If van Gogh's *The Starry Night* depicts perfect turbulence, so should Degas' *A Woman Seated Beside a Vase of Flowers*

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ABSTRACT: A recent study suggests that the sky of van Gogh's *The Starry Night* accurately depicts the intrinsic and complex structure of real, fully developed turbulent flows. This conclusion was reached by comparing the slope of the power spectral density of the image to Kolmogorov's famous $-5/3$ law of turbulence. In this essay we show that this correspondence is coincidental and anecdotal and argue that examining the spectral slope alone is not sufficient to state whether or not a painting, or any other type of image, accurately reflects Kolmogorov-like turbulence. Otherwise, we would be forced to conclude that Degas' *A Woman Seated Beside a Vase of Flowers* also accurately depicts turbulence.

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Every now and then, a striking new scientific claim — still unchallenged at the time — makes a big media splash with results that seem too good to be true. The faster-than-light neutrinos episode is a well-known example of how initial excitement can outpace careful verification (Reich 2012).

A more recent case — and one of particular relevance to the geophysical fluid dynamics community — is the study by Ma et al. (2024), which suggests that the night sky in van Gogh's *The Starry Night* (Figure 1) reflects the statistical properties of fully developed turbulence as understood in modern fluid mechanics. The idea captured the imagination of both the scientific community and the general public, drawing enthusiastic media coverage (e.g., Marshall 2024; Hunt 2024; Encheva 2024; Buitekant 2024, to cite a few). As one striking example of the public response, the Wikipedia page for *Turbulence* (Wikipedia 2024) was updated just ten days after the Ma et al. (2024) study was published, featuring van Gogh's *The Starry Night* as a new emblem of turbulence. Motivated by the work of Ma et al. (2024), Matsumoto (2025) argues, for his part, that patterns loosely interpreted as resembling river swirls in Ogata Kōrin's *Red and White Plum Blossoms* also follow Kolmogorov's law of turbulence.

Yet, as we show in this essay, such claims rest on a flawed understanding of what spectral analysis can — and cannot — reveal about turbulent flows.

We are not the first to raise concerns about such studies. The work of Ma et al. (2024) has recently been sharply and unequivocally criticized by Riley and Gad-el-Hak (2025), who write that "the conclusions of the paper are totally baseless" and that "the claims of the authors would normally be rejected out-of-hand by researchers in turbulent flows." Parallel to their critique, we raise here additional concerns in a candid and playful spirit, directed at a broader audience.

To that end, let us first take a closer look at the method used by Ma et al. (2024) to reach their surprising conclusion. The demonstration they carried out is based on comparing the shape of the power spectral density (PSD) of the image pixel intensity to Kolmogorov's famous $-5/3$ law of turbulence (Kolmogorov 1941; Vallis 2017)[1]. It was found that the low wavenumber portion of *The Starry Night*'s spectrum was characterized by a slope close to $-5/3$ when examined in the logarithmic space (Figure 2). This coincidence has led the authors to conclude that:

[1]Note that the $-5/3$ exponent is not found explicitly in Kolmogorov's paper. According to Vallis (2017, footnote 5 on p. 442), it was Obukhov (1941) who came up with the spectral slope of $-5/3$ by reinterpreting Kolmogorov's result in the spectral space.

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FIG. 1. Faithful photographic reproduction of public domain Vincent van Gogh's painting entitled *The Starry Night* (1889). Oil on canvas; Dimension: 28.7×36.2 in. (73×92 cm). Museum of Modern Art, New York City. Source: Wikimedia Commons.

> ... van Gogh had a very careful observation of real flows, so that not only the sizes of whirls/eddies in *The Starry Night* but also their relative distances and intensity follow the physical law that governs turbulent flows (Ma et al. 2024).

However, this logic is problematic: the fact that fully developed turbulent flows exhibit a $-5/3$ power spectrum does not imply that any field with a $-5/3$ spectrum is turbulent. All roses are flowers, but not all flowers are roses.

Let us illustrate, through a *reductio ad absurdum* exercise, that the presence of a spectral slope close to $-5/3$ in van Gogh's sky is merely coincidental and anecdotal, and that this apparent correspondence with Kolmogorov's theory cannot, by itself, justify the popular belief that "van Gogh painted perfect turbulence" (Ball 2006).

The image chosen for this demonstration is Edgar Degas' painting entitled *A Woman Seated Beside a Vase of Flowers* (Figure 3). As shown in Figure 2, the PSD of this painting — computed using a method comparable to that of Ma et al. (2024) — exhibits spectral slopes in both directions

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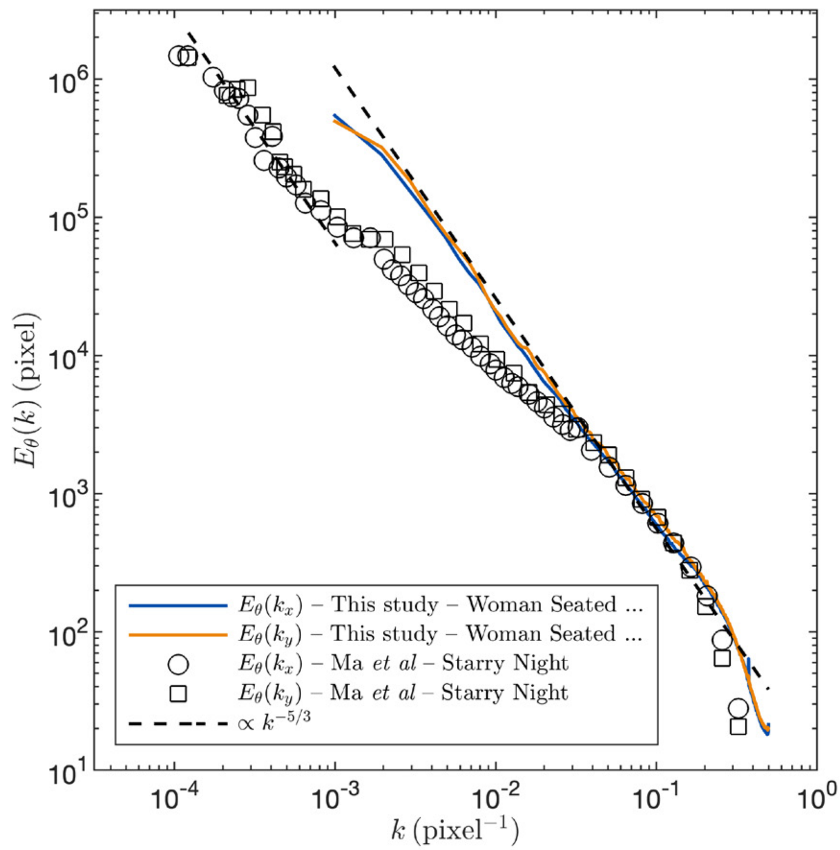

FIG. 2. Means of one-dimensional power spectra of the pixel intensity of Figure 3 when taken along rows (blue) or along columns (orange). For visual reference, the black dashed line has a slope of $-5/3$. The circle and rectangle symbols were manually digitized from the Figure 3 of Ma et al. (2024).

remarkably close to $-5/3$. In fact, the fit is arguably better than what was obtained by Ma et al. (2024) for *The Starry Night*. And yet, it would be difficult to find anyone seriously claiming that Degas was painting turbulence.

The problem with the logic of Ma et al. (2024) is that, as already pointed out by Finlay (2020) in a similar critique of this type of image analysis, many ordinary images — including subjects such as people, animals, countrysides, buildings, and plants — exhibit a power spectrum with a negative power law dependence (Tolhurst et al. 1992; Redies et al. 2007). It is therefore not difficult to find images unrelated to turbulence that happen to display a spectral slope of $-5/3$, as illustrated with the Degas painting analyzed here. Several other images could have been used for this exercise.

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FIG. 3. Faithful photographic reproduction of public domain Edgar Degas' painting entitled *A woman seated beside a vase of flowers (Madame Paul Valpinçon?)* (1865). Oil on canvas; Dimension: $29 \times 36\ 1/2$ in. (73.7×92.7 cm). Image pixel resolution: 3732×2963 pixels. Metropolitan Museum of Art, New York City. Source: Wikimedia Commons.

More fundamentally, it has long been known that spectral slopes alone are insufficient indicators of image structures in general (Oppenheim and Lim 1981) and of turbulence in particular (Armi and Flament 1985). This is because the crucial information defining the structural arrangement of a particular image, whether of an ordinary image or an image of a turbulent flow, lies in the phase shifts between spectral components, which are typically neither preserved nor interpreted during the analysis. This was elegantly demonstrated by Armi and Flament (1985), who constructed an artificial image by applying a random phase to the power spectrum magnitude of a real infrared image of sea surface temperature that originally exhibited coherent swirls and eddies. The resulting image (their Plate 3) contains only unstructured, cloudlike features that bear no resemblance to the original image (their Figure 1), despite the two images having identical power spectra.

As an analogy, one finds a similar dependence on phase in the time domain. To paraphrase a comment by the late physical oceanographer Henry Stommel (1920–1992), the inverse spectrum of

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a piece by Beethoven would be unrecognizable if only the spectrum's magnitude were preserved, without accounting for phase (see the acknowledgments in Armi and Flament 1985). Inspired by this comment, we created — purely for amusement and pedagogical purposes — a new original symphonic piece based on the inverse Fourier transform of Beethoven's *Symphony No. 5*, using a random phase rather than the actual phase that characterizes the masterpiece. The result, provided as an audio file in the supplementary material, sounds like a 30-minute-long, uninterrupted, complex, and noisy chord — just as Stommel anticipated. Clearly, no one would guess that this noisy piece has anything to do with Beethoven's style or mastery. Yet, the power spectrum of this noise is identical to that of the original masterpiece. If the method proposed by Ma et al. (2024) were applied to analyse our creation, it might lead to the somewhat surprising conclusion that this barely tolerable, noisy chord of ours is representative of Beethoven's work — and that we, too, should be hailed as geniuses.

Taken together, these considerations show that the presence of spectral slopes near $-5/3$ in *The Starry Night* does not demonstrate that the painting depicts turbulence as understood in fluid mechanics, nor does it imply that van Gogh possessed a unique gift for perceiving and representing turbulent flow. Otherwise, if it were scientifically accepted that *The Starry Night* accurately portrays fully developed turbulence solely on the basis of its spectral slope, one would also have to conclude that Degas's *A Woman Seated Beside a Vase of Flowers* represents turbulence.

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Data availability statement. The documented MATLAB codes developed for this study, the data, the image of Degas' painting ('Degas_Woman_Seated_Besides_a_Vase_of_Flowers.jpg'), the Beethoven Symphony No. 5 audio file ('ToscaniniBeethoven5_64kb.mp3'), our random phase sound track ('ToscaniniBeethoven5_64kb_rand_phase.mp3') as well as a PDF document ('Methods.pdf') detailing the methods used are published and available through the computational research platform *code ocean* (Bourgault and Chavanne 2025).

The original public domain audio file (ToscaniniBeethoven5_64kb.mp3) of Beethoven Symphony No. 5 in C minor, Op. 67, played by the NBC Symphony Orchestra and conducted by Arturo Toscanini Symphony Orchestra was downloaded from Internet Archive here: https://archive.org/details/BeethovenSymphonyNo.5. It was then converted to a .wav file.

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