Understanding the Impacts of Climate Variability/Change on Hydrological Extremes

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Motivation:

- Climate variability and climate change have significant impacts on precipitation as well as near-surface variables such as air temperature and relative humidity. All these variables are important to hydrological modeling.
- The intensity and frequency of flood and drought have been increased and the trend is expected to continue. This study conducted WRF-Hydro offline simulations driven by WRF-downscaled climate variables to understand the climate change impact on hydrological extremes and to provide information to climate resilience and risk assessment.

Model Description:

- WRF-Hydro (offline):WRF-Hydro version 5 with a basic configuration. No nudging, no spatially distributed soil-related parameters.
- The LSM is at a grid spacing of 4 km; hydrological routing is at a spatial resolution of 200 m. Time step is 10 seconds.
- Surface flow, saturated subsurface flow, gridded channel routing, and a conceptual baseflow ("pass-through") are active in this study.

Meteorological Input for WRF-Hydro:

- WRF driven by CCSM4, 1995-2004, 2045-2054, RCP8.5
- WRF driven by GFDL-ESM2G, 1995-2004, 2045-2054, RCP8.5
- WRF driven by HadGEM-ES, 1995-2004, 2045-2054, RCP8.5

Model Calibration for Hurricane Charley in August 2004:

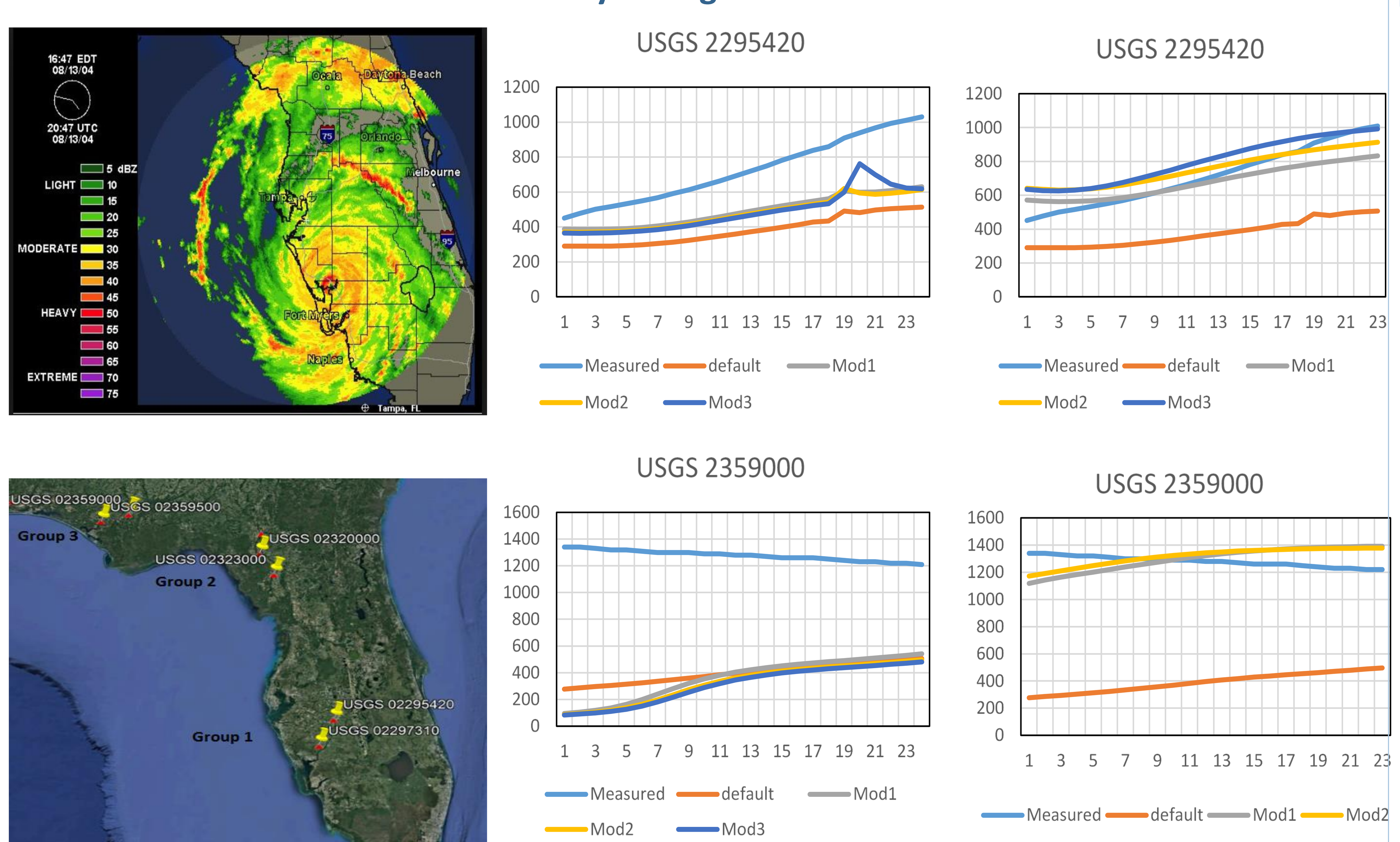


Figure 1. Left: two sites are calibrated together without zoning; Right: two sites are calibrated separately.

Key findings for calibration:
Because there is only one parameter for the entire domain that represents one key feature, it is difficult to adjust that only parameter to improve model performance over the entire domain. We found that, compared to calibrating the only parameter over entire domain of interest, using spatial zoning approach can significantly improve the model performance, because the bias over the three groups are different, and the calibration need to work on the parameters for these groups towards different directions.

WRF-Hydro Model Evaluation against Observed Discharge over USGS Sites

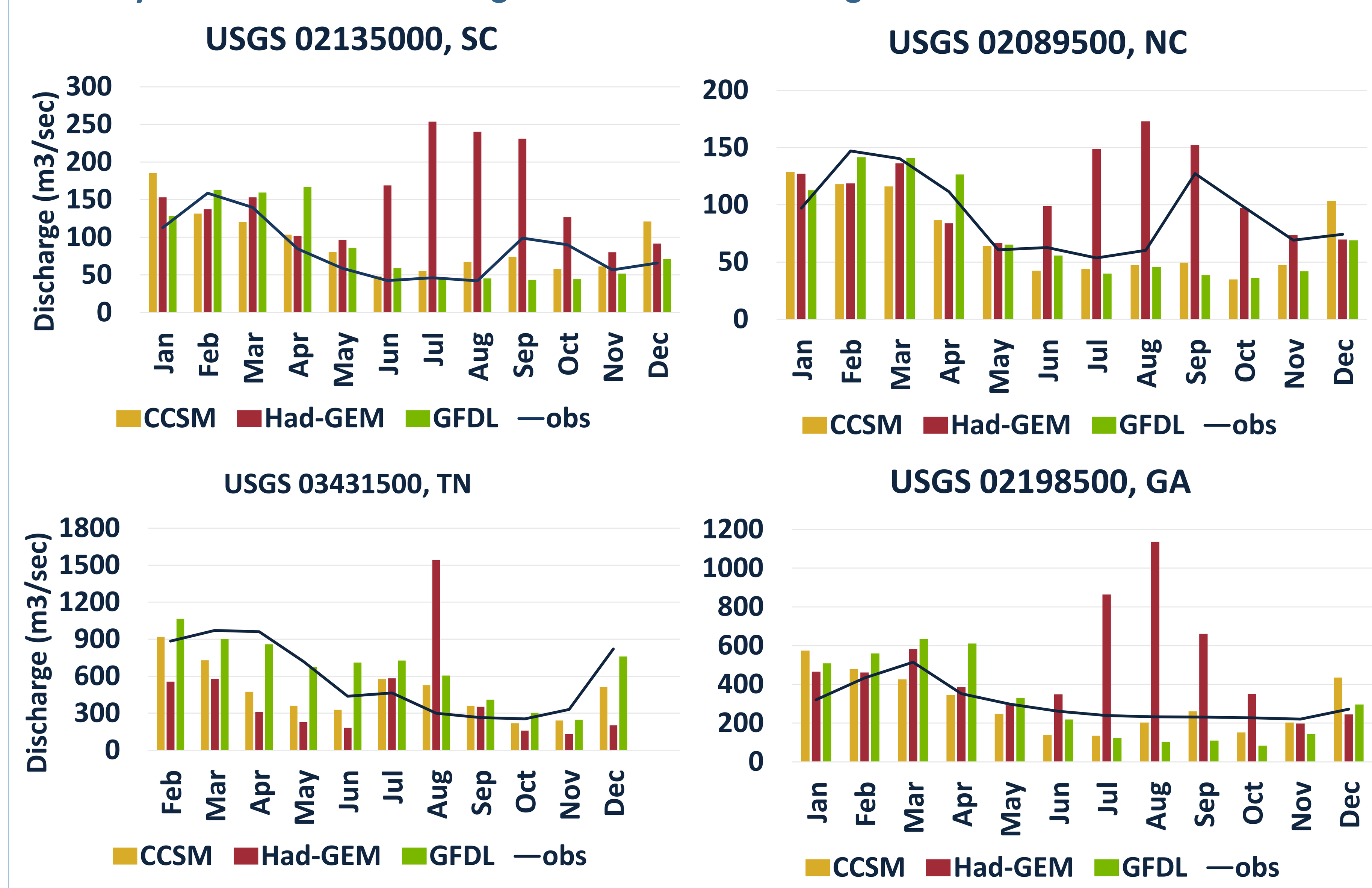
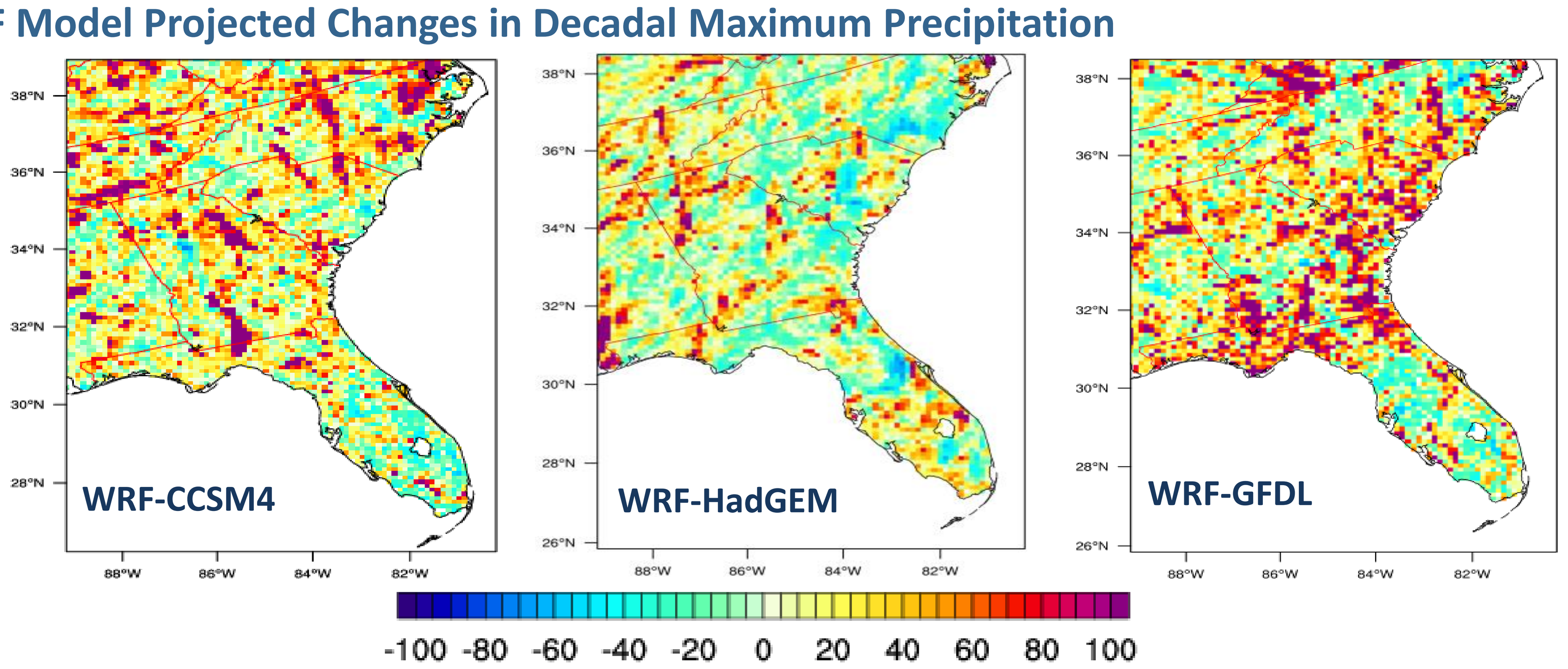


Figure 2. Comparison in 10yr monthly mean discharge between USGS observation and WRF-hydro simulations. The WF-hydro input is provided by WRF_CCSM, WRF_HadGEM and WRF_GFDL, respectively.

WRF Model Projected Changes in Decadal Maximum Precipitation



WRF-Hydro Model Projected Changes in Discharge

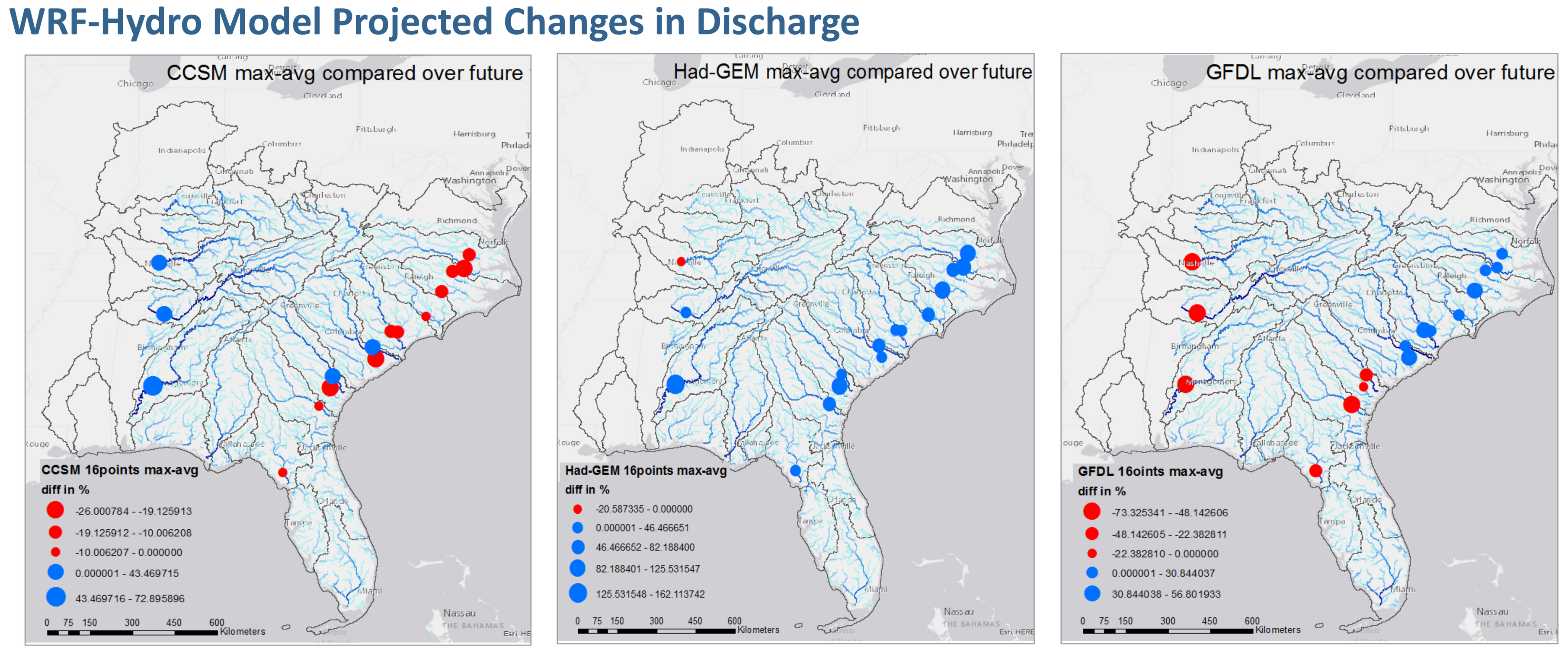


Figure 3. Dots: projected changes (%) in 10yr averaged annual maximum discharge from historical to mid-century under RCP8.5 scenario. Background map: future 10yr mean annual maximum discharge projected by WRF-Hydro driven by three different WRF simulations.

WRF-Hydro Model Projected Changes in Surface Water Depth

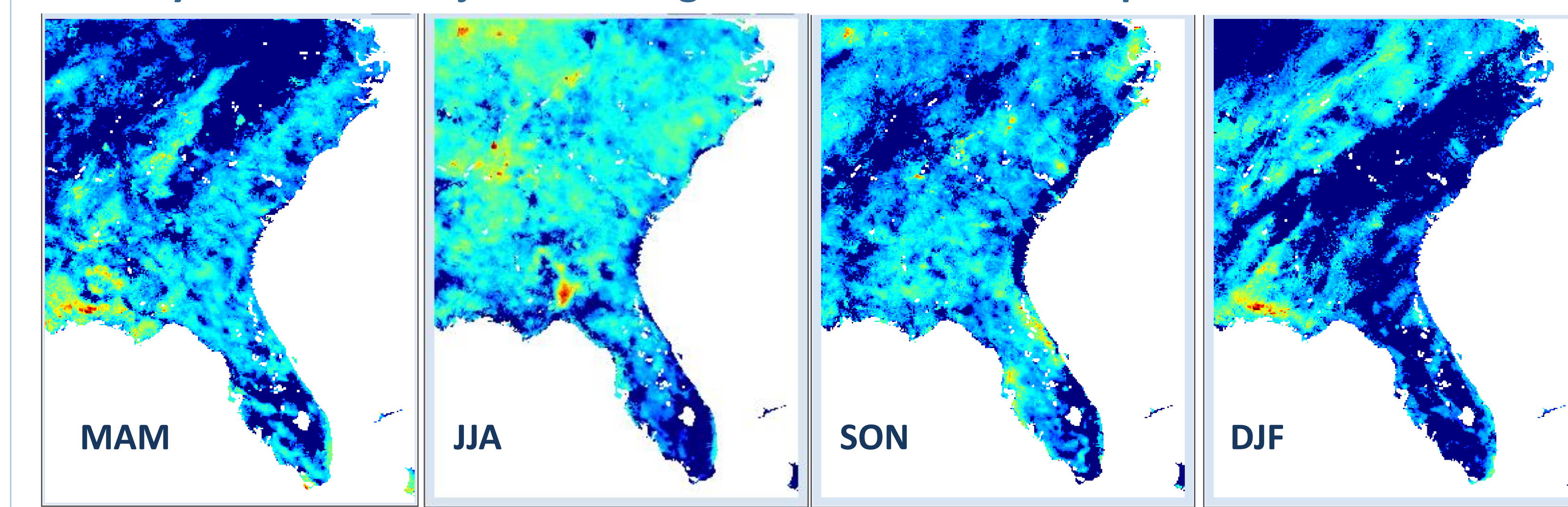


Figure 4. WRF-Hydro driven by WRF_CCSM4 projected changes (%) in 10yr seasonal average surface-water-depth. The numbers are normalized by historical 10yr annual average.

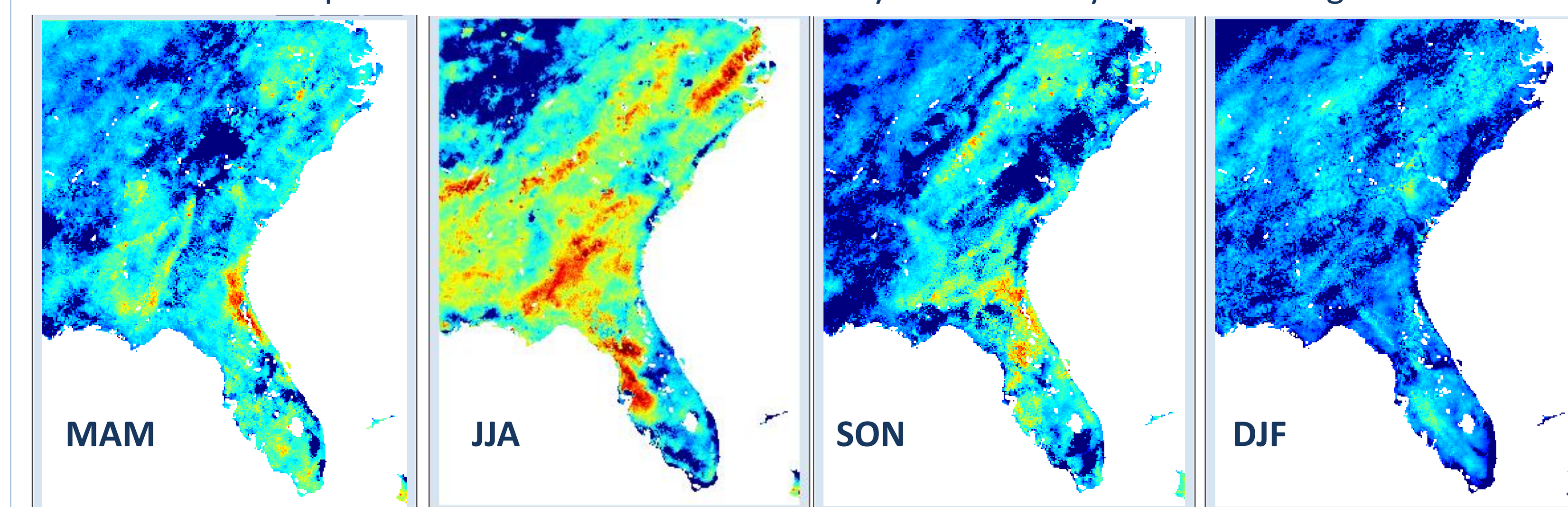


Figure 5. WRF-Hydro driven by WRF_HadGEM projected changes (%) in 10yr seasonal average surface-water-depth. The numbers are normalized by historical 10yr annual average.

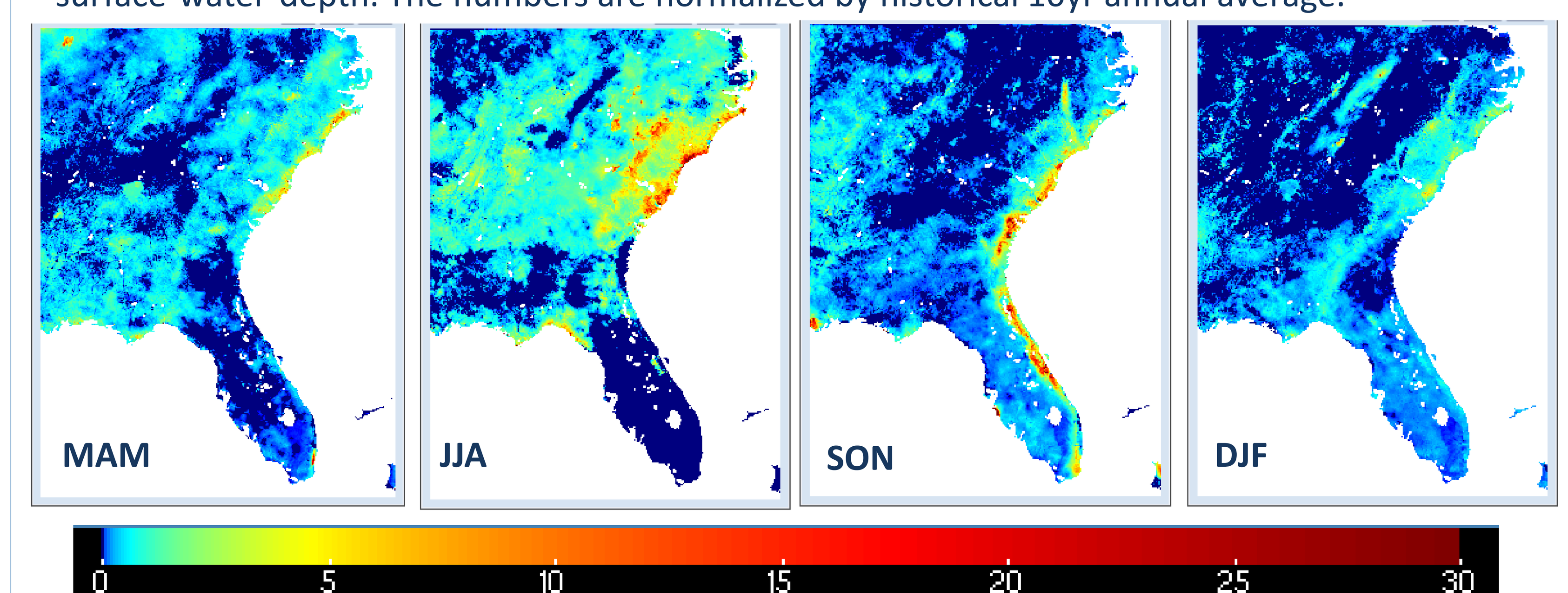


Figure 6 WRF-Hydro driven by WRF_GFDL projected changes (%) in 10yr seasonal average surface-water-depth. The numbers are normalized by historical 10yr annual average.

WRF-Hydro Model Projected Extremes of Surface Water Depth

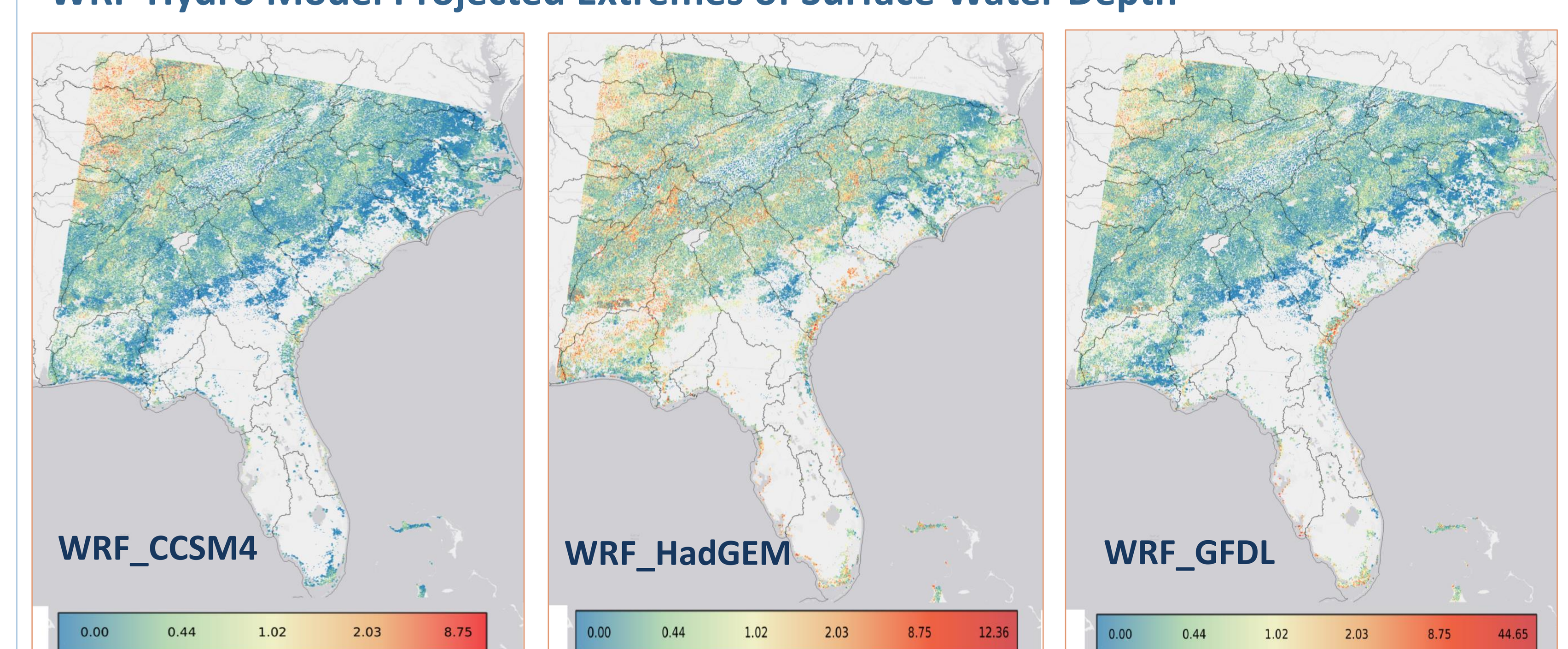


Figure 7. Non-stationary GEV estimated 50-yr return level of surface water depth (unit: ft). The GEV use 20yr data from historical and future periods.