Geophysical Research Abstracts
Vol. 17, EGU2015-7363, 2015
EGU General Assembly 2015

Effects of slope orientation on fine surface fuel moisture content: implications for ignition probabilities and connectivity of fuels

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This study quantifies topographic effects on microclimate and moisture dynamics in litter and near surface soil with the aim to improve spatial representation of fine surface fuel moisture content (FFMC) in mountainous terrain where forest fires typically operate. FFMC was monitored at 30-minute intervals using a novel field method for measuring moisture content of litter, providing unique data on the spatial-temporal variation in FFMC throughout a fire season. Moisture sensors were inserted into litter packs at sites on different slope aspects (North, South, West and East) and paired with manual measurement of gravimetric water content to relate sensor output to water content. Hydrochron sensors (or iButtons) were placed within the litter packs, measuring temperature at the interface between the litter layer and the soil. During the monitoring period the mean daily moisture content in the litter layer ranged from 0.07-1.30 kg kg^{-1} on the north-facing slope and from 0.11–1.83 kg kg^{-1} on the south-facing slope. The number of days during the fire season when the litter was below the fiber saturation point ($\sim$0.35 kg kg $^{-1}$) was 49 and 128 on the south and north aspects, respectively, highlighting the very large aspect-driven variation in FFMC and the need for spatially explicit data on microclimate. Differences in moisture content were caused by aspect-related variation in incoming radiation which resulted in large temperature differences within the litter layer. On the warmest day of the monitoring period (38.9˚C on 17 January), for example, the difference in litter temperature between North and South aspect was 14˚C. Differences in surface temperature were driven mainly by the systematic variation in vegetation cover, and hence shading, which emerge as a result of aspect (i.e. eco-hydrologic effect) and partly by the effects of slope orientation (i.e. geometric effect) on incoming radiation. Furthermore, the differences in FFMC due to evaporative demand were augmented by the systematic increase in litter depth (and thus the overall water holding capacity of the fuel bed) with decreasing incoming radiation. The combined effects of slope orientation, vegetation and litter bed properties on FFMC was up-scaled to explore how ignition probabilities and fuel connectivity vary in space and time during drying and wetting cycles throughout a fire season. Results from the study will be used to improve the spatial modeling of microclimate and FFMC and provide a basis for i) more spatially explicit predictions of fuel availability for wildfires and ii) more targeted, safe and effective scheduling of fuel reduction burns.