Unveiling heat waves in southern South America: a regional analysis

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INTRODUCTION & MOTIVATION

How is South American climatology?

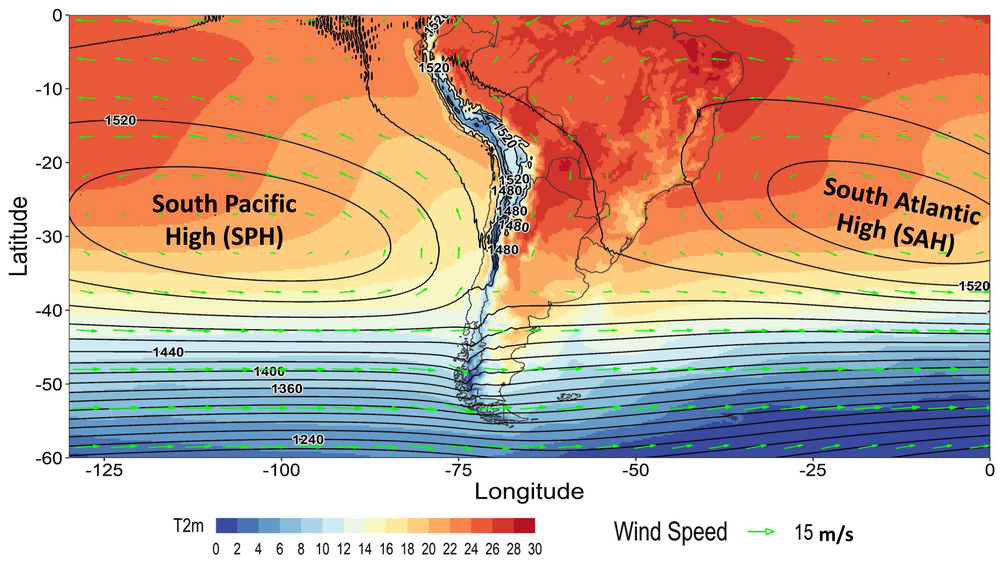


Figure 1. Climatology (1981–2010) of the low-level atmospheric circulation over South America during the warm season: 2 m temperature (colour shading, ◦C), 850 hPa geopotential height (contours, m) and 850 hPa vector wind (arrows, m s^{-1}) from the ERA5 reanalysis

Why we want to study heat waves in South America?

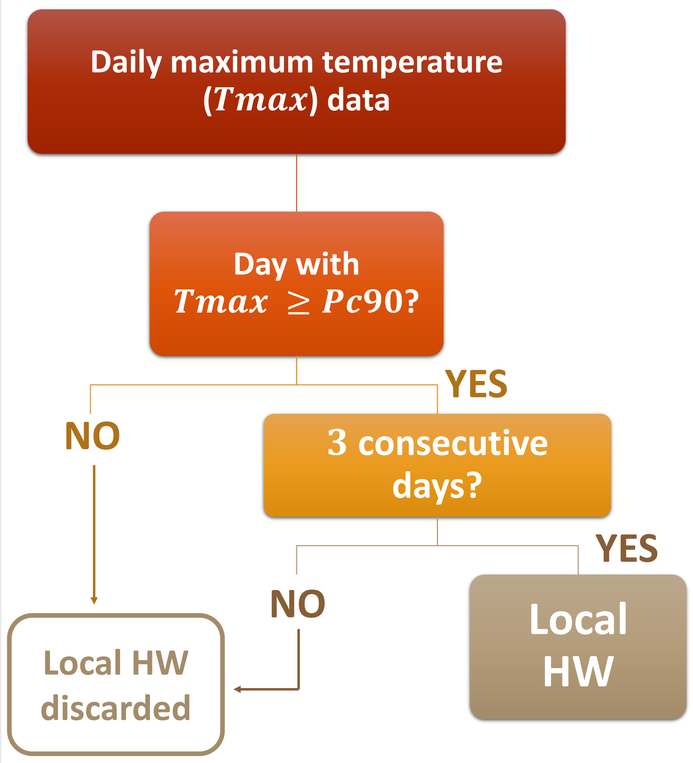
- **Heat waves (HWs)** have become **more intense and frequent** across most land regions since 1950s and will further increase in the future[1].
- **The understanding of HWs at regional scales** is incomplete and requires further research, mainly in regions with scarce observations, such as **southern South America (SSA).**

Main Objective

To identify and characterise regional HWs in SSA during the austral warm seasons (WS, Oct - Mar) of 1977 - 2018

DATA & METHODOLOGY

What is a local HW?



What is a regional HW?

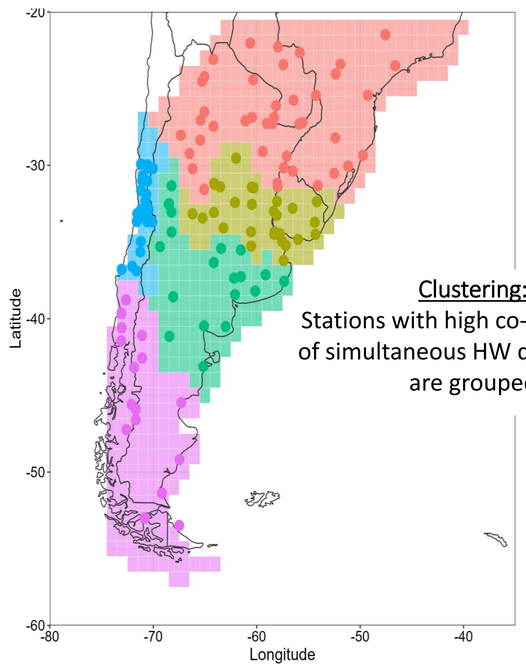


Figure 2. Regionalisation of SSA based on the co-occurrence of HWds during the warm seasons of 1977–2018. Stations (points) are coloured according to the region they belong: C1—northern of SSA (NS), C2—central-eastern of SSA (CES), C3—central Argentina and northern Argentinian Patagonia (CA), C4—central Chile (CCH), C5—Argentinian Patagonia and southern Chile, southern SSA (SS).

≥ 40% of the stations of the region with local HW event

Clustering:
Stations with high co-occurrence of simultaneous HW days (HWds) are grouped

Regional HW (RHW)

How we characterise regional HWs?

Regional HW metrics	
HWD	D = Total number of consecutive regional HW days (RHWds)
HWE	$\left(\frac{\overline{S(d)}}{N}\right)$ = Mean % of stations in the region experiencing local HW conditions
HWI	$\overline{\lceil T'(s,d) \rceil}$ = Daily mean T_{max} anomaly for all stations of the region under local HW conditions and all days of the event
HWS	$\sum_{d=1}^{D} \lceil T'(s,d) \rceil \left(\frac{S(d)}{N}\right) \approx$ HWD · HWI · HWE

RESULTS

1. How regional HWs changed in the past?

Significant positive trends in the frequency of RHWds over CA (1,7 days decade^{-1}) and CCH (1,1 days decade^{-1})

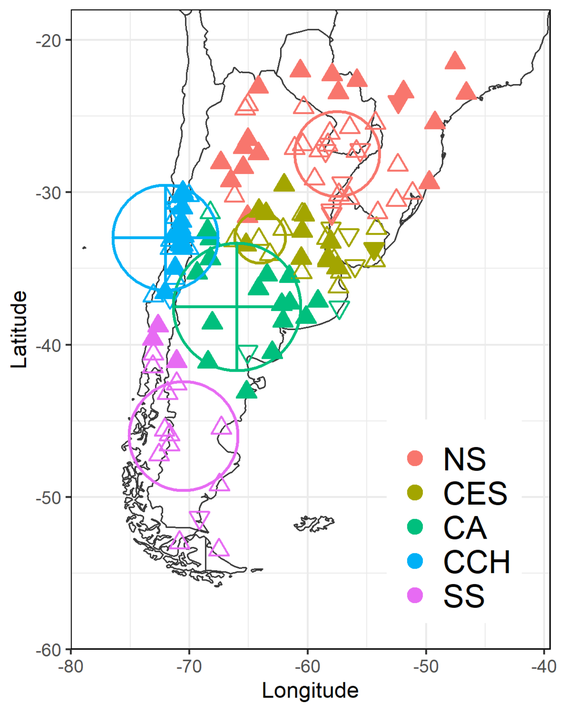


Figure 3. Linear trends (1977-2018) in the frequency of HWds for each station (triangles) and region (circles). Positive (negative) local trends are indicated with upwards (downwards) triangles, with filled colors denoting significance at p<0.01 level. Crossed circles indicate statistically significant positive trends in regional HWds.

2. Which mechanisms triggered regional HWs in SSA?

The synoptic patterns associated with HWs **reveal significant regional differences**

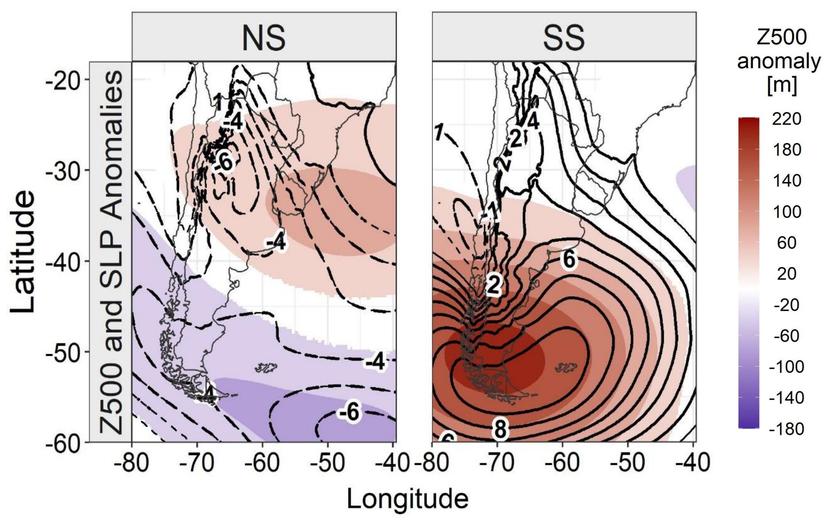


Figure 4. Composites of 500 hPa geopotential height (Z500) anomalies (in m, shading) and sea level pressure (SLP) (in hPa, contours) anomalies for RHWds of each region during the warm seasons of 1979–2018. Shaded fields are only shown for regions where anomalies are statistically significant at p < 0.05.

HWs of NS, CES, CA and CCH are related to **shifts/intensification of subtropical** semi-permanent **high-pressure systems**

SS HWs are associated with **extratropical blocking systems**, with a barotropic structure

These systems can **promote warm advection, adiabatic warming by subsidence and/or clearer sky conditions**

3. Tracking regional HWs from a new perspective: from Eulerian to Lagrangian approach

Calibration and evaluation of a **novel algorithm**[2] that focuses on the spatial pattern of extreme temperature events and its evolution

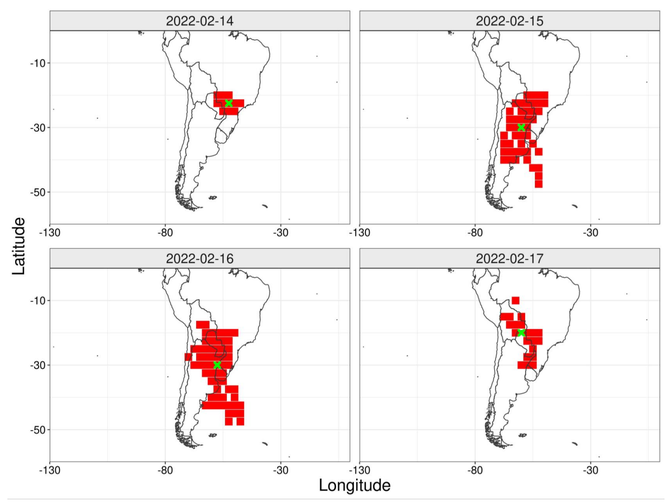


Figure 5. February 2022 HW (2022/02/14-2022/02/17) daily evolution. The green cross indicate the mean location of the HW event.

Eulerian perspective: emphasizes *local aspects* of HWs (e.g., impacts)

Limitation: not suitable to diagnose HWs at regional scales, which show changing patterns along their life-cycle

Lagrangian perspective: identifies and tracks the *spatio-temporal evolution* of HW patterns

CONCLUSIONS

- Five homogeneous SSA regions were identified based on hierarchical clustering of stations with high co-occurrence of HW conditions.
- We provided a statistical and synoptic characterisation of regional HWs in SSA.
- Significant increases in the frequency of RHWds were only detected over CA and CCH.
- We calibrated and evaluated the novel semi-lagrangian HWs algorithm. It represented correctly RHWs in SSA.

REFERENCES

[1]IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate.

[2]Sánchez-Benítez, A., Barriopedro, D., & García-Herrera, R., 2020. Tracking Iberian heatwaves from a new perspective. Weather and Climate Extremes, 28, 100238.

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