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Edge-preserving data assimilation for fire monitoring using optical data

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Monitoring fire using optical data from moderate spatial resolution sensors is in essence a change detection process, where changes in reflectance (or a vegetation index) within two dates or periods are interpreted as fires if the change meets a number of spectral rules. A major challenge in any of these algorithms is accounting for angular effects due to different acquistion/illumination geometry. The MODIS Coll5 algorithm for example, uses linear kernel models to forward predict observations, and based on a statistical test, decides whether a change has occurred and labels it as a potential fire. While the algorithm is successful in many regions, it has problems dealing with cloudy periods,
and with limitations in the available observations. In this work, we propose a new approach based on (i) a more advanced signal tracking method using edge-preserving data assimilation techniques
and (ii) an interpretation of the change signal using a spectral linear model.

The signal tracking approach uses linear kernel models, but solves for them using regularisation in time as a prior. This allows for a transfer of information from data rich periods to other periods where data may be more sparse. To minimise information leaking over the actual fire, we implement an edge-preserving mechanism that limits the information transfer over the disturbance. The result of this is a complete time series of surface reflectance acquired with a constant geometry. Note that the system provides complete uncertainty estimates of the parameters, taking into account the initial level of uncertainty in the observations of surface reflectance.

A second stage interprets post-fire reflectance as a mixture of a "typical burn signal" and an unburned component, which we assume to be the pre-fire reflectance. We propose a simple spectral
model for the burn signal, a constrained quadratic function. This model is appropriate for a number of burned material spectrum. We demonstrate using the MODIS burned area product that the approach provides useful complementary information about fires, describing the spectral nature of
the burn signal, as well as providing information on potentially the impact of the fire in the pixel.

Both approaches are then combined into a multispectral burned area algorithm with MODIS land surface observations. We test the performance of the proposed method, compare to other well-established products, and show some of the shortcomings of the proposed algorithm.