INFERNO

INTRODUCTION

The sudden increase in Amazon fires early in the 2019 fire season made global headlines. While fires were likely caused by deliberate human ignitions or landscape changes, there have also been some suggestions that meteorological conditions could have played a role. Here, we develop a Bayesian framework that can track the influence of, and uncertainties in, climate and vegetation change on fires using the ConFire model [1,2]. We use this framework to ask two questions: were the 2019 fires in the Amazon unprecedented in the historical record?; and did the meteorological conditions contribute to the increased burning?

Bayesian approach to fire modelling

Bayes' theorem states that the likelihood of the values of the set, \( \beta \), containing model parameters, an error term, and our known model inputs, given a set of observations (Obs), is proportional to the prior probability distribution of \( \beta \) (\( P(\beta) \)) multiplied by the probability of the observations given \( \beta \):

\[
P(\beta|\text{Obs}) \propto P(\beta) \times P(\text{Obs}|\beta)
\]

Using Bayesian theorem allows us to account for inherent uncertainty in model parameters based on the observed historic record [2]. Standard fire models allow just one set of parameter combinations (e.g. INFERNO, below left for two common model parameters). For ConFire, nice, large, uninformed priors (\( P(\beta) \) - black blob, left) are used mainly to set physical bounds of parameters. Our resultant posterior distribution (\( P(\beta|\text{Obs}) \) - yellow and red) is therefore dominated by observational relationship, and can also be used to assess how parameters vary with one another.

We trained the model on 2001-2018 burnt area using observed meteorology, land cover and land use (ULLC) [6]. The model was then run in predictive mode for 2019 with varying meteorology but human-fire interactions consistent with the historic record. Simulated burnt area suggests that areas of low fire activity in 2019 should have extended right across the region. This implies that meteorological conditions did not significantly contribute to increased fire activity in 2019.

We also compare model forecasted burnt area to observed burnt area for 2019 and 2020. ConFire suggests that a majority of the increase in burning is due to increased fire activity in 2019, while both the model and the bayesian framework suggest that the relatively low burning in 2020 compared to the long-term record is largely due to the absence of fire events.

Conclusion

It is likely (93% probability) based on past relationships between burnt area and meteorological conditions, that the weather conditions did not trigger the increase in burning in Amazonia during the early fire season in 2019. This result points to social-economic factors, which were kept constant, having a strong role in the high recorded fire activity. Our Bayesian modelling approach can be easily adapted to provide assessment of meteorological drivers of other unusual fire events, such as the recent Australian fires.