MEOSAR Performance

SAR Controllers Workshop 2018
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Jesse Reich
SARSAT Ground Systems Engineer
NOAA

Introduction

- On 13 December 2016 the Cospas-Sarsat system entered the Early Operational Capability (EOC) for the MEOSAR System

- The MEOLUT location accuracy requirements for EOC are:
  - Single burst: 70% within 5 km; and 90% within 10 km
  - Multiple burst: 95% < 5 km and 98% < 10 km, within 20 minutes

- And, location accuracy requirements in the future (IOC/FOC) are:
  - Single burst: 90% within 5 km (no 10 km criteria)
  - Multiple burst: 95% < 5 km and 98% < 10 km, within 10 minutes

- The US MEOLUTs are currently meeting the EOC location accuracy requirements and in most cases the IOC/FOC requirements

Moving Beacon Accuracy

- However, recent international studies, and *more importantly* real world data collected by the USCG, have identified that location accuracy from MEOSAR data can be significantly degraded when the beacon is in motion

- In the current system, an activated beacon could be moving rapidly (e.g., on an aircraft), but the current concern is with "slow" moving beacons (e.g., < 5 knots) resulting generally from beacons drifting at sea (which happens quite often), but could also apply to a hiker walking with a PLB and other conditions

- MEOLUTs use 406 MHz beacon burst data relayed via multiple satellites to compute a Difference of Arrival (DOA) location using both Time of Arrival (TOA), and Frequency of Arrival (FOA) measurements

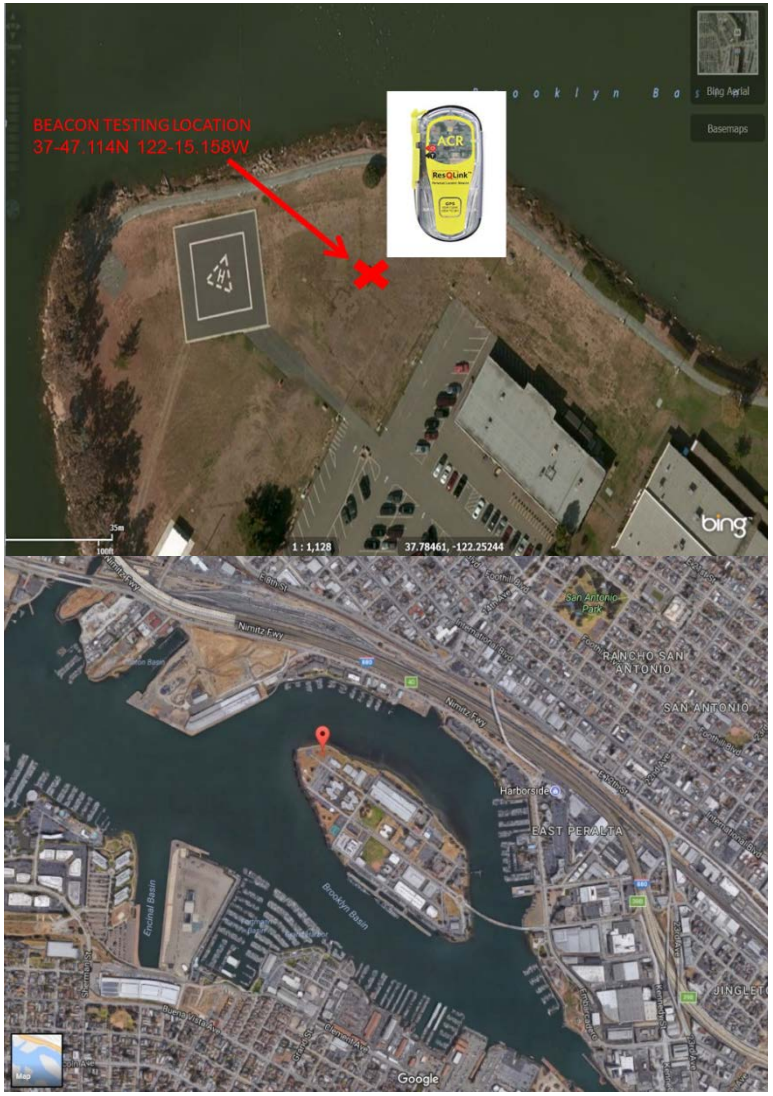
- The reason that location accuracy is degraded stems from using Frequency of Arrival (FOA) in the computation, as the relative motion between the beacon and satellites produces a small but detrimental Doppler shift into these frequency measurements

“Real-World” Testing

- The US SARSAT Program conducted tests in July 2017 with beacons to gauge MEOSAR system performance.
- Many RCC’s participated by activating the beacons and provided information regarding times, locations, conditions, etc… So Thank you!
- This testing has provided valuable insights about system performance and how to improve it.
- Tests were generally conducted by activating a real (test-coded) beacon for a 24-hour period.
- Results of the tests are very good, and demonstrate that the MEOSAR system is providing accurate and timely alerts in various locations within the US AOR. Some of these results are presented here, but there are far more that can be provided if desired.

Site #1 - Alameda

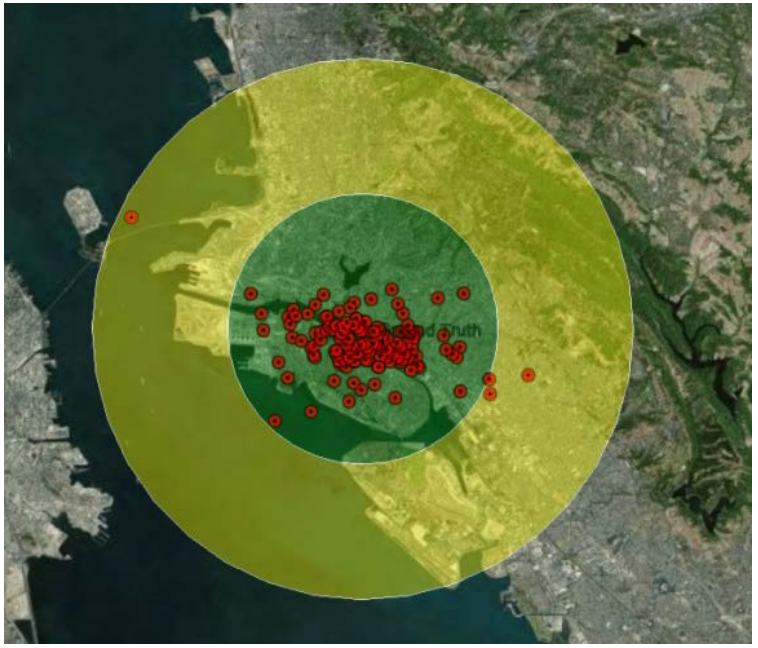
MEOLUT	Hawaii	Florida
Ground Truth Lat	37.7852	37.7852
Ground Truth Lon	-122.2526	-122.2526
Distance from MEOLUT (km)	**3867.1**	**4147.7**
Time First Burst	7/11/2017 17:01	7/11/2017 17:01
Time Last Burst	7/12/2017 17:32	7/12/2017 17:32
Expected MBL	148	74
Number MBL Detected	136	73
Prob MBL	91.89%	98.65%
Num MBL < 5 km	132	73
% MBL < 5 km	97.06%	100%
Num MBL < 10 km	136	73
% MBL < 10 km	100%	100%
NumMBL <5km (vs Enc)	131	72
% MBL <5km (vs Enc)	96.32%	98.63%
NumMBL <10km (vs Enc)	135	72
% MBL <10km (vs Enc)	99.26%	98.63%
NumMBL <20km (vs Enc)	135	72
% MBL <20km (vs Enc)	99.26%	98.63%



Site #1 – Alameda cont'd
Multiburst "Windowed" Locations

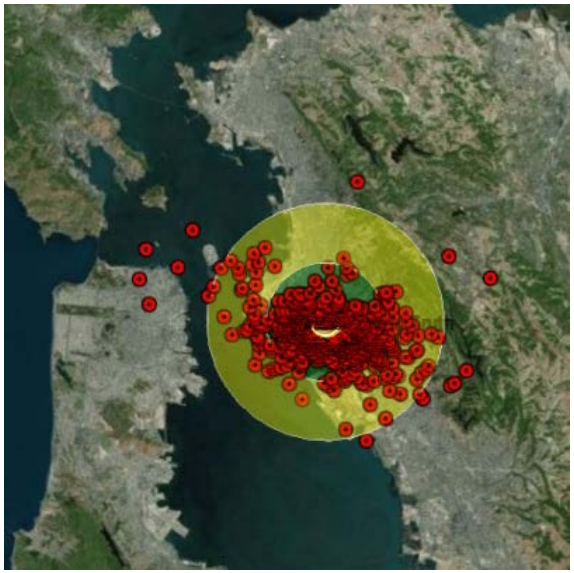
Hawaii (3385)

Florida (3669)

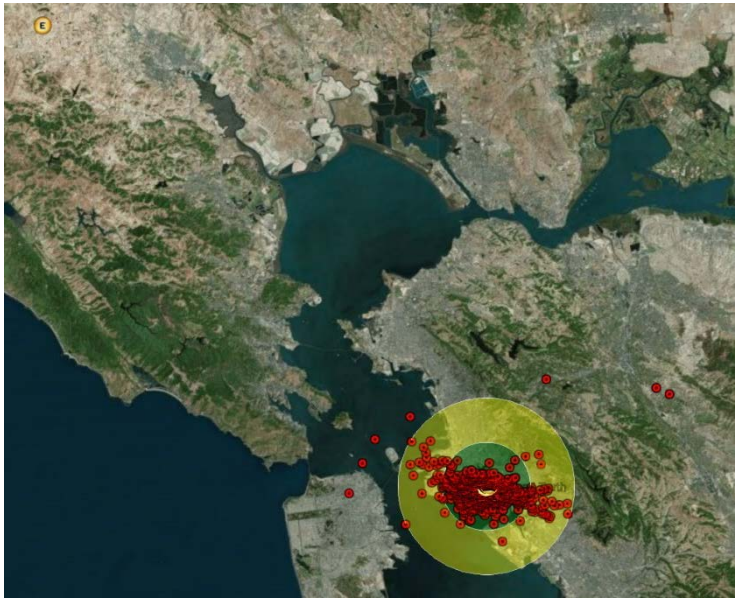


Site #1 – Alameda cont'd
All MEOLUT Locations

Hawaii (3385)



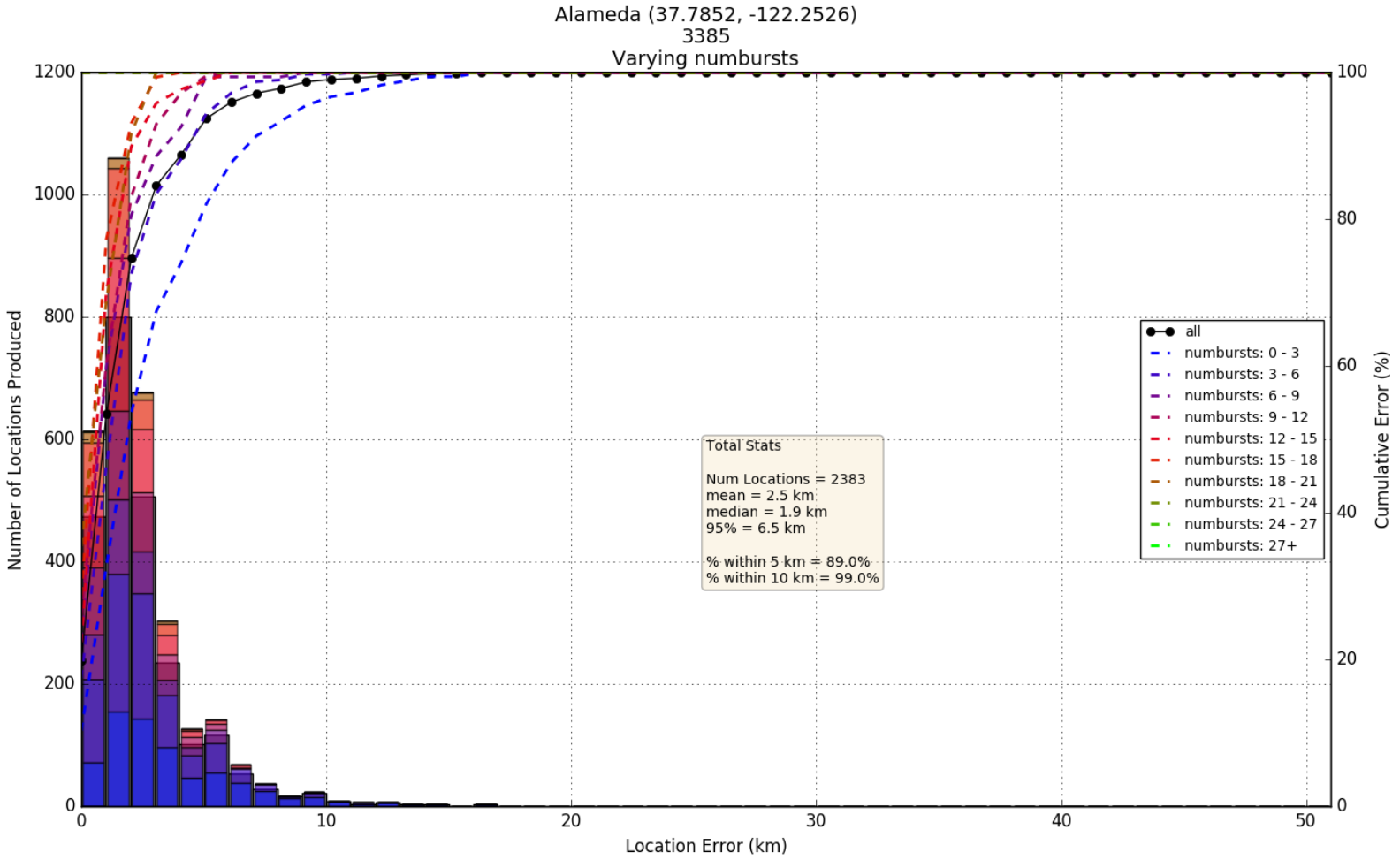
Florida (3669)



Location	MEO-1	# locations	ave	# <5 km	% < 5 km	# < 10 km	% < 10 km	# < 20 km	% < 20 km	median (km)	75% (km)	90% (km)	95% (km)
Alameda	3385	2383	2.49	2116	0.89	2352	0.99	2383	1.0	1.88	3.02	5.14	6.54
Alameda	3669	2452	2.2	2301	0.94	2439	0.99	2448	1.0	1.67	2.77	4.16	5.37

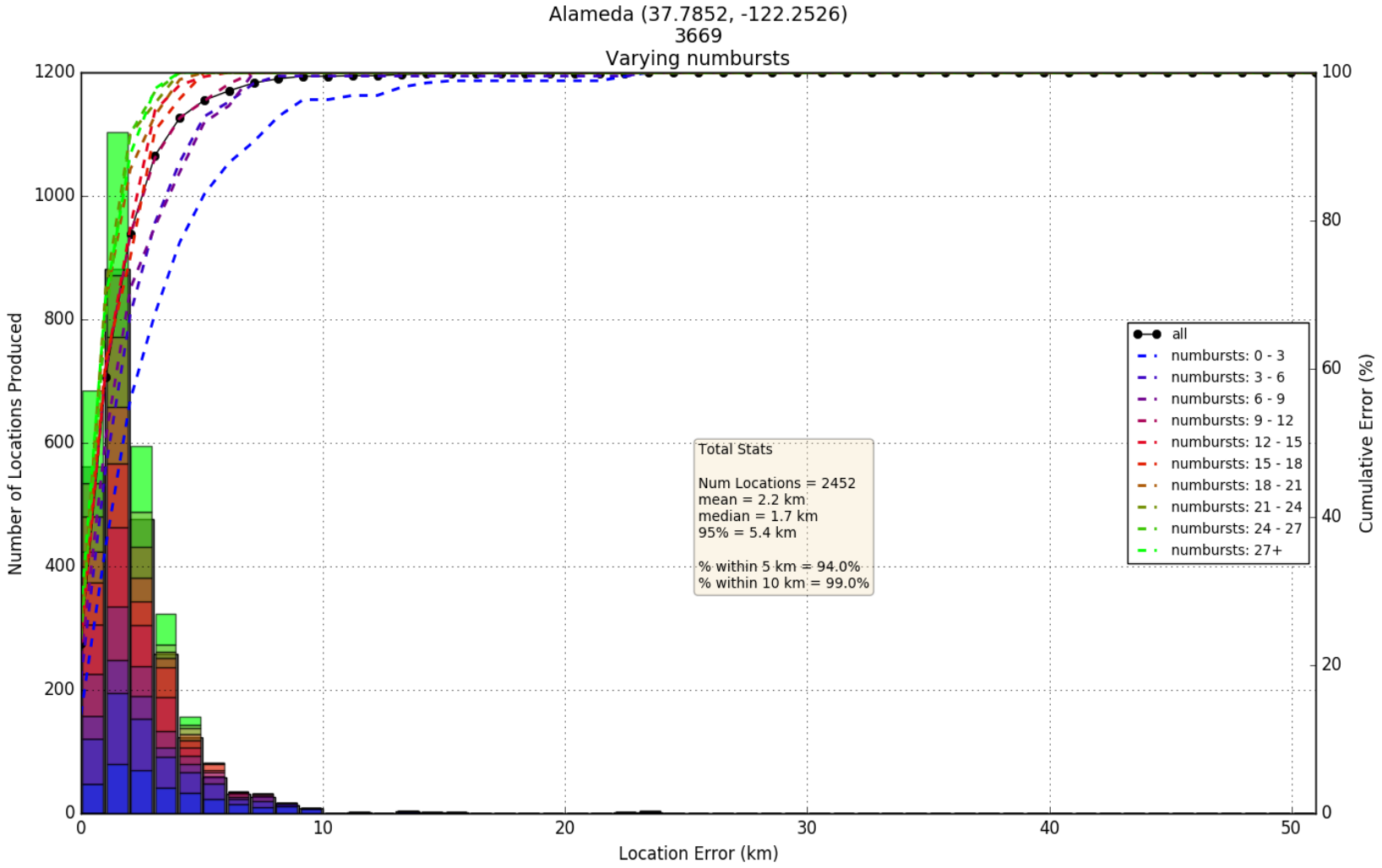
Site #1 – Alameda cont'd
Assessing Number of Bursts

Hawaii (385)



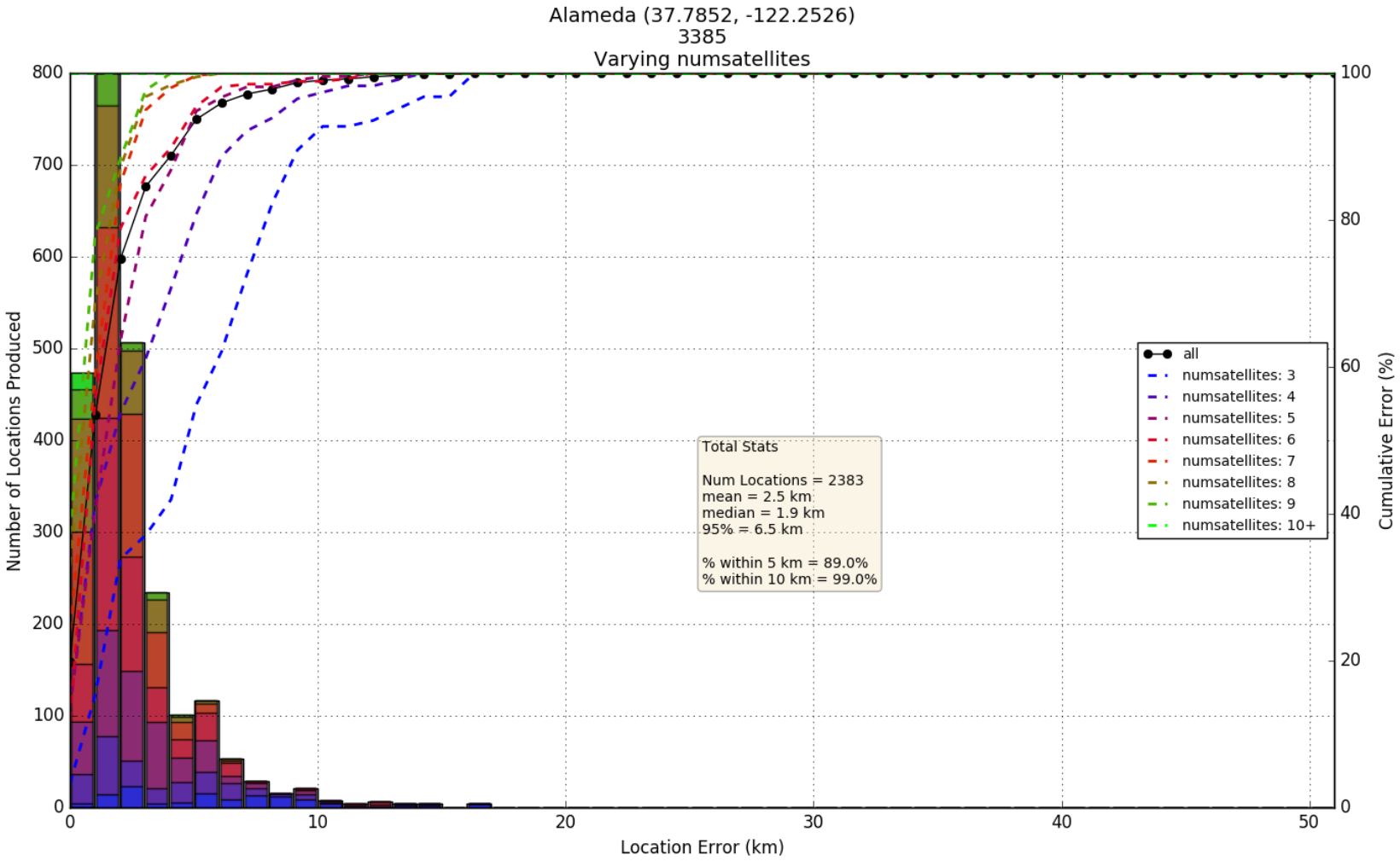
Site #1 – Alameda cont'd
Assessing Number of Bursts

Florida (3669)



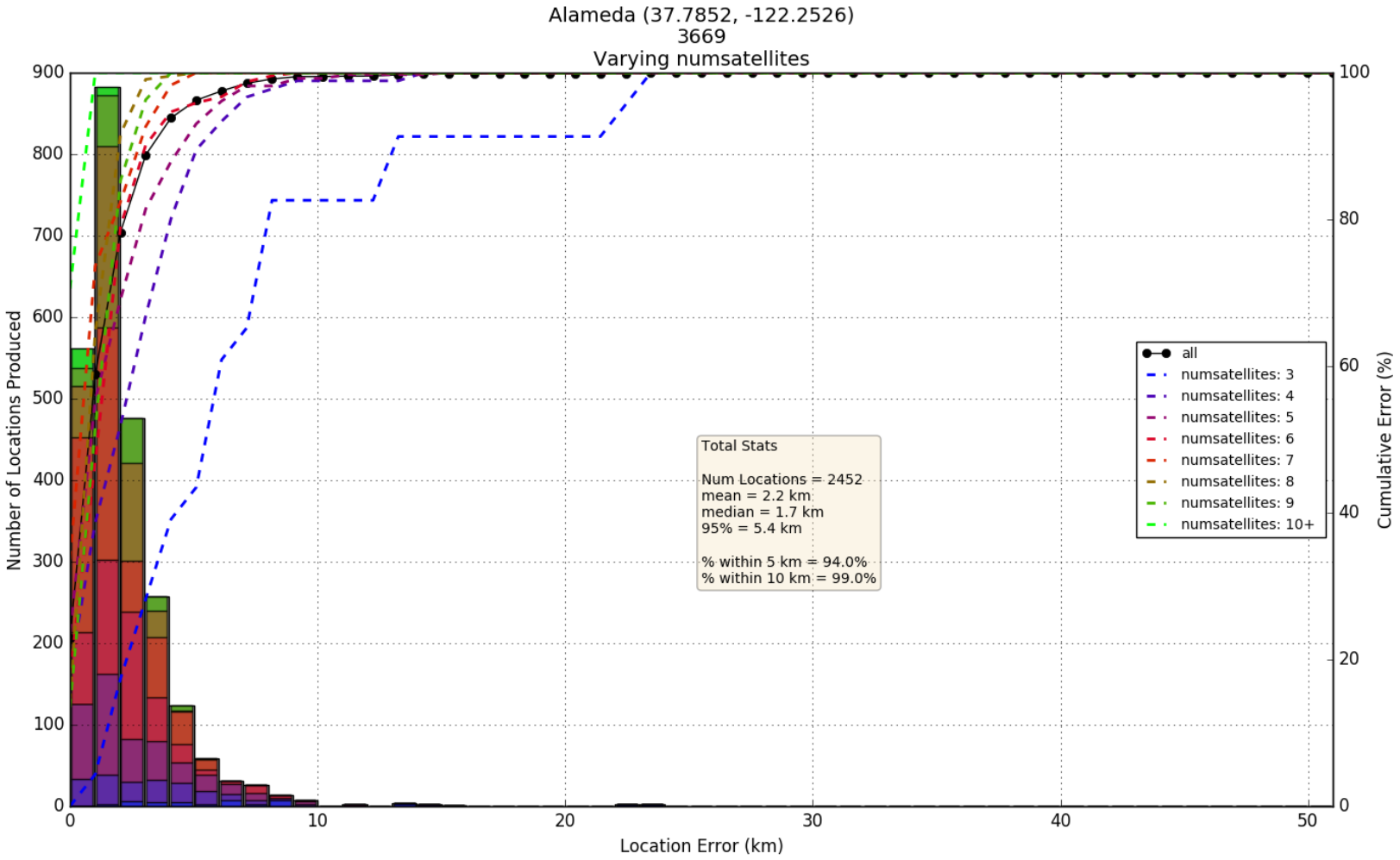
Site #1 – Alameda cont'd
Assessing Number of Satellites

Hawaii (385)



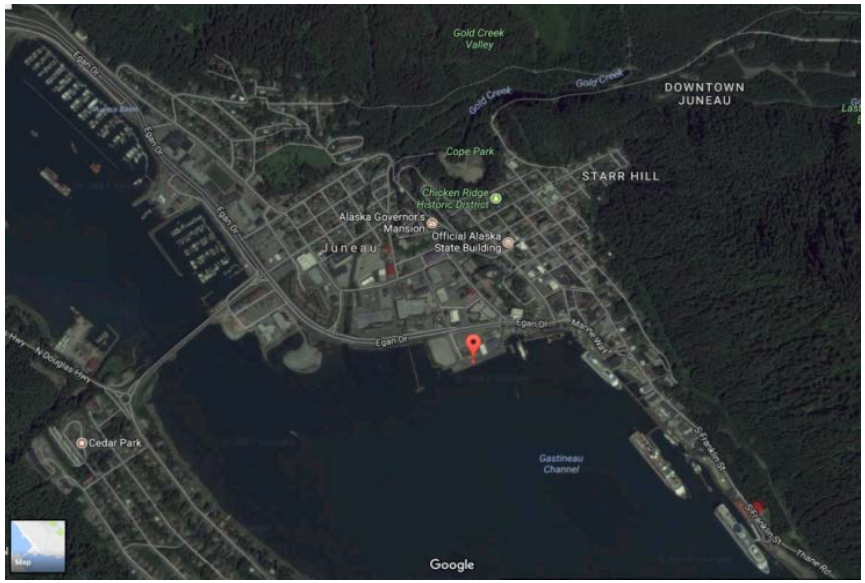
Site #1 – Alameda cont'd
Assessing Number of Satellites

Florida (3669)



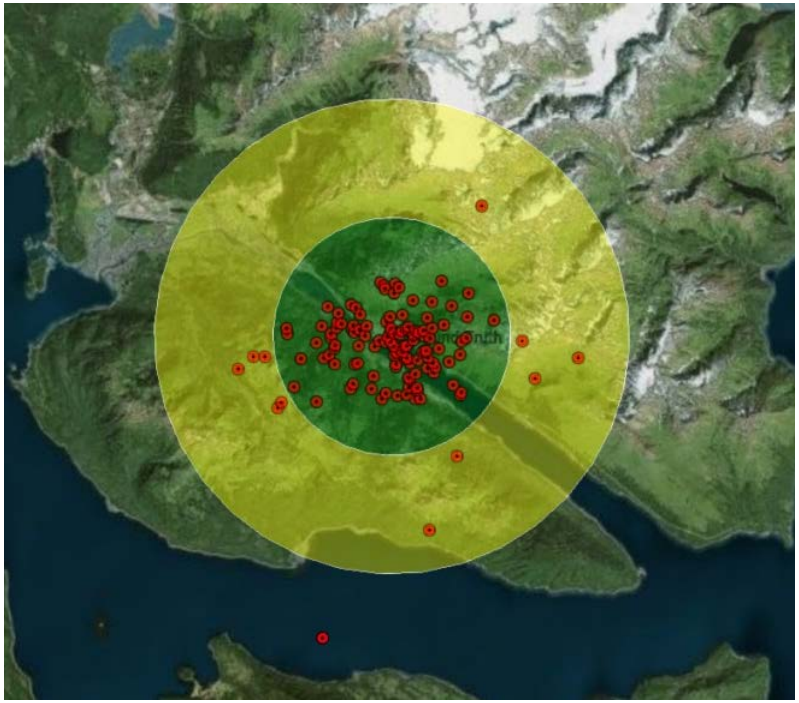
Site #2 – Juneau

MEOLUT	Hawaii	Florida
Ground Truth Lat	58.2983	58.2983
Ground Truth Lon	-134.4124	-134.4124
Distance from MEOLUT (km)	4507.2569	5533.2675
Time First Burst	7/13/2017 18:05	7/13/2017 18:05
Time Last Burst	7/14/2017 18:19	7/14/2017 18:19
Expected MBL	146	73
Number MBL Detected	130	71
Prob MBL	89.04%	97.26%
Num MBL < 5 km	118	67
% MBL < 5 km	90.77%	94.37%
Num MBL < 10 km	129	70
% MBL < 10 km	99.23%	98.59%
NumMBL <5km (vs Enc)	118	67
% MBL <5km (vs Enc)	90.77%	94.37%
NumMBL <10km (vs Enc)	129	70
% MBL <10km (vs Enc)	99.23%	98.59%
NumMBL <20km (vs Enc)	130	71
% MBL <20km (vs Enc)	100.00%	100.00%

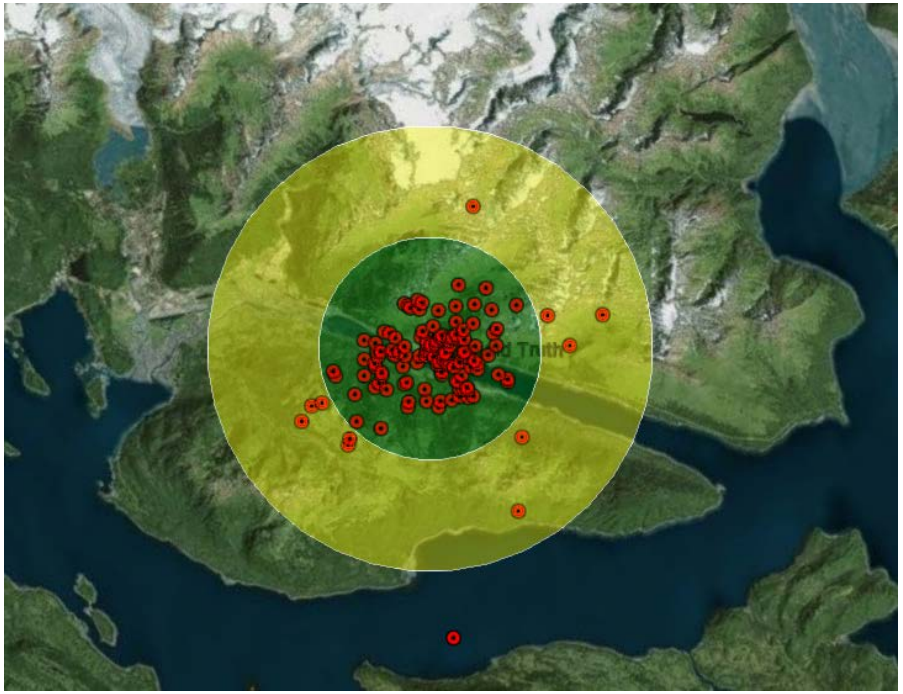


Site #2 – Juneau cont'd
Multiburst "Windowed" Locations

Hawaii (3385)

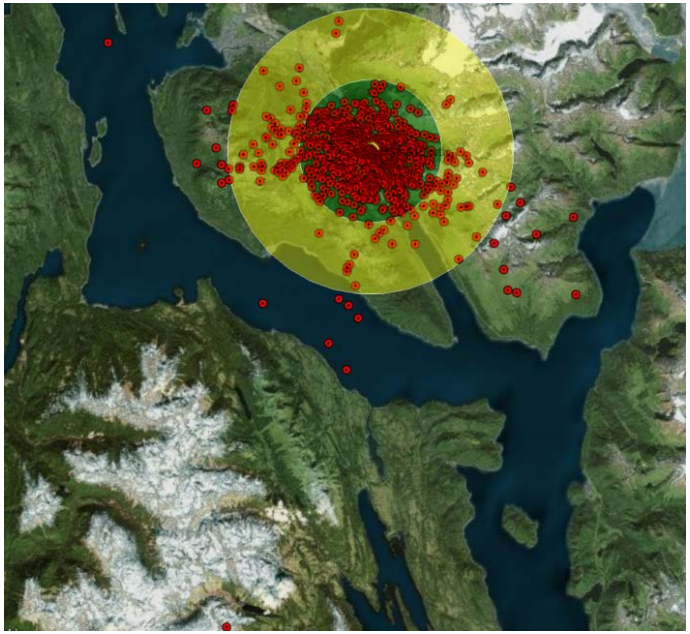


Florida (3669)

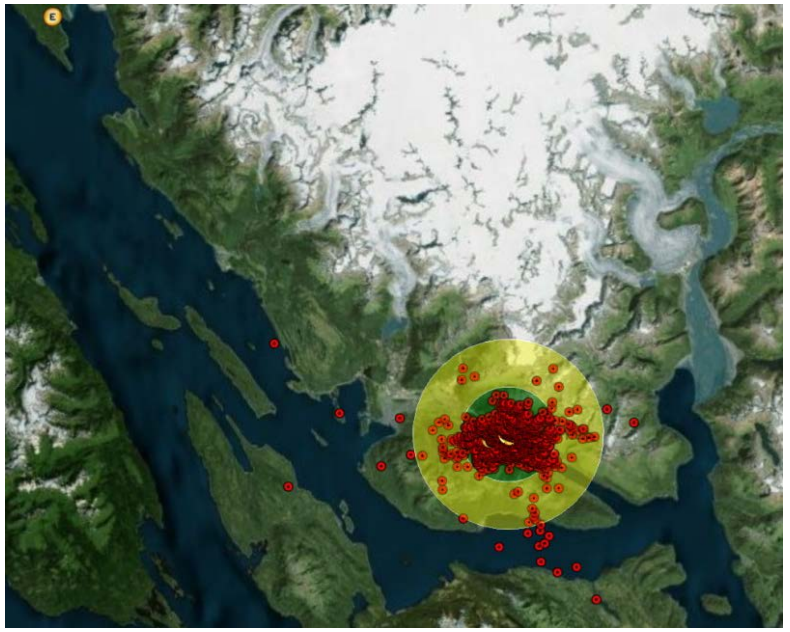


Site #2 – Juneau cont'd
All MEOLUT Locations

Hawaii (3385)



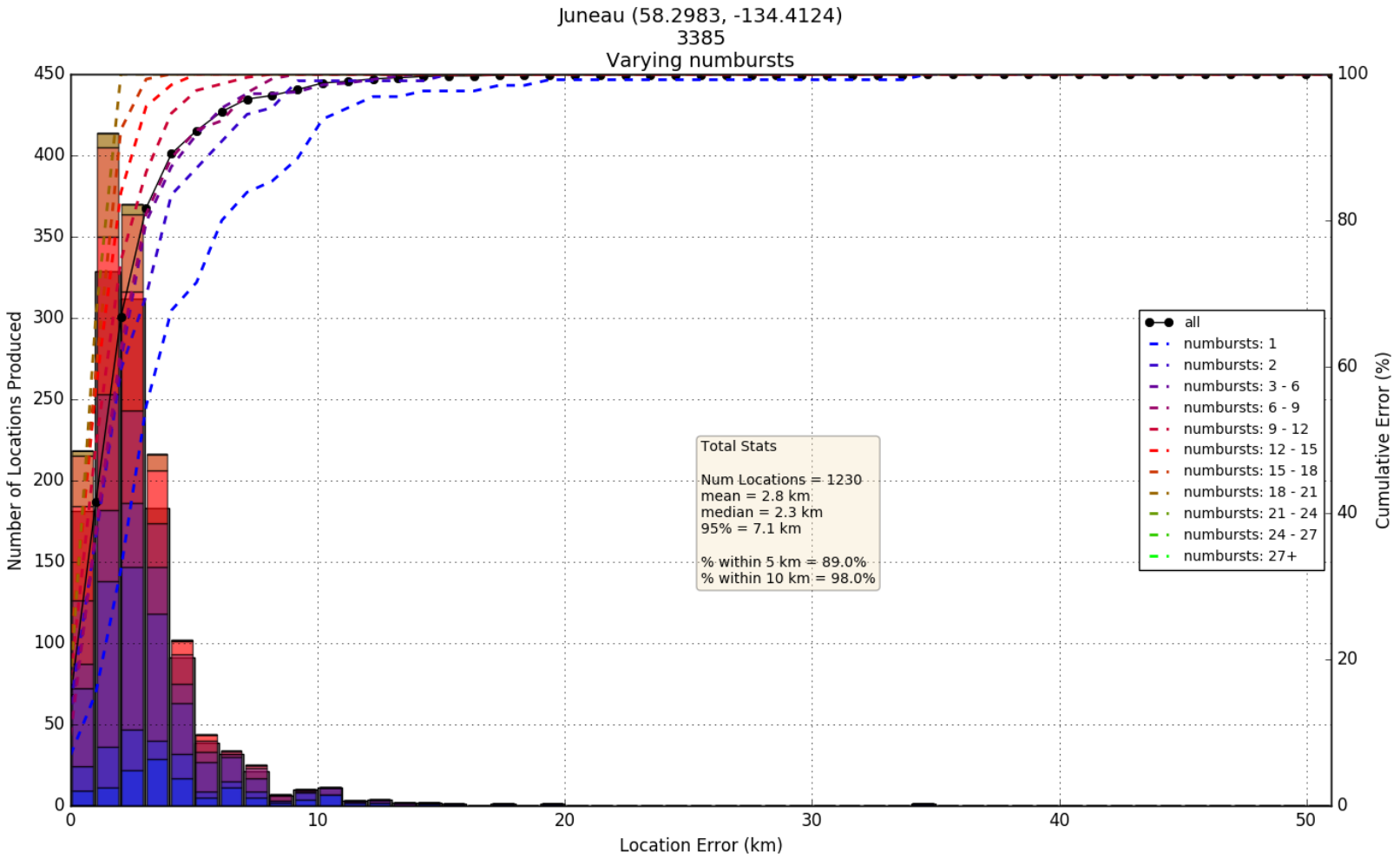
Florida (3669)



Location	MEO-1	# locations	ave	# <5 km	% < 5 km	# < 10 km	% < 10 km	# < 20 km	% < 20 km	median (km)	75% (km)	90% (km)	95% (km)
Juneau	3385	1230	2.83	1096	0.89	1204	0.98	1229	1.0	2.32	3.47	5.33	7.09
Juneau	3669	1236	2.79	1126	0.91	1217	0.98	1234	1.0	2.37	3.33	4.71	6.33

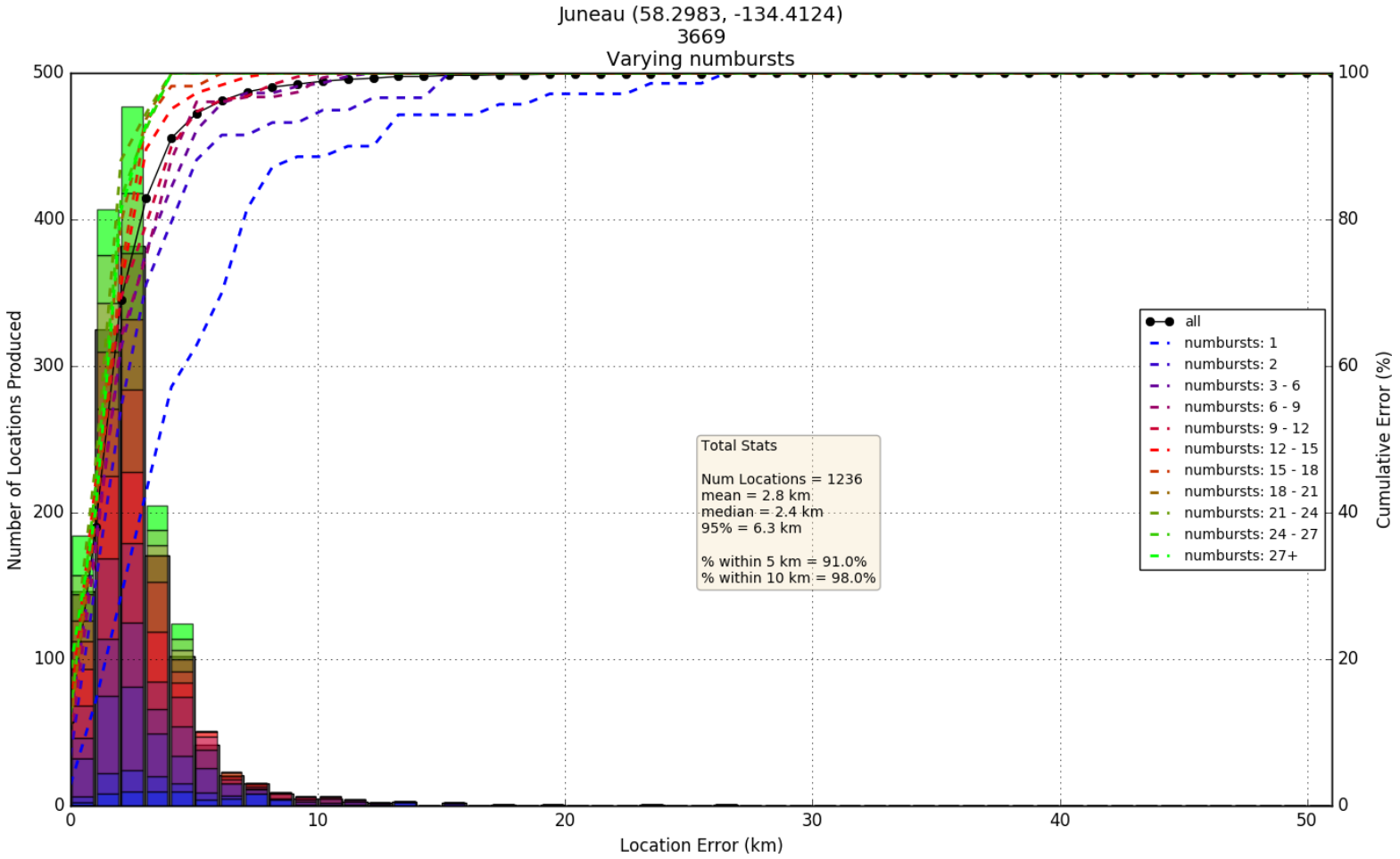
Site #2 – Juneau cont'd
Assessing Number of Bursts

Hawaii (385)



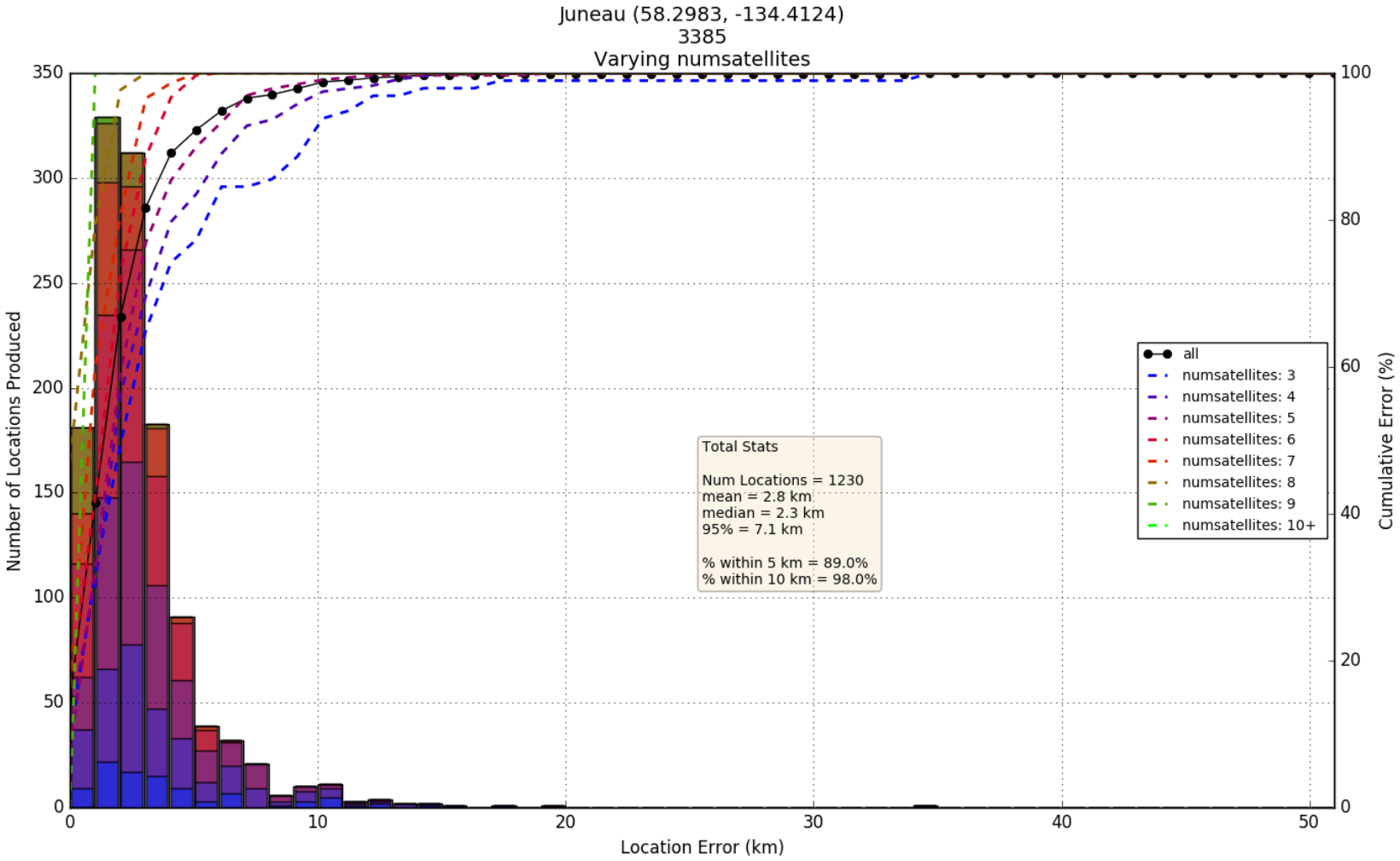
Site #2 – Juneau cont'd
Assessing Number of Bursts

Florida (3669)



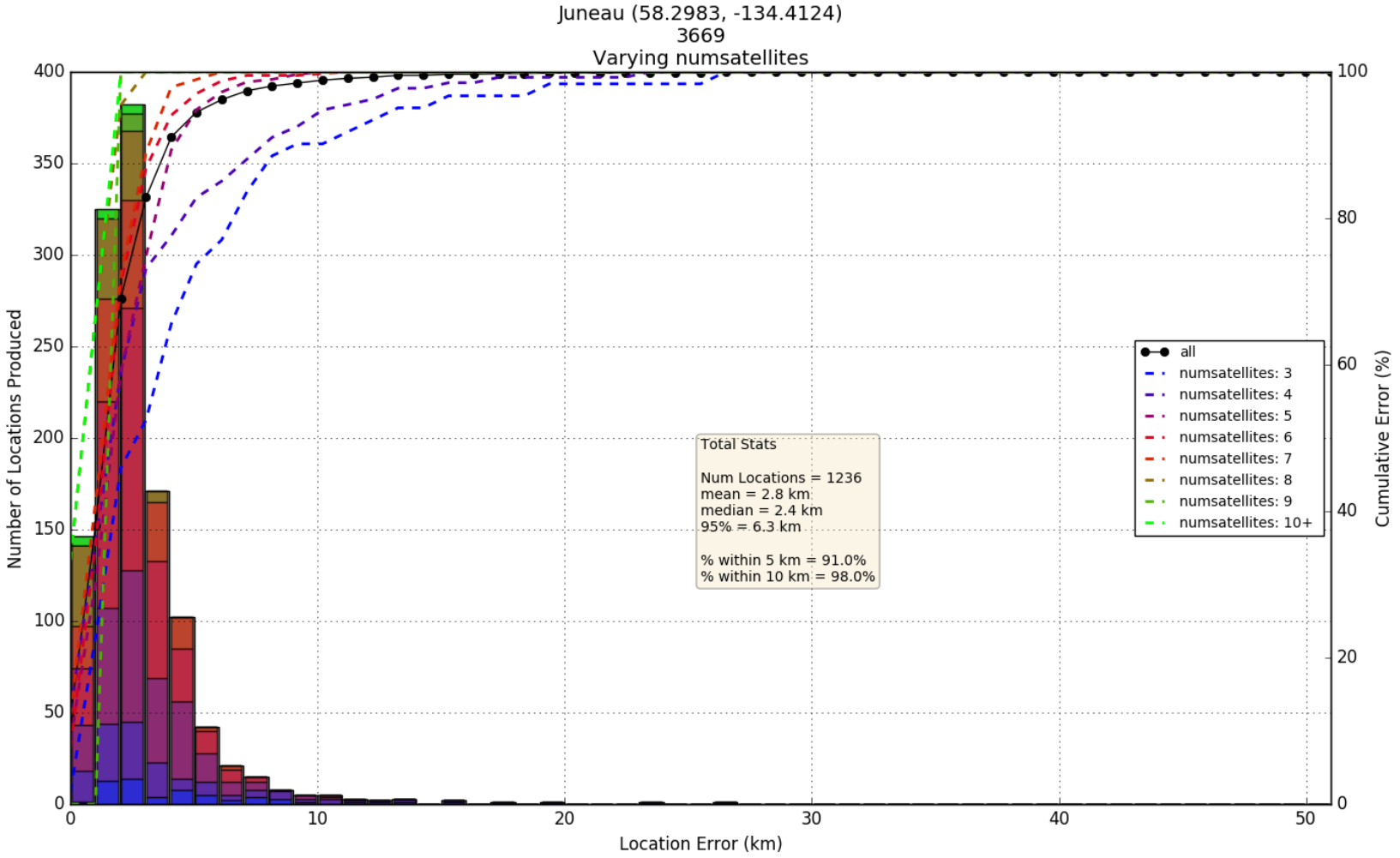
Site #2 – Juneau cont'd
Assessing Number of Satellites

Hawaii (385)



Site #2 – Juneau cont'd
Assessing Number of Satellites

Florida (3669)



Real World Case
EPIRB off coast of Mexico

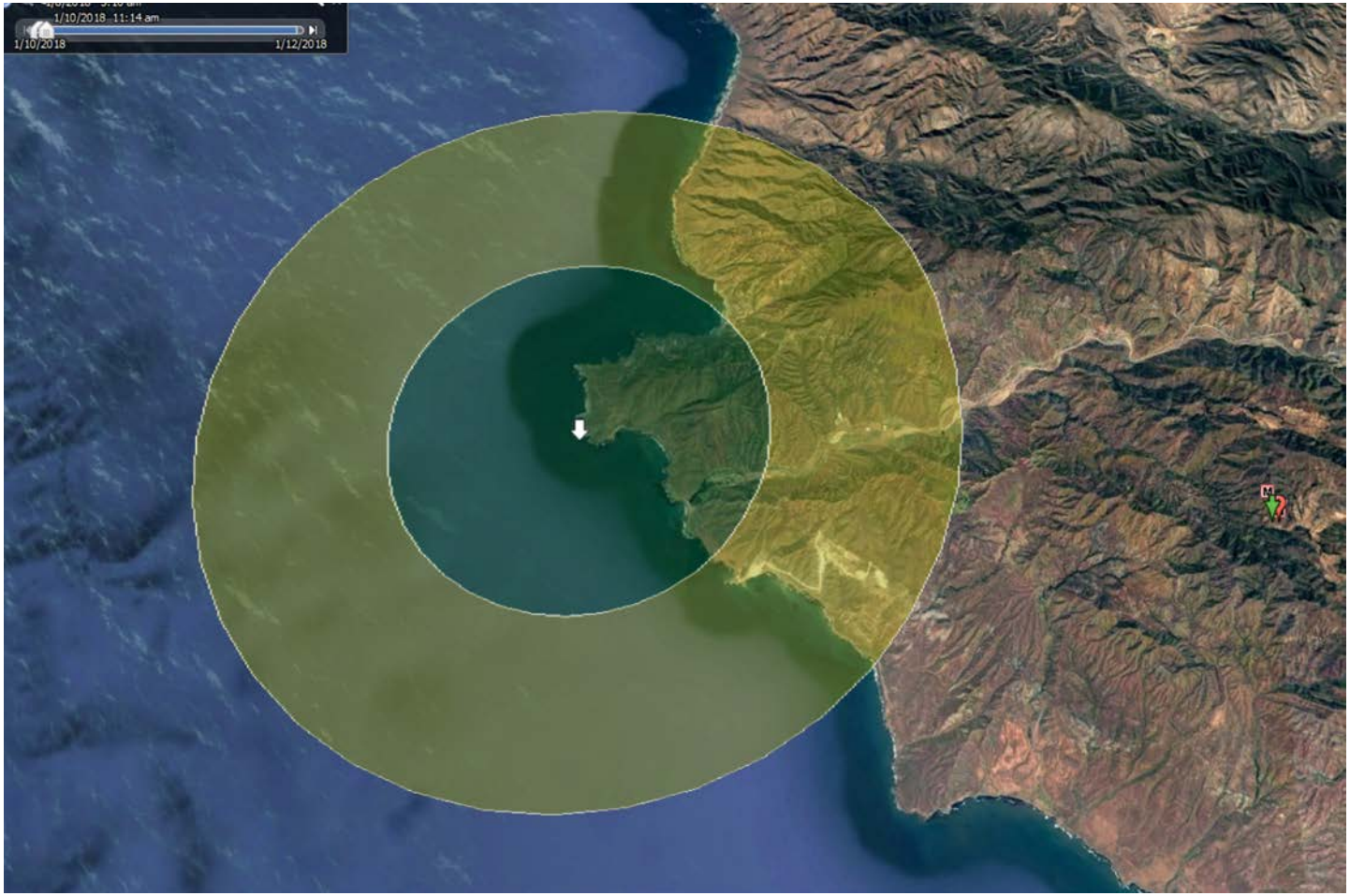
- A USA coded EPIRB, registered to an owner in Florida, was detected 10 Jan 2018 1045z, off of the coast of Ensenada, Mexico
- The case tragically ended with two deceased.
- Two conditions likely degraded performance
  - Boat was battered against the rocks
  - There was a cliff that likely caused some masking of beacon transmissions
- The USMCC had various rules in place that triggered different messages to various districts.
- Ground Truth of the following analysis was assumed to be the most prevalent encoded location. It appears to be accurate and reliable, however, the beacon could have been moving in the water during this event.
- 8 locations in the histograms appeared 2 days later with errors of 120 km. The EPIRB was likely moved and the system detected it.

Real World Case
EPIRB off coast of Mexico
Summary of Events / Performance

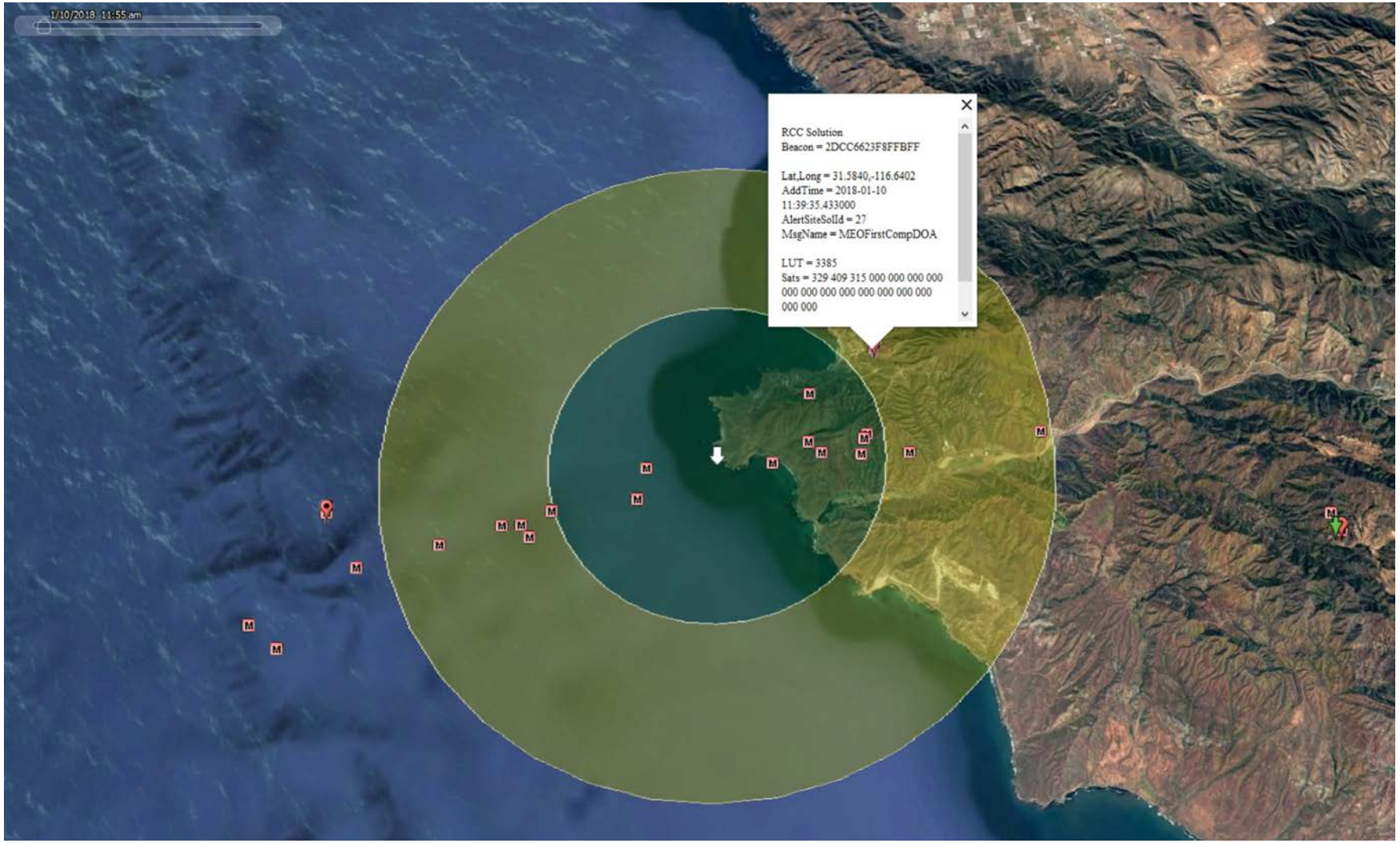
- First messages at 1045z were GEO and MEO Unlocated (no MEO Locations, no encoded locations)
- MEOLUTs generated independent locations at 1048z (still no encoded)
- MCC created composite location at 1138z, based only on MEOLUT solutions
- First LEO Solution was 1223z (but marked as blown due to incorrect A/B selection. B solution was still about 35km off)
- First encoded location was 1236z

Location	# locations	ave	# <5 km	% < 5 km	# < 10 km	% < 10 km	# < 20 km	% < 20 km	median (km)	75% (km)	90% (km)	95% (km)
EPIRB - Mexico	291	6.69	193	0.66	261	0.9	281	0.97	4.08	5.53	10.33	14.77

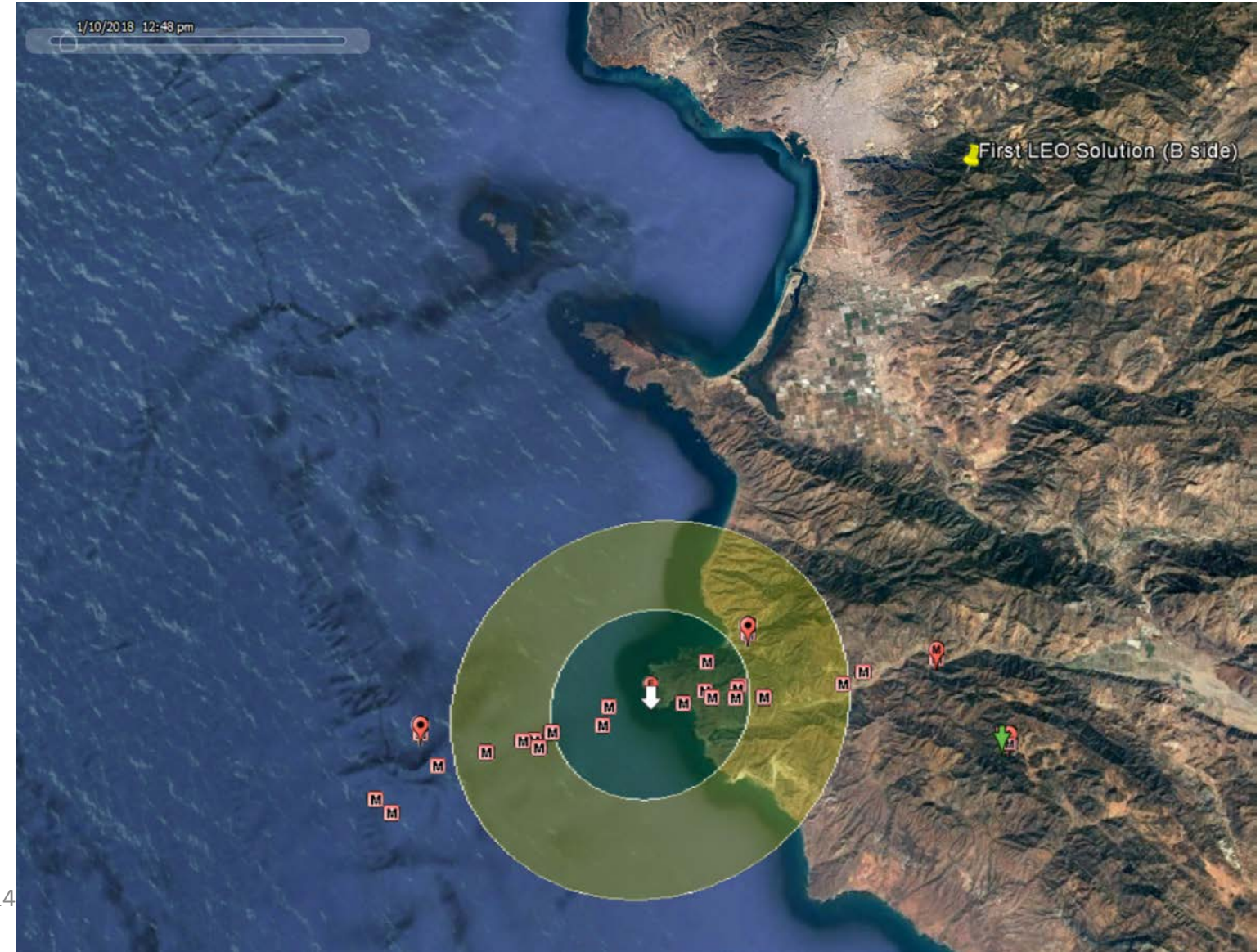
EPIRB off coast of Mexico
First MEOSAR Locations



EPIRB off coast of Mexico
First MEOSAR Composite

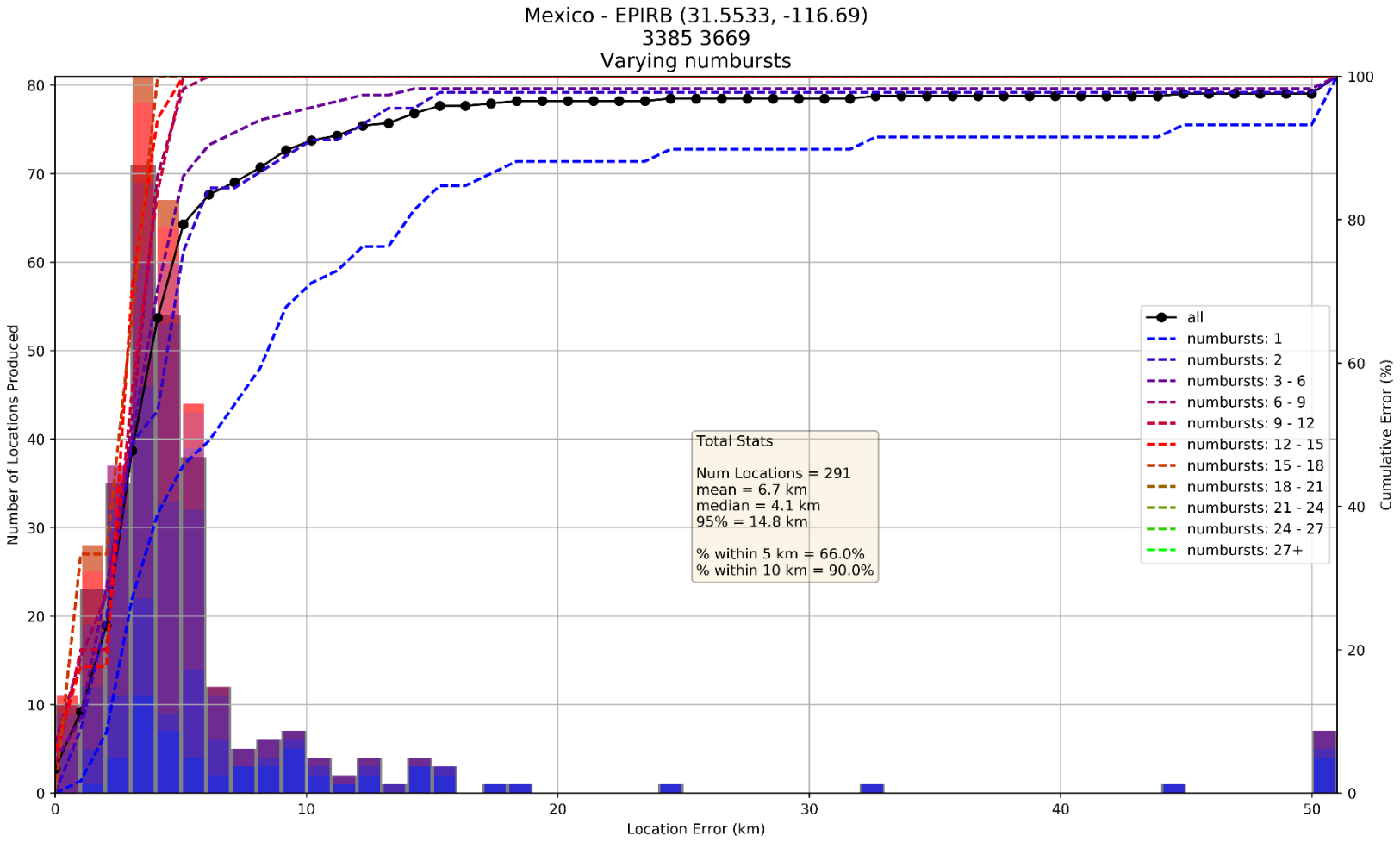


EPIRB off coast of Mexico
First LEOSAR Location

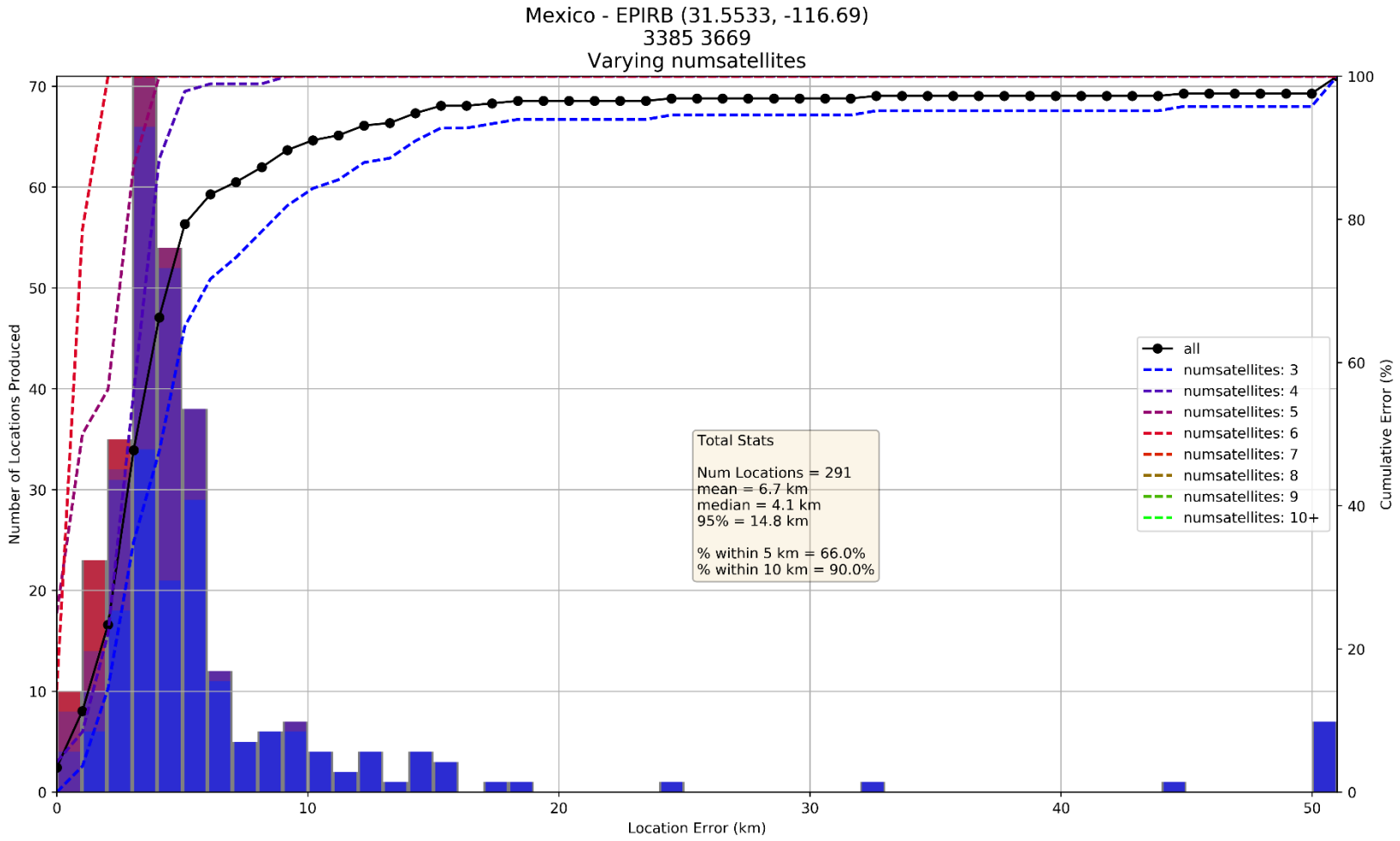


EPIRB off coast of Mexico
First Encoded Locations

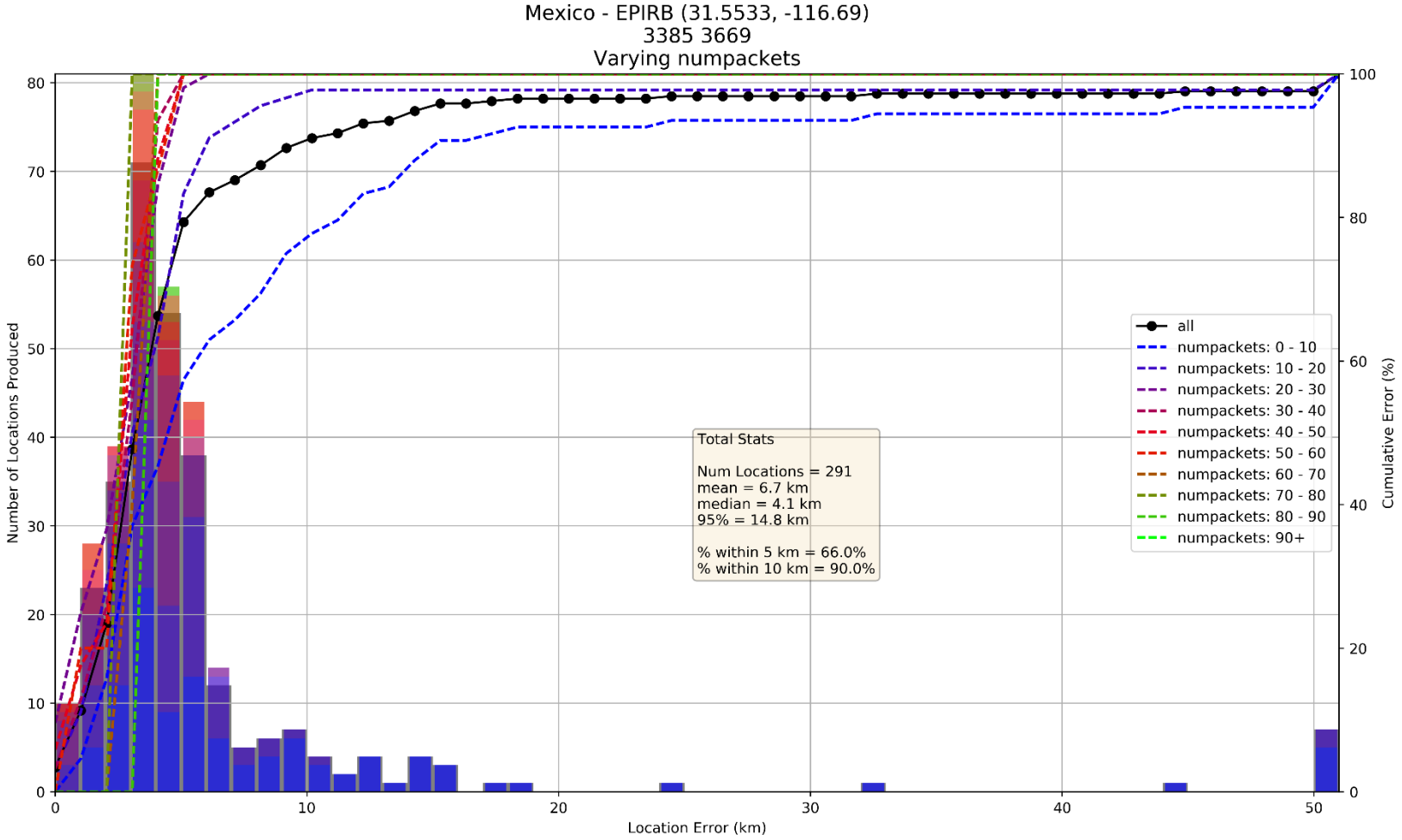
Real World Case
EPIRB off coast of Mexico
Assessing Number of Bursts



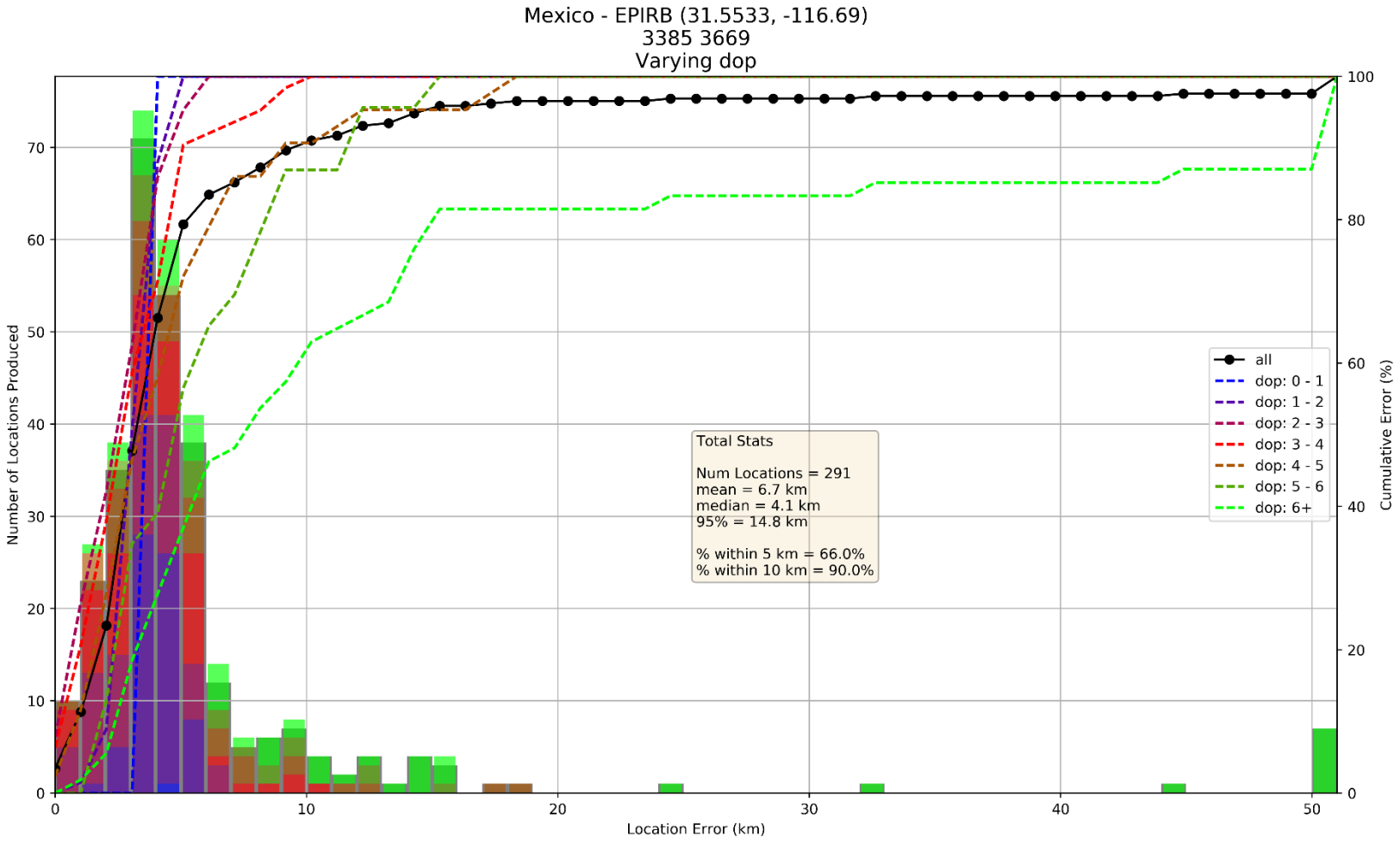
Real World Case
EPIRB off coast of Mexico
Assessing Number of Satellites



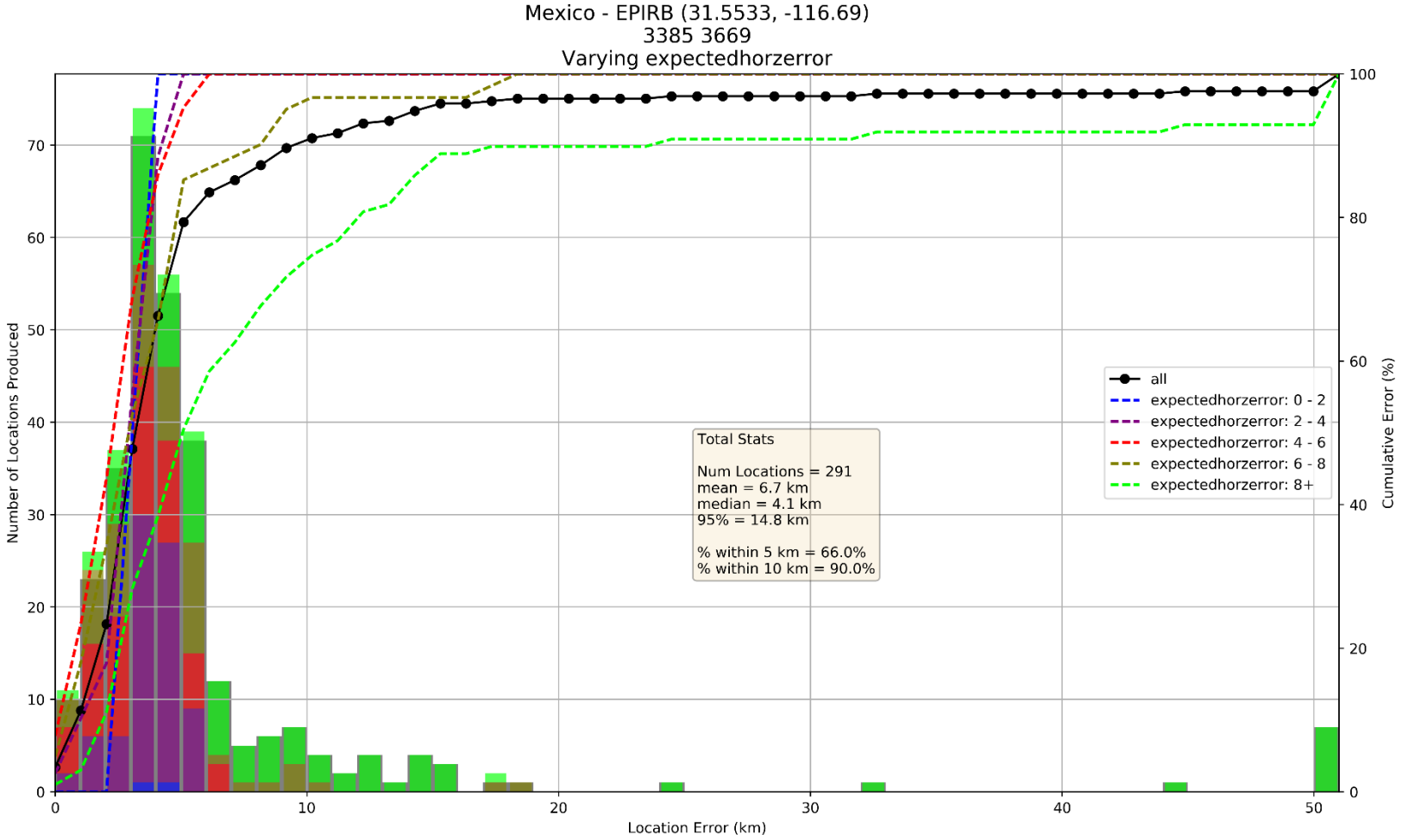
Real World Case
EPIRB off coast of Mexico
Assessing Number of Packets



Real World Case
EPIRB off coast of Mexico
Assessing DOP



Real World Case
EPIRB off coast of Mexico
Assessing EHE

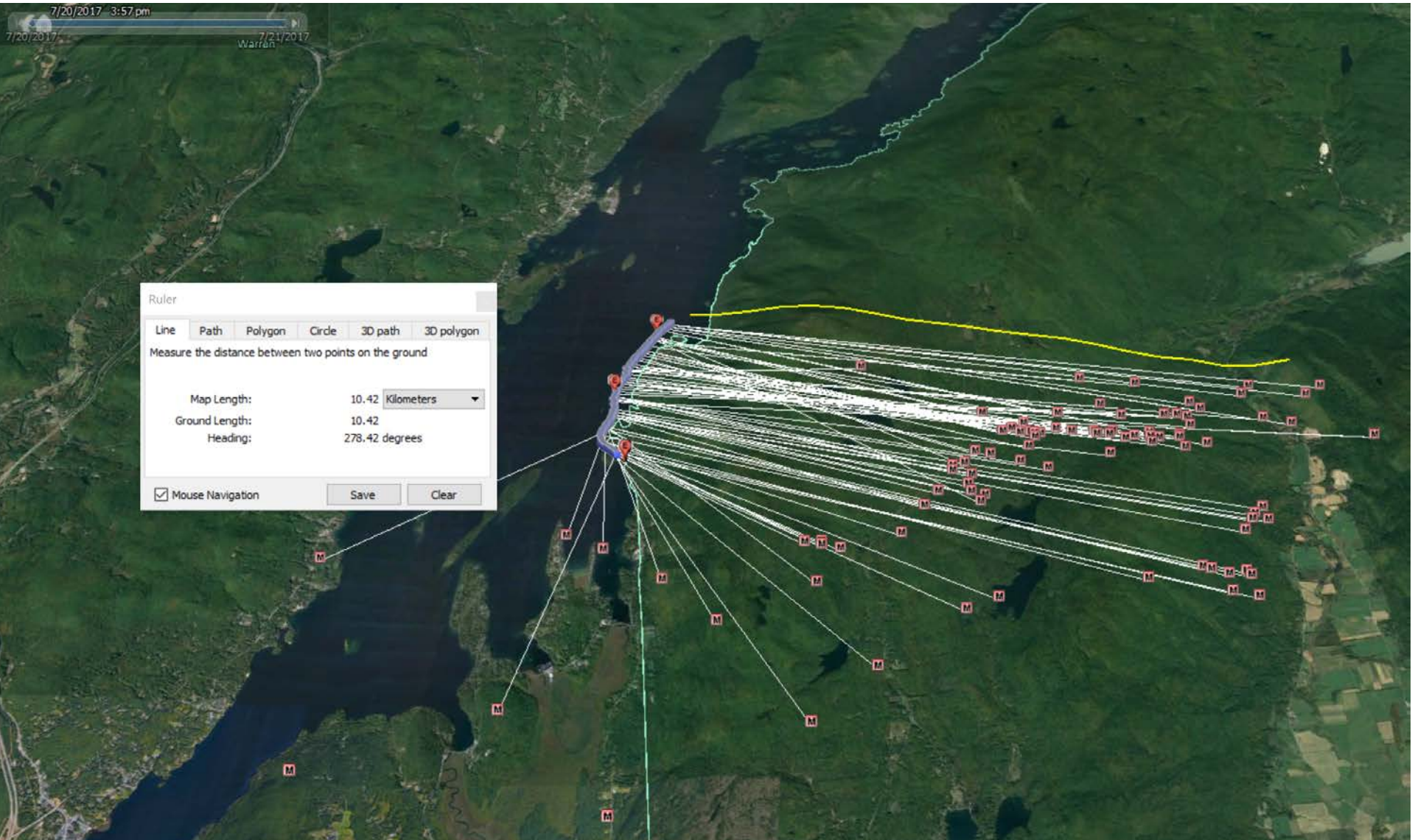


Moving Beacon Study
Lake George

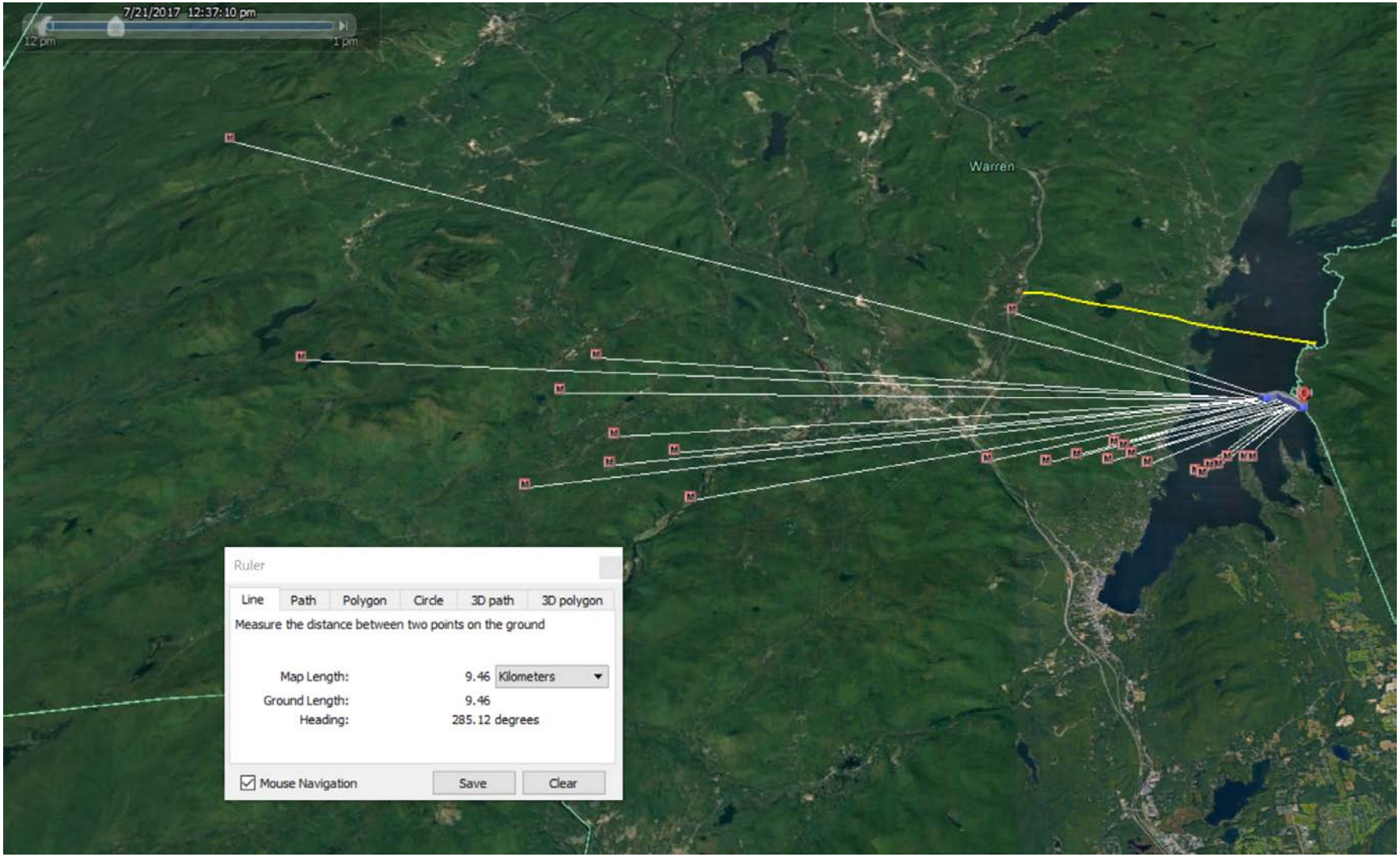
- A PLB was used for a series of tests on and around Lake George in upstate New York (7943 km from Hawaii, 2080 km from Florida, location is 43.493, -73.63)
- The results appear typical of MEOSAR performance during moving beacon events.
- Focus on Config #1 and #5

Location	# locations	ave	# <5 km	% < 5 km	# < 10 km	% < 10 km	# < 20 km	% < 20 km	median (km)	75% (km)	90% (km)	95% (km)
Config # 1 - Slow speed – Boat	399	7.71	132	0.33	301	0.75	383	0.96	6.73	9.92	13.17	18.59
Config # 2 - High speed – Hand	25	19.73	2	0.08	5	0.2	23	0.92	12.48	14.31	15.89	68.72
Config # 3 - Bobbing Dock	155	2.62	146	0.94	155	1	155	1	2.26	3.32	3.76	5.08
Config # 4 - Bobbing Morring	1583	2.29	1497	0.95	1571	0.99	1576	1	1.83	2.65	3.89	5.2
Config # 5 - Slow speed – Hand	64	11.04	22	0.34	38	0.59	53	0.83	6.97	16.76	21.71	34.74
Config # 6 – Hike	231	7.13	127	0.55	185	0.8	220	0.95	4.41	8.97	14.91	19.85
Config # 7 - Fixed Dock	538	1.75	518	0.96	537	1	537	1	1.42	2.2	3.1	4.56

Config #1


7/20/2017 3:57 pm
7/20/2017
7/21/2017
Warren
Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between two points on the ground
Map Length:
10.42
Kilometers
Ground Length:
10.42
Heading:
278.42 degrees
Mouse Navigation
Save
Clear

Config #5


7/21/2017 12:37:10 pm
12 pm
1 pm
Warren
Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between two points on the ground
Map Length:
9.46
Kilometers
Ground Length:
9.46
Heading:
285.12 degrees
Mouse Navigation
Save
Clear