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# UNIVERSAL SPECTRUM FOR BOUNDARY LAYER FLUXES OF SENSIBLE HEAT AND MOMENTUM

A.M. Selvam and M. Radhamani

Indian Institute of Tropical Meteorology, Pune 411 008, India

#### 1. INTRODUCTION

symbiotic existence of fluctuations of all scales ranging size-duration from millimetrethousands second (turbulence) to of kilometres-days (planetary scale) contribute to the vertical fluxes sensible heat and momentum in the atmospheric boundary layer (ABL) and result in the formation of weather systems of all scales. The temporal fluctuations of meteorological parameters exhibit selfsimilarity, i.e., the power spectra follow the inverse power law of form 1/f where f is the frequency and B, the exponent. Inverse power law indicates scaling or selfsimilarity. The values of B, the scaling factor is found to be different for different length scales. Fritts and Van Zandt (1993) have summarised numerous studies over the last three decades, of the remarkably uniform spectral shape of fluctuations which are signatures of atmospheric gravity (buoyancy) waves. spectral shape, namely, the inverse power law form is universal and independent of time, location and altitude of observation. Lovejoy Schertzer (1985,1986) Tesser et al (1993) have also documented and discussed the universal nature of the inverse power law fluctuations temporal spectra o£ Such selfatmospheric flows.

\* Corresponding author address: A.Mary Selvam, Indian Institute of Tropical Meteorology, Pune-411008, INDIA. similar scaling behaviour in geophysical parameters also has been documented (Agnew, 1992). Inverse power law form for power spectra indicate temporal long-range correlations. Atmospheric flows exhibit long-range spatial correlations also as manifested in the selfsimilar fractal geometry to the global cloud cover pattern documented by Lovejoy and Schertzer (1986). Such selfsimilar fractal pattern evolution by selfsimilar fluctuations on all time scales is generic to all dynamical systems in nature and is recently identified as signature of self-organized criticality (Bak, Tang and Wiesenfeld 1988). Self-organcriticality implies long-range spatiotemporal correlations, sensitive dependence on initial conditions in real world extended dynamical system such as atmospheric flows. Finite precision computer realizations mathematical nonlinear atmospheric flows also exhibit such sensitive dependence on initial conditions identified as deterministic chaos, an area of intensive research all branches of science. The in physics of deterministic chaos or self-organized criticality in real world and model dynamical systems is not yet identified. Deterministic chaos in computed model dynamical systems precludes long-term predictadeterministic Traditional bility. models of atmospheric flows cannot explain satisfactorily the observed selfsimilarity in atmospheric flows (Tesser et al 1993). Recently (since 1980) developed concepts in nonlinear dynamical systems theory may help observed fractal identify the

amplitude therefore represents probability of occurrence. Such concept that additive amplitudes of eddies, when squared, represent probability densities is observed in subatomic dynamics of quantum systems. Atmospheric flows therefore follow quantum-like mechanics with inherent long-range spatiotemporal self-organized correlation, i.e., criticality, since, by concept, the power spectrum of temporal fluctuations follow the universal inverse power law form of statistical normal distribution. Atmospheric energy spectrum has unique structure independent of details of dynamics.

### 3. DATA AND ANALYSIS

Continuous periodogram spectral analysis (Jenkinson, 1977) was done for TOGA (Tropical Ocean Global Atmosphere) global 1000 mb 00 GMT temperature data for the 92-day period June to August 1988. The latitudinal mean power spectra are plotted in Figure 1 as the cumulative percentage contrito total variance bution versus the normalised standard deviation t equal to  $(logL/logT_{50})-l$  where L is the period in days and  $T_{50}$ the period upto which the cumulapercentage contribution tive total variance is equal to 50. The power spectra are found to closely follow the statistical normal districonsistent bution with model predictions.

## 4. CONCLUSION

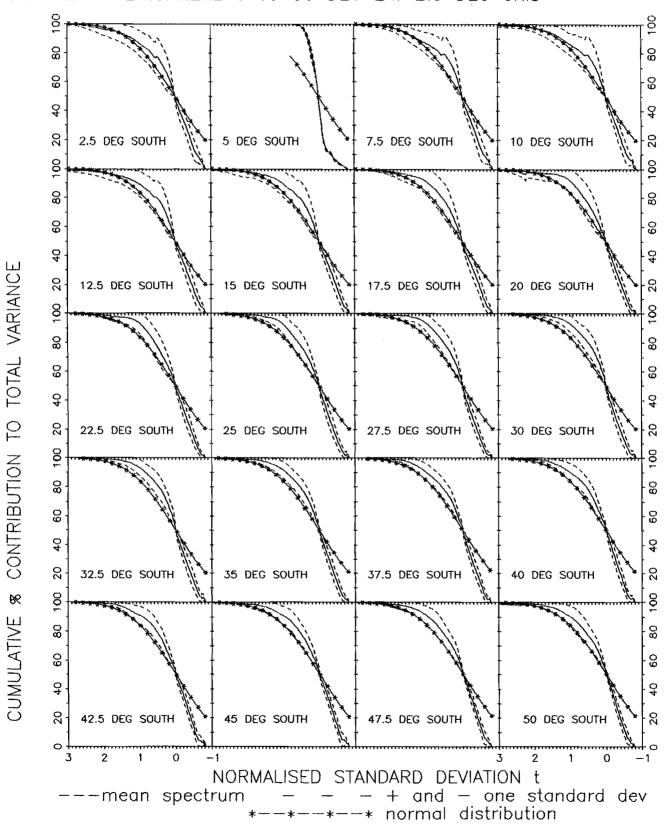
Universal structure for atmospheric eddy energy spectrum presented in this paper is independent of details of dynamics and does not require arbitrary assumptions and approximations for modelling atmospheric flows such as in traditional NWP models. Energy input into any one scale propagates to all scales so as to conform to the universal spectrum.

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LATITUDINAL MEAN POWER SPECTRA TOGA 1000MB 00GMT DAILY TEMPERATURE JUNE—AUGUST 1988 SOUTHERN HEMISPHERE 0 TO 50 DEG LAT 2.5 DEG GRID



PROBABILITY

PERCENTAGE

CUMULATIVE