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Assessing the influence of fire weather danger indexes on fire frequency and burned area in mainland Spain

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Fire danger rating indexes based on weather data are a well-established way to identify favorable ignition-spread conditions. In this study, we investigate the association between FWI (Canadian Fire Weather Index), BI (US Burning Index) and FFDI (Australian Forest Fire Danger Index) with fire occurrence (N) and burnt area size (BA) at regional level in Spain. Fire indexes were retrieved from the European Centre for Medium-Range Weather Forecasts (ECMWF) Interim Reanalysis, later aggregated into a Composite Fire Danger Index (CFDI) which is calculated as the average normalized value of FWI, BI and FFDI. Fire frequency and burnt area statistics were calculated from the Spain's General Statistics on Wildfires database.

Monthly time series (from 1979 to 2013) of CFDI, N and BA were constructed and later decomposed into seasonal and trend components, representative of the intra-annual cycles and the temporal evolution of fire activity, respectively. The resulting series are then compared by means of cross-correlation functions (CCF). CCF allows identifying lags in the association between two variables. Here, we applied CCF to the decomposed time series of CFDI, N and BA exploring several lags (-3, -2, -1 and 0 months). Additionally, we applied the Mann-Kendall test to the trend component so that we can detect significant trends. The proposed method was applied using two spatial scales. In a first attempt we split Spain into three regions – Northwest (NW), Hinterland (HL) and Mediterranean (MED) – providing a broader picture. In a second stage we used a more spatial-explicit approach, applying CCF on a pixel-basis (0.75x0.75º), allowing mapping correlation values.

Regional results reveal a strong positive association between N, BA and CFDI for 0 and -1 lag comparisons. Overall, cross-correlations are greater in the HL (Nl=0=0.74, Nl=-1=0.59; BAl=0=0.60, Bal=-1=0.45) and MED (Nl=0=0.64, Nl=-1=0.48; BAl=0=0.43, Bal=-1=0.23) regions, and higher in the case of number of fires. The NW region shows moderate correlations (Nl=0=0.43, Nl=-1=0.29; BAl=0=0.50, Bal=-1=0.36) possibly due to its differential intra-annual behavior, with a secondary occurrence peak during winter way larger than the other regions. This secondary maximum is linked with human activities rather than weather conditions, which may explain the low correlation values. In the case of the trend component an increase in CFDI is detected. In turn, according to Mann-Kendall, N shows significant and positive trends in NW and HL, while MED experienced decreased fire occurrence. BA showed non-significant trends in all the study area excluding MED, with a negative trend. However, correlation values depict a different scenario than that from the seasonal component. No association is detected in NW (N,BAl=n≈0). The combination of negative trend in N and BA and overall positive trend in CFDI produces negative correlations values (N,BAl=n<0.3). The only region with positive association is observed in N in HL (Nl=n>0.4). We can conclude that weather conditions control intra-annual variation of fire activity but has limited influence on long-term trends. The spatial disaggregation of the CCF yields positive association of CFDI and N both for season and trend components in part of Spain.