Rabbit Holes and Butterfly Effects: Narrative Probabilities and Climate Science[1]

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Probability is a central concept in scientific models of causation. When I say, for instance, that 'smoking causes lung cancer,' I am not implying that smoking will necessarily result in lung cancer; I am only suggesting a strong (causal) relationship between smoking habits and the incidence of lung cancer. That relationship is probabilistic and based on statistical models which help scientists distinguish merely accidental outcomes from causal linkage. In this article, I focus on how this kind of probabilistic relation brought into view by scientific models puts pressure on the 'folk' understanding of causation that underlies storytelling. Probability also plays an important role in narrative: when readers or viewers parse a sequence of narrated actions, their interpretation will build on assumptions about both causation (action 1 led to action 2) and probability (how likely action 2 is as an outcome of action 1). Crucially, however, narrative probability reflects cultural expectations surrounding human behavior, not statistical regularities. By contrast, narrative engagements with complex phenomena (particularly, in this article, climate change) call for new ways of thinking about narrative causation—ways that approximate the probabilistic understanding of statistical models.

We can start from the observation that climate change is an elusive phenomenon that unfolds on a global scale and whose local consequences may be hard to predict or ascribe to climate change with absolute certainty. This spatiotemporal distribution of climate change can give rise to manifestations that are far more surprising than the probabilistic link between

smoking and lung cancer, both of which are locally observable events. In the science of complexity, the phrase "butterfly effect" (coined by meteorologist Edward Norton Lorenz) refers to how a seemingly minor disturbance within a complex system can have large-scale ramifications at a spatiotemporal remove. By extension, I use the term to describe the unanticipated consequences of a complex probabilistic phenomenon.[2] The butterfly metaphor comes from Lorenz's talk at the 1972 convention of the American Association for the Advancement of Science, where he asked: "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" (qtd. in Hilborn 425). For an example that is directly relevant to the climate crisis, consider the devastating wildfires that swept through Australia in early 2020. A *Nature* article states that "human-induced climate change increased the risk of the weather conditions that drove the fires [in Australia] by at least 30%" (Phillips). This is a butterfly effect in that the causal history of these wildfires is complex and can ultimately be located far away from Australia, in the processes of industrialization and capitalism that, emerging in Western Europe at the turn of the eighteenth century, have become the main driver of greenhouse gas emissions and therefore climate change around the globe. It is only in probabilistic terms that we can say that climate change *caused* these particular wildfires. This probabilistic causation differs fundamentally from the notions of probability at the heart of narrative.

This problem has been articulated with particular lucidity by Indian writer Amitav Ghosh in *The Great Derangement* (2016), which discusses the contemporary novel's confrontation with climate change. For Ghosh, the realist novel struggles to account for the catastrophic consequences of rising sea levels or global temperatures: "To introduce such happenings into a novel is in fact to court eviction from the mansion in which serious fiction has long been in residence," he contends (24). Ghosh's claims have encountered a great deal of opposition in

ecologically oriented criticism (or ecocriticism), particularly because of Ghosh's problematic dichotomy between 'serious' fiction and genres such as the fantastic, the horror, and science fiction. This way of thinking, as argued for instance by Ursula K. Heise in a review of Ghosh's book, severely downplays the potentialities of non-realist, speculative fiction vis-à-vis the ecological crisis.

Another aspect of Ghosh's discussion has attracted less attention, though. For Ghosh, the failure of the realist novel to encapsulate climate change has to do with probability: "Within the pages of a novel an event that is only slightly improbable in real life—say, an unexpected encounter with a long-lost childhood friend—may seem wildly unlikely"; as a result, "the writer will have to work hard to make it appear persuasive" (*The Great Derangement* 24). Ghosh is here skirting discussions on the *vraisemblable*—the plausible or verisimilar—as an aesthetic concept that has long influenced the theory and reception of the novel.[3] Because of this focus on plausibility, Ghosh continues, "the modern novel, unlike geology, has never been forced to confront the centrality of the improbable: the concealment of its scaffolding of events continues to be essential to its functioning" (23). One way to read this statement is to say that narrative progression (the "scaffolding of events") should be justified in terms of the logic of the human characters' actions, each situation flowing from the previous ones, without any external (nonhuman) intervention.

It is significant that Ghosh contrasts the modern novel's reliance on a specific understanding of probability with a science ("geology"), which—he implies—is better equipped to deal with seemingly improbable events and their causes. Arguably, both storytelling and science are concerned with probability—with what is the likely effect of what. However, the conceptions of probability they implicate are profoundly different. Monika Fludernik argued in

Towards a 'Natural' Narratology (1996) that narrative has an "anthropomorphic bias" (9), since it is geared towards the embodied and cognitive make-up of social animals like us. Therefore, when narrative theorists such as Brian Richardson and Emma Kafalenos talk about causality in narrative, this concept is primarily understood in terms of human *action*: a causal connection is seen as probable when it is justified in terms of the beliefs and desires that readers have come to ascribe to the narrative's characters. This preoccupation with psychological plausibility is particularly strong in the realist novel, a genre that, to quote from Ian Watt's seminal study, "requires a world view which is centered on the social relationships between individual persons" (84). Causal relations outside of the social domain may also play a role in novelistic narrative, of course, but they tend to be subsumed ("concealed") within what Ghosh calls the "scaffolding" of human events.

Novels that engage the climate crisis are thus faced with the task of bridging the gap between two conceptions of probability. The first concerns (expectations surrounding) human action, particularly the teleological patterning of the characters' goals and desires.[4] We can call this 'folk probability,' by analogy with folk psychology, with which folk probability is closely bound up: just as folk psychology is an implicit (and pre-scientific) understanding of how the mind works, folk probability defines the likelihood of a certain narrative outcome based on readers' assumptions about human behavior (as well as their familiarity with literary genres and conventions).[5] The second conception of probability is a statistical understanding that brings together abstract concepts and concrete events, the global nature of climate change and its surprising local manifestations (or butterfly effects).

In *The Great Derangement*, Ghosh comes across as quite pessimistic about the realist novel's ability to address this divide in a satisfying manner. However, his novel *Gun Island*

(2019), published three years after *The Great Derangement*, contains a very different response to the challenge of reconciling the scientific probabilities of climate change and the psychological stakes of modern narrative. Indeed, it can be argued that the plot of *Gun Island* successfully integrates the probabilistic causation of climate models by destabilizing the sense of folk (psychological) probability that undergirds the realist novel. How does Ghosh the novelist pull off a feat that Ghosh the essayist has written off as impossible? I will argue that he does so by revisiting the idea of coincidence and by adopting it as the central principle of a plot unfolding on a global stage.

Using Ghosh's *Gun Island* as a case study, this article seeks to reassess the concept of probability in narrative (and narrative theory) in light of the probabilistic nature of climate models. This interest in climate, probability, and narrative form can be positioned within the field of ecocriticism, and "econarratology" (James and Morel) more specifically. Econarratologists have started to interrogate the ways in which the forms of storytelling can speak to scientific knowledge of human impact on the planet's climate. In parallel, scientists and science communication researchers are highlighting the value of narrative in disseminating scientific models of climate change: stories, they contend, are well placed to turn abstract concept and intangible probabilistic correlations (such as those between wildfires and rising global temperatures) into situated, experiential knowledge. According to Michael F. Dahlstrom, narrative "may represent a method of packaging phenomena into human scale: providing a possible remedy for the problems of communicating a meaningful sense of distant science topics" (13618). This interdisciplinary convergence on narrative's engagement with climate models is, of course, an excellent opportunity for narrative theory. But, as I argue in this article, divergent conceptions of probability in narrative and science represent a significant stumbling

block for this interdisciplinary encounter. To understand how narrative (and narrative theory) may navigate the difference between folk and scientific probability, we need to come to grips with both the probabilistic nature of climate change and with how folk probability shapes the organization and readerly experience of plot. That is the task of the next two sections, which will pave the way for my reading of *Gun Island* in the final section.

Climate Change and Scientific Probability

In a handbook of modern (Bayesian) statistics, astronomist Phil Gregory explains that, "in science, the available information is always incomplete so our knowledge of nature is necessarily probabilistic" (2). In broad strokes, statistics offers a set of mathematical tools that help scientists distinguish merely random series of events from causally connected ones. Very few contemporary issues bring out the importance of probability in scientific models as forcefully as climate change. There is a clear consensus in the scientific community that the Earth's climate is changing, and that these changes are caused by human activities in industrialized societies. Nevertheless, the impact that these transformations will have on the future of human communities and more-than-human ecosystems remains uncertain. We know that the disastrous consequences of climate change include deadly heat waves, flooding, and food shortage, but it is difficult for even the most sophisticated scientific models to predict the exact magnitude of these consequences as well as where and when disaster will strike. Typically, scientists present us with a range of scenarios that go from the moderately optimistic to the catastrophic, depending on a vast number of assumptions about trends in fossil fuel consumption. The uncertainty of the future is such that it does not merely represent an outcome of statistical models but also a variable that is explicitly addressed by some models (as exemplified by Heiko

Paeth et al.'s work). This uncertainty is also significant because it plays into the hands of climate change deniers, who use, misleadingly, the variability of predictions to cast into doubt the validity of the underlying science.[6]

When, in *The Great Derangement*, Ghosh calls a climate change-related catastrophe "improbable," he is adopting a novelistic understanding of probability, which reflects the internal teleology of the characters' actions as well as readers' pre-scientific assumptions about the mind's workings. From a scientific perspective, catastrophes are not improbable so much as linked to climate change in probabilistic terms: one could not say with absolute certainty that a disastrous hurricane (or heatwave, drought, etc.) would not have happened without climate change, but there is a substantial *likelihood* that it would not have happened. This model of causation challenges an intuitive understanding of causes and effects as linked in linear terms, with an event A leading directly to event B. Nonlinearity creates significant hurdles for a representational practice like narrative, which is grounded in local, personal, embodied interactions (recall Fludernik's "anthropomorphic bias").[7] Since Aristotle's *Poetics*, narrative has been defined in relation to human action. Even in much more recent theories of narrative, the organization of what we call 'plot' is thought to reflect, primarily, the way in which psychological states—the characters' beliefs and desires—are integrated with their observable behavior.[8] This view of plot involves a privileging of spatiotemporal scales that are commensurable with human subjectivity and action. The probability that underlies the sequentiality of story is thus centered on an individual's—typically, the protagonist's—attempts to achieve certain goals or respond to external events that have a bearing on his or her well-being. This individualistic bias explains narrative's focus on contexts of direct human interaction, such as one may find within relatively small communities and spatial locales.

The psychological causation that fuels these interactions is different from the statistical causation of scientific models, at two levels. First, it is not explicitly probabilistic, even though current work on reader-response and narrative (discussed in the next section) brings to light the cognitive-level predictions that underpin readers' understanding of plot. Second, narrative causation foregrounds the particular and the local, while scientific models of climate change operate on a global, planetary scale. One of the most frequently voiced ideas in the environmental humanities is that climate change presents us with spatiotemporal scales that are far from everyday experience. This global scale of climate change complicates the calculus of probabilistic causation even further. To return to my example in the introduction, 'smoking causes lung cancer' identifies a probabilistic causal relation. However, because smoking is a human-scale action and lung cancer has directly observable consequences, the causal relation between them remains relatively straightforward. The statement 'climate change has caused the wildfires in Australia in early 2020,' which also implies a probabilistic understanding of causation, does not work in the same way, because climate change is not a locatable entity, but a complex series of global patterns and feedback loops. Thus, one could not say that greenhouse gas emissions in Australia caused the wildfires in Australia and that it was the coal burned there in the 2010s that caused the disaster: both spatially and temporally, the probabilistic causes of the wildfires are distributed around the globe and across a stretch of time that goes back at least to the industrial revolution at the end of the eighteenth century. These surprising connections between events that seem unrelated on a macroscopic scale, but that are probabilistically linked in statistical terms, are known as butterfly effects.

For narrative, probabilistic connections across vast spatiotemporal scales create unique challenges because they clash with story's bias towards psychological causation and concrete

social interactions in specific, and relatively self-contained, locales. Certainly, climate change can be referenced within stories that remain, in other respects, focused on interactions among a small group of characters, as is often the case in so-called climate fiction.[9] Such textual references to climate change may help narrative "package [scientific] phenomena into human scale," to quote again Dahlstrom (13618), but they also involve a considerable distortion of climate models: they run the risk of turning a complex and probabilistic global phenomenon into a linear, deterministic one, in which there is no sense of the scalar distance between everyday interaction and the global level.[10] However, while stories may not be able to hold a mirror up to complex systems in their entirety, they could still implement formal devices that evoke particular features of complex systems.[11]

For instance, in novels like *The Overstory* (2018) by Richard Powers or *Clade* (2015) by James Bradley, the plot takes the form of a network of characters whose paths intersect, either because they physically converge (in *The Overstory*) or because they belong to the same family (in *Clade*).[12] These characters are brought together by a growing awareness of entanglement across multiple scales. Entanglement is a key dimension of the ecological crisis highlighted influentially by Dipesh Chakrabarty, who writes about the convergence of biological, geological, and human histories in times of climate change. More generally, entanglement is a feature of any complex system.[13] It is evoked by Powers's central analogy between the protagonists and the mycorrhizal network of a forest or by Bradley's focus on global catastrophe and its consequences for human communities.[14] *A Tale for the Time Being* (2013), by Ruth Ozeki, uses a material object (a diary) and a natural disaster (a tsunami) to bring together two characters separated by the Pacific Ocean.[15] These narrative strategies reflect the interdependency of human communities and the nonhuman world in times of ecological crisis. Embracing the global scale

of climate change in narrative is not impossible, but it requires rethinking the very structure of novelistic plot and uncoupling it from the preference for a single protagonist. Alternatively, and this is the path taken by Ghosh in *Gun Island*, channeling the scale and probabilistic nature of climate change encourages a reappraisal of the probabilistic logic of narrative sequentiality, via a focus on unlikely coincidences. The next section prepares my reading of Ghosh's novel by discussing narratological work on probability and coincidence.

Probability Design and the Coincidence Plot

The last decade saw the rise of a theory of cognition known as "predictive processing" (Hohwy; Clark). In essence, predictive processing regards the human brain as busy with a form of probability calculus: knowledge—in the broadest sense of the term—is a dynamic process of forming expectations about the world and updating those expectations as we gather more data and come up with more precise predictions. These guesses are thought to shape cognition from basic perception to emotional meaning-making and more advanced forms of cultural cognition. None of these activities is conscious, of course. However, the neurophysiological processes that underlie what I am calling 'predictions' or 'guesses' follow a statistical logic that is fundamentally probabilistic, and that in fact has been described with the language of Bayesian statistics.[16] Andy Clark, a philosopher of mind, offers the example of taking "a sip of tea under the strong impression of coffee" (3). Experientially, finding out that there is tea in the cup, when one was expecting coffee, causes surprise; cognitively, when confronted with new sensory information, the brain is forced to readjust its predictions, which are in turn based on a history of predictive interactions—for instance, with other breakfast drinks or coffee mugs. Uncertainty

thus becomes a fundamental dimension of the brain's (and the whole body's) probabilistic encounters with the world.

This theory of predictive cognition has been productively extended to literary reading by Karin Kukkonen. For Kukkonen, the act of engaging with novelistic narrative involves a large number of predictions which feed into each other and fuel involvement in story. What Kukkonen calls "first-order predictions" concern the sequencing of events: they have to do with readers' expectations as to the continuation of the plot and its eventual outcome. Second-order predictions arise from stylistic cues that steer readers' engagement with characters and may enrich their understanding of the plot by giving rise to an immersive experience of "sensory flow" (8). Finally, third-order predictions reflect intertextual knowledge, particularly familiarity with genres *qua* patterns that structure literary experience. These orders of prediction are carefully orchestrated in literary narrative, with the author anticipating not just the reader's predictions but also their "prediction errors"—a key concept in Kukkonen's account—as they are repeatedly asked to update their expectations during engagement. This orchestration constitutes what Kukkonen calls the "probability design" of literary narrative.

Probability thus constitutes a central dimension of narrative comprehension—but it is, as I have argued above, a 'folk' kind of probability that does not necessarily match statistical relations in the real world. When engaging with stories, audiences are constantly—if unconsciously—weighing the probability of certain outcomes or formal choices against others, based on their familiarity with both assumed patterns of human behavior and narrative conventions. This is perhaps best illustrated by suspense, an emotional effect of narrative that involves mentally juggling (at least) two outcomes, one being more desirable than the other.[17] As the probability of less desirable outcome increases, the reader starts experiencing suspense,

which is an emotional correlate of the unconscious predictions that underlie narrative experience. The more unlikely the positive outcome appears, the more suspense the reader experiences as he or she wonders how the character will survive a certain encounter "against all odds." Thus, the dynamics of suspense can be effectively described in a probabilistic manner—like all other emotions and expectations that arise during narrative engagement.

If the fabric of the reading experience is probabilistic through and through, what makes a catastrophic event caused by climate change so "improbable," to borrow Ghosh's terminology from *The Great Derangement*, in a novelistic context? Largely, the implausibility derives from the fact that most "probability designs" readers are familiar with foreground human-scale actions and the teleology of a character's intentions: at the level of plot events (Kukkonen's first-order predictions), narrative's sensory flow (second-order predictions), and also novelistic conventions (third-order predictions), readers come to expect a psychologically coherent patterning of human actions. Introducing an abstract, spatiotemporally distributed phenomenon such as climate change undermines psychological coherence through an abrupt departure from human (or anthropomorphic) intentionality. In a genre like the realist novel, where psychological life tends to take center stage, this kind of design choice can be perceived as fundamentally flawed.

Seen in this light, the challenge of narrating climate change turns into the question of what kind of probability design might be able to encompass the global scale of the ecological crisis. Readers' probability calculus needs to be adjusted at all the levels identified by Kukkonen, so that the effects of climate change do not register as a problematic deviation from novelistic conventions, but as a productive expansion of the scope of the novel. While there are undoubtedly many ways of achieving this goal, I focus here on the design of the coincidence plot and how it may be able to dramatically rewrite readers' probability calculus and therefore

confront them with the probabilistic and spatiotemporally distributed nature of climate change—in other words, with the likelihood of butterfly effects. Coincidence has, of course, a long history as a plot device at least since Oedipus killed his father and married his mother. In the modern novel it tends to be used sparingly in order to preserve the plausibility of the narrated events. Recall that human agency and psychological states such as desires and goals play a central role in novelistic plots: if a novel features too many coincidences, it runs the risk of losing focus, because the teleology of characters' intentions will be completely sidelined. Nevertheless, coincidences do appear in the novel; Hilary P. Dannenberg has offered the most comprehensive discussion of the coincidence plot in recent narrative theory.

Dannenberg draws a distinction between what she calls "traditional coincidences" (which are characteristic of the Victorian novel) and "modernist and postmodernist forms of coincidence" (105). In the former, the conjunction of events takes the form of characters crossing paths in unexpected ways or entails the revelation that characters are connected (again, surprisingly) through kinship. This kind of coincidence creates "cognitive stability" (108) in that the characters' relationship is completely determinate by the end of the narrative: we know who the parents of a certain character are, for instance, or what the outcome of a certain chance encounter is.[18] In twentieth-century coincidence narratives, by contrast, the coincidence is not enacted at the level of plot—through physical encounters or family relations—but remains evocative and analogical: for example, Michael Cunningham's 1998 novel *The Hours* centers on three women (including Virginia Woolf) who are affected by Woolf's novel *Mrs. Dalloway* (1925). While these characters exist in different time periods and never cross paths physically, their lives are subtly interconnected by analogies and resonances with Woolf's modernist masterpiece. This device in the contemporary novel "leaves the narrative in a permanent sense of

flux in which the relationships of analogical links are never replaced by definitive connections within the story" (108). The uncertainty at the heart of coincidence is thus magnified instead of being downplayed or rationalized (as it tends to be when the Victorian novel achieves cognitive stability).

Dannenberg's account of the coincidence plot is no doubt a broad-strokes one, especially in its aligning certain types of narrative coincidence with particular historical periods and literary movements. But the discussion is nevertheless valuable in that it brings into focus the unique probability design of the coincidence plot. At the level of Kukkonen's first-order predictions (which have to do with plot progression), coincidence confounds the reader's probability calculus by chaining events with low real-world likelihood. Especially when it is not resolved or otherwise explained away by the narrative, coincidence generates an experience of uncertainty that helps shape the reader's sensory flow, via second-order predictions directed at characters who experience unlikely echoes or analogies. In the process, the coincidence plot may upset third-order predictions having to do with the generic conventions that underlie novelistic narrative: readers' expectation that the plot is driven or at least oriented by the characters' (usually, the protagonist's) goals is challenged. This is what happens in Ghosh's *Gun Island*, in which coincidence—defined by an apparent lack of causal relation—becomes a paradoxical stand-in for the probabilistic, global causality of climate change, as my reading of the novel will detail.

Framing Coincidences in *Gun Island*

Gun Island weaves a number of contemporary global issues—not just climate change but also poverty in the Global South and migration—into a narrative in which "improbabilities" are

abundant, resulting in a pronounced departure from Western realism. The narrator is a rare book dealer, Dinanath ("Deen") Datta, who divides his time between New York City and his native Kolkata. "I'm a compulsive note-taker and record-keeper" (13), remarks Deen early on in the novel, a comment that helps characterize him as reasonable and empirically minded, someone who is not prone to flights of fancy. Yet the novel's events repeatedly put Deen's mental stability to the test. The novel starts out as a quest of sorts: during a casual conversation at a wedding reception, a friend of Deen's brings up a mythical figure, the Bonduki Sadagar ("Gun Merchant"). This Merchant is strongly reminiscent of a traditional hero of Bengali folklore, who is also the protagonist of the epic poem—a classic of early Bangla literature—that became the subject of Deen's research thesis at university. Nevertheless, the epithet "Gun Merchant" is new to Deen, which is why he is intrigued by his friend's reference to a shrine in the Sundarbans that is associated with this figure. Later, Deen learns more about the Gun Merchant's story from an old acquaintance: "Plagued by snakes and pursued by droughts, famines, storms, and other calamities, he had fled overseas to escape the goddess's wrath, finally taking refuge in a land where there were no serpents, a place called 'Gun Island'—Bonduk-dwip" (17).

Deen speculates that this figure might point to an early convergence between Bangla, Persian, and Arabic traditions and the culture of the European colonizers on the Indian subcontinent. The narrator would thus seem to have good reason to pursue this lead and inspect the shrine mentioned by his friend. This visit is made more urgent by the fact that the shrine is located on an island in the Bay of Bengal that—we are told—is bound to disappear as a result of climate change and rising sea levels. However, despite Deen's interest in the figure of the Gun Merchant, he is reluctant to go, until a striking coincidence changes his mind. Out of the blue, he receives a phone call from an old-time Italian friend, Cinta, who reminisces about her first visit

to Kolkata, some twenty years earlier, when she and Deen had attended a folk performance centered on a snake goddess, Manasa Devi. Deen suddenly realizes that this goddess is also dedicatee of the shrine in the Sundarbans, which—legend has it—was built by the Gun Merchant after a successful sea voyage. Prompted by Cinta's unexpected allusion to the Gun Merchant's story, Deen decides to travel to the shrine.

It is worth pausing this summary to observe that this plot device ties in with Dannenberg's (post)modernist type of coincidence: rather than characters coming together in the storyworld, we have a striking series of references to the same mythical figure, a convergence that the narrator captures through the metaphor "the Gun Merchant entered my life" (3). This personification of the Gun Merchant's story is remarkable because it detracts from the narrator's agency, as if the plot reflected this mythical figure's influence rather than the conscious decisions made by the protagonist. Indeed, the beginning of the novel evokes the conventional narrative template of the quest—with the Gun Merchant's identity as the object of the quest—but also deviates sharply from it: the plot doesn't advance in parallel with the narrator's goal (which is the conventional narrative logic of the quest) but despite his reluctance or unwillingness to pursue the many coincidences that spring up along the way. This device generates significant uncertainty, which the novel—unlike many other coincidence-driven narratives—does not attempt to reduce by bringing in an external frame of reference (such as God or fate).

Cinta's serendipitous phone call is anything but an isolated instance in Ghosh's novel, which brims with unlikely events and happenstance. Soon, these accumulating coincidences start taking their toll on Deen's mind. The "cognitive stability" that Dannenberg associates with coincidence in the Victorian novel is here repeatedly denied, with a pervasive sense of mystery destabilizing the narrator's psyche. En route to Los Angeles for a conference, he has a

hallucinatory vision of snakes on the plane, which almost gets him arrested. In Los Angeles, the opening keynote on apocalypticism in the seventeenth century evokes in Deen's mind the calamities from which the Gun Merchant was escaping according to the ancient Bangla legend. Meanwhile, devastating wildfires creep closer and closer to the city, until the participants are abruptly evacuated from the museum that is hosting the convention. In her talk at the conference, Cinta—who is an expert in Venetian history—refers to the Jewish ghetto in Venice as "an island within an island," a phrase that brings back a strange symbol that Deen has seen on the walls of the Gun Merchant's shrine in the Sundarbans. Suddenly, it occurs to him that the Bangla word "bundook" is derived from an Arabic term for both guns and the city of Venice, so that what he had translated as the "Gun Merchant" could also denote "the Merchant who went to Venice" (151).

As soon as an opportunity presents itself, Deen travels to Venice to retrace the Gun Merchant's mythical footsteps, and here more near misses and chance encounters take place. Deen, who describes himself early in the novel as a "rational, secular, scientifically minded person" (36), is severely shaken. While in Venice, he mulls over the fact that "chance" (by which he means a purely statistical understanding of coincidence) is often described as "pure"—that is, unadulterated by supernatural or magical connections. He adds: "To cease to believe in [this view of chance] was to cross over into the territory of fate and destiny, devils and demons, spells and miracles. . . . I had to cling to my faith in chance, at all costs. It was almost as though my fidelity were being tested [by all these improbable events]" (201). A remarkable inversion of the language of faith and science is at work in this passage. Scientific rationality—the absence of an ulterior meaning to the coincidences that affect the narrator—is turned into an object of faith, something the narrator clings to in an attempt to salvage the worldview of the West, seen as the

"wellspring of scientific rationality" (37). Instead, the sheer improbability of the events the narrator experiences calls for a supernatural reading, which he strongly resists throughout the novel.

What Deen does not realize, however, is that the mysterious coincidences that drive the plot are butterfly effects—that is, manifestations of the probabilistic causality of climate change. Just as the beaching of dolphins in the Sundarbans reflects anthropogenic damage to ecosystems, the reappearance in Venice of a character first encountered by the narrator in West Bengal depends on patterns of global migration created by rising sea levels and other climate change-related disasters. The opposition set up by the narrator between the science of "pure chance" and supernatural belief is thus shown to be misleading, or at least complicated significantly: the "rationalist" viewpoint turns out to be oblivious to the global connections between the climate and human societies that are insistently emerging in the narrator's life as unlikely coincidences. These connections do not spring from irrational belief but from scientific models that reveal the planetary dimension of the ecological crisis, as well as the surprising dynamic patterns that climate change, like other inherently complex phenomena, can give rise to. What the narrator is framing as a conflict between European rationality and belief in supernatural connection thus turns out to be something entirely different: it points to the distinction between a mechanical, and ultimately flawed, understanding of causality (whereby each effect can be assigned an unambiguous cause) and a probabilistic model, in which unlikely events—so-called butterfly effects—can and do happen at a considerable spatiotemporal remove from their causes. If the latter form of causation appears to "cross over into the territory of fate and destiny," it is because the language of myth represents, for the narrator and for Ghosh, the only effective means of

channeling within the medium of the novel the global scale and probabilistic nature of climate change.

In this way, the probability design of *Gun Island* uses the narrator's reluctance to accept the deeper significance of the coincidences he repeatedly experiences in order to hint at a different form of blindness, namely the unwillingness to accept the strange—but devastating—consequences of human actions on a global scale. Ghosh invites us to read against the grain of the narrator's explicit framing of these coincidences, because the 'mystery' or the 'strangeness' that punctuate the novel do not stand in contrast to scientific thinking but actually convey two interrelated scientific ideas: the unexpected ramifications of human activities on a global scale, as well as uncertainty as an intrinsic element of scientific models of the climate. Uncertainty and the improbable do not oppose scientific rationality, as Deen seems to think, but grow from the radical complexity of the variables that will determine the Earth's future.

Halfway through the novel, as the coincidences begin piling up, Deen feels as if he "were tumbling down a rabbit hole of mathematical uncertainty. I fell into a kind of paralysis, a state of drawn-out, perpetual panic" (159). By the end of the novel, however, the narrator has begun to accept this "rabbit hole" without giving in to panic: as he watches a vast congregation of cetaceans somersaulting in the Mediterranean Sea (an unprecedented spectacle) he feels "overtaken by an overwhelming feeling of gratitude—towards the Gun Merchant, to his story, to Manasa Devi, and even to that king cobra: it was as if they had broken a spell of bewitchment and set me free" (294–95). The inexplicable "miracle" (309) that is unfolding in front of Deen is no longer framed as a disturbing coincidence, but as a moment of affective and aesthetic intensity. Ghosh invites the reader to adopt a similar stance, one in which mystery is embraced as part of reality (*including* scientific reality) rather than explained away by the conventional

narratives of faith or deterministic science. In the process, folk probability is displaced by the surprising probability of butterfly effects as the main engine of narrative progression.

The probability design of *Gun Island* thus manages to integrate the improbable and use it to reorient the reader's third-order predictions, which have to do with the conventions of the realist novel as a genre in which narrative progression is primarily linked to human intentions and agency, not to more-than-human mystery and uncertainty. As the coincidences multiply and the scale of the novel expands to encompass global connections between the Western world (Brooklyn, Venice) and the Indian subcontinent, Ghosh's orchestration of the plot elicits a shift in readers' predictions: the sheer improbability of the narrative—the "rabbit hole of mathematical uncertainty" into which the narrator has fallen—does not signal loose causality but rather hints at probabilistic causation on a vast scale. The language of myth (the Gun Merchant's story) captures the global linkage that underlies today's crises, especially climate change, poverty, and migration. There is no real opposition between contemporary scientific models and the permutations of mythical narrative in that respect, but shared recognition of uncertainty as a fundamental dimension of the experience of the present.

Conclusion

This article has demonstrated that the probabilistic understanding of causation inherent in scientific models can prompt a rethinking of probability as a basic concept of narrative practice and narrative theory. Brian Richardson and Emma Kafalenos have offered important insights about causality in stories, but they have foregrounded the psychological causality and teleology of human action. That focus is, of course, fully justified given how central mental states are to the workings of narrative—and to readers' interpretation thereof. Nevertheless, causation exists

outside of the domain of human action; indeed, it is one of the conceptual centerpieces of the natural sciences. The science of the Earth system in particular—including climate change—reveals probabilistic patterns of causation that bring together, surprisingly, human societies and nonhuman ecosystems, as well as distant parts of the world. That is the intuition behind the phrase "butterfly effects," which refers to surprising (and, in some cases, devastating) consequences at a significant distance from their causes—a typical feature of a complex, nonlinear system like the Earth's climate. Capturing butterfly effects and other large-scale phenomena in narrative is tricky; it can send authors, narrators, and (potentially) readers down treacherous "rabbit holes," as the protagonist of Ghosh's *Gun Island* can attest. Yet understanding how narrative may integrate this kind of probabilistic causality is a major step towards developing narrative strategies that are capable of conveying the planetary scale of climate change—an important desideratum, not just in literary narrative but also in climate change communication projects that make use of stories to disseminate scientific models.

If probability is an inherent dimension of the reading experience, as Kukkonen's cognitive model suggests, readers' probability calculus needs to be retrained thoroughly as the likelihood of characters' actions is complicated by what has been called, aptly, "global weirding" (Thomas Friedman's terminology)—that is, the strange ramifications of climate change. Ghosh's supercharged coincidence plot is an example of how narrative may use improbable events to hint at the scale of the current ecological crisis. In that way, *Gun Island* effectively addresses the problem Ghosh himself identified in his nonfiction *The Great Derangement*, but there are undoubtedly many other formal solutions that have been developed (or are being developed) by contemporary writers to navigate the same "rabbit hole of mathematical uncertainty."

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Notes

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[2] For more on narrative and butterfly effects, see Caracciolo, *Narrating the Mesh*, 51–55.

[3] See, e.g., Gérard Genette's influential essay on the *vraisemblable*.

[4] This pre-understanding of human action is what Paul Ricoeur describes as "mimesis$_1$" in *Time and Narrative* (54).

[5] For more on the definition of folk psychology, see Paul M. Churchland.

[6] See Stephan Lewandowsky et al. for discussion of the link between uncertainty and climate skepticism or denialism. On uncertainty as a major conceptual and ethical focus of contemporary climate fiction, see Caracciolo, *Contemporary Fiction*.

[7] I discuss narrative form and nonlinearity more fully in *Narrating the Mesh*, Chapter 1.

[8] This is a centerpiece of Ricoeur's account of narrative and also of Marie-Laure Ryan's possible worlds-inspired model.

[9] On climate fiction, see Antonia Mehnert's discussion.

[10] For more on this scalar gap and its significance vis-à-vis the climate crisis, see Derek Woods.

[11] Richard Walsh offers a sustained argument on how scientific complexity could never be fully encapsulated in narrative form.

[12] The term "network narrative" comes from David Bordwell, Chapter 7. See again Caracciolo, *Narrating the Mesh*, Chapter 1, for more on how the narrative form of the network can engage with more-than-human realities.

[13] See Michel Baranger's helpful introduction to complex systems.

[14] Shannon Lambert discusses this analogy between fungal and human networks in her reading of *The Overstory*.

[15] See Caracciolo, "Object-Oriented Plotting," for more on this technique.

[16] David C. Knill and Alexandre Pouget offer an overview of Bayesian approaches to the brain.

[17] Together with surprise and curiosity, suspense is one of Meir Sternberg's "narrative universals." Not a direct quote, just one of Sternberg's main ideas See also John Beatty on how narrative builds on the split between what happened and what could have happened.

[18] Caroline Levine also foregrounds the role of chance encounters in Charles Dickens's *Bleak House*, in an effective New Formalist analysis that sees the plot of the novel as an interpersonal "distributed network" (125).