SLR Contributions in the Establishment of the Terrestrial Reference Frame

Erricos C. Pavlis,
JCET and NASA Goddard Space Flight Center
Univ. of Maryland Baltimore County
Baltimore, Maryland (epavlis@JCET.umbc.edu)

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Outline

- **Motivation**
- **SLR Observations Contributing in:**
  - **"Geocenter" Variations**
  - ***Moment of Inertia Variations***
  - **EOP**
  - **…**
- **Correlation with geophysical signals**
- **Modeling Improvements**
- **…**
- **Summary - Conclusions**

Technology ⟷ Science

- Advances in technology require concomitant advances in science
- Changes in one, sooner or later bring changes in the other
- After the giant steps taken in the mid-80s and early 90s, SLR technology advances forced major “rehabilitation” of the way SLR data are analyzed and redirected our products in markedly different areas.

Current Areas of Application

- **Terrestrial Reference Frame**
  - Establishment: Site Positions & Velocities
  - Monitoring: Earth Orientation Parameters, Scale, Geocenter, Moments of Inertia, Temporal Gravity Variations,…
- Orbit Determination, Calibration, Validation
- Atmospheric Refraction Model Improvement, Validation
- Fundamental Physics & Interplanetary Experiments
- Target Characterization, Orbital Debris Tracking…

Terrestrial Reference Frame

- "State-of-the-art" definition of a TRF:

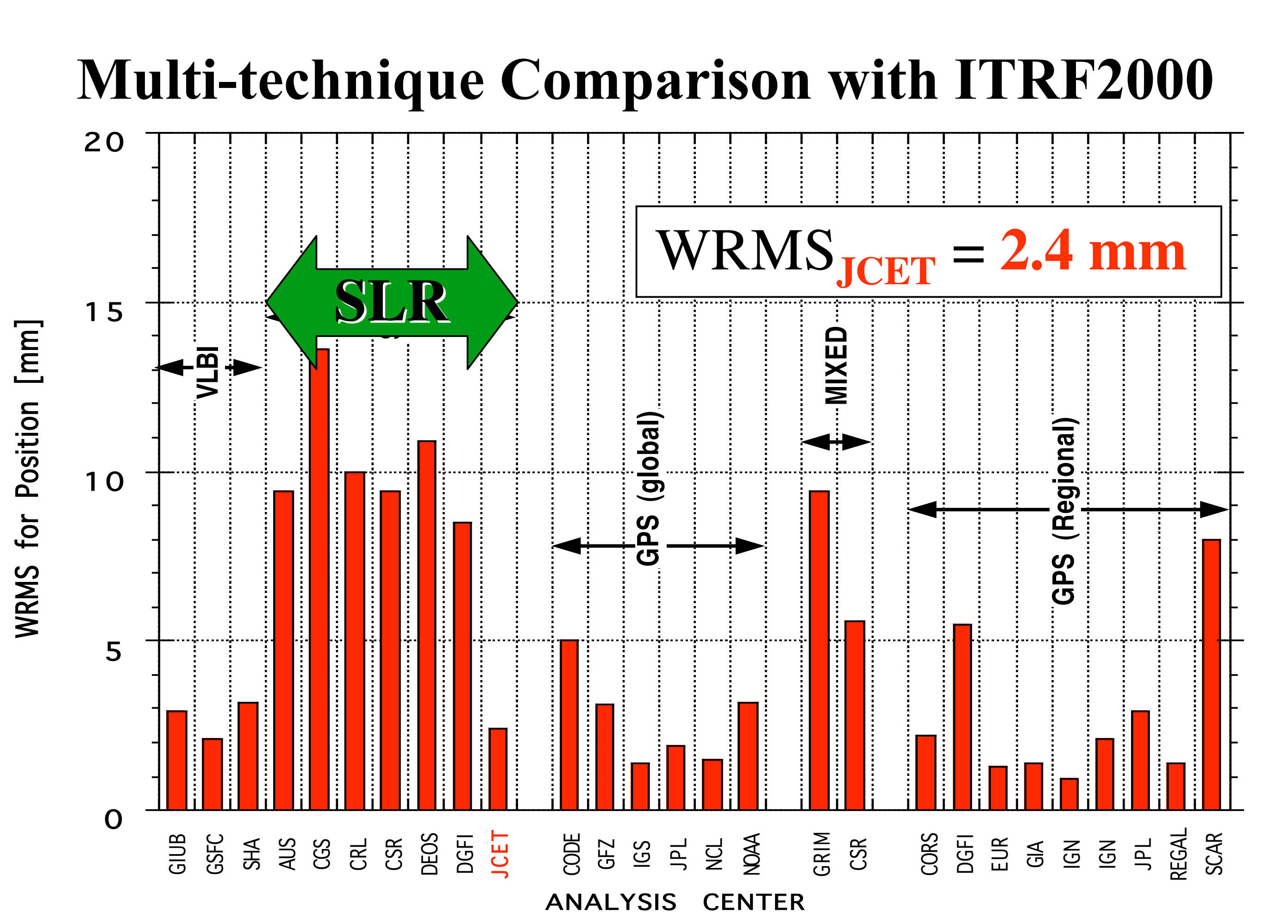
  ITRF2000

- Long-term stability affected by long-wavelength temporal gravity variations

- SLR is the primary technique for the definition of the origin and scale of the TRF

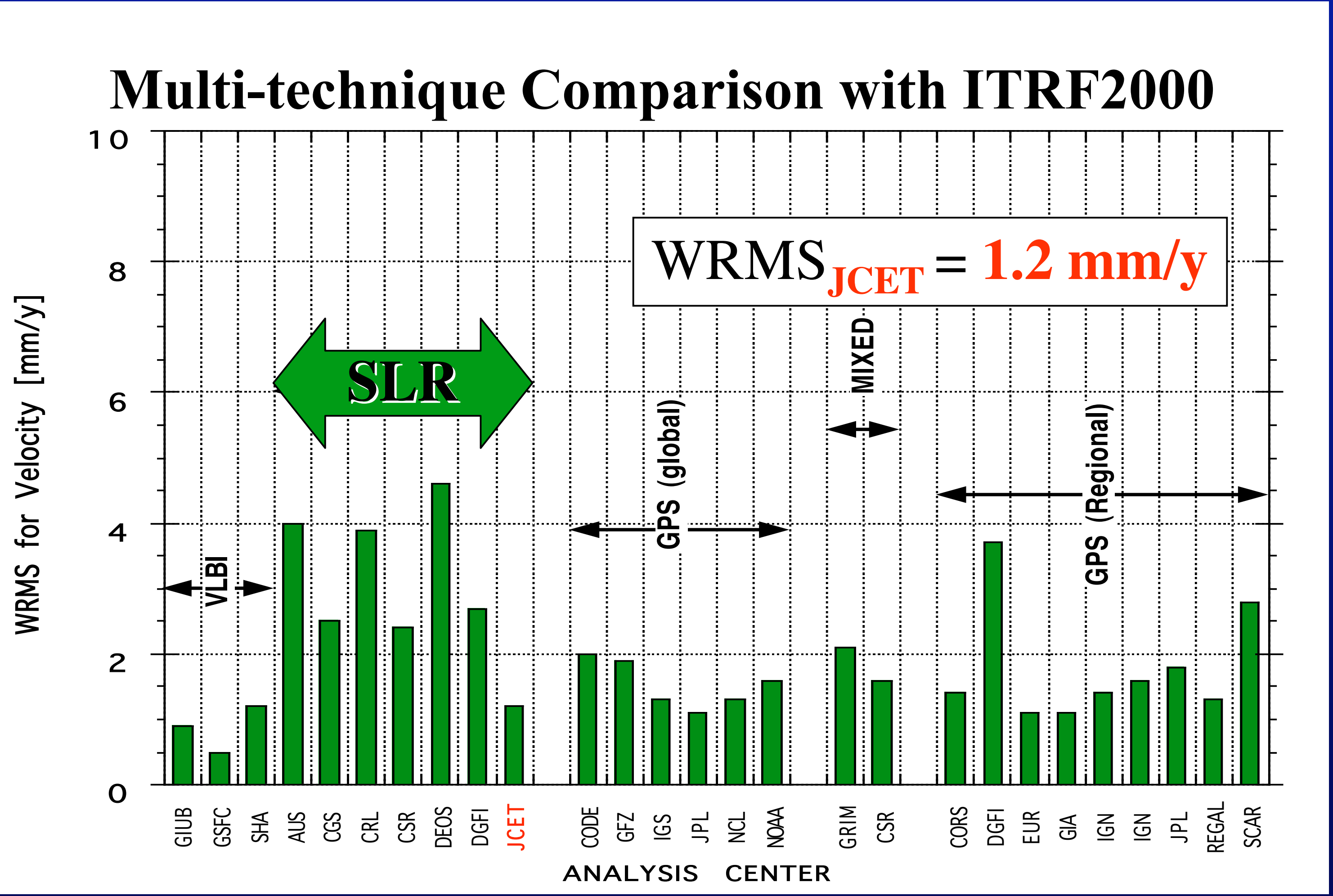
Comparison of Current TRFs

Position

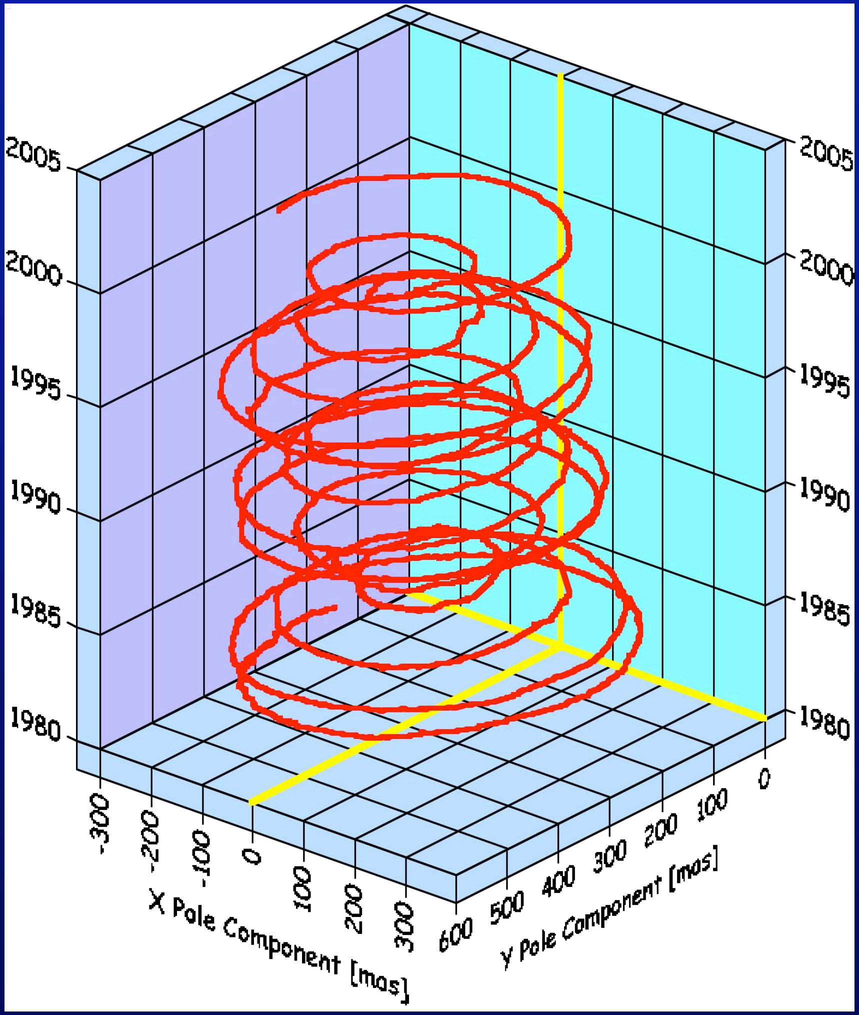


Comparison of Current TRFs (cont.)

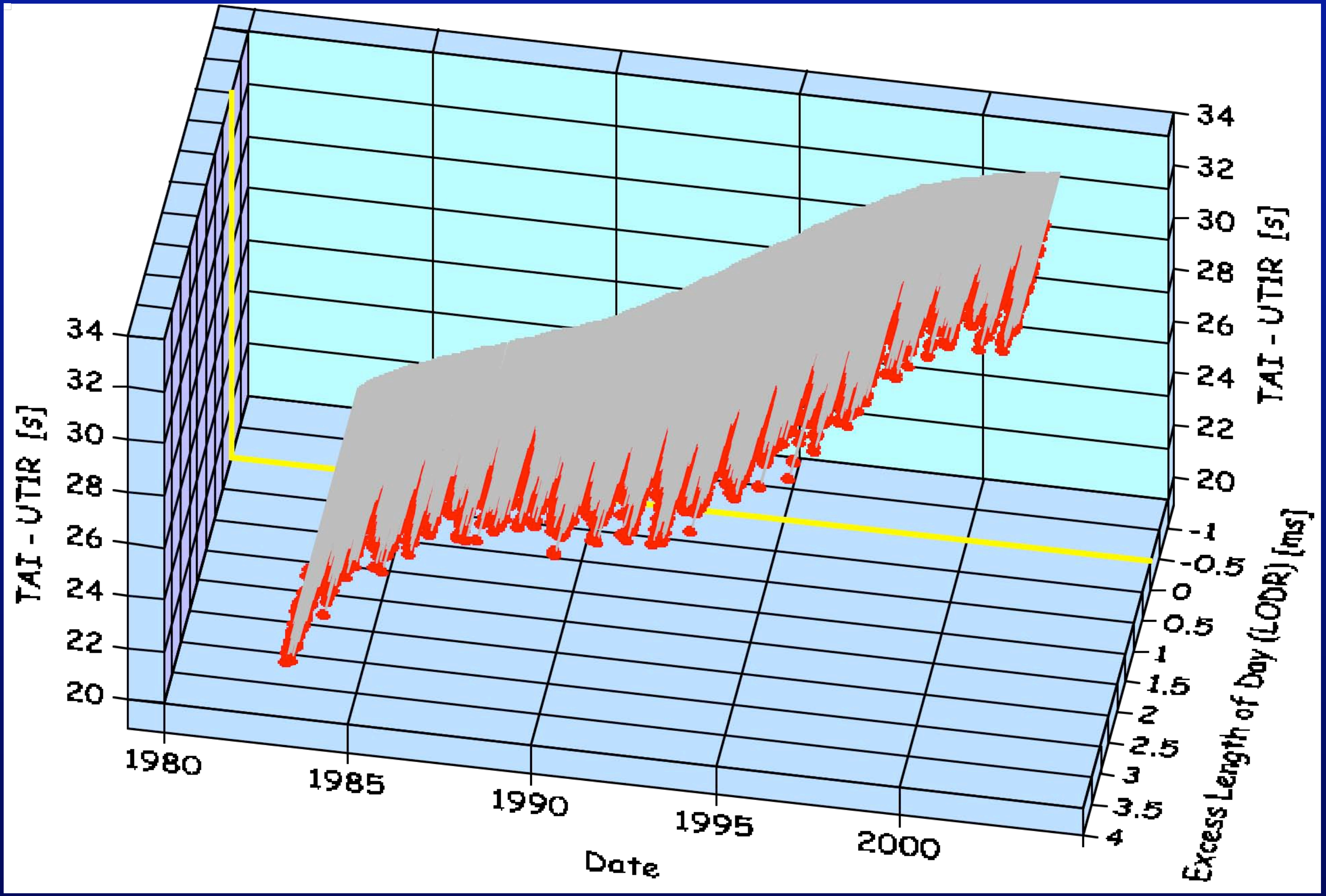
Velocities



TRF Orientation: Polar Motion

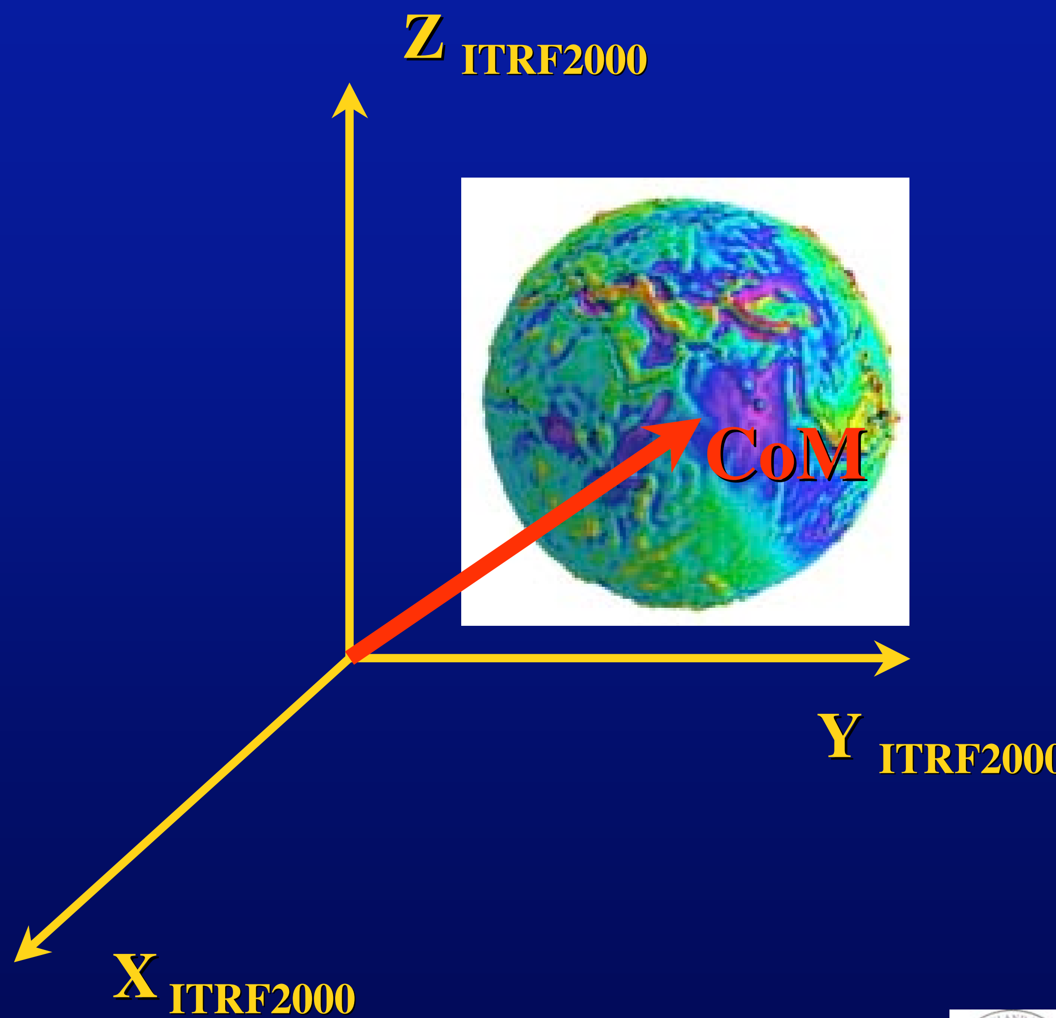


TRF Orientation: UT1 & Length of Day



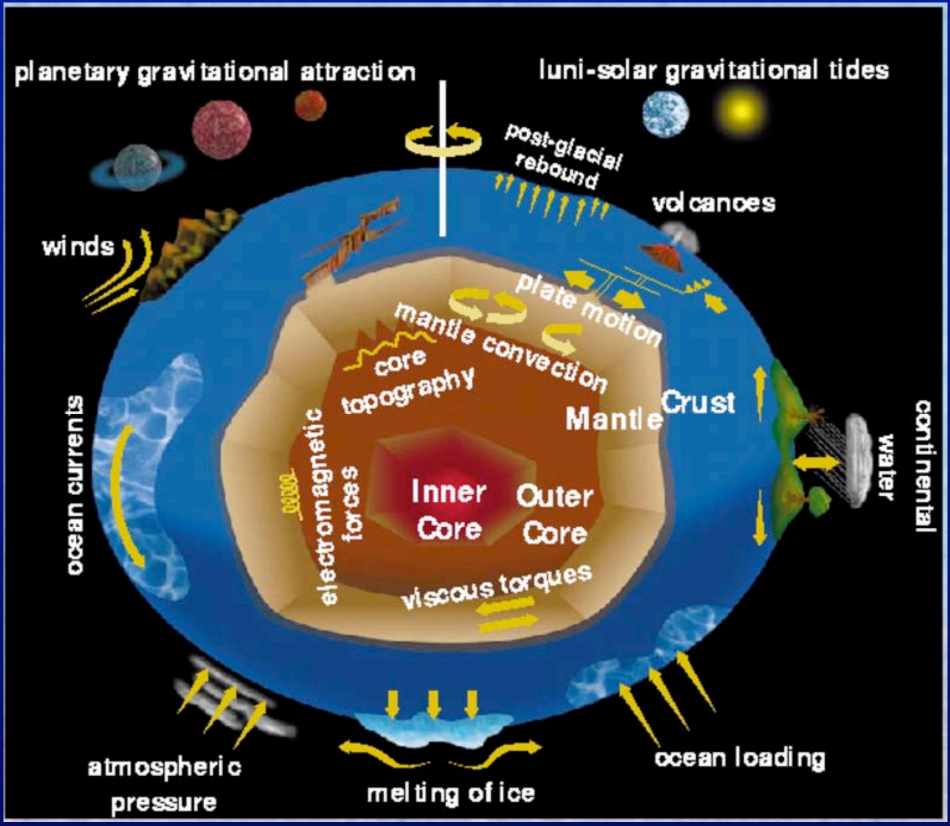
TRF and CoM

The coordinates of the sites defining the TRF determine the origin of the TRF, while the CoM is defined by the instantaneous distribution of mass in the Earth system.

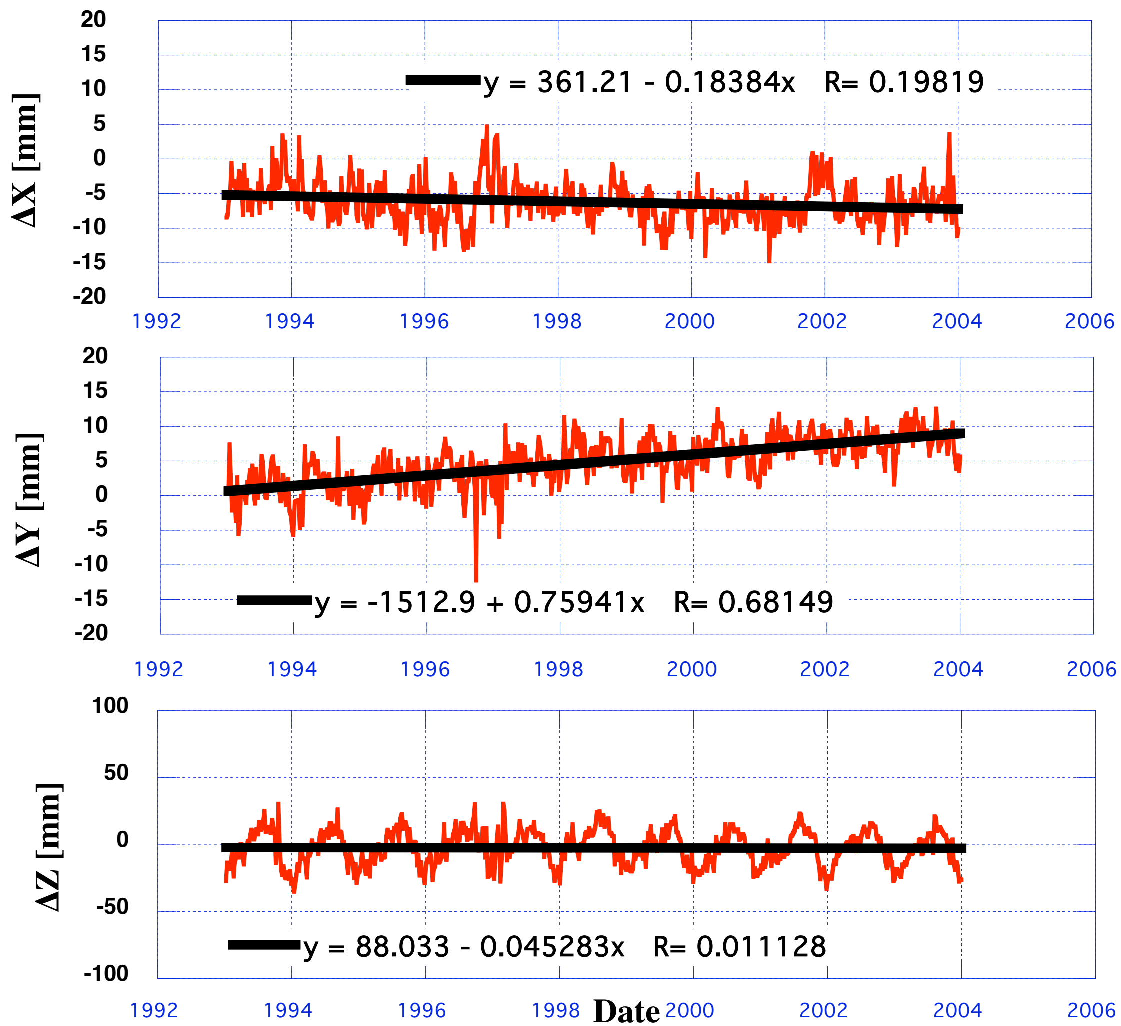


ΔGravity - TRF Coupling I

Mass redistribution in the fluid envelope of Earth displaces the **center of mass** of the system relative to the solid crust (on which the tracking sites are fixed) and modifies the **moments of inertia**, with consequent changes in the rotational kinematics and dynamics of the system.



CoM Variations in TRF



TRF: Scale

GM Estimate and Uncertainty

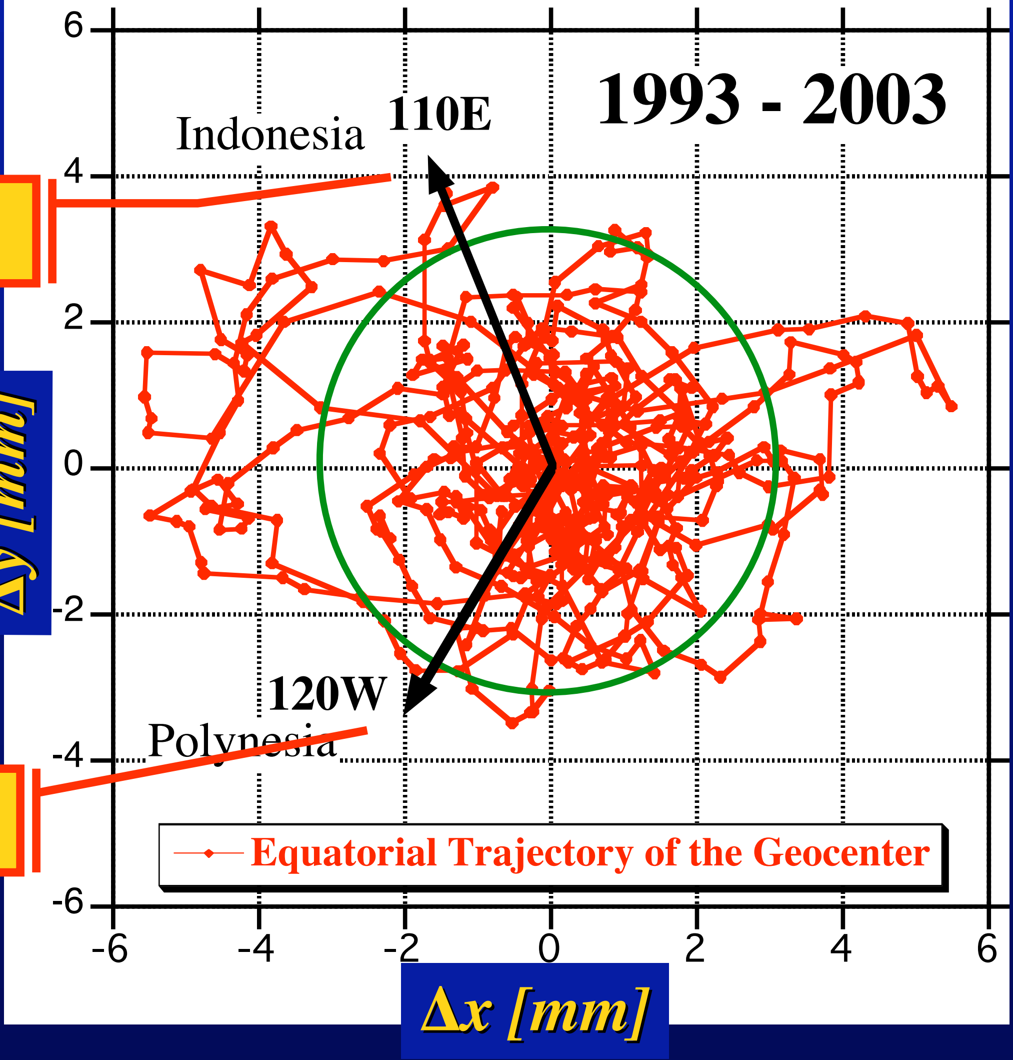
GM_{IERS} = 398600.441500 x 10^9 [m^3/s^2]

GM_{SLR} = 398600.441644 x 10^9 [m^3/s^2]

1□□ $GM_{\ SLR}$ = 0.000006 x 10^9 [m^3/s^2]

TRF scale at ″ 0.3 parts in 10^9

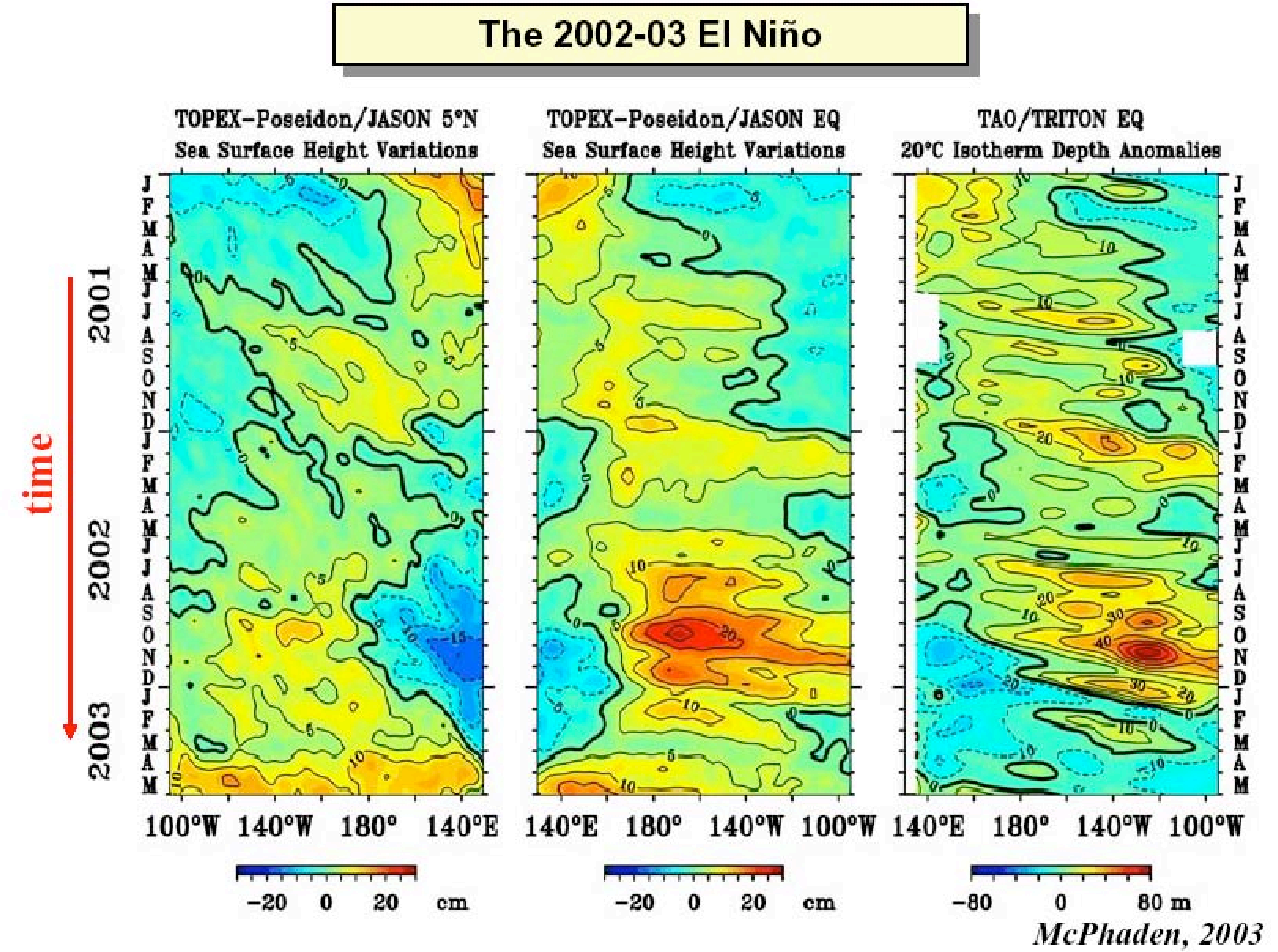
CoM Trajectory
1993 -2003



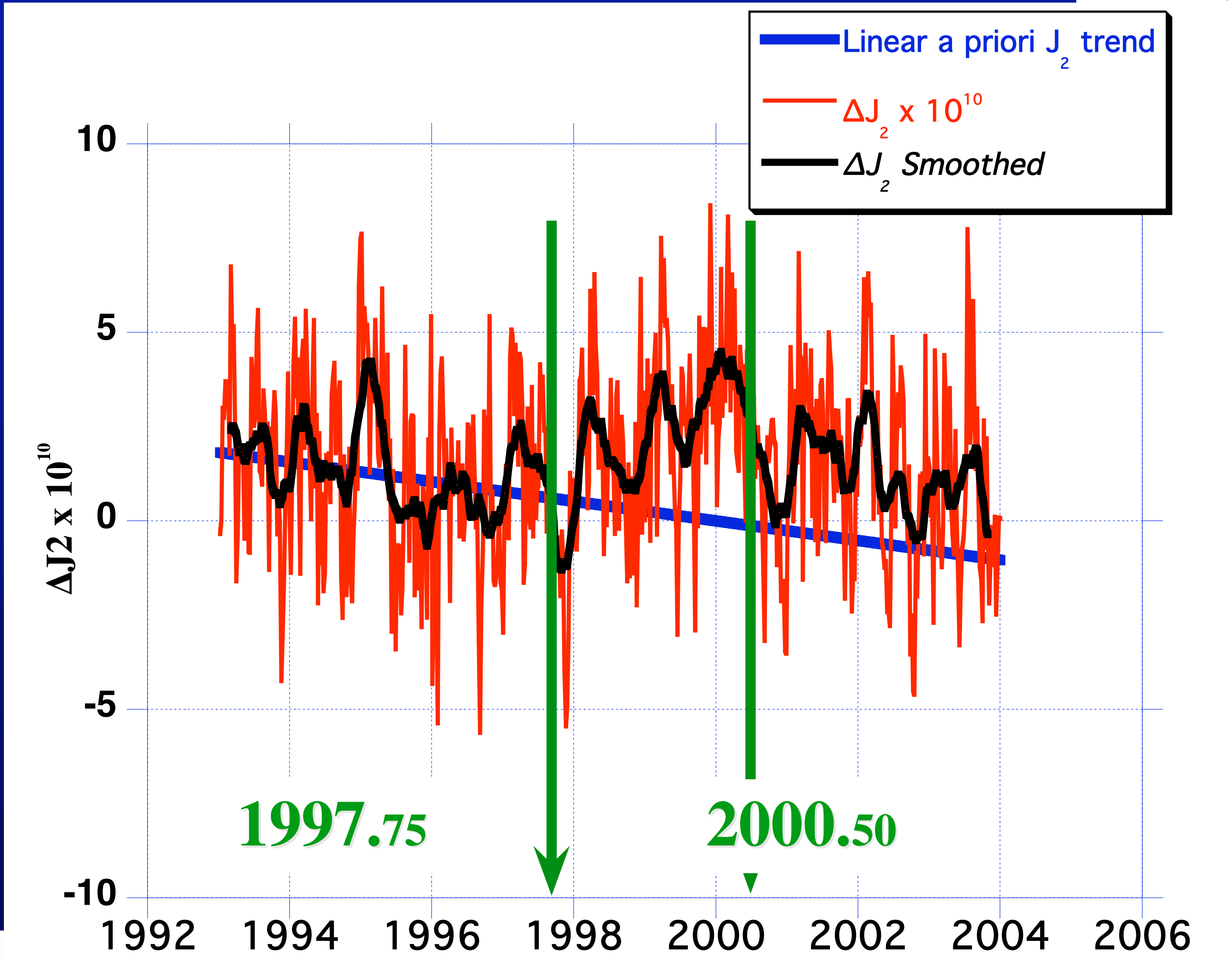
Indonesia

Polynesia

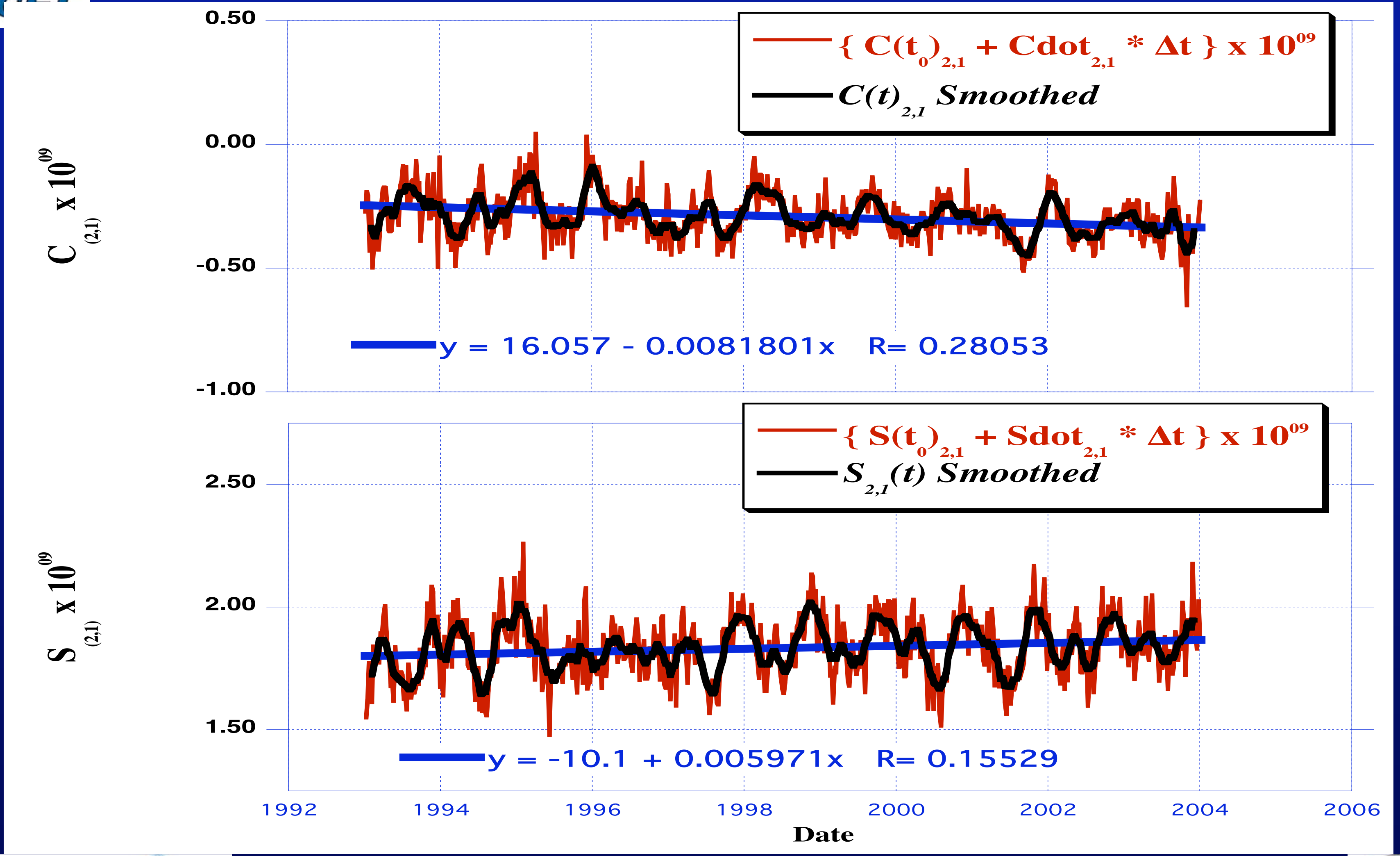
SSH Variations 2001 - 2003



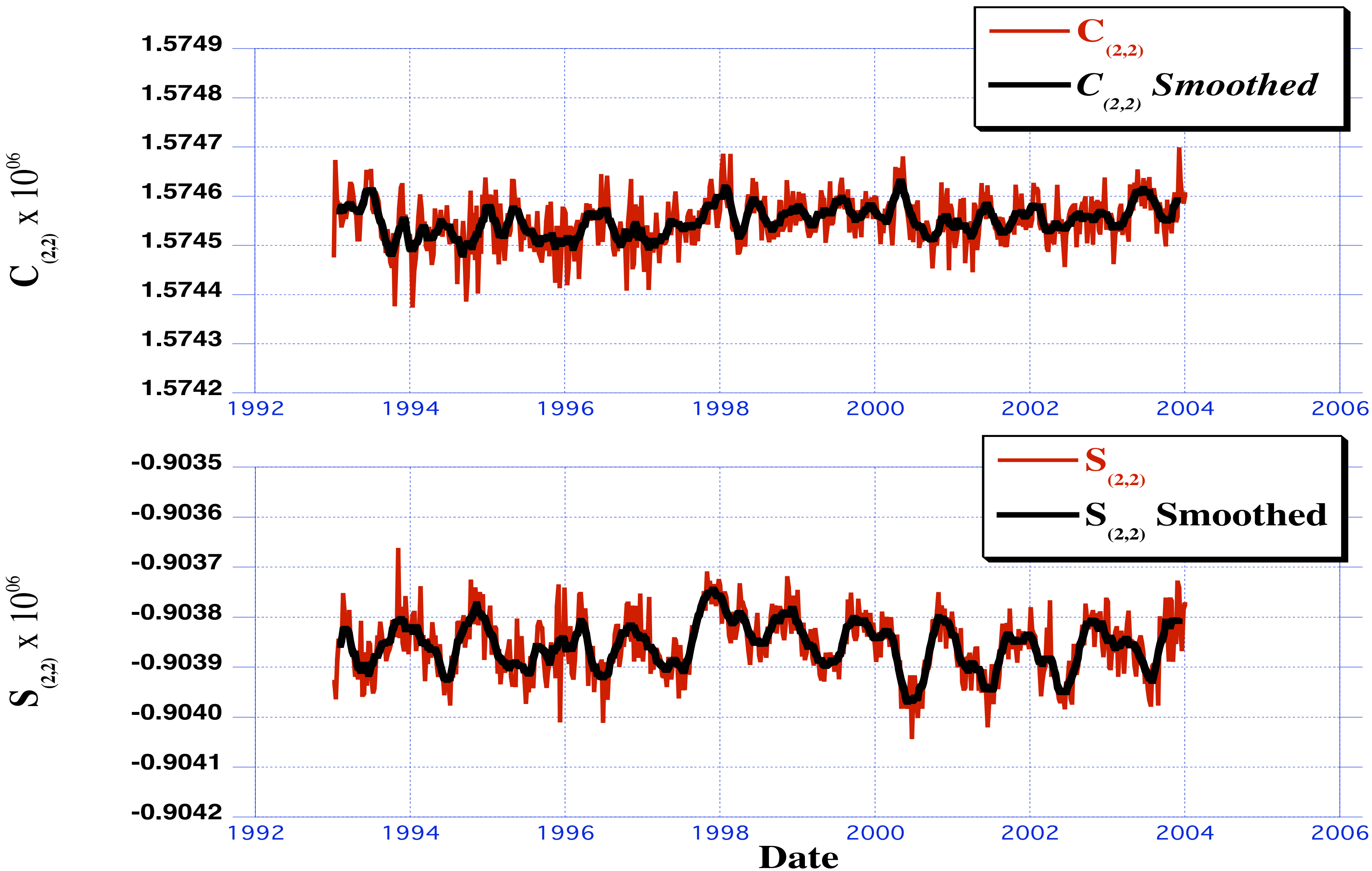
Zonal Variations: J_2-dot



Axis of Figure: $C_{2,1}$ & $S_{2,1}$



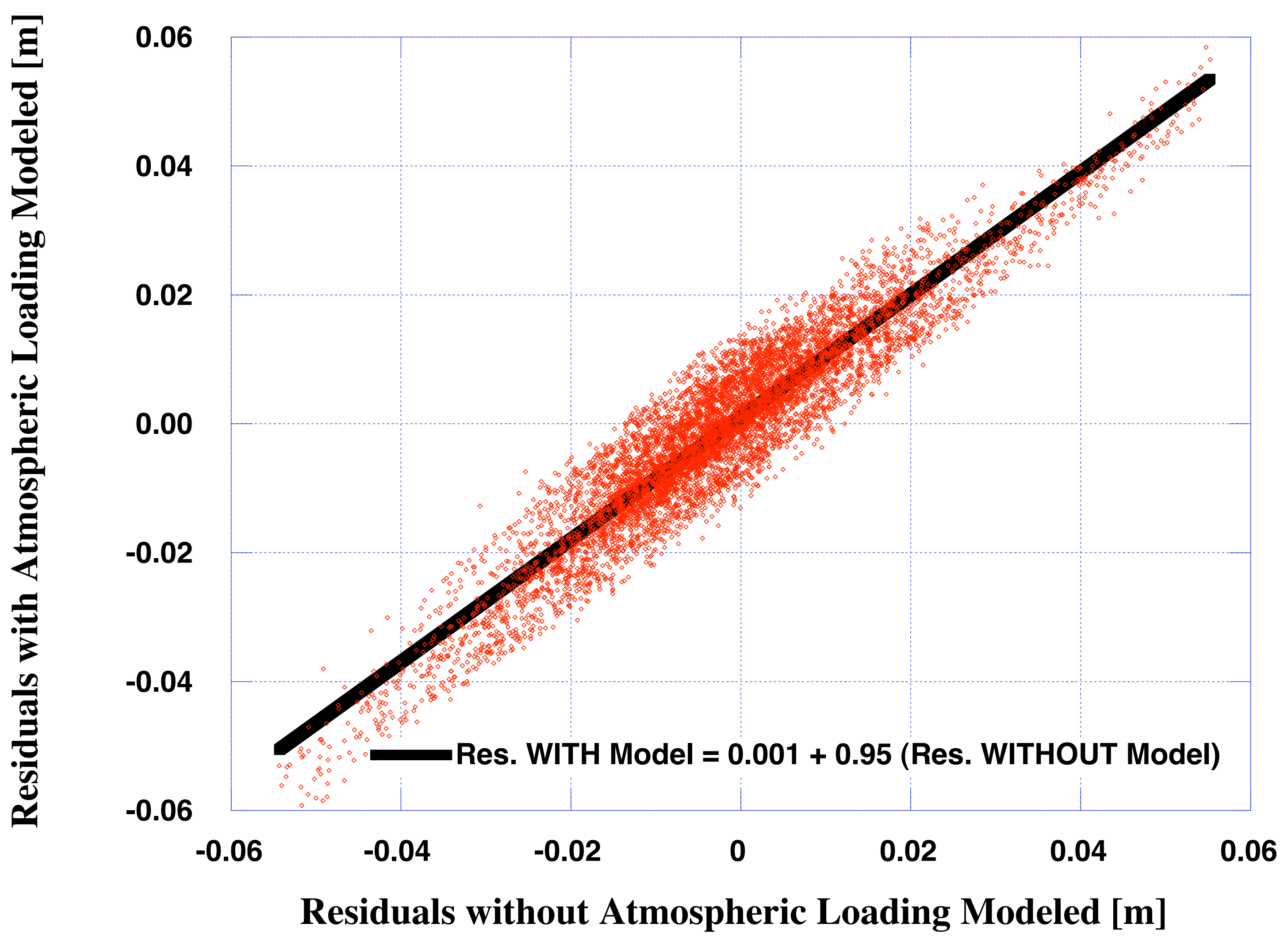
Equatorial Flattening: $C_{2,2}$ & $S_{2,2}$



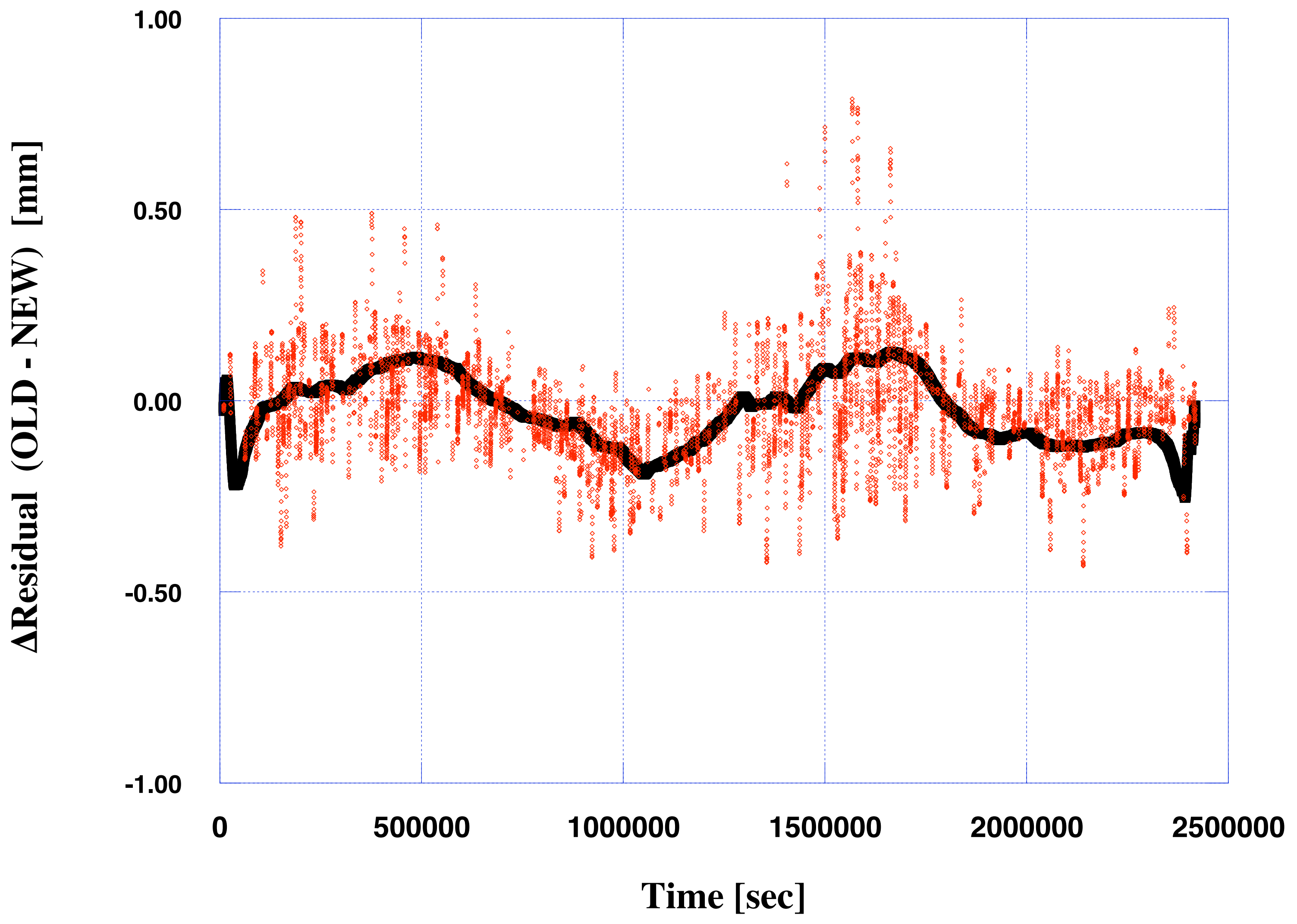
Modeling Improvements

- Strict enforcement of the IERS Conventions 2000
  - Improved nutation
  - Tides (Solid Earth, Oceans and Atmospheric)
  - …
- Consideration of geophysical fluids' effects on the sites and on the orbits (done consistently)
  - Ocean loading
  - Atmospheric loading
  - …
- Improved atmospheric refraction models valid throughout the utilized wavelengths (.355-1.064 μm)
- Target-dependent modeling (orbit, CoM, attitude,…)

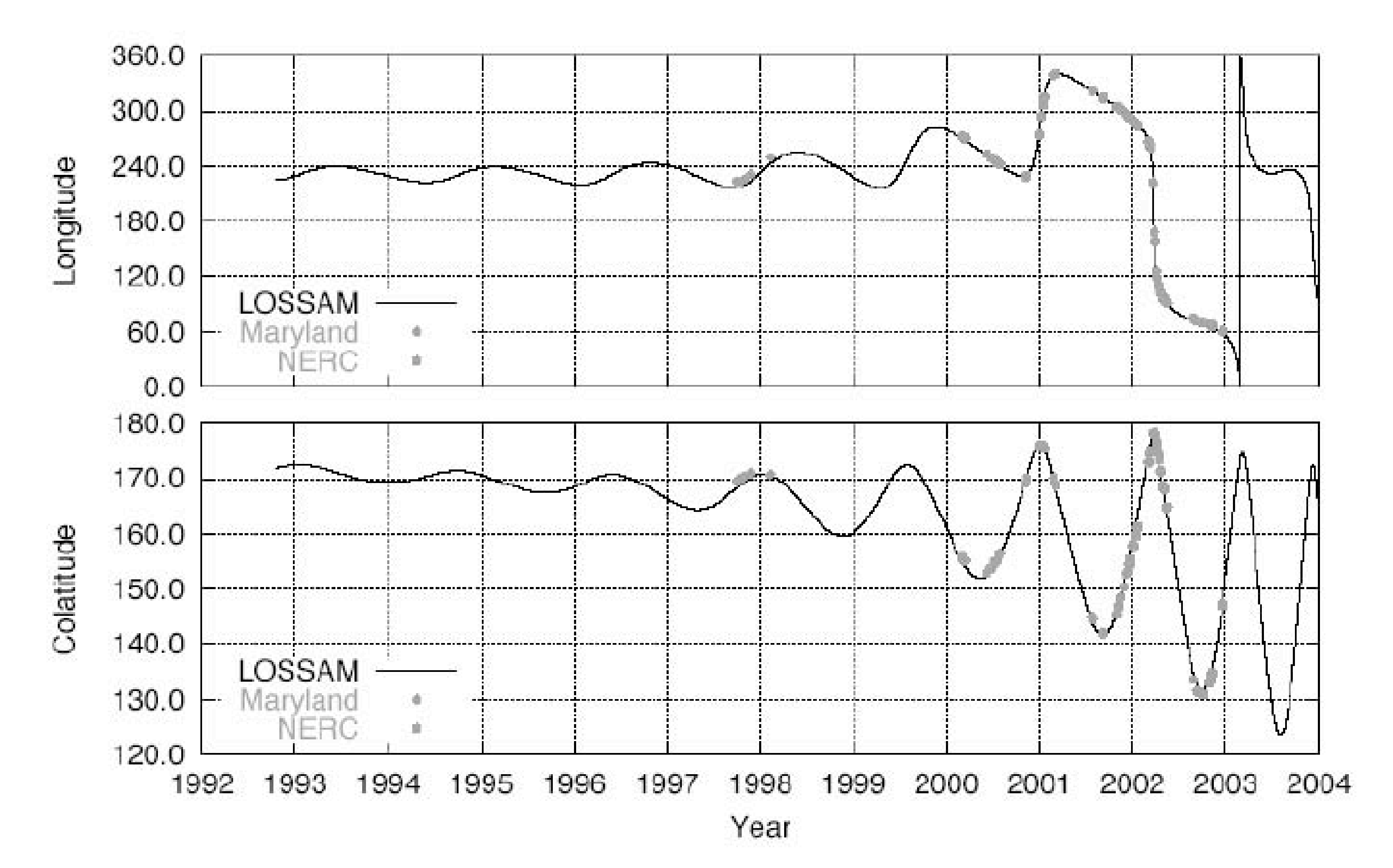
Example: Atmospheric Loading



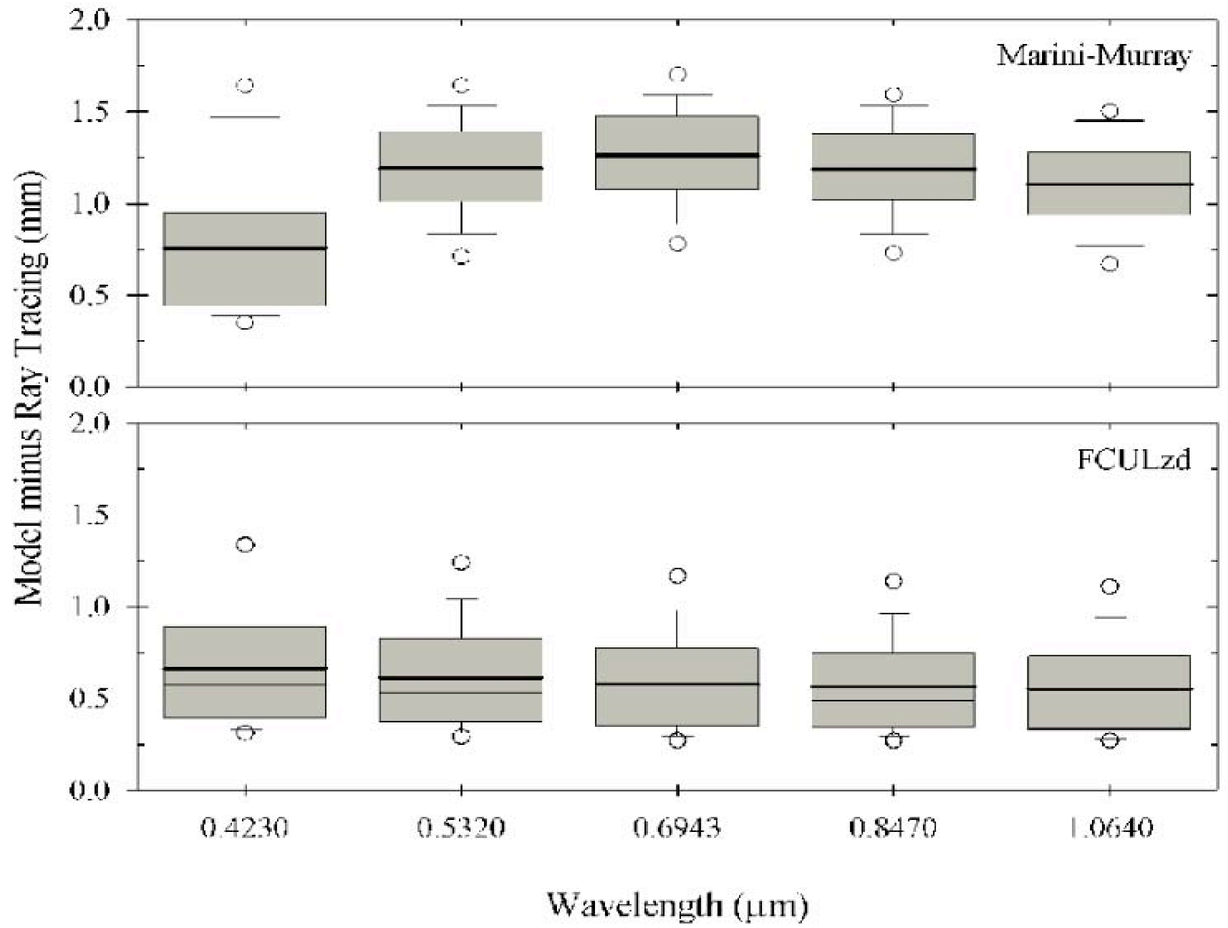
Example: Site Tidal Variations



Example: Orbital Attitude



Example: Atmospheric Refraction



The End

… a re-analysis to be released by July 2004!