INTERANNUAL AND ANNUAL VARIATIONS IN THE GEOPOTENTIAL OBSERVED USING SLR

Goddard Space Flight Center

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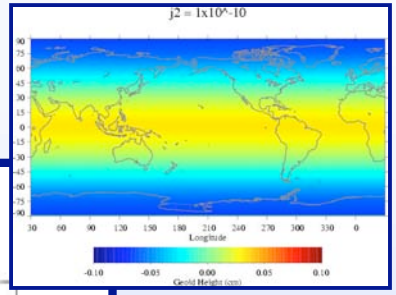
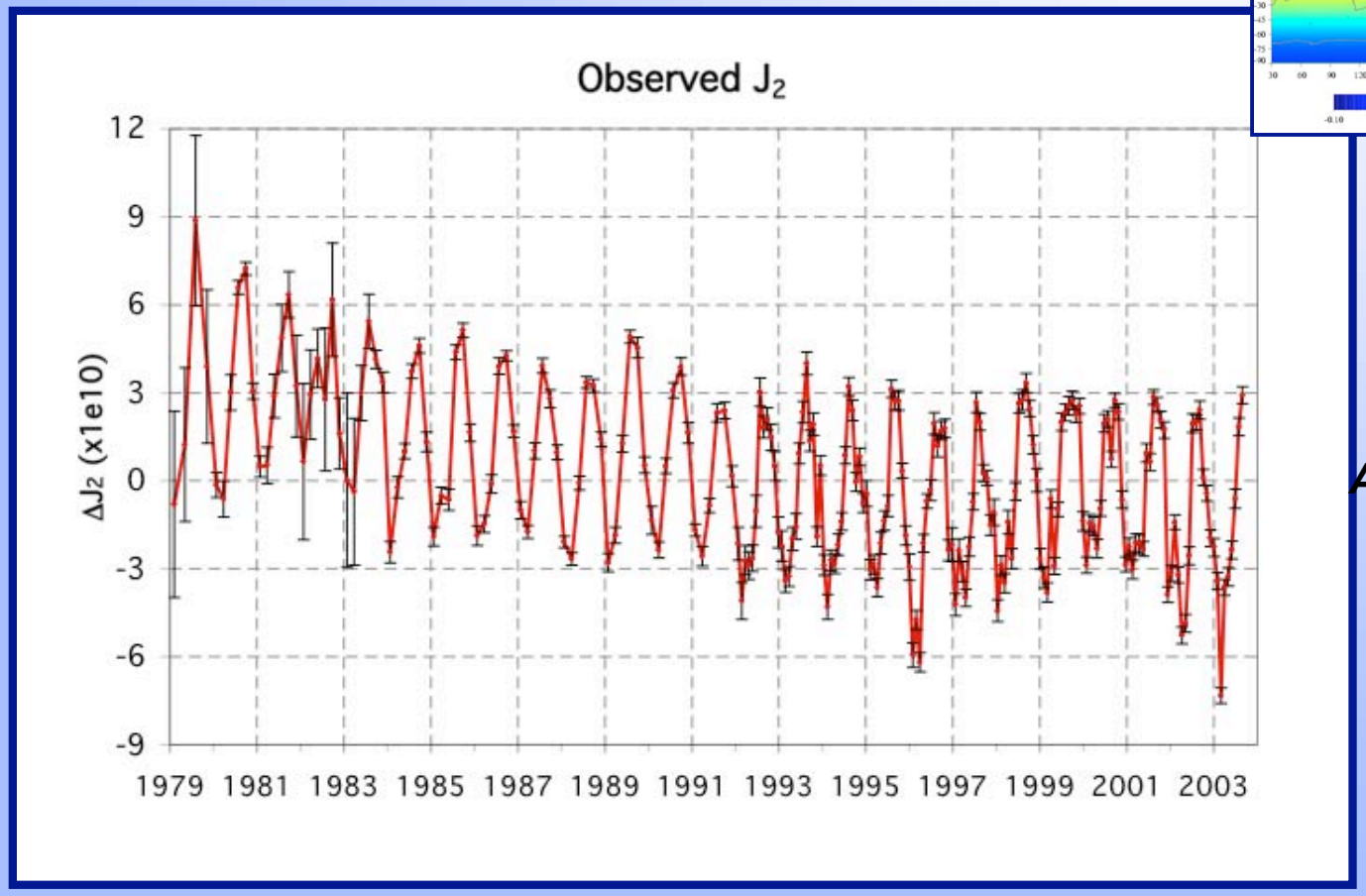
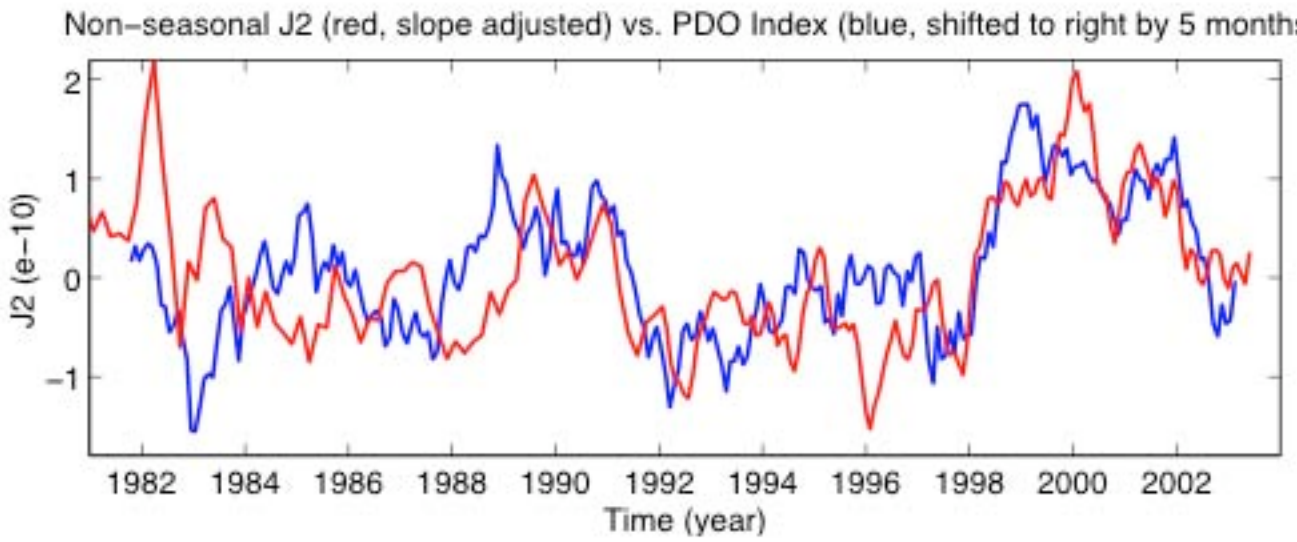
SLR Observed J_2





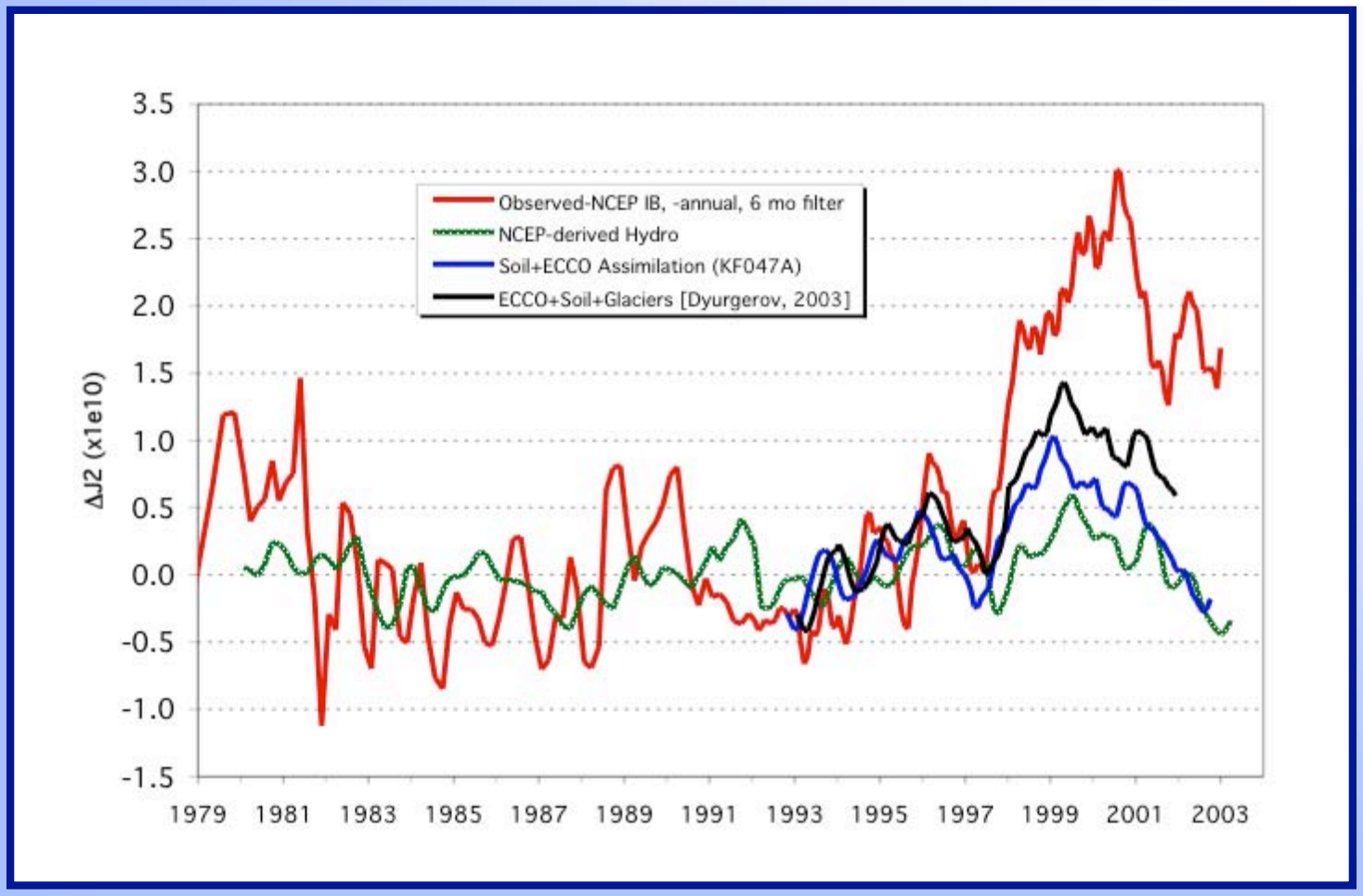
Includes Atmosphere

J_2 and the Pacific Decadal Oscillation Index



Chao, B.F., A.Y. Au, J-P.Boy, C.M. Cox, Time-Variable Gravity Signal of an Anomalous Redistribution of Water Mass, in the Extratropic Pacific during 1998-2002, *Geochem. Geophys. Geosyst.*, Vol. 4, No. 11, 1096, DOI 10.1029/2003GC000589, 14 November 2003.

J_2, Hydrology, Oceans, and Glaciers



pre-1998 rate removed from all data

Recent Progress

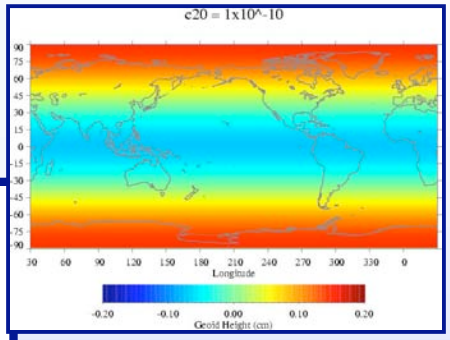
- **Effort made to recover entire field for any given period**
  - ***Science* [2002] results effectively discarded the non-zonal terms**
    - **Some indication of geophysical signal recovery, however**
- **All SLR data have been or are being reprocessed**
  - **ITRF 2000 Reference frame**
  - **Latest pre GRACE gravity model**
  - **The base tide set is from GOT 99.2 model (Richard Ray)**
    - **Complete to degree 10 for: 2N2 2Q1 Ae2 J1 L2 M1 Oo1 Phi1 Pi1 Psi1 R2 T2**
    - **Complete to degree 20 for: K1 K2 M2 N2 O1 P1 Q1 S2**
    - **Equilibrium long period tides**
    - **18.6 yr from long period rate and tide solution [Cox, et al. 2001]**
  - **Atmospheric gravity *variations wrt 2000-2001 mean* modeled**
    - **Monthly, 5x5 correction**
    - **IB assumed for Ocean**
  - **Rates and annuals for $J_{2\text{-}4}$ modeled**
    - **Reduces errors associated with non-uniform temporal tracking coverage**
  - **Much more data cleanup….**
- **Maximum spherical harmonic degree of 4 recovered, although a max degree of 5 possible with ‘93 onward**
    - **Pre ‘86 recovery of Nmax=4 field is weak**

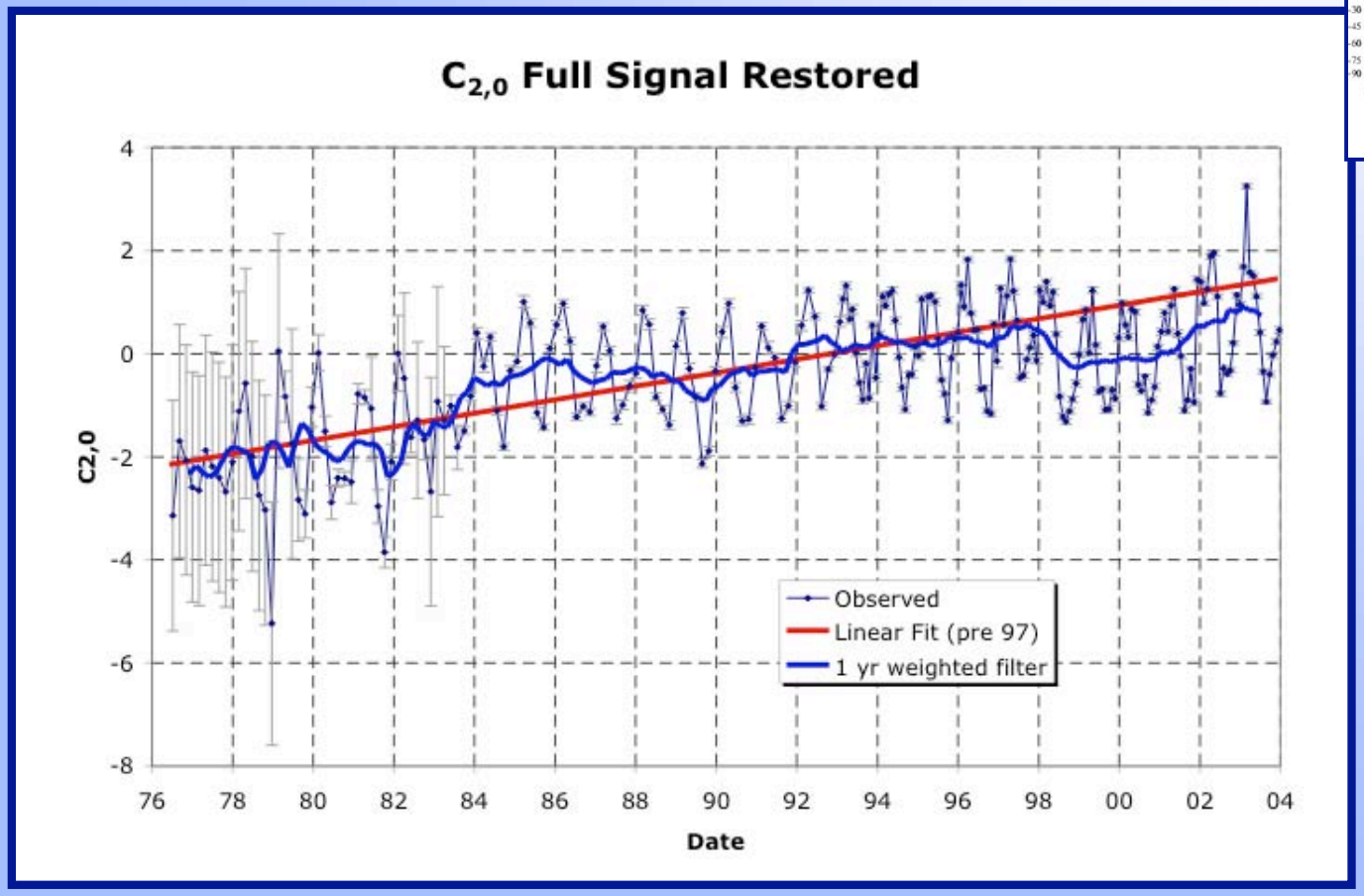
Satellites Used

SLR Satellites Used:

- **LAGEOS-1**
- **LAGEOS-2**
- **Ajisai**
- **Starlette**
- **Stella**
- **Beacon Explorer C**
- **TOPEX/Poseidon**
- **GFZ-1**
- **Westpac**

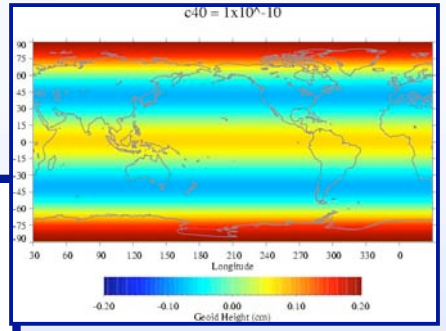
New (improved) Series $C_{2,0}$

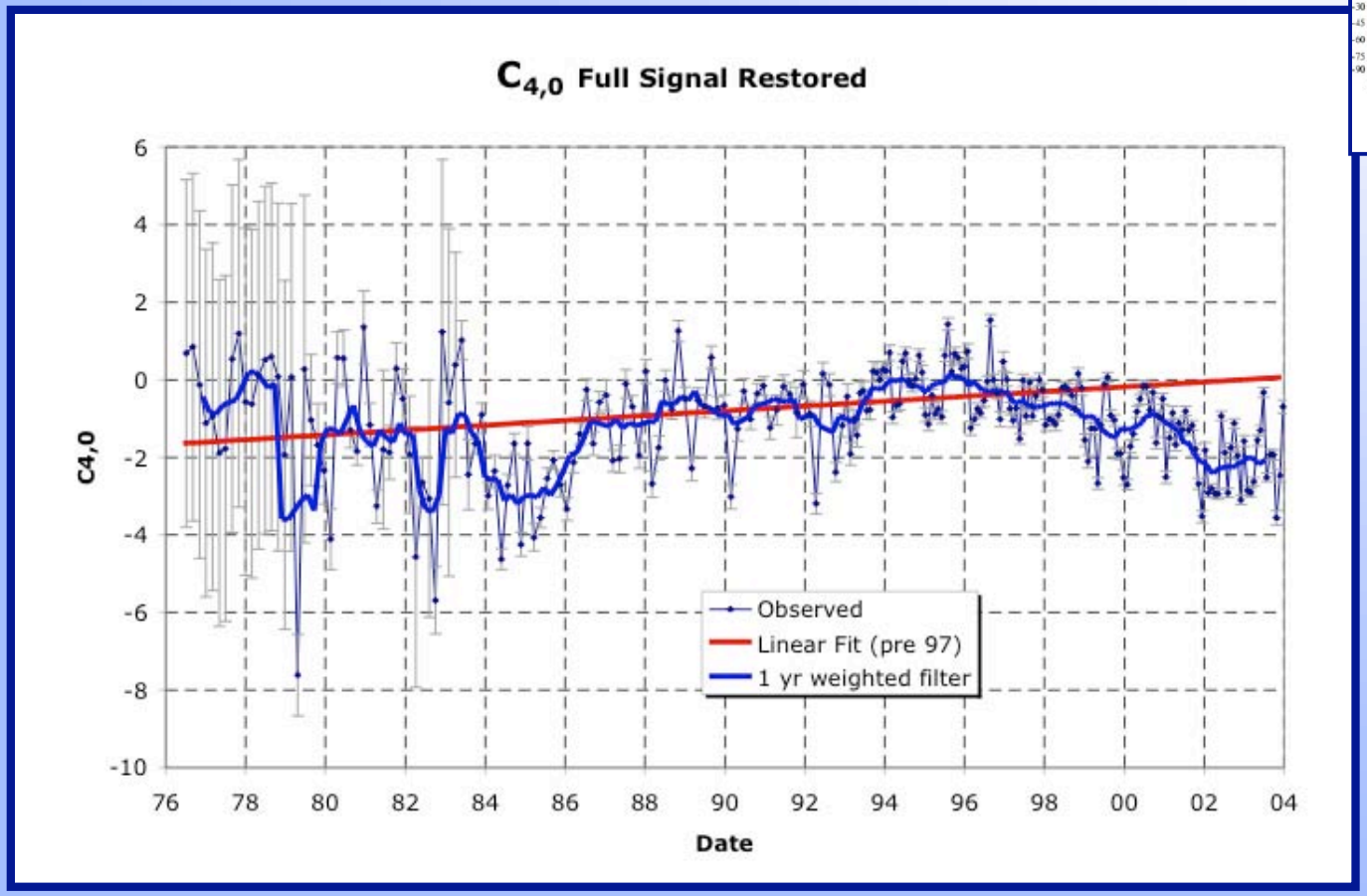




$$\overline{C}_{2,0} = \Delta J_2 / \sqrt{5}$$

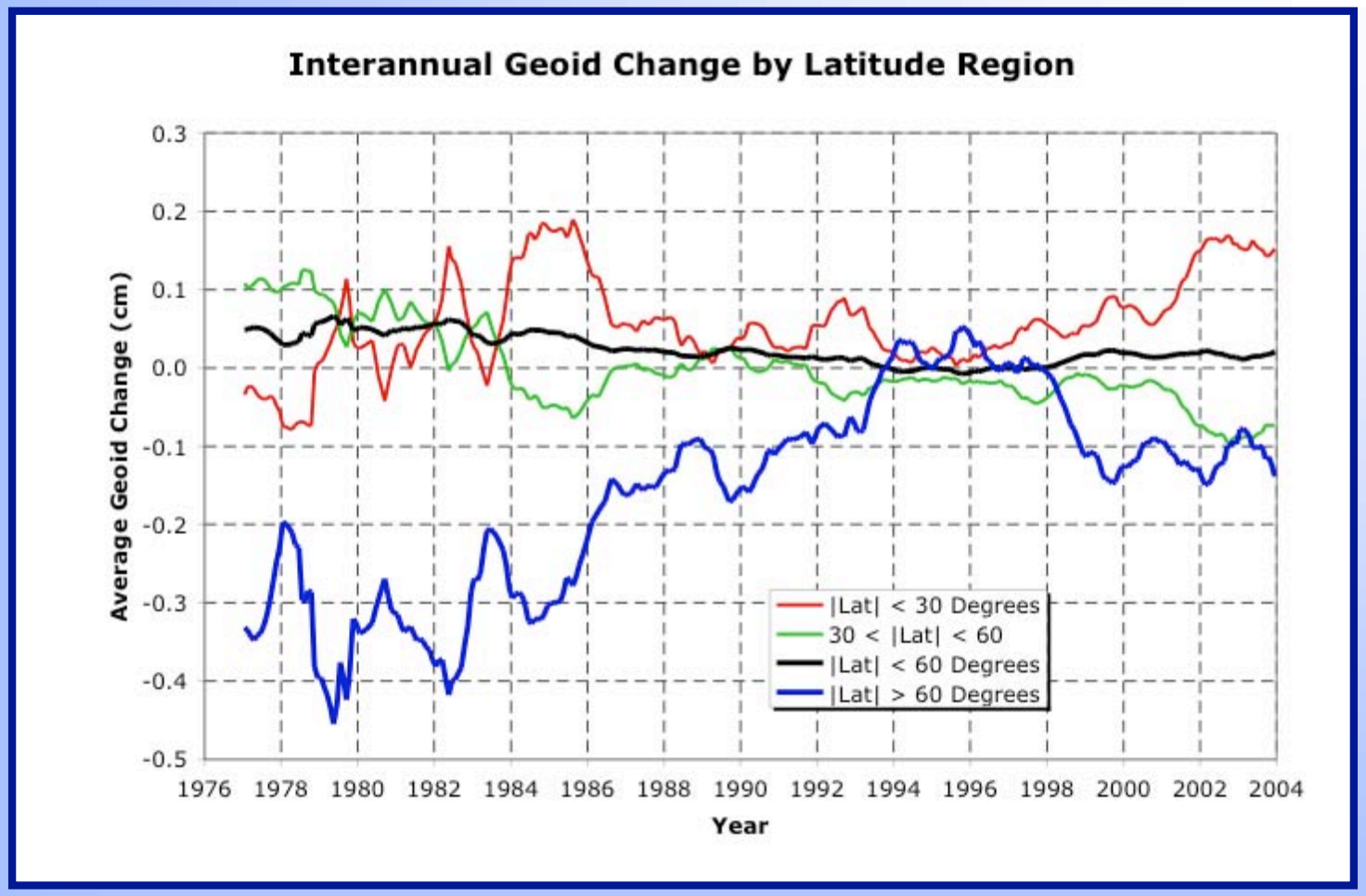
New Series $C_{4,0}$





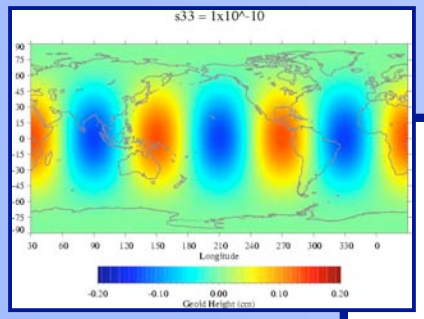
$$\overline{C}_{4,0} = \Delta J_4 / \sqrt{9}$$

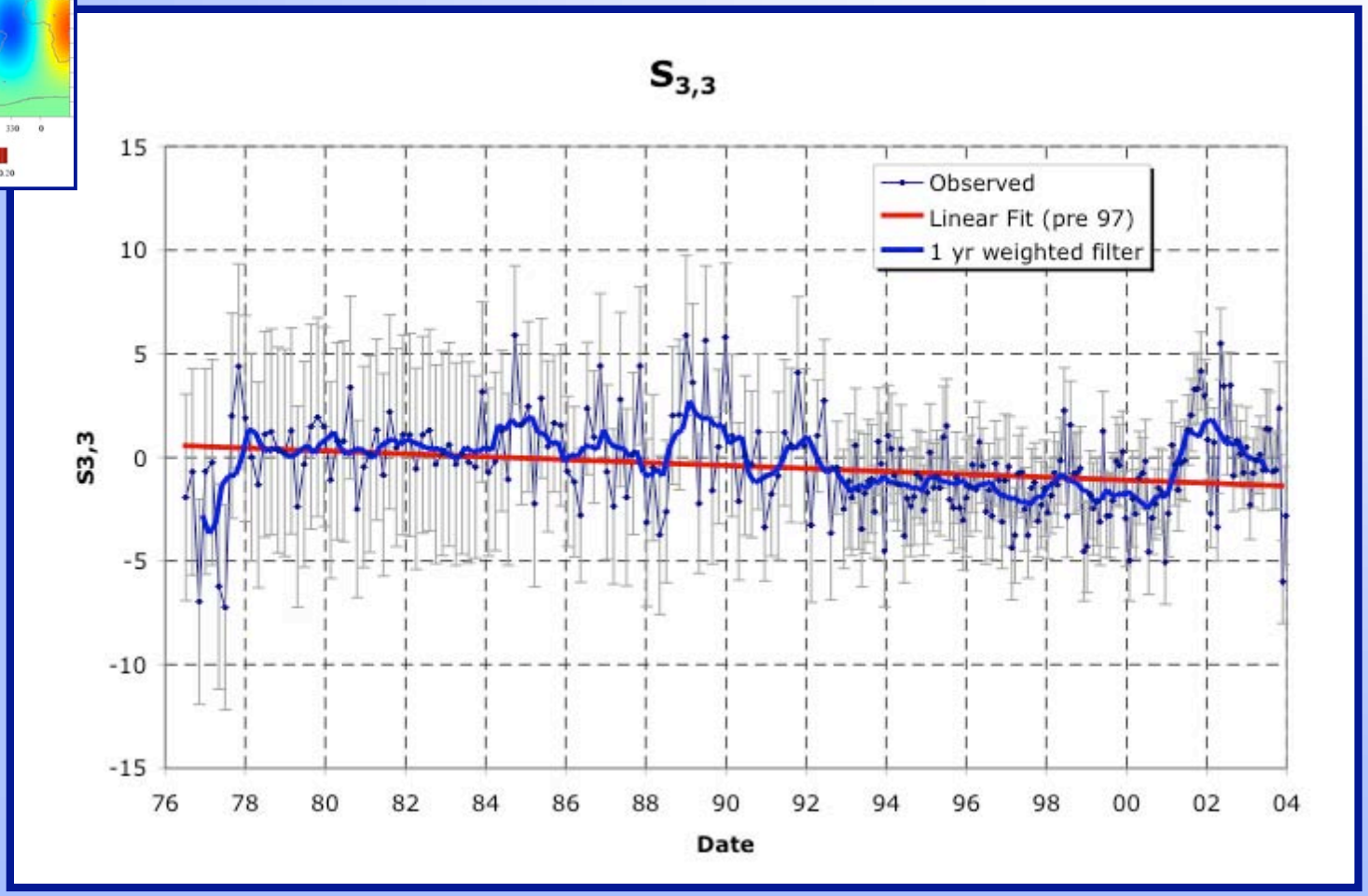
Zonal Changes in Geoid



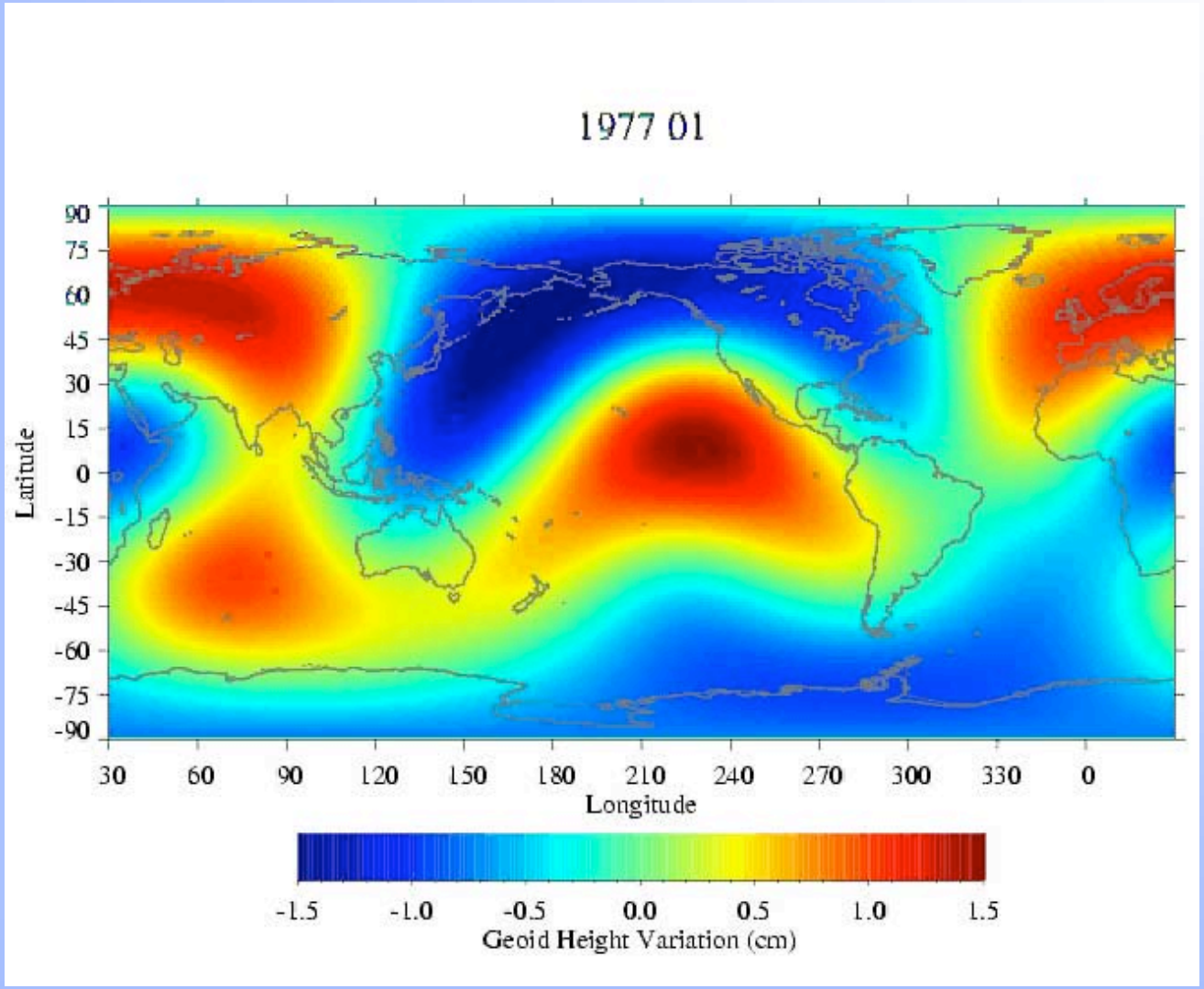
Computed from zonal harmonics only

$S_{3,3}$

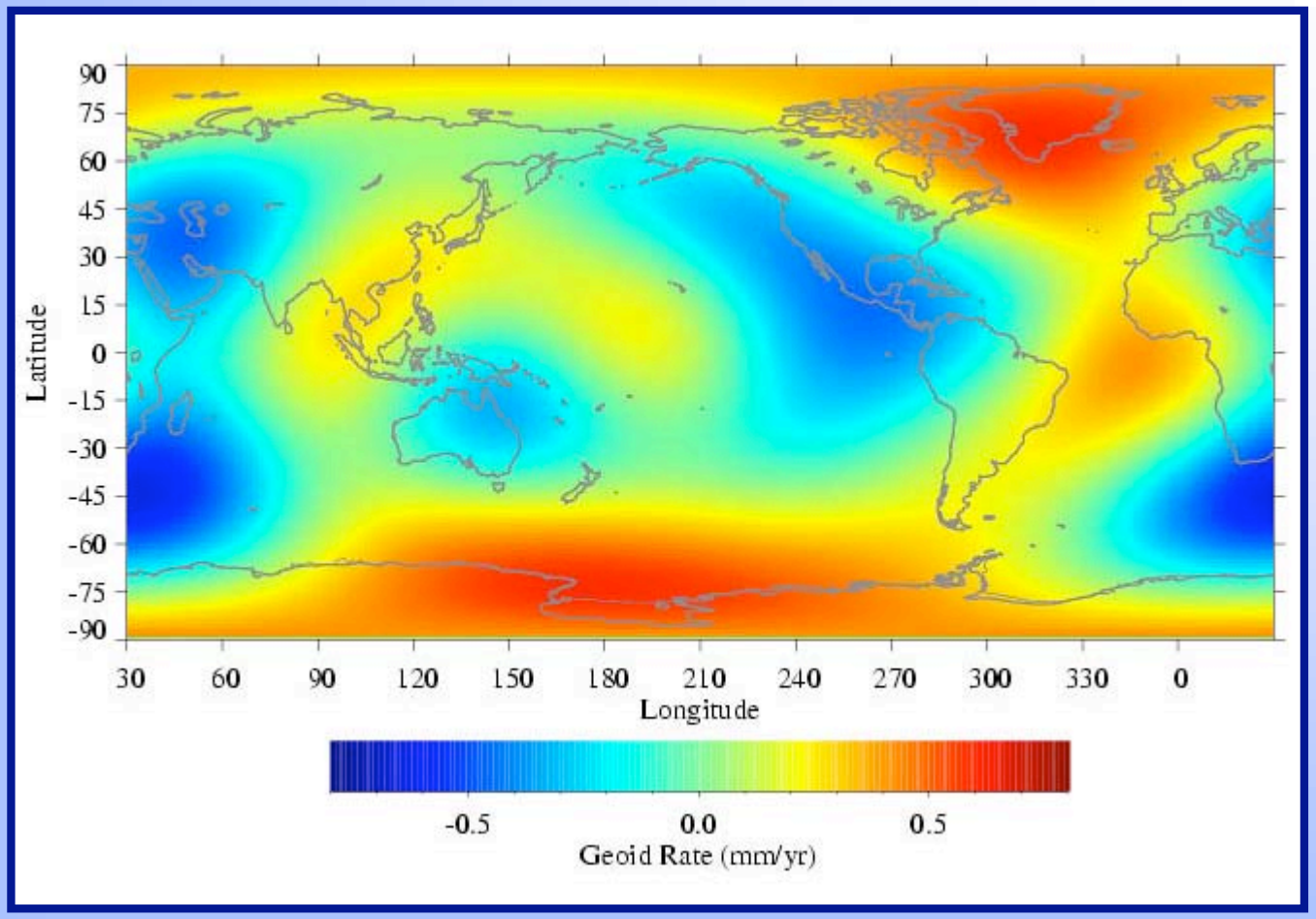

s33 = 1x10^-10
Longitude
Geoid Height (cm)


S3,3
Observed
Linear Fit (pre 97)
1 yr weighted filter
S3,3
Date
15
10
5
0
-5
-10
-15
76
78
80
82
84
86
88
90
92
94
96
98
00
02
04

Interannual Variations (SLR observed through Degree 4)



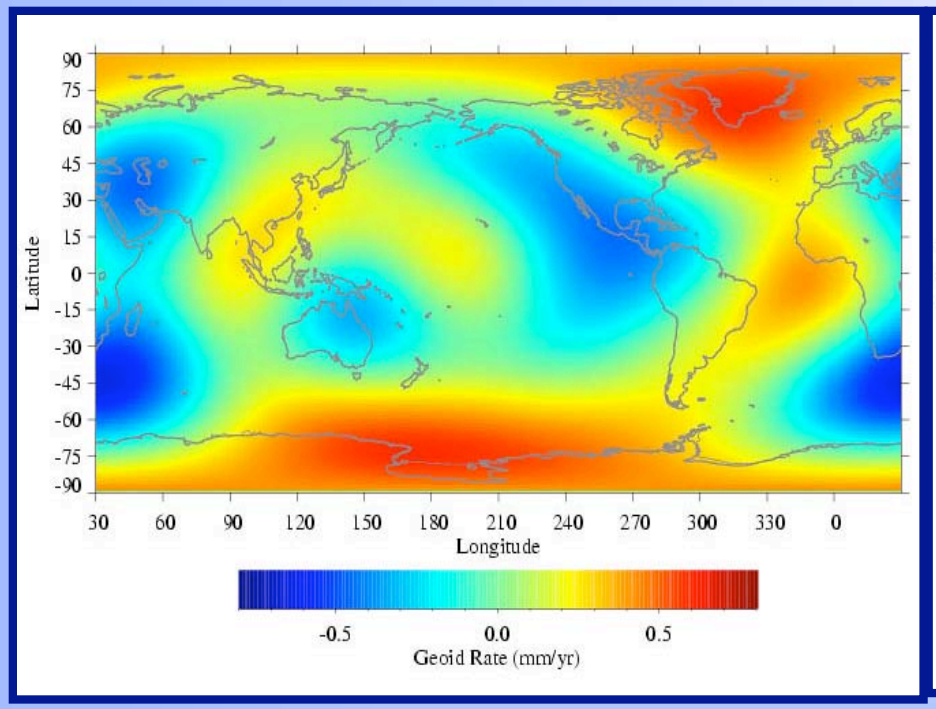
SLR Observed Geoid Rates Through Degree 4



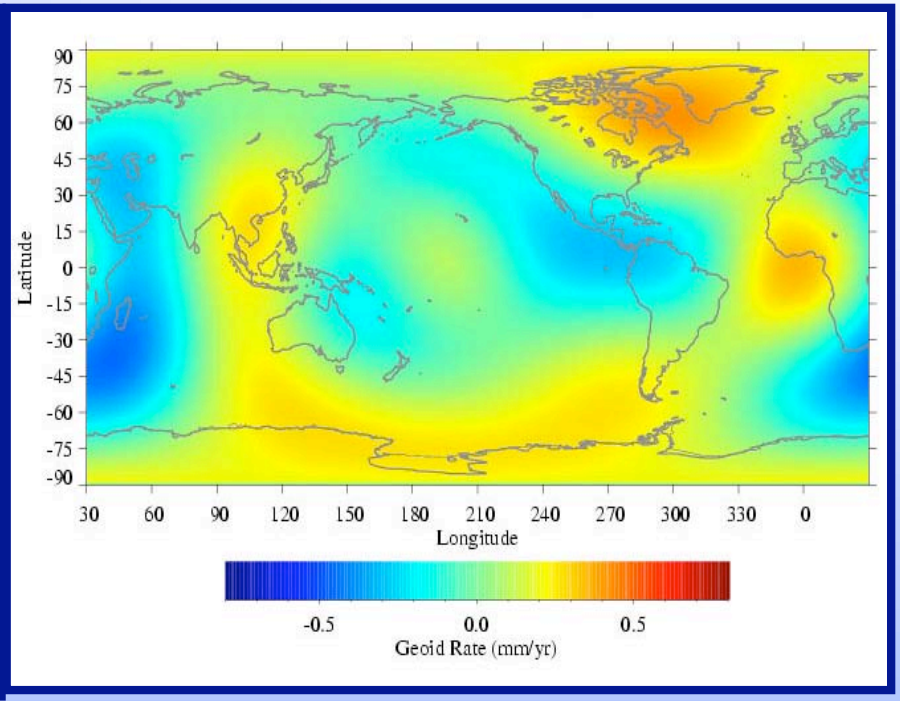
Period: 1980-1997

wrt ITRF2000 Definition for $C/S_{2,1}$ Rates

SLR Observed Geoid Rates Through Degree 4

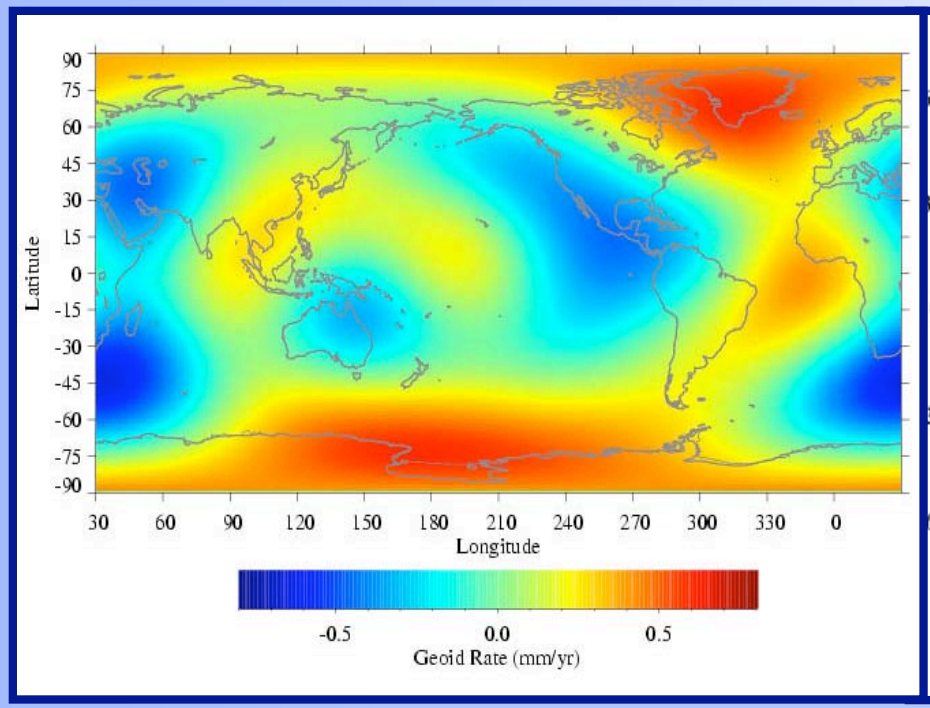


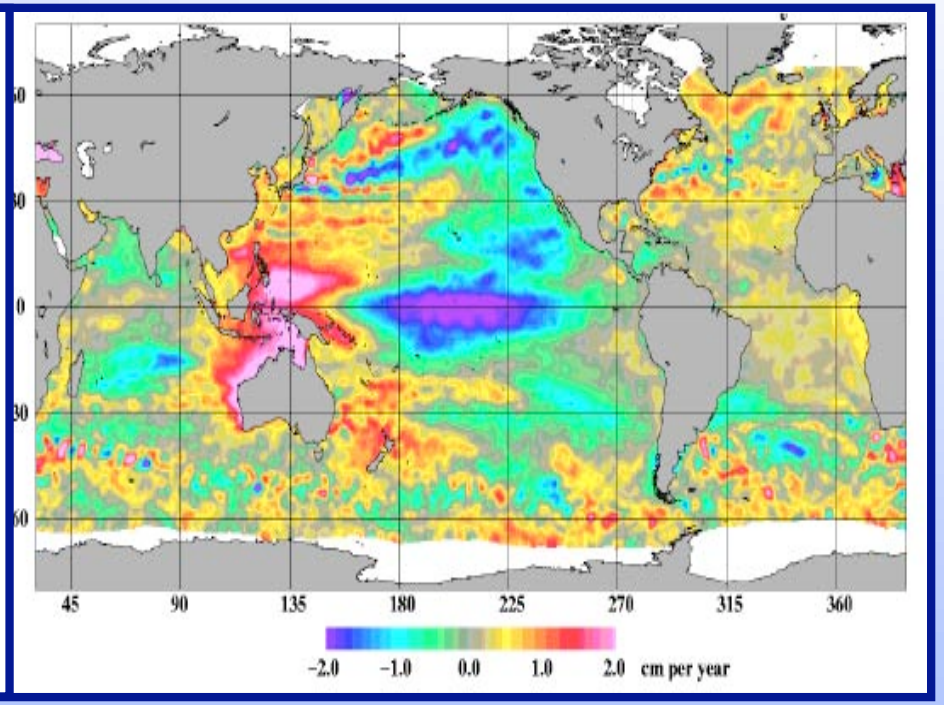
1980 - 1997



1980 - 2002

Comparison with TOPEX/Poseidon Sea Level Change

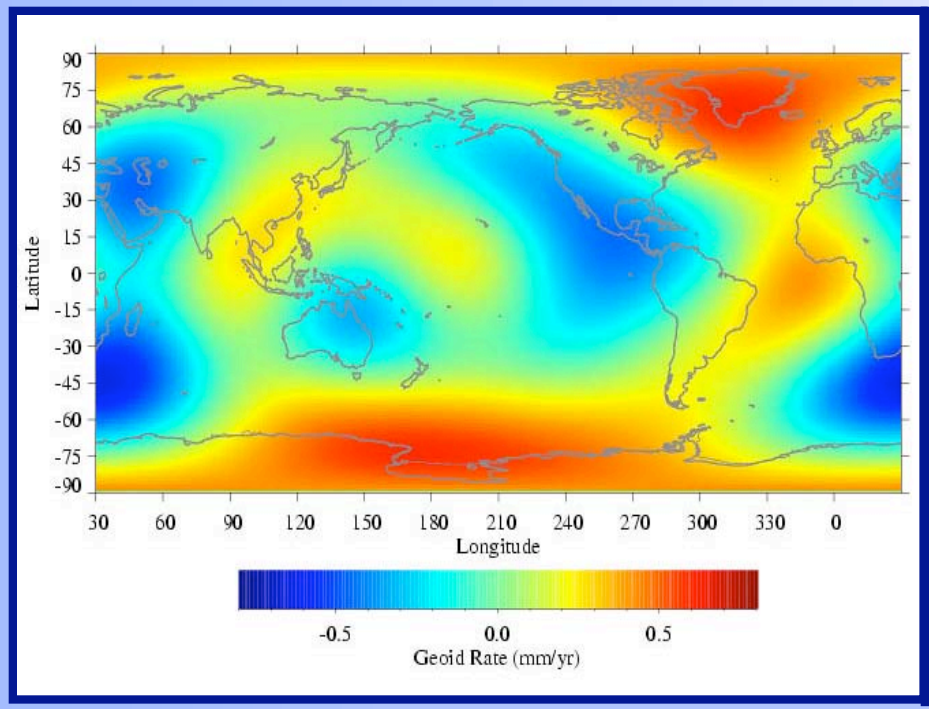


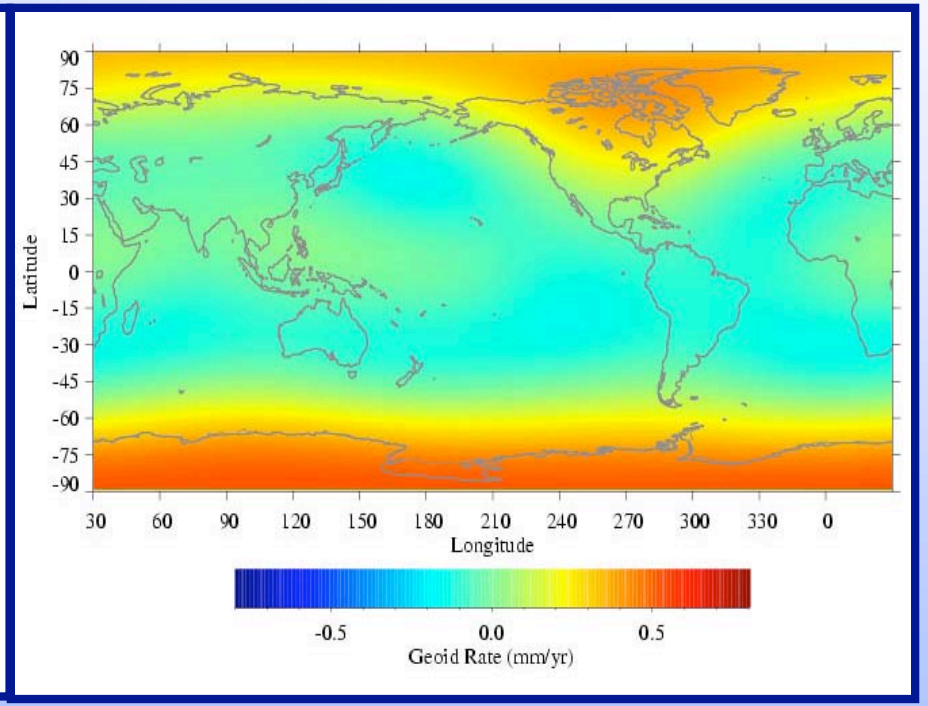


SLR, 1980 - 1997

T/P (Anderson et al. 2004)

Comparison with ICE-3G Predicted Geoid Rates Through Degree 4

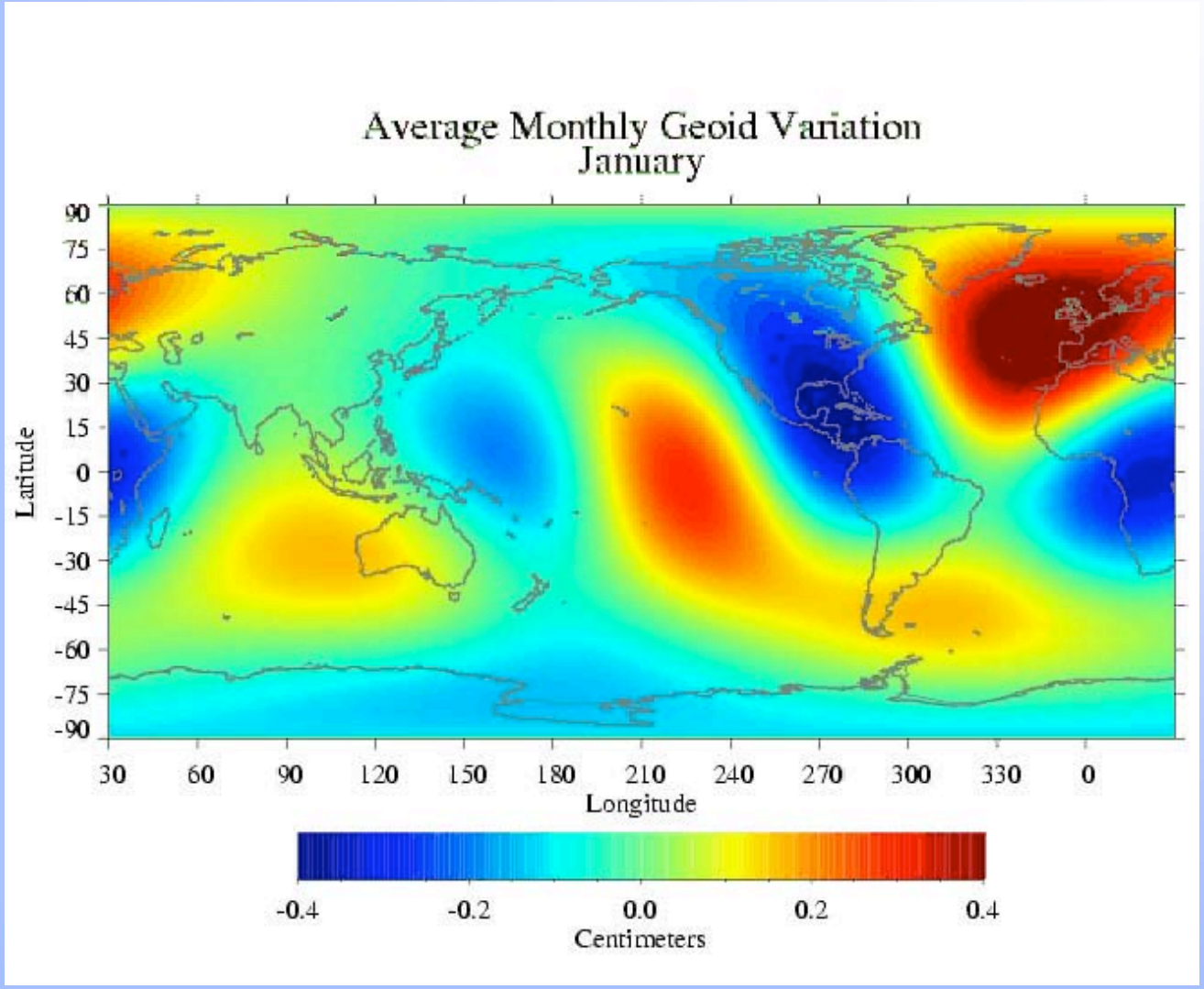




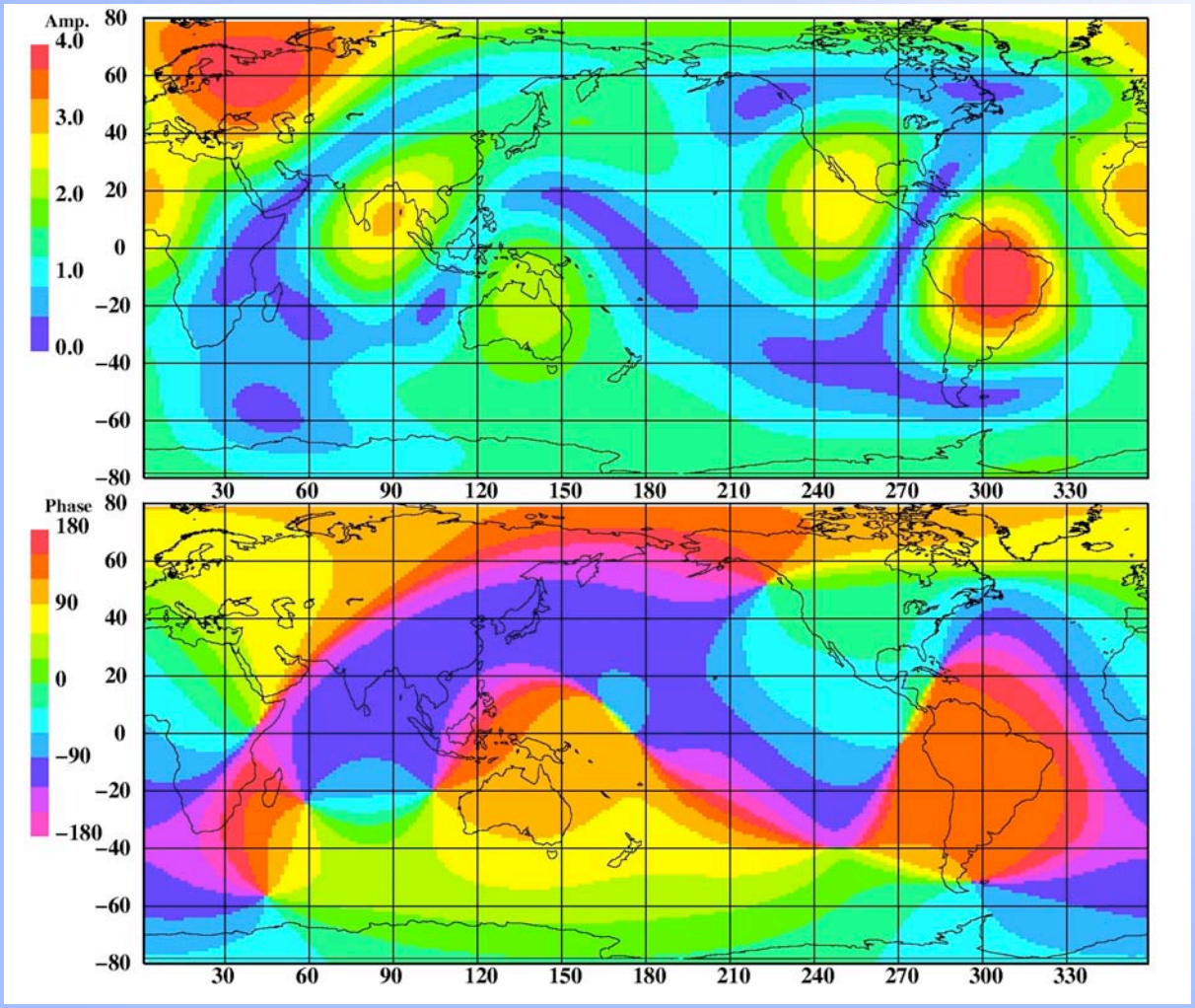
SLR, 1980 - 1997

GIA Model Courtesy of Erik Ivins
Lower Mantle Viscosity = 2×10^{21} Pa s

1998-2002 Average Annual Variation (non-atmosphere, IB)



GRACE Annual Geoid Signal (N_{max}=4) (non-atm, non-ocean)



Amplitude, mm

Courtesy of
Ole Anderson

Phase wrt Jan. 1

Conclusions

- Large change in J_2 behavior starting ~1998
  - Has returned >50% since peak
  - Ocean, Hydrology, and Mountain Glaciers each only explain ~20%?
    - Changes consistent with timing of PDO and extratropic SST and SSH changes
    - Glaciers are possibly significant contributor [*Dickey et al.*, 2002]
    - Dyurgerov [2003] data implies J_2 change on order of ECCO or Soil
  - Connection with J_4
  - Sum of zonals indicates possibility of rapid geoid drop in polar regions
    - If so, where did the mass go?
- Regional interannual geoid variation of 5 to 8 mm
  - Eastern Pacific low
    - Negative mass anomaly corresponding with El Nino?
  - Wandering geoid high in NW Pacific
  - Post 1998 low in Northern Russia
- Observed geoid rates are similar to Post Glacial Rebound predictions
  - Differences in Equatorial Regions
  - Signal in N. America/Greenland larger relative to Antarctica
    - Implications for present day mass rates?
- Long-wavelength annual signals in good general agreement with GRACE
  - Initial comparisons show similar amplitudes, structures, and phases for similar resolutions