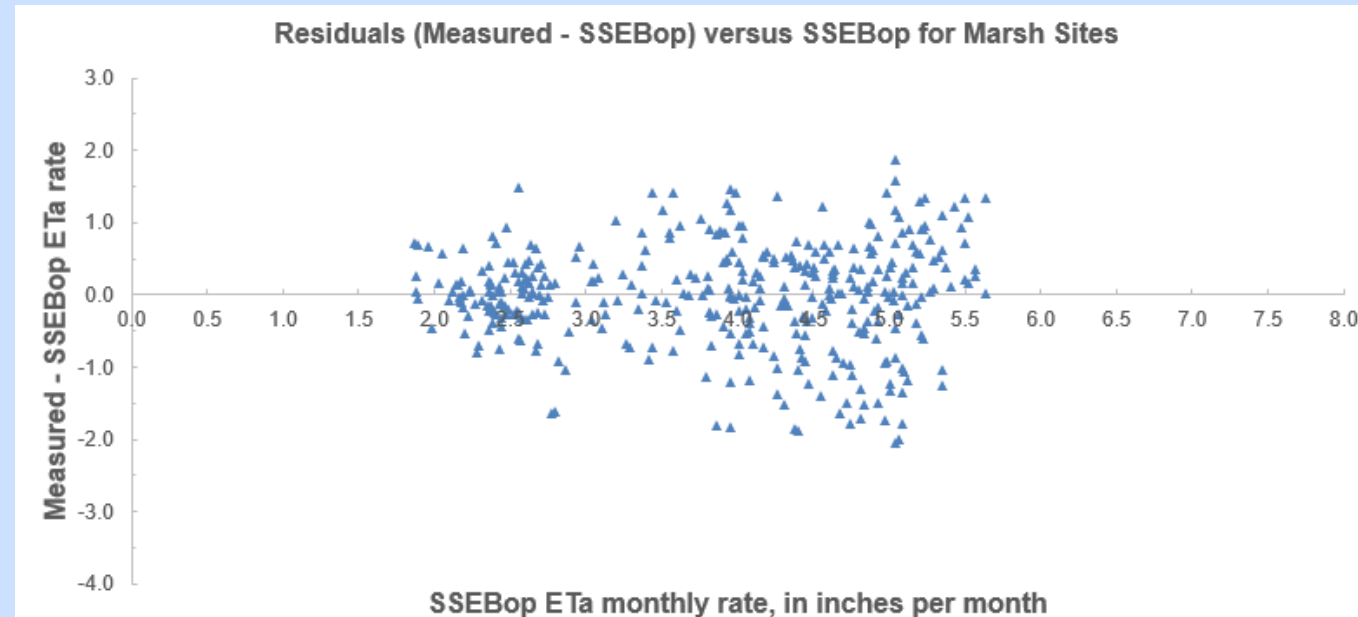
Correction of Bias in Residuals mETa - SSEBop at Marsh ET Stations

Uncorrected
Bias in
Residuals



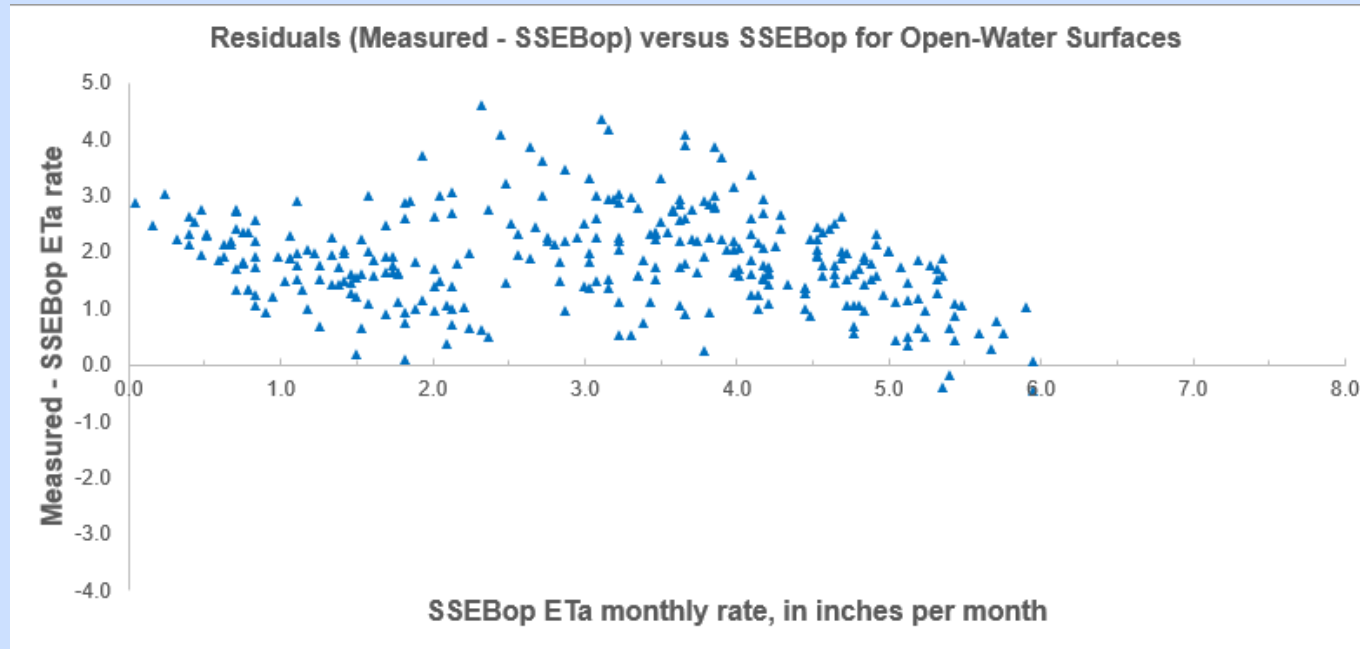
$$mETa - SSEBop = m * SSEBop + b \rightarrow SSEBop_{corrected} = (1 + m)SSEBop + b$$

Corrected
Bias in
Residuals



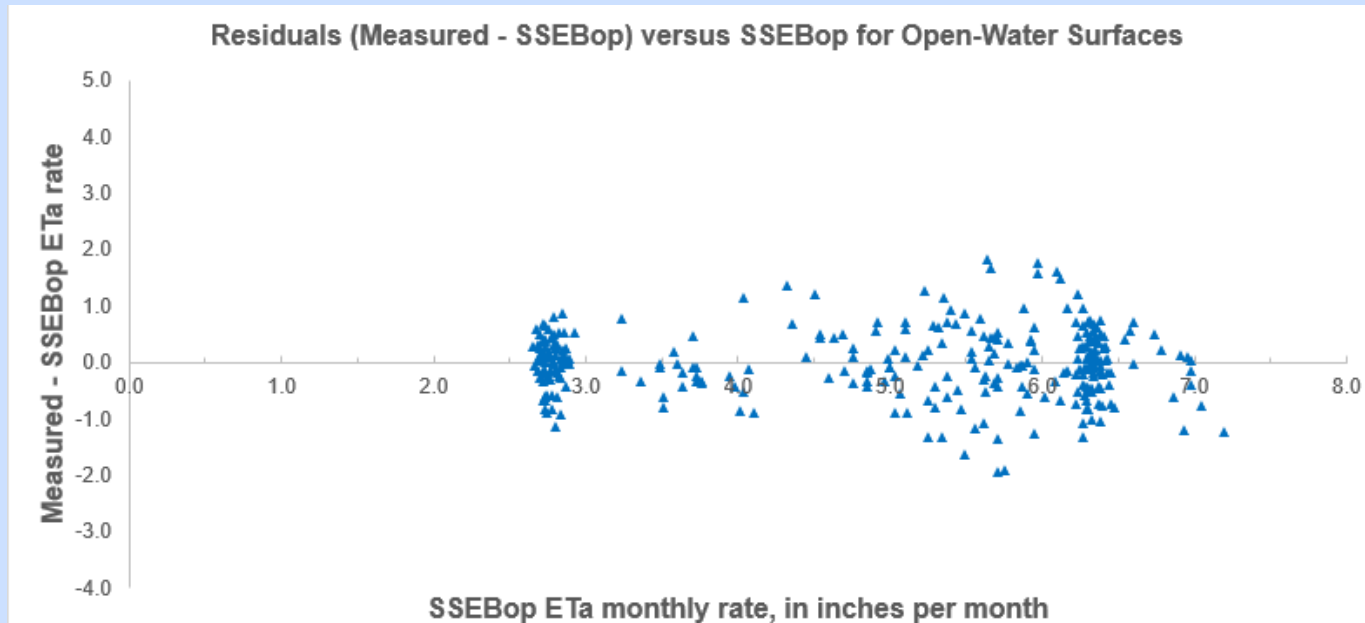
Correction of Bias in Residuals mETa - SSEBop at Open-Water Surface ET Stations

Uncorrected
Bias in
Residuals

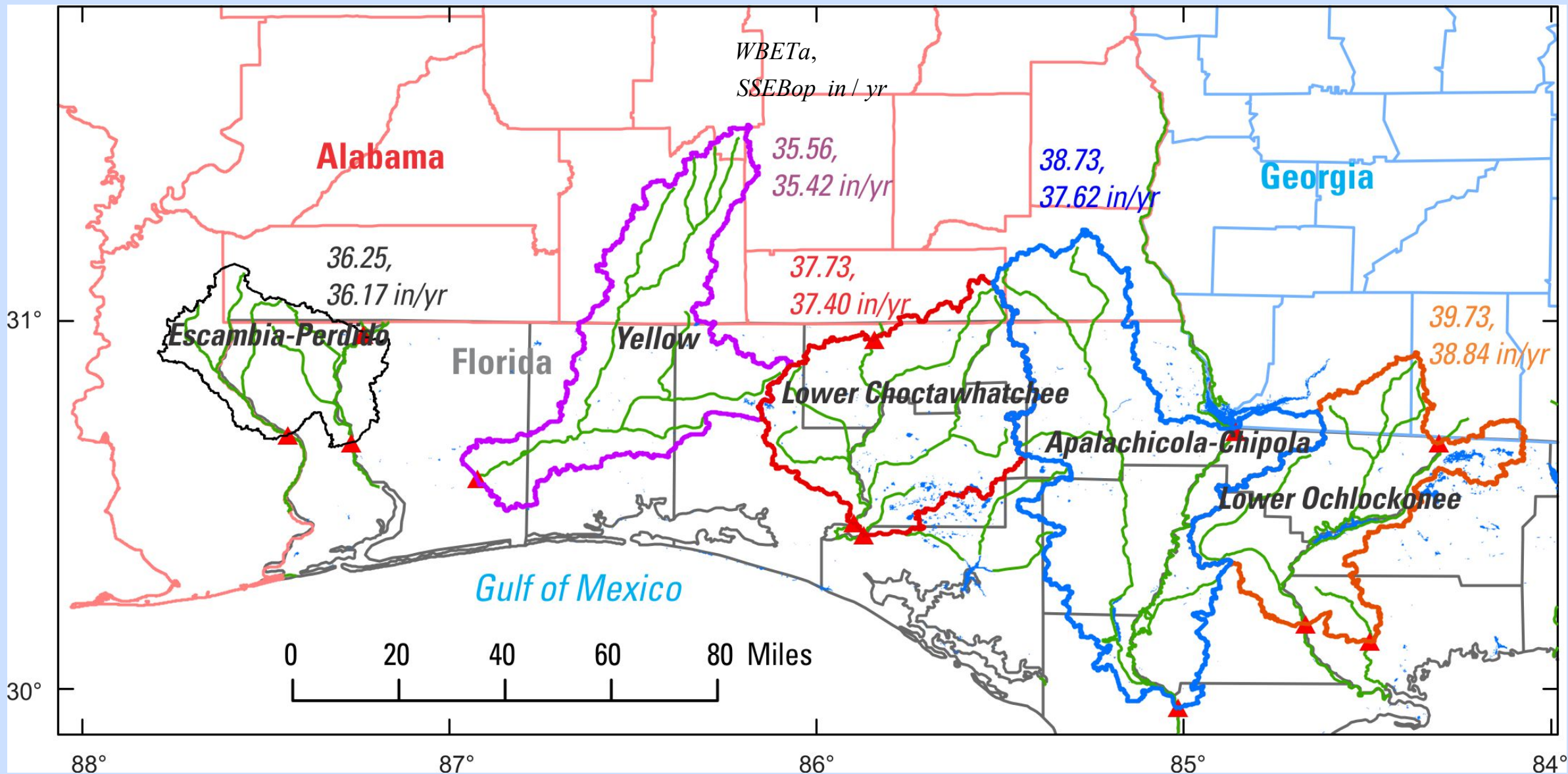


$$mETa - SSEBop = m * SSEBop + b \rightarrow SSEBop_{corrected} = (1 + m)SSEBop + b$$

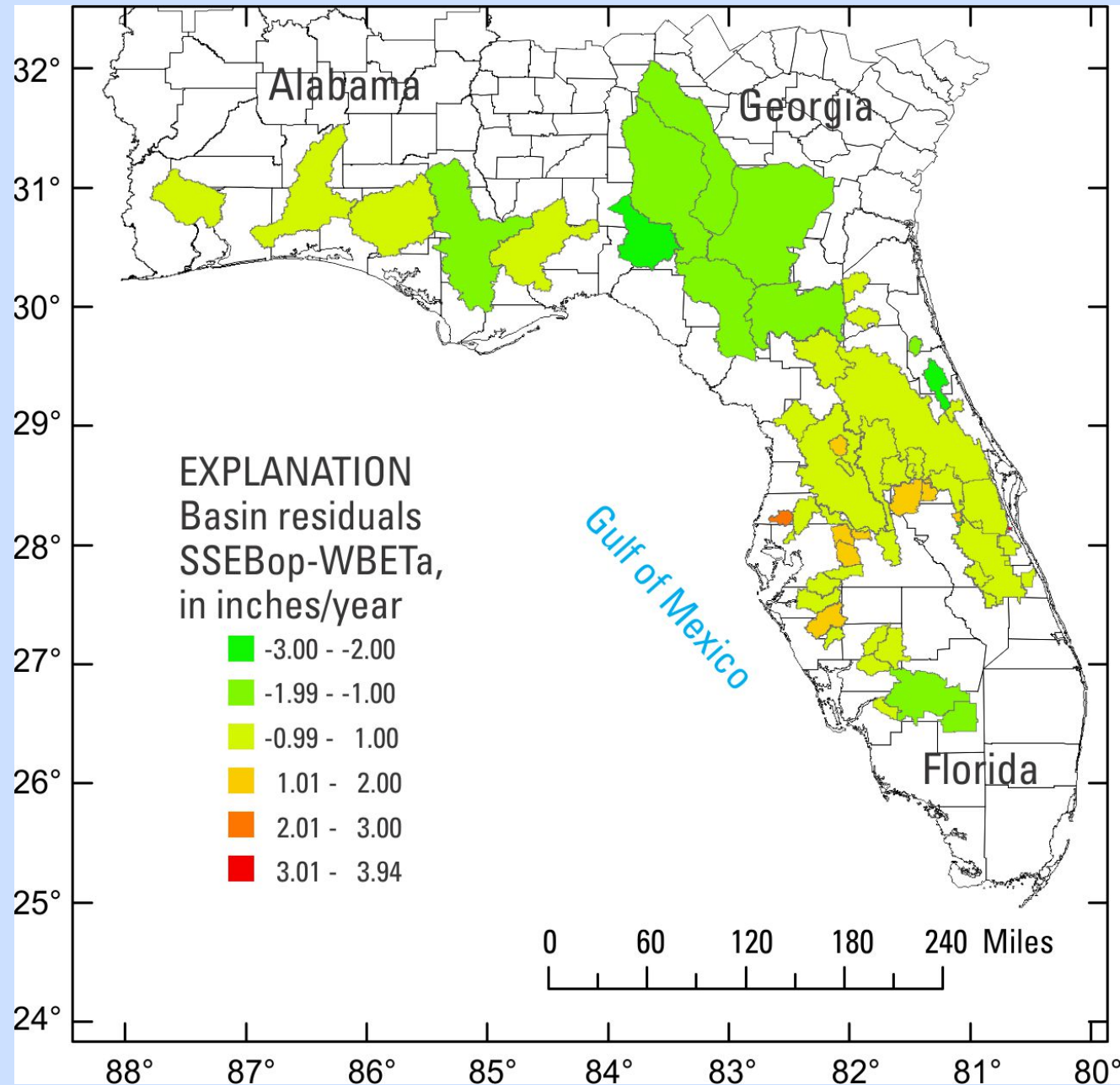
Corrected
Bias in
Residuals



Basins in NFWWMD, showing average ETa rates from 2000 to 2017

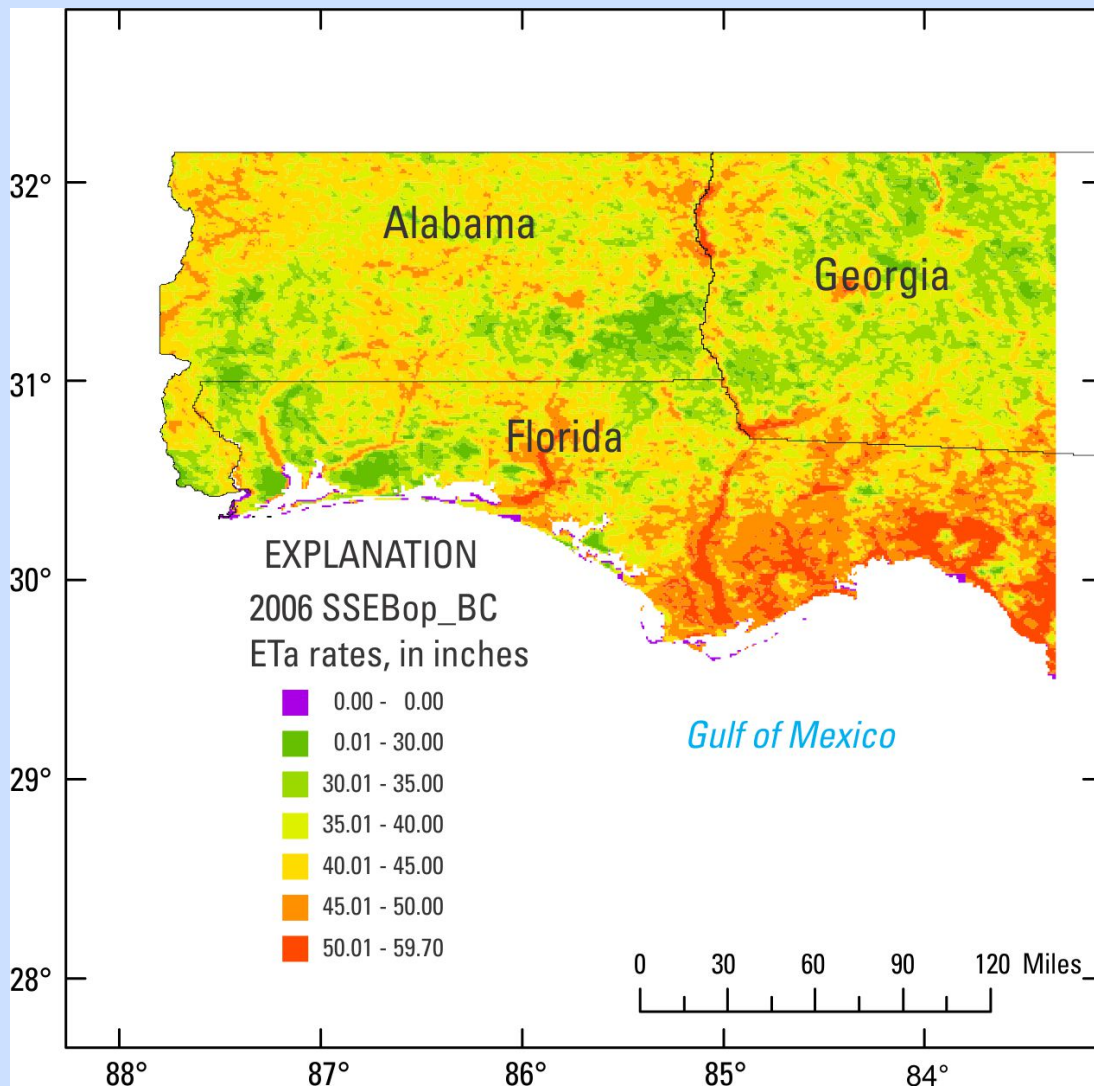


Residuals SSEBop-WBETa for Basins in Florida – Average from 2000 to 2017

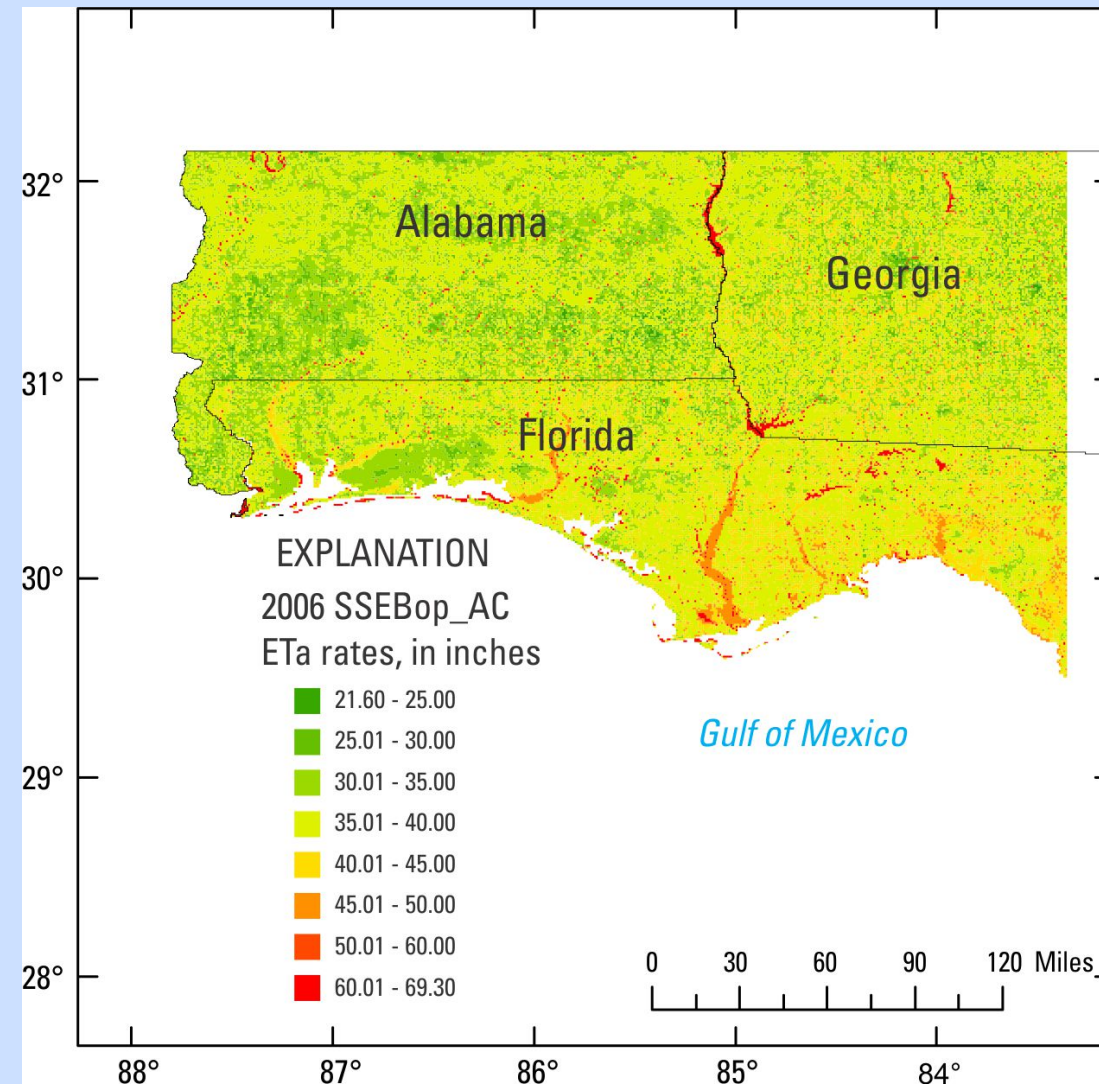


2006 SSEBop ETa rates – in NFWFMD, in inches/year

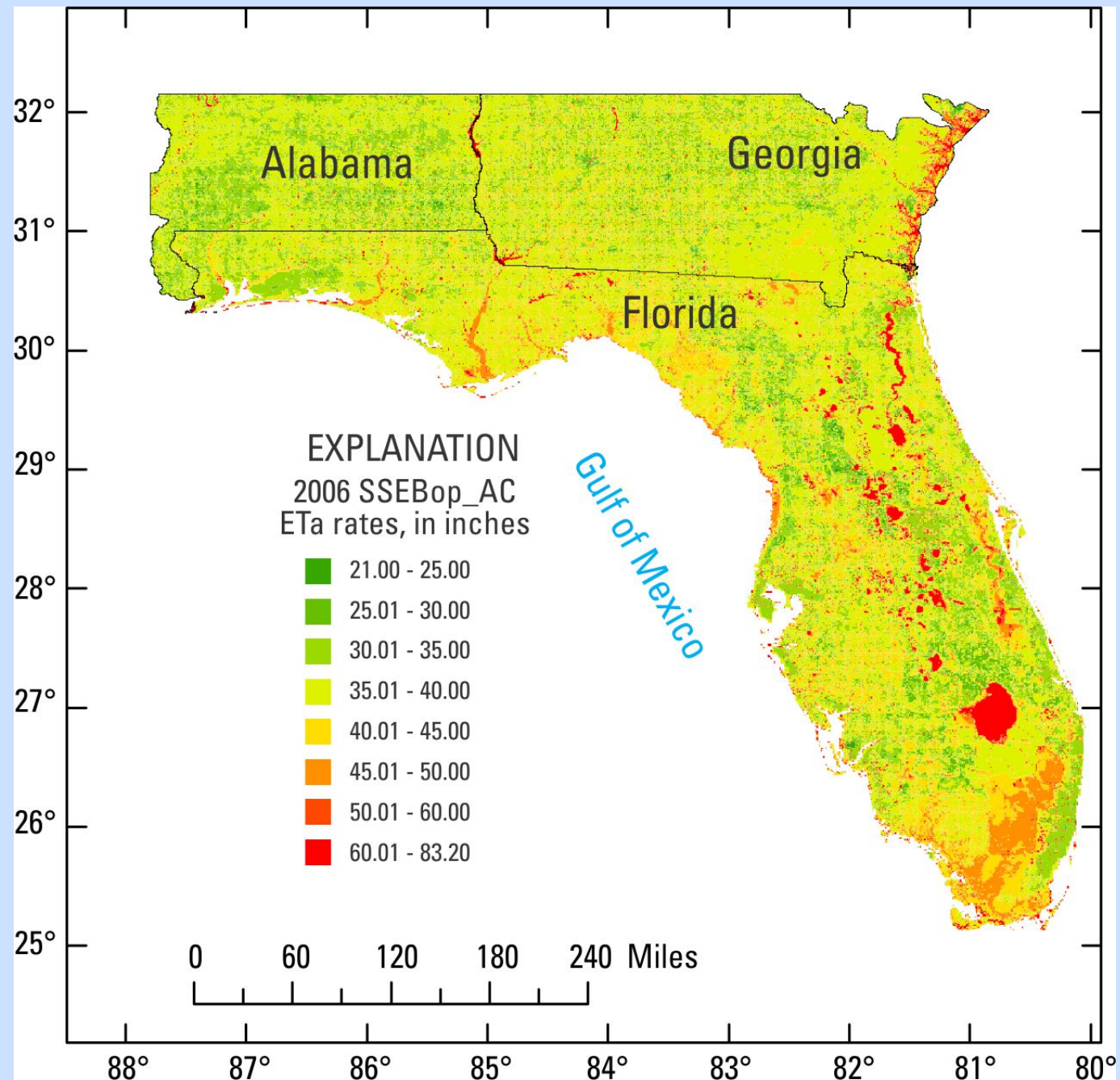
Before Bias Corrections



After Bias Corrections



Bias-corrected SSEBop 2006 ETa rates in and near Florida



Conclusions

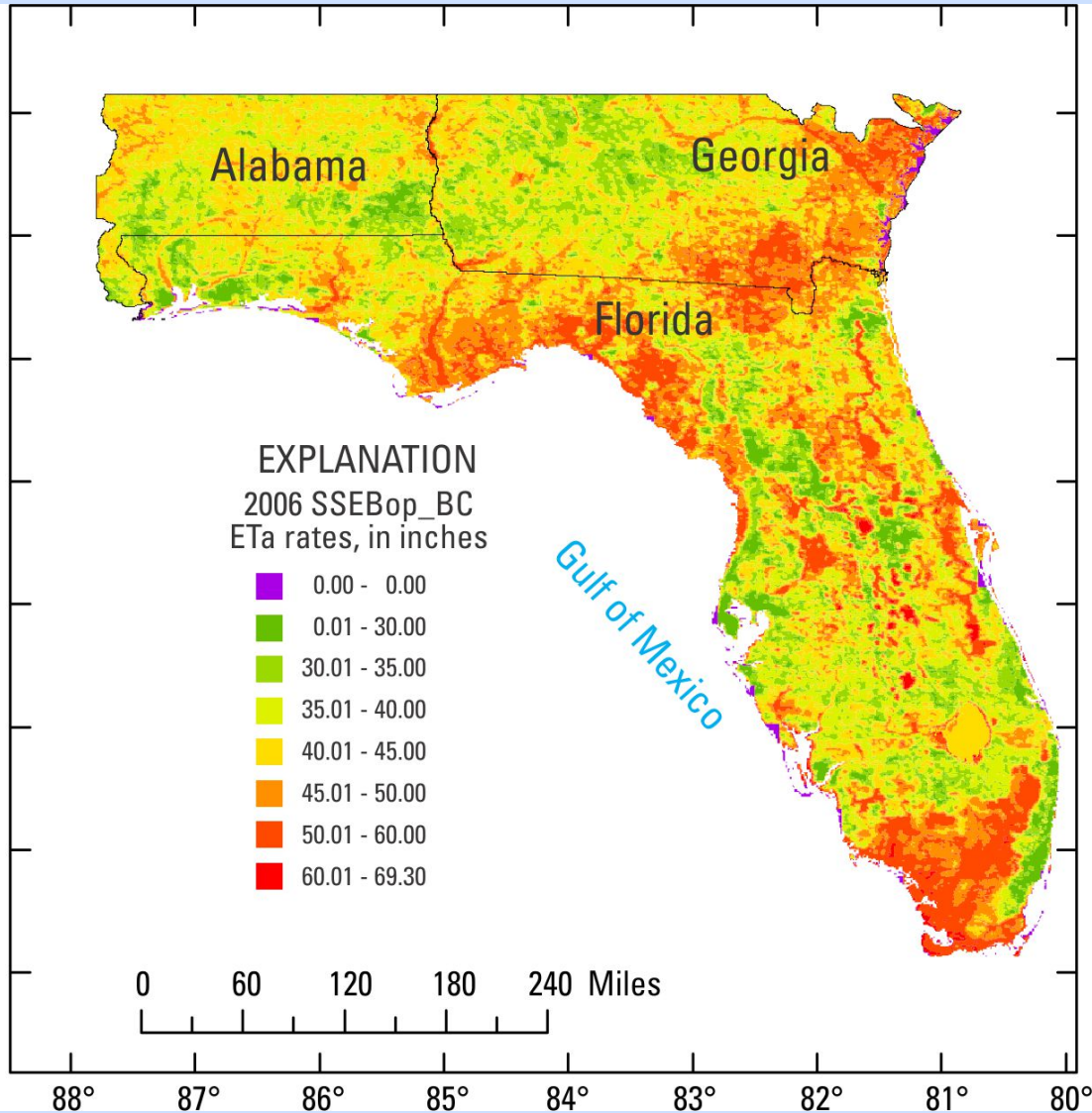
- **Bias in mETa - SSEBop ETa residual rates was removed for each land use and each season.**
- **Root-mean-square errors of WBETa – SSEBop ETa over all 55 basins were reduced from 3.92 in/yr before bias removal to 1.44 in/yr after.**
- **Average residual WBETa – SSEBop over all basins was 3.1 % after bias corrections.**
- **Coefficient of determination (R square) between the uncorrected bias SSEBop and mETa was 0.37; R square between bias-corrected SSEBop and mETa was 0.86.**
- **Bias-corrected monthly SSEBop ETa rates are available for Florida at the square kilometer level for the 2000-2017 period.**

METHOD LIMITATIONS AND FUTURE DIRECTIONS

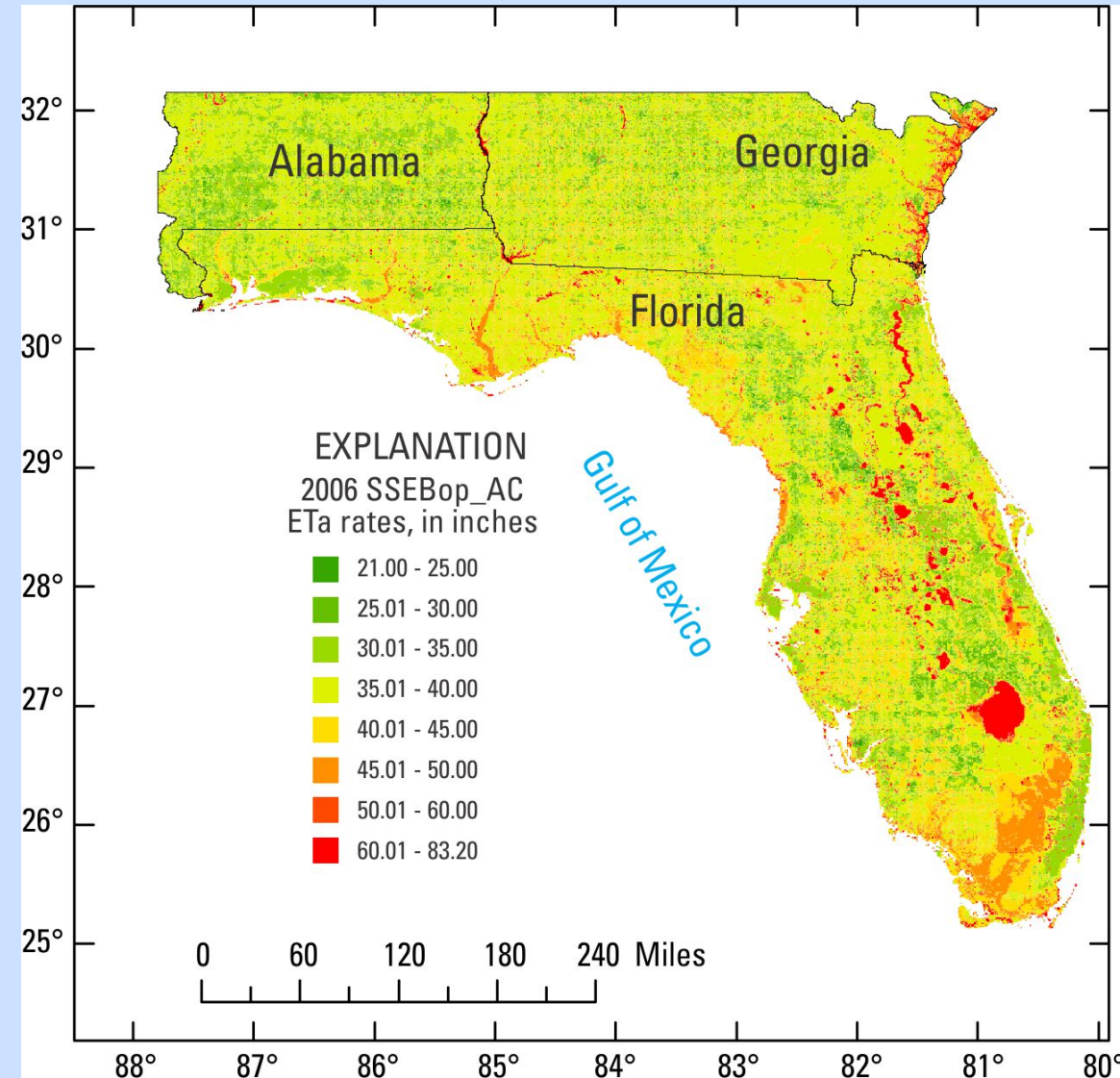
- Can we improve SSEBop rates with additional measured ETa data?
- Need additional forest and urban ET stations!
- Mine the SSEBop product to better understand the ETa processes.
- Can ETr rates from the Florida GOES ET Network improve SSEBop ETa rates? The ETr from the Florida GOES ET Network captures high resolution solar radiation and is available daily.

SSEBop 2006 ETa rates in Florida and parts of Georgia and Alabama

Before Bias Corrections



After Bias Corrections

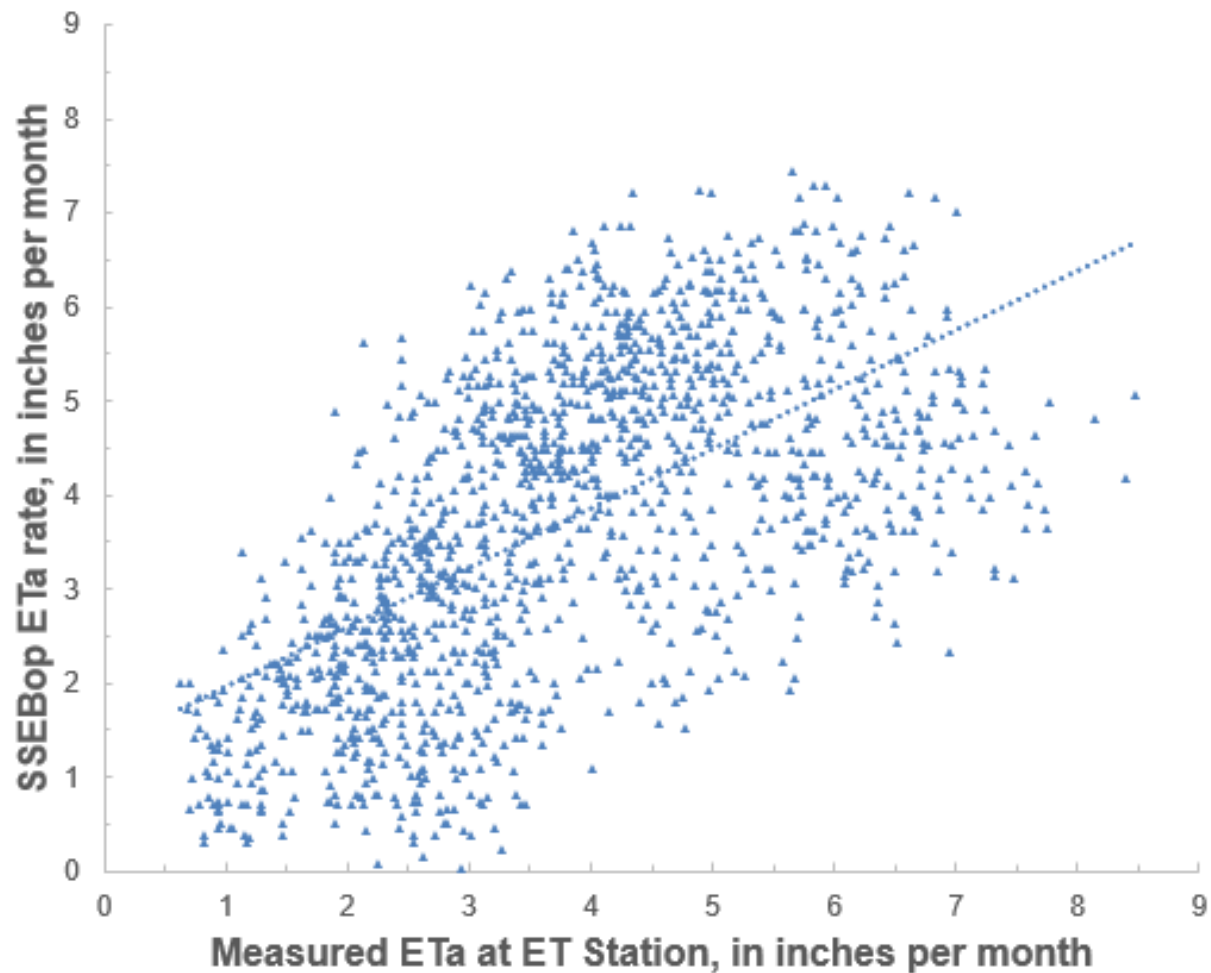


SSEBop ETa vs mETa at ALL ET stations

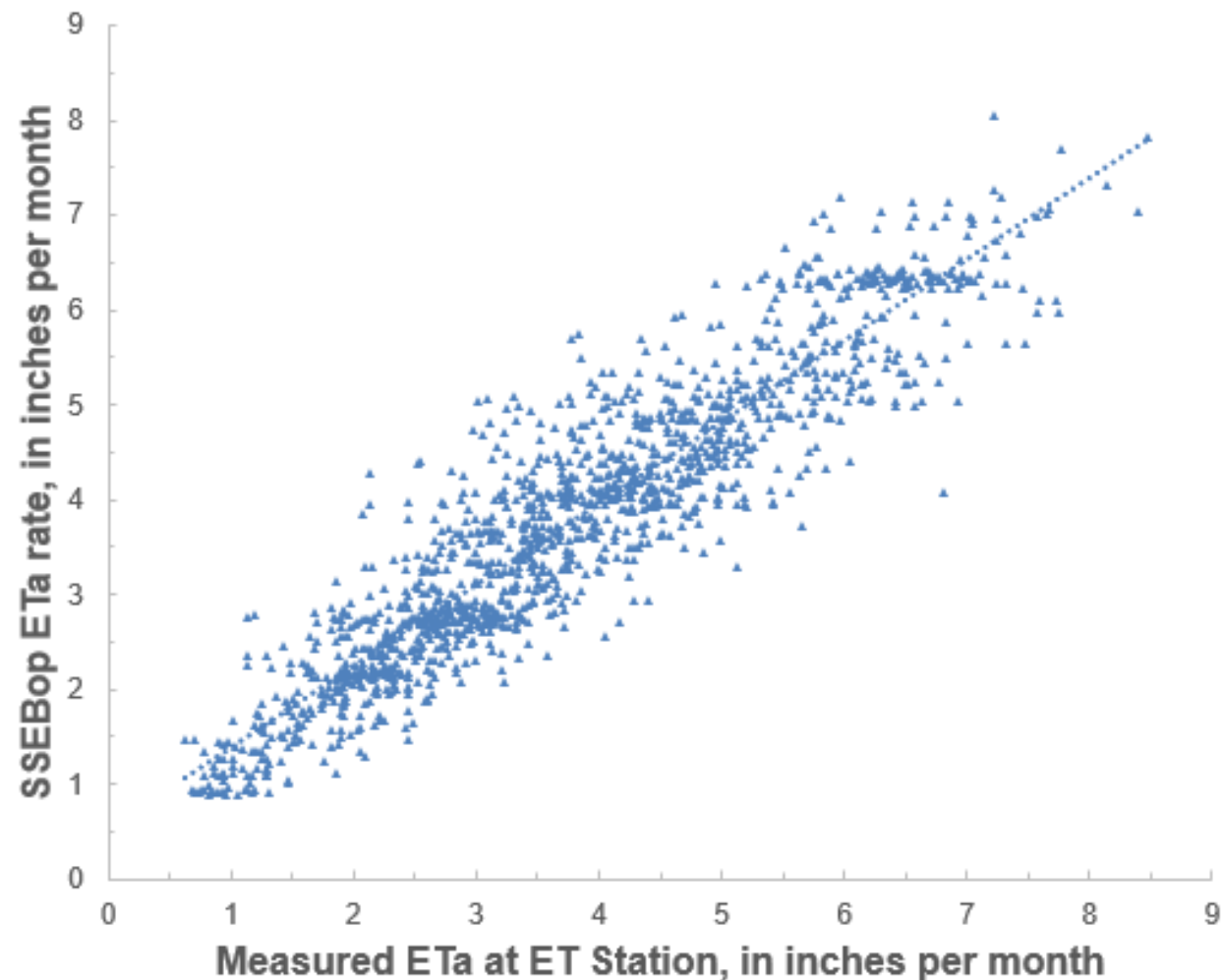
Before Bias Corrections

After Bias Corrections

Measured vs SSEBop ETa rates, 2000-17
N=1418, R²=0.37, Land Use: All_Land_Uses

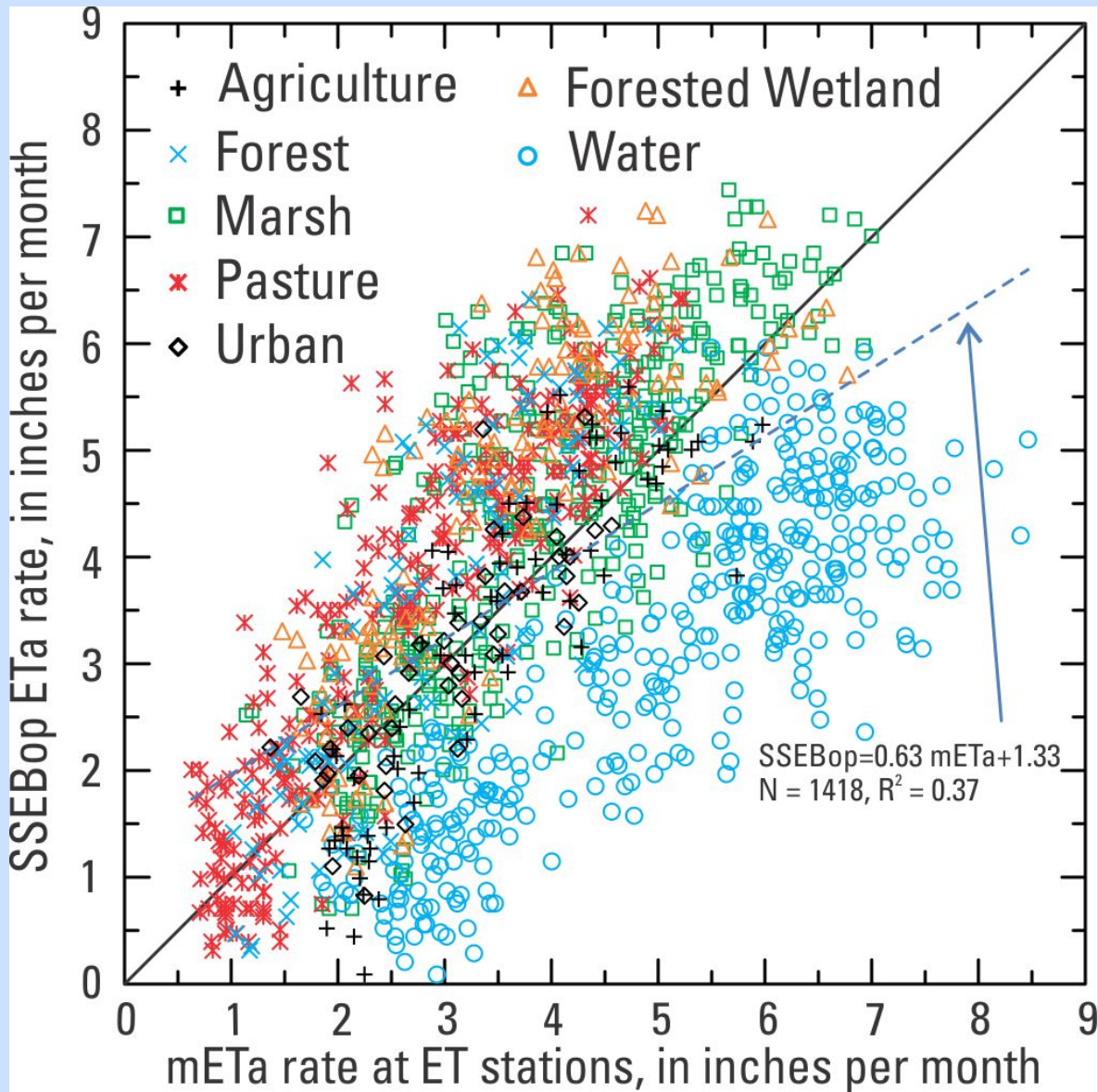


Measured vs SSEBop ETa rates, 2000-17
N=1418, R²=0.86, Land Use: All_Land_Uses



SSEBop ETa vs mETa at ALL ET stations

Before Bias Corrections



After Bias Corrections

