Firebrand flux

186 m

0 m

320 m

FBP X

FBP Y

FBP Z

FCS X

FCS Y

FCS Z

Fire line

Road

320 m

160 m

300 m

250 m

150 m

100 m

50 m

|  |  |
| --- | --- |
| Trail | Total input number (pcs/s) |
| TR1 | 14 446 |
| TR2 | 10203 |
| TR3, TR4 | 9880 |

Firebrands landing time span in experiment

FCS X 407 s

FCS Y 513 s

FCS Z 394 s

Previous simulation **1500** mm grid

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| location | **Firebrand density (pcs/m2)** | | | **Diff%**  **Exp vs TR4** | **Flux (pcs/m2. s)** | | | **Diff%**  **Exp vs TR4** |
| Exp | **TR3** | **TR4** | **Exp** | **TR3** | **TR4** |
| FCS X | 335 | 260 | 285 | +14.9 | 0.824 | 0.776 | 0.700 | +15.1 |
| FCS Y | 463 | 478 | 487 | -05.1 | 0.902 | 0.931 | 0.950 | -05.3 |
| FCS Z | 536 | 738 | 571 | -06.5 | 1.361 | 1.377 | 1.451 | -06.6 |

Current simulation **750** mm grid

Prediction after **193** seconds

Total number of firebrands collected in the field experiment = 335+463+536

=1334

Total number of firebrands received at X,Y,Z in the simulation =285+487+571

=1343

Difference =[(1334-1343)/1334] x 100%

=-0.67%

Comparison of firebrand flux at X, Y and, Z location in the experiment and the simulation.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Area**  **(x 10-5)[m2]** | **Firebrand flux at collection sites (pcs)** | | | | | |
| **Experiment** | | | **Simulation** | | |
| **FCS X** | **FCS Y** | **FCS Z** | **FCS X** | **FCS Y** | **FCS Z** |
| **0.75 - 5** | 0.6483 | 0.6858 | 1.0473 | 0.697364 | 0.919257 | 1.087356 |
| **5 - 10** | 0.1034 | 0.1352 | 0.1873 | 0.001642 | 0.019453 | 0.219632 |
| **10 -20** | 0.0537 | 0.0618 | 0.0856 | 0.000545 | 0.007546 | 0.083238 |
| **20 -30** | 0.0054 | 0.0075 | 0.0236 | 0.000000 | 0.002889 | 0.038234 |
| **30 - 50** | 0.0081 | 0.0043 | 0.0118 | 0.000000 | 0.000369 | 0.010233 |
| **>50** | 0.0054 | 0.0075 | 0.0059 | 0.000000 | 0.000514 | 0.011933 |

Estimated number of firebrands landed on the collection points X, Y and Z during the collection times of 335 s, 463 s, 536 s

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Area**  **(x 10-5)[m2]** | **Number of firebrands received by collection sites (pcs)** | | | | | |
| **Experiment** | | | **Simulation** | | |
| **FCS X** | **FCS Y** | **FCS Z** | **FCS X** | **FCS Y** | **FCS Z** |
| **0.75 - 5** | 264 | 352 | 413 | 284 | 472 | 428 |
| **5 - 10** | 42 | 69 | 74 | 1 | 10 | 87 |
| **10 -20** | 22 | 32 | 34 | 0 | 4 | 33 |
| **20 -30** | 2 | 4 | 9 | 0 | 1 | 15 |
| **30 - 50** | 3 | 2 | 5 | 0 | 0 | 4 |
| **>50** | 2 | 4 | 2 | 0 | 0 | 5 |
| **Total** | 335 | 463 | 536 | 285 | 487 | 572 |

Firebrands accumulation on X, Y, Z collection sites.

Total input number of firebrands (193 s) = 632 384 pcs

Total landed number of firebrands at X, Y, Z locations (300 m2) = 17 821 pcs

Landing percentage =(17 821 pcs/632 384 pcs) x 100

=2.81%

Heat release rate and mass loss rate

|  |
| --- |
|  |
|  |

Pitch pine forest

Average heat release rate (MW) = 2392 [122 s to 193 s]

Firebrands inputting rate (pcs/s) =9881

Total firebrands input from 130 s to 193 s (pcs) =632 384

Firebrands inputting rate vs fire intensity =

Douglas fir tree

Average heat release rate (MW) = 3.396 [11.6 s to 26.4 s: where HRR reached 300 kW]

Total firebrands’ input (pcs) =350 pcs within 32 seconds

Firebrands inputting rate (pcs/s) =23.33 pcs/s

Firebrands inputting rate vs fire intensity =

=

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case | Wind velocity(m/s) | Particle velocity  (U,V,W) | Ember input rate pcs/s | **Flux (pcs/m2. s)** | | |
| FCS X | FCS Y | FCS Z |
| TR1 |  | (0.0,0.0,2.0) | 14 446 | 0.076 | 0.937 | 3.027 |
| TR2(1500 mm grid) | ~3.9 | (0.0,0.0,2.0) | 10 203 | 0.683 | 1.019 | 1.564 |
| TR3(1500 mm grid) | ~4.2 | (0.0,0.0,2.0) | 9880 | 0.598 | 1.032 | 1.428 |
| TR4(750 mm grid) | ~ 4.4 | (0.0,0.0,2.0) | 9880 | 0.700 | 0.950 | 1.451 |
| TR5(1500 mm grid) | ~2.2 | (6.2, 0.0,2.1) | 9880 | 0.255 | 1.499 | 1.332 |
| TR6(1500 mm grid) | ~ 2.1 | (8.3, 0.0,2.1) | 9880 | 0.625 | 1.284 | 0.667 |
| TR6(1500 mm grid and no fire) | ~2.3 | (0.0,0.0,2.1) | 9880 | 0.303 | 2.016 | 1.512 |
| Experiment | 1.4±0.6 | NA | NA | 0.824 | 0.902 | 1.361 |

**Determining particles’ initial velocity of TR5 (based on single tree and wind velocity)**

Single tree burning particles initial velocity(U,V,W) (m/s) =(2.1,0, 0.7)

Forest fire particles’ initial velocity (U,V,W) (m/s) =(8.3, 0, 2.1)

Wind velocity of forest fire (m/s) = 1.4 ± 0.6 --- > 2.0

U velo = 3 x U velo of single tree particle + wind velocity

= (3 x 2.1 + 2)

= 8.3 m/s

W velocity = 3 x W velo of single tree particle

= 3 x 0.7

= 2.1 m/s

Forest fire simulations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Case | Wind velocity  (m/s) | Particle velocity  (U,V,W) m/s | Ember input rate pcs/s | **Flux (pcs/m2. s)** | | |
| FCS Z | FCS Y | FCS X |
| T A | ≈1.94 | (4.2, 0.0, 2.1) | 9881 | 2.1054 | 1.562 | 0.074 |
| T B | ≈2.02 | (6.2, 0.0, 2.1) | 9881 | 1.332 | 1.499 | 0.255 |
| T C | ≈1.93 | (8.3, 0.0, 4.2) | 9042 | 1.218 | 1.120 | 0.522 |
| T D | ≈1.89 | (8.3, 0.0, 5.2) | 9042 | 1.253 | 1.341 | 0.306 |
| T E | ≈1.87 | (8.3, 0.0, 6.2) | 9042 | 1.154 | 1.196 | 0.271 |
| T F | ≈1.95 | (9.3, 0.0, 4.2) | 8907 | 1.343 | 1.230 | 0.289 |
| T G | ≈1.98 | Varied on particle | 9881 | 0.738 | 1.415 | 0.214 |
| T H | ≈2.1 | (8.3, 0.0, 2.1) | 11006 | 1.465 | 1.302 | 0.701 |
|  |  |  |  |  |  |  |
| Experiment | 1.4±0.6 | NA | NA | 1.361 | 0.902 | 0.824 |
| Difference(%) |  |  |  | 7.6 | 44.3 | -14.9 |

* Lower initial horizontal velocity – results more particles accumulating on FCS Z (case T A).
* Higher initial horizontal velocity – results more particles moving away from the fire line and landing on Y, X locations. However, increasing vertical velocity results landing less firebrands on X location (TH, TD, TE, TF).
* So, TH case is being used to adjust the input composition of firebrands to get a closer value to the experiment.

AS3959-Clarification

1. Positioning the house: minimum distance or the maximum distance of each BAL limit.

* Assume extreme flux will be at minimum distance.
* minimum distance may be helpful for smaller grid preparation since the domain size of the smaller grid is less.

1. Firebrand: Input number will be calculated according to the 'Basic Calculation'. What about the properties of the firebrands?

* Possibility of using pitch pine firebrand sizes, types etc?
* All other available firebrand data are from tree burning

1. Thermo-physical data of fuel: Some are available. Refer 'Thermal properties-vegetation' document.

* Possibility of estimating from similar types of vegetation.

1. House design: Any standard house designs with features proposed by the authorities?

* Single storey house, two storey house, A house with sub-floor.
* HF devices positioning- front, back, side walls, corners(door, window)
* see this reference: <https://www.edigitalagency.com.au/architecture/best-bushfire-resistant-house-design-ideas/>

Shapes of the landed firebrands

\*\*expecting to add eccentricity of firebrands of Manzello et al.

\*\*expecting to compare surface area vs mass of firebrands same as the Manzello’s experiment (Fire and Materials 2009).