Baoying Shan[1,2], Bernard De Baets[1], Niko E.C. Verhoest[2]

[1] KERMIT, DEPARTMENT OF DATA ANALYSIS AND MATHEMATICAL MODELLING; [2] HYDRO-CLIMATIC EXTREMES LAB; GHENT UNIVERSITY, 9000 GHENT, BELGIUM.

Four Climate Extremes and Their Relevance to Ecological Effects: A Case Study of England Butterflies

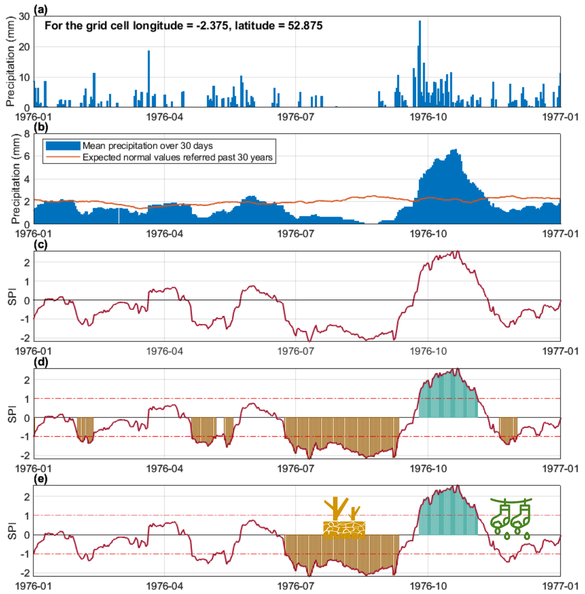
➢ 1. Motivation

Changes in the magnitude and frequency of extreme climate events (ECEs) can substantially impact ecosystems more than changes in long-term climate means. However, **most studies** concerning the effects of ECEs on the ecosystem **focus on a single type of extreme event in a specific season**.

❖ We incorporate four types of climate extreme events: drought, wet, heatwave and cold wave
❖ Work on the daily basis
❖ Across four seasons

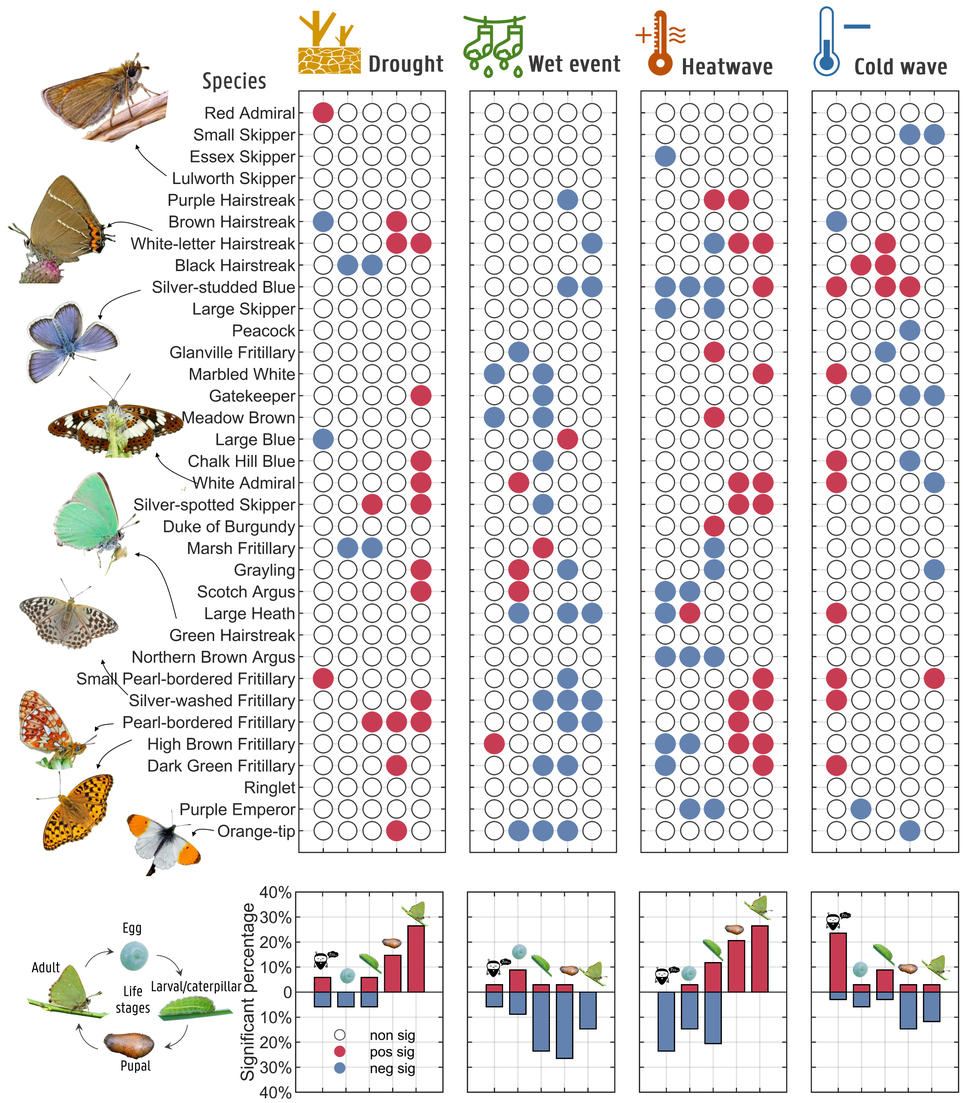
➢ 2. Why butterflies, why England

1. First, butterflies have egg, larval, pupal, and adult life stages and an overwintering period throughout the year.
2. Second, butterflies are one of the most well-studied groups of insects and have been used as a valuable environmental indicator group due to their ectothermic nature and short life cycles.
3. Most important, the 45-year observation dataset from the UK Butterfly Monitoring Scheme (UKBMS) makes it possible to include more less frequent but high-impact ECEs and further examine them.
4. Finally, England has a lot of observational data.



➢ 3. Methods

- Daily SPI and SHI are calculated, where zero problems, non-stationarity problem, and curve fitting problems are solved
- Statistical procedures for removing minor spells and merging dependent spells are applied
- Four climate extremes are identified in a consistent way
- The most extreme climate events are identified based on a Pareto front



❖ There are associations between climate extreme severity during a life stage and butterfly abundance changes at the spatial scale of England as a whole

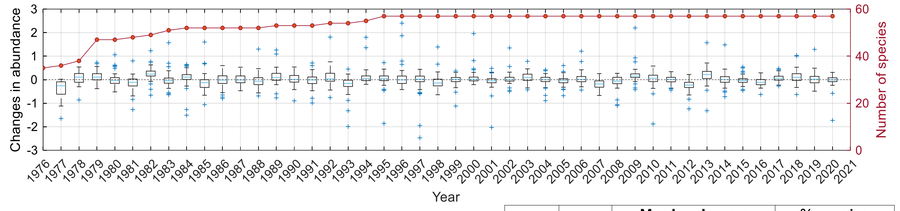
➢ 4. Results: correlation

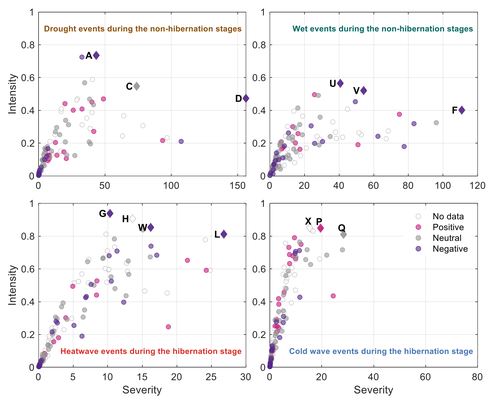
- Kendall's correlation is used to examine the relationships between the severity of a climate extreme during a life stage and the abundance changes
- Species exhibit individualistic differences in their sensitivity to ECEs
- Wet events have a detrimental effect during the larval, pupal, and adult stages
- Droughts appear beneficial during the pupal and adult stages, positively correlating with abundance changes in 26.5% and 20.6% of species
- Heatwaves and cold waves during the hibernation stage have opposite effects
- Heatwaves negatively affect 23.5% of species, while cold waves during this stage positively impact 23.5% of species

❖ Large, synchronized population swings of butterflies are well associated with the most extreme events

➢ 5. Results: responses to the most extreme events

- First, we identify the most extreme drought and wet events during the **non-hibernation stages** (Mar. 1st to Oct. 31st) and the most extreme heatwave and cold wave events during the hibernation stages. The reason to pick these stages is that the hibernation stage is most sensitive to temperature-related extremes, while it is not sensitive to precipitation-related extremes.
- Results show more than two third of the species have negative changes in abundance in **seven out of the eight** years that have the most extreme droughts, heatwaves, and wet events.
- One of the two years having the most extreme cold wave events during the hibernation stage relates to positive synchronized population changes (89.6% of species showing an increase).
- Drought events may imply ***both positive and negative*** impacts for butterflies with the same climate in the same area, which may be attributed to varying levels of drought severity.





	Label	Most extreme events	% species decrease
	A	1993/02/09-1993/04/08	***81.5%***
	C	1996/12/24-1997/05/07	43.9%
	D	1975/10/25-1976/09/19	***97.1%***
	U	1976/09/10-1976/11/20	***97.1%***
	V	2007/05/13-2007/08/24	***84.2%***
	F	2012/04/19-2013/01/19	***89.5%***
	G	1980/11/15-1980/11/25	***68.1%***
	H	1950/01/03-1950/01/17	No observation
	W	2000/11/26-2000/12/14	***66.7%***
	L	2015/11/30-2016/01/01	***71.2%***
	X	1954/01/25-1954/02/11	No observation
	P	1981/12/7-1981/12/29	***10.4%***
	Q	2010/11/24-2010/12/28	49.1%
	T	1962/12/22-1963/3/5	No observation

➢ 6. Take home messages

In the study of climate extremes and ecological influences:

1. All seasons matter
2. All extremes matter
3. Extreme events are not always negative
4. "Most extreme" drought events may have the opposite impact of "moderate extreme" ones
5. ALL analyses in this study are data-driven, containing little ecophysiological interpretation.

Baoying.Shan@ugent.be
OSPP