Evaluating Tide Models for Operational Prediction of EOPs

Richard S. Gross

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109–8099, USA

18th International Symposium on Geodynamics and Earth Tides

June 5–9, 2016
Trieste, Italy

© 2016 California Institute of Technology. U.S. Government sponsorship acknowledged.

Introduction

- Tide raising potential
  - Symmetric about Earth's polar axis
  - Deforms axisymmetric solid Earth
    - Excites length-of-day but not polar motion
  - Deforms asymmetric oceans
    - Excites length-of-day and polar motion
- Examine tidal effects on polar motion
  - Remove atmospheric and oceanic effects from observations
    - Strong fortnightly tidal signal evident in residual observations
  - Evaluate recent dynamic ocean tide models
    - Including recent model of Ray & Egbert (2012)
    - Does any recent dynamic ocean tide model fully explain observed signal?
  - Evaluate recent empirical ocean tide models
    - Including recent model of Ray & Egbert (2012)

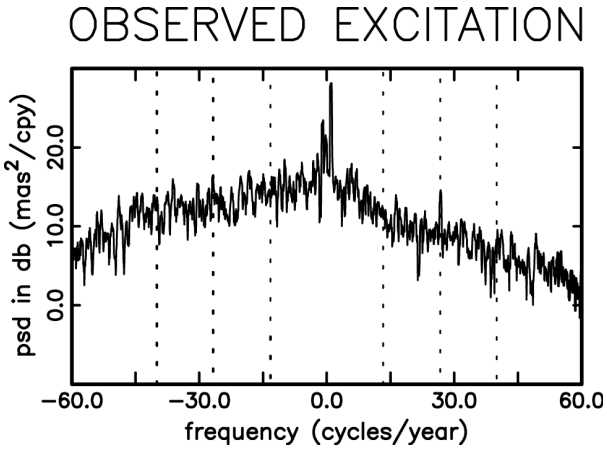
Data Sets

- Observed polar motion excitation
  - COMB2009 combined EOP series
    - Combination of optical astrometric, LLR, SLR, VLBI, & GNSS observations
    - Polar motion rate observations not used (contaminated by tidal artifacts)
    - Daily values at midnight spanning January 20, 1962 to May 28, 2010
- Remove atmospheric & non-tidal oceanic effects
  - NCEP/NCAR reanalysis AAM
    - Wind & inverted barometer pressure terms
    - Daily values at midnight spanning January 2, 1948 to July 17, 2010
  - ECCO/JPL OAM model kf080
    - Constrained by *in situ* & altimetric data
    - Daily values at midnight spanning January 2, 1993 to June 29, 2010

Tide models

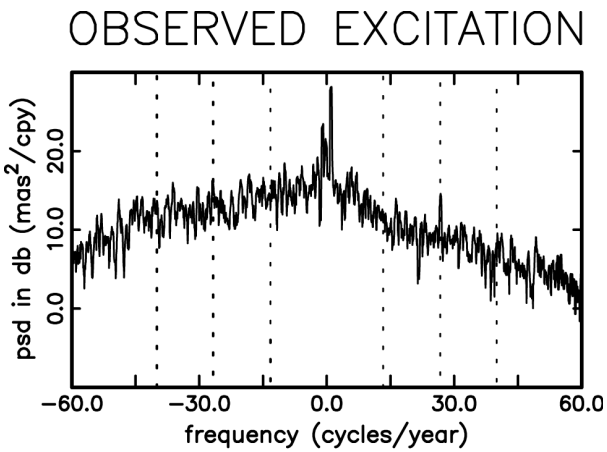
- Dynamic ocean tide models
  - Dickman (1993) as reported by Gross et al. (1997)
    - Hydrodynamic ocean model unconstrained by data (Sa, Ssa, Mm, Mf, Mtm, …)
  - Dickman & Nam (1995) reported by Dickman & Gross (2010)
    - Revised version of Dickman (1993) model (Sa, Ssa, Mm, Mf, Mtm, …)
  - Weis (2006) as reported by Gross (2009)
    - Hydrodynamic ocean model unconstrained by data (Sa, Ssa, Mm, Mf, Mtm, …)
  - Ray and Egbert (2012)
    - Hydrodynamic ocean model constrained by altimeter data (Mf only)
- Empirical ocean tide models
  - Gross et al. (1997), Gross (2009), Gross & Dickman (2011)
    - Weighted least-squares fit to observations (Mm, Mf, Mtm)
    - Nodal variations modeled by constraining Mf & mf (Gross, 2009; GD, 2011)
  - Ray and Egbert (2012)
    - Unweighted least-squares fit to observations spanning 1988–2009 (Mf reported)
    - Nodal variations modeled by applying amp & phase modulation parameters

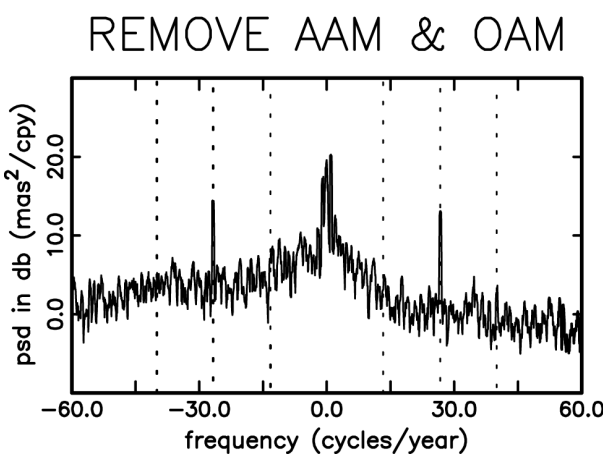
Dynamic Ocean Tide Models



(March 25, 1995 to May 28, 2010)

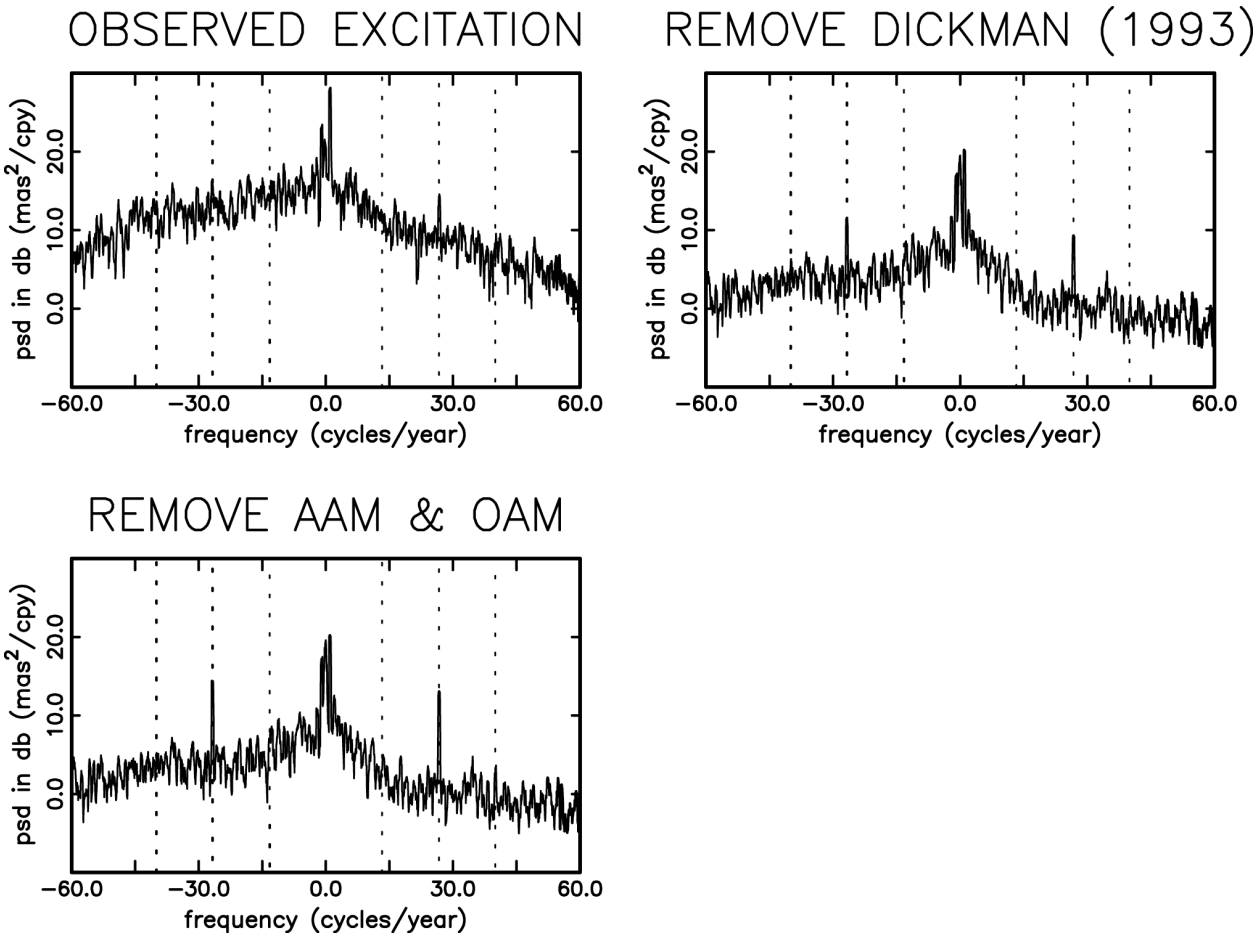
Dynamic Ocean Tide Models





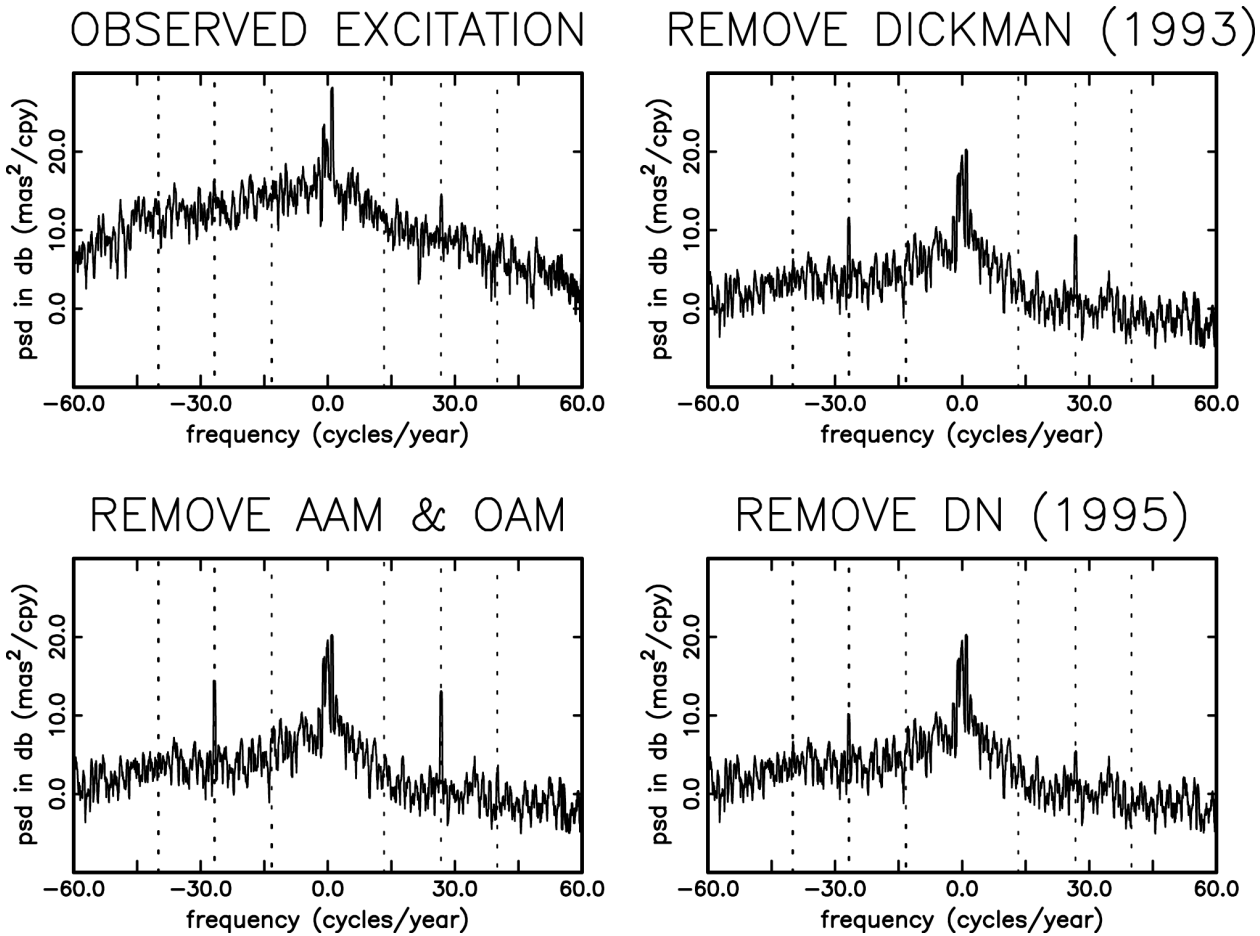
(March 25, 1995 to May 28, 2010)

Dynamic Ocean Tide Models



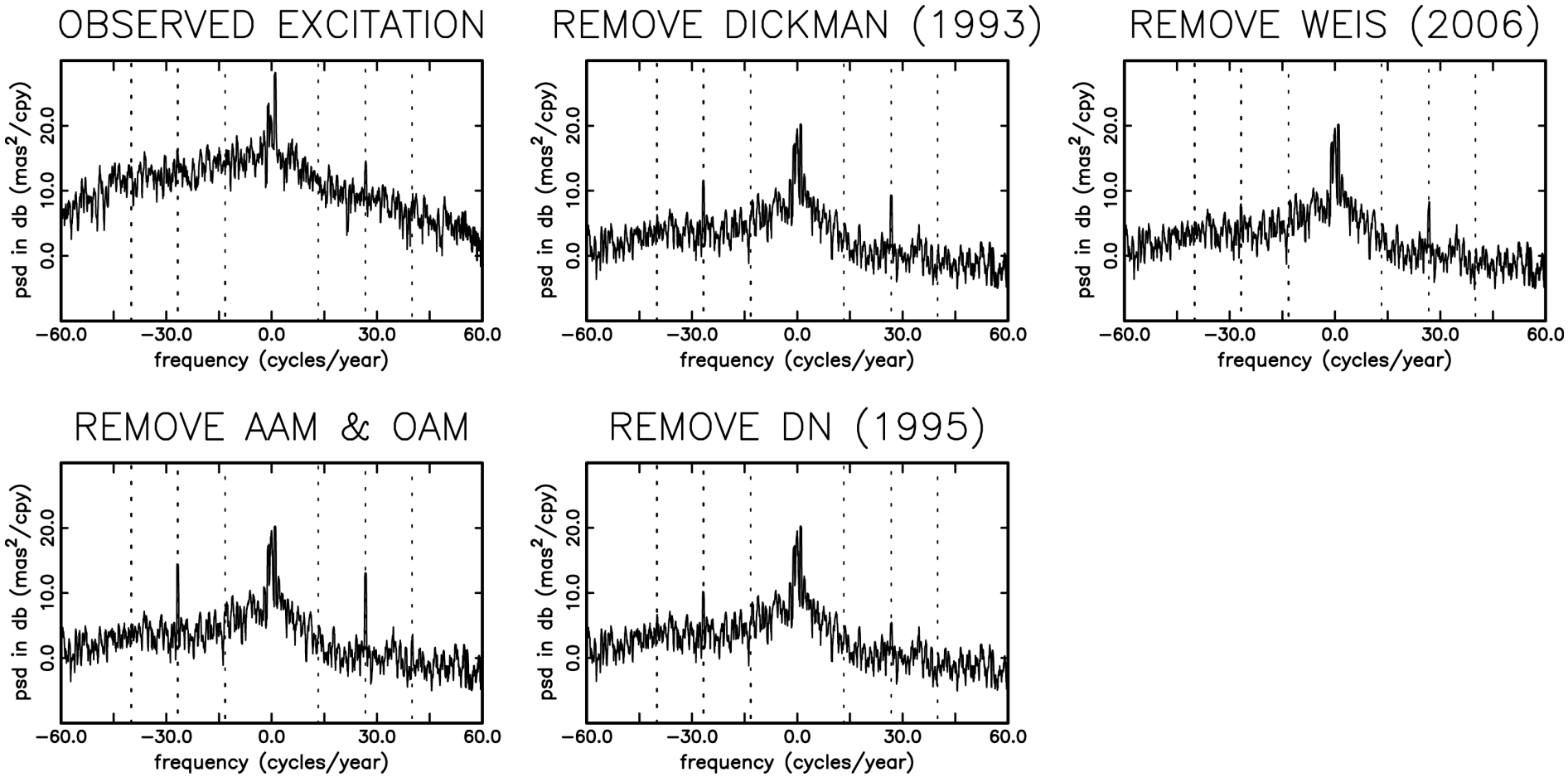
(March 25, 1995 to May 28, 2010)

Dynamic Ocean Tide Models



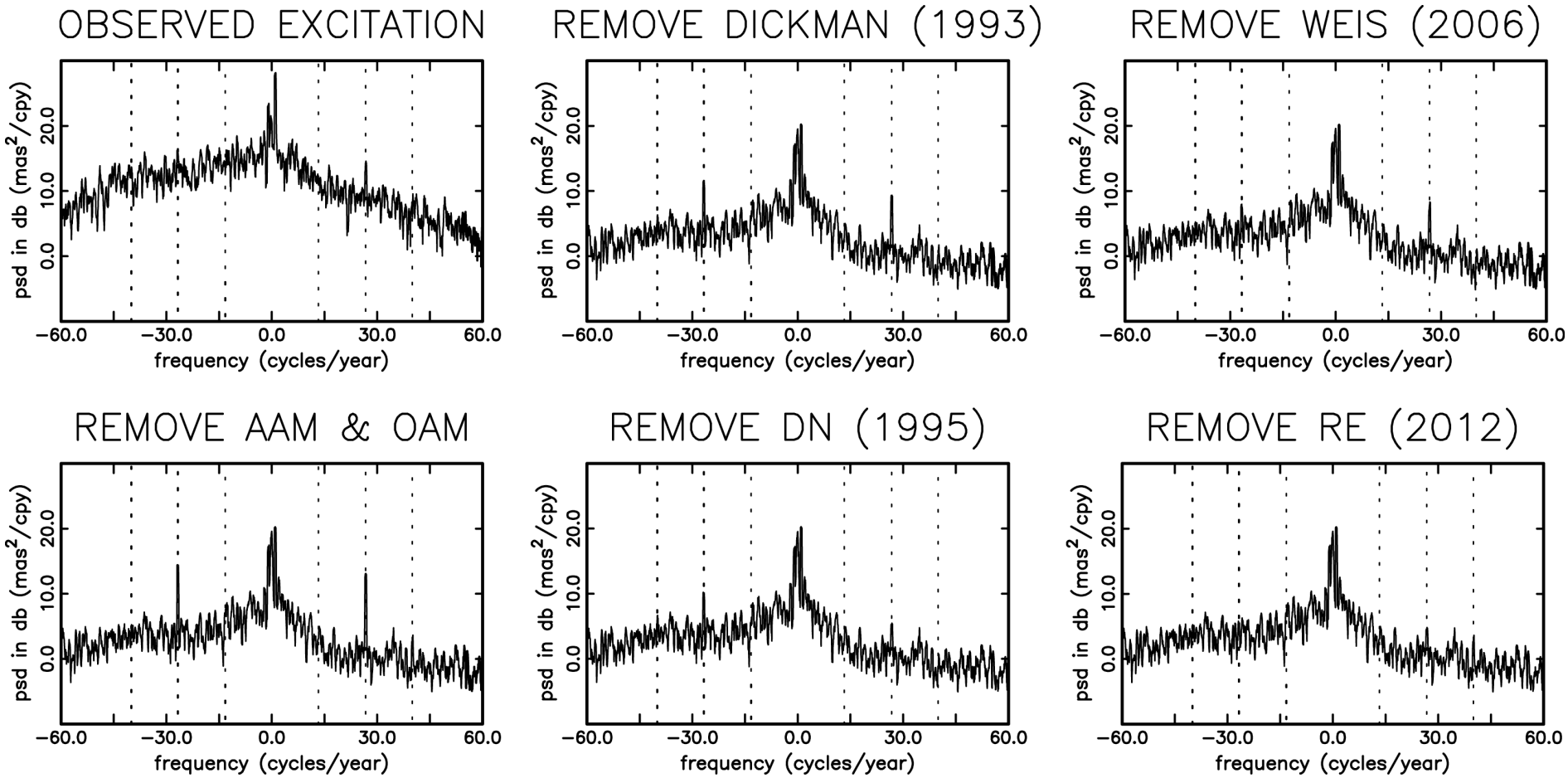
(March 25, 1995 to May 28, 2010)

Dynamic Ocean Tide Models



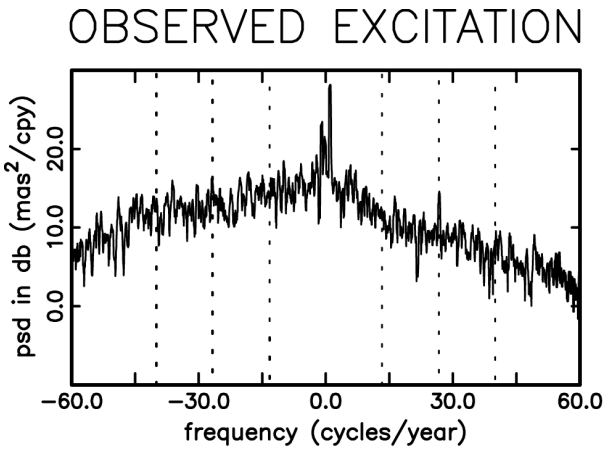
(March 25, 1995 to May 28, 2010)

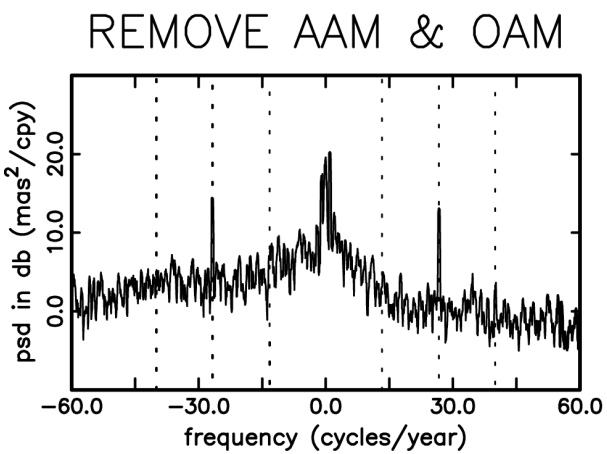
Dynamic Ocean Tide Models

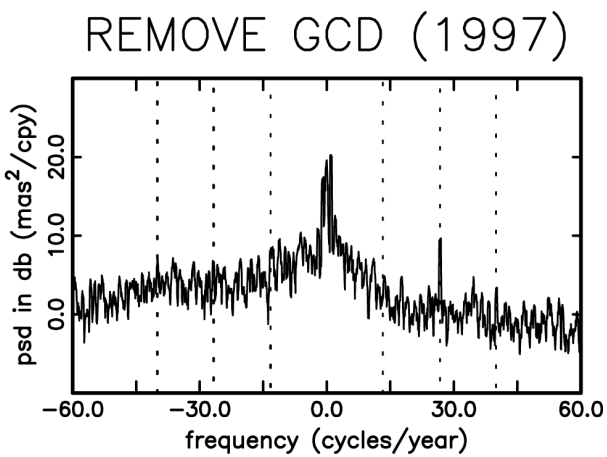


(March 25, 1995 to May 28, 2010)

Empirical Ocean Tide Models

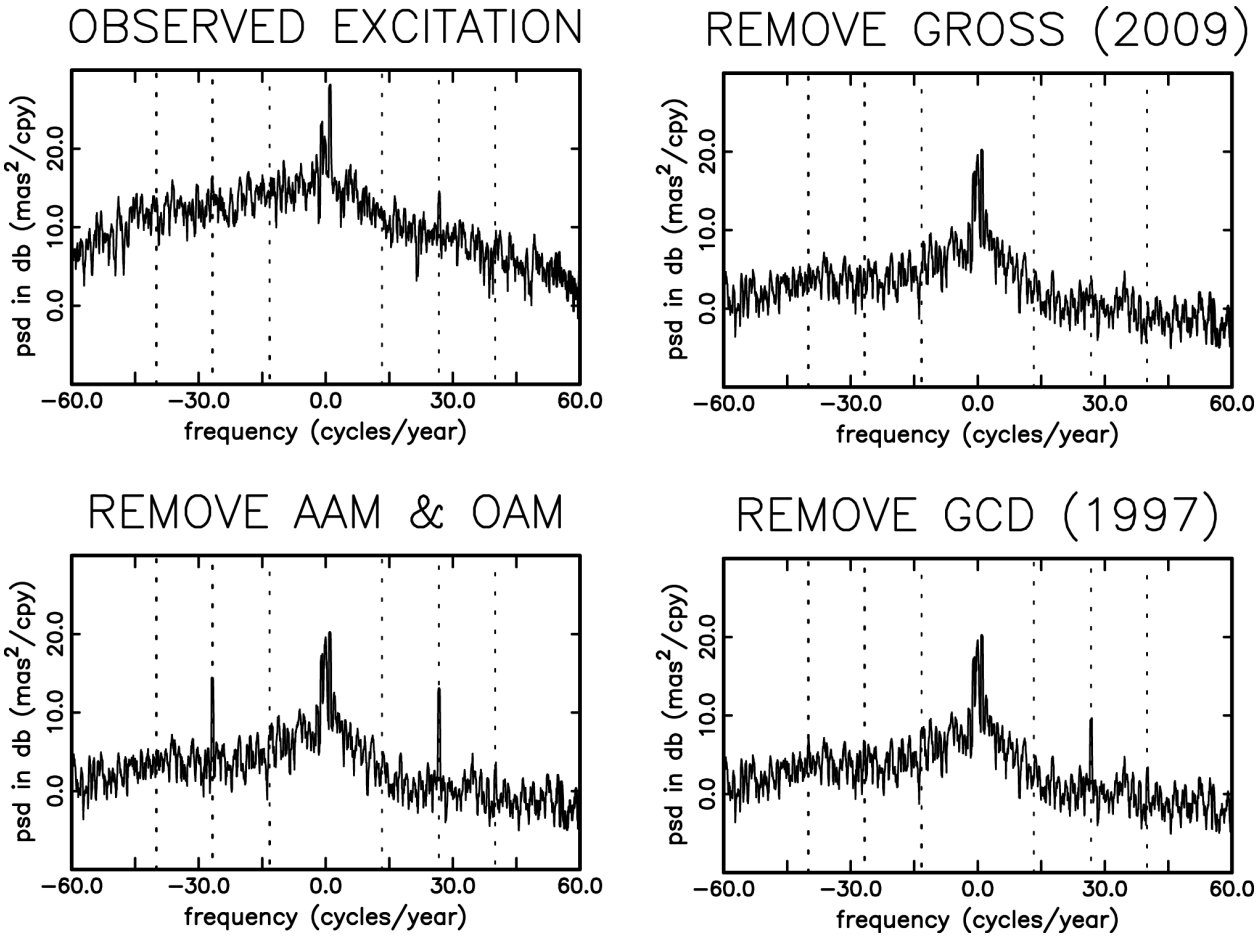






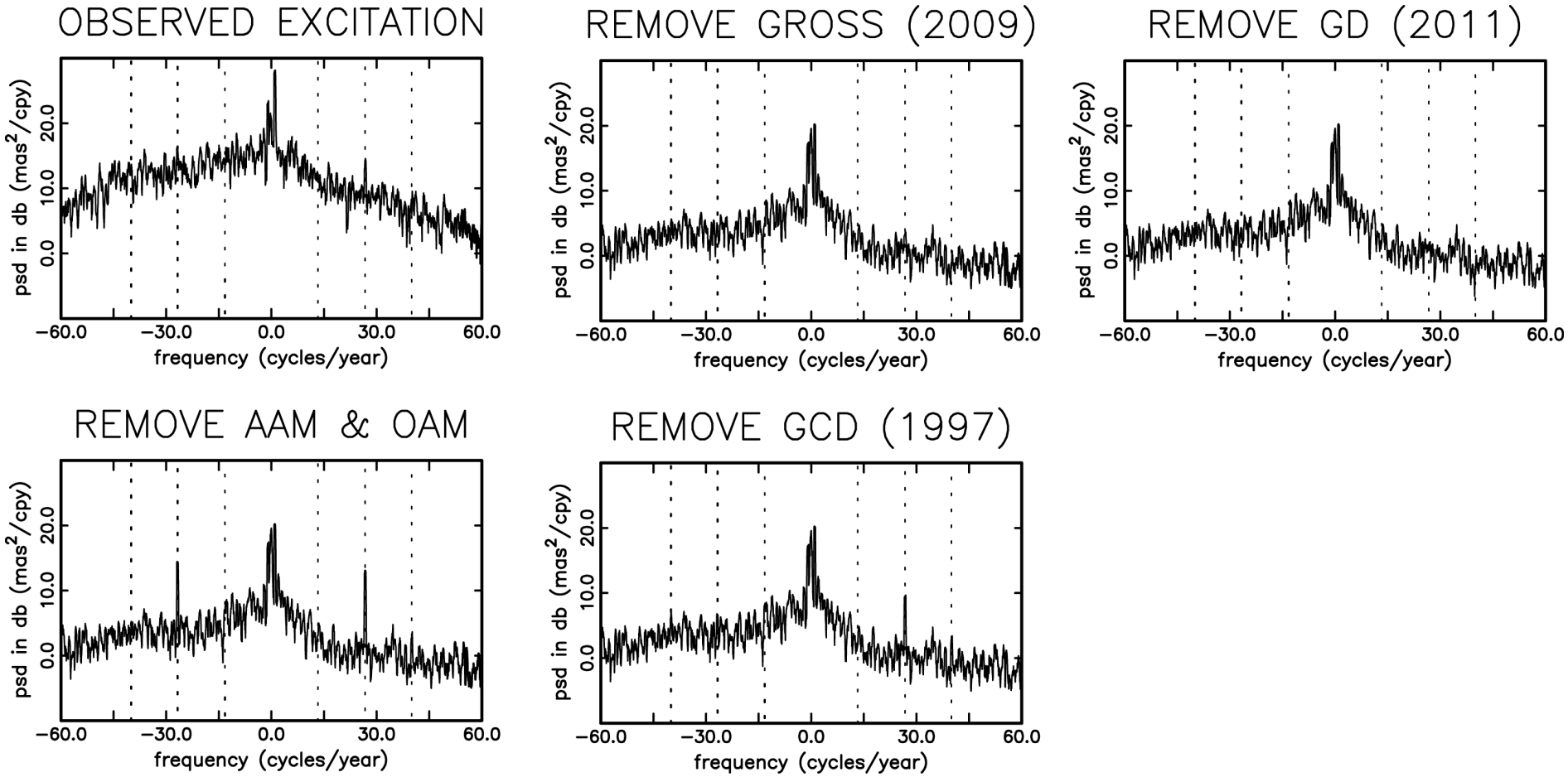
(March 25, 1995 to May 28, 2010)

Empirical Ocean Tide Models



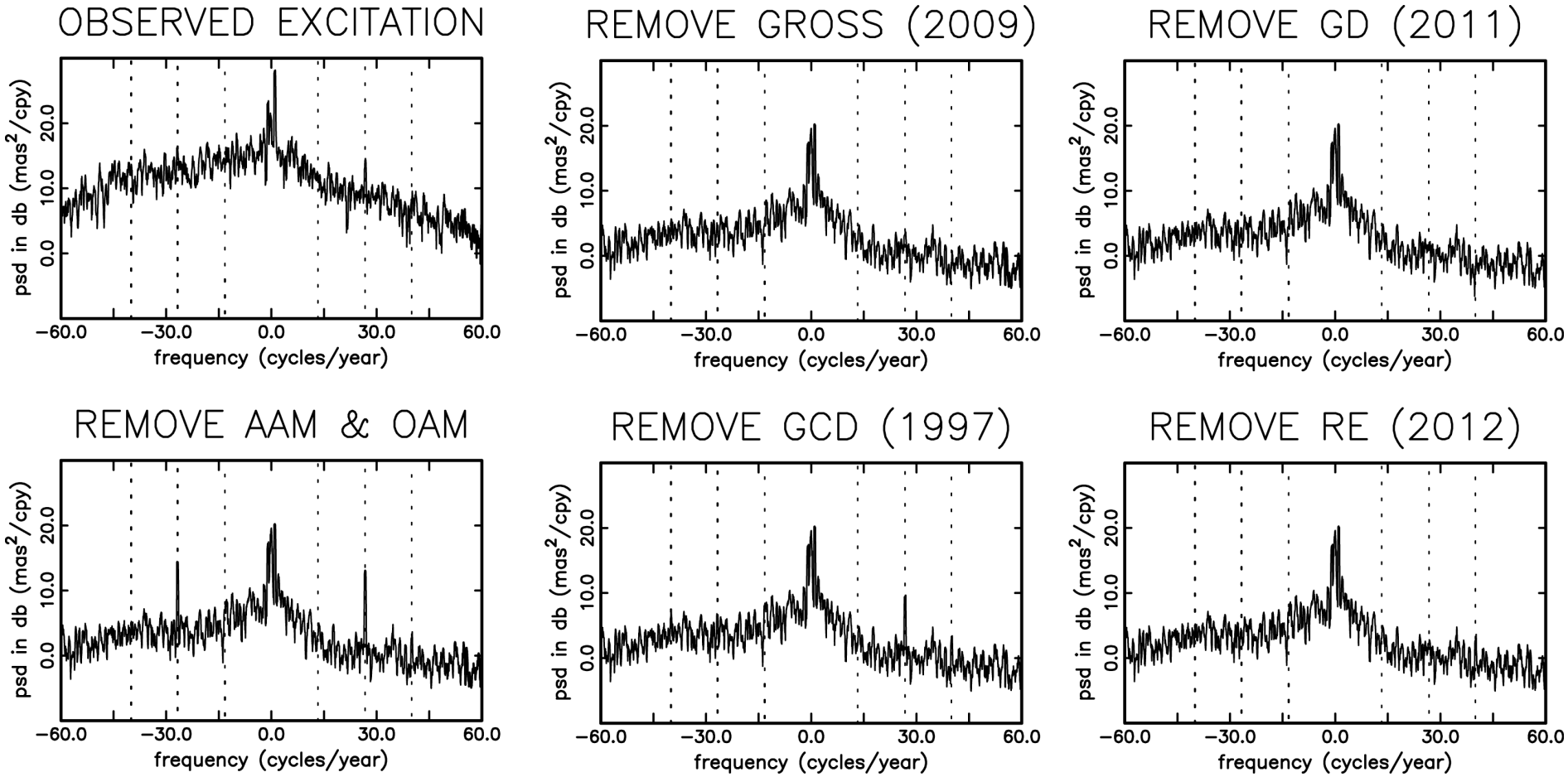
(March 25, 1995 to May 28, 2010)

Empirical Ocean Tide Models



(March 25, 1995 to May 28, 2010)

Empirical Ocean Tide Models



(March 25, 1995 to May 28, 2010)

Summary

- Recent empirical ocean tide models
  - Those that model nodal variations can completely account for observed fortnightly tidal power
    - Different models determined from observations spanning different time intervals
    - Assessment done on observations spanning March 25, 1995 to May 28, 2010
- Recent dynamic ocean tide models
  - None completely accounts for observed fortnightly tidal power
  - Ray and Egbert (2012) model
    - Only model constrained by data
    - Further reduces but does not eliminate fortnightly tidal power
- More accurate dynamic model still desirable
  - But most tide models do not include currents
    - Needed for their contribution to ocean tidal angular momentum