Berkeley Lab

Testing the robustness of uncertainty when estimating heavy precipitation using extreme value theory

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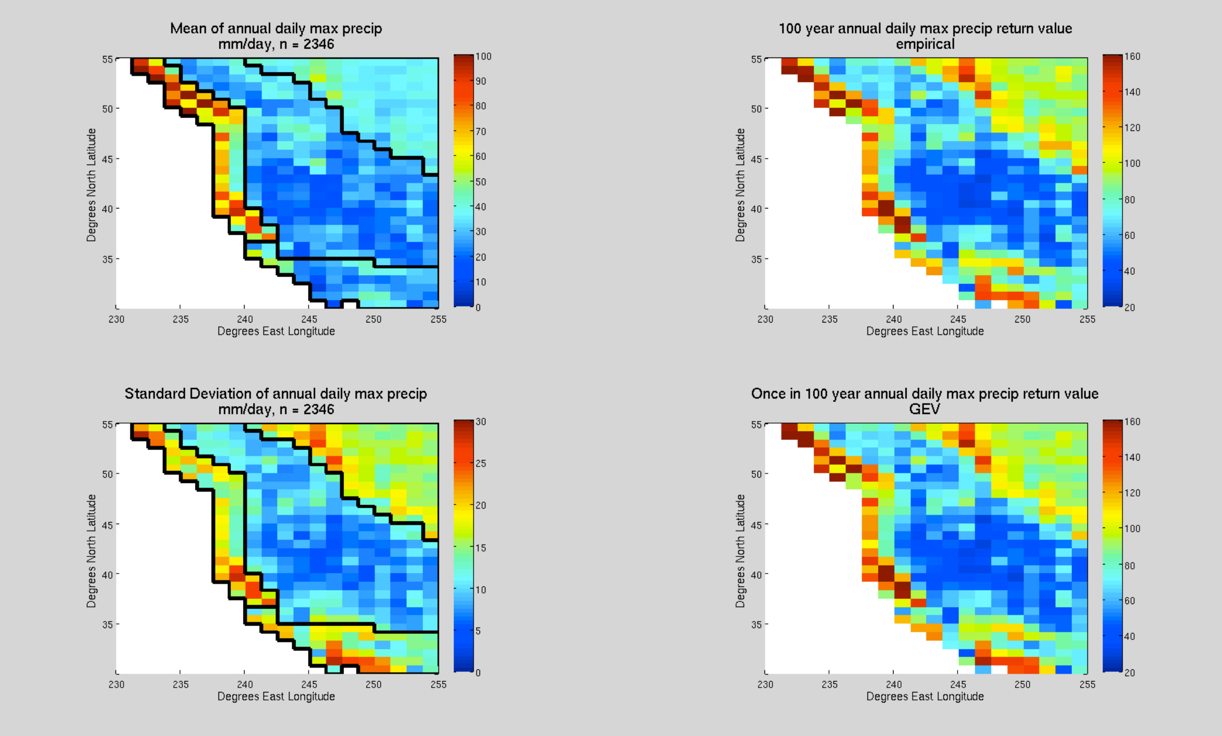


Motivation:

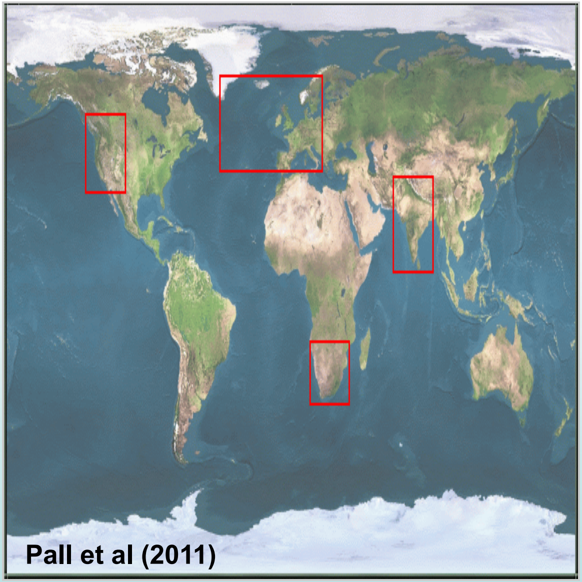
- Explicit sampling of extremes is often hampered by limited length observational records or limited number of model simulations. Thus Extreme Value Theory (EVT) is often used to extrapolate the distribution of a limited data sample to its extremes.

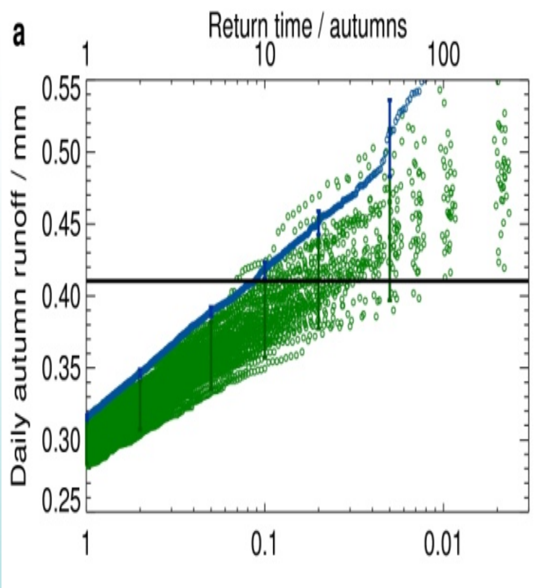
- However EVT has implicit assumptions regarding the characteristics of the distribution, so the true nature of extreme behaviour may not be represented accurately.

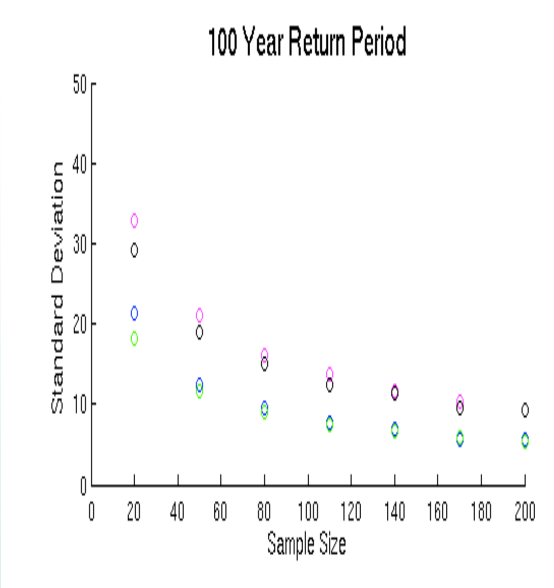
- Furthermore, the associated uncertainty bounds depend on the the sample size. Thus how large a sample size do we need to accurately represent extremes with EVT: when do the uncertainties become robust?

- Here we test this using a very large set of climate model data, for a specific case: western US daily precipitation for a single year.

Experiment design:







1. Take very large daily precip data set from a past project (which studied attributable risk)

~2000 1-year simulations using a ~100km global climate model.
Look at Western US.

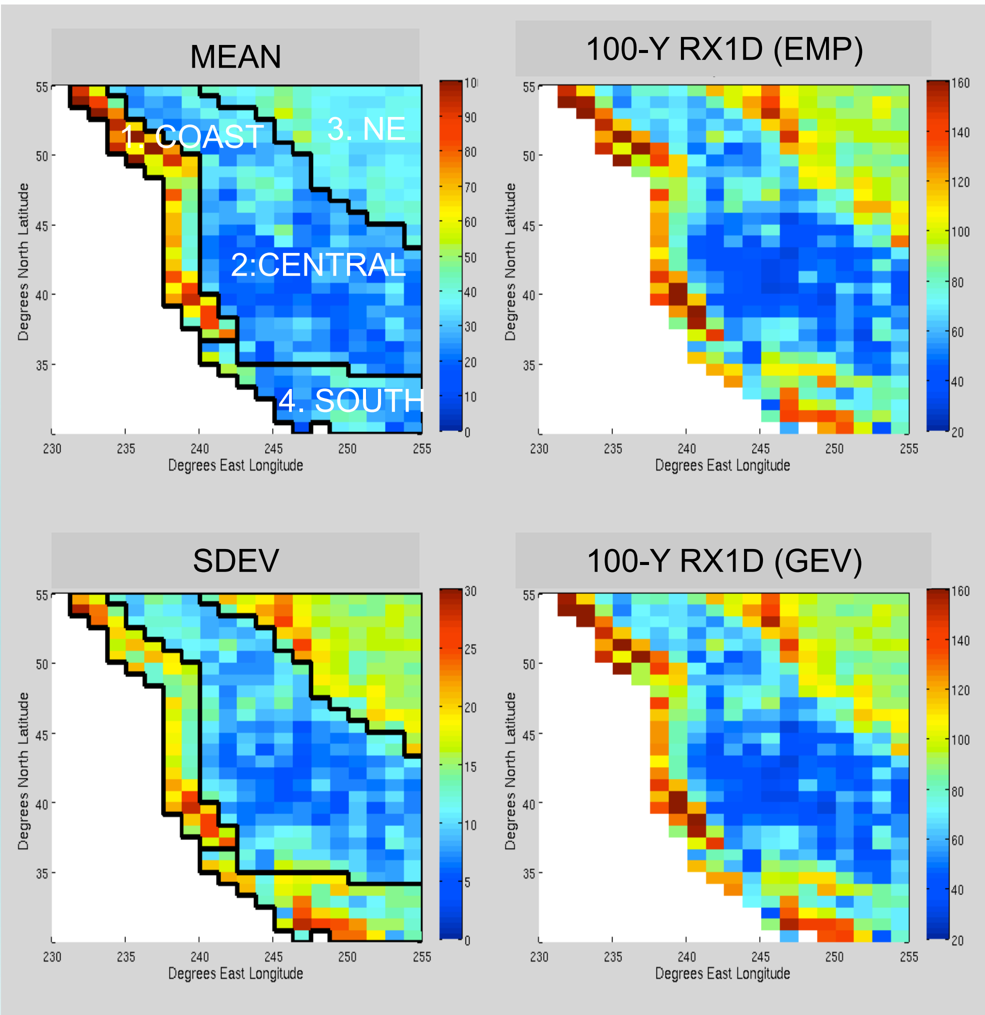
2. Determine return values empirically and with GEV (block maxima) fits for annual max precip (RX1D), using all the data

[BTW, note the shift in curve for very extreme return values in this example?]

3. Test robustness of GEV fit uncertainty for a range of return periods and sub-samples of the data

→ Gives a 'best practice' number of simulations required

Results:
Region definition

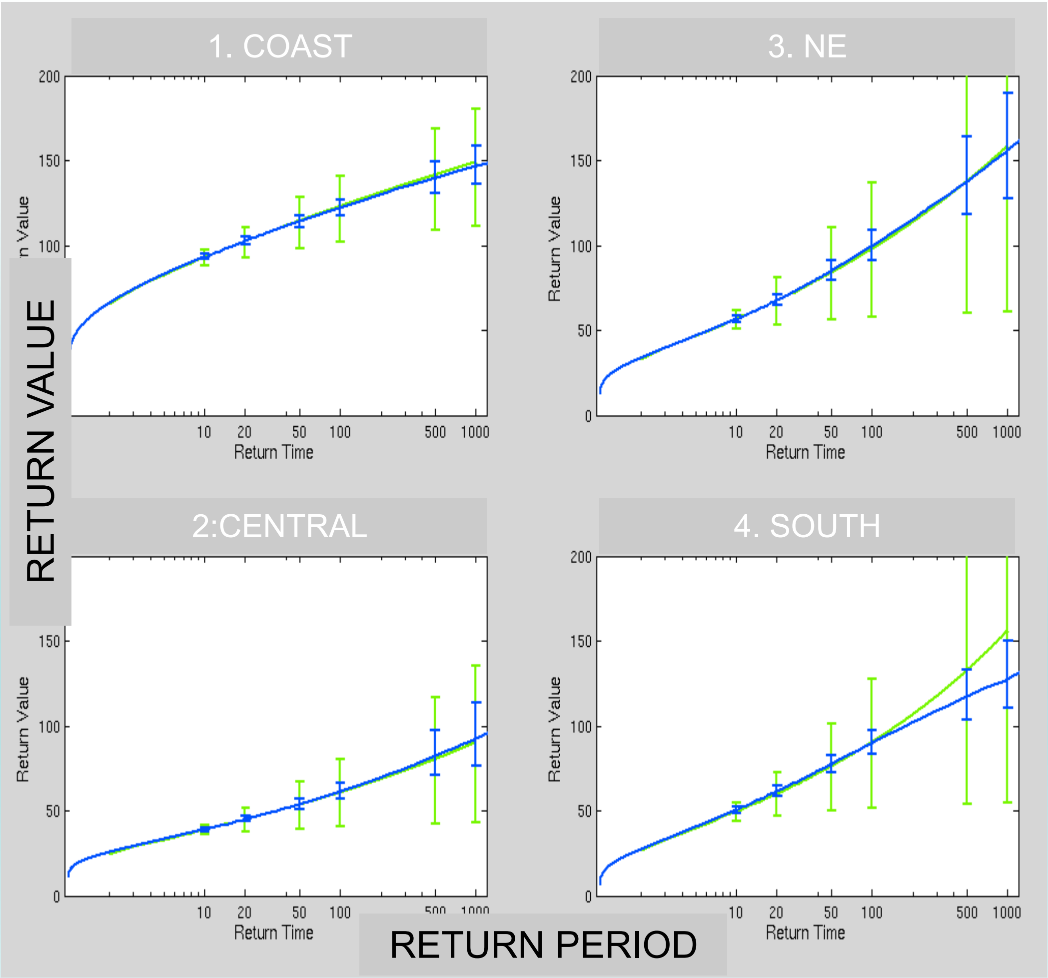


Divide Western US into four regions based on grid-box-resolution mean and standard deviation of RX1D

Estimate empirical and GEV fit returns using all the data (e.g. here the 100-y returns agree very well)

Also, we initially used a non-parametric, non-replacement, sampling method, with L-moments, to make the GEV estimates. Will come to this later…

Results:
Empirical vs. GEV return values

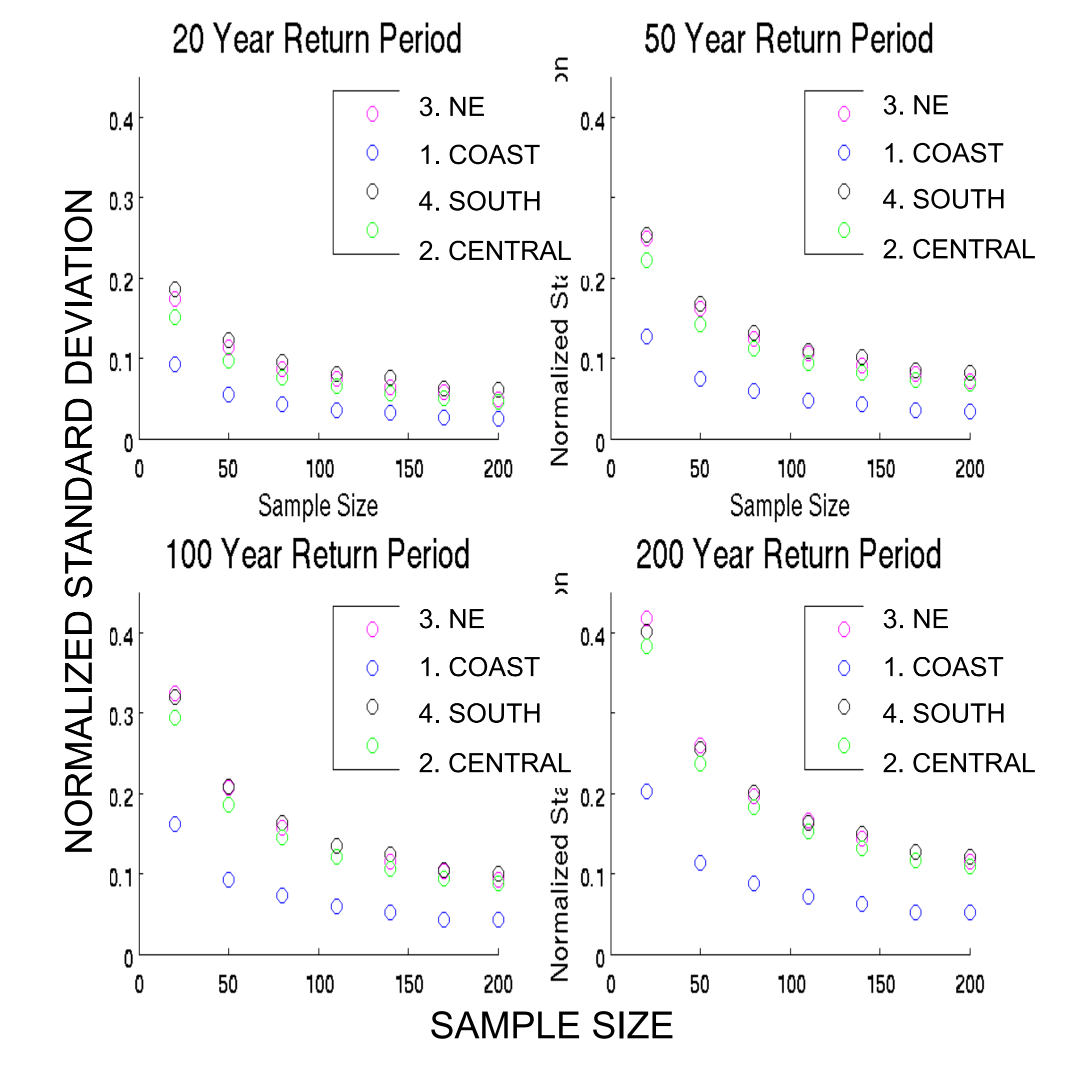


Repeat for a range of return levels, still at grid-box-resolution (and still using all data). Then average across each region.

Generally empirical and GEV values agree very well

But note how GEV fit breaks down in the South region (desert)

Results:
Robustness of GEV uncertainty



Repeat for a range of return periods, still at grid-box-resolution, now using sub-samples of data. Then average across each region.

Use standard deviation of GEV fit as a measure of uncertainty (standard formula for method used here: MLE)

Convergence of uncertainty varies by return period and region. E.g. ~80-100 samples needed for 20-y returns

Rules of thumb?

Summary

- We want to know 'how much data is enough' when applying EVT to limited data samples in order to estimate extremes.
- We investigate the robustness of EVT uncertainty, as a function of sample size, when applying GEV fits to a large data set of climate model daily annual maxima precipitation (RX1D), for four regions of the western US
- We find that convergence of uncertainty varies by return period and region. E.g. ~80-100 samples needed for 20-y returns, >100 samples for higher returns.
- Results may also depend on fitting procedure (e.g. L-moments vs MLE)?

END

Results: Seasonal

Annual wet coast dominated by DJF, and dry interior by summer, as expected.