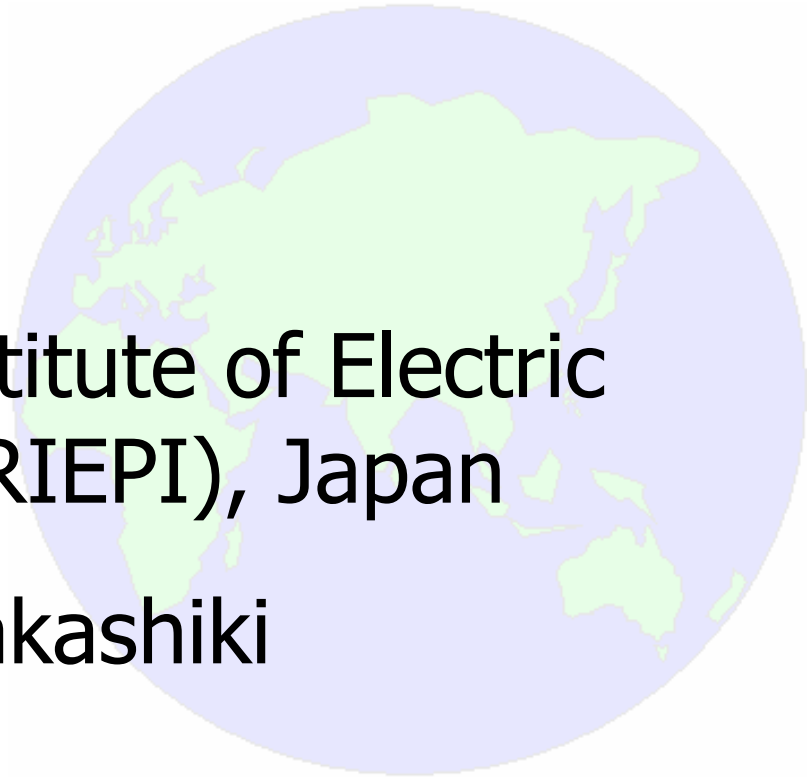
Projection of Global Warming

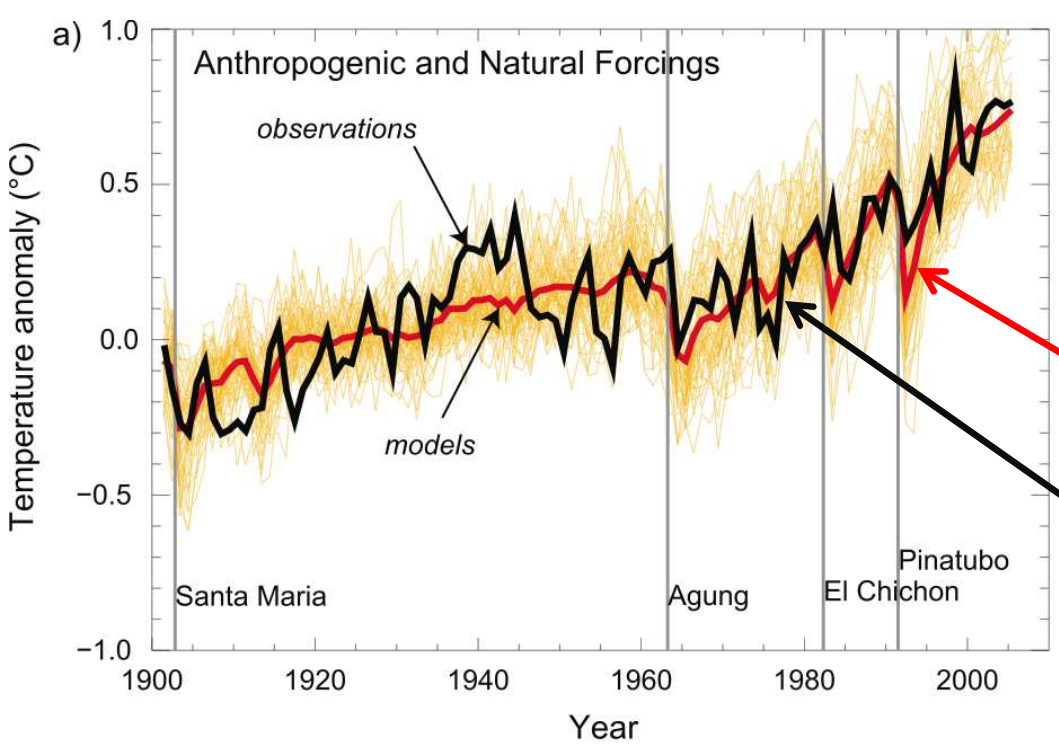
(IPCC-AR4 & CRIEPI Study)



Central Research Institute of Electric Power Industry (CRIEPI), Japan

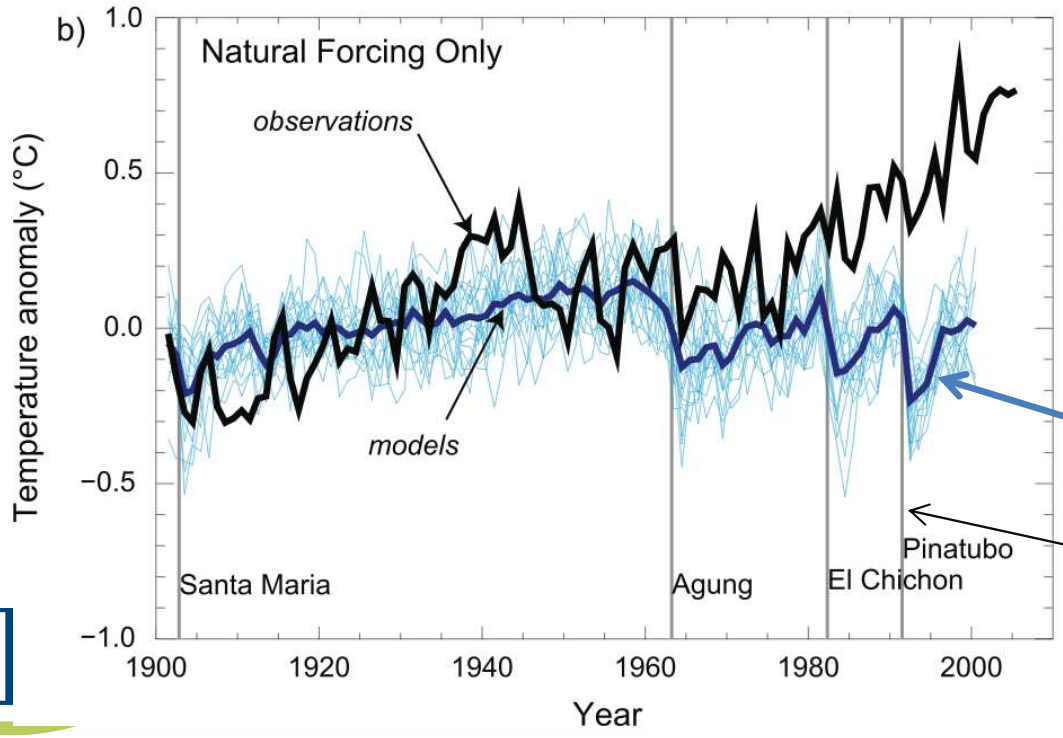
Norikazu Nakashiki

Global mean surface temperature anomalies
in 20th century



Multi-model ensemble with both *anthropogenic and natural forcings*

Observed (black line)



Most of the observed increase in global average temperatures since the mid-20th century is **very likely due to the observed increase in anthropogenic greenhouse gas concentrations**.

Multi-model ensemble with *natural forcings only*

Major volcanic events

IPCC- AR4, WG1, TS.23

Four qualitative storylines of IPCC-SRES scenarios

Homogeneous world (convergence among regions)

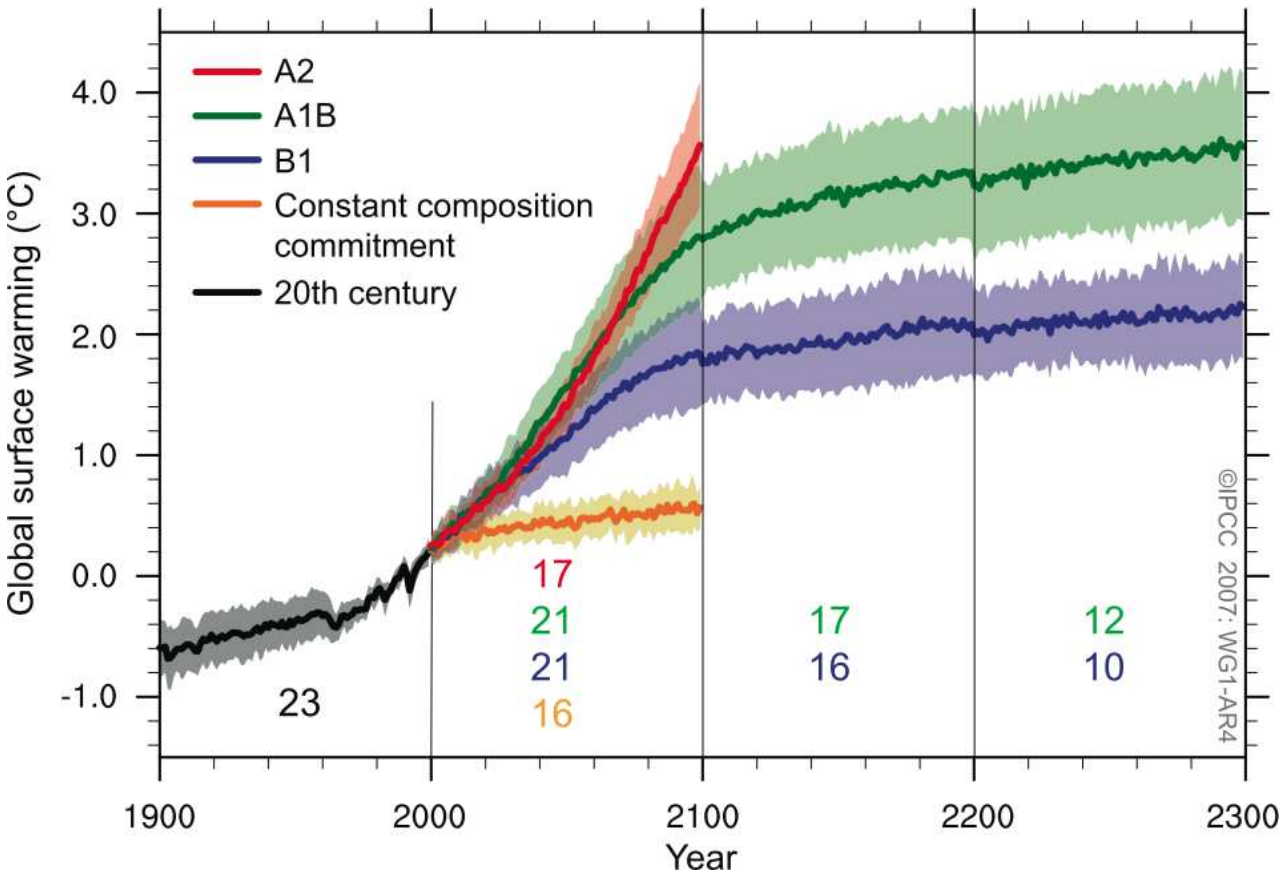
A1B scenarios
* Very **rapid economic growth**
* **Balance across all energy sources**
* Population peaks in mid-century

B1 scenarios
* Global solutions to **economic, social, and environmental sustainability**
* Toward a **service and information economy**
* Same global population as A1

environmental sustainability

A2 scenarios
* Slower economic growth and technological change
* **Regionally oriented economic development**
* Increasing global population (x2.4)

B2 scenarios
* Intermediate levels of economic development
* Local solutions to economic, social, and environmental sustainability.
* Increasing global population (x1.7)



Multi-model means of surface warming and sea level rise

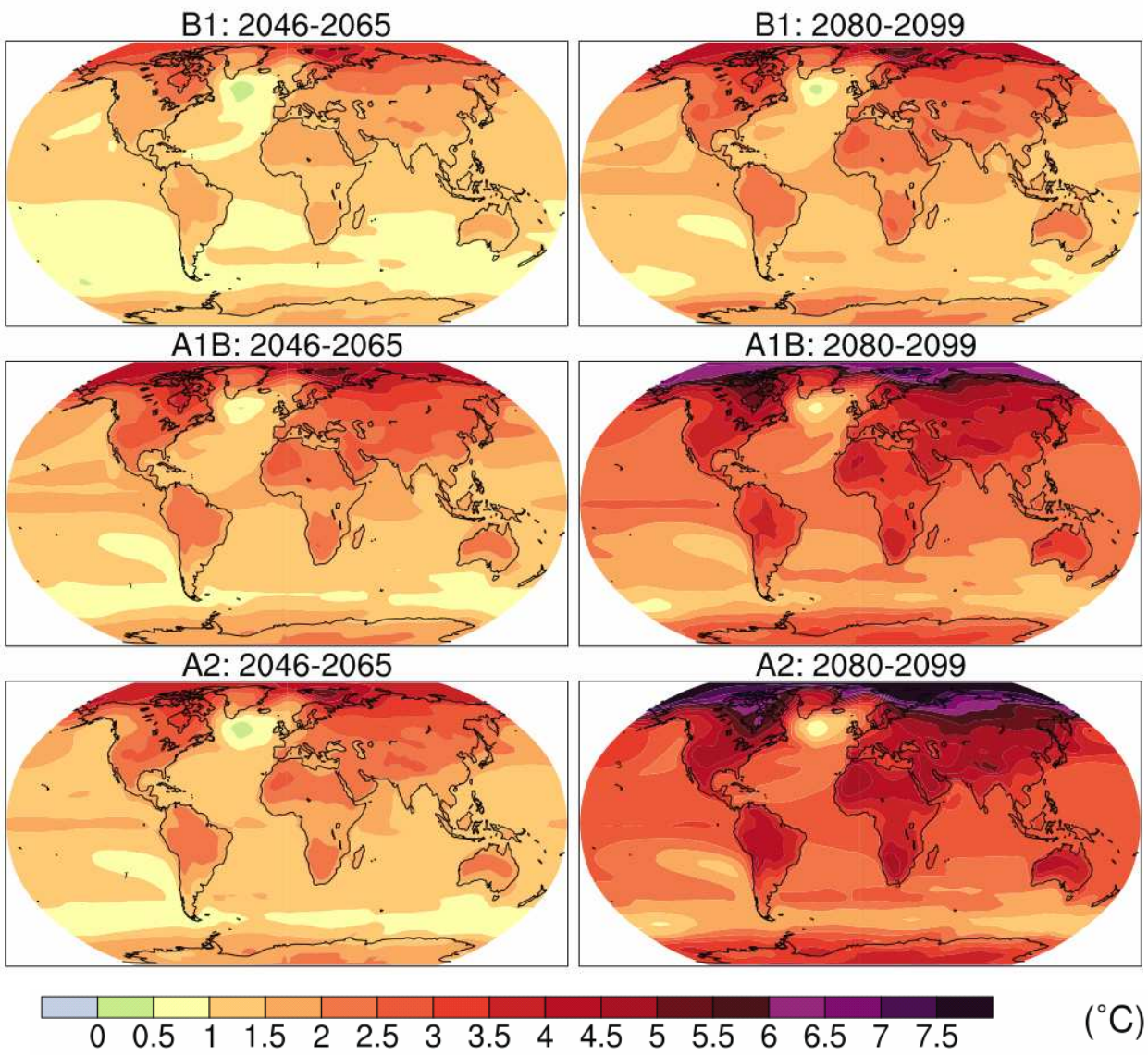
(compared to the 1980–1999 base period)

IPCC-AR4, WG1, TS.32

IPCC-AR4, WG1, Table SPM.3

	Temperature Change		Sea Level Rise
Case	Best Estimate	Likely Range	
Constant Year 2000	0.6 (°C)	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38 (m)
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51

Multi-model mean of annual mean surface warming
(surface air temperature change, °C)



Greater warming over most land areas is evident.

Over the ocean, warming is **relatively large in the Arctic** and along the **equator in the eastern Pacific**,

with **less warming over the North Atlantic** and **the Southern Ocean**.

IPCC-AR4, WG1, ch10, Figure 10.8

CRIEPI Central Research Institute of Electric Power Industry

Anomalies are relative to the average of the period 1980 to 1999

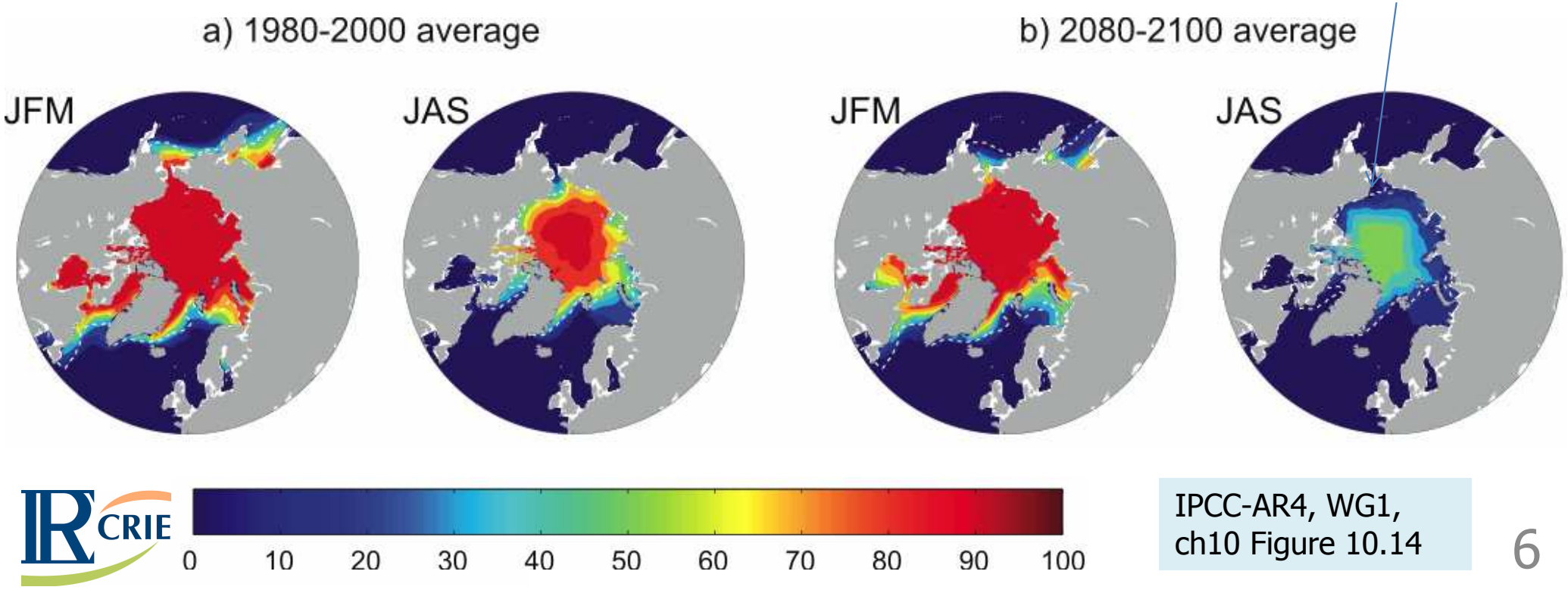
Multi-model mean sea ice concentration (%)

for January to March (JFM) and June to September (JAS)
in the SRES A1B scenario

Summer ice area declines far more rapidly than winter ice.

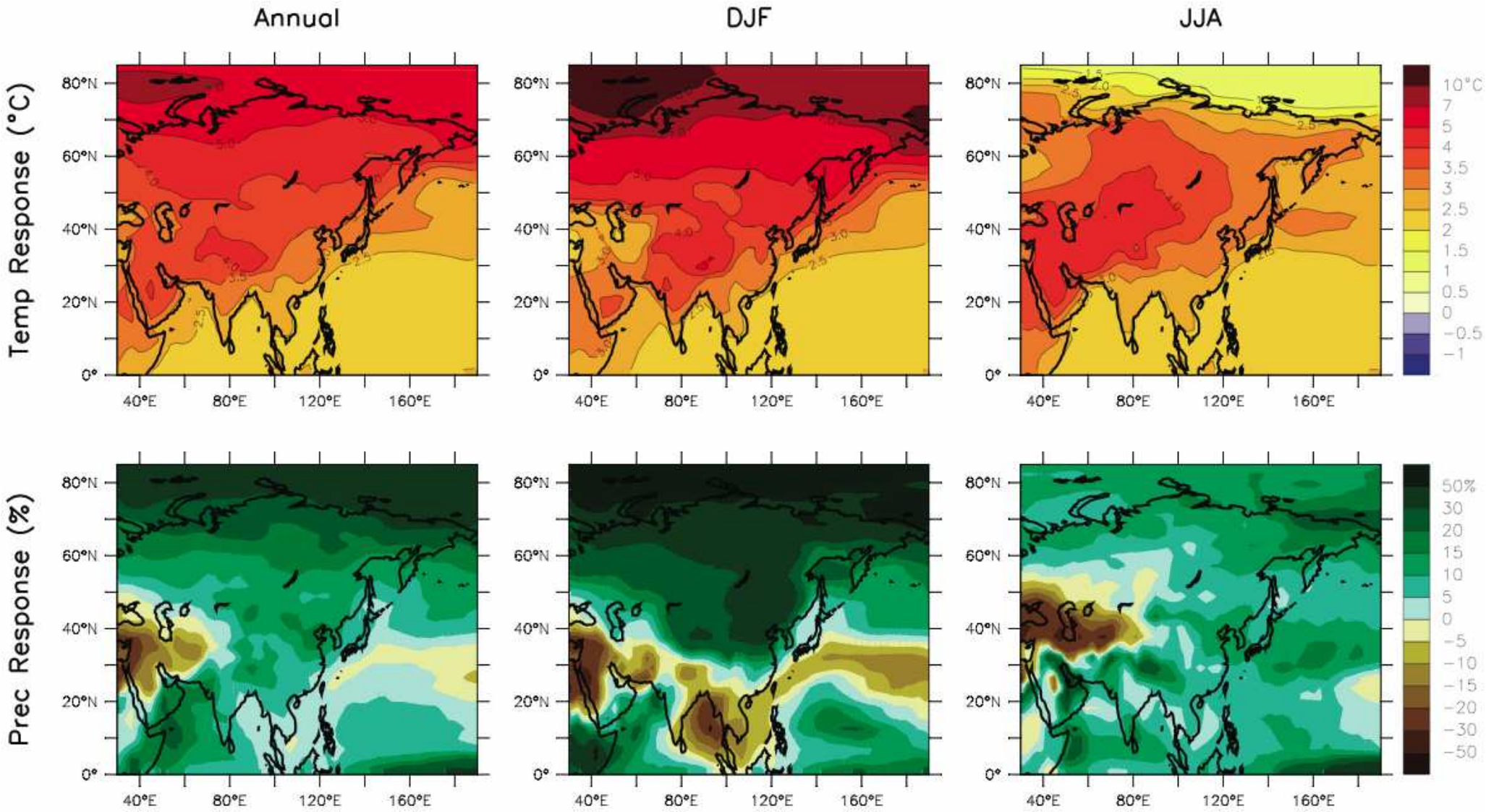
Arctic sea ice thins fastest where it is initially thickest, a characteristic that future climate projections share with sea ice thinning observed in the late 20th.

Dashed line: present-day 15%



IPCC-AR4, WG1, ch10 Figure 10.14

Temperature and precipitation changes over Asia
from A1B Simulation



Season	Temp. Response (°C)	Prec. Response (%)	Extreme Season (%)		
	50%	50%	Warm	Wet	Dry
Annual	3.3	9	100	47	1

IPCC-AR4 WG1, Ch11, Figure 11.9 & Table 11.1

Long-term mitigation & future climate change

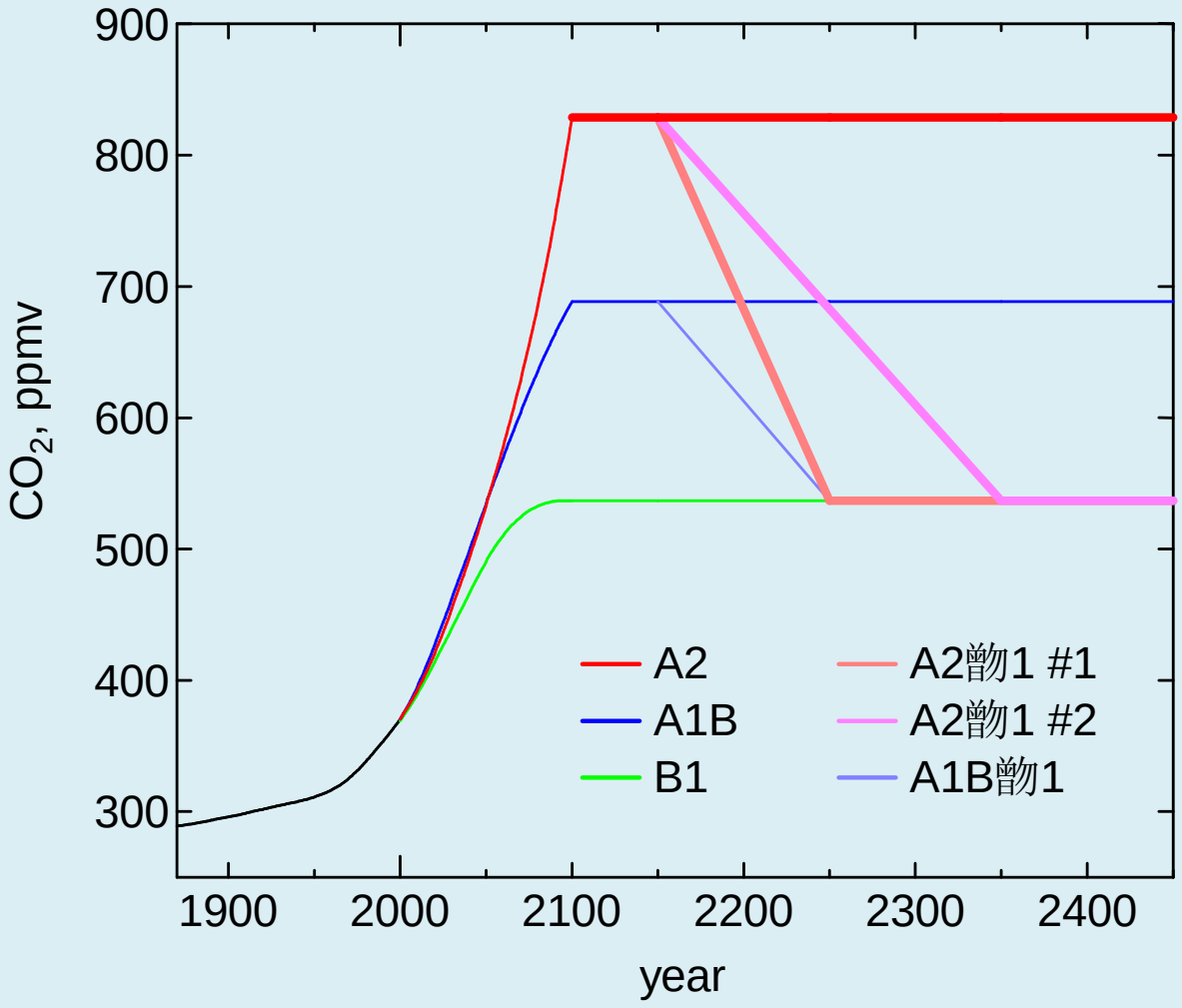
Objective & Motivation;

In future, using international framework & new technology (Energy conservation & efficiency, Nuclear, CCS, etc.), **can we reduce GHGs emission and, stabilize or decrease atmospheric GHGs concentration?**

If so, how the climate response to it?
Different pathway to stabilized or overshoot scenario will make different future climate?

> **CRIEPI carried out numerical experiment with Atmosphere-Ocean coupled climate model (CCSM3).**

Overshoot scenario & CO_2 concentration

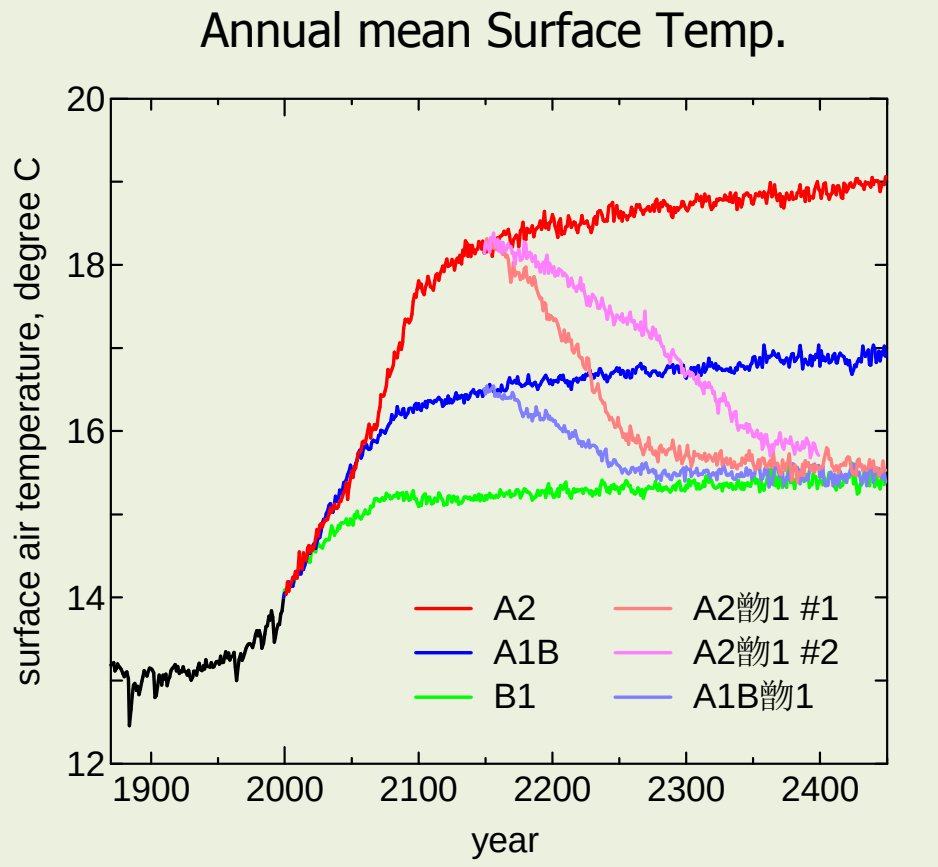


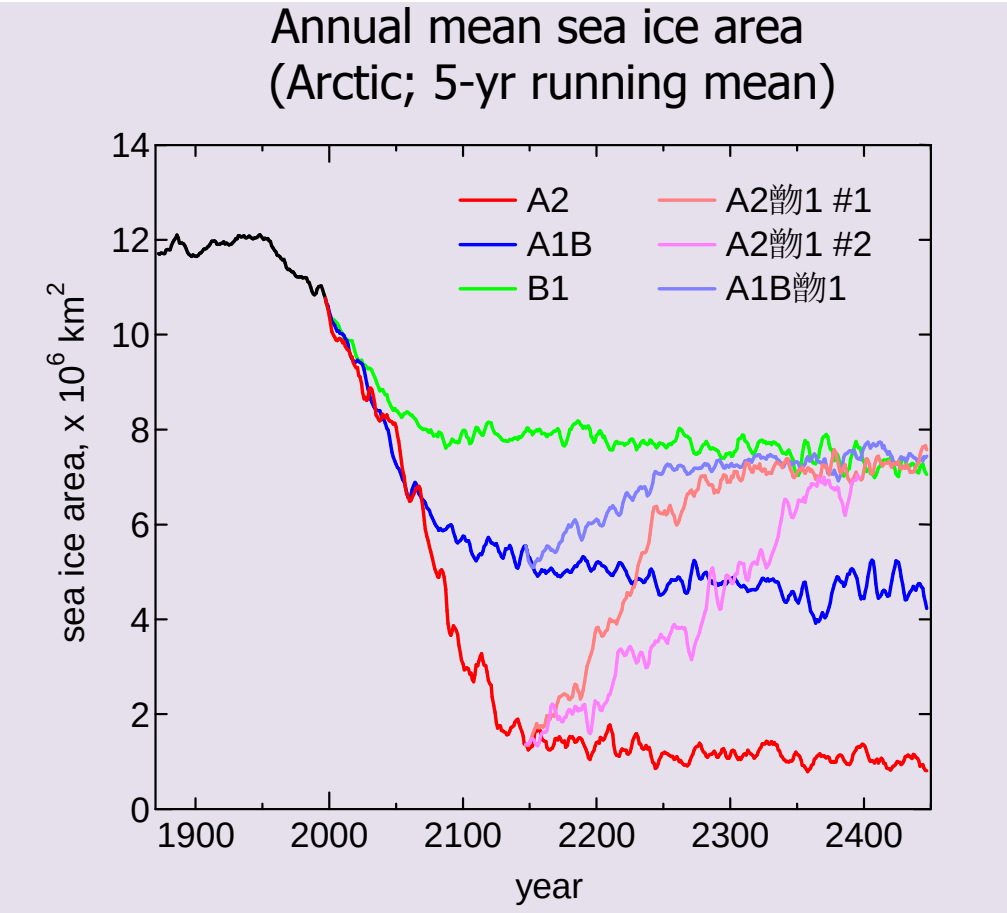
- **Stabilized GHGs** at SRES A2 level (2100-)
- **Three overshoot GHGs** profiles

* Two overshoot from A2 to B1

* One overshoot from A1B to B1

Temporal change of surface air temp. and sea ice area

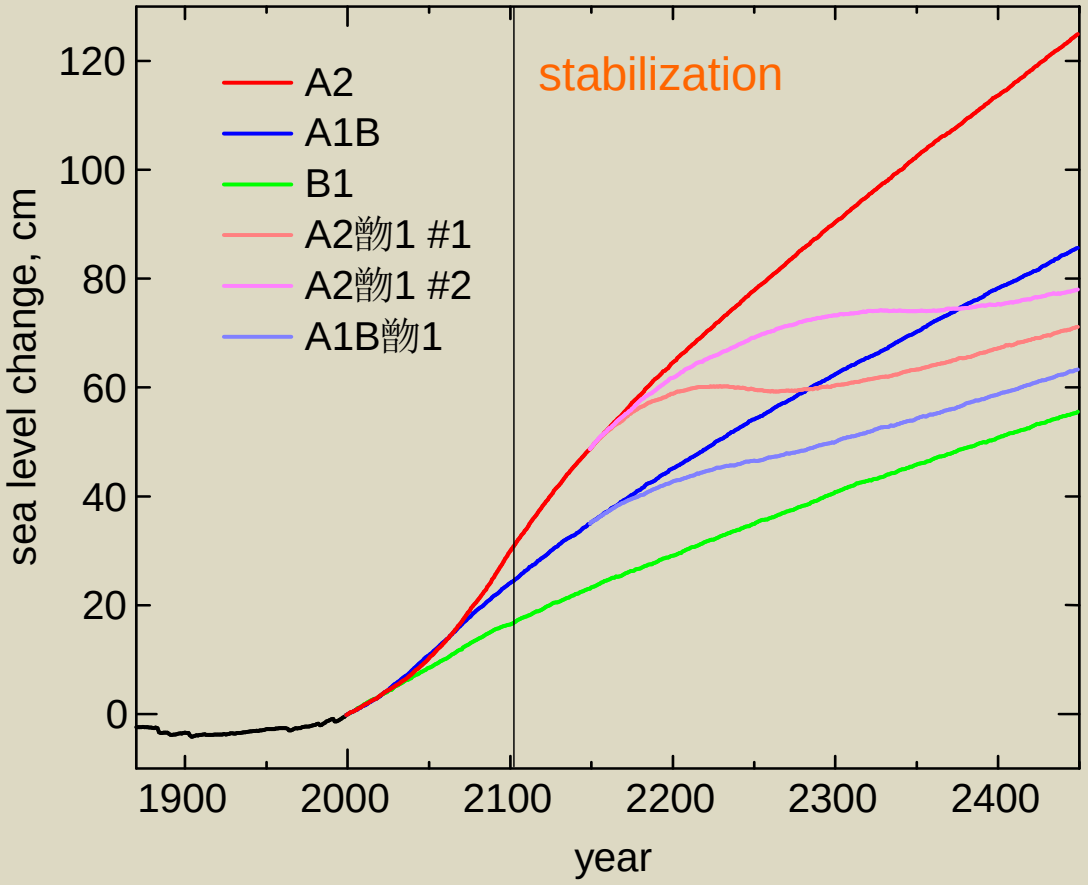




- temperature rise during 21C: 3.7 degree C (A2), 2.5 (A1B), 1.5 (B1)
- larger temperature increase after GHGs stabilization under A2

- rapid decrease during 21C in northern hemisphere
- continuous decrease after stabilization in southern hemisphere

Sea level rise due to thermal expansion



Source of sea level rise

* **Thermal expansion**
* Glaciers and ice caps
* Greenland Ice Sheet
* Antarctic Ice Sheet

- sea level rise: 25 cm (A2), 18 cm (A1B), 11 cm (B1) during 21C
- depends on GHGs increase paths (hysteresis effect)

Summary: Climate response to overshoot scenarios

* Close agreement obtained between the temporal change of atmospheric CO_2 concentration and global mean surface temperature, sea ice extent, etc, because of **quick response of atmosphere.**

* Sea surface rise increases after the stabilization or overshoot due to **the heat accumulation in the ocean**.

* **Uncertainty;**
  Biogeochemical process (**carbon cycle**) in ocean and land is not included. **Ice sheet melt** on Greenland and Antarctic is also not considered, here.

Thank You