Future hydrological predictions: Does **dynamical downscaling** add any value?

Moetasim Ashfaq
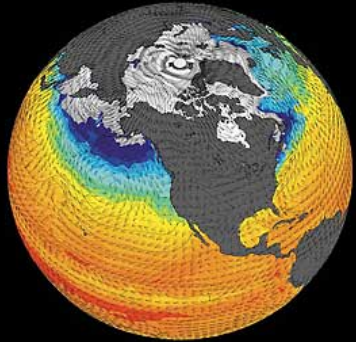*Oak Ridge National Lab*

Co-investigators
Shih-Chieh Kao
Oak Ridge National Lab
Noah Diffenbaugh
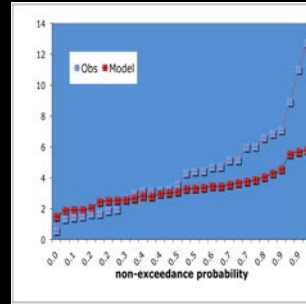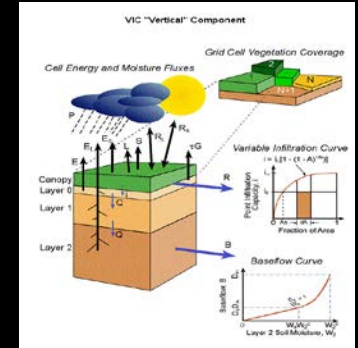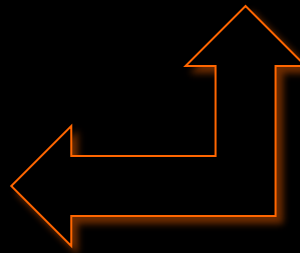*Stanford University*

September 20, 2011

Global Climate Model

Statistical Correction

Hydrological model

Regional Climate Model
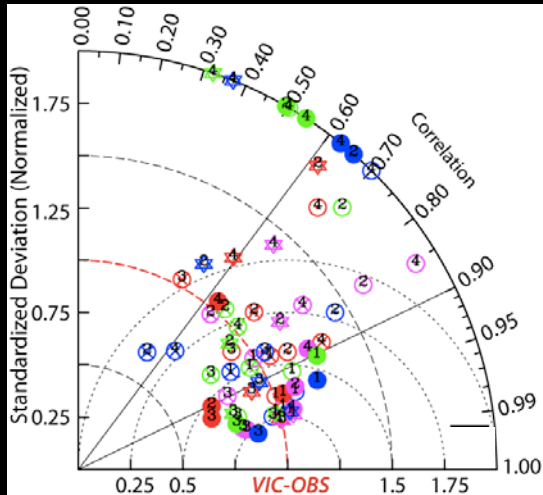
OAK RIDGE
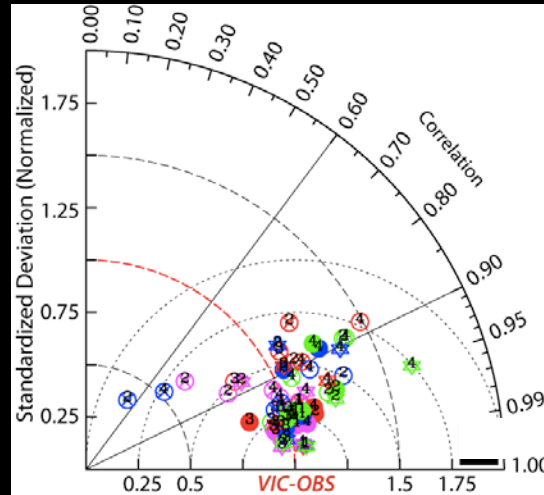National Laboratory

Hydrological Predictions

Baseline (1960-1999)

Future (1960-1999)

Original-VIC versus OBS-VIC

Corrected-VIC versus OBS-VIC

Original-VIC versus Corrected-VIC

Legend:
- ⊙ Northeast
- ✡ Southwest
- ● Southeast
- ⊗ Northwest

- ▬ DJF (red)
- ▬ MAM (magenta)
- ▬ JJA (blue)
- ▬ SON (green)

1 Soil Moisture
2 Runoff
3 Evapotranspiration
4 Baseflow

OAK RIDGE National Laboratory
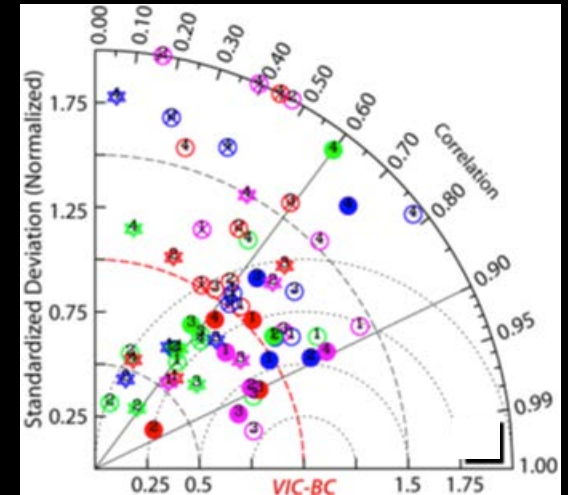
- **Two sets of Variable Infiltration Capacity (VIC) model simulations**

- **Set one** -
  Driving data : GCM (CCSM at T85)

  - **Simulation periods**

    - **1960-1999** (baseline)

    - **2000-2039** (near-term future)

  - **Total no of ensembles: Five**

  - **VIC model resolution 0.125 degree**

- **Set two** -
  Driving data : RCM (RegCM at 0.25 degree)

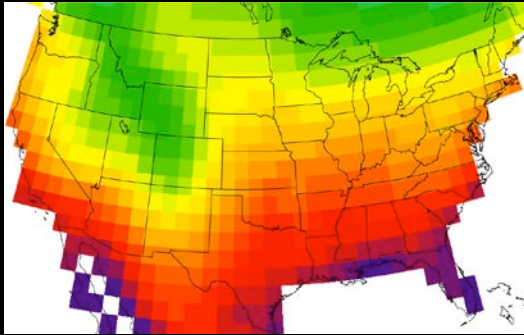 - **Simulation periods**

    - **1960-1999** (baseline)

    - **2000-2039** (near-term future)
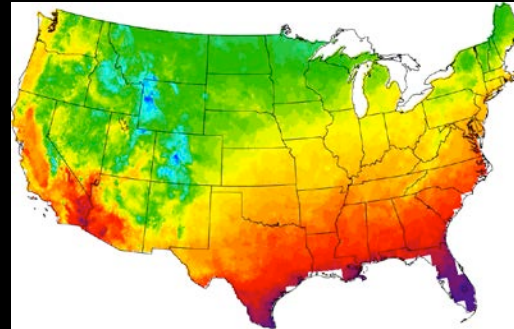
  - **Total no of ensembles: Five**
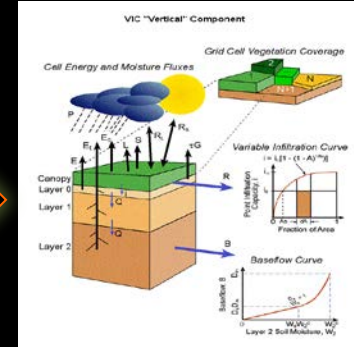
  - **VIC model resolution 0.125 degree**

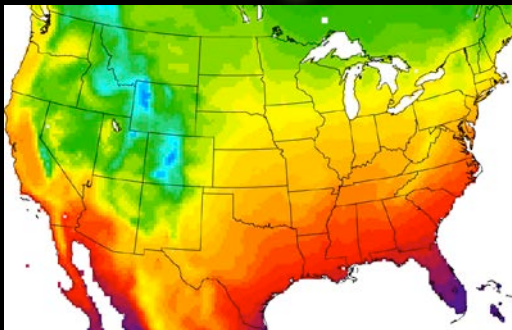OAK RIDGE National Laboratory
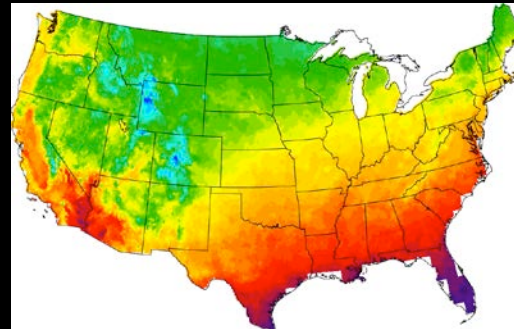
GCM

Corrected-GCM
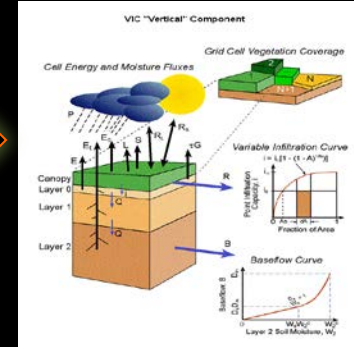
GCM-VIC

RCM

Corrected-RCM

RCM-VIC

- Different horizontal resolution
- Different means and SD
- Different autocorrelation and future changes

- Similar horizontal resolution
- Similar means and SD
- Different autocorrelation and future changes

?

for the Department of Energy

OAK RIDGE
National Laboratory

- **Comparison of Precipitation and temperature extremes**

  - **Observations: *NARR, Maurer et al.***

- **Western United States snow cover**

  - **declining**

  - **trends are driven by temperature changes**

  - **Observations: *Snow course***

- **Surface runoff over Continental United States**

  - **directly influenced by precipitation extremes**

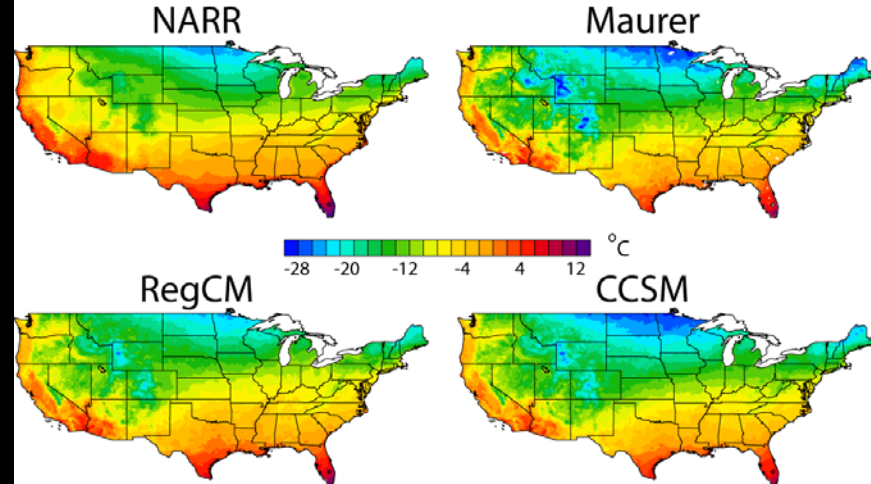 - **Observations: *USGS runoff, Observations driven VIC***

OAK RIDGE
National Laboratory

Baseline Comparisons

Hot Extreme (95th percentile) (1960-1999)
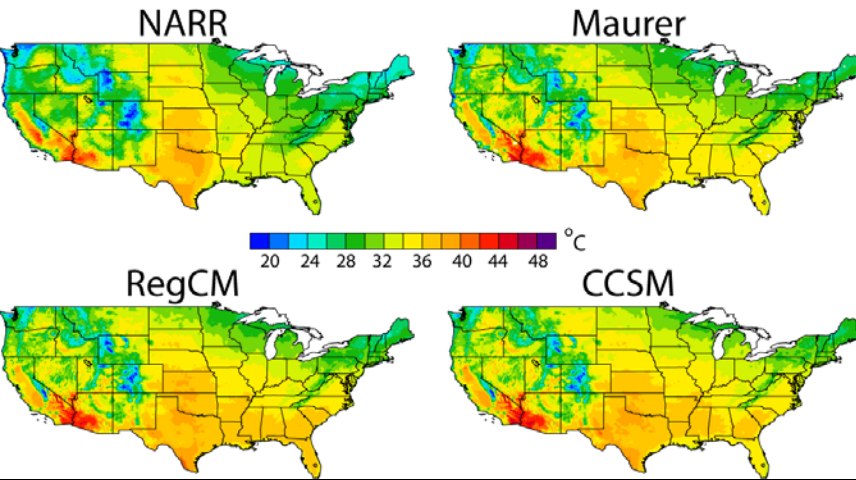
Cold Extreme (5th percentile) (1960-1999)

Extreme Precipitation (95th percentile) (1960-1999)

OAK RIDGE
National Laboratory
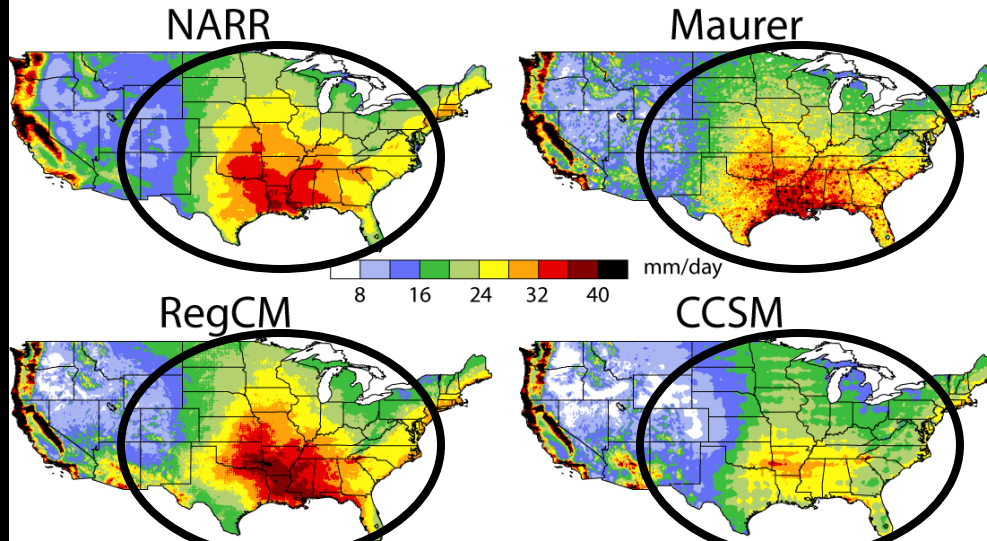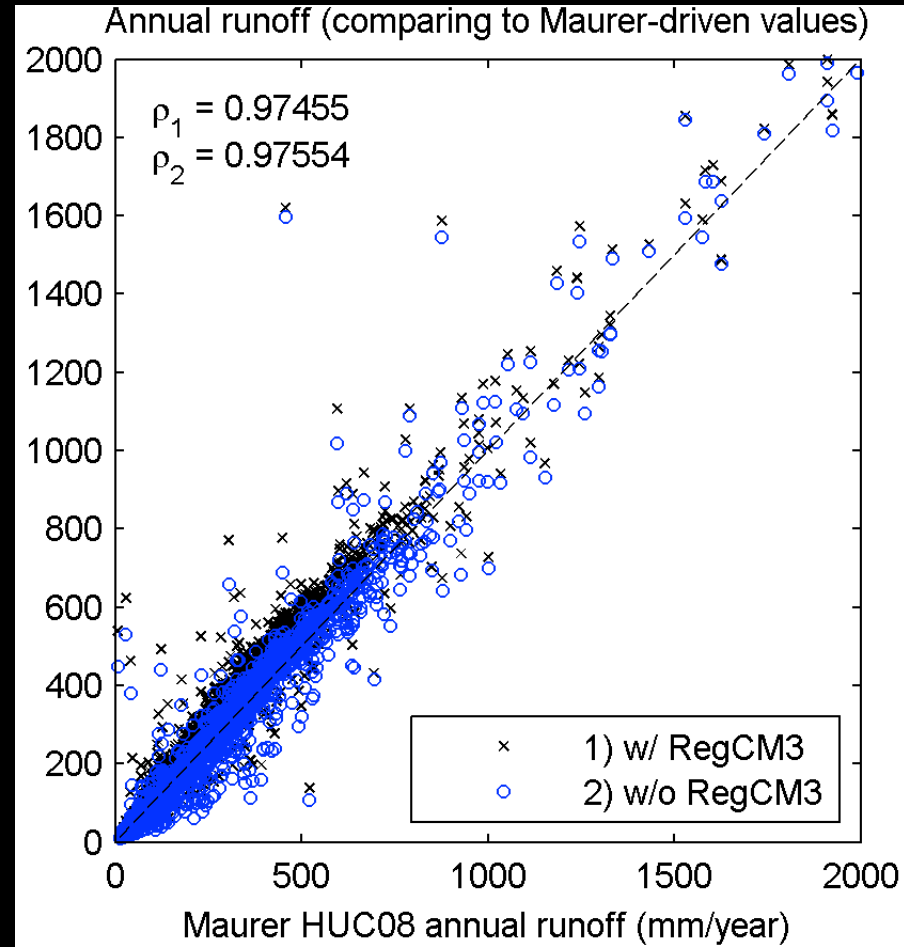
Baseline Comparisons

Mean Annual Runoff at HUC08 level
(1960-1999)

Model-VIC versus USGS
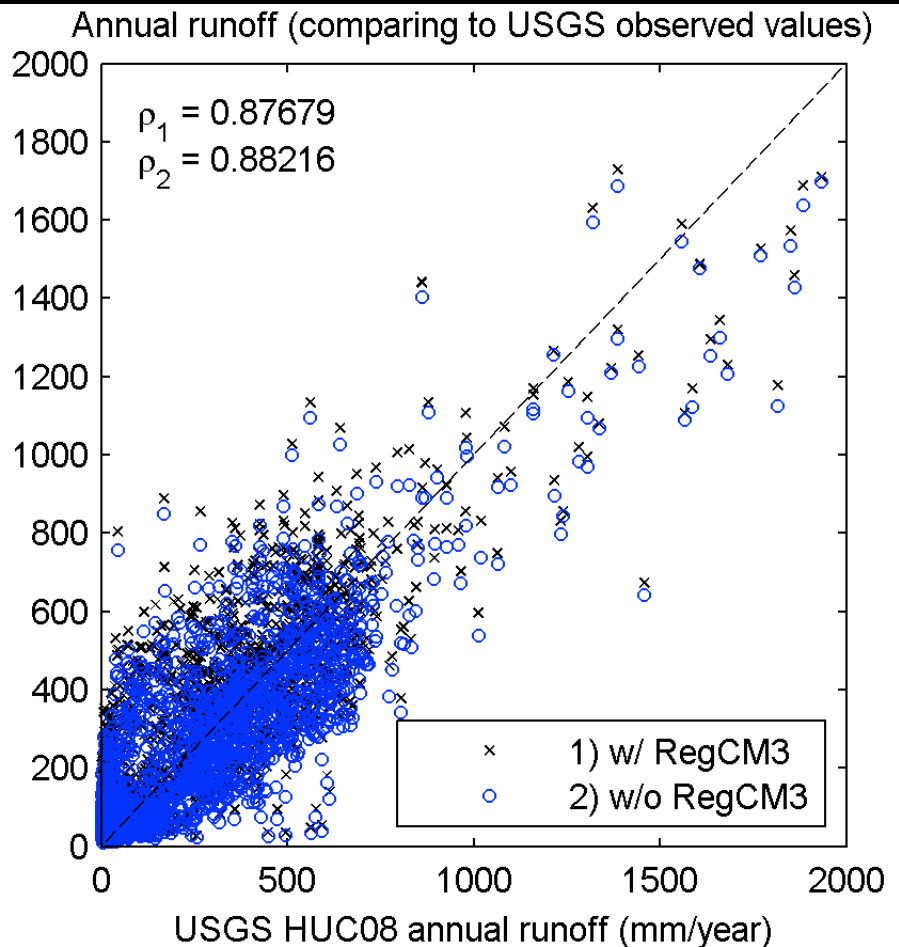
Model-VIC versus OBS-VIC

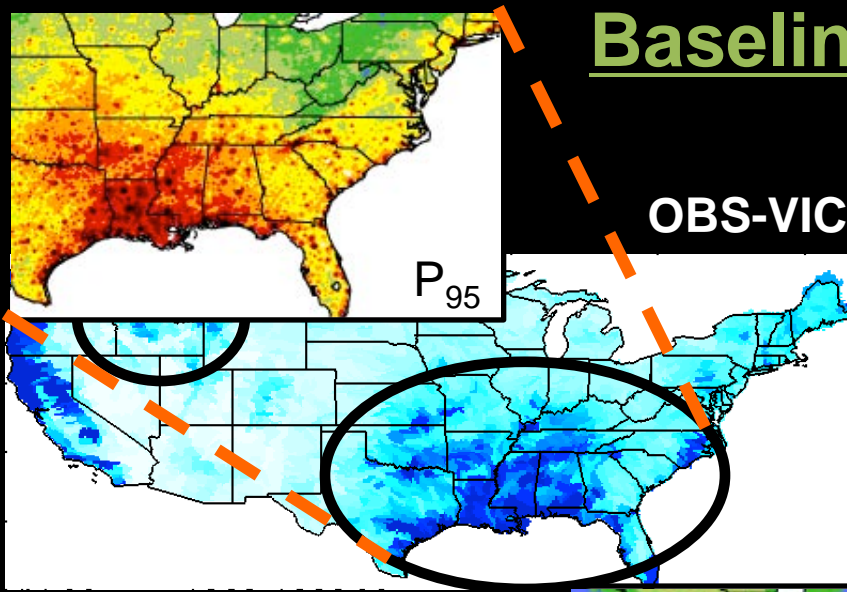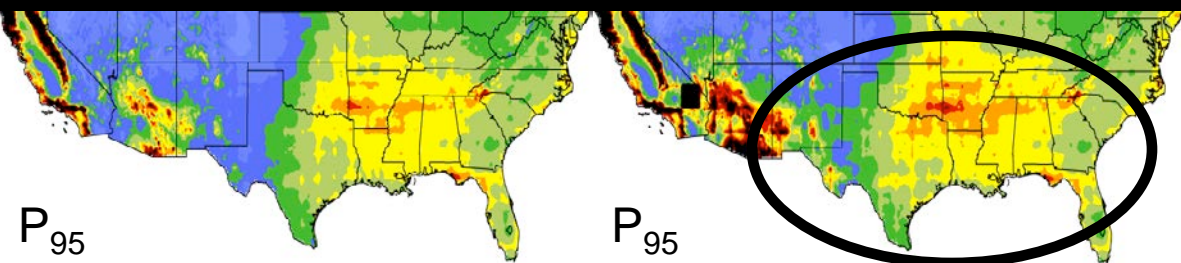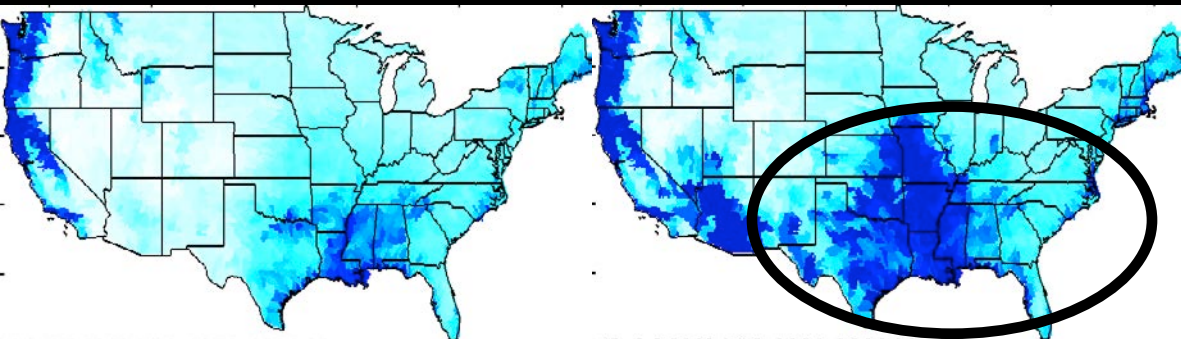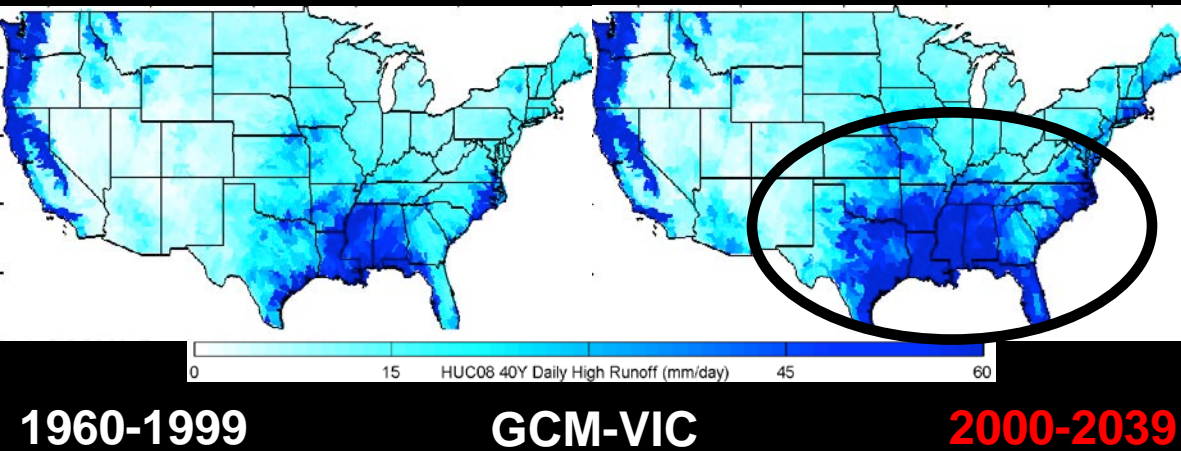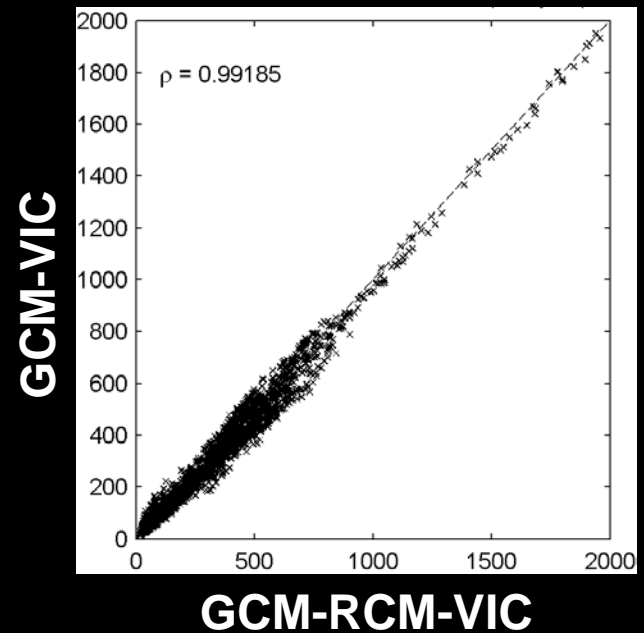**Baseline Comparisons**

40 yr Daily High Runoff (1960-1999)

OBS-VIC

GCM-RCM-VIC

GCM-VIC

P_{95}

HUC08 40Y Daily High Runoff (mm/day)

0   15   45   60

P_{95} 8   16   24   32   40   mm/day

Managed by UT-Battelle
for the Department of Energy

OAK RIDGE
National Laboratory

Near-term Future

P$_{95}$

P$_{95}$
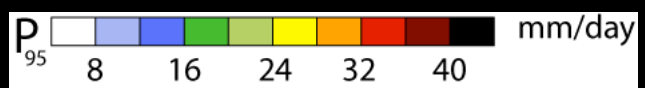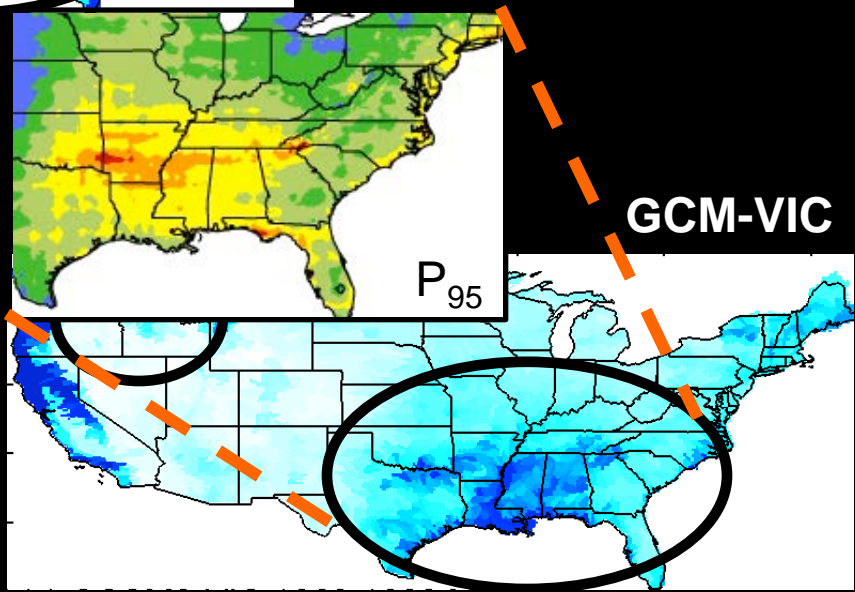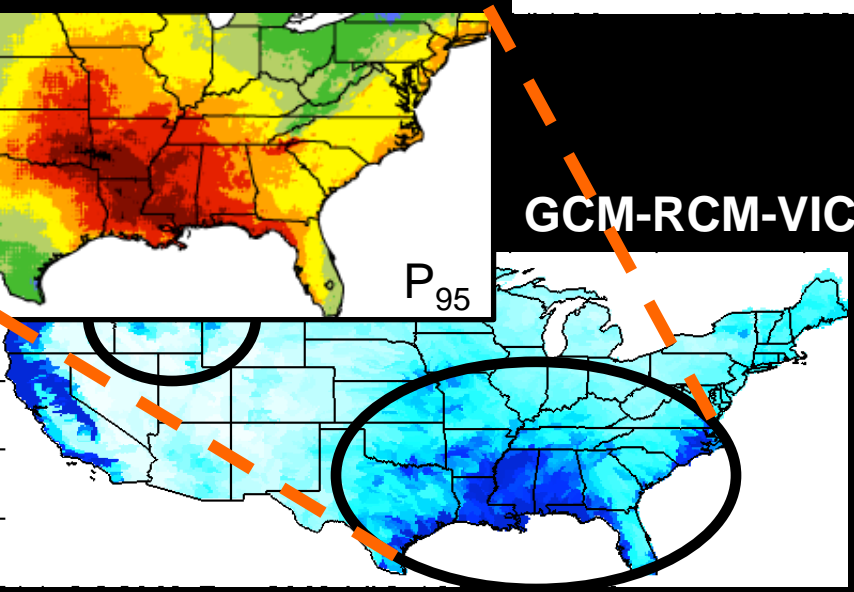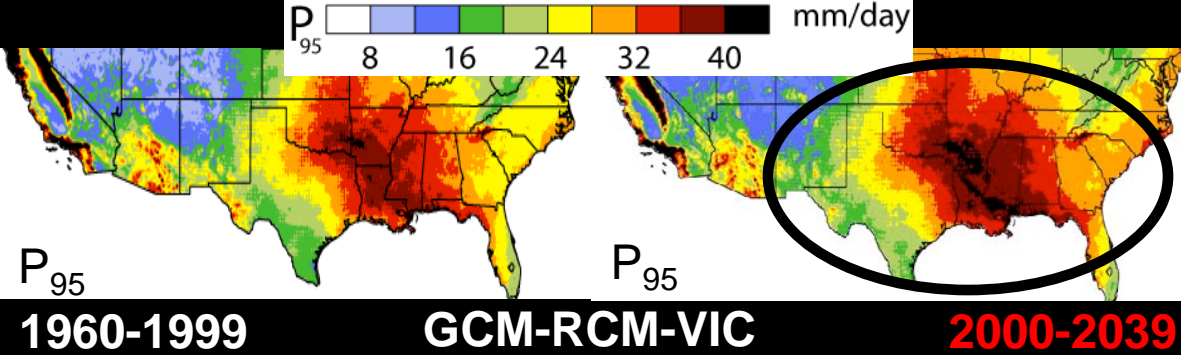
1960-1999   GCM-RCM-VIC   2000-2039

Mean Annual Runoff
HUC08
(2000-2039)

HUC08 40Y Daily High Runoff (mm/day)   15   45   60

1960-1999   GCM-VIC   2000-2039

$\rho = 0.99185$

GCM-VIC

GCM-RCM-VIC

P$_{95}$

P$_{95}$

OAK RIDGE
National Laboratory

April 1st SWE Trend (1960-1999)

Snow Course Observations
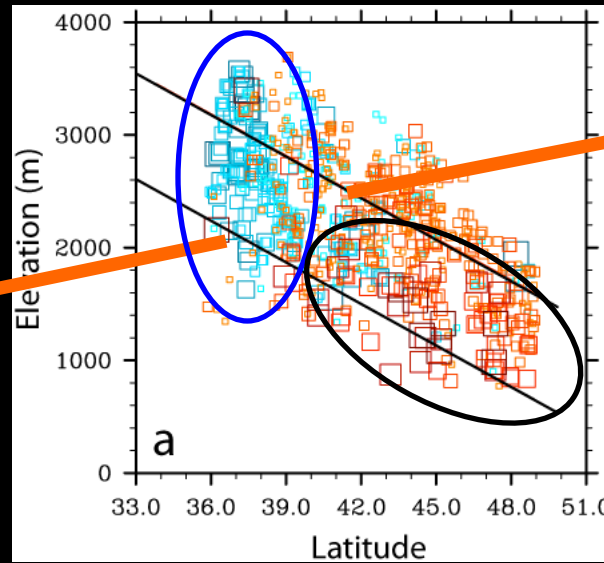
5 °C isotherm

0 °C isotherm

GCM-RCM-VIC

GCM-VIC

-60> ▢ -32> ▢ -12> ▢ 0< ▫ 24< ▫ 48< ▢ %
-48> ▢ -24> ▢ 0> ▪ 12< ▫ 36< ▢ 60< ▢
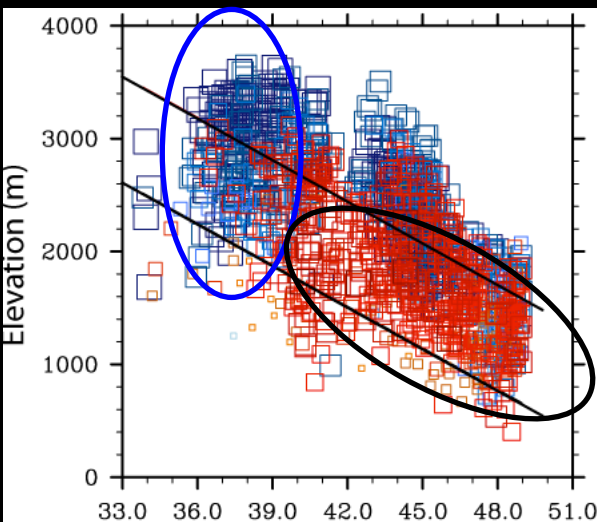
RIDGE
National Laboratory
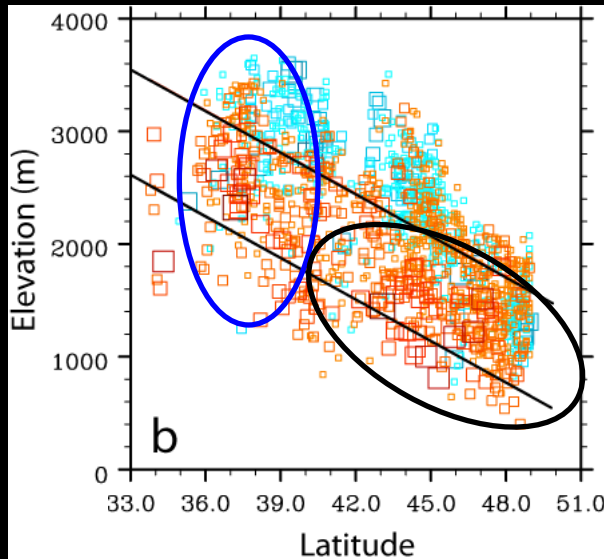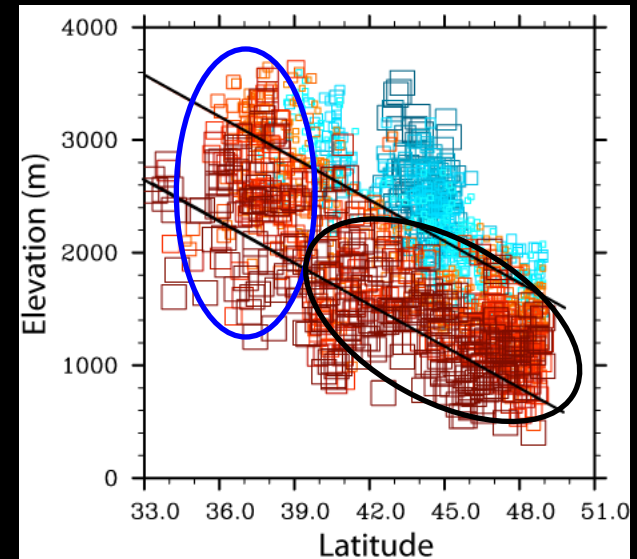
Relationship of April 1st SWE with cold season precipitation and temperature
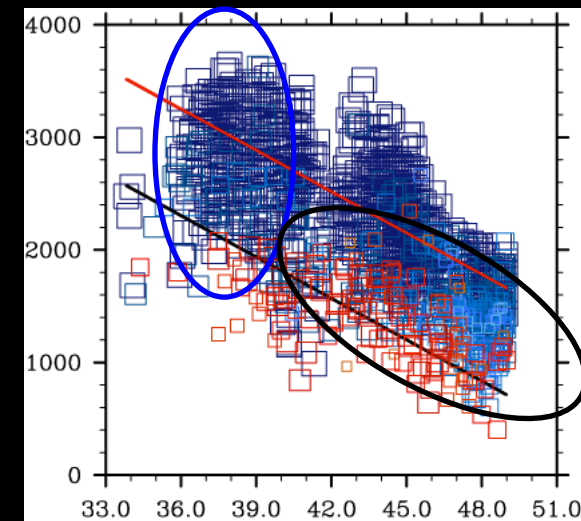
Observations
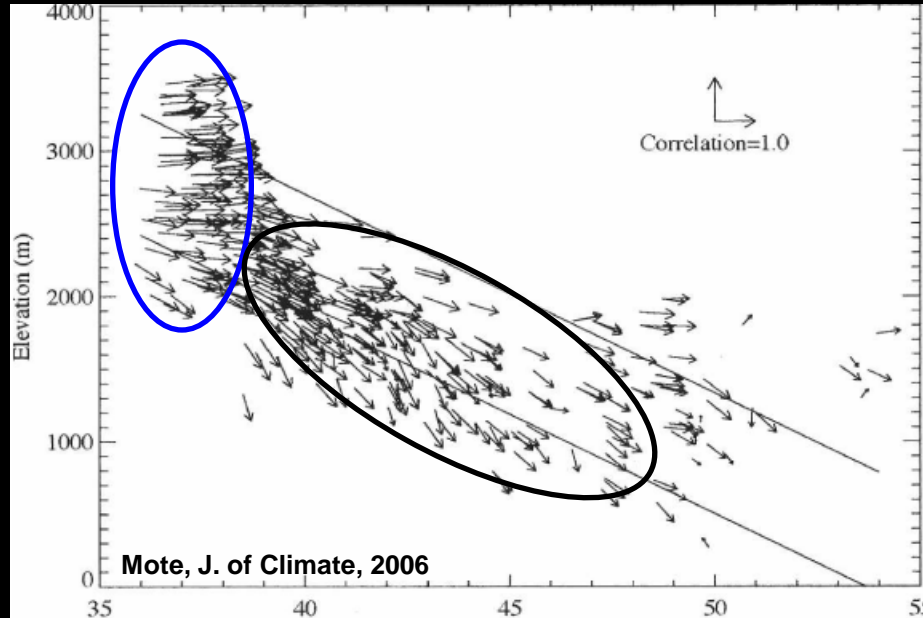
GCM-RCM-VIC
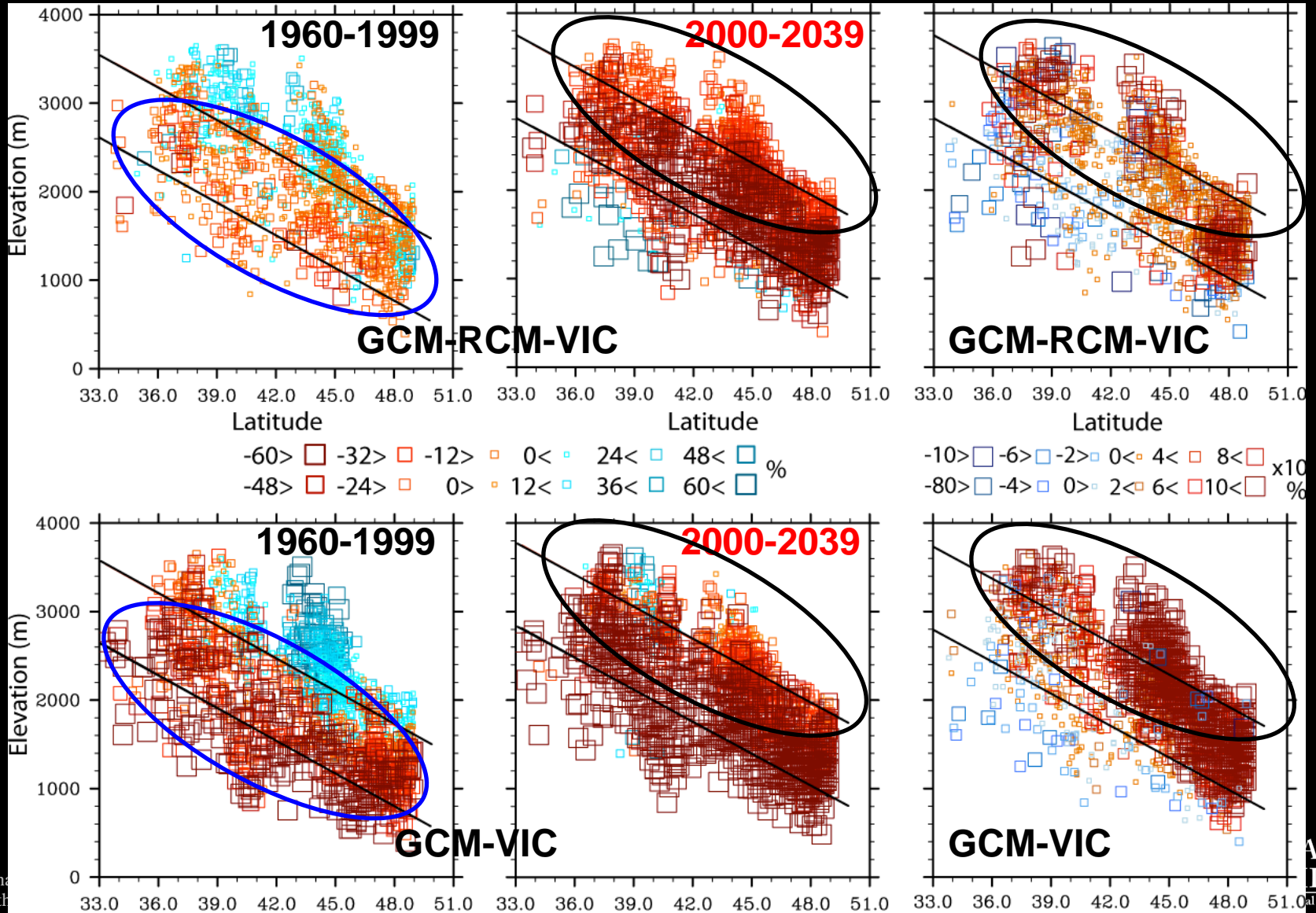
GCM-VIC

Blue: Precipitation driven
Red: Temperature driven

April 1st SWE Trend

Change in relationship in April 1st SWE with Temperature

Future hydrological predictions: Does dynamical downscaling (or high-resolution climate modeling) add any value?

Yes, it does.