External Comparison of EOP Results

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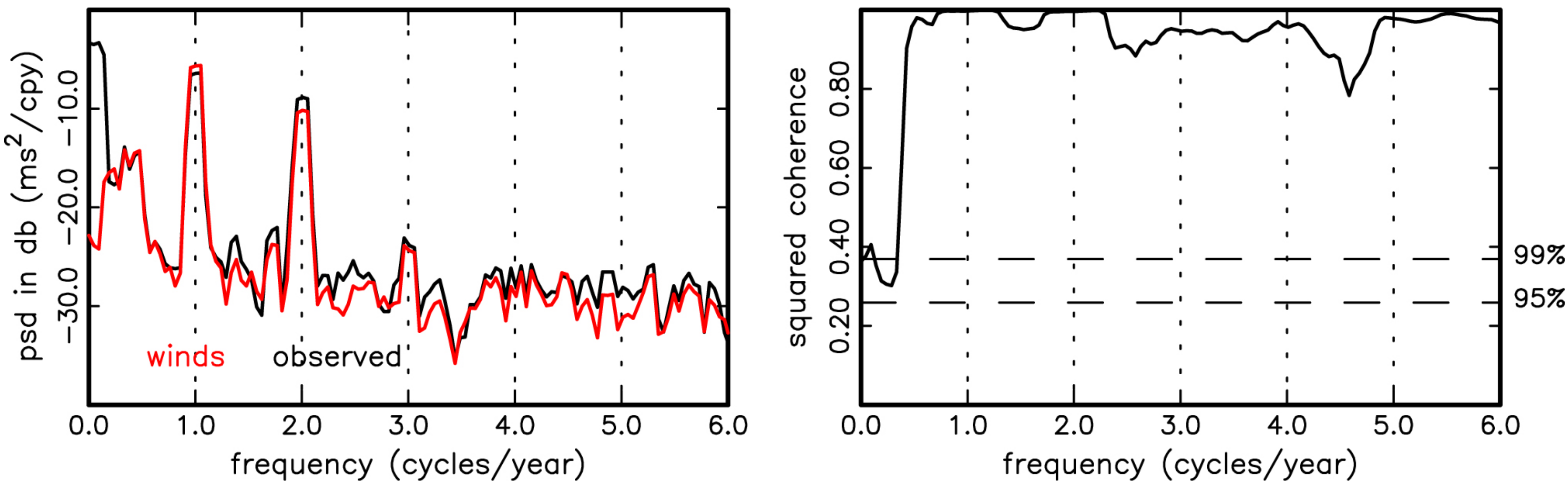
IGS Workshop

June 28 – July 1, 2010
Newcastle upon Tyne, England

An Approach to Assessing EOPs

- Compare observed and modeled EOPs
  - Observations provide estimates of UT1, polar motion, and their rates-of-change
  - Models provide angular momenta of geophysical fluids
    - Angular momentum directly related to lod and polar motion excitation
- Minimize manipulation of observations
  - Do not interpolate observations
    - Interpolation adds error
  - Do not estimate polar motion rate from polar motion values
    - Construct observed polar motion excitation estimates from observed polar motion and polar motion rate estimates
- Compare in both time and frequency domains
  - Correlation, residual rms, and observed variance explained
  - Spectrum and coherence

Nontidal LOD Variations



Power spectra (left panel) and squared magnitude of the coherence (right panel) of the observed length-of-day variations during 1980–2000 and those due to atmospheric winds below 10 hPa. The power spectral density (psd) estimates in the left panel, given in decibels (db), were computed by the multitaper method with the spectrum of the observed variations shown in black and that due to the winds shown in red. The horizontal dashed lines in the right panel indicate the 95% and 99% confidence levels of the squared magnitude of the coherence between the observed and wind-driven LOD variations.

Gross et al. (2004)

Assess Reprocessed EOPs

- 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

Data Sets Assessed

- Analysis center solutions
  - 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
- Combined solutions
  - Combination of reprocessed GPS EOPs
  - IGS Final combined (igs00p03)
  - Multi-technique combination (COMB2008)

Modeled Angular Momenta

- 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 (OA), SLR, LLR, VLBI, and GPS observations (no OA observations after 1982; includes igs00p03 GPS LOD and PM values)
    - No polar motion rate measurements are used
    - Daily values spanning January 20, 1962 to July 2, 2009

Polar Motion Excitation

- Long-period Liouville equation

$$\mathbf{p}(t) + \frac{i}{\sigma_{cw}} \frac{d\mathbf{p}(t)}{dt} = \boldsymbol{\chi}(t) = \frac{1.61}{\Omega\,(C-A)} \left[\mathbf{h}(t) + \frac{\Omega}{1.44}\, \mathbf{c}(t) \right]$$ (time domain)

$$\mathbf{p}(\omega) - \frac{\omega}{\sigma_{cw}}\, \mathbf{p}(\omega) = \boldsymbol{\chi}(\omega) = \frac{1.61}{\Omega\,(C-A)} \left[\mathbf{h}(\omega) + \frac{\Omega}{1.44}\, \mathbf{c}(\omega) \right]$$ (frequency domain)

$\mathbf{p}(t) = p_x(t) - i\, p_y(t)$ (location of Celestial Intermediate Pole in Terrestrial Reference Frame)

$\sigma_{cw} = 2\pi / T_{cw}\,(1 + i / 2Q_{cw})$ (complex-valued frequency of Chandler wobble)

$\boldsymbol{\chi}(t) = \chi_x(t) + i\, \chi_y(t)$ (polar motion excitation function)

$\mathbf{h}(t) = h_x(t) + i\, h_y(t)$ (angular momentum due to motion relative to rotating TRF)

$\Omega\, \mathbf{c}(t) = \Omega\, [\Delta I_{xz}(t) + i\, \Delta I_{yz}(t)]$ (angular momentum due to rearrangement of mass within TRF)

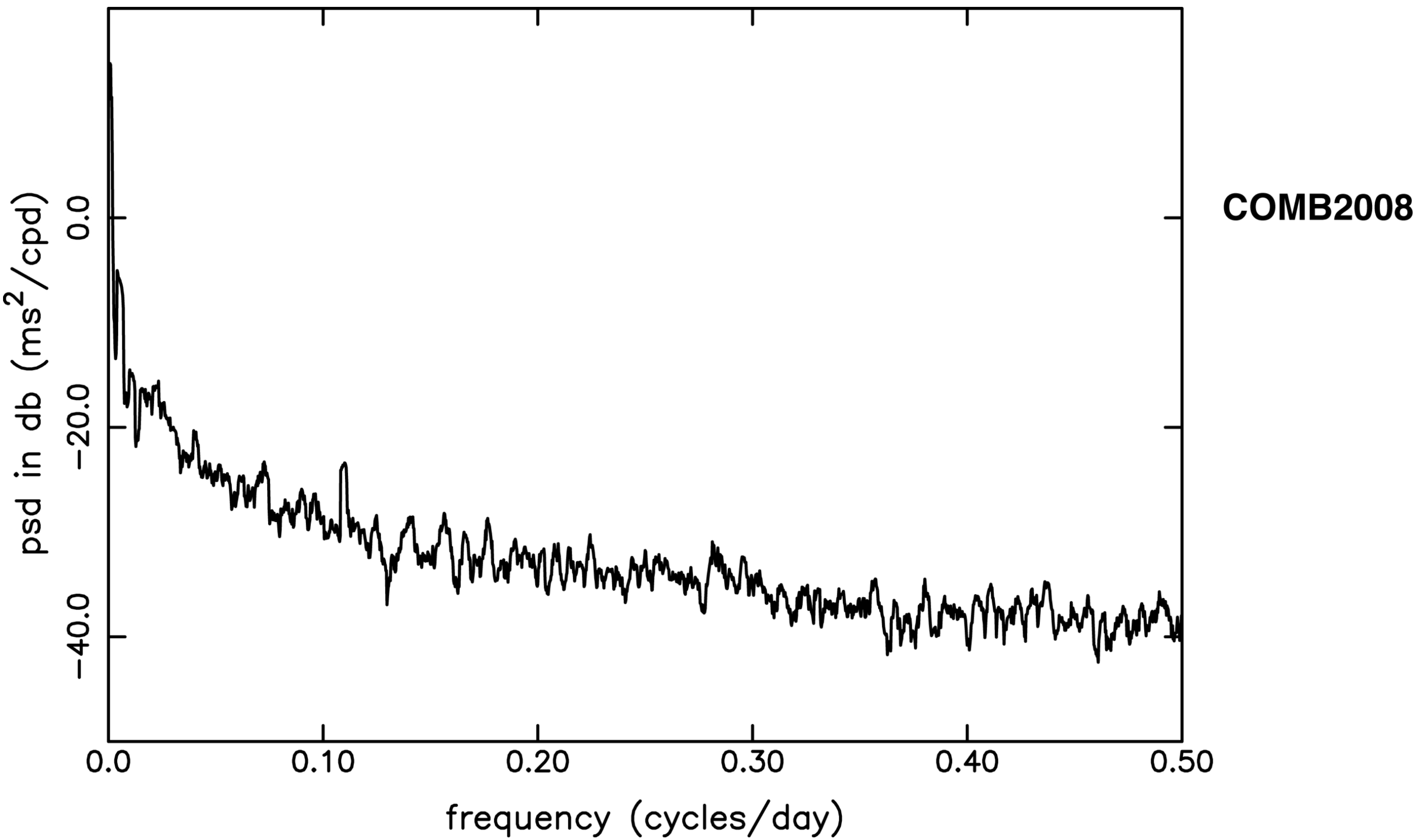
- At low frequencies $(\omega << \sigma_{cw})$

$$\mathbf{p}(\omega) \approx \boldsymbol{\chi}(\omega)$$

- At high frequencies $(\omega >> \sigma_{cw})$

$$-\frac{\omega}{\sigma_{cw}}\, \mathbf{p}(\omega) \approx \boldsymbol{\chi}(\omega)$$

LOD – Tides – (AAM+OAM)



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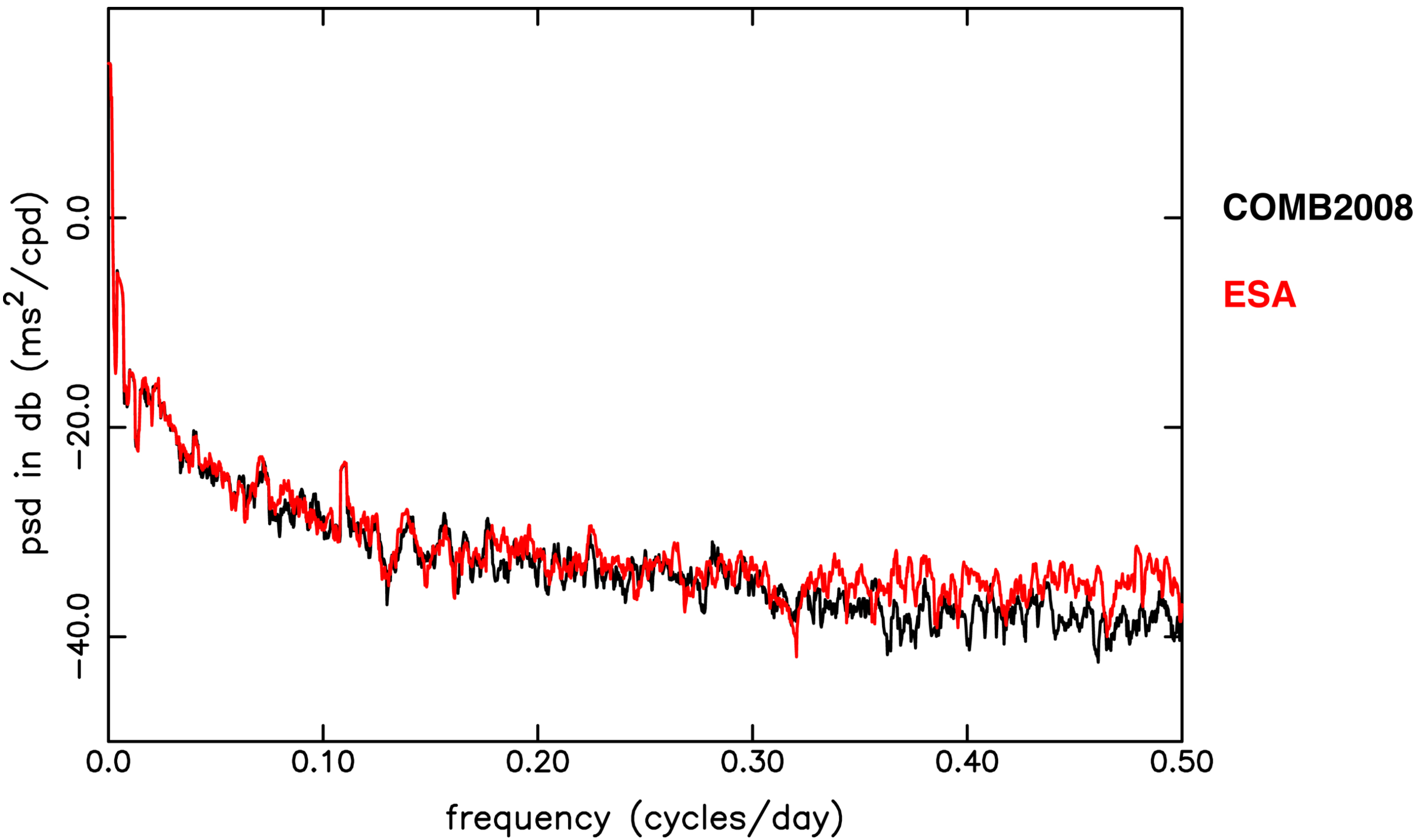

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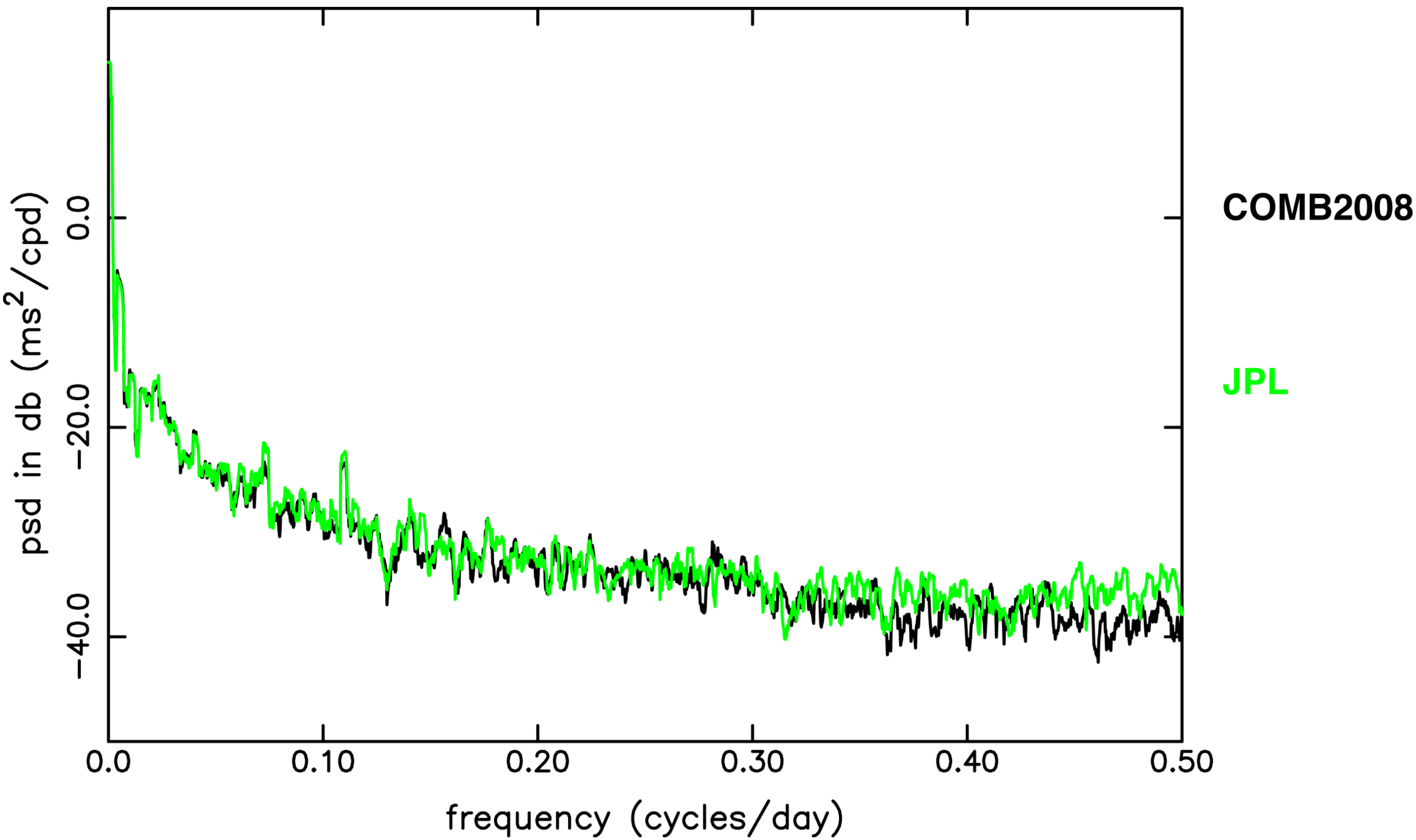

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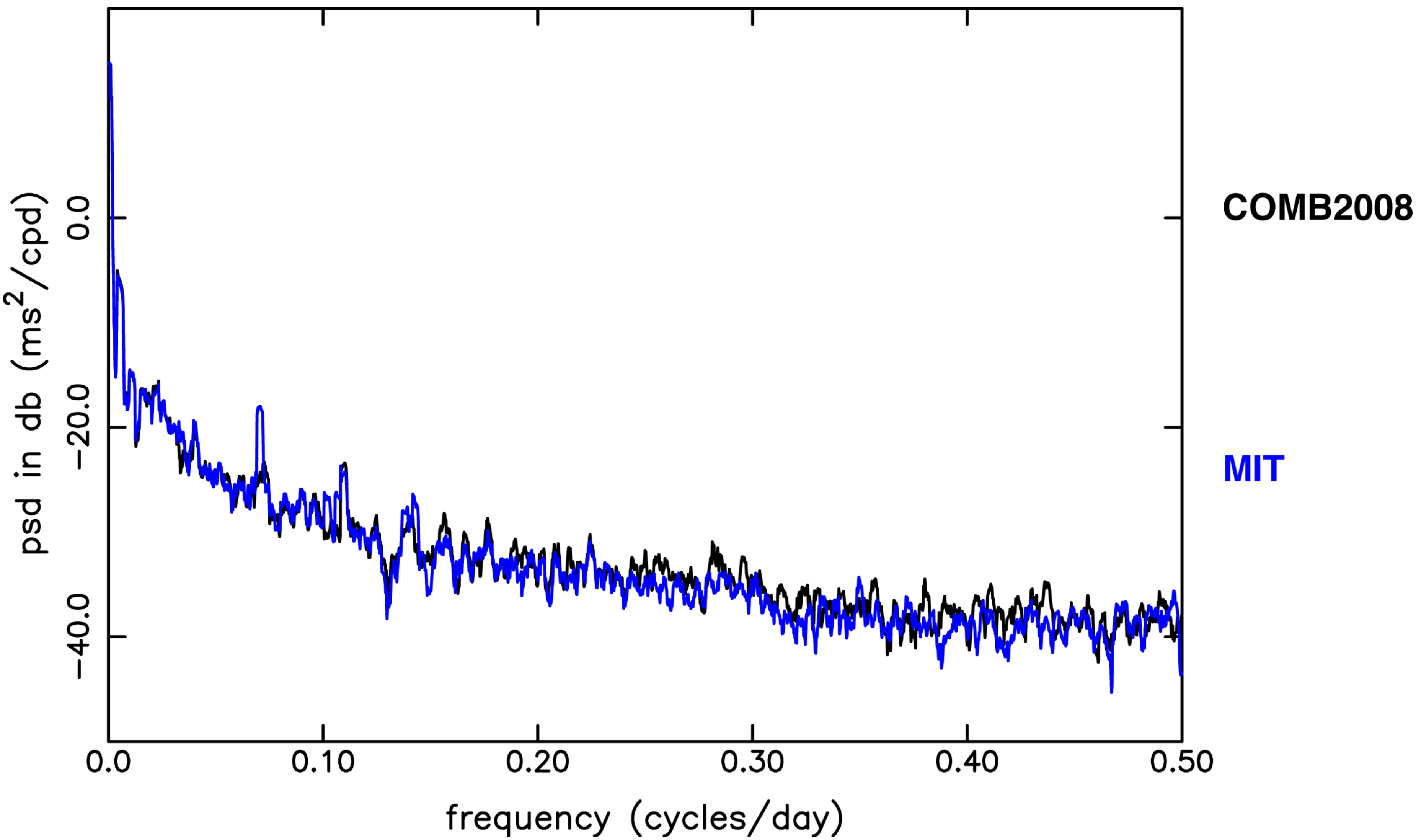

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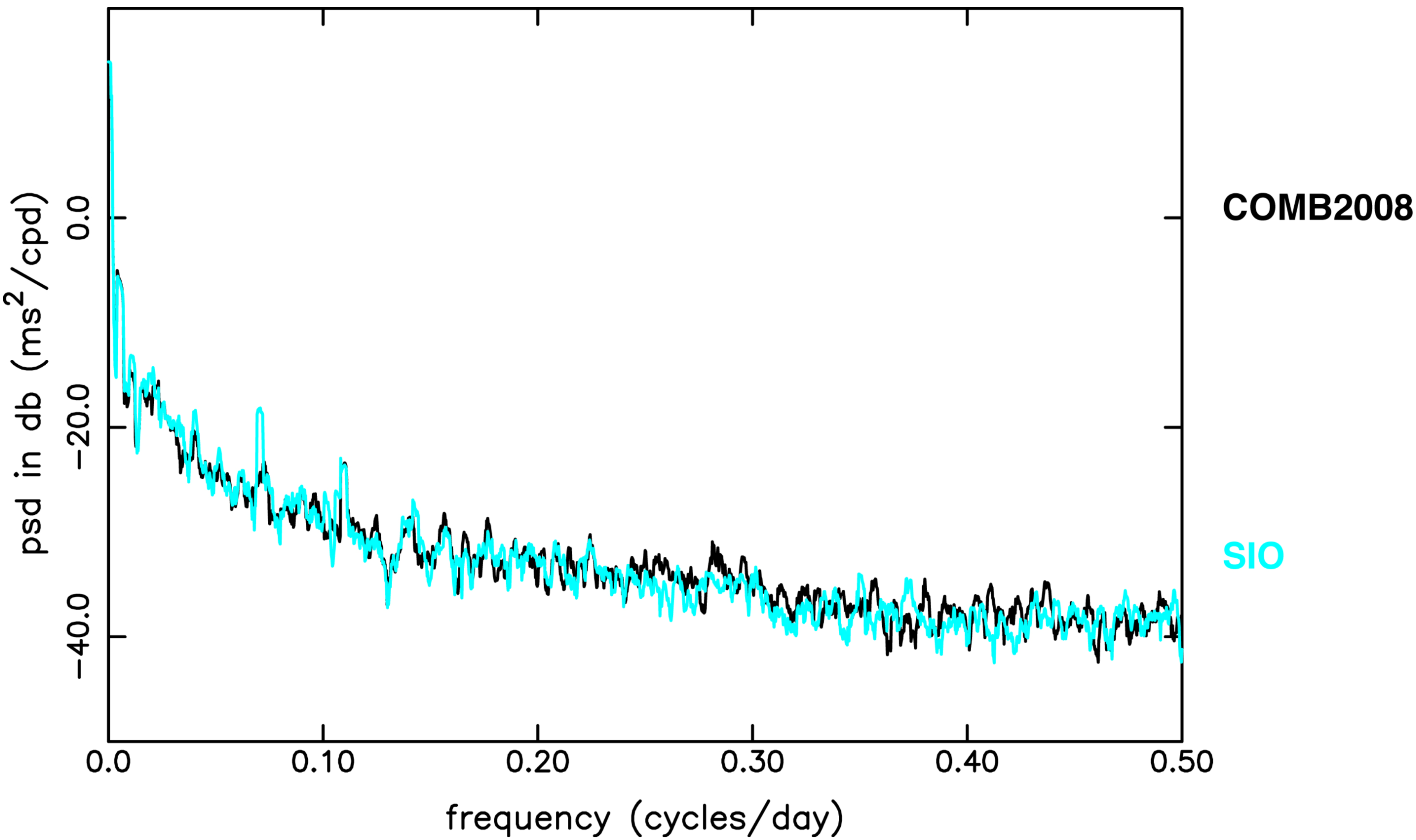

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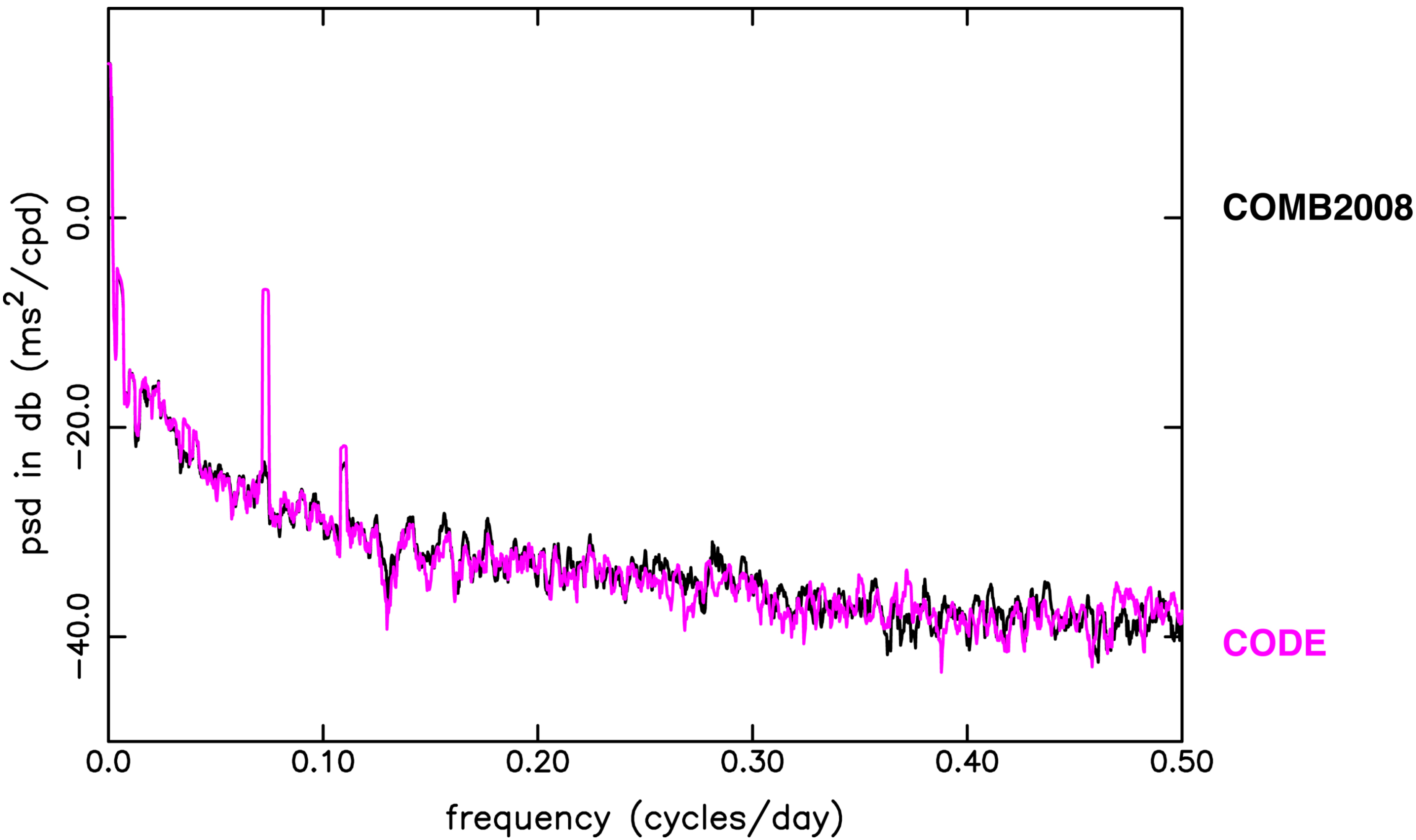

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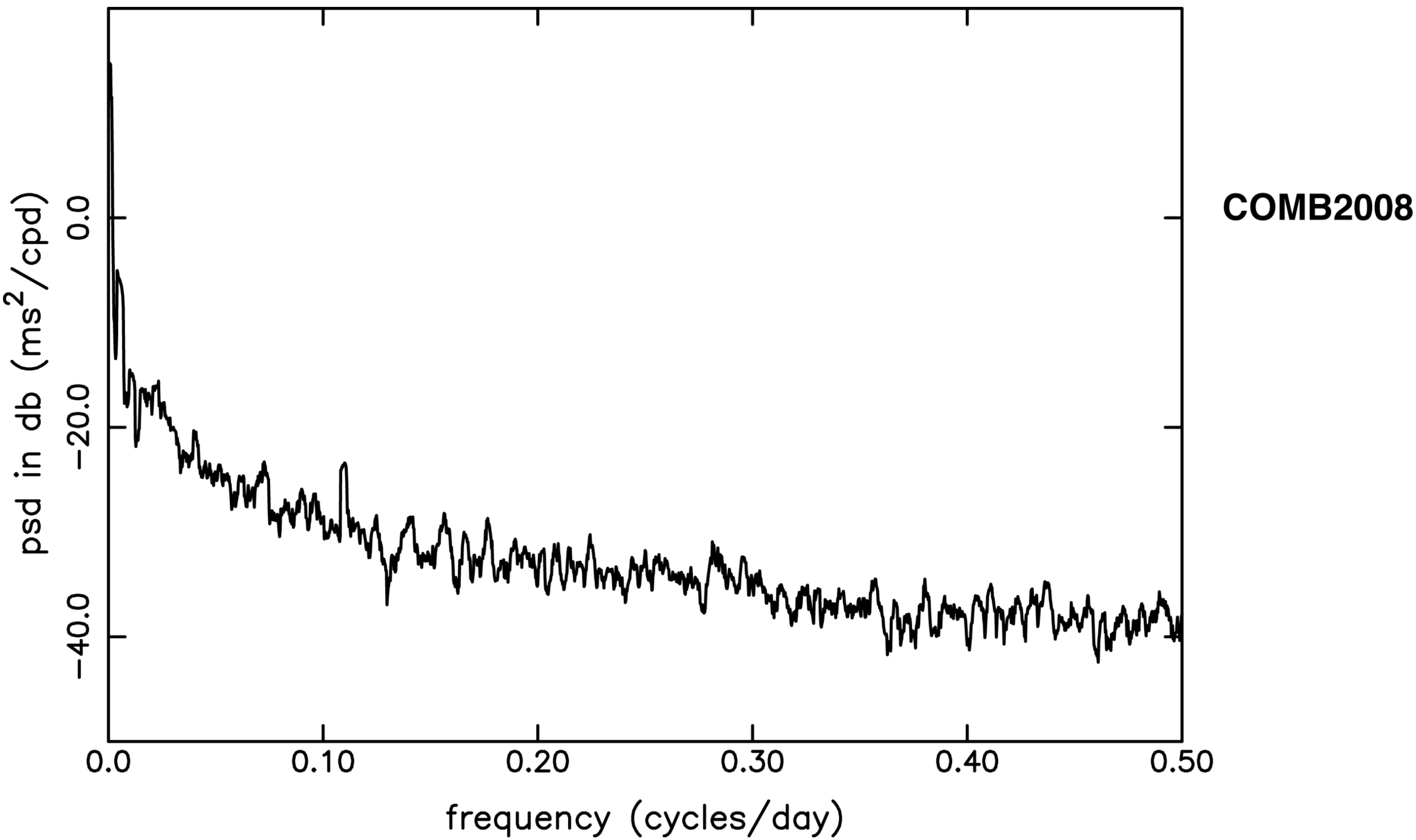

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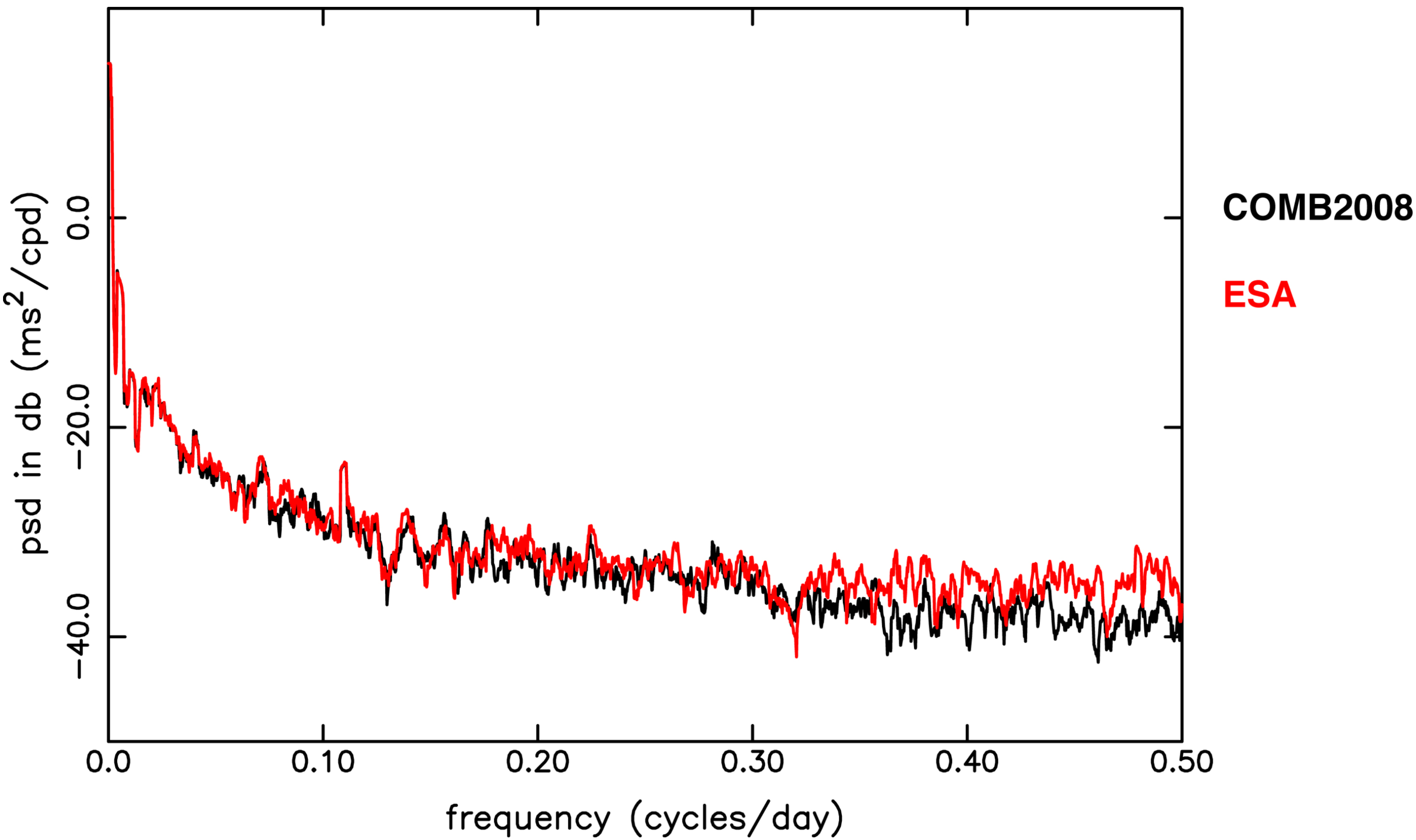

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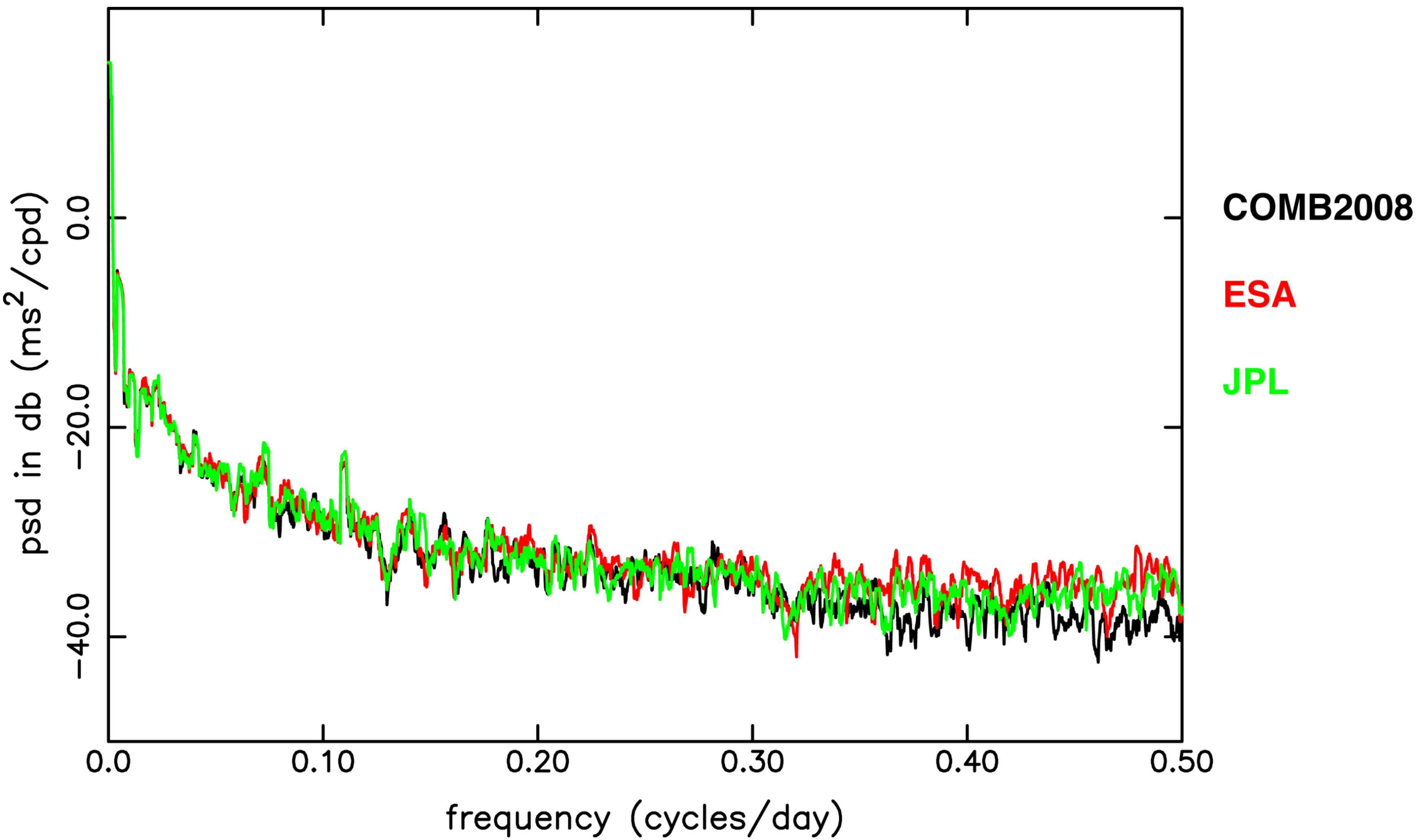

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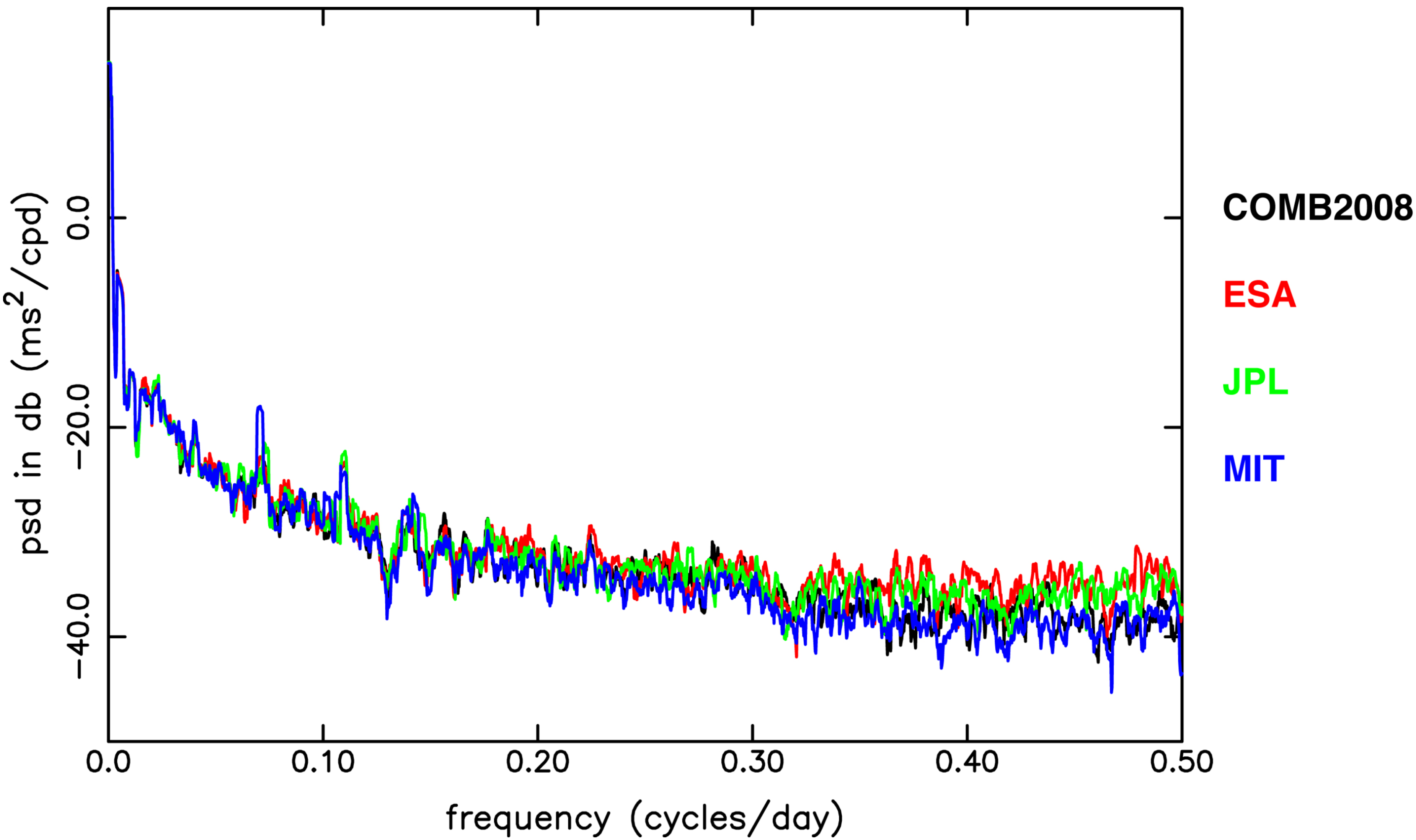

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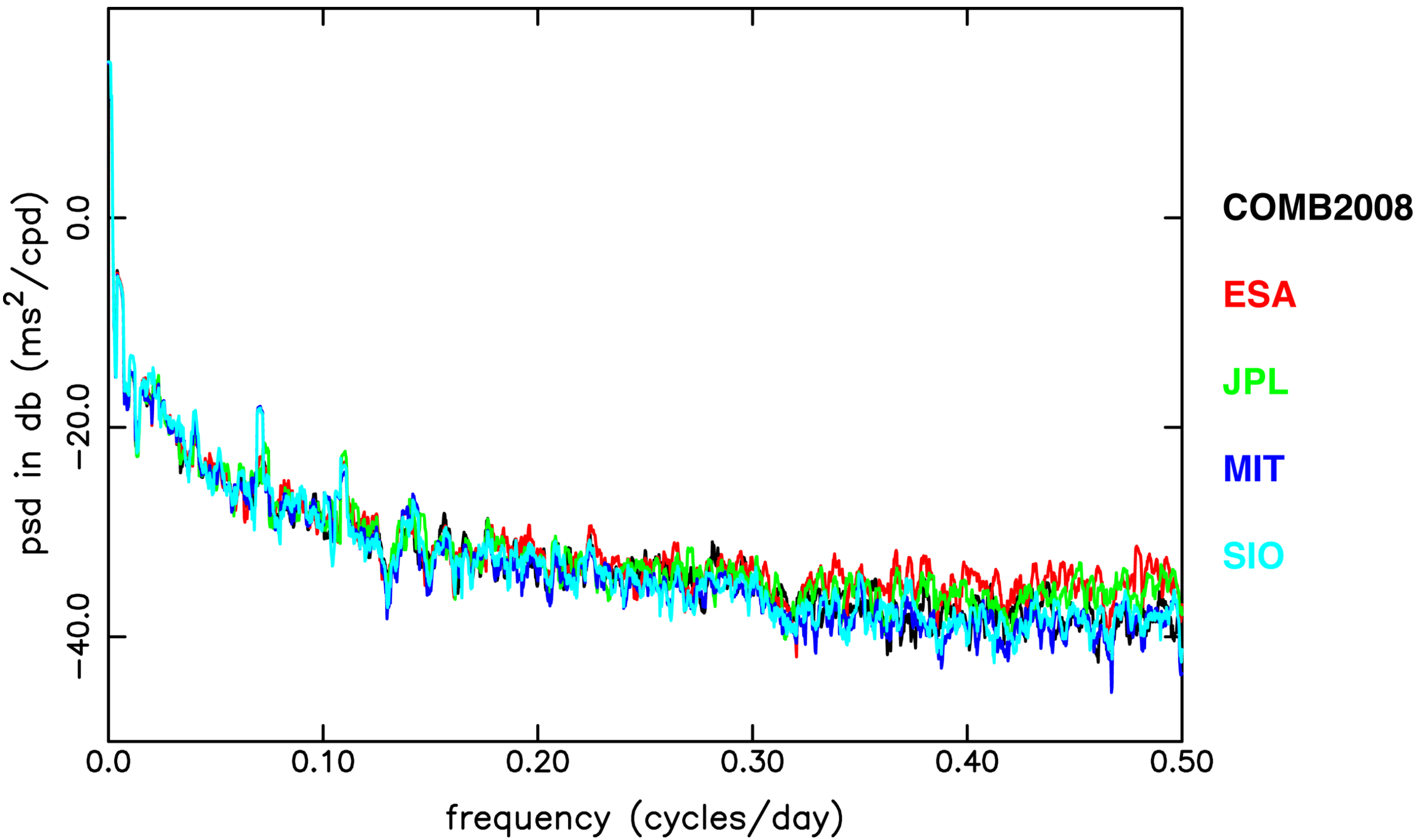

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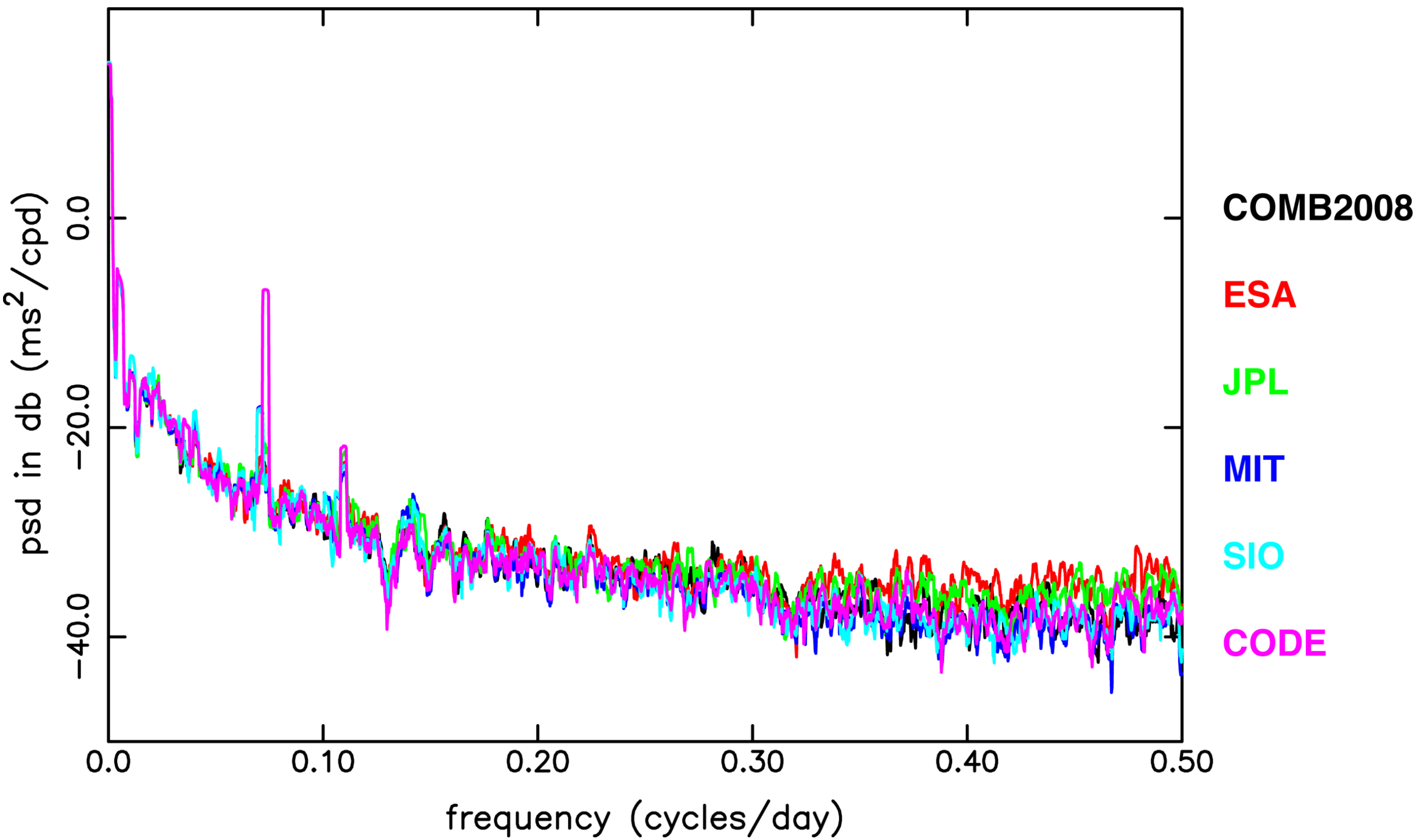

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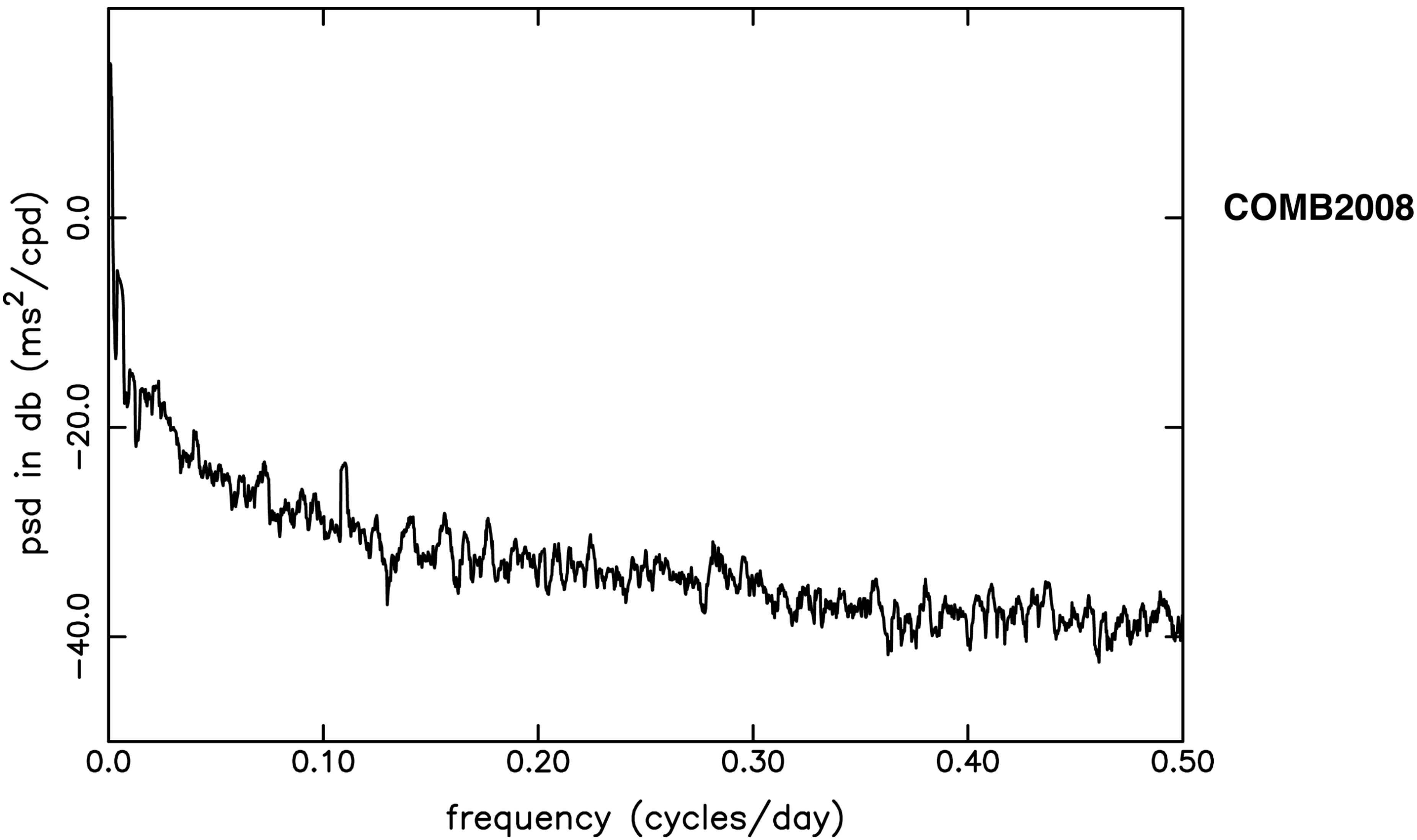

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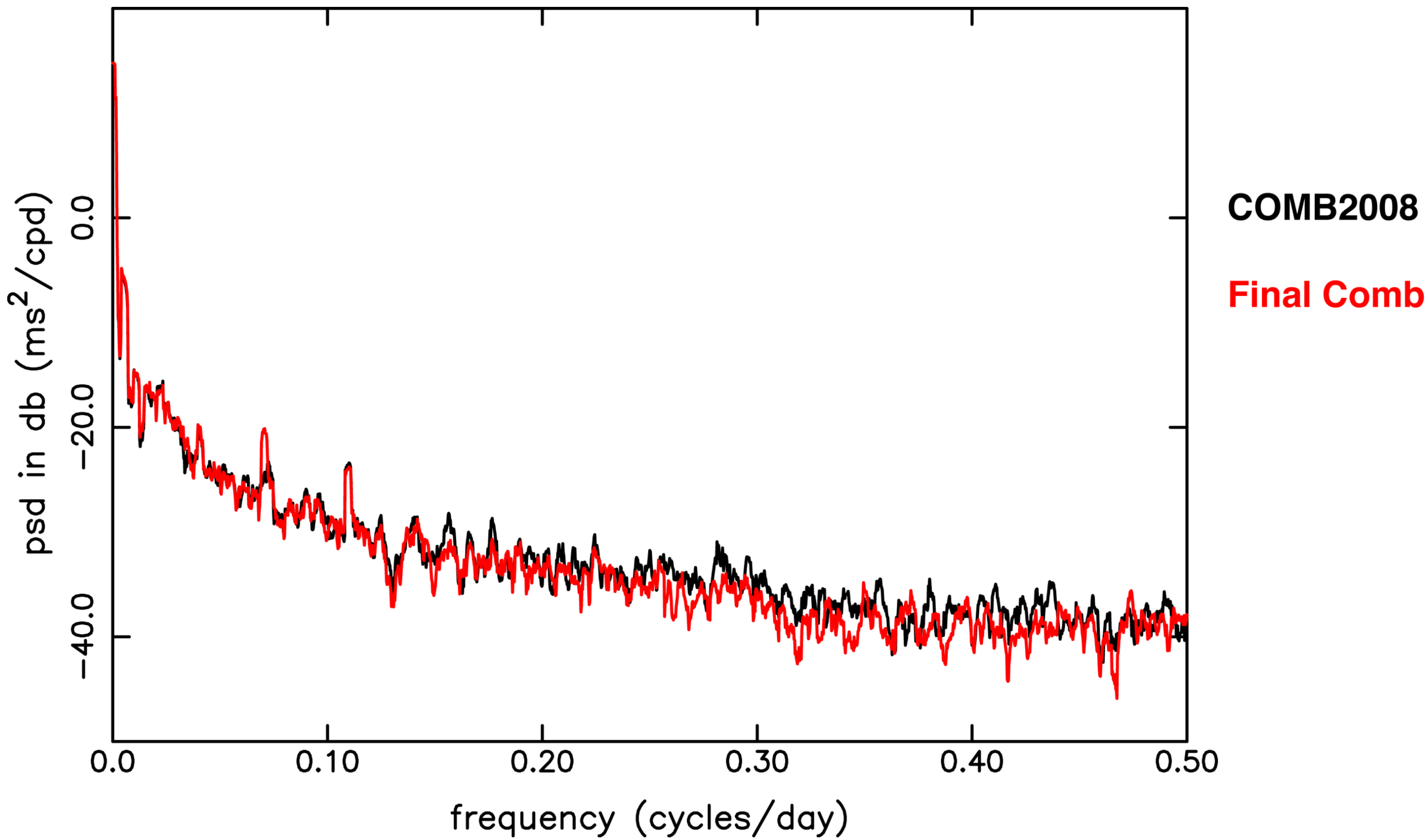

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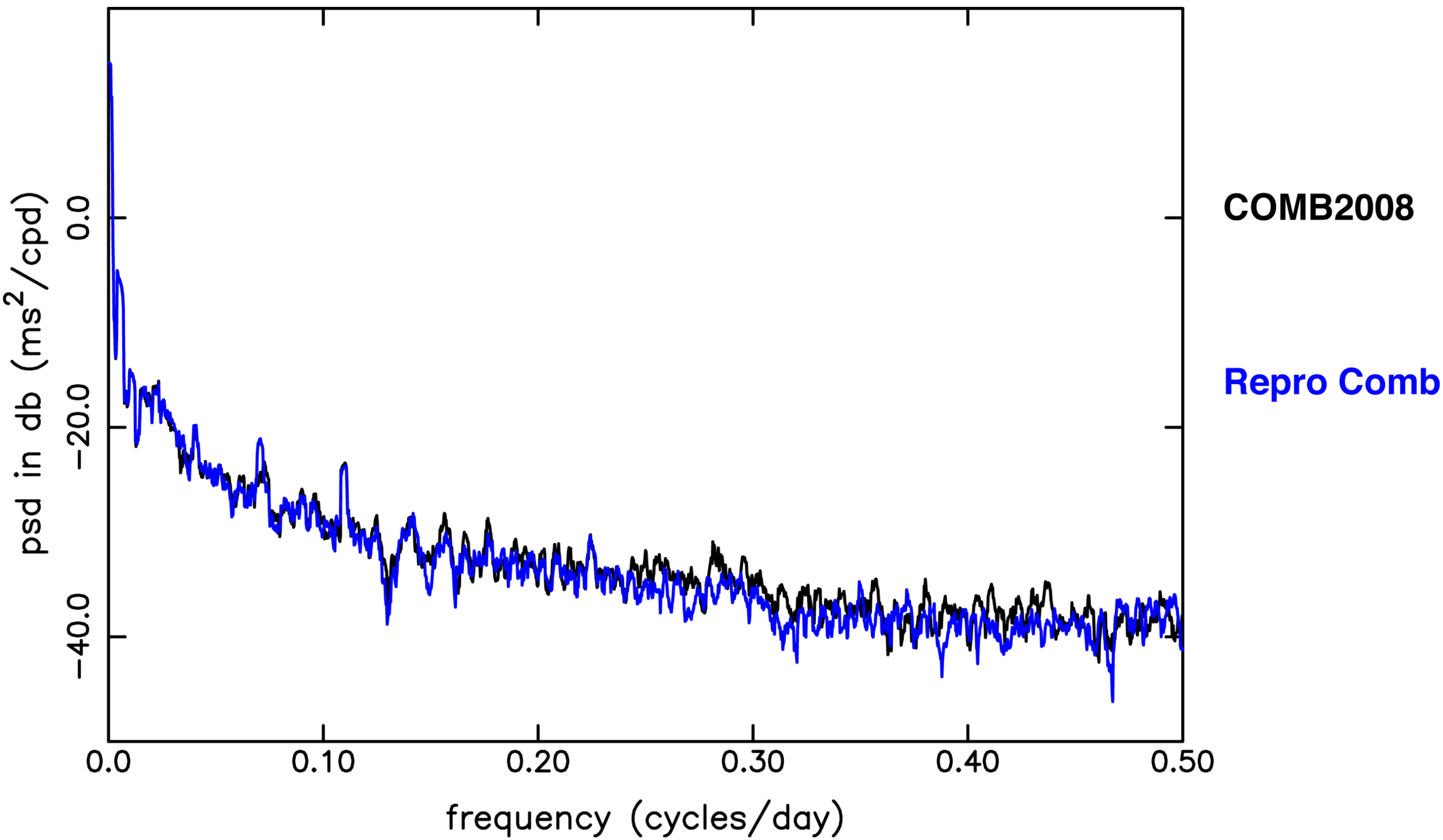

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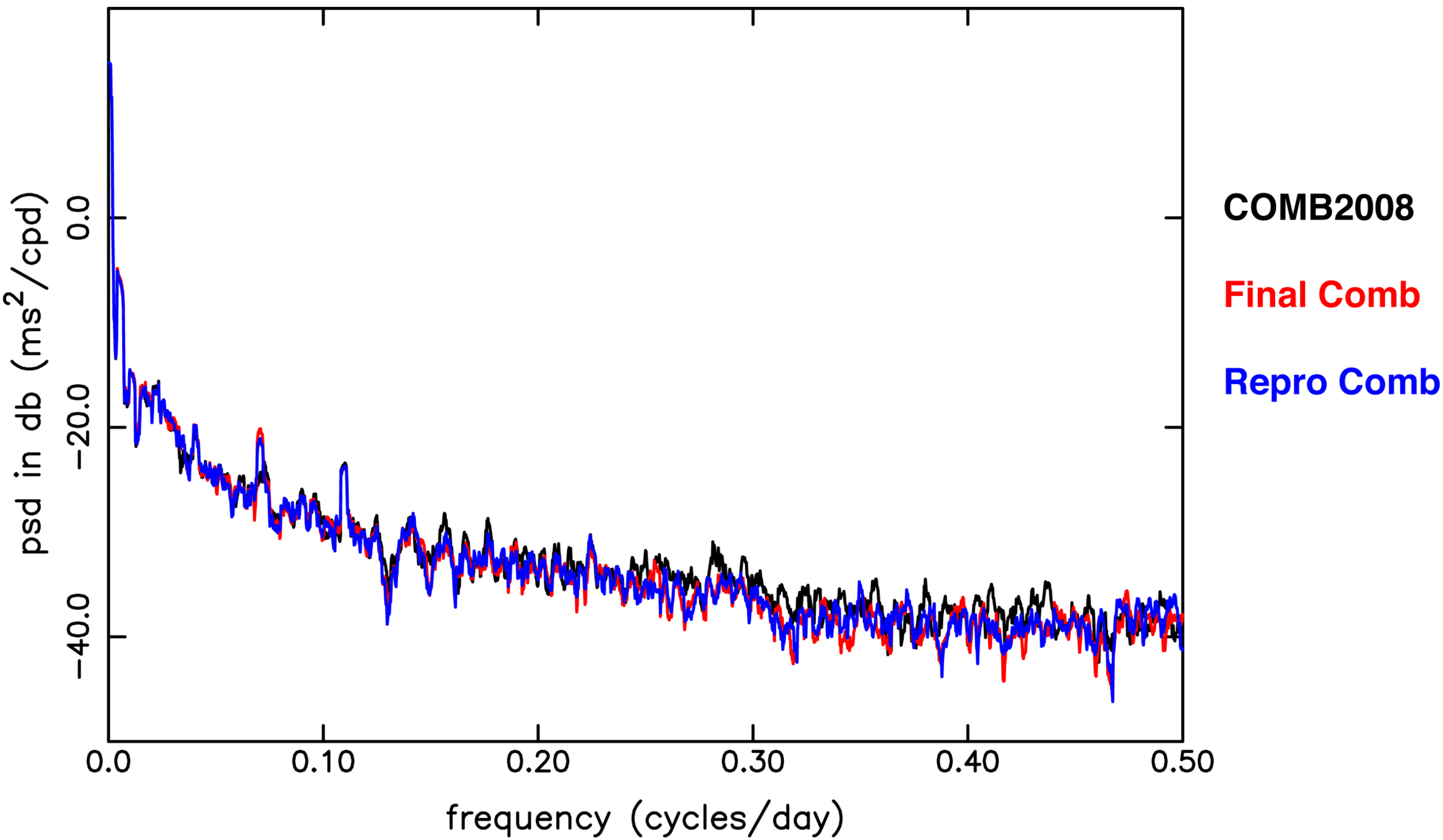
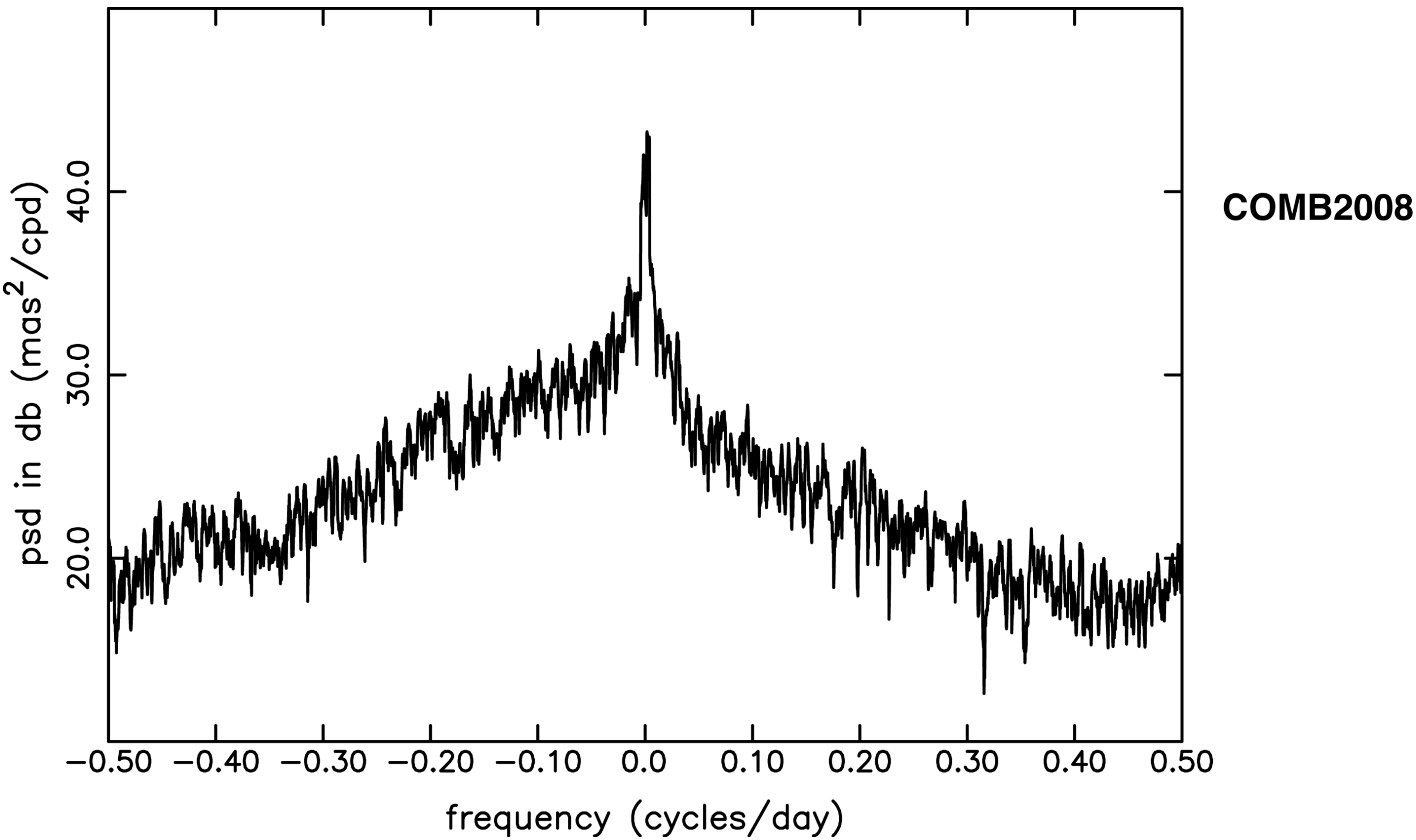


Period of Spectral Peaks (LOD)

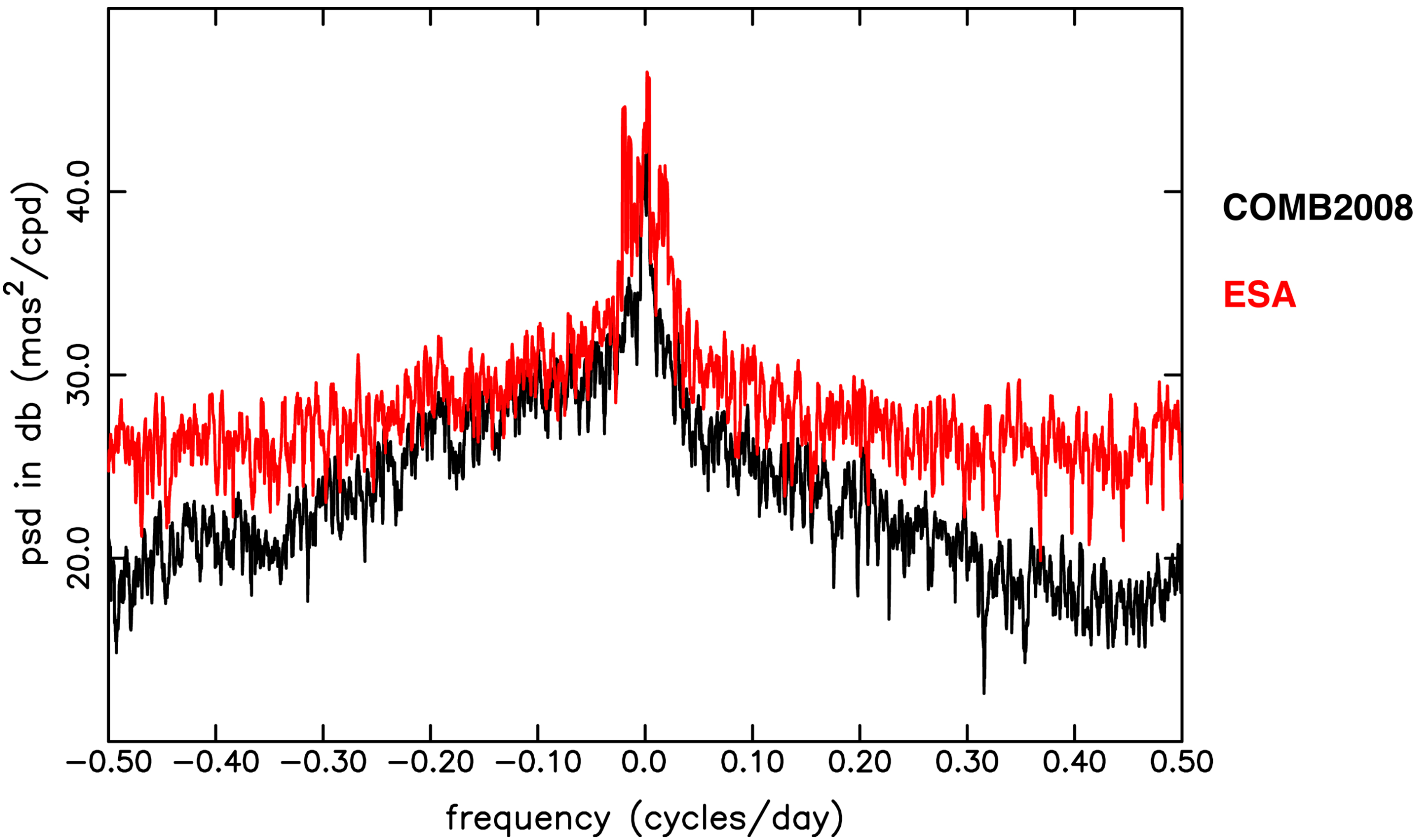
Analysis Center	Mtm	Mf	Aliased O1
JPL	9.1	13.6	
CODE	9.1	13.6	
ESA	9.1		14.2
MIT	9.1		14.2
SIO	9.1		14.2
Repro Comb	9.1		14.2
Final Comb	9.1		14.2
COMB2008	9.1		

(period given in solar days)

PM Exc – Tides – (AAM+OAM)



PM Exc – Tides – (AAM+OAM)



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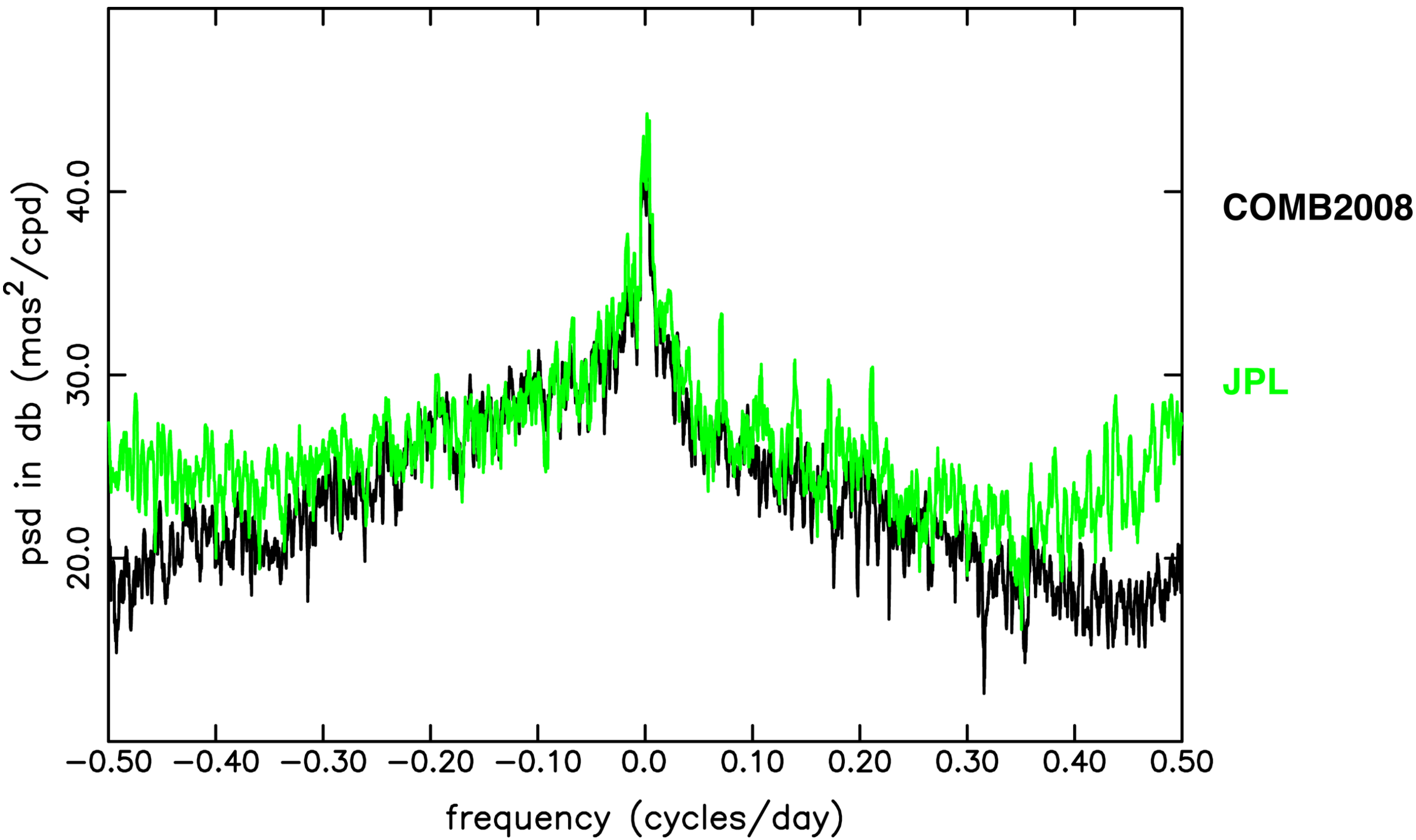

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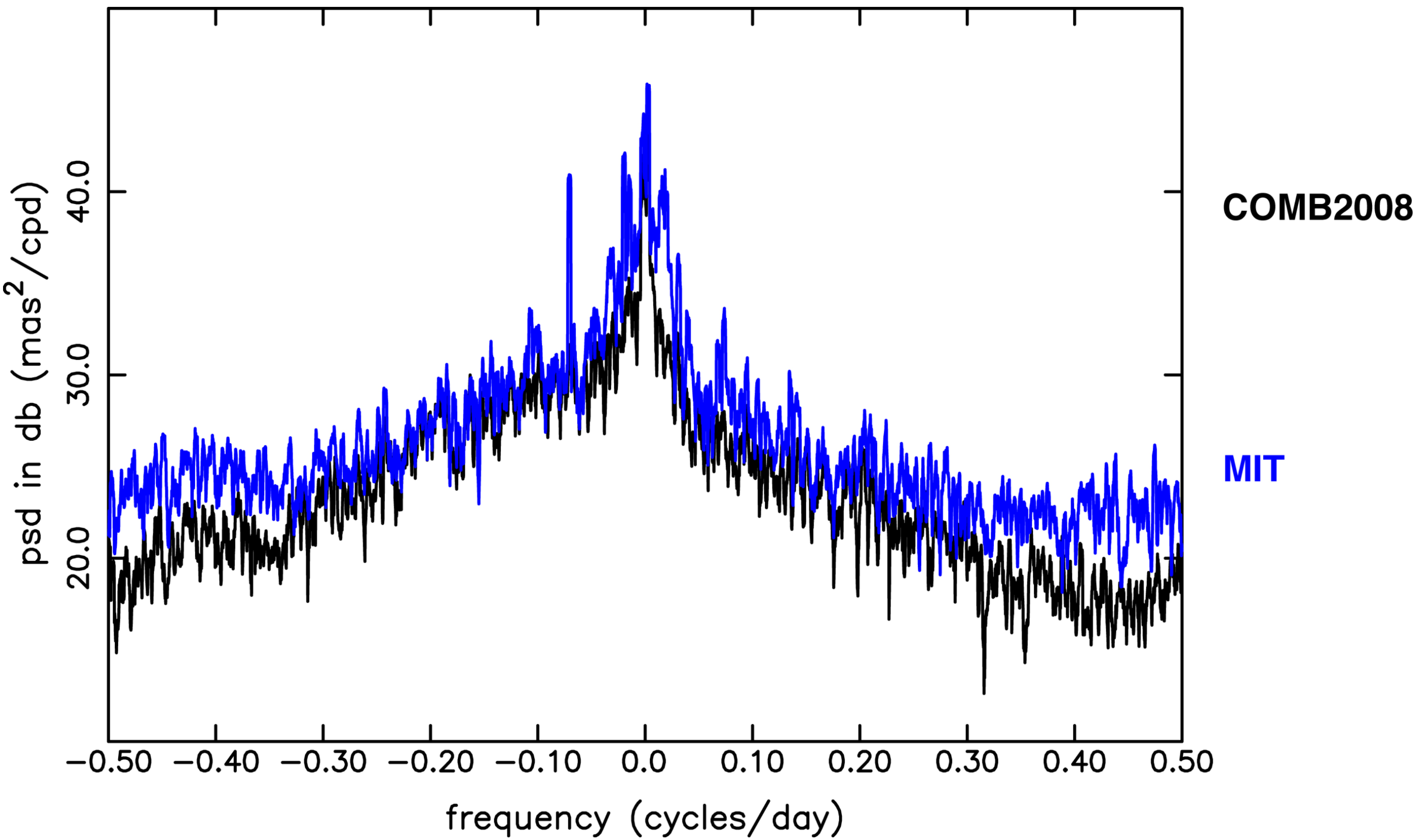

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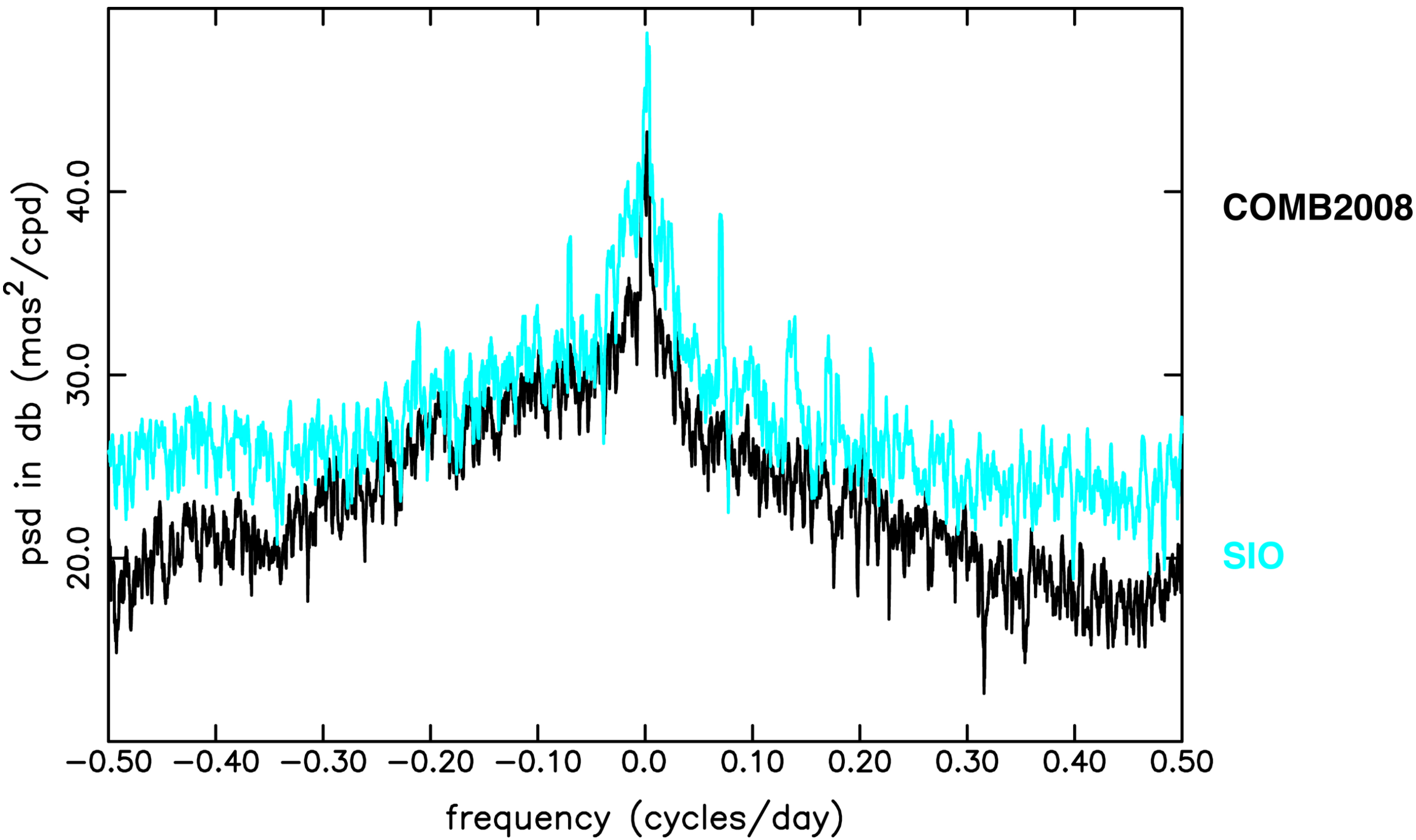

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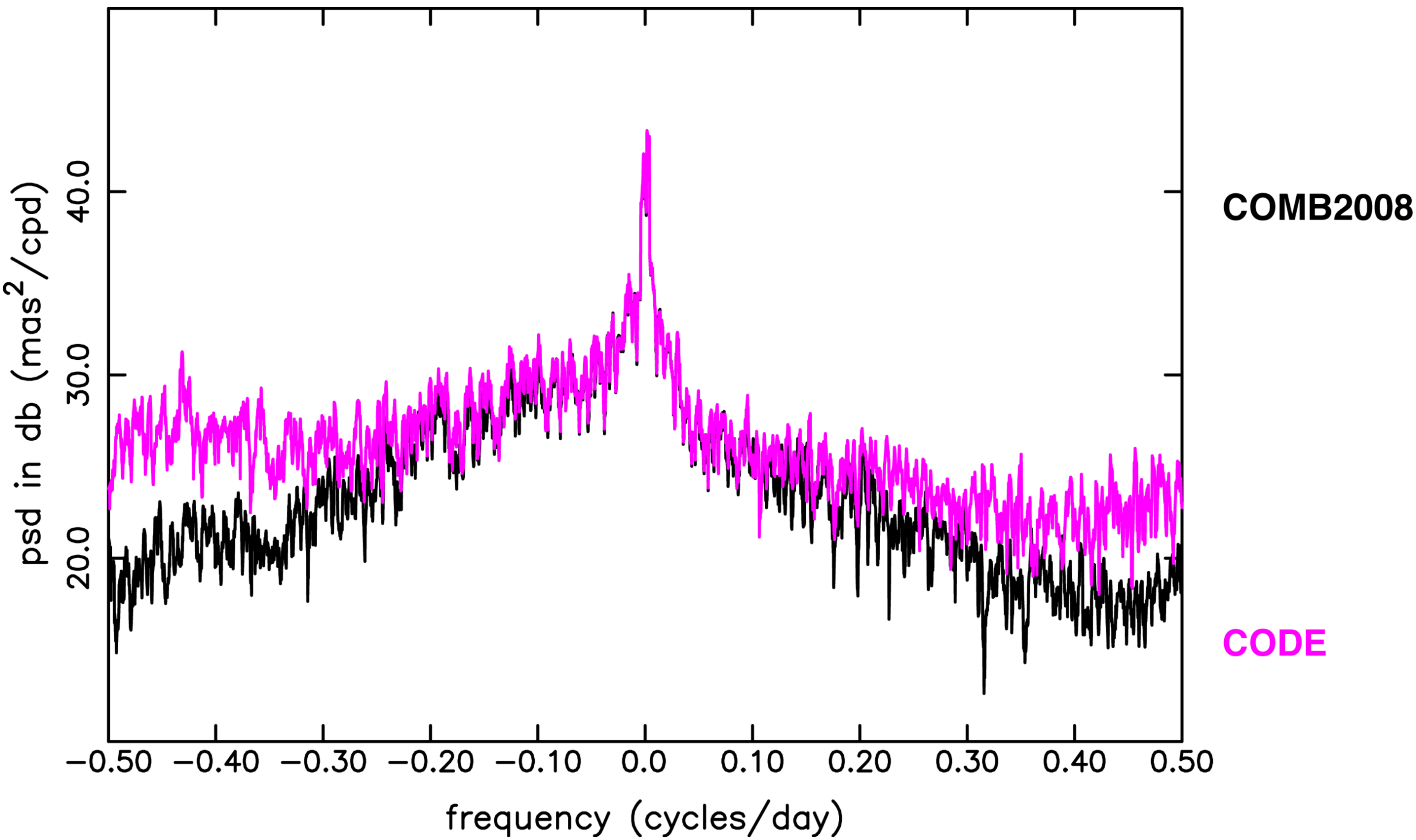

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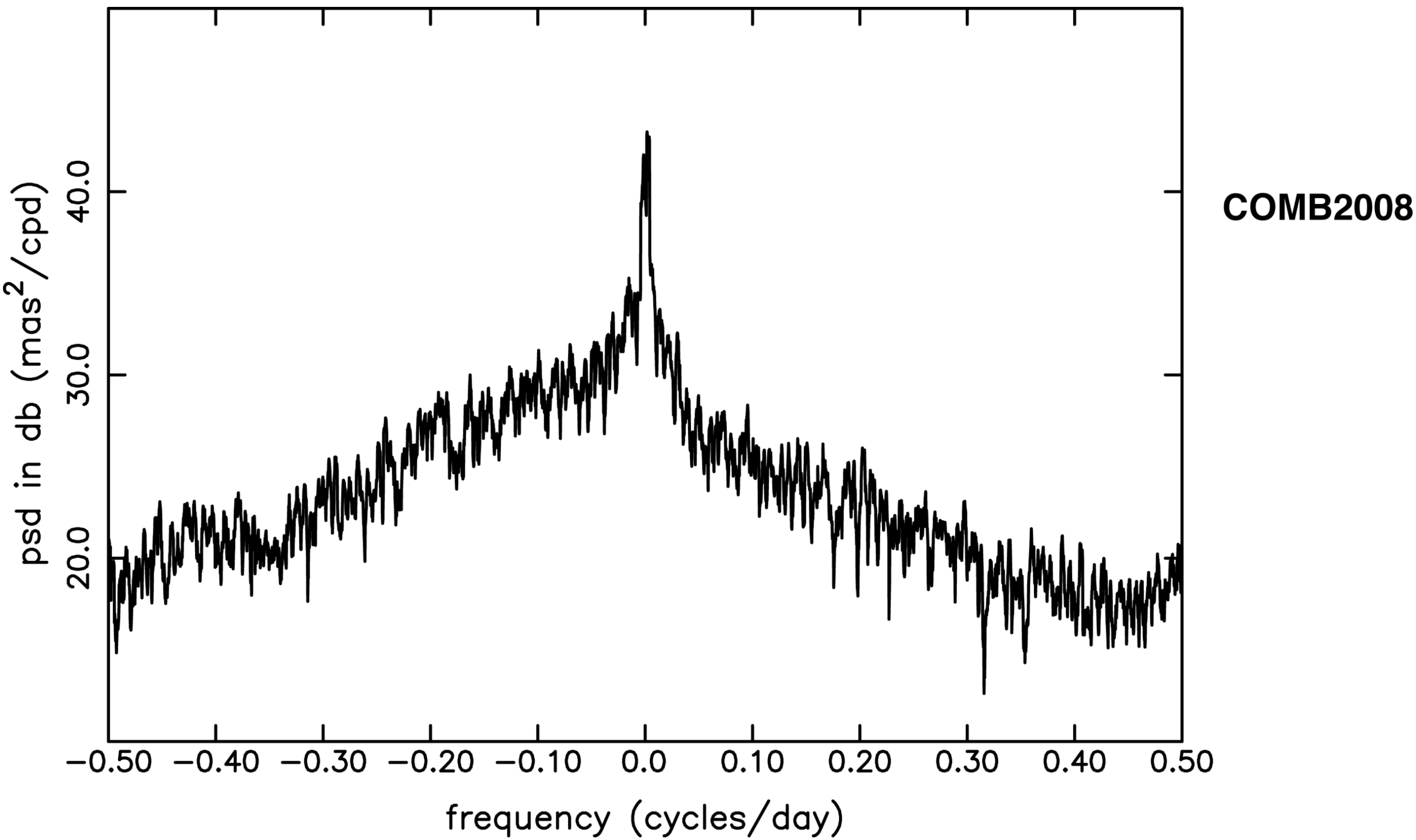

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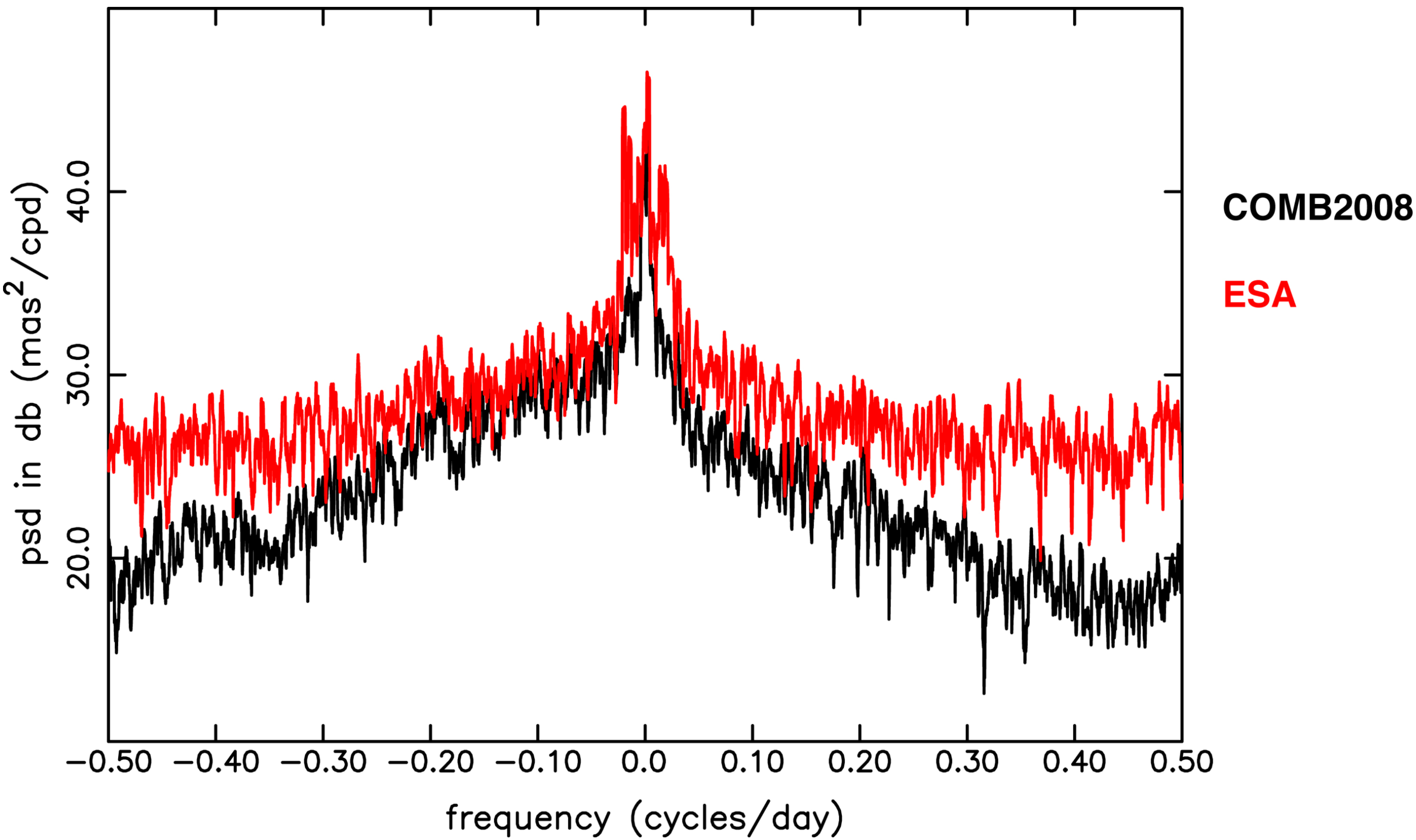

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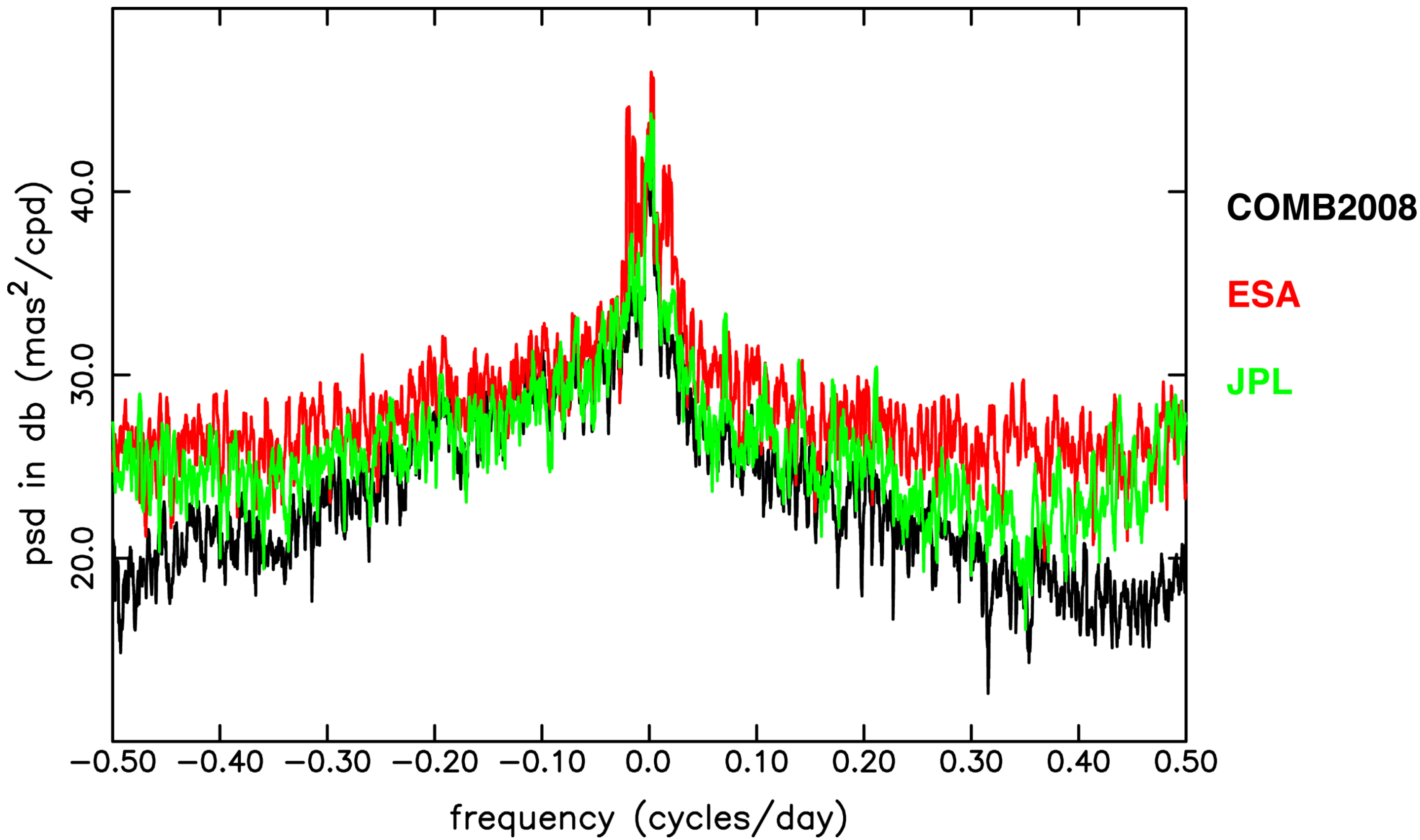

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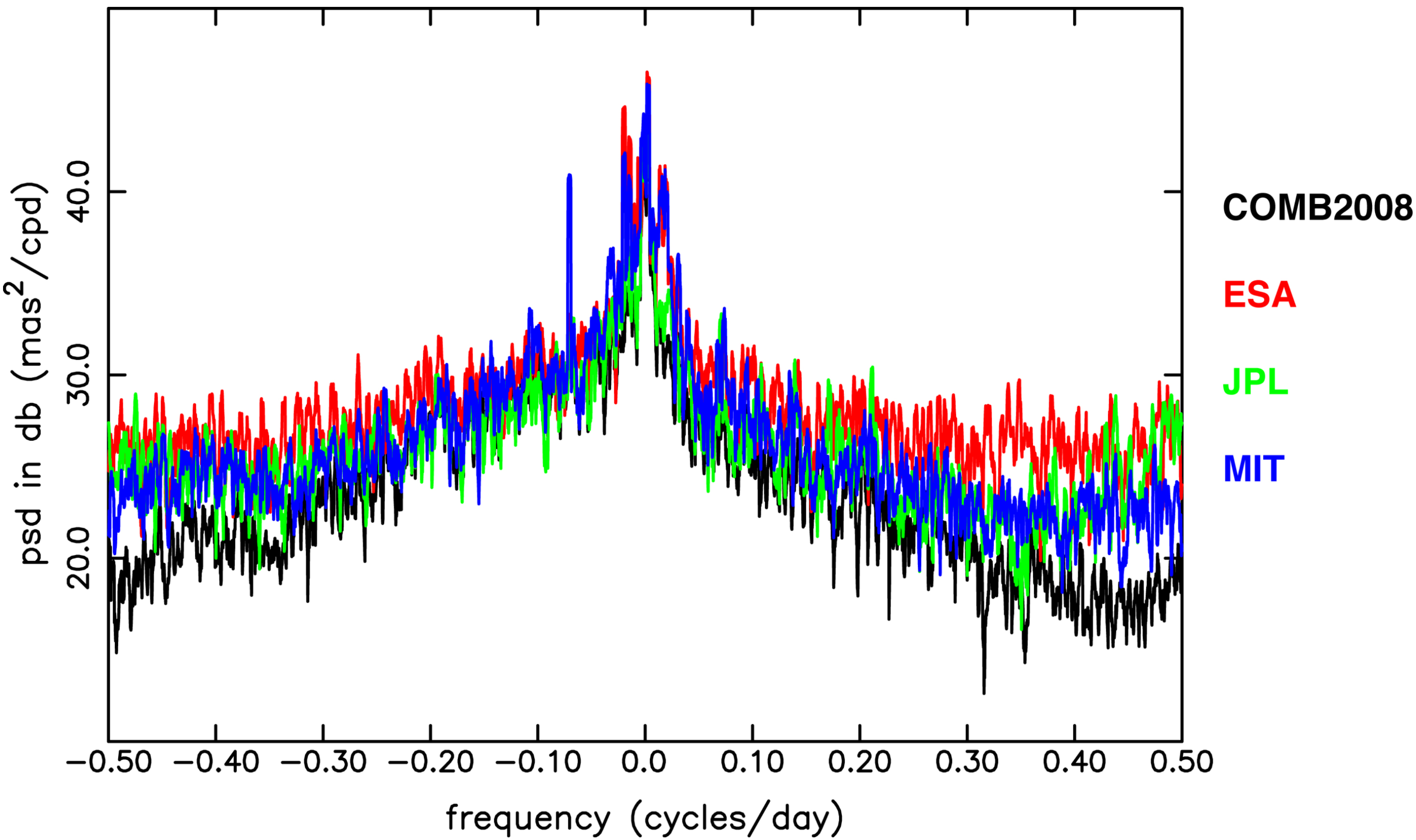

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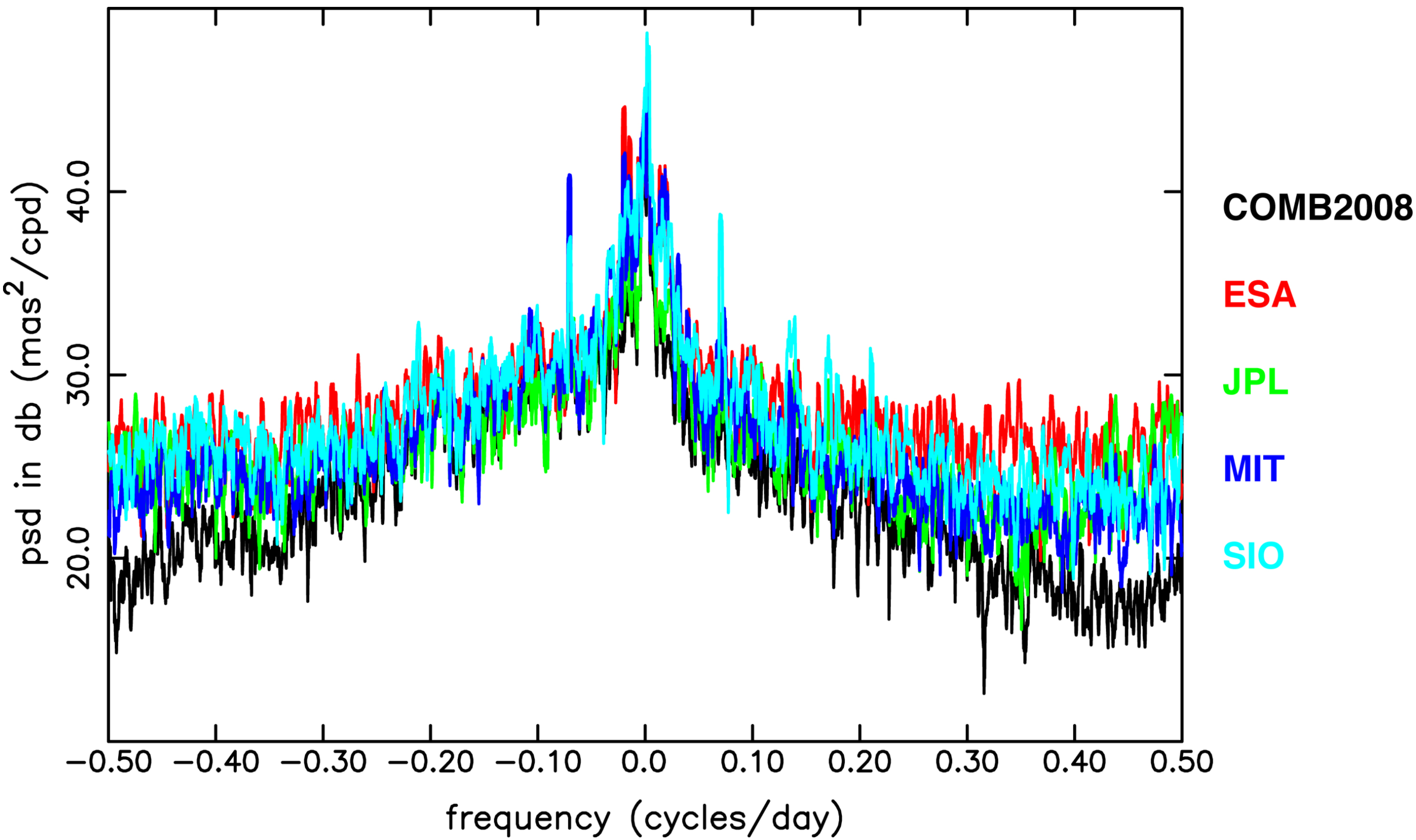

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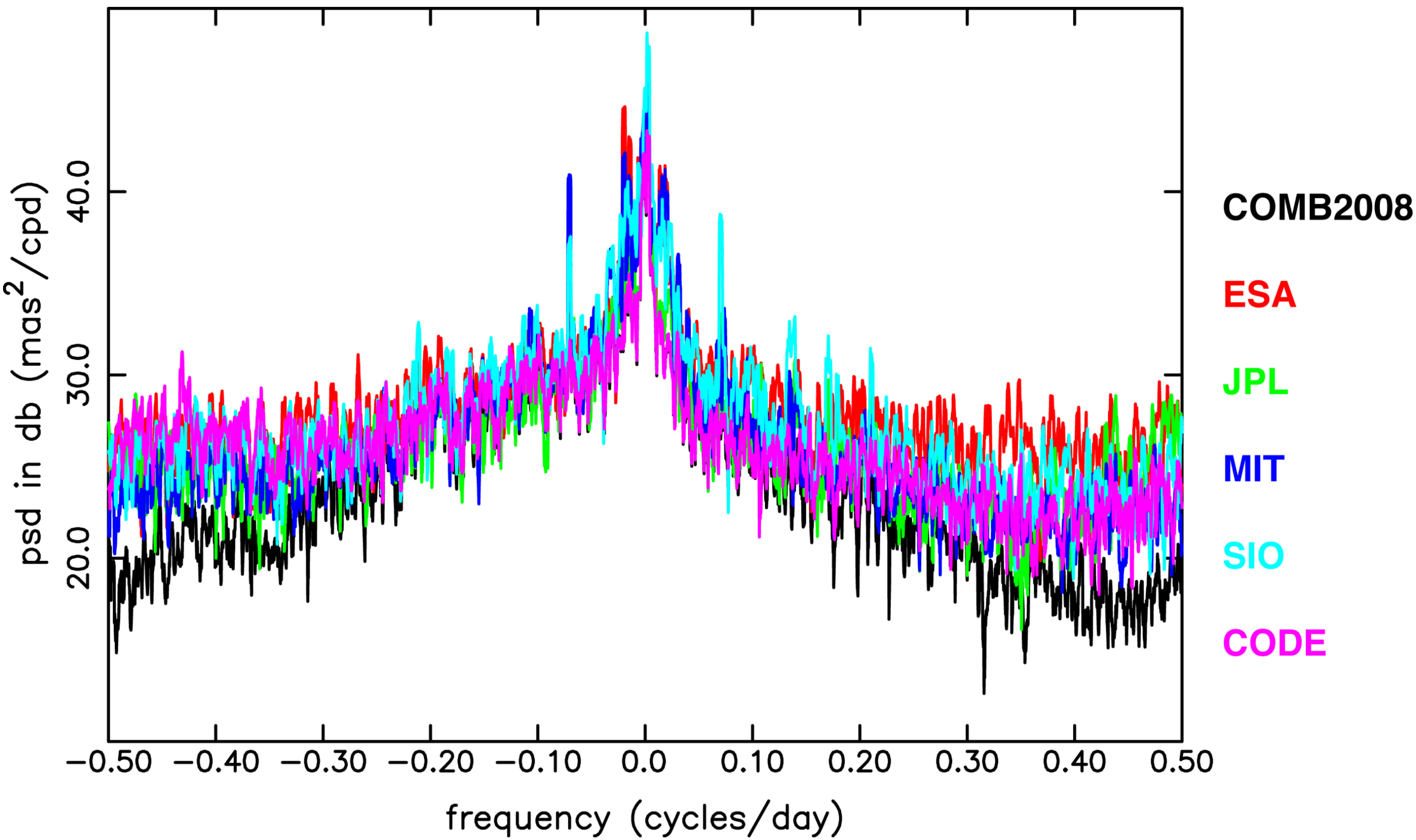

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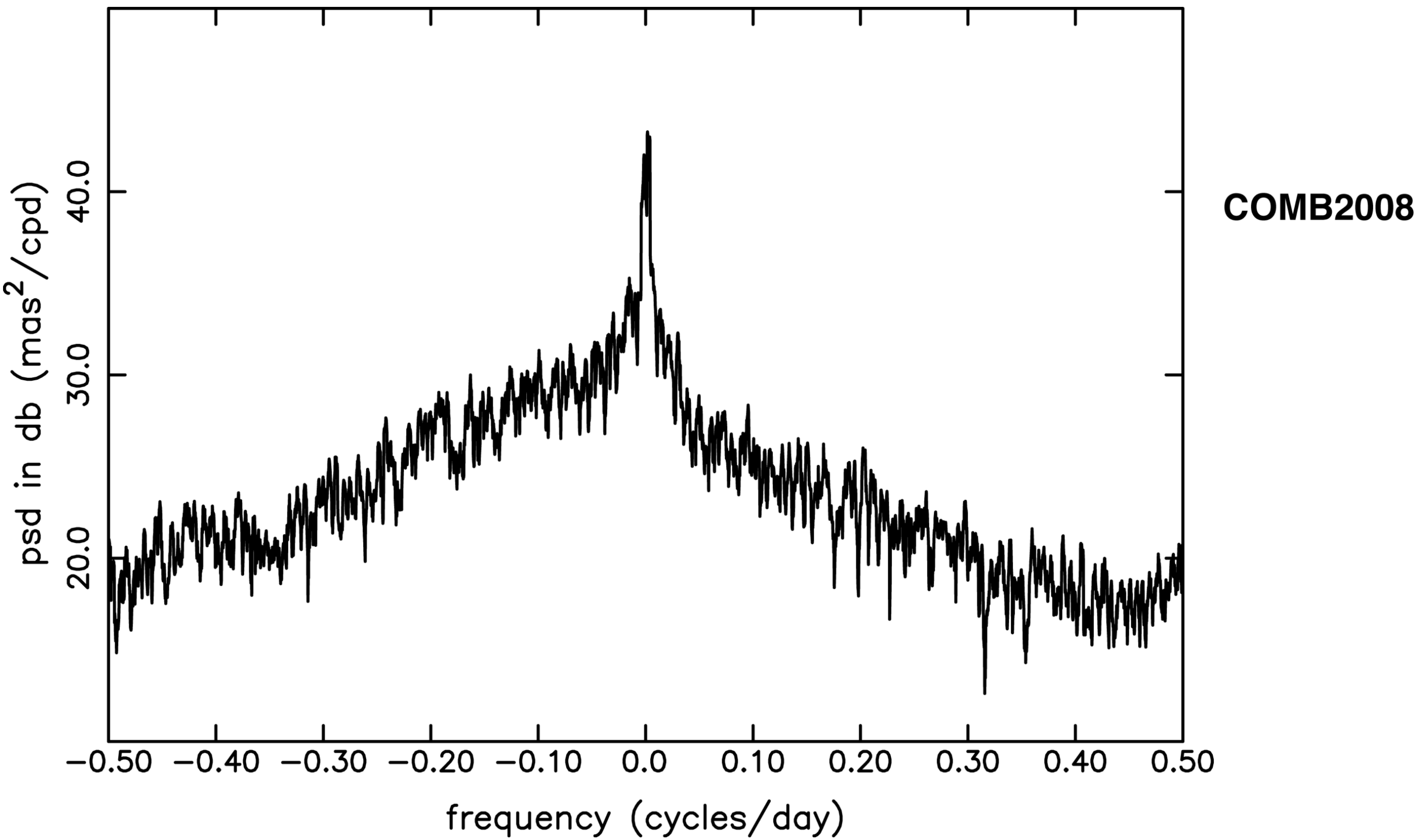

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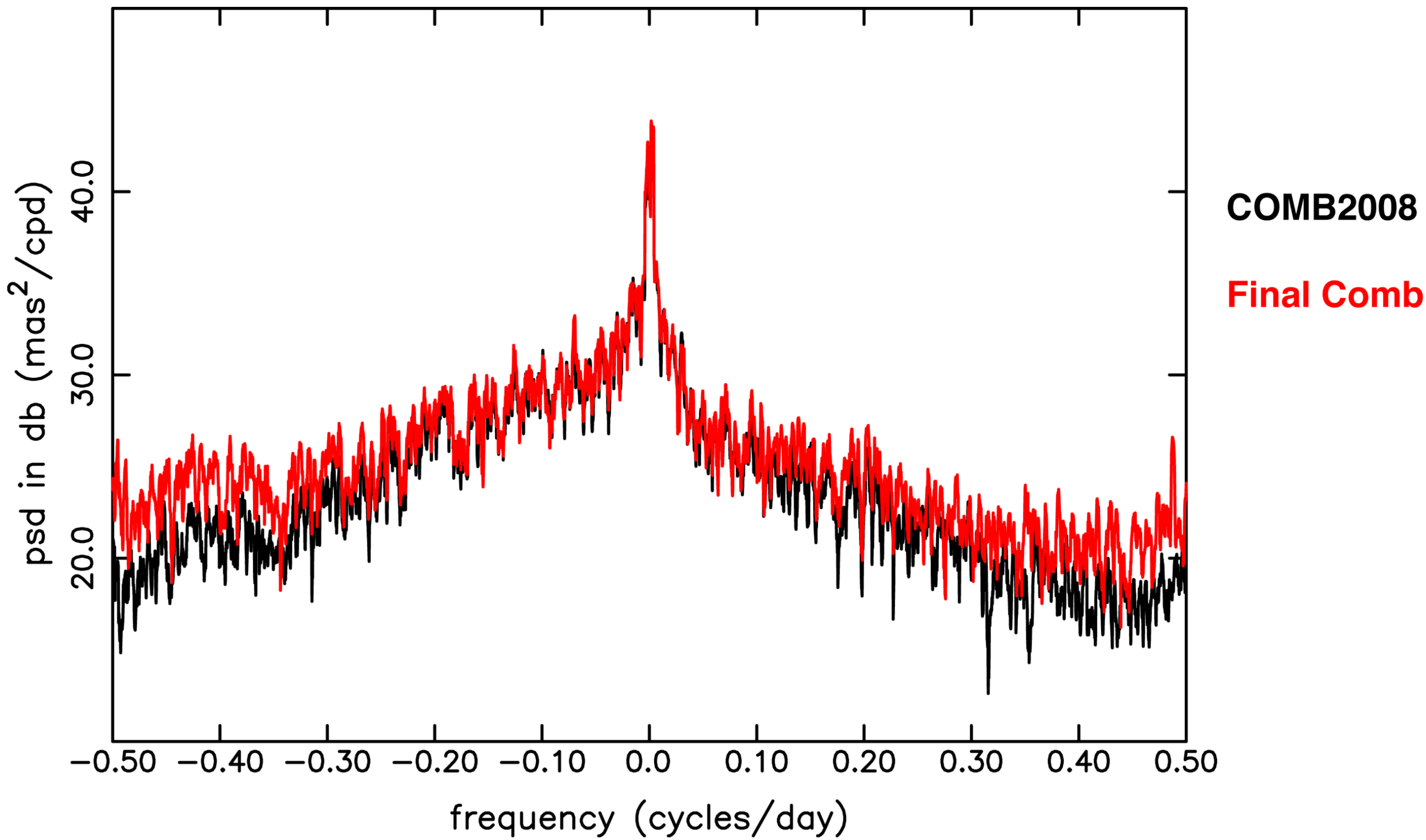

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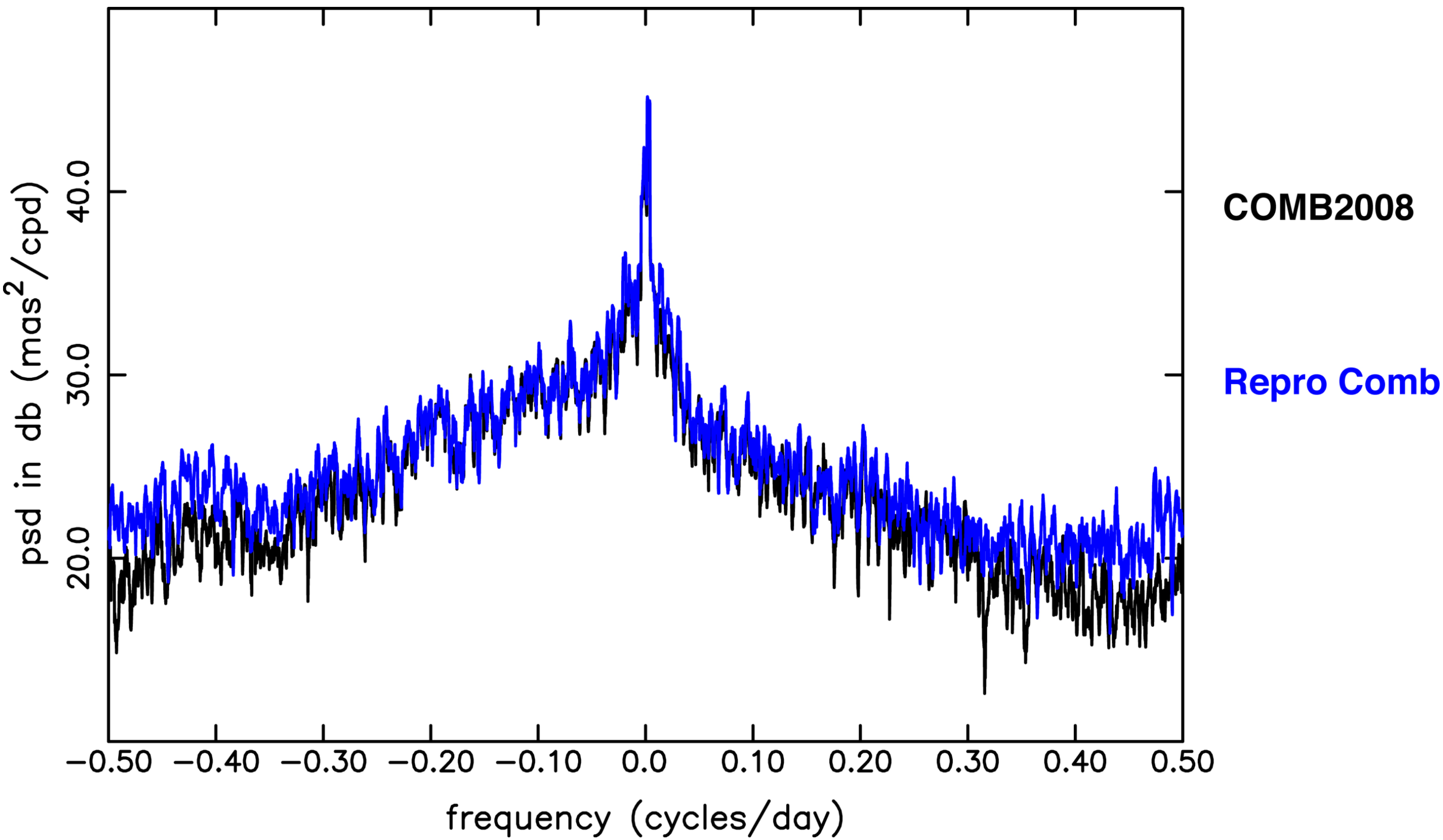

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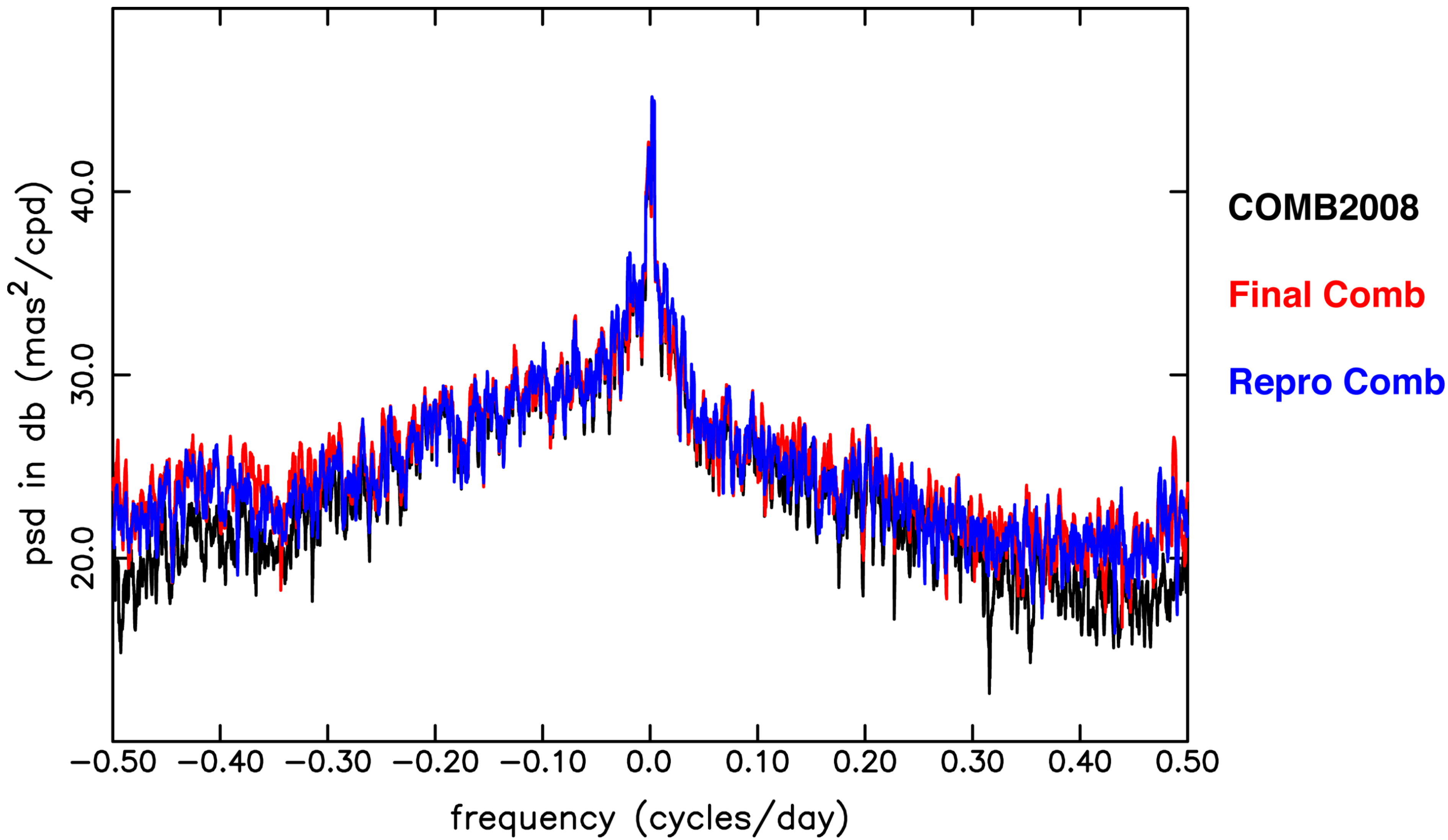

Period of Spectral Peaks (PM Exc)

Analysis Center	Aliased O1					
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	---
Repro Comb	---	---	---	---	---	---
Final Comb	---	---	---	---	---	2.05
COMB2008	---	---	---	---	---	---

(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)