
Contributions of DORIS to Precision Orbit Determination, Station Positioning and Gravity Field Investigations

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**DORIS DAYS
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A satellite is shown in space, emitting a beam of light towards the Earth. The Earth is depicted with a gravity field visualization, showing contour lines over the ocean and landmasses. The satellite has a large solar panel and a dish antenna. The background is a starry space.

DORIS is an important component in the precise orbit determination of TOPEX/POSEIDON

DORIS station solutions are a regular part of the determination of the terrestrial reference frame

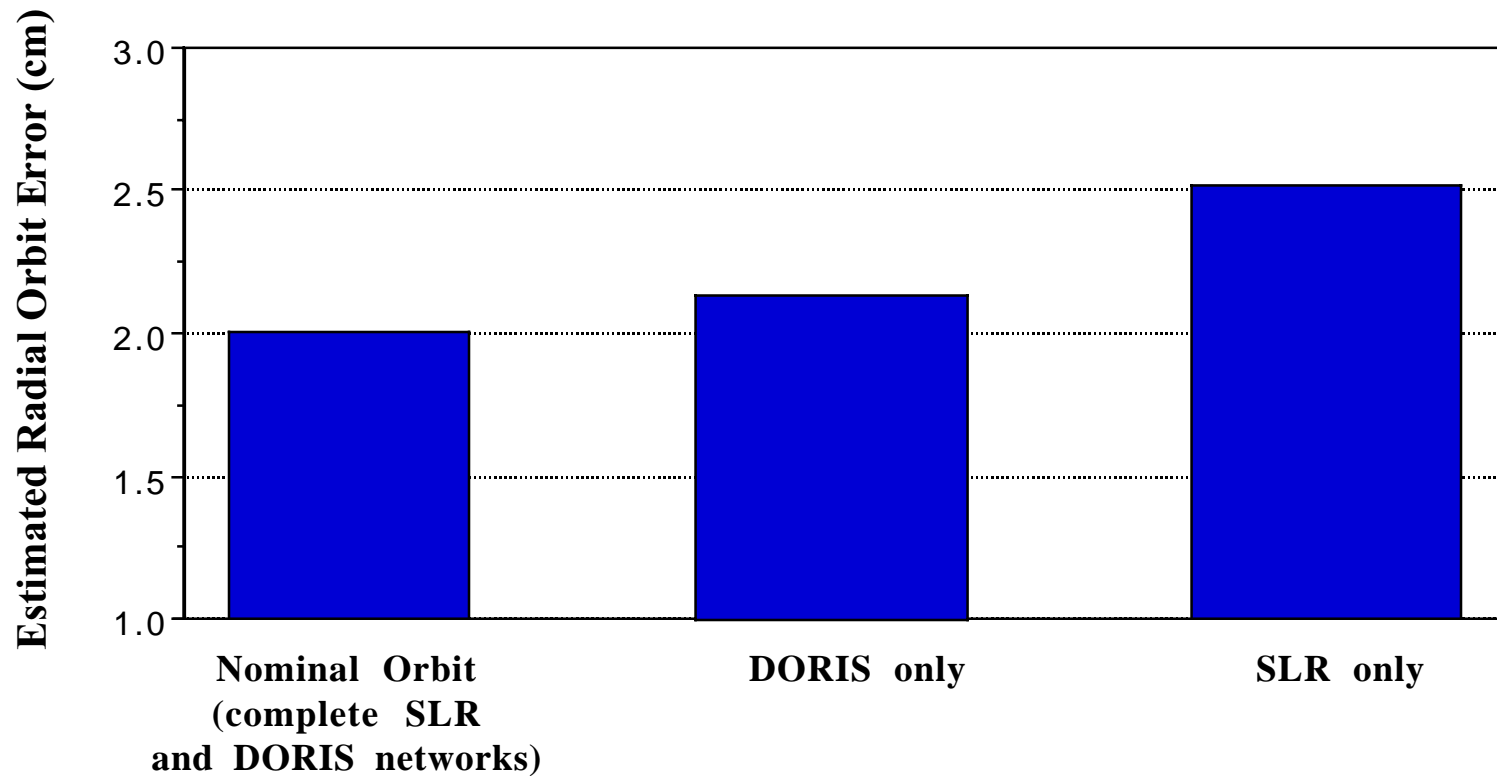
Satellites tracked by DORIS provide valuable information regarding variations of Earth's gravity field

DORIS ON TOPEX/POSEIDON

- Global distribution of tracking stations
- DORIS alone supports orbits nearly as accurate as those from the combination of SLR and DORIS
- Station location and motion knowledge continues to improve; important for long-term altimeter analyses
- DORIS has had very few outages
- At current level of orbit accuracy, DORIS data on T/P is nearly noise limited (receiver on Jason-1 will have reduced noise)

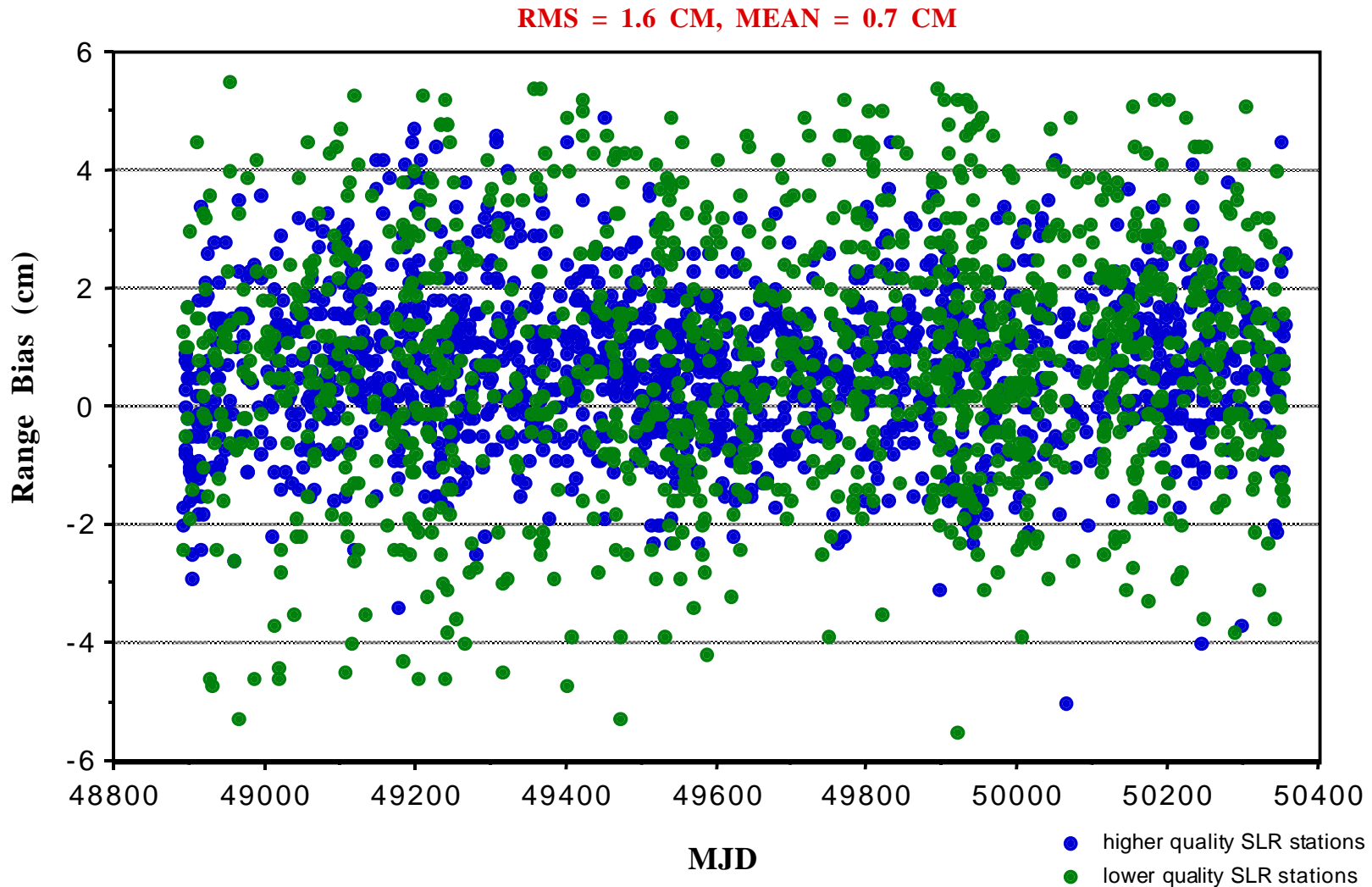
<u>Gravity Model</u>	<u>SLR fit RMS (cm)</u>	<u>DORIS fit RMS (mm/s)</u>
JGM-2 models	4	0.55
JGM-3 models	2.5	0.54

2 CM T/P ORBIT ACCURACY DUE LARGELY TO DORIS



HIGH ELEVATION SLR PASSES FOR T/P SUPPORT

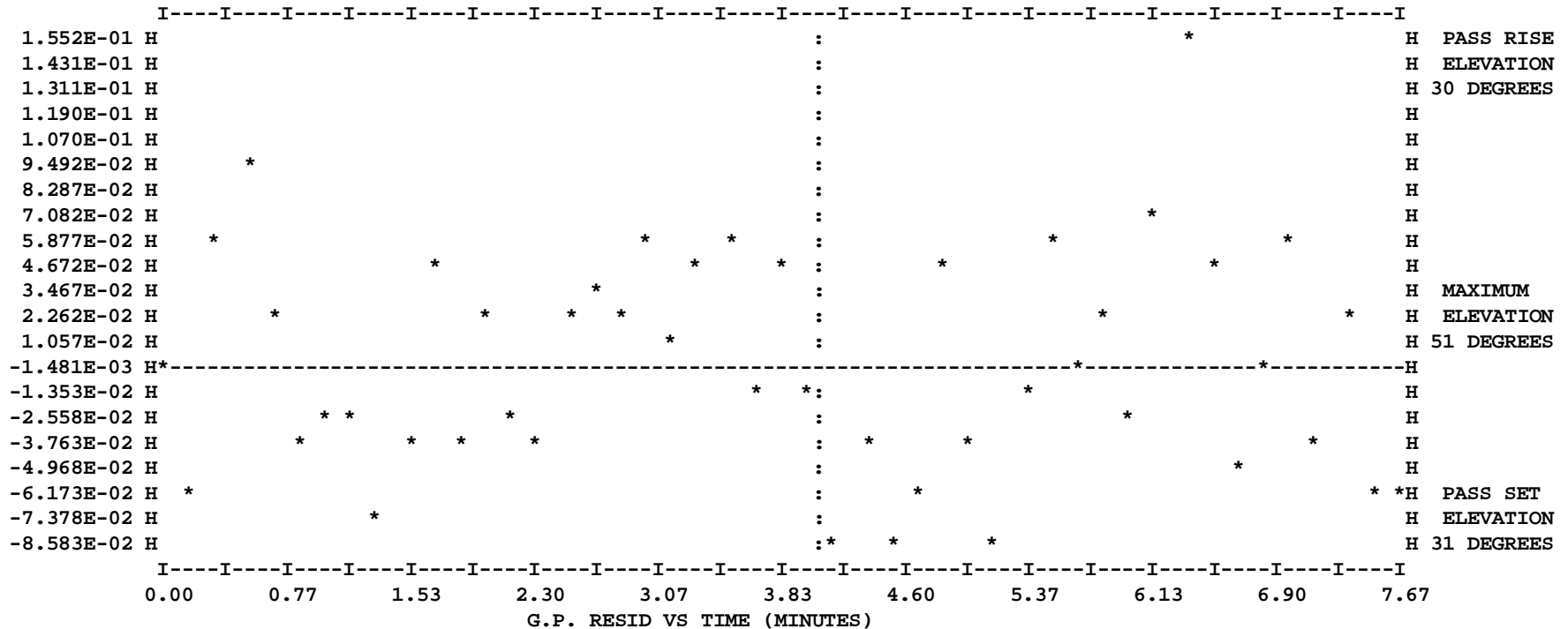
2 CM ORBIT ACCURACY ESTIMATE



TYPICAL DORIS RESIDUALS

STATION: 4005 TRIA (LAT:-31.0) PASS: 1 RMS: 0.1 TIME: 1/18/98 20:36 (LST 19:46) DURATION: 7.7 ASCENDING PASS DAYTIME

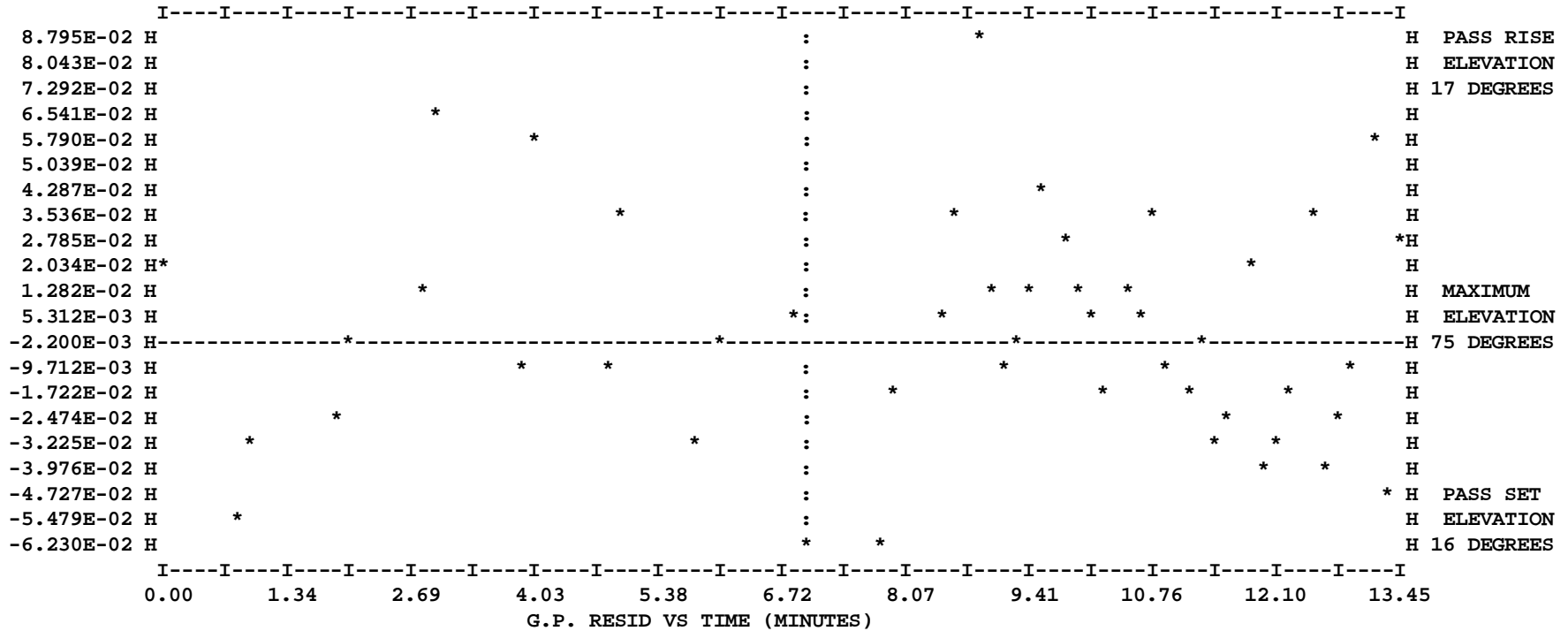
ITER	GOOD OBS	FLAGGED OBS	RAW RMS	SLANT ERROR	SLANT SIGMA	TANG ERROR	TANG SIGMA	FREQ OFFSET	FREQ SIGMA	TROP SCALE	TROP SIGMA	CORRELATIONS			GUIER RMS	EDIT CRIT
												T-DF	S-TR	DF-TR		
0	47	0	0.052	-11.55	18.45	-2.41	10.43	-3.05E-13	1.13E-12	-0.019	0.033	0.96	0.95	-0.03	0.052	1.00



TYPICAL DORIS RESIDUALS

STATION: 4006 META (LAT: 40.9) PASS: 10 RMS: 0.0 TIME: 1/21/98 3:40 (LST 5:17) DURATION: 13.4 DESCENDING PASS NIGHTTIME

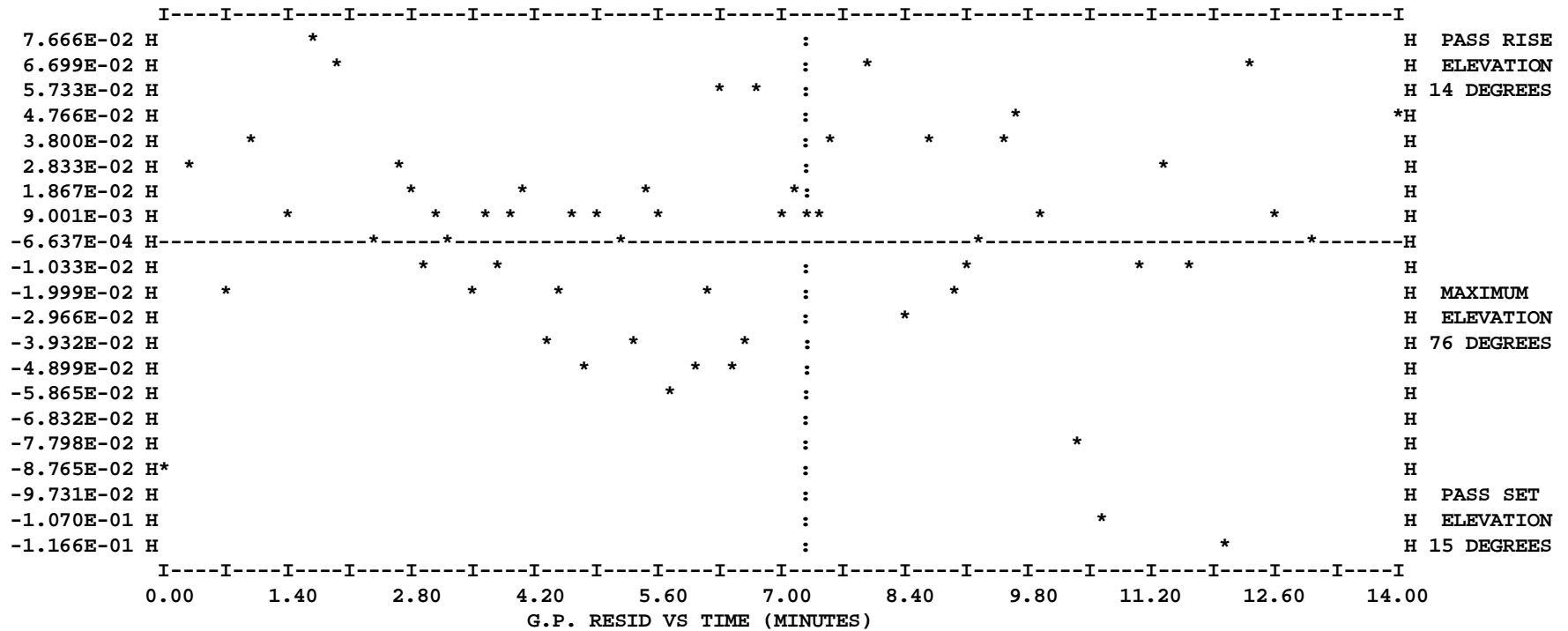
ITER	GOOD OBS	FLAGGED OBS	RAW RMS	SLANT ERROR	SLANT SIGMA	TANG ERROR	TANG SIGMA	FREQ OFFSET	FREQ SIGMA	TROP SCALE	TROP SIGMA	CORRELATIONS			GUIER RMS	EDIT CRIT
0	48	0	0.036	-2.99	8.32	-10.42	6.72	-7.79E-13	5.95E-13	-0.004	0.008	0.84	0.78	0.38	0.033	1.00



TYPICAL DORIS RESIDUALS

STATION: 4012 REUA (LAT:-19.8) PASS: 3 RMS: 0.0 TIME: 1/21/98 6:03 (LST 9:45) DURATION: 14.0 DESCENDING PASS DAYTIME

ITER	GOOD OBS	FLAGGED OBS	RAW RMS	SLANT ERROR	SLANT SIGMA	TANG ERROR	TANG SIGMA	FREQ OFFSET	FREQ SIGMA	TROP SCALE	TROP SIGMA	CORRELATIONS			GUIER RMS	EDIT CRIT
0	58	0	0.046	-2.63	6.85	-12.91	5.20	-1.17E-12	5.28E-13	0.000	0.008	0.85	0.75	-0.17	0.042	1.00



REFERENCE FRAME DETERMINATION

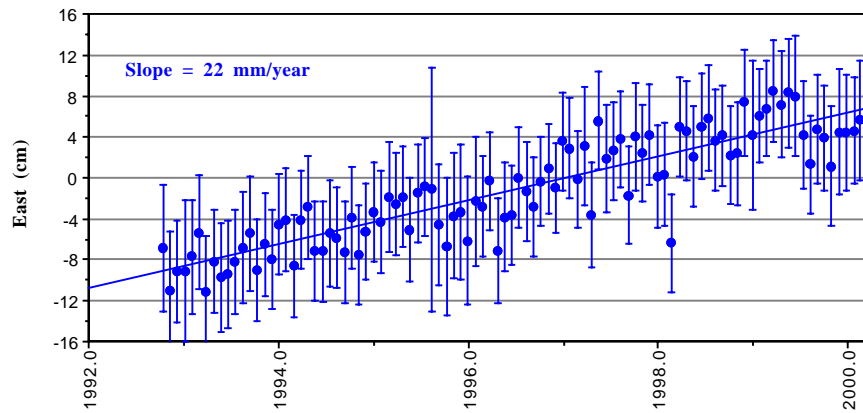
- For long-term altimetry studies, accurate velocities are essential (especially average drift in Z)
- Drifts and biases in the terrestrial frame can affect determination of sea level variations
 - Previous studies have shown that orbit will follow terrestrial frame in Z direction at about 1 for 1
 - Z-drift affects global mean sea level at about the 10% level but up to 40-50% level for regional sea level
(1 mm/yr z-drift = 0.1 mm/yr in global mean sea level)
- More than 7 years of DORIS tracking of T/P, with its high accuracy orbit and minimal geographically correlated error, is providing high quality positions and velocities for DORIS stations
 - T/P provides unique opportunity to determine joint SLR/DORIS reference frame

PRELIMINARY CSR00D01 SOLUTION

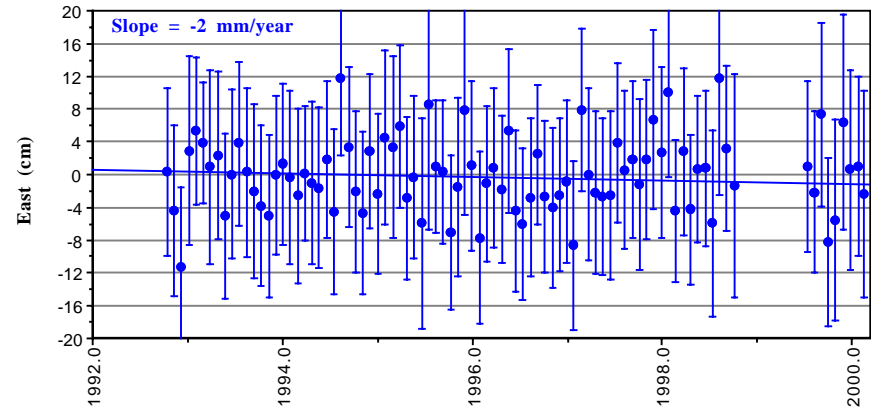
- **Monthly solutions from T/P using both SLR and DORIS**
 - 7.3 years of data available from T/P (97 28-day batches)
- **Subset solutions from SLR-only and DORIS-only can be compared to combined solution**
- **Combined SLR/DORIS solution to be submitted to ITRF**

TYPICAL SOLUTIONS FOR EAST COMPONENT OF POSITION

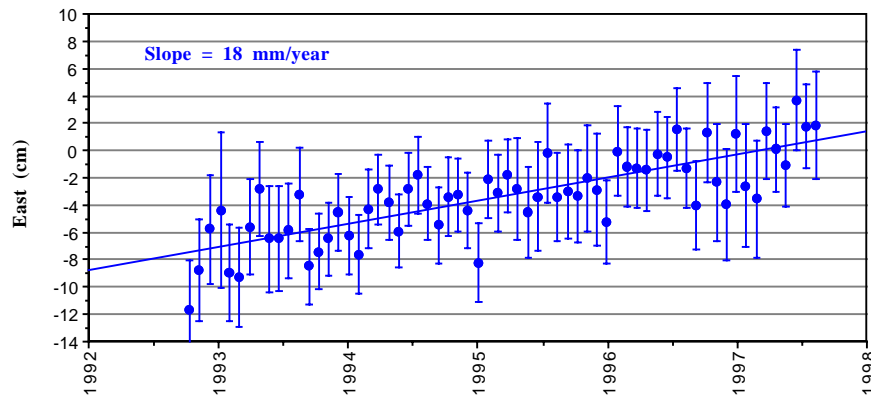
Tristan da Cunha



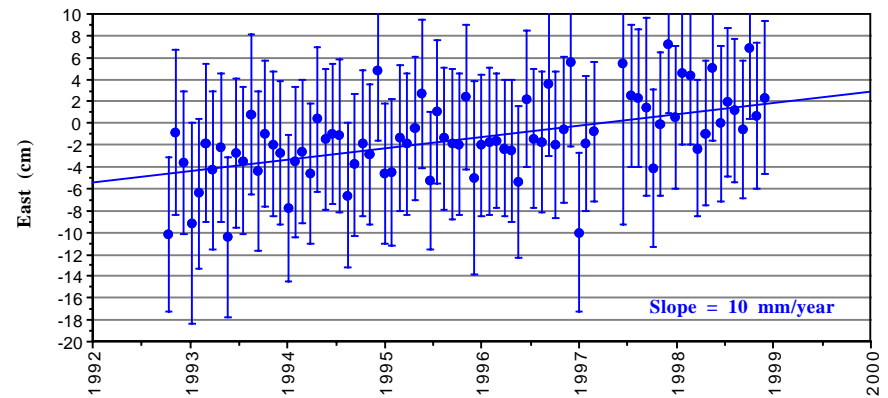
Cachoeira Paulista, Brazil



Toulouse

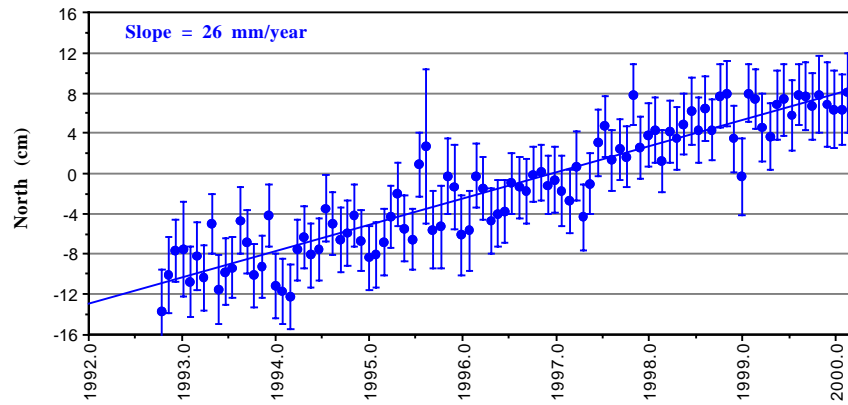


La Reunion Island

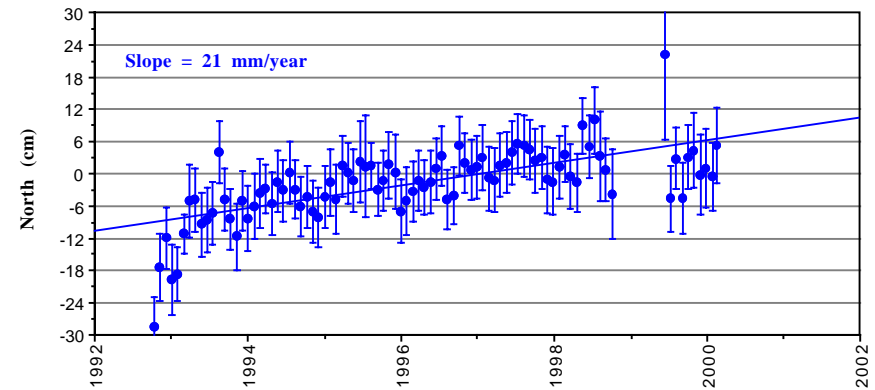


TYPICAL SOLUTIONS FOR NORTH COMPONENT OF POSITION

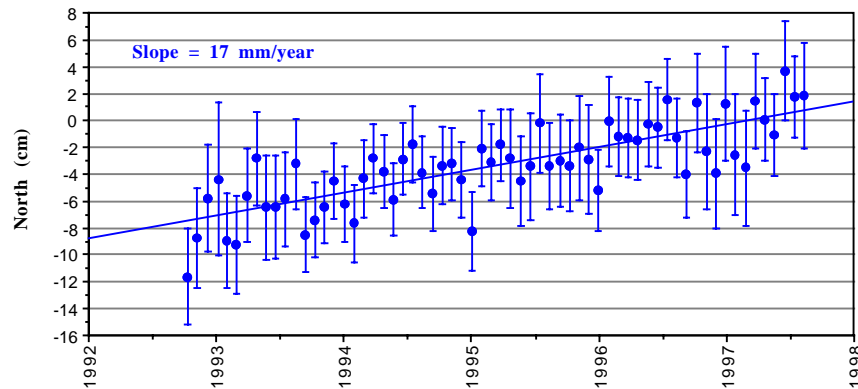
Tristan da Cunha



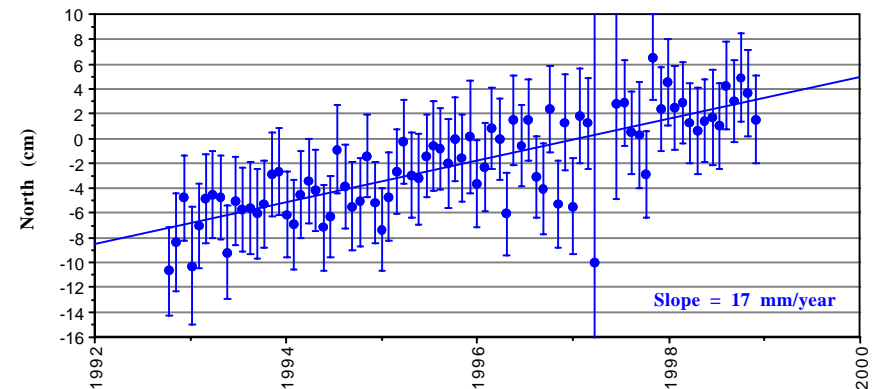
Cachoeira Paulista, Brazil



Toulouse

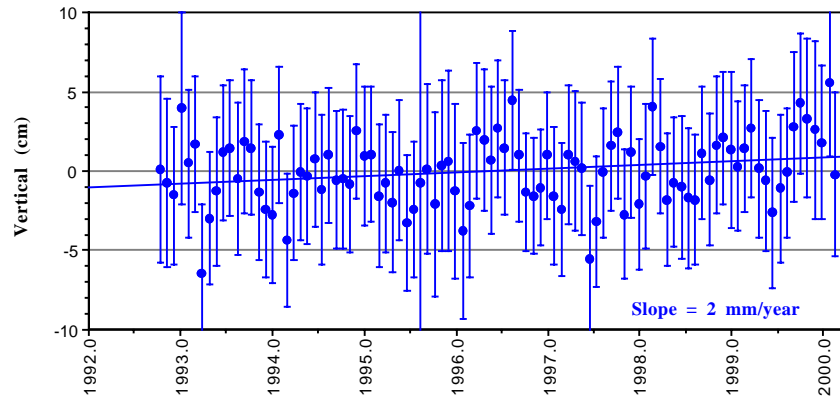


La Reunion Island

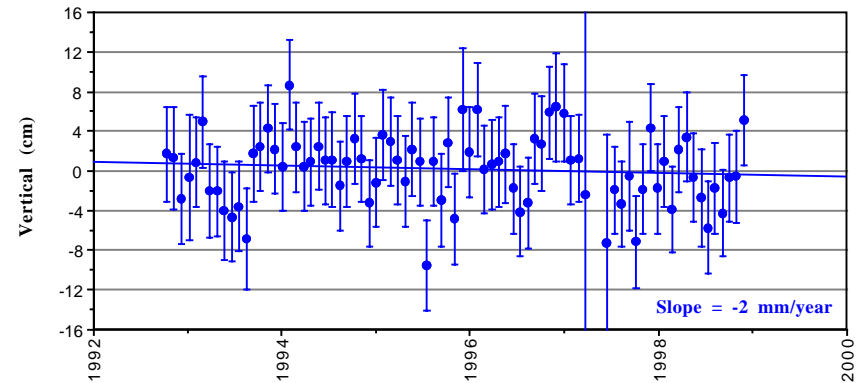


TYPICAL SOLUTIONS FOR VERTICAL COMPONENT OF POSITION

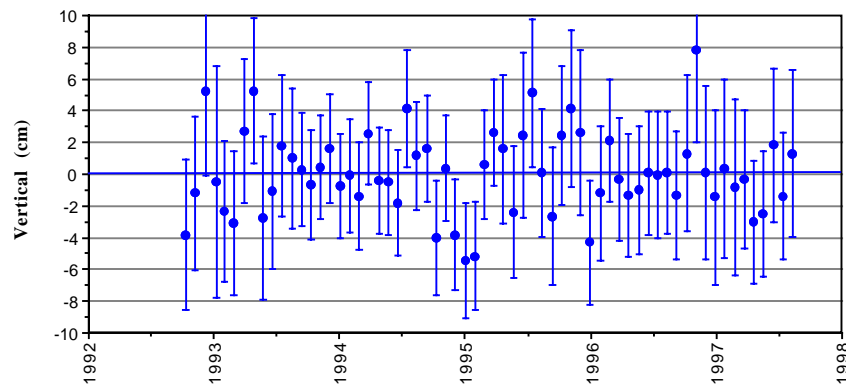
Tristan da Cunha



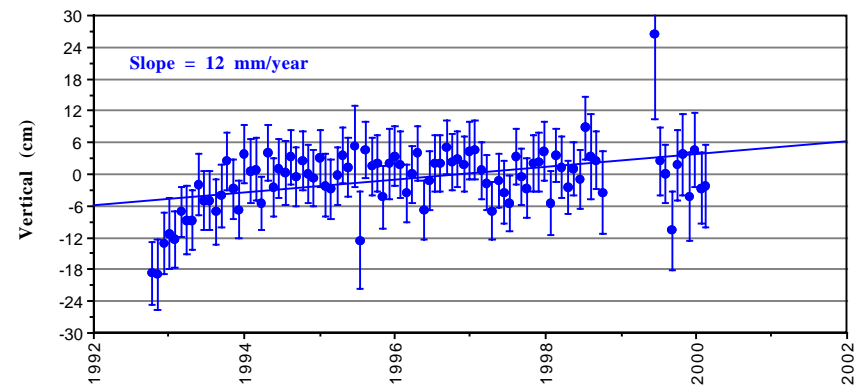
La Reunion Island



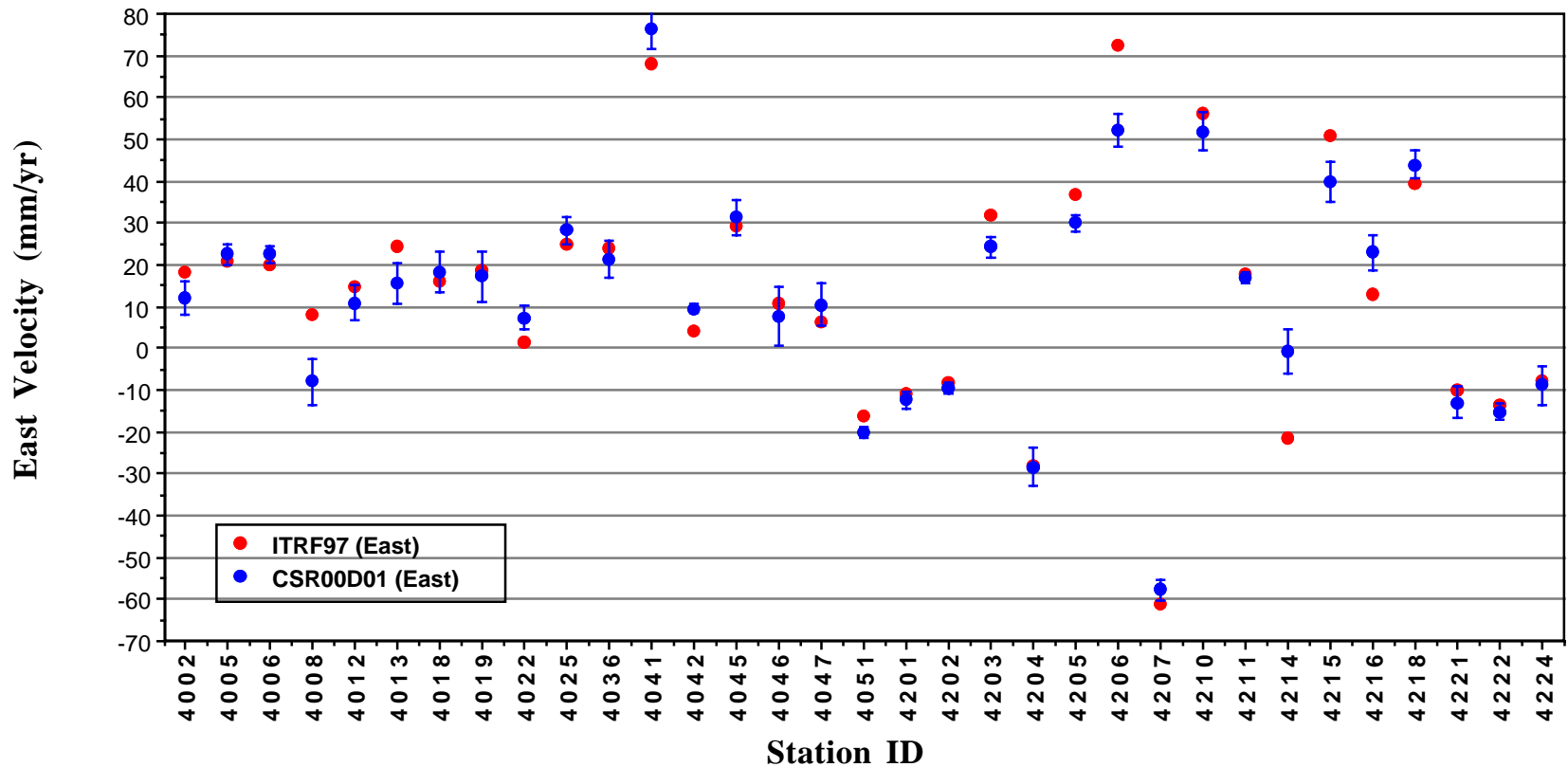
Toulouse



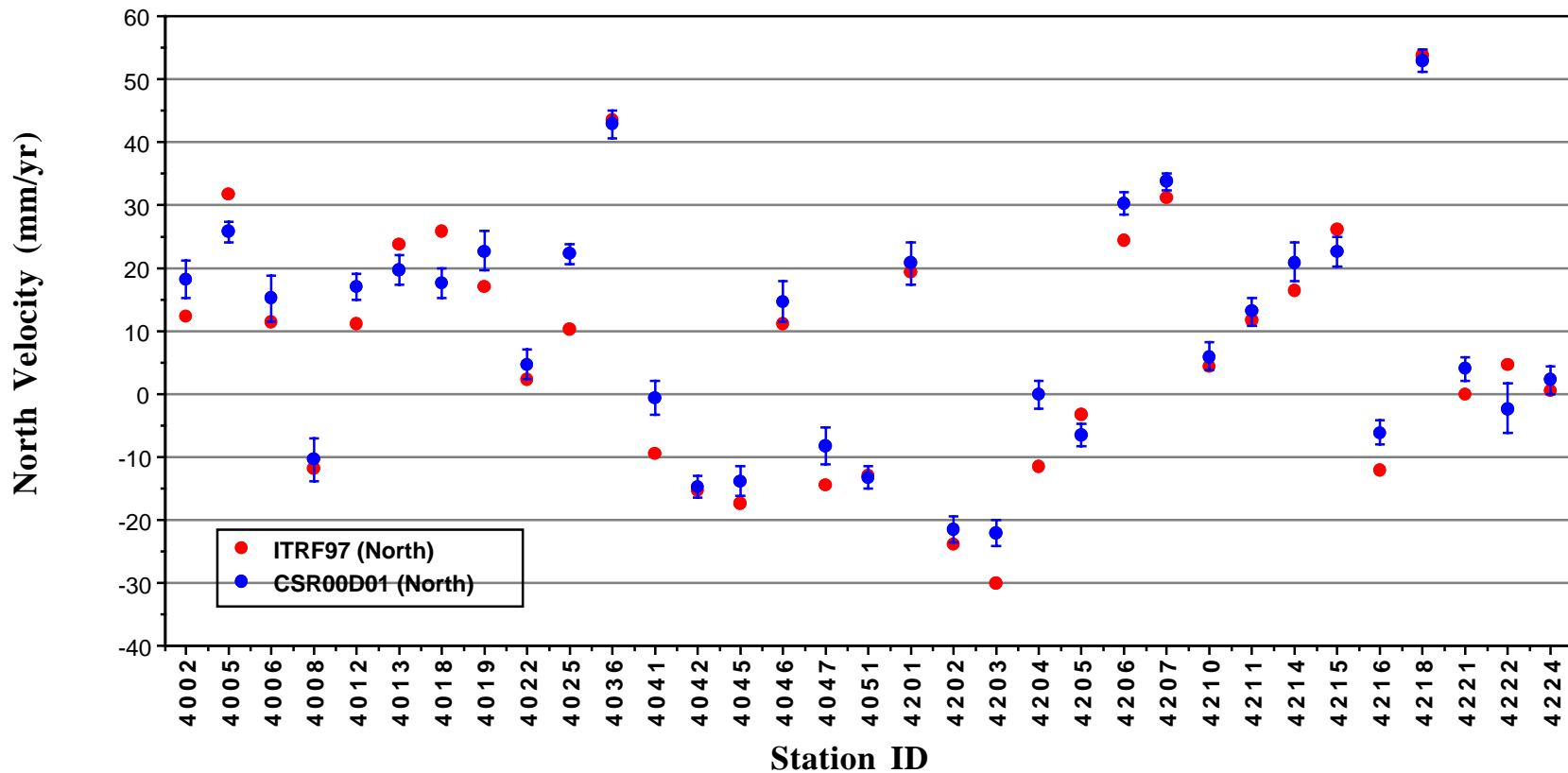
Cachoeira Paulista, Brazil



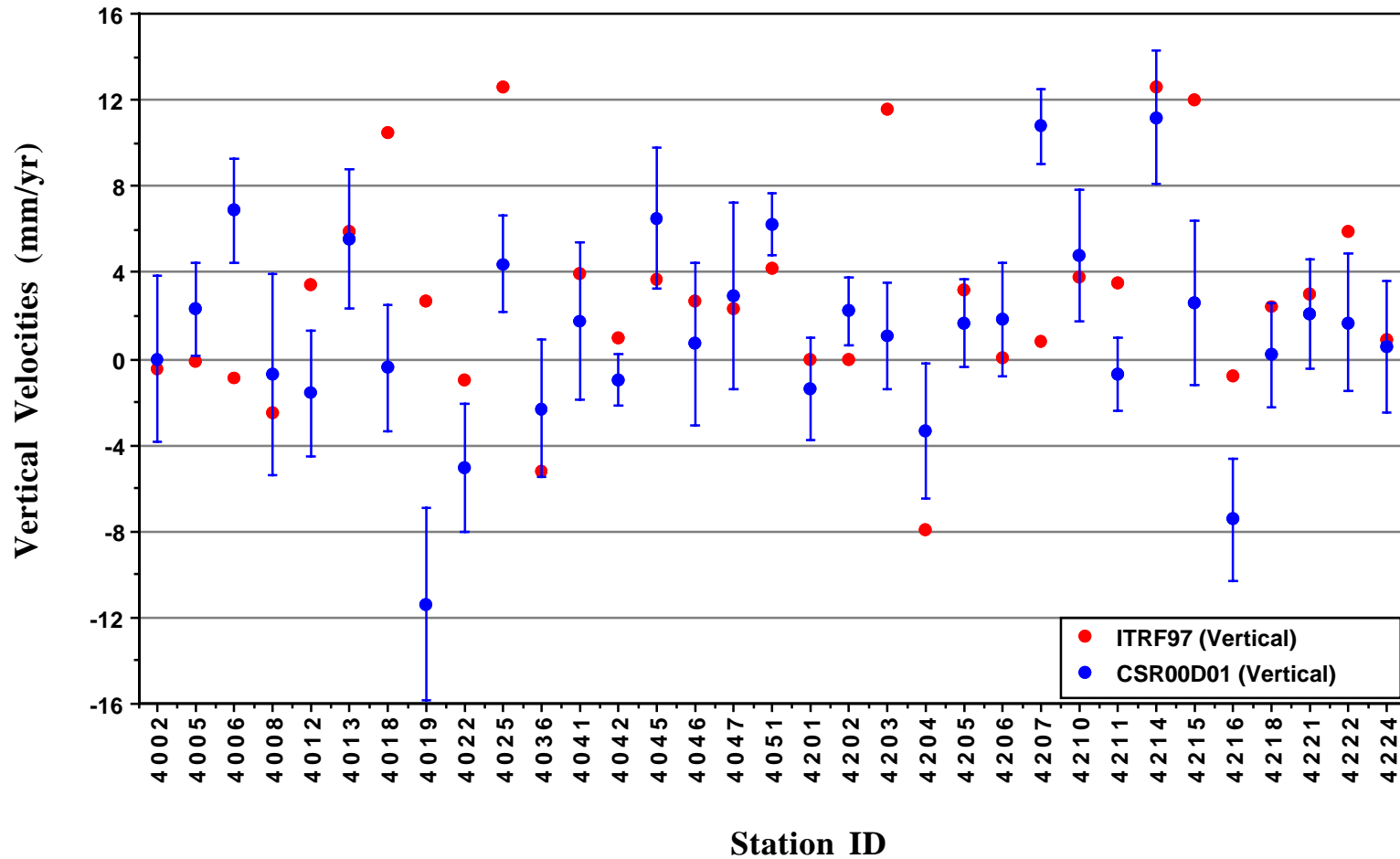
EAST VELOCITIES ESTIMATES FROM PRELIMINARY CSR00D01 vs ITRF97



NORTH VELOCITIES ESTIMATES FROM PRELIMINARY CSR00D01 vs ITRF97



VERTICAL VELOCITIES ESTIMATES FROM PRELIMINARY CSR00D01 vs ITRF97



PRELIMINARY REFERENCE FRAME SOLUTION CONCLUSIONS

- **Good consistency is observed in DORIS and SLR solutions**
 - DORIS, SLR and combined solutions are consistent in scale to 0.2 ppb, and all indicate ITRF97 scale should be at least 1 ppb smaller
 - ITRF scale may reflect decreased weight of SLR in determining scale; this should be re-evaluated
 - SLR solution from T/P matches LAGEOS 1/2 solution to 1 ppb in scale and 3 mm in geocenter
 - T/P is a clearly a good target for terrestrial frame analyses
- **Scatter of monthly geocenter solutions is consistent**
 - Scatter in geocenter for DORIS-only solution is 8 and 9 mm in X and Y, very comparable to 6 and 8 mm for the SLR-only solution
 - Scatter in the Z component of geocenter is 21 mm for DORIS-only, which is only a little larger than 16 mm for SLR-only
 - Further analysis is needed to determine if seasonal geocenter variations are consistent and reasonable compared to LAGEOS 1/2

PRELIMINARY REFERENCE FRAME SOLUTION CONCLUSIONS (cont.)

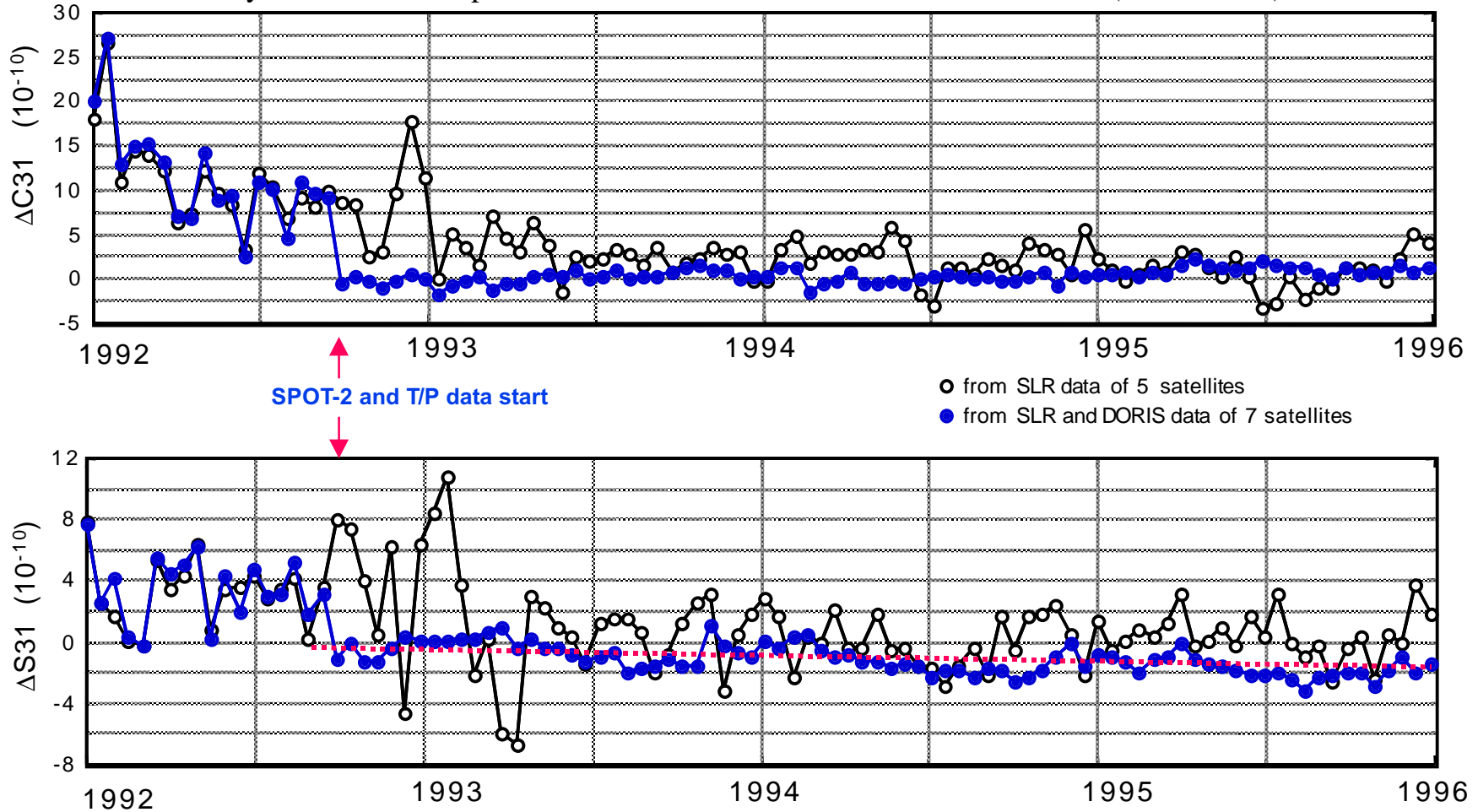
- **Preliminary DORIS-only station solution indicates ITRF97 DORIS stations are 22 mm too low in Z**
 - Recent Lageos 1/2 solution also sees 20 mm bias in SLR stations
 - This offset has been observed in in previous ITRF solutions
- **DORIS-only station solution indicates ITRF97 has a drift of 2.0 mm/yr in Z; Lageos 1/2 sees 2.2 mm/yr**

CONTRIBUTIONS TO GRAVITY FIELD INVESTIGATIONS

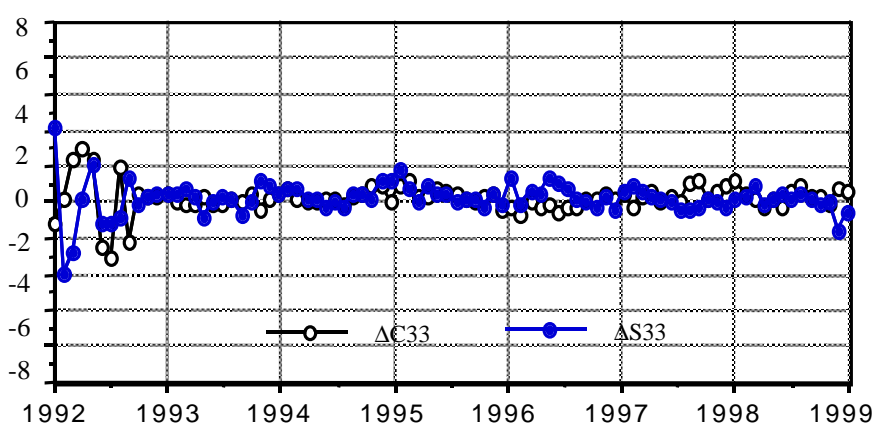
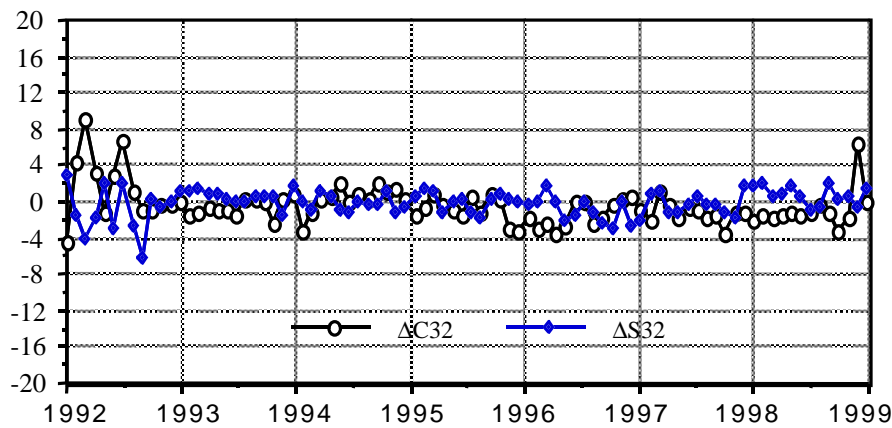
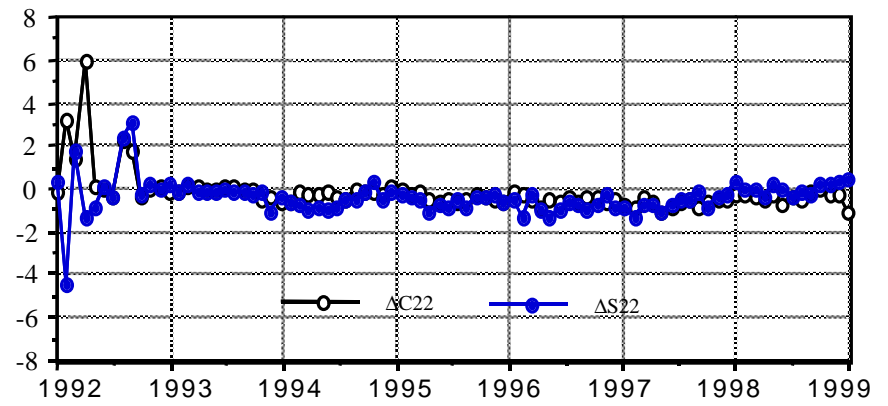
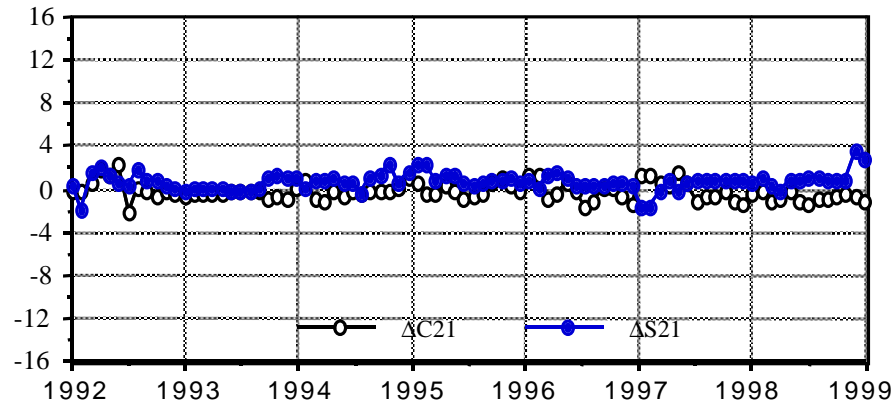
- **Temporal variations in zonal coefficients difficult to evaluate with satellites with complex surface forces**
 - Signal is absorbed by the estimation of 1/revs
 - Odd zonal variations generally cannot be determined
 - Even zonals can be investigated by analyzing 1/rev normal accelerations
- **Recovery of non-zonal coefficients is enhanced with DORIS tracking of T/P and SPOT-2**
 - Gravity coefficients recovered with DORIS (T/P and SPOT-2) included have considerably less scatter than when estimated with SLR satellites only (Lageos 1 & 2, Ajisai, Stella, Starlette)

CONTRIBUTION TO STUDY OF TEMPORAL VARIATIONS IN THE EARTH'S GRAVITY FIELD

15-day Solution of Geopotential Coefficients from SLR and DORIS Data (1992 - 1995)



OBSERVED VARIATIONS IN GEOPOTENTIAL COEFFICIENTS FROM SLR AND DORIS DATA OF 7 SATELLITES OVER 1992-1998

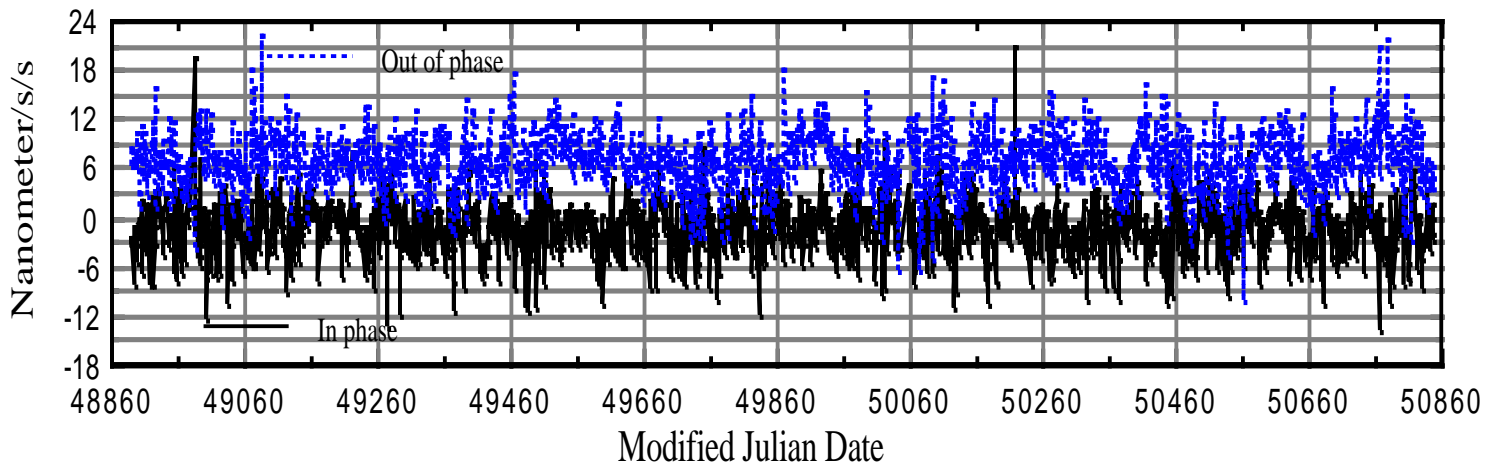


(all units 10^{-10})

ANNUAL GRAVITATIONAL EXCITATIONS OF TOPEX, SPOT-2, SPOT-3

$$\frac{d\Delta i}{dt} - j \sin i \bar{i} \frac{d\Delta\Omega}{dt} = \frac{1}{2\bar{n}\bar{a}} (N_C - jN_S) = Q_R + jQ_i \quad Q_i = -\sin i \sum_{k=2} N_k \delta J_k$$

"Once Per Rev" Normal Acceleration on Topex (9/92 - 2/98)



	TOPEX	SPOT-2	SPOT-3
Excitation	(mas/year)	(mas/year)	(mas/year)
Q_i^{Sa} (Obs)	396	1057	636
Q_i^{Sa*} (SLR)	392	1048	440

SUMMARY

- Current orbit accuracy of nearly 2 cm radially is due dominantly to precision and dense distribution of DORIS tracking data
 - SLR data provides critical role in centering of orbit, mainly in Z, and in evaluating radial orbit error using high elevation passes
- More than 7 years of DORIS tracking to T/P is providing significantly improved positions and velocities of DORIS stations
- DORIS tracking of T/P provides significant information about temporal variations of gravity field
 - Unique opportunity to investigate consistency and determine a joint solution from both SLR and DORIS

Jason-1



Goal: 1 cm orbit !