NASA/TM–2019-219035

Mabel Engineering Flights, 2010 - 2013

Flight Report

Kelly M. Brunt, Eugenia L. De Marco, William B. Cook, Matt McGill, Daniel L. Reed, Andrew Kupchock, Bill Hart, Thomas A. Neumann, and Thorsten Markus

July 2019

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Flight Report

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Abstract

In December 2010, NASA deployed for the first time the Multiple Altimeter Beam Experimental Lidar (MABEL), an airborne simulator for Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) algorithm development. Between 2010 and 2013, engineering flights were conducted in the continental United States, to ready the instrument for deployments to Alaska and Iceland, where flight lines could be designed and flown over sea ice and grounded ice. Ultimately, MABEL engineering missions included: 1) flights based out of NASA Armstrong Flight Research Center (California, formerly Dryden Flight Research Center) in 2010, 2011, and 2012; flights based out of NASA Wallops Flight Facility (Virginia) in 2012; flights based out of NASA Langley Research Center (Virginia) in 2013; and flights based out of the Mojave Air and Space Port (California) in 2013.

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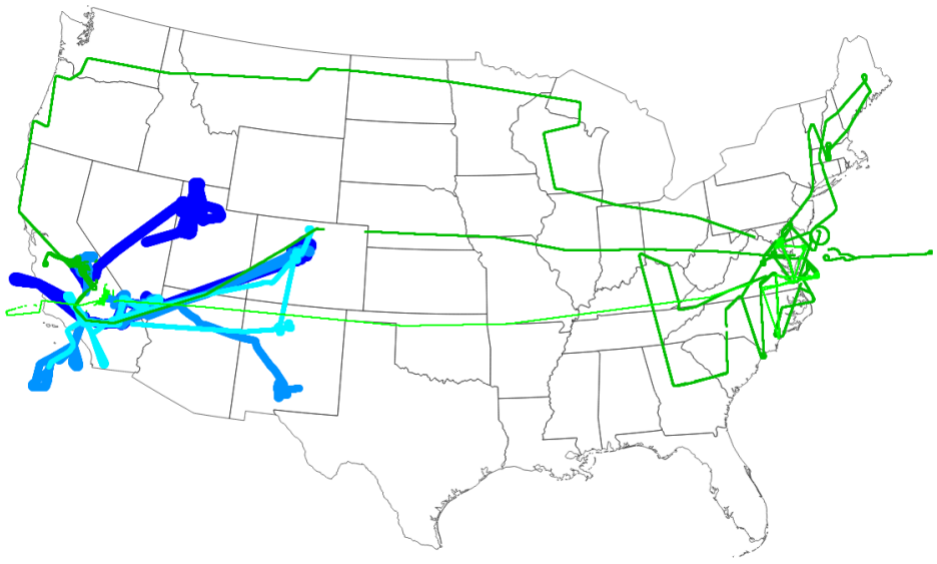
Introduction

In support of Ice, Cloud, and land Elevation Satellite-2 (ICESat-2; Markus et al., 2017), NASA has conducted a series of airborne campaigns primarily to enable the development of ICESat-2 geophysical algorithms prior to launch, which is scheduled for 2018. ICESat-2 will carry the Advanced Topographic Laser Altimeter System (ATLAS), which will be a six-beam photon-counting laser altimeter using 532-nm wavelength pulses. Given this new approach to satellite surface elevation measurement, a series of airborne lidar campaigns were designed to: 1) enable the development of ICESat-2 geophysical algorithms prior to launch; 2) enable ICESat-2 error analysis; and 3) provide ATLAS model validation.

The primary airborne instrument used for algorithm development has been the Multiple Altimeter Beam Experimental Lidar (MABEL; McGill et al., 2013). Matt McGill developed the instrument and was the Principal Investigator for the 2010 and 2011 campaigns; Bill Cook was the PI for the remainder of the MABEL deployments. MABEL is a photon-counting multibeam lidar sampling at both 532- and 1064-nm wavelengths.

The initial MABEL engineering flights included a series of engineering flights in a high-altitude aircraft based out of NASA Armstrong Flight Research Center (formerly Dryden Flight Research Center), in Palmdale, California (2010, 2011, and 2012). Other engineering campaigns within the continental United States included targets associated with vegetation 'leaf-on' conditions; these were based out of NASA Wallops Flight Facility, in Wallops Island, Virginia (2012), Mojave, California (2013), and NASA Langley Research Center in Hampton, Virginia (2013).

These engineering flights were developed with the ultimate goal of taking MABEL to colder environments, to match the environmental conditions associated with ICESat-2 Level 1 mission requirements, associated with land ice and sea ice; campaigns that addressed these conditions were based out of Keflavik, Iceland, in March and April 2012 (Cook et al., 2017; Brunt et al., 2014) and Fairbanks, Alaska, 2014 (Brunt et al., 2017; Brunt et al., 2016).



Overview of MABEL flights: Armstrong 2010 (dark blue); Armstrong 2011 (light blue); Armstrong 2012 (cyan); Wallops 2012 (dark green); Mojave 2013 (light green); Langley 2013 (light green).

Instrumentation and Aircraft

MABEL is optimized for high-altitude sampling (above 15 km) with a goal of sampling at about 20 km above sea level (ASL), or above more than 90% of the atmosphere. To accomplish this, MABEL has been deployed on 2 high-altitude aircraft: the NASA Armstrong ER-2 and the Scaled Composites Proteus. For the 2013 deployments in Mojave and Langley, MABEL was integrated underneath the Scaled Composites Proteus; for all other campaigns, MABEL was integrated into the nosecone of the ER-2. Flights in the ER-2 were planned at about 7 to 8 hours, including takeoff and decent; data collection totaled about 6 to 7 hours per flight. Flights in the Proteus were ~2 hours shorter.

NASA Armstrong ER-2.

Scaled Composites Proteus

MABEL has beams at both 532 (green) and 1064 (near infrared) nm wavelengths. MABEL has as many as 16 green beams and as many as 8 near infrared beams. MABEL beams are arranged in a

linear array, perpendicular to the direction of flight. The system allows for beam-geometry changes between flights with a maximum view angle of ±1 km from a 20 km ASL nominal altitude. The repetition rate of MABEL is variable (between 5 and 25 kHz); most campaigns used 5 kHz. At this nominal altitude, repetition rate, and an aircraft speed of ∼200 m/s, MABEL samples a ∼2-m footprint every ∼4 cm along track.

While MABEL was integrated in the NASA ER-2, other lidars have been deployed to provide additional atmospheric information. These lidars have included Cloud Physics Lidar (CPL) and Airborne Cloud-Aerosol Transport System (ACATS; often referred to in the flight summaries as 'CATS', prior to the development of the spaceborne version of this instrument, that currently flies on the International Space Station). Matt McGill is the CPL Principal Investigator. CPL is a 3-wavelength lidar (355, 532, and 1064 nm) for atmospheric applications with 30 m vertical resolution (REF). Processed CPL is key for atmospheric validation of processed MABEL data. Further, real-time quick-look imagery telemetered from CPL provides an assessment of what MABEL is sampling in real-time. During the MABEL deployments, Matt McGill was also the ACATS Principal Investigator. ACATS is a multichannel Doppler lidar, in the 532 nm wavelength (Yorks et al., 2014). It is also a high-spectral-resolution lidar system. The telescope system can scan up to 45° off-nadir and has 30 m vertical resolution.

A camera system was sometimes deployed in a separate part of the aircraft, relative to MABEL. For various missions, the NASA ER-2 Cirrus Digital Camera System (CDCS; often referred to in the flight summaries as 'DCS') was deployed in the main body of the ER-2 (Cube A). The CDCS camera system is a 16-megapixel Hasselblad 555ELD color digital camera (Elvidge et al., 2007) with a 150 mm lens from Zeiss optics with a 26° field of view. It produces a 4072 x 4072-pixel image; at a nominal altitude of 20 km ASL, it produces a total swath of ~5 km and a ~1.2 m nominal pixel resolution. The 150 mm lens had not been deployed on the ER-2 prior to this deployment.

Discussion and Conclusions

MABEL requires clear sky conditions for sampling. These deployments experienced a broad range of atmospheric conditions. Therefore, some data are compromised by clouds, and are therefore more suited to atmospheric analyses.

MABEL detectors are sensitive not just to MABEL's transmit signal, but also the ambient light in the 532 nm wavelength. MABEL often integrated an etalon filter to further minimize the amount of solar background in this part of the spectrum. However, this filter was not always ready for deployment. Thus, MABEL flights that lacked an etalon filter at the time of deployment were generally flown at night to reduce background. The presence or absence of the etalon is noted in the campaign-summary text below because this factor has a significant impact on, among other things, logistics and signal-to-noise ratios.

The appendix of this document includes summaries associated with each individual mission flight. Details captured in these summaries include maps of flight tracks, relative channel footprint locations, comments about the instrumentation, and comments about weather.

The campaigns covered in these appendices include missions based out of NASA Armstrong Flight Research Center (2010, 2011, and 2012), NASA Wallops Flight Facility (2012), Mojave, California (2013), and NASA Langley Research Center (2013). Below is a section that provides an overview of each campaign.

The MABEL field team for these engineering flights included: Bill Cook, Matt McGill, Eugenia De Marco, Kelly Brunt, Dan Reed, Ryan Cargo, Mark Shappirio, Kaitlin Walsh, Tom Neumann, and Lisa Callahan.

The field team members that deployed with MABEL, but primarily in support of ACATS or CPL included: Bill Hart, Andrew Kupchock, John Yorks, Spencer Disque, Scott Ozog, Rodney Faulkner, and Patrick Selmer.

2010 (December): NASA Armstrong Flight Research Center, Palmdale, CA
Principal Investigator: Matt McGill
Field team: De Marco, Brunt, Reed, Kupchock, Hart, Cargo, Callahan
Aircraft: NASA ER-2
Other instruments: CPL
Etalon filter: NO; night flights to mitigate ambient green-light background
Targets: Lake Mead; California Sierras; Colorado Rockies; Bonneville; open ocean
Missions (4): 12/8/2010; 12/9/2010; 12/10/2010; 12/11/2010

2011 (March-April): NASA Armstrong Flight Research Center, Palmdale, CA
Principal Investigator: Matt McGill
Field team: De Marco, Brunt, Reed, Hart, Cargo, Kupchock, Disque, Faulkner
Aircraft: NASA ER-2
Other instruments: CPL; ACATS
Etalon filter: YES; thus, there are day flights
Targets: Lake Mead; California Sierras; Colorado Rockies; White Sands; open ocean
Missions (7): 3/22/2011; 3/24/2011; 3/30/2011; 3/31/2011; 4/1/2011; 4/4/2011; 4/5/2011;

2012 (February): NASA Armstrong Flight Research Center, Palmdale, CA
Principal Investigator: Bill Cook
Field team: De Marco, Brunt, Reed, Hart, Kupchock, Disque, Neumann
Aircraft: NASA ER-2
Other instruments: CPL; ACATS; CDCS
Etalon filter: NO; twilight flights to mitigate ambient green-light background
Targets: Lake Mead; Colorado Rockies; trees in New Mexico; open ocean
Missions (3): 2/21/2012; 2/22/2012; 2/23/2012 (H5 data files are UTC; dates are 1-day different)

2012 (September): NASA Wallops Flight Facility, Wallops Island, VA
Principal Investigator: Bill Cook
Field team: De Marco, Brunt, Reed, Hart, Disque, Yorks, Walsh, Selmer
Aircraft: NASA ER-2

Other instruments: CPL; ACATS
Etalon filter: **YES**; mostly twilight/night flights, however there were a couple day flights
Targets: trees and reservoirs in Maine; New Hampshire; Vermont; Massachusetts; and Virginia; Lake Erie; Chesapeake Bay; open ocean; AMIGA lines; cites (New York City, Portland)
Missions (11): 9/5/2012; 9/7/2012; 9/9/2012; 9/14/2012; 9/15/2012; 9/19/2012; 9/20/2012; 9/21/2012; 9/23/2012; 9/26/2012; 9/27/2012

2013 (July and September): Mojave Air and Space Port, Mojave, CA and NASA Langley Research Center, Hampton, VA
Principal Investigator: Bill Cook
Field team: De Marco, Brunt, Reed, Shappirio
Aircraft: Scaled Composites Proteus
Other instruments: None
Etalon filter: YES; day flights
Targets: Trona, California; Chesapeake Bay; open ocean; AMIGA lines
Missions (9): 7/1/2013; 7/2/2013; 7/3/2013; 9/18/2013; 9/19/2013; 9/20/2013; 9/23/2013; 9/25/2013; 9/27/2013

All datasets associated with MABEL are available on the ICESat-2 website (http://icesat-2.gsfc.nasa.gov/legacy-data/mabel/mabel_docs.php).

Acknowledgements
We thank the MABEL, CPL, ACATS, and CDCS instrument field teams: Spencer Disque, Ryan Cargo, Mark Shappirio, Kaitlin Walsh, Rodney Faulkner, John Yorks, Scott Ozog, Patrick Selmer, and Lisa Callahan. We thank the NASA Armstrong ER-2 pilots: Tim Williams, Denis Steele, Stu Broce, and Tom Ryan. We thank the NASA Armstrong ER-2 Project Managers: Tim Moes and Chris Jennison. We thank the Scaled Composites pilot and engineer field teams: Brian Binnie and Ben Harvey. And we thank NASA Goddard Flight Center personnel for data processing and analysis support: David Hancock, Jeff Lee, Scott Luthcke, Charles Webb.

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McGill, M., Hlavka, D., Hart, W., Scott, V. S., Spinhirne, J., & Schmid, B. (2002). Cloud physics lidar: Instrument description and initial measurement results. *Applied Optics*, 41(18), 3725–3734, doi: 10.1364/AO.41.003725.

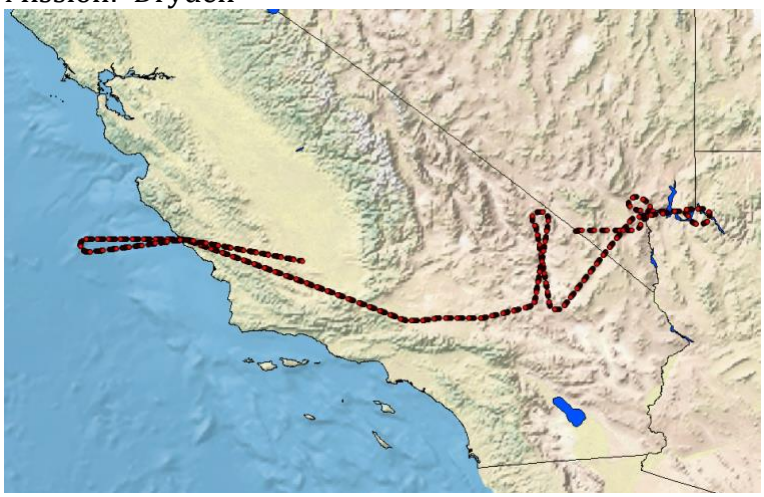
Yorks, J., McGill, M., Scott, V., Wake, S., Kupchock, A., Hlavka, D., Hart, W., & Selmer, P. A. (2014). The Airborne Cloud–Aerosol Transport System: Overview and Description of the Instrument and Retrieval Algorithms. *Journal of Atmospheric and Oceanic Technology*, 31(11), 2482–2497, doi: 10.1175/JTECH-D-14-00044.1

Appendix

The appendix of this document includes summaries associated with each individual mission flight. Details captured in these summaries include maps of flight tracks, comments about the instrumentation, and comments about weather. This document focuses on MABEL, as the primary instrument.

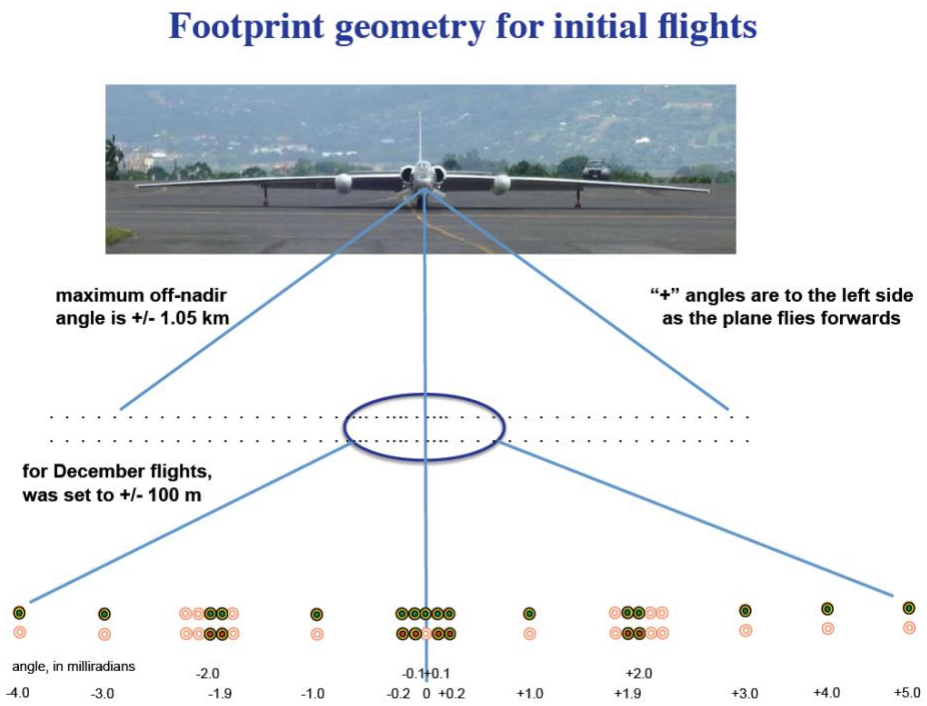
12/08/2010

Mission: 'Dryden'



Weather: clear inland (over Las Vegas) and cloudy over the ocean
Comments: This was the second MABEL flight; MABEL continuously power-cycled due to thermal thresholds. This issue was rectified for the next mission. This flight path is intended to mimic the initialization flight path of IceBridge.

ER-2
No Etalon
Sample rate: 5 kHz
Energy levels throughout channels: static
FOV: 'spread pattern' (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	-1	-2	-5	-6
Channel	94	96	98	100	44	46	48	50
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	3.29	2.45	1.69	2.50	2.45	1.96	2.33
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	-0.1	-0.2	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	-2	-4	-38	-40

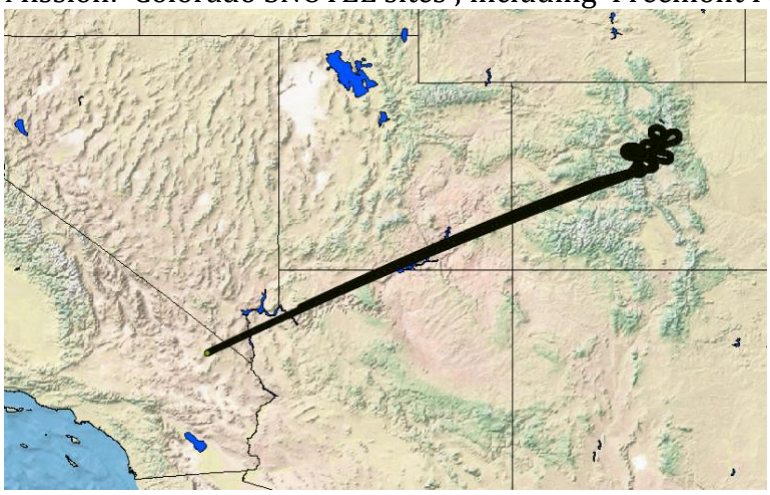
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-10	-9	-6	-5	-3	-2	-1	0	1	2	3	5	6	9	10	11
Channel	3	5	1	7	65	9	63	11	61	13	59	15	57	51	55	53
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	4.44	4.94	2.59	3.41	3.81	3.68	3.38	4.31	4.17	3.97	3.80	3.81	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-4	-3	-2	-1.9	-1	-0.2	-0.1	0	0.1	0.2	1	1.9	2	3	4	5
Approx offset on ground (m): 65k'	-79	-59	-40	-38	-20	-4	-2	0	2	4	20	38	40	59	79	99

Points of interest:

Time (UTC)	TOF File	Description
23:28:49	0	Laser status healthy
23:35:12	11	start first leg over Lk Meade
23:37:42	15	end first leg over Lk Meade
23:42:55	22	start second leg over Lk Meade
23:46:39	26	end second leg over Lk Meade
23:55:12	40	start third leg over Lk Meade
23:59:14	44	end third leg over Lk Meade
01:22:29	62	stat leg over ocean
01:43:8	63	end leg over ocean
01:55:50	64	Laser off

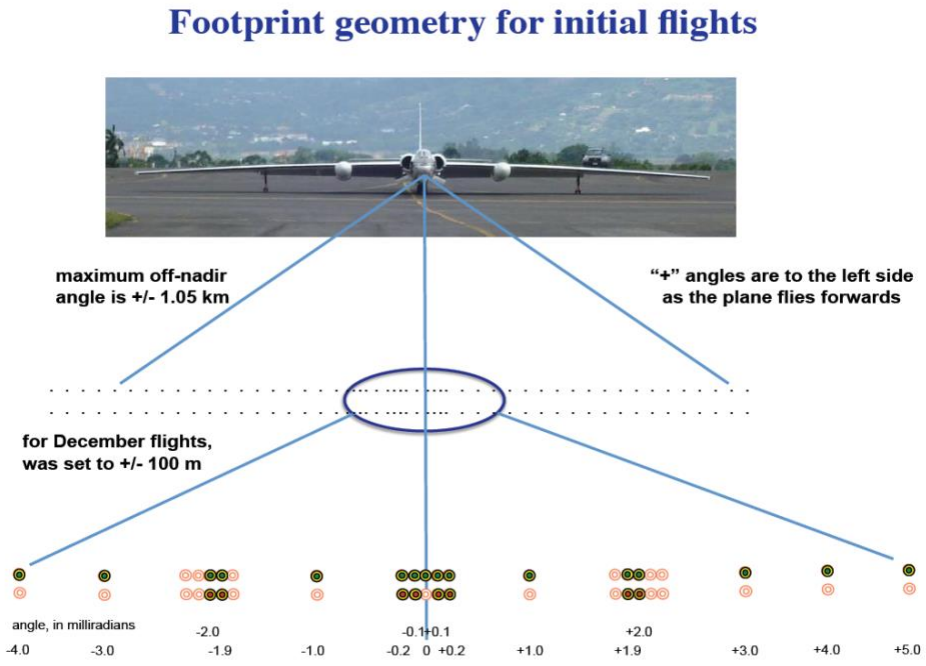
12/09/2010

Mission: ‘Colorado SNOTEL sites’; including ‘Freemont Pass’ and ‘Loveland Basin’



Weather: cloudy in transit; openings over target
Comments: The pilot reported that, although the flight was generally cloudy, he could see lights while over our targets in CO.
Loveland ski area reported 0 new snow in the previous 24 hours; 4” of new snow in the previous 48 hours; and 16: of new snow in the previous 72 hours.

ER-2
No Etalon
Sample rate: 5 kHz
Energy levels throughout channels: static
FOV: ‘spread pattern’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	-1	-2	-5	-6
Channel	94	96	98	100	44	46	48	50
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	3.29	2.45	1.69	2.50	2.45	1.96	2.33
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	-0.1	-0.2	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	-2	-4	-38	-40

Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-10	-9	-6	-5	-3	-2	-1	0	1	2	3	5	6	9	10	11
Channel	3	5	1	7	65	9	63	11	61	13	59	15	57	51	55	53
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	4.44	4.94	2.59	3.41	3.81	3.68	3.38	4.31	4.17	3.97	3.80	3.81	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-4	-3	-2	-1.9	-1	-0.2	-0.1	0	0.1	0.2	1	1.9	2	3	4	5
Approx offset on ground (m): 65k'	-79	-59	-40	-38	-20	-4	-2	0	2	4	20	38	40	59	79	99

Points of interest:

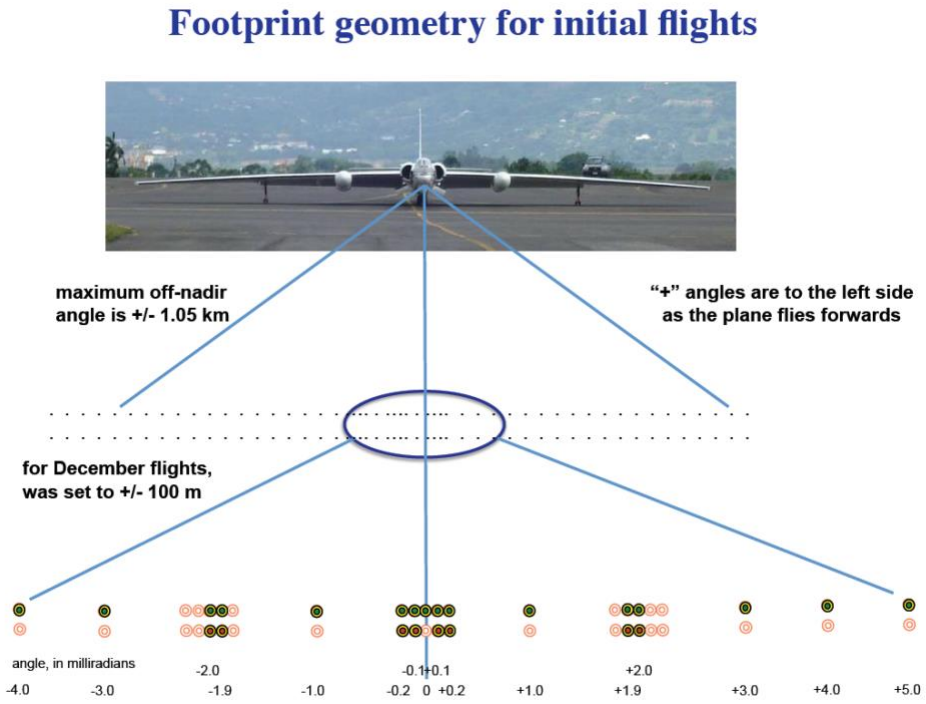
Time (UTC)	TOF File	Description
20:00:54	0	Laser status healthy
00:43:42	21	start of run over SNOTEL targets
02:20:50	37	end of run over SNOTEL targets
03:36:47	47	Laser off

12/10/2010

Mission: ‘Sierras’

Weather: thin cirrus throughout; CPL, flown concurrently, could see the ground
Comments: There was fresh snow in the Sierras at the time of this flight. Surveying at 65,000 ft, the surface and high-elevation clouds can be confused in 10 kHz data.

ER-2
No Etalon
Sample rate: **10** kHz
Energy levels throughout channels: static
FOV: ‘spread pattern’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	-1	-2	-5	-6
Channel	94	96	98	100	44	46	48	50
Power (Matt, mW)	26.8	31.5	23	12.6	23	22.4	17.3	23.6
Filter	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Raw Energy (Matt, uJ)	2.68	3.15	2.3	1.26	2.3	2.24	1.73	2.36
Filtered Energy (uJ)	1.31	1.54	1.13	0.62	1.13	1.10	0.85	1.16
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	-0.1	-0.2	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	-2	-4	-38	-40

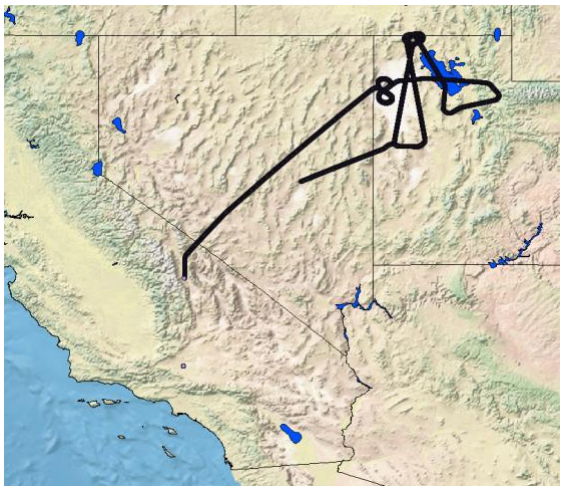
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-10	-9	-6	-5	-3	-2	-1	0	1	2	3	5	6	9	10	11
Channel	3	5	1	7	65	9	63	11	61	13	59	15	57	51	55	53
Power (Matt, mW)	36.9	35.8	31.6	38.8	23.4	25	29.2	29.7	25.4	31.4	29.6	27.6	28.4	26.8	33.8	34.3
Filter	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	3.69	3.58	3.16	3.88	2.34	2.5	2.92	2.97	2.54	3.14	2.96	2.76	2.84	2.68	3.38	3.43
Filtered Energy (uJ)	2.55	2.47	2.18	2.68	1.61	1.73	2.01	2.05	1.75	2.17	2.04	1.90	1.96	1.85	2.33	2.37
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-4	-3	-2	-1.9	-1	-0.2	-0.1	0	0.1	0.2	1	1.9	2	3	4	5
Approx offset on ground (m): 65k'	-79	-59	-40	-38	-20	-4	-2	0	2	4	20	38	40	59	79	99

Points of interest:

Time (UTC)	TOF File	Description
00:26:03	0	Laser status healthy
00:24:55	7	start of Sierra run
01:47:52	25	end of Sierra run
01:54:33	27	Laser off

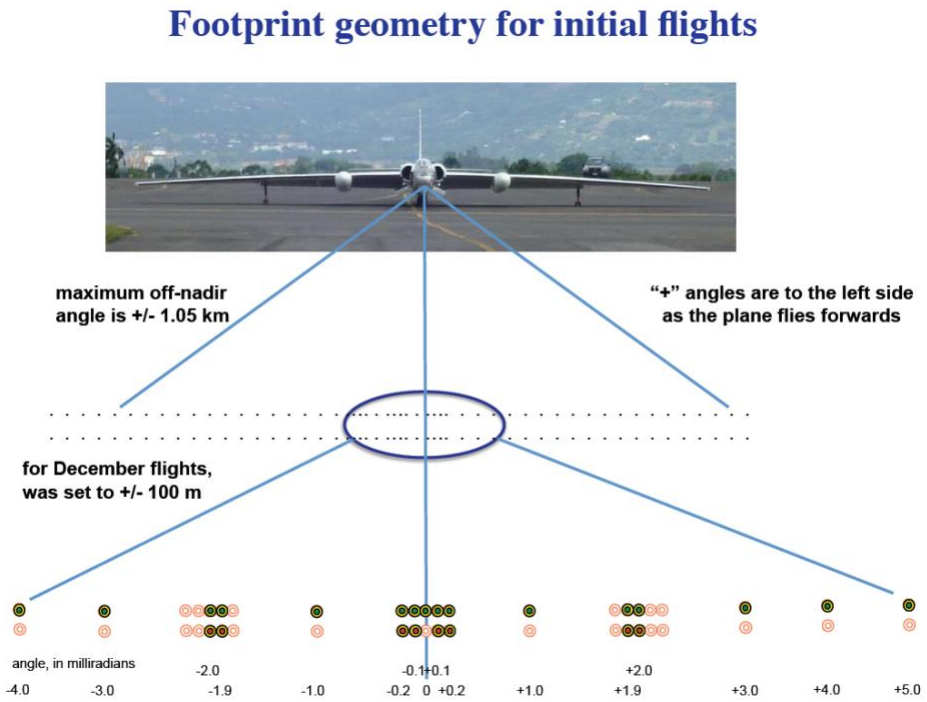
12/11/2010

Mission: ‘Bonneville’



Weather: overcast with holes
Comments: GPS/IMU fails to communicate for part of this trip; reset.

ER-2
No Etalon
Sample rate: **10** kHz
Energy levels throughout channels: static
FOV: ‘spread pattern’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	-1	-2	-5	-6
Channel	94	96	98	100	44	46	48	50
Power (Matt, mW)	26.8	31.5	23	12.6	23	22.4	17.3	23.6
Filter	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Raw Energy (Matt, uJ)	2.68	3.15	2.3	1.26	2.3	2.24	1.73	2.36
Filtered Energy (uJ)	1.31	1.54	1.13	0.62	1.13	1.10	0.85	1.16
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	-0.1	-0.2	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	-2	-4	-38	-40

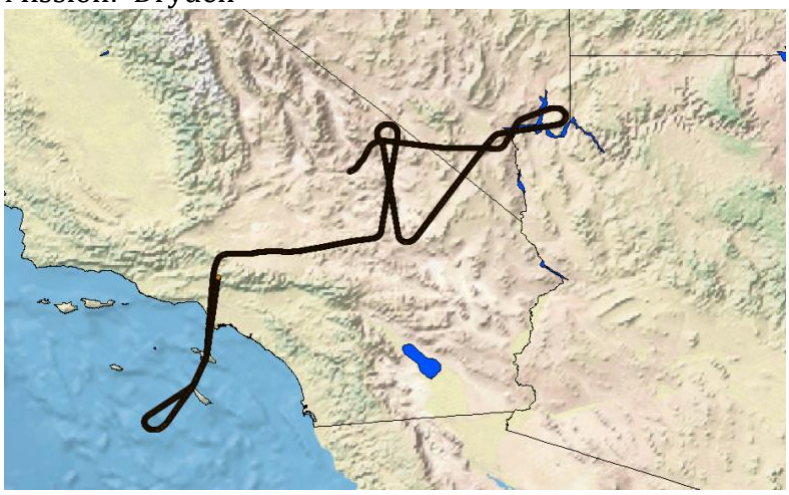
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-10	-9	-6	-5	-3	-2	-1	0	1	2	3	5	6	9	10	11
Channel	3	5	1	7	65	9	63	11	61	13	59	15	57	51	55	53
Power (Matt, mW)	36.9	35.8	31.6	38.8	23.4	25	29.2	29.7	25.4	31.4	29.6	27.6	28.4	26.8	33.8	34.3
Filter	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	3.69	3.58	3.16	3.88	2.34	2.5	2.92	2.97	2.54	3.14	2.96	2.76	2.84	2.68	3.38	3.43
Filtered Energy (uJ)	2.55	2.47	2.18	2.68	1.61	1.73	2.01	2.05	1.75	2.17	2.04	1.90	1.96	1.85	2.33	2.37
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-4	-3	-2	-1.9	-1	-0.2	-0.1	0	0.1	0.2	1	1.9	2	3	4	5
Approx offset on ground (m): 65k'	-79	-59	-40	-38	-20	-4	-2	0	2	4	20	38	40	59	79	99

Points of Interest:

Time (UTC)	TOF File	Description
23:54:54	3	Laser status healthy
00:11:04	14	start of first ICESat NE run
00:31:00	19	end of first ICESat NE run
00:37:55	21	start of first ICESat SE run
00:56:05	25	end of first ICESat SE run
01:02:40	27	start of second ICESat NE run
01:22:26	32	end of second ICESat NE run
01:28:30	33	start of first ICESat SE run
01:46:49	38	end of first ICESat SE run
01:53:18	39	start of third ICESat NE run
02:13:03	44	end of third ICESat NE run
02:20:50	46	start of first leg over Great Salt Lk
02:27:33	48	end of first leg over Great Salt Lk
02:48:02	53	start of second leg over Great Salt Lk
02:54:00	55	end of second leg over Great Salt Lk
03:00:46	56	start of small calibration run
03:23:25	62	end of small calibration run
04:27:32	78	Laser off

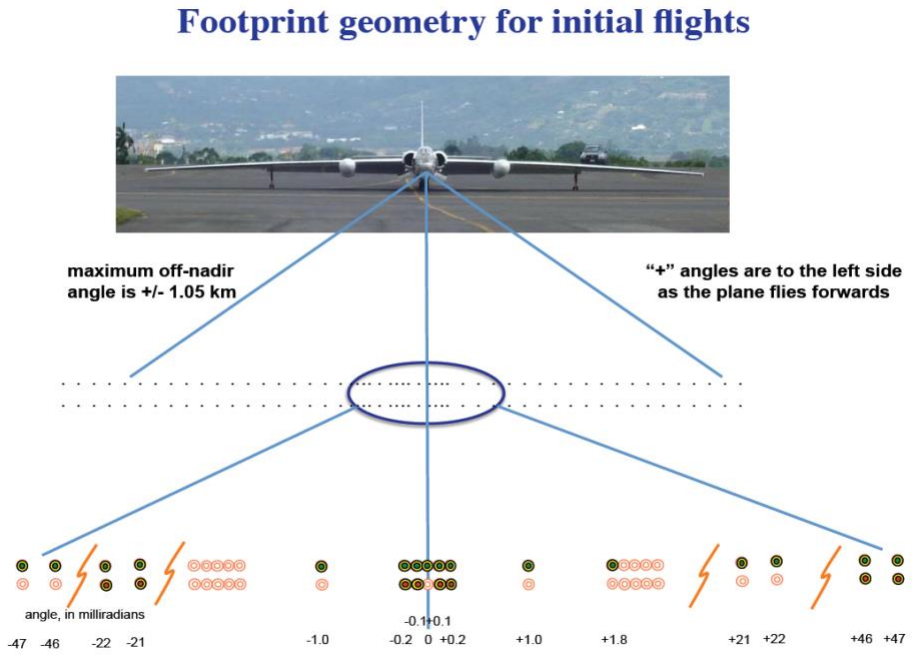
03/22/2011

Mission: ‘Dryden’



Weather: partly cloudy throughout; cloudy over ocean
Comments: First flight with ‘variable energy’ settings (see comment below). This flight path is intended to mimic the initialization flight path of IceBridge.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Wide FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	53	52	2	1	-1	-2	-27	-28
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	47	46	0.2	0.1	-0.1	-0.2	-21	-22
Approx offset on ground (m): 65k'	932	912	4	2	-2	-4	-416	-436

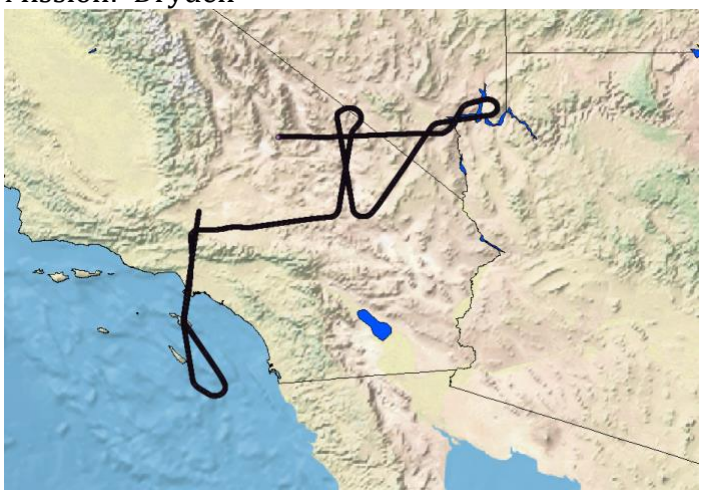
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-53	-52	-28	-27	-3	-2	-1	0	1	2	3	4	27	28	52	53
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	3.72	4.44	3.51	2.59	2.42	3.81	2.62	3.38	3.06	4.17	2.82	3.80	2.70	4.31	3.08
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-47	-46	-22	-21	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	21	22	46	47
Approx offset on ground (m): 65k'	-932	-912	-436	-416	-20	-4	-2	0	2	4	20	36	416	436	912	932

Points of Interest:

Time (UTC)	TOF File	Description
16:34:27	2	Laser status healthy
16:49:43	87	start first leg over Lk Meade
16:54:07	115	end first leg over Lk Meade
16:58:30	137	start second leg over Lk Meade
17:02:29	159	end second leg over Lk Meade
18:06:14	576	stat leg over ocean
18:33:28	631	end leg over ocean
18:38:26	672	Laser off

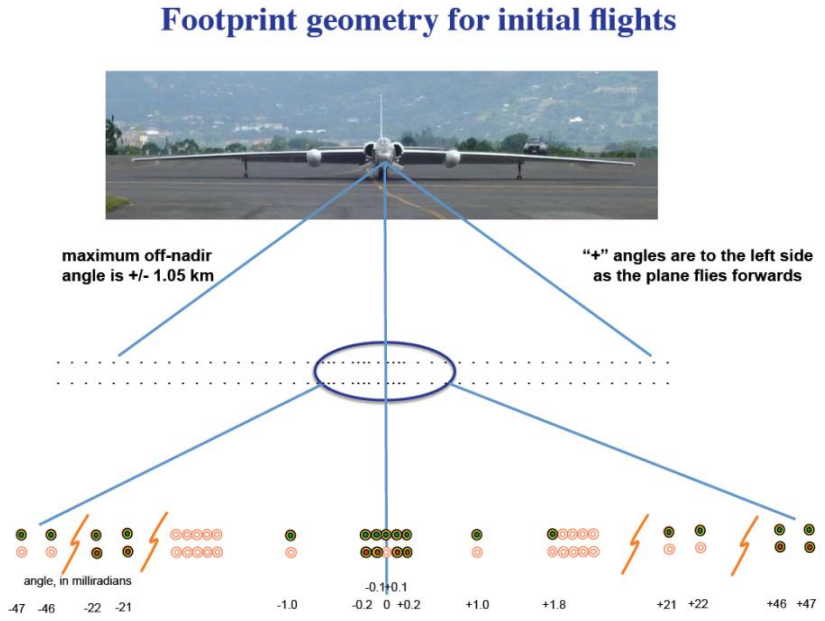
03/24/2011

Mission: 'Dryden'



Weather: Clear
Comments: This is the same as the flight on 3/22, however, in reverse. Note 'variable energy' settings (see comment below). This flight path is intended to mimic the initialization flight path of IceBridge.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 'weak' beams (see **colored** channels below).
FOV: 'Wide FOV' (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	53	52	2	1	-1	-2	-27	-28
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	47	46	0.2	0.1	-0.1	-0.2	-21	-22
Approx offset on ground (m): 65k'	932	912	4	2	-2	-4	-416	-436

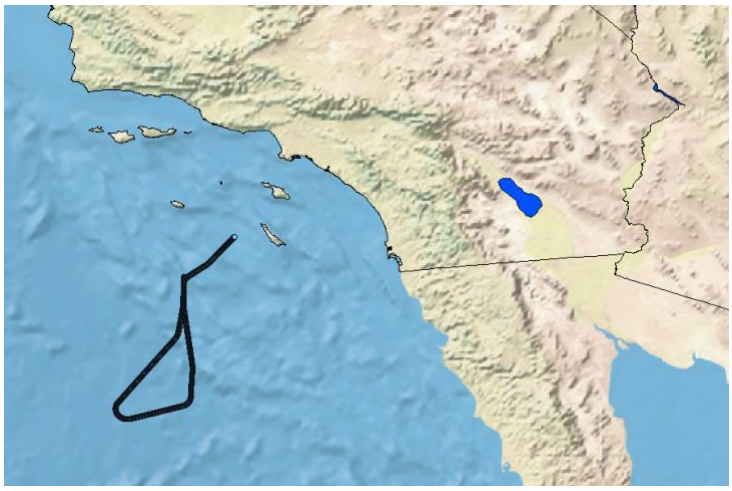
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-53	-52	-28	-27	-3	-2	-1	0	1	2	3	4	27	28	52	53
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49	0.69	0.49
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	3.72	4.44	3.51	2.59	2.42	3.81	2.62	3.38	3.06	4.17	2.82	3.80	2.70	4.31	3.08
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-47	-46	-22	-21	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	21	22	46	47
Approx offset on ground (m): 65k'	-932	-912	-436	-416	-20	-4	-2	0	2	4	20	36	416	436	912	932

Points of interest:

Time (UTC)	TOF File	Description
14:18:05	1	Laser status healthy
14:27:27	14	stat leg over ocean
14:54:54	43	end leg over ocean
15:59:14	264	start first leg over Lk Meade
16:03:07	272	end first leg over Lk Meade
16:06:30	286	start second leg over Lk Meade
16:11:18	305	end second leg over Lk Meade
16:29:19	391	Laser off

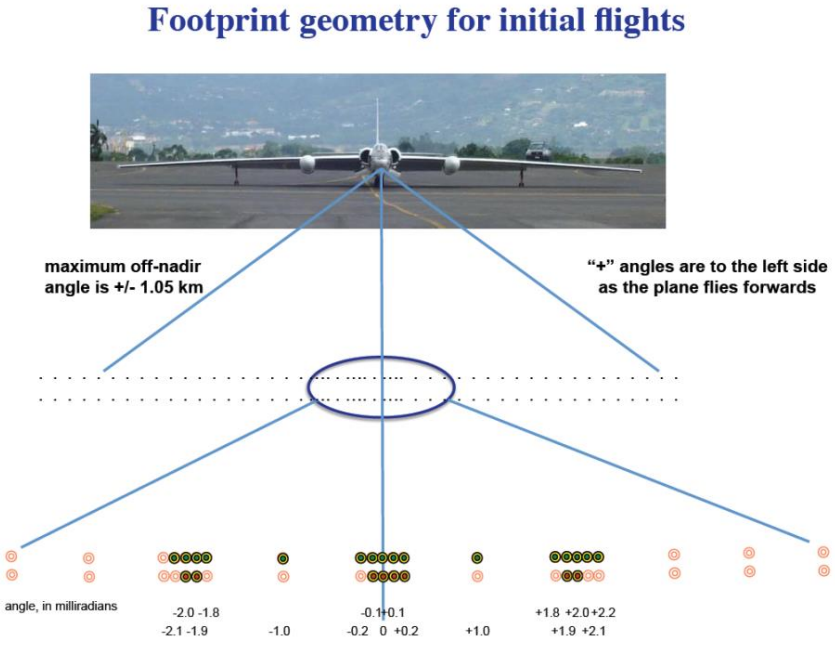
03/30/2011

Mission: ‘CATS Ocean’



Weather: Clear
Comments: This was officially a CATS mission, which flew out over the ocean. Data stopped recording at a late point in the flight

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	0	-1	-5	-6
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	0	-0.1	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	0	-2	-38	-40

Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.69	0.49	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	3.16	4.94	2.59	3.41	3.81	2.62	3.38	4.31	4.17	3.97	3.80	2.70	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	-2	-1.9	-1.8	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	1.9	2	2.1	2.2
Approx offset on ground (m): 65k'	-42	-40	-38	-36	-20	-4	-2	0	2	4	20	36	38	40	42	44

Points of interest:

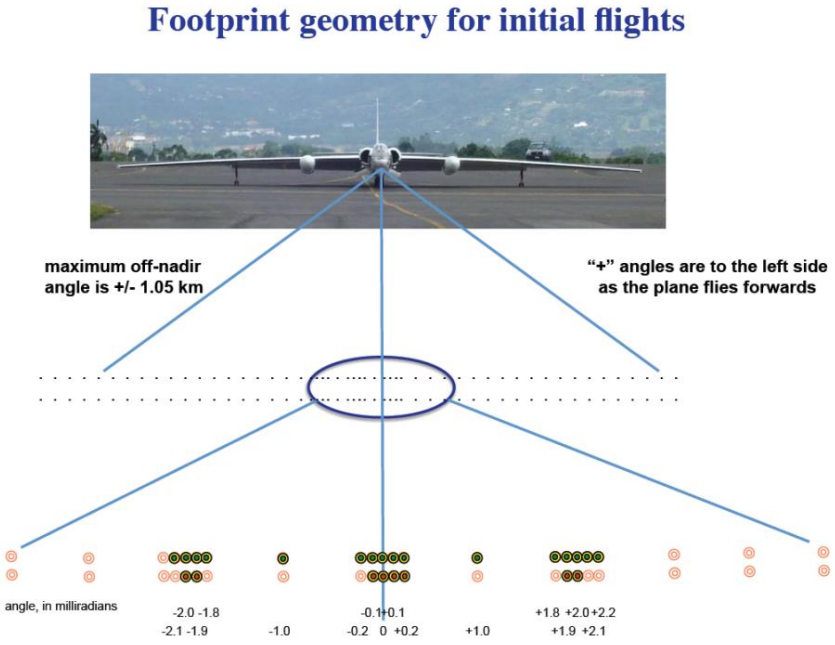
Time (UTC)	TOF File	Description
16:54:50	0	Laser status healthy
18:22:58	31	Laser off

03/31/2011

Mission: ‘Sierras’

Weather: Clear
Comments: There was snow in the Sierras at the time of this flight. A small, potentially ice-covered lake was also surveyed.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	0	-1	-5	-6
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	0	-0.1	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	0	-2	-38	-40

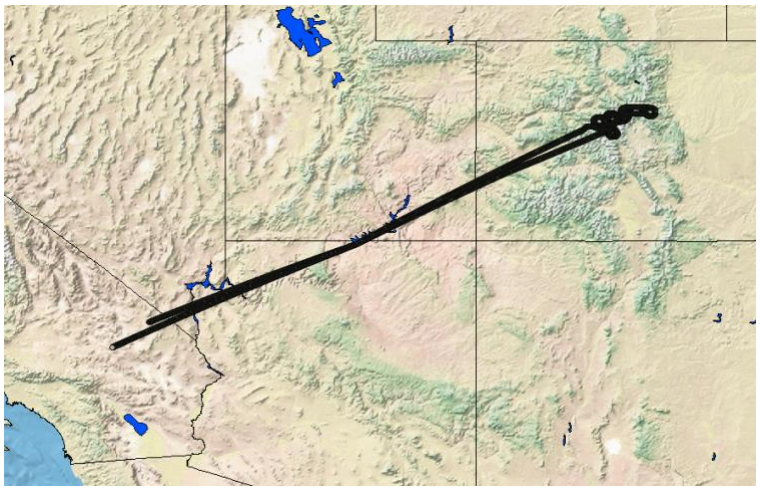
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.69	0.49	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	3.16	4.94	2.59	3.41	3.81	2.62	3.38	4.31	4.17	3.97	3.80	2.70	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	-2	-1.9	-1.8	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	1.9	2	2.1	2.2
Approx offset on ground (m): 65k'	-42	-40	-38	-36	-20	-4	-2	0	2	4	20	36	38	40	42	44

Points of interest:

Time (UTC)	TOF File	Description
16:18:42	1	Laser status healthy
16:25:17	54	start of Sierra run
17:30:45	479	end of Sierra run
17:38:53	556	start of Lk Crowley SE run
17:39:31	563	end of Lk Crowley SE run
17:44:04	608	start of Lk Crowley SW run
17:44:37	614	end of Lk Crowley SW run
17:55:44	786	Laser off

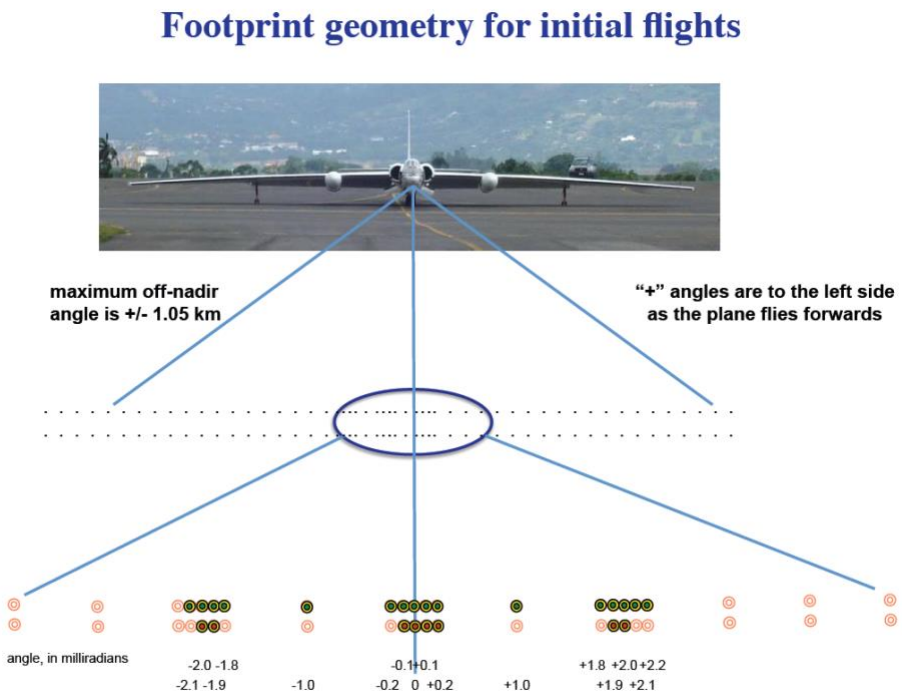
04/01/2011

Mission: ‘Colorado’



Weather: Partly cloudy in transit to CO; CO clear.
Comments: This flight may contain high clouds for engineering analysis.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	0	-1	-5	-6
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	0	-0.1	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	0	-2	-38	-40

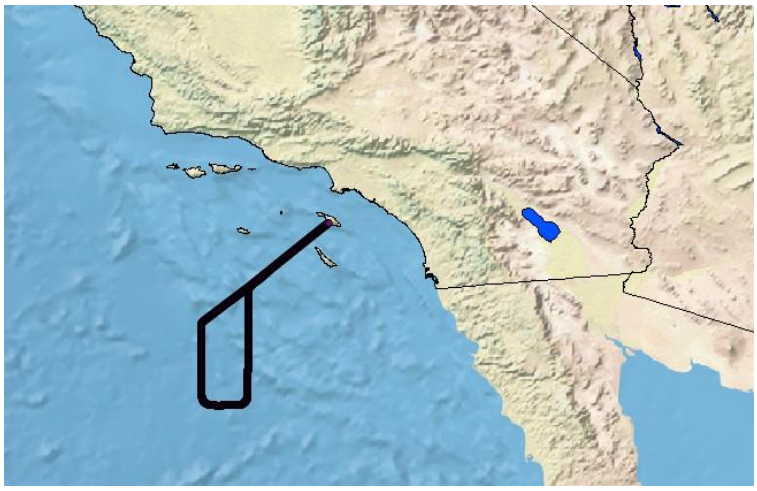
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.69	0.49	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	3.16	4.94	2.59	3.41	3.81	2.62	3.38	4.31	4.17	3.97	3.80	2.70	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	-2	-1.9	-1.8	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	1.9	2	2.1	2.2
Approx offset on ground (m): 65k'	-42	-40	-38	-36	-20	-4	-2	0	2	4	20	36	38	40	42	44

Points of interest:

Time (UTC)	TOF File	Description
16:14:56	1	Laser status healthy
17:28:17	533	start of run over SNOTEL targets
18:33:11	1533	end of run over SNOTEL targets
19:55:18	2251	Laser off

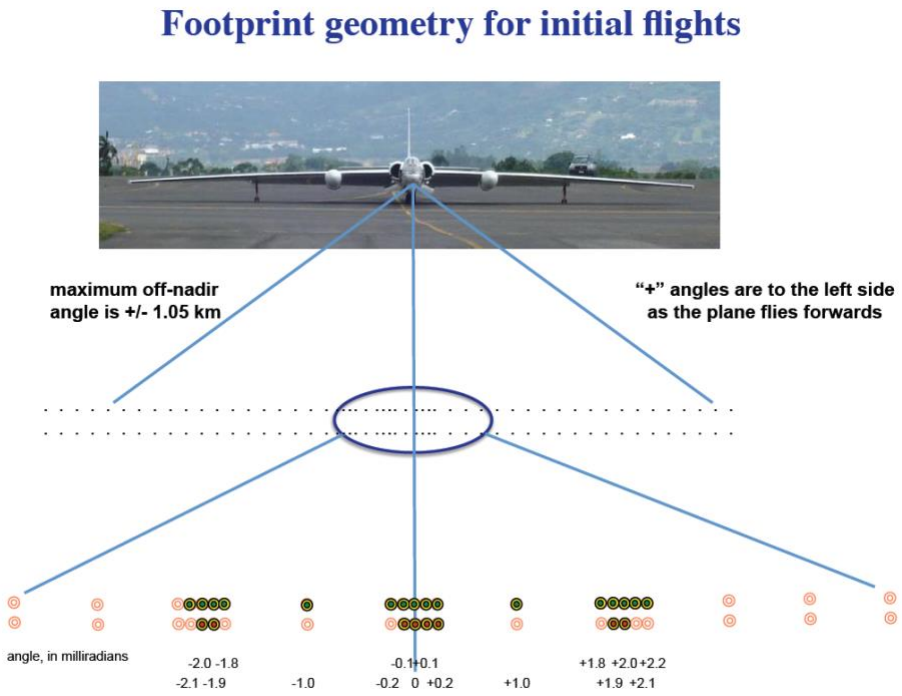
04/04/2011

Mission: ‘CATS Ocean’



Weather: Cloudy; marine layer
Comments: This was officially a CATS mission, which flew out over the ocean.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	0	-1	-5	-6
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	0	-0.1	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	0	-2	-38	-40

Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.69	0.49	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	3.16	4.94	2.59	3.41	3.81	2.62	3.38	4.31	4.17	3.97	3.80	2.70	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	-2	-1.9	-1.8	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	1.9	2	2.1	2.2
Approx offset on ground (m): 65k'	-42	-40	-38	-36	-20	-4	-2	0	2	4	20	36	38	40	42	44

Points of interest:

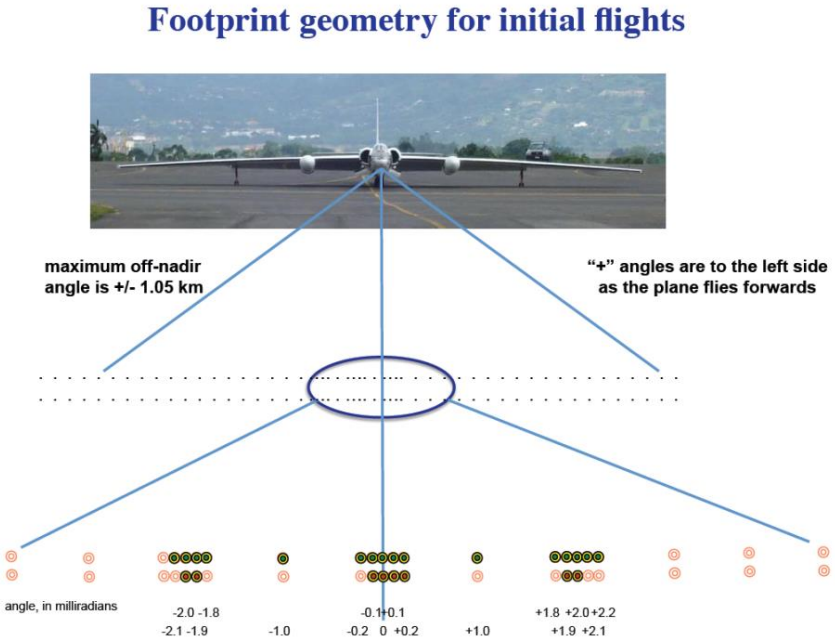
Time (UTC)	TOF File	Description
20:02:45	0	Laser status healthy
20:48:26	335	Laser off

04/05/2011

Mission: ‘White Sands’

Weather: Clear
Comments: Mission to White Sands and White River, AR. However, sometime after the targets at White Sands the laser died.

ER-2
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	6	5	2	1	0	-1	-5	-6
Channel	47	48	49	50	46	45	44	43
Power (Matt, mW)	32	33.6	25	17.2	25.2	25	20	23.8
Filter	0.49	0.15	0.49	0.15	0.49	0.15	0.49	0.15
Raw Energy (Matt, uJ)	6.4	6.72	5	3.44	5.1	5	4	4.76
Filtered Energy (uJ)	3.14	1.01	2.45	0.52	2.50	0.75	1.96	0.71
Path Lengths (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	2	1.9	0.2	0.1	0	-0.1	-1.9	-2
Approx offset on ground (m): 65k'	40	38	4	2	0	-2	-38	-40

Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
Channel	2	3	1	4	16	5	15	6	14	7	13	8	12	9	11	10
Power (Matt, mW)	34.4	38	32.2	35.8	18.8	24.7	27.6	26.7	24.5	31.2	30.2	28.8	27.5	27.6	31.2	31.4
Filter	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.49	0.69	0.69	0.69	0.69	0.69	0.49	0.69	0.69
Raw Energy (Matt, uJ)	6.88	7.6	6.44	7.16	3.76	4.94	5.52	5.34	4.9	6.24	6.04	5.76	5.5	5.52	6.24	6.28
Filtered Energy (uJ)	4.75	5.24	3.16	4.94	2.59	3.41	3.81	2.62	3.38	4.31	4.17	3.97	3.80	2.70	4.31	4.33
Path Lengths (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	-2	-1.9	-1.8	-1	-0.2	-0.1	0	0.1	0.2	1	1.8	1.9	2	2.1	2.2
Approx offset on ground (m): 65k'	-42	-40	-38	-36	-20	-4	-2	0	2	4	20	36	38	40	42	44

Points of interest:

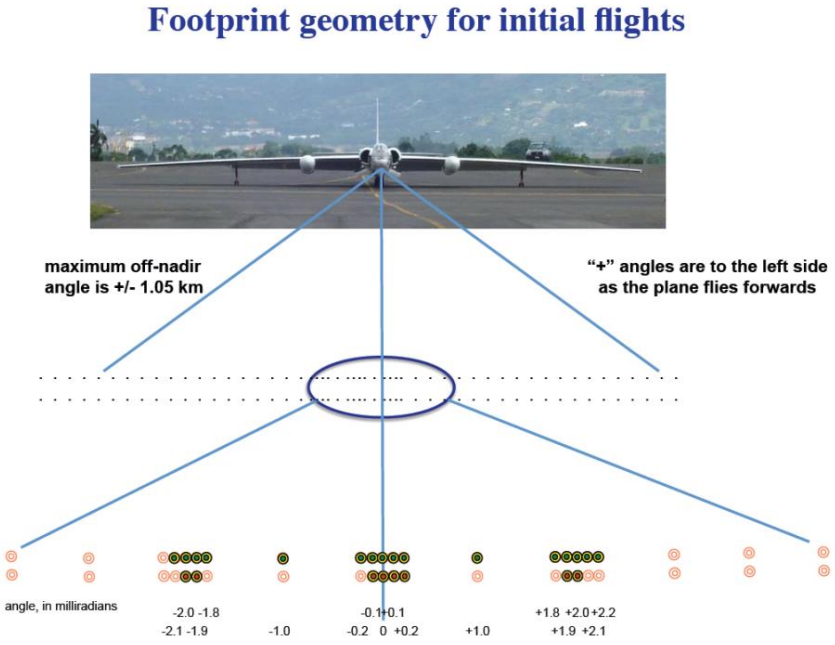
Time (UTC)	TOF File	Description
16:21:57	1	Laser status healthy
16:34:27	66	start Grand Canyon leg
16:37:26	82	end Grand Canyon leg
16:46:04	133	start Flagstaff run
16:47:52	142	end Flagstaff run
17:12:41	315	start McCarty's run
17:16:9	332	end McCarty's run
17:33:14	470	start Carrizoz run
17:34:13	477	end Carrizoz run
17:36:18	502	start of first ICESat SW run
17:39:25	551	end of first ICESat SW run
17:44:02	607	start of first ICESat NW run
17:47:24	666	end of first ICESat NW run
17:52:32	720	start of second ICESat SW run
17:55:39	770	end of second ICESat SW run
17:59:45	819	start of second ICESat NW run
18:03:03	877	end of second ICESat NW run
18:07:38	924	start of third ICESat SW run
18:10:44	974	end of third ICESat SW run
18:14:37	1022	start of third ICESat NW run
18:17:54	1080	end of third ICESat NW run
18:22:22	1121	start of White Sands NP SE run
18:24:37	1164	end of White Sands NP SE run
18:28:25	1206	start of White Sands NP SW run
18:30:37	1248	end of White Sands NP SW run
18:37:50	1347	Laser dies (sometime after this)

02/21/2012

Mission: ‘Dryden 1’

Weather: High cirrus local to Dryden
Comments: Also included: CATS, CPL, DCS;
5 degree pitch and roll maneuvers.

ER-2
No Etalon; Twilight flights
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	-6	-5	-1	0	1	2	5	6
Channel	43	44	45	46	47	48	49	50
Power (Matt, mW)	0	0	0	0	0	0	0	0
Filter	0.25	0.25	0.25	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	-2	-1.9	-0.1	0	0.1	0.2	1.9	2
Approx offset on ground (m): 65k'	-40	-38	-2	0	2	4	38	40
Elevaton (mrad)	1.5	2.0	1.0	1.5	2.0	2.5	1.0	1.5
Approx offset on ground (m): 65k'	30	40	20	30	40	50	20	30

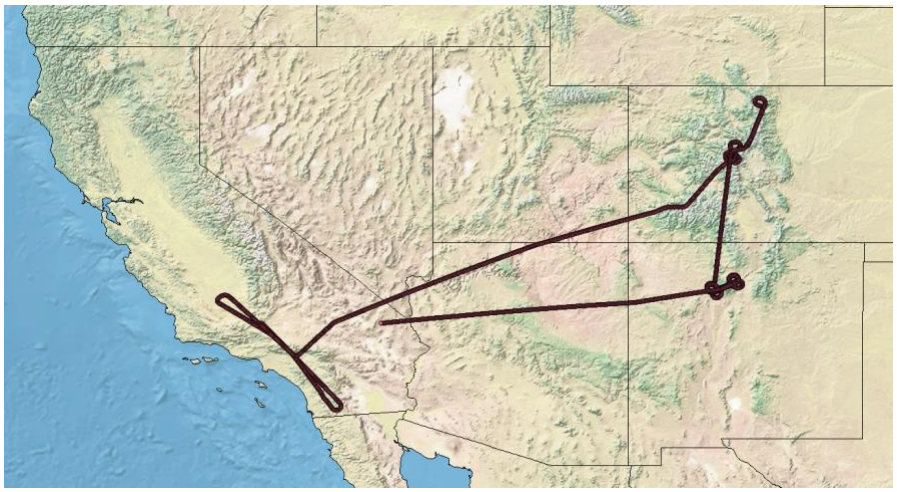
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	**-7**	**5**	**2**	**3**	**6**	**-2**	**99**	**4**	**-5**	**7**	**1**	**-4**	**-6**	**0**	**-3**	**8**
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Power (Matt, mW)	3.48	12.03	13.48	13.04	11.01	13.77	11.30	12.61	9.86	10.43	16.52	12.17	10.87	16.96	13.01	0.00
Filter	0.69	0.69	0.69	0.69	0.25	0.69	0.37	0.69	0.37	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0.7	2.41	2.7	2.61	2.2	2.75	2.26	2.52	1.97	2.09	3.3	2.43	2.17	3.39	2.61	0
Filtered Energy (uJ)	0.48	1.66	1.86	1.80	0.55	1.90	0.84	1.74	0.73	1.44	2.28	1.68	1.50	2.34	1.80	0.00
Relative path difference (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	1.9	0.2	1	2	-0.2	0	1.8	-1.9	2.1	0.1	-1.8	-2	0	-1	2.2
Approx offset on ground (m): 65k'	-42	38	4	20	40	-4	0	36	-38	42	2	-36	-40	0	-20	44
Elevaton (mrad)	-2.0	-2.0	-0.5	-1.5	-1.5	-2.5	0.0	-2.5	-1.0	-1.0	-1.0	-0.5	-1.5	-1.5	-1.5	-0.5
Approx offset on ground (m): 65k'	-40	-40	-10	-30	-30	-50	0	-50	-20	-20	-20	-10	-30	-30	-30	-10

Points of interest:

Time (UTC)	Description
1:0:13	Laser status healthy; over open ocean
1:22:3	End of open ocean
2:6:57	Start Lake Mead
2:21:49	End Lake Mead
2:46:36	Laser off

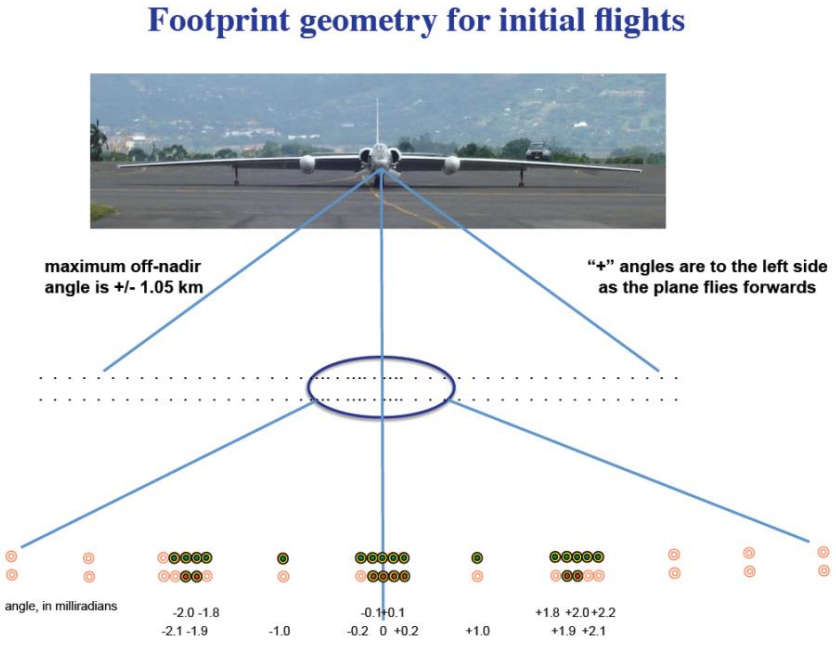
02/22/2012

Mission: ‘New Mexico and Colorado’



Weather: ‘Good’ throughout most of the flight
Comments: Also included: CPL, DCS;
John Anderson’s targets at RAMPW (2x).

ER-2
No Etalon; Twilight flights
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	-6	-5	-1	0	1	2	5	6
Channel	43	44	45	46	47	48	49	50
Power (Matt, mW)	0	0	0	0	0	0	0	0
Filter	0.25	0.25	0.25	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	-2	-1.9	-0.1	0	0.1	0.2	1.9	2
Approx offset on ground (m): 65k'	-40	-38	-2	0	2	4	38	40
Elevaton (mrad)	1.5	2.0	1.0	1.5	2.0	2.5	1.0	1.5
Approx offset on ground (m): 65k'	30	40	20	30	40	50	20	30

Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	**-7**	**5**	**2**	**3**	**6**	**-2**	**99**	**4**	**-5**	**7**	**1**	**-4**	**-6**	**0**	**-3**	**8**
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Power (Matt, mW)	3.48	12.03	13.48	13.04	11.01	13.77	11.30	12.61	9.86	10.43	16.52	12.17	10.87	16.96	13.01	0.00
Filter	0.69	0.69	0.69	0.69	0.25	0.69	0.37	0.69	0.37	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0.7	2.41	2.7	2.61	2.2	2.75	2.26	2.52	1.97	2.09	3.3	2.43	2.17	3.39	2.61	0
Filtered Energy (uJ)	0.48	1.66	1.86	1.80	0.55	1.90	0.84	1.74	0.73	1.44	2.28	1.68	1.50	2.34	1.80	0.00
Relative path difference (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	1.9	0.2	1	2	-0.2	0	1.8	-1.9	2.1	0.1	-1.8	-2	0	-1	2.2
Approx offset on ground (m): 65k'	-42	38	4	20	40	-4	0	36	-38	42	2	-36	-40	0	-20	44
Elevaton (mrad)	-2.0	-2.0	-0.5	-1.5	-1.5	-2.5	0.0	-2.5	-1.0	-1.0	-1.0	-0.5	-1.5	-1.5	-1.5	-0.5
Approx offset on ground (m): 65k'	-40	-40	-10	-30	-30	-50	0	-50	-20	-20	-20	-10	-30	-30	-30	-10

Points of interest:

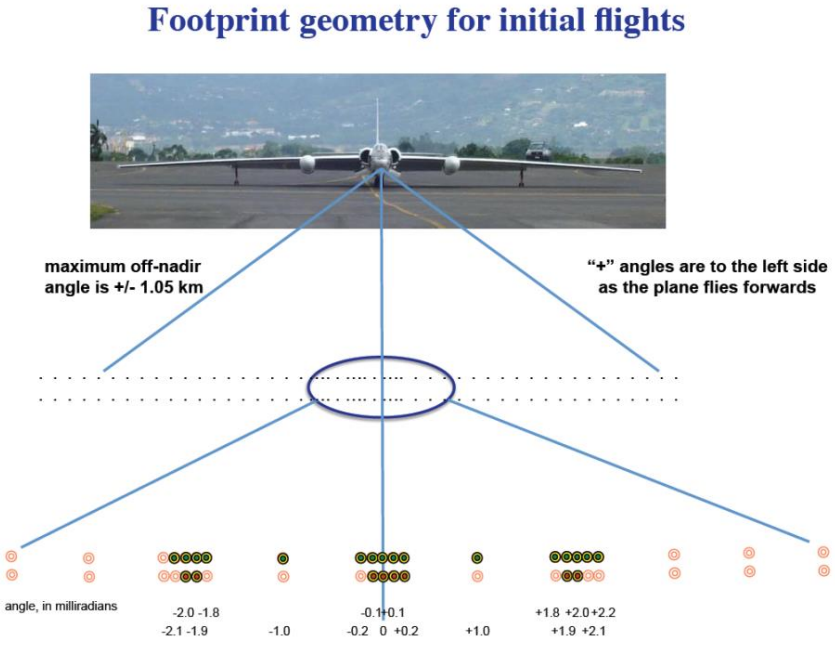
Time (UTC)	Description
1:4:1	Laser status healthy
1:51:45	RAMPW 1
2:22:17	RAMPW 2
3:47:32	Senator Beck area
4:2:36	Start of CO run
5:4:53	End of CO run
5:30:4	Start NM run
7:5:7	End NM run
8:7:1	Laser off

02/23/2012

Mission: 'Dryden x2'

Weather: Good; Lake Mead clear on 1st pass; questionable on 2nd
Comments: Also included: CPL, DCS;
John Anderson's targets at RAMPW (6x); 2 passes of the 'Dryden' mission.

ER-2
No Etalon; Twilight flights
Sample rate: 10 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 'weak' beams (see **colored** channels below).
FOV: 'Cluster FOV' (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	-6	-5	-1	0	1	2	5	6
Channel	43	44	45	46	47	48	49	50
Power (Matt, mW)	0	0	0	0	0	0	0	0
Filter	0.25	0.25	0.25	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	0	16	32	48	65	81	97	113
Angle (mrad)	-2	-1.9	-0.1	0	0.1	0.2	1.9	2
Approx offset on ground (m): 65k'	-40	-38	-2	0	2	4	38	40
Elevaton (mrad)	1.5	2.0	1.0	1.5	2.0	2.5	1.0	1.5
Approx offset on ground (m): 65k'	30	40	20	30	40	50	20	30

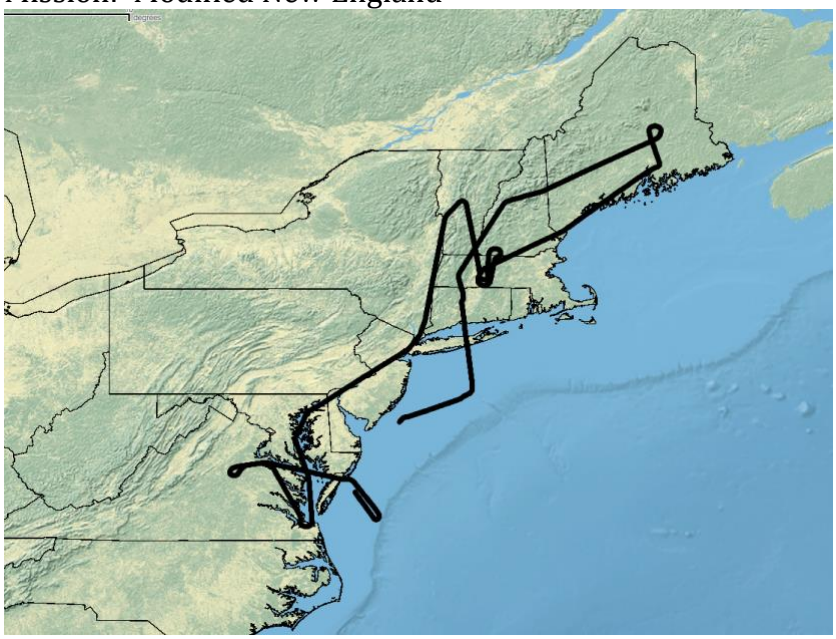
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	**-7**	**5**	**2**	**3**	**6**	**-2**	**99**	**4**	**-5**	**7**	**1**	**-4**	**-6**	**0**	**-3**	**8**
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Power (Matt, mW)	3.48	12.03	13.48	13.04	11.01	13.77	11.30	12.61	9.86	10.43	16.52	12.17	10.87	16.96	13.01	0.00
Filter	0.69	0.69	0.69	0.69	0.25	0.69	0.37	0.69	0.37	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Raw Energy (Matt, uJ)	0.7	2.41	2.7	2.61	2.2	2.75	2.26	2.52	1.97	2.09	3.3	2.43	2.17	3.39	2.61	0
Filtered Energy (uJ)	0.48	1.66	1.86	1.80	0.55	1.90	0.84	1.74	0.73	1.44	2.28	1.68	1.50	2.34	1.80	0.00
Relative path difference (Matt, mm)	27	43	59	75	92	108	124	140	156	172	188	204	221	237	253	269
Angle (mrad)	-2.1	1.9	0.2	1	2	-0.2	0	1.8	-1.9	2.1	0.1	-1.8	-2	0	-1	2.2
Approx offset on ground (m): 65k'	-42	38	4	20	40	-4	0	36	-38	42	2	-36	-40	0	-20	44
Elevaton (mrad)	-2.0	-2.0	-0.5	-1.5	-1.5	-2.5	0.0	-2.5	-1.0	-1.0	-1.0	-0.5	-1.5	-1.5	-1.5	-0.5
Approx offset on ground (m): 65k'	-40	-40	-10	-30	-30	-50	0	-50	-20	-20	-20	-10	-30	-30	-30	-10

Points of interest:

Time (UTC)	Description
1:32:8	Laser status healthy
1:35:34	RAMPW 1
2:19:40	RAMPW 2
2:47:40	RAMPW 3
3:32:10	RAMPW 4
4:1:18	RAMPW 5
4:38:12	Start Lake Mead 1
4:51:39	End Lake Mead 1
5:34:7	RAMPW 6
6:15:17	Start Lake Mead 2
6:28:32	End Lake Mead 2
6:54:37	Laser off

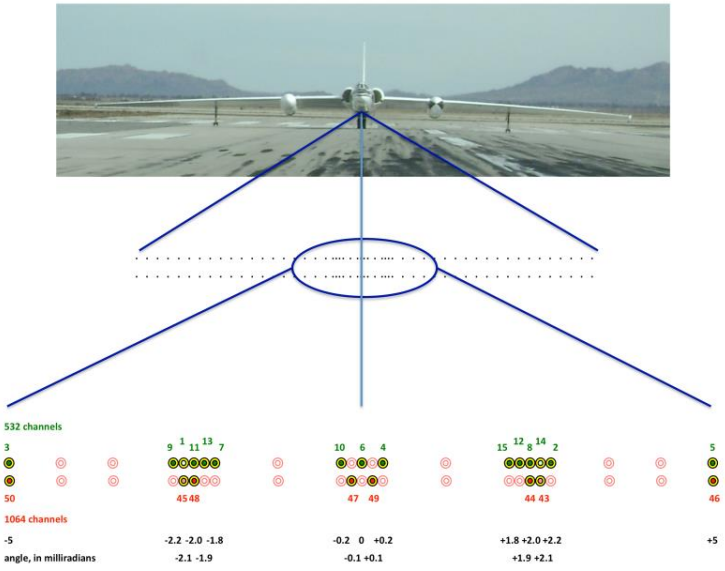
09/14/2012

Mission: ‘Modified New England’



Weather: Generally clear in eastern New England; high cirrus rolling in from the west; NYC might have been obscured by high cirrus; Chesapeake was clear
Comments: Also included: CPL, CATS.

ER-2
Etalon; night flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

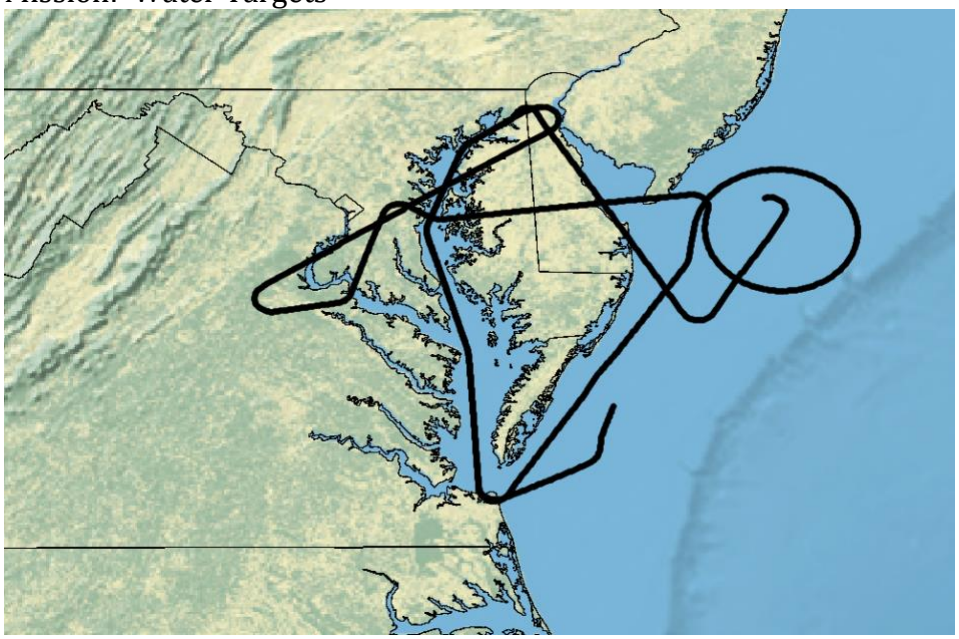
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
20:10:15	Laser status healthy
20:16:0	Start of P&R maneuvers
20:20:0	End of P&R maneuvers
23:10:0	Start of NYC run
23:30:30	Start of Chesapeake run
23:52:0	End of Chesapeake run
0:40:0	Start of P&R maneuvers
0:45:0	End of P&R maneuvers
0:47:0	Start of P&R maneuvers
0:52:0	End of P&R maneuvers
0:52:10	Laser off

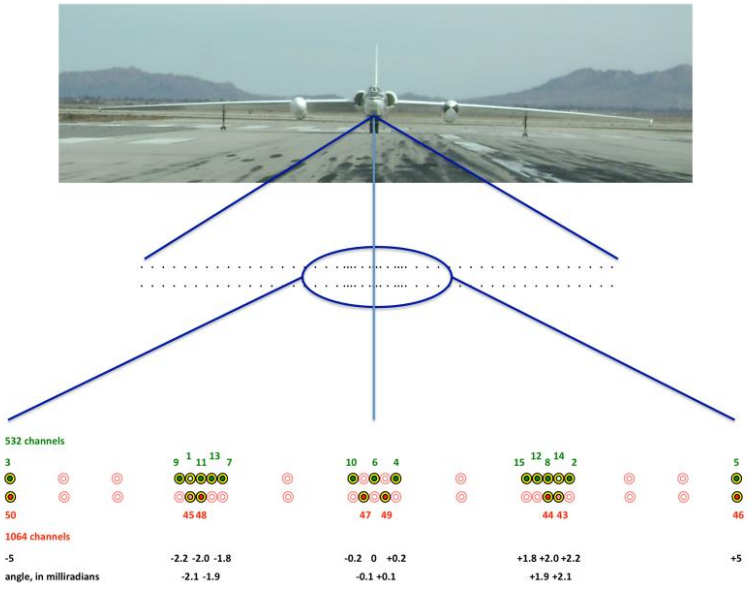
09/15/2012

Mission: ‘Water Targets’



Weather: High cirrus
Comments: Also included: CPL, CATS.

ER-2
Etalon; night flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

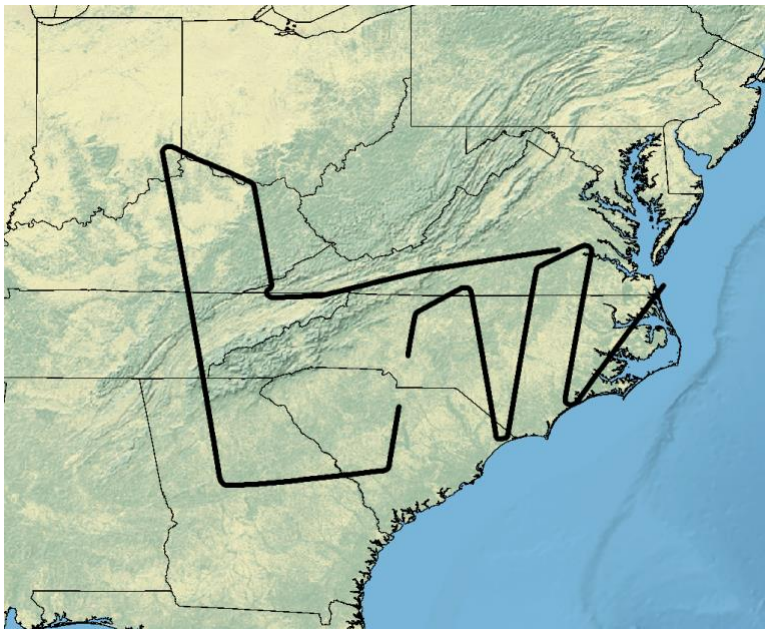
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
20:06:30	Laser status healthy
20:11:0	Start of P&R maneuvers
20:13:0	End of P&R maneuvers
20:32:0	Start of Chesapeake run
20:59:45	End of Chesapeake run
21:05:0	Start of P&R maneuvers
21:08:0	End of P&R maneuvers
22:31:30	Start of Chesapeake run
22:55:45	End of Chesapeake run
22:59:0	Start of P&R maneuvers
23:01:0	End of P&R maneuvers
23:4:30	Laser off

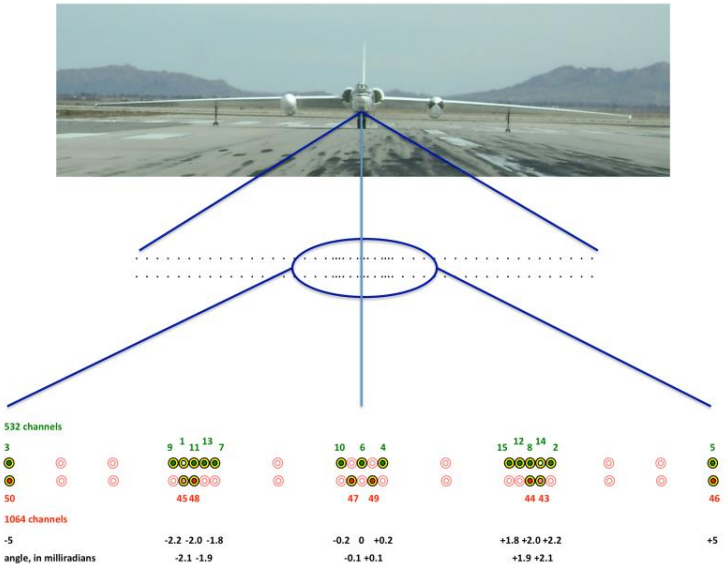
09/20/2012

Mission: ‘Modified Southeast’



Weather: Dense clouds for the first half of flight (AMIGA lines SE of the Appalachian Range); clear NW of range
Comments: Also included: CPL, CATS.

ER-2
Etalon; night flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

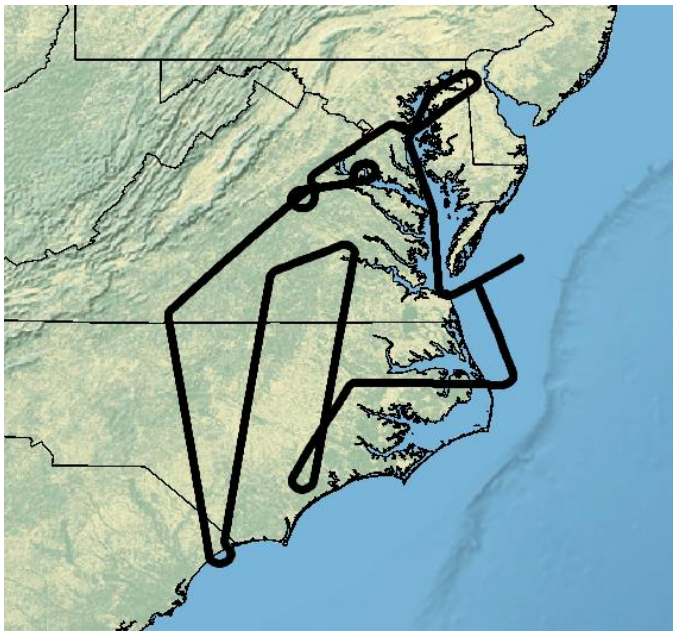
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
22:16:45	Laser status healthy
0:9:15	Power cycle start (data loss)
0:44:30	Power cycle end (data loss)
1:7:45	Start of clear weather
3:13:45	Laser off

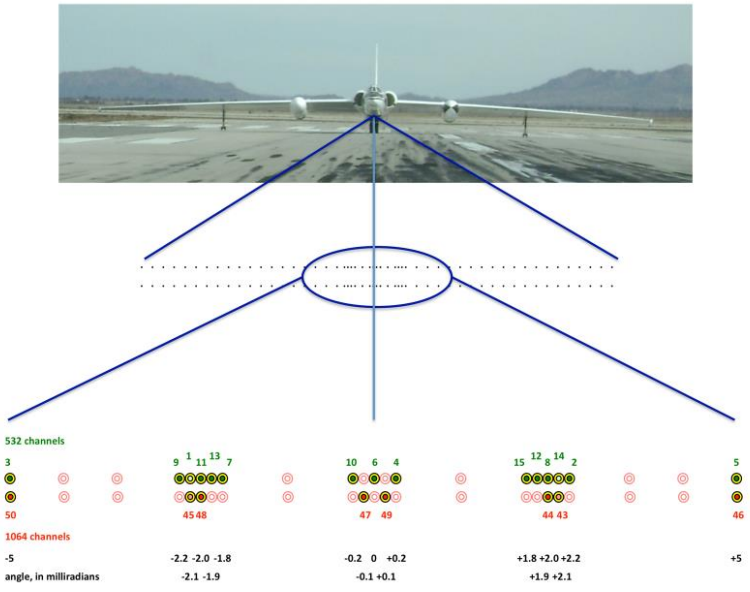
09/21/2012

Mission: ‘Modified Mid-Atlantic’



Weather: Very clear; best flight with respect to weather
Comments: Also included: CPL, CATS.

ER-2
Etalon; night flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 ‘weak’ beams (see **colored** channels below).
FOV: ‘Cluster FOV’ (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

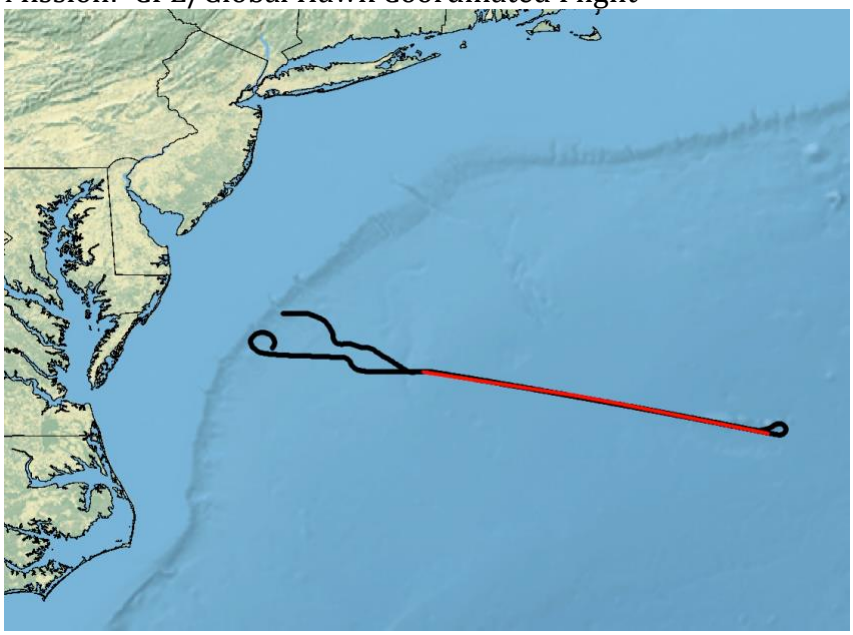
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
21:24:0	Laser status healthy
21:25:0	Start of P&R maneuvers
21:29:0	End of P&R maneuvers
0:46:15	Start of Chesapeake run
1:11:0	End of Chesapeake run
1:14:0	Start of P&R maneuvers
1:19:0	End of P&R maneuvers
1:19:14	Laser off

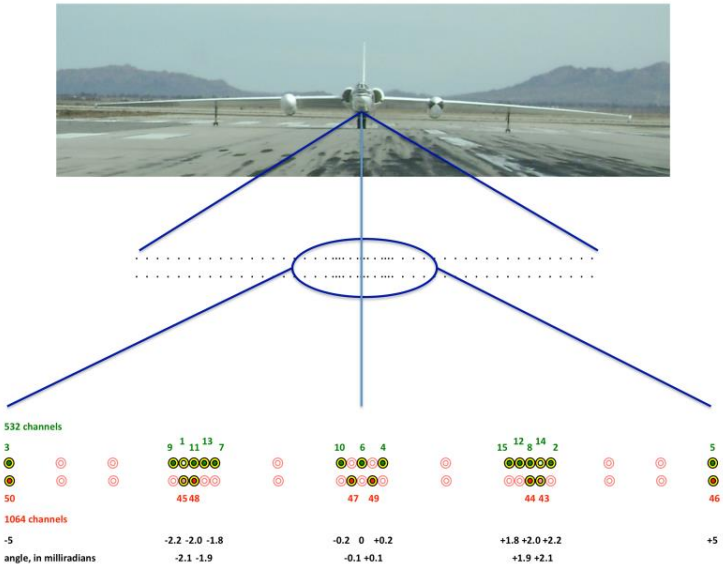
09/23/2012

Mission: 'CPL/Global Hawk Coordinated Flight'



Weather: Variable clouds at various elevations
Comments: Coordinated flight with CPL on Global Hawk (red line above) which tookoff on 9/22/12; fourth data segment of that flight includes the coordinated stretch. ER-2 also included: CPL, CATS.

ER-2
Etalon; DAYTIME flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 'weak' beams (see **colored** channels below).
FOV: 'Cluster FOV' (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

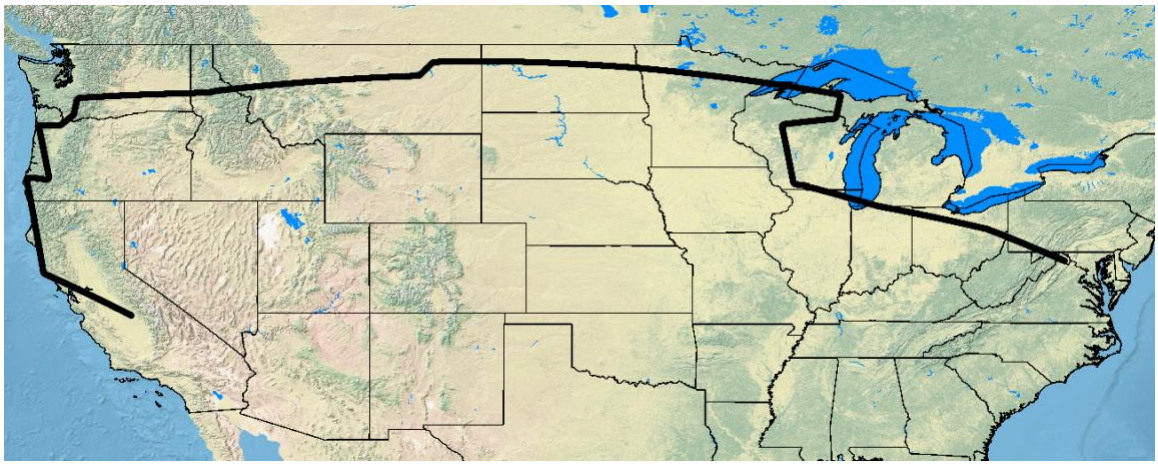
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
15:58:0	Laser status healthy
16:53:45	Global hawk coordination start time
17:20:0	Global hawk coordination end time
17:36:0	Laser off

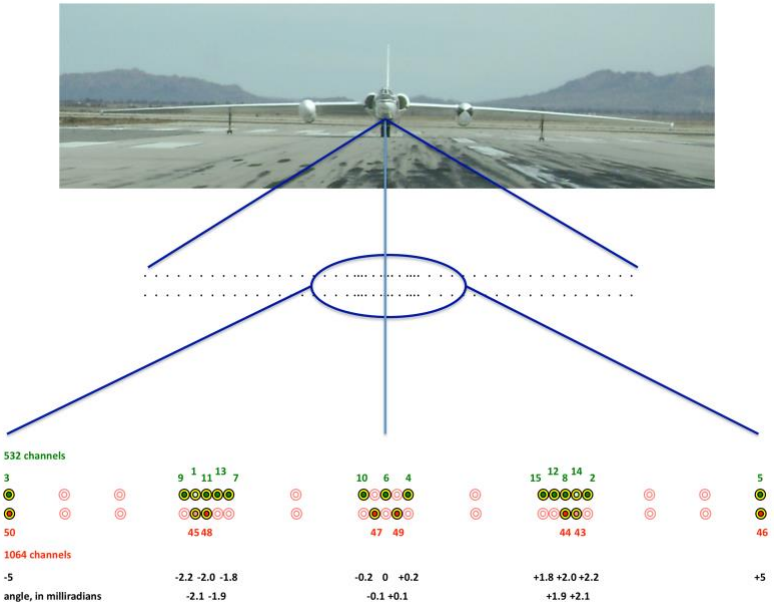
09/26/2012

Mission: 'Transit to KPMD'



Weather: Clear over Lk Michigan; clear over WI G-LiHT line; cloudy over MI G-LiHT line, MT, ID, and eastern OR; pilot reported clear over Portland; clear on west coast.
Comments: Also included: CPL, CATS.

ER-2
Etalon; night flight
Sample rate: 5 kHz
Energy levels throughout channels: variable: some beams were filtered to simulate ICESat-2 'weak' beams (see **colored** channels below).
FOV: 'Cluster FOV' (see image below)



Angle to Channel map:

Fiber	1	2	3	4	5	6	7	8
Connector	7	6	-7	11	-1	-6	1	-11
Channel	43	44	45	46	47	48	49	50
Transmitter Power (mW)	6.17	7.12	4.7	7.67	8.26	7.06	8.73	7.67
Filter	0.25	0.25	0.25	0.49	0.49	0.25	0.49	0.49
Receiver Power (mW) MEASURED	2.49	4.45	2.07	7.43	7.53	4.33	9.27	5.68
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	48	0	97	32	16	81	113	65
Angle (mrad)	2.1	2	-2.1	5	-0.1	-2	0.1	-5
Approx offset on ground (m): 65k'	42	40	-42	99	-2	-40	2	-99
Elevaton (mrad)	2.0	1.5	1.0	1.5	1.0	1.5	2.0	1.5
Approx offset on ground (m): 65k'	40	30	20	30	20	30	40	30

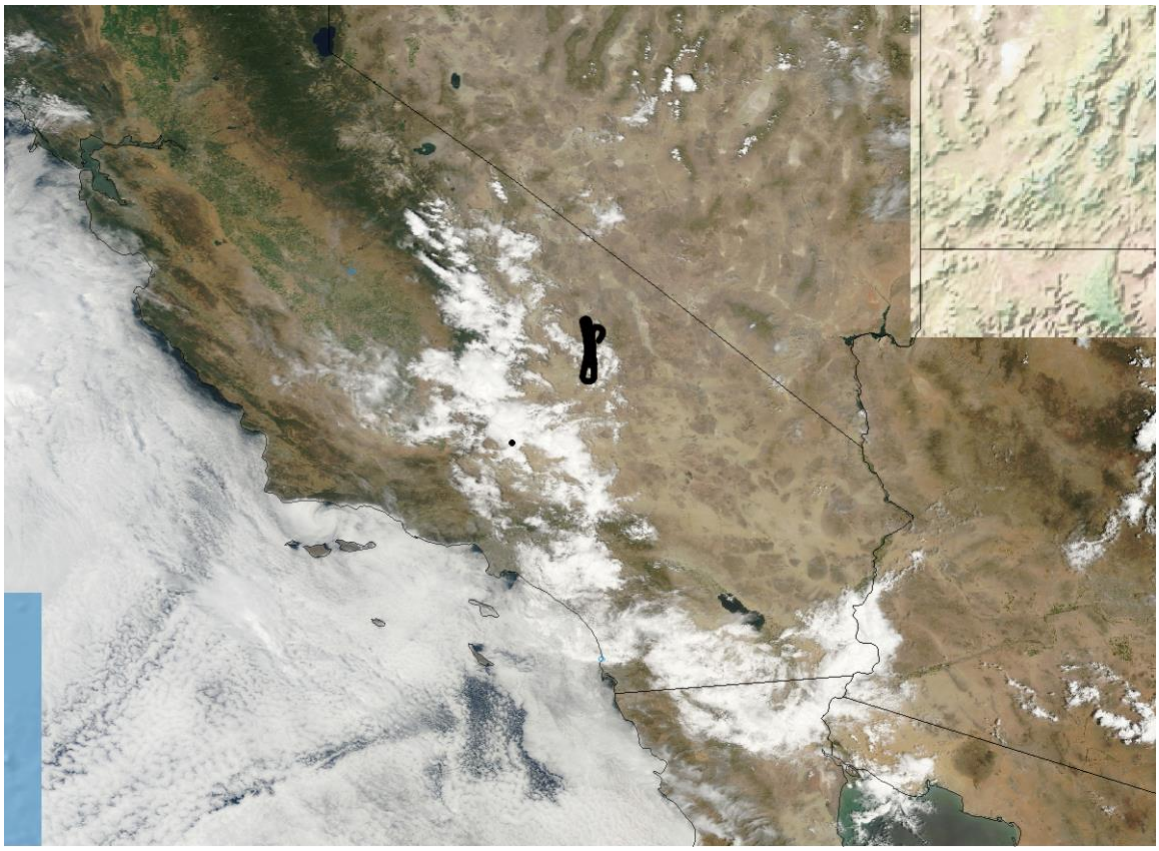
Fiber	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connector	-7	8	-11	2	11	0	-4	6	-8	-2	-6	5	-5	7	4	10
Channel	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Transmitter Power (mW)	1.08	3.22	7.35	2.92	6.92	9.86	3.19	3.41	2.99	1.33	3.09	3.55	0.01	1.36	3.08	0.01
Filter	0.25	0.37	0.69	0.69	0.69	0.69	0.49	0.37	0.37	0.69	0.37	0.69	0.69	0.25	0.37	0.69
Receiver Power (mW) MEASURED	1.59	2.41	3.01	1.91	2.89	3.21	2.26	2.61	1.98	1.76	2.23	2.67	1.09	1.89	2.21	1.05
Raw Energy (Matt, uJ)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filtered Energy (uJ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative path difference (Matt, mm)	172	237	253	75	188	140	59	221	43	27	108	204	269	156	124	92
Angle (mrad)	-2.1	2.2	-5	0.2	5	0	-1.8	2	-2.2	-0.2	-2	1.9	-1.9	2.1	1.8	4
Approx offset on ground (m): 65k'	-42	44	-99	4	99	0	-36	40	-44	-4	-40	38	-38	42	36	79
Elevaton (mrad)	-2.0	-0.5	-1.5	-0.5	-1.5	-1.5	-0.5	-1.5	-2.5	-2.5	-1.5	-2.0	-1.0	-1.0	-2.5	-1.5
Approx offset on ground (m): 65k'	-40	-10	-30	-10	-30	-30	-10	-30	-50	-50	-30	-40	-20	-20	-50	-30

Points of interest:

Time (UTC)	Description
21:30:30	Laser status healthy
21:35:0	Start of P&R maneuvers
21:40:0	End of P&R maneuvers
21:42:30	Data loss start
22:11:45	Data loss end
2:35:30	Start of Portland run
4:22:30	Laser off

07/01/2013

Mission: ‘Trona1’



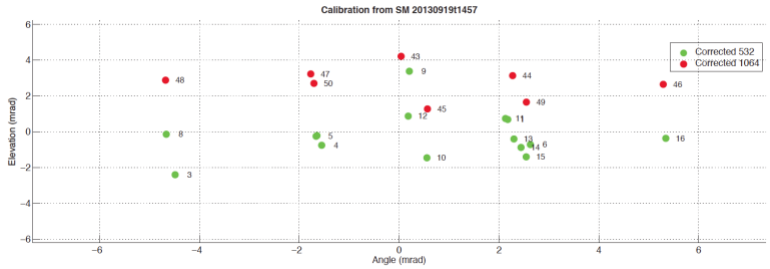
Weather: Generally clear over Trona targets

Proteus
Etalon; day flight
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: ‘Cluster FOV’

Points of interest:

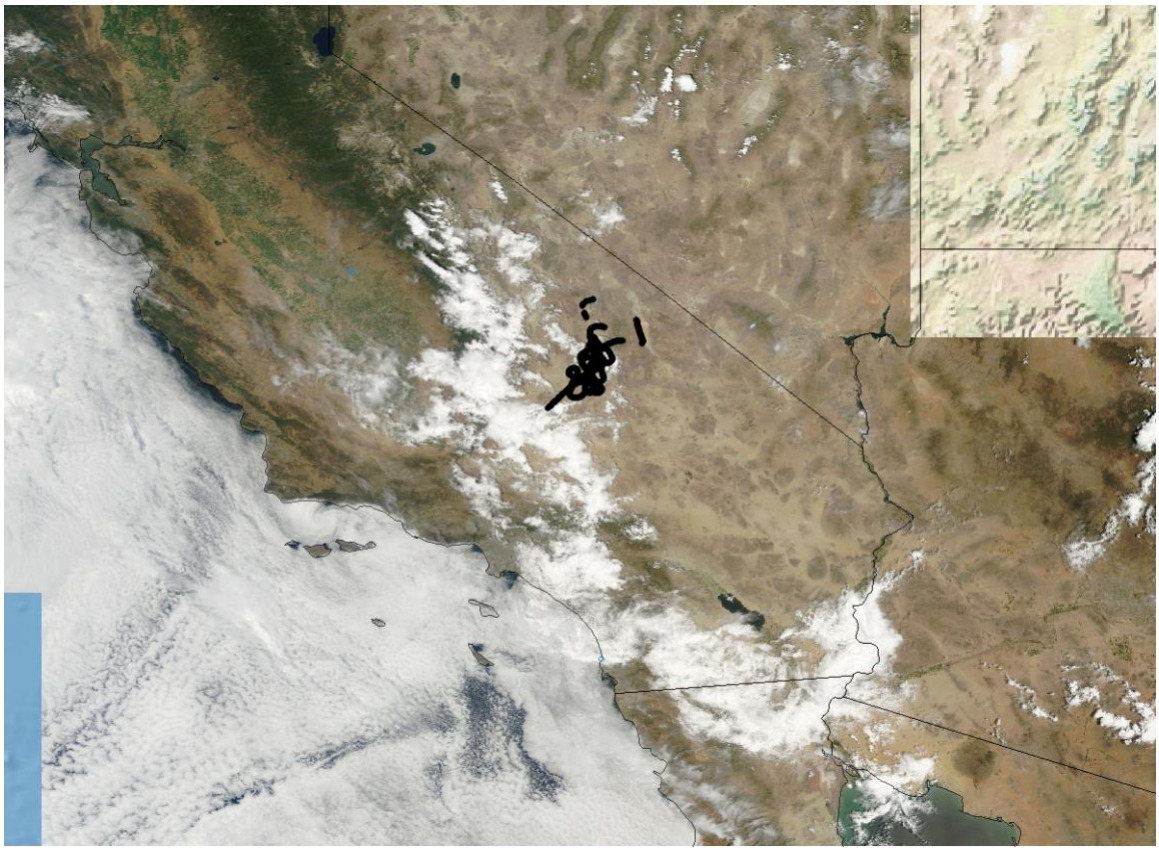
Time (UTC)	Description
22:46:15	Laser status healthy
23:10:45	Laser off

Relative footprint geometry:



07/02/2013

Mission: ‘Trona2’



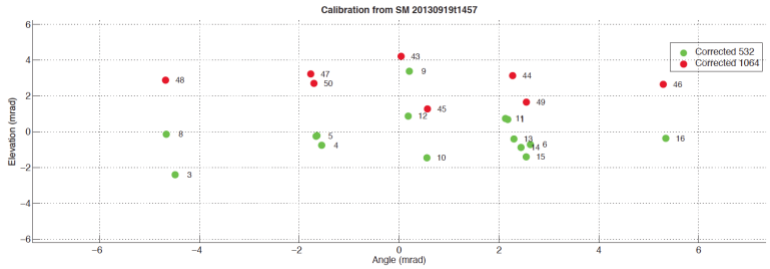
Weather: Generally clear over Trona targets.
Comments: MABEL performed intermittently; use KML to find good data stretches

Proteus
Etalon; day flight
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: ‘Cluster FOV’

Points of interest:

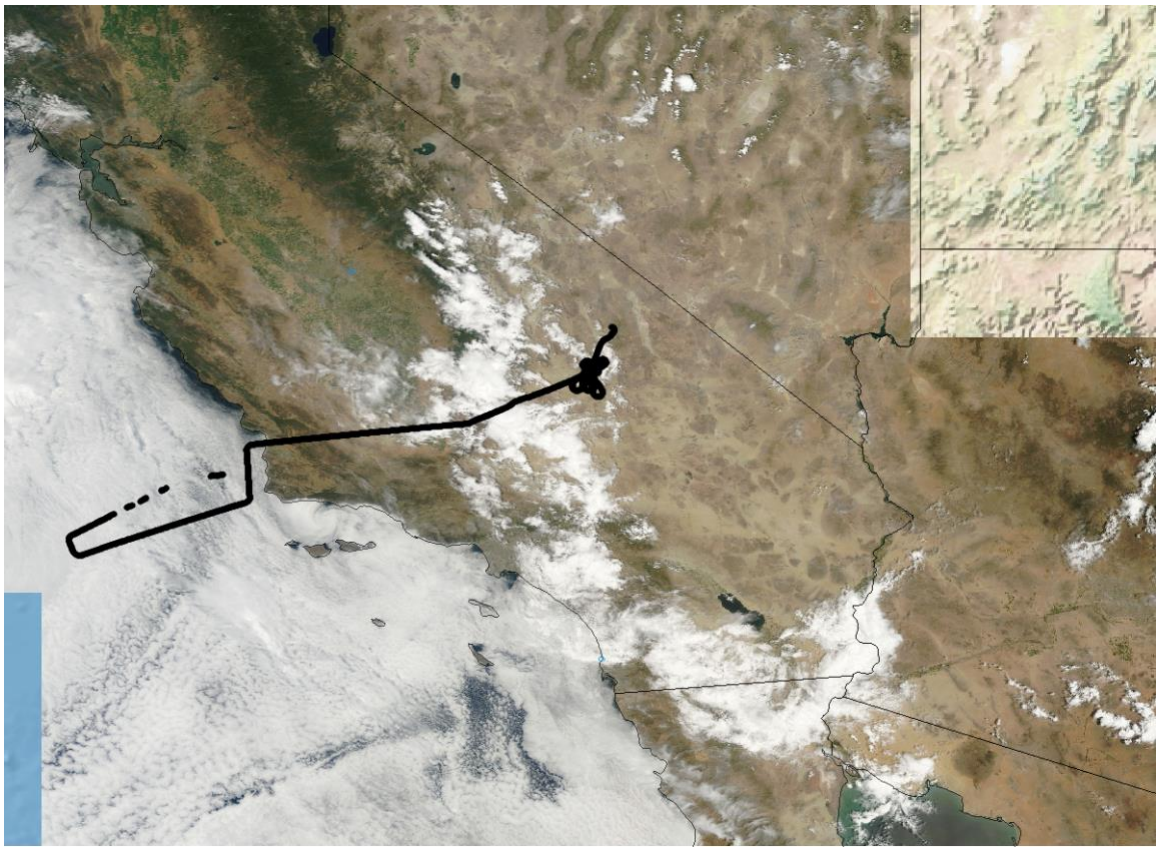
Time (UTC)	Description
22:26:00	Laser status healthy
23:26:30	Laser status OFF
23:55:15	Laser status healthy again
00:28:45	Laser off

Relative footprint geometry:



07/03/2013

Mission: ‘Trona3’



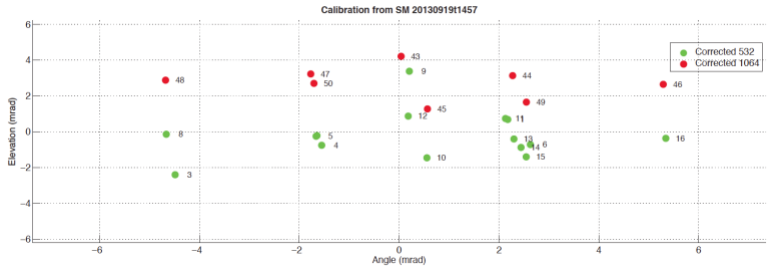
Weather: Generally clear over Trona targets; cloudy over the ocean

Proteus
Etalon; day flight
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: ‘Cluster FOV’

Points of interest:

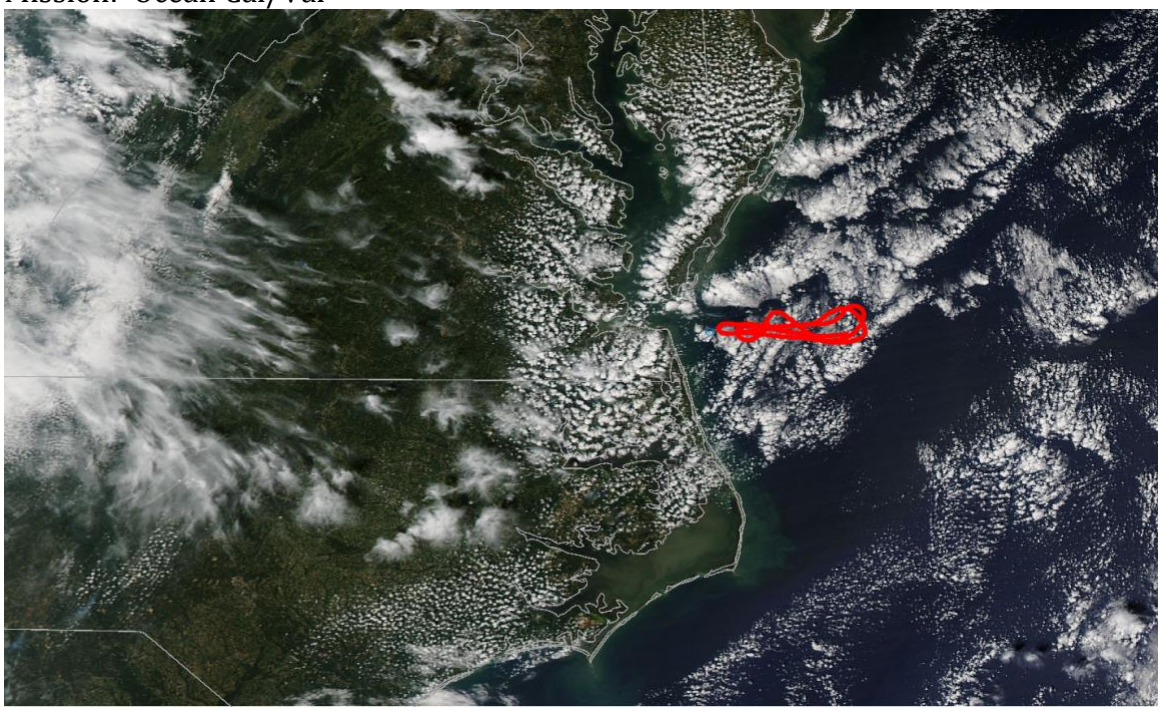
Time (UTC)	Description
18:47:30	Laser status healthy
20:44:30	Laser off

Relative footprint geometry:



09/18/2013

Mission: ‘Ocean Cal/Val’



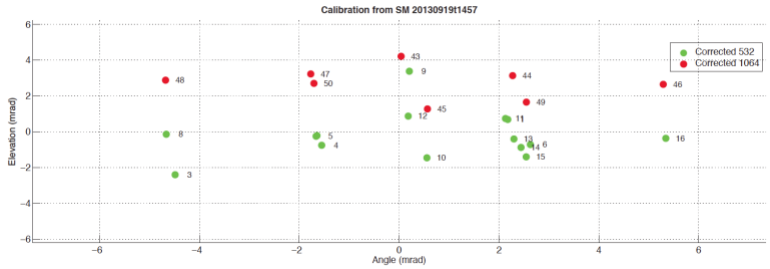
Weather: Intermittent clouds over the ocean

Proteus
DAY flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: ‘Cluster FOV’

Points of interest:

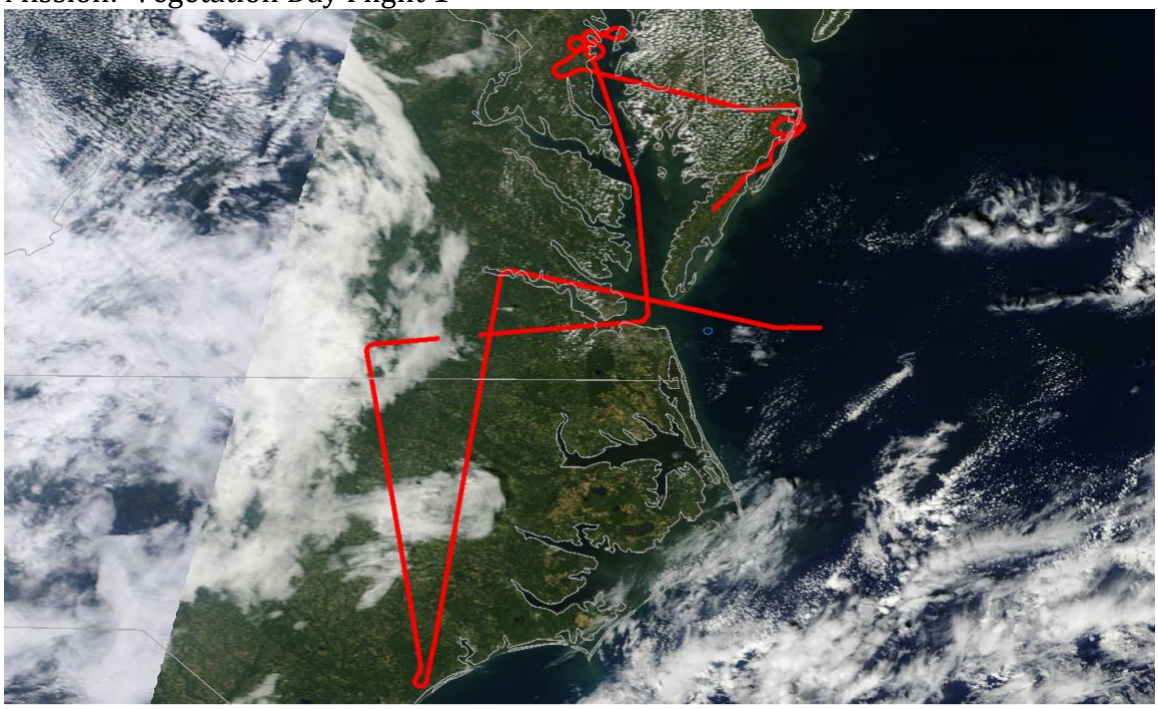
Time (UTC)	Description
14:12:00	Laser status healthy
	P/R maneuvers throughout
15:11:30	Laser off

Relative footprint geometry:



09/19/2013

Mission: 'Vegetation Day Flight 1'



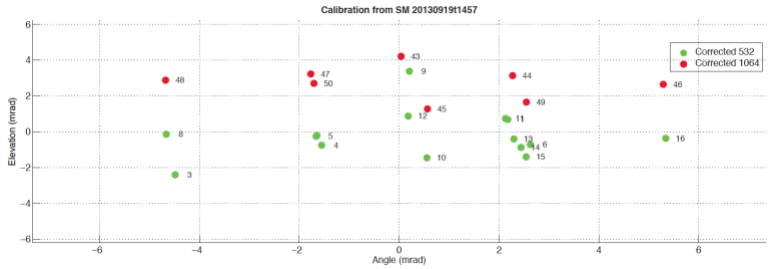
Weather: Generally clear; clouds building on NW parts of GLiHT lines; MODIS image gives a reasonably accurate assessment

Proteus
DAY flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: 'Cluster FOV'

Points of interest:

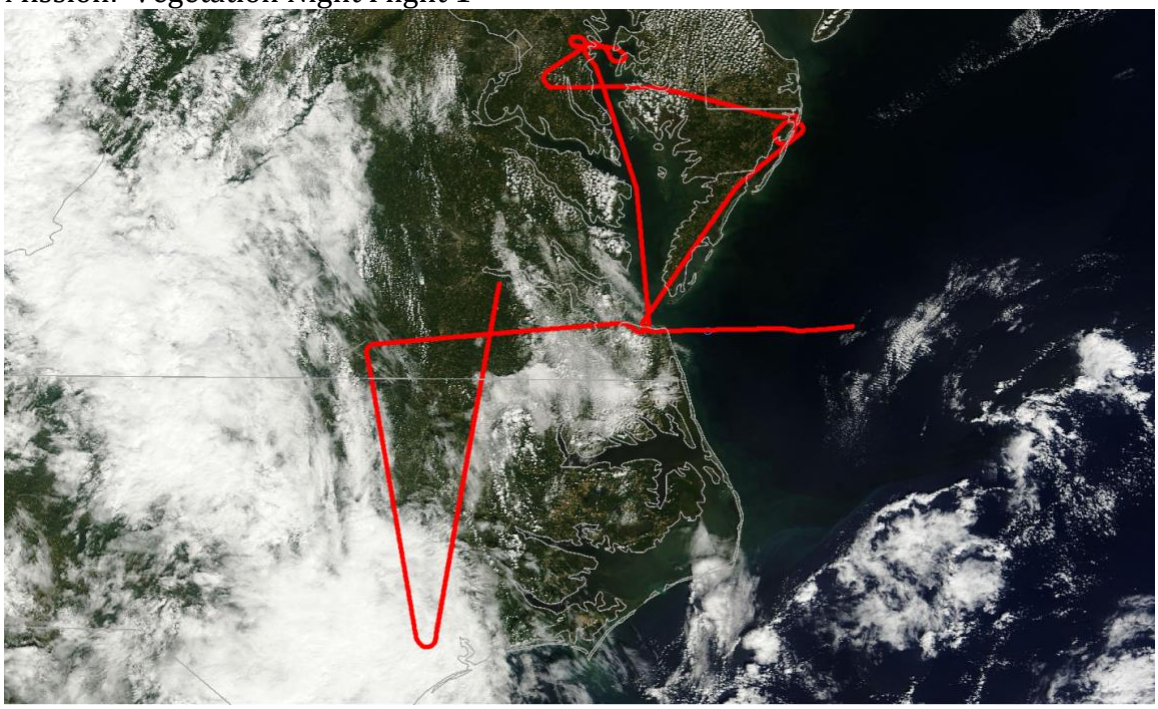
Time (UTC)	Description
14:53:00	Laser status healthy
14:54:00	P/R maneuvers start
15:04:00	P/R maneuvers end
15:21:00	Start of G-LiHT Lines
16:40:00	End of G-LiHT lines
17:03:00	Start of Chesapeake
17:30:00	End of Chesapeake
17:49:00	SERC
18:20:00	Ocean City
18:32:00	Laser off

Relative footprint geometry:



09/20/2013

Mission: 'Vegetation Night Flight 1'



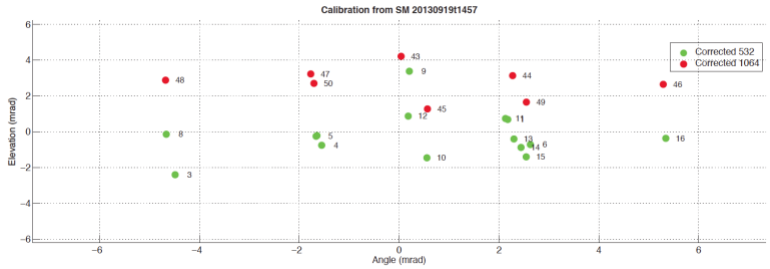
Weather: Generally cloudy over southern and western GLiHT lines

Proteus
NIGHT flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: 'Cluster FOV'

Points of interest:

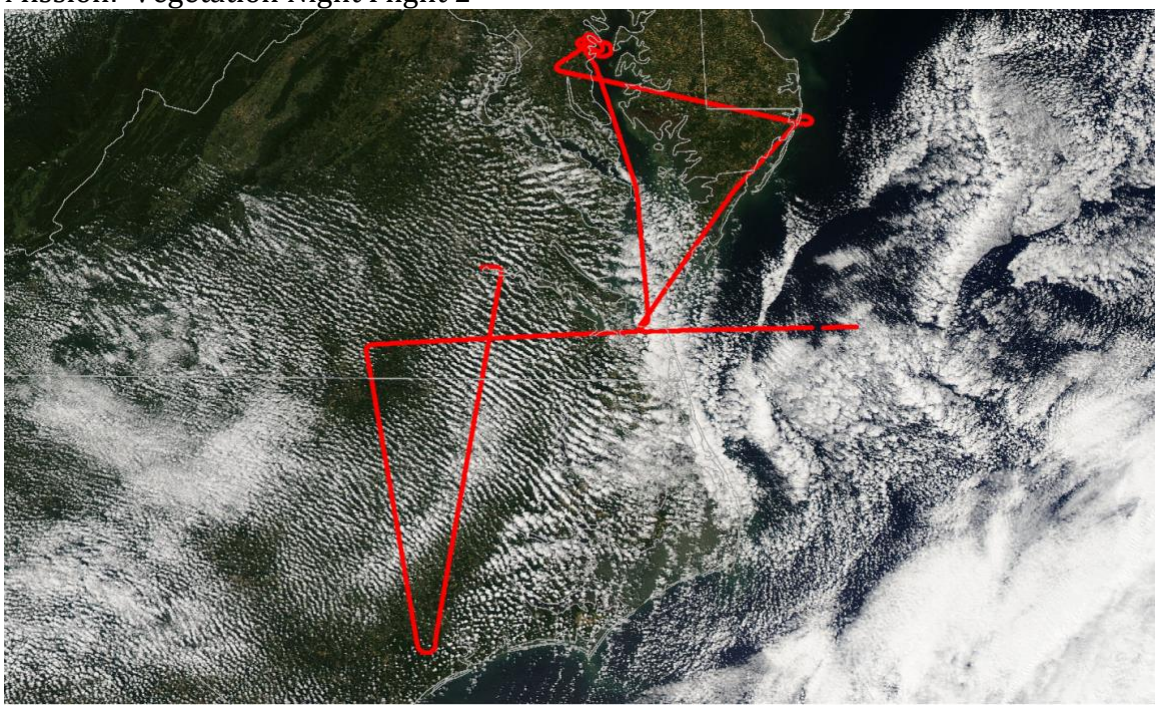
Time (UTC)	Description
22:09:00	Laser status healthy
22:11:00	P/R maneuvers start
22:23:00	P/R maneuvers end
22:56:00	Ocean City
23:32:00	SERC
23:45:00	Start of Chesapeake
00:08:00	End of Chesapeake
00:34:00	Start of G-LiHT lines
01:42:00	End of Chesapeake
01:43:00	Laser off

Relative footprint geometry:



09/23/2013

Mission: 'Vegetation Night Flight 2'



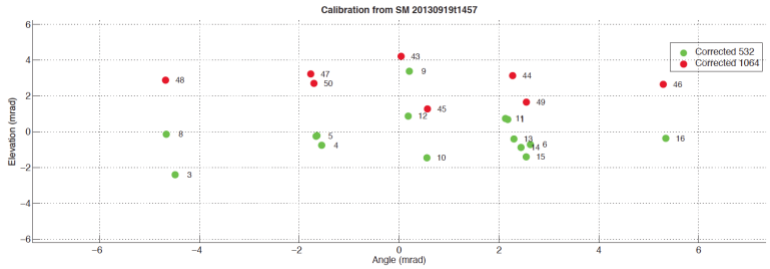
Weather: Generally cloudy over southern and western GLiHT lines

Proteus
NIGHT flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: 'Cluster FOV'

Points of interest:

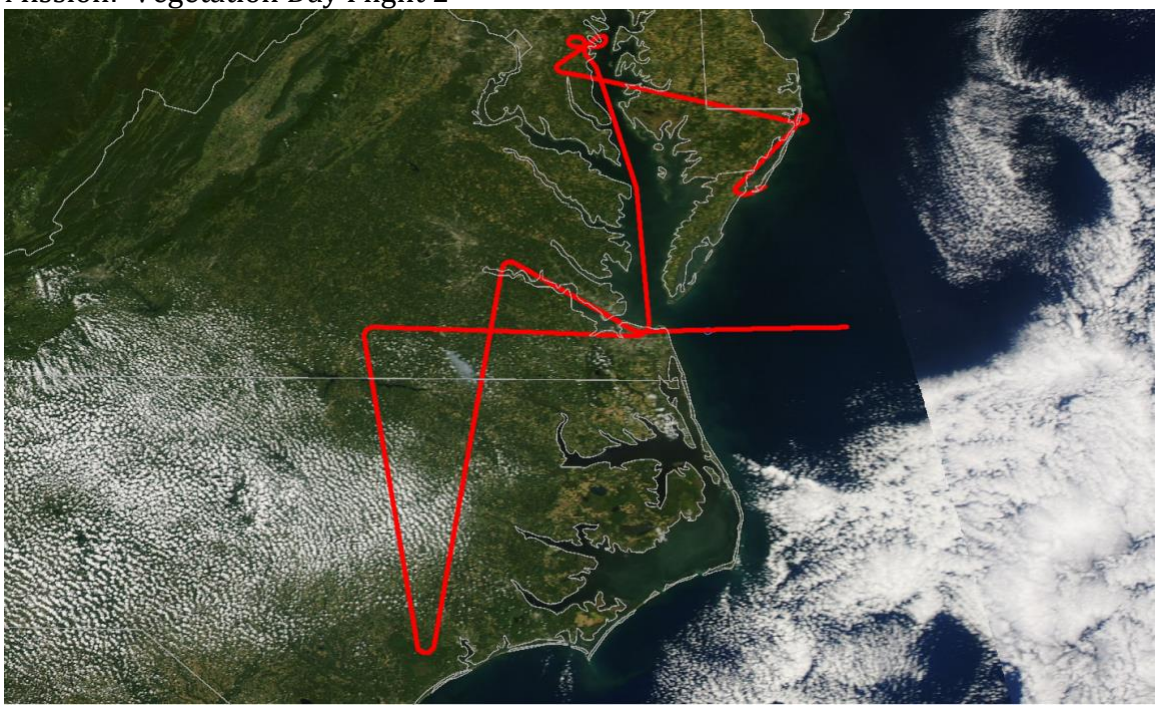
Time (UTC)	Description
22:12:00	Laser status healthy
22:14:00	P/R maneuvers start
22:33:00	P/R maneuvers end
23:02:00	Ocean City
23:41:00	SERC
23:54:00	Start of Chesapeake
00:18:00	End of Chesapeake
00:48:00	Start of G-LiHT lines
01:55:00	End of Chesapeake
01:58:00	Laser off

Relative footprint geometry:



09/25/2013

Mission: 'Vegetation Day Flight 2'



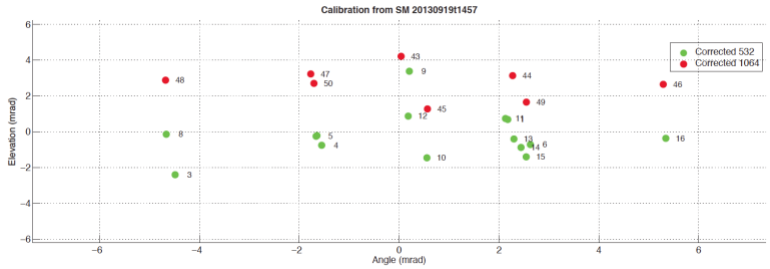
Weather: Generally clear; best weather flight

Proteus
DAY flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: 'Cluster FOV'

Points of interest:

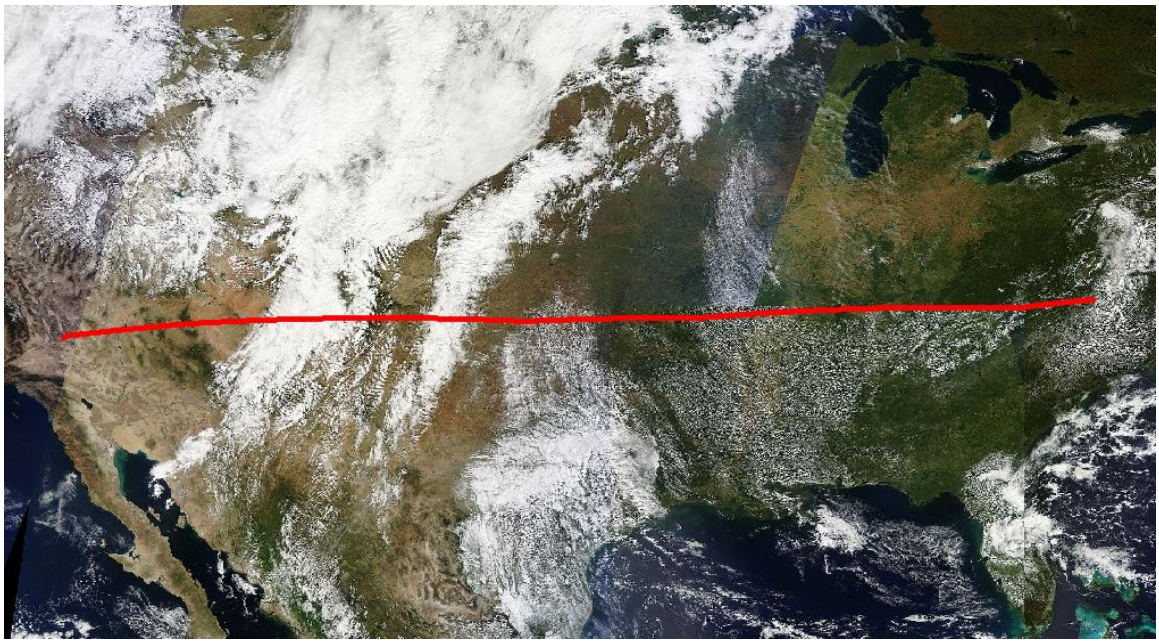
Time (UTC)	Description
14:11:00	Laser status healthy
14:14:00	P/R maneuvers start
14:28:00	P/R maneuvers end
14:50:00	Start of G-LiHT Lines
16:08:00	End of G-LiHT lines
16:29:00	Start of Chesapeake
16:55:00	End of Chesapeake
17:00:00	SERC
17:27:00	Ocean City
17:42:00	Laser off

Relative footprint geometry:



09/27/2013

Mission: ‘Transit’



Weather: clouds over the eastern Rocky Mountains

Proteus
DAY flight
Etalon
Sample rate: 5 kHz
Energy levels throughout channels: variable.
FOV: ‘Cluster FOV’

Points of interest:

Time (UTC)	Description
12:17:00	Laser status healthy
20:19:00	Laser off

Relative footprint geometry: