The Canadian Smoke Newsletter

2015

"Connecting diverse terrestrial, emissions, air quality and modelling communities."

Welcome to the 2015 issue of the Canadian Smoke Newsletter.

The spring and early summer of 2015 have certainly left an impression on Western Canada. As of early July, substantial portions of the western provinces as well as the southern Northwest Territories were covered with fire and smoke. Southwestern British Columbia coped with significant drought while Vancouver and area experienced smoke-related air quality advisories. Over 10,000 people were evacuated from communities in northern Saskatchewan. Huge plumes of smoke wafted southward to affect the continental US (Figure 1a). Fortunately, by mid-July several large low pressure systems moved across the affected regions, generating rain and temporarily alleviating the worst of the conditions.

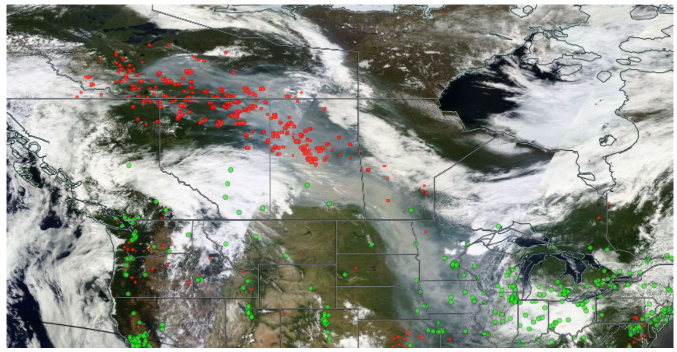
Meanwhile, Eastern Canada, having experienced a colder than normal winter and spring, remained virtually free of significant fires, with the only notable smoke drifting east from Western Canada. According to Natural Resources Canada, the number of fires and area burned in Canada as of July 15, 2015, were 136% and 238% of normal values respectively.

According to NOAA, there is a greater than 90% chance that current El Niño conditions in the Pacific (see Figure 1.b) above) will continue through the 2015-16 Northern Hemisphere winter, and around an 80% chance it will last through early spring 2016. If that forecast succeeds, the potential is there for another round of significant fire and smoke at the start of the next fire season.

Best regards,

Al Pankratz

a)



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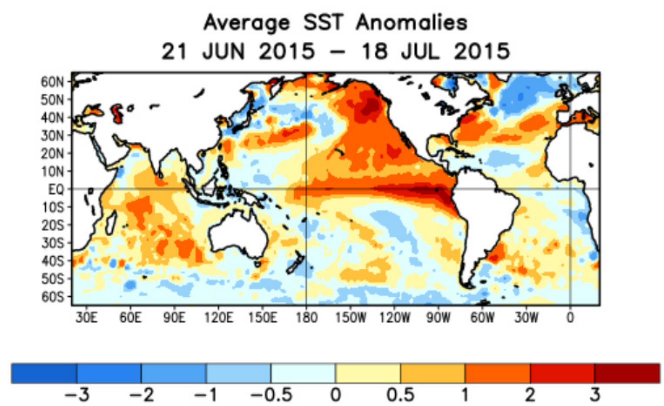

Figure 1. a) June 29, 2015. Smoke from hundreds of wildfires sweeps southeastward into the US, image courtesy NOAA/NASA. b) Sea surface temperature anomalies, courtesy NOAA. Note warm water adjoining western North America.

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In this issue:

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"Connecting diverse terrestrial, emissions, air quality and modelling communities."

A Report on the Halifax National Smoke Forum, October 14, 2014

by Steve Sakiyama[1] , Al Pankratz[2], Brian Simpson[3] and Kerry Anderson[3]

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In order to take advantage of the facilities and organization of the Wildland Fire Canada conference, the BlueSky Canada project team held a one-day forum on wildfire smoke in the same venue the day after the WFC concluded. Approximately 40 attendees enjoyed a packed program of presentations and panel discussions. The following report follows the presentations in order, with the most relevant points extracted from each.

Why Do We Care about Wildfire Smoke?

A Global Fire/Smoke Perspective (Brian Stocks)

- Global burned area is highly variable, generally between 3 and 6 million square kilometers.
- Some areas, such as southeast Asia and South America, get smoke from wildfires more frequently.
- There have been a couple of very significant events that demonstrate how dangerous smoke can be when combined with weather events:
  - o 1997-8 in Indonesia (which was El Niño related), and
  - o 2010 in Moscow, related to drained peatlands that had been abandoned and never reclaimed or re-flooded.
- North America has had episodes from various fires that combined with weather to create air quality issues.
- Most burning in the world is still in the tropical areas, particularly Africa, though fire and smoke seems to be growing in boreal and temperate zones.

Figure 1. National Smoke Forum meeting in the Marriott Harbourfront hotel, Halifax, Nova Scotia.

The History of Wildland Fire Smoke in Manitoba (Barbara Crumb)

- Smoke disproportionately impacts remote communities.
- In Manitoba, 1989 was a record fire year with unprecedented challenges:
  - o 24,500 people from 32 communities were evacuated,
  - o 25 communities were

evacuated in one week,
    - communication was poor with no formalized evacuation plans, and
    - coordination of aircraft to remove people was a problem.
- Most evacuations occurring today are still due to smoke.
- General guidelines that are currently missing but which should be provided are:
    - air quality levels for health that will trigger an evacuation, and
    - the identification of priority groups for evacuations.
- Evacuations are still ad hoc.
- An air quality trigger of an AQHI (Air Quality Health Index) reading > 10 is proposed as a decision point.
- There is a disconnect between fire management agencies and health organizations.

Wildfire Smoke Contribution to Surface $PM_{2.5}$ in Halifax, Nova Scotia during the BORTAS-B Experiment (Mark Gibson)

- The goal of the experiment was to validate $PM_{2.5}$ measurements, in particular boreal wildland fire contributions to $PM_{2.5}$. The specific task was to go from instrument measurements in an airplane to an estimate of chemical species that come from wildfires.
- The study compared four different air quality models to aircraft measurements - the best prediction model employs Positive Matrix Factorization.

Wildfire Smoke and Health Evidence (Sarah Henderson)

- Evidence indicates that the most extreme concentrations of $PM_{2.5}$ are due to smoke from wildland fires and not background sources.
- $PM_{2.5}$ is not measured close to fires.
- Everyone is affected by smoke at those high concentrations, but for most people the effect is sub-clinical.
- Smoke exposure also affects pre-natal health and very young children.
- There are correlations between smoke/$PM_{2.5}$ and prescriptions for asthma medication, nitroglycerin (for angina), and middle-ear infections.
- Smoky days have an increase in mortality, particularly from stroke, respiratory episodes and pneumonia.

The State of Smoke Science, Information, and Tools

Primary sources of wildland fire & smoke information (Roland Schigas)

Primary information sources are:

- the CWFIS (Canadian Wildland Fire Information System) at http://cwfis.cfs.nrcan.gc.ca/home,
- the BlueSky Canada smoke forecast website at http://firesmoke.ca, with several additional products including:
    - SmartFire 2 – fire GIS database, and
    - BlueSky Playground tool for prescribed burn smoke prediction,
- the US Forest Service AirFire website at www.airfire.org, and
- the NOAA Hazard Mapping System at http://www.ospo.noaa.gov/Products/land/hms.html.

BlueSky Canada Research (Rosie Howard)

- Research topics include:
    - verification of $PM_{2.5}$ forecasts,
    - running the HYSPLIT dispersion model in puff mode and particle mode,
    - production of column-integrated output, and
    - investigation of spot forecast issues including missed timing and extent of smoke due to missing hotpots, plume rise model errors, and weather station variability.
- Of note is that the HYSPLIT model does not include precipitation, and background levels of $PM_{2.5}$ are not modelled.

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Canadian Meteorological Centre Smoke Forecasting System: FireWork 2014 (Didier Davignon)

- FireWork uses near-real time wildfire emissions derived from fire activity data provided by the Canadian Forest Service.
- The system performs a full scale alternate air quality forecast where near-real time wildfire emissions are added on top of other known pollutant sources. Meteorologists can access this alternate model guidance to adjust the official AQHI forecast.
- For the 2014 fire season, partners external to CMC were offered access to 48 hour animations of smoke concentration forecast by FireWork, produced twice per day on a continental domain at 10 km resolution. In addition, a KML/WMS feed was established for GIS integration.
- A preliminary evaluation of Firework forecasts against observations for the summer of 2014 indicated that adding wildfire emissions improved the $PM_{2.5}$ forecast in most situations.
- The MSC is willing to adjust its smoke forecast products to fit the needs of provincial partners dealing with wildfire smoke management.

Smoke Forecast Model Performance (Steve Sakiyama)

- Ideally, users would have access to a 60-hour forecast of all fires and smoke at all locations.
- In practical terms, there is model error in timing and extent, and initialization error from fire size, location and behaviour.
- Satellite hotspot data is not reliable in cloudy weather
- Various statistical methods are used for validation and for the most part show moderate correlations of predictions with observations.
- Smoke predictions improve with daily vs. hourly predictions, and when qualitative vs. quantitative assessments are made.

Ground-truthing BlueSky Playground (David Schroeder)

- Prescribed burns need a quick turnaround for smoke forecasts.
- AESRD set up a portable weather stations (EBAMS) to measure smoke. It was difficult to locate EBAMS in the correct position to capture the smoke plume and validate the model.
- BlueSky Playground doesn't forecast smoke immediately adjacent to the fire.
- Temporal burn windows are limited, which makes it harder to plan.
- BlueSky Playground needs additional spatial data output formats.

Smoke and Emissions Model Intercomparison Project (SEMIP) and Implications (Sim Larkin)

- Model comparisons were undertaken using the US BlueSky framework.
- The largest uncertainties in emissions and air quality due to smoke were due to fuels, plume rise modelling, and fire modelling.
- It is difficult to detect all fires with satellites.
- There are huge discrepancies in fuel load.
- Current plume rise models are weak.
- Higher resolution forecasts give better results.
- There are potential improvements if terrain models and diurnal profile models are incorporated.

Where Do We Go From Here and How Do We Get There?

Monitoring Wildland Fire Smoke: Manitoba's Common Operating Picture (Barbara Crumb and Darlene Oshanski)

- There is a need to switch to evidence-based approaches for evacuations and disaster management of fires.
- We need better visualization tools.

- Manitoba needs an improved monitoring system (currently there are only five NAPS stations in all of Manitoba).
- Smoke monitoring has been enhanced with TSI DustTrak II plus Netronix ICU (Thiamis) which are portable and deployable.
- Manitoba has made the Common Operating Picture (COP) operational. Its main features are:
  - everything is on the Amazon cloud (no hardware requirements),
  - the COP software contains information on fire, weather, air quality, hospitals, aerodromes, and
  - it is based on the ESRI Javascript API, and ArcGIS Desktop/Server.
- BlueSky and Firework are not yet operational as a service within the COP environment.
- All the departments involved in the emergency gather to manage the response at the Emergency Operations Centre.

Health Messaging in Wildland Fire Smoke Events: Manitoba`s Approach (Jeffrey Joaquin)

- Health messaging for smoke events should be consistent and appropriate.
- Messages should be fast, accurate, and targeted to specific groups.
- Manitoba is developing Special Air Quality Statements and First Nations Special Air Quality Statements.
- Planners need to take into account simultaneous heat and smoke events.

US Perspectives on the Future of Smoke Management (Pete Lahm)

- Wildfire is an air quality issue, while prescribed burning is a smoke management issue.
- 1 in 3 households have someone with respiratory issues.
- Public air quality warnings are effective.
- According to estimates, anywhere from $8 to $80 are spent per person on medical costs due to exposure to wildfire smoke.
- Health effects due to smoke occur along a gradient from minimal to severe.
- Up to 25 agencies are active on large incidents in the US; Air Resource Advisors help explain the air quality implications of wildfires.
- There is a need for thresholds for warnings and evacuations but there are many jurisdictions who want to have input on these values.
- $PM_{2.5}$ has limited monitoring. Also the US does not have a cumulative health index similar to the Canadian AQHI.
- Fire agencies are 24/7 organizations but partner agencies may not be.
- It is difficult to force evacuations in the US.
- The US has produced a draft Wildland Fire Personnel Smoke Exposure Guidebook.

Future of Smoke Science (Sim Larkin)

- Current issues when modelling smoke are:
  - Weather, e.g., mixing height,
  - Fire information (detection, accuracy, growth models), and
  - Fuels – type, structure, and load.
- People can be sensitive to smoke at very low levels (below health alert thresholds).
- Smoke models currently have the following characteristics:
  - they are at a relatively coarse scale,
  - they are slow,
  - bias correction is difficult, and
  - results may be hard to interpret.
- We need enhanced fuels databases which:
  - produce maps that contain their own uncertainty (variability of load and structure), and
  - are more dynamic.

- We need a better plume rise model (three dimensional spatial model, with time).
- Smoke chemistry needs to be included.
- Smoke forecasts should use a coupled fire-atmospheric model, tied into atmospheric transport models.
- Forecasts could be probabilistic. For example: a 30% chance of light to moderate smoke (i.e., combination of two different probabilities – chance of smoke and severity of smoke).
- Better forecasts require new observations of smoke, e.g., the Joint Fire Science experimental plume burn.

Future of Health Science (Sarah Henderson)

- Studies need to distinguish between acute and chronic effects of smoke.
- Air pollution in general (chronic) is decreasing but wildfire smoke (acute) is increasing.
- Occupational health exposure (e.g., for firefighters) is different than that of the general population.
- There is evidence that the 48-hour forecast from BlueSky is reasonable under extreme conditions (e.g., British Columbia, 2010).
- BC Asthma Monitoring System (BCAMS) provides information to BC health regions regarding particulate matter and potential drug dispensations.
- Medical dispensations tied to a statistical model of smoke exposure indicate good agreement.
- There is a need to differentiate between short-term and >24 hour exposure.
- Studies should consider pollutant mixtures; the effect on asthmatics might not be from $PM_{2.5}$.
- Current science doesn't consider the age of smoke and how it changes over time, or the type of smoke: e.g., smouldering vs. flaming, wildfires vs. prescribed burns, fuel type.

Possible Smoke/Fire Research Organization Models (Brian Stocks)

- The US is ahead of Canada in smoke science and management in that the American Joint Fire Science Program (JFSP) has conducted research on smoke emissions, fire and smoke, smoke and population as well as climate change and smoke.
- Australia has the Bushfire Cooperative Research Centre which:
  - o conducts strong wildfire research, and
  - o mirrors North American research themes,
- Canada has the Canadian Wildland Fire Strategy, but there is no mention of smoke in it.
- A framework is needed to assist Canadian researchers in accessing research funds.
- Smoke researchers should join forces with the health care community to lobby for active science on smoke management and health.

Discussion panel - audience and experts (Kerry Anderson, Barbara Crumb, Pete Lahm, Sim Larkin and Brian Stocks, with Jeff Eyamie of Health Canada as moderator)

1) What groups should be involved who weren't at the meeting?

- Include First Nations and Emergency Response organizations.
- Include Eastern Canadian emergency management groups.
- Include Environment Canada's Downsview Air Quality Science Division.
- Regarding emergency management groups: in order to engage them, make the point about how they are affected and that better smoke information is value-added. For example, good smoke forecasts help with aviation resources on a fire, local communities get smoke

exposure forecasts, etc.
- We need a broad-based research community involved, such as landscape ecologists, combustion physicists, atmospheric scientists, and AQ monitoring people (which could include the public in data gathering through social media and smartphones).
- Tap into social media, target health and emergency managers, and private industry (e.g., Manitoba Hydro).
- Include the Canadian Lung Association.
- There is policy happening here. You need policy makers involved.

Should there be a better Canadian link to the U.S. Joint Fire Science Program?

- One possibility is to collaborate with US colleagues under the JFSP. Such research would have proposals for funding from Canada but research would need to benefit the US, and would need US collaborators.
- JFSP Knowledge Consortia have been created to disseminate the smoke/fire research. The North Atlantic section of the JFSP, which includes Quebec and Nova Scotia, already exists.

Wildfire Smoke and Guidance for Health Officials

- **Q**. Regarding the document "Wildfire Smoke: A guide for public health officials" available from the US EPA, when will it be updated to reflect more recent health evidence?

  A. It needs to be updated to create consistent thresholds for warnings and evacuations from a federal viewpoint. Populations respond differently, so the thresholds vary by group.
- A strength of the US Air Resource Advisor position is that they are present with the affected population and can help each group decide on an appropriate response.
- Communities demand hard numbers to make decisions. "will get smoky" is not specific enough (due to liability issues).
- In the US, the federal government is on the hook for evacuation costs.
- There is a dividing line between researchers who want to be rigorous and include uncertainty, and people on the public health side who need hard numbers to help make decisions.
- Significant efforts have been made to standardize data and methods amongst fire management agencies. $PM_{2.5}$ is an example of such a standard. It is important not to lose that data standard.

Should Canada have Air Resource Advisors (ARAs)?

- ARAs are a bit like fire meteorologists. If the usual Canada to US ratio of 1:10 holds, perhaps we should have three ARAs in Canada (that is, 10% of the number in the US).Who would be in charge? Is this a provincial or federal jurisdiction?
- Having ARAs should be a provincial responsibility. They would be the first point of contact for each agency. Fire Behaviour Analysts (FBANs) can't coordinate the message while they are also on a fire. Someone needs to coordinate the response for smoke.
- The ARAs need to be able to deploy at various levels. The further removed from the incident, the less onsite information you have. ARA managers would need to be flexible.
- Canadians are invited to join the US ARA training and to go out on deployments.
- It took years to get operational support for ARAs in the US. At a regional level, there will likely be no uptake but ARAs need to be on an Incident Command Team to get good uptake.
- Has cross boundary smoke ever caused the feds to get involved?
- Where is the division between federal and provincial

jurisdictions for smoke?
- The feds should supply an Air Quality coordinator.
- Smoke is interdisciplinary, inter-jurisdictional and international (it changes). The feds join public safety efforts when provincial resources become over-taxed.

How do we collaborate to improve our products (BlueSky, Firework, AQHI)?

- A result of this Forum should be a formal venue to collaborate.
- What is the role of the Canadian Interagency Forest Fire Centre (CIFFC)?
- Don't think in terms of operational vs. policy; this issue crosses both worlds. Collaboration is even more important if you include research.
- We need to take into account the need to maintain carbon stocks in the forest, and to keep our ecosystems resilient.
- Everyone agrees that collaboration is a good thing, and it should be formalized.
- There should be a presentation on fire, smoke, and climate change to the Federation of Canadian Municipalities (FCM), including information about the effects of smoke on health.
- Should we set up a smoke group on Google Groups or Yahoo?
- There may be another international smoke forum organized through the IAWF.
- We need a national strategy, a white paper and people who will commit to writing it. We need to get feedback from all of the users of this data.
- This effort should include the North (Yukon, NWT, and Nunavut).

Panel Summary and Observations

- Smoke needs to be on the priority list.
- BC and Manitoba are leading the way in being early implementers.
- Researchers should internalize the messages of this group in their planning.
- Avoid getting the right answer for the wrong reasons.
- We need to maintain a common set of questions.
- We need situational awareness and communication.
- Hold on to the energy, and continue to update information (e.g., daily BlueSky use by Ontario).
- Build common data standards that use the same language.
- We need to continue the smoke forum and broaden engagement.
- Don't wait for someone else to do this. §

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The Northwest Territories Up In Smoke: the summer of 2014

by Al Pankratz[1], Dave Fox[2] and Matt Seaboyer[3]

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[3] *Environment and Natural Resources, Government of the Northwest Territories*

It is safe to say that the summer of 2014 will long be remembered in Canada's Northwest Territories (NWT) for the unprecedented amount of wildfire and smoke that occurred between June 15 and August 31st. During this period, 385 wildfires burned a record 3.42 million hectares (Figure 1 [http://activefiremaps.fs.fed.us/activefiremaps.php]), an area larger than Belgium, and triple the amount burned in the rest of Canada in 2014. The cost of fire suppression was $56 million.

In comparison, over the past 20 years the average annual number of forest fires in the NWT was 245, burning an average 570,000 hectares each year, with an annual fire program budget of $7.5 million [2014 NWT Fire Season Review Report, May 2015]. To put this into a national perspective, the 10 year national average area burned is 2 million hectares [http://cwfis.cfs.nrcan.gc.ca/report].

Effects of fire and smoke across the NWT

Given the amount of area burned, it is not surprising that a huge amount of smoke was generated, which at times drifted southward into the Prairie provinces and even into the US. However, the most drastic effects occurred closer to the fires. Many NWT communities were affected and some were evacuated due to the proximity of the fires and due to health concerns from forest fire smoke. Highway 3, the only road in or out of the capital Yellowknife, was closed 26 times due to the close proximity of fires or heavy smoke impairing visibility. At one point, fire came as close as 30 km to Yellowknife, and the city was surrounded on three sides by large fires. Depending on wind direction Yellowknife was often blanketed in thick smoke. In addition:

- public health warnings due to smoke-related poor air quality were issued
- commercial vehicles were escorted in convoys through breaks in the fire and smoke to deliver needed supplies to Yellowknife, such as fuel for the airport
- a hydroelectic plant was temporarily closed, forcing towns to rely on electricity generated by diesel power
- campgrounds were closed
- evacuation notices were posted on individual cabins
- fire threatened telecom equipment such as cellphone towers
- fibre optic cables were destroyed
- in one two week period, over 1 million attempts were made to access the government's NWT live fire map, causing the servers to crash

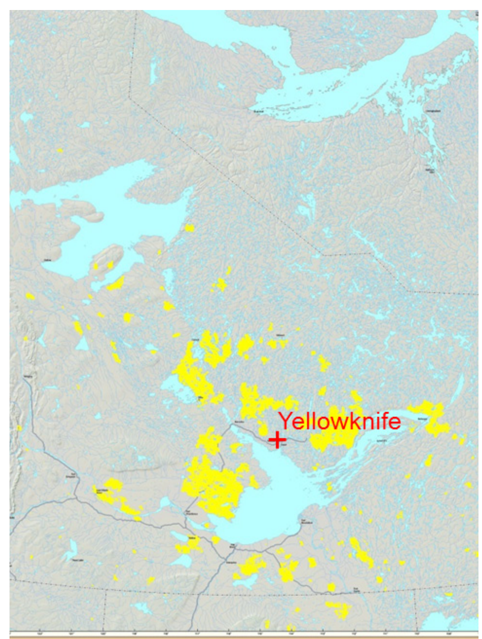

Figure 1. MODIS active fire detections across the NWT in 2014. Image courtesy US Forest Service.

Meteorology

What were the reasons behind the extraordinary amount of wildfire on the NWT landscape in 2014? Examination of weather charts reveals a familiar story - the jet stream spent a considerable portion of the summer in what is known as an Omega pattern - so named for the resemblance of the jetstream to the shape of the Greek letter Omega (Ω) (see Figure 2). This very resilient upper atmospheric feature diverted most weather systems around the southern NWT, resulting in below normal precipitation and allowing vegetation to become extremely dry.

Statistics for Yellowknife, the capital of the NWT, tell the story. June and July of 2014 were the 11th and 12th warmest June/ July, respectively, since records began 73 years ago in 1942. Total precipitation for June and July in 2014 was the fifth lowest since 1942. June had 4.2 mm and July had 14.6 mm of precipitation, compared to normals for these months of 28.9 mm and 40.8 mm, respectively (normals based on data from 1981-2010). During the period from May 24 to July 29, 2014, only 11 mm of rain fell - ideal conditions for one of the most severe forest fire seasons ever recorded.

Upper ridge breakdown is known to be one of the triggers for lightning and fire starts, as it allows weather

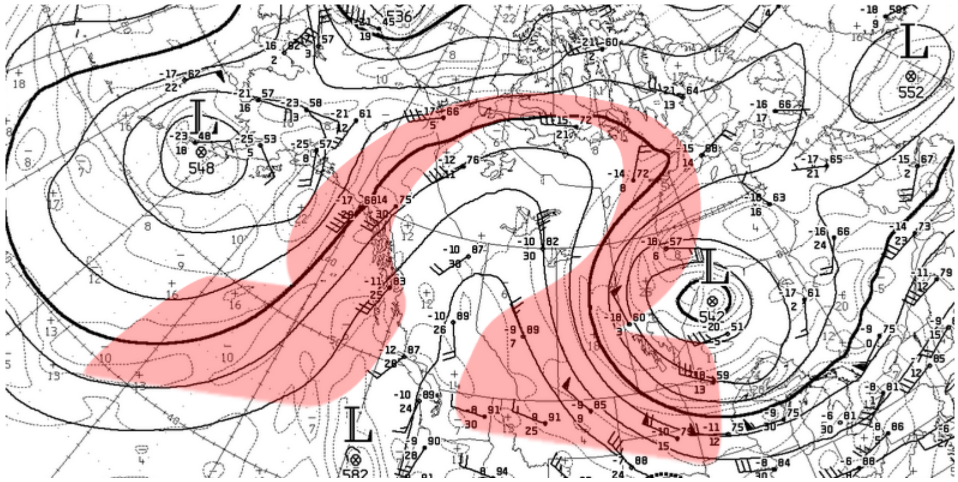

Figure 2. Typical Omega pattern of the 500 millibar upper winds, July 13, 2014. Images courtesy of Environment Canada.

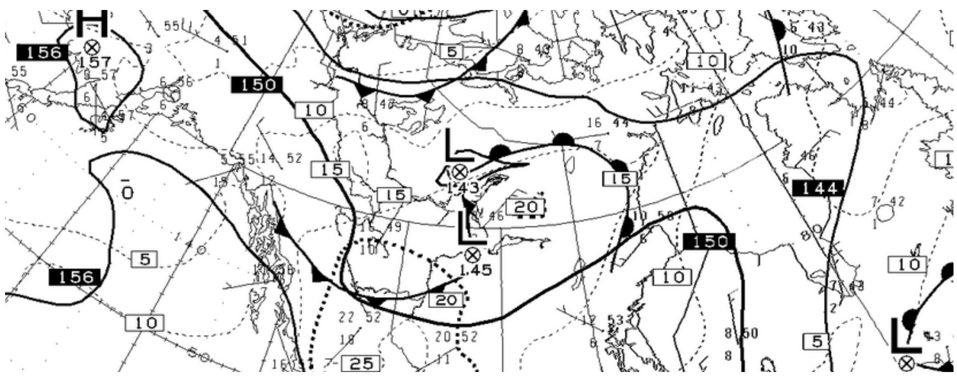

Figure 3. Temporary ridge breakdown as a frontal system moves across the region. Fronts are depicted on an 850 millibar upper air chart at 6 pm MDT, 15 July, 2014.

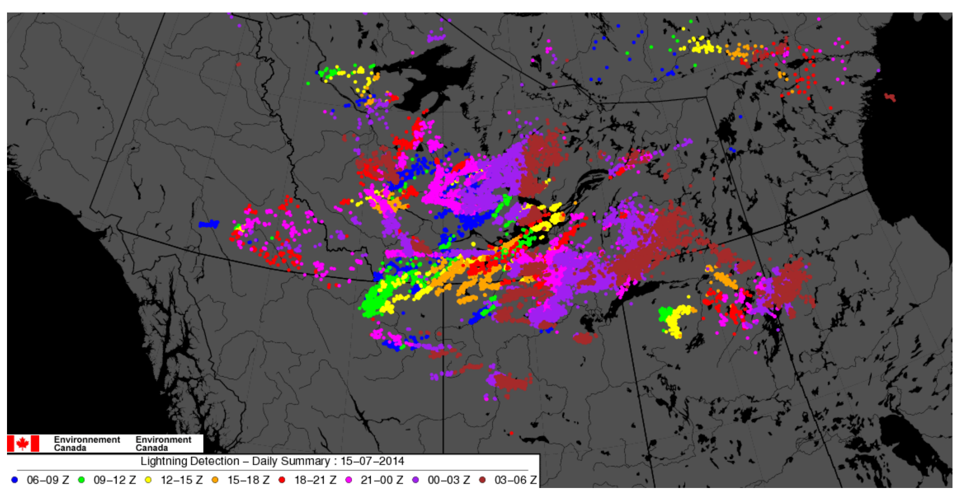

Figure 4. Corresponding massive lightning outbreak across the southern NWT, 15 July, 2014, UTC. Each dot represents one cloud to ground lightning strike; colours indicate time of day.

systems to cross the region. Under the right circumstances, these systems can generate significant thunderstorms and lightning, the latter initiating fire activity. In one memorable instance, an active thunderstorm from such a system incorporated particles from previously existing fires into its circulation, so that the rain that fell was accompanied by ash, and the lightning appeared red in colour.

An excellent example of upper ridge breakdown accompanied by a frontal system occurred on July 15th, 2014 and is shown in Figures 3 and 4 (previous page). This system blanketed the area around Great Slave Lake with lightning, and set the stage for extensive fire and smoke activity in the latter part of July and early August.

Air Quality

The NWT government maintains four air quality measuring stations at Fort Smith, Yellowknife, Norman Wells and Inuvik. $PM_{2.5}$ (particulate matter smaller than 2.5 microns) and PM_{10} (particulate matter smaller than 10 microns) as well as other species are measured at all four sites, with CO also measured at Yellowknife and Inuvik. Readings from Inuvik show that the Mackenzie River delta escaped the bulk of the surface smoke with only a few spikes between 20 and 25 µg/m³ (Figure 5). The Sahtu

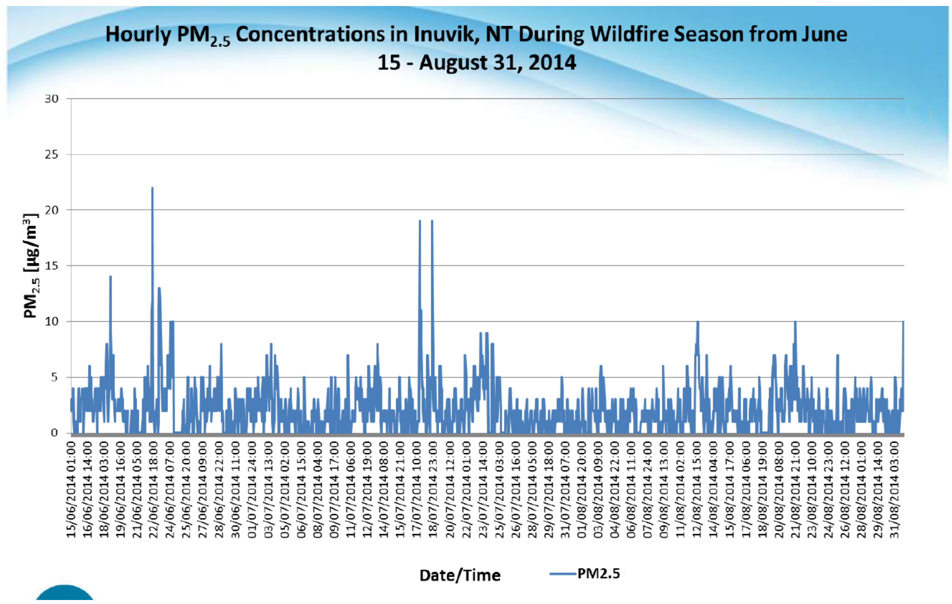

Figure 5. Hourly $PM_{2.5}$ values at Inuvik, NWT.

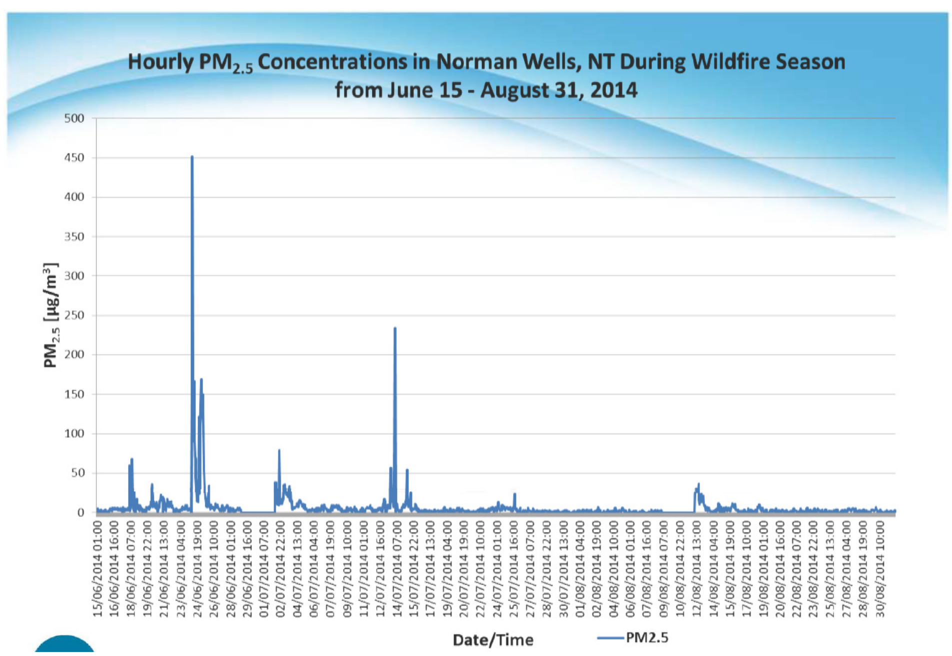

Figure 6. Hourly $PM_{2.5}$ values at Norman Wells, NWT.

region further south in the central Mackenzie was subjected to several days of higher $PM_{2.5}$ around the end of June and again in mid-July (Figure 6) with the maximum hourly $PM_{2.5}$ value topping 450 µg/m³ on the 24th of June.

By far the worst of the smoke and elevated $PM_{2.5}$ occurred in the southern Mackenzie, and the worst values across the southern Mackenzie were measured in Yellowknife and Fort Smith. By way of background, Yellowknife is a small city of 20,000 people [http://www.statsnwt.ca/population/population-estimates/commtotal.html], located on the northern shore of Great Slave Lake. It is in the taiga shield high boreal ecoregion which is dominated by jack pine and spruce forests with stands of aspen and birch [Department of the Environment and Natural Resources, Government of the Northwest Territories, Ecological Regions of the Northwest Territories: Taiga Shield, 2008].

There are few anthropogenic combustion sources in and around Yellowknife: of the ones that do exist, diesel power generation, heating, and mobile emissions are predominant. Generally the air quality in Yellowknife is pristine. Any poor air quality that does occur tends to be associated with forest fire smoke or wind blown dust.
In 2014 there were three air quality stations operating in Yellowknife: a National Air Pollution Surveillance (NAPS) station that measures continuous sulphur dioxide (SO_2), nitrogen oxides (NO_x), nitrogen dioxide (NO_2), nitric oxide (NO), ozone (O_3), carbon monoxide (CO), PM_{10} and $PM_{2.5}$; and two air quality stations, Marina and N'Dilo, associated with the Giant Mine Remediation project, that measure continuous PM_{10} and $PM_{2.5}$.

Emissions from forest fires were observed to elevate Yellowknife ambient concentrations of NO_x, NO_2, O_3, CO, PM_{10}, and $PM_{2.5}$. Hourly ambient concentrations for O_3 in the NWT typically range from 10 to 40 ppb. The maximum hourly concentration seen for ozone was 59 ppb, higher than typical levels but well below the air quality standard (see Table 1). The typical ambient concentrations for carbon monoxide range from 0 – 0.2 ppm. The maximum observed hourly CO concentration during this period was 7.8 ppm (60% of the ambient standard) and the maximum 8-hour average concentration was 4.9 (98% of the 8-hour ambient standard - see Figure 7 below).

The smoke events caused numerous exceedances of ambient air quality

Pollutant	Usual NWT Readings	Air Quality Standards		
		1-hr	8-hr	24-hr
SO_2	0 – 5 ppb	172 ppb		57 ppb
H_2S	0 – 2 ppb	10 ppb		3 ppb
O_3	10 – 40 ppb		63 ppb	
NO_2	0 – 10 ppb	213 ppb		106 ppb
CO	0 – 0.2 ppm	13 ppm	5 ppm	
$PM_{2.5}$	0 – 10 ug/m^3			28 ug/m^3

Table 1. NWT ambient air quality standards.

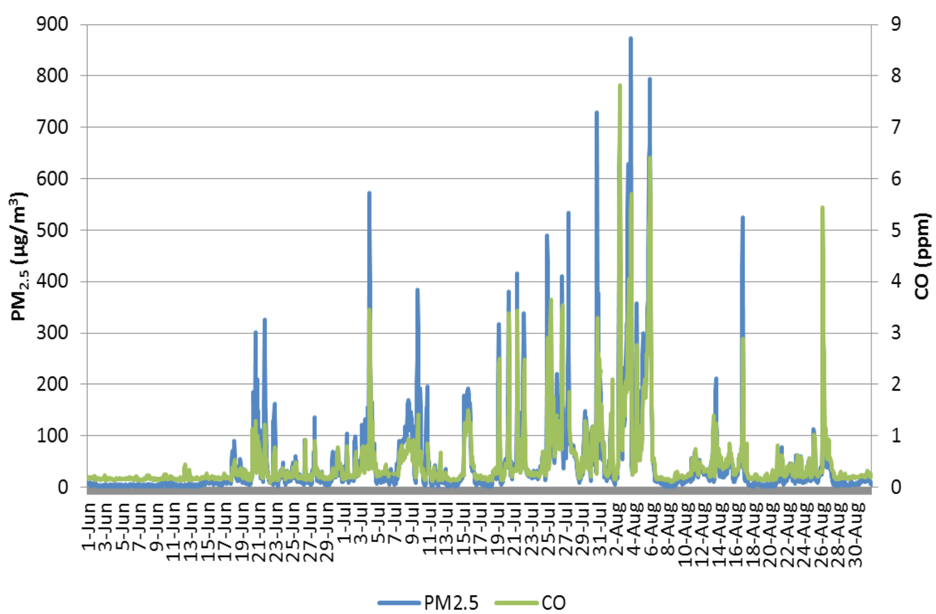

Figure 7. Hourly ambient concentrations of $PM_{2.5}$ and CO from the Yellowknife NAPS air quality station.

standards for $PM_{2.5}$. The NWT ambient air quality standard for 24-hour average $PM_{2.5}$ is 28 μg/m³. During the 2014 smoke events this ambient standard was exceeded at the Yellowknife NAPS station 39 times with a maximum 24-hour $PM_{2.5}$ concentration of just over 330 μg/m³ (Figure 8).

The maximum hourly $PM_{2.5}$ attained during the fire season at Yellowknife was 873 μg/m³ in early August (see Figure 10 on the following page for a satellite image of the southern NWT taken August 4th). There were 270 hours when the $PM_{2.5}$ concentrations were more than 100 μg/m³ and 108 hours when the $PM_{2.5}$ concentrations were more than 200 μg/m³. The Canadian Ambient Air Quality Standard metric for $PM_{2.5}$ of 28 μg/m³ is based on a 3-year average of the annual 98th percentile of the daily 24-hour average concentration. During the fire season (June, July, August) of 2014, the 98th percentile of the 24-hour $PM_{2.5}$ in Yellowknife was 138 μg/m³.

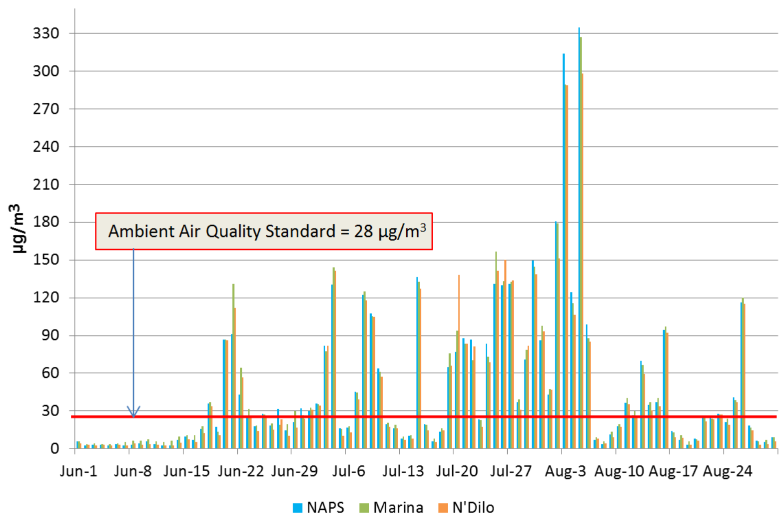

Figure 8. Daily 24-hour average $PM_{2.5}$ from the Yellowknife NAPS, Giant Mine Marina, and N'Dilo air quality stations. The horizontal red line indicates the NWT ambient standard of 28 μg/m³ for 24-hour $PM_{2.5}$.

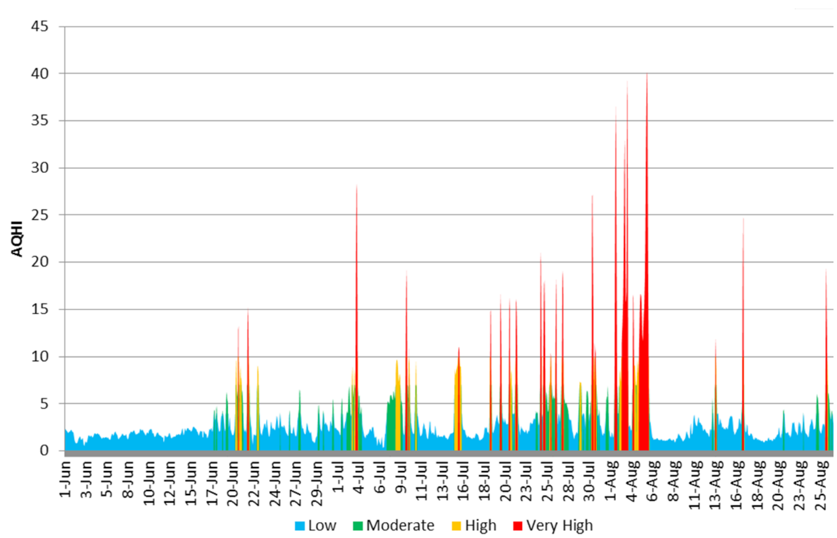

Figure 9. Hourly Air Quality Health Index for Yellowknife in 2014. The colours indicate the various AQHI ranges: blue is low risk (AQHI 1–3), green is moderate risk (AQHI 4–6), orange is high (AQHI 7–10), and red is very high (AQHI > 10).

The Air Quality Health Index (AQHI) is based on the relative risks of O_3, $PM_{2.5}$ and NO_2. There are four categories for the AQHI:

- low risk (AQHI 1-3)
- moderate risk (AQHI 4-6)
- high risk (AQHI 7-10), and
- very high risk (AQHI > 10).

During the periods when forest fire smoke was affecting Yellowknife, the AQHI was dominated by $PM_{2.5}$ concentrations. The maximum AQHI calculated was 40. During June, July and August, there were 488 hours (22% of the time) spent at the moderate risk level, a further 241 hours (11%) at the high risk level and a further 132 hours (6%) at the very high risk level (Figure 9).

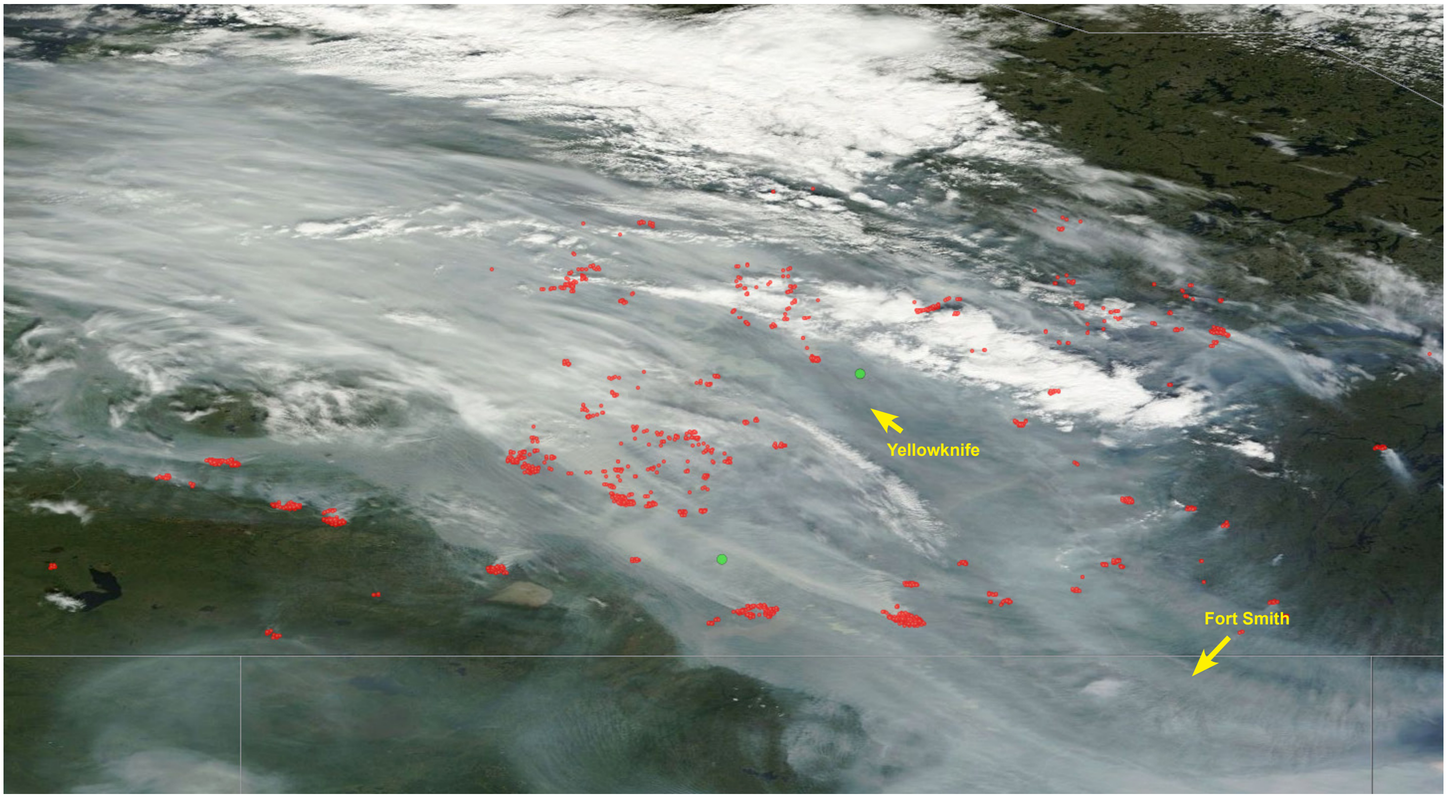

Figure 10. MODIS image of a wide swath of smoke over and around Great Slave Lake on August 4th, 2014. Satellite photo courtesy of NOAA/NASA.

The other air quality site which measured extremely high values in the southern Mackenzie was located at Fort Smith. Fort Smith is a town of approximately 2500 people, located next to the Slave River, virtually on the border between the NWT and Alberta, and near Wood Buffalo National Park. This location deep within the boreal forest means that Fort Smith experiences smoke episodes fairly regularly.

Fort Smith was especially hard hit during the early August episode (Figure 10, above), with an hourly maximum $PM_{2.5}$ concentration around 420 ug/m^3 (Figure 11).

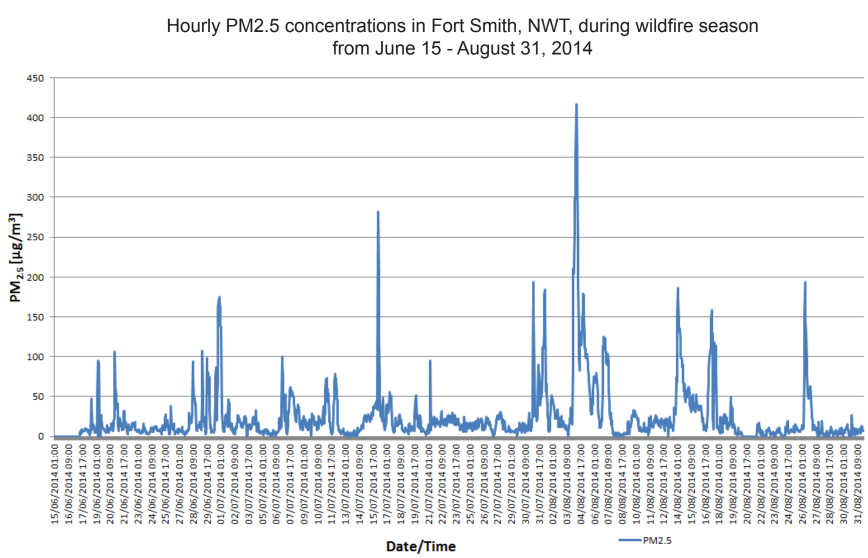

Figure 11. 2014 fire season hourly $PM_{2.5}$ concentrations at Fort Smith, NWT.

Post-fire-season workshop

The extensive smoke and fire of 2014 had wide-ranging effects on the people of the NWT. Concern about what episodes like this might mean for the NWT in the light of ongoing climate change lead the territorial government to convene a workshop in February of 2015 which brought together over 100 participants. Representatives from the Government of the NWT, academia and the federal government, as well as a few experts from the US attended. Given the effects of fire on the ecosystems of the northern boreal forest, the goal of the workshop was

Figure 12. Images of the Birch Creek Complex fire, mid-July, 2014. Figure 12b) shows a pyro-CB, or wildfire-generated cumulonimbus (thunderstorm) cloud. Images courtesy of NWTFire, Government of the Northwest Territories.

Figure 13. a) Flying under smoke near the Birch Creek Complex, b) fire and smoke threaten a highway. Images courtesy of NWTFire, Government of the Northwest Territories.

Figure 14. Smoke obscuration inYellowknife. Photo taken when the AQHI value was 18. Image by Matt Seaboyer, GNWT.

to identify and prioritize knowledge gaps and to outline new research needed to fill those gaps. A report on the workshop was prepared by Jennifer Balzer (Wilfred Laurier University) and Jill Johnstone (University of Saskatchewan) [2015].

Summary

The summer of 2014 was an unprecedented event in the recorded history of the Northwest Territories. Extensive wildfires and the smoke emitted from them resulted in large scale disruptions to peoples' daily lives as well as to the economy of the southern Mackenzie (Figures 13, 14 and 15). A large number of extremely poor air quality days were recorded, and dense smoke resulted in, among other things, health alerts and road closures.

These disruptions and the severity of the wildfires have raised a number of difficult questions about what can reasonably be expected in the future in light of climate trends, and what reasonable responses might be. As a first step in addressing these issues, the government of the NWT brought in experts to look at a wide range of issues affecting the northern boreal forest and its inhabitants. Significant areas of research were outlined. It remains to be seen whether concrete outcomes will result. §

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Integrative Wildland Fire & Smoke Modeling: Case Study of a Labrador Smoke Plume reaching Greenland

by David Lavoué

Earth LMents, Welland, Ontario

For many years, atmospheric research has been emphasizing that wildland fire smoke is an important parameter in chemical transport models for climate and air quality studies (e.g., Ivey et al. [2014]). Smoke includes numerous gaseous and particulate species that have a great influence on atmospheric composition at global and regional scales. Fires contribute significantly to greenhouse gas emissions and are a major player in global carbon cycling. Aerosols emitted by fires not only affect visibility but also impact climate by reflecting and absorbing sunlight. For instance, particulate black carbon present in smoke has a warming effect because it absorbs sunlight.

In the 2013 issue of the Canadian Smoke Newsletter (CSN), I wrote a short paper presenting an overview of the synoptic transport of wildfire smoke plumes to Greenland [Lavoué, 2013]. The paper described the case of a large smoke plume released by wildfires in central Labrador being transported to southern Greenland during June 2012. The present article continues where the previous article left off by describing the integration of various numerical models that simulate fire growth, subsequent gaseous and particulate emissions, smoke plume rise and eventual atmospheric transport over the Labrador Sea.

2012 fire season in Newfoundland and Labrador

In 2012, the fire protection agency of the Canadian province of Newfoundland and Labrador (denoted NL in the following) reported a total of 87 fires that swept through 223,500 hectares of forest in Labrador (http://www.nr.gov.nl.ca/nr/forestry/fires/, accessed 1 June 2015).

By mid-June 2012, MODIS (Moderate Resolution Imaging Spectrometer) remote sensors on both NASA Aqua and Terra satellites detected numerous active hotspots corresponding to the high fire activity in central Labrador. In the 2013 CSN issue, I focused on the hotspots forming group#2 (Figures 1 & 2). As shown in Figure 1, these hotspots were detected in the Modified Response zone (MRz). Wildfires usually burn naturally in the MRz because suppression is

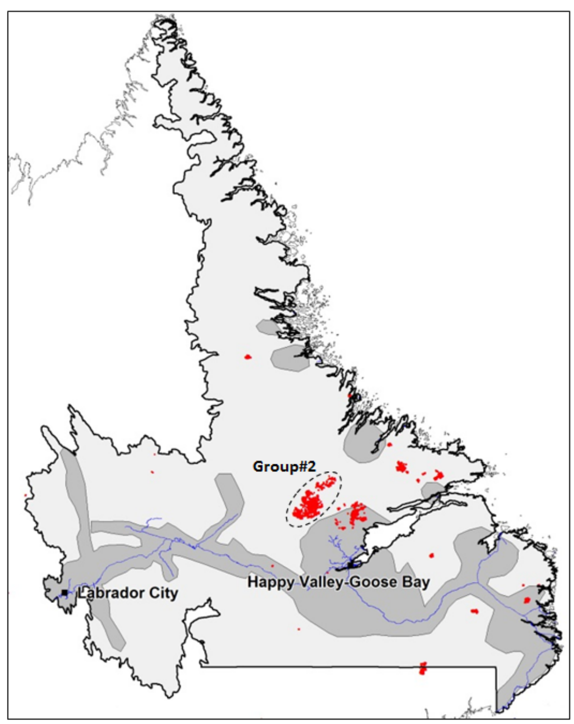

Figure 1: MODIS fire hotspots (red dots) detected across Labrador in June 2012. The active fire suppression zone or full response zone (FRz) is shown in dark gray and the modified response zone (MRz) is in light gray (adapted from Magnussen and Taylor [2012]). The road network is indicated in blue.

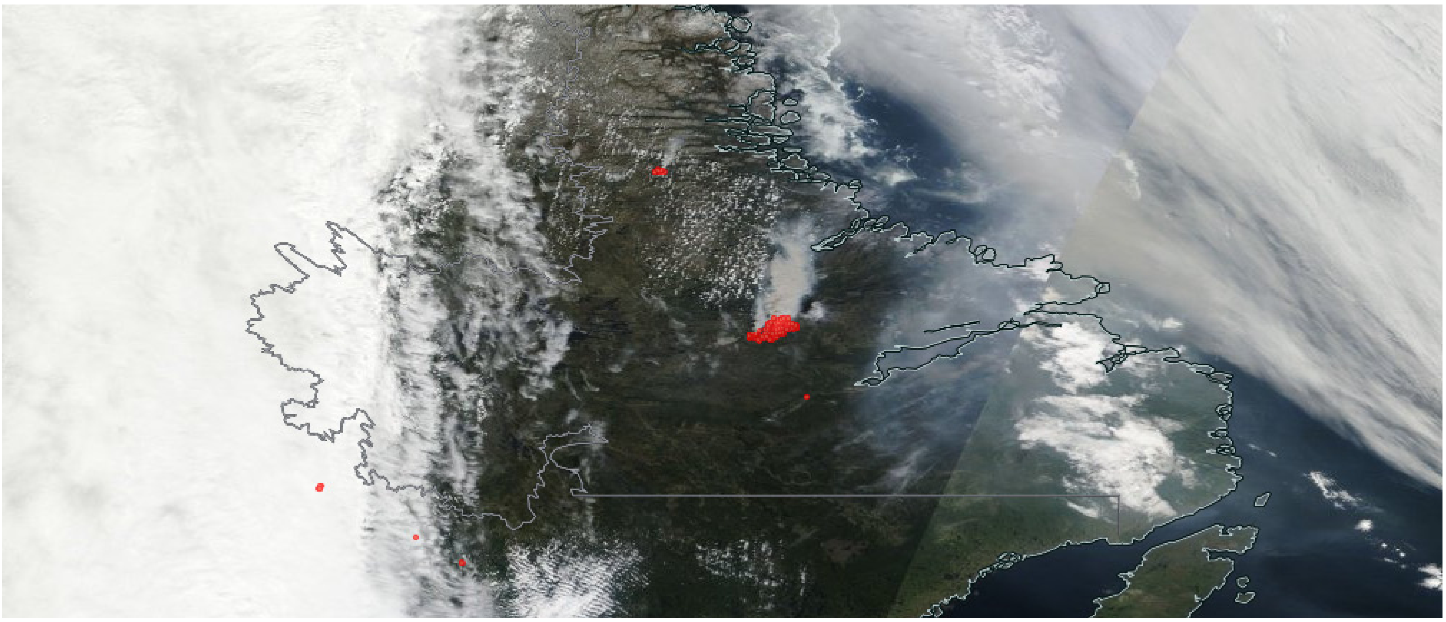

Figure 2. MODIS image of Labrador fire area, 13 June, 2015 . Image courtesy NOAA/NASA and NASA Worldview (https://earthdata.nasa.gov/labs/worldview/).

practiced only when communities or assets are at risk. As a consequence, fires burning in this zone may become large [Stocks, 2013]. As specified in CIFFC (Canadian Interagency Forest Fire Center) reports, dozens of lightning strikes were responsible for nearly 150,000 hectares burned in Labrador during the second half of June 2012 (Figure 3).

Late spring/early summer weather promoted extreme fire activity in central Labrador. A stationary upper-air ridge situated over Labrador Sea, as shown by the positive anomaly of the 500 mb geopotential height from 10-30 June 2012 (Figure 4a, following page), resulted in a period of warm weather during most of June. At Goose Bay, the maximum daily temperature for June averaged

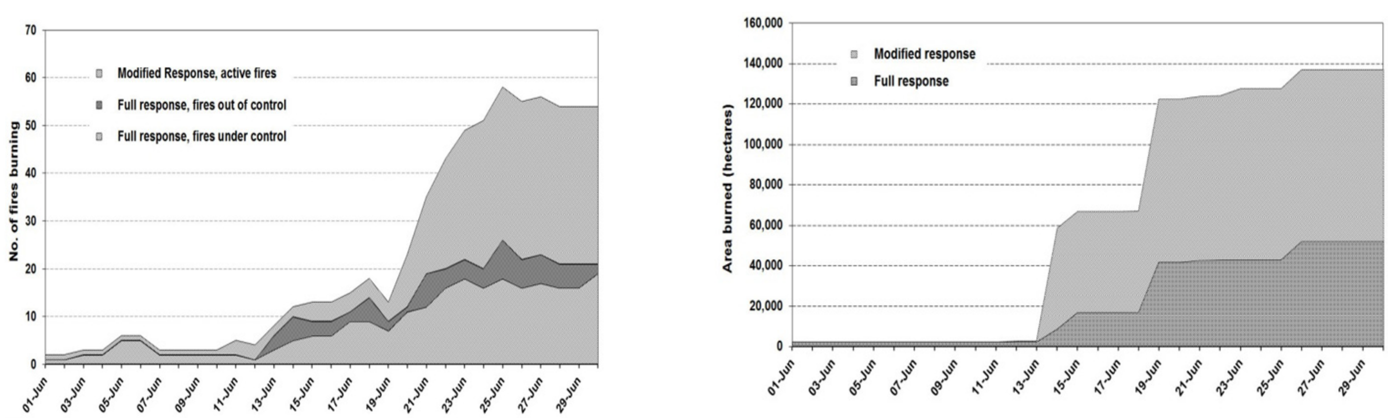

Figure 3: Daily active fires number (left) and area burned (right) in the Province of Newfoundland and Labrador during June 2012; both plots were created from the fire situation reports compiled daily by the Canadian Interagency Forest Fire Center (http://www.ciffc.ca, accessed 24 September 2013).

22.2°C, 5°C over the climate normal (Figure 4b), climbing to 30+°C around mid-June. Moreover, rainfall for the entire month was one-third below the normal value (http://climate.weather.gc.ca/, accessed 10 September 2013).

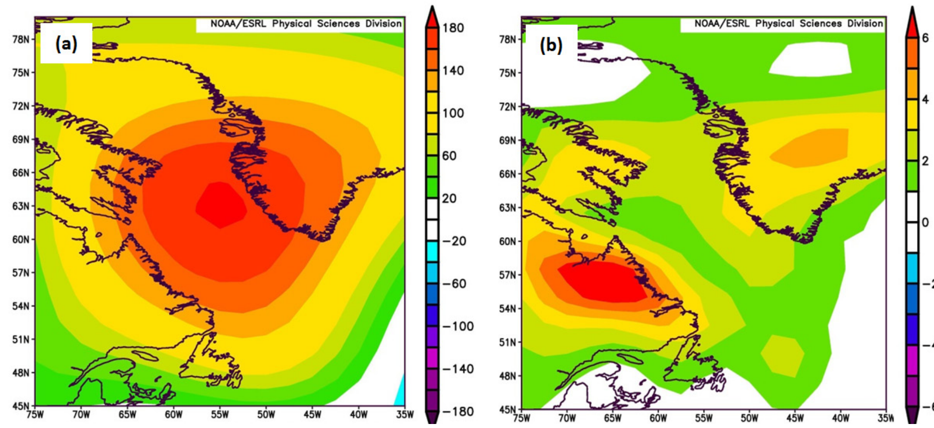

Figure 4: Composite anomaly for (a) 500-mb geopotential height in meters and (b) surface air temperature in °C, during the period of 10-30 June 2012. Calculation is based on 30 years of climatology (1981-2010) from NCEP/NCAR reanalysis.

Fire Growth

In the following discussion, the hotspots forming group#2 are assumed to constitute a single fire, referred to as fire#2, which grew naturally. In fire modelling, the growth of a fire is typically simulated by an elliptical shape in a uniform wind field (i.e., constant wind speed and direction), on flat terrain and without any obstacles (e.g., water bodies) influencing its spread. However, when at least one of these conditions is not fulfilled, a more complex numerical approach has to be employed to predict area growth [Richards and Bryce, 1995]. The Canadian fire growth model Prometheus [Tymstra et al., 2009] is one such model and was used to simulate the growth of fire#2 during June 13th, employing the June 12th convex hull as the initial fire perimeter (Figure 5a). Surface meteorology recorded at Environment Canada's Goose Bay weather station on June 13th was used to calculate hourly fire behaviour characteristics (e.g., rate of spread, fuel consumption) for 24 hours, using the Canadian Fire Behaviour Prediction (FBP) System. A 1-km resolution FBP fuel map (K. Anderson, Canadian Forest Service, personal communication, 2011) was used to take into account the geographical variability of fuel types in the active fire region (Figure 5b).

Hourly fire perimeters predicted

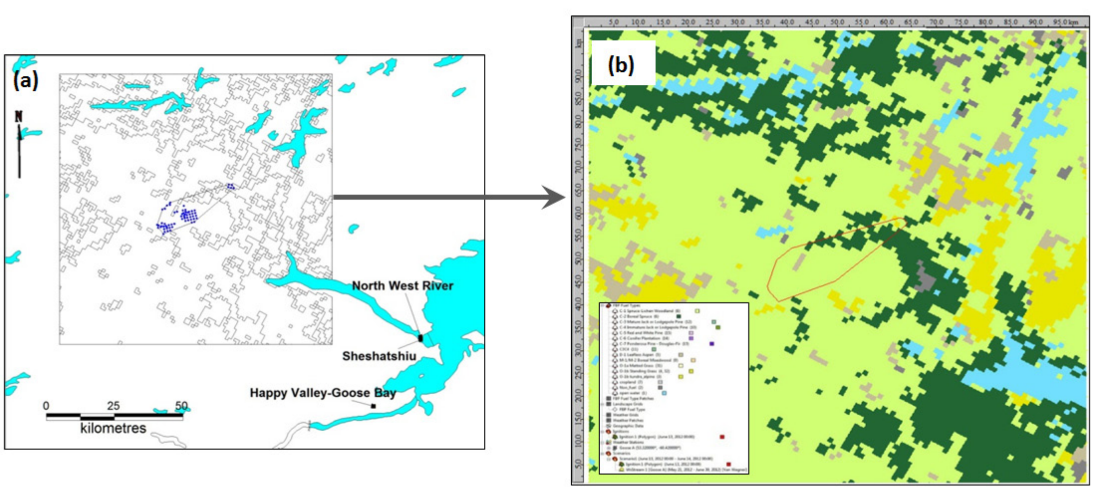

Figure 5: (a) Convex hull of the group#2 of hotspots (dark blue dots) detected with MODIS on June 12th; (b) same convex hull in the 100 km x 100 km FBP fuel grid (1-km resolution). Light blue polygons correspond to water bodies on both maps.

by Prometheus were superimposed on a Google Earth map of central Labrador (Figures 6a & 6b). Gridded values of head fire rate of spread indicate a very fast, northward spreading fire front (Figure 6c). With a starting fire polygon of 21,000 ha, Prometheus predicted that the fire size would reach 95,000 ha in 24 hours (Figure 6d). However, a comparison of the modelled fire polygons to MODIS hotspots on June 13th suggests that final fire size may have been overestimated by a factor ~2 (Figure 6b). This is indicated by the lack of hotspots detected in the northern portion of the estimated burned area, and by the presence of hotspots in the middle part of the initial fire perimeter, which was assumed to have burned completely on or before June 12th.

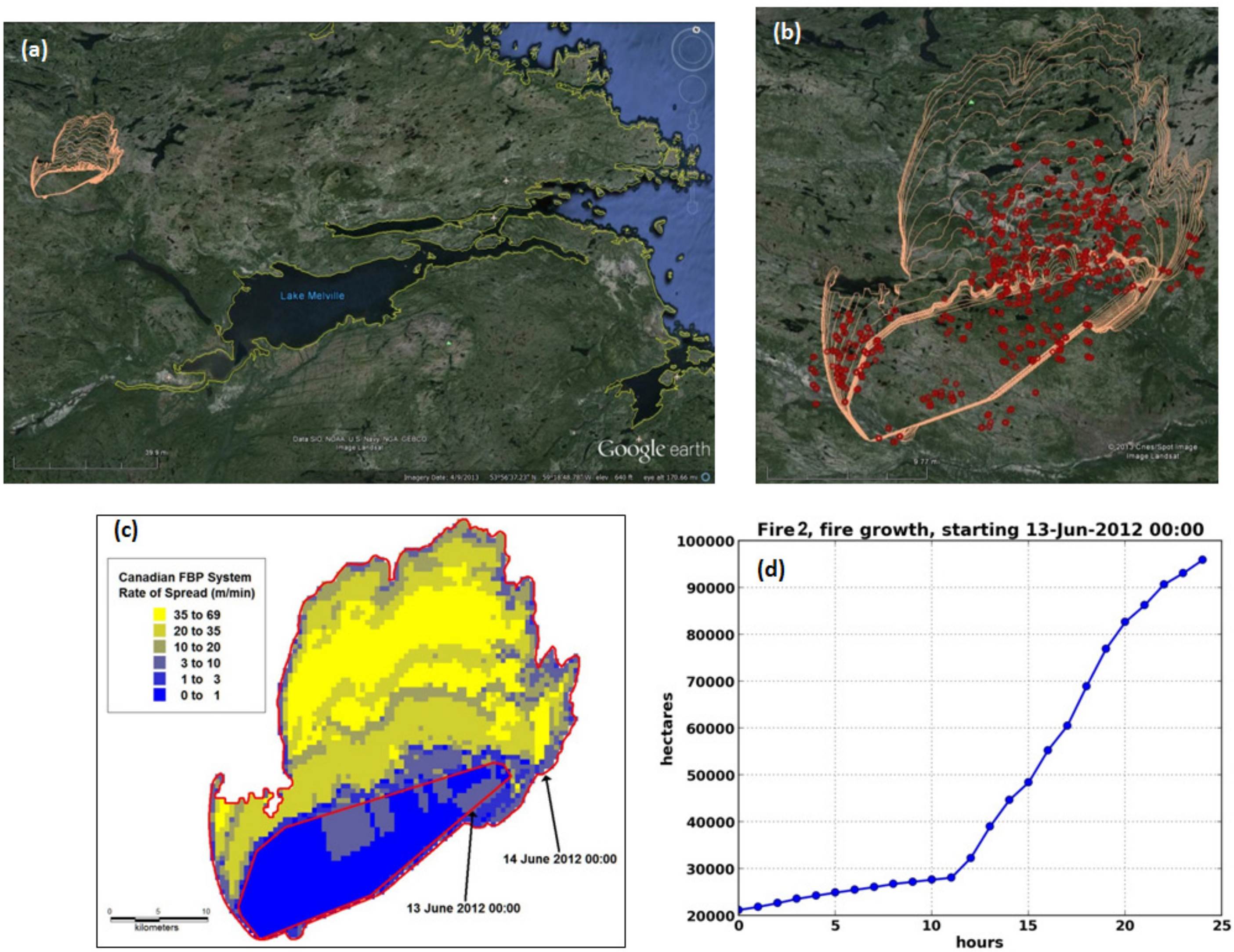

Figure 6: Fire growth simulation results for June 13th started from the initial perimeter of June 12th; (a) overall view of hourly fire perimeters in central Labrador; (b) closer view of fire perimeters with MODIS hotspots detected on the same day as that of the simulation; (c) geographical variability of rate of spread in m/min; (d) cumulative fire size in hectares for 24 hours of simulation (hour#1 is the first hour of simulation).

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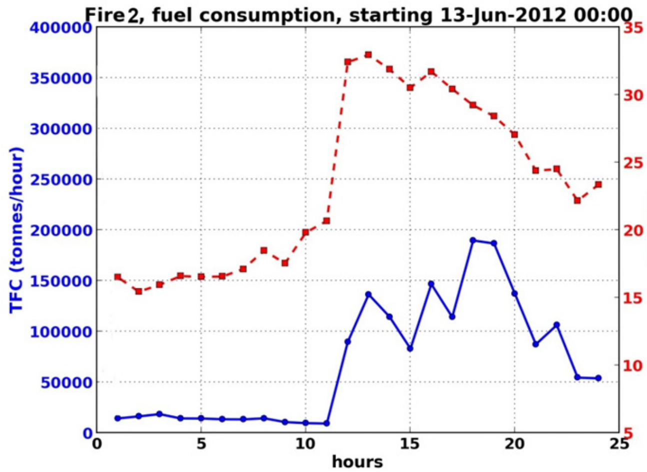

Figure 7: Total fuel consumption (TFC, blue line) for every fire polygon over 24 hours of fire growth simulation with Prometheus. Crown fuel consumption (CFC, red dashed line) is expressed as a % of TFC.

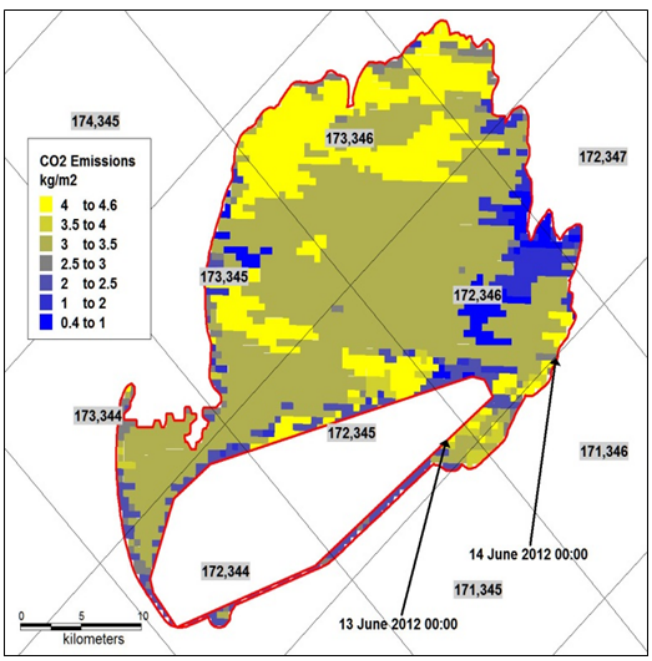

Figure 8: Map of the spatial distribution of modelled CO_2 emission fluxes from fire#2 for June 13th. The grid shown here is Environment Canada’s 15 km-air quality forecast model GEM-MACH grid (https://weather.gc.ca/aqfm/index_e.html, accessed 25 June 2015); each grid cell in an Eulerian or semi-Lagrangian air quality model is addressed with its index (i, j) and corresponding cell IDs are given as 1000 x j + i.

Fire polygons and gridded fuel consumption values were combined using GIS to calculate total amounts of fuel consumed for every hour of the simulation (Figure 7). Modelling outputs suggest that crown fuel accounted for up to one-third of total fuel consumption during the second half of the simulation period.

Atmospheric Emissions

Emissions of greenhouse gases, trace gases and particulate matter were calculated using hourly rates of fuel consumption from fire#2 and emission factors data. As an example, Figure 8 shows a map of the spatial distribution of total CO_2 emission fluxes over 24 hours; a similar type of map can be plotted for other chemical species.

Hourly emission time-series (Figure 9) show that emissions were relatively low and quite steady during the first half of the simulation period, and then increased to higher values for the remaining time. Simulation results suggest that the fire released nearly 3,000 and 3,300 kilotonnes of CO_2 and GHG’s (greenhouse gases) respectively, assuming that fire#2 burned 70,000+ hectares in a single day, i.e. on June 13th. Fire emissions are

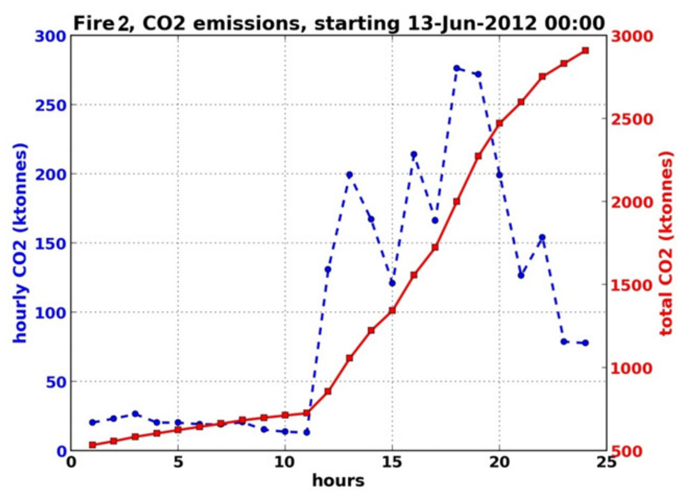

Figure 9: Hourly (blue dashed line) and cumulative (red line) CO_2 emissions for 24 hours of fire growth simulation.

comparable in magnitude to total annual anthropogenic emissions in NL in 2011 (Table 1).

PM emissions calculated from fire polygons can be directly implemented as point or area sources in Lagrangian transport models, such as HYSPLIT, to study smoke dispersion patterns. Moreover, emissions of other chemical species can also be gridded to the mesh used in climate or chemical transport models; these models solve equations in a fixed array of computational cells defining the simulation domain (Figure 8). Figure 10 shows a bar graph with carbon dioxide emissions by hour (x-axis) and by GEM-MACH’s grid cells.

Fire Intensity

Specialized literature presents various methods to quantify the energy released from a wildland fire. One common approach is to calculate Byram’s Fire Intensity (FI), which corresponds to the rate of heat release per unit of time per unit of fire front and is expressed in kW/m [Byram, 1959]. FI integrates both radiant and convective energy of the fireline. At hour#12 of the simulation, an FI over 10,000 kW/m (Figure 11) suggests that the head fire was spreading northward as a continuous crown fire [Taylor et al., 1996].

Plume Rise

Plume rise is a key parameter

Chemical Species	Fire#1 (70,000+ ha) *13 June 2012*	NL Anthropogenic Sources *2011*
CO_2, CH_4 & N_2O ($ktCO_{2\ eq}$)	3270	9360
CO (kt)	238	141
NO_x (kt)	4	44
PM_{10} (kt)	44	11
$PM_{2.5}$ (kt)	36	8
BC (kt)	1.7	0.9

Table 1: Comparison of June 13th emissions from the selected wildfire to annual anthropogenic emissions in the Province of Newfoundland and Labrador (Environment Canada, accessed 8 September 2013) (kt=kilotonnes, PM=Particulate Matter, BC=Black Carbon).

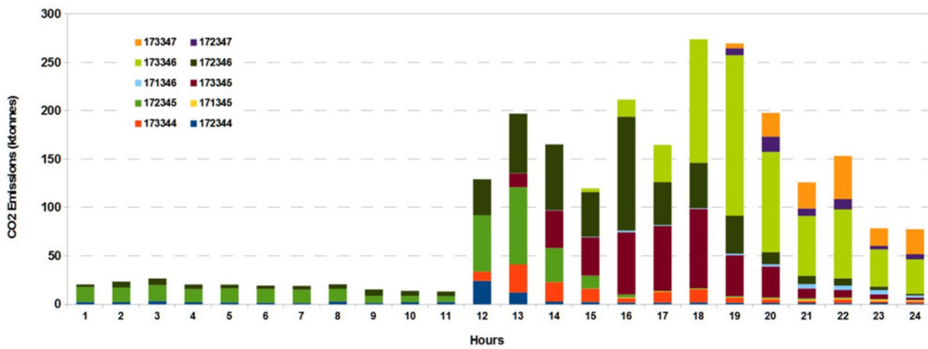

Figure 10: CO_2 emissions in kilotonnes by hours of simulation and by grid cells (shown in Figure 8) over 24 hours of fire growth.

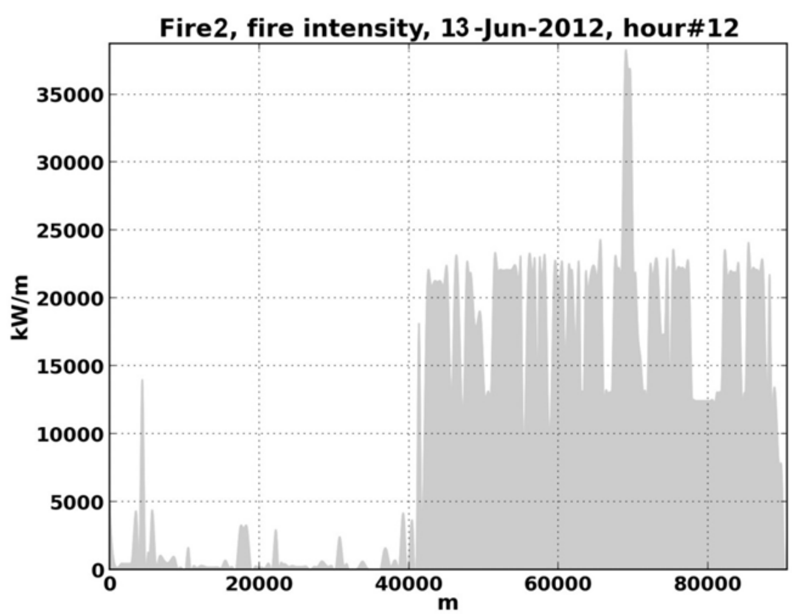

Figure 11: Fire intensity (kW/m) along the fire perimeter at hour#12 of the simulation with Prometheus.

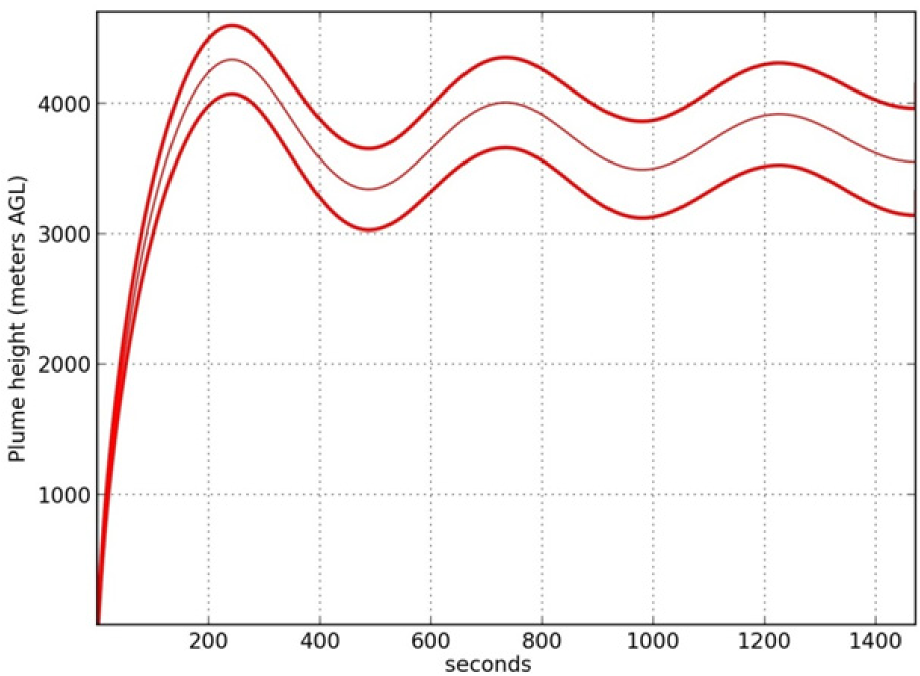

Figure 12: Plume height calculated with Harrison and Hardy's [2002] Lagrangian model for fire#2, burning 2,900 hectares in one hour and 1.9 kg/m² of forest fuel, assuming that 10% of heat release is convected. Thick lines correspond to plume widths and the thin line is the puff-centered height.

in simulating smoke dispersion, long-range transport and impact on visibility. It is therefore necessary when investigating atmospheric transport of smoke plumes with air quality models to first estimate satisfactory plume heights in order to build three dimensional field emissions of air pollutants.

To quickly estimate plume height, a "trial and error" technique can be employed. Air mass trajectories are generated at different altitudes with a trajectory model such as HYSPLIT (version 4, http://ready.arl.noaa.gov/HYSPLIT.php, accessed 8 July 2013) and are superimposed on satellite visible imagery to determine which trajectory matches the smoke plume direction. By using this technique, Lavoué [2013] showed that the smoke plume altitude from Labrador fires on June 13th reached an altitude of 4,000 meters AGL.

Another approach is to apply a plume rise model such as Harrison and Hardy's [2002] Lagrangian model. This puff model computes plume height based on atmospheric conditions and fire behaviour characteristics. Its mathematical formulation integrates components describing the buoyancy effect, gravity effect and entrainment drag. The model also accounts for the influence of ambient temperature profile on plume rise. Atmospheric soundings from Environment Canada's Goose Bay Upper Air station were used in the model to estimate the altitude reached by the plume generated by fire#2 on June 13th (Figure 12).

Fire specialists acknowledge that not all the heat released during combustion is convected. Ferguson et al. [2000] claim that 40 to 80% of the heat is transferred to the convection column. A recent study by K. Anderson (Canadian Forest Service, personal communication, 2015) suggests that the convected fraction could be as low as ~10%. Table 2 presents sensitivity tests of plume height for fire#2 with different convected fractions and areas burned. Energy outputs modeled with Prometheus were multiplied by the various factors (i.e., 80%, 40% or 10%) to account only for convective energy in the puff model.

Fraction of heat convected	Area burned	
	70,000 ha/day	35,000 ha/day
80% (high)	6,900 m	5,700 m
40% (medium)	5,700 m	4,700 m
10% (low)	3,700 m*	3,000 m

Table 2: Sensitivity tests on plume height (meters AGL). Daily areas burned were converted to hourly values as inputs to the puff model (*corresponds to Figure 12).

Smoke Plume Transport to Greenland

Trajectories of mid-tropospheric air masses originating from central Labrador exhibited a curly pattern around the northern tip of the high pressure ridge located over southern Greenland (Figure 13a; see also Figure 6 in Lavoué [2013]). The meridional wind pattern observed in June 2012 is linked to the negative phase of the Arctic Oscillation (https://www.ncdc.noaa.gov/teleconnections/ao/, accessed 30 June 2015).

Moderate resolution remote sensing systems, including TOMS and MODIS (data available at http://disc.sci.gsfc.nasa.gov/giovanni, accessed 1 June 2015), indicate the northward transport of the smoke plume to Greenland. MODIS Aerosol Optical Depth (AOD), an optical measure of particle amount in the atmospheric column, shows that the plume was positioned off the coast of Labrador on 13-14 June (Figure 13b). Furthermore, on June 14th, UV Aerosol Index (AI) from OMI TOMS (http://disc.sci.gsfc.nasa.gov/giovanni, accessed 1 June 2015) shows very high values over the Labrador Sea as well as the arcing of the smoke plume northward and then eastward towards the southern coast of Greenland. AI is an indication of absorbing particles, such as black carbon, in the vertical column (Figure 13c).

The smoke dispersion pattern was simulated with HYSPLIT, a particle model appropriate for long-range transport (http://ready.arl.noaa.gov/HYSPLIT.php). The same emission rate of 10^9 grams/hour of PM_{10} was assigned to all hours of three consecutive days (i.e., 12, 13 and 14 June 2012). PM_{10} was released as a single point source at an altitude of 4000 m AGL. GDAS (Global Data Assimilation System) 1 degree gridded meteorological data was used in this modeling exercise.

The smoke plume transport shape computed with the dispersion model shows good agreement with the AI product (Figures 13c & 13d). Vertically-averaged concentrations between the surface and 5000 m AMSL exhibit values between 0.001 and 0.1 mg/m^3, based on the previously mentioned emission rate of 10^9 grams/hour from fire#2. Concentration fields modeled with HYSPLIT cannot be directly validated with either AOD or AI

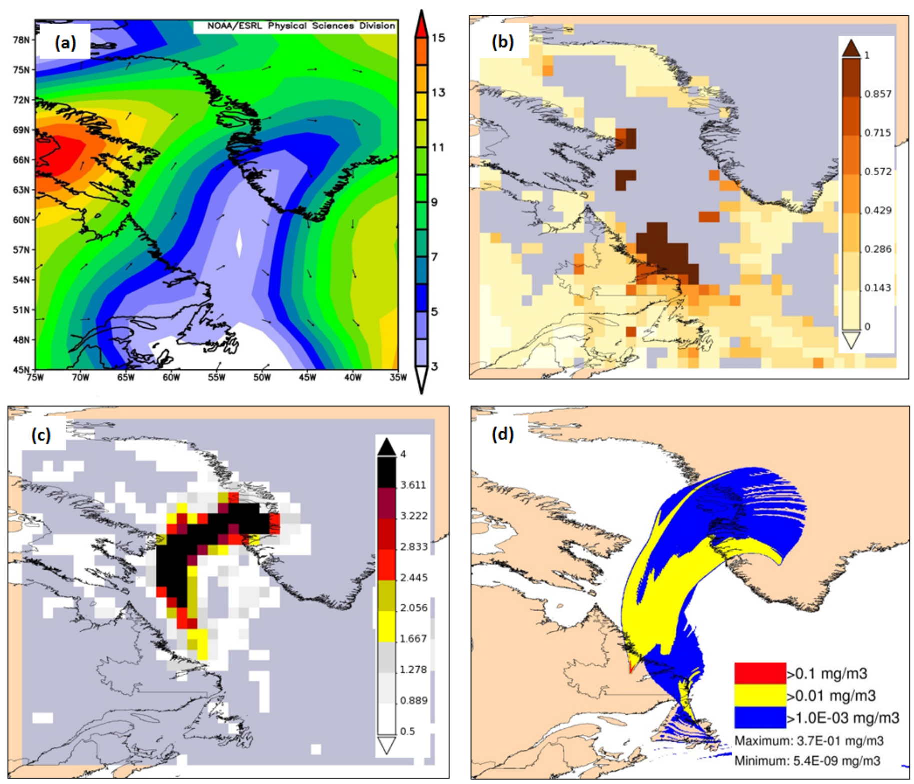

Figure 13: Various datasets depicting long range transport of wildfire smoke from Labrador to Greenland; (a) 500 mb-mean wind (wind speed in m/s) during 10-30 June 2012 over Eastern Canada and southern Greenland (from NCEP/NCAR Reanalysis); (b) high values of Aerosol Optical Depth (AOD) measured by MODIS off the mid-Labrador coast on 13-14 June; (c) UV Aerosol Index (AI) from OMI TOMS on June 14th showing the smoke plume over Labrador Sea; (d) PM_{10} concentrations (surface to 5000 m) estimated with the dispersion model HYSPLIT for June 14th.

since these space-based aerosol products correspond to aerosol optical properties, which are not part of HYSPLIT modeling outputs. A proper validation of the smoke plume simulation performed with the integrative fire and smoke modeling system presented here would require computing aerosol concentrations and their relevant optical properties with a comprehensive aerosol package such as the one in WRF-CHEM (https://www2.acom.ucar.edu/wrf-chem, accessed 19 July 2015).

Future Development

The goal of the present study was to integrate various numerical models into a fire and smoke modeling system in order to track wildfire smoke from source to eventual dispersion in the atmosphere. Three dimensional emission fields were calculated by combining outputs from a fire growth model, an emission factors look-up table and a plume rise model. The modeling system was applied to the 2012 Labrador fires to simulate the long-range transport of smoke to Greenland with a Lagrangian dispersion model. Future work will focus on improving techniques for the determination of the initial fire perimeter used for predicting fire growth with Prometheus. §

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Job Posting

Environmetrics Research Scientist SE-RES-1 (Postdoctoral Research Program)
Natural Resources Canada, Pacific Forestry Centre, Victoria, B.C.

Position Summary:
Natural Resources Canada (NRCan) is looking for a postdoctoral researcher to develop and apply statistical methods to predict the occurrence and duration of severe wildfires in Canada. The researcher will work with fire scientists from NRCan and statisticians at NRCan and at Western University, London, ON, as part of the interdisciplinary Severe Wildfire Risk Prediction project.

We seek a statistician or a quantitative environmental scientist with expertise and interest in statistical methods relevant for atmospheric/environmental sciences. The position offers an excellent environment for working with a highly skilled interdisciplinary team in NRCan and at Western University. The expertise of team members includes applied statistical modelling, biometrics, smoothing and generalized additive models, spatial statistics, stochastic processes, survey statistics, survival analysis, climate analyses, and wildfire behavior and occurrence prediction. The successful candidate will focus on the analysis of the influence of weather and other fire danger variables on the occurrence and duration of severe fires and the development of predictive models for such occurrence. Understanding and predicting such megafires is an area of intensive current research in the fire science community and important to public safety.

The position requires developing and applying a combination of statistical methods such as spatio-temporal statistics, extreme value analysis, survival analysis, machine learning, and possibly Bayesian methods to estimate the probabilities of climate events under different scenarios. A key focus will be to quantify the uncertainty in the probabilities in light of a wide variety of sources of uncertainty. The researcher will evaluate, extend and implement existing methods and develop new statistical frameworks and methods to predict the occurrence and duration of wildfires in relation to forecasted weather and other explanatory variables. The researcher will work with fire scientists to apply and to weather forecasts and implement them within in a wildfire information system.

Specific Responsibilities:
- Develop and apply statistical methods for prediction of the occurrence and duration of severe wildfires.
- Evaluate the uncertainty in model forecasts due to forecast error and model formulation.
- Compare predictions to past observations to evaluate the fidelity of models and examine the risk of model failure (false negatives)
- Produce and deliver oral and written presentations of scientific results.
- Work effectively in a large and integrated team.

Essential Qualifications:
- PhD in statistics or environmental sciences to be completed within the last 3 years and as of the start date for this position
- Experience in planning and conducting research
- Experience in working with a team of researchers and support staff
- Excellent written and oral communication skills.

Additional Desired Qualifications:

- Ability to use R or SAS
- Ability to manipulate large datasets and data bases and carry out efficient computation
- Experience in one or more of the following areas: categorical data analysis, generalized additive models / functional data analysis, statistical learning, spatial statistics, survival analysis, Bayesian statistics
- Experience in environmental, forest or atmospheric science, forest science

How To Apply:

- To submit your application follow the Apply online link at : https://emploisfp-psjobs.cfp-psc.gc.ca/psrs-srfp/applicant/page1800?poster=785734
- You will need to create a jobs.gc.ca account
- In the Text Requirement 2 section of the application, indicate a specialization in Biostatistics in Natural Resources,Forest Fire Science, or Forest Modelling
- You will be required to include a resume in the application
- Send a note to staylor@nrcan.gc.ca indicating your interest in the position

Notes:

Successful candidates will be hired as term SE-RES-1 employees (salary range: $53,161 - $69,942).

This is a 1-year term position with the possibility of renewal for a second year based upon satisfactory job performance and continuing availability of funds. The position will be initially located in Victoria, BC, with the possibility of relocation to Western University, London, ON, in a second year. The anticipated start date is September 2015.

Team members are :
- Steve Taylor, Pacific Forestry Centre, Canadian Forest Service
- Steen Magnussen, Pacific Forestry Centre, Canadian Forest Service
- Mike Wotton, Canadian Forest Service & University of Toronto
- Douglas Woolford, Western University

The Canadian Smoke Newsletter

2015

"Connecting diverse terrestrial, emissions, air quality and modelling communities."

Papers of Interest

Smoke Exposure from Wildland Fires: Interim Guidelines for Protecting Community Health and Wellbeing - 2012 edition.

Paper published by Manitoba Health, a department of the Manitoba provincial government. Please note that this document is in the process of being revised. This review is of the 2012 version.

Under the reasonable assumption that it is better to be prepared than make things up at the last minute, Manitoba Health issued a 29 page document of interim guidelines in 2012 to assist the health care sector and affected communities in dealing with wildfire smoke.

When one considers that the Canadian boreal forest covers the majority of the province, and that many Manitoba communities are remote and nestled within that forest, it is not surprising that a substantial portion of the Manitoba population must be ready to deal with wildfire and smoke each year. Difficult decisions on how to cope, how to assist people with already compromised health and whether to evacuate entire communities or ride out the adverse conditions in place are a regular summertime challenge for municipal and provincial officials.

The objectives of this guidelines document, as stated in the introduction, are "to assist the health sector, communities and other stakeholders in communicating health risks and recommending actions or precautions to protect people from wildland fire smoke exposure."
The document is divided into four main sections:

- Introduction, where background is provided on the chain of authority, as well as the underlying science
- Roles and Responsibilities, where the obligations and roles of various agencies are explained
- Recommendations, where prevention, mitigation, response and recovery procedures are outlined, and
- Appendices, a set of five mini-documents expanding on plans and preparations referred to in the main document.

Introduction. It is of interest to note that in Manitoba, the final authority for the declaration of an emergency within a community is vested in the office of the local mayor, chief or his/her representative.

The health effects of exposure to $PM_{2.5}$ and carbon monoxide are explained in this section, and the types of individuals who may be most at risk are identified, e.g., people with existing respiratory or cardiovascular conditions, smokers, diabetics, the elderly, pregnant mothers, children, infants and outdoor workers.

Roles and Responsibilities. In an actual emergency, the mayor or chief consults with the local council, as well as various agencies, such as the provincial Emergency Measures Organization, Manitoba Health, regional health authorities, and in the case of First Nations communities, the Manitoba Association of Native Fire Fighters, band councils, First Nation and Inuit Health, to name a few. It is apparent that this amount of coordination can be a daunting task, and that having procedures laid out well in advance is critical.

Recommendations. This section contains lists of items to consider for purposes of preparation and planning for local authorities, health authorities and health facilities. For example, local authorities should identify in advance landmarks as visibility markers to assist in estimating smoke concentrations, and should have a list of sites that can act as clean air shelters, and ensure that they are available for emergencies.

Appendices. The five appendices included are:

- sample evacuation plans for health facilities and home care clients
- identification and preparation of clean air shelters
- a checklist for creating a clean air shelter at home
- suggested preparations for evacuation
- a fact sheet for preventing food-borne illness after returning home from an evacuation

Manitoba Health and the Office of Disaster Management are to be congratulated for their leadership in issuing this interim document. As mentioned before, the document is currently being updated. Questions regarding the document should be directed to Barbara.Crumb@gov.mb.ca
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