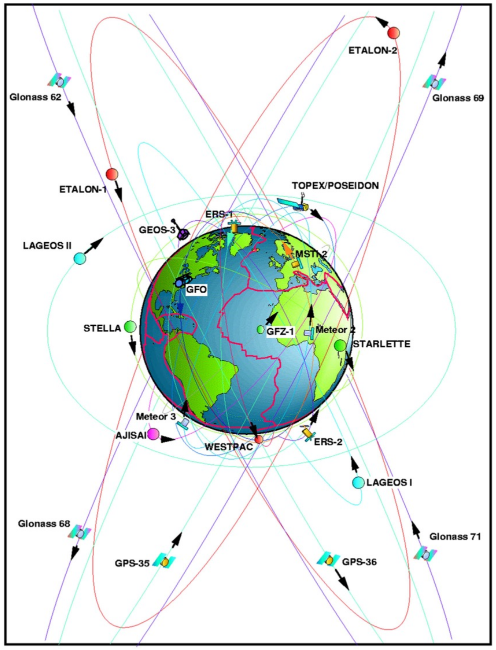
# Seasonal variations in the station ranging bias and tropospheric zenith delay from SLR

**Minkang Cheng**

Center for Space Research
The University of Texas at Austin, USA




- Motivition:

There are difference in Geocenter solutions from SLR and GPS based global invention. If this difference is due to deficiency of the distribution of SLR tracking stations?

- Rang bias and Seasonal variations, impact on geocenter solution.

- Seasonal tropospheric zenith delay.

# Ranging Model

- **Ranging Model**

$$\rho_{1way}=\rho_{2way}/2 + \Delta a+\Delta Com+R_b+T_b+\Delta GR$$

- **Residual analysis after orbit fitting from path by path**

$$\delta\rho_{\varepsilon} = R_b + T_b d\rho / dt + \varepsilon_p$$

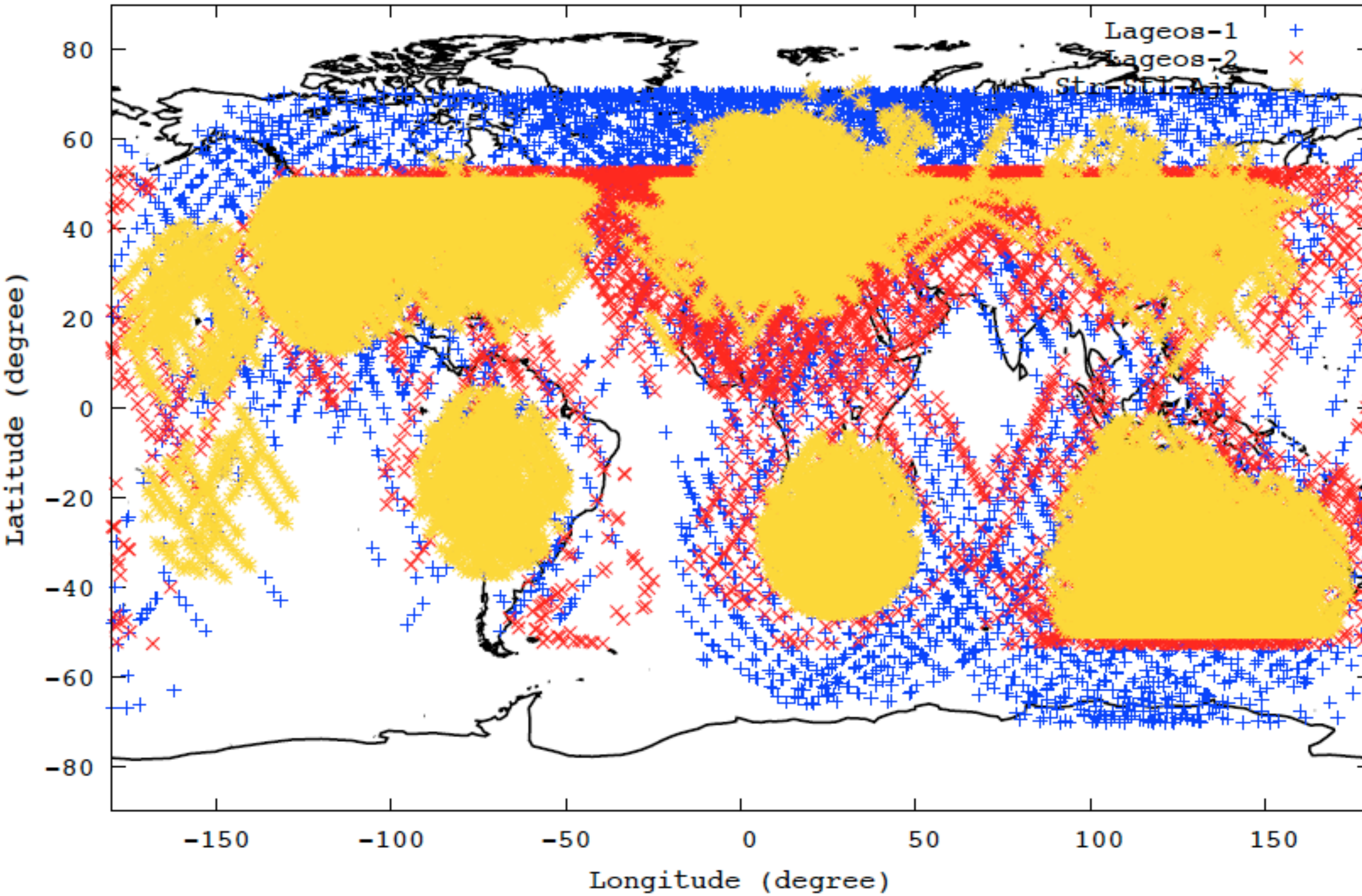
- **Atmospheric troposphere delay and gradients**

$$\Delta a_{DL} = (Z_{dm} + \Delta z) M_{mpf}(Z) + m_g(e)[G_N \cos(A) + G_e \sin(A)]$$

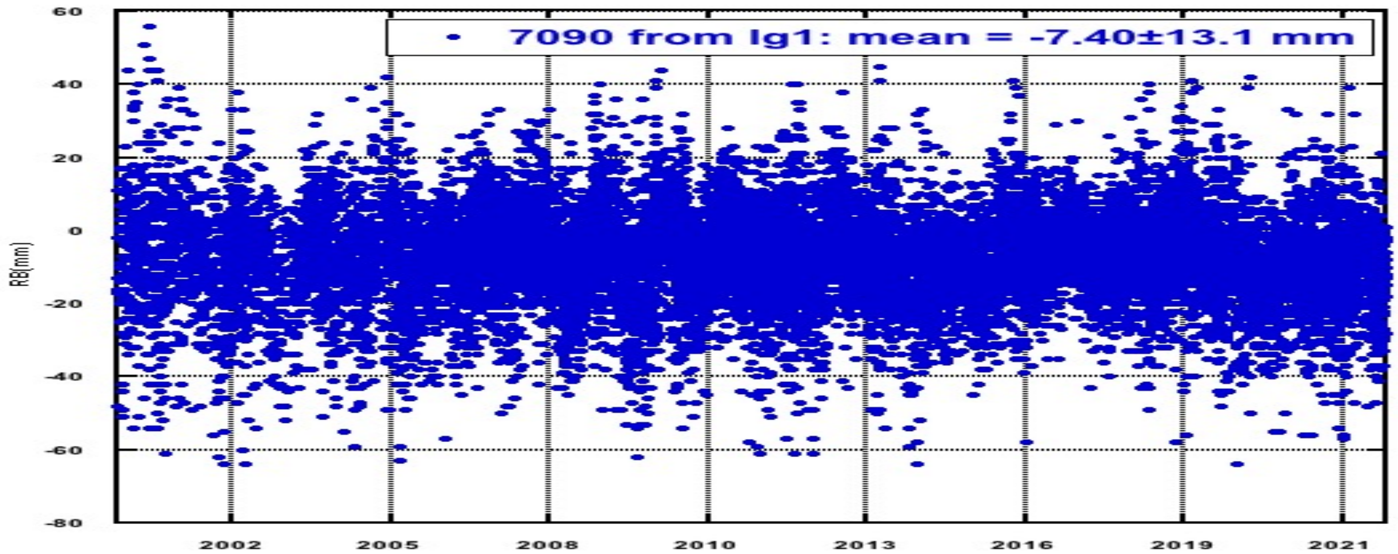
$Z_d$, $M_{mpf}$, from Mendes and Pavlis [2002, 2004].

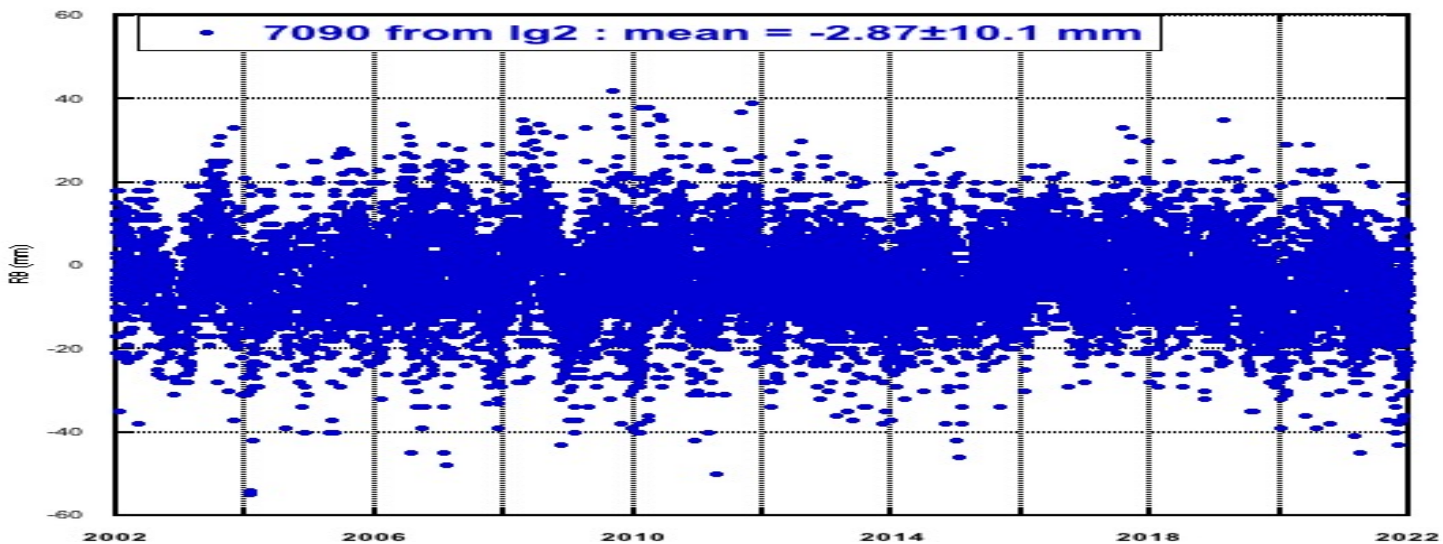
# Monthly ground track for August 2015 from 5 satellites

## Observatiuon Equation: $Y = Hx + \varepsilon$

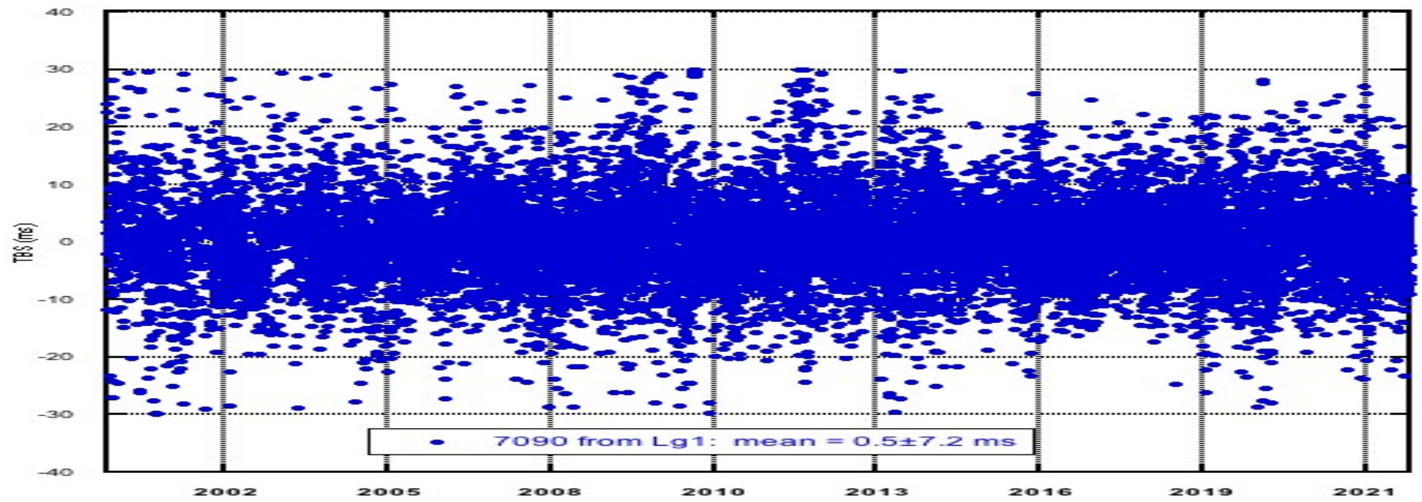


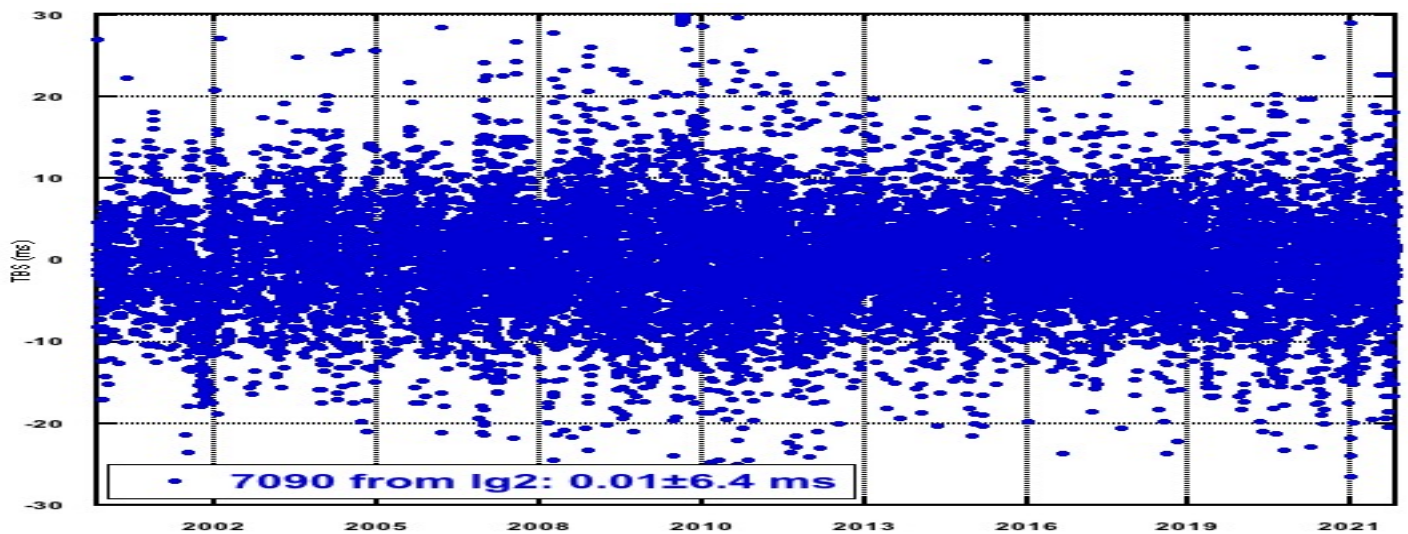
# Ranging bias estimate  for 7090 from Lageos 1 and 2



# Time bias estimate for 7090 from Lageos 1 and 2



# Annual variation in ENU from SLR and GRACE

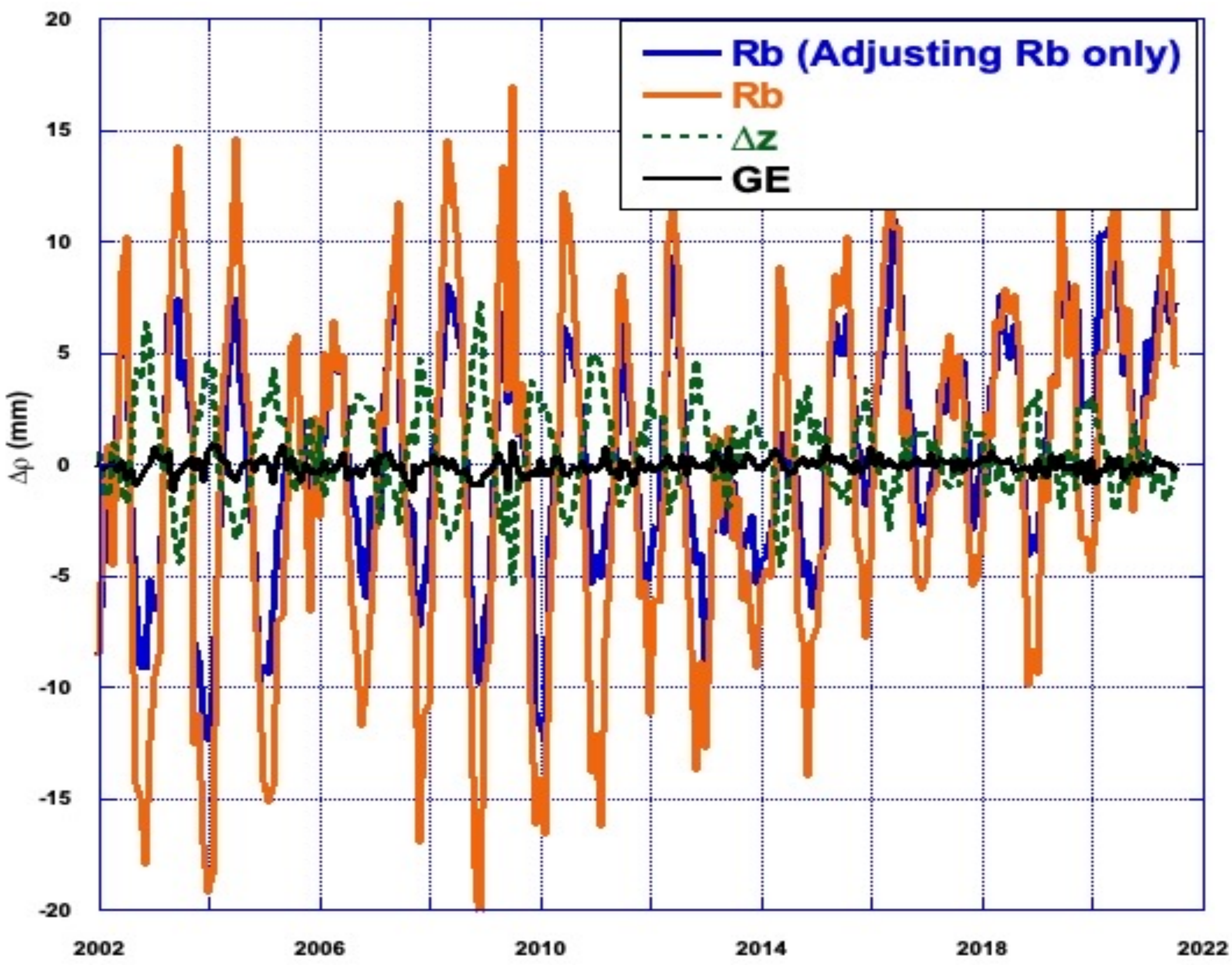
1) High degree effects predicted from time series of Monthly GRACE solution with 60x60 field, which is ~50% of observed variations from SLR

2) Reported in ITRF2020 solution

3) Estimated from SLR data of 5 satellites along with 5x5 gravity field, is comparable with ITRF2020 solution

| Solution | E(mm/deg) | N(mm/deg) | Up(mm/deg) |
|---|---|---|---|
| GRACE | 0.228/322 | 0.165/299 | 1.77/327 |
| ITRF2020 | 0.851(0.24)/64(46) | 2.369(0.44)/269(46) | 3.65(0.31)/317(45) |
| SLR | | | 3.61(0.1)1/315(5) |

# Seasonal variations in ranging bias and Δz,GE for 7090



# Annual variations for 7090 estimated from SLR

| Case | solution | Rb(A/ψ) | Δz(A/ψ) | GN(A/ψ) | GE(A/ψ) |
|---|---|---|---|---|---|
| 1 | $R_b$ only | 5.01/154 | | | |
| 2 | Rb+Δz+hg | 8.56/152 | 2.05/327 | 0.07/261 | 0.16/69 |
| 3 | Rb+hg | 4.43/151 | | 0.15/183 | 0.25/36 |
| 4 | Rb+Δz | 9.34/154 | 2.19/331 | | |
| 5 | Δz+hg | | 2.26/327 | 0.22/187 | 0.34/18 |
| 6 | Up+Δz+hg | 7.36/332 | 0.26/238 | 0.05/345 | 0.15/19 |

**Results suggest that the troposphere delay (Δz) and horizontal gradients (hg: GN and GE) can be separated from simultaneously estimating with the loading induced range bias (Rb) from SLR data, but cannot be separated from the surface loading induced change in the station height.**

# Annual variation (amplitude/phase) in Geocenter

| solution | X (mm/deg) | Y(mm/deg) | Z(mm/deg) |
|---|---|---|---|
| SLRw2013 | 2.7±0.3/40±2 | 2.8±0.2/323±2 | 5.2±0.2/30±3 |
| ITRF2014 | 2.6±0.1/46±3 | 3.1±0.1/320±2 | 5.7±0.2/28±2 |
| ITRF2020 | 1.2±0.2/57±7 | 3.5±0.2/333±3 | 2.8±0.3/41±7 |
| SLR (gbs) | 3.4±0.4/17±5 | 2.5±0.4/301±6 | 5.1±0.4/10±5 |
| SLR(mbs) | 1.8±0.2/46±4 | 2.7±0.2/307±4 | 2.4±0.3/27±5 |
| Global Inv | 1.8±0.2/49±3 | 2.7±0.2/325±3 | 4.2±0.2/31±3 |
| TN13 (JPL) | 1.4 /52 | 2.5 /325 | 3.2 /45 |

SLR (gbs): Estimate of Rb from entire time span
SLR (mbs):Estimate of Rb from monthly time span
Global Inv1:GPS based+OBP
TN13: GRACE + OBP

# Summary

- Significant seasonal signal appearing in the station ranging bias (as the kinematic effects) can be separated from the degree one loading induced geocenter variation with annual amplitude of a few mm. The distribution of SLR tracking stations with well-distributed ground track from multiple satellites is capable for determination of geocenter variation in comparable with the GPS based global inversion or TN13
- The effects of the mismodeling of the troposphere delay ($\Delta z$) and atmospheric horizontal gradients (*hg*) must be taken intot account for estimating of the seasonal displacement in ENU direction of station

Thank you four your attention