Negative extreme events in gross primary productivity and their drivers in China during the past three decades

Weizhe Chen[a,b,*], Dan Zhu[b], Chunju Huang[a,c], Philippe Ciais[b], Yitong Yao[d], et al

[a] State Key Laboratory of Biogeology and Environmental Geology, School of Earth Sciences, China University of Geosciences, Wuhan 430074, China; * Email: wzchen@cug.edu.cn
[b] Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, Gif-sur-Yvette 91191, France
[c] Laboratory of Critical Zone Evolution, School of Earth Sciences, China University of Geosciences, Wuhan 430074, China
[d] Sino-French Institute for Earth System Science, College of Urban and Environmental Sciences, Peking University, Beijing 100871, China

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1. Introduction

Extreme events are generally defined as statistically unusual episodes or occurrences, which are beyond the bounds of typical or normal variability. Extreme events have been defined both from climatic and impact perspectives. Lloyd-Hughes (2012) firstly proposed a novel 3-dimensional (longitude, latitude, time) structure-based approach to describe drought events. Zscheischler et al. (2013) further improved the method and performed the first global analysis of spatio-temporally contiguous carbon-cycle extremes. This method has advantages in analyzing the size, shape, temporal evolution and other interesting quantities of extreme events.

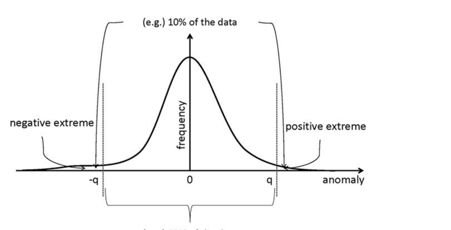
In this study, we carried out an analysis of negative extreme events in gross primary productivity (GPP) in China and the sub-regions during 1982-2015, using monthly GPP simulated by 12 process-based models (TRENDYv6) and an observation-based model (Yao-GPP).

2. Materials and methods

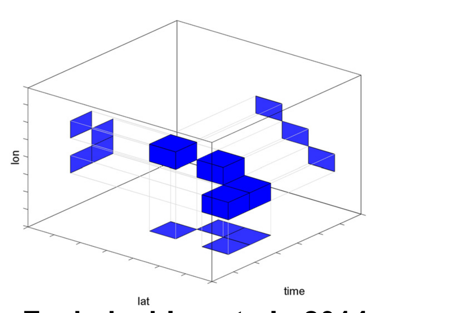
Summary of monthly GPP estimates, climate and fire data used in this study. Some of the datasets extend beyond 1982–2015, but the analysis in this paper is confined to those years.

Data source	monthly variable	Resolution	Period	Citation
Yao-GPP	GPP	0.1°	1982-2015	Yao et al., 2018, GCB
TRENDYv6	GPP and soil moisture	0.5°-1°	1982-2015	Le Quéré et al., 2018, ESSD
ITPCAS	Ta and P	0.1°	1982-2015	Chen et al., 2011, JGR
CRU	Ta and P	0.5°	1982-2015	Harris et al., 2014, IJOC
CRU	scPDSI	0.5°	1982-2015	van der Schrier et al., 2013, JGR
GFEDv4	Burned area and fire emissions	0.25°	1997-2015	Randerson et al., 2017

* Abbreviations: Air temperature (Ta); Precipitation (P); self-calibrating Palmer Drought Severity Index (scPDSI)



Zscheischler, et al., 2014



Zscheischler, et al., 2014

In order to quantify the GPP extreme events, we defined extremes as the negative 5th percentile of all the GPP anomalies.

Contiguous extreme negative GPP anomalies (i.e. voxels) are further merged into individual extreme events following Zscheischler et al. (2014). By "contiguous", we mean any of the 26 neighbors in three-dimensional (latitude × longitude × time) space also experiencing an extreme GPP anomaly.

3. Results and Discussion

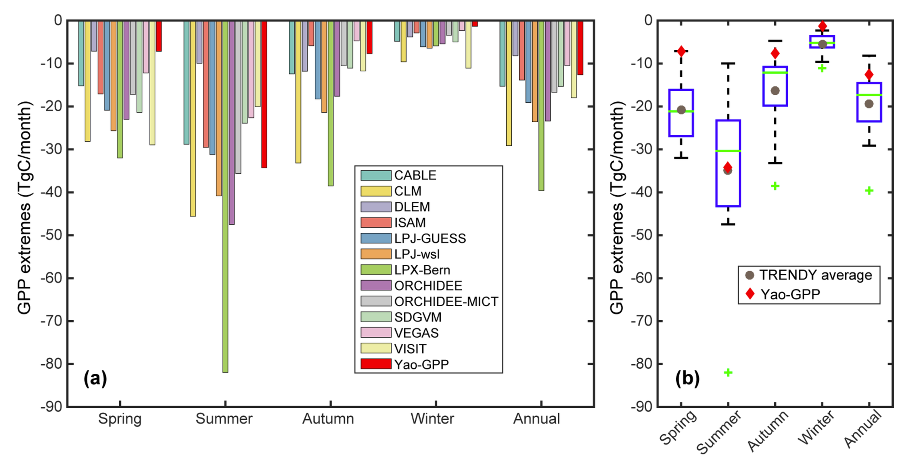


Fig. (a) Bar graph and (b) boxplot of GPP extremes in four seasons and annual mean. The legend in panel (a) distinguishes the 13 GPP datasets. The lower and upper edges of the box indicate 25th and 75th percentile of the GPP anomalies over the 12 process-based models. The green line and cross are median and outliers, respectively.

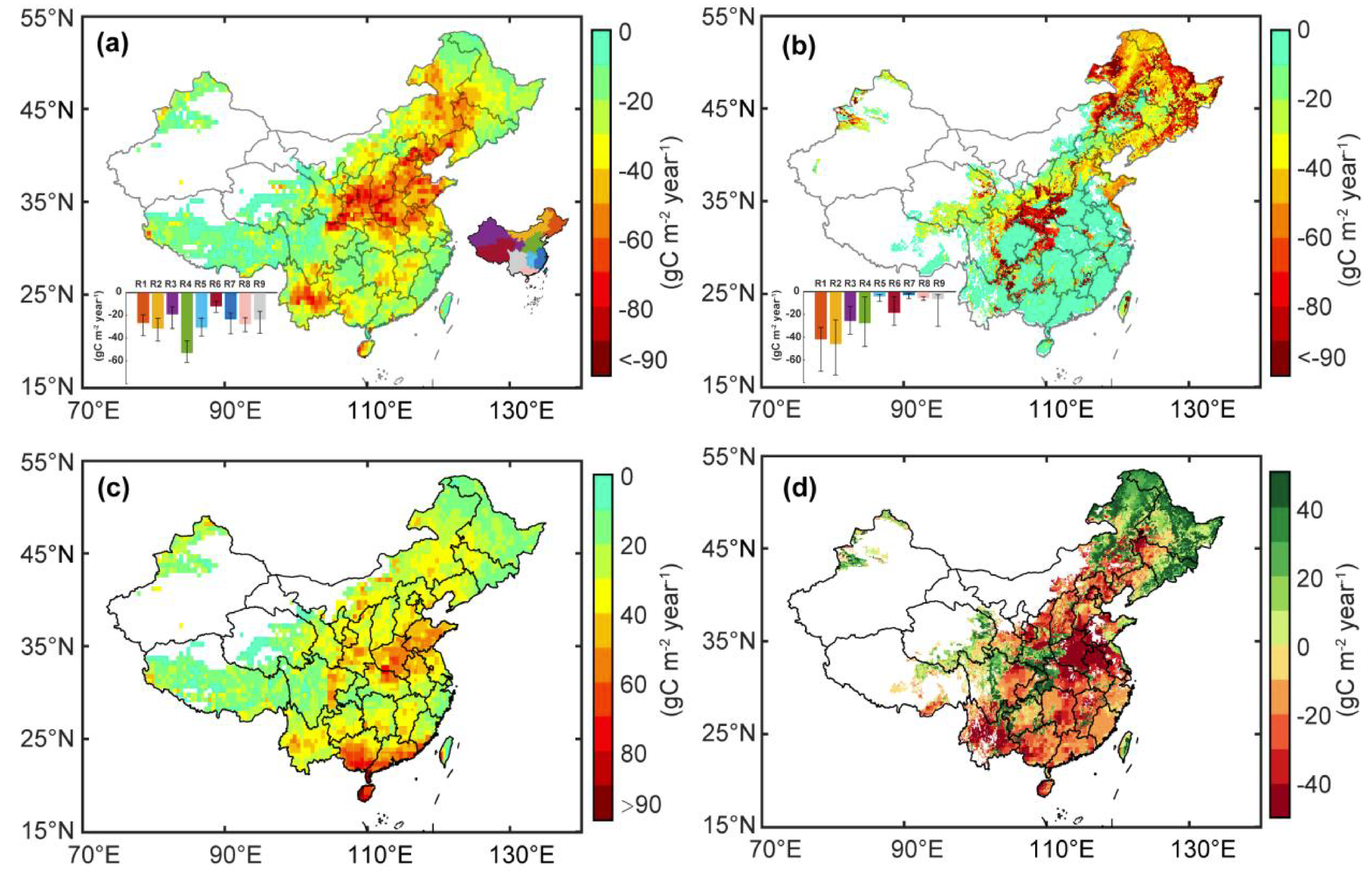


Fig. Spatial distributions of the magnitude of the 1000 largest negative extreme events in GPP (GPP1000) from (a) the median of the 12 process-based TRENDY models and (b) the observation-based GPP model Yao-GPP, (c) standard deviation over TRENDY models and (d) the TRENDY median minus Yao-GPP. The left insets in panel (a) and (b) denote the median, 25th and 75th percentile of GPP anomalies for each sub-region. The right inset in panel (a) presents the definition of the nine sub-regions in China.

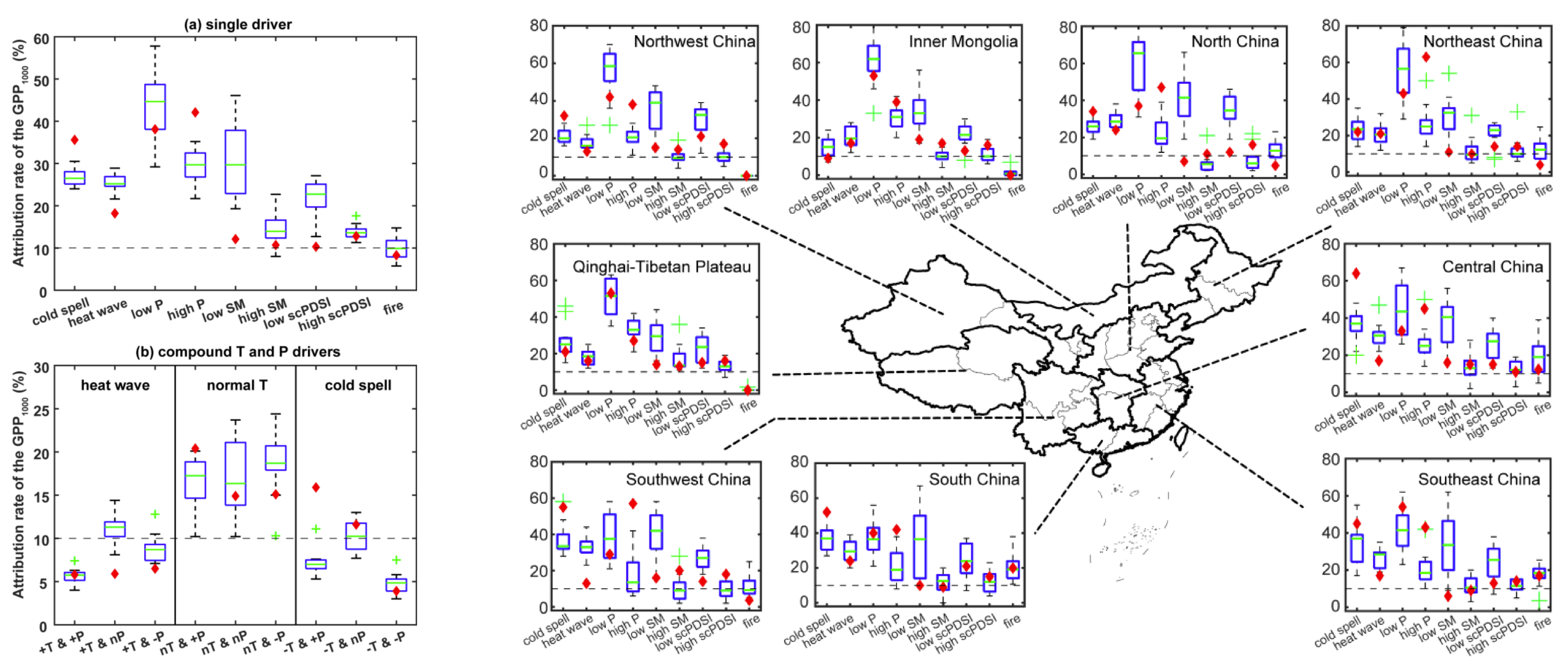


Fig. Attribution rate (%) of the GPP1000 for (a) single or (b) compound drivers (left figure). Attributions rate of GPP100 to climate drivers and fire in the nine sub-regions of China (right figure). Boxplots result from the TRENDY models and red diamonds are for Yao-GPP. The nT and nP in panel (b) represent normal T and normal P, respectively.

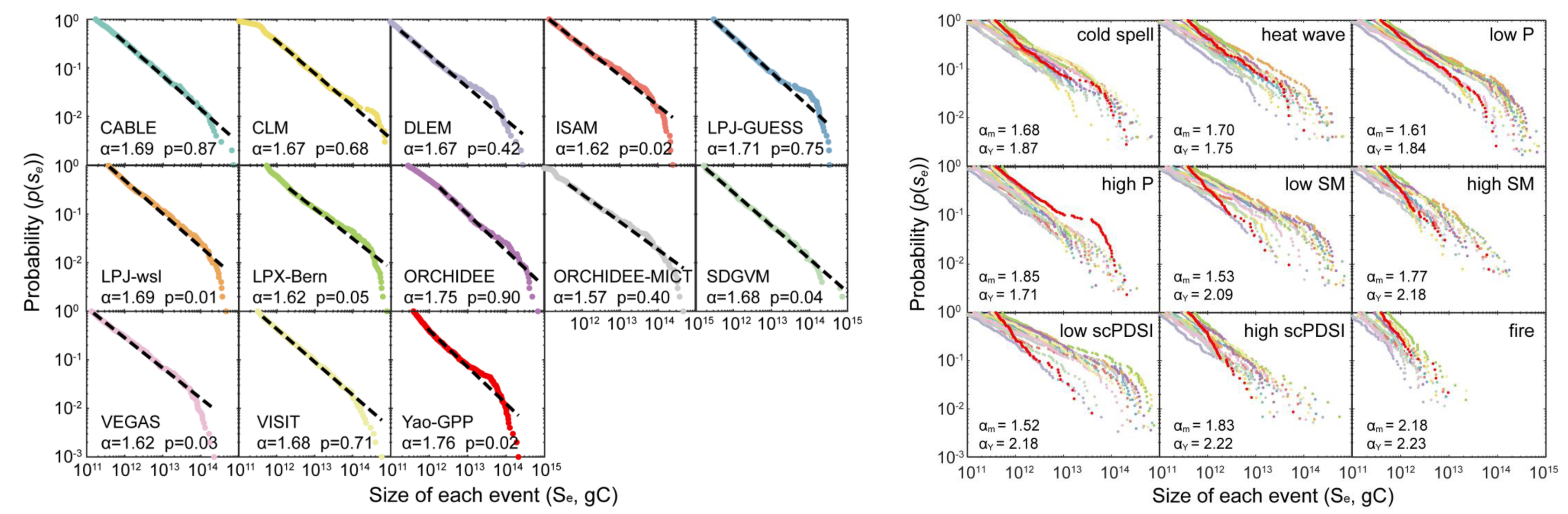


Fig. Fitted power law distributions to sizes of negative GPP anomalies for each GPP datasets (left figure) and for each driver (right figure).

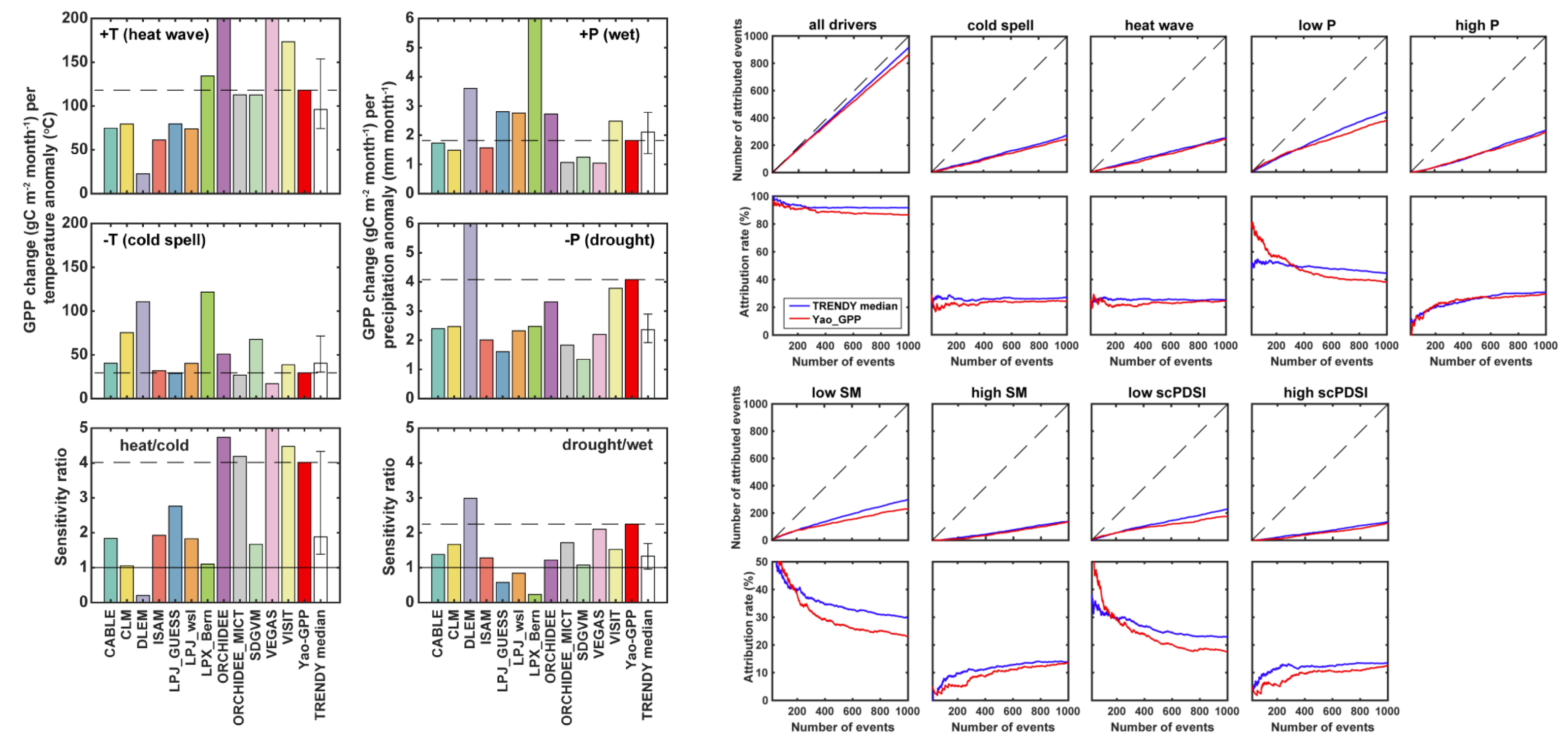


Fig. Sensitivities of GPP anomalies to single driver of heat wave, cold spell, wet and drought during extreme events among the 13 models. The white bar in each panel shows TRENDY median, 25th and 75th percentile (left right). Number of Attributed events and ttribution rate for different number of studied largest GPP events and for each drive (right).

4. Conclusion

Our study presents the first attempt to analyze spatio-temporally contiguous GPP extreme events at the national scale and sub-regions in China.

1. Over the past three decades, 45% and 68% of GPP deficits in China occurred in summer in TRENDY models and Yao-GPP, respectively.

2. GPP extreme events decrease annual GPP by 2.8% in TRENDY and 2.3% in Yao-GPP.

3. Hotspots of GPP extreme events are diagnosed in North China and Northeast China.

4. GPP is more sensitive to heat/drought than to cold/wet during extreme events.

5. The impacts of cold spells on GPP are notable in southern China.

5. References and Acknowledgements

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