CANADIAN ROCKIES & FOOTHILLS
BIOGEOSCIENCE INSTITUTE
UNIVERSITY OF CALGARY

Wildfire Pyroconvection and CAPE

Buoyancy's drying and atmospheric intensification

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Outlines

- Canadian fire analysis and our motivation
- Fort McMurray wildfire
- WRF-Fire simulation and entrainment
- The roadblocks

Historical Analysis

The large fires account for the vast majority of the total area burned. Fires smaller than 100ha account for less than 1% of the area burned (Johnson et al., 1998).

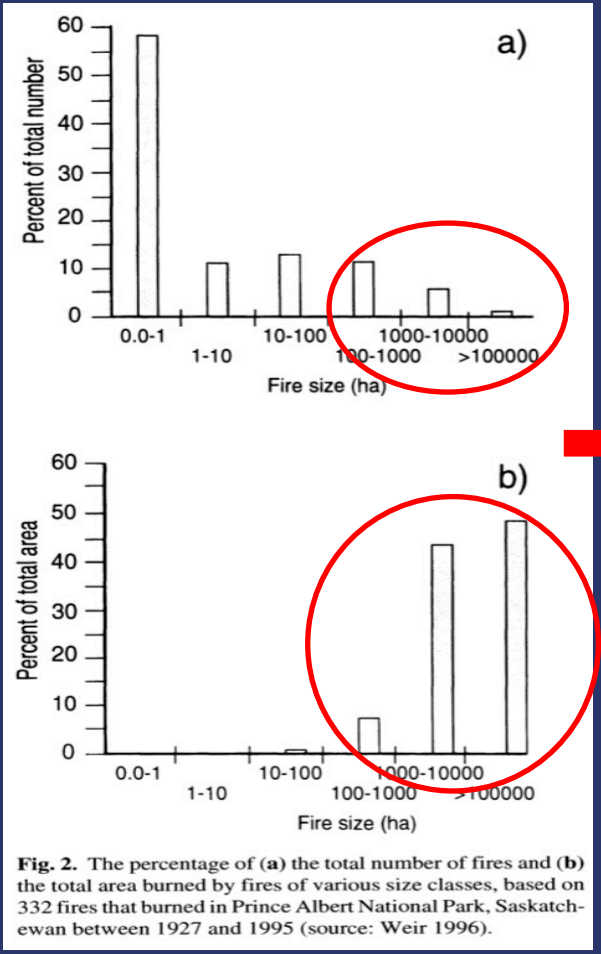
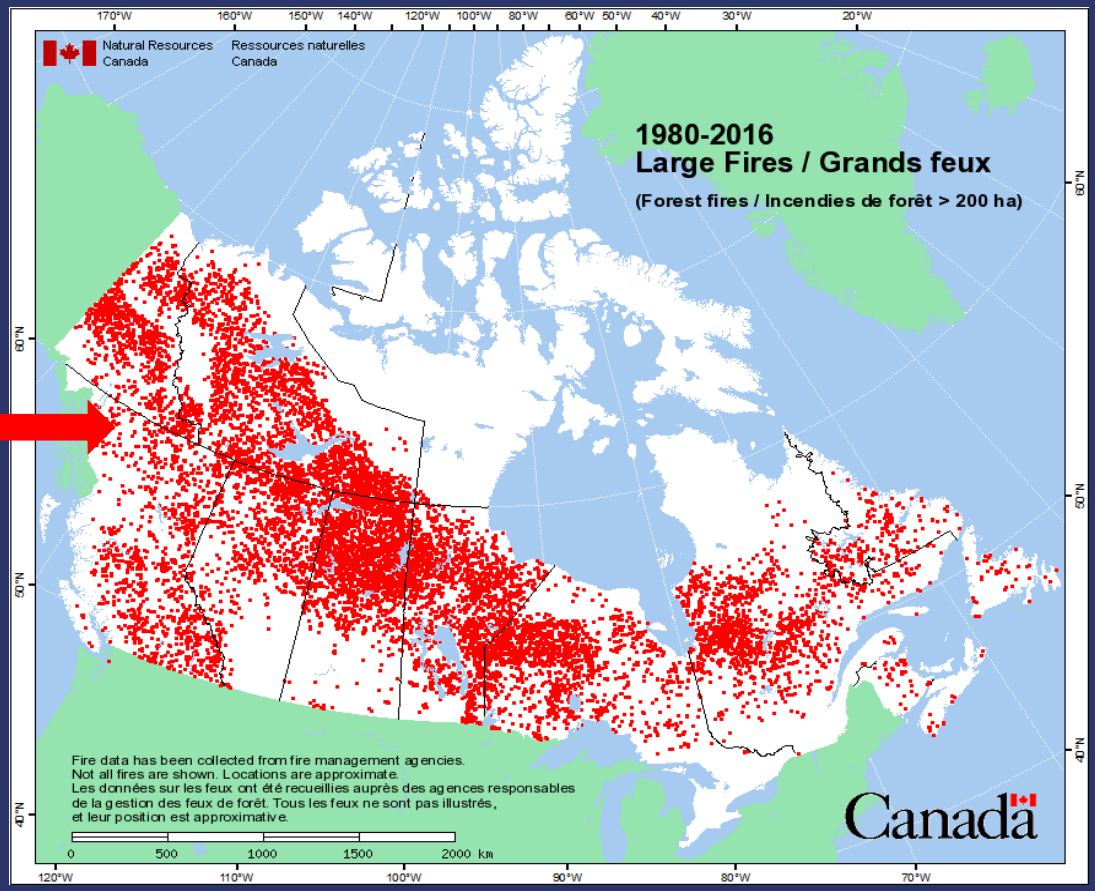
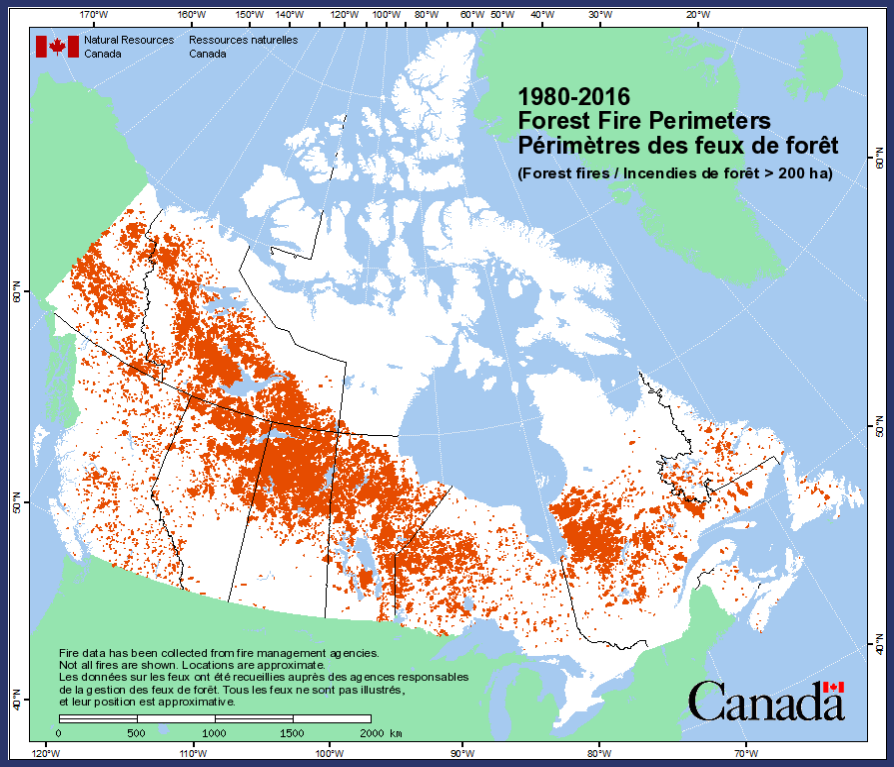


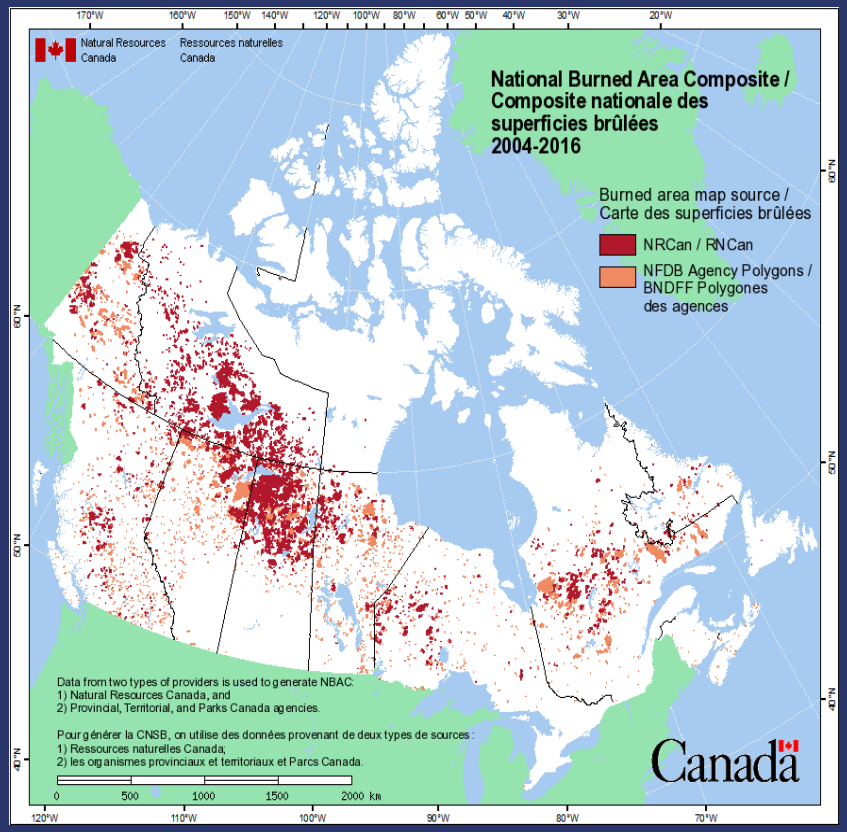
Fig. 2. The percentage of **(a)** the total number of fires and **(b)** the total area burned by fires of various size classes, based on 332 fires that burned in Prince Albert National Park, Saskatchewan between 1927 and 1995 (source: Weir 1996).



Historical Analysis

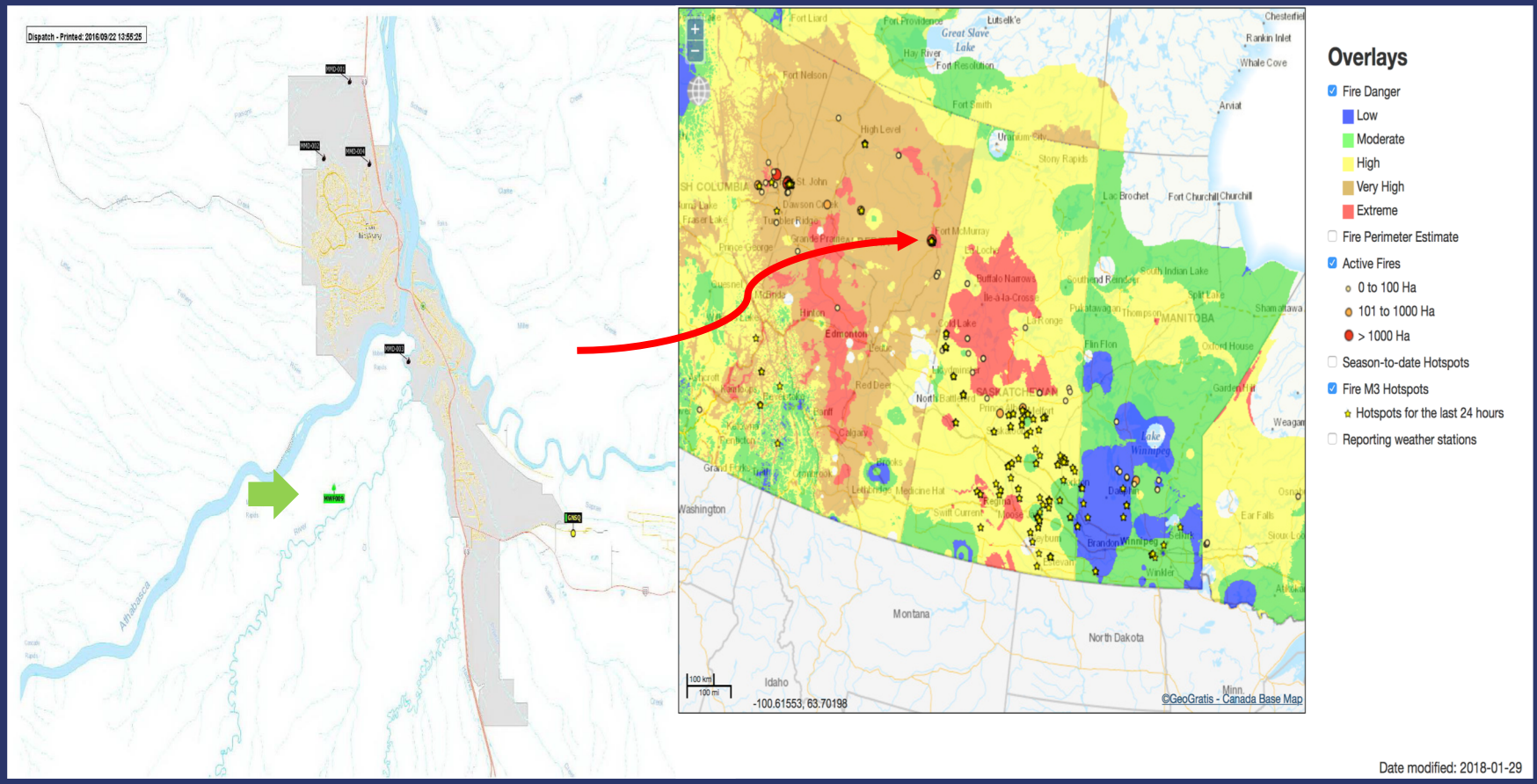


These represent a small percentage of all fires but account for most of the area burned (usually more than 97% of total area burned)



A GIS database that calculates the area of forest burned on a national scale for each year since 2004.

Can we predict the large wildfires in a reasonable time?

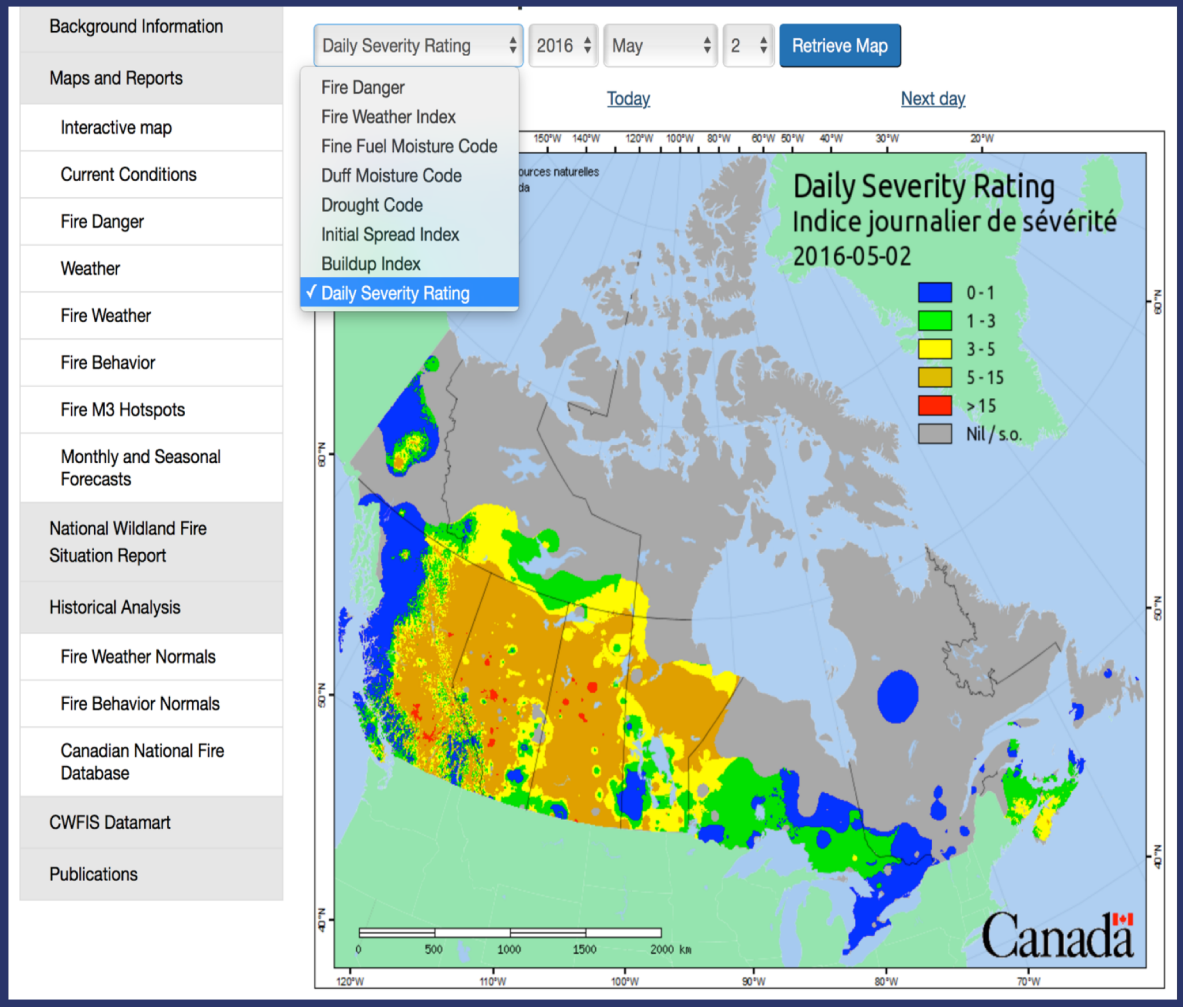


Source: Horse River Wildfire, MWF-009-16

Canadian Wildland Fire Information System Interactive Map

Canadian Wildland Fire Information System

Does not incorporate 3-d atmosphere profile



Fort McMurray May-July 2016

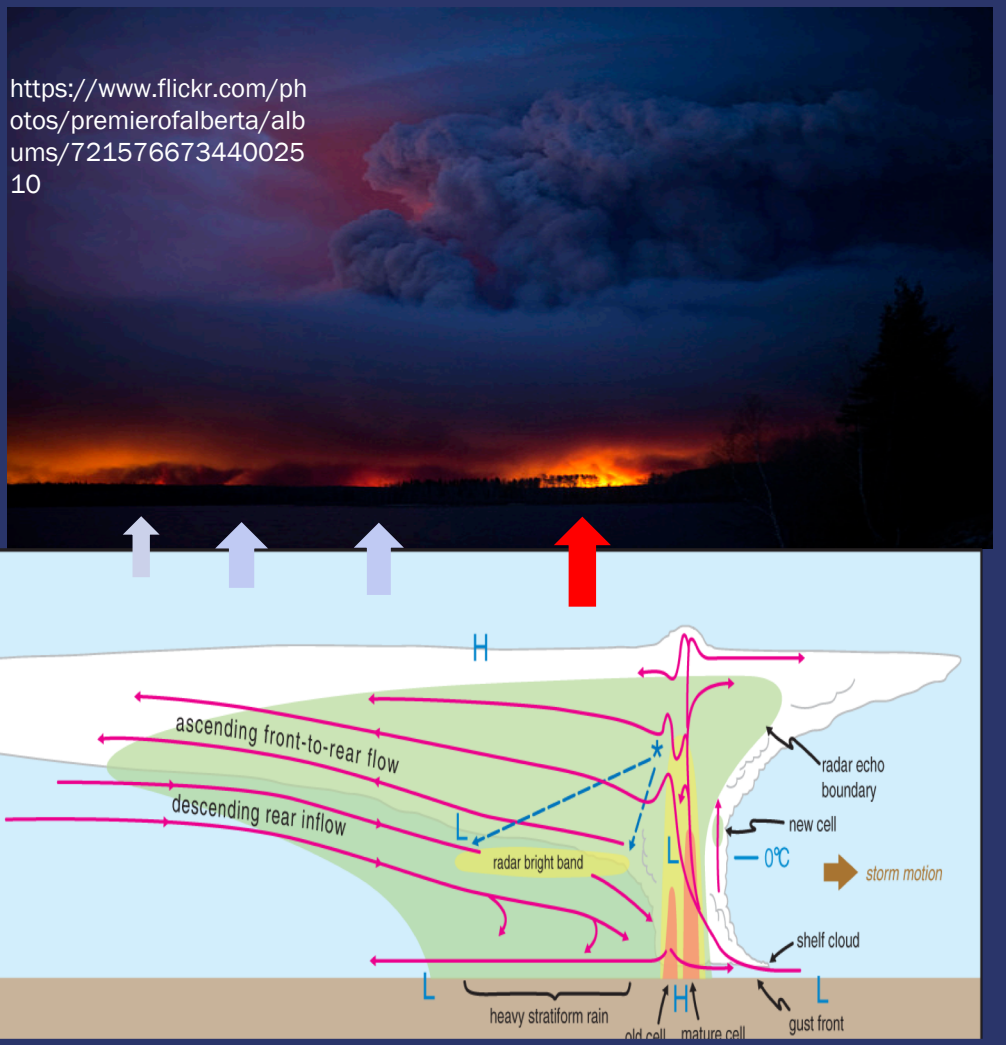
It destroyed over 2,400 homes and buildings.

The insured damages estimated over 3.5 billions while the overall costs are announced around 9.5 billions.

The fire started on May 1st, 2016 and the mandatory evacuation was issued on May 3rd

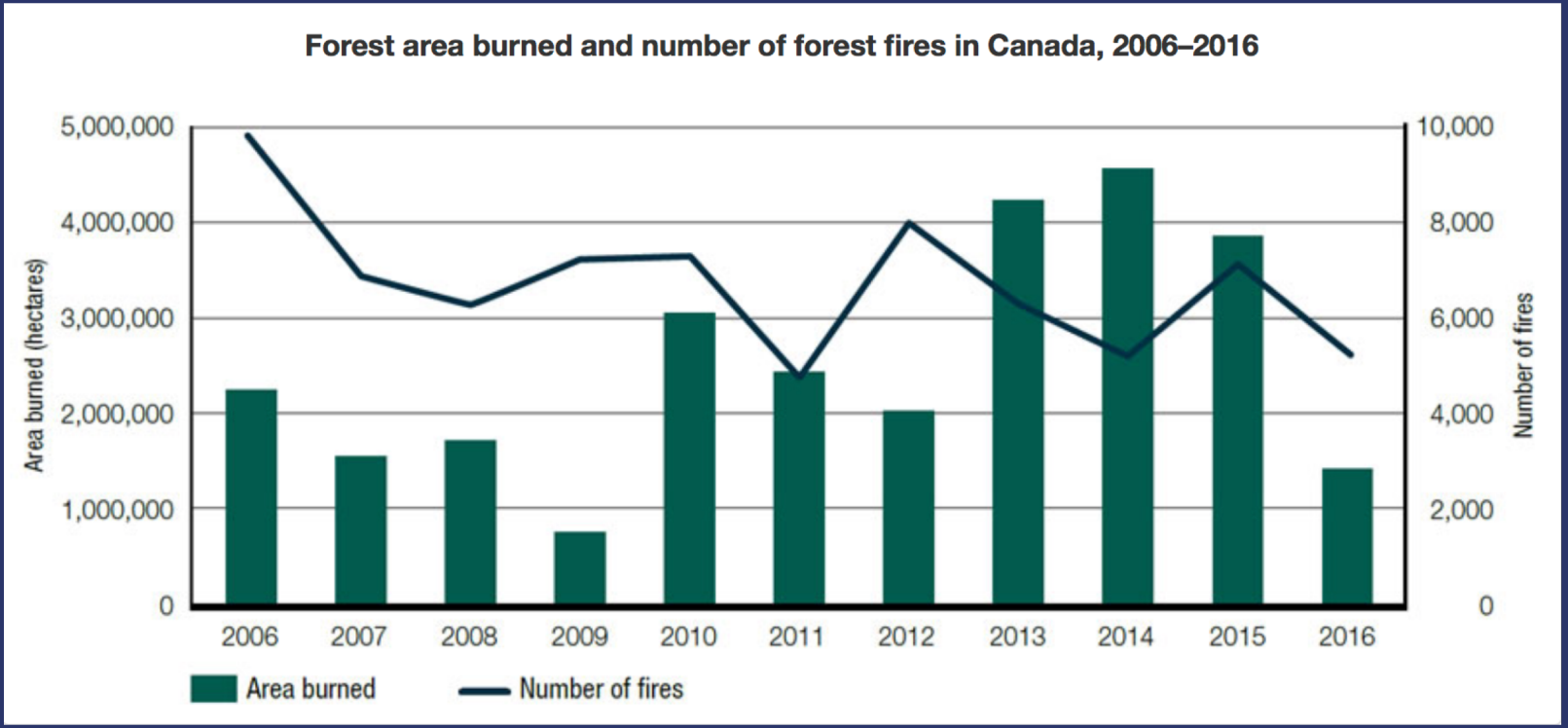
The burning area covered 589,552 hectares.

The fire was declared under control July 4, 2016.



http://www.atmos.albany.edu/facstaff/torn/atm418/mcs_schematic.png

2016 was a below average fire year

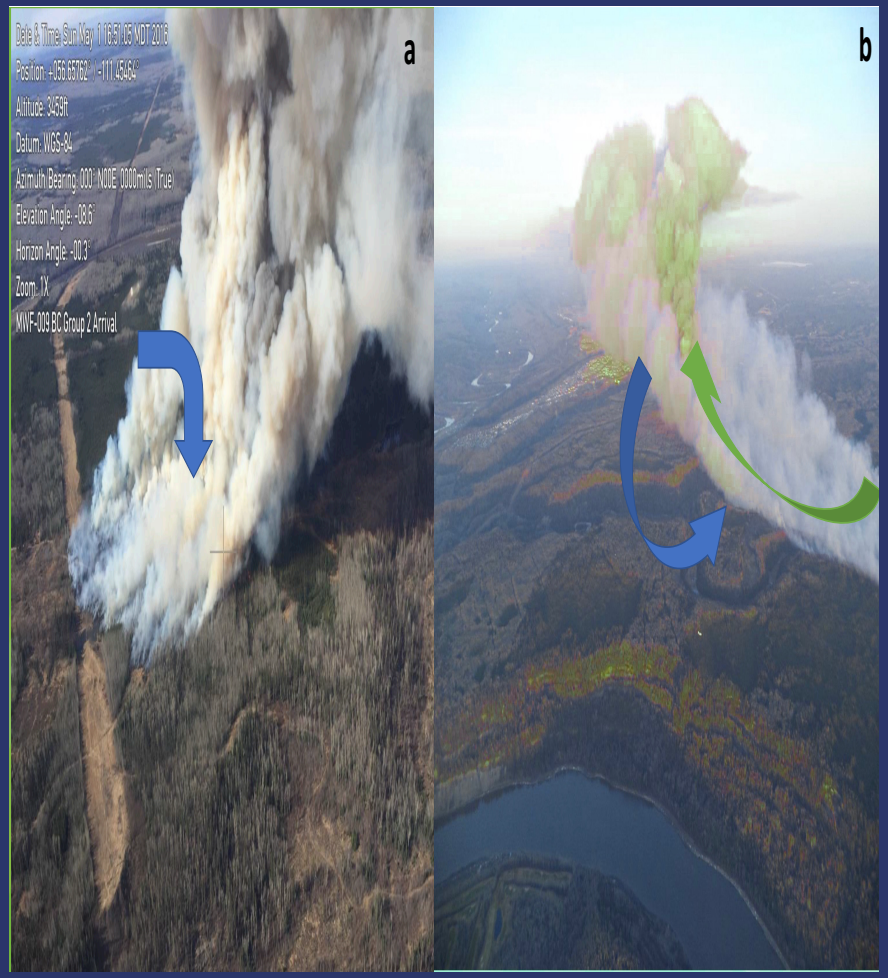


National Forestry Database. (http://www.nrcan.gc.ca/forests/report/disturbance/16392)

Ignition

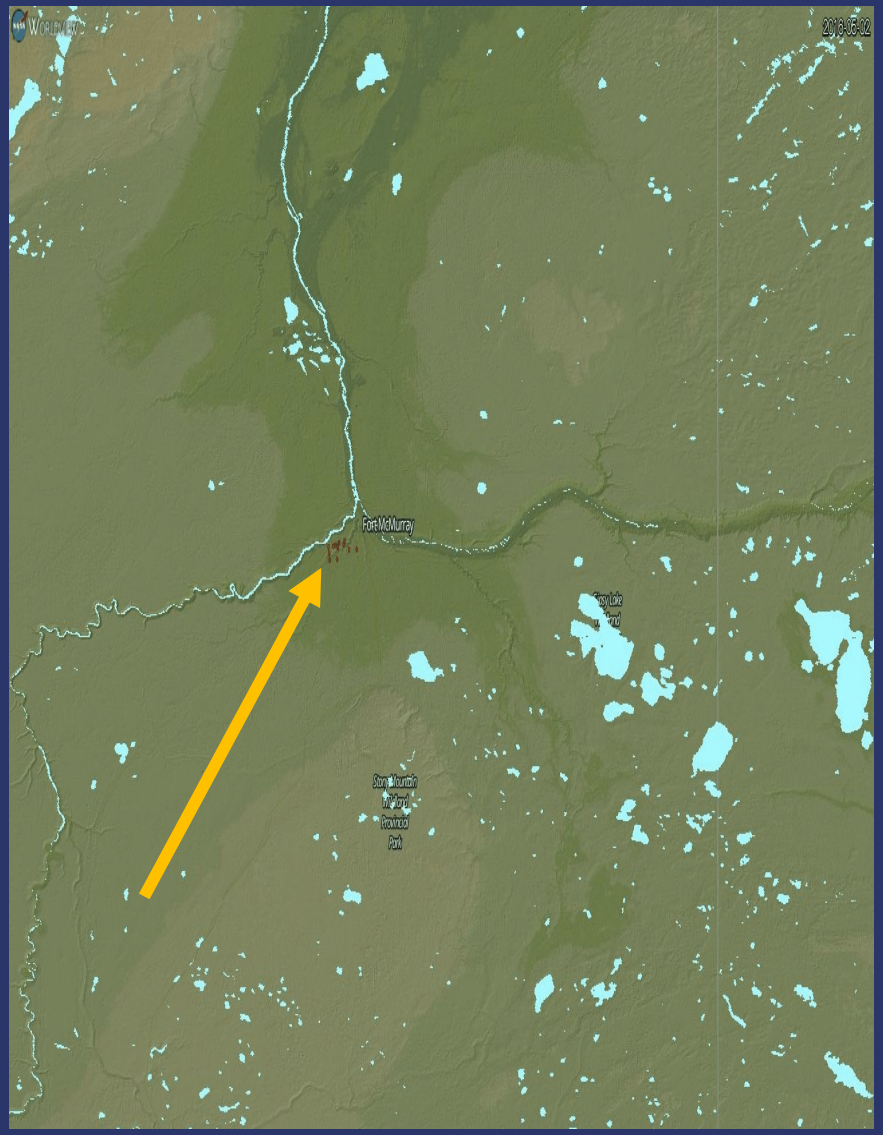
- Horse River fire (MWF009-2016) was reported 16:03 (23:03 UTC) on May 1st, 2016

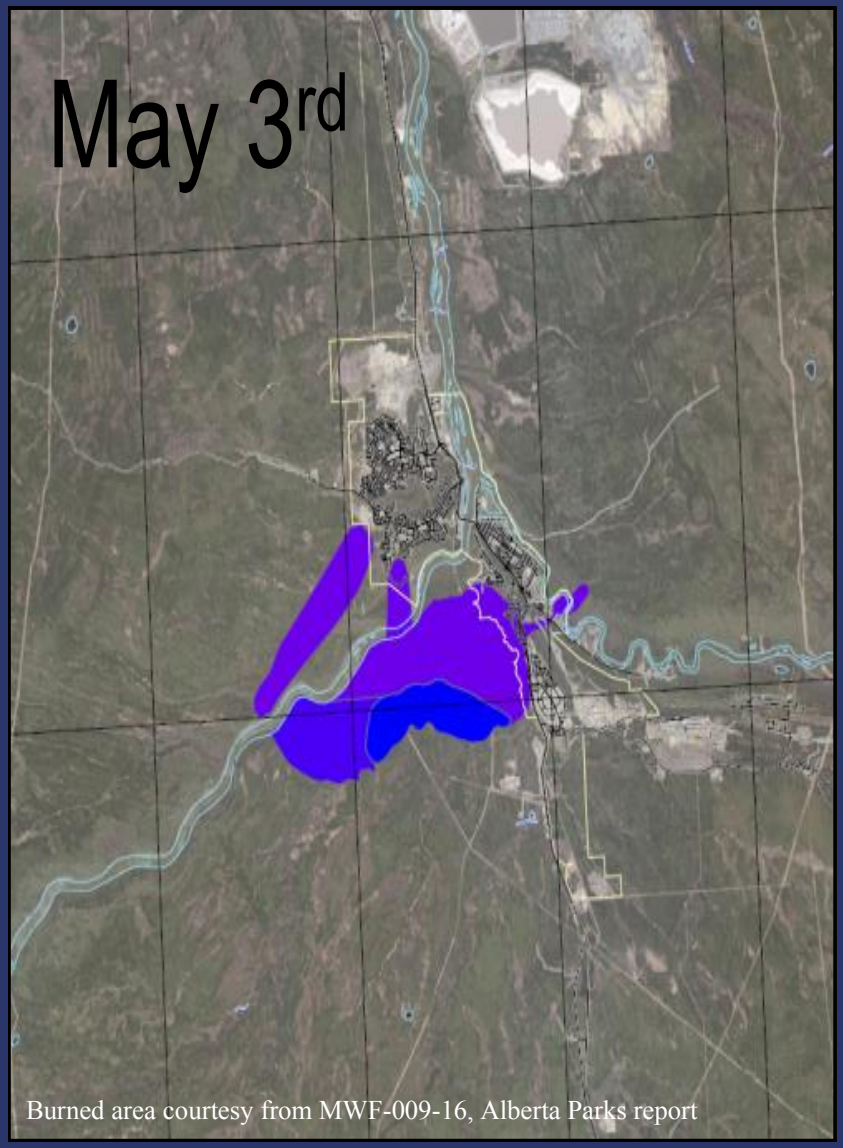
- Then the NRT hotspots has almost a 5-hour delay and located about 2 km west of the MWF-009 fire report's location (figure 2).



Fire Images are courtesy from MWF-009-16, Alberta Parks report

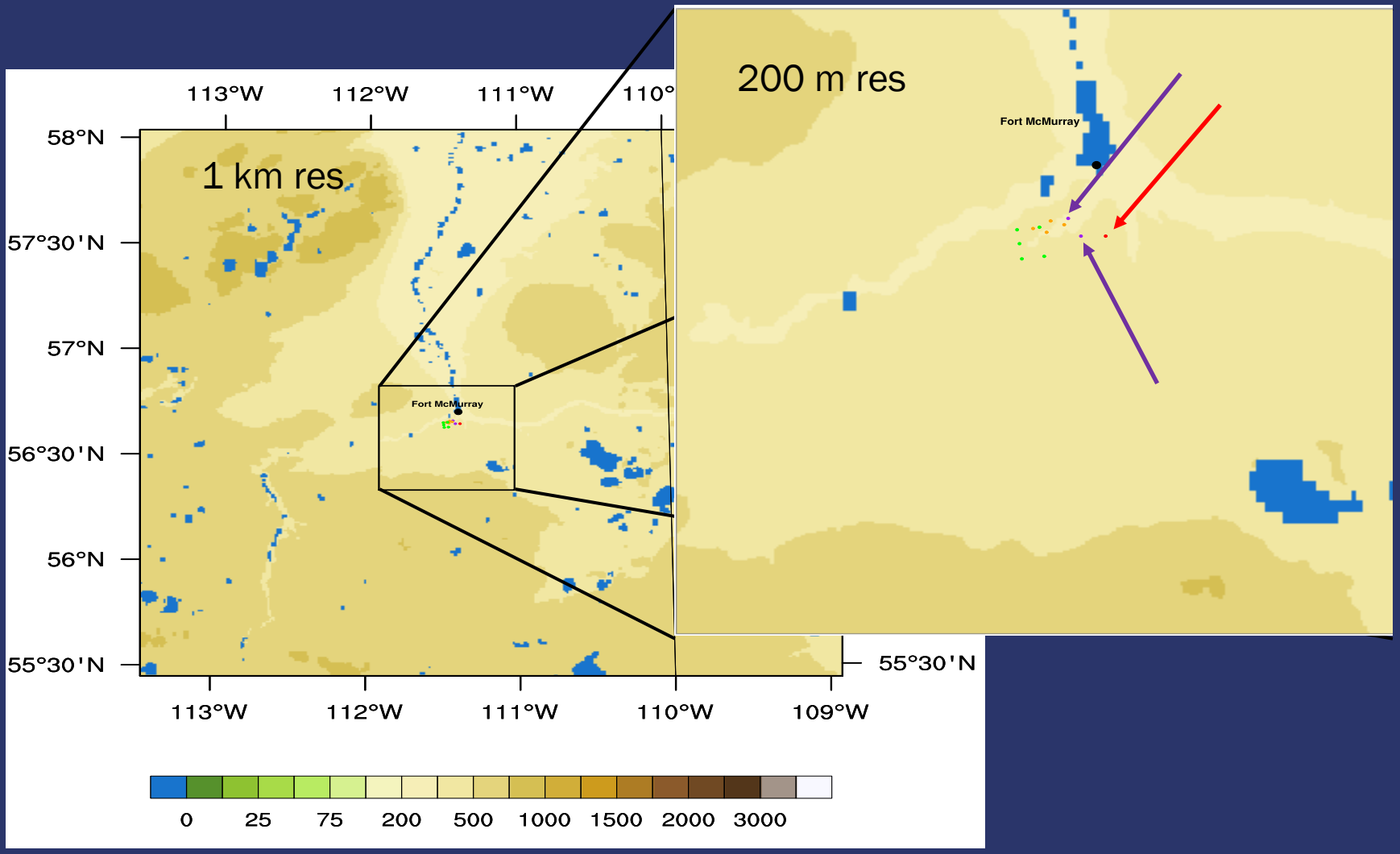
NRT Hotspots





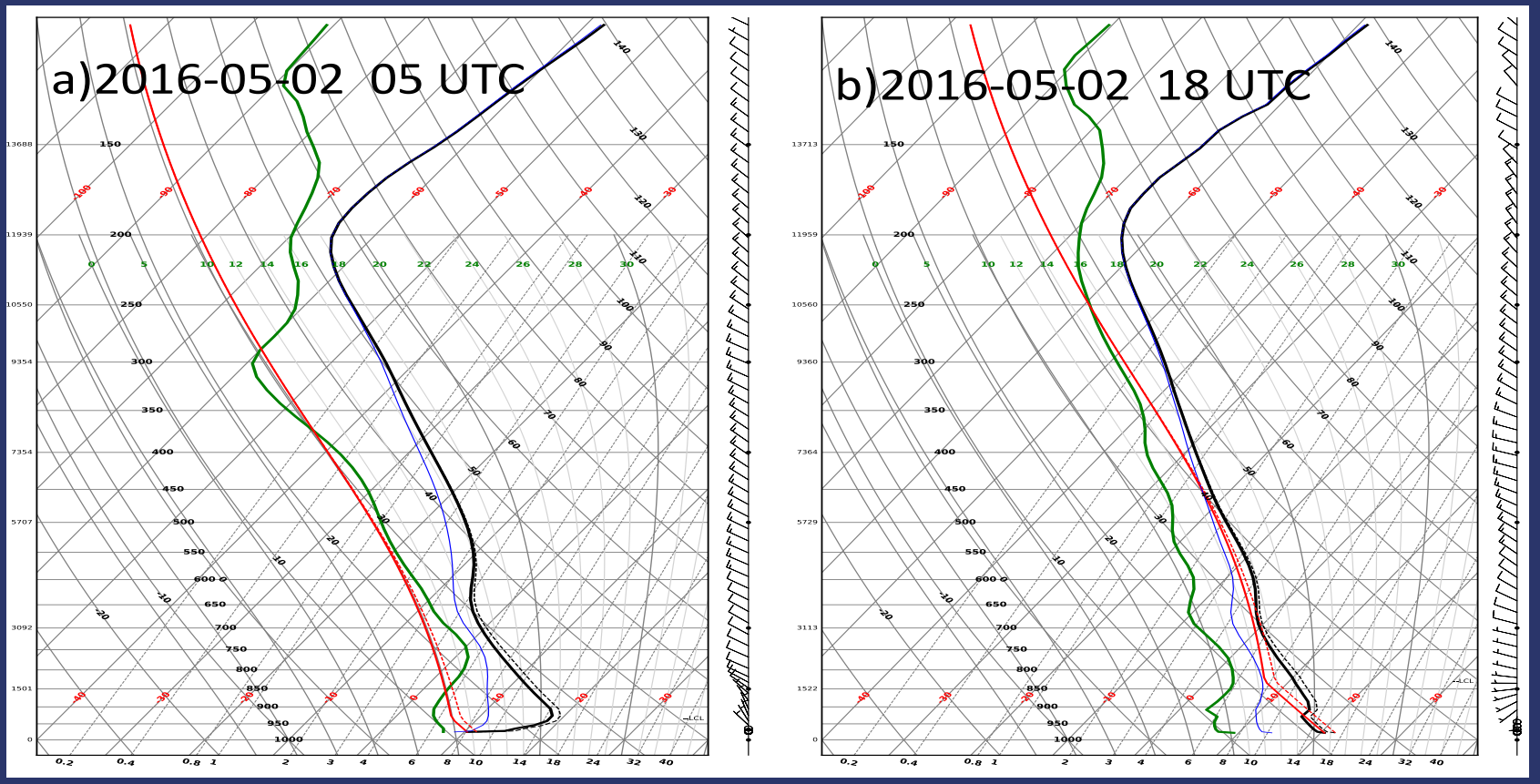
Burned area courtesy from MWF-009-16, Alberta Parks report

WRF-Fire Simulation



The hotspots are colored based on the the detection time

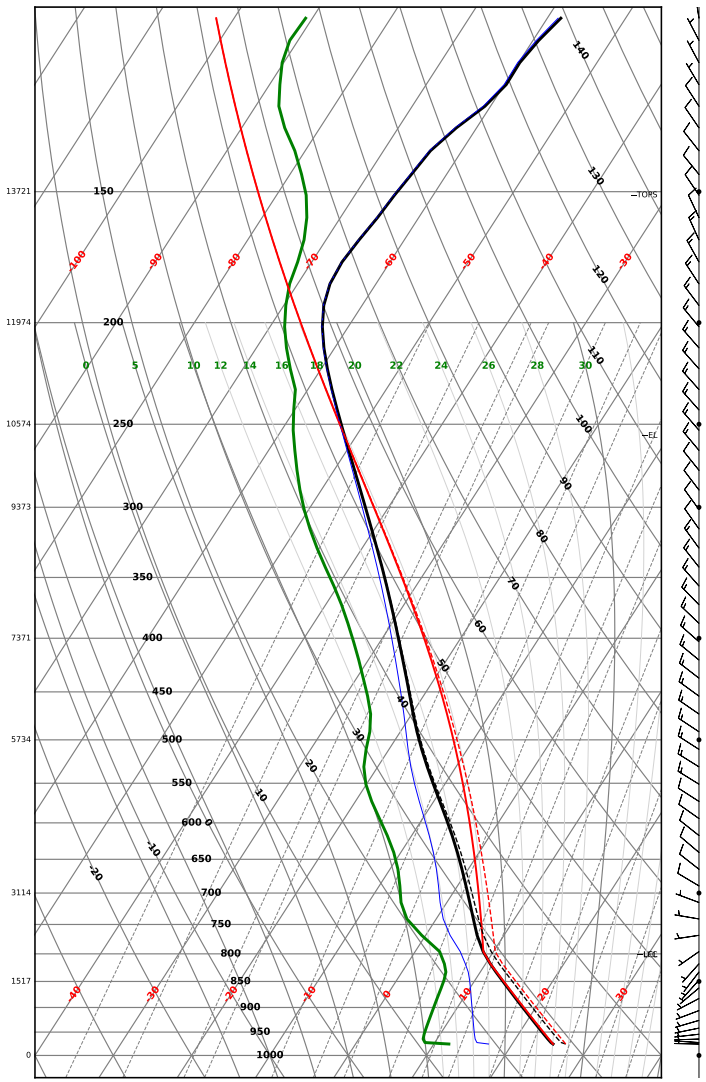
Model's Atmosphere Profiles

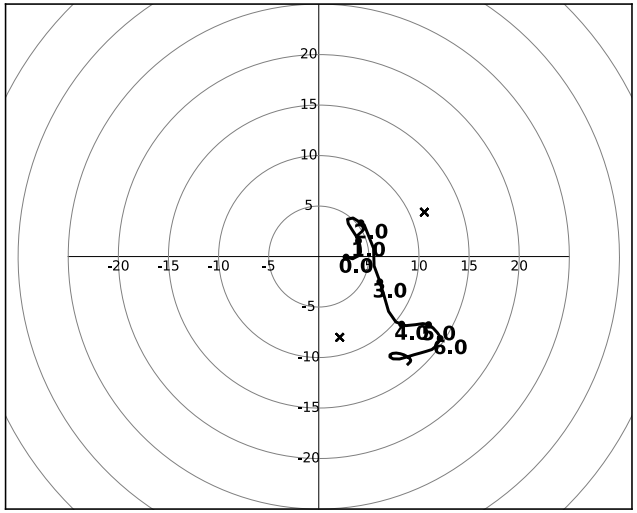


The simulation demonstrated a rapid change in environmental CAPE started at 18 UTC on May 2nd. The unstable atmosphere caused by diurnal heating and moistening the lower PBL. While nocturnal thermal inversion disappeared shortly after 18 UTC.

Fast Growing CAPE and BRN

- 887J/kg increases of CAPE in less than 5 hours
- BRN of 93
- LI of -4.7





Sounding at location 56.689895 N, -111.39035 W
time: 2016-05-02 23 UTC

Sounding at location 56.689859 N, 111.39035 W. Time = 2016-05-02_23:00:00. 61 vertical levels

Estimated storm motion (supercell right mover) -> 165° 8.3 m/s

Surface Parcel		
CAPE	887	J kg^{-1}
CIN	0	J kg^{-1}
TOPS	13672.33	km
θ_e	325.4	K
LI$_{MAX}$	-5.7	C
LI$_{500}$	-4.7	C
LI$_{300}$	-1.1	C
Parcel	975	mb

Most Unstable Parcel		
CAPE	887	J kg^{-1}
CIN	0	J kg^{-1}
TOPS	13672.33	km
θ_e	325.4	K
LI$_{MAX}$	-5.7	C
LI$_{500}$	-4.7	C
LI$_{300}$	-1.1	C
Parcel	975	mb

500 m Mixed Layer Parcel		
CAPE	887	J kg^{-1}
CIN	0	J kg^{-1}
TOPS	13672.33	km
θ_e	325.4	K
LI$_{MAX}$	-5.7	C
LI$_{500}$	-4.7	C
LI$_{300}$	-1.1	C
Parcel	975	mb

Hodograph
0-1 km shear 37° 2.0 m/s
0-3 km shear 126° 4.2 m/s
0-6 km shear 130° 12.4 m/s
SRH 0-1 : 6 m2/s2
SRH 0-3 : 44 m2/s2
ERH 0-1 : -6 m2/s2
ERH 0-3 : 22 m2/s2
BRN : 93
0-1 km shear 37° 2.0 m/s
1-2 km shear 7° 1.8 m/s
2-3 km shear 162° 6.1 m/s
3-4 km shear 152° 4.7 m/s
4-5 km shear 91° 2.7 m/s
5-6 km shear 139° 1.8 m/s

Temperature
Virtual Temperature
Dew-point Temperature
Wet-bulb Temperature
Lifted Surface Parcel Temperature
Lifted Surface Parcel Virtual Temperature

Pyroconvection & Updraft

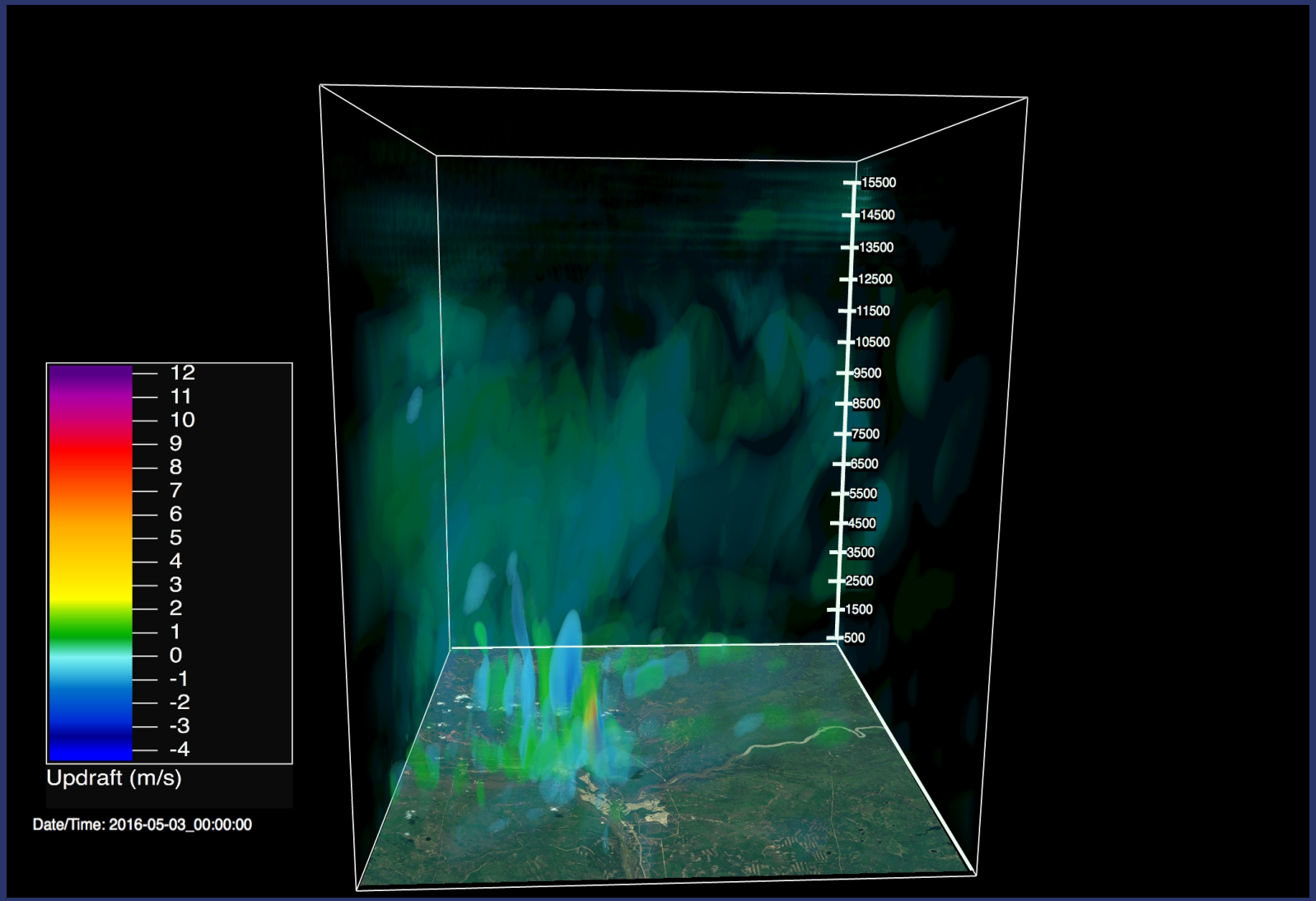
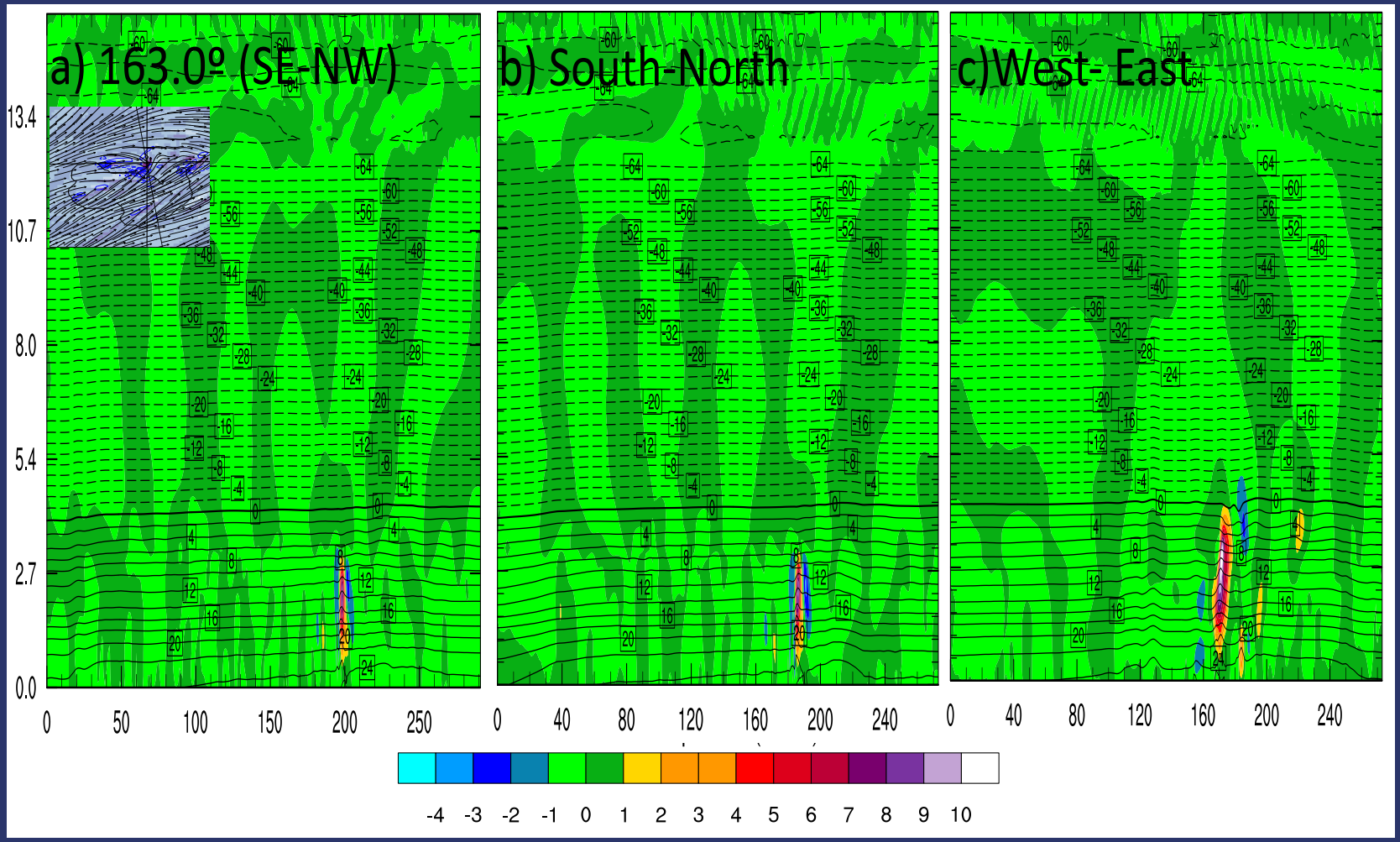
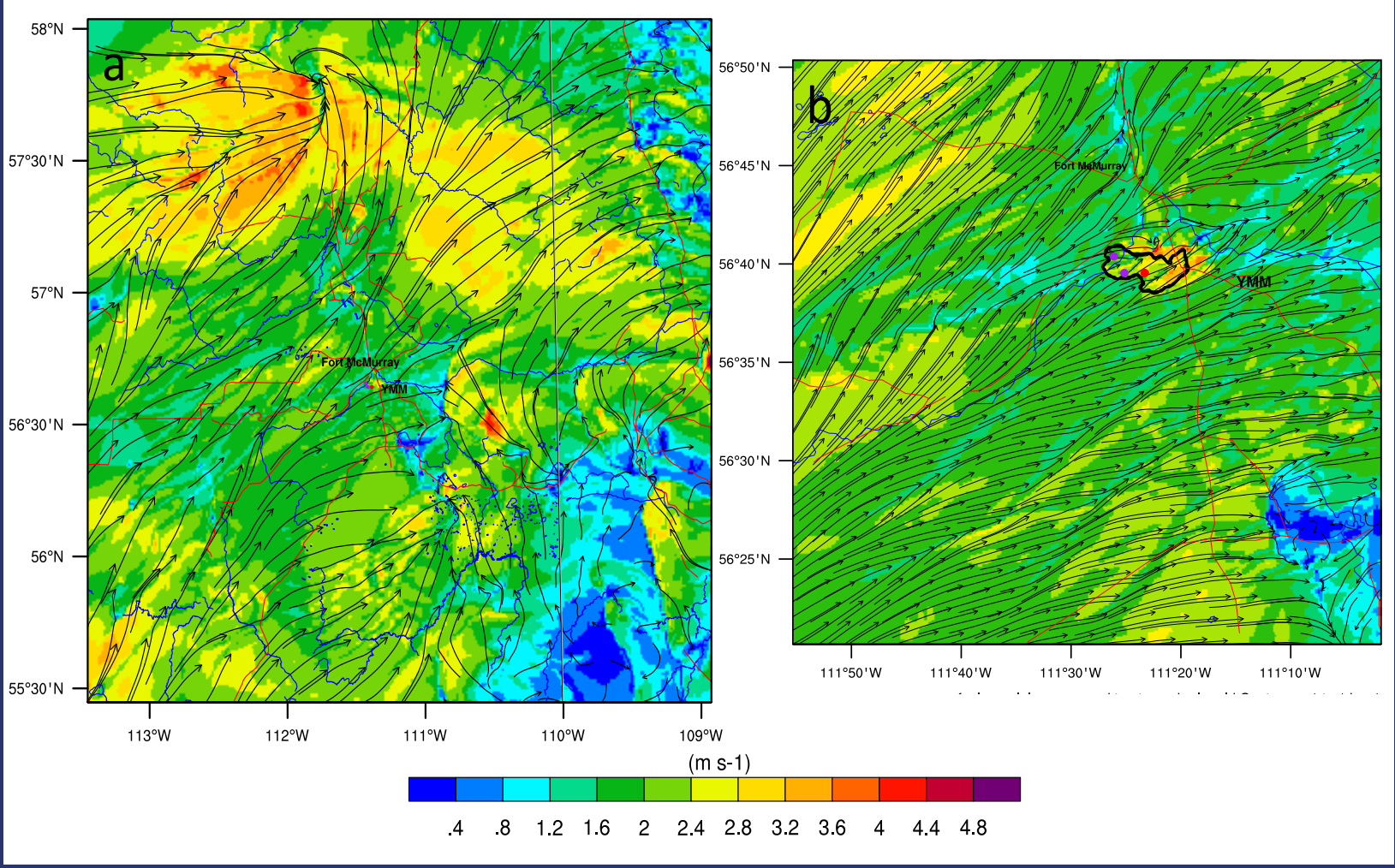


Image produced by VAPOR (www.vapor.ucar.edu)

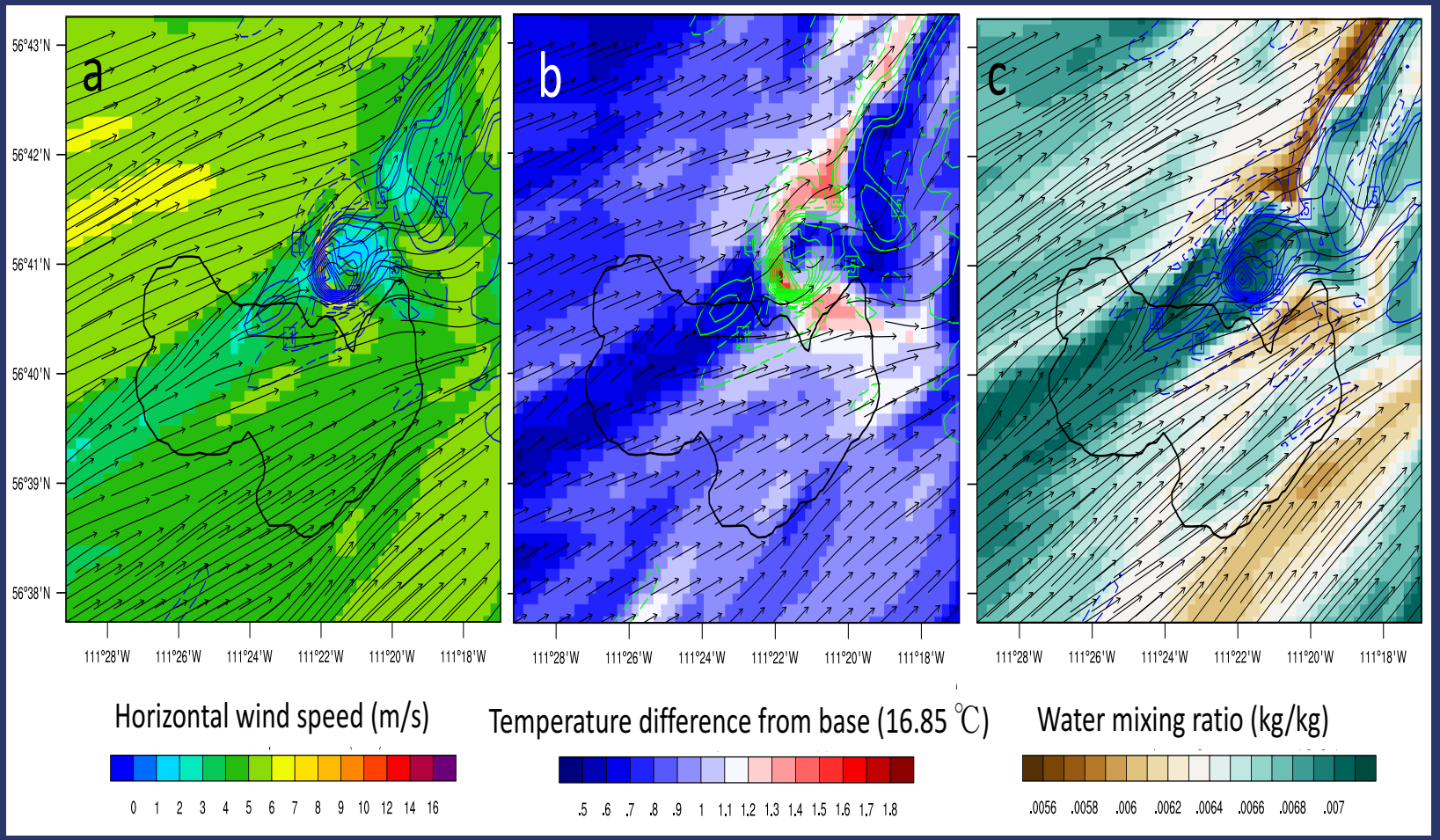
Vertical wind speed



Horizontal wind

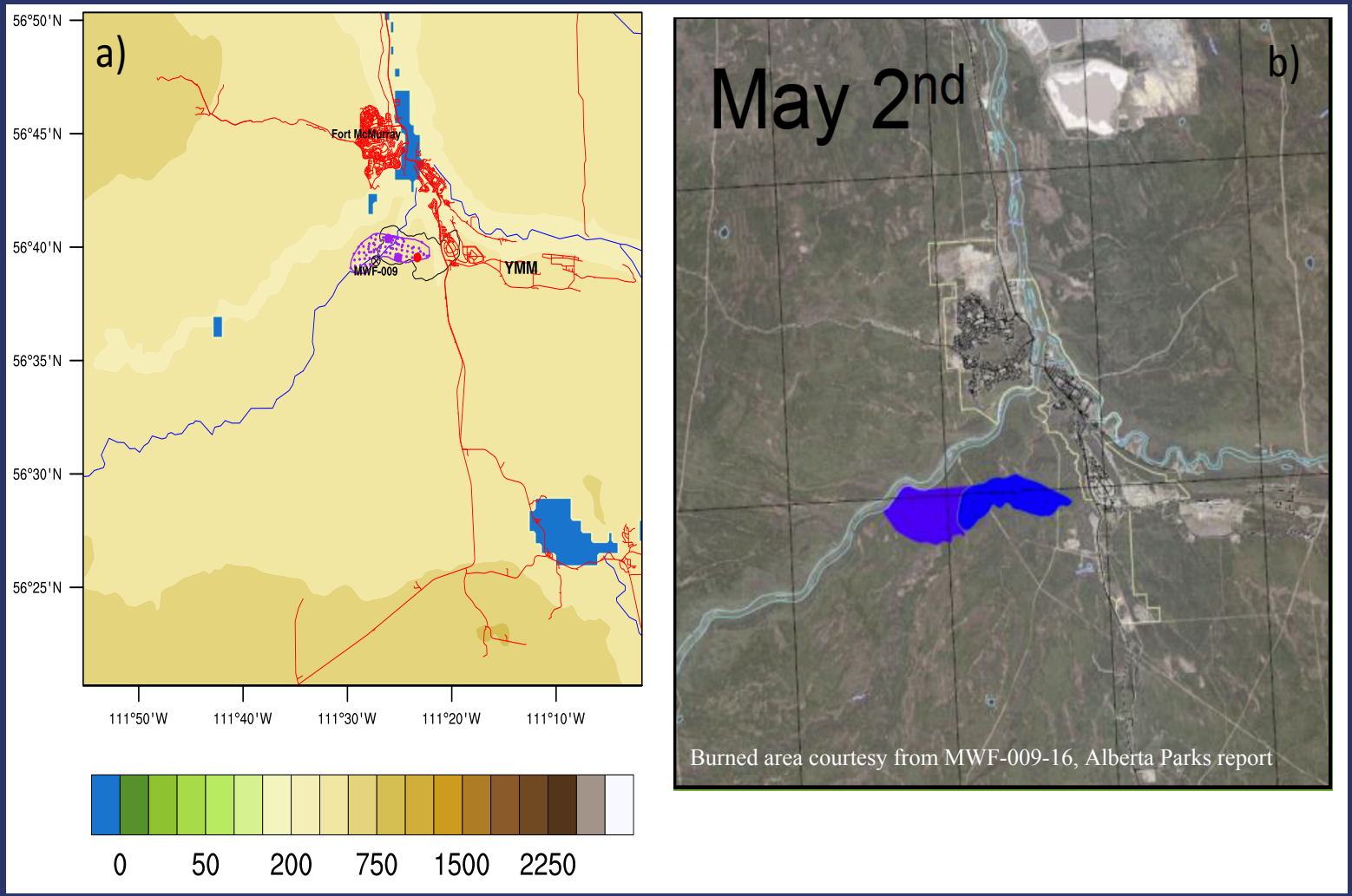


Entrainment and Drying



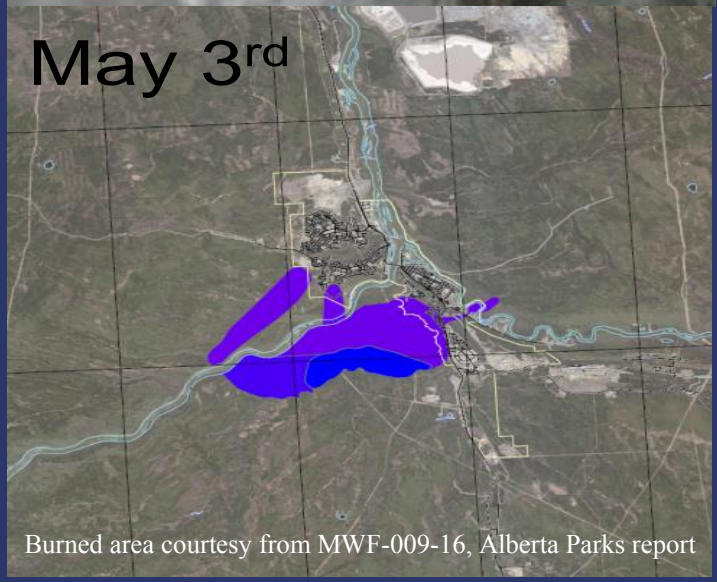
- 2-d plots at 10th model levels

Evaluation


a)
56°50'N
56°45'N
56°40'N
56°35'N
56°30'N
56°25'N
Fort McMurray
MWF-009
YMM
111°50'W
111°40'W
111°30'W
111°20'W
111°10'W
0
50
200
750
1500
2250
b)
May 2nd
Burned area courtesy from MWF-009-16, Alberta Parks report

Summary

- The simulation detected the rapid change in environmental CAPE started at 18 UTC on May 2nd. The CAPE reached to 887 J/kg in less than 5 hours with no CIN
- The high BRN of 93 at 23 UTC was an indicator of the small vertical wind shear.
- Mid-level Lifted Index changed from positive (1.5) to negative (-4.7) during the same period of time.
- The burning area is not exact match due to uncertainties in ignition and suppression and model biases.



The roadblocks

- Data
  - Spatial and temporal resolution
  - Consistency
  - Availability
- Optimization of WRF vertical levels
- Top of model
- Evaluation
- Dynamic Digital Fuel Map

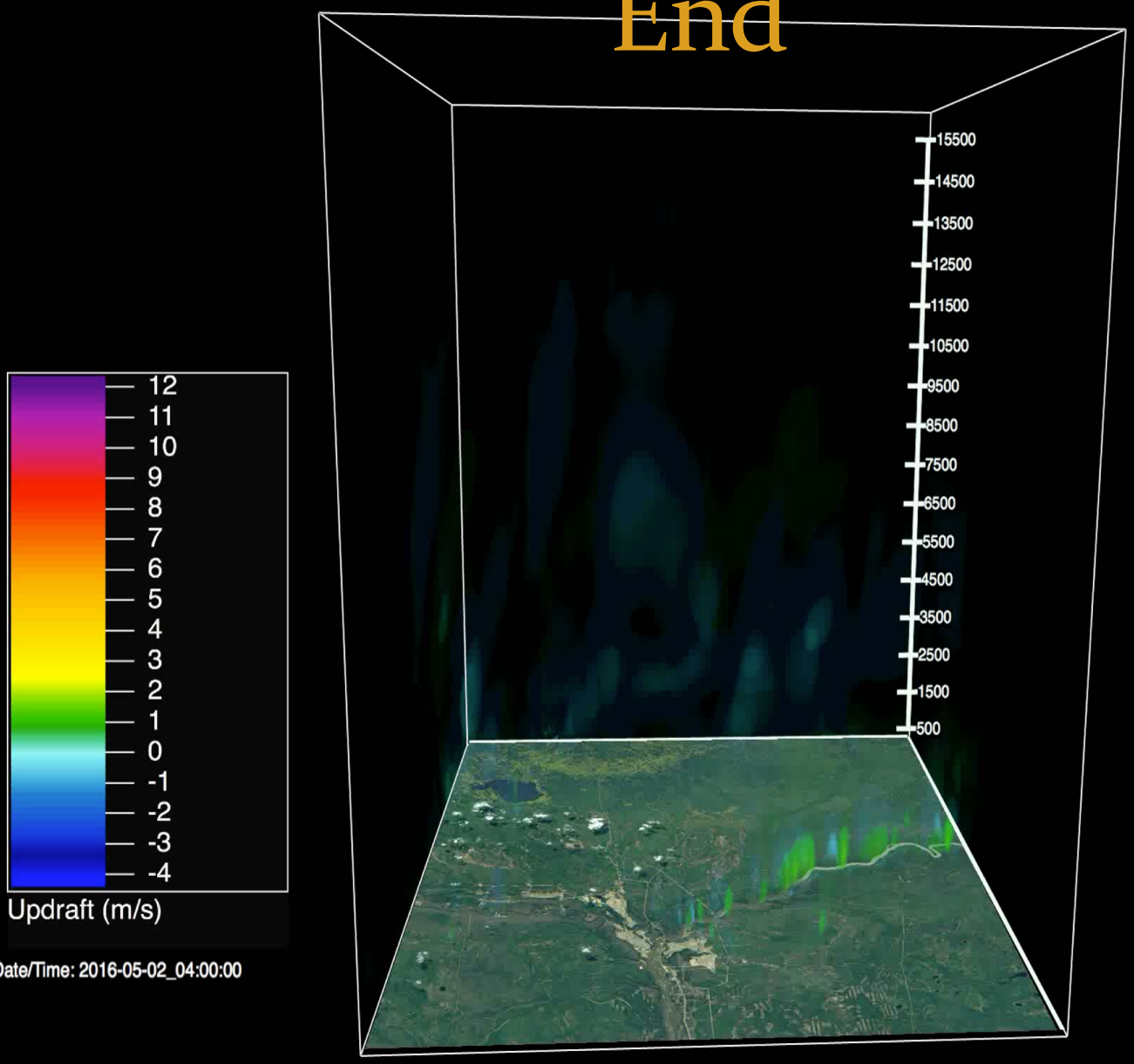
https://www.flickr.com/photos/premierofalberta/26860742705/in/album-72157667344002510/

Acknowledgment

- Edward Johnson, Kiyoko Miyanishi, Jan Mandel, Branko Kosovic, Pedro Jimenez, Adam Kochanski, Michael Duda, Scott Pearse, Kate Fossell, and Doug Phillips.

- University of Calgary, NCAR and WestGrid.

End



24 hours simulations of updrafts