

# The Human Factor in Climate Change



**Rob van Dorland**

**KNMI**

Amman, Damascus, Beirut,  
November 2010

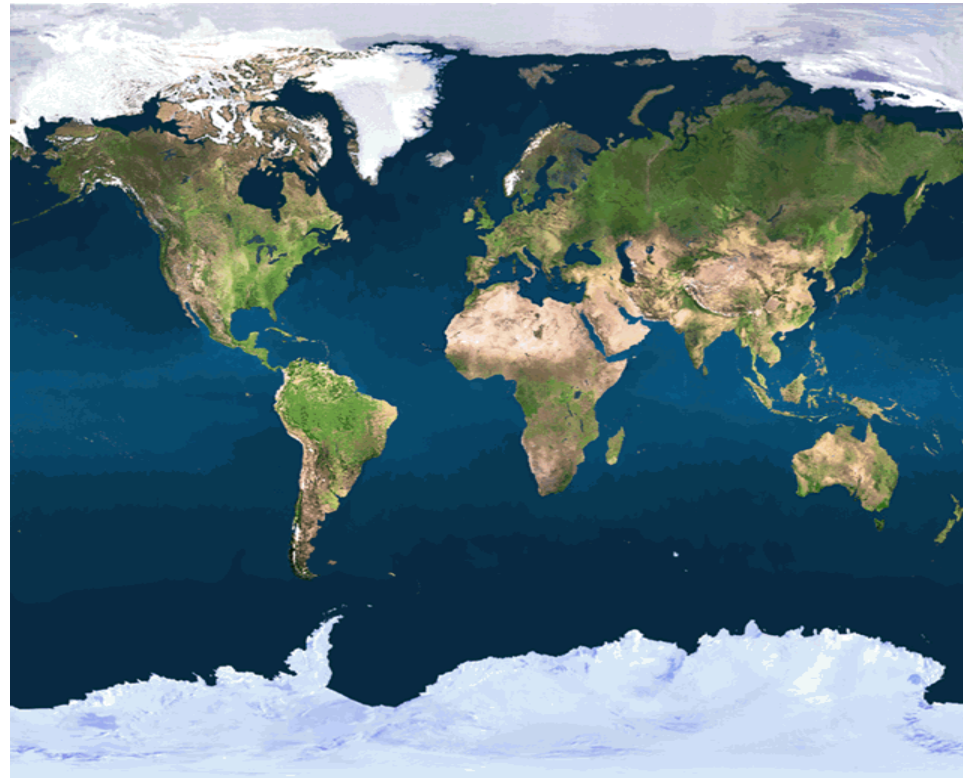
Koninklijk Nederlands Meteorologisch Instituut

# Outline

- **Main conclusions IPCC (2007)**
- **Global climate scenarios**
- **Regional climate scenarios**

# Key questions climate research

- **Detection**
- **Attribution**
- **Projection**



# IPCC

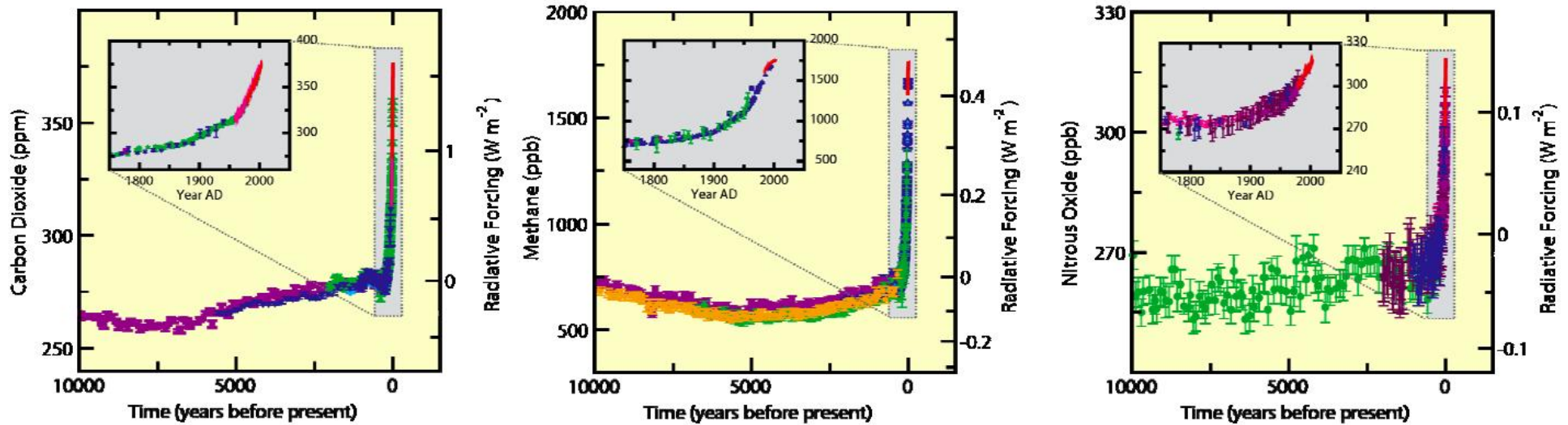
## Intergovernmental Panel on Climate Change

- Established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP)
- Assessment reports:
  - The Physical Science Basis (WG1)
  - Impacts, Adaptation and Vulnerability (WG2)
  - Mitigation of Climate Change (WG3)
- Reports of IPCC workshops and expert meetings

## **IPCC WG1 report (2007) describes progress in understanding of:**

- **Drivers of climate change:  
natural and anthropogenic**
- **Observed climate change:  
atmosphere, ocean, snow and ice coverage**
- **Insight in climate processes:  
feedbacks and biogeochemical cycles**
- **Projections: global and regional  
using a set of emission scenarios**

# Greenhouse gases



- Concentrations now far exceed pre-industrial values spanning many thousands of years
- The increase of concentrations of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are primarily due to human activities

Source: IPCC, 2007

# A Paleoclimatic Perspective:

Paleoclimatic information supports the interpretation that the warmth of the last 50 years is unusual in at least the previous 1300 years .

Source: IPCC, 2007

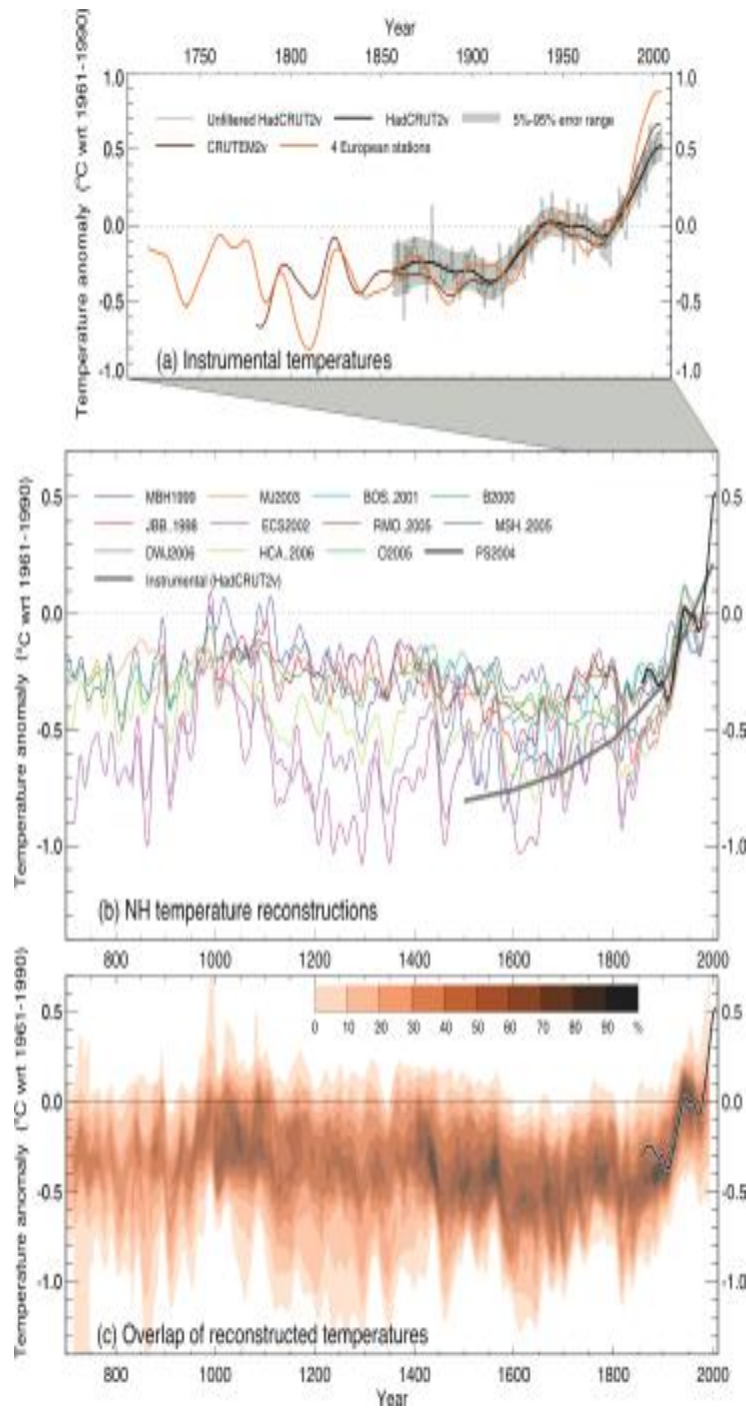
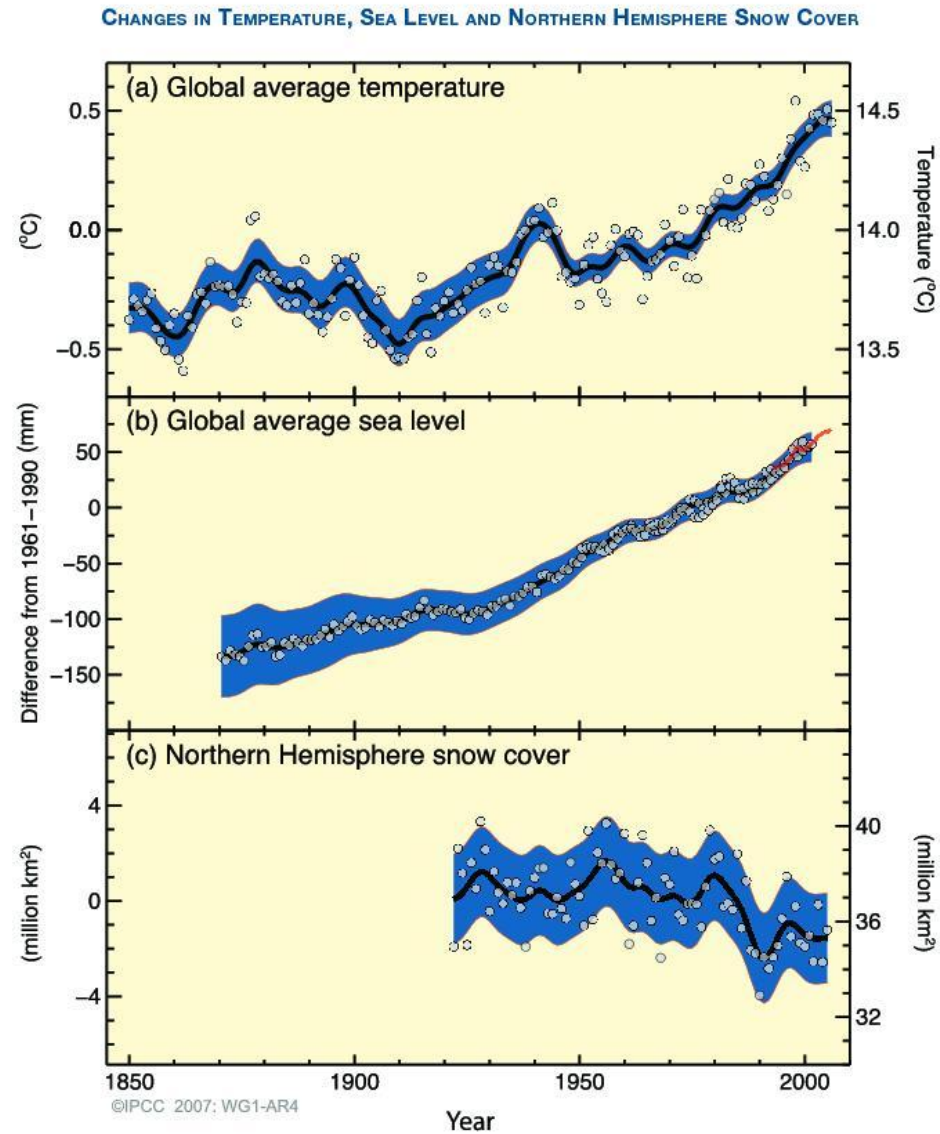


Figure 6.10

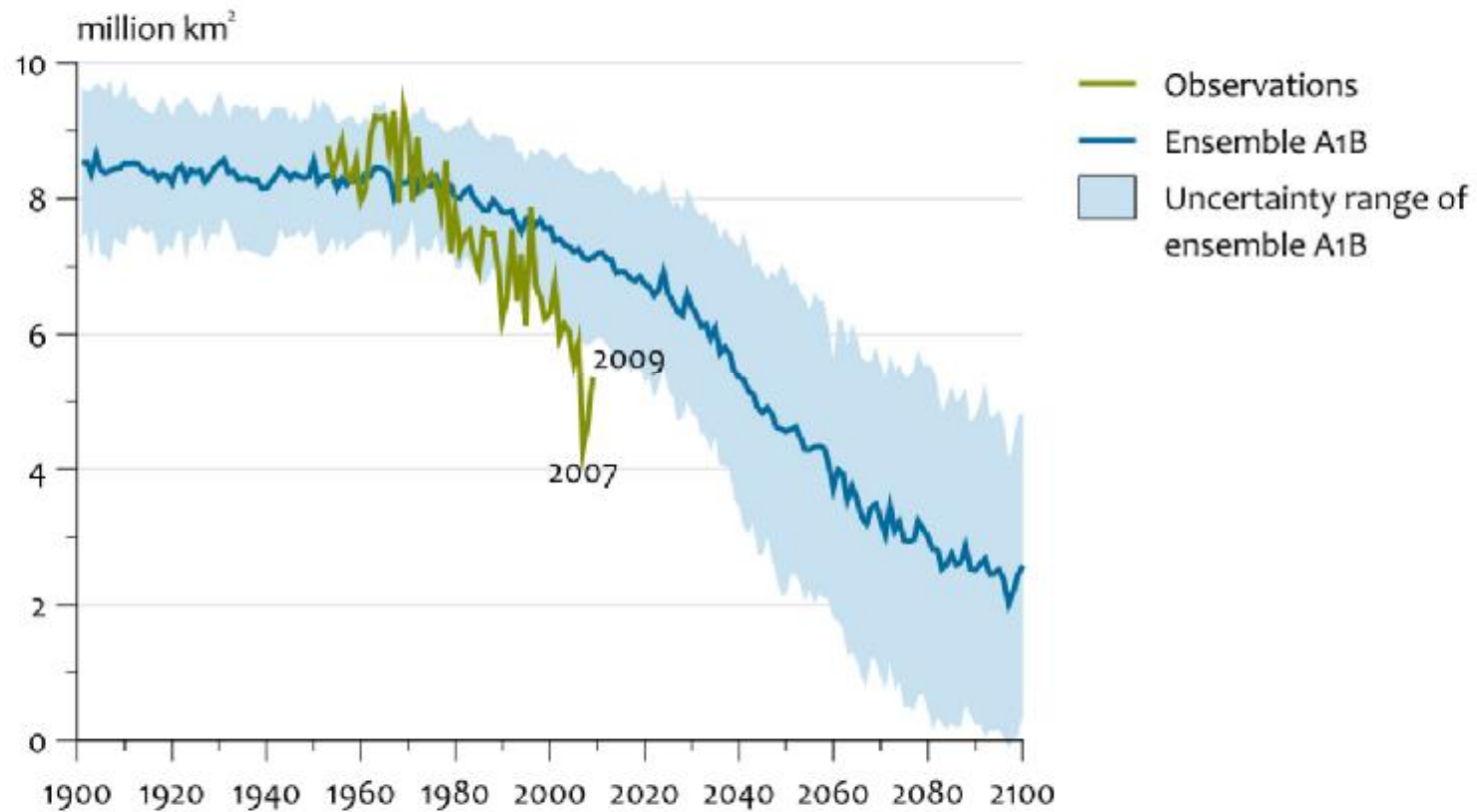
# Climate changes 20<sup>th</sup> century



Source: IPCC, 2007

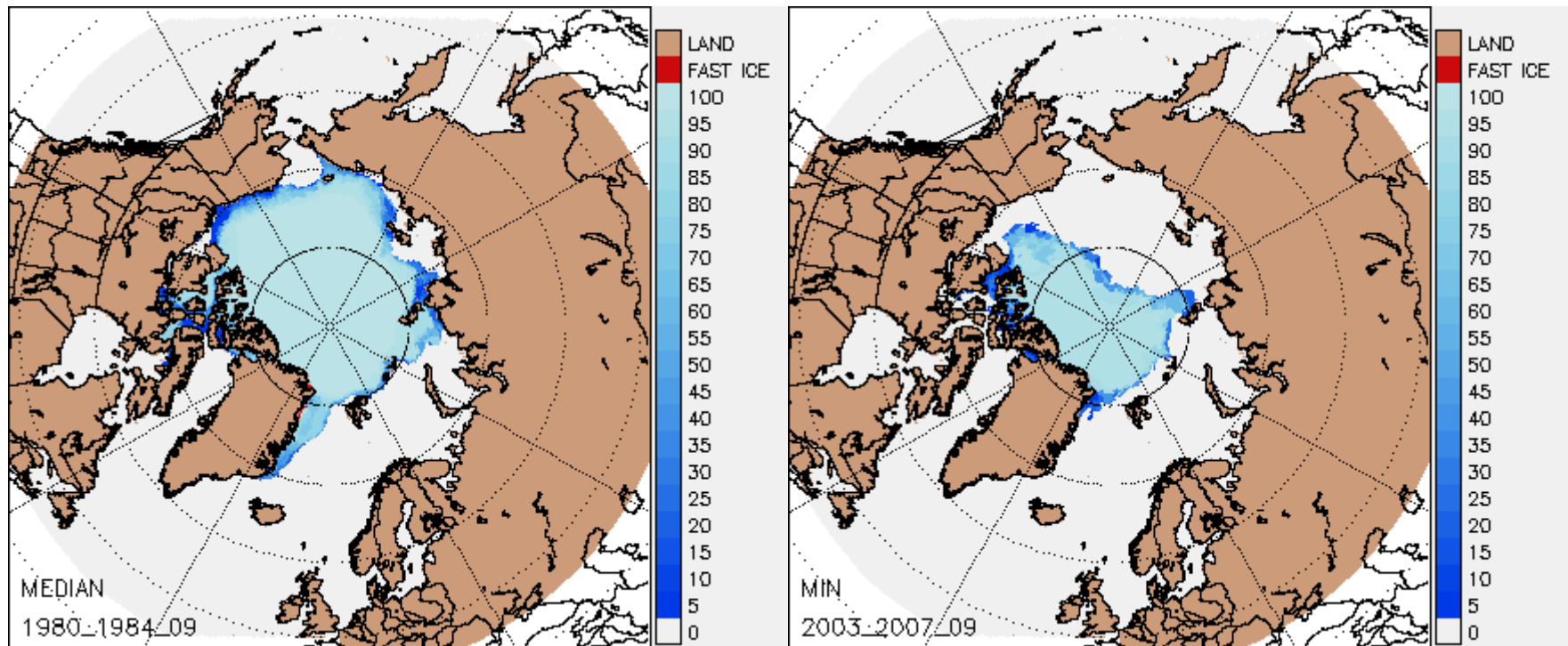
# Arctic sea ice retreat

## Minimum arctic ice extent



Source: Van Dorland et al., 2009

# Melting Arctic Sea Ice



September median  
1980-1984

September 2007

# Radiative Balance of the Climate System



← Incoming Solar Radiation  
**341 Wm<sup>-2</sup>**

→ Reflected Solar Radiation  
**102 Wm<sup>-2</sup> (about 30%)**

↘  
↘  
↘  
Outgoing Infrared Radiation  
**239 Wm<sup>-2</sup>**

# Perturbations of the Radiative Balance



← Incoming Solar Radiation  
**341**  $\text{Wm}^{-2}$  +/- change

→ Reflected Solar Radiation  
**102**  $\text{Wm}^{-2}$  +/- change

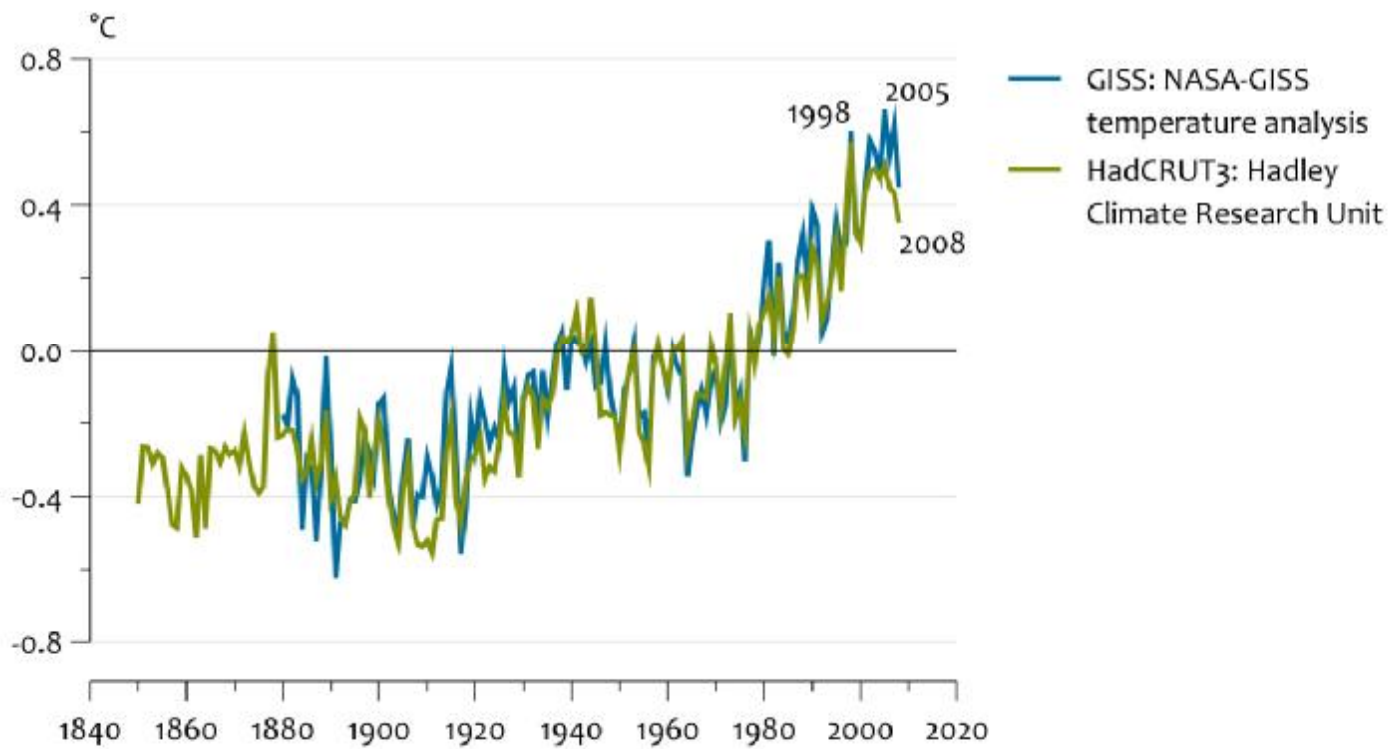
↘ ↙ ↘  
Outgoing Infrared Radiation  
**239**  $\text{Wm}^{-2}$  +/- change

## Changes in the energy balance

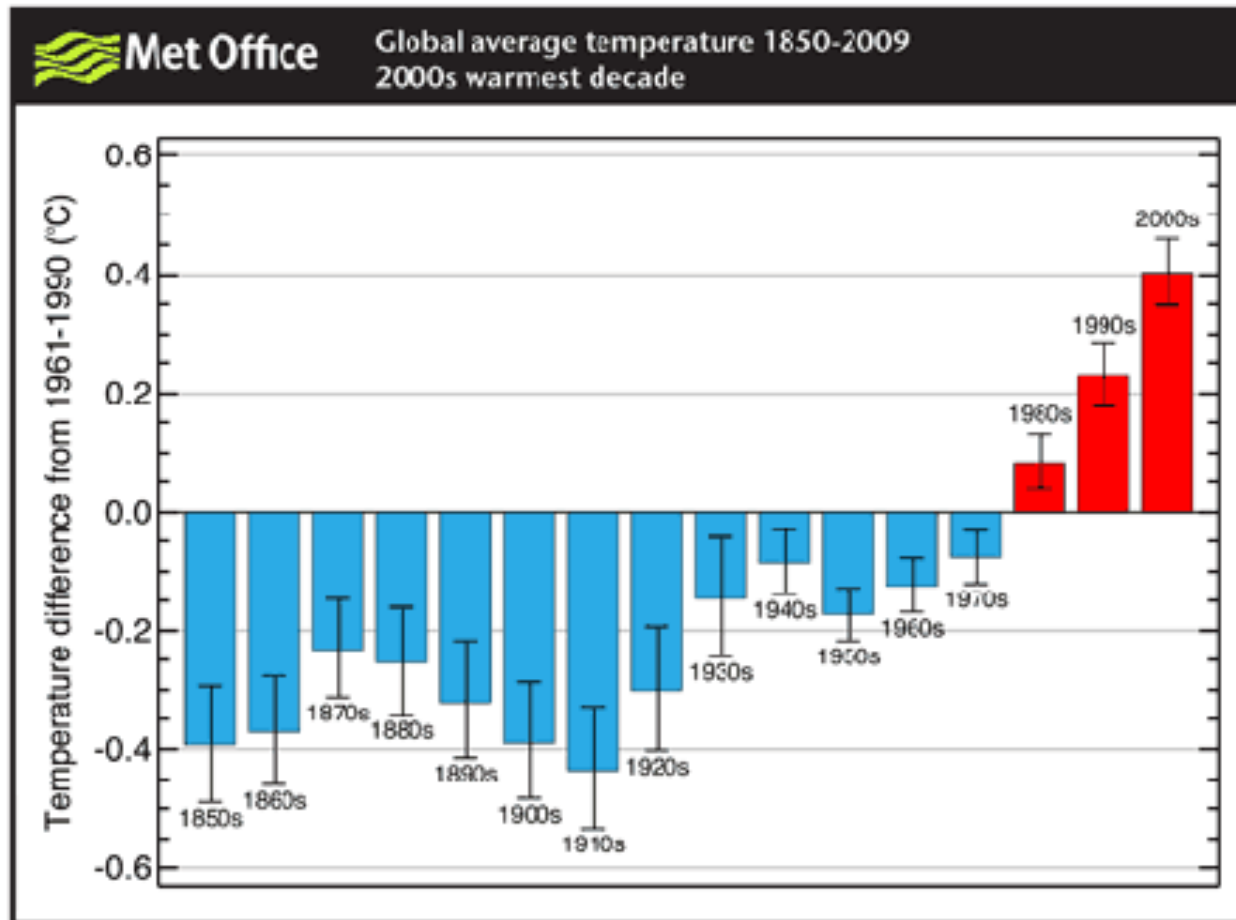
- **Changes in the energy flows (incoming solar energy, reflected energy or emitted infrared radiative energy) result in changes in the global mean temperature.**
- **If nothing else would change but temperature, a doubling of the CO<sub>2</sub> content would result in a temperature rise of 1.1°C.**
- **There are many temperature dependent processes in the climate system (e.g. evaporation, ice volume and clouds), which can attenuate or amplify the initial temperature change.**
- **The sum of all known processes will amplify the temperature increase within the range 2 - 4.5°C (best estimate: 3°C) for a doubling of the CO<sub>2</sub> content in the atmosphere.**

# Global mean temperature change

Global temperature anomalies compared to 1961-1990 average



# 2000-2009 warmest decade

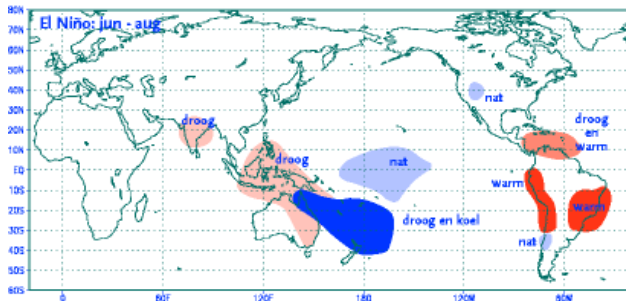
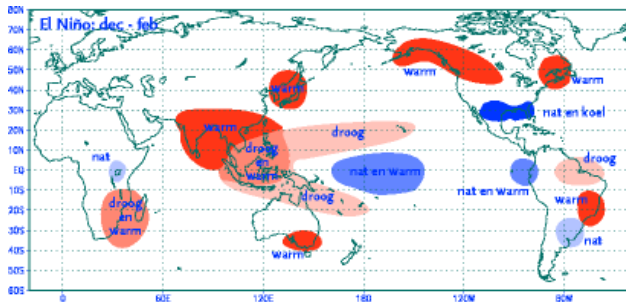


# Natural Climate Factors 20<sup>th</sup> Century



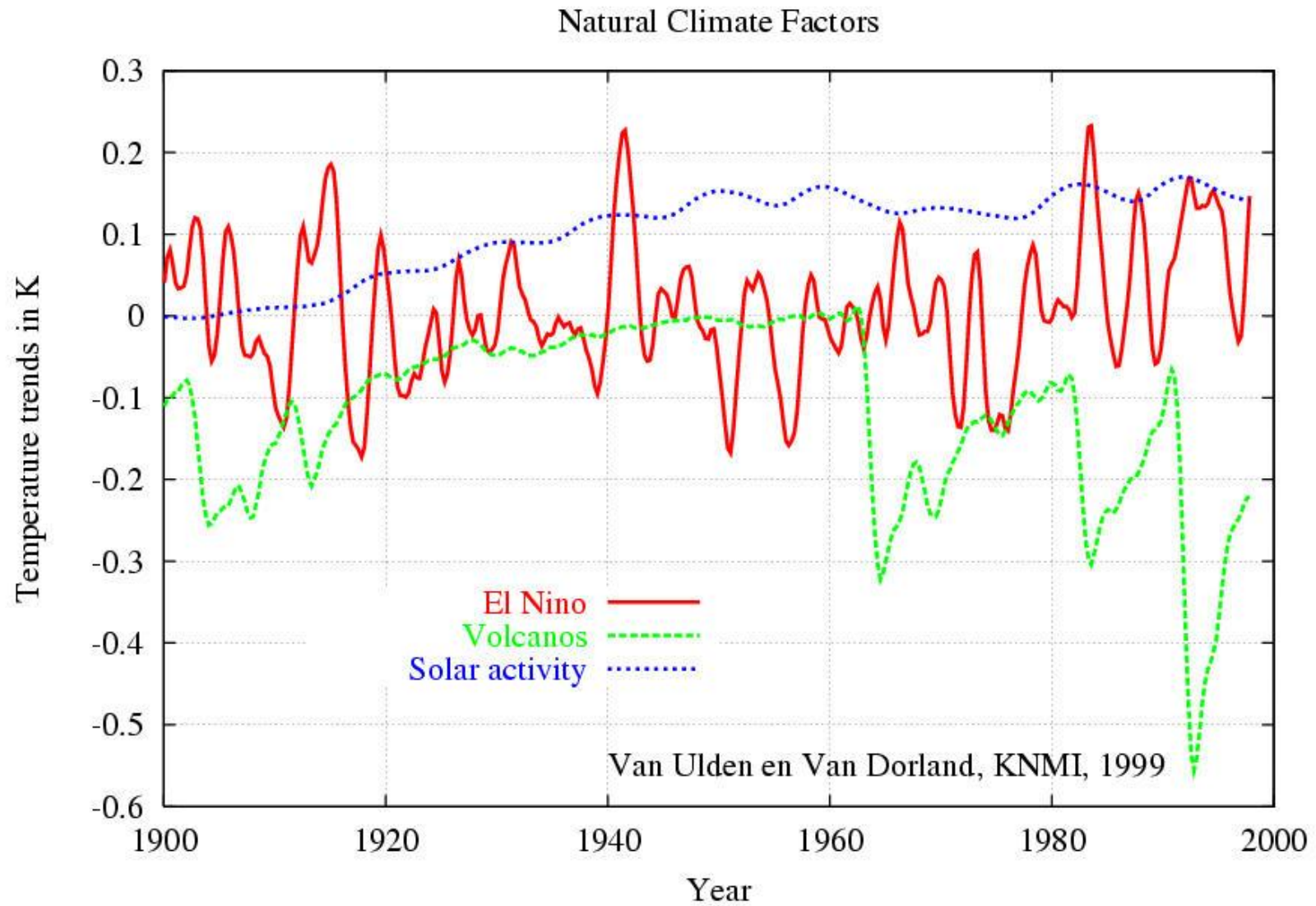
## 1. Volcanic eruptions

## 2. Solar activity

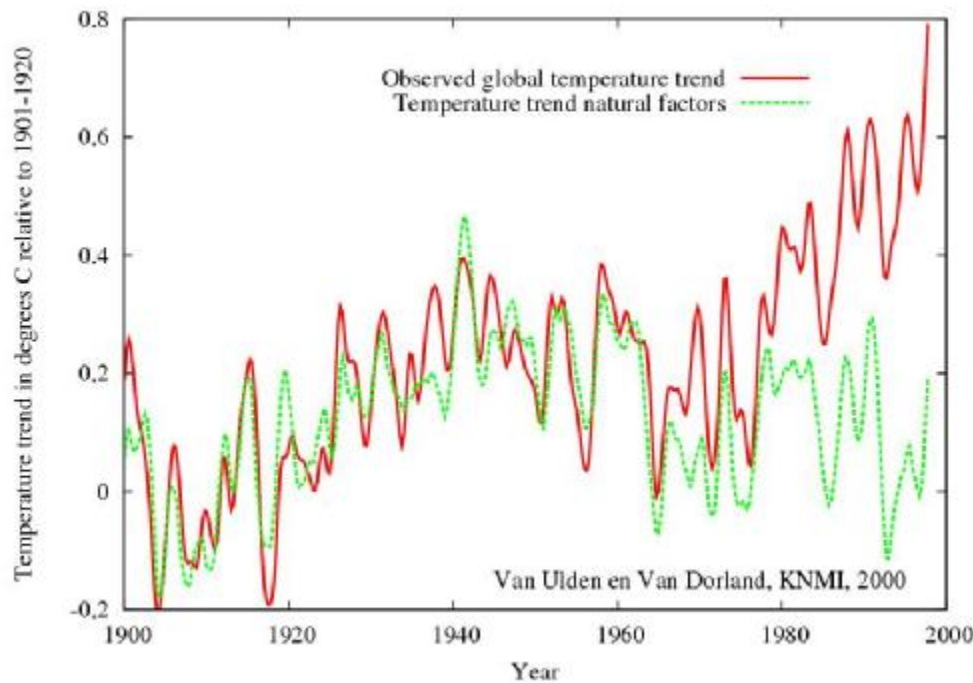


## 3. El Niño - Southern Oscillation

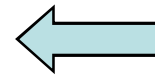
# Natural drivers 1900-1998



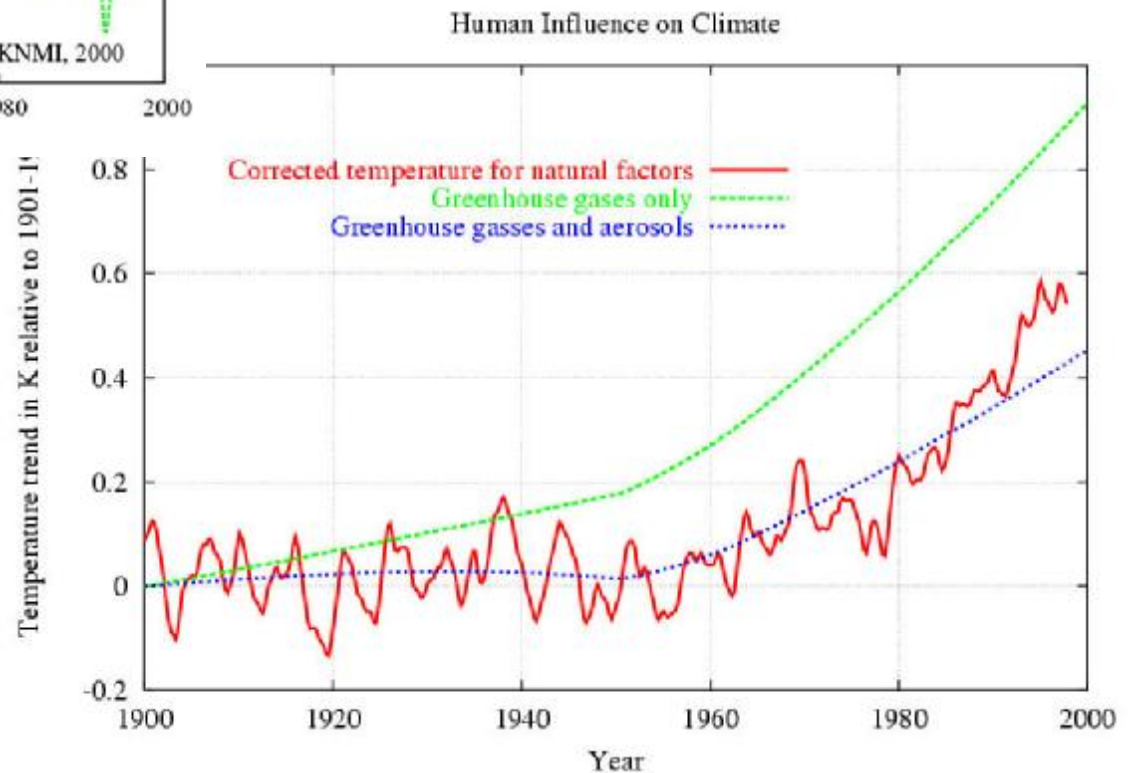
# Causes of 20<sup>th</sup> century warming



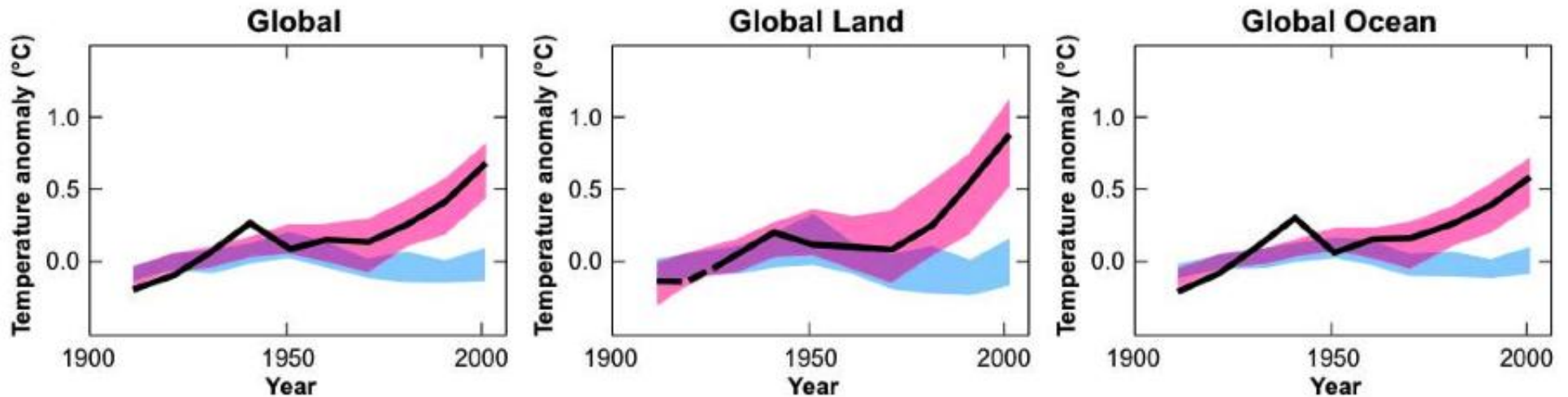
Temperature trends:  
Observation &  
Calculated sum of  
natural factors



Very likely  
human  
influence



# Global attribution



Black: observed temperature (smoothed)

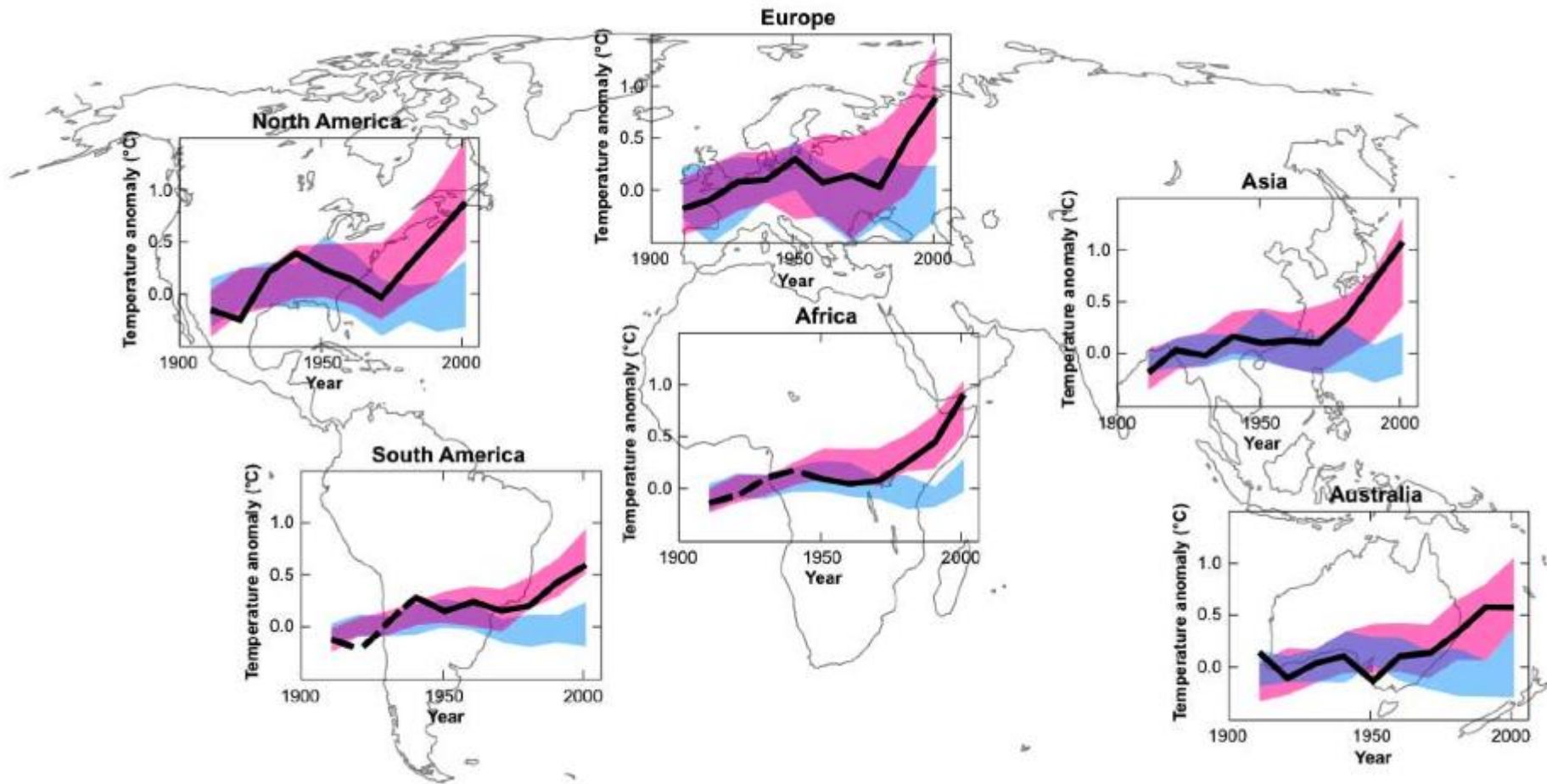
Blue: models using only natural forcings

Pink: models using both natural and anthropogenic forcings

**Most of the observed increase in globally averaged temperatures since the mid-20<sup>th</sup> century is very likely due to observed increase in anthropogenic greenhouse gas concentrations.**

Source: IPCC, 2007

# Regional attribution



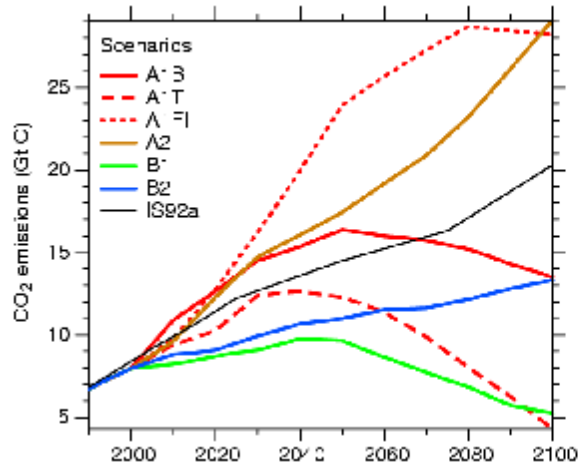
**The human influence starts to be visible on continental scale as well**

# Global Climate Projections for the 21<sup>st</sup> Century

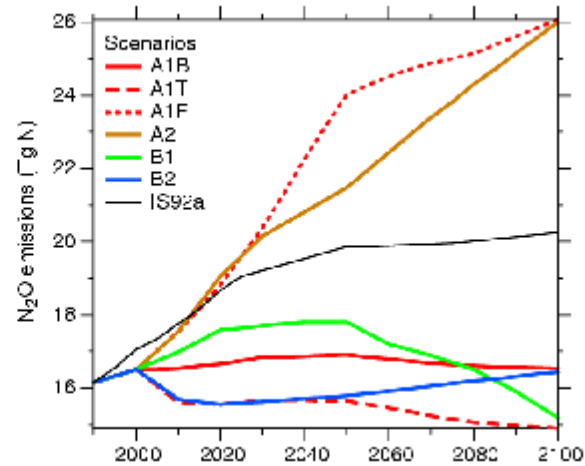
- **Based on the range of available coupled physical ocean-atmosphere-land models**
  - Validated against climate of the 20<sup>e</sup> century
- **Uncertainties:**
  - Climate model differences (climate sensitivity)
  - Range in scenarios of greenhouse gasses and aerosols

# Emission scenarios (SRES)

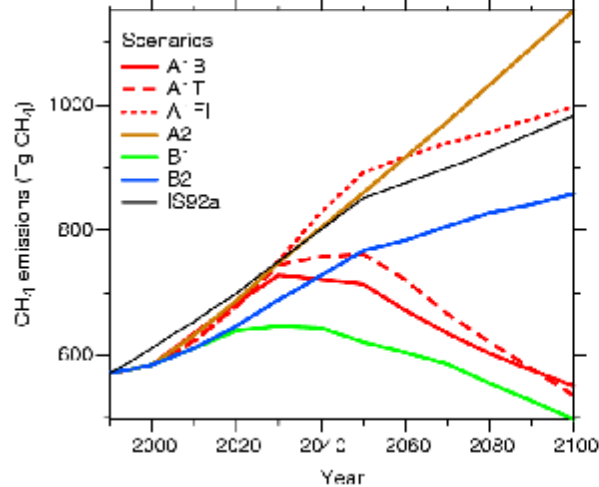
**CO<sub>2</sub>**



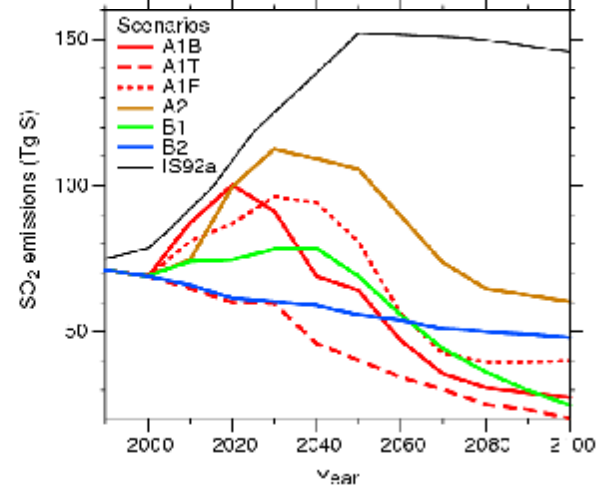
**N<sub>2</sub>O**



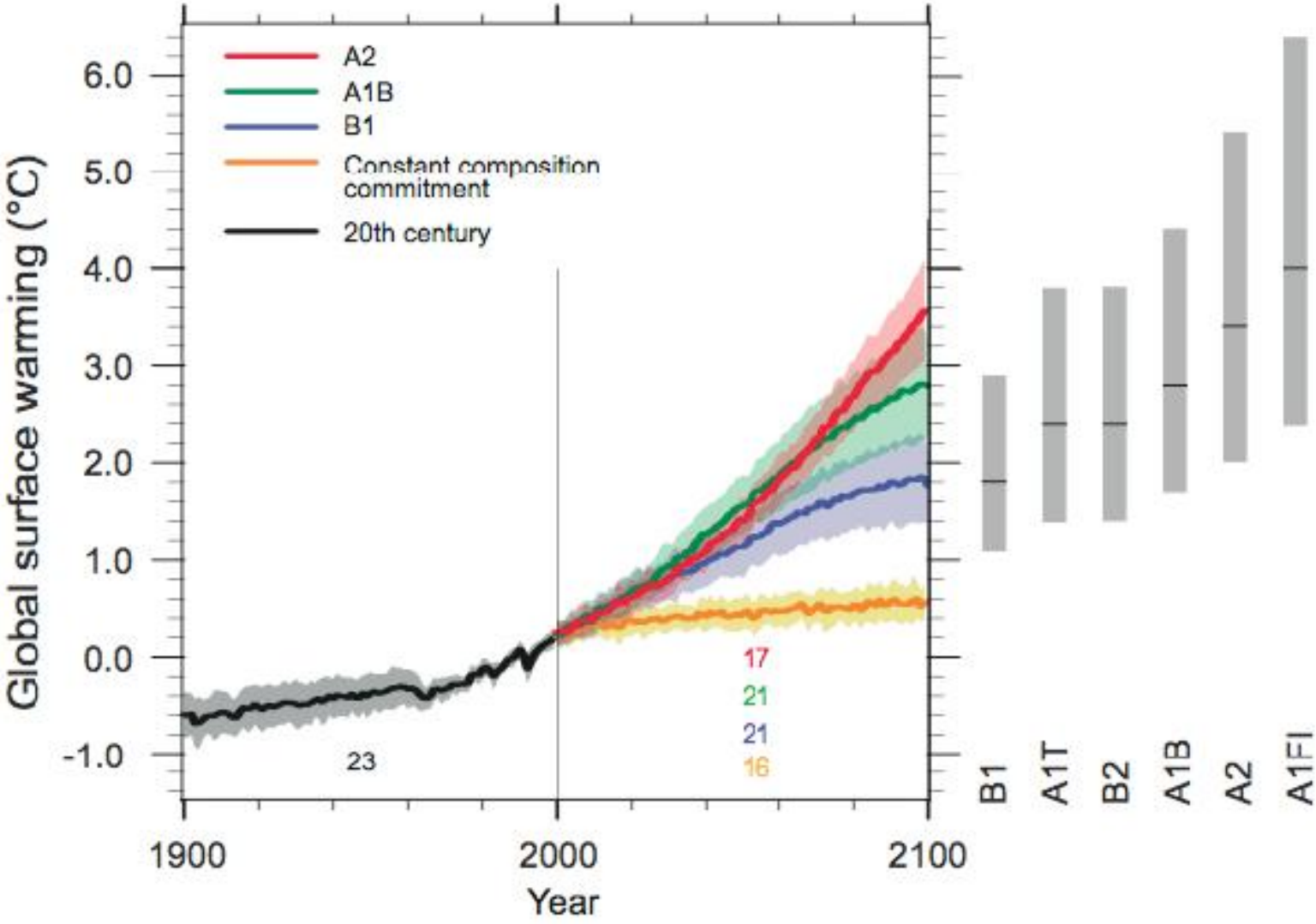
**CH<sub>4</sub>**



**SO<sub>2</sub>**

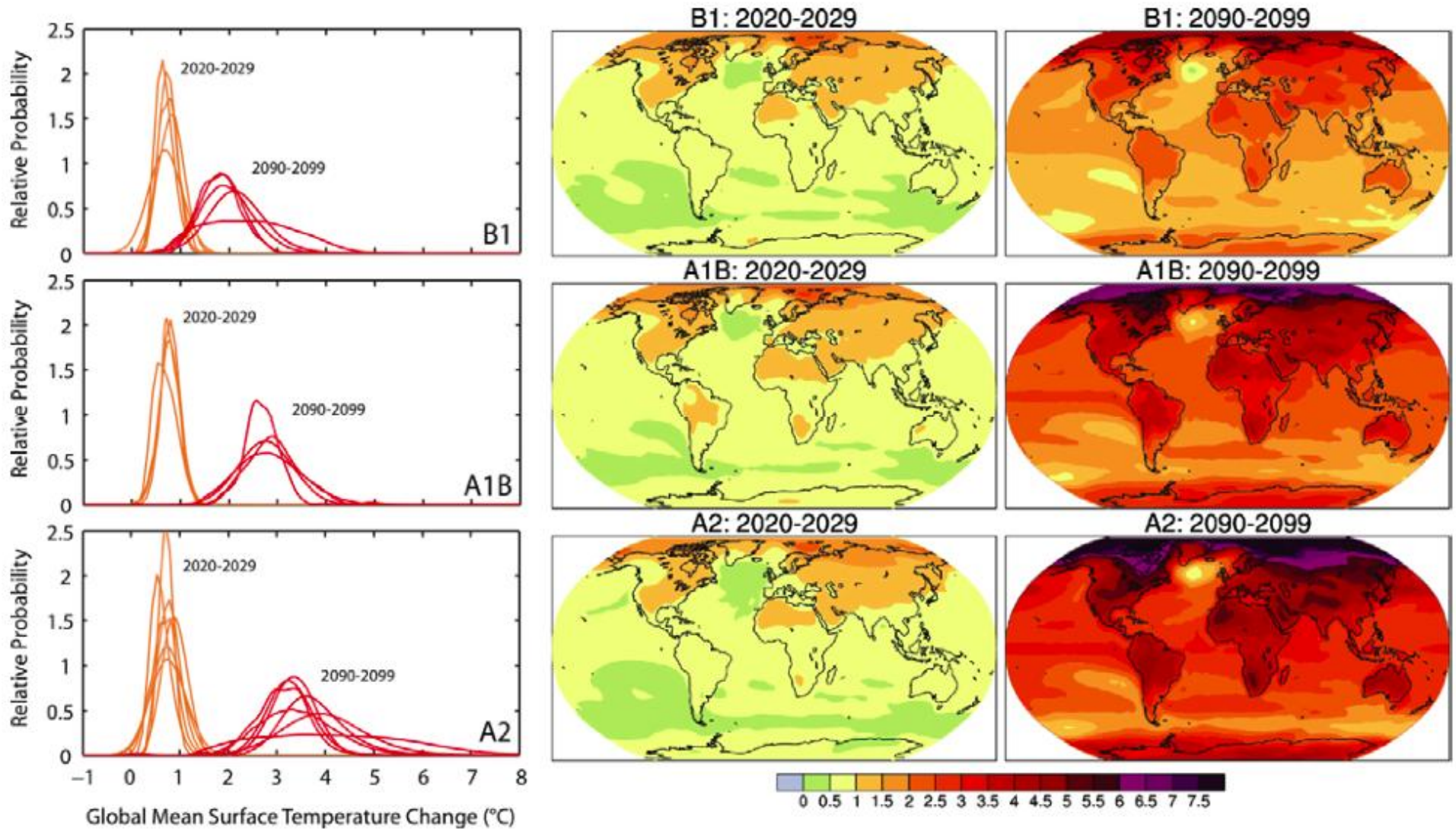


# Global temperature projections



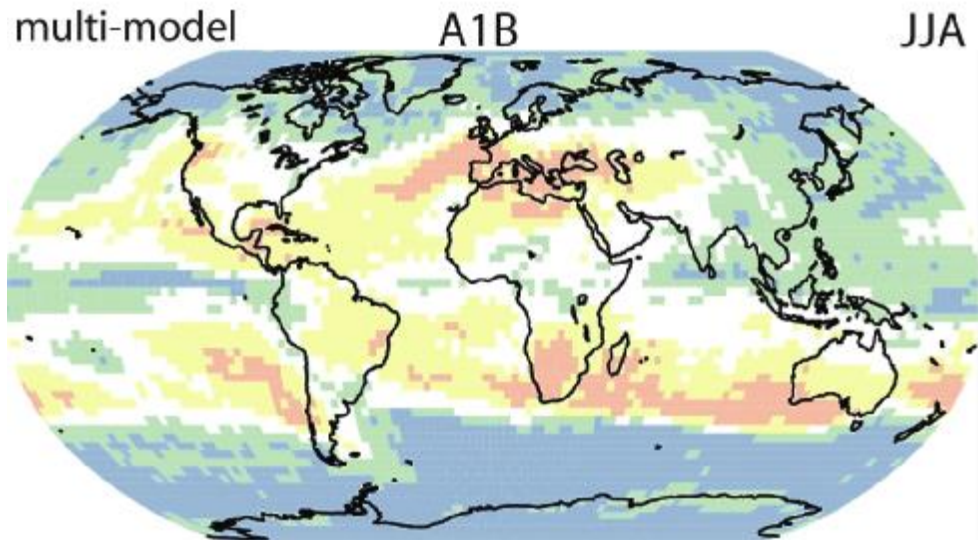
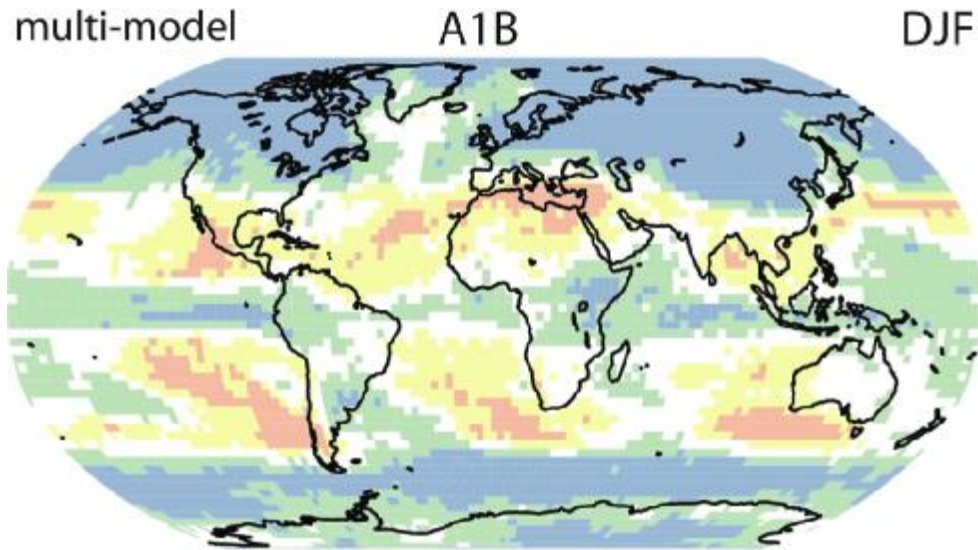
Source: IPCC, 2007

# Response on emission scenarios



Source: IPCC, 2007

# Precipitation changes



# Sea Level Rise

Global: sea level rise (SLR) of **18 tot 59 cm** (2090-2099 relative to 1980-1999), due to

- Thermal expansion
- Melting of glaciers and small icecaps
- Gradual changes of large icecaps of Greenland and Antarctica

If increased ice flow, suggested by recent observations, is proportional to the projected temperature, sea level will rise extra with **10 to 20 cm**

However, it is not known whether the observed acceleration is structural or not

# Middle East & Asia projections IPCC AR4

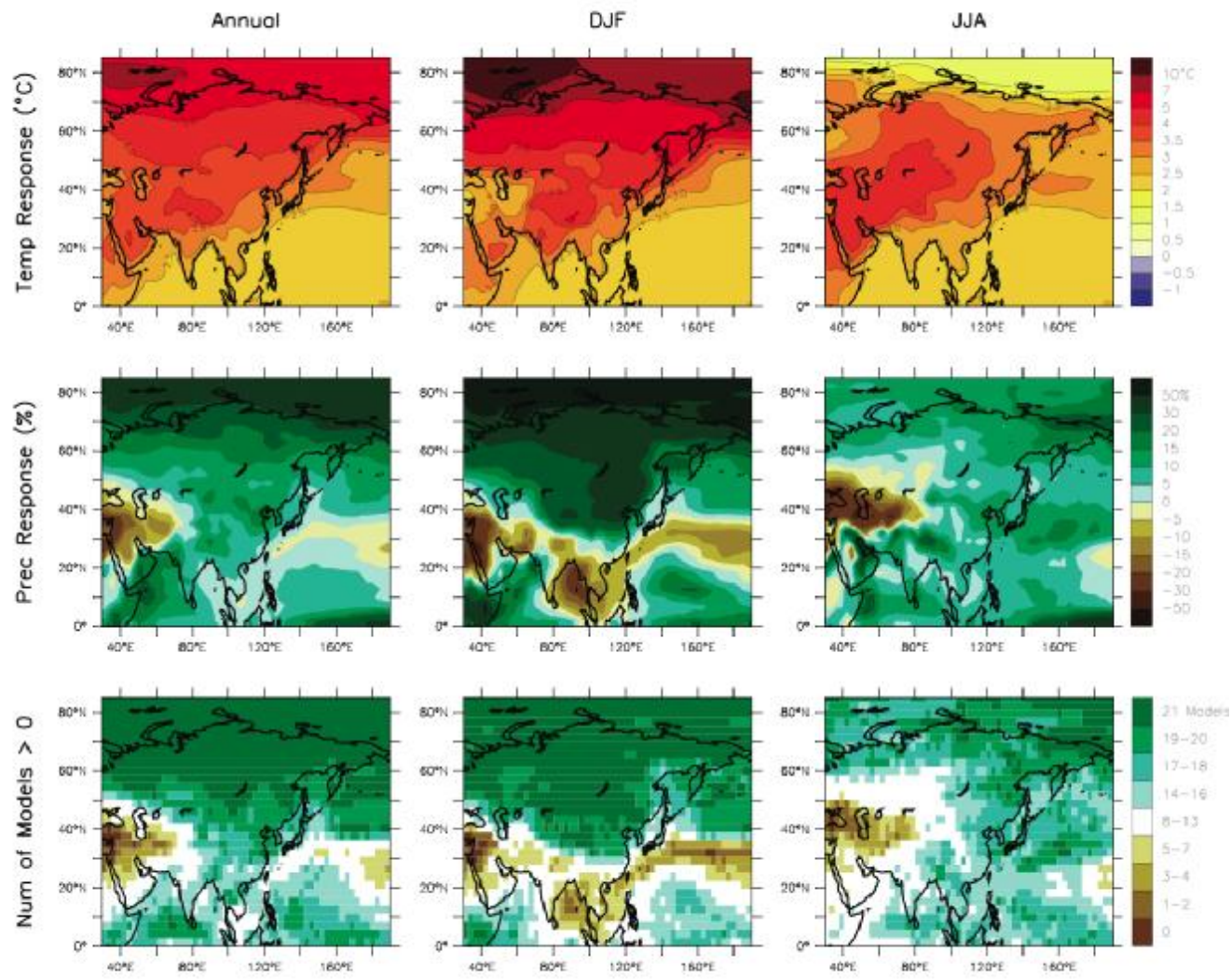


figure 11.9

# How to make regional climate projections?

## Two steps:

- Analyse global climate models
- Convert to the regional situation using regional climate models and observations

Source: KNMI climate change scenarios 2006 for the Netherlands  
([www.knmi.nl](http://www.knmi.nl))

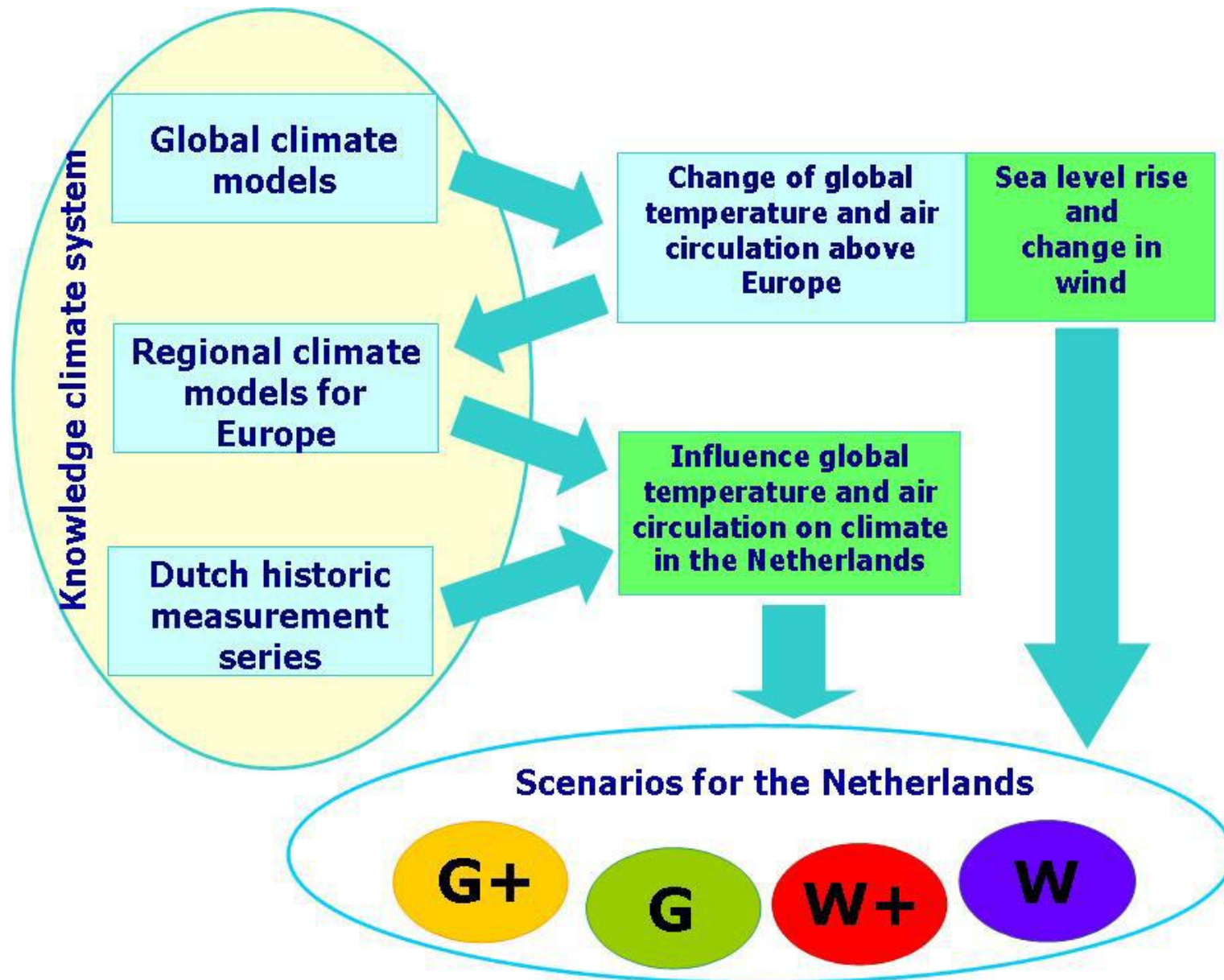
# Communication approach

Intensive collaboration with end users of climate scenarios to search for the relevant parameters needed

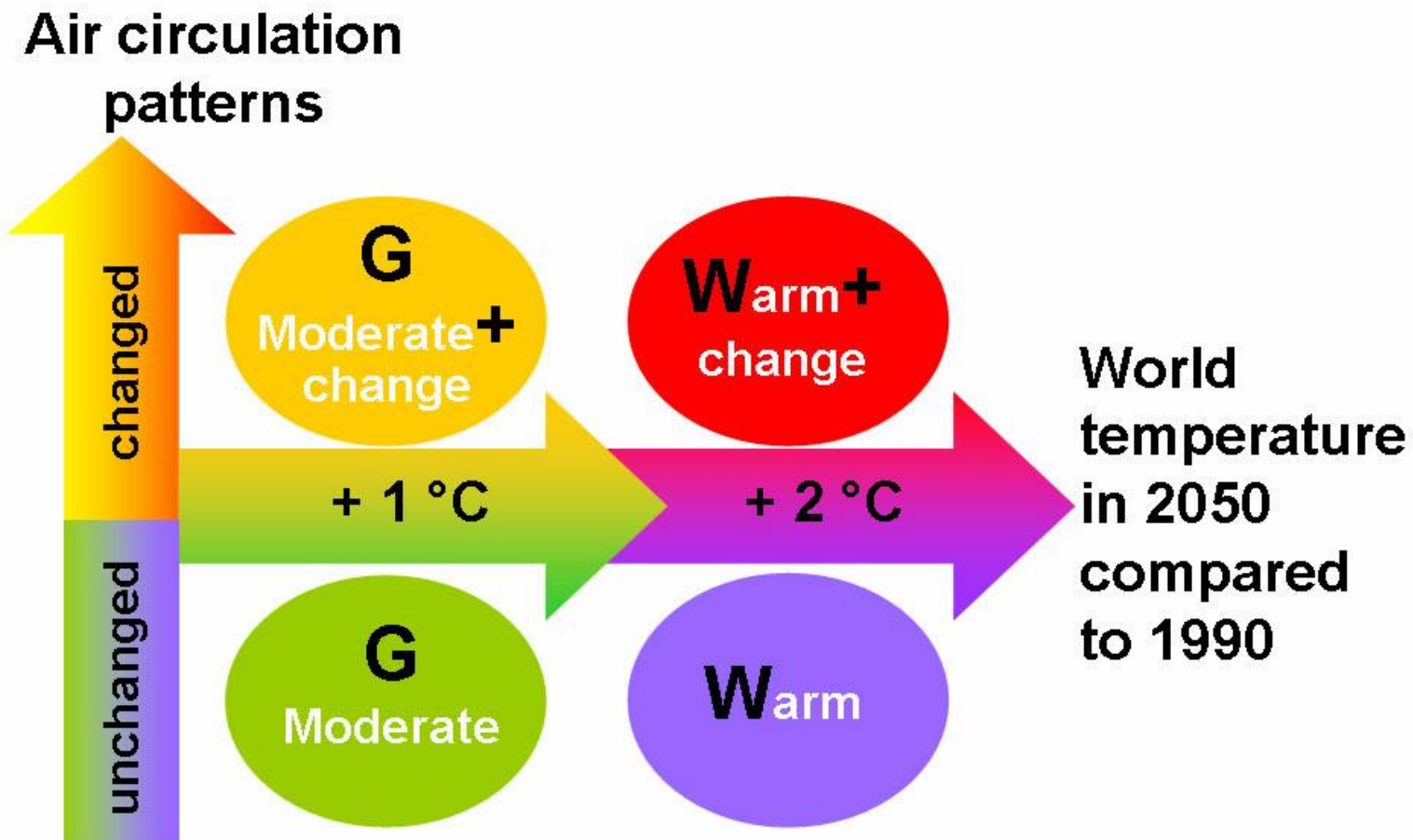
Tailored climate information for many sectors, e.g: water management, coastal defence, agriculture, energy, ecology and tourism



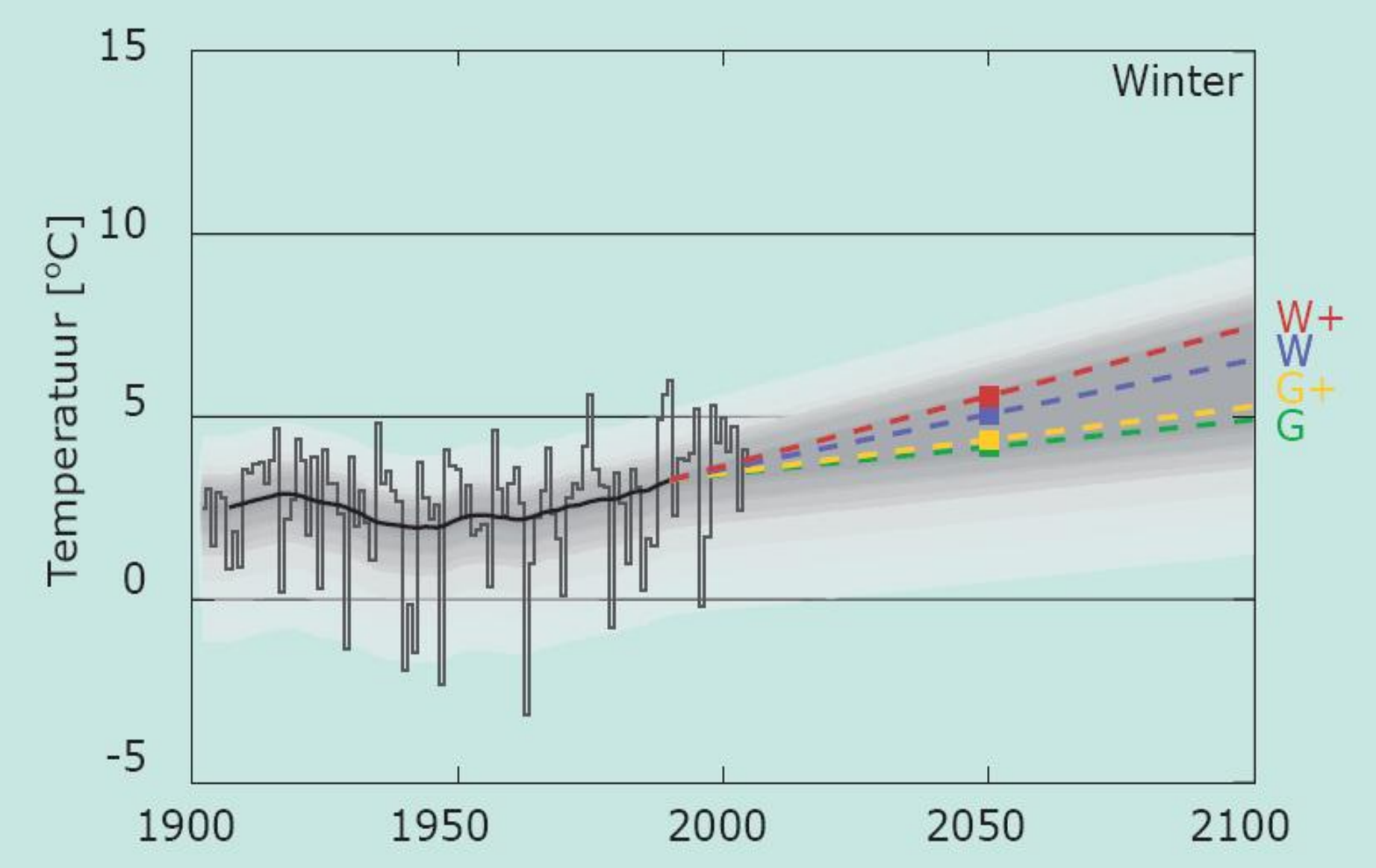
# Translation to the Dutch situation



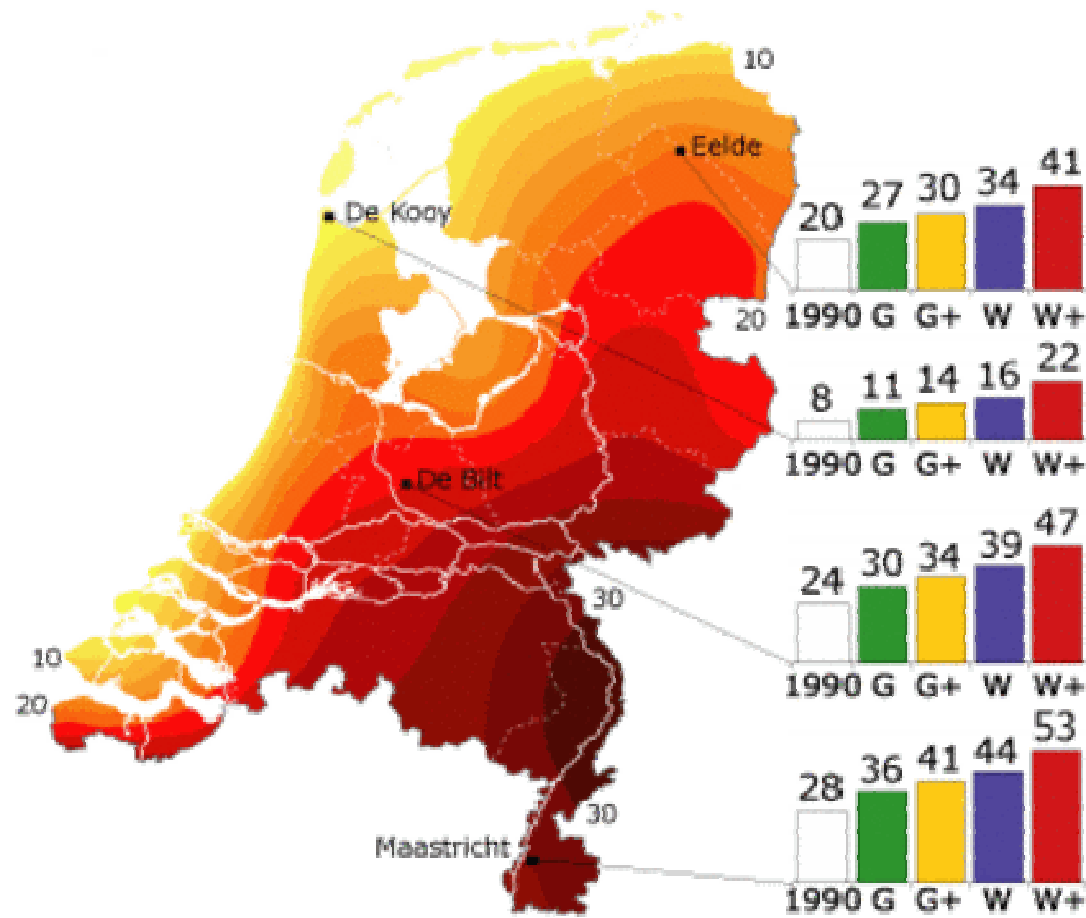
# Two axes; four scenarios



# Average winter temperature in the Netherlands



# Number of days with $T > 25^{\circ}\text{C}$ in 1990 and in 2050 for 4 scenarios and 4 regions



# Summary of Conclusions

**The human influence on climate is now unequivocal**

- **Most of the observed warming over the last 50 years is very likely due to increases in greenhouse gases**
- **Global temperature is projected to increase in the range 1.1 to 6.4 °C in 2100**
- **Implications: precipitation changes, glacier melt and sea level rise, more heat waves, severe droughts**
- **Regional climate scenarios: more than looking at the outcome of climate models and communicating tailored information**

