Identification of Spatio-temporal Contiguous Carbon Cycle Extreme Events

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Research Objectives

Based on the simulations from Earth System Models:

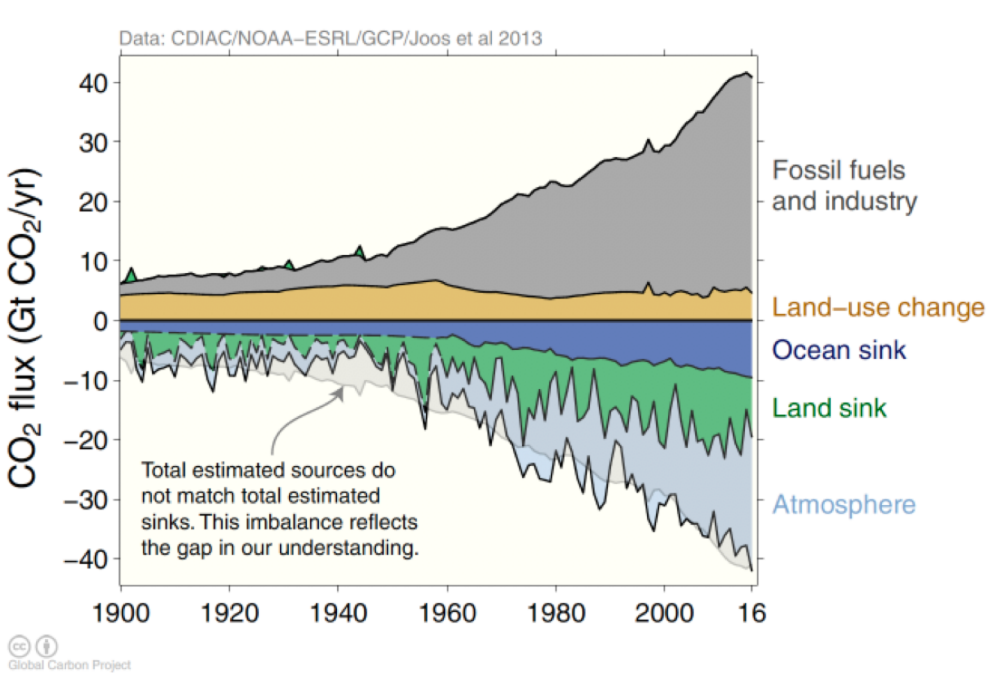
1. How will terrestrial carbon cycle extreme events evolve beyond 21st century?

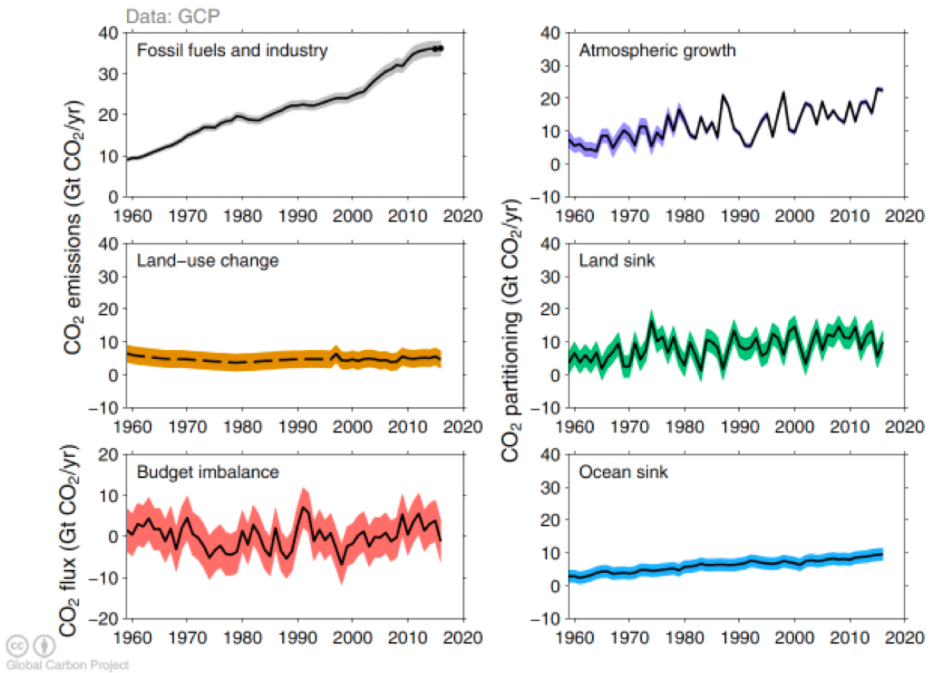
2. How do selection of different structuring elements affect the extent, duration, and magnitude of Spatio-temporal Contiguous (STC) extreme events?

3. What are the dominant climate drivers for the observed extreme events?

Global Carbon Dioxide Budget

The sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere





Source : CDIAC, NOAA_ESRL; Global Carbon Budget 2017

Climate Extremes and Carbon Cycle

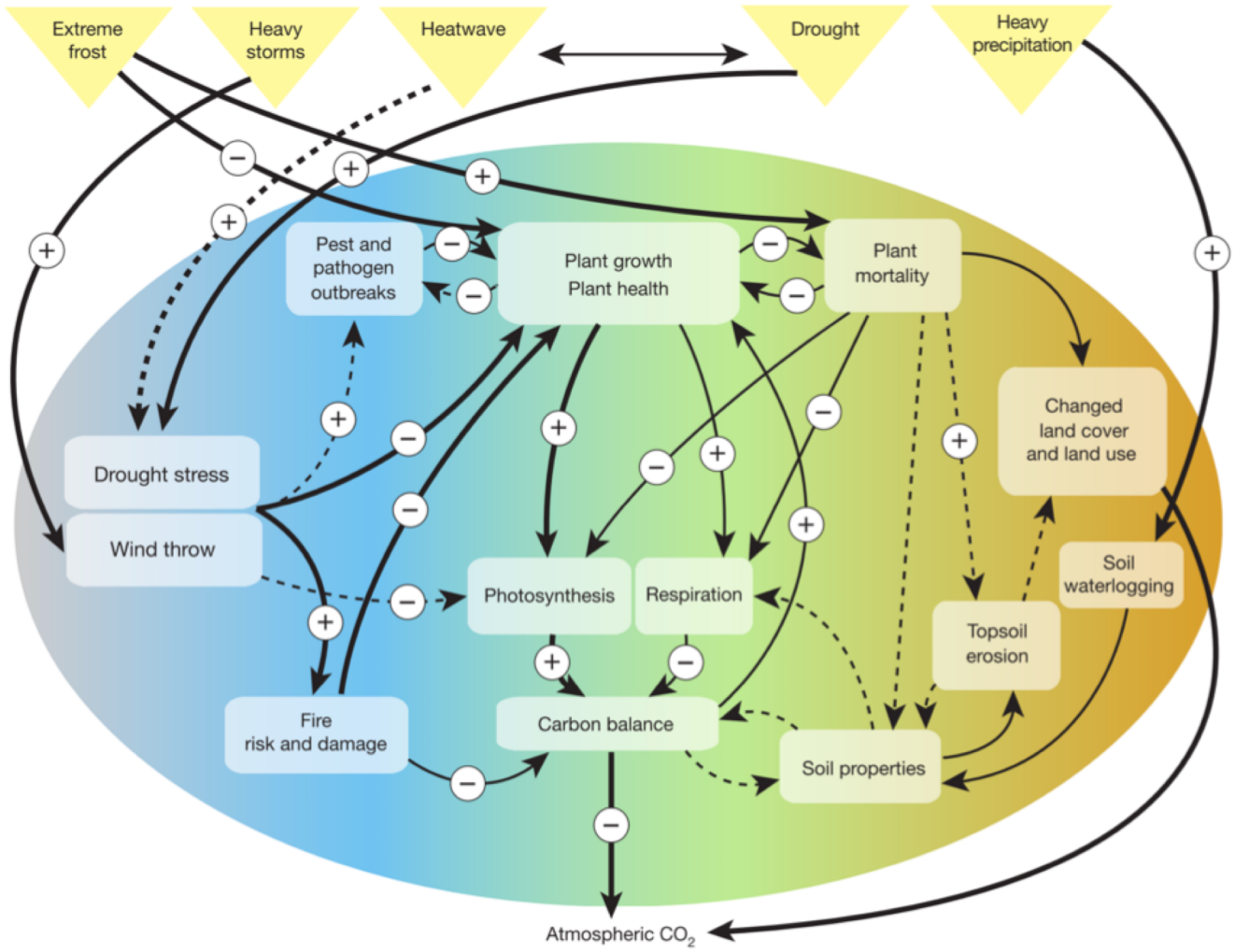
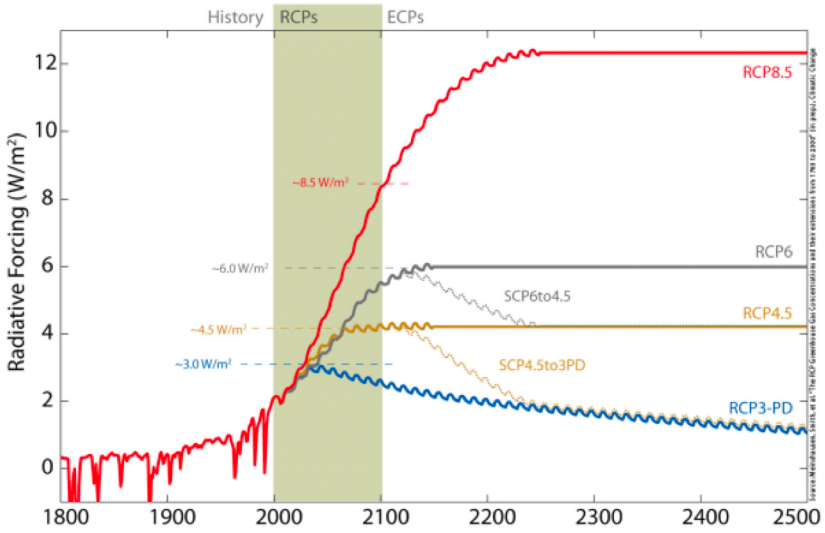


Figure Processes and feedbacks triggered by extreme climate events. The extreme events considered are droughts and heatwaves, heavy storms, heavy precipitation and extreme frost. Solid arrows show direct impacts; dashed arrows show indirect impacts. The relative importance of the impact relationship is shown by arrow width (broader arrows are more important).

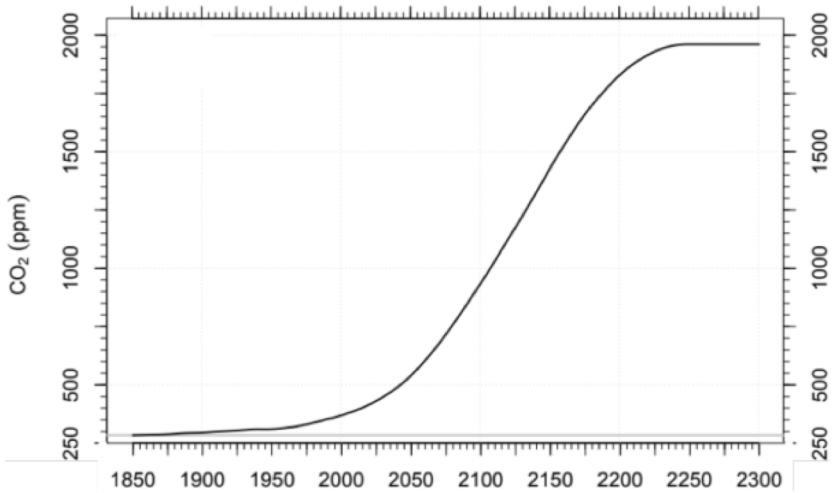
Source : Reichstein (2013)

Data Source

Community Earth System Model Biogeochemistry Working Group, CESM1-BGC



Meinshausen et al. (2011) extended RCP forcing out to 2500

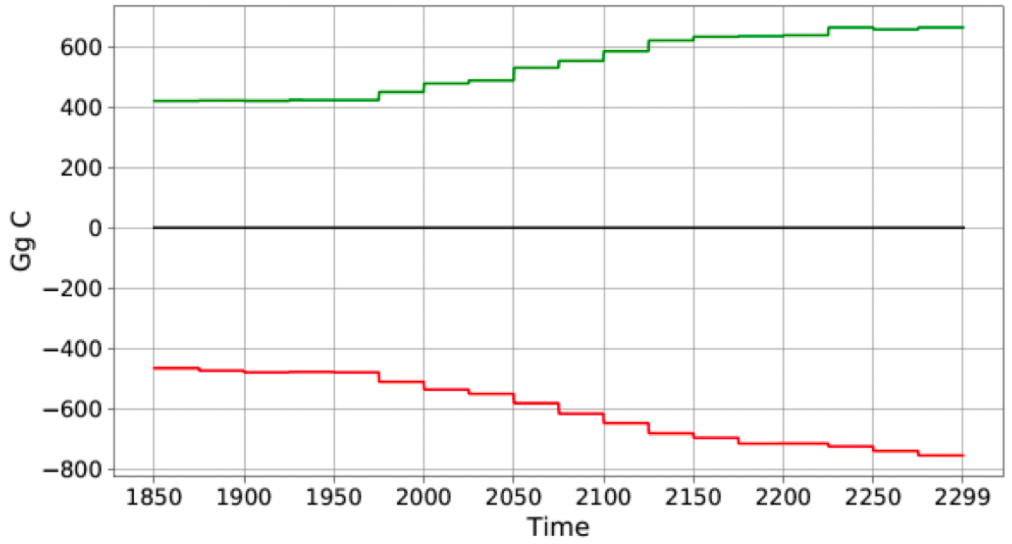


Prescribed atmospheric CO_2 mole fraction was stabilized at 1962 ppm around 2250

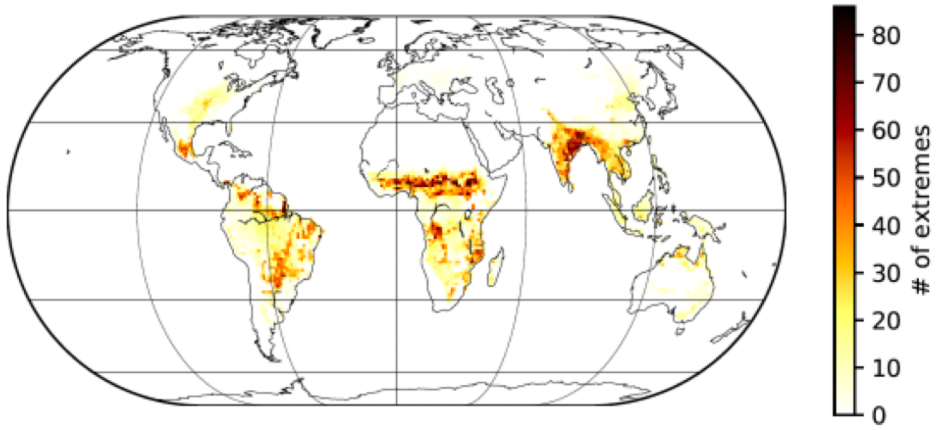
Source: Hoffman 2017 (AGU)

- Resolution: 0.9375° x 1.25° (lat x lon)
- Monthly Mean Data

Threshold & Spatial Distribution of Negative Extremes

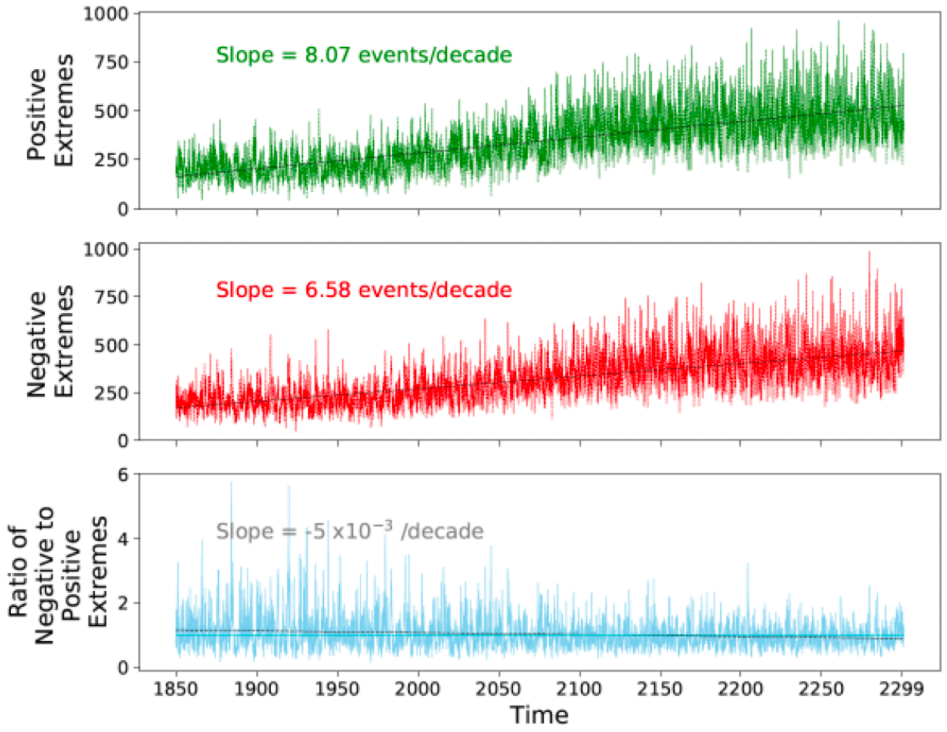


Thresholds when percentile is 1.0 and time period is 25 years

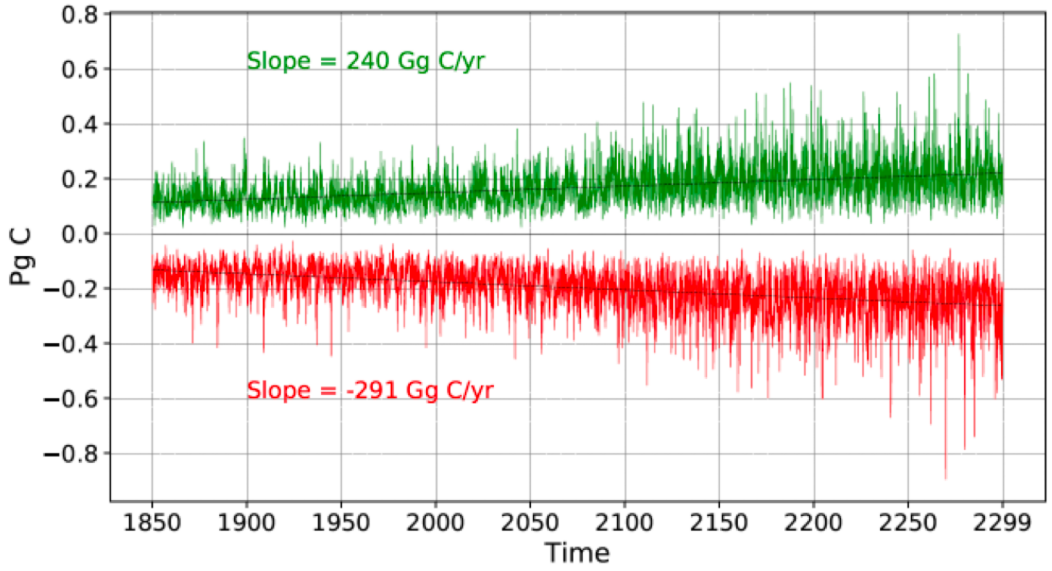


Frequency of negative extreme events for 2175–2199, percentile: 1.0

Time series of Extreme Events

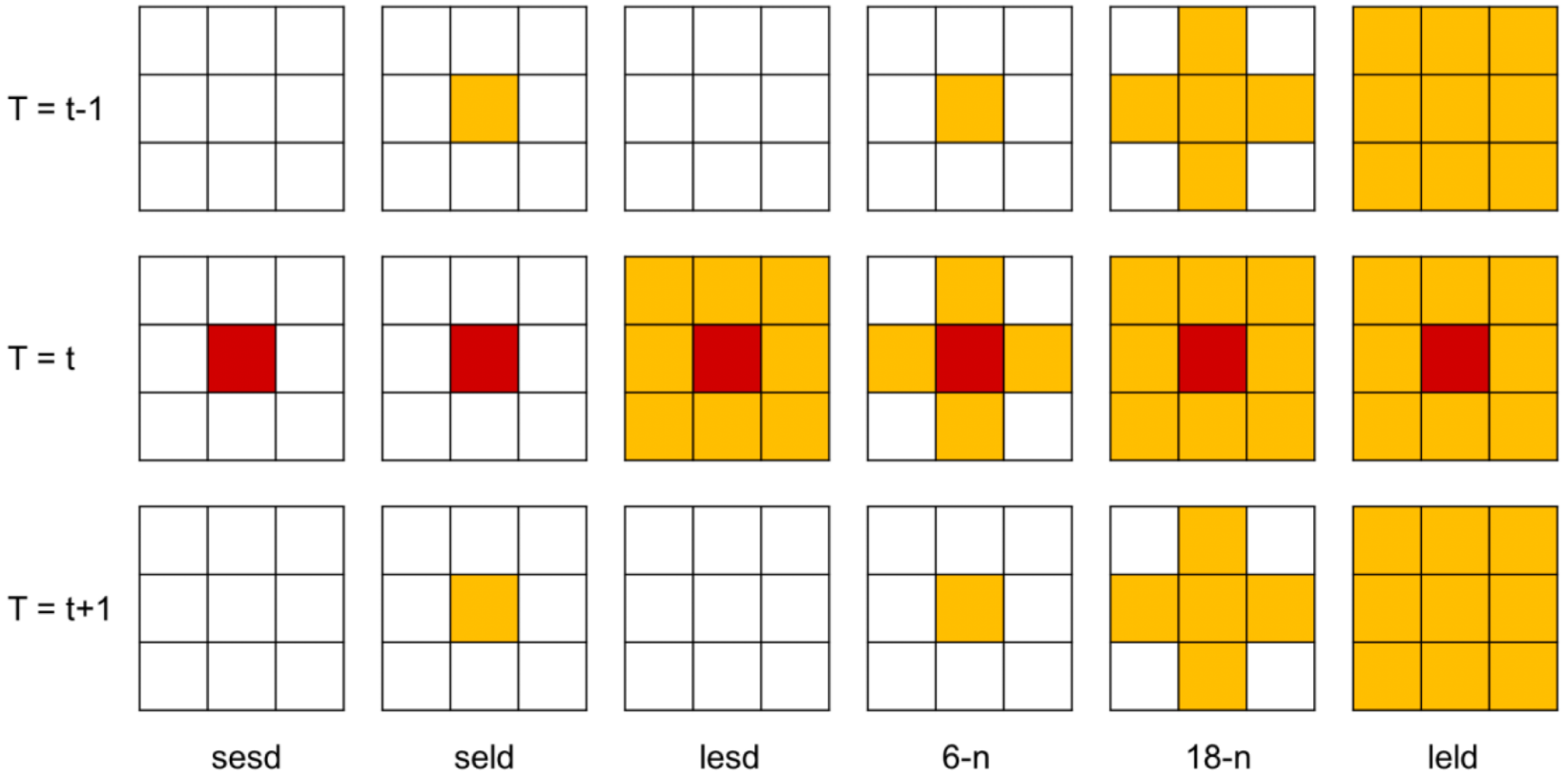


Counts of extremes relative to the threshold of 1850–1999



Global timeseries of extreme events when percentile is 1.0 and time period is 25 years

Spatio-Temporal Contiguous (STC) events

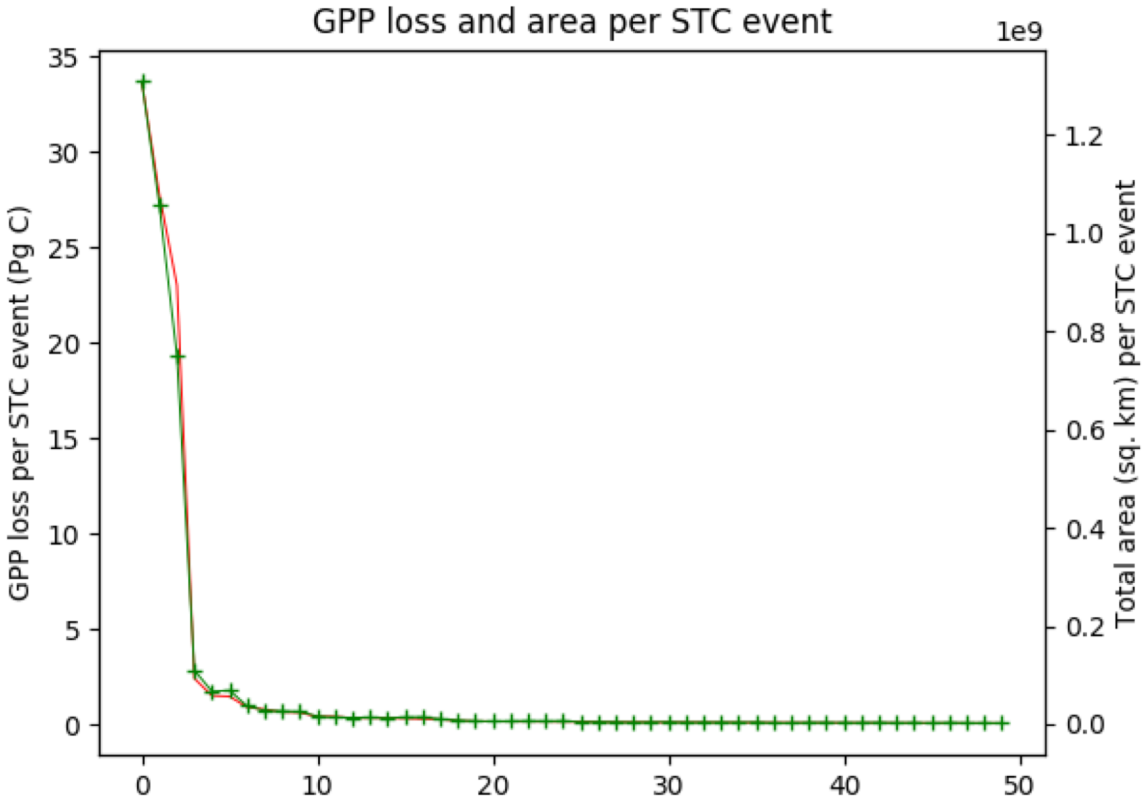


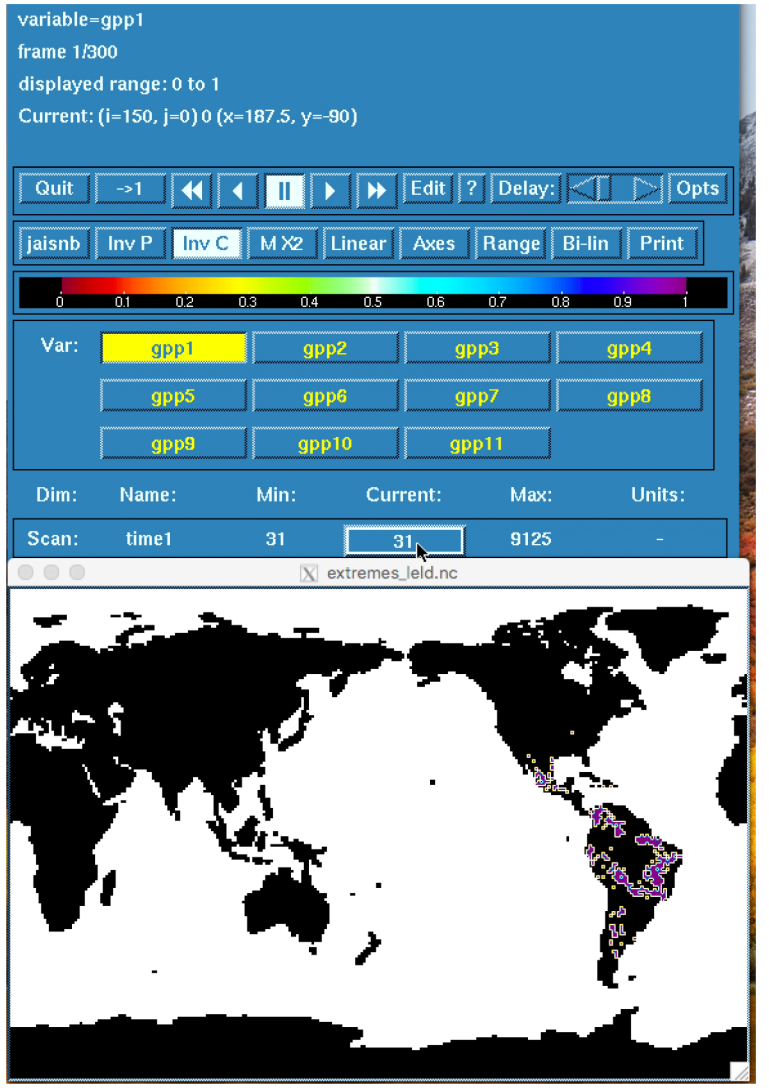
Types of Structuring Elements

Abbreviations:

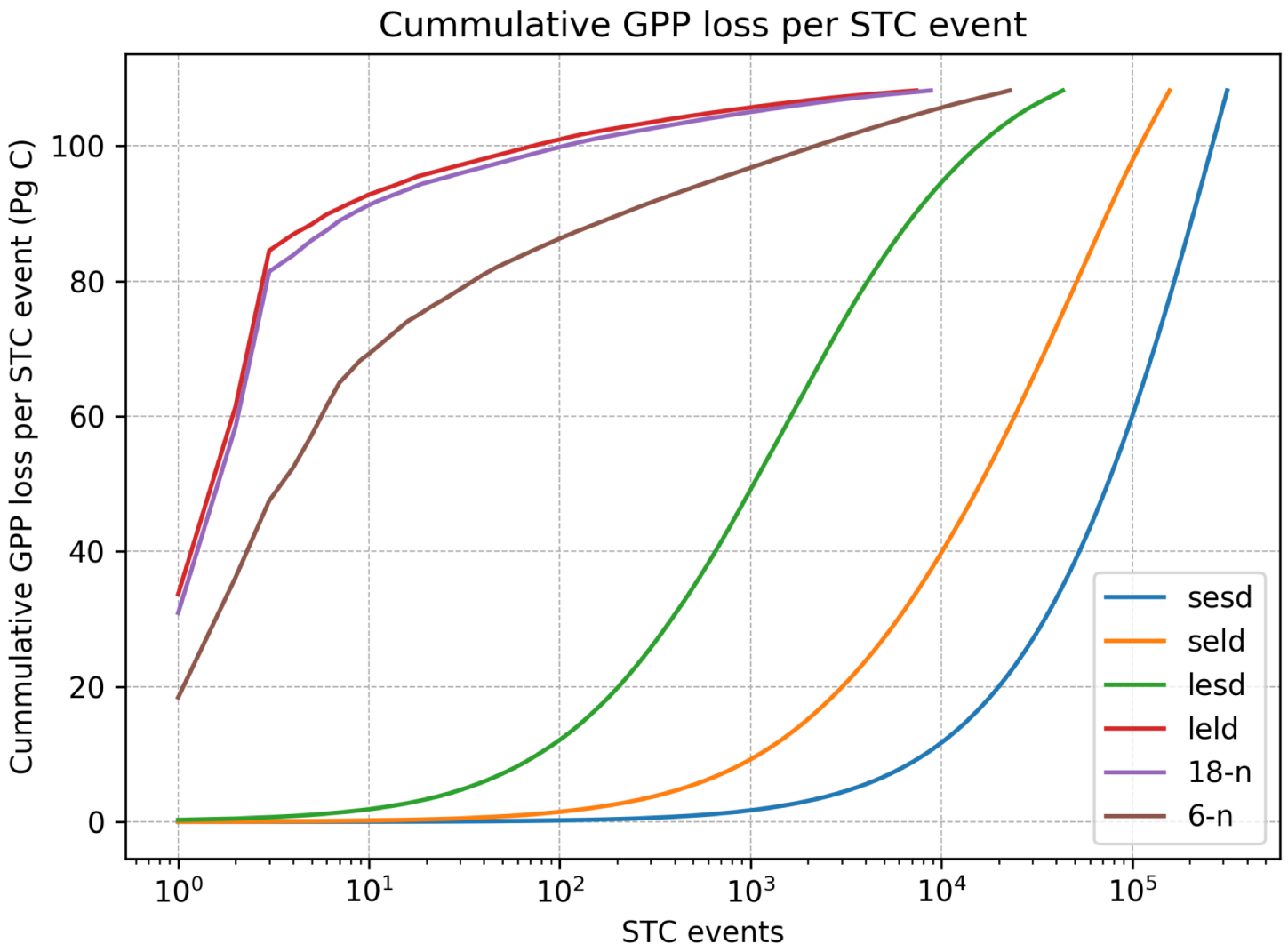
sesd	Small Extent Short Duration
seld	Small Extent Long Duration
lesd	Large Extent Short Duration
leld	Large Extent Long Duration
6-n	6 Neighbors in Cardinal Directions
18-n	18 Neighbors

Three Largest STC Extremes for ‘leld’

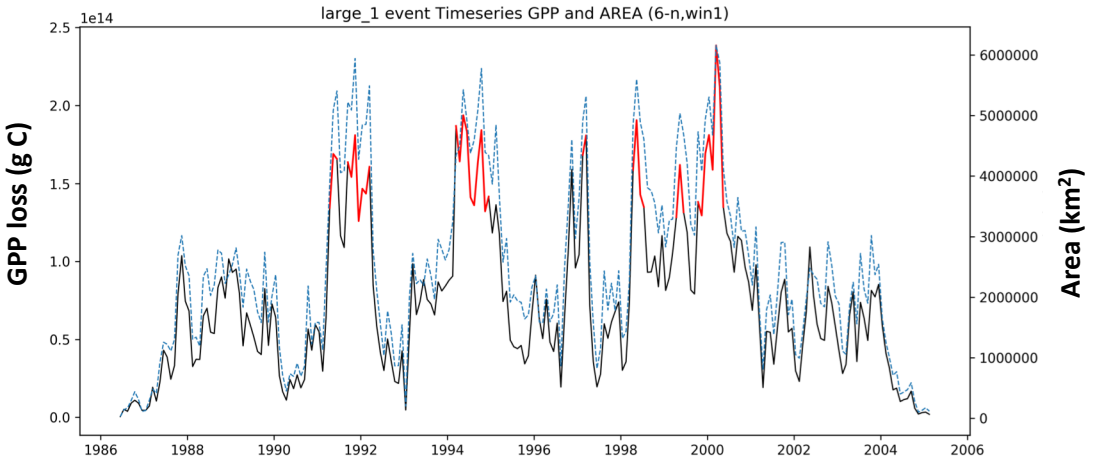


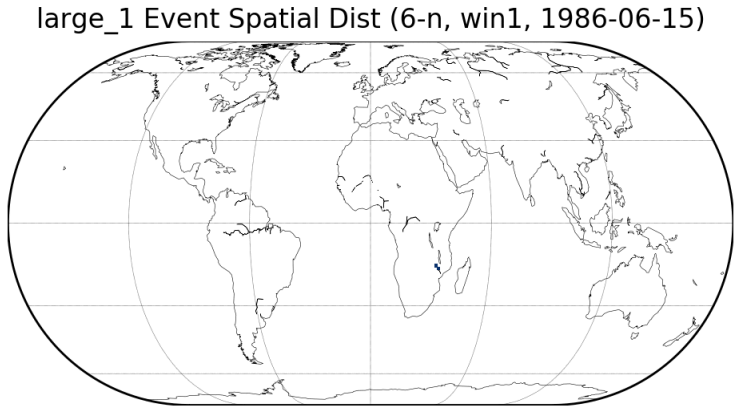


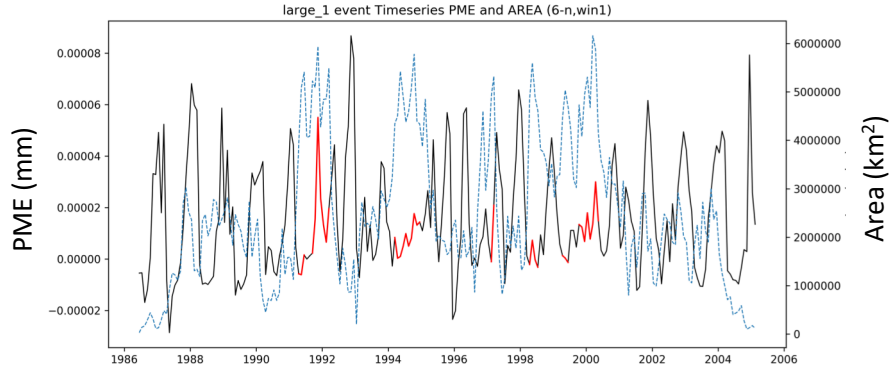
Cumulative GPP loss per STC event

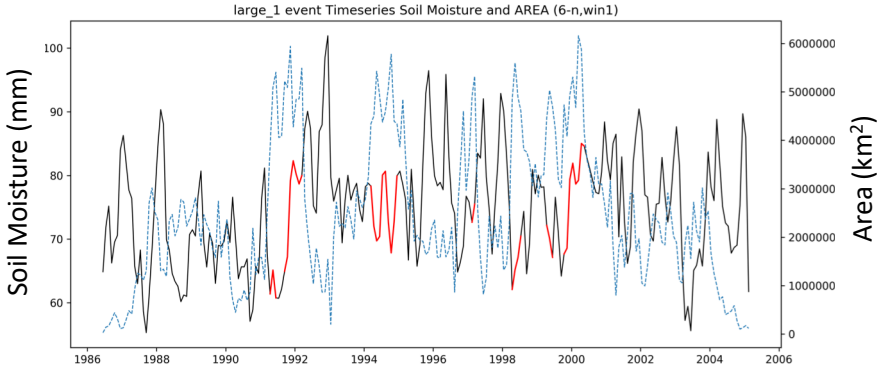


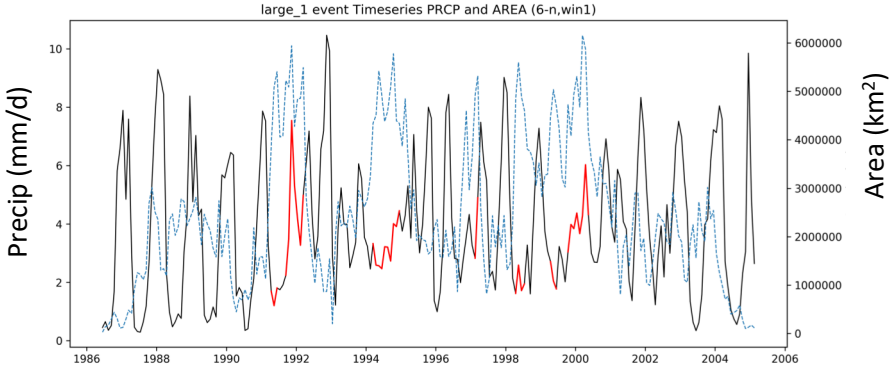
Largest STC Event for 6-n in Africa

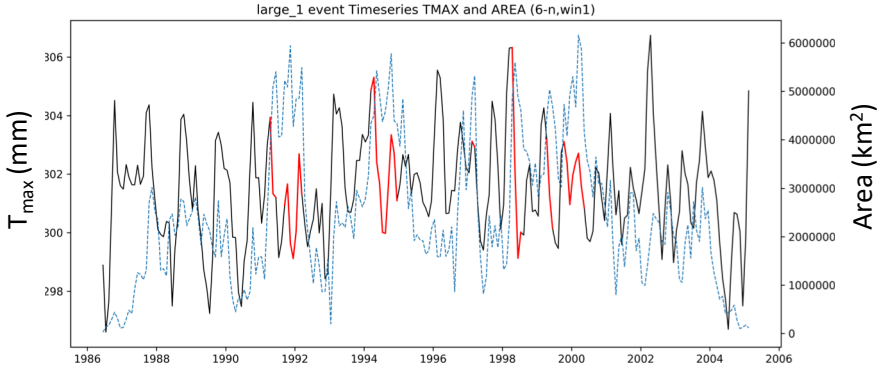




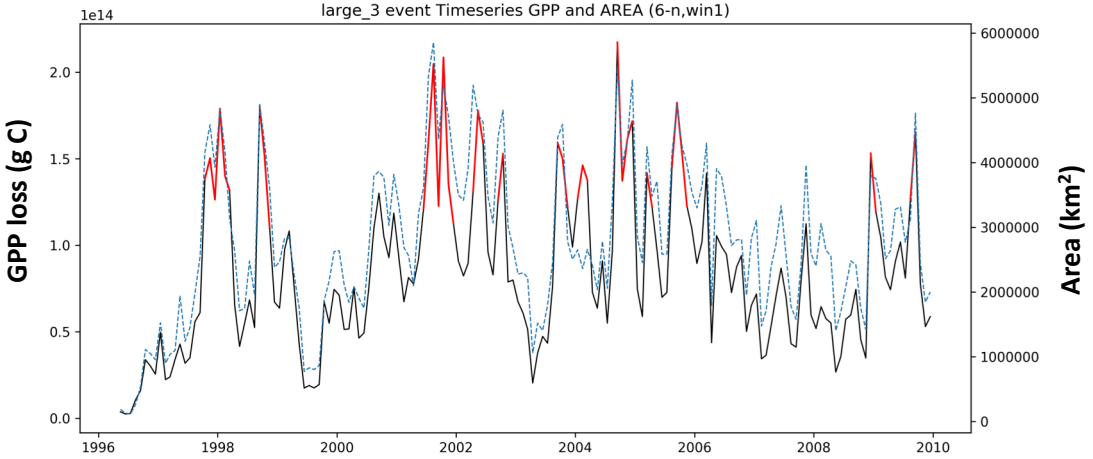


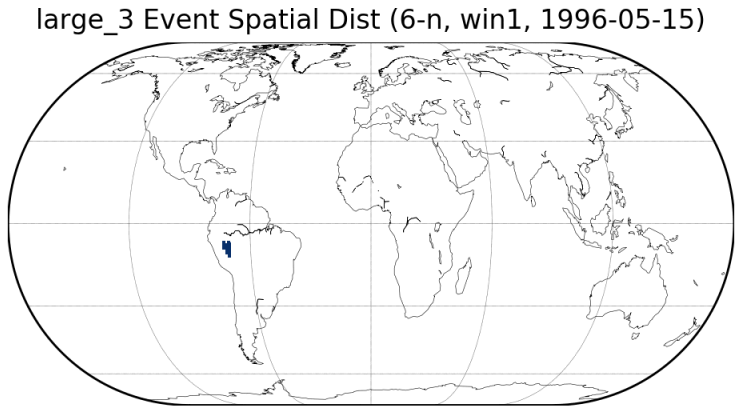


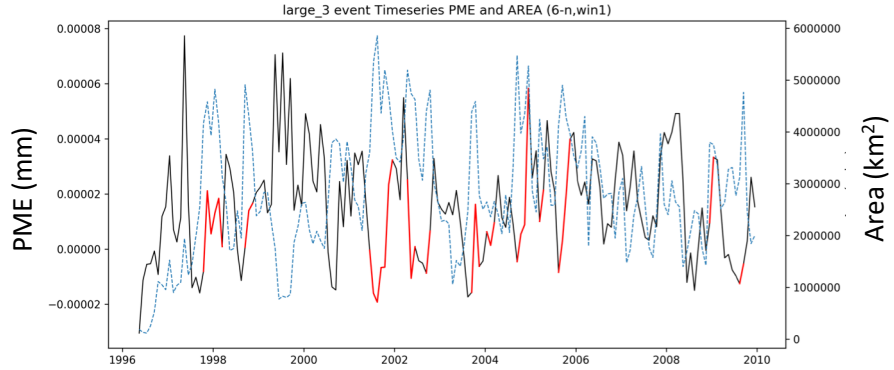


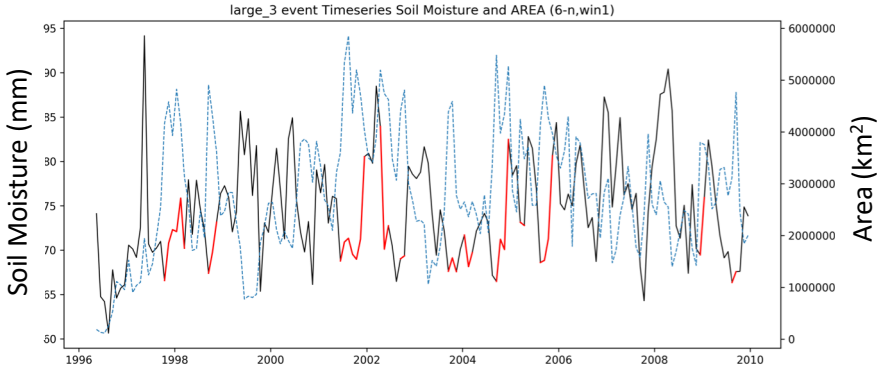


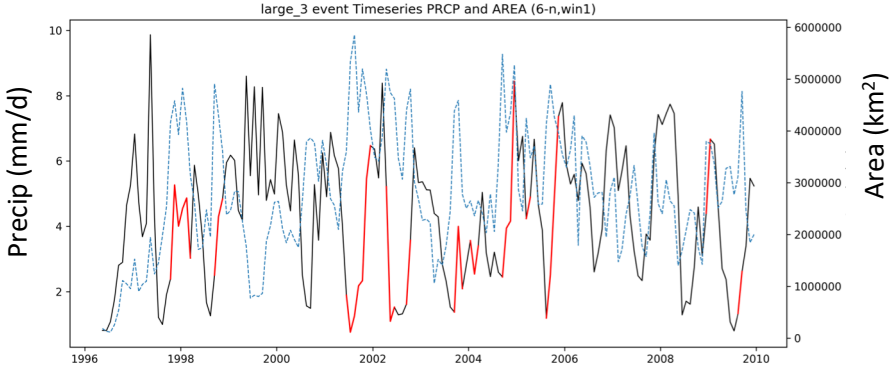
Largest STC Event for 6-n in South America

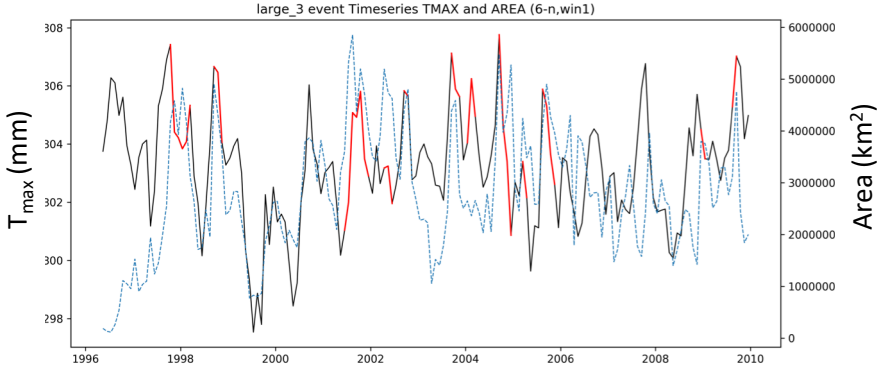




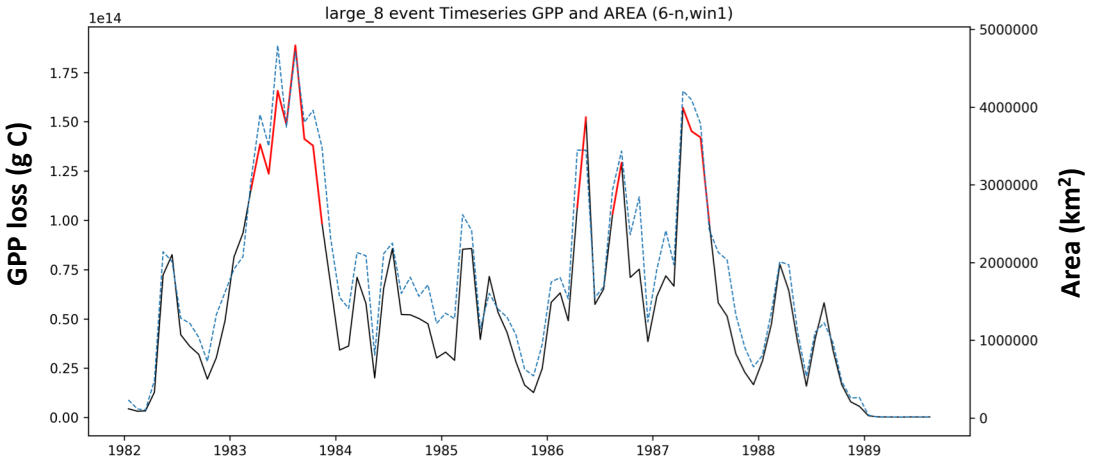


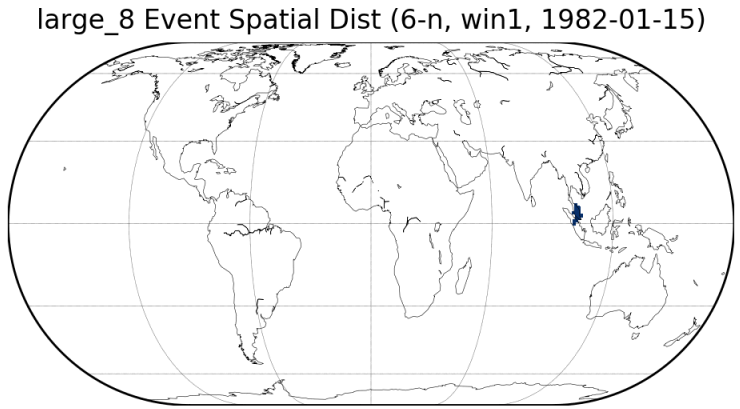


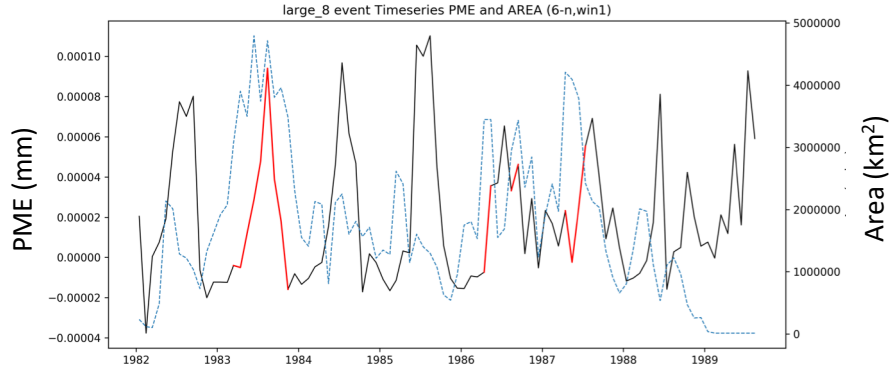


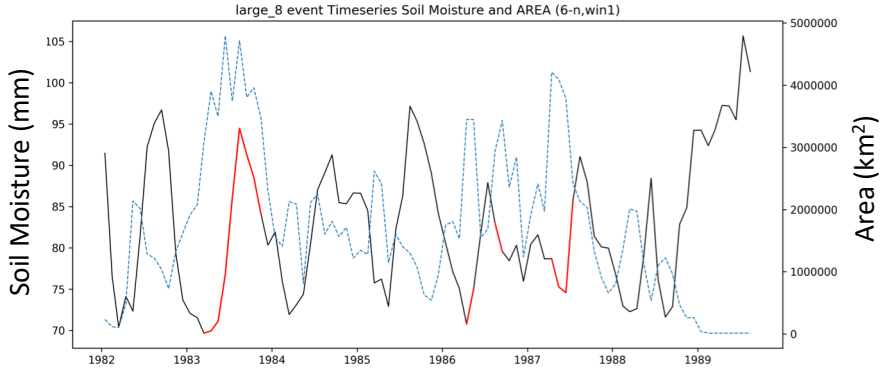


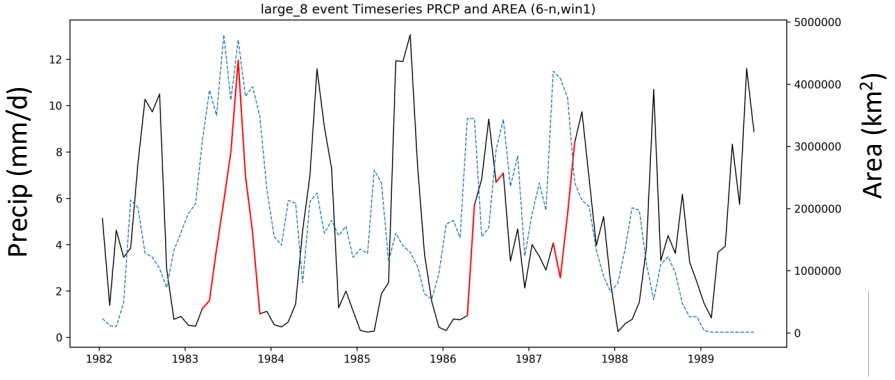
Largest STC Event for 6-n Asia

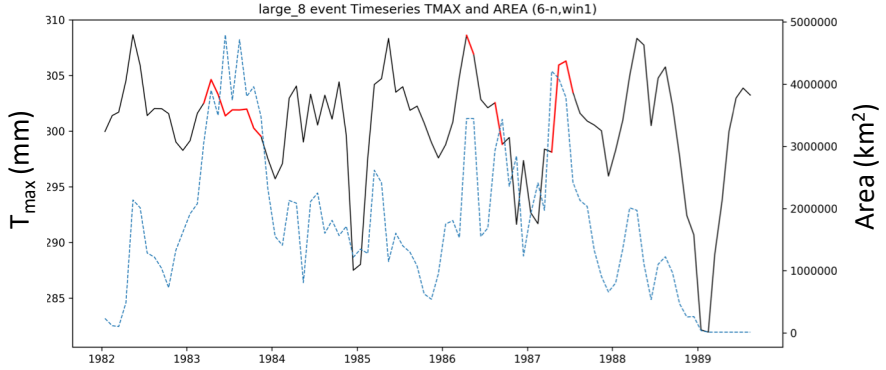




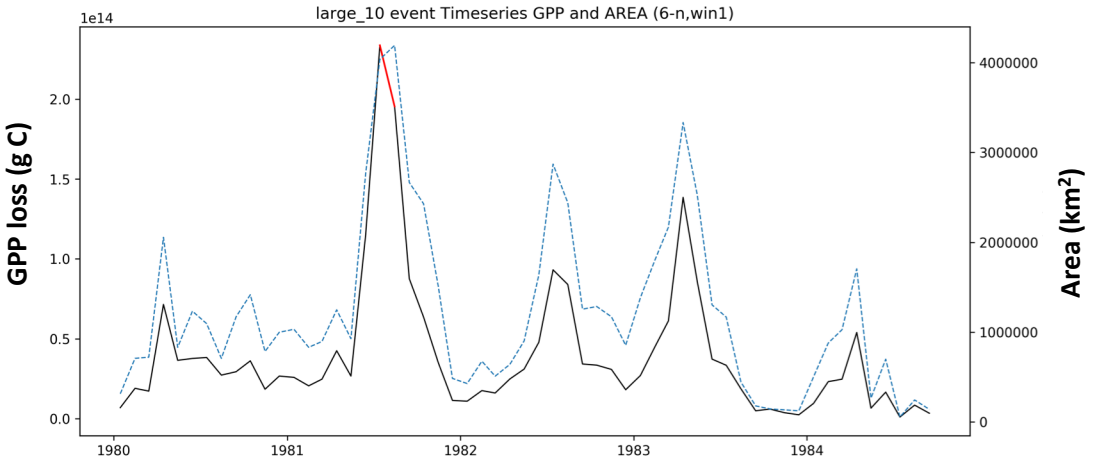


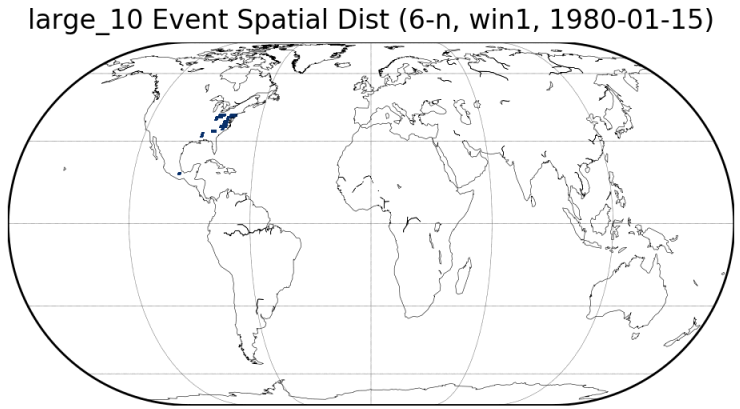


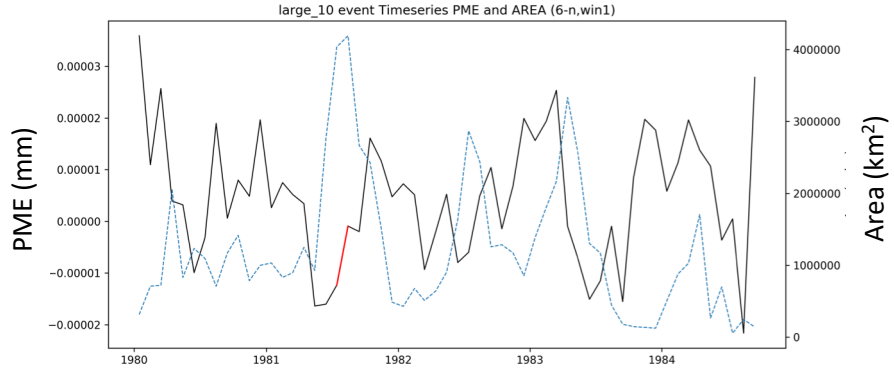


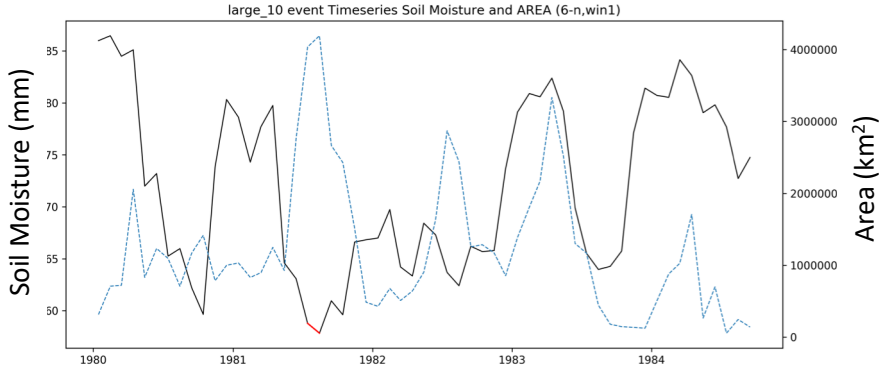


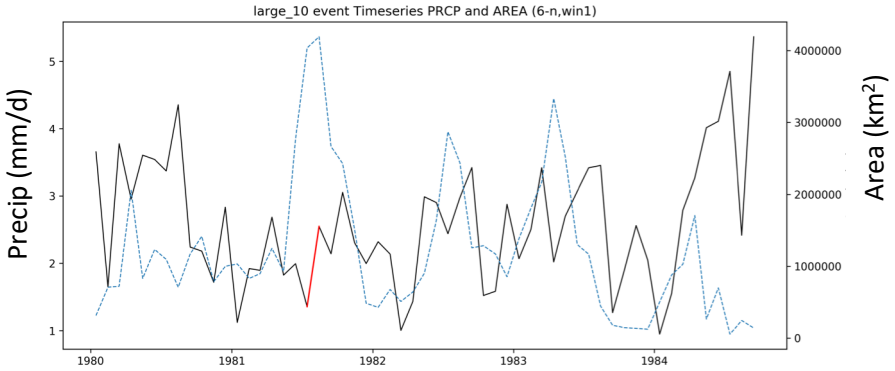
Largest STC Event for 6-n North America

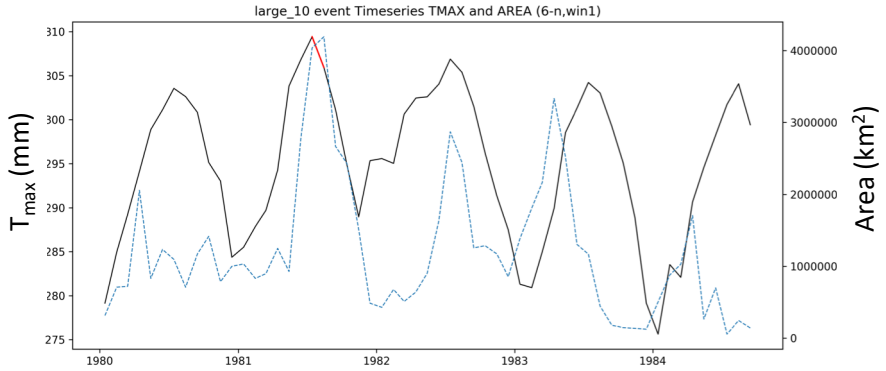




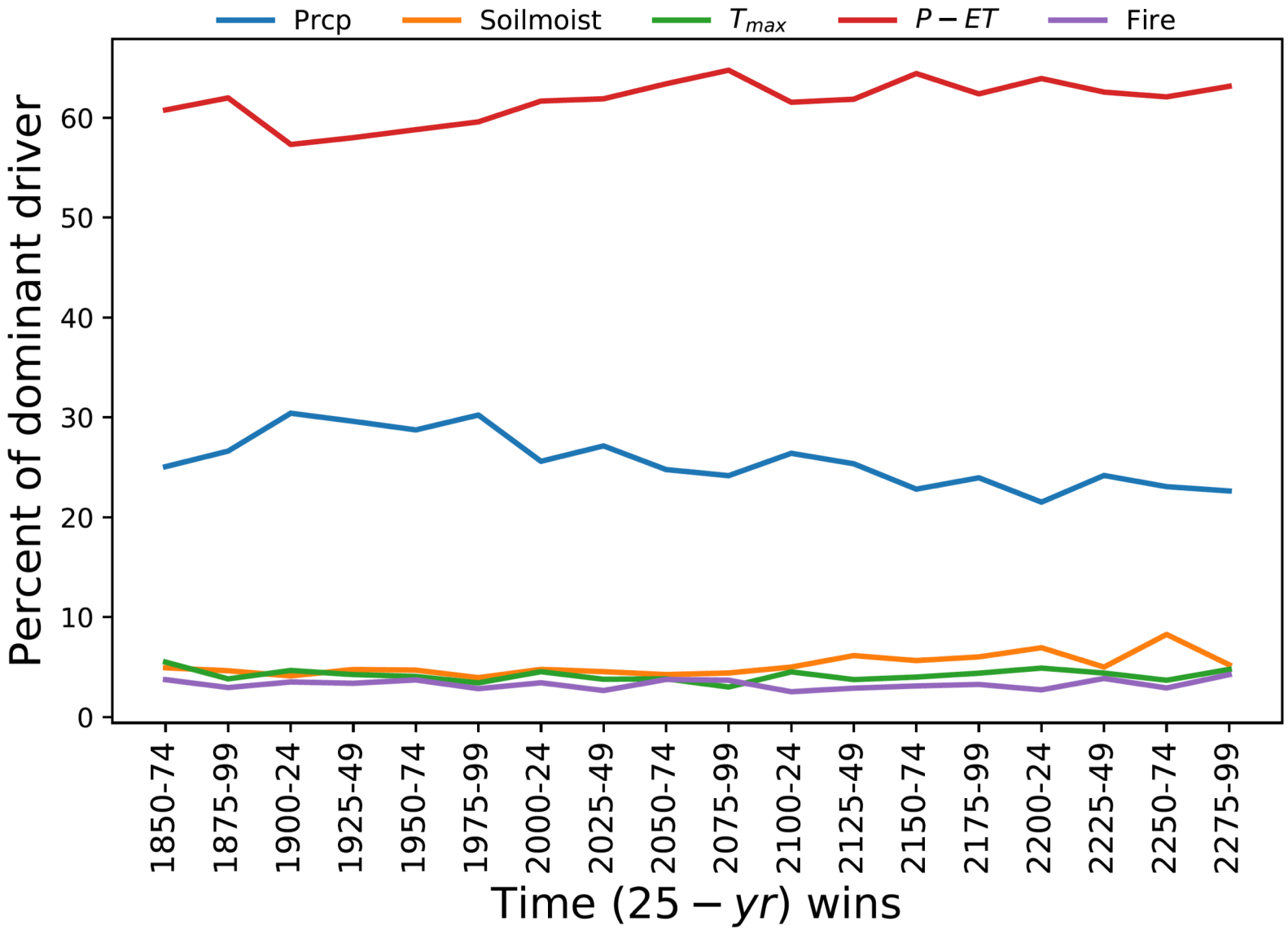








Dominant Climate Drivers



Conclusion and Future Works

The CESM1-BGC (rcp, ecp 8.5) suggests that:

- The rate of increase in the Negative extreme events in the GPP (gC) increase at least 20 % higher than the positive extremes
- STC extremes → detect extreme events close to actuality
- Quantification of STC extremes → depends on the structuring element
- P-ET is the major driver of negative extremes in GPP followed by Precip

- *Perform regional analysis based on the plant functional types*