



Unusual fire seasons in a changing climate - A Bayesian approach.

Douglas Ian Kelley¹, Chantelle Burton², Rhys Whitley³, Chris Huntingford¹, Ioannis Bistinas⁴, Megan Brown^{1,5}, Ning Dong⁶, and Toby R. Marthews¹

¹UK Centre for Ecology & Hydrology, Hydro-climate risks, Wallingford, United Kingdom of Great Britain and Northern Ireland (douglas.i.kelley@gmail.com)

²Met Office Hadley Centre, Exeter

³Natural Perils Pricing, Commercial and Consumer Portfolio and Product, Suncorp Group, Sydney, Australia

⁴ATOS Nederland B.V., Amstelveen, The Netherlands

⁵School of Physical Sciences, The Open University, Milton Keynes, UK

⁶Department of Biological Sciences, Macquarie University, North Ryde, Australia

A series of fire events have captured the attention of the public and press in the last couple of years. South America, for example, saw the largest increase in fire count in nearly 10 years, mainly in areas historically associated with deforestation in Amazonia. Meanwhile, South Eastern Australia has seen a number of devastating bush fires in recent months, resulting in (at time of writing) 27 deaths and the destruction of over 2000 properties. These two fire events, in particular, have sparked debates about whether the levels of burning were unprecedented, and if so, whether they were driven by changes in human ignitions or land management, or if the fire season was drier than normal and whether climate change played a role. However, confidently determining the main drivers of fire events such as these often remains challenging. There is an ever-increasing availability of near-real-time meteorological and fire activity data that could be used to determine drivers, but the complex interplay of different fire controls makes teasing apart drivers of fire difficult from observations alone. Many coarse-scale fire-enabled terrestrial biosphere models account for some interplay of controls. However, most fail to reliably reproduce trends in fire, and often rely on inputs that are not available for some time after these fire seasons have passed.

Here, we have developed a Bayesian framework which addresses this by inferring fire drivers directly from observations and tracking uncertainty in a simple fire model. The model uses coarse resolution, monthly data that is available at near-real-time and emulates most fire-enabled land surface schemes by summarizing drivers as controls describing fuel continuity; moisture; lightning and human ignitions; and human suppression. The framework can be trained on different fire-related variables and finds a posterior probability distribution of both the model parameters and the expected fire activity from the model as a whole. This allows us to determine the probability of a particular fire season event within the context of the historical meteorological record, as well as the main drivers of unusual fire events.

This framework is first applied globally, identifying tropical forests and woodland ecosystems as

key hotspots of long term fire regime shifts. In South Eastern Australian woodland, changes in fuel continuity and moisture point to a weak, long term decline in fire activity, but with increased variability, indicating a higher probability of extreme fire years. The arc of deforestation in the Amazon shows long-term increased susceptibility to fire due to drying conditions from changes in land cover. However, when focusing the framework specifically on Amazonia, we show lower meteorologically driven fire counts than we see in the observations for 2019, and that it is extremely likely (>95% probability) that the weather conditions have not triggered the very high levels of fire seen in the Amazon this last year. This demonstrates the potential of the framework for use in rapid attribution of drivers in future extreme fire seasons.