Projected Trends in Great Plains Extreme Rainfall Return Intervals Using CMIP5 LOCA Ensembles

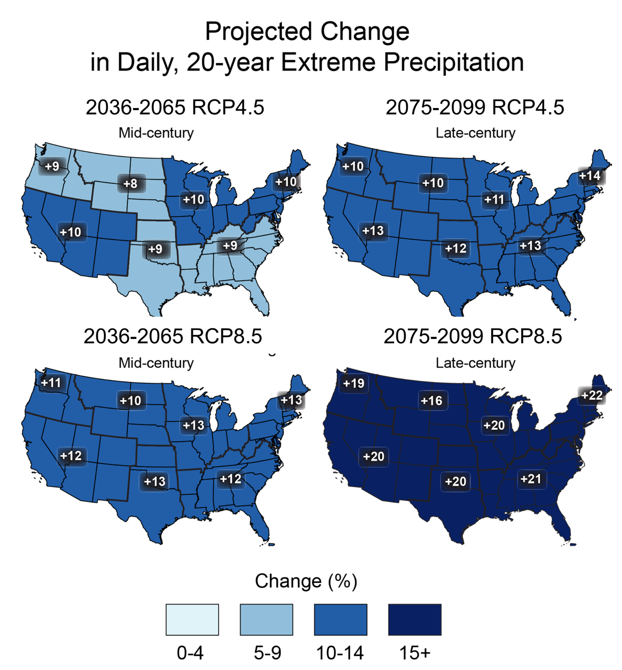
SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Bill Capehart, Heidi Sieverding, Lucas Graunke, and Lisa Kunza

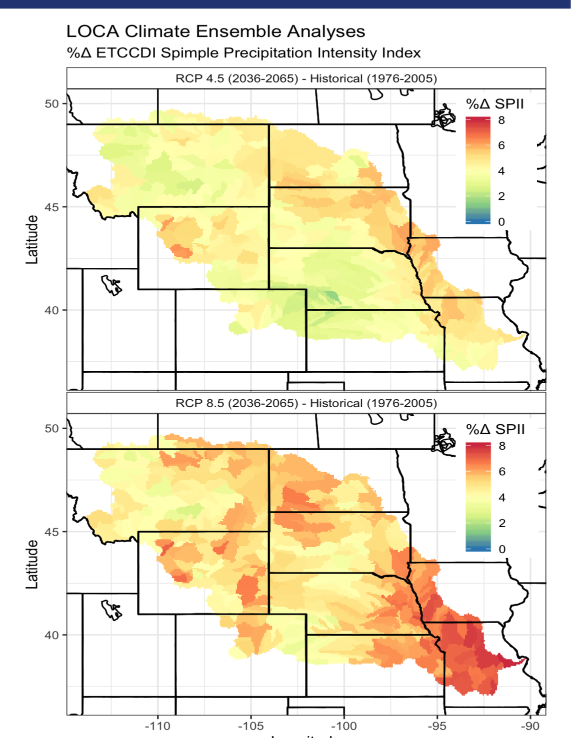
Impacts of Climate Change on Extreme Rainfall

Climate change, as it progresses through the 21st century, is expected to affect the amount and frequency of rainfall events. These changes in peak rainfall return frequencies as well as periods between wetting rains will impact infrastructure, sediment loading, wildland fire, flood plain extent, and some elements of disaster planning.

Detectability of rainfall extremes is challenging due to the discontinuous nature of rainfall and non-local effects (e.g. flooding) whereby extreme rain in one location can impact hydrologic units downstream from the event. Likewise, single future scenarios due to isolated rainfall events cannot effectively capture the potential of extreme events for a given future time interval, especially under nonstationary climate change.



Mid- and Late-century projections of daily, 20-year return maximum daily precipitation under low (RCP 4.5) and high (RCP 8.5) emissions scenarios. Historical baseline period is 1976-2005. Sources: K. Kunkel CICS, NOAA-NCEI, CICS-NC, NCA4 (Easterling et al., 2017)



Mid-century projections of daily ETCCDI SPII changes under low (RCP 4.5) and high (RCP 8.5) emissions scenarios. Historical baseline period is 1976-2005.

Creating Future Rainfall Return Maps

Our approach is to use CMIP5 LOCA ensembles (Pierce et al., 2014) regionally localized and aggregated by hydrologic units or climate zone divisions to assess changes in extreme rainfall event returns and the implication of those changes.

CMIP 5 LOCA Ensemble Members

Only USGS-CIDA-archived CMIP5 ensembles that included daily maximum and minimum temperatures, and daily precipitation were used in this study. The ensembles used are listed here.

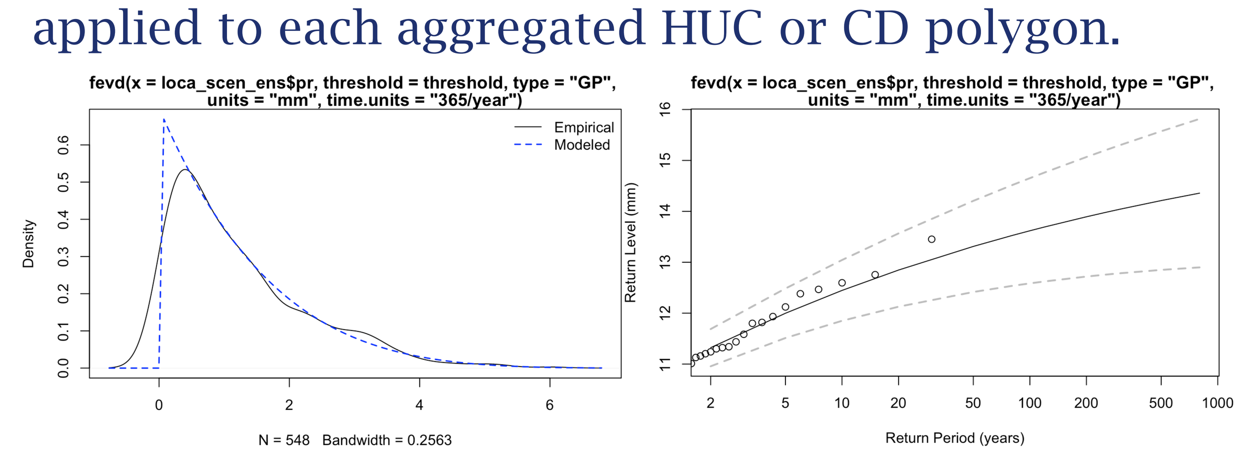
ACCESS1-0_r1i1p1	CanESM2_r1i1p1	IPSL-CM5A-MR_r1i1p1
ACCESS1-3_r1i1p1	FGOALS-g2_r1i1p1	MIROC-ESM-CHEM_r1i1p1
CCSM4_r6i1p1	GFDL-CM3_r1i1p1	MIROC-ESM_r1i1p1
CESM1-BGC_r1i1p1	GFDL-ESM2G_r1i1p1	MIROC5_r1i1p1
CESM1-CAM5_r1i1p1	GFDL-ESM2M_r1i1p1	MPI-ESM-LR_r1i1p1
CMCC-CMS_r1i1p1	HadGEM2-AO_r1i1p1	MPI-ESM-MR_r1i1p1
CMCC-CM_r1i1p1	HadGEM2-CC_r1i1p1	MRI-CGCM3_r1i1p1
CNRM-CM5_r1i1p1	HadGEM2-ES_r1i1p1	NorESM1-M_r1i1p1
CSIRO-Mk3-6-0_r1i1p1	IPSL-CM5A-LR_r1i1p1	bcc-csm1-1-m_r1i1p1

Because of the the spotty nature of precipitation (especially convective rainfall) and the impact of a local, or sometimes remote, event on flood events and assessments of flood events, daily rainfall fields were aggregated to USGS HUC-08 watershed polygons for the Missouri Basin to the maximum daily rainfall value within a given polygon.

Alternatively, we experimented with Central US NCEI Climate Divisions to study the sensitivity of aggregation scale and theme.

Extreme Event Analysis

For this study we use the NCAR *extRemes* package (Gilleland and Katz, 2014) for R to calculate statistically-derived return intervals from extreme maximum precipitation amounts. Using 30-year period intervals and a 95% percentile daily rainfall threshold, a Generalized Pareto (GP) distribution is applied to each aggregated HUC or CD polygon.



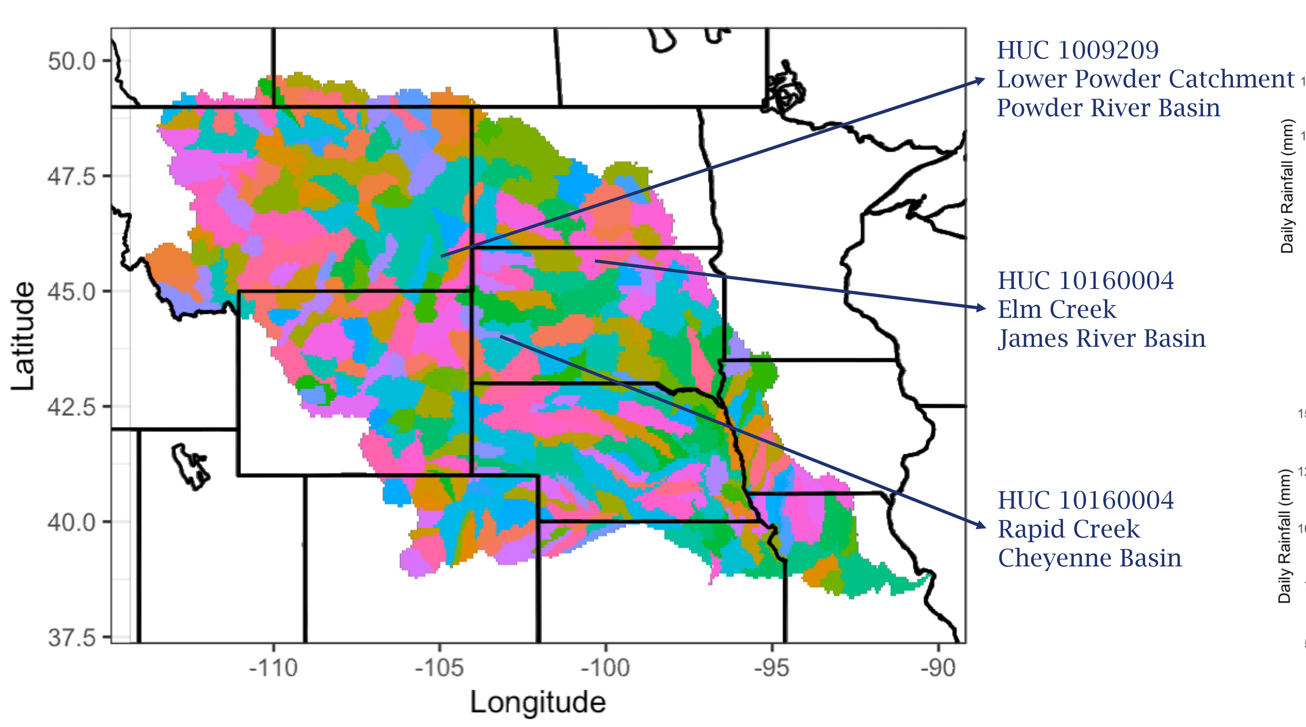
Creating Comparative Return Maps

GP extreme event analyses were applied to 30-year evaluation periods for the end of the CMIP5 Historical (1976-2005), mid-21st Century (2036-2065), and late-21st Century (2070-2099) Periods.

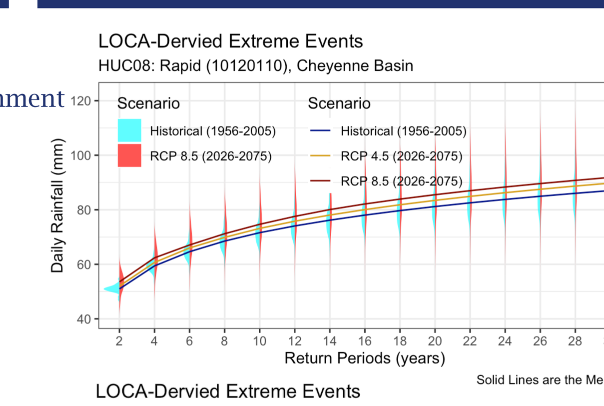
Resulting extreme analyses return periods were collected archived by, evaluation period, ensemble member and RCP Pathway. For a single unitary value per map element and period/pathway these resulting periods were aggregated by median daily rainfall amount for a given return period.

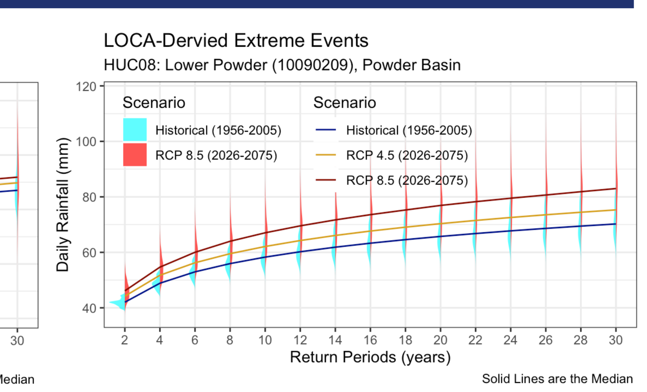
Analyses and Return Maps

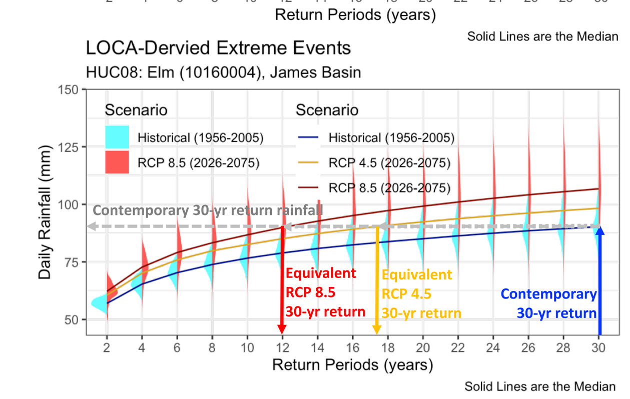
HUC-08 Regions for Missouri River Basin



Mapping Return Periods by Time





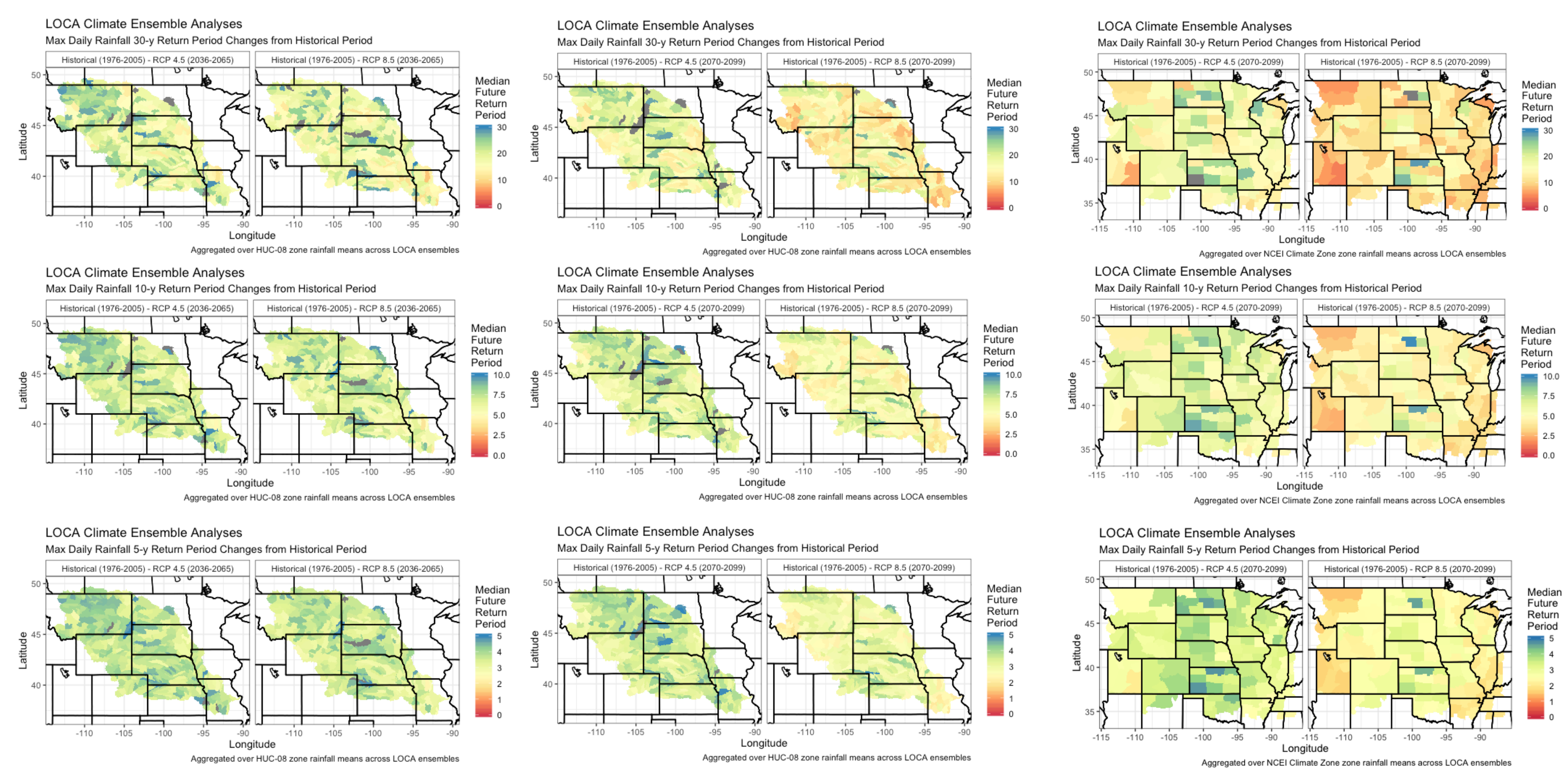


*Distributions of return event interval comparisons for mid-21st century vs contemporary periods (using a **50-yr** sampling period) for three HUC-08-scale catchments in the Missouri River Basin. Also shown is approach by which historical return events are translated into future climate scenarios (Elm Catchment only).*

Return Interval Maps

Mapping by HUC-08 Catchments

Mapping by NCEI Climate Divisions



References

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017: Precipitation change in the United States. In: *Climate Science Special Report: Fourth National Climate Assessment*, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 207-230, doi: 10.7930/J0H993CC.

Gilleland, E., and R.W. Katz, 2016: extRemes 2.0: An Extreme Value Analysis Package in R, *Journal of Statistical Software*, **72**, 1-39, doi: 10.18637/jss.v072.i08

Pierce, D. W., D. R. Cayan, and B. L. Thrasher, 2014: Statistical downscaling using Localized Constructed Analogs (LOCA). *Journal of Hydrometeorology*, **15**(6), 2558-2585, doi: *10.1175/JHM-D-14-0082.1.*

We would like to acknowledge high-performance computing support from Yellowstone (ark:/85065/d7wd3xhc) provided by NCAR's Computational and Information Systems Laboratory, sponsored by the National Science Foundation. We also wish to thank the USGS-Center for Integrate Data Analysis for access to the CMIP5 LOCA products.