Forecasting Long-Range Transport of Wildfire Smoke in North America with the FireWork Air Quality Forecast System

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Abstract

The wildfire season in Canada generally starts in the spring and ends in the late fall. ECCC has been running an AQ forecast system with near-real-time biomass-burning emissions named FireWork during the Canadian wildfire season since 2013. ECCC objectives for FireWork are not limited to AQ forecasts for regions close to wildfires. Long-range transport and the associated pollution at different atmospheric levels are also considered. In fact, over the last four years, a number of major wildfire events have occurred in western Canada and the western U.S., where smoke from these fires has been transported over long distances, affecting air quality even in eastern North America. In particular, in both 2014 and 2015, smoke from wildfires in northwestern Canada travelled thousands of kilometers across North America, reaching the East Coast and the Gulf of Mexico. This poster presents analyses of forecasted long-range transport of wildfire smoke using surface observations and satellite images. Lessons learned, model weaknesses, and potential improvements are also reviewed.

Long-Range Transport of Wildfire Smoke

Figure 1: Aerial photo of 2014 wildfires in western Canada.

- Smoke from wildfires can be transported thousands of kilometers downwind and even injected into stratosphere by intense pyroCb's.
- Over the last few years, smoke from wildfires in western Canada has been transported for more than 10,000 km downwind, reaching northern Europe.
- Since 2013 ECCC has run FireWork, an AQ forecasting system with near-real-time biomass-burning emissions; during this time FireWork has demonstrated the ability to forecast the long-range transport of wildfire pollution across North America.

2013

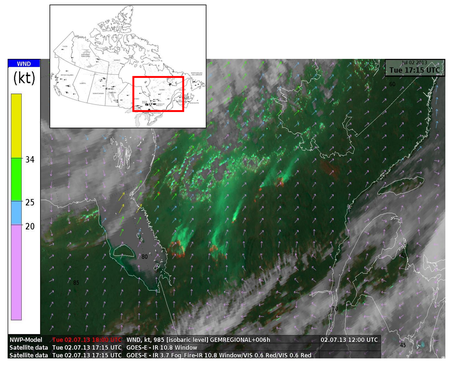


Figure 2: GOES-E satellite Image with detected Quebec wildfires (red dots) and forecasted winds, both valid at 2013-07-02 17:15UTC. Strong westerly winds transported smoke toward the Atlantic Ocean.

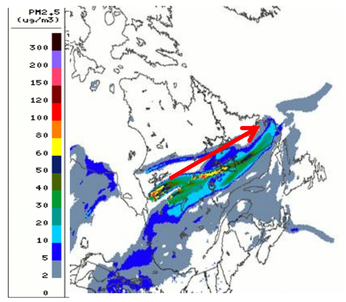
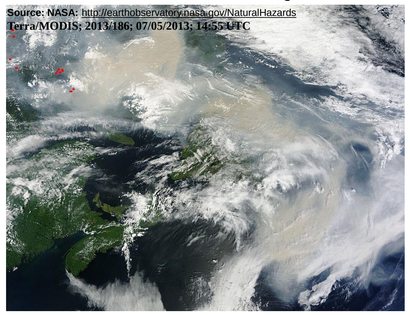


Figure 3: Contribution of forecasted wildfire emissions to total surface $PM_{2.5}$ field valid at 2013-07-04 00UTC, forecasted by the 2013-07-03 00UTC model run.

Smoke and Wildfires in Quebec



Smoke from Canadian fires over Scandinavia

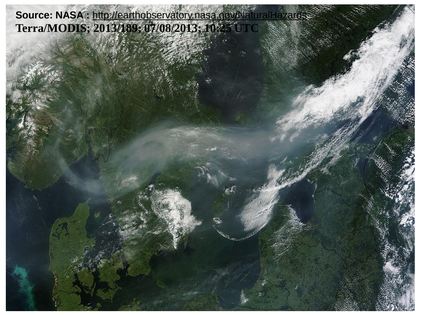


Figure 4: MODIS satellite images over eastern Canada and the Atlantic Ocean (left) valid at 2013-07-05 14:55UTC and over Scandinavia (right) valid at 2013-07-08. In 5-6 days, smoke from wildfires in western Quebec was **transported downwind for more than 10.000 km**, reaching Northern Europe on July 8th 2013.

2014

In July 2014 the Northwest Territories of Canada experienced one of its worst fire seasons. Smoke from these wildfires reached the central U.S. and the East Coast.

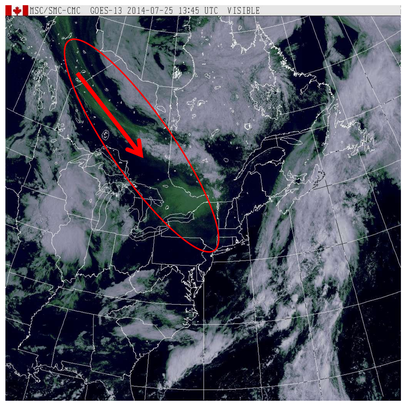


Figure 5: MODIS satellite image valid at 2014-07-25 13:45UTC. The region with detected smoke layers transported from the Northwest Territories is encircled in red.

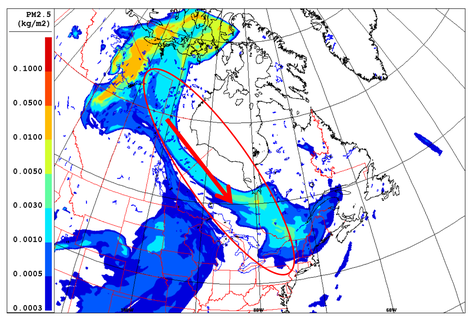


Figure 6: Contribution of forecasted wildfire emissions to total column $PM_{2.5}$ valid at at 2014-07-25 13UTC, forecasted by the 2014-07-24 12UTC run. This forecast was issued 24 hours before the smoke was detected by satellite images (shown in Figure 5).

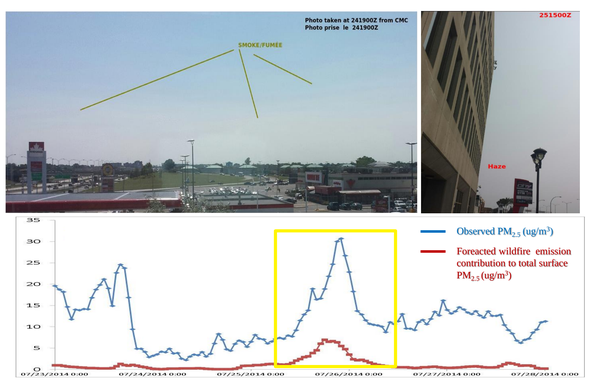


Figure 7: Smoke from the Northwest Territories wildfires was observed in Montreal, Quebec, roughly 3500 km downwind, on July 9th 2014. This smoke can be seen in the 2 images to the left taken in the front of the Canadian Meteorological Centre building in Montreal.

FireWork forecasted 48 h in advance (bottom image) the time when wildfire smoke reached Montreal.

This example demonstrates FireWork's capability to forecast long-range transport thousands of kilometers from the source.

2015

According to the Canadian Interagency Forest Fire Centre (CIFFC: http://www.ciffc.ca), in terms of total area burned in Canada, 2014 was the 5th most intense wildfire season in the past 34 years, followed by 2015, which was the 6th most intense season.

In 2015, the majority of intense wildfires occurred in northwestern Canada from mid June to mid July. Pollution from these wildfires reached the Gulf of Mexico and the Atlantic Ocean.

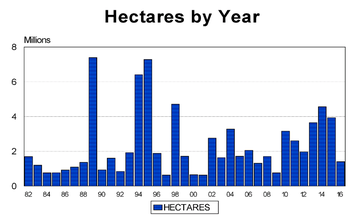


Figure 8: Total area burned (1982-2016) by wildfires in Canada (source: CIFFC, 2006).

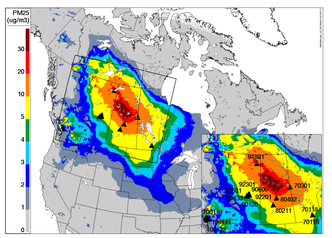


Figure 9: Contribution of forecasted wildfire emissions to average surface $PM_{2.5}$ concentrations for the period from June 24 to July 15, 2015 over the FireWork domain. The graphical insert shows a zoomed region and AQ observations stations affected by smoke.

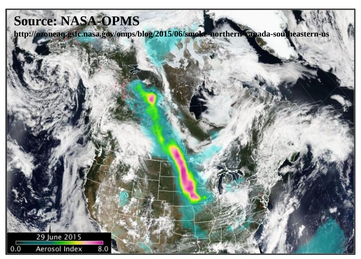


Figure 10: MODIS satellite image valid at 2015-06-29 12UTC with the OMPS (Ozone Mapping & Profiler Suite) aerosol index superimposed.

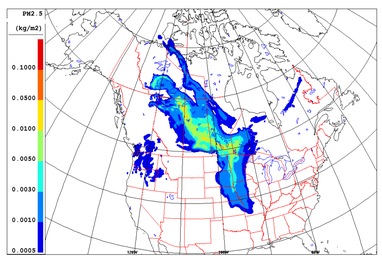


Figure 11: Contribution of forecasted wildfire emissions to total column $PM_{2.5}$ valid at at 2015-06-29 12UTC, forecasted by the 2015-06-28 12UTC run. The region affected by smoke was forecasted 24 hours in advance.

2016

The 2016 Canadian wildfire season was marked by the **Fort McMurray wildfire** that occurred in May near this industrial city in the oil sands area of northeastern Alberta. Part of the city was burned, causing the evacuation of 88,000 people down a single highway.

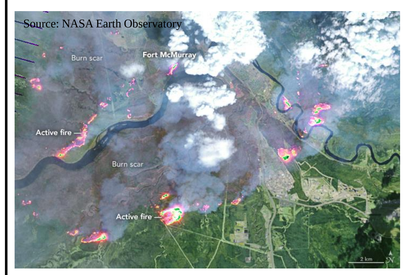


Figure 12: Infrared, near infrared and green-light images from Landsat 7, taken on May 4th 2016 are combined here to penetrate the clouds and reveal burn scars and hot spots.

Figure 13: A view of the Fort McMurray wildfire from a nearby highway. Photo taken on April 3rd 2016.

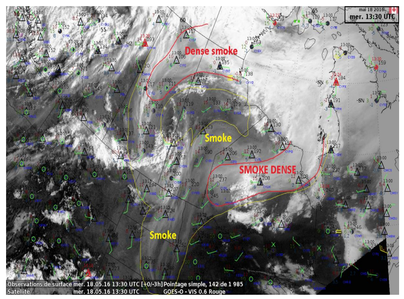


Figure 14: GOES satellite image showing the area affected by wildfire smoke, analyzed by operational Canadian Meteorological Centre forecasters, valid for May 18th 2016 13:30UTC

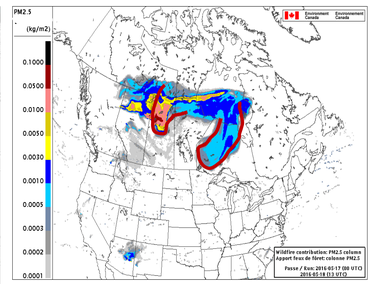


Figure 15: Contribution of wildfire emissions to total column $PM_{2.5}$ valid at 2014-07-25 13UTC, forecasted by the 2014-07-24 12UTC run. The region affected by dense smoke was forecasted 24 h in advance.

Conclusions

The ECCC AQ forecasting system with near-real-time biomass burning emissions, named FireWork has proven to be capable of forecasting the long-range transport of wildfire pollution. This capability was demonstrated during the 2014, 2015 and 2016 wildfire seasons, when smoke from wildfires in northwestern Canada travelled thousands of kilometers across North America, reaching the East Coast and the Gulf of Mexico. FireWork forecasts correlated well with satellite images in terms of the time and area affected by long-range transport. However some $PM_{2.5}$ under-estimates were sometimes observed. ECCC will continue to improve FireWork, especially wildfire emission estimates, injection heights and dispersion. Some major improvements are planned for the next (2017) wildfire season.