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Seasonal forecasting of fire weather based on a new global fire weather database

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Introduction

Seasonal forecasting of fire weather is examined based on a recently produced global database of the Fire Weather Index (FWI) system beginning in 1980. Seasonal average values of the FWI are examined in relation to measures of the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). The results are used to examine seasonal forecasts of fire weather conditions throughout the world.

Data and methods

FWI data are obtained from the Global Fire Weather Database (GFWED) as described by Field et al. [2015]. The data have a spatial resolution of 0.667 degrees in longitude and 0.5 degrees in latitude. Seasonal average values of the data for December, January and February (DJF), March, April and May (MAM), June, July and August (JJA) and September, October and November (SON) are examined here for the period from 1983 to 2014. The FWI data are based on wind speed, relative humidity and temperature (obtained from the NASA Modern Era Retrospective-Analysis for Research and Applications, MERRA [Rienecker et al. 2011]) together with precipitation from a gridded analyses of land-based rain gauge data (obtained from the Climate Prediction Center, CPC, of NOAA [Chen et al. 2008]).

The El Niño-Southern Oscillation (ENSO: as represented by the NINO3.4 index) and the Indian Ocean Dipole (IOD: as represented by the Dipole Mode Index, DMI) are examined based on sea-surface temperature (SST) data obtained from the CPC. Seasonal averages of these indices are used here for the DJF, MAM, JJA and SON seasons.

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Hindcasts (i.e., reforecasts) of NINO3.4 values were obtained from NOAA for the 1996-2010 period, based on forecasts of the tropical Pacific SSTs [Xue and Leetmaa, 2000]. Seasonal average values are used here for the DJF, MAM, JJA and SON seasons, with the hindcast values based on a three-month lead time prior to the start of a season (e.g., values for the DJF season are based on initial conditions for the preceding September).

The sample Pearson's correlation coefficient, r, is used to examine the dependence between datasets. The 95% confidence level is used to examine the significance of results, determined using a nonparametric bootstrap method based on 10 000 random permutations of the data, with two-sided confidence intervals based on percentiles.

Results

Large-scale drivers of fire weather variability

Figure 1 shows the relationship between ENSO and the FWI. The correlations are calculated individually for each grid point of the study region. Correlations are based on seasonal values throughout the 32-year study period (from 1983 to 2014) and are calculated individually for each season. Figure 2 is similar to Figure 1, but for the relationship between IOD and the FWI.

The correlations shown in Figures 1 and 2 indicate that for each of the four seasons, ENSO appears to have a stronger and more widespread influence than the IOD in general throughout the world. Additionally, the significant relationships that do occur between DMI and the FWI are broadly similar to the results for NINO3.4 in some cases (noting that ENSO and IOD are somewhat related [Allan et al. 2001]). Hence hereafter the focus is on the ENSO/FWI relationship.

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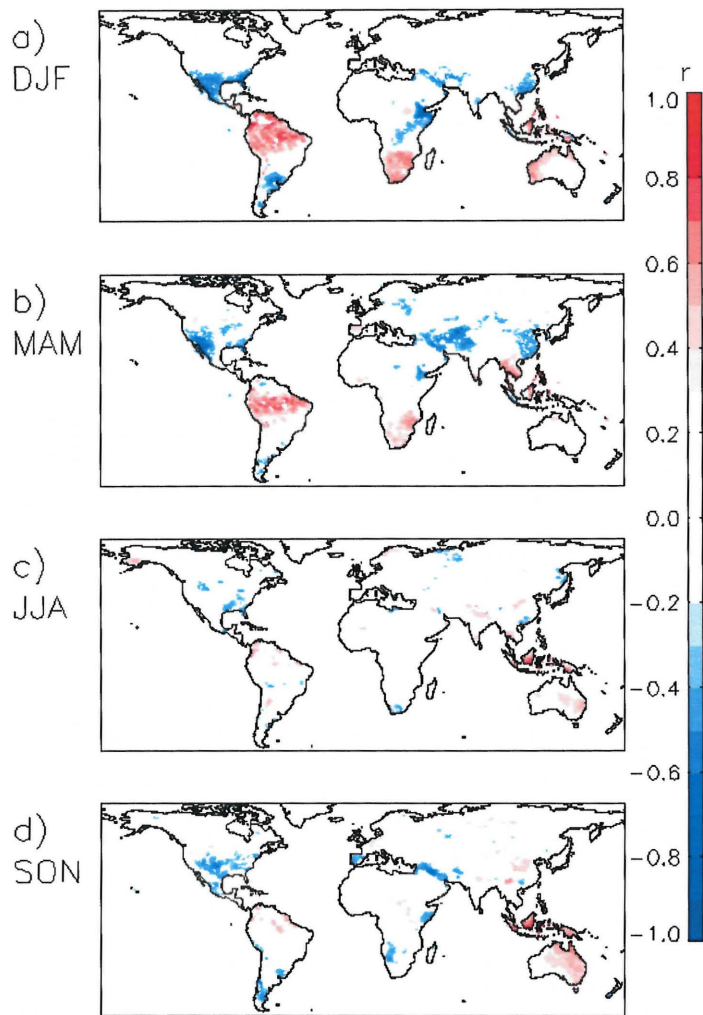Published by the International Association of Wildland Fire, Missoula, Montana, USA

Figure 1: Correlations between seasonal mean values of FWI and NINO3.4 (as an indication of ENSO conditions) for the period from 1983 to 2014. The correlations are shown for locations where the relationship is significant at the 95% confidence level, calculated individually for each season: DJF (a), MAM (b), JJA (c) and SON (d).

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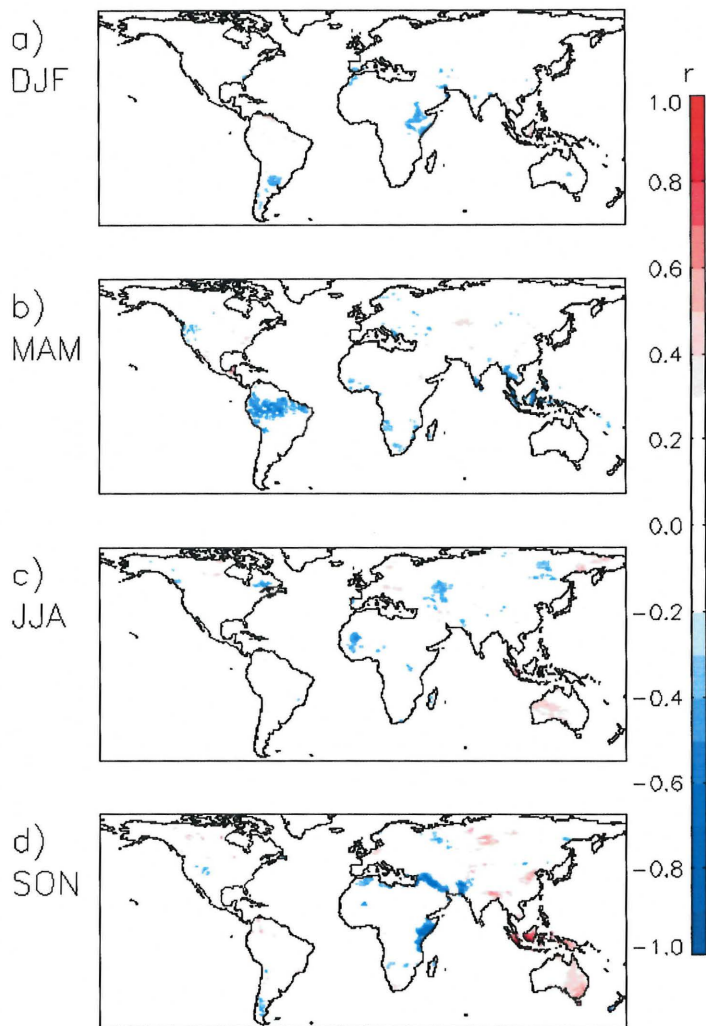
Figure 2: Correlations between seasonal mean values of FWI and DMI (as an indication of IOD conditions) for the period from 1983 to 2014. The correlations are shown for locations where the relationship is significant at the 95% confidence level, calculated individually for each season: DJF (a), MAM (b), JJA (c) and SON (d).

Predictability

Predictions of FWI values, as either higher or lower than their seasonal median value, are considered here based on whether the hindcast NINO3.4 values are higher or lower than their seasonal median value. For example, in cases where a positive correlation occurs (from Fig. 1) a high FWI value would be predicted if the hindcast NINO3.4 value is high, with the converse being the case for negative correlations.

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Figure 3 shows the prediction accuracy, calculated as the number of correct predictions divided by the total number of predictions during the period 1996-2010. The accuracy is higher in general for DJF, MAM and SON than for JJA. The low accuracy during JJA is associated with a period of low hindcast skill for NINO3.4 in the months preceding the JJA season (i.e. March, April and May) and is an example of the challenges that remain in understanding ENSO variability and predictability. There are a number of cases where the accuracy of the predictions is relatively high (e.g., above 80%) throughout large geographic regions, such as in northern and eastern Australia for the SON season.
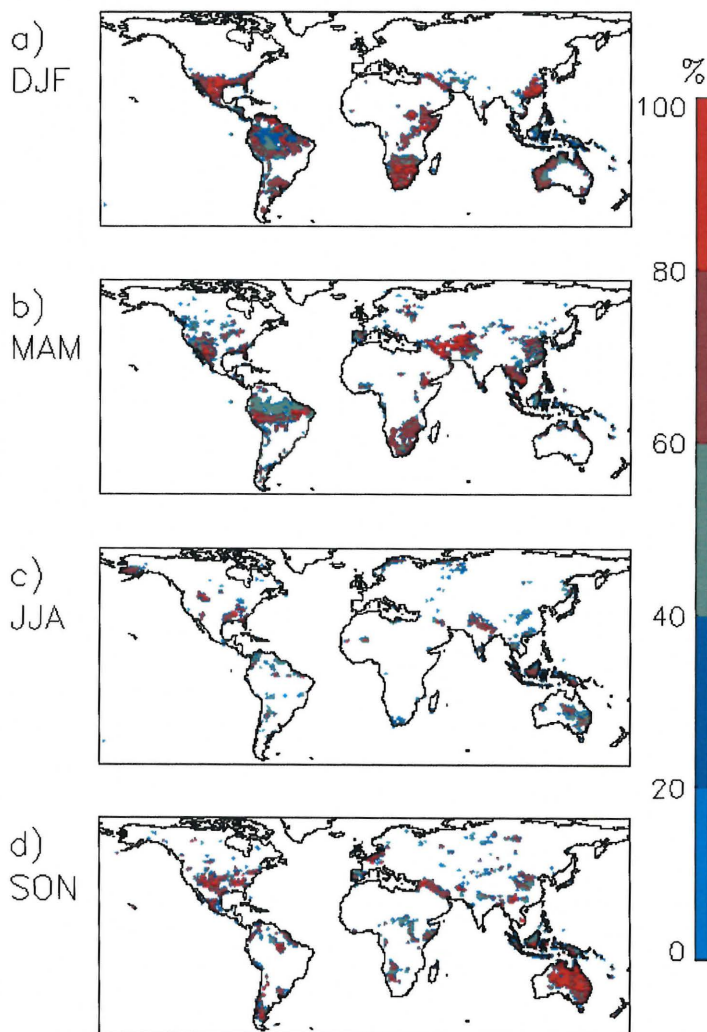

Figure 3: Seasonal prediction of global fire weather, with a lead time of 3 months. The accuracy of the forecast is shown here as the percentage number of predictions that are correct, based on predictions of FWI values as either above or below the seasonal median value, for the period from 1996 to 2010. This is shown for locations where a significant relationship exists between FWI and the NINO3.4 index (from Fig. 1).

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Conclusions

A recently produced database of the Fire Weather Index (FWI) system was used to examine seasonal forecasting of fire weather conditions. ENSO was found to have a stronger and more widespread influence on fire weather conditions than IOD in general throughout the world. As ENSO can be predictable several months in advance in some cases, this relationship was used to examine seasonal predictions of fire weather conditions. The results indicate considerable accuracy in predicting the upcoming seasonal fire weather conditions for various seasons and regions throughout the world.

Acknowledgements

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