BlueSky

Wildfire Smoke Prediction Model – 2018 Issues

Interagency Meeting on Wildfire Smoke Communications in British Columbia
5 Feb 2019

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Topics:

1. BlueSky Basics
2. 2018 issues, hot spots and satellite images
3. BlueSky Diagnosis
   a) Operational 2018 issues
   b) Post-mortem diagnosis
   c) Computation Issues
   d) BlueSky / Hysplit Issues
   e) Reforecast Comparisons
4. Ops Plans for 2019
5. Research

Colleagues:
Tim Chui
Frans Liqui Lung
Nadya Moisseeva

1. BlueSky-System Framework (BSF) Basics

2000s

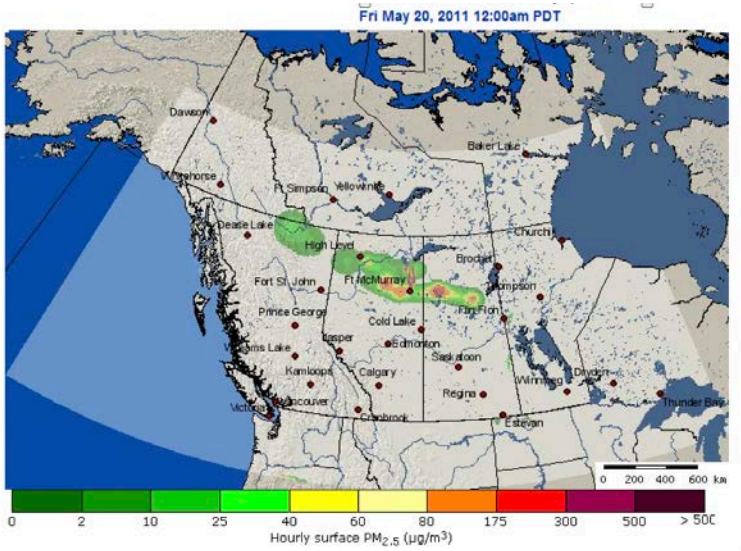
BlueSky (RAINS) was created by USFS AirFire team in Seattle (Sim Larkin) and UWash Environ. & Forest Sci (Joel Dubowy). RAINS -> BSF

2007-2009

BC Ministry of Environment (Steve Sakiyama) & AB Environment (David Lyder) contracted with UBC and Sonoma Tech Inc (STI) to Canadianize BlueSky.

2010-2011

UBC ran 4xdaily operational BlueSky/MM5 fcsts. for W. Canada, with BC & AB $



2012-2016

UBC BlueSky W. Can. fcsts. expand thru prairies. New Eastern Canada domain (ON $). Change from MM5 to WRF weather model.

2013-2015

UBC BlueSky expansion with DND/CSSP->CFS $ and BC, AB, SK, ON $

2017-2019

UBC BlueSky Canada-wide nested 12 & 4 km domains: BC, AB, SK, ON, NT $

BlueSky Framework Components

Weather

1) Get initial and boundary condition weather from US NCEP NAM.
2) Run the **WRF** numerical weather prediction model at UBC for Canada-wide domain at 12 & 4* km grid-spacing out to 3+ days.
3) Use **BSF** to convert WRF output to ARL format for input to hysplit

Fires

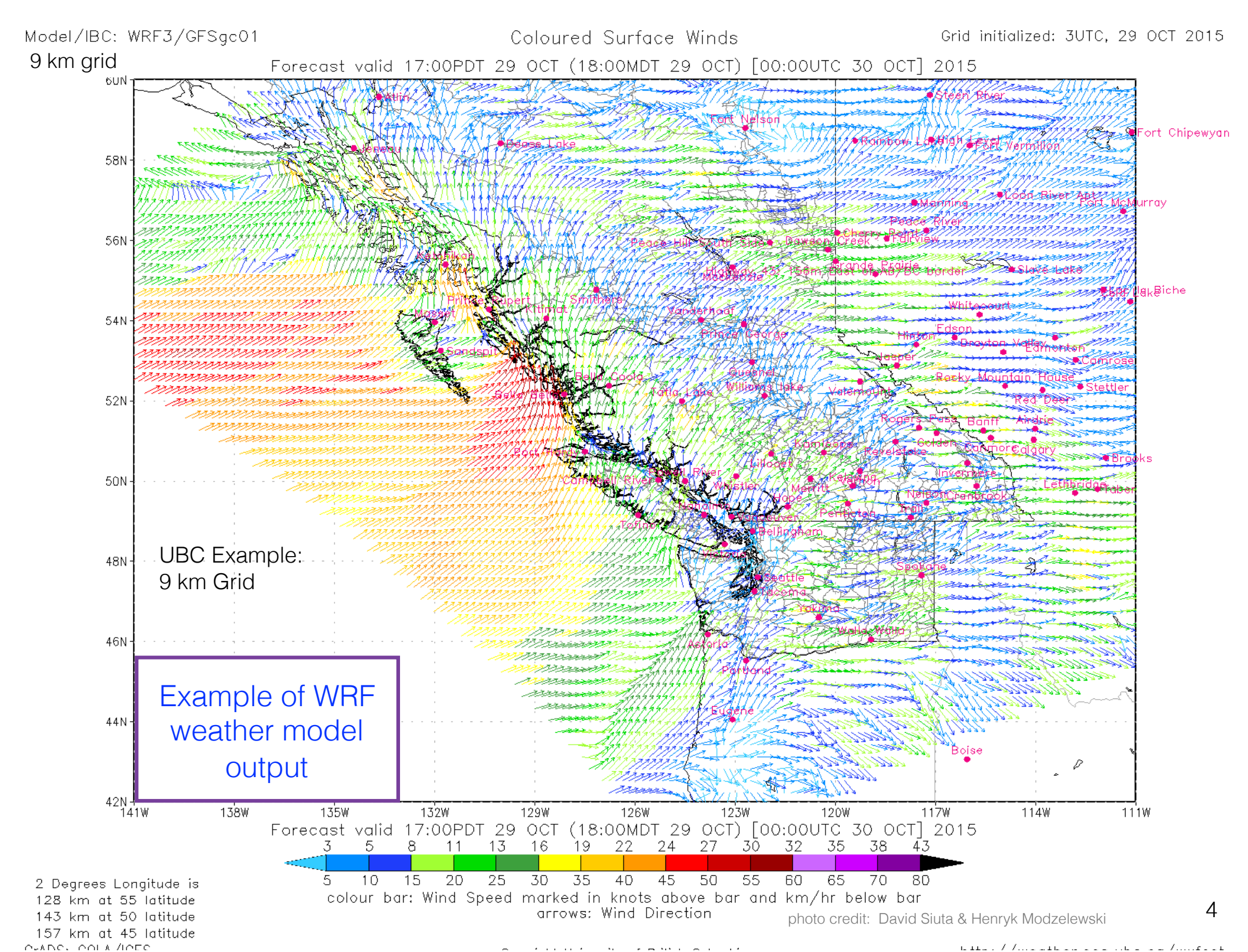
1) Satellite hotspots and ground reports are collected by CFS in CWFIS.
2) CWFIS adds Can. Fire Wx Index (fine-fuel moisture, duff moisture, drought code, initial spread index, buildup index, fire wx indices) & Fire Behavior Prediction (rate of spread, head-fire intensity, total & sfc fuel consump.)
3) These data grabbed by UBC.
4) UBC runs **Smartfire** to clump, associate & reconcile the data sources -> data stream.

Dispersion

1) Collect: ARL weather, new emissions, & carryover smoke from day before as input to:
2) Run the **HYSPLIT** puff-dispersion model to predict 3-D PM2.5 conc.
3) Compute graphics (kmz, web viewer, jpg, text) for surface PM2.5 & display on **firesmoke.ca**

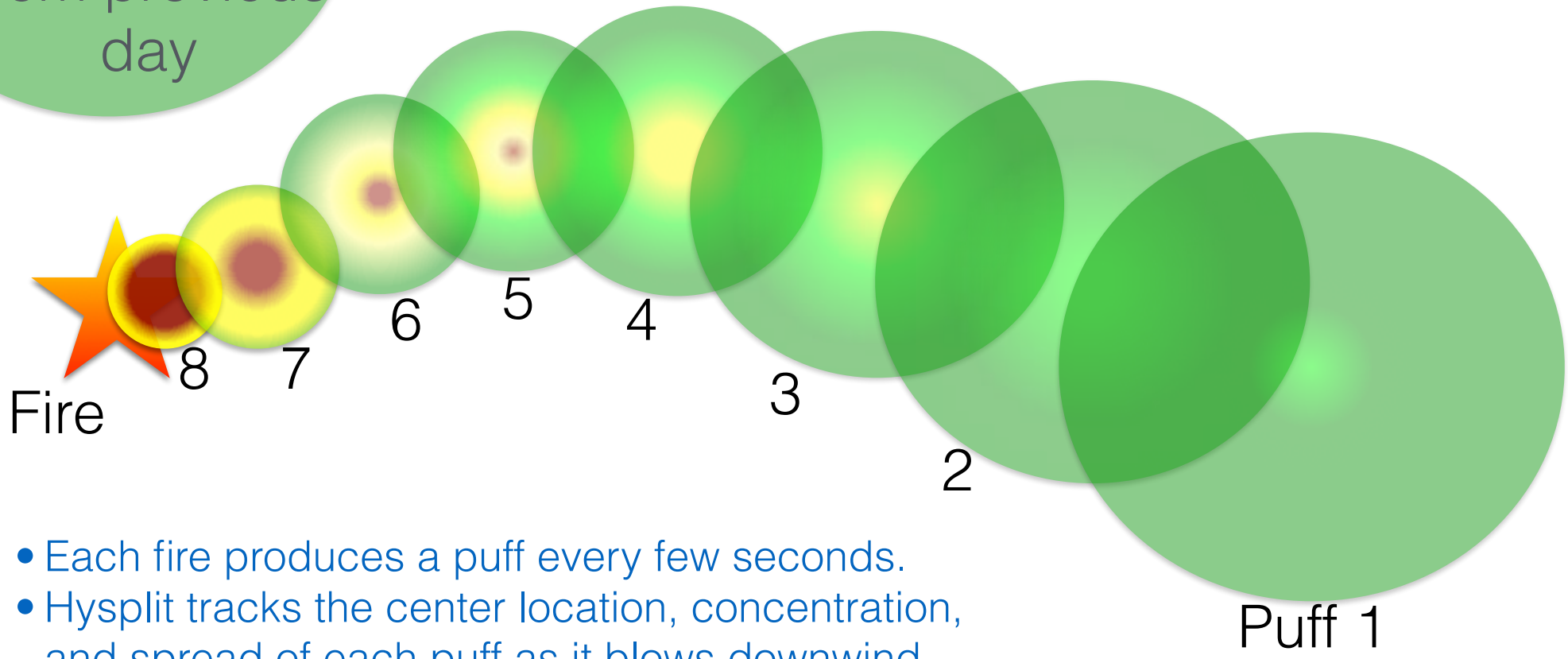
Emissions

1) Every 4 hours **BSF** grabs fire data from Smartfire. Has 48 hours spin up & 60+ hours of forecast
2) **BSF** Computes: fuel consumption, FEPS time profile, emissions, & plume-rise.
3) Create emission & plume-rise data as time series for each fire source to send to hysplit.


Model/IBC: WRF3/GFSgc01
Coloured Surface Winds
Grid initialized: 3UTC, 29 OCT 2015
9 km grid
Forecast valid 17:00PDT 29 OCT (18:00MDT 29 OCT) [00:00UTC 30 OCT] 2015
UBC Example:
9 km Grid
Example of WRF weather model output
Forecast valid 17:00PDT 29 OCT (18:00MDT 29 OCT) [00:00UTC 30 OCT] 2015
3 5 8 11 13 16 19 22 24 27 30 32 35 38 43
5 10 15 20 25 30 35 40 45 50 55 60 65 70 80
colour bar: Wind Speed marked in knots above bar and km/hr below bar
arrows: Wind Direction
2 Degrees Longitude is
128 km at 55 latitude
143 km at 50 latitude
157 km at 45 latitude
photo credit: David Siuta & Henryk Modzelewski
4

Carry-over from previous day

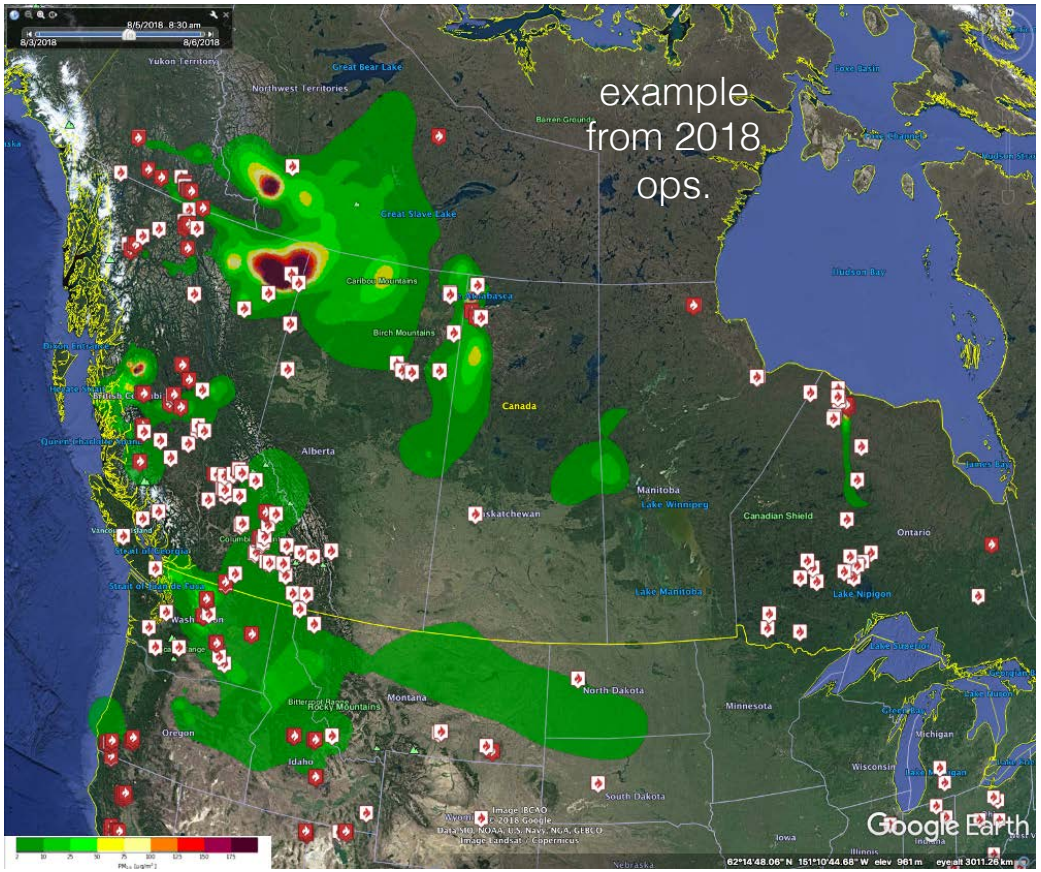
Hysplit (Lagrangian) Dispersion Model

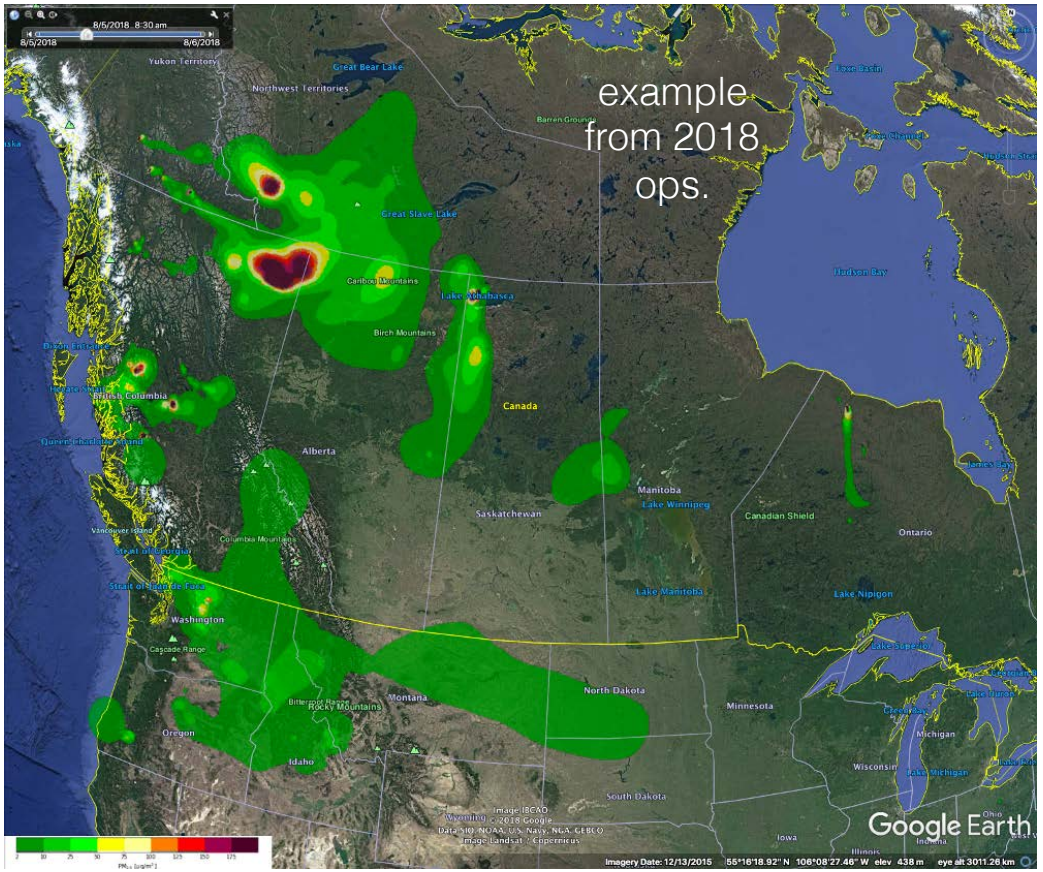


- Each fire produces a puff every few seconds.
- Hysplit tracks the center location, concentration, and spread of each puff as it blows downwind.
- Each puff has its own “age”.
- Puffs are merged in the horiz. or split in the vertical as needed.
- To prevent calculation of an infinite number of puffs, if Npuff > maxPar, then lower-numbered (older) puffs are deleted.
- To prevent calculation of ancient puffs, those puffs older than KHmax are deleted.

ρ = air density, U = wind speed, L = length scale, μ = molecular viscosity, g = accel. due to gravity, T = temperature, z = height, θ=T+(9.8K/km)·z.

Results in animated maps of Estimated **Surface** PM2.5





Example of BlueSky surface smoke concen. output

Option to display **with** or **without** hotspots

2) BlueSky Issues

Issues in 2018:

- Many fires in W. Canada
- Light-to-calm winds allowed smoke to accumulate for many days

Results:

- More fires and more carryover smoke produced more total smoke puffs than BlueSky could handle
- Gross under-prediction of surface concentrations

- Loss of confidence by the public.
- Triggered an intense 4-month post-mortem effort at UBC to diagnose the root causes.

Case Study Period: 5 - 18 Aug 2018

Lots of fires
(hot spots)

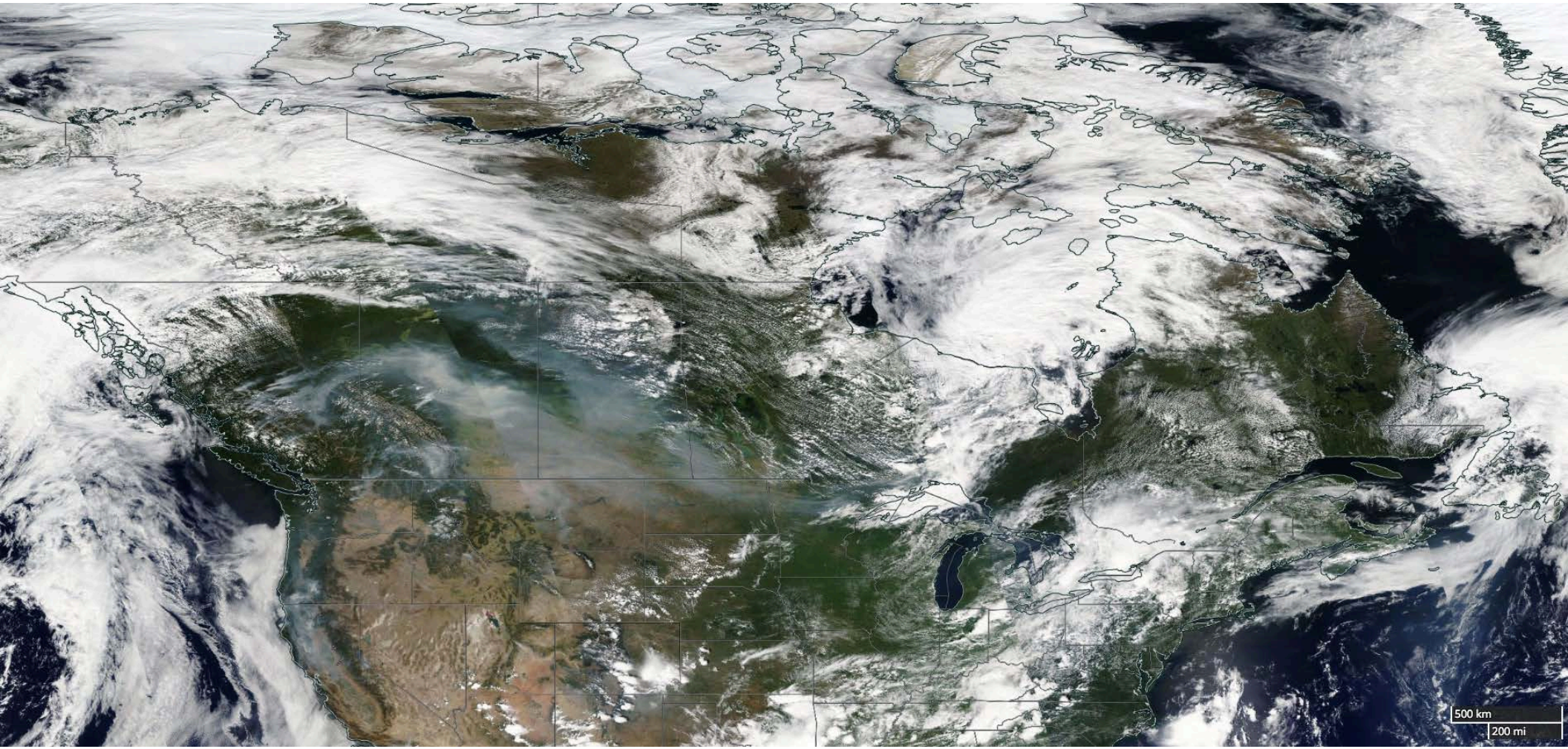
Aug 2018	Hotspots
5	2071
6	1380
7	2532
8	156
9	558
10	6985
11	4434
12	4408
13	4246
14	4154
15	4408
16	4611
17	5569
18	5652

Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

Lots of smoke

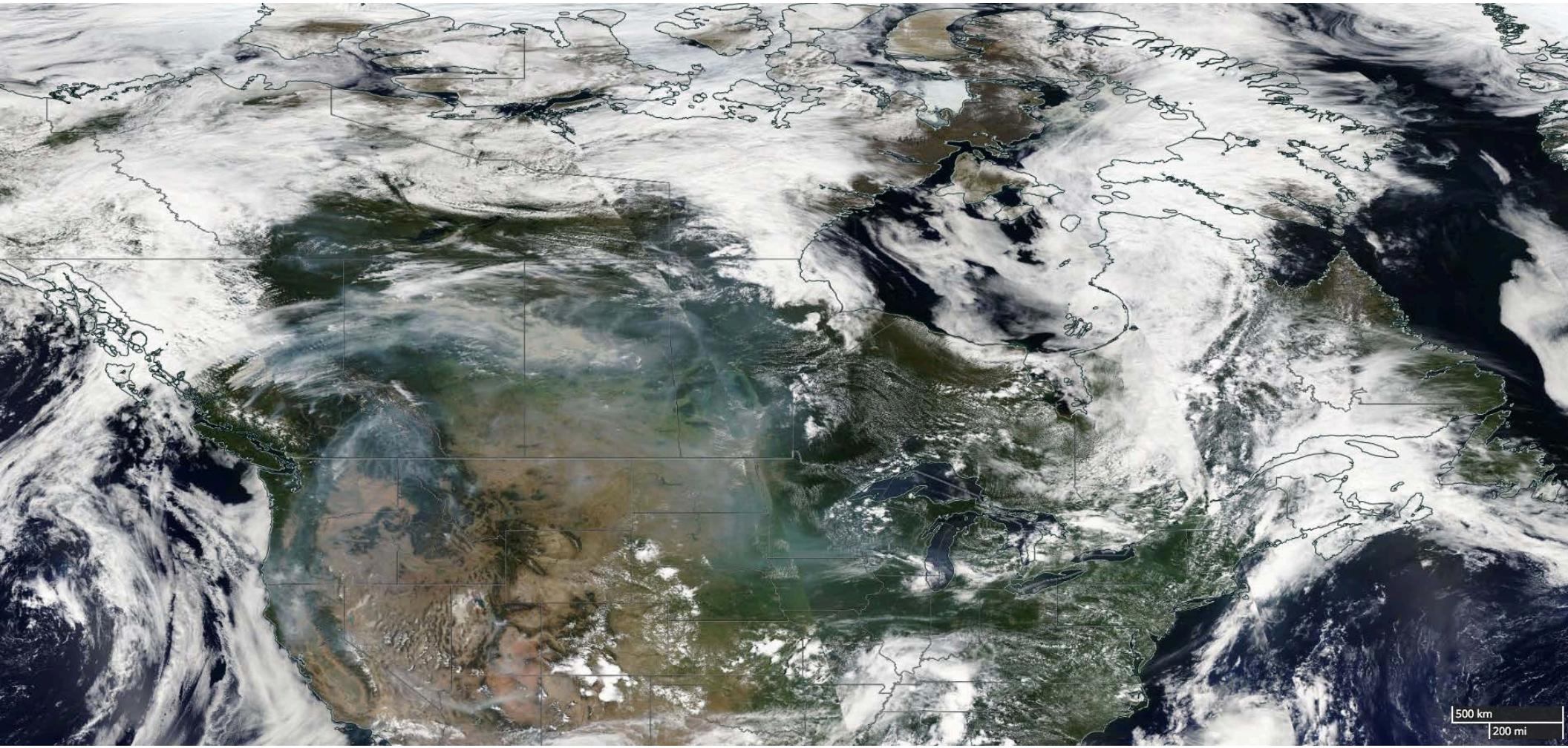
08 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

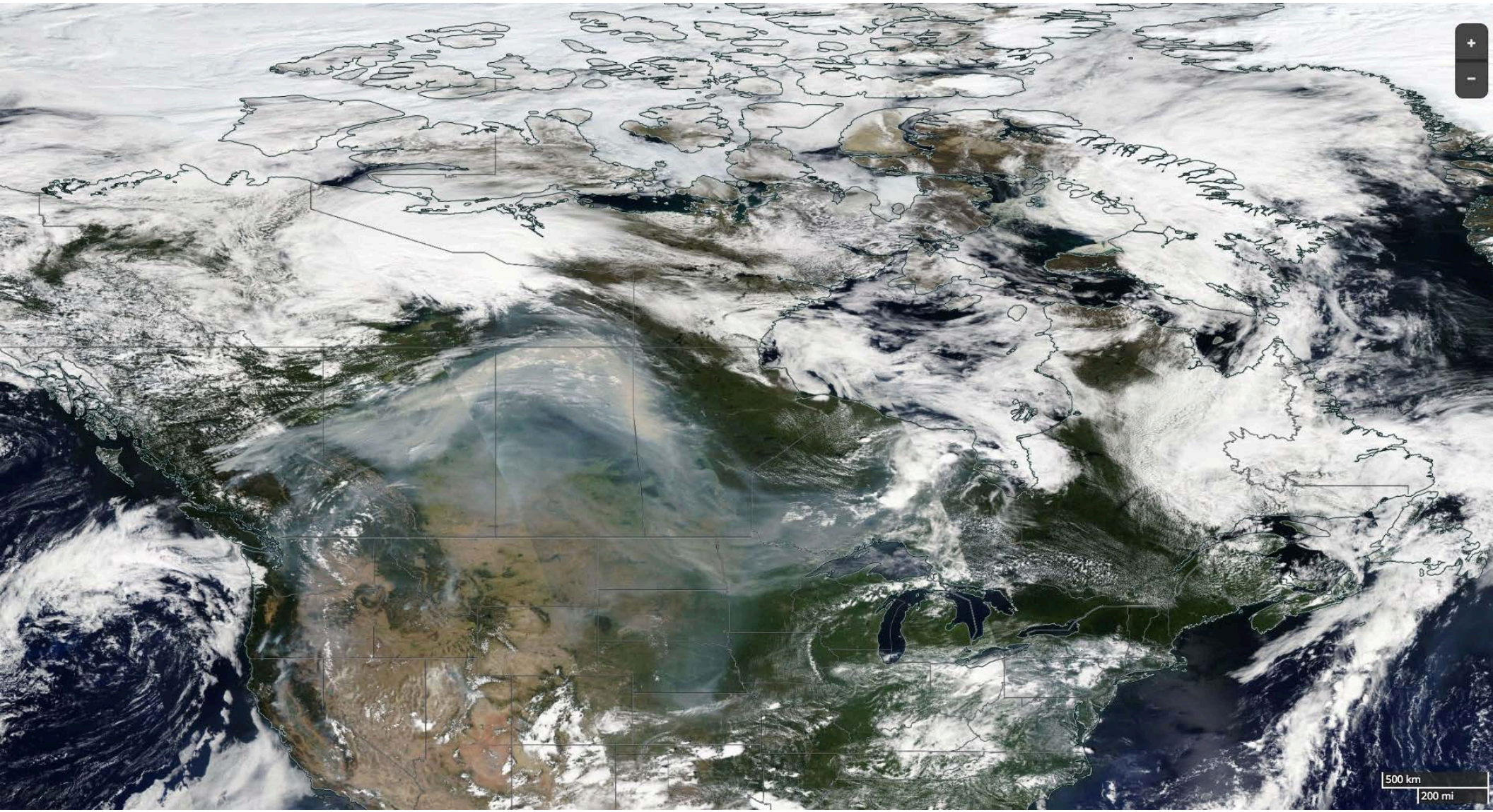
09 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

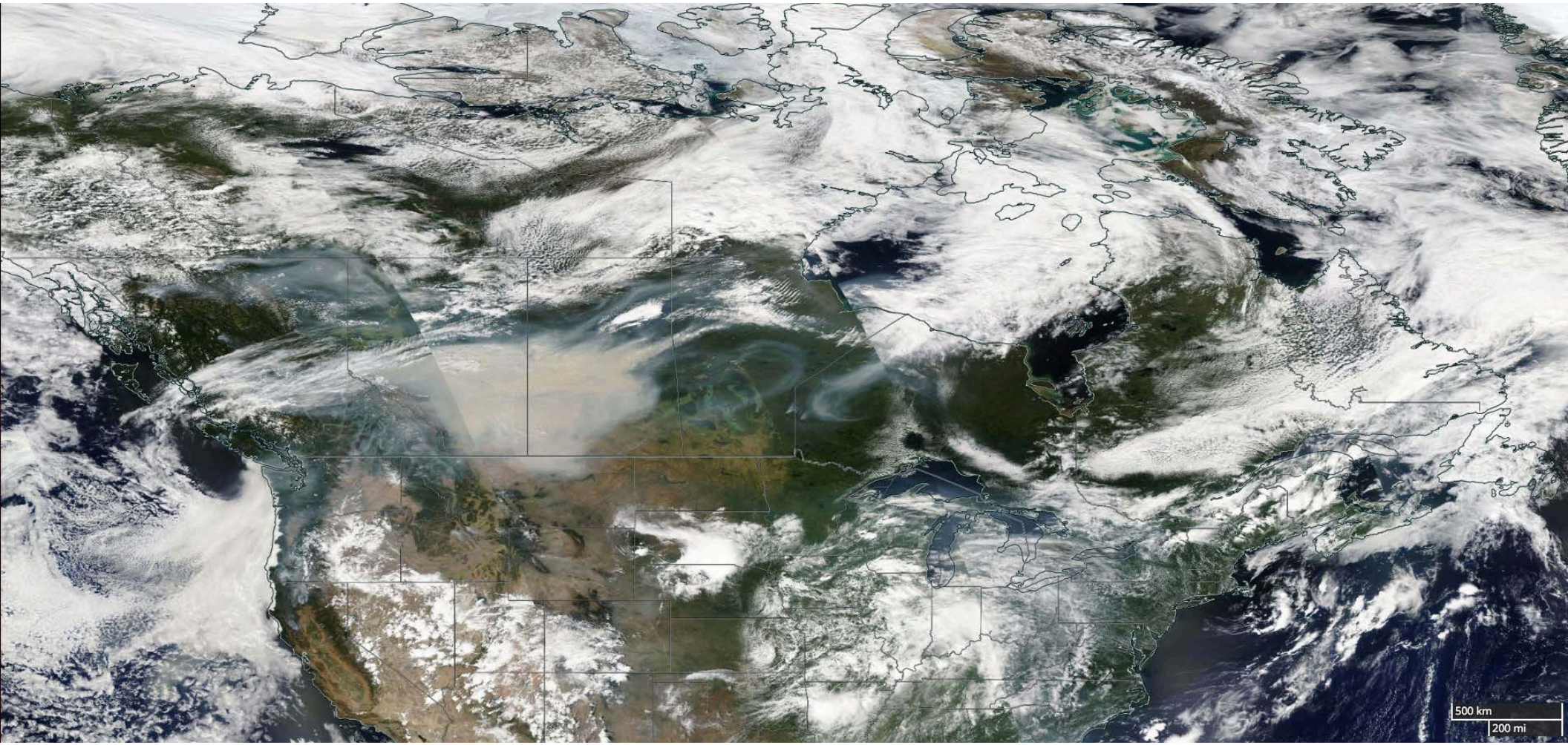
10 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

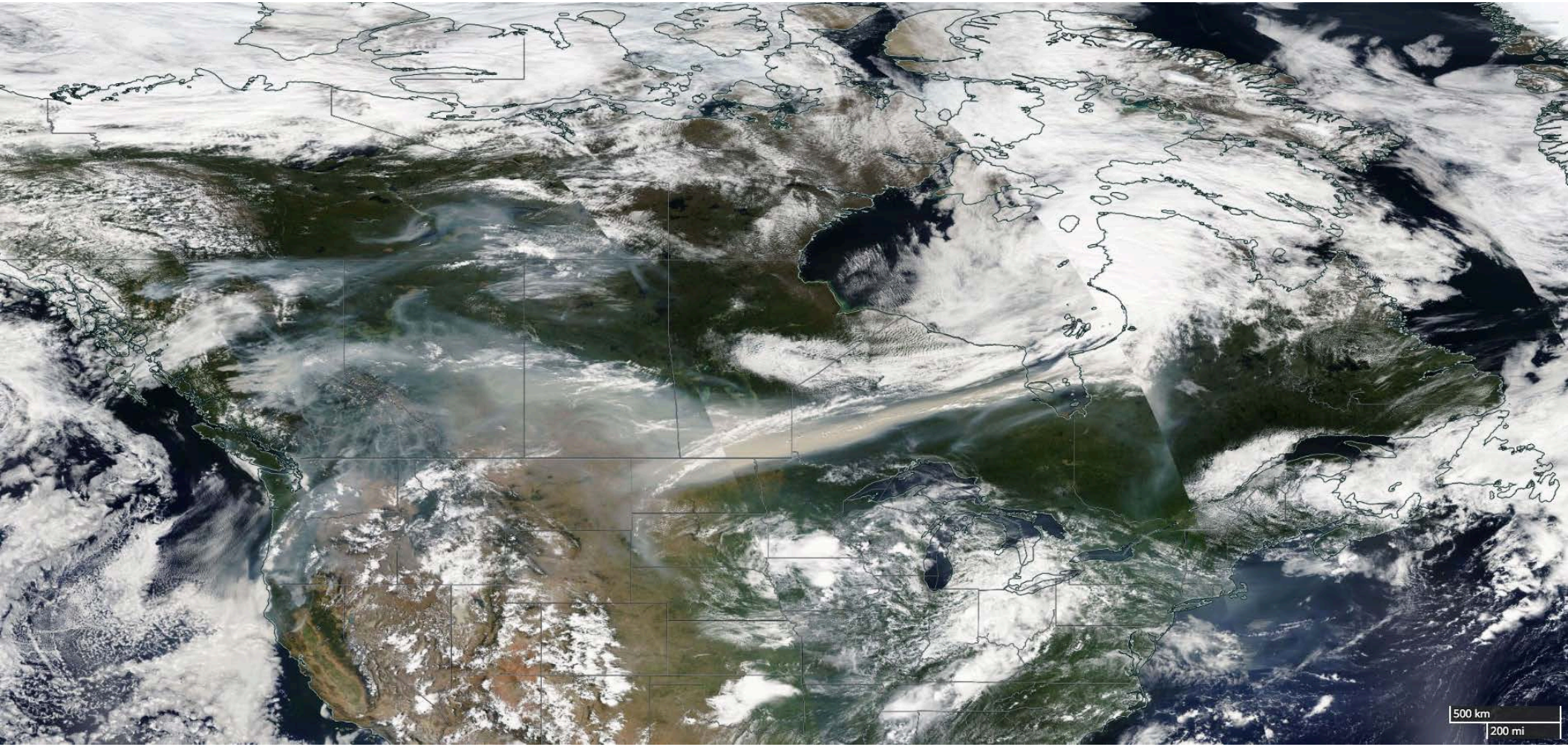
15 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

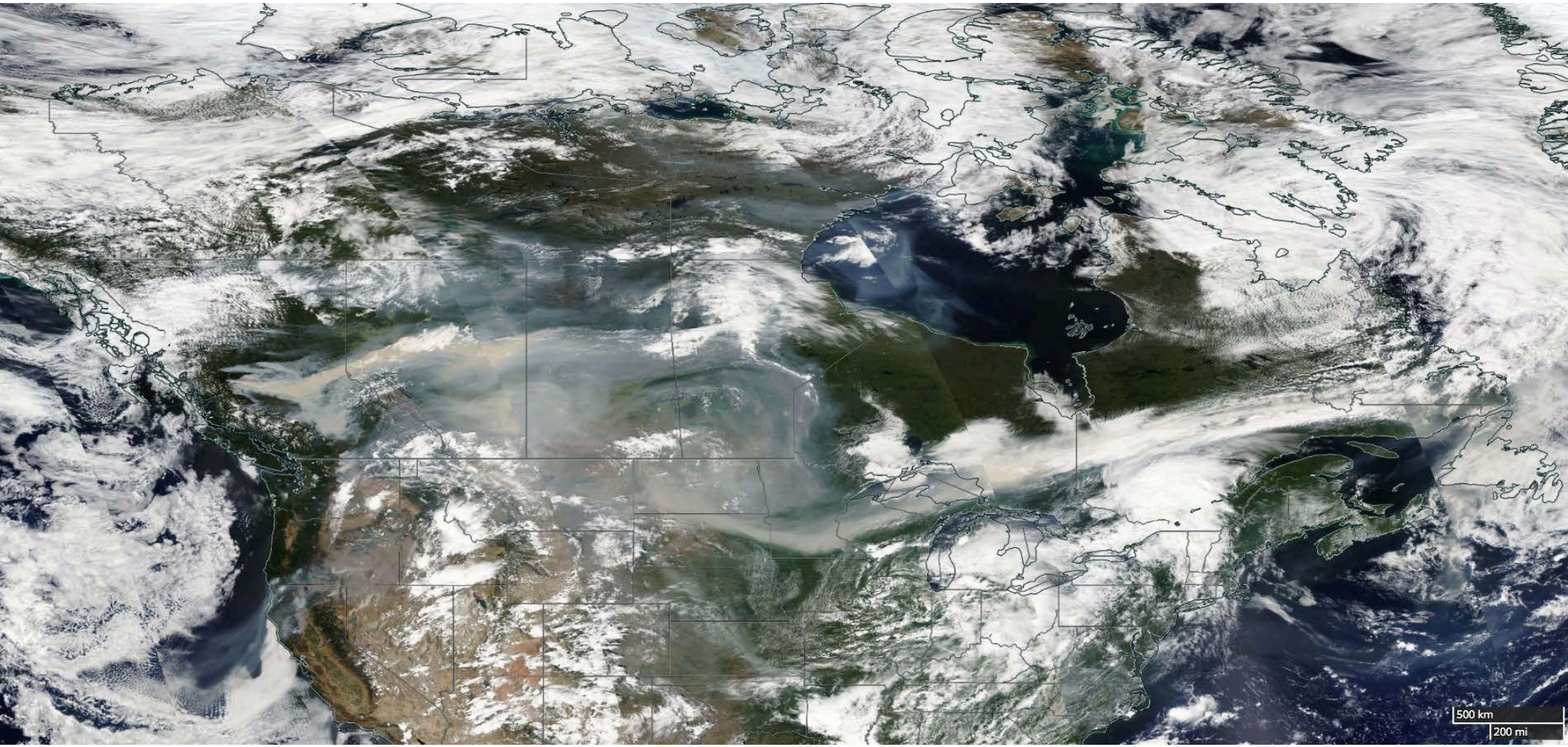
16 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

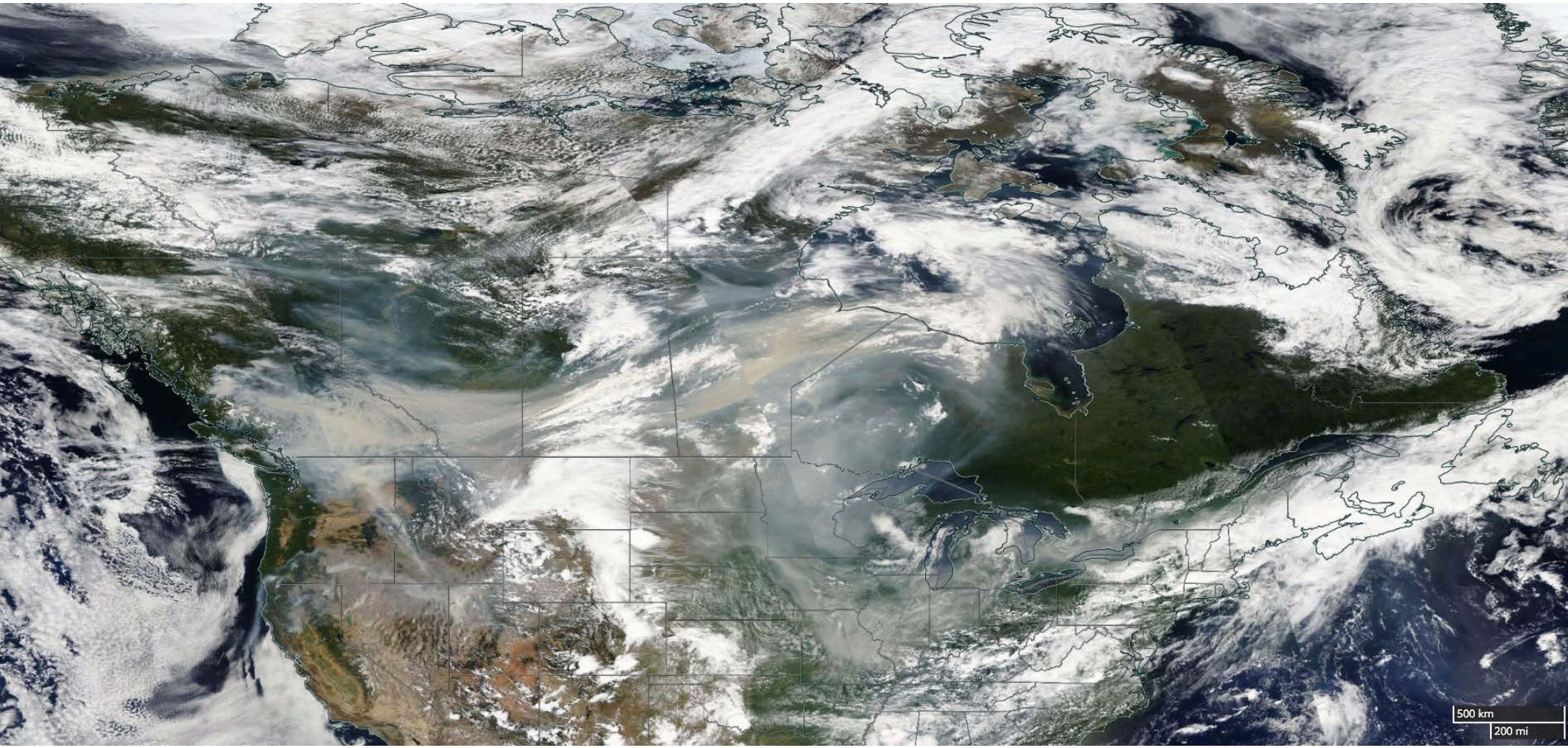
17 Aug 2018



Case Study Period: 5 - 18 Aug 2018

Starts relatively clean, but has widespread dense smoke later.

18 Aug 2018



3) BlueSky Post-mortem Diagnosis

Caught by Surprise:

- Nothing in BlueSky was changed from 2017 to 2018.
- But hints of problems had already existed in 2017.

Conducted 4-month In-depth Post-mortem Case-study Analysis:

- Was it due to updates of our operating system? NO
- Was it due to changes in our computer hardware? NO
- Was it due to changes in our weather model output? NO
- Was it due to incomplete downloads of fire info from CWFIS? NO
- Was it due to incomplete SmartFire reconciliation? **YES**
- Why? BSF sometimes accessed older emissions, not most recent.
- Also, BSF was sometimes accessing incomplete or missing emission files.
- Why? SmartFire would sometimes hang on ground reports.
- Why? Some old ground-reported fires unclosed from April.
- **Solution** to this issue: Turn off ground reports. Speed up SmartFire processing. Delay BSF's access to the fire data.

Note: STI provided compiled binaries of BlueSky to UBC.
Bottom line: we have limited ability to fix intrinsic problems.

Case Study Period: 5 - 18 Aug 2018

Aug 2018	Hotspots	SmartFire's Hotspots	
5	2071	2071	
6	1380	1380	
7	2532	2986	4 h old
8	156	156	
9	558	558	
10	6985	1970	4 h old
11	4434	1970	28 h old
12	4408	4408	
13	4246	4246	
14	4154	4154	
15	4408	4408	
16	4611	4611	
17	5569	5569	
18	5652	5652	

BlueSky Diagnosis

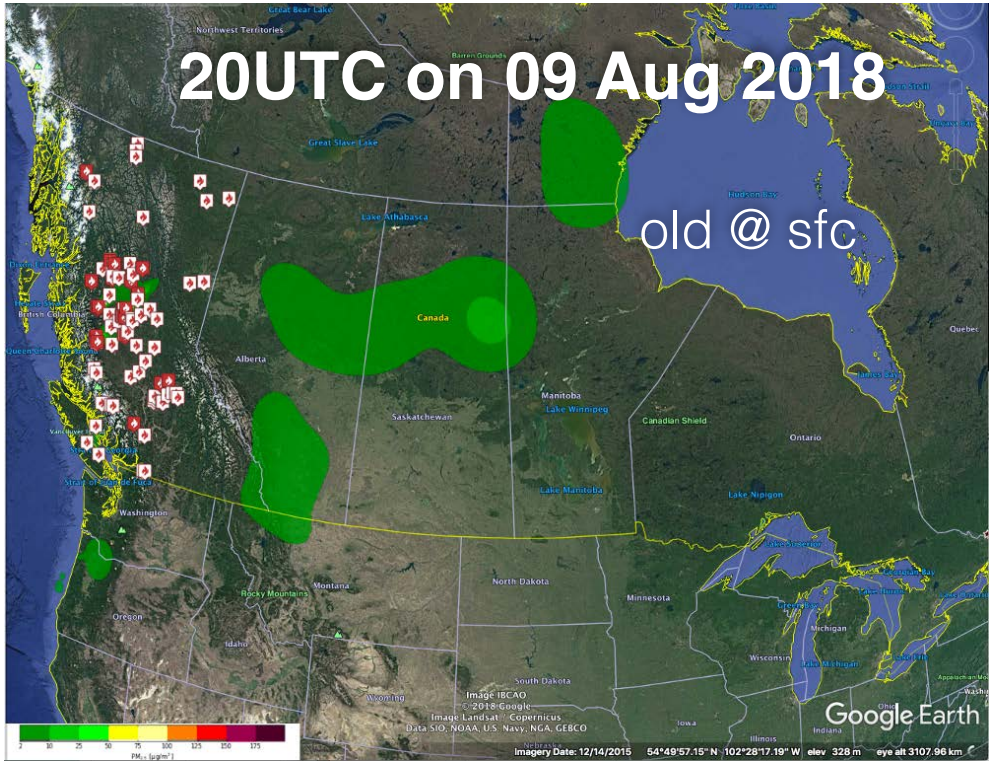
- Re-forecast the case study with actual (correct) hot spots.
- Did the SmartFire fixes solve the problem? Not completely. Keep looking.

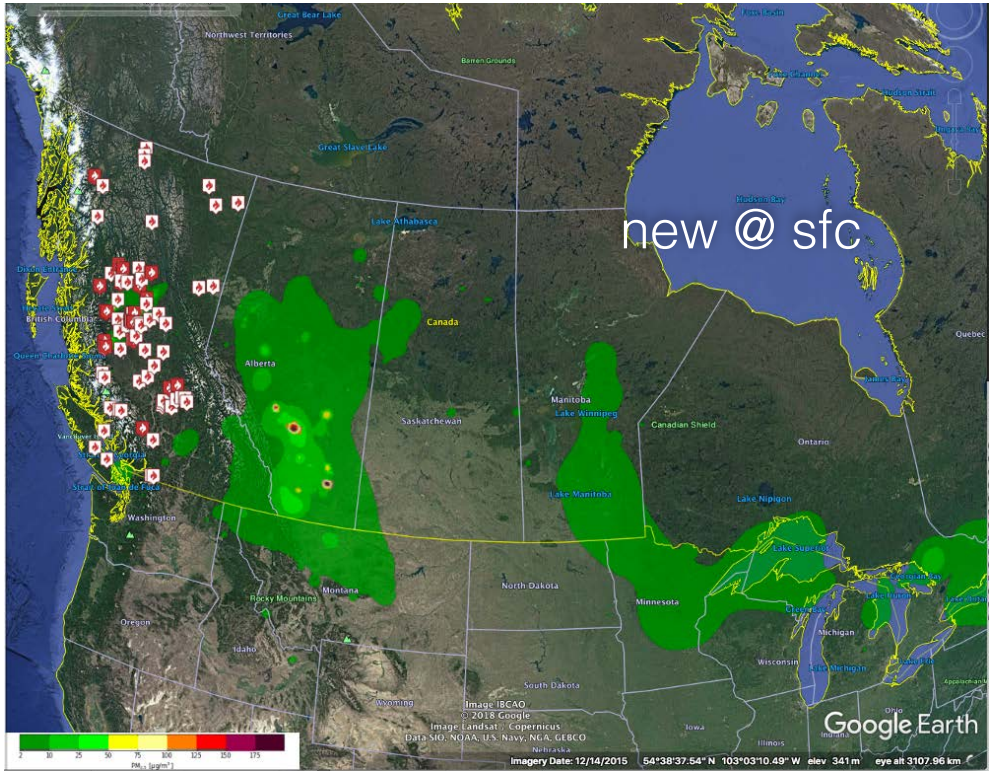
- Did the puff count exceed default maxPar = 175,000? YES.
- Did the puff age exceed default KHmax = 3 days? YES
- Why? Too many puffs = [carryover puffs from days before] + [new puff emissions].
- Other ramifications of the above? YES, puff-splitting stopped.
- What was the result: **too little smoke in the forecasts**.

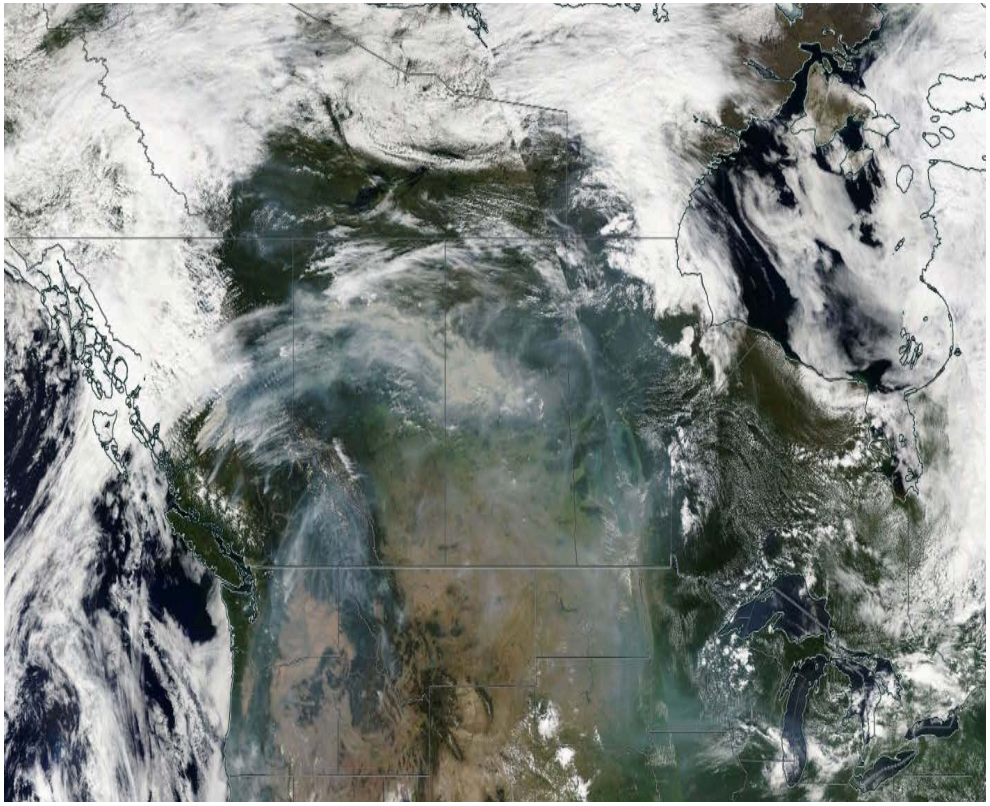
- Solutions? Increase maxPar and KHmax toward infinity .
- Drawbacks? Takes infinite time to run. Not timely for clients.
- Sensitivity Tests with different maxPar & KHmax values.
- Result: Optimum maxPar = 840,000. KHmax = 8 days.

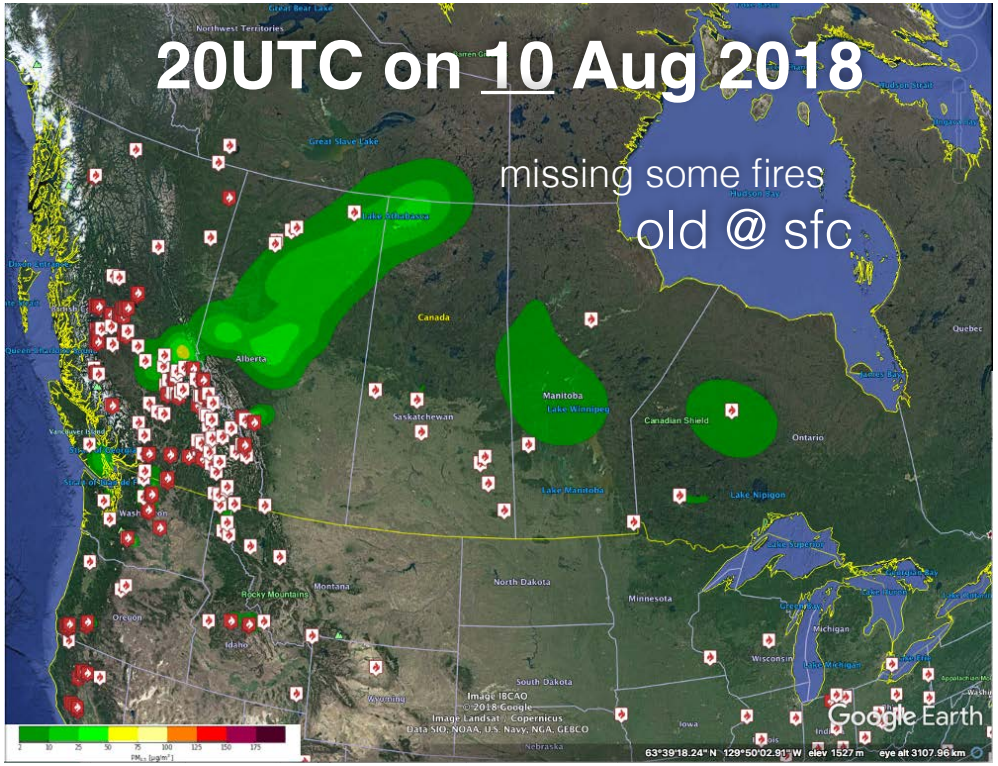
Compare BlueSky Reforecasts for new vs old parameters …

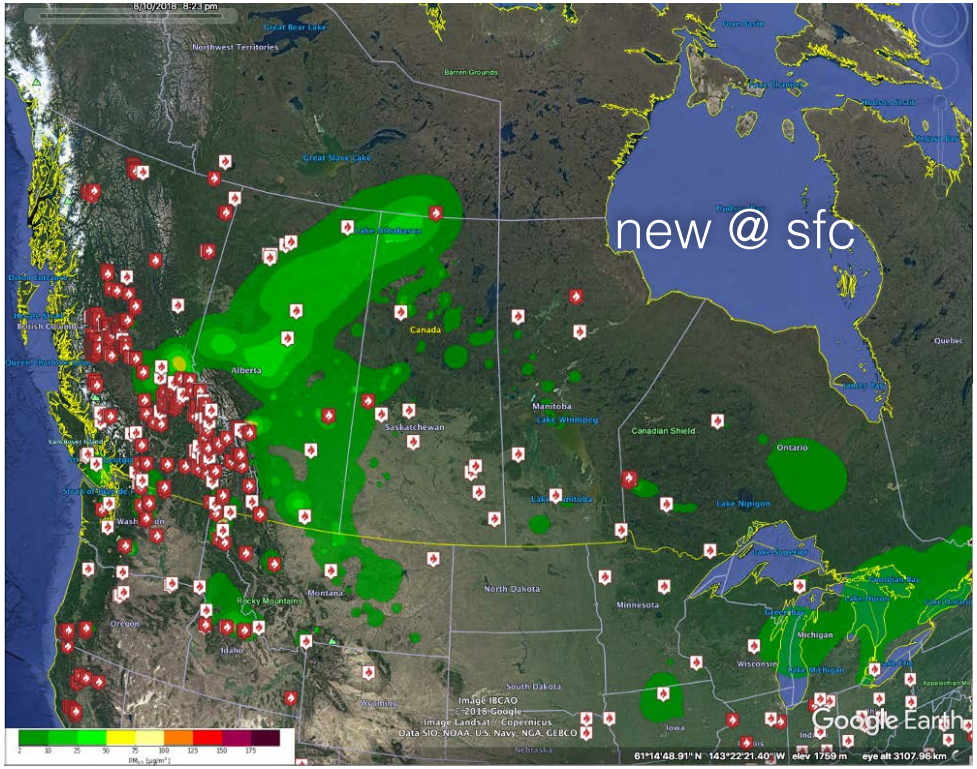
20UTC on 09 Aug 2018








20UTC on 10 Aug 2018
missing some fires
old @ sfc
Google Earth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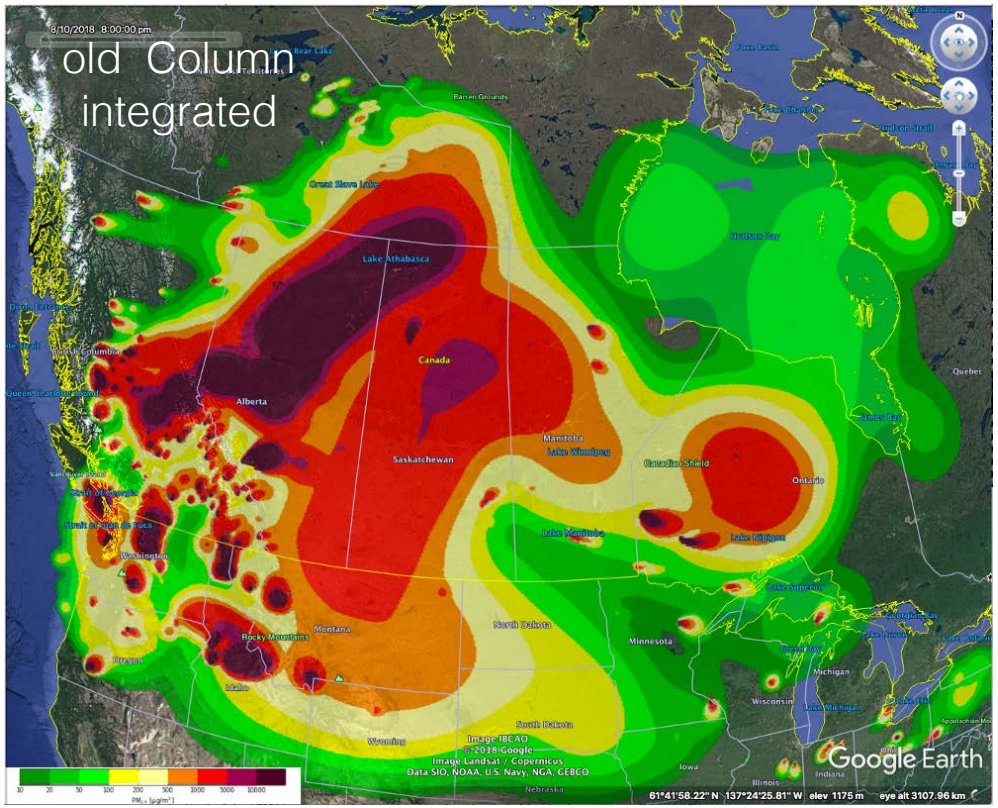
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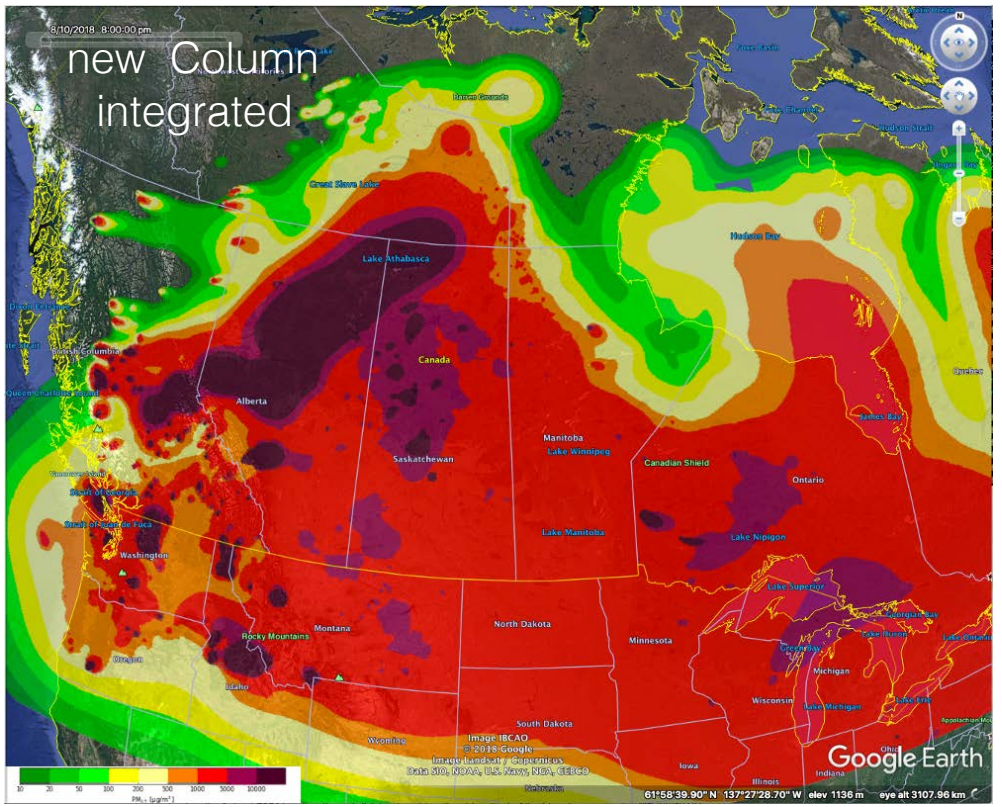
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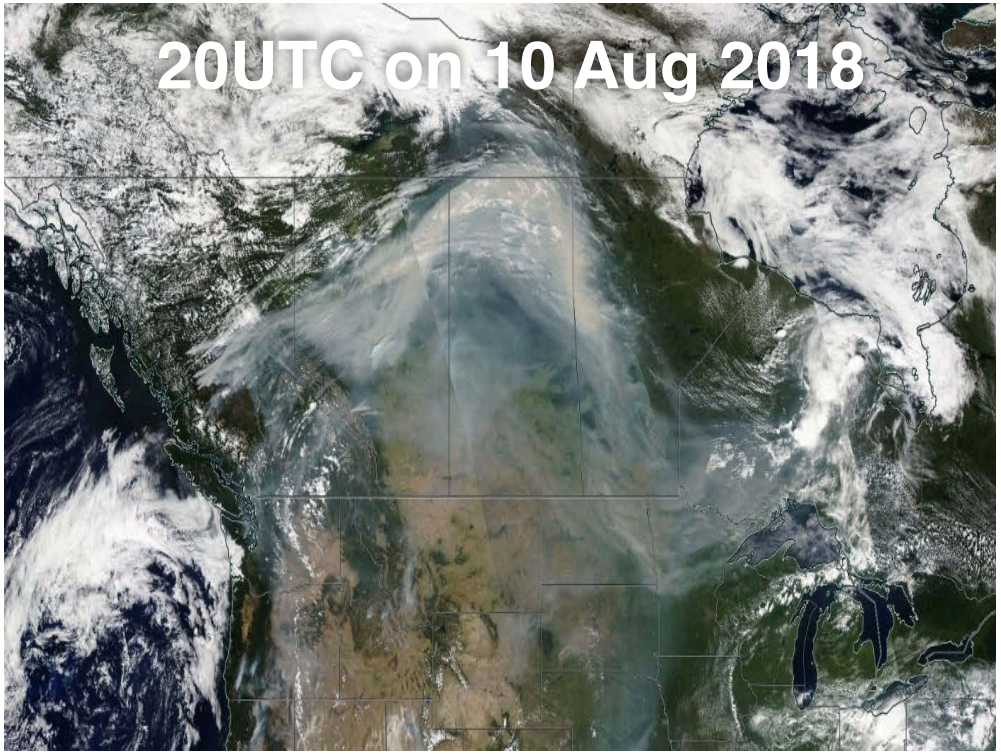
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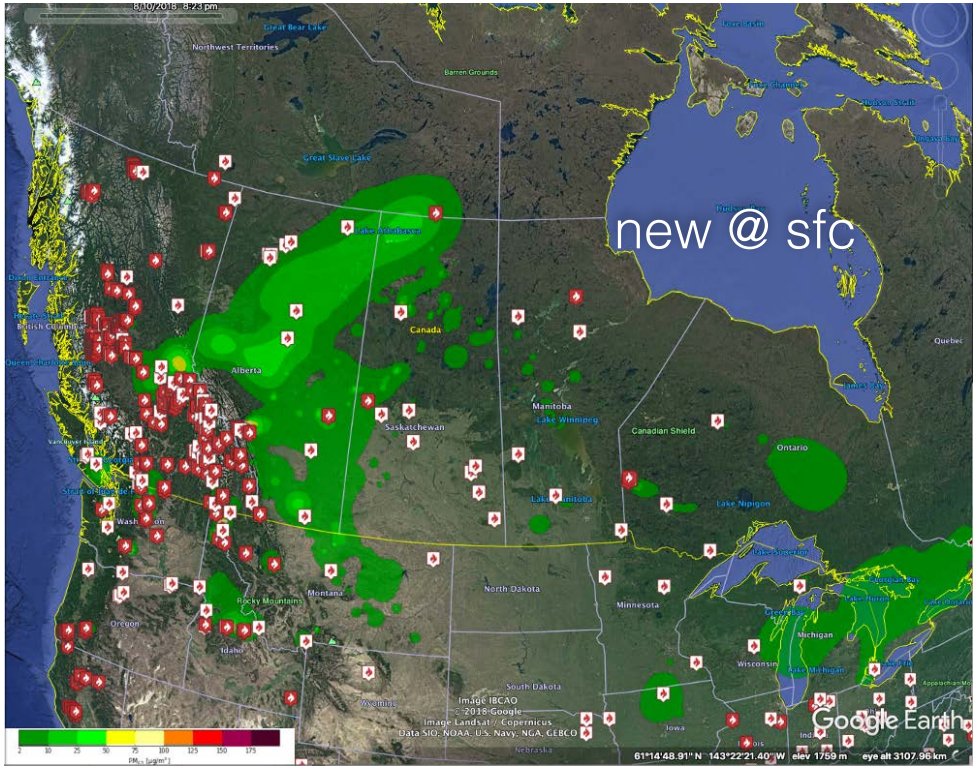
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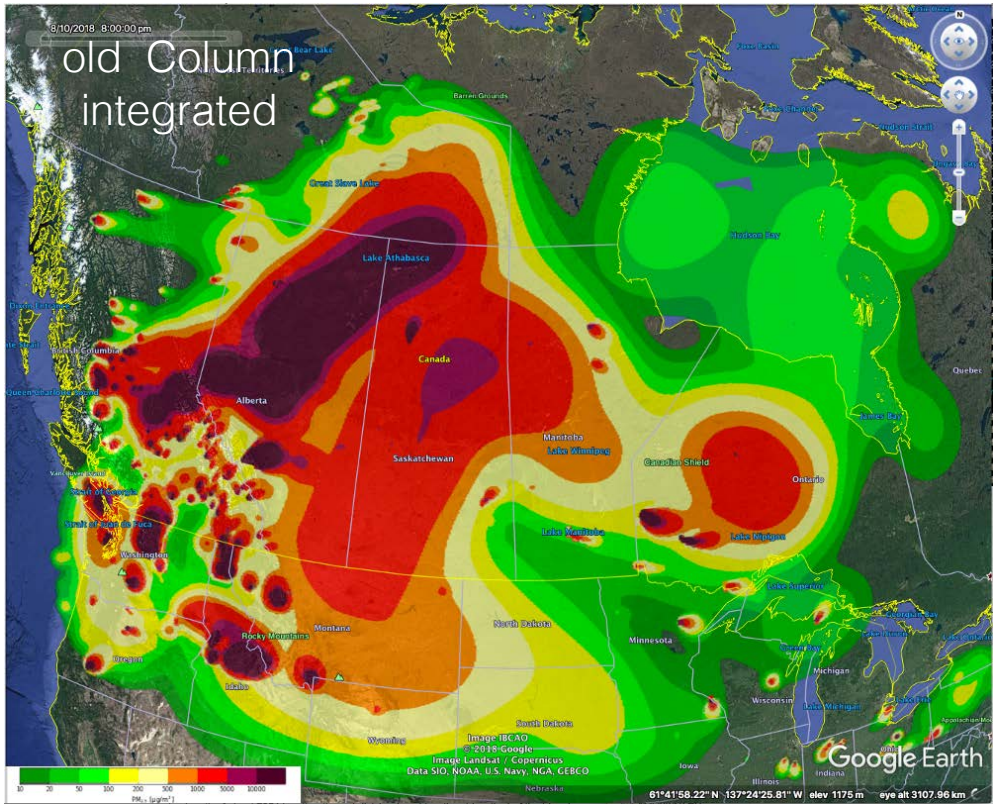
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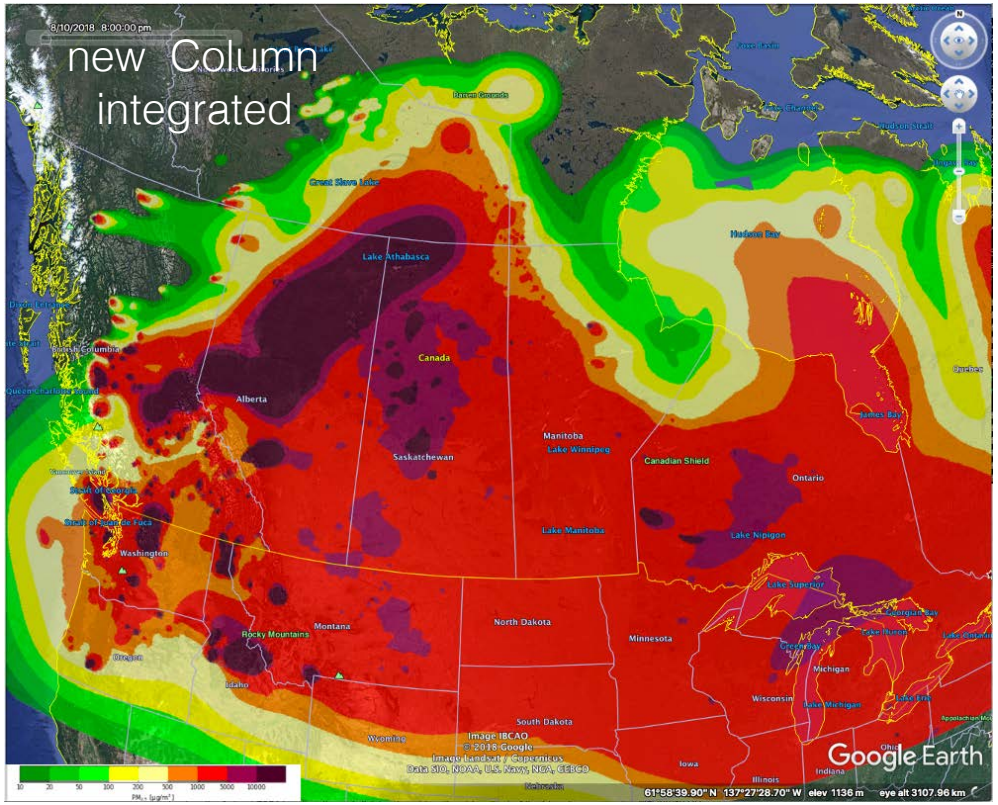
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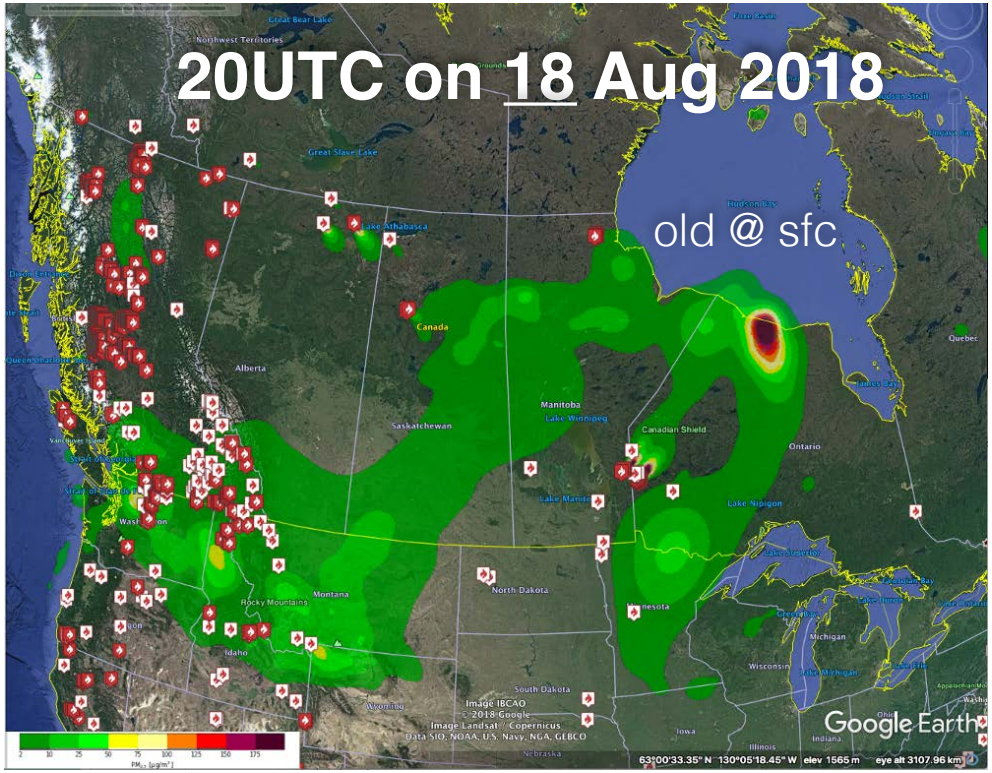

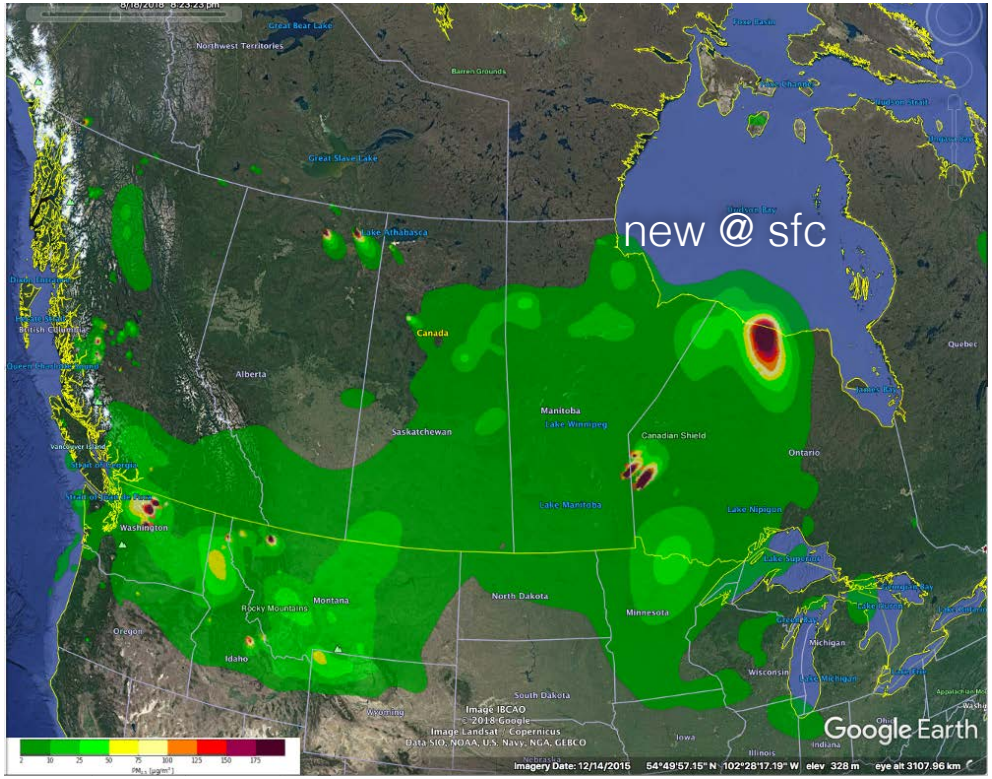

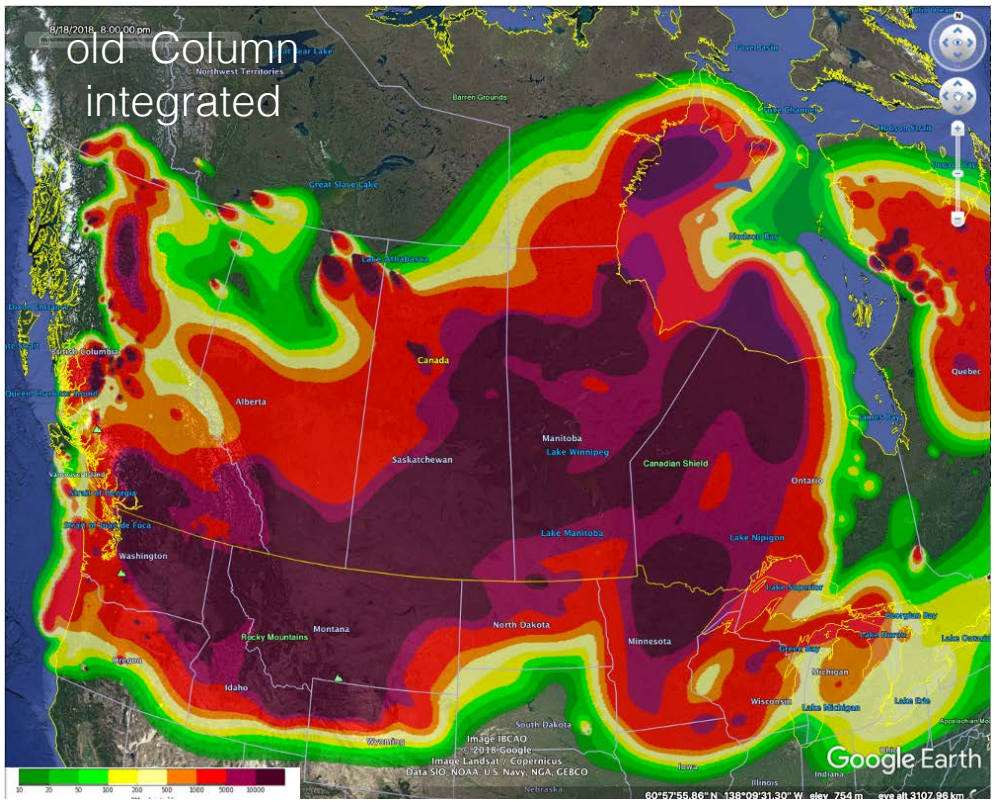

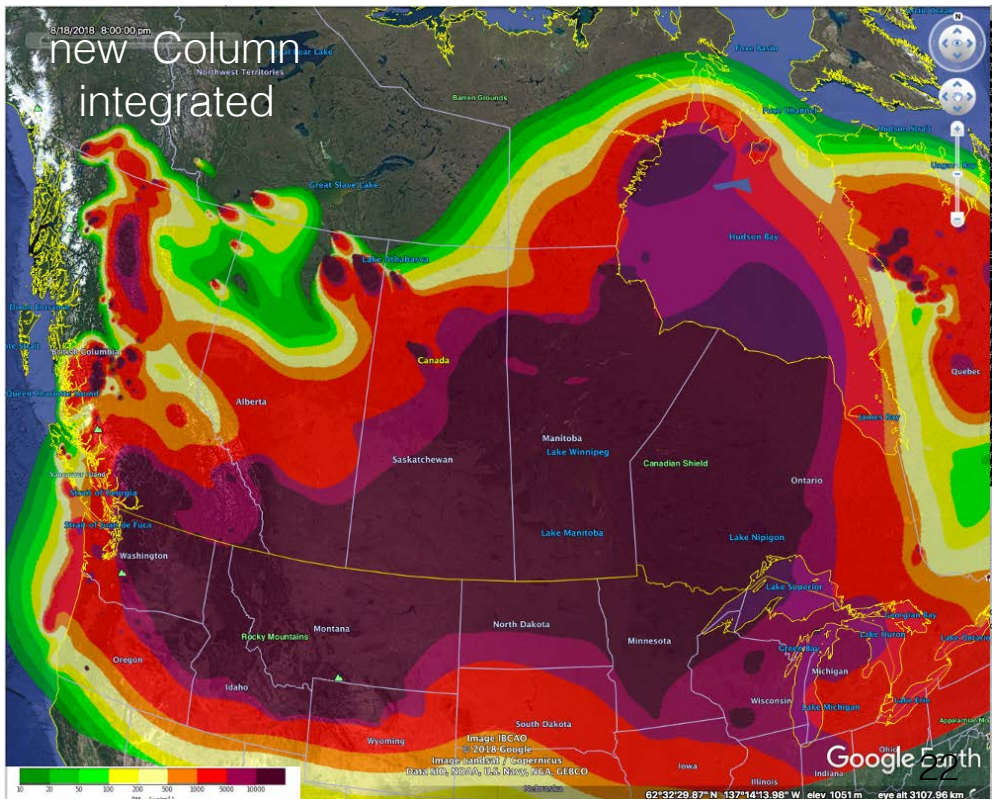

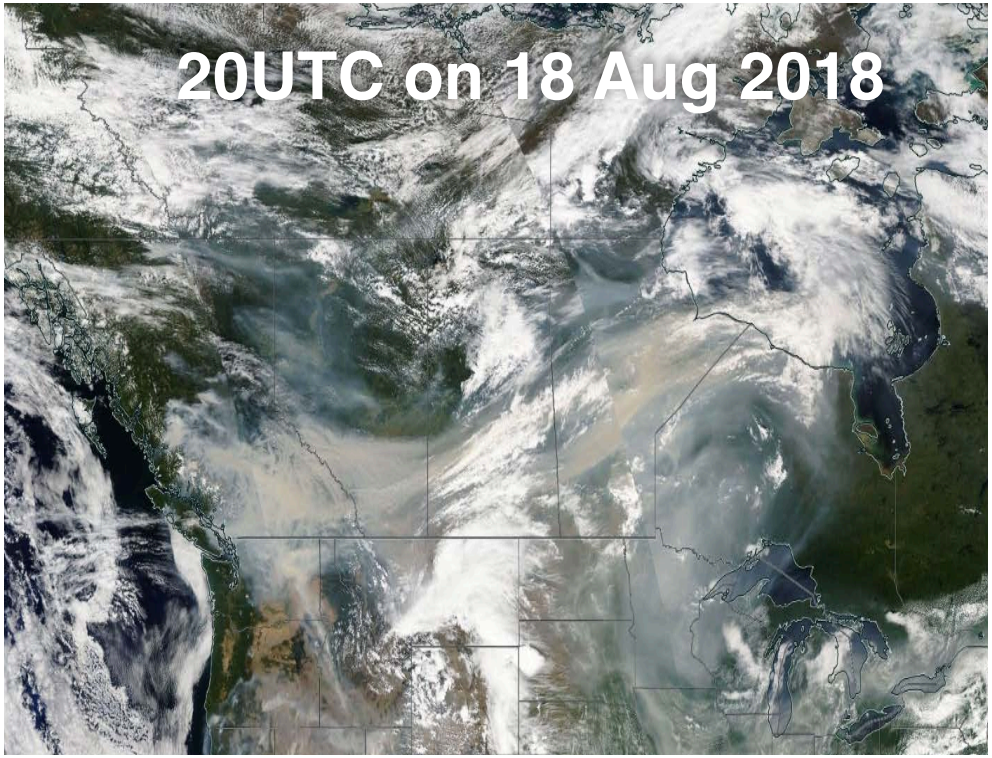
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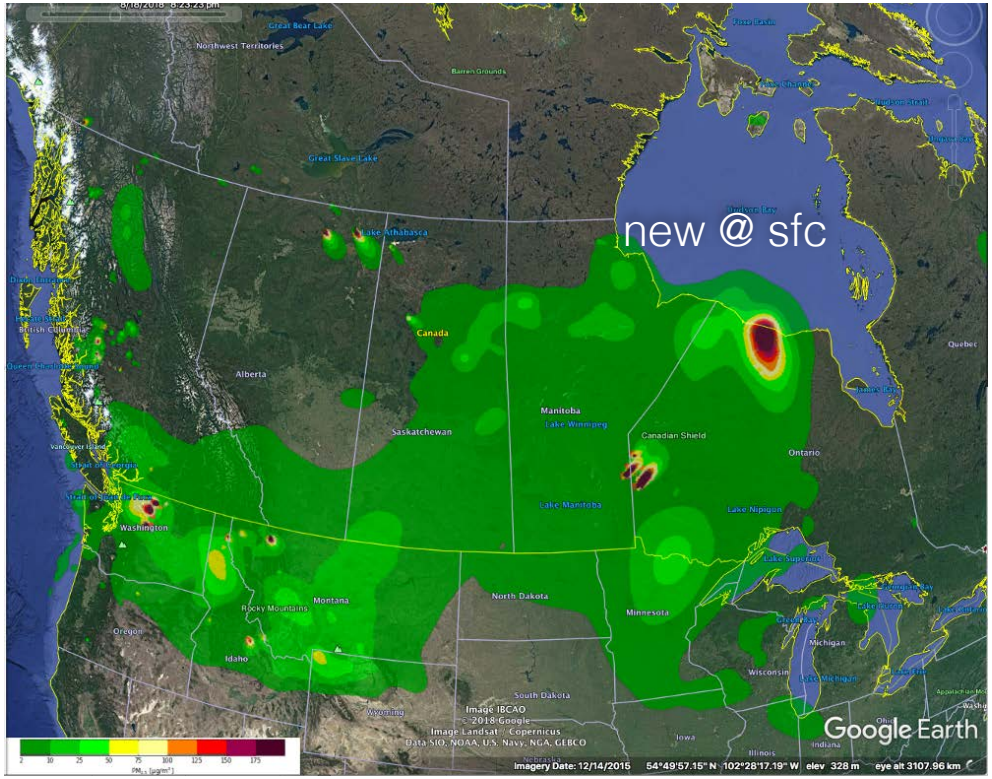
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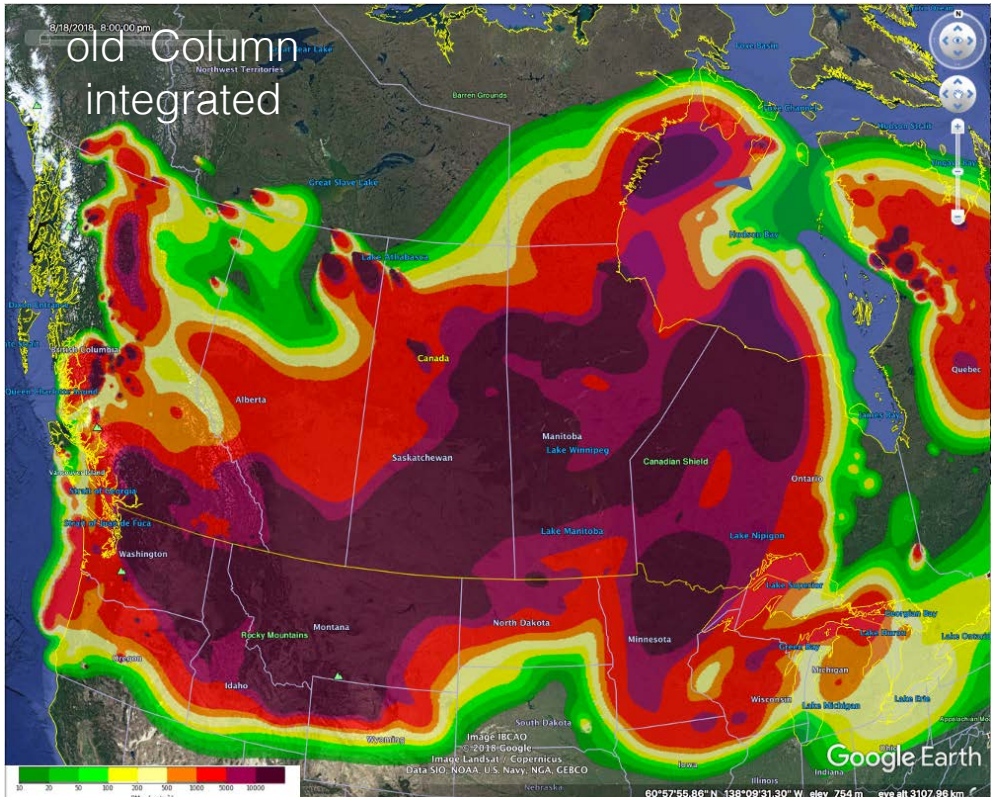
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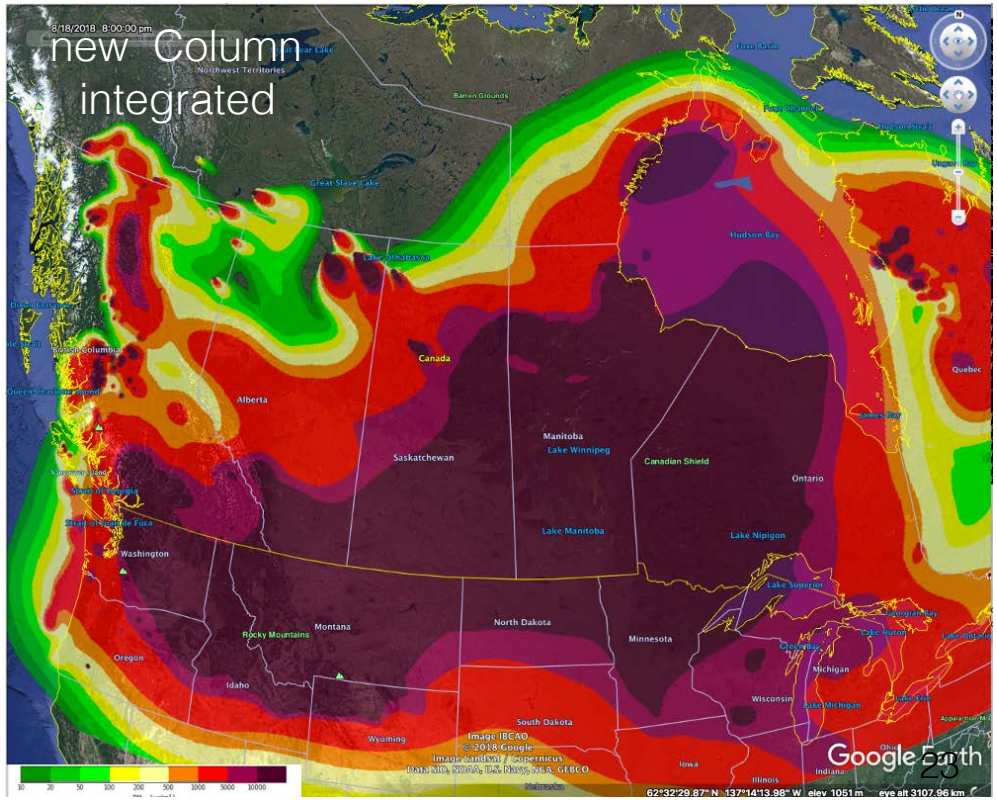
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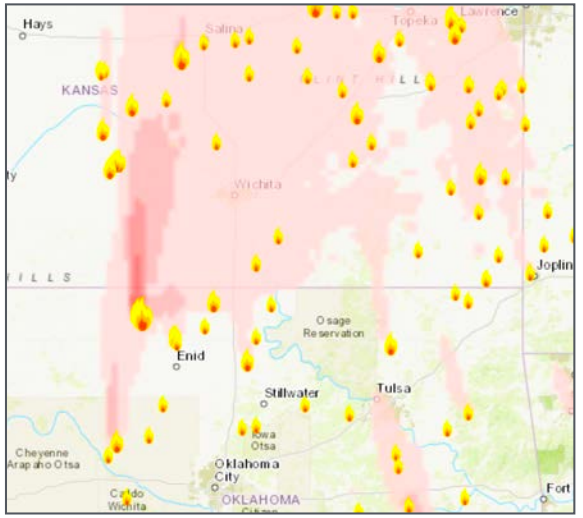
4) Operations Plans for 2019

- Feb - Mar 2019: Continue fine tuning parameters. Also verify with PM2.5 obs at surface (AB & BC).
- Apr - Oct 2019: Operational forecasts with new params. & careful checking daily by humans.

5) Research for 2019



BlueSky/Pipeline/Websky:

- Adapt new BlueSky from USFS/AirFire to Canada.
- In late summer begin operational runs, in parallel with old BlueSky

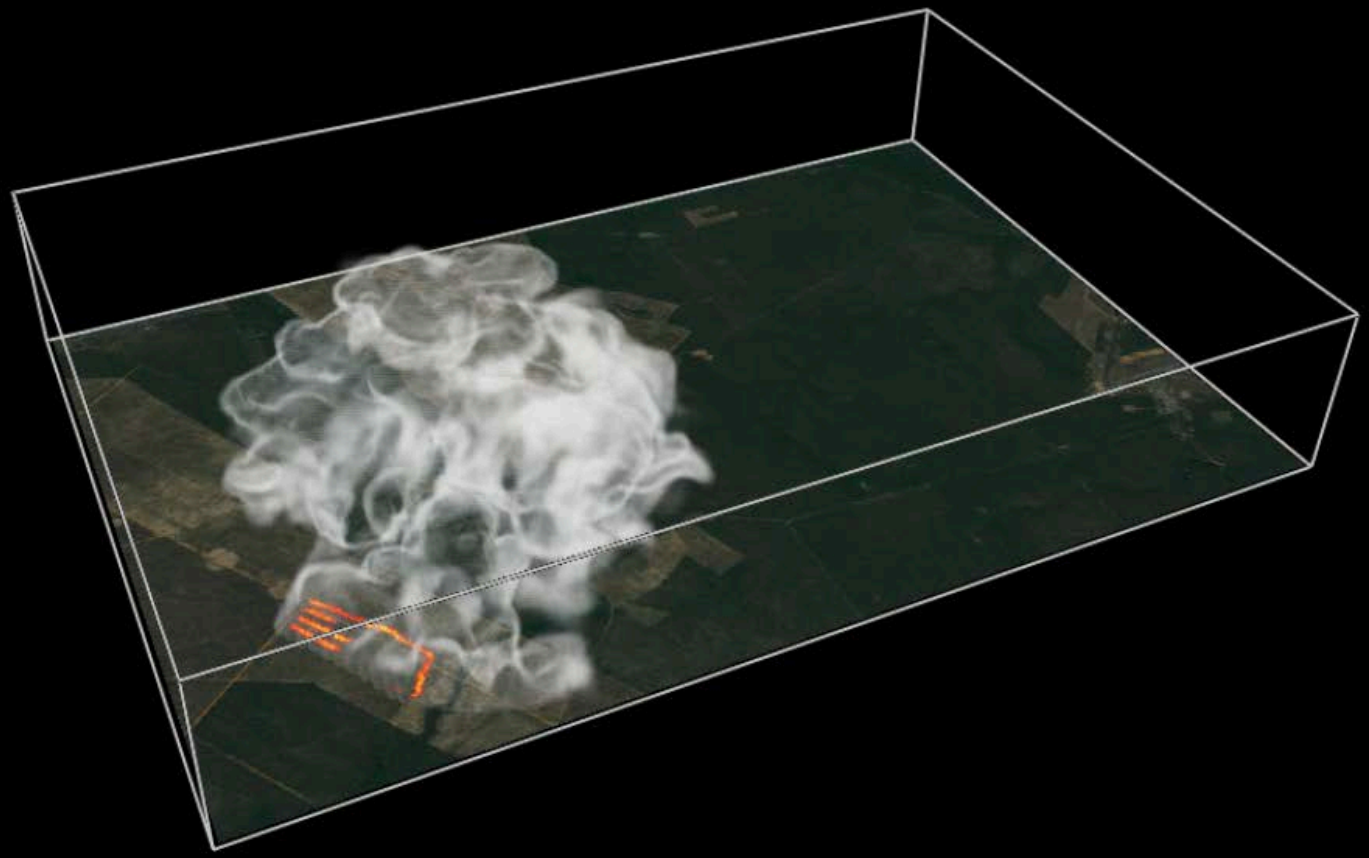
Large Eddy Sims (LES) of Atmos. Response & Plume Rise:

- WRF-SFIRE LES, experiments by Nadya Moisseeva
- Dutch Atm. LES (DALES), experiments by Frans Liqui Lung & Dr. Rosie Howard

Large-Eddy Simulation (WRF-SFIRE): first experiments

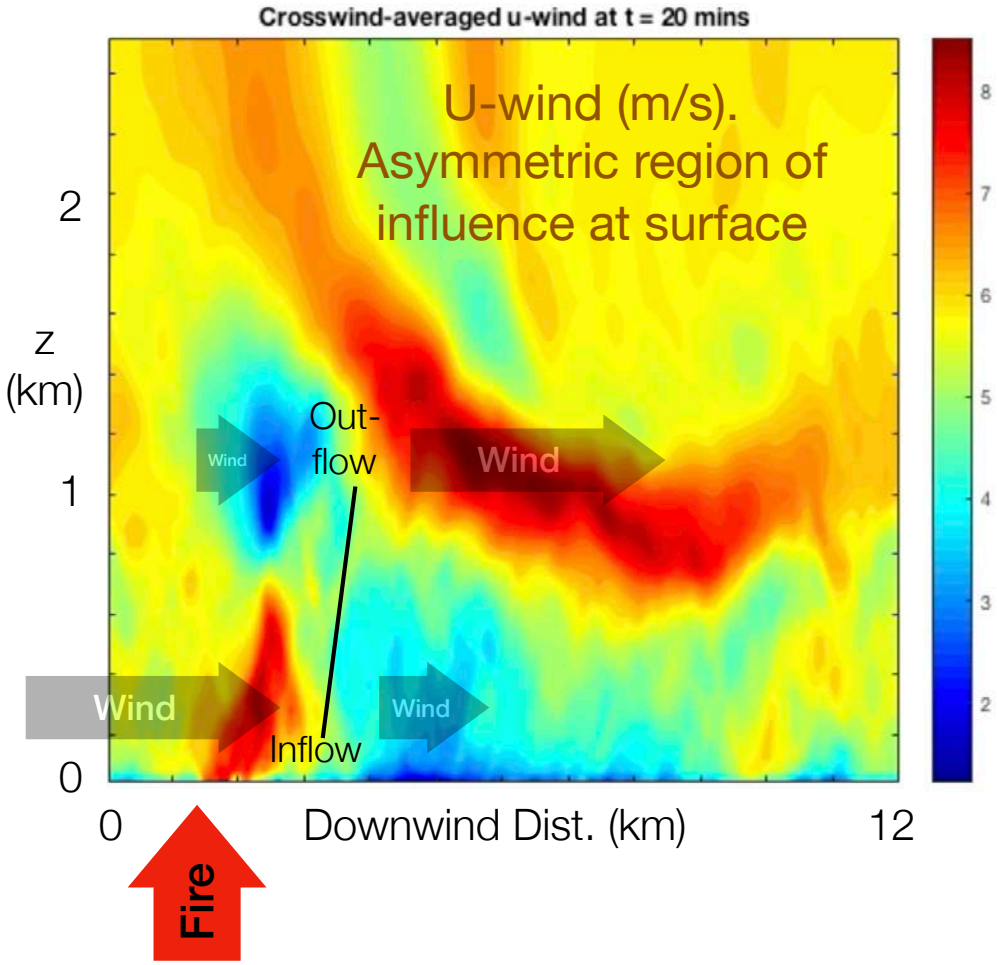
Research by Nadya Moisseeva at UBC.

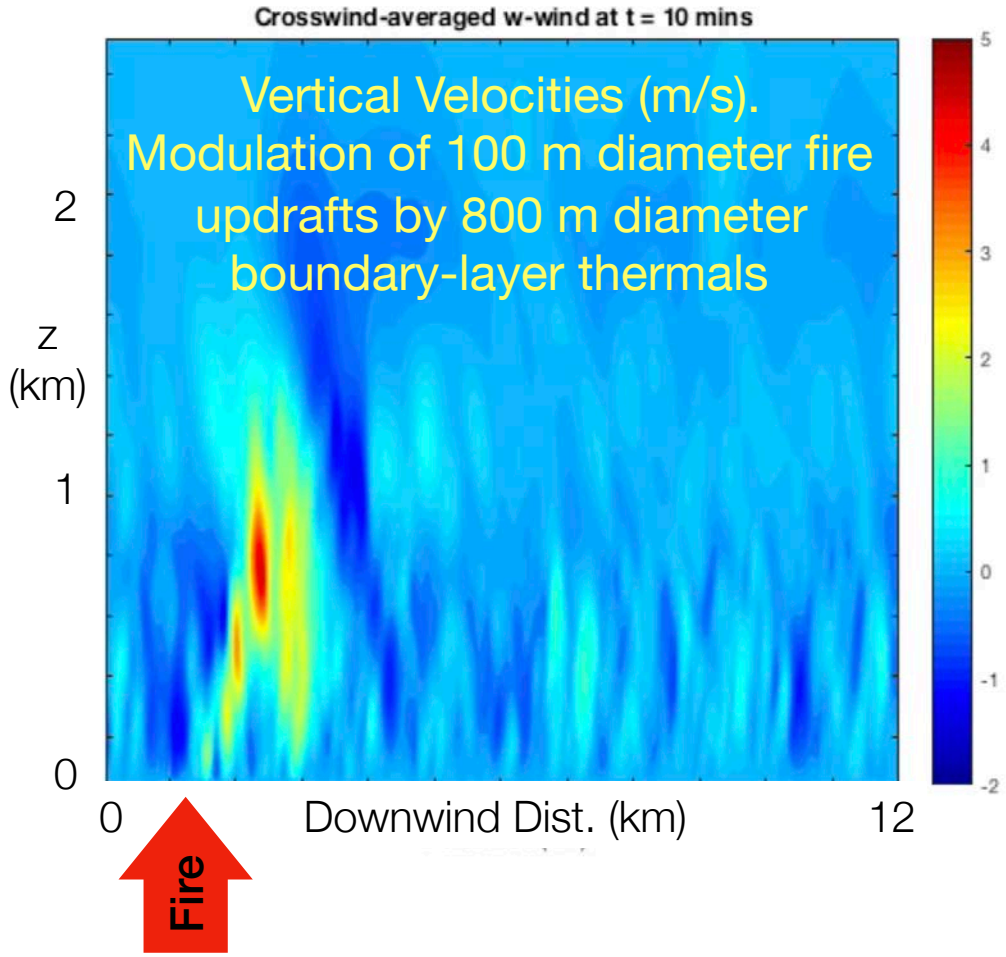
- Simulating the prescribed burn: RxCADRE 2012 (Nov 10, 2012 – Elgin Air Force Base, Florida) two large lots (shrub/forest). Surface/air measurements of emissions, including H_2O vapor

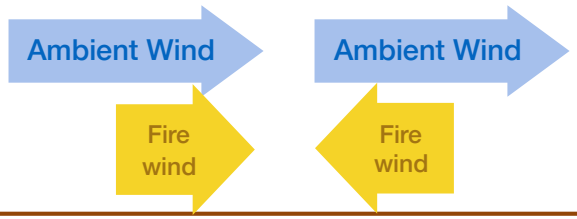


WRF-SFIRE

Convective-Structures. LES runs by Nadya Moisseeva. Analysis by Rosie Howard at UBC

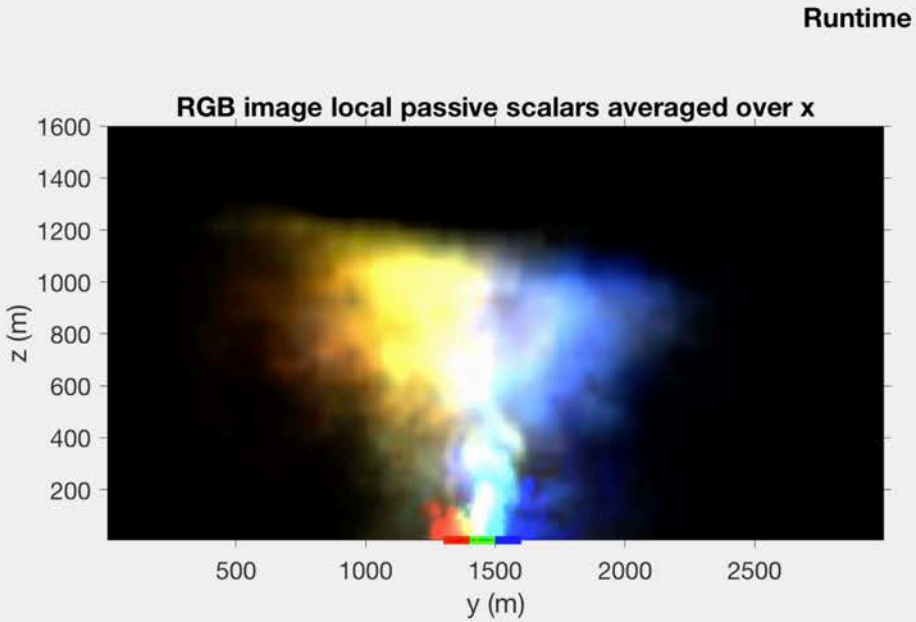


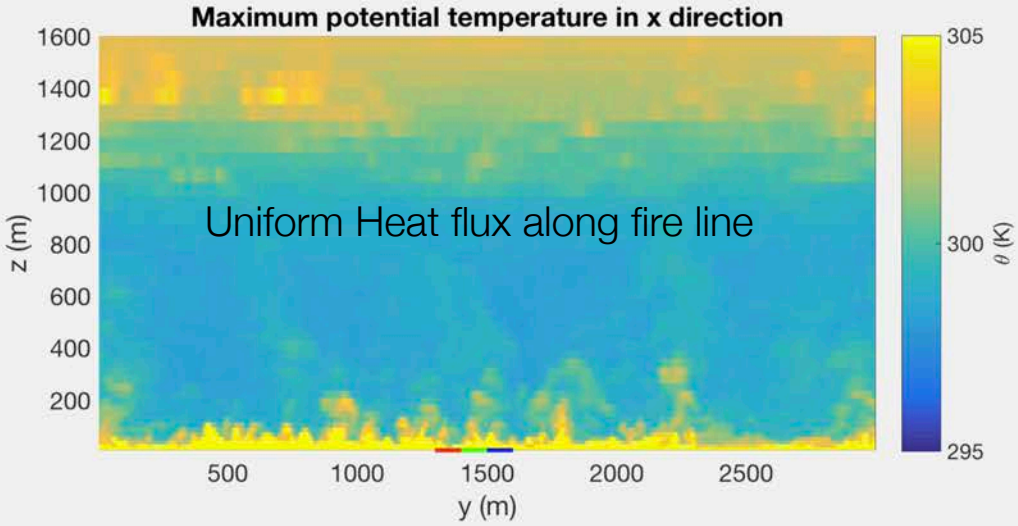




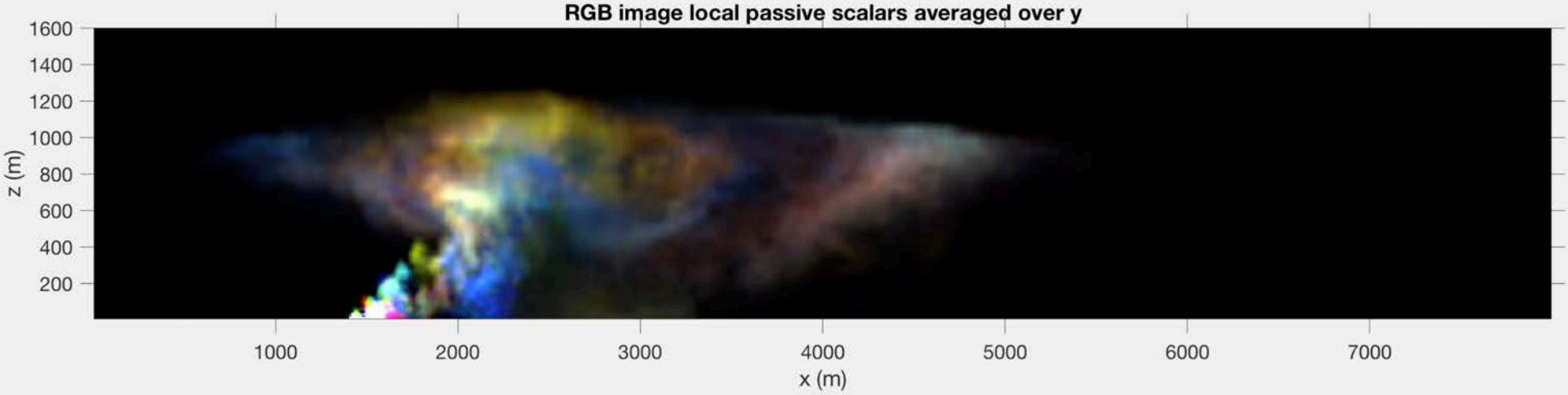
DALES

Fire-convection Structures. Analysis by Frans Liqui Lung at UBC & Delft



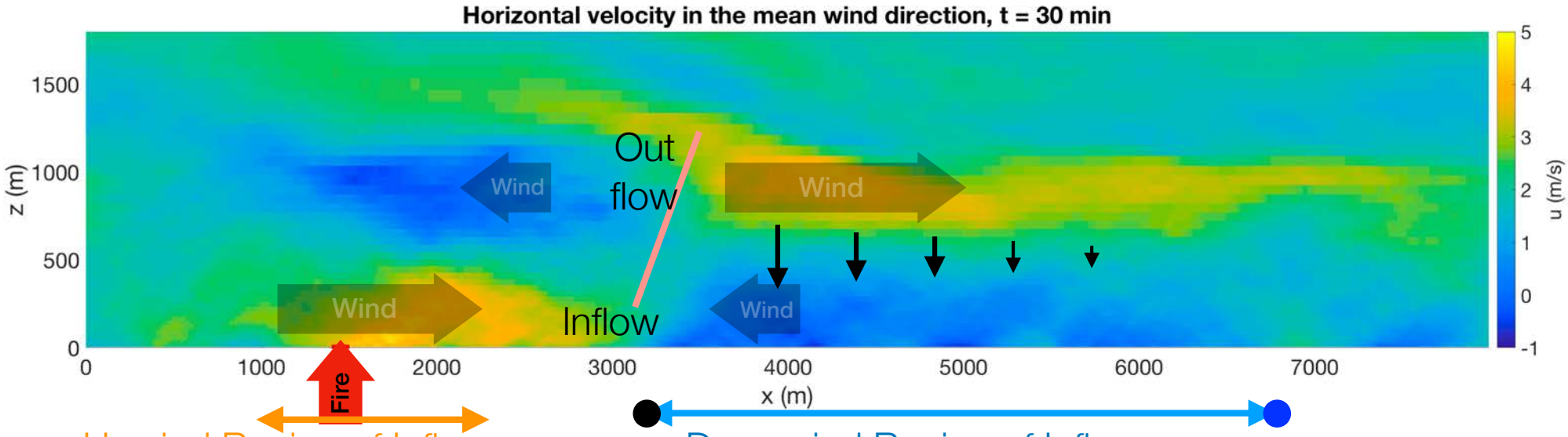


Absolute Concentrations. But emitted from very small portion of fire line.



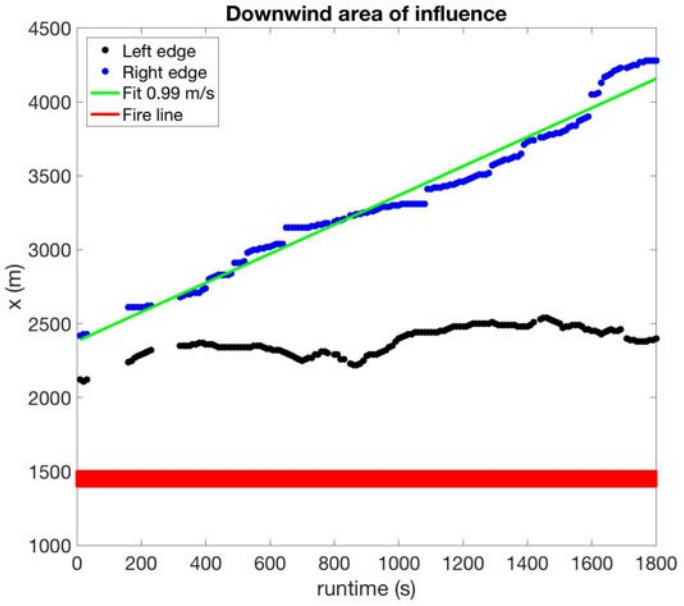
DALES

Region of Influence. Analysis by Frans Liqui Lung at UBC & Delft



Upwind Region of Influence.

Downwind Region of Influence.

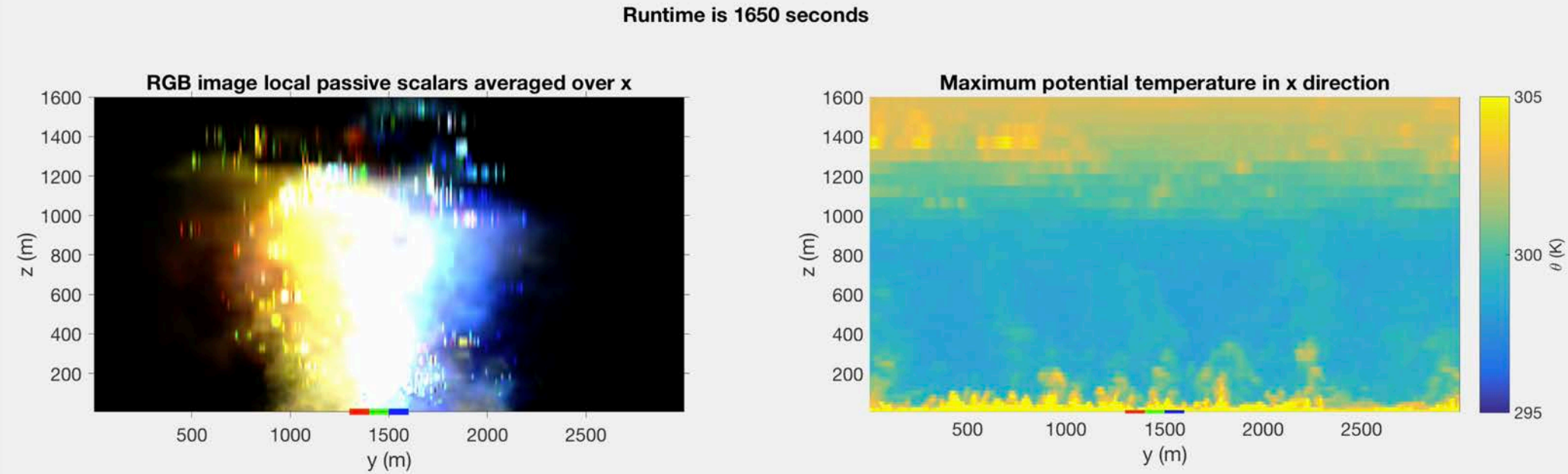


Mean wind is 2 m/s.
Heat flux of fire plume is 8 K m/s.
Heat flux of environment is 0.2 K m/s.
Width of fire line is 100 meters.

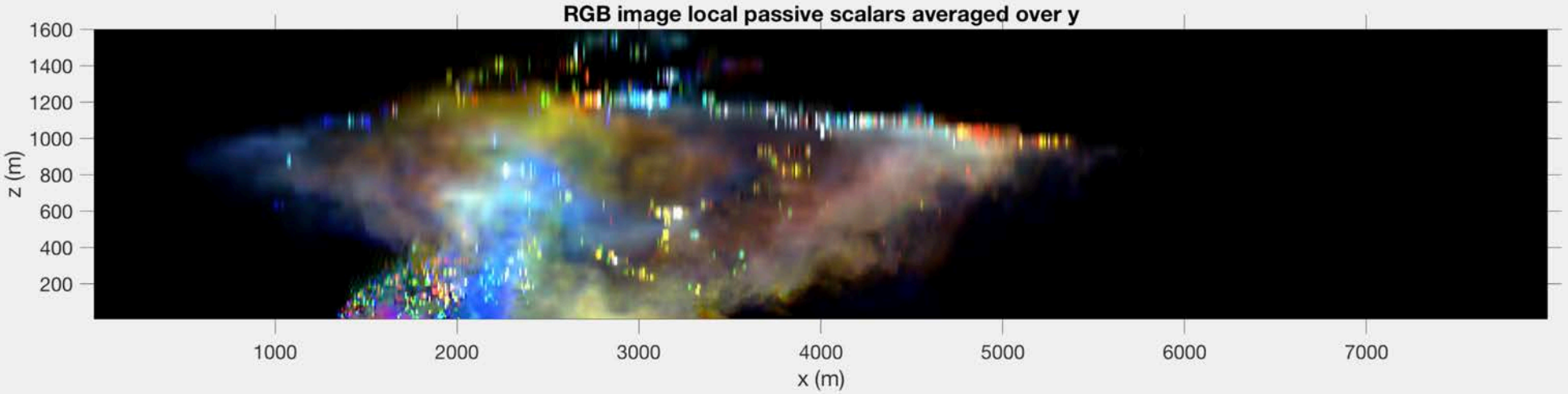
Region of influence is where smoke aloft is brought down to the surface by fire-induced circulations.

DALES

Convective-Structures. Analysis by Frans Liqui Lung at UBC & Delft

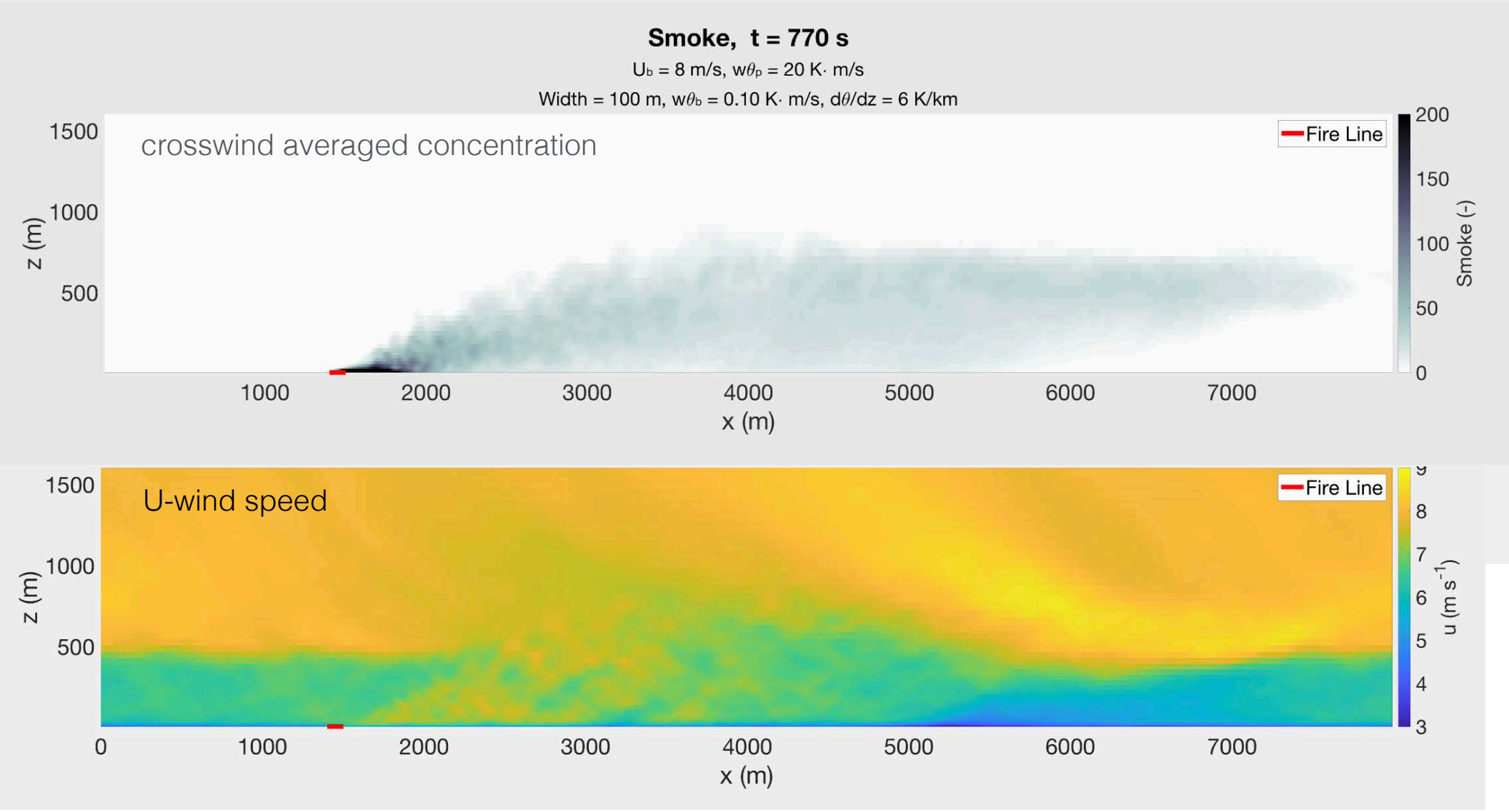


Relative (percentage) Concentration. Reveals backflow toward fireline at surface



DALES experiments with Stronger Winds & Fire

Experiments by Rosie Howard, UBC



Wind speed u = 8 m/s (3-hour spin up was run with this value and then final time from spin up used to initialize this 30-minute smoky run), plume heat flux = 20 K m/s (kinematic).

Thanks to our Sponsors

Current operations supported by:

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Development & past operations supported by:

Research supported by

BC Clean Air Research Fund

BlueSky

Wildfire Smoke Prediction Model – 2018 Issues

Interagency Meeting on Wildfire Smoke Communications in British Columbia
5 Feb 2019

Roland Stull
Rosie Howard, Roland Schigas,
Henryk Modzelewski, Maggie Campbell
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Topics:

1. BlueSky Basics
2. 2018 issues, hot spots and satellite images
3. BlueSky Diagnosis
   a) Operational 2018 issues
   b) Post-mortem diagnosis
   c) Computation Issues
   d) BlueSky / Hysplit Issues
   e) Reforecast Comparisons
4. Ops Plans for 2019
5. Research

Colleagues:
Tim Chui
Frans Liqui Lung
Nadya Moisseeva

Any Questions?