Quantifying the Effect of Changes in Climate-Driven Carbon Cycle Extremes on the Terrestrial Carbon Budget through Year 2300

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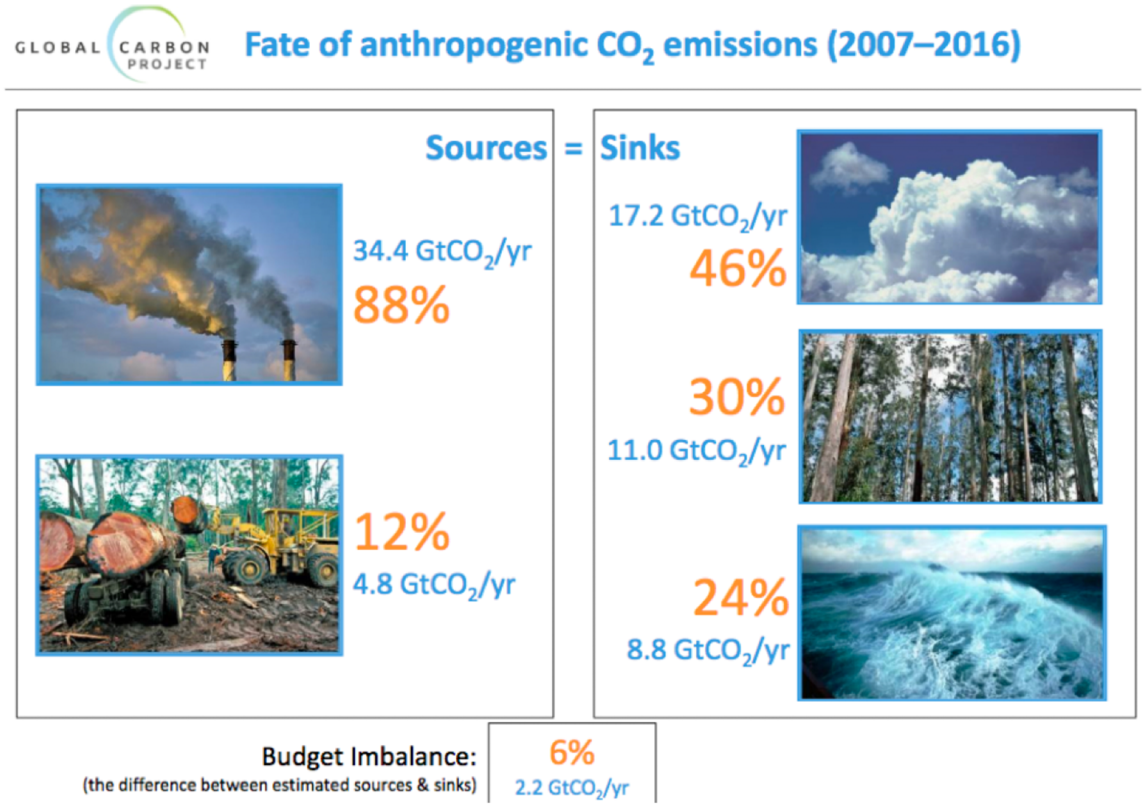
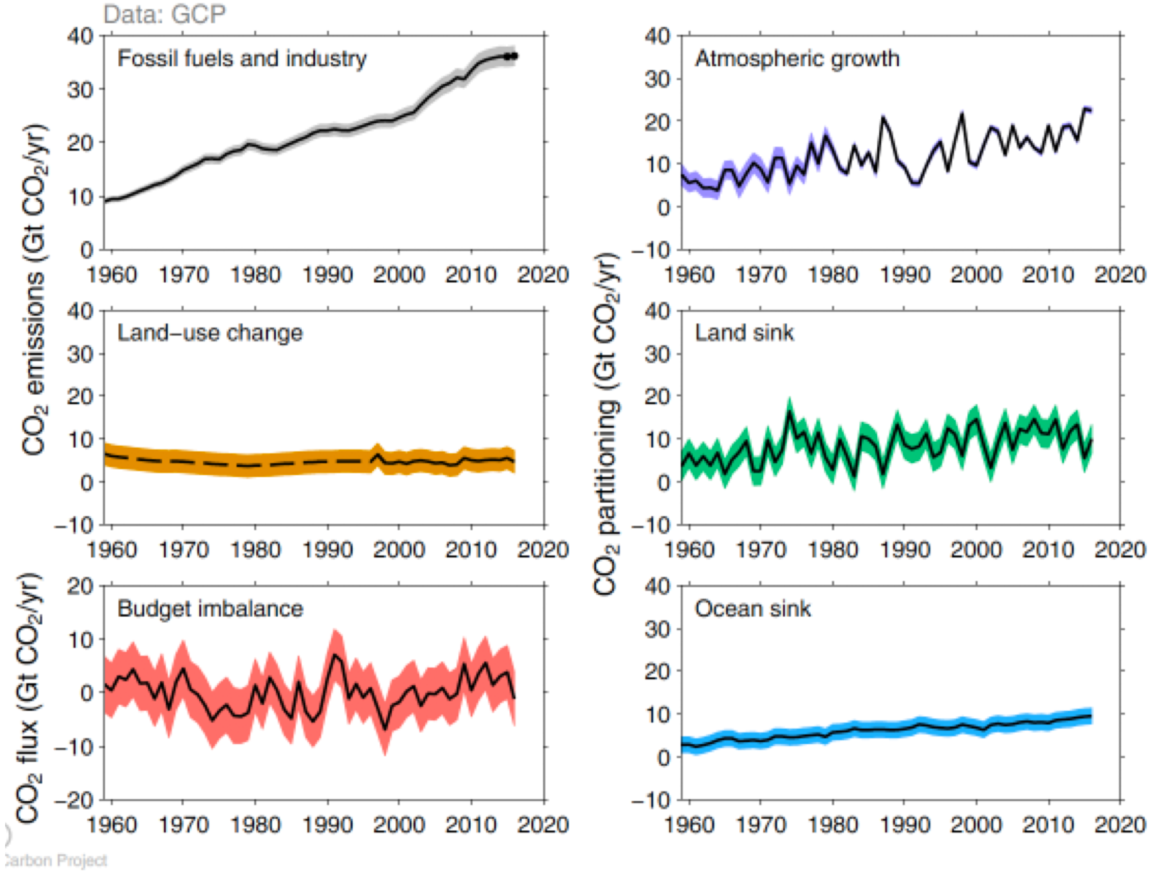
Global Carbon Budget

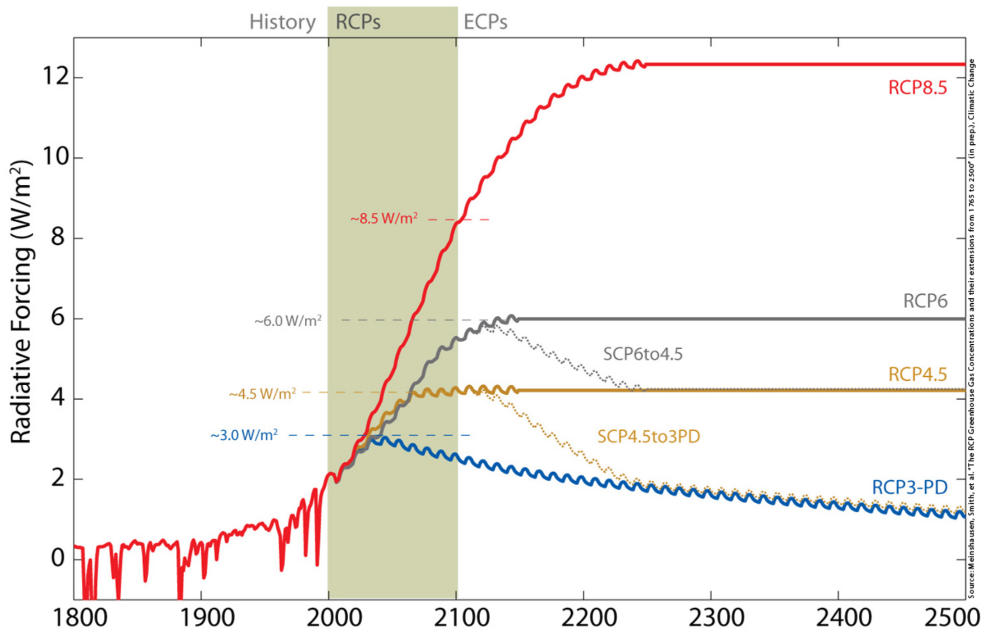


The budget imbalance is the total emissions minus the estimated growth in the atmosphere, land and ocean. It reflects the limits of our understanding of the carbon cycle.



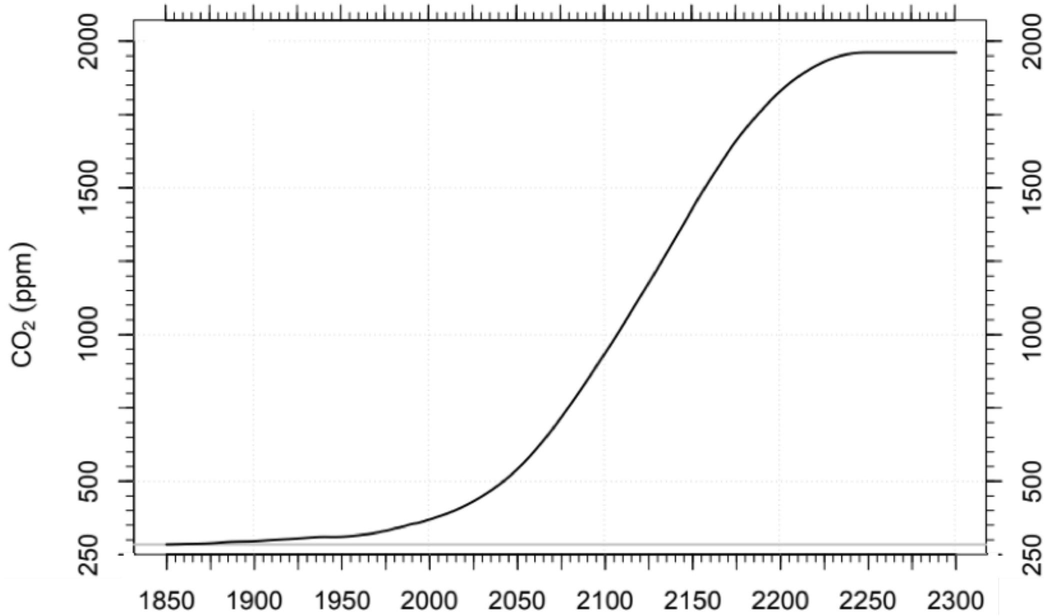
Source : CDIAC, NOAA_ESRL; Global Carbon Budget 2017

Data Source



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

Source: Hoffman 2017 (AGU)

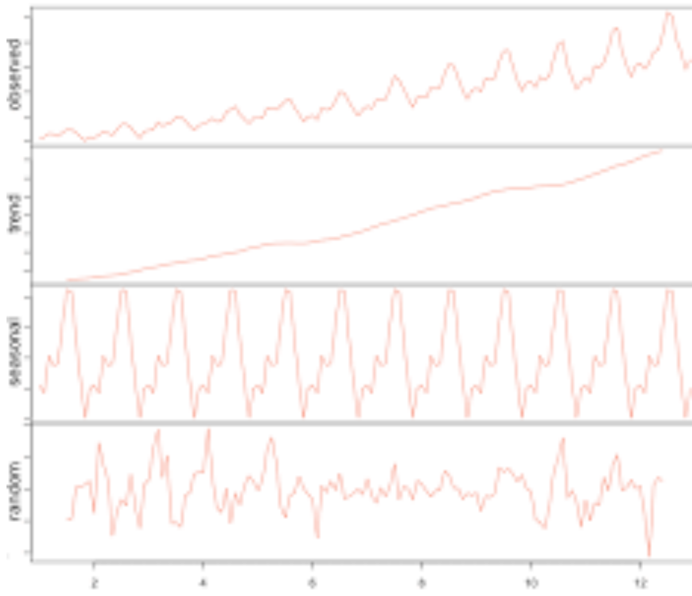


Prescribed atmospheric CO_2 mole fraction was stabilized at 1962 ppm around 2250

Community Earth System Model Biogeochemistry Working Group, CESM1-BGC
Resolution: 0.9375° X 1.25° (lat x lon)
Monthly Mean Data
Constant Land Use: Pre-industrial forcing
Time Period : 1850 - 2300

Definition of Extreme Events

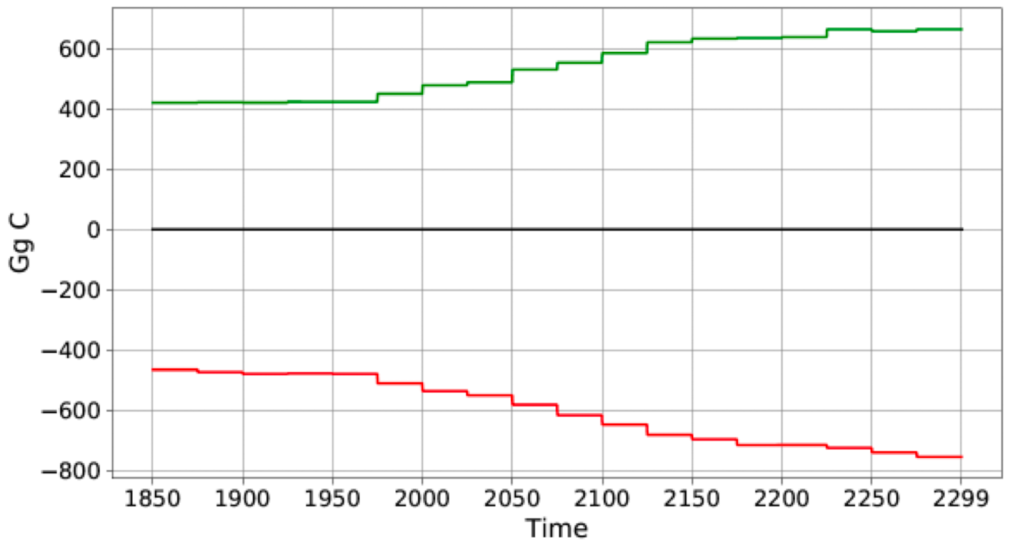
1. Original signal of GPP at every pixel.
2. Calculate annual (seasonality) and decadal+ signals (trend).
3. Anomalies = Original - Trend - Seasonality
4. Select the time period(s) [*25 years*].
5. Thresholds for that time period(s) based on a defined percentile [*1.0*].
6. Global GPP extreme events.



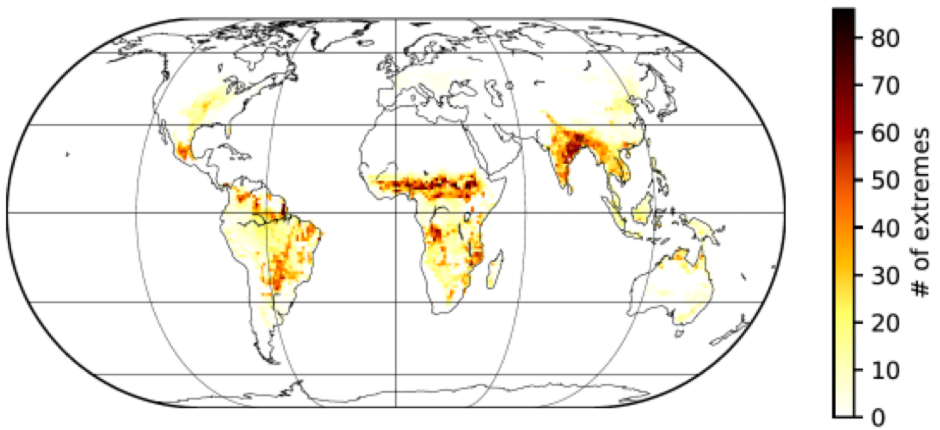
Negative carbon cycle extremes ~ Carbon loss

Positive carbon cycle extremes ~ Carbon gain

Threshold & Spatial Distribution of Extremes

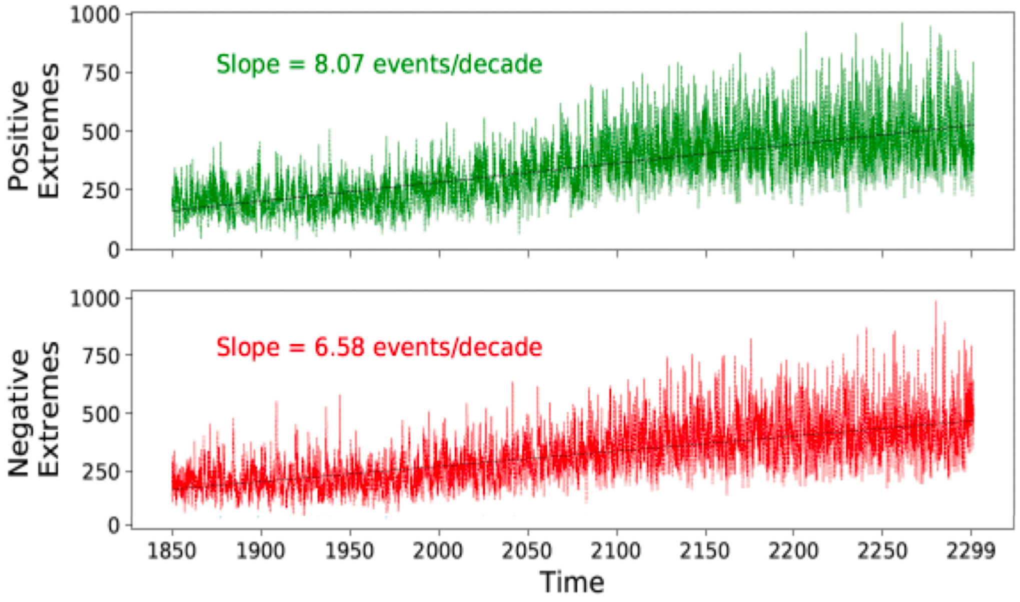


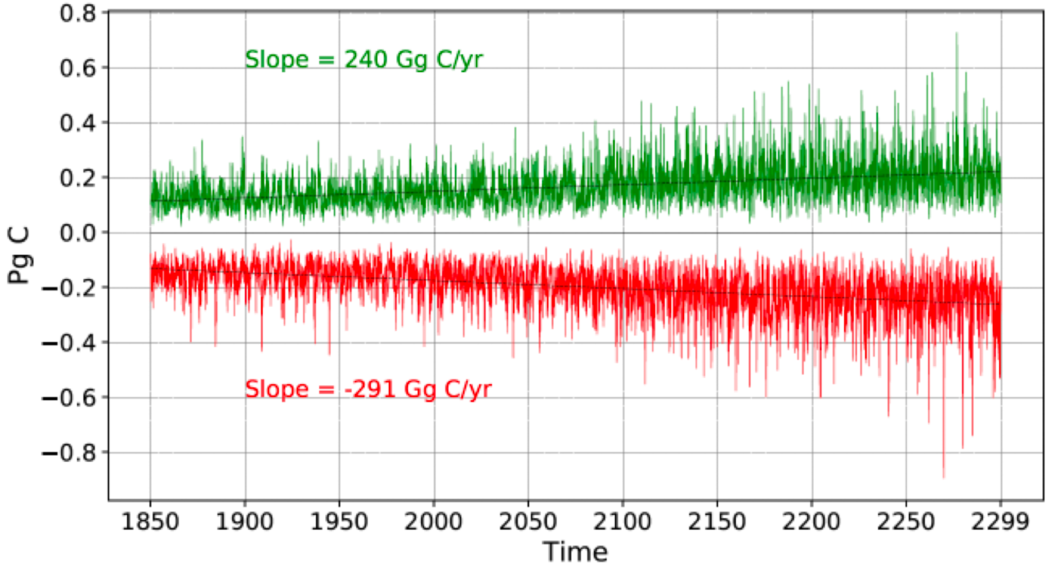
Thresholds when percentile is 1.0 and time period is 25 years



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

Time series of Extreme Events



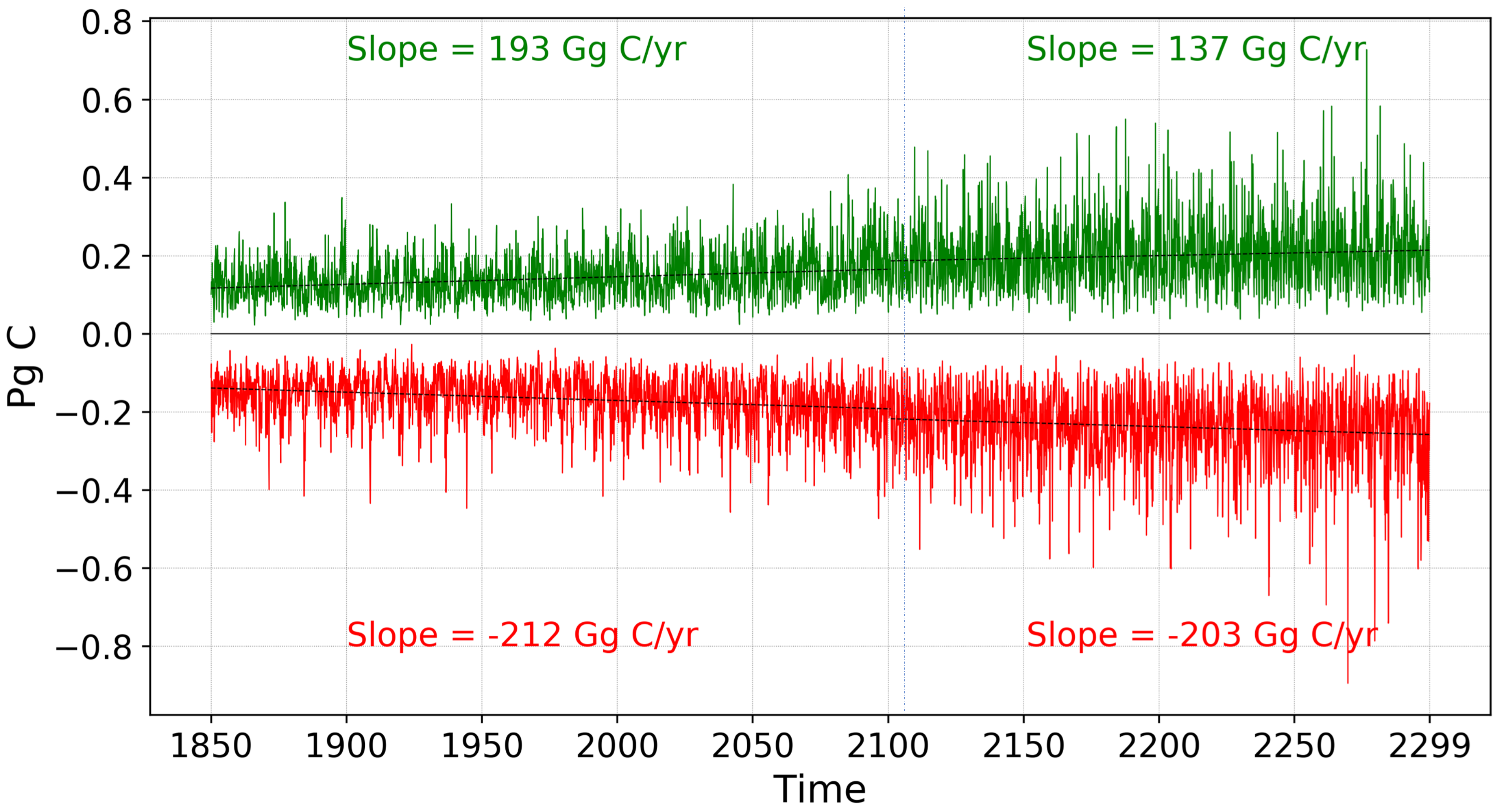


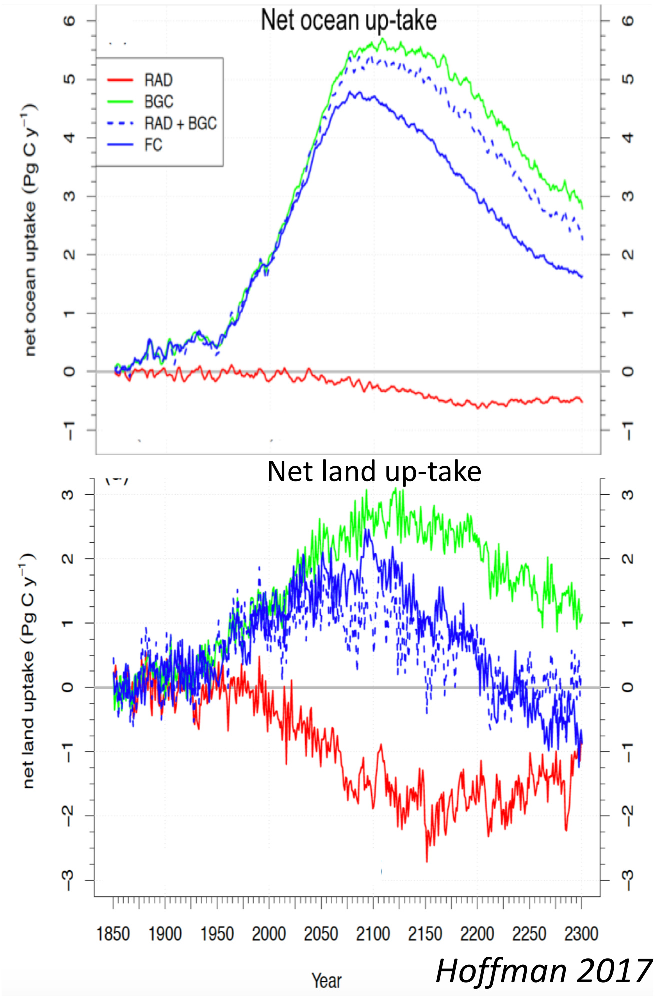
Counts of extremes relative to the threshold of 1850–1999

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

Time series of Extreme Events

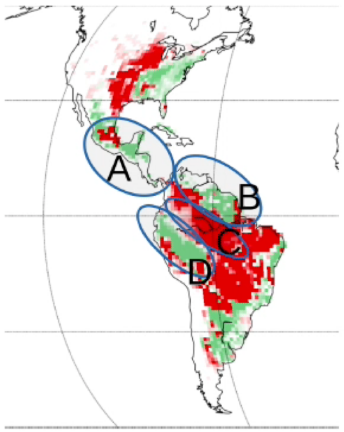
Global GPP Extreme Events (1850-2100, 2101-2300)





Hoffman 2017

Changing Spatial Distribution of Negative Extremes

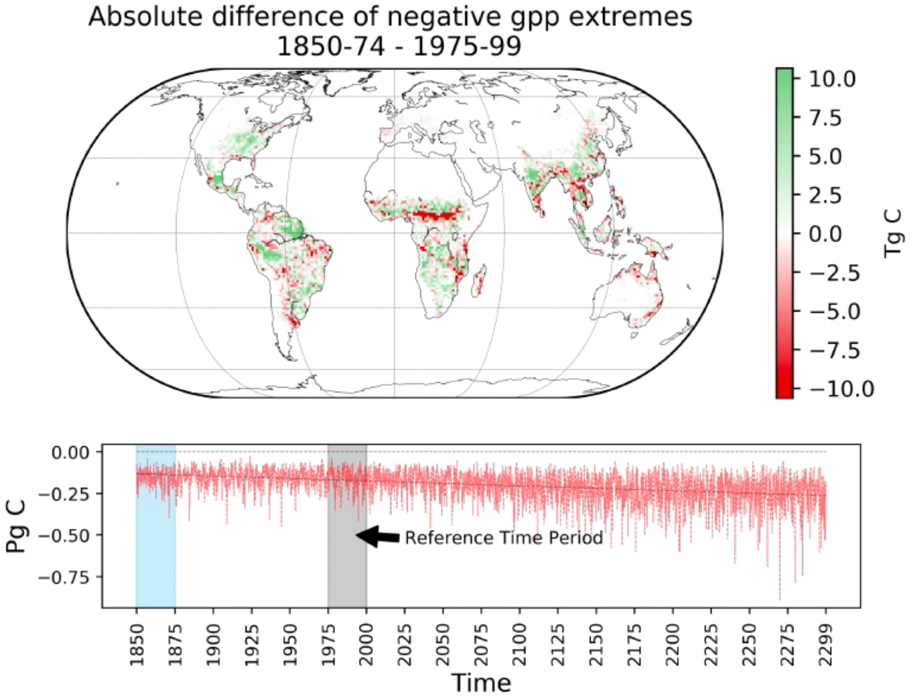


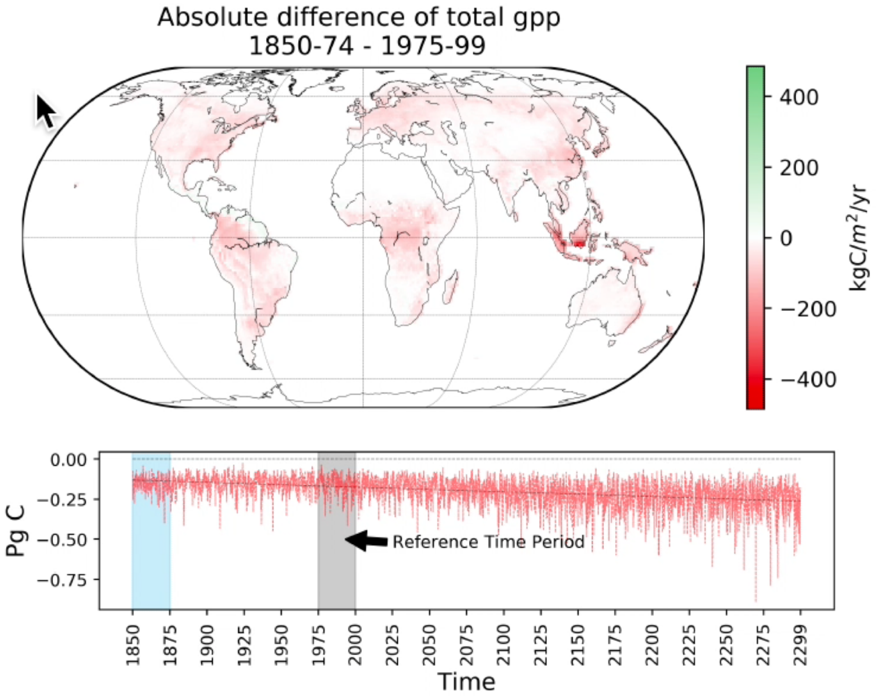
A：Central America

B：North of the South American Tropics

C：Central Amazon Basin

D：Southwest Amazon Basin





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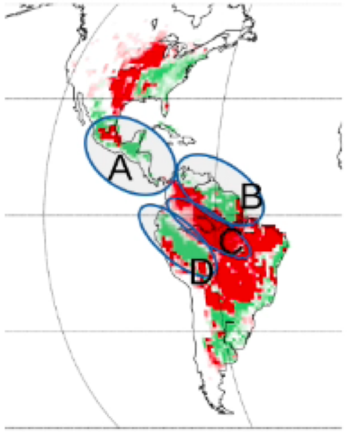

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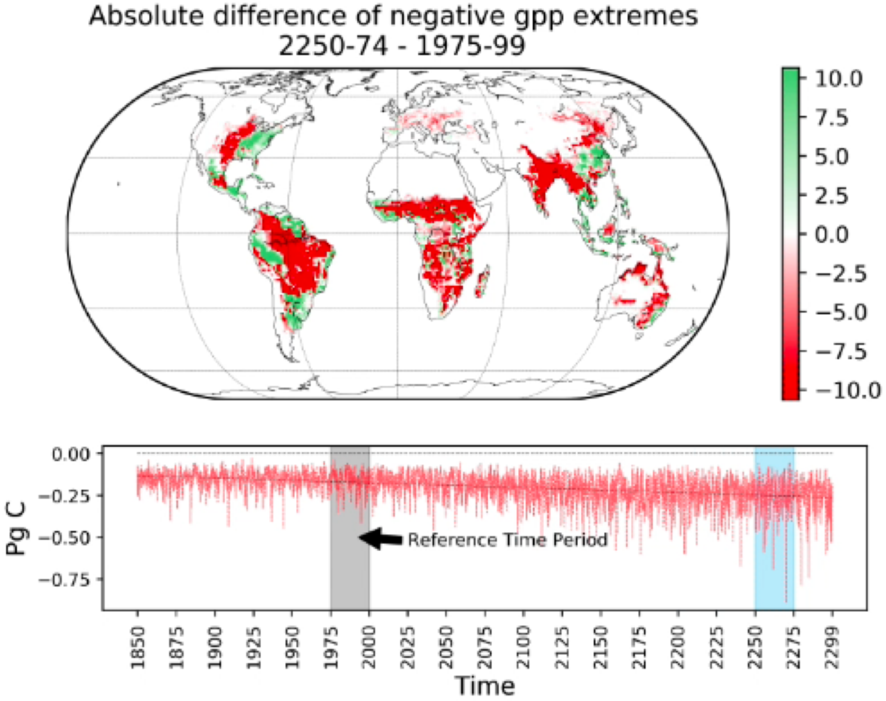
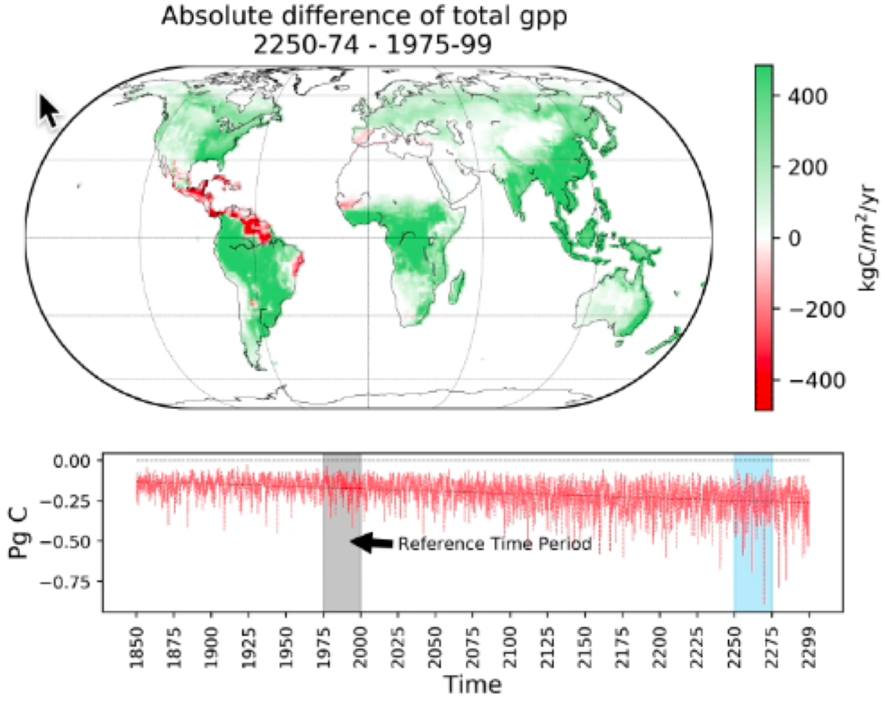




Attribution

The correlation coefficients of GPP anomalies and extremes were computed:

- At every pixel
- For all 18 25-year time-periods from 1850-2299
- For prior lags from 0 to 12 months

With original, detrend and anomalies of following climate drivers:

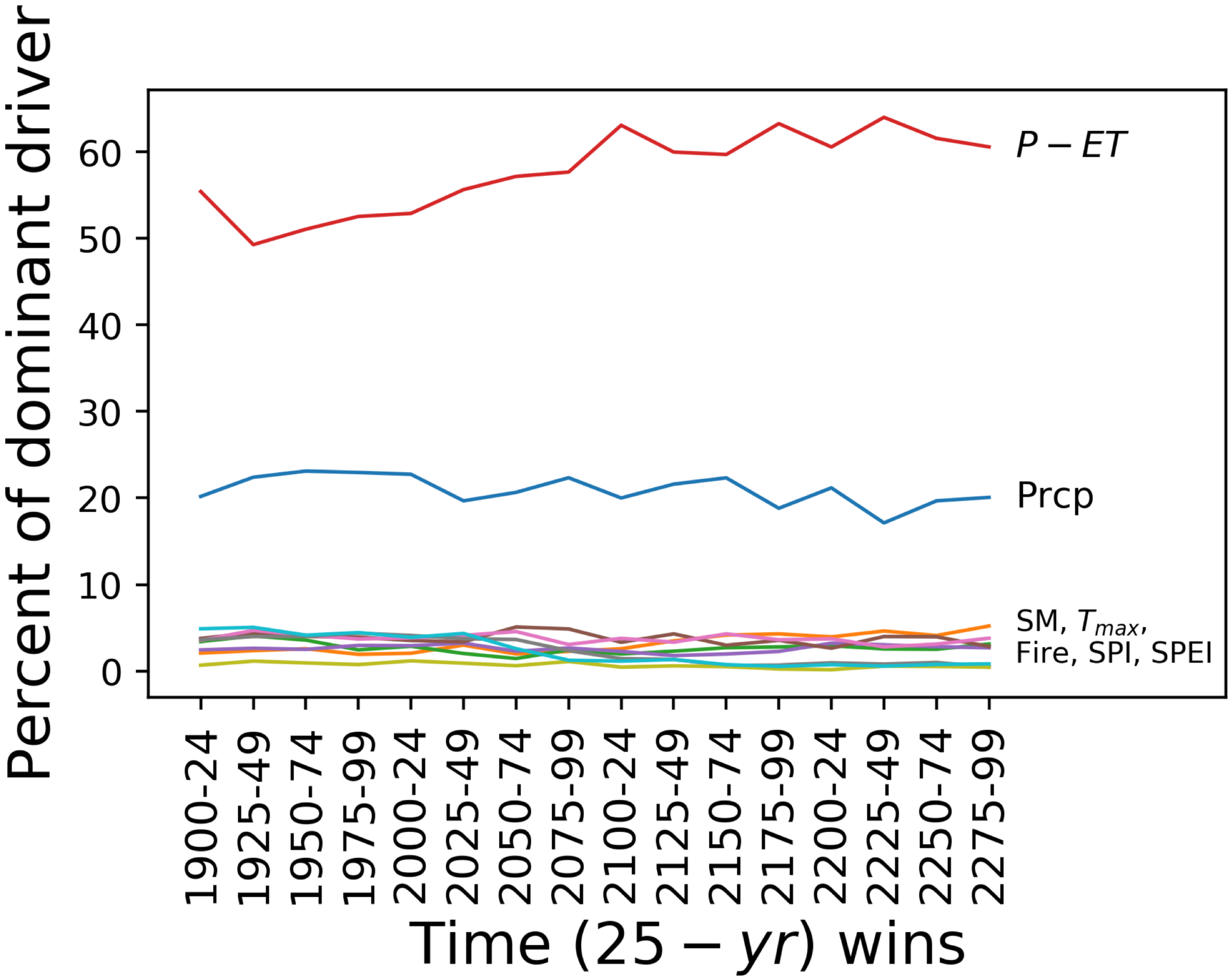
Prcp	Atmospheric rain + snow
Soilmoist	Soil moisture to 1-m depth
T_{av}	Monthly mean daily temperature
T_{max}	Monthly maximum daily temperature
P-ET	Precipitation minus Evapotranspiration
Fire	Total column level carbon loss due to fire
SPI	*Standard Precipitation Index (γ = 6,12)*
SPEI	*Standardized Precipitation-Evapotranspiration Index (γ = 6,12)*

Multi-linear Regression –adj. R-squared

Numbers = prior month lags ; X = excluded

Cases	Prcp	Soilmoist	T_{max}	P-ET	Fire	Rsq_adj
Case 1	0	0	0	0	0	**0.5813**
Case 2	1	1	1	1	1	0.4094
Case 3	2	2	2	2	2	0.3369
Case 4	0	0	0	0	1	0.5531
Case 5	0	0	0	1	0	0.4033
Case 6	0	0	1	0	0	0.5651
Case 7	0	1	0	0	0	0.5768
Case 8	1	0	0	0	0	0.4361
Case 9	0	0	0	0	X	0.5361
Case 10	0	0	0	X	0	0.4022
Case 11	0	0	X	0	0	0.5503
Case 12	0	X	0	0	0	0.5545
Case 13	X	0	0	0	0	0.4209
Case 14	0	X	X	X	X	0.3394
Case 15	X	X	X	0	X	0.3195
Case 16	0	X	X	0	X	0.4672

Dominant Climate Driver



Conclusions and future work

Conclusions:

- Intensity of both negative and positive carbon cycle extreme events is increasing.
- The rate of increase of negative compare to positive extremes is more by 20% (1850-2300), 50% (2100-2300).
- The changing pattern of extremes over time maybe due to vegetation trends (major loss as in Region A&B).
- The regions that are showing increases in extremes may actually experience large increases in productivity (Region C).
- P – ET anomalies is the most dominant climate driver attributed to the negative extremes.

Future Work:

- Analysis using the dynamic land use scenario
- Finer time resolution is needed for attribution analysis
- Look at positive extremes
- Detailed analysis of the regions around Amazon basin

Acknowledgement

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Thank You!

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