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Modelling multidimensional causes and impacts of extreme fires in the climate system through X-ECV analysis (XFires)

Stephen Sitch[1], Clement Albergel[2], Philippe Ciais[3], Simon Bowring[3], Emilio Chuvieco[4], Pierre Defourny[5], Wouter Dorigo[6], Tom Eames[1], Darren Ghent[7], María Lucrecia Pettinari[4], James Haywood[1], Daan Hubert[8], Ben Johnson[9], Stine Kildegaard Rose[10], Céline Lamarche[5], Mary Francesca Langsdale[10], Carlota Segura García[4], Erika Cristina Solano Romero[4], Roland Vernooij[11], Guido van der Werf[11], and the XFires Team[*]

[1]Exeter, United Kingdom of Great Britain – England, Scotland, Wales (s.a.sitch@exeter.ac.uk)
[2]European Space Agency
[3]Laboratoire des Sciences du Climat et de l'Environnement, France
[4]University of Alcala, Spain
[5]Université Catholique de Louvain, Belgium
[6]Technical University Wien, Austria
[7]University of Leicester, UK
[8]Royal Belgian Institute for Space Aeronomy, Belgium
[9]Met Office Hadley Centre, UK
[10]Technical University of Denmark, Denmark
[11]Wageningen University, The Netherlands
[*]A full list of authors appears at the end of the abstract

Fire plays an important role in the Earth system, affecting atmospheric composition and climate, vegetation, soil and societal resources. Extreme fires are particularly important, as they entail the most severe damages, both in terms of social and ecological values. According to the European Commission, within Europe "most damage caused by fires is due to extreme fire events, which only account for about 2% of the total number of fires". Their occurrence and impacts are closely linked to climate change, and are related to a wide range of climatic and environmental state variables, such as soil and vegetation moisture content, biomass, temperature, etc. Fires have a powerful impact on the atmosphere and thus aerosol, greenhouse gases, and ozone concentrations, while the indirect effects of fire-related particles affect also water bodies and ice sheets.

Here we summarize progress on the XFires project, which aims to research and quantify all of the above interactions to gain a holistic understanding of extreme fires, including understanding drivers of extreme fire events, modelling their occurrence and their impact in the Earth system. A particular focus of this project lies in gaining an improved theoretical and quantitative understanding of what the medium-term net effects of fire are on global carbon and radiative forcing budgets. This is important because at a global scale, little is known regarding how extreme fires impact vegetation and soil recovery timescales with respect to the time until the same system

next experiences fire. Extreme fires are of particular interest because of how different biomes might hypothetically respond to, and recover from, different extreme fire characteristics, which have significant potential bearing on the global carbon cycle. To address these questions, we first use a cross-Essential Climate Variable (ECVs) approach to define and characterise extreme fires. Results show almost 20k extreme fire events over the period 2003 to 2022. We then explore trends in extreme fire events across biomes and associated greenhouse gas emissions. We will then develop and apply machine-learning approaches to model extreme fires and generate new emissions datasets to be used as input into an Earth System Model, to quantify impacts on atmospheric composition and climate. Finally, we will explore the wider impact of extreme fires on human health, lakes, and via black carbon affecting melt-rates on the Greenland ice-sheet.

XFires Team: Stephen Sitch, Clement Albergel, Simon Bowring, Emilio Chuvieco, Philippe Ciais, Pierre Defourny, Wouter Dorigo, Tom Eames, Darren Ghent, James Haywood, Daan Hubert, Ben Johnson, Amin Khairoun, Stine Kildegaard Rose, Céline Lamarche, Mary Langsdale, Hoontaek Lee, Patricia Oliva Pavón, María Lucrecia Pettinari, Monica Pinardi, Lizzy Quaye, Carlota Segura García, Louise Sandberg Sørensen, Erika Cristina Solano Romero, Daniela Stroppiana, Roland Vernooij, Guido van der Werf, Yidi Xu