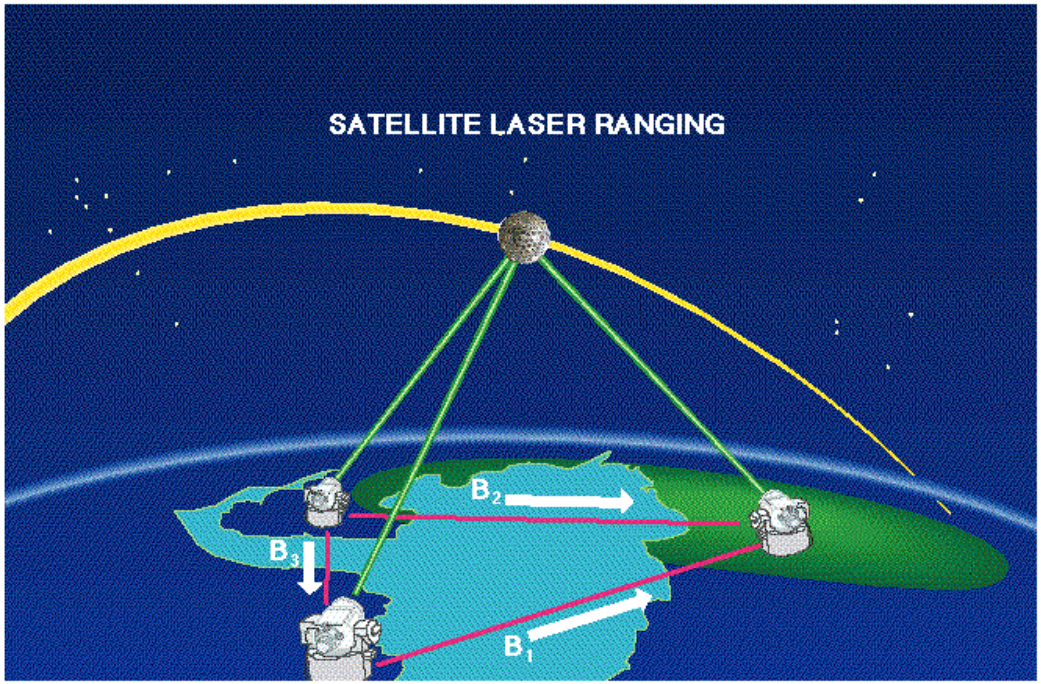
Bias and Center of Mass Issues for SLR

- What is influence of range bias and CoM model on TRF scale?
- In particular, how is GM influenced, since GM sets the scale for all satellite-based techniques?



GM estimation from SLR

- In 2005, estimated GM using 12+ years of SLR data from LAGEOS and LAGEOS-2
  - GM = 398600.44163 ± 0.00042 km^3/s^2 (± 1 ppb)
- Considering a 1 cm bias (single average bias) for each station increased uncertainty to 0.00027 (~ 0.7 ppb)
  - Estimating or not estimating biases changed the GM solution by less than the estimated uncertainty
- Atmosphere refraction contribution likely < 0.2 ppb
- CoM model was identified as likely 'tall pole' in error budget
  - Using 'guesstimate' of 4 mm error in the CoM correction led to an increase of the estimated error in GM to 0.00042 (~1 ppb)

Center of mass offset impact

- ITRF2005 scale issue motivated more careful analysis of impact of CoM model errors on GM, for LAGEOS and other satellites

Satellite (A in Earth radii)	CoM Error required for 1 ppb error in GM
Starlette (~1)	1 mm
LAGEOS (~2)	3 mm
GPS (~4)	~8 mm (extrapolated)

- Low satellites are much too sensitive to CoM errors
- Laser reflectors on high-altitude satellites, such as future GPS satellites, could provide helpful scale information but the CoM has to be known very well to provide better accuracy

Testing ITRF2005 with Starlette

SLR residual RMS for 2000-2005 using 6-day arcs, GGM02C, full network, Mendes/Pavlis refraction model

	ITRF2000 (75 mm CoM)	ITF2005 (75 mm CoM)	ITRF2005 (scaled -1.2 ppb, 75 mm CoM)	ITRF2005 (scaled -1.2 ppb, 80 mm CoM)
SLR RMS (mm)	**19.7**	**18.8**	**19.1**	**18.7**
SLR Mean (mm)	**-3.9**	**-0.1**	**-3.7**	**0.1**

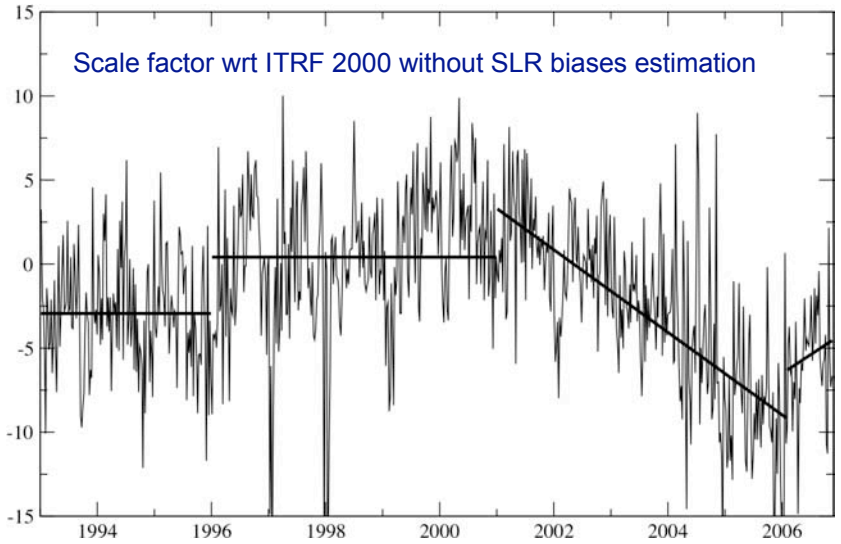
Recent more detailed analyses indicates CoM for Starlette should be closer to 80 mm than 75 mm

TRF scale from SLR and CoM offset are fundamentally related

GM, Scale and Satellite CoM

- GM and TRF scale implicitly defined by CoM offset used for LAGEOS-1 and 2 (changing CoM linearly scales both)
- Current CoM for LAGEOS is 251 mm (246 mm for RGO)
- Recent analysis suggests something smaller may be appropriate for a number of other sites, perhaps ~247 mm
- Significant changes could require update to GM, resulting in TRF scale changes as well as heights of satellite orbits
    - Probably not desirable for altimeter satellite applications

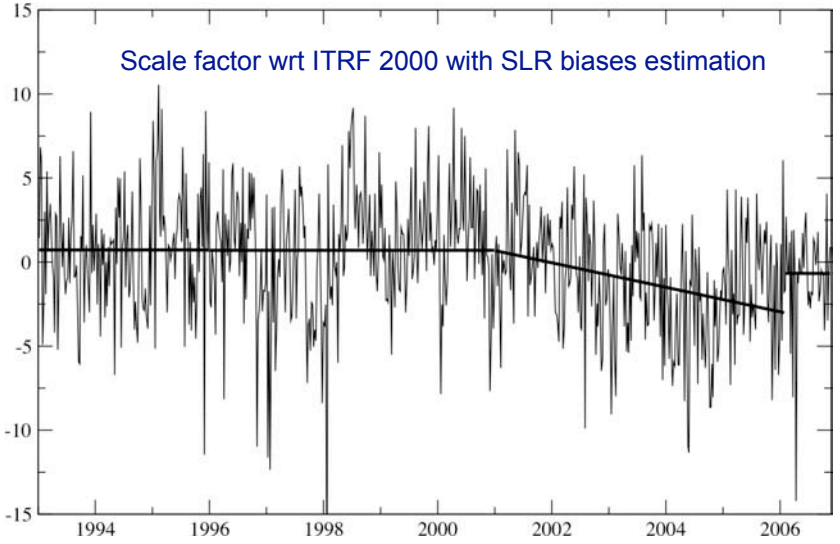
Impact of biases on TRF determination



Coulot, D., P. Berio, D. Féraudy, O. Laurain, and P. Exertier, *Different ways of considering biases for Satellite Laser Ranging data processing: consequences on Terrestrial Reference Frame scale factors, submitted to Geophys. Res. Lett., 2007.* ***(see also poster in G1 session)***

SLR ranging biases should be routinely estimated (with appropriate care)

Without a ‘place to go’, biases will distort TRF determination



Conclusions

- Biases in range data need not necessarily bias scale, since these can be included in the estimation
  - Apparent SLR scale variations in SLR contribution to ITRF2005 may be explainable by unestimated biases
  - However, optimal way to constrain biases is not trivial
- Center-of-Mass offset model for LAGEOS satellites directly determines estimate for GM ⇒ TRF scale
  - Each 3 mm change in CoM changes TRF by 3 mm and GM by 1 ppb
  - Using higher satellites would help if CoM uncertainty is small
- Standard values for CoM for Starlette/Stella (and Ajisai) are almost certainly incorrect (not currently used for TRF)