A Regional Hydroclimate Project for the Rocky Mountains

integrate ongoing research activities in Canada and the USA

- Understanding the impacts of climate variability and change on water availability across the river basins of the Rocky Mountains
- Key Questions:
  - *How do changes in seasonal cycles of snow affect the partitioning of precip. between ET and runoff?*
  - *How do results depend on limitations in water and energy as manifest in gradients across latitude and elevation?*
  - *How will expected changes in extreme events (floods and of drought) impact the timing and availability of seasonal water supplies?*
  - *To what degree do landscape disturbances alter the natural patterns land-atmosphere coupling and runoff partitioning?*

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- Understanding the impacts of climate variability and change on water availability across the river basins of the Rocky Mountains
- Research needs:
- ***Observational synthesis:***
  - *Coordinated multi-scale field and remote sensing campaigns to quantify cross-scale controls on regional hydroclimatic processes*
  - *Understanding of key processes and compilation of data to test model hypotheses*
- ***Modeling synthesis:***
  - *Controlled comparison of different modeling approaches*
  - *Improved model physics parameterization development for integrated water cycle projections*

Motivated by issues of water security

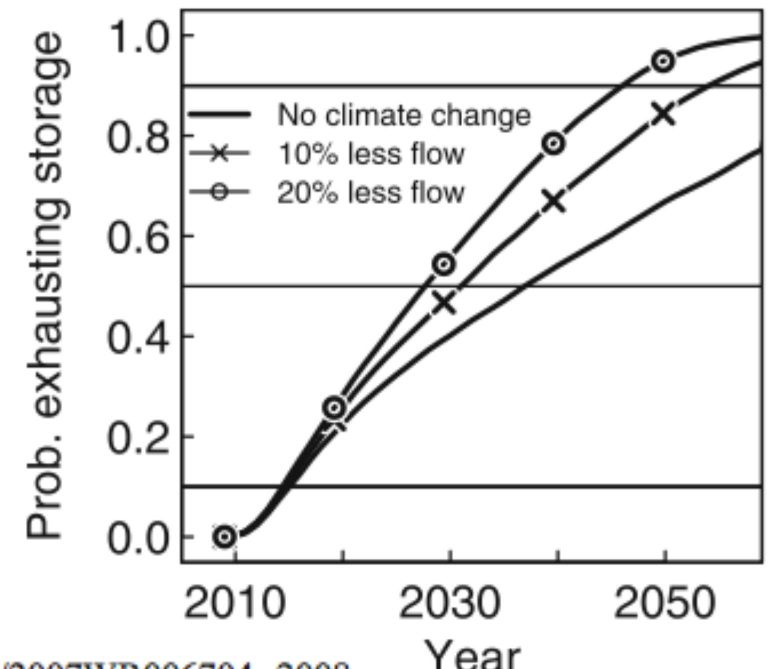
When will Lake Mead go dry?

Tim P. Barnett[1] and David W. Pierce[1]

Received 27 November 2007; revised 22 January 2008; accepted 5 February 2008; published 29 March 2008.

[1] A water budget analysis shows that under current conditions there is a 10% chance that live storage in Lakes Mead and Powell will be gone by about 2013 and a 50% chance that it will be gone by 2021 if no changes in water allocation from the Colorado River system are made. This startling result is driven by climate change associated with

Probability of Lake Mead "going dry"



WATER RESOURCES RESEARCH, VOL. 44, W03201, doi:10.1029/2007WR006704, 2008

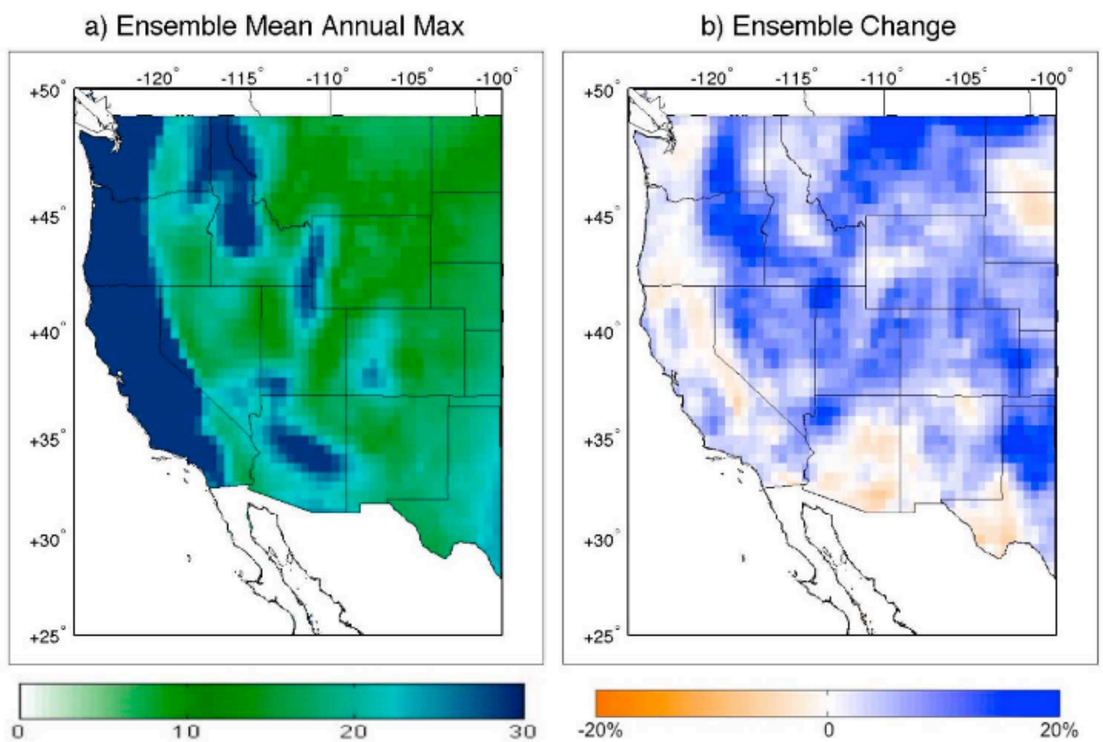
Motivated by issues of water security

Changes in winter precipitation extremes for the western United States under a warmer climate as simulated by regional climate models

F. Dominguez,[1] E. Rivera,[1] D. P. Lettenmaier,[2] and C. L. Castro[1]

Received 2 January 2012; revised 1 February 2012; accepted 2 February 2012; published 2 March 2012.

"We find a consistent and statistically significant increase in the intensity of future extreme winter precipitation events [. Models] consistently show an increase in the intensity of extreme winter precipitation…with the multi-model mean projecting an area-averaged 12.6% increase in 20-year return period and 14.4% increase in 50-year return period daily precipitation."

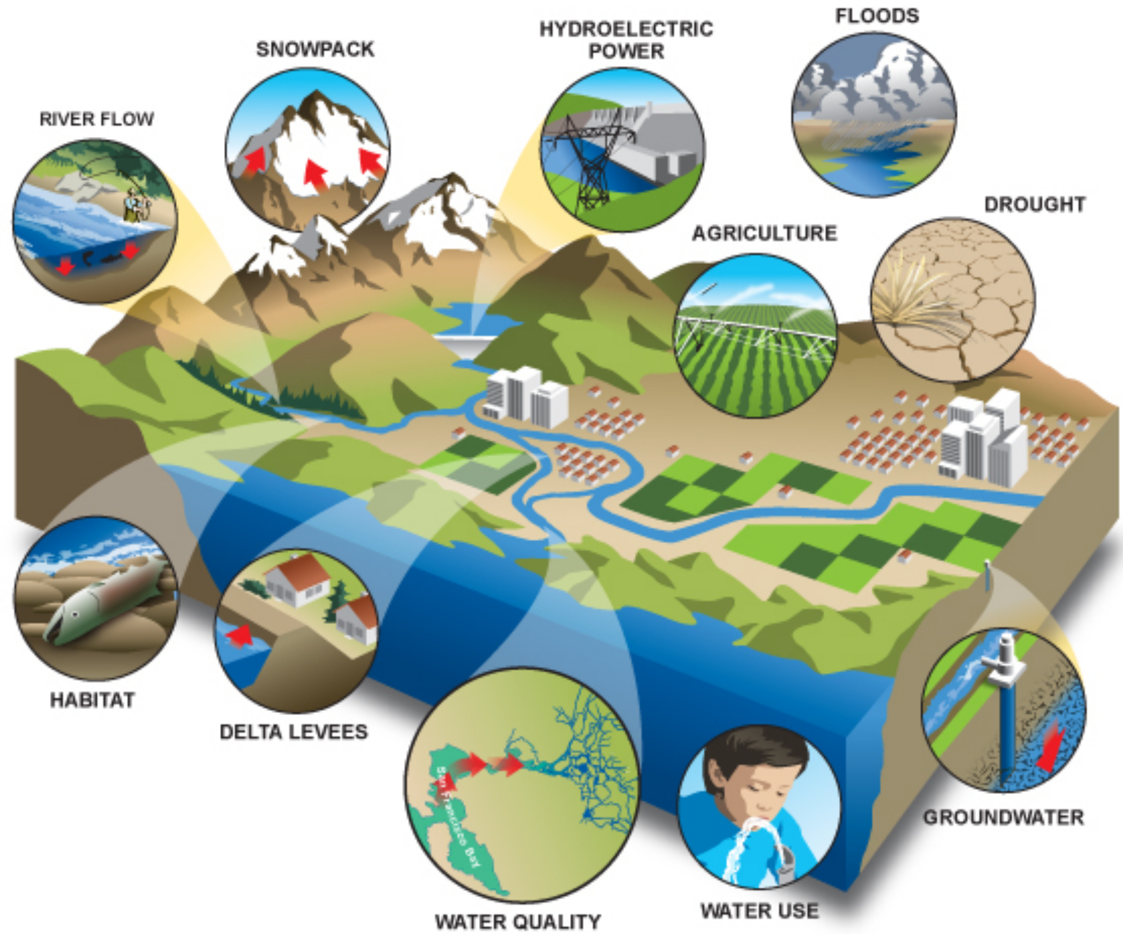


(2038-2070 minus1968-1999)

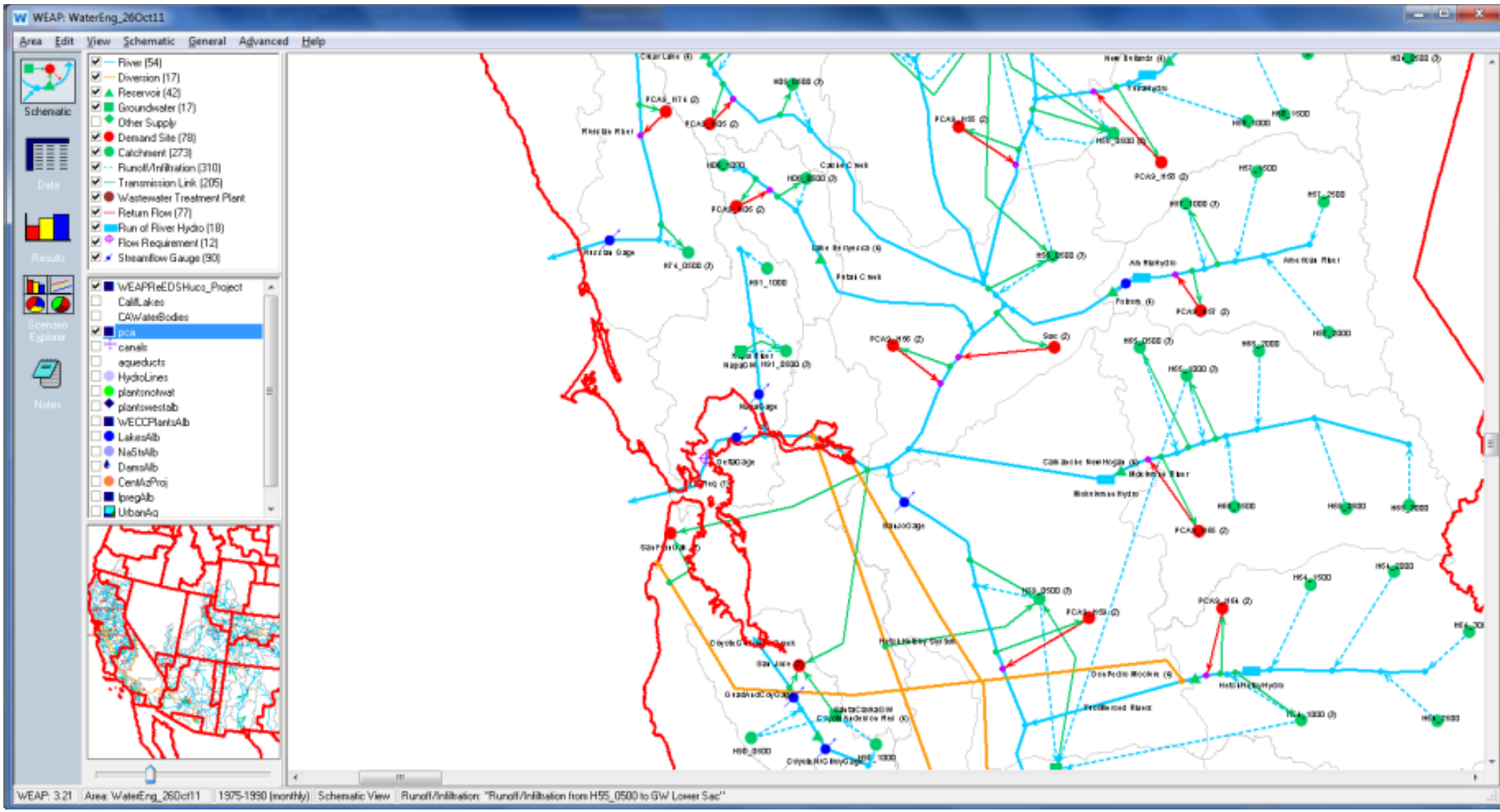
Geophys. Res. Lett., 39,L05803, doi:10.1029/2011GL050762

3. Water Evaluation and Planning (WEAP)

- **Integrated hydrology / water planning model**
- **Physical simulation of water demands and supplies.**
- **User-created variables and modeling equations.**
- **Seamless watershed hydrology, water quality and financial modules**
- **GIS-based, graphical drag & drop interface.**



WEAP model applied to the Southwest U.S.

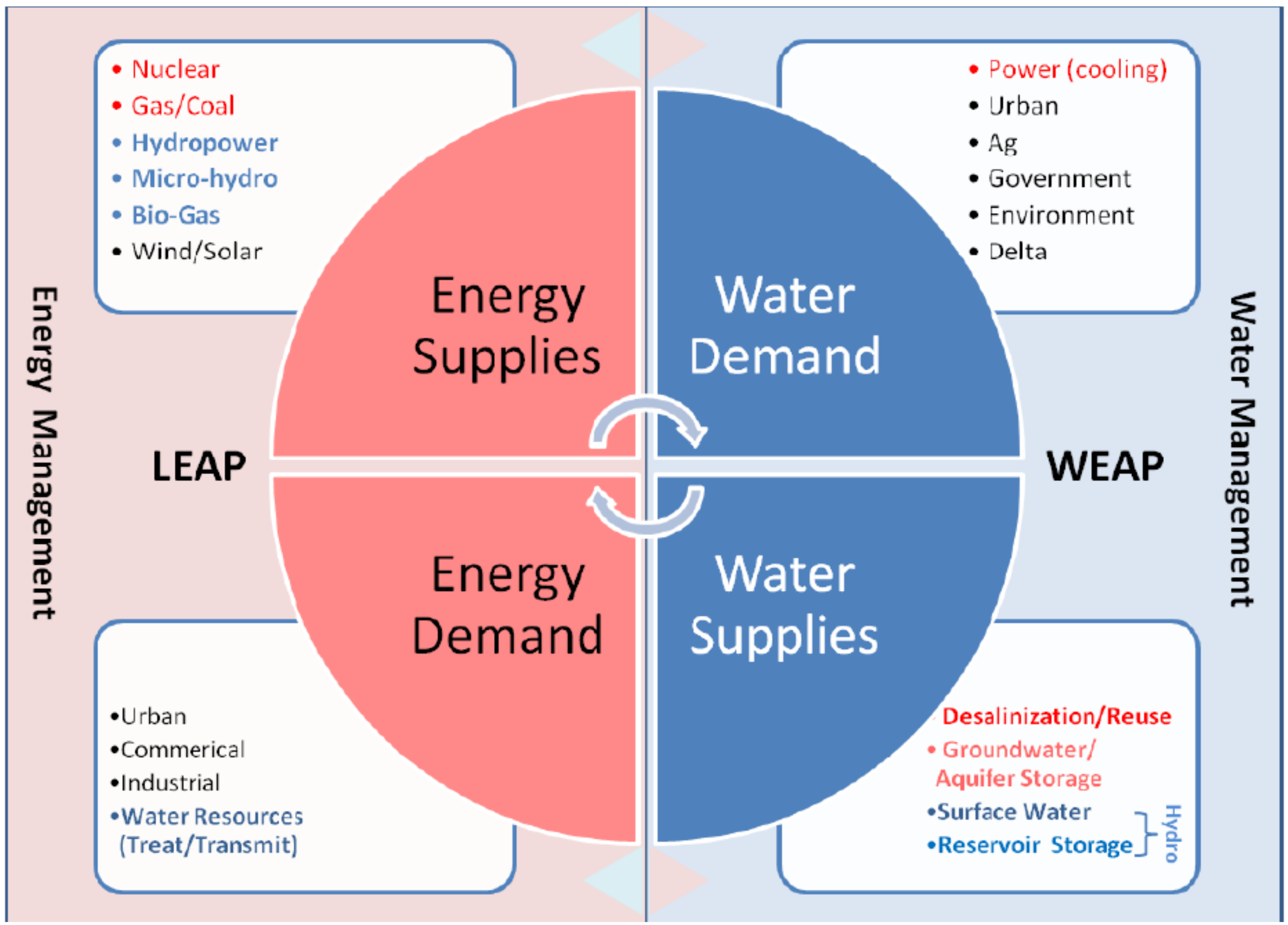


LEAP

WEAP

Long range Energy Alternatives Planning System www.energycommunity.org

Water Evaluation And Planning System www.weap21.org



Potential Research Questions for RHP

1. Downscale CONUS simulation to 1 km over specific regions to study land use/land cover impacts on regional climate (urbanization and agriculture feedbacks), including current and future projections.
2. Downscale CONUS with WRF-Hydro to study details of the water cycle in agriculturally important regions (streamflow, high flows, low flows).
3. Conduct simulation of WRF-Hydro including groundwater in the two chosen agricultural regions (Great Plains and California).
4. Carbon/nitrogen cycles and soil processes.
5. Development of higher resolution current climate dataset through blending of CONUS and observations.
6. Investigate the cause for the warm bias in models over the central U.S.
7. Examine snow physics and snowpack at even higher resolution than CONUS (snow albedo feedback may be sensitive to the resolution). Not well understood. Need to come up with empirical methods. Conceptual/statistical model based on albedo. Need more validation. Snow fraction. Impacts the timing of the runoff, drying of soils, ET, water balance.
8. Disturbance impact (beetle kill, fire, land atmosphere feedback). Change of ET and roughness.

Potential Research Questions for RHP (cont.)

8. Measurements of snowfall and snowpack at elevations other than the high elevations of SNOTEL.
9. Measurement and simulation of ET very important for the water balance (need more eddy covariance sites). Need better regional estimates of ET.
10. Hydrology on the snow ephemeral zone.
11. Uncertainty in high elevation precipitation trends (Charlie Luce paper). Decrease in streamflow, but obs don't show a dropoff in precipitation. Do we need more SNOTEL observations? Can we examine using the CONUS runs? Do we need to extend the CONUS runs back in time?
12. GEWEX soils and water meeting in June.
13. Snowpack in the Sierras' improved with CONUS high resolution. Convection in the central U.S. better represented. Soil moisture/convection feedback.
14. Do we need to extend the CONUS runs back in time? Better job on global trends. Run one or two year overlap period in order to match to two trends (account for spin up).
15. Run ICAR over the continental U.S.

RHP Scoping and development plan:

- High-level research plan to address Rocky Mountain RHP research questions:

  1. Years 1-2: Data synthesis and coordinated execution of comparative studies documenting expected changes in water cycle behavior across Rocky Mountain transect
  2. Years 2-4: Development of a regional enhanced observational period (surface and remotely sensed data) to provide improved benchmark data of terrestrial and atmospheric water cycle components across terrain and latitude gradient
  3. Years 3-5: Coordinate integrated land-atmo-hydro model benchmarking studies to assess model performance across scales
  4. Years 4-5: Refine prediction models and future estimates of changes in integrated water budget components