



# Long-term LAGEOS data analysis with GRACE RL04 type non-tidal atmosphere and ocean mass variations

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## Motivation

- **Process LAGEOS data with GRACE RL04 standards**
  - **Direct comparison with GRACE results**
  - **Rigorous combination with GRACE**
  - **Long-term meteorological/hydrological analysis**
  
- **Therefore**
  - **Extension of the Atmosphere and Ocean De-aliasing (AOD) product to the pre-GRACE era back to 1976**
  - **AOD consistency over time for LAGEOS applications**

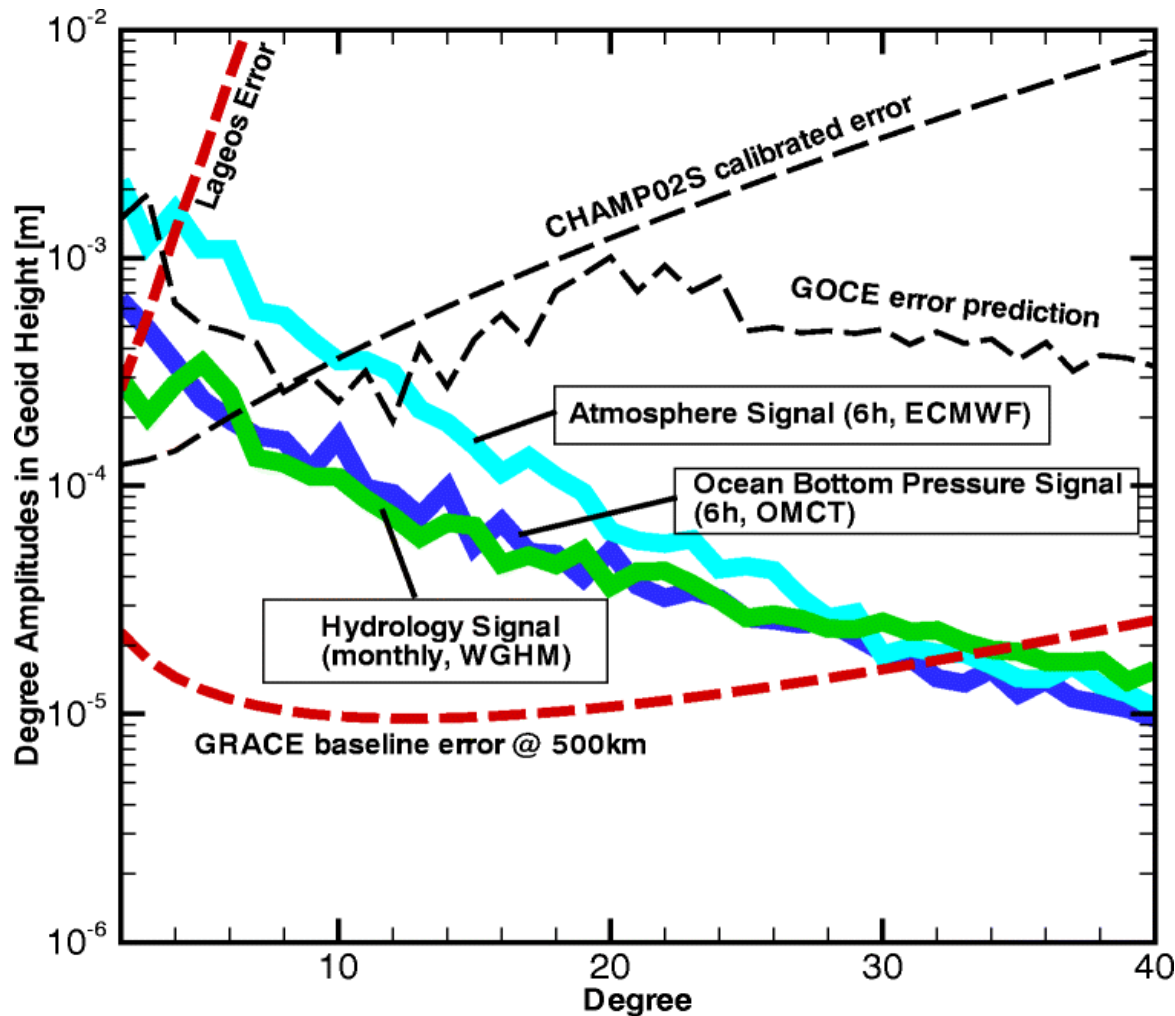


## The AOD Products

- **Why AOD?**
  - **Appropriate models for Earth, atmosphere, ocean tides exist**
  - **GRACE is sensitive to short-term (weekly to hourly) non-tidal mass variations in atmosphere, oceans and continental water storage**
  - **AOD products are short-term non-tidal atmospheric and oceanic mass variation models**
- **GRACE AOD1B products:**
  - **6-hourly series of spherical harmonics up to degree and order 100**
  - **Routinely provided by the GRACE Science Data System**
  - **Based on ECMWF operational data**
  - **Available for CHAMP and GRACE processing since 2001**



## Mission Sensitivities to Atmosphere, Ocean, Hydrology



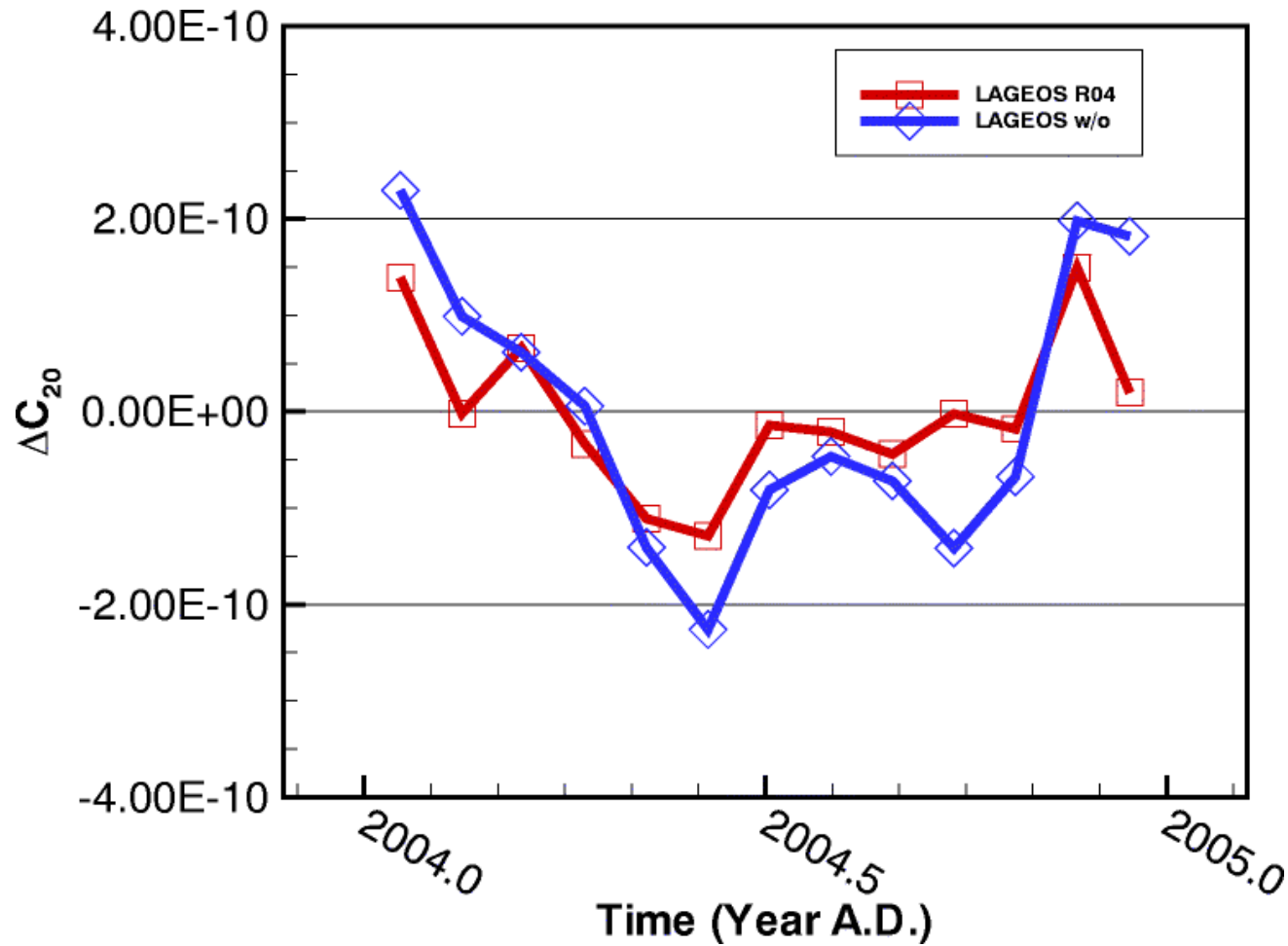


## The AOD Products, II

- **Backward extension:**
  - **Vertical integration -> surface pressure (vertical structure of atmospheric masses neglected)**
  - **ECMWF operational data -> ERA-40 (ECMWF re-analysis over 40 years) data**
  - **Consistency for LAGEOS processing checked in overlapping period 2001**



## Impact on LAGEOS derived $C(2,0)$



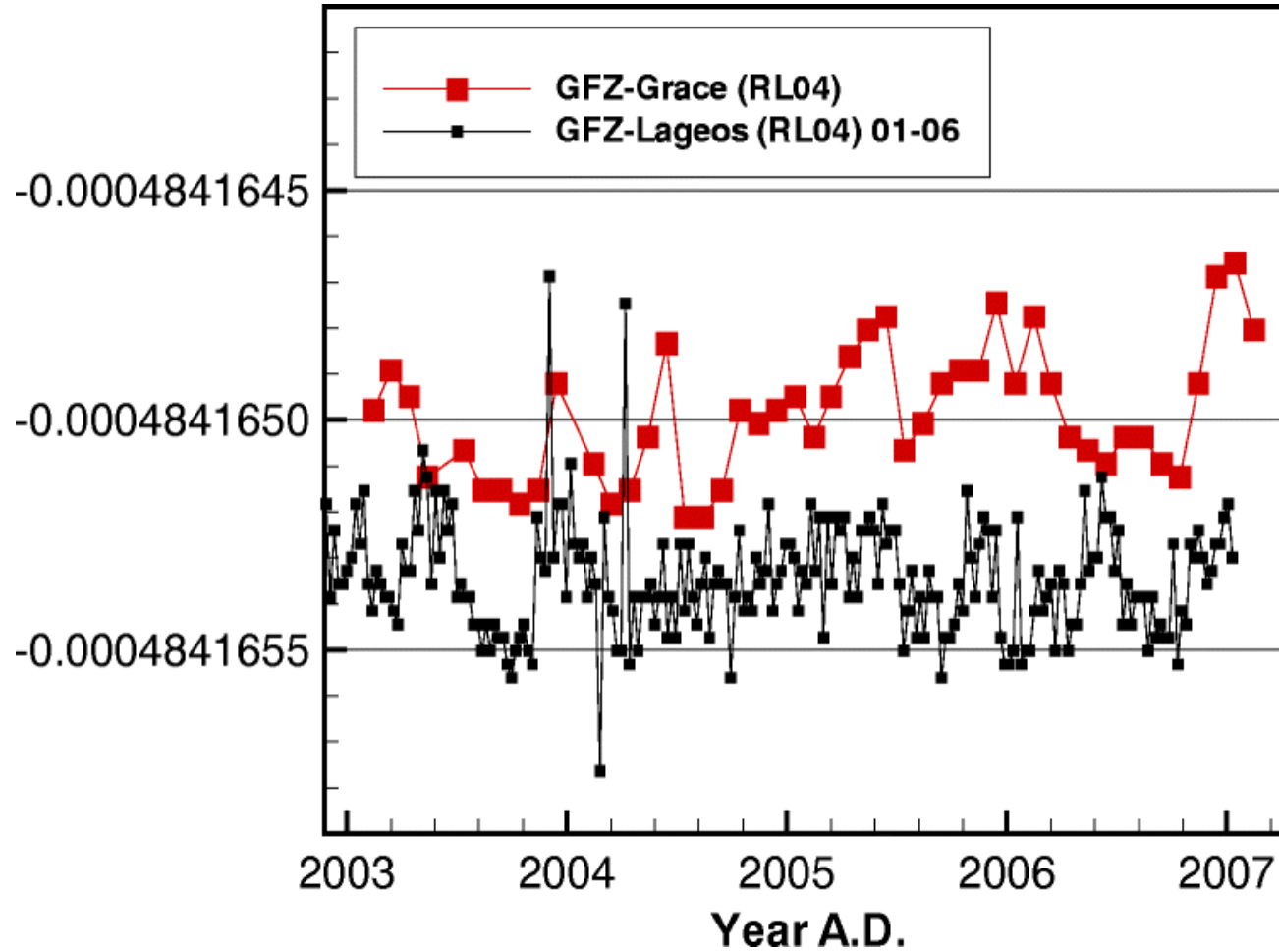


## The LAGEOS Solution

- Weekly arcs from LAGEOS-1 and -2 for OCT 1992 to DEC 2006
- GRACE RL04 standards
  - A priori gravity EIGEN-GL04C
  - Ocean tides FES2004
  - Atmospheric tides Bode&Biancale2003
  - De-aliasing AOD1B ...
- Weekly normal equations summed up to yield
  - Global station coordinates
  - Daily EOPs
  - Global gravity field coefficients up to degree and order 10, except
  - weekly C(2,0)

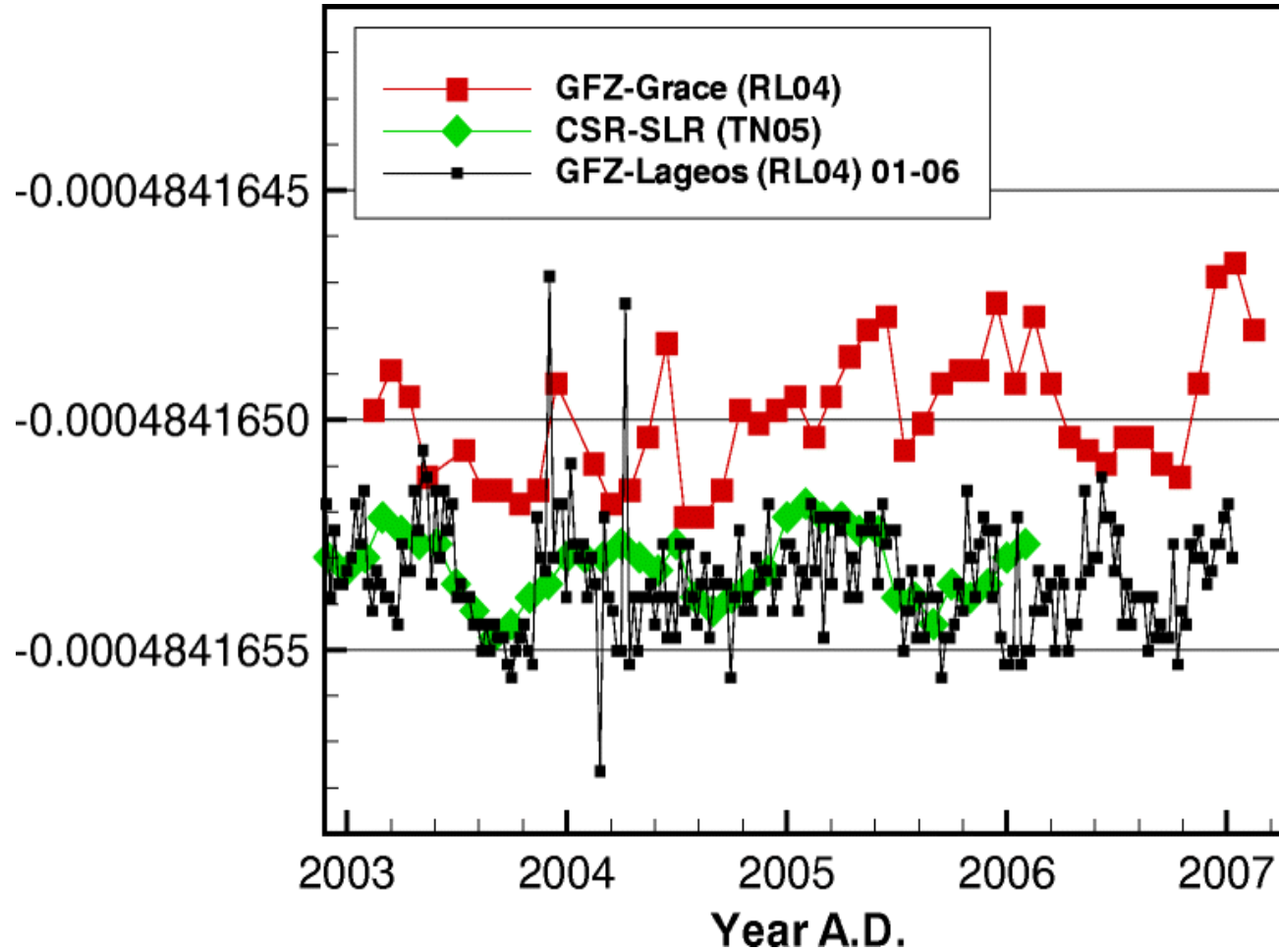


## Comparison of C(2,0) to External Series



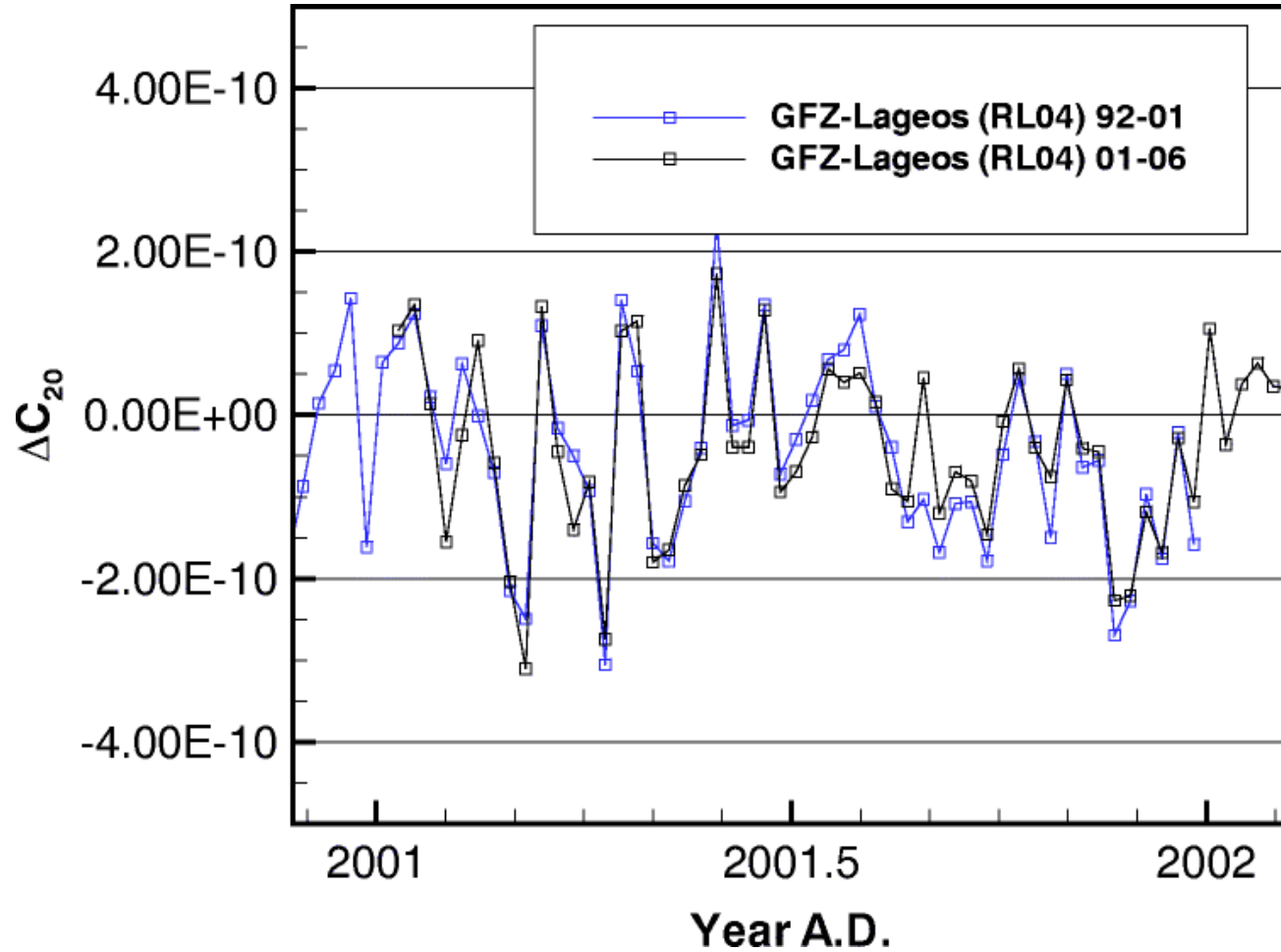


## Comparison to External Series, II



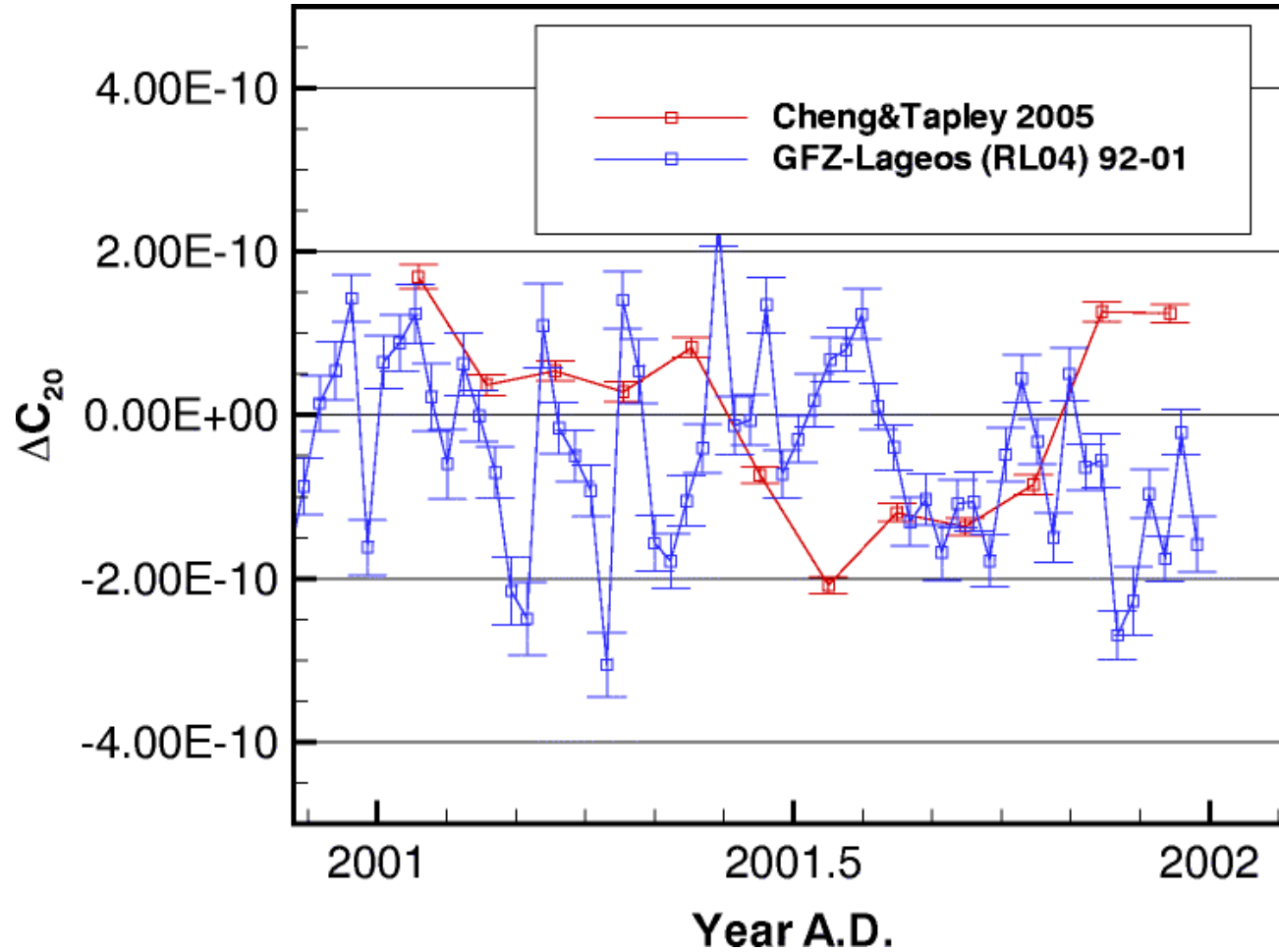


## Consistency of Series in 2001



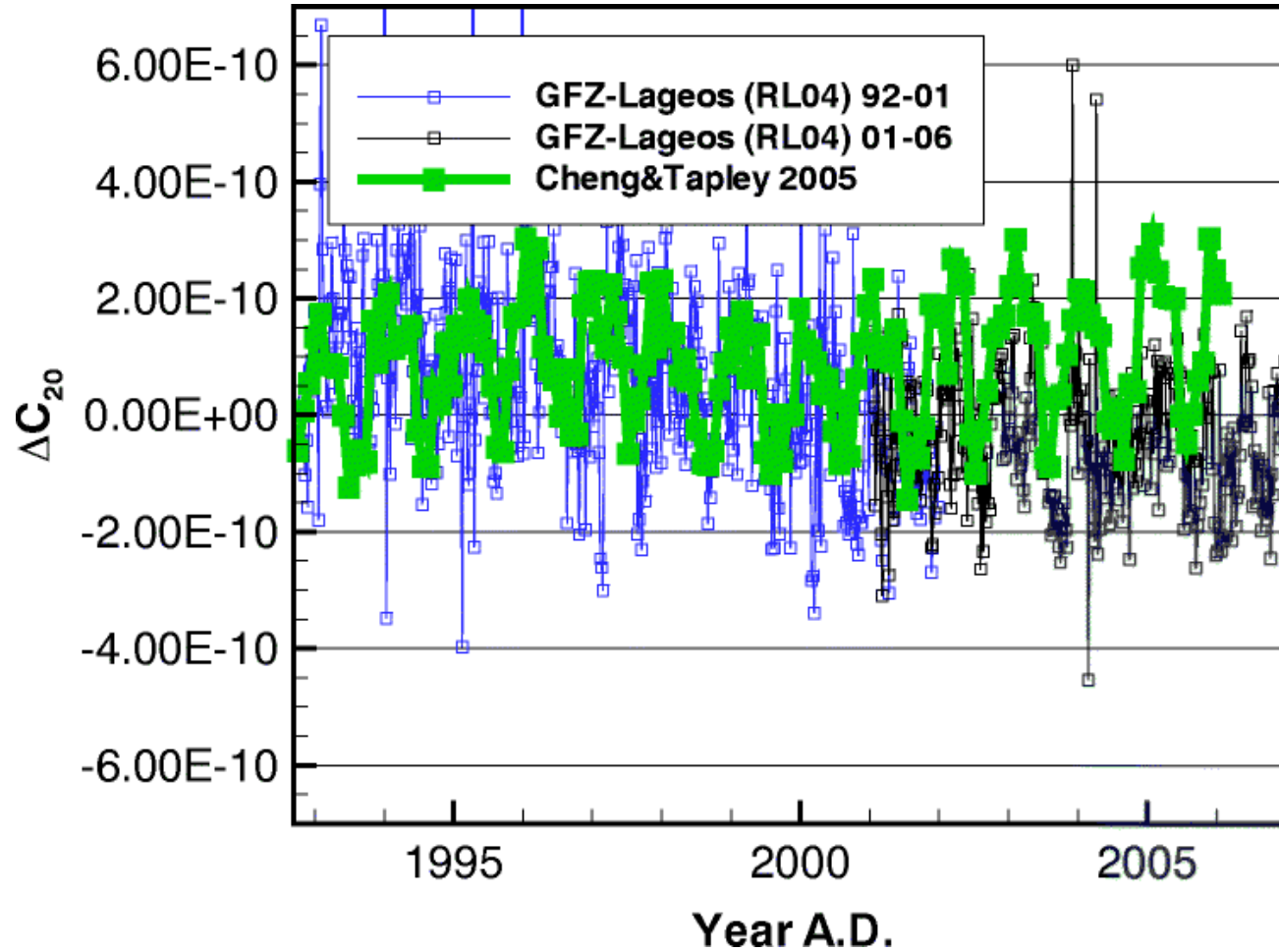


### Comparison to External Series, III



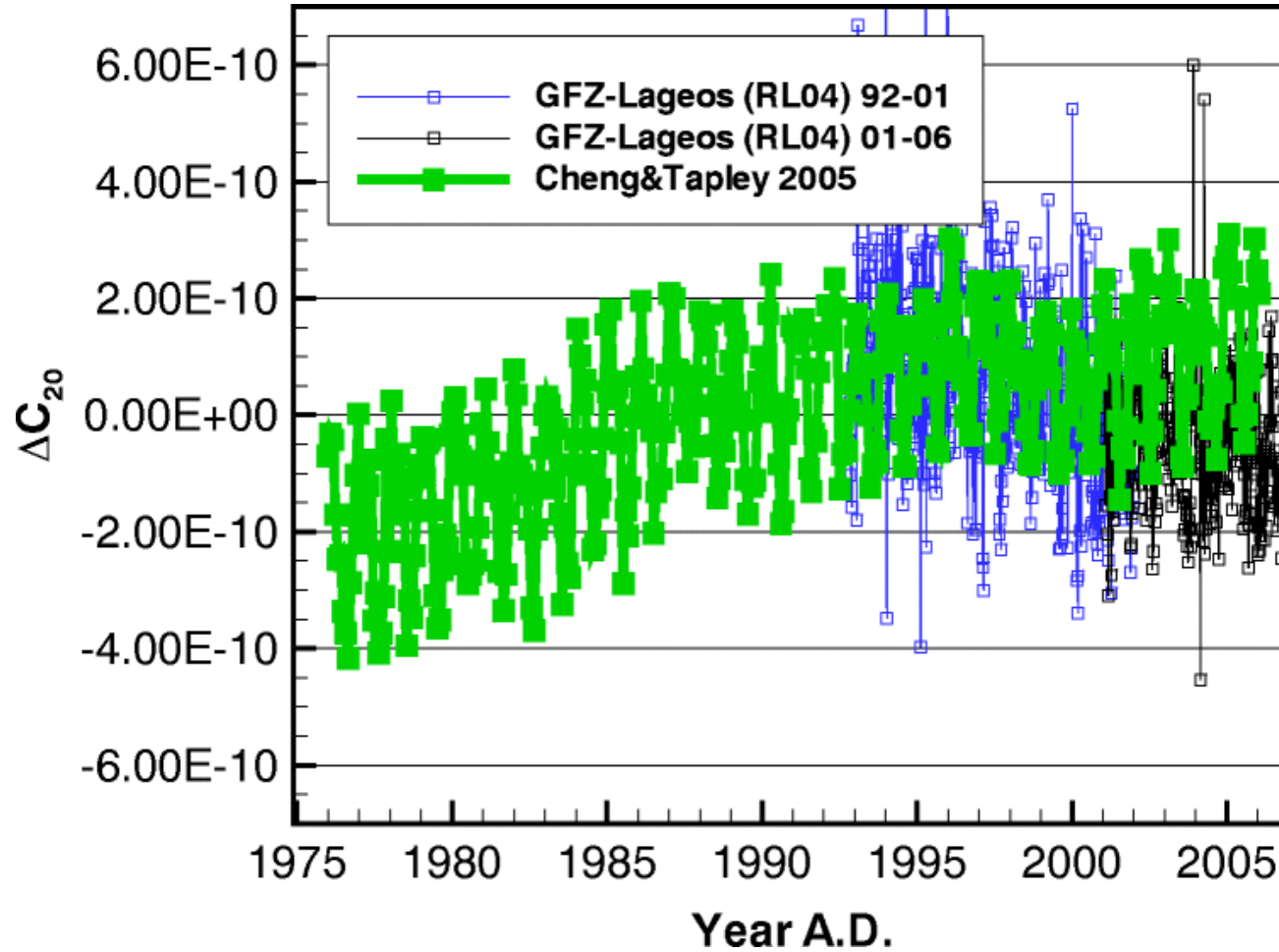


## Comparison to External Series, IV



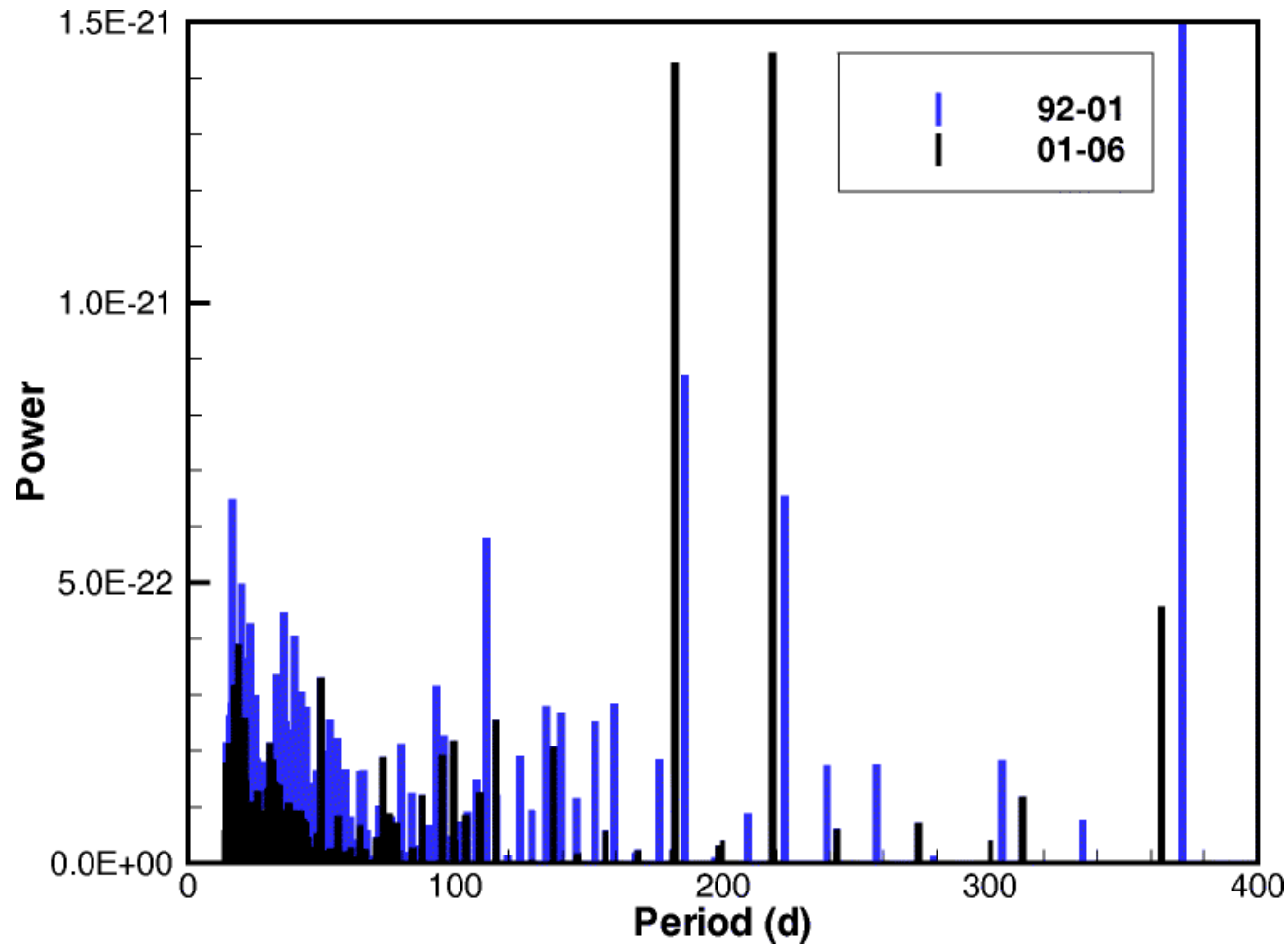


## Comparison to External Series, V





## Frequency Spectrum Contained





## Conclusions

- Consistent AOD product available for LAGEOS RL04 processing
- LAGEOS RL04 C(2,0) series 1992-2006
  - Reliable estimates, higher scatter in weekly resolution
  - AOD removes part of annual signal in C(2,0)
  - Long-term trend different to Cheng&Tapley 2005 ?
    - Due to ERA40 ?
  - Dominant periods at 365, 220, 182, 112, 50, 20 days