# Using Satellite and Station Data to Evaluate the Ability of Fire Weather to Estimate Extreme Fire Events in Siberia in Preparation for Future Fire Weather Prediction


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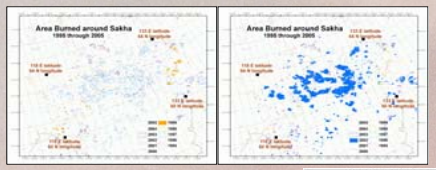
*Introduction:* **Fire is the dominant disturbance that precipitates ecosystem change in boreal regions, and fire is largely under the control of weather and climate[1,2,3]. Boreal systems contain the largest pool of terrestrial carbon, and Russia holds about 2/3 of the boreal forests. Fire frequency, fire severity, area burned and fire season length are predicted to increase in boreal regions under current climate change scenarios[4]. Therefore to predict fire weather and ecosystem change, we must understand the factors that influence fire regimes and at what scale these are viable.**

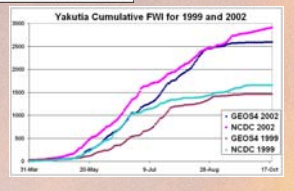
*Objective:* **The goal of this research is to assess the viability of large-scale (1°) data to be used to assess fire weather severity and fire regimes, so that large-scale data can be confidently used to predict future fire regimes using large-scale fire weather data, like that available from current International Panel of Climate Change (IPCC) climate change scenarios.**

*Methodology:* **We compare fire indices from interpolated surface station and large-scale reanalysis data during the fire season in Siberia in 1999, 2002 and 2004. The Canadian Fire Weather Index (FWI) is used for this comparison, and it is calculated using local noon surface-level air temperature, relative humidity, wind speed, and daily (noon-noon) rainfall[5,6]. The Canadian Forest Service (CFS) Natural Resources Canada derived spatially-explicit FWI for Russia by interpolating National Climatic Data Center (NCDC) surface station data to 0.04°x0.04° resolution in Geographic Information Systems (GIS). For this comparison, these data are re-gridded to 1°x1° by averaging the data in each cell. Large-scale FWI are calculated at the NASA Langley Research Center (LaRC) using NASA Goddard Earth Observing System version 4 (GEOS-4) large-scale reanalysis and NASA Global Precipitation Climatology Project (GPCP) data. The GEOS-4 reanalysis weather data are 3-hourly data at a 1°x1° resolution and the GPCP precipitation data are also at 1°x1° resolution.**




| FWI Category Danger Rating | |
|---|---|
| Danger Class | FWI Range |
| Very Low | 0-1 |
| Low | 2-4 |
| Moderate | 5-8 |
| High | 9-16 |
| Very High | 17- 29 |
| Extreme | 30 + |

**Comparison of a minimal fire year (1999) and an extreme fire year (2002) for 1 station [Sakha (formerly Yakutia)], demonstrating the ability of the FWI to capture extreme fire weather and fire seasons. The LaRC NCDC and LaRC GEOS-4/GPCP cumulative FWI are in close agreement throughout the fire seasons[7].**

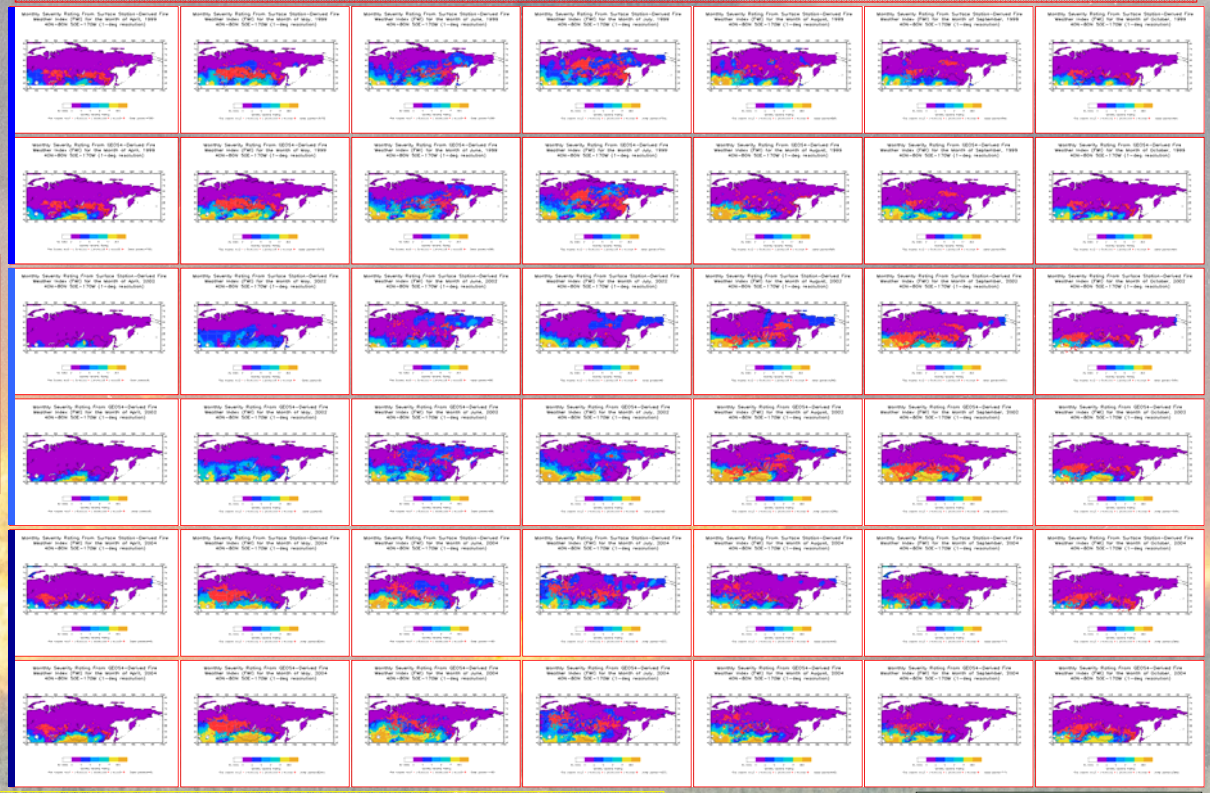



**In general, the daily and monthly patterns of LaRC GEOS-4- and CFS NCDC-based FWI are remarkably similar. Also, increasing FWI correlate well with the increasing number of active fire counts and relative fire activity.**

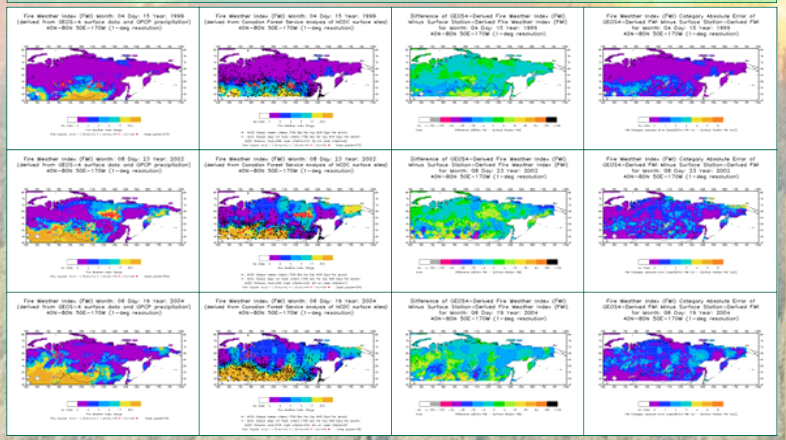
**The influence of weather and climate on the fire season are evident, as the larger FWI categories move north and south in sync with summertime seasonal warming and cooling. The daily time series is too large for display, however we hope to make these data available on a website in the next few months. The MSR is designed to emphasize the larger FWI values[8].**

$$MSR = \sum_{i=1}^{n} 0.0272 * FWI_i^{1.77}$$

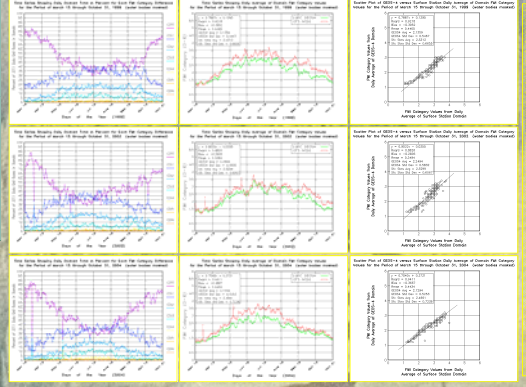
*Time Series of LaRC GEOS4-derived and CFS NCDC-interpolated Monthly Severity Ratings (MSR) Overlain with Fire Counts.*



*Examples of Daily Langley-derived GEOS-4/GPCP FWI, CFS-interpolated Surface FWI, Total FWI Difference and Category FWI Difference*



*Time Series and Scatter Plot Comparisons of GEOS-4/GPCP-derived and NCDC-interpolated FWI Category Differences*



**In this comparison, the difference in FWI categories are accumulated daily over the geographic domain and shown in percent total in each of the seven FWI Categories for March through October in 1999, 2002 and 2004. Additionally, the daily average of each of the domain FWI categories is shown over time.**

**The greatest difference between the LaRC GEOS/GPCP- and CFS NCDC-based FWI is during the peak of the fire season (~ June 1st – August 15th). Even then, approximately 74% of the cells contain 1 category FWI difference or less (2 CD ~18%; 3 CD ~7%). The larger differences are generally at the edges of large regions of agreement and in the south.**

**The station and large-scale FWI correlate well spatially and temporally resulting in overall $R^2$ values of 0.92 in 1999, 0.88 in 2002 and 0.94 in 2004. Even though the data correlate well, the CFS NCDC time series (red) data are consistently larger, which is likely due to the interpolation process.**

*Conclusion:*

**The LaRC GEOS-4/GPCP and CFS NCDC fire weather indices compare well spatially, temporally and quantitatively, and increased fire activity generally compares well with increasing FWI ratings.**

**The density and accuracy of Siberian surface station data can be limited, which would lead to results that might not be representative of the spatial reality. *GEOS-4/GPCP-derivied FWI can serve to spatially enhance current and historic FWI, because these data are spatially and temporally consistency.***

**Most importantly, large-scale weather and climate data, in this case from the GEOS 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.* In future work, we will statistically compare fire counts to FWI categories.**

*CFS-NCDC interpolated station data offers detailed weather data that are available from Siberia, however one advantage of the LaRC-GEOS data is that it is spatially and temporally consistent over time. Surface station locations are overlaid on the CFS-NCDC maps highlighting data availability and the distance between the stations.*

**NCDC stations meeting the criteria of 75% of the possible reporting observations per day and 60% of the possible days in each month are indicated with black circles. Those not meeting the criteria but used in FWI interpolation are indicated with open boxes.**

**Fire counts are shown in red.**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Background photo provided by Brian Stocks.