25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Recovery of fire-impacted ecosystems: Detection using a state-of-the-art diagnostic evapotranspiration model

Zhenwu Xu [a,b], **Yongqiang Zhang** [a] **and Ning Ma** [a]

[a] *Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Beijing, China*
[b] *University of Chinese Academy of Sciences, Beijing, China*
Email: xuzw.20b@igsnrr.ac.cn

Abstract: Fires are one of the most common natural disturbances that perturb ecosystem processes. While satellites can detect fire-impacted ecosystems ranging from savannas to forests across the globe, studies on fire impacts are mostly limited to site-scale, where eddy flux observations are available. Changes in ecosystem processes and the post-fire recovery remain poorly understood at the global scale.

Here, we investigate the recovery of fire-impacted ecosystems based on a diagnostic model (Penman-Monteith-Leuning Version 2, PML-V2), which provides coupled estimations of evapotranspiration (ET) and gross primary production (GPP). Using climate reanalysis and remote sensing data as forcing, the PML-V2 model can simulate the changes of ET components in response to the post-fire reductions and recovery of leaf area index (LAI) and surface albedo, including the decreased interception and transpiration of trees, and the increased soil evaporation. The model estimations were validated against observations from 24 burned eddy flux sites and 95 unburned sites.

Fire impacts were determined by a controlled experiment between burned and unburned grid ensembles, which possibly show different responses after fires. Based on MODIS MCD64A1 burned area data, the original 500-m 8-day ET and GPP data were classified into the two kinds of grid ensembles and then aggregated into new 0.1° 1-month data, allowing a lower time requirement for global-scale analysis. Due to similar climate and vegetation cover for the pre-fire period, these two kinds of grids can be paired based on the similarity of fluxes, most of which show a high $R2 > 0.85$. The fire impacts were then extracted between the time series of burned grids and those transformed from the reference unburned grids.

According to the analysis, we show that fires cause an immediate change in burned ecosystems by a median of -45.7% and -15.9% for GPP and ET, respectively. The subsequent time for full recovery takes on a median of 4.7 and 3.7 years. Fire impacts and ecosystem recovery are diverse among different ecosystems. Burned forests show significant and greater immediate changes, requiring more time for full recovery, while other non-forest species take less time for a full recovery. Especially, it is unable to detect significant immediate fire impacts on GPP in almost half of the grassland fires. As a physical explanation, recovery of the two fluxes could be correlated to LAI and albedo changes. Such physical changes can be further attributed to fire regime, vegetation type, and post-fire climate.

Overall, this study demonstrates the potential of utilizing remotely sensed data and climate analysis for diagnosing ecosystem recovery in burned ecosystems.

REFERENCES

Collar, N. M., Saxe, S., Rust, A. J., & Hogue, T. S. (2021). A CONUS-scale study of wildfire and evapotranspiration: Spatial and temporal response and controlling factors. Journal of Hydrology, 603 (4), 127162.

Liu, Z., Ballantyne, A. P., & Cooper, L. A. (2019). Biophysical feedback of global forest fires on surface temperature. Nature Communication, 10 (1), 214.

Keywords: *Fire, ecosystem recovery, evapotranspiration, gross primary production, PML-V2*