# Predicting the Future

Intergovernmental Panel on Climate Change

IPCC

www.ipcc.ch

Established 1988

By World Meteorological Organization and
United Nations Environmental Program

IPCC has mission of assessing scientific knowledge on climate change and its mitigation.

1990 – First Assessment Report

1995 – Second Assessment Report

2001 – Third Assessment Report

2007 – Fourth Assessment Report

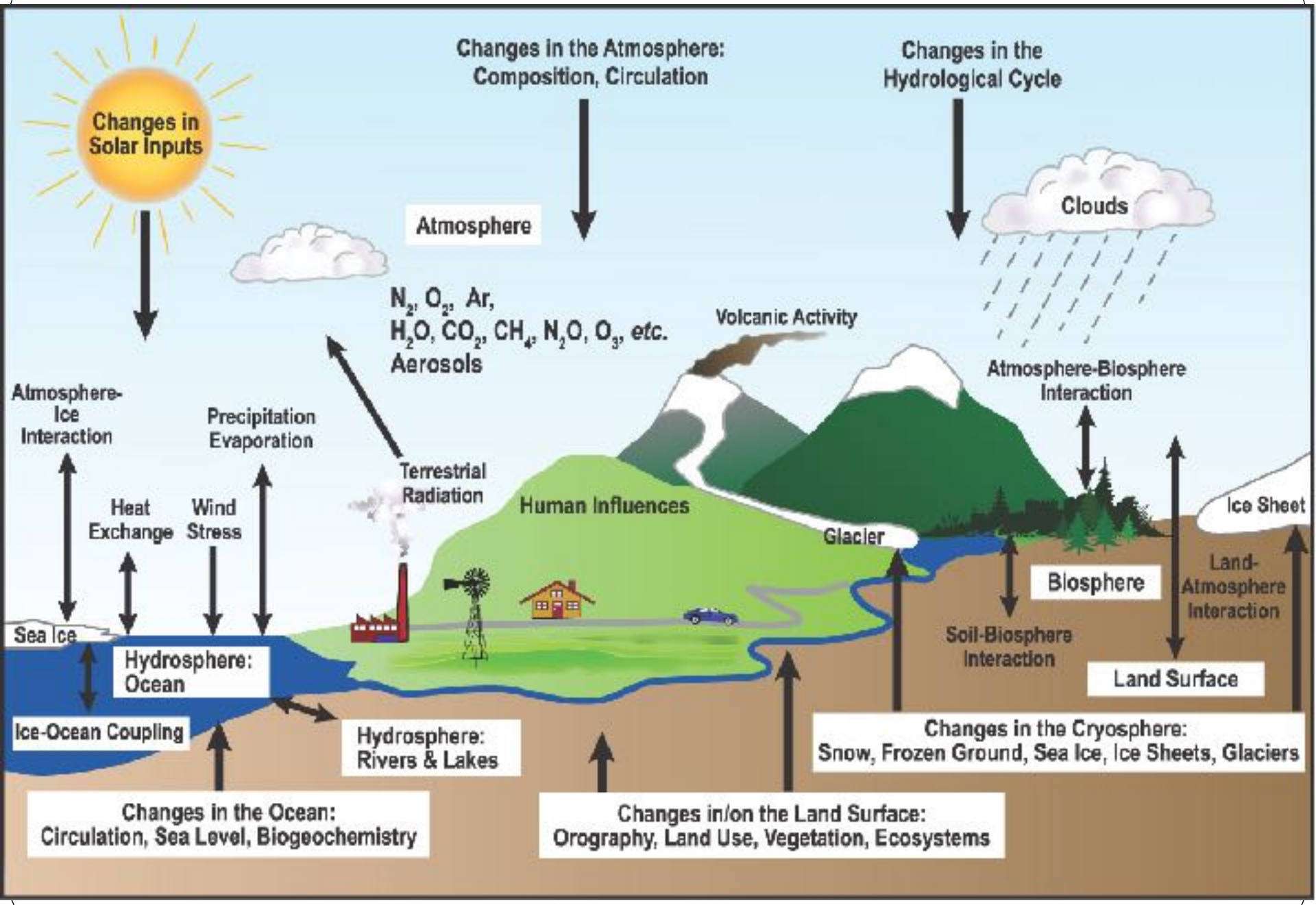
Fourth Assessment Report, 2007
Working Group I, “The Physical Science Basis”

152 coordinating lead authors from over 30 countries
Reviewed by over 600 experts
Approved by officials from 113 governments

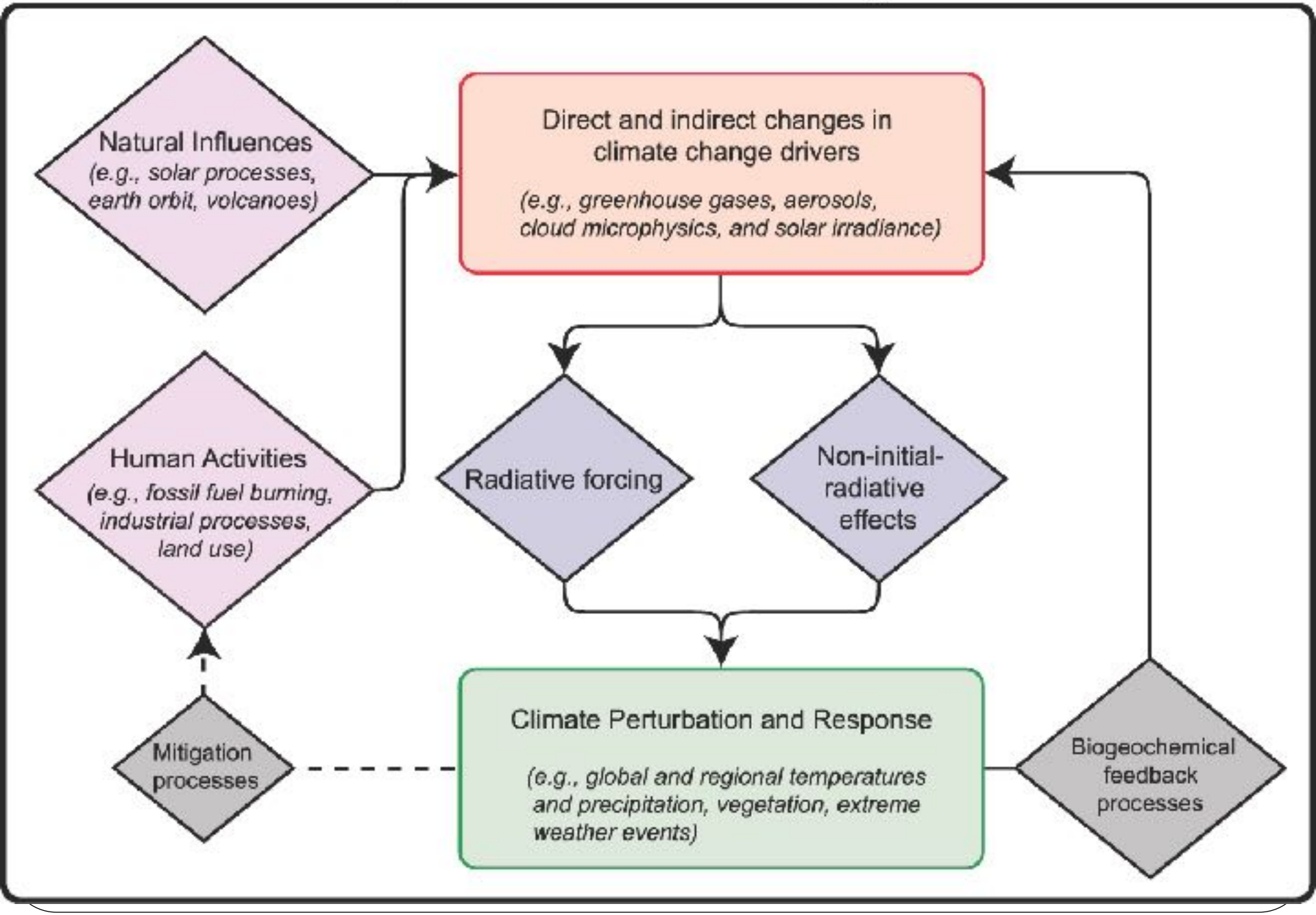
# Atmosphere Ocean General Circulation Models AOGCMs

Three dimensional models (latitude, longitude, and altitude) that couple the atmosphere and oceans

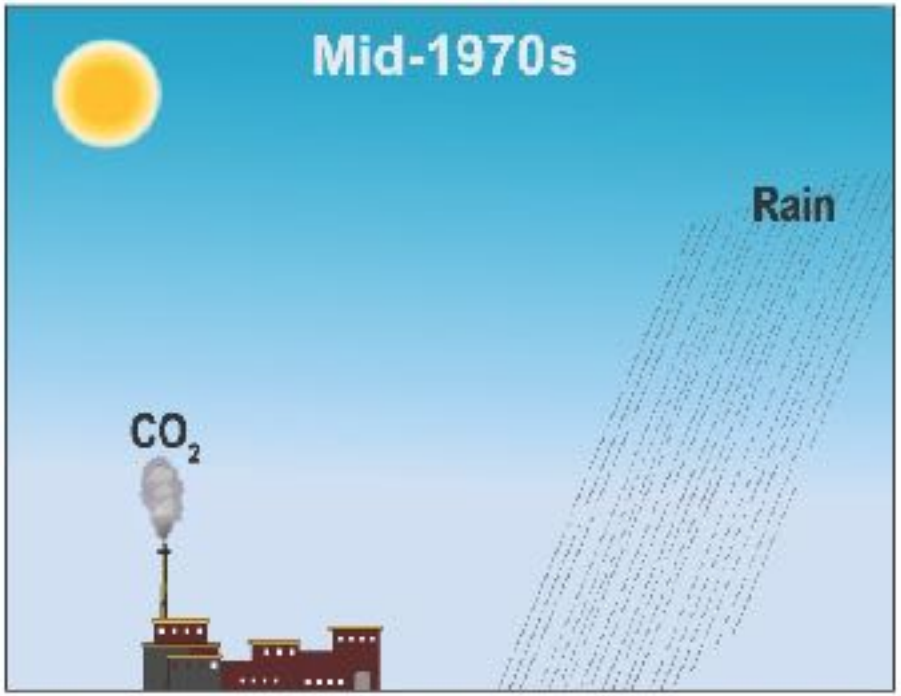
23 AOGCMs used in AR4

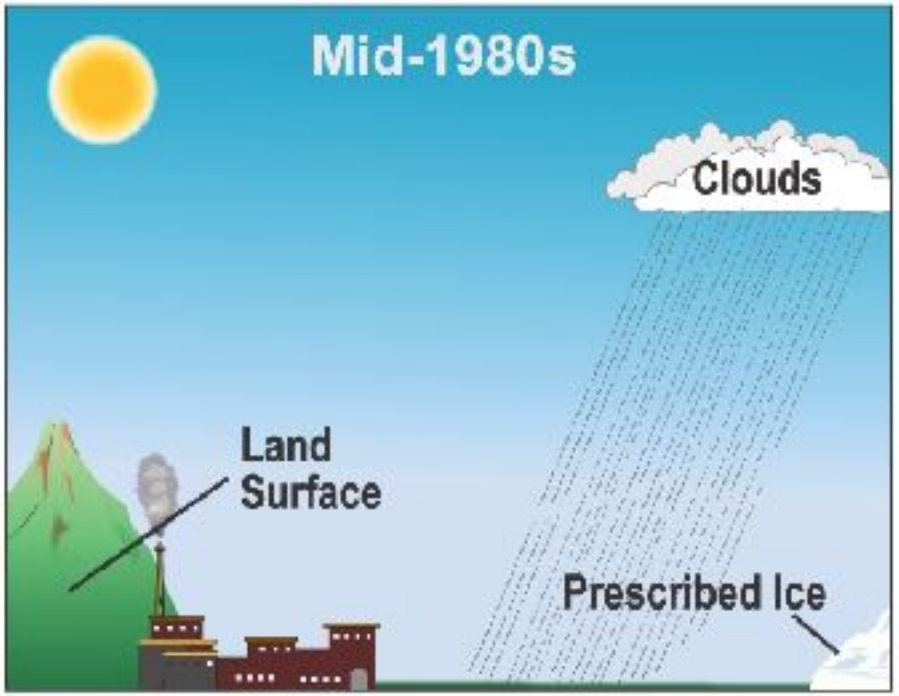

Changes in Solar Inputs
Changes in the Atmosphere: Composition, Circulation
Changes in the Hydrological Cycle
Atmosphere
Clouds
$N_2$, $O_2$, Ar,
$H_2O$, $CO_2$, $CH_4$, $N_2O$, $O_3$, *etc.*
Aerosols
Volcanic Activity
Atmosphere-Biosphere Interaction
Atmosphere-Ice Interaction
Precipitation
Evaporation
Terrestrial Radiation
Heat Exchange
Wind Stress
Human Influences
Glacier
Ice Sheet
Biosphere
Land-Atmosphere Interaction
Sea Ice
Hydrosphere: Ocean
Soil-Biosphere Interaction
Land Surface
Ice-Ocean Coupling
Hydrosphere: Rivers & Lakes
Changes in the Cryosphere: Snow, Frozen Ground, Sea Ice, Ice Sheets, Glaciers
Changes in the Ocean: Circulation, Sea Level, Biogeochemistry
Changes in/on the Land Surface: Orography, Land Use, Vegetation, Ecosystems

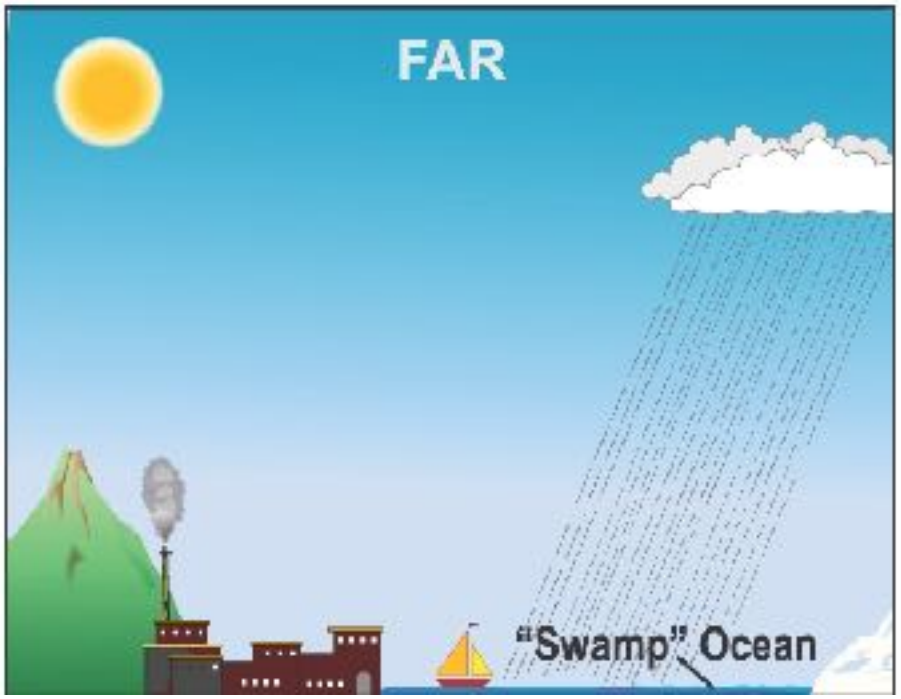
# Components of the Climate Change Process

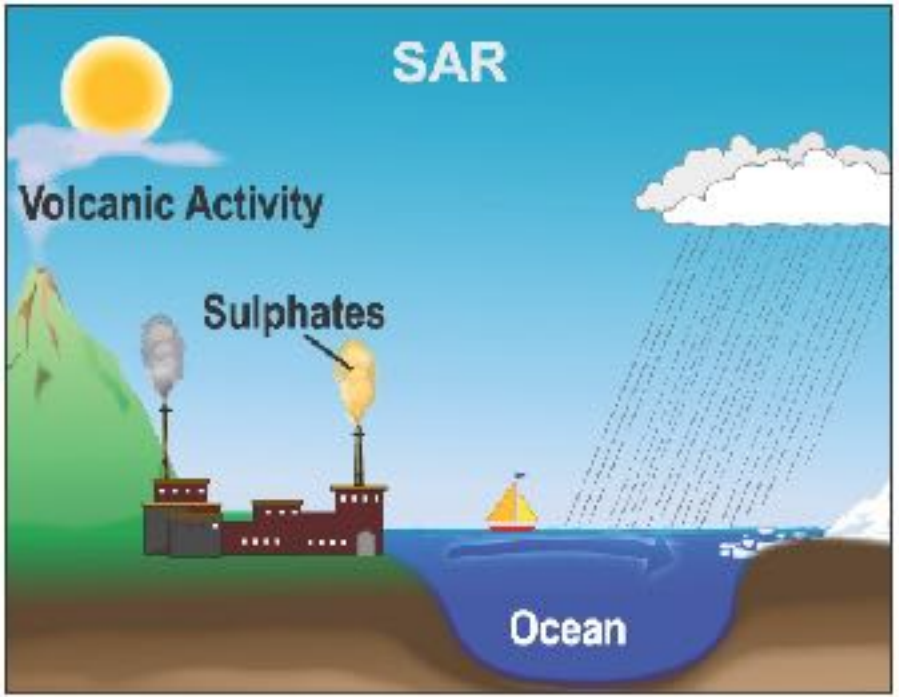


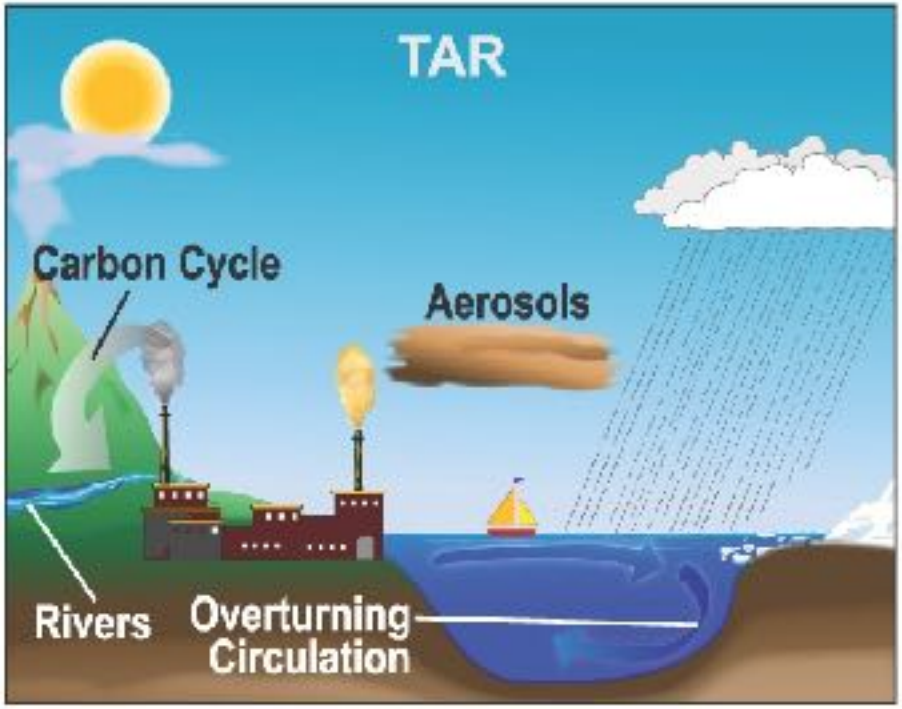
# The World in Global Climate Models

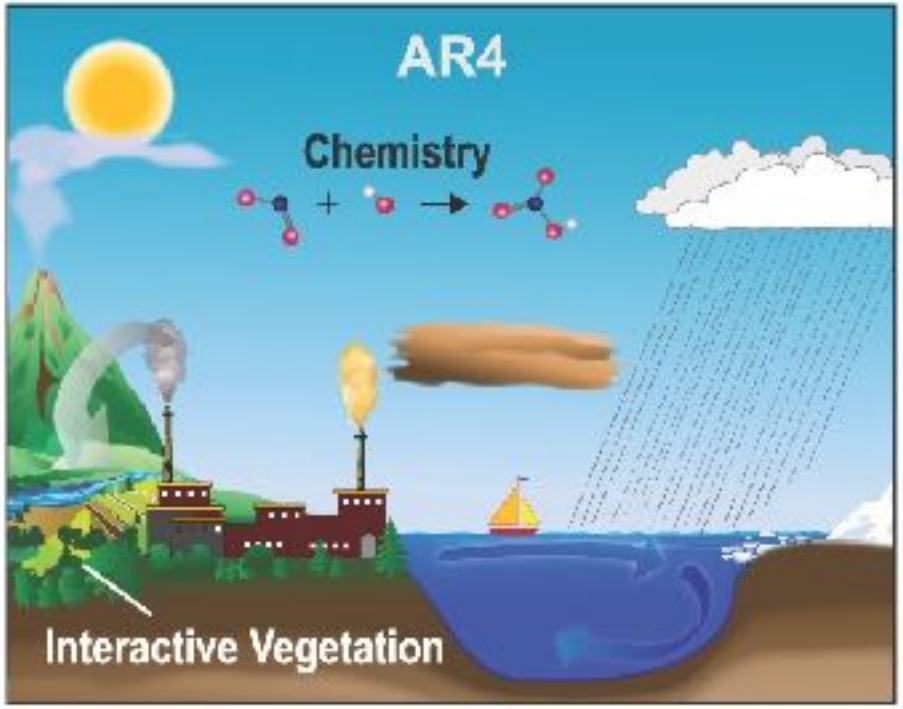


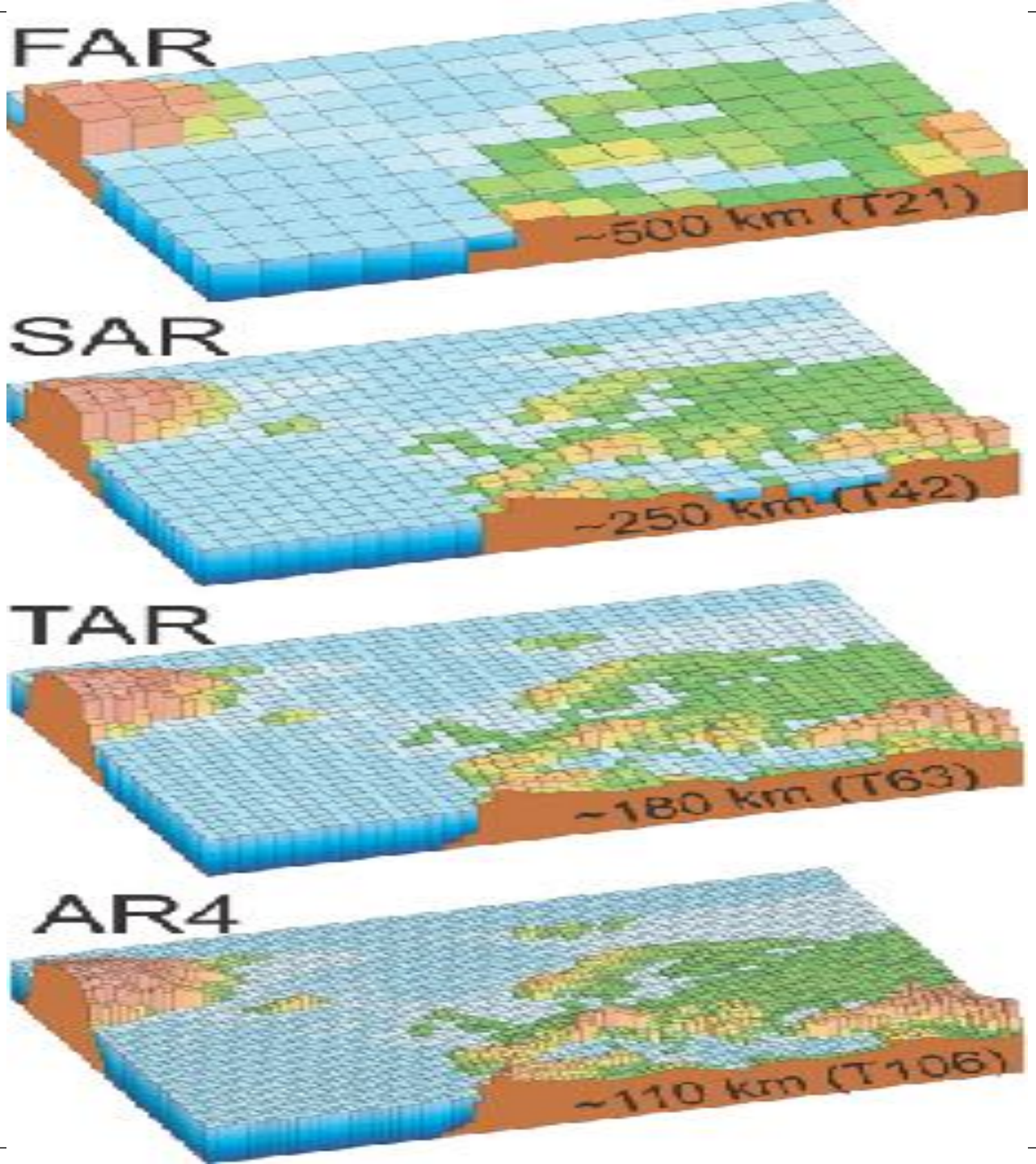




FAR
"Swamp" Ocean


SAR
Volcanic Activity
Sulphates
Ocean


TAR
Carbon Cycle
Aerosols
Rivers
Overturning
Circulation


AR4
Chemistry
Interactive Vegetation


FAR
~500 km (T21)
SAR
~250 km (T42)
TAR
~180 km (T63)
AR4
~110 km (T106)

Figures for Slides 8 through 13 from the IPCC Fourth Assessment Report, “Physical Science Basis”

# How accurate are the models?

June 1991 – Mt. Pinatubo erupted in the Phillippines

Millions of tons of $SO_2$ were spewed into the stratosphere where they stayed for several years.

Sulfate aerosols formed that reflected more sunlight than normal

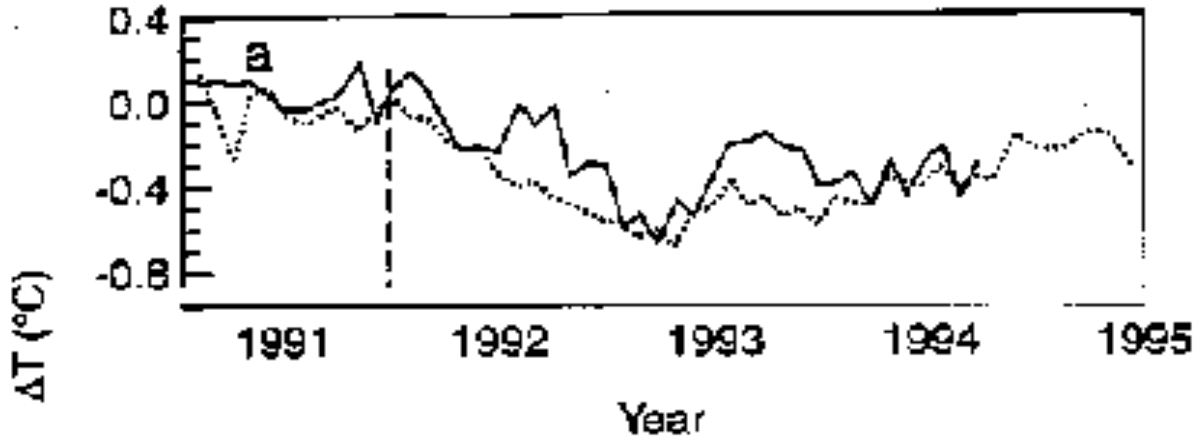
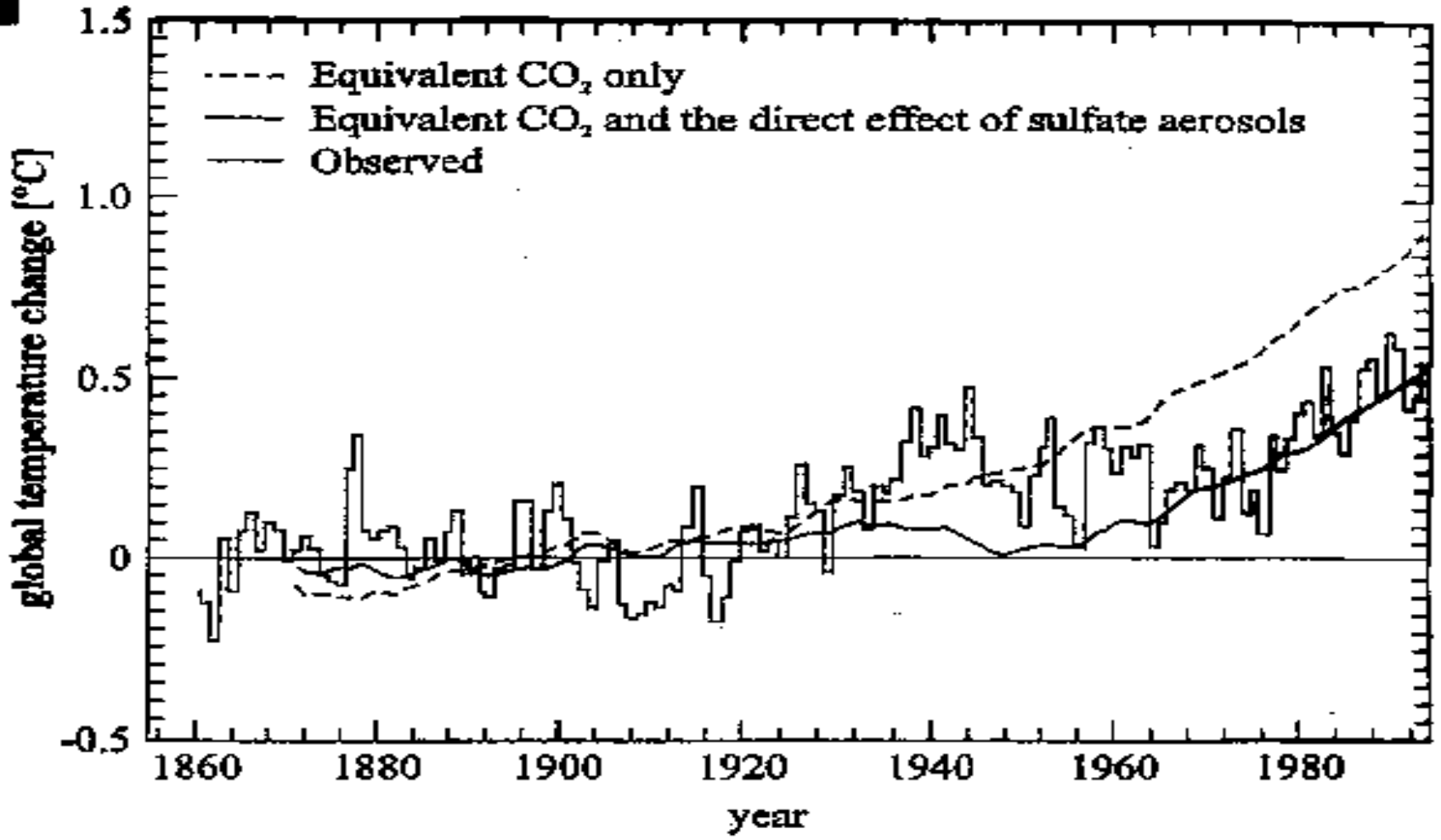
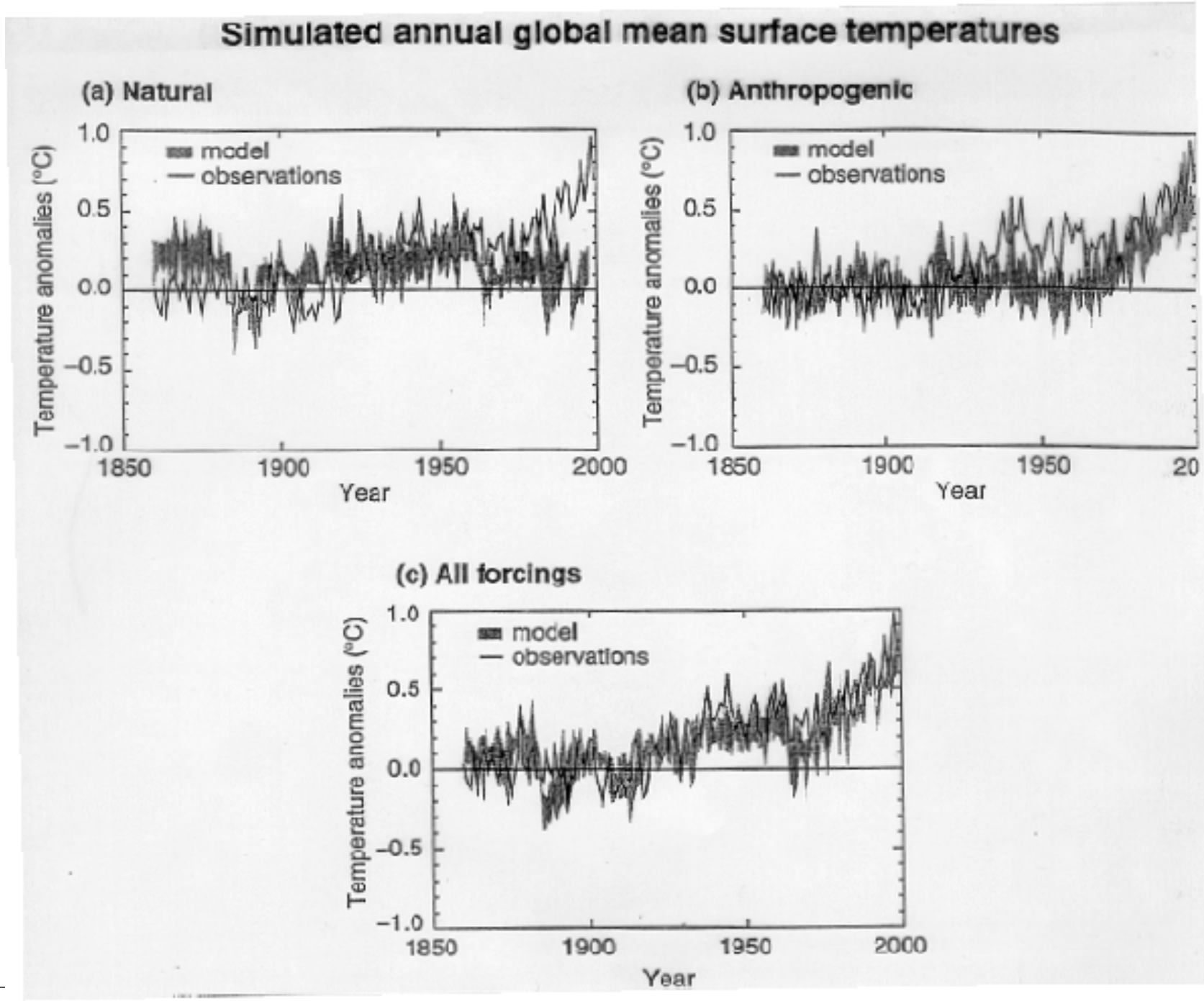



FIGURE 14.30 Measured (—) and model-predicted (···) change in monthly mean temperatures at the earth's surface

GCM calculations in late 1991 predicted the cool winters of 1993 and 1994




0C is average temperature from 1880 – 1920. The step function is from measurements.

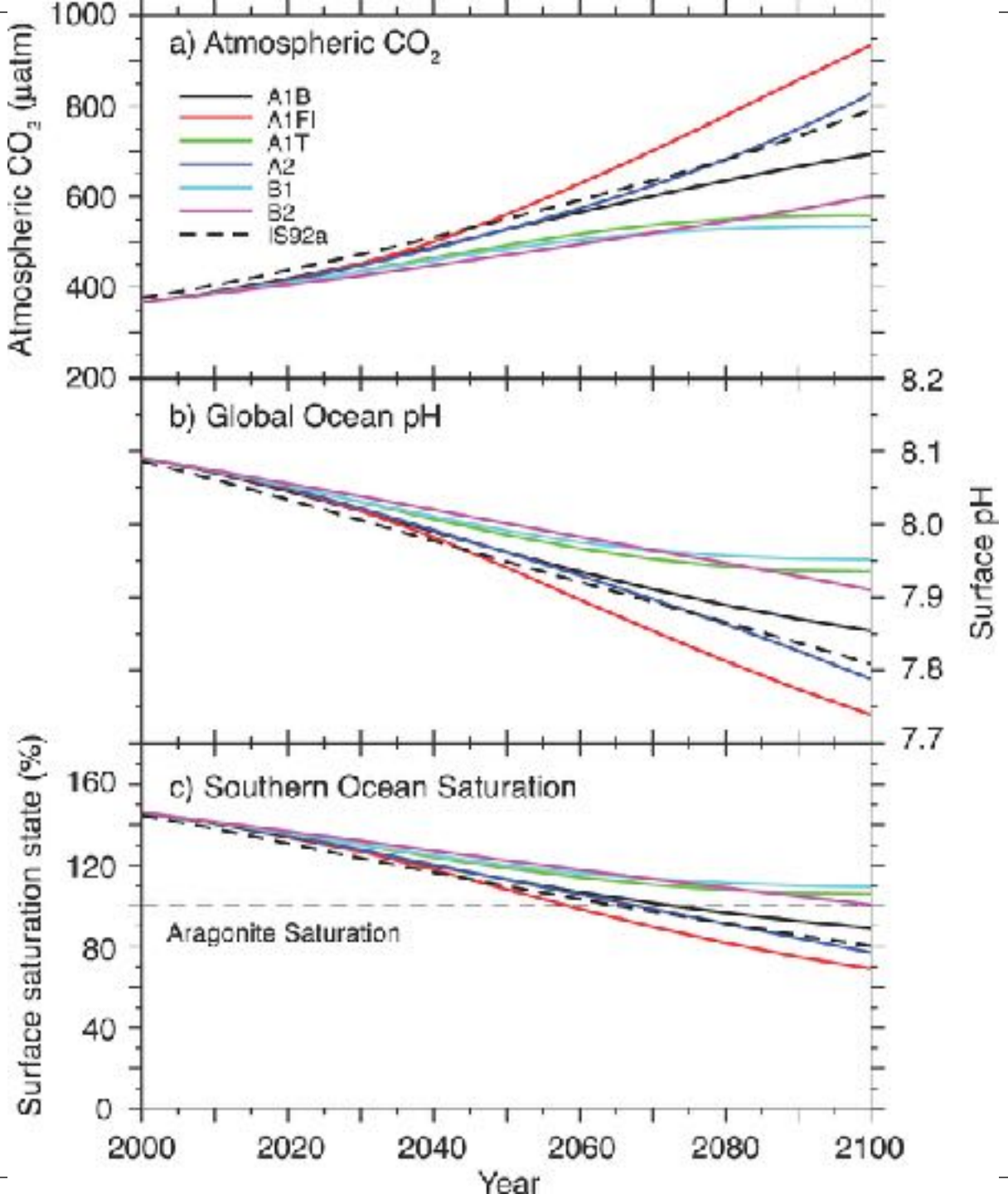

Simulated annual global mean surface temperatures
(a) Natural
(b) Anthropogenic
(c) All forcings
model
observations
Temperature anomalies (°C)
Year
1.0
0.5
0.0
−0.5
−1.0
1850
1900
1950
2000

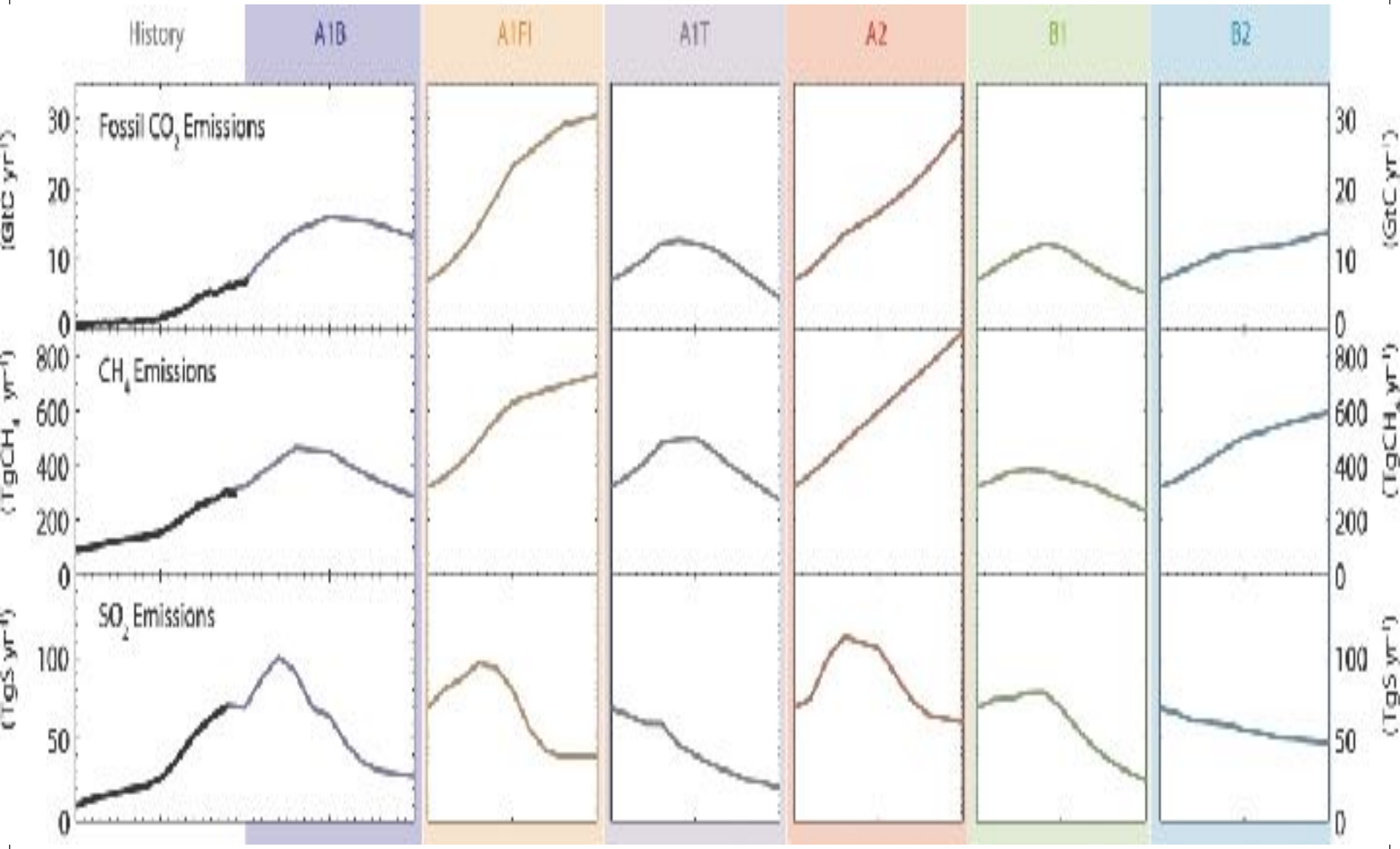
# What is the greatest uncertainty for modeling climate change in the future?

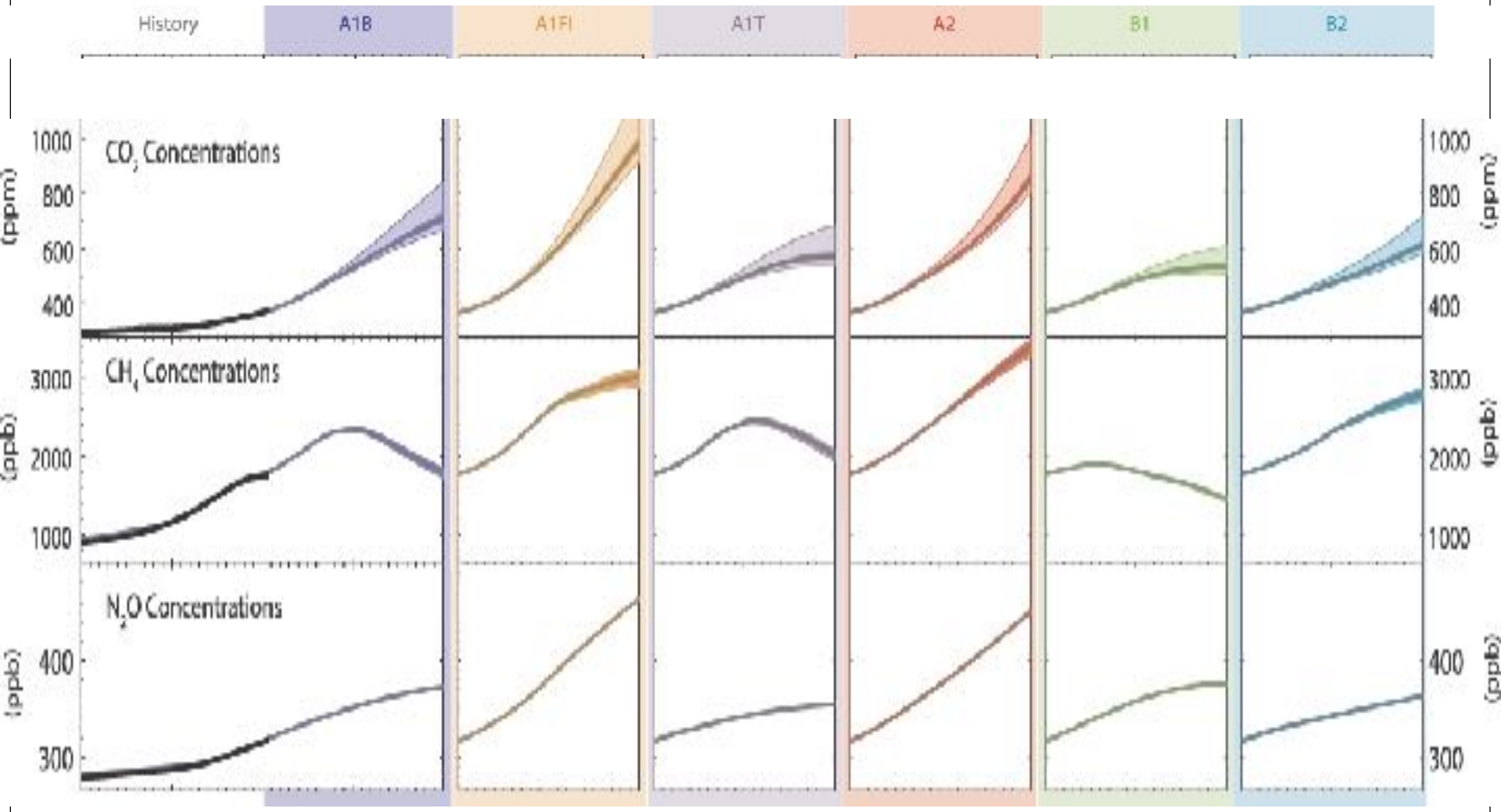
How we humans will behave in the future?

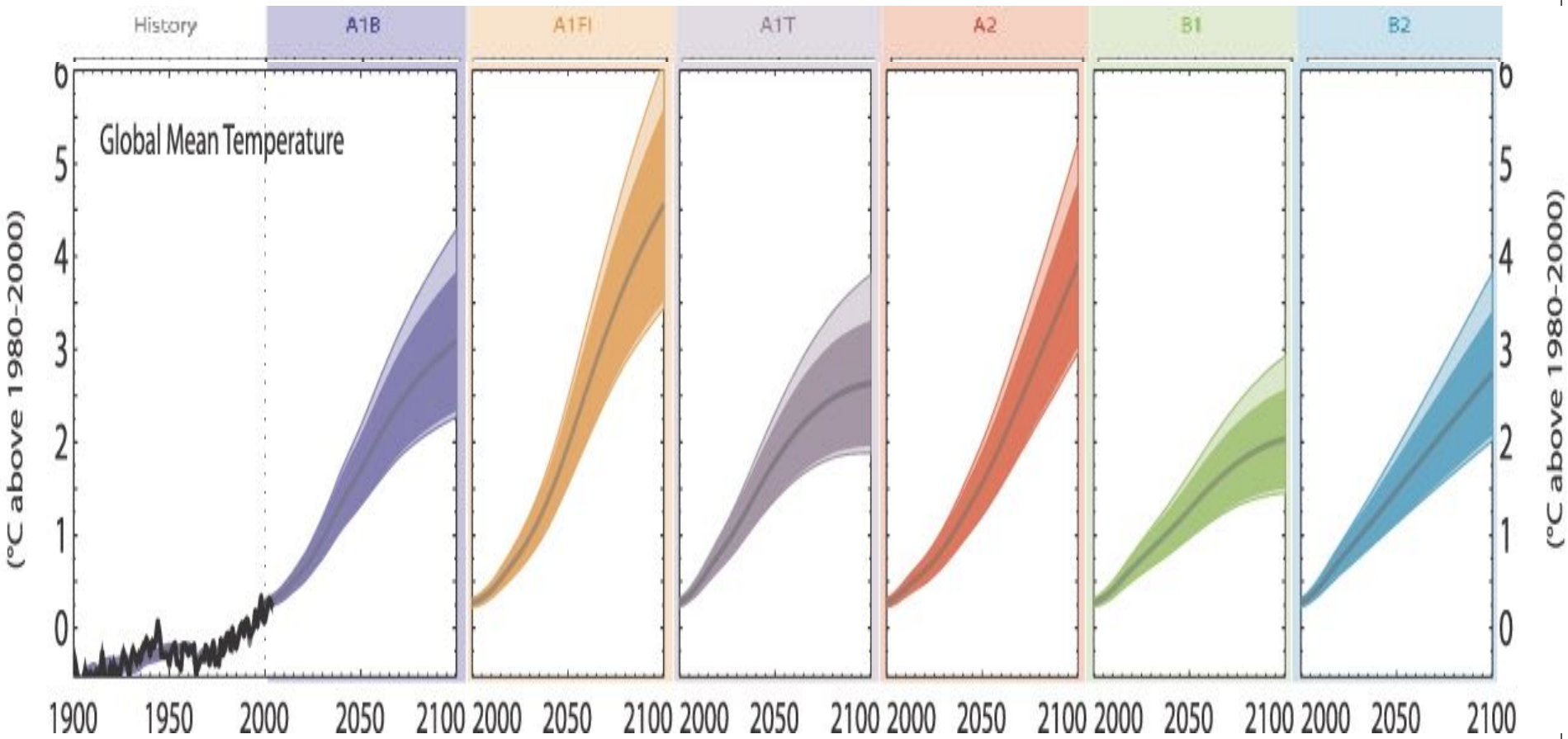
To take this into account, the IPCC uses several **scenarios**

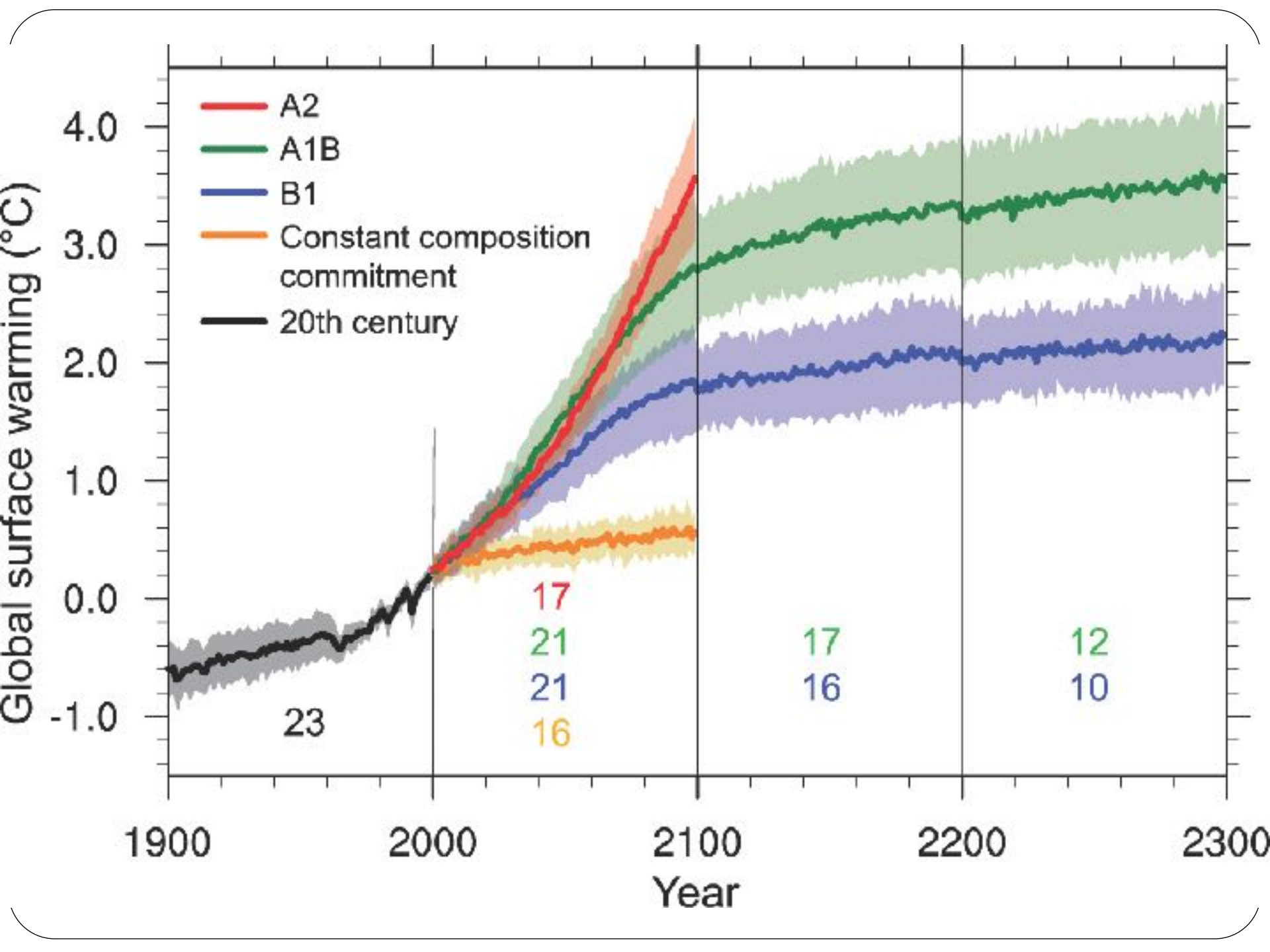
| | ECONOMY | POPULATION | TECHNOLOGY |
|---|---|---|---|
| A1F1 | Rapid growth | Peaks in 2050 and declines | Fossil intensive |
| A1T | " | " | Non-fossil energy |
| A1B | " | " | Balanced fossil and non-fossil |
| A2 | Local solutions Slow growth | Continuously increasing | Slowly changing |
| B1 | Global solutions Service & information | Peaks in 2050 and declines | Clean and resource efficient energy |
| B2 | Local solutions Intermediate growth | Continuously increasing, < A2 | Slow change |

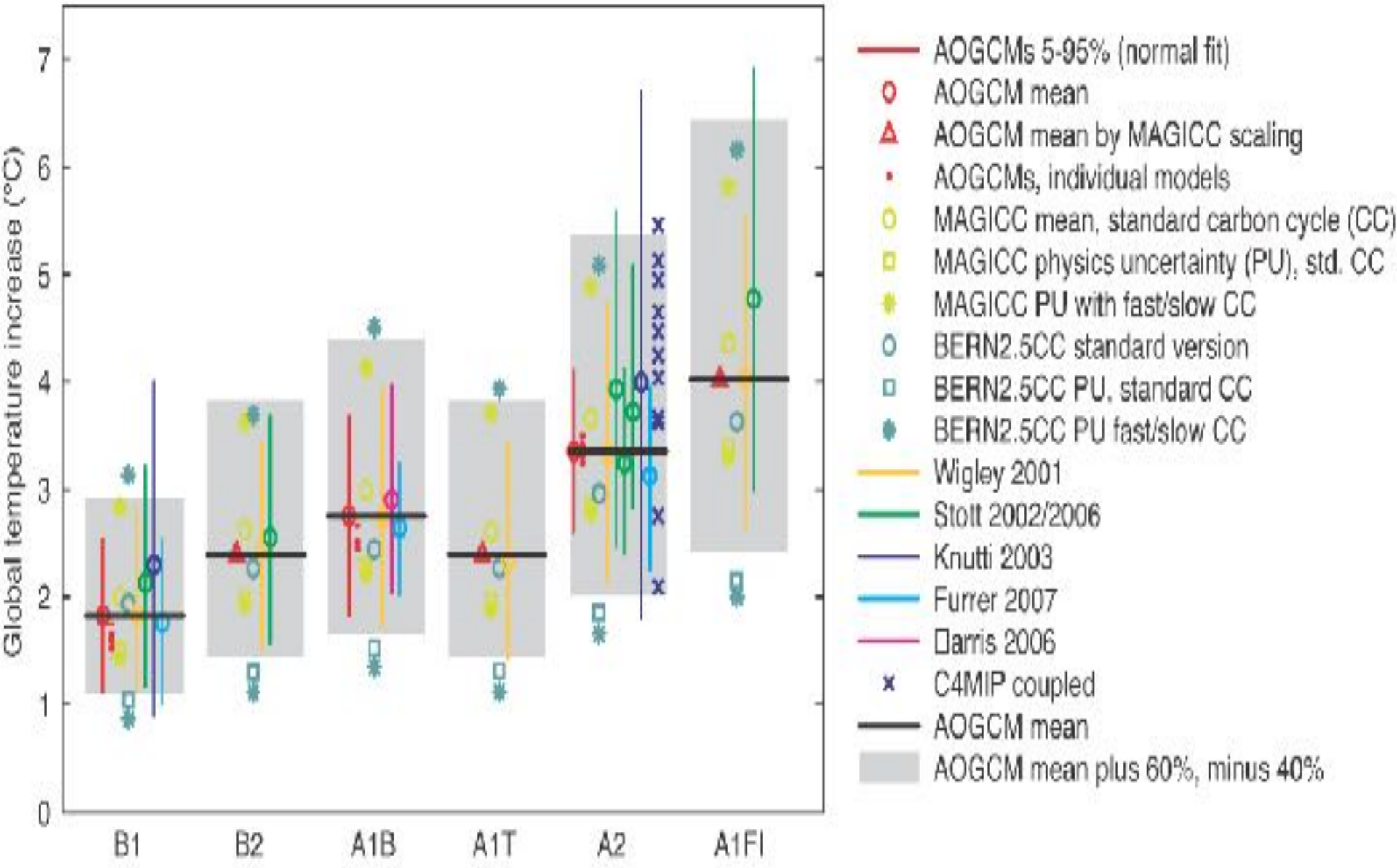

a) Atmospheric $CO_2$
A1B
A1FI
A1T
A2
B1
B2
IS92a
Atmospheric $CO_2$ (µatm)
1000
800
600
400
200
b) Global Ocean pH
8.2
8.1
8.0
7.9
7.8
7.7
Surface pH
c) Southern Ocean Saturation
Aragonite Saturation
Surface saturation state (%)
160
120
80
40
0
2000
2020
2040
2060
2080
2100
Year

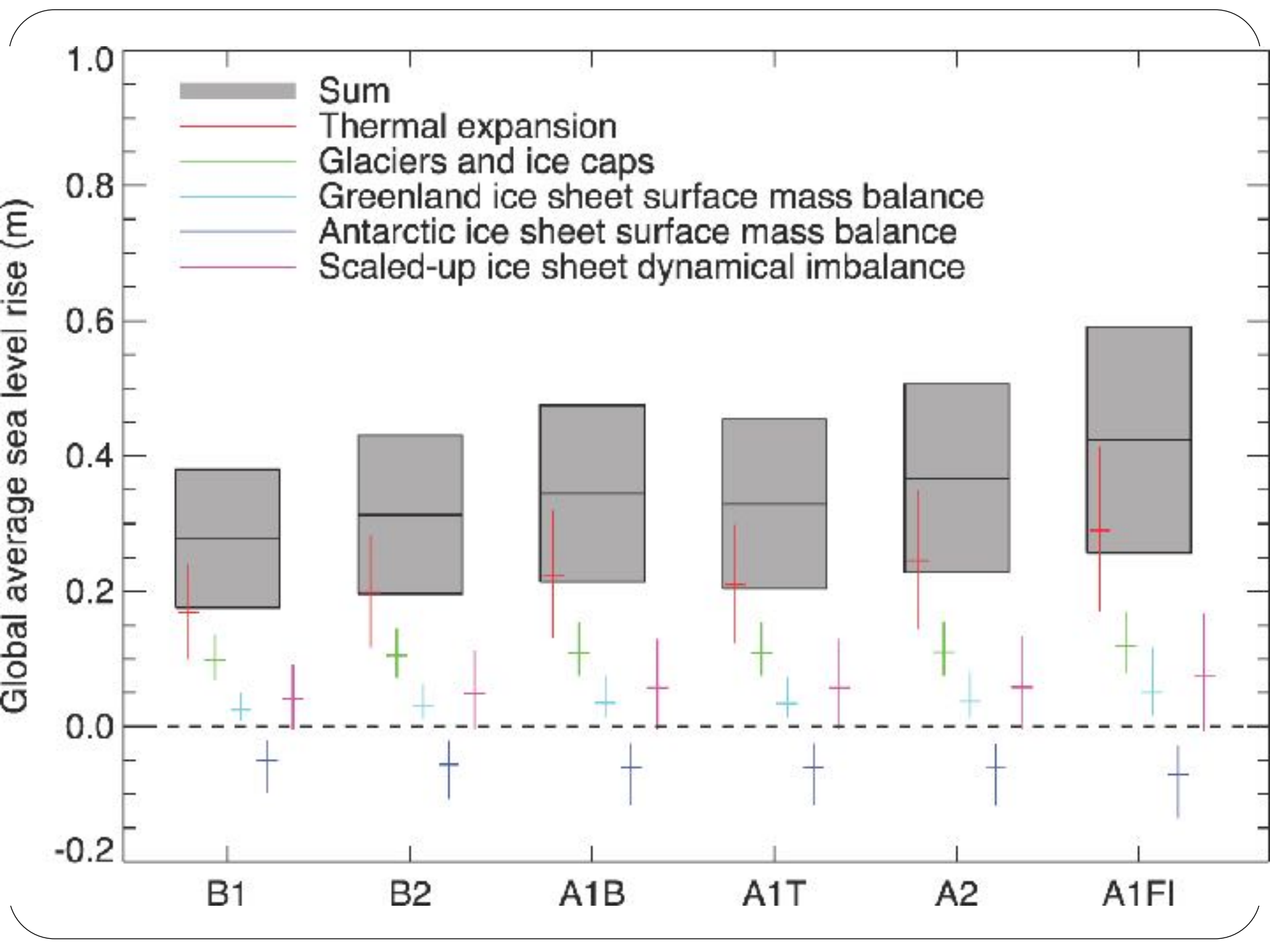

History
A1B
A1FI
A1T
A2
B1
B2
Fossil $CO_2$ Emissions
$CH_4$ Emissions
$SO_2$ Emissions
30
20
10
0
800
600
400
200
0
100
50
0
(GtC yr⁻¹)
(TgCH₄ yr⁻¹)
(TgS yr⁻¹)

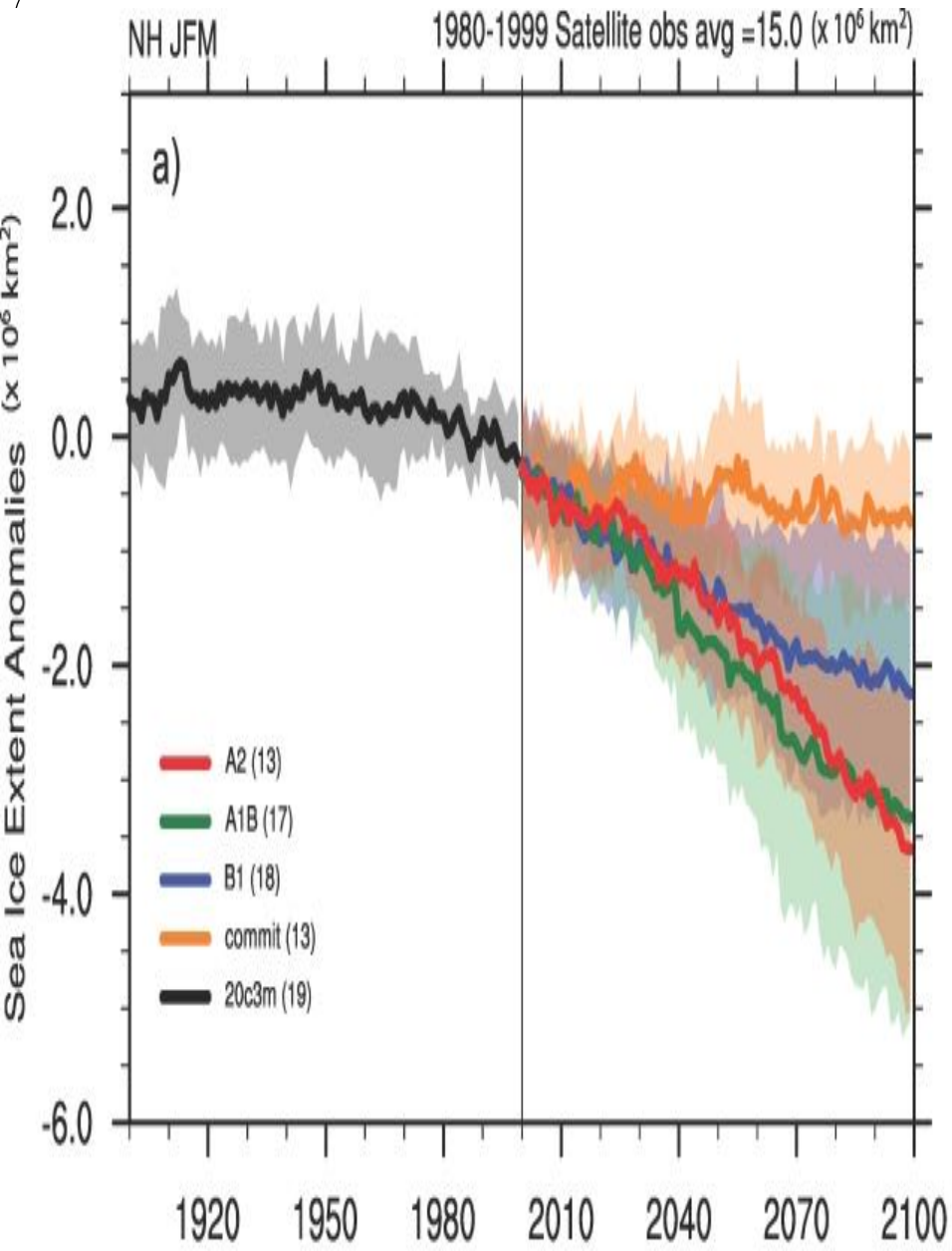

History
A1B
A1FI
A1T
A2
B1
B2
CO2 Concentrations
(ppm)
1000
800
600
400
CH4 Concentrations
(ppb)
3000
2000
1000
N2O Concentrations
(ppb)
400
300

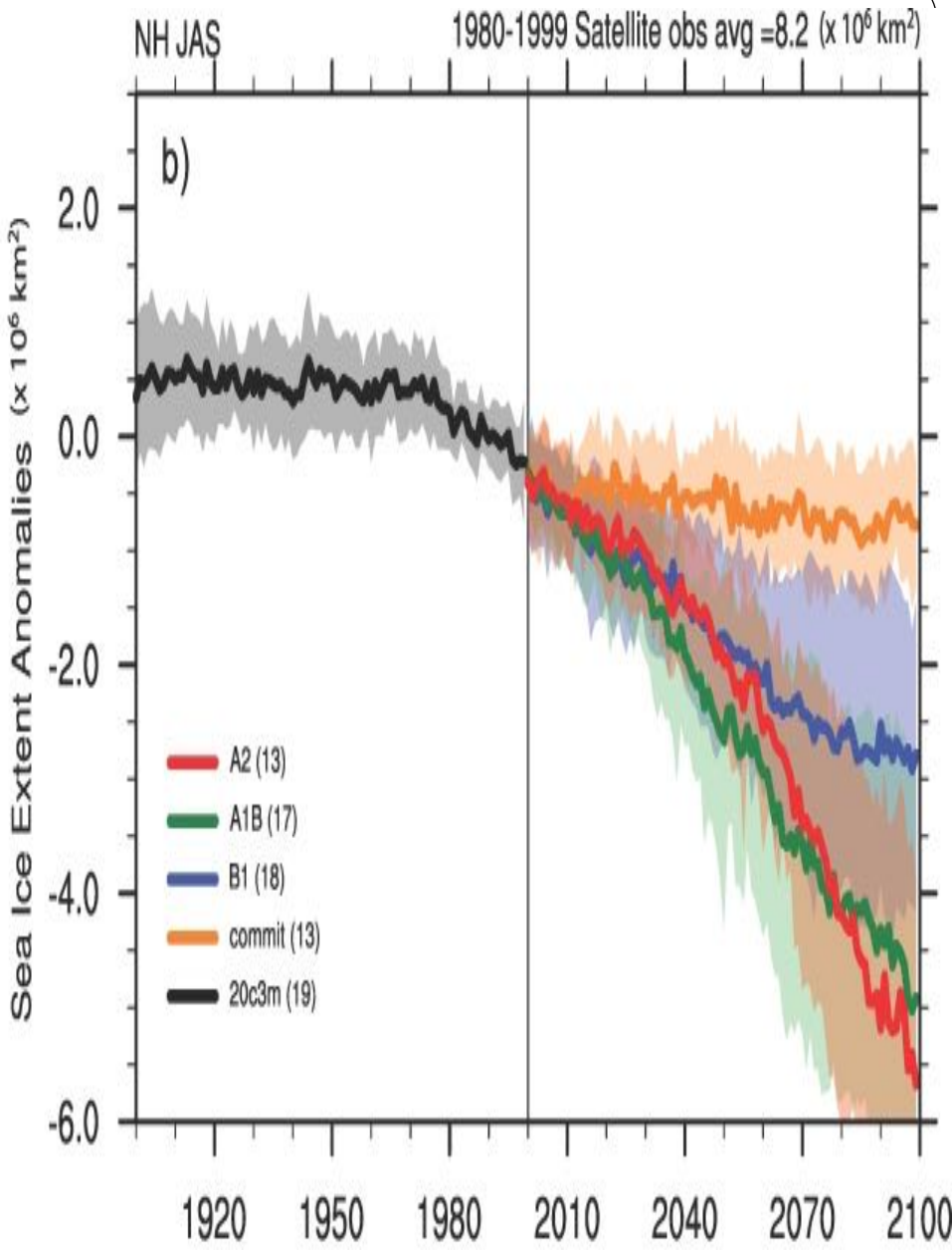

History
A1B
A1FI
A1T
A2
B1
B2
Global Mean Temperature
(°C above 1980-2000)
0
1
2
3
4
5
6
1900
1950
2000
2050
2100

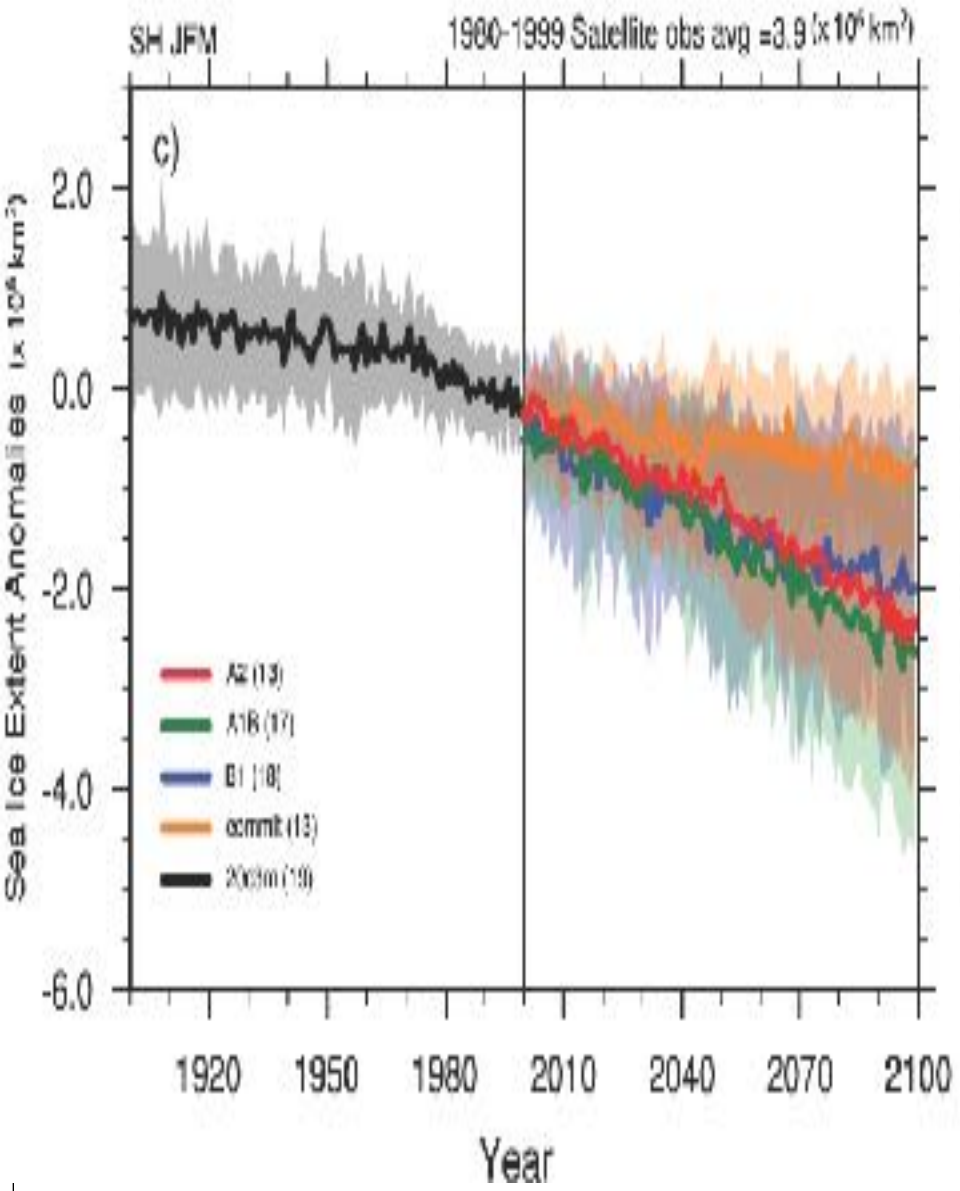

A2
A1B
B1
Constant composition commitment
20th century
Global surface warming (°C)
4.0
3.0
2.0
1.0
0.0
-1.0
23
17
21
21
16
17
16
12
10
1900
2000
2100
2200
2300
Year

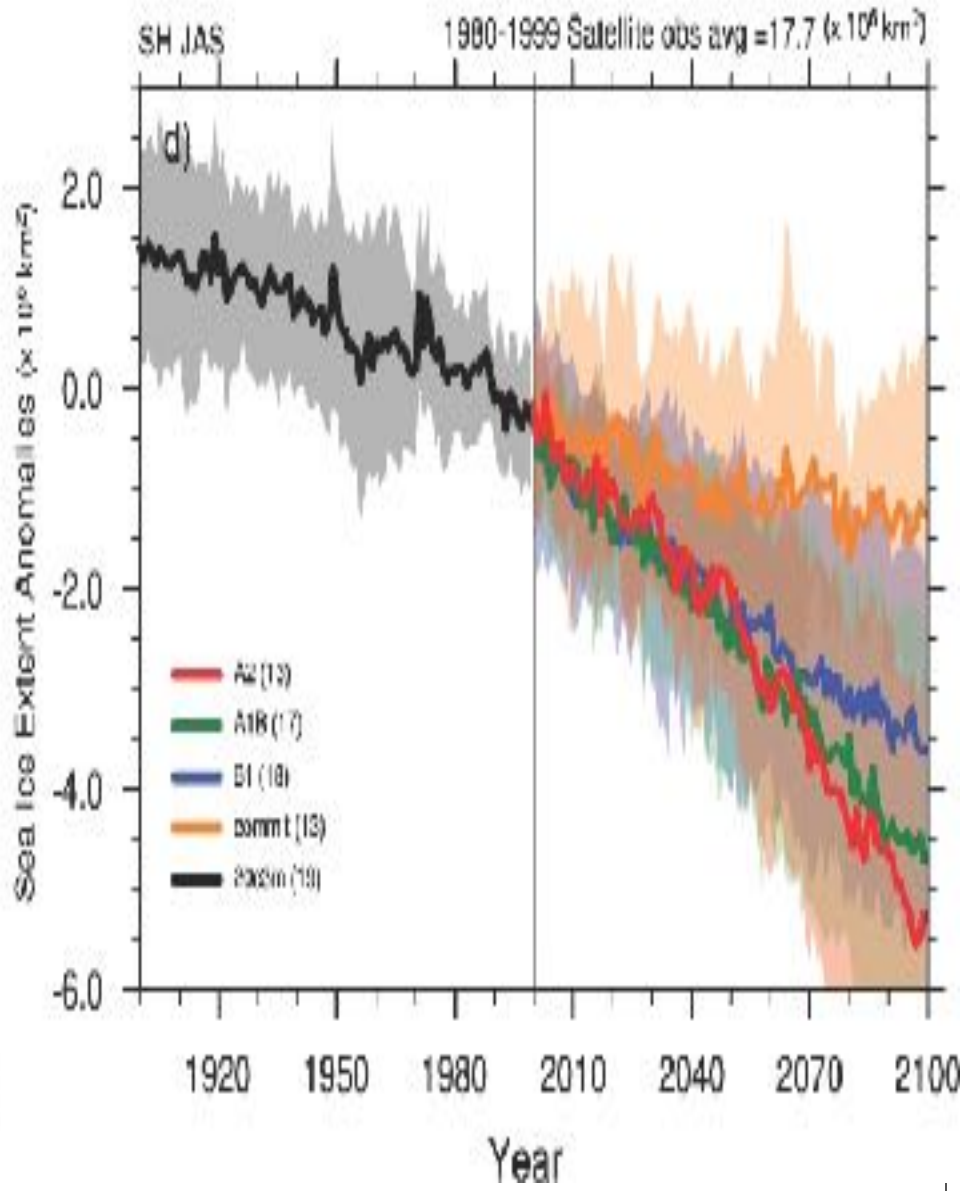

Global temperature increase (°C)
0
1
2
3
4
5
6
7
B1
B2
A1B
A1T
A2
A1FI
AOGCMs 5-95% (normal fit)
AOGCM mean
AOGCM mean by MAGICC scaling
AOGCMs, individual models
MAGICC mean, standard carbon cycle (CC)
MAGICC physics uncertainty (PU), std. CC
MAGICC PU with fast/slow CC
BERN2.5CC standard version
BERN2.5CC PU, standard CC
BERN2.5CC PU fast/slow CC
Wigley 2001
Stott 2002/2006
Knutti 2003
Furrer 2007
arris 2006
C4MIP coupled
AOGCM mean
AOGCM mean plus 60%, minus 40%


Sum
Thermal expansion
Glaciers and ice caps
Greenland ice sheet surface mass balance
Antarctic ice sheet surface mass balance
Scaled-up ice sheet dynamical imbalance
Global average sea level rise (m)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
B1
B2
A1B
A1T
A2
A1FI


NH JFM
1980-1999 Satellite obs avg =15.0 (x 10⁶ km²)
a)
Sea Ice Extent Anomalies (x 10⁶ km²)
2.0
0.0
-2.0
-4.0
-6.0
1920
1950
1980
2010
2040
2070
2100
A2 (13)
A1B (17)
B1 (18)
commit (13)
20c3m (19)


NH JAS
1980-1999 Satellite obs avg =8.2 (x 10⁶ km²)
b)
Sea Ice Extent Anomalies (x 10⁶ km²)
2.0
0.0
-2.0
-4.0
-6.0
1920
1950
1980
2010
2040
2070
2100
A2 (13)
A1B (17)
B1 (18)
commit (13)
20c3m (19)


SH JFM
1980-1999 Satellite obs avg =3.9 (x 10⁶ km²)
c)
Sea Ice Extent Anomalies (x 10⁶ km²)
2.0
0.0
-2.0
-4.0
-6.0
1920
1950
1980
2010
2040
2070
2100
Year
A2 (13)
A1B (17)
B1 (18)
commit (13)
20c3m (19)


SH JAS
1980-1999 Satellite obs avg =17.7 (x 10⁶ km²)
d)
Sea Ice Extent Anomalies (x 10⁶ km²)
2.0
0.0
-2.0
-4.0
-6.0
1920
1950
1980
2010
2040
2070
2100
Year
A2 (13)
A1B (17)
B1 (18)
commit (13)
20c3m (19)

Figures for Slides 22 through 28 from the IPCC Fourth Assessment Report, “Physical Science Basis”