Vegetation moisture dictates susceptibility to fire ignition and propagation. Policy makers need daily maps of this parameter to plan prevention activities. Optical remote sensing has been successfully used to produce estimates of vegetation equivalent water thickness (EWT), which is defined as the mass of liquid water per unit of leaf surface. However, fire models rely on the live fuel moisture content (LFMC) as a measure of moisture. LFMC is defined as the ratio of EWT and dry matter content (DMC, mass of the oven-dried leaf per unit of surface), and traditional spectral indexes fail in capturing its variability. The objective of this research was to understand whether spectral measurements from MODIS are sensitive to the effect of LFMC variability on vegetation reflectance and whether this can be translated into a simple spectral index.

The proposed index was evaluated against the LOPEX database of leaf optical and water content measurements. Indirect validation was performed assessing the values of the index calculated from MODIS images at fire locations against a dataset of more than 6200 events recorded in 2000-2008 in Campania (13595 km²), Italy.

In the Cartesian plane of MODIS reflectance measurements in bands 2 and 5, points with constant LFMC lie on straight and parallel lines. The PMI measures the change in LFMC as a variation of the distance of that point from a reference line. The LAI is the main factor influencing the quality of the relationship between the PMI and LFMC. However, good results can be achieved when LAI>2, which is a typical condition in a large variety of vegetation associations prone to fires such as those in Mediterranean ecosystems.

The soil line and the dry vegetation line appear to be parallel in our experiments. This means that it is not possible to introduce modification to the index in order to make it robust to LAI variations. Both reductions in LAI and in LFMC reduce the value of PMI, i.e. with lower LAI, LFMC is underestimated. This can be considered safe in the field of fire prevention, where a missed alarm may have worse consequences than a false alarm.

The indirect validation with MODIS images and fire data showed that with decreasing values of PMI the average fire propagation speed increased. This is what would be expected, whereas fires spread faster in drier environments.

The plane allowing the best separability of group of points with the same value of LFMC is that spanned by channels 2 (860 nm) and 5 (1240 nm). The positions of the centres of each cluster appear to be ordered from lower to higher LFMC values.

When the vegetation cover is dense, i.e. leaf area index (LAI) >4, data appear to concentrate along a straight line. With decreasing values of LAI, more background soil is exposed, and points shift towards the soil line. This effect is particularly strong when LAI<2.

When vegetation cover is dense (LAI=4), points with a constant value of LFMC align on a straight line. These lines are parallel, and shift towards lower NIR and higher SWIR reflectance values with decreasing LFMC.

A spectral index achieves maximum sensitivity to LFMC when it measures the displacement of points perpendicularly to its isolines. Since LFMC isolines are parallel, we propose the Perpendicular Moisture Index (PMI) as the distance of the measured reflectance from the reference line of completely dry vegetation (LFMC=0% and EWT = 0), so that an increase in LFMC corresponds to an increase in PMI.

The PMI was initially validated against simulated data.

Independent validation was performed against LOPEX data scaled to canopy reflectance with SAIL model.

In the validation against fire data, we found a clear correlation between the PMI and the mean fire rate of spread (as derived from fire size and duration). Since propagation speed is affected by a large number of factors, we averaged its value in bins of PMI.