

# Impact Assessment of Climate Change on Rice Production in Asia in Comprehensive Consideration of Uncertainties in Future Climate projections

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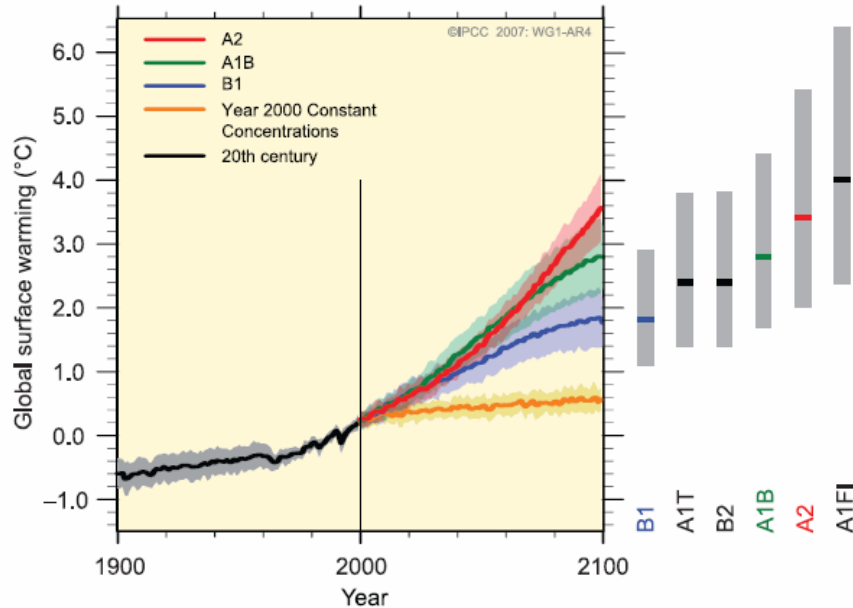
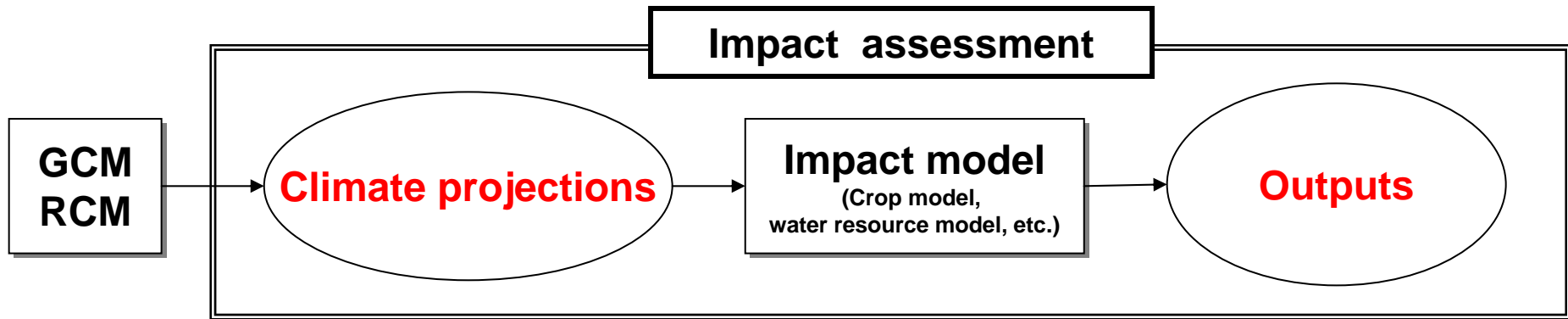
1): Center for Environmental Science in Saitama

2): National Institute for Environmental Studies

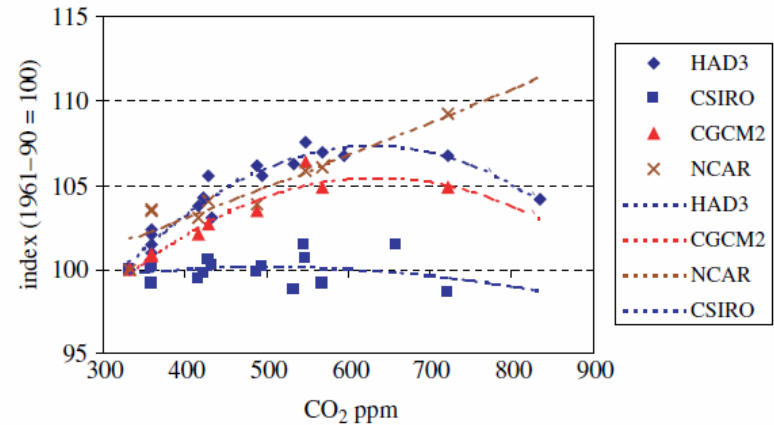
3): Kyoto University

# Introduction I

## -Uncertainties in impact assessment-



(IPCC AR4)



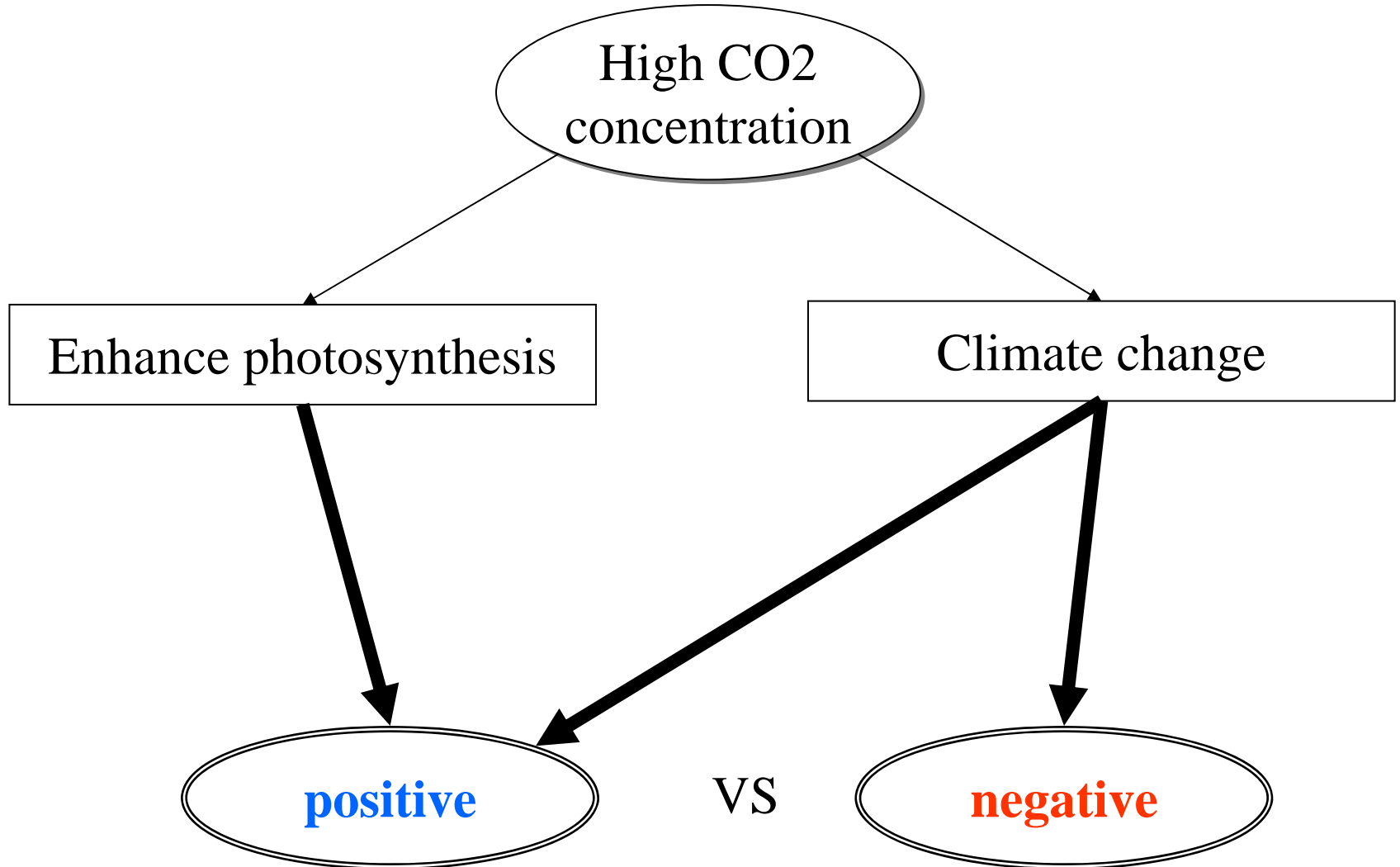
(Fischer et al., (2005))

# 1<sup>st</sup> Key Question

- How much impact does climate change have in comprehensive consideration of uncertainty in future climate projections?

# Introduction II

## - CO<sub>2</sub> fertilization effect -

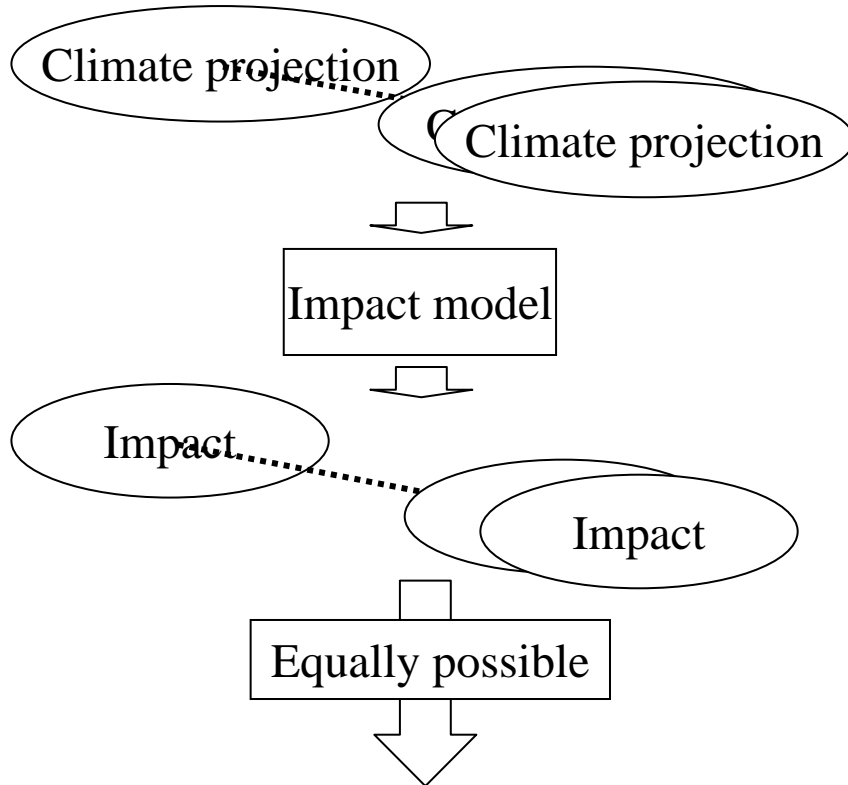


## 2<sup>nd</sup> Key Question

- Is **net effect** of elevated CO<sub>2</sub> concentration positive or negative?
  - In the 2020s, 2050s, and 2080s

# Method

- How to take uncertainties into consideration?-



1. Average
2. Standard deviation
3. Probabilities

- Step1
  - Calculation of **multi-impacts** by using **multi-climate** projections
- Step2
  - Assuming that each impact is **equally possible**, we calculate statistical metrics.

Ex. **-5%, 5%, -15%, -10%, 9%**

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Ave. =  $[-5+5+(-15)+(-10)+9]/5$   
= -3.2 [%]  
Stdev. = 10 [%]  
Pr. of yield decrease = 60 [%]

# Climate projections (from PCMDI)

Country	Model name	A1B (18 GCMs)	A2 (14 GCMs)	B1 (17 GCMs)
Norway	BCCR-BCM2.0		○	○
Canada	CGCM3.1(T47)	○	○	○
Canada	CGCM3.1(T63)	○		○
France	CNRM-CM3	○	○	○
Germany	ECHAM5/MPI-OM	○	○	○
Germany / Korea	ECHO-G	○	○	○
China	FGOALS-g1.0	○		○
USA	GFDL-CM2.0	○	○	○
USA	GFDL-CM2.1	○	○	○
USA	GISS-AOM	○		○
USA	GISS-EH	○		
USA	GISS-ER	○	○	○
Russia	INM-CM3.0	○	○	○
France	IPSL-CM4	○	○	○
Japan	MIROC3.2(hires)	○		○
Japan	MIROC3.2(medres)	○	○	○
Japan	MRI-CGCM2.3.2	○	○	○
UK	UKMO-HadCM3	○	○	○
UK	UKMO-HadGEM1	○	○	

# Crop model

- **M-GAEZ model**

- Based on **Global Agro-Ecological Zone model (GAEZ-model)**

- **GAEZ-model** was Developed by IIASA and FAO (Fischer et al., 2002)

- was used for the assessment of global food security in IPCC AR4.

- is one of main tools used by FAO for analyses of land resources



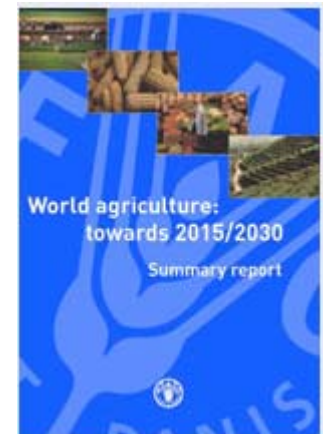
Global Agro-ecological Assessment  
for Agriculture in the 21st Century:  
Methodology and Results

RR-02-02  
March 2002

Manual of GAEZ

Reference	2020		2050		2080	
	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS
A1	663	663	208	208	108	108
A2	782	782	721	721	768	769
B1	749	749	239	240	91	90
B2	630	630	348	348	233	233

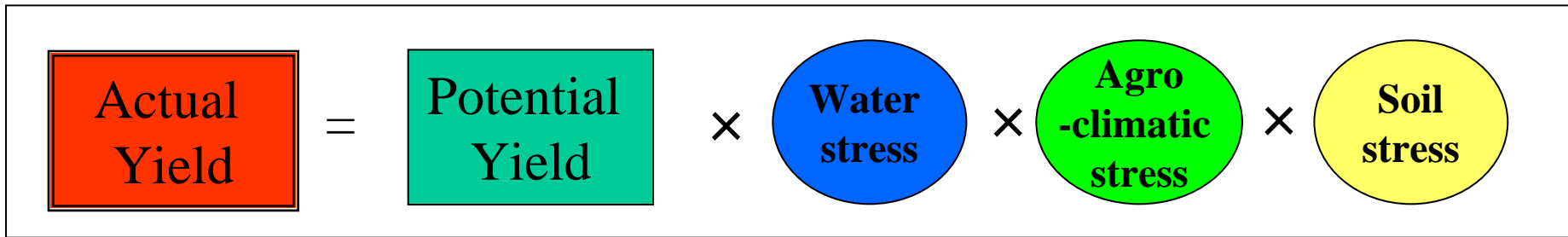
Number of hunger (IPCC AR4)



FAO report



# M-GAEZ methodology



**Potential Yield**

: Yield limited by Temperature and Radiation  
: Photosynthesis (T,R) – Respiration (T)

**Water stress**

: Multiplier determined by soil water stress

**Agro-climatic stress**

: Multiplier related to constraints by insect, pest, weed, etc.  
: Ex. Yearly warm region has high agro-climatic stress.

**Soil stress**

: Crop can not grow in rock and sandy region

# Advantages and Disadvantages of M-GAEZ model

- Advantages

- Multi-crops: 26 crops (154 sub-species)
- Soil water balance (FAO56 methodology)
  - crop water demand can be calculated.
- Constraints by pest, insect, weed are considered
  - But poor!

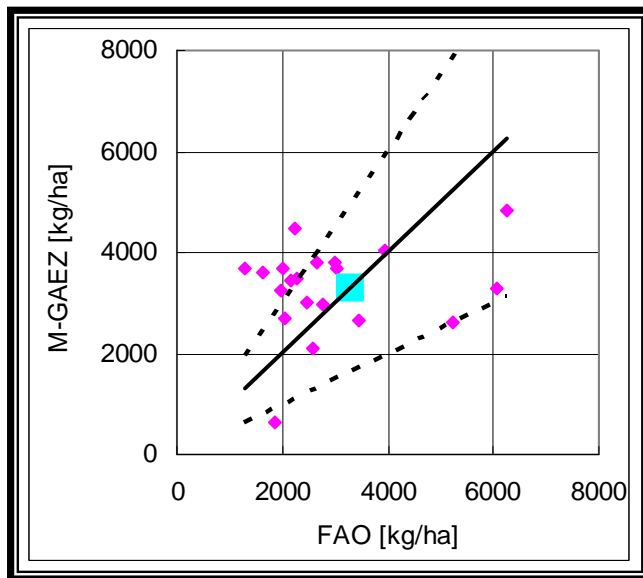
- Disadvantages

- Old type process model (or semi-process model)
  - Based on 1970s' knowledge
- No soil nutrient dynamics (no fertilizer effect)

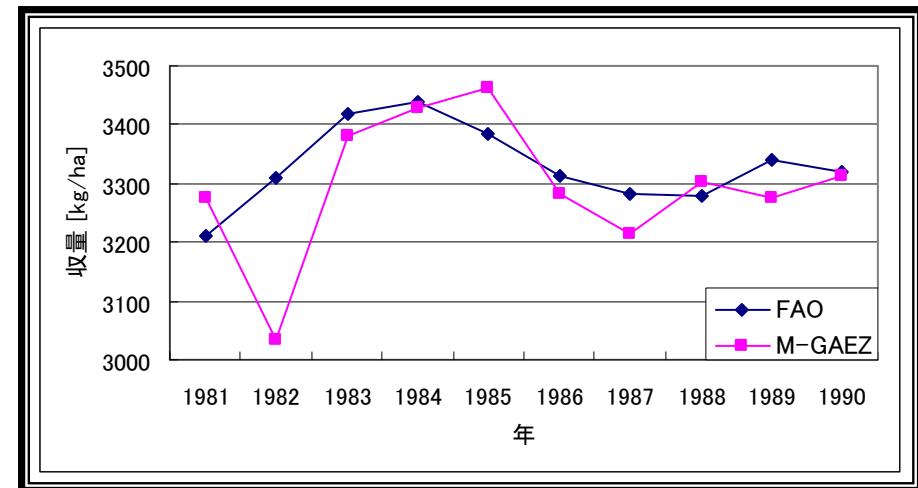
# Validation of M-GAEZ

Comparison of yields between simulation and observation

Average yields for 1980s by Asian countries



Yearly variability in yields in 1980s in Asia



# Result I - without CO2 fertilization effect -

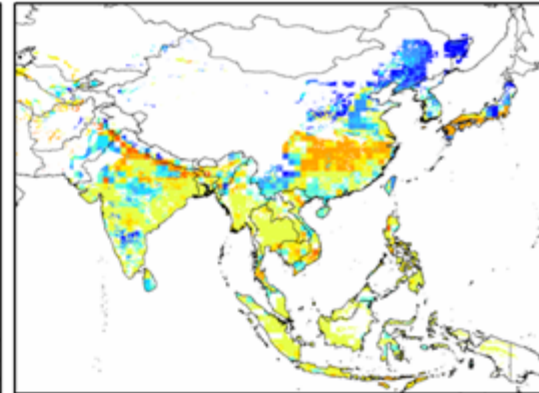
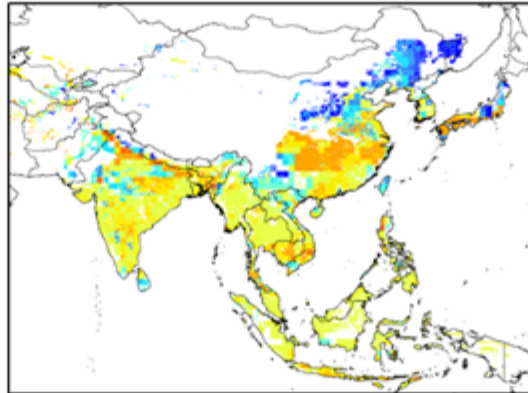
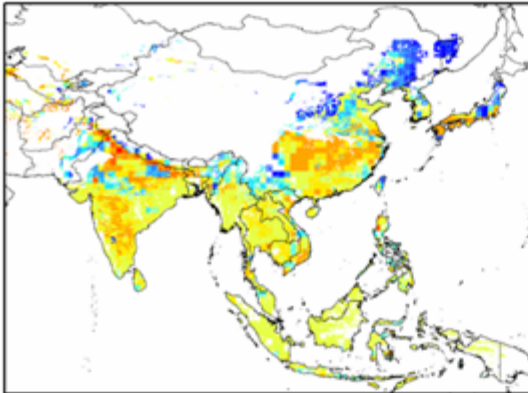
A1B

A2

B1

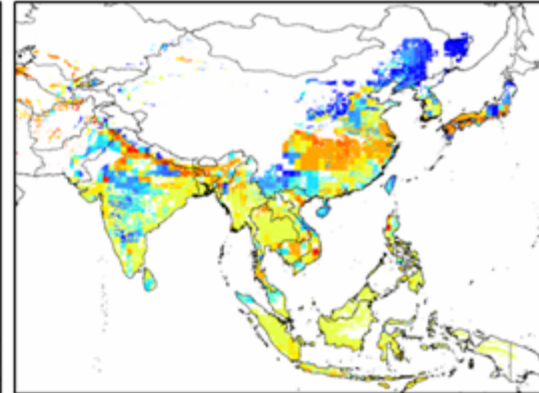
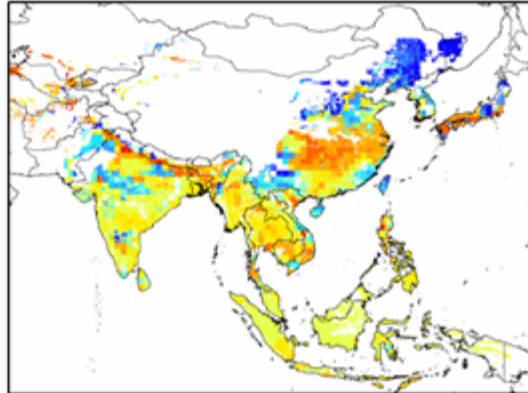
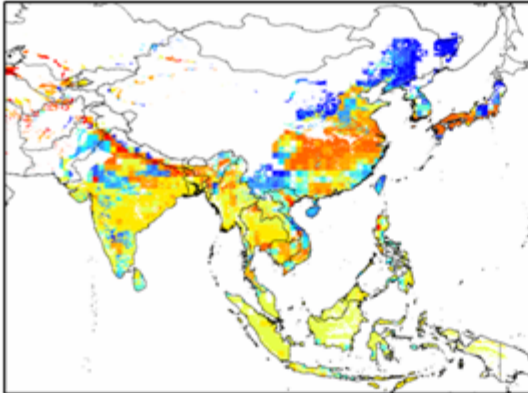
1990s - 2020s

Average change in yields (ACY) [%]



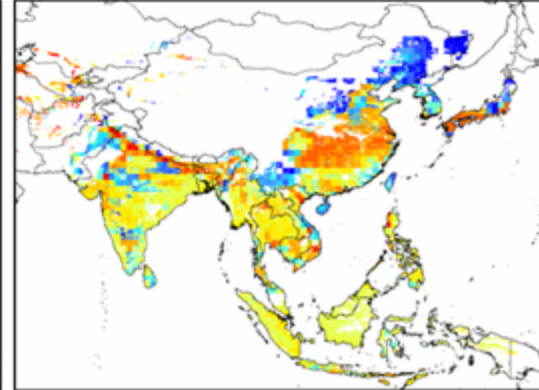
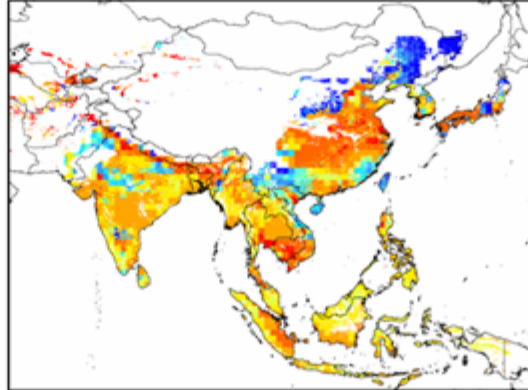
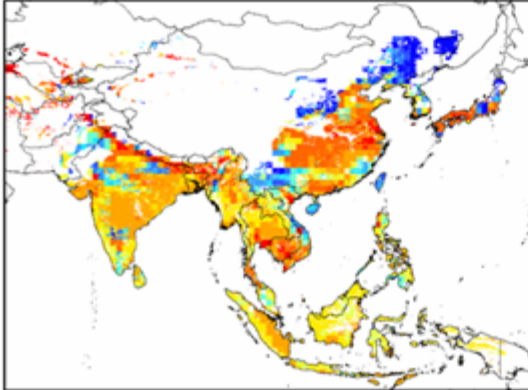
1990s - 2050s

Average change in yields (ACY) [%]



1990s - 2080s

Average change in yields (ACY) [%]



# Result II - with CO2 fertilization effect -

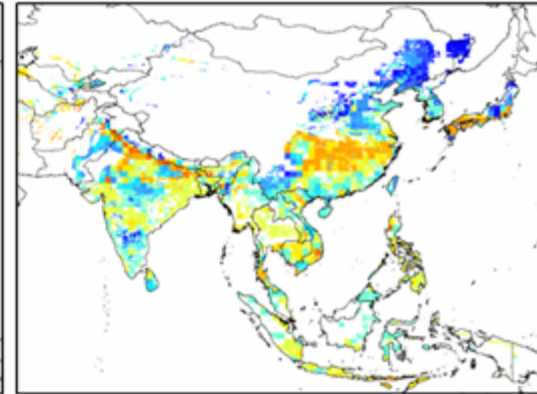
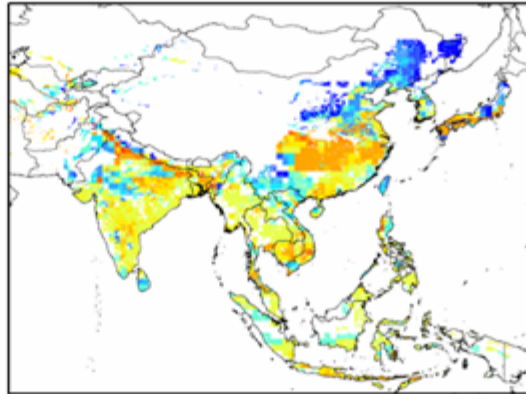
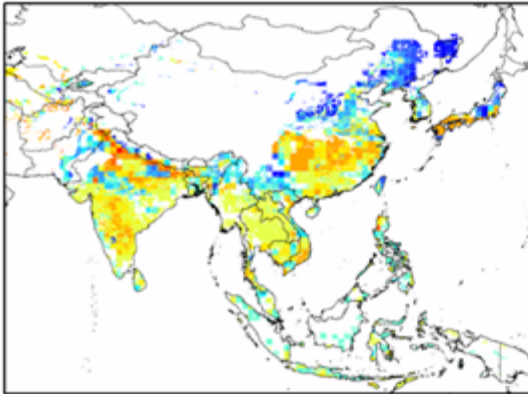
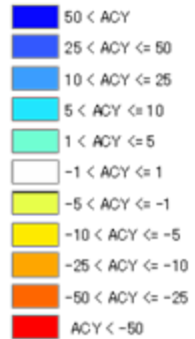
A1B

A2

B1

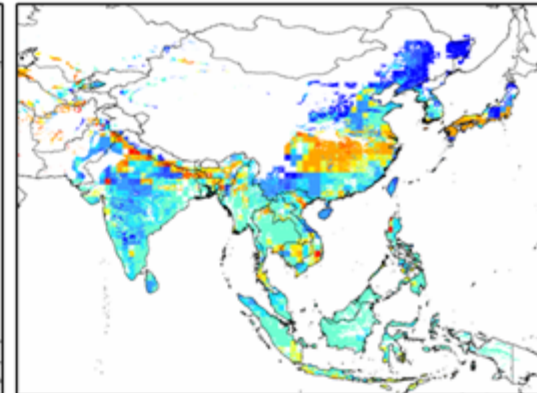
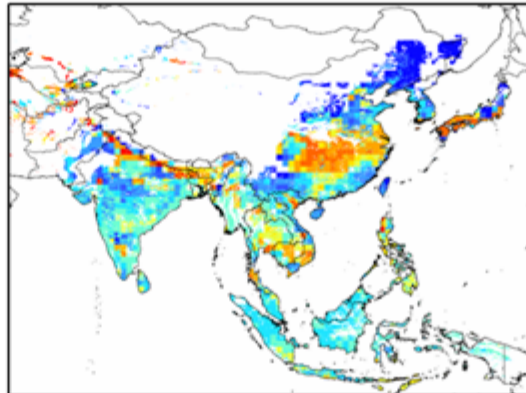
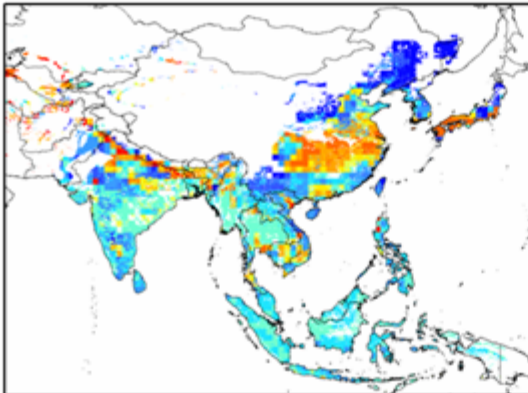
1990s - 2020s

Average change in yields (ACY) [%]



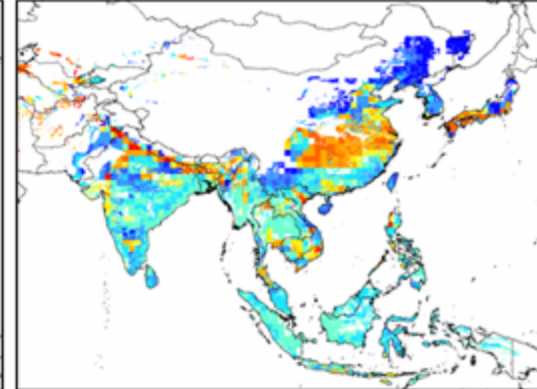
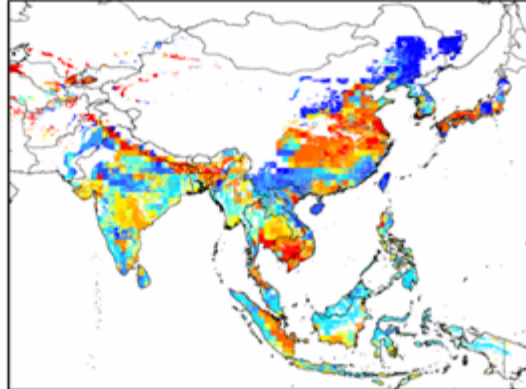
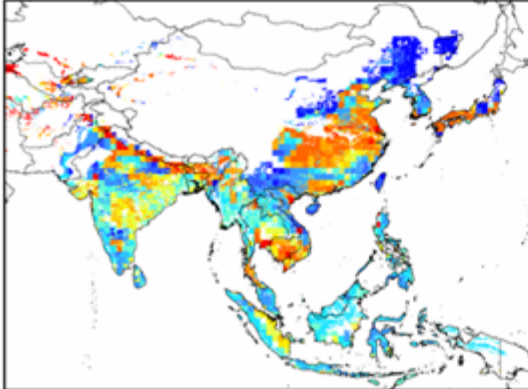
1990s - 2050s

Average change in yields (ACY) [%]



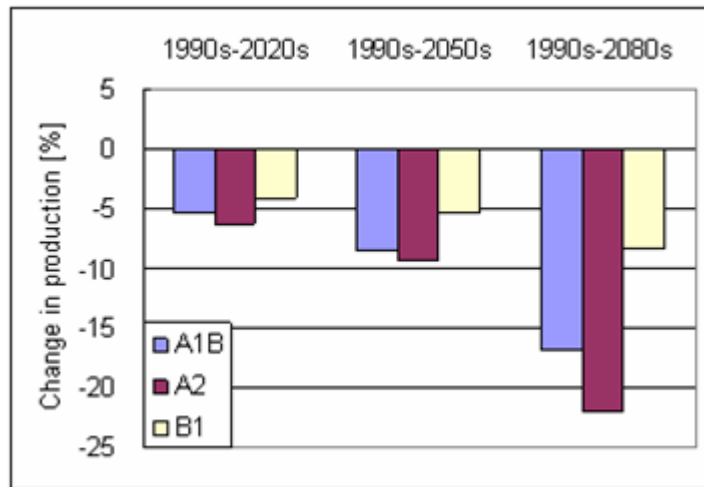
1990s - 2080s

Average change in yields (ACY) [%]

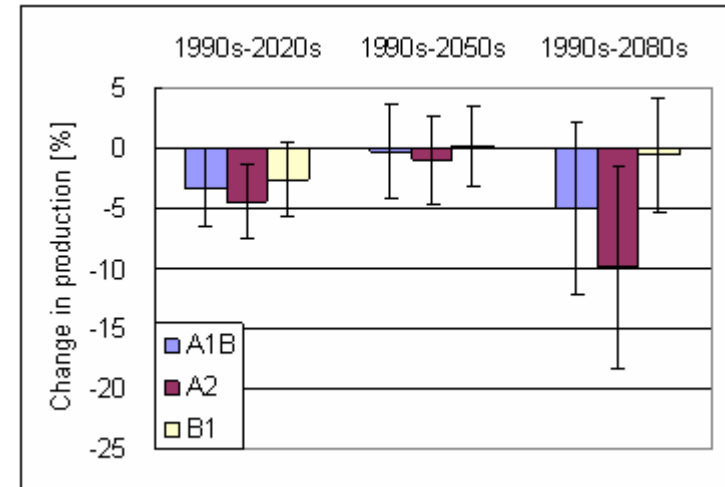




# Result III



without CO<sub>2</sub> fertilization effect



with CO<sub>2</sub> fertilization effect

	1990s-2020s			1990s-2050s			1990s-2080s		
	A1B	A2	B1	A1B	A2	B1	A1B	A2	B1
<i>ACP</i> without CO <sub>2</sub> effect	-5.2	-6.3	-4.2	-8.6	-9.4	-5.4	-16.8	-22.0	-8.4
<i>ACP</i>	-3.3	-4.5	-2.5	-0.3	-0.9	0.2	-5.0	-9.9	-0.5
<i>SDCP</i>	3.2	3.2	3.1	3.9	3.7	3.3	7.2	8.4	4.8
Pr( <i>CP</i> <0)	83.3	100.0	76.5	44.4	57.1	52.9	72.2	85.7	47.1

- In the 2020s
  - Little difference in average changes in production (*ACPs*) among SRES scenarios
  - The probabilities of production decrease (Pr(*CP*<0)) are high for all SRES scenarios
- In the 2050s
  - Positive and negative effects are in equilibrium
- In the 2080s
  - Large difference in *ACPs* and Pr(*CP*<0))s among SRES scenarios.
    - A2 has largest adverse effect although A2 has the largest CO<sub>2</sub> fertilization effect

# Summary of the results

- **Key questions**
  - How much impact does climate change have **in comprehensive consideration of future climate projections**?
  - Is **net effect** of elevated CO<sub>2</sub> concentration positive or negative?
- **Our answer**
  - **Net effect** of elevated CO<sub>2</sub> concentration **in comprehensive consideration of future climate projections** is **negative in the 2020s and 2080s**, and **nearly zero in the 2050s**.
- **Suggestions**
  - **It is necessary to take immediate adaptive actions in the near future, regardless of socio-economic development.**
    - **Because the probabilities of production decrease are high for all SRES scenarios in the 2020s**
  - **The reduction of CO<sub>2</sub> emission in the long term has a large potential to mitigate negative changes.**
    - **Large difference in change in production** among SRES scenarios **in the 2080s**
    - High CO<sub>2</sub> concentration scenario, **A2**, has **largest adverse effect** in the 2080s, while low CO<sub>2</sub> concentration scenario, **B1**, has **smallest adverse effect** in the 2080s.

Thank you for your attention!