# Case study information pertaining to the Dogrib sample dataset for Prometheus

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## Fire Chronology

The Dogrib fire (RWF085) started on September 25, 2001 as the result of an abandoned camp fire in the Rocky Mountain front ranges of southwest Alberta. The fire was detected at 17:00 MDT on September 29 and reported at 18:30 MDT. The fire was 70 ha in size and burning out of control when assessed on September 30 at 09:54 MDT. The fire's size continued to increase on September 30 reaching 95 ha at 10:46 MDT, 136 ha at 11:30 MDT, and 675 ha at 18:30 MDT. Fire fighting started October 1 at 06:00 MDT. The fire was classified as being held on October 2 at 08:00 MDT, and under control at 708 ha on October 4 at 10:00 MDT.

Limited fire growth occurred between October 4 and 15. The fire grew by 19 and 15 ha on October 6 and 13 respectively. On October 15 the fire's size increased to 852 ha at which time the status reverted to out of control. A wind event resulted in a major fire run on October 16. Local terrain funneled wind flow along the Red Deer River, and through a gap in the surrounding mountains. This pushed the fire east along the river valley. The fire jumped the Red Deer River and an adjacent road and then resumed a northeast spread direction. The fire spread 19 km in 6.7 hrs for an average spread rate of 47.3 m/min. (Figure 1).

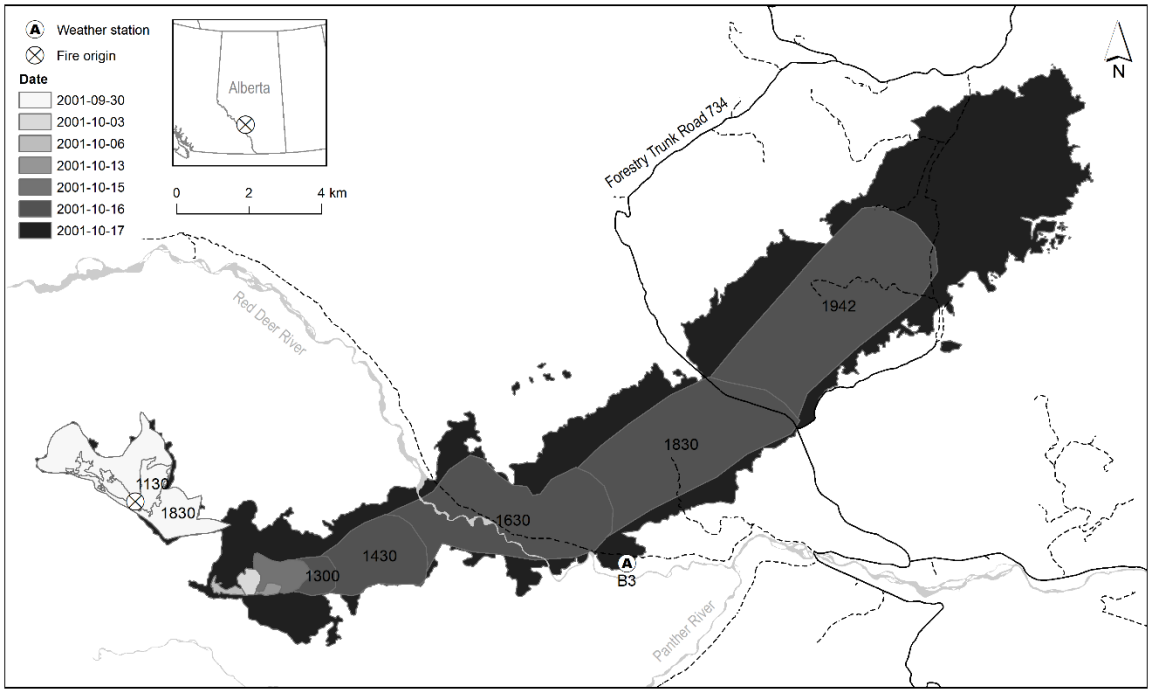


**Figure 1.** Progression of the Dogrib fire from its point of origin on September 25, 2001 to the final area burned on October 17, 2001. Capture times are shown for September 30 and October 16, 2001 progression perimeters.

The final fire size including partially burned areas was 10,216 ha. The October 16 fire run accounted for ninety percent of the total area burned between September 25 and October 17 and resulted in high to very high burn severities as detected by Landsat 7 (Figure 2).

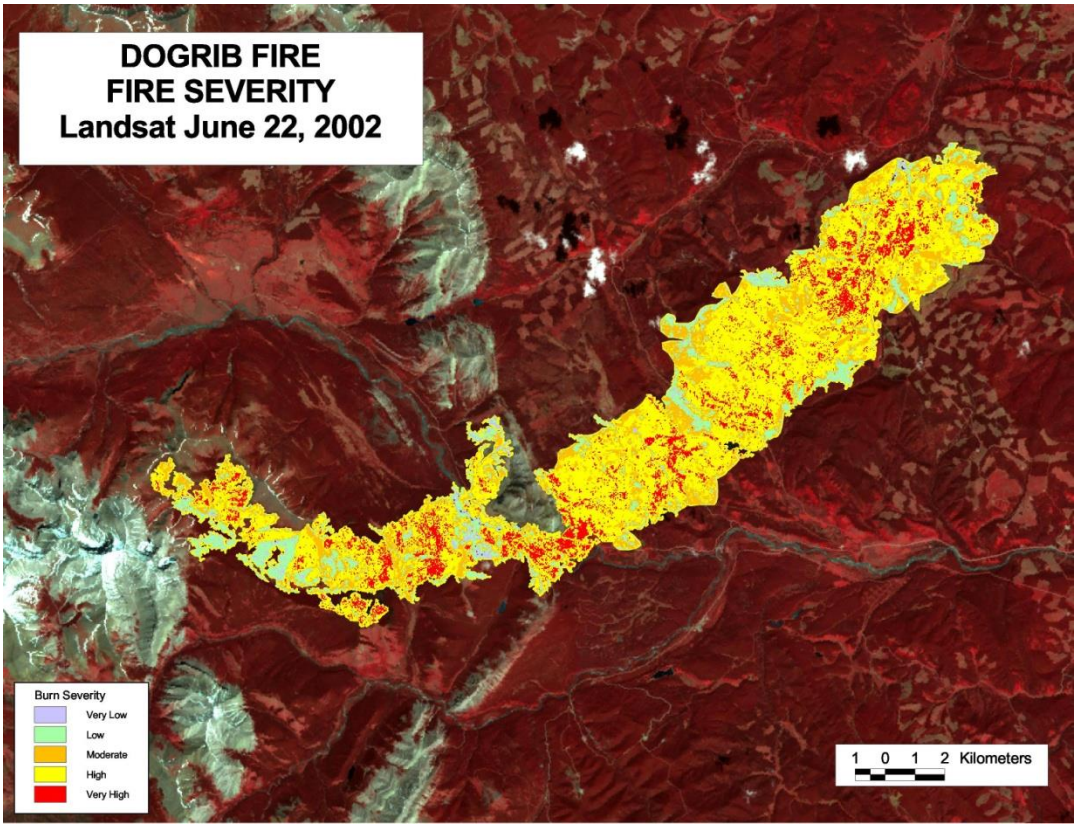


**Figure 2.** Dogrib burn severity interpreted from June 22, 2002 Landsat 7 imagery.

# Fuels and Topography

The Dogrib fire occurred in three natural subregions of the Rocky Mountain and Foothills regions of Alberta (Natural Regions Committee 2006)[1]. The fire started in the Subalpine natural subregion at an elevation of 1,964 m. Initially the fire spread northwest into surrounding Alpine areas. The large fire run on October 16 crossed the Red Deer River and spread northeast into the Lower Foothills. Elevation within the final fire perimeter ranged from 1,420 to 2,457 m. Aspects throughout the fire were predominately south to west facing with average slopes ranging 32 to 45 % in the three natural subregions (Table 1). The greatest proportion of area burned occurred in the Upper Foothills (65%), followed by the Subalpine (30%) and Alpine (5%).

Dominant vegetation communities contributing to fire spread included dwarf shrub-heath with scattered dwarf trees (krummholz) in the Alpine, Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) in the Subalpine, and even-aged lodgepole pine (*Pinus contorta*) stands in the Upper Foothills. The Canadian Fire Behavior Prediction System fuel types used to model fire spread through these vegetation communities include 0-1a, C-1, C-2, and C-3

[1] Natural Regions Committee (2006) Natural Regions and Subregions of Alberta. Compiled by Downing DJ and Pettapiece WW. Government of Alberta. Publication No. T/852.

respectively. Several harvested cut blocks occurred throughout the Lower Foothills and were modelled with the O-1a fuel type. Barriers to fire spread included rocky slopes in the Alpine and water and gravel beds along the Red Deer River.

**Table 1.** Topographic statistics for the 2001 Dogrib fire by Natural Subregion.

| **Natural Subregion** | **Elevation (m)** | | | **Slope (%)** | | | **Aspect** |
|---|---|---|---|---|---|---|---|
| *(% of final area burned)* | *Min* | *Max* | *Mean* | *Min* | *Max* | *Mean* | *Mode* |
| Upper Foothills (65) | 1,420 | 1,940 | 1,625 | 0 | 198 | 45 | south |
| Subalpine (30) | 1,527 | 2,238 | 1,853 | 0 | 195 | 39 | west |
| Alpine (5) | 2,001 | 2,457 | 2,212 | 0 | 167 | 32 | southwest |

# Prometheus Data Set

## *Fuel Lookup Table*

A Comma-Separated Value (CSV) file associating integer grid values with Canadian Fire Behavior Prediction (FBP) System fuel types and display colors. This file is identical to the Prometheus national default fuel lookup table provided for Canada.

- **Filename:** fbp_lookup_table.csv

## *Landscape Grids*

100m resolution ASCII and GeoTiff raster files. Projection information for ASCII raster files is contained within the associated *.prj files.

- **Filename:** fbp_fuel_type.asc
  - Integer values representing Canadian FBP System fuel types.
- **Filename:** fbp_fuel_type_randomized.asc
  - Randomized integer values representing equal proportions of each Canadian FBP System fuel type contained in fbp_fuel_type.asc. Non-fuels were not randomized.
- **Filename:** elevation.asc
  - Integer values representing elevation measured in meters above mean sea level.
- **Filename:** degree_of_curing_100.tif
  - Degree of curing equals 100% where grass fuel types occur.

## *Landscape Properties*

- Time Zone is MDT: Mountain Daylight Time (-6:00)

## *Fuel Patches*

One polygon fuel patch is used to convert all combustible fuels to vegetated non-fuel within the area burned as of October 16, 2001 at 13:00 MDT.

- **Filename:** perimeter_rwf085_20011016_1300.kml

## *Ignitions*

Two point ignitions are provided as Keyhole Markup Language (KML) files. The first ignition represents the fire's point of origin on September 29, 2001. The second ignition approximates where the large fire run on October 16, 2001 originated. The file naming convention "ignition_point_Ymd_HM.kml" is used where, Y = year, m = month, d = day, H = hour, and M = minute.

- **Filename:** ignition_ point_20010929_1700.kml
    - Start Time: September 29, 2001 17:00
    - Coordinates: 51.669200°, -115.557900°
- **Filename:** point_ ignition_20011016_1300.kml
    - Start Time: October 16, 2001 13:00
    - Coordinates: 51.652858°, -115.476529°

## *Weather Station*

The Yaha Tinda automatic station (B3) recorded hourly weather conditions for the duration of the Dogrib fire. Station B3 is location on the north side of the Red Deer River and east of the final fire boundary (Figure 1).

- Name: B3 - Yaha Tinda Auto
- Coordinates: 51.6547°, -115.3617°
- Elevation: 1,486 m

### Weather Stream

Hourly weather records from station B3 are provided for the period September 25 to October 30, 2001 in a Comma-Separated Value (CSV) file. The maximum wind speed recorded during the October 16 fire run was 46 km/h from the southwest. Maximum temperature was 17.7 °C. Minimum relative humidity was 18 %. The Diurnal (Lawson) method is used to calculate hourly FFMC values. Yesterday's daily starting codes for September 25 are as follows: FFMC 89, DMC 58, DC 482, Precip 0.0 mm. A value of 94 @ Hour 17 is recommended for today's starting value if using the Hourly (Van Wagner) method to calculate HFFMC.

- **Filename:** weather_B3_hourly_20010925to1030.csv

## *Weather Patch*

Two weather patches are used to modify hourly wind directions from station B3. A landscape weather patch is used to add 15 degrees to wind directions between 13:00 and 18:30 MDT on October 16, 2001. This landscape weather patch compensates for spread direction error due to wind observations rounded to the nearest cardinal direction. A hand-sketched polygon weather patch is used to set wind direction along the Red Deer River to 280 degrees accounting for terrain funneling. The polygon weather patch is applied between 13:00 and 20:00 MDT on October 16, 2001

- **Filename:** weather_patch_polygon_wd_280.kml

## *Weather Grids*

WindNinja 3.5.0 was used to model the influence of terrain on wind flow[2]. Two methods were used to compute spatially explicit wind direction and wind speed grids. The `conserv_mass` folder contains grids produced using a Conservation of Mass method. The `conserve_mass_moment` folder contains grids produced using a Conservation of Mass and Momentum method. Each wind grid was simulated using a 100 m mesh resolution, trees for surface vegetation, and 10 m-SI input and output heights. The grids are provided as ASCII raster files. Projection information for the ASCII raster files is contained within the associated *.prj files. The first number in the filenames represents the domain average wind direction in degrees. The second number is the domain average wind speed in km/h. The third number is the output grid resolution (100 m). The last three letters specify the type of grid where, 'ang' represents angle, and 'vel' represents velocity.

Prometheus uses hourly wind speed and direction from a scenario's primary weather stream to activate wind grids during a fire simulation. The wind speed value associated with each grid must be calibrated to the primary weather stream location as opposed to the domain average. The primary weather stream used to simulate the Dogrib fire is from station B3. Wind direction and speed values at the B3 station location are provided for both Conservation of Mass (cm) and Conservation of Mass and Momentum (cmm) wind grid files bellow.

### Wind Direction Grid Files (wind at station B3)

- North: windninja_360_30_100m_ang.asc (cm = 358, cmm = 354)
- East: windninja_90_30_100m_ang.asc (cm = 92, cmm = 90)
- Southwest: windninja_240_30_100m_ang.asc (cm = 247, cmm = 251)
- West: windninja_270_30_100m_ang.asc (cm = 272, cmm = 287)
- Northwest: windninja_315_30_100m_ang.asc (cm = 308, cmm = 320)

### Wind Speed Grid Files (speed at station B3)

- North: windninja_360_30_100m_vel.asc (cm = 22.1, cmm = 22.7)
- East: windninja_90_30_100m_vel.asc (cm = 28.3, cmm = 31.6)
- Southwest: windninja_240_30_100m_vel.asc (cm = 26.1, cmm = 8.9)
- West: windninja_270_30_100m_vel.asc (cm = 28.3, cmm = 28.9)
- Northwest: windninja_315_30_100m_vel.asc (cm = 26.4, cmm = 36.1)

Winds at the B3 station location are 2 to 8 km/h slower than domain averages for Conservation of Mass grids. Depending on the direction input, winds are up to 20 km/h slower or 6 km/h faster for Conservation of Mass and Momentum grids. Wind grids are applied to scenarios 2 and 4. Wind speed calibrations must be entered in the Prometheus Wind Speed Grid dialog. The start and end times for wind grids are September 29, 2001 00:00 and October 17, 2001 23:59 respectively.

[2] https://www.firelab.org/project/windninja

## *Physical Features*

Three physical features are provided for reference in ESRI Shapefile (SHP, dbf, prj, sbn, sbx, shx) and Keyhole Markup Language (KML) formats. Access features contain linear road networks throughout the fire area. The hydrology feature contains digitized river polygons at a 1 to 20,000 scale that may not be captured in the fuel grid. These features are provided for display purposes and are not used as fuel breaks.

### Access Files

- access_gravel_road.shp
- access_unimproved_road.shp

### Hydrology Files

- hydrology_river.kml

Two fire perimeters and two fire progressions are provided as Keyhole Markup Language (KML) files. The fire perimeter files show area burned as of October 16, 2001 13:00 MDT and October 17, 2001 11:52 MDT (Figure 1). The later file is the final fire perimeter digitized from aerial photographs. The first progression file contains two fire perimeters from September 29, 2001. The second progression file contains four fire perimeters captured during the October 16 fire run. The file naming conventions "perimeter_rwf085_Ymd_HM.kml" and "progression_ rwf085_Ymd_HM.kml" are used where, Y = year, m = month, d = day, H = hour, and M = minute.

### Perimeters

- perimeter_rwf085_20011016_1300.kml
- perimeter_rwf085_20011017_1152.kml

### Progression

- progression_rwf085_20010930.kml
- progression_rwf085_20011016.kml

# Prometheus Fire Growth Model

A binary Prometheus fire growth model (FGM) file containing all model inputs, parameters and settings is included with the dataset. This file was generated with Prometheus 6.2.4 and is not backwards compatible with previous versions.

- **Filename:** Dogrib_v624.fgm

## *Scenarios*

Two scenarios are included in the Dogrib FGM. Scenario 1 models the period September 29 to 30 starting from the fire's point of origin. Scenario 2 models the large fire run on October 16. The following sections summarize inputs for each of the scenarios.

### Scenario 1

- **Start and End Times:** Sep 29 2001 17:00 - Sep 30, 2001 18:30
- **Ignitions:** ignition_ point_20010929_1700.kml
- **Weather Streams:** B3 - Yaha Tinda Auto: weather_B3_hourly_20010925to1030.csv
- **Grids and Patches:** degree_of_curing_100.tif

### Scenario 2

- **Start and End Times:** Oct 16 2001 13:00 - Oct 16, 2001 19:42
- **Ignitions:** ignition_ point_20011016_1300.kml
- **Weather Streams:** B3 - Yaha Tinda Auto: weather_B3_hourly_20010925to1030.csv
- **Fuel Breaks:** perimeter_rwf085_20011016_1300.kml
- **Grids and Patches:**
    - degree_of_curing_100.tif
    - perimeter_rwf085_20011016_1300.kml
    - weather_patch_polygon_wd_280.kml
    - weather_patch_landscape_wd+15deg

## *Scenario Settings*

### Burning Conditions

Burning Conditions are applied to all scenarios where an hourly Initial Spread Index greater than 8, wind speed greater than 5 km/h, and relative humidity greater than 50 % are required for fire growth to occur.

### Fire Weather Interpolation

Fire weather interpolation is not applied to any scenarios as the B3 weather station was located in close proximity to the fire.

### Fire Behavior

*Terrain effect* and *Breaching* are both on in all scenarios. Breaching occurs when non-fuel grid cells or linear fuel breaks fail to stop an advancing fire front. The width of a barrier to fire spread must be at least 1.5 times the expected flame length to prevent breaching. Surface fire flame length ($L_{SF}$) is derived from Fire Intensity (FI) with the equation $L_{SF} = 0.0775 \times FI^{0.46}$. Crown fire flame length ($L_{CF}$) is calculated from tree height using the equation $L_{CF} = 2.5 \times$ tree height.

*FMC (%) override* and *Percentile rate of spread* are both off in all scenarios.

*Green-up* is set to May 15 to September 15 for all scenarios. The green-up setting applies to the D-1/D-2, M-1/M-2, and M-3/M-4 fuel types. When green-up is off: D-1/D-2 behaves like D-1 (Leafless Aspen); M-1/M-2 behaves like M-1 (Boreal Mixedwood – Leafless); and M-3/M-4 behaves like M-3 (Dead Balsam Fir/Mixedwood – Leafless).

*Standing Grass* is set to June 15 to November 30 for all scenarios. The standing grass setting applies to the O-1a/O-1b fuel type. When standing grass is on O-1a/O-1b behaves like O-1b (Standing Grass).

*Grass Curing* is set to 100 % for both scenarios for the period September 29 to December 31. A landscape grid is also available in the Dogrib FGM which can be used to set grass curing degree to 100 % wherever the O-1a/O-1b fuel type occurs. Landscape grids are useful for providing spatially explicit grass curing values. However, start and end dates cannot be defined for landscape grids and simulation times are slower. For this reason, the grass curing table is used in both scenarios as opposed to the degree of curing grid.

### Propagation

Display interval is set to 30 min. Defaults for all other propagation settings are used. The time required to simulate a scenario can be decreased by turning the "*Use dynamic resolution setting*" on. This setting increases the distance and perimeter resolutions for propagating fire vertices from 1 to 4 grid cells as fire size increases from 0 to 10,000 ha. Distance and perimeter resolutions remain at 4 grid cells beyond a 10,000 ha fire size.

## Prometheus Outputs

Figure 3 shows simulated fire perimeters from four versions of Scenario 2. The only difference among the four versions is their wind inputs. Scenario 2b used a polygon weather patch along the Red Deer River and produced the best results with respect to spread direction, spread distance, and overlap with the observed fire progression. Scenario 2d used conservation of mass and momentum wind grids and produced the worst results.

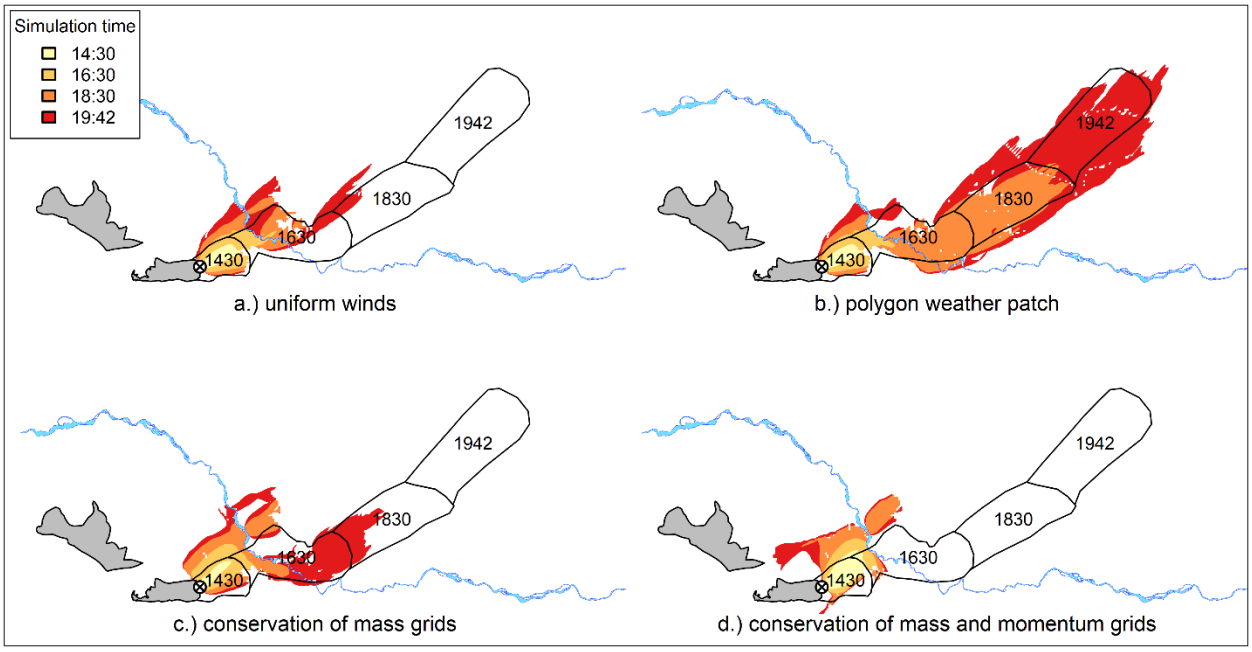


**Figure 3.** Dogrib fire progression observed on October 16, 2001 from 13:00 to 19:42 MDT (black outlines) over simulated hourly perimeters from four Prometheus scenarios. Upper-left scenario (a) used uniform wind inputs. Upper-right scenario (b) used a polygon weather patch to account for wind funnelling along the Red Deer River. Lower-left scenario (c) used conservation of mass wind grids. Lower-right scenario (d) used conservation of mass and momentum wind grids. Gray polygons represent area burned as of 13:00 MDT. The cross-hatched point approximates where the October 16 fire run started. The Red Deer River appears in blue.