Geophysical Research Abstracts
Vol. 16, EGU2014-4843, 2014
EGU General Assembly 2014

Quantifying post-fire recovery of forest canopy structure and its environmental drivers using satellite image time-series

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Fire is a recurring disturbance in most of Australia's forests. Depending on fire severity, impacts on forest canopies vary from light scorching to complete defoliation, with related variation in the magnitude and duration of post-fire gas exchange by that canopy. Estimates of fire impacts on forest canopy structure and carbon uptake for south-eastern Australia's forests do not exist. Here, we use 8-day composite measurements of the fraction of Absorbed Photosynthetically Active radiation (FPAR) as recorded by the Moderate-resolution Imaging Spectroradiometer (MODIS) to characterise forest canopies before and after fire and to compare burnt and unburnt sites. FPAR is a key biophysical canopy variable and primary input for estimating Gross Primary Productivity (GPP). Post-fire FPAR loss was quantified for all forest areas burnt between 2001 and 2010, showing good agreement with independent assessments of fire severity patterns of 2009 Black Saturday fires. A new method was developed to determine the duration of post-fire recovery from MODIS-FPAR time-series. The method involves a spatial-mode principal component analysis on full FPAR time series followed by a K-means clustering to group pixels based on similarity in temporal patterns. Using fire history data, time series of FPAR for burnt and unburnt pixels in each cluster were then compared to quantify the duration of the post-fire recovery period, which ranged from less than 1 to 8 years. The results show that time series of MODIS FPAR are well suited to detect and quantify disturbances of forest canopy structure and function in large areas of highly variable climate and phenology. Finally, the role of post-fire climate conditions and previous fire history on the duration of the post-fire recovery of the forest canopy was examined using generalized additive models.