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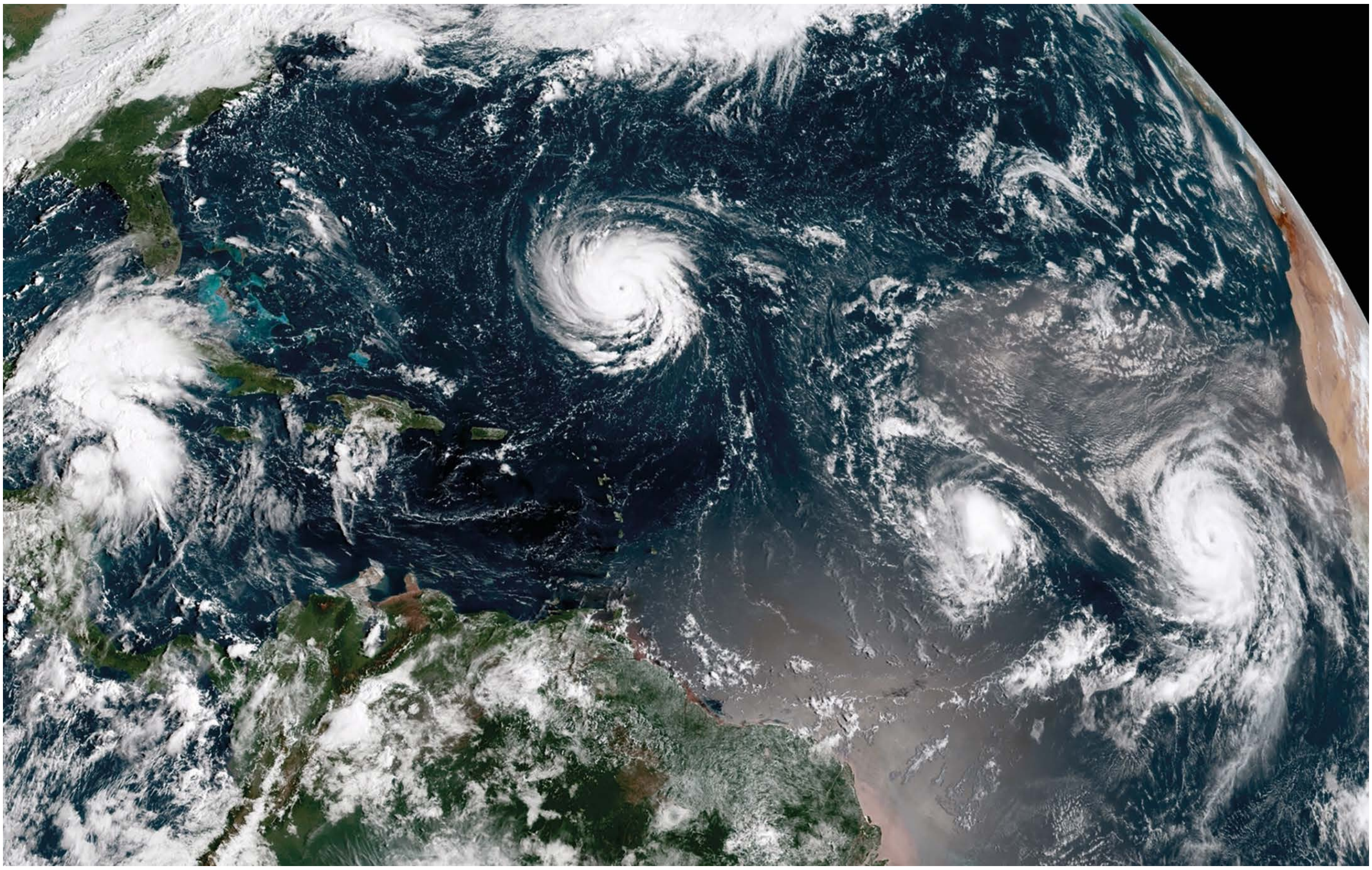
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Figure 1 | Tropical cyclones over the Atlantic Ocean. Wang *et al.*[3] compiled a record of 84,110 wind-speed measurements taken during tropical cyclones that occurred between 1991 and 2020.

Climate science

Seas reveal a surge in the strength of tropical storms

Robert L. Korty

A 30-year record of ocean-current velocities has been used to infer wind speeds during tropical cyclones. The data show that these storms have intensified over time, supporting claims that their strength will increase as the planet warms. **See p.496**

Tropical cyclones, such as hurricanes and typhoons, are predicted to intensify with the temperature increases expected under current projections for global warming[1]. However, it is unclear whether historical records already show signs of this trend, because these storms form over areas of ocean that are often far from land, where direct measurements of surface wind speeds can be both dangerous and impractical to obtain[2]. On page 496, Wang *et al.*[3] report that the intensity of surface winds can be inferred from measurements of the ocean currents that build beneath them. The authors' data show that, over the past 30 years, tropical storms have grown stronger in all ocean basins in which they occur.

Warm ocean waters provide the conditions necessary for tropical cyclones to form, delivering energy that drives these storms as heat and moisture are transferred to the atmosphere. Aircraft can be used to drop instruments that measure the surface winds of a storm while it is at sea, and although the data collected provide invaluable information about the strength of tropical storms, such methods can be used in only some cases. Drones and unmanned vessels will enable more measurements to be collected in the future, but the historical record is constrained by the limited data available. For the past 35 years, aircraft missions have been restricted mainly to storms in the Atlantic Ocean.

In the absence of direct measurements, meteorologists instead rely on estimates derived from the analysis of satellite images[4]. This technique fills the void remarkably well[5], but it is nevertheless subject to biases and uncertainties, in part because it relies on subjective interpretations of the data[6,7]. These shortcomings mean that researchers have had limited confidence in using these images to assess whether the historical records of tropical cyclones contain evidence that such storms have intensified.

Wang *et al.* took a different approach, by making use of the relationship between ocean-current velocities and the forces that winds exert on the ocean's surface. Using a vast network of floating devices called drifters, which move with the ocean currents, they pulled together a record of 84,110 wind-speed measurements taken during tropical cyclones that occurred between 1991 and 2020 (Fig. 1).

Ocean currents near the surface exhibit extremely high velocities in a tropical cyclone, in response to the rapid onset of strong winds at the surface[8]. However, the instruments used by Wang *et al.* are equipped with a funnel-shaped device, known as a drogue, that allows the instruments to drift smoothly through the ocean's mixed layer — a thin layer of warm water adjacent to the surface. The stability of these surface drifters enables them to record highly accurate data[9], even when violent storms are raging. The authors showed that estimates of the surface winds obtained with these instruments were consistent with wind measurements recorded by nearby buoys.

A clear message emerges from this data set: the ocean currents beneath tropical cyclones have grown stronger over the past three decades, and there are upward trends in all ocean basins in which these storms occur. The coverage of these devices in the western North Pacific Ocean is sufficient for the authors to conclude that the increase occurred beneath storms of all intensities. However, the network of drifters intersects strong storms infrequently in other ocean basins, so Wang *et al.* restricted their analysis to weak tropical cyclones.

The authors' results are supported by further data showing that surface cooling in the wake of tropical storms has increased in the past 30 years. Strong currents near the surface create a shear across the base of the mixed layer, which, in turn, induces mixing to bring deeper, colder waters up to the surface. This process leaves the ocean surface colder after the passage of a tropical cyclone than it was before. Wang *et al.* note that there were no substantial changes to other factors that could modify the extent of cooling, such as the depth of the mixed layer or the speed of currents during storms. They therefore conclude that the trend towards increased cooling beneath tropical cyclones confirms their results from ocean-current velocities: storms are stronger now than they were 30 years ago.

Wang and colleagues caution that their results are robust only for weak storms, because the sample of data collected during stronger storms is, at present, too small to allow their analysis to be extended to the full range of intensities. I suspect, though, that their data constitute evidence that all tropical cyclones have grown in intensity. After all, even the strongest storms spend a considerable time in a relatively weak form, both as they are developing and — for those that remain at sea — during their decline. The authors are confident that their data show an increase in the wind speeds of storms with a maximum intensity that means they are classed as tropical storms and weak hurricanes. But the data actually pertain to any storm that passes over an ocean drifter while its wind speed is in this low-intensity range, so some of the data do actually correspond to stronger storms.

Previous work has shown that the strongest typhoons and hurricanes tend to have occurred more often in recent years, compared with the 1970s[10]. When viewed in conjunction with this finding, Wang and colleagues' analysis should boost our confidence in predictions that the intensity of storms will also increase as the planet warms. It certainly leaves little doubt that tropical storms around the globe have intensified in the past 30 years.

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Spinal-cord injury

Cells that aid recovery from paralysis identified

Kee Wui Huang & Eiman Azim

Improved treatments for spinal-cord injury require both technological development and insights into the biology of recovery. High-resolution molecular maps of the nervous system are beginning to provide the latter. **See p.540**

Spinal-cord injury can lead to a debilitating loss of movement and sensation. Although full recovery of mobility remains an elusive goal, electrical stimulation of the spinal cord during rehabilitation has enabled substantial improvements in movement, even in individuals who were completely paralysed[1]. On page 540, Kathe *et al.*[2] begin to uncover the neural mechanisms that underlie this improvement. The authors present a detailed molecular map of the injured spinal cord in mice during recovery from paralysis, and use this map to identify a cell type that has a crucial role in rehabilitation. This type of biological understanding is an important step towards achieving full restoration of motor function.

Epidural electrical stimulation (EES) was originally developed more than 50 years ago as a method of pain relief[3,4]. EES involves implanting flexible paddles that contain multiple electrodes under the muscle and bone, just above the spinal-cord dura mater (the outermost membrane that encases the nervous system). The electrodes deliver electric currents that can activate nearby neurons in the spinal cord, as well as neuronal pathways that enter and exit the spinal cord. In the context of spinal-cord injury, this approach has been used to stimulate surviving neurons below the injury, improving motor function[5].

However, progress in treating paralysis using EES initially faced several challenges. For example, the designs of early EES electrodes were not optimal for activating components of the spinal cord that are crucial for motor recovery. Furthermore, EES devices could not flexibly produce the diverse patterns of stimulation that are needed to support a wide range of movements in a manner tailored to the individual[6].

In the past decade, much progress has been made in improving both the technology and our understanding of the biological mechanisms that underpin successful rehabilitation. A key step has been the development of improved implants and stimulation programs[1,7], motivated in part by the discovery that previous designs disrupted sensory