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Using actual evapotranspiration to estimate fire danger from MODIS satellite imagery: a case study in a Eucalyptus stand

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Wildfires belong to the Portuguese Mediterranean climate, nevertheless, climatic changes and variability influence fire occurrence with higher frequency and the destruction of ever larger areas, having impact on economy and human life. One of the processes mostly concerned in fire danger is the moisture content estimation of living and dead fuels. Soil moisture influences the moisture content of the above stacked fuel particles and changes with precipitation, evapotranspiration (ET), and water vapor exchanges between fuels and the atmosphere. In the past, only a few models considered ET to estimate the soil water or fuel moisture content, from which most studies used the potential ET (ETpot) and only few the actual ET (ETa).

Here, the simplified two-source energy balance model (STSEB) was applied to estimate ETa before a fire event in central Portugal, which ignited on 2nd of April 2015. To operate the model, meteorological data (e.g. air temperature, wind speed), satellite imagery (here Moderate Resolution Imaging Spectroradiometer, MODIS) and vegetation properties (e.g. tree height) were needed. For all cloudless days, energy heat flux densities and other variables (i. e. Normalized Difference Vegetation Index = NDVI, surface temperature = Trad) were retrieved, approximately one month before the fire.

The combination of MODIS products with weather station measurements enabled to monitor the water status of the vegetation over larger areas, reducing errors of interpolating point weather measurements. The estimates of the STSEB method were related to vegetation properties and gave information about changes in the soil water storage.

On average, sensible heat (H) was higher and latent heat (LE) lower at the burnt area compared to the surrounding areas (control areas), before the fire ignited. This indicates a warmer surface with lower ETa for the burnt area. In this case, the energy heat fluxes increased before fire ignition, especially H over the whole region, being exposed to similar fire spreading risks in terms of weather influencing conditions, e.g. wind speed. The ratio NDVI/Trad and the Normalized Difference Water Index (NDWI), being related to live vegetation moisture content, fit and complement the ETa estimates. Based on the results a new ratio was developed to improve fire danger rating.

Easy access to satellite products and further development of two-source energy balance models to estimate ETa should be re-considered and implemented into fire danger methods to improve estimates of the available water budget and therefore the estimate to fire susceptibility.