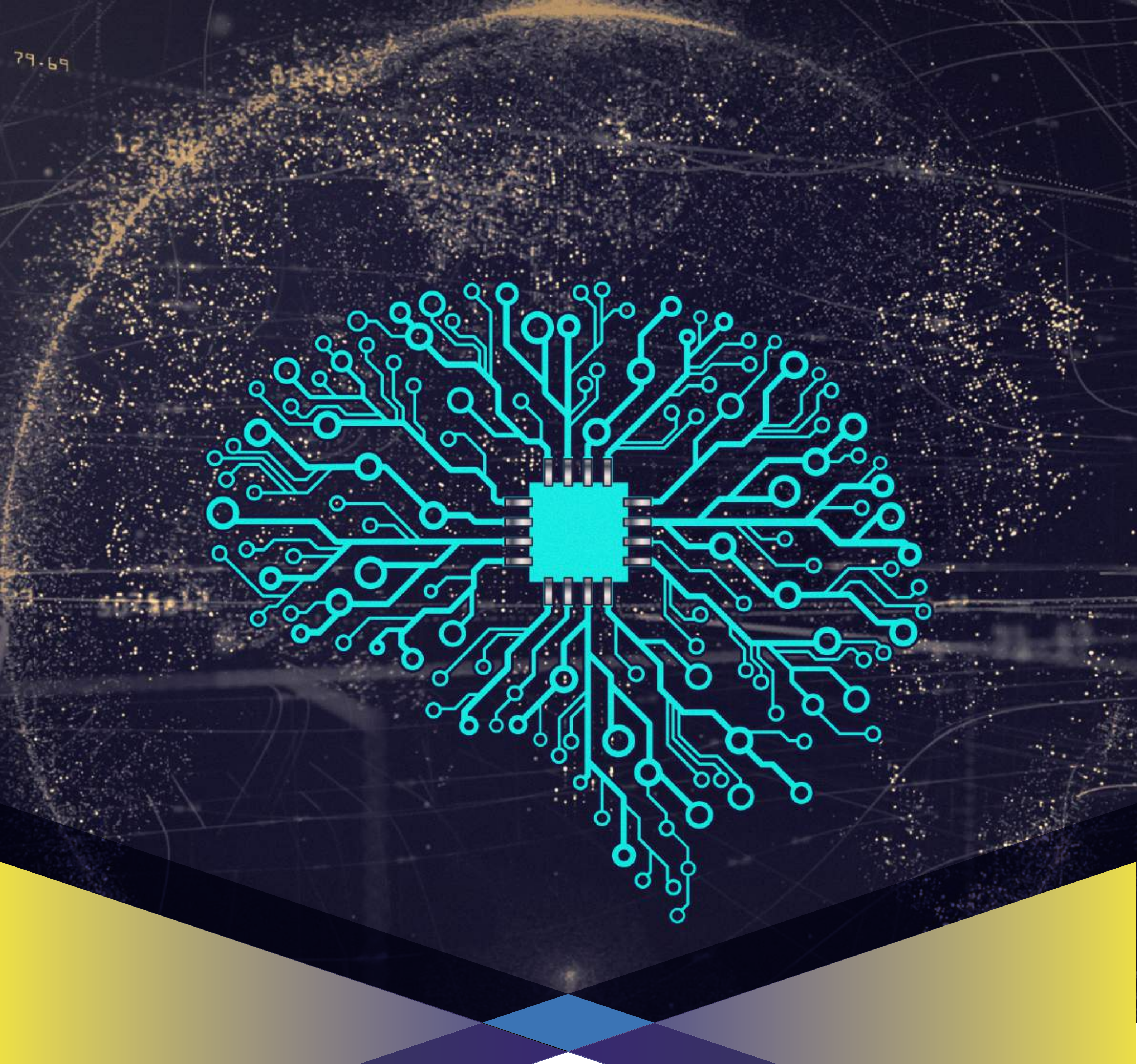

PROJECTION OF GLOBAL WARMING TRAJECTORIES WITH ARTIFICIAL NEURAL NETWORKS

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Recent breakthroughs in Artificial Intelligence (AI) technologies such as the launch of the freely available chatGPT developed by OpenAI have recently been captivating the world as to the new opportunities and possibilities to come.

While the main purpose of this language model is to "assist users in generating text for various purposes, such as answering questions or providing information" (according to chatGPT itself), AI approaches are increasingly being used in a wide range of other applications, including climate science and global warming projections, and are widely used at Risk Frontiers.

A NOVEL AND UNIQUE AI FRAMEWORK FOR ASSESSING GLOBAL WARMING TRAJECTORIES

Previous projections of global warming have used global climate models to simulate future warming trajectories, statistical techniques to extrapolate recent warming rates, and carbon budgets to calculate how quickly emissions will need to decline to stay below the 2015 Paris Agreement targets.

Diffenbaugh and Barnes (2023, see also Stanford News, 2023) used an entirely different and novel approach based on AI neural networks. They trained artificial neural networks (ANNs) on the vast archive of annual temperature anomaly (relative to the 1951-1980 period) outputs from widely used global climate model simulations. After the neural network had learned patterns from these simulations, the researchers used the ANNs to predict the number of years until a given temperature threshold will be reached when given maps of observed annual temperature anomalies for a specific emission scenario.

Unlike all previous AI approaches, no observations are used during the training, validation, or testing of the model, which limits the number of biases and assumptions necessary to extract climate change signals and uncertainties. Nevertheless, the ANNs accurately predict the timing of historical global warming from maps of historical annual temperature anomalies.

CONFIRMING FAST APPROACHING THRESHOLDS

To test for accuracy, the researchers used their trained ANNs to predict the time remaining until the current (2021) level of global warming, 1.1°C (as reported by the most recent IPCC's assessment), when given historical temperature anomaly data for each year from 1980 to 2021 as input (top panel in Figure 1).

The ANNs correctly predicted that the current level of warming would be reached in 2022, with a most likely range of 2017 to 2027. The models also correctly predicted the rate of decline in the number of years until 1.1°C is reached that has occurred over the recent decades.

The prediction is very close to the theoretical value of one year of decline per year. Accuracy in predicting the timing of the current level of global warming was consistent across all three different climate forcing scenarios (High: SSP3-7.0; Intermediate: SSP2-4.5, and Low: SSP1-2.6).

In the case of a 1.5 °C warming, the observed pattern of annual temperature anomalies in 2021 leads to a predicted time-to-threshold of 2035 (2030 to 2040) in the High scenario, 2033 (2028 to 2039) in the Intermediate scenario, and 2033 (2026 to 2041) in the Low scenario (Figure 1). For 2°C, the ANNs predicted a time-to-threshold of 2050 (2043 to 2058) in the High scenario, 2049 (2043 to 2055) in the Intermediate scenario, and 2054 (2044 to 2065) in the Low scenario.

The slope over the past 15 years has been close to −1 y/year for both the 1.5 °C and 2 °C thresholds in the High scenario (Fig. 3), showing that the ANNs have learned to largely remove the impact of natural climate variability (e.g. ENSO) when assessing the time-to threshold.

The ANNs central estimate for the 1.5 °C global warming threshold is between 2033 and 2035, consistent with previous assessments including the IPCC Sixth Assessment Report (AR6). However, the central estimate for the 2.0 °C global warming threshold is between 2049 and 2054, suggesting a substantial probability of exceeding the 2.0 °C threshold by 2050 even in the Low (SSP1-2.6) climate forcing scenario. This is inconsistent with the most recent report from the Intergovernmental Panel on Climate Change, which concludes that the 2.0 °C level is unlikely to be reached if emissions decline to net zero before 2080 (SSP1-2.6).

Crossing the 1.5°C and 2.0° C thresholds would mean failing to achieve the goals of the 2015 Paris Agreement, in which countries pledged to keep global warming to "well below" 2.0 °C above pre-industrial levels, while pursuing the more ambitious goal of limiting warming to 1.5° C.

The authors consider that it nevertheless remains possible to avert more extreme climate change by rapidly reducing the amount of carbon dioxide, methane, and other greenhouse gases being added to the atmosphere.

In the years since the 2015 Paris Agreement, many nations have pledged to reach net-zero emissions more quickly than is reflected in the low-emissions scenario used in this new study. Countries that have net-zero goals between 2050 and 2070 include China, the European Union, India, and the United States.

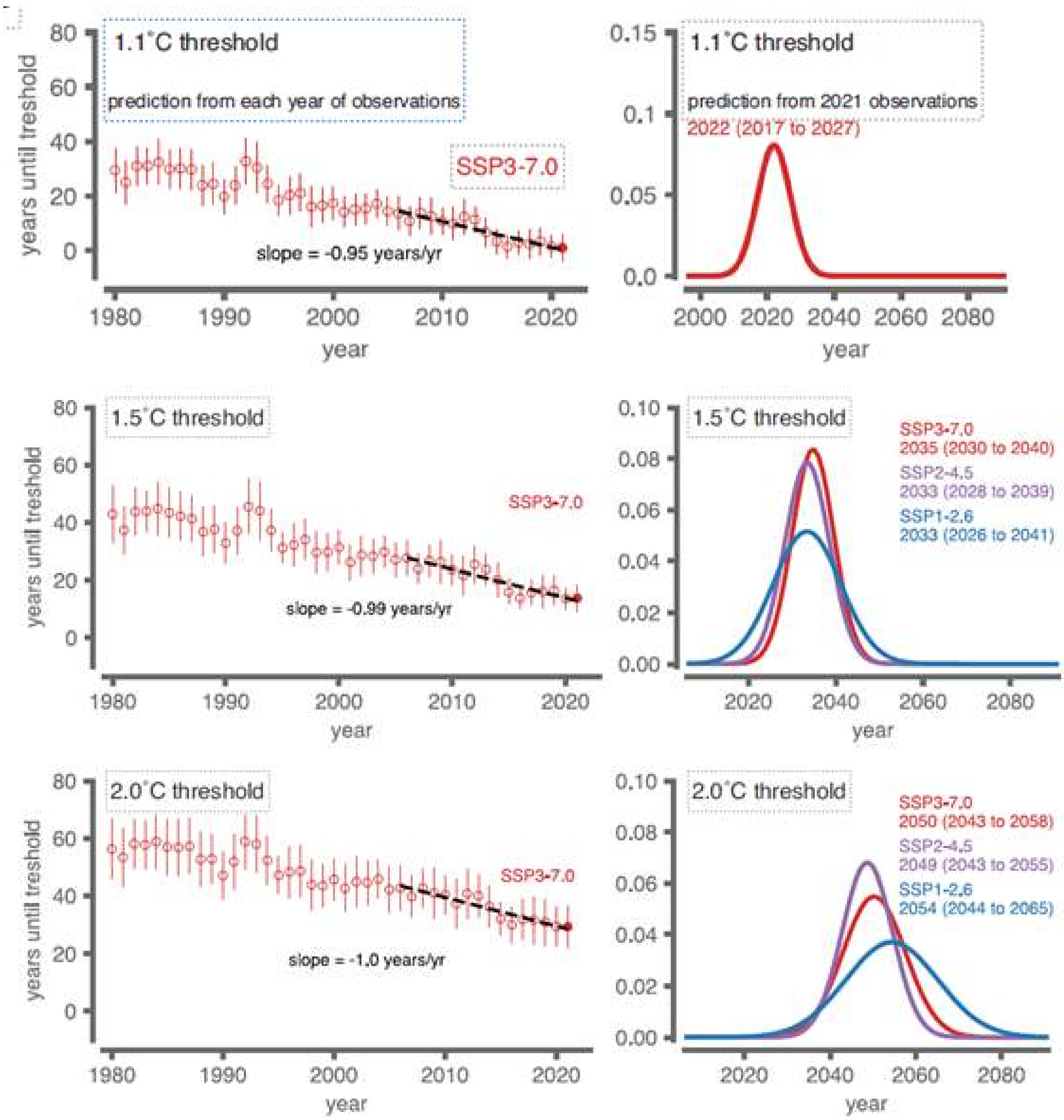

Figure 1. Left: The time to 1.1 °C (top), 1.5 °C (centre), and 2.0 °C (bottom) of global warming predicted from the observed map of annual temperature anomalies, using the artificial neural networks (ANNs) trained on a global warming of the respective threshold in the High climate forcing scenario (SSP3-7.0). The Right panels show the distribution of predicted years in which the threshold will be reached based on the observed map of annual temperature anomalies in 2021 for the High scenario (red), Intermediate scenario (magenta) and Low scenario (blue) Source: Diffenbaugh and Barnes, 2023.

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Paul is Chief Geoscientist at Risk Frontiers. He has a PhD in Geophysics, and has 45 years experience as an engineering seismologist, including 15 years with Risk Frontiers. He has had first hand experience of damaging earthquakes in California, Japan, Taiwan and New Zealand. He works with Valentina Koschatzky in the development of QuakeAUS and QuakeNZ.

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