# The science of the UK Climate Projections

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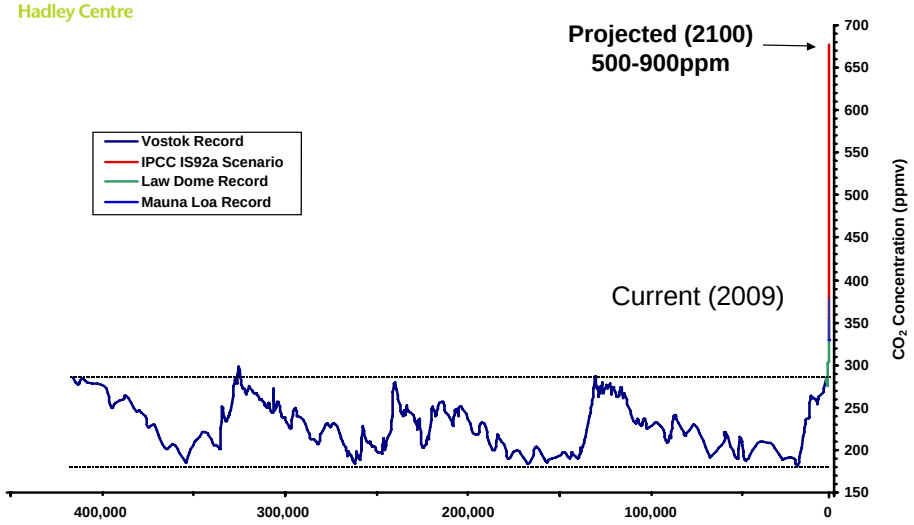
# Basic Science

-what every good sceptic ought to know

## Current (and projected future) CO2 concentrations exceed those of the last 400,000yrs. Not like a natural cycle?



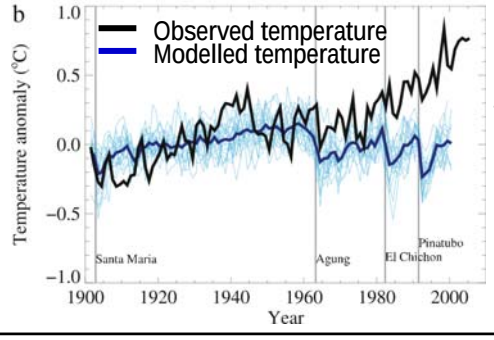



## Physics of greenhouse effect

### Change in temperature ($^0$C) for doubled carbon dioxide

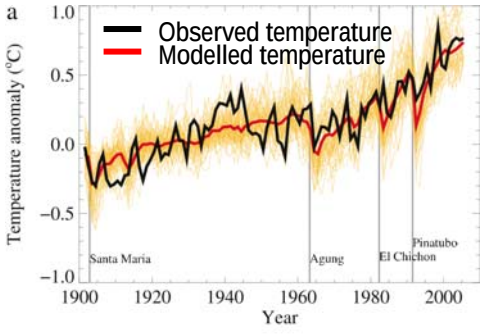
| | | |
|---|---|---|
| • Temperature only | 1.0 | School physics |
| • Water vapour | 2.0 | Empirical, model, and analogue evidence |
| • Sea-ice, snow, clouds feedbacks | 1.5 – 5.5 | Uncertainties due to modelling |

# Is the observed change natural?

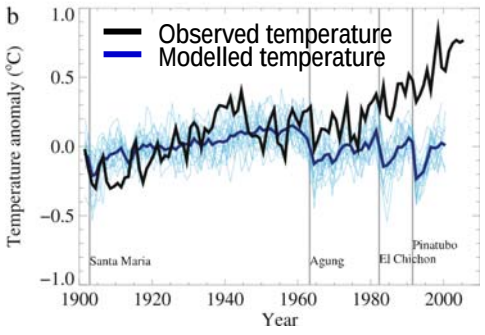



modelled temperature: natural forcing only






modelled temperature: natural plus human forcing




modelled temperature: natural forcing only

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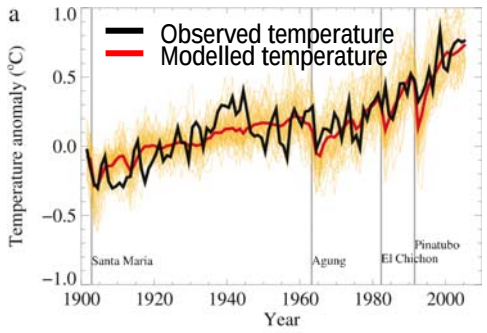
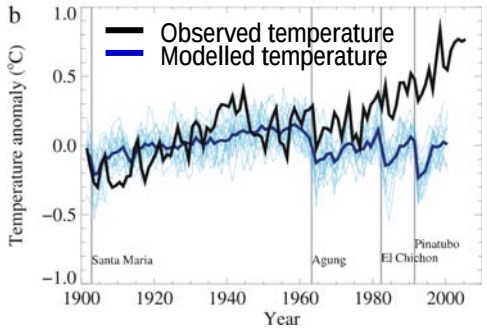
Need human effects to explain the obs record




modelled temperature: natural plus human forcing




modelled temperature: natural forcing only



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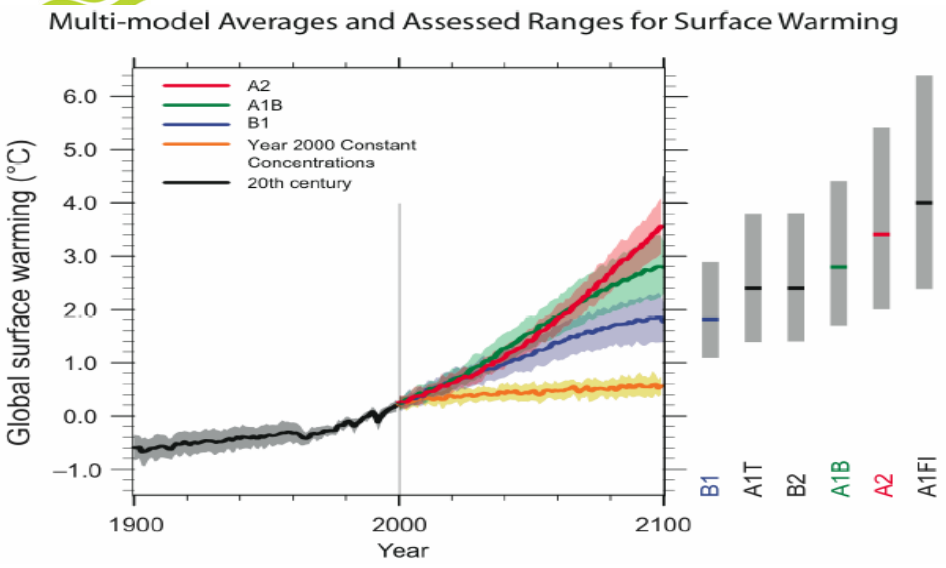
# Global modelling

# Projections and uncertainties (1)




**IPCC 4th assessment, 2007**



# Projections and uncertainties (2)

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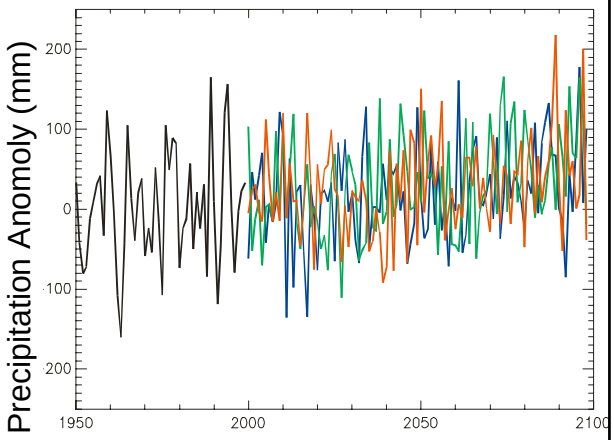
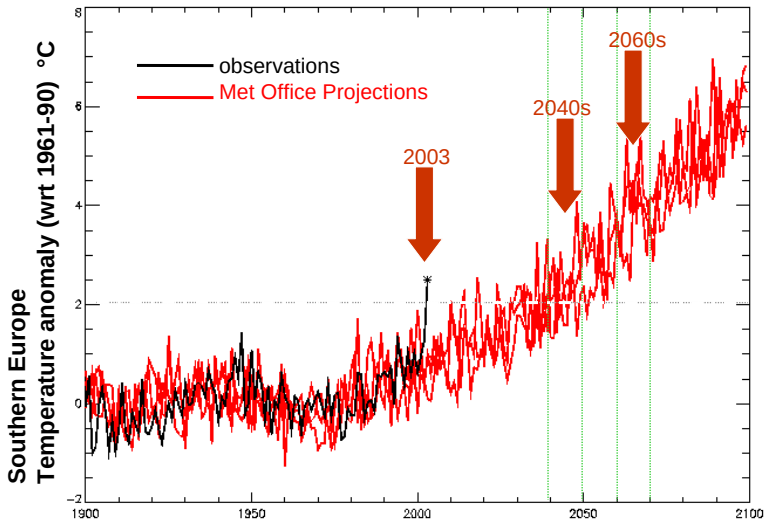
- **Natural variability**

  Chaotic variations in circulation and long term cycles such as El Nino




England &Wales Precipitation

# Adaptation – even 2C is not trivial

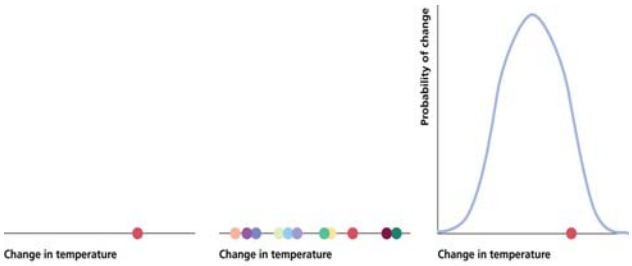





# Regional climate change and probabilistic predictions

# -UKCP09

# Moving from uncertainty to probability




UKCIP02 gave a single estimate of changes

Using many models in IPCC AR4 gave a range of estimated changes

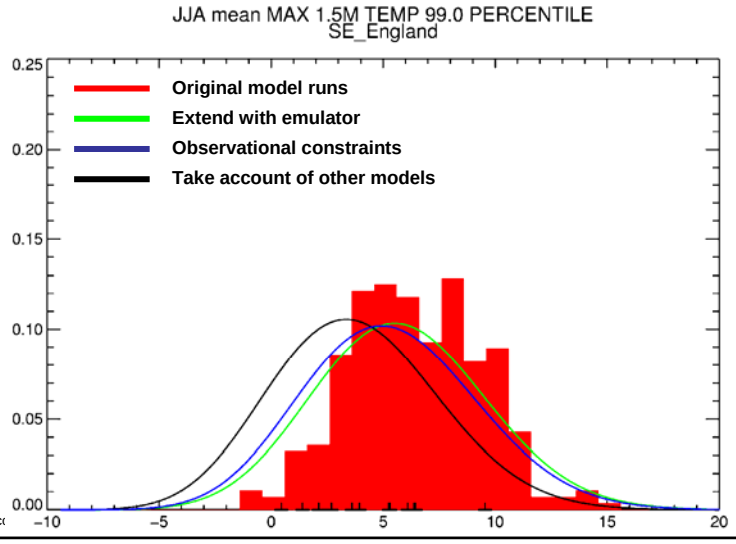
UKCP09 uses over 400 model projections to give the probability of estimated changes



# From frequency to probabilities

- Run climate model with several hundred variations of the models parameters
- Systematically cover parameter space using a statistical emulator
- Weight according to climate constraints
- Allow for differences with other climate models (IPCC AR4)

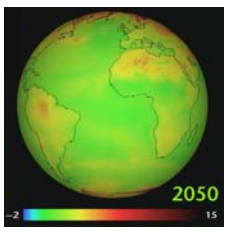
# From frequency to probabilities

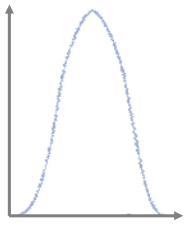




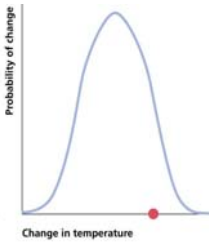

# Moving from a global to a regional scale

400 global climate projections



11 regional climate projections



# Generating regional information

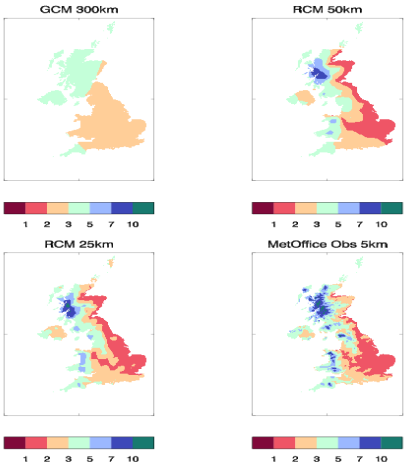
- High resolution regional projections account for the effects of coastlines, mountains, and other regional influences

300km Global Model

50km Regional Model

25km Regional Model

5km Observed

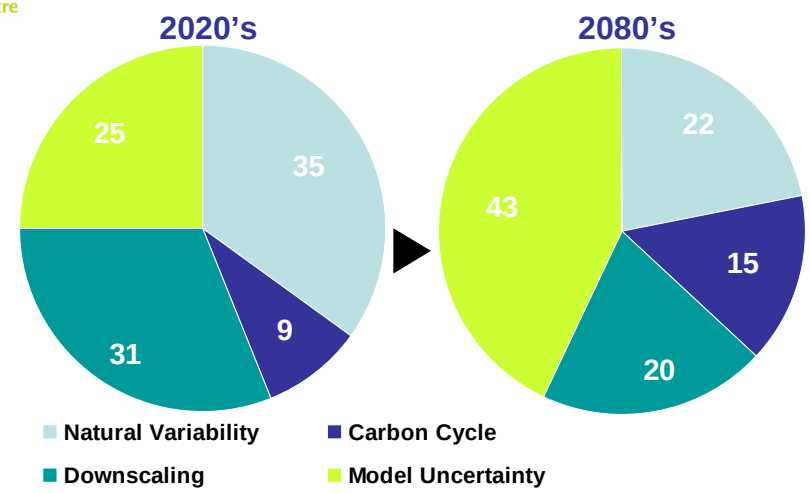



Winter precipitation for 1961-2000, mm/day



# Contributions to uncertainty

(Winter rainfall in south east England)



# Giving probabilities

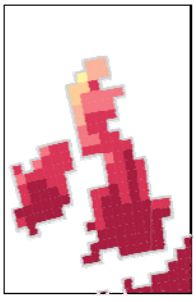
- UKCP09 provides probabilities which measure how strongly different outcomes for climate change **are supported by current evidence** (models, observations, understanding)
- We can make statements like “The central estimate is X, it is very likely to be higher than Y, and very likely to be lower than Z.”



# More confident projections

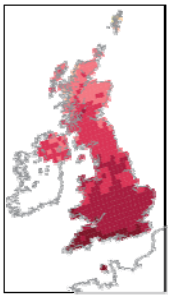
UKCIP02

Single projection

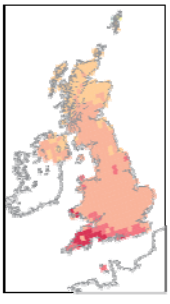


UKCP09

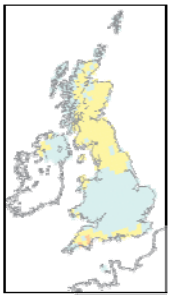
Very unlikely to be less than (10%)

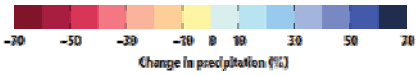


Central estimate (50%)



Very unlikely to be more than (90%)





# Climate over Eastern Scotland

## 2050s Medium Emissions

| | 0% | 50% | 90% |
|---|---|---|---|
| Winter temperature | 0.7 | 1.7 | 2.9 |
| Summer temperature | 1.1 | 2.4 | 3.8 |
| Winter precipitation (%) | 2 | 10 | 20 |
| Summer precipitation (%) | -26 | -12 | 1 |

5.0



# Sea Level

- The sea level in Edinburgh is expected to rise:

13.9 cm by 2050

24.4 cm by 2080

30.5 cm by 2095

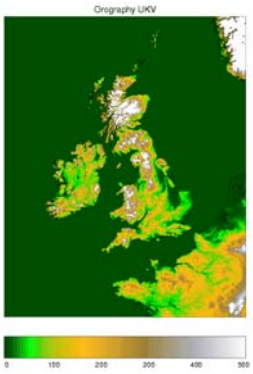

Central estimates based on 1961-1990 baseline, medium emissions scenario

# A long-term vision for future UKCPs

Integrated weather and climate prediction for estimating hazards and risk:

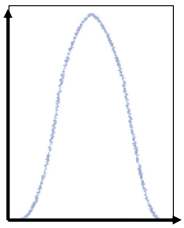
N x Global predictions at ~20km with lead times of days to years:

**Synoptic drivers**




<N x Regional predictions at ~1km:

**Local meteorology**



PDF of local hazard:

**Impacts**



# Summary

- Climate is changing due to increases in greenhouse gases, and will continue to change
- There are a number of sources of uncertainty in climate predictions including natural variability, future emissions and limitations in modelling climate.
- Predictions at a regional scale are less certain that global scale- hence the need for a probabilistic approach
- UKCP09 accounts for major known sources of uncertainty in future projections, apart from common model errors

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# Questions and answers



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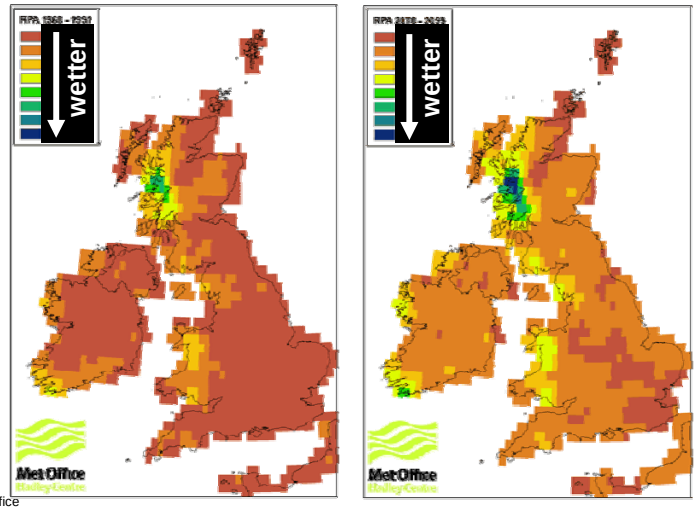
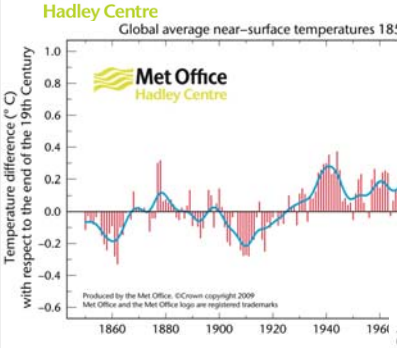
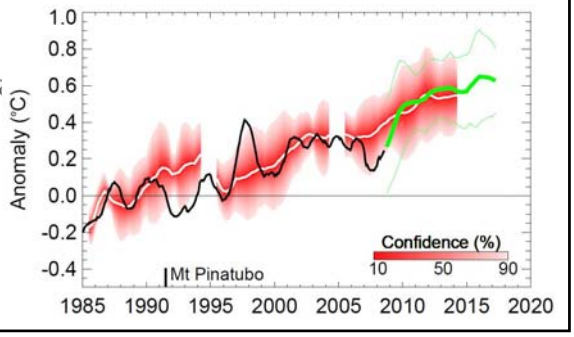
# How extreme weather will change



# Has global warming gone away?



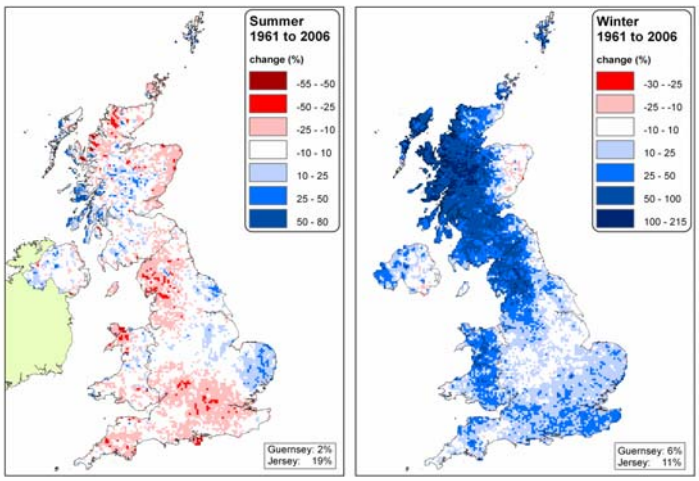

Since 1998, the warmest year on record, observations have shown a levelling off of the warming signal.



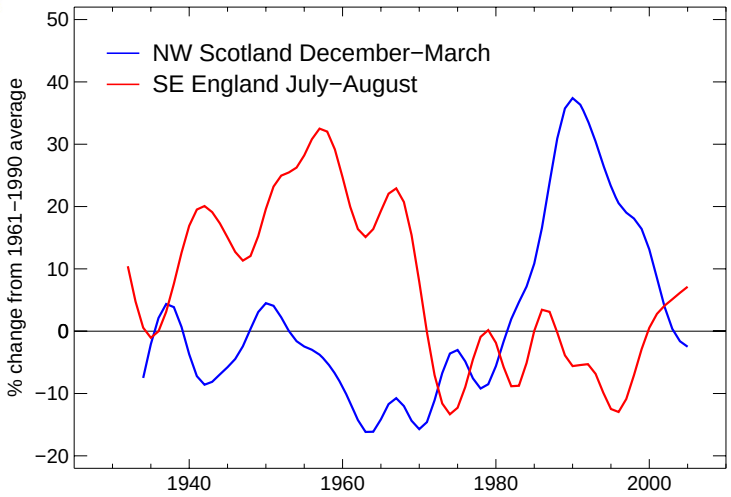

Latest decadal prediction shows that global warming will reassert itself. Beyond 2010 at least half the years are expected to be warmer than 1998.



# Change in winter and summer precipitation 1961–2006



# Not all change is human induced






# UK climate change +0.7°C now

2008 More than doubled risk of heat waves

2050 Glasgow - average increase 1.6ºC

Glasgow - hottest day increase 2.3 ºC

## By the 2050s…

| | | |
|---|---|---|
| + 2.3ºC | + 2.0ºC | + 2.4ºC |
| + 1.7ºC | + 1.7ºC | + 1.9ºC |
| - 12% | - 10% | - 12% |
| + 10% | + 13% | + 15% |

## By the 2080s…

| | | |
|---|---|---|
| + 3.5ºC | + 3.0ºC | + 3.5ºC |
| + 2.3ºC | + 2.2ºC | + 2.6ºC |
| - 16% | - 11% | - 15% |
| + 12% | + 17% | + 21% |

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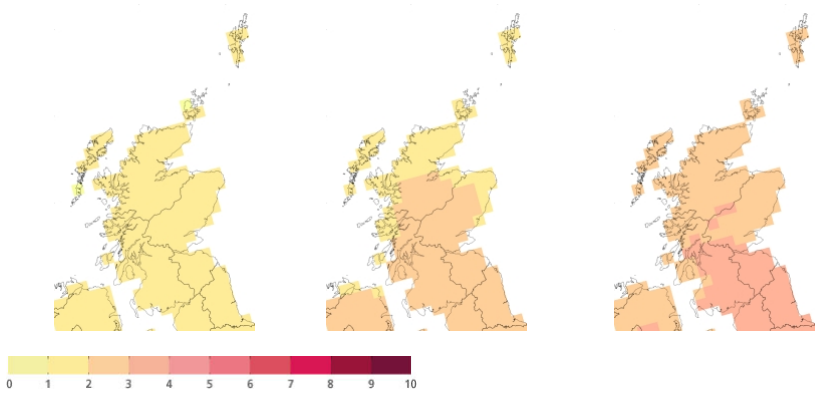
# Information is available as maps

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# Users can compare different emissions scenarios