Validating Earth Orientation Series with Models of Atmospheric & Oceanic Angular Momenta

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Reprocessed GPS EOPs

- Assessed
  - CODE
    - 02 JAN 1994 – 27 DEC 2008
  - ESA
    - 01 JAN 1995 – 27 SEP 2009
  - JPL
    - 04 JAN 1998 – 13 SEP 2008
  - MIT
    - 27 JUL 1997 – 27 SEP 2009
  - SIO
    - 04 JAN 1992 – 07 NOV 2009
- Not assessed
  - EMR
    - Missing values (3 week-long gaps)
  - Combination
    - Preliminary (excessive residual LOD power)

Approach

- Assess reprocessed GPS EOPs by comparing to atmospheric and oceanic angular momentum
  - Length-of-day
  - Polar motion excitation
    - Constructed from polar motion and polar motion rate estimates
- After removing tidal effects
  - LOD
    - Yoder et al. (1981) solid body tides
    - Kantha et al. (1998) ocean tides for Mf and Mm
  - Polar motion excitation
    - Gross (2009) empirical model for Mtm, Mf, and Mm
- Compare in frequency domain
  - During common time span (duration of JPL series)
    - 04 JAN 1998 – 07 SEP 2008 (3900 values)
  - Remove mean and trend

Polar Motion Excitation

- **Conservation of angular momentum expressed within rotating, body-fixed reference frame**

$$\frac{\partial \mathbf{L}}{\partial t} + \omega \times \mathbf{L} = \tau$$

where the angular momentum vector $\mathbf{L} = \mathbf{I} \cdot \omega + \mathbf{h}$

- **Assume rotation is small perturbation from state of uniform rotation at rate Ω. Keeping terms to first order results in long period Liouville equation**

$$\mathrm{m}(t) + \frac{i}{\sigma_{cw}} \frac{\partial \mathrm{m}}{\partial t} = \psi(t) = \chi(t) - \frac{i}{\Omega} \frac{\partial \chi}{\partial t}$$

where: $\mathrm{m} \equiv (\omega_1 + i\,\omega_2)/\Omega$ (terrestrial location of rotation pole)

$\psi(t), \chi(t)$ are the polar motion excitation functions

σ_{cw} is complex-valued frequency of Chandler wobble

- **Written in terms of reported polar motion parameters:**

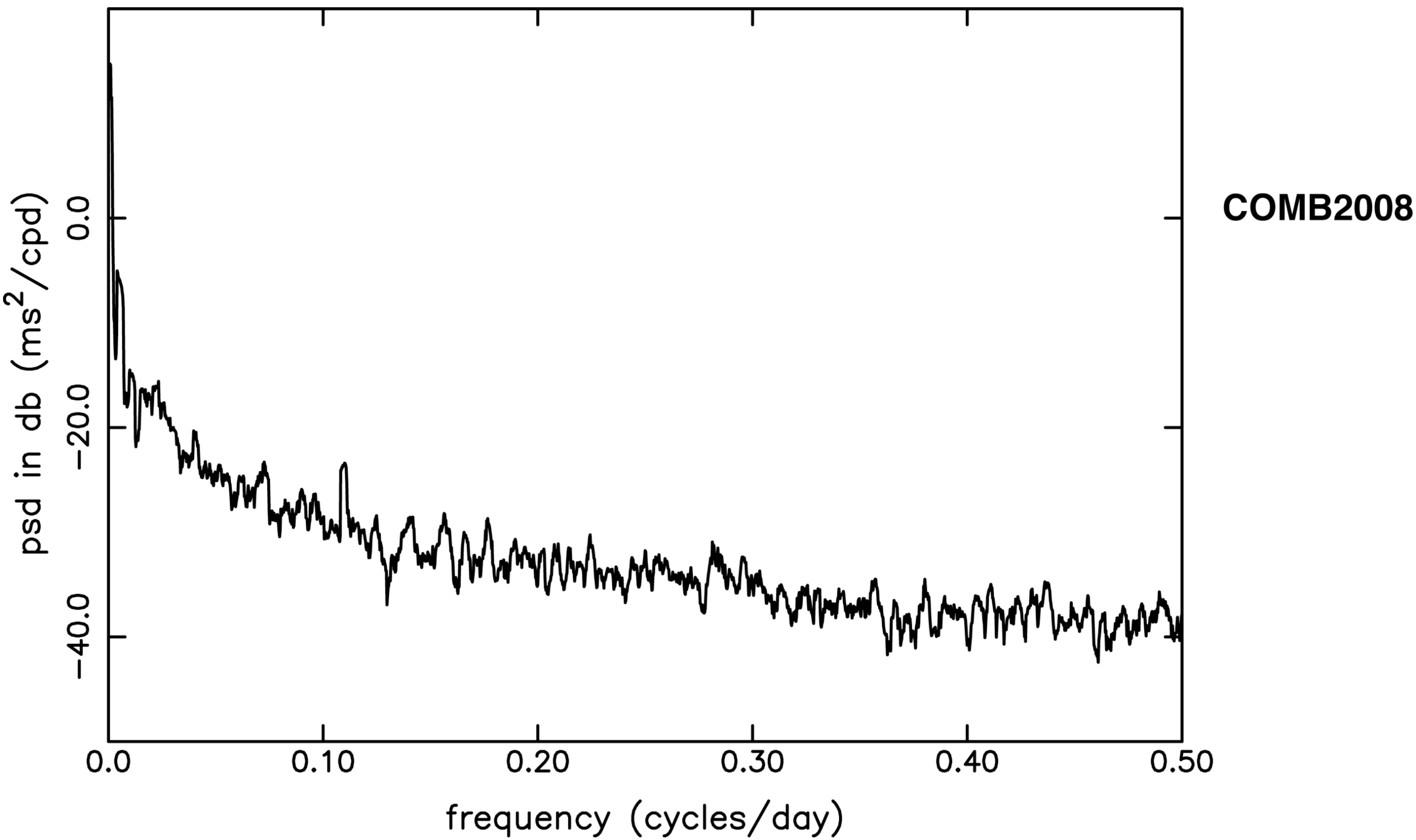
$$\mathrm{p}(t) + \frac{i}{\sigma_{cw}} \frac{\partial \mathrm{p}}{\partial t} = \chi(t) = \frac{1.61}{\Omega\,(C-A)} \left[\mathrm{h}(t) + \frac{\Omega\, \mathrm{c}(t)}{1.44} \right]$$

where: $\mathrm{p}(t) = x_p(t) - i\, y_p(t)$
$\mathrm{c}(t) = c_{13}(t) + i\, c_{23}(t)$

Data Sets

- Geophysical fluid models
  - AAM
    - NCEP/NCAR reanalysis project
    - 6-hour values spanning January 1, 1948 to present
    - Averaged to daily values at noon
    - Sum of wind and inverted barometer pressure terms
  - OAM
    - ECCO/JPL data assimilating ocean model designated kf080
    - Corrected for artificial mass changes caused by Boussinesq approximation
    - Hourly values spanning January 1, 1993 to September 27, 2009
    - Averaged to daily values at noon
    - Sum of current and bottom pressure terms
- Reference EOP series
  - COMB2008
    - Combination of optical astrometric, SLR, LLR, VLBI, and GPS observations (no optical astrometric observations after 1982)
    - Daily values spanning January 20, 1962 to July 2, 2009

LOD – Tides – (AAM+OAM)



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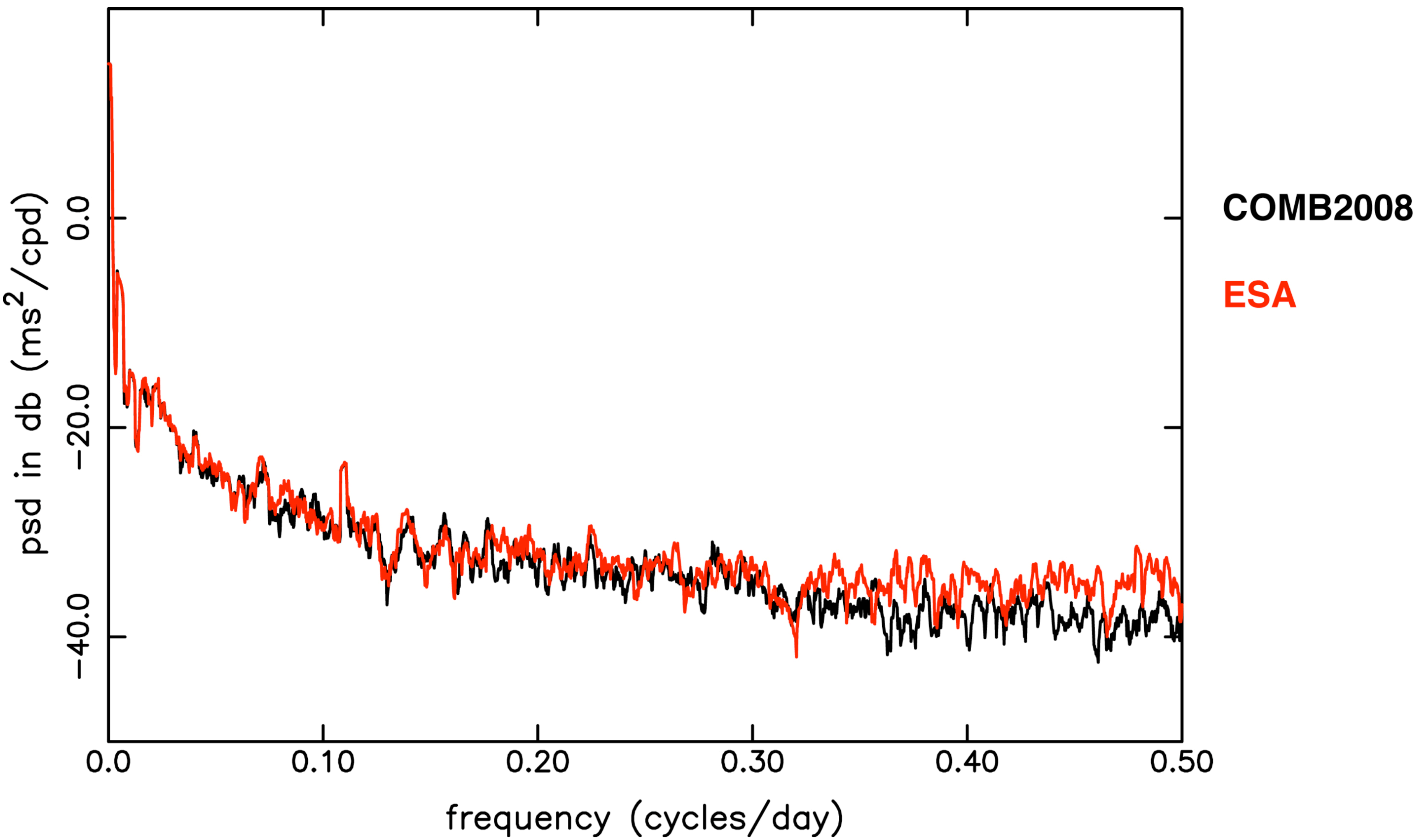

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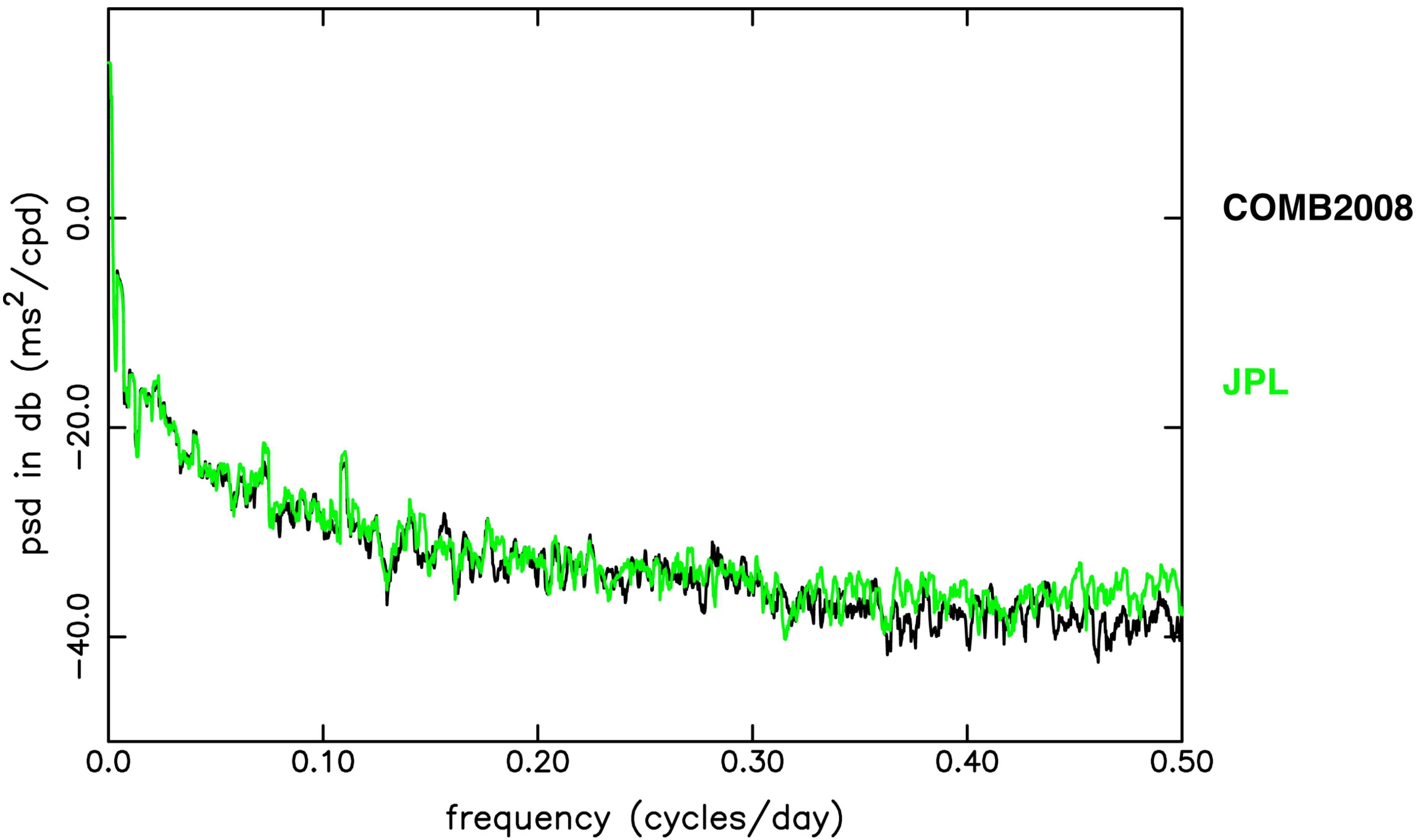

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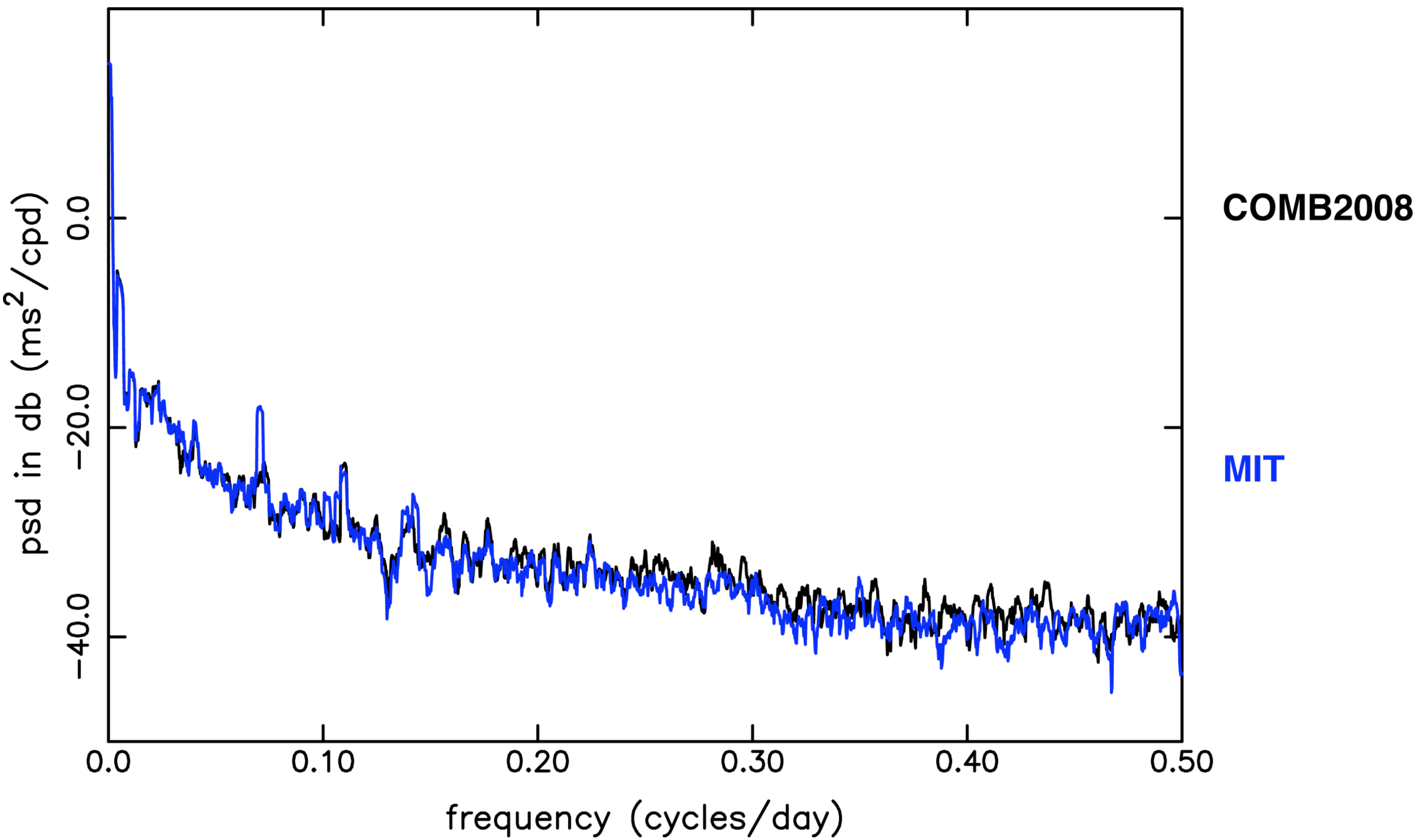

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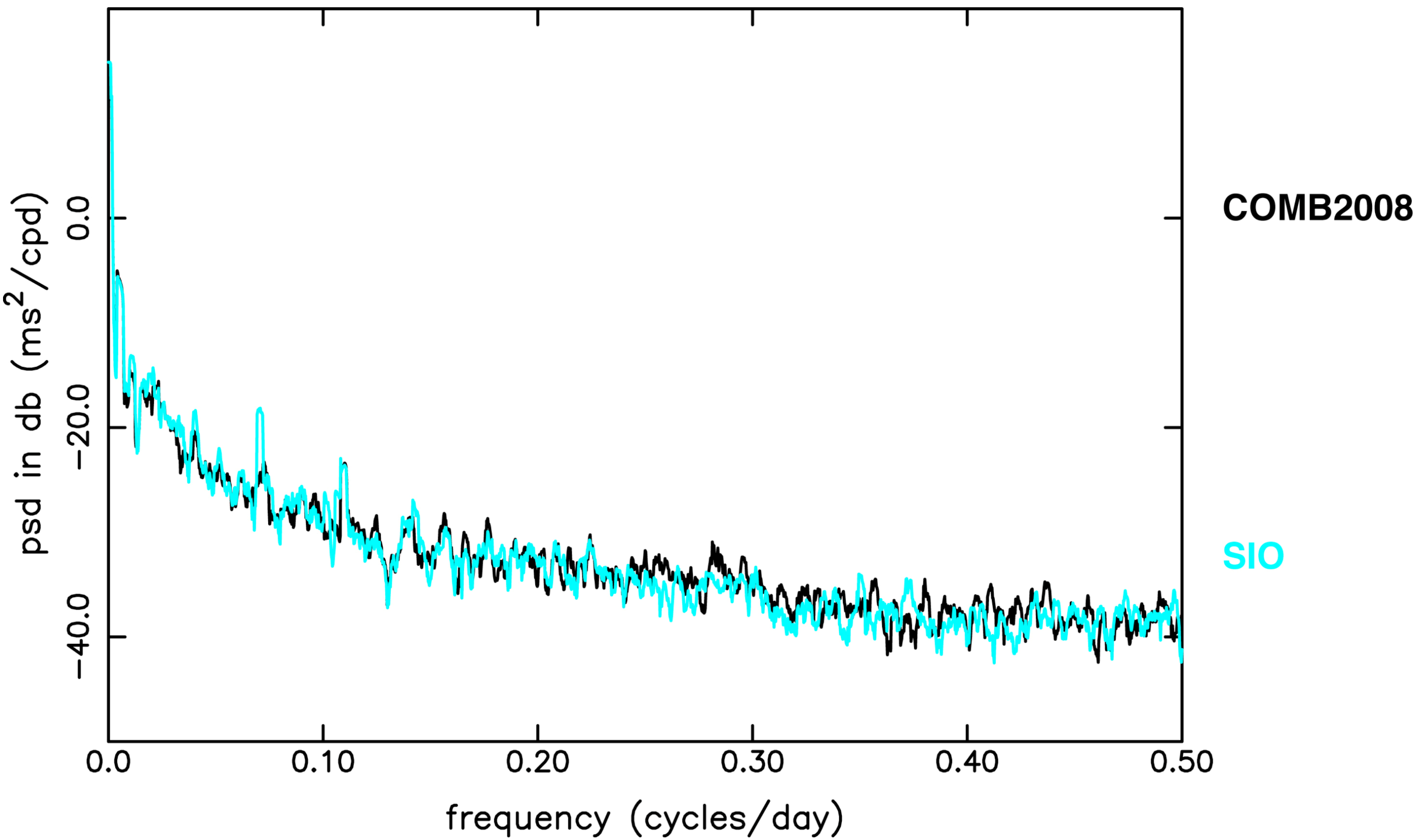

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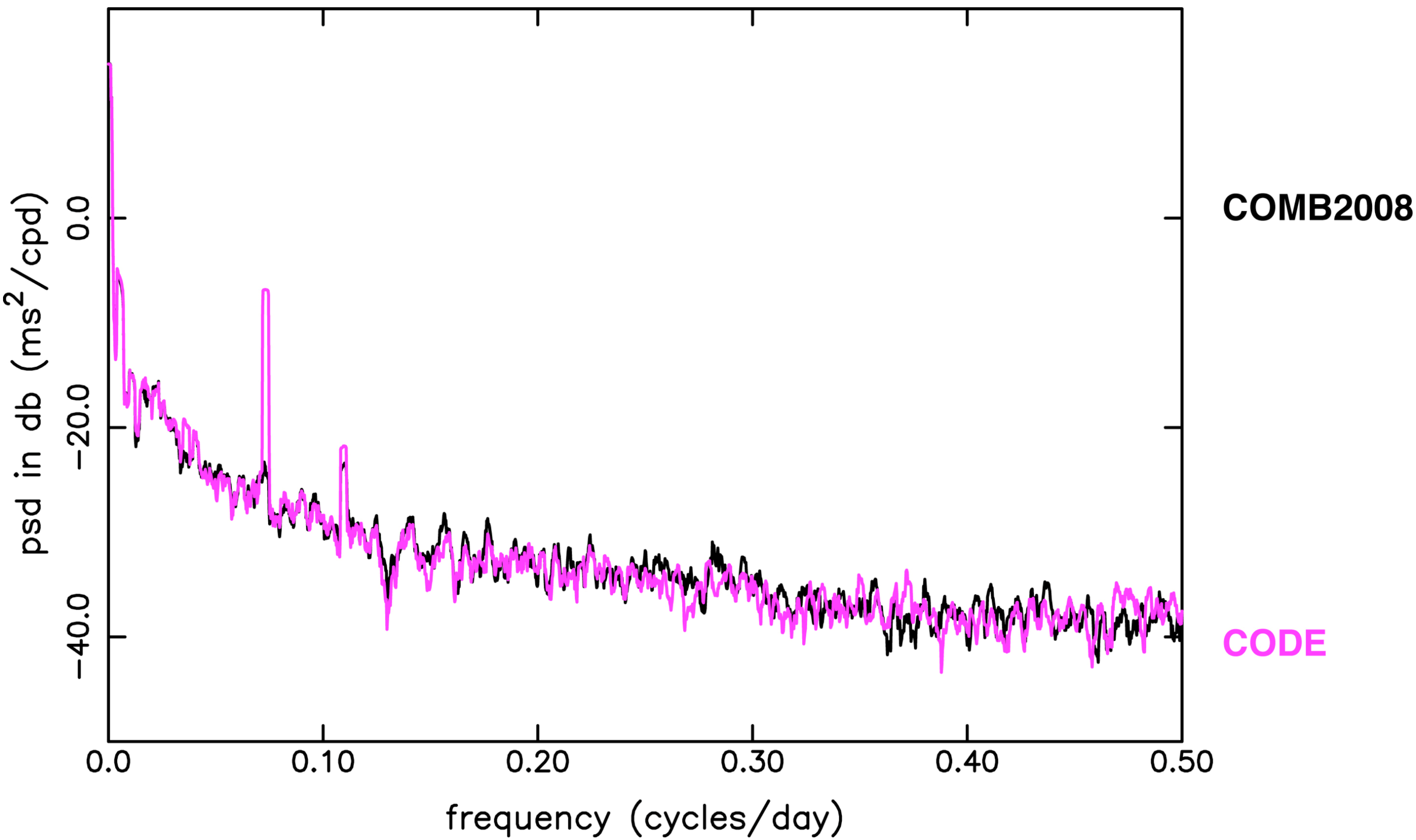

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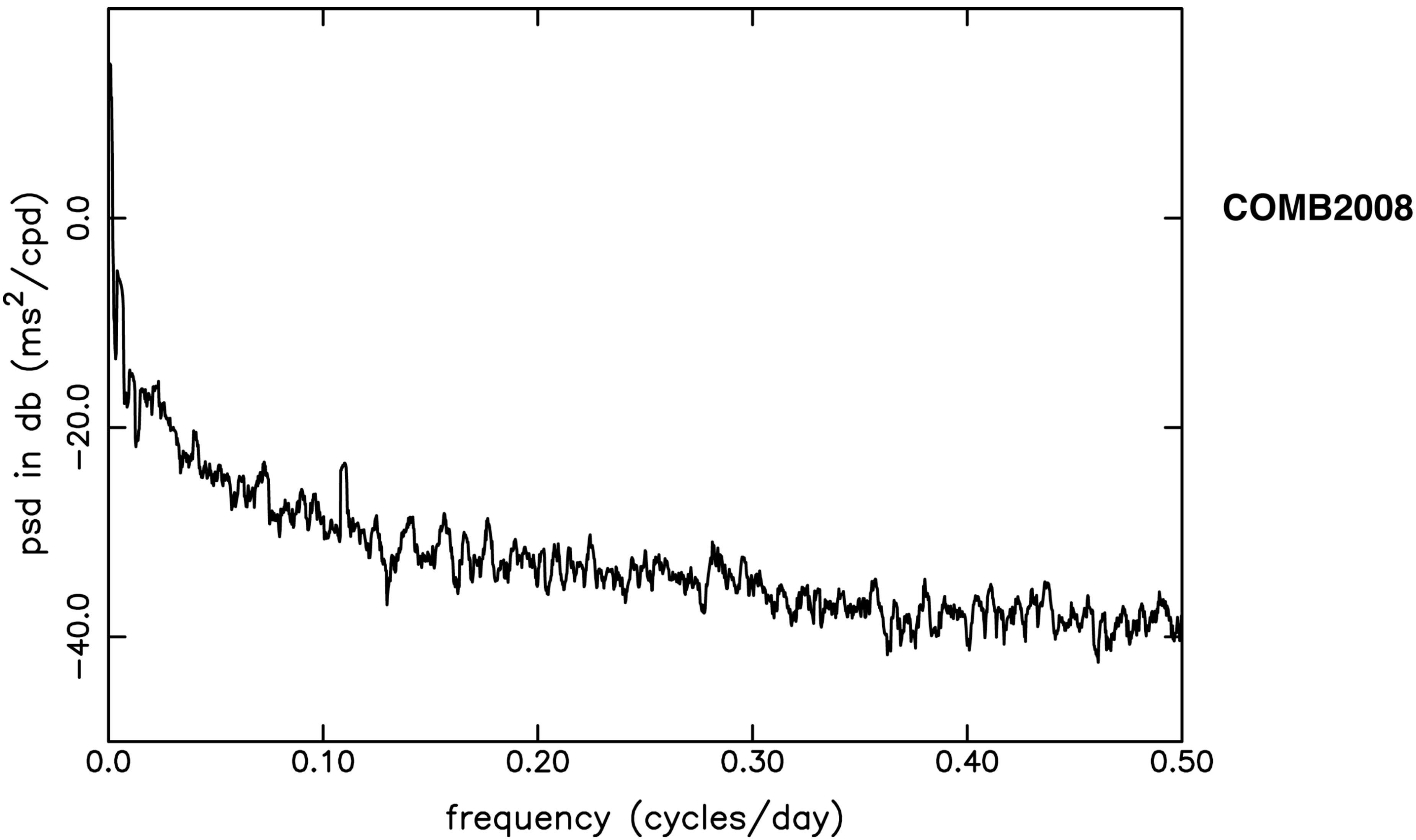

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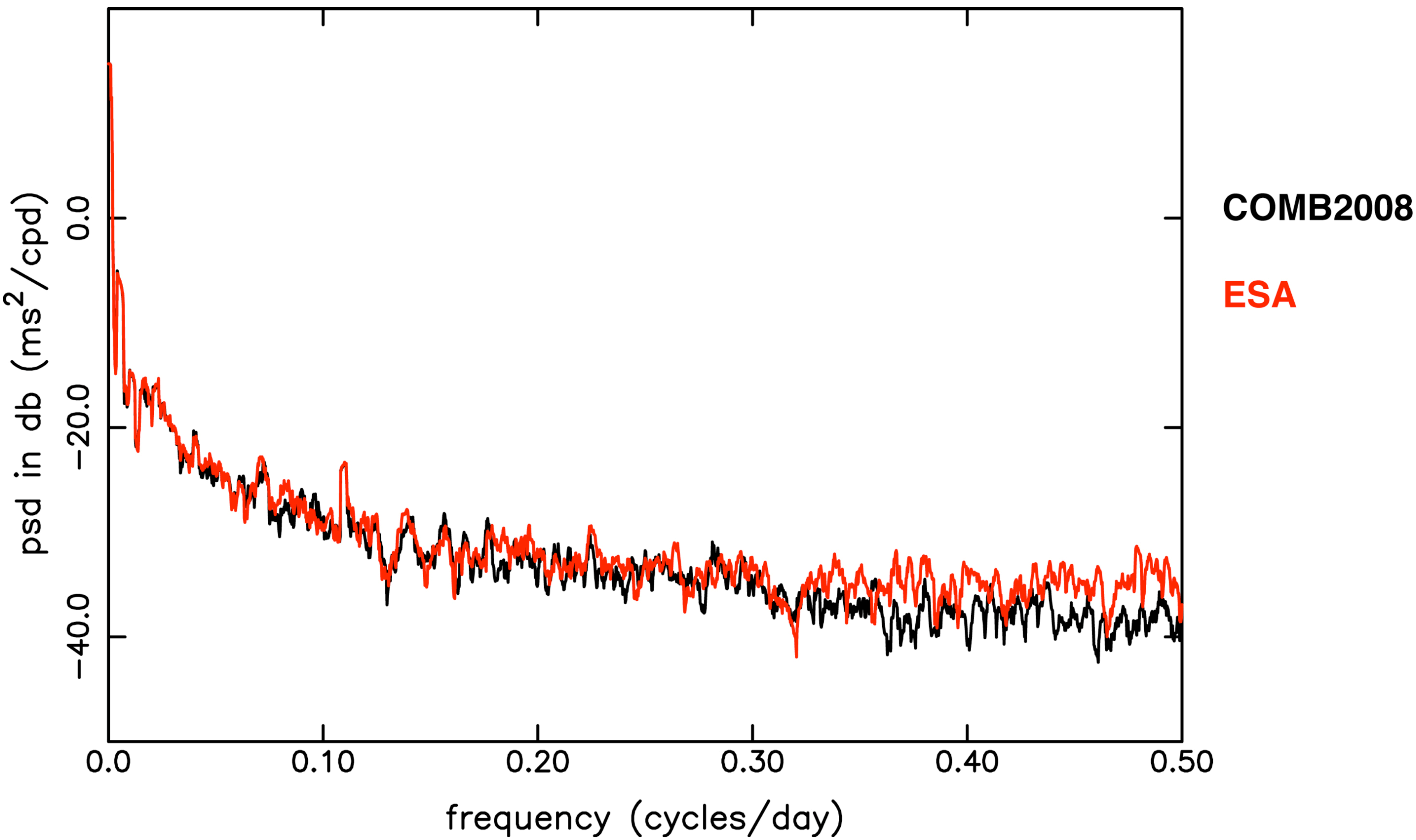

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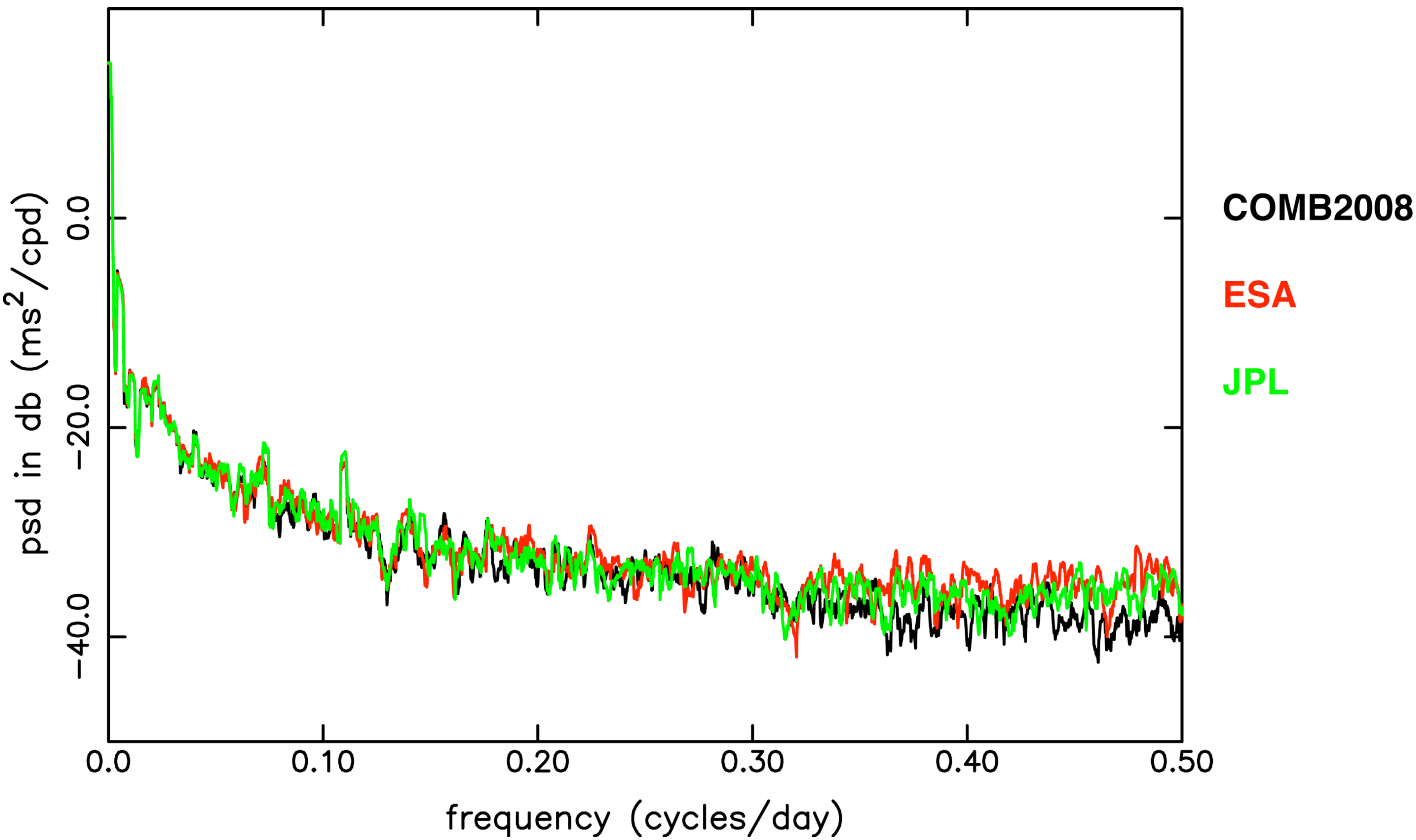

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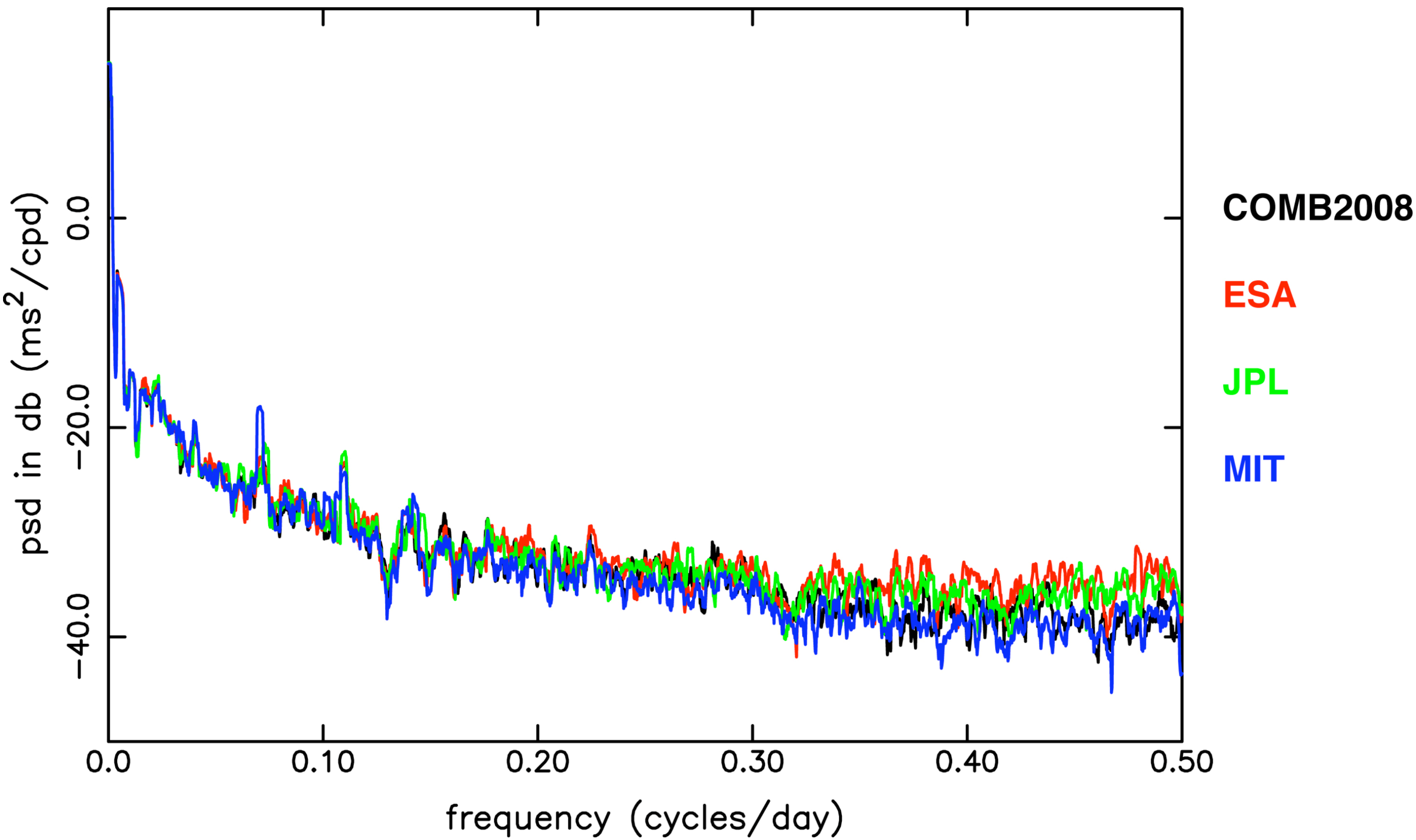

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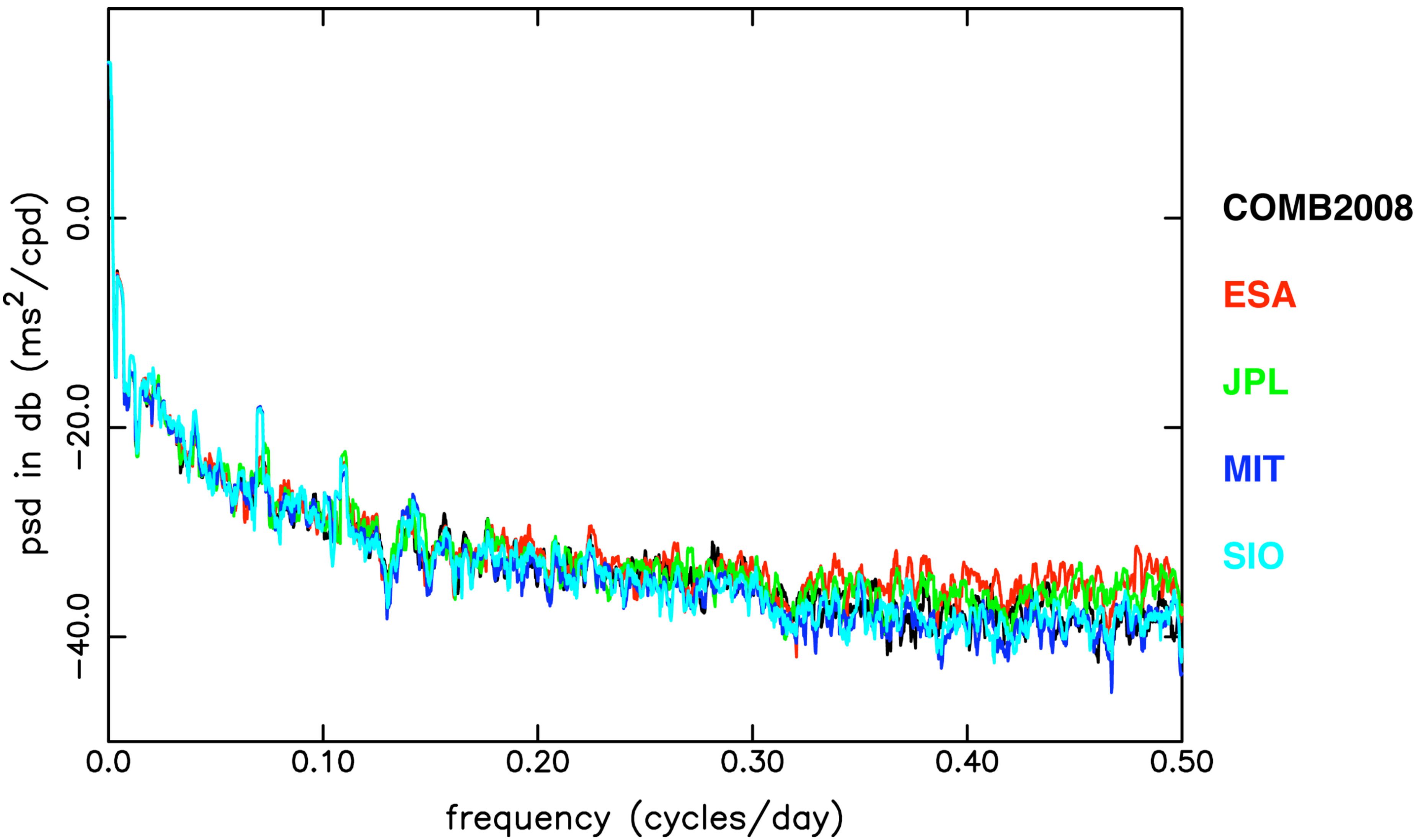

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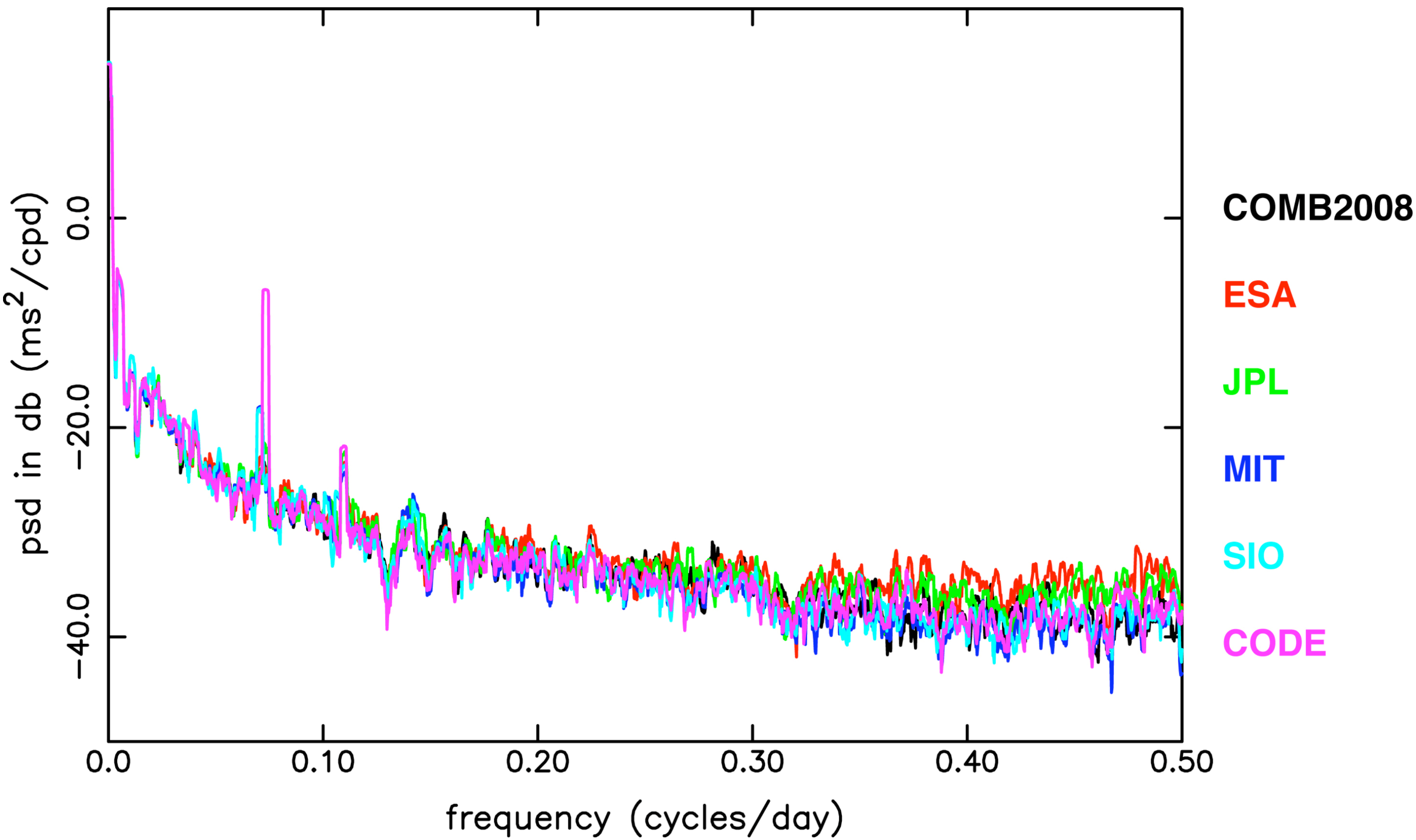
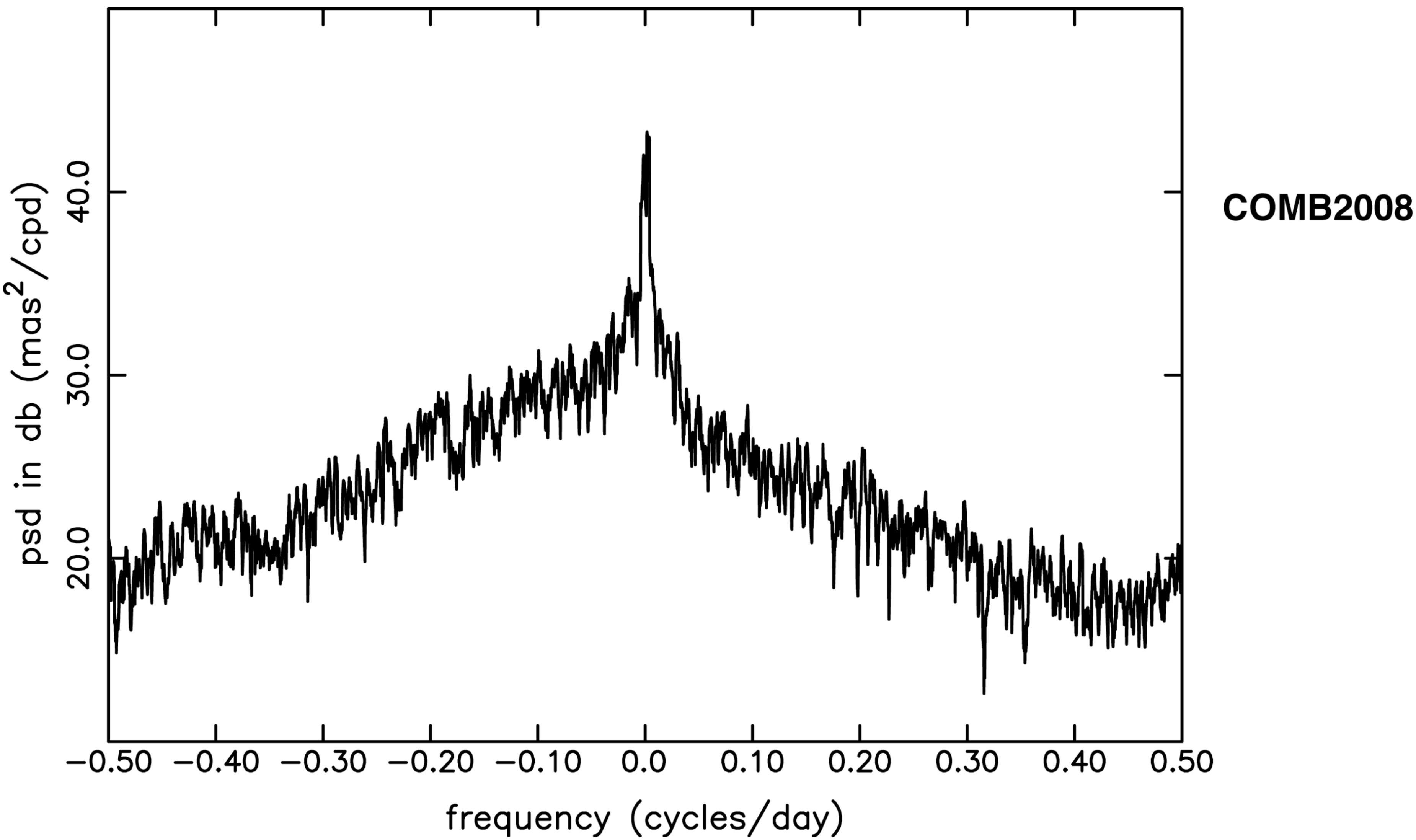


Period of Spectral Peaks (LOD)

Analysis Center	Mtm	Mf	Aliased O1
COMB2008	9.1		
JPL	9.1	13.6	
CODE	9.1	13.6	
ESA	9.1		14.2
MIT	9.1		14.2
SIO	9.1		14.2

(period given in solar days)

PM Exc – Tides – (AAM+OAM)



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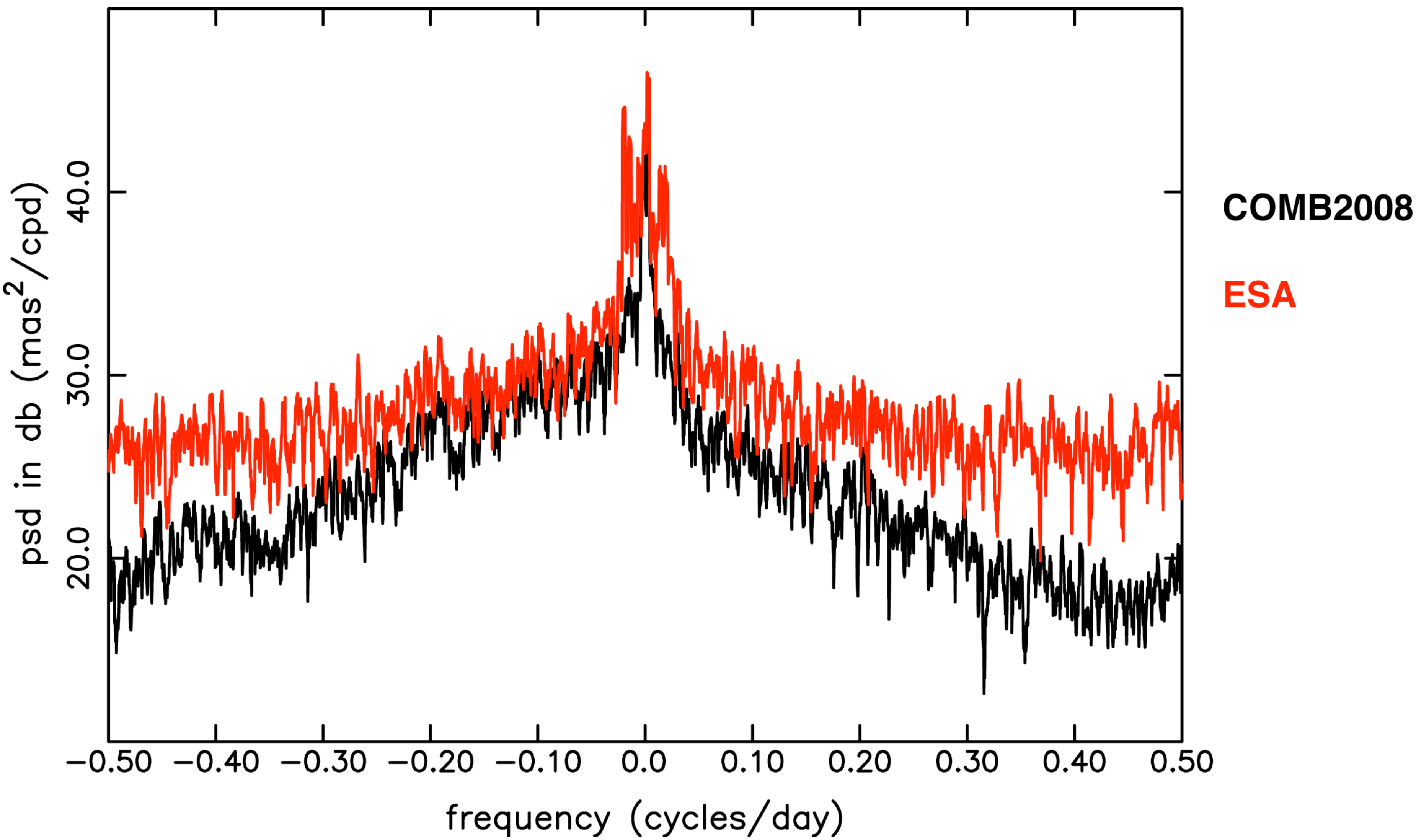

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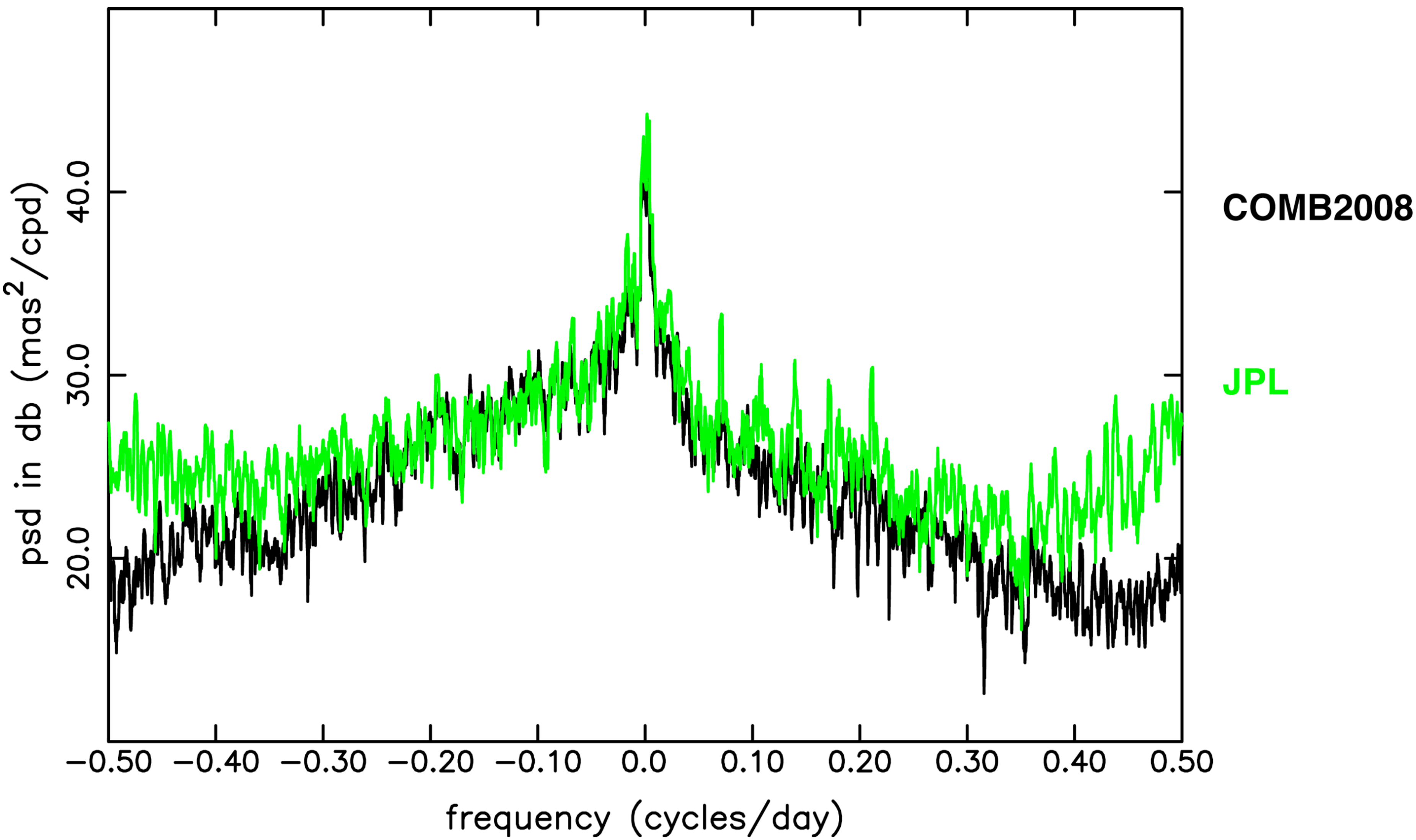

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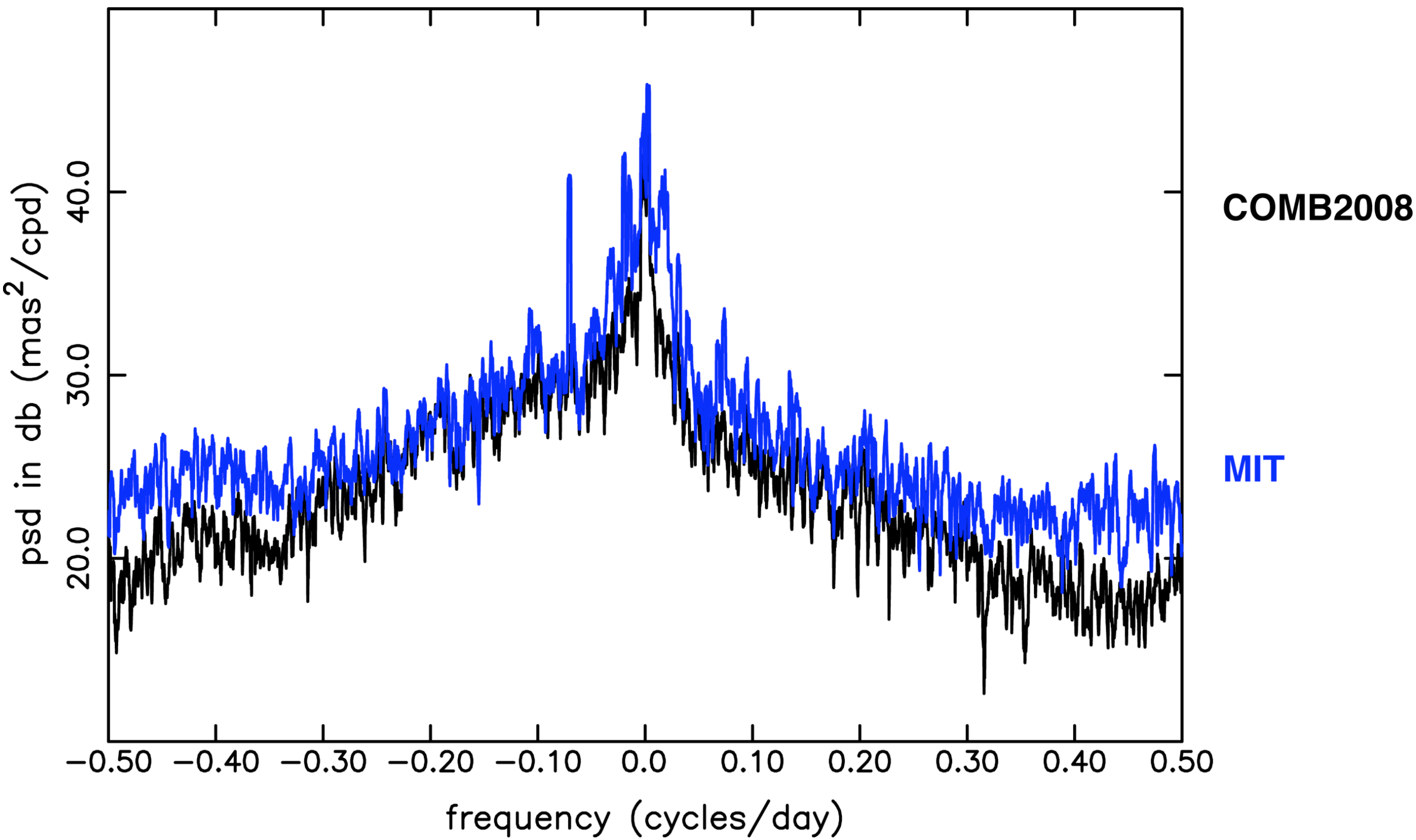

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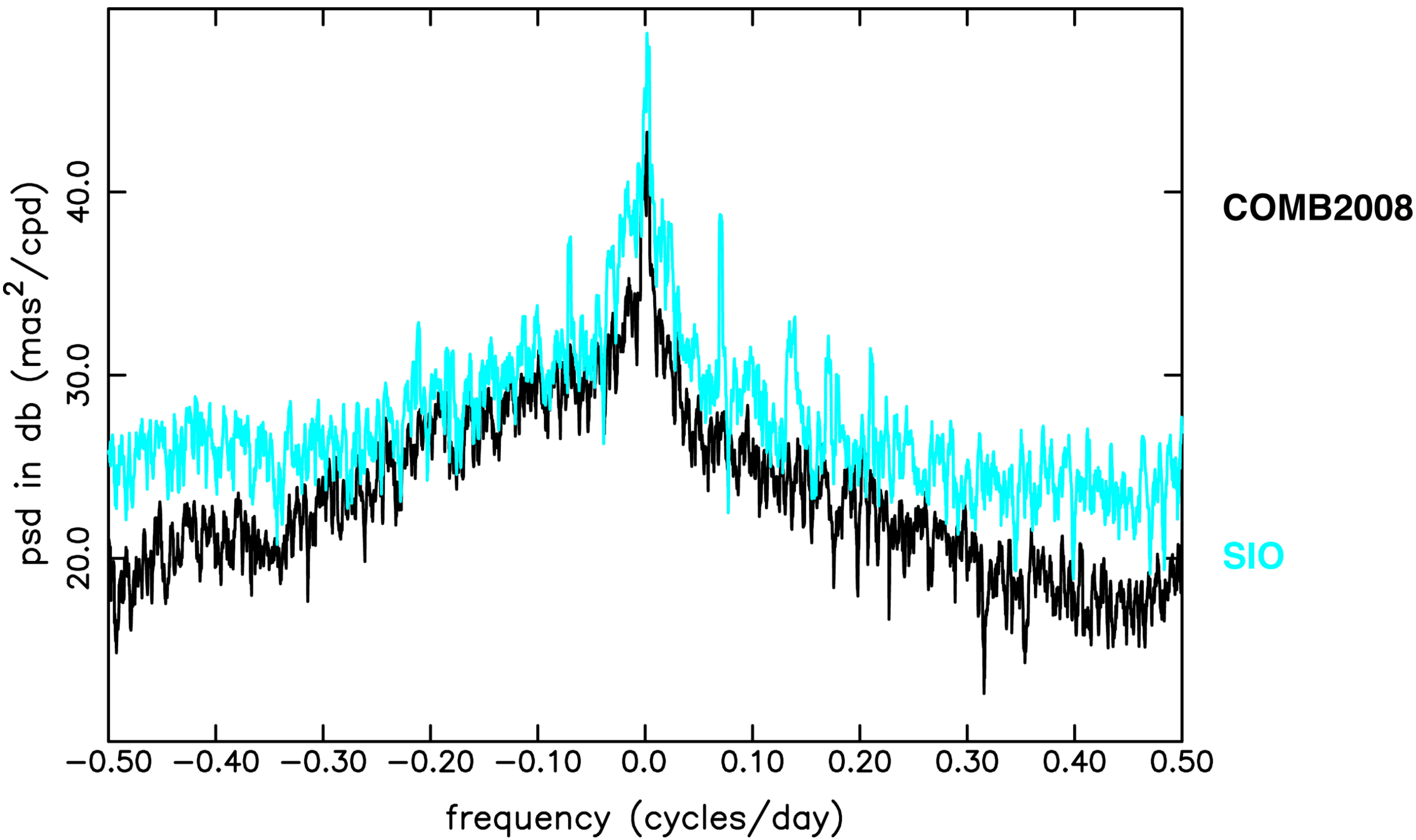

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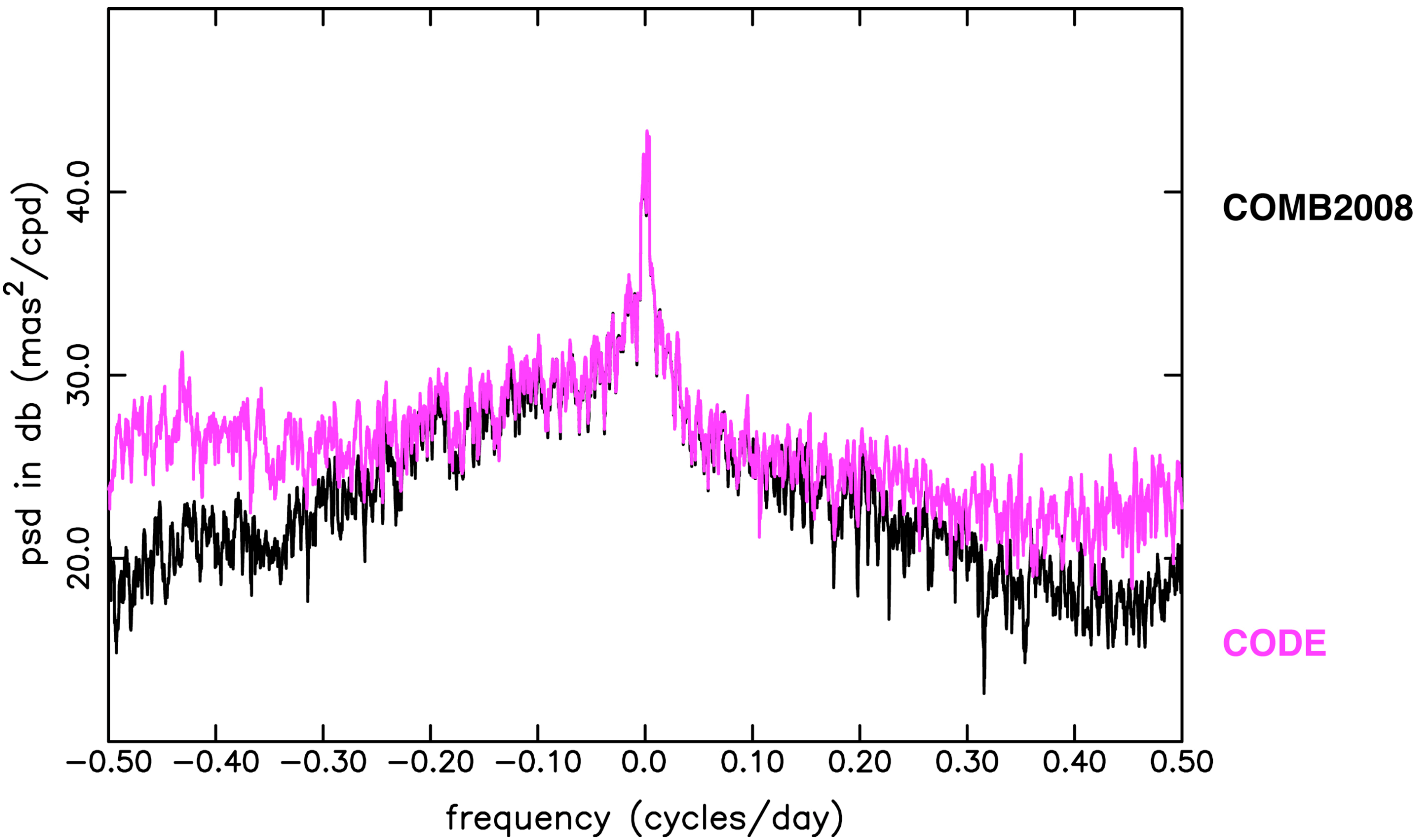

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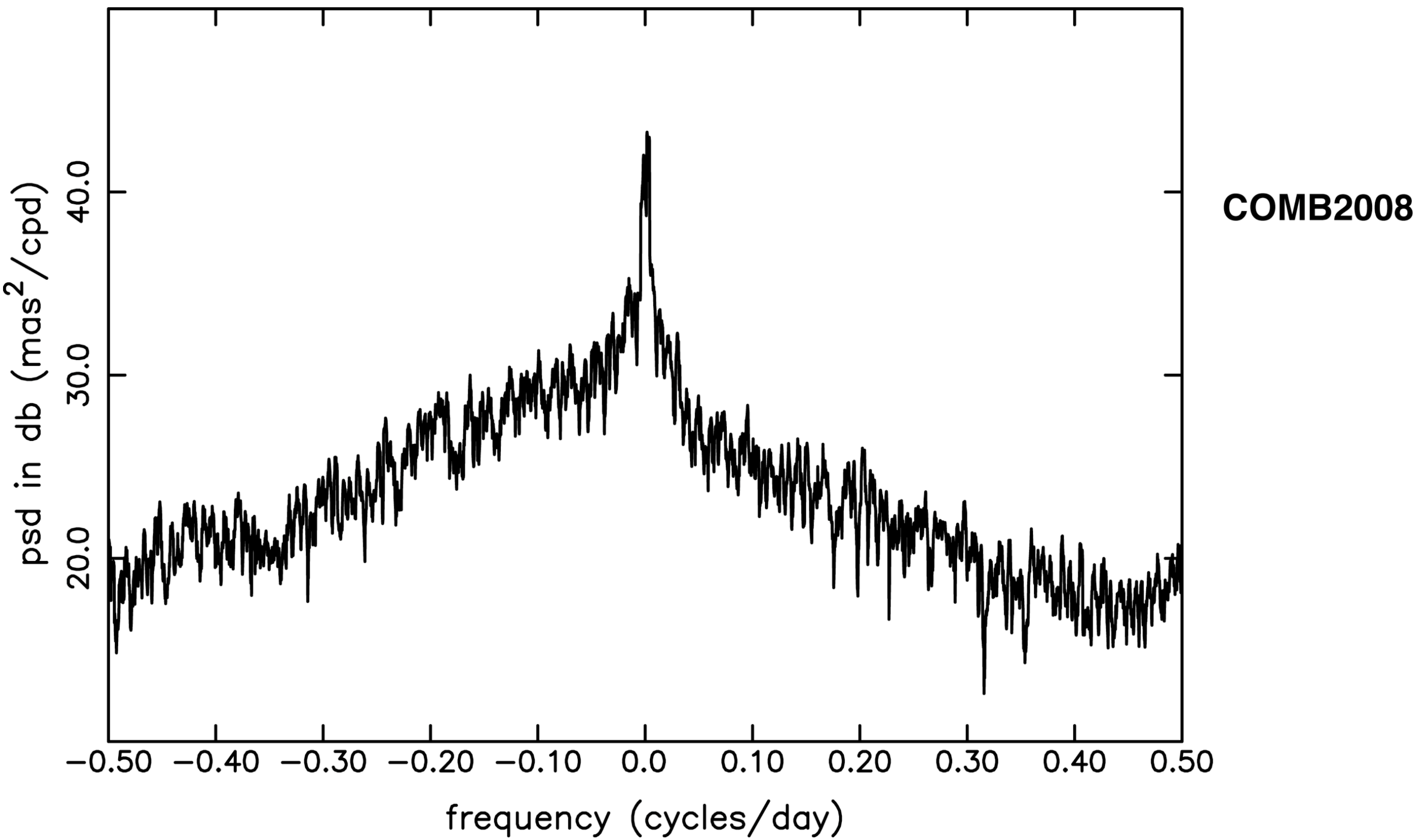

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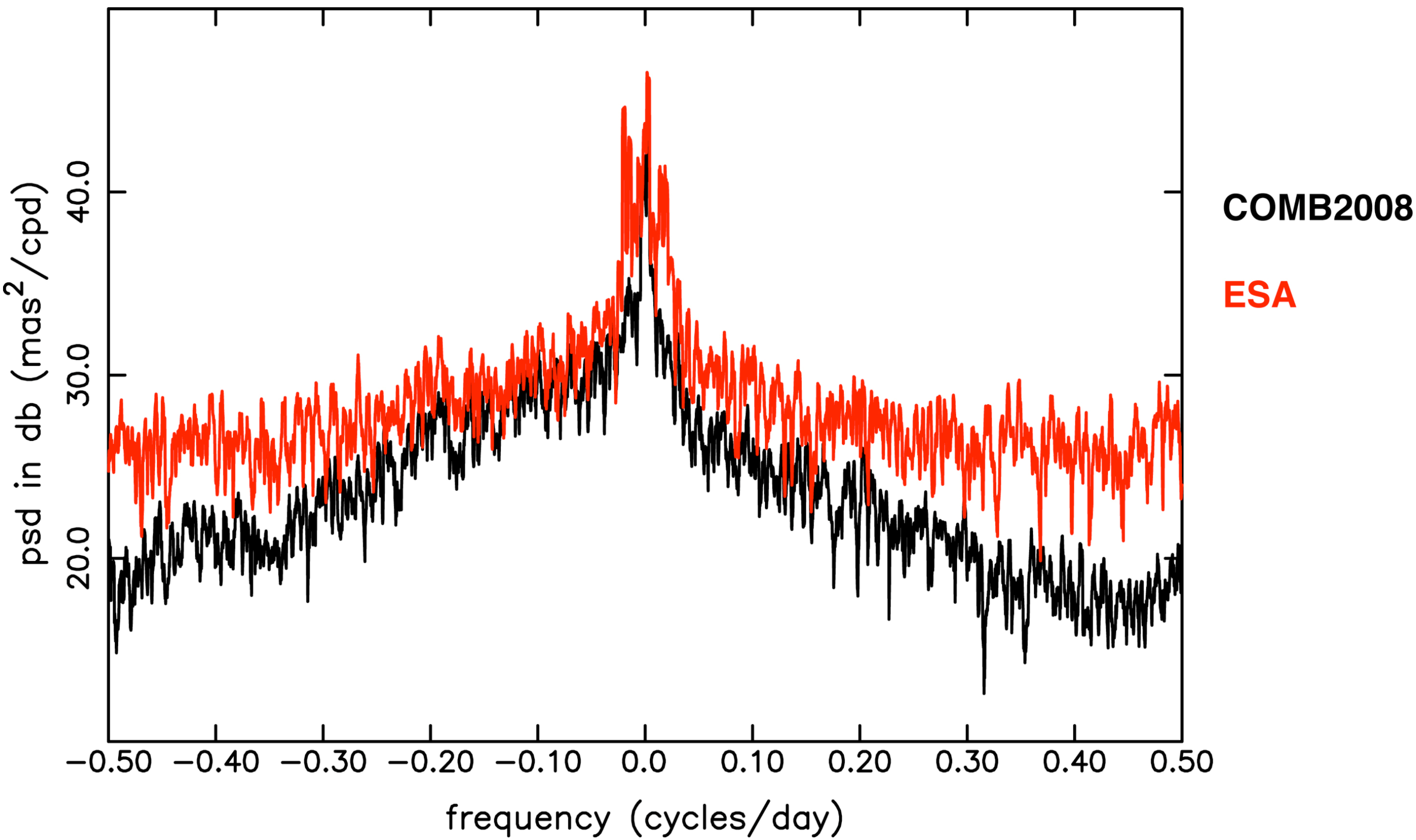

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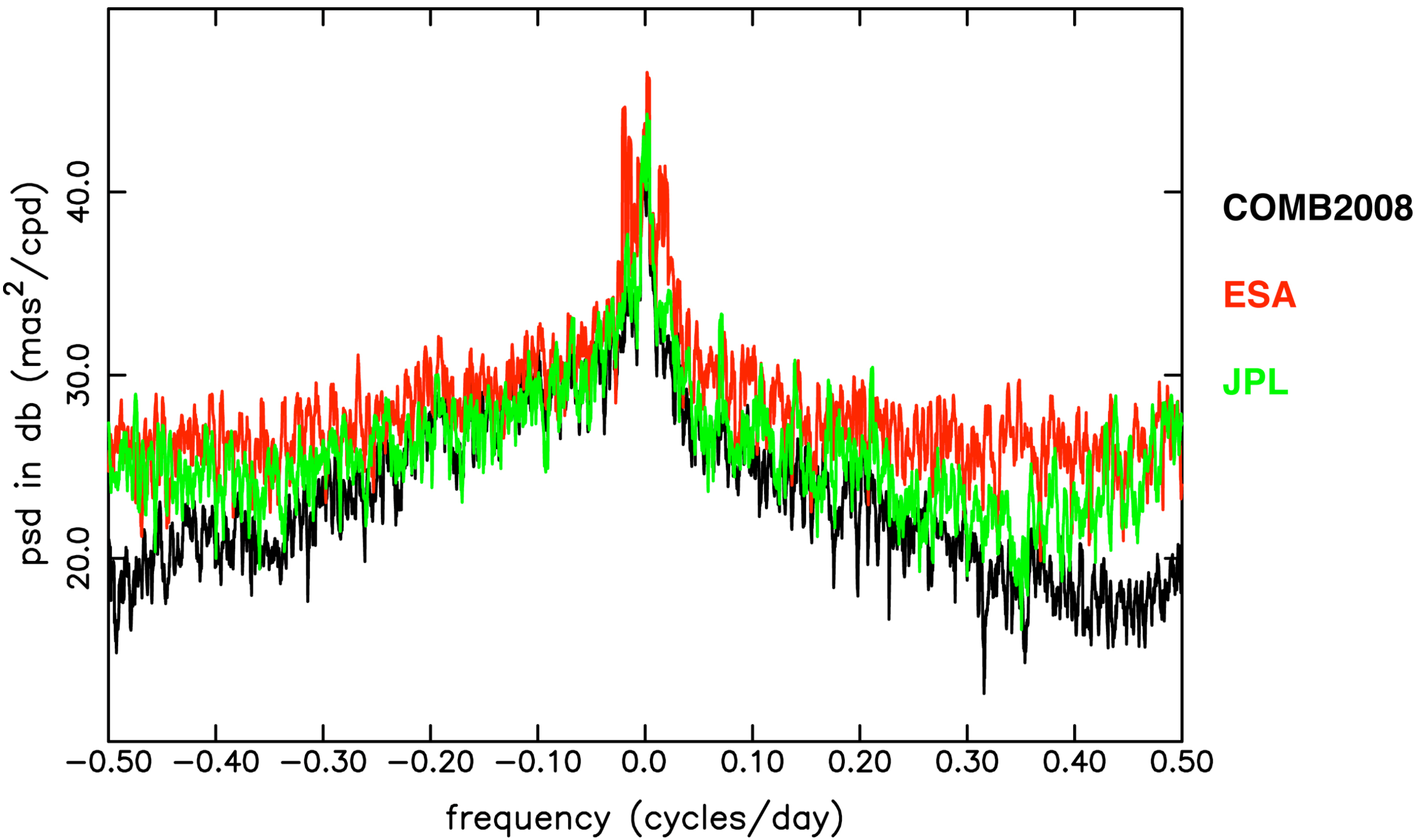

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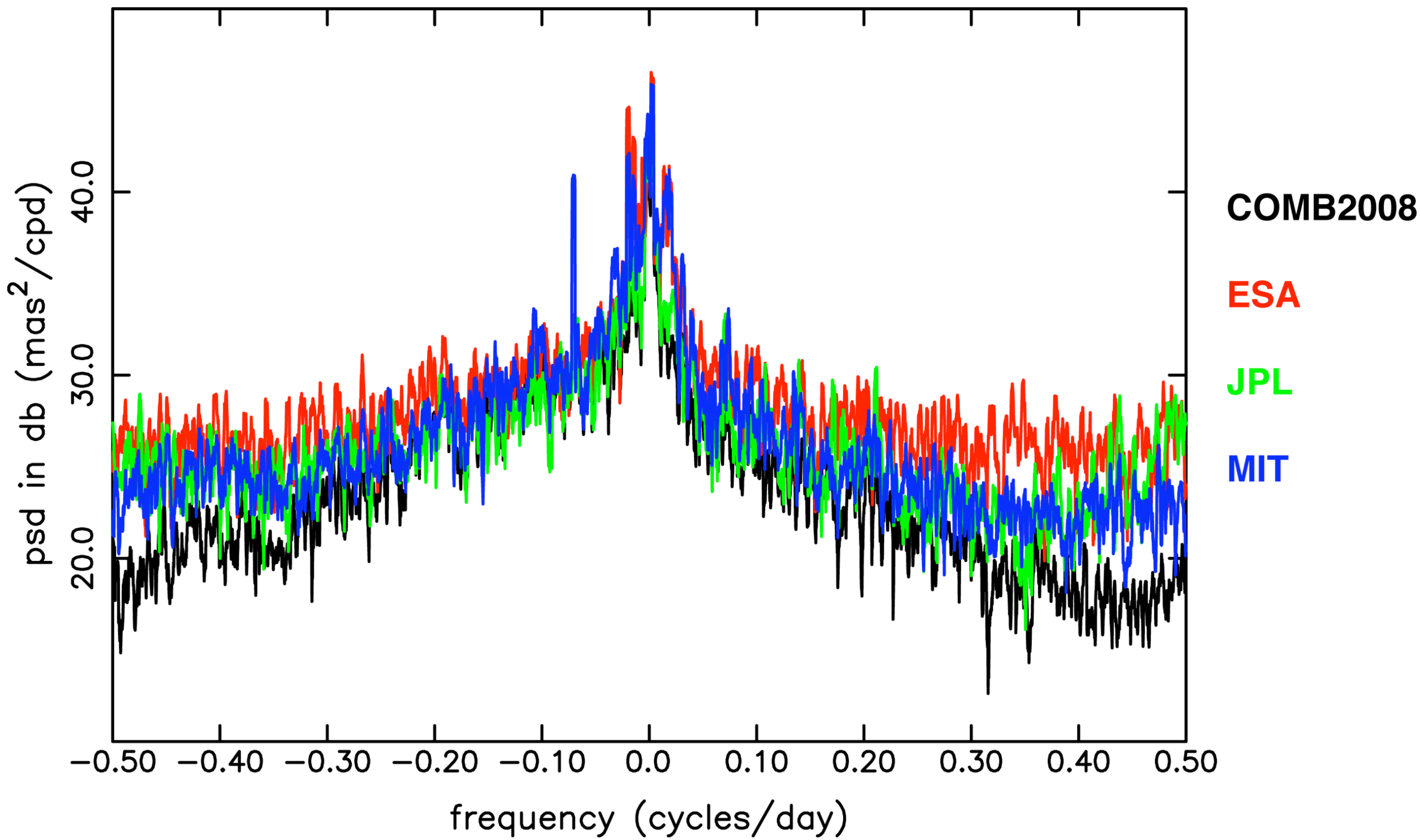

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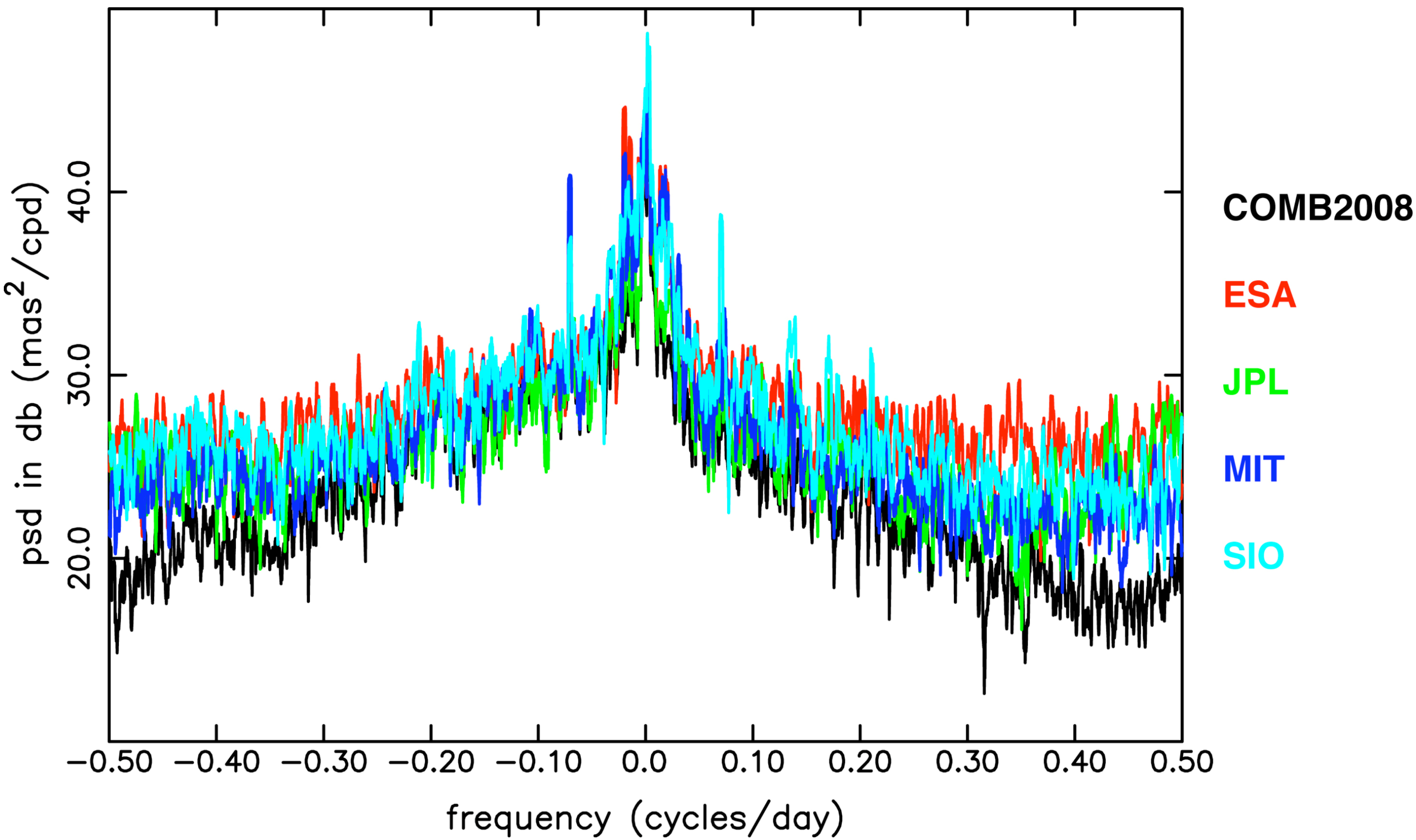

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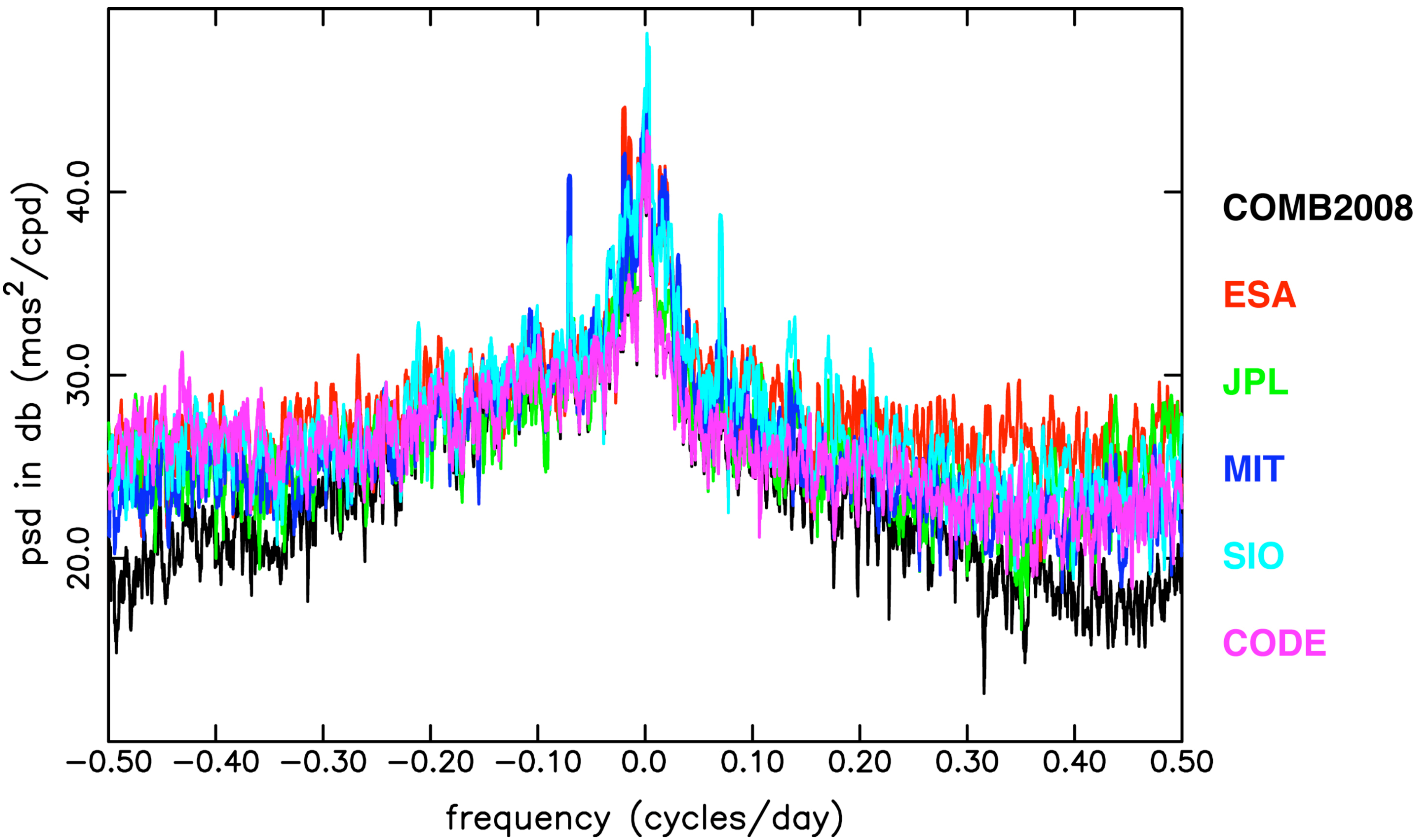

Period of Spectral Peaks (PM Exc)

Analysis Center	Aliased O1				
COMB2008	---	---	---	---	---
ESA	---	---	---	---	---
CODE	---	---	---	---	---
JPL	± 14.2	9.3	7.1	5.8	4.7
MIT	-14.2,13.7	-9.3	---	---	---
SIO	±14.2	---	±7.2	5.8	±4.7

(period given in solar days)

Summary

- Assessed reprocessed GPS EOPs
  - Length-of-day
    - All series are in good agreement with AAM+OAM at long periods (> 3 days)
    - MIT, SIO, and CODE agree best with AAM+OAM at short periods (< 3 days)
  - Polar motion excitation
    - JPL and especially CODE agree best with AAM+OAM at long periods (> 5 days)
    - COMB2008 agrees best with AAM+OAM at short periods (< 5 days)
    - NB: Polar motion-rate term dominates at frequencies studies here
- Tidal effects
  - Length-of-day
    - JPL and especially CODE exhibit spurious spectral peaks at 13.6 days (Mf)
    - ESA and esp. MIT & SIO exhibit spurious spectral peaks at 14.2 days (aliased O1)
    - All series including COMB2008 exhibit real peaks at 9.1 days (Mtm ocean tide)
  - Polar motion excitation
    - JPL, MIT, and SIO exhibit spurious spectral peaks (var. aliases of subdaily tides?)
    - MIT also exhibits spurious spectral peak at 13.6 days (Mf)