

Plume Analysis

```
In [1]: import pandas as pd
import numpy as np
import math
import datetime as dt
from matplotlib import pyplot as plt
import matplotlib.dates as mdates

import os
import shutil
import glob
import xarray as xr

from scipy.interpolate import griddata
from scipy.signal import argrelextrema, find_peaks

from bens_functions import *

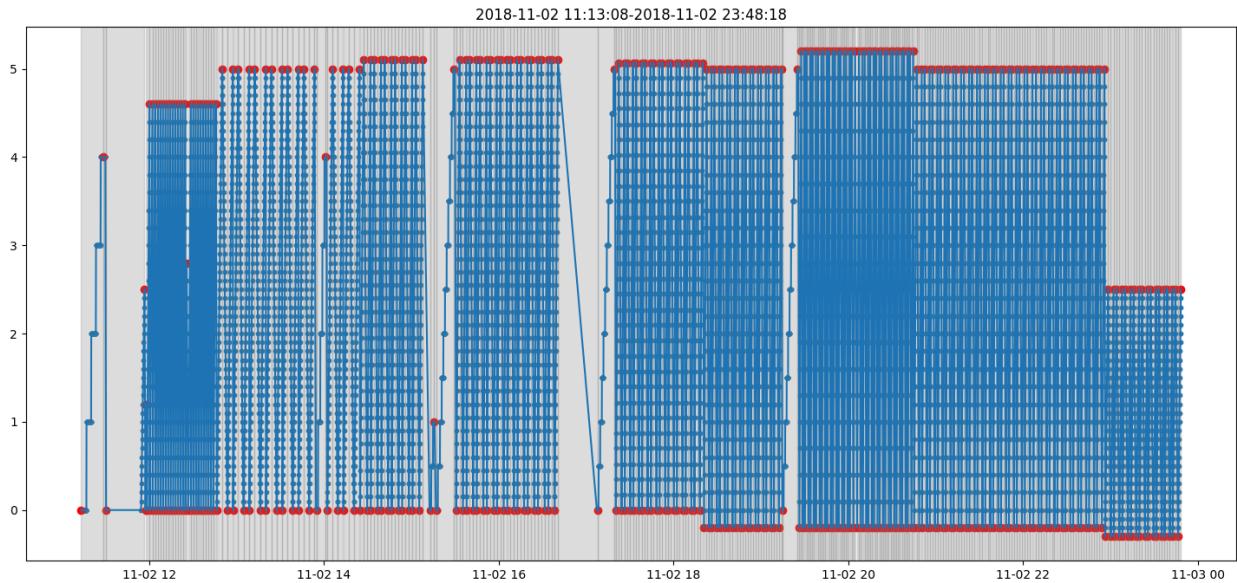
import warnings
warnings.filterwarnings('ignore')
```

```
In [2]: lidar_data_dir = './data/raw_lidar/extracted_data'
iops = ([name for name in os.listdir(lidar_data_dir) if name.endswith('2018')])
iops.sort()
print(iops)
```

```
['10272018', '11022018', '11072018', '11102018', '11112018', '11132018']
```

```
In [3]: ## TEST SEVERAL DAYS OUT TO FIND THE RIGHT DATA.
#iop_1027 = read_metadata(os.path.join(lidar_data_dir, iops[0]))
iop_1102 = read_metadata(os.path.join(lidar_data_dir, iops[1])) # issues with times -- find_sc
#iop_1107 = read_metadata(os.path.join(lidar_data_dir, iops[2])) # no scanning
#iop_1110 = read_metadata(os.path.join(lidar_data_dir, iops[3]))
#iop_1111 = read_metadata(os.path.join(lidar_data_dir, iops[4]))
#iop_1113 = read_metadata(os.path.join(lidar_data_dir, iops[5])) # Very little data
```

```
In [4]: selected_iop = iop_1102                                # change to any of these...[iop_1027, iop_11
selected_iop_name = '11022018'                                # change to any of these...['10272018', '110
scans_to_investigate = find_scans(selected_iop)
```



```
In [5]: # ## RUN THIS IF YOU NEED TO FIND A SPECIFIC SEGMENT THAT IS BEHAVING ODD.
# find_scans(iop_1102, '2018-11-02 13:50', '2018-11-02 14:30')
```

```
In [6]: scans_to_investigate[1][100:110]
```

```
Out[6]: [[Timestamp('2018-11-02 16:15:07'), Timestamp('2018-11-02 16:17:23')],
[Timestamp('2018-11-02 16:17:23'), Timestamp('2018-11-02 16:19:40')],
[Timestamp('2018-11-02 16:19:53'), Timestamp('2018-11-02 16:22:08')],
[Timestamp('2018-11-02 16:22:08'), Timestamp('2018-11-02 16:24:23')],
[Timestamp('2018-11-02 16:24:23'), Timestamp('2018-11-02 16:26:44')],
[Timestamp('2018-11-02 16:26:56'), Timestamp('2018-11-02 16:29:11')],
[Timestamp('2018-11-02 16:29:11'), Timestamp('2018-11-02 16:31:30')],
[Timestamp('2018-11-02 16:31:30'), Timestamp('2018-11-02 16:33:50')],
[Timestamp('2018-11-02 16:34:02'), Timestamp('2018-11-02 16:36:15')],
[Timestamp('2018-11-02 16:36:15'), Timestamp('2018-11-02 16:38:24')]]
```

```
In [7]: process_iop?
```

Signature: process_iop(directory, max_distance=400, filter_t=2)

Docstring:

Processes the entire directory using the file_to_data function.

Parameters

directory (str): Path to the LiDAR text file.

Returns

pandas.DataFrame: A DataFrame containing the processed LiDAR data with background noise correction and spatial coordinates (x, z, distance) for the entire directory.

Examples

File: ~plume_analysis/bens_functions.py

Type: function

```
In [8]: research_df = process_iop(os.path.join('./data/raw_lidar/extracted_data', selected_iop_name),
```

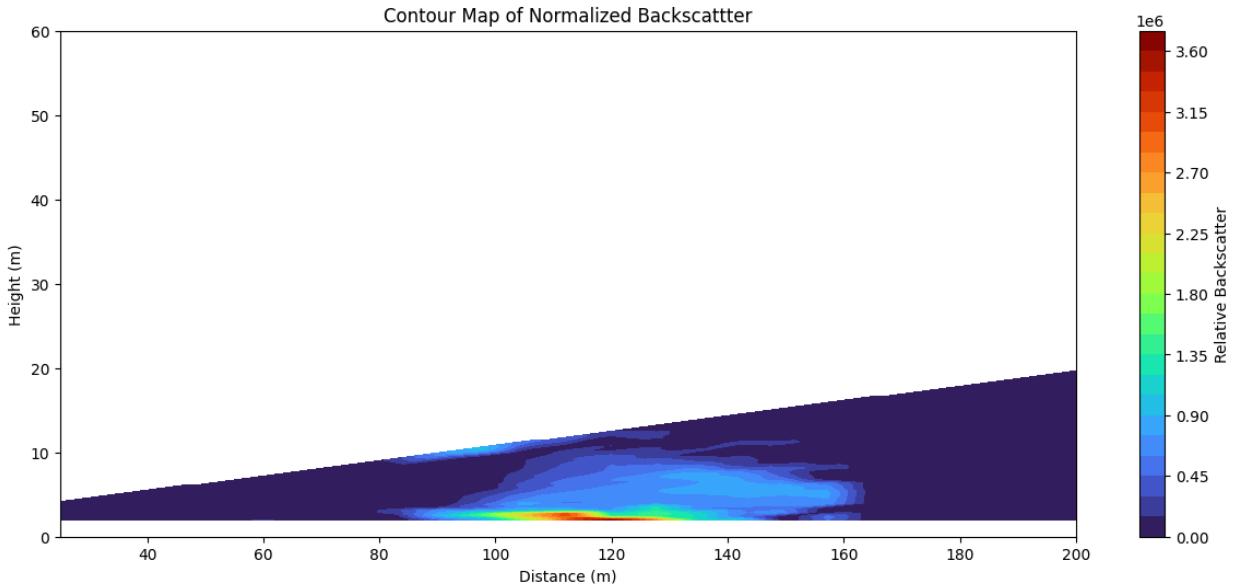
```
In [9]: research_df
```

Out[9]:

	analog	photon	start	end	zenith	distance	x	z	analog_bgc	photo
0	3.8574	116.0	2018-11-02 19:59:25	2018-11-02 19:59:25	0.70	7.5	7.499440	2.091628	0.0	
1	3.9795	156.0	2018-11-02 19:59:25	2018-11-02 19:59:25	0.70	15.0	14.998881	2.183255	0.0	
2	3.9307	152.0	2018-11-02 19:59:25	2018-11-02 19:59:25	0.70	22.5	22.498321	2.274883	0.0	
3	3.9307	168.0	2018-11-02 19:59:25	2018-11-02 19:59:25	0.70	30.0	29.997761	2.366510	0.0	
4	3.8818	148.0	2018-11-02 19:59:25	2018-11-02 19:59:25	0.70	37.5	37.497201	2.458138	0.0	
...
270130	46.0547	128.0	2018-11-02 14:54:35	2018-11-02 14:54:35	1.95	172.5	172.400106	7.869718	0.0	
270131	45.0977	144.0	2018-11-02 14:54:35	2018-11-02 14:54:35	1.95	180.0	179.895762	8.124923	0.0	
270132	40.5176	128.0	2018-11-02 14:54:35	2018-11-02 14:54:35	1.95	187.5	187.391419	8.380128	0.0	
270133	39.2969	136.0	2018-11-02 14:54:35	2018-11-02 14:54:35	1.95	195.0	194.887076	8.635333	0.0	
270134	36.1035	152.0	2018-11-02 14:54:35	2018-11-02 14:54:35	1.95	202.5	202.382733	8.890538	0.0	

270135 rows × 13 columns

In [10]: `scans_to_investigate[1][94:96]#[94:246]`Out[10]: `[[Timestamp('2018-11-02 16:01:08'), Timestamp('2018-11-02 16:03:23')], [Timestamp('2018-11-02 16:03:23'), Timestamp('2018-11-02 16:05:43')]]`In [11]: `start = pd.to_datetime('2018-11-02 18:02')
stop = pd.to_datetime('2018-11-02 18:04')
temp = research_df[(research_df['start']>start) & (research_df['start']<stop)]
plot_contour_scan(temp, x_limits=(25, 200), y_limits=(0, 60), method='linear')`



```
In [12]: def threshold(scan_df, t=0.10):
    # Identify max backscatter value
    max_rcs_index = scan_df['analog_rcs'].idxmax()
    max_backscatter_data = scan_df.loc[max_rcs_index]
    max_rcs = max_backscatter_data['analog_rcs']

    # Define threshold (0.10 - 0.20)
    threshold_percentage = t
    threshold_value = max_rcs * threshold_percentage
    # Create the new masked column
    scan_df['analog_masked'] = np.where(
        scan_df['analog_rcs'] > threshold_value,
        scan_df['analog_rcs'], 0
    )
```

```
In [13]: threshold(temp)
temp
```

Out[13]:

	analog	photon	start	end	zenith	distance	x	z	analog_bgc	pho
2970	3.2959	106.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	7.5	7.495789	2.251280	0.0	
2971	3.2959	136.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	15.0	14.991579	2.502561	0.0	
2972	3.2959	146.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	22.5	22.487368	2.753841	0.0	
2973	3.3162	133.3333	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	30.0	29.983157	3.005122	0.0	
2974	3.3162	133.3333	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	37.5	37.478947	3.256402	0.0	
...
262138	47.0215	132.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	172.5	172.178253	12.530873	0.0	
262139	44.4580	132.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	180.0	179.664264	12.988737	0.0	
262140	42.1631	144.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	187.5	187.150275	13.446601	0.0	
262141	37.6953	124.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	195.0	194.636286	13.904465	0.0	
262142	35.6689	116.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	202.5	202.122297	14.362329	0.0	

756 rows × 14 columns



In [14]:

```
# Example of a plume
x = temp['x']
z = temp['z']
value = temp['analog_masked']

# Create a grid
xi = np.linspace(x.min(), x.max(), 100)
zi = np.linspace(z.min(), z.max(), 100)
Xi, Zi = np.meshgrid(xi, zi)

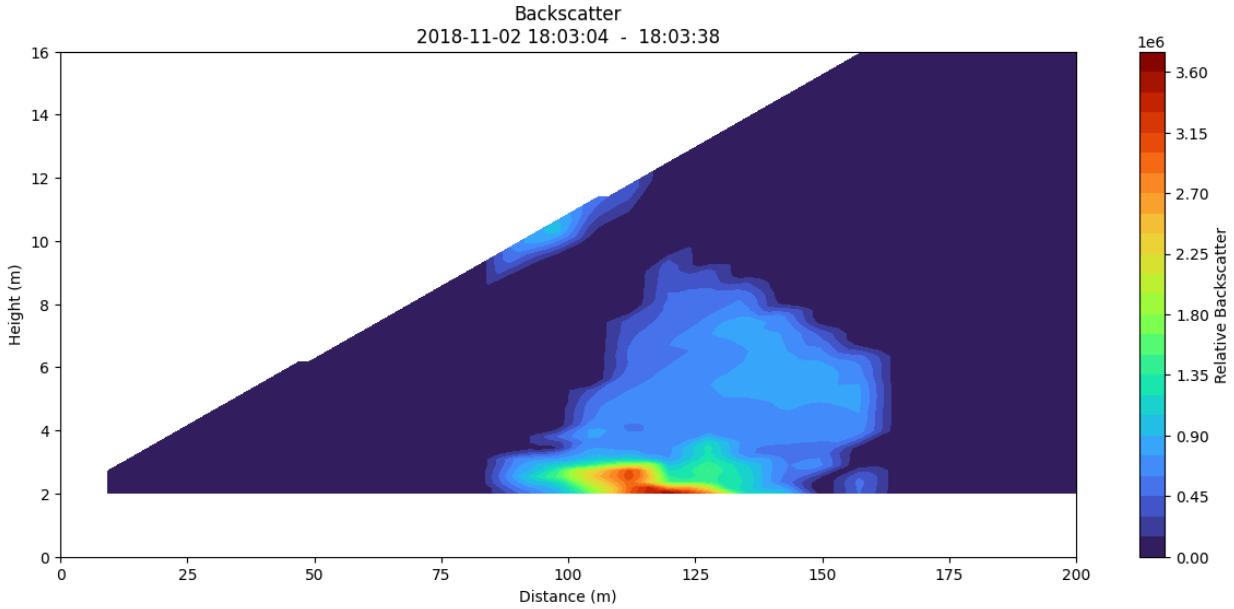
# Interpolate data
Ai = griddata((x, z), value, (Xi, Zi), method='linear') # methods: linear, nearest, cubic

# Plot contour map
plt.figure(figsize=(15, 6))
contour = plt.contourf(Xi, Zi, Ai, cmap="turbo", levels=30) # gist_ncar
```

```

plt.colorbar(label="Relative Backscatter")
plt.xlabel("Distance (m)")
plt.ylabel("Height (m)")
plt.title(f"Backscatter\n{n{temp.iloc[0]['start']} - {temp.iloc[-1]['start'].strftime('%H:%M:%S')}}")
plt.xlim(0,200)
plt.ylim(0,16)
plt.show()

```



In [15]:

```

# now creating a plot. I am having a lot of issues with plotting, so I will leave this part in
def plot_backscatter(temp, column='analog_masked', title='Backscatter', mark_max=False):
    x = temp["x"]
    z = temp["z"]
    value = temp[column]
    # Create a grid for interpolation for plotting and metrics
    xi = np.linspace(x.min(), x.max(), 100)
    zi = np.linspace(z.min(), z.max(), 100)
    Xi, Zi = np.meshgrid(xi, zi)

    # Calculate the step size and cell area
    delta_x = xi[1] - xi[0]
    delta_z = zi[1] - zi[0]
    cell_area = delta_x * delta_z

    # Interpolate data
    Ai = griddata((x, z), value, (Xi, Zi), method='linear') # methods: linear, nearest, cubic

    # Plot contour map
    plt.figure(figsize=(15, 6))
    contour = plt.contourf(Xi, Zi, Ai, cmap="turbo", levels=30) # gist_ncar
    plt.colorbar(label="Relative Backscatter")
    plt.xlabel("Distance (m)")
    plt.ylabel("Height (m)")
    plt.title(title)

    plt.xlim(0,200)
    plt.ylim(0,16)

    # while creating the Interpolated grid, I want to calculate some metrics too.
    # Now I want to find the maximum backscatter value in my scan

    max_rcs_value = np.nanmax(Ai)

```

```

max_index = np.unravel_index(np.nanargmax(Ai), Ai.shape)
row_idx, col_idx = max_index

max_x = Xi[row_idx, col_idx]
max_z = Zi[row_idx, col_idx]

print(f"Maximum Backscatter Value: {max_rcs_value:.3f} (Normalized)")
print(f"Location (X, Z): ({max_x:.2f} m, {max_z:.2f} m)")

# now estimate plume area
# create a threshold for 10% of maximum backscatter value
final_t = np.nanmax(Ai)*.1

# Create a boolean mask
plume_mask = Ai > final_t

# Count how many cells in the mask are TRUE
plume_cell_count = np.sum(plume_mask)

# Calculate the total area
plume_area_sq_m = plume_cell_count * cell_area

print(f"The calculated plume area is: {plume_area_sq_m:.2f} square meters.")

# Add mark for max backscatter.
if mark_max==True:
    plt.annotate(
        'Maximum Backscatter',
        xy=(max_x, max_z),
        xytext=(25,13),
        arrowprops=dict(
            arrowstyle='->',
            color='red',
            lw=2
        ),
        fontsize=12,
        color='red'
    )

plt.show()
return [temp["start"].min(), temp["start"].max(), max_rcs_value, max_x, max_z, plume_area_
```

In [16]: `temp`

Out[16]:

	analog	photon	start	end	zenith	distance	x	z	analog_bgc	pho
2970	3.2959	106.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	7.5	7.495789	2.251280	0.0	
2971	3.2959	136.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	15.0	14.991579	2.502561	0.0	
2972	3.2959	146.6667	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	22.5	22.487368	2.753841	0.0	
2973	3.3162	133.3333	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	30.0	29.983157	3.005122	0.0	
2974	3.3162	133.3333	2018-11-02 18:03:04	2018-11-02 18:03:04	1.92	37.5	37.478947	3.256402	0.0	
...
262138	47.0215	132.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	172.5	172.178253	12.530873	0.0	
262139	44.4580	132.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	180.0	179.664264	12.988737	0.0	
262140	42.1631	144.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	187.5	187.150275	13.446601	0.0	
262141	37.6953	124.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	195.0	194.636286	13.904465	0.0	
262142	35.6689	116.0000	2018-11-02 18:03:38	2018-11-02 18:03:38	3.50	202.5	202.122297	14.362329	0.0	

756 rows × 14 columns



In [17]:

```
# Now I want to run statistics and make plots of many plumes.
all_stats = []
for time_period in scans_to_investigate[1][90:250]:      # [130:190]
    start, stop = time_period
    temp = research_df[(research_df['start']>start) & (research_df['start']<=stop)]

    try:
        threshold(temp)
        plume_stats = plot_backscatter(temp, 'analog_masked', title=f'Backscatter {start} to {stop}')
        all_stats.append(plume_stats)
    except Exception as e:
        print(f'error processing {start}, {stop}: {e}')

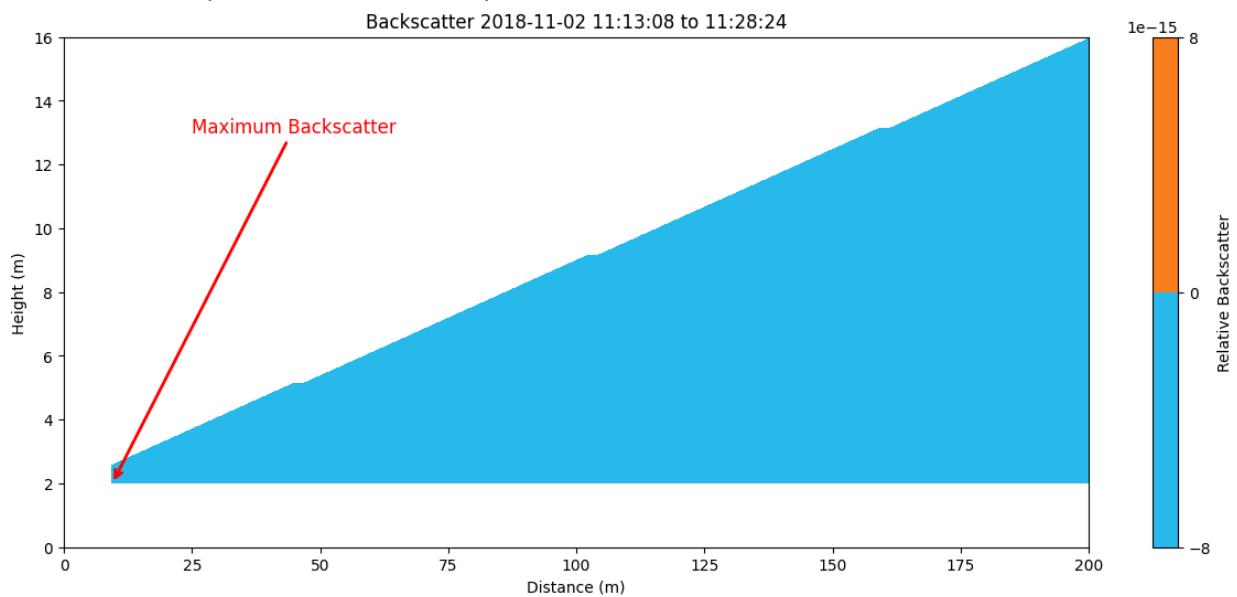
# plt.scatter(temp['x'], temp['z'], c=temp['analog_rcs'])
# plt.show()
```

```
# plot_contour_scan(temp, x_Limits=(0, 350), y_Limits=(0, 60), method='Linear')
```

Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.00 m)

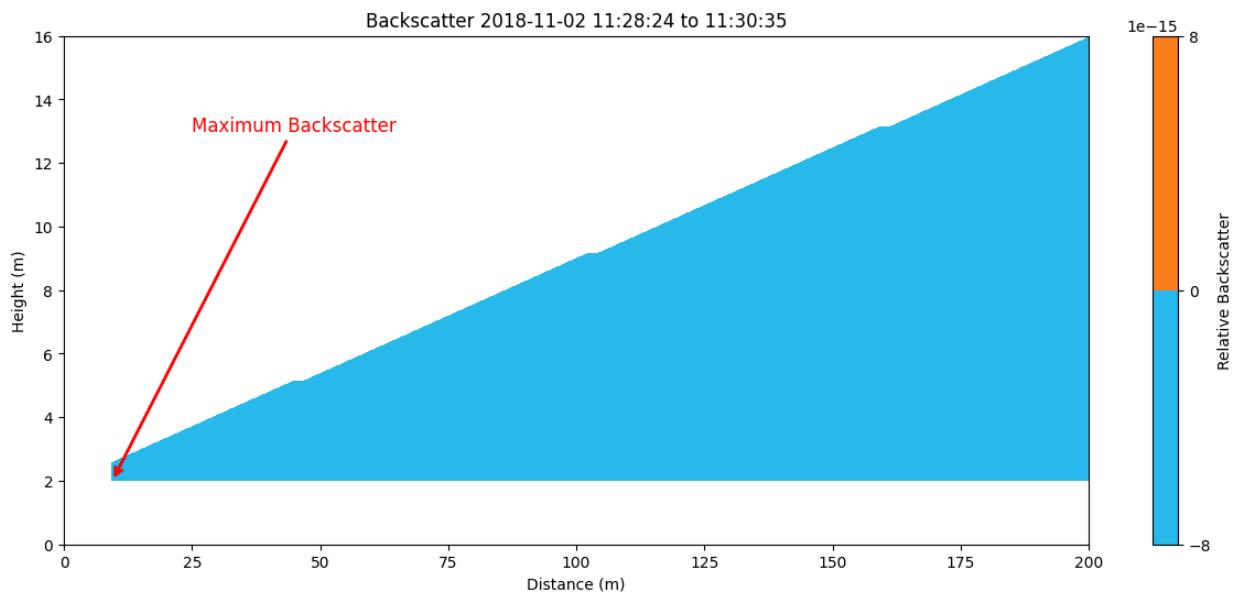
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.00 m)

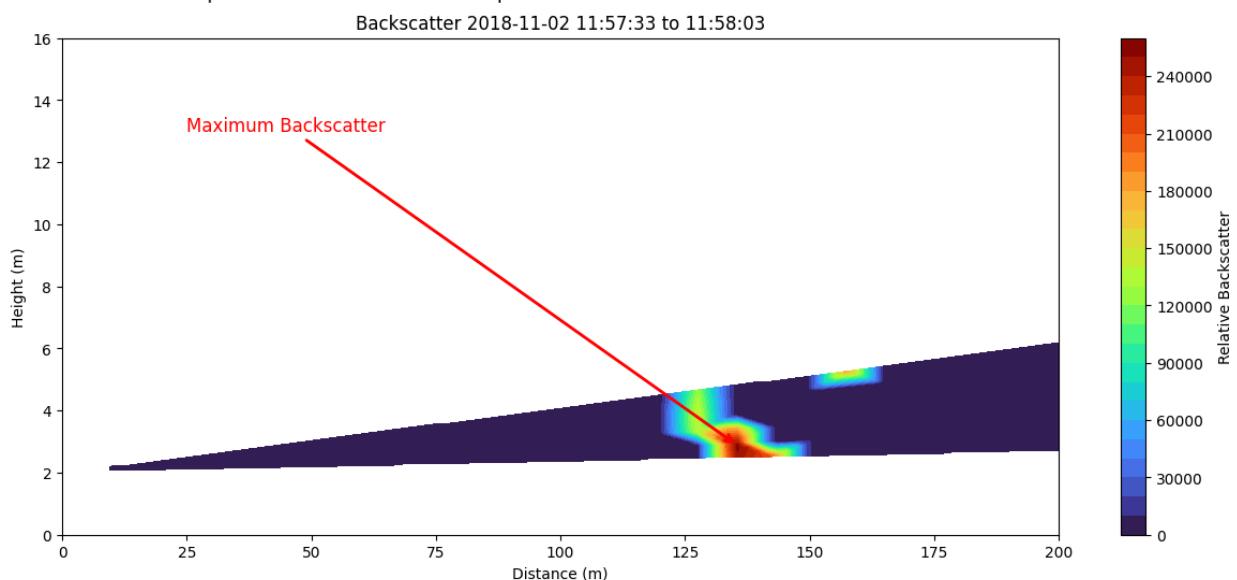
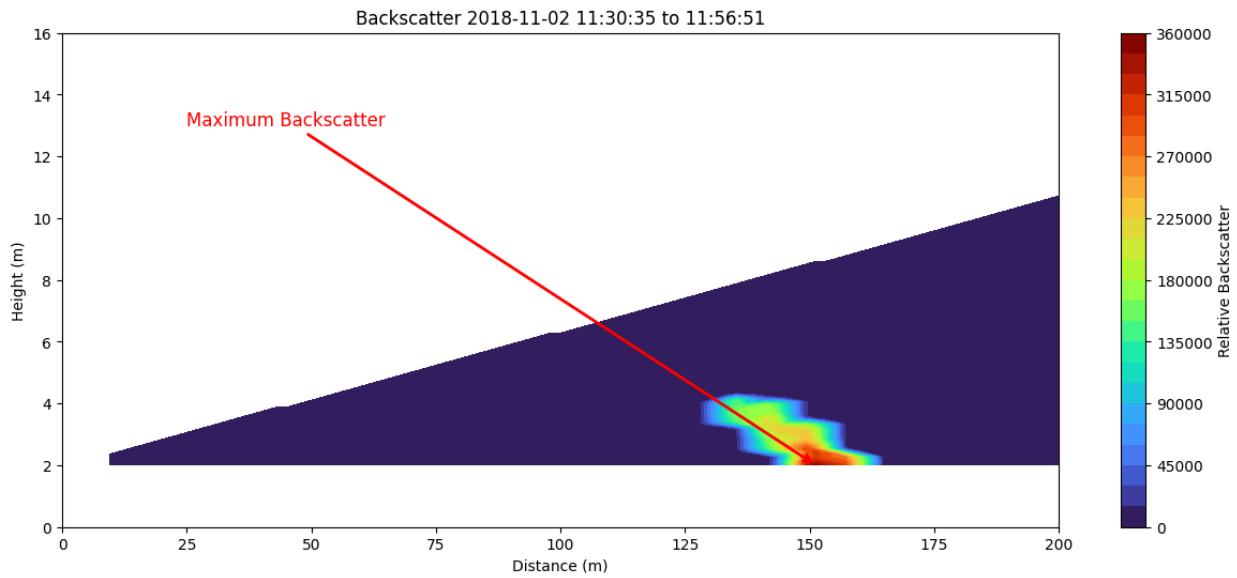
The calculated plume area is: 0.00 square meters.

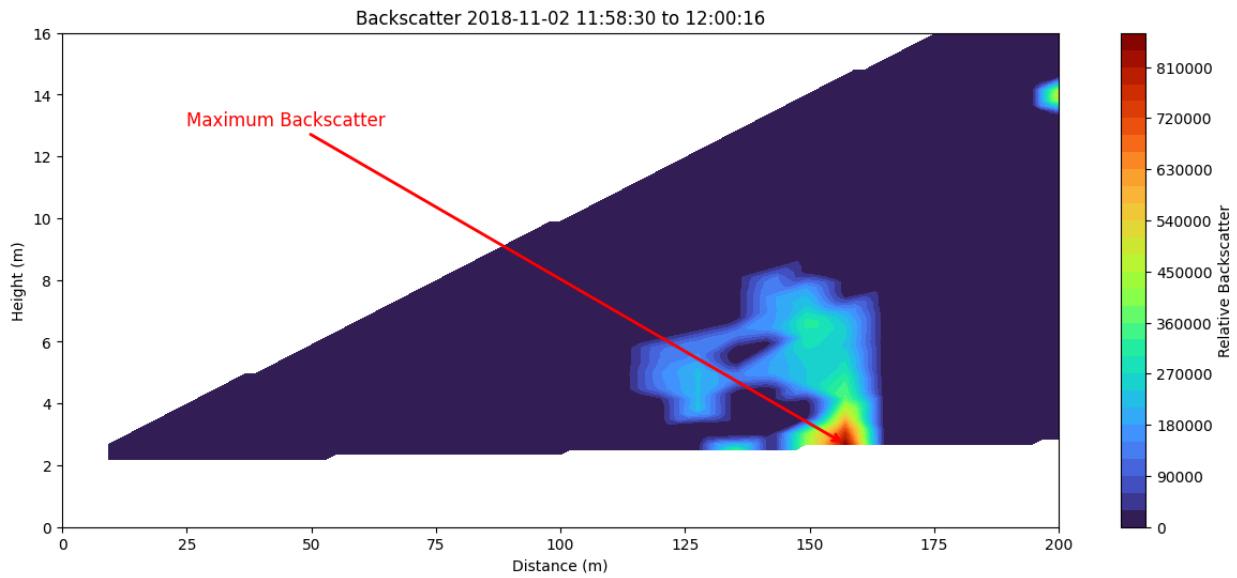


Maximum Backscatter Value: 351696.326 (Normalized)

Location (X, Z): (151.29 m, 2.00 m)

The calculated plume area is: 46.40 square meters.

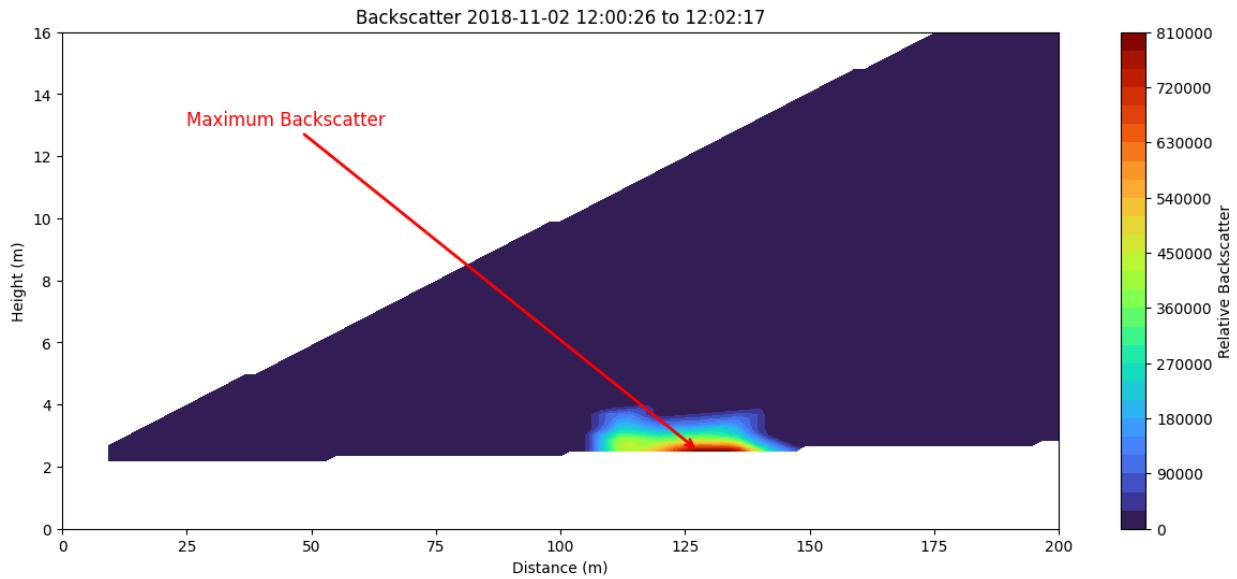




Maximum Backscatter Value: 796100.987 (Normalized)

Location (X, Z): (127.64 m, 2.52 m)

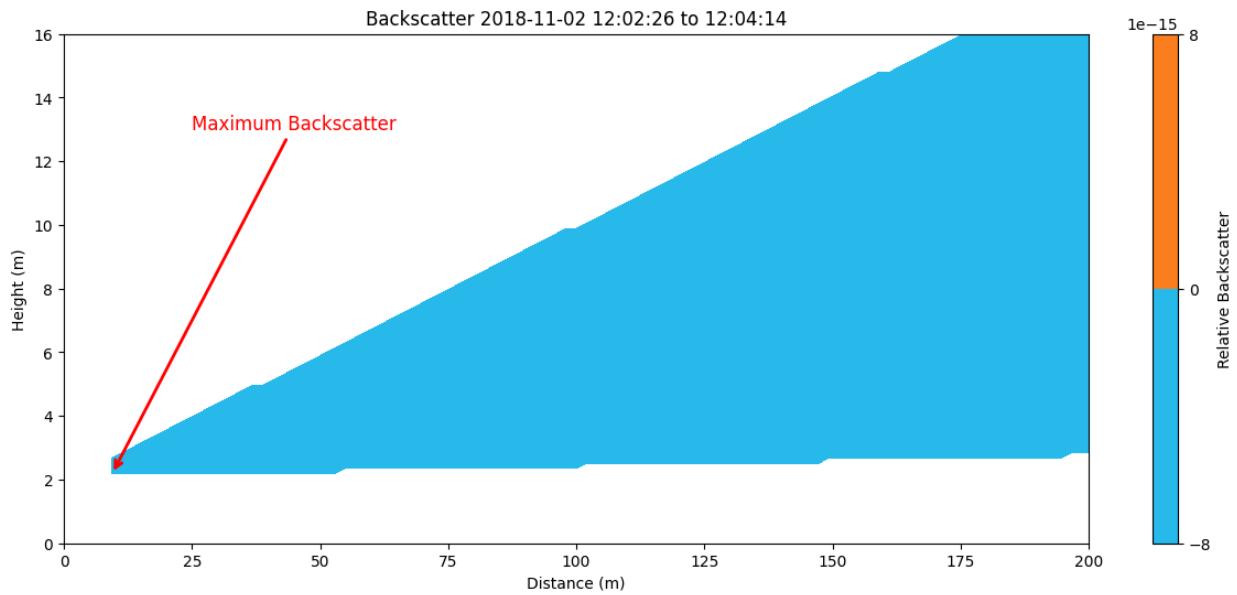
The calculated plume area is: 40.01 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

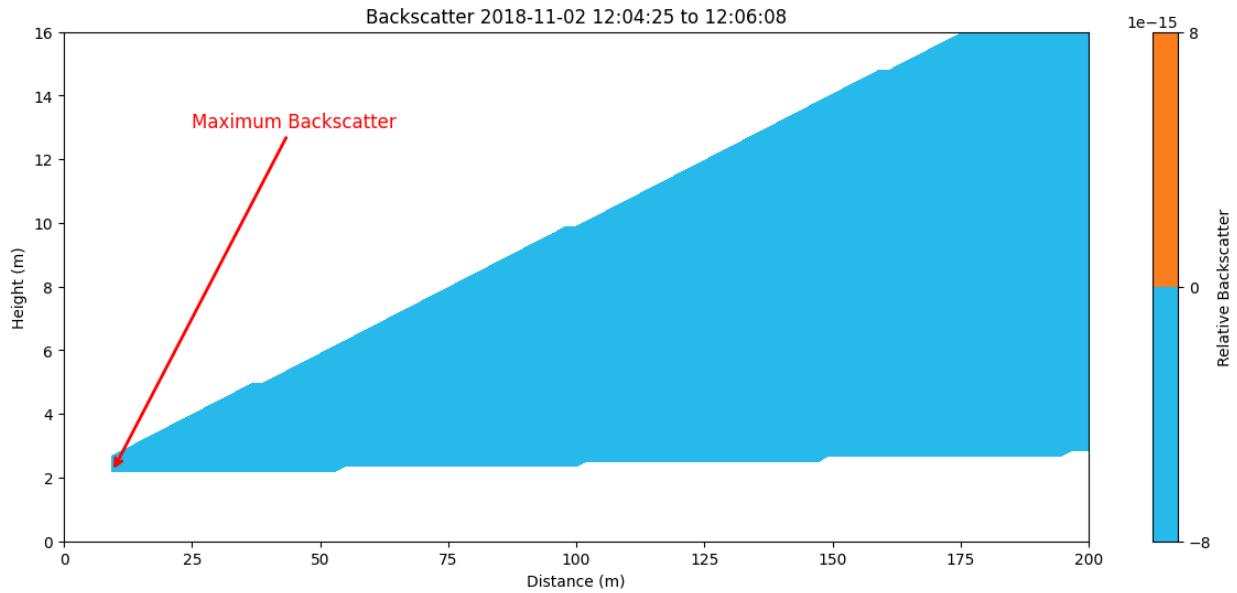
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

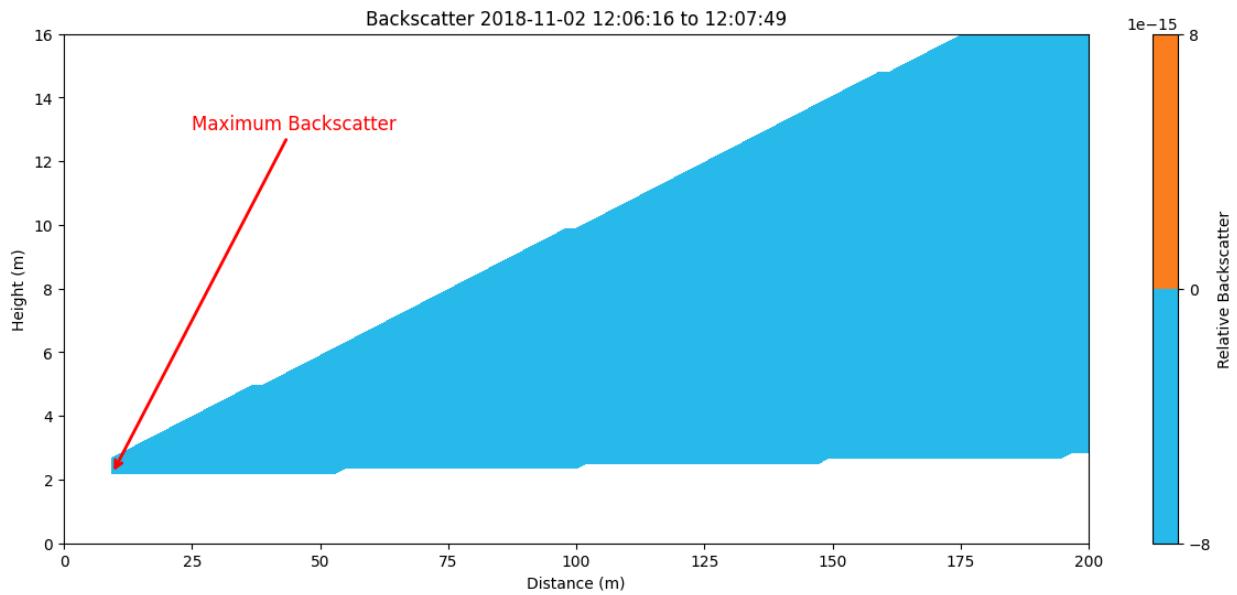
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

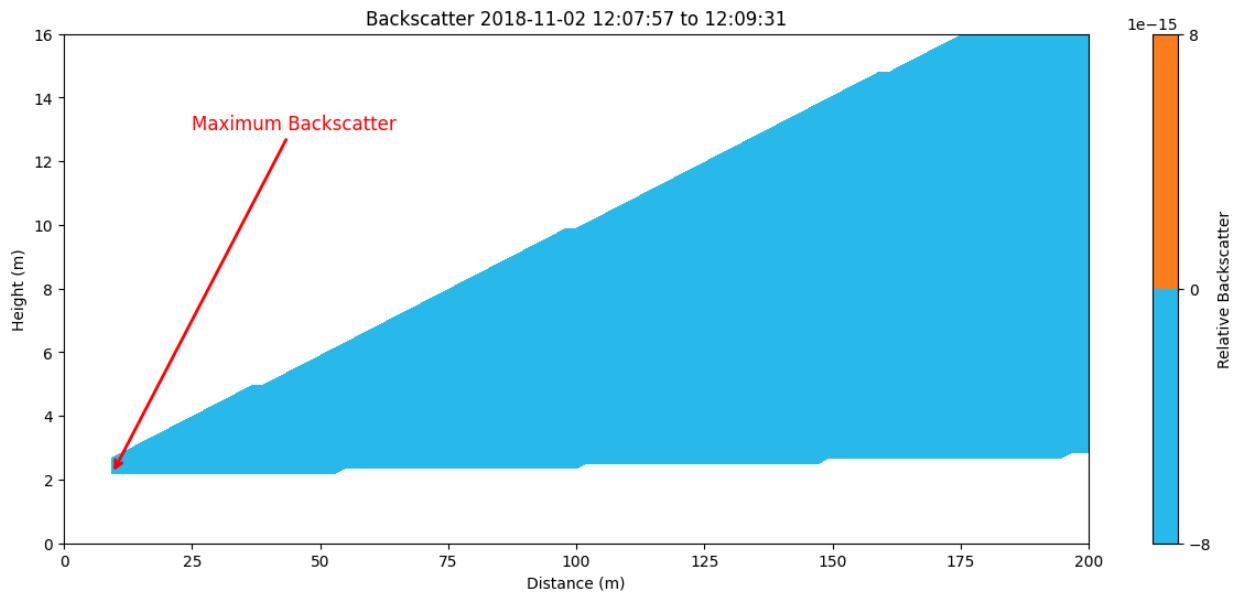
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

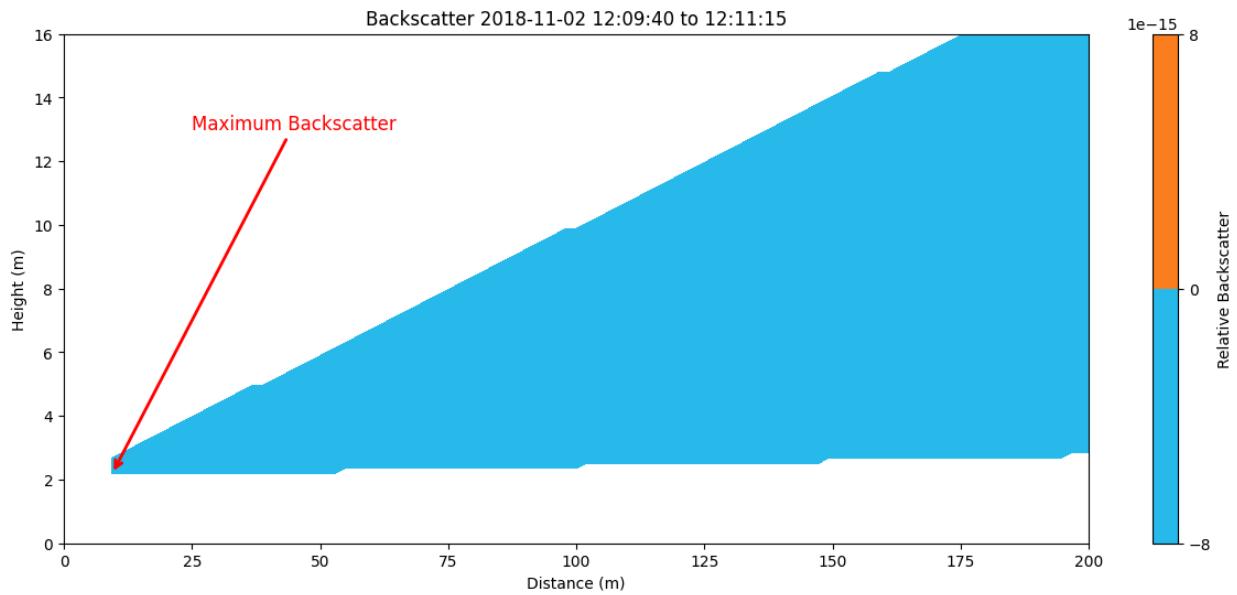
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

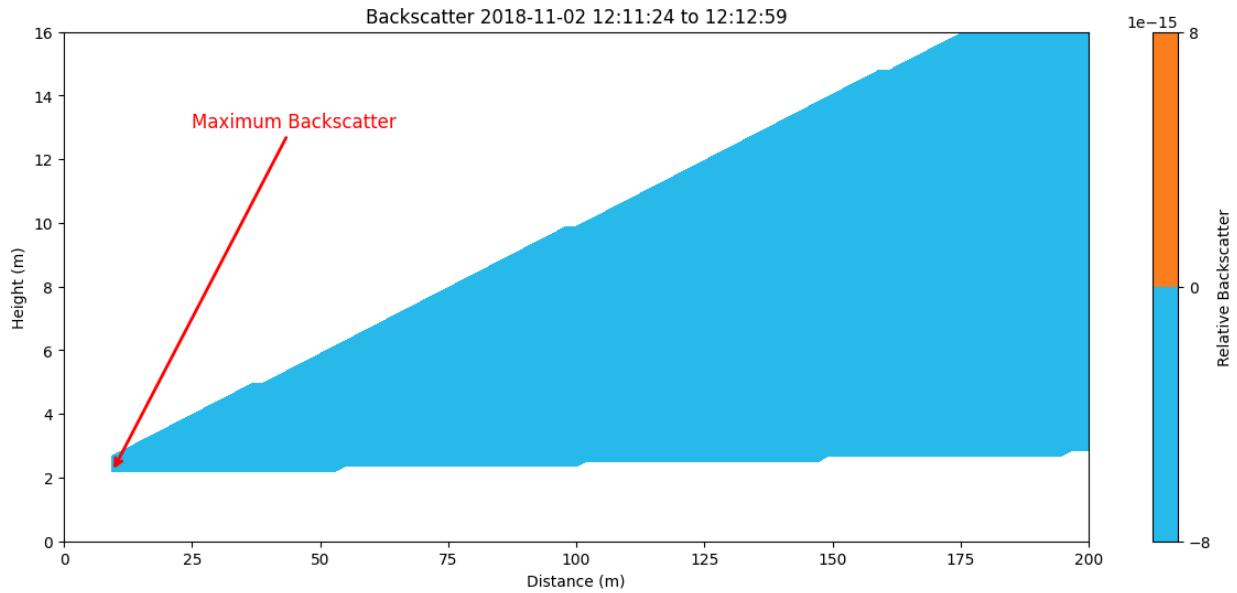
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

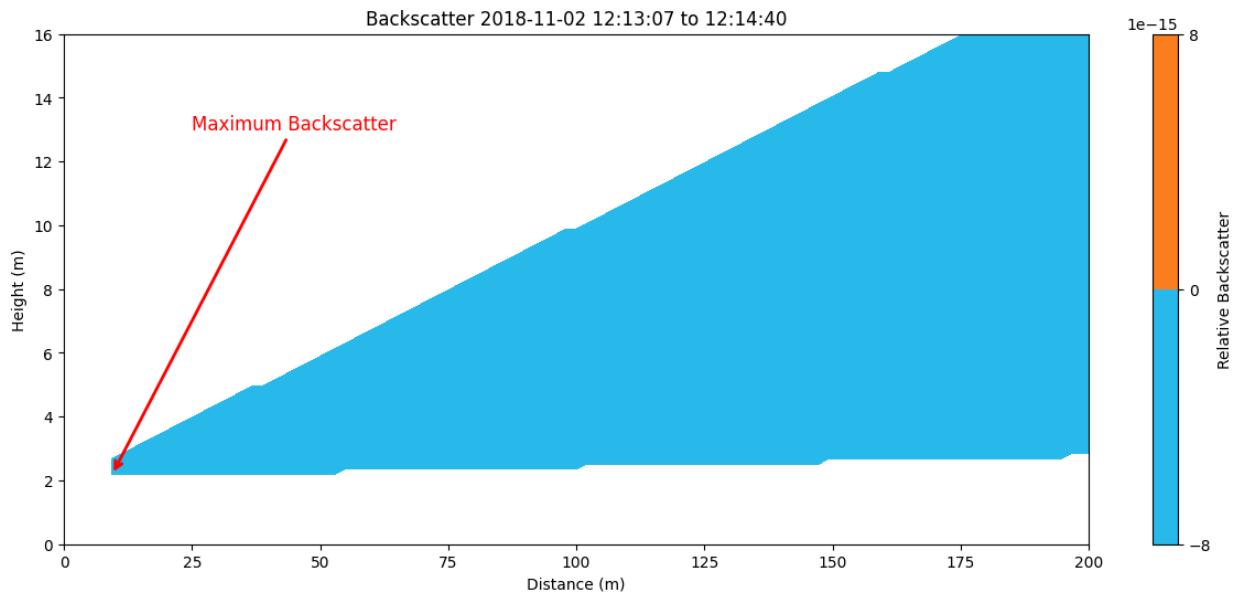
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

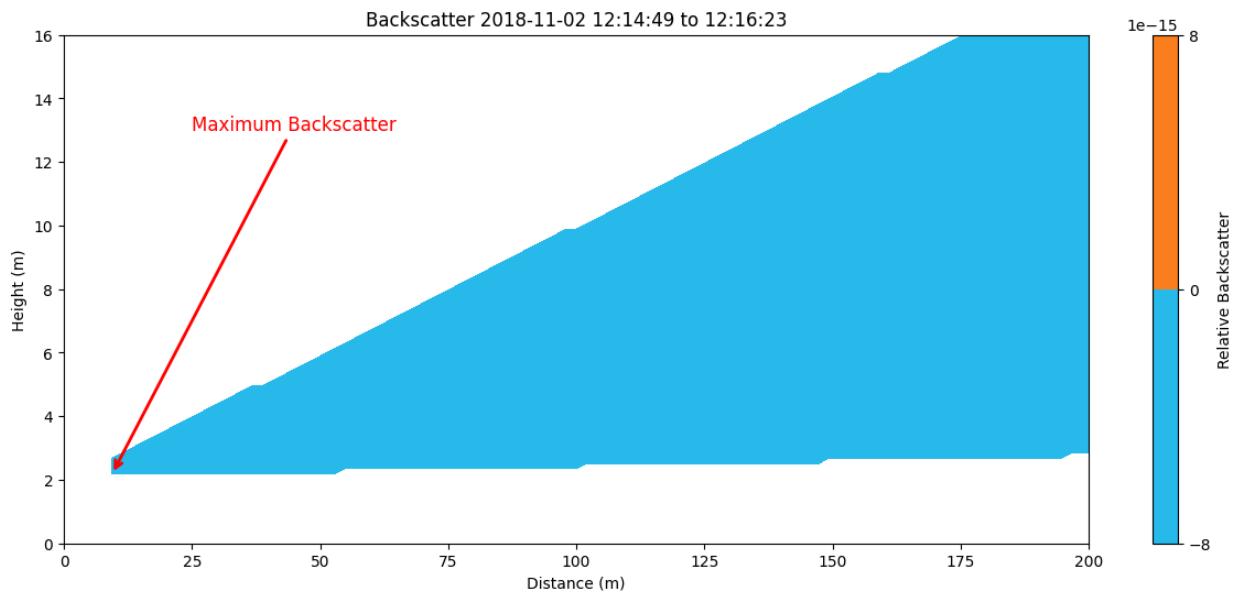
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

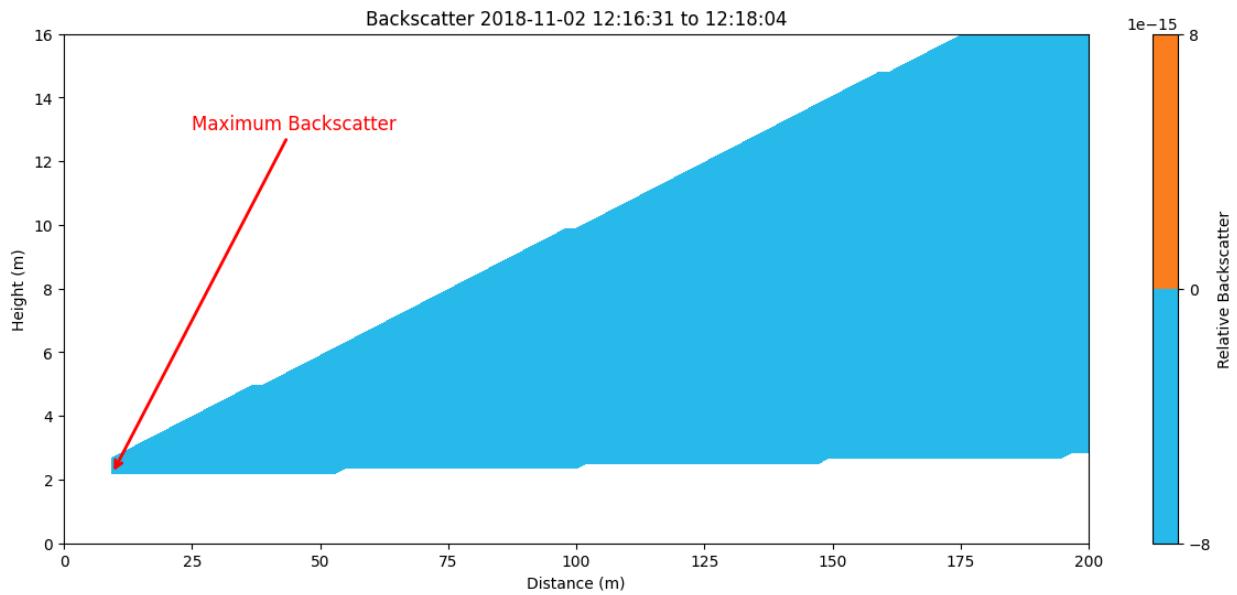
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

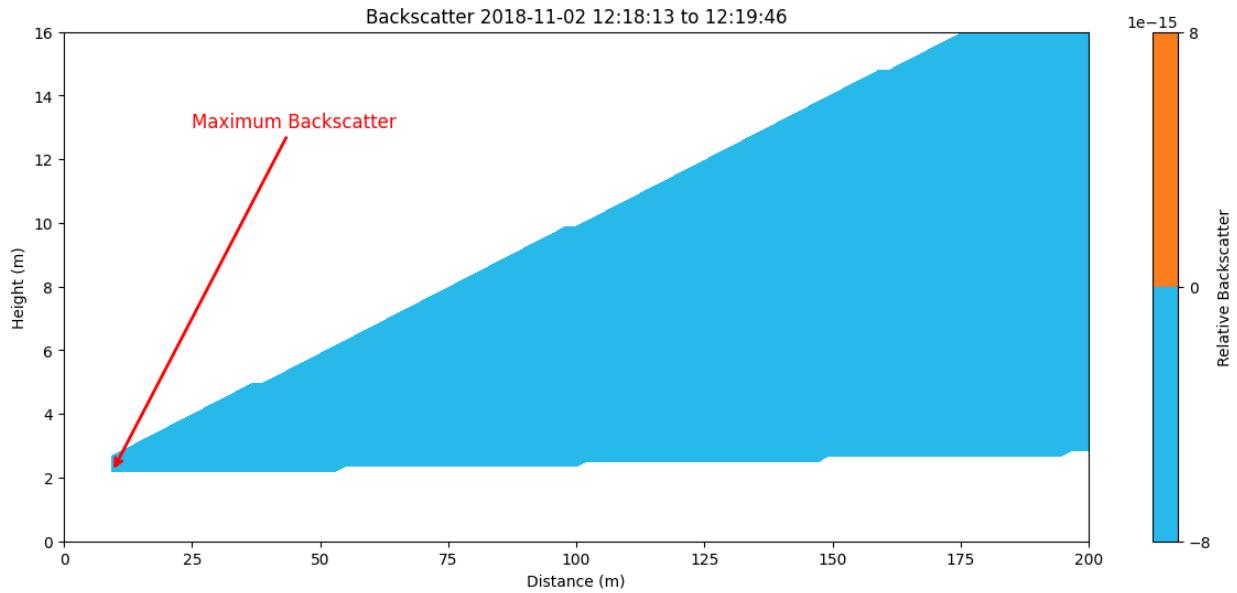
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

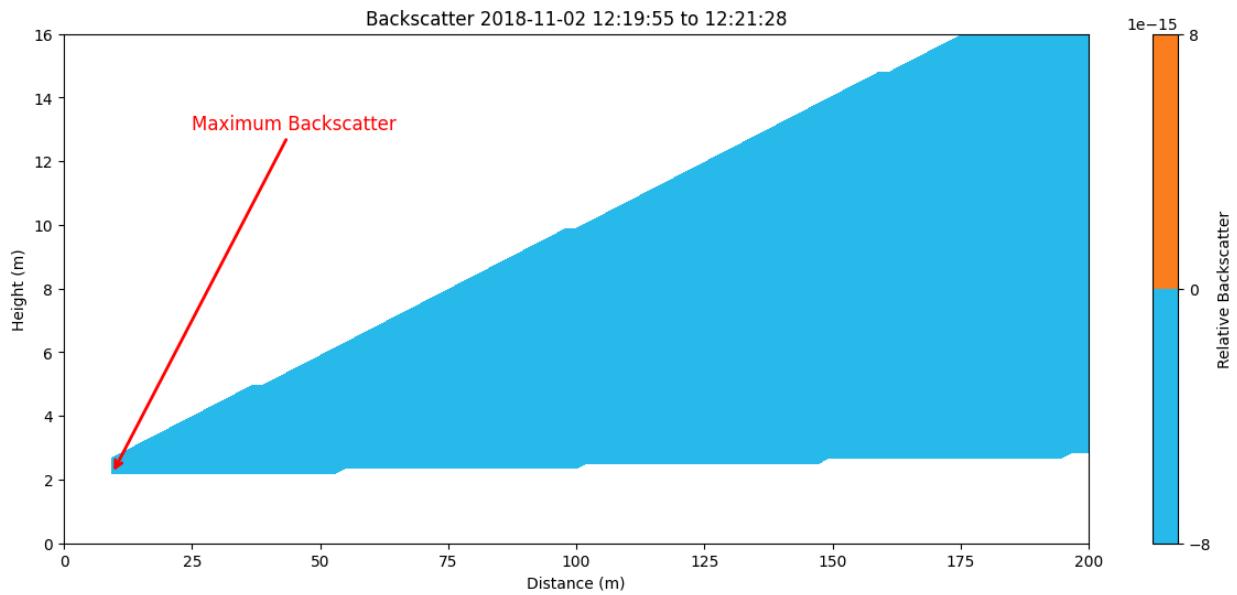
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

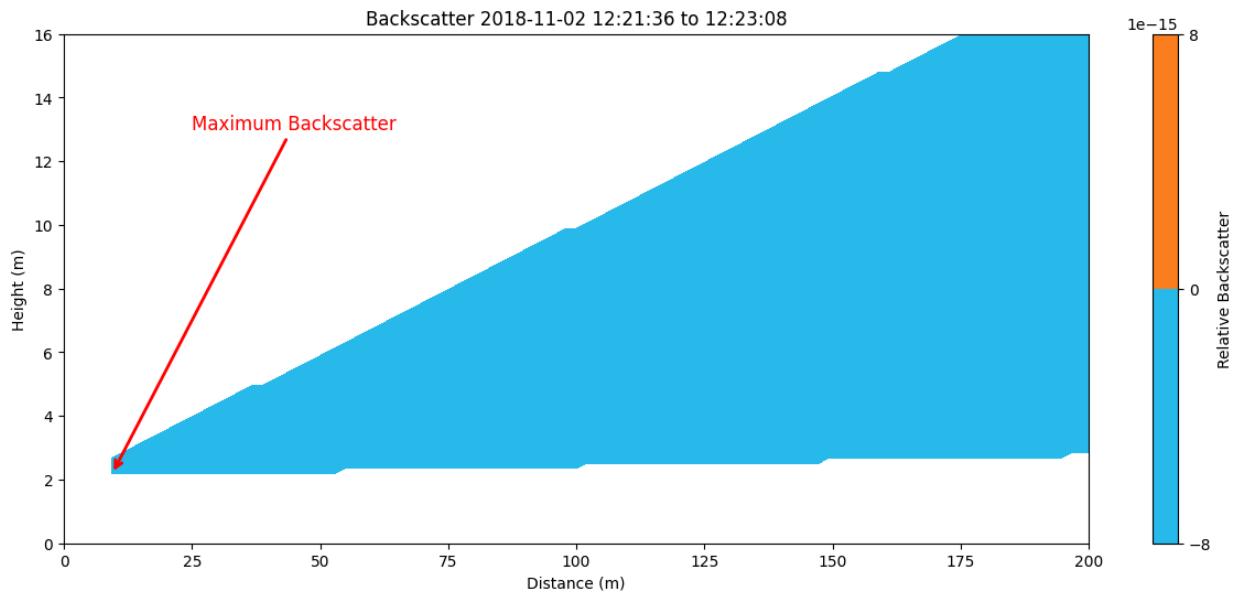
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.45 m, 2.19 m)

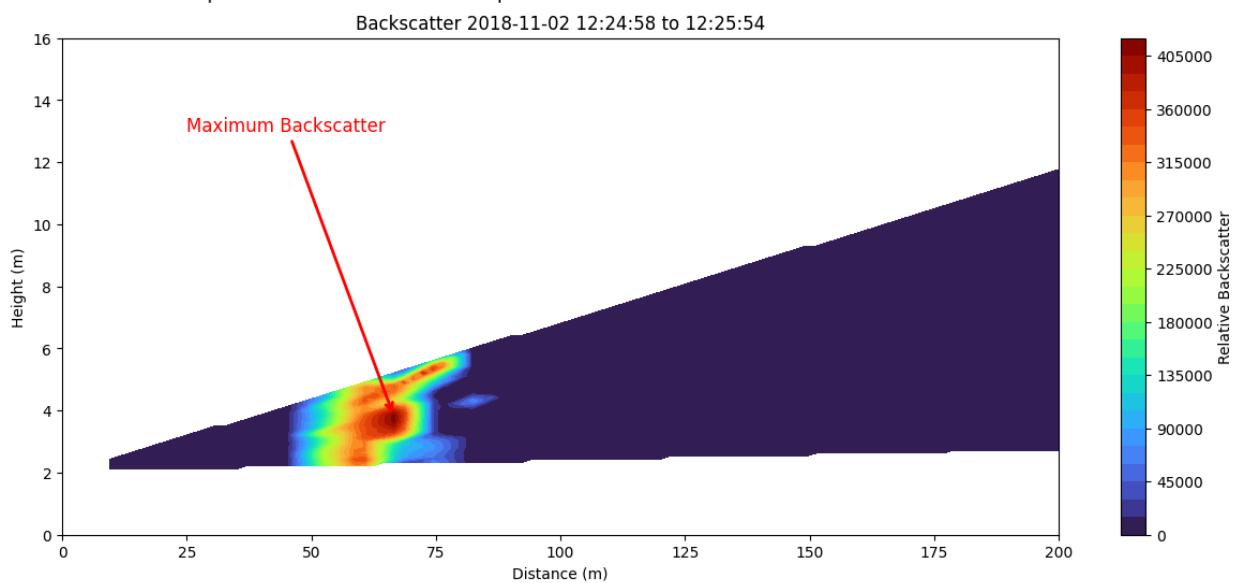
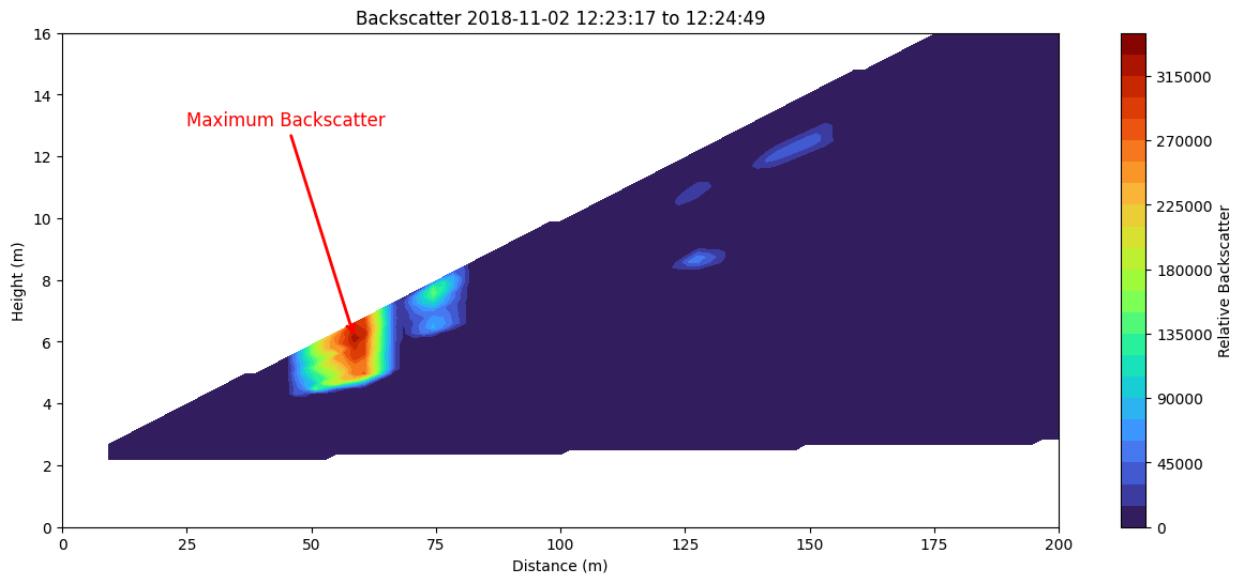
The calculated plume area is: 0.00 square meters.

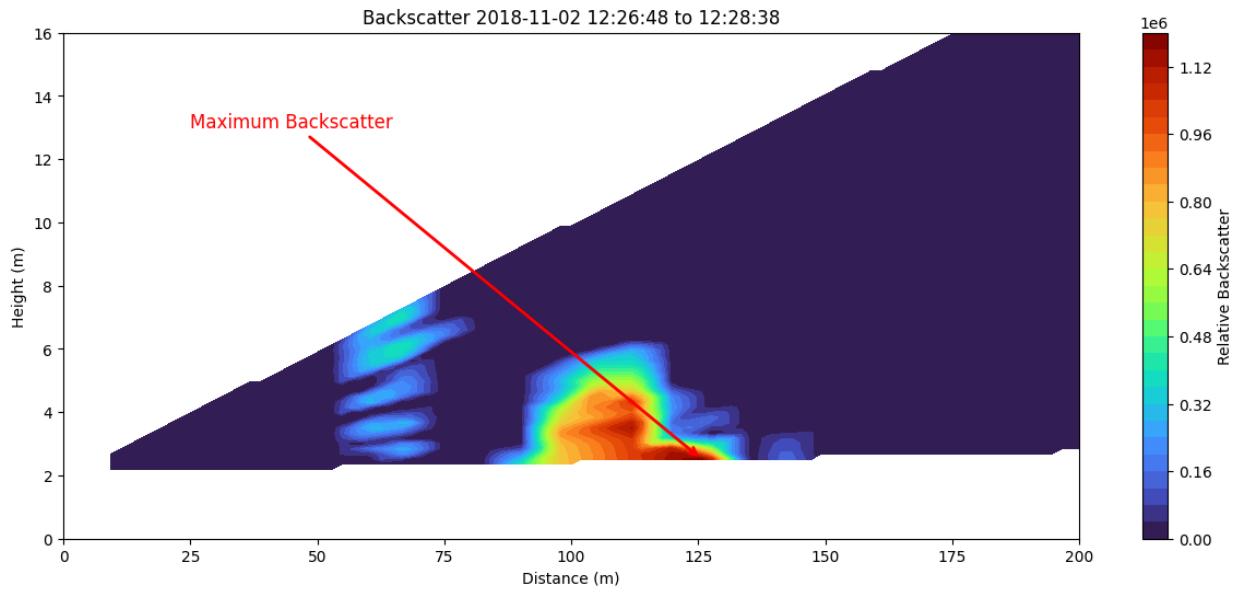


Maximum Backscatter Value: 330201.318 (Normalized)

Location (X, Z): (58.69 m, 6.12 m)

The calculated plume area is: 60.65 square meters.

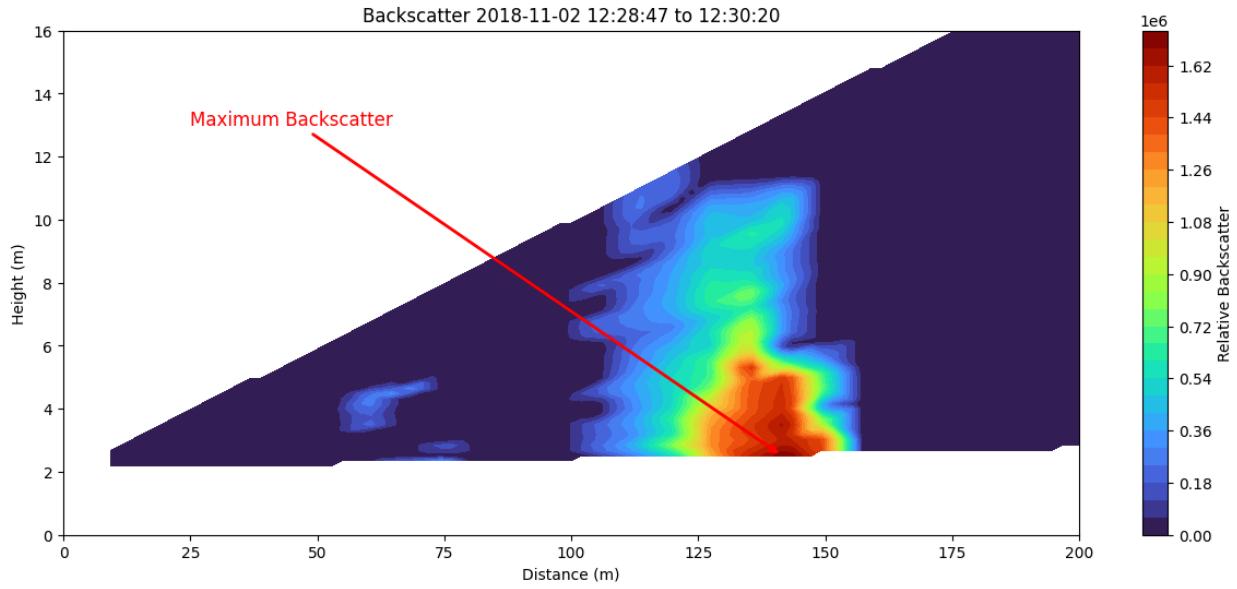




Maximum Backscatter Value: 1720860.856 (Normalized)

Location (X, Z): (141.43 m, 2.52 m)

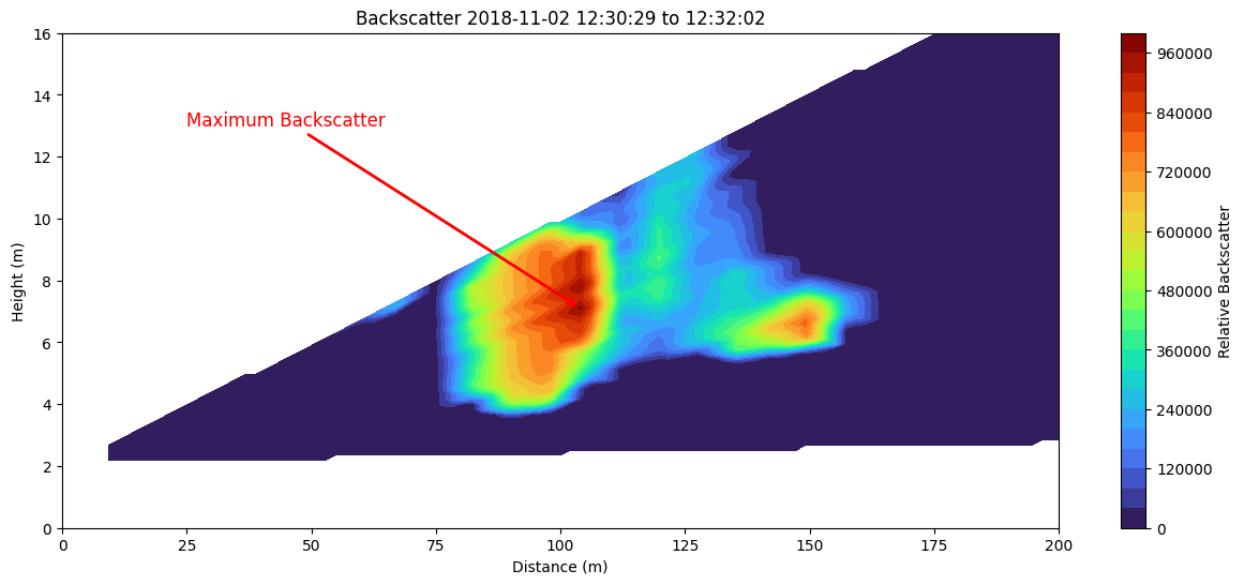
The calculated plume area is: 346.18 square meters.



Maximum Backscatter Value: 973104.613 (Normalized)

Location (X, Z): (104.00 m, 7.10 m)

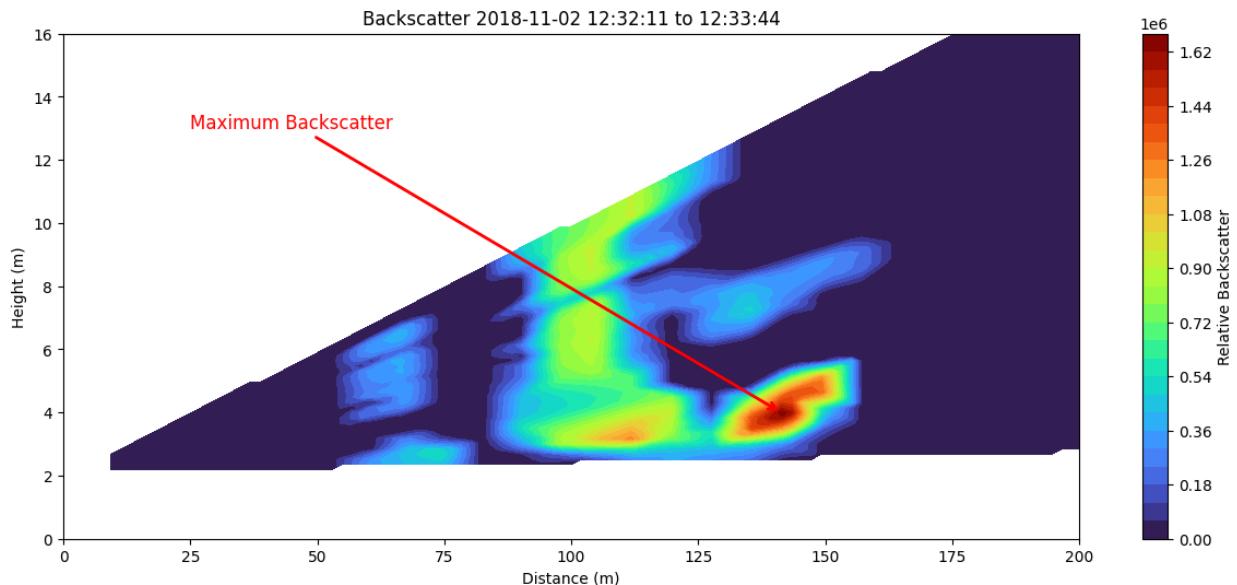
The calculated plume area is: 407.16 square meters.



Maximum Backscatter Value: 1667836.884 (Normalized)

Location (X, Z): (141.43 m, 3.99 m)

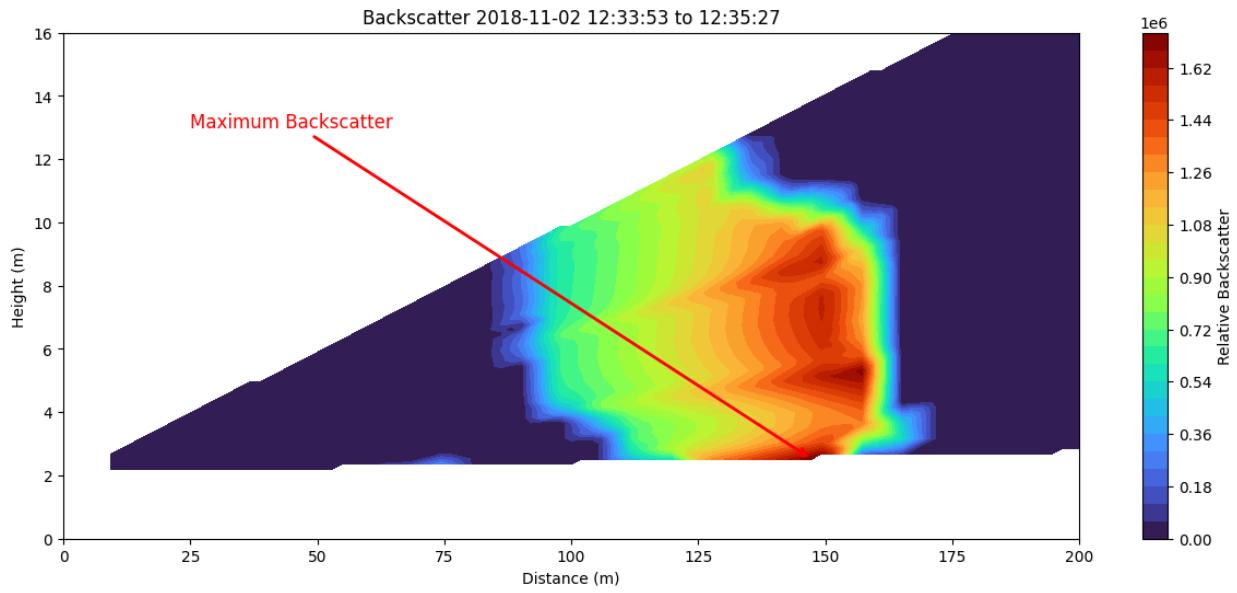
The calculated plume area is: 436.84 square meters.



Maximum Backscatter Value: 1734088.411 (Normalized)

Location (X, Z): (147.34 m, 2.52 m)

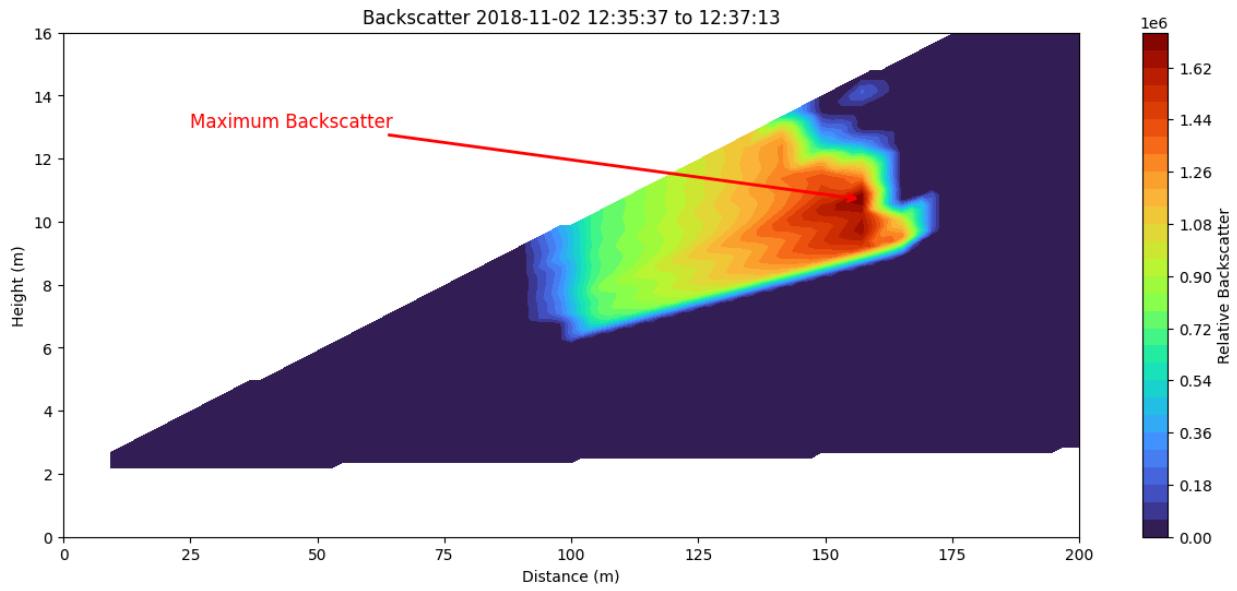
The calculated plume area is: 619.78 square meters.



Maximum Backscatter Value: 1724470.311 (Normalized)

Location (X, Z): (157.19 m, 10.71 m)

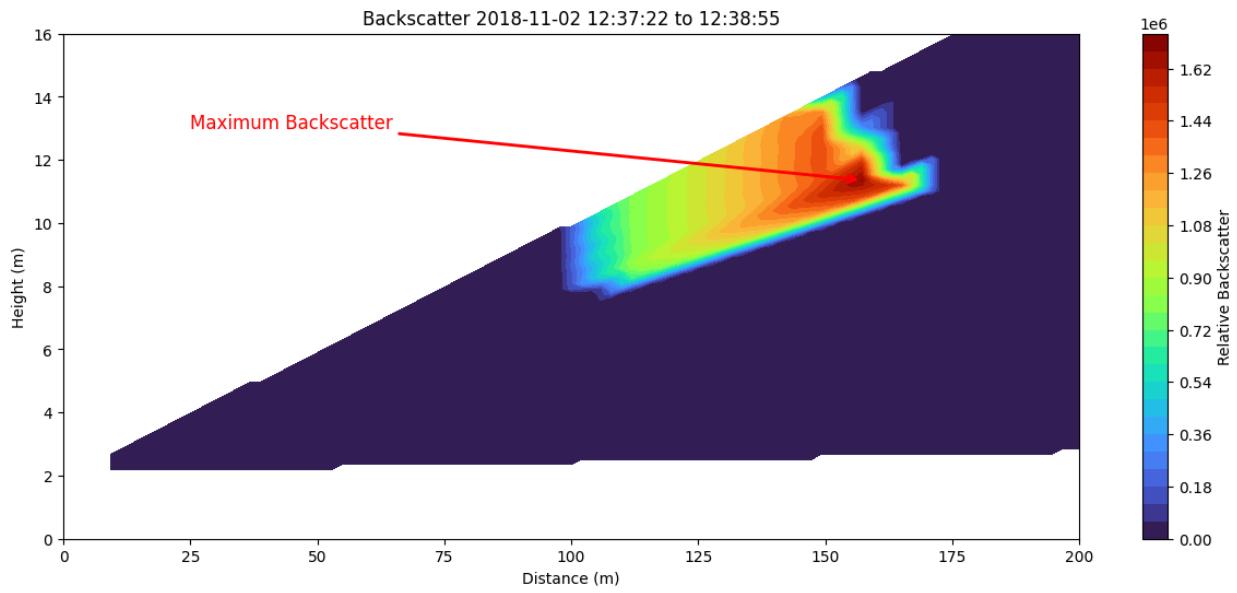
The calculated plume area is: 319.08 square meters.



Maximum Backscatter Value: 1685502.241 (Normalized)

Location (X, Z): (157.19 m, 11.36 m)

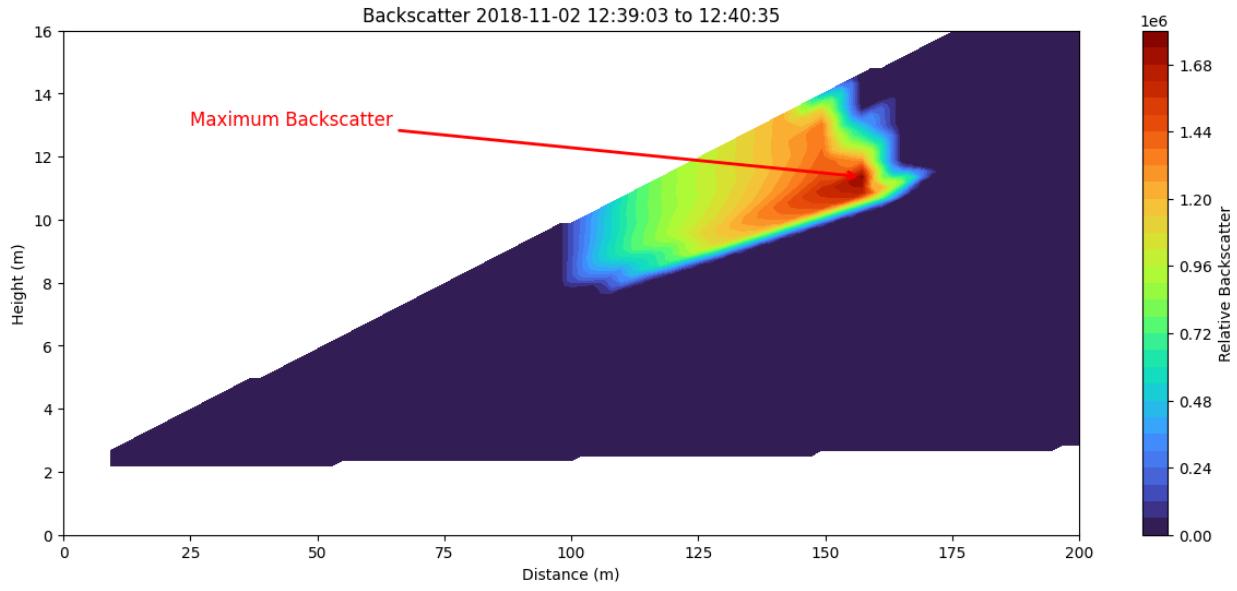
The calculated plume area is: 223.58 square meters.



Maximum Backscatter Value: 1743382.543 (Normalized)

Location (X, Z): (157.19 m, 11.36 m)

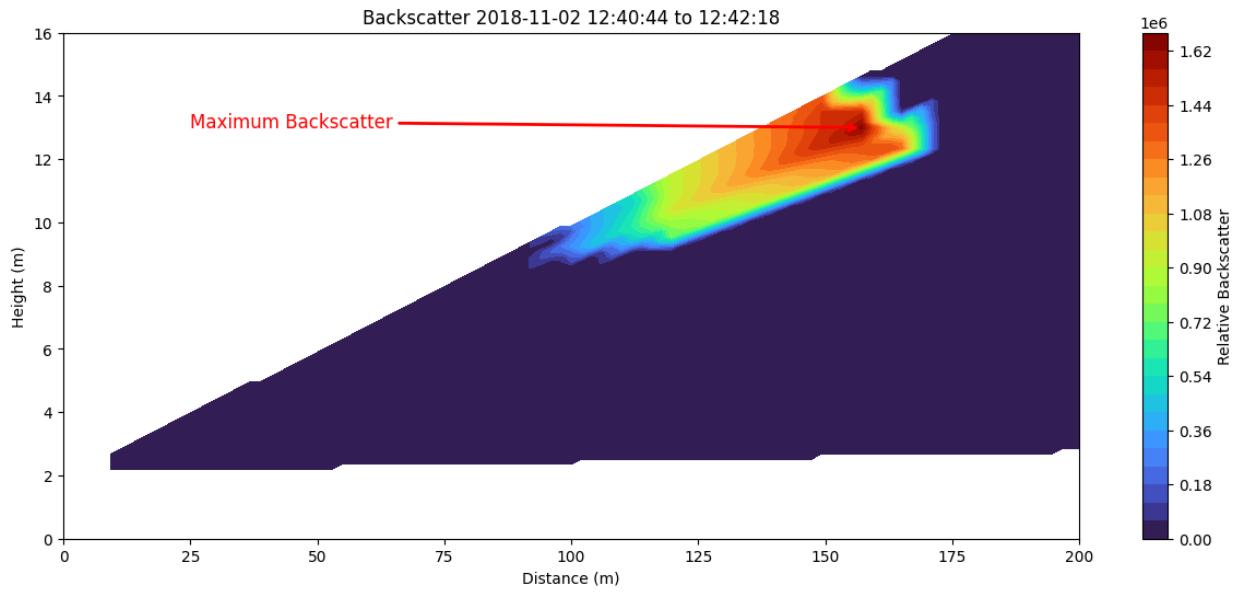
The calculated plume area is: 215.52 square meters.



Maximum Backscatter Value: 1641256.912 (Normalized)

Location (X, Z): (157.19 m, 13.00 m)

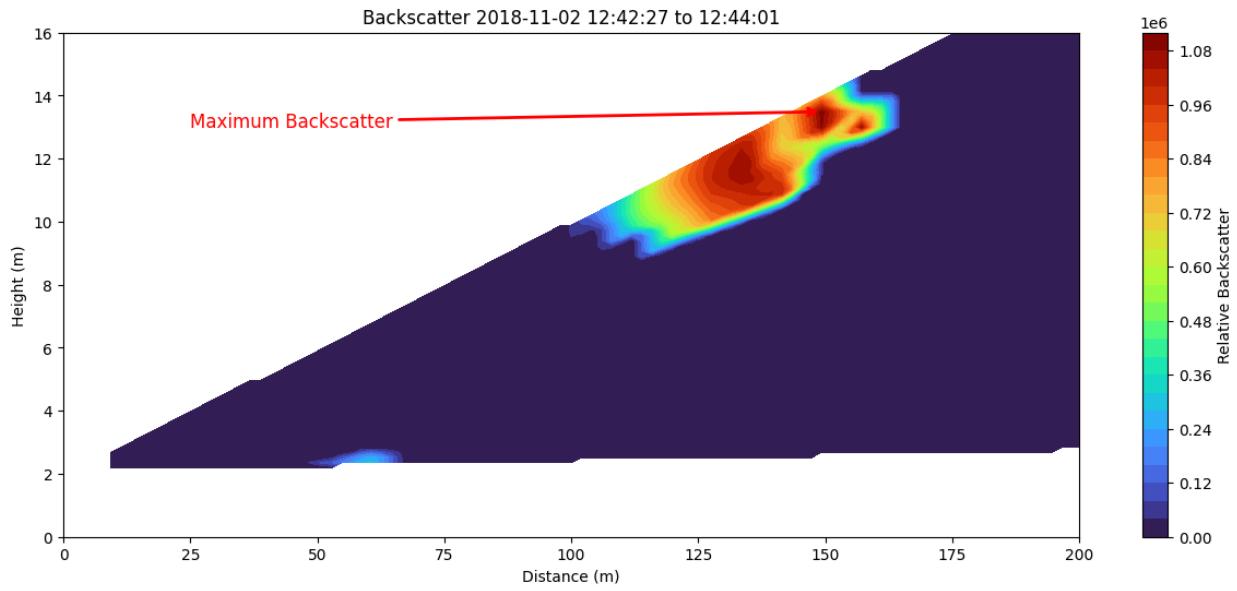
The calculated plume area is: 175.51 square meters.



Maximum Backscatter Value: 1099710.145 (Normalized)

Location (X, Z): (149.31 m, 13.49 m)

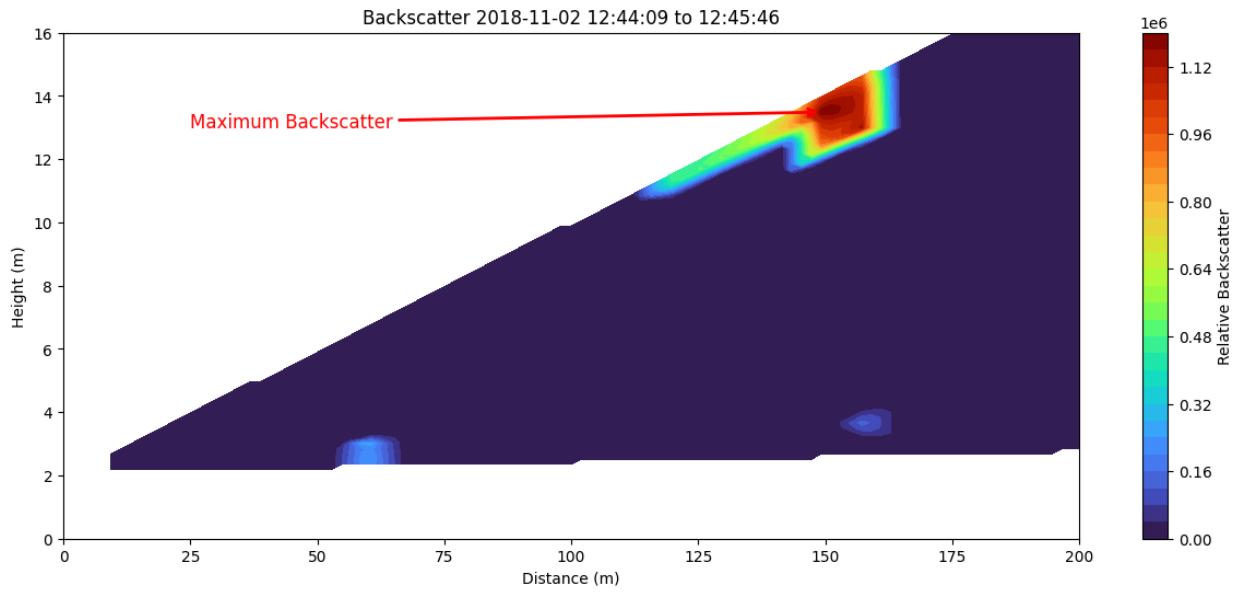
The calculated plume area is: 135.51 square meters.



Maximum Backscatter Value: 1194677.825 (Normalized)

Location (X, Z): (149.31 m, 13.49 m)

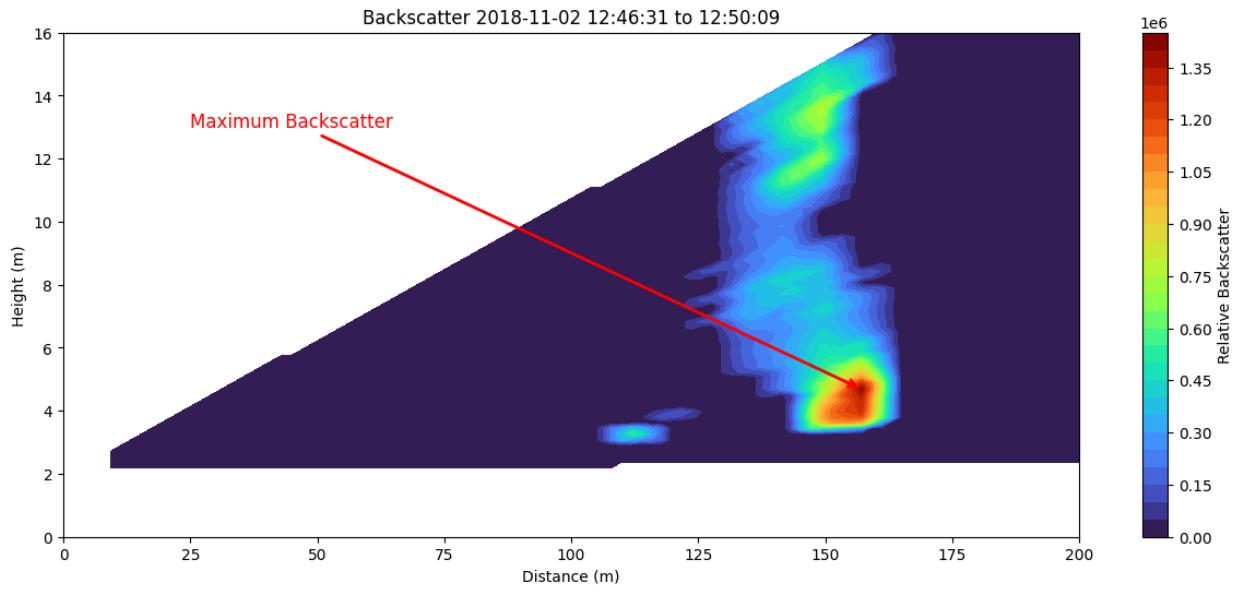
The calculated plume area is: 74.53 square meters.



Maximum Backscatter Value: 1406801.242 (Normalized)

Location (X, Z): (157.19 m, 4.69 m)

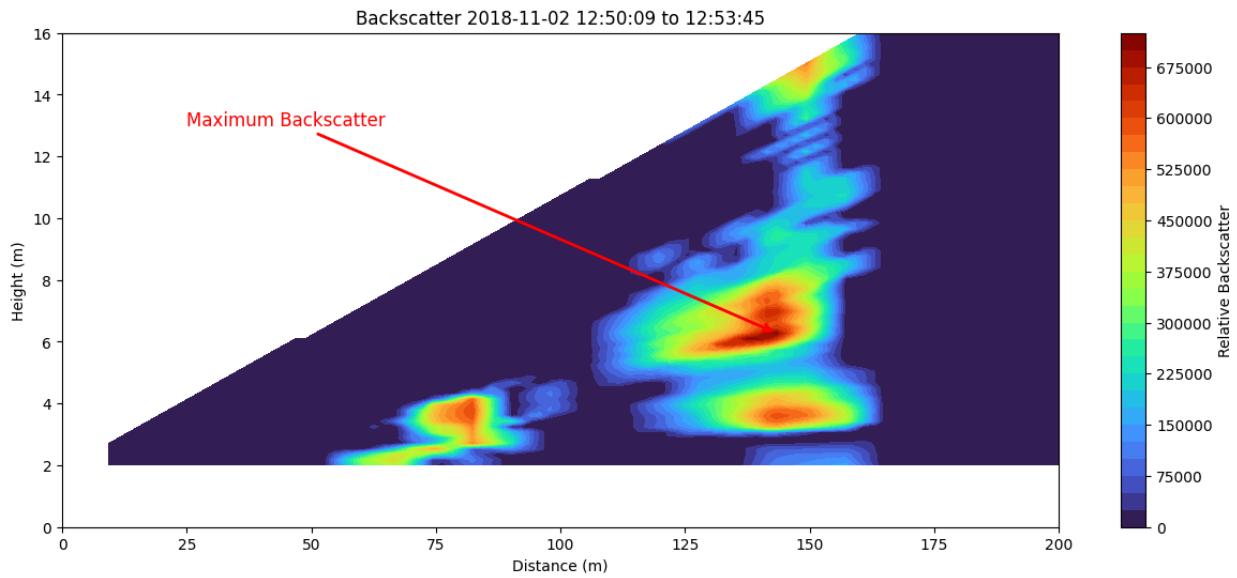
The calculated plume area is: 276.54 square meters.



Maximum Backscatter Value: 704618.514 (Normalized)

Location (X, Z): (143.40 m, 6.28 m)

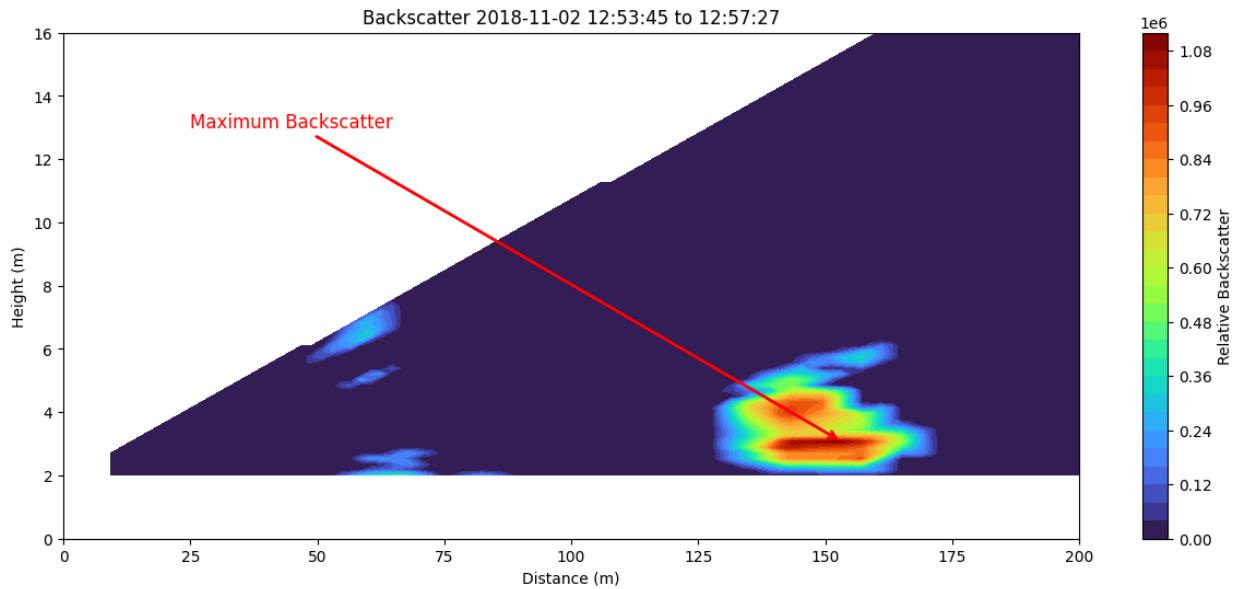
The calculated plume area is: 429.86 square meters.



Maximum Backscatter Value: 1087317.100 (Normalized)

Location (X, Z): (153.25 m, 3.07 m)

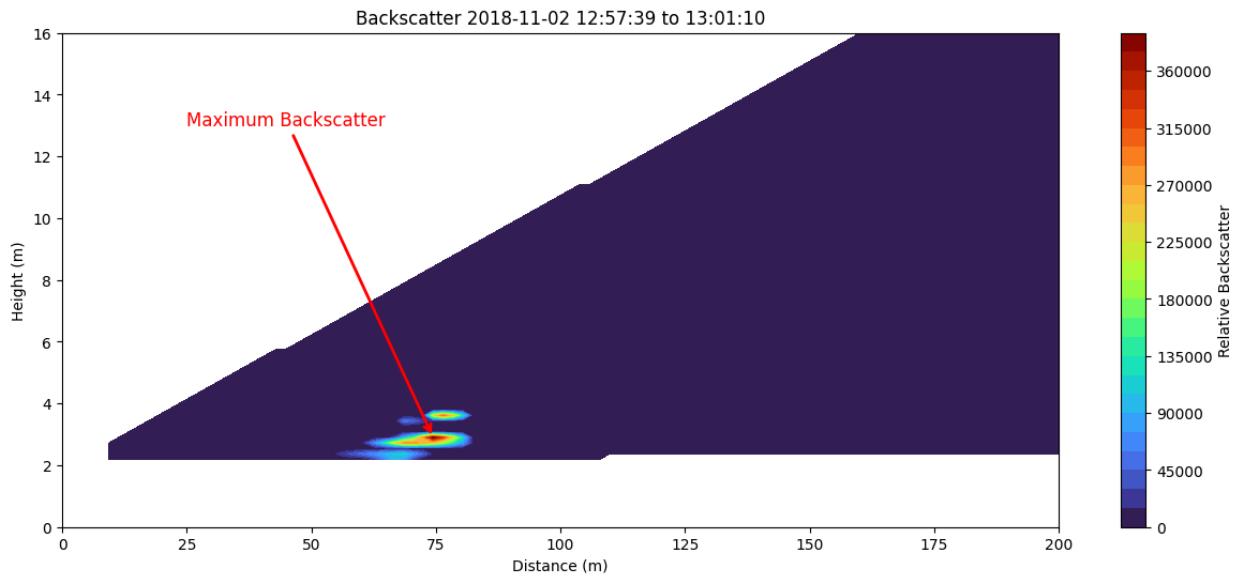
The calculated plume area is: 125.03 square meters.



Maximum Backscatter Value: 385305.894 (Normalized)

Location (X, Z): (74.45 m, 2.90 m)

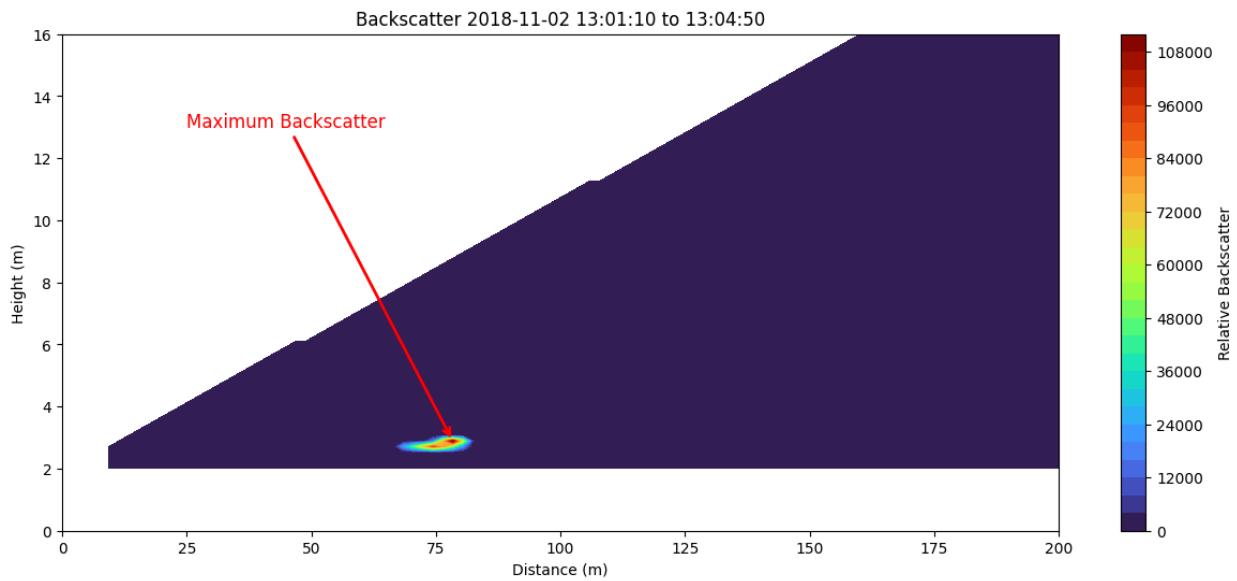
The calculated plume area is: 11.93 square meters.



Maximum Backscatter Value: 110852.349 (Normalized)

Location (X, Z): (78.39 m, 2.89 m)

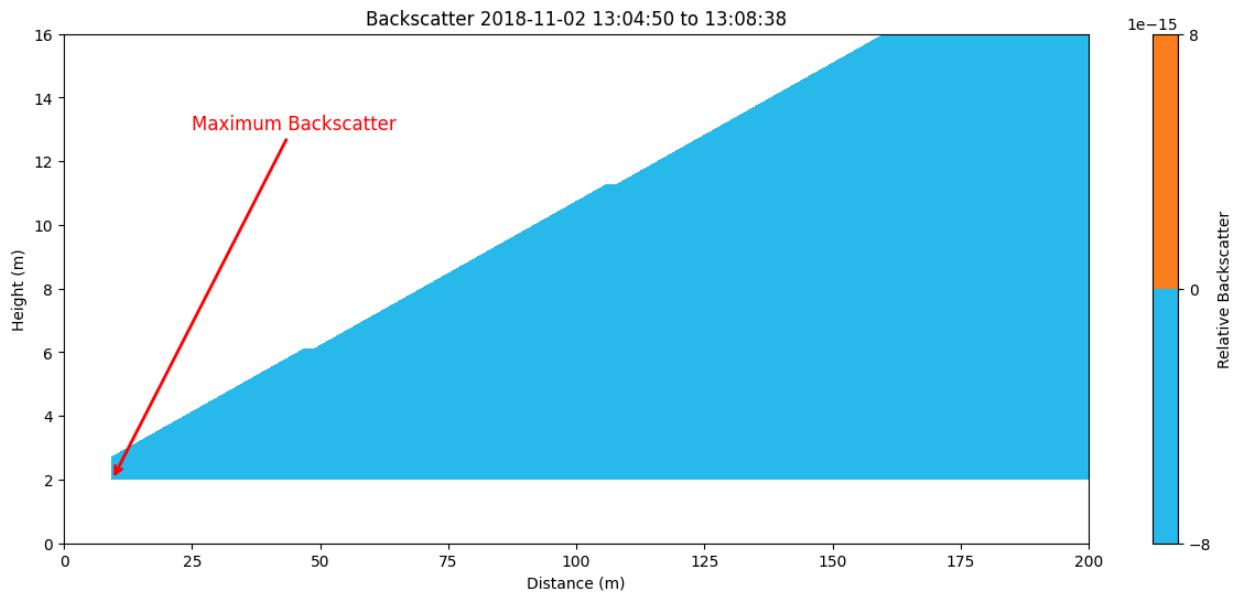
The calculated plume area is: 3.86 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

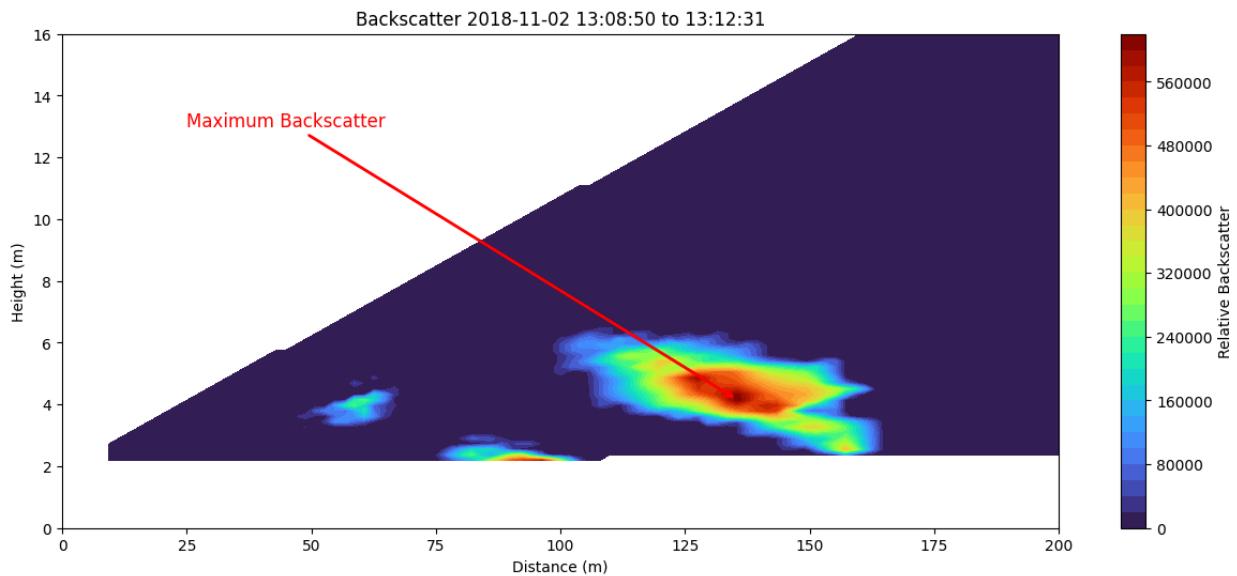
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 616643.357 (Normalized)

Location (X, Z): (135.52 m, 4.15 m)

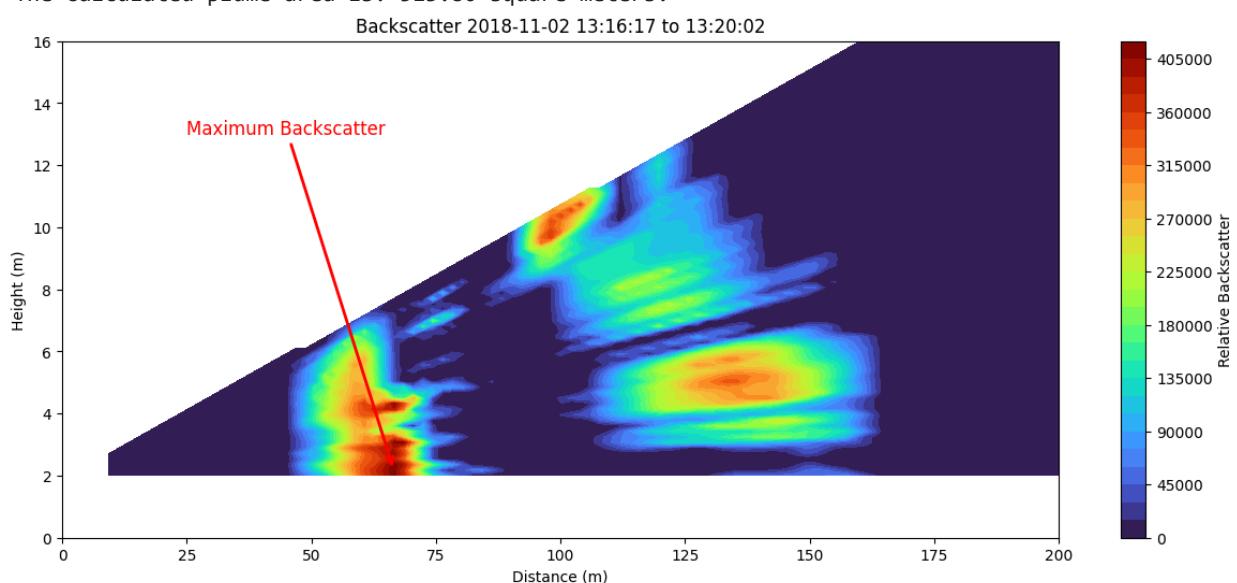
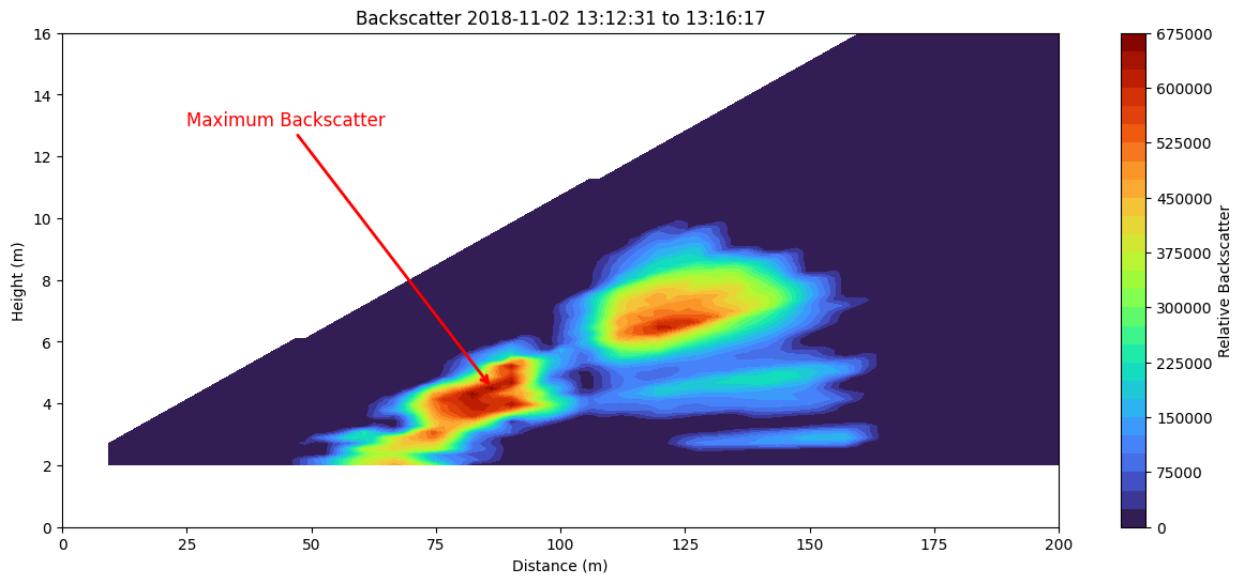
The calculated plume area is: 158.62 square meters.

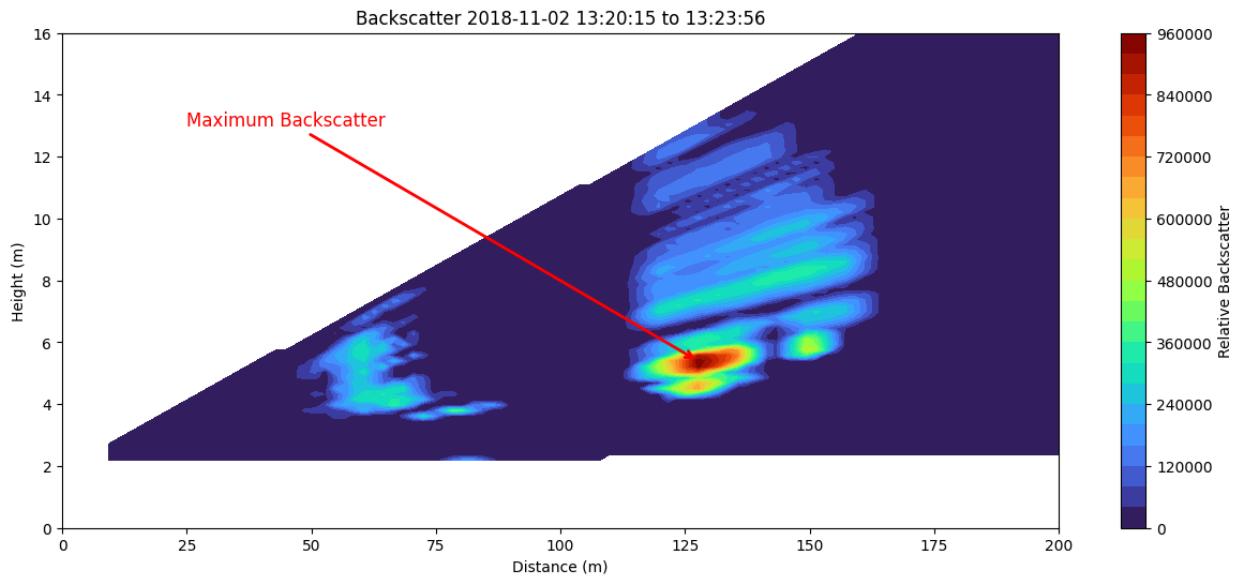


Maximum Backscatter Value: 653765.043 (Normalized)

Location (X, Z): (86.27 m, 4.50 m)

The calculated plume area is: 392.64 square meters.

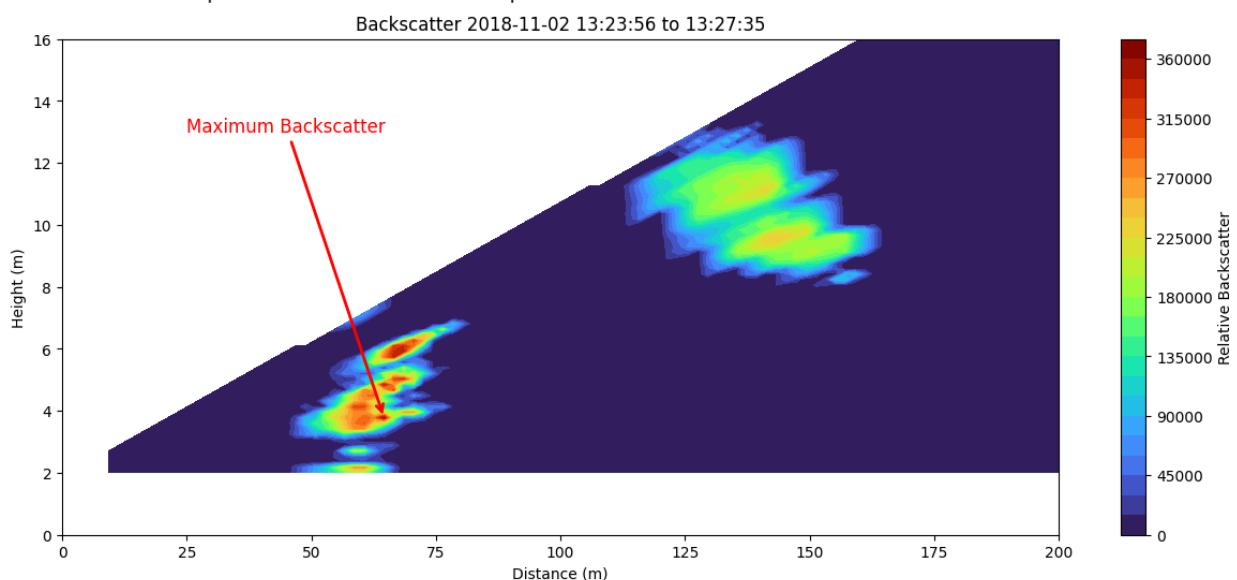




Maximum Backscatter Value: 360255.132 (Normalized)

Location (X, Z): (64.60 m, 3.78 m)

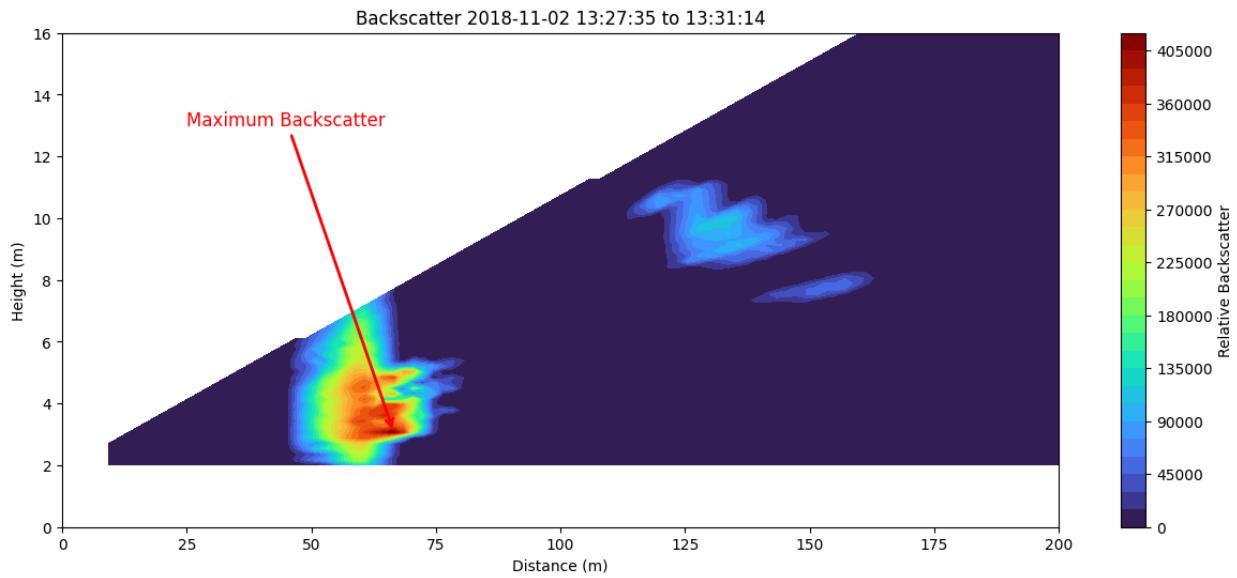
The calculated plume area is: 212.82 square meters.



Maximum Backscatter Value: 414386.691 (Normalized)

Location (X, Z): (66.57 m, 3.07 m)

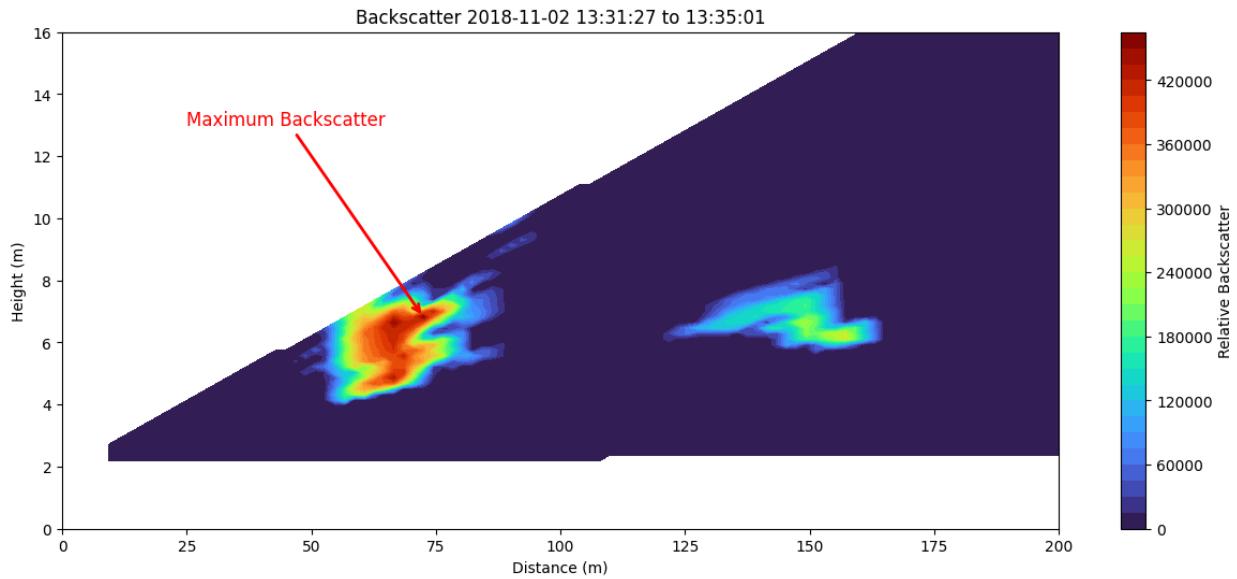
The calculated plume area is: 161.55 square meters.



Maximum Backscatter Value: 451702.942 (Normalized)

Location (X, Z): (72.48 m, 6.82 m)

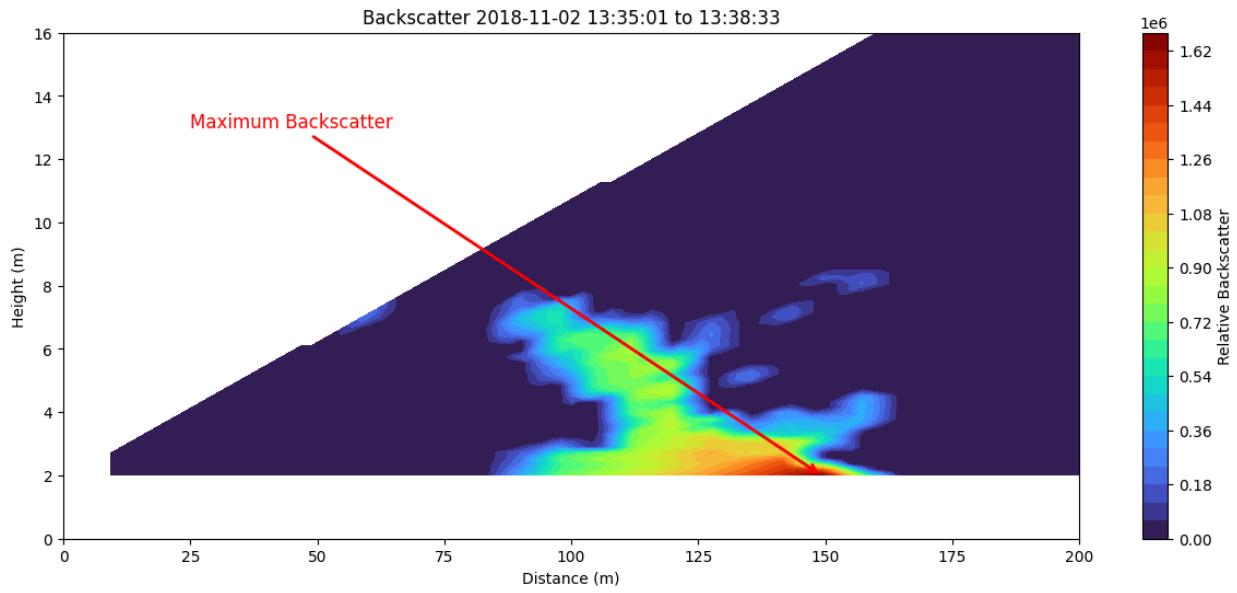
The calculated plume area is: 130.55 square meters.



Maximum Backscatter Value: 1667002.061 (Normalized)

Location (X, Z): (149.31 m, 2.00 m)

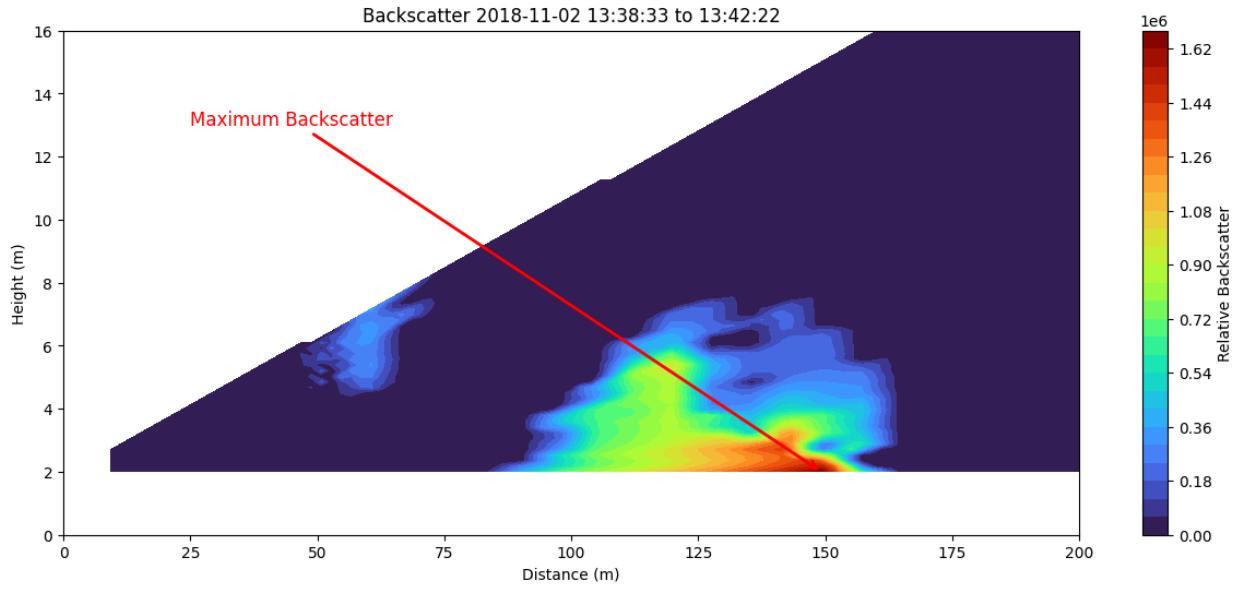
The calculated plume area is: 231.09 square meters.



Maximum Backscatter Value: 1665857.044 (Normalized)

Location (X, Z): (149.31 m, 2.00 m)

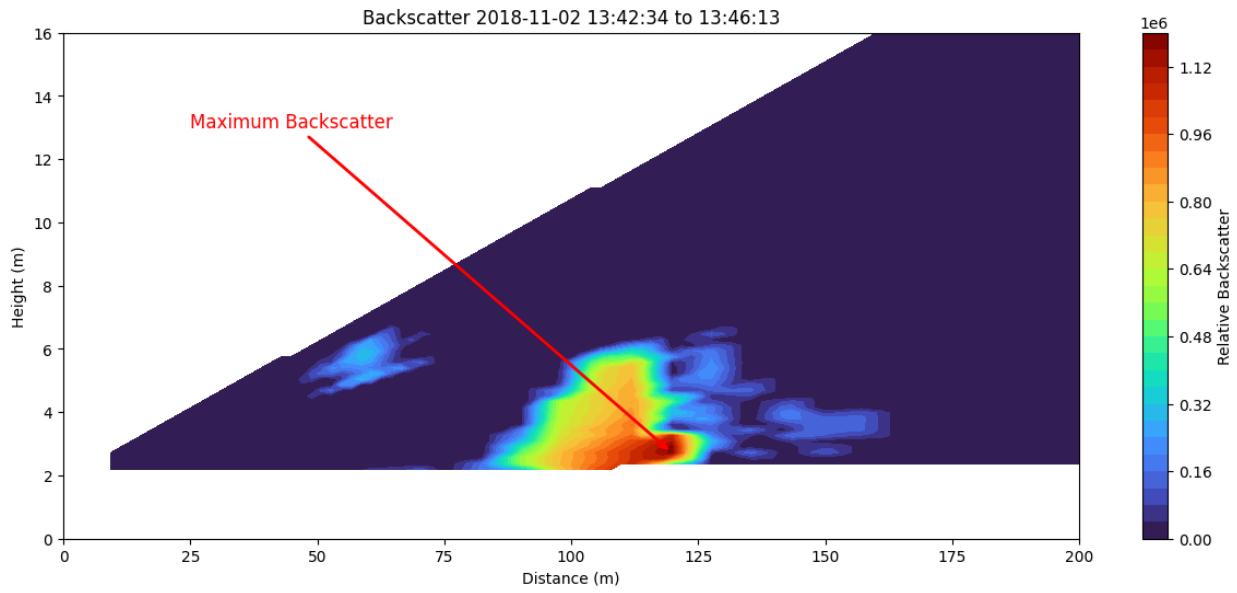
The calculated plume area is: 290.09 square meters.



Maximum Backscatter Value: 1175134.841 (Normalized)

Location (X, Z): (119.76 m, 2.73 m)

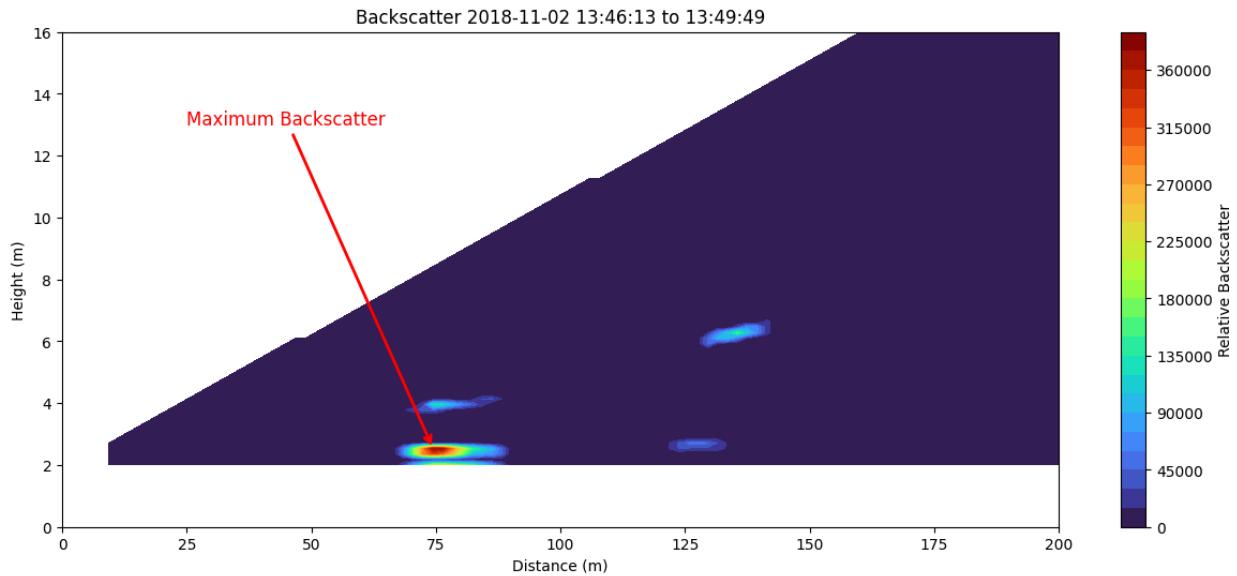
The calculated plume area is: 165.29 square meters.



Maximum Backscatter Value: 375099.458 (Normalized)

Location (X, Z): (74.45 m, 2.53 m)

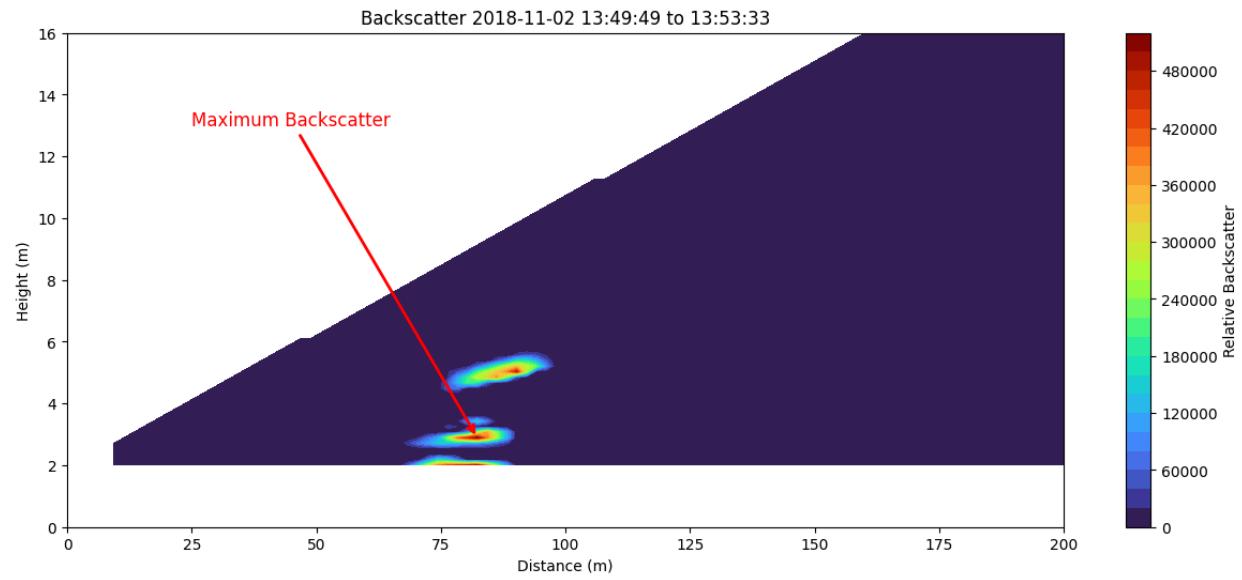
The calculated plume area is: 18.61 square meters.



Maximum Backscatter Value: 501085.243 (Normalized)

Location (X, Z): (82.33 m, 2.89 m)

The calculated plume area is: 25.99 square meters.



```
error processing 2018-11-02 13:53:33, 2018-11-02 13:55:18: QH6154 Qhull precision error: Initial simplex is flat (facet 1 is coplanar with the interior point)
```

```
While executing: | qhull d Qc Q12 Qbb Qt Qz
Options selected for Qhull 2019.1.r 2019/06/21:
  run-id 1544171889 delaunay Qcoplanar-keep Q12-allow-wide Qbbox-bound-last
  Qtriangulate Qz-infinity-point _pre-merge _zero-centrum Qinterior-keep
  Pgood _max-width 2e+02 Error-roundoff 2.8e-13 _one-merge 2e-12
  Visible-distance 5.6e-13 U-max-coplanar 5.6e-13 Width-outside 1.1e-12
  _wide-facet 3.4e-12 _maxoutside 2.2e-12
```

The input to qhull appears to be less than 3 dimensional, or a computation has overflowed.

Qhull could not construct a clearly convex simplex from points:

- p1(v4): 15 2 0.76
- p297(v3): 1e+02 2 2e+02
- p26(v2): 2e+02 2 1.8e+02
- p0(v1): 7.5 2 0

The center point is coplanar with a facet, or a vertex is coplanar with a neighboring facet. The maximum round off error for computing distances is 2.8e-13. The center point, facets and distances to the center point are as follows:

center point 82.5 2 96.83

```
facet p297 p26 p0 distance= 0
facet p1 p26 p0 distance= 0
facet p1 p297 p0 distance= 0
facet p1 p297 p26 distance= 0
```

These points either have a maximum or minimum x-coordinate, or they maximize the determinant for k coordinates. Trial points are first selected from points that maximize a coordinate.

The min and max coordinates for each dimension are:

0:	7.5	202.5	difference= 195
1:	2	2	difference= 0
2:	0	202.5	difference= 202.5

If the input should be full dimensional, you have several options that may determine an initial simplex:

- use 'QJ' to joggle the input and make it full dimensional
- use 'QbB' to scale the points to the unit cube
- use 'QR0' to randomly rotate the input for different maximum points
- use 'Qs' to search all points for the initial simplex
- use 'En' to specify a maximum roundoff error less than 2.8e-13.
- trace execution with 'T3' to see the determinant for each point.

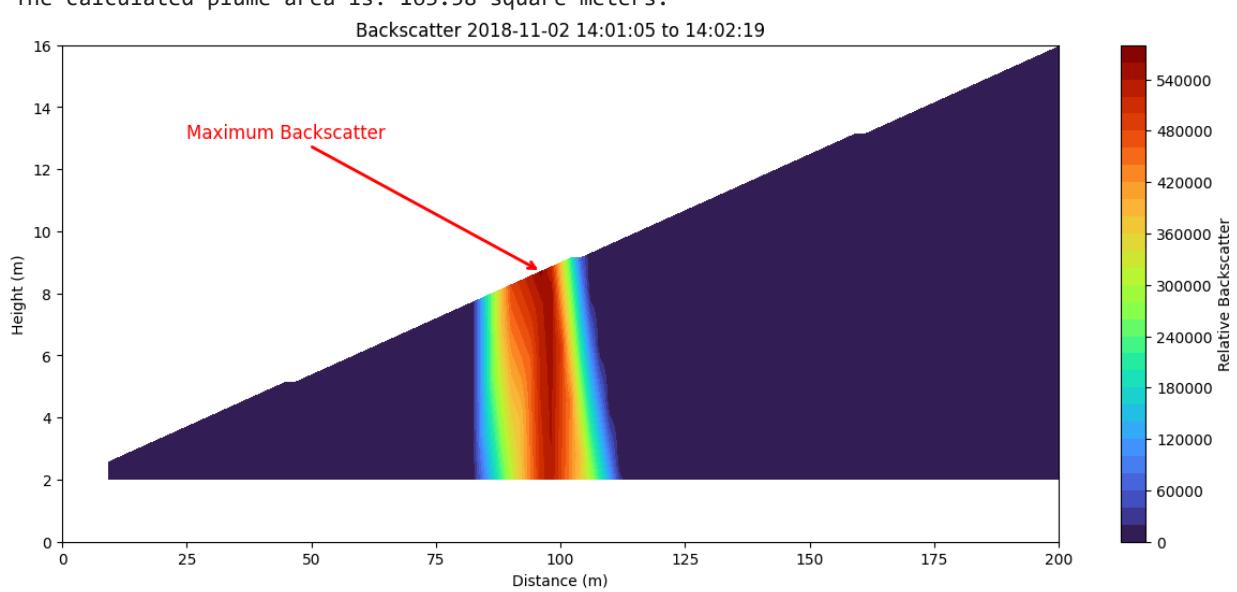
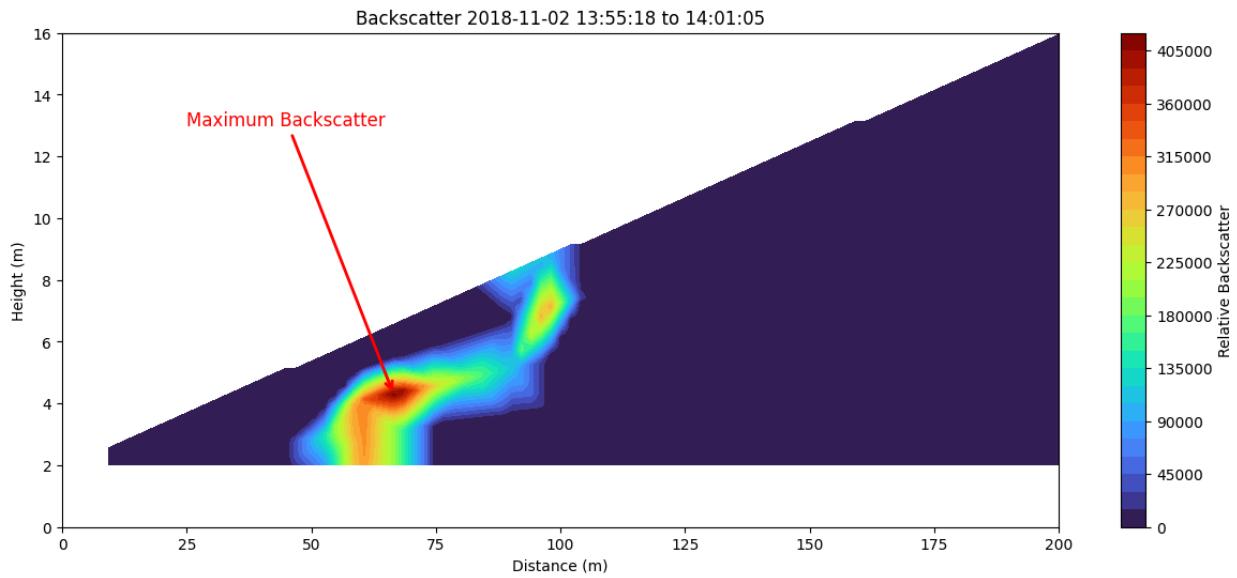
If the input is lower dimensional:

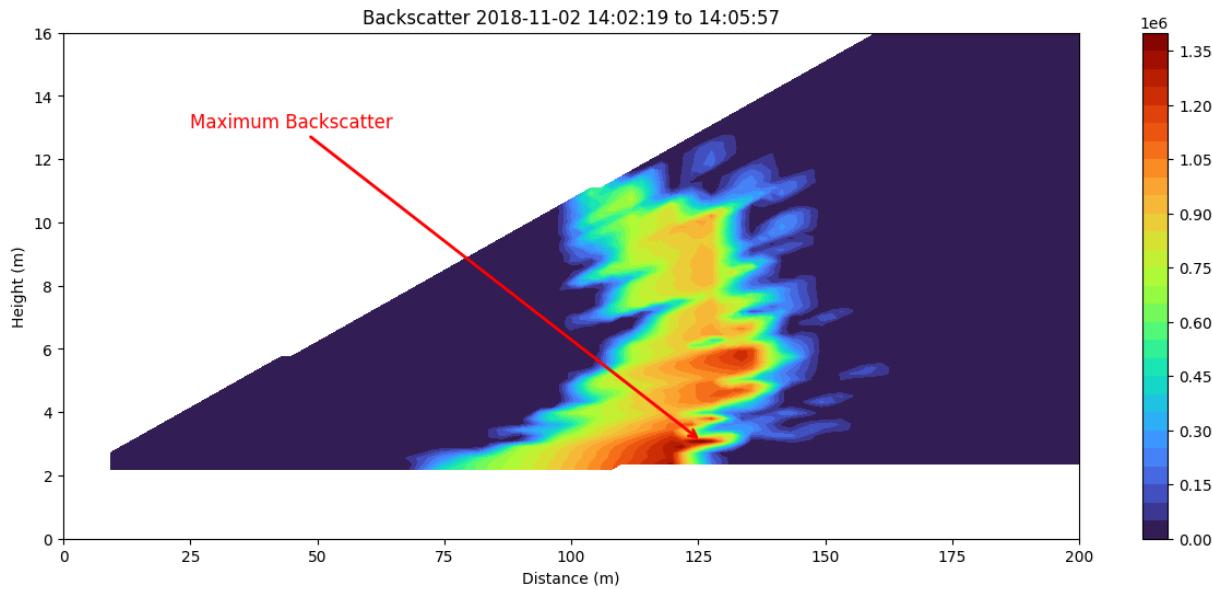
- use 'QJ' to joggle the input and make it full dimensional
- use 'Qbk:0Bk:0' to delete coordinate k from the input. You should pick the coordinate with the least range. The hull will have the correct topology.
- determine the flat containing the points, rotate the points into a coordinate plane, and delete the other coordinates.
- add one or more points to make the input full dimensional.

Maximum Backscatter Value: 409455.486 (Normalized)

Location (X, Z): (66.58 m, 4.28 m)

The calculated plume area is: 152.62 square meters.

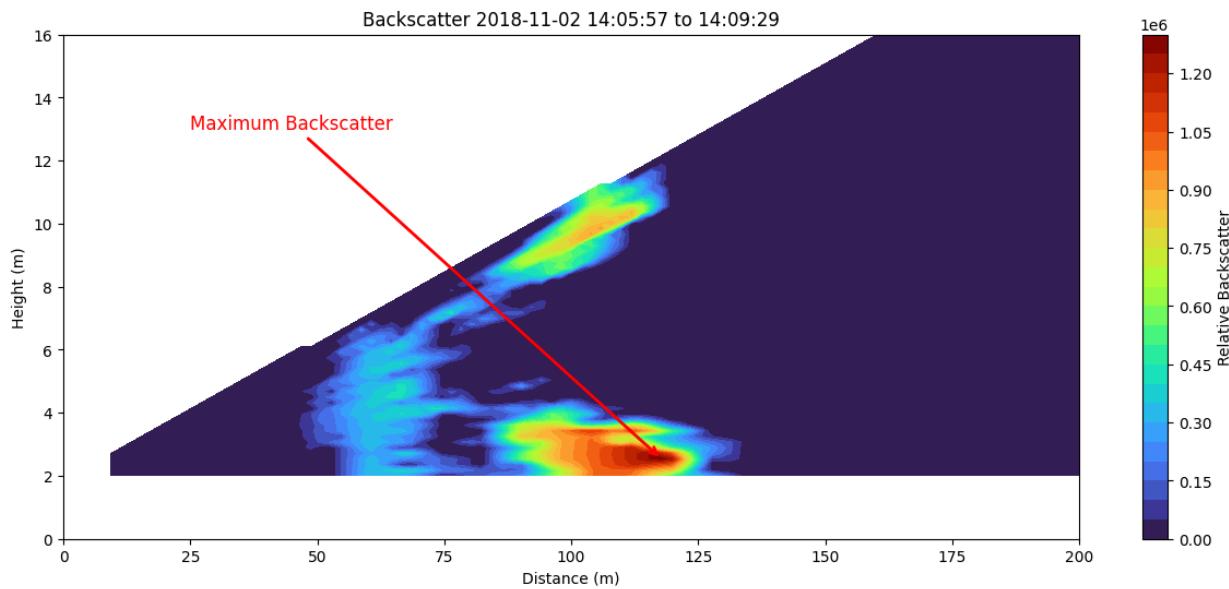




Maximum Backscatter Value: 1271804.048 (Normalized)

Location (X, Z): (117.79 m, 2.53 m)

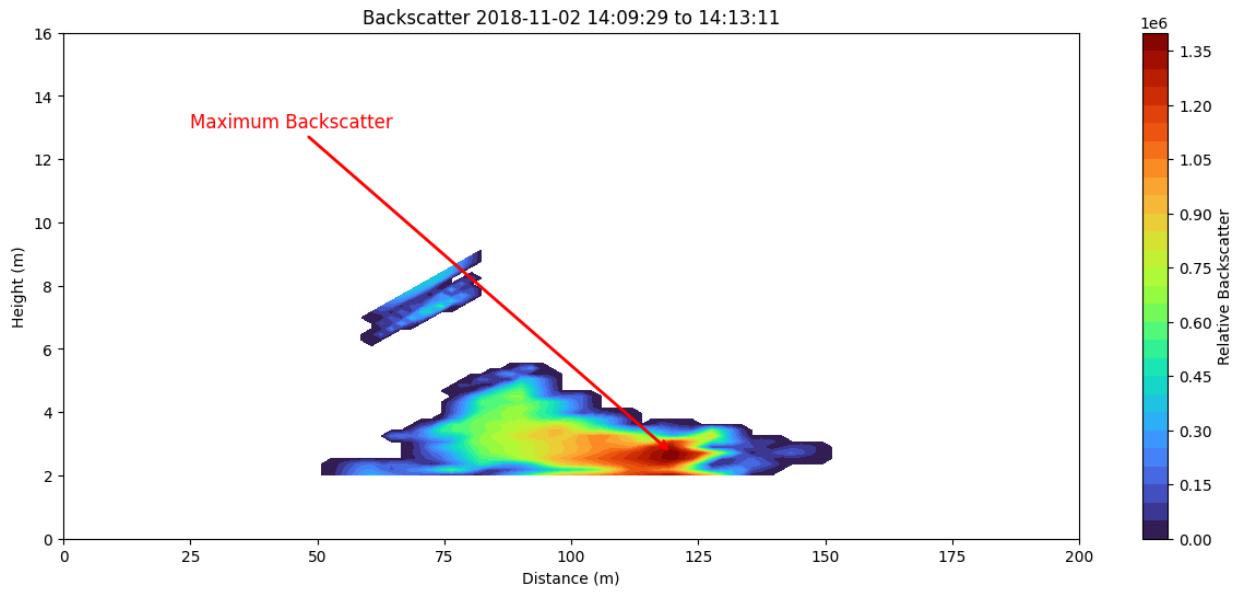
The calculated plume area is: 249.35 square meters.



Maximum Backscatter Value: 1388240.404 (Normalized)

Location (X, Z): (119.76 m, 2.71 m)

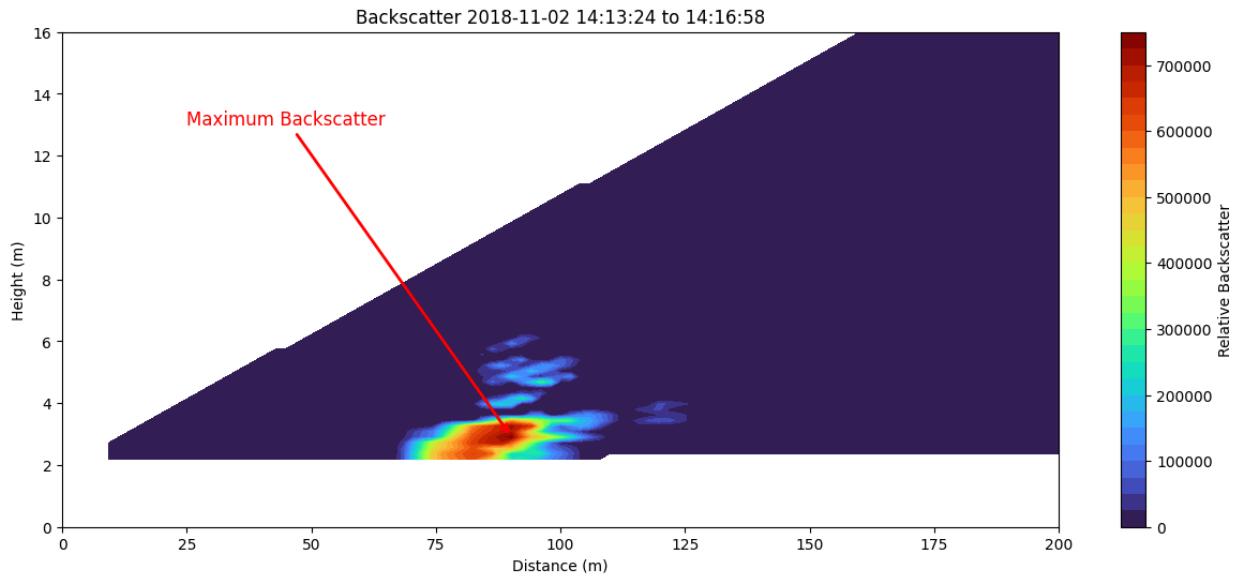
The calculated plume area is: 152.42 square meters.



Maximum Backscatter Value: 733239.921 (Normalized)

Location (X, Z): (90.21 m, 2.90 m)

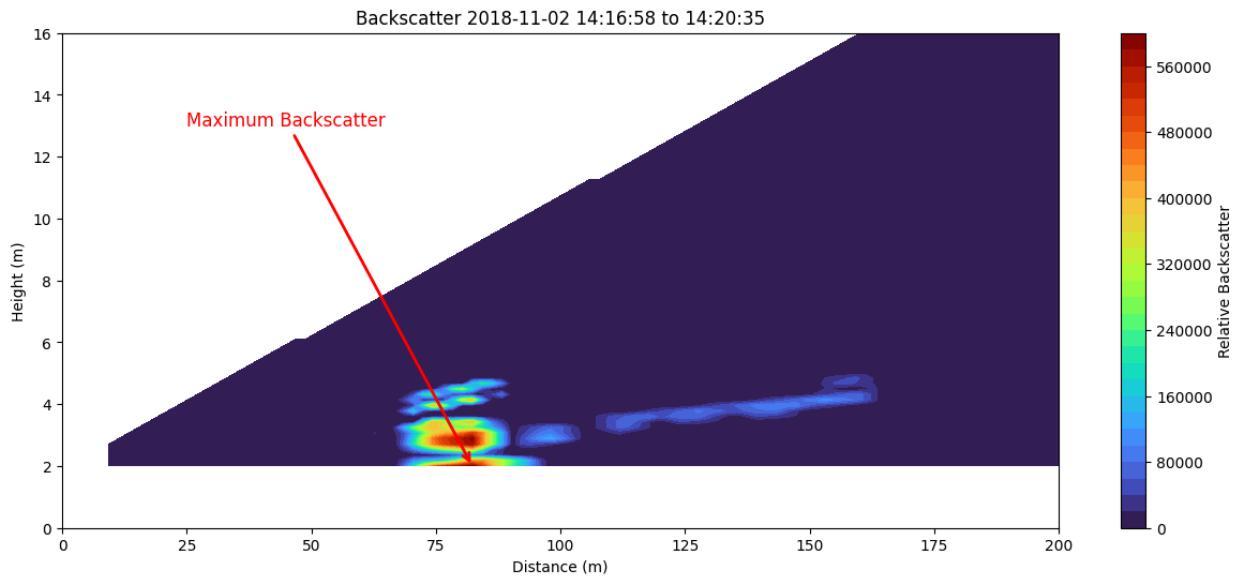
The calculated plume area is: 55.80 square meters.



Maximum Backscatter Value: 593969.677 (Normalized)

Location (X, Z): (82.33 m, 2.00 m)

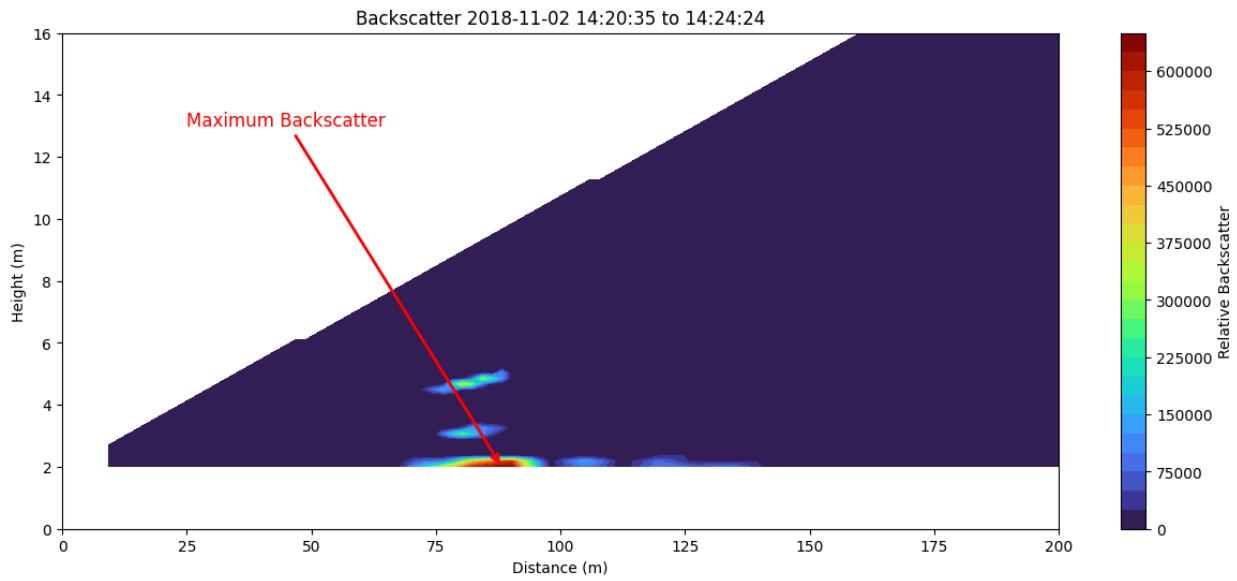
The calculated plume area is: 54.44 square meters.



Maximum Backscatter Value: 632328.966 (Normalized)

Location (X, Z): (88.24 m, 2.00 m)

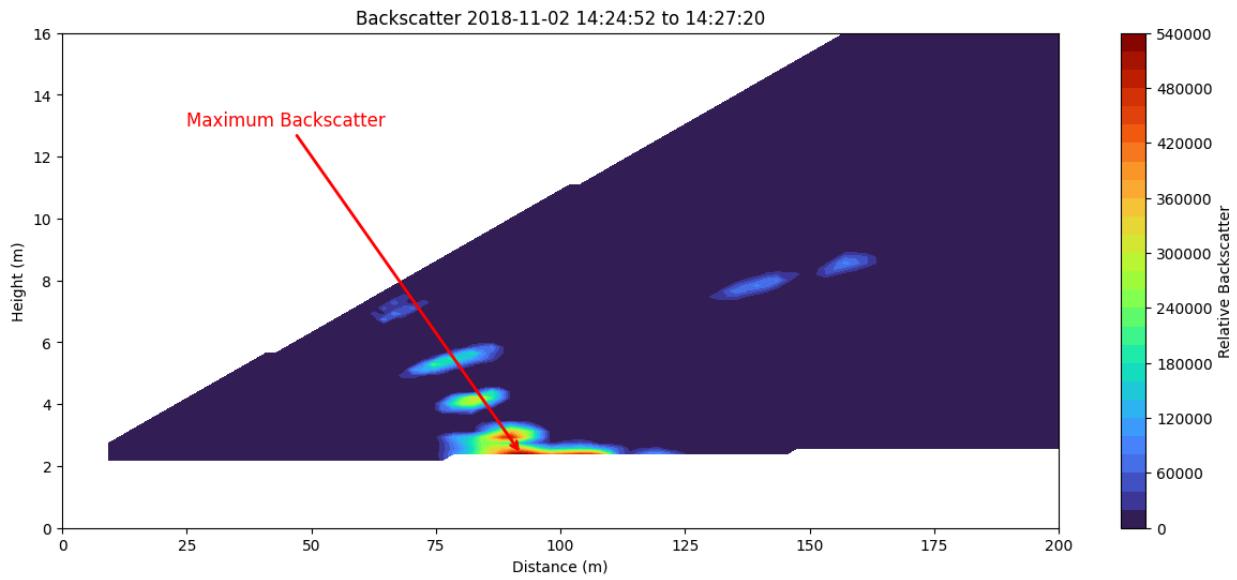
The calculated plume area is: 22.83 square meters.



Maximum Backscatter Value: 534498.419 (Normalized)

Location (X, Z): (92.18 m, 2.38 m)

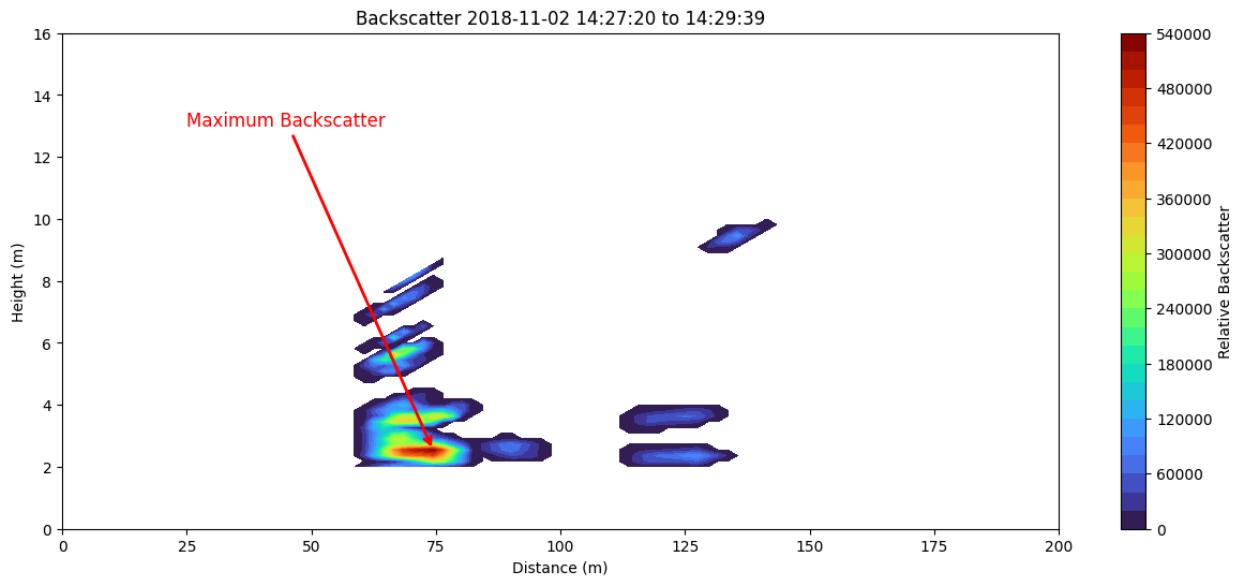
The calculated plume area is: 45.44 square meters.



Maximum Backscatter Value: 528622.567 (Normalized)

Location (X, Z): (74.45 m, 2.55 m)

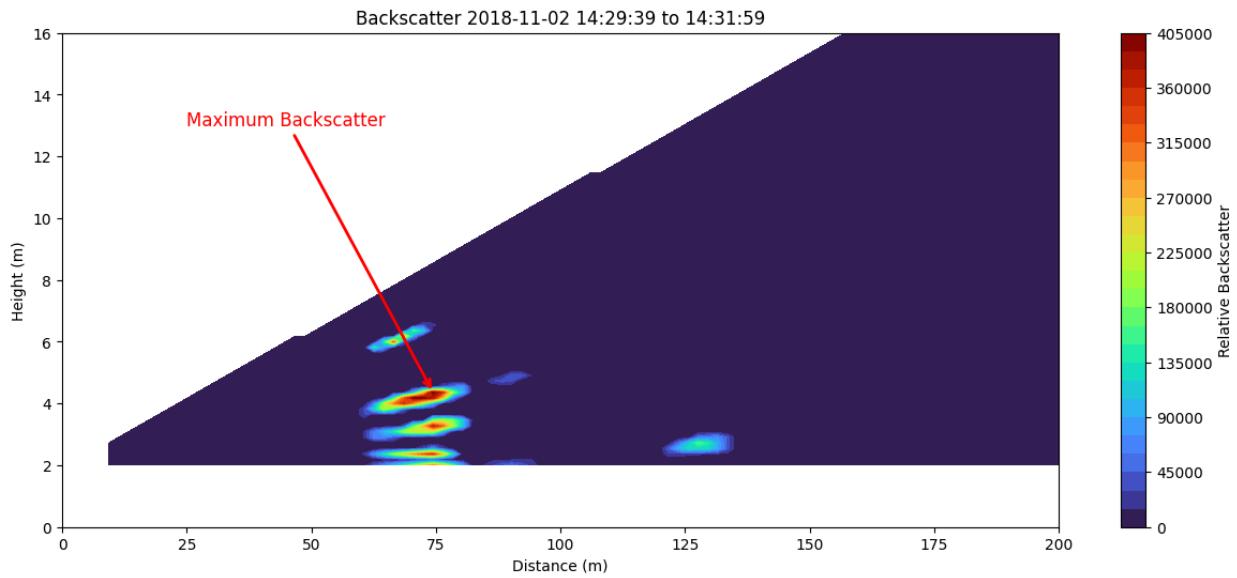
The calculated plume area is: 48.00 square meters.



Maximum Backscatter Value: 399701.505 (Normalized)

Location (X, Z): (74.45 m, 4.36 m)

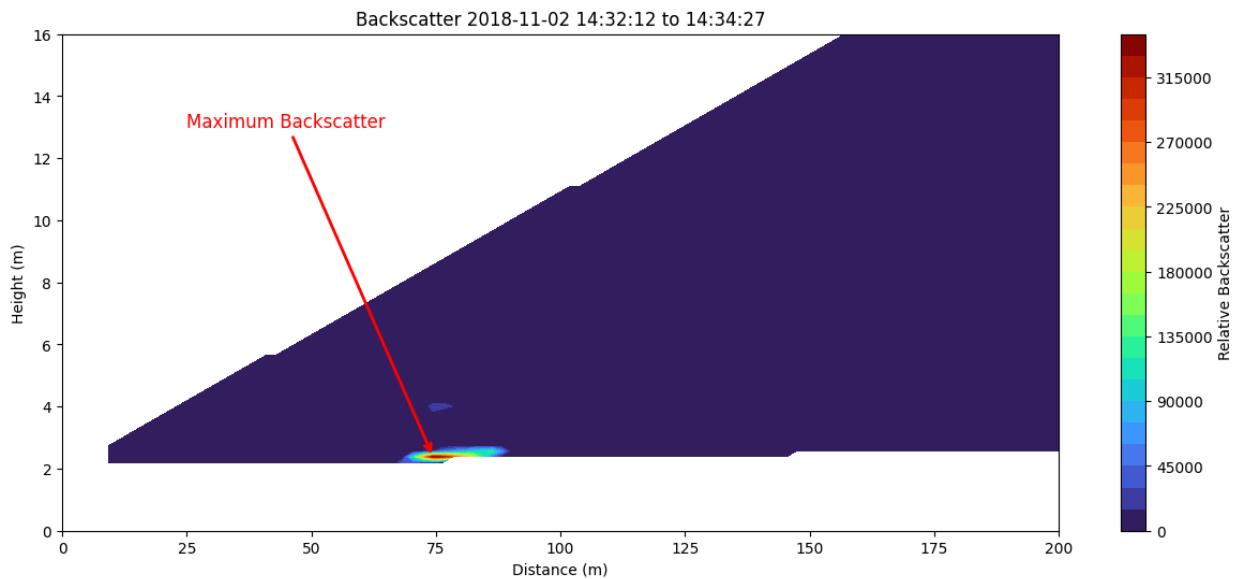
The calculated plume area is: 33.31 square meters.



Maximum Backscatter Value: 330966.614 (Normalized)

Location (X, Z): (74.45 m, 2.38 m)

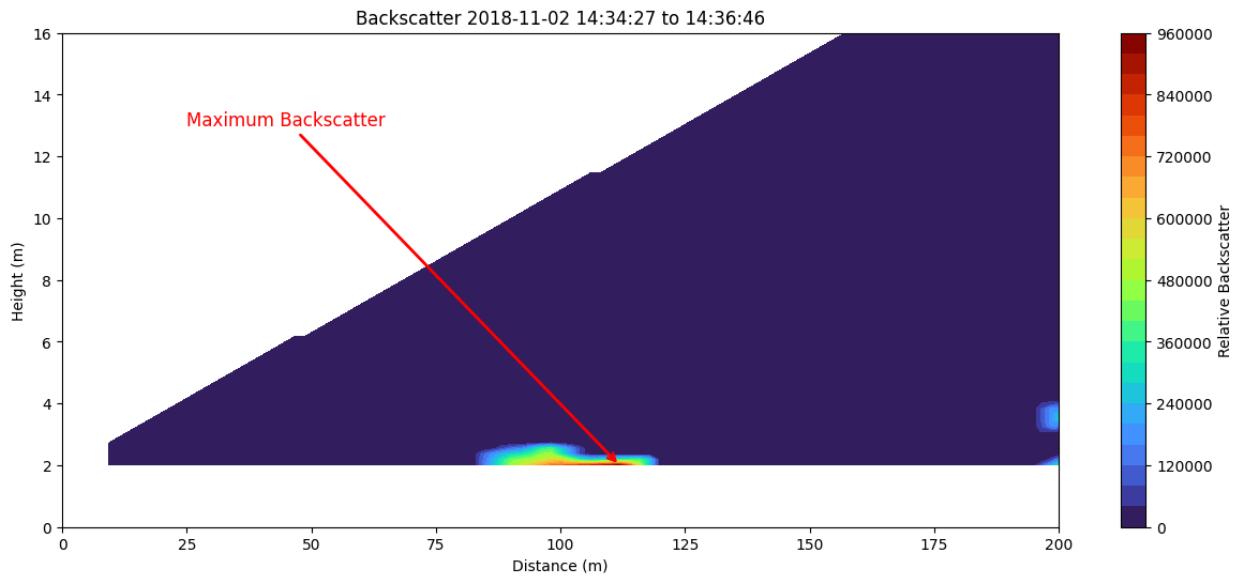
The calculated plume area is: 6.08 square meters.



Maximum Backscatter Value: 935010.948 (Normalized)

Location (X, Z): (111.88 m, 2.00 m)

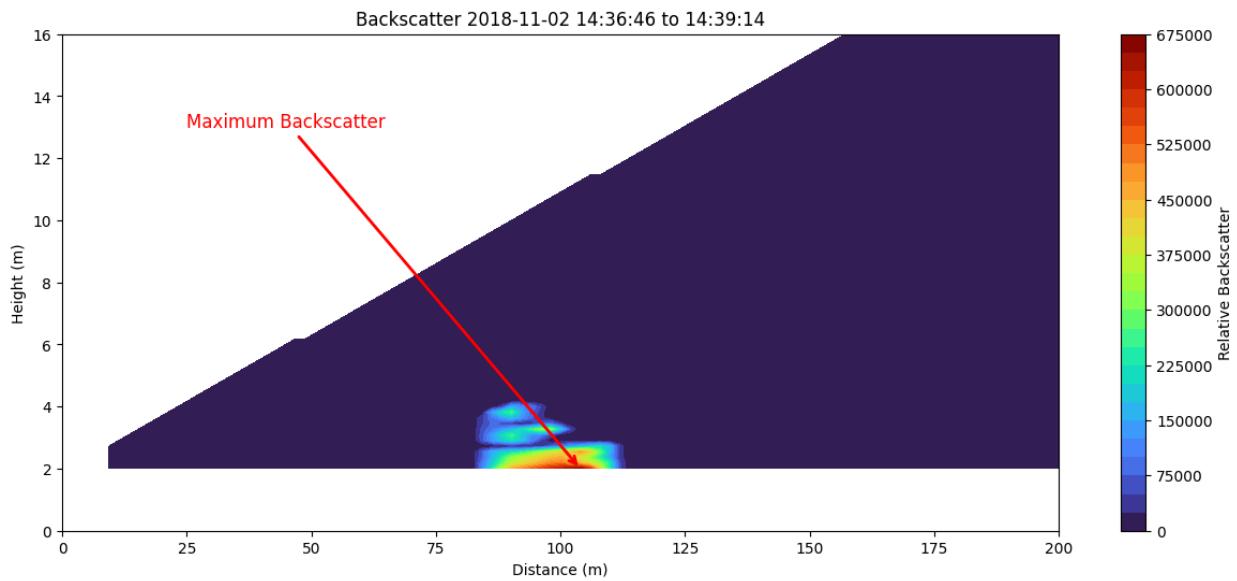
The calculated plume area is: 23.64 square meters.



Maximum Backscatter Value: 665310.975 (Normalized)

Location (X, Z): (104.00 m, 2.00 m)

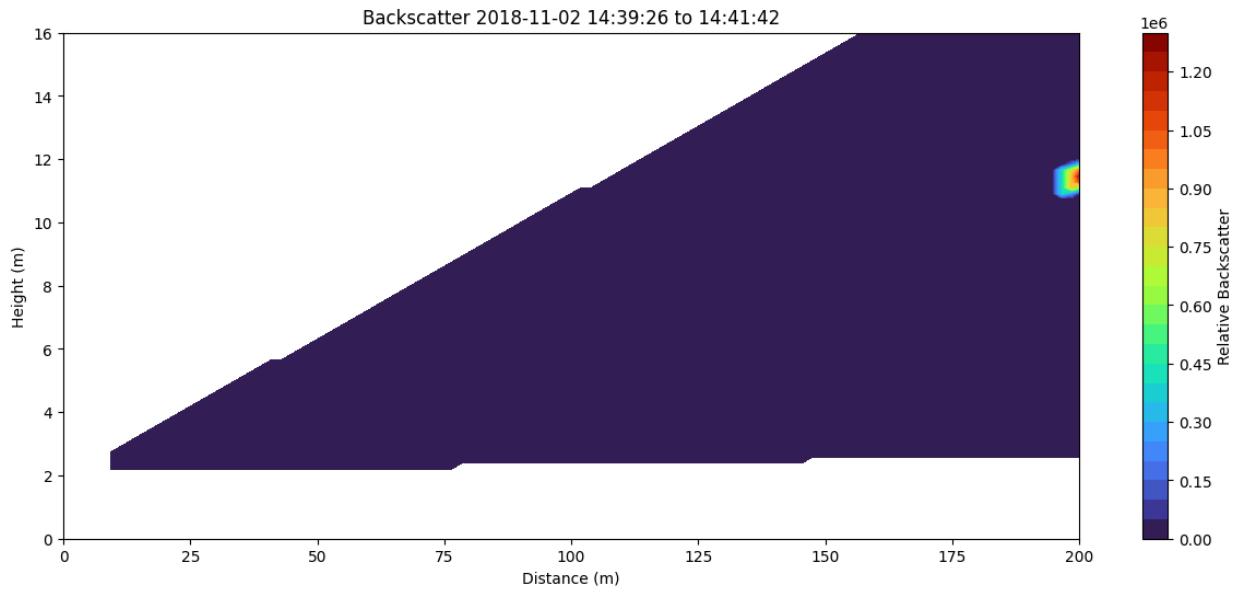
The calculated plume area is: 35.10 square meters.



Maximum Backscatter Value: 1284626.117 (Normalized)

Location (X, Z): (200.53 m, 11.46 m)

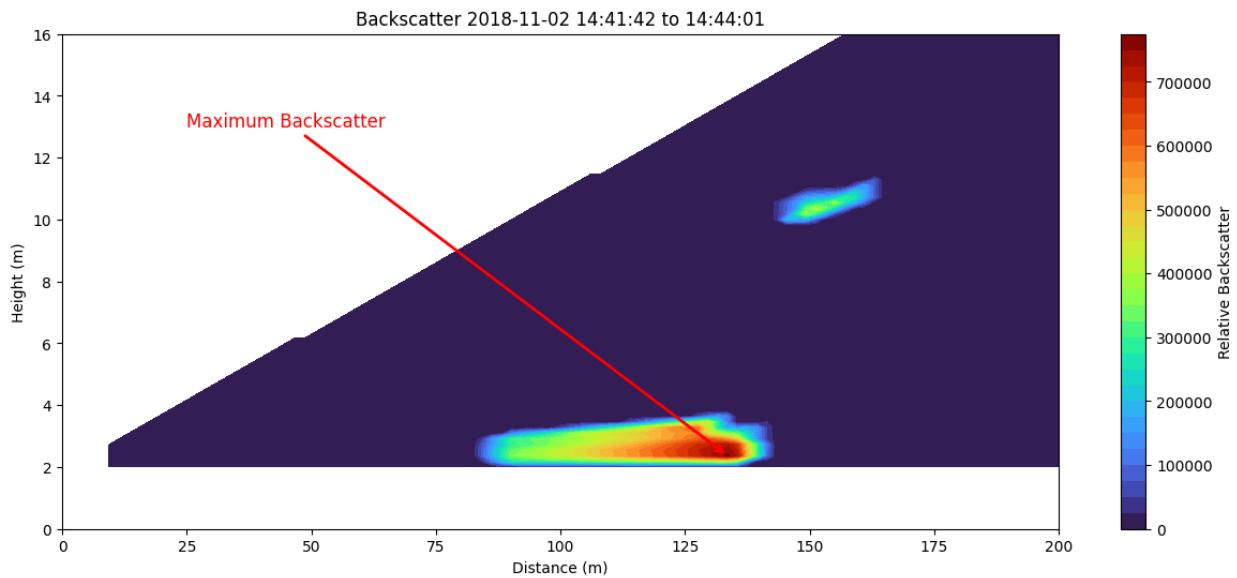
The calculated plume area is: 5.72 square meters.



Maximum Backscatter Value: 758162.075 (Normalized)

Location (X, Z): (133.55 m, 2.36 m)

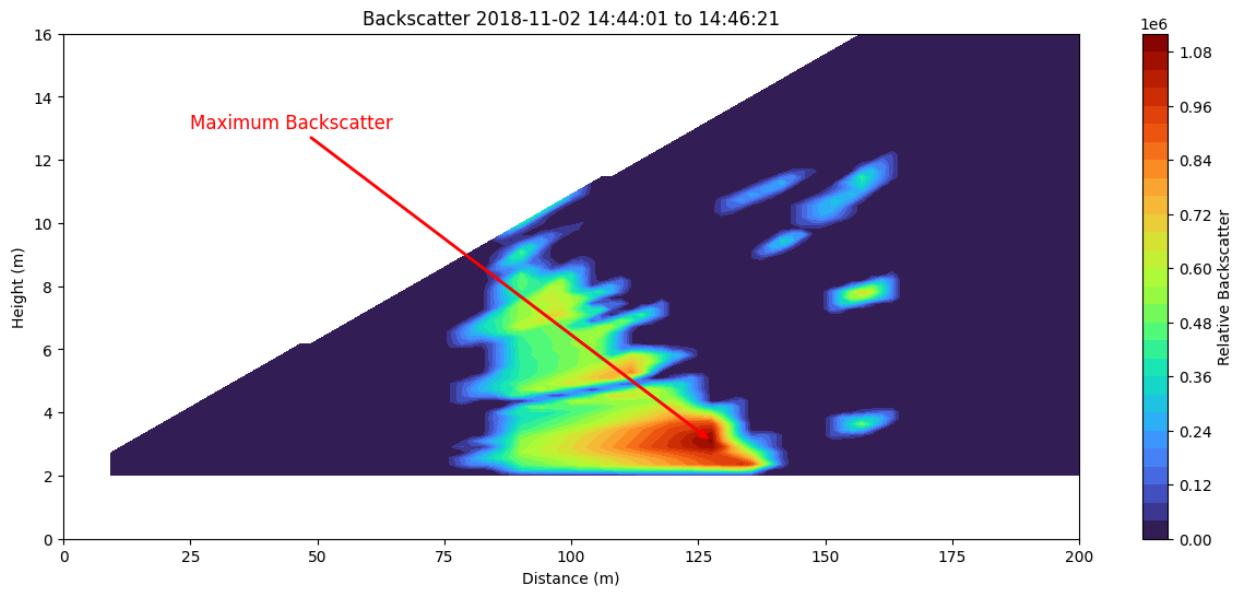
The calculated plume area is: 87.76 square meters.



Maximum Backscatter Value: 1084176.572 (Normalized)

Location (X, Z): (127.64 m, 3.09 m)

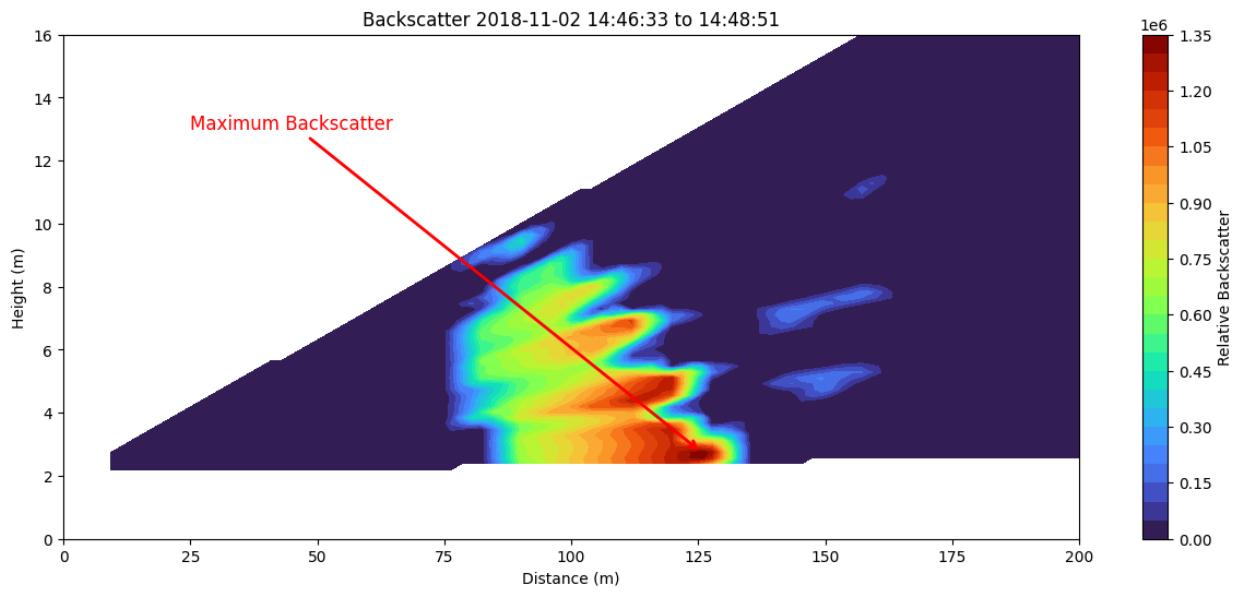
The calculated plume area is: 306.98 square meters.



Maximum Backscatter Value: 1330135.276 (Normalized)

Location (X, Z): (125.67 m, 2.75 m)

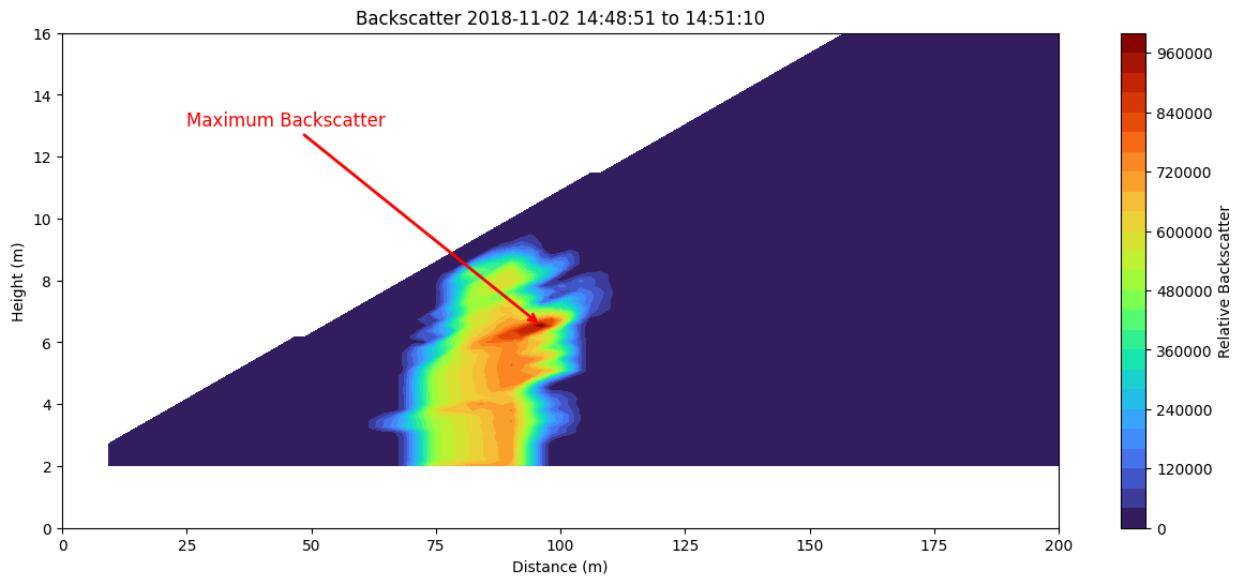
The calculated plume area is: 288.40 square meters.



Maximum Backscatter Value: 993741.241 (Normalized)

Location (X, Z): (96.12 m, 6.55 m)

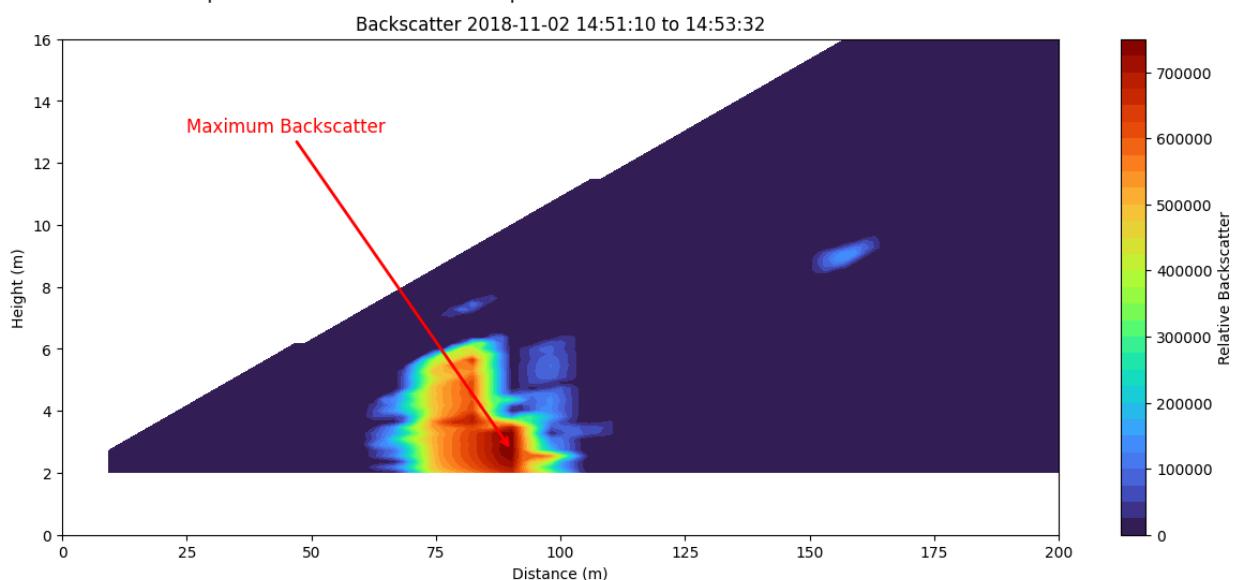
The calculated plume area is: 205.61 square meters.



Maximum Backscatter Value: 743387.348 (Normalized)

Location (X, Z): (90.21 m, 2.73 m)

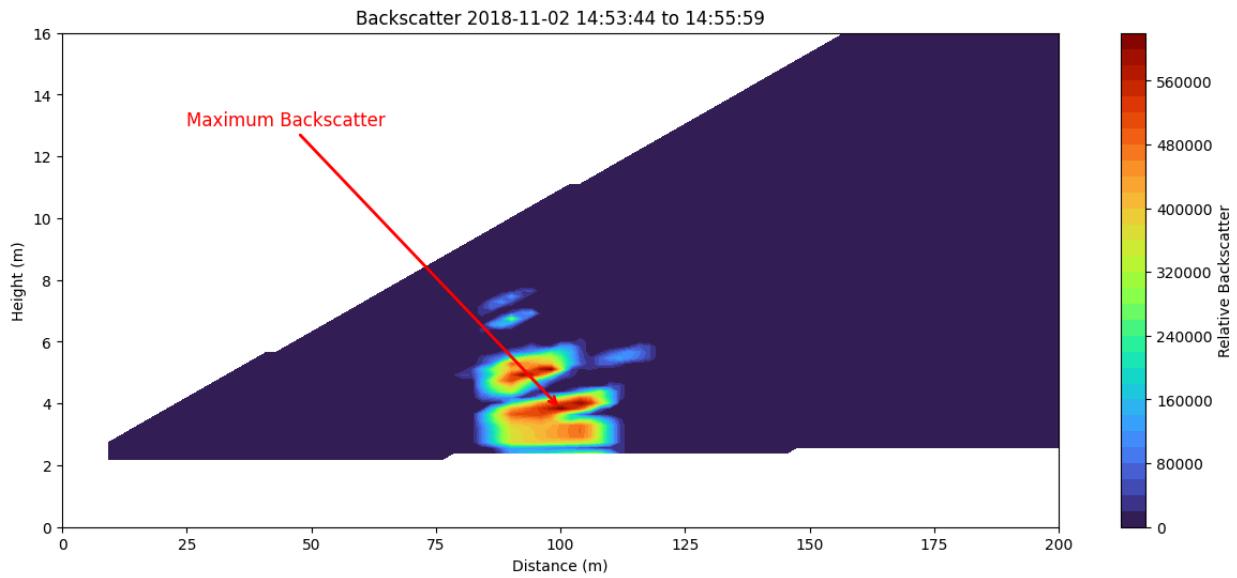
The calculated plume area is: 132.54 square meters.



Maximum Backscatter Value: 612033.712 (Normalized)

Location (X, Z): (100.06 m, 3.84 m)

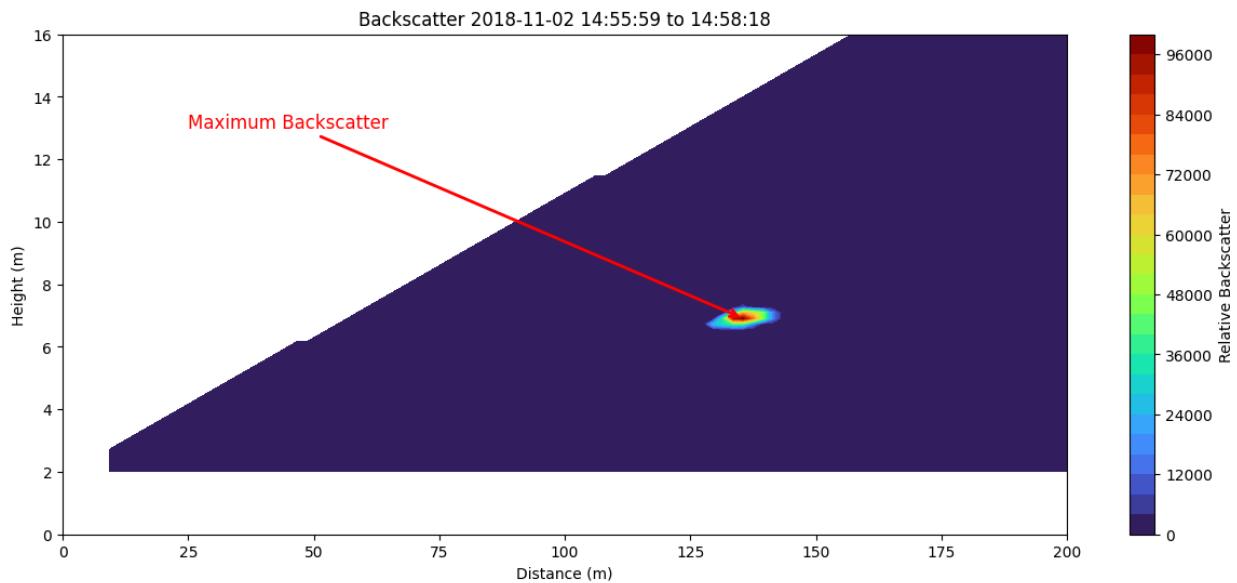
The calculated plume area is: 80.51 square meters.



Maximum Backscatter Value: 97716.168 (Normalized)

Location (X, Z): (135.52 m, 6.91 m)

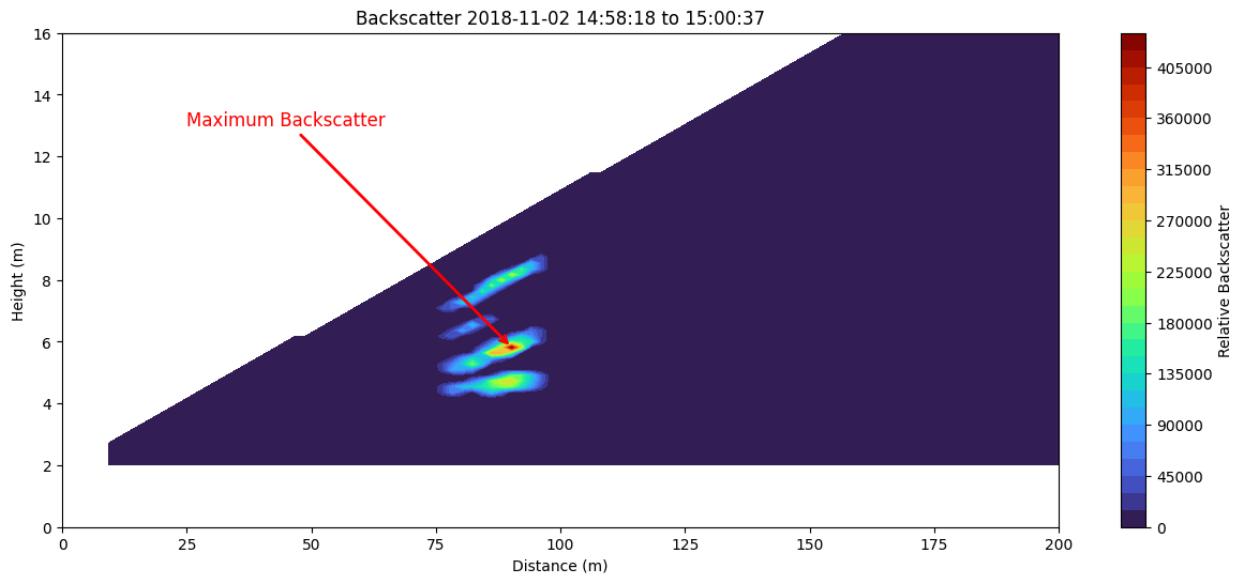
The calculated plume area is: 5.73 square meters.



Maximum Backscatter Value: 423487.127 (Normalized)

Location (X, Z): (90.21 m, 5.82 m)

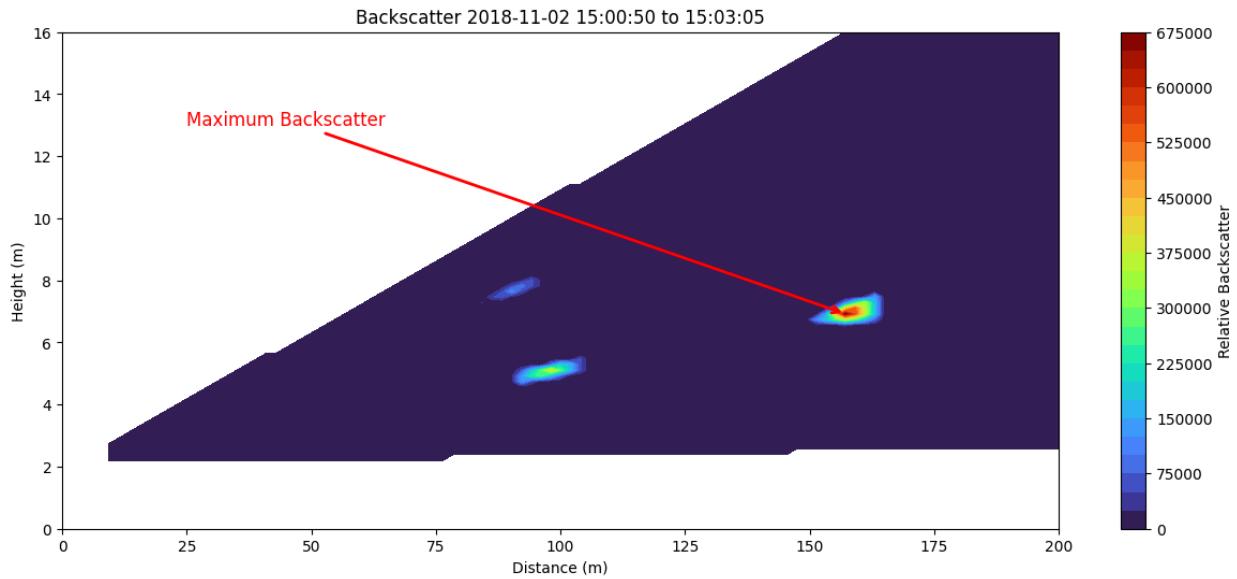
The calculated plume area is: 28.66 square meters.



Maximum Backscatter Value: 659682.290 (Normalized)

Location (X, Z): (157.19 m, 6.92 m)

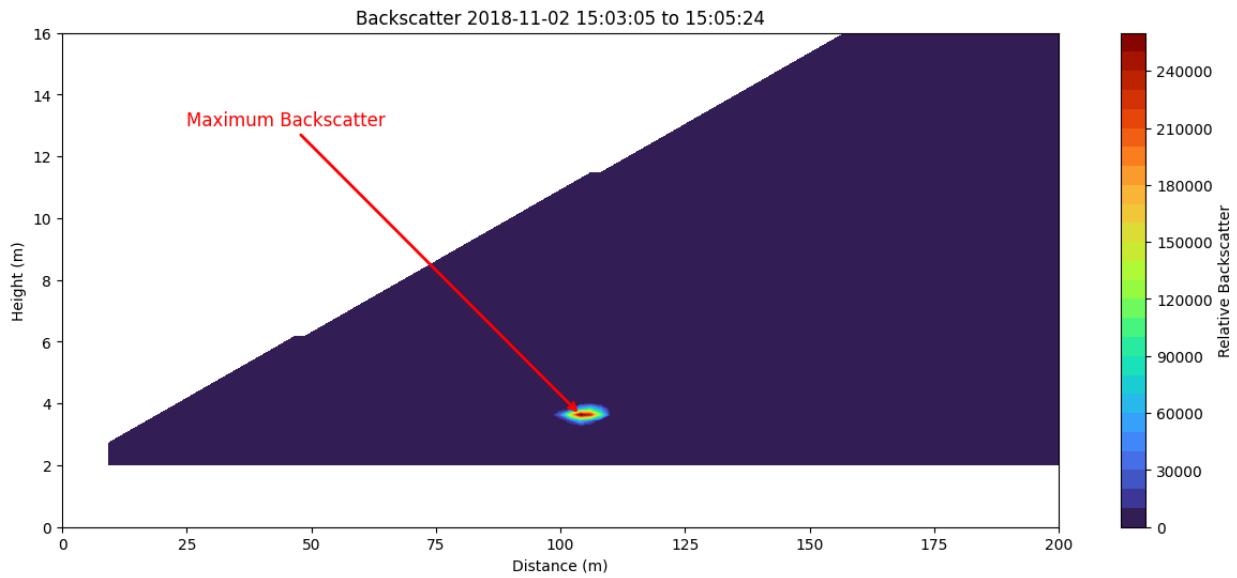
The calculated plume area is: 13.95 square meters.



Maximum Backscatter Value: 256046.209 (Normalized)

Location (X, Z): (104.00 m, 3.64 m)

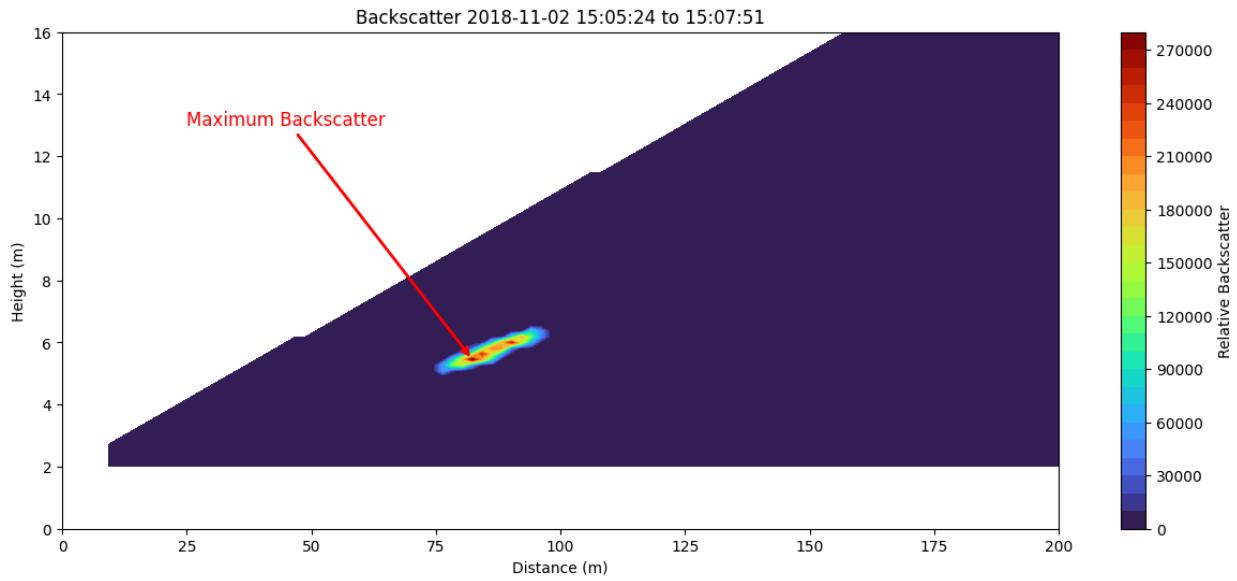
The calculated plume area is: 3.58 square meters.



Maximum Backscatter Value: 272365.127 (Normalized)

Location (X, Z): (82.33 m, 5.45 m)

The calculated plume area is: 11.10 square meters.



```
error processing 2018-11-02 15:07:51, 2018-11-02 15:13:05: QH6154 Qhull precision error: Initial simplex is flat (facet 1 is coplanar with the interior point)
```

```
While executing: | qhull d Qc Q12 Qbb Qt Qz
Options selected for Qhull 2019.1.r 2019/06/21:
  run-id 1544272731 delaunay Qcoplanar-keep Q12-allow-wide Qbbound-last
  Qtriangulate Qz-infinity-point _pre-merge _zero-centrum Qinterior-keep
  Pgood _max-width 2e+02 Error-roundoff 2.8e-13 _one-merge 2e-12
  Visible-distance 5.6e-13 U-max-coplanar 5.6e-13 Width-outside 1.1e-12
  _wide-facet 3.4e-12 _maxoutside 2.2e-12
```

The input to qhull appears to be less than 3 dimensional, or a computation has overflowed.

Qhull could not construct a clearly convex simplex from points:

- p1(v4): 15 2 0.76
- p243(v3): 1e+02 2 2e+02
- p26(v2): 2e+02 2 1.8e+02
- p0(v1): 7.5 2 0

The center point is coplanar with a facet, or a vertex is coplanar with a neighboring facet. The maximum round off error for computing distances is 2.8e-13. The center point, facets and distances to the center point are as follows:

center point 82.5 2 96.83

```
facet p243 p26 p0 distance= 0
facet p1 p26 p0 distance= 0
facet p1 p243 p0 distance= 0
facet p1 p243 p26 distance= 0
```

These points either have a maximum or minimum x-coordinate, or they maximize the determinant for k coordinates. Trial points are first selected from points that maximize a coordinate.

The min and max coordinates for each dimension are:

0:	7.5	202.5	difference= 195
1:	2	2	difference= 0
2:	0	202.5	difference= 202.5

If the input should be full dimensional, you have several options that may determine an initial simplex:

- use 'QJ' to joggle the input and make it full dimensional
- use 'QbB' to scale the points to the unit cube
- use 'QR0' to randomly rotate the input for different maximum points
- use 'Qs' to search all points for the initial simplex
- use 'En' to specify a maximum roundoff error less than 2.8e-13.
- trace execution with 'T3' to see the determinant for each point.

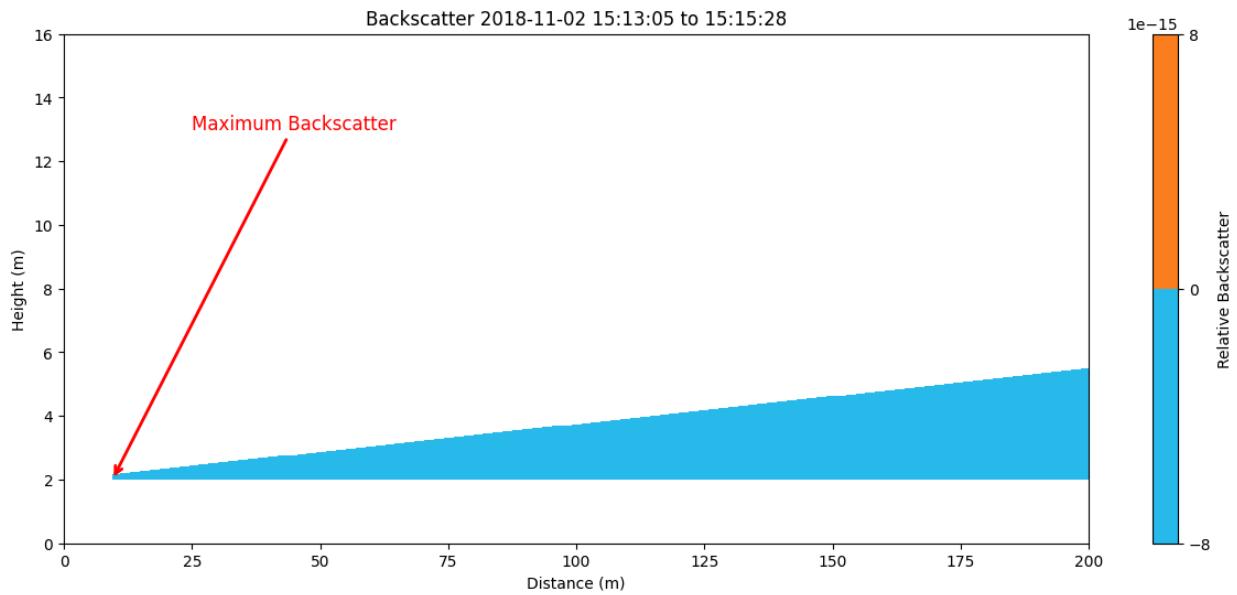
If the input is lower dimensional:

- use 'QJ' to joggle the input and make it full dimensional
- use 'Qbk:0Bk:0' to delete coordinate k from the input. You should pick the coordinate with the least range. The hull will have the correct topology.
- determine the flat containing the points, rotate the points into a coordinate plane, and delete the other coordinates.
- add one or more points to make the input full dimensional.

Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.47 m, 2.00 m)

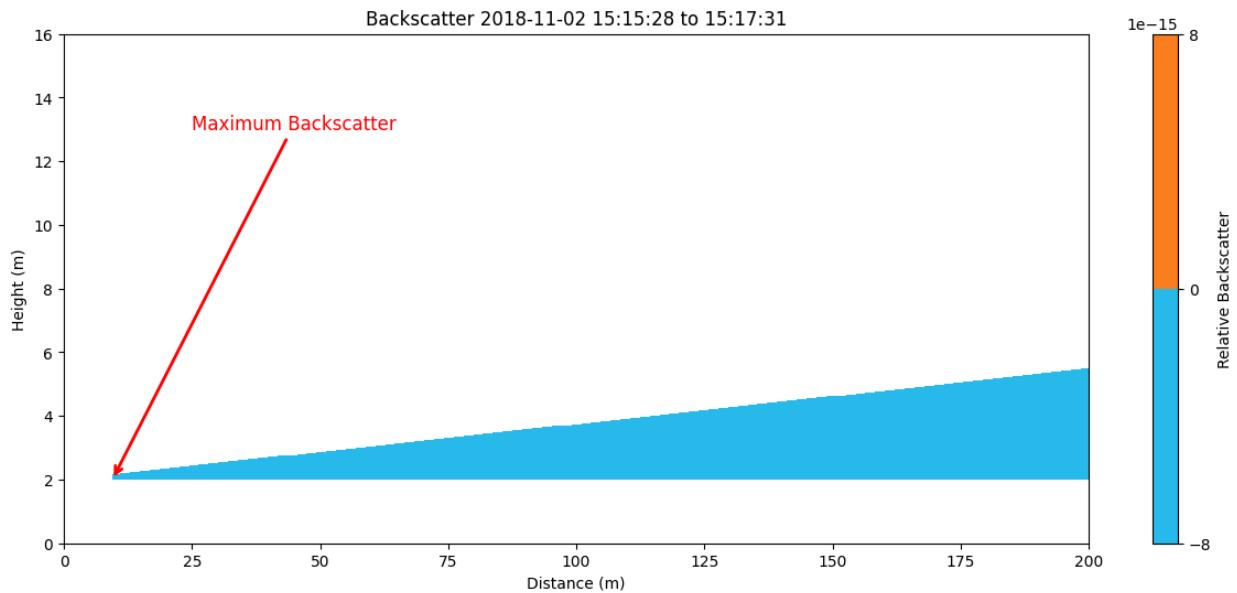
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.47 m, 2.00 m)

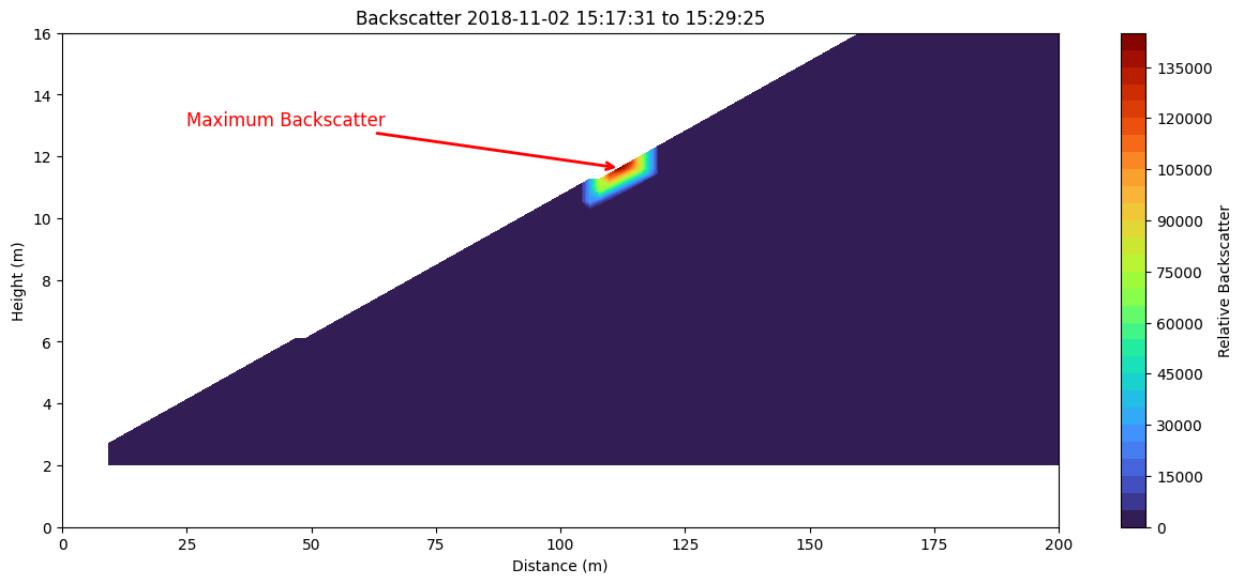
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 141275.119 (Normalized)

Location (X, Z): (111.88 m, 11.63 m)

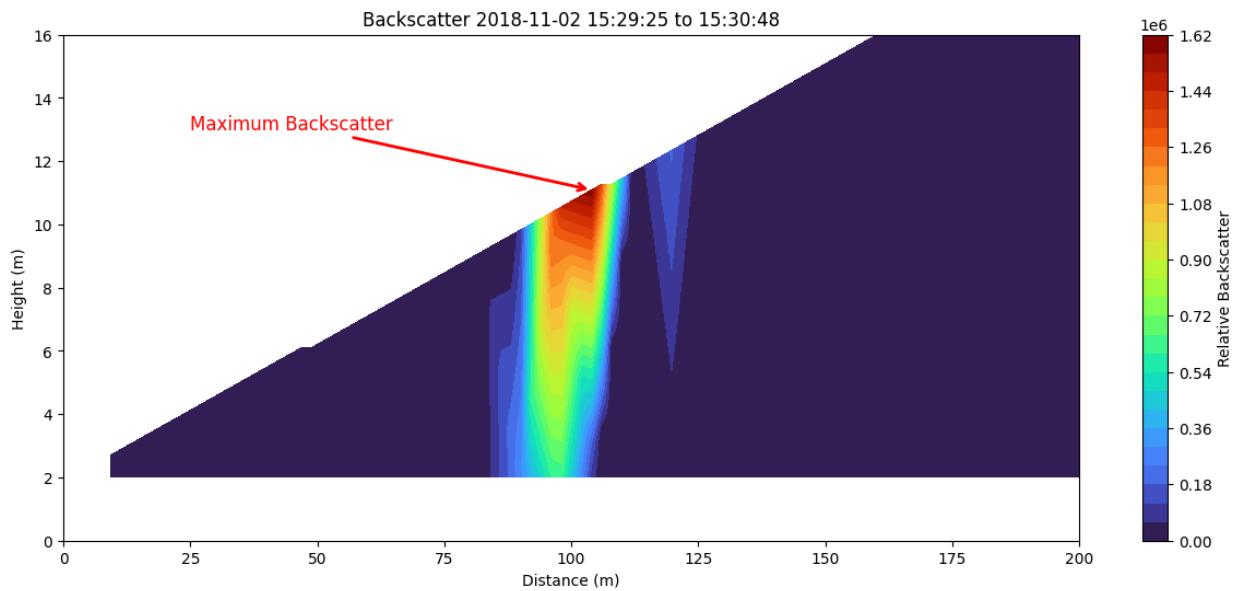
The calculated plume area is: 11.94 square meters.



Maximum Backscatter Value: 1594812.884 (Normalized)

Location (X, Z): (104.00 m, 11.09 m)

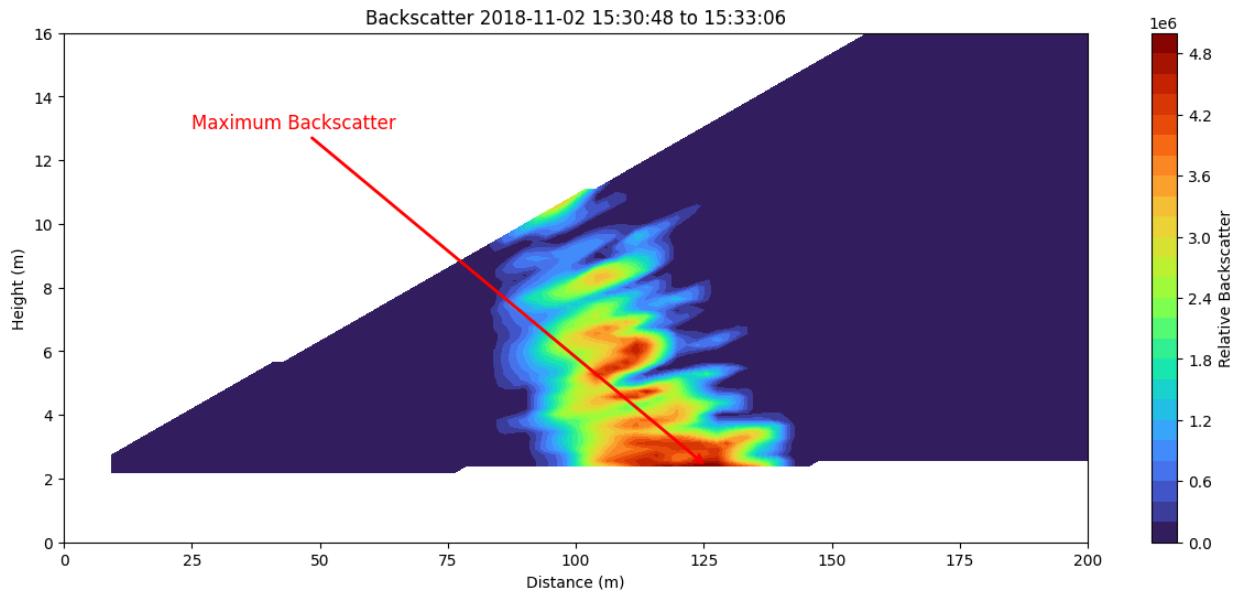
The calculated plume area is: 165.41 square meters.



Maximum Backscatter Value: 4981395.364 (Normalized)

Location (X, Z): (125.67 m, 2.38 m)

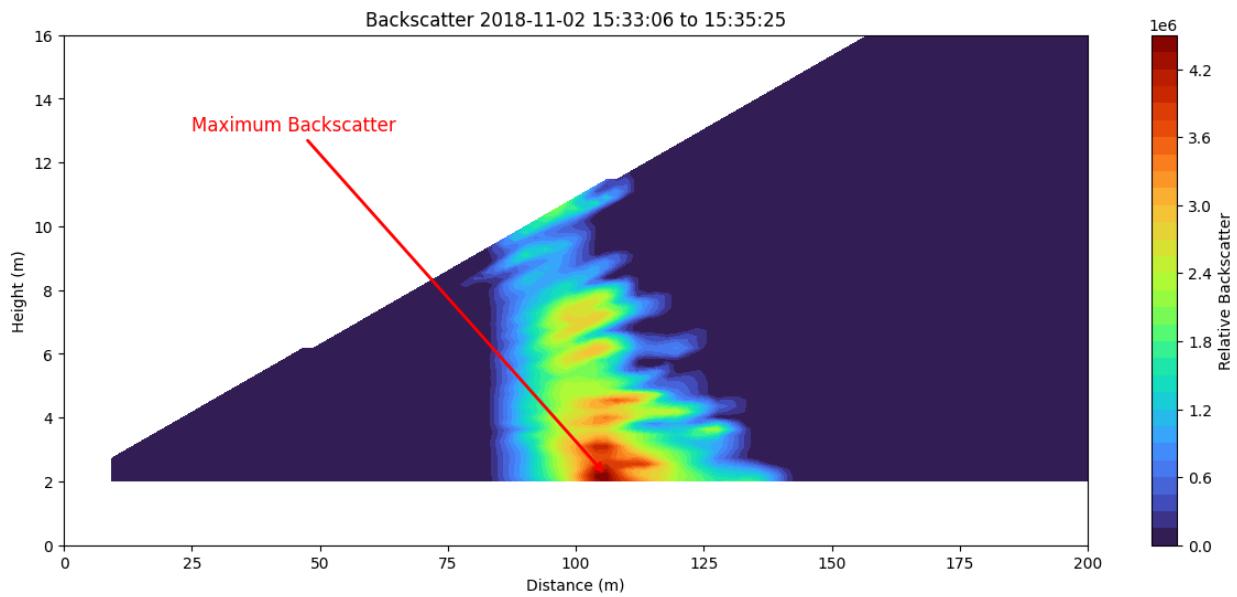
The calculated plume area is: 275.51 square meters.



Maximum Backscatter Value: 4439456.952 (Normalized)

Location (X, Z): (105.97 m, 2.18 m)

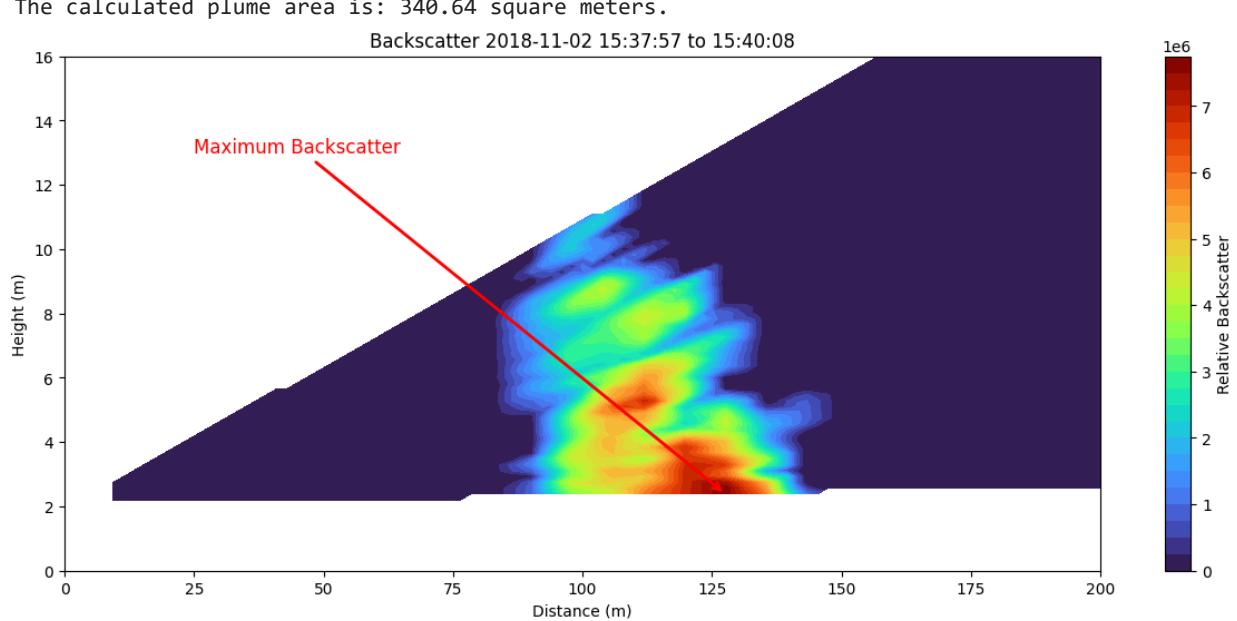
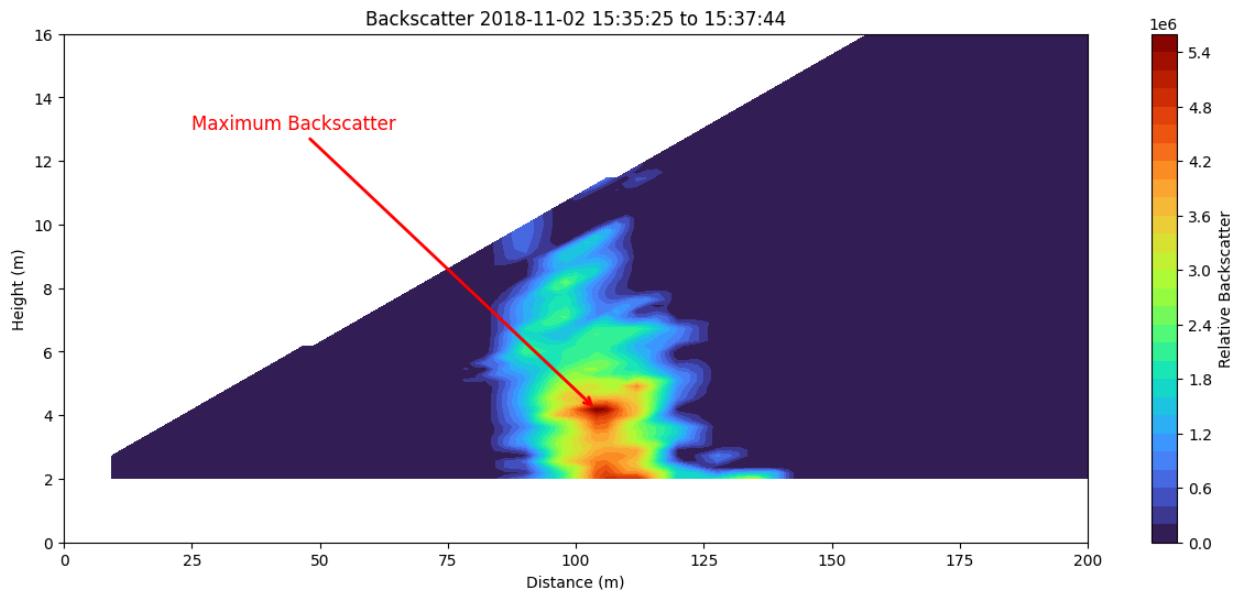
The calculated plume area is: 280.11 square meters.

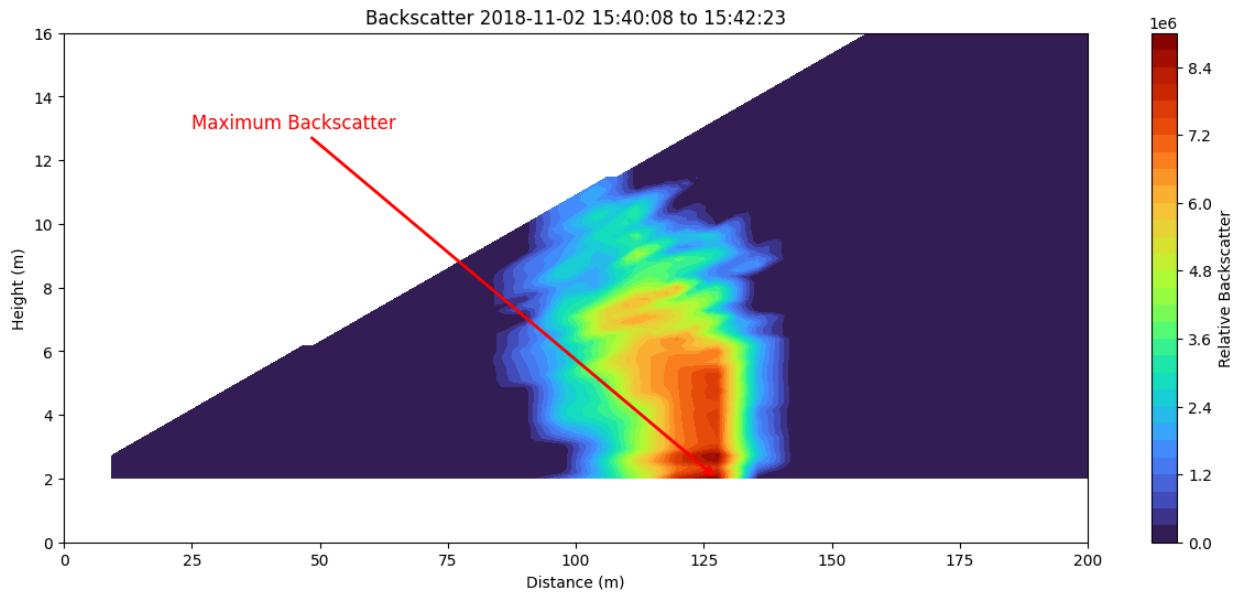


Maximum Backscatter Value: 5566164.237 (Normalized)

Location (X, Z): (104.00 m, 4.18 m)

The calculated plume area is: 242.50 square meters.

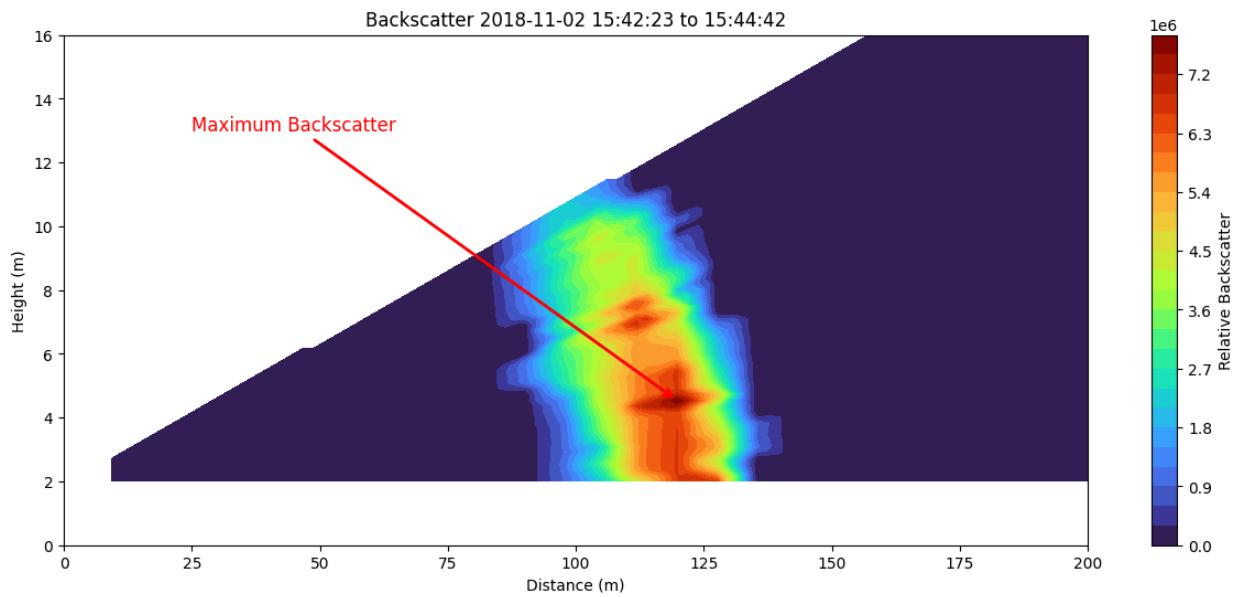




Maximum Backscatter Value: 7773229.592 (Normalized)

Location (X, Z): (119.76 m, 4.55 m)

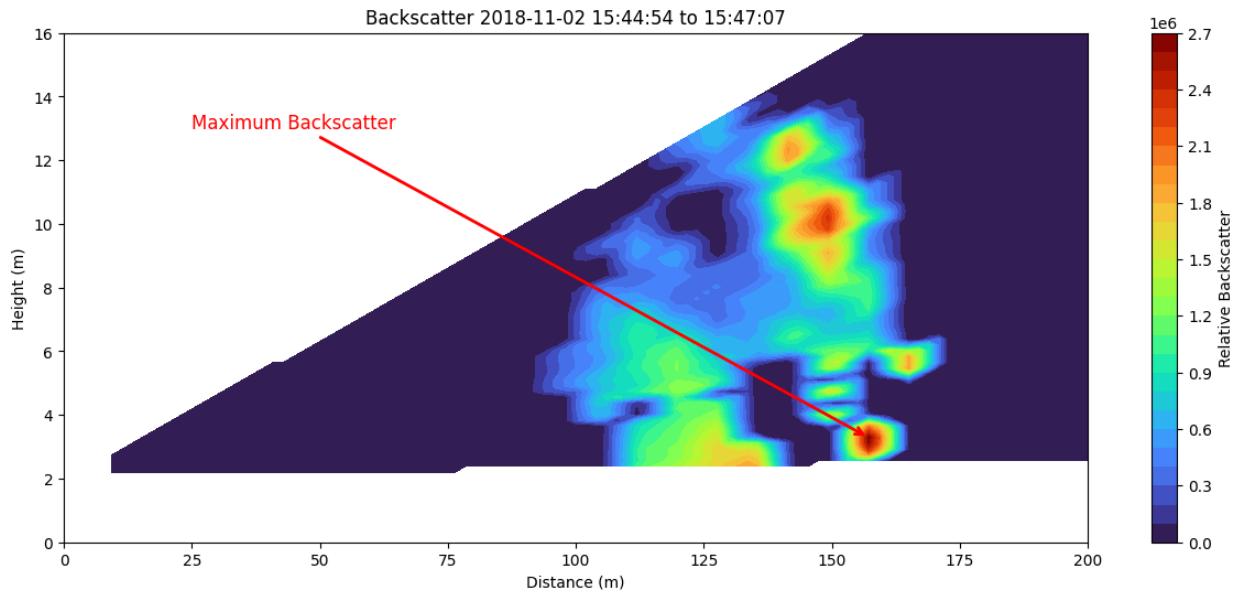
The calculated plume area is: 342.08 square meters.



Maximum Backscatter Value: 2658503.837 (Normalized)

Location (X, Z): (157.19 m, 3.29 m)

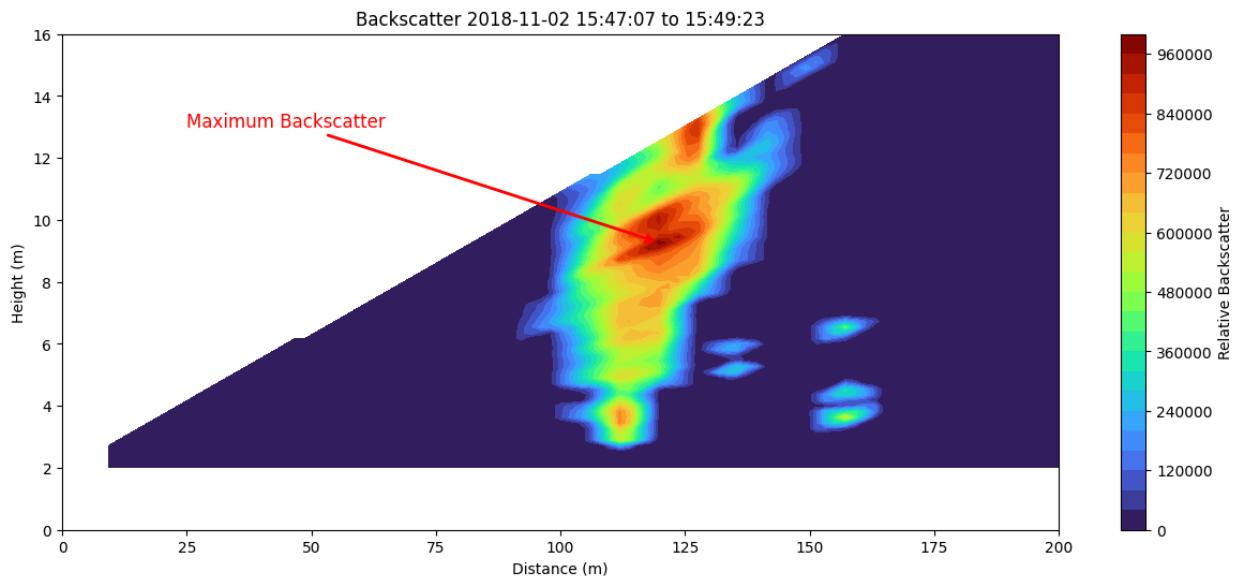
The calculated plume area is: 509.17 square meters.



Maximum Backscatter Value: 980868.386 (Normalized)

Location (X, Z): (119.76 m, 9.27 m)

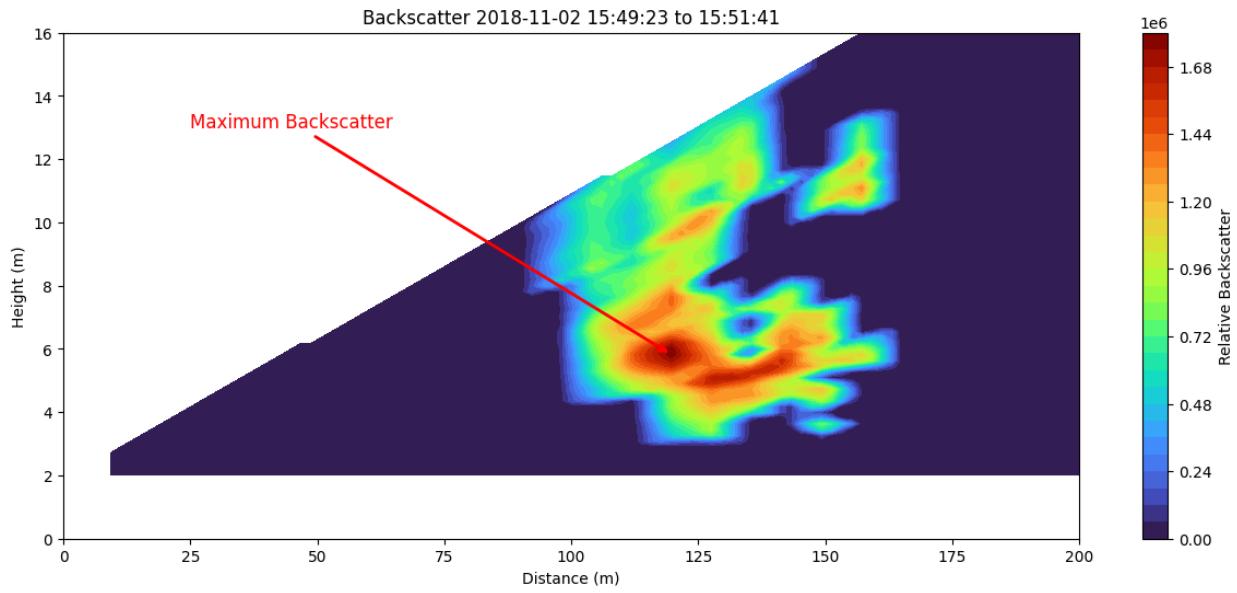
The calculated plume area is: 342.44 square meters.



Maximum Backscatter Value: 1784350.523 (Normalized)

Location (X, Z): (119.76 m, 5.82 m)

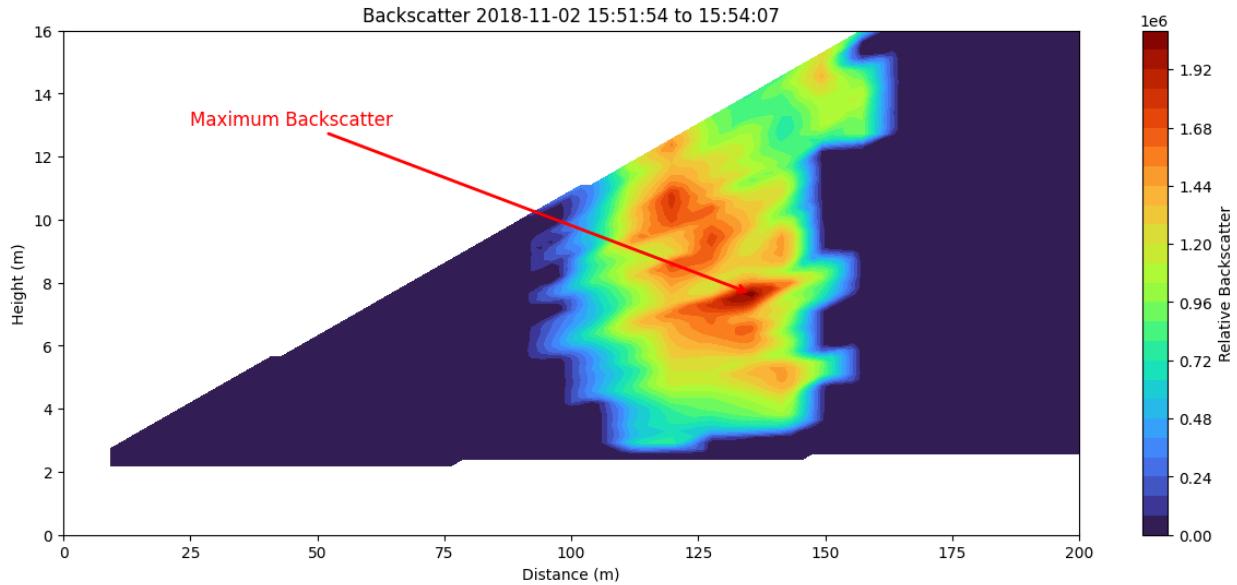
The calculated plume area is: 476.77 square meters.



Maximum Backscatter Value: 2066496.172 (Normalized)

Location (X, Z): (135.52 m, 7.65 m)

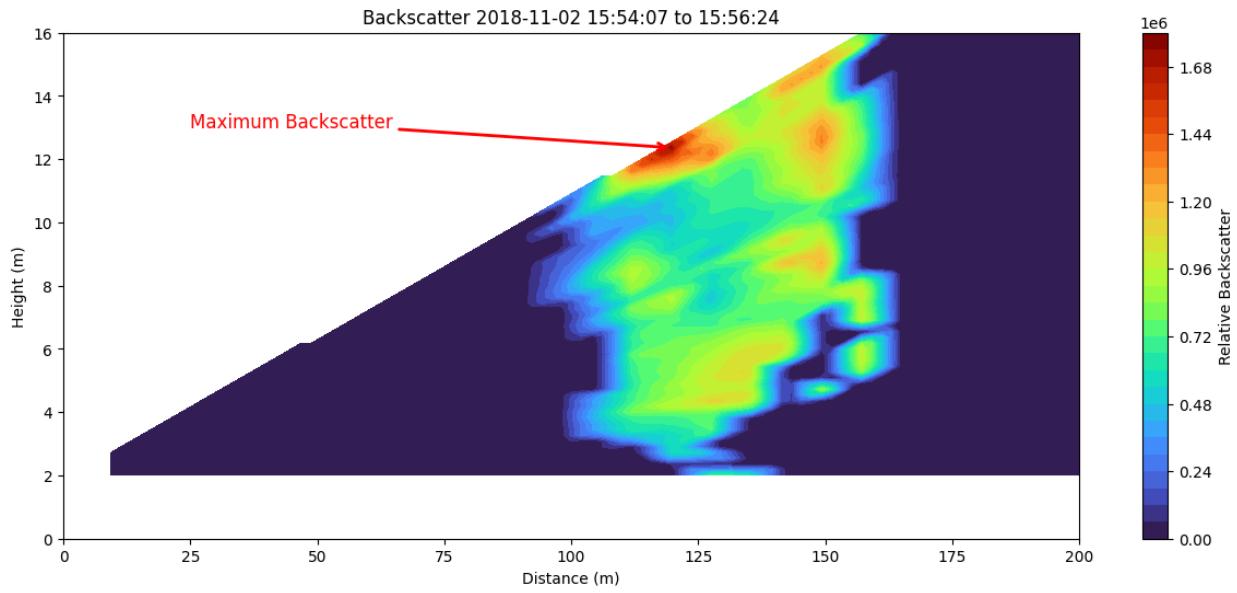
The calculated plume area is: 551.74 square meters.



Maximum Backscatter Value: 1741431.123 (Normalized)

Location (X, Z): (119.76 m, 12.36 m)

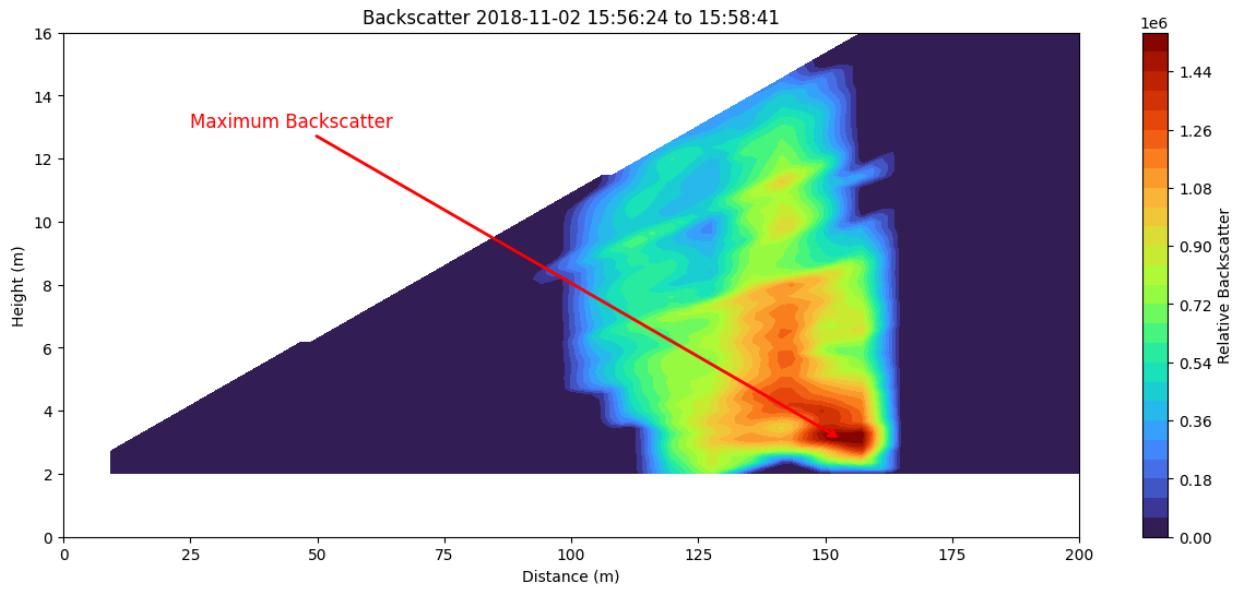
The calculated plume area is: 595.69 square meters.



Maximum Backscatter Value: 1551832.517 (Normalized)

Location (X, Z): (153.25 m, 3.09 m)

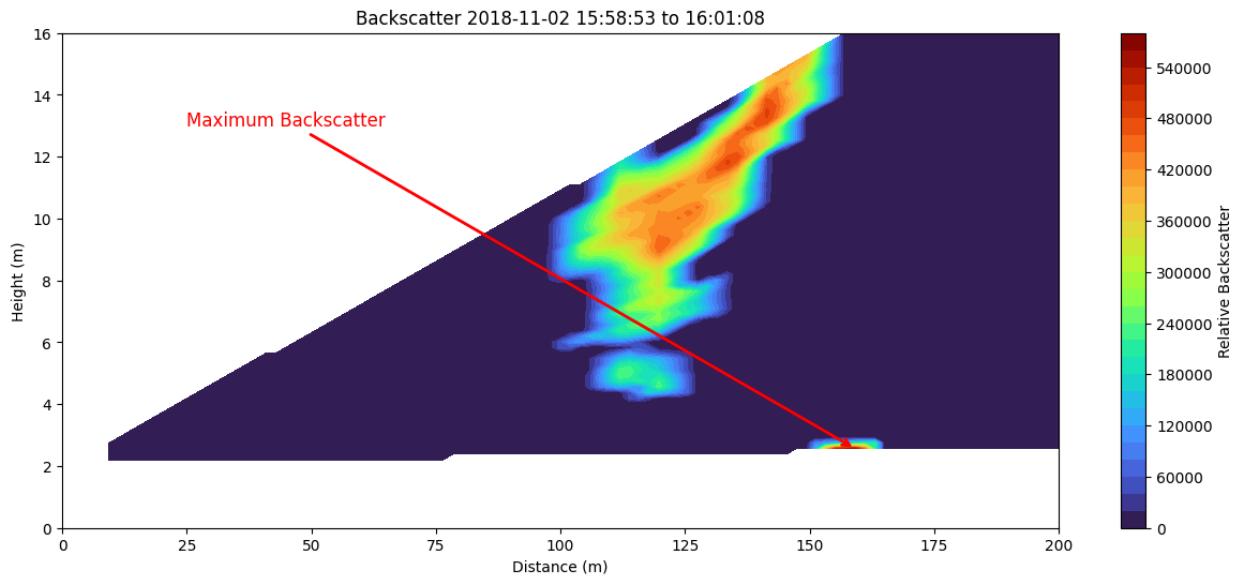
The calculated plume area is: 648.71 square meters.



Maximum Backscatter Value: 561415.483 (Normalized)

Location (X, Z): (159.16 m, 2.56 m)

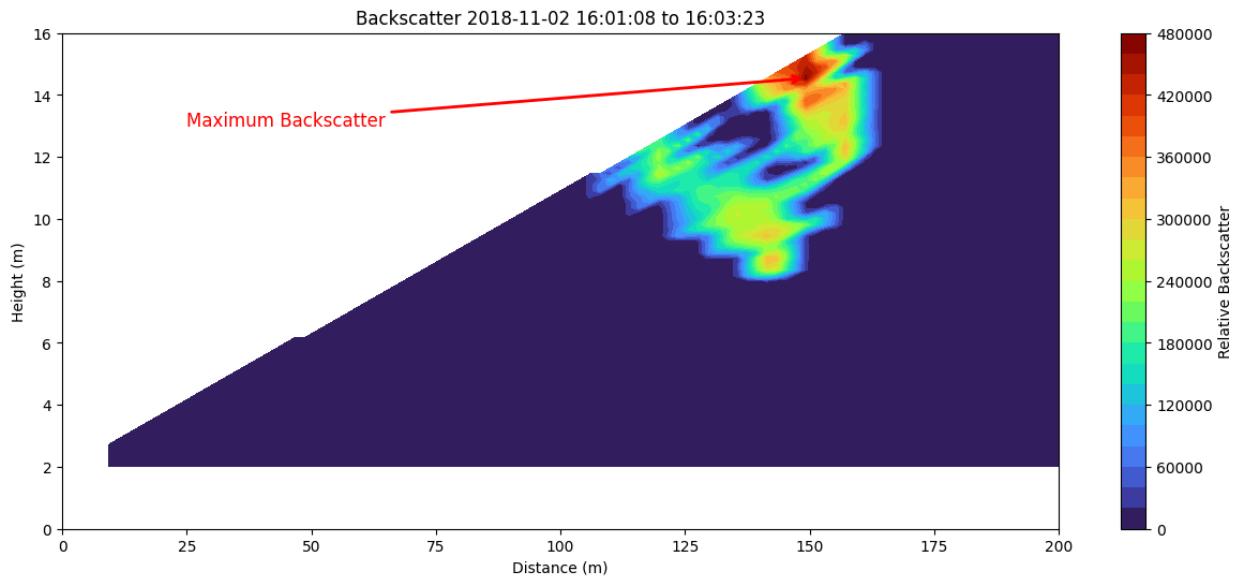
The calculated plume area is: 265.14 square meters.



Maximum Backscatter Value: 469241.119 (Normalized)

Location (X, Z): (149.31 m, 14.55 m)

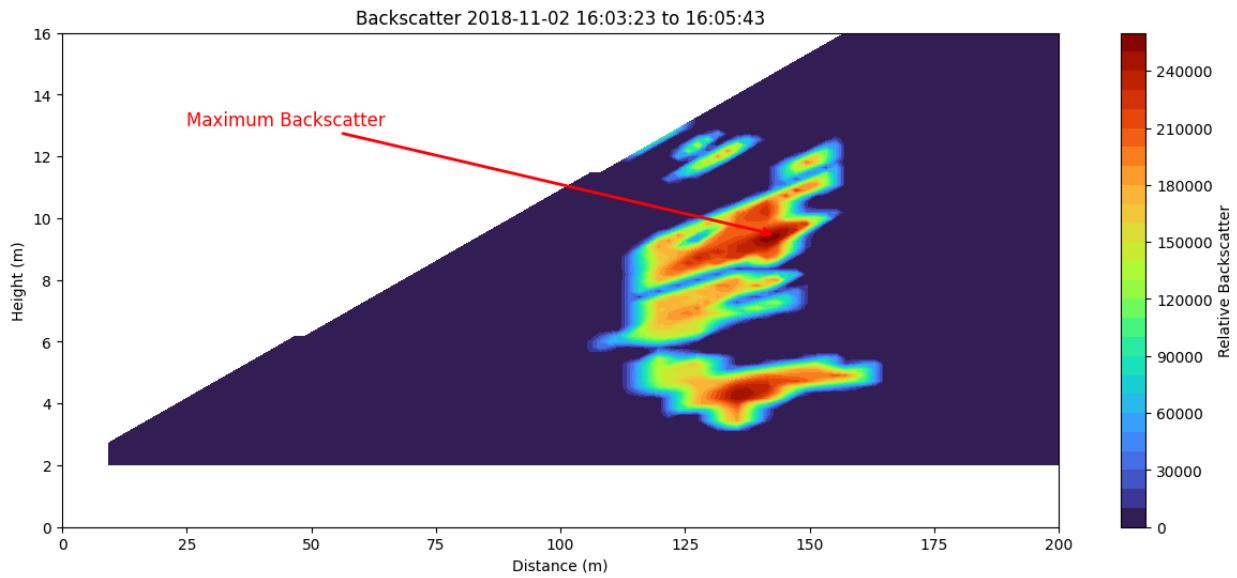
The calculated plume area is: 205.61 square meters.



Maximum Backscatter Value: 255055.257 (Normalized)

Location (X, Z): (143.40 m, 9.45 m)

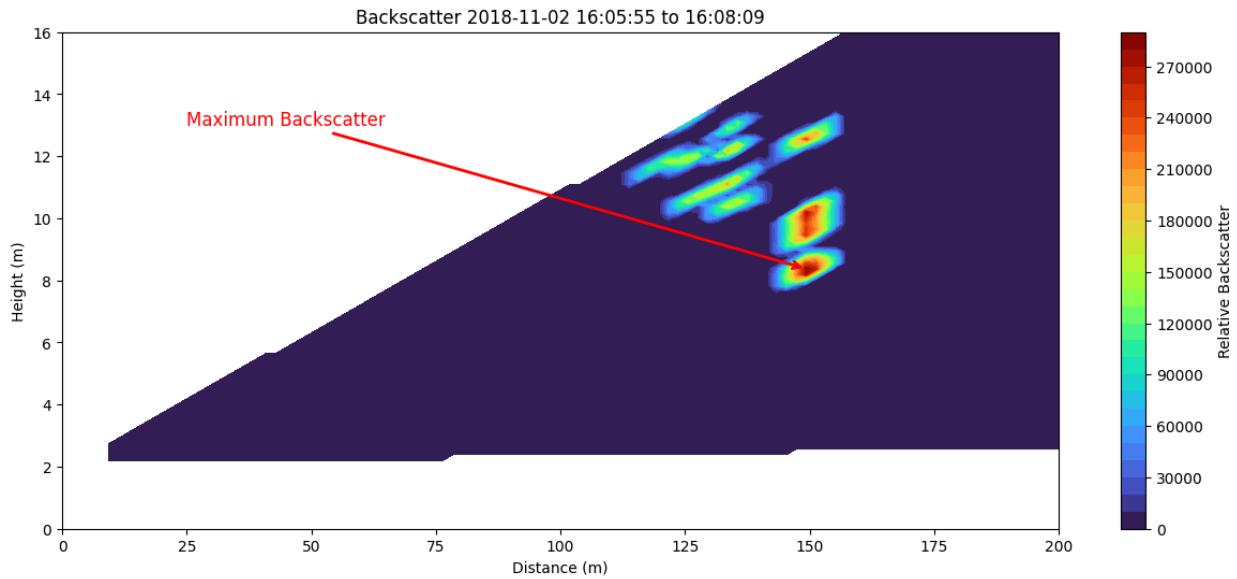
The calculated plume area is: 235.34 square meters.



Maximum Backscatter Value: 280857.935 (Normalized)

Location (X, Z): (149.31 m, 8.38 m)

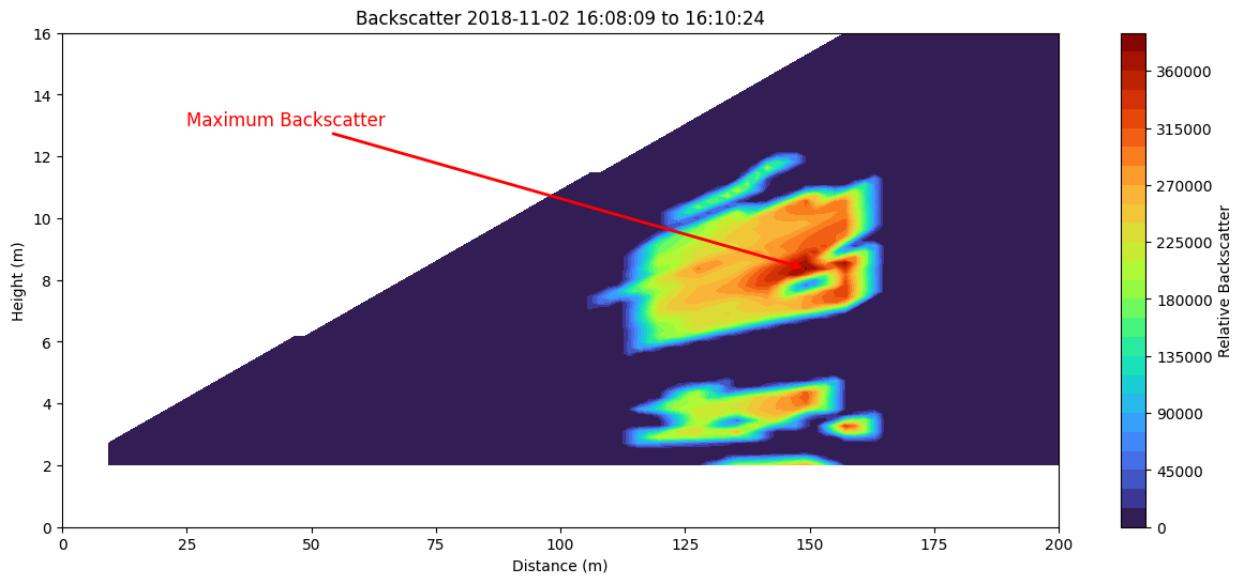
The calculated plume area is: 77.64 square meters.



Maximum Backscatter Value: 376041.757 (Normalized)

Location (X, Z): (149.31 m, 8.36 m)

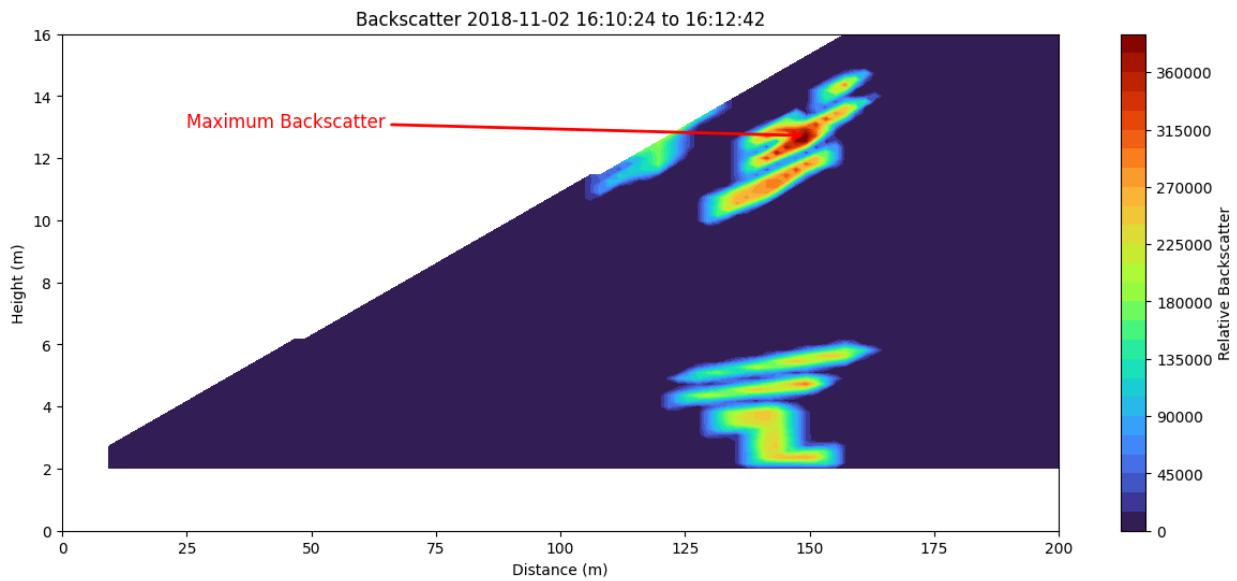
The calculated plume area is: 291.22 square meters.



Maximum Backscatter Value: 383253.655 (Normalized)

Location (X, Z): (149.31 m, 12.73 m)

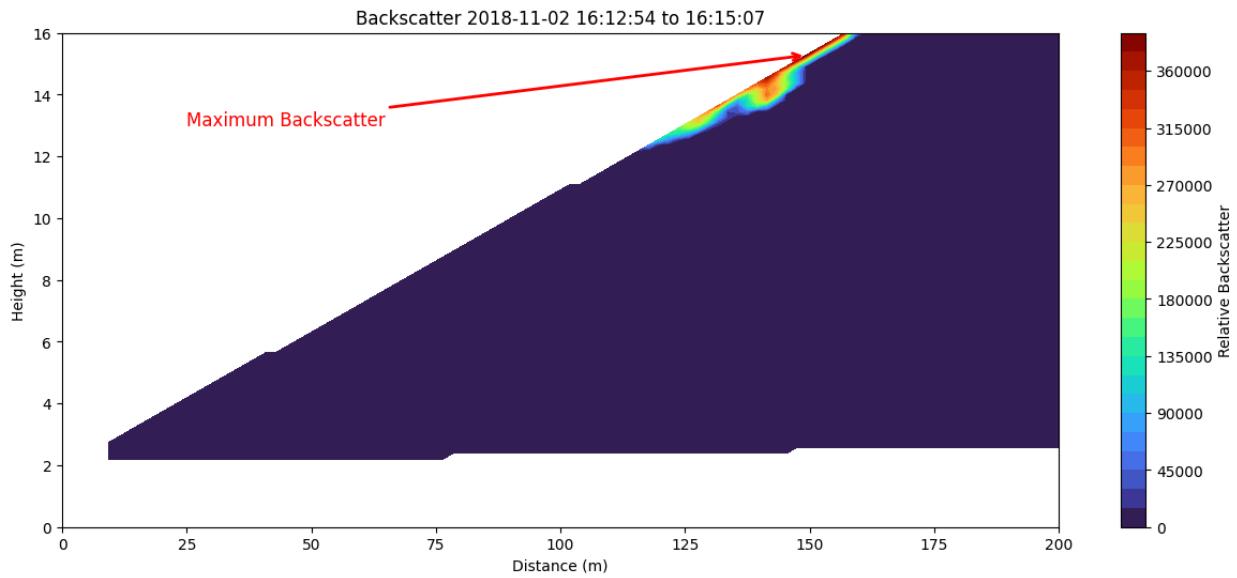
The calculated plume area is: 155.46 square meters.



Maximum Backscatter Value: 381778.649 (Normalized)

Location (X, Z): (149.31 m, 15.28 m)

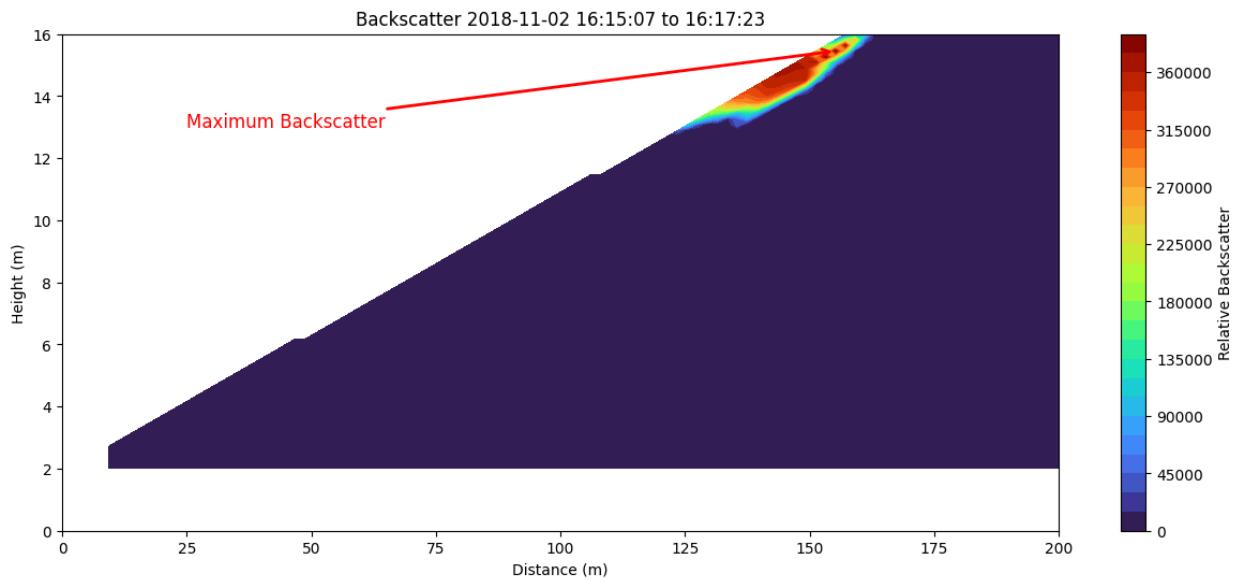
The calculated plume area is: 25.05 square meters.



Maximum Backscatter Value: 382351.829 (Normalized)

Location (X, Z): (155.22 m, 15.46 m)

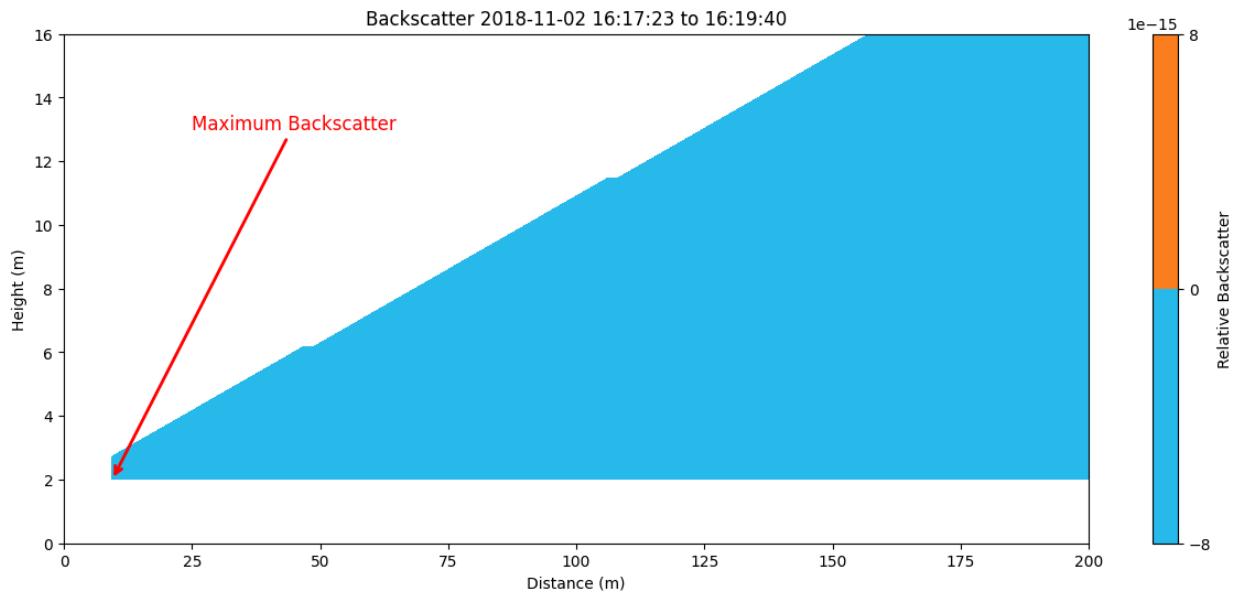
The calculated plume area is: 30.45 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

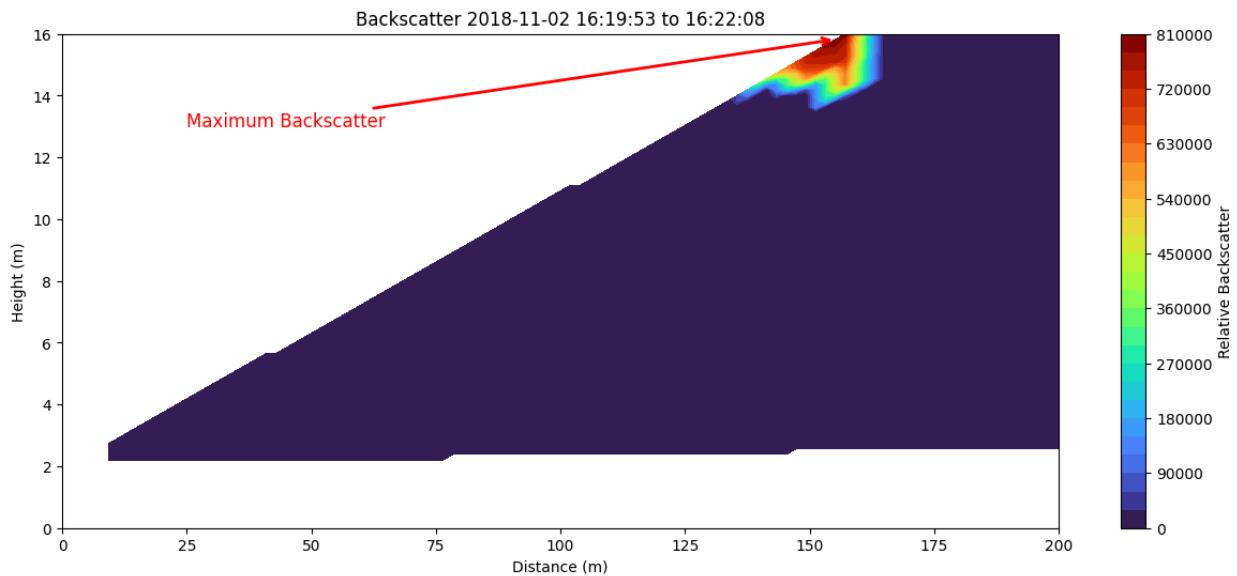
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 809569.511 (Normalized)

Location (X, Z): (155.22 m, 15.82 m)

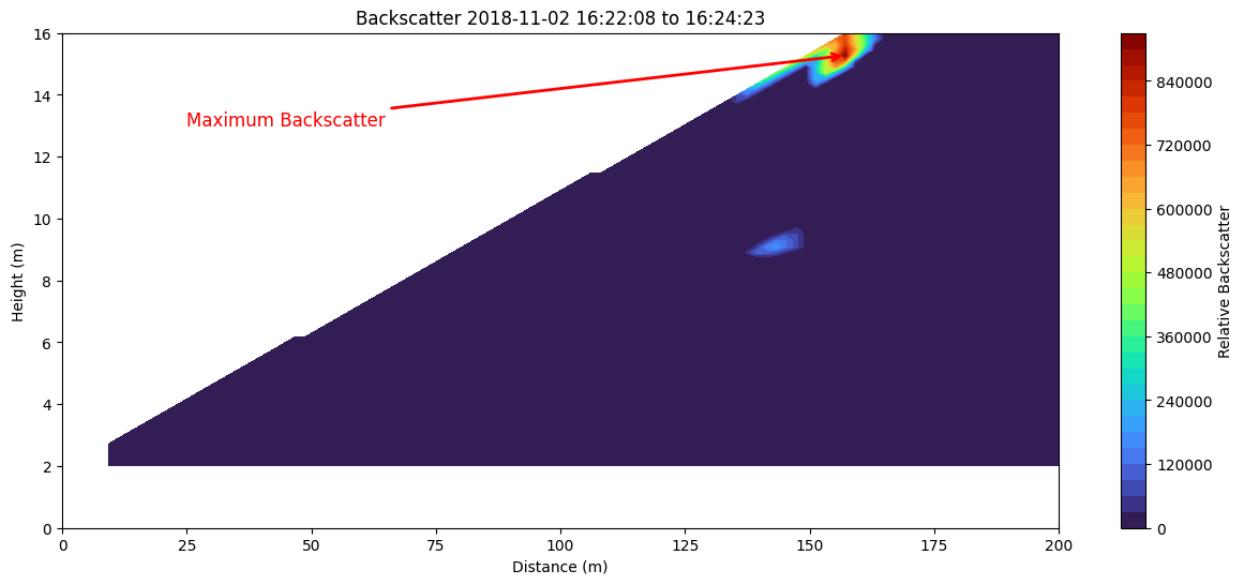
The calculated plume area is: 38.29 square meters.



Maximum Backscatter Value: 913801.117 (Normalized)

Location (X, Z): (157.19 m, 15.27 m)

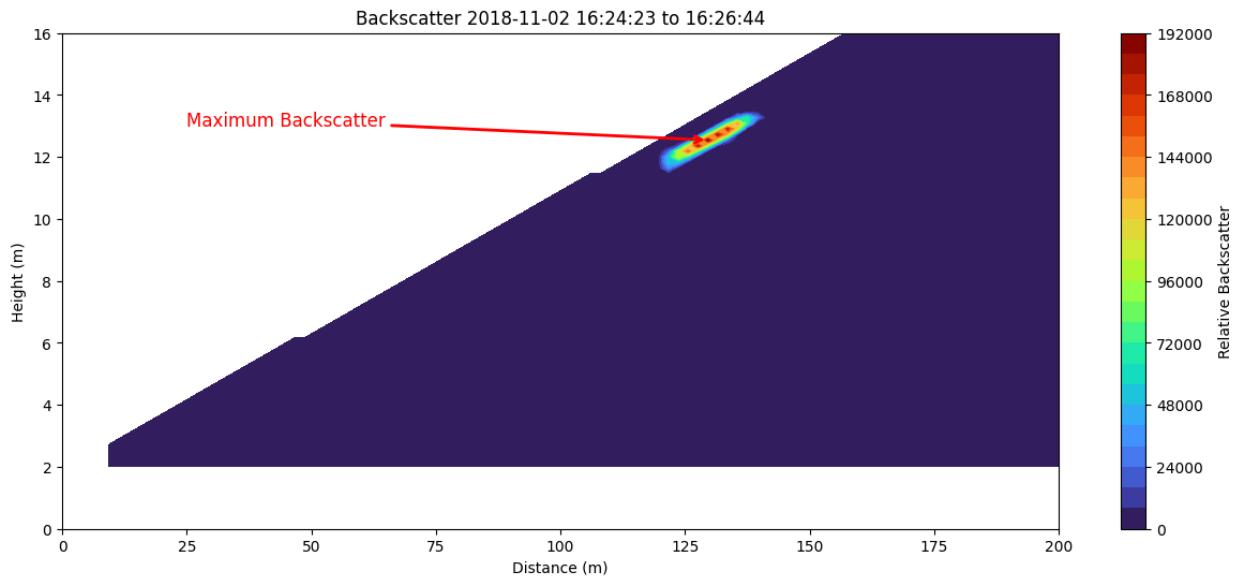
The calculated plume area is: 23.64 square meters.



Maximum Backscatter Value: 187908.307 (Normalized)

Location (X, Z): (129.61 m, 12.55 m)

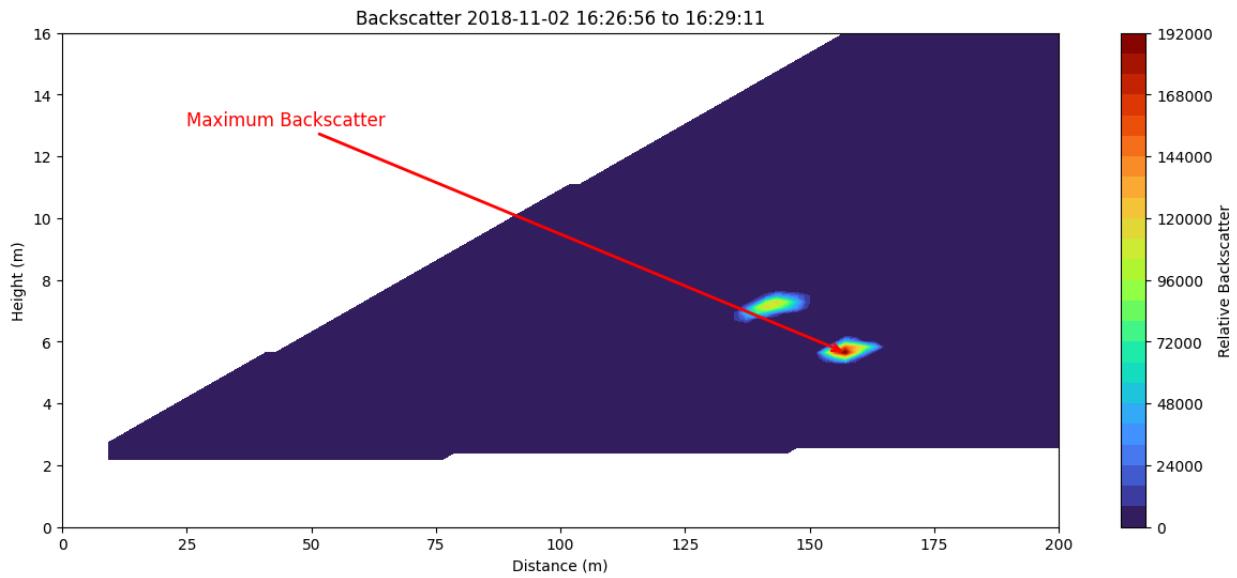
The calculated plume area is: 10.39 square meters.



Maximum Backscatter Value: 190377.366 (Normalized)

Location (X, Z): (157.19 m, 5.65 m)

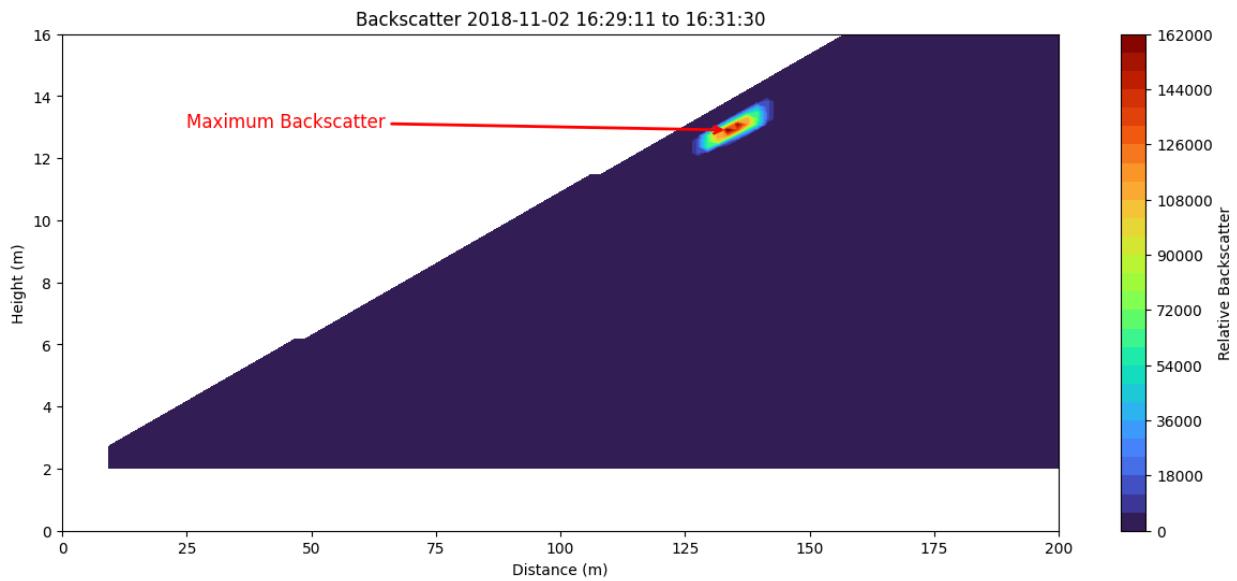
The calculated plume area is: 12.17 square meters.



Maximum Backscatter Value: 160643.751 (Normalized)

Location (X, Z): (133.55 m, 12.91 m)

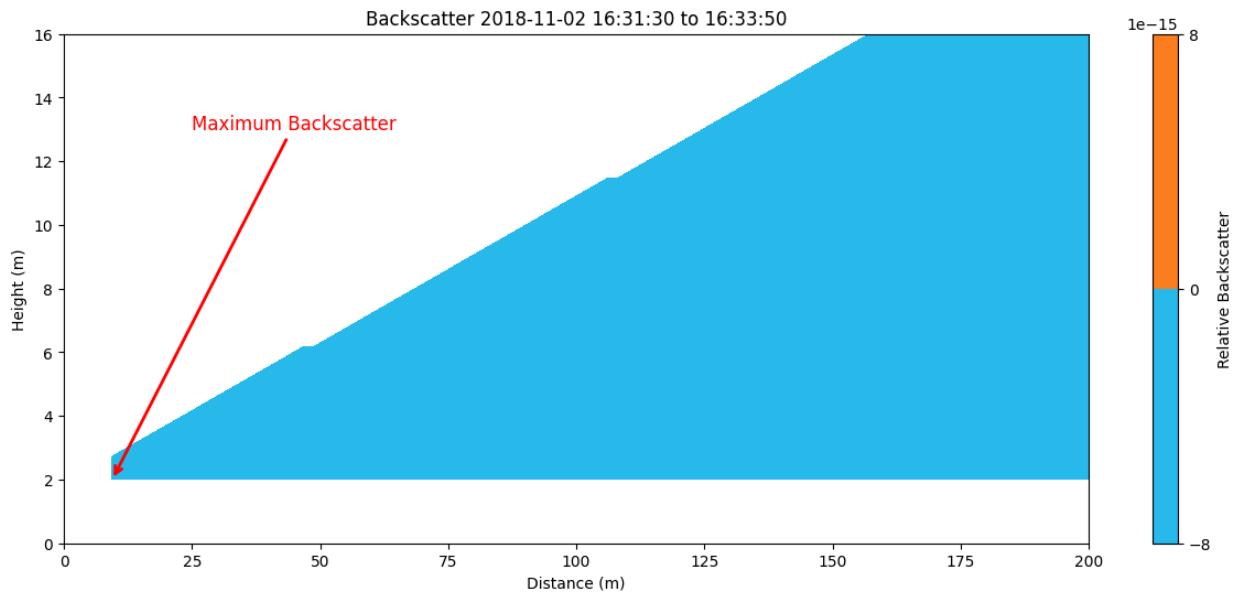
The calculated plume area is: 7.88 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

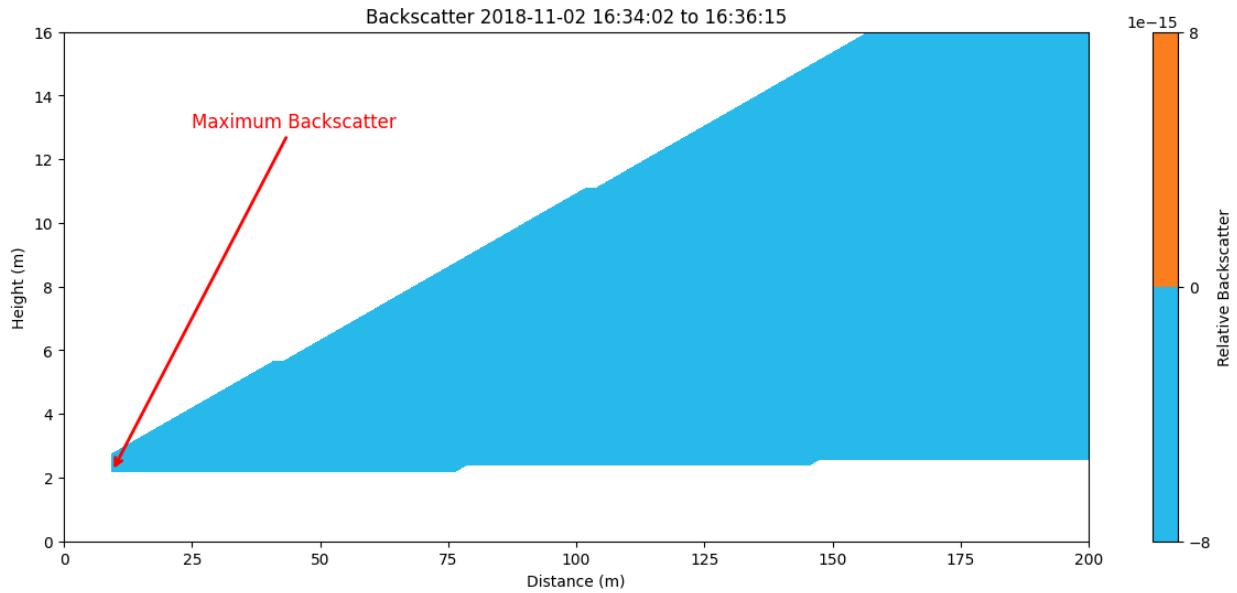
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.20 m)

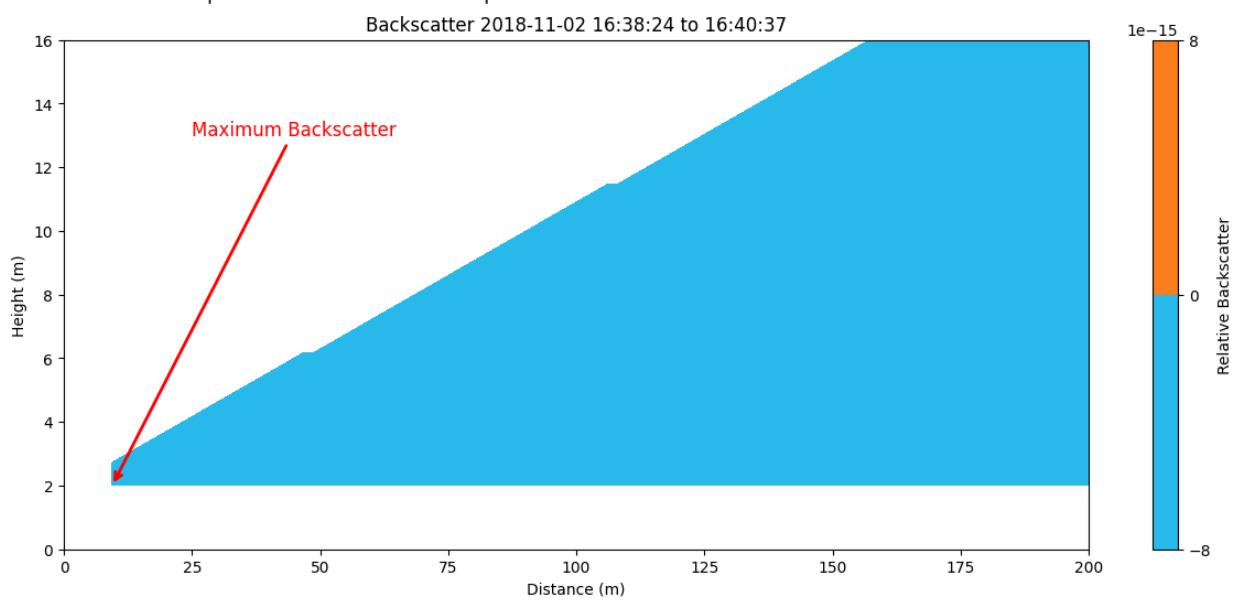
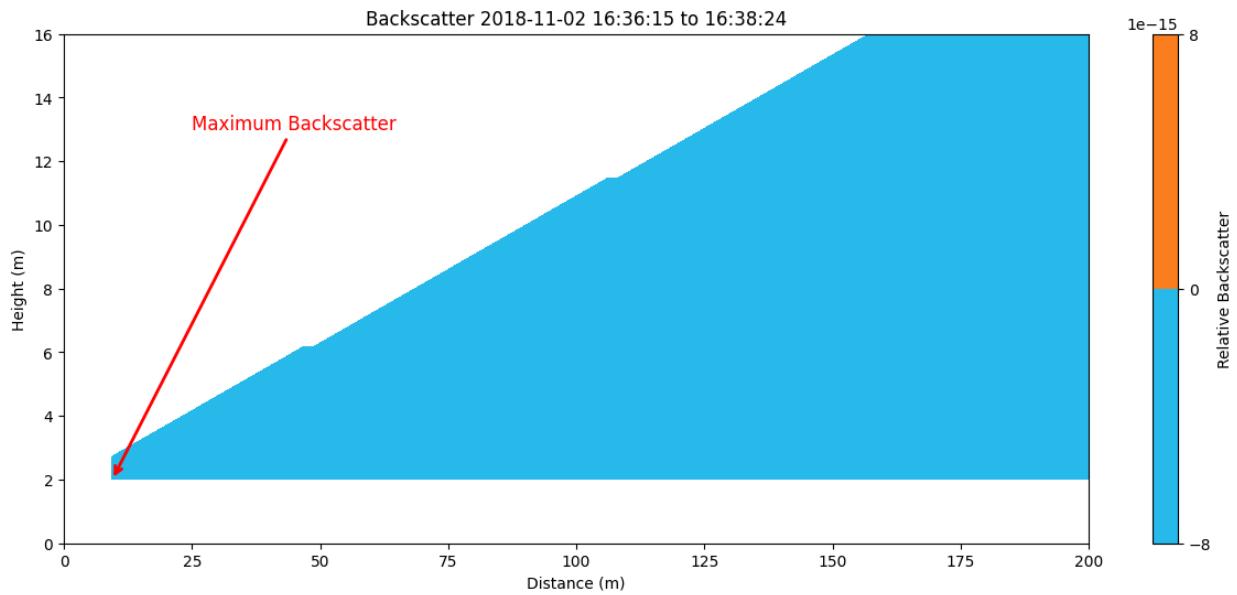
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

The calculated plume area is: 0.00 square meters.



```
error processing 2018-11-02 16:40:37, 2018-11-02 17:07:58: QH6154 Qhull precision error: Initial simplex is flat (facet 1 is coplanar with the interior point)
```

```
While executing: | qhull d Qc Q12 Qbb Qt Qz
Options selected for Qhull 2019.1.r 2019/06/21:
  run-id 1544407187 delaunay Qcoplanar-keep Q12-allow-wide Qbbox-last
  Qtriangulate Qz-infinity-point _pre-merge _zero-centrum Qinterior-keep
  Pgood _max-width 2e+02 Error-roundoff 2.8e-13 _one-merge 2e-12
  Visible-distance 5.6e-13 U-max-coplanar 5.6e-13 Width-outside 1.1e-12
  _wide-facet 3.4e-12 _maxoutside 2.2e-12
```

The input to qhull appears to be less than 3 dimensional, or a computation has overflowed.

Qhull could not construct a clearly convex simplex from points:

- p1(v4): 15 2 0.76
- p243(v3): 1e+02 2 2e+02
- p26(v2): 2e+02 2 1.8e+02
- p0(v1): 7.5 2 0

The center point is coplanar with a facet, or a vertex is coplanar with a neighboring facet. The maximum round off error for computing distances is 2.8e-13. The center point, facets and distances to the center point are as follows:

center point	82.5	2	96.83
--------------	------	---	-------

facet p243 p26 p0 distance=	0
facet p1 p26 p0 distance=	0
facet p1 p243 p0 distance=	0
facet p1 p243 p26 distance=	0

These points either have a maximum or minimum x-coordinate, or they maximize the determinant for k coordinates. Trial points are first selected from points that maximize a coordinate.

The min and max coordinates for each dimension are:

0:	7.5	202.5	difference= 195
1:	2	2	difference= 0
2:	0	202.5	difference= 202.5

If the input should be full dimensional, you have several options that may determine an initial simplex:

- use 'QJ' to joggle the input and make it full dimensional
- use 'QbB' to scale the points to the unit cube
- use 'QR0' to randomly rotate the input for different maximum points
- use 'Qs' to search all points for the initial simplex
- use 'En' to specify a maximum roundoff error less than 2.8e-13.
- trace execution with 'T3' to see the determinant for each point.

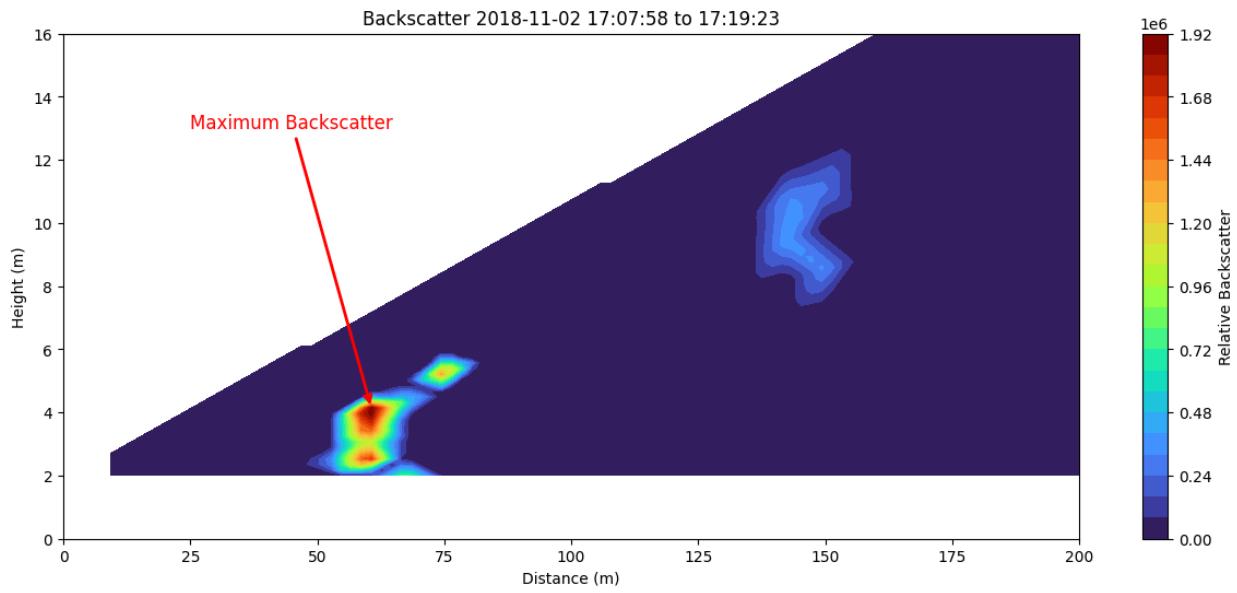
If the input is lower dimensional:

- use 'QJ' to joggle the input and make it full dimensional
- use 'Qbk:0Bk:0' to delete coordinate k from the input. You should pick the coordinate with the least range. The hull will have the correct topology.
- determine the flat containing the points, rotate the points into a coordinate plane, and delete the other coordinates.
- add one or more points to make the input full dimensional.

Maximum Backscatter Value: 1917856.461 (Normalized)

Location (X, Z): (60.66 m, 4.14 m)

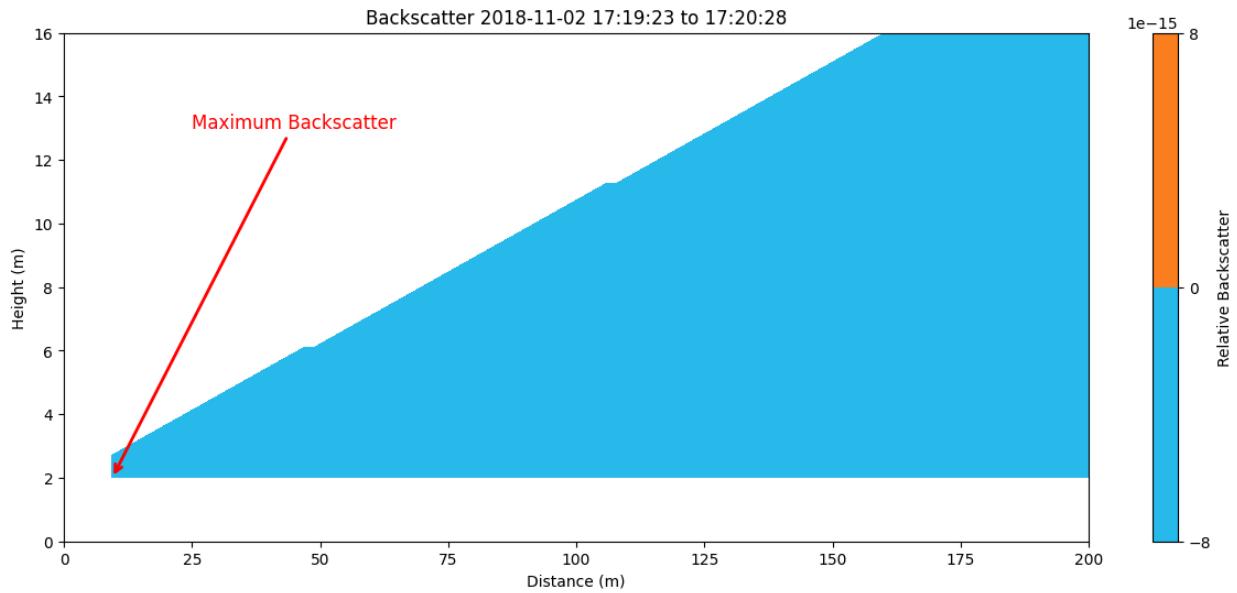
The calculated plume area is: 75.16 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

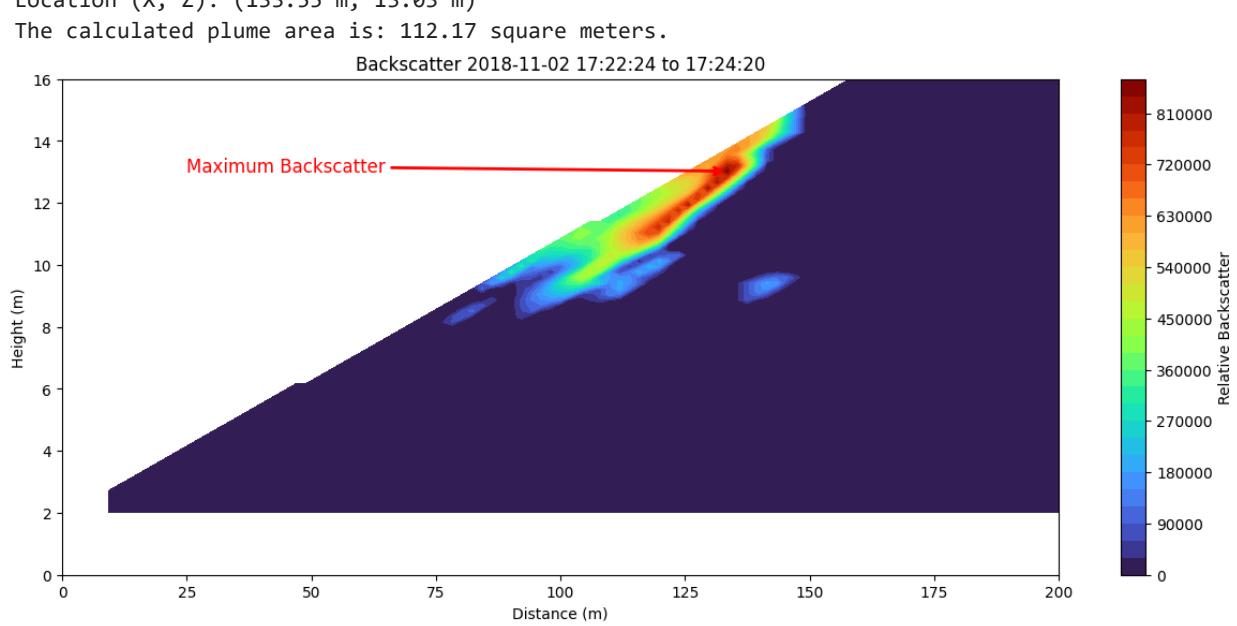
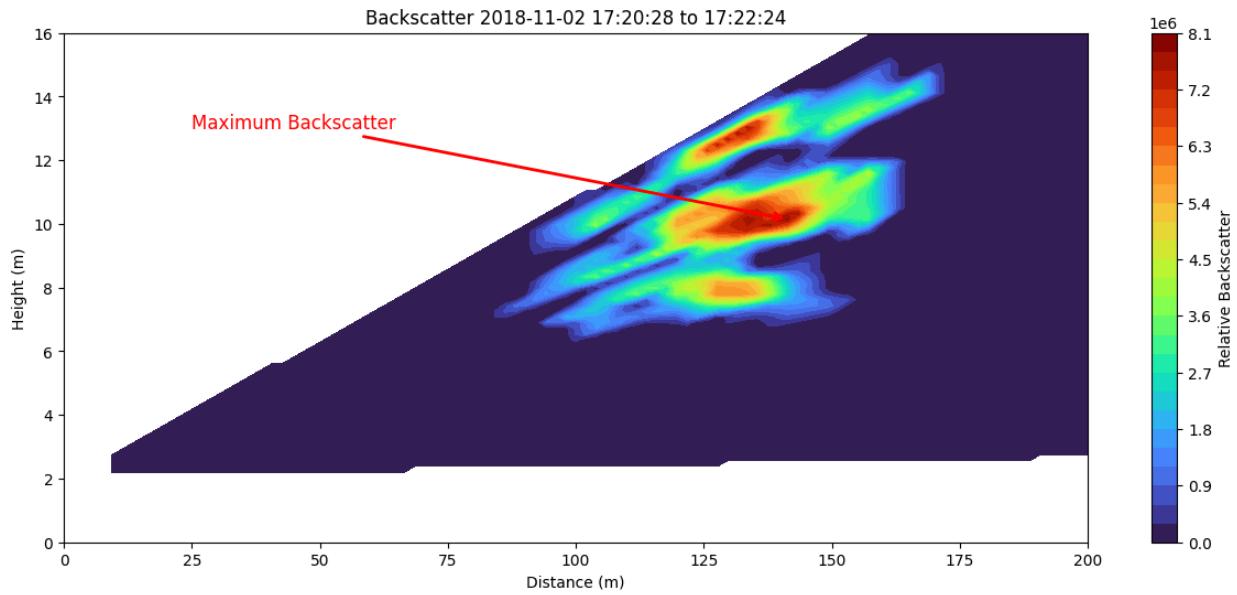
The calculated plume area is: 0.00 square meters.

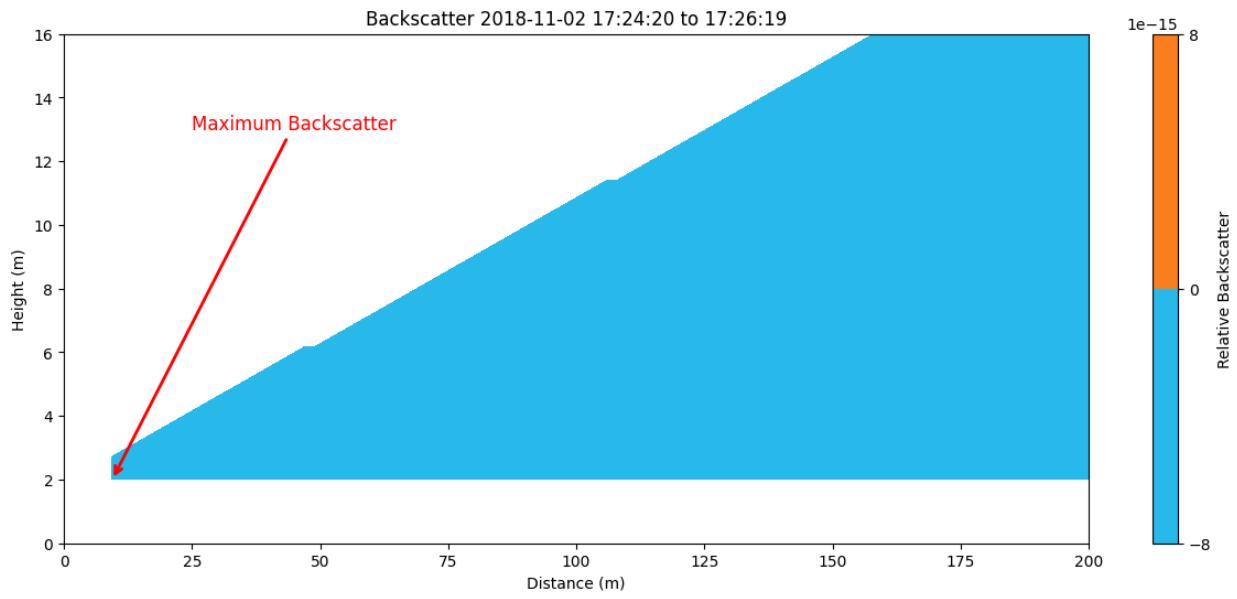


Maximum Backscatter Value: 7819020.266 (Normalized)

Location (X, Z): (141.43 m, 10.15 m)

The calculated plume area is: 300.17 square meters.

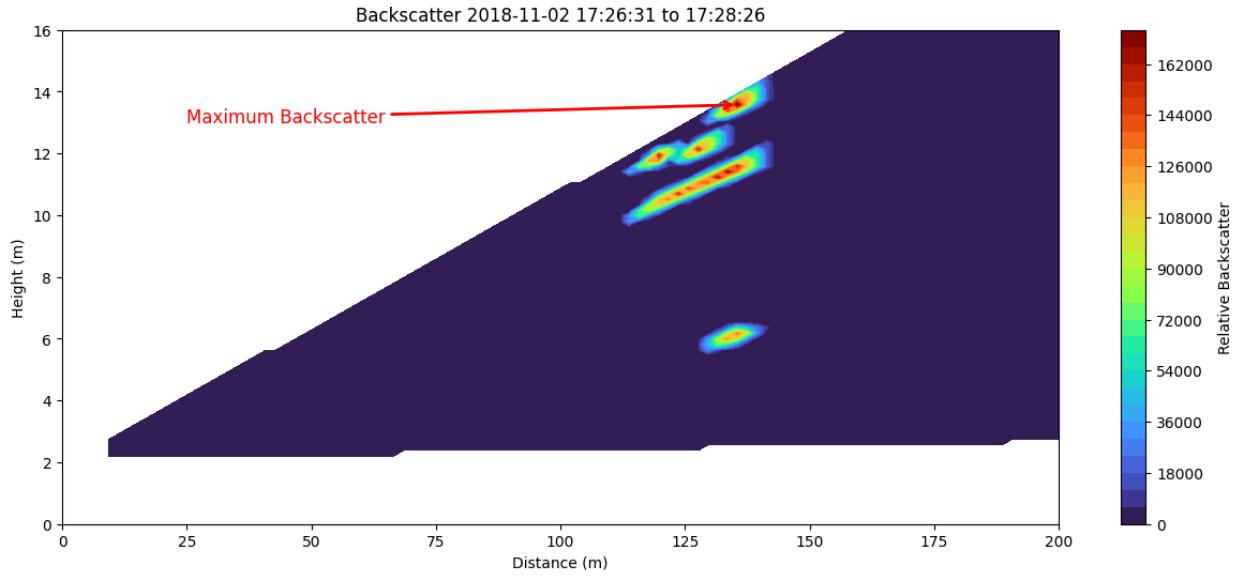




Maximum Backscatter Value: 171122.456 (Normalized)

Location (X, Z): (135.52 m, 13.58 m)

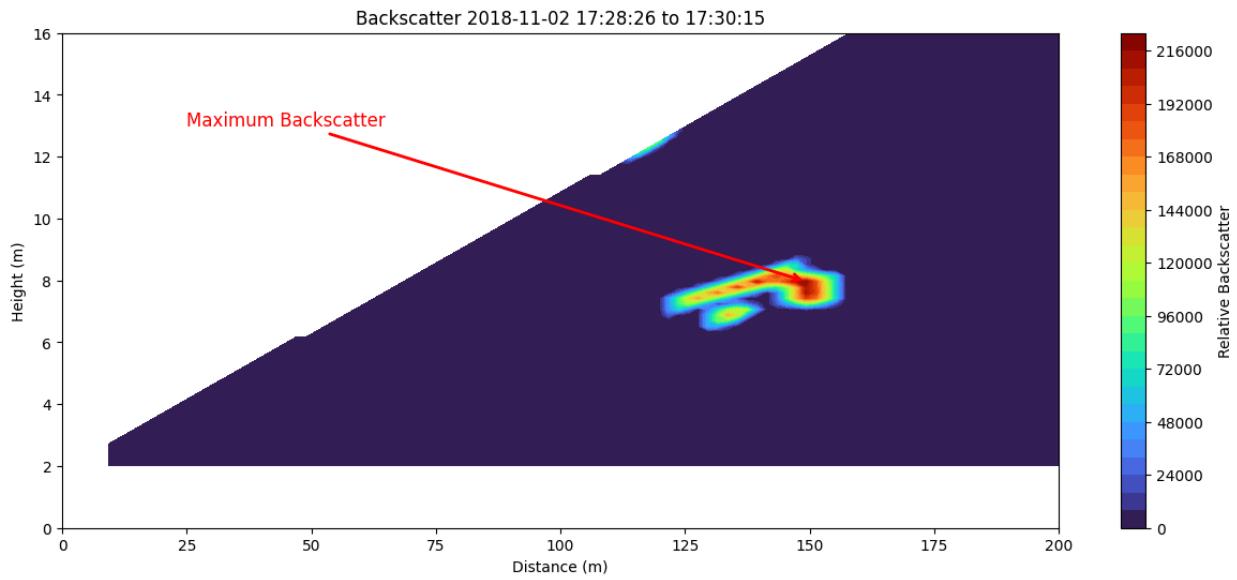
The calculated plume area is: 45.17 square meters.



Maximum Backscatter Value: 216126.367 (Normalized)

Location (X, Z): (149.31 m, 7.97 m)

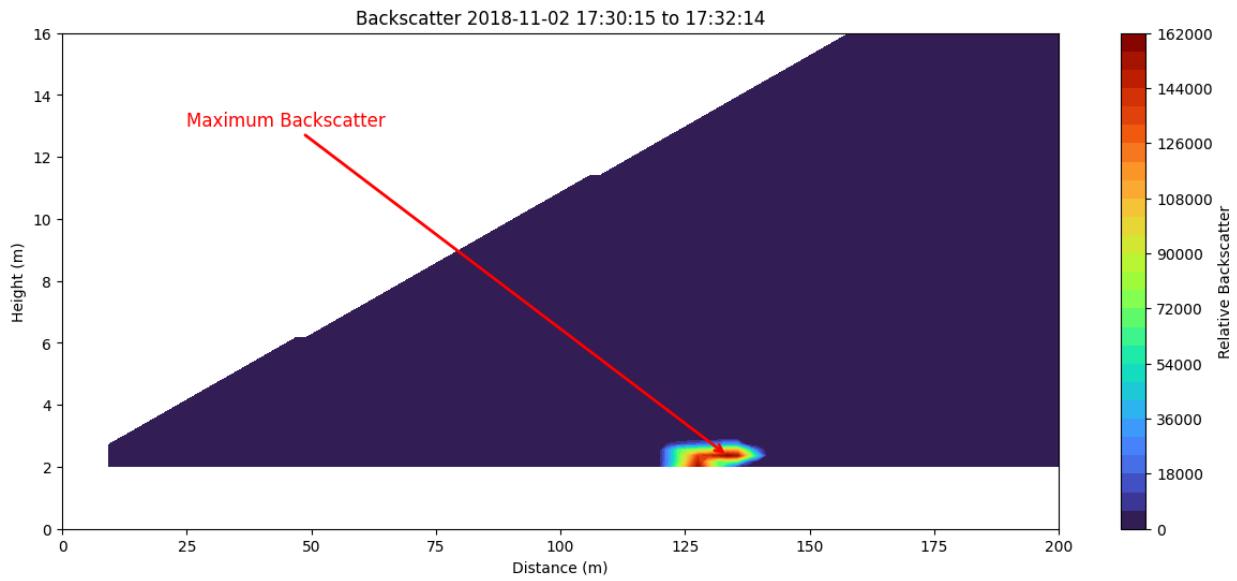
The calculated plume area is: 43.09 square meters.



Maximum Backscatter Value: 158170.338 (Normalized)

Location (X, Z): (133.55 m, 2.36 m)

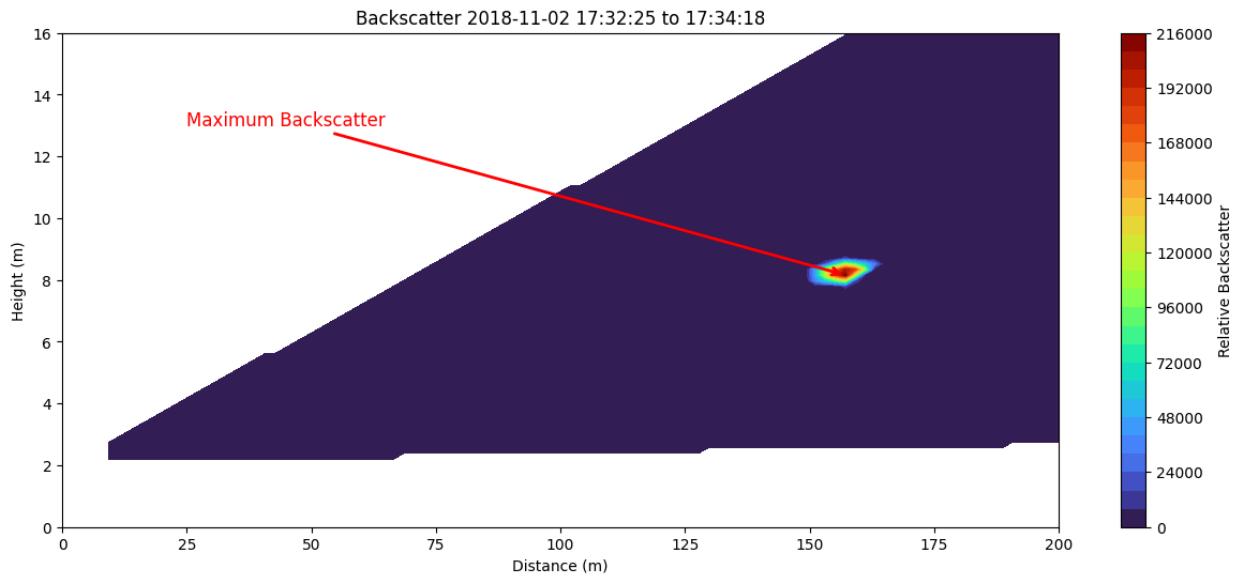
The calculated plume area is: 14.60 square meters.



Maximum Backscatter Value: 212375.253 (Normalized)

Location (X, Z): (157.19 m, 8.16 m)

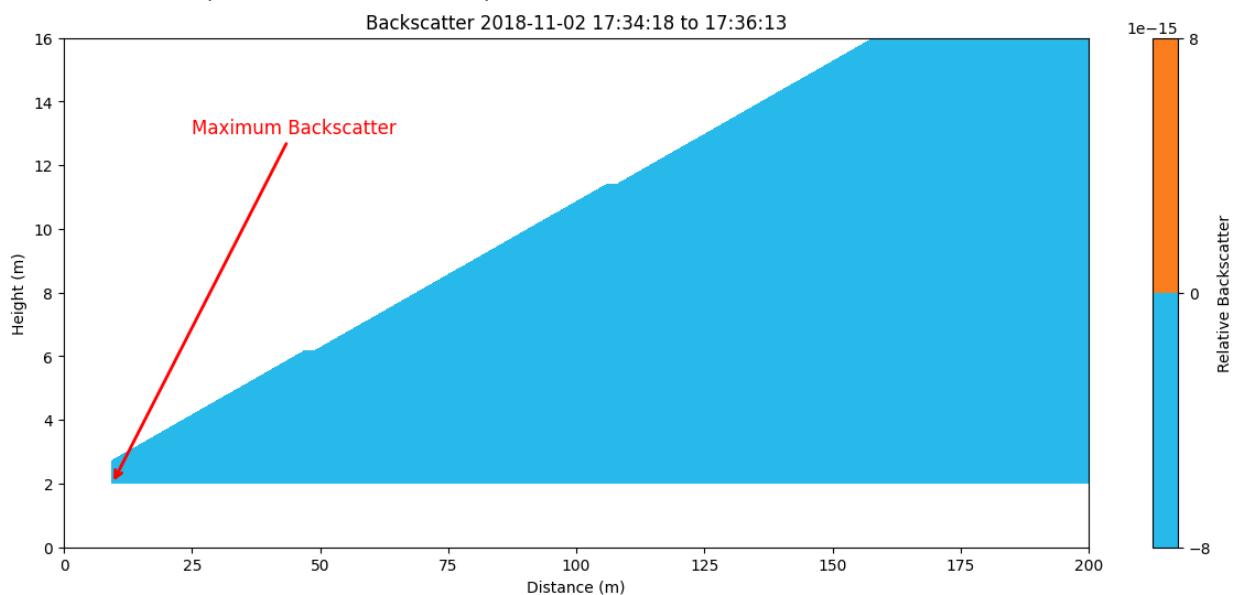
The calculated plume area is: 7.11 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

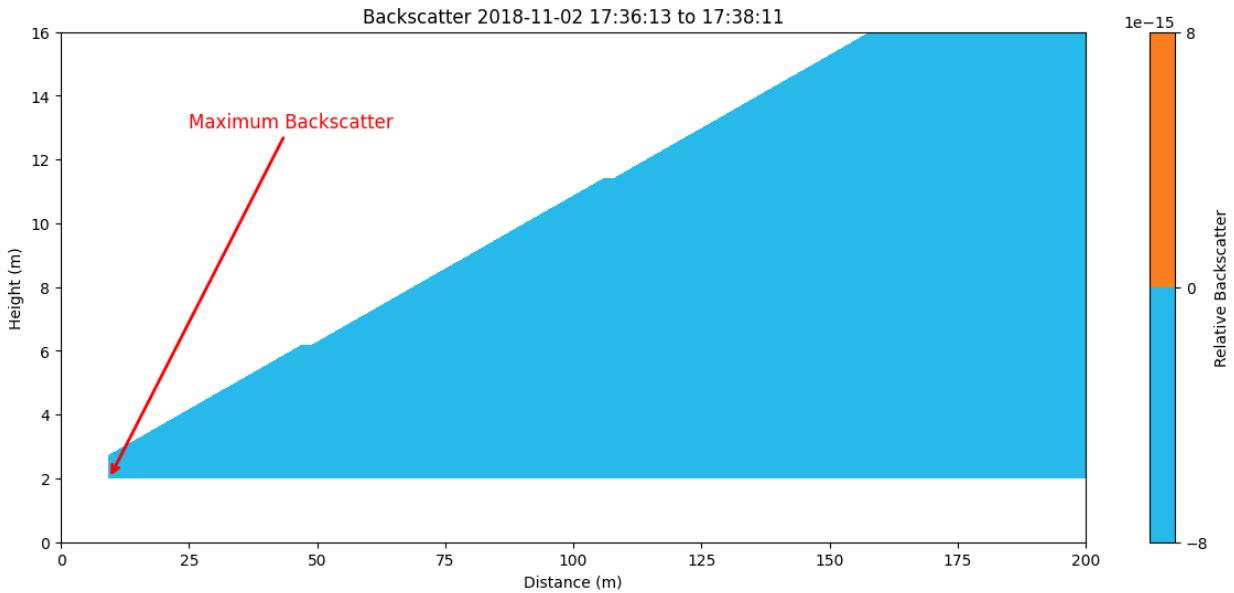
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (9.44 m, 2.00 m)

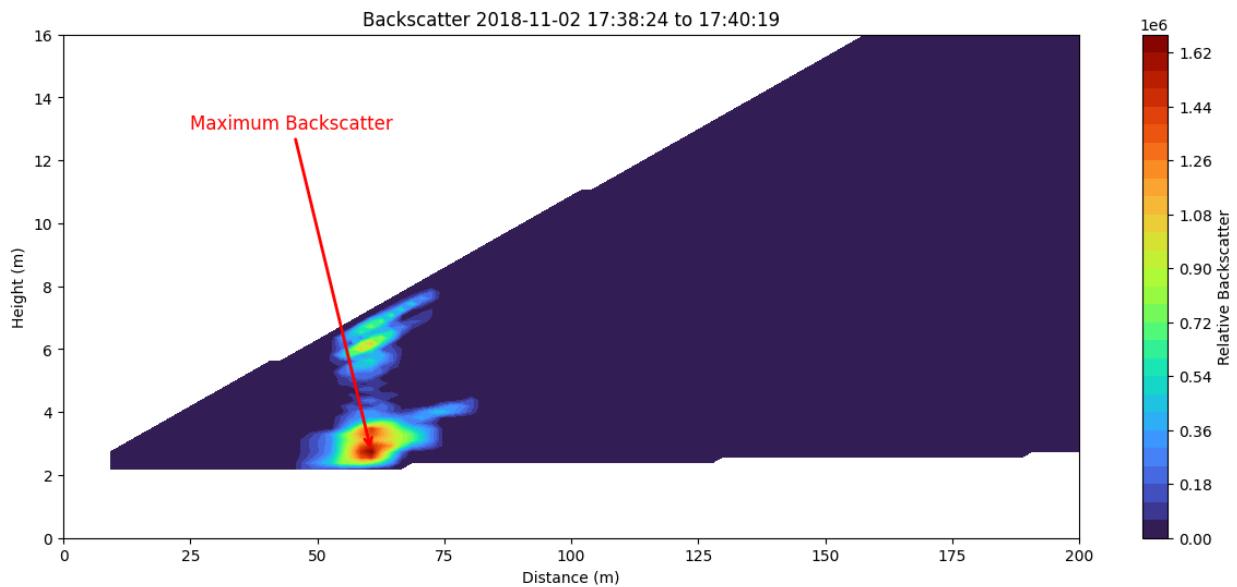
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 1630274.672 (Normalized)

Location (X, Z): (60.66 m, 2.74 m)

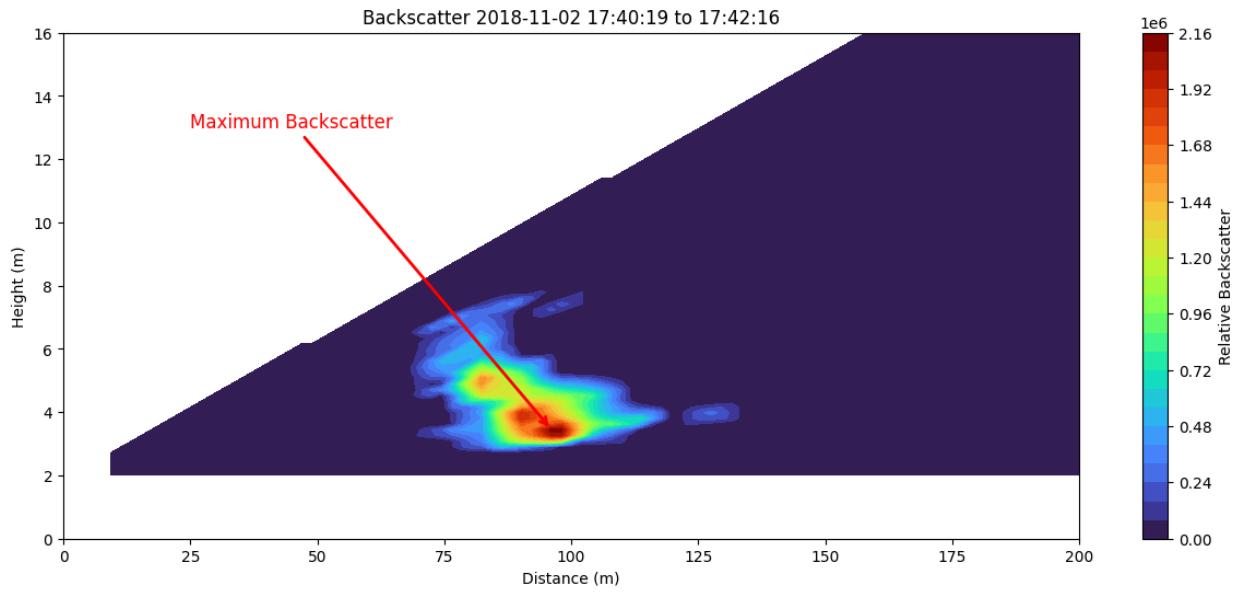
The calculated plume area is: 57.62 square meters.



Maximum Backscatter Value: 2127434.545 (Normalized)

Location (X, Z): (96.12 m, 3.45 m)

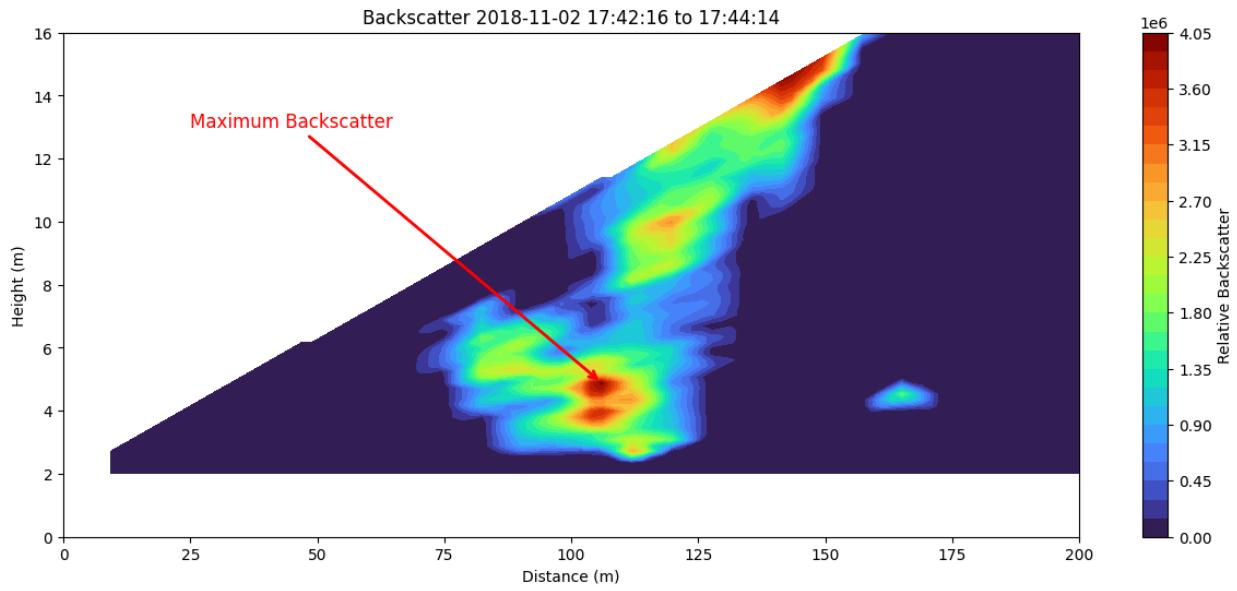
The calculated plume area is: 112.88 square meters.



Maximum Backscatter Value: 3948052.515 (Normalized)

Location (X, Z): (105.97 m, 4.89 m)

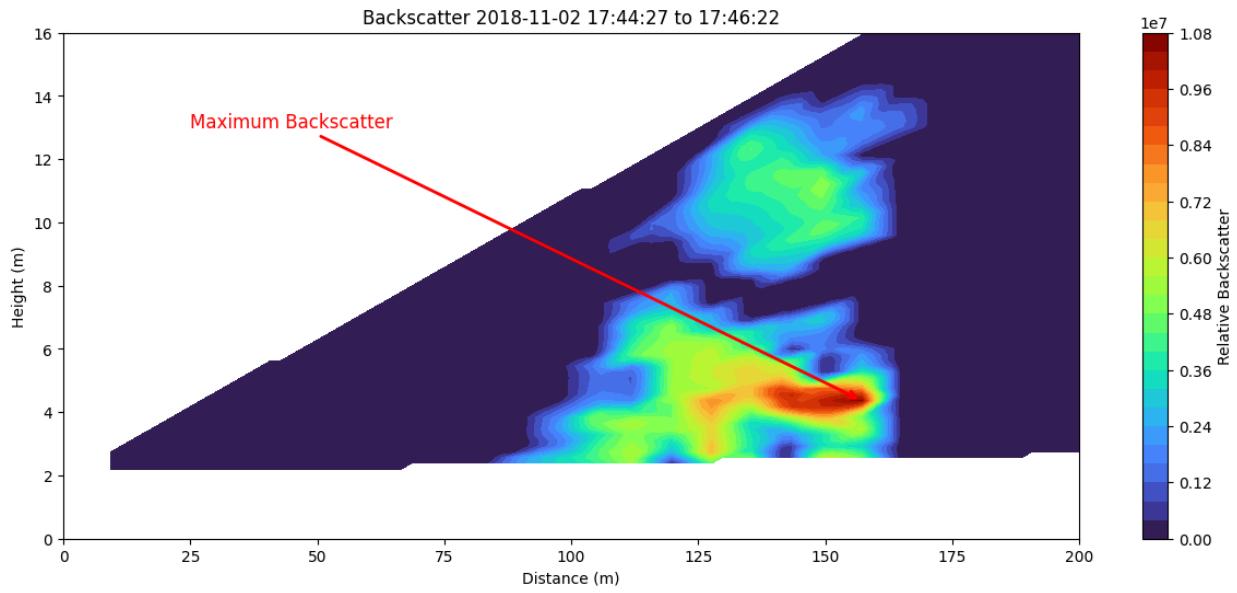
The calculated plume area is: 428.39 square meters.



Maximum Backscatter Value: 10503540.515 (Normalized)

Location (X, Z): (157.19 m, 4.37 m)

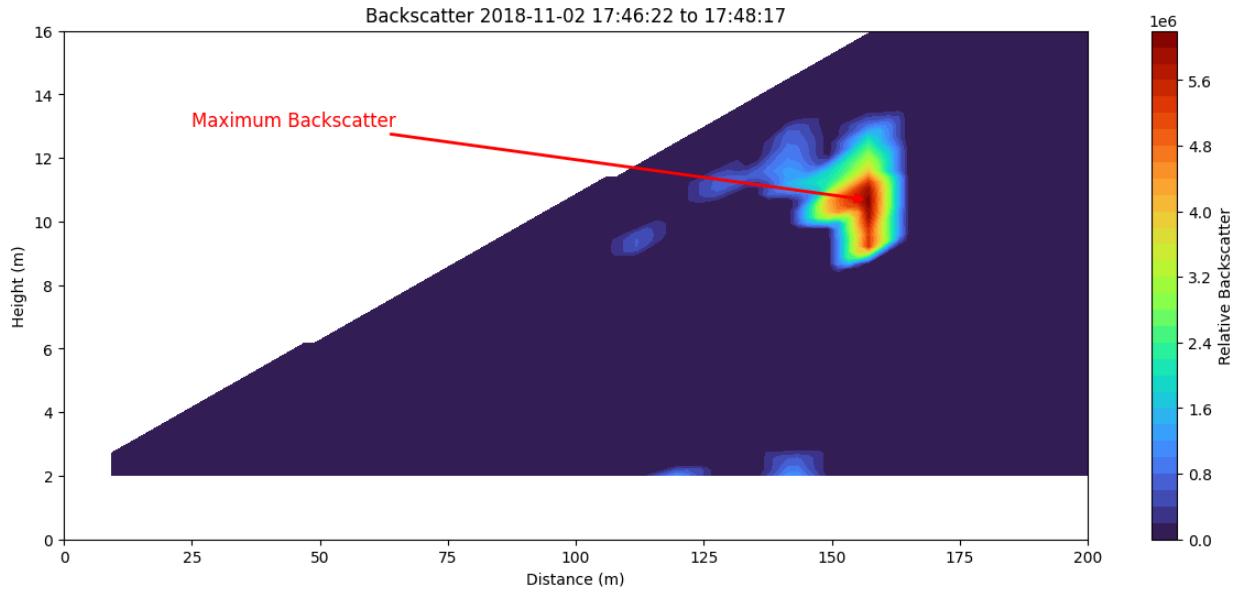
The calculated plume area is: 477.65 square meters.



Maximum Backscatter Value: 6104193.640 (Normalized)

Location (X, Z): (157.19 m, 10.68 m)

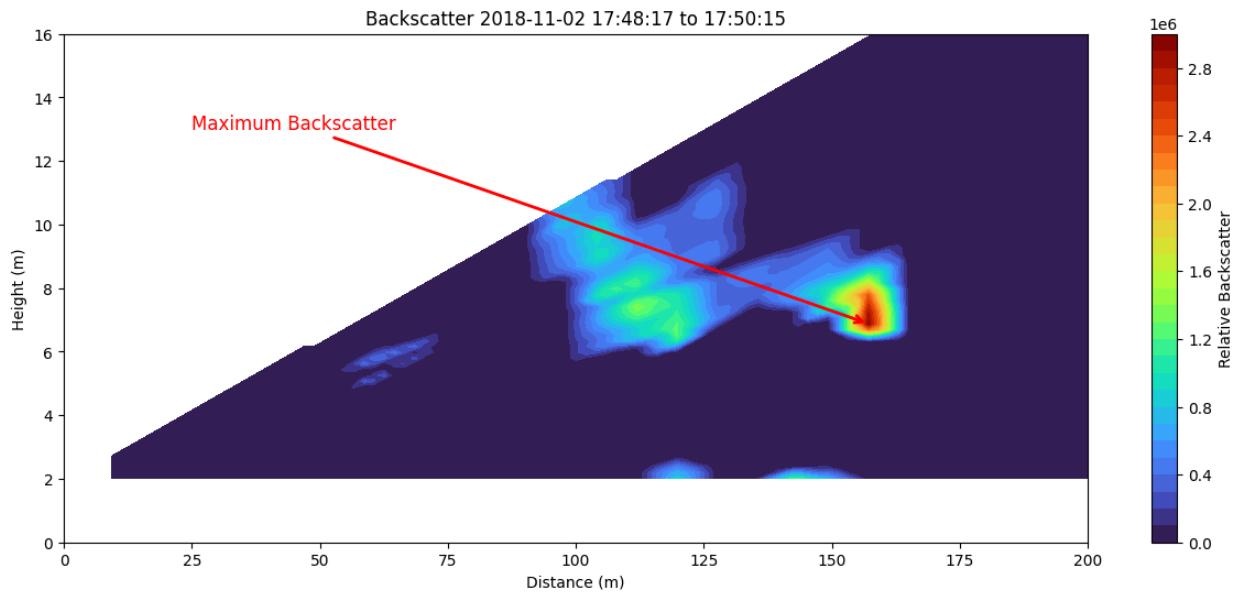
The calculated plume area is: 87.24 square meters.



Maximum Backscatter Value: 2907990.527 (Normalized)

Location (X, Z): (157.19 m, 6.88 m)

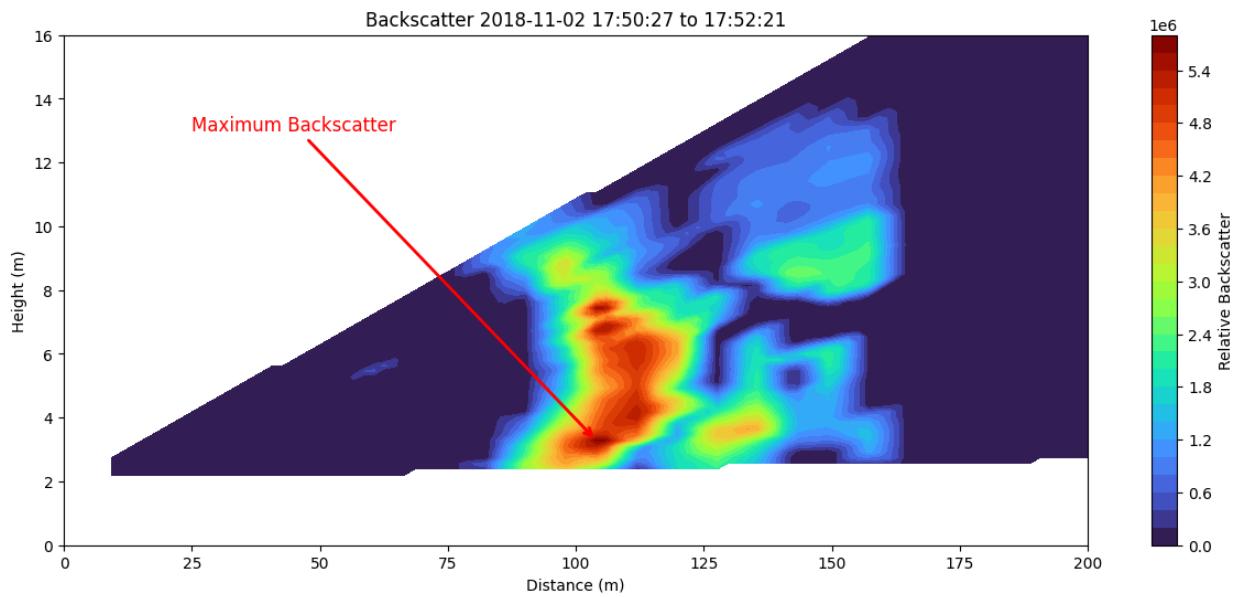
The calculated plume area is: 224.70 square meters.



Maximum Backscatter Value: 5648024.431 (Normalized)

Location (X, Z): (104.00 m, 3.29 m)

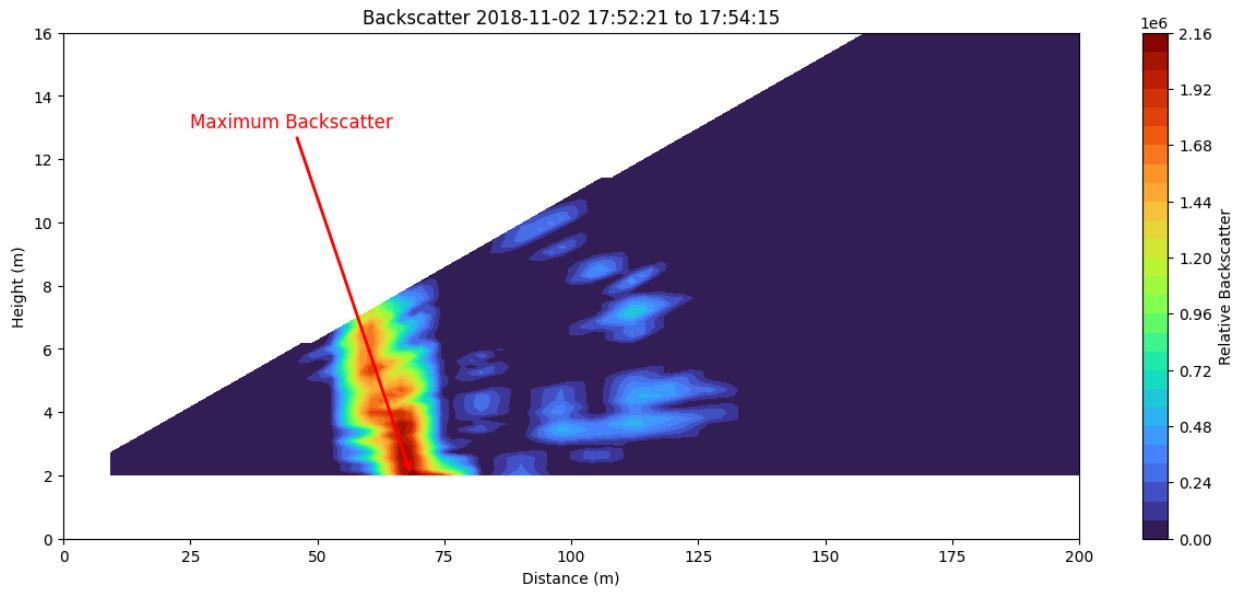
The calculated plume area is: 575.10 square meters.



Maximum Backscatter Value: 2158618.576 (Normalized)

Location (X, Z): (68.54 m, 2.00 m)

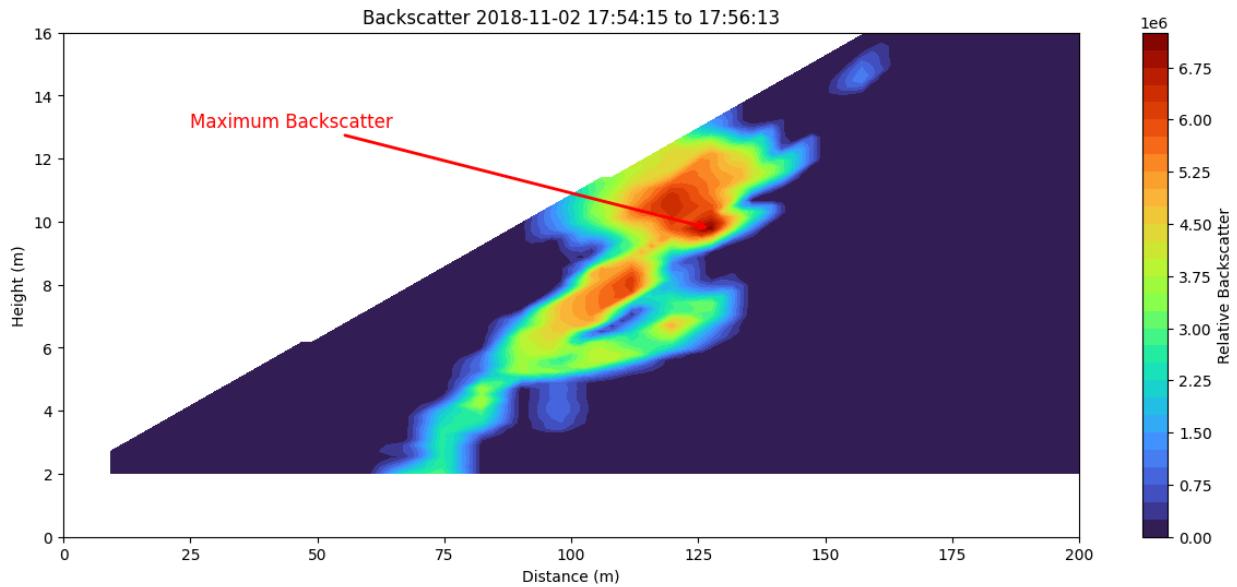
The calculated plume area is: 179.83 square meters.



Maximum Backscatter Value: 7069297.089 (Normalized)

Location (X, Z): (127.64 m, 9.77 m)

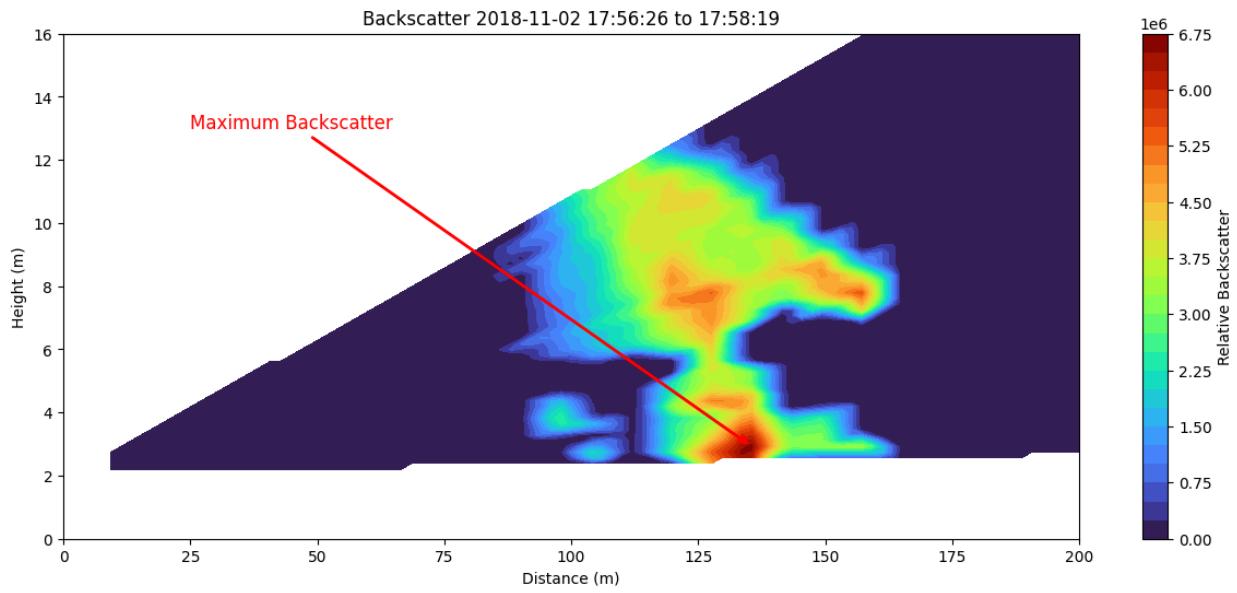
The calculated plume area is: 335.80 square meters.



Maximum Backscatter Value: 6599551.231 (Normalized)

Location (X, Z): (135.52 m, 2.92 m)

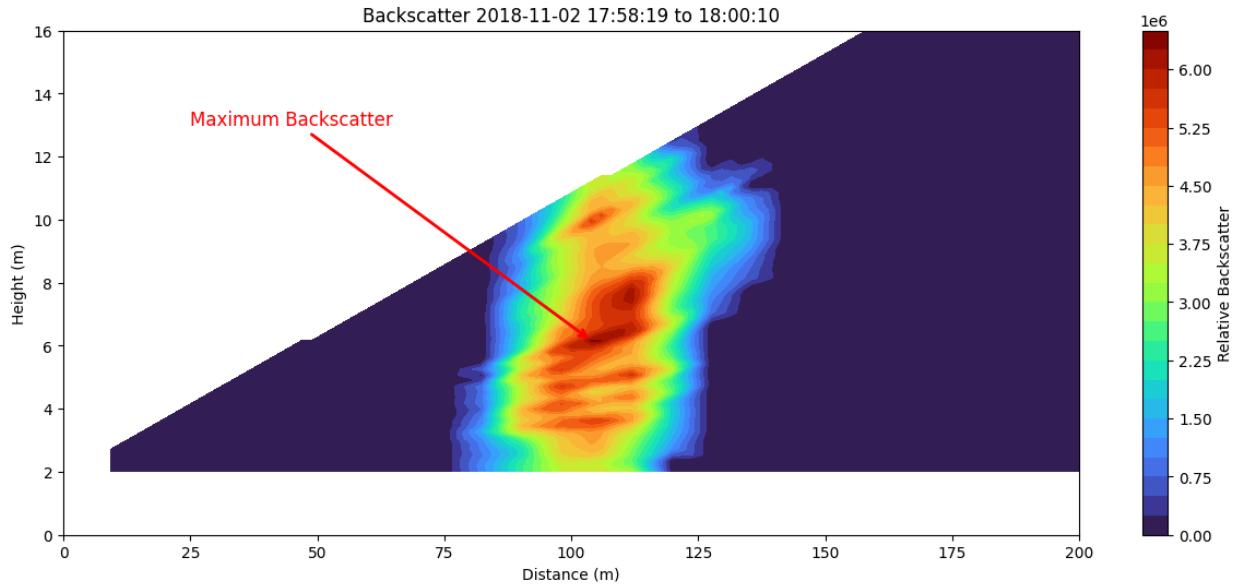
The calculated plume area is: 472.31 square meters.



Maximum Backscatter Value: 6305383.082 (Normalized)

Location (X, Z): (104.00 m, 6.16 m)

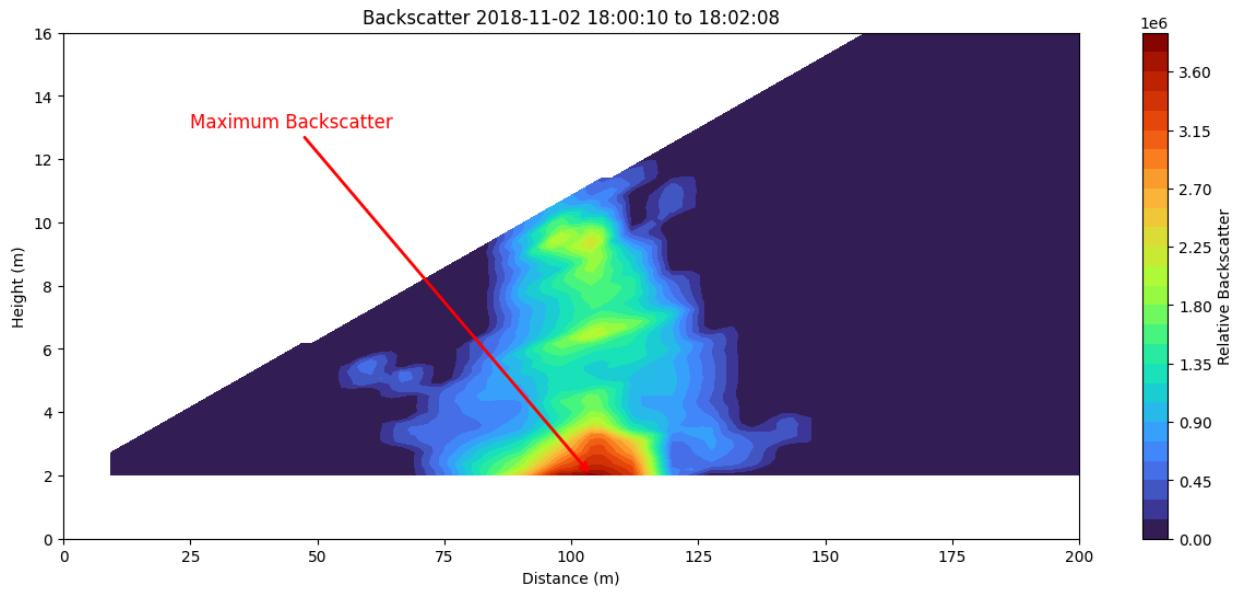
The calculated plume area is: 429.81 square meters.



Maximum Backscatter Value: 3815057.357 (Normalized)

Location (X, Z): (104.00 m, 2.00 m)

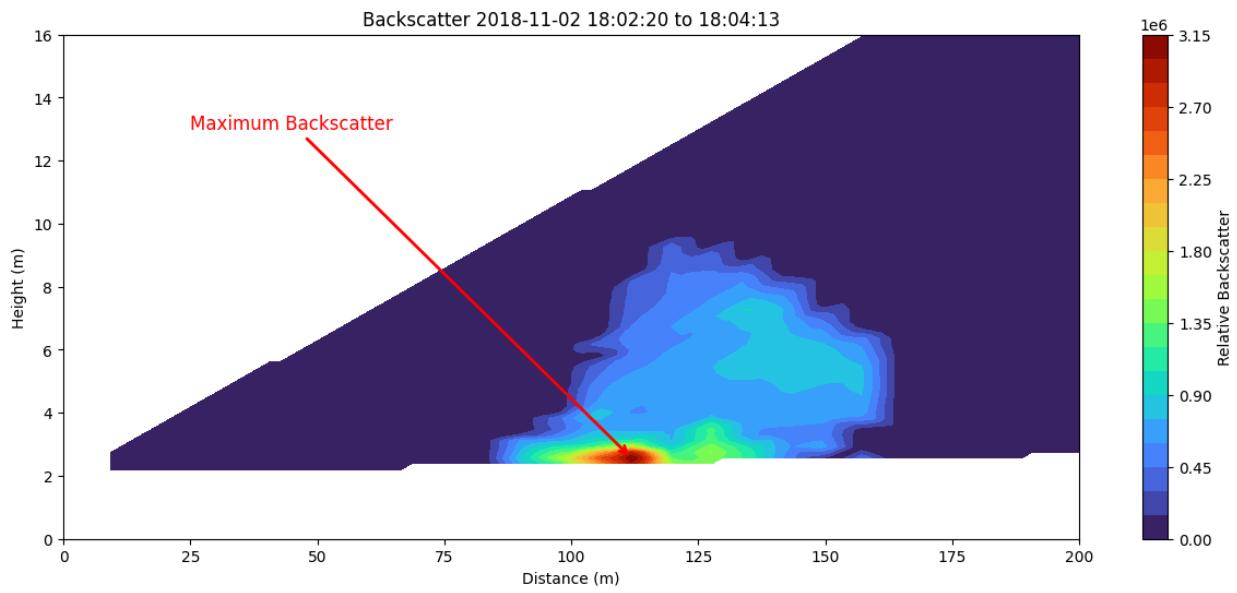
The calculated plume area is: 406.67 square meters.



Maximum Backscatter Value: 3120692.272 (Normalized)

Location (X, Z): (111.88 m, 2.56 m)

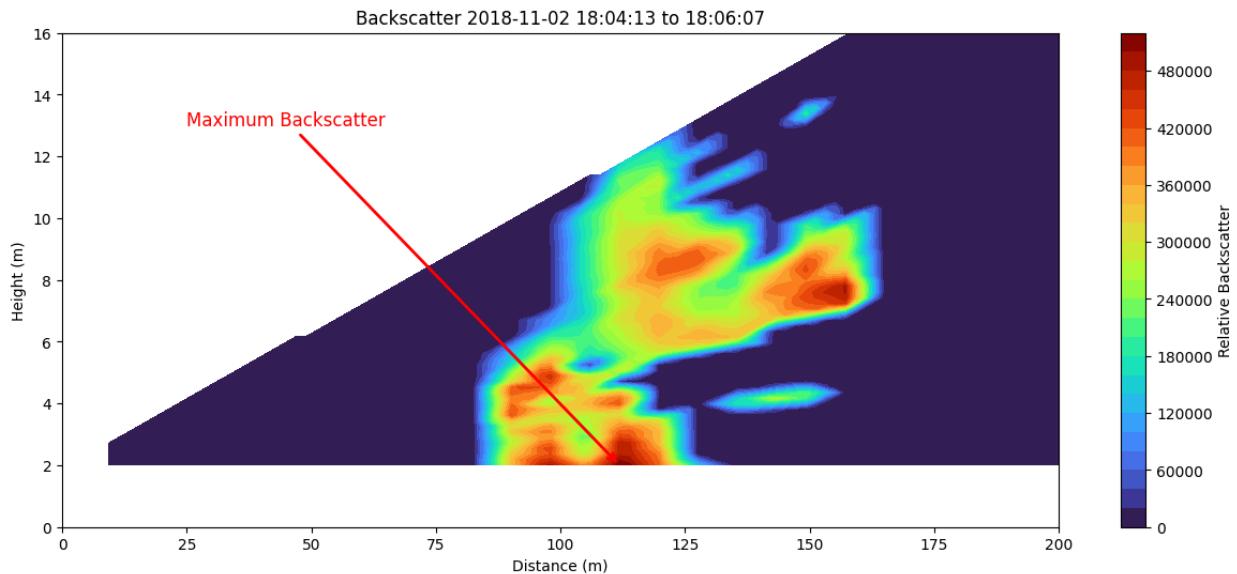
The calculated plume area is: 327.20 square meters.



Maximum Backscatter Value: 516598.525 (Normalized)

Location (X, Z): (111.88 m, 2.00 m)

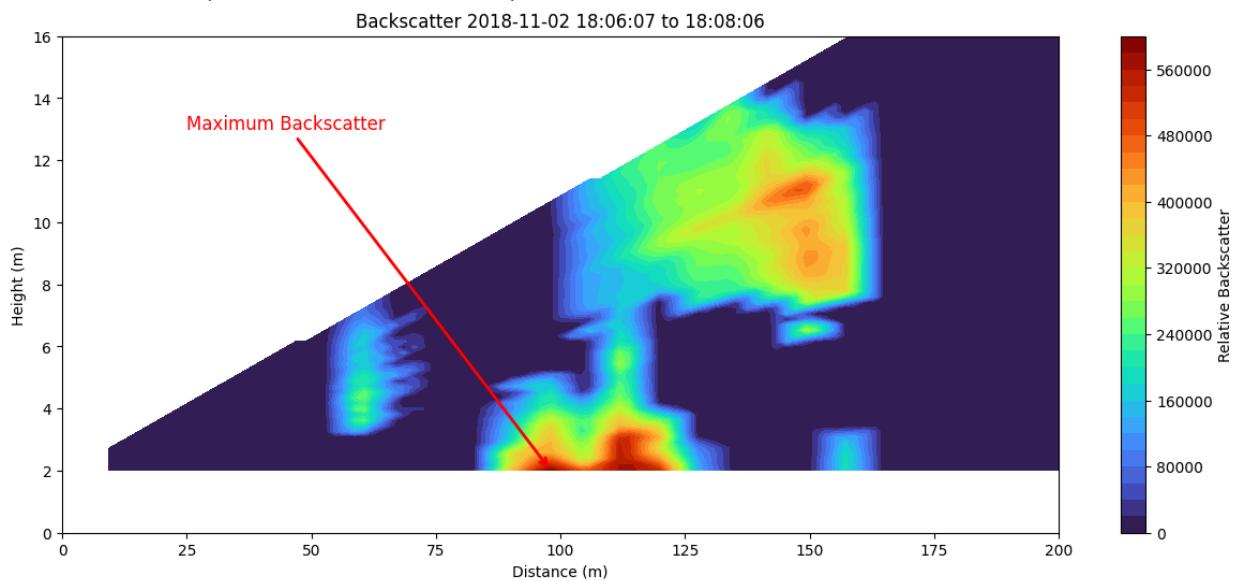
The calculated plume area is: 490.71 square meters.



Maximum Backscatter Value: 590568.981 (Normalized)

Location (X, Z): (98.09 m, 2.00 m)

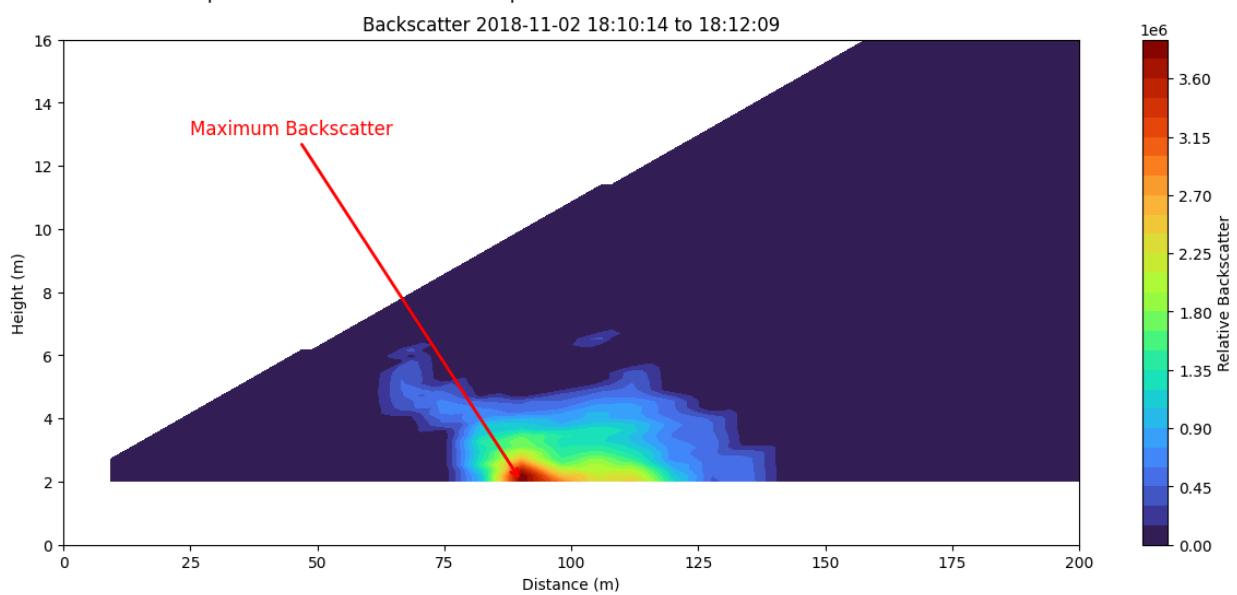
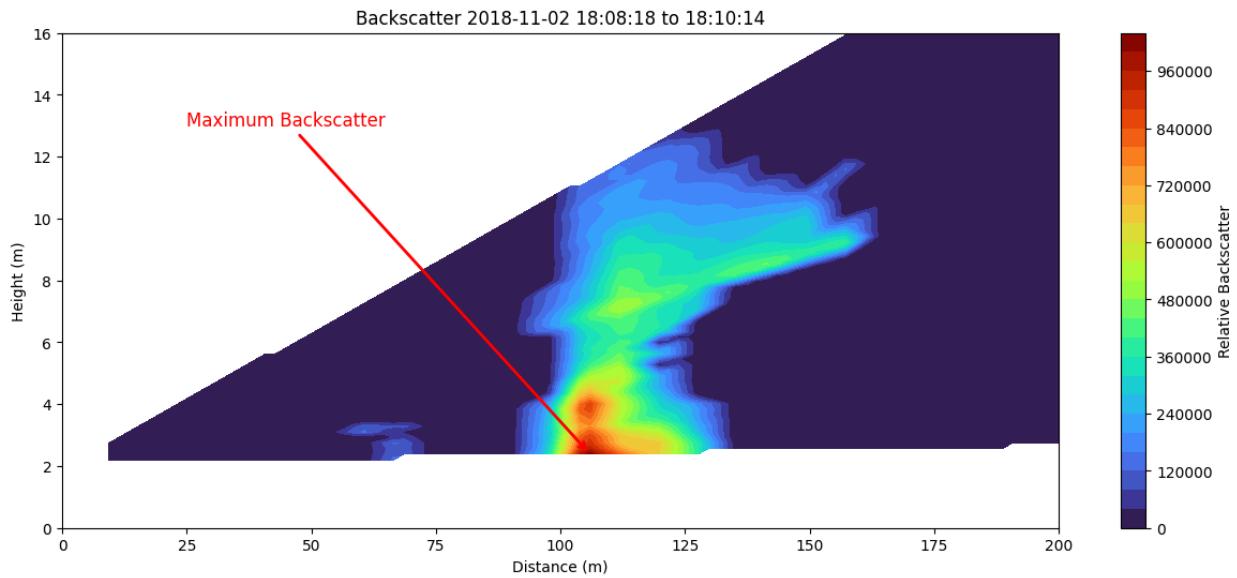
The calculated plume area is: 578.66 square meters.

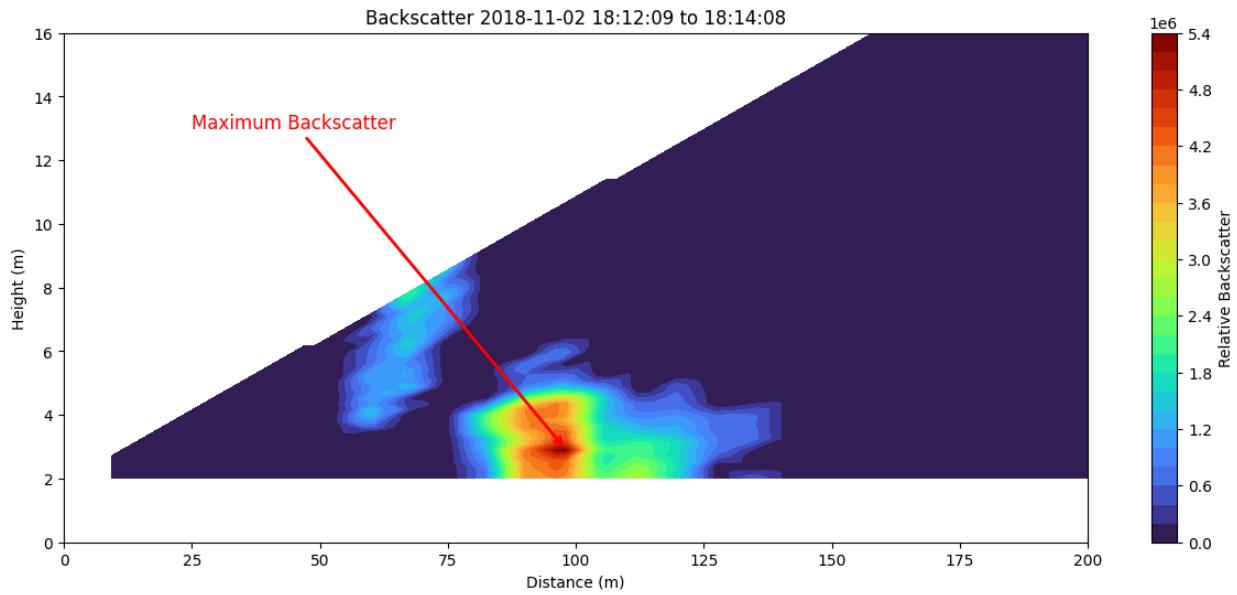


Maximum Backscatter Value: 1026960.838 (Normalized)

Location (X, Z): (105.97 m, 2.38 m)

The calculated plume area is: 379.13 square meters.

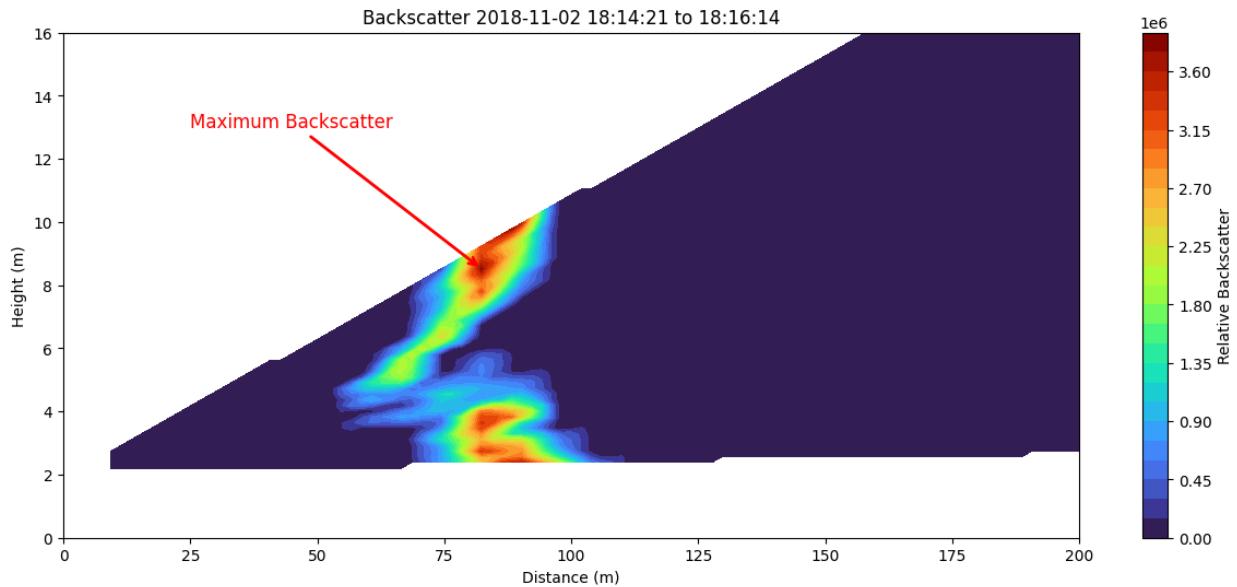




Maximum Backscatter Value: 3786233.558 (Normalized)

Location (X, Z): (82.33 m, 8.52 m)

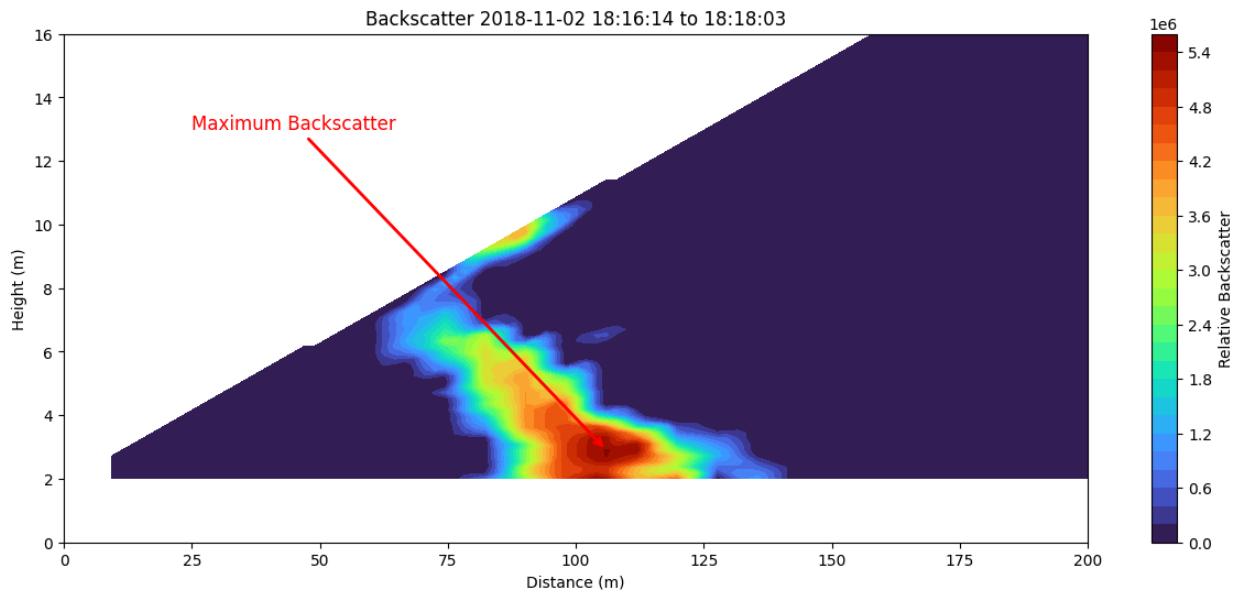
The calculated plume area is: 173.92 square meters.



Maximum Backscatter Value: 5408023.852 (Normalized)

Location (X, Z): (105.97 m, 2.90 m)

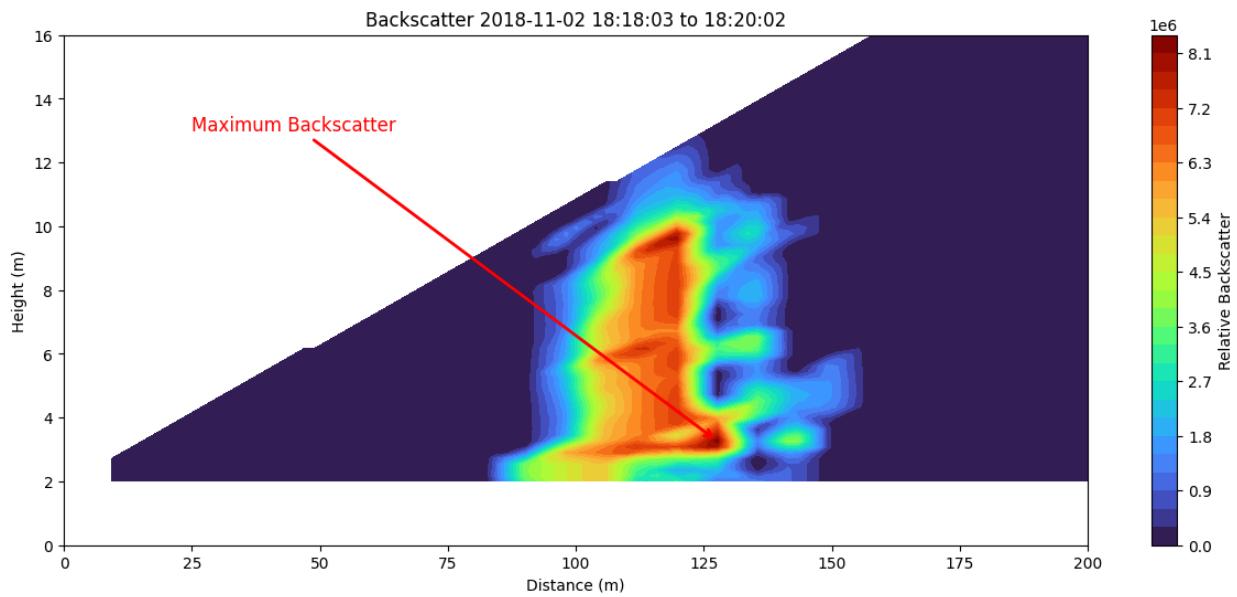
The calculated plume area is: 214.02 square meters.



Maximum Backscatter Value: 8310023.490 (Normalized)

Location (X, Z): (127.64 m, 3.27 m)

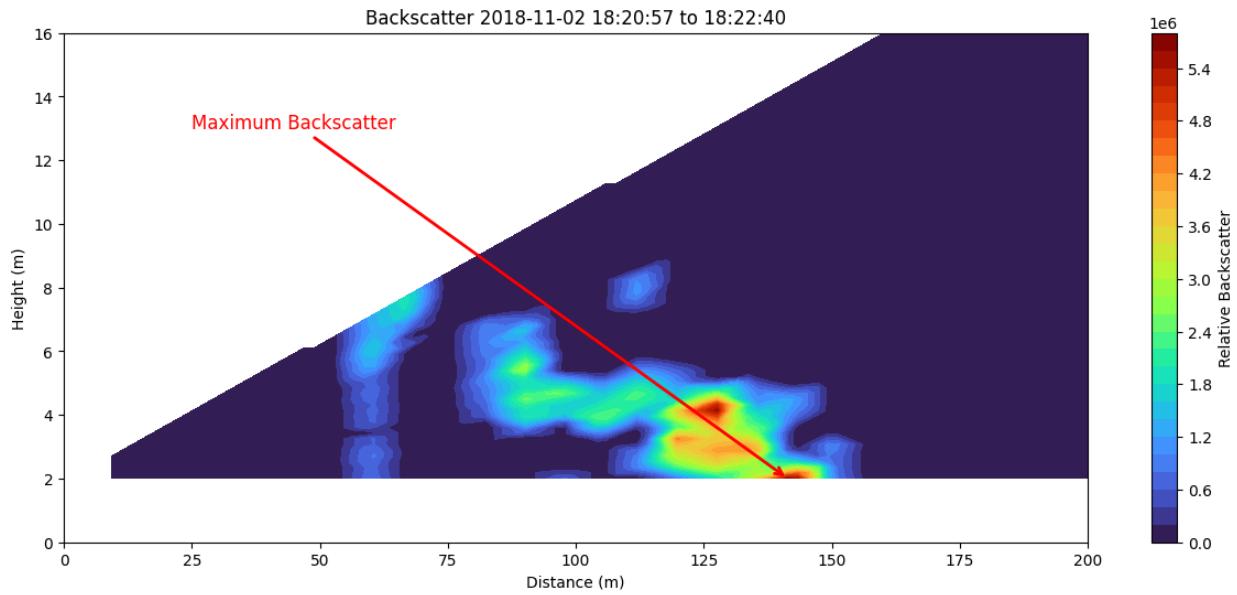
The calculated plume area is: 436.94 square meters.



Maximum Backscatter Value: 5675191.584 (Normalized)

Location (X, Z): (141.43 m, 2.00 m)

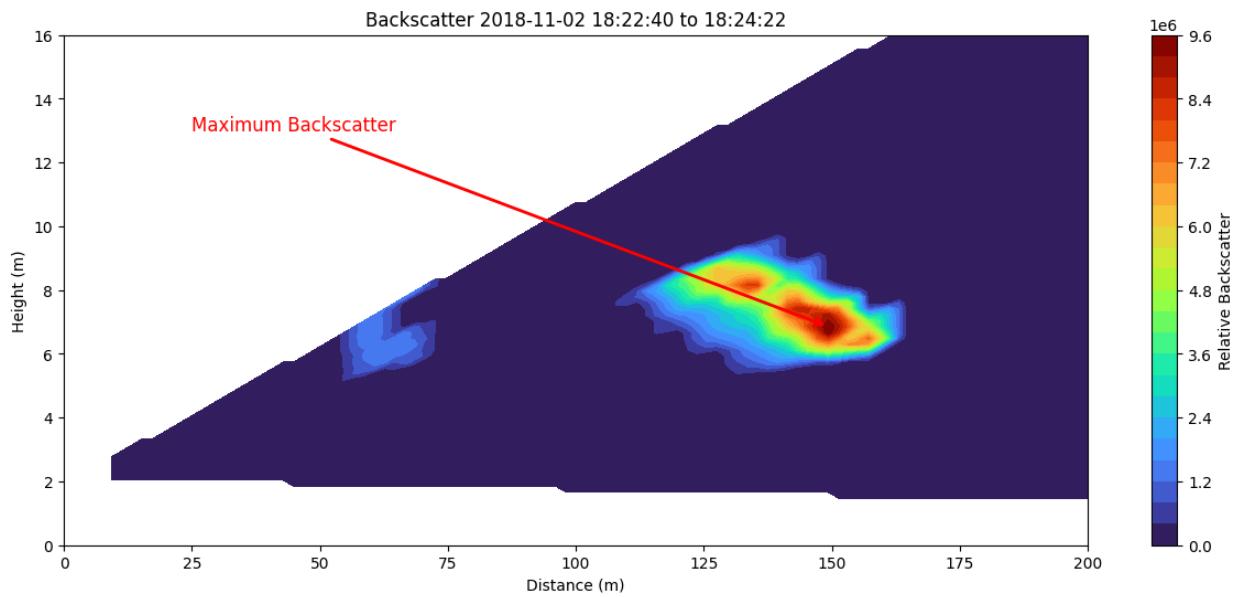
The calculated plume area is: 234.25 square meters.



Maximum Backscatter Value: 9589507.012 (Normalized)

Location (X, Z): (149.31 m, 6.86 m)

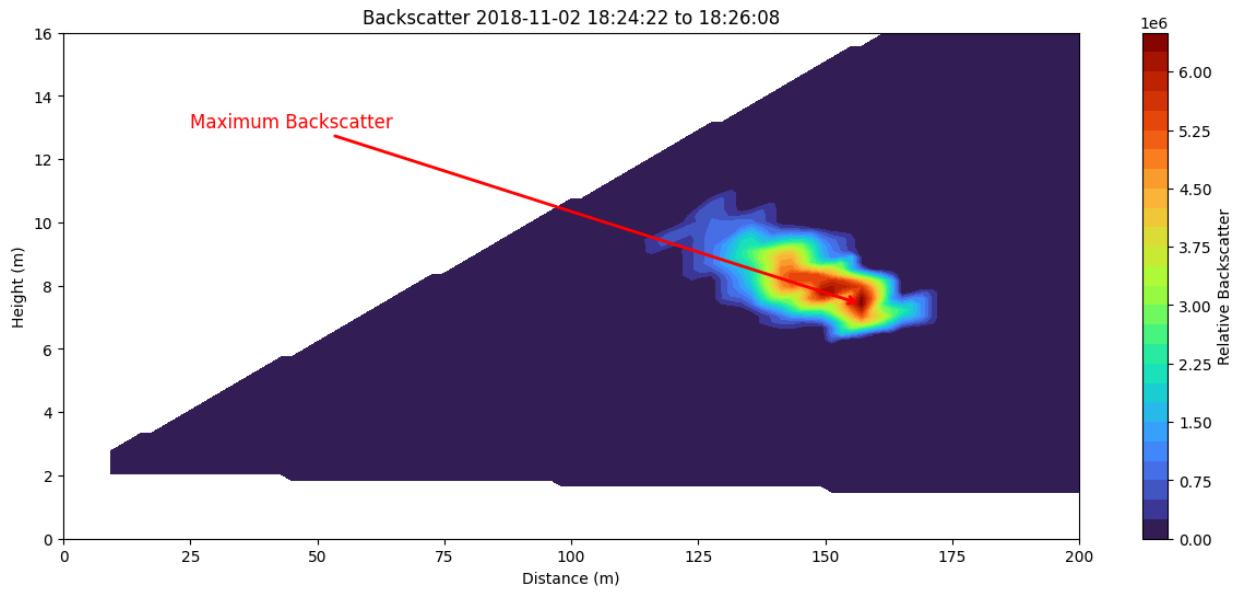
The calculated plume area is: 141.36 square meters.



Maximum Backscatter Value: 6374610.228 (Normalized)

Location (X, Z): (157.19 m, 7.41 m)

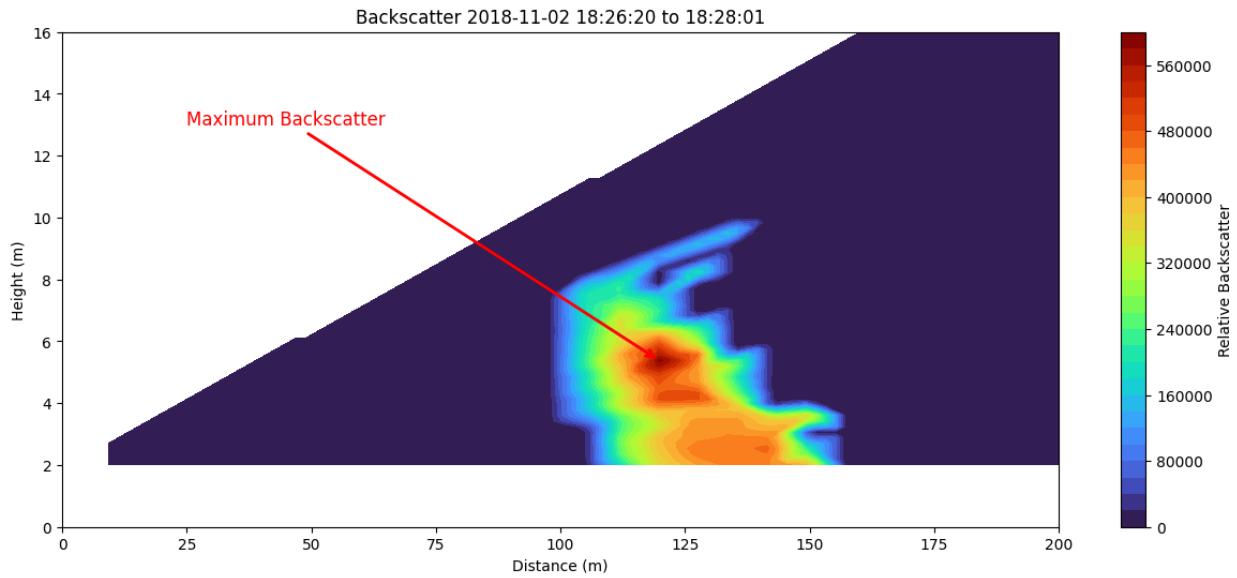
The calculated plume area is: 102.64 square meters.



Maximum Backscatter Value: 587692.082 (Normalized)

Location (X, Z): (119.76 m, 5.39 m)

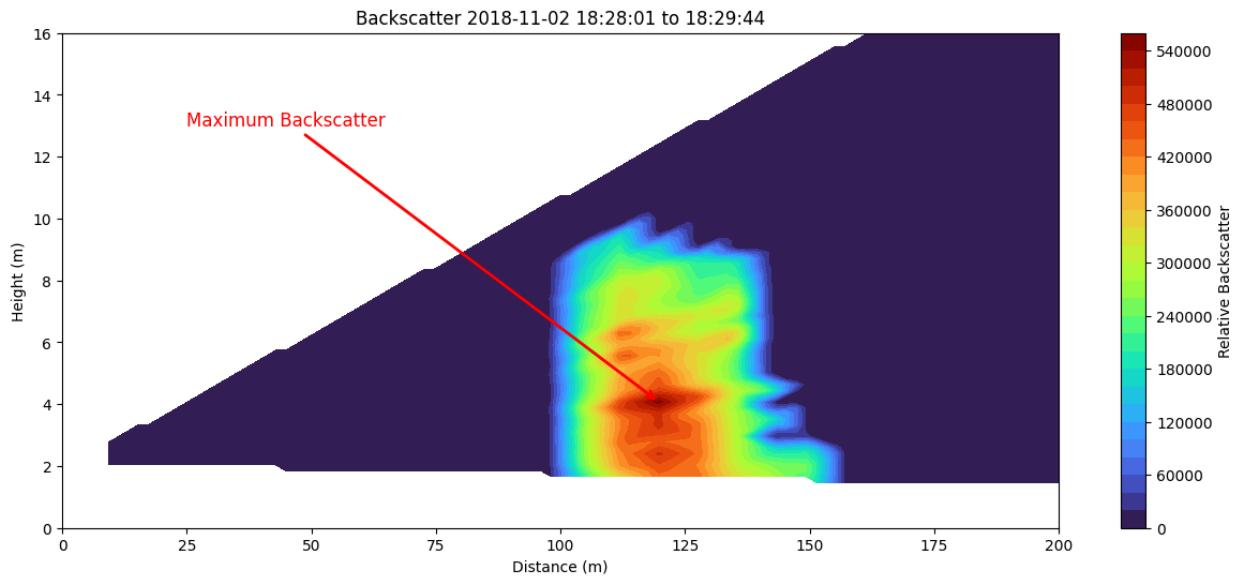
The calculated plume area is: 261.99 square meters.



Maximum Backscatter Value: 549182.192 (Normalized)

Location (X, Z): (119.76 m, 4.07 m)

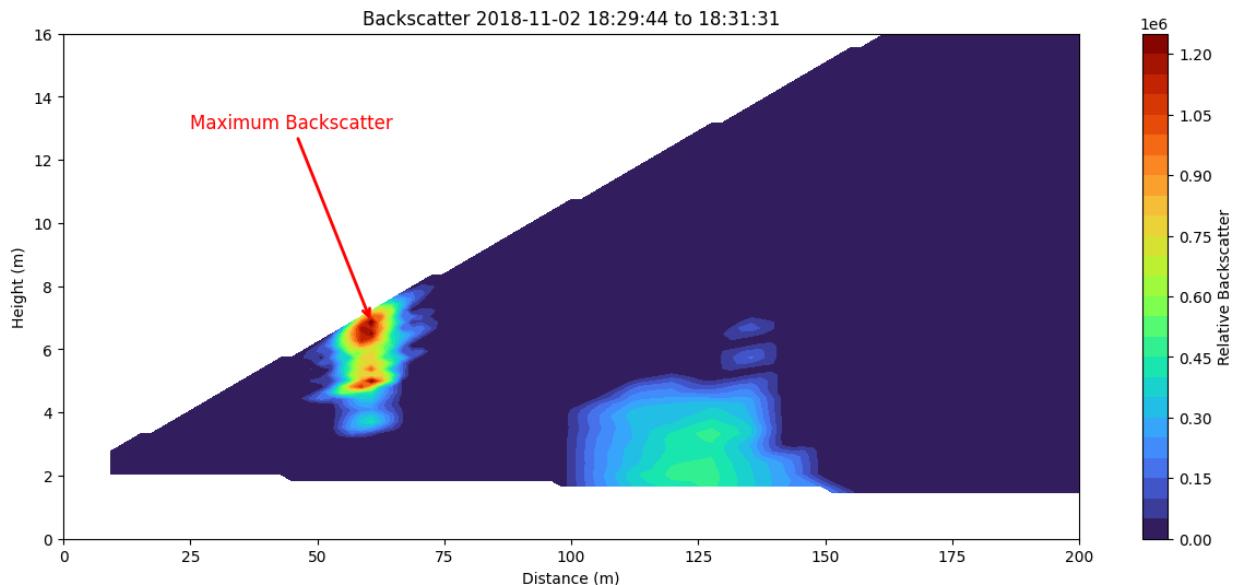
The calculated plume area is: 348.09 square meters.



Maximum Backscatter Value: 1246007.390 (Normalized)

Location (X, Z): (60.66 m, 6.86 m)

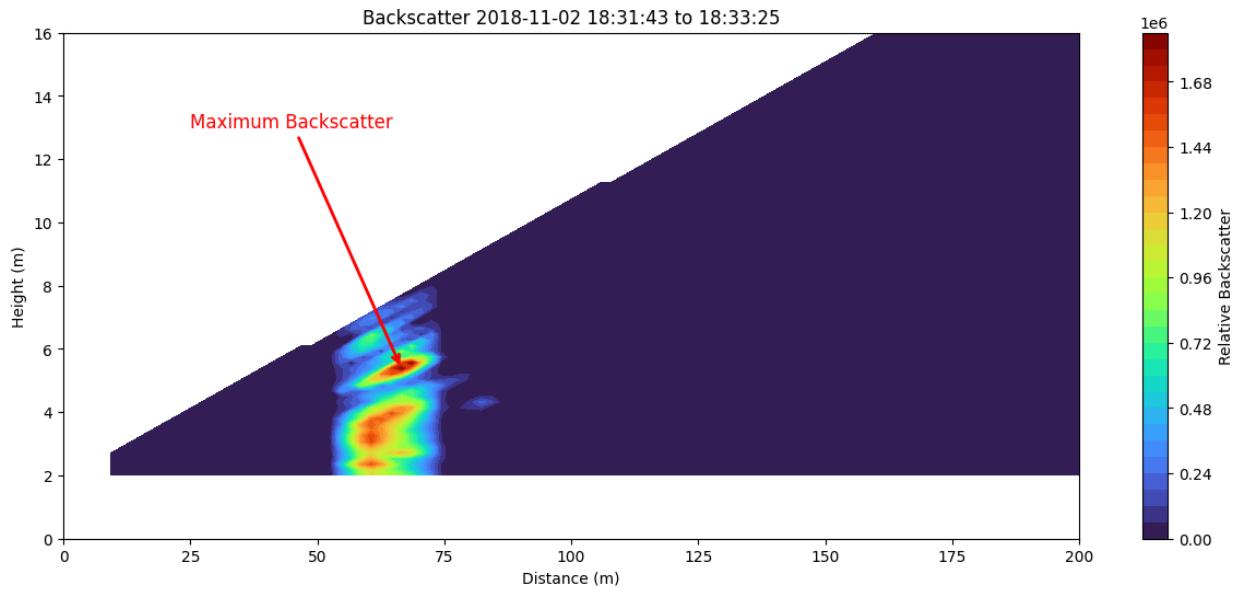
The calculated plume area is: 185.19 square meters.



Maximum Backscatter Value: 1814665.619 (Normalized)

Location (X, Z): (66.57 m, 5.39 m)

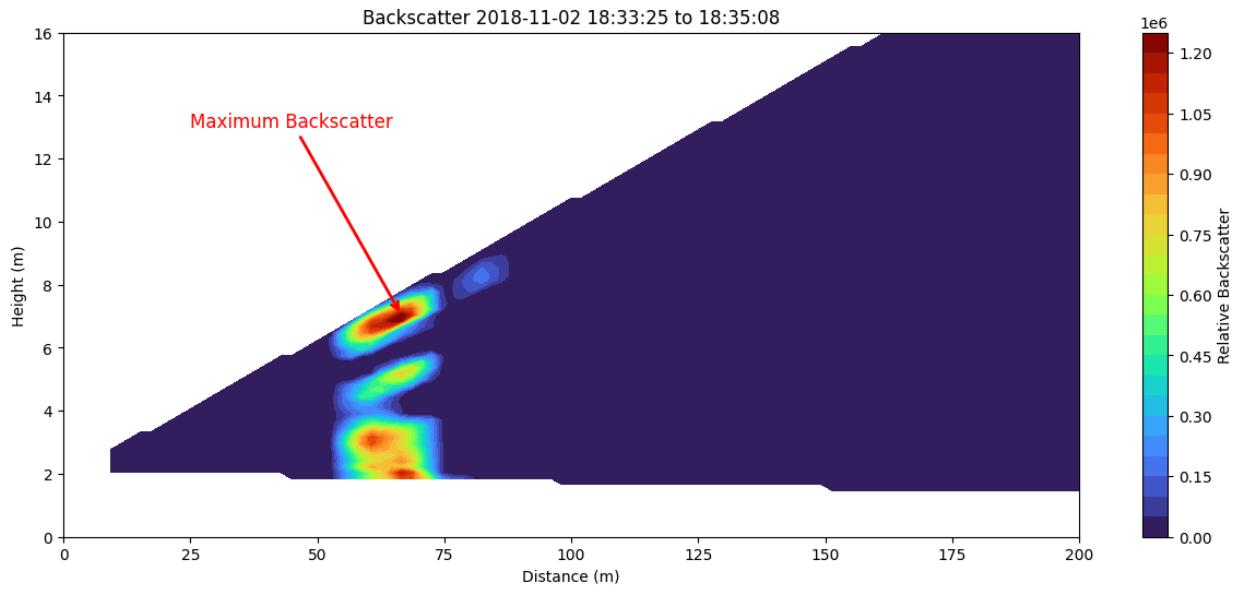
The calculated plume area is: 89.55 square meters.



Maximum Backscatter Value: 1249795.688 (Normalized)

Location (X, Z): (66.57 m, 7.04 m)

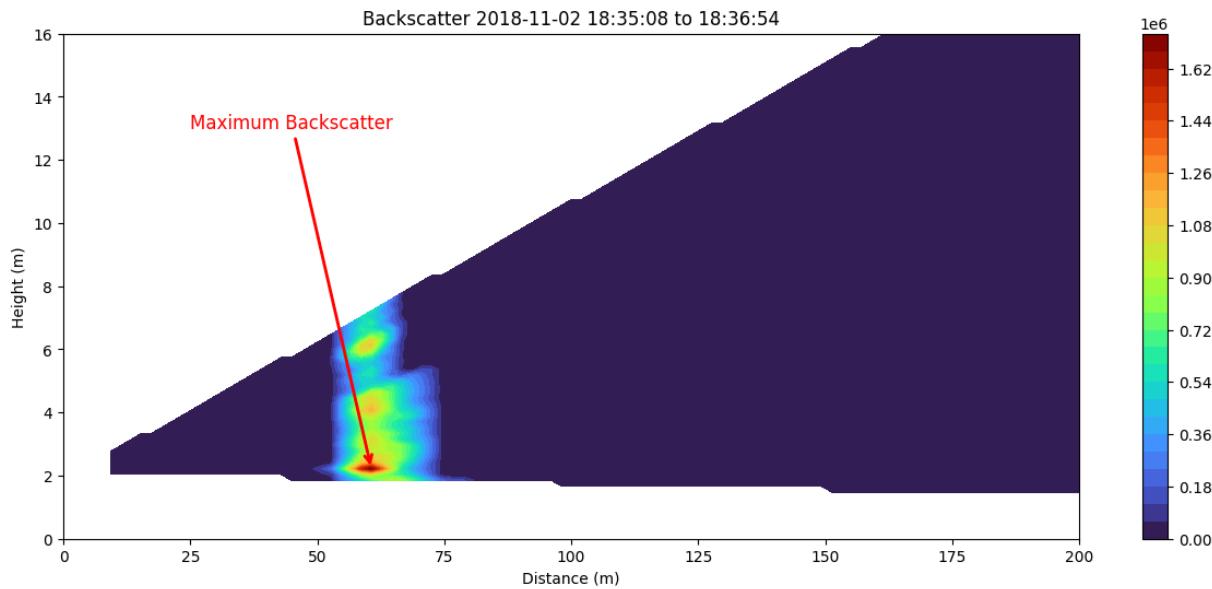
The calculated plume area is: 88.39 square meters.



Maximum Backscatter Value: 1736856.768 (Normalized)

Location (X, Z): (60.66 m, 2.22 m)

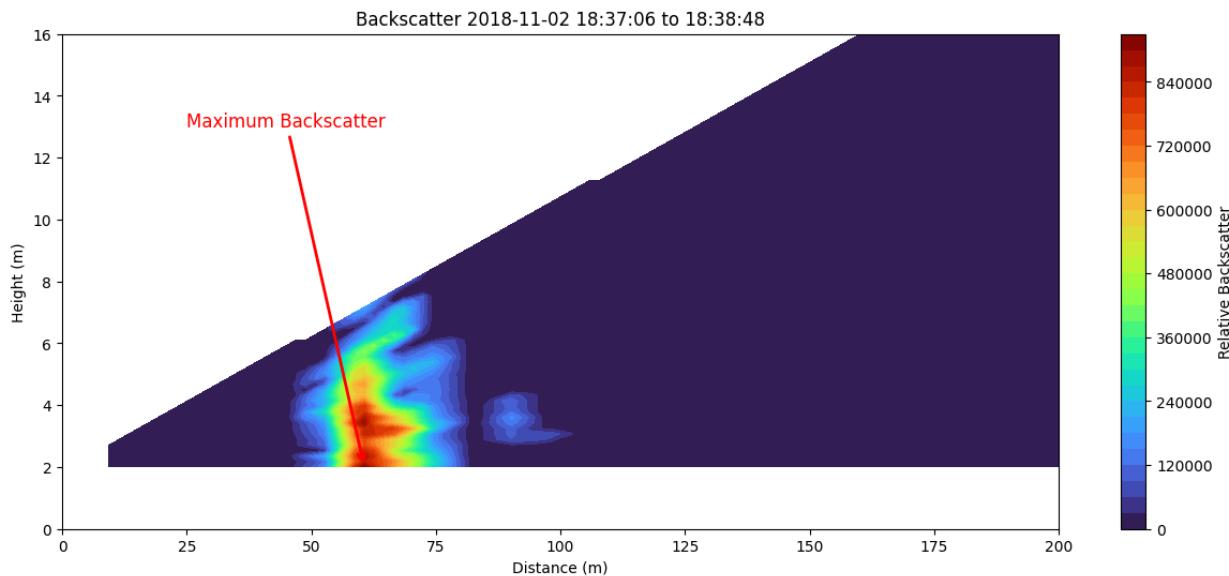
The calculated plume area is: 89.49 square meters.



Maximum Backscatter Value: 915634.112 (Normalized)

Location (X, Z): (60.66 m, 2.00 m)

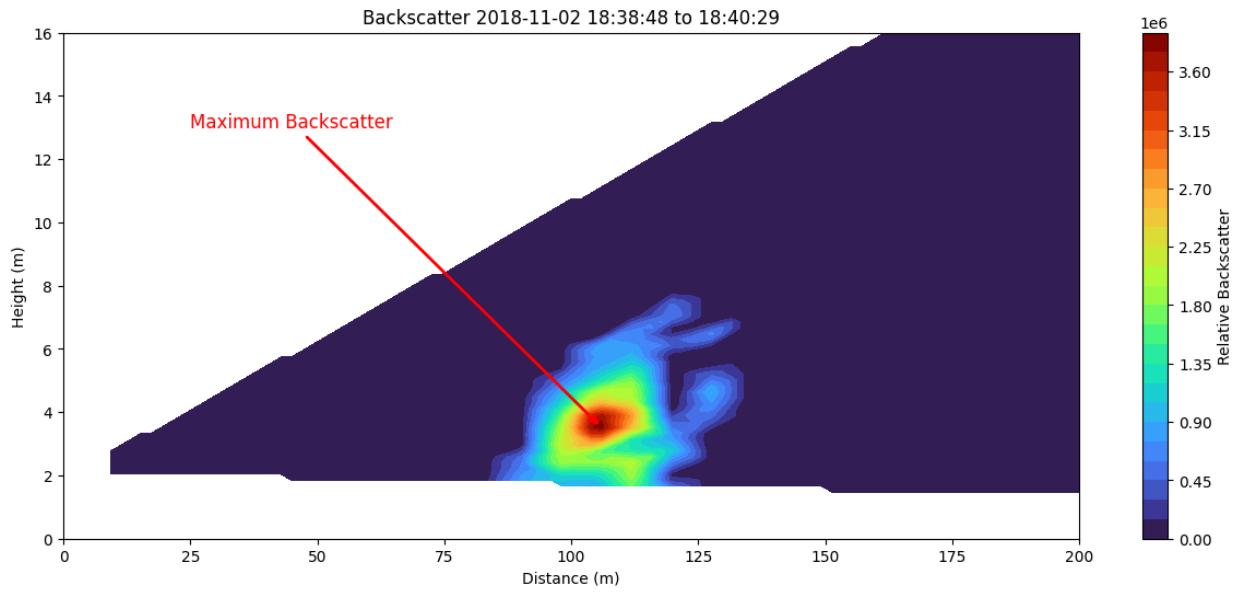
The calculated plume area is: 129.59 square meters.



Maximum Backscatter Value: 3843297.229 (Normalized)

Location (X, Z): (105.97 m, 3.52 m)

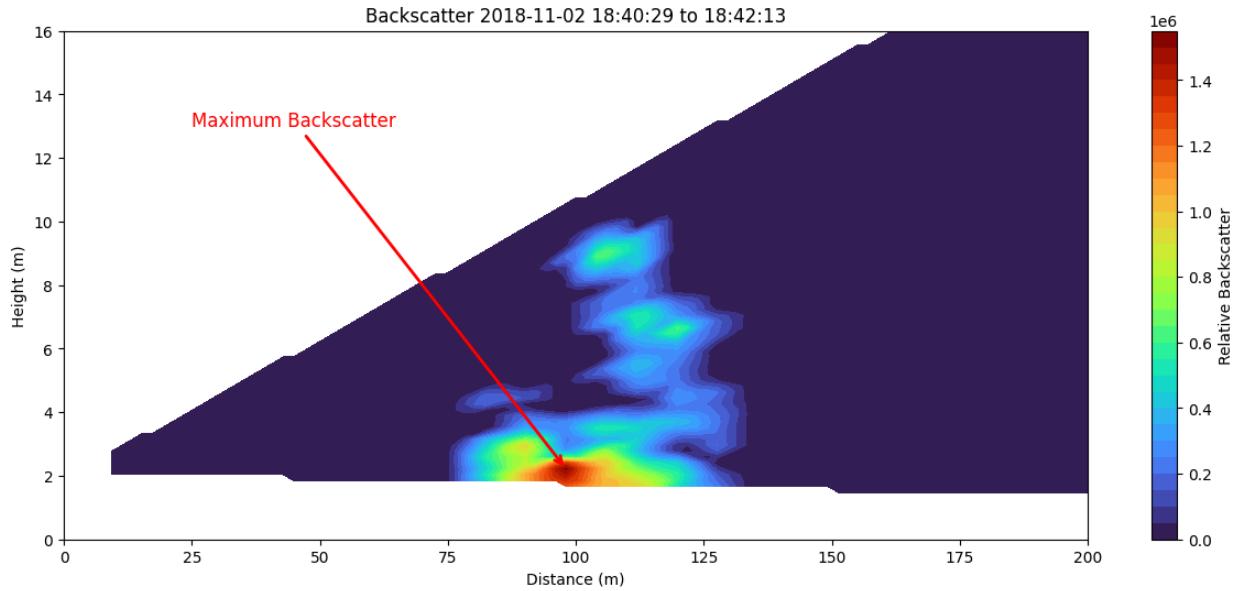
The calculated plume area is: 148.66 square meters.



Maximum Backscatter Value: 1515506.510 (Normalized)

Location (X, Z): (98.09 m, 2.22 m)

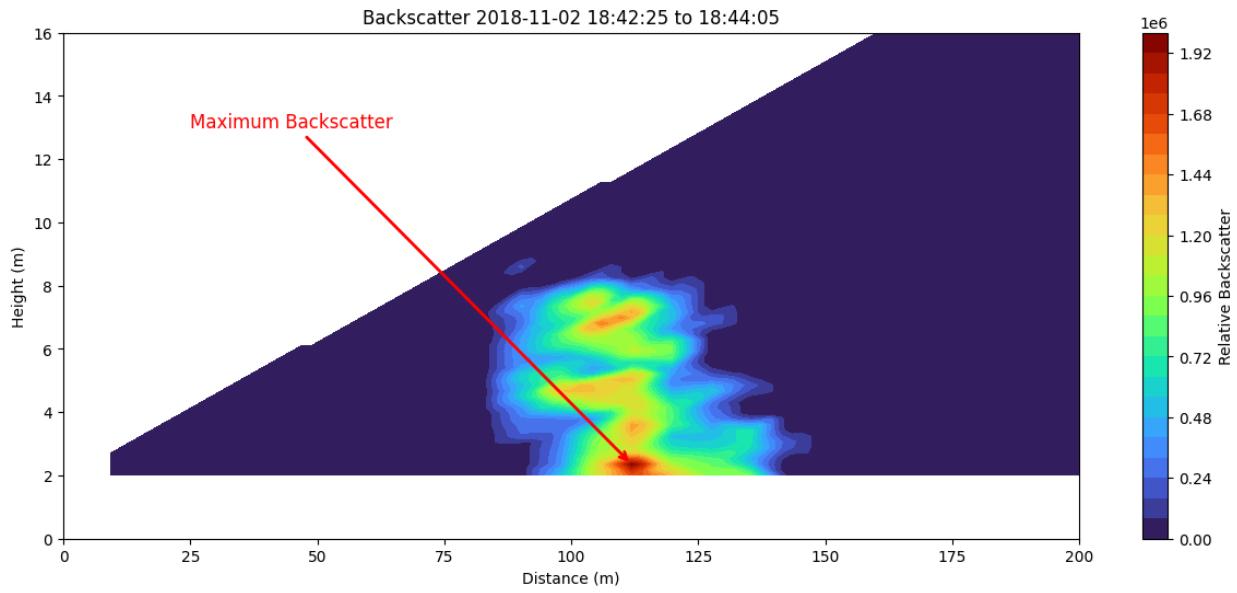
The calculated plume area is: 204.55 square meters.



Maximum Backscatter Value: 1938829.747 (Normalized)

Location (X, Z): (111.88 m, 2.36 m)

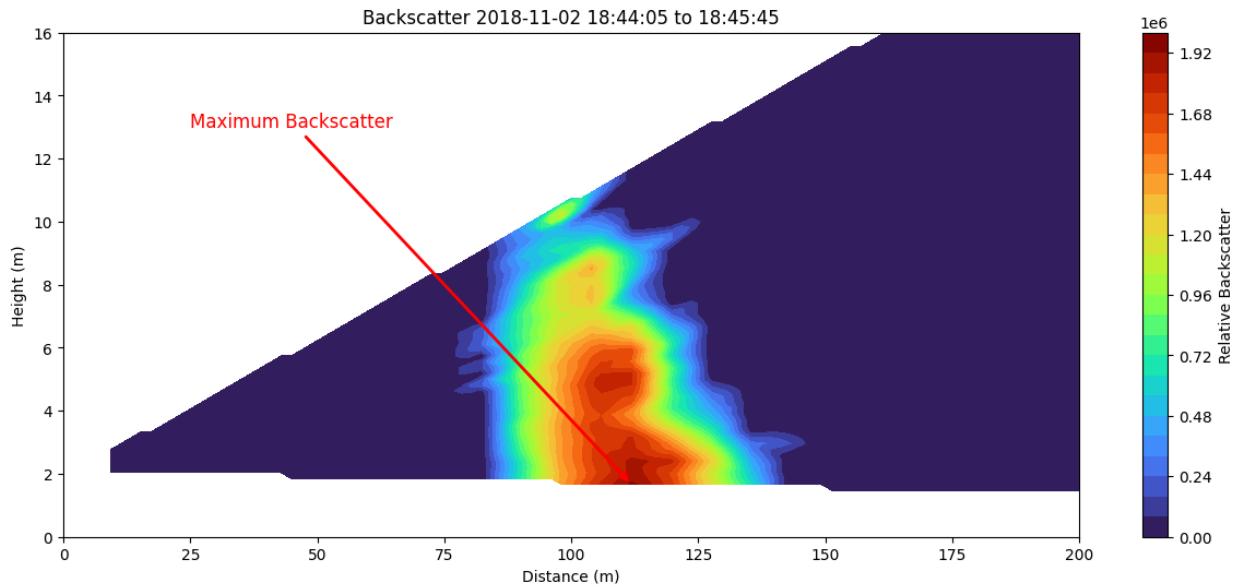
The calculated plume area is: 264.80 square meters.



Maximum Backscatter Value: 1935270.422 (Normalized)

Location (X, Z): (111.88 m, 1.66 m)

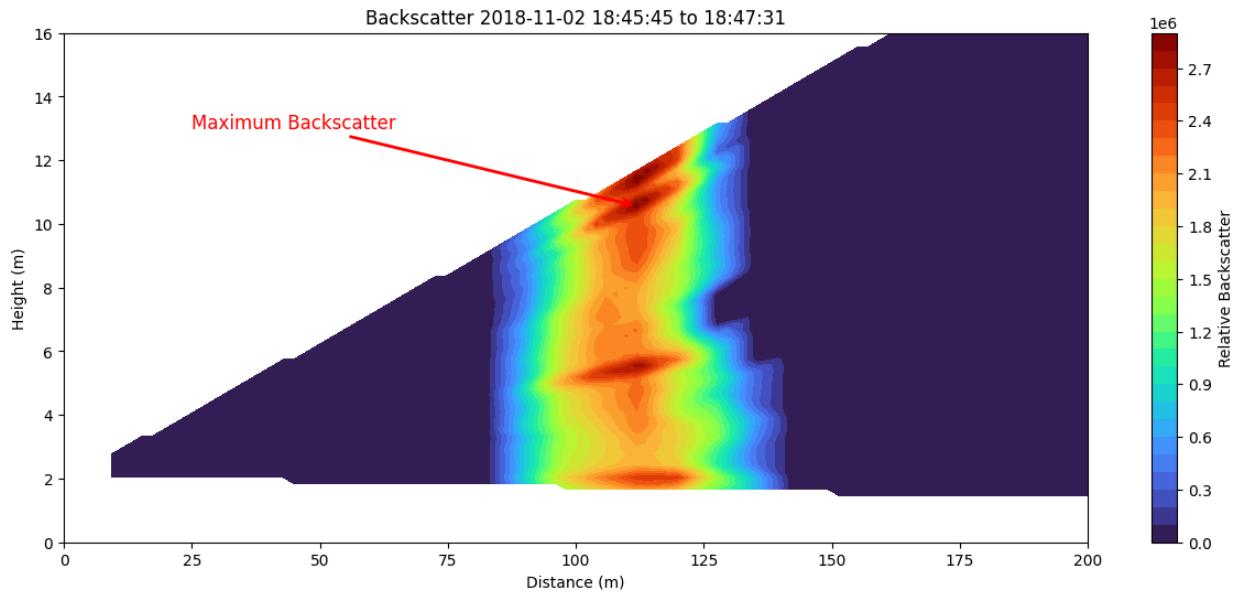
The calculated plume area is: 358.69 square meters.



Maximum Backscatter Value: 2879224.803 (Normalized)

Location (X, Z): (111.88 m, 10.56 m)

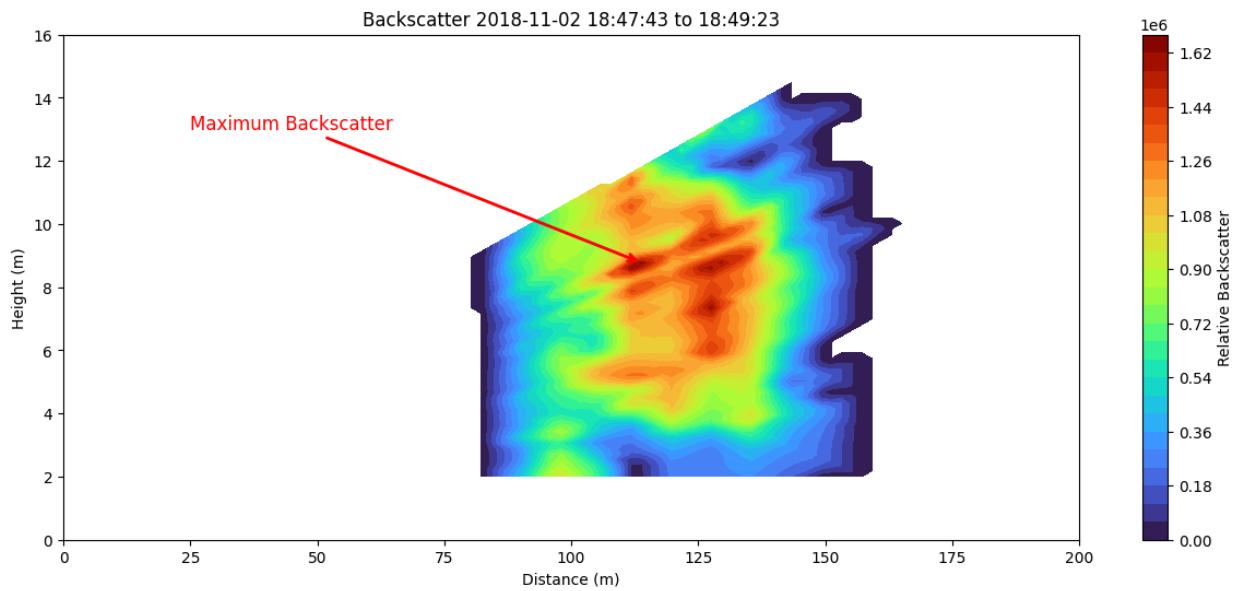
The calculated plume area is: 469.73 square meters.



Maximum Backscatter Value: 1627298.397 (Normalized)

Location (X, Z): (113.85 m, 8.77 m)

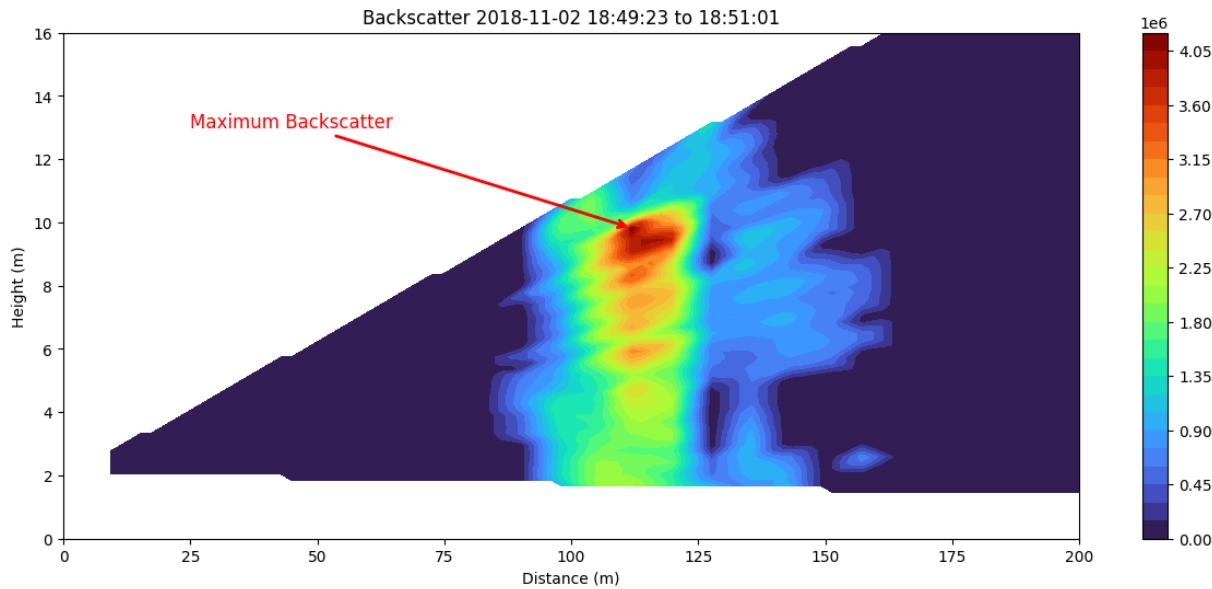
The calculated plume area is: 655.33 square meters.



Maximum Backscatter Value: 4171892.112 (Normalized)

Location (X, Z): (111.88 m, 9.82 m)

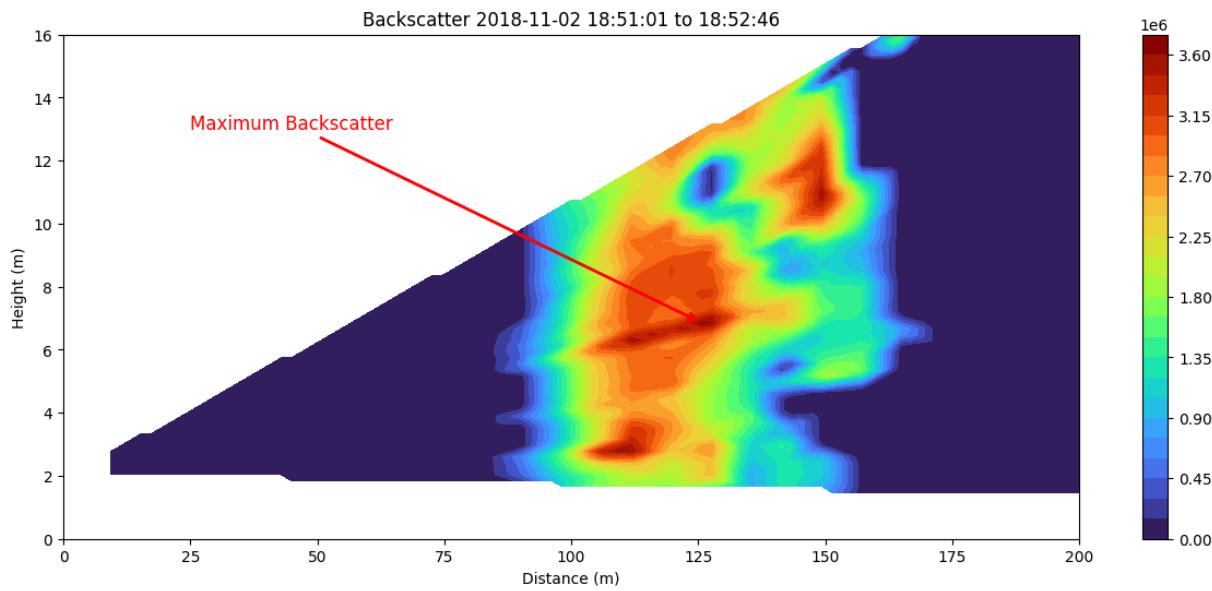
The calculated plume area is: 572.36 square meters.



Maximum Backscatter Value: 3617363.292 (Normalized)

Location (X, Z): (125.67 m, 6.86 m)

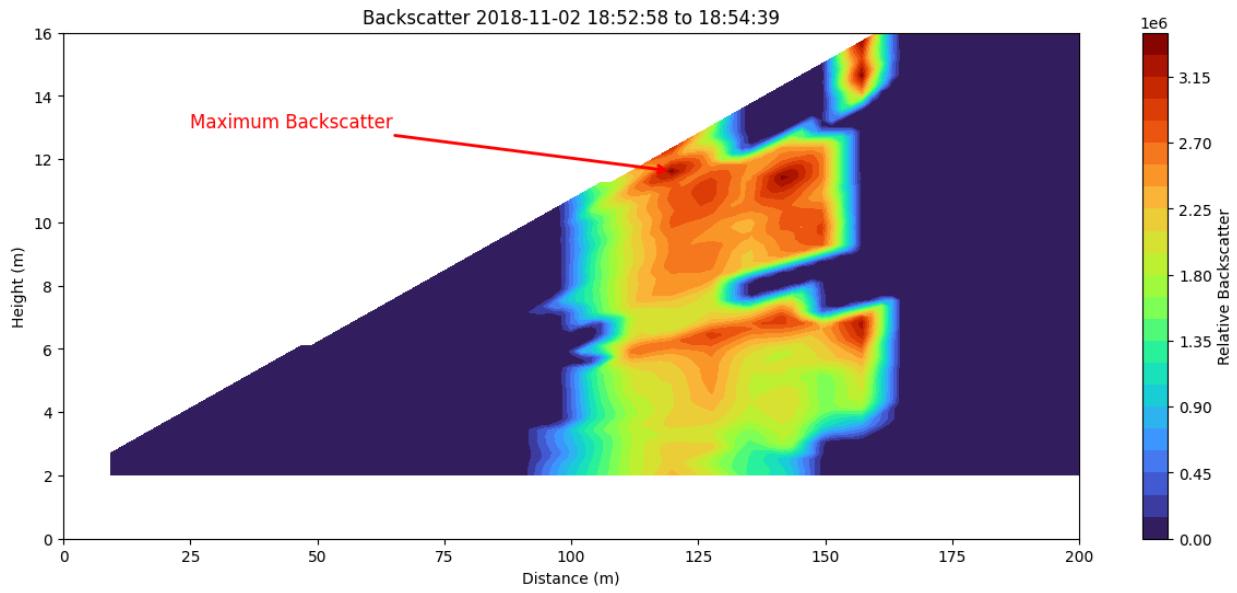
The calculated plume area is: 754.99 square meters.



Maximum Backscatter Value: 3348833.459 (Normalized)

Location (X, Z): (119.76 m, 11.63 m)

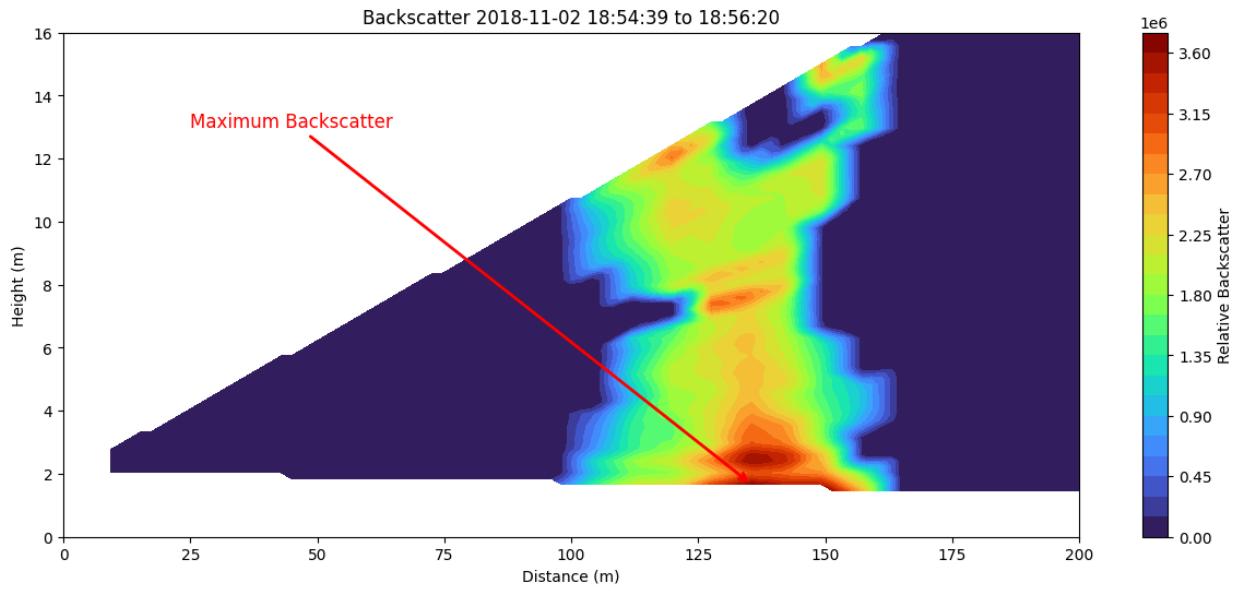
The calculated plume area is: 629.69 square meters.



Maximum Backscatter Value: 3658960.423 (Normalized)

Location (X, Z): (135.52 m, 1.66 m)

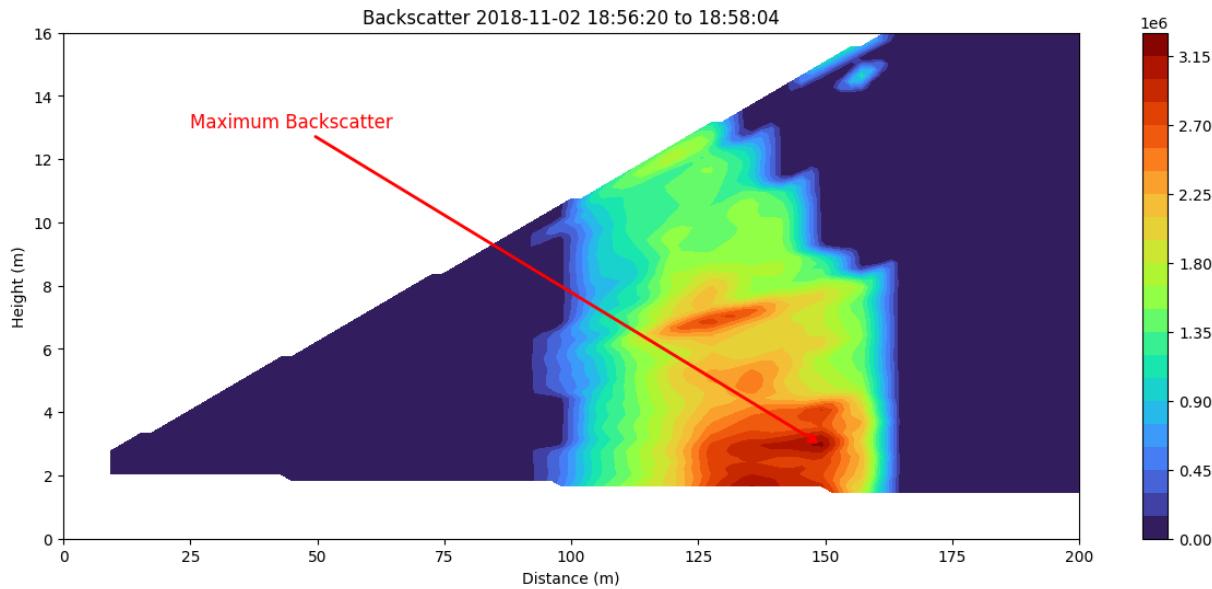
The calculated plume area is: 595.01 square meters.



Maximum Backscatter Value: 3175235.227 (Normalized)

Location (X, Z): (149.31 m, 2.96 m)

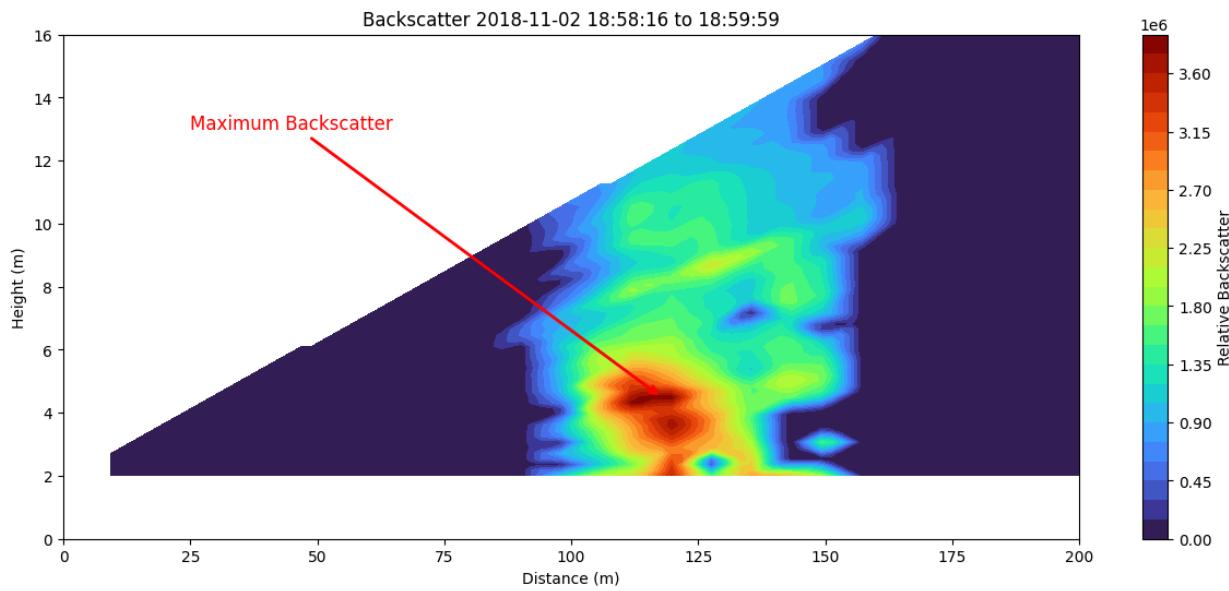
The calculated plume area is: 660.76 square meters.



Maximum Backscatter Value: 3827871.729 (Normalized)

Location (X, Z): (117.79 m, 4.50 m)

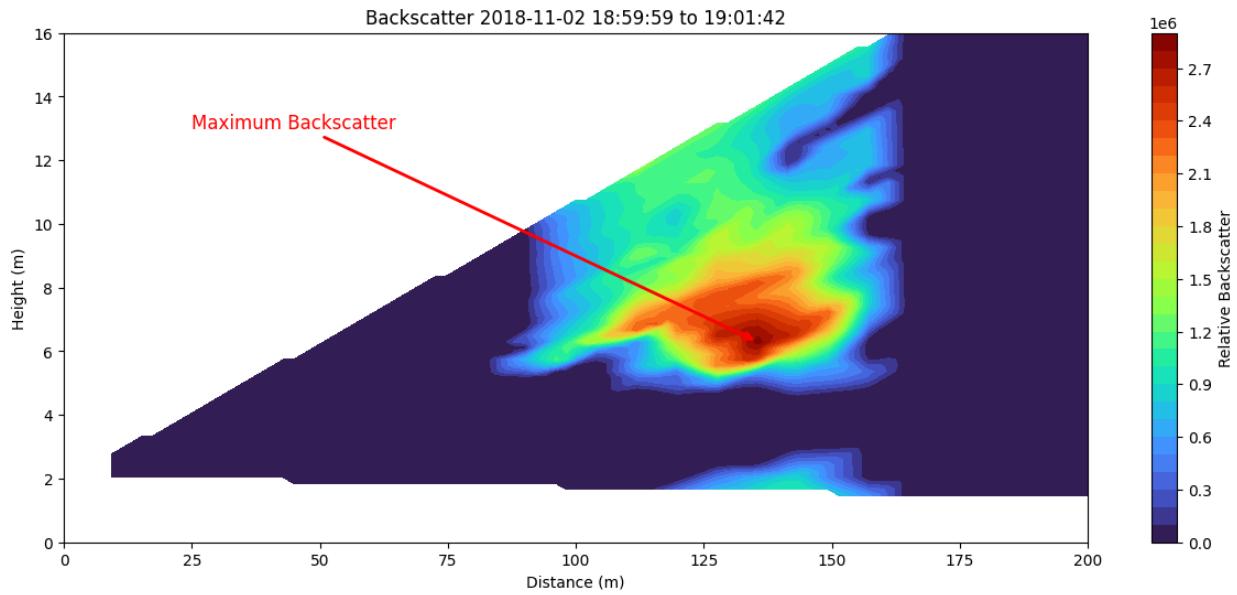
The calculated plume area is: 636.72 square meters.



Maximum Backscatter Value: 2847317.256 (Normalized)

Location (X, Z): (135.52 m, 6.30 m)

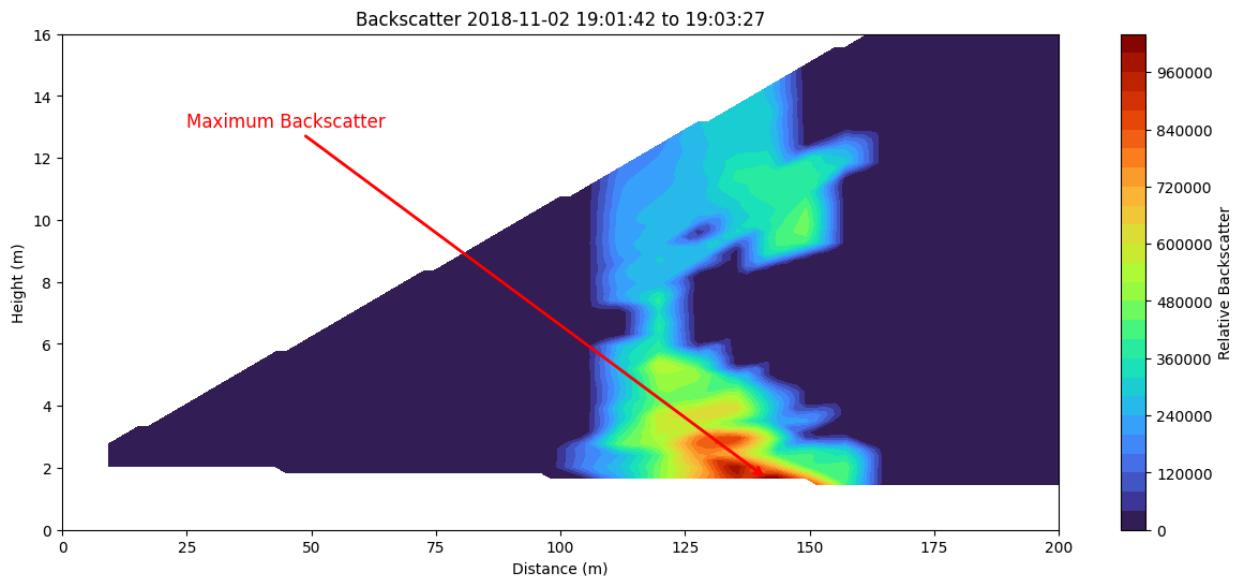
The calculated plume area is: 550.45 square meters.



Maximum Backscatter Value: 1032344.159 (Normalized)

Location (X, Z): (141.43 m, 1.66 m)

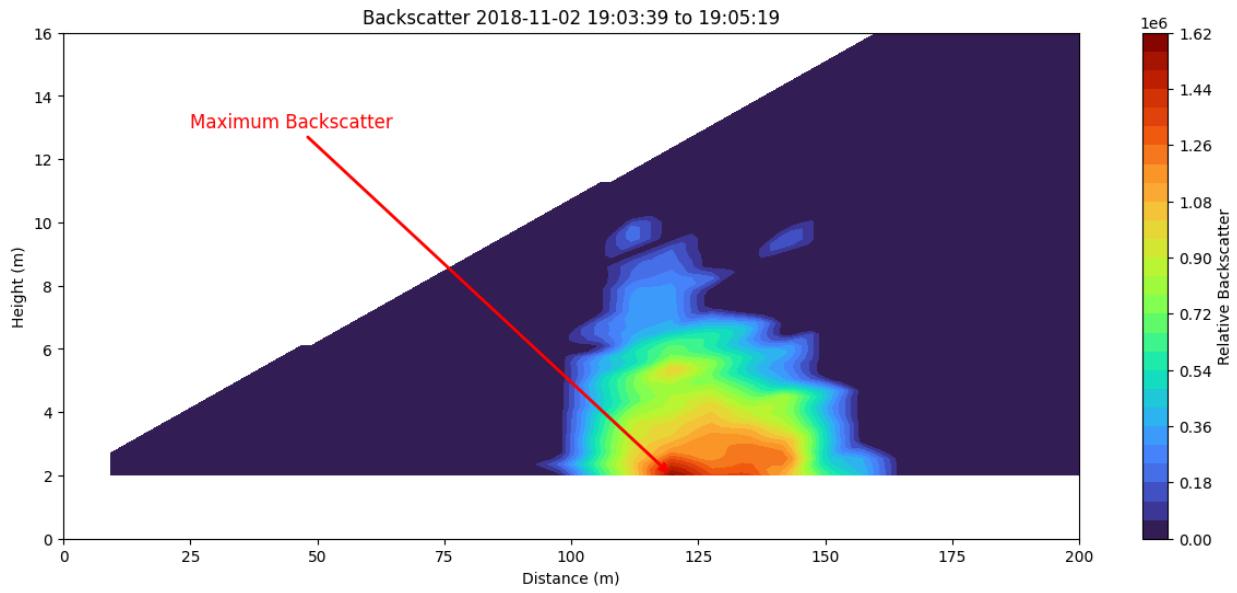
The calculated plume area is: 434.66 square meters.



Maximum Backscatter Value: 1566975.456 (Normalized)

Location (X, Z): (119.76 m, 2.00 m)

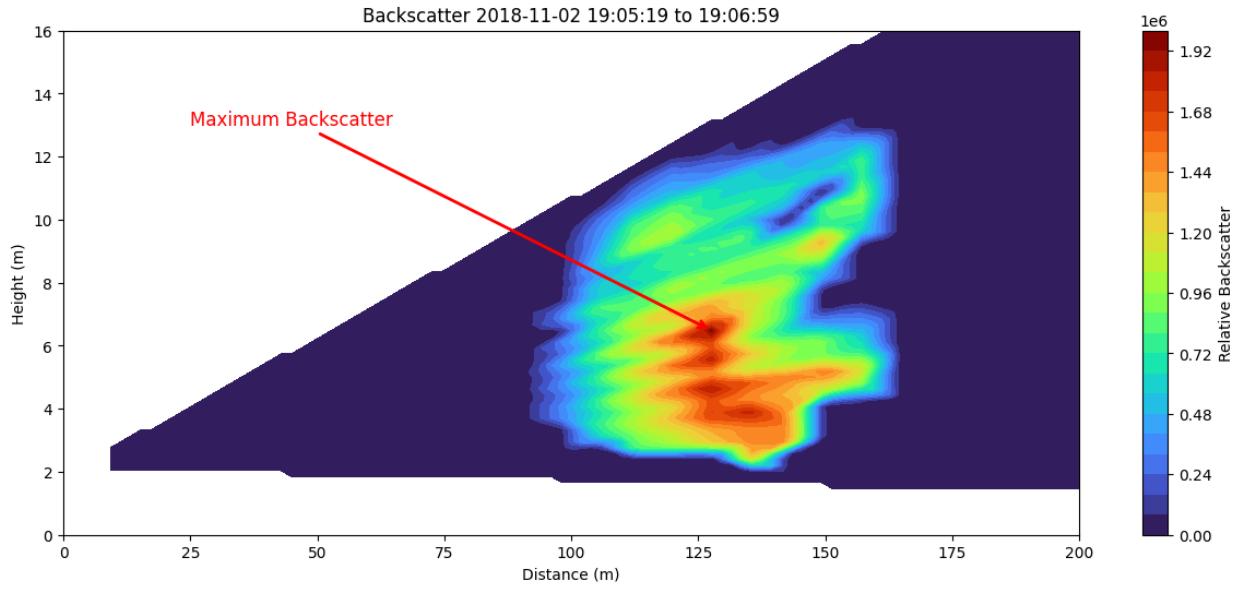
The calculated plume area is: 289.39 square meters.



Maximum Backscatter Value: 1951722.534 (Normalized)

Location (X, Z): (127.64 m, 6.48 m)

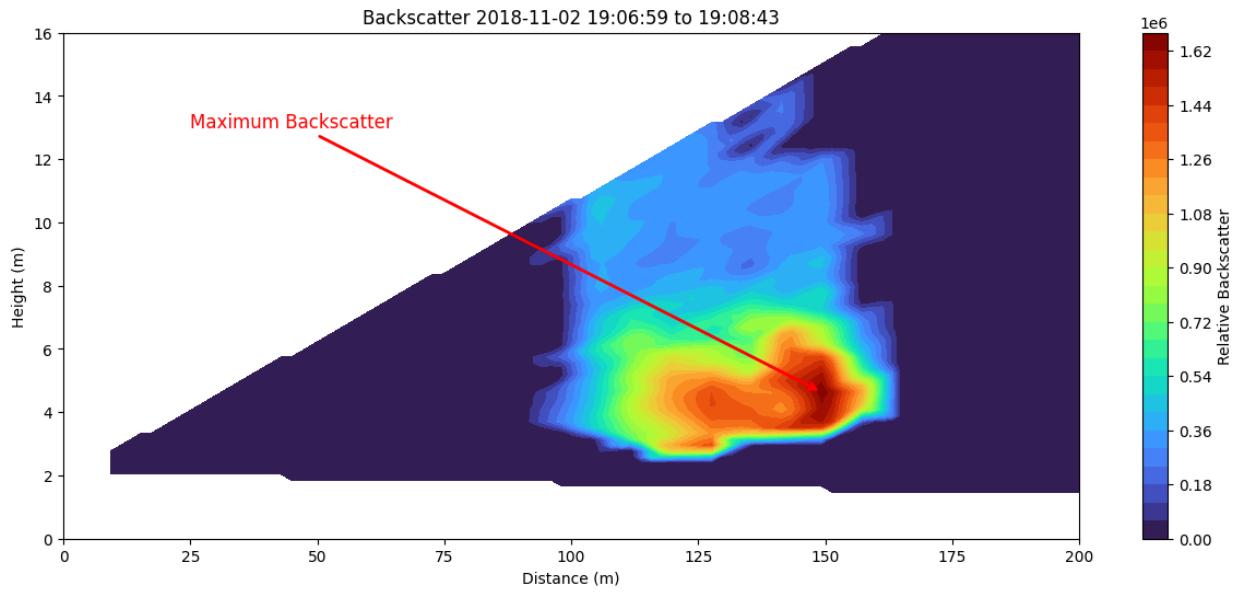
The calculated plume area is: 542.78 square meters.



Maximum Backscatter Value: 1655709.768 (Normalized)

Location (X, Z): (149.31 m, 4.63 m)

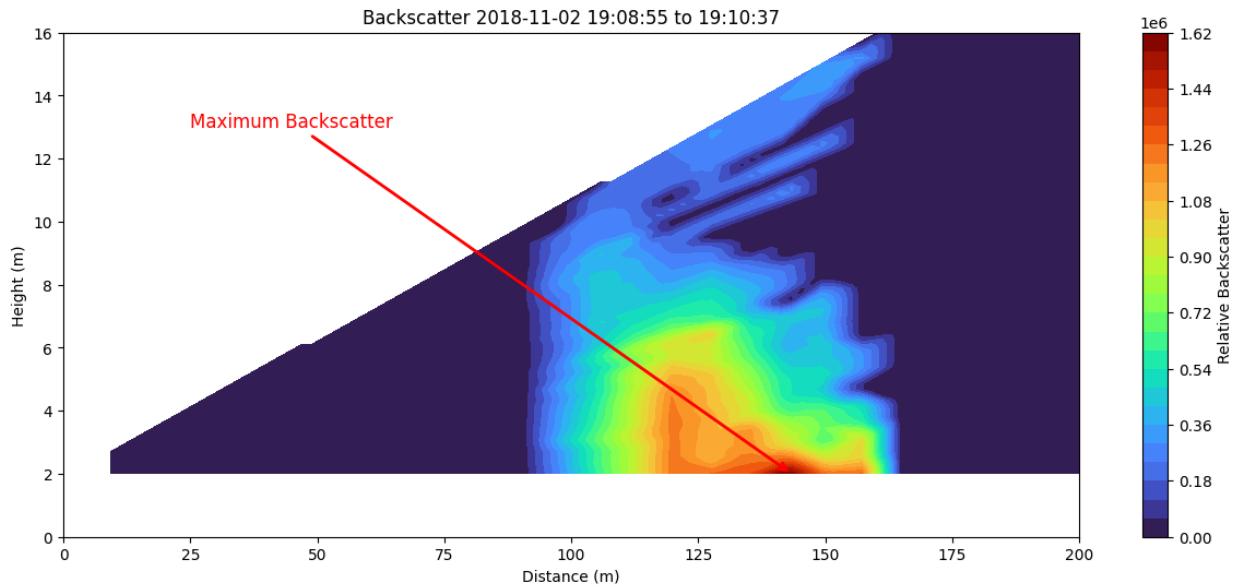
The calculated plume area is: 548.99 square meters.



Maximum Backscatter Value: 1611652.113 (Normalized)

Location (X, Z): (143.40 m, 2.00 m)

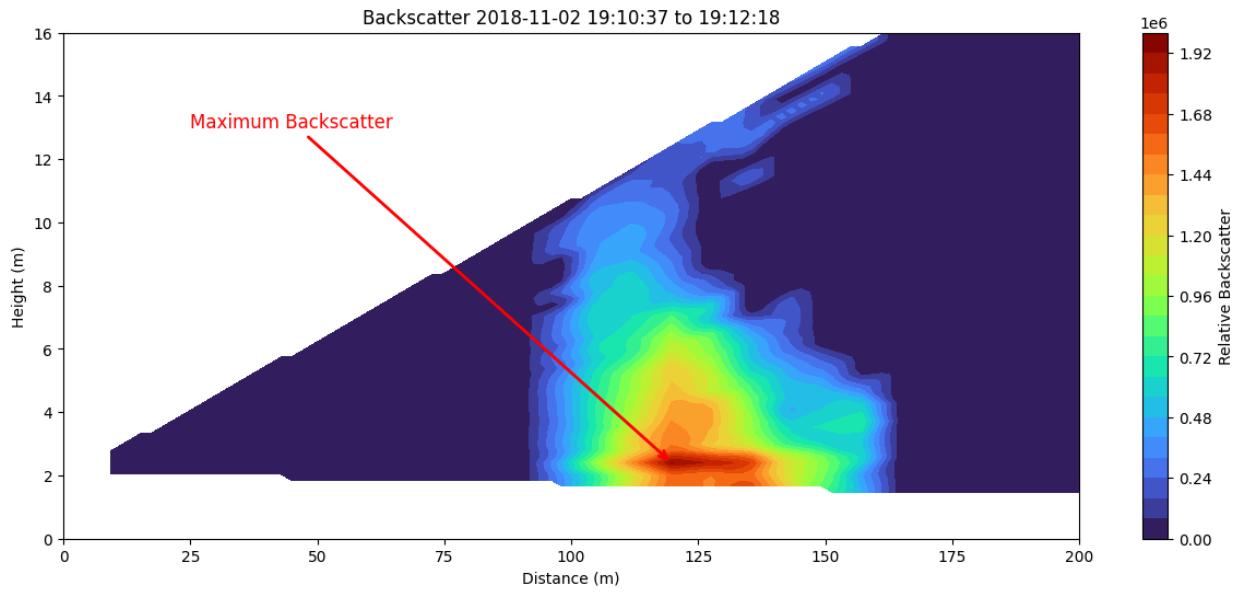
The calculated plume area is: 568.94 square meters.



Maximum Backscatter Value: 1923318.398 (Normalized)

Location (X, Z): (119.76 m, 2.41 m)

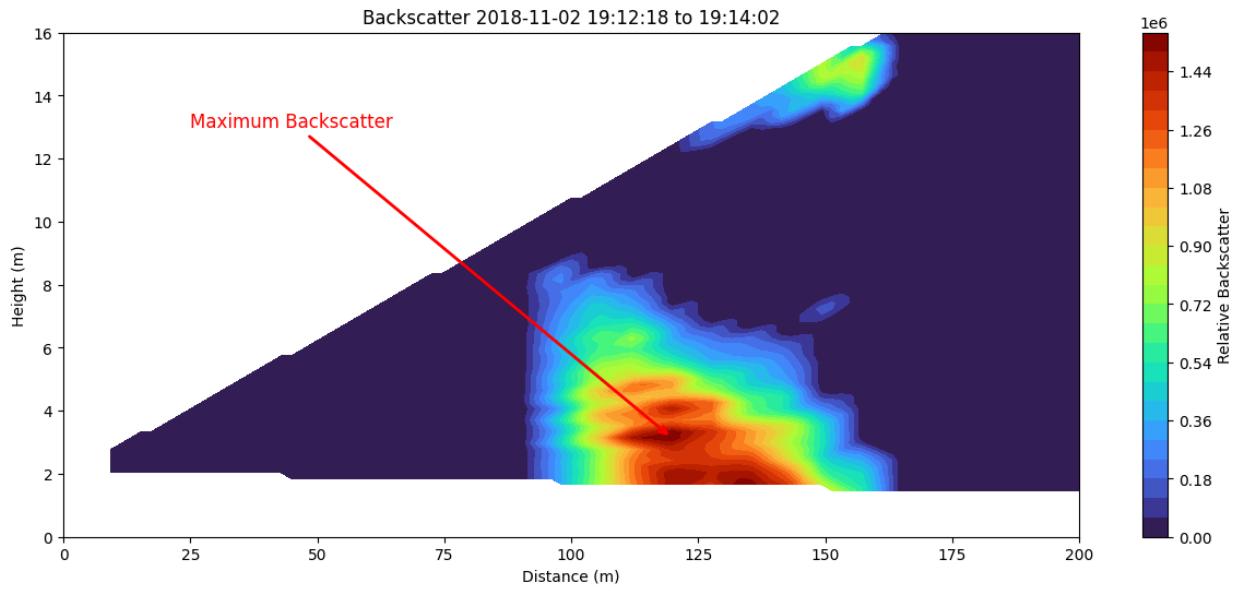
The calculated plume area is: 479.95 square meters.



Maximum Backscatter Value: 1555553.898 (Normalized)

Location (X, Z): (119.76 m, 3.15 m)

The calculated plume area is: 382.06 square meters.



```
error processing 2018-11-02 19:14:02, 2018-11-02 19:15:09: QH6154 Qhull precision error: Initial simplex is flat (facet 1 is coplanar with the interior point)
```

```
While executing: | qhull d Qc Q12 Qbb Qt Qz
Options selected for Qhull 2019.1.r 2019/06/21:
  run-id 1544625678 delaunay Qcoplanar-keep Q12-allow-wide Qbbound-last
  Qtriangulate Qz-infinity-point _pre-merge _zero-centrum Qinterior-keep
  Pgood _max-width 2e+02 Error-roundoff 2.8e-13 _one-merge 2e-12
  Visible-distance 5.6e-13 U-max-coplanar 5.6e-13 Width-outside 1.1e-12
  _wide-facet 3.4e-12 _maxoutside 2.2e-12
```

The input to qhull appears to be less than 3 dimensional, or a computation has overflowed.

Qhull could not construct a clearly convex simplex from points:

- p1(v4): 15 2 0.76
- p216(v3): 1e+02 2 2e+02
- p26(v2): 2e+02 2 1.8e+02
- p0(v1): 7.5 2 0

The center point is coplanar with a facet, or a vertex is coplanar with a neighboring facet. The maximum round off error for computing distances is 2.8e-13. The center point, facets and distances to the center point are as follows:

center point 82.5 2 96.83

```
facet p216 p26 p0 distance= 0
facet p1 p26 p0 distance= 0
facet p1 p216 p0 distance= 0
facet p1 p216 p26 distance= 0
```

These points either have a maximum or minimum x-coordinate, or they maximize the determinant for k coordinates. Trial points are first selected from points that maximize a coordinate.

The min and max coordinates for each dimension are:

0:	7.5	202.5	difference= 195
1:	2	2	difference= 0
2:	0	202.5	difference= 202.5

If the input should be full dimensional, you have several options that may determine an initial simplex:

- use 'QJ' to joggle the input and make it full dimensional
- use 'QbB' to scale the points to the unit cube
- use 'QR0' to randomly rotate the input for different maximum points
- use 'Qs' to search all points for the initial simplex
- use 'En' to specify a maximum roundoff error less than 2.8e-13.
- trace execution with 'T3' to see the determinant for each point.

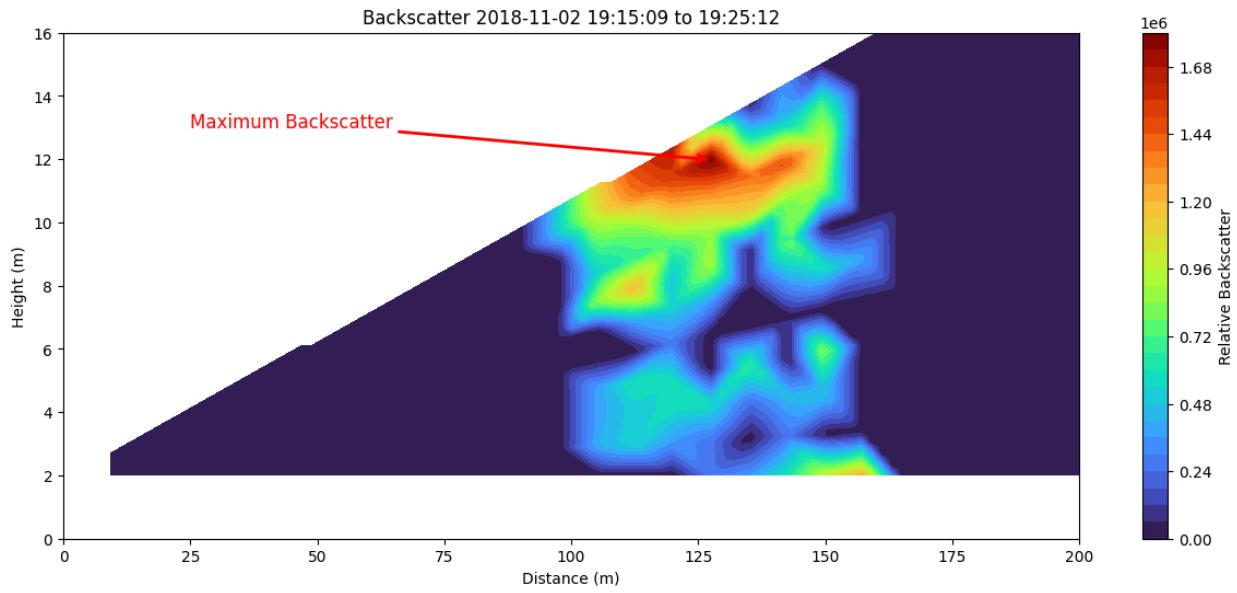
If the input is lower dimensional:

- use 'QJ' to joggle the input and make it full dimensional
- use 'Qbk:0Bk:0' to delete coordinate k from the input. You should pick the coordinate with the least range. The hull will have the correct topology.
- determine the flat containing the points, rotate the points into a coordinate plane, and delete the other coordinates.
- add one or more points to make the input full dimensional.

Maximum Backscatter Value: 1773112.986 (Normalized)

Location (X, Z): (127.64 m, 11.98 m)

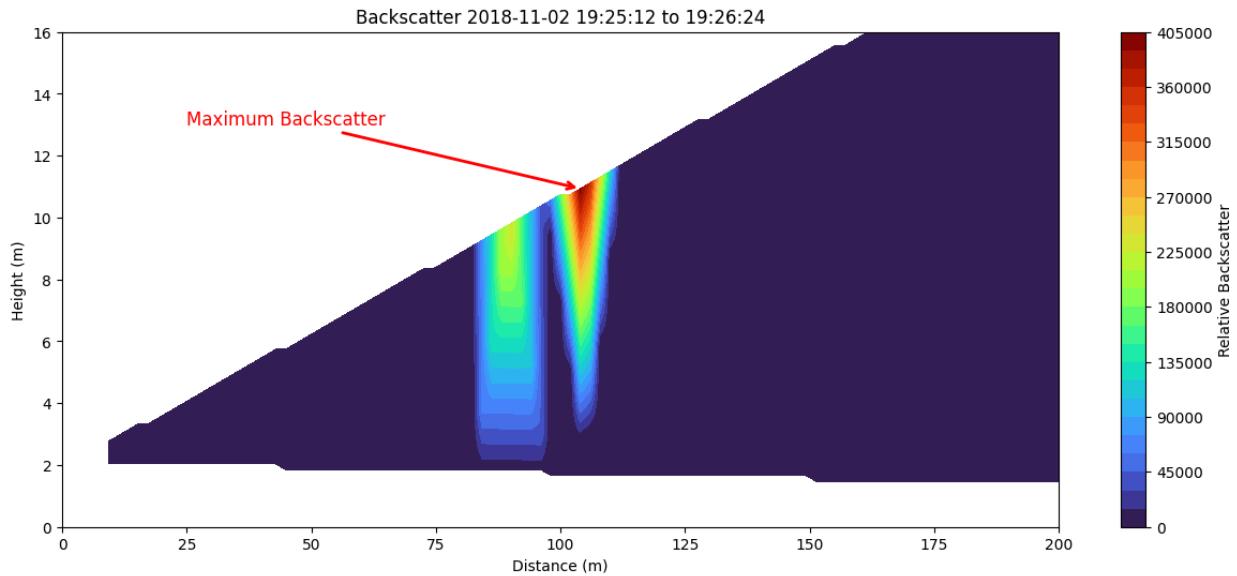
The calculated plume area is: 542.60 square meters.



Maximum Backscatter Value: 397929.553 (Normalized)

Location (X, Z): (104.00 m, 10.93 m)

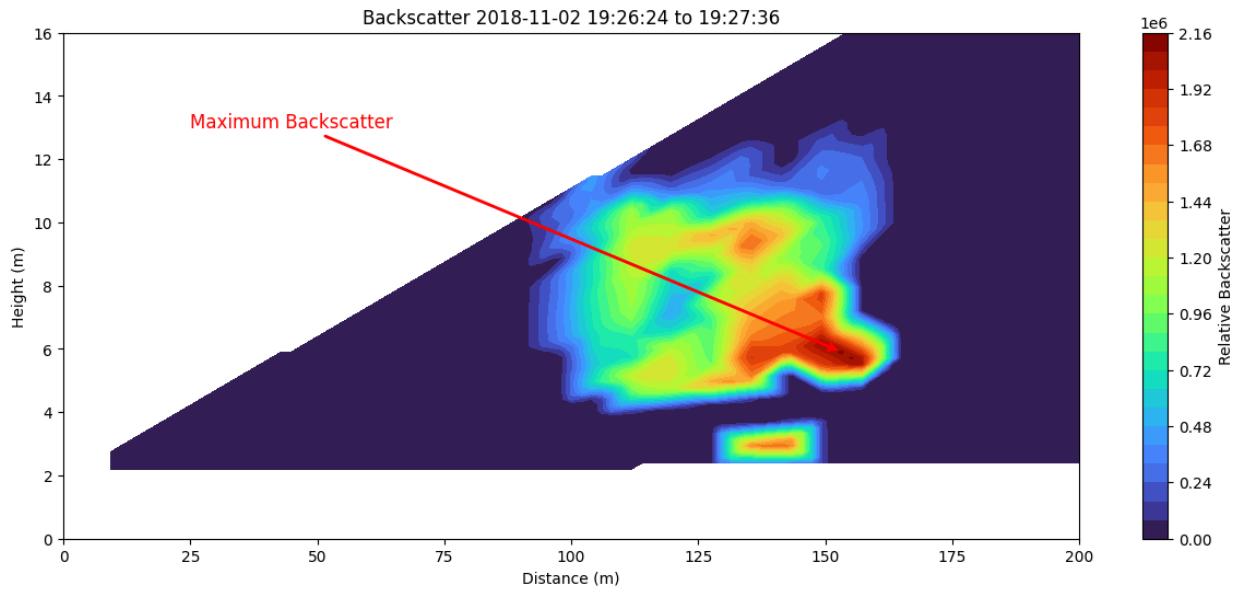
The calculated plume area is: 143.55 square meters.



Maximum Backscatter Value: 2105496.758 (Normalized)

Location (X, Z): (153.25 m, 5.90 m)

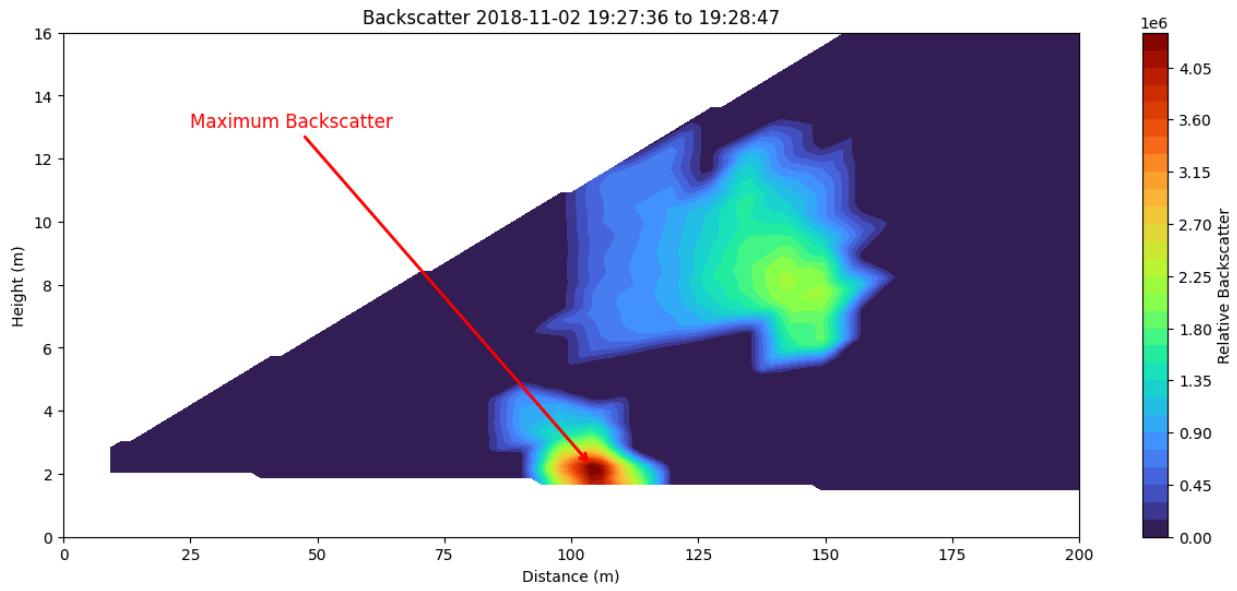
The calculated plume area is: 472.97 square meters.



Maximum Backscatter Value: 4335764.013 (Normalized)

Location (X, Z): (104.00 m, 2.26 m)

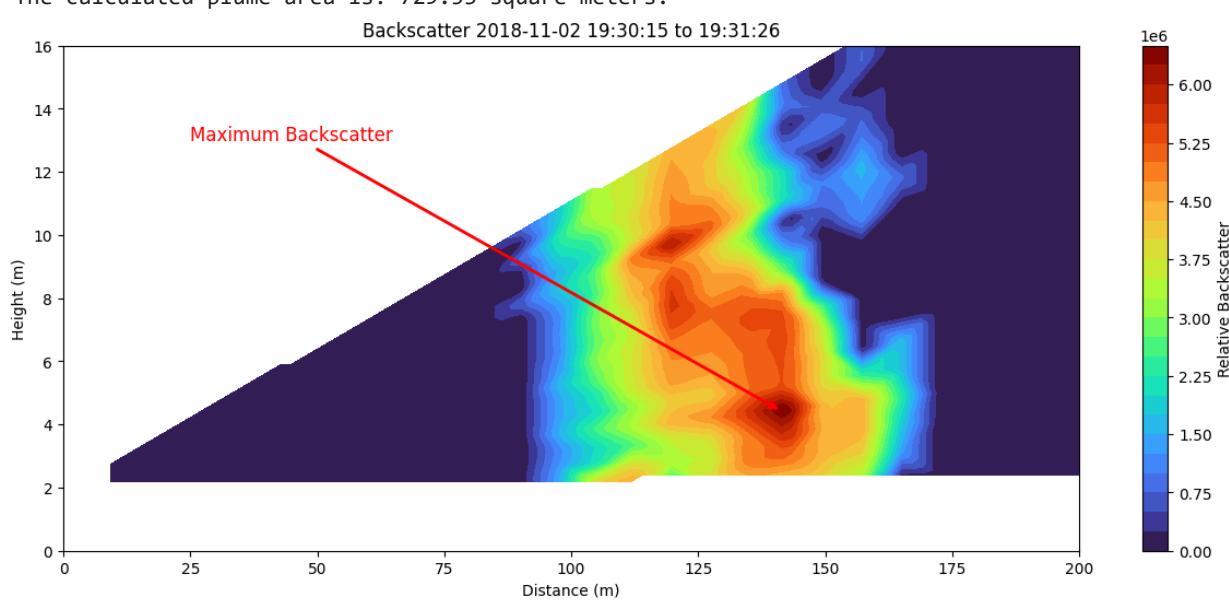
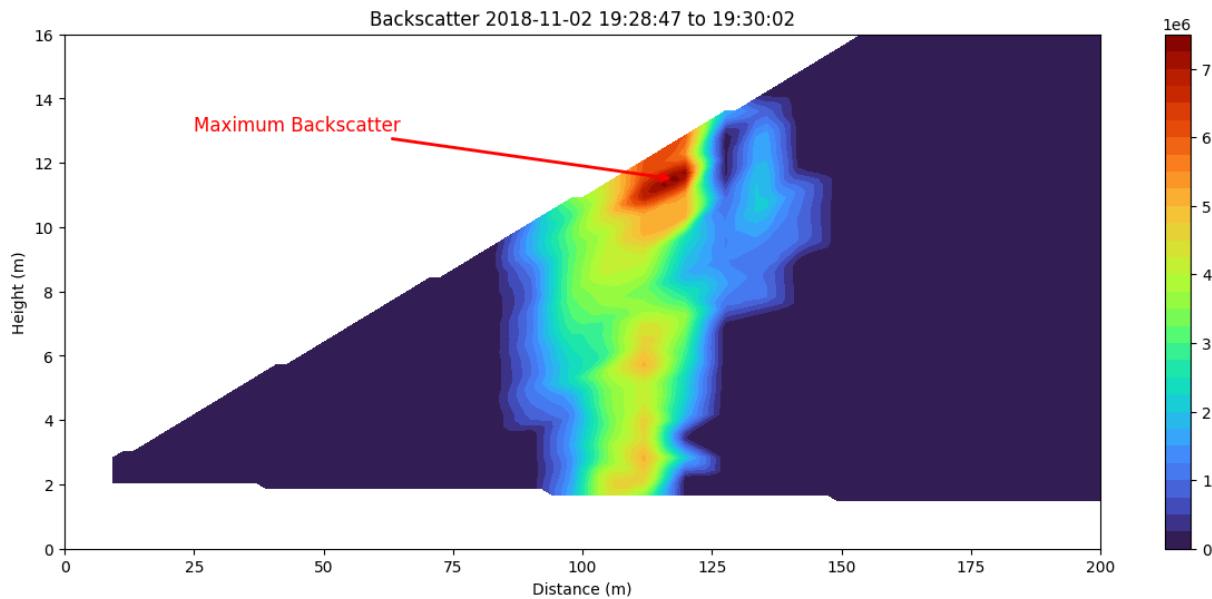
The calculated plume area is: 389.89 square meters.

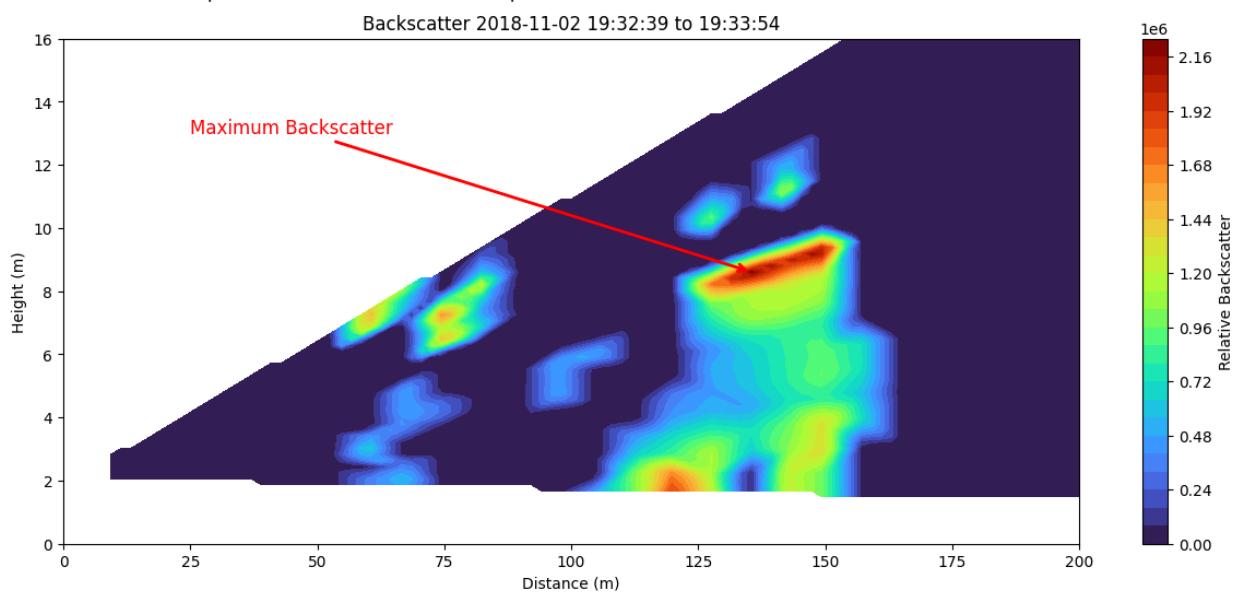
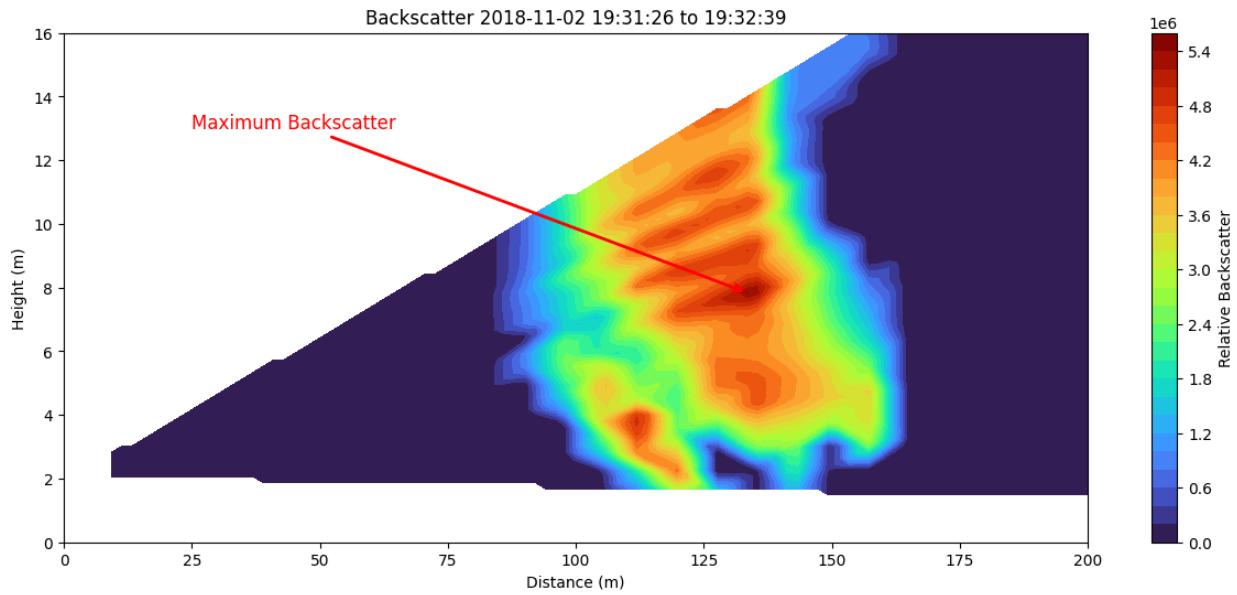


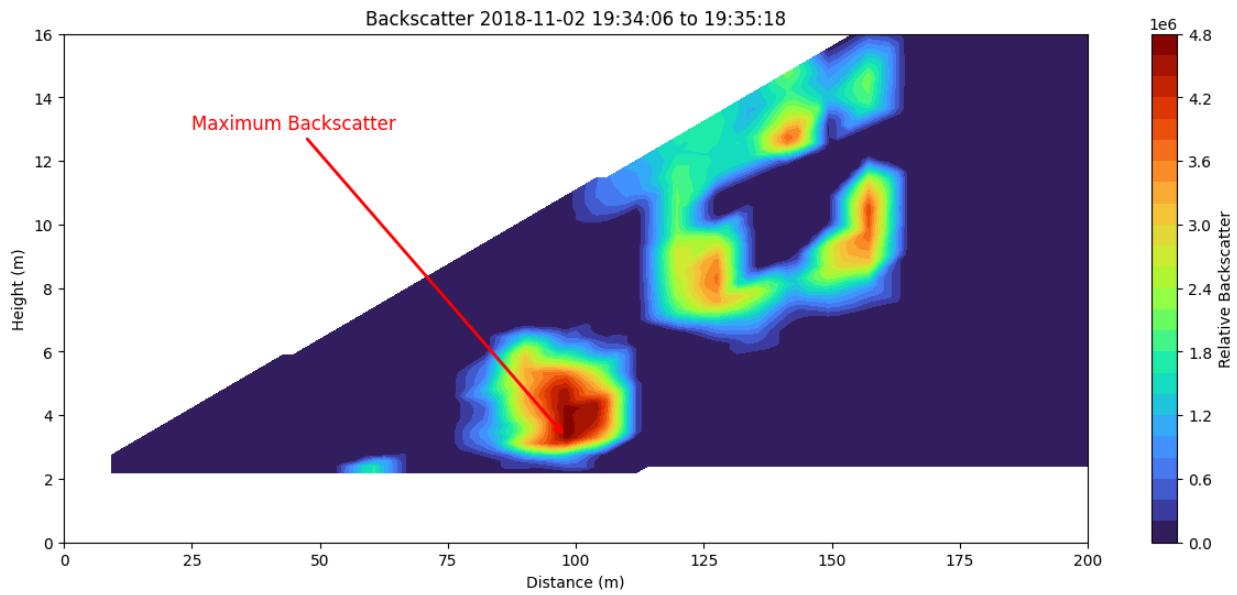
Maximum Backscatter Value: 7474831.547 (Normalized)

Location (X, Z): (117.79 m, 11.50 m)

The calculated plume area is: 437.68 square meters.



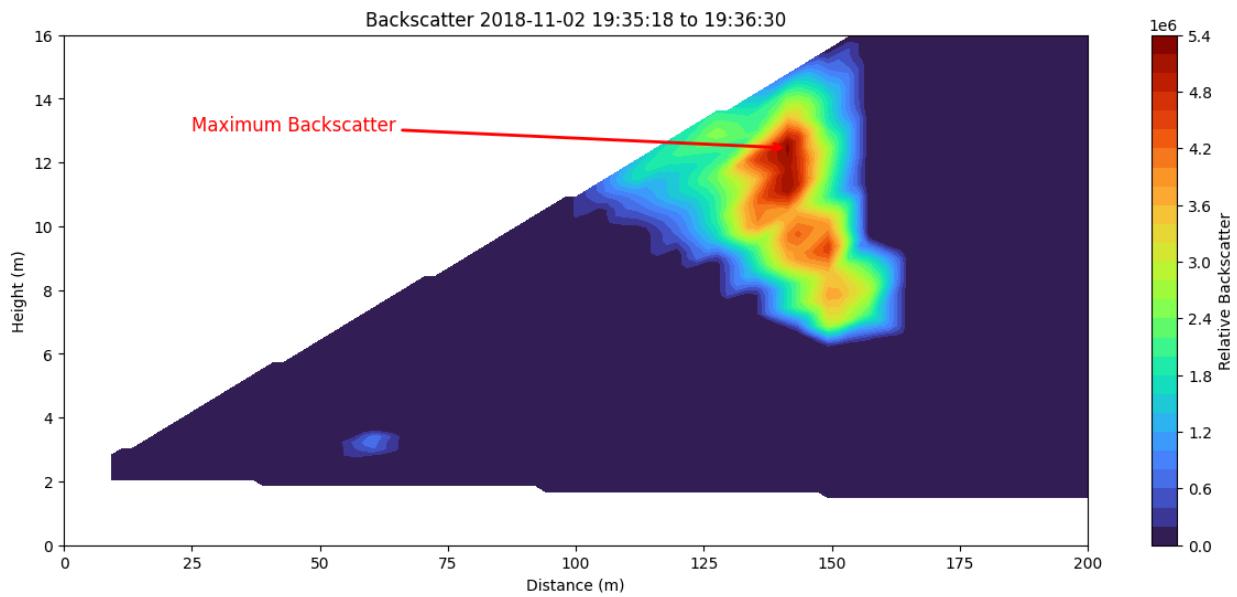




Maximum Backscatter Value: 5232494.091 (Normalized)

Location (X, Z): (141.43 m, 12.46 m)

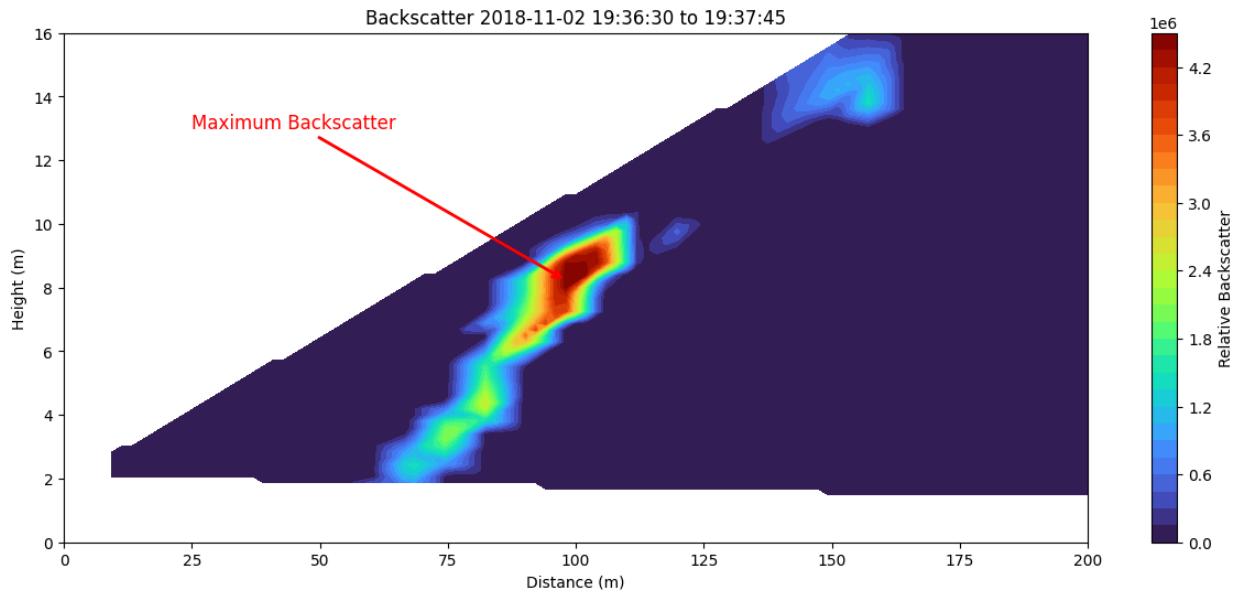
The calculated plume area is: 289.39 square meters.



Maximum Backscatter Value: 4451441.997 (Normalized)

Location (X, Z): (98.09 m, 8.22 m)

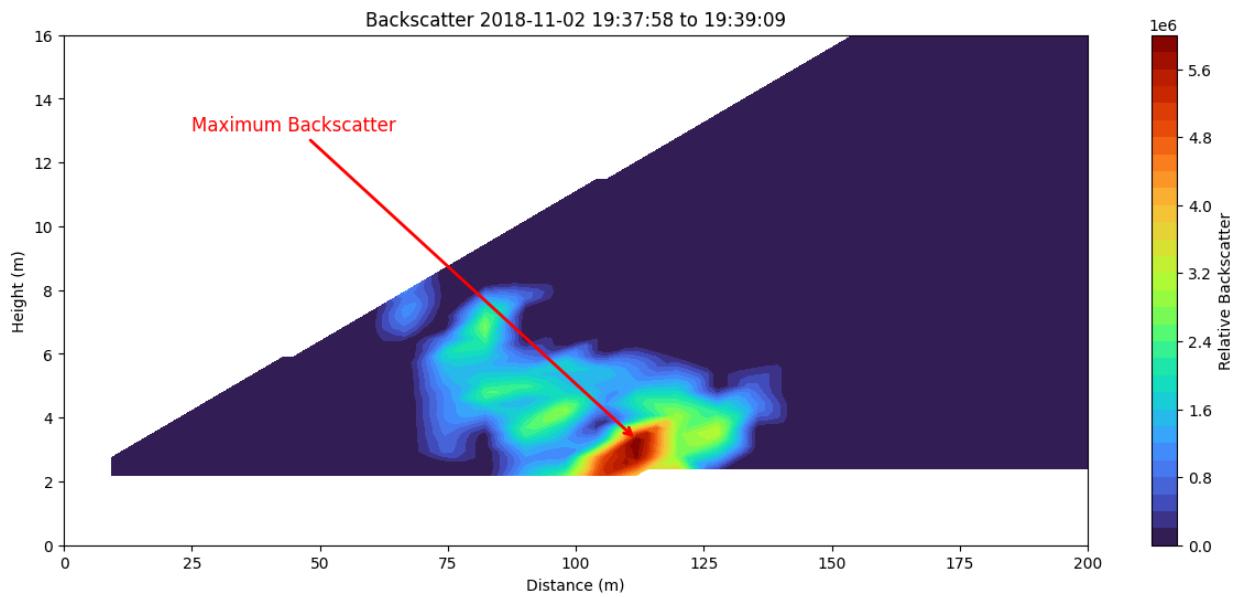
The calculated plume area is: 169.16 square meters.



Maximum Backscatter Value: 5994955.630 (Normalized)

Location (X, Z): (111.88 m, 3.31 m)

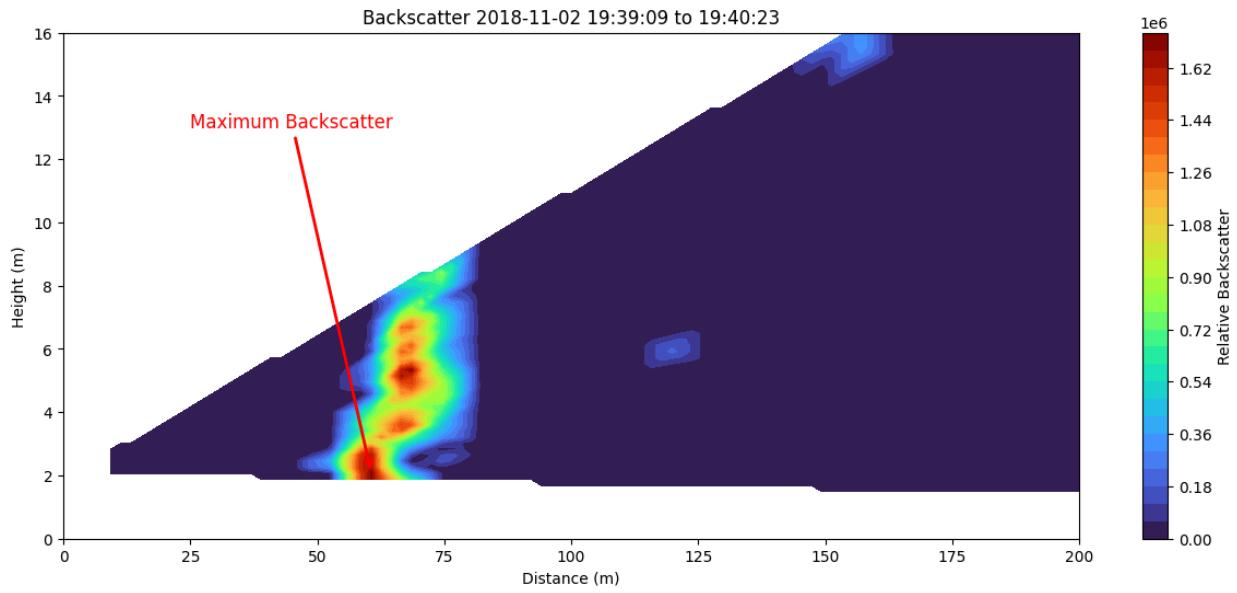
The calculated plume area is: 241.23 square meters.



Maximum Backscatter Value: 1699771.861 (Normalized)

Location (X, Z): (60.66 m, 2.06 m)

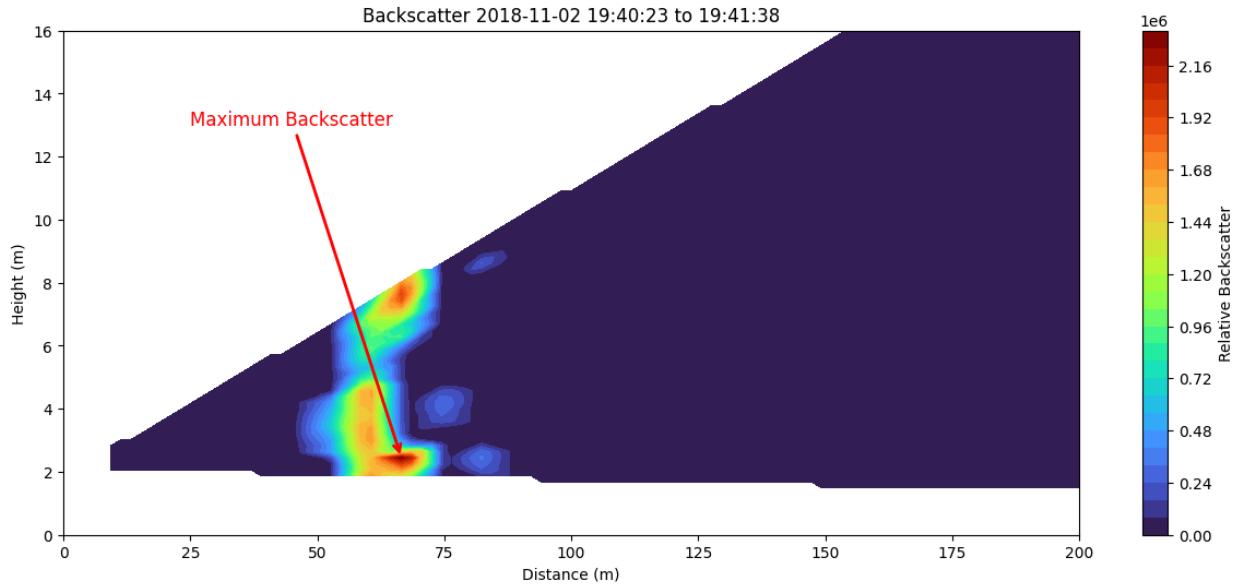
The calculated plume area is: 147.16 square meters.



Maximum Backscatter Value: 2293147.042 (Normalized)

Location (X, Z): (66.57 m, 2.45 m)

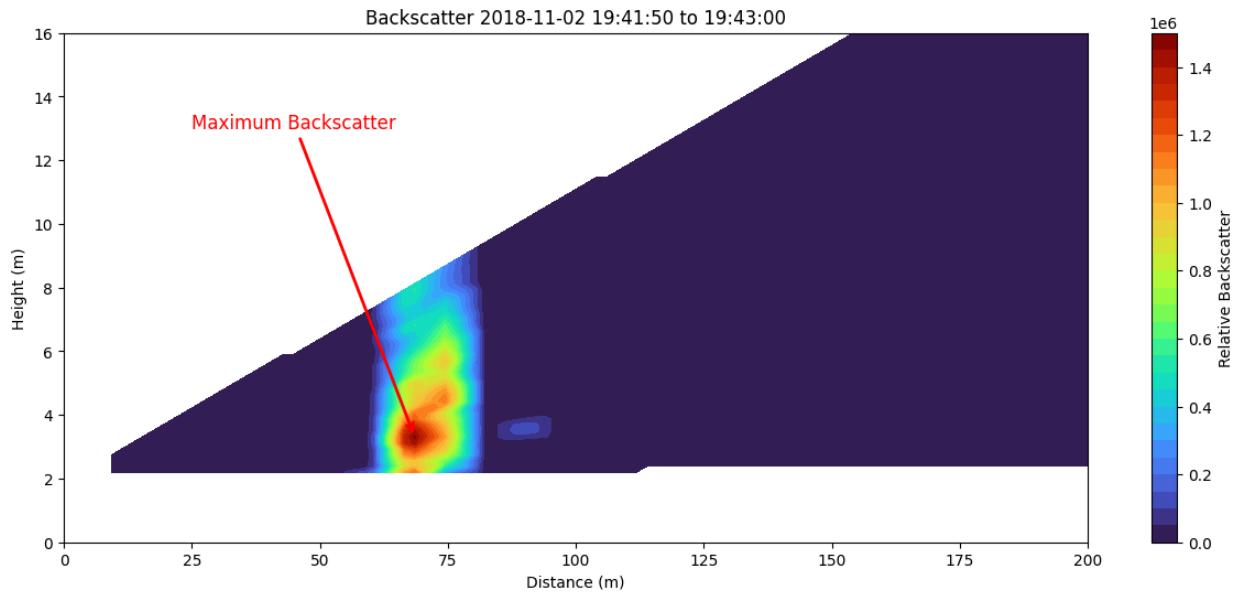
The calculated plume area is: 106.58 square meters.



Maximum Backscatter Value: 1462688.082 (Normalized)

Location (X, Z): (68.54 m, 3.31 m)

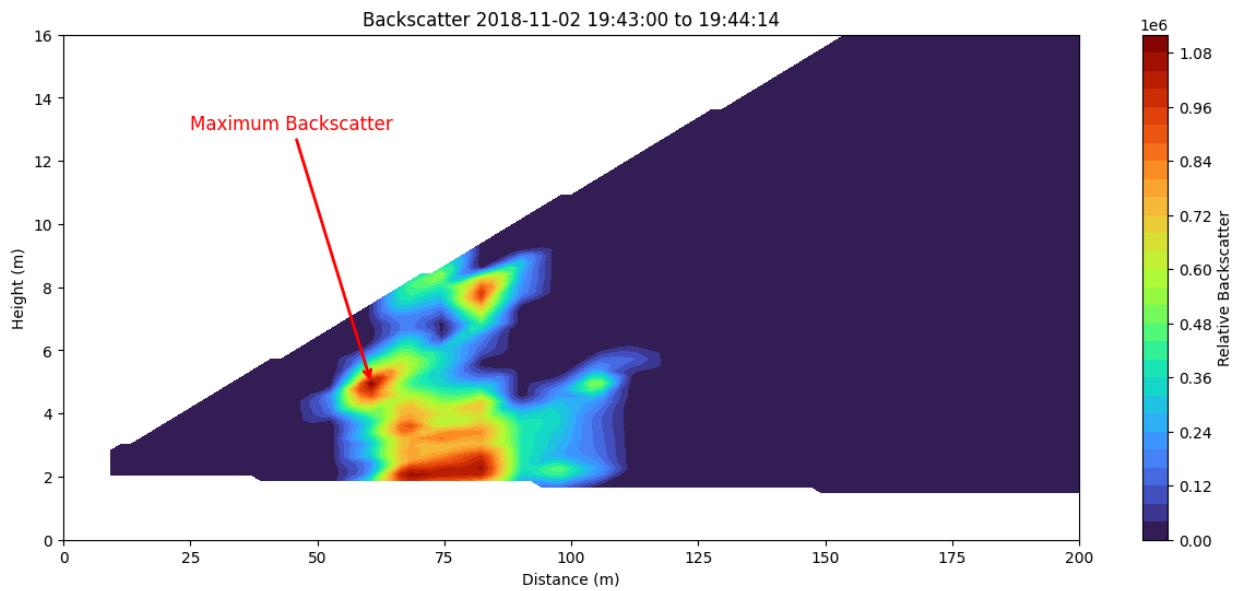
The calculated plume area is: 118.97 square meters.



Maximum Backscatter Value: 1098620.338 (Normalized)

Location (X, Z): (60.66 m, 4.95 m)

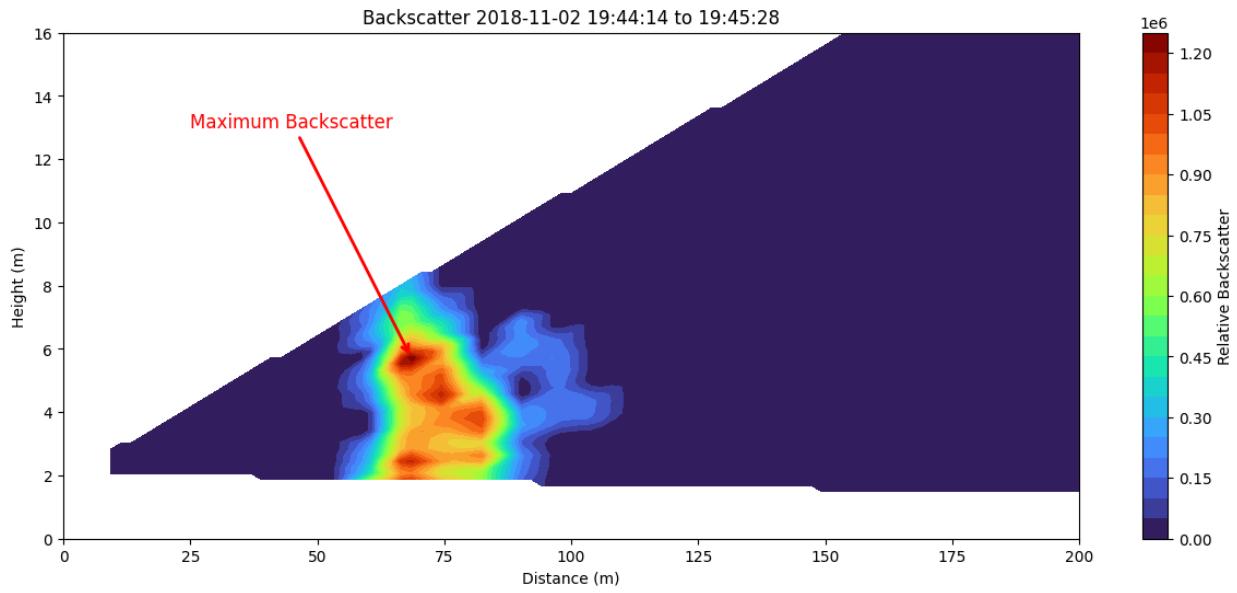
The calculated plume area is: 268.53 square meters.



Maximum Backscatter Value: 1249779.457 (Normalized)

Location (X, Z): (68.54 m, 5.72 m)

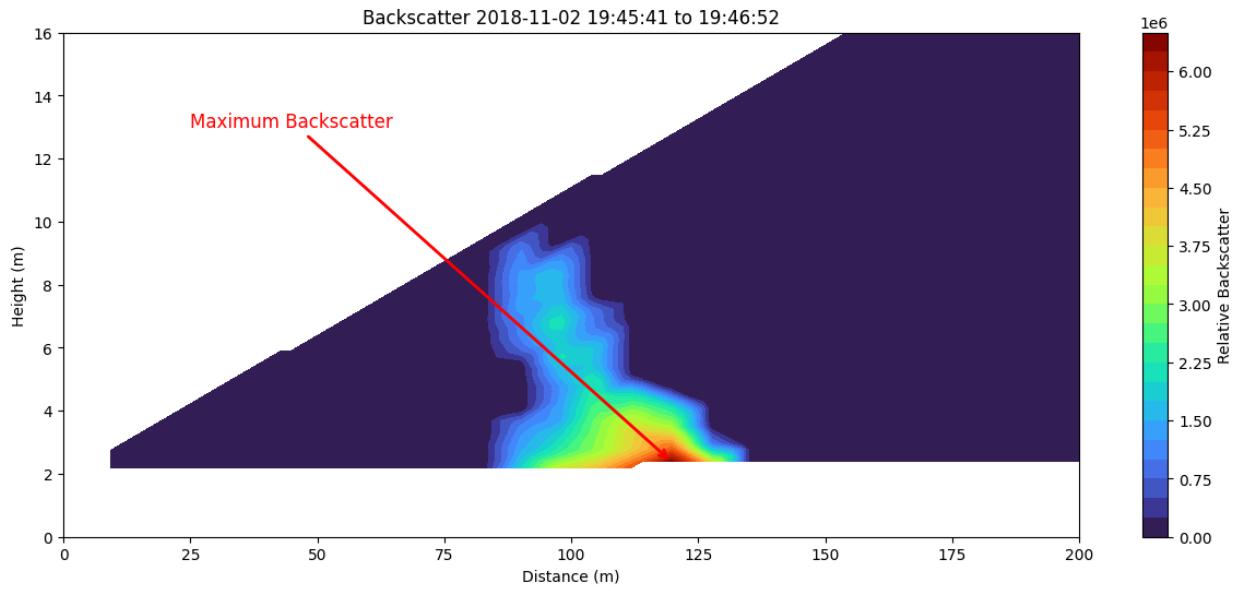
The calculated plume area is: 211.26 square meters.



Maximum Backscatter Value: 6408545.474 (Normalized)

Location (X, Z): (119.76 m, 2.38 m)

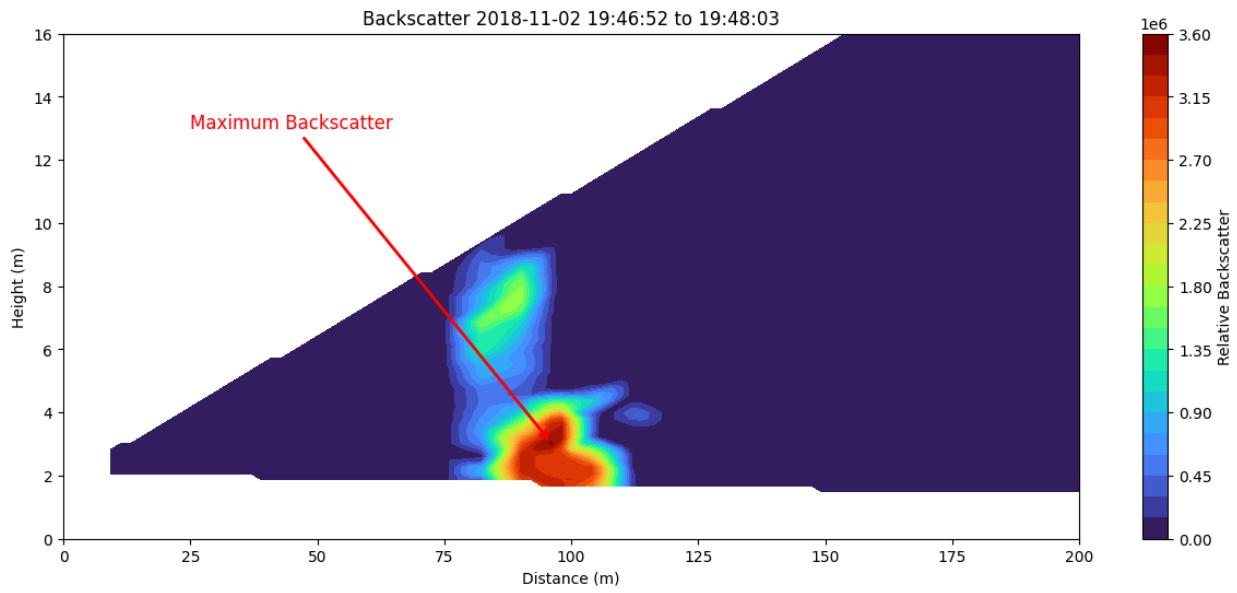
The calculated plume area is: 181.01 square meters.



Maximum Backscatter Value: 3490518.441 (Normalized)

Location (X, Z): (96.12 m, 3.03 m)

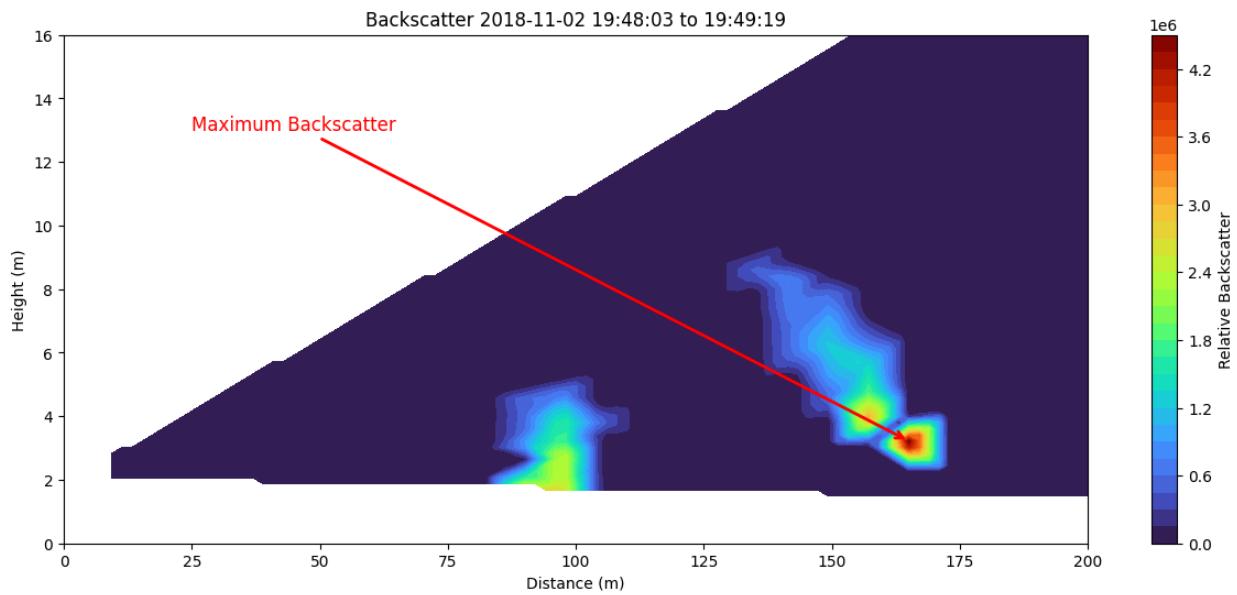
The calculated plume area is: 155.50 square meters.



Maximum Backscatter Value: 4450940.074 (Normalized)

Location (X, Z): (165.07 m, 3.22 m)

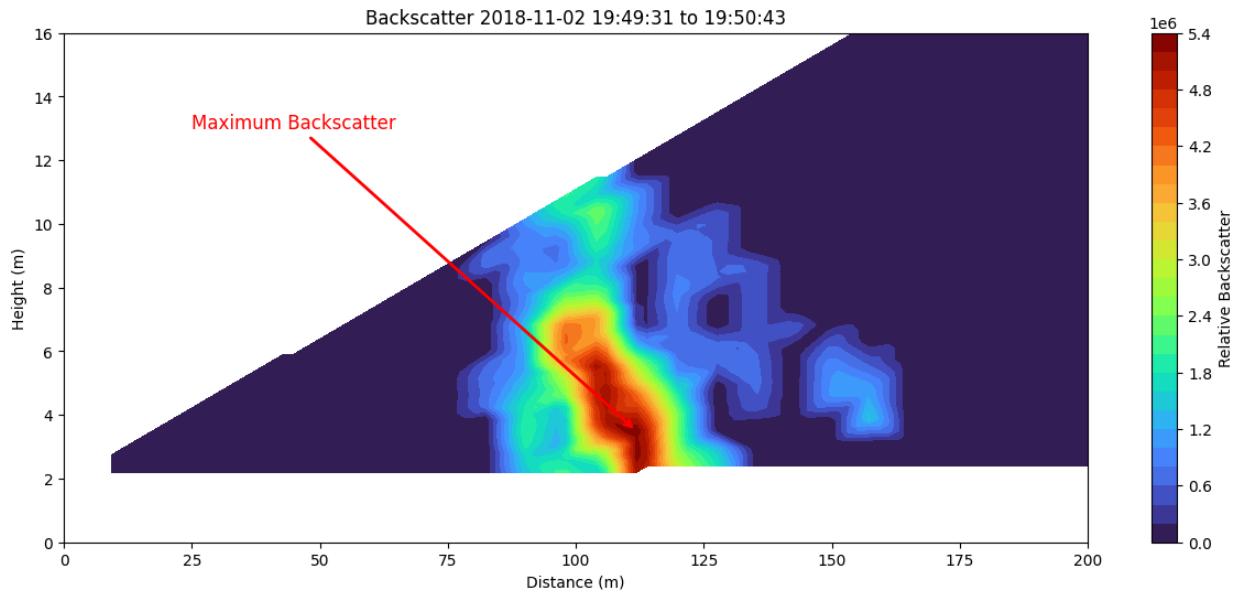
The calculated plume area is: 144.50 square meters.



Maximum Backscatter Value: 5369213.169 (Normalized)

Location (X, Z): (111.88 m, 3.50 m)

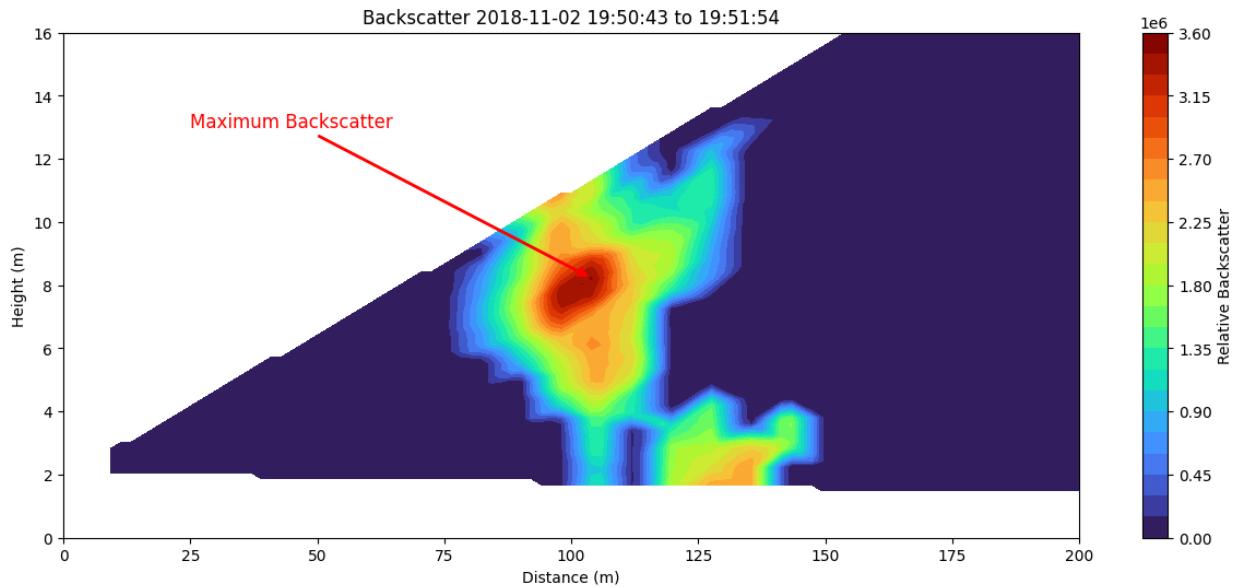
The calculated plume area is: 399.62 square meters.



Maximum Backscatter Value: 3460059.117 (Normalized)

Location (X, Z): (104.00 m, 8.22 m)

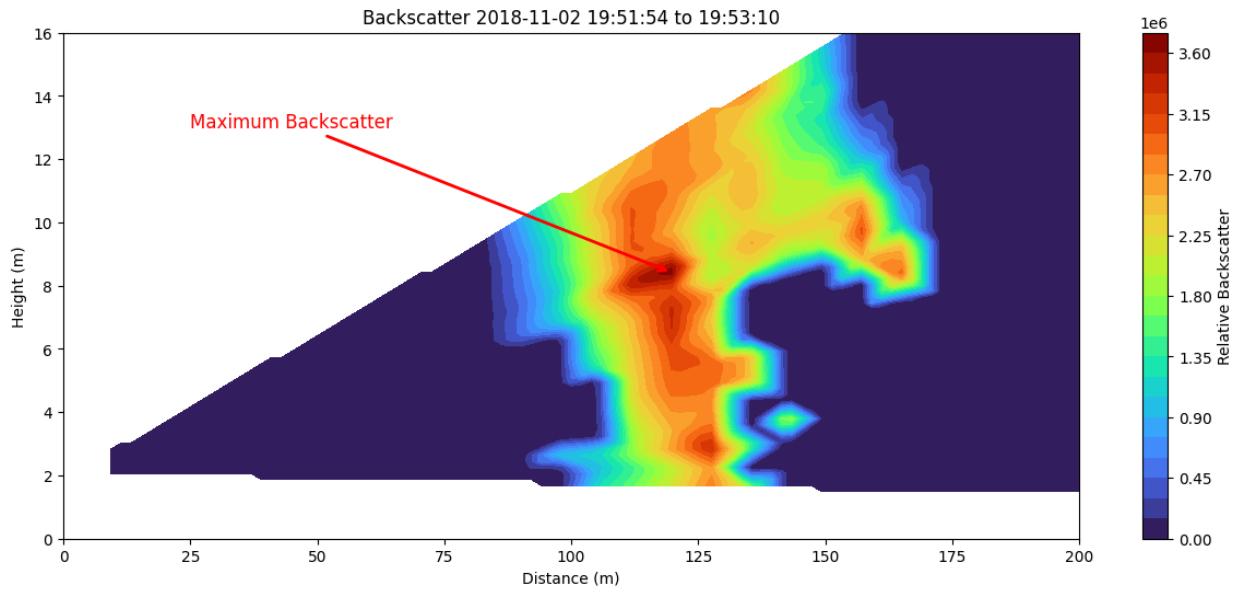
The calculated plume area is: 426.68 square meters.



Maximum Backscatter Value: 3667301.857 (Normalized)

Location (X, Z): (119.76 m, 8.42 m)

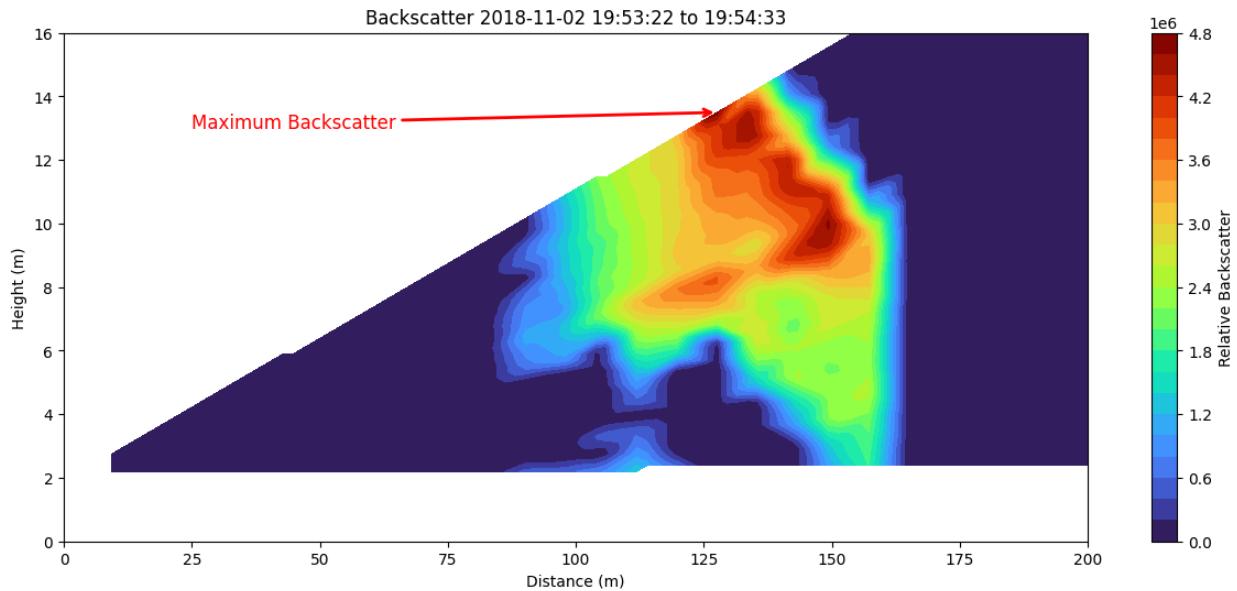
The calculated plume area is: 665.63 square meters.



Maximum Backscatter Value: 4687503.697 (Normalized)

Location (X, Z): (127.64 m, 13.50 m)

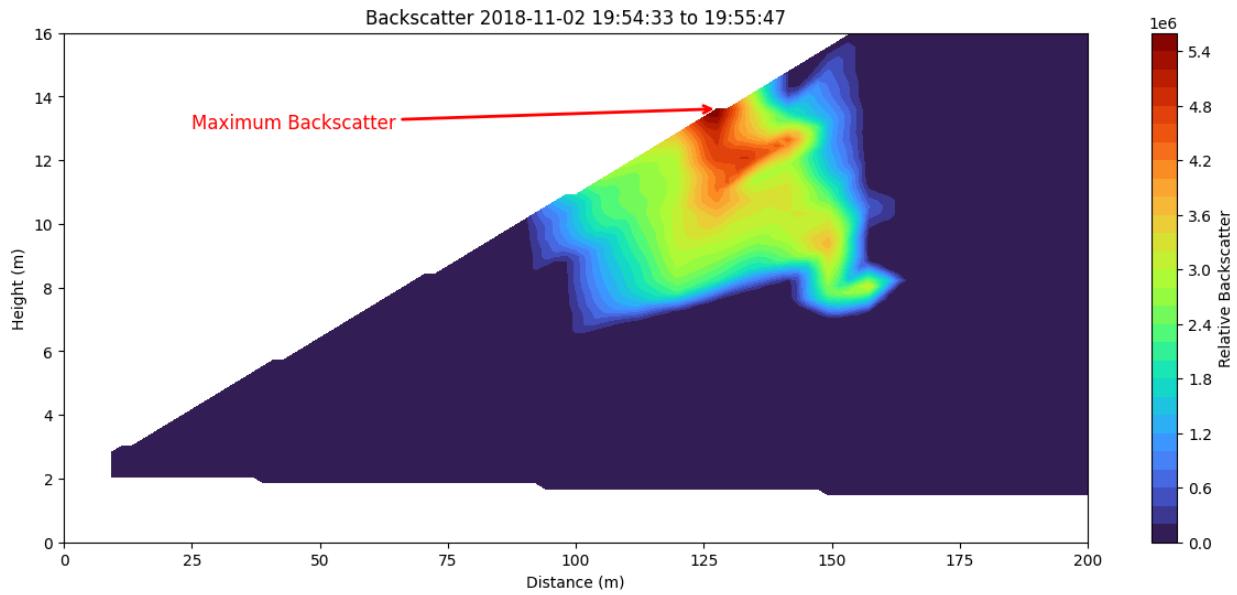
The calculated plume area is: 623.33 square meters.



Maximum Backscatter Value: 5538639.225 (Normalized)

Location (X, Z): (127.64 m, 13.61 m)

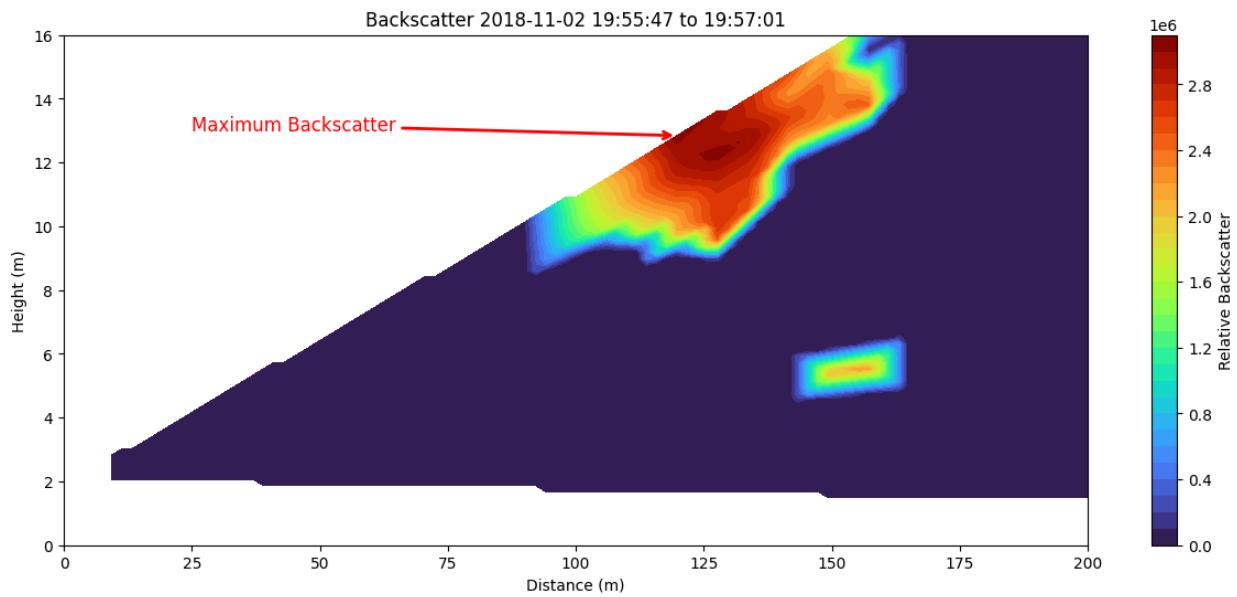
The calculated plume area is: 335.28 square meters.



Maximum Backscatter Value: 3060063.542 (Normalized)

Location (X, Z): (119.76 m, 12.84 m)

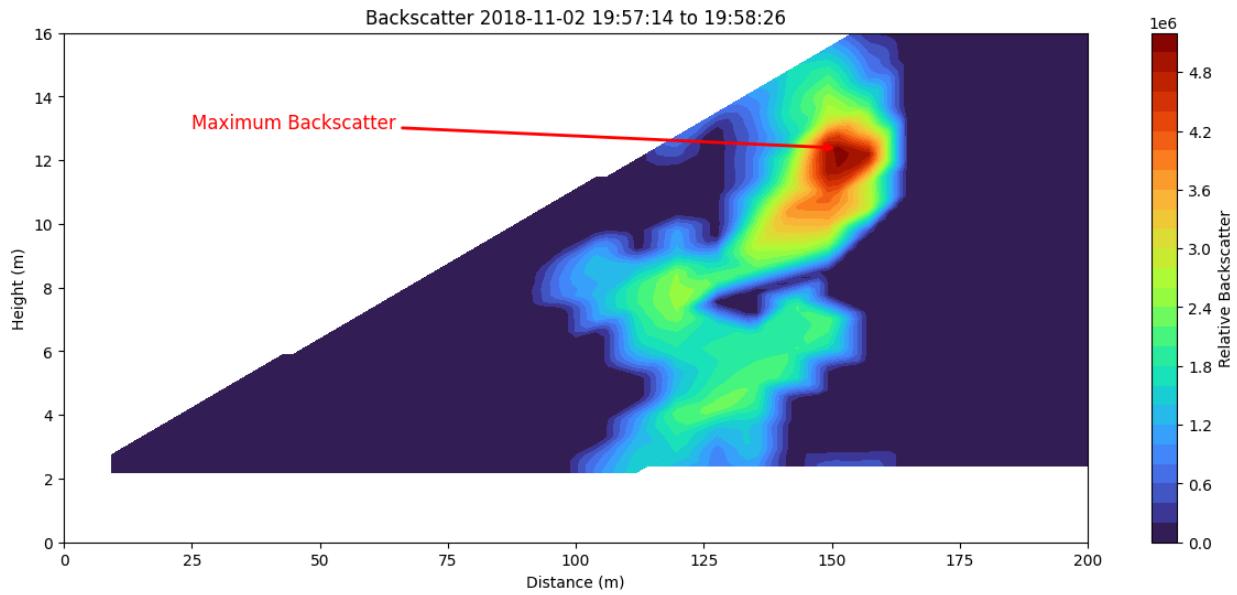
The calculated plume area is: 249.18 square meters.



Maximum Backscatter Value: 5033806.818 (Normalized)

Location (X, Z): (151.28 m, 12.39 m)

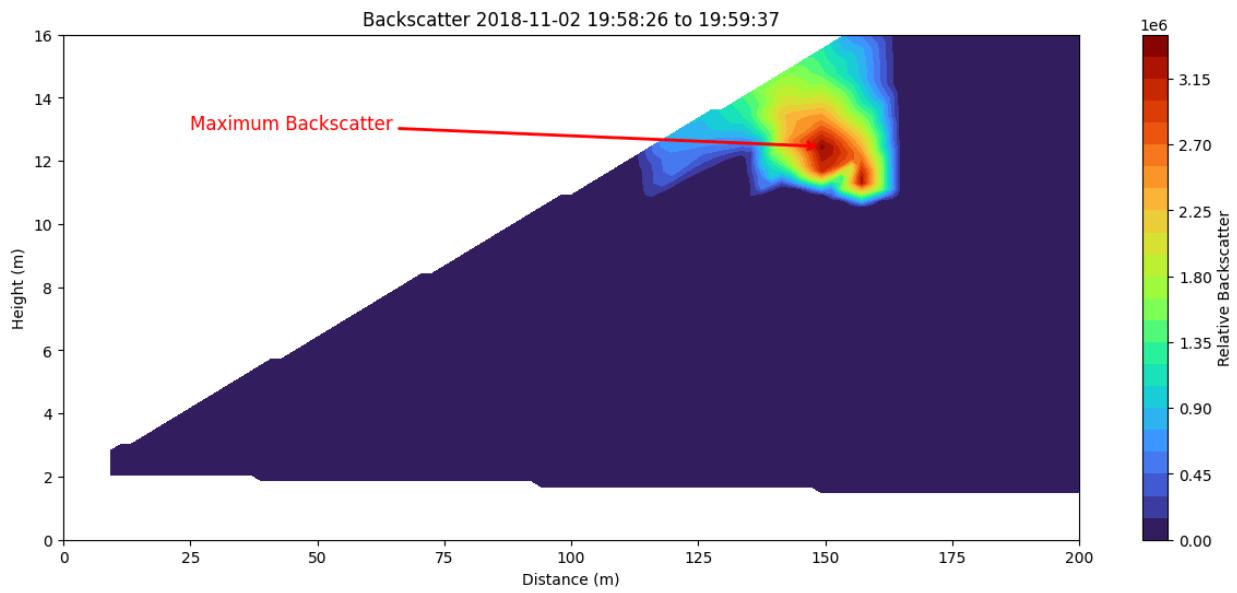
The calculated plume area is: 486.11 square meters.



Maximum Backscatter Value: 3340676.507 (Normalized)

Location (X, Z): (149.31 m, 12.46 m)

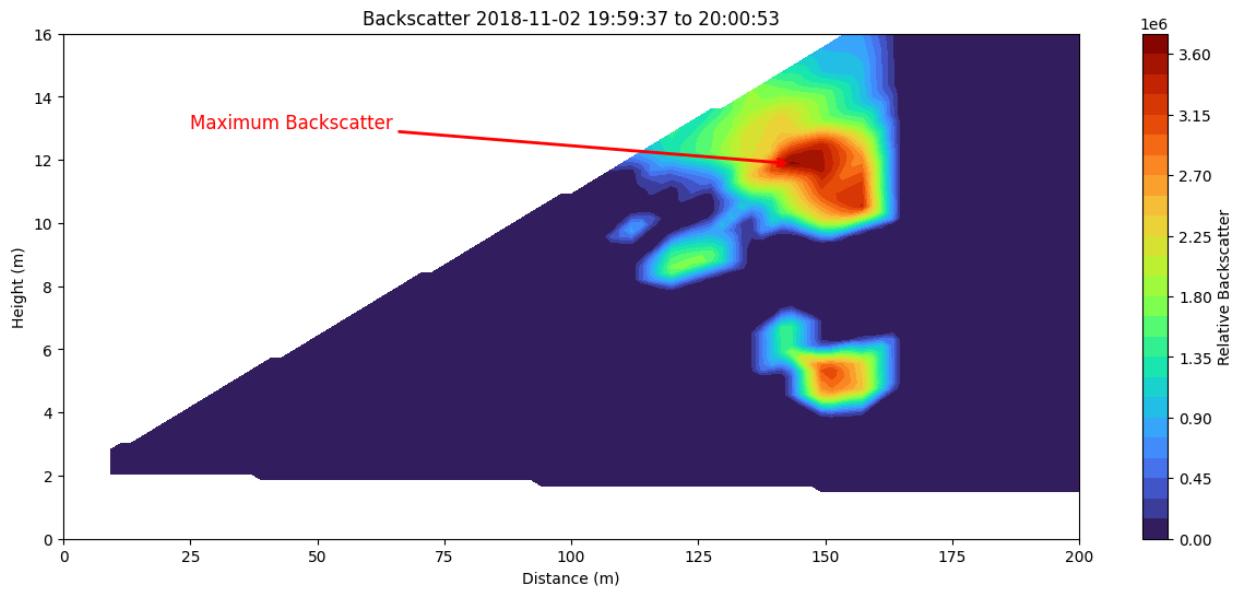
The calculated plume area is: 155.88 square meters.



Maximum Backscatter Value: 3611633.026 (Normalized)

Location (X, Z): (143.40 m, 11.88 m)

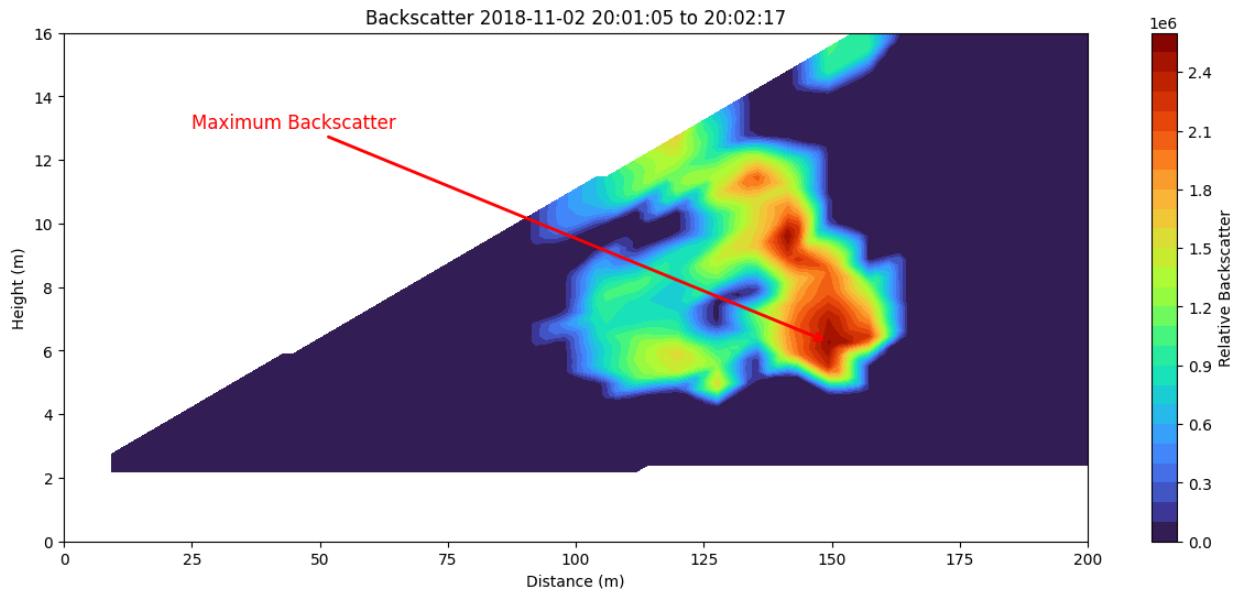
The calculated plume area is: 302.66 square meters.



Maximum Backscatter Value: 2504094.731 (Normalized)

Location (X, Z): (149.31 m, 6.27 m)

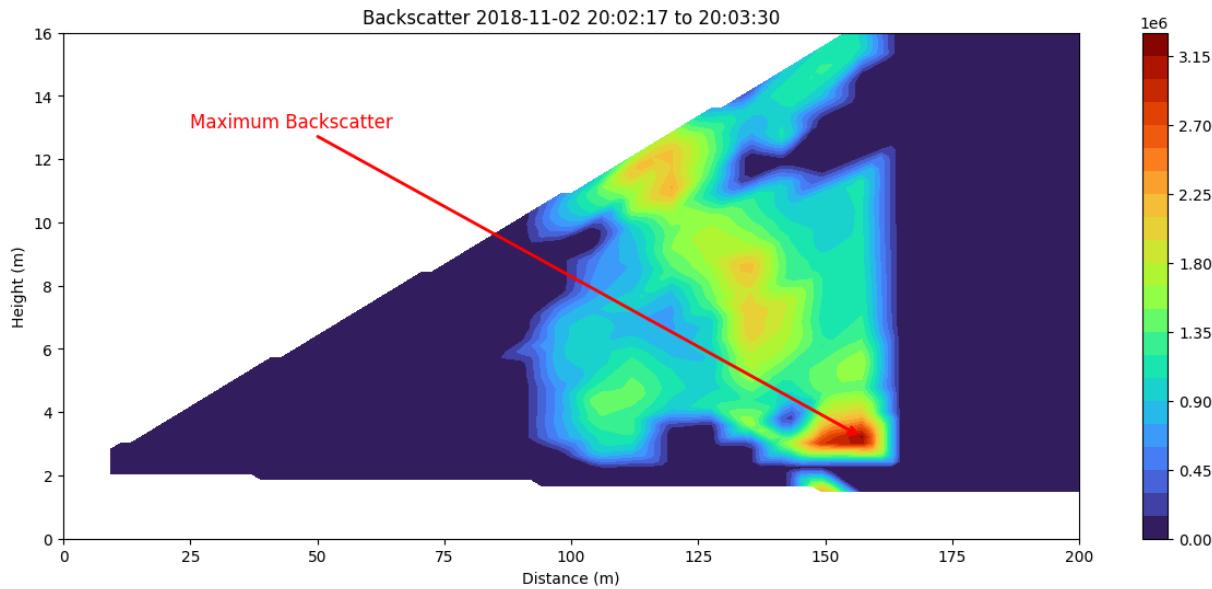
The calculated plume area is: 436.84 square meters.



Maximum Backscatter Value: 3156889.052 (Normalized)

Location (X, Z): (157.19 m, 3.22 m)

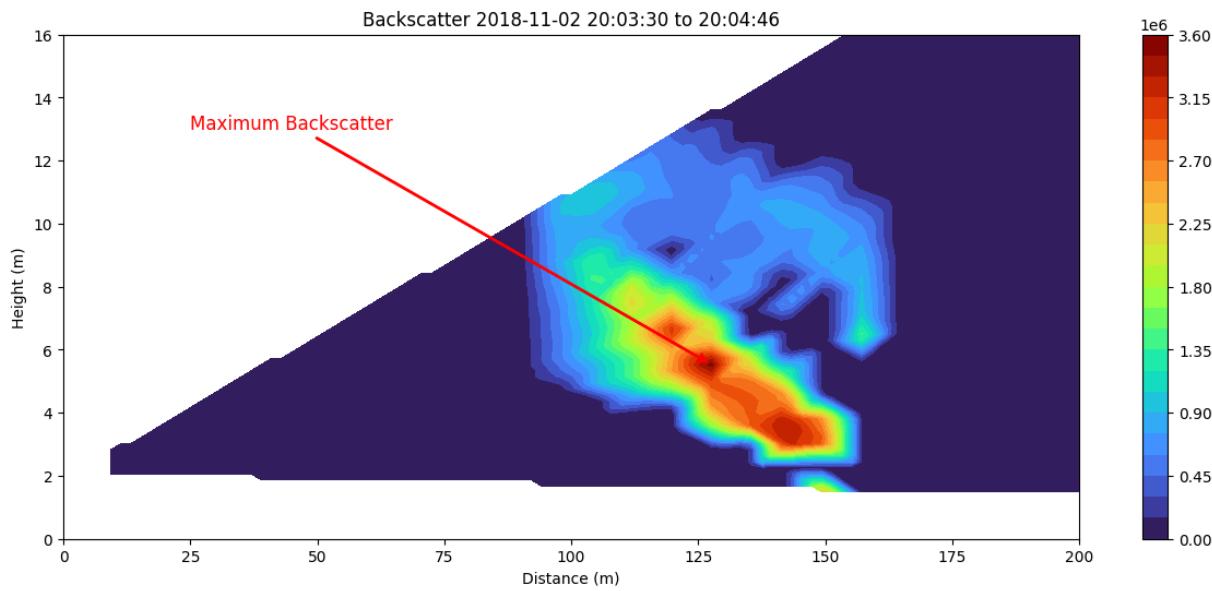
The calculated plume area is: 689.52 square meters.



Maximum Backscatter Value: 3517363.649 (Normalized)

Location (X, Z): (127.64 m, 5.53 m)

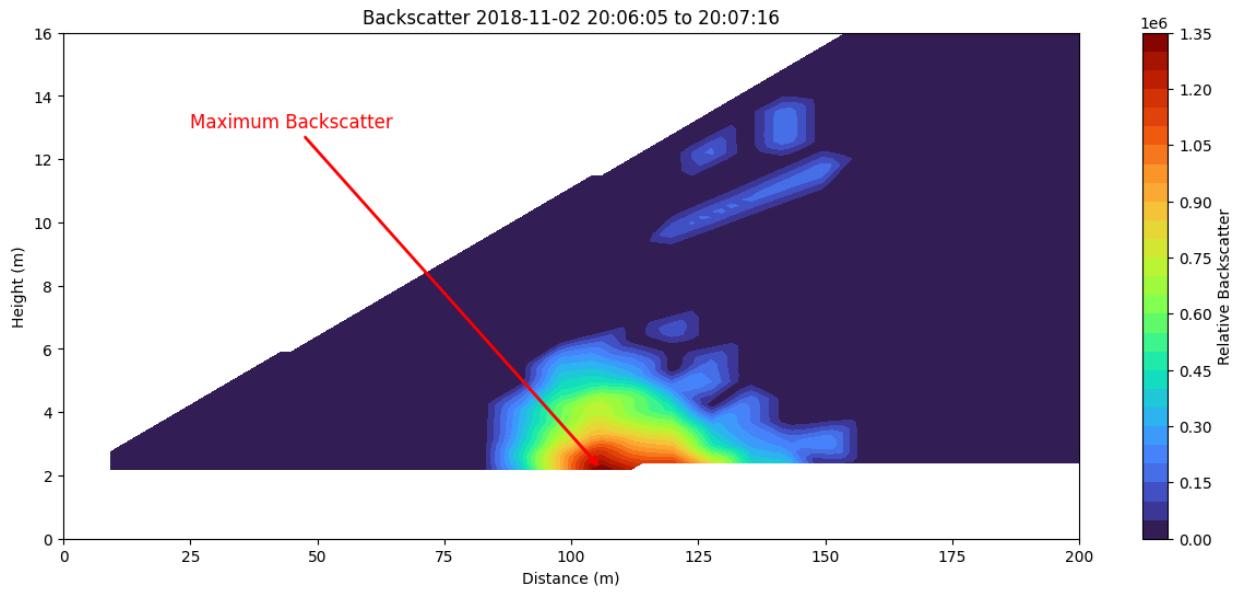
The calculated plume area is: 498.37 square meters.



Maximum Backscatter Value: 1339896.828 (Normalized)

Location (X, Z): (105.97 m, 2.20 m)

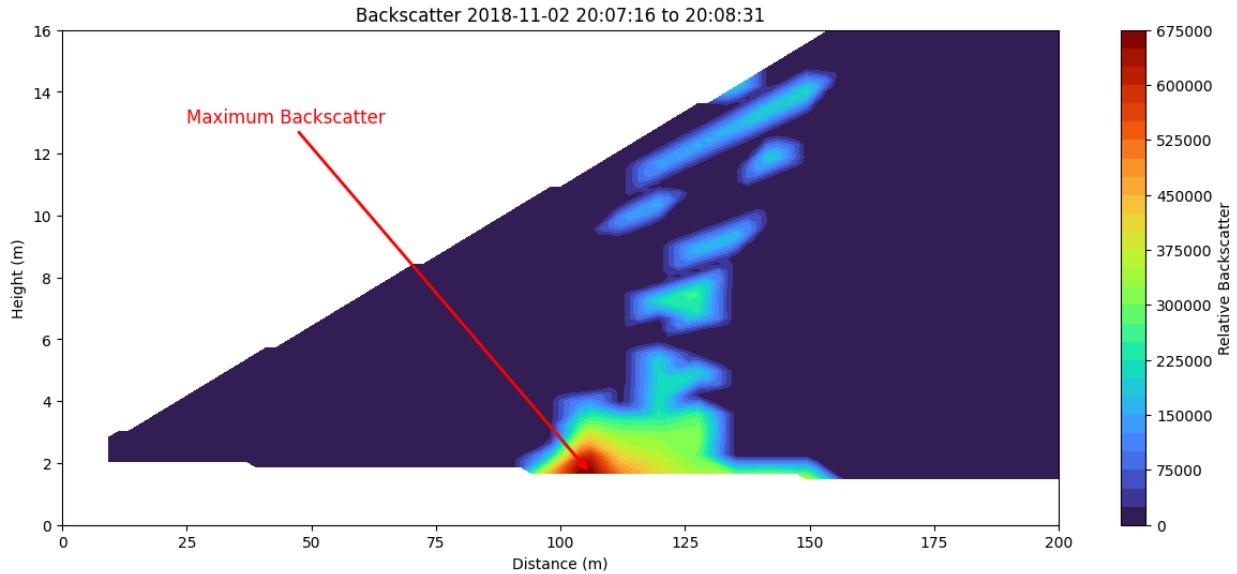
The calculated plume area is: 199.26 square meters.



Maximum Backscatter Value: 674864.044 (Normalized)

Location (X, Z): (105.97 m, 1.68 m)

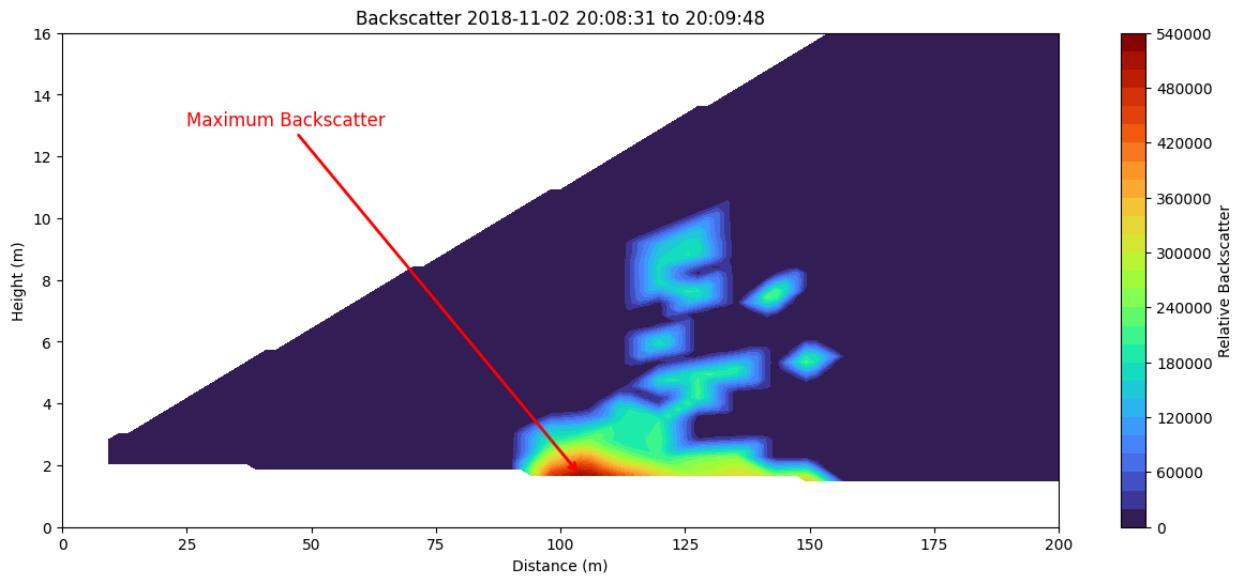
The calculated plume area is: 213.15 square meters.



Maximum Backscatter Value: 521189.474 (Normalized)

Location (X, Z): (104.00 m, 1.68 m)

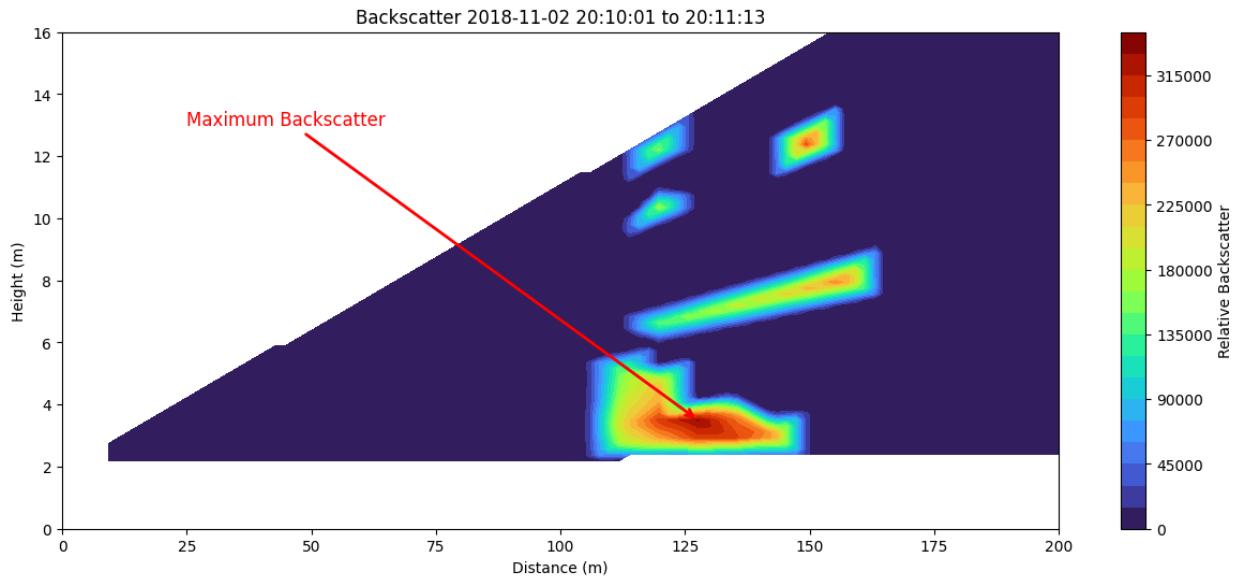
The calculated plume area is: 199.12 square meters.



Maximum Backscatter Value: 331067.460 (Normalized)

Location (X, Z): (127.64 m, 3.50 m)

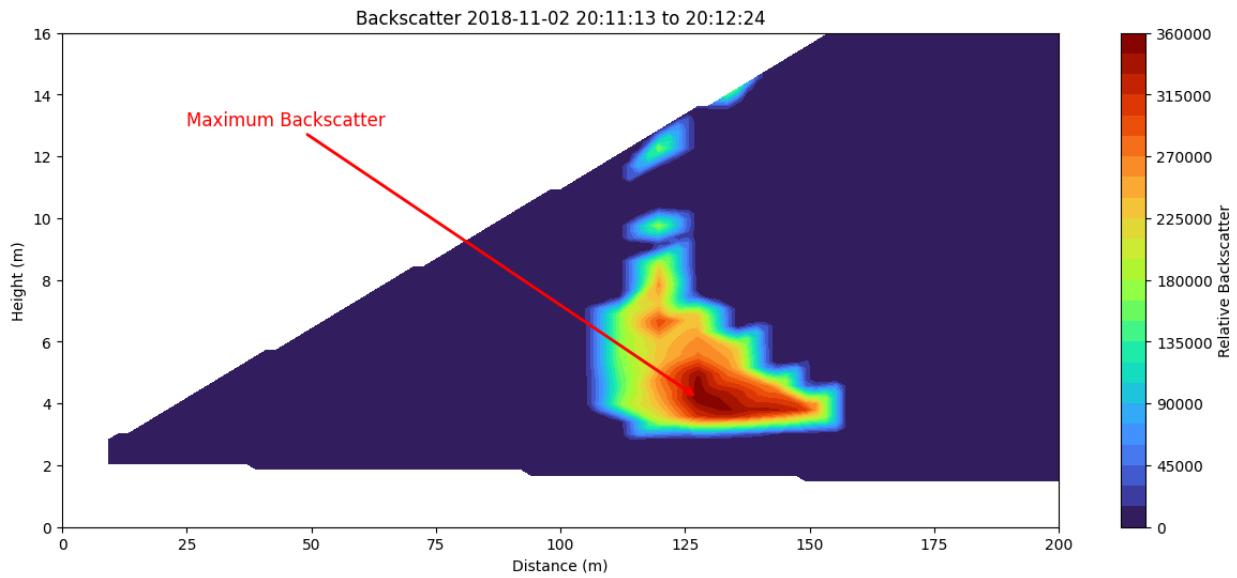
The calculated plume area is: 202.18 square meters.



Maximum Backscatter Value: 357768.847 (Normalized)

Location (X, Z): (127.64 m, 4.18 m)

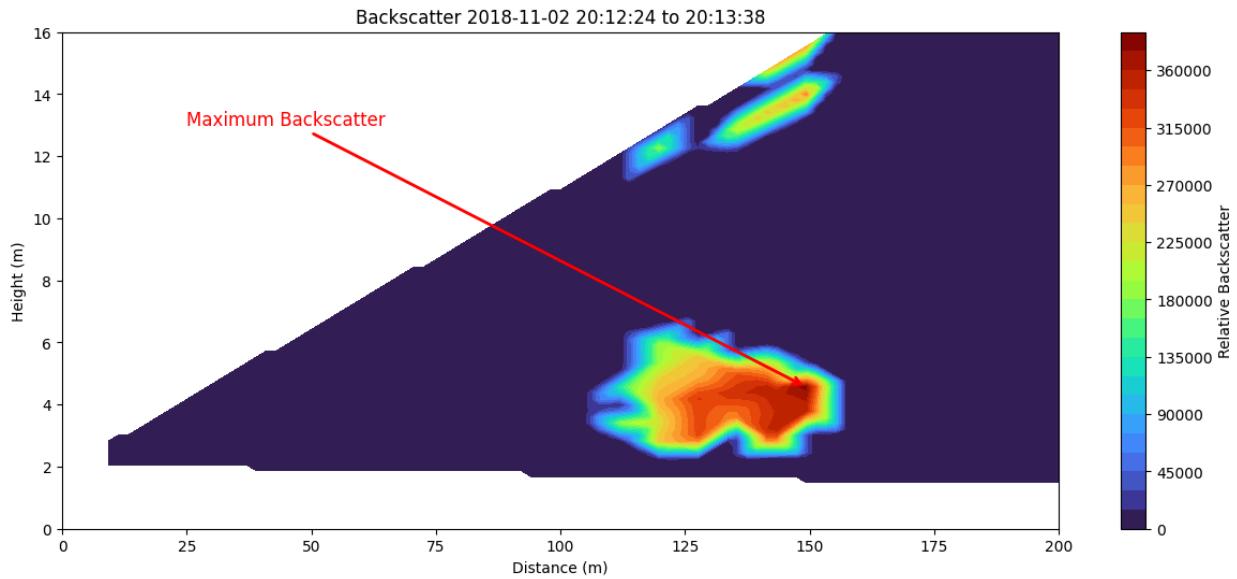
The calculated plume area is: 210.50 square meters.



Maximum Backscatter Value: 378445.431 (Normalized)

Location (X, Z): (149.31 m, 4.57 m)

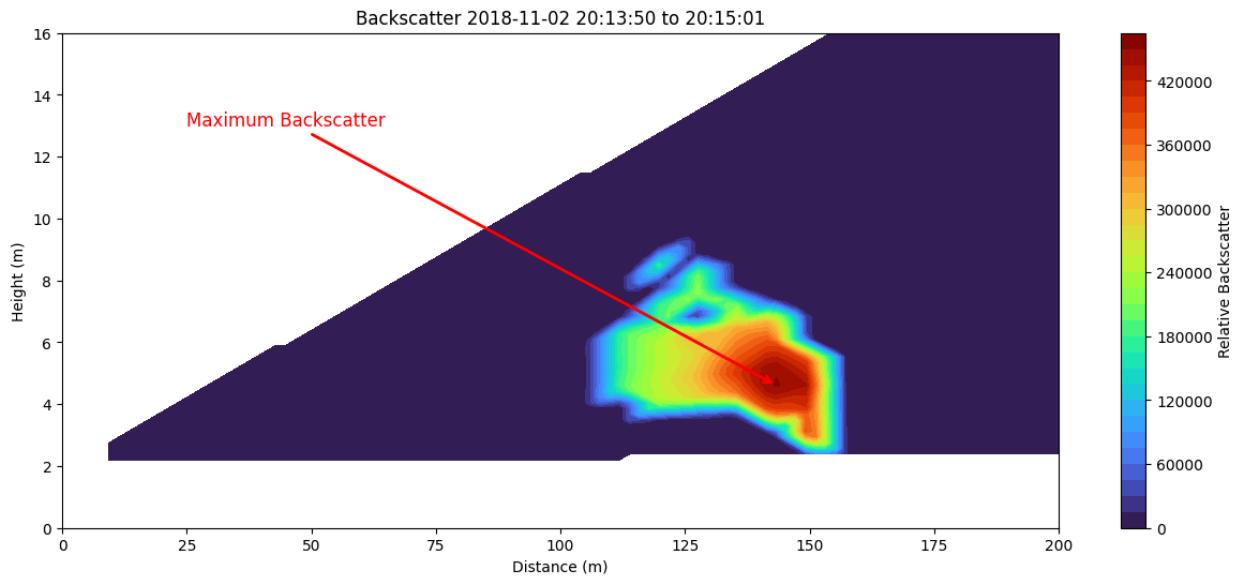
The calculated plume area is: 199.12 square meters.



Maximum Backscatter Value: 451558.171 (Normalized)

Location (X, Z): (143.40 m, 4.61 m)

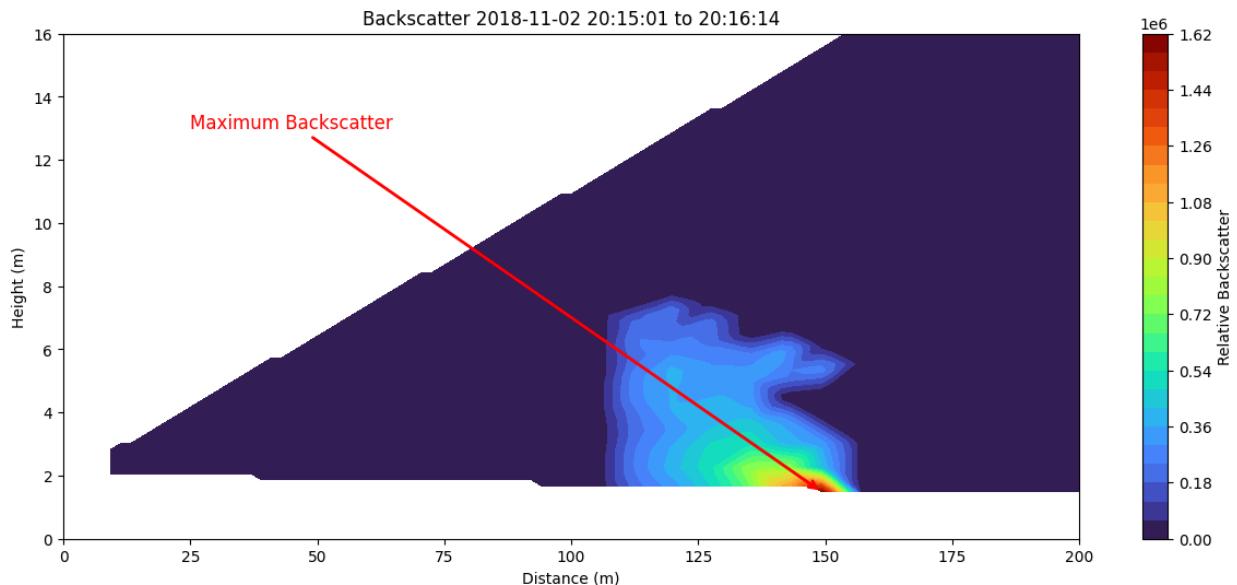
The calculated plume area is: 199.63 square meters.



Maximum Backscatter Value: 1589083.396 (Normalized)

Location (X, Z): (149.31 m, 1.49 m)

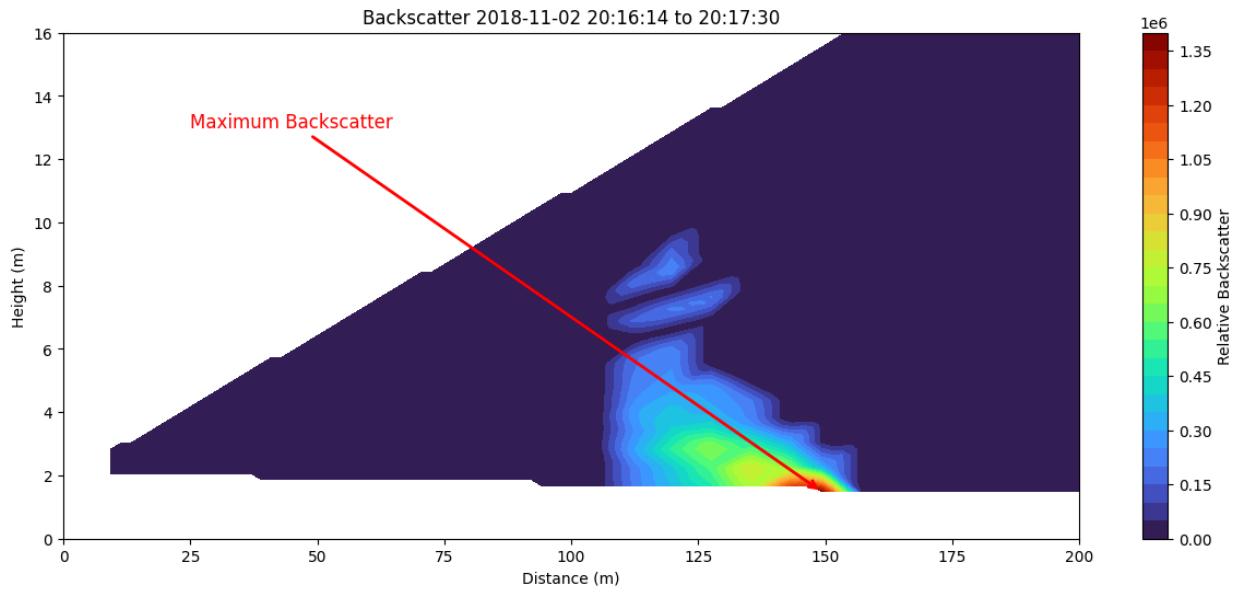
The calculated plume area is: 196.09 square meters.



Maximum Backscatter Value: 1365896.810 (Normalized)

Location (X, Z): (149.31 m, 1.49 m)

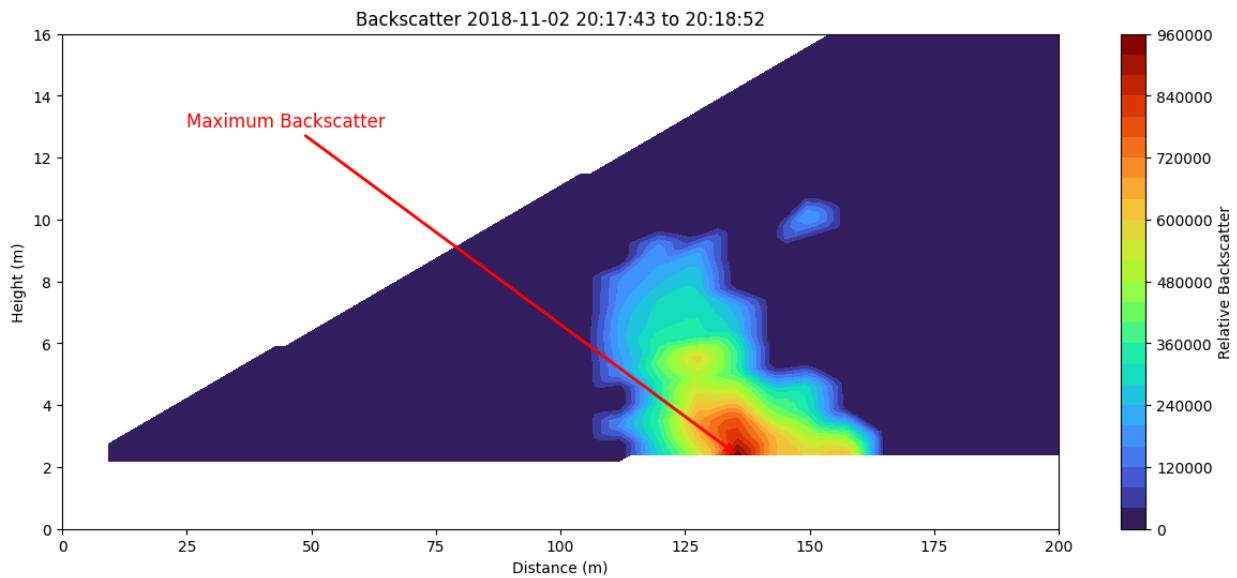
The calculated plume area is: 156.26 square meters.



Maximum Backscatter Value: 950448.735 (Normalized)

Location (X, Z): (135.52 m, 2.38 m)

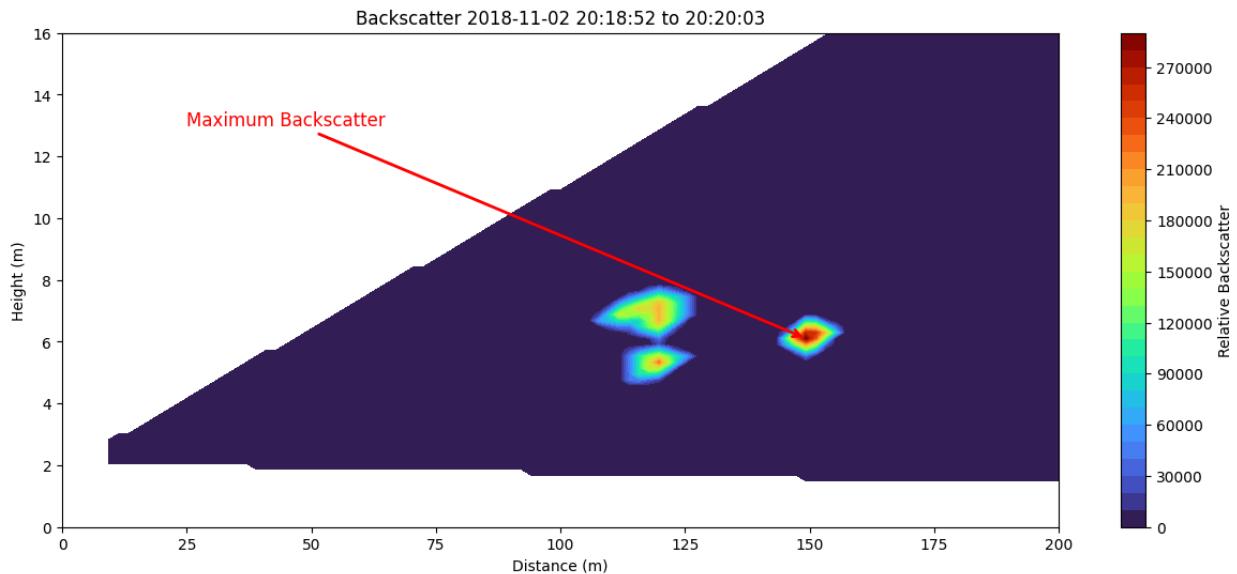
The calculated plume area is: 247.07 square meters.



Maximum Backscatter Value: 285879.006 (Normalized)

Location (X, Z): (149.31 m, 6.11 m)

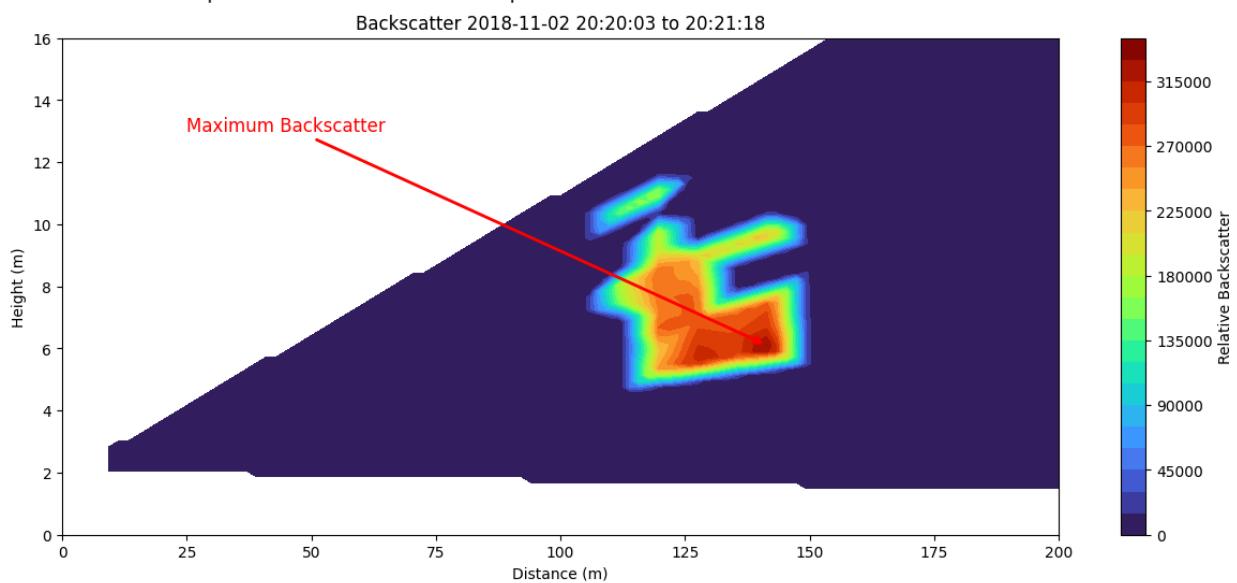
The calculated plume area is: 42.48 square meters.



Maximum Backscatter Value: 330365.868 (Normalized)

Location (X, Z): (141.43 m, 6.11 m)

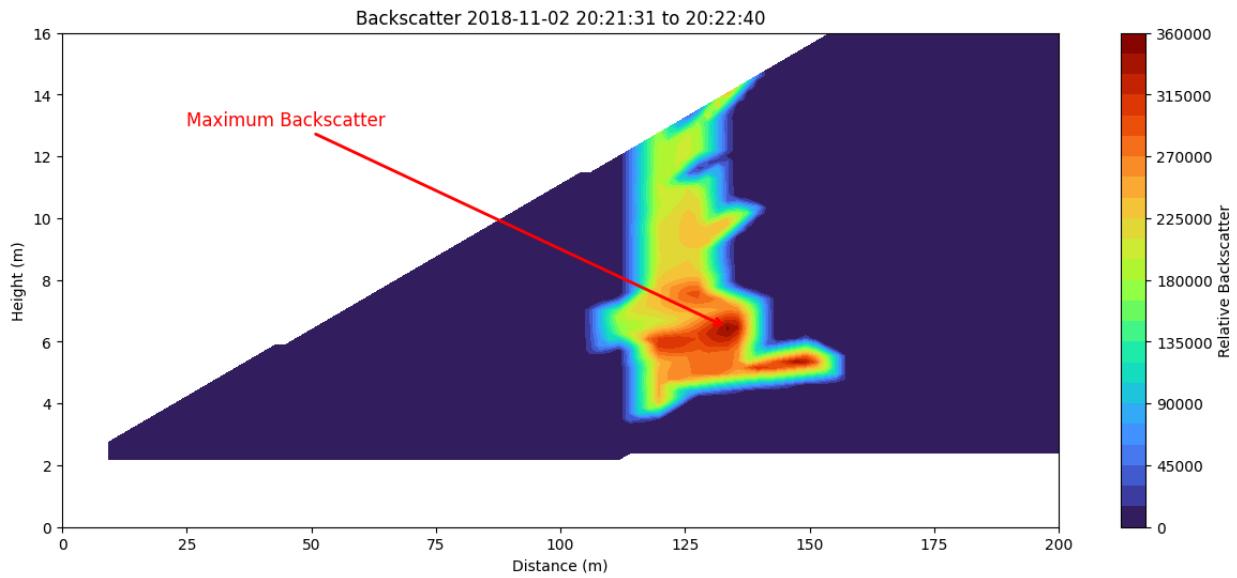
The calculated plume area is: 183.95 square meters.



Maximum Backscatter Value: 347208.128 (Normalized)

Location (X, Z): (133.55 m, 6.46 m)

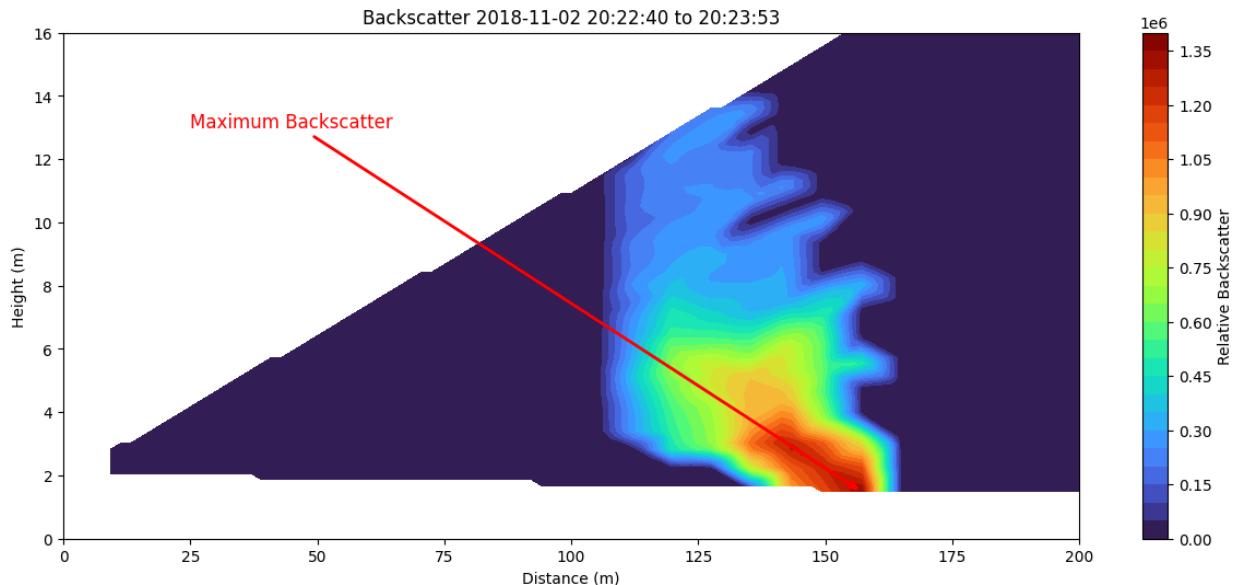
The calculated plume area is: 251.08 square meters.



Maximum Backscatter Value: 1351872.667 (Normalized)

Location (X, Z): (157.19 m, 1.49 m)

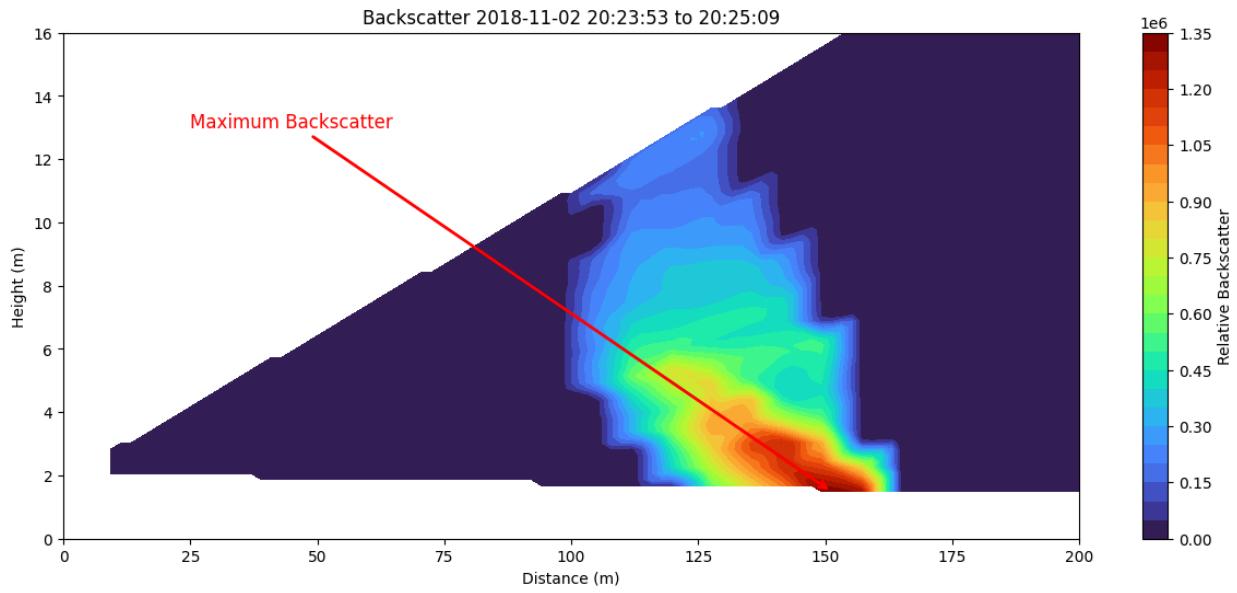
The calculated plume area is: 478.64 square meters.



Maximum Backscatter Value: 1342864.709 (Normalized)

Location (X, Z): (151.28 m, 1.49 m)

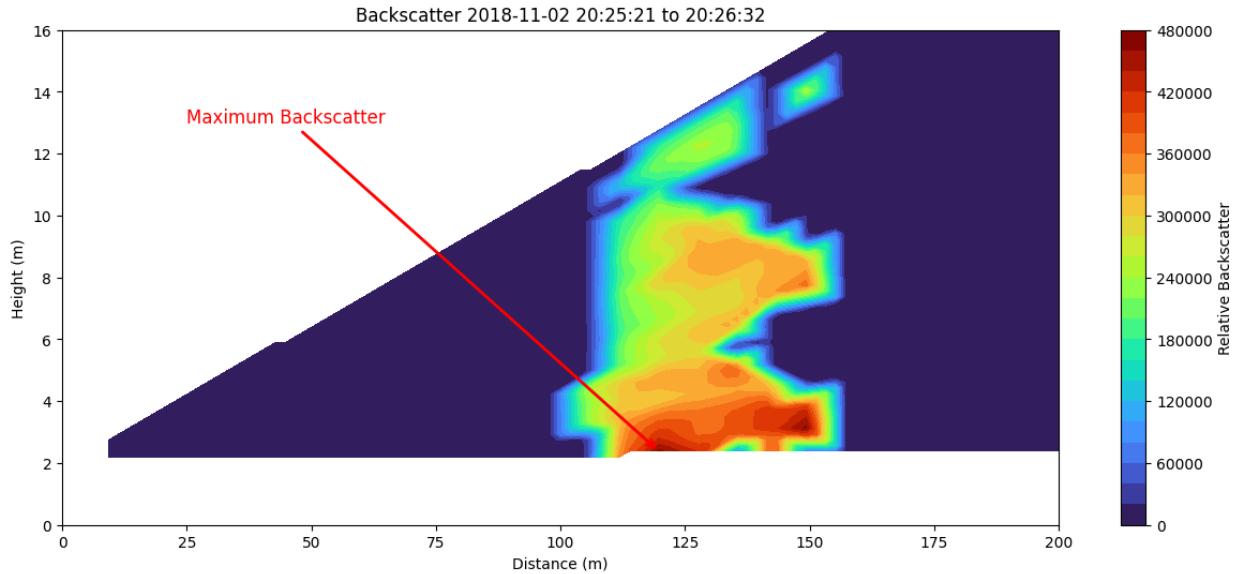
The calculated plume area is: 474.85 square meters.



Maximum Backscatter Value: 465064.475 (Normalized)

Location (X, Z): (119.76 m, 2.38 m)

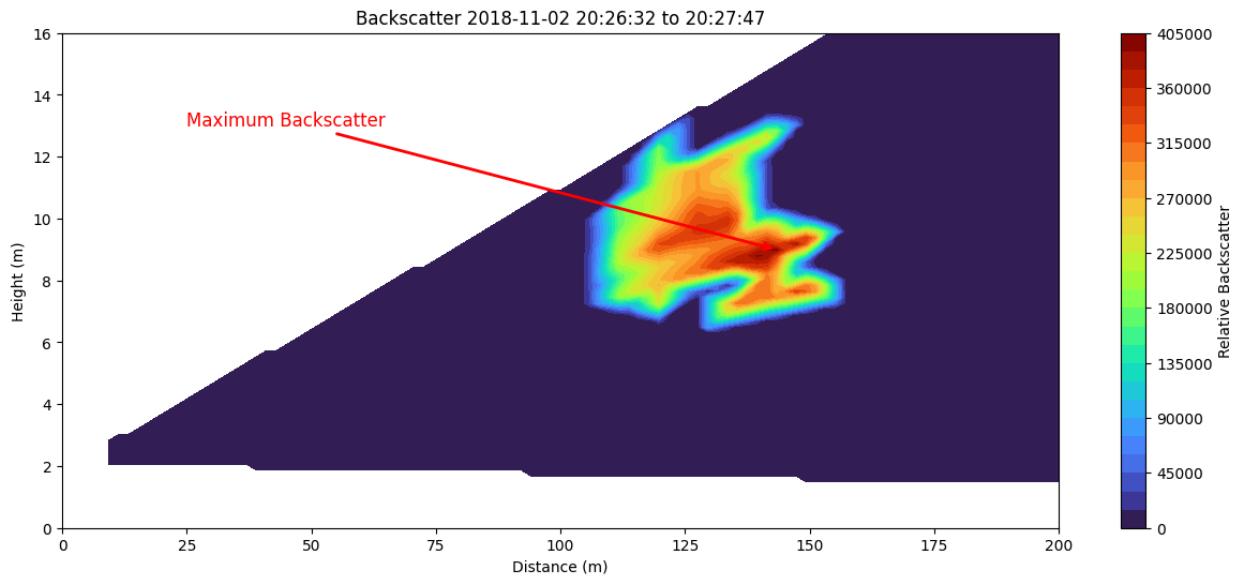
The calculated plume area is: 452.54 square meters.



Maximum Backscatter Value: 393231.640 (Normalized)

Location (X, Z): (143.40 m, 8.99 m)

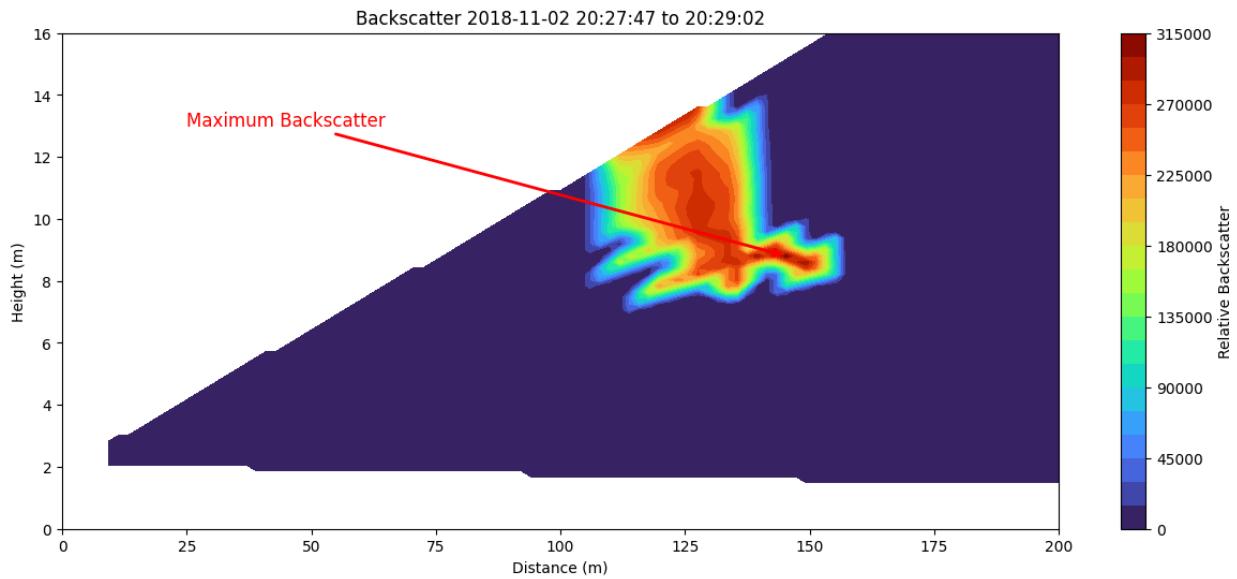
The calculated plume area is: 226.05 square meters.



Maximum Backscatter Value: 312667.381 (Normalized)

Location (X, Z): (145.37 m, 8.80 m)

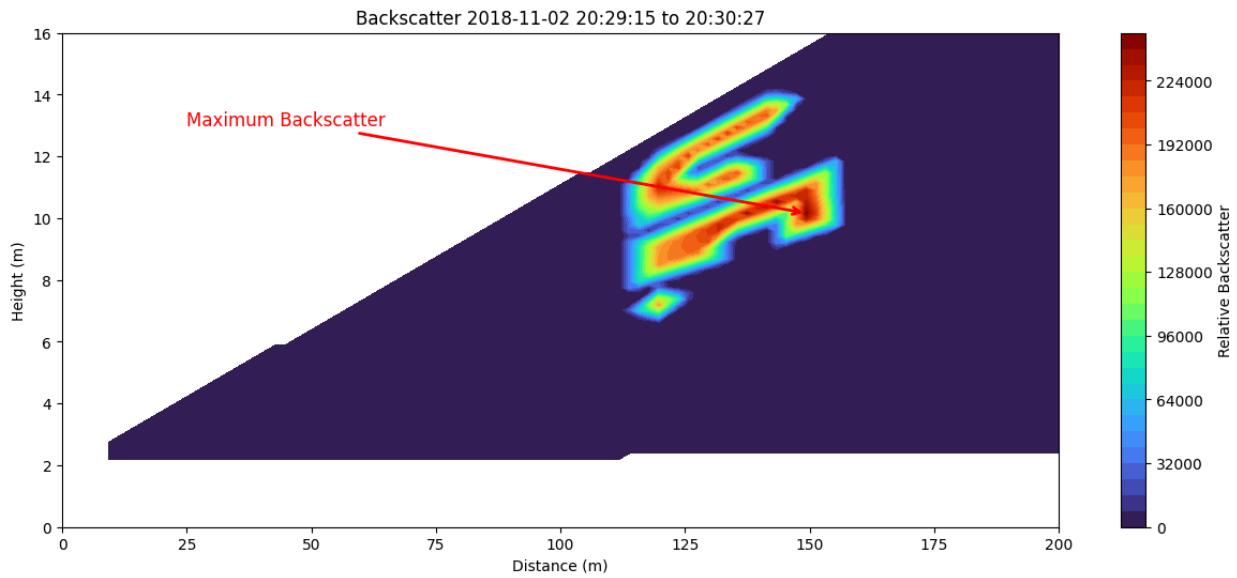
The calculated plume area is: 209.74 square meters.



Maximum Backscatter Value: 242986.028 (Normalized)

Location (X, Z): (149.31 m, 10.16 m)

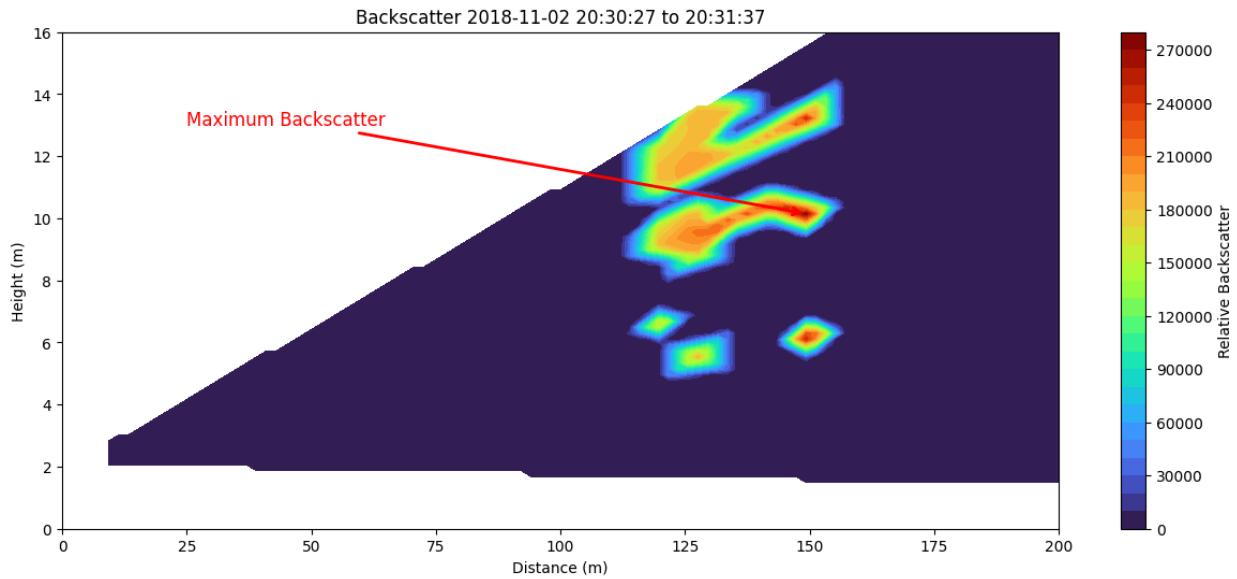
The calculated plume area is: 155.10 square meters.



Maximum Backscatter Value: 271750.843 (Normalized)

Location (X, Z): (149.31 m, 10.15 m)

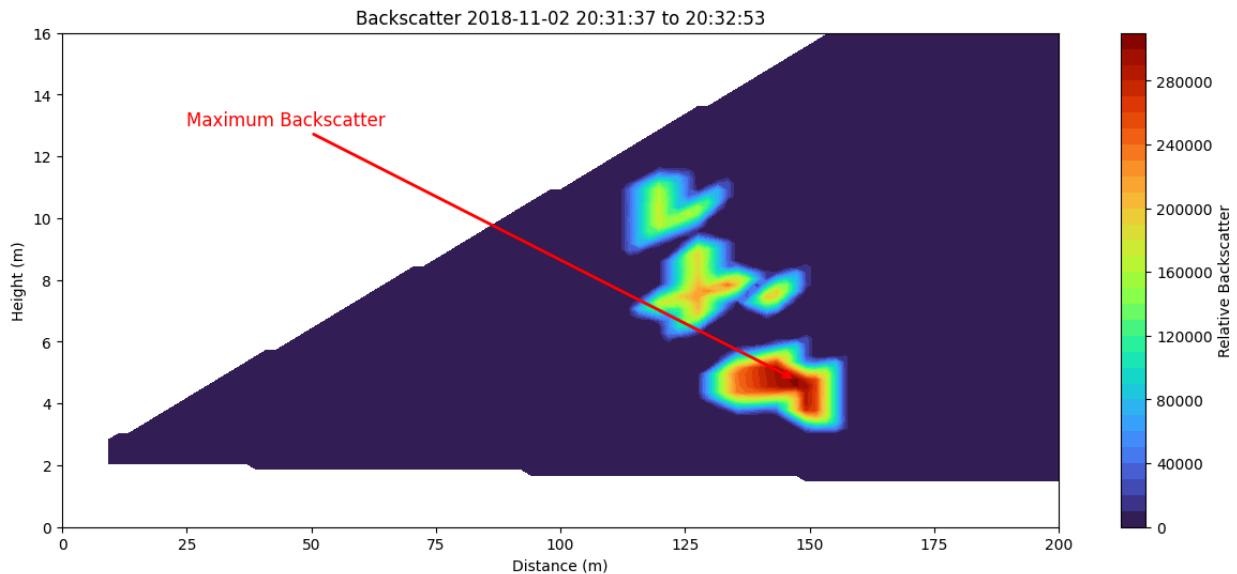
The calculated plume area is: 186.22 square meters.



Maximum Backscatter Value: 304446.648 (Normalized)

Location (X, Z): (147.34 m, 4.76 m)

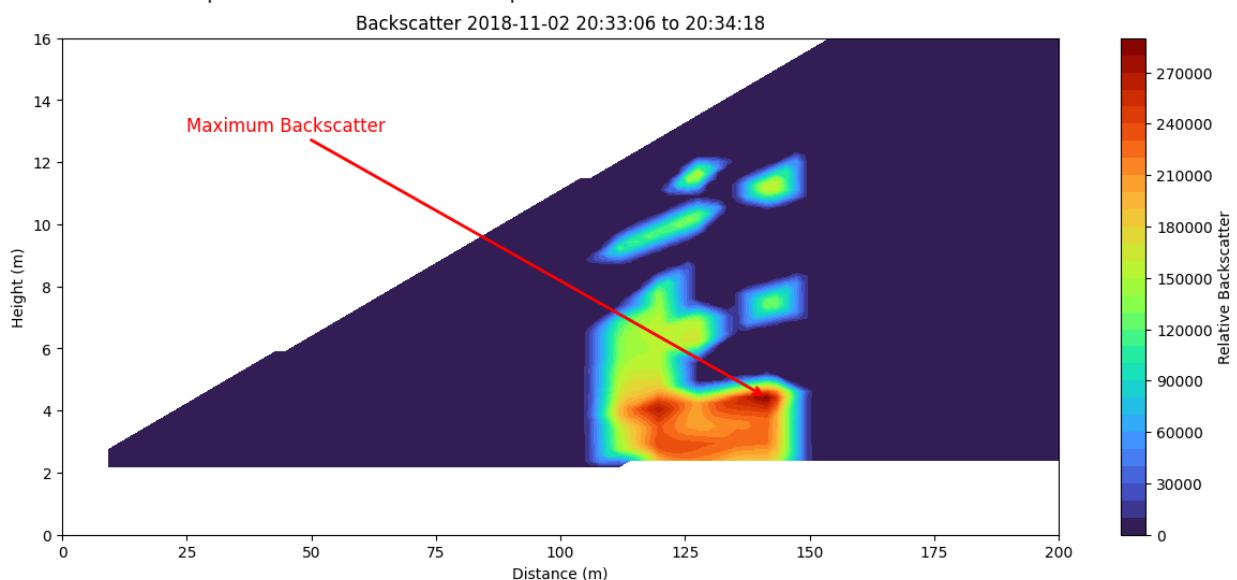
The calculated plume area is: 146.02 square meters.



Maximum Backscatter Value: 281181.808 (Normalized)

Location (X, Z): (141.43 m, 4.42 m)

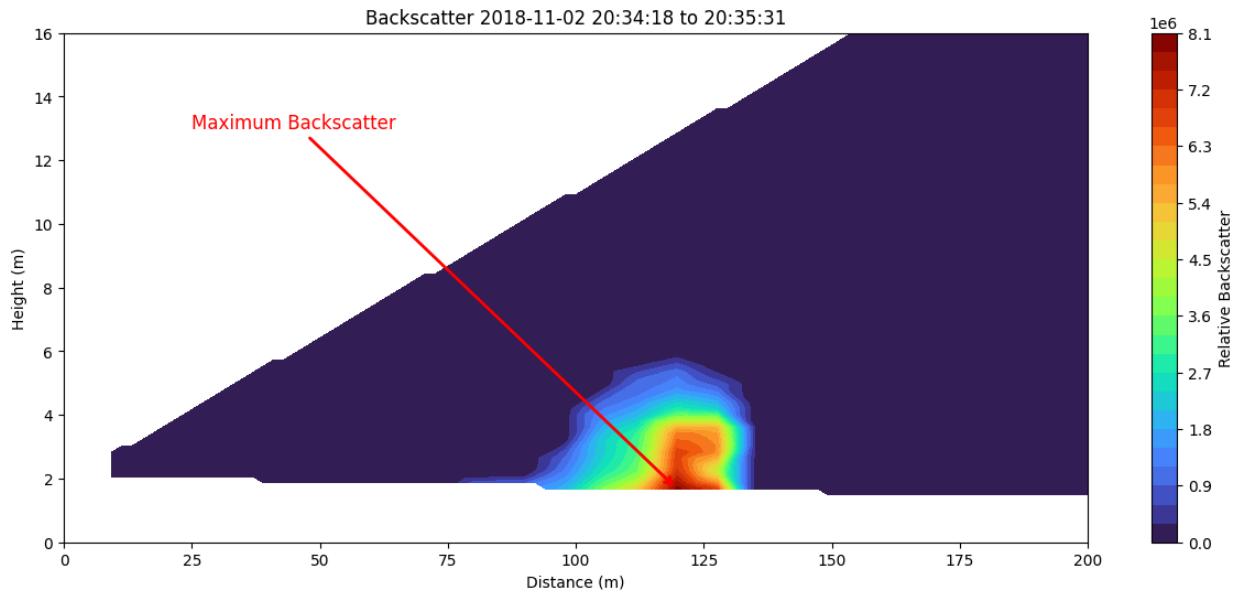
The calculated plume area is: 232.11 square meters.



Maximum Backscatter Value: 7950119.887 (Normalized)

Location (X, Z): (119.76 m, 1.68 m)

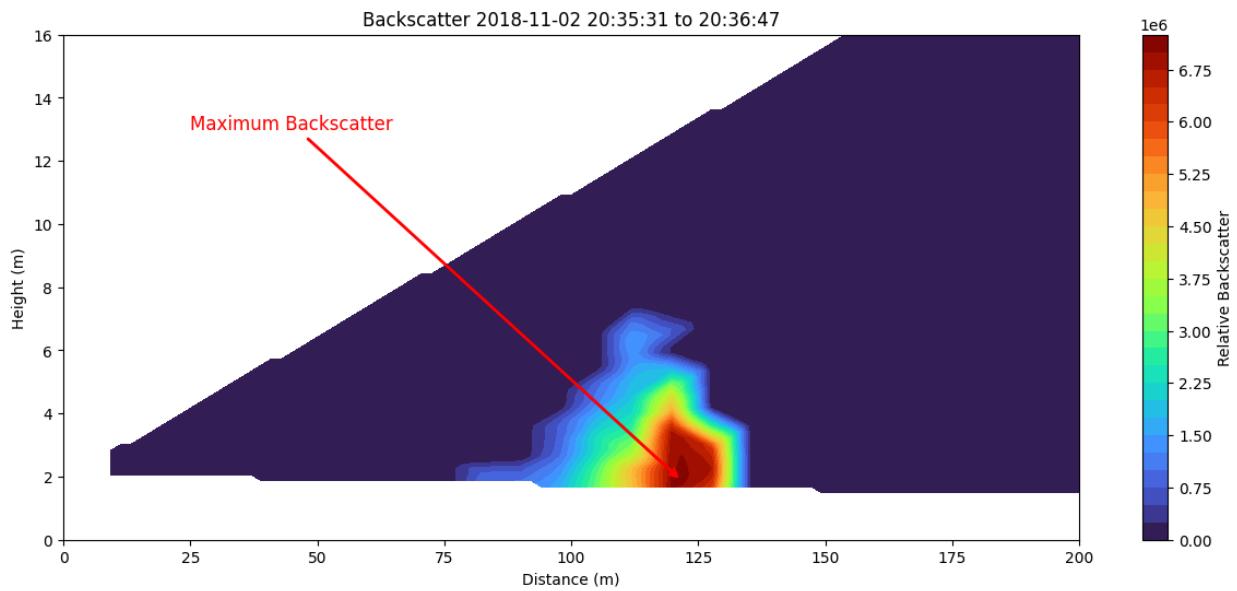
The calculated plume area is: 120.61 square meters.



Maximum Backscatter Value: 7037941.190 (Normalized)

Location (X, Z): (121.73 m, 1.87 m)

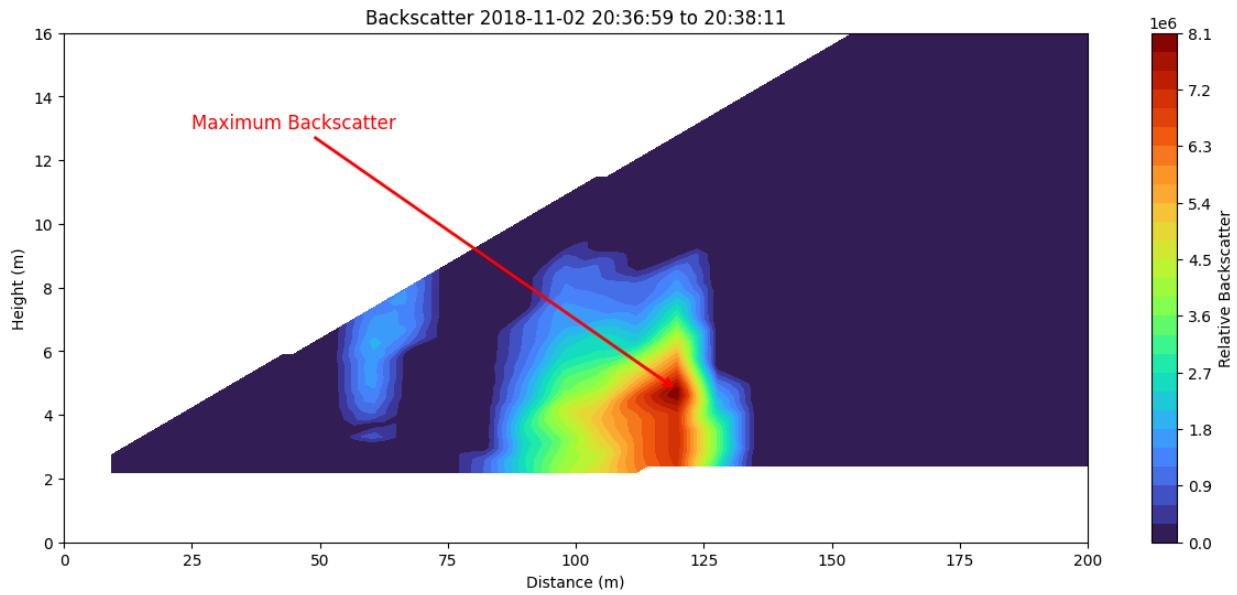
The calculated plume area is: 146.78 square meters.



Maximum Backscatter Value: 8028680.480 (Normalized)

Location (X, Z): (119.76 m, 4.79 m)

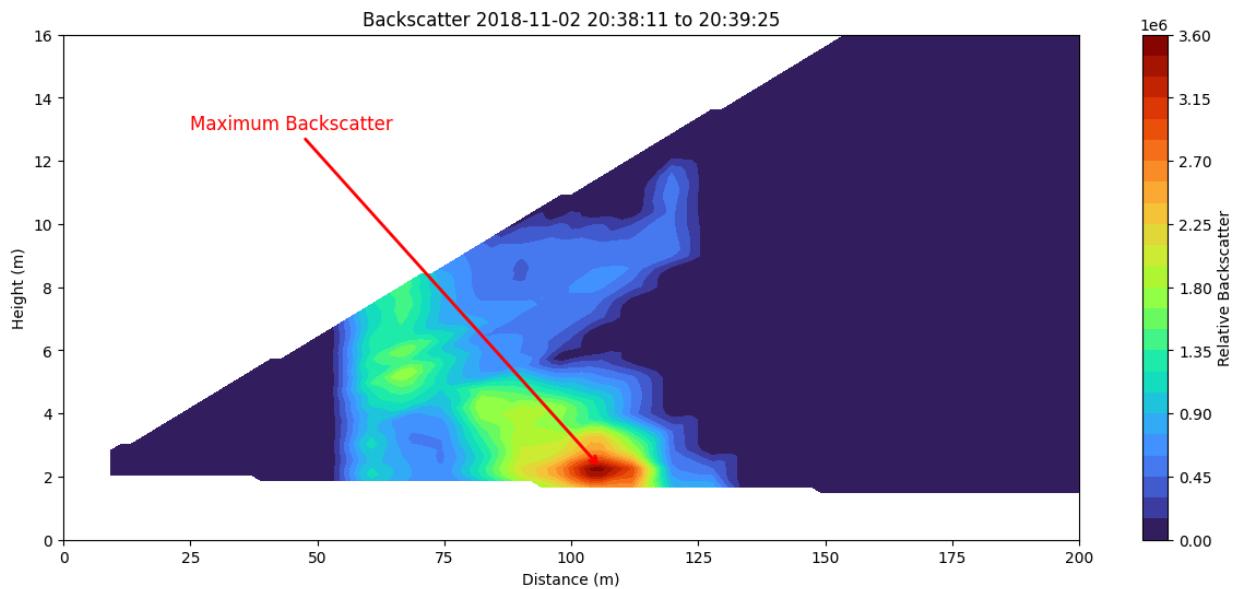
The calculated plume area is: 298.53 square meters.



Maximum Backscatter Value: 3493024.653 (Normalized)

Location (X, Z): (105.97 m, 2.26 m)

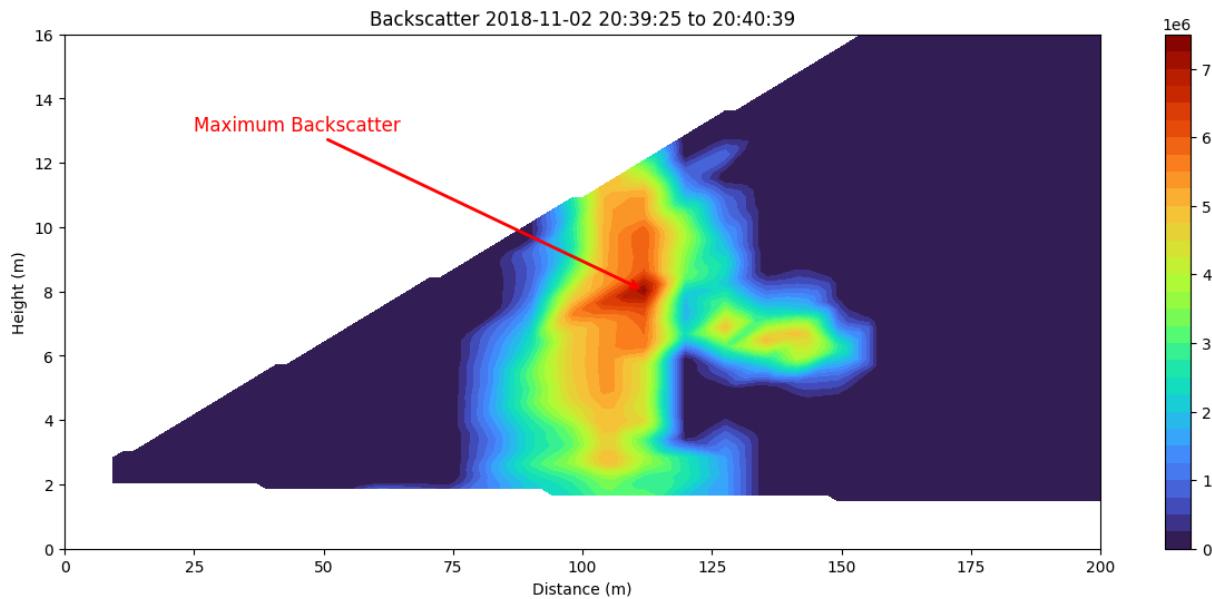
The calculated plume area is: 451.72 square meters.



Maximum Backscatter Value: 7277882.062 (Normalized)

Location (X, Z): (111.88 m, 8.03 m)

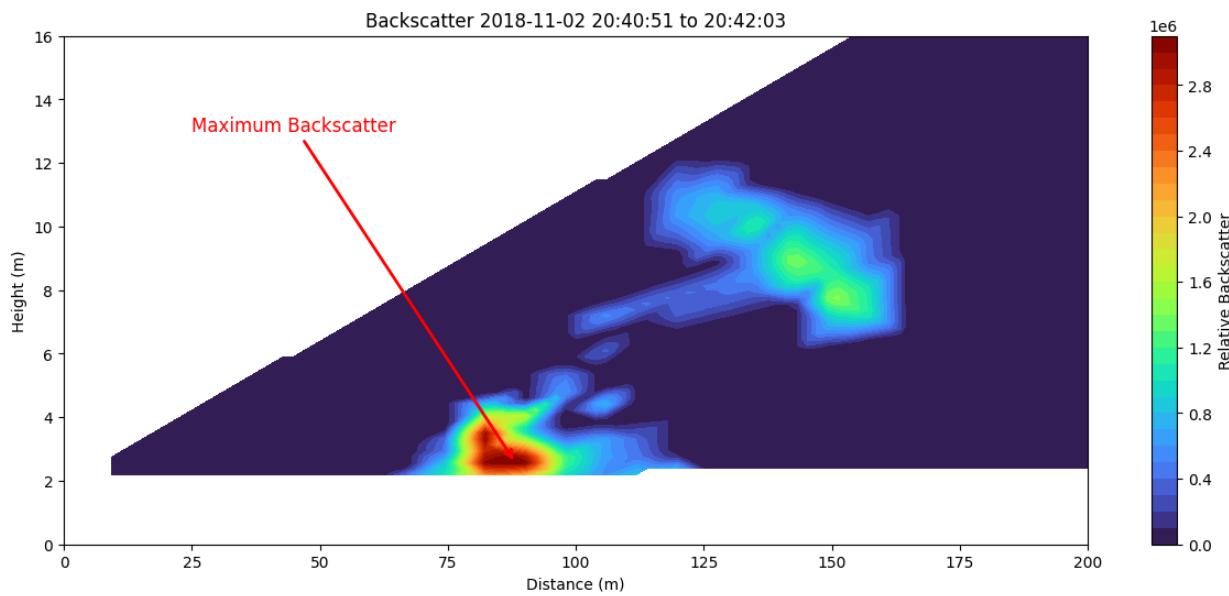
The calculated plume area is: 505.57 square meters.



Maximum Backscatter Value: 3081681.728 (Normalized)

Location (X, Z): (88.24 m, 2.57 m)

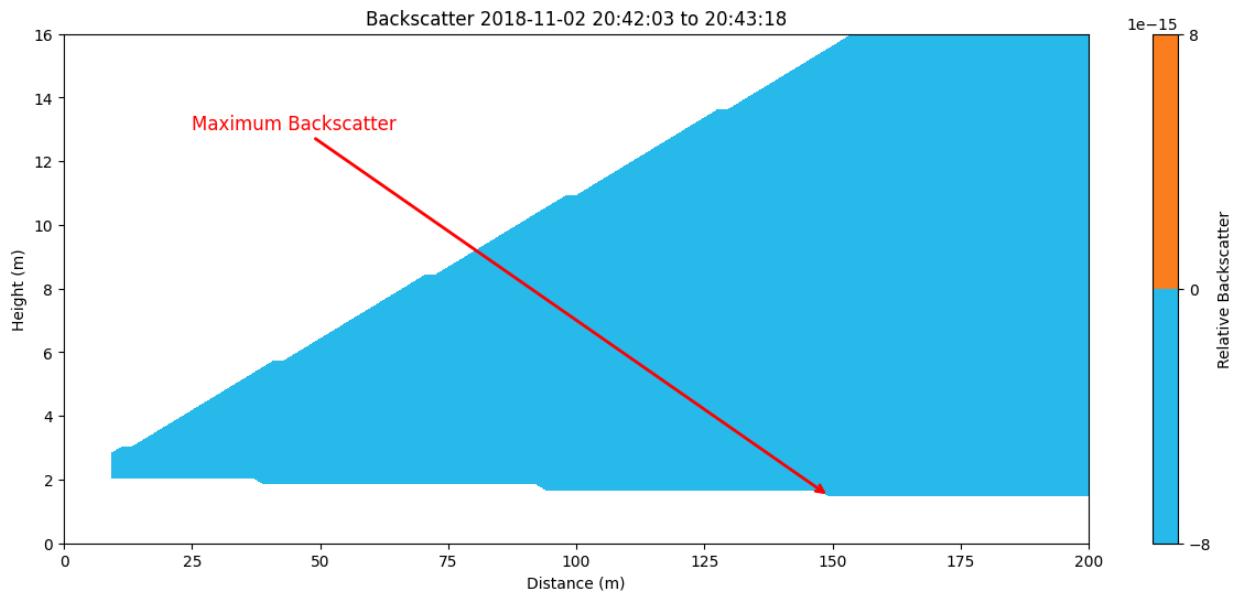
The calculated plume area is: 252.54 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (149.31 m, 1.49 m)

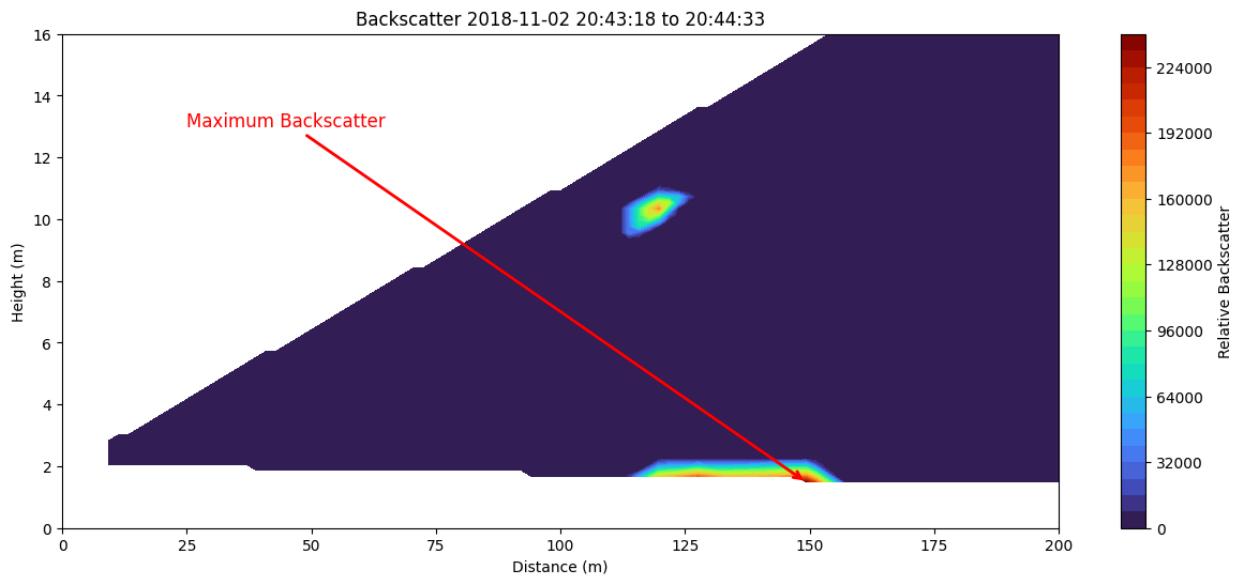
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 235883.071 (Normalized)

Location (X, Z): (149.31 m, 1.49 m)

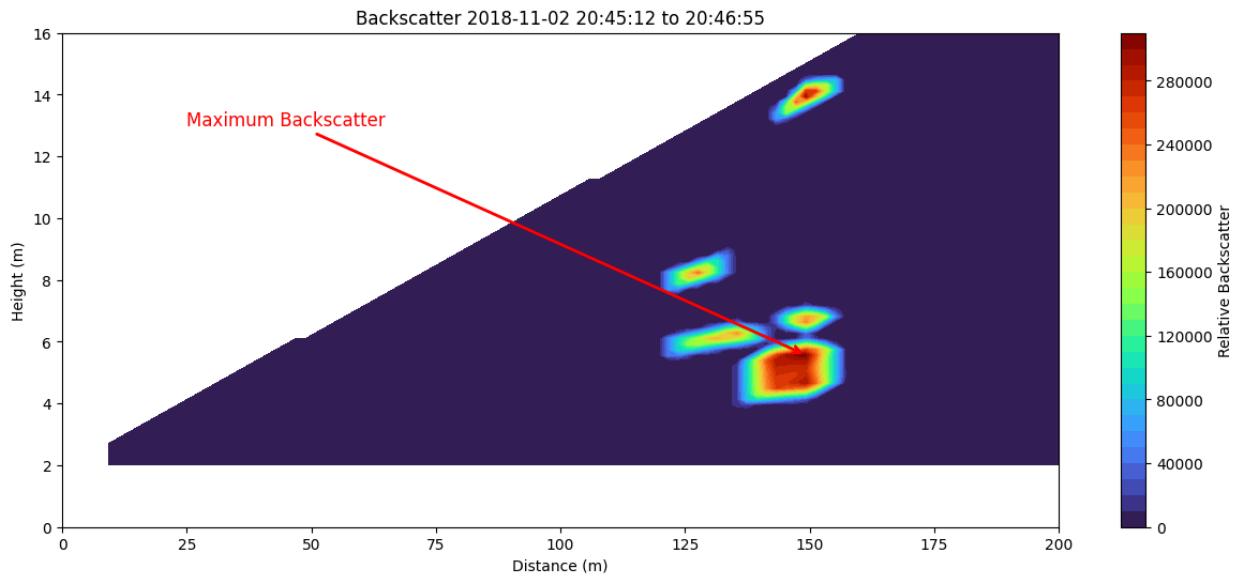
The calculated plume area is: 32.62 square meters.



Maximum Backscatter Value: 303993.882 (Normalized)

Location (X, Z): (149.31 m, 5.57 m)

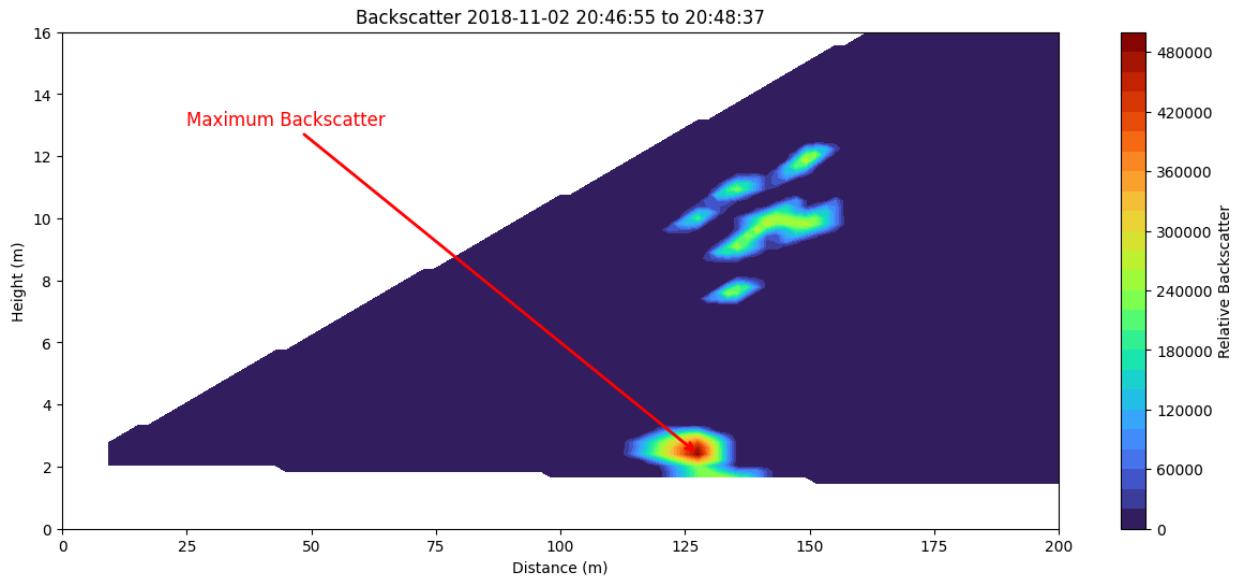
The calculated plume area is: 77.61 square meters.



Maximum Backscatter Value: 484094.092 (Normalized)

Location (X, Z): (127.64 m, 2.41 m)

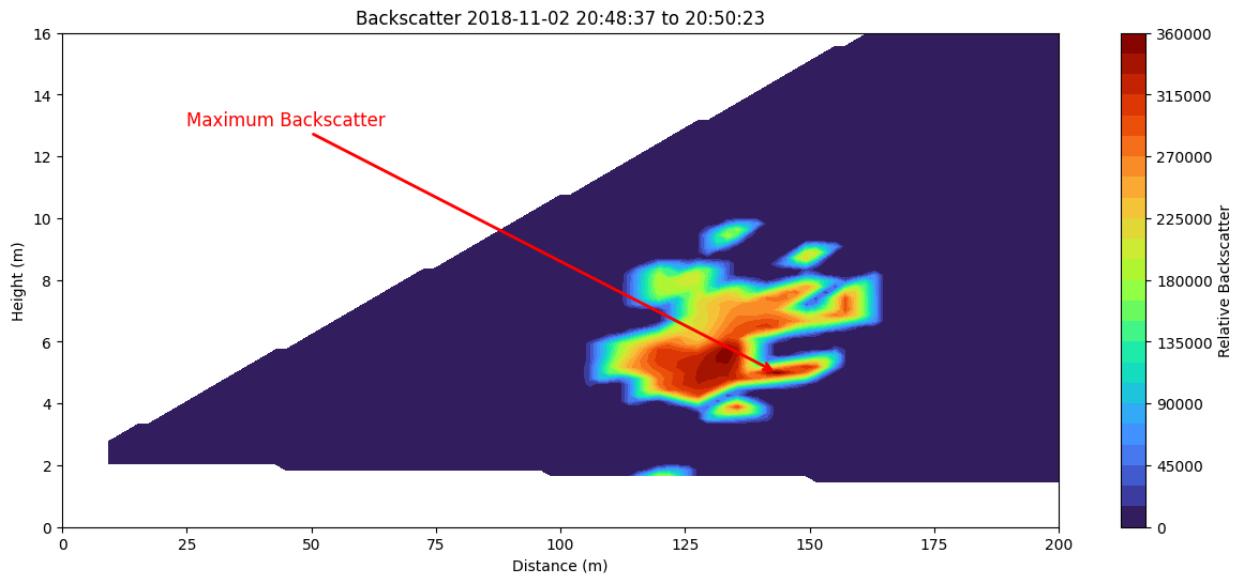
The calculated plume area is: 75.61 square meters.



Maximum Backscatter Value: 356214.764 (Normalized)

Location (X, Z): (143.40 m, 5.00 m)

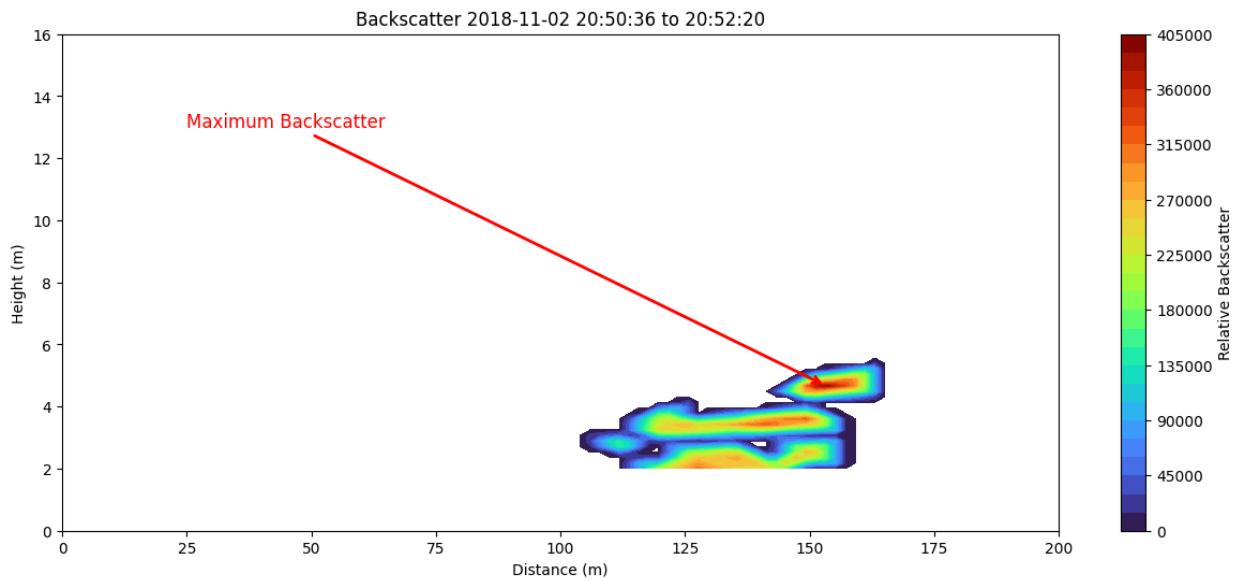
The calculated plume area is: 201.26 square meters.



Maximum Backscatter Value: 390209.781 (Normalized)

Location (X, Z): (153.25 m, 4.67 m)

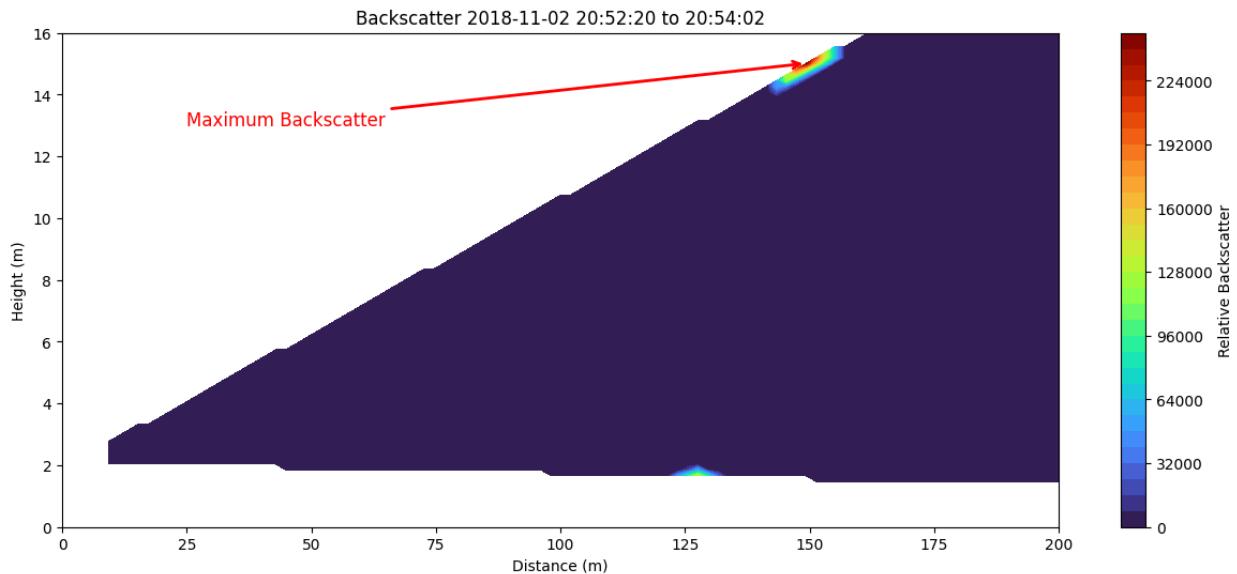
The calculated plume area is: 90.61 square meters.



Maximum Backscatter Value: 241563.490 (Normalized)

Location (X, Z): (149.31 m, 15.01 m)

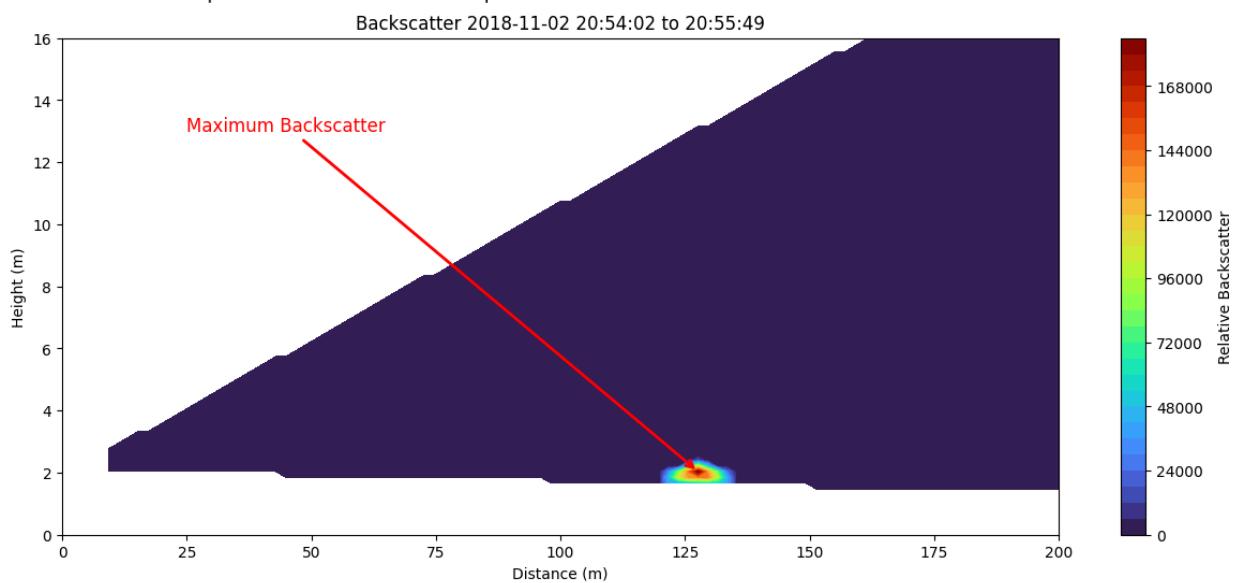
The calculated plume area is: 9.50 square meters.



Maximum Backscatter Value: 184820.549 (Normalized)

Location (X, Z): (127.64 m, 2.03 m)

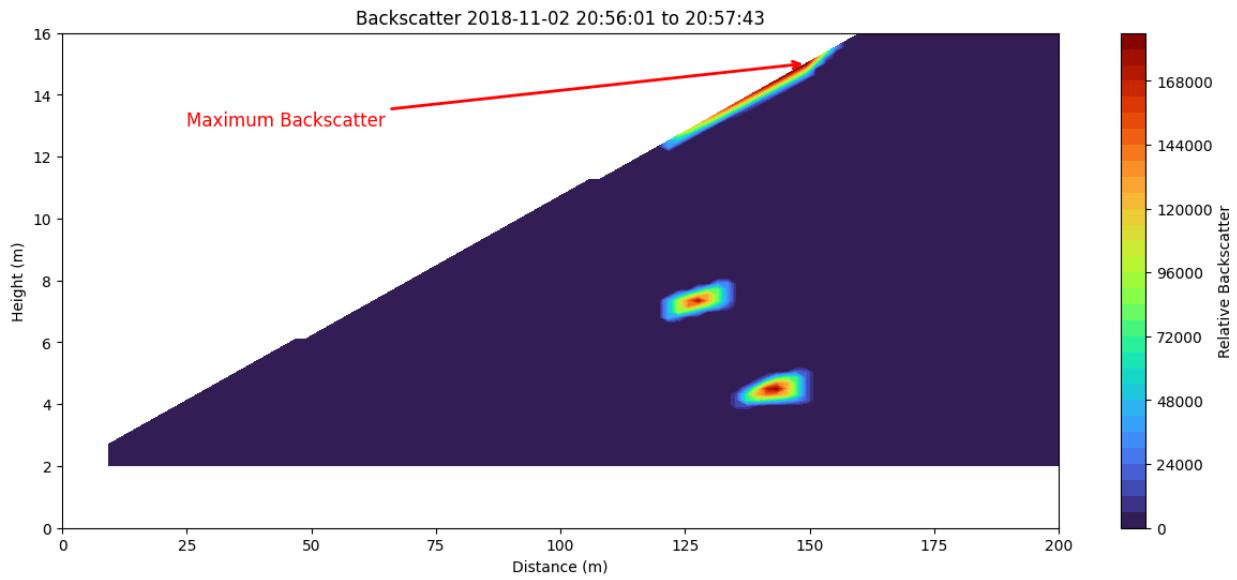
The calculated plume area is: 8.77 square meters.



Maximum Backscatter Value: 185000.138 (Normalized)

Location (X, Z): (149.31 m, 15.01 m)

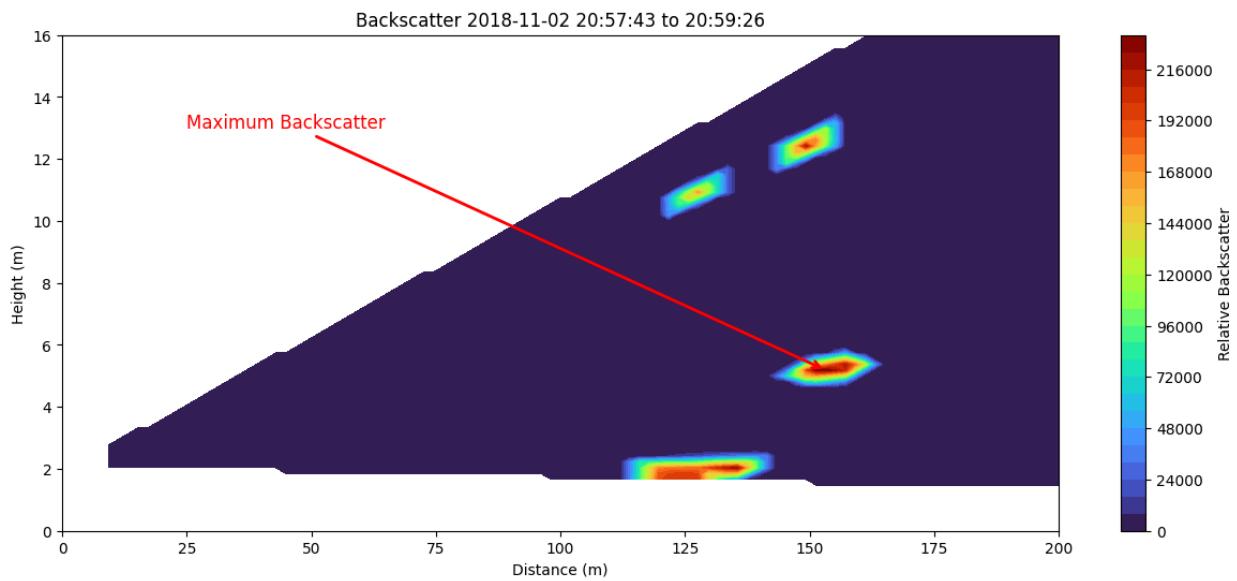
The calculated plume area is: 35.47 square meters.



Maximum Backscatter Value: 231381.177 (Normalized)

Location (X, Z): (153.25 m, 5.19 m)

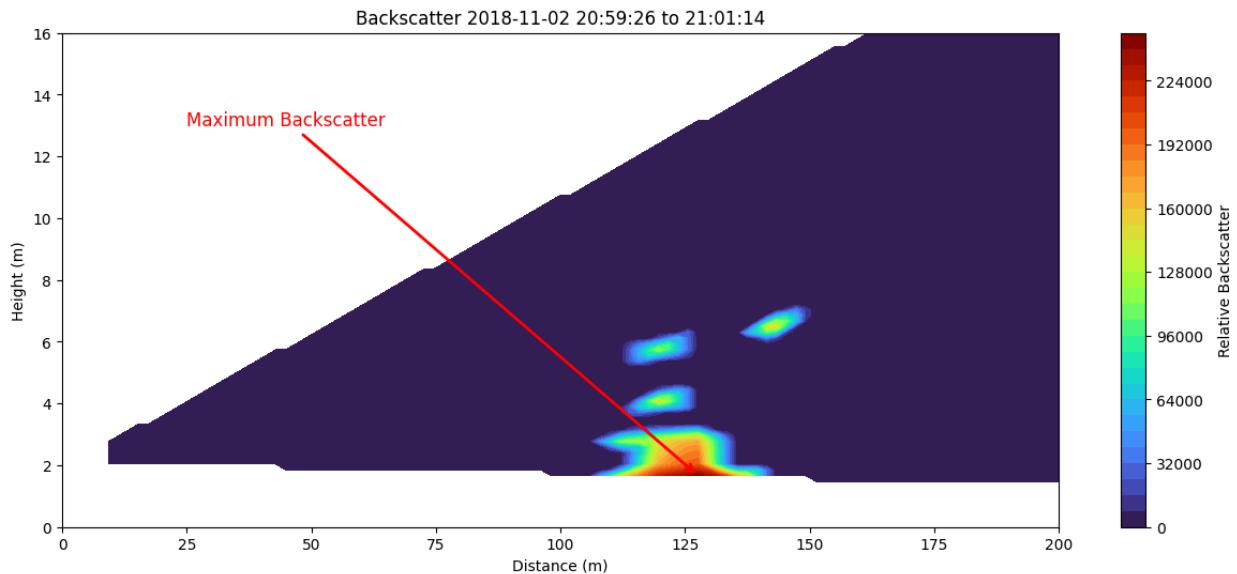
The calculated plume area is: 61.00 square meters.



Maximum Backscatter Value: 245584.082 (Normalized)

Location (X, Z): (127.64 m, 1.66 m)

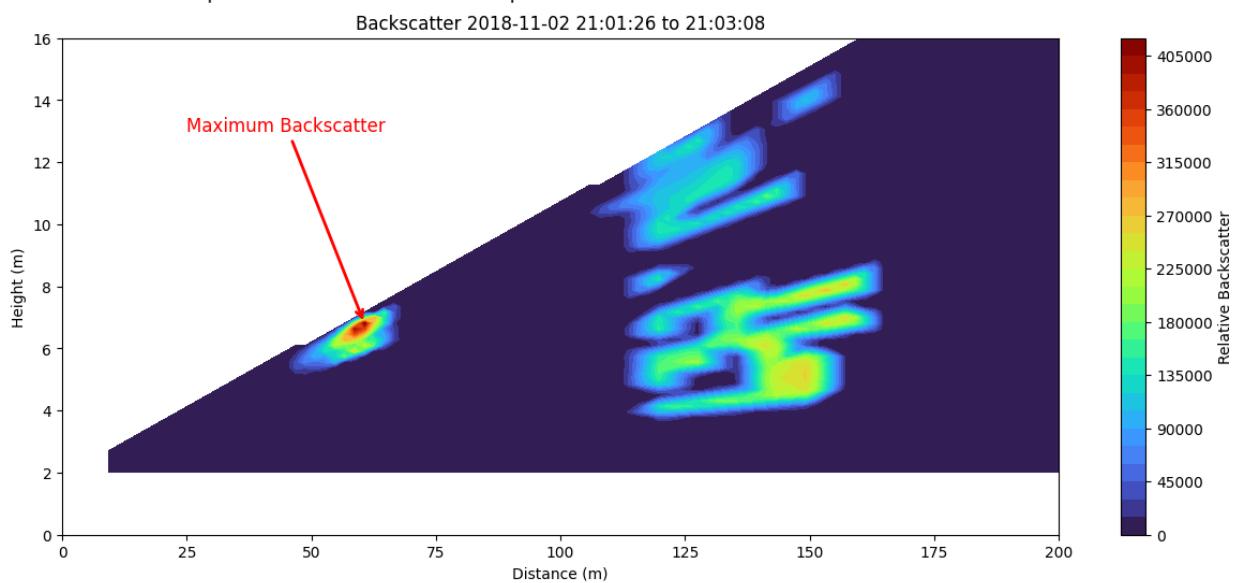
The calculated plume area is: 63.92 square meters.



Maximum Backscatter Value: 407944.141 (Normalized)

Location (X, Z): (60.66 m, 6.81 m)

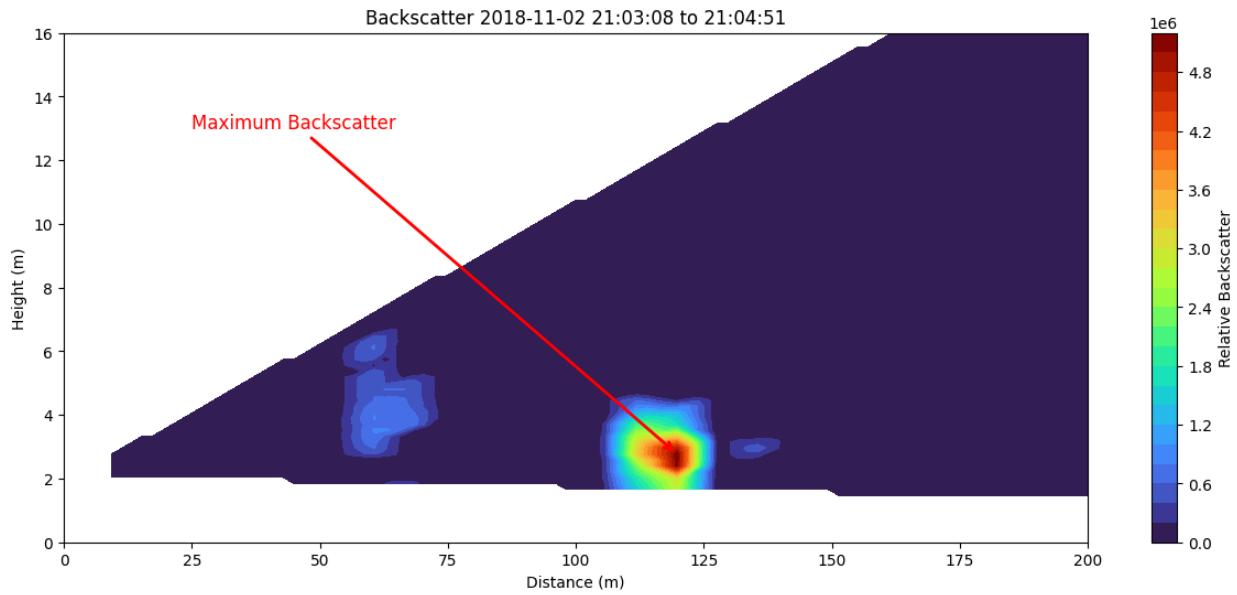
The calculated plume area is: 254.27 square meters.



Maximum Backscatter Value: 5145878.300 (Normalized)

Location (X, Z): (119.76 m, 2.78 m)

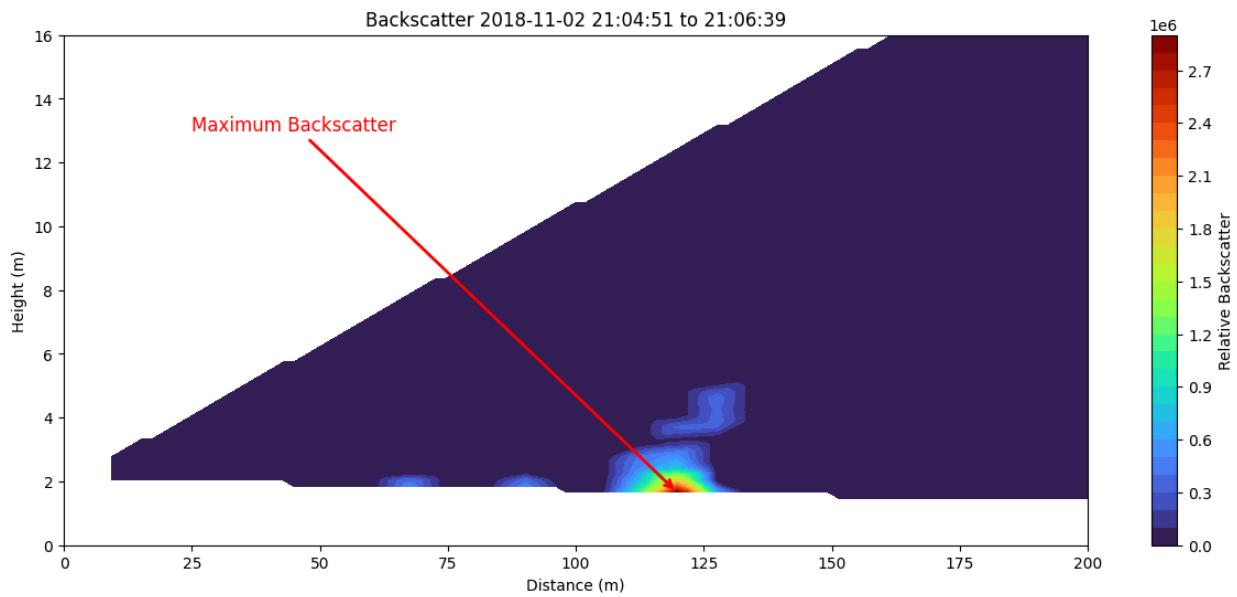
The calculated plume area is: 75.24 square meters.



Maximum Backscatter Value: 2879823.489 (Normalized)

Location (X, Z): (119.76 m, 1.66 m)

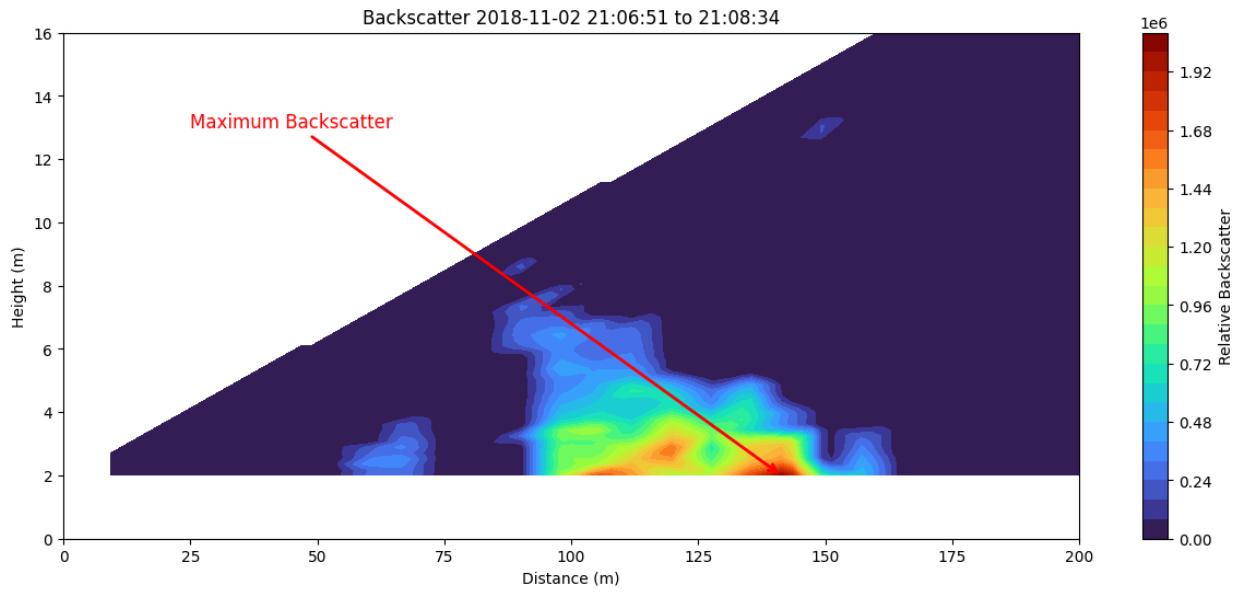
The calculated plume area is: 31.41 square meters.



Maximum Backscatter Value: 2020051.395 (Normalized)

Location (X, Z): (141.43 m, 2.00 m)

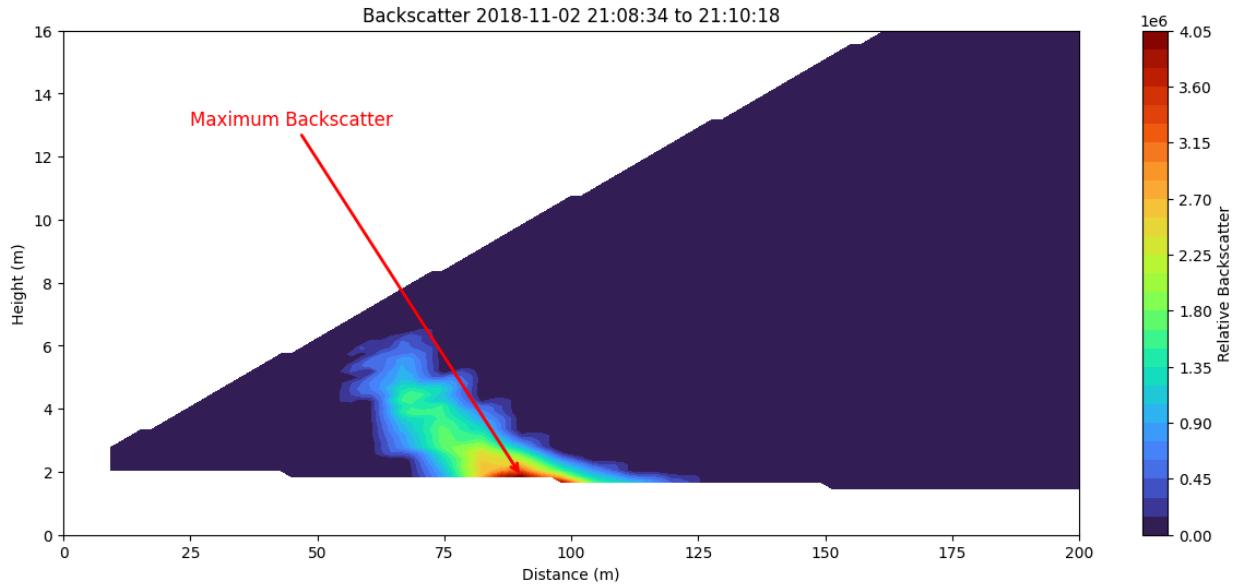
The calculated plume area is: 240.92 square meters.



Maximum Backscatter Value: 4004559.740 (Normalized)

Location (X, Z): (90.21 m, 1.85 m)

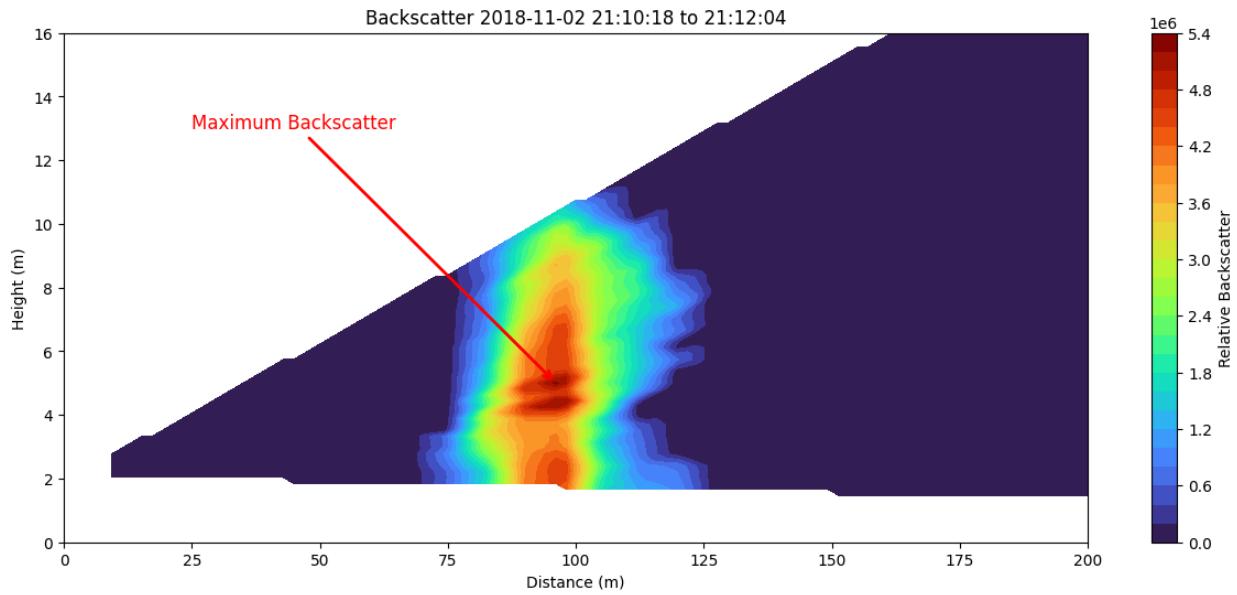
The calculated plume area is: 105.93 square meters.



Maximum Backscatter Value: 5273209.611 (Normalized)

Location (X, Z): (96.12 m, 5.00 m)

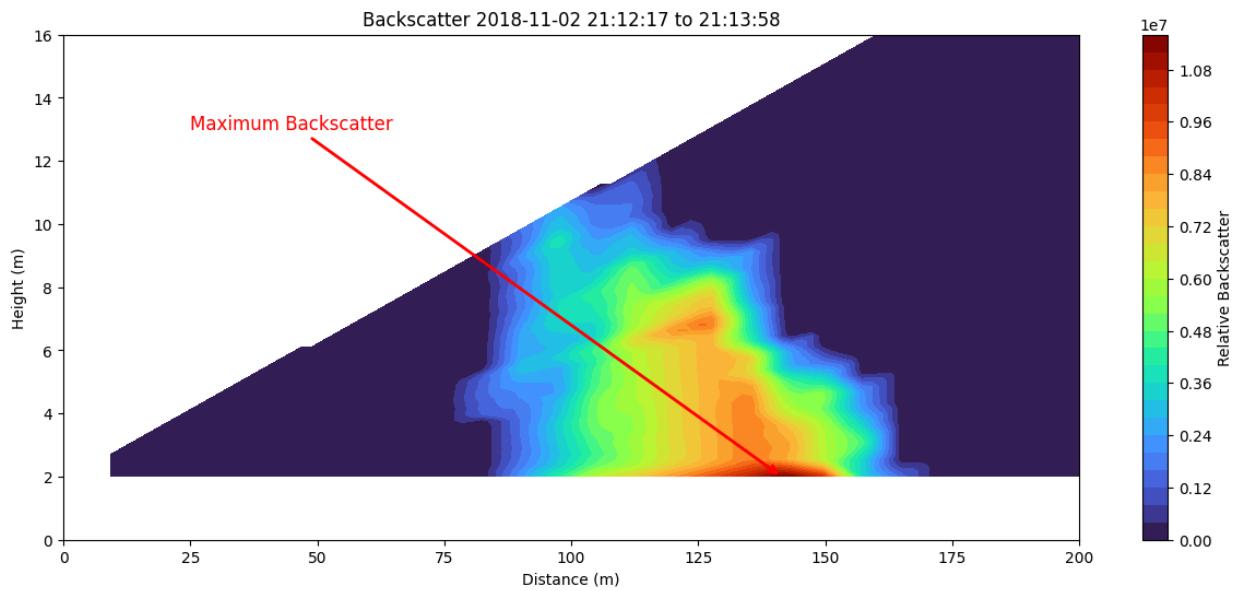
The calculated plume area is: 339.33 square meters.



Maximum Backscatter Value: 11532665.655 (Normalized)

Location (X, Z): (141.43 m, 2.00 m)

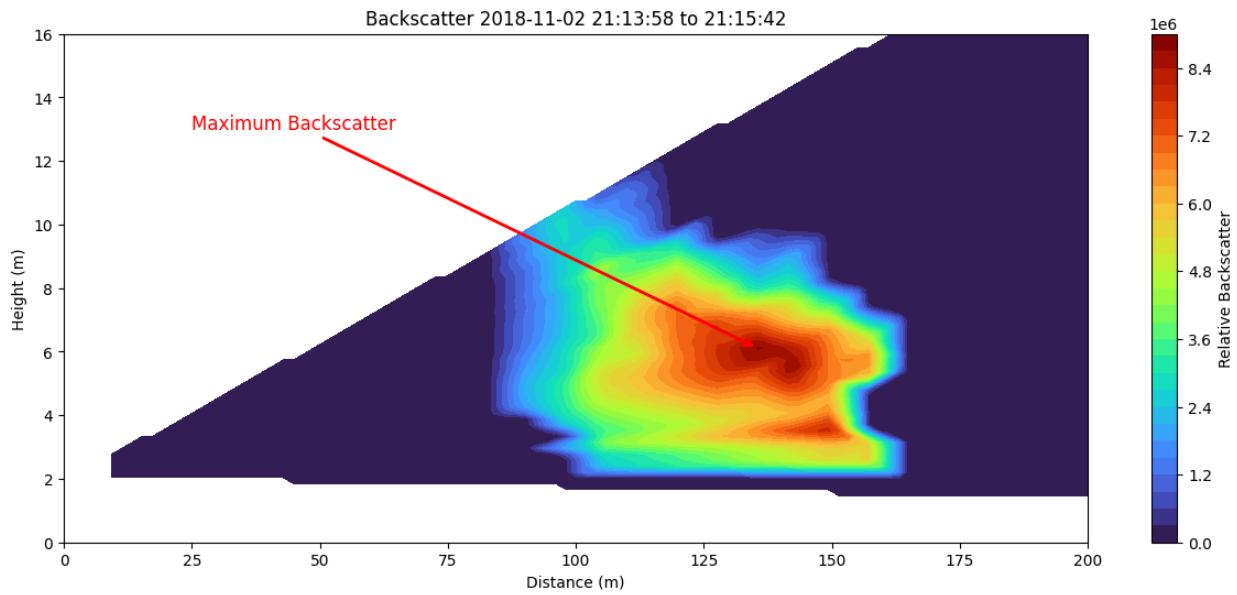
The calculated plume area is: 525.04 square meters.



Maximum Backscatter Value: 8718566.350 (Normalized)

Location (X, Z): (135.52 m, 6.11 m)

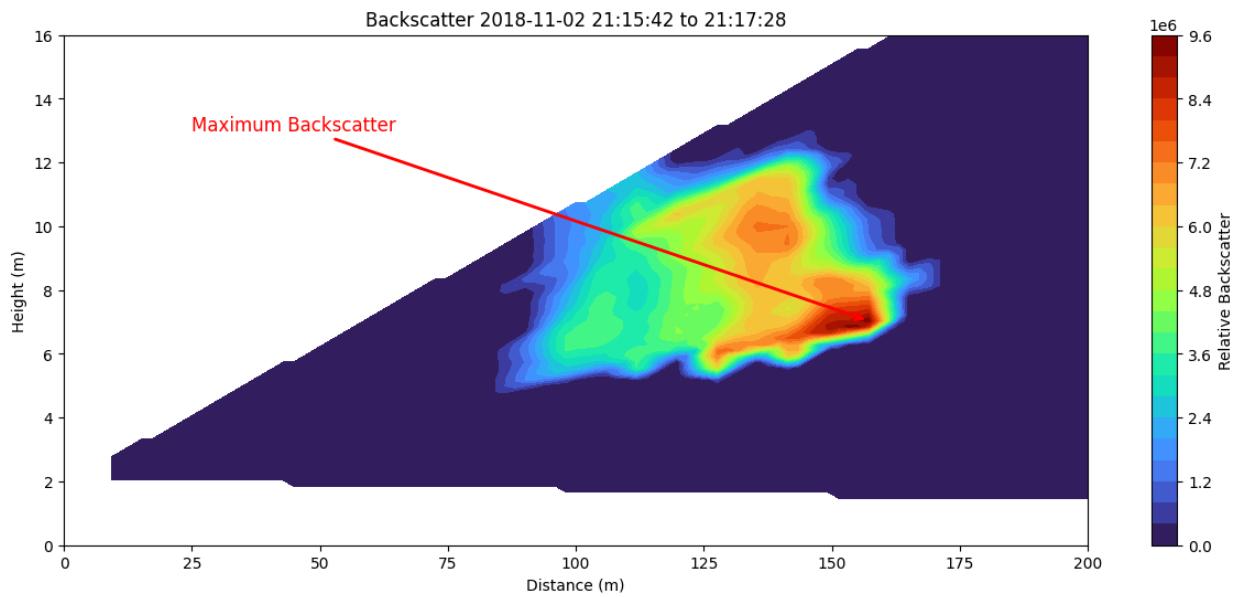
The calculated plume area is: 542.78 square meters.



Maximum Backscatter Value: 9468453.214 (Normalized)

Location (X, Z): (157.19 m, 7.04 m)

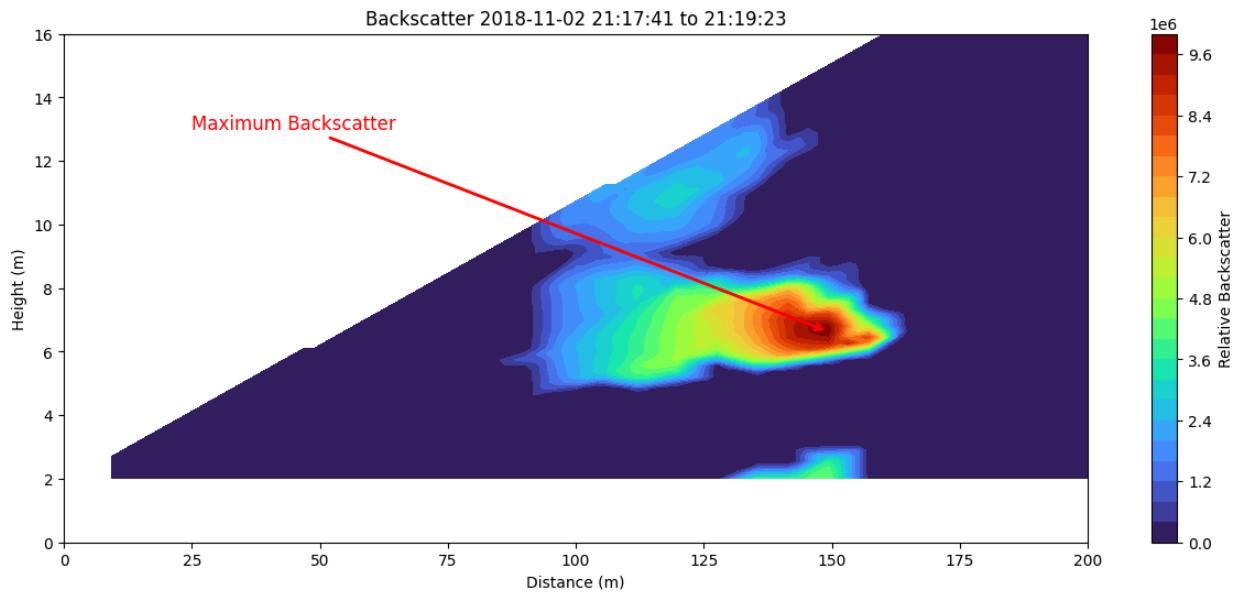
The calculated plume area is: 414.94 square meters.



Maximum Backscatter Value: 9911857.832 (Normalized)

Location (X, Z): (149.31 m, 6.64 m)

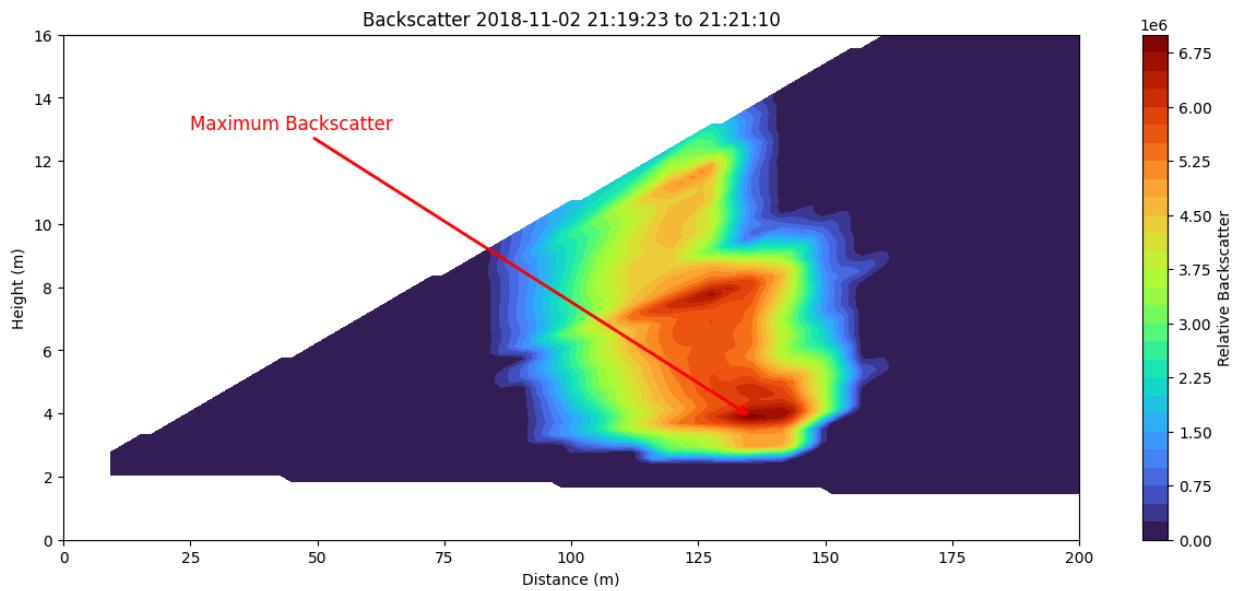
The calculated plume area is: 344.52 square meters.



Maximum Backscatter Value: 6930358.170 (Normalized)

Location (X, Z): (135.52 m, 3.89 m)

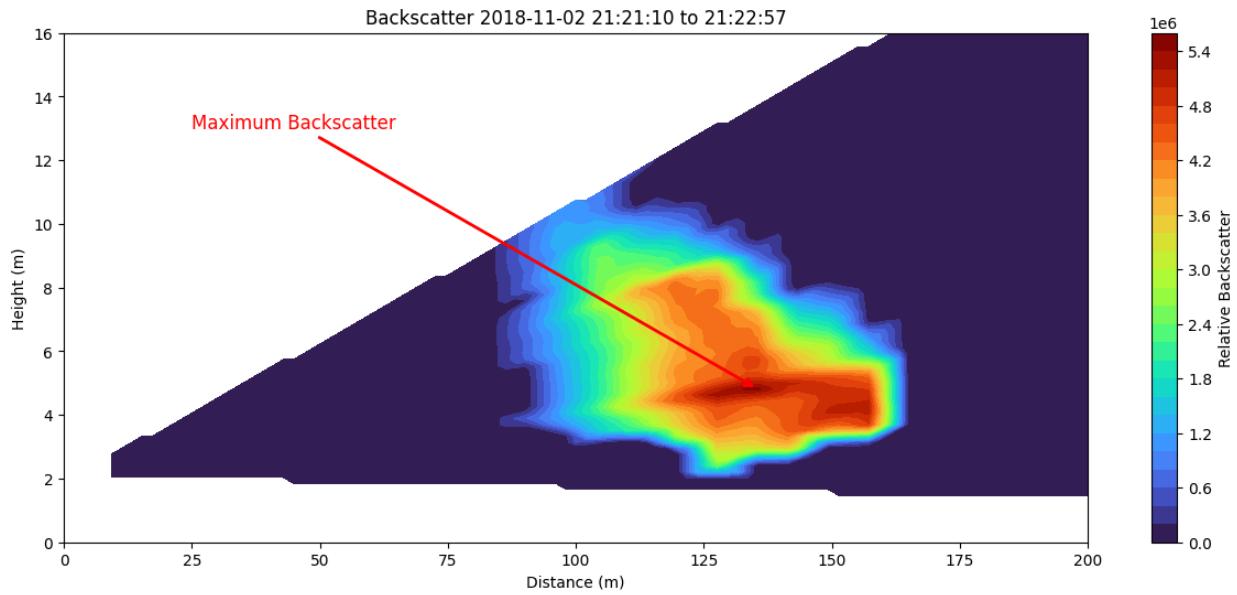
The calculated plume area is: 557.75 square meters.



Maximum Backscatter Value: 5461410.997 (Normalized)

Location (X, Z): (135.52 m, 4.82 m)

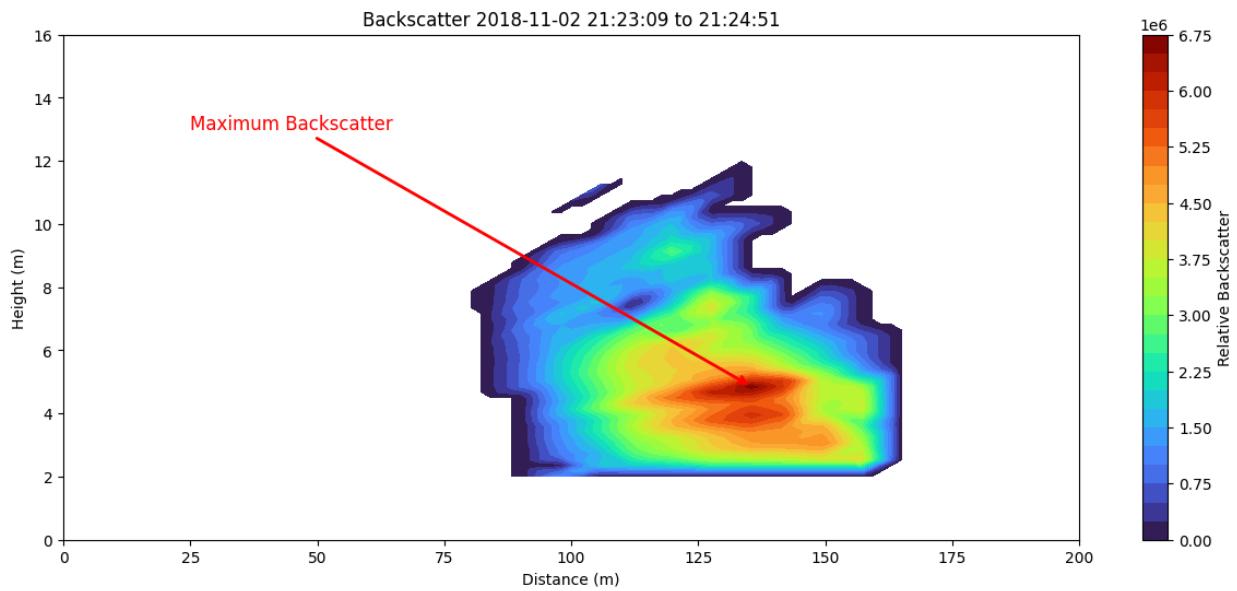
The calculated plume area is: 464.61 square meters.



Maximum Backscatter Value: 6647340.827 (Normalized)

Location (X, Z): (135.52 m, 4.85 m)

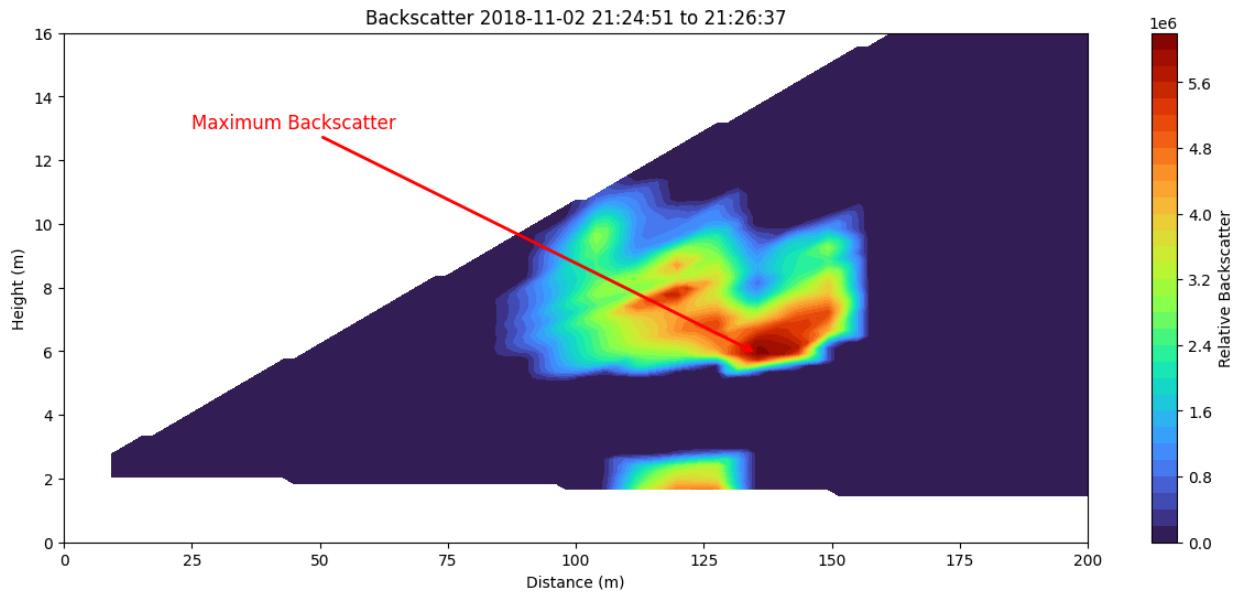
The calculated plume area is: 481.14 square meters.



Maximum Backscatter Value: 6015318.660 (Normalized)

Location (X, Z): (135.52 m, 5.93 m)

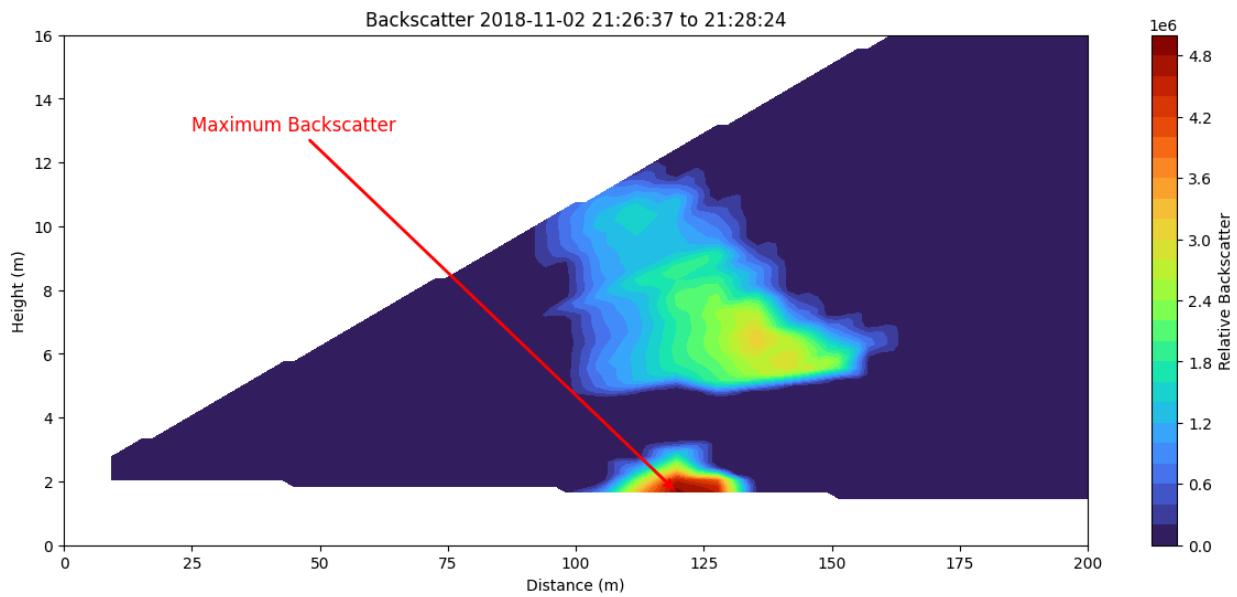
The calculated plume area is: 342.61 square meters.



Maximum Backscatter Value: 4832155.045 (Normalized)

Location (X, Z): (119.76 m, 1.66 m)

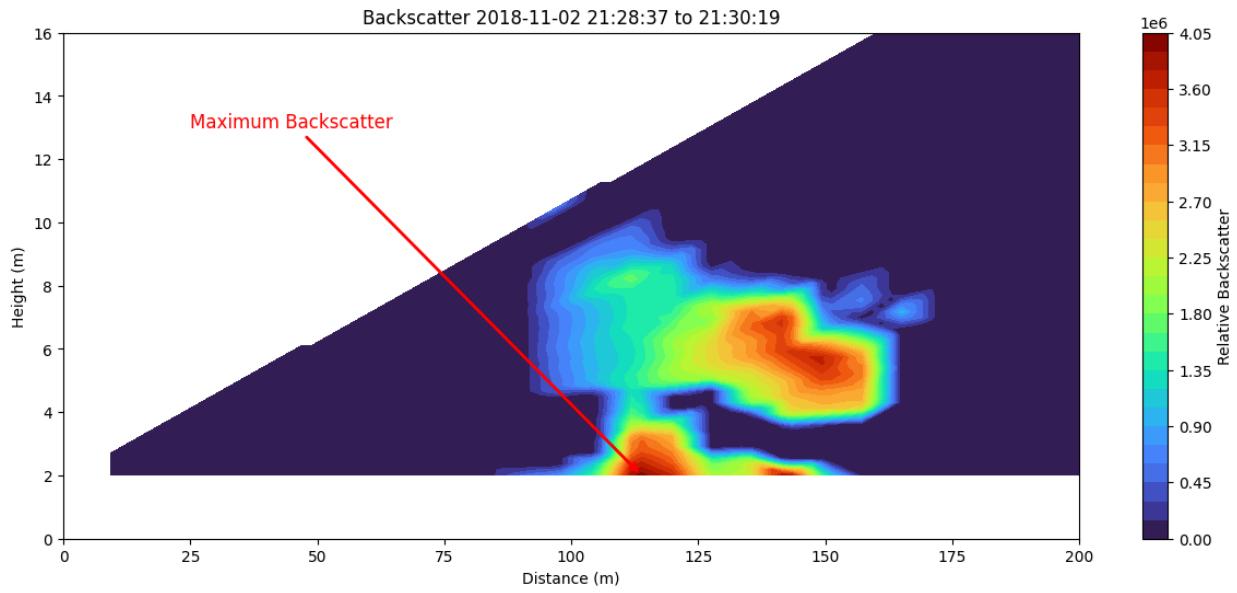
The calculated plume area is: 297.69 square meters.



Maximum Backscatter Value: 3971590.468 (Normalized)

Location (X, Z): (113.85 m, 2.00 m)

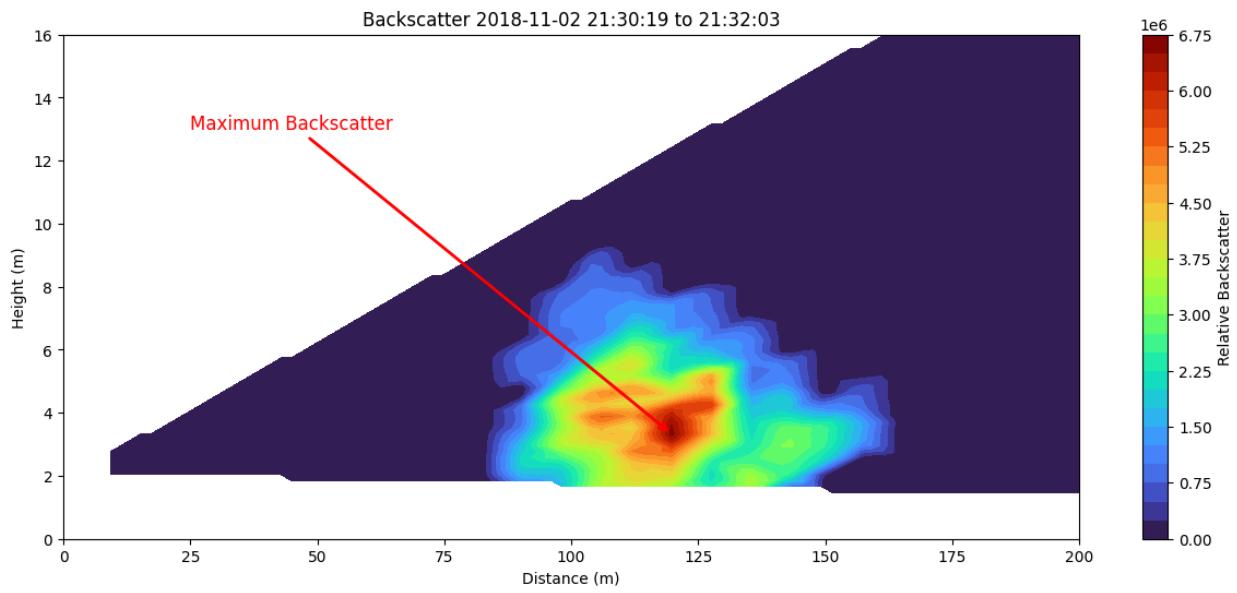
The calculated plume area is: 375.08 square meters.



Maximum Backscatter Value: 6613718.291 (Normalized)

Location (X, Z): (119.76 m, 3.33 m)

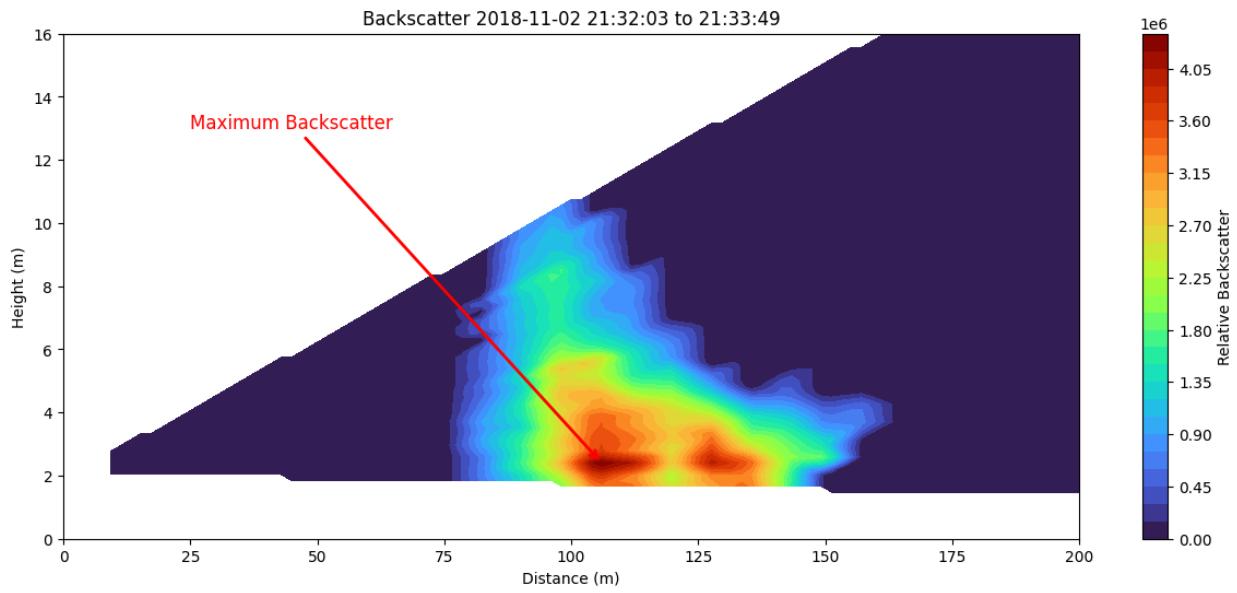
The calculated plume area is: 363.80 square meters.



Maximum Backscatter Value: 4308294.002 (Normalized)

Location (X, Z): (105.97 m, 2.41 m)

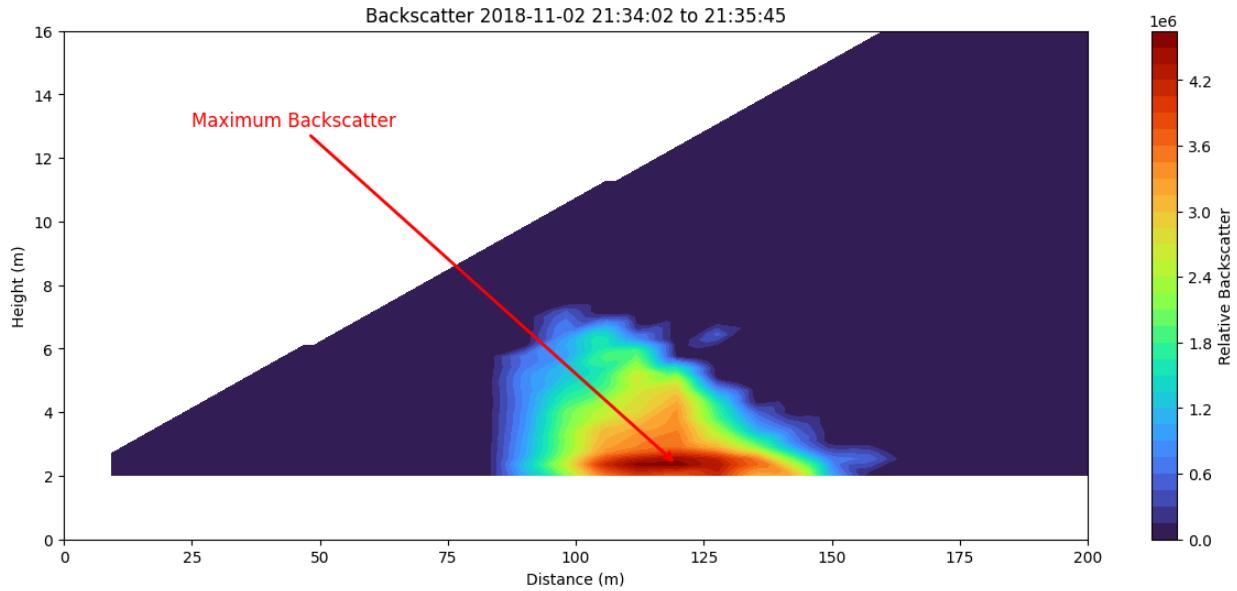
The calculated plume area is: 410.19 square meters.



Maximum Backscatter Value: 4599455.504 (Normalized)

Location (X, Z): (119.76 m, 2.36 m)

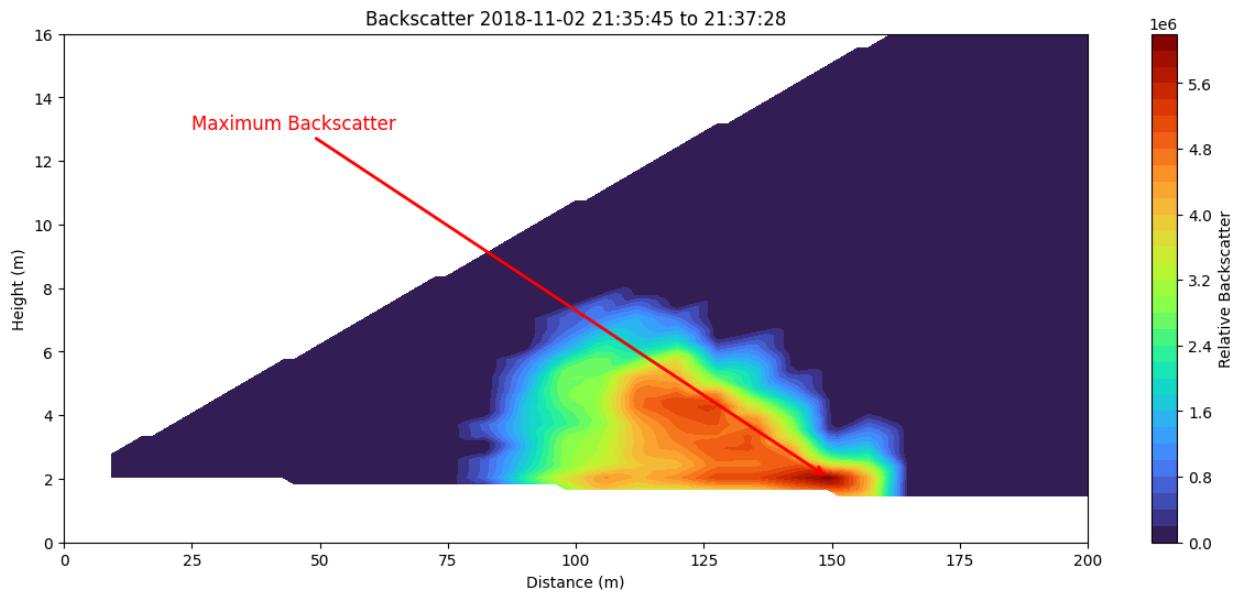
The calculated plume area is: 226.17 square meters.



Maximum Backscatter Value: 6101252.397 (Normalized)

Location (X, Z): (149.31 m, 2.03 m)

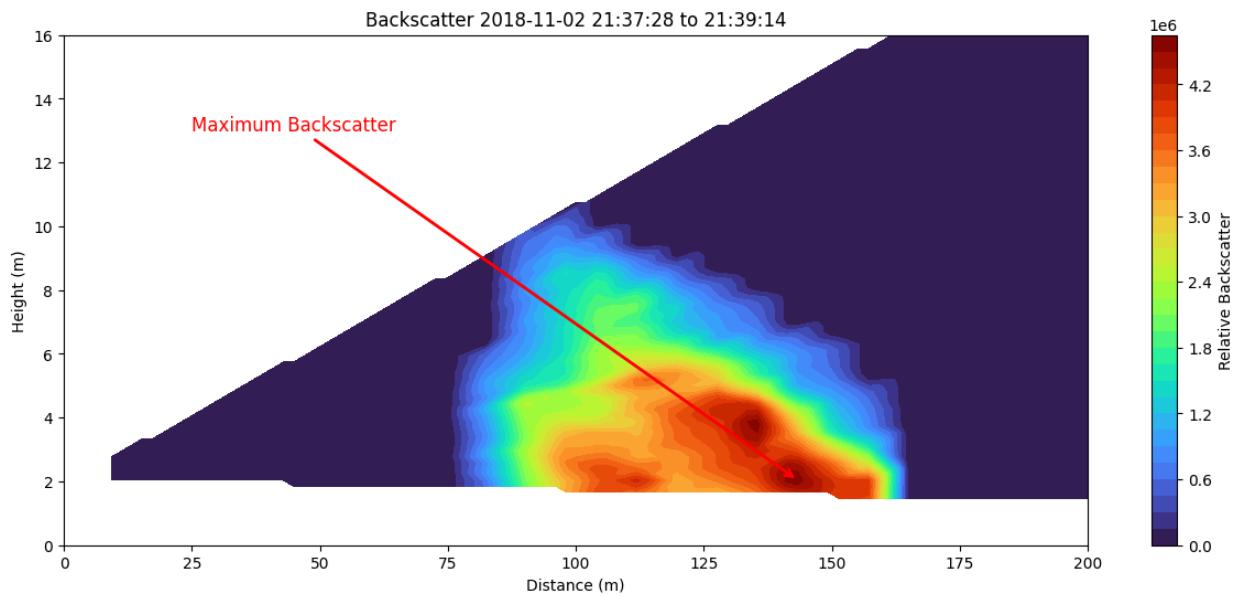
The calculated plume area is: 344.44 square meters.



Maximum Backscatter Value: 4583064.642 (Normalized)

Location (X, Z): (143.40 m, 2.03 m)

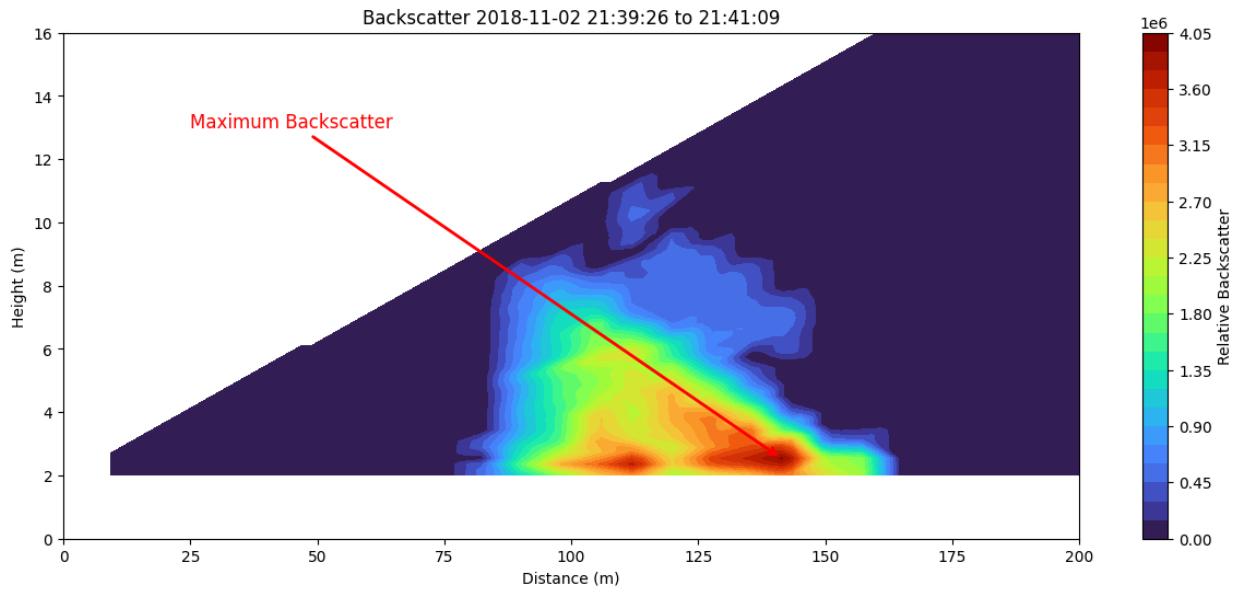
The calculated plume area is: 514.65 square meters.



Maximum Backscatter Value: 3926971.744 (Normalized)

Location (X, Z): (141.43 m, 2.53 m)

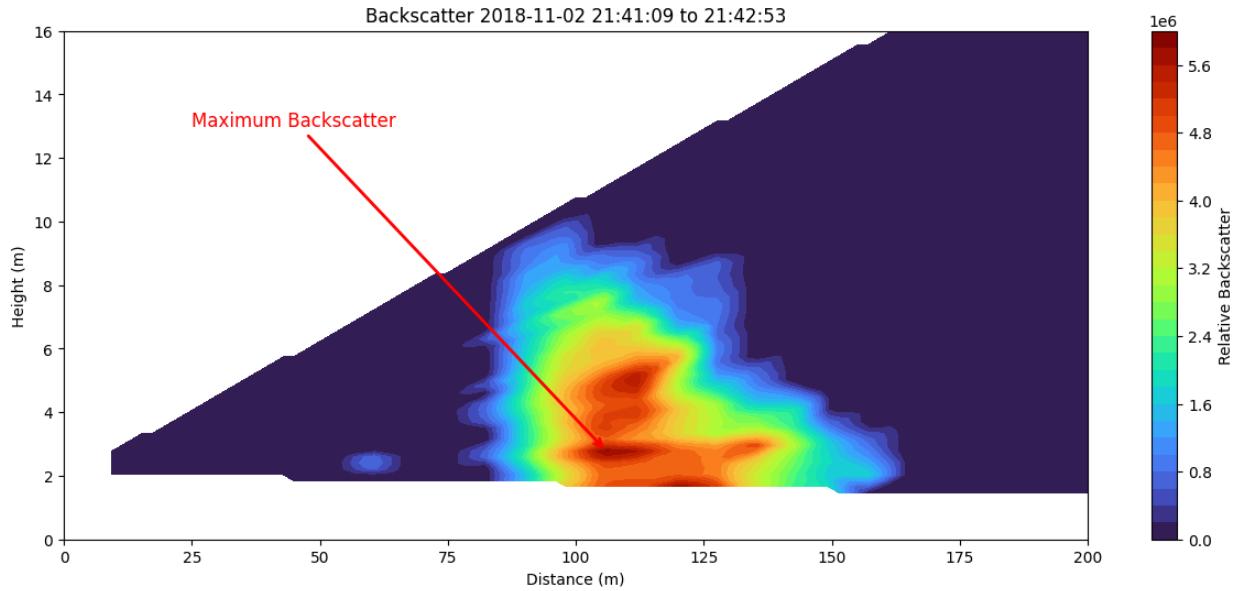
The calculated plume area is: 405.63 square meters.



Maximum Backscatter Value: 5811532.422 (Normalized)

Location (X, Z): (105.97 m, 2.78 m)

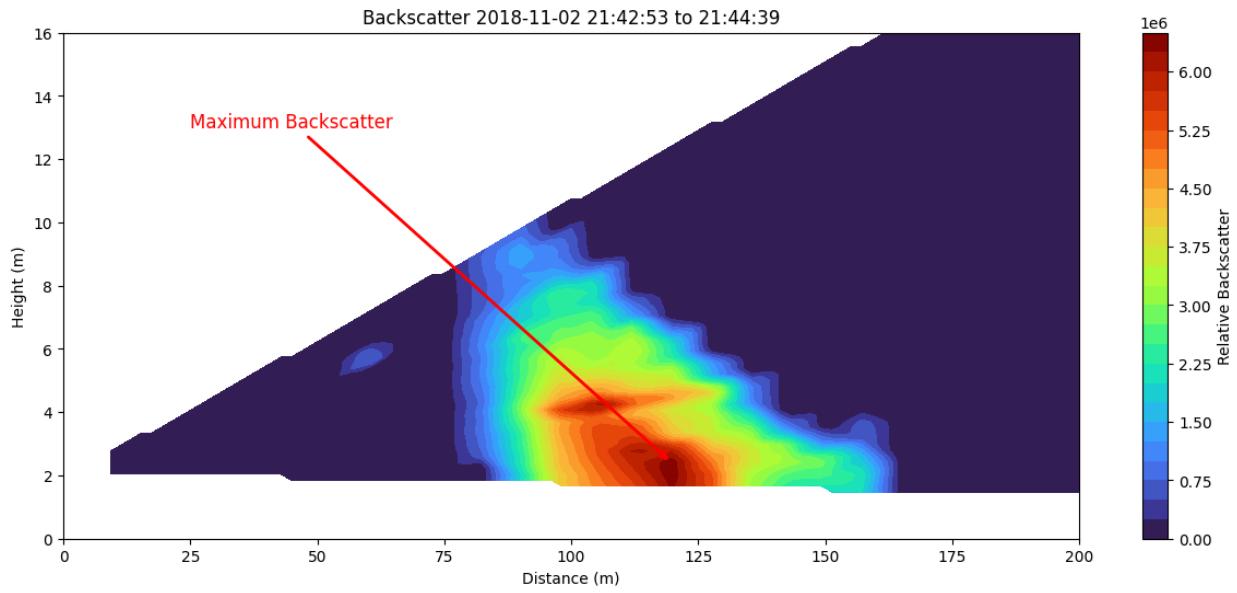
The calculated plume area is: 424.80 square meters.



Maximum Backscatter Value: 6428378.686 (Normalized)

Location (X, Z): (119.76 m, 2.41 m)

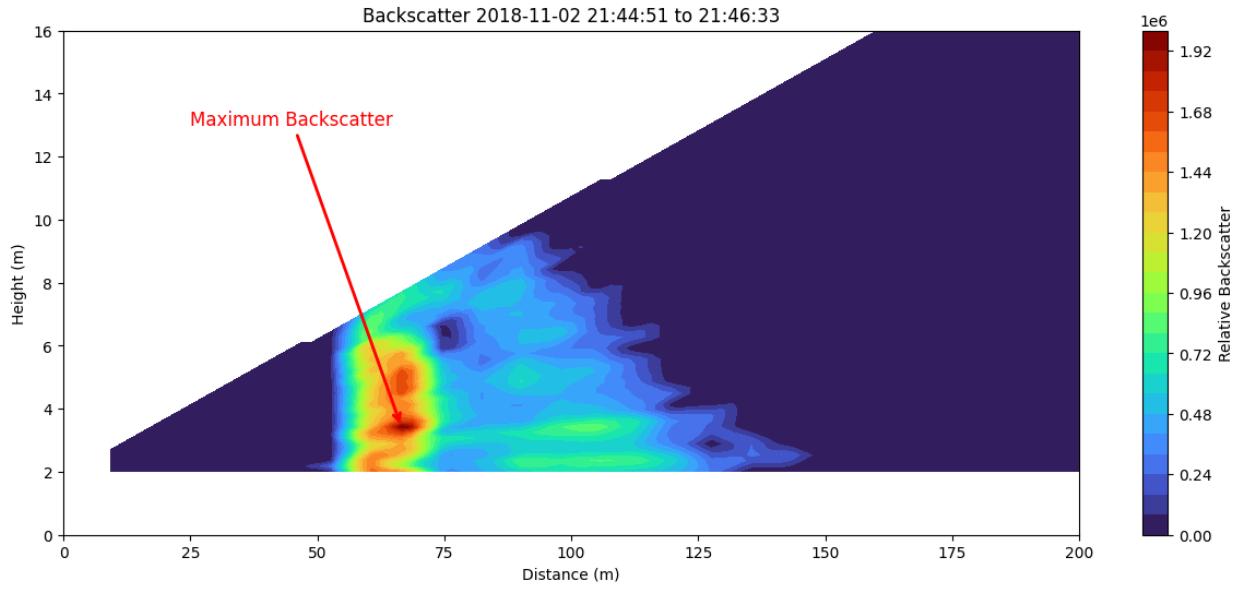
The calculated plume area is: 403.25 square meters.



Maximum Backscatter Value: 1980421.139 (Normalized)

Location (X, Z): (66.57 m, 3.43 m)

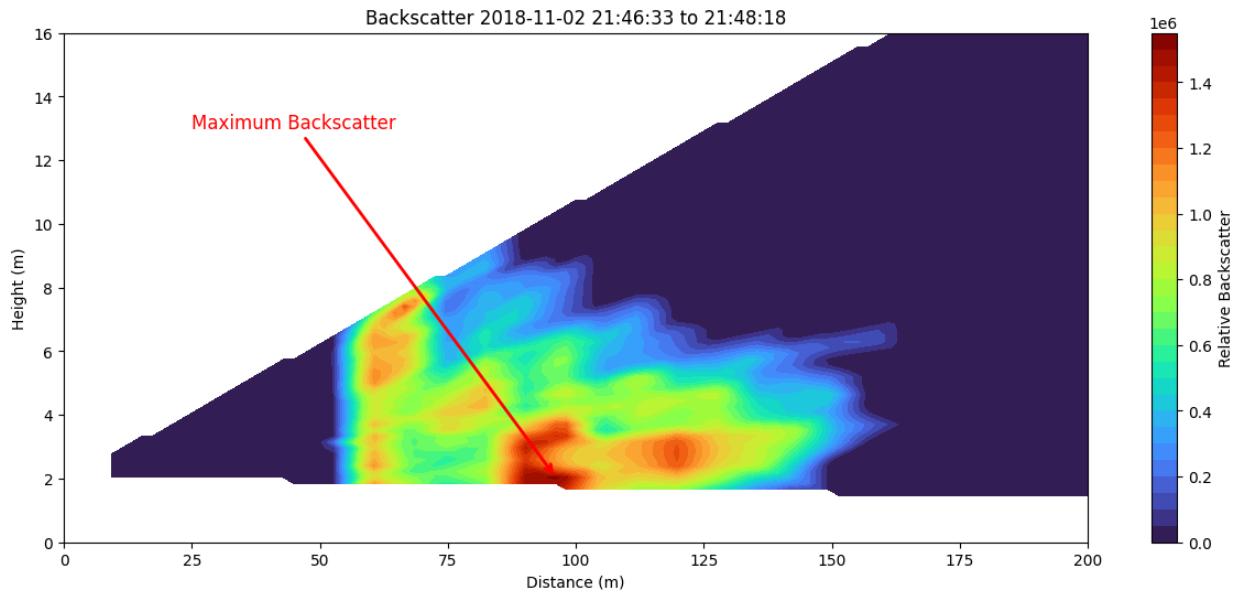
The calculated plume area is: 395.09 square meters.



Maximum Backscatter Value: 1510112.507 (Normalized)

Location (X, Z): (96.12 m, 2.03 m)

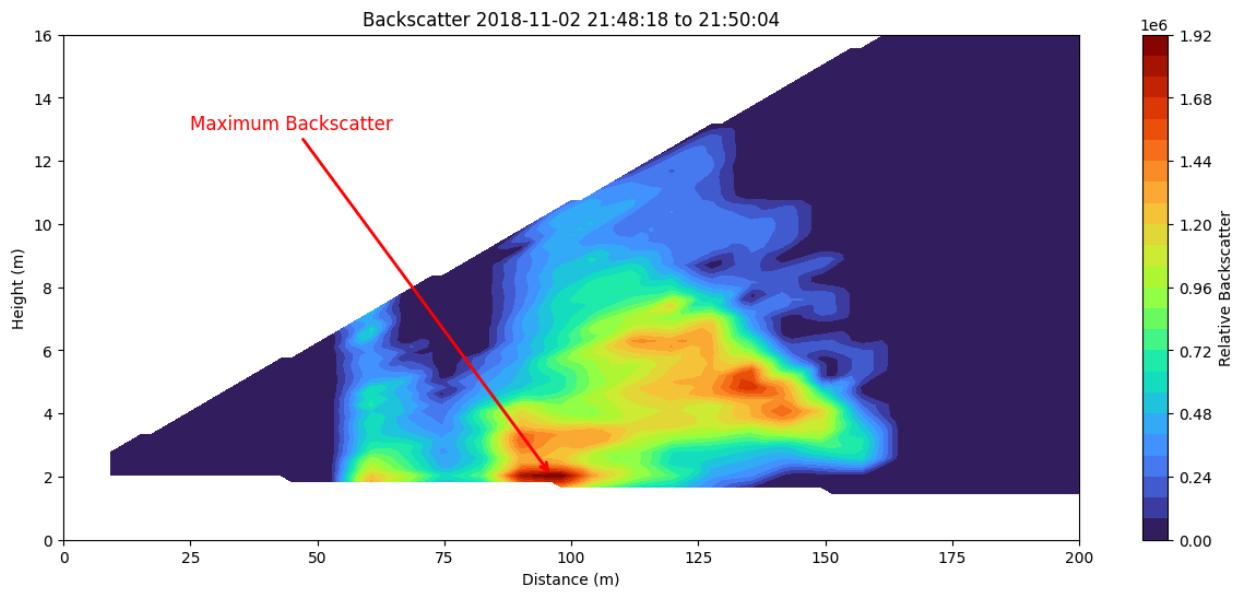
The calculated plume area is: 557.75 square meters.



Maximum Backscatter Value: 1911468.479 (Normalized)

Location (X, Z): (96.12 m, 2.03 m)

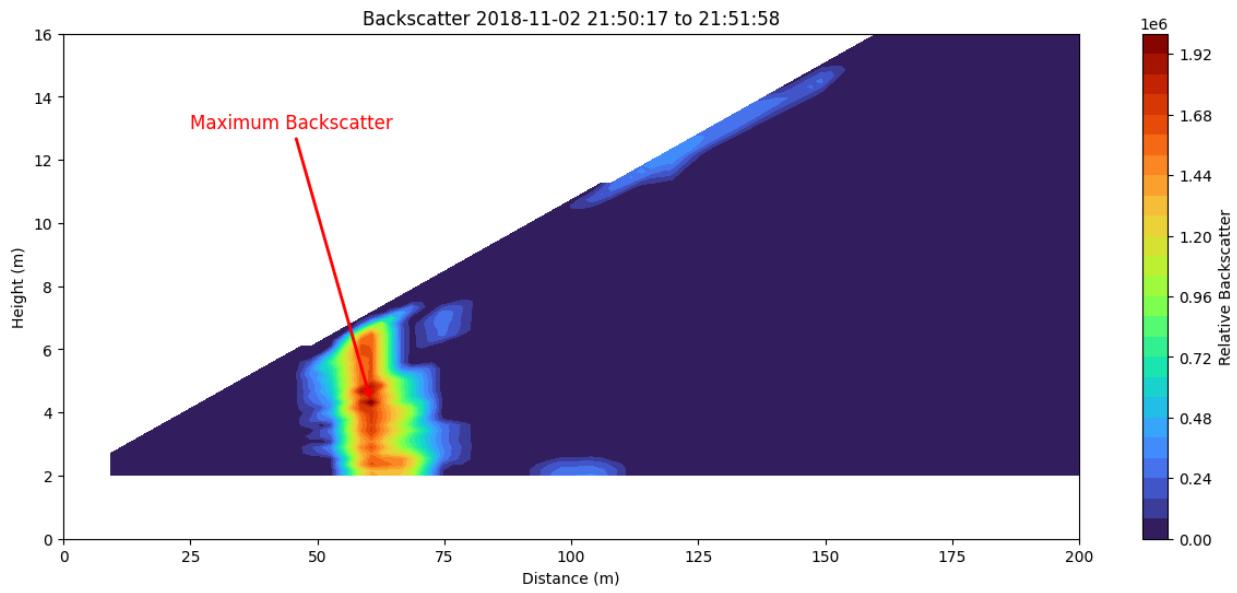
The calculated plume area is: 702.40 square meters.



Maximum Backscatter Value: 1987425.956 (Normalized)

Location (X, Z): (60.66 m, 4.32 m)

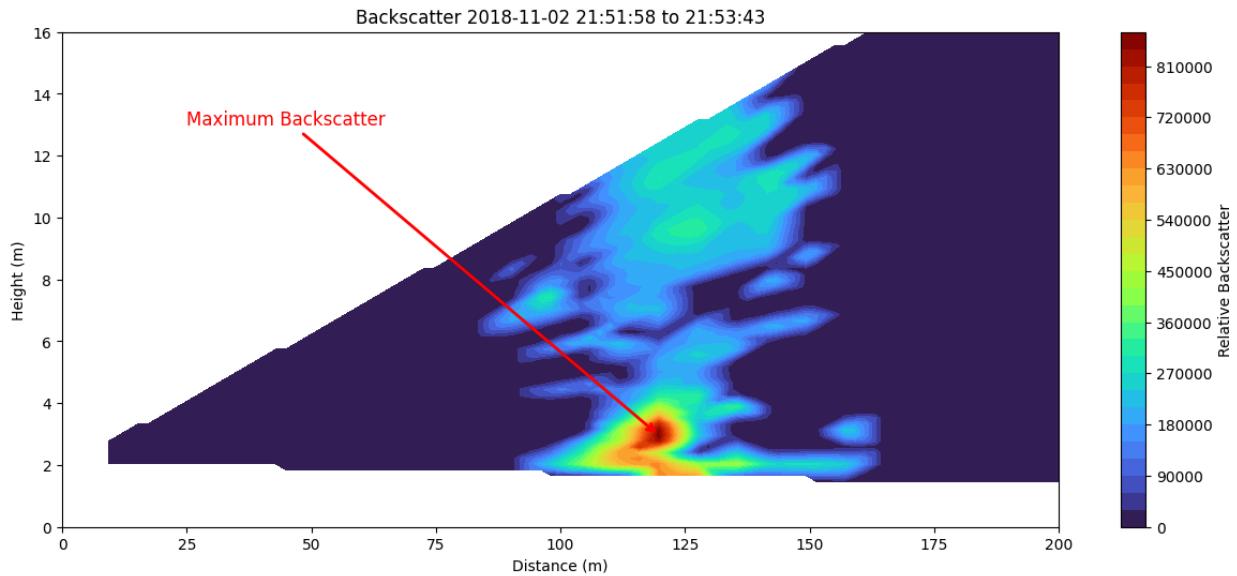
The calculated plume area is: 140.13 square meters.



Maximum Backscatter Value: 856511.484 (Normalized)

Location (X, Z): (119.76 m, 2.96 m)

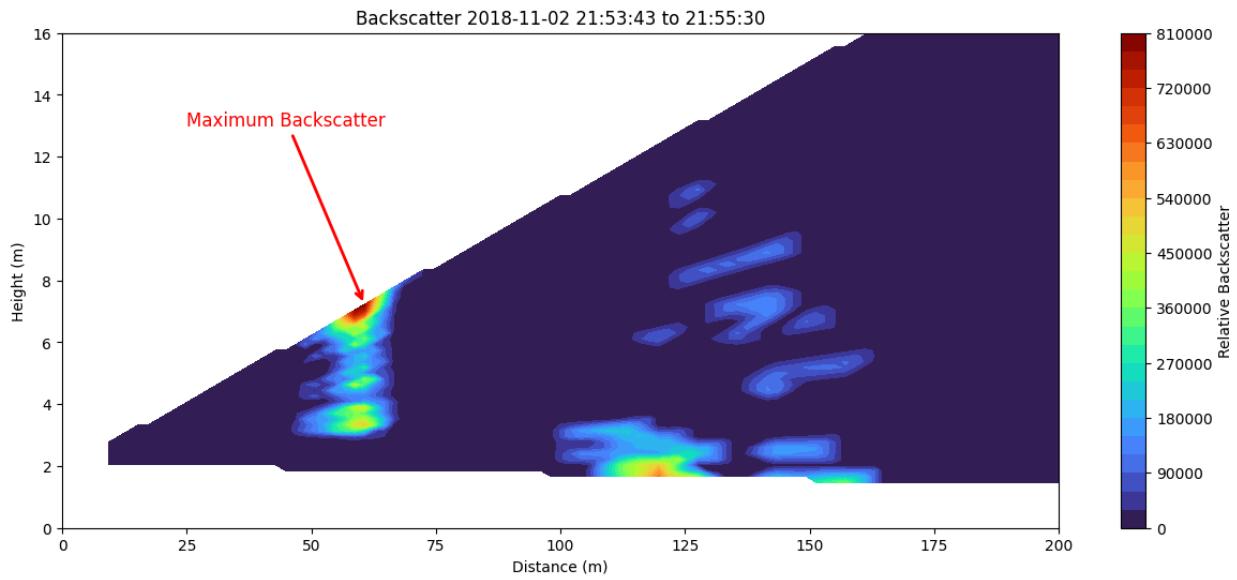
The calculated plume area is: 428.45 square meters.



Maximum Backscatter Value: 795276.958 (Normalized)

Location (X, Z): (60.66 m, 7.23 m)

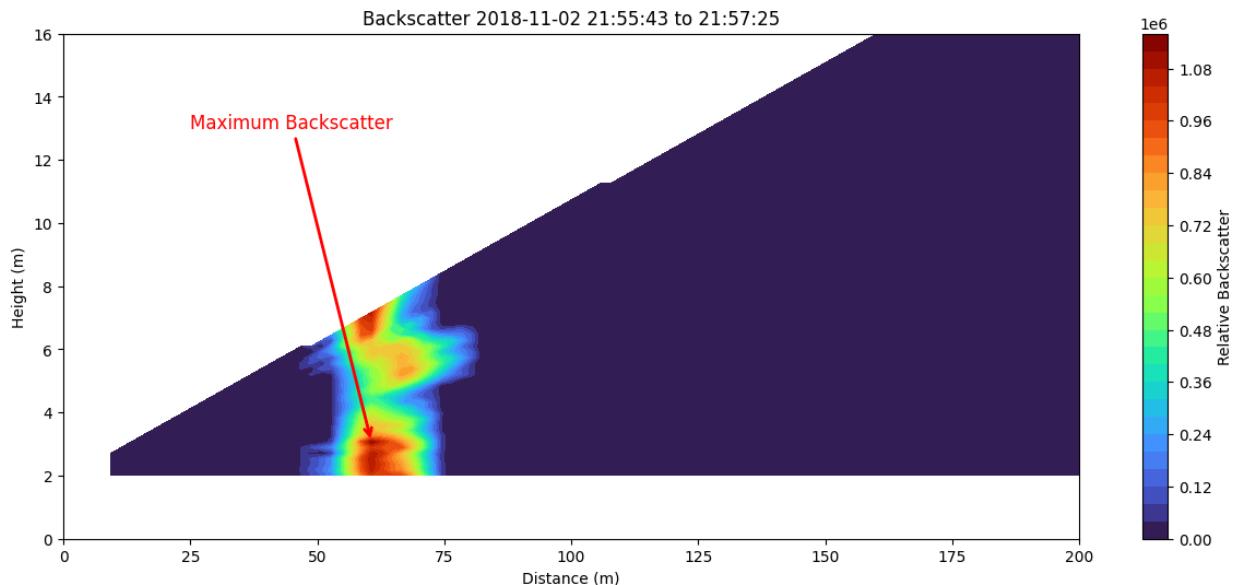
The calculated plume area is: 139.16 square meters.



Maximum Backscatter Value: 1122096.417 (Normalized)

Location (X, Z): (60.66 m, 3.07 m)

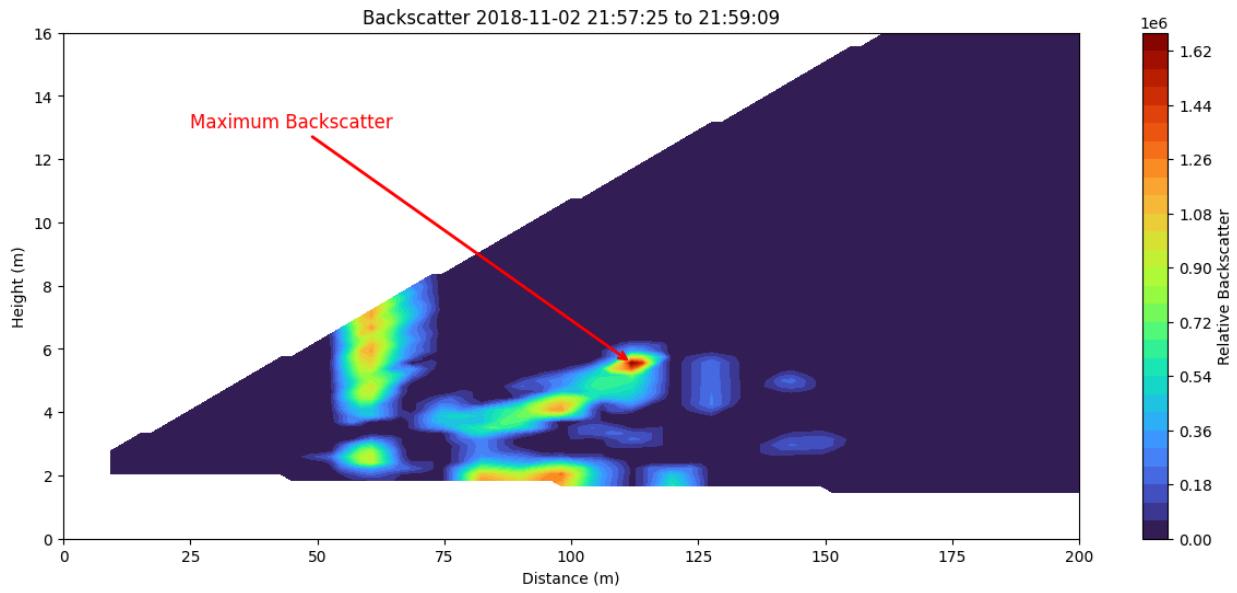
The calculated plume area is: 124.67 square meters.



Maximum Backscatter Value: 1629320.182 (Normalized)

Location (X, Z): (111.88 m, 5.56 m)

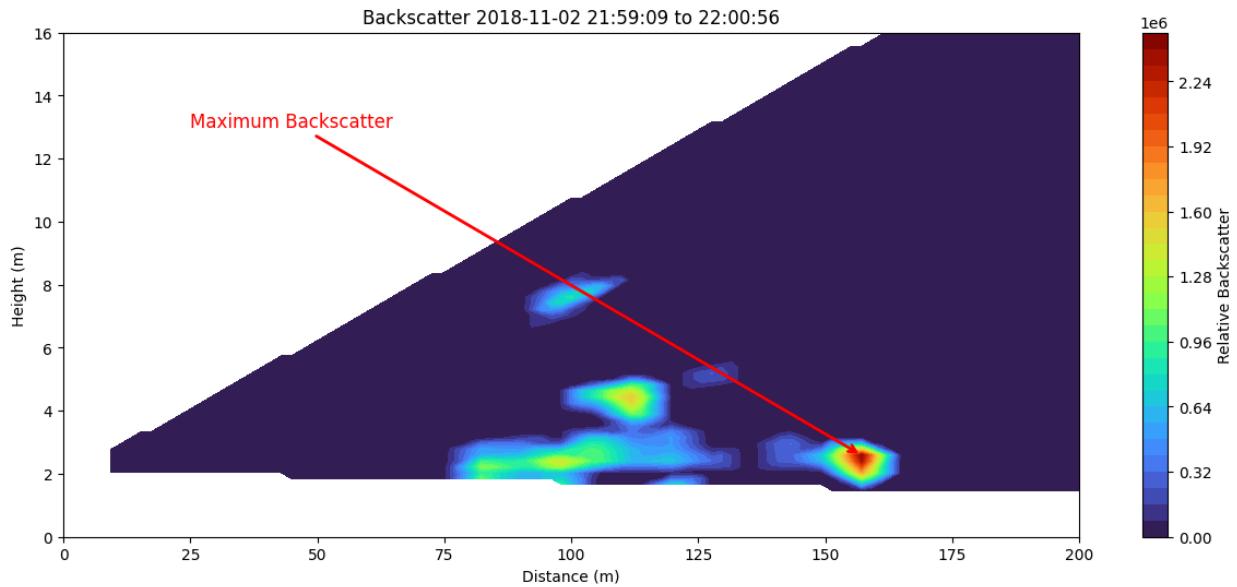
The calculated plume area is: 188.11 square meters.



Maximum Backscatter Value: 2400960.911 (Normalized)

Location (X, Z): (157.19 m, 2.59 m)

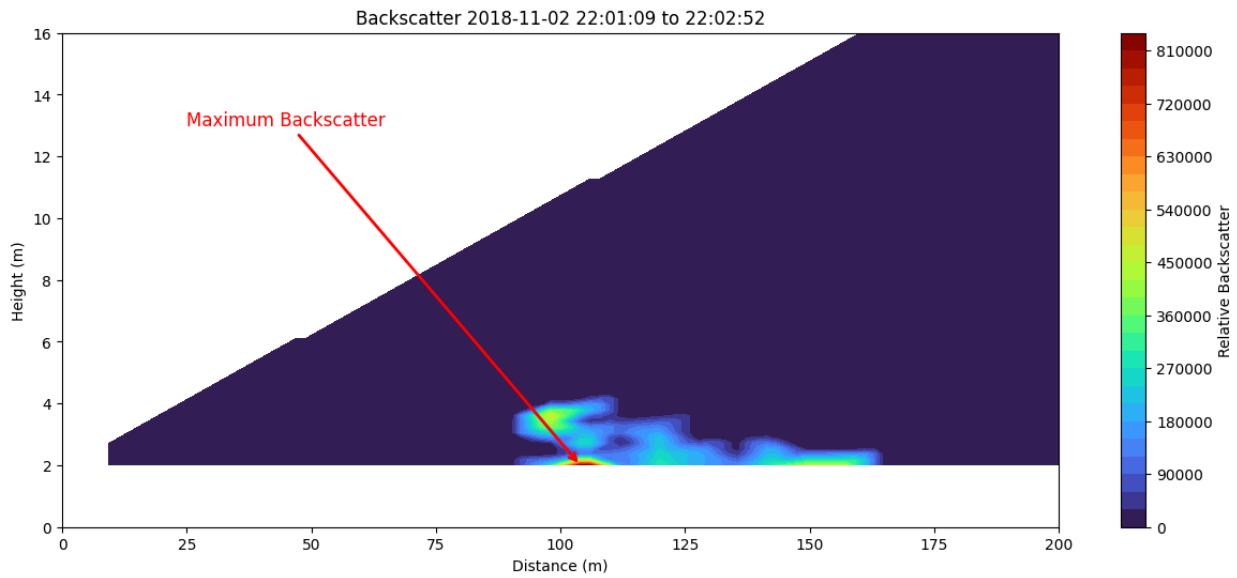
The calculated plume area is: 119.81 square meters.



Maximum Backscatter Value: 820640.287 (Normalized)

Location (X, Z): (104.00 m, 2.00 m)

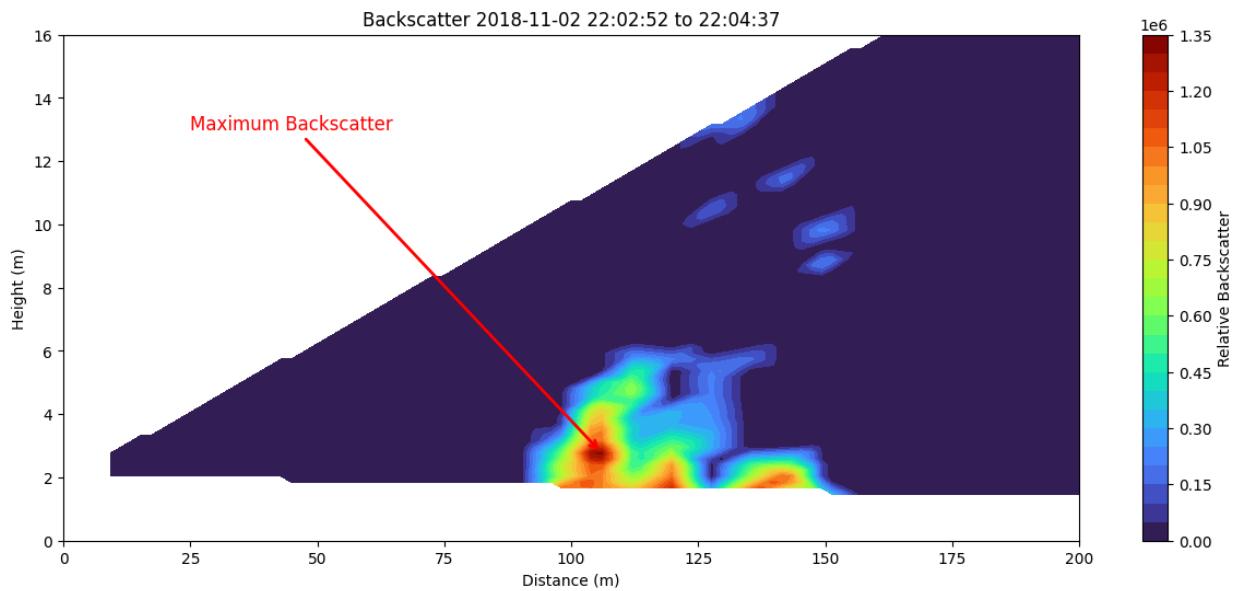
The calculated plume area is: 73.75 square meters.



Maximum Backscatter Value: 1314014.698 (Normalized)

Location (X, Z): (105.97 m, 2.78 m)

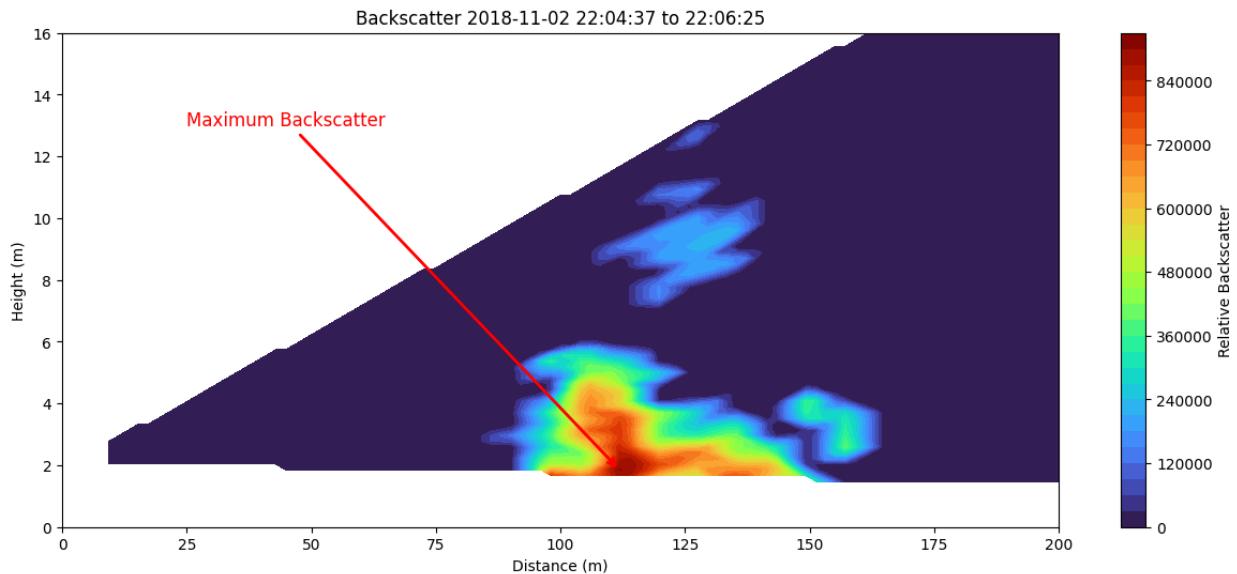
The calculated plume area is: 168.39 square meters.



Maximum Backscatter Value: 902090.598 (Normalized)

Location (X, Z): (111.88 m, 1.85 m)

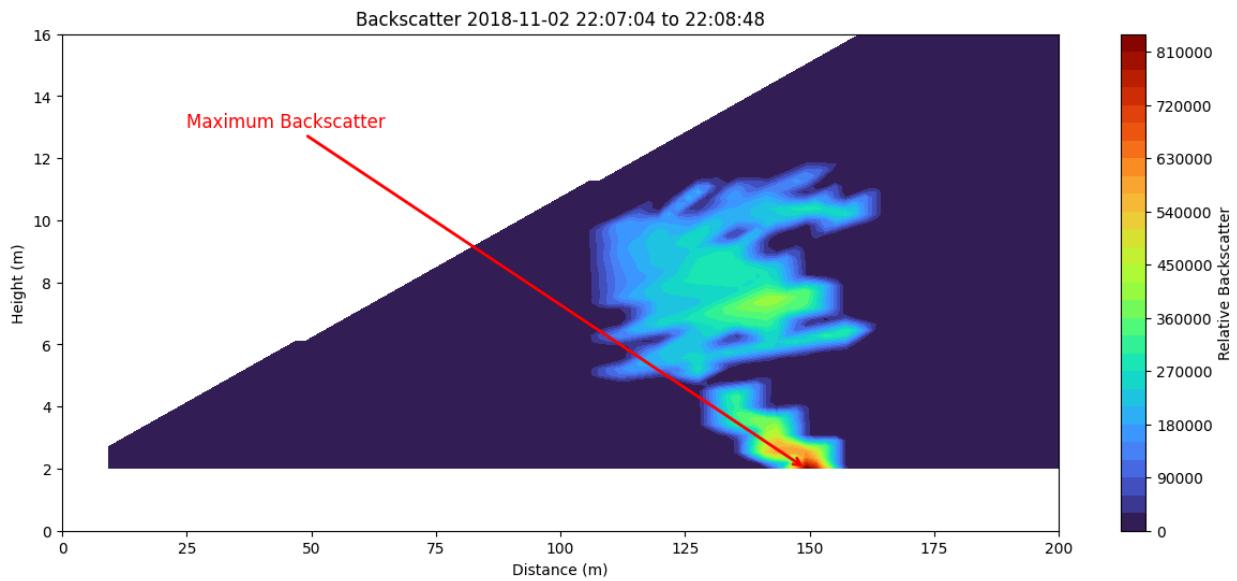
The calculated plume area is: 247.65 square meters.



Maximum Backscatter Value: 837928.245 (Normalized)

Location (X, Z): (149.31 m, 2.00 m)

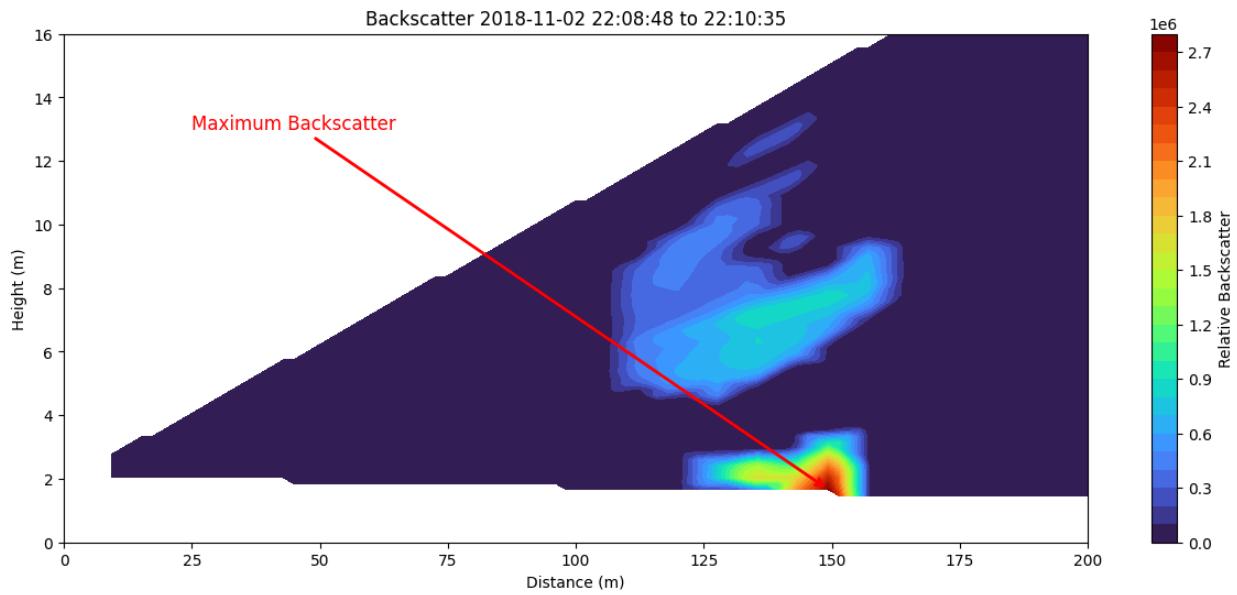
The calculated plume area is: 273.58 square meters.



Maximum Backscatter Value: 2728825.993 (Normalized)

Location (X, Z): (149.31 m, 1.66 m)

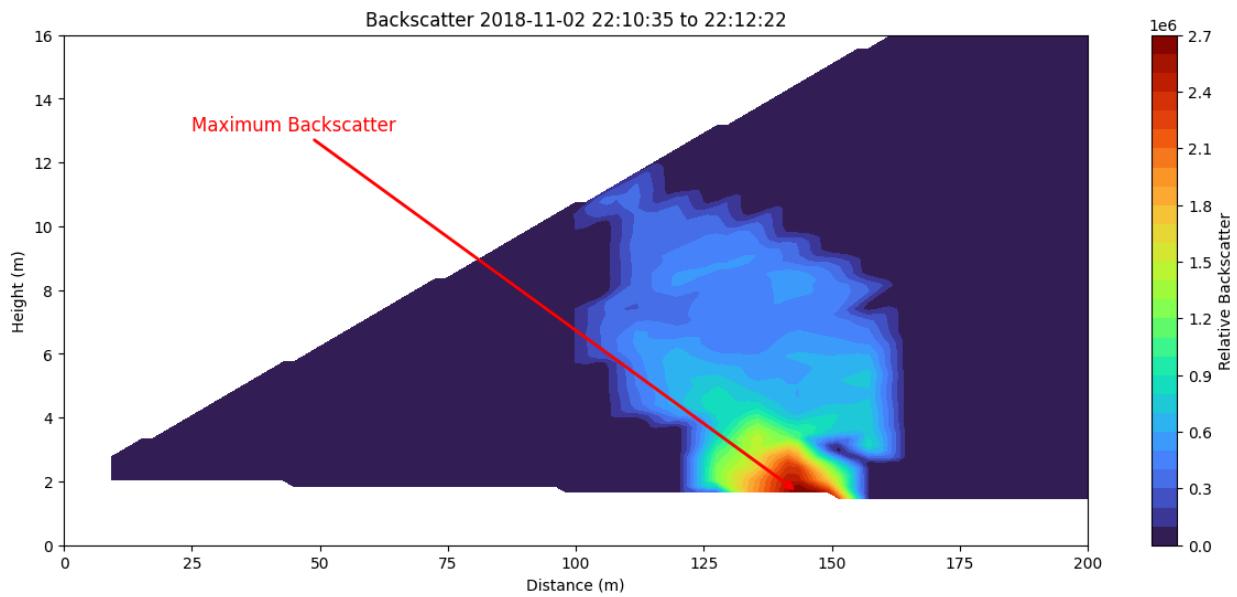
The calculated plume area is: 237.78 square meters.



Maximum Backscatter Value: 2686483.585 (Normalized)

Location (X, Z): (143.40 m, 1.66 m)

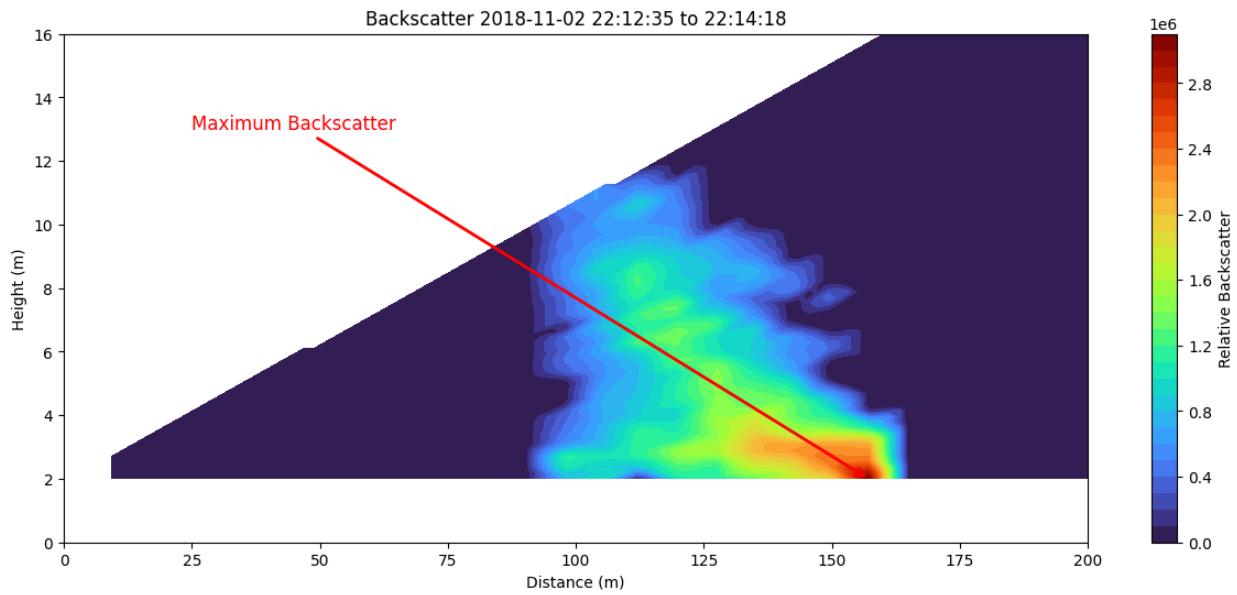
The calculated plume area is: 391.19 square meters.



Maximum Backscatter Value: 3084484.688 (Normalized)

Location (X, Z): (157.19 m, 2.00 m)

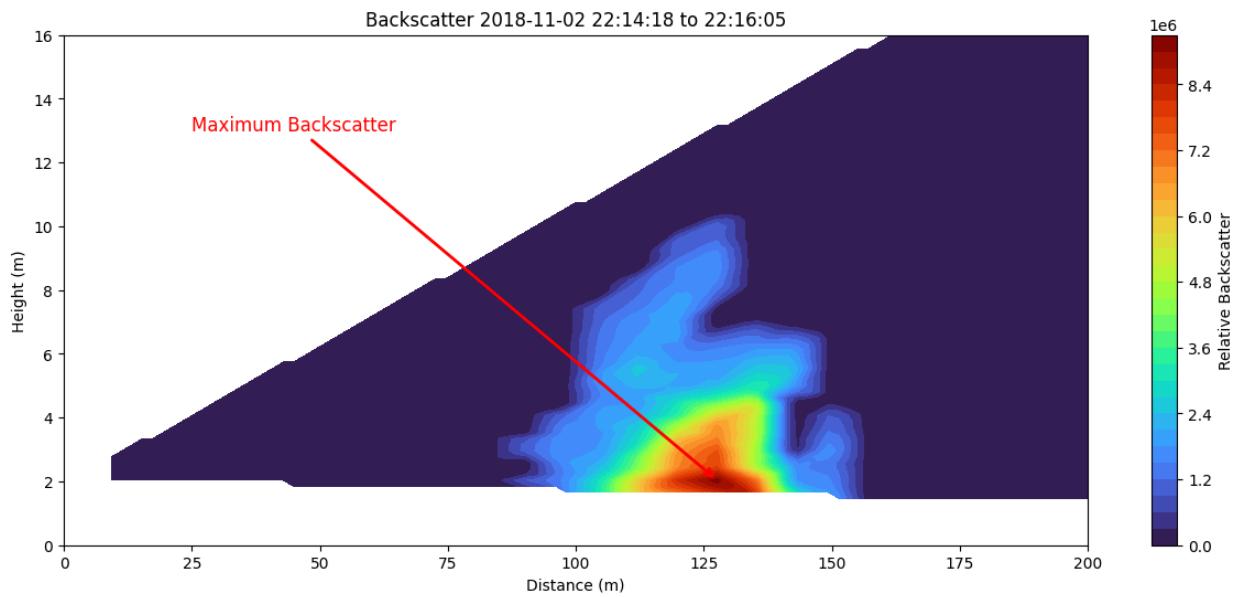
The calculated plume area is: 461.47 square meters.



Maximum Backscatter Value: 9174499.302 (Normalized)

Location (X, Z): (127.64 m, 2.03 m)

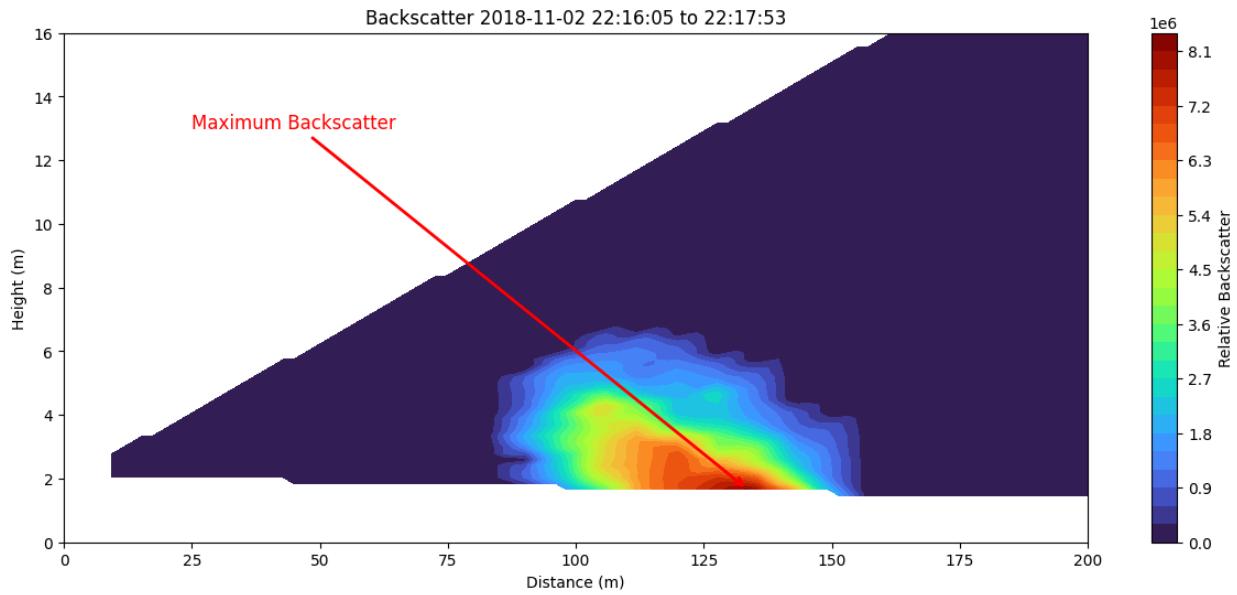
The calculated plume area is: 306.09 square meters.



Maximum Backscatter Value: 8126653.230 (Normalized)

Location (X, Z): (133.55 m, 1.66 m)

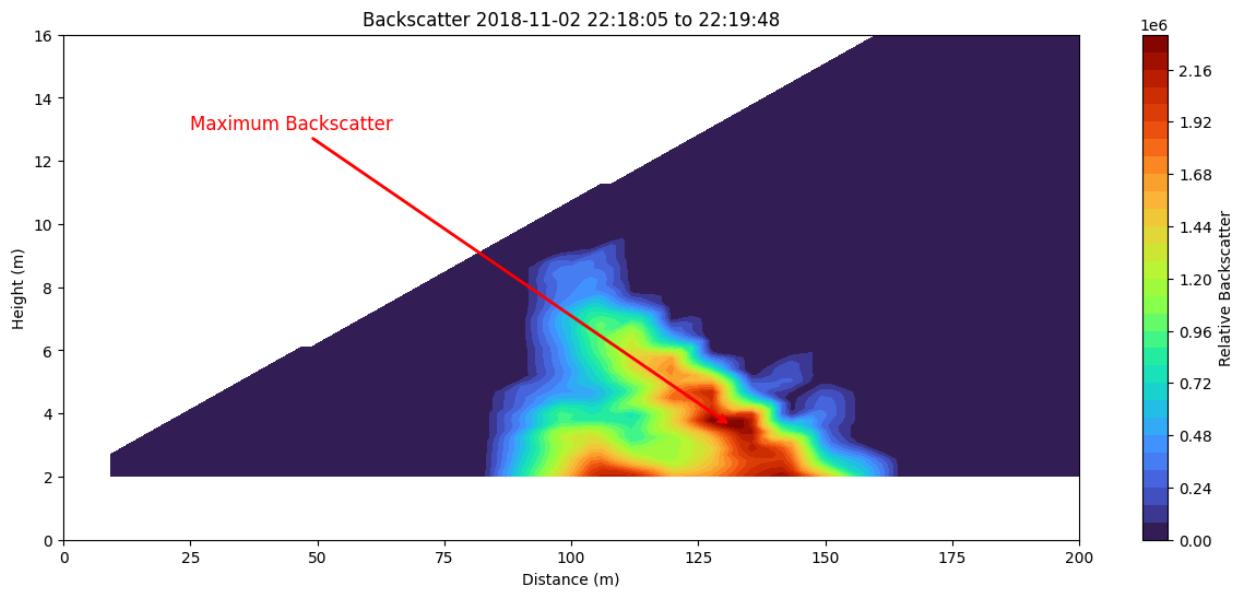
The calculated plume area is: 245.09 square meters.



Maximum Backscatter Value: 2282479.784 (Normalized)

Location (X, Z): (131.58 m, 3.60 m)

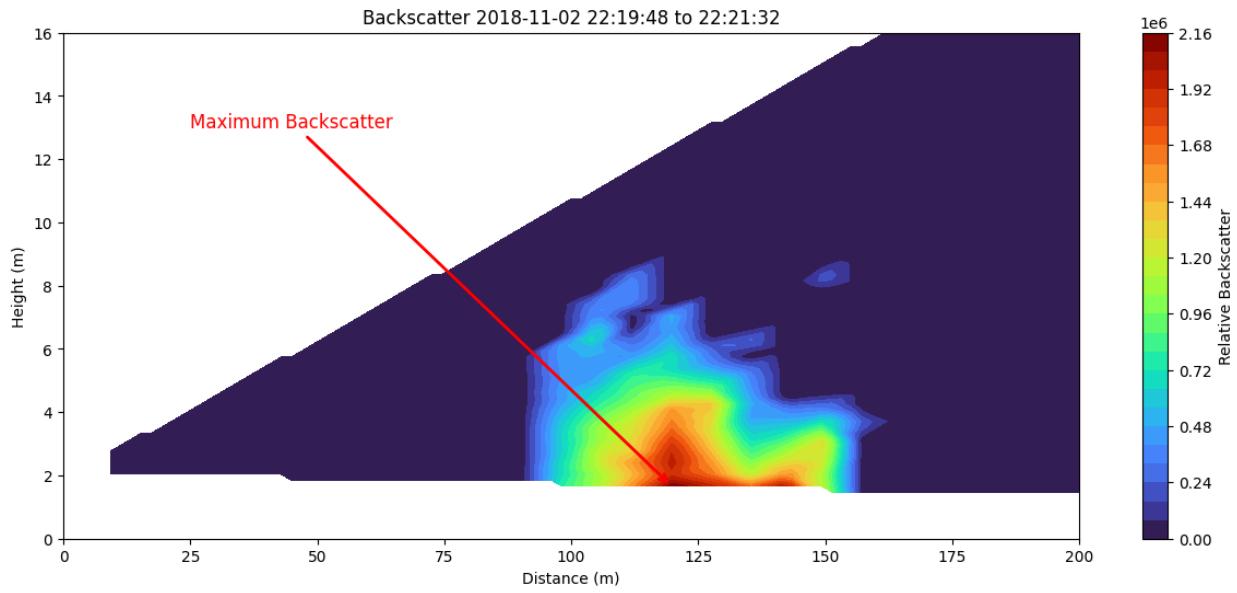
The calculated plume area is: 300.97 square meters.



Maximum Backscatter Value: 2149211.455 (Normalized)

Location (X, Z): (119.76 m, 1.66 m)

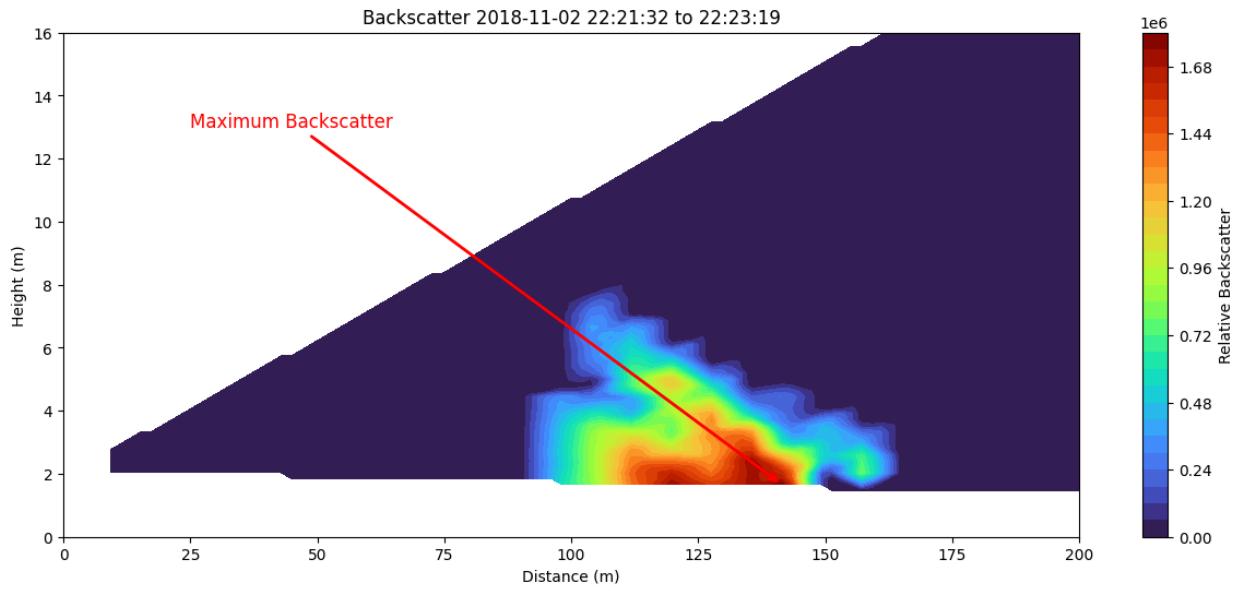
The calculated plume area is: 284.54 square meters.



Maximum Backscatter Value: 1788166.555 (Normalized)

Location (X, Z): (141.43 m, 1.66 m)

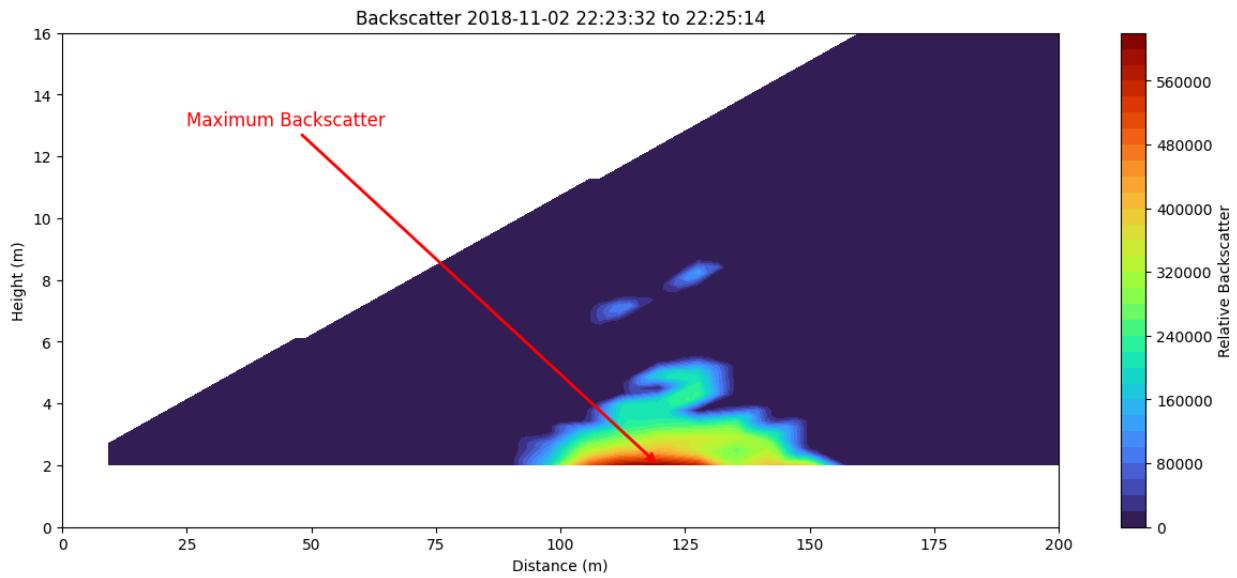
The calculated plume area is: 241.80 square meters.



Maximum Backscatter Value: 605809.253 (Normalized)

Location (X, Z): (119.76 m, 2.00 m)

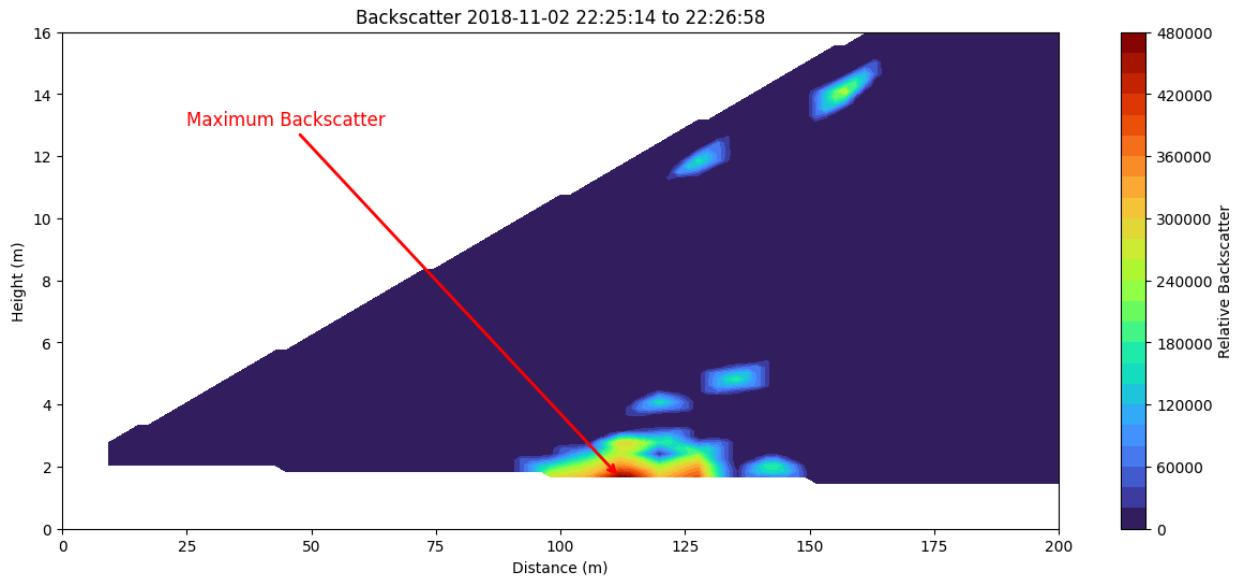
The calculated plume area is: 122.92 square meters.



Maximum Backscatter Value: 476127.849 (Normalized)

Location (X, Z): (111.88 m, 1.66 m)

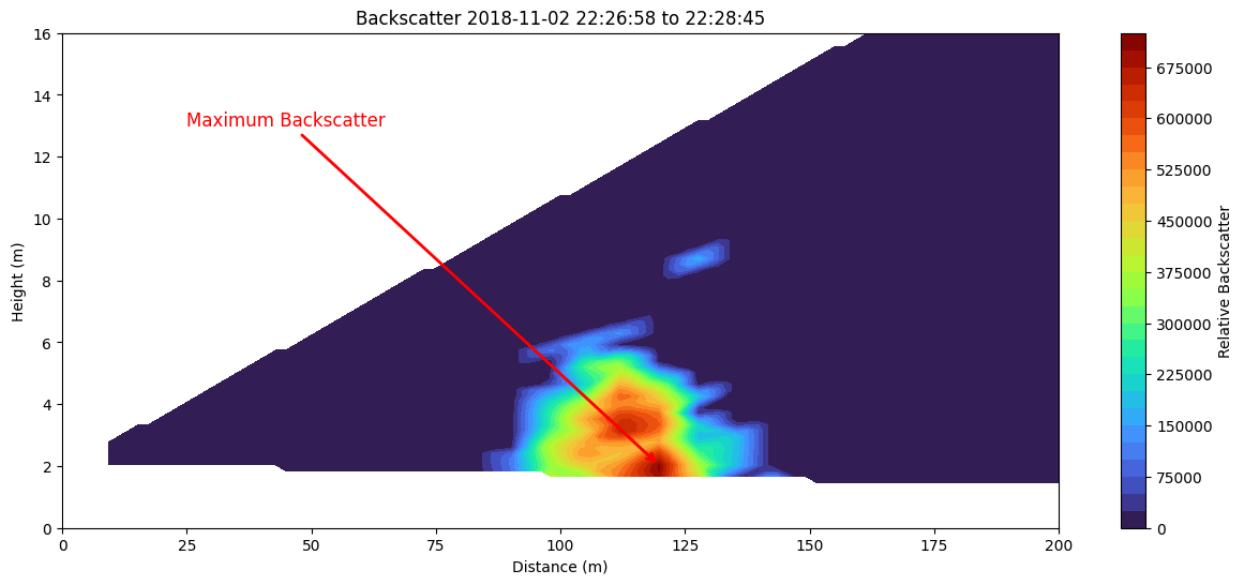
The calculated plume area is: 86.20 square meters.



Maximum Backscatter Value: 704068.162 (Normalized)

Location (X, Z): (119.76 m, 2.03 m)

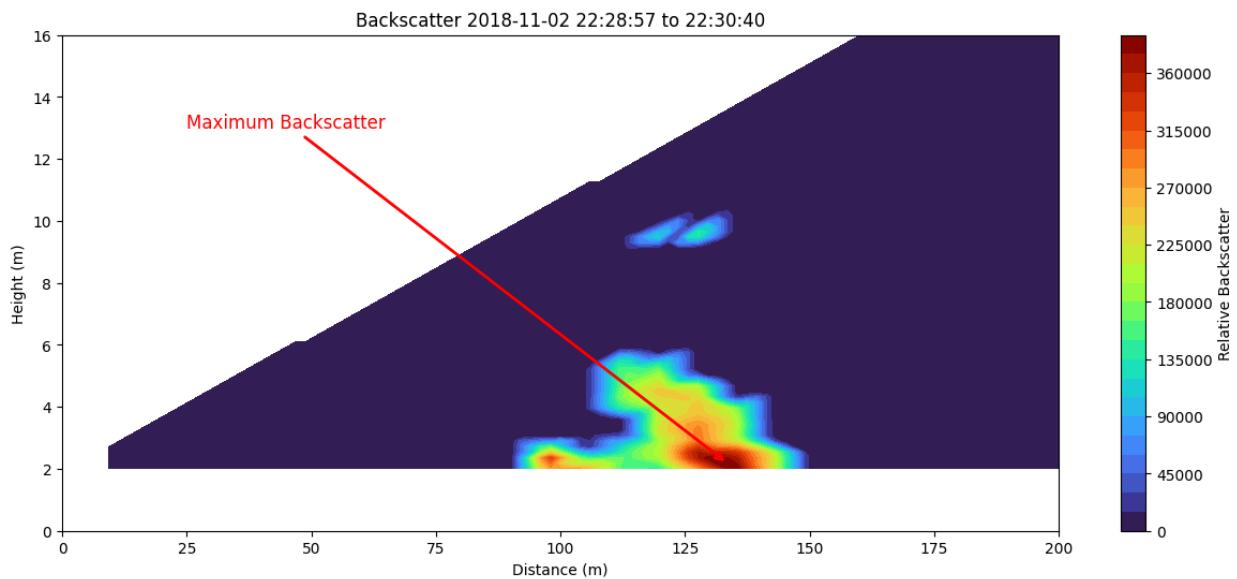
The calculated plume area is: 174.23 square meters.



Maximum Backscatter Value: 388647.140 (Normalized)

Location (X, Z): (133.55 m, 2.18 m)

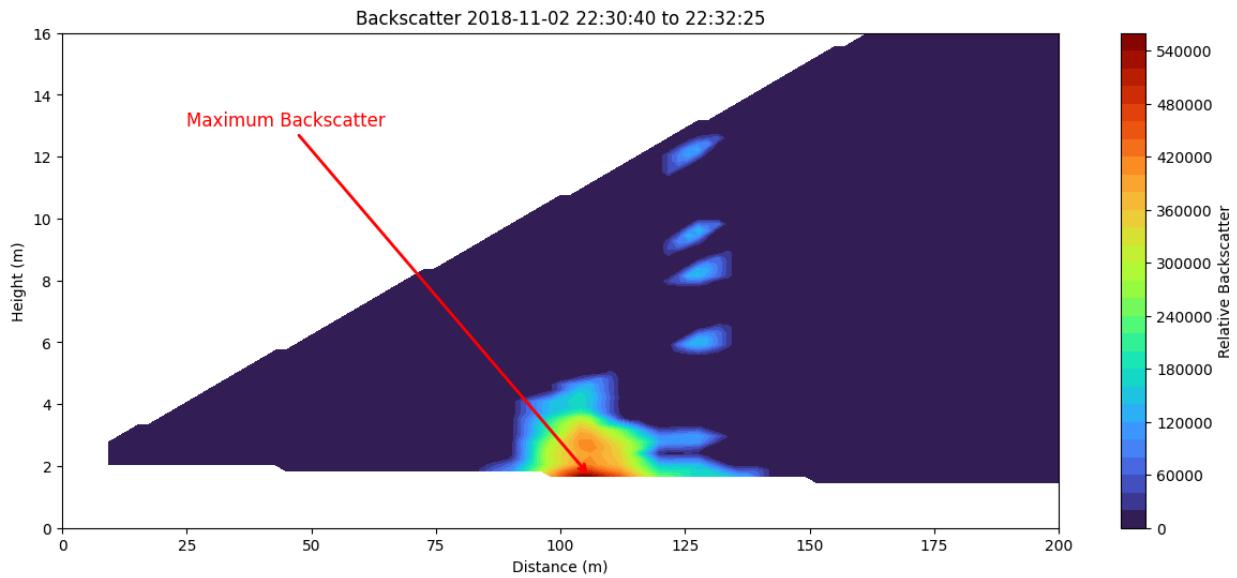
The calculated plume area is: 139.42 square meters.



Maximum Backscatter Value: 553148.146 (Normalized)

Location (X, Z): (105.97 m, 1.66 m)

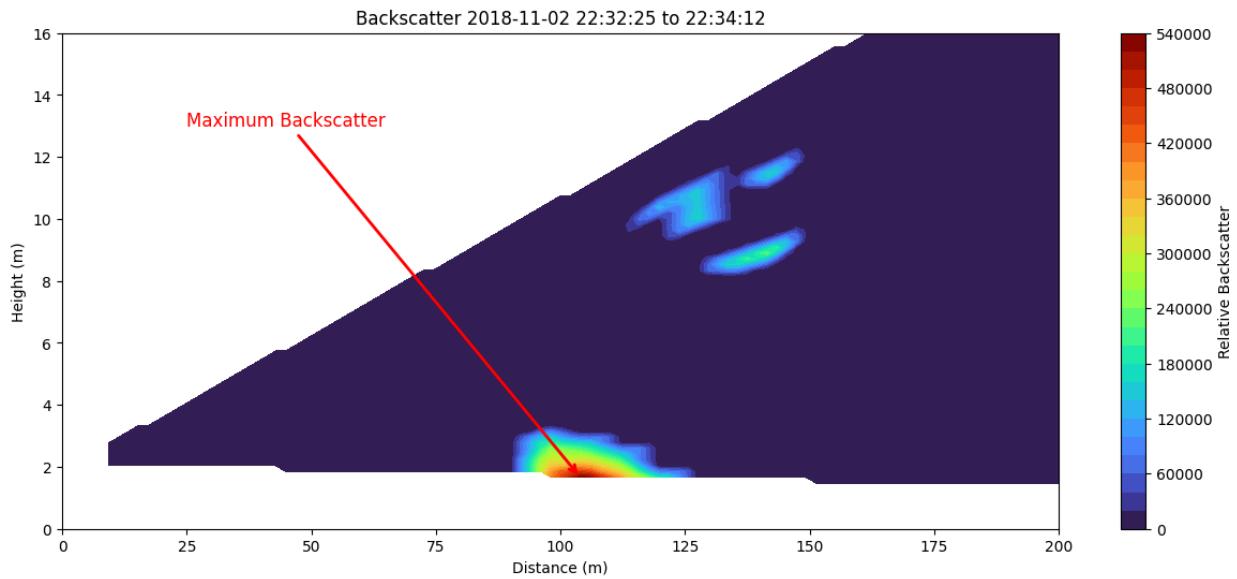
The calculated plume area is: 106.29 square meters.



Maximum Backscatter Value: 535756.862 (Normalized)

Location (X, Z): (104.00 m, 1.66 m)

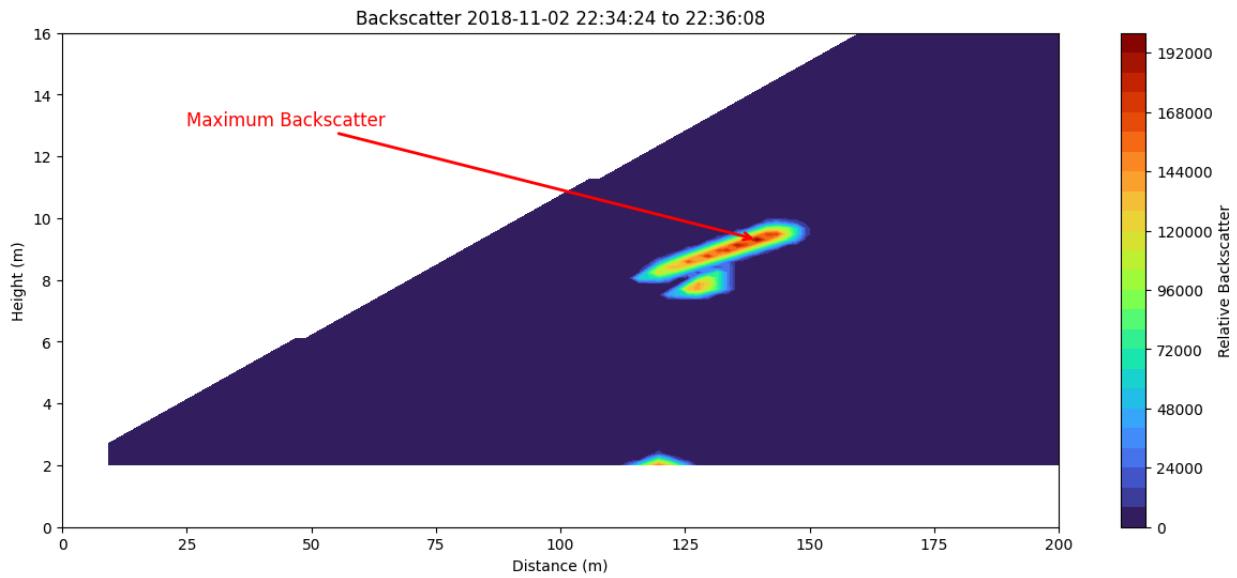
The calculated plume area is: 75.97 square meters.



Maximum Backscatter Value: 193809.180 (Normalized)

Location (X, Z): (139.46 m, 9.31 m)

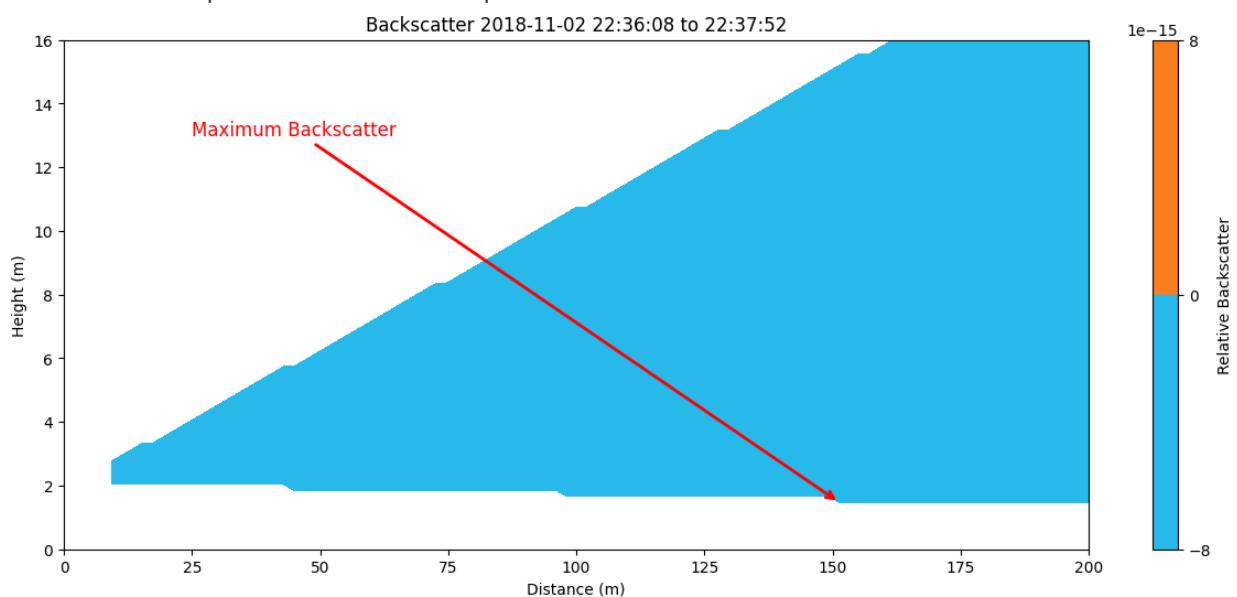
The calculated plume area is: 36.88 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (151.28 m, 1.48 m)

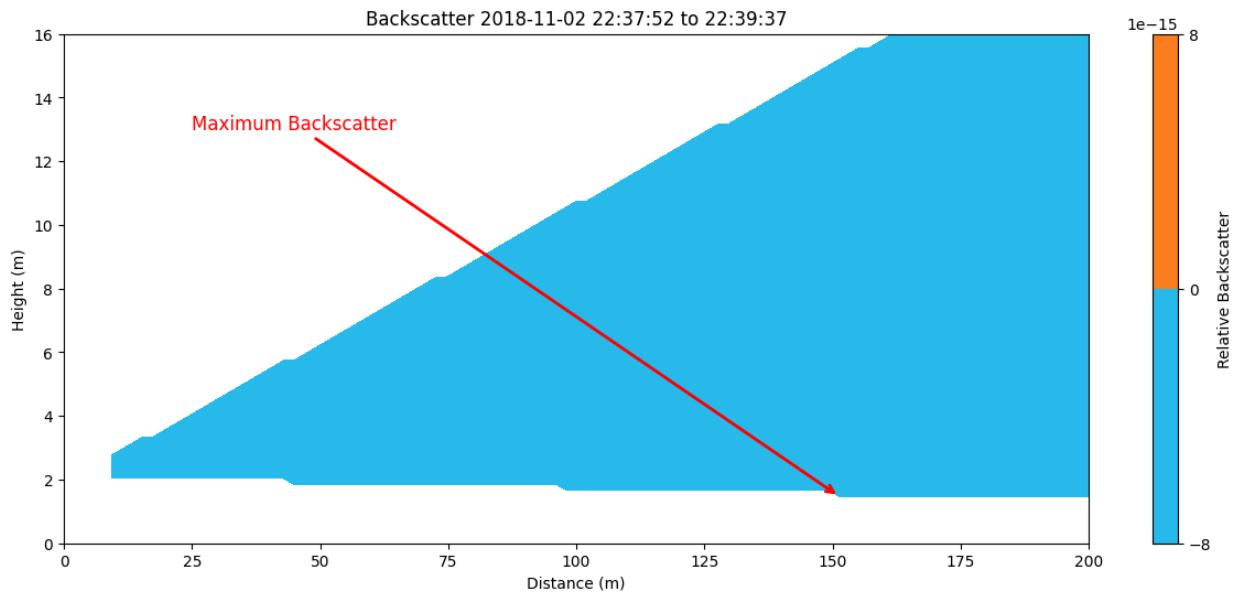
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (151.28 m, 1.48 m)

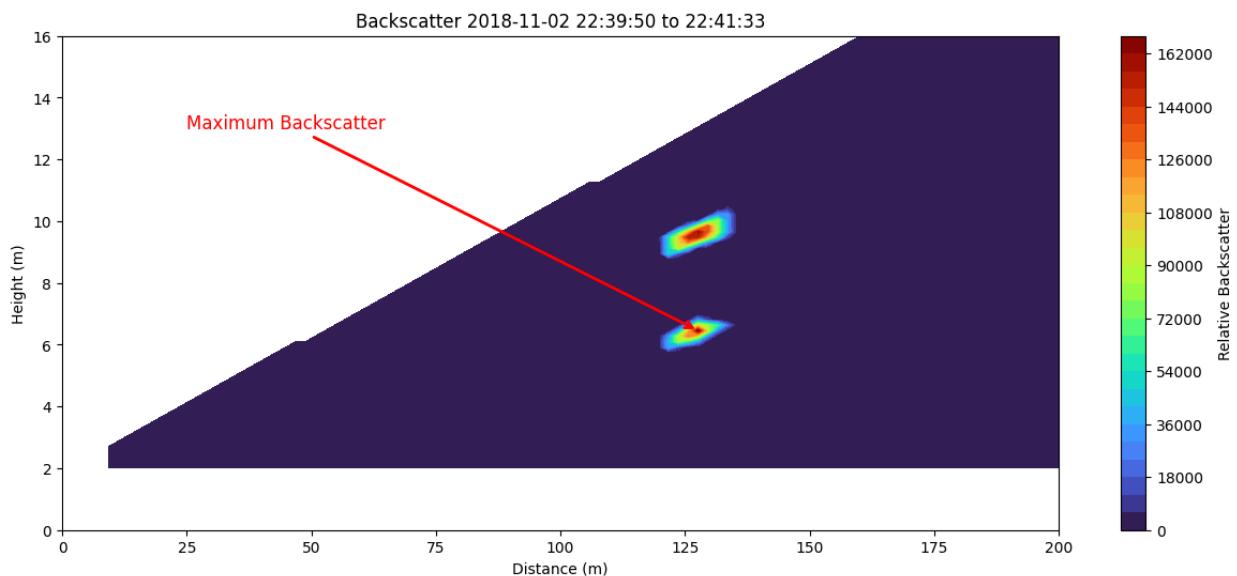
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 166983.479 (Normalized)

Location (X, Z): (127.64 m, 6.46 m)

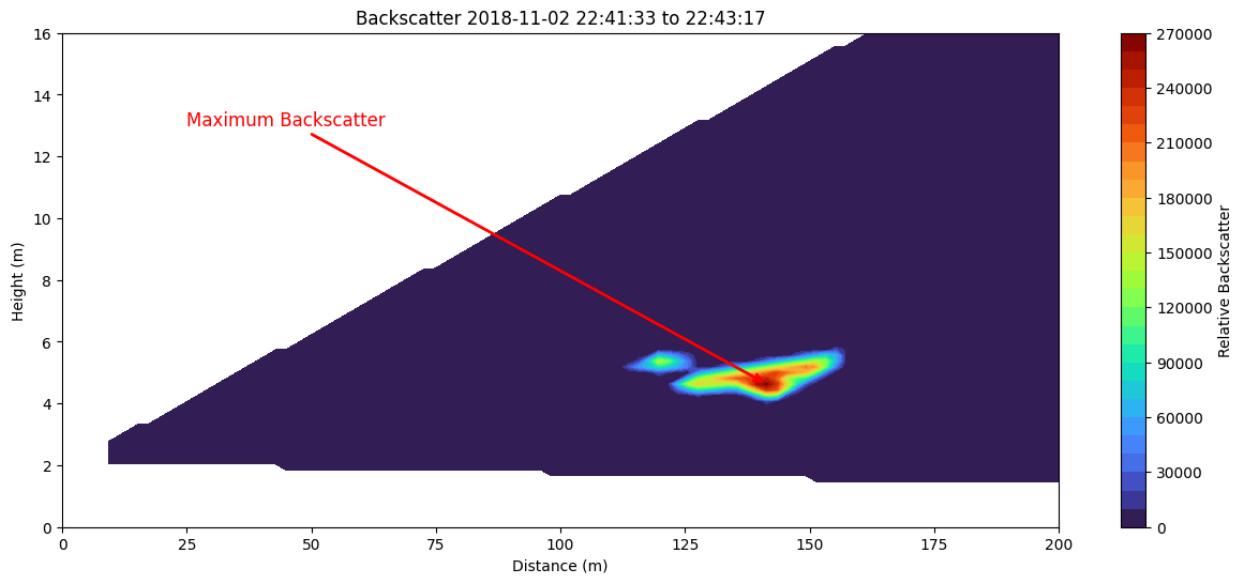
The calculated plume area is: 18.26 square meters.



Maximum Backscatter Value: 262691.732 (Normalized)

Location (X, Z): (141.43 m, 4.63 m)

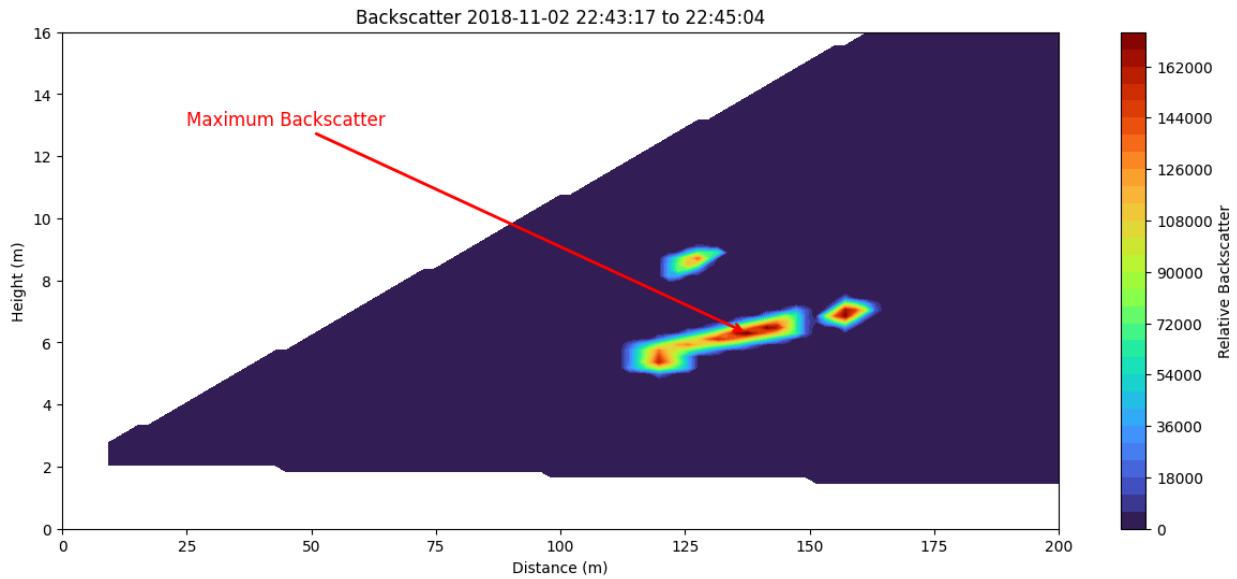
The calculated plume area is: 34.70 square meters.



Maximum Backscatter Value: 172988.692 (Normalized)

Location (X, Z): (137.49 m, 6.30 m)

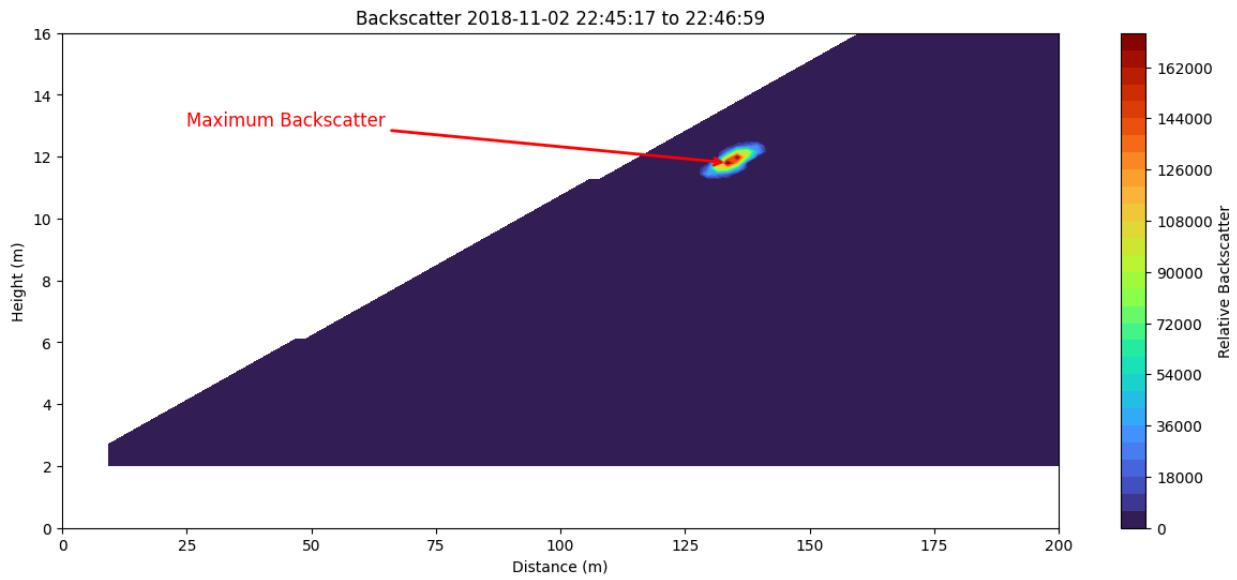
The calculated plume area is: 47.12 square meters.



Maximum Backscatter Value: 173231.852 (Normalized)

Location (X, Z): (133.55 m, 11.81 m)

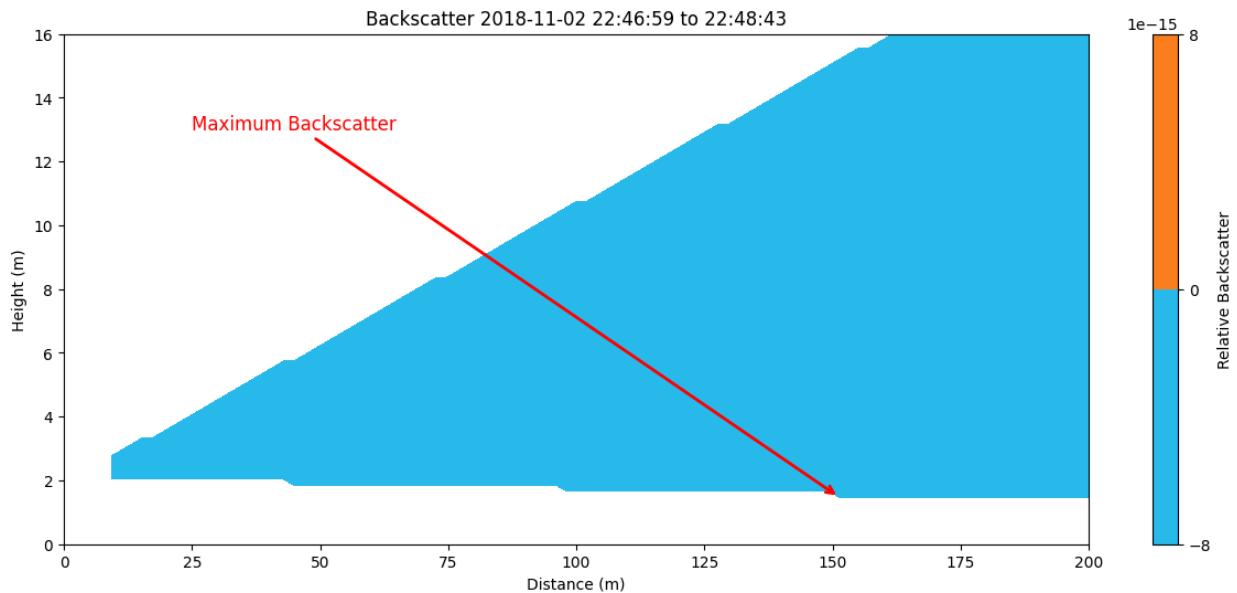
The calculated plume area is: 6.67 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (151.28 m, 1.48 m)

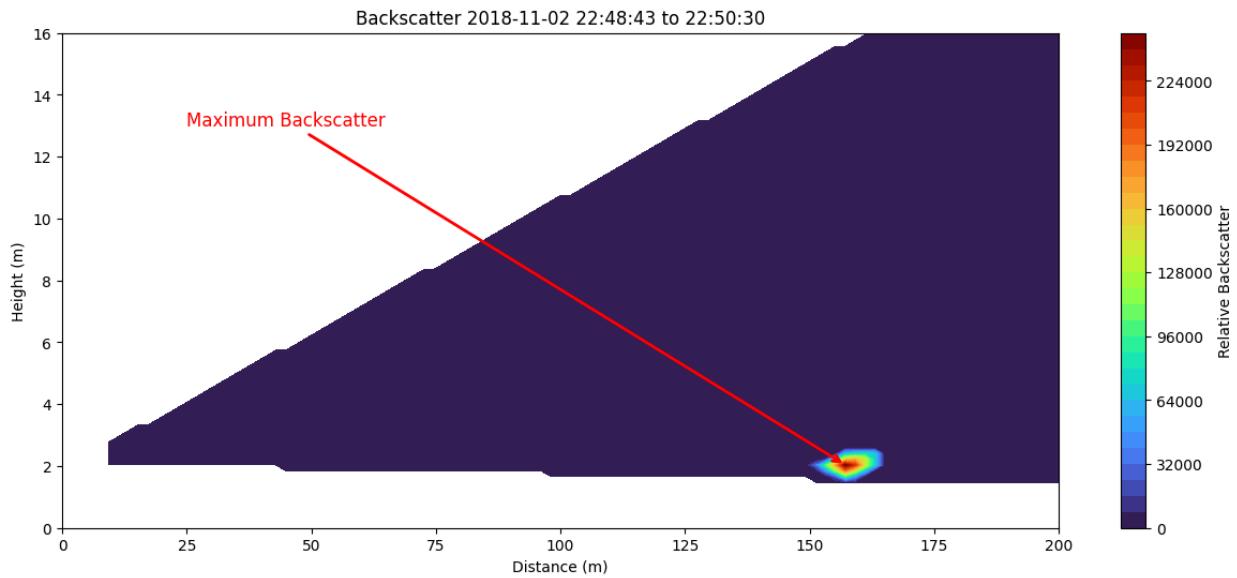
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 244302.296 (Normalized)

Location (X, Z): (157.19 m, 2.03 m)

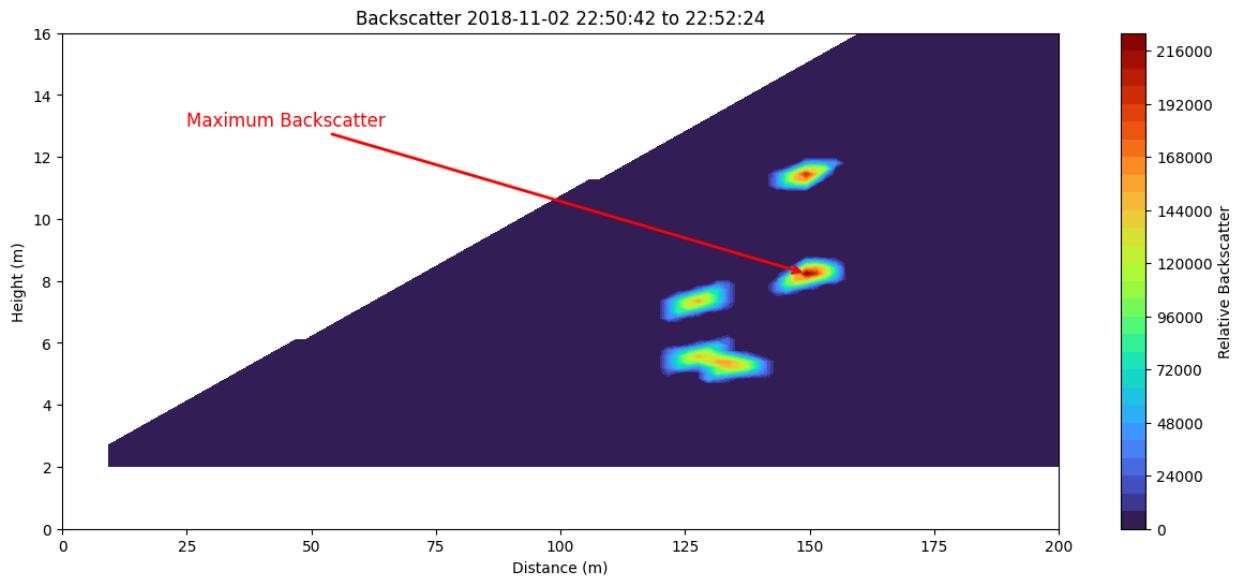
The calculated plume area is: 8.40 square meters.



Maximum Backscatter Value: 220711.191 (Normalized)

Location (X, Z): (149.31 m, 8.24 m)

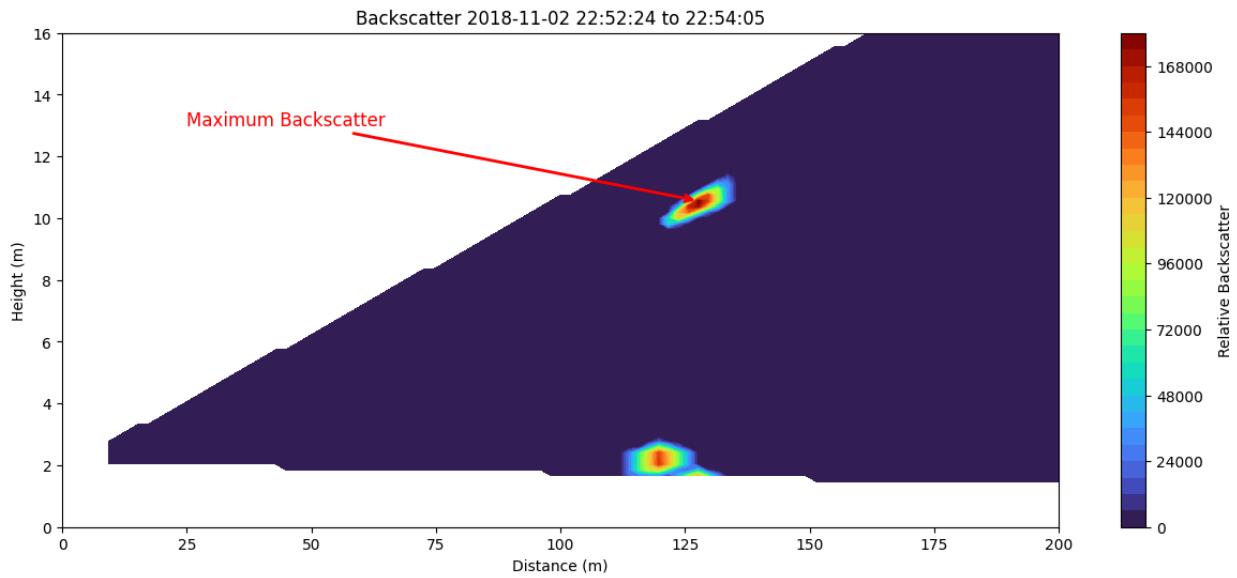
The calculated plume area is: 47.06 square meters.



Maximum Backscatter Value: 178738.371 (Normalized)

Location (X, Z): (127.64 m, 10.56 m)

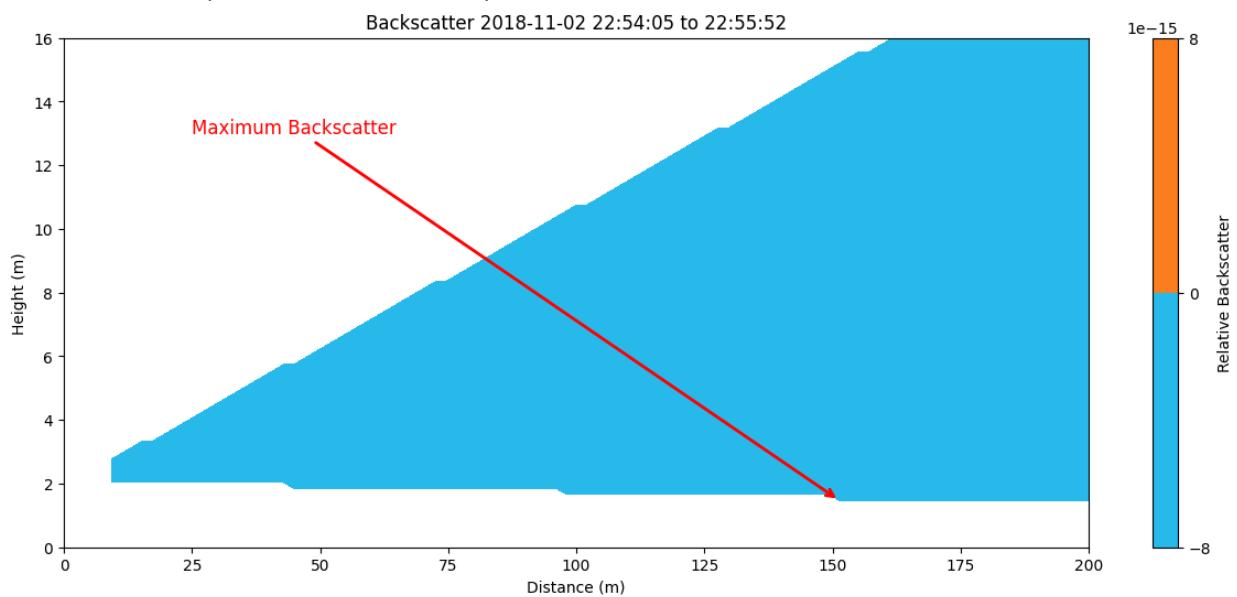
The calculated plume area is: 25.20 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (151.28 m, 1.48 m)

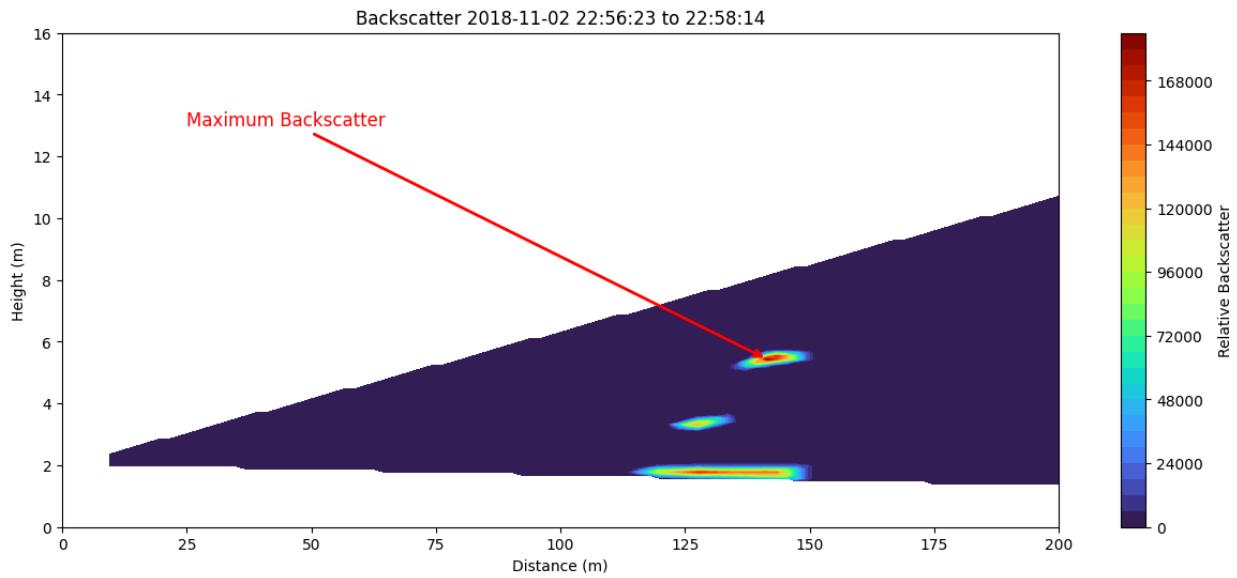
The calculated plume area is: 0.00 square meters.



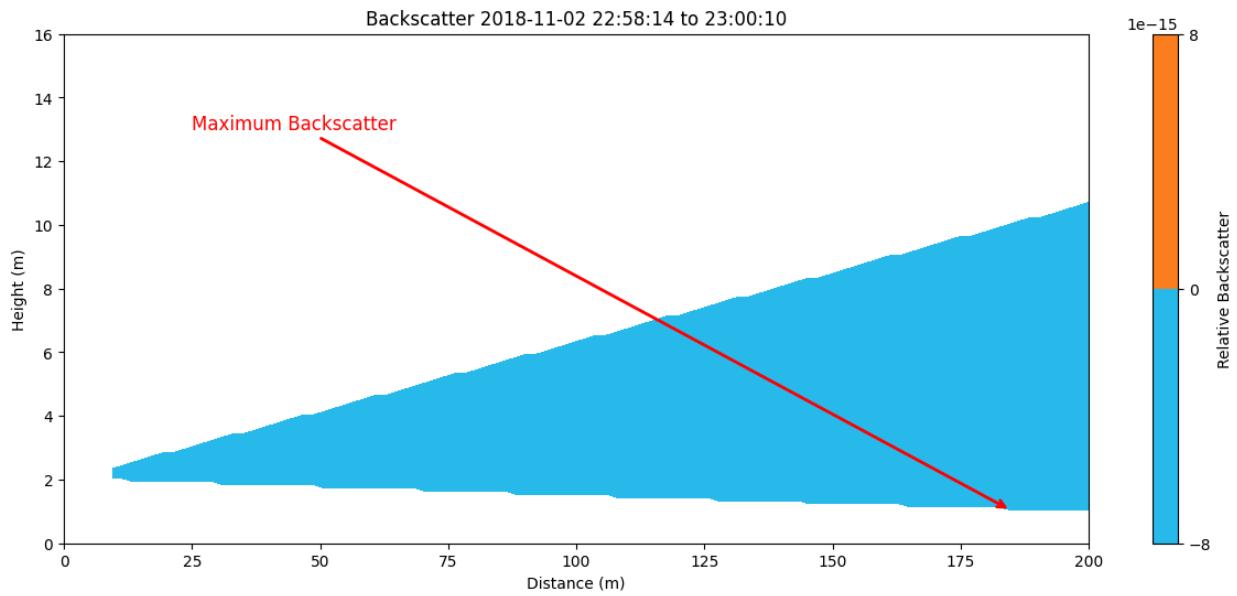
Maximum Backscatter Value: 182796.874 (Normalized)

Location (X, Z): (141.44 m, 5.44 m)

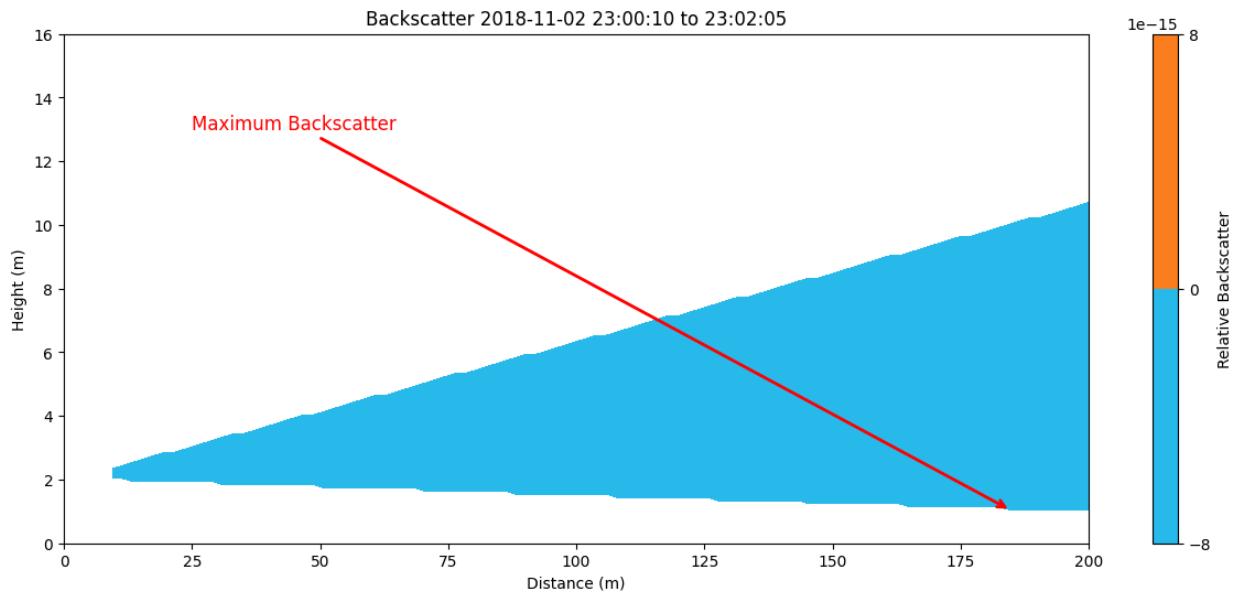
The calculated plume area is: 20.88 square meters.



Maximum Backscatter Value: 0.000 (Normalized)
 Location (X, Z): (184.77 m, 1.04 m)
 The calculated plume area is: 0.00 square meters.



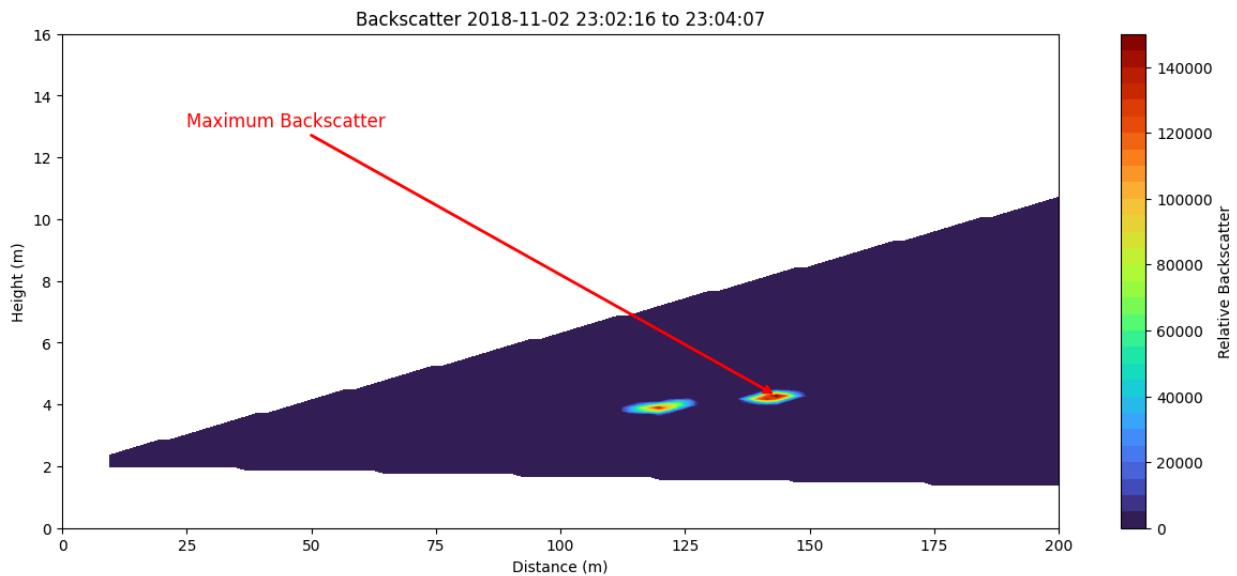
Maximum Backscatter Value: 0.000 (Normalized)
 Location (X, Z): (184.77 m, 1.04 m)
 The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 145755.795 (Normalized)

Location (X, Z): (143.41 m, 4.28 m)

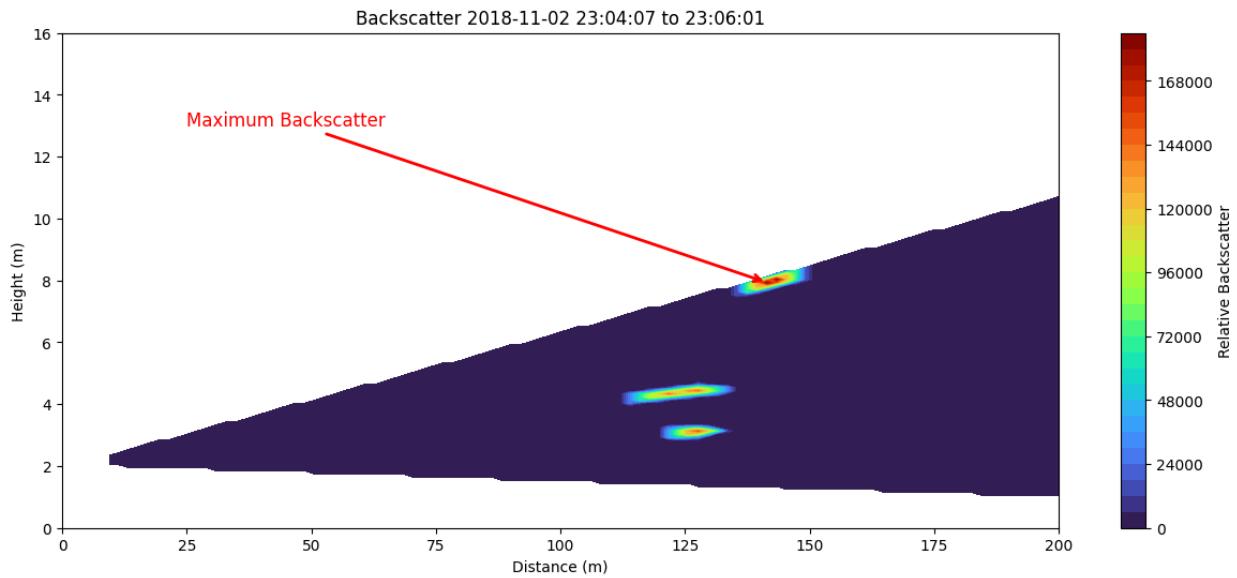
The calculated plume area is: 7.21 square meters.



Maximum Backscatter Value: 180143.285 (Normalized)

Location (X, Z): (141.44 m, 7.93 m)

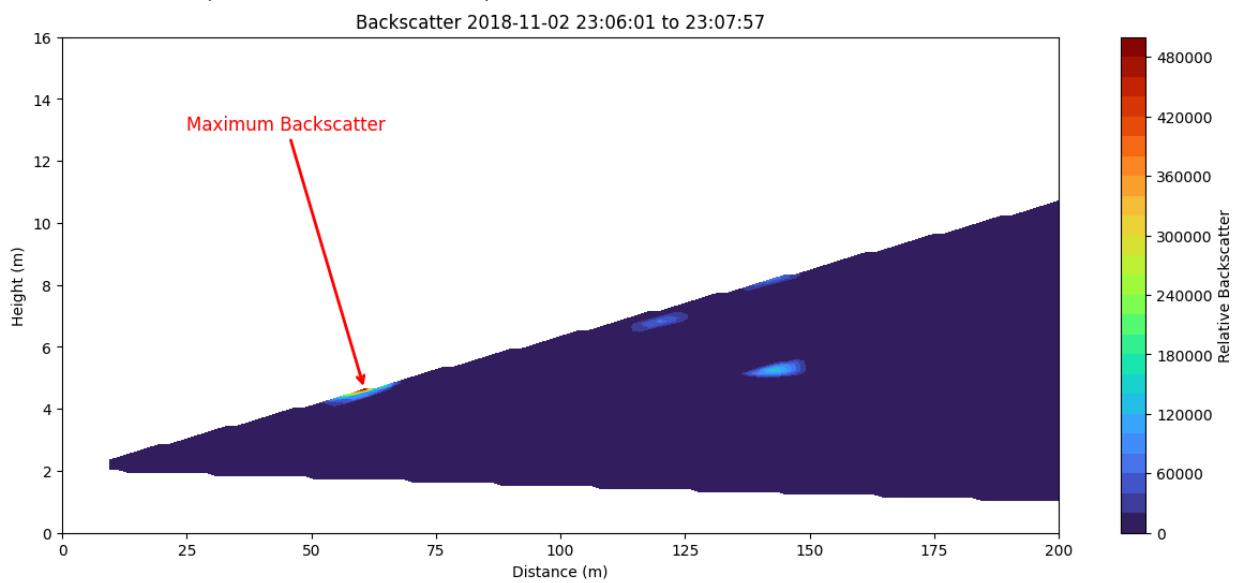
The calculated plume area is: 16.73 square meters.



Maximum Backscatter Value: 484304.475 (Normalized)

Location (X, Z): (60.68 m, 4.64 m)

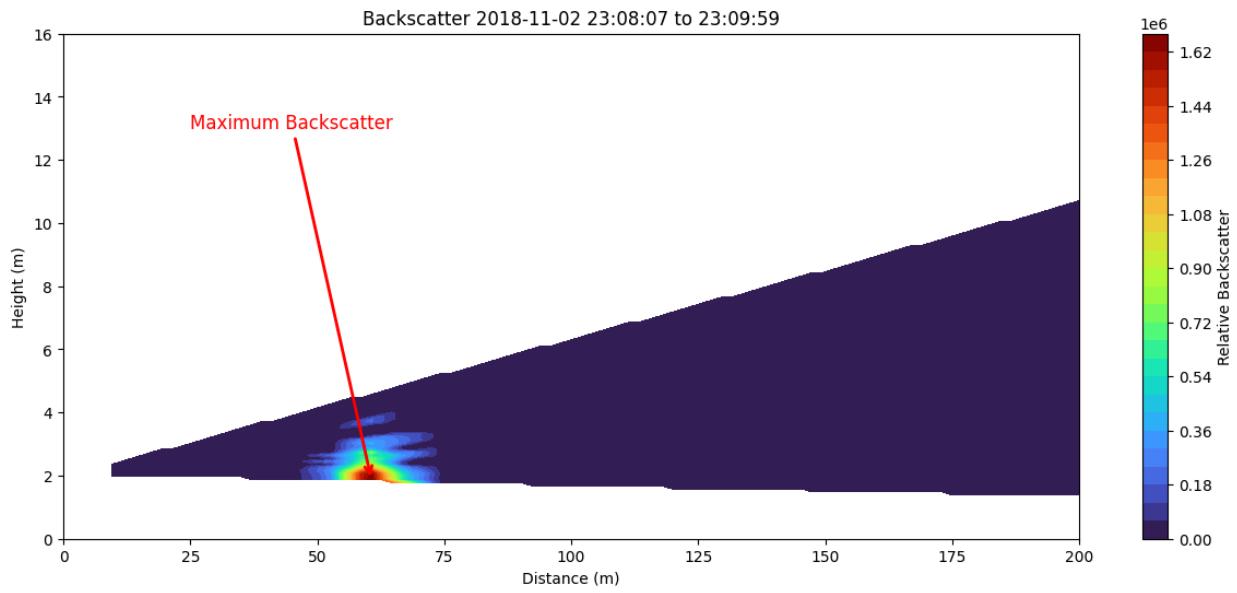
The calculated plume area is: 7.28 square meters.



Maximum Backscatter Value: 1677900.969 (Normalized)

Location (X, Z): (60.68 m, 1.87 m)

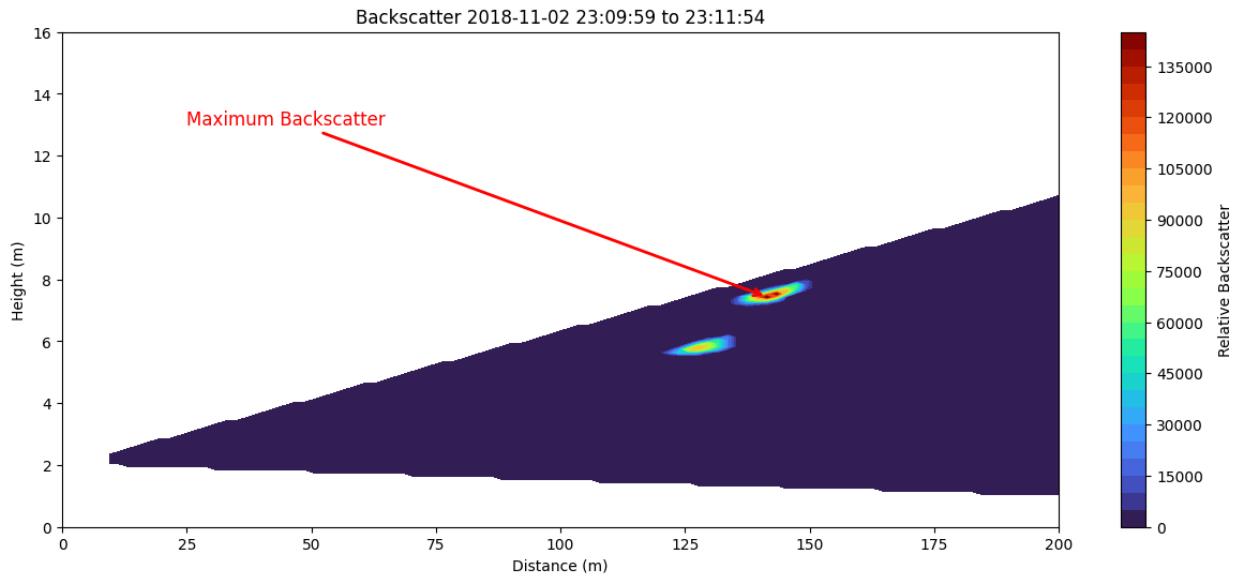
The calculated plume area is: 24.11 square meters.



Maximum Backscatter Value: 143270.263 (Normalized)

Location (X, Z): (141.44 m, 7.44 m)

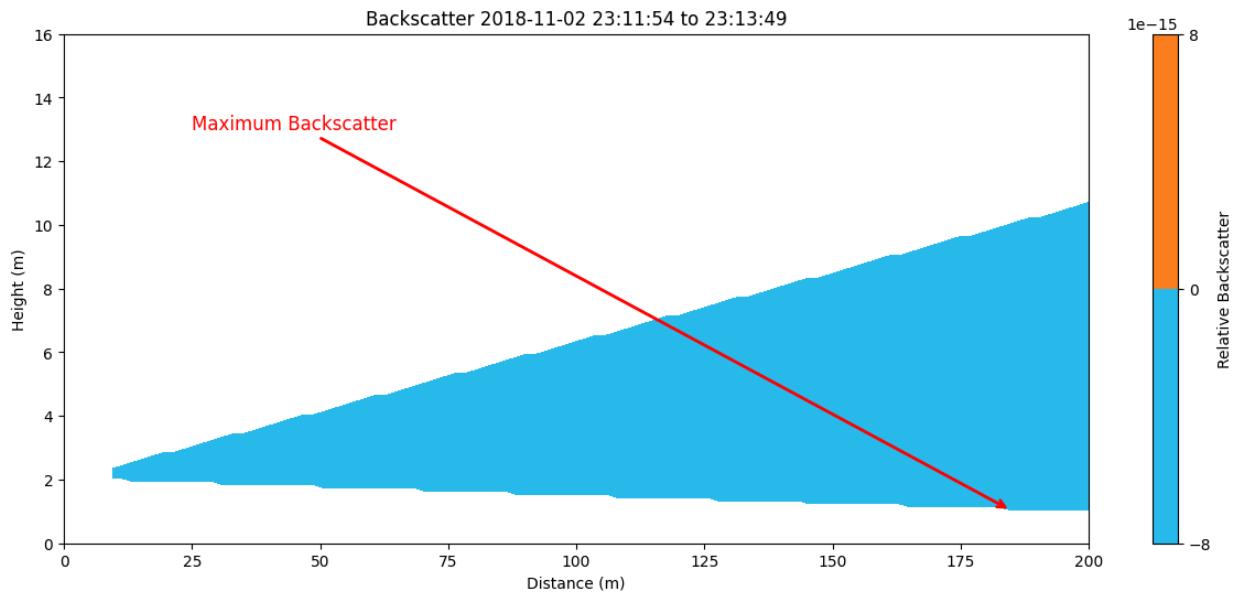
The calculated plume area is: 8.66 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (184.77 m, 1.04 m)

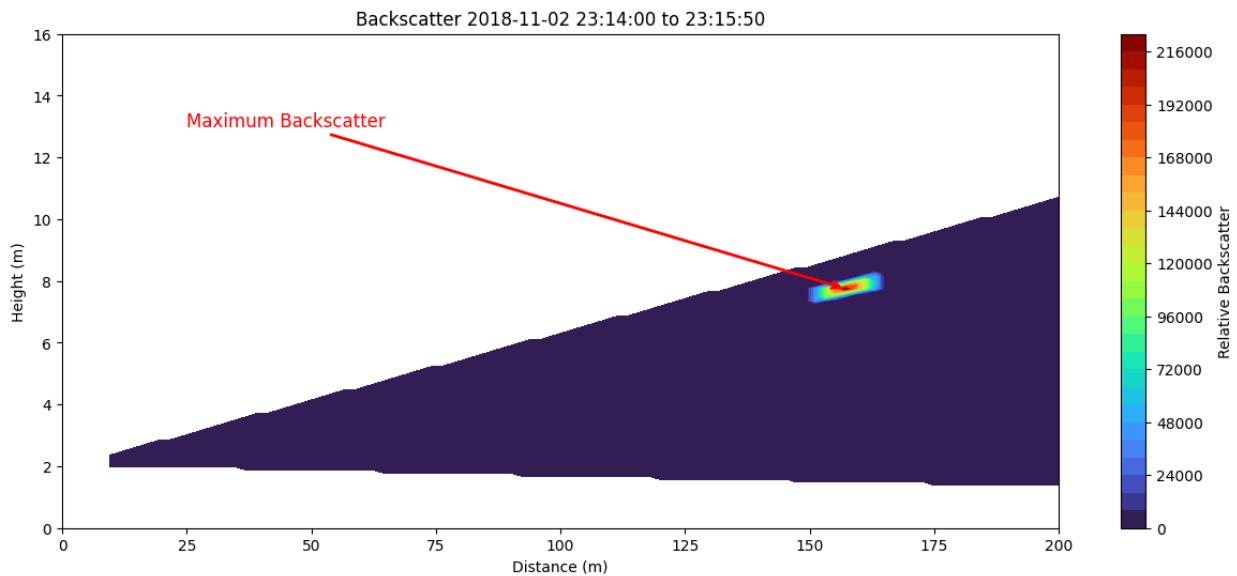
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 220478.270 (Normalized)

Location (X, Z): (157.20 m, 7.75 m)

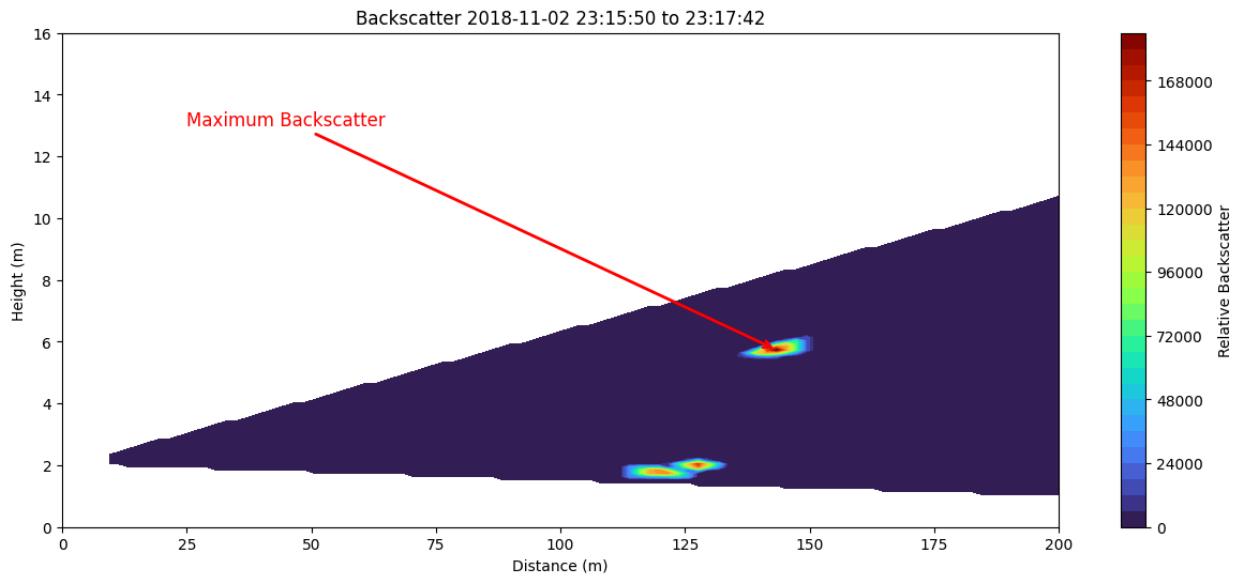
The calculated plume area is: 7.02 square meters.



Maximum Backscatter Value: 183779.611 (Normalized)

Location (X, Z): (143.41 m, 5.74 m)

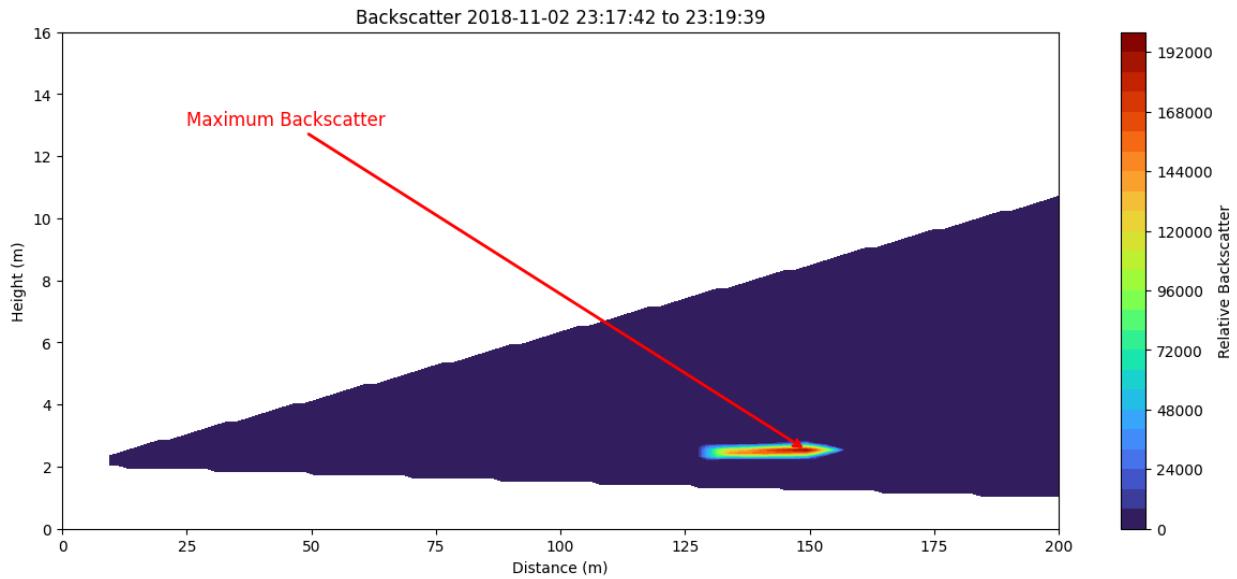
The calculated plume area is: 11.81 square meters.



Maximum Backscatter Value: 193581.669 (Normalized)

Location (X, Z): (149.32 m, 2.54 m)

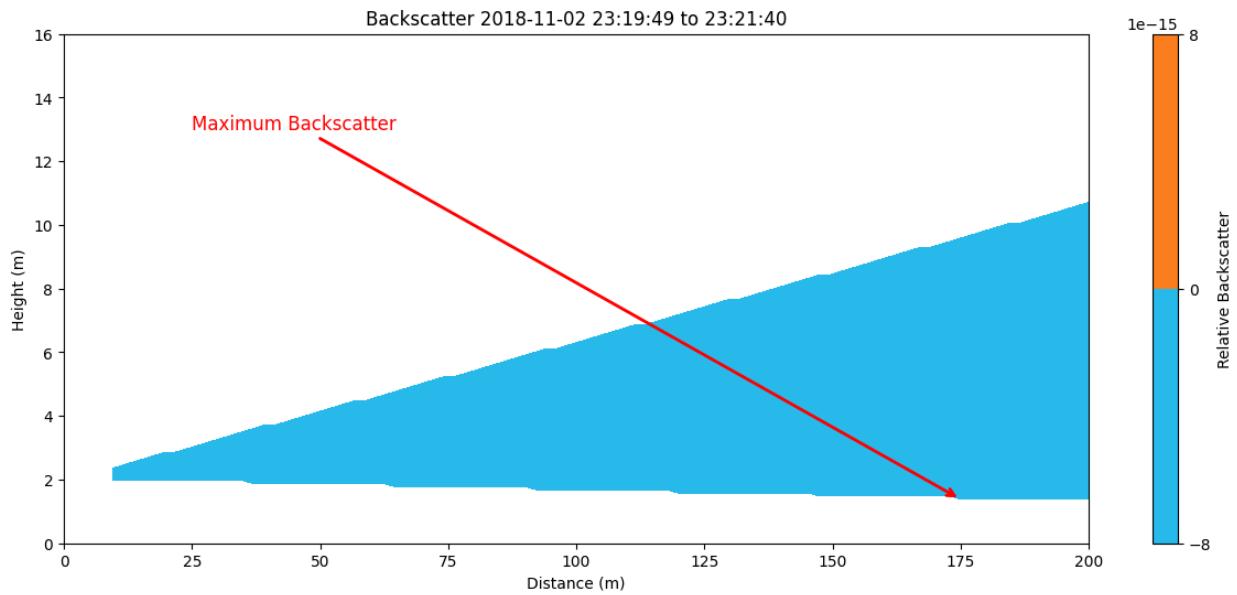
The calculated plume area is: 10.63 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (174.92 m, 1.39 m)

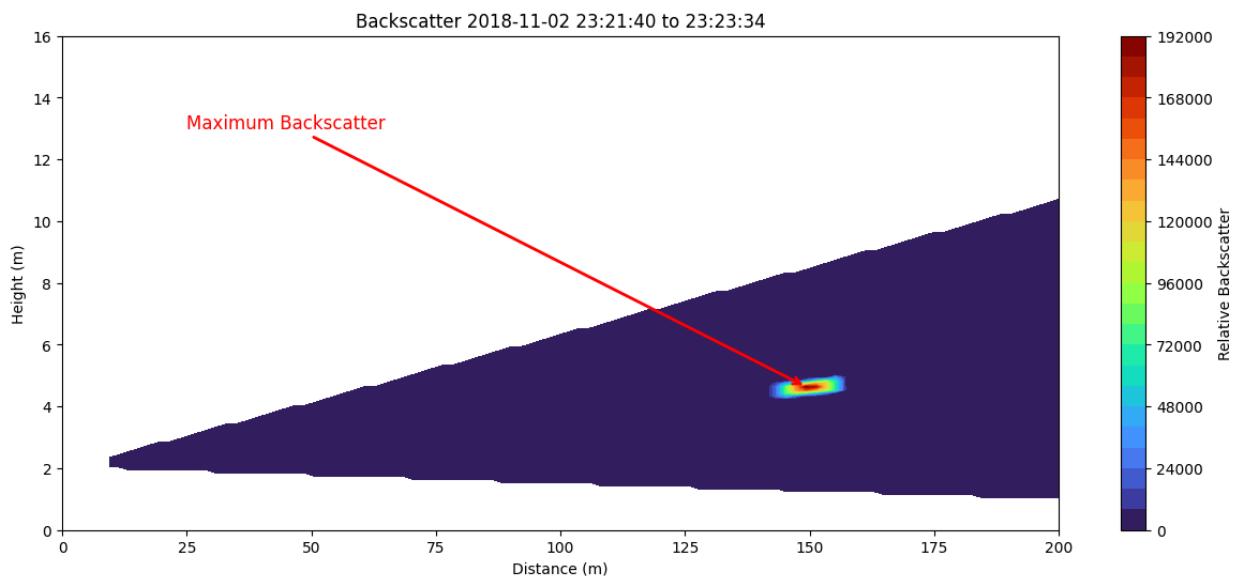
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 186999.893 (Normalized)

Location (X, Z): (149.32 m, 4.64 m)

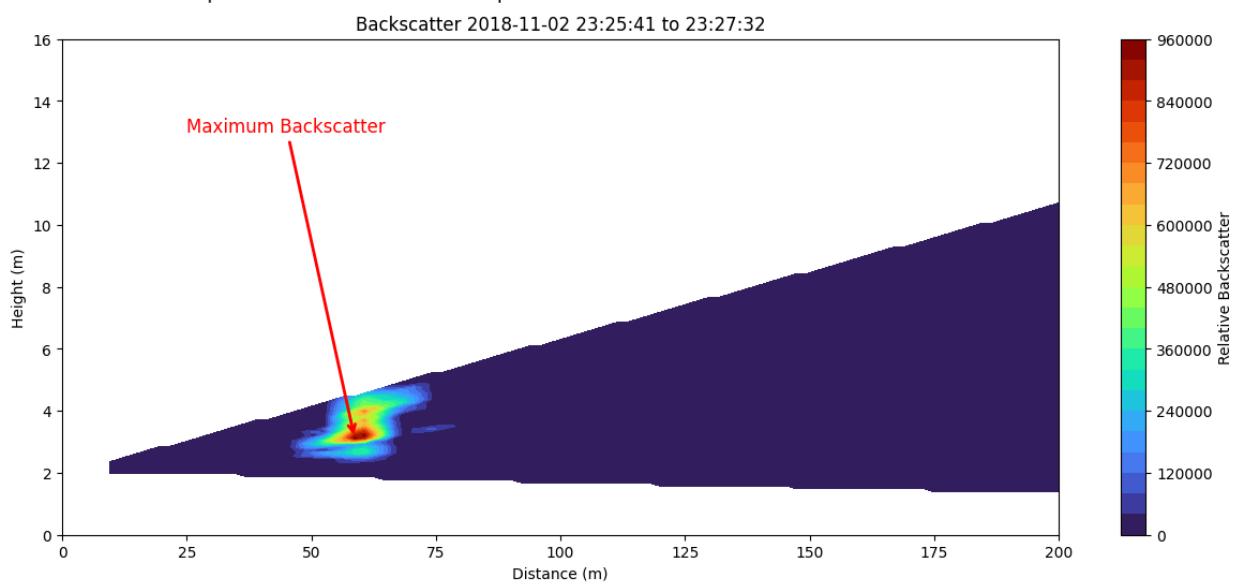
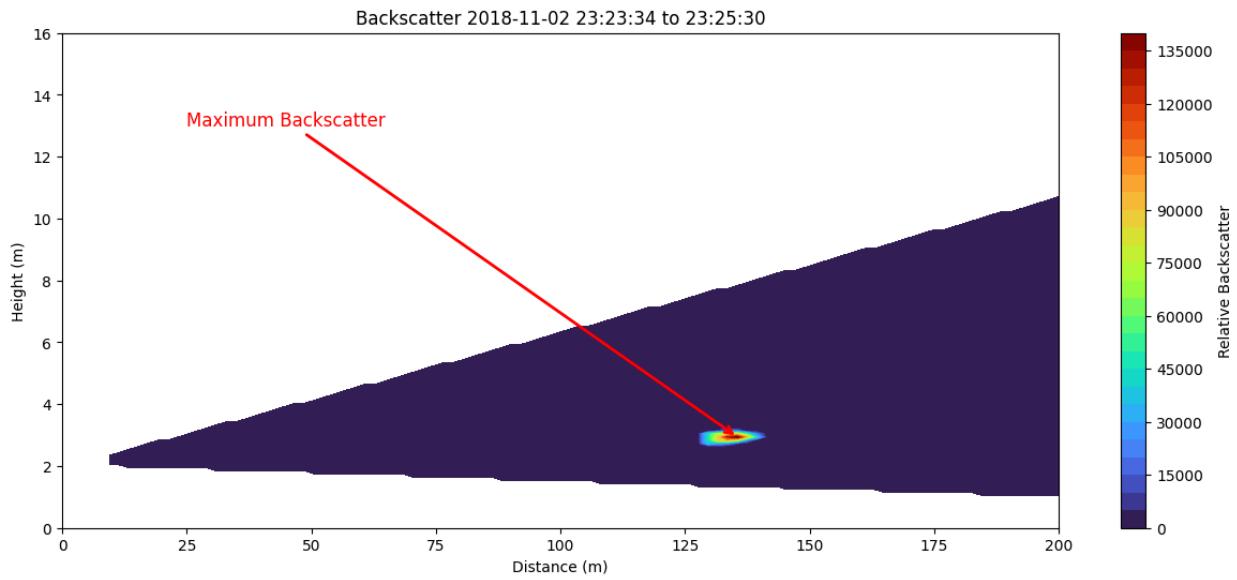
The calculated plume area is: 6.50 square meters.

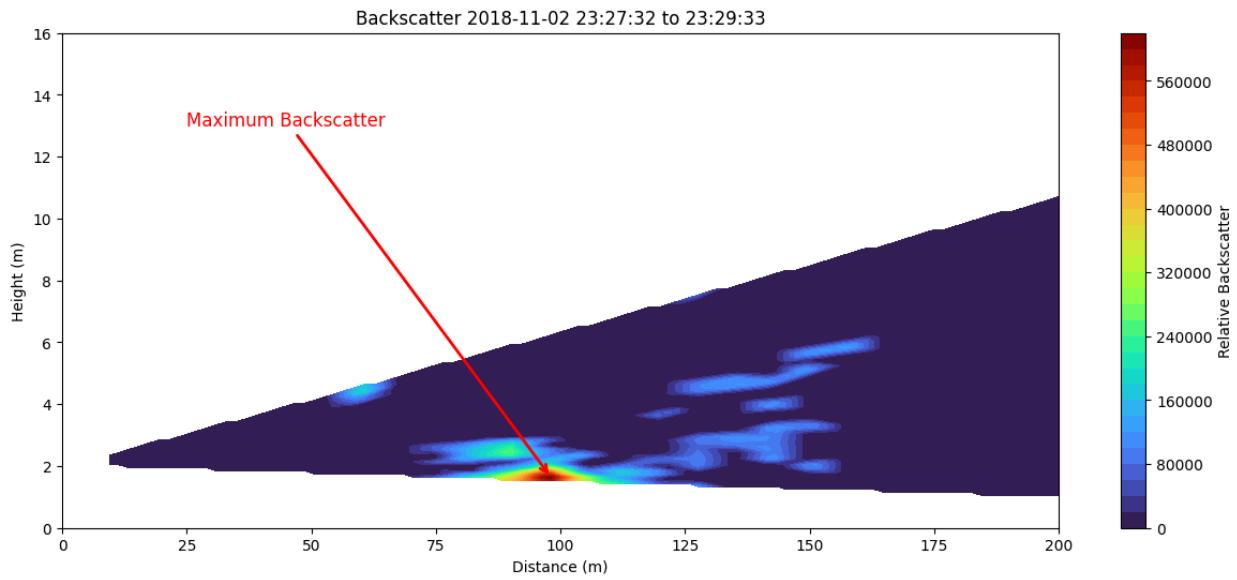


Maximum Backscatter Value: 139725.065 (Normalized)

Location (X, Z): (135.53 m, 2.94 m)

The calculated plume area is: 4.33 square meters.

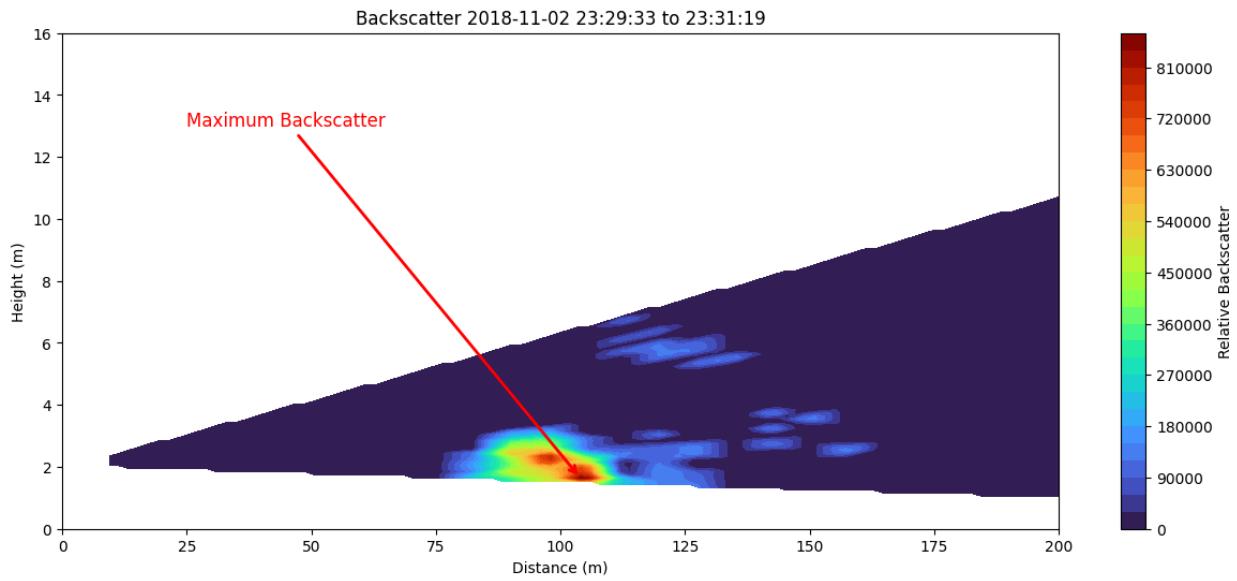




Maximum Backscatter Value: 854730.043 (Normalized)

Location (X, Z): (104.01 m, 1.64 m)

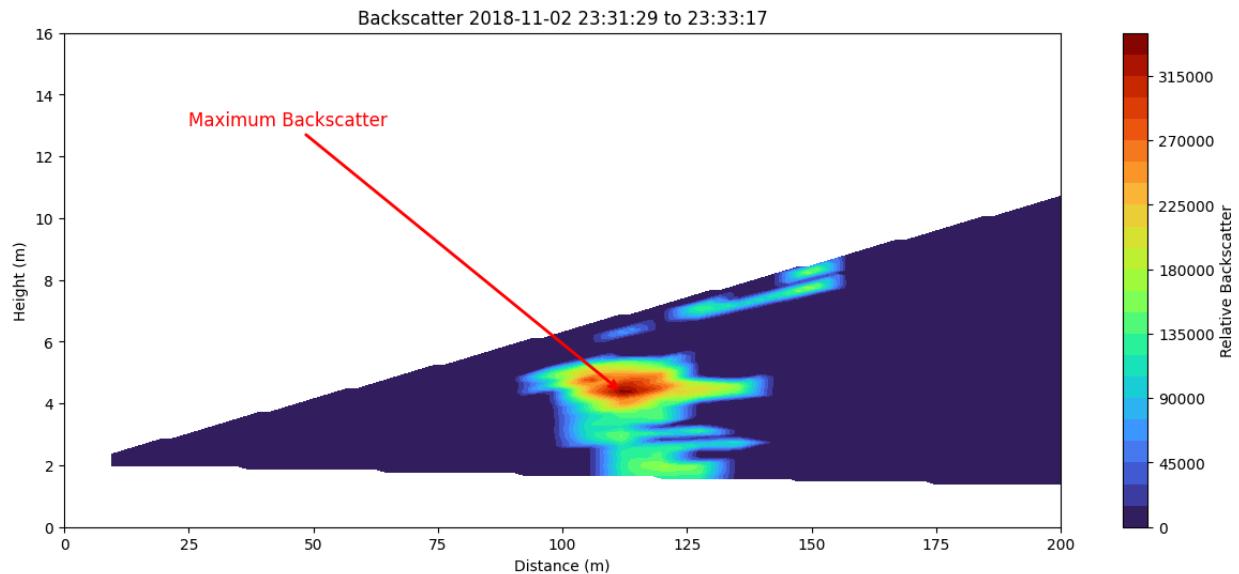
The calculated plume area is: 77.36 square meters.



Maximum Backscatter Value: 335750.917 (Normalized)

Location (X, Z): (111.89 m, 4.38 m)

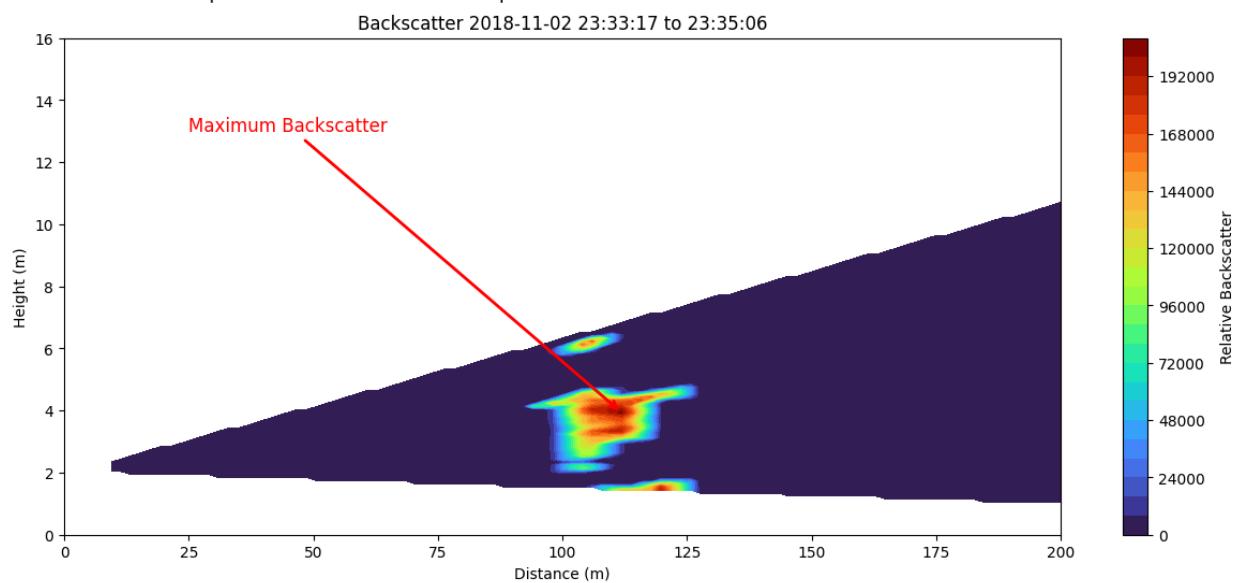
The calculated plume area is: 141.22 square meters.



Maximum Backscatter Value: 202740.885 (Normalized)

Location (X, Z): (111.89 m, 3.94 m)

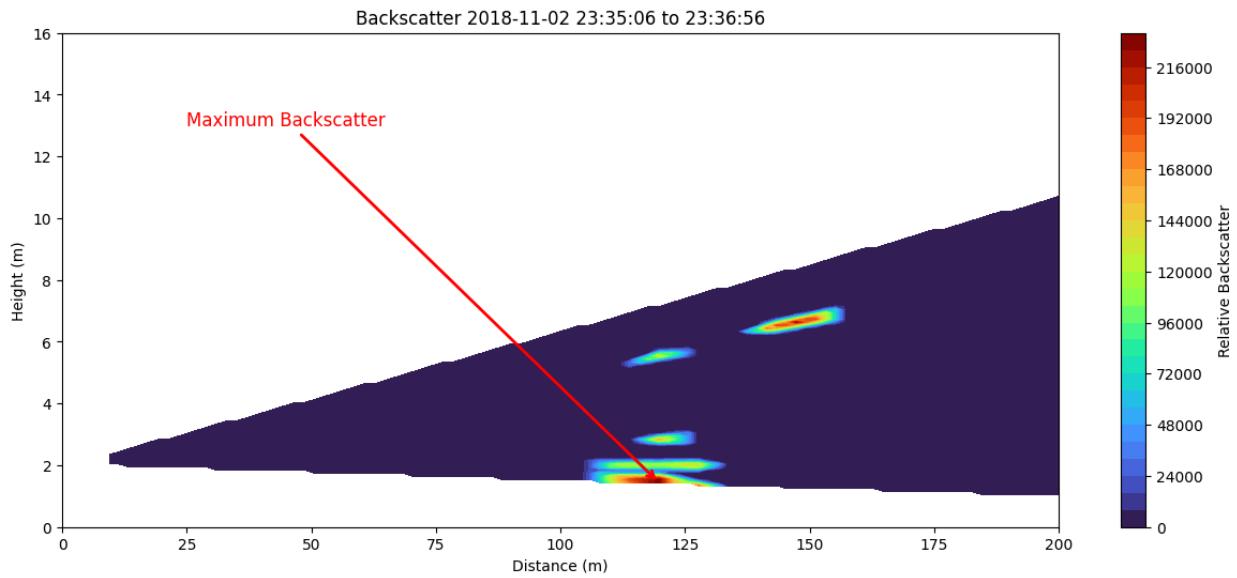
The calculated plume area is: 54.72 square meters.



Maximum Backscatter Value: 229063.821 (Normalized)

Location (X, Z): (119.77 m, 1.44 m)

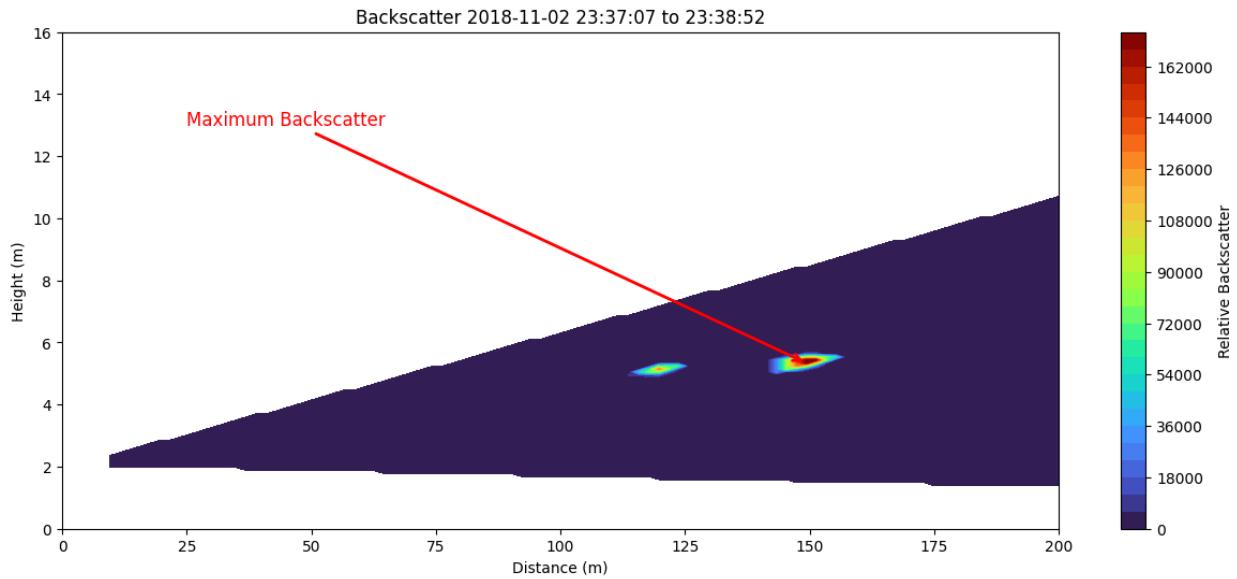
The calculated plume area is: 32.68 square meters.



Maximum Backscatter Value: 172368.508 (Normalized)

Location (X, Z): (149.32 m, 5.34 m)

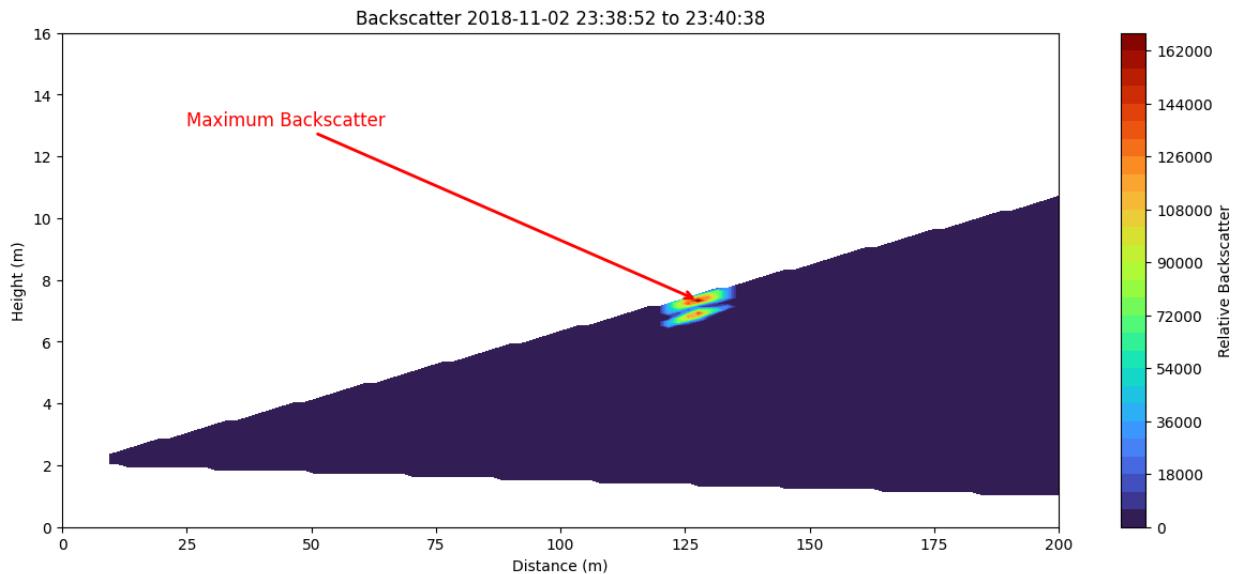
The calculated plume area is: 6.45 square meters.



Maximum Backscatter Value: 163115.801 (Normalized)

Location (X, Z): (127.65 m, 7.34 m)

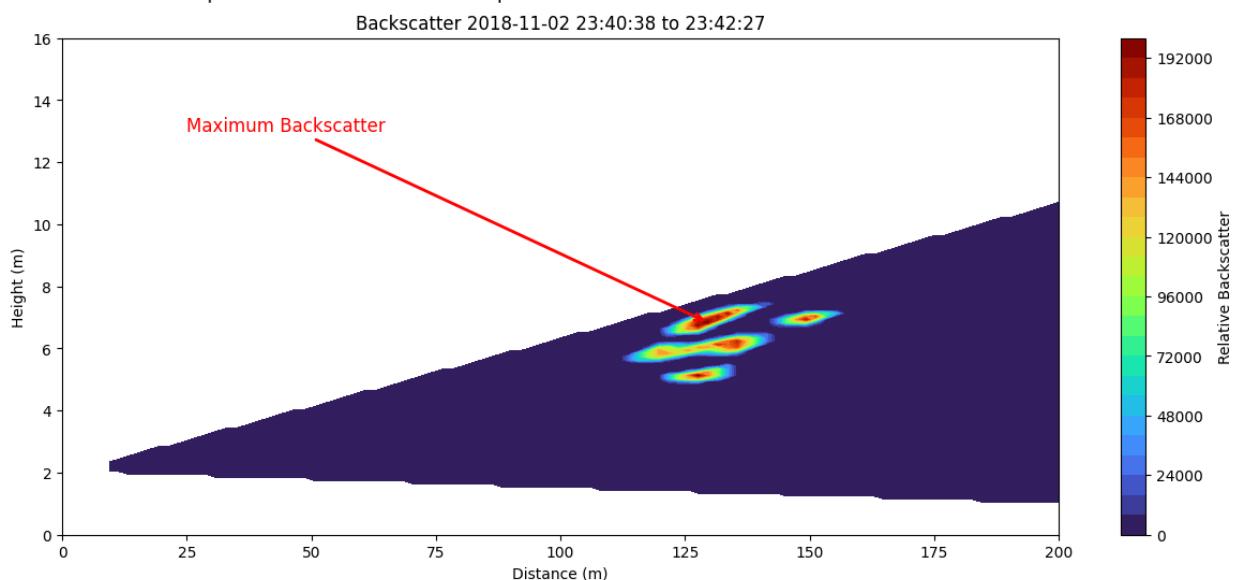
The calculated plume area is: 9.05 square meters.



Maximum Backscatter Value: 196722.933 (Normalized)

Location (X, Z): (129.62 m, 6.84 m)

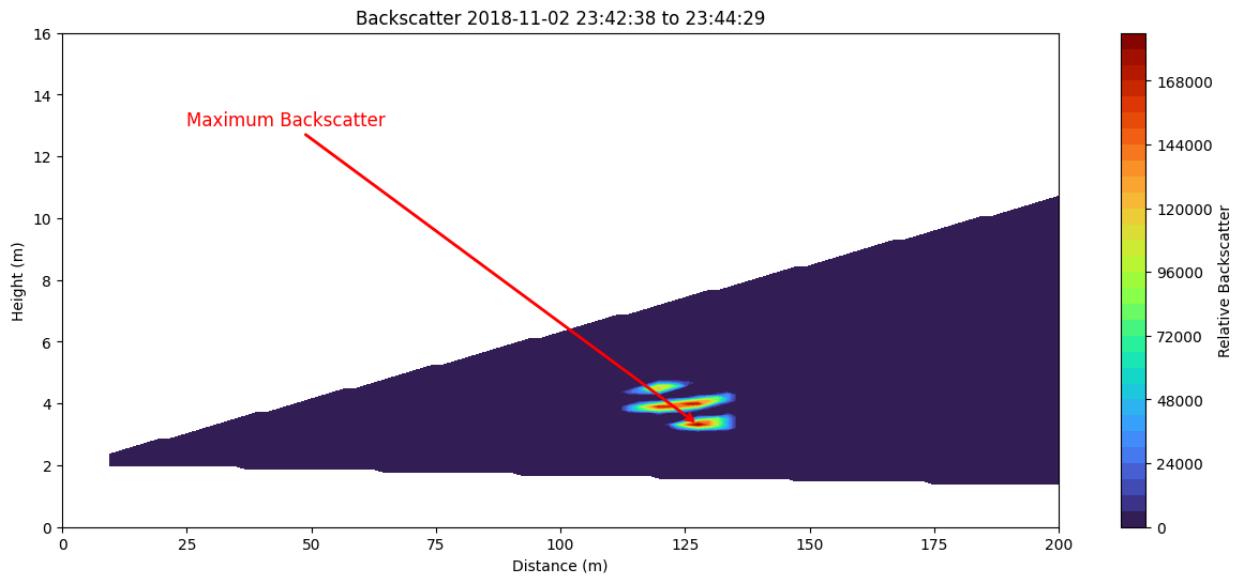
The calculated plume area is: 30.51 square meters.



Maximum Backscatter Value: 180803.343 (Normalized)

Location (X, Z): (127.65 m, 3.32 m)

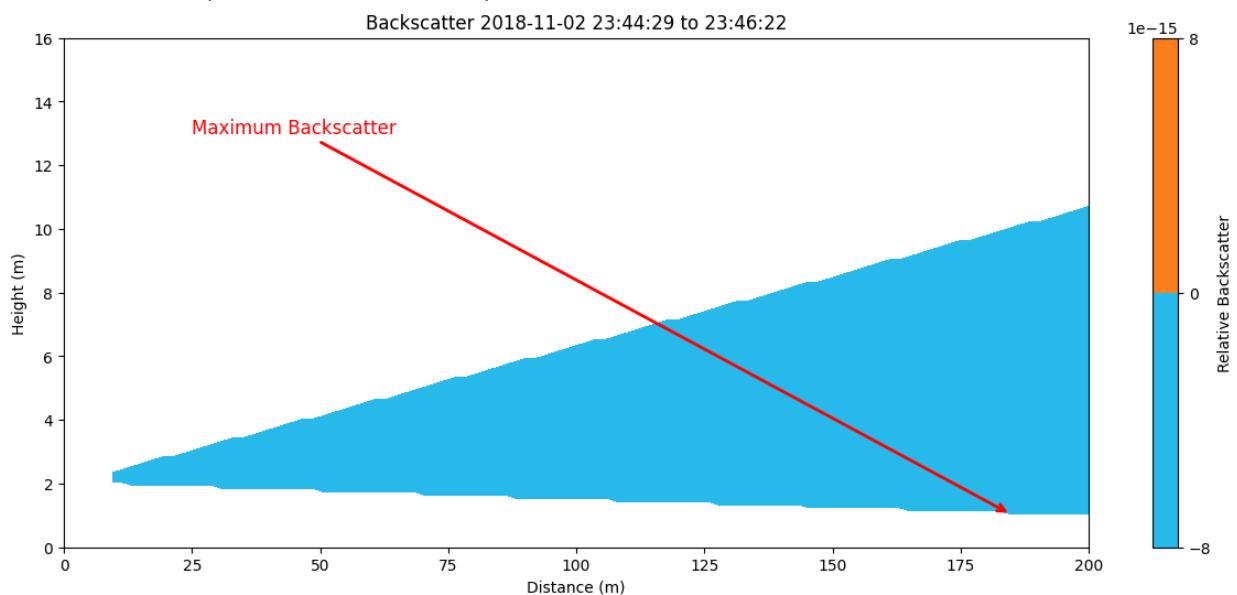
The calculated plume area is: 14.05 square meters.



Maximum Backscatter Value: 0.000 (Normalized)

Location (X, Z): (184.77 m, 1.04 m)

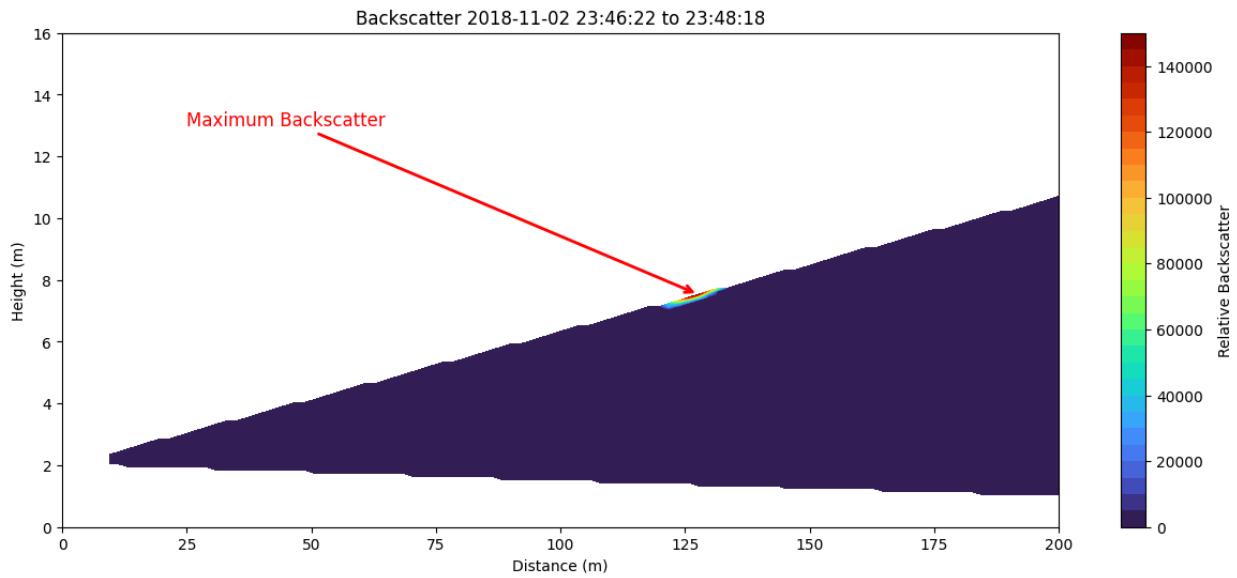
The calculated plume area is: 0.00 square meters.



Maximum Backscatter Value: 145654.328 (Normalized)

Location (X, Z): (127.65 m, 7.54 m)

The calculated plume area is: 2.17 square meters.



```
In [18]: columns = ['start', 'stop', 'max_rcs_value', 'max_x', 'max_z', 'plume_area_sq_m']
plume_time_series = pd.DataFrame(all_stats, columns=columns)
plume_time_series
```

Out[18]:

	start	stop	max_rcs_value	max_x	max_z	plume_area_sq_m
0	2018-11-02 11:13:14	2018-11-02 11:28:24	0.000000	9.451612	2.000000	0.000000
1	2018-11-02 11:28:30	2018-11-02 11:30:35	0.000000	9.451612	2.000000	0.000000
2	2018-11-02 11:54:30	2018-11-02 11:56:51	351696.326238	151.286004	2.000000	46.396865
3	2018-11-02 11:57:39	2018-11-02 11:58:03	253742.814910	135.528928	2.877626	42.933635
4	2018-11-02 11:58:36	2018-11-02 12:00:16	843318.098042	157.190410	2.681295	156.154156
...
327	2018-11-02 23:38:56	2018-11-02 23:40:38	163115.800827	127.648775	7.335327	9.054722
328	2018-11-02 23:40:42	2018-11-02 23:42:27	196722.933493	129.618544	6.835670	30.510476
329	2018-11-02 23:42:42	2018-11-02 23:44:29	180803.342660	127.648775	3.316733	14.045924
330	2018-11-02 23:44:33	2018-11-02 23:46:22	0.000000	184.772078	1.039649	0.000000
331	2018-11-02 23:46:26	2018-11-02 23:48:18	145654.328422	127.648775	7.535190	2.165260

332 rows × 6 columns

```
In [19]: plume_time_series['corrected_time'] = plume_time_series['start'] + pd.Timedelta(hours=12) # co
```

```
In [20]: friendly_colors = ['#D81B60', '#1E88E5', '#FFC107', '#004D40']
time_labels = ['04:00 - 05:00', '05:00 - 06:00', '06:00 - 07:00', '07:00 - 08:00']

t1 = pd.to_datetime('2018-11-03 04:00')
t2 = pd.to_datetime('2018-11-03 05:00')
t3 = pd.to_datetime('2018-11-03 06:00')
t4 = pd.to_datetime('2018-11-03 07:00')
t5 = pd.to_datetime('2018-11-03 08:00')

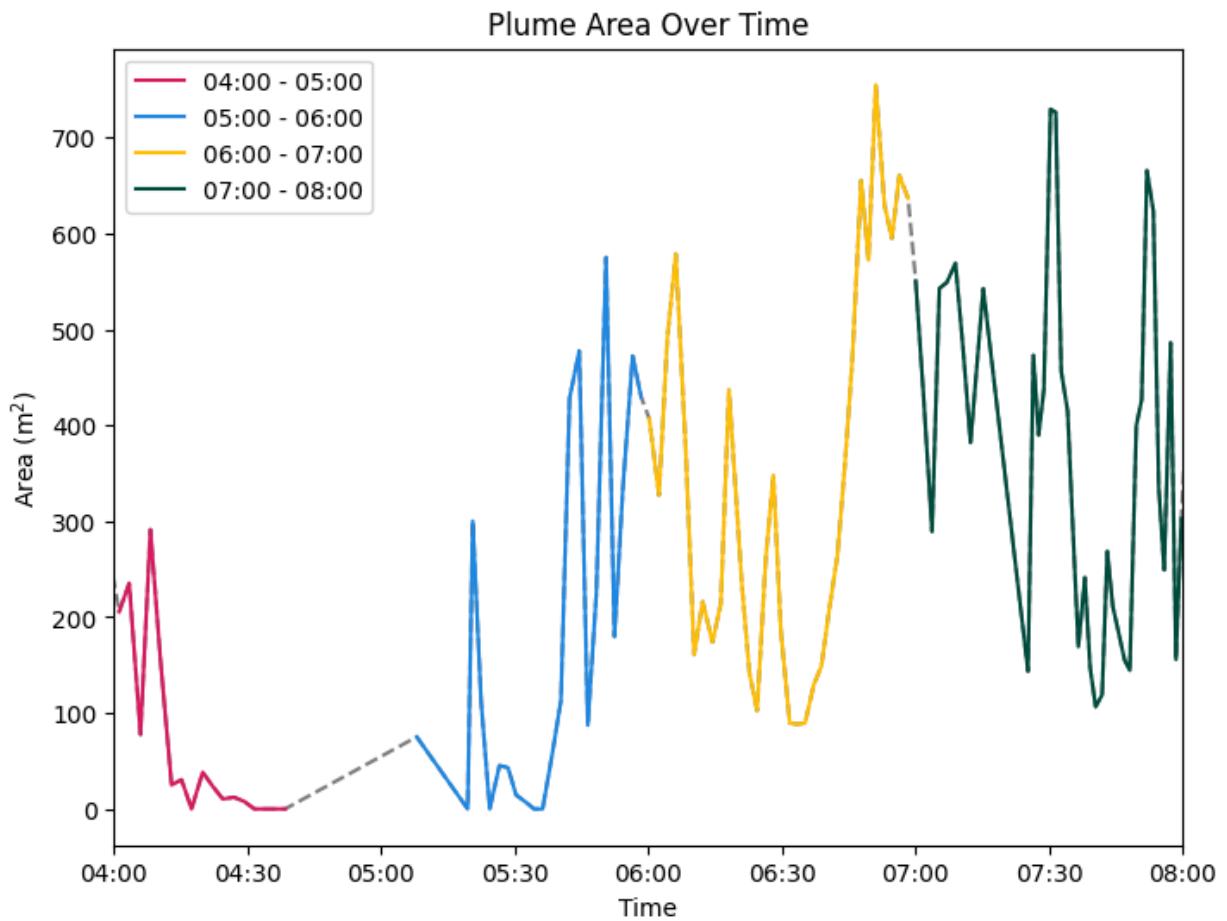
t1_series = plume_time_series[(plume_time_series['corrected_time']>=t1) & (plume_time_series['corrected_time']<=t2)]
t2_series = plume_time_series[(plume_time_series['corrected_time']>=t2) & (plume_time_series['corrected_time']<=t3)]
t3_series = plume_time_series[(plume_time_series['corrected_time']>=t3) & (plume_time_series['corrected_time']<=t4)]
t4_series = plume_time_series[(plume_time_series['corrected_time']>=t4) & (plume_time_series['corrected_time']<=t5)]

plt.figure(figsize=(8,6))
plt.plot(plume_time_series['corrected_time'], plume_time_series['plume_area_sq_m'], linestyle='solid', color=friendly_colors[0], label=time_labels[0])
plt.plot(t1_series['corrected_time'], t1_series['plume_area_sq_m'], label=time_labels[0], color=friendly_colors[0])
plt.plot(t2_series['corrected_time'], t2_series['plume_area_sq_m'], label=time_labels[1], color=friendly_colors[1])
plt.plot(t3_series['corrected_time'], t3_series['plume_area_sq_m'], label=time_labels[2], color=friendly_colors[2])
plt.plot(t4_series['corrected_time'], t4_series['plume_area_sq_m'], label=time_labels[3], color=friendly_colors[3])

plt.title('Plume Area Over Time')
plt.xlabel('Time')
plt.ylabel(r'Area ($\mathsf{m}^2$)')

time_format = mdates.DateFormatter('%H:%M')
plt.gca().xaxis.set_major_formatter(time_format)

plt.xlim(t1, t5)
plt.legend()
plt.savefig('./figures/PlumeArea.png')
```



In []:

In []:

Now I just want to create a few figures.

In []: