USING AI TO FIGHT CLIMATE CHANGE

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AI is a powerful tool to help us MITIGATE & ADAPT to climate change:

Resource Management
x3 sustainable rate

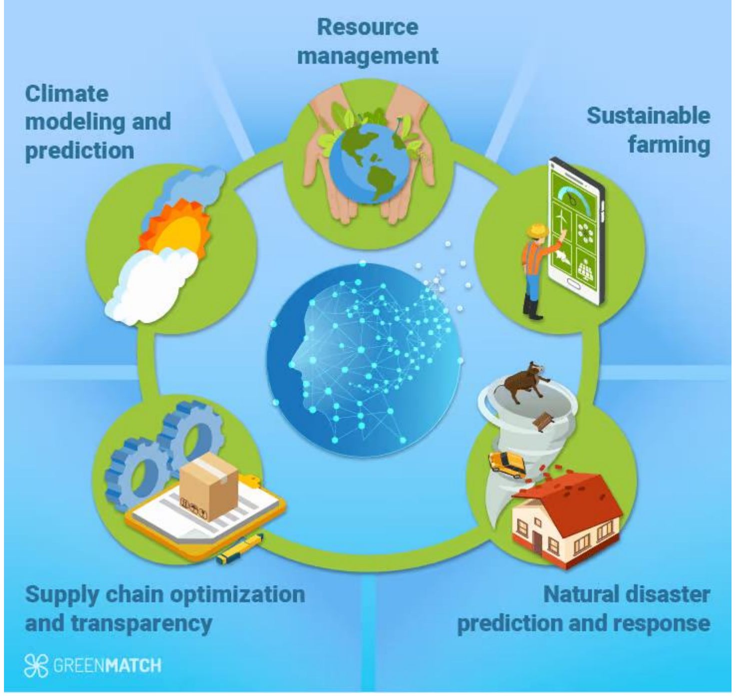
Reduce Emissions Across Market Sectors

Lower Carbon Footprint

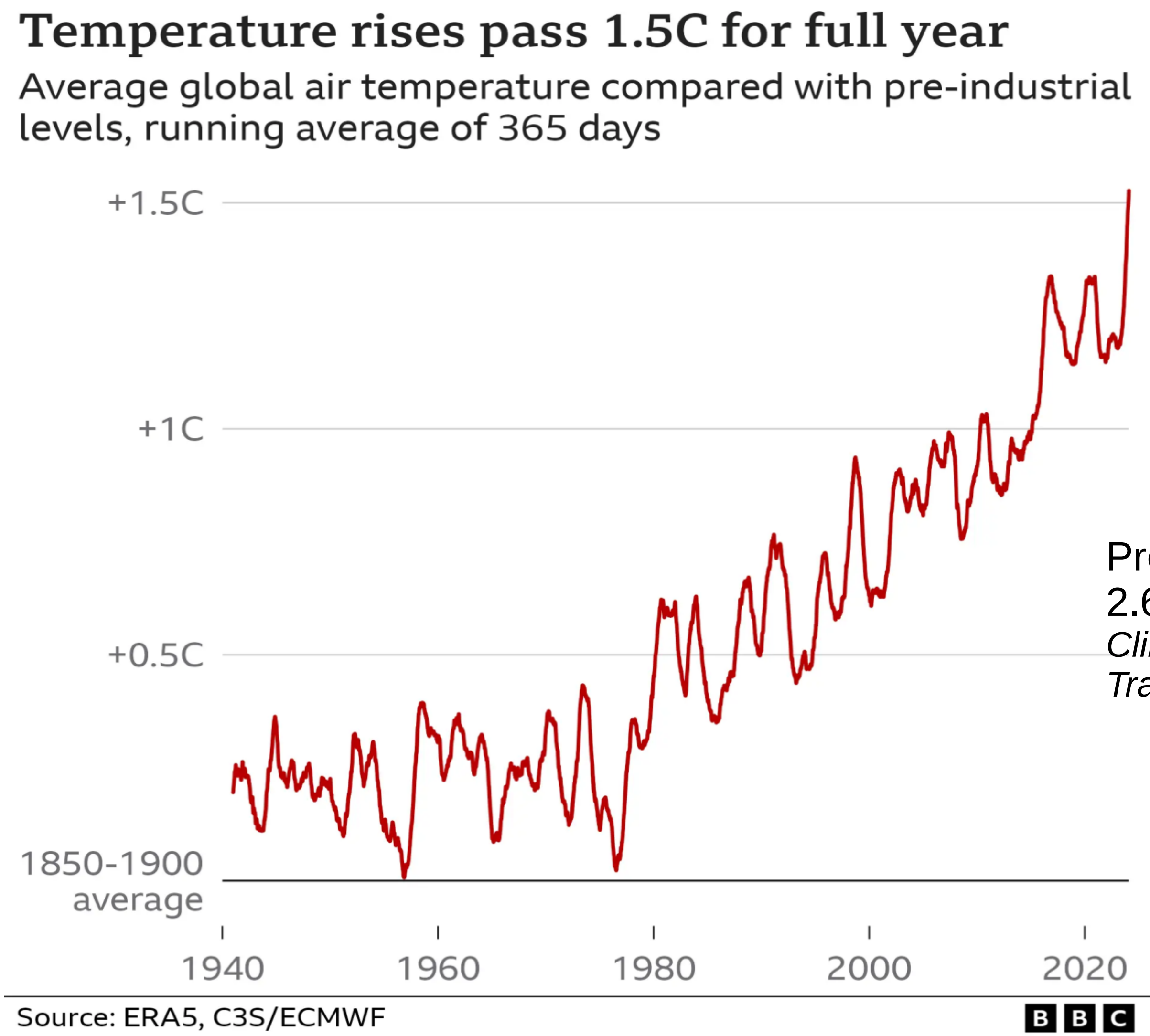
Climate Change Forecasting

Extreme Weather Events

Geoengineering Future Climate

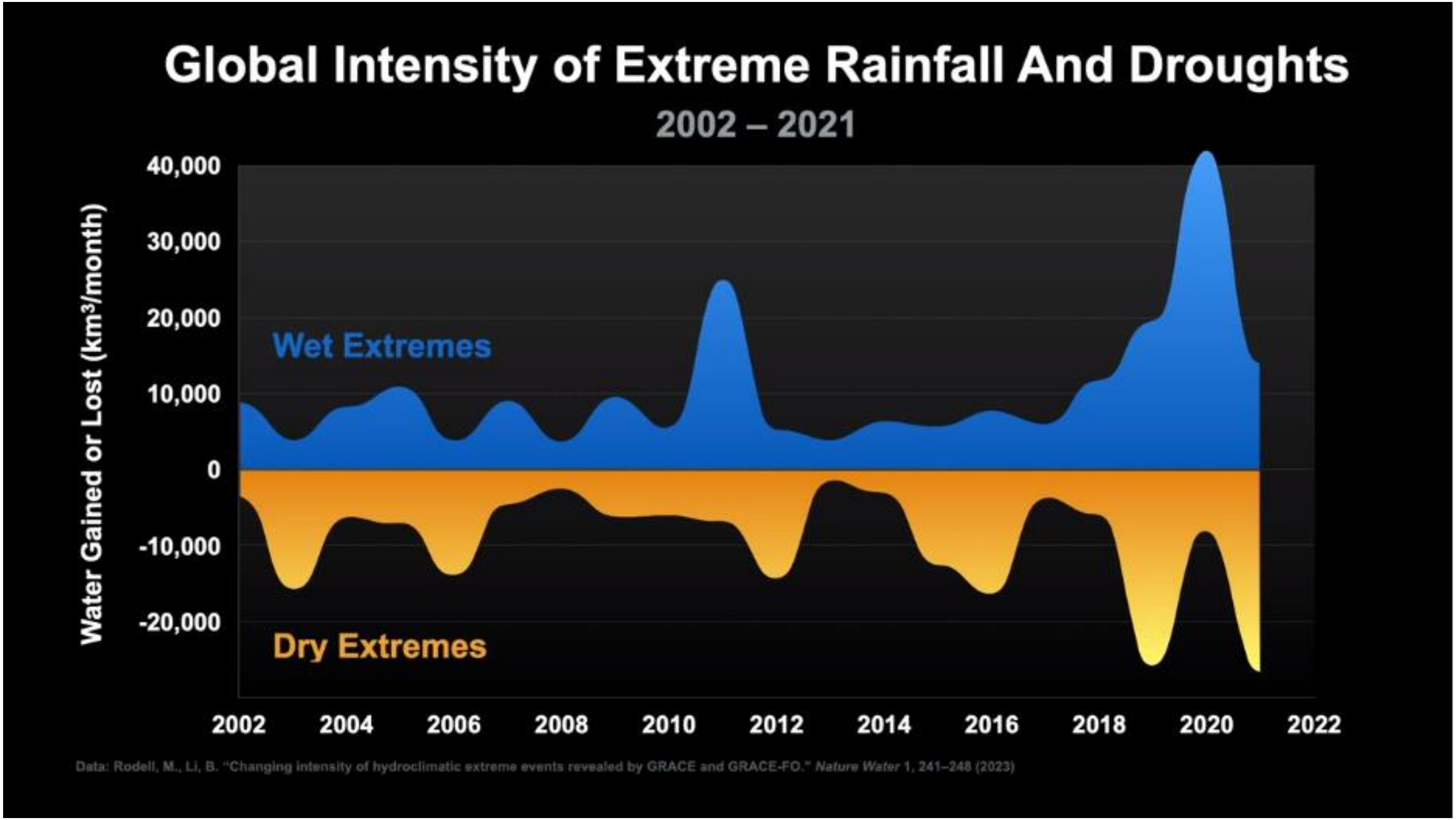


GLOBAL AVERAGE TEMPERATURE

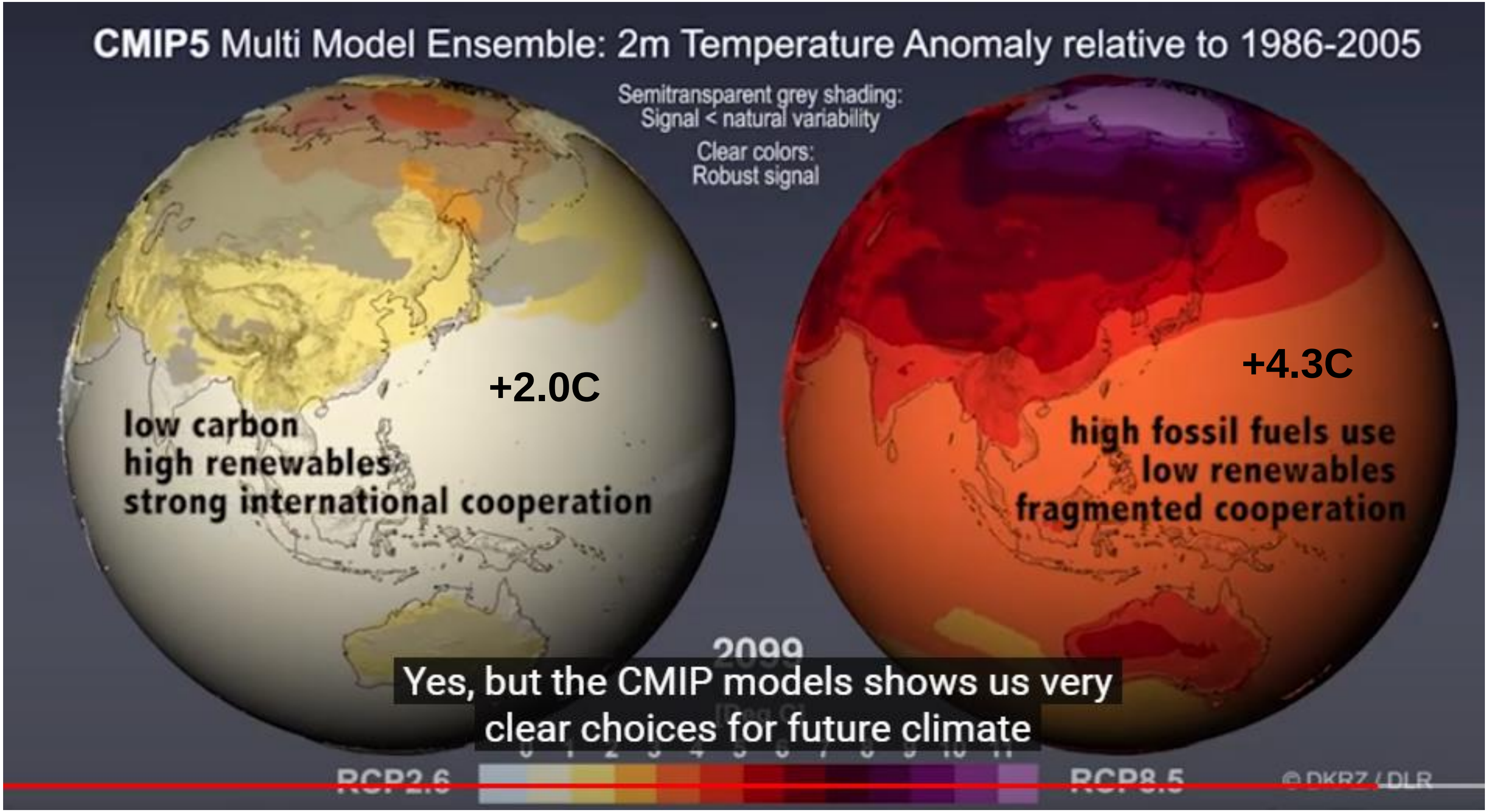


Predicted Rise
2.6C – 2.9C by 2100
Climate Action Tracker

EXTREME WEATHER - RAINFALL & DROUGHTS

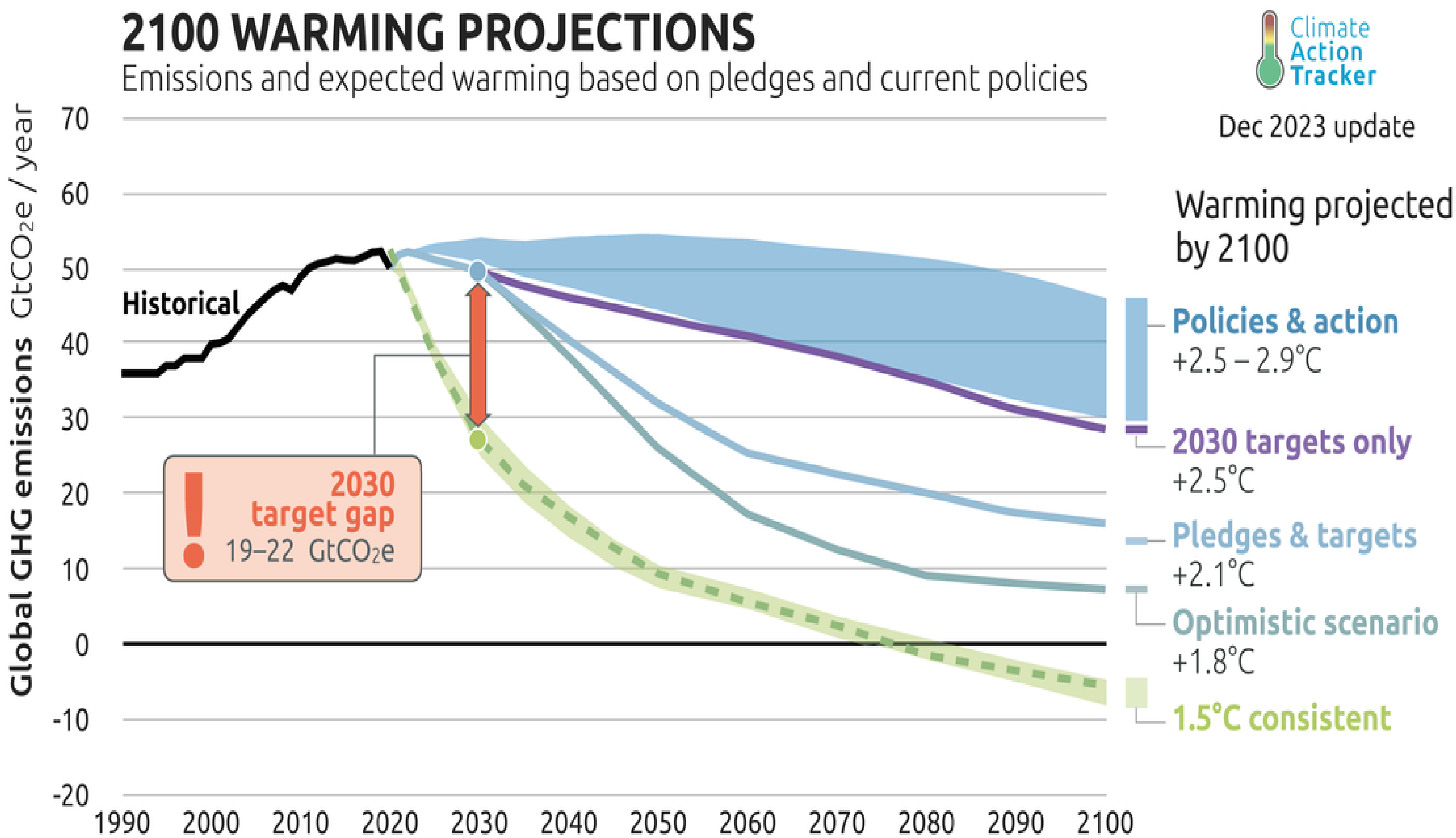


COMPUTER MODEL TEMPERATURE RISE PREDICTIONS 2100



CLEAR CHOICES FOR FUTURE CLIMATE

GLOBAL WARMING



GLOBAL CLIMATE MODEL PREDICTION 2100+

Predicted global average temperature rise ~3C

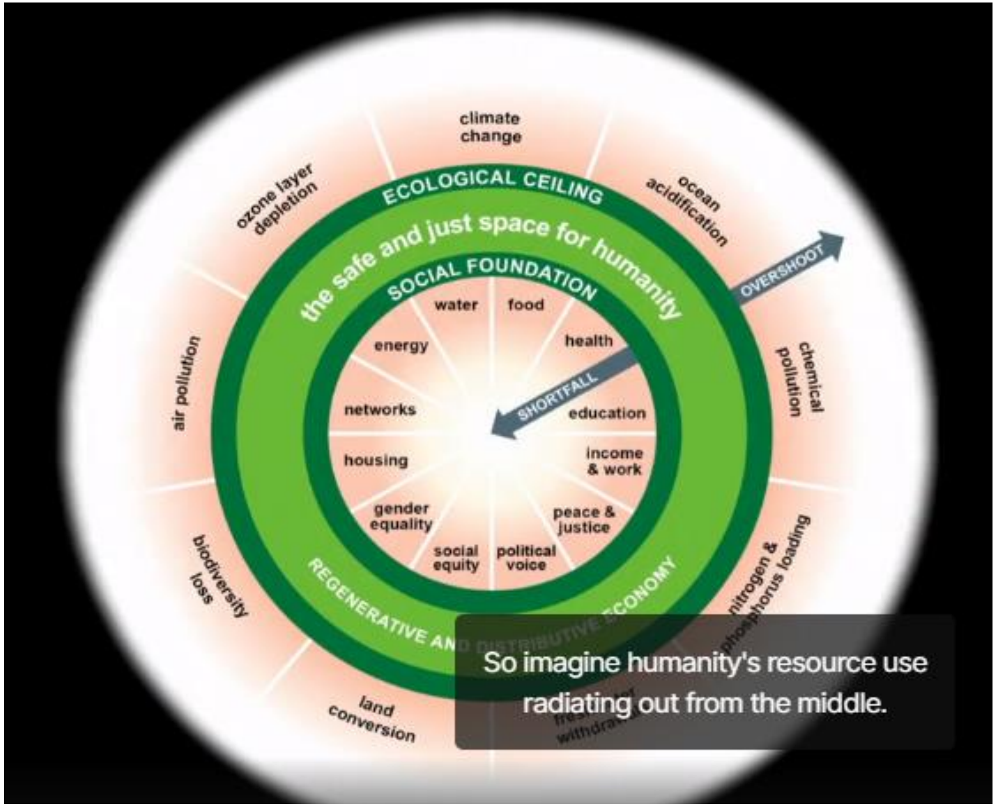
Increased desertification   Water Supply   Food Production   Mass migration

Extreme weather   Coastal Flooding   Coastal cities move inland

USE OF EARTHS RESOURCES

Current use of resources is about x3 sustainable limits

Producing climate change, pollution & loss of biodiversity



Better resource management using AI will help keep us below our sustainability limits

COLLECT & ANALYSE THE DATA

Satellite Image Analysis:
Satellite imagery tracks trends in deforestation, melting ice caps, changing land cover *Aqua, Aura, Terra, Copernicus, Sentinel*

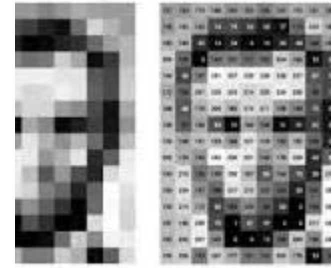
Land/Ocean Sensor Networks:
Analyse sensor data from oceans, forests, and urban environments to identify underlying trends & mechanisms

Analysis:
AI recognizes patterns in satellites & ground sensor data
Help understand climate change mechanisms
Improve planning & resource management

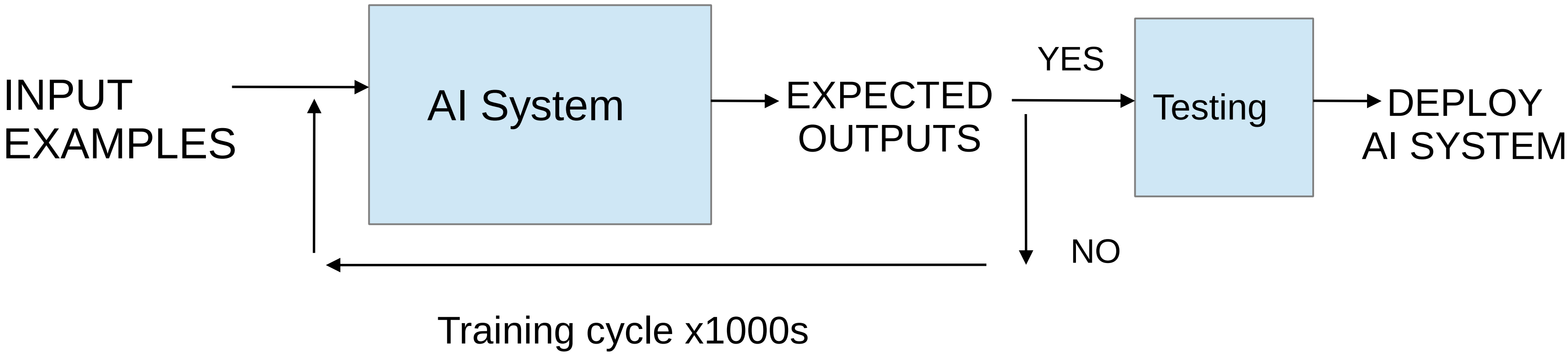
Monitor global seismic activity
The Global Seismographic Network is made up of over 150 seismic stations

Identify patterns giving early warnings of earthquakes

AI TRAINING



Train the AI on 1000's historical records (supervised learning)



Compare AI system outputs with expected outputs

Adjust the internal parameters algorithms/neural network to reduce the error

The trained working AI system can now make predictions from similar input data

Add software constrains to ensure the <u>AI systems receive clean data</u> & <u>solutions obey physical laws</u>

NOTE: Unsupervised learning is good for finding new patterns in the data

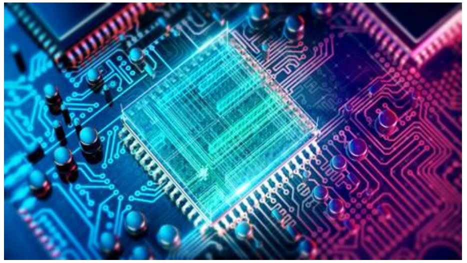
AI TECHNOLOGY IS GETTING FASTER

AI is getting better faster
AI capability increasing x2 every 2 years (Moors law)
In 10 years AI Capability x 30
In 20 years AI Capability x1000
In 30 years AI Capability x 10,000 (Quantum Computing)

AI uses algorithms and/or neural networks trained on 'Big Data'

AI algorithms are computer programmes that tell the system how to operate on its own & self improve

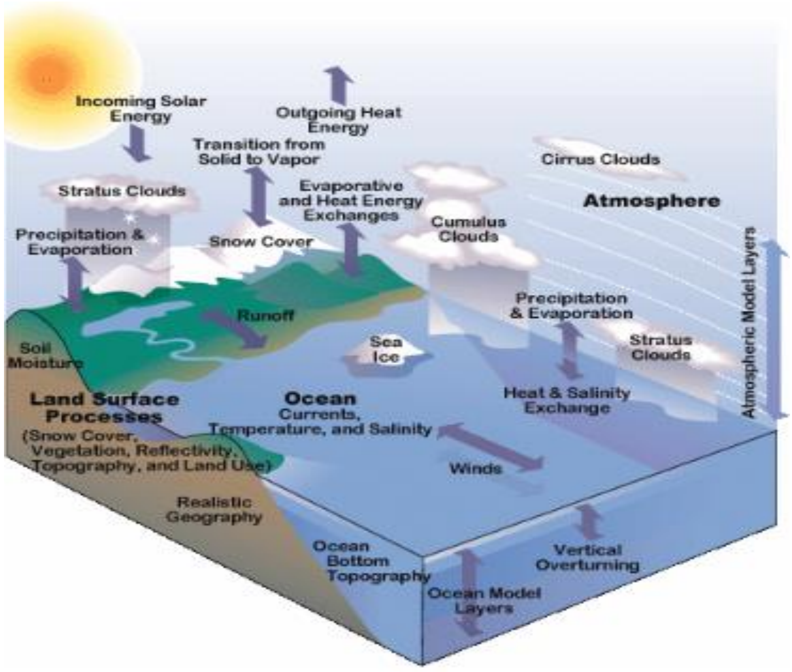
Neural networks build interconnections to perform a specific range of task & learn
Resembles the human brain



PREDICTING WEATHER & CLIMATE

Weather is short term atmospheric changes
Climate is long term trends

Both involve complex interactions between multiple systems



Predictions made by solving mathematical equations involving energy, ocean, atmosphere & land

This is slow & uses simplifying assumptions

SOLVING THE EQUATIONS

Numerical solution of complex equations on super computers

Basic Equations

Conservation of momentum:

$$\frac{\partial \vec{V}}{\partial t} = -(\vec{V} \bullet \nabla)\vec{V} - \frac{1}{\rho}\nabla p - \vec{g} - 2\vec{\Omega} \times \vec{V} + \nabla \bullet (k_m \nabla \vec{V}) - \vec{F}_d$$

Conservation of energy:

$$\rho c_v \frac{\partial T}{\partial t} = -\rho c_p (\vec{V} \bullet \nabla) T - \nabla \bullet \vec{R} + \nabla \bullet (k_T \nabla T) + C + S$$

Conservation of mass:

$$\frac{\partial \rho}{\partial t} = -(\vec{V} \bullet \nabla)\rho - \rho(\nabla \bullet \vec{V})$$

Conservation of H_2O (vapor, liquid, solid):

$$\frac{\partial q}{\partial t} = -(\vec{V} \bullet \nabla) q + \nabla \bullet (k_q \nabla q) + S_q + E$$

Equation of state:

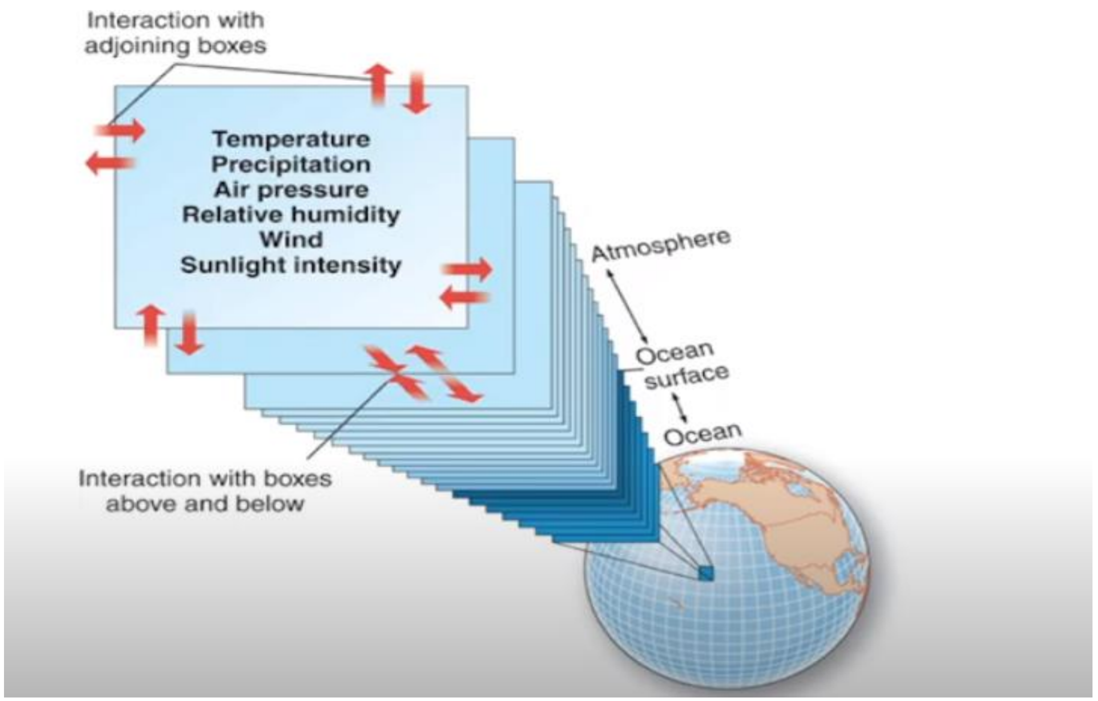
$$p = \rho R_d T$$

V = velocity
T = temperature
p = pressure
ρ = density
q = specific humidity
g = gravity
Ω = rotation of earth
F_d = drag force of earth
R = radiation vector
C = conductive heating
c_p = heat capacity, const. p
E = evaporation
S = latent heating
S_q = phase-change source
k = diffusion coefficients
R_d = dry air gas constant

It is slow and complex limiting the number of simulations possible

CLIMATE MODELLING METHOD

Divide the atmosphere into grid boxes extended vertically & horizontally



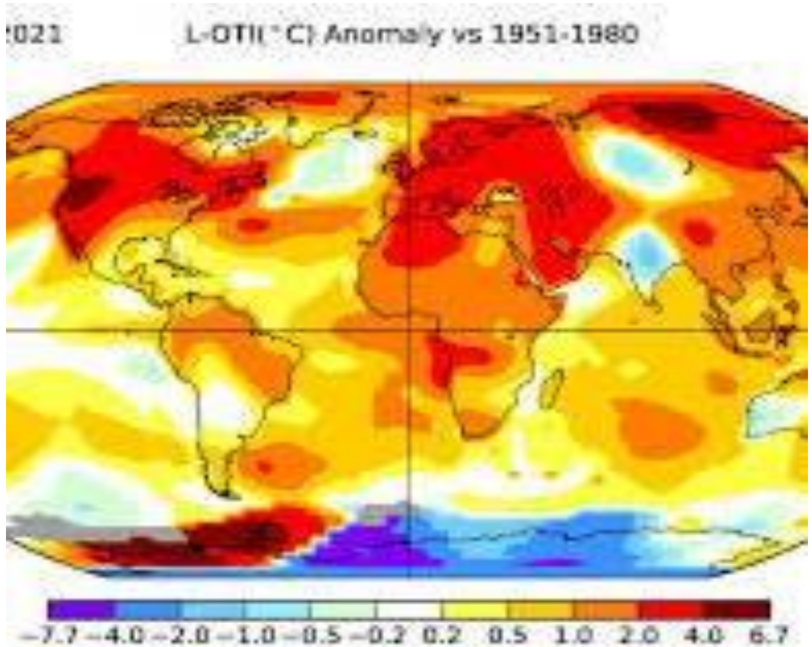
Apply the laws of physics

Compute the variables for each location

Analyse the results

USE OF AI SIMPLIFIES THE MODELS

AI enhanced models reduce computation time & produce faster forecasts



The models are trained on data from weather stations, satellites, and radar

AI algorithms/neural nets sift through the data and identifies the patterns

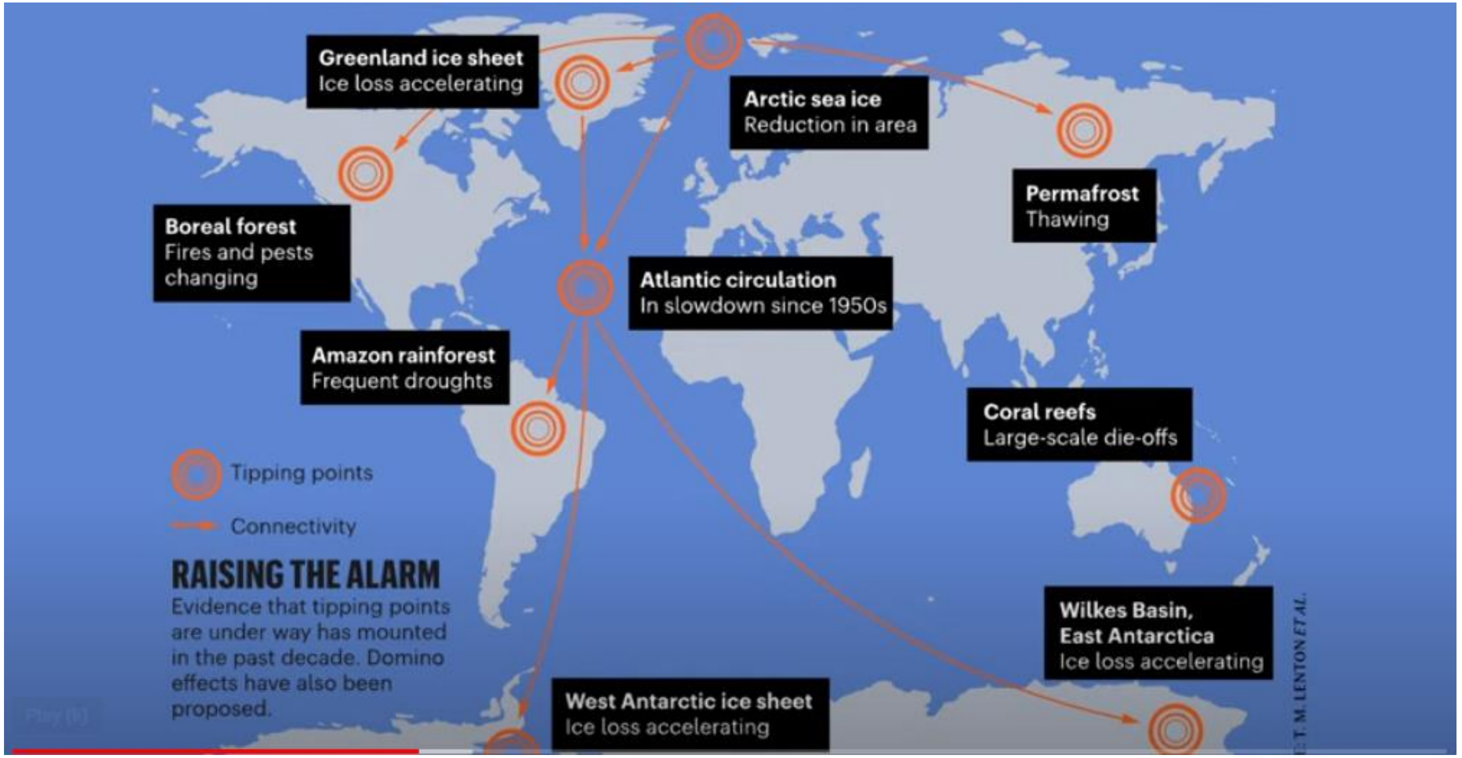
The patterns are used to produce forecasts much faster than traditional methods

Faster simulation times enables multiple scenarios to be explored improving accuracy

COMPLEX CLIMATE SYSTEMS

Warming the planet beyond a Tipping Point flips the climate into a new irreversible state

There are 16+ tipping points and 5 are already passed



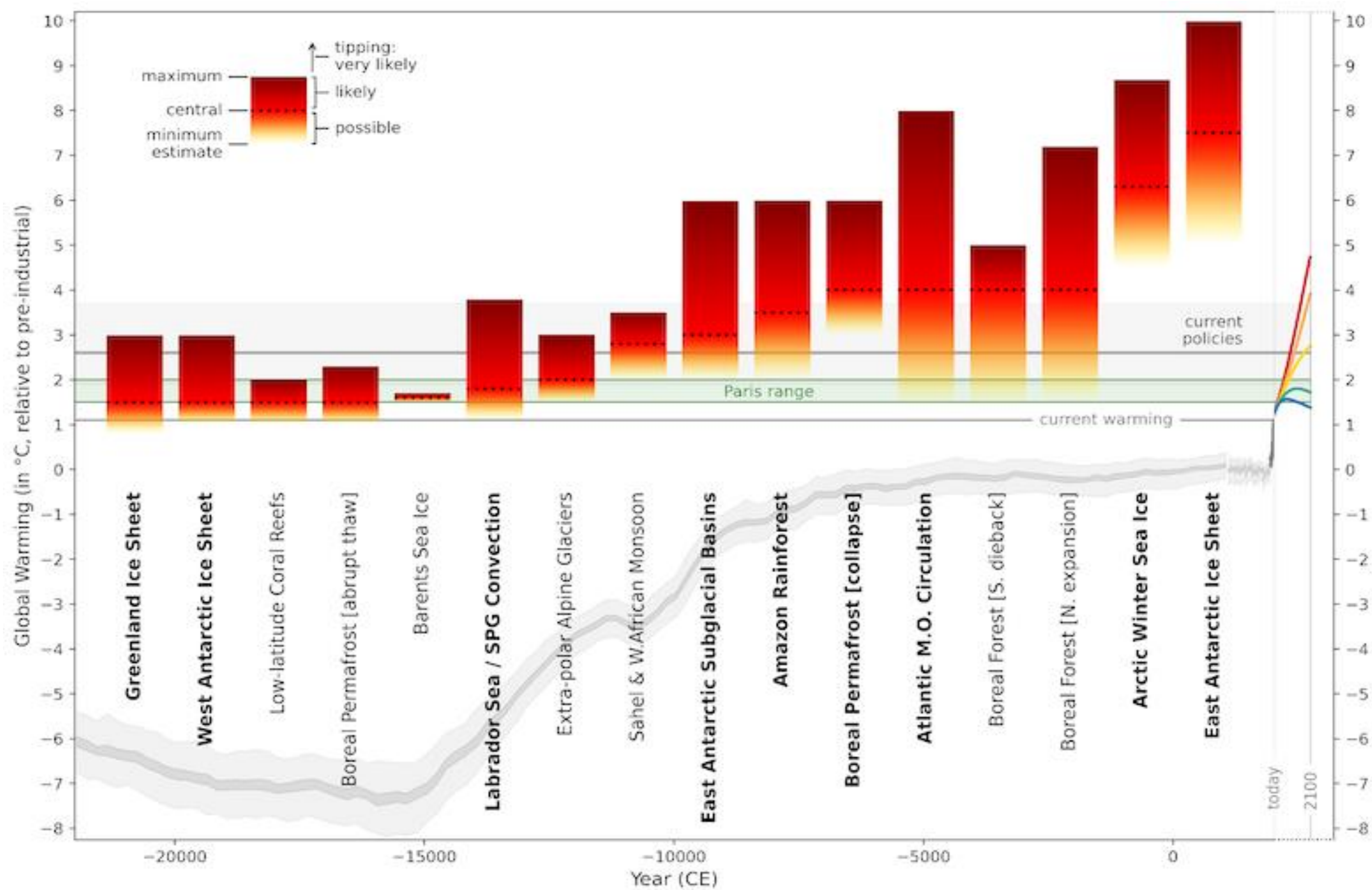
AI enhanced climate models help us understand tipping points

Predict when tipping points will be reached

CLIMATE TIPPING POINTS

16 Tipping Points

Temp
Rise



Human-caused warming of 1.3C means 4 tipping points already reached

Climate modelling indicates a 3C rise would trigger most of the remaining tipping points

THE MET OFFICE IS USING AI

The Met Office is actively using AI to improve its climate modelling.

Collaboration:
The Met Office has partnered with research institutions including *The Alan Turing Institute* to develop AI models for weather forecasting & understanding & predicting extreme weather events

New Techniques:
They're exploring the use of neural networks to analyse weather patterns and improve the accuracy of forecasts

Data Expertise:
The Met Office has a rich archive of meteorological data and expertise in weather science. This data is crucial for training and developing AI models for climate modelling.

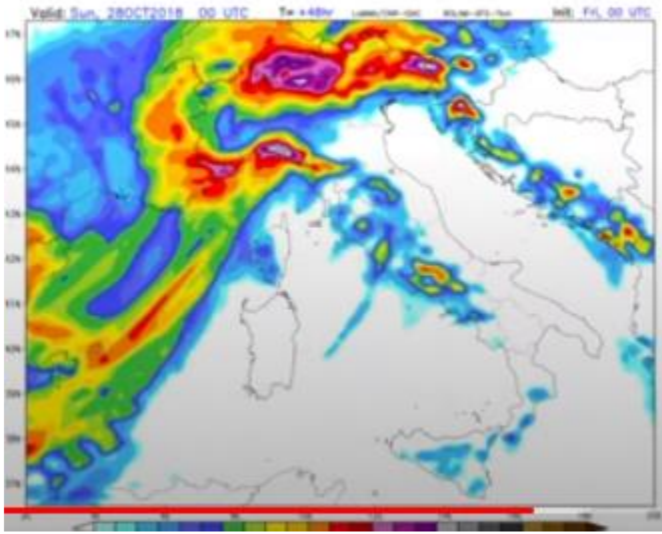
EXTREME EVENT MODELLING USING AI

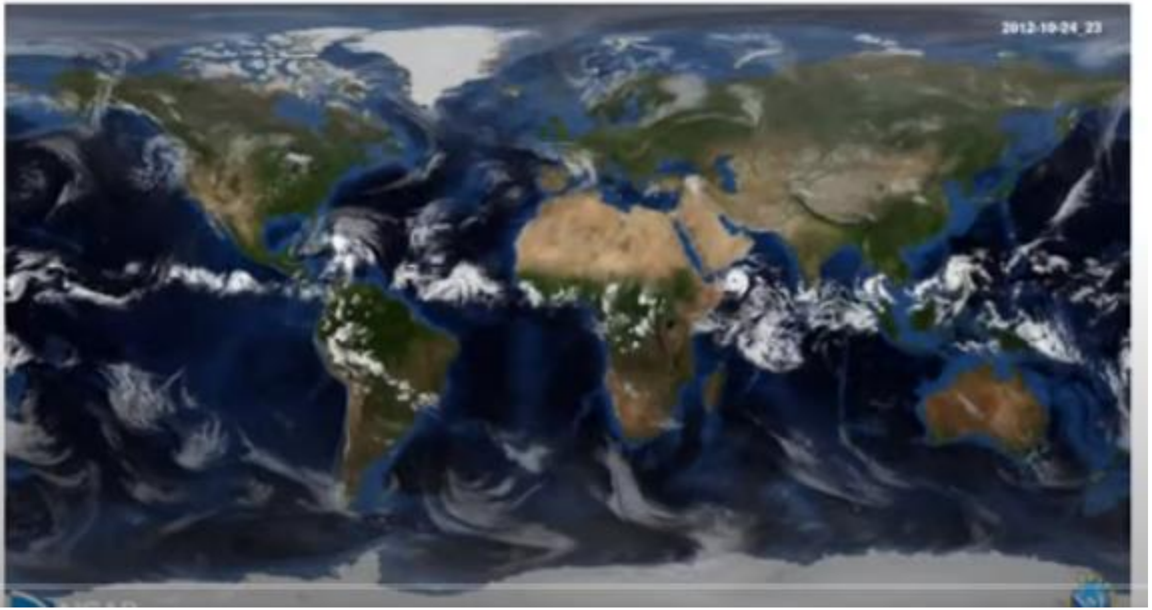
AI enhanced modelling enables faster & more accurate prediction of extreme climate events

What are the signs? When will they occur? How often will they occur?

How intense will they be? What is their extent?

AI finds patterns in the data & predicts the outcome





Google DeepMind AI tool predicted where hurricane Lee would make landfall in Canada three days ahead of existing methods

AI MODELLING TO OPTIMISE USE OF AGRICULTURAL LAND

AI enhanced modelling improves our understanding of the complex relationships between agriculture, land use & environment.

Helps develop sustainable agricultural practices & improved food security against climate change

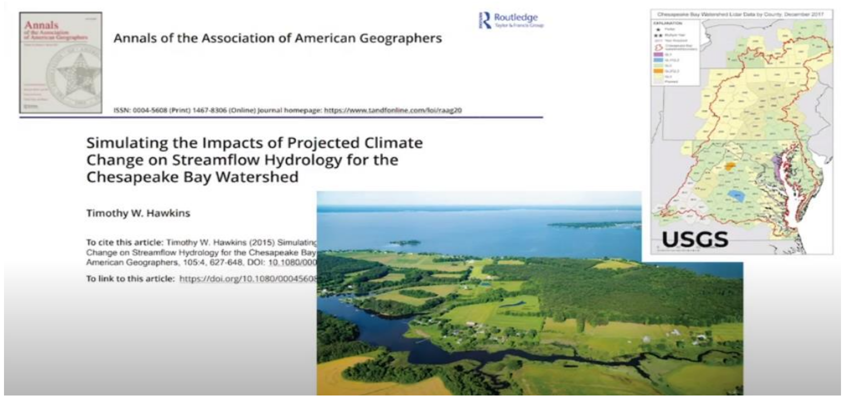
Optimize Crop Yields: Model agricultural practices, soil conditions & climate change to identify optimal planting times, irrigation levels & fertilization strategies

Predict Food Shortages: Analyse land degradation, extreme weather events, pest outbreaks & supply chains & enable proactive interventions

Reduce Greenhouse Gas Emissions: Evaluate the carbon footprint of different agricultural practices and identify strategies for reducing emissions

AI MODELLING OF WATER SUPPLY, ENVIRONMENT & INFRASTRUCTURE - Impact of climate change

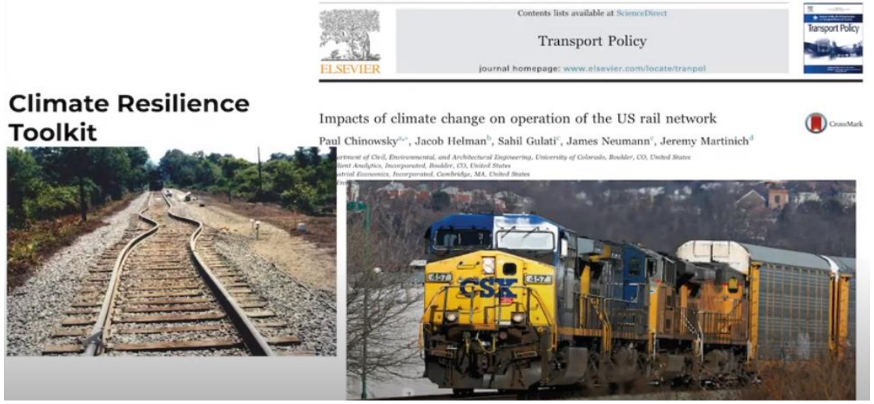
Impact on Water Supply



Impact On Agriculture

Impact On Environment

Impact On Infrastructure

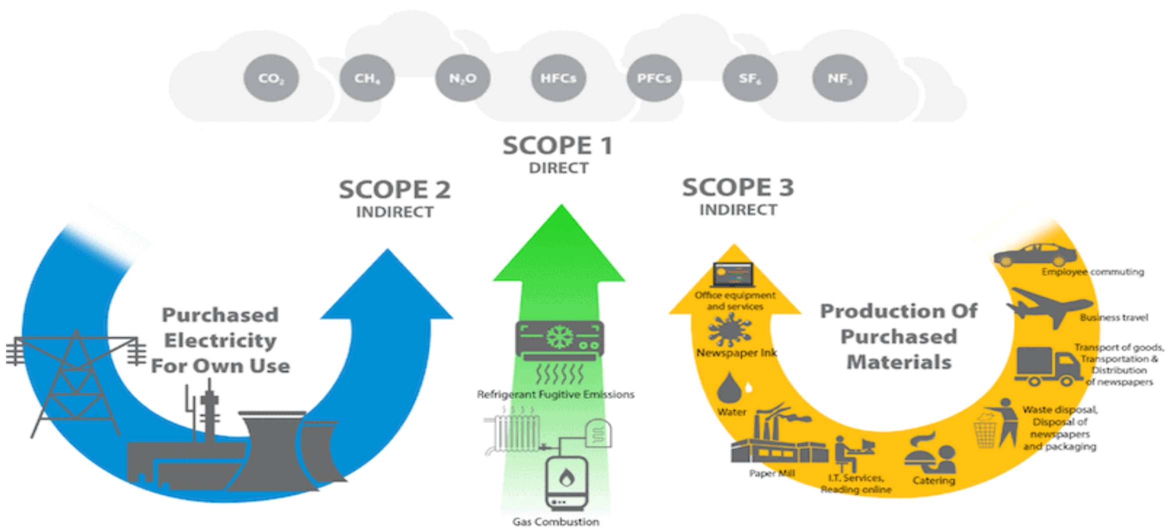


REDUCING EMISSIONS USING AI

Type 1 Direct emissions from sources that are owned or controlled by an organization

Type 2 Indirect emissions associated with the purchase of electricity, heat, or cooling

Type 3 Indirect emissions along the entire value chain of a company's operations

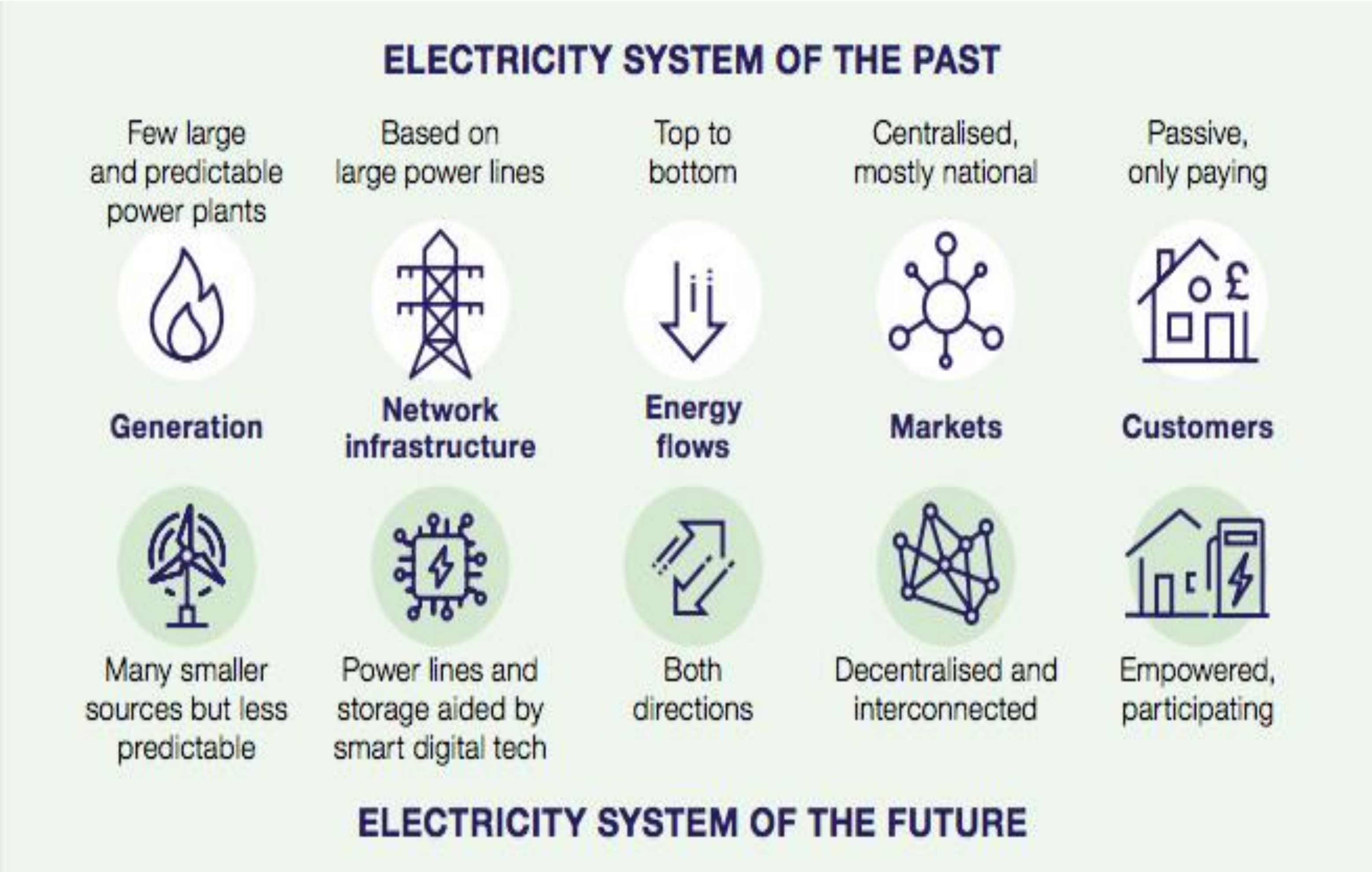


By understanding all 3 types of emissions governments & companies can develop strategies to reduce their overall environmental impact

AI can analyse the data, optimize & improve the solutions over time

AI CONTROLLED ENERGY NETWORK

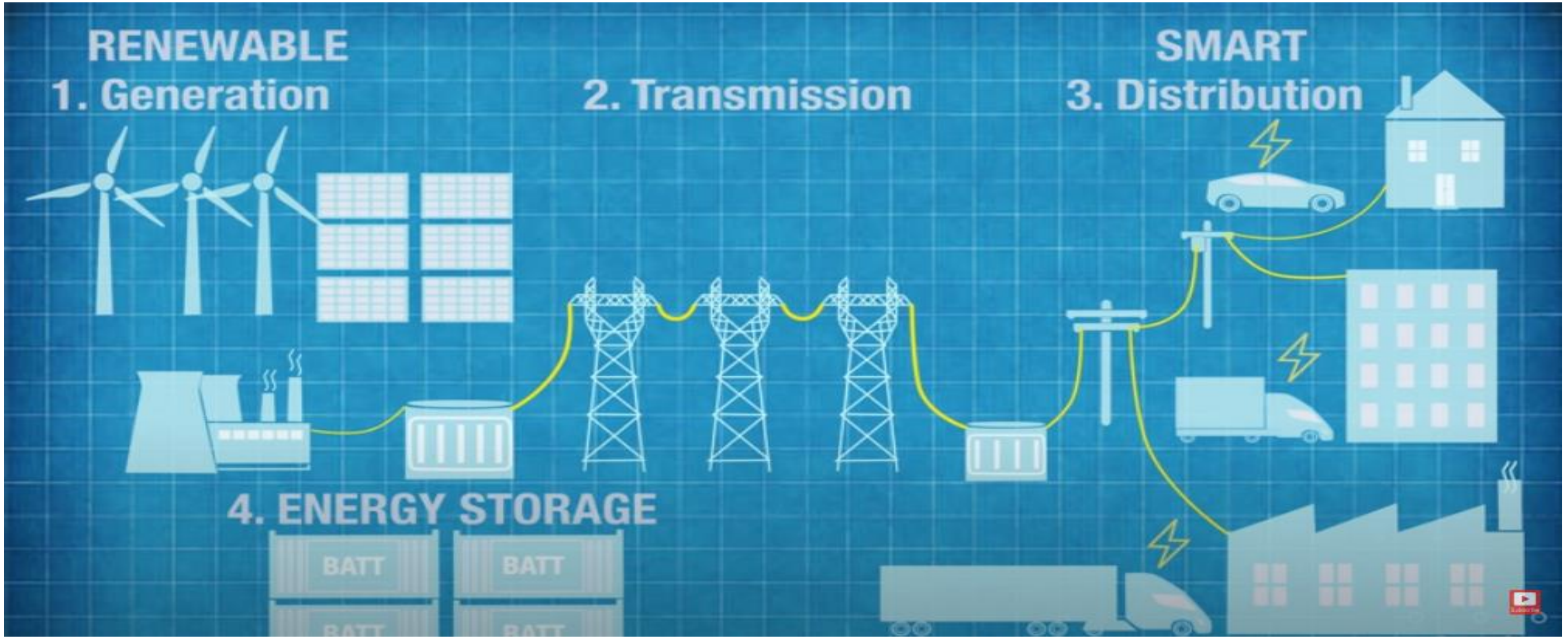
Optimise Use Of Energy Resources & Reduce Emissions



Upgrade cost >£50 billion

AI ENHANCED ENERGY NETWORK

Smart energy distribution & storage



Multiple energy sources
Organic growth

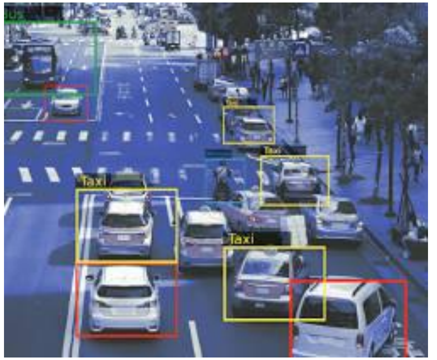
Energy storage
Bi-directional flow

Decentralised control
Resilience

AI analysis of real-time energy demand & forecasting

AI balanced power grids to optimize use of renewable energy

AI ENHANCED TRANSPORT NETWORK



Traffic Management Systems:
AI algorithms analyse traffic patterns and optimize traffic flow,
Reduce congestion, fuel consumption & emissions

Self Drive vehicles:
AI plan routes on passenger request
AI uses radar & laser sensors to avoid obstacles
AI vehicles learn & pool experiences
AI control systems updated remotely

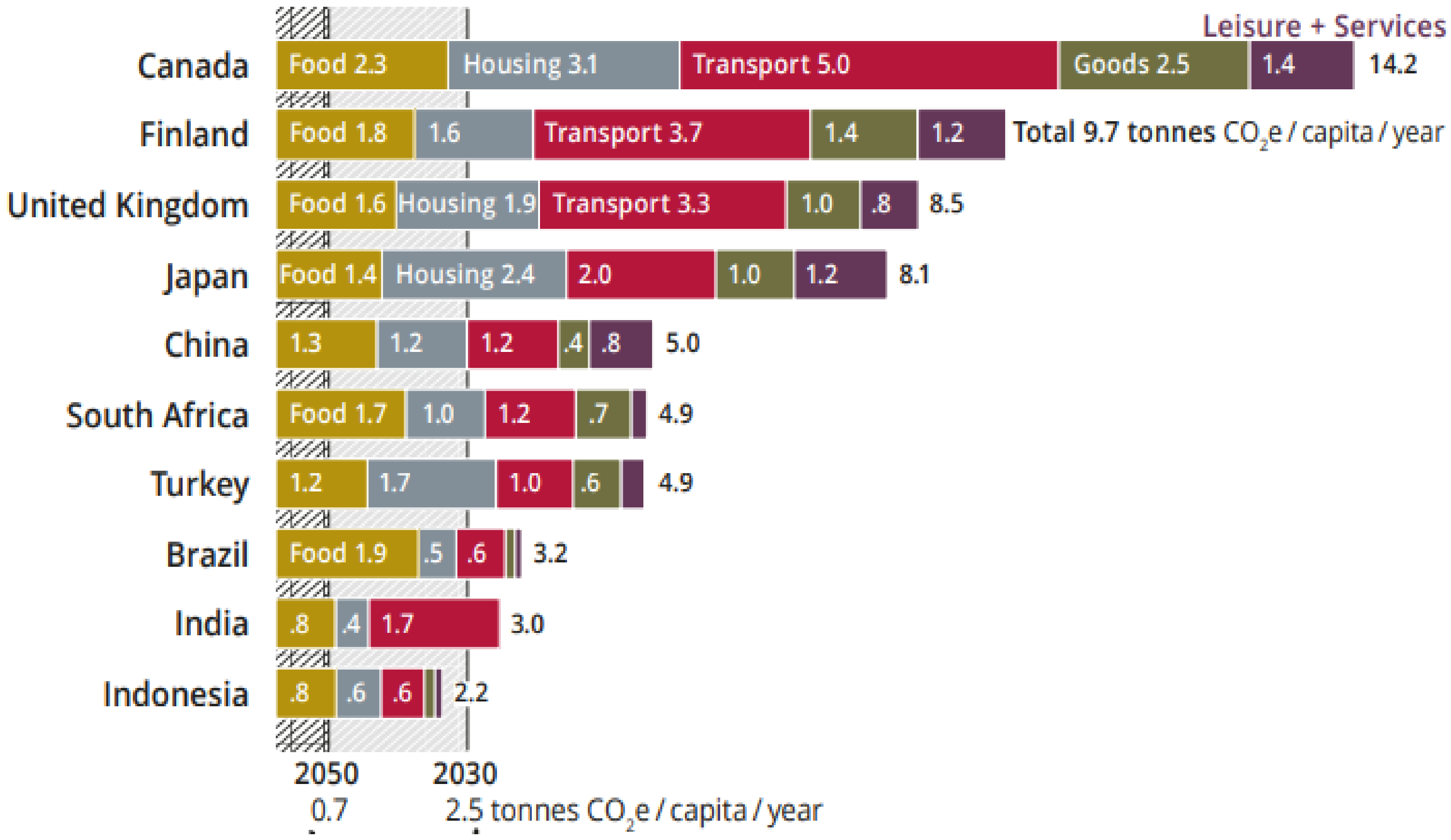
Challenges:
Comms Infrastructure
Road & weather conditions
Minor road comms
New situations
Accident liability

Benefits:
Reduced accidents
Zero driving skill required
Mobility for all
Real time vehicle monitoring of road surfaces

INDIVIDUAL CARBON FOOTPRINT

CO2e/capita/year

Average annual carbon footprint tonnes CO2e per year by sector

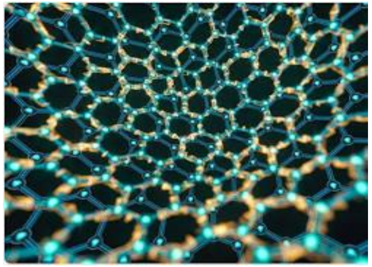


Target 3 tonnes by 2030 & 0.7 tonnes by 2050

Embedded AI in systems helps reduce emissions

AI & GREEN TECHNOLOGIES

Material Science
AI can predict the properties of new materials, reducing the need for physical testing and enabling faster development.
AI can streamline manufacturing processes to minimize waste and energy consumption

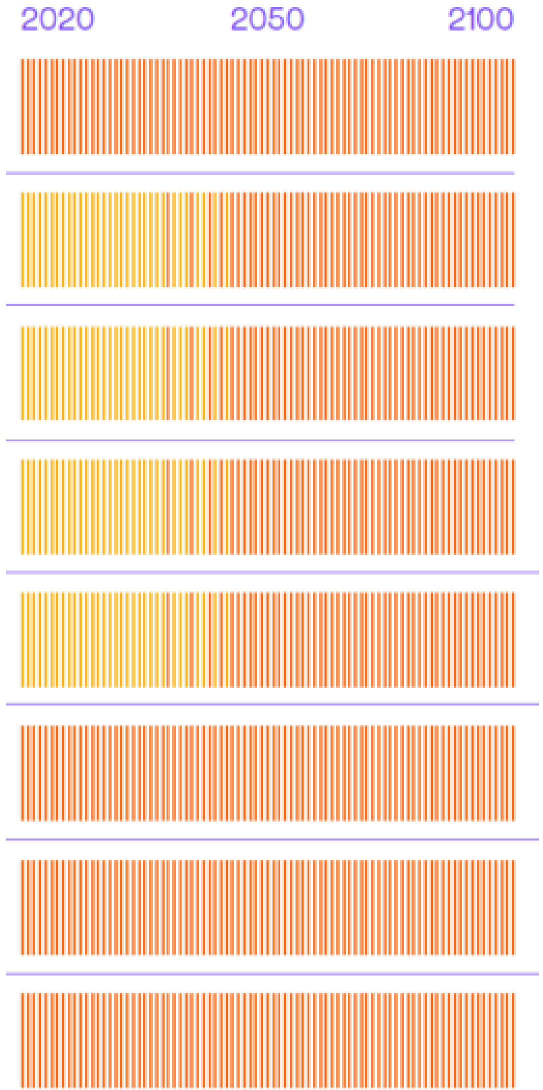


Regenerative Agriculture
AI to optimise use of energy, water & natural fertiliser
Maintain cover crop to keep carbon & moisture in the ground
AI analysis of images & sensor data to identify crop diseases & pests,
Enable targeted interventions reducing reliance on harmful pesticides.

Smart Homes
Reduction of household waste and automated recycling
Robotic sensing & cleaning
Solar panel maintenance
Intelligent fridge communicates with the delivery van
Security using facial recognition
Optimize heating, lighting, and cooling systems, minimizing energy consumption

ADAPTING TO CLIMATE CHANGE

AI will help us use our resources more effectively in a hotter climate



Top 8 Risks	Impact
Risks to diversity of land & freshwater habitats	Continued decline in animal & plant biodiversity
Risks to soil health from flooding & drought	**Pressure on agriculture especially in SE England**
Risks to natural carbon stores bogs & forests	Essential to achieve Net Zero
Risk to crops & live stock due to frequent drought	**Reduced food supply & Increased prices**
Risks to industry supply chains	Increased cost of goods & services
Risk to power supply due to more extreme weather	**Power outages**
Risks to human health due to overheating	**x3 heat related deaths by 2050 2,000 to 7,000 each year**
Risk to imports	**Supply of overseas goods become less reliable**

FIXING THE CLIMATE?

Having trashed the Earths atmosphere we may wish to fix it!

Excess carbon dioxide remains in the atmosphere for thousands years

Geoengineering is the deliberate large-scale intervention in the Earth's natural systems

The two principle geoengineering methods are <u>massive CO2 removal</u> & <u>reflection of solar energy back into space</u>

AI enhanced modelling enables <u>benefits & risks</u> of geoengineering interventions to be assessed

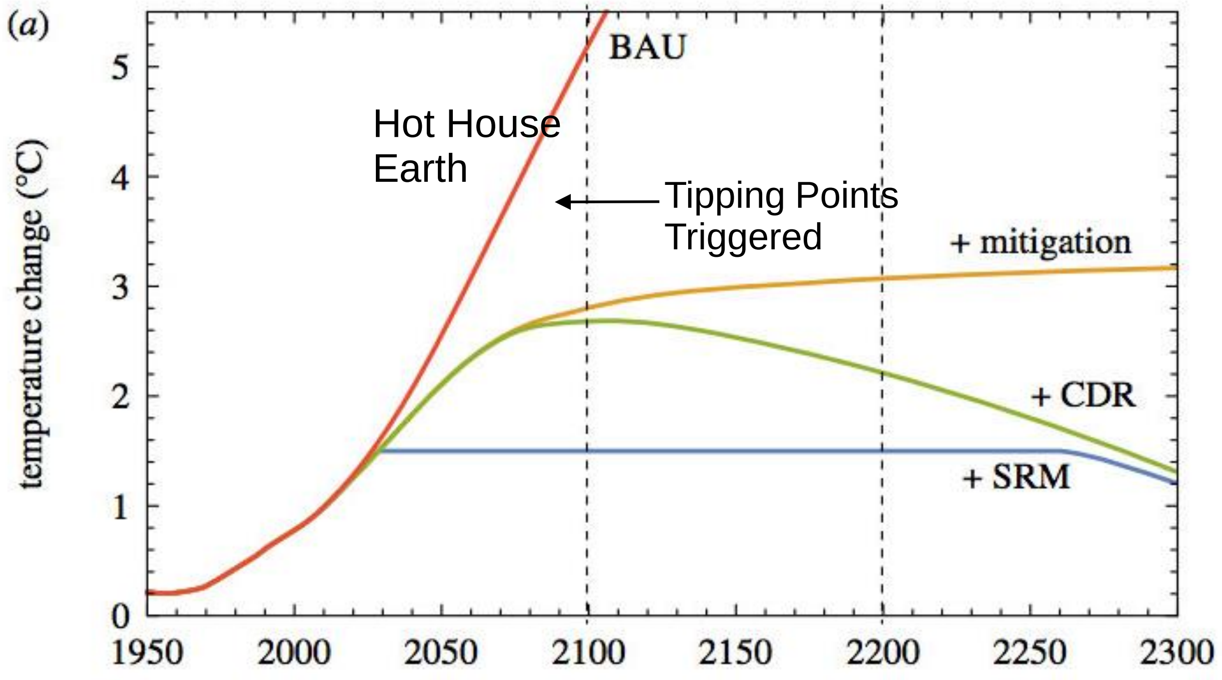
Understand how these techniques should be applied

Geoengineering research has expanded significantly over the past 5 years
The White House has began a five-year research programme into “climate interventions”

BENEFITS OF GEOENGINEERING THE CLIMATE

AI enables analysis of climate geoengineering solutions typically CDR and SRM

CDR= Carbon Dioxide Removal   SRM= Solar Radiation Management

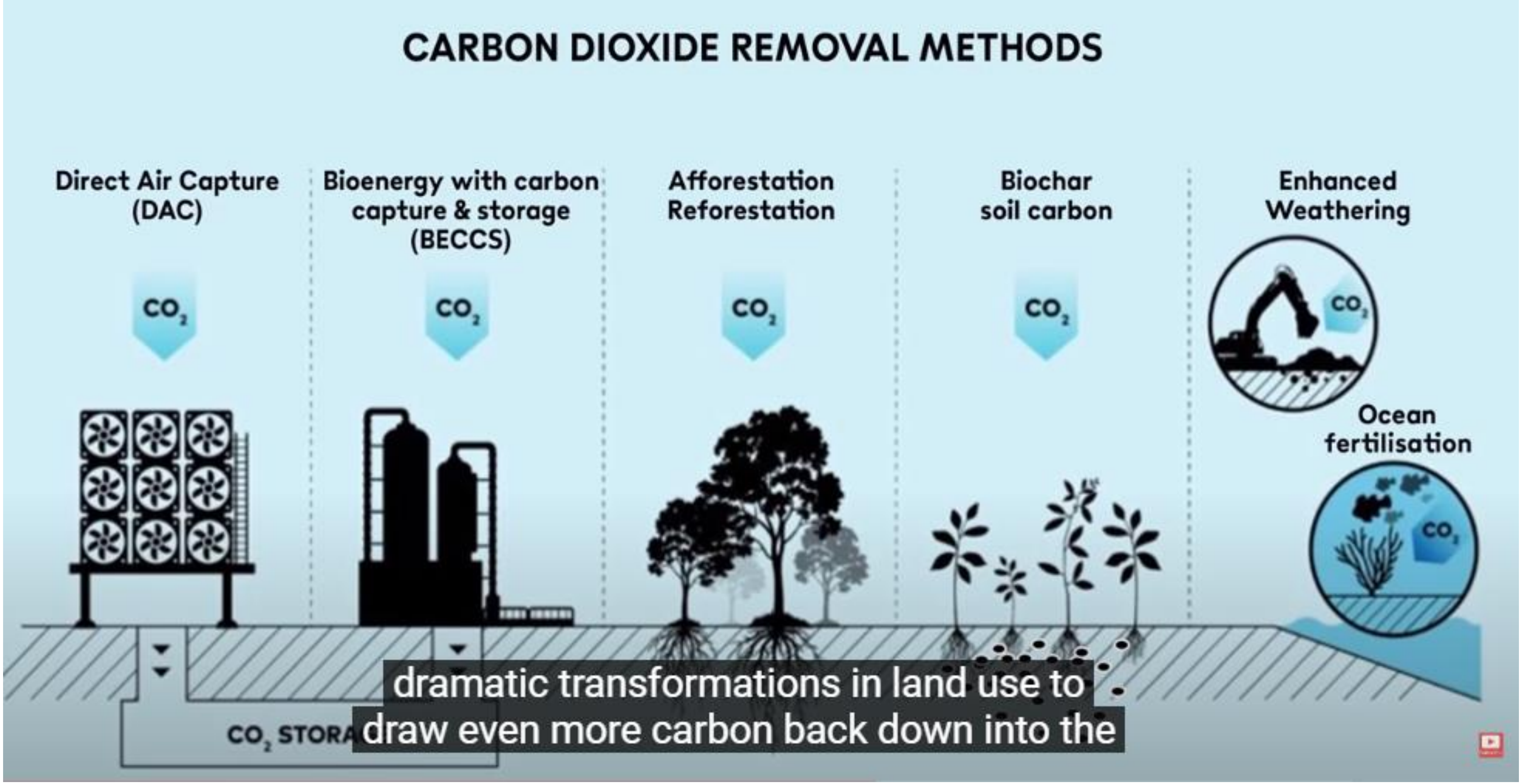


The issue is <u>scalability</u> and <u>unexpected consequences</u>

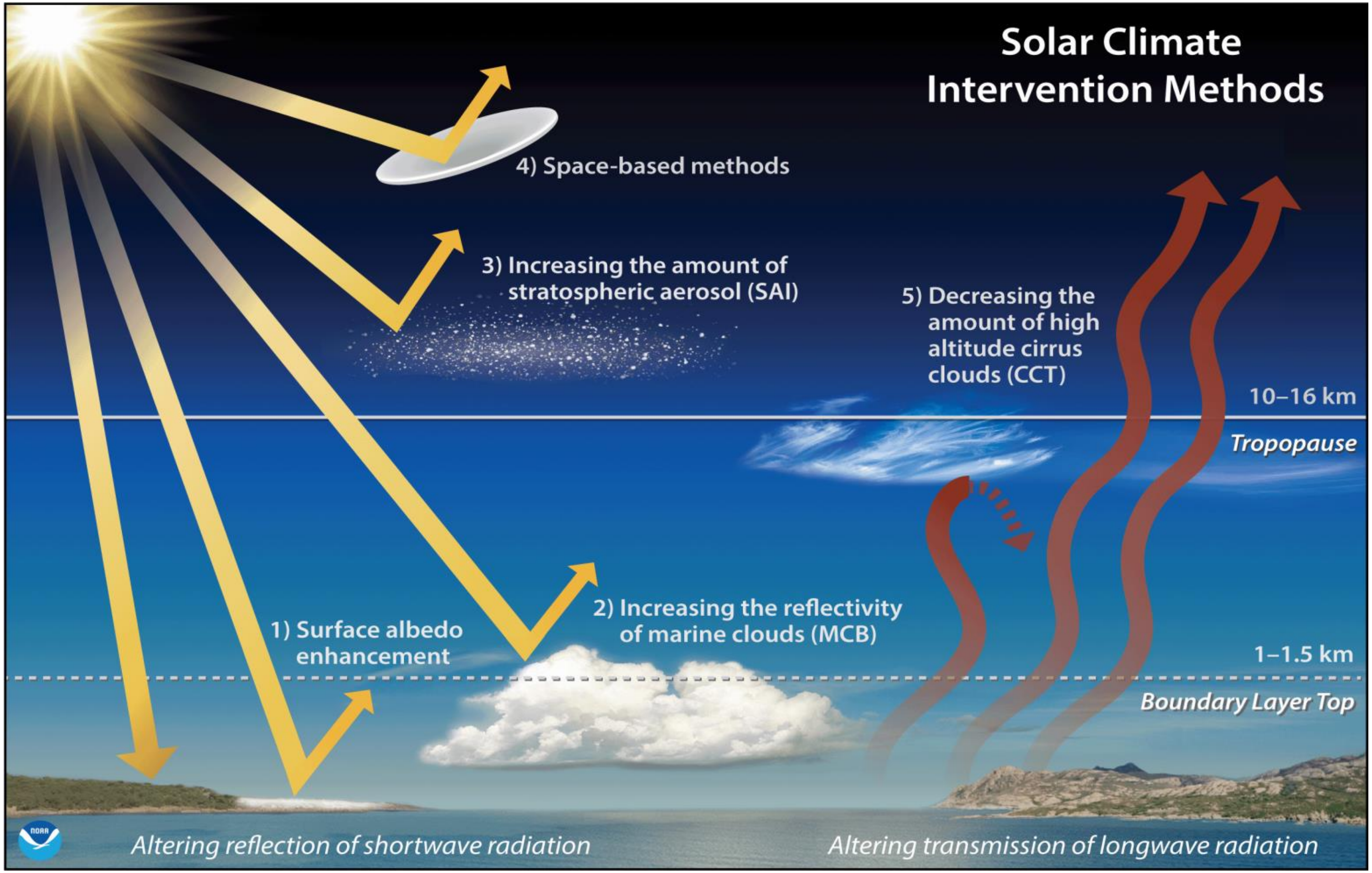
AI analytic methods allow exploration & evaluation of climate fixing scenarios

MASSIVE DEPLOYMENT OF CARBON CAPTURE TECHNOLOGY

x1million



SOLAR RADIATION MANAGEMENT



AI enhanced modelling to evaluate the effectiveness of different SRM methods

Explore the risks of SRM on weather patterns & climate (unexpected consequences)

SUMMARY
AI & Climate Change

AI helps us:
Collect & analyse complex climate data
Predict future climate change
Assess methods to mitigate & adapt to climate change
Develop new green technologies

Remember
AI has no understanding - it sees only the data
Erroneous data needs to be filtered

AI comes with its own climate challenges
AI is being used to accelerate oil and gas exploration and extraction
AI power demand increasing carbon footprint 2-3% emissions
Training AI systems needs large quantities of good data (expensive)
But worthwhile!