Risk assessment of climate change for rice productivity in Asia

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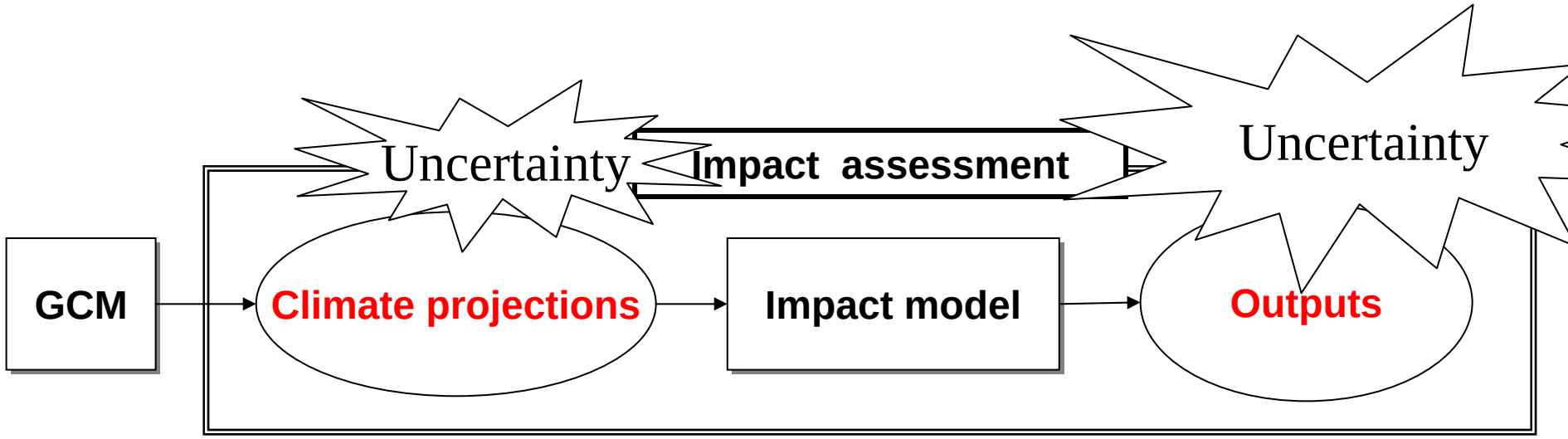
Center for Global Environmental Research,
National Institute for Environmental Studies（NIES）, Japan
Postdoctoral fellow

Yuji Masutomi

Introduction
-Uncertainties in impact assessment-



We can not deterministically predict the impacts of climate change

Introduction - Risk assessment -

- Risk assessment approach is useful
  - This approach is not deterministic but probabilistic approach
  - Risk is calculated by
    - Σ impact $\times$ probability

We can know the impacts of climate change in the form of risk even if the uncertainties are included in the impacts.

Objective

- To assess risk of climate change on agricultural productivity
  - Where is the region with high risk?
    - Identify high risk regions
  - Which SRES scenario has high risk?
    - Identify high risk SRES scenarios
    - CO_2 fertilization effect VS Climate impact
      - Crop productivity increase as CO_2 concentration increase.
  - What is an effective action to reduce risk?
    - Identify effective actions.

Simulation setting

- **Simulation settings**
  - **Crop**: Rice
  - **Area**: Asia (90% of rice is produced in Asia)
  - **Period**: 2080s （from 1990s）
  - **Crop model**: Global Agro-Ecological Zone model (Ficsher et al., 2002)
    - Input: climate variables, elevation, soil data and so on.
    - Output: Crop yield [kg/ha] (Potential yield)

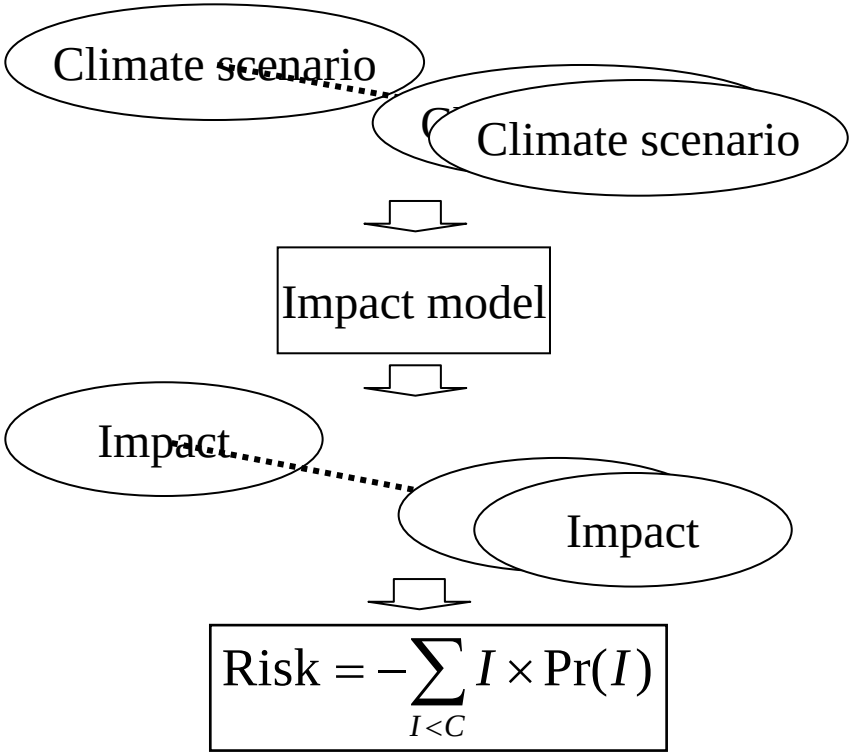
Method
–Estimation of risk-

- Step1
  - We calculate multi-impacts using multi-climate scenarios

- Step2

$$\text{Risk} = -\sum_{I<C} I \times \Pr(I)$$

  - ***I***: impact
    - change in rice production [%] calculated by crop model
  - **Pr**: probability of impact *I*
    - We assume that each climate scenario is equally possible
    - the probability of an impact is **1/N** (N: number of climate scenarios)
  - **C**: threshold of impact
    - production decrease (C=0)



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

Risk= -(-5+(-15)+(-10))/5=6

Max : 100; Min: 0

Climate scenarios (from PCMDI)

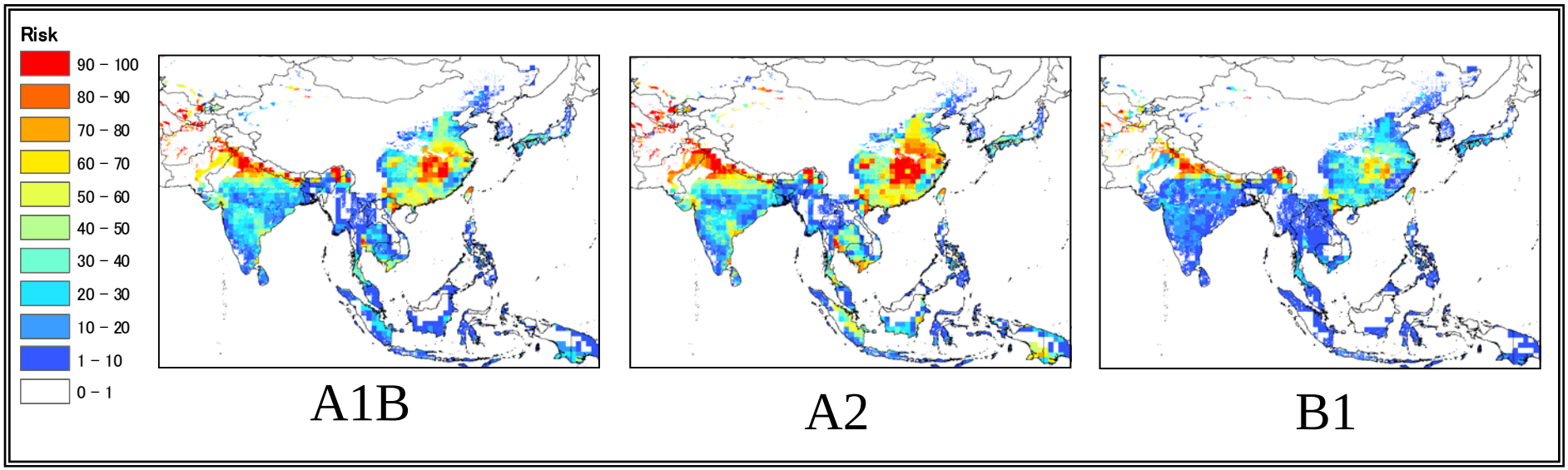
Country	Model name	A1B (18 GCMs)	A2 (14 GCMs)	B1 (17 GCMs)
Norway	BCCR-BCM2.0		○	○
Canada	CGCM3.1(T47)	○	○	○
Canada	CGCM3.1(T63)	○		○
France	CNRM-CM3	○	○	○
Germany	ECHAM5/MPI-OM	○	○	○
Germany / Korea	ECHO-G	○	○	○
China	FGOALS-g1.0	○		○
USA	GFDL-CM2.0	○	○	○
USA	GFDL-CM2.1	○	○	○
USA	GISS-AOM	○		○
USA	GISS-EH	○		
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	○	○	

Adaptive actions

- Two adaptive actions
  - 1: Changes in crop variety and planting date (**Variety and date**)
    - Changing to suitable crop variety and planting date for future climate condition
      - Ex. Rice with high temperature tolerant
      - Ex. Planted on the date so as to avoid too hot period to grow
  - 2: Building irrigation facility (**Irrigation**)
    - From currently level
    - Stable water supply for crop growing in irrigated area

Result I : No action case

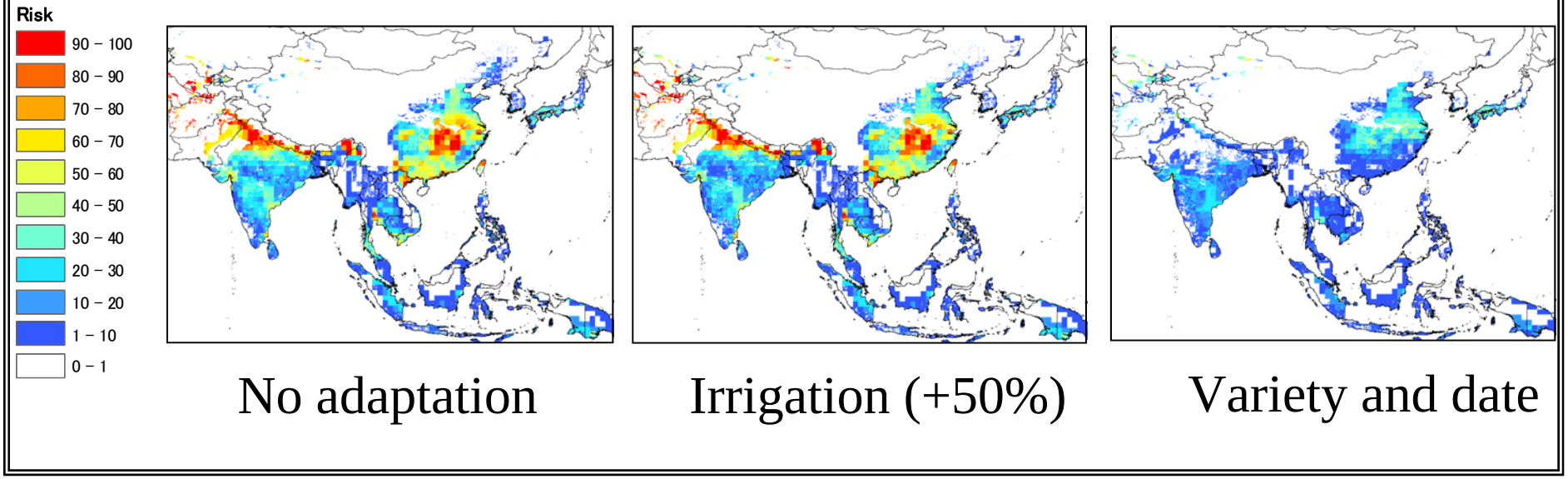
- Where is the regions with high risk-
- Which SRES scenario has high risk -



- Middle China and north India have high risk for all SRES scenarios
- A1B and A2 have high risk
- B1 has low risk

Result II : A1B

- What is an effective action to reduce risk?-



- Small difference between No adaptation and Irrigation action
  - Effect of building irrigation is small
- Big difference between No adaptation and Variety and date action
  - Variety and date action has big effect to reduce risk

Result III
-Quantitative risk assessment-

Table. Risk in Asia for each SRES scenario and adaptive action

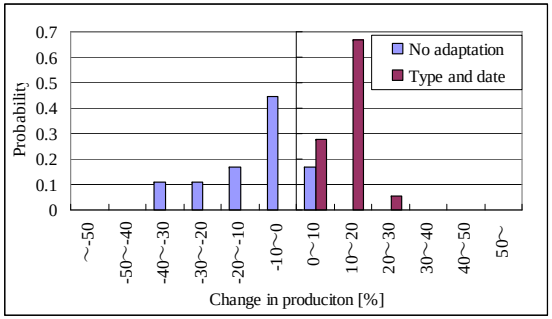
Risk	No adaptation	Irrigation (+50%)	Variety and date
A1B	9.4	6.5	0.0
A2	15.8	12.8	0.1
B1	2.7	0.9	0.0

- A2 (no adaptive action)
  - has 1.5 times higher risk than A1B
  - has 6 times higher risk than B1
- Variety and date action can reduce risk to zero or nearly zero!!

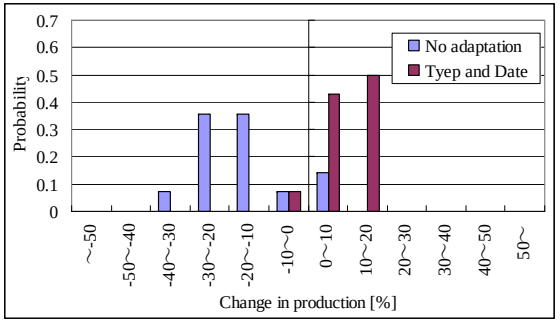
Analysis

-Effect of changes in crop variety and planting date-

A1B



A2



B1

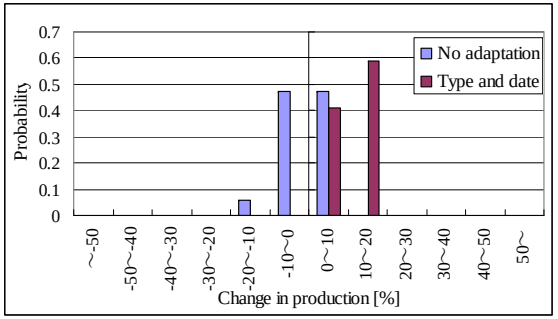
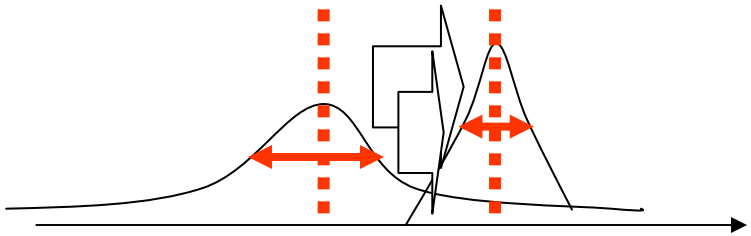


Figure . PDFs of change in production

Table. Average and Standard deviation

	Ave.		Stdev.	
	No adaptation	Variety and date	No adaptation	Variety and date
A1B	-9.3	12.7	11.5	5.1
A2	-16.5	10.7	12.1	7.1
B1	-1.2	10.3	6.0	2.4



- Variety and date action reduce risk by not only shifting average but also reducing deviation!!

Analysis II

-Effect of building irrigation facility-

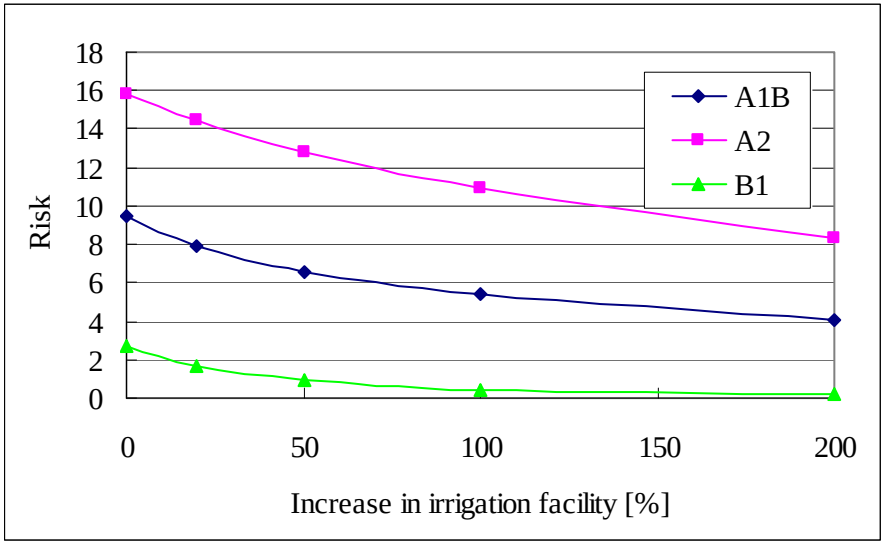


Figure. Risk reduction

- Irrigation action can reduce more risk as irrigation facility increase.
- For example, if we double irrigation facility in B1, risk will decrease to nearly zero even if we do not take variety and plant action

Summary

- We assessed risk of production decrease for rice in Asia
  - Middle china and north India have high risk if we take no adaptation.
  - A2 scenario has high risk .
  - Changes in crop variety and planting date can reduce risk to nearly zero.
    - Not only by shifting average but also by reducing variation of production change.

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