


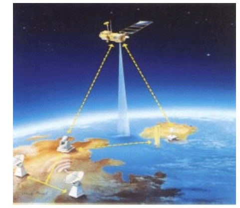
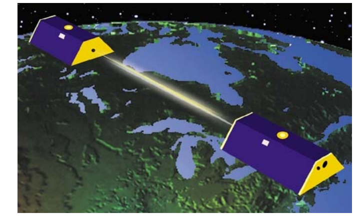

Geocenter Motion and Reference Frame - Geophysical and Geodetic Perspectives

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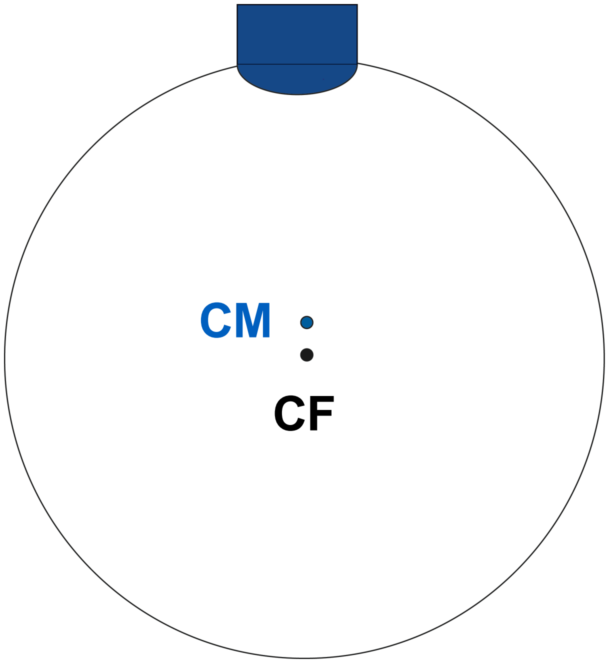
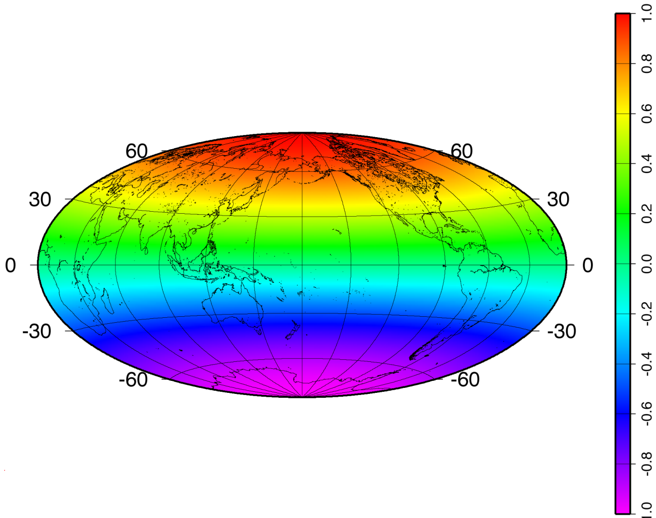
EGU 2007

Significance of Geocenter Motion





$$\sigma(t) = \sum_{n=1} \sum_{mq} M_{nmq}(t) Y_{nmq}(\theta,\phi)$$

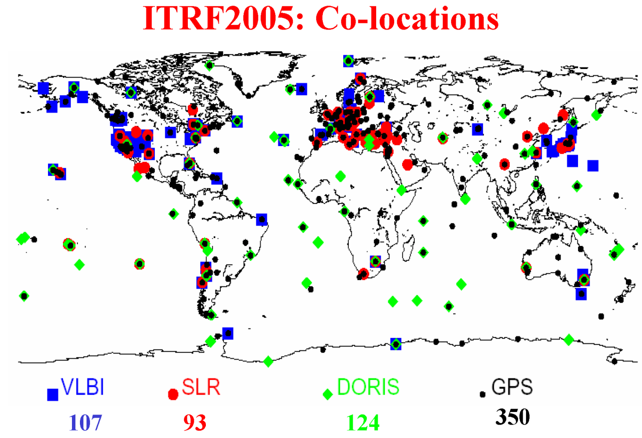
- **Geophysical Geocenter Motion due to n=1 loading**

$$\vec{S}_{cm} - \vec{S}_{cf} = \frac{4\pi}{\sqrt{3}} \frac{R_e^3}{M_e} \left[1 - \frac{h_1' + 2l_1'}{3} \right] (M_{11c}\hat{e}_x + M_{11s}\hat{e}_y + M_{10c}\hat{e}_z)$$

  - Ocean Tides < 5 mm
  - Climatic mass transport
  - PGR 0.2-0.5 mm/yr
- **Geocenter motion + Gravity ⇒ Complete Surface Mass Spectrum**
- **Geodetic Geocenter-CM**
  - Separating Orbit and deformation
  - ITRF origin

Geocenter Motion Determination Methods

- **Direct Satellite Determination**
  - In the CM frame $\vec{S}_{cm} - \vec{S}_{cn} = -\frac{1}{N}\sum_{i} \vec{S}_i = -\vec{T}$
  - SLR
  - GPS

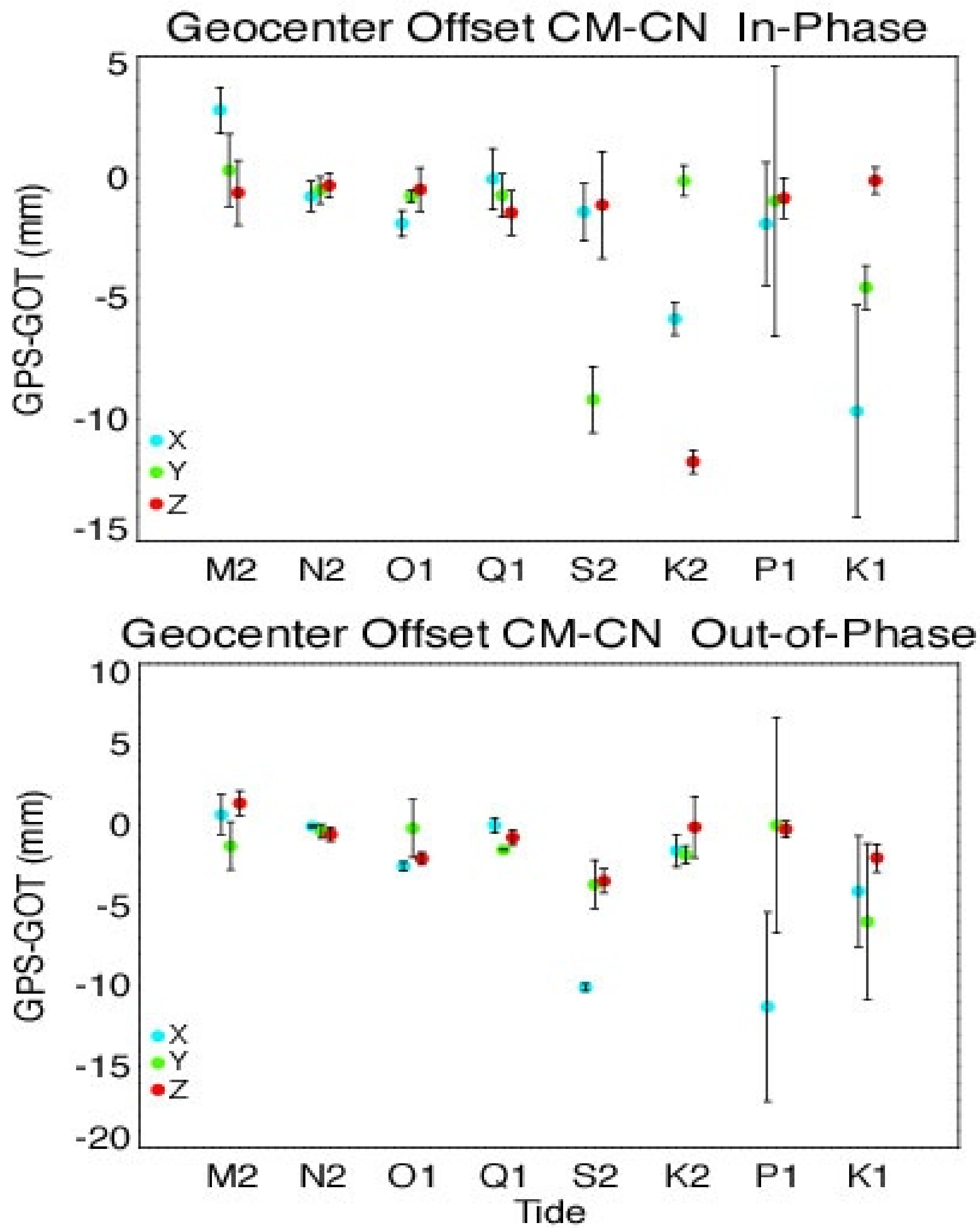


- **Inverse Solution of** $\mathbf{M}_{1mq} \propto \vec{\mathbf{S}}_{cm} - \vec{\mathbf{S}}_{cf}$
  - GPS
  - Ocean Bottom Pressure (OBP)
  - GRACE

$$G(\theta,\phi,t) = \sum_{nmq} G_{nmq}(\theta,\phi,p..)M_{nmq}(t)$$

- **CF and CN are different** $\vec{S}_{cf} = \frac{1}{4\pi}\oint\oint S\,d\Omega \neq \vec{S}_{cn}$

Direct Satellite Determination (GPS Ocean Tides)



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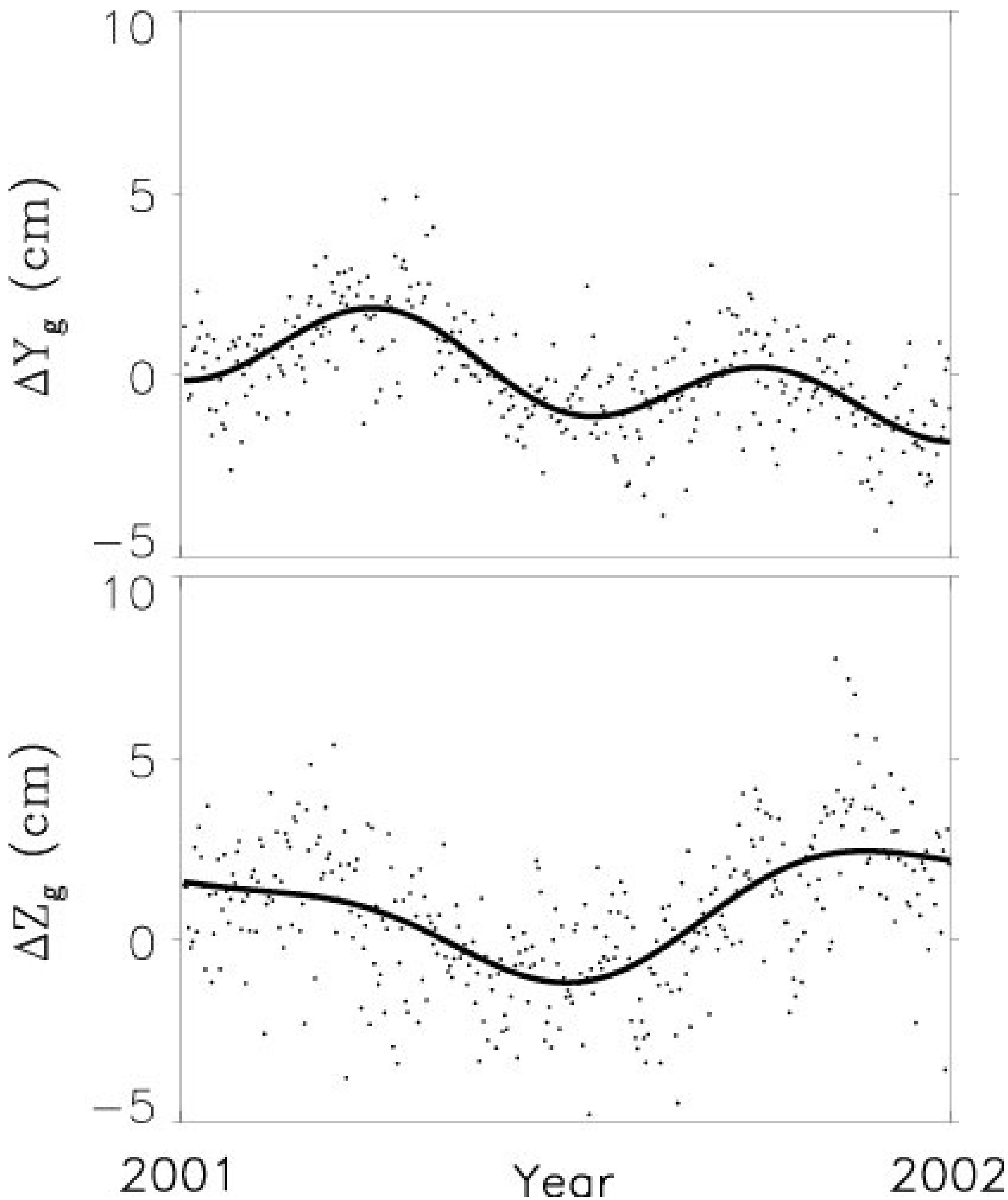
Direct Satellite Determination (GPS Daily)



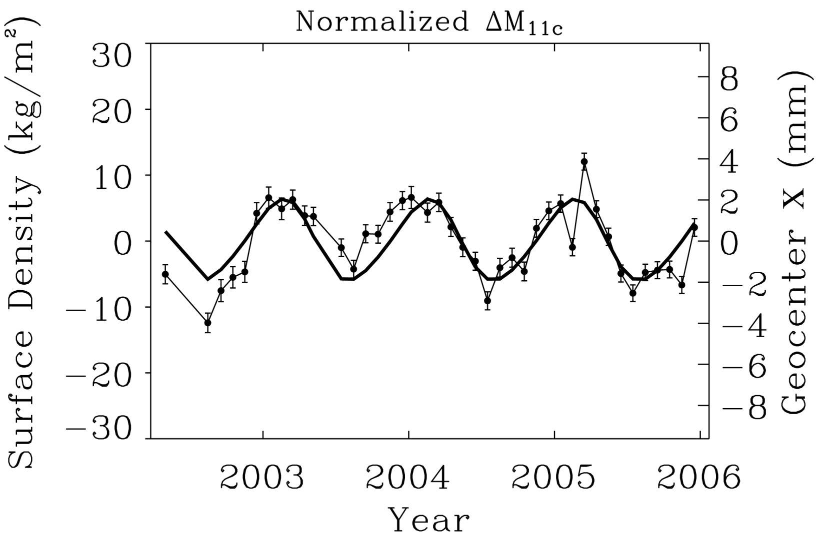
SVD Inverse GPS+OBP+GRACE Solution

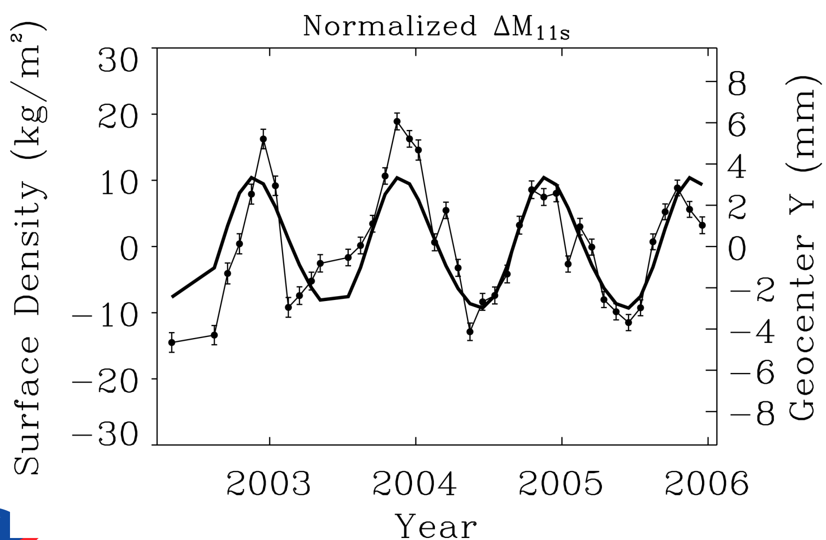
n=1 Mass and Geocenter Motion From GPS+OBP+GRACE

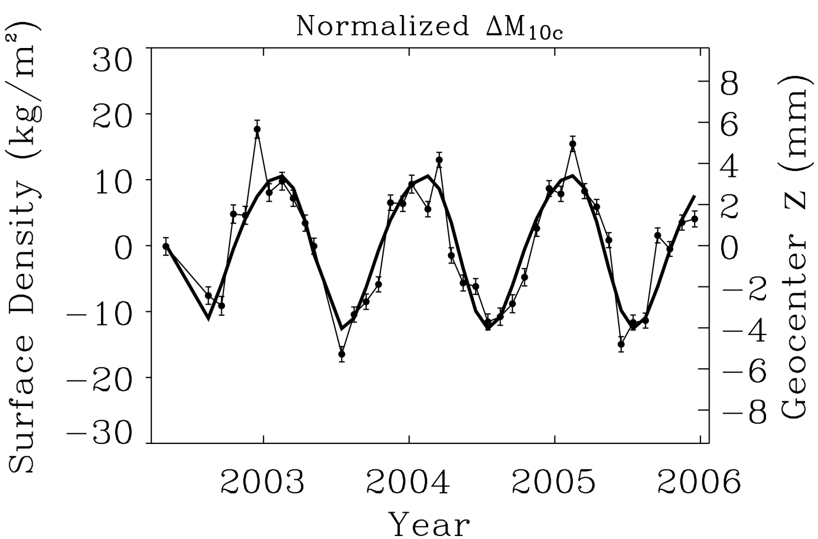
$X^a = 1.9 \pm 0.3$ mm

$Y^a = 3.0 \pm 0.4$ mm

$Z^a = 3.6 \pm 0.3$ mm



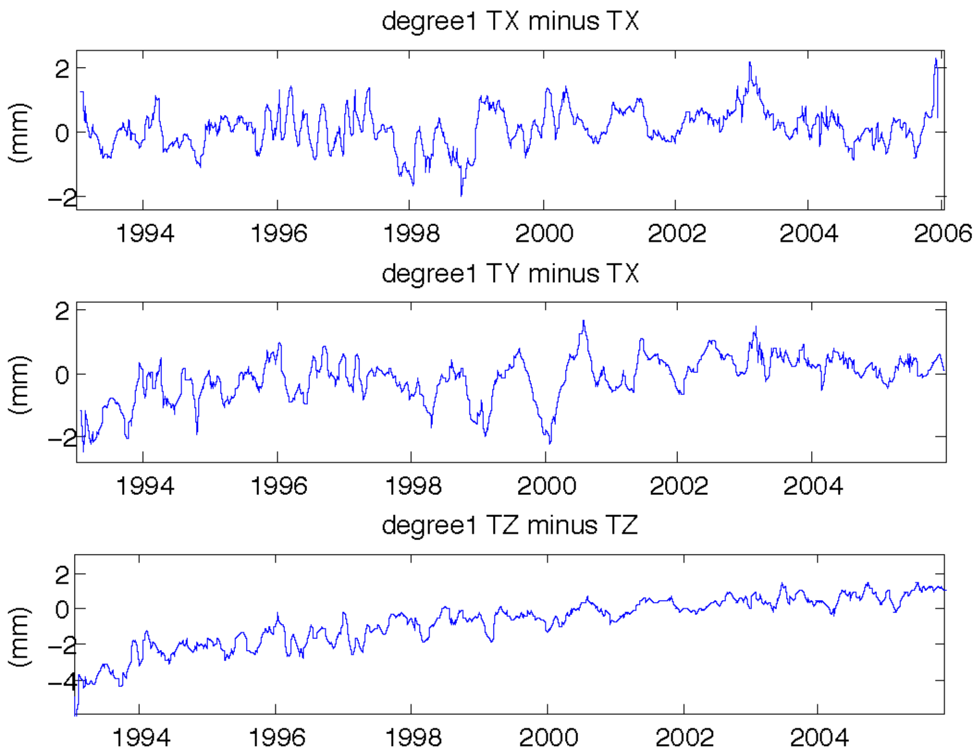




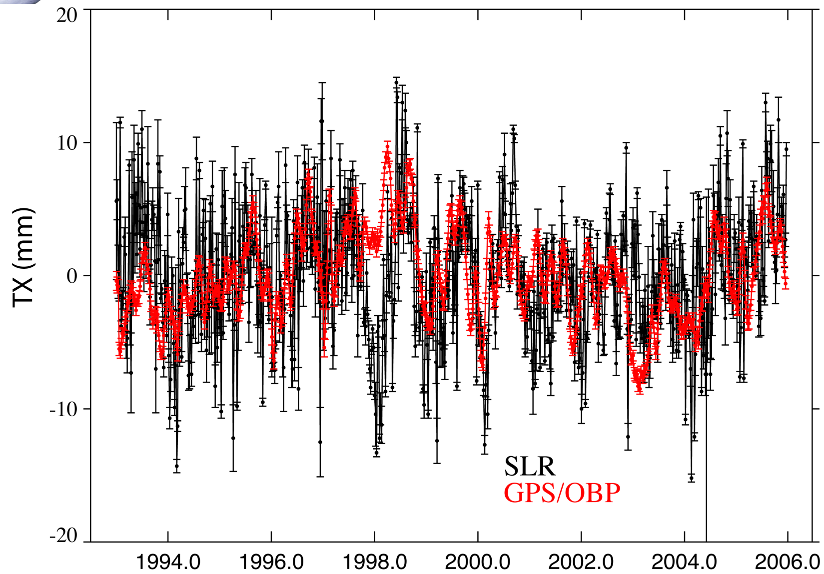
Comparison of Solutions For Annual Geocenter Motion

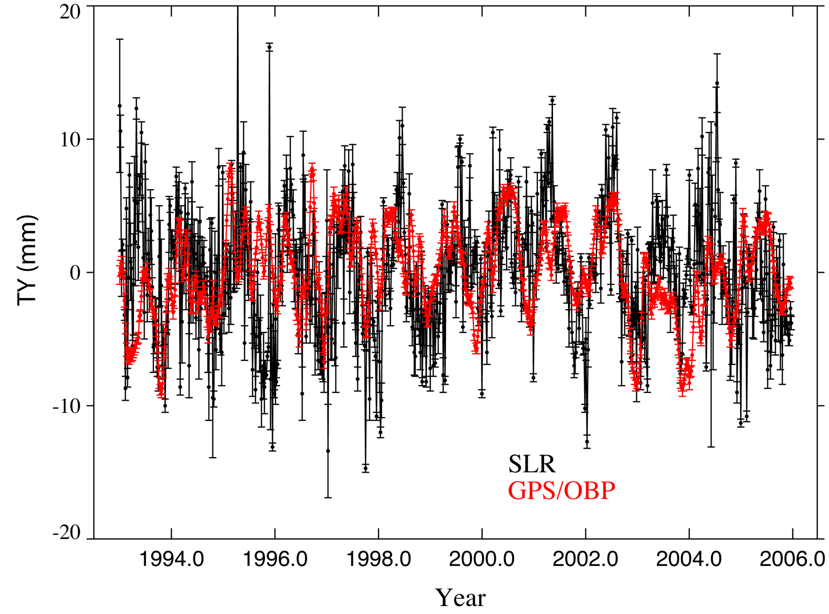
Data	ΔX_g		ΔY_g		ΔZ_g		Ref
	Amp mm	Phase day	Amp mm	Phase day	Amp mm	Phase day	
SLR (L1/L2)	2.2	60	3.2	303	2.8	46	*Eanes97*
SLR	2.1± 0.5	48	2.0± 0.5	327	3.5±1.5	43	*Bouille00*
GPS	0.7±1.5	119±131	3.8±1.2	16±20	4.5±1.0	27 ±13	*Wu.. 03*
GPS+OBP	1.6±0.7	27± 21	1.9±0.4	326±11	5.2± 0.5	23 ± 5	*Wu.. 06*
GPS+OBP+GRACE	1.8±0.4	46±15	2.5±0.3	329±5	3.9±0.4	28 ±5	*Wu..06*

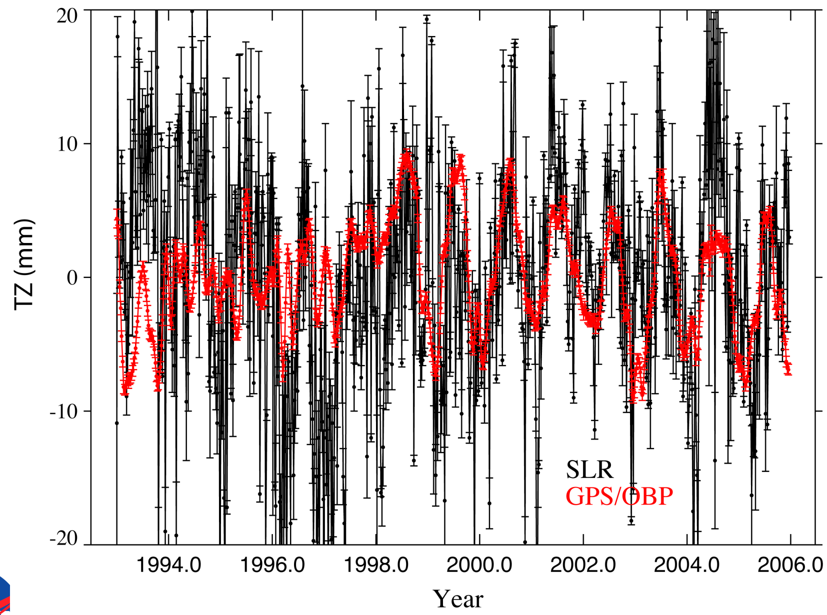
CF and CN Difference in Inverted Model



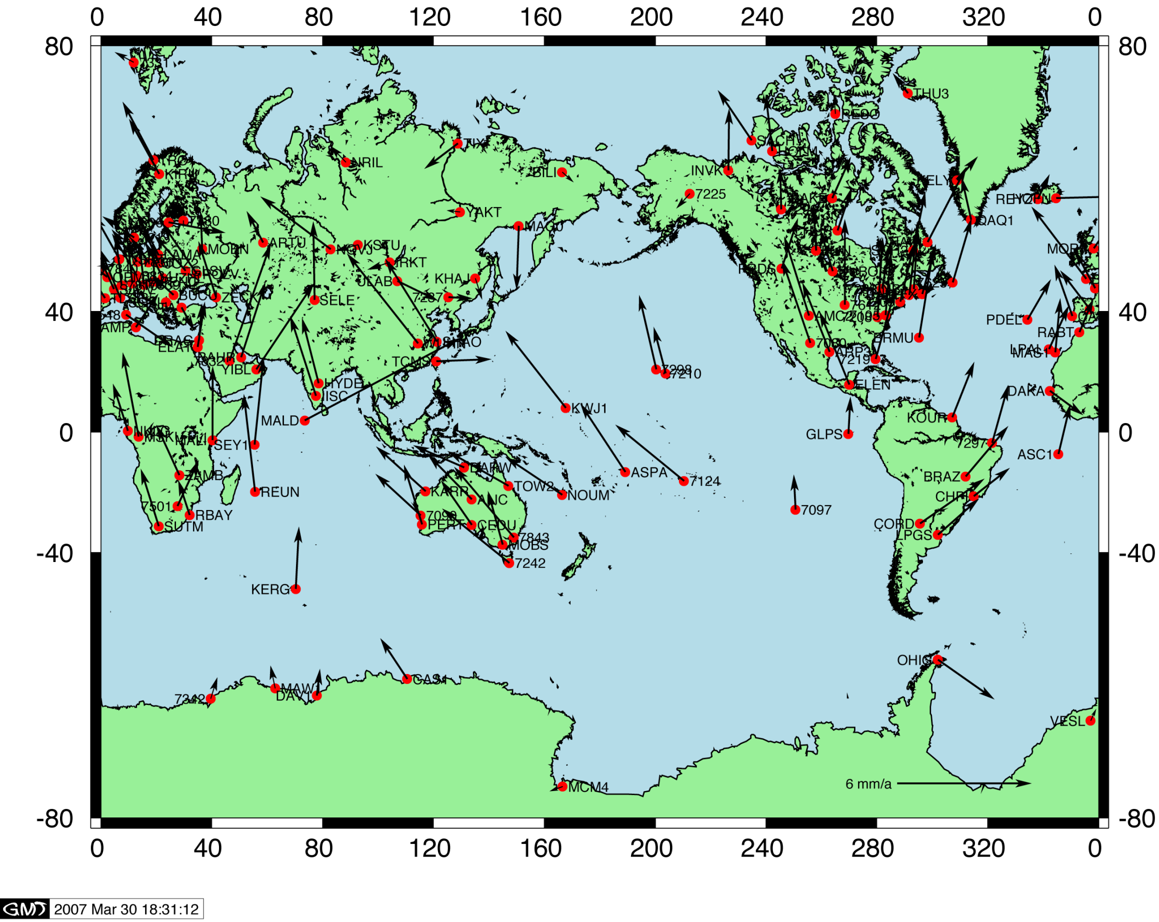
SLR and GPS/OBP Inverted Tx, Ty, Tz







Geocenter Velocity - Direct Determination

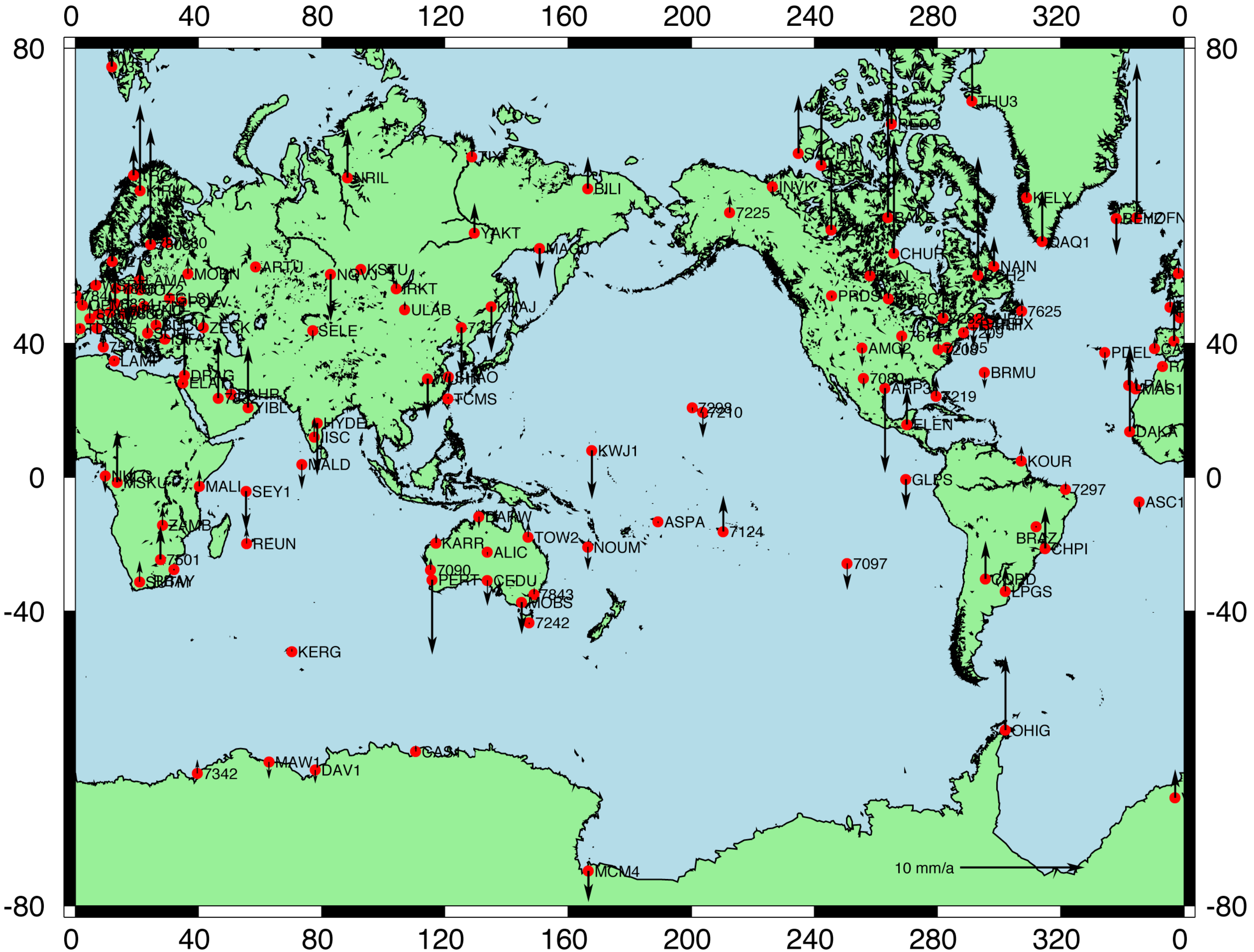


- Global Sites away from Plate Boundaries
- Deducting NUVEL-1A Vel
  - $V_x = 0.1$ mm/a
  - $V_y = -0.6$ mm/a
  - $V_z = 1.0$ mm/a
- Deducting REVEL Vel
  - $V_x = 0.4$ mm/a
  - $V_y = 0.3$ mm/a
  - $V_z = 2.3 \pm 2.0$ mm/a

Summary and Future

- n=1 mass ∝ Geocenter motion due to load
- Geocenter = Accurate and stable geodetic ref frame origin
- Direct GPS Geocenter error at mm level for lunar ocean tides but noisier for longer periods, particularly for Tz
- Inverse and SLR agree - seasonal and interannual
- Secular climatic geocenter motion challenging
- Sub-secular geocenter motion from SLR+VLBI+GPS?

Vertical Velocities



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