Quantifying the direct influence of climate change on the rate of spread of wildfires in the Iberian Peninsula

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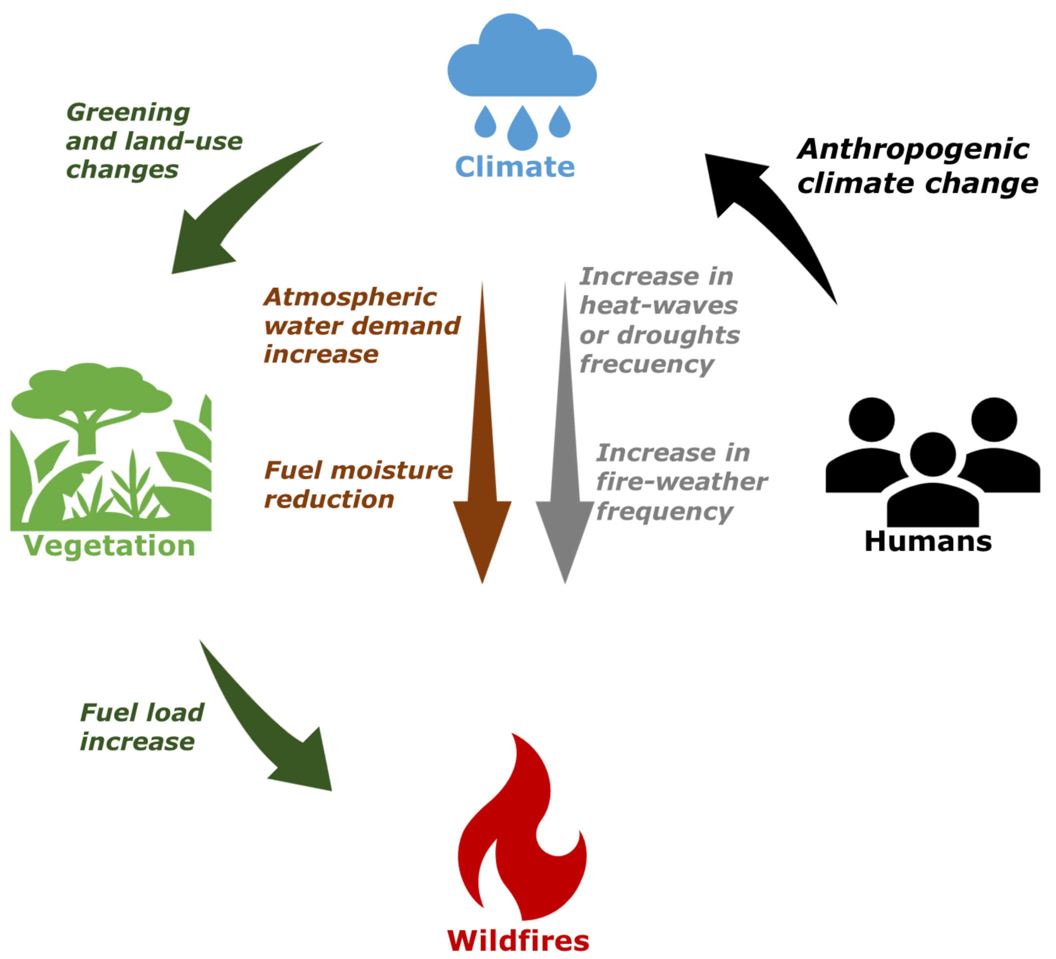
Introduction

The influence of climate change on fire behaviour can be divided into three components:

- The increased atmospheric water demand of a warmer atmosphere leads to a general fuel moisture reduction (**thermodynamic component**).
- The enhanced vegetation growth due to climate change and CO2 fertilization may increase fuel load and fuel continuity (**vegetation component**).
- Possible changes in the frequency of fire-prone weather patterns such as heatwaves or droughts (**dynamic component**).



Objectives

For all 2001-2021 wildfires in the Iberian Peninsula with burned area >500 ha:

1. **Quantify the increase on the rate of spread (ROS) attributable to the thermodynamic and vegetation component of climate change since pre-industrial conditions (before 1850).**
2. **Assess the potential ROS increase in the future using an intermediate-emissions scenario (SSP2-4.5).**

Methodology

Using NFDRS2016 equations **[1,2]** and ERA5 climate data **[3]**, we compute the rate of spread (ROS) of all 2001-2021 wildfires in the Iberian Peninsula with burned area >500 ha. We compare this factual ROS dataset against 4 different counterfactual datasets:

- **Pre-industrial (thermodynamic).** Obtained by perturbing the ERA5 temperature and relative humidity with the anomalies since the pre-industrial period of 5 different CMIP6 models.
- **Pre-industrial (vegetation).** Obtained by perturbing the defined fuel loads according to the net primary production (NPP) change anomalies since the pre-industrial period derived from 8 different CMIP6 models.
- **Future SSP2-4.5 (thermodynamic).** Obtained by perturbing the ERA5 temperature and relative humidity with the anomalies between the end of the 21st century and the present projected by 5 different CMIP6 models using SSP2-4.5 scenario.
- **Future SSP2-4.5 (vegetation).** Obtained by perturbing the defined fuel loads according to the net primary production (NPP) change between the end of the 21st century and the present projected by 8 different CMIP6 models using SSP2-4.5 scenario.

Results

By fuel category:

- **Average ROS increase between 2.6% to 11.3% since pre-industrial conditions due to the thermodynamic component of climate change**
- **The influence of vegetation alterations due to climate change in ROS could potentially be even higher.**
- **A future intensification of the thermodynamic contribution is expected, surpassing the effect of vegetation.**

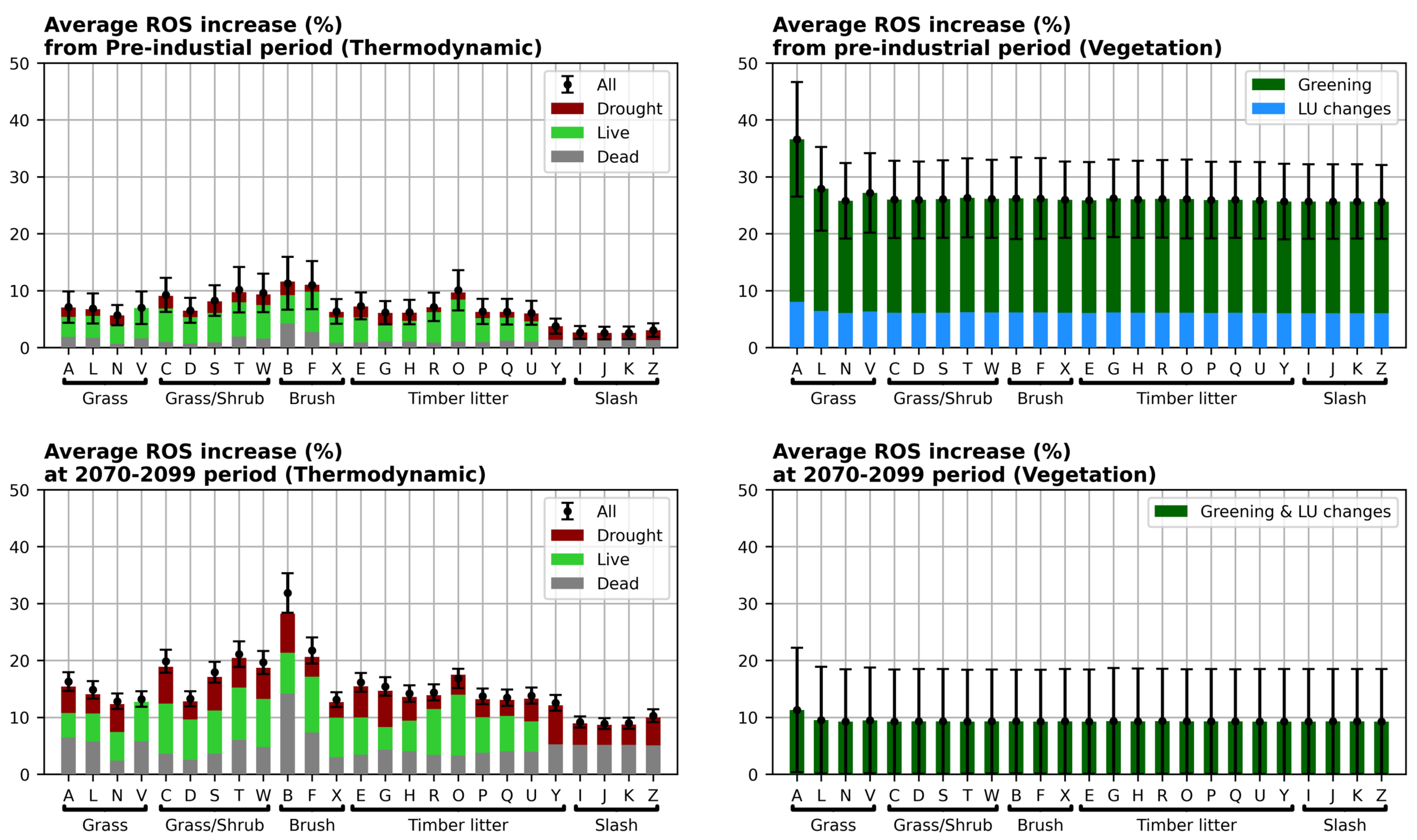


Figure 1. For each fuel category (x-axis), average ROS increase of all >500 ha wildfires between 2001 and 2021 in the Iberian Peninsula. The thermodynamic component (left panels) is divided into dead fuel, live fuel and drought factors. Black dots depict ROS changes obtained perturbing all factors, and error bars indicate the standard deviation between different CMIP6 models.

By wildfire event:

- **Some fire events have experienced ROS increases of >30% since pre-industrial conditions.**
- **More pronounced ROS changes are found in the most fire-affected region (the northwest).**

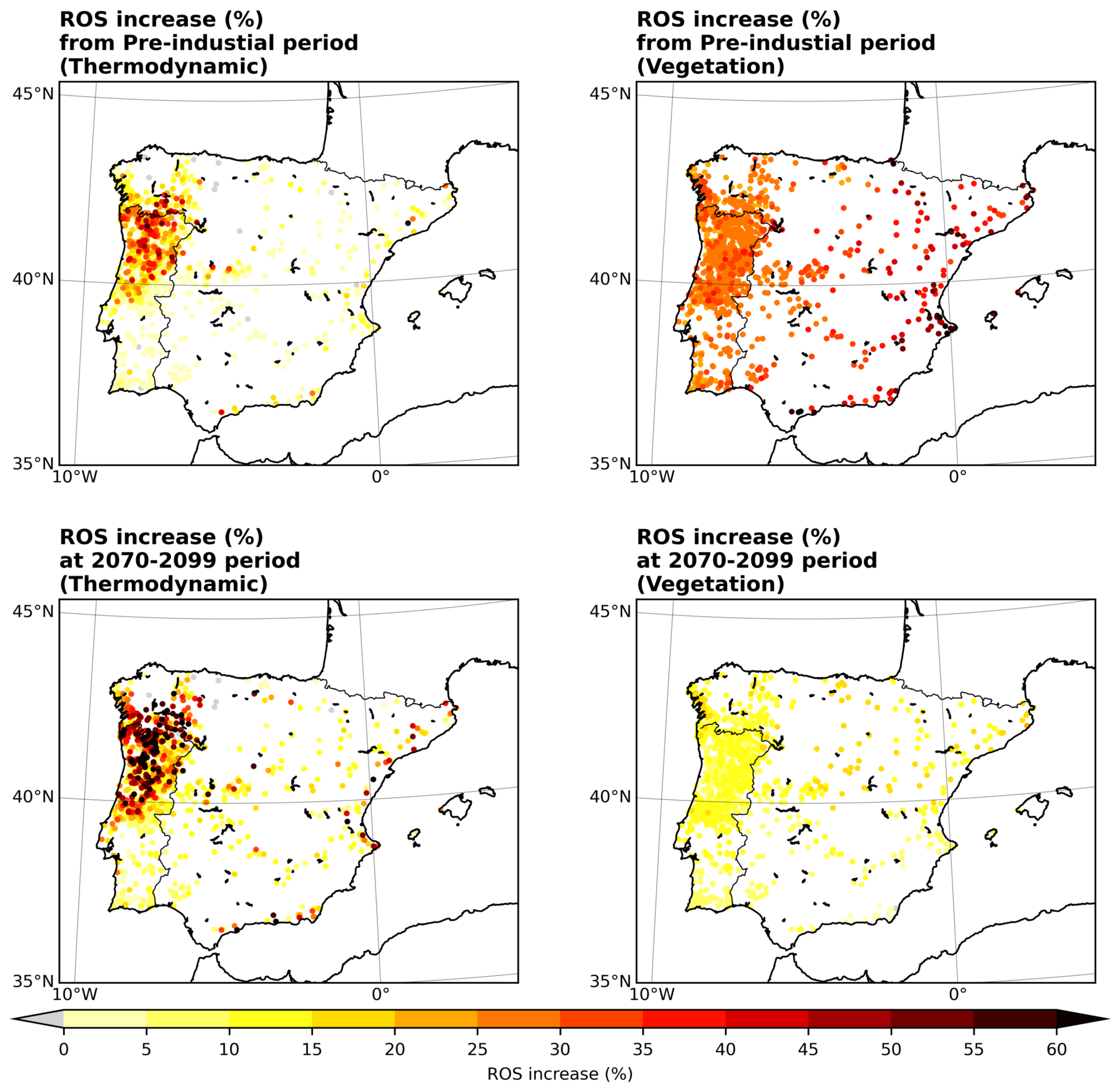


Figure 2. Fuel category-averaged ROS increase of each >500ha wildfire between 2001 and 2021 in the Iberian Peninsula.

Conclusions

- A significant influence of climate change on the rate of spread since pre-industrial times is found, for the thermodynamic and the vegetation component.
- The most sensitive region to ROS increases is the north of Portugal and the south of Galicia.
- ROS increases in the future will be mainly driven by the projected temperature rise, rather than by the enhanced vegetation growth.

More Information

Senande-Rivera, M., Insua-Costa, D. and Miguez-Macho, G. The Influence of Climate Change on Wildfire Behaviour in the Ibereian Peninsula (Preprint). Available at SSRN:

References

[1] Cohen, J. D. The National fire Danger Rating System: basic equations. Techreport PSW-82, US Department of Agriculture Forest and Service (1988).
[2] Andrews, P. L. The Rothermel Surface fire spread model and associated developments: A comprehensive explanation. Techreport RMRS-GTR-371, US Department of Agriculture Forest and Service (2018).
[3] Hersbach, H. et al. The ERA5 global reanalysis. Quarterly Journal of the Royal Meteorological Society 146, 1999-2049 (2020).