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Probabilistic calibration of the SPITFIRE fire spread model using Earth observation data

Jose Gomez-Dans (1), Martin Wooster (2), Philip Lewis (1), and Allan Spessa (3)

(1) Dept. of Geography, King's College London, UK., (2) Dept. of Geography, University College London, UK., (3) NCAS-Climate, Dept. of Meteorology, University of Reading, UK.

There is a great interest in understanding how fire affects vegetation distribution and dynamics in the context of global vegetation modelling. A way to include these effects is through the development of embedded fire spread models. However, fire is a complex phenomenon, thus difficult to model. Statistical models based on fire return intervals, or fire danger indices need large amounts of data for calibration, and are often prisoner to the epoch they were calibrated to. Mechanistic models, such as SPITFIRE, try to model the complete fire phenomenon based on simple physical rules, making these models mostly independent of calibration data. However, the processes expressed in models such as SPITFIRE require many parameters. These parametrisations are often reliant on site-specific experiments, or in some other cases, paremeters might not be measured directly. Additionally, in many cases, changes in temporal and/or spatial resolution result in parameters becoming effective.

To address the difficulties with parametrisation and the often-used fitting methodologies, we propose using a probabilistic framework to calibrate some areas of the SPITFIRE fire spread model. We calibrate the model against Earth Observation (EO) data, a global and ever-expanding source of relevant data. We develop a methodology that tries to incorporate the limitations of the EO data, reasonable prior values for parameters and that results in distributions of parameters, which can be used to infer uncertainty due to parameter estimates. Additionally, the covariance structure of parameters and observations is also derived, whcih can help inform data gathering efforts and model development, respectively.

For this work, we focus on Southern African savannas, an important ecosystem for fire studies, and one with a good amount of EO data relevnt to fire studies. As calibration datasets, we use burned area data, estimated number of fires and vegetation moisture dynamics.