158736 Advanced Machine Learning

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Deep Learning in Sustainable Energy and Climate Change

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THE CHALLENGE AND THE OPPORTUNITY

CLIMATE CHANGE: THE URGENCY AND THE POTENTIAL OF AI/DL

- Climate change presents a significant global challenge, demanding urgent action [1]

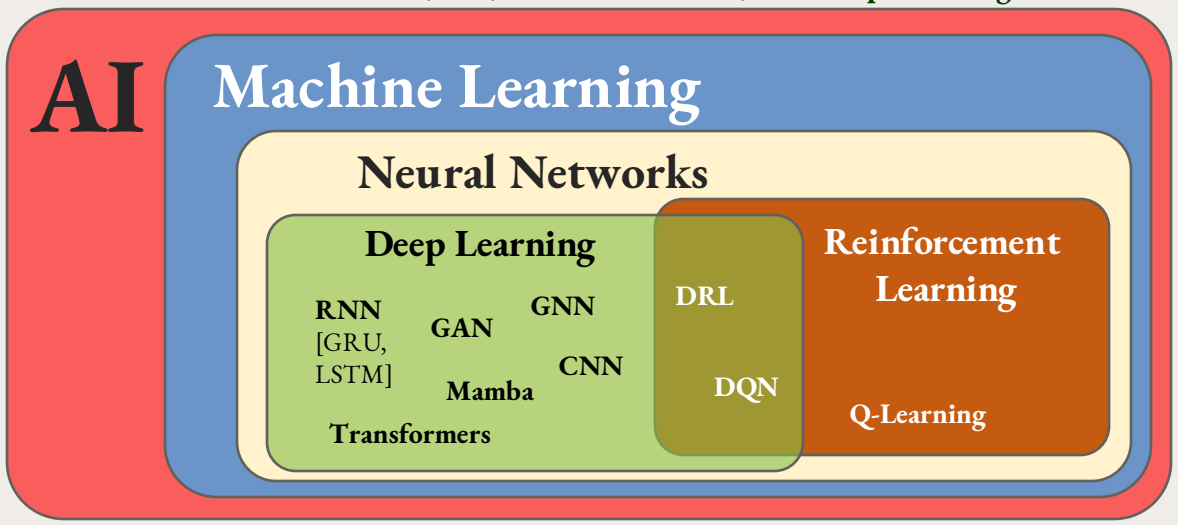
  e.g.: IEA's Roadmap to "Net Zero by 2050" [2]

- Deep Learning (DL) advances, a subfield of AI, following LeCun, Bengio & Hinton [3] foundational work, play an increasingly crucial role in tackling this through renewable energy and climate modelling

Exploring the deep learning applications in:

- Optimising renewable energy generation and forecasting
- Maximising energy utilisation and efficiency
- Enhancing climate modelling and prediction

Hierarchical Structure of AI, ML, Neural Networks, and Deep Learning Models



RENEWABLE ENERGY FORECASTING

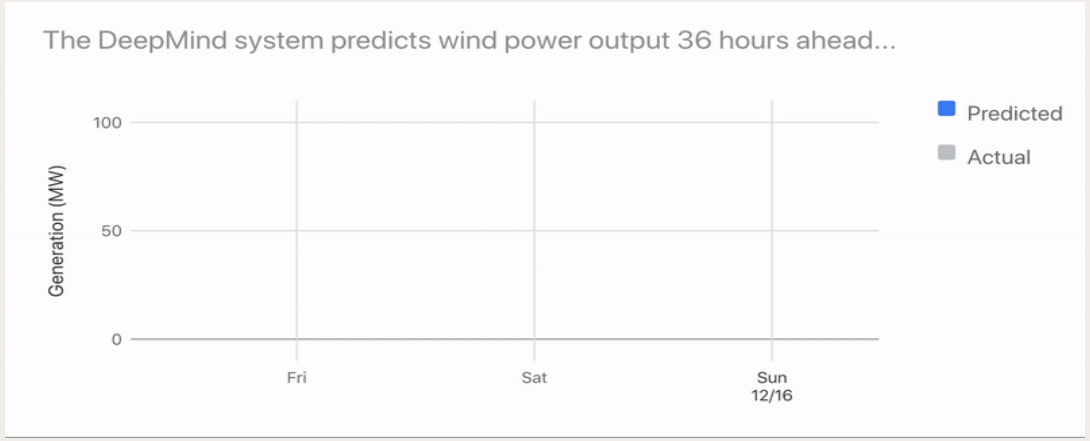
PREDICTING THE POWER OF NATURE WITH DEEP LEARNING

Emerging Deep Learning models enhancing prediction accuracy for solar power:

- GRU models optimising renewable energy scenarios [4]
- DRNN outperforming traditional methods for solar irradiance forecasting [5]
- Hybrid models combining ConvGNN and LSTM for geospatial solar irradiance forecasting [6]
- Enhanced short-term solar power forecasting using GRUs [7], or using LSTM [8]

Wind power forecasting:

- GRU/LSTM forecasting wind speeds or energy output
- DeepMind's use DL for wind power forecasting



Google DeepMind using DL for predicting optimal wind power generation [24]

SMART GRIDS AND ENERGY MANAGEMENT

SMART GRIDS OPTIMISATION WITH DEEP LEARNING

Optimisation is crucial for efficient integration of intermittent renewable energy in smart grids

- Deep Reinforcement Learning (DRL) optimises energy allocation in response to dynamic demand
- Integration with blockchain enhances security and transparency [9]
- Deep learning improves grid stability, fault detection and facilitates efficient energy storage integration [10]
- Anomaly detection in power grid equipment using Mask R-CNN [11]

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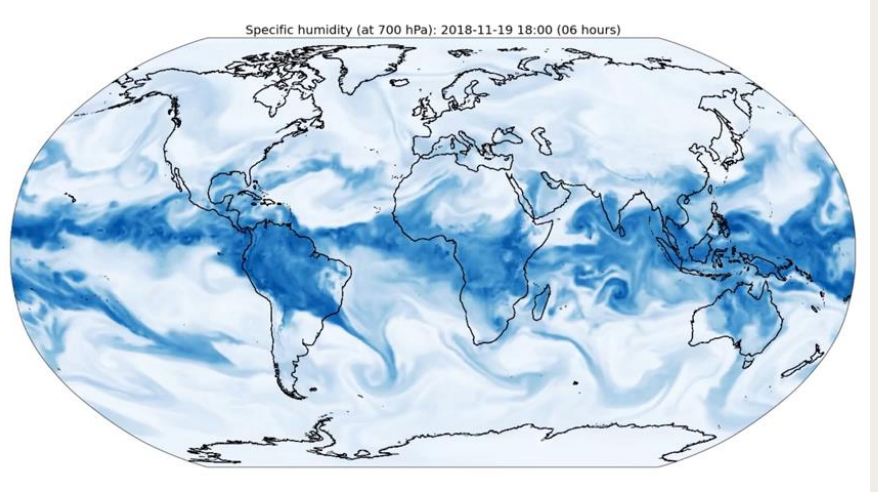
CLIMATE MODELLING AND EXTREME WEATHER PREDICTION

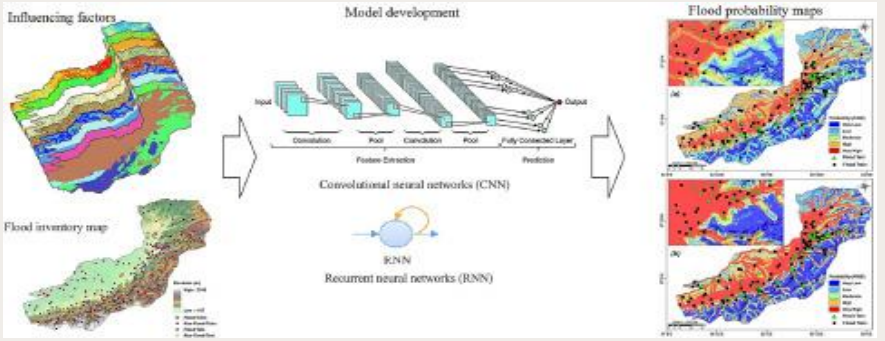
PREDICTING A CHANGING CLIMATE WITH DEEP LEARNING

Deep learning contributes to climate change research and supports SDGs [12], enhancing climate modelling and prediction of extreme weather events:

- GraphNN for improved global weather forecasting [13]
- LSTM networks enhance flood prediction accuracy globally [14]
- Earthquake prediction using DL [15, 16] to understanding climate-related impacts and vulnerabilities
- Mamba and Transformer integration for time-series forecasting of weather dynamics [17]



Source: Google GraphCast model [12]

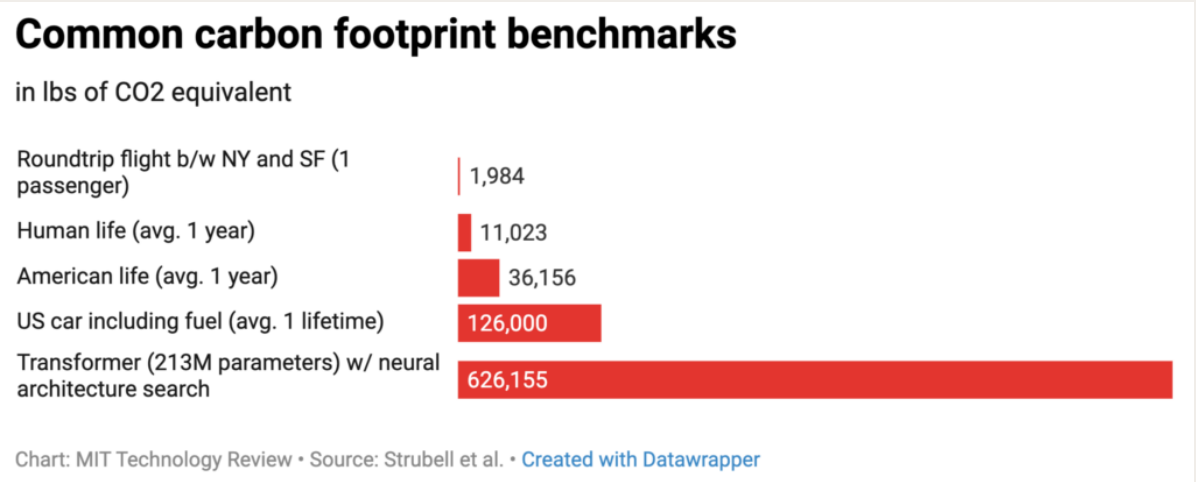


Deep Learning Flash Flood Prediction [18]

SUSTAINABLE AI

MINIMISING THE CARBON FOOTPRINT OF AI/DL

- AI related carbon emissions soaring and leading to stressed power grids [19]
- LLM training, climate and seismic forecasting contribute to substantial energy consumption in data centres (e.g.: Microsoft 20-year Three Mile Island Nuclear power deal [20])
- New research focusing on developing energy-efficient models, using a Sustainable-Accuracy Metric to help assess trade-off between accuracy and energy use [21]
- DL can also optimise energy consumption in various sectors [22], offering a potential pathway to offset its own carbon footprint



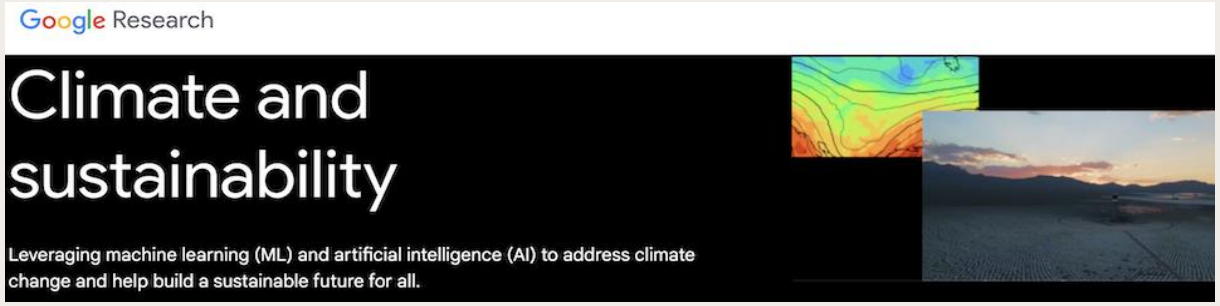
Source: MIT Technology Review

KEY ORGANISATIONS AND INITIATIVES

DRIVING INNOVATION: KEY PLAYERS IN AI FOR SUSTAINABILITY

Source: climatechange.ai

- Climate Change AI: community and platform fostering research and collaboration on climate change solutions using AI
- Microsoft's AI for Good Lab, and Microsoft Climate Research Initiative
- Google Climate and Sustainability: developing AI-driven solutions for climate mitigation and adaptation

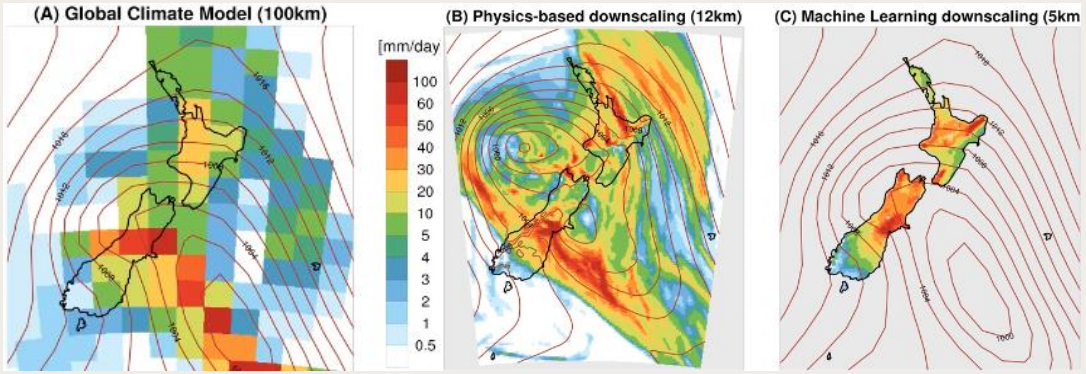


Source: Google Research - Climate and Sustainability

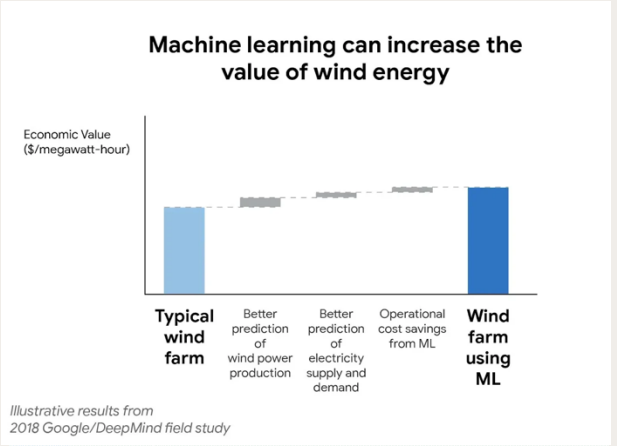
REAL-WORLD APPLICATIONS & CASE STUDIES

DL TRANSFORMING SUSTAINABILITY & CLIMATE LANDSCAPES

- Google's FireBench for wildfire simulation [23], GraphCast for weather forecast [12]
- DeepMind's wind farm 20% efficiency gain using predictive modelling [24]
- Vestas, minds.ai & Microsoft use RL to increase energy capture in wind farms [25]
- Deep RL controls plasma in nuclear fusion reactors [26]
- Amazon's packaging waste reduction using DL [27]
- NZ's NIWA climate modelling [28]



Source: National Institute of Water and Atmospheric Research (NIWA) [28]



Source: Google's FireBench [23]

FUTURE DIRECTIONS AND CONCLUSION

THE FUTURE OF DEEP LEARNING IN SUSTAINABILITY

- Rapidly evolving field with vast potential for addressing climate change, understanding and improving aerosols [29]
- Continued research and development are crucial for further advancements and modelling impacts [30]
- Interdisciplinary collaboration is essential for integrating DL/AI effectively into sustainability initiatives [31]

Focus areas:

- Enhanced climate resilience
- More accurate and efficient climate DL models
- Sustainable AI development

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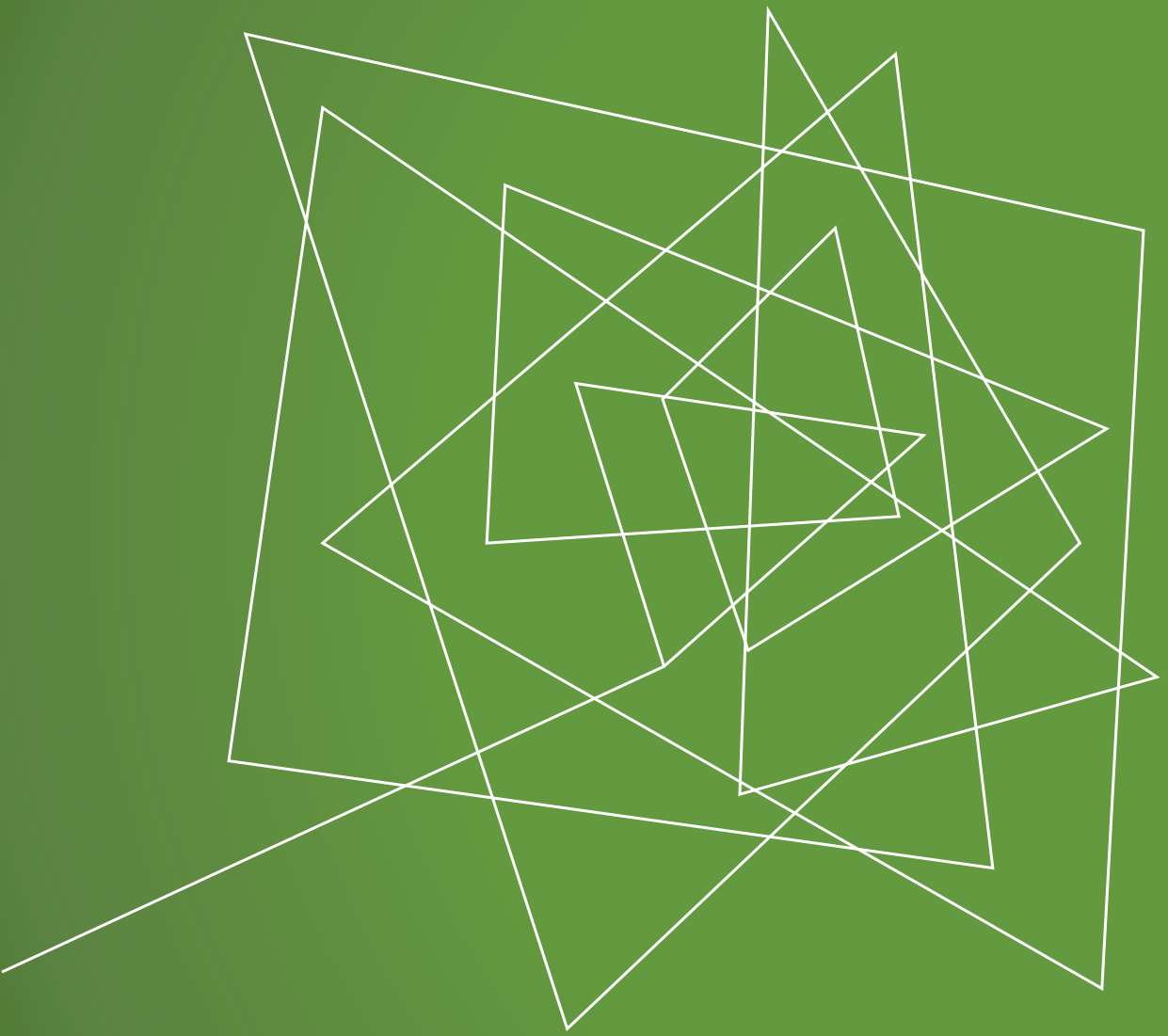

THANK YOU

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