Unraveling Intermittency: A Comprehensive Analysis through Low-Order Parameters, Characterization, and Quantification of Flow Dynamics

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Intermittency, a phenomenon pervasive in dynamic systems, remains a complex and intriguing aspect of various processes – one of which is turbulence under the impact of a density stratification. This abstract aims to comprehensively describe and identify statistical metrics for the detection of intermittency and analyze intermittency within a specific dataset concerning direct numerical simulation of turbulent Ekman flow using the tLab tool-suite [1]. We seek to discern intermittent patterns through low-order parameters and thus unravel the nuanced dynamics that contribute to it.Intermittency occurs when a parameter is changed in a wave or fluid system close to a bifurcation that leads to turbulence. It has been shown from observations that in a sufficiently stable environment, globally intermittent turbulence can be triggered by a variety of internal and external disturbances including orographic obstacles, solitary and internal gravity waves [2]. In this case, the system dynamics shifts frequently between the former stable state – usually regular – and a turbulent state or turbulent periods accompanied by intermittent behavior.

Based on a large dataset spanning orders of magnitude in scale separation and various regimes of stratification strength, we seek to answer the following question: What non-dimensional statistical indicators can be used to detect and characterize intermittency in this rotating stratified flow? Leveraging low-order parameters allows us to identify and quantify intermittent states, shedding light on the underlying mechanisms that drive such phenomena. Examining internal and external parameters, we aim to provide a comprehensive qualification of intermittency, elucidating its dependencies on specific factors and variables aiming at a quantitative parameterization of the intermittency factor 'γ', i.e. the extent of turbulent flow within the dataset. With the atmospheric boundary layer as real-world counterpart in mind, we seek to elucidate for which parameters, the flow exhibits intermittent behavior and, importantly, quantify the extent of gaps between turbulent episodes. Study show that in the intermittent period, the vertical fluctuations always reveal consecutive strong dipoles, i.e., positive–negative pairs, which could be associated with slow near surface waves or hairpin-like vortices[3]. This quantitative assessment aims to provide a clear and measurable understanding of the prevalence and duration of intermittency in the dataset, and adds depth to our comprehension of this phenomenon, paving the way for more informed analyses and applications in meteorology and beyond.

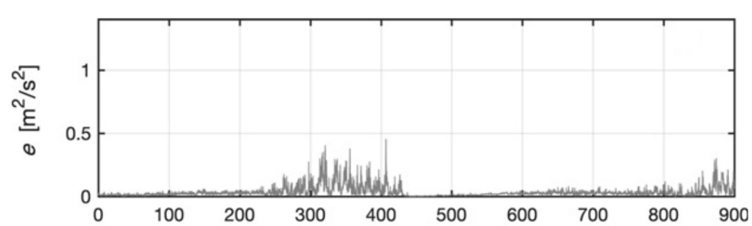

Figure 1: Illustrations of an intermittent period

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[1]Open-source code available under github.com/turbulencia/tlab
[2]Ansorge, Cedrick and Mellado, Juan Pedro, *Boundary-layer meteorology* **153** (2014):p. 89–116.
[3]Allouche et al., *Journal of the Atmospheric Sciences* **79** (2022):p. 1171–1190.