



# Climate science, data and projections

Dr. Richard Jones

Science Fellow, Climate Information: Met Office Hadley Centre

Visiting Professor, School of Geography and Environment,  
University of Oxford



# Fundamentals of Climate Change Science

The effect of greenhouse gases and the warming potential of the enhanced greenhouse effect

Observed global and regional warming and demonstrating this is attributable to human activities

Global and regional temperatures and sea-level will continue to change – current and future climate will not be the same as in the past



# The greenhouse effect and its role in climate change

Solar radiation powers the climate system.



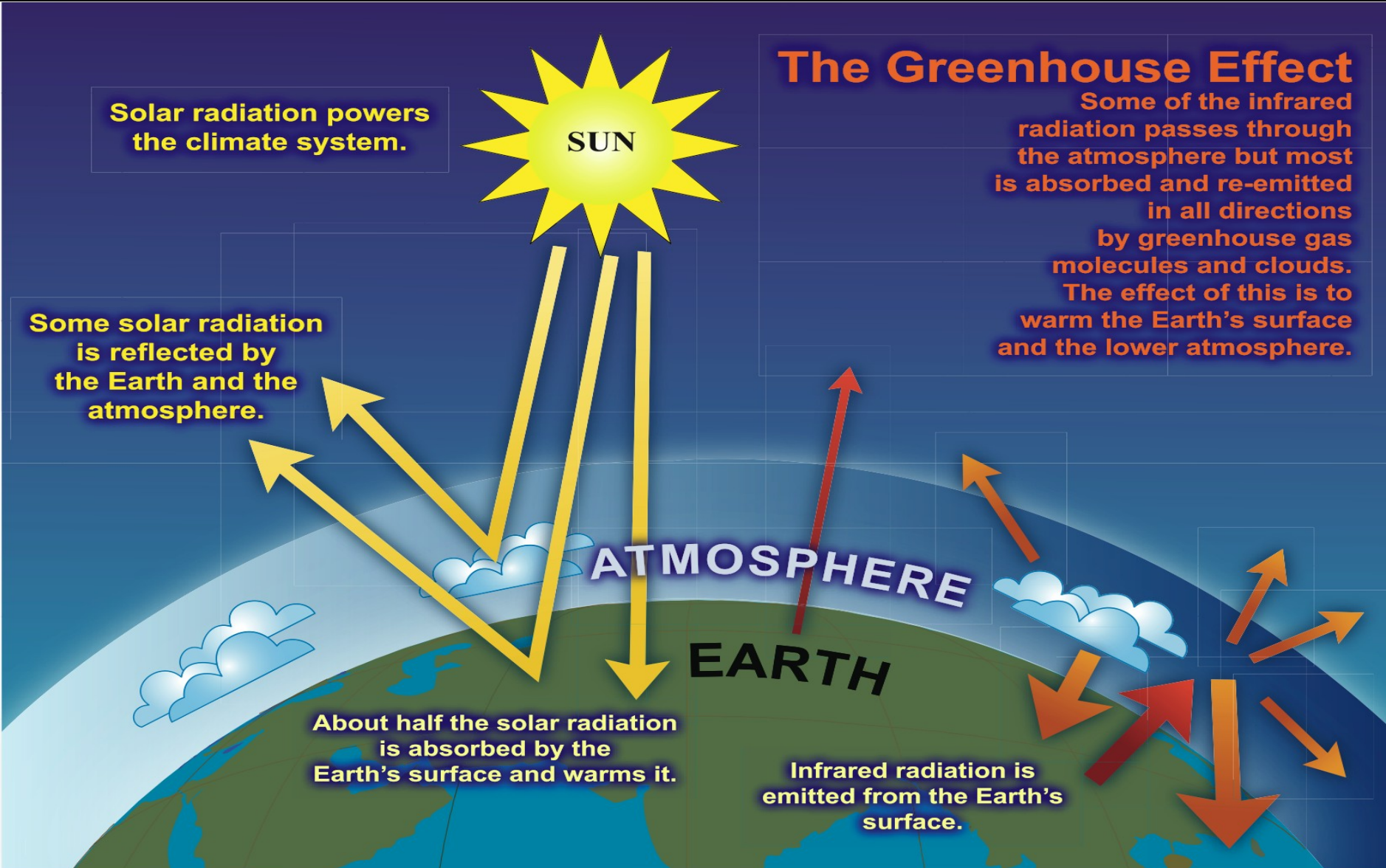
Some solar radiation is reflected by the Earth and the atmosphere.

About half the solar radiation is absorbed by the Earth's surface and warms it.

## The Greenhouse Effect

Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.

Infrared radiation is emitted from the Earth's surface.

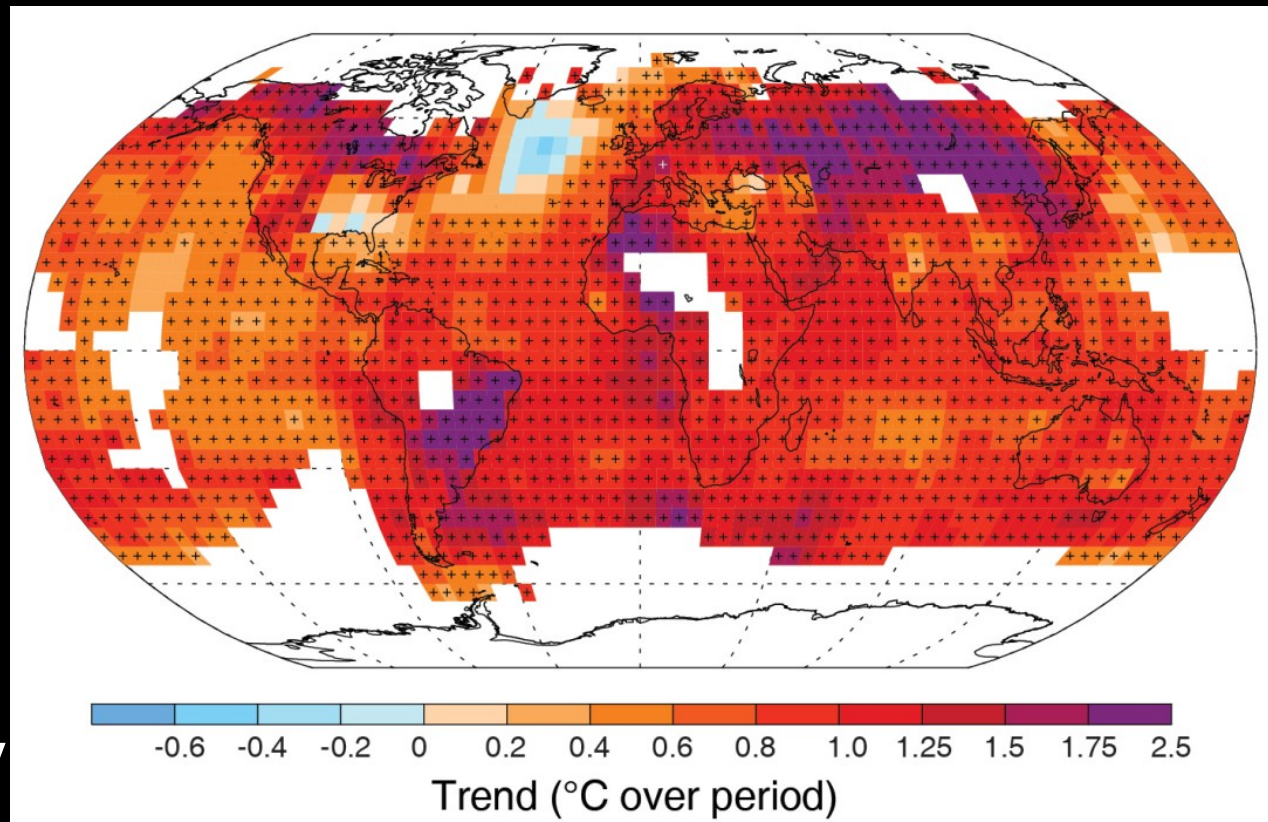




# The greenhouse effect is essential – but increasing

With no atmosphere and only the effect of the sun heating the earth, its temperature would be about  $-18^{\circ}\text{C}$ . So the greenhouse effect is essential to maintain temperatures high enough for life.

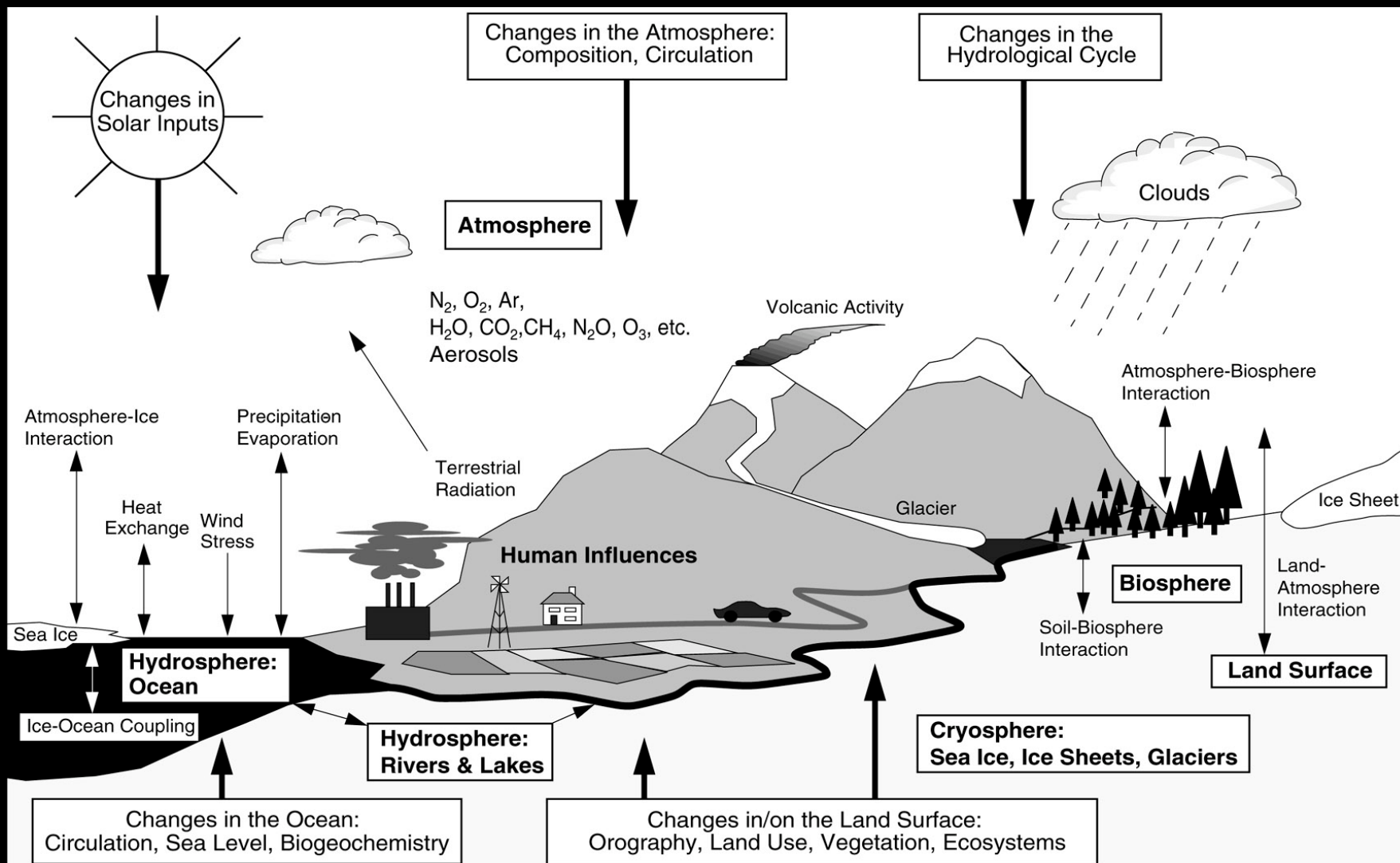
Since people have been using coal, oil and gas for energy (for heating, industry, transport) and have increased agriculture these greenhouse gases and their warming effect have increased significantly





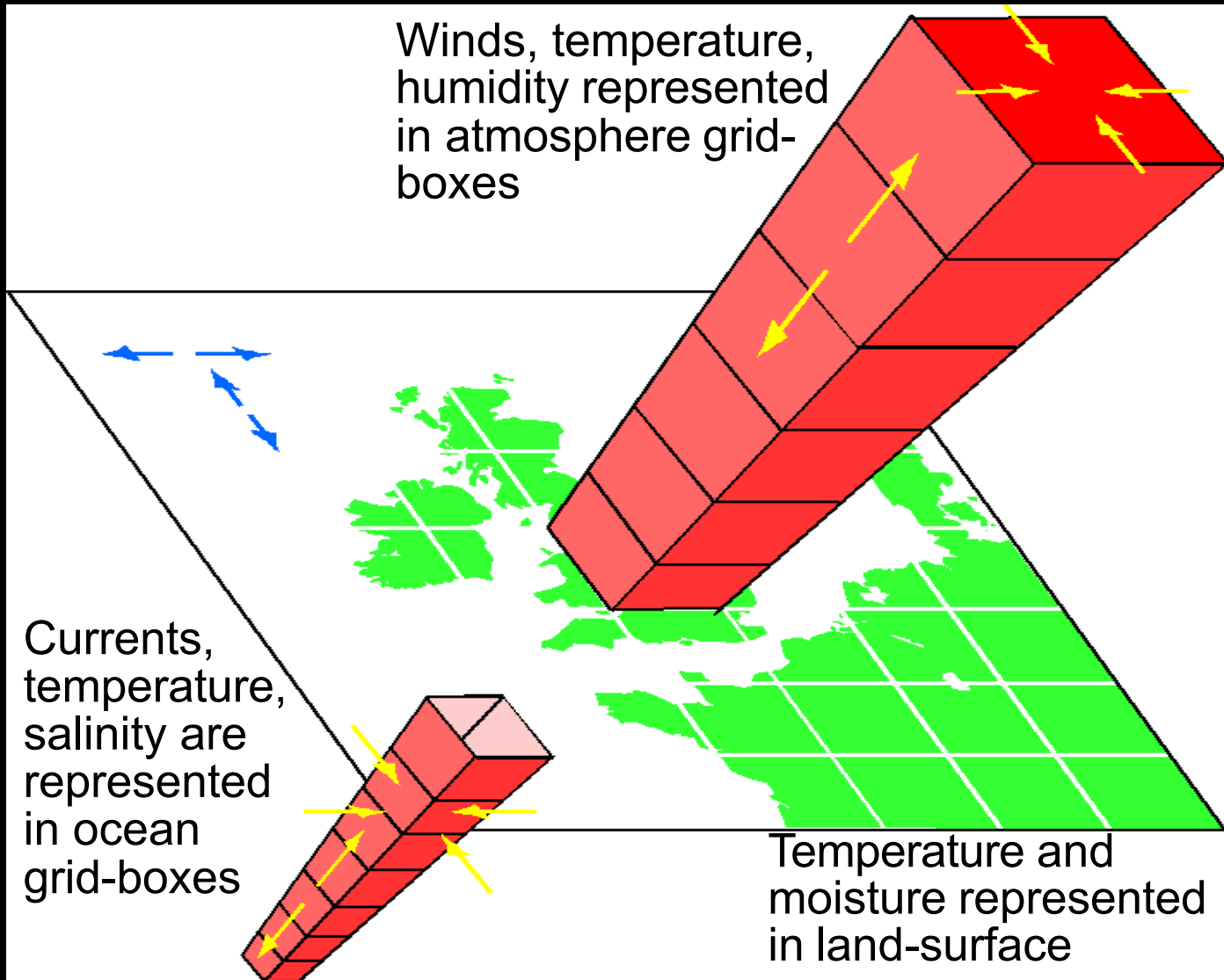
Met Office

# To understand climate change we use models representing all relevant earth system processes



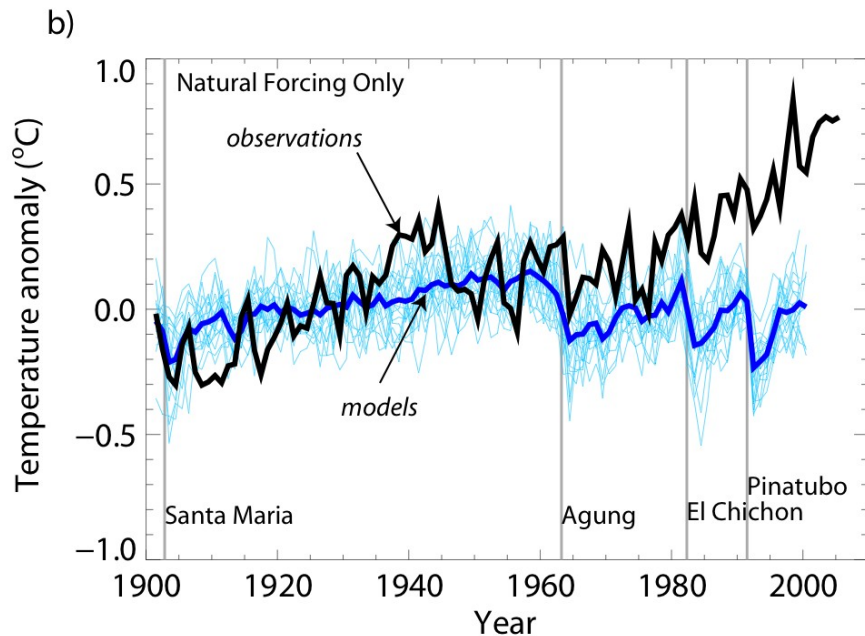
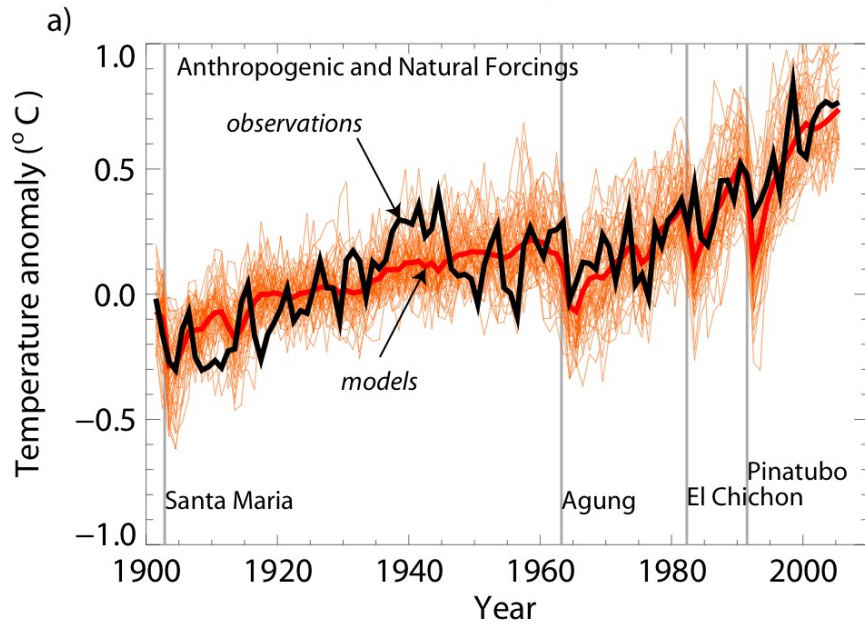


# Global climate models represent the climate system on a grid of discrete elements – horizontal resolution ~150km



Other processes are represented as smaller-scale interactions averaged over the grid-boxes  
Examples are:  
Radiation,  
aerosols, clouds,  
precipitation and evaporation,  
convection,  
land/sea-surface and atmosphere interactions

## Global Mean Surface Temperature Anomalies



When we run the climate models for the recent past they simulate the observed warming ...

if they include observed changes in greenhouse gases, aerosols and natural factors

(volcanoes, solar output but not if they only include natural factors

**Using global models with observed human-related and natural factors is key to this understanding**

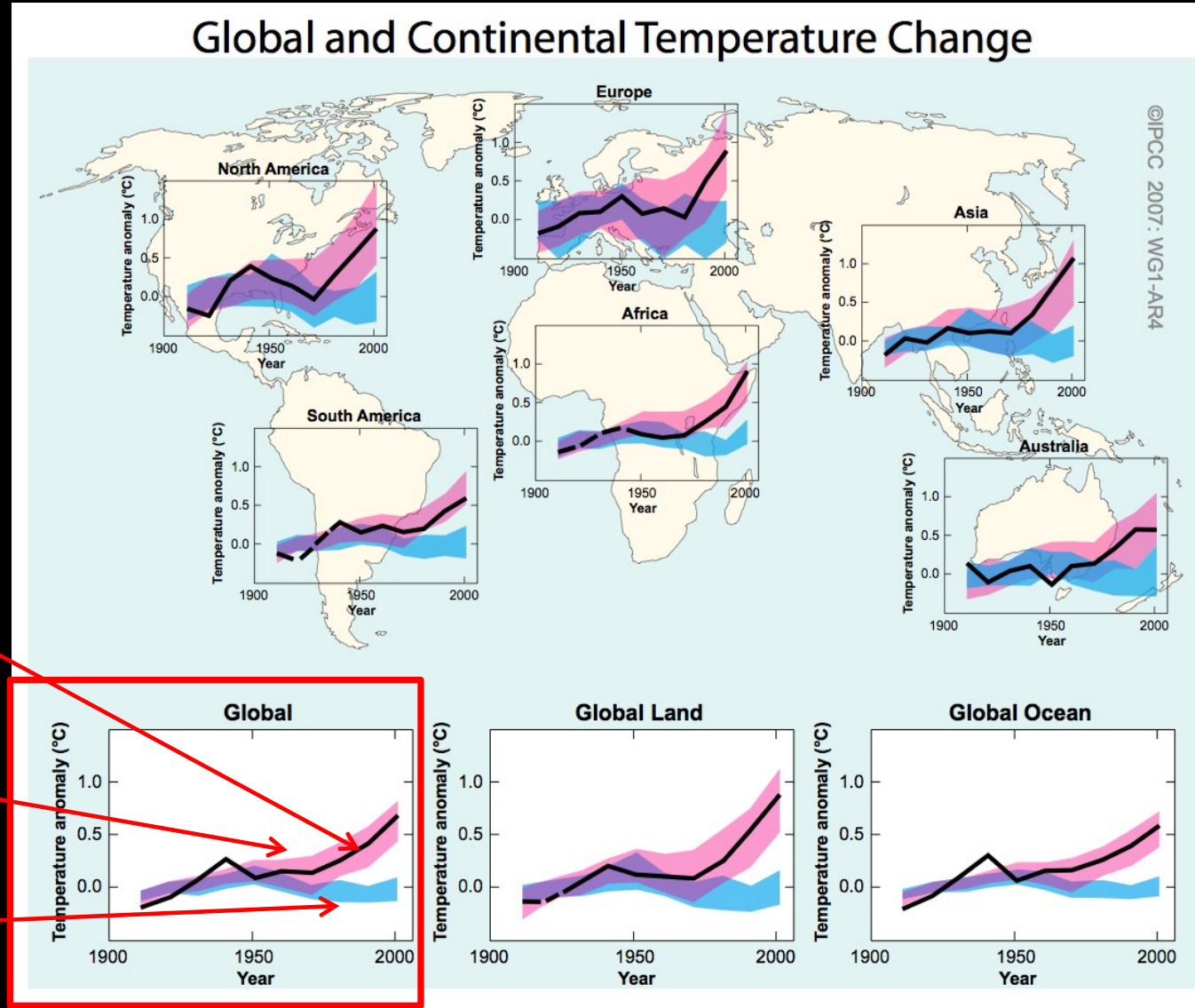
# Understanding and attributing regional climate change

Anthropogenic warming is discernible on all inhabited continents

Observed (black line)

Expected for all forcings (red band)

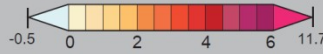
Natural forcing only (blue band)





# The climate change context

## Observed Temperature Change



Based on trend over 1901-2012 (°C over period)

Solid Color

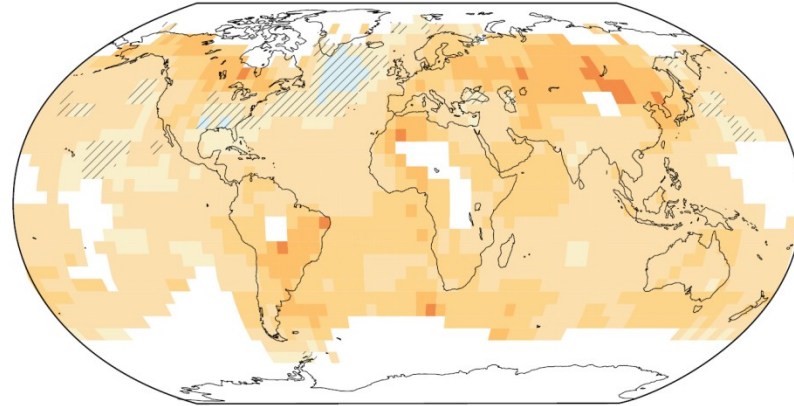
Significant trend

Diagonal Lines

Trend not statistically significant

White

Insufficient data



## Projected Temperature Change

Difference from 1986-2005 mean (°C)



Solid Color

Very strong agreement

White Dots

Strong agreement

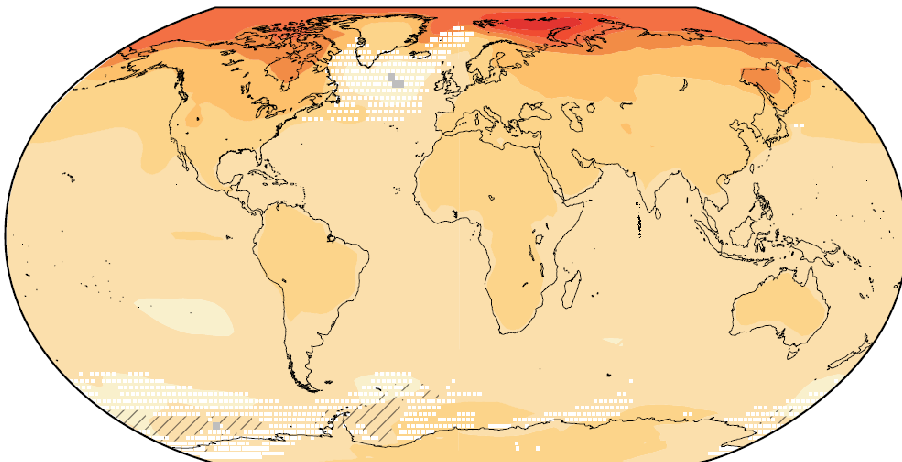
Gray

Divergent changes

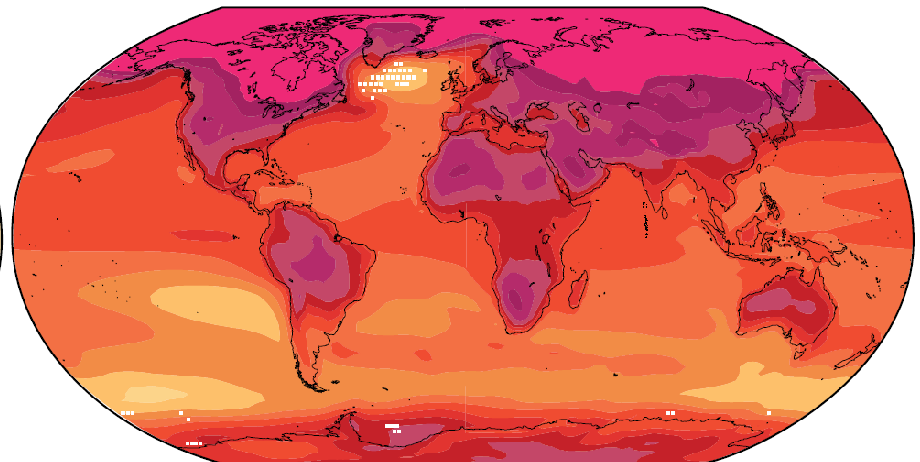
Diagonal Lines

Little or no change

RCP2.6 2081 - 2100

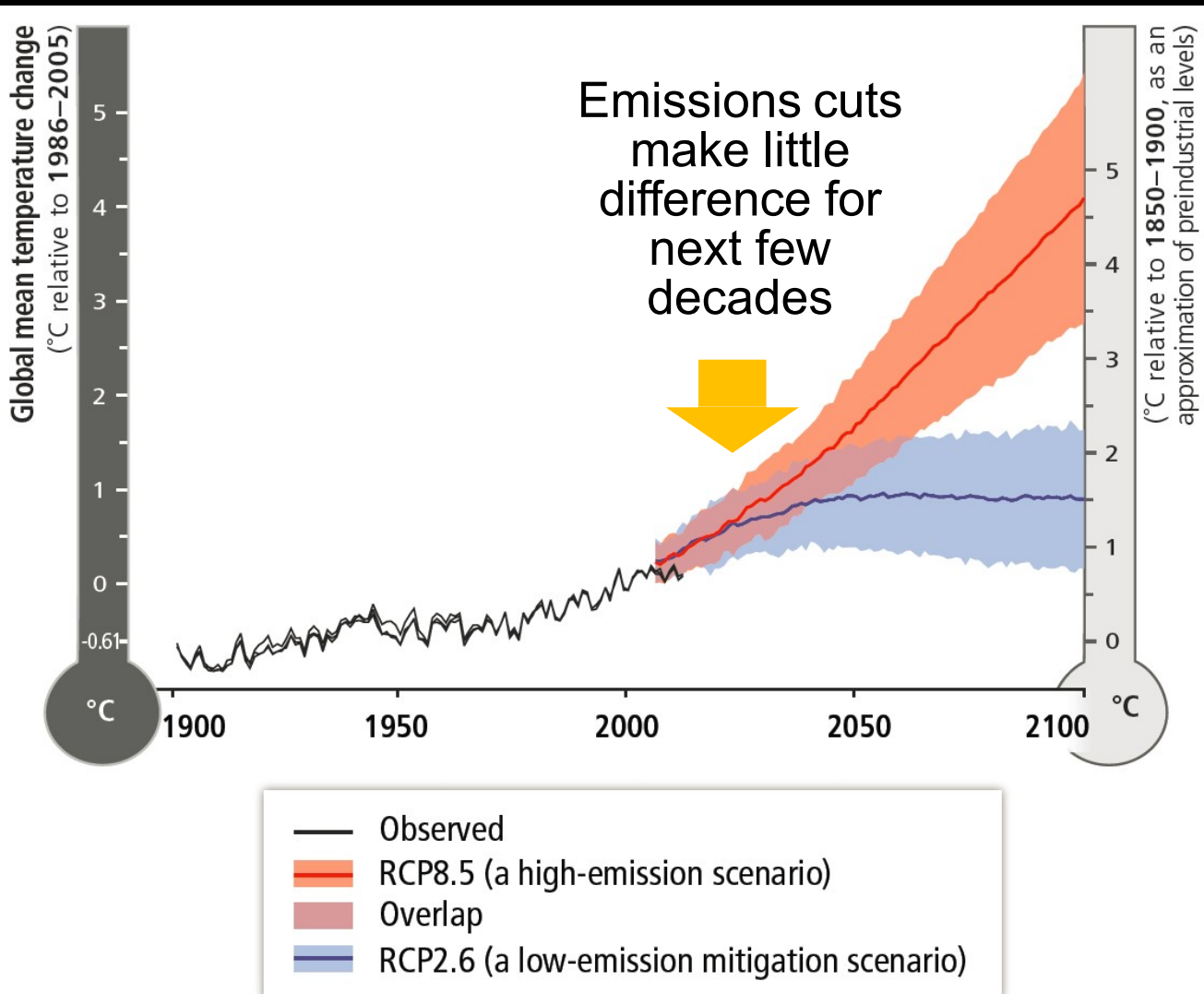


RCP8.5 2081 - 2100





# Projections of future temperature change with high and low emissions



Ongoing increases in global greenhouse gas emissions

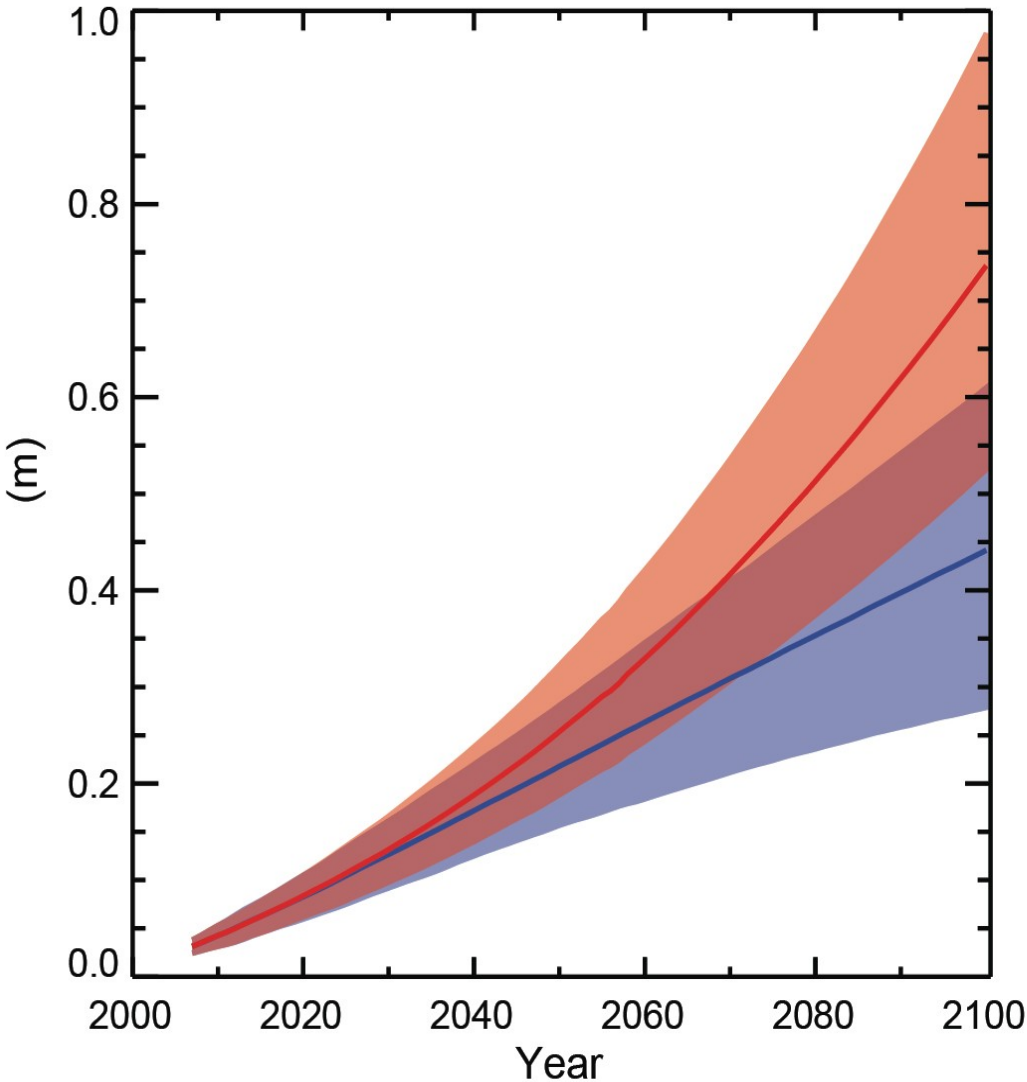
If global emissions peak within next few years then decline

Projections from multiple global climate models assessed in IPCC AR5 using low and high greenhouse gas Concentrations Pathways (RCPs)



# Sea-levels will continue to rise

Global mean sea level rise



Mean over 2081–2100

RCP2.6

RCP4.5

RCP6.0

RCP8.5

With large increases in global greenhouse gas emissions sea-levels will continue to rise exponentially

Even if global emissions peak within next few years then decline sea levels will continue to rise (for centuries)

Projections from multiple global climate models assessed in the IPCC AR5 using four Representative greenhouse gas Concentrations Pathways (RCPs)



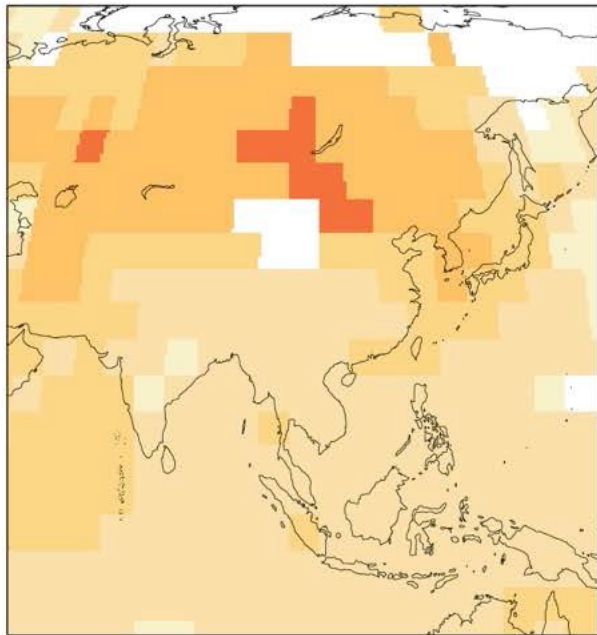
# Projected temperature changes in Asia

Trend over 1901-2012  
(°C over period)

Annual Temperature



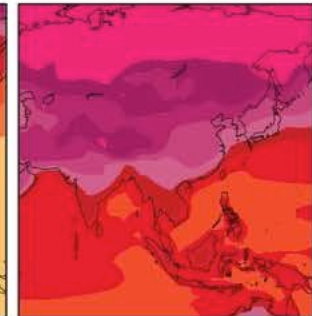
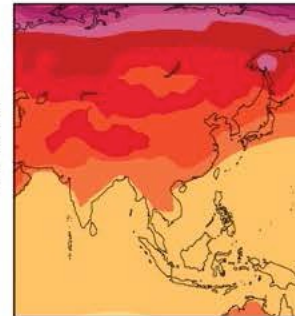
Difference from 1986-2005 mean  
(°C)



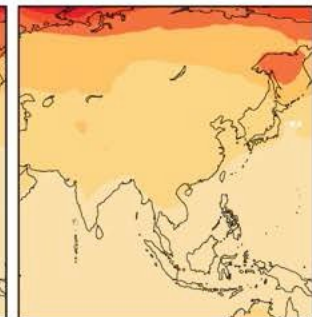
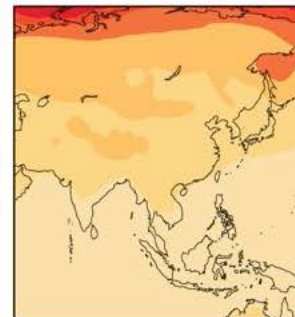
mid-21st century

late-21st century

RCP8.5



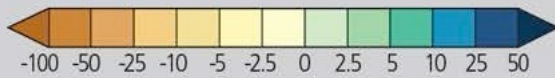
RCP2.6



- Clear warming trends everywhere we have good data
- Significantly more warming in the future but much less with aggressive mitigation

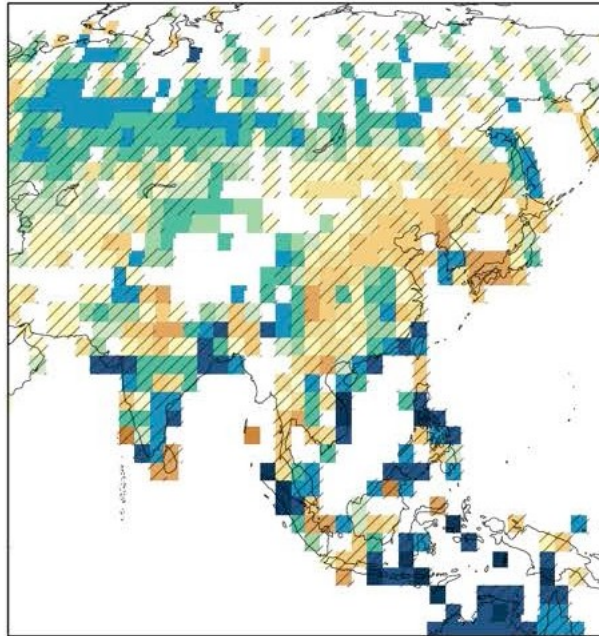
# Projected precipitation changes in Asia

Trend over 1951-2012 (mm/year/decade)



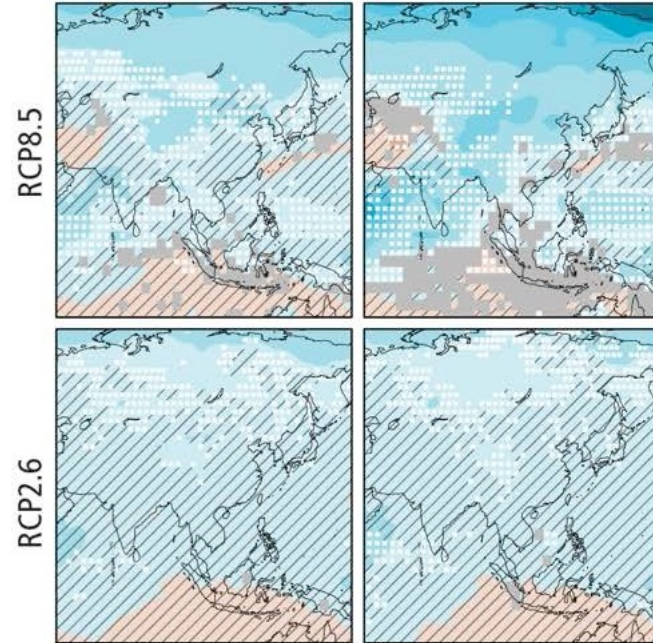
Annual Precipitation

Difference from 1986-2005 mean (%)



mid-21st century

late-21st century



Solid Color

Significant trend

Diagonal Lines

Trend not statistically significant

White

Insufficient data

Solid Color

Very strong agreement

White Dots

Strong agreement

Gray

Divergent changes

Diagonal Lines

Little or no change

- Mixed trends in precipitation
- General tendency for increases in average precipitation
- Areas of uncertainty in some tropical/central Asian regions



# Conclusions

- The greenhouse effect is strengthening as human activity increases greenhouse gases in the atmosphere
- Using observations and climate models demonstrates human influence has caused most observed warming and the models can be used to predict future changes
- The world will continue to warm, and more than has been observed to date even with aggressive mitigation
- Sea-levels will continue to rise and precipitation will change in many regions

**Today and tomorrow's climate is not as it used to be**