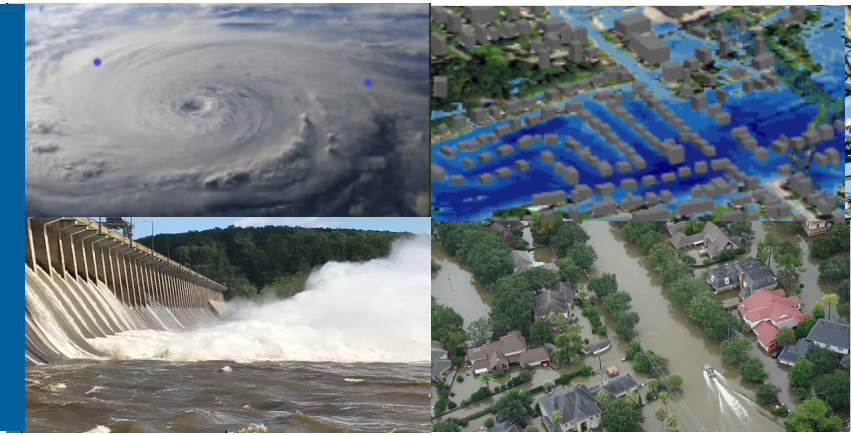
CASE STUDY: IDF ANALYSIS IN THE FACE OF CLIMATE CHANGE

Supporting Casco Bay Region Climate Change Adaptation



EUGENE YAN
Argonne Nation Laboratory

October 15, 2019
Westborough, MA

CLIMATE CHANGE ADAPTATION PLANNING IN THE CASCO BAY REGION OF MAINE

Regional Resiliency Assessment Program

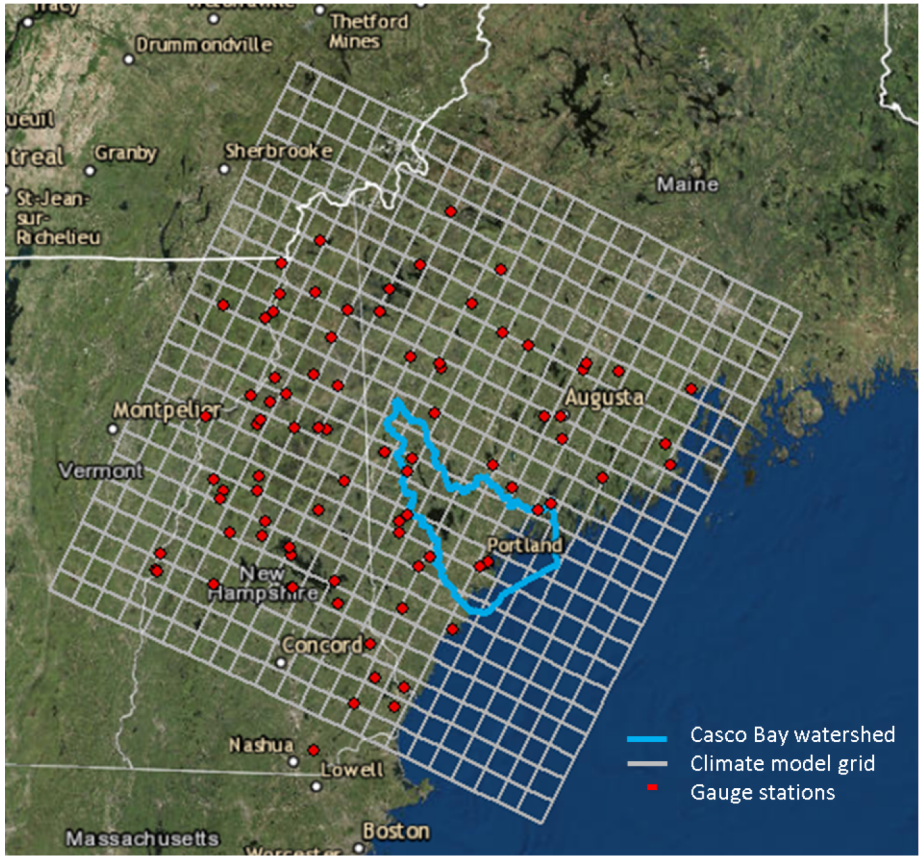
- Regional Climate Modeling (RCM)
- Intensity Duration Frequency (IDF) Curve Development
- Radar-Based Rainfall Data and Urban Flood Modeling
- Storm Surge Modeling

NEW COMPONENTS FOR IDF DEVELOPMENT

- Snowmelt effect on IDF
- Future climate projections
- Non-stationary frequency analysis

CASE STUDY: CASCO BAY REGION

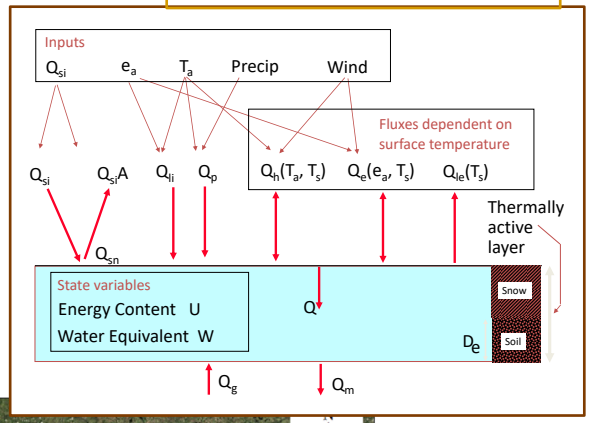
- Casco Bay watershed
  - City of Portland located downstream of the watershed
  - Recent flooding in 2007, 2014, and 2015 impacted by both stream flow and costal storm surge
- Data sources:
  - Precipitation historical records from daily and hourly rain gauges from the NOAA network
  - Precipitation future projections (shown as grids) extracted from regional climate dynamic downscaling results by Argonne using WRF (1965-2004; 2035-2065)

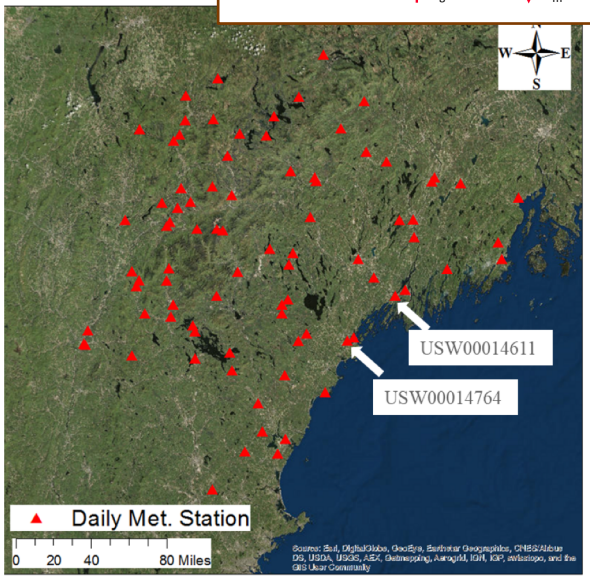


INCORPORATING SNOWMELT EFFCTS

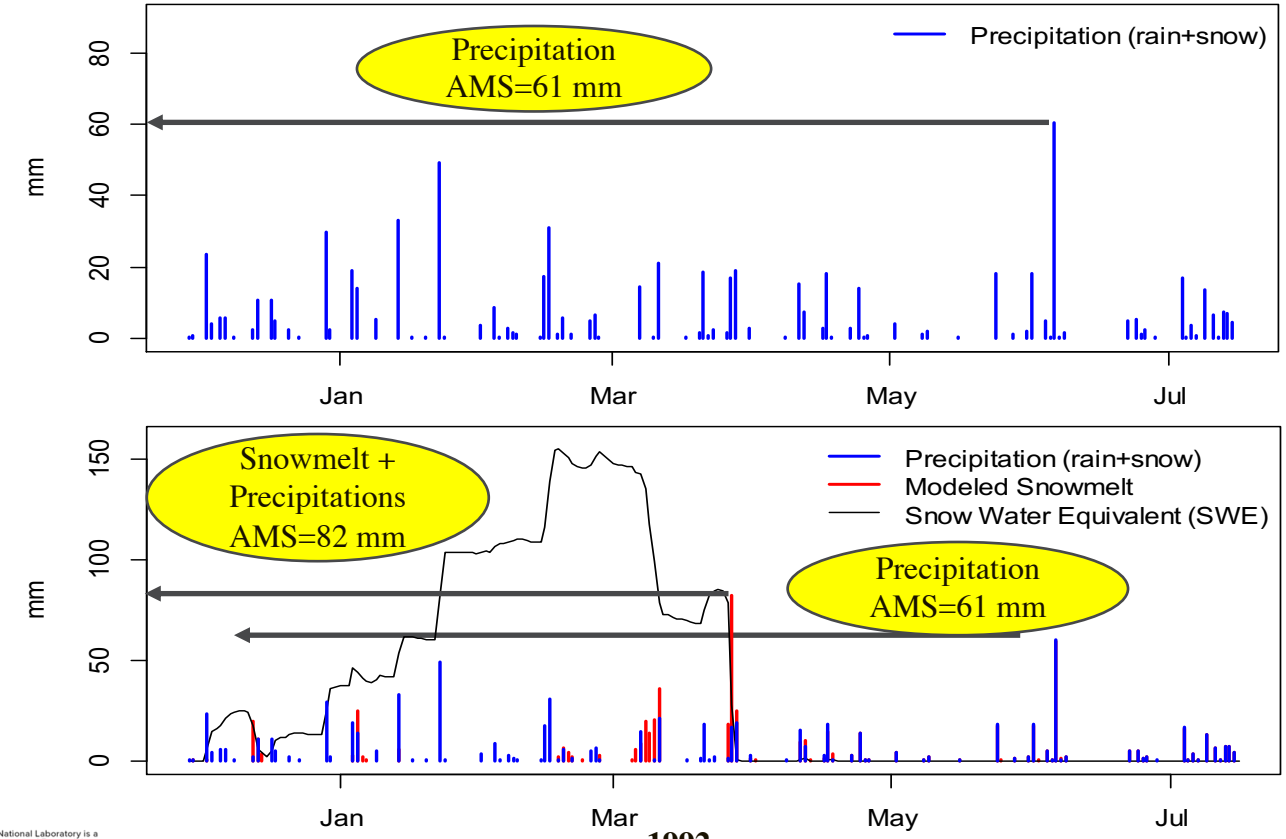
- Physically-based simulation of snow energy balance with Utah Energy Balance model (UEB)
- Model implementation
  - The snowmelt model was run for the same 85 stations with main climate inputs
  - Site parameters for each station were prepared using DEM, land cover, and leaf index data
  - Model calibration with Snow Water Equivalent (SWE) data, which were available only at two stations
  - Canopy cover was adjusted to match the simulated SWE with daily observed SWE to calibrate the model

Tarboton et al. (1995) and Mahat and Tarboton, (2012)





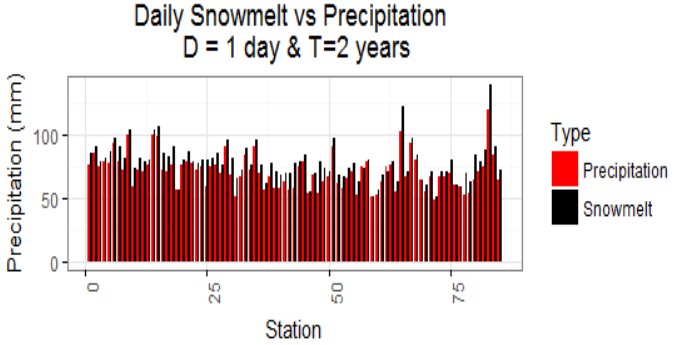
RESULTS OF SIMULATED SNOWMELT AND PRECIPITATION FOR "USW00014764"

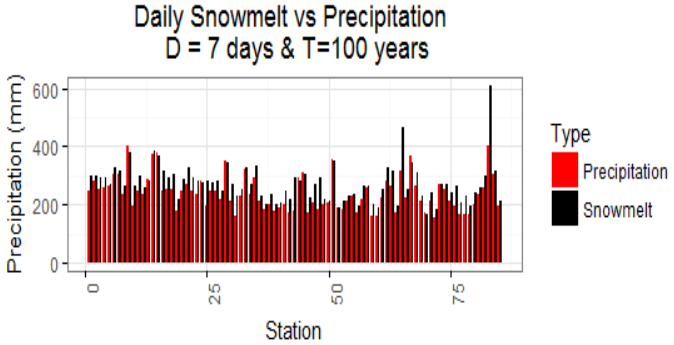


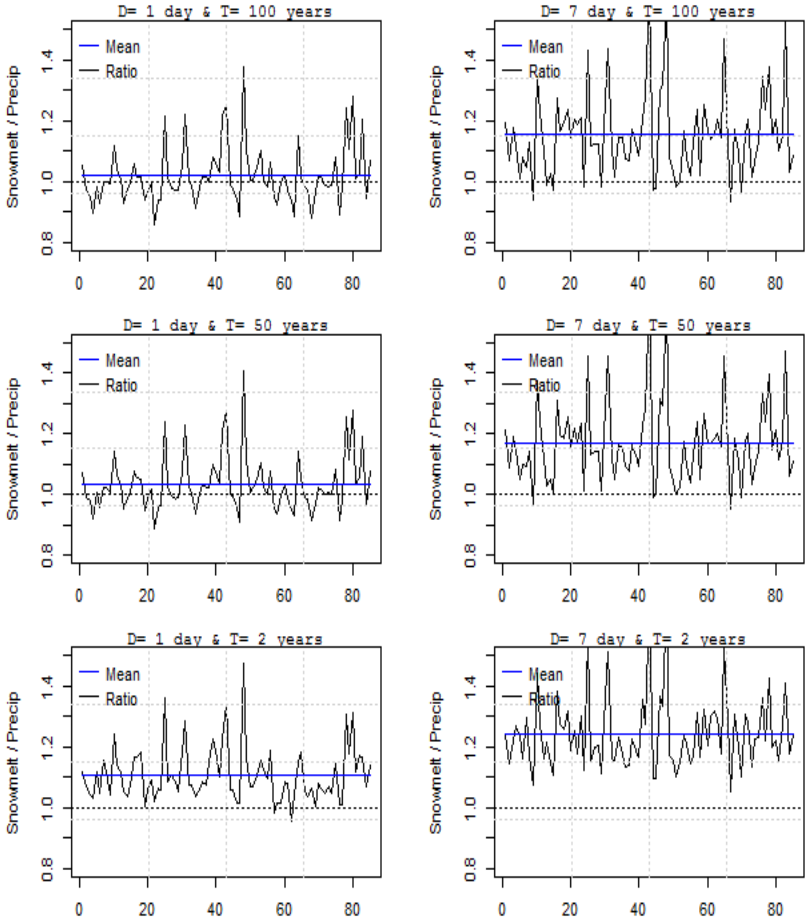
1992

IDF COMPARISON: SNOWMELT VS. PRECIPITATION (DAILY)

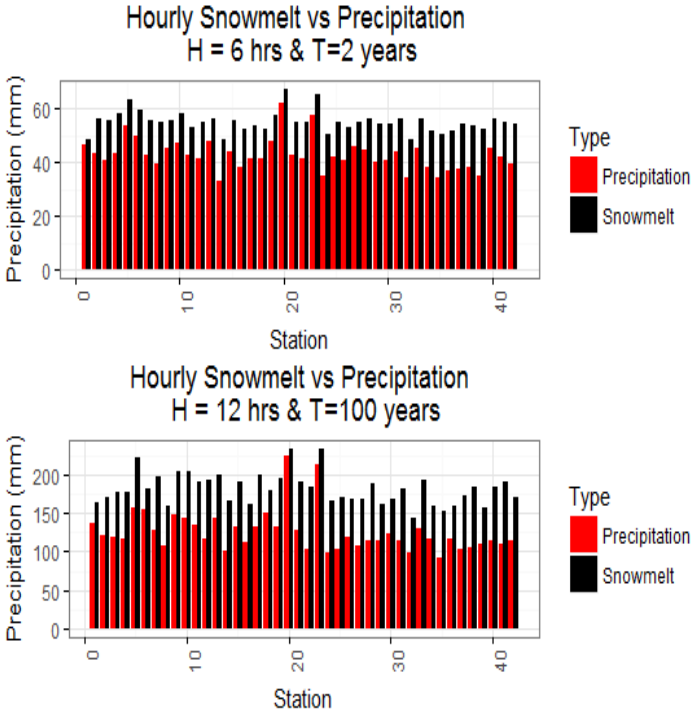
- The effect of snowmelt varies across stations, durations and return periods

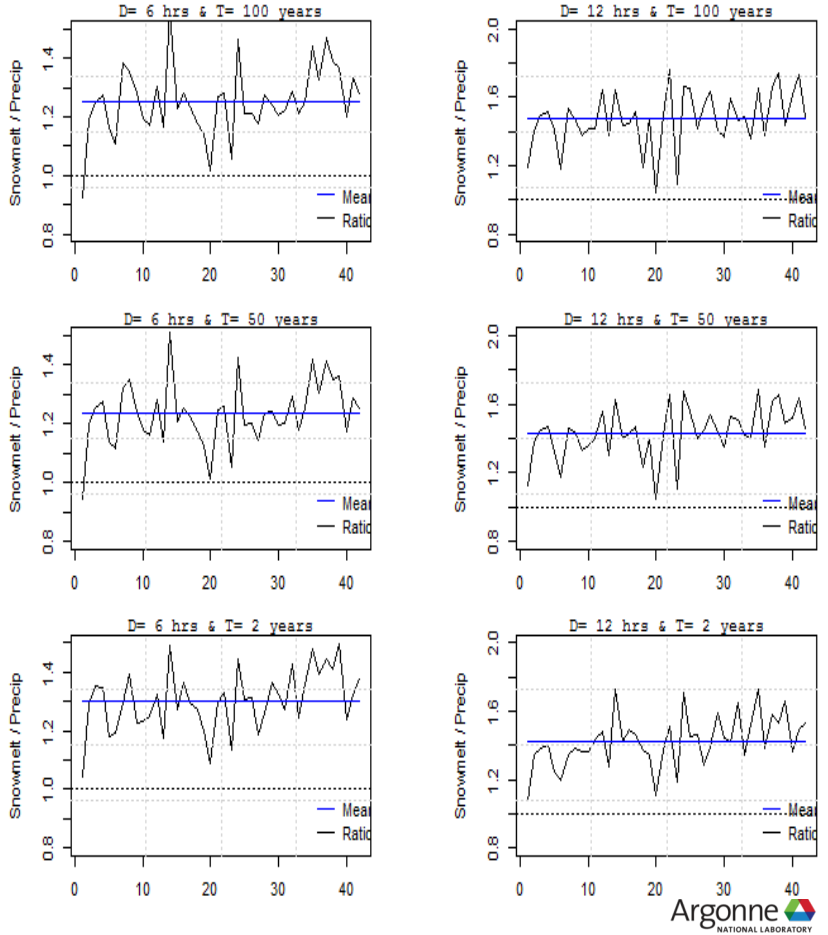






IDF COMPARISON: SNOWMELT VS. PRECIPITATION (HOURLY)

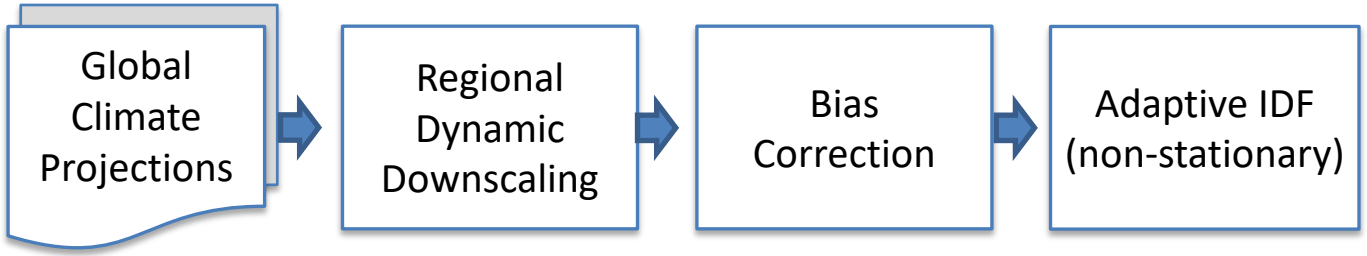




- More significant effect of nowmelt for sub-daily situations

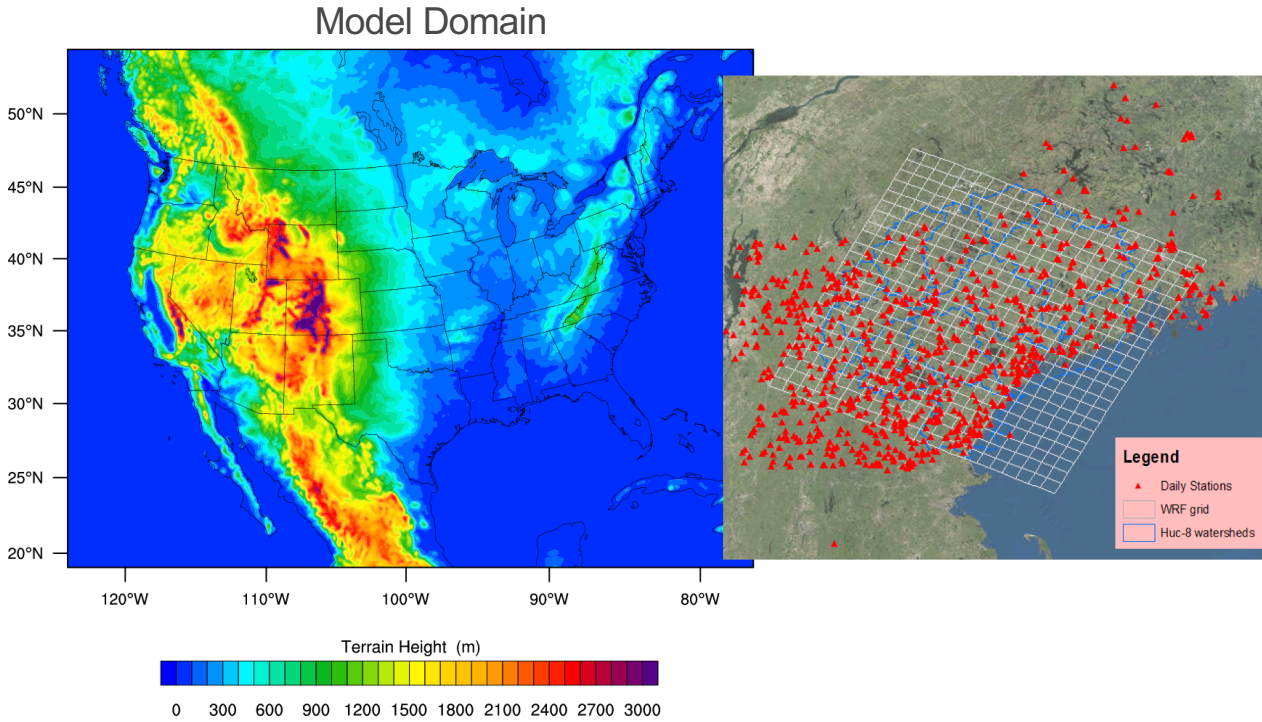
APPROACH

- Global climate projections (CCSM and GFDL model output for emission scenarios with RCP 4.5 and 8.5)
- Regional dynamic downscaling with Weather Research and Forecasting (WRF) modeling tool
- Bias correction of future projections
- Adaptive (non-stationary) IDF using future projections



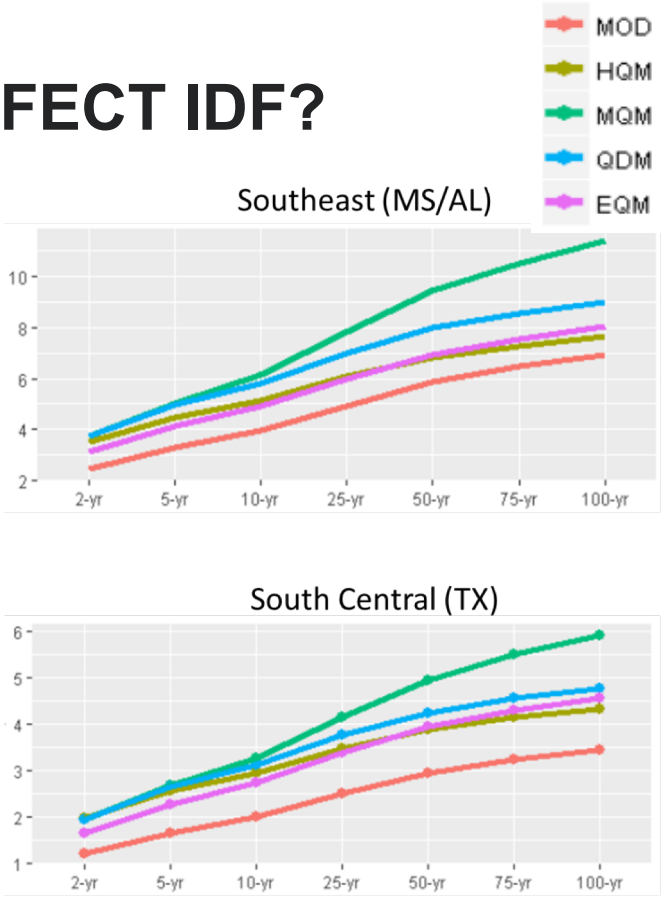
DYNAMICAL DOWNSCALING USING WRF

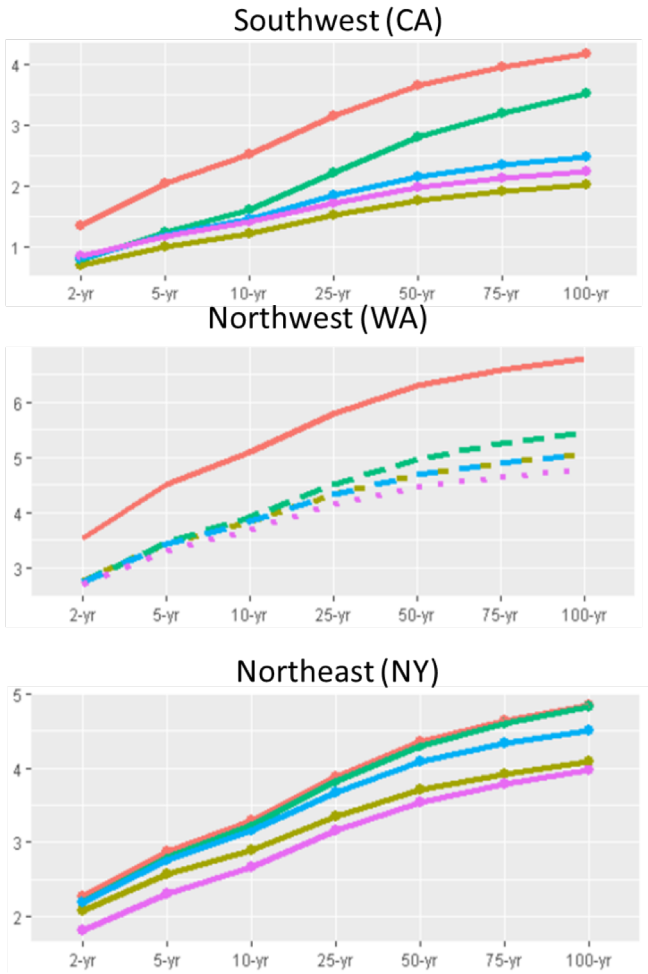
- Domain
  - Centered at 38.5 N and 97.5 W
  - Size: 5400 × 4080 km^2
  - Number of grids: 4 millions
  - Spatial resolution: 12 km
  - Number of output: >50
- Results
  - Driven by CCSM4 and GFDL
- Bias correction
  - 1974-2004- control period for bias correction
  - 2034-2064



HOW DOES BIAS CORRECTION AFFECT IDF?

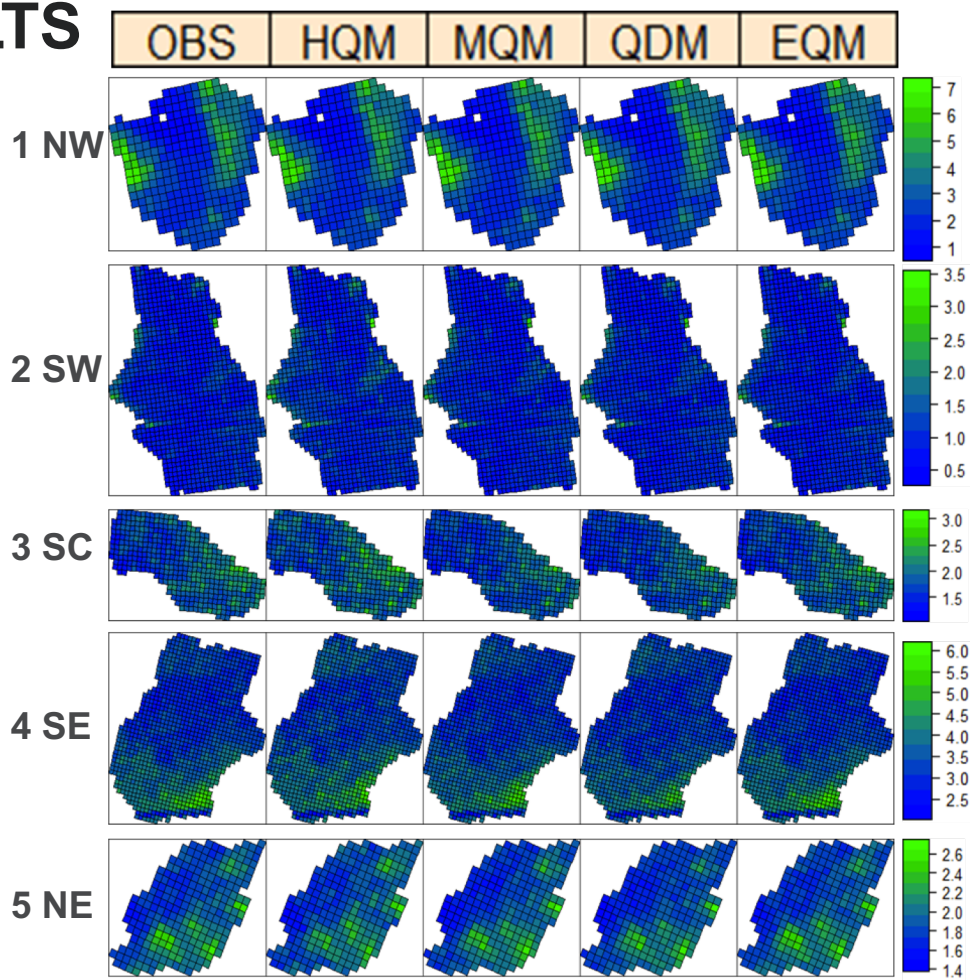
- **Analysis**: IDFs are derived from GEV distribution fitted by 30-yr future 1-day precipitations
- **Comparison**: Area-averaged 1-day duration IDF curves (inches)
- **Performance**: Different bias correction methods result in significantly different IDFs





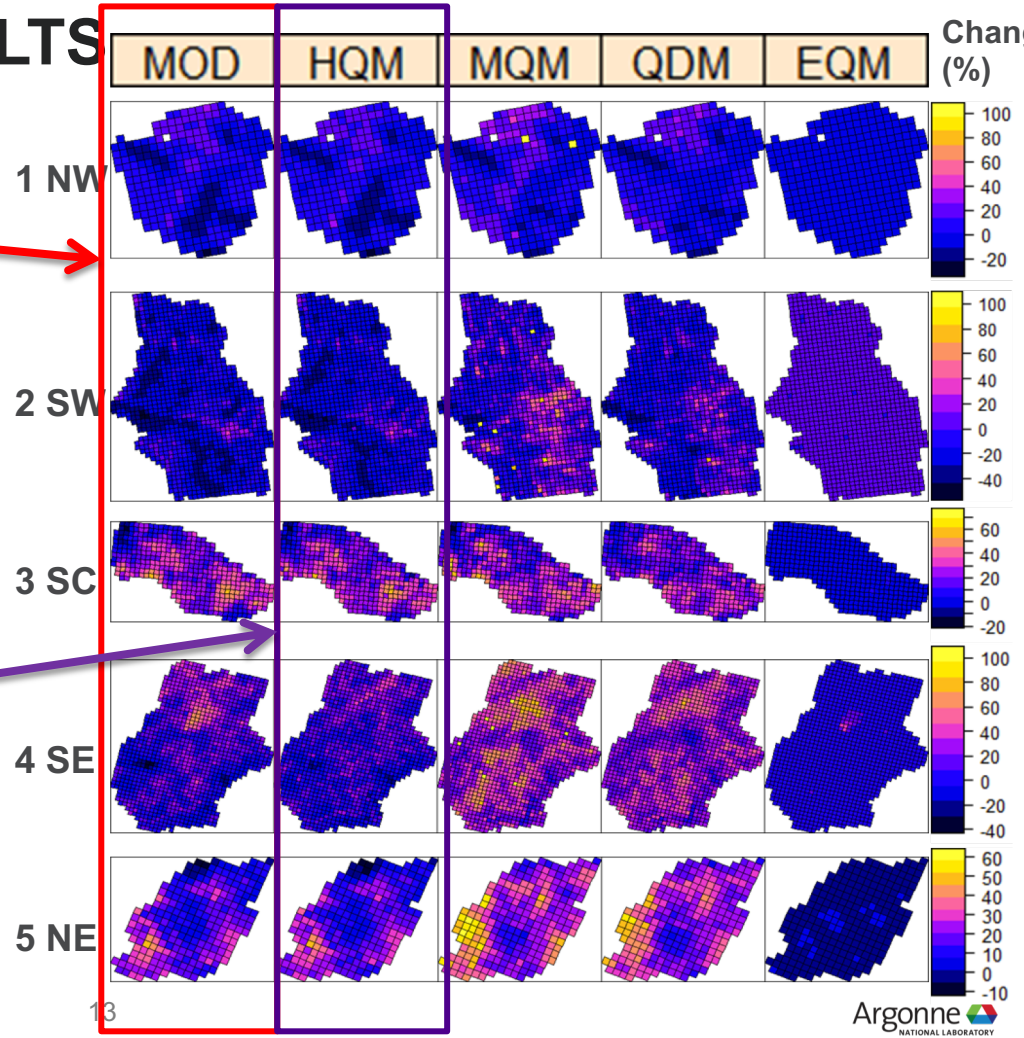
BIAS CORRECTION RESULTS (CONTROL PERIOD)

- **Comparison**: mean annual maximum (in inches) in control period period (1975-2004)
- **Performance**: all methods show similar performance of removing bias for the control period



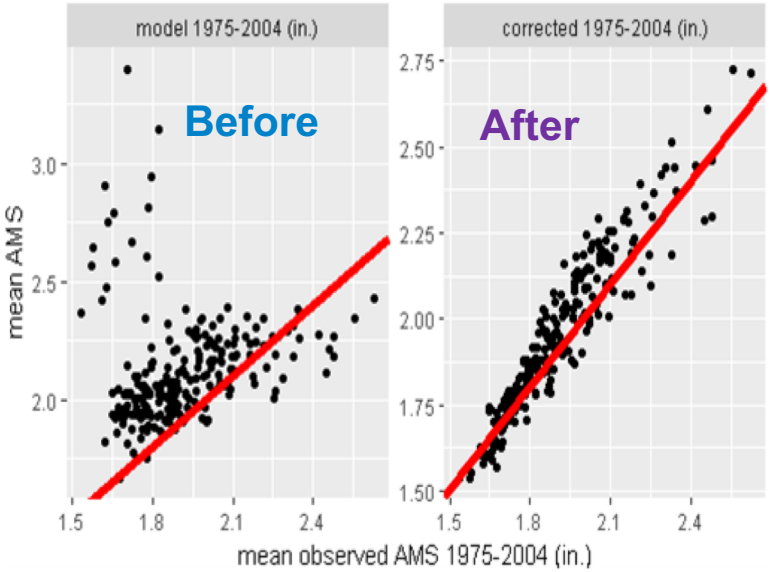
BIAS CORRECTION RESULTS (CHANGE IN FUTURE)

- **Comparison**: percent change in mean annual maximum (MAM) from historical (1975-2004) to future (2035-2064) periods
- **Performance**: HQM method best preserves changes from historical period to future period

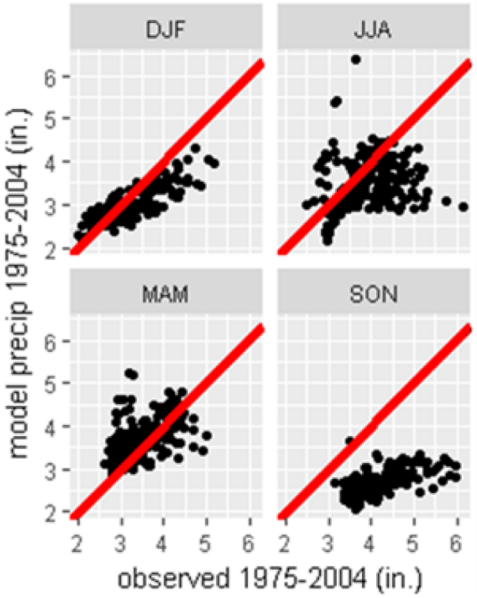


BIAS-CORRECTED VS NOT CORRECTED

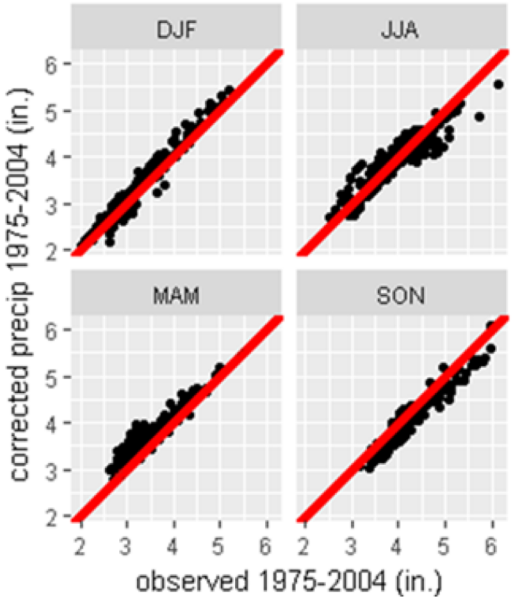
- Mean seasonal maximum precipitation for winter (DJF), spring (MAM), summer (JJA), and fall (SON) before and after corrections
- Mean annual maximum precipitation before and after corrections



Before Bias Correction

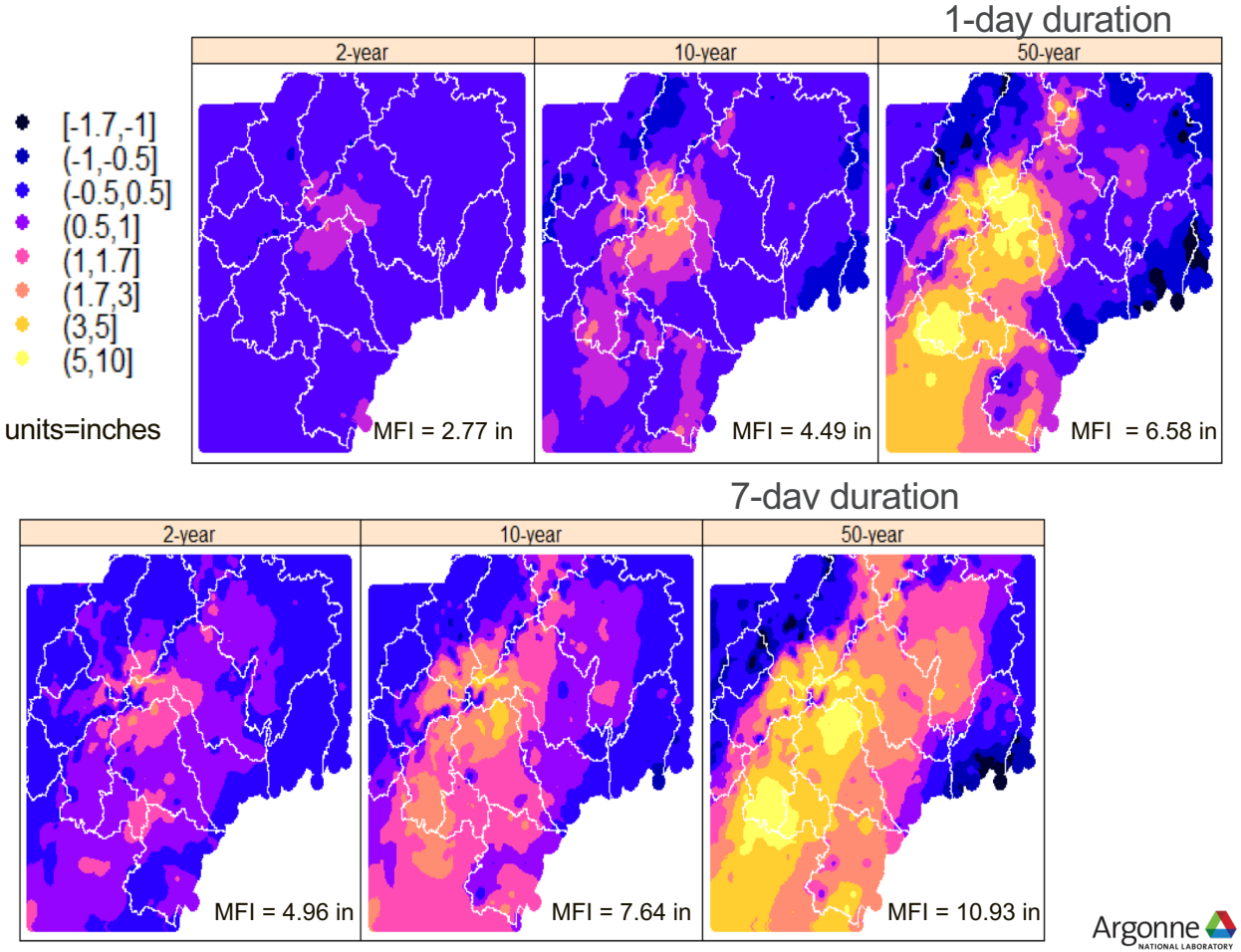


After Bias Correction



IDF COMPARISON – COMBINED FUTURE VS. HISTORIC

- Comparing mean 1-day and mean 7-day IDF estimates
- Difference = Combined future IDF - historical IDF
- Greatest increases at higher return periods or located at higher elevations



SUMMARY

- **This case study includes the following components in IDF analysis:**
  - Quantification of snowmelt effects
  - Dynamic downscaling with a high-resolution WRF model to better project the extreme events
  - Identification and correction of bias from regional climate model output to minimize the model uncertainty while preserving the increasing trend projected from the model
  - Incorporation of future projections and non-stationary distributions for new IDF