

# Historical Assessment of Compound Summer Drought and Heatwave events in Southeast Brazil

João L Geirinhas | Ana Russo | Renata Libonati | Pedro M Sousa | Diego G Miralles | Ricardo M Trigo



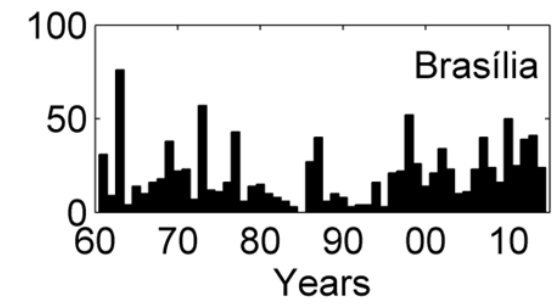
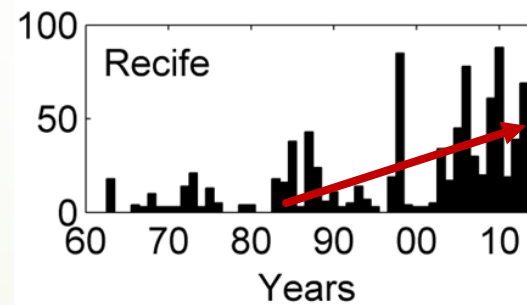
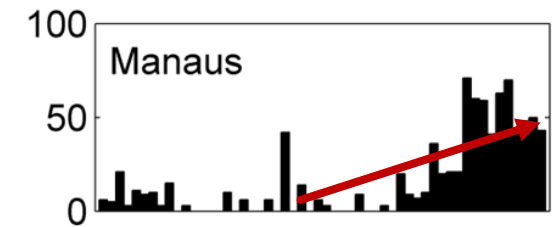
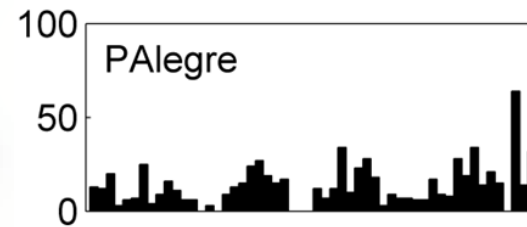
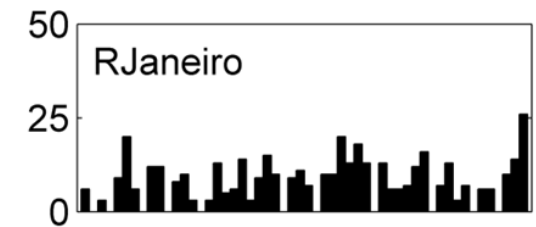
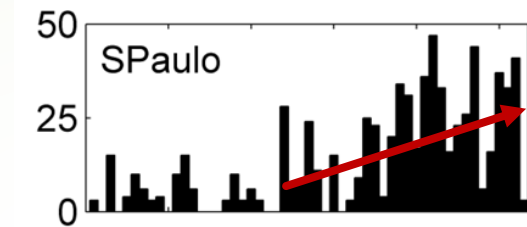
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# Why Southeast Brazil?



1. Increasing frequency of Heatwaves in Brazil:

Geirinhas et al. 2018



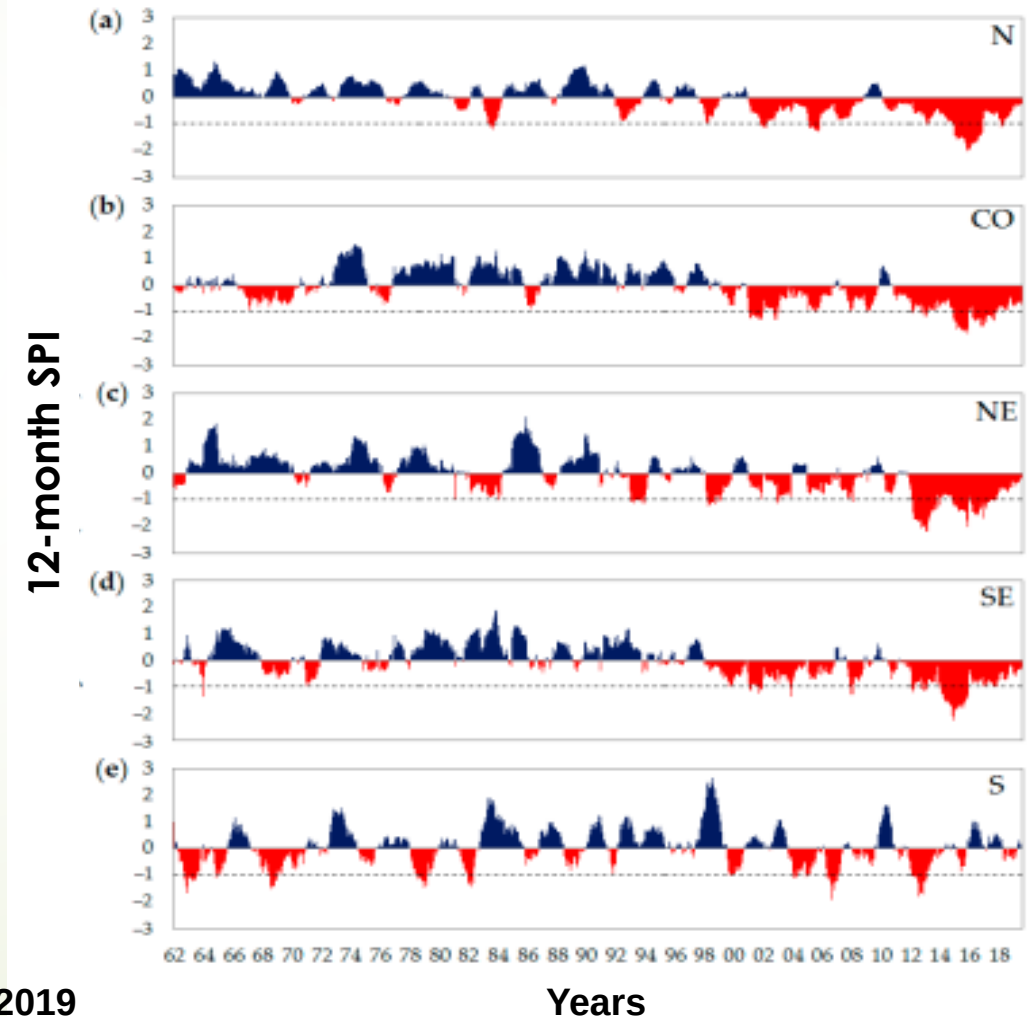
# Why Southeast Brazil?



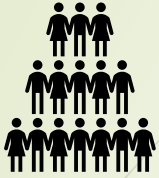
2. Increasing frequency of Drought Periods in Brazil:



Monthly time series of 12-month SPI:

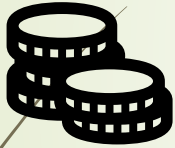


# Why Southeast Brazil?



## 3. A heavy populated region:

- In 2018, the living estimated population was of more than 87 million individuals (42% of the total Brazilian population).
- The region encompasses the Metropolitan Areas of Belo Horizonte, Rio de Janeiro and São Paulo (the fourth most populated mega-city in the world).



## 4. The economic relevance:

- Southeast Brazil accounts for 60% of whole Brazilian gross domestic product.



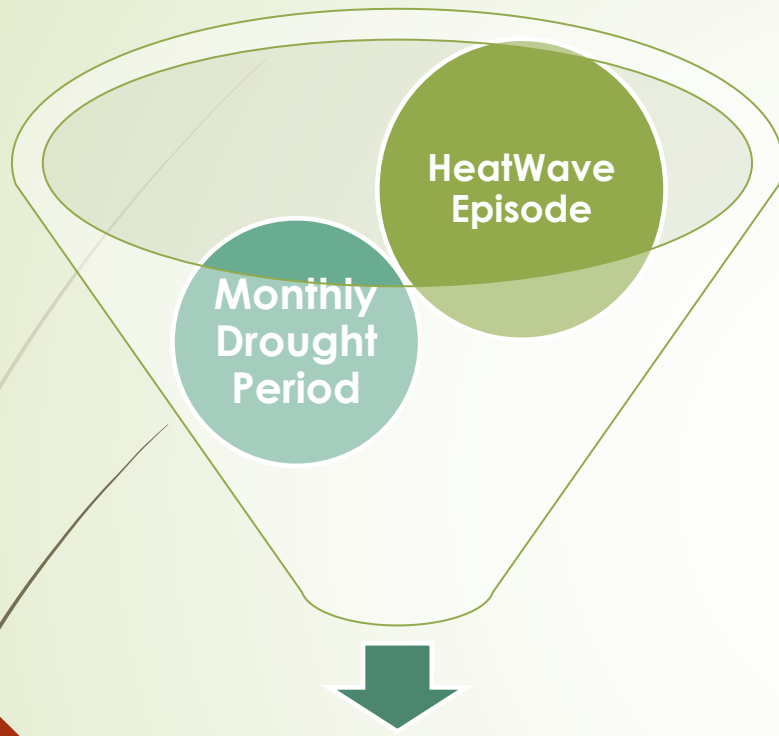
## 5. A shortage of scientific investment on this problematic:

- Despite some exceptions, the analysis of concurrent heatwaves and droughts and their impacts is still a challenge for this region.

# The objectives:

1. Assess for the first time the historical evolution of compound summer (DJF) drought and heatwave events for Southeast Brazil and for the period of 1980–2018.
2. Undertake a detailed analysis of the surface and synoptic conditions, as well as of the land–atmosphere coupling processes that led to the occurrence of individual and compound dry and hot extremes.

# Compound Summer Drought and Heatwave (CDH) Event – Definition:



**CDH**



**Heatwave** that occurs during a month under **drought** conditions (i.e. a month with an associated 3 month SPI value  $<-1$ )

- **Droughts** were defined at a monthly scale and considering 3 month Standardized Precipitation Index (SPI) values  $<-1$

- **Heatwaves** were identified as periods of consecutive days with daily Tmax values above a certain percentile of Tmax for the particular calendar day (calculated on a 15 day window)

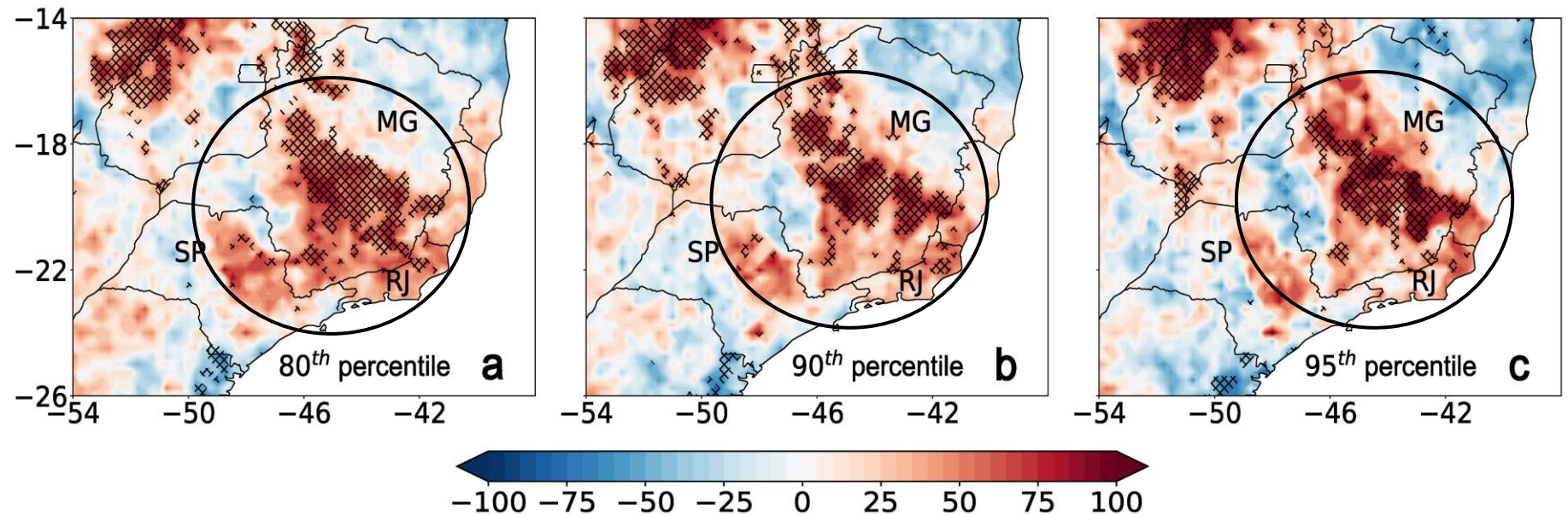
# CDH events – Historical Characterization:

**Period of analysis:** Summer seasons (DJF) between 1980-2018.

- **1<sup>st</sup> sub-period:** 1980/81 – 1998/1999 summer seasons;
- **2<sup>nd</sup> sub-period:** 1999/00 – 2017/2018 summer seasons;

**Data:** ERA5 reanalysis  
(0,25°x0,25°)

$$\text{Percent change (\%)} = \frac{N^{\circ} \text{ of compound events (2nd sub-period)} - N^{\circ} \text{ of compound events (1st sub-period)}}{N^{\circ} \text{ of concurrent events (total analysis period)}} \times 100$$



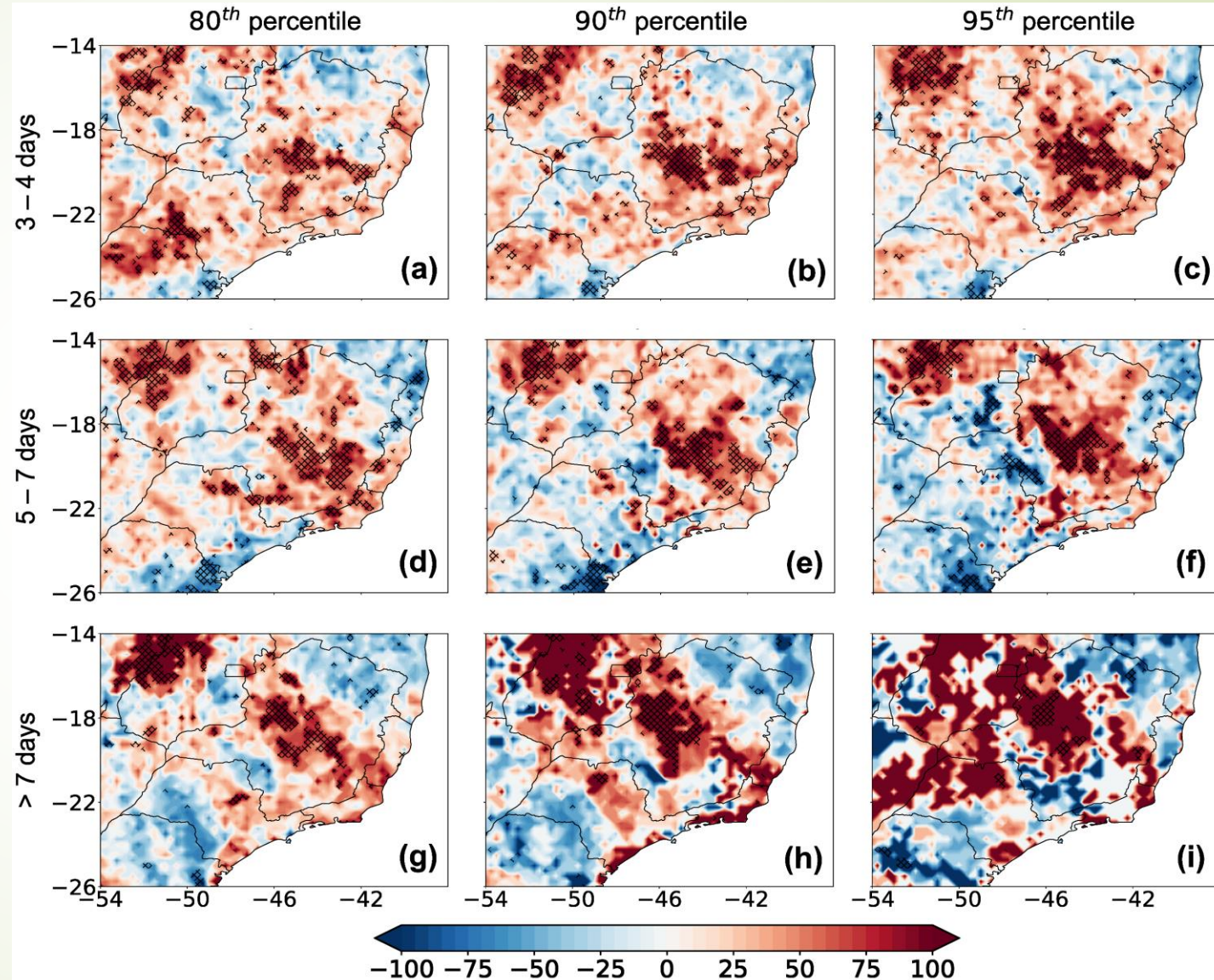
The occurrence of CDH events increased substantially (values between 50% and 100%) in some regions of Southeast Brazil (SEB) from 1980 to 2018.

# CDH events– Historical Characterization:

Considering different heatwave durations (rows) and severities (columns)



The concurrence increase proved to be more intense as we considered more extreme and longer-lasting heatwave classes



# CDH events– Historical Characterization:

The percentage of total summer pixels under a compound regime was also analyzed:

The idea was to compute the percentage of total number of pixels (*pixels<sub>total</sub>*) for each summer season that were in CDH conditions

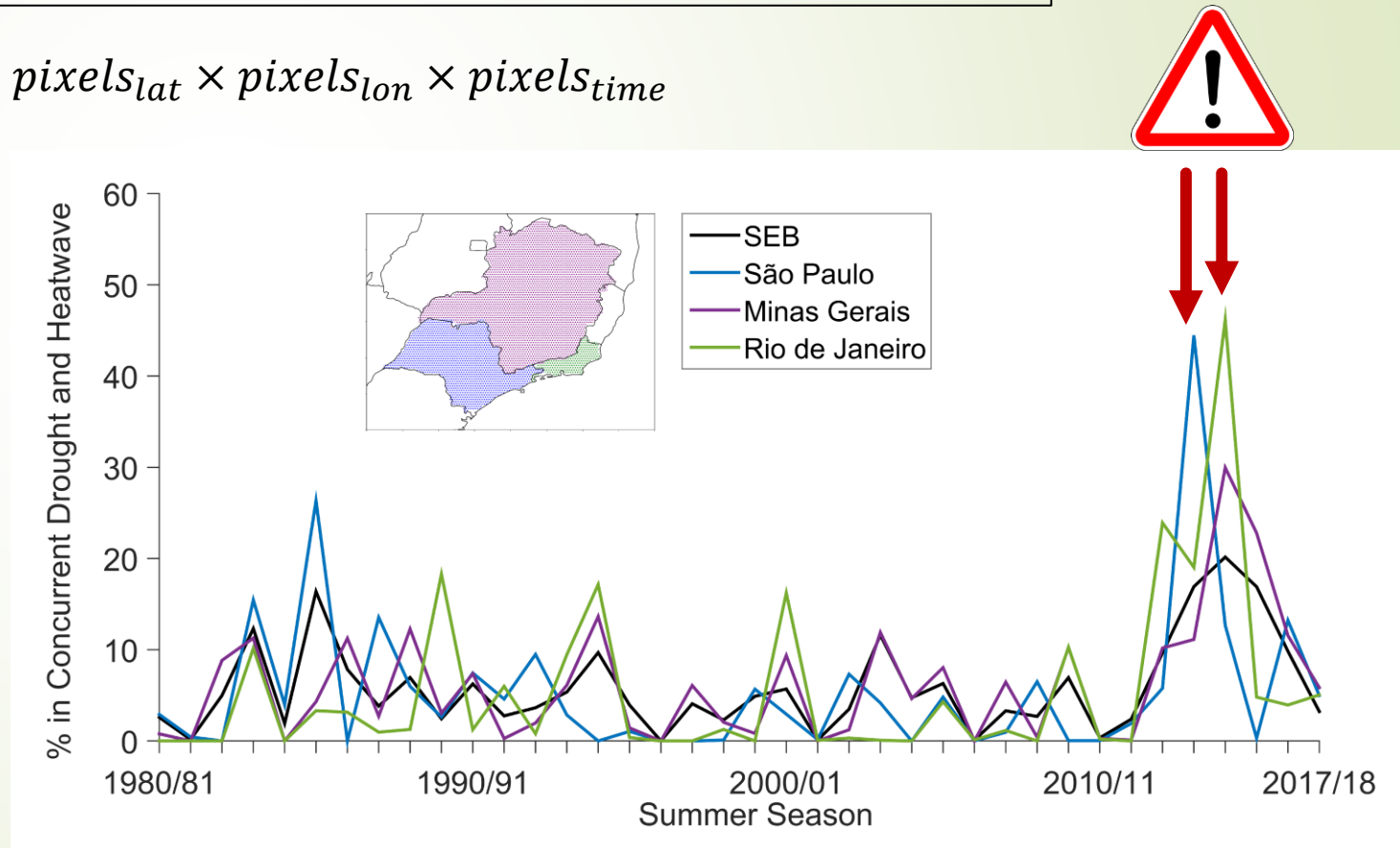
$$pixels_{total} = pixels_{lat} \times pixels_{lon} \times pixels_{time}$$

**A percentage of 100%:**



Concurrence conditions for the entire area as well as during all summer days

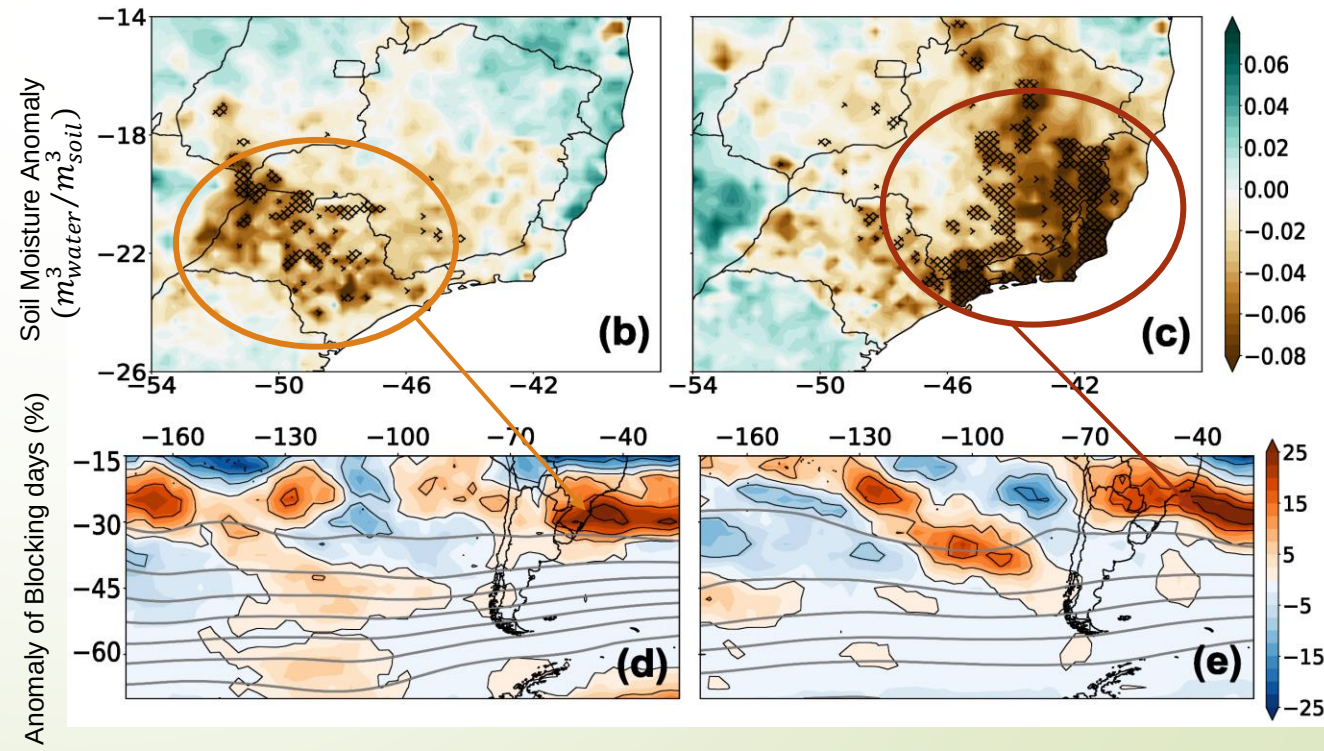
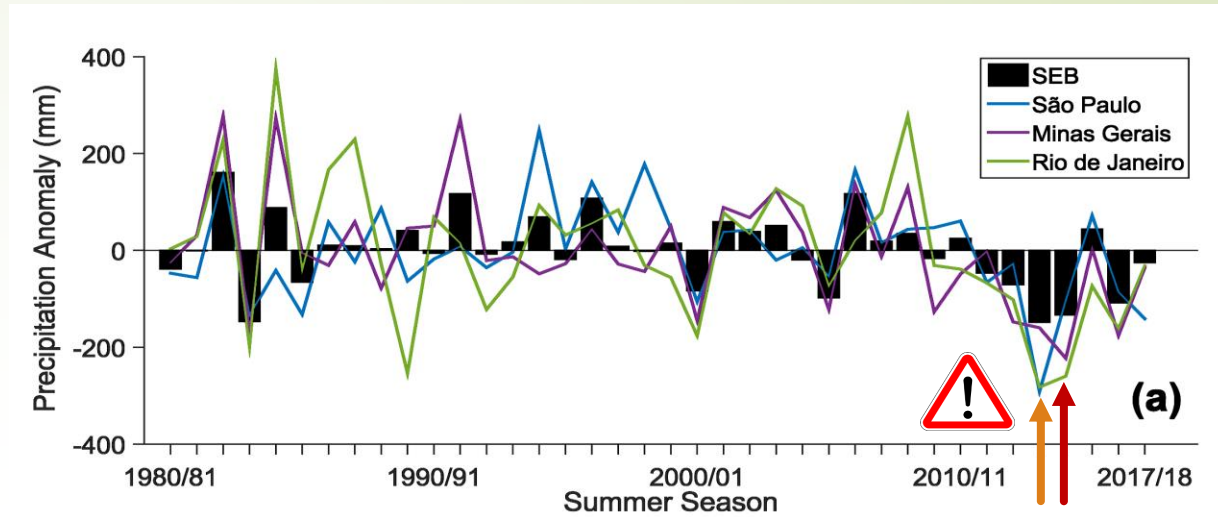
**The most critical summer seasons in terms of concurrence percentage were observed during the last decade (2013/14 and 2014/15 summers).**



# CDH events – 2013/14 and 2014/15 summer seasons:

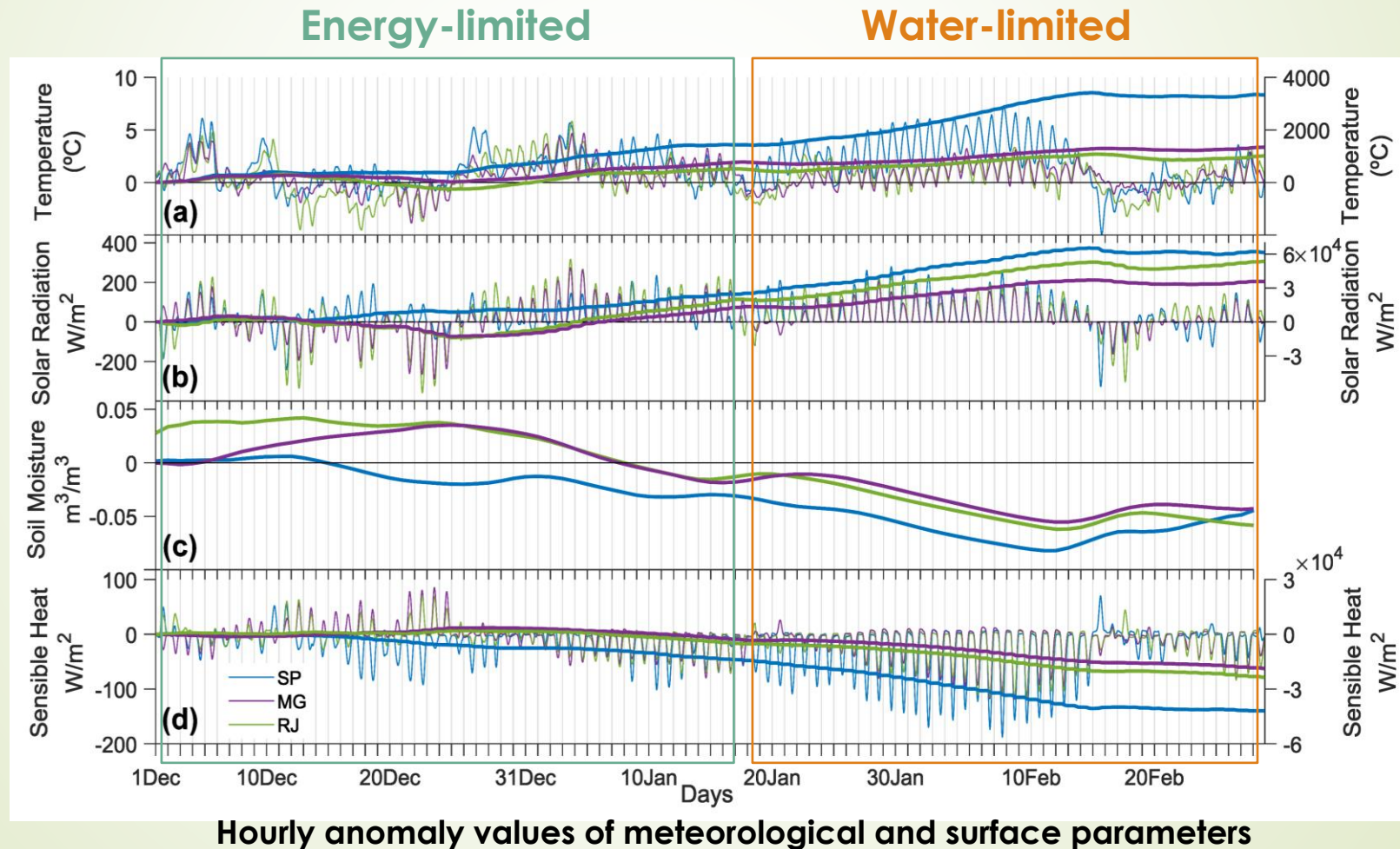
- Large precipitation deficits (a) triggered a pronounced soil desiccation during the **2013/14** and **2014/15** summers (b and c).

- Such clear skies conditions were promoted by **persistent anticyclonic circulation patterns**. In fact, during both summer seasons, Southeast Brazil experienced a **higher than normal** percentage of days under **atmospheric blocking conditions** (d and e).



# CDH events – 2013/14 and 2014/15 summer seasons:

- A **long-term precipitation deficit** coupled with the occurrence of consecutive hot periods were important to **trigger soil desiccation** during the first half of the 2013/14 summer.

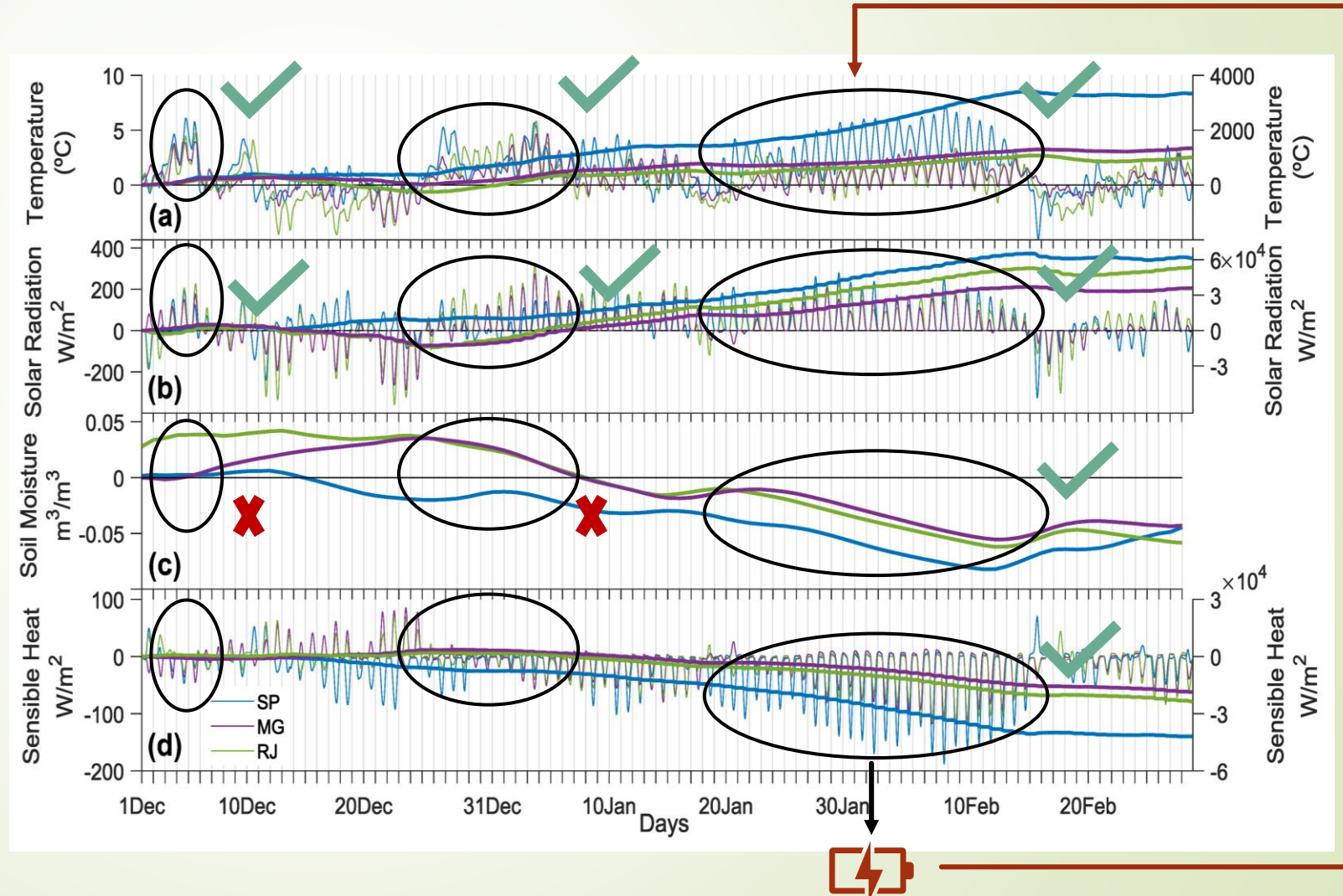


# CDH events – 2013/14 and 2014/15 summer seasons:

The ideal synoptic conditions for the incidence of **high levels of solar radiation at surface** were maintained and, due to a **severe dryness** of the surface, a **high coupling regime (water-limited)** was imposed

- Surface lost its capability to satisfy the **atmospheric water demand** and started to disproportionately dissipate **the incoming radiation as sensible heat**, instead of latent heat (evaporation).

**Temperature anomalies** over SEB were strongly amplified by the **simultaneously dry conditions** leading to the occurrence of **mega-heatwave episodes**.



# Conclusions:

1. Over the last decades extreme dry and hot conditions have intensified over the densely-populated region of Southeast Brazil.
2. The increase in the concurrence of CDH events proved to be more intense as we considered the most extreme and longer-lasting heatwave classes
3. The summer seasons of 2013/14 and 2014/15 were clear examples of such an association between drought and heatwave in this important region of Brazil.
4. This inter-relationship was controlled by two soil–atmosphere coupling regimes that were predominant during distinct periods of both summer seasons, and defined by pronounced evaporative demands and different evaporation levels and soil moisture availability.

**In summary, our findings reveal a substantial contribution of persistent dry conditions to heatwave episodes, highlighting the vulnerability of the region to climate change**

# For more information:

- João L Geirinhas et al 2021 Environ. Res. Lett. 16 034036 (<https://doi.org/10.1088/1748-9326/abe0eb>)

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LETTER

Recent increasing frequency of compound summer drought and heatwaves in Southeast Brazil

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**Keywords:** Southeast Brazil, compound events, droughts, heatwaves, climate extremes

Supplementary material for this article is available [online](#)

**Abstract**  
An increase in the frequency of extremely hot and dry events has been experienced over the past few decades in South America, and particularly in Brazil. Regional climate change projections indicate a future aggravation of this trend. However, a comprehensive characterization of drought

Thank you!



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