BROWARD COUNTY FLORIDA

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Future Extreme Rainfall Projections in Broward County

UF Water Institute Symposium

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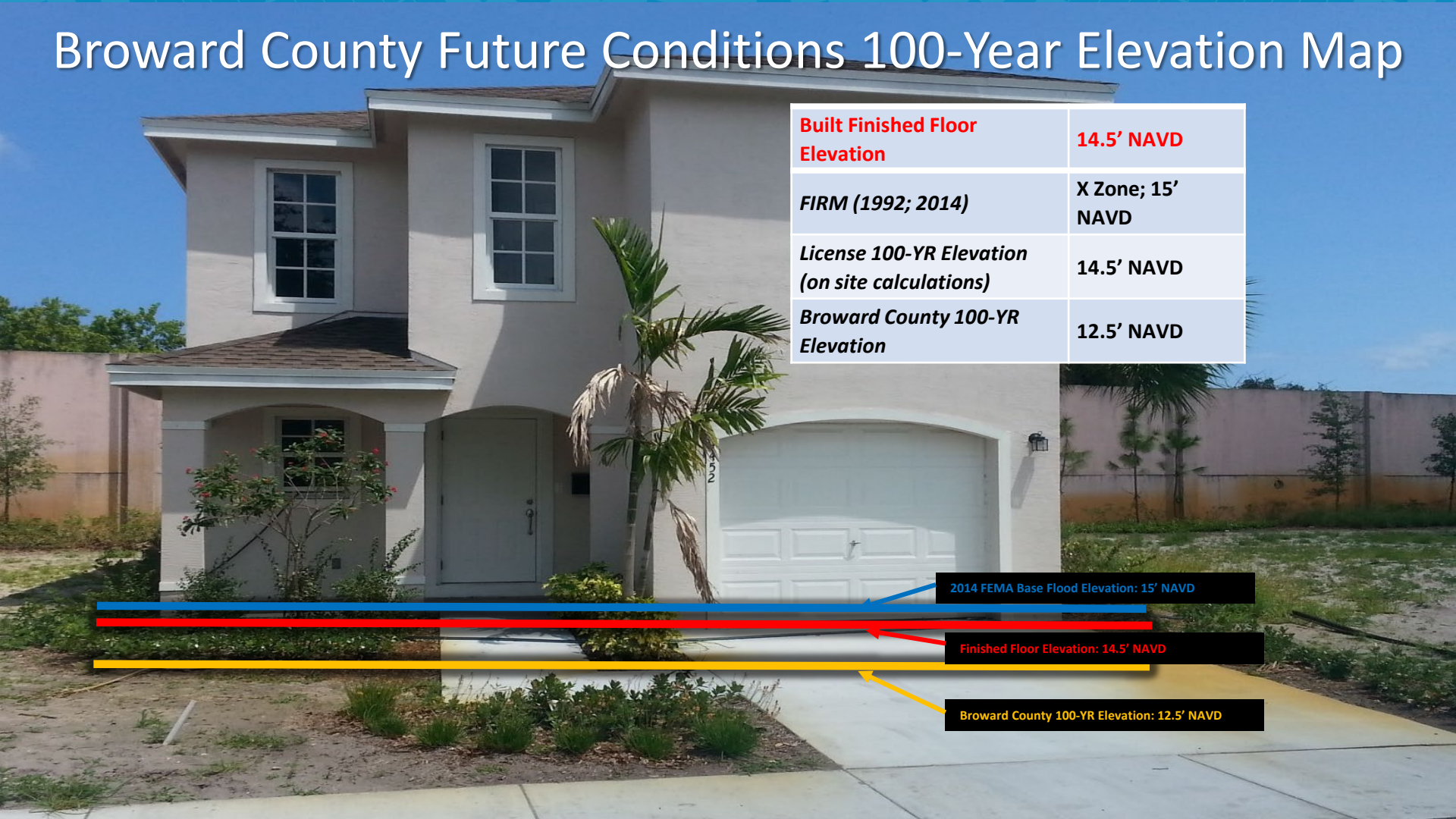
February 26, 2020

Sustainable Water Resources
Complex Challenges, Integrated Solutions

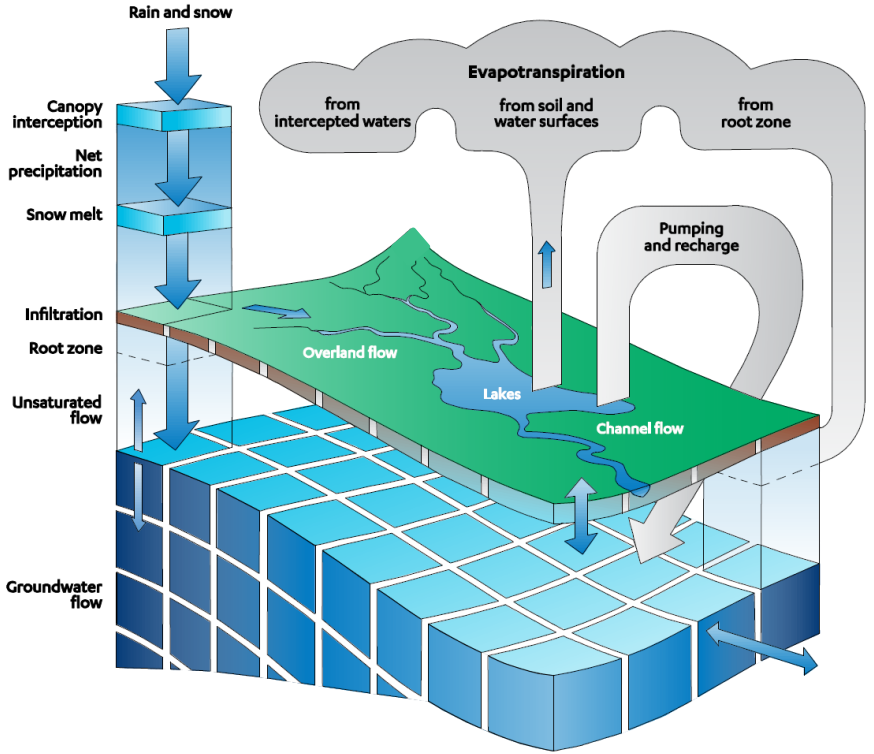
Broward County Future Conditions 100-Year Elevation Map

Built Finished Floor Elevation	**14.5’ NAVD**
FIRM (1992; 2014)	**X Zone; 15’ NAVD**
License 100-YR Elevation (on site calculations)	**14.5’ NAVD**
Broward County 100-YR Elevation	**12.5’ NAVD**



Future Conditions Flood Elevation Map

- Mapping Future Floodplains:
  - Increased rainfall due to warming climate
  - Year 2060-2069 sea level rise
  - Increased runoff due to higher water table
  - Land use changes
- Accomplished through integrated GW/SW modeling
- Will enhance infrastructure resilience:
  - Regulatory purpose
  - Finished floor elevations, streets, sanitary manholes, etc.



Future Conditions 100-Year Flood Elevation Map

Future Extreme Rainfall Analysis – Proposed Steps

Obtain Rainfall Observations Dataset	Obtain Global Climate Models / Downscaled Datasets	Fitting Probab. Distribution Curve to both Observations and Downscaled Data	Compare Extreme Observations vs. Downscaled Data (historical period)	Calculate Change Factors (ratio future to historic) (Bias correction)	Estimate and Distribute Future Rainfall Projections

Available Data / Approaches:

- NOAA Atlas 14
- CPC Merged Analysis over CONUS
- SFWMD GARR (Baxter)
- NEXRAD
- SFWMD Regular Gauges

- BCCA – Statically (Reclamation)
- LOCA (UCSD) – Stat.
- CORDEX (WCRP) – Dynami…
- COAPS (FCL / FSU) Dynam…ally
- …ES… – Dynamically
- BCSA (UF)
- WRF – Jupiter
- Raw GCMs - SimClim

- Annual Maxima
- Partial Duration Series
- GEV and other …stribution types
- …earson III, Par…
- Shape/Location/Scale Parameters: L-Mom x MLE
- Regional Frequency vs. At site Frequency distributions

- Correlation metrics (RMSE, IVSS, Taylor Diagram)
- Bias ca…ulation

- Quantile Mapping x Quantile Delta Mapping
- Multiplicative x Additive Quantile Delta Mapping
- …Model Res… x …ensemble approach
- Super ensemble vs. subset of best performing models
- Fit IDF Curves to selected durations and frequencies

- Add calculated deltas individually to each station x regional average
- Deterministic vs. perform stochastic simulation on ranges of calculated deltas
- Hourly distribution approaches (Santa Barbara, SFWMD, NOAA Atlas 14)

General Goals / Considerations:

- Represent extreme rainfall precipitation
- Sub daily datasets preferable
- Appropriate Broward coverage
- Length of time series (min 25-30 years)

- Daily Rainfa… Data sub… daily?)
- IPCC AR5 (C…)
- Regional Models
- RCP 8.5 and others?
- 2060 Horizon projection
- Min. 20 years of historical simulation
- Spatial Resolution (less than 30km)

- Duratio… …ter…ties of Inter… (indepen…ently versus joint)
- Rolling window for annual maxima
- NOAA scaling factors (constrained x non-constrained)
- Bias Correction Steps applied previously?

- …atio… …parame… (RM…E, S…) …qual… metrics
- Visualization of data – heat maps

- …dependency x …stationarity bias calculation
- Average biases? Models? Spatially?
- Select best performing methods or combine them all together?

- Representing Uncertainties (stochastic approach)
- Spatial differences among changing factors

Large associated uncertainties

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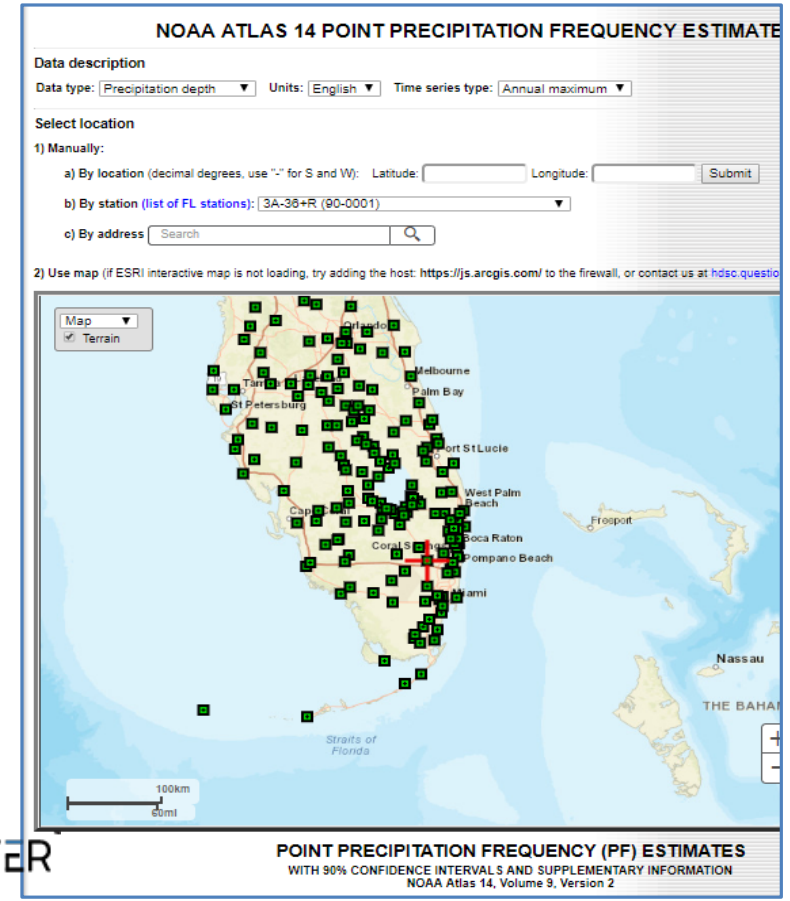
Future Rainfall Analysis Climate Datasets

- Evaluated Datasets
  - CLIMsystems
    - BC
    - Perion
    - SU COADS
    - CORDEX
    - Raw GCMs
  - Jupiter Intelligence
    - LOCA
    - Jupiter WRF
- Leverage Atlas 14 Rainfall Stations
- Target Future Year 2060

All best currently available global model data



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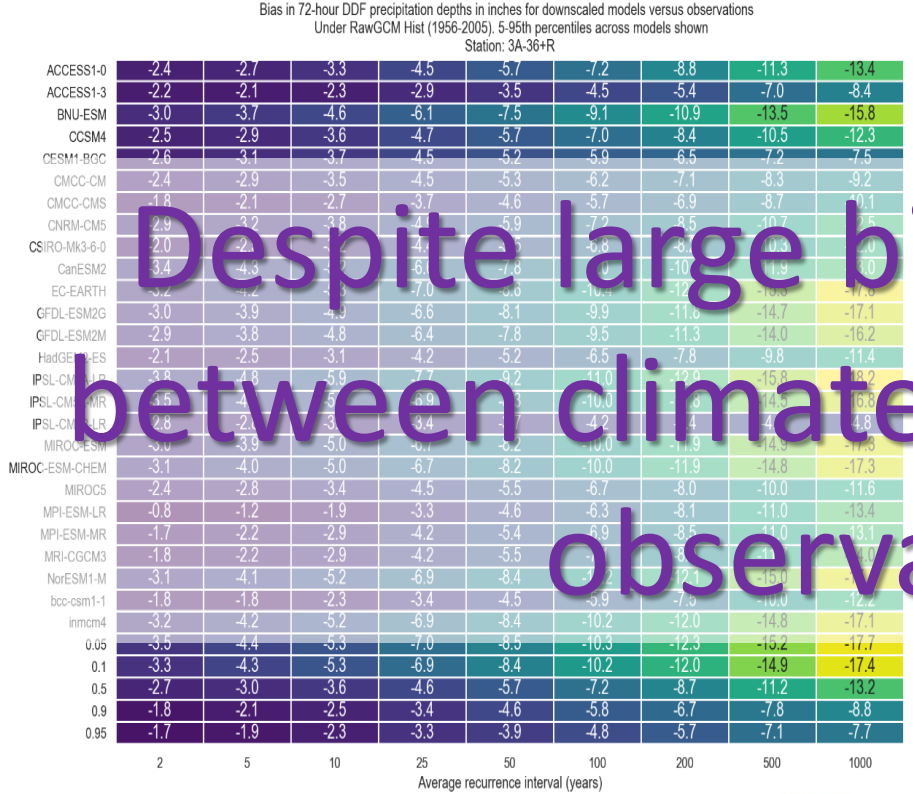
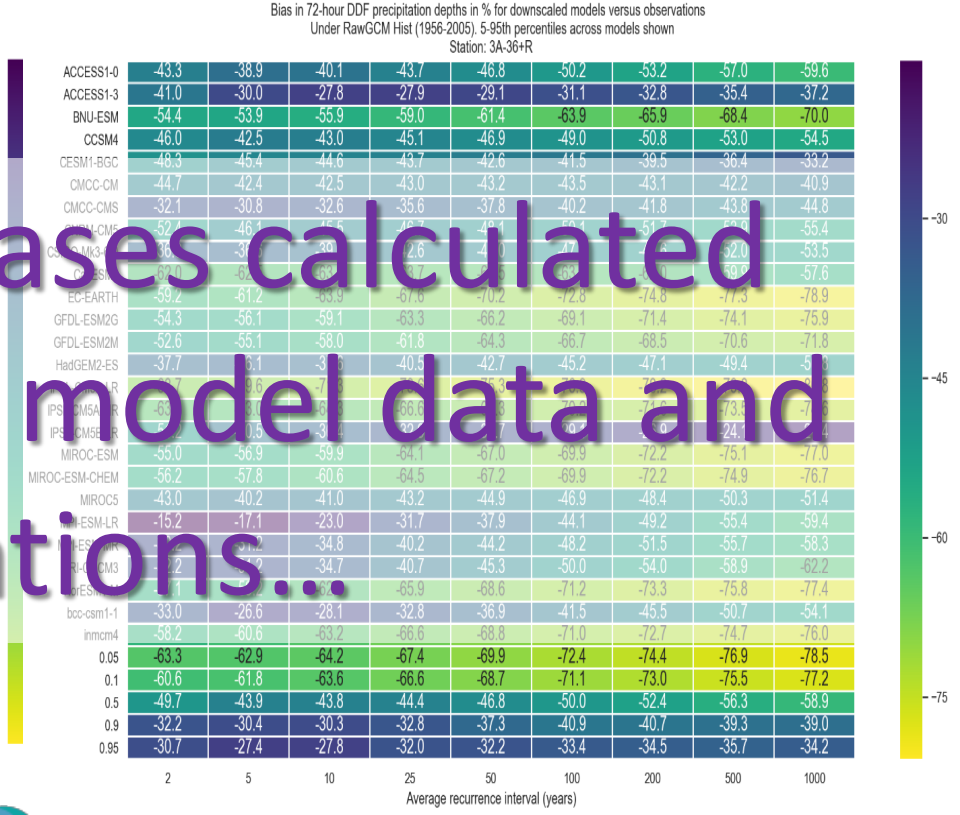
Model x Observation Data: Bias estimation





Despite large biases calculated between climate model data and observations...

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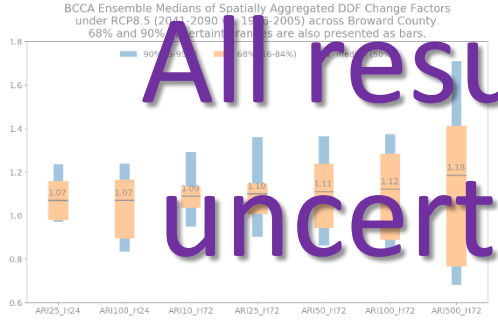
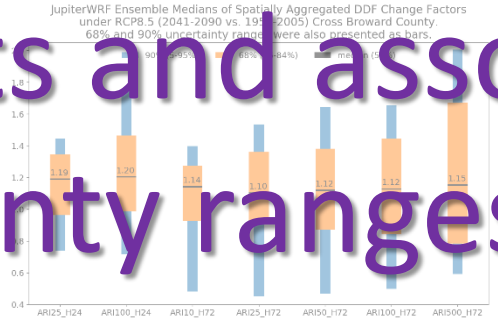
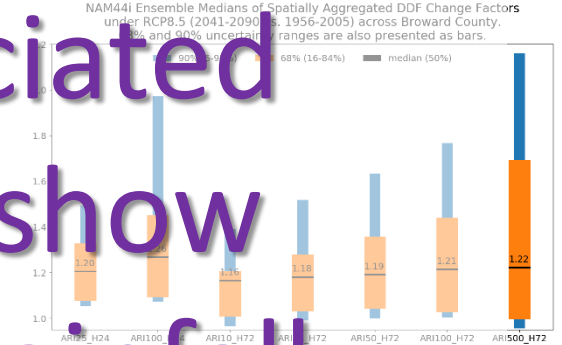
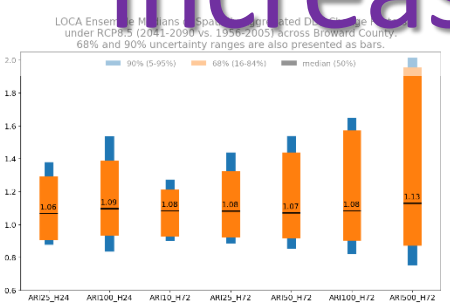
Calculating Changing Factors

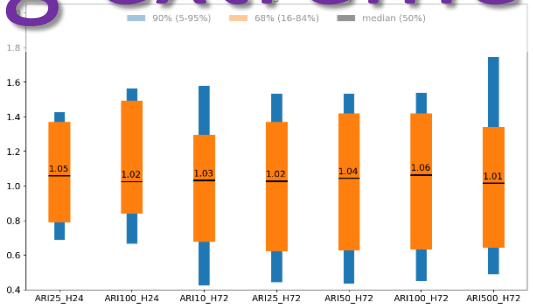
All results and associated uncertainty ranges show increasing extreme rainfall

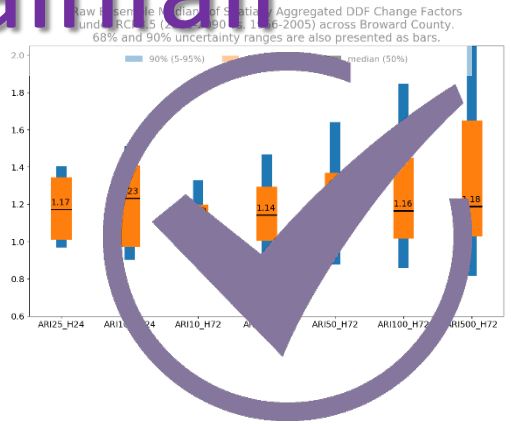












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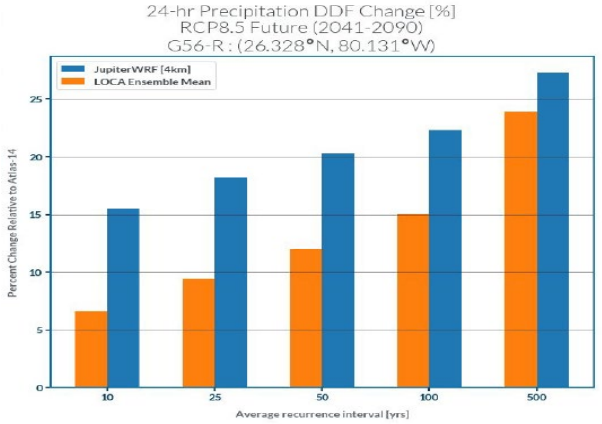
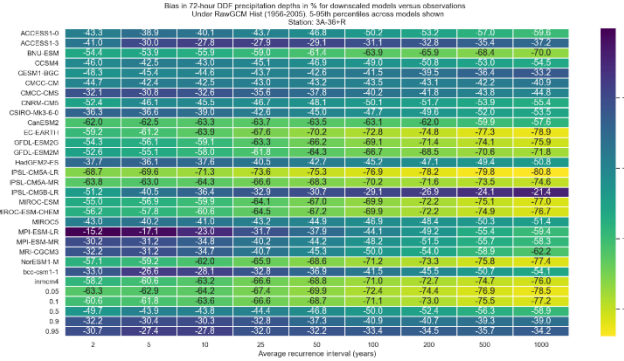
Future Conditions 100-Year Flood Elevation Map

Future Rainfall – Experts Panel

- Workshop on September 17
  - Representatives from:
    - Broward County
    - SFMD
    - FIU
    - USGS
    - Consultant Team
    - Other interested parties
  - Consensus on strategy for moving forward:

Super-Ensemble approach





Future Conditions 100-Year Flood Elevation Map

Combining Results for Broward

- Best available approach
- No significant difference for the calculated CF among stations (small spatial variability)
- Apply CF to NOAA Atlas 14 values

ADOPT SINGLE AVERAGE FACTOR (%) FOR THE ENTIRE URBAN AREA

Future Conditions 100-Year Flood Elevation Map

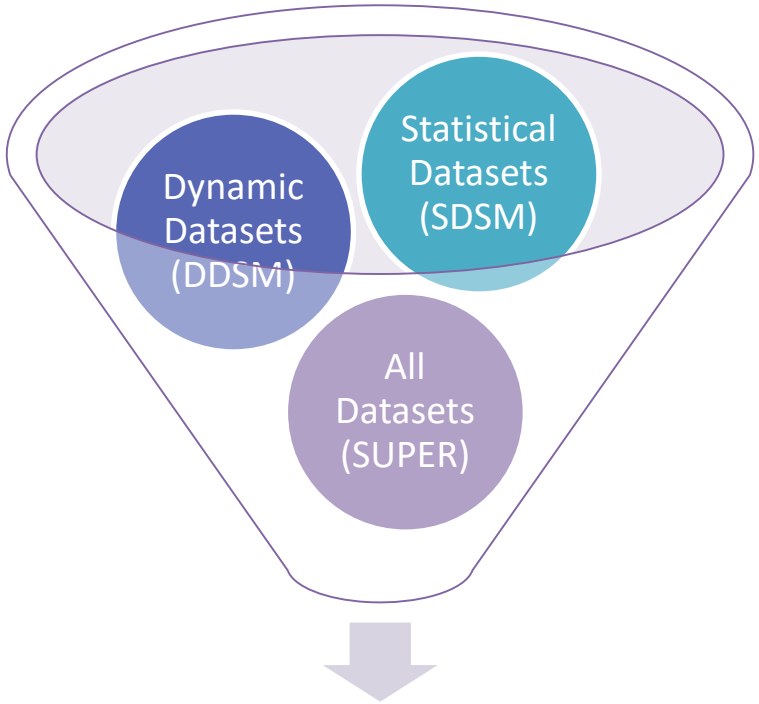
IPCC Recommendations

- Evaluating Results from Multiple Models
- Measure of Model Skills (model performance): yet to be identified
- Importance of characterizing uncertainty:
  - More than one dataset to represent observations
  - Multi-model calculations out-perform individual models
  - Multiple sources (RawGCMs, regional models, statistical & dynamical downscaled data)
  - Weighting or Subsets Approaches: need to determine statistical significance of the difference between models – given metric
  - ***Super Ensemble Approach,*** plus documentation of all individual results
  - Sample uncertainty space

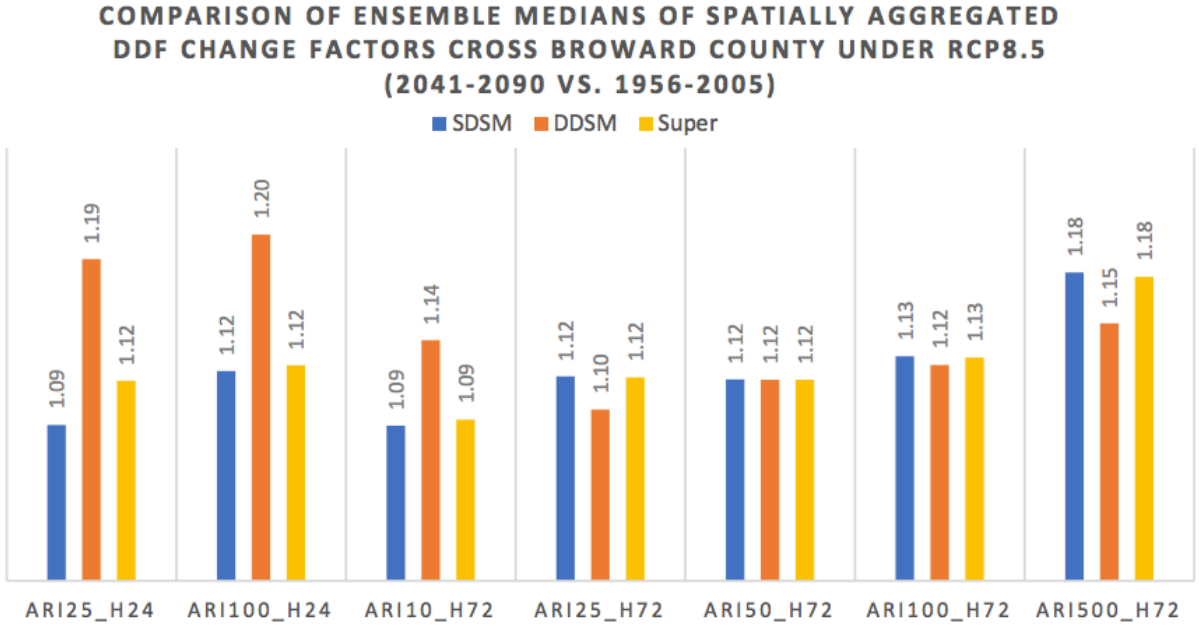
Aligned with IPCC Recommendations

Super Ensemble Approach

- Different subsets of all the individual model projections from the different datasets are chosen and fittings are calculated from each of these subsets (prob. analysis)
- This approach more explicitly calculates the uncertainty in the median change factors and reduce the generalization error of the predictions
- This approach converges on providing a single model domain-wide scaling value to use for storm events



Ensemble Results



Note: (1) SDSM=Raw + BCCA + LOCA, DDSM=NAM22i + NAM44i + JupiterWRF, Super=SDSM + DDSM; (2) JupiterWRF only contributed to H24 in DDSM and Super.

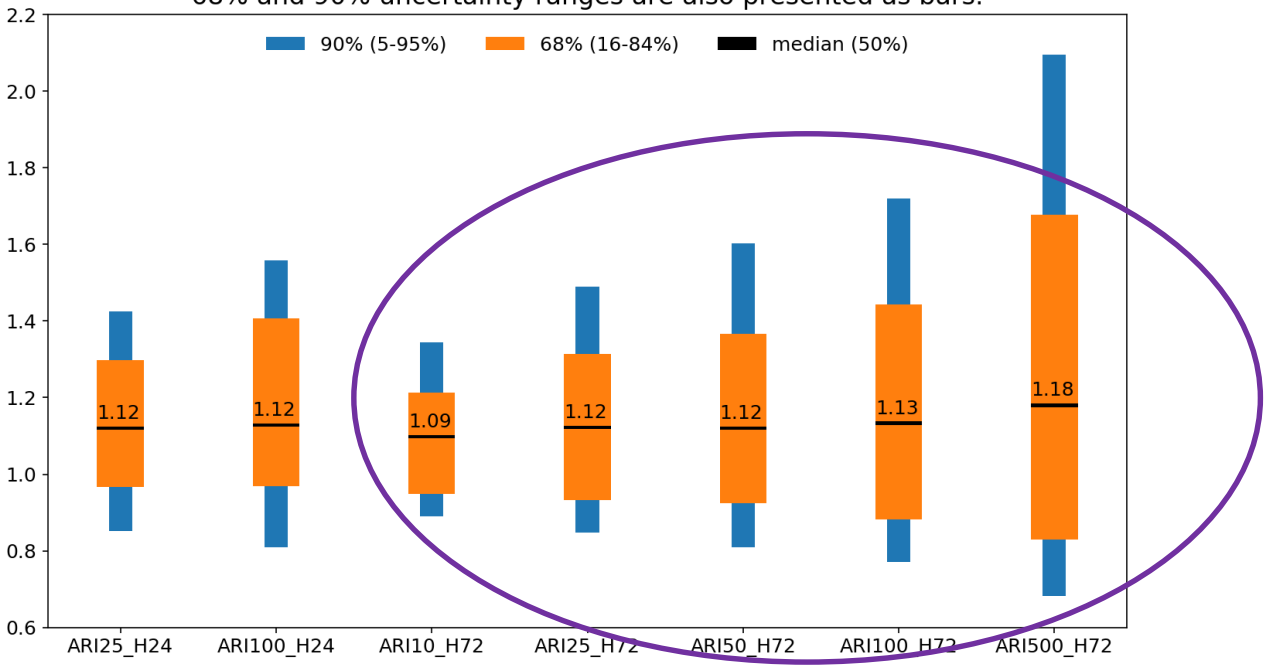
Super-ensemble Results for Design Storms (Longer Durations - 3 days)

Single model domain-wide scaling values for design storm events

- 10 year/3 day = 9% increase*
- 25 year/3 day = 12% increase*
- 50 year/3 day = 12% increase*
- **100 year/3 day = 13% increase***
- 500 year/3 day = 18% increase*

**To be applied over NOAA Atlas 14 precipitation frequency estimates*

Super Ensemble Medians of Spatially Aggregated DDF Change Factors under RCP8.5 (2041-2090 vs. 1956-2005) across Broward County. 68% and 90% uncertainty ranges are also presented as bars.



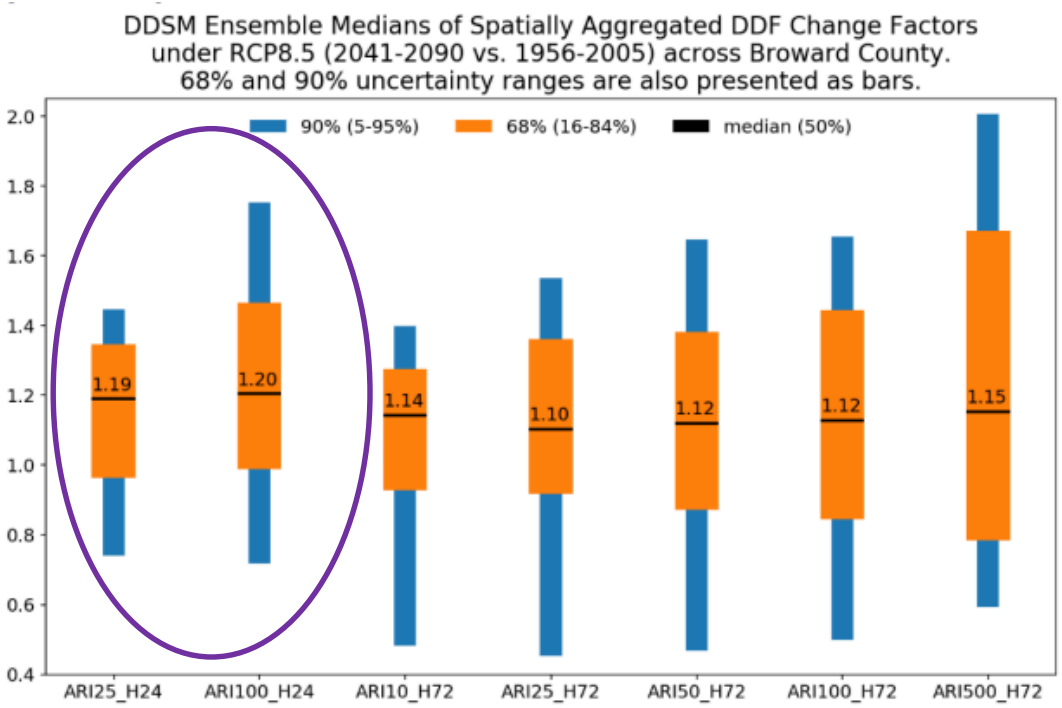
Whisker diagram of SUPER ensemble medians of spatially aggregated DDF change factors with uncertainty ranges.

Super-ensemble Results for Design Storms (Shorter Durations – 24 hours)

Single model domain-wide scaling values for design storm events

- 25 year/1 day = 19% increase*
- 100 year/1 day = 20% increase*

**To be applied over NOAA Atlas 14 precipitation frequency estimates*



Whisker diagram of DDSM ensemble medians of spatially aggregated DDF change factors with uncertainty ranges.