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Effects of active forest fire on terrestrial ecosystem production and greenhouse gas emissions

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The forest fire is one of the most catalysing agents which degrade an ecosystems leading to the loss of net and gross primary productivity (NPP & GPP) and carbon sequestration service. Additionally, it can suppress the efficiency of service providing capacity of an ecosystem throughout the time and space. Remote sensing-based forest fire estimation in a diverse ecosystem is very much essential for mitigating the biodiversity and productivity losses due to the forest fire. Satellite-based Land Surface Temperature (LST) has been calculated for the pre-fire and fire years to identify the burn severity hotspot across all eco-regions in the Lower Himalaya region. Several burn severity indices: Normalized Burn Ratio (NBR), Burnt Area Index (BAI), Normalized Multiband Drought Index (NMDI), Soil Adjusted Vegetation Index (SAVI), Global Environmental Monitoring Index (GEMI), Enhance Vegetation Index (EVI) have been used in this study to quantify the spatial and temporal changes (delta) of the selected indices. Two Light Use Efficiency (LUE) models: Carnegie- Ames-Stanford-Approach (CASA) and Vegetation Photosynthesis Model (VPM) have been used to quantify the terrestrial Net Primary Productivity (NPP) in the pre-fire and fire years across all biomes of the region. A novel approach has been preceded in this field to demonstrate the correlation between forest fire density (FFD) and NPP. A strong positive correlation was found between burn severity indices and predicted NPP: BAI and NPP (r = 0.49), NBR and NPP: (r = 0.58), EVI and NPP: (r = 0.72), SAVI and NPP: (r = 0.67), whereas, a negative association has noted between the NMDI and NPP: (r = -0.36) during the both studied years. Results have shown that the NPP is highly correlated with the forest fire density (R^2 = 0.75, RMSE = 5.03 gC m^{-2} $month^{-1}$). The estimated LST of the individual fire days has witnessed a sharp temperature increase by $> 6^oC$ – 9^oC in comparison to the non-fire days clearly indicates high fire risk (in Uttarakhand) due to the subtle water stress condition with lesser soil moisture content into the ground. Among the 13 districts, the maximum net emissions of carbon and nitrogen compounds have been observed in 7 districts (accounting for high biomass and forest cover loss by the 2016 forest fire), whereas, the rest of the 6 districts acts as the sequester of greenhouse compounds. This new approach having the potentiality of quantifying the losses of ecosystem productivity due to forest fires and could be used in broader aspects if more accurate field based observation can be obtained in the near future.