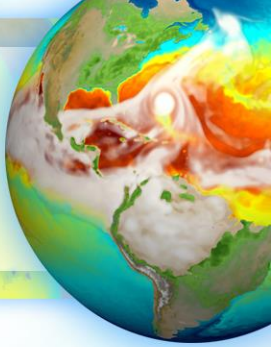
Evaluating the water cycle over CONUS using multiple metrics for the Energy Exascale Earth System Model (E3SM) Across Resolution



“How may increasing model resolution improve features important to the water cycle and affect simulations of river flow and freshwater supplies at watershed scale?”

Goals

I. Evaluating the CONUS water cycle performance at low and high resolutions across a variety of metrics.

II. Benchmarking, i.e., creating metrics to evaluate the model performance as we progress toward convection permitting simulations

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E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

Details

Simulations:

- HR (ne120) transient simulation
- LRtunedHR (ne30 with ne120 tunings) transient simulation

Time scale:

- 1950-1970

Spatial scale:

- watershed scale (HUC2 basins)

$$\Delta S = P - ET - Q - D$$

Change in storage
- soil moisture
- snowpack
- groundwater

precipitation

evapotranspiration

surface and sub-surface runoff

USGS Hydrologic Unit Maps (HUC2)

Metrics – sampling each category.

- Spatial RMSE
- Diurnal Cycle
- Seasonal phase & amplitude
- Snowpack
- Streamflow
- Runoff
- Unevenness
- IDF curves
- Extremes
- Meteorological droughts
- Tropical Cyclones

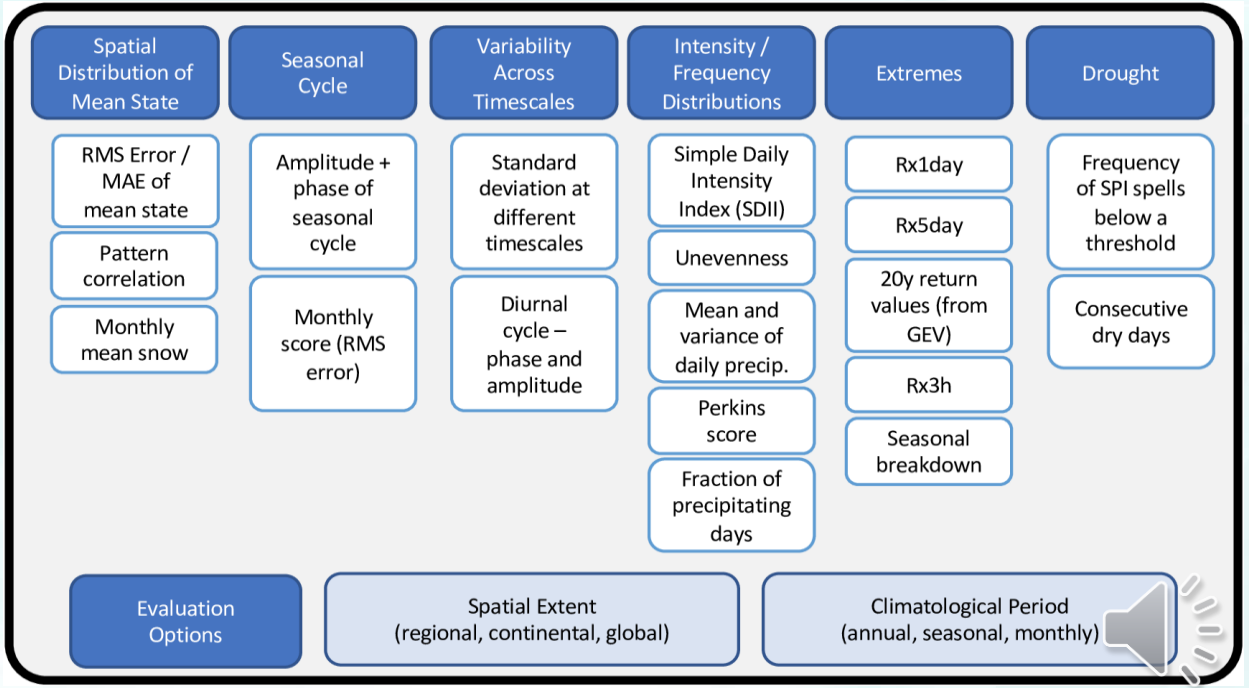
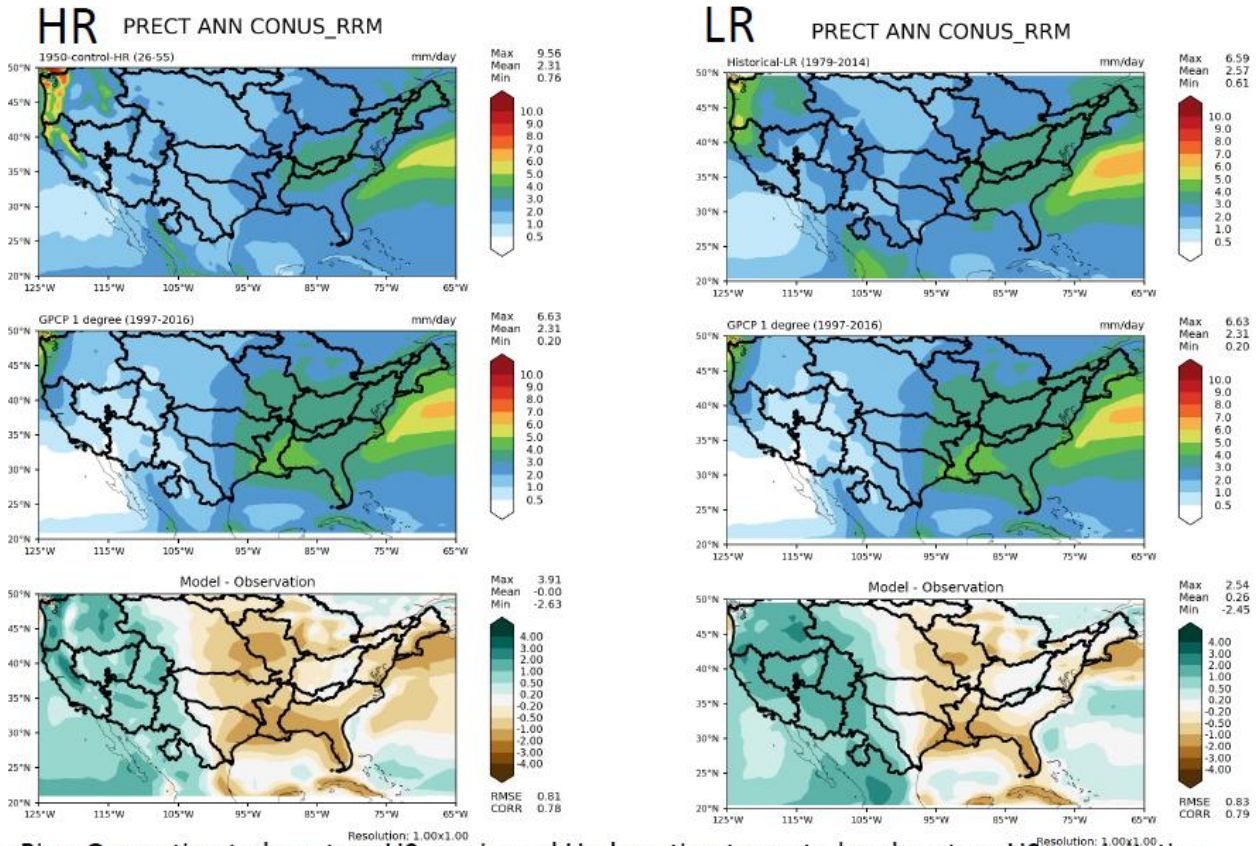


Table from "Benchmarking Simulated Precipitation in Earth System Models: Workshop Report"

Spatial RMSE

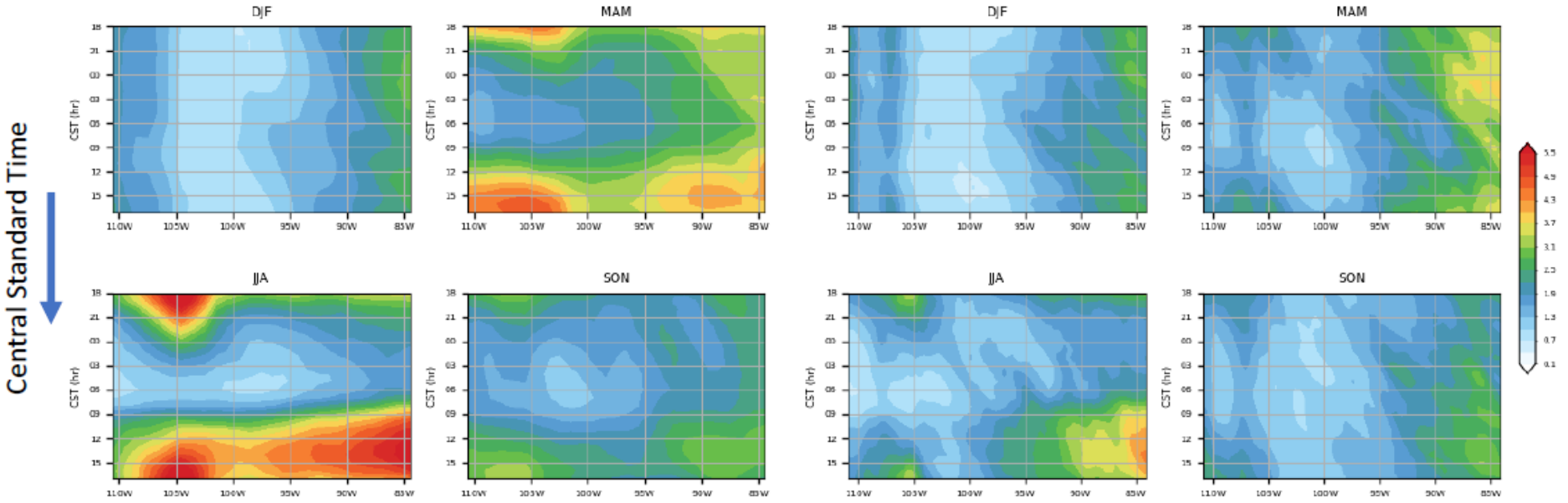
PRECT



Precipitation Bias: Overestimated western US precip and Underestimate central and eastern US precipitation. Similar pattern for all seasons.

Diurnal Cycle

The Hovmöller diagrams of the precipitation rate 35°N–45°N



LR (ne30)

HR (ne120)

Seasonal phase & amplitude

Markham (1970) *AAAG*

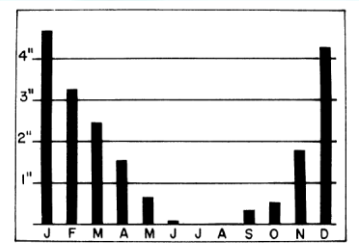


FIG. 1. Mean monthly rainfall at San Francisco, 1951–1960. Plotted conventionally.

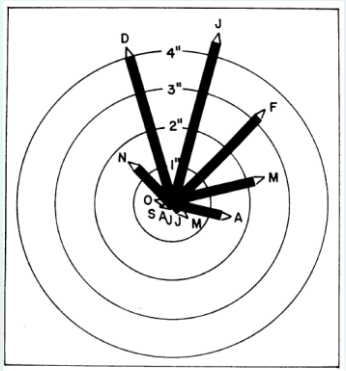


FIG. 2. Mean monthly rainfall at San Francisco, 1951–1960. Plotted vectorially.

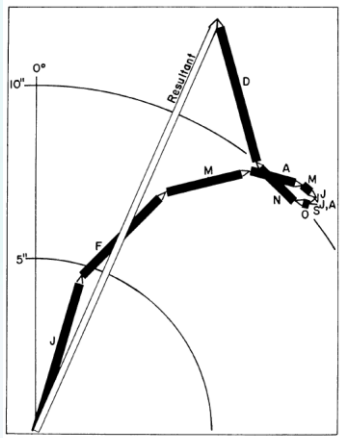
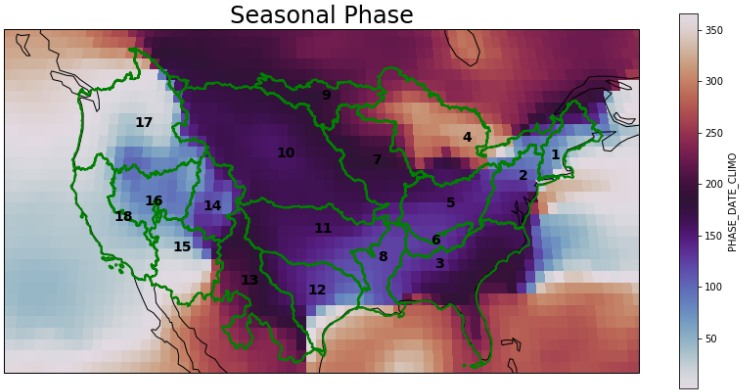
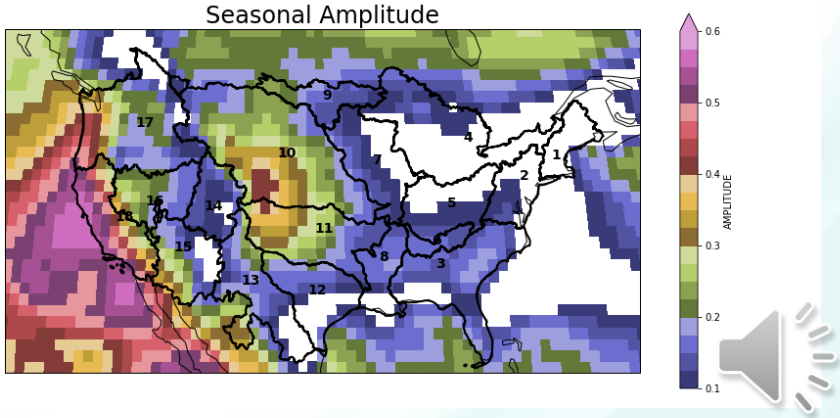


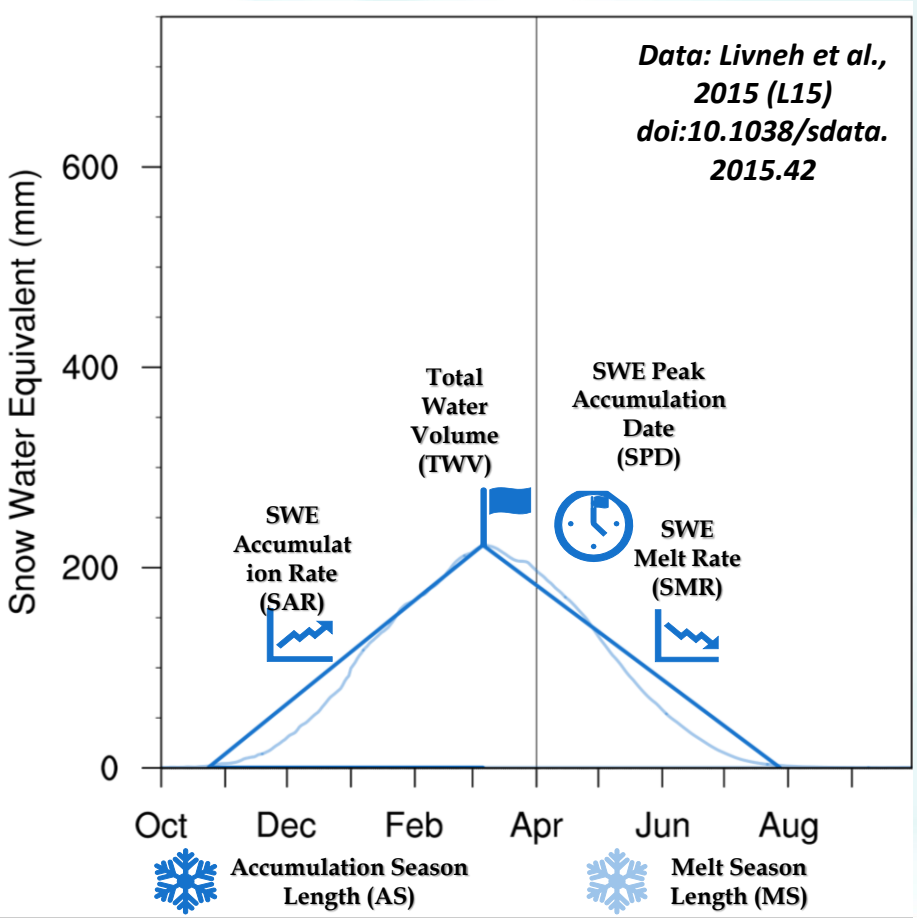
FIG. 3. Mean monthly rainfall at San Francisco, 1951–1960. Added vectorially.

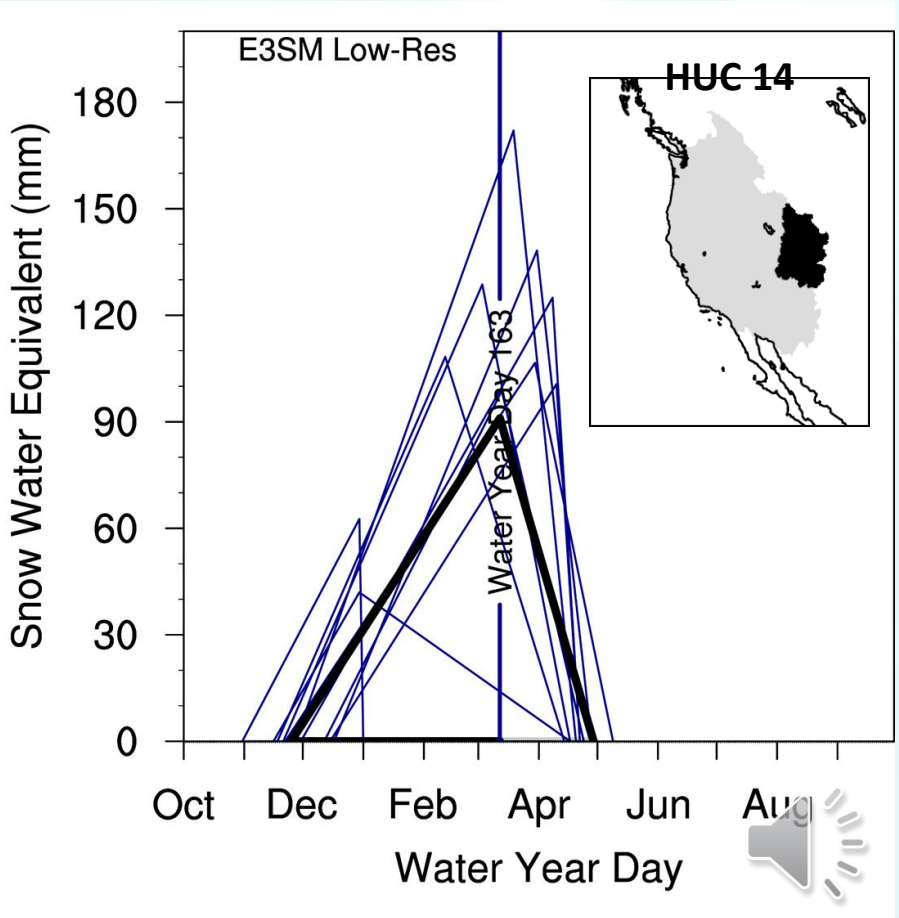




Snowpack

What are the key components of a snow season?



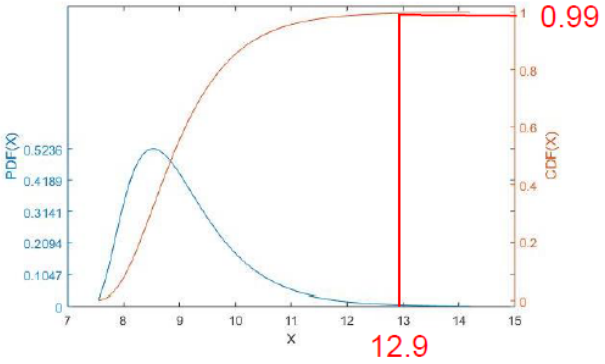


Streamflow

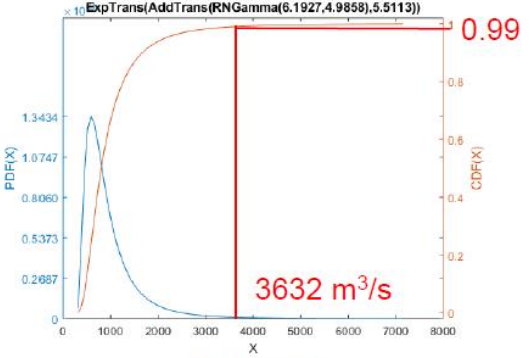
Pearson type 3 distribution

Cumulative distribution function:

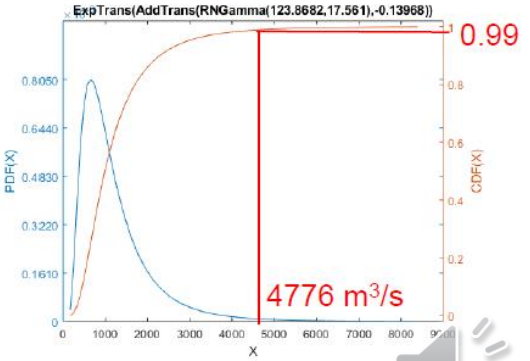
$$F(x) = \int_{c}^{x} \frac{1}{b\Gamma(a)} \left(\frac{x-c}{b}\right)^{a-1} \exp\left\{-\frac{x-c}{b}\right\} dx$$



Sacramento River at Shasta Dam

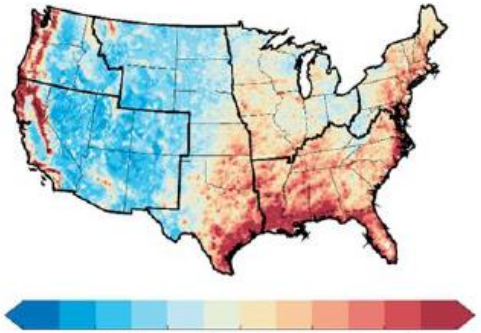


Historical

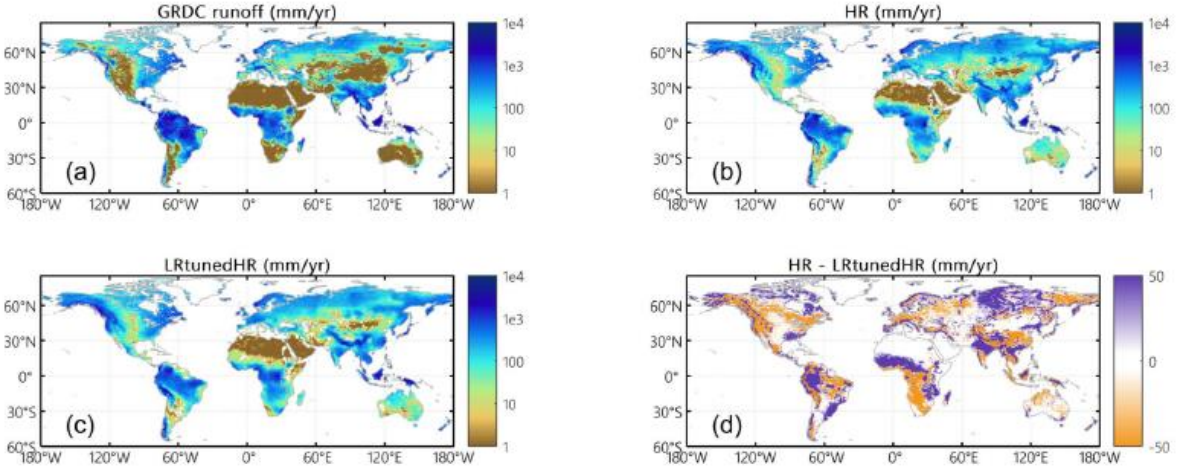


Future (30% more extreme)

Runoff



Extreme event frequency analysis



Runoff bias analysis (Caldwell et al. 2019)

Unevenness

The number of days to reach 50% of the annual total.

Pendergrass and Knutti (2018) *GRL*