Impact circumstances and atmospheric breakup behaviour of 2022 WJ_1

P. Brown[1,2], D. Vida[1,2] ,P. McCausland[2,3], M. Mazur[1], P. Wiegert[1,2] and H. Devillepoix[4]

[1]Department of Physics and Astronomy
[2]Institute for Earth and Space Exploration
[3]Dept of Earth Sciences
University of Western Ontario, London Ontario, CANADA
[4]Space Science and Technology Centre, School of Earth and Planetary Sciences, Curtin University, Perth WA , AUSTRALIA

Planetary Defense Conference
Apr 4, 2023

First discovered near 5 UT on Nov 19
Fireball became luminous @ 08:26:42 UT

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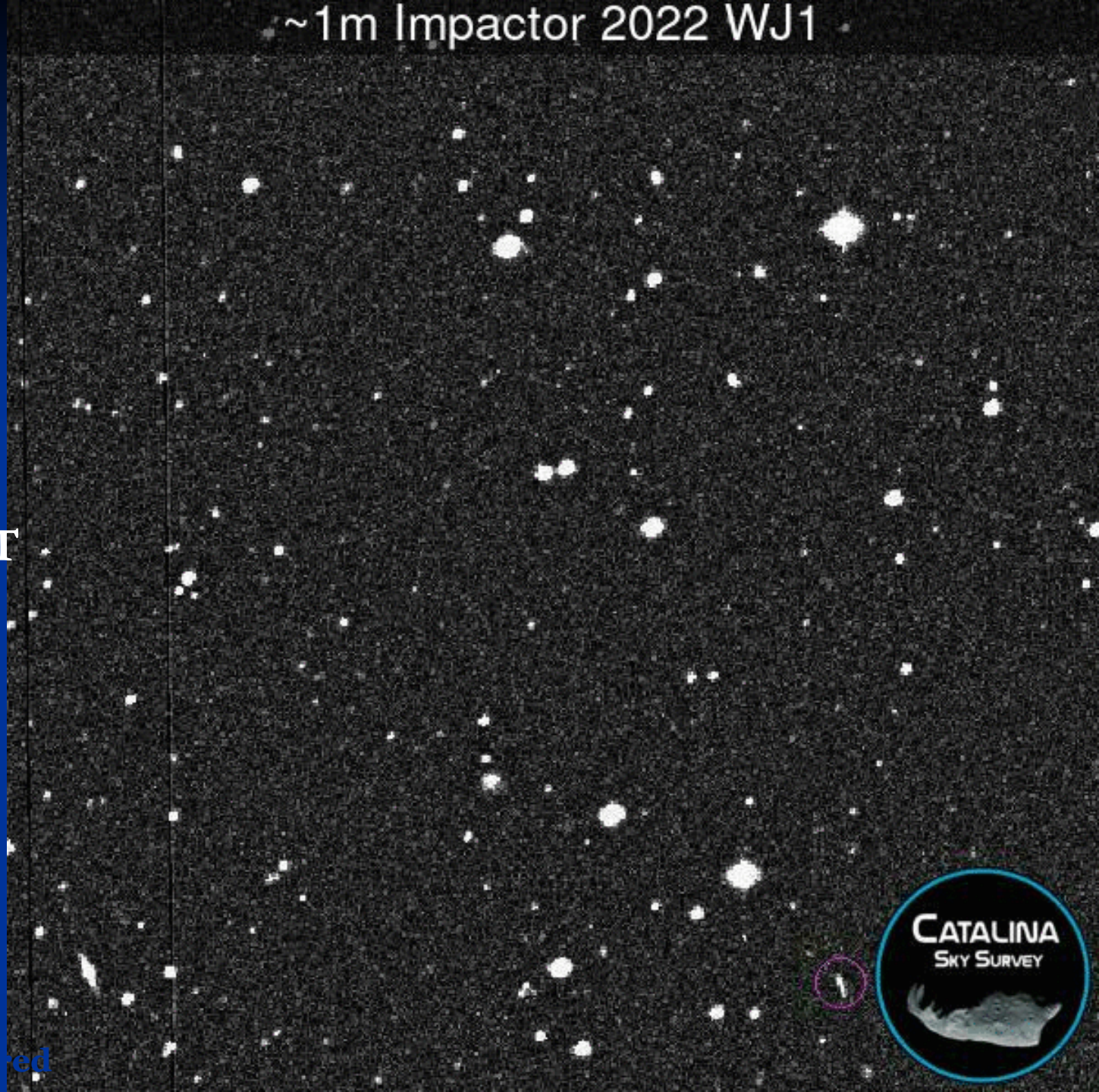
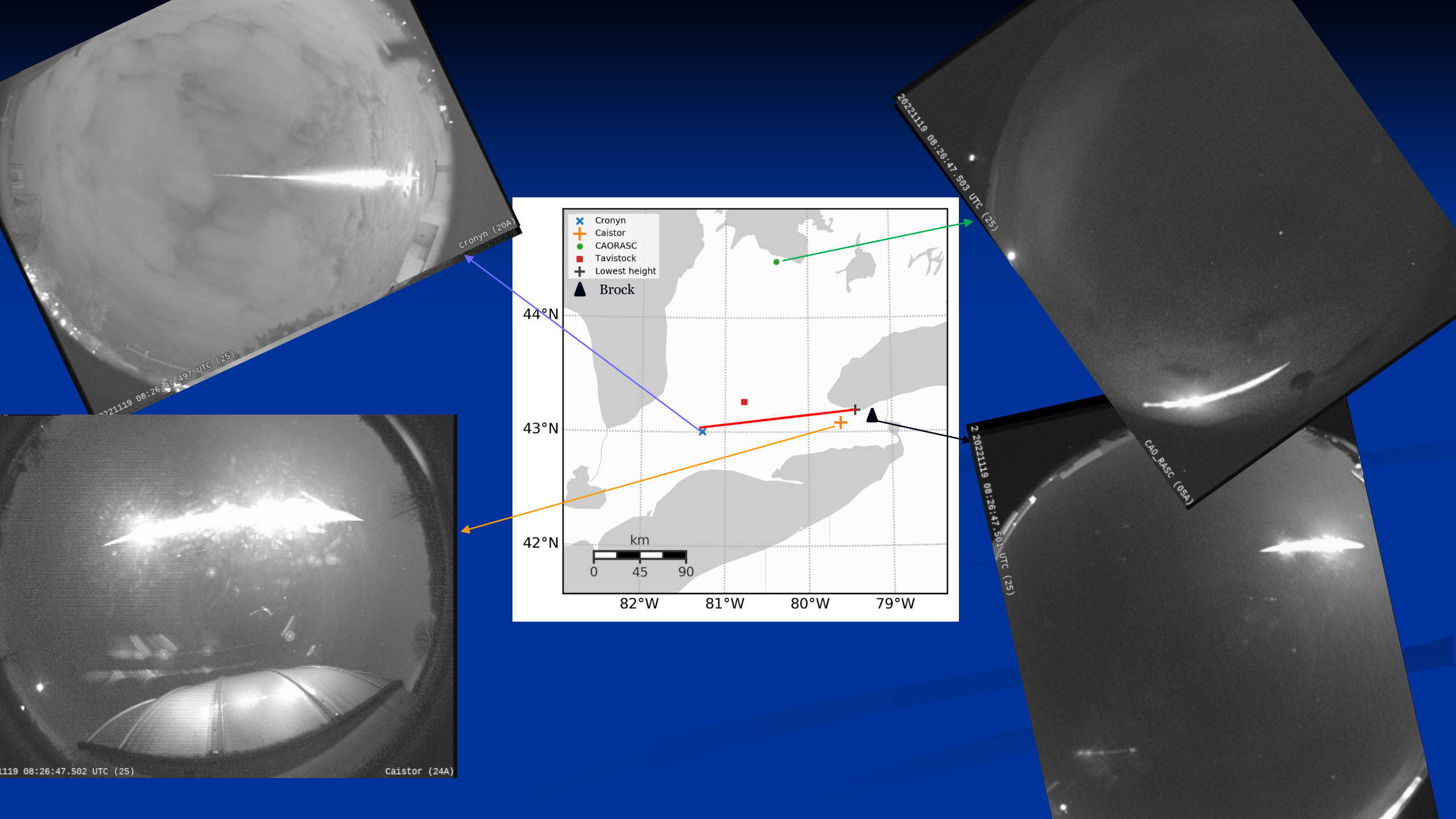
2022 WJ1

D. Rankin detected a fast moving object in images taken at Mt. Lemmon Survey (G96). The observations triggered a warning of an imminent impact. Seven observatories were able to observe the sub-meter object before it impacted the Earth's atmosphere on Nov. 19 at approximately 08:27 UTC over Brantford, Ontario, Canada.




Cronyn (20A)
20221119 08:26:47.497 UTC (25)
20221119 08:26:47.503 UTC (25)
CAO_RASC (05A)
20221119 08:26:47.501 UTC (25)
Caistor (24A)
1119 08:26:47.502 UTC (25)
Cronyn
Caistor
CAORASC
Tavistock
Lowest height
Brock
44°N
43°N
42°N
82°W
81°W
80°W
79°W
km
0
45
90

Entry Conditions

Entry angle = 21°

Ablation start height = 83 km

Ablation end height = 21.5 km

Entry Speed = 14.31 ± 0.004 km/s

Final Speed = 3.7 km/s

Duration = 12.1 sec

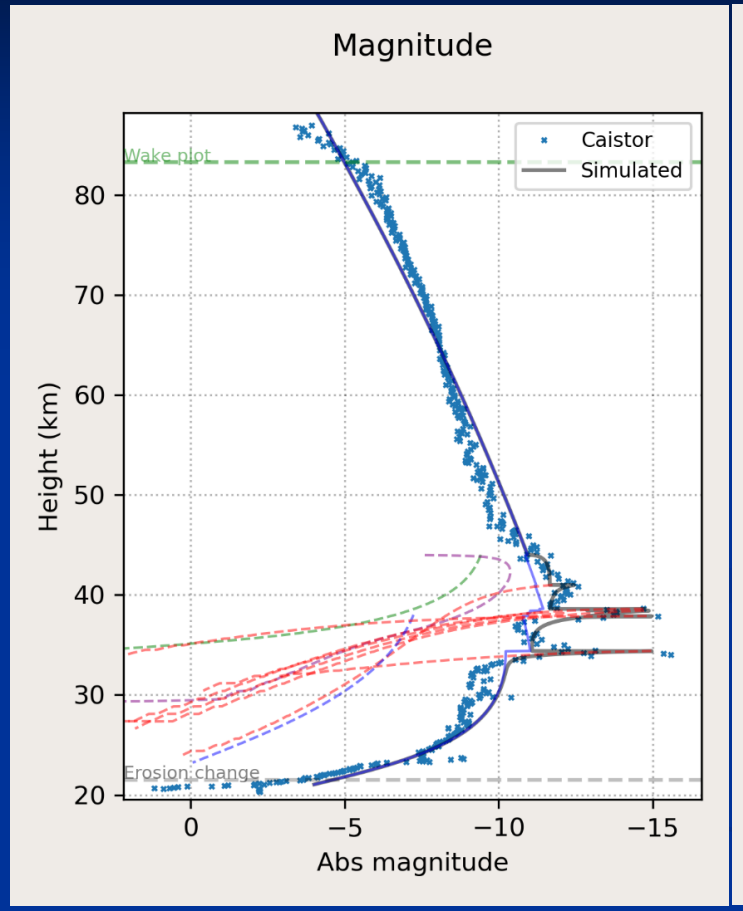
Total path length = 143 km

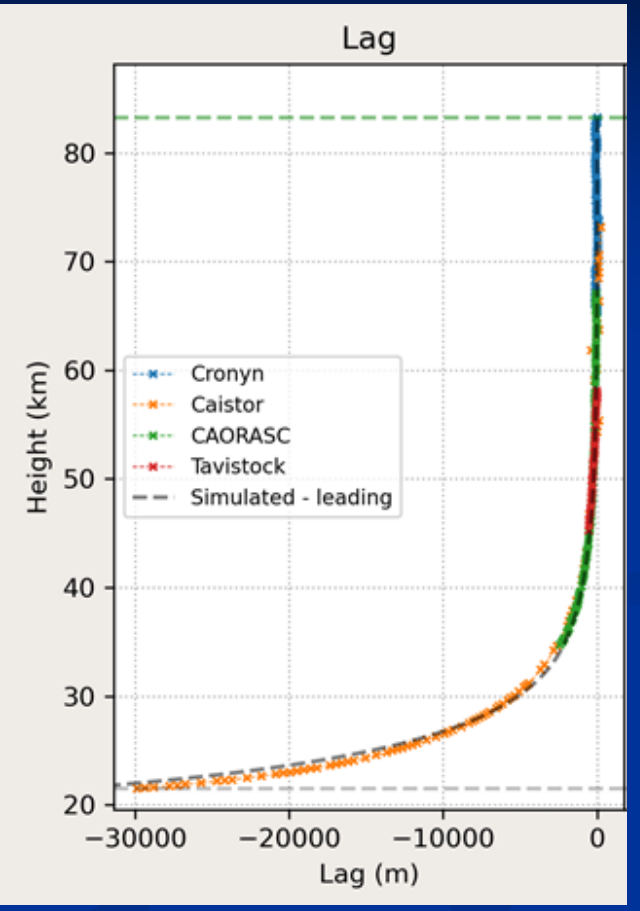
Peak Brightness -15 ± 1

	a (AU)	e	i (°)	Ω (°)	ω (°)	q (AU)	Source
Value	1.8727	0.50433	2.5821	56.7456	35.036	0.928241	*JPL*
error	3.00E-04	9.50E-05	5.00E-04	1.00E-04	3.00E-03	3.00E-04	*Horizons*
Value	1.8705	0.504405	2.5626	56.709	35.4	0.927004	*Model/Fireball*
error	5.90E-04	2.00E-04	2.10E-03	4.00E-05	2.00E-03	8.00E-05	*Solution*
Diff	2.20E-03	-7.50E-05	1.95E-02	3.66E-02	-3.64E-01	1.24E-03	

Semi-Empirical Ablation Modelling

- Used closest station with three cameras to estimate lightcurve using piece-wise fits to avoid saturation
  - Non detection by GLM places limit for peak brightness at less than -15 to -16
- Precise astrometry from four stations produced lag measurements
- Applied Borovicka et al (2020) semi-empirical fireball model to fit lightcurve and lag





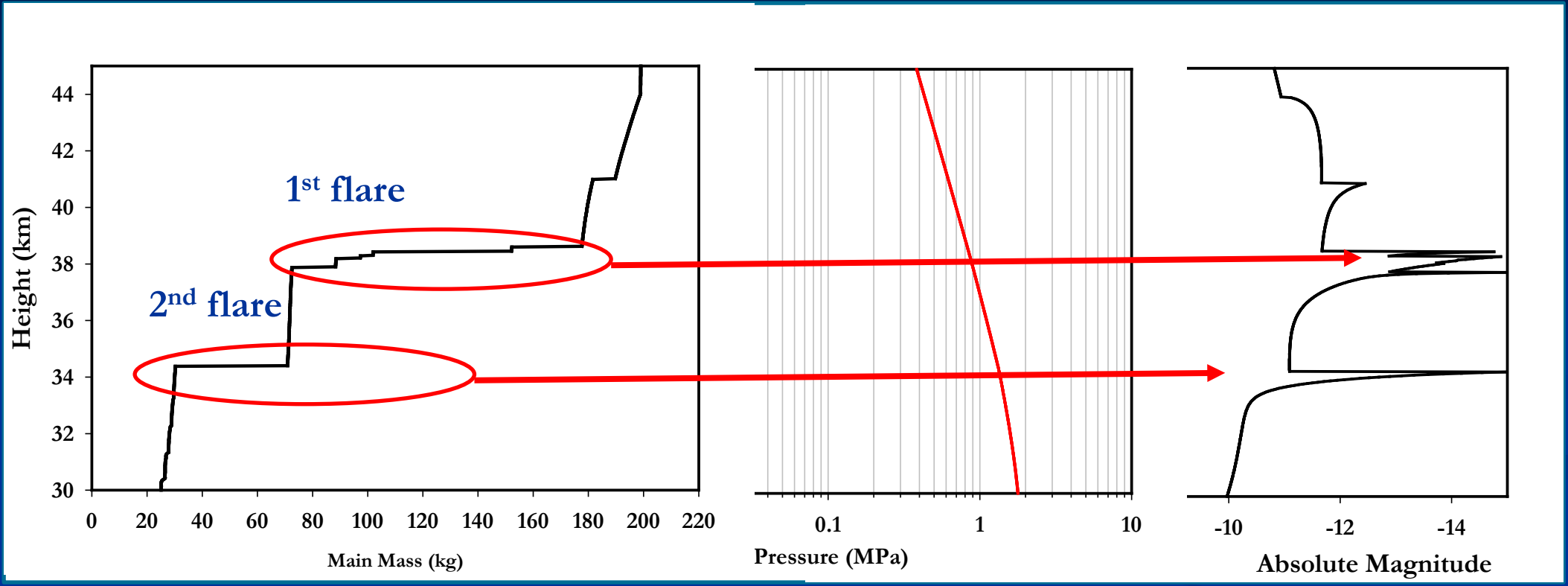
Main Fragment

Eroding grains

Secondary fragments

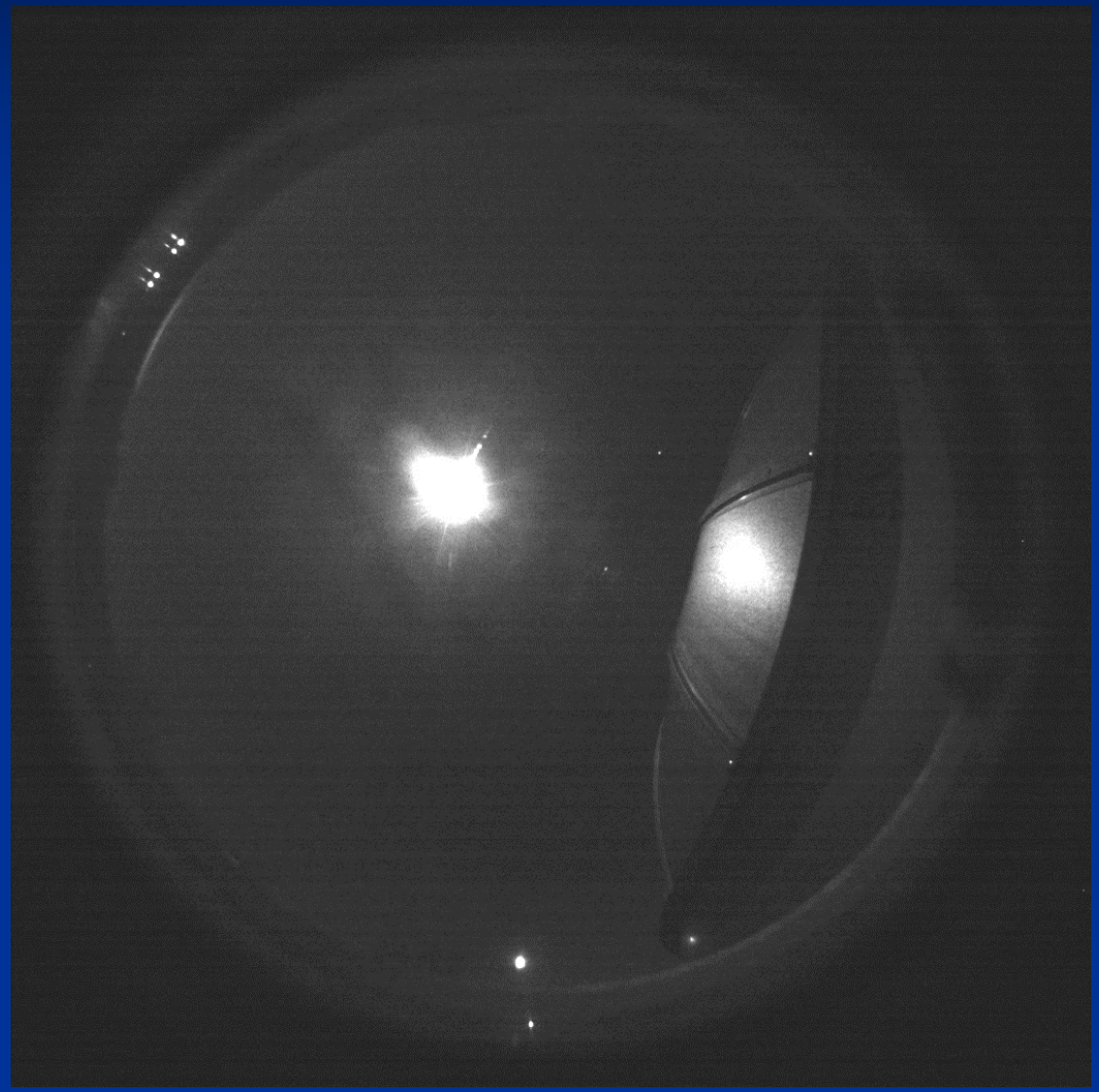
Immediate dust release

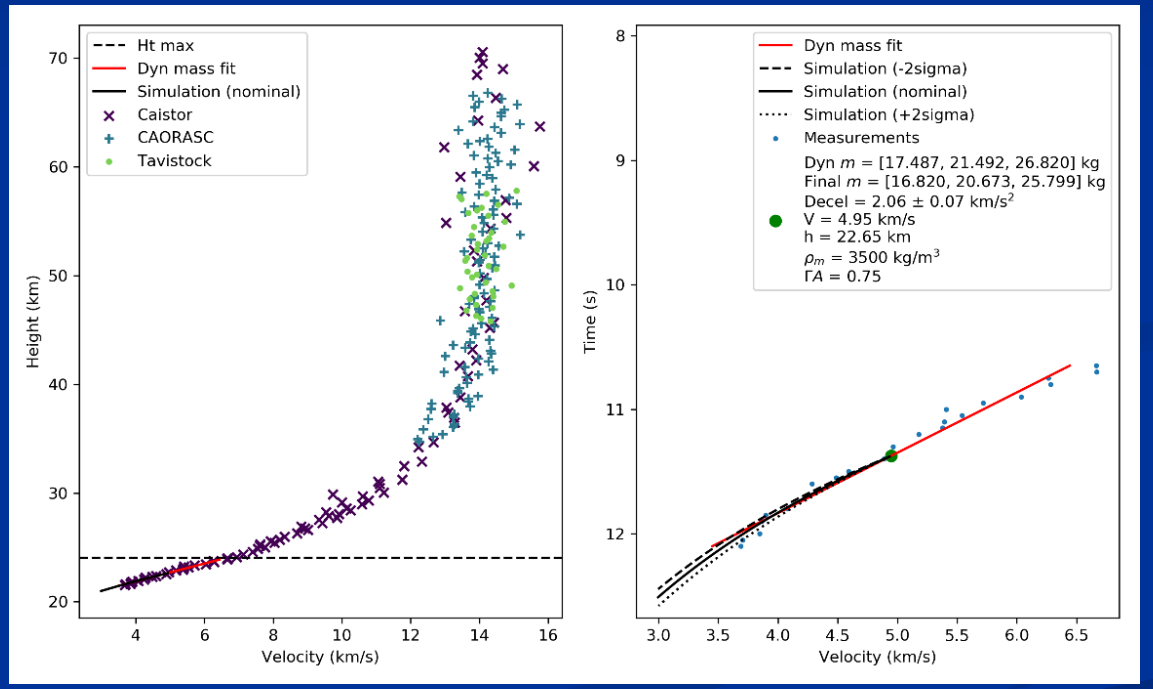
Modelling Results



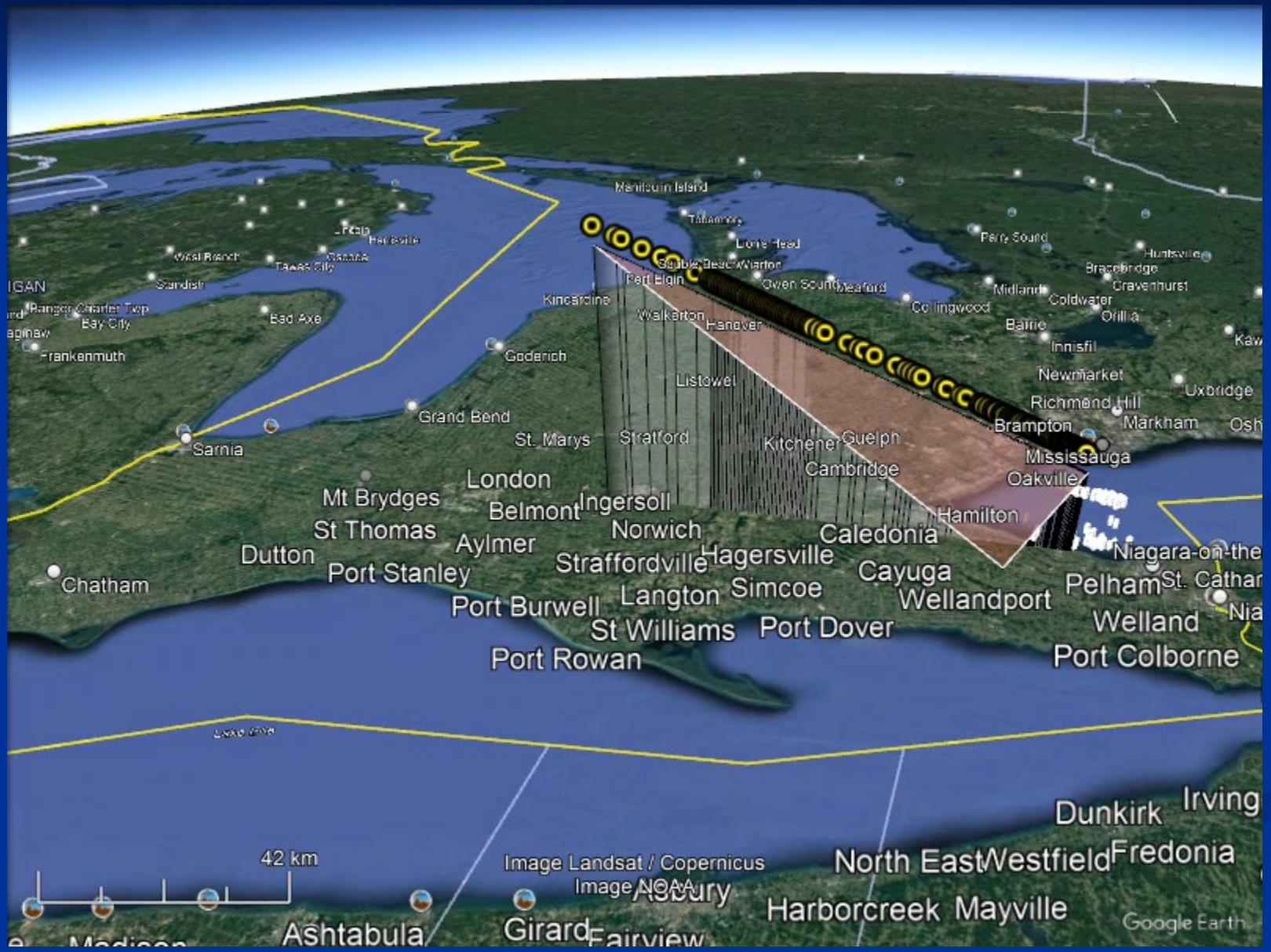
- Initial mass ~200 kg (diameter ~ 0.5m)
- Two major flares @ 38 km and 34 km
  - First flare releases 90 kg of dust at 0.9 MPa dynamic pressure
  - Second flare releases 40 kg of dust at 1.4 MPa dynamic pressure
- Final main mass ~ 20 kg.

Leading fragment

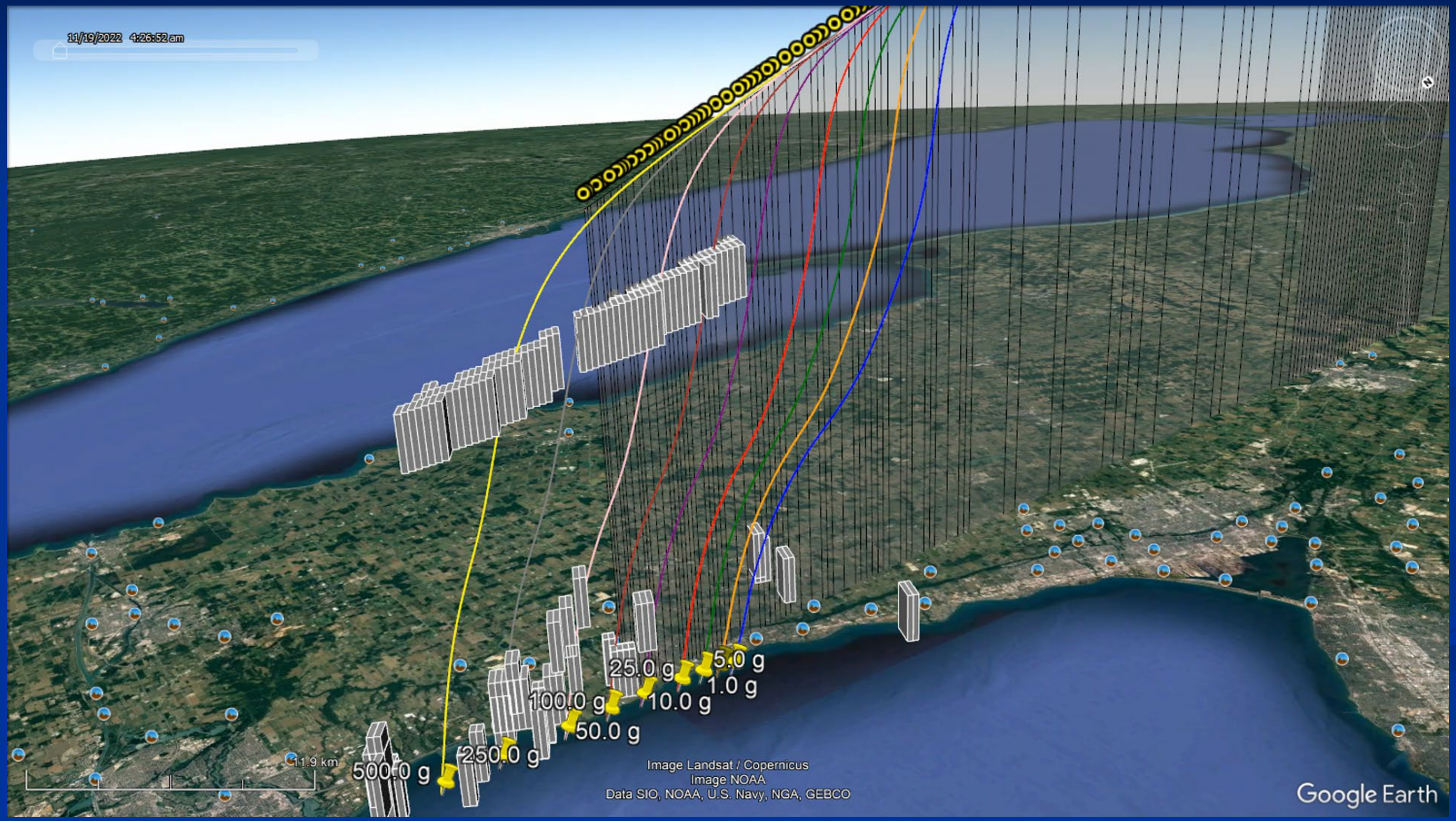


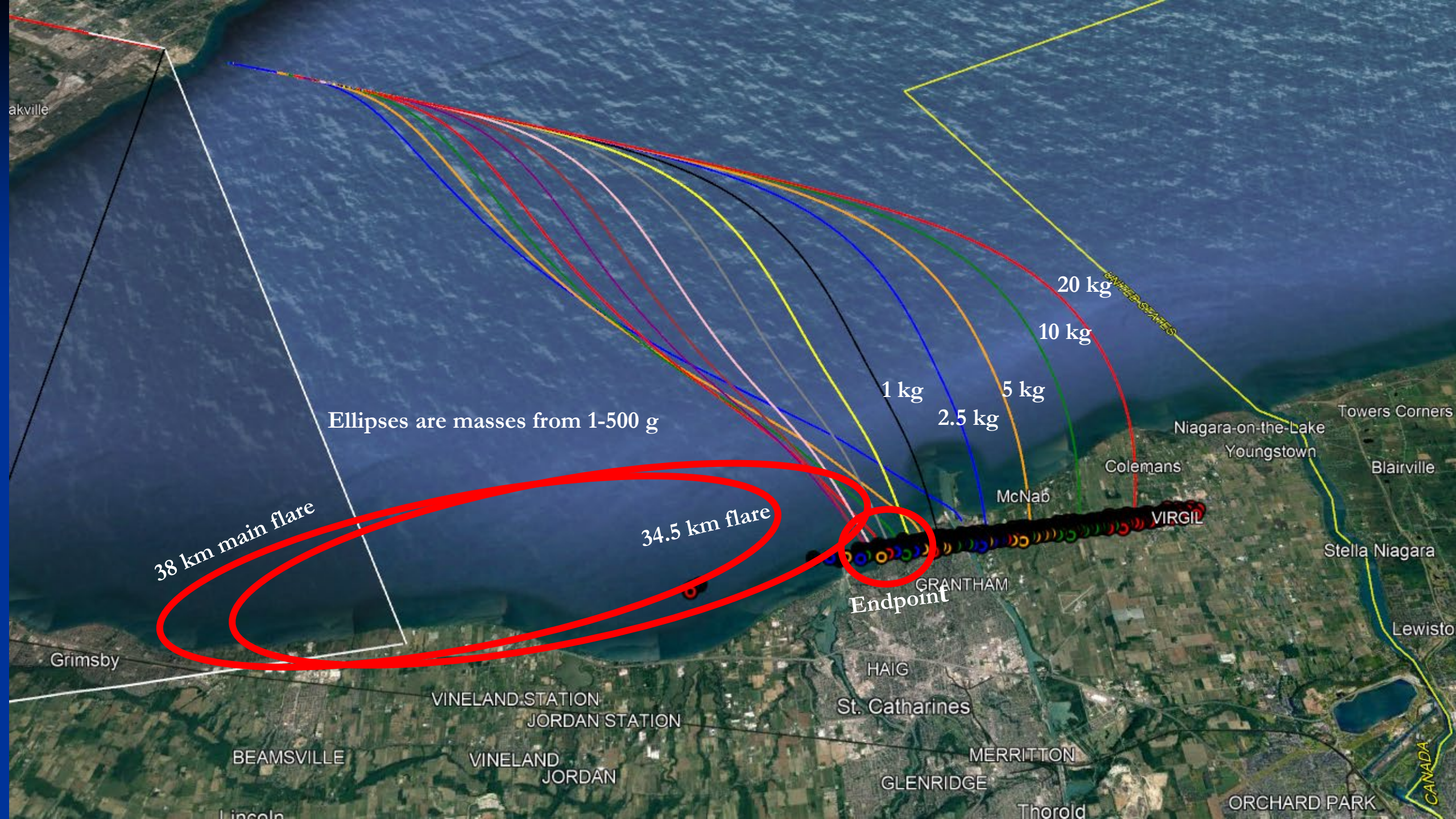


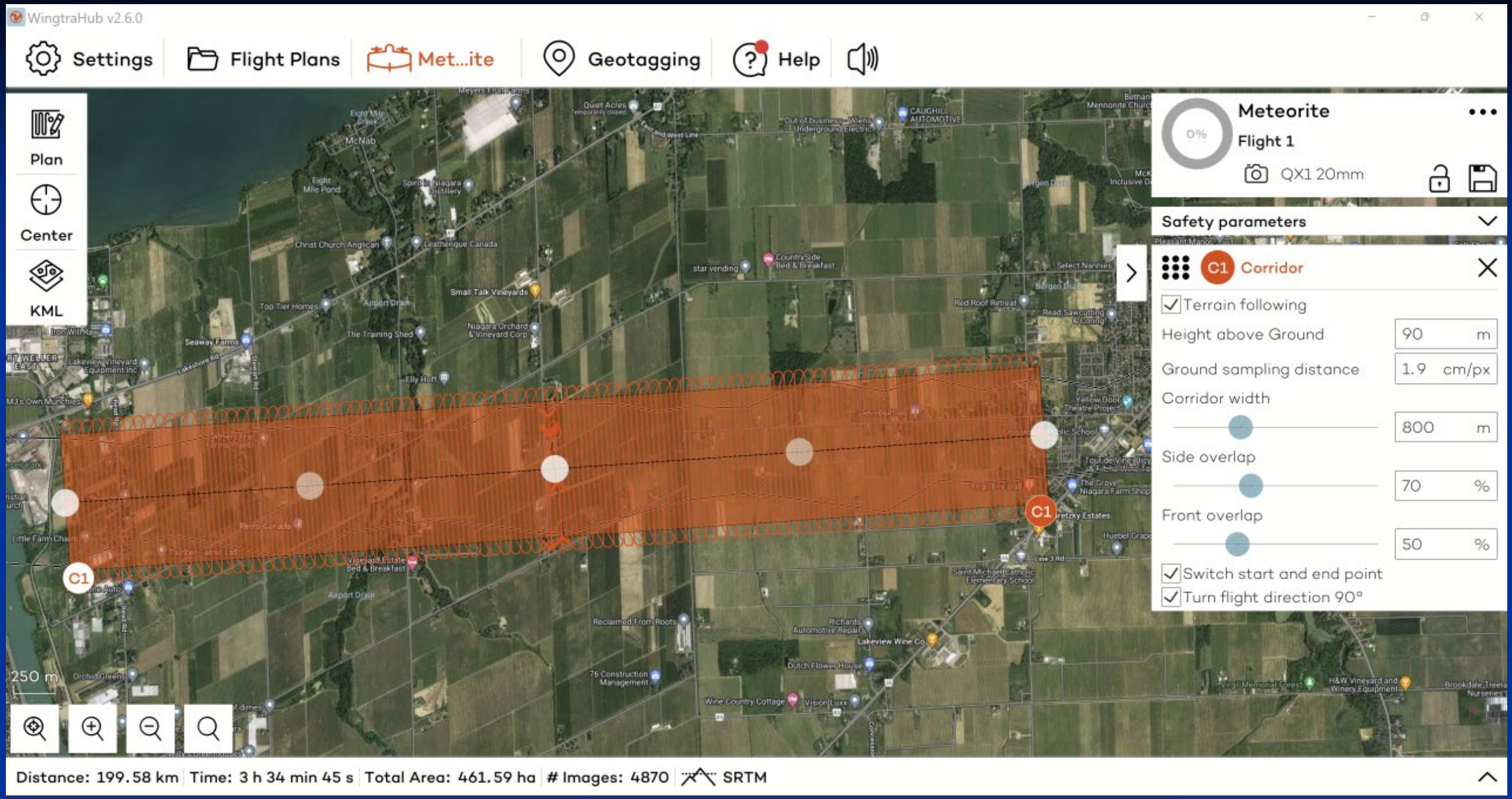
Doppler signature of meteoritic debris



Darkflight from main burst at 38 km




20 kg
10 kg
5 kg
2.5 kg
1 kg
Ellipses are masses from 1-500 g
38 km main flare
34.5 km flare
Endpoint
Towers Corners
Niagara-on-the-Lake
Youngstown
Colemans
Blairville
McNab
VIRGIL
Stella Niagara
GRANTHAM
Lewisto
Grimsby
HAIG
VINELAND STATION
JORDAN STATION
St. Catharines
BEAMSVILLE
VINELAND
JORDAN
MERRITTON
GLENRIDGE
Thorold
ORCHARD PARK
CANADA


WingtraHub v2.6.0
Settings
Flight Plans
Met...ite
Geotagging
Help
Plan
Center
KML
Meteorite
0%
Flight 1
QX1 20mm
Safety parameters
C1 Corridor
Terrain following
Height above Ground
90 m
Ground sampling distance
1.9 cm/px
Corridor width
800 m
Side overlap
70 %
Front overlap
50 %
Switch start and end point
Turn flight direction 90°
C1
C1
250 m
Distance: 199.58 km
Time: 3 h 34 min 45 s
Total Area: 461.59 ha
Images: 4870
SRTM


Line 2 Rd
Line 2 Rd
Line 2 Rd

Summary

- 2022 WJ_1 showed most fragmentation/mass loss at ~1 MPa – at low strength end of typical meteorite producing fireballs
  - Almost all mass lost as dust
  - Doppler radar signatures consistent with many gram-sized to few hundred gram sized fragments
- Initial mass from model ~200 kg
  - Corresponds to body 0.5m in diameter
  - For H=33.6 implies albedo ~ 0.25
- Most meteorites in Lake Ontario – one main mass (20 kg) likely in vineyards NE of St Catherines, ON
- Ground searches from drone imagery to be conducted in spring 2023

Backup


Line 2 Rd
Line 2 Rd
Line 2 Rd
Concession 7 Rd