Precipitation extremes and their relationship to ENSO in an ensemble of regional climate models (NARCCAP)

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Introduction

Winter precipitation extremes in North America reveal a significant relationship to large-scale modes of climate variability such as the El Niño-Southern Oscillation (ENSO). Based on composite analysis and extreme value analysis including the Southern Oscillation index (SOI) as covariate, it is investigated whether the relationship between the ENSO climate variability and precipitation extremes is also represented in regional climate models (RCM) as provided by the North American Regional Climate Change Assessment Program (NARCCAP). A realistic representation of this relationship in the NARCCAP models is essential for further downscaling applications of extreme precipitation.

Methodology

Composite Analysis

The composite analysis is based on monthly maximum 1-day precipitation (mpx1d) in the extended **winter season from November to March** (NDJFM). From the available 25 years (1979 to 2003) for all models, months with the 10 highest and 10 lowest SOI values are selected, which reflect approx. the upper and lower 10% of the distribution of the SOI for NDJFM (i.e., 125 months). A non-parametric bootstrap method is applied to test the significance of the composite pattern.

Extreme Value Analysis

A non-stationary **Generalized Extreme Value (GEV) distribution** is fitted to winter (NDJFM) maxima of daily precipitation for the time period 1979 to 2003 (i.e., 25 maxima). The mean winter (NDJFM) SOI is used as covariate (z=SOI), which is linearly linked to the location parameter of the GEV distribution:

$$G(x) = \exp\{-[1+\xi(x-\mu)/\sigma]^{-1/\xi}\}$$

with

$$\mu(z) = \beta_0 + \beta_1 * z$$

where μ, σ, and ξ denote the location, scale and shape parameter, respectively.

Model and Observational Data

RCM simulations

• Daily precipitation from **RCM simulations driven with the NCEP re-analysis**, which were performed as part of NARCCAP (Mearns et al. 2011). Detailed information on the RCM simulations are available on the web site: http://www.narccap.ucar.edu/data/model-info.html

Observations

• Daily precipitation from the **0.25°x0.25° gridded observational precipitation data set** provided by the NOAA Climate Prediction Center (CPC): http://www.esrl.noaa.gov/psd/data/gridded/data.unified.html.

• **Monthly SOI** time series are available at the Climate Research Unit (CRU) web site: http://www.cru.uea.ac.uk.

Composite Analysis

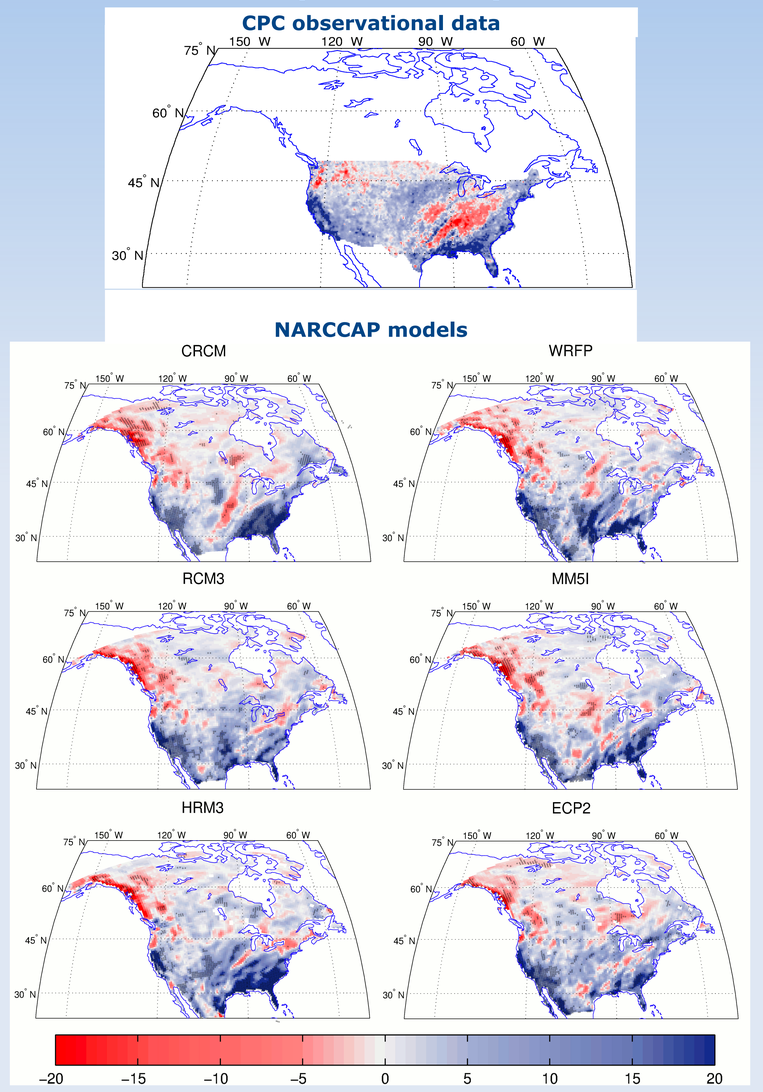

Figure 1: Difference in the max. 1-day precipitation amount (mpx1d in [mm]) for the CPC observational data set and 6 NARCCAP models averaged over the NDJFM months between the 10 lowest and 10 highest SOI values. Significant differences to the 10% level are gray-shaded.

References

Mearns, L.O., et al., 2007, updated 2011: *The North American Regional Climate Change Assessment Program dataset*, National Center for Atmospheric Research Earth System Grid data portal, Boulder, CO. Data downloaded 2011-07-06.

Zhang, X., J. Wang, F.W. Zwiers, P. Ya Groisman, 2010: The influence of large scale climate variability on winter maximum daily precipitation over North America. Journal of Climate, 23, 2902- 2915.

Extreme Value Analysis

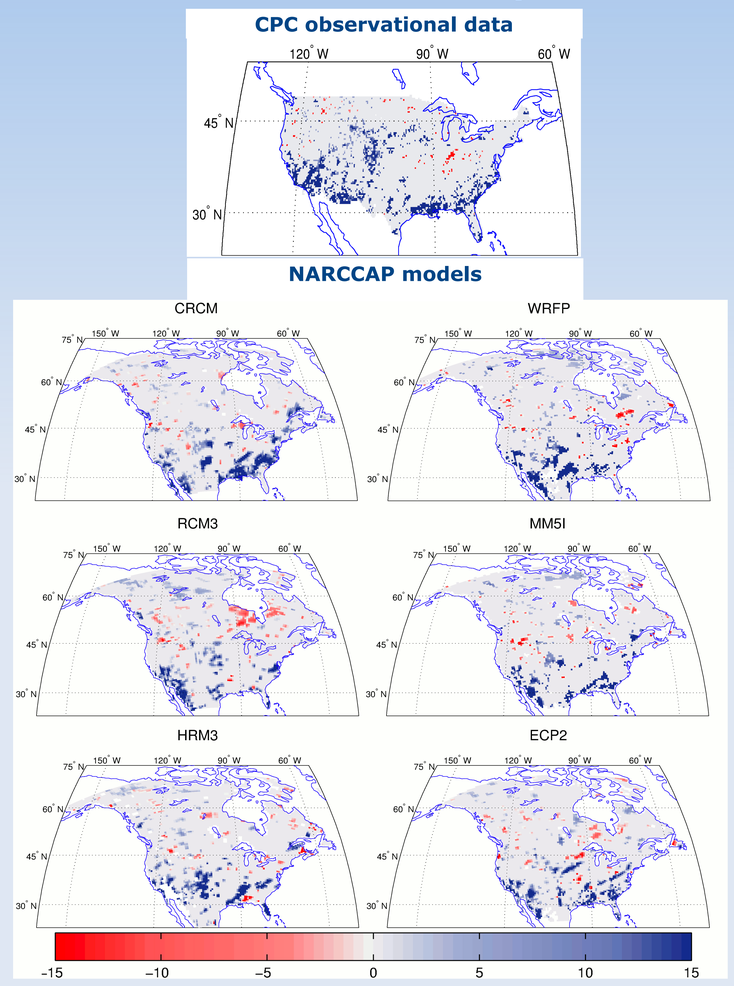

Figure 2: Differences in 20-year return values of NDJFM seasonal extreme precipitation [in mm] between years with the 3 lowest and 3 largest SOI values (upper and lower 10% of the SOI distribution). Shown are grid boxes where the non-stationary GEV distribution significantly improved the fit to the underlying precipitation data according to the deviance statistic with a 5% significance level.

Conclusion

Coherent patterns of significant negative differences occur in the composites of mpx1d indicating that **extreme precipitation increases during El Niño seasons** (low SOI) in the NARCCAP models. This is also reflected in the **20-year return values** of the extreme NDJFM precipitation which are **increased** during low SOI seasons. Approx. 12% of all land grid boxes are significantly influenced by SOI in the NARCCAP models, which is similar to station-based (Zhang et al. 2010) and gridded observational data.