Geocenter Motion: Causes and Modeling Approaches

Erricos C. Pavlis
JCET/UMBC & NASA Goddard 698
and
Magdalena Kuźmicz-Cieślak
JCET/UMBC

16th International Laser Ranging Workshop,
Poznań, Poland 13-17 October, 2008

GODDARD SPACE FLIGHT CENTER

UMBC

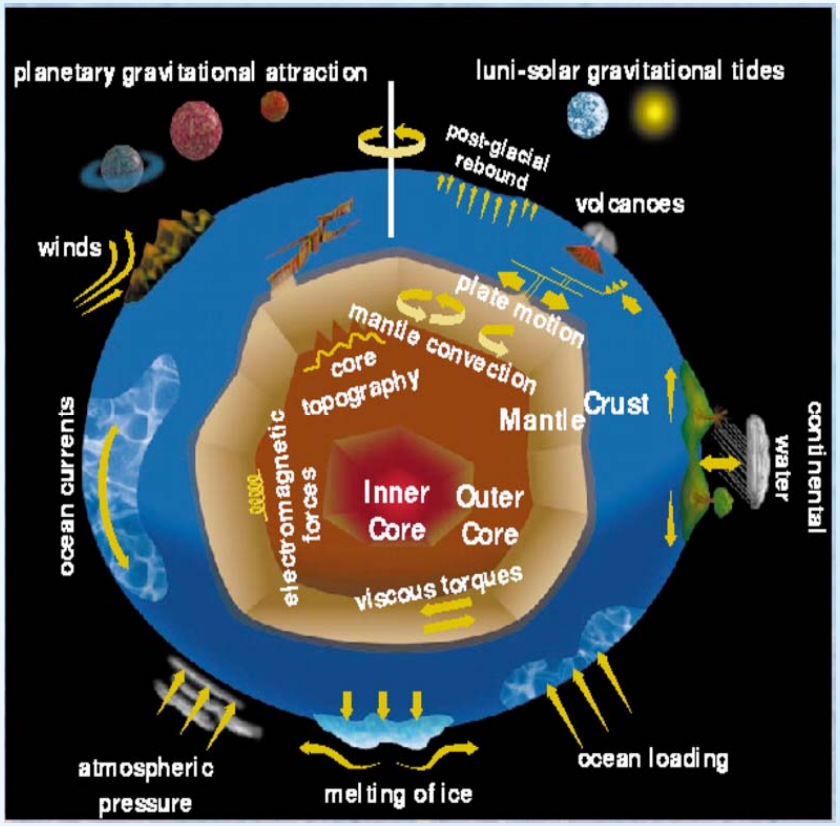
Outline

- "SLR network origin to geocenter" vector
- Variations due to mass redistribution
- SLR monitoring of geocenter variations
- Examples of SLR results' application
- Summary and Conclusions

We gratefully acknowledge the support of the ILRS and their network for making their SLR tracking data available to us for this work, as well as the GRACE Mission Project for the release of GSM products.

TRF and Center of Mass

We concentrate here on Earth's "Center of Mass", the geocenter, the fidelity and accuracy with which SLR defines its average location over decades and monitors its seasonal variations associated with the redistribution of geophysical fluids.

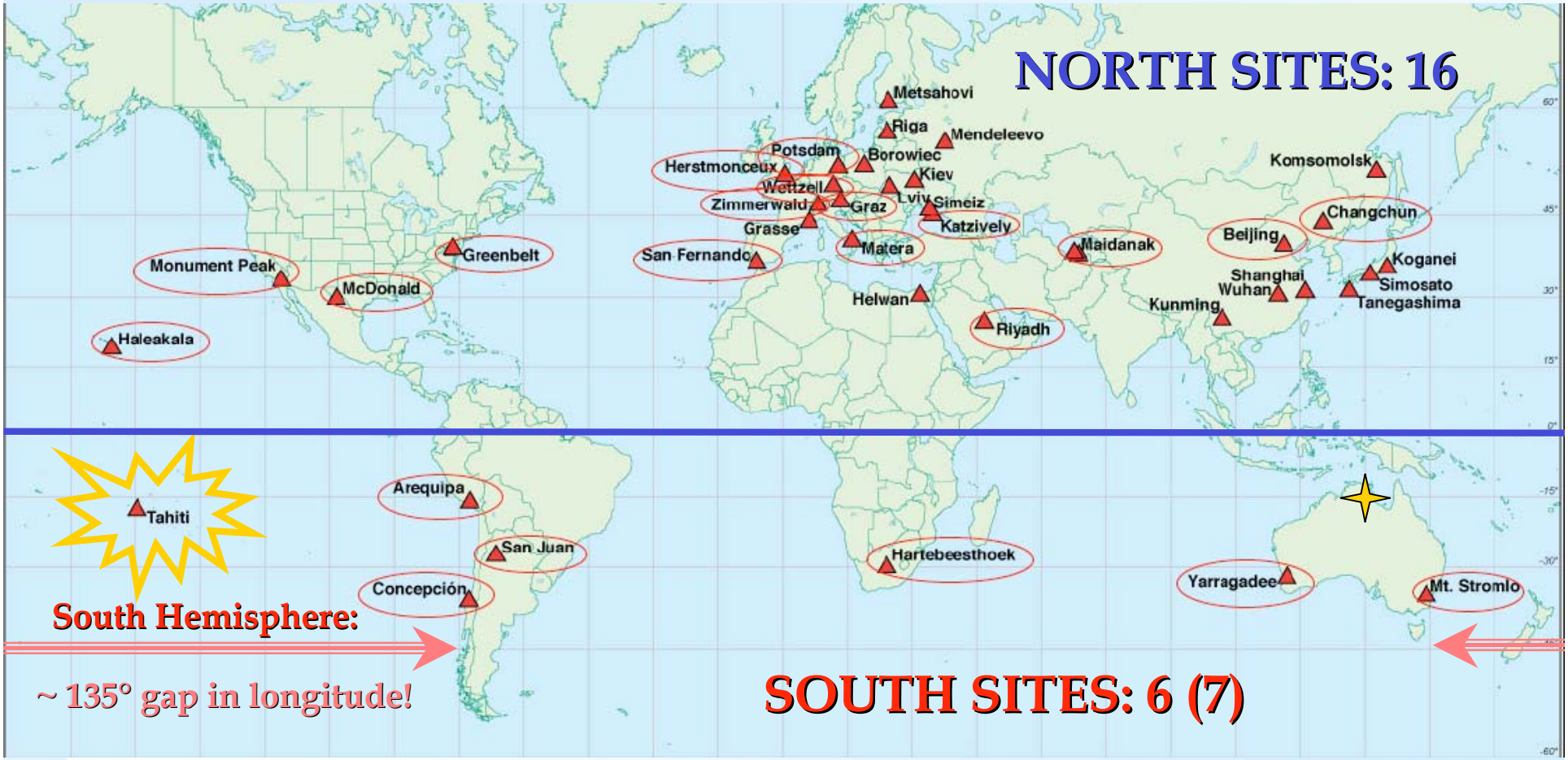


Secular Geophysical Signals

Source	Magnitude	Induced motion	Ref.
Sea level	1.2 mm/y	0.064 ±0.02 mm/y	2
Ice sheets (G)	2 mm/y	0.046±0.20 mm/y	2
Tectonics	AMO-2	0.309±0.05 mm/y	2
Postglacial rebound	ICE-3G	0.2 - 0.5 mm/y	1

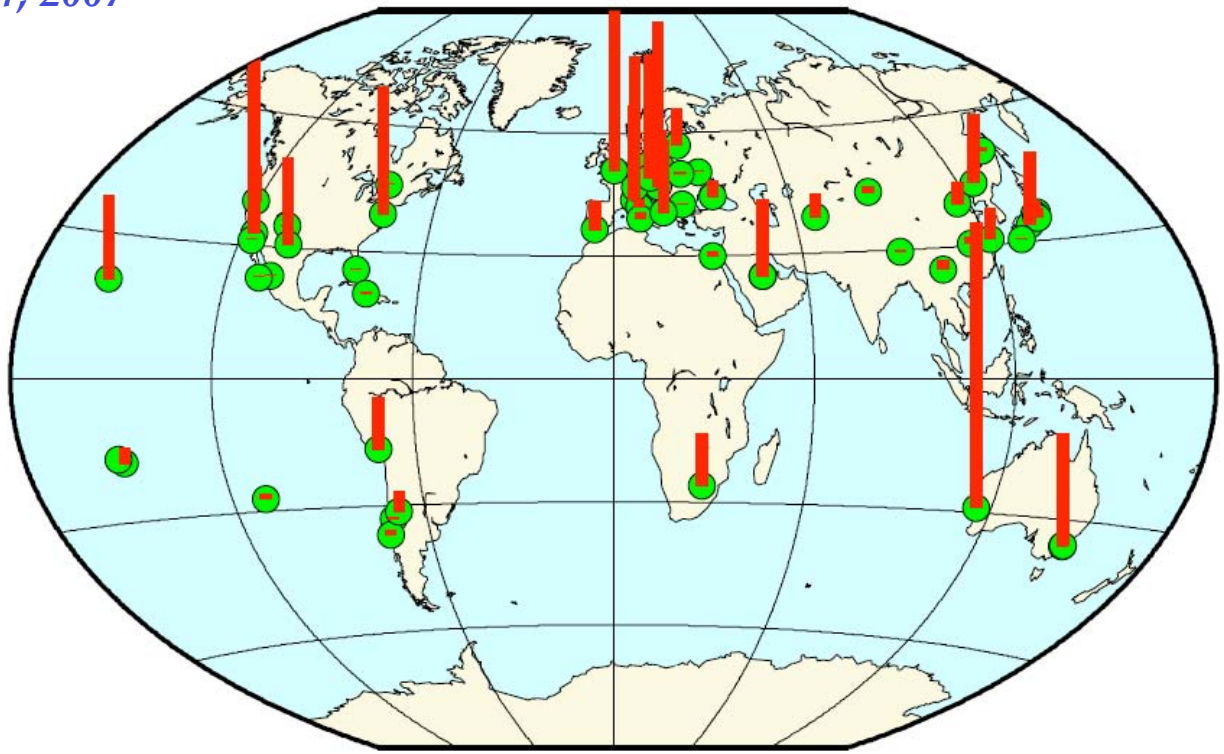
(1) : Marianne Greff-Lefftz (2000)
(2) : Yu. Barkin (1997)

The ILRS Network



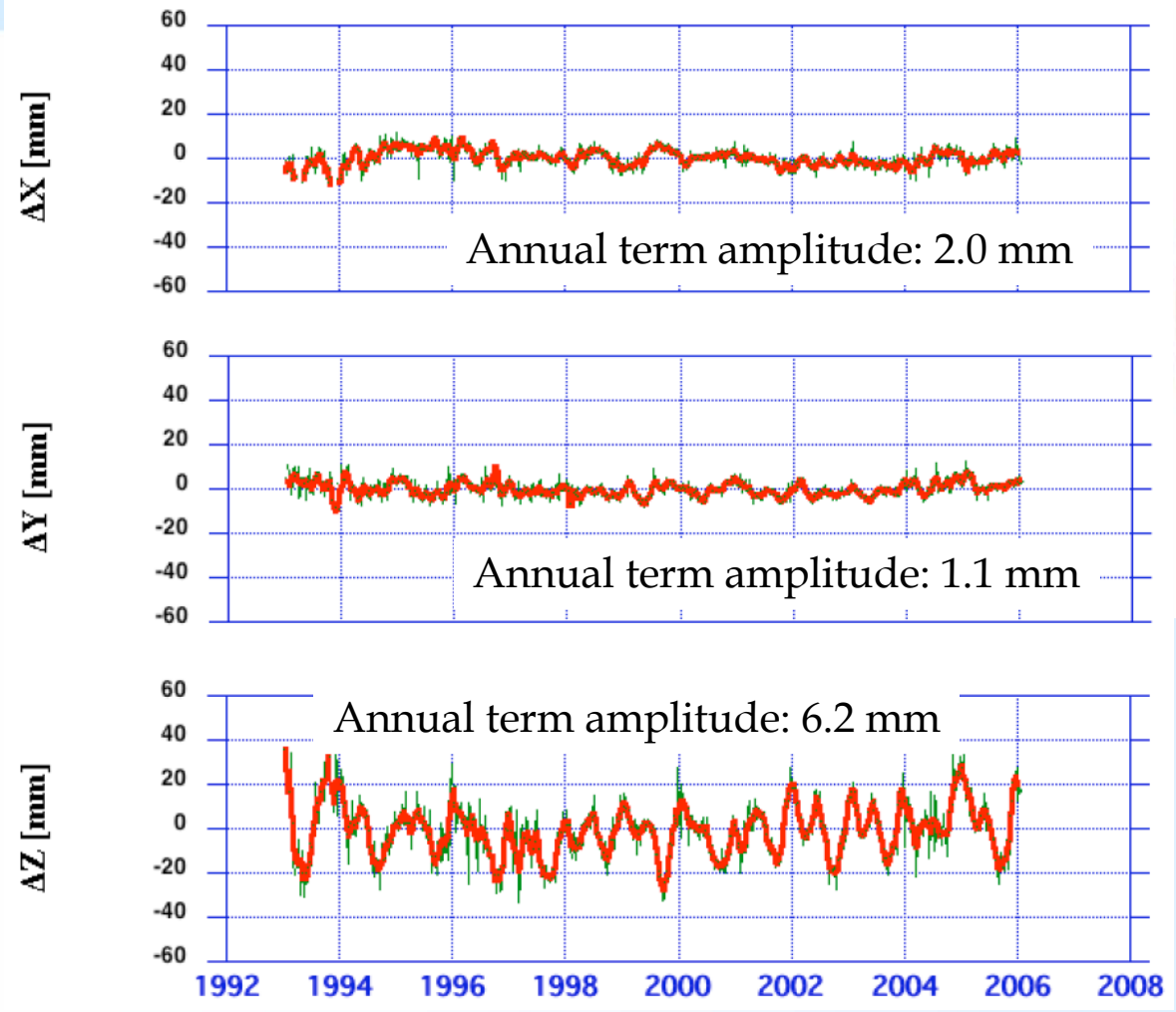
The ILRS Network Yield

Angermann & Müller, 2007



LAGEOS 1 & 2 SLR network stations. The bars show the number of observed normal points from 1993 until 2007.

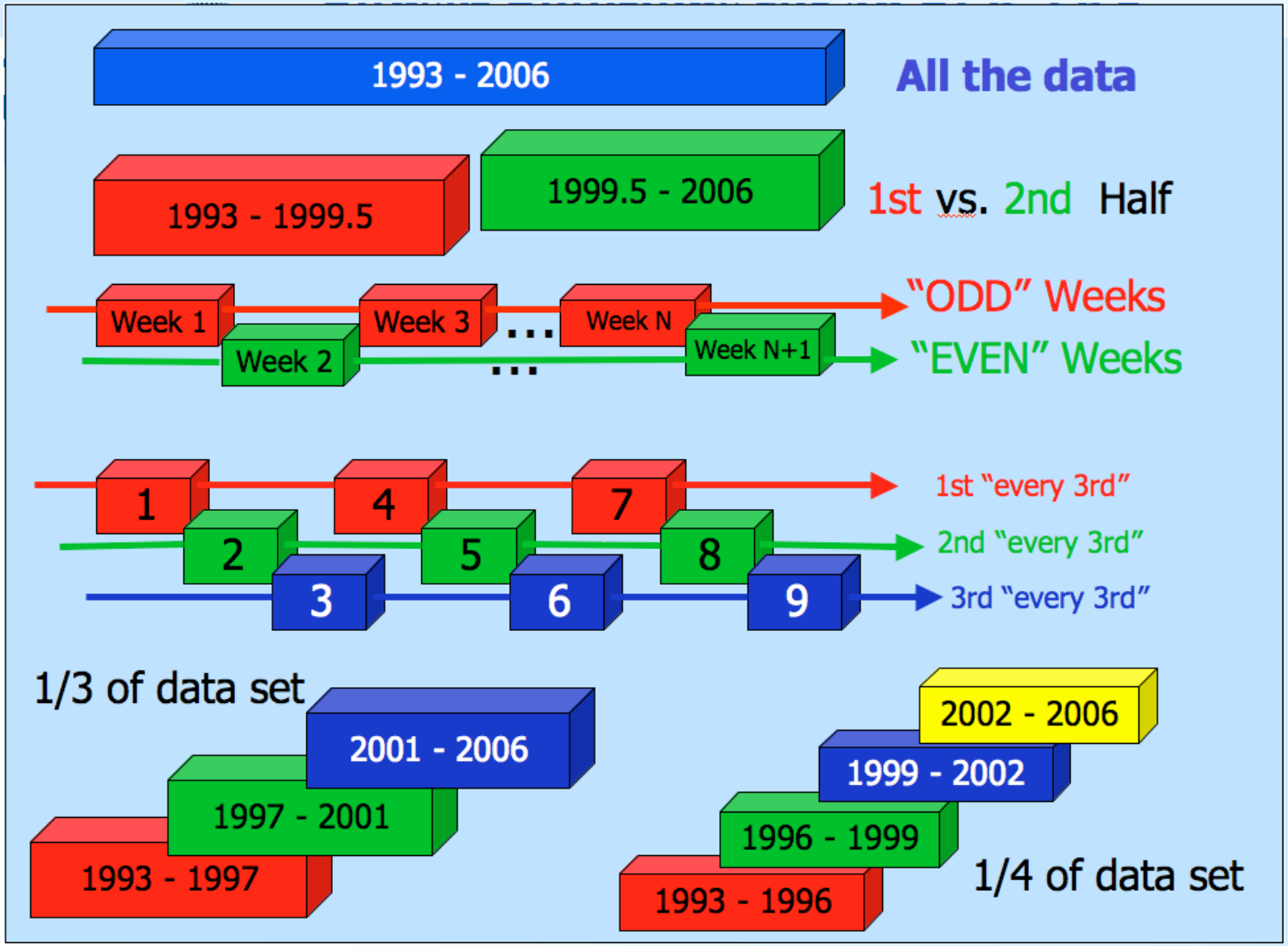
Geocenter from SLR to LAGEOS



~ 1 inch

Geocenter with respect to ITRF2000 with secular rates removed, raw (green) and 30-day smoothed (red) values [SSC(JCET) 06 L25].

Subset Solutions for an SLR TRF



TRF Subset Solutions Statistics [mm]

Case	ΔX $\sigma_{\Delta X}$	ΔY $\sigma_{\Delta Y}$	ΔZ $\sigma_{\Delta Z}$	3D |Δ| $\sigma_{3D\,\Delta}$
3 **Odd**	-8.37 ±10.91	19.25 ±10.78	-4.20 ±10.32	**21 ± 17**
4 **Even**	-12.62 ± 8.93	5.15 ± 8.82	-12.50 ± 8.44	**18 ± 16**
1 **1/2**	-41.20 ±35.82	6.26 ±35.38	-10.10 ±33.86	**43 ± 61**
2	1.74 ± 6.76	8.06 ± 6.68	7.28 ± 6.39	**11 ± 11**
15 **1/4**	-60.49 ± 23.68	57.43 ±23.39	7.48 ±22.39	**84 ± 40**
16	18.65 ± 31.40	-57.81 ±30.88	-6.19 ±29.50	**61 ± 53**
17	-0.27 ± 18.01	-4.74 ±17.79	15.72 ±17.03	**16 ± 31**
18	2.07 ± 12.29	7.16 ±12.18	1.73 ±11.60	**8 ± 21**

AC Performance (2006)

Table 1. Scatter of similarity transformation parameters w.r.t. ITRF2000 for successive weekly ILRS solutions for 2006 (offsets in mm, scale in ppb).

		Tx	Ty	Tz	Scale
Individual	ASI	3.8	3.1	8.5	1.2
	BKG	4.0	1.6	2.4	0.6
	DGFI	4.7	3.9	9.0	0.8
	GFZ	4.2	2.7	6.9	0.9
	JCET	3.0	2.2	7.1	0.9
	NSGF	6.1	7.3	12.0	1.4
Combination	ILRS-A	2.8	2.2	6.5	0.5

Our Future Goals

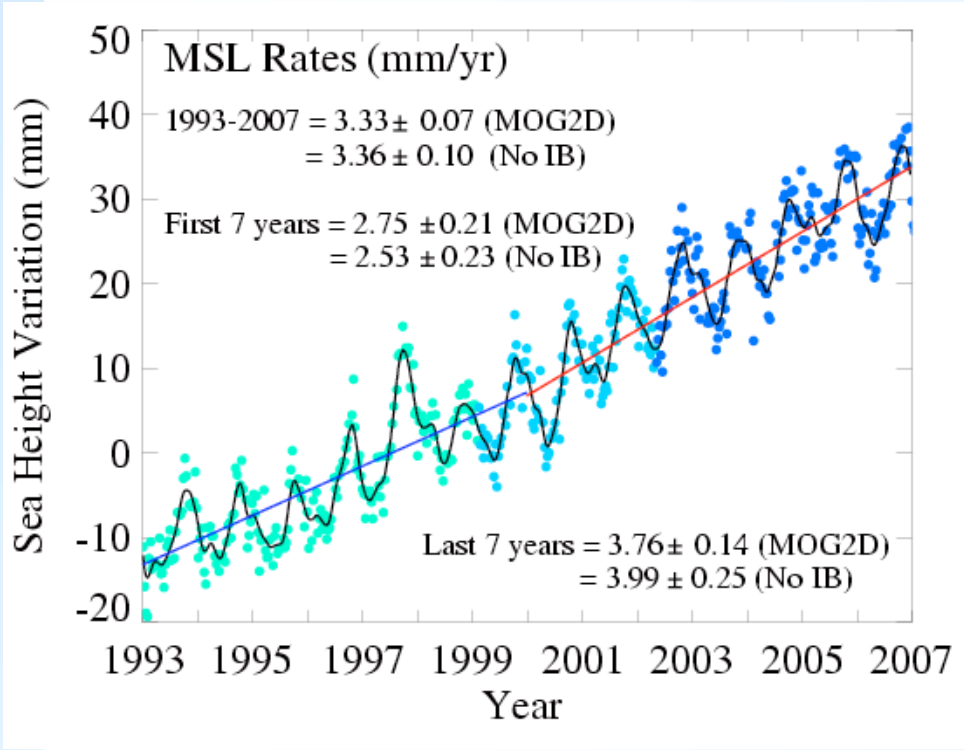
- Future networks should deliver consistently and reliably:

<1 mm epoch position, and

< 0.1 mm/y secular change

Why 1 mm / 0.1 mm/y?

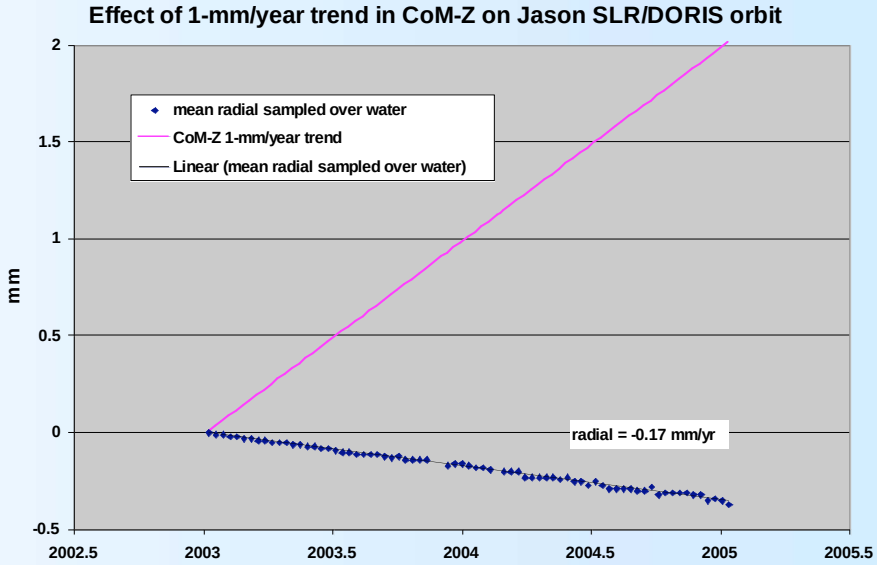
ITRF2005: 3.3 +/- 0.07 mm/yr



Beckley et al. (2007), *GRL, Fig 4*

For every 1 mm/y Z-trend in the TRF origin, sea-level rates are affected by ~ 0.2 mm/y

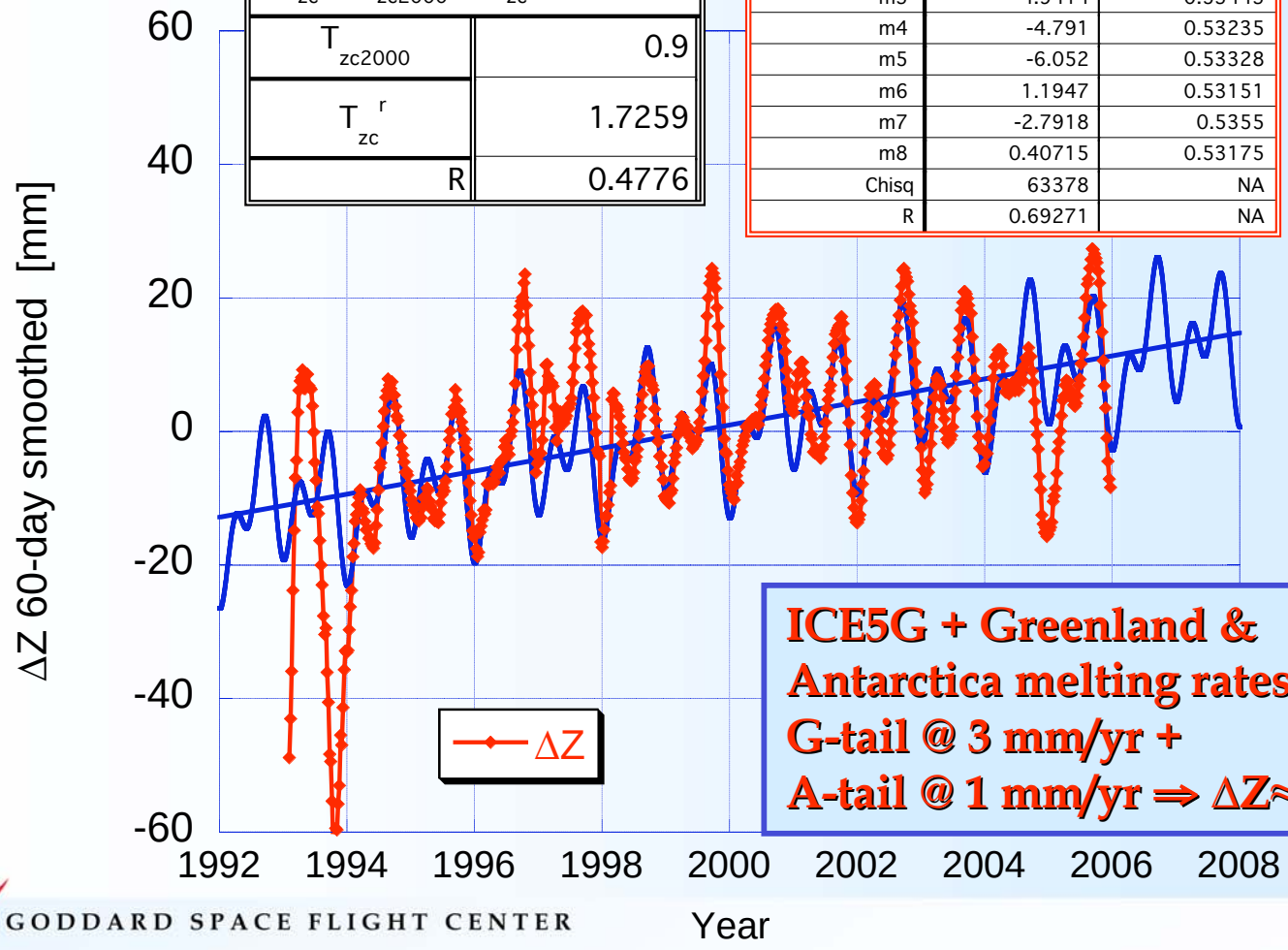
Lemoine et al. (2008), EGU2008-A-11368



Geocenter Monitoring (Z)

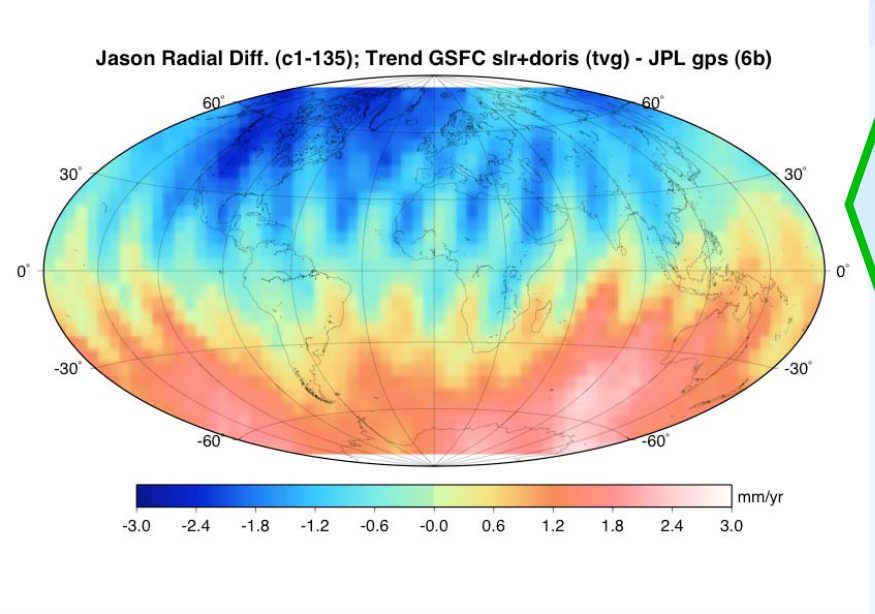
$T_{zc} = T_{zc2000} + T_{zc}^{r}*(t-2000)$	
T_{zc2000}	0.9
T_{zc}^{r}	1.7259
R	0.4776

ΔZ Secular + Biennial + Annual + Semi-annual		
	Value	Error
m1	0.91063	0.38014
m2	1.6981	0.10128
m3	-4.9414	0.53443
m4	-4.791	0.53235
m5	-6.052	0.53328
m6	1.1947	0.53151
m7	-2.7918	0.5355
m8	0.40715	0.53175
Chisq	63378	NA
R	0.69271	NA

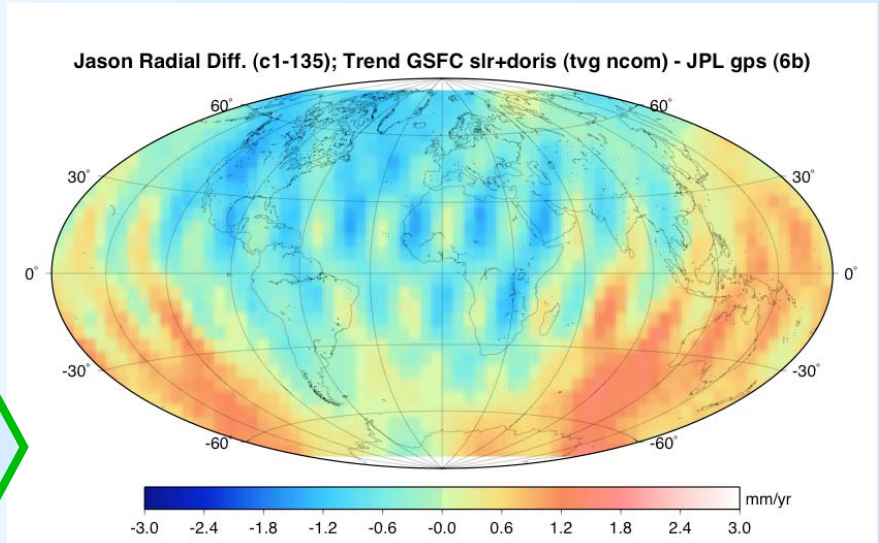


ICE5G + Greenland & Antarctica melting rates: G-tail @ 3 mm/yr + A-tail @ 1 mm/yr ⇒ ΔZ≈ 1 mm/yr

Geocenter Correction for POD (1)



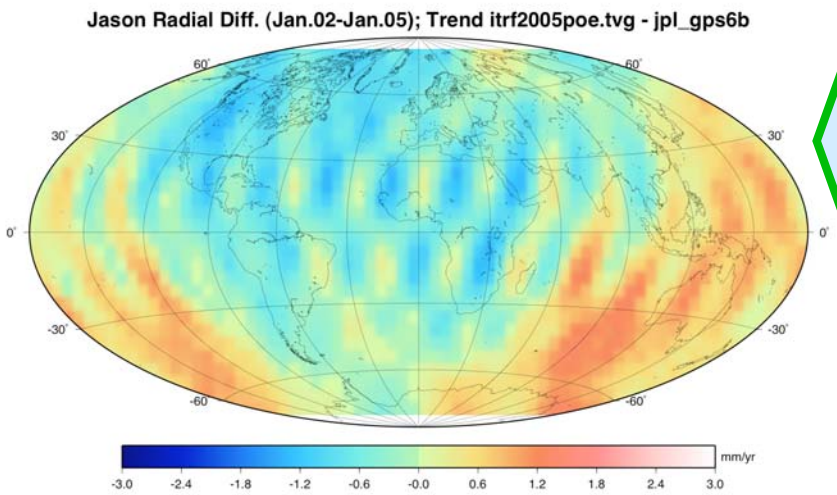
Radial orbit Differences
GSFC(SLR+DORIS) - **JPL**(GPS)
WITHOUT Geocenter correction



Radial orbit Differences
GSFC(SLR+DORIS) - **JPL**(GPS)
WITH Geocenter correction

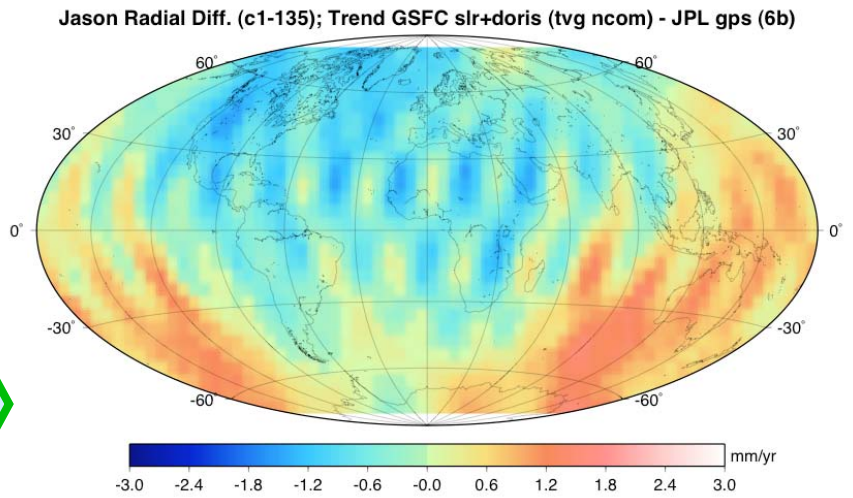
S.B. Luthcke et al. NASA GSFC, Code 698

Geocenter Correction for POD (2)



Radial orbit Differences
GSFC(SLR+DORIS) - **JPL**(GPS)
Using **ITRF2005** (no correction)

Radial orbit Differences
GSFC(SLR+DORIS) - **JPL**(GPS)
WITH Geocenter correction



S.B. Luthcke et al. NASA GSFC, Code 698

Summary - Conclusions

- Tracking-network origin definition varies from week to week due to geophysical fluid redistribution in Earth system
- ILRS monitors this at the "few mm" level including linear rates
- SLR network non-uniformity and data yield result in variable quality of the above results over the past decade
- Future requirement of definition at epoch at < 1mm and rates of < 0.1mm/y are dictated by MSL change studies
- Application of SLR monitoring of "geocenter" WRT previous ITRF (2000) in altimetry data reductions produces MSL results qualitatively equivalent to those derived from the new ITRF (2005), demonstrating SLR's ability to accurately monitor these variations