Evaluations of Reanalysis Simulations for U.S. Precipitation Extremes

Vimal Mishra[1], Michael Bosilovich[2], and Dennis P. Lettenmaier[1]
1. Department of Civil and Environmental Engineering, University of Washington
2. Global Modeling and Assimilation Office, NASA/GSCF

AT-38

1 Introduction

- Extreme precipitation events are the proximate cause of flooding, which is one of the most costly natural hazards
- Both observations and climate global and regional climate model simulations suggest increases in precipitation intensity and frequency in a warming climate
- Urban flooding is especially sensitive to changes in the statistics of short duration precipitation extremes, whereas floods in large river basins are more sensitive to accumulated precipitation over multiple day and longer periods.

2 Objective:

- To evaluate reanalysis products for sub-daily to multi-day extreme precipitation in comparison with observations across the continental U.S. (CONUS).

3 Study Domain

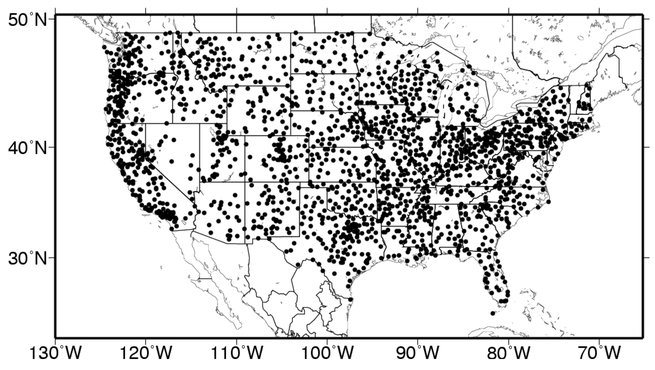

Figure 1. Location of the hourly precipitation observation stations

4 Reanalysis Data

Reanalysis Data	Period	Spatial Resolution	Temporal Resolution
NCEP-NCAR	1979-2009	T62 Gaussian grid	6-hour
NCEP-DOE(R2)	1979-2009	T62 Gaussian grid	6-hour
20th Century (20CR)	1979-2009	2.5 Degree	6-hour
MERRA	1979-2009	1/2 Degree, 2/3 Degree	1-hour
ERA-40	1979-2002	2.5 Degree	6-hour
ERA-Interim	1979-2009	1.5 Degree	3-hour
NARR	1979-2009	0.3 Degree	3-hour

5 Methodology

Data Analysis

- We obtained hourly precipitation data (DS3240) from the National Climatic Data Center (NCDC) for the period 1979-2009 for about 6000 stations across the CONUS.
- We then examined data quality in terms of: (i) number of years with significant missing (more than 10 %) data, and (ii) changes in the precision of measurement (from 0.01 inch to 0.1 inch).
- We finally selected 1814 stations (Figure 1) that had less than 10% missing data in any given year during the period of record (1979-2009).
- Using hourly precipitation observations, we estimated annual maximum precipitation (AMP) for 6, 12, 24, 48, and 120 hour durations.
- Annual maximum precipitation from the selected stations was gridded at 0.5 degree spatial resolution across the CONUS after applying the areal reduction factor (*Leclerc and Schaake*, 1972) to minimize the effect of spatial resolution.

100 Year Precipitation Maxima

- We estimated annual precipitation maxima from the selected reanalysis products at 6, 12, 24, 48, and 120 hour durations.
- Annual maximum precipitation was gridded to 0.5 degree after applying areal reduction factors to minimize influence of spatial resolution.
- We then estimated L-moments (*Hosking and Wallis*, 1997) for each dataset and duration.
- The L-moments were used to fit Generalized Extreme Value (GEV) distributions for each durations.
- Using the GEV distribution, we estimated precipitation maxima for 100 year return periods for the selected precipitation durations.

6 Results

100 year observed and reanalysis precipitation maxima

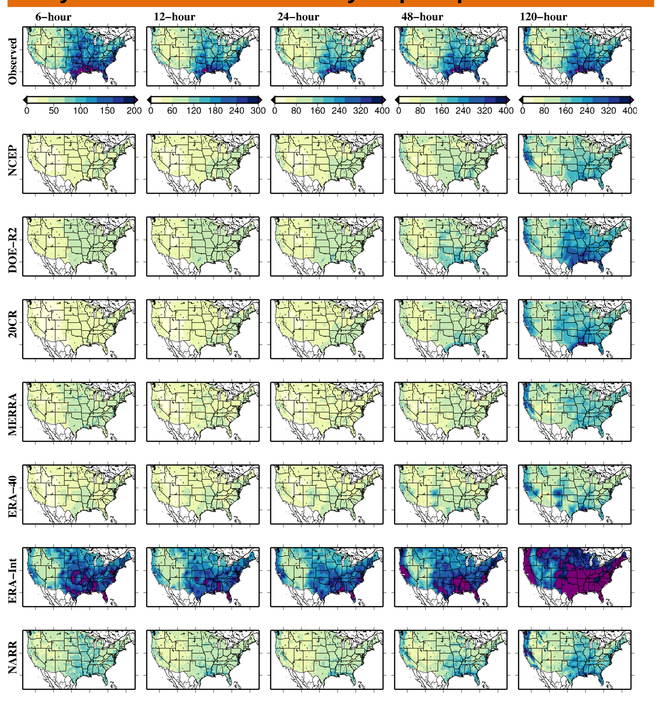

Figure 2: Comparison of observed and reanalysis simulated 100 year precipitation maxima for 6, 12, 24, 48, and 120 hour precipitation durations. For both observed and reanalysis simulated datasets 100 year precipitation maxima were estimated using precipitation maxima in each year for the period of 1979-2009. For ERA-40, 100 year precipitation maxima was estimated using data for the 1979-2002 period.

Bias (%) in reanalysis simulated precipitation maxima

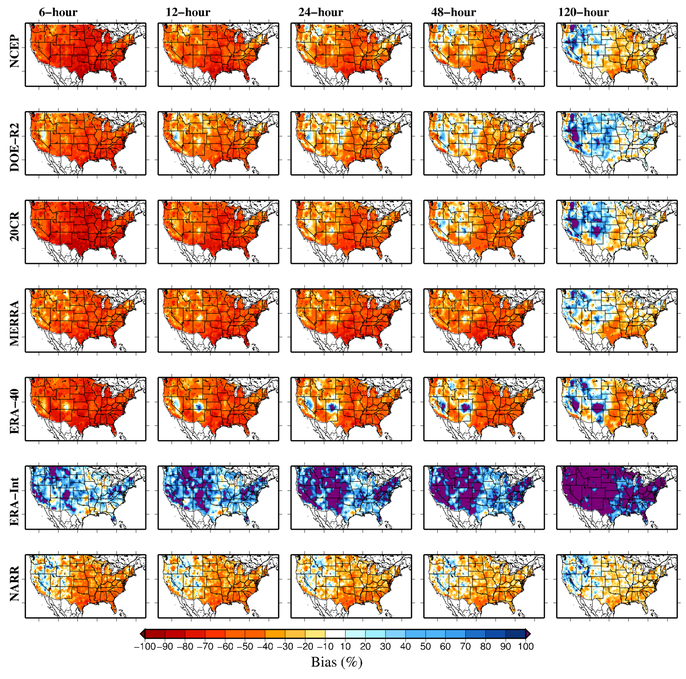

Figure 3: Percentage bias in reanalysis simulated 100 year precipitation maxima for 6, 12, 24, 48, and 120 hour precipitation durations. Red and blue colors show under and over estimation of 100 year precipitation maxima in reanalysis simulations, respectively.

Median Bias (%)

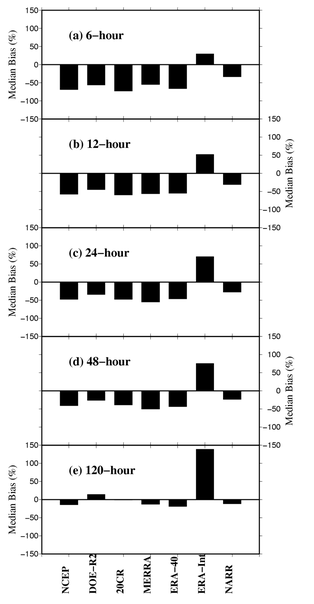

Figure 4: Percentage median bias in reanalysis simulated 100 year precipitation maxima for 6, 12, 24, 48, and 120 hour precipitation durations.

7

- For most of the reanalysis simulation median bias decreases with the increase in precipitation duration.
- Except ERA-interim all reanalysis simulations largely underestimate 100 year precipitation maxima at most of the selected durations.

8 Conclusions

- Observed 100 year precipitation maxima at 6, 12, 24, 48, and 120 hour durations is significantly higher in the eastern U.S. than that of western U.S.
- Most of the reanalysis simulations (except ERA-Int) underestimate 100 year precipitation maxima across the CONUS especially at sub-daily to daily precipitation durations.
- 100 year precipitation maxima at 48 and 120 hour durations was underestimated in the eastern U.S. while overestimated in the western U.S. in majority of reanalysis simulations.
- 100 year precipitation maxima was substantially overestimated in ERA-Int simulations at all the selected precipitation durations. Positive bias in 100 year precipitation maxima in ERA-Int simulations increased with precipitation duration.
- 100 year precipitation maxima simulated from NARR showed the lowest bias at all durations.

9 Bibliography

- Hosking, J. R. M., and J. R. Wallis (1997), Regional frequency analysis: an approach based on L-moments, Cambridge University Press
- Leclerc, G., and J. C. Schaake, Jr., Derivation of hydrologic frequency curves, Tech. Rep. 142, Ralph M. Parsons Lab. for Water Resources and Hydrodynamics, Mass. Inst. of Technol., Cambridge, Mass., January 1972
- **Contact Information**: vmishra@hydro.washington.edu