DORIS Analysis at CSR

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Areas of Recent Analysis

- Orbit comparisons for Jason-1 (MOE and POE)
- Analysis of effect of South Atlantic / South American Anomaly
- Contribution of DORIS to multi-technique orbits
- Contributions of DORIS to gravity time series

DORIS Performance on Jason-1

- DORIS fits significantly better on Jason-1 than T/P (excluding stations affected by South Atlantic Anomaly)
  - RMS on T/P averages **0.46 mm/s** vs **0.37mm/s** on Jason-1
  - MOE orbits from DORIS are about twice as accurate as those from T/P

	Jason (MOE vs POE)		TOPEX (MOE vs POE)	
Jason Cycle	Mean (mm)	RMS (mm)	Mean (mm)	RMS (mm)
3	-1.3	14.9	---	---
4	-1.6	14.1	---	---
5	0.9	15.6	---	---
6	8.6	24.1	---	---
7	9.2	34.8	---	---
8	2.8	15.7	-2.1	25.4
9	-0.3	15.2	-0.7	35.0
10	-1.1	19.4	-7.8	54.4
11	0.9	16.6	-2.8	61.6
12	9.3	26.6	5.9	33.5
Avg	2.7	19.7	-1.5	42.0

Jason-1 Orbits Comparisons

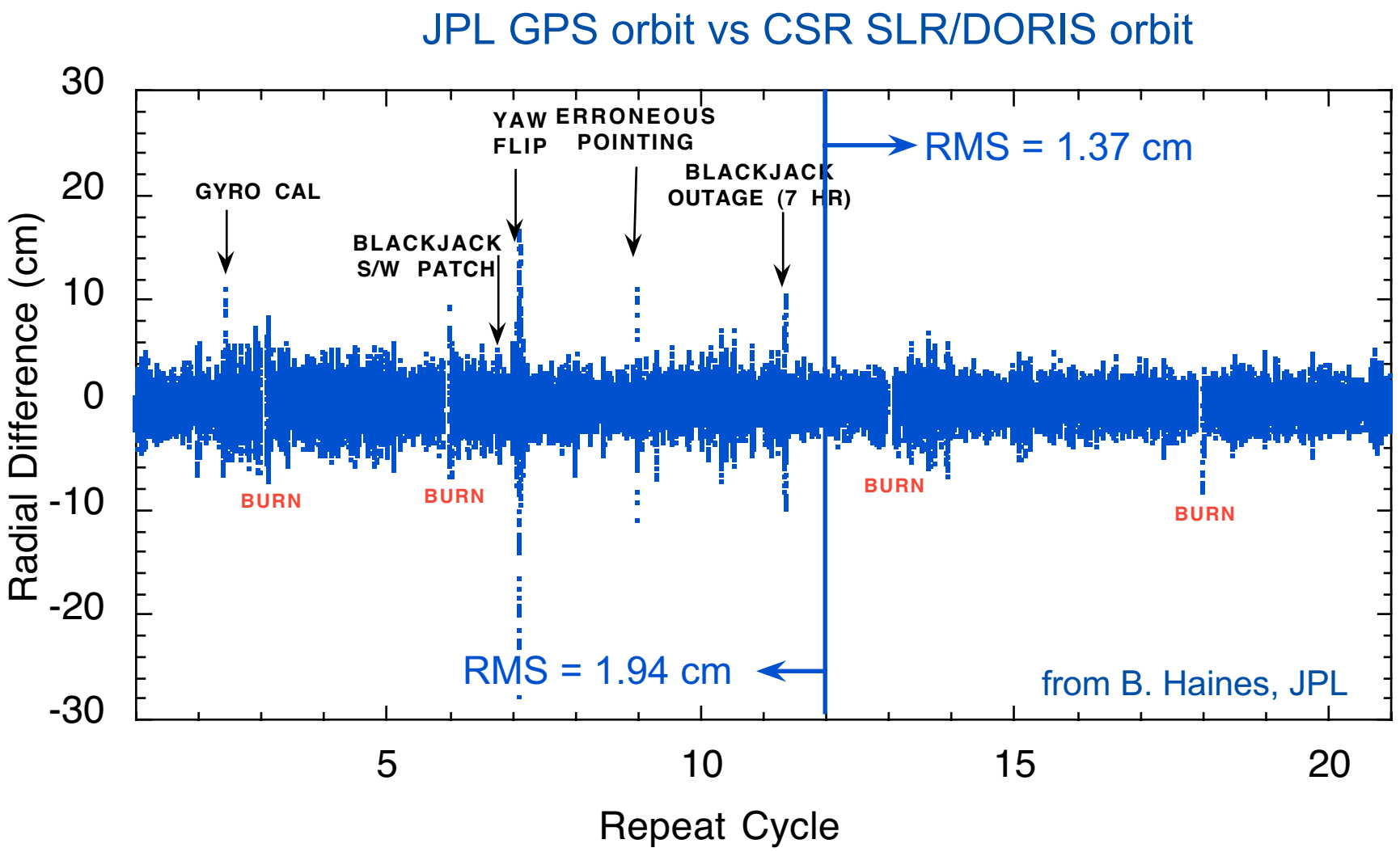
- As part of Jason-1 Cal/Val, CNES orbits based on SLR/DORIS were compared to nominal CSR orbits (also using SLR/DORIS) as well as with altimeter crossovers

CNES (SLR/DORIS)

	Crossover (CSR)		Crossover (CNES)		Radial Diff		X	Y	Z
Cycle	Mean (mm)	RMS (mm)	Mean (mm)	RMS (mm)	RMS (mm)	Mean (mm)	Mean (mm)	Mean (mm)	Mean (mm)
8	5	62.5	14	64.6	14	4	3	1	3
9	2	59.7	7	60.6	17	3	5	6	3
10	-6	62.5	-3	66.3	27	2	2	8	5
11	-11	63.1	-8	61.4	14	0	-3	10	7
12	-9	56.5	-7	56.5	12	0	-4	7	-7
13	-3	62.4	12	63.2	17	0	-3	8	-12
14	-7	59.8	6	59.7	14	-1	-7	3	3
15	-4	58.0	8	58.0	16	-1	-5	2	3
16	-7	62.0	10	62.9	15	-1	-3	-4	1
17	4	60.4	21	63.8	14	-1	-2	-1	4
18	-5	59.2	7	56.8	12	0	-2	-5	1
19	7	61.9	18	63.3	13	-1	2	-3	2
20	8	61.4	14	61.7	12	-1	3	4	5
Mean	-2	60.7	8	61.4	15	0	-1	3	1

- Other orbits from CNES, NASA, JPL, JPL/IGN, DEOS and CSR, based on various combinations of tracking systems, were compared similarly
- Consistency between various groups providing orbits was very good, generally better than 2 cm radially and 1 cm in centering

Time Series Plots



Contribution of DORIS to Jason-1 POD

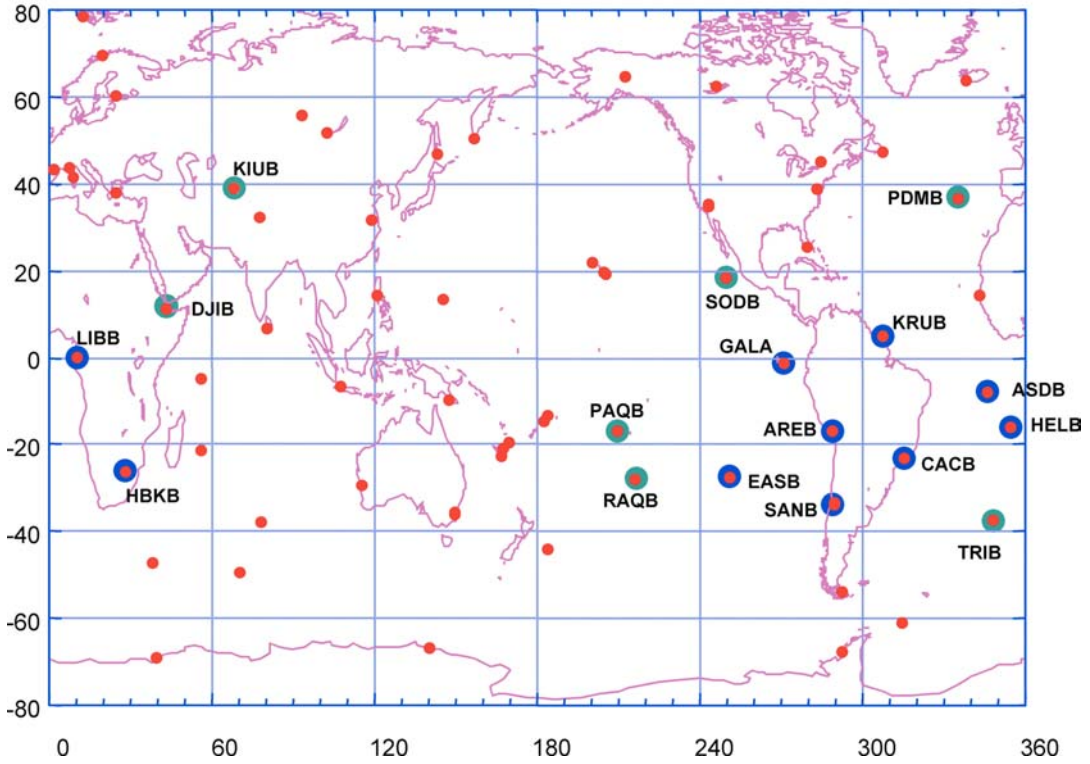
Case (10 cm for SLR, 2mm/s for DORIS, 25 cm for GPS)	Cycle 8 [cm]				Cycle 10			
	Xover		SLR residuals (>70deg)		Xover		SLR residuals (>70deg)	
	mean	rms	mean	rms	mean	rms	mean	rms
DORIS + SLR	0.45	6.25	0.23	1.01	-0.55	6.26	0.52	1.09
GPS-only	0.56	6.24	0.00	0.94	0.59	6.15	-0.75	1.38
GPS + DORIS	0.77	6.19	0.05	0.92	0.01	5.97	-0.71	1.26
GPS + SLR	0.18	6.13	-0.08	0.77	0.15	6.00	-0.56	0.98
GPS + SLR + DORIS	0.39	6.12	-0.02	0.76	-0.16	5.92	-0.57	1.00

Combining DORIS with other data types improves the orbit quality

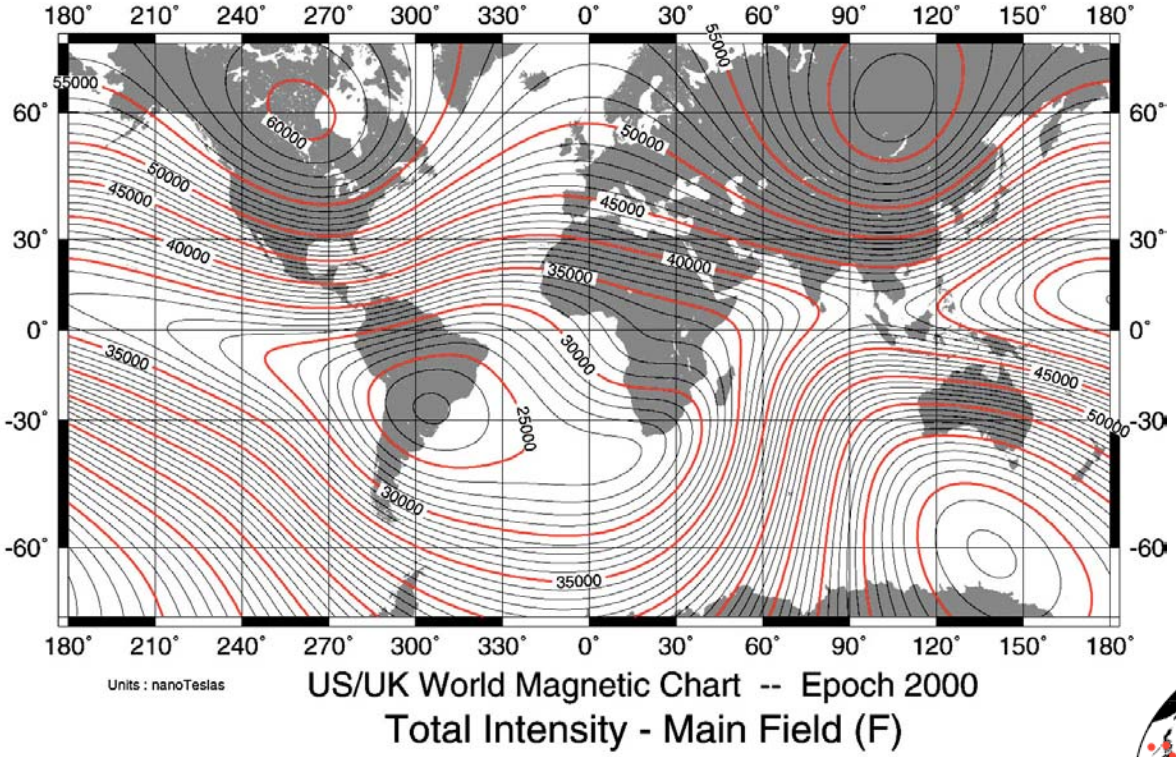
Weighting of DORIS not overly sensitive; 1-2 mm/s seems appropriate

SAA Effect on Jason-1

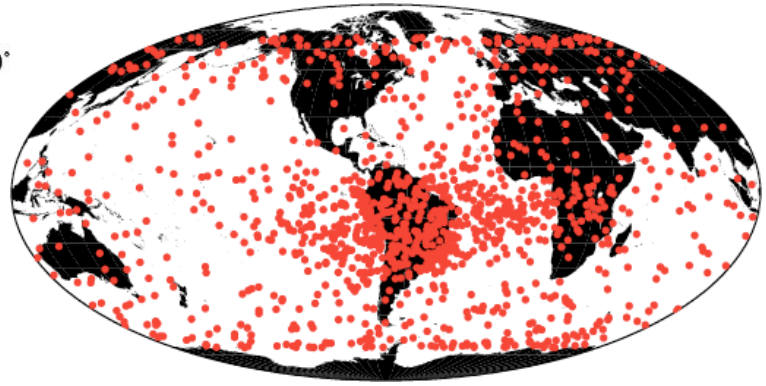
- It is clear that the oscillator on Jason-1 experiences significant frequency changes during exposure to the increased radiation environment of the SAA
  - Effect on station positioning is so serious that geodetic applications for these sites is not possible; effect appears to be getting worse with time
  - Effect on POD appears to be less serious, so far



South Atlantic/South America Anomaly

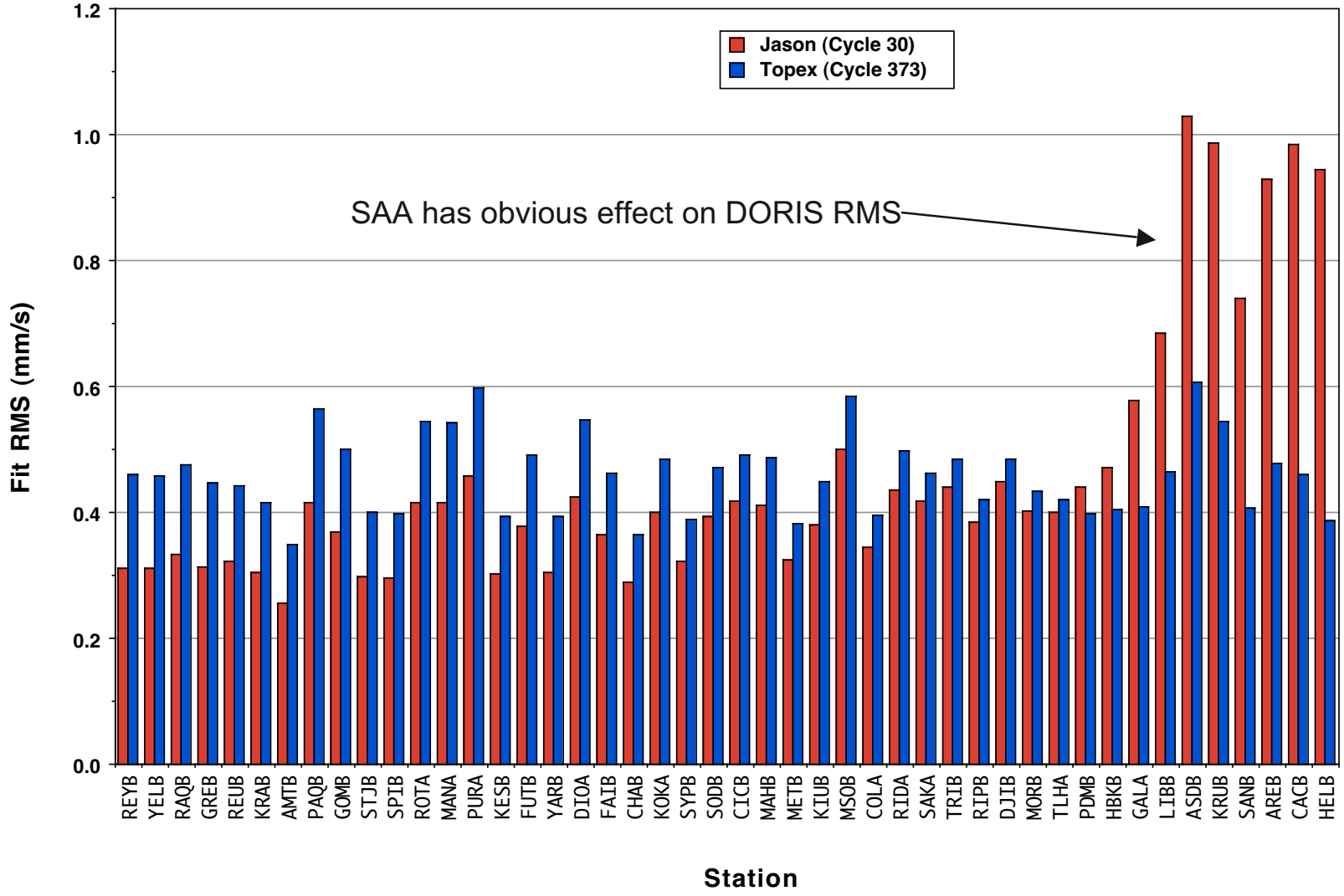


SAA is an area of low magnetic field and captured disturbance particles that can cause various electronic upsets



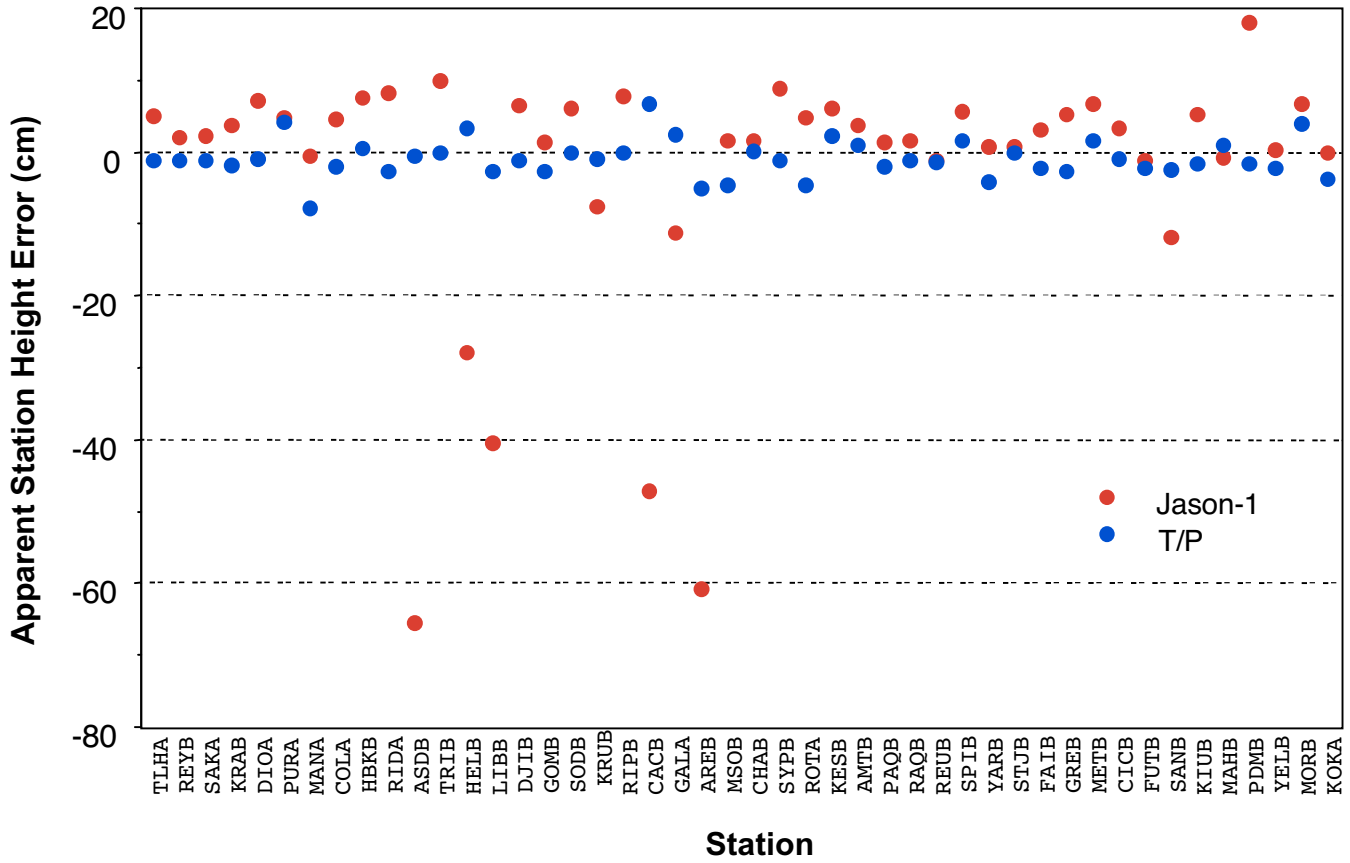
Jason-1 Blackjack GPS Receiver Resets

DORIS on Jason-1 and T/P



Geodetic Consequences

- There is a systematic error in the frequency model used to scale phase to range that is the result of the SAA effect, which is affecting all DORIS data from Jason-1
  - All stations outside of affected area have height errors which are biased in the opposite sense of the affected stations



SAA Effect on POD

Eight stations in vicinity of SAA were down-weighted in a test orbit solution

Orbit was compared with nominal orbit which used all stations at same weight

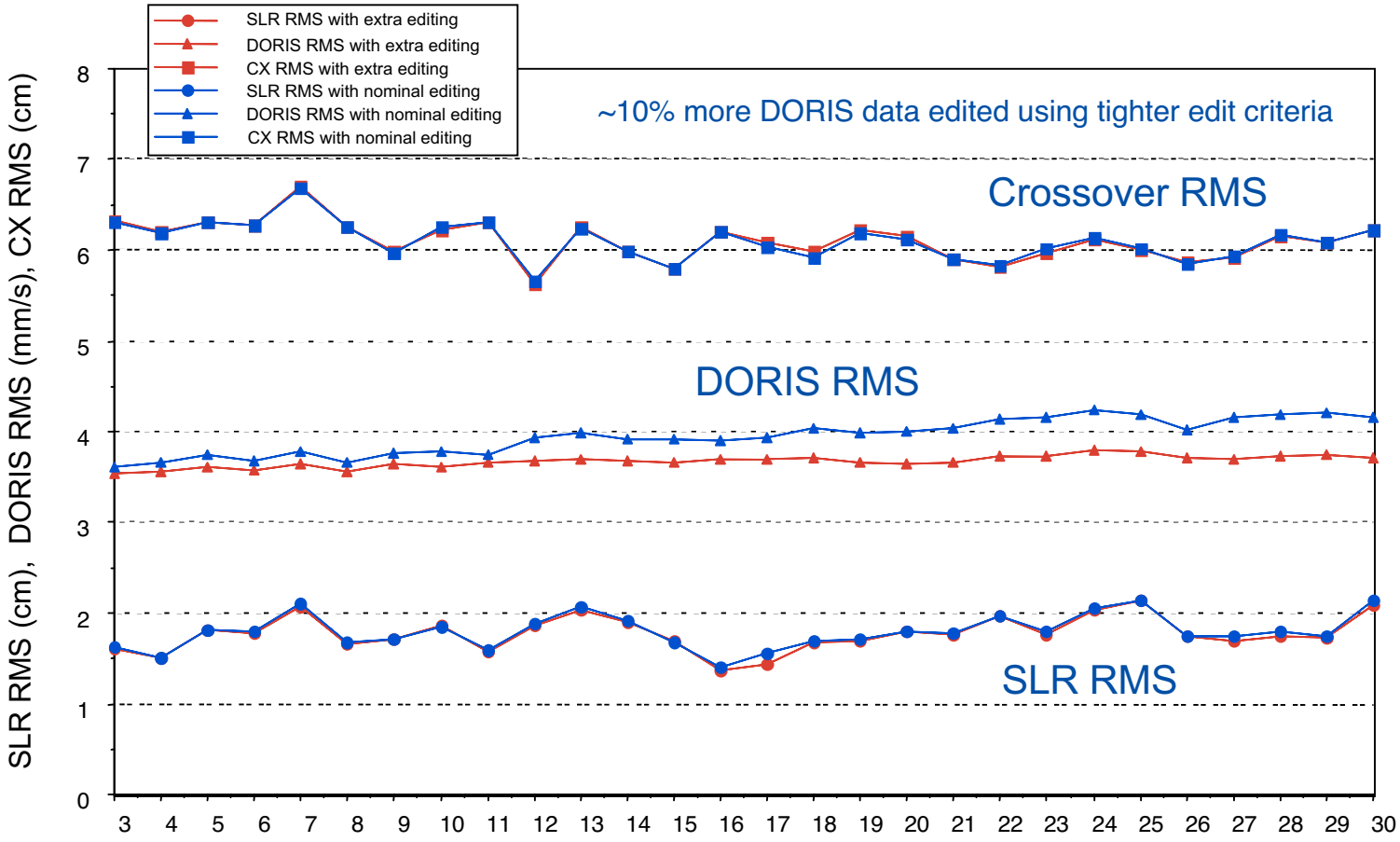
CSR (SLR/DORIS - Downweight DORIS stations in SAA region)

	Crossover (CSR)		Crossover (SAA Downweight)		Radial Diff		X	Y	Z
Cycle	Mean (mm)	RMS (mm)	Mean (mm)	RMS (mm)	RMS (mm)	Mean (mm)	Mean (mm)	Mean (mm)	Mean (mm)
8	5	62.5	6	62.7	1	0	0	0	1
9	2	59.7	4	59.8	2	0	0	0	0
10	-6	62.5	-3	62.3	2	0	0	0	0
11	-11	63.1	-7	62.5	2	0	0	0	0
12	-9	56.5	-6	56.1	2	0	0	0	-2
13	-3	62.4	2	62.6	4	0	1	0	-1
14	-7	59.8	-6	59.7	2	0	0	0	-1
15	-4	58.0	-1	57.8	2	0	0	0	-2
16	-7	62.0	-5	61.9	2	0	0	0	-1
17	4	60.4	7	60.8	3	0	0	0	-3
18	-5	59.2	-2	58.9	4	0	0	0	-2
19	7	61.9	10	62.3	3	0	0	0	-3
20	8	61.4	10	61.5	4	0	0	0	-5
Mean	-2	60.7	1	60.7	3	0	0	0	-1

Effect on orbits was insignificant, even for the later cycles where the SAA effect is worse

However, these results may only apply to longer arcs using a dynamic approach

Is Tighter Edit Criteria Beneficial?

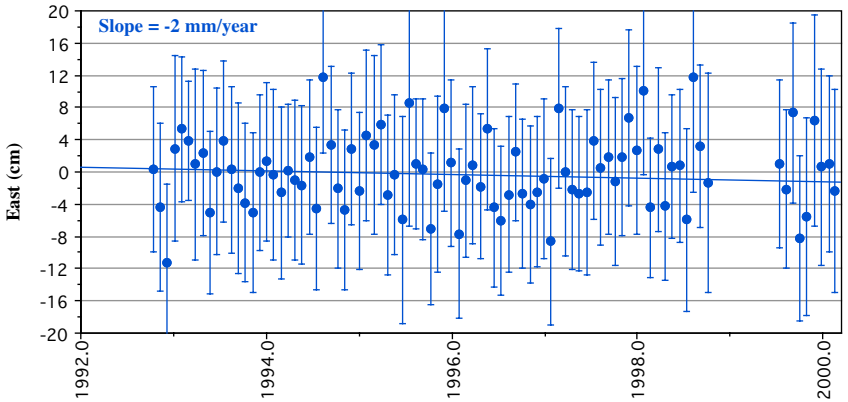


Additional edit criteria:
Pass RMS < 0.6 mm/s
slant and tangential navigation errors < 50 cm
troposphere errors < 4%

Effect on orbits was insignificant
Radial rms < 3 mm
X,Y,Z shifts < 2 mm
Crossover RMS and mean essentially unchanged

Is There Evidence of a Similar Effect Early in T/P Mission? Maybe

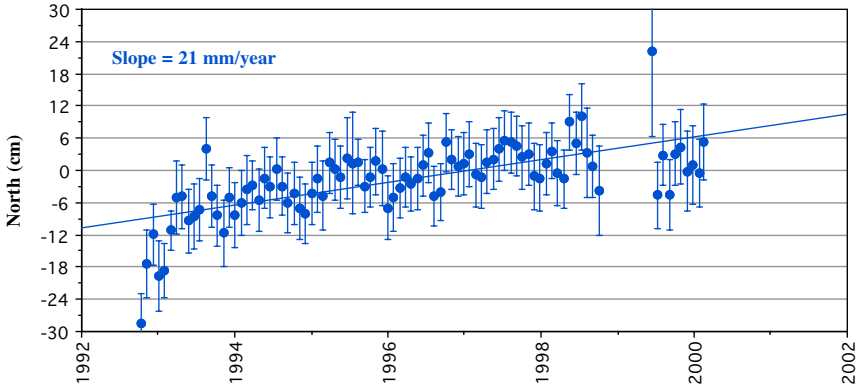
East component



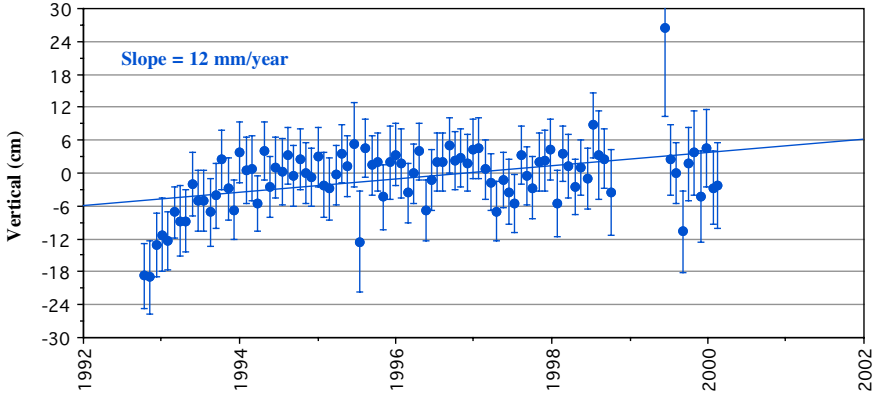
These station position time series from DORIS on T/P for CACB suggest either a short-duration local deformation or an anomaly similar to Jason-1 which took about 1 year to settle down

Jason-1 is more extreme, however, and seems to be increasing

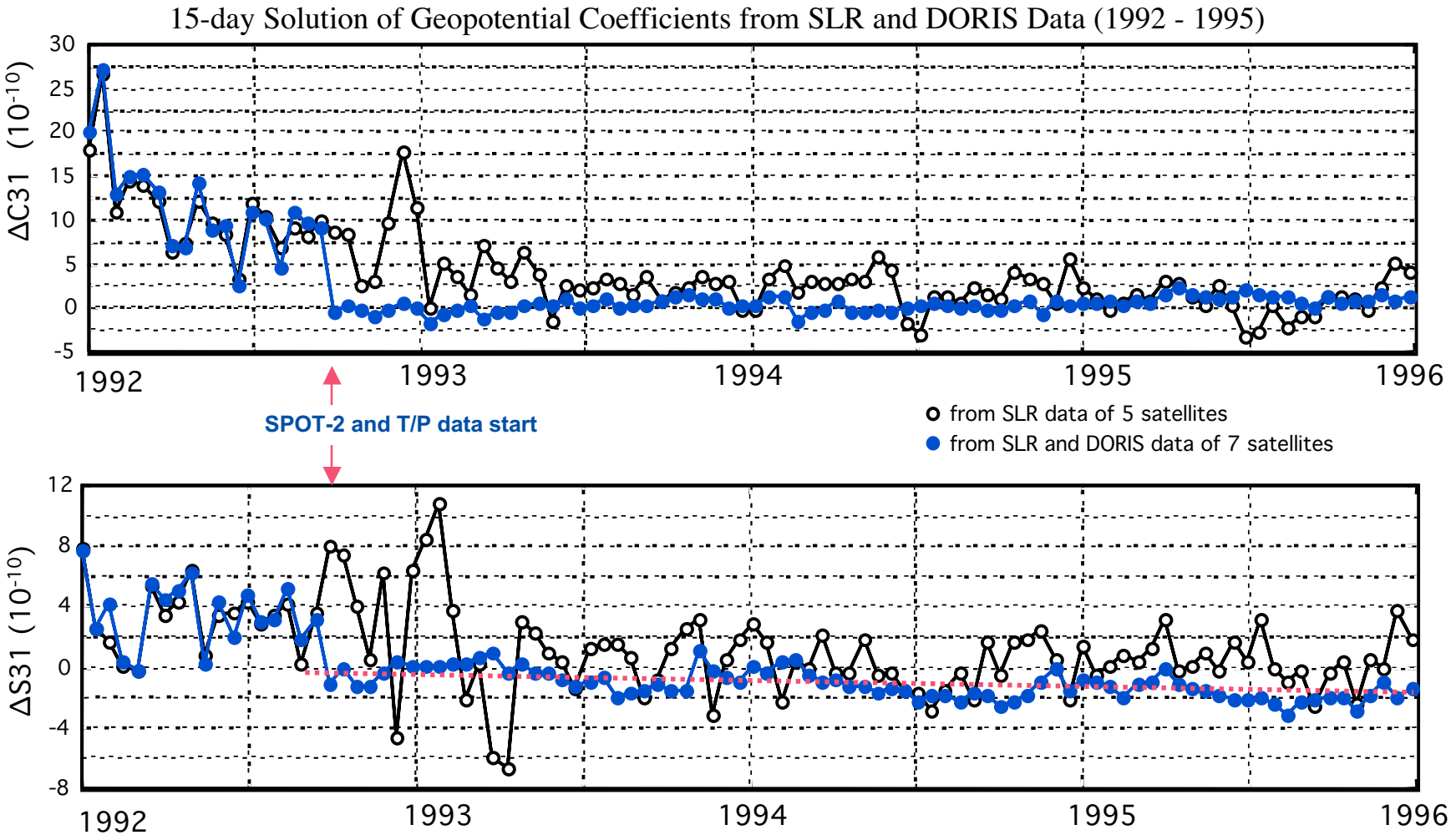
North component



Vertical component

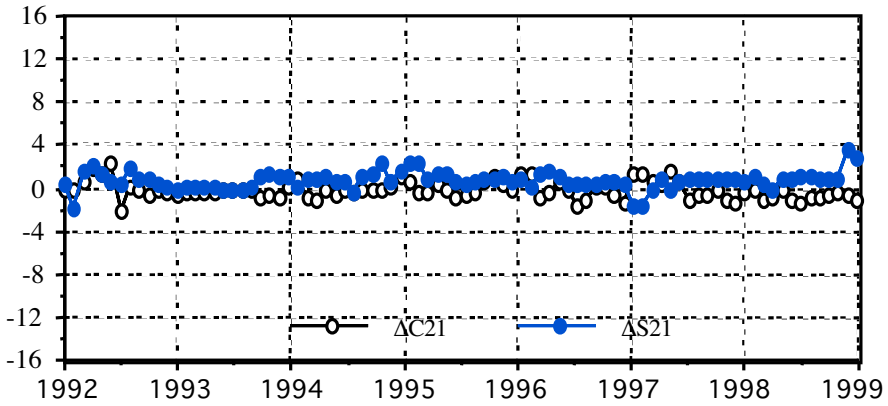


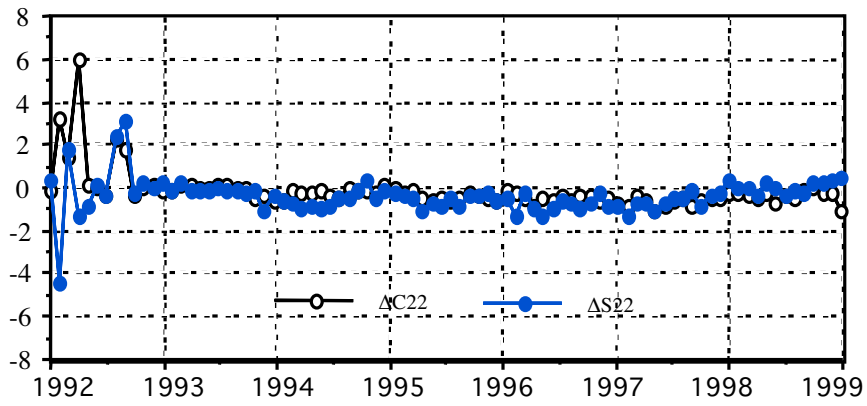
Contribution of DORIS to the Study of Temporal Gravity Variations (1)

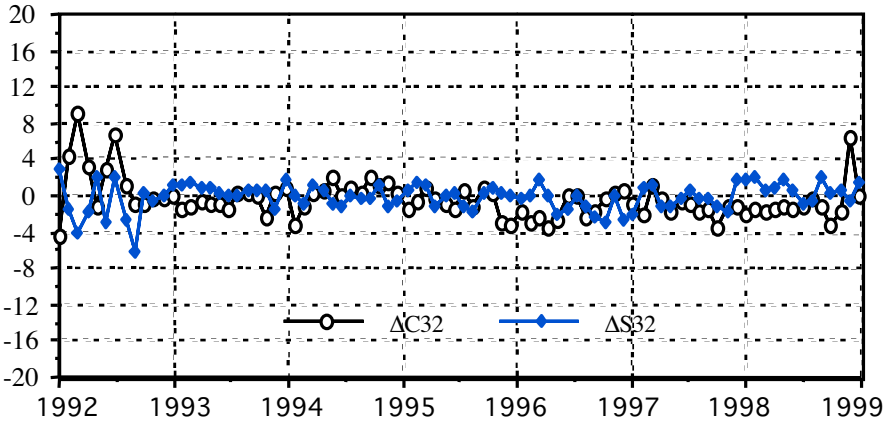


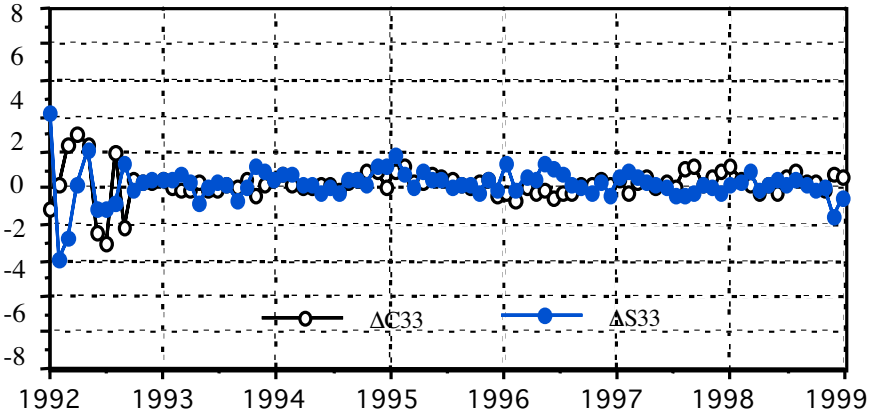
Inclusions of DORIS data has dramatic improvement in temporal gravity estimates

Contribution of DORIS to the Study of Temporal Gravity Variations (2)









(all units 10^{-10})

Conclusions

- MOE orbits for Jason-1 considerably better than for T/P
- Comparison of various Jason-1 orbits demonstrated good consistency
  - RMS difference relative to nominal CSR orbit rarely exceeded 2 cm, showing that the SLR/DORIS combination is still an accurate and robust tracking system
  - Centering differences generally less than 1 cm
- Anomalous behavior of DORIS data from Jason-1 in and around the SAA is a significant problem, which seems to be getting worse
  - Effect on POD still seems to be minor (for long-arc dynamics-based solutions)
    - May not be true for very short arcs or 'reduced-dynamic' approaches
  - Concern: can the majority of the data be 'salvaged' for geodetic applications?
    - Is estimating a frequency drift the correct solution?
- DORIS tracking from SPOT-2 and T/P significantly help constrain temporal gravity estimates; updated results in progress
  - Long time series from other DORIS satellites should also be beneficial