Evidence of non-existence of a 'spectral-gap' in turbulent data measured above Rondonia, Brazil. Part I: Amazonian Forest

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ABSTRACT

Wavelet and Fourier analyses are used to identify the spectral characteristics of wind velocity, temperature, humudity and CO_2 concentration data sets, obtained in Amazonian Florest. Analyses are performed over a wide frequency range, from the inertial subrange domain up to one day time-scale. Data are studied for a five day only spectrum and for one day mean spectra and cospectra. Results showed that is not possible to identify spectra gap in any of the investigated variables.

Fourier and Wavelet Analisys

In Fourier analisys signals $f(t) \in L^2$ 2π periodic are represented by series like

$$f(t) = \sum_{\xi=-\infty}^{\infty} \hat{f}(\xi)\, e^{i\xi t},$$

where $\hat{f}(\xi)$ are called Fourier coefficients. Fourier analisys has only frequency localization.

Fourier spectra is defined as

$$\mathcal{S}_{\mathcal{F}}(\xi) = \lim_{T\to\infty} \frac{1}{T} \left| \int_{-\frac{T}{2}}^{\frac{T}{2}} f(t) e^{i\xi t} dt \right|^2$$

and Fourier cospectra of signals $f(t)$ and $g(t)$ is defined as

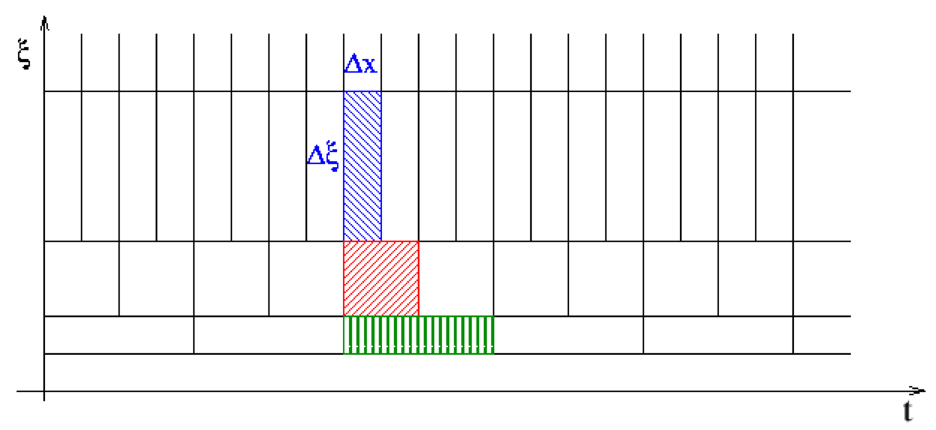
$$\mathcal{C}_{\mathcal{F}}(\xi) = \frac{\hat{f}(\xi)\overline{\hat{g}(\xi)}}{\sqrt{\| \hat{f}(\xi) \| \| \hat{g}(\xi) \|}}.$$

In Wavelet analisys, signals $f(t)$ are represented by series like

$$f(t) = \sum_{j=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} d_k^j \, \psi_k^j(t)$$

where $\psi_k^j(t) = \psi(2^j t - k)$ are called wavelets, and d_k^j the wavelet coefficients (Daubechies 1992; Chui 1992). In a general sense, wavelets have both time-frequency localization, with time resolution inverse proportional to frequency resolution

$$\Delta^j t \times \Delta^j \xi = constant$$



In this work the biorthogonal Daubechies wavelet ψ, family $\{1, 5\}$, are used (Cohen et al. 1993).

The wavelet spectra of a zero mean signal with 2^J points is given by the total energy contained in a scale j

$$S_w^j = \frac{ds}{2\,\pi\, ln(2)}\, 2^{-(J-j)} \sum_{k=1}^{2^{J-j}} \left[d_k^j \right]^2,$$

with wavenumber

$$k^j = \frac{2\pi}{2^j\, ds},$$

where ds is the interval of the observation samples (Katul and Parlange 1994; Percival and Walden 2000). The wavelet cospectrum of two functions f and g can be calculated from their wavelet coefficients vectors d^j at a scale j using

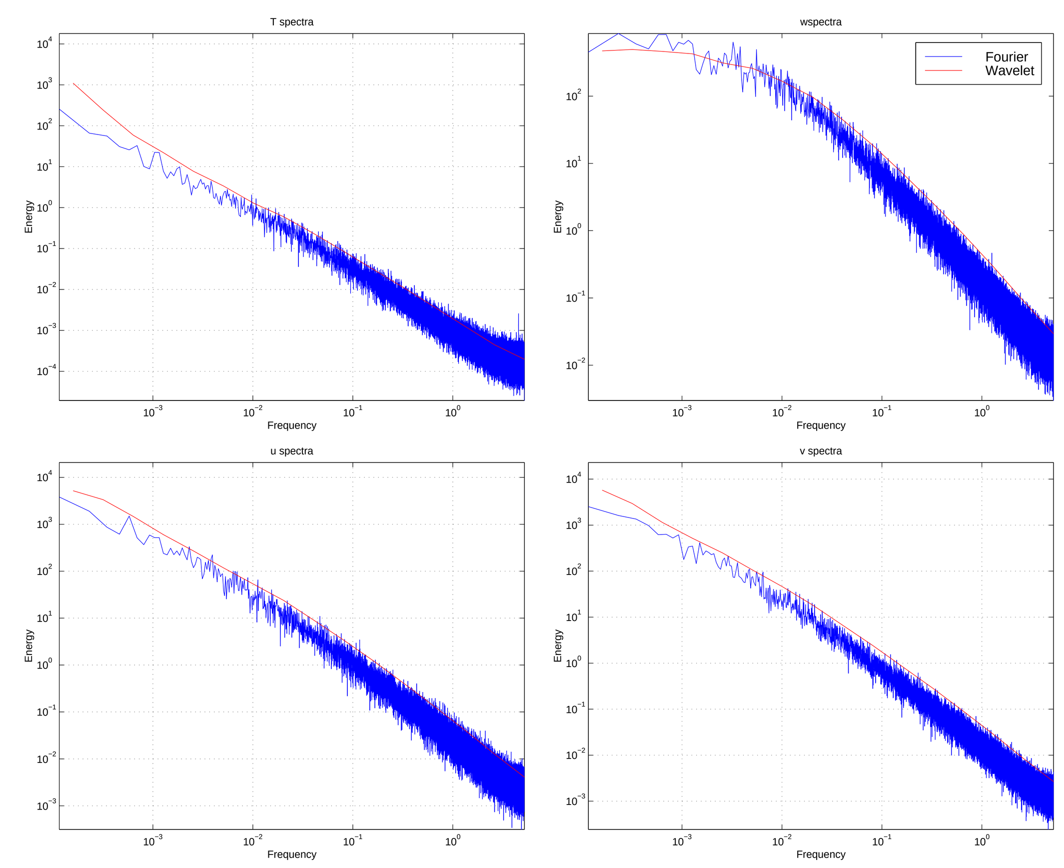
$$\mathcal{C}_w^j = \frac{ds}{2^j\, ln(2)} \sum_{k=1}^{2^j} d_k^{j,(f)}\, d_k^{j,(g)}.$$

REBIO JARU DATA SET

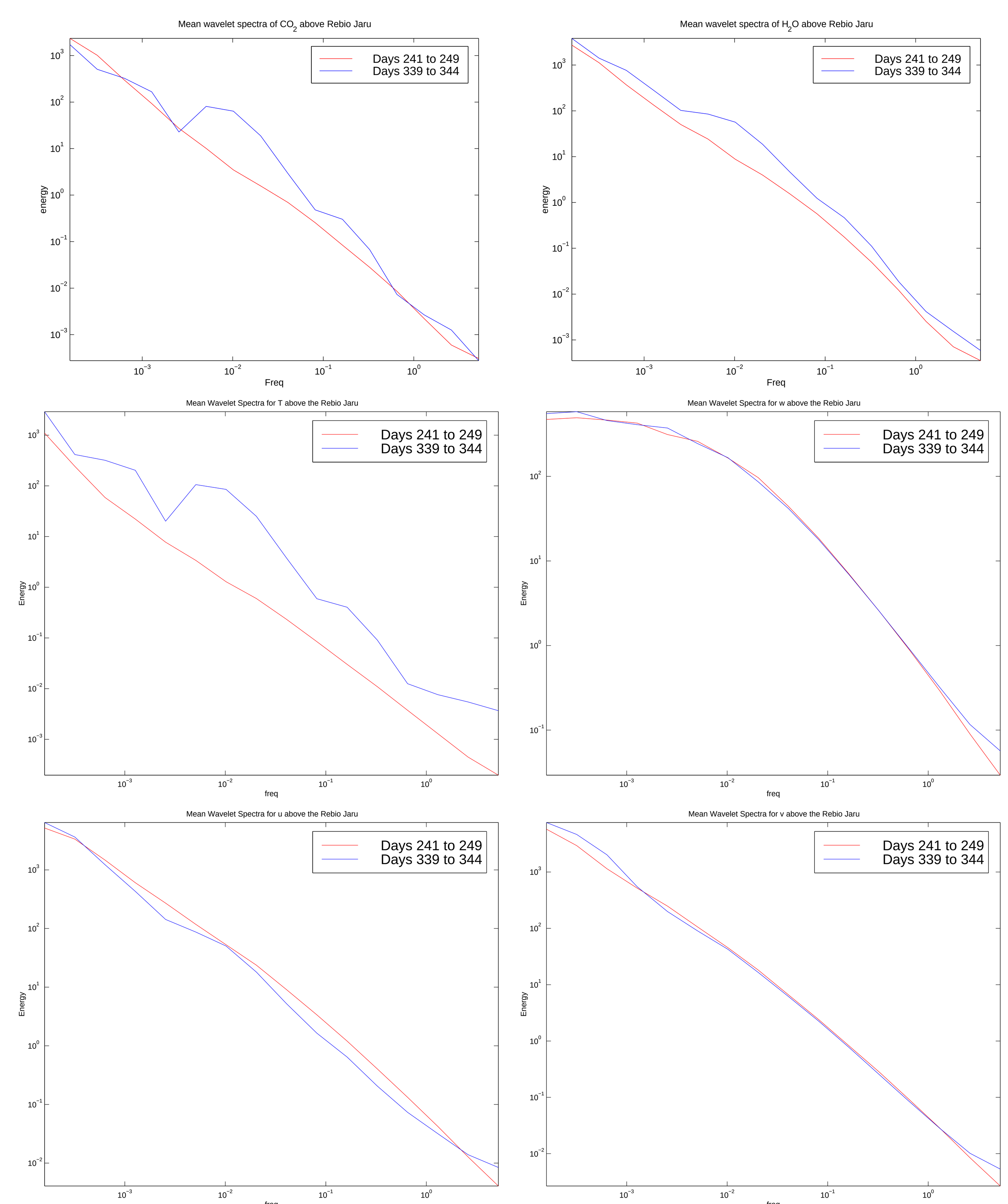
The data of wind velocity (u, v, w components), temperature, humudity and CO2 concentration were measured in August-September(dry-season) and in December (wet-season), year of 2000, as a part of the Brazil/European Union LBA Tower Consortium, in southwestern part of Amazonian region. Measurements are made at micrometeorological tower located in the Biological Reserve of Jaru (10^o 4´S, 61^o 56´W) above a 32 m height forest canopy. The fast response wind speed and temperature measurements, sampled at 10.42 Hz rate, were made using a three-dimensional sonic anemometer (Solent A1012R, Gill Instruments), at a height of 62.7 m.

REBIO JARU Results

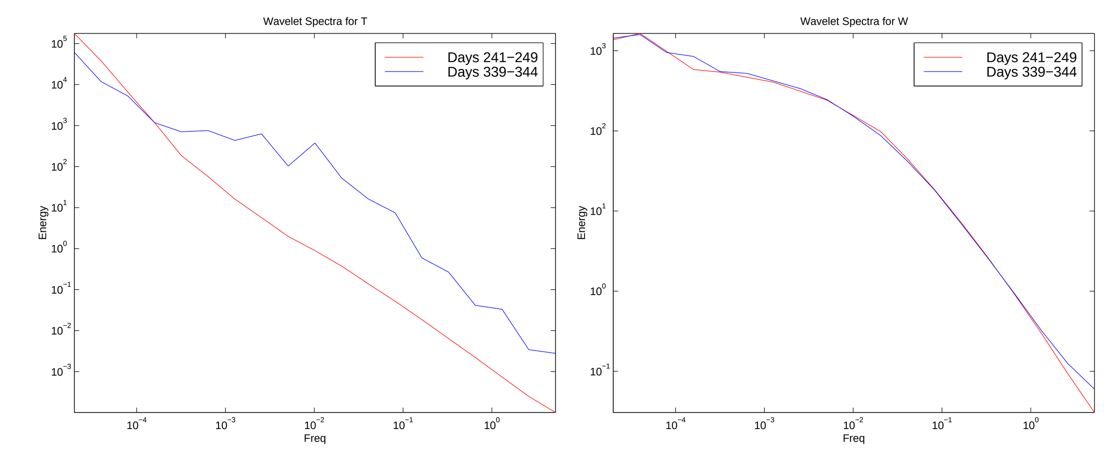
Wavelet Spectra and Fourier Spectra



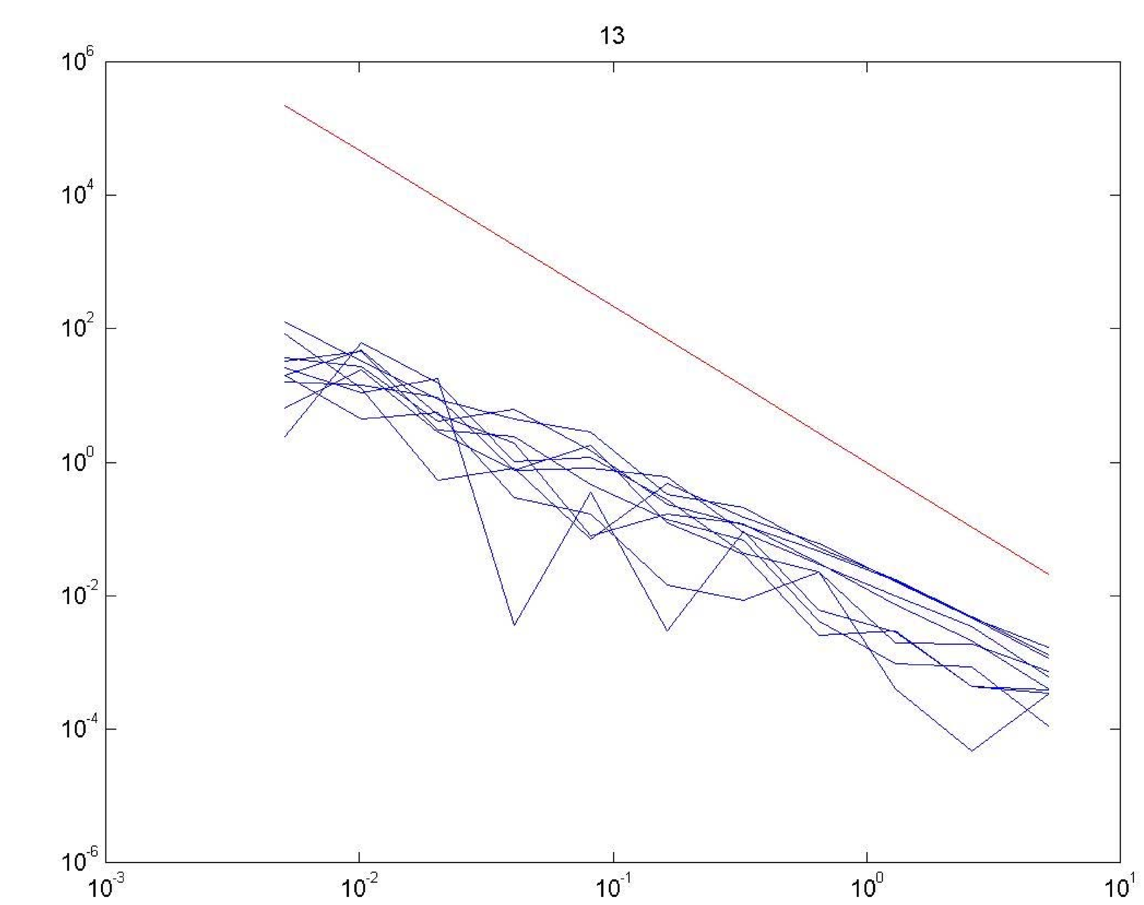
Mean Wavelet Spectra (1 day)



Wavelet Spectra (5 day)



Wavelet Cospectra w'T'



Results showed that is not possible to identify spectra gap in any of the investigated variables. This has important consequence in that separating the turbulence flow into mean and fluctuation components. This also makes it difficult to determine a cutoff frequency for filtering the data. This absence of a spectral gap is probably due to the non-stationary characteristics of turbulent fields above Amazonian forest. Some physical phenomena in tropical meteorology are proposed to explain the findings.

REFERENCES

Chui, C. (Ed.) 1992. *Wavelets:A tutorial in theory and applications*, Volume 2. Academic Press.

Cohen, A., Daubechies, I., & Vial, P. 1993, Applied and Computacional Harmonic Analysis, 1, 54.

Daubechies, I. 1992. *Ten Lectures on Wavelets*, Volume 61 of *CBMS-NSF Regional Conference (Series in Applied Mathematics)*. Philadelphia, PA: SIAM.

Katul, G. G., & Parlange, M. B. 1994, Journal of the atmospheric science, *51*(15), 2181.

Percival, D. B., & Walden, A. T. 2000. *Wavelet Methods for time series analysis*. Cambridge Series in Statistical and Probabilistic Mathematics. Cambridge, UK: Cambridge University.