Wildfire duration model for Air Quality Forecast systems

Jong-Jae Lee[1,2], Hyun Cheol, Kim[2,3], Cheol Hee Kim[1], Fantine Ngan[2,3], Ariel Stein[2,4], and Pius Lee[2]

[1]Division of Earth Environmental System, Pusan National University, Busan, Korea
[2] NOAA/Air Resources Laboratory, College Park, MD
[3] Cooperative Institute for Climate and Satellites (CICS), College Park, MD
[4] ERT, Inc. Laurel, MD

(Email: jongjae.lee@noaa.gov or leejongjae2791@gmail.com)

Introduction

- Wildfire is one of major concerns in the United States' regional air quality, and the establishment of effective prevention and early warning systems are crucial to reduce impacts on the environment and losses of properties.
- In order to forecast the impact of wildfire emissions to regional air quality, it is essential to have accurate and prompt detection of wildfire events with respect to both timing and location. Satellite detection of active wildfires is one of the most efficient ways of retrieving wildfire information, and is widely used for fire impact forecast systems. Such systems, however, have inherent weaknesses since satellite products have finite latency, so they cannot provide any fire emission information for the real-time and the future.
- We utilize Fire weather index (FWI), which is daily indicator of fire danger based upon meteorological information, to develop wildfire duration model. The goal of this study is to provide information for predicting how long current fire events, detected by satellites, can last by given meteorological conditions.

Data

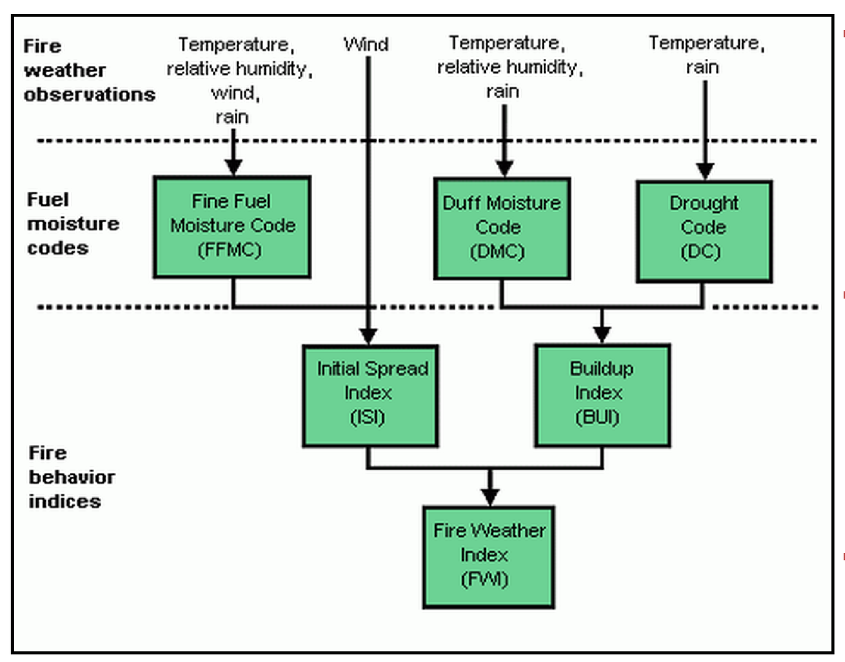

Fig. 1. Structure of the FWI System (www.nrcan-rncan.gc.ca)

- **Canadian Fire Weather Index (FWI)** is an index for fire danger, and is constructed using four meteorological conditions: 24-hr accumulated precipitation, temperature (°C), relative humidity, and wind speed (km h^{-1}), at noon local standard time. Based on these four variables, six standard components are computed, and then merged to calculate FWI.
- Satellite-detected fire data come from the National Oceanic and Atmospheric Administration (NOAA) **Hazard Mapping System (HMS**; http://www.ssd.noaa.gov/PS/FIRE/hms.html). HMS fire data are created by combining hot-spot detections from several satellites and applying manual quality control by a trained satellite-data analyst.
- The Weather Research and Forecasting (WRF) Model was used to provide meteorological fields to compute FWI. The study domain covers contiguous US in 36-km resolution and the simulation period is May, 2012.

Results & Discussions

1. Wildfires in North America

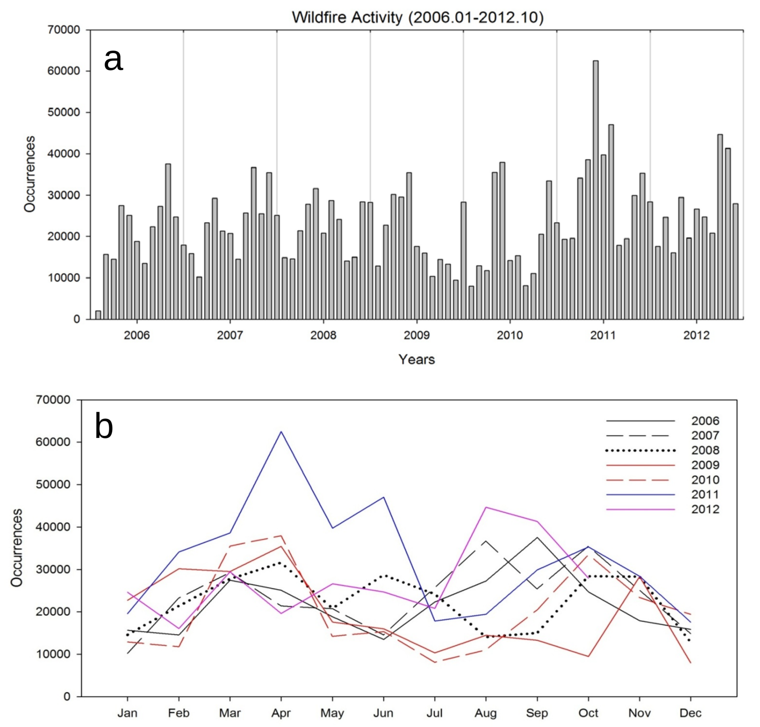

Fig. 2. Time series (a) and seasonal variations (b) of the HMS fire detections in CONUS

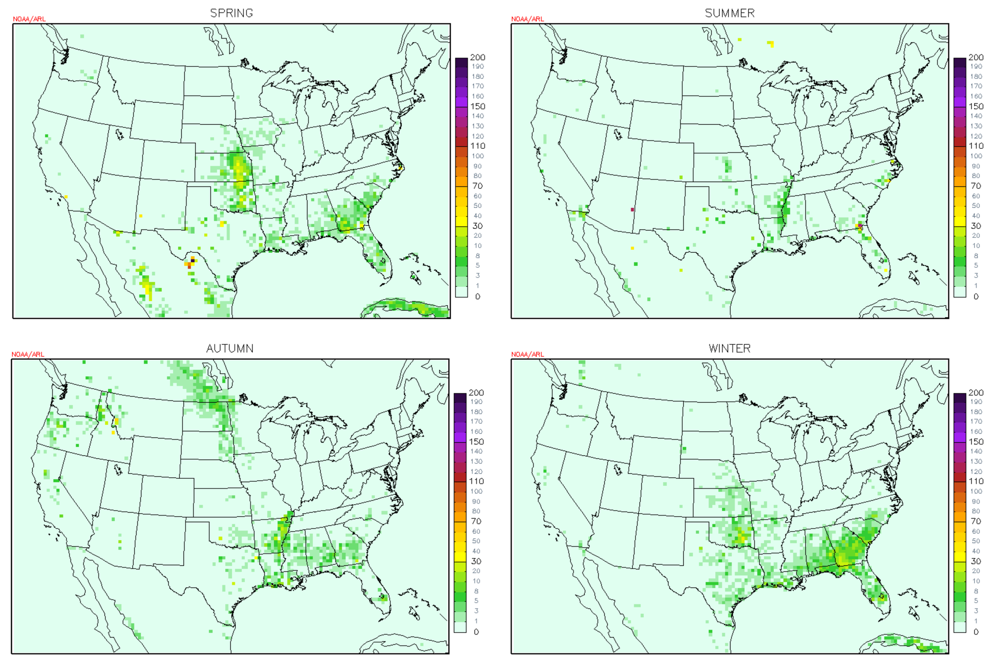

Fig. 3. Spatial distribution of the seasonal fire occurrence during 2006-2012

- Wildfires in North America has two seasonal peaks in spring and autumn.
- Interannual variations show a high peak in 2011 spring, associated with severe drought in that season.

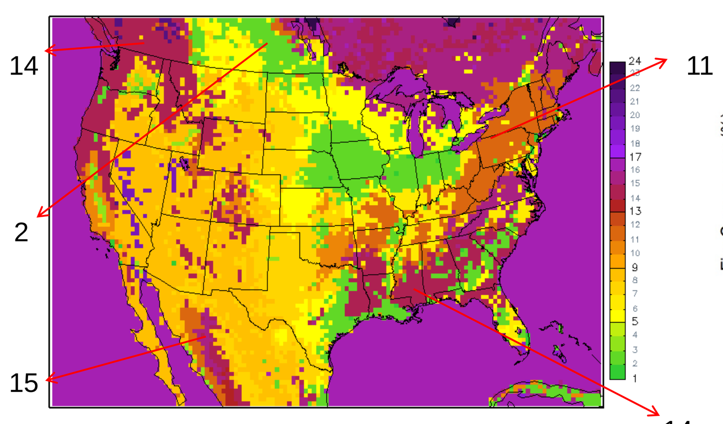

Fig. 4. Spatial distribution of land-use categories (USGS24). Arrows and numbers indicate USGS land-use type at each region.

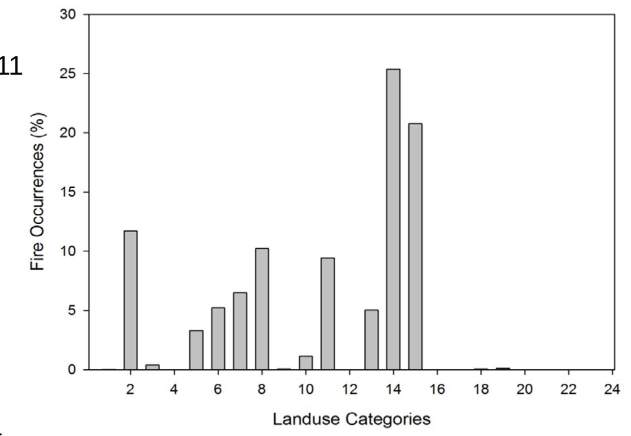

Fig. 5. Percent of Fire Occurrence for each land-use category during May 2012.

- USGS numbers 2, 11, 14, and 15 indicate dry land/crop, deciduous broadleaf, evergreen needle and mixed forest, respectively.
- Evergreen (13 and 14) and mixed forest (15) are dominant land-use type in the study domain, nearly 50% of total fire occurrence.
- Crop mosaic areas and evergreen areas are related with spring season fires and deciduous broadleaf and dry land/crop areas are related with autumn season (harvest season).

2. FWI and Fire Occurrence

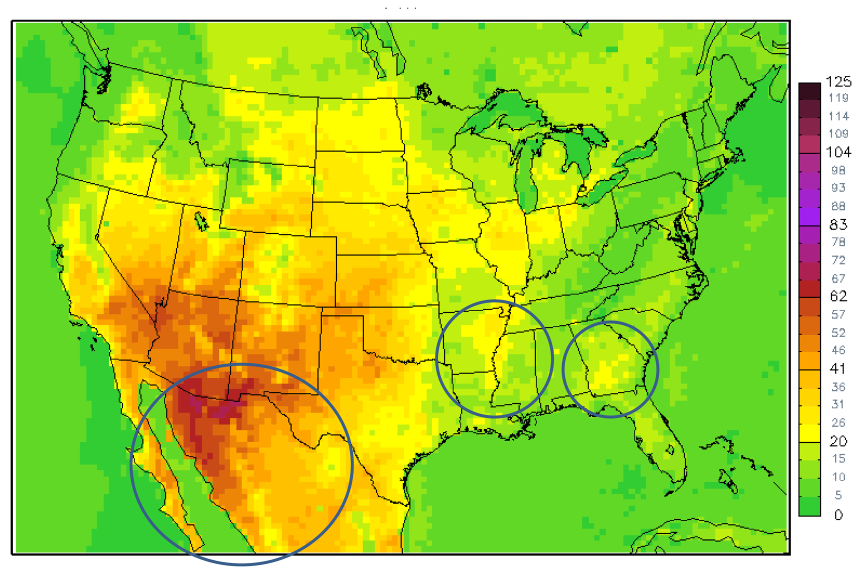

Fig. 6. Spatial distribution of averaging FWI in May 2012.

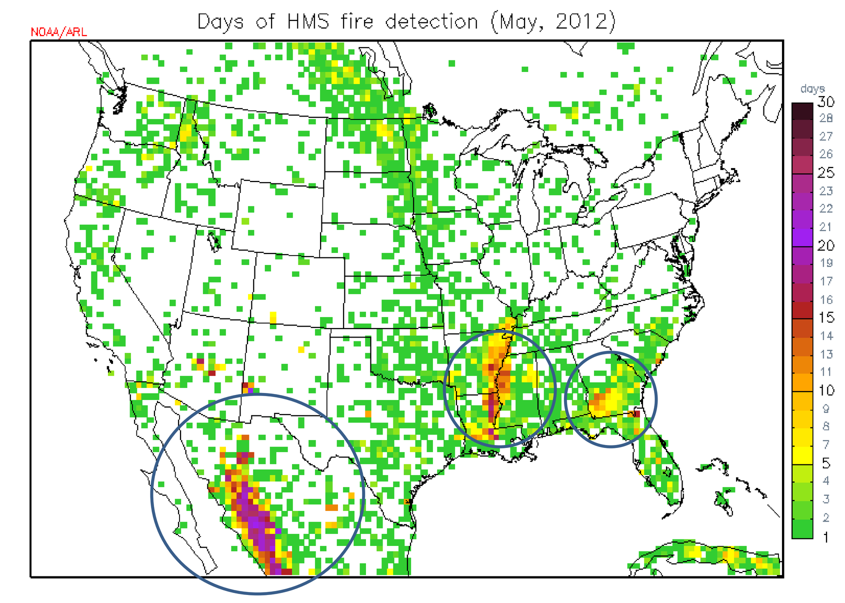

Fig. 7. Number of days with HMS fire detection in May 2012.

- Wildfire occurrence is usually well associated with high FWI (Fig. 6 & 7), but high FWI does not always guarantee fire occurrence. This implies more local conditions should be considered to predict the initiation of wildfires.

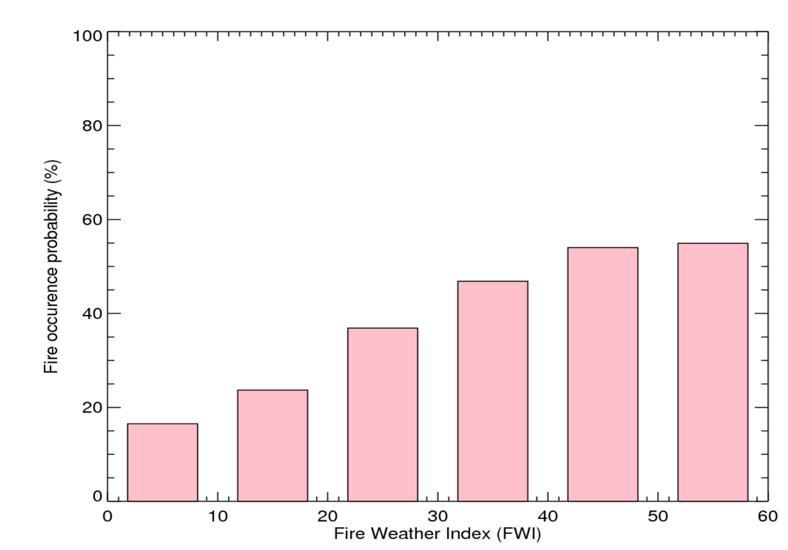

Fig. 8. Probability distribution of fire occurrence according to Fire Weather Index (FWI).

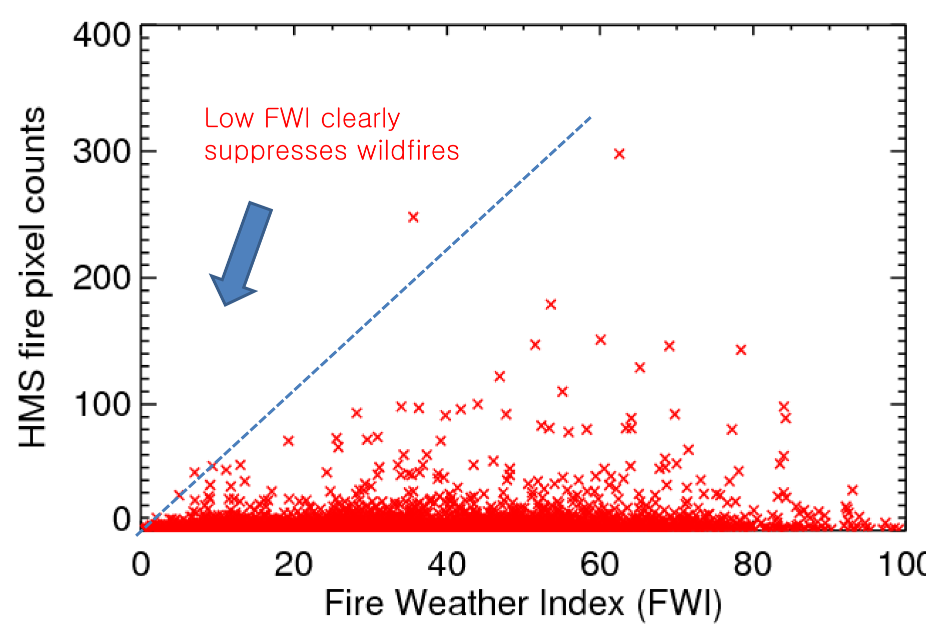

Fig. 9. Relationship between Fire Weather Index (FWI) and fire occurrence

- By examining high fire frequency regions (+5 days from Fig. 7), the fire occurrence probability is well correlated with FWI (Fig. 8)
- Fig. 9 shows that low FWI clearly suppresses wildfires, so we can assume next day's fire frequency will be reduced a lot, if next day's FWI is very low.

3. Fire suppression by FWI and fire emission estimation

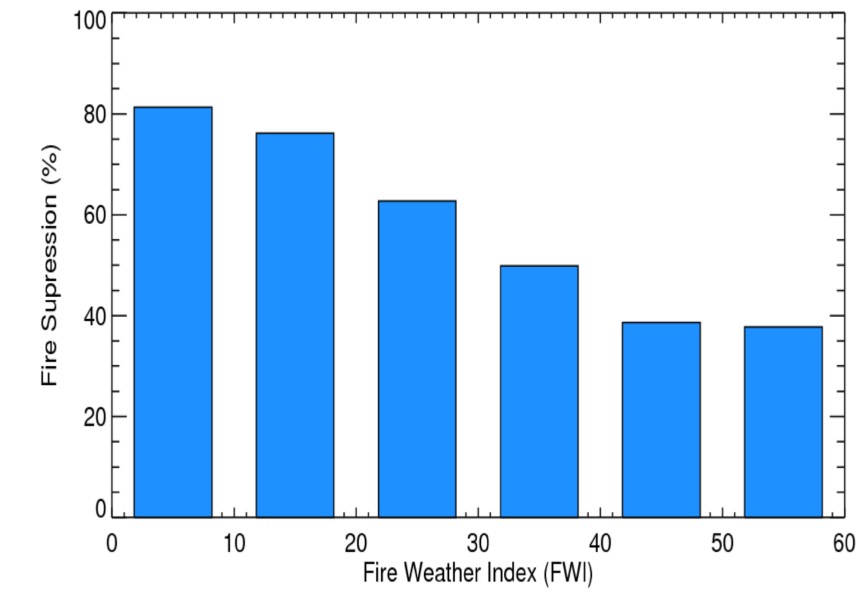

Fig. 10. Fire suppression rate according to FWI

- Although there is still very high uncertainty in predicting the initiation of wildfires according to FWI, the duration of existing wildfire events, however, is more robust because we already know the occurrence of wildfire events.
- By investigating 2 consecutive days' fire occurrence frequency, we calculated fire suppression rate in 10-FWI bins, which can be used as fire emission decaying rate.
- For AQF systems, we can assume tomorrow's fire emission using fire suppression rate based on FWI.

$$Fire\ emission_{tomorrow} = Emission_{today} \cdot (1 - Fire\ suppression\ rate)$$

Conclusive remarks & Future Work

- Reasonable estimation and prediction of wildfire emissions is very important in Air Quality Forecast systems. Most of previous systems did not have a capability of future wildfire emission prediction, or have used a flat decaying rate of fire emissions, without considering changes of weather conditions.
- We have utilized HMS satellite fire detection produces and Canadian Fire Weather Index (FWI), to develop a wildfire duration model, which predict the change of future fire emission, based on today's satellite fire detection and tomorrow's FWI calculation.
- We will extend this analysis for longer time period (multiple years) and with the use of detailed land use data.