Note, this is a preliminary release of results for comment and lacks references and further discussion.

FDS 5.0.3 was run on a grid sensitivity study. A 9m x 9m x 20m H space was modeled with an axi-symmetric plume using uniform grid spacings from 3 cells per meter to 12 cells per meter – see Table 1, which includes run times. The fire was a 1 m x 1 m "pool" fire using all default FDS values. Three Heat Release Rates per Unit Area (HRRPUA) of 500, 2,000, and 4,000 kW/m^2 were used.

Fires were modeled for 50 seconds of run-time allowing for 20 seconds of flow stabilization and 30 seconds of averaging. A centerline vertical (constant Y [i.e. PBY=?]) was used for centerline temperatures and four horizontal slice positions (constant Z [i.e. PBZ=?]) were used at 5.0, 10.0, 15.0, and 19.0 m. The last was chosen to be one meter prior to the computational boundary at 20 m.

Using fds2ascii, the slice files for temperature and velocity were used to average and report results on simulation times 20 to 50 (delta=30) seconds. The results are presented graphically below. See Figures 1, 2, & 3.

Additional simulations were run to determine the effect of using a higher aspect ratio in the Z direction in order to reduce the total number of grid cells required for the simulation. Cells were still square in plan and therefore ranged from 1:1:1 to 1:1:5. See Figures 4 & 5 (the 2 MW data is not yet reduced).

Some comparative ("error") analysis was performed with centerline temperatures starting at Z=8.0 m see Figures 6, 7, & 8. The simulated values were compared to the Alpert centerline temperature correlation and an error was calculated through (predicted-modeled)/predicted where "predicted" = Alpert correlation and "modeled" = the results from the FDS run. While there are a long list of reanalysis of the plume centerline data and their associated correlations, the Alpert correlation gave a basis for analysis in that it roughly fell within the model results for the higher grid resolution so that it set a bench-mark for comparison.

It appears as though the results are fairly insensitive to the fire size when calculating the centerline temperatures in that grid resolutions above 12.5 cm/cell were fairly consistent between 12.5 to 8.3 cm/cell. Lower grid resolution led to under-predicted temperatures below the flaming region and over-predicted temperatures above that point. Of course, run-times lengthen with increasing fire size for the same grid size due to meeting the CFL criterion. However, looking for some better sense of appropriate grid sizes is helpful to planning an overall analysis and setting expectations for answering questions posed by the analysis.

Radial temperature distribution analysis was also compared to the method described by Heskestad in the SFPE Handbook. They show that the lower resolution grids do not sufficiently capture the mixing phenomena consistent with the above discussion on over-predicted centerline temperatures. These are presented without further discussion in Figures 9-12, Figures 13-16, and Figures 17-20 for 500, 2,000, and 4,000 kW/m^2 at elevations of Z= 5.0, 10.0, 15.0, and 19.0 m, respectively.

Note: This is neither an endorsement nor a recommendation of any particular cell size or grid resolution for any particular discussion. This research is intended to encourage discussion within the industry and does not, on its face validate or invalidate any FDS work.

Table 1 Simulation dimensions, cell sizes & run times

coord	x	y	z					Runtime (hours)		
dimension	9	9	20	m						
cells/m	cells-x	cells-y	cells-z	Total	size-x (cm)	size-y (cm)	size-z (cm)	0.5 MW	2.0 MW	4.0 MW
3	27	27	60	43,740	33.3	33.3	33.3	0.2	0.2	0.2
4	36	36	80	103,680	25.0	25.0	25.0	0.6	0.8	0.8
5	45	45	100	202,500	20.0	20.0	20.0	1.5	2.3	2.5
6	54	54	120	349,920	16.7	16.7	16.7	2.9	5.3	5.5
8	72	72	160	829,440	12.5	12.5	12.5	8.3	12.1	16.5
9	81	81	180	1,180,980	11.1	11.1	11.1	17.5	22.5	29.0
10	90	90	200	1,620,000	10.0	10.0	10.0	28.7	32.1	32.8
12	108	108	240	2,799,360	8.3	8.3	8.3	38.8	61.4	64.0
Ratio 1:1:								0.5 MW	2.0 MW	4.0 MW
2	90	90	100	810,000	10.0	10.0	20.0	4.5	10.6	7.8
3.125	90	90	64	518,400	10.0	10.0	31.3	3.1	5.3	4.2
4	90	90	50	405,000	10.0	10.0	40.0	2.0	3.2	4.7
5	90	90	40	324,000	10.0	10.0	50.0	1.1	2.4	2.8

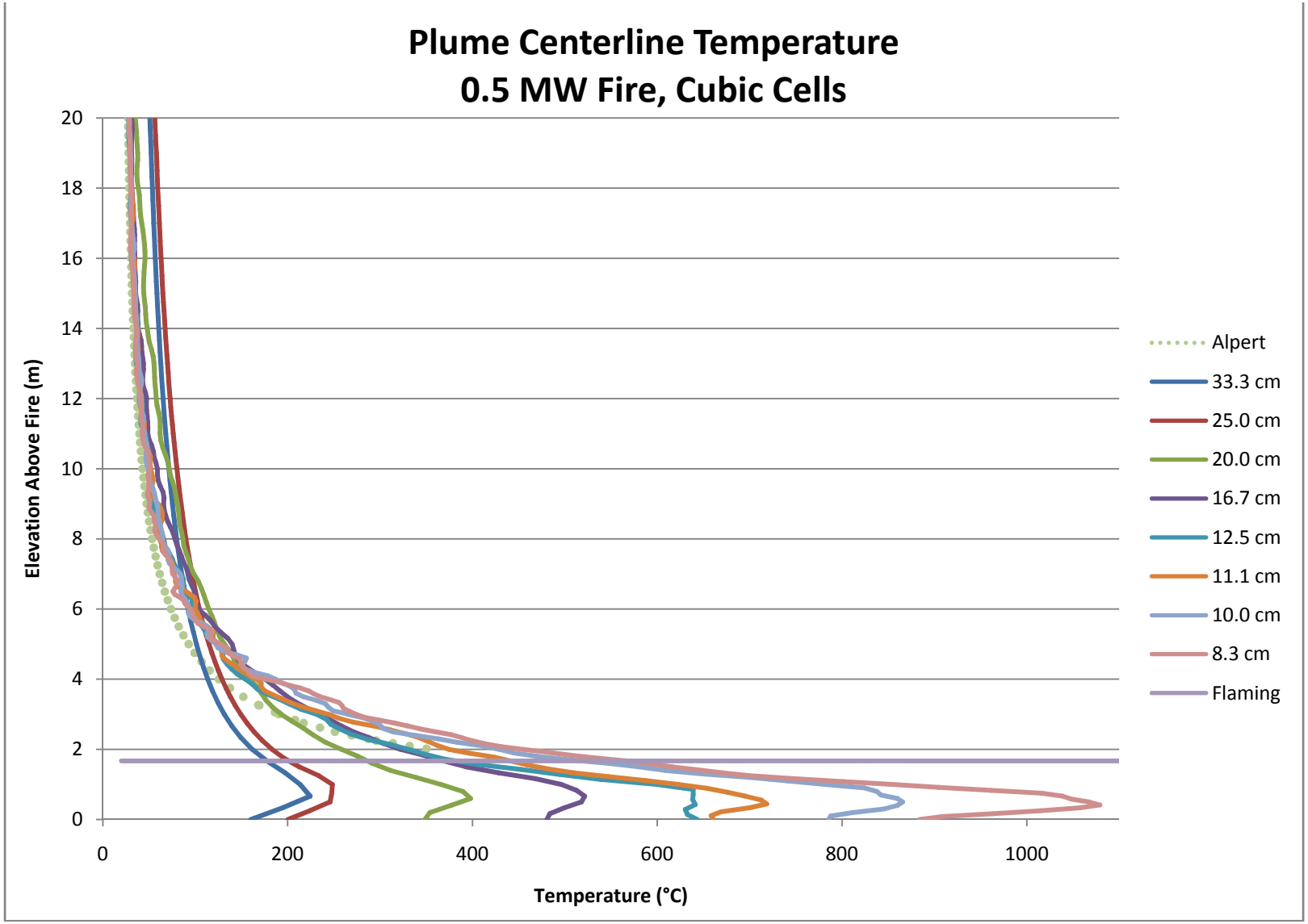
Plume Centerline Temperature
0.5 MW Fire, Cubic Cells
Elevation Above Fire (m)
0
2
4
6
8
10
12
14
16
18
20
0
200
400
600
800
1000
Temperature (°C)
Alpert
33.3 cm
25.0 cm
20.0 cm
16.7 cm
12.5 cm
11.1 cm
10.0 cm
8.3 cm
Flaming

Figure 1

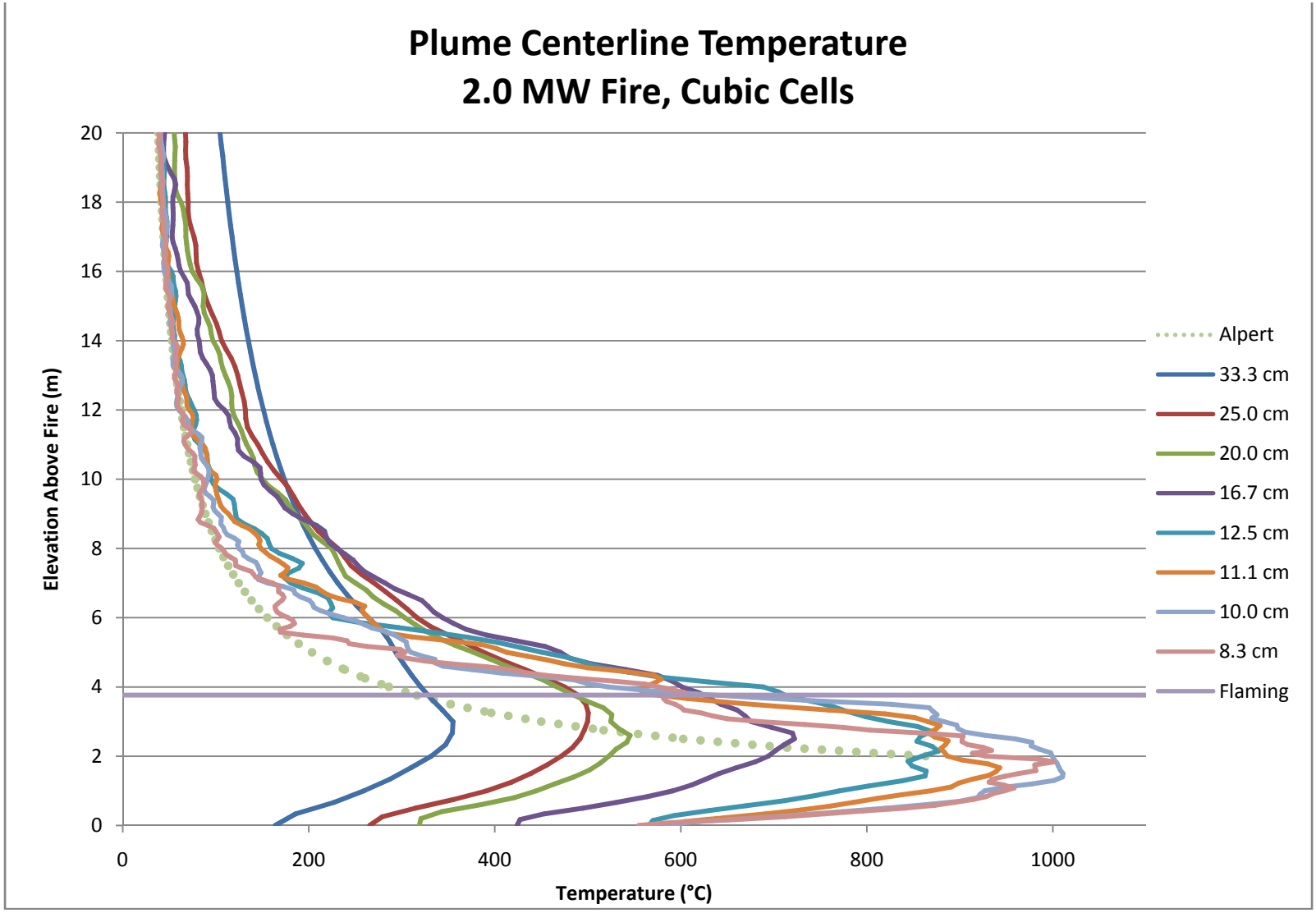
Plume Centerline Temperature
2.0 MW Fire, Cubic Cells
Elevation Above Fire (m)
0
2
4
6
8
10
12
14
16
18
20
0
200
400
600
800
1000
Temperature (°C)
Alpert
33.3 cm
25.0 cm
20.0 cm
16.7 cm
12.5 cm
11.1 cm
10.0 cm
8.3 cm
Flaming

Figure 2

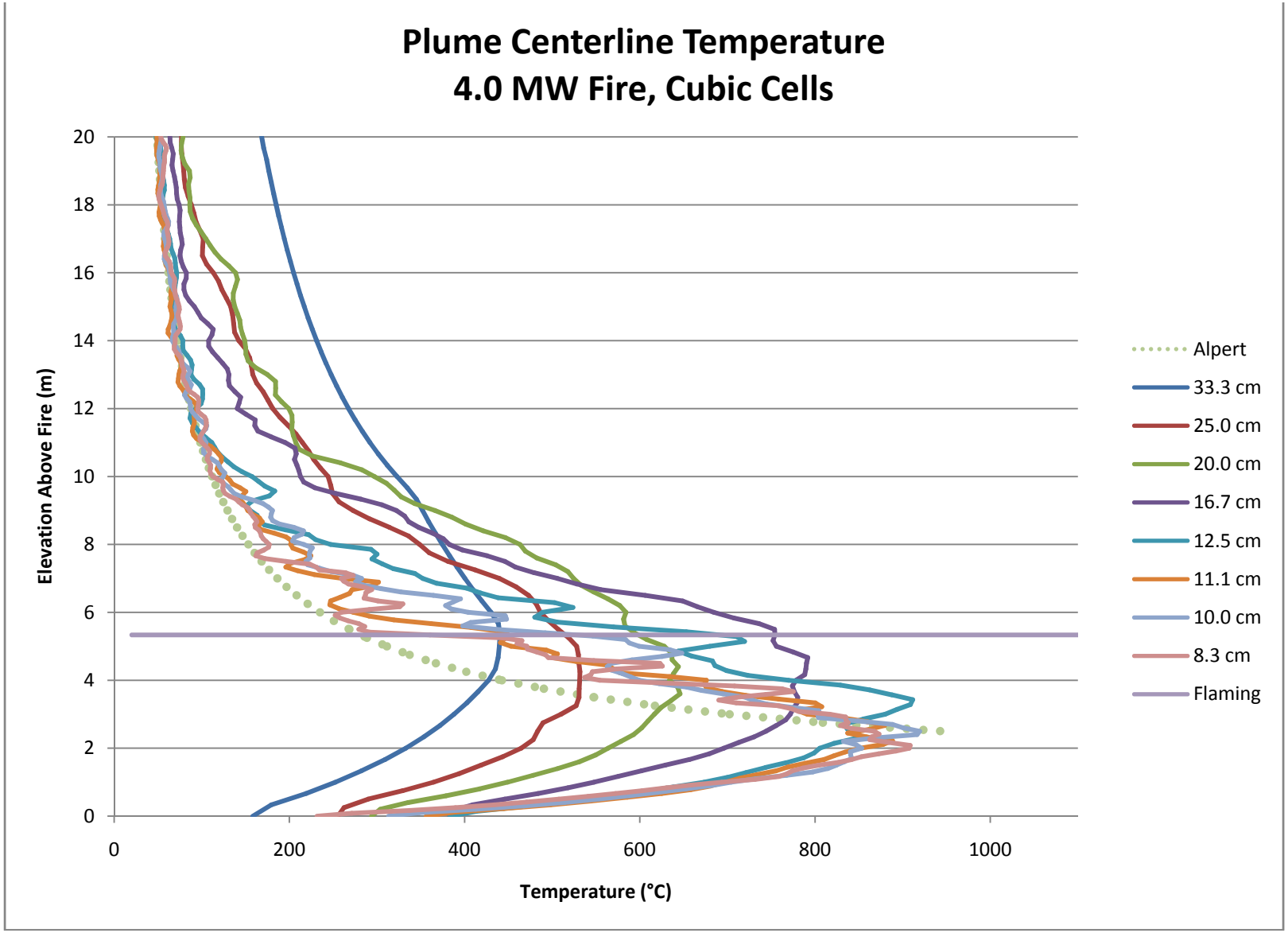
Plume Centerline Temperature
4.0 MW Fire, Cubic Cells
Elevation Above Fire (m)
0
2
4
6
8
10
12
14
16
18
20
0
200
400
600
800
1000
Temperature (°C)
Alpert
33.3 cm
25.0 cm
20.0 cm
16.7 cm
12.5 cm
11.1 cm
10.0 cm
8.3 cm
Flaming

Figure 3

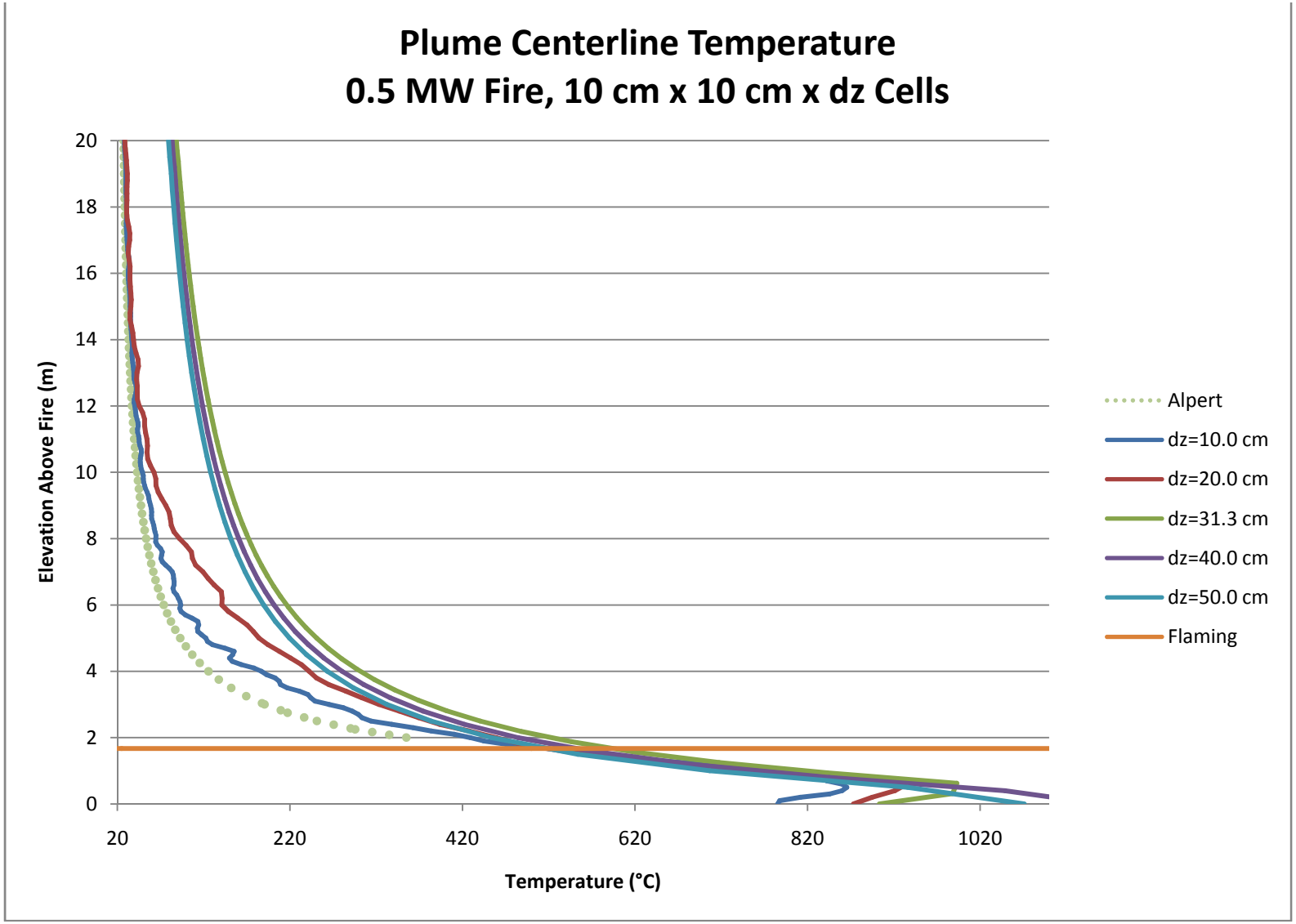
Plume Centerline Temperature
0.5 MW Fire, 10 cm x 10 cm x dz Cells
Elevation Above Fire (m)
0
2
4
6
8
10
12
14
16
18
20
Temperature (°C)
20
220
420
620
820
1020
Alpert
dz=10.0 cm
dz=20.0 cm
dz=31.3 cm
dz=40.0 cm
dz=50.0 cm
Flaming

Figure 4

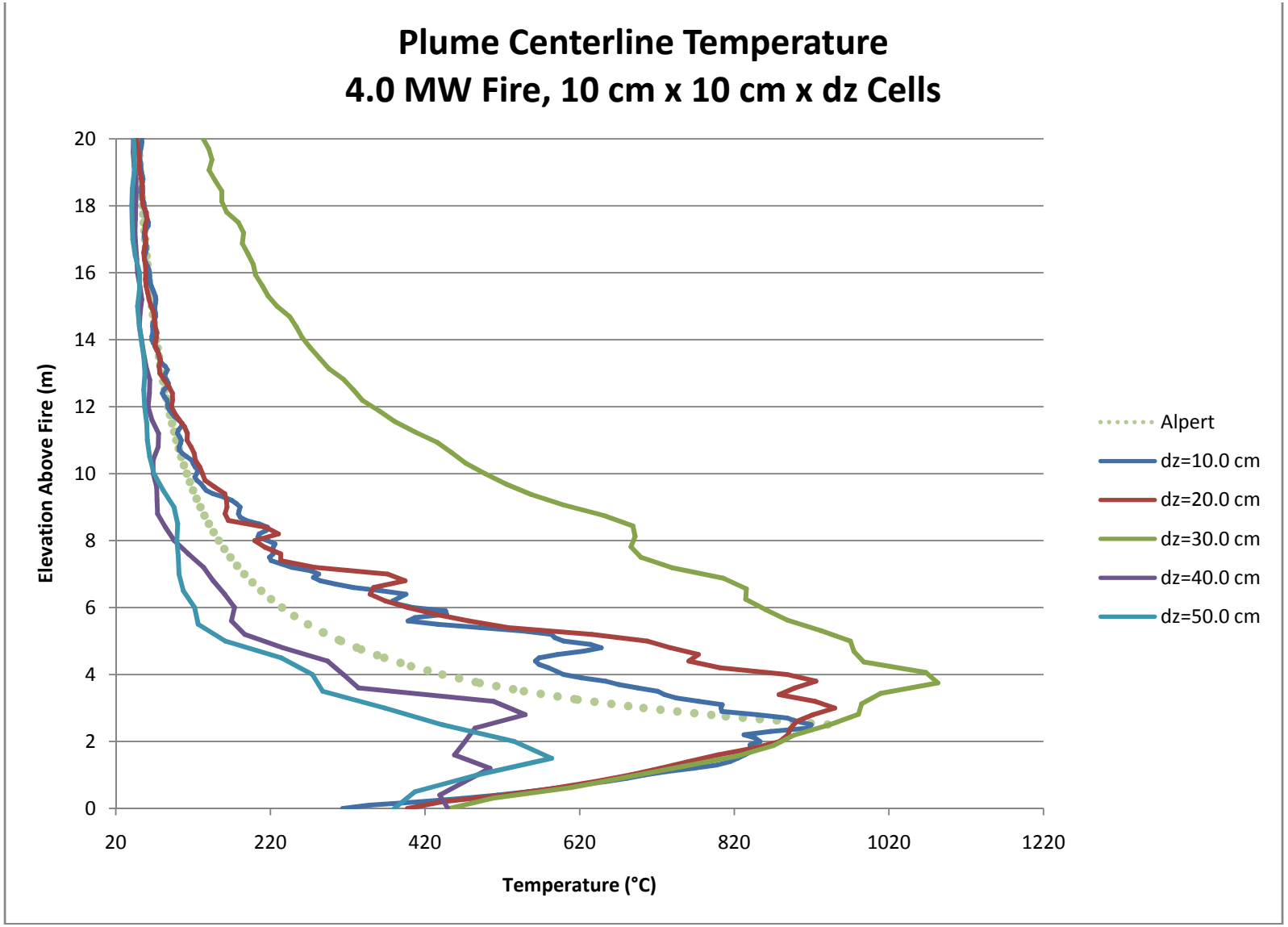
Plume Centerline Temperature
4.0 MW Fire, 10 cm x 10 cm x dz Cells
Elevation Above Fire (m)
0
2
4
6
8
10
12
14
16
18
20
20
220
420
620
820
1020
1220
Temperature (°C)
Alpert
dz=10.0 cm
dz=20.0 cm
dz=30.0 cm
dz=40.0 cm
dz=50.0 cm

Figure 5

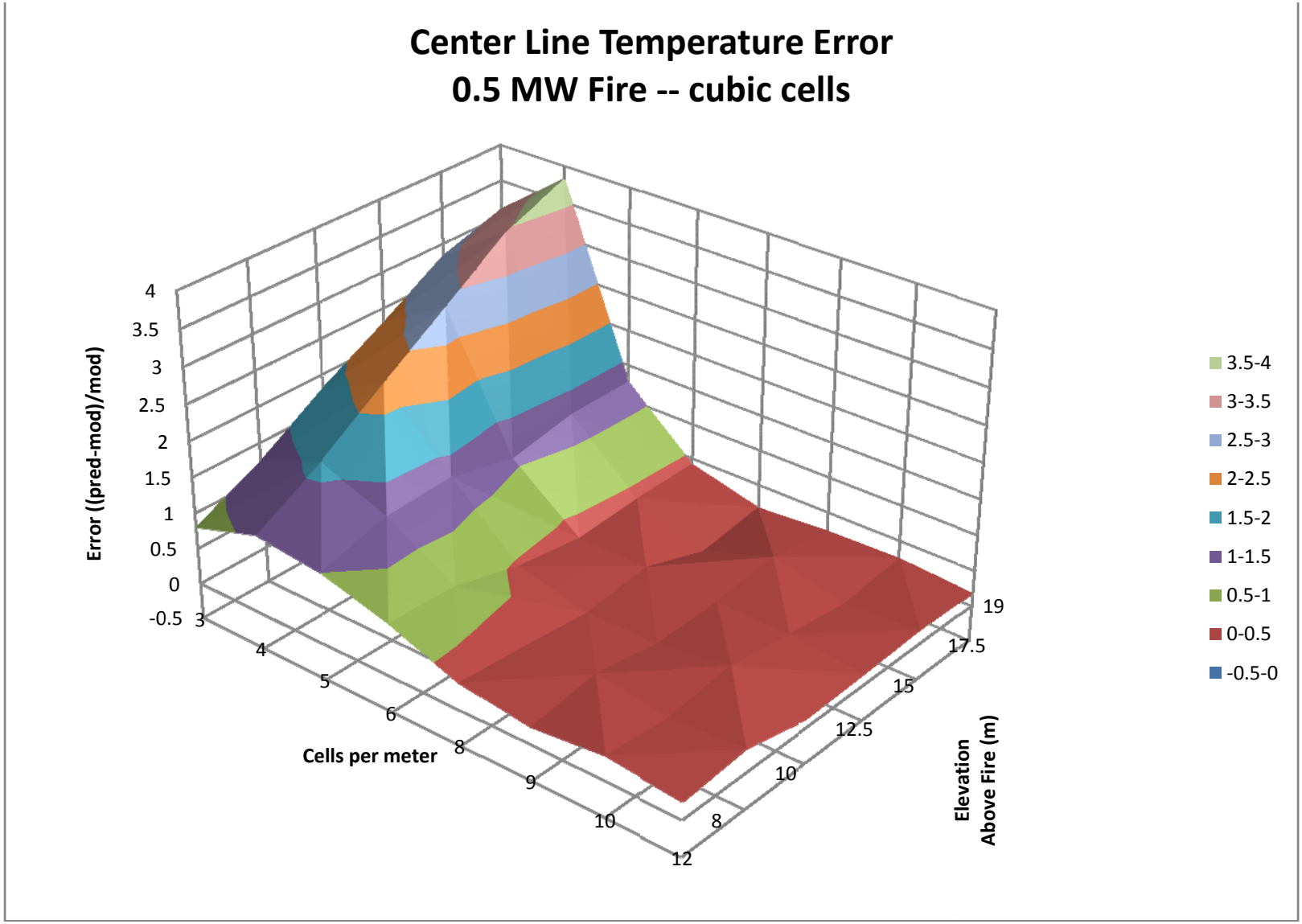
Center Line Temperature Error
0.5 MW Fire -- cubic cells
Error ((pred-mod)/mod)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Cells per meter
3
4
5
6
8
9
10
12
Elevation Above Fire (m)
19
17.5
15
12.5
10
8
3.5-4
3-3.5
2.5-3
2-2.5
1.5-2
1-1.5
0.5-1
0-0.5
-0.5-0

Figure 6

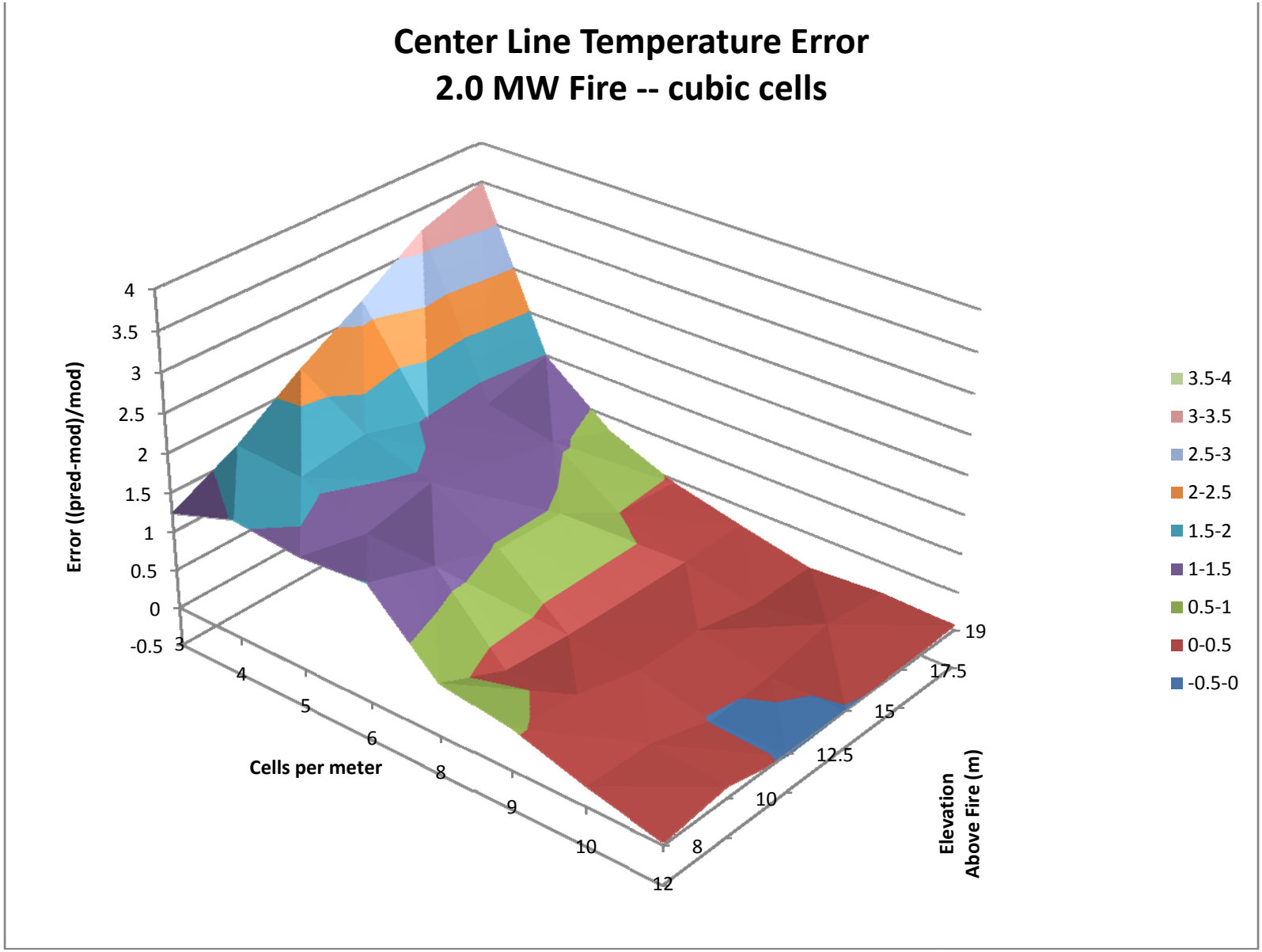
Center Line Temperature Error
2.0 MW Fire -- cubic cells
Error ((pred-mod)/mod)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Cells per meter
3
4
5
6
8
9
10
12
Elevation Above Fire (m)
8
10
12.5
15
17.5
19
3.5-4
3-3.5
2.5-3
2-2.5
1.5-2
1-1.5
0.5-1
0-0.5
-0.5-0

Figure 7

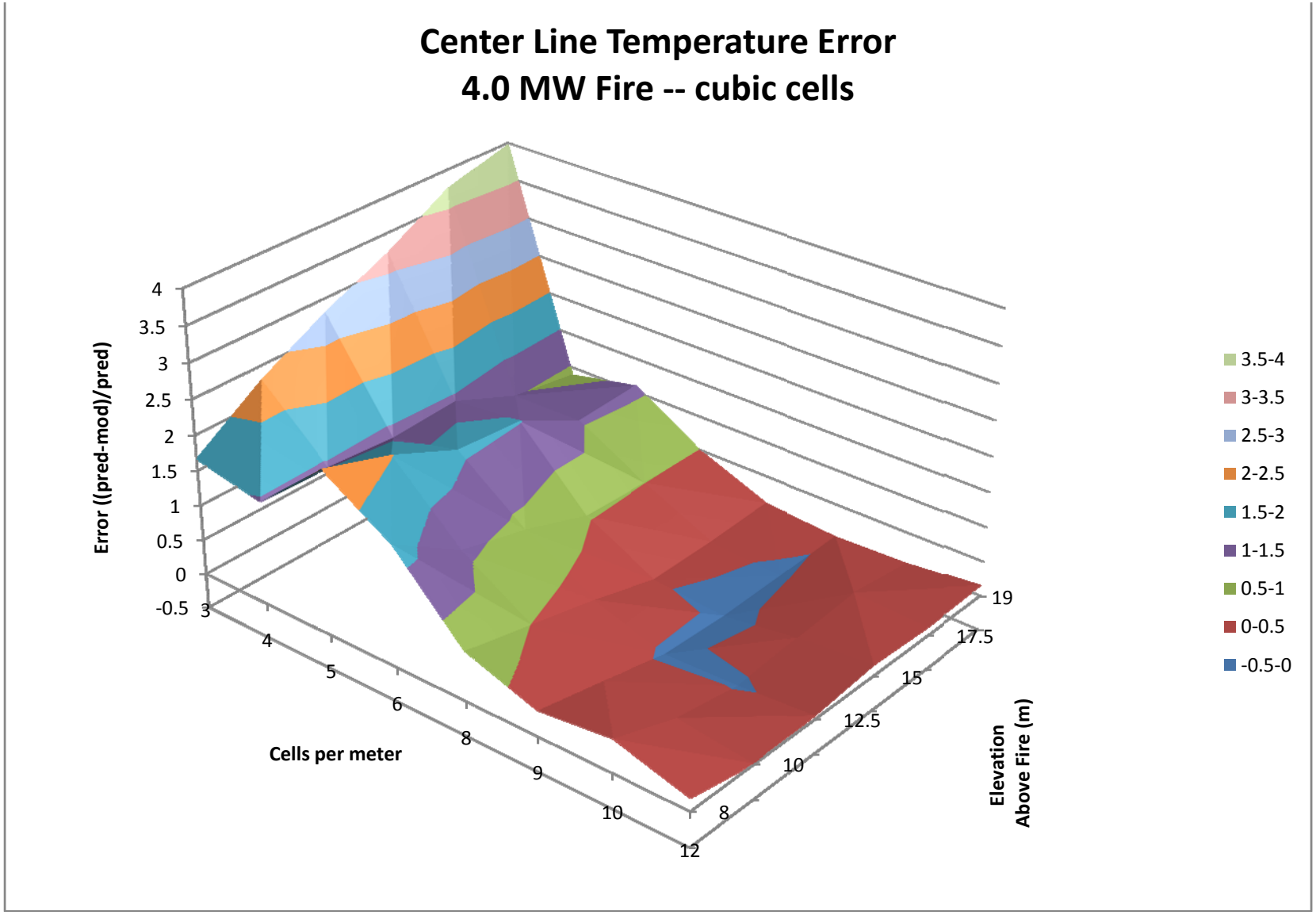
Center Line Temperature Error
4.0 MW Fire -- cubic cells
Error ((pred-mod)/pred)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Cells per meter
3
4
5
6
8
9
10
12
Elevation Above Fire (m)
19
17.5
15
12.5
10
8
3.5-4
3-3.5
2.5-3
2-2.5
1.5-2
1-1.5
0.5-1
0-0.5
-0.5-0

Figure 8

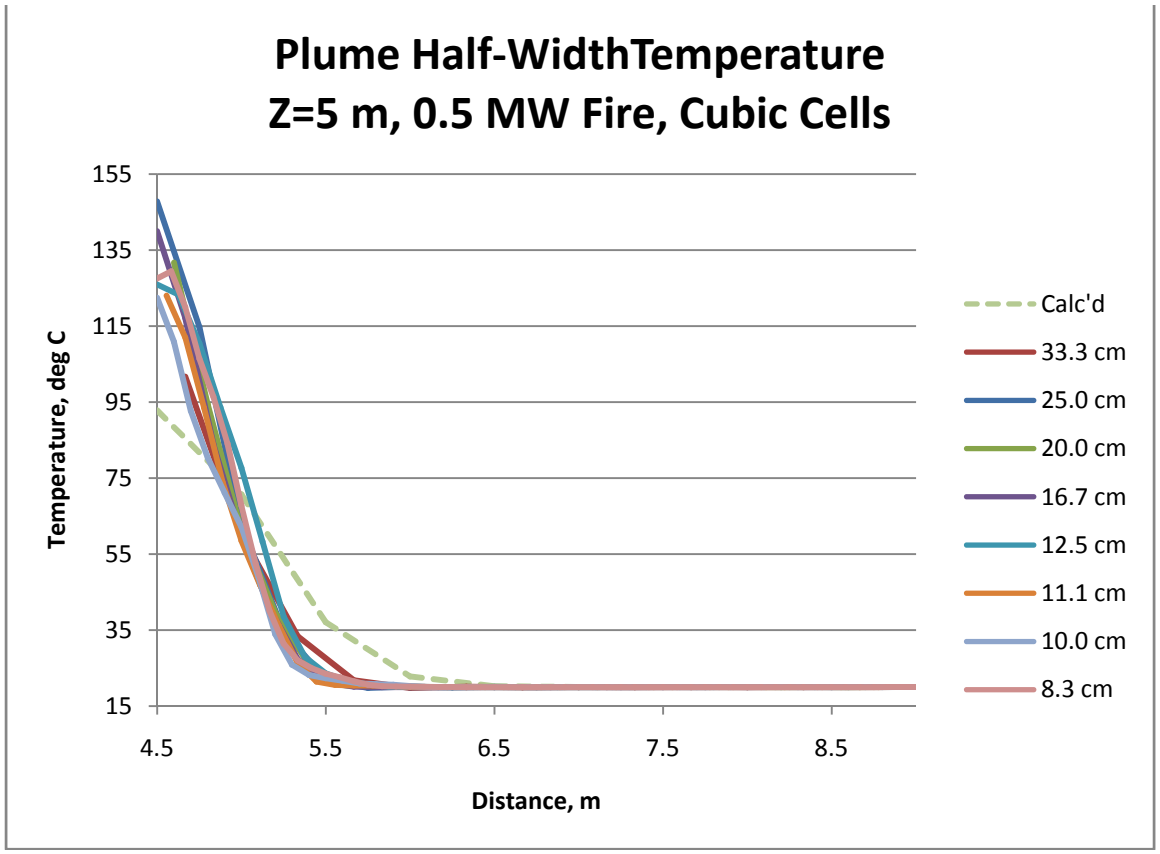

Figure 9

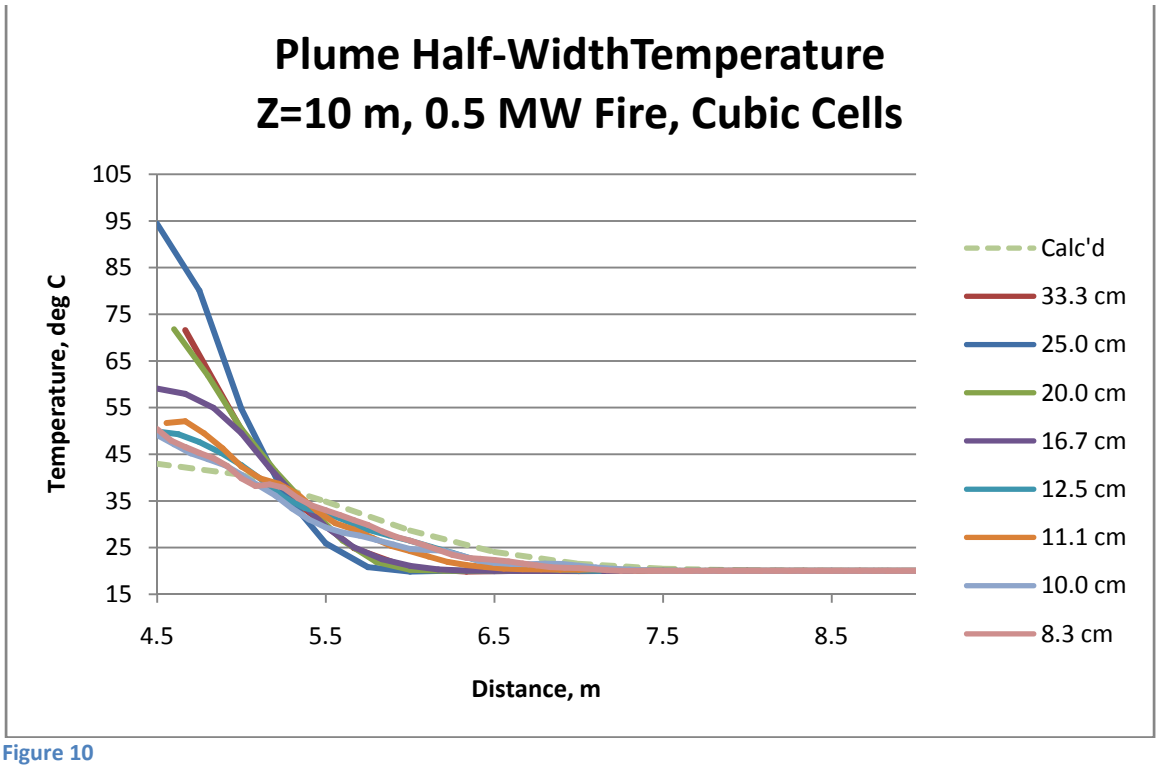

Figure 10

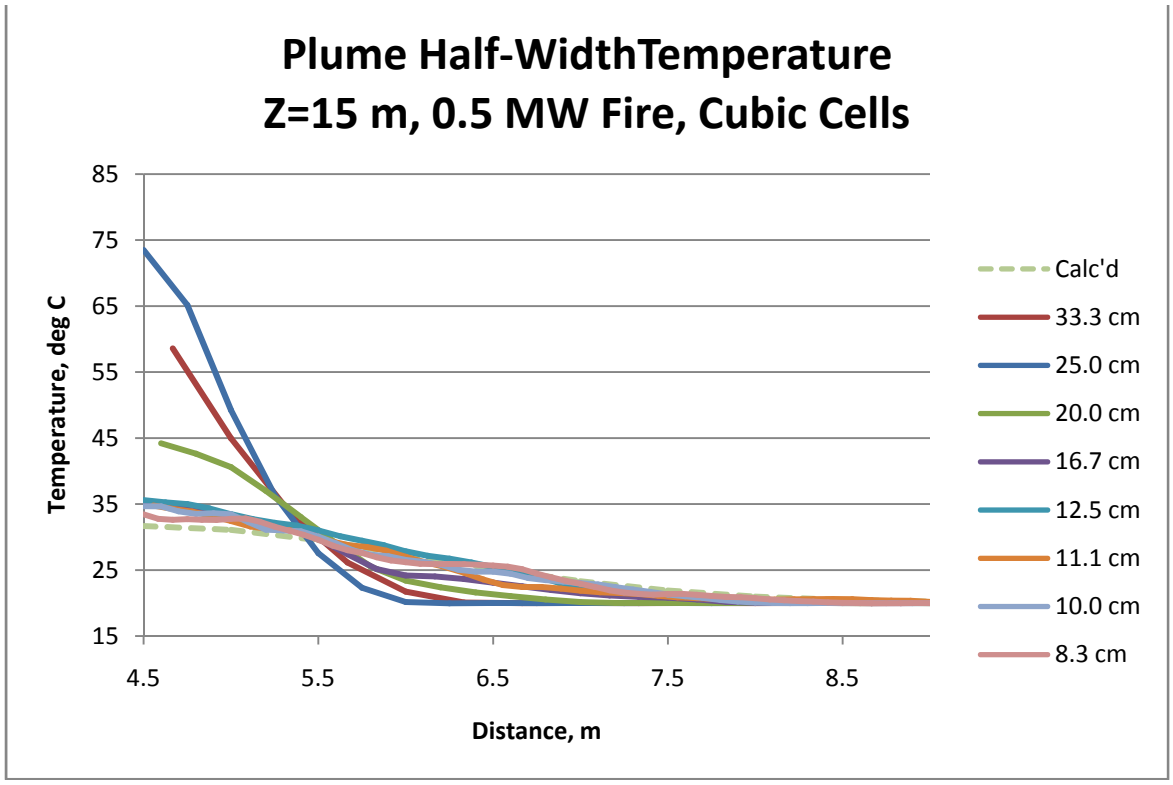

Figure 11

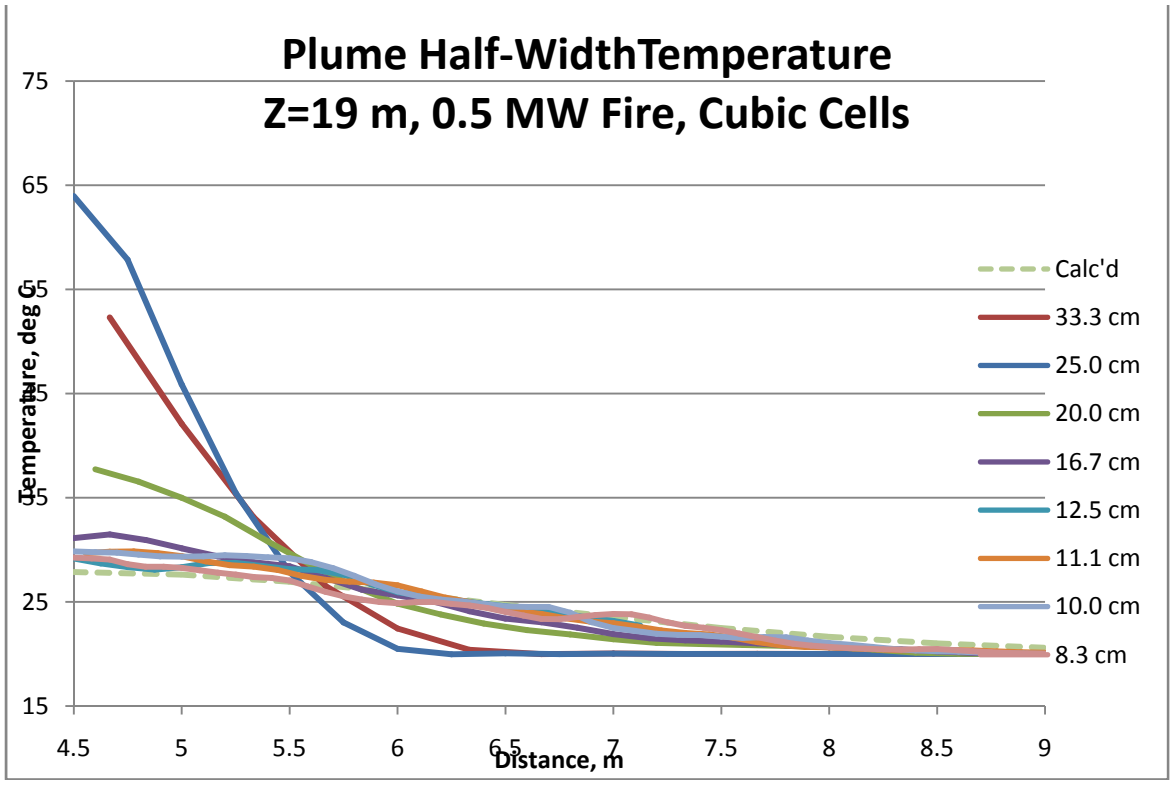

Figure 12

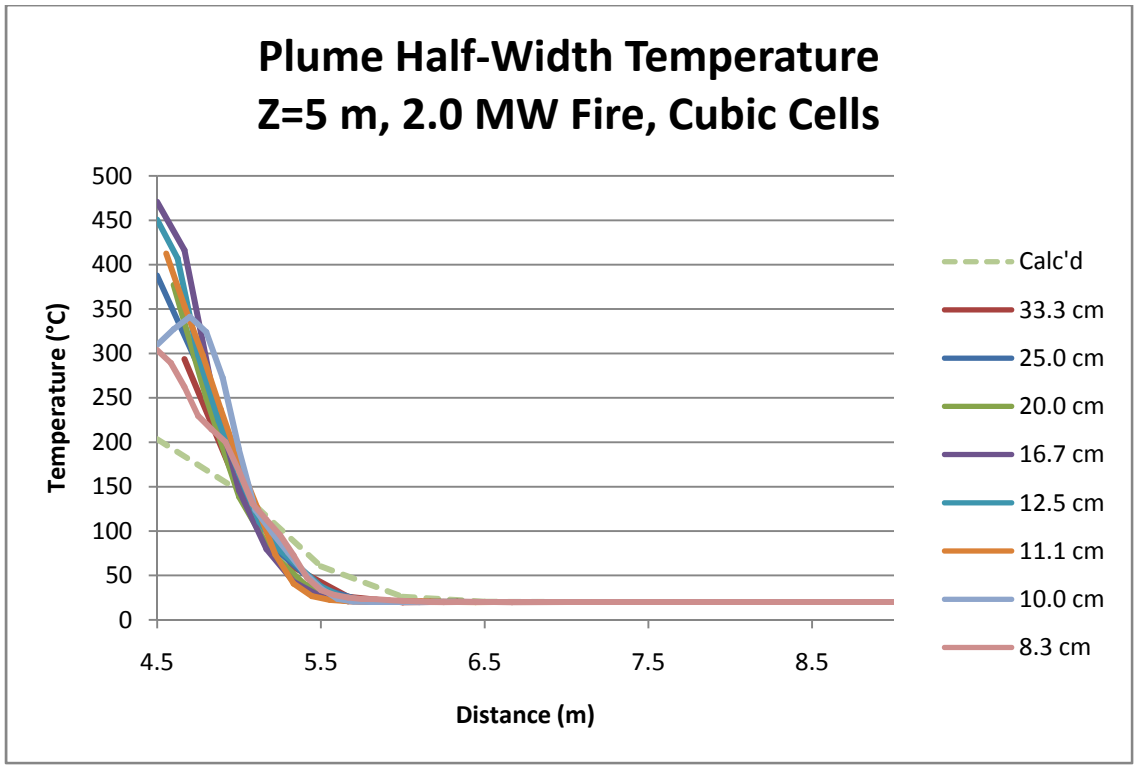

Figure 13

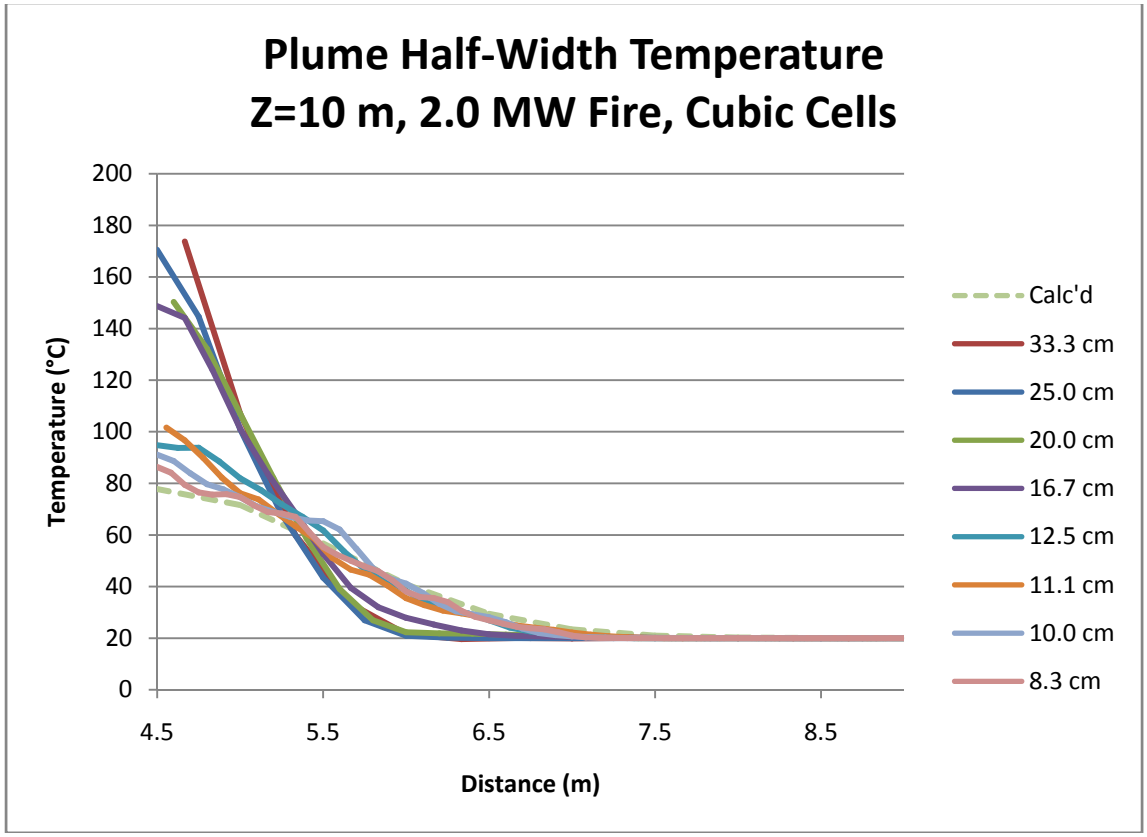

Figure 14

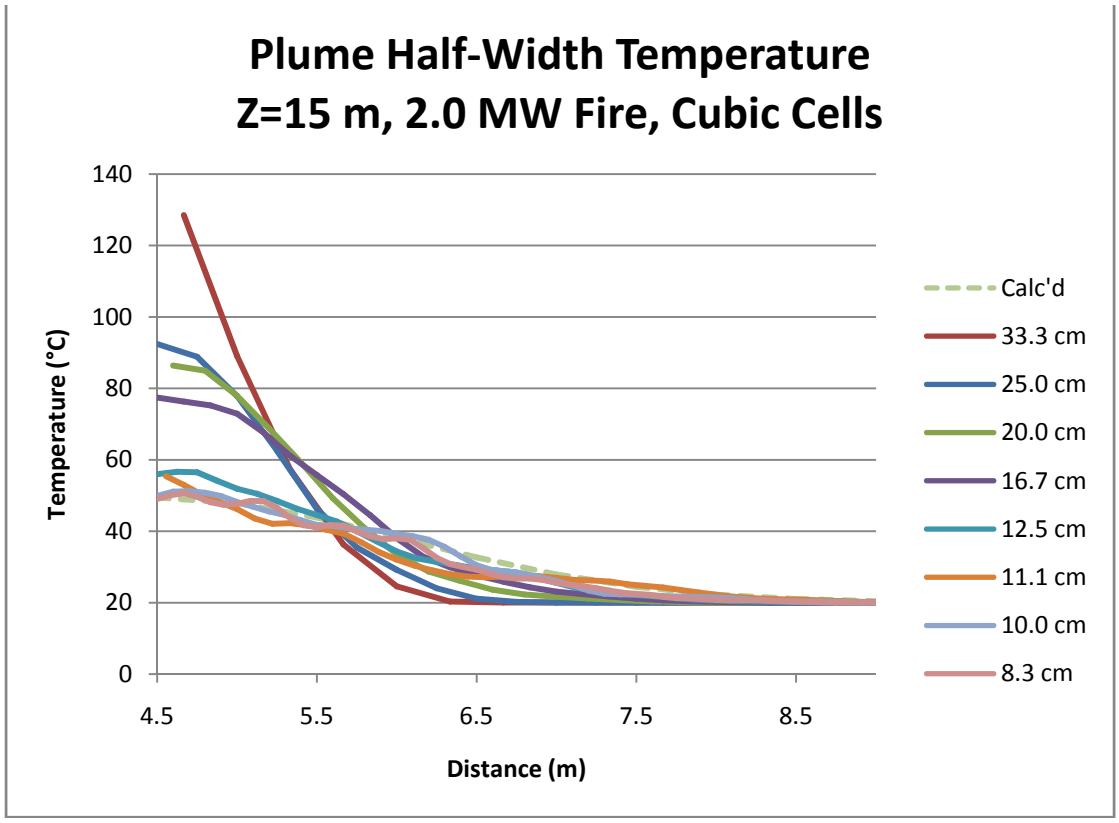

Figure 15

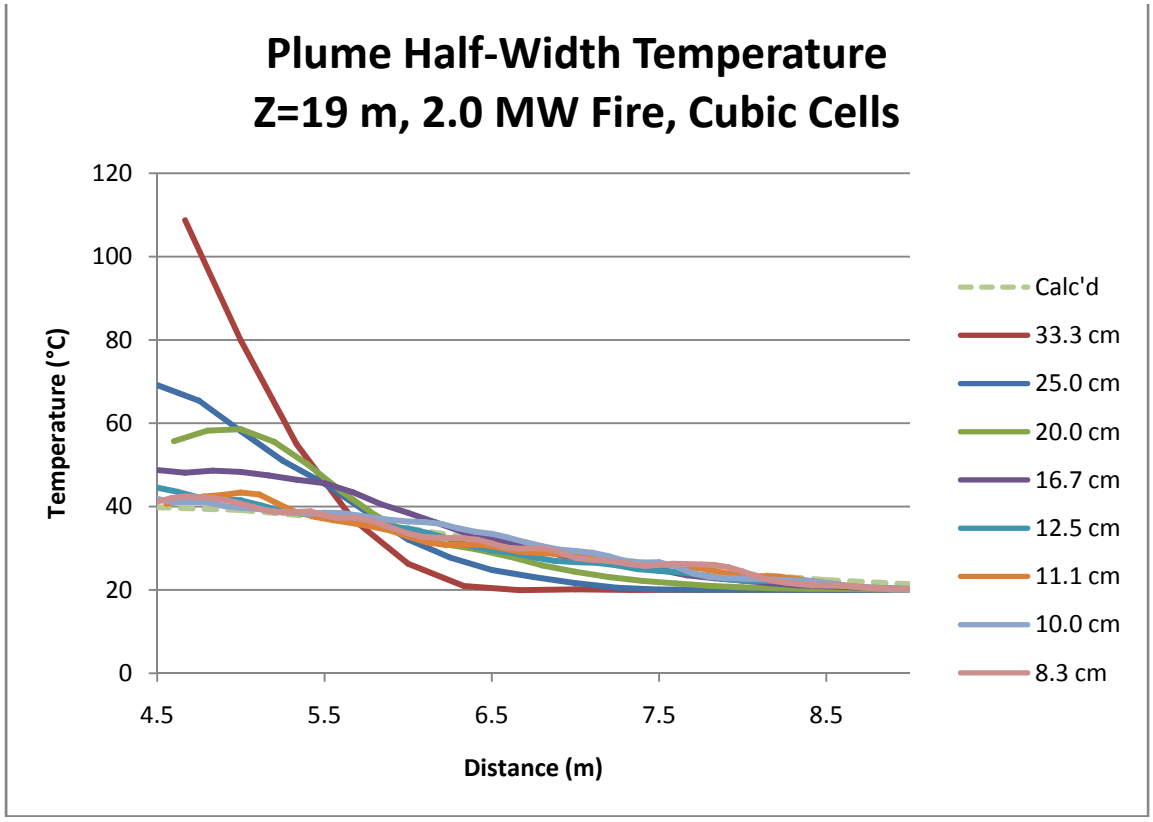

Figure 16

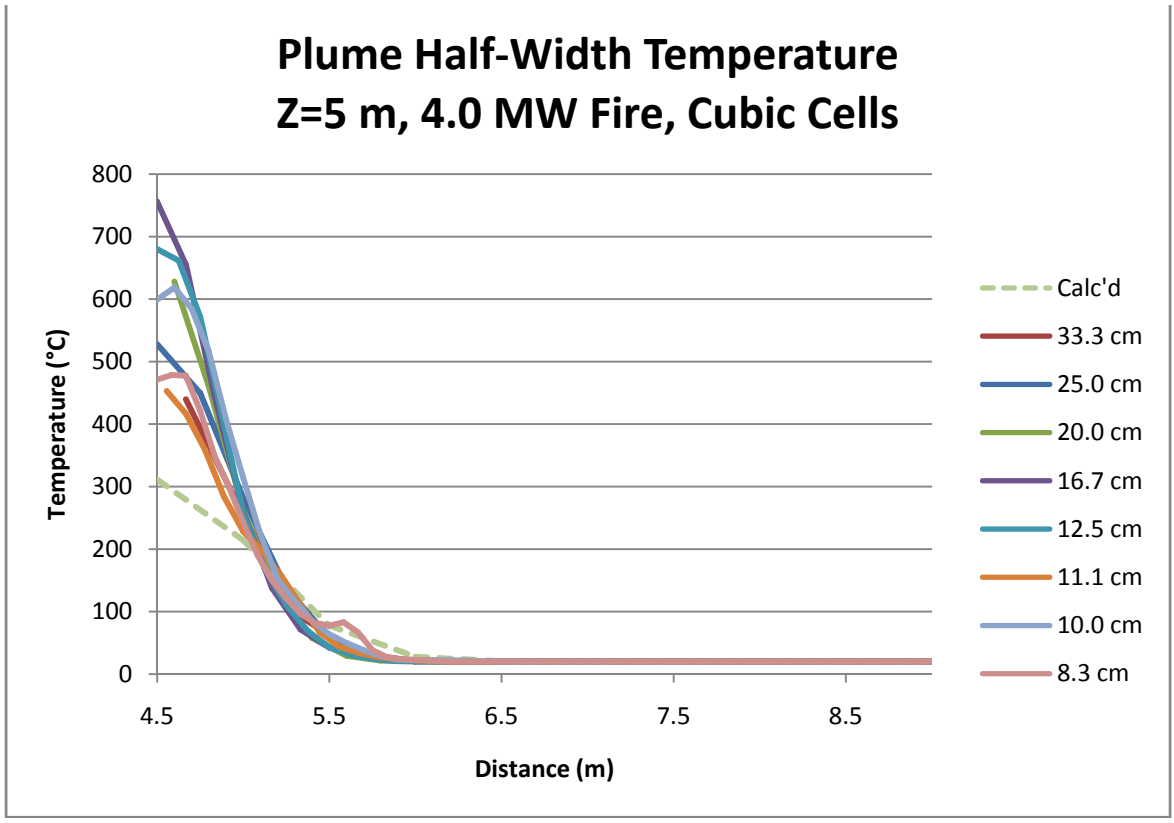

Figure 17

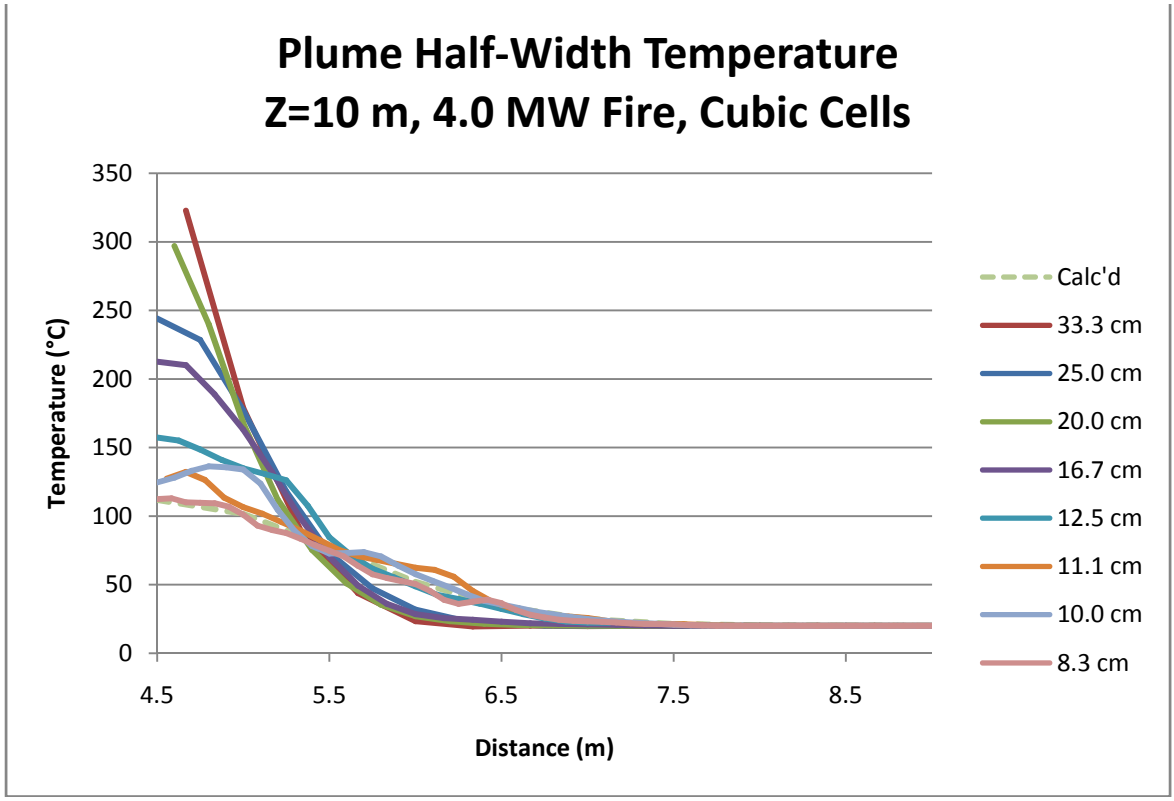

Figure 18

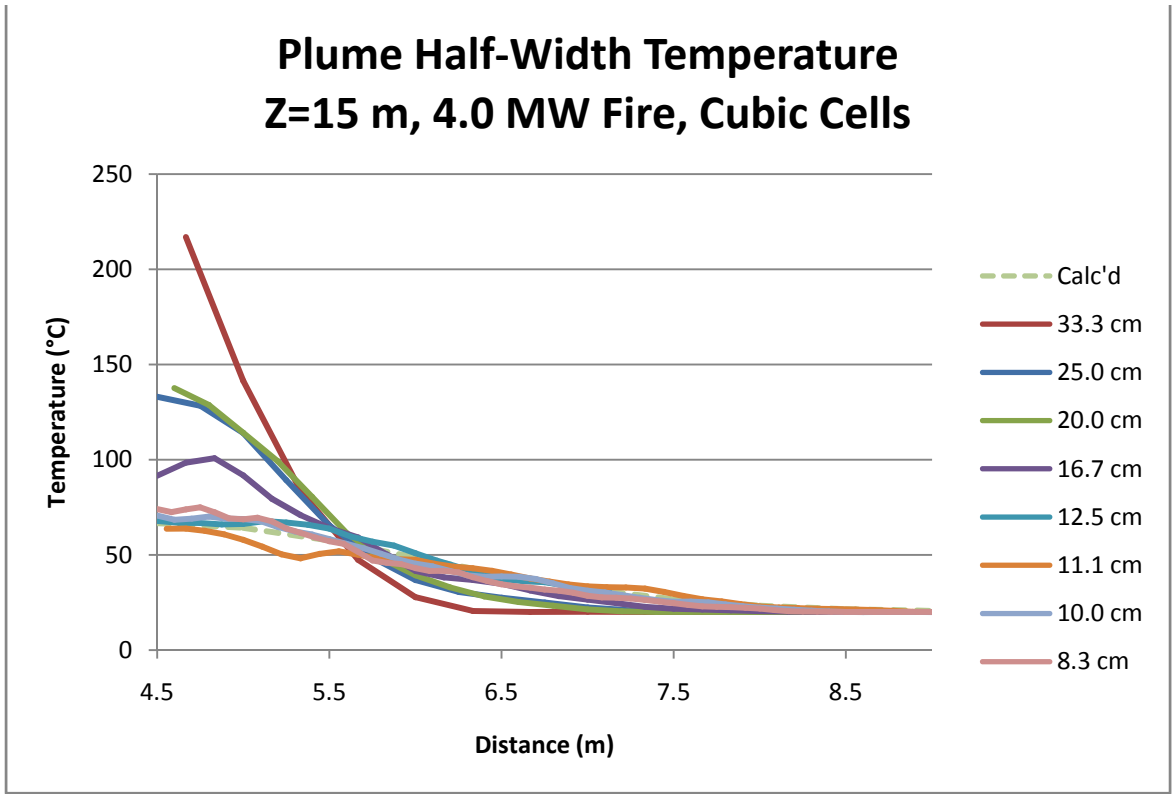

Figure 19

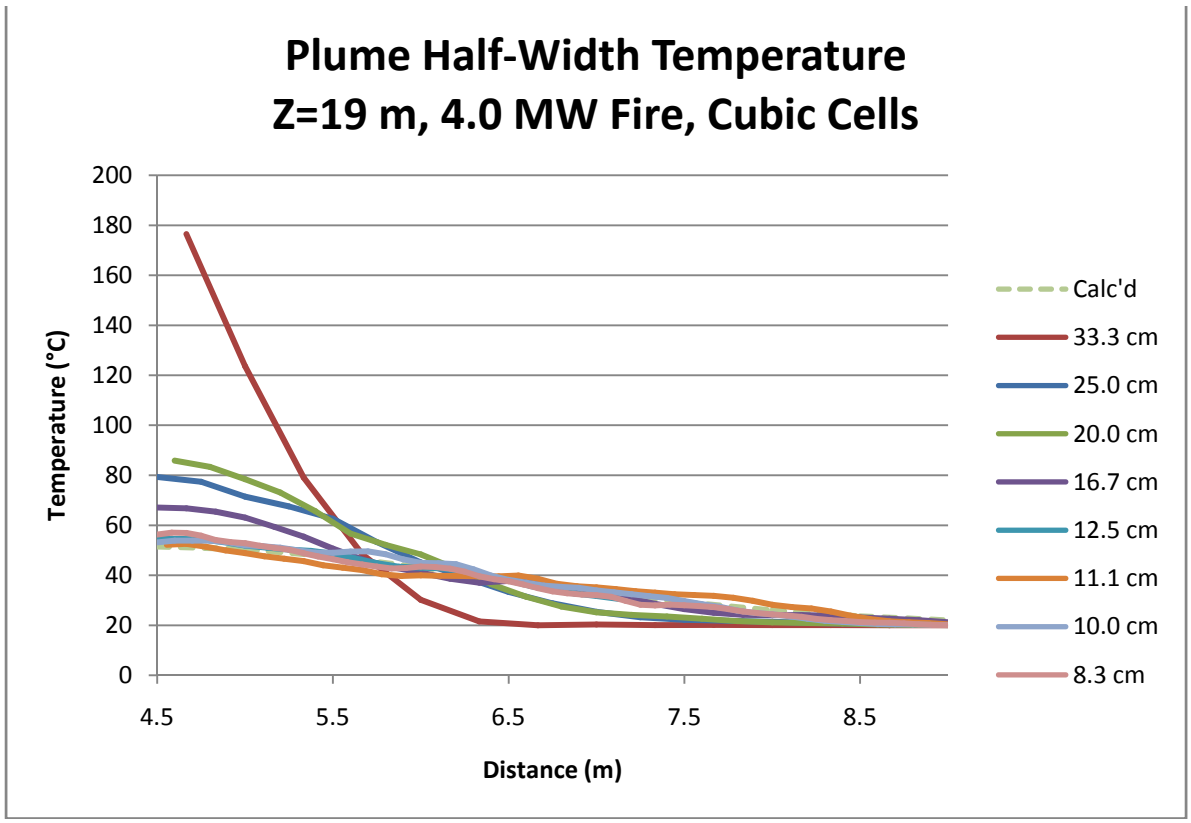

Figure 20