Geophysical Research Abstracts
Vol. 12, EGU2010-5597, 2010
EGU General Assembly 2010

Linking Satellite-Derived Fire Counts to Satellite-Derived Weather Data in Fire Prediction Models to Forecast Extreme Fires in Siberia

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Fire is the dominant disturbance that precipitates ecosystem change in boreal regions, and fire is largely under the control of weather and climate. Boreal systems contain the largest pool of terrestrial carbon, and Russia holds 2/3 of the global boreal forests. Fire frequency, fire severity, area burned and fire season length are predicted to increase in boreal regions under climate change scenarios. Meteorological parameters influence fire danger and fire is a catalyst for ecosystem change. Therefore to predict fire weather and ecosystem change, we must understand the factors that influence fire regimes and at what scale these are viable.

Our data consists of NASA Langley Research Center (LaRC)-derived fire weather indices (FWI) and National Climatic Data Center (NCDC) surface station-derived FWI on a domain from 50°N-80°N latitude and 70°E-170°W longitude and the fire season from April through October for the years of 1999, 2002, and 2004. Both of these are calculated using the Canadian Forest Service (CFS) FWI, which is based on local noon surface-level air temperature, relative humidity, wind speed, and daily (noon-noon) rainfall. The large–scale (1°) LaRC product uses NASA Goddard Earth Observing System version 4 (GEOS-4) reanalysis and NASA Global Precipitation Climatology Project (GEOS-4/GPCP) data to calculate FWI. CFS Natural Resources Canada uses Geographic Information Systems (GIS) to interpolate NCDC station data and calculate FWI.

We compare the LaRC GEOS- 4/GPCP FWI and CFS NCDC FWI based on their fraction of 1° grid boxes that contain satellite-derived fire counts and area burned to the domain total number of 1° grid boxes with a common FWI category (very low to extreme). These are separated by International Geosphere-Biosphere Programme (IGBP) 1°x1° resolution vegetation types to determine and compare fire regimes in each FWI/ecosystem class and to estimate the fraction of each of the 18 IGBP ecosystems burned, which are dependent on the FWI. On days with fire counts, the domain total of 1°x1° grid boxes with and without daily fire counts and area burned are totaled. The fraction of 1° grid boxes with fire counts and area burned to the total number of 1° grid boxes having common FWI category and vegetation type are accumulated, and a daily mean for the burning season is calculated. The mean fire counts and mean area burned plots appear to be well related.

The ultimate goal of this research is to assess the viability of large-scale (1°) data to be used to assess fire weather danger and fire regimes, so these data can be confidently used to predict future fire regimes using large-scale fire weather data. Specifically, we related large-scale fire weather, area burned, and the amount of fire-induced ecosystem change. Both the LaRC and CFS FWI showed gradual linear increase in fraction of grid boxes with fire counts and area burned with increasing FWI category, with an exponential increase in the higher FWI categories in some cases, for the majority of the vegetation types. Our analysis shows a direct correlation between increased fire activity and increased FWI, independent of time or the severity of the fire season. During normal and extreme fire seasons, we noticed the fraction of fire counts and area burned per 1° grid box increased with increasing FWI rating. Given this analysis, we are confident large-scale weather and climate data, in this case from the GEOS-4 reanalysis and the GPCP data sets, can be used to accurately assess future fire potential. This increases confidence in the ability of large-scale IPCC weather and climate scenarios to predict future fire regimes in boreal regions.