



**INTERNATIONAL  
DORIS  
SERVICE**



# DORIS Inter-center Orbit Comparisons

*F. G. Lemoine(1), D. Chinn(1,2), K. Le Bail(1,3,4)*

*(1) Planetary Geodynamics Lab., NASA GSFC*

*(2) SGT Inc.*

*(3) UMBC*

*(4) IGN/LAREG*



DORIS AWG, Paris FRANCE March 13-14, 2008





## Purpose

1. Intercompare orbits between IDS Centers.  
Establish level of agreement (or disagreement) using latest models (ITRF2005, GRACE gravity models etc.)  
*(Done routinely for IGS, for IDS we have not done this systematically for all satellites; Many in IDS have studied in detail orbit comparisons for TOPEX & Jason-1).*
2. Perform quality control by looking for systematic phenomena in the orbit differences. Look for spurious arc specific outliers and alert AC's.
3. Work with analysis centers to identify issues and develop improvements.
4. Ultimate objective: Develop the best possible IDS product for ITRF2008.





## Orbits Compared

### ***DORIS-only orbits***

1. IGN: ENV, SP2, SP4, SP5, 2005.
  2. INA: ENV, SP2, SP4, SP5, JA1, 2005.
  2. LCA: ENV, SP2, SP4, SP5, JA1, 2005-2007.
  3. GOP: ENV, SP2, SP4, SP5, JA1, Jan. 2005.
  4. GSFC: ENV, SP2, SP4, SP5, JA1, 2005-2006.  
version 1 (geodyn 0511)  
version 2 (geodyn 0712+setup  
corrections)
  5. AUS: ENV, SP2, SP5, JA1
- SLR+DORIS orbits**
6. ESOC: ENV, 2005-2007.



## Center OD Software Packages

- |          |   |
|----------|---|
| 1. IGN:  | Gypsy:  |
| 2. INA:  | Gypsy:  |
| 3. LCA:  | GINS:   |
| 4. GOP:  | Bernese:  |
| 5. GSFC: | GEODYN<br>version 1 (geodyn 0511)<br>version 2 (geodyn 0712+setup<br>corrections) |
| 6. AUS:  | GEODYN (geodyn 0511; Used for GA/<br>ILRS products)                               |
| 7. ESOC: |   |

# ENVISAT RMS Orbit Differences

ENVISAT				
Orbit Set	Npts	RMS Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
<b>ESOC vs IGN</b>	<b>299</b>	<b>1.5</b>	<b>3.2</b>	<b>5.4</b>
IGN vs GSFC	295	1.7	4.2	6.3
IGN vs INA	294	1.3	4.8	11.6
INA vs GSFC	292	2.0	6.0	13.0
ESOC vs INA	292	1.6	4.5	12.6
<b>ESOC vs GSFC</b>	<b>347</b>	<b>1.3</b>	<b>3.6</b>	<b>4.8</b>
AUS vs GSFC	42	1.0	9.2	8.3
ESOC vs GOP	29	1.8	4.7	9.8
GOP vs GSFC	28	2.4	5.0	11.7
GOP vs IGN	30	2.1	4.7	11.8
GOP vs LCA	20	5.7	7.5	15.9
IGN vs LCA	284	5.4	7.2	14.6
GSFC vs LCA	227	5.6	7.3	15.4
INA vs LCA	274	5.8	7.1	14.7
ESOC vs LCA	732	5.5	6.5	15.3
AVERAGES				
ALL		2.6	5.7	11.4
ALL w/out LCA		1.7	5.0	9.6

Large INA Diffs

Large AUS/GSFC Diffs

Awaiting ENVISAT orbit updates for LCA

~ 3 ppb

# ENVISAT Average (Mean) Orbit Differences

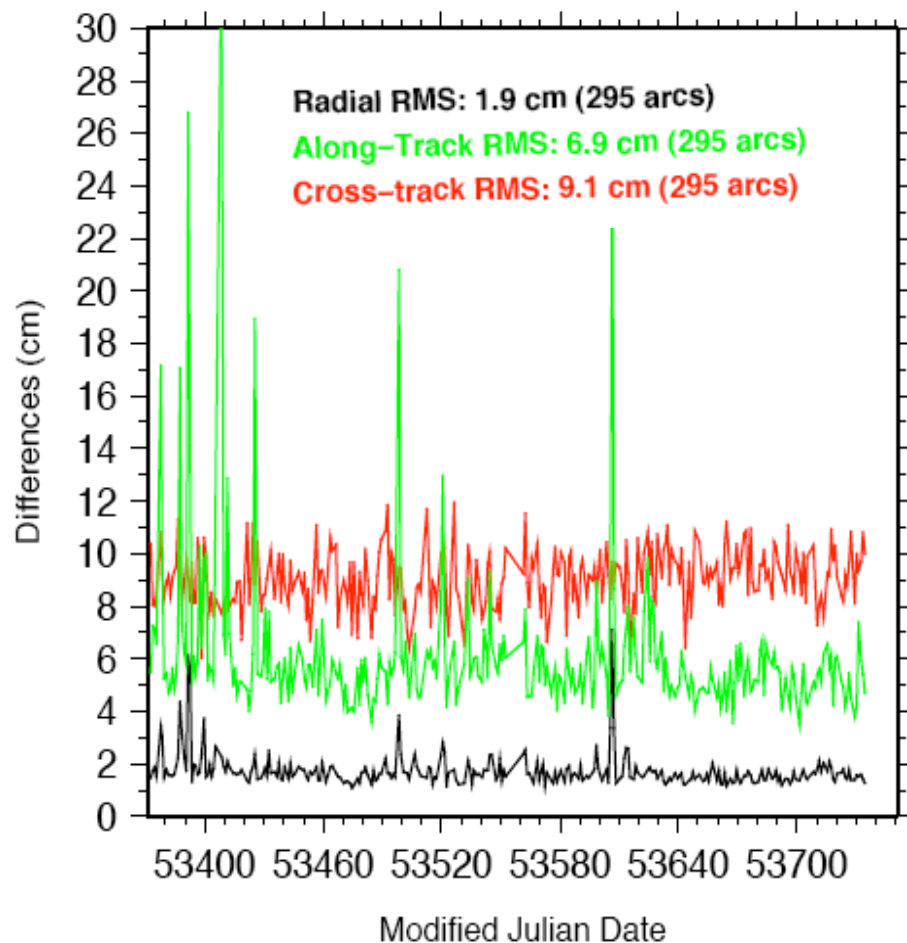
Large INA Mean Diffs - Along-track,  
(w. all centers)

Large AUS/GSFC Mean Diffs  
Along-Track

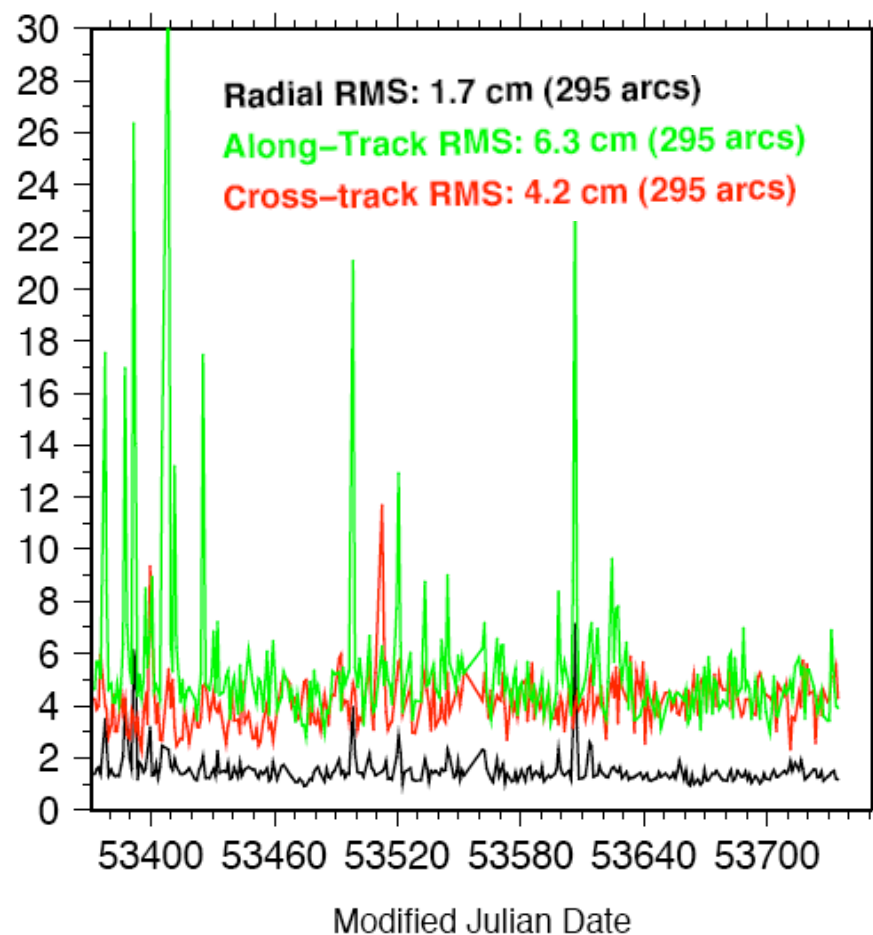
Mean Cross-track  
differences in GSFC  
orbits about 1 cm with  
other centers

ENVISAT				
Orbit Set	Npts	Average Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
ESOC vs IGN	299	0.1	-0.1	-0.6
IGN vs GSFC	295	-0.2	-0.8	-0.2
IGN vs INA	294	-0.5	-0.3	9.5
IGN vs LCA	284	-0.2	-1.0	8.1
LCA vs GSFC	227	-0.4	-1.9	9.5
INA vs LCA	274	0.3	-0.6	-2.2
ESOC vs LCA	732	-0.2	-0.9	9.6
INA vs GSFC	292	-0.7	-1.2	9.7
ESOC vs INA	292	0.6	0.2	-10.1
ESOC vs GSFC	347	-0.1	-0.9	-0.5
AUS vs GSFC	42	0	0	2.5
ESOC vs GOP	29	0.5	0.1	0.4
GOP vs GSFC	28	-0.7	-1.2	-1.1
GOP vs IGN	30	0.4	0.3	0.8
GOP vs LCA	20	5.7	7.5	15.9

# ENVISAT RMS Orbit Differences IGN vs GSFC (v1 & v2)

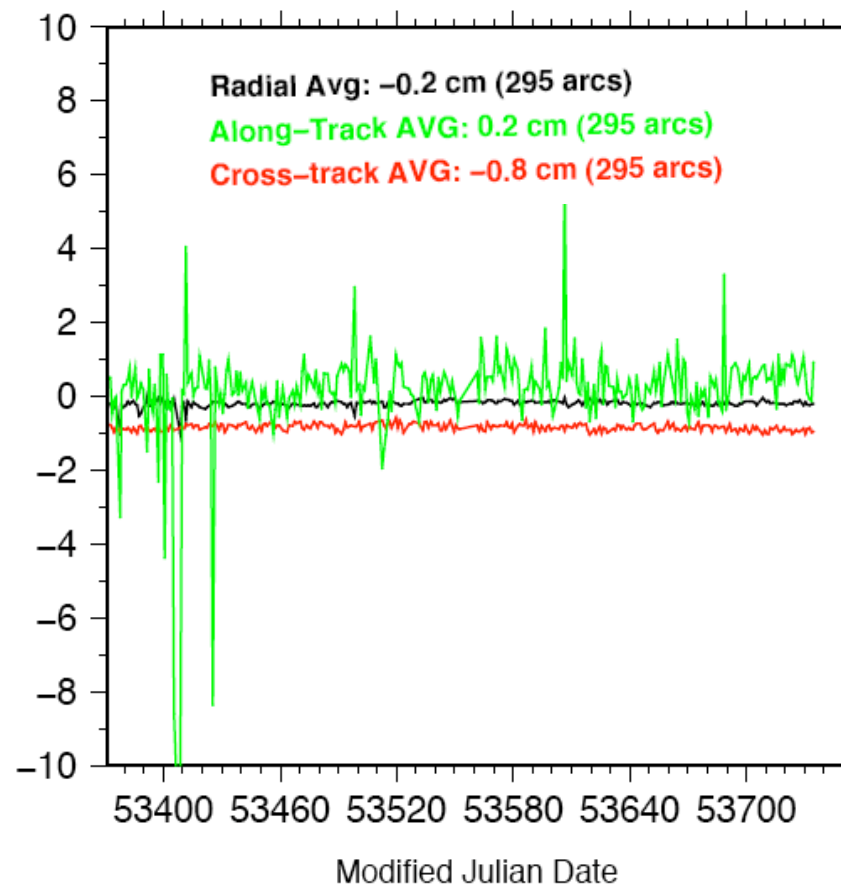
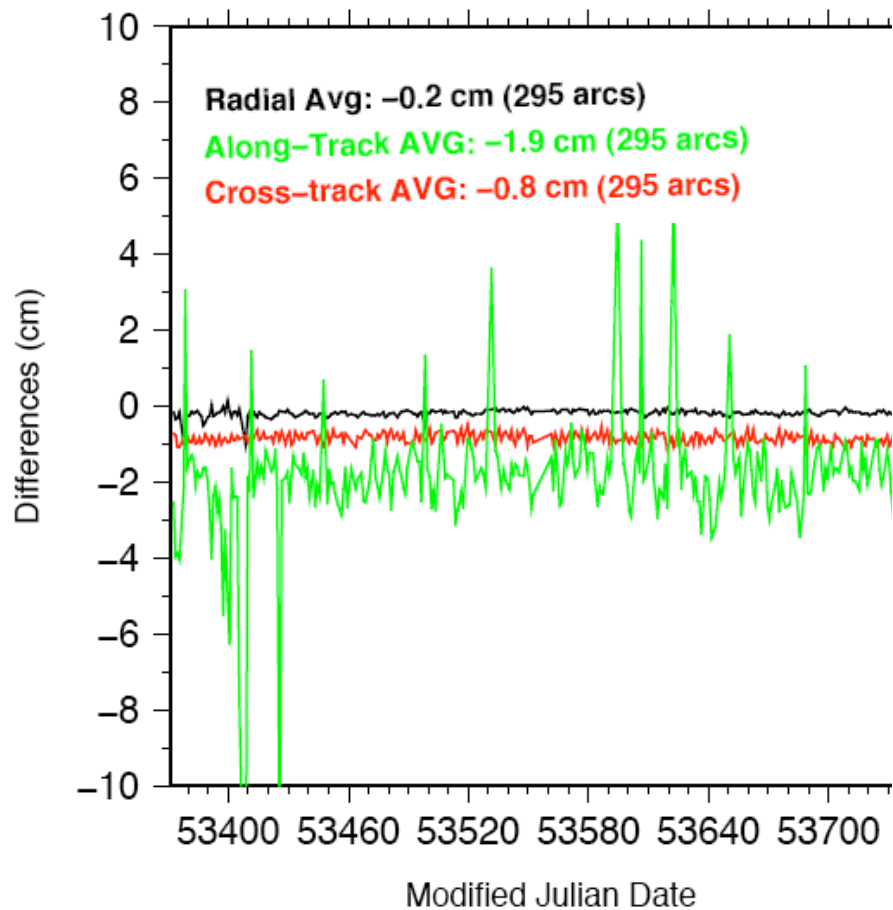


**GSFC Version 1:**



**GSFC Version 2:**

# ENVISAT Average Orbit Differences IGN vs. GSFC (v1 & v2)



**GSFC Version 1:**

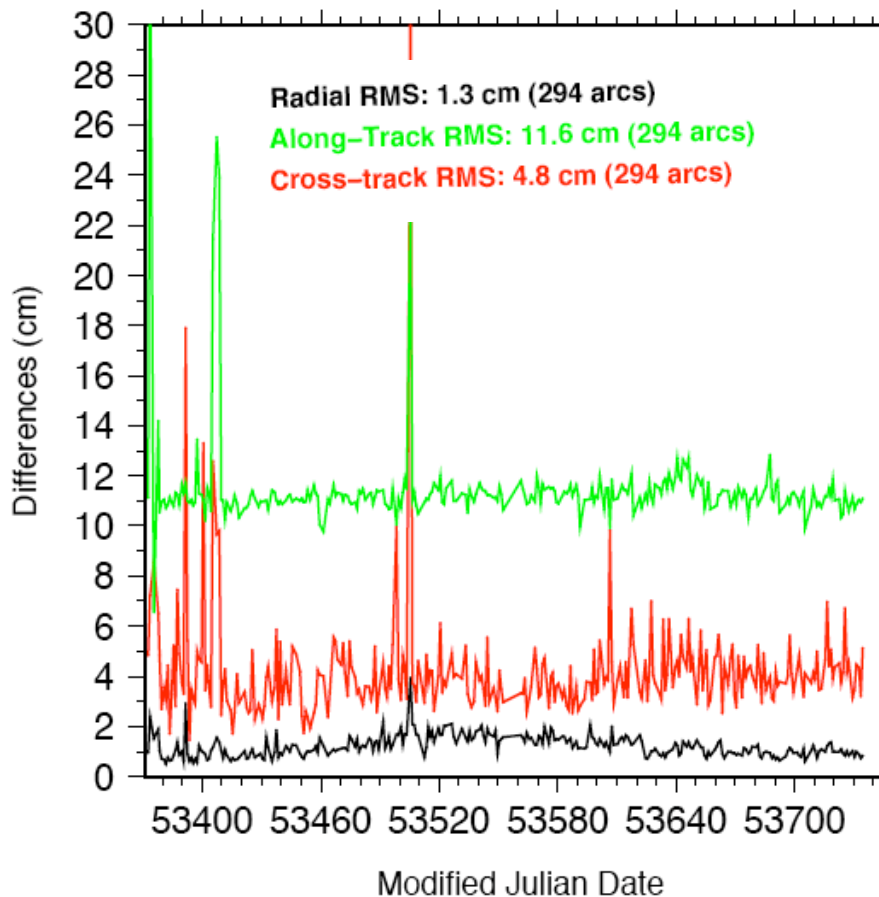
**GSFC Version 2:**



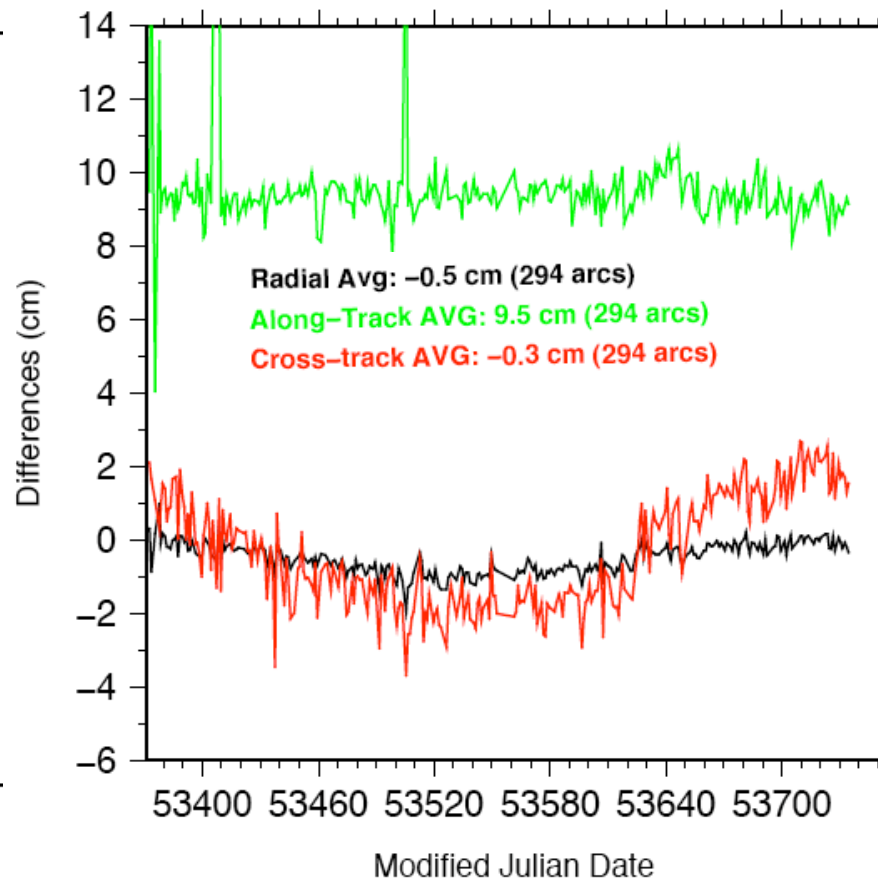


# ENVISAT Orbit Differences IGN vs. INASAN

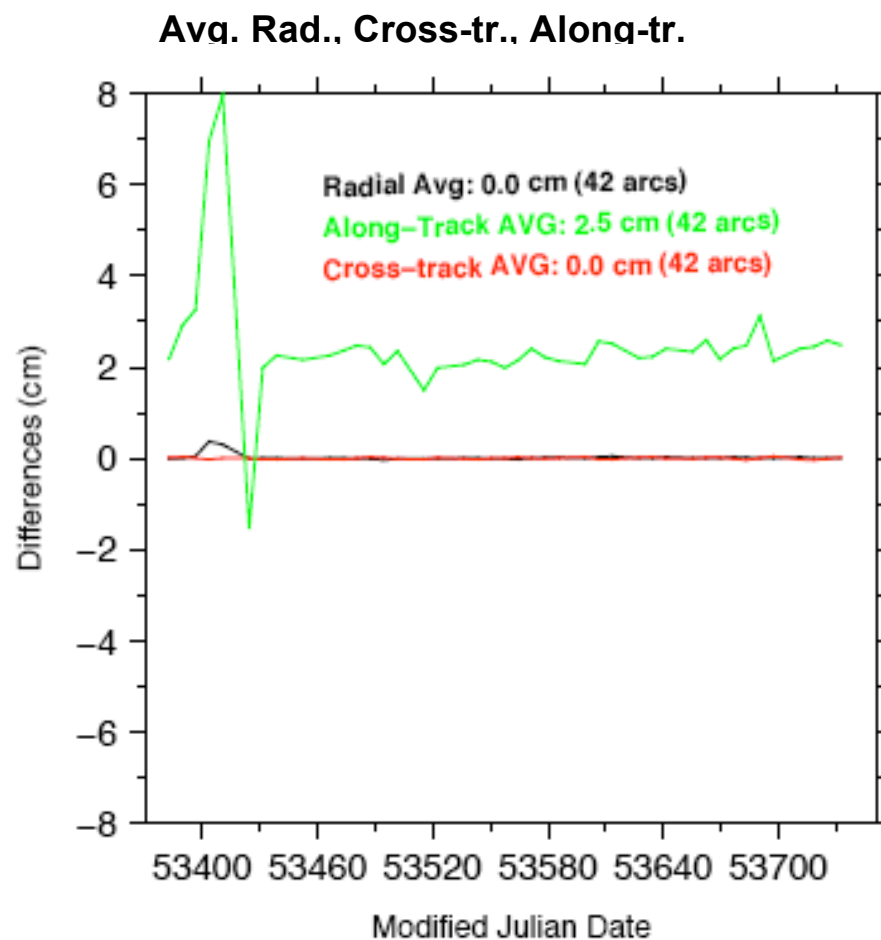
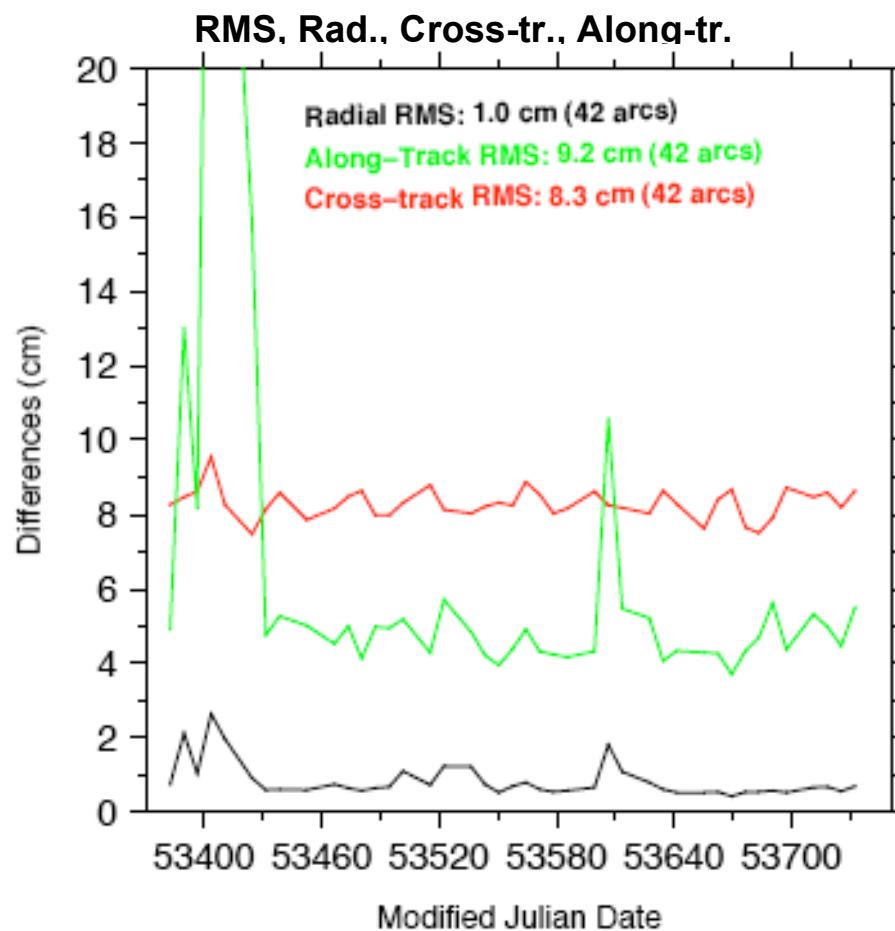
**RMS, Rad., Cross-tr., Along-tr.**



**Avg. Rad., Cross-tr., Along-tr.**

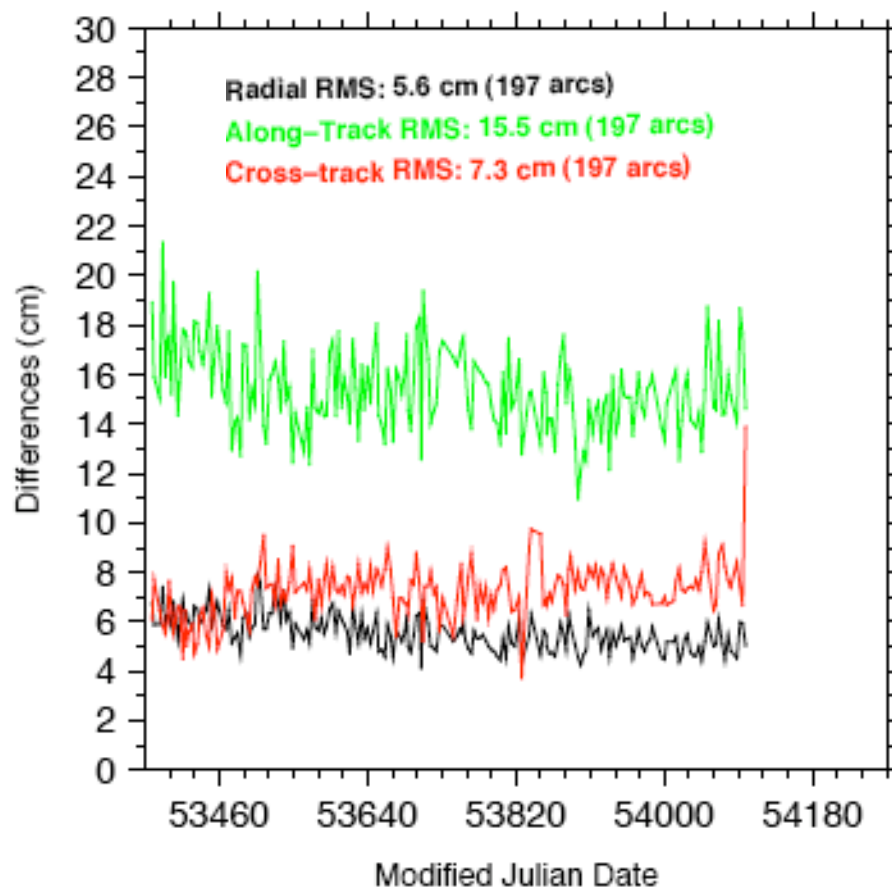


# ENVISAT Orbit Differences GSFC v2 vs AUS

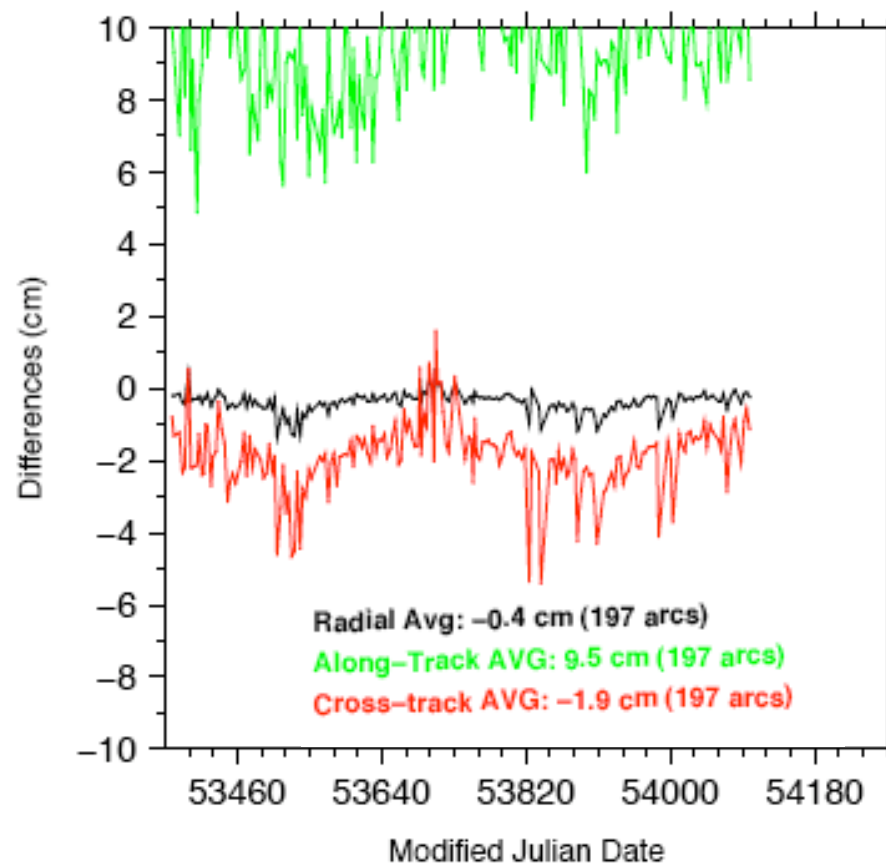


# ENVISAT Orbit Differences LCA vs GSFC v2

**RMS, Rad., Cross-tr., Along-tr.**

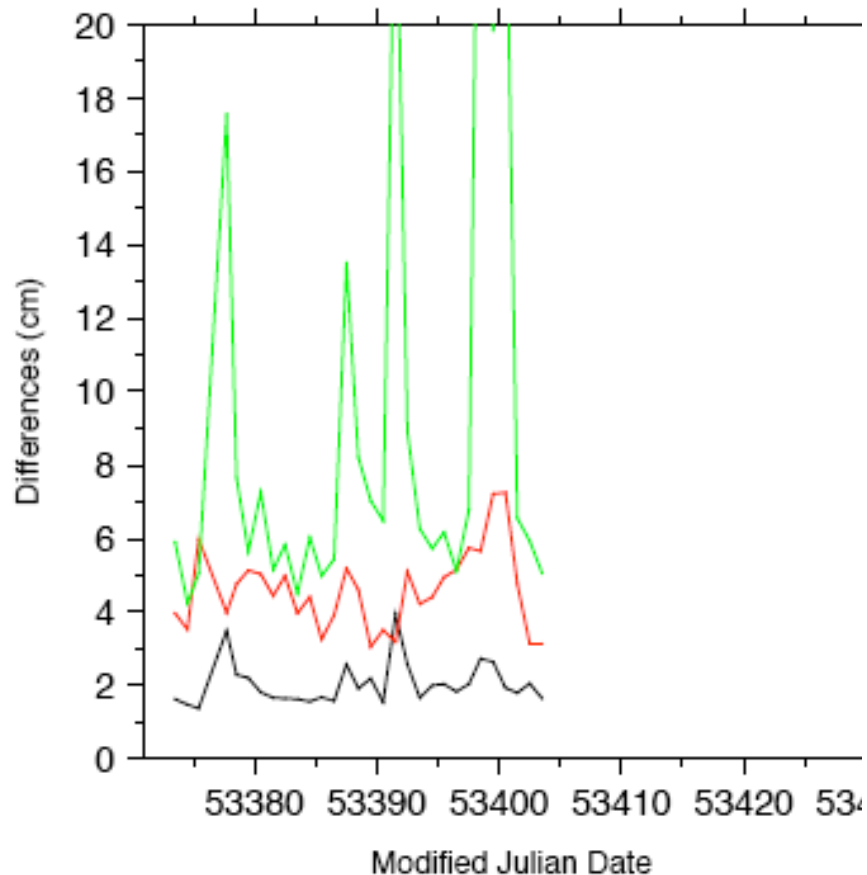


**Avg. Rad., Cross-tr., Along-tr.**



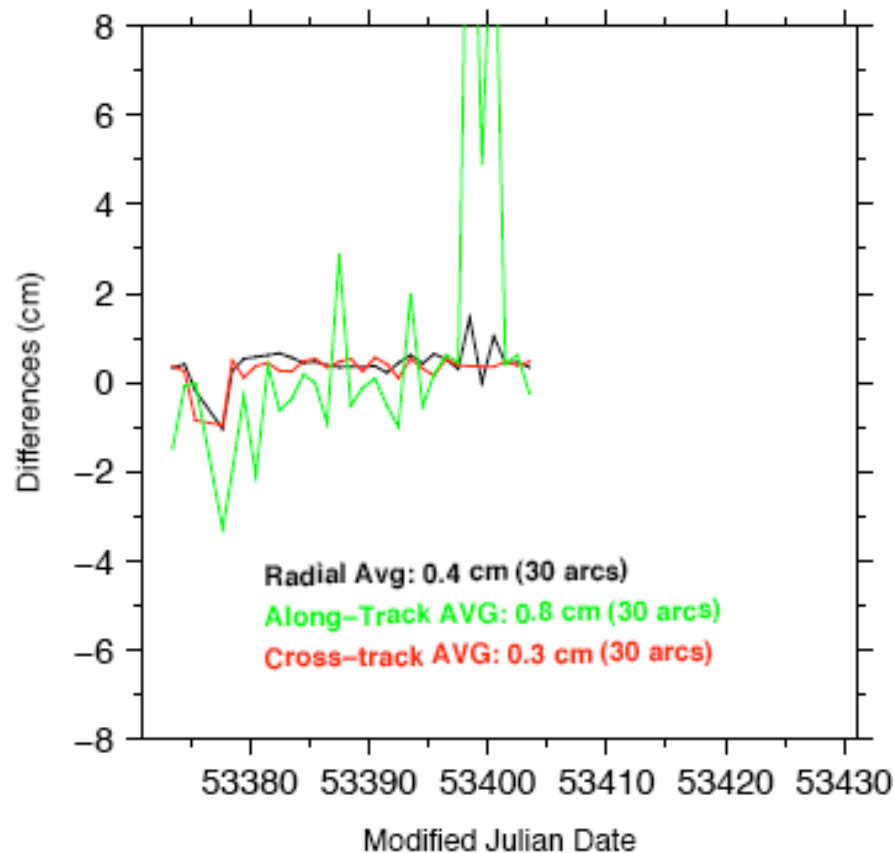
# ENVISAT Orbit Differences GOP vs IGN

**RMS, Rad., Cross-tr., Along-tr.**



**Radial RMS: 2.1 cm (30 arcs)**  
**Along-Track RMS: 11.8 cm (30 arcs)**  
**Cross-track RMS: 4.7 cm (30 arcs)**

**Avg. Rad., Cross-tr., Along-tr.**

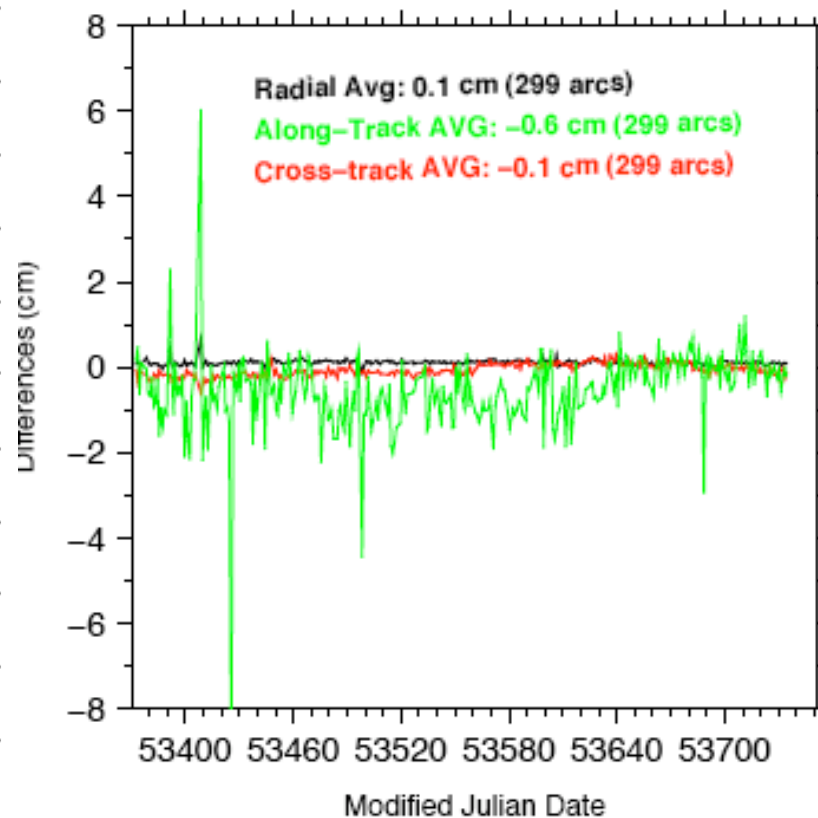
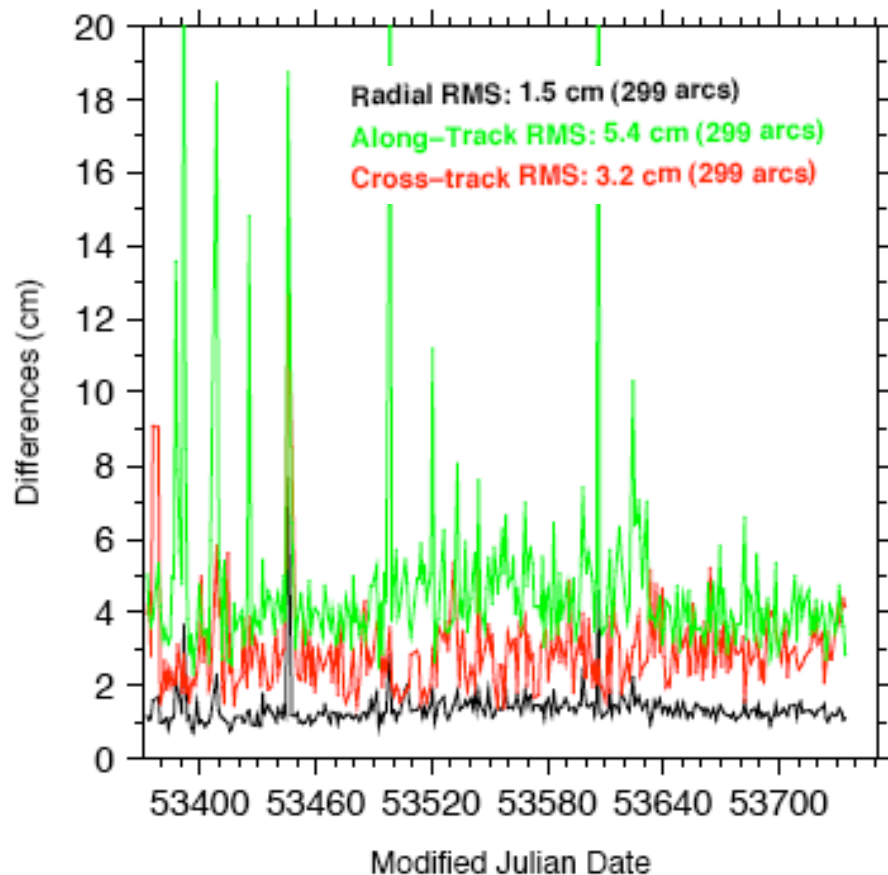


**Radial Avg: 0.4 cm (30 arcs)**  
**Along-Track AVG: 0.8 cm (30 arcs)**  
**Cross-track AVG: 0.3 cm (30 arcs)**

# ENVISAT Orbit Differences ESOC vs IGN

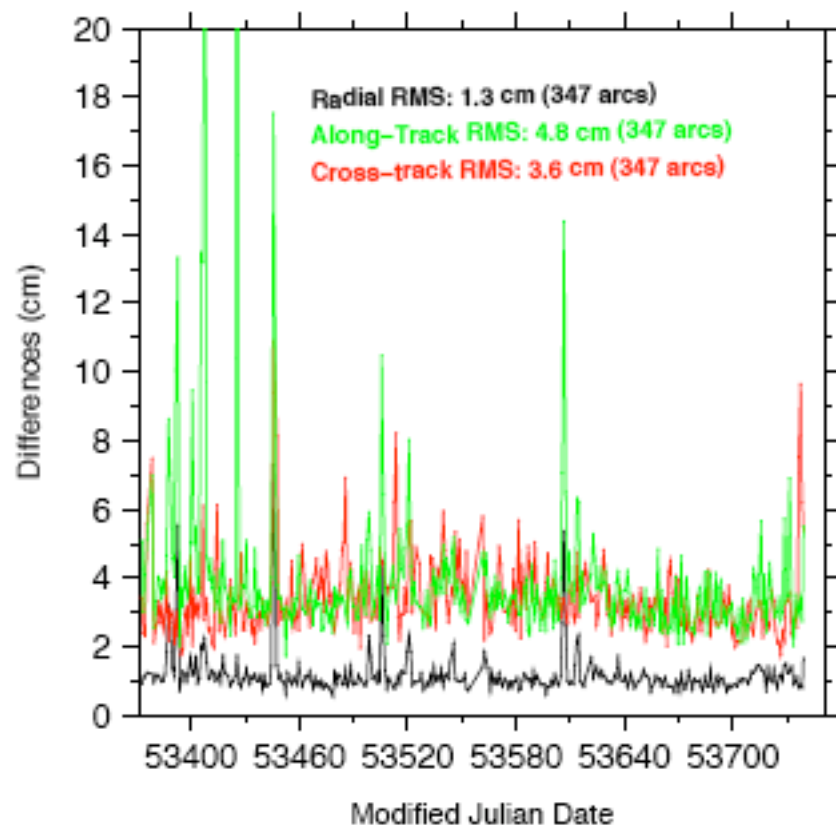
**RMS, Rad., Cross-tr., Along-tr.**

**Avg. Rad., Cross-tr., Along-tr.**

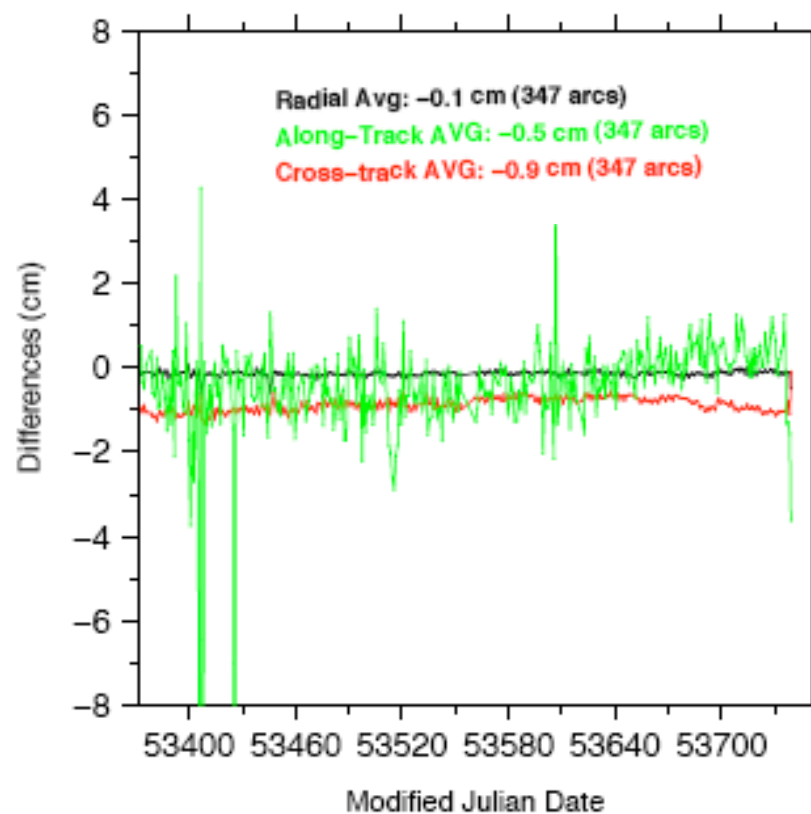


# ENVISAT Orbit Differences ESOC vs GSFC v2.

**RMS, Rad., Cross-tr., Along-tr.**



**Avg. Rad., Cross-tr., Along-tr.**



# SPOT-2 RMS Orbit Differences

SPOT2				
Orbit Set	Npts	RMS Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	340	1.4	4.1	6.0
IGN vs INA	344	1.3	4.7	11.8
INA vs GSFC	322	1.8	5.3	11.8
AUS vs GSFC	42	0.8	8.4	7.9
GOP vs GSFC	28	2.0	5.1	8.8
GOP vs IGN	20	2.4	5.1	9.3
GOP vs LCA	20	2.2	5.2	7.0
<b>IGN vs LCA</b>	<b>284</b>	<b>1.5</b>	<b>4.1</b>	<b>5.4</b>
<b>GSFC vs LCA</b>	<b>227</b>	<b>1.1</b>	<b>3.4</b>	<b>4.6</b>
INA vs LCA	274	1.8	5.2	11.9
AVERAGES				
ALL		1.6	5.0	8.5

Large AUS/GSFC Diffs

GOP RMS Radial Differences about 2 cm

## SPOT-2 Average Orbit Differences

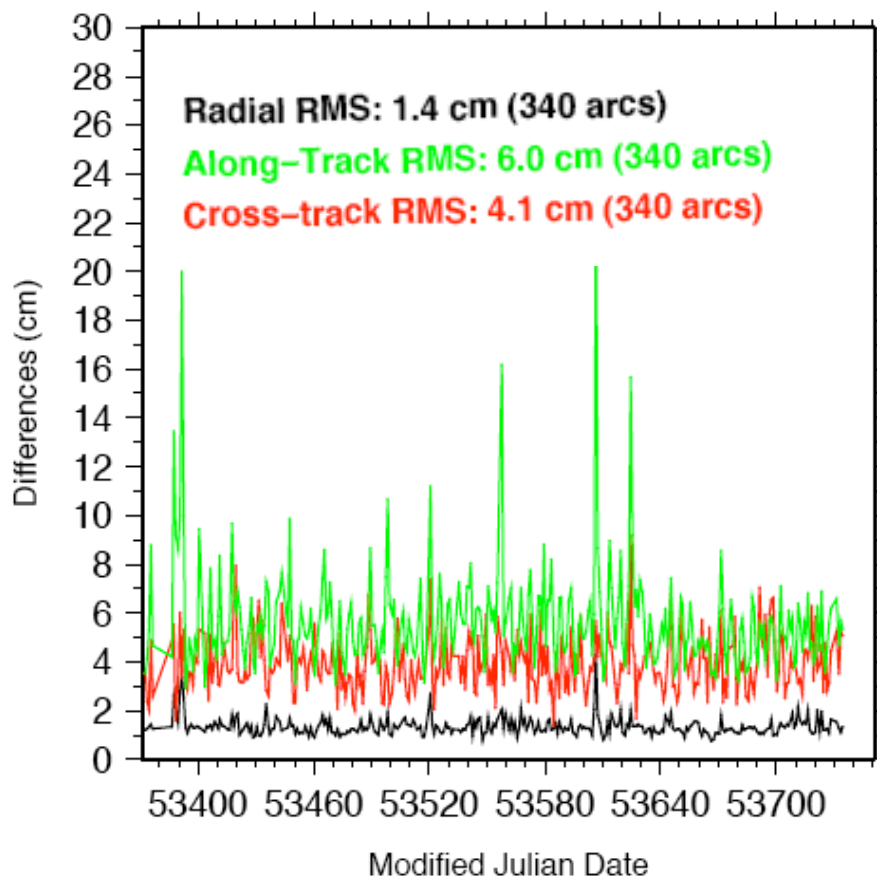
SPOT2				
Orbit Set	Npts	Average Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	340	0.0	-0.3	-0.5
IGN vs INA	344	-0.4	-0.5	9.0
IGN vs LCA	322	-0.1	0.0	0.4
GSFC vs LCA	188	-0.1	-0.3	-0.2
INA vs LCA	322	0.3	0.5	-9.3
INA vs GSFC	341	-0.4	-0.8	8.4
AUS vs GSFC	41	0.0	-0.1	0.2
GSFC vs GOP	20	-0.5	-0.9	-0.2
GOP vs IGN	20	0.5	0.5	0.0
GOP vs LCA	20	0.4	0.4	0.2

GOP Mean Radial Diffs  
about 0.5 cm

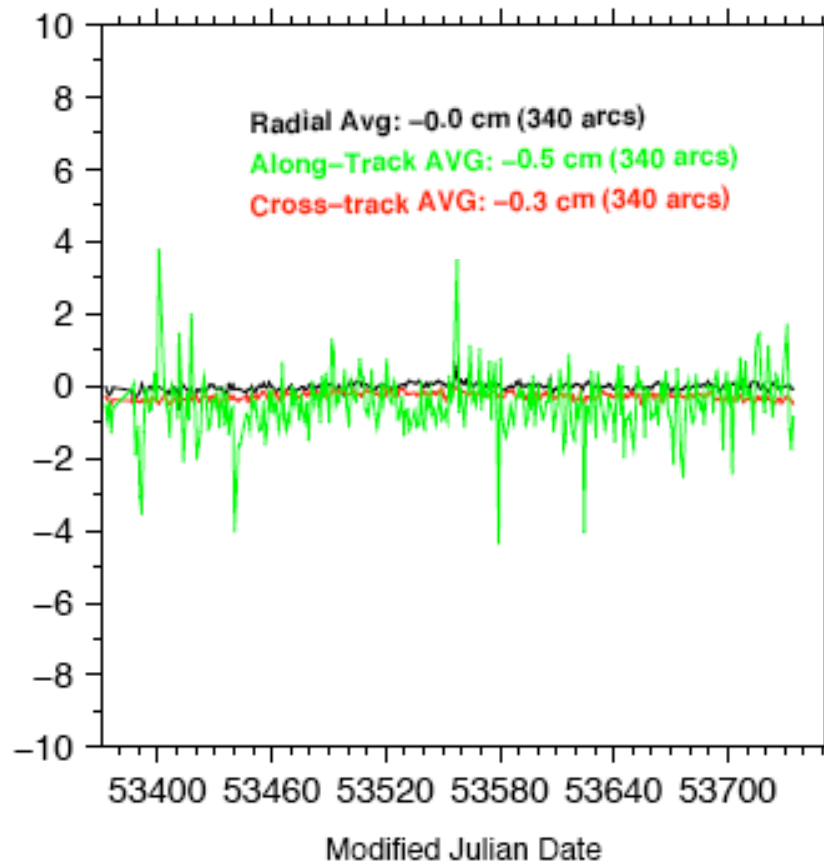


# SPOT-2 Orbit Differences IGN vs. GSFC

**RMS, Rad., Cross-tr., Along-tr.**

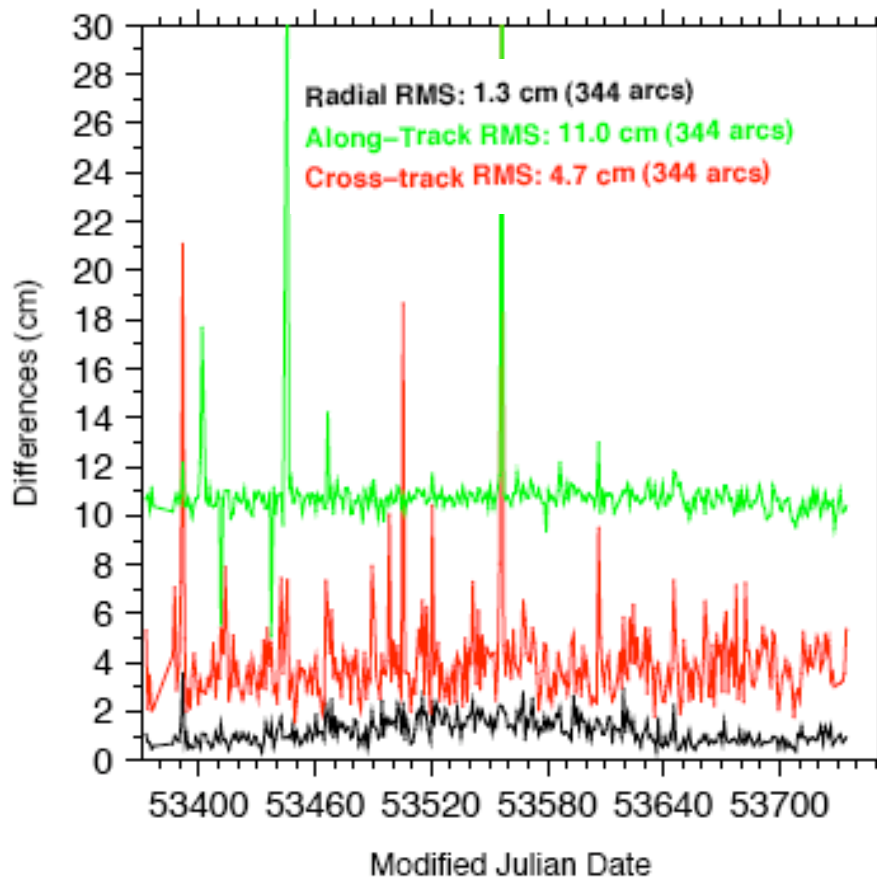


**Avg. Rad., Cross-tr., Along-tr.**

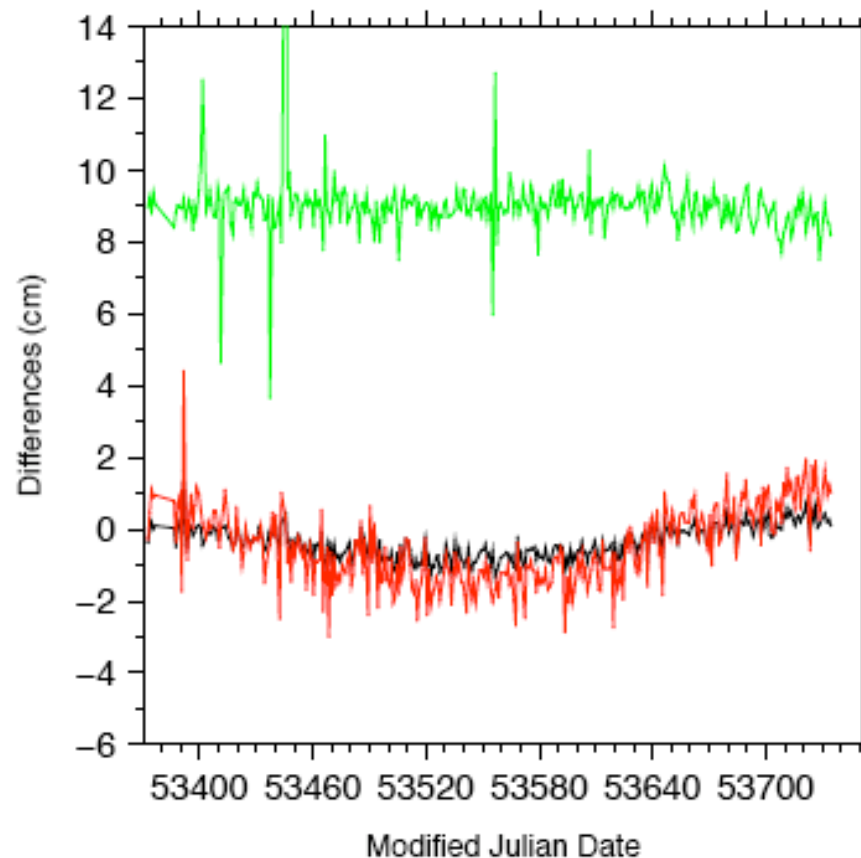


# SPOT-2 Orbit Differences IGN vs. INASAN

**RMS, Rad., Cross-tr., Along-tr.**



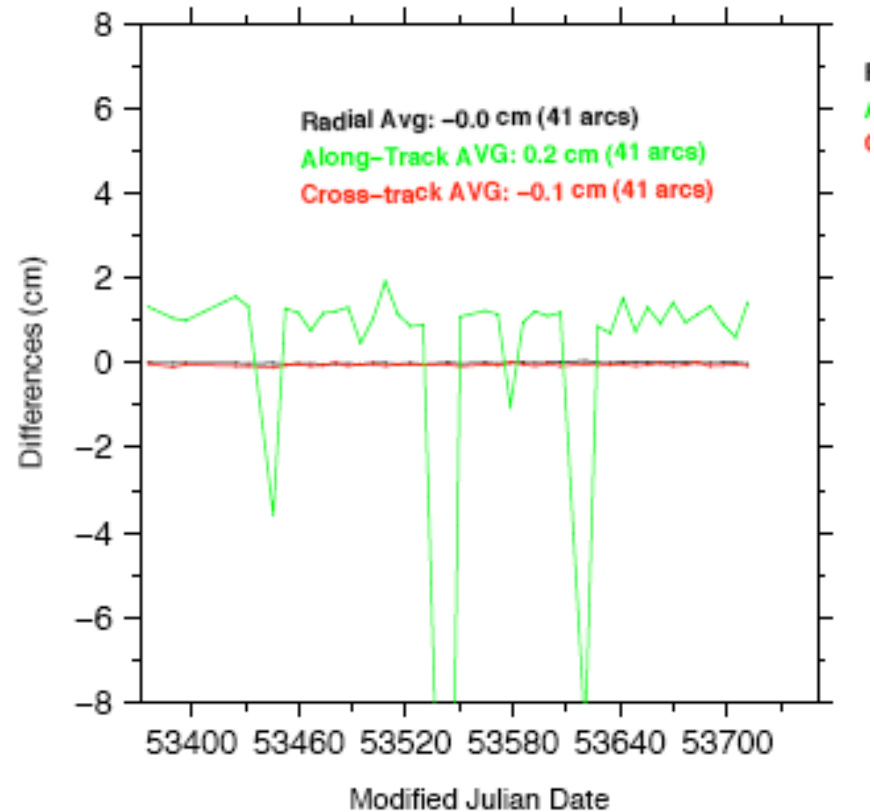
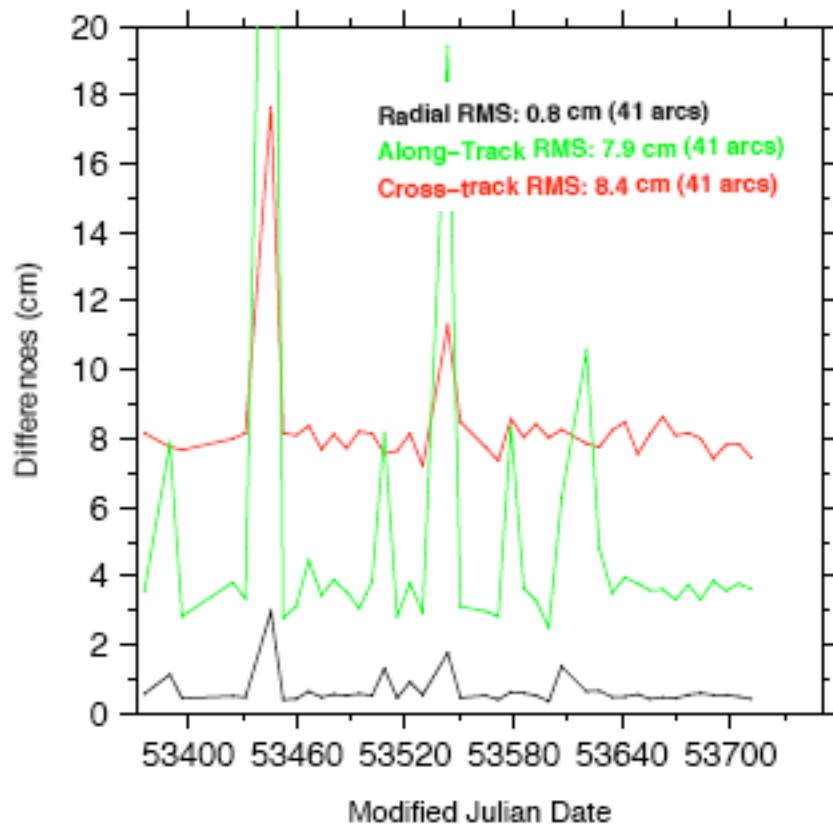
**Avg. Rad., Cross-tr., Along-tr.**



# SPOT-2 Orbit Differences GSFC vs AUS

**RMS, Rad., Cross-tr., Along-tr.**

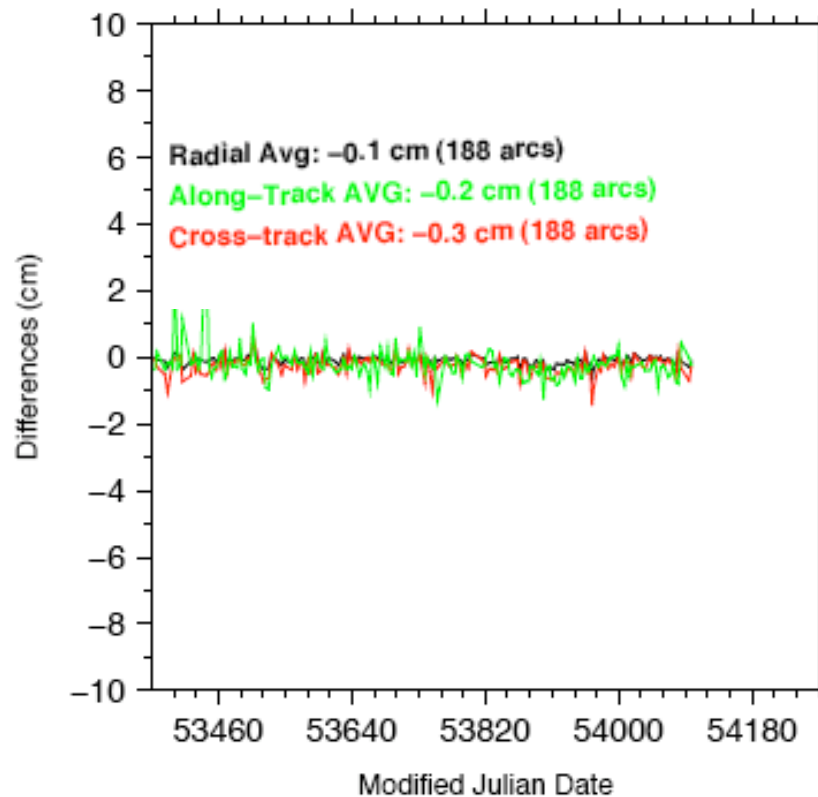
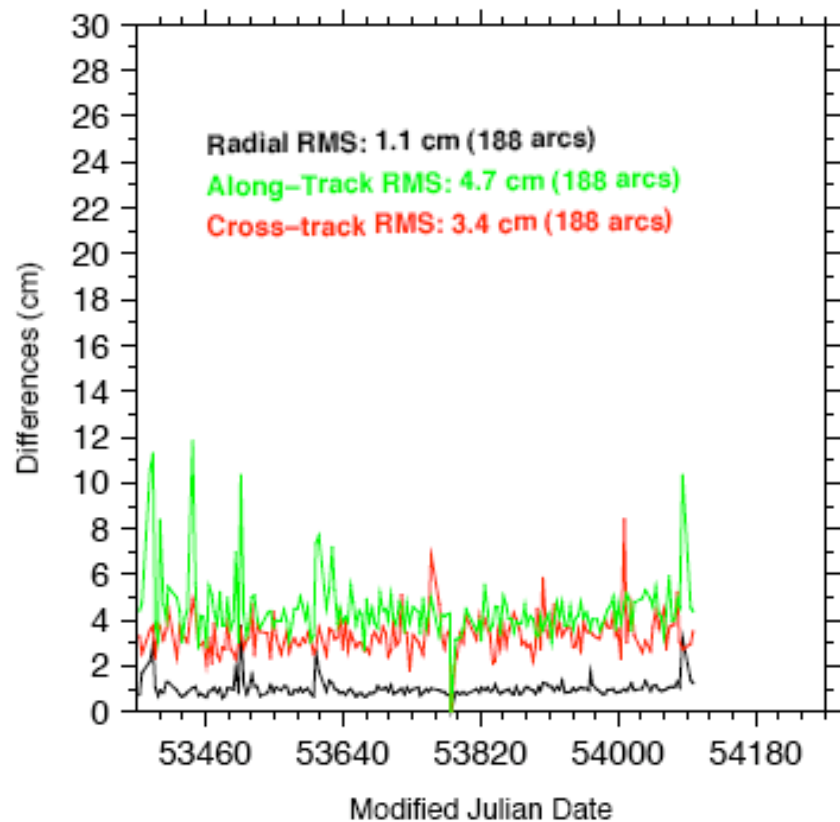
**Avg. Rad., Cross-tr., Along-tr.**



# SPOT-2 Orbit Differences GSFC vs LCA

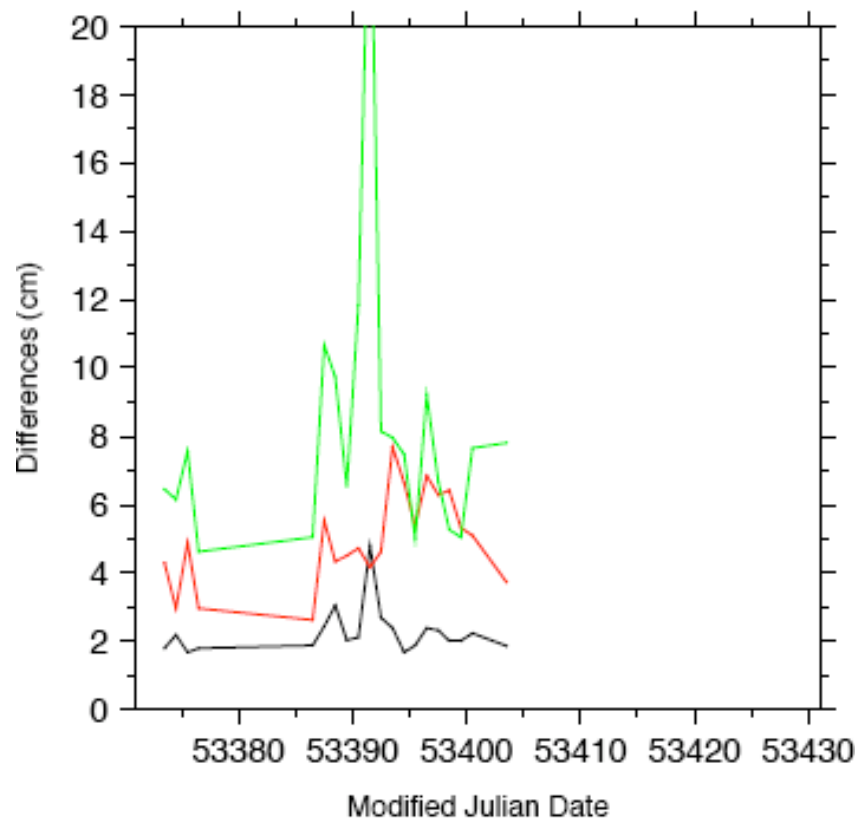
**RMS, Rad., Cross-tr., Along-tr.**

**Avg. Rad., Cross-tr., Along-tr.**



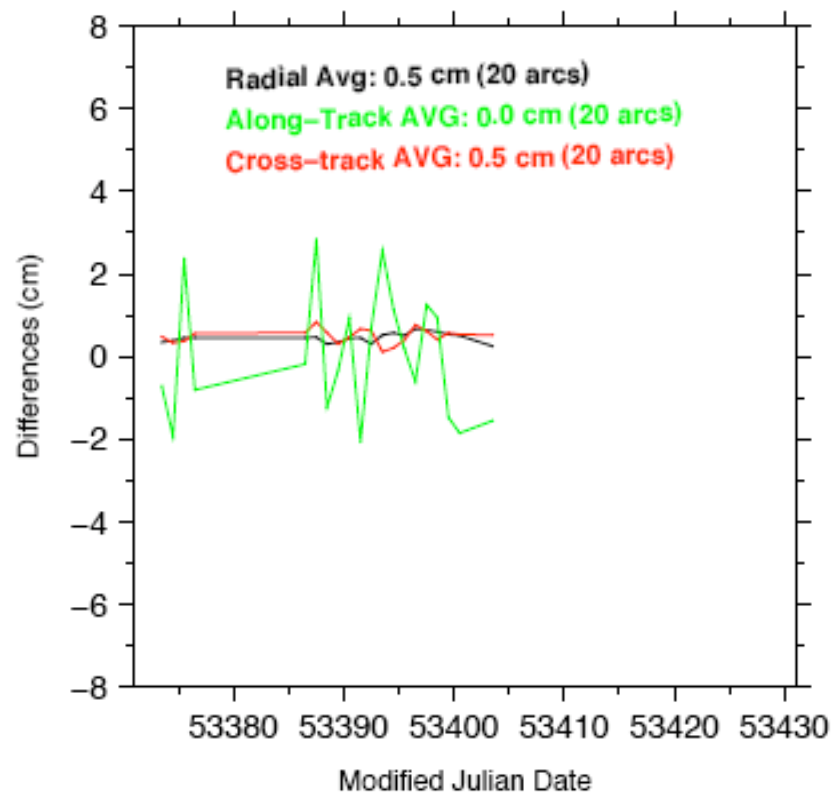
# SPOT-2 Orbit Differences GOP vs IGN

**RMS, Rad., Cross-tr., Along-tr.**



**Radial RMS: 2.4 cm (20 arcs)**  
**Along-Track RMS: 9.3 cm (20 arcs)**  
**Cross-track RMS: 5.1 cm (20 arcs)**

**Avg. Rad., Cross-tr., Along-tr.**



# SPOT-4 RMS Orbit Differences

SPOT4				
Orbit Set	Npts	RMS Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	292	1.4	4.6	5.2
IGN vs INA	303	1.2	4.4	10.7
INA vs GSFC	306	1.7	5.6	11.4
AUS vs GSFC	-	-	-	-
GOP vs GSFC	31	1.7	5.8	7.1
GOP vs IGN	22	2.1	4.8	8.6
GOP vs LCA	31	2.3	4.9	7.1
IGN vs LCA	295	1.4	3.7	4.8
GSFC vs LCA	185	1.1	5.7	3.6
INA vs LCA	303	1.6	4.6	11.4
AVERAGE S				
ALL		1.6	4.9	7.8

GOP RMS Radial Differences about 2 cm

# SPOT-4 Average Orbit Differences

Large INA Mean Diffs - Along-track,  
(w. all centers)

GOP Mean Radial Diffs  
about 0.5 cm

Mean Cross-track  
differences in GSFC  
orbits about 1.3 cm with  
other centers

SPOT4				
Orbit Set	Npts	Average Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	292	-0.1	-1.3	-0.4
IGN vs INA	303	-0.2	0.0	8.9
INA vs GSFC	306	-0.3	-1.3	8.5
AUS vs GSFC	-			
GOP vs GSFC	31	-0.5	-2.3	-0.4
GOP vs IGN	22	0.4	0.6	0.1
GOP vs LCA	31	0.5	0.8	0.5
IGN vs LCA	295	0.0	0.2	0.3
GSFC vs LCA	185	-0.1	-1.5	-0.7
INA vs LCA	303	0.2	0.2	-9.4

# SPOT-5 RMS Orbit Differences

SPOT5				
Orbit Set	Npts	RMS Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	296	1.3	4.2	6.0
IGN vs INA	284	1.1	3.5	10.6
INA vs GSFC	297	1.6	5.5	13.0
AUS vs GSFC	43	0.4	8.0	4.0
GOP vs GSFC	29	1.6	4.9	5.8
GOP vs IGN	28	1.8	4.6	6.8
GOP vs LCA	26	1.8	5.1	5.6
IGN vs LCA	273	1.4	3.8	7.2
GSFC vs LCA	188	0.9	3.1	4.2
INA vs LCA	276	1.5	4.3	11.5
AVERAGE S				
ALL		1.3	4.7	7.5

Overall orbit differences are the best of satellites so far.



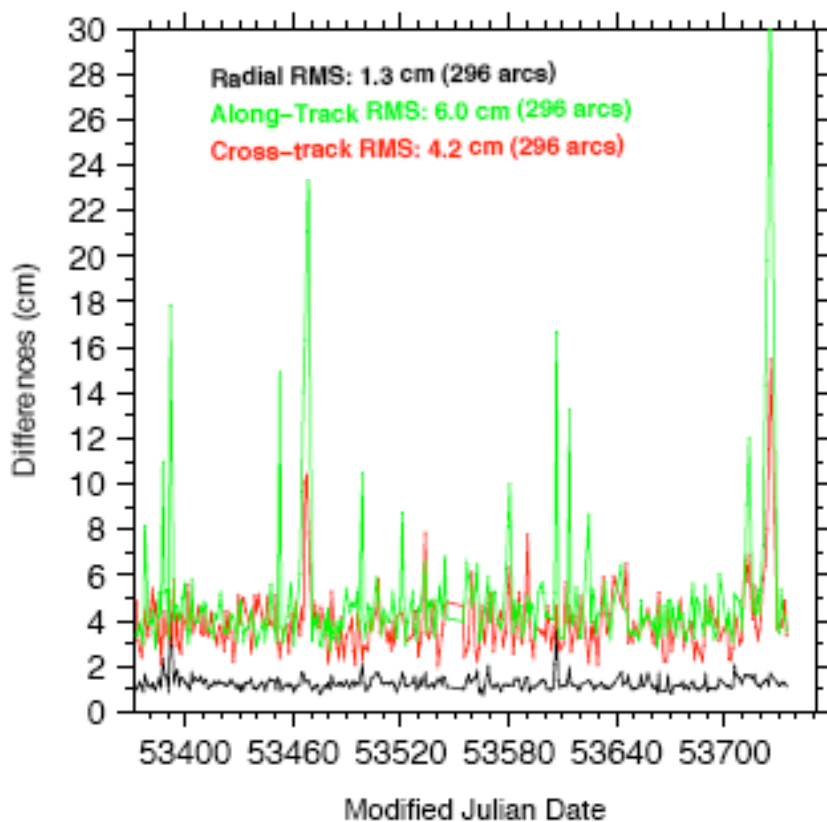
# SPOT-5 Average Orbit Differences

GSFC orbits again have 1 cm mean along-track difference.

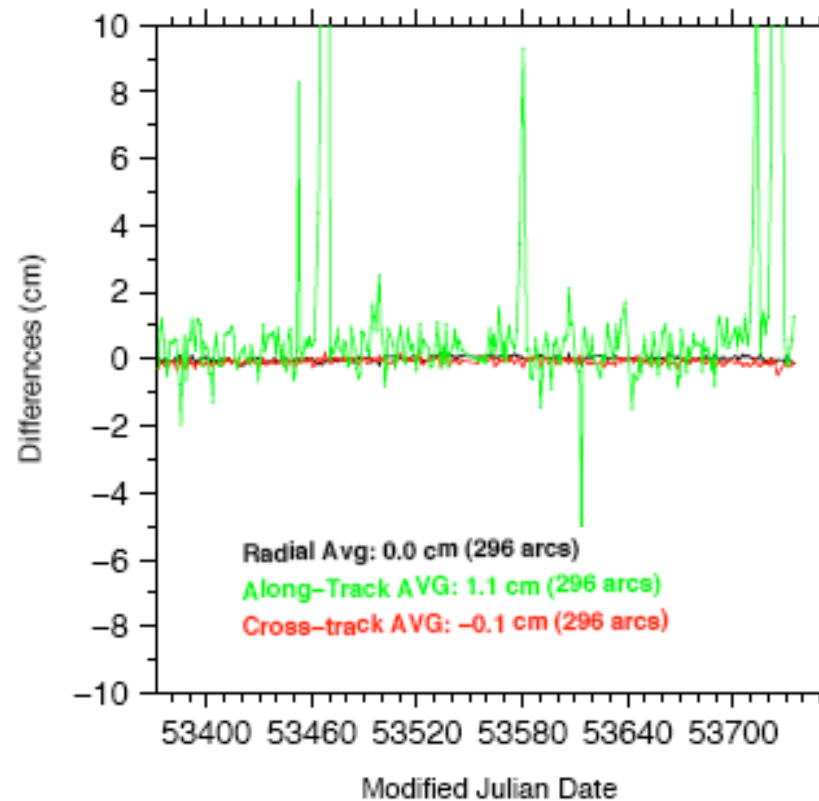
SPOT5				
Orbit Set	Npts	Average Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
IGN vs GSFC	296	0.0	-0.1	1.1
IGN vs INA	284	-0.2	0.0	9.0
INA vs GSFC	297	-0.1	0.1	10.0
AUS vs GSFC	43	0.0	0.0	2.5
GOP vs GSFC	29	-0.5	-0.6	0.2
GOP vs IGN	28	0.5	0.5	0.2
GOP vs LCA	26	0.6	0.5	0.5
IGN vs LCA	273	0.1	0.0	-0.1
GSFC vs LCA	188	0.1	-0.1	1.0
INA vs LCA	276	0.3	-0.1	-9.6

# SPOT-5 Orbit Differences GSFC vs IGN

**RMS, Rad., Cross-tr., Along-tr.**

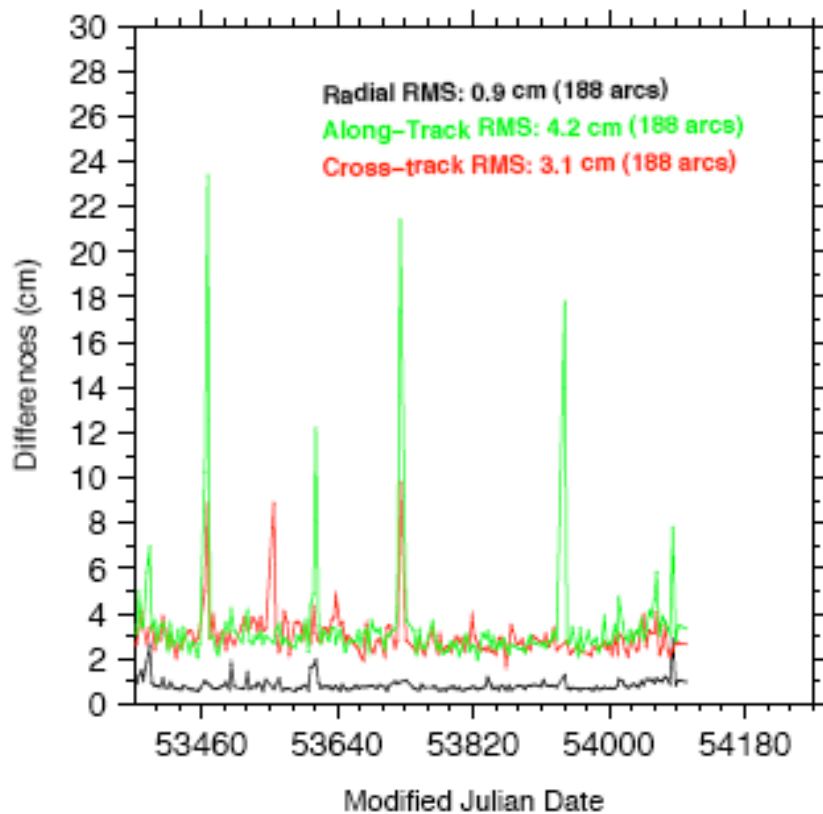


**Avg. Rad., Cross-tr., Along-tr.**

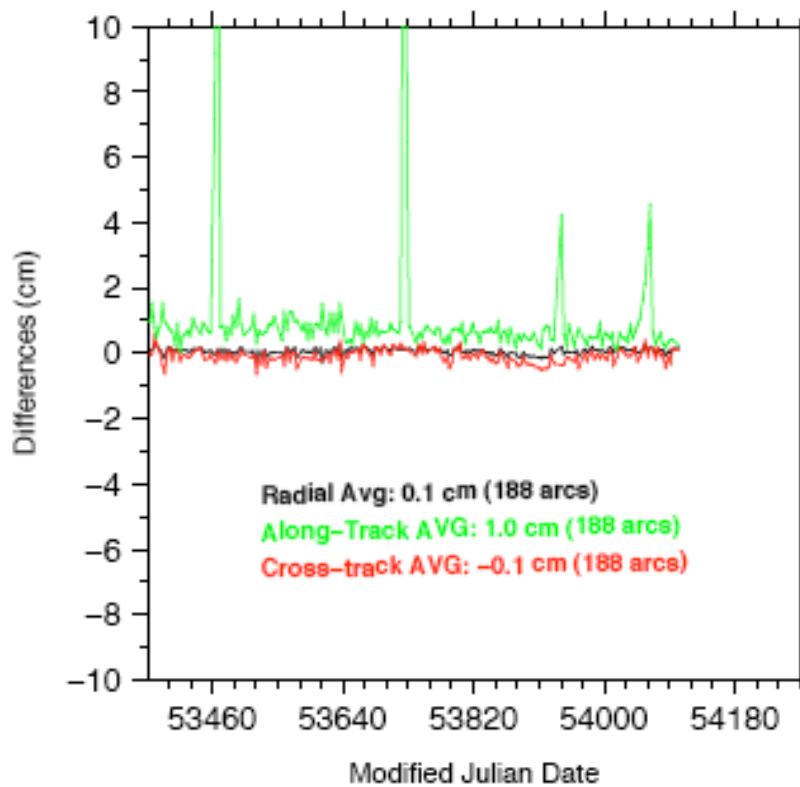


# SPOT-5 Orbit Differences GSFC vs LCA

**RMS, Rad., Cross-tr., Along-tr.**

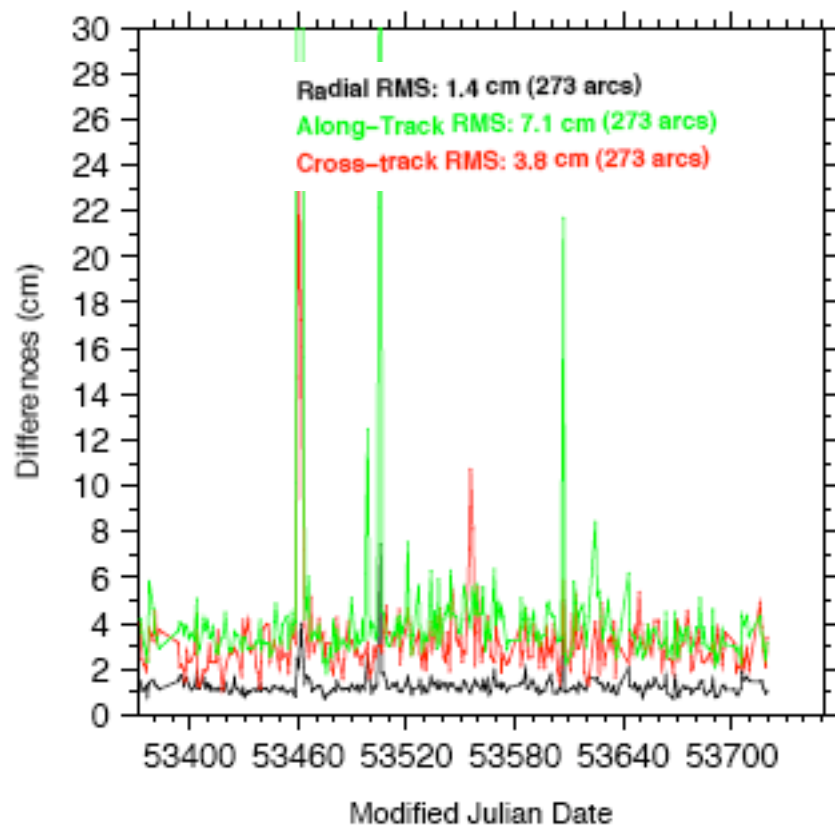


**Avg. Rad., Cross-tr., Along-tr.**

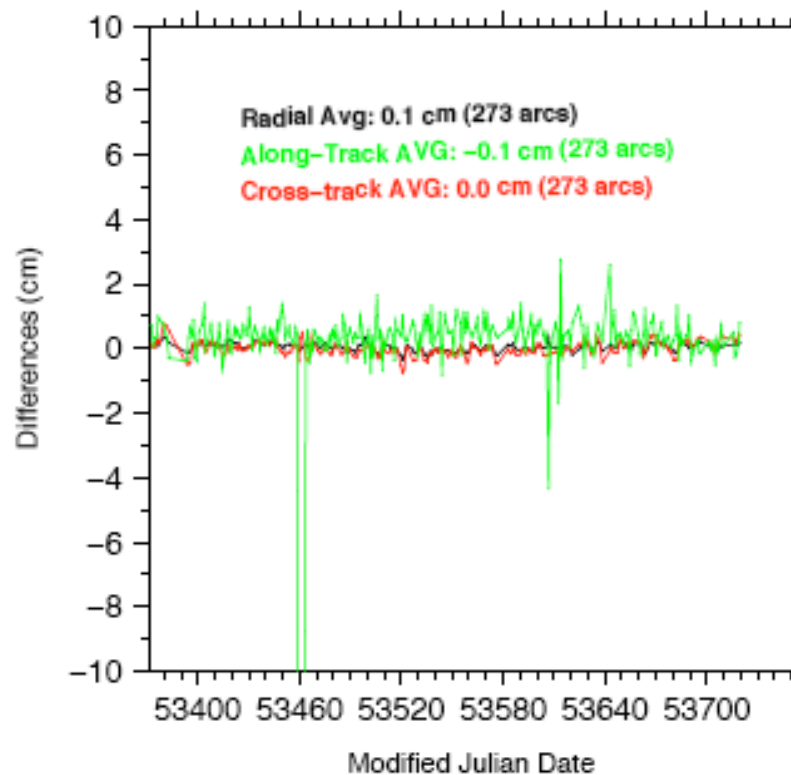


# SPOT-5 Orbit Differences IGN vs LCA

**RMS, Rad., Cross-tr., Along-tr.**

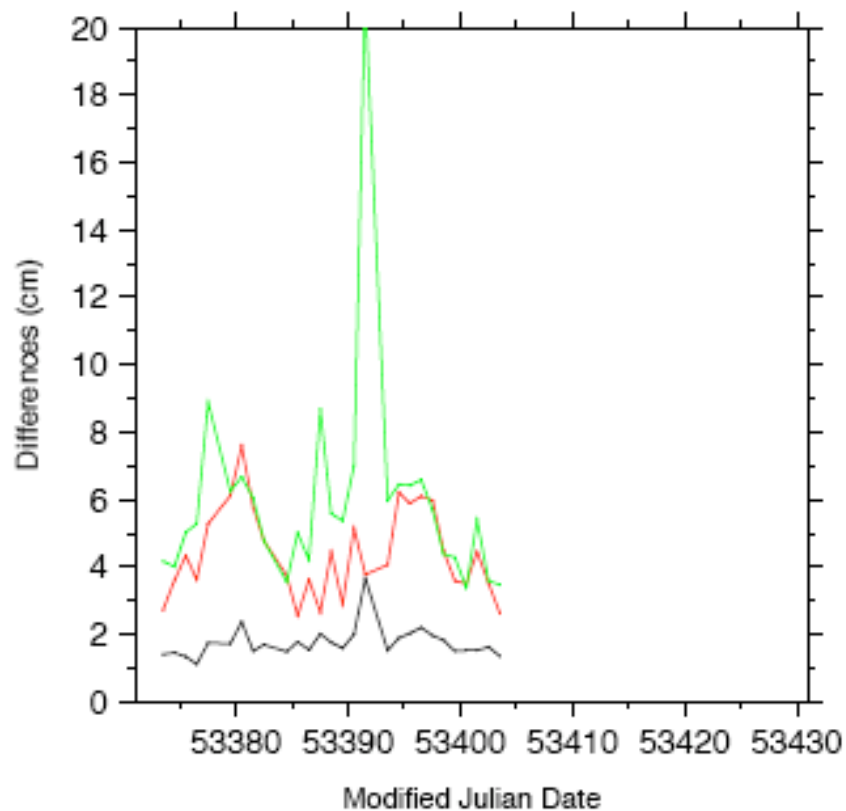


**Avg. Rad., Cross-tr., Along-tr.**



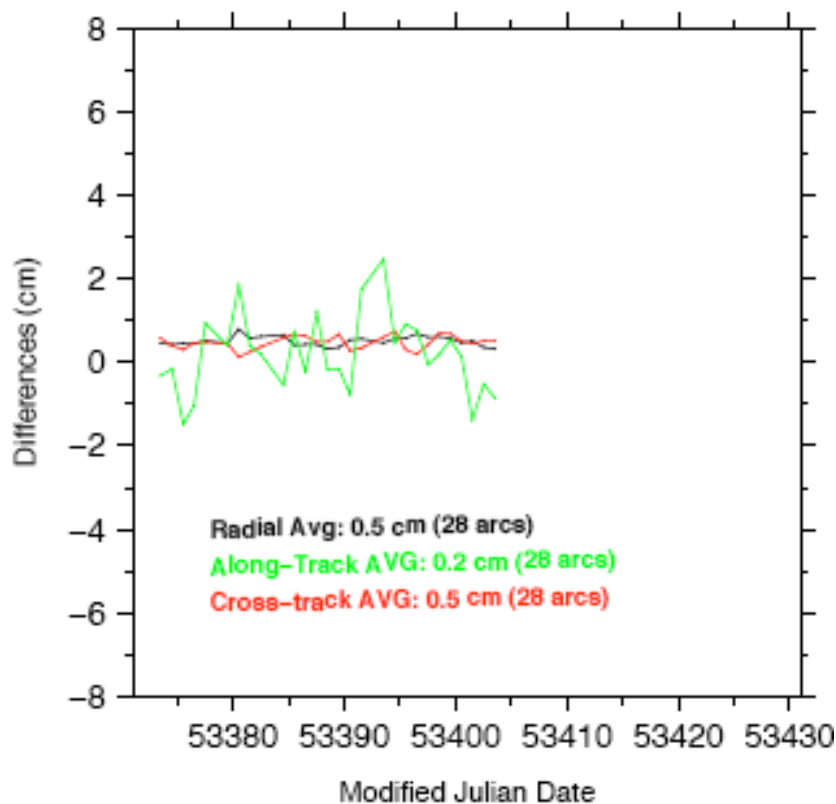
# SPOT-5 Orbit Differences IGN vs GOP

**RMS, Rad., Cross-tr., Along-tr.**



**Radial RMS: 1.8 cm (28 arcs)**  
**Along-Track RMS: 6.8 cm (28 arcs)**  
**Cross-track RMS: 4.6 cm (28 arcs)**

**Avg. Rad., Cross-tr., Along-tr.**



## JASON-1 RMS Orbit Differences

JASON-1				
Orbit Set	Npts	RMS Orbit Differences (cm)		
		Radial	Cross-tr.	Along-tr.
AUS vs GSFC	42	1.1	7.2	7.1
GOP vs GSFC	24	2.5	9.4	8.5
GOP vs LCA	21	2.1	9.0	7.7
INA vs GSFC	296	2.8	13.1	15.2
INA vs LCA	268	2.8	11.4	13.3
LCA vs GSFC	252	1.8	9.4	6.4
<i>GSFC vs GSFC slr+doris</i>	53	0.9	3.9	4.1
AVERAGES				
		2.2	10.6	9.7

## Summary

0. Overall inter-center orbit consistency is good:  
< 2 cm (radially) even with issues by some centers.
1. Systematic orbit differences revealed, by center and sometimes by satellite.
2. Causes of orbit differences must be elucidated before we begin work on ITRF2008.
3. Some differences, (eg., IGN vs INA; new LCA ENV orbits) should be easy to resolve.
4. Other systematic orbit differences are more subtle: (1 cm mean along-track diff in some GSFC orbits).



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