

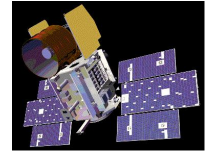
# ICESat-1 pointing cal/val and obatt file correction summary

The final delivery

Scott B. Luthcke and Terry Pennington  
NASA/GSFC, Code 698  
Feb. 7, 2012



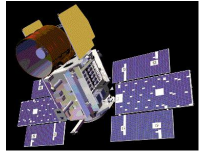
# ICESat Laser Periods



- Consists of 18 laser periods over more than 6 years
- Laser periods are defined to be  $\sim 33$  days
- Many laser periods offer a unique challenge in data processing due to:
  - laser energy
  - laser temperature
  - spacecraft orientation
  - spacecraft maneuvers
  - sun angle



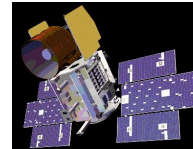
# ICESat Laser Period Processing



- Laser periods are typically processed in 8-day arc-sets, where remaining days in the laser period beyond the multiple of 8-days are placed in the last set.
- Exceptions to the above arc-set definition are due to spacecraft maneuvers, laser temperature changes, sun acquisition and low laser energy. In the special cases, arc-sets were arranged to accommodate these system events.
- Typically, the pointing biases, long-term trends and orbit variations in both GCS X and Y are estimated from a combination of ocean scan (OS) data, round-the-world (RTW) scan data and short-period (~8-day) ice sheet crossovers.



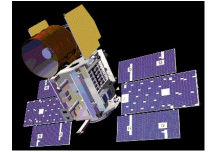
# Obatt Correction Key



- **corr1b** – This is the standard obatt correction. The obatt correction is done by estimating both the GCS X and Y orbit variation and time varying bias correction **for each arc set within the laser period**. Processing steps include:
  - Edit ice-sheet short-period (~8-day) crossover data based upon GLA06 saturation correction validity flags.
  - Apply valid saturation correction to the OS, RTW and crossover data from GLA06.
  - Editing of OSs, RTW scans and crossover data based upon GLA06 troposphere correction validity flags.
  - Processing of obatt files using OSs and RTW scans to estimate the GCS X and Y time varying biases as first iteration.
  - Editing of ice-sheet short period crossover data based upon crossover height discrepancies.
  - Merge edited ice-sheet short period crossover data with the OSs and RTW scan data.
  - Estimate GCS X and Y orbit variation (every 15° in orbit angle) from OSs, RTW scans and ice-sheet short-period crossover data.
  - Compute GCS X and Y obatt correction for each arc set by fitting a function (typically a 6 degree polynomial) to the orbit variation estimates (above).
  - Correct the obatt files using the above functional fit for each arcset.
  - Special modifications to the corr1b process include:
    - corr2 – Data used in processing includes OSs and all surface type short-period crossovers (as opposed to just ice-sheet crossovers in the standard corr1b)
    - corr3 – Data used in processing include **NO** OSs and all surface type short-period crossovers



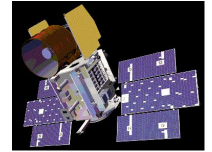
# Obatt Correction Key – Cont.



- **corr1c** – The obatt correction is done the same way as in the corr1b process, except the data **over the entire laser period** is used to estimate a single GCS X and the GCS Y orbital variation correction (does not have the correction per ~8-day arcset).
- **corr2b** - The obatt correction is done differently for either the GCS X or the GCS Y component. The first component is done exactly like the corr1b correction. The second component is corrected in two steps. First, the corr1b process is performed. Then, a **second step** corrects for any remaining long-term variation in the biases. This is for laser periods that had significant long-term variation that could not be accounted for with the standard corr1b process (orbit variation per ~8-day arcset). The corr1b orbit variation corrections are applied to the obatt file and used as *a priori* for estimating the remaining long-term bias variation from OSs and RTW scan data. A polynomial is fit to the bias estimates from the OSs and RTW scans. The obatt file that was corrected for orbit variation, is now further corrected using the polynomial for the long-term bias variation.



# L1B – Special Case



- L1B Laser Period Summary:

Time of Laser Period:

Start: 2003 080 17:19:59

Stop: 2003 088 14:57:29

Sun Acquisition:

Start: 2003 085 11:41:00

Stop: 2003 086 00:57:29

Ocean Scans:

Two Oceans scans on 2003 087

- L1B Data Processing:

Divided into two arc sets:

Start Arc Set (2003 080-085): 2003 080 17:19:59

Stop Arc Set (2003 080-085): 2003 085 11:41:00

Start Arc Set (2003 086-088): 2003 086 00:57:29

Stop Arc Set (2003 086-088): 2003 088 23:59:59

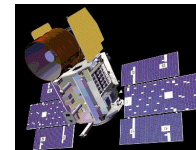
- Obatt Correction Delivered:

corr1b corr3: 2003 080-085

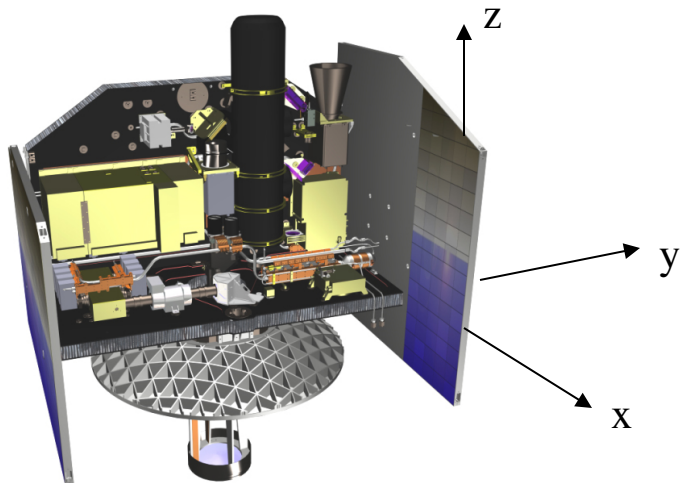
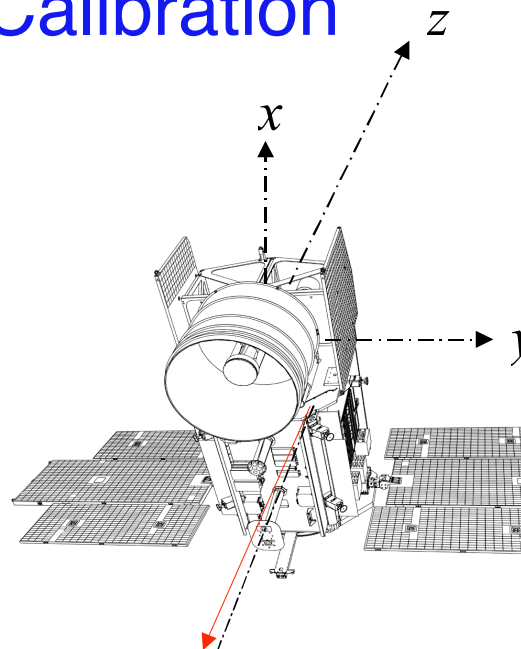
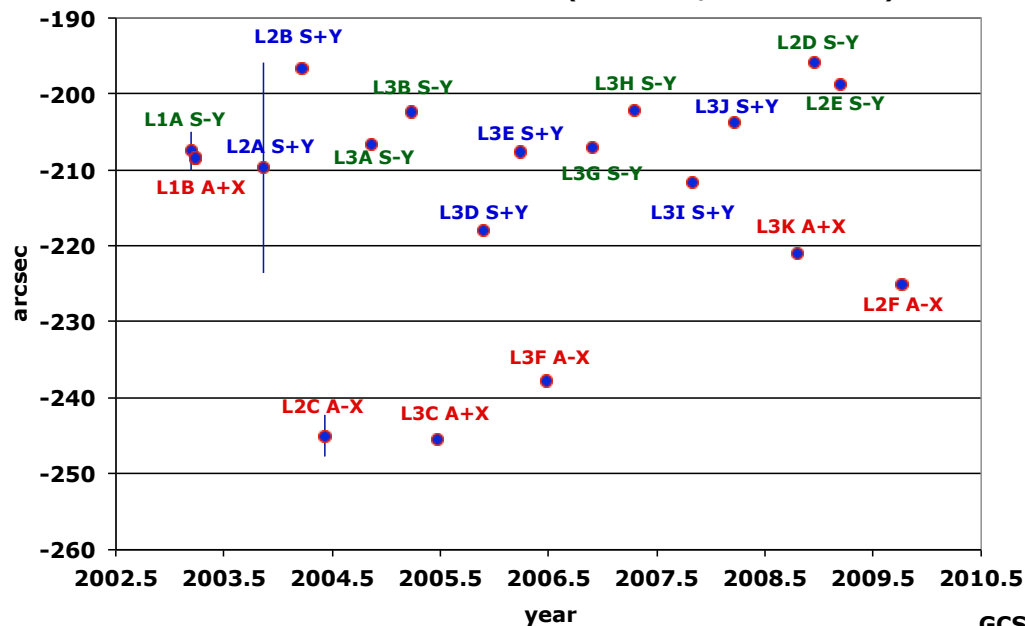
corr1b corr2: 2003 086-088



# Initial Pointing Bias Calibration

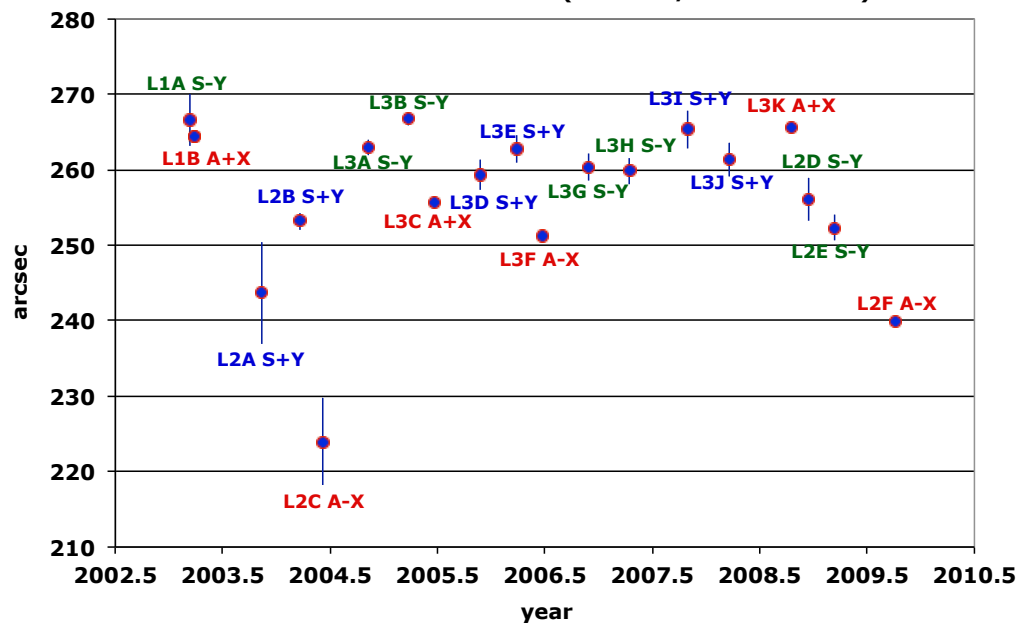


GCS X RTW mean before correction ( $-213.19 \pm 15.24$  arcsec)



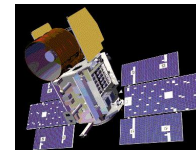
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GCS Y RTW mean before correction ( $256.40 \pm 10.87$  arcsec)

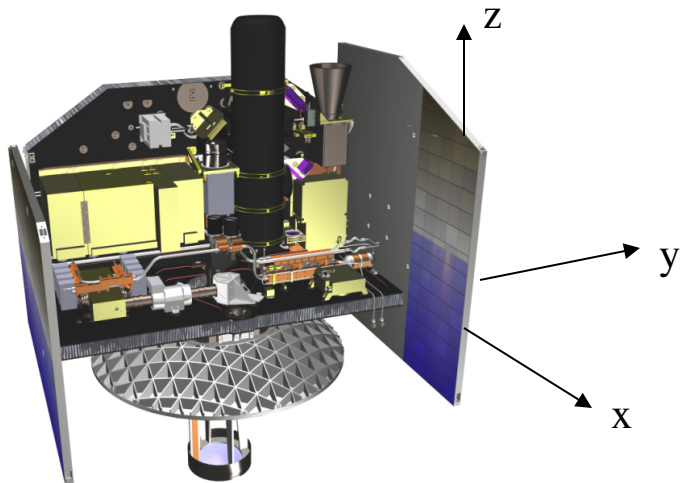
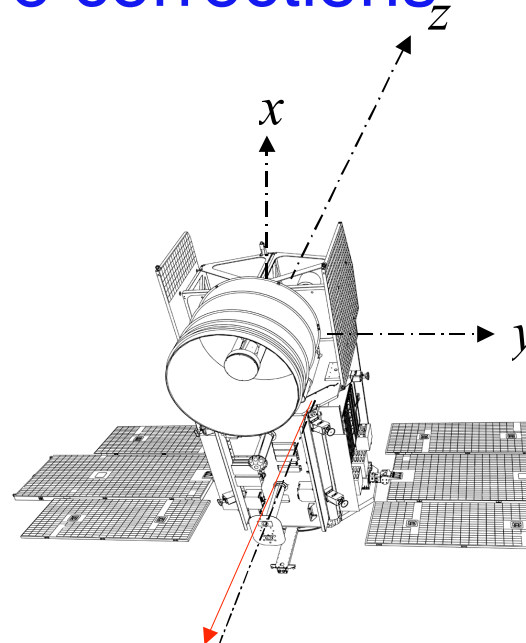
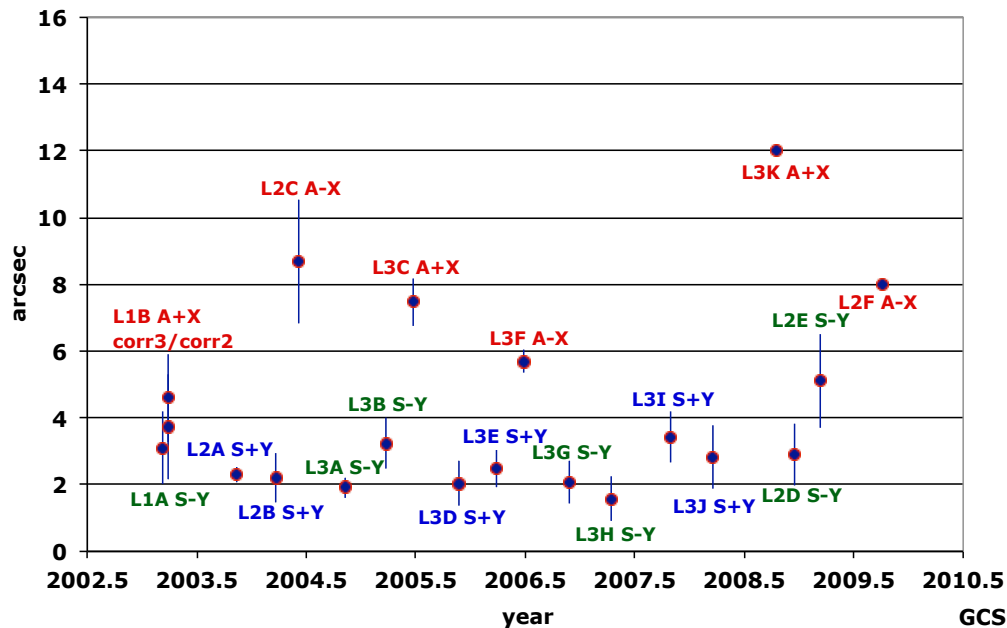




# RTWS 1CPR amp. before corrections

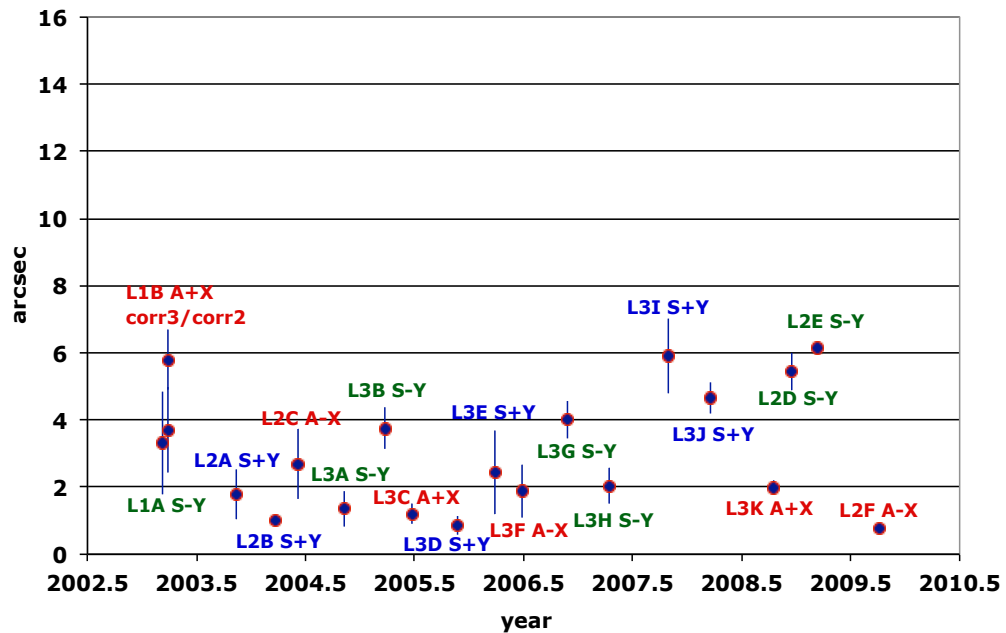


GCS X RTW 1CPR amp before correction (4.27 +/- 2.79 arcsec)



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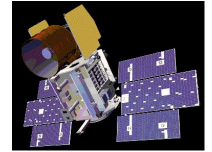
GCS Y RTW 1CPR amp before correction (3.03 +/- 1.80 arcsec)







# Combination Ice Sheet, Land and Ocean (All Surface Types) Xover Summary



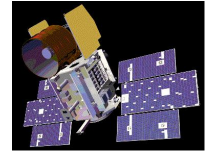
All in cm	Date	Antarctica		Greenland	
		rms	% $\Delta$ Var.	rms	% $\Delta$ Var.
L1A 333	2/20/03-	14.67		26.50	
rel333 corr1c	3/21/03	13.59	-14.23	25.70	-5.96
L1B rel333	3/21/03-	20.29		18.69	
rel333 corr1b	3/29/03	18.40	-17.78	14.90	-36.43

*8-day xover; <0.6 deg. slope*

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## Ice Sheet Xover Summary

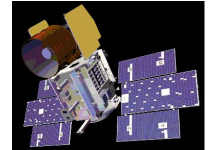


All in cm	Date	Antarctica		Greenland	
		rms	% $\Delta$ Var.	rms	% $\Delta$ Var.
L2A 333	9/25/03 -	12.11		16.07	
rel333 corr1b	11/19/03	10.80	-20.58	13.49	-29.56
L2B rel333	2/17/04 -	8.53		11.11	
rel333 corr1b	3/21/04	8.13	-9.13	9.51	-26.72
L2C rel333	5/18/04 -	15.60		22.49	
rel333 corr1c	6/21/04	9.19	-65.26	9.70	-81.39
L3A rel863	10/3/04 -	10.66		12.99	
rel863 corr1b	11/8/04	9.59	-19.02	11.23	-25.19
L3B rel333	2/17/05 -	11.29		14.94	
rel333 corr1b	3/24/05	9.34	-31.50	10.24	-53.02
L3C rel333	5/20/05 -	10.91		11.62	
rel333 corr1b	6/23/05	10.69	-4.01	10.66	-15.89

*8-day xover; <0.6 deg. slope*



# Ice Sheet Xover Summary

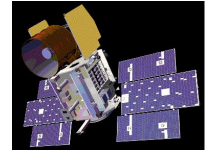


All in cm	Date	Antarctica		Greenland	
		rms	%ΔVar.	rms	%ΔVar.
L3D rel333	10/21/05 -	8.89		10.88	
rel333 corr1b	11/24/05	8.15	-15.99	9.71	-20.38
L3E rel333	2/22/06 -	9.00		9.79	
rel333 corr1b	3/28/06	7.69	-26.99	7.95	-34.12
L3F rel333	5/24/06 -	14.02		19.17	
rel333 corr1b	6/26/06	11.47	-33.01	12.35	-58.47
L3G rel333	10/25/06 -	9.79		11.32	
rel333 corr1b	11/27/06	8.43	-25.80	9.13	-34.98
L3H rel333	3/12/07 -	9.40		12.85	
rel333 corr1b	4/14/07	8.54	-17.45	9.94	-40.18
L3I rel333	10/02/07 -	11.16		13.55	
rel333 corr1b	11/05/07	9.55	-26.84	10.19	-43.48

*8-day xover; <0.6 deg. slope*



# Ice Sheet Xover Summary

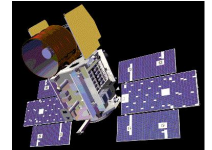


All in cm	Date	Antarctica		Greenland	
		rms	% $\Delta$ Var.	rms	% $\Delta$ Var.
L3J rel333	2/18/08 -	10.86		12.80	
rel333 corr1b	3/22/08	8.82	-34.05	8.62	-54.72
L3K rel333	10/04/08 -	9.70		13.20	
rel333 corr2b	10/19/08	9.01	-13.61	10.83	-32.66
L2D rel333	11/25/08 -	11.84		12.77	
rel333 corr1b	12/17/08	11.27	-9.34	10.52	-32.12
L2E rel333	3/09/09 -	12.38		13.89	
rel333 corr1c	4/11/09	11.53	-13.27	11.88	-26.89
L2F rel333	9/30/09 -	10.64		14.49	
rel333 corr1c	10/11/09	10.38	-4.94	10.43	-48.24

*8-day xover; <0.6 deg. slope*



## SM Cal./Val. Correction Summary long-arc (~1700 km) estimate

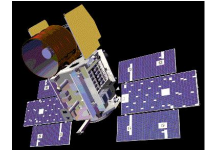


Obs. Period	Date	Release cal/ val correction	Pointing accuracy (arcsec)	Horizontal accuracy (m)	Vertical Accuracy 0.4° slope (cm)
L1A Sailboat -Y	2/20/03 - 3/21/03	333 corr1c	$0.32 \pm 0.86$	$0.93 \pm 2.51$	$0.6 \pm 1.75$
L1B Airplane X	3/21/03 - 3/29/03	333 corr1b corr3/corr2(*)	$1.16 \pm 0.82$	$3.36 \pm 2.38$	$2.3 \pm 1.66$
L2A Sailboat Y	9/25/03 - 11/19/03	333 corr1b	$0.23 \pm 0.90$	$0.66 \pm 2.61$	$0.5 \pm 1.83$
L2B Sailboat Y	2/17/04 - 3/21/04	333 corr1b	$0.22 \pm 0.64$	$0.64 \pm 1.85$	$0.5 \pm 1.29$
L2C Airplane -X	5/18/04 - 6/21/04	333 corr1c	$0.18 \pm 1.75$	$0.52 \pm 5.10$	$0.4 \pm 3.56$
L3A Sailboat -Y	10/3/04 - 11/8/04	864 corr1b	$0.26 \pm 0.63$	$0.77 \pm 1.84$	$0.5 \pm 1.28$
L3B Sailboat -Y	2/17/05 - 3/24/05	333 corr1b	$0.31 \pm 0.99$	$0.91 \pm 2.87$	$0.6 \pm 2.01$
L3C Airplane X	5/20/05 - 6/23/05	333 corr1b	$0.43 \pm 1.15$	$1.24 \pm 3.33$	$0.9 \pm 2.33$
L3D Sailboat Y	10/21/05 - 11/24/05	333 corr1b	$0.35 \pm 0.56$	$1.02 \pm 1.63$	$0.7 \pm 1.14$
L3E Sailboat Y	2/22/06 - 3/28/06	333 corr1b	$0.21 \pm 0.69$	$0.60 \pm 2.00$	$0.4 \pm 1.39$

\* Special case, see Obatt Correction Key slides



## SM Cal./Val. Correction Summary long-arc (~1700 km)



Obs. Period	Date	Release cal/ val correction	Pointing accuracy (arcsec)	Horizontal accuracy (m)	Vertical Accuracy 0.4° slope (cm)
L3F Airplane -X	5/24/06 - 6/26/06	333 corr1b	0.32 ± 1.01	0.93 ± 2.95	0.7 ± 2.06
L3G Sailboat -Y	10/25/06 - 11/27/06	333 corr1b	0.15 ± 0.48	0.44 ± 1.39	0.3 ± 0.97
L3H Sailboat -Y	3/12/07 - 4/14/07	333 corr1b	0.21 ± 0.63	0.60 ± 1.83	0.4 ± 1.28
L3I Sailboat Y	10/02/07 - 11/05/07	333 corr1b	0.32 ± 0.97	0.93 ± 2.82	0.7 ± 1.97
L3J Sailboat Y	2/18/08 - 3/22/08	333 corr1b	0.24 ± 1.01	0.70 ± 2.94	0.4 ± 2.05
L3K Airplane X	10/04/08 - 10/19/08	333 corr2b	0.11 ± 0.76	0.31 ± 2.20	0.2 ± 1.54
L2D Sailboat -Y	11/25/08 - 12/17/08	333 corr1b	0.31 ± 1.07	0.90 ± 3.10	0.6 ± 2.16
L2E Sailboat -Y	3/09/09 - 4/11/09	333 corr1c	0.31 ± 1.94	0.90 ± 5.66	0.6 ± 3.95
L2F Airplane -X	9/30/09 - 10/11/09	333 corr1c	1.60 ± 4.94	4.65 ± 14.36	3.3 ± 10.03