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Research workshop on future directions
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Studies on Climate Change Impacts on Rice Production in JAPAN and the Mekong Delta, VIETNAM

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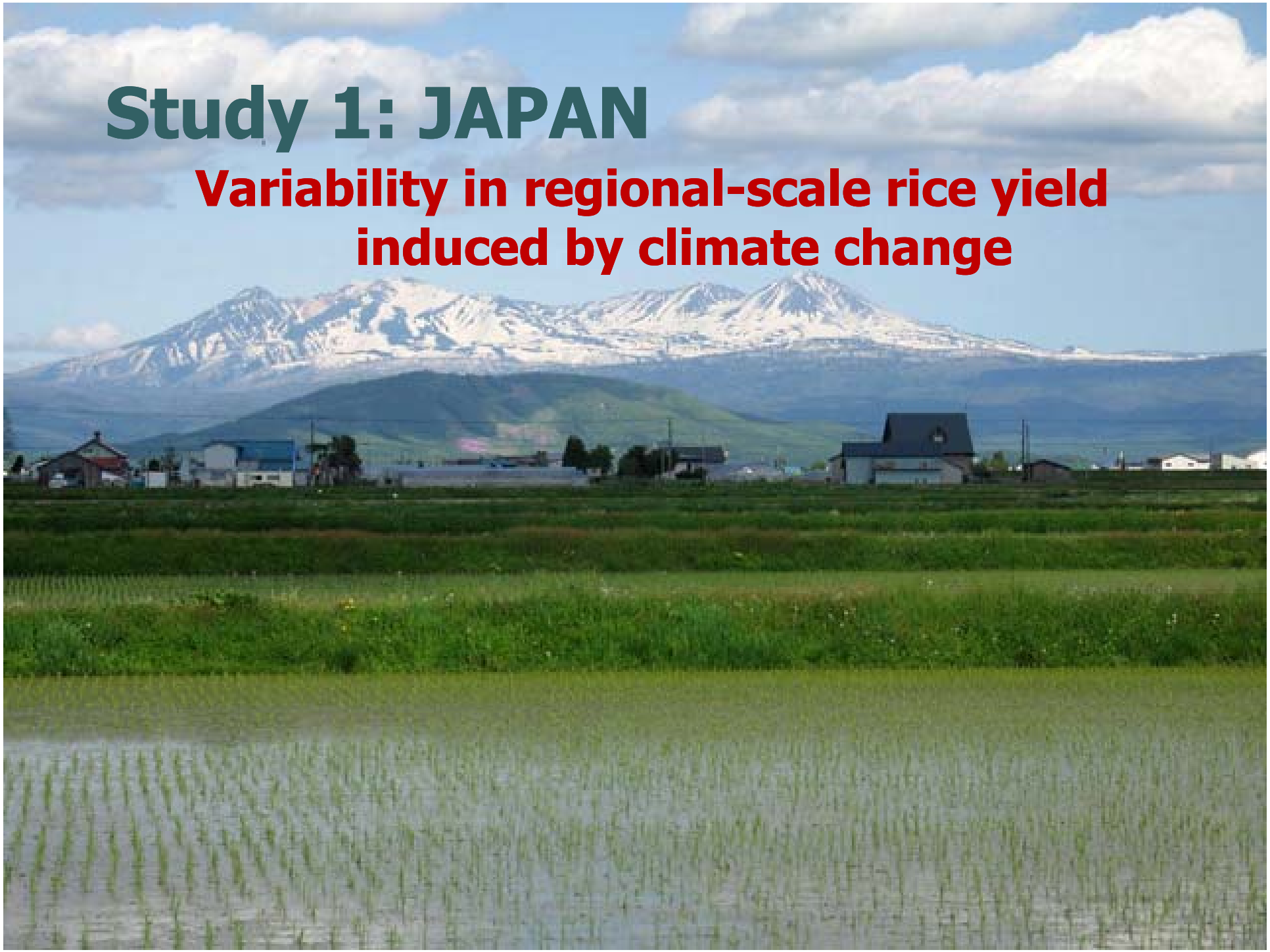
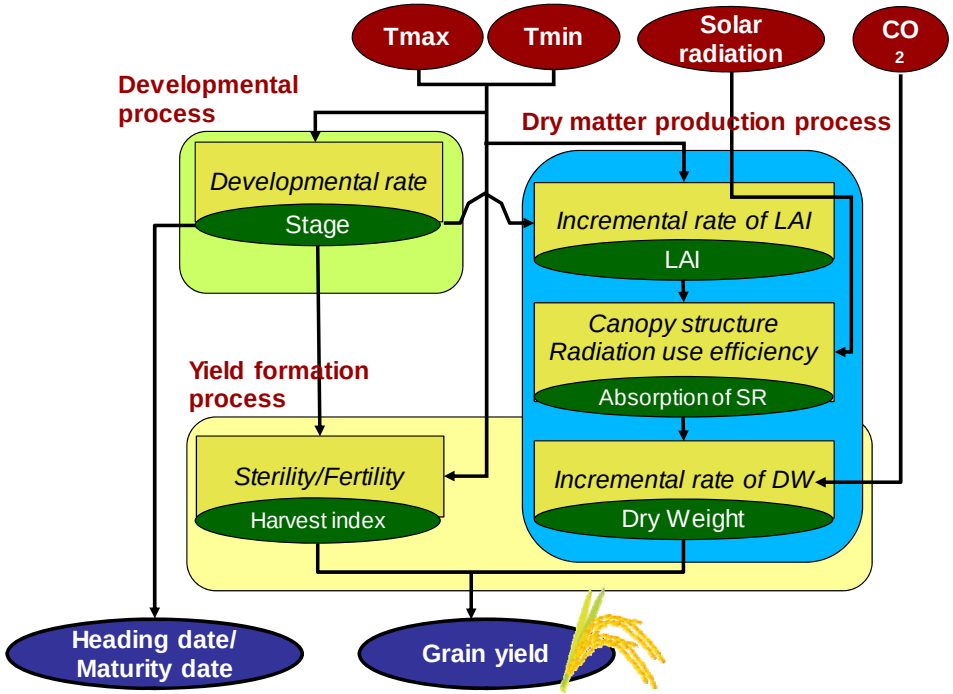


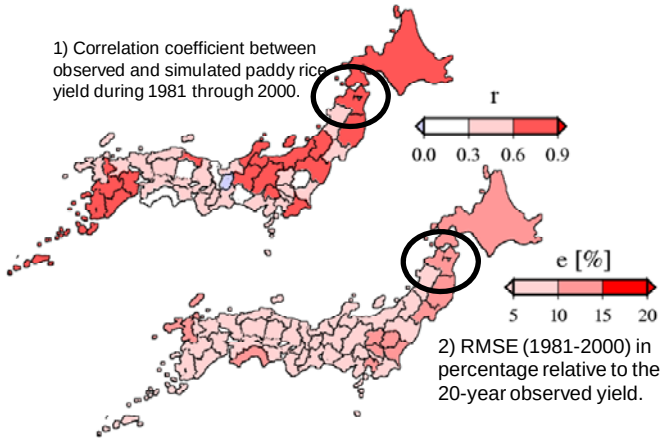
Study 1: JAPAN

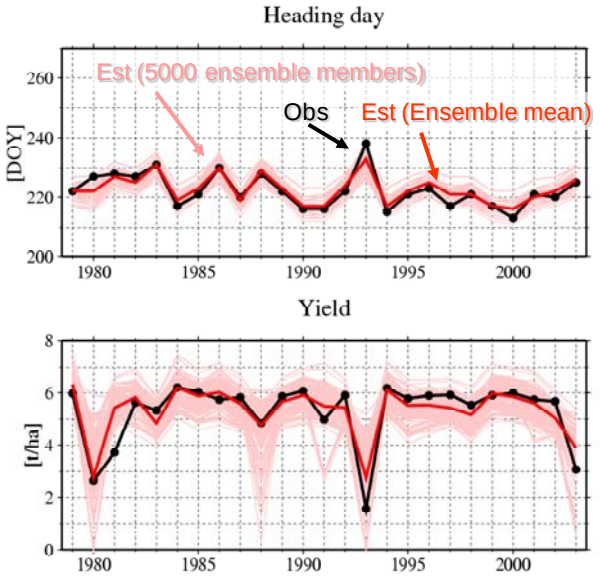
Variability in regional-scale rice yield induced by climate change

The Rice Growth Model



PRYSBI (Iizumi et al., 2009)





- The model can catch up year-to-year variation of rice yield at national scale

Climate change scenarios

Experiment period	Scenario
1981-2000:	Observed data
2046-2065:	Climate change scenarios of **6 GCMs (8 climate projections)** with **2 emission scenarios** (A1B and A2)
2081-2100:	

CGCM3.1 (3 members)
CSIRO-Mk3.0,
CSIRO-Mk3.5,
GFDL-CM2.0,
MIROC3.2-MED
MRI-CGCM2.3.2A
(Bias-corrected and downscaled)

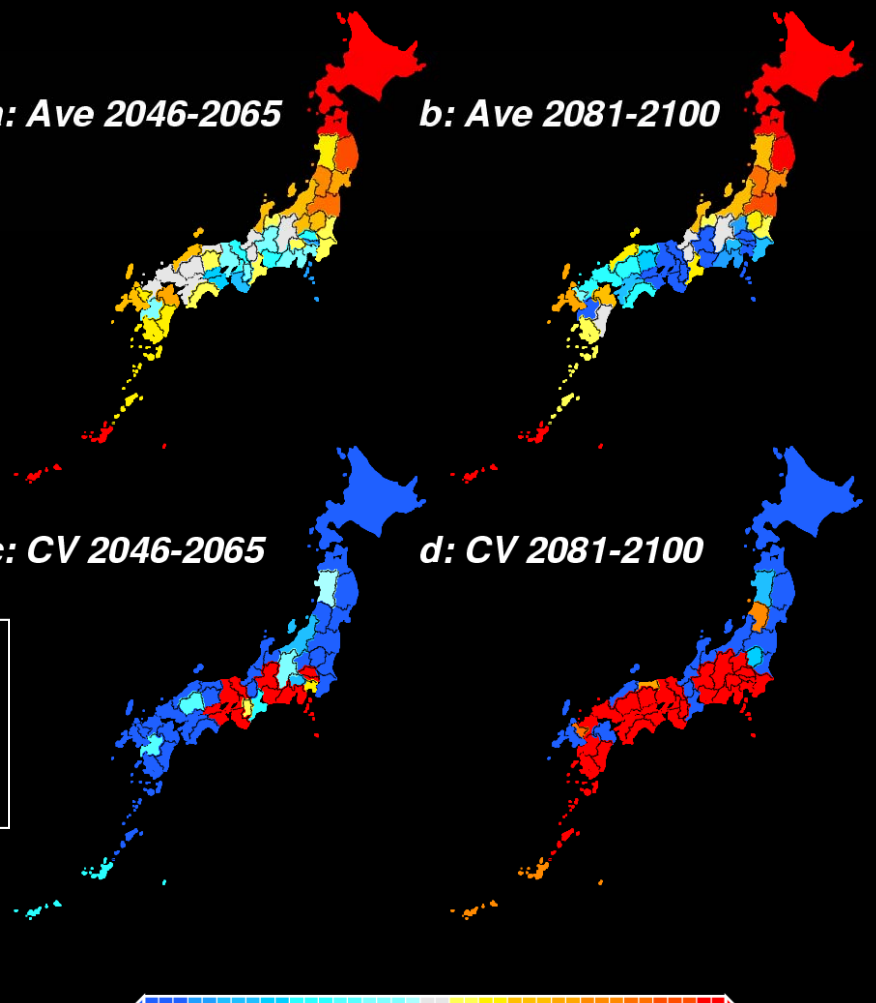
Spatial pattern of yield change due to CC

SRES-A1B, MIROC3.2-HIRES

（without adaptation）

Change in 20-year mean yield

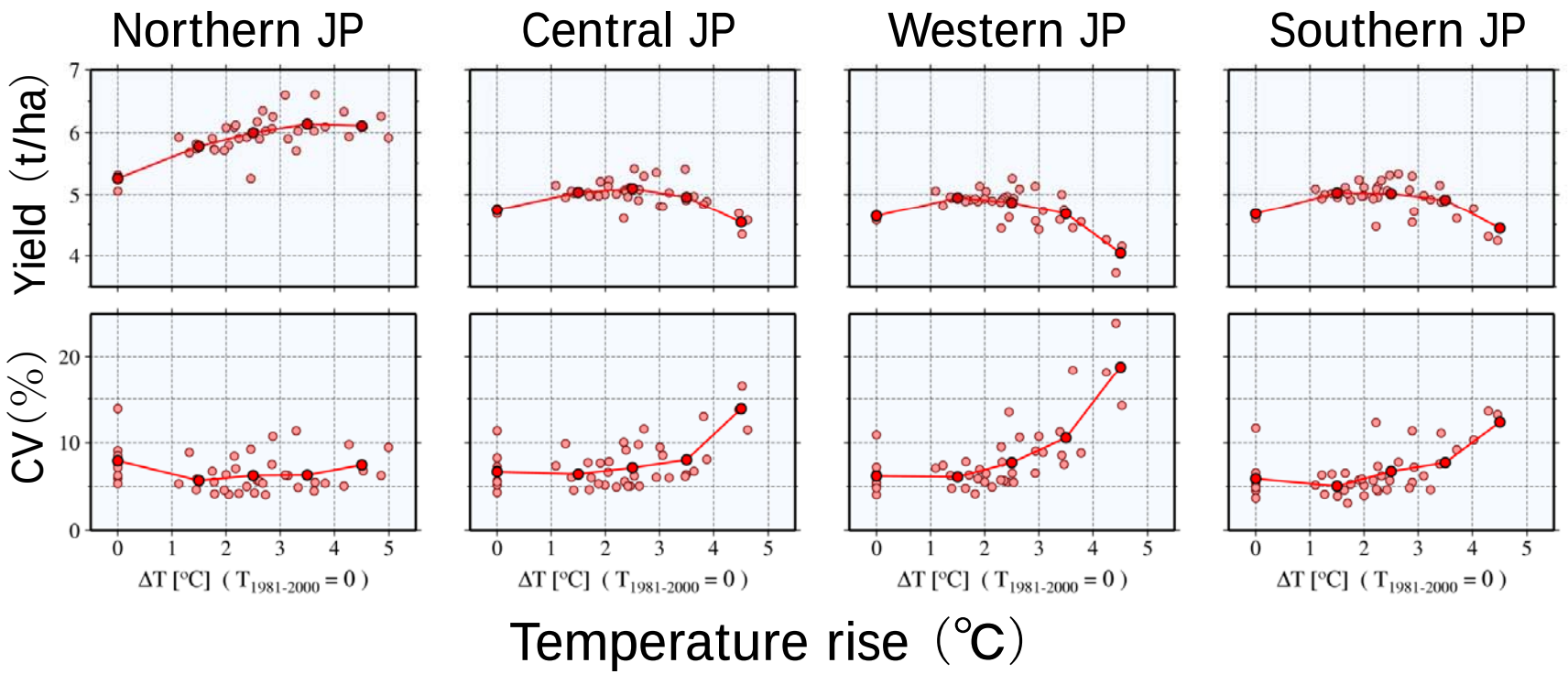
Change in Coefficient of Variation: CV for 20 years



Percentage change (relative to 1981-2000)

Regional pattern of yield change due to CC

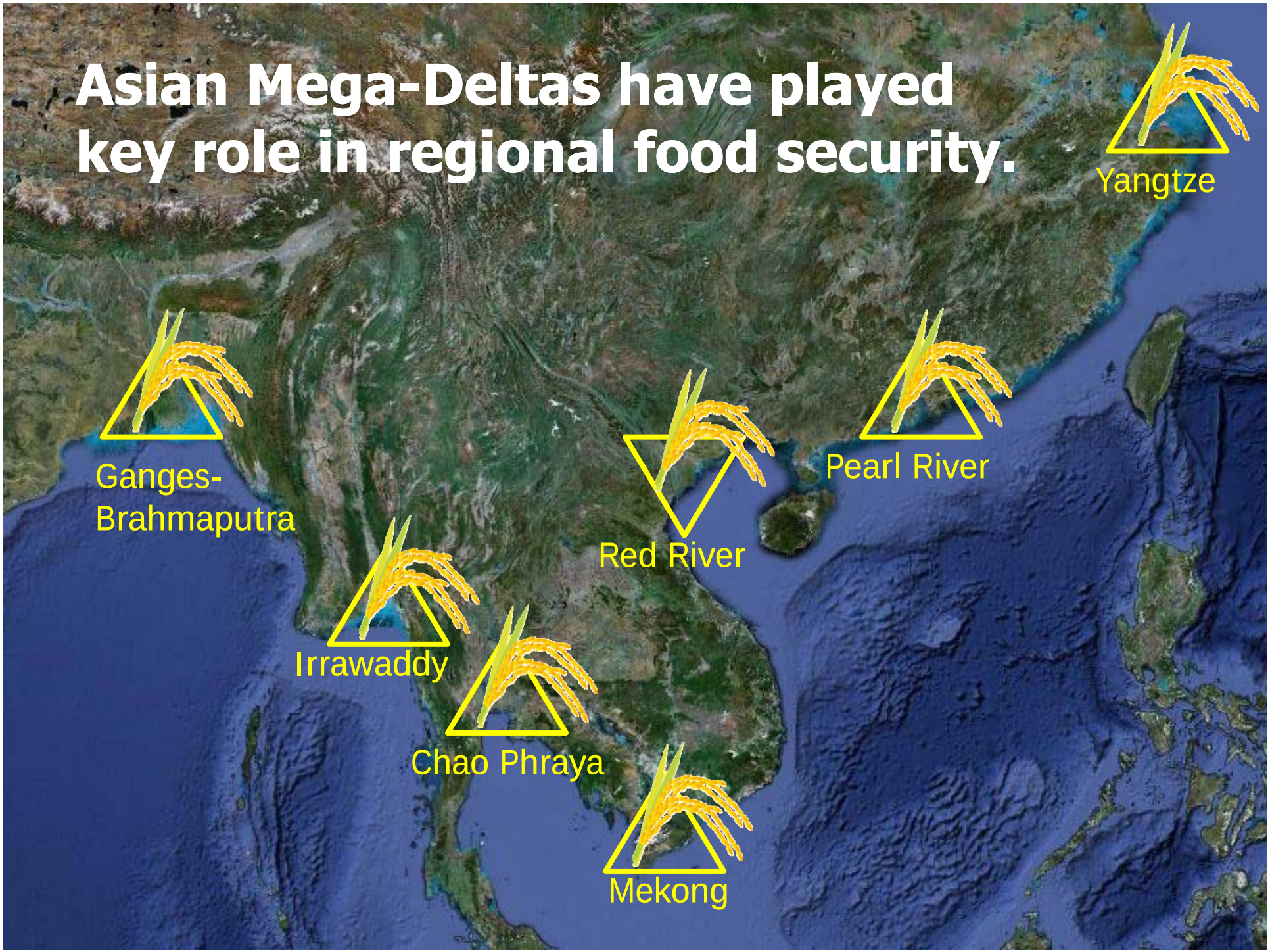
（without adaptation）



- Rice yield is projected to increase in northern area, decrease in western and southern areas.
- Yearly variation would be enhanced.

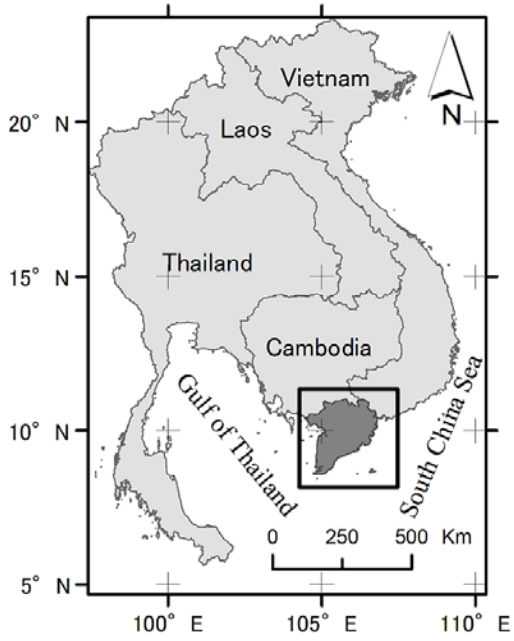
Study 2:
The Mekong Delta, VIETNAM

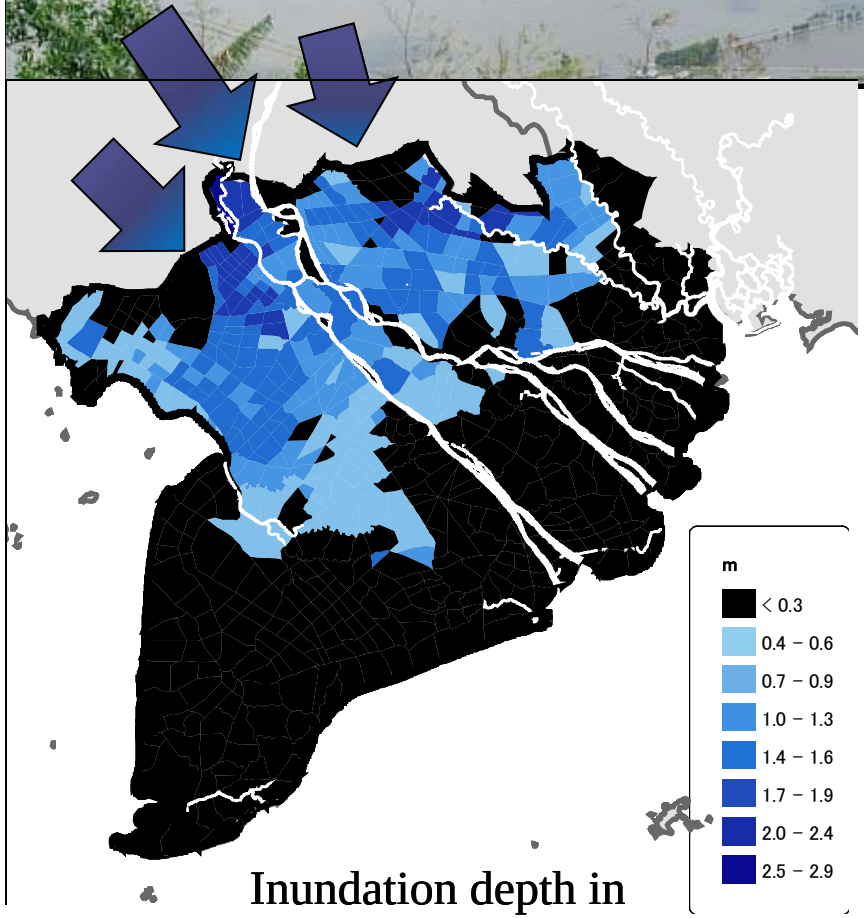
Vulnerability in rice cropping system to water resources change


Asian Mega-Deltas have played key role in regional food security.
Yangtze
Ganges-Brahmaputra
Pearl River
Red River
Irrawaddy
Chao Phraya
Mekong

Rice production in the Mekong Delta (Vietnamese part)

- Production: **19 mill.ton/year**
  - A half of whole Vietnam and a double of Japan.
- Export: **5 mill.ton/year** (in whole Vietnam)
  - More than 90% of which is produced in the Mekong Delta
  - Second place in the world after Thailand
- Yield: **5 ton/ha**
- Harvest area: **3.8 mill.ha/year**
  - Paddy area: 2 mil. ha
  - Multi-rice cropping (up to triple /year)

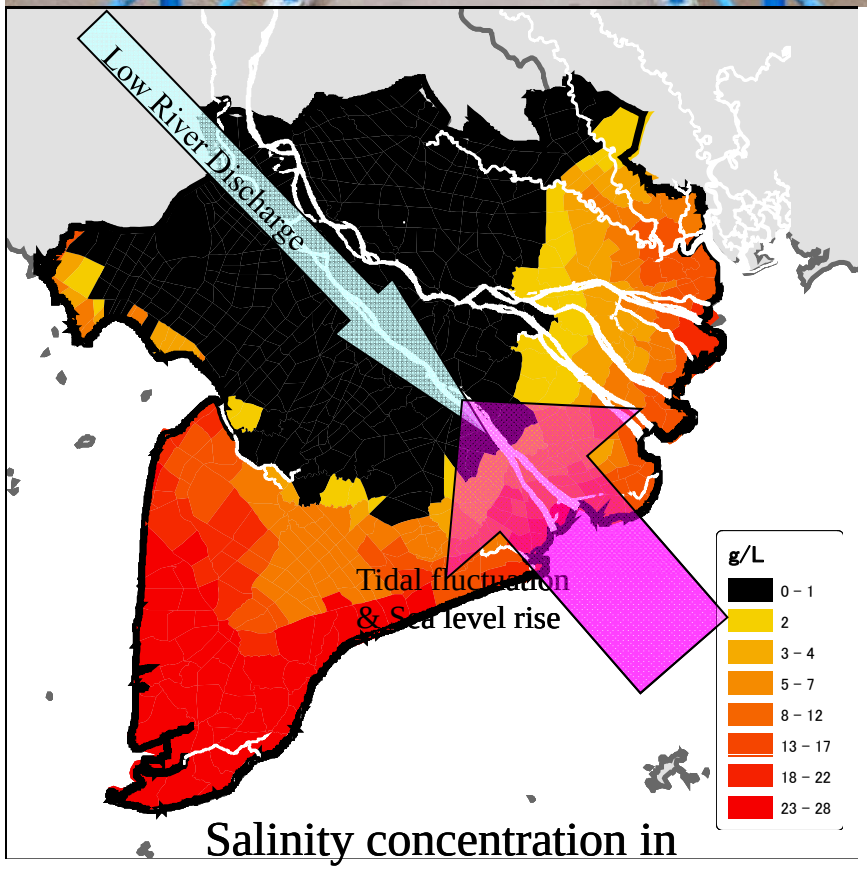




Inundation depth in Oct. 2000

Inundation

- Inundation in back-swamp of the Delta is caused by the seasonal flooding of the Mekong river **during the wet season** (August to December).

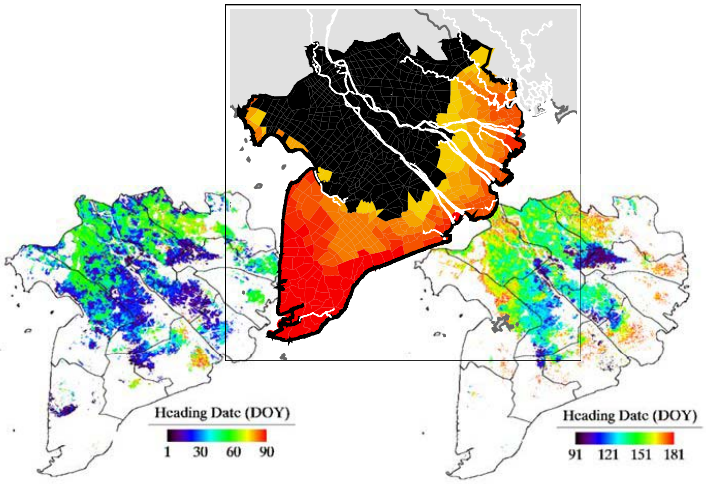


Salinity concentration in Apr.1998

Salinity intrusion

- Sea-water intrudes into the river and canals, when the river level decrease lower than the sea-level **during the dry season**.
- Sea level rise and decreasing of flow discharge of the Mekong River will expand salinity intrusion.

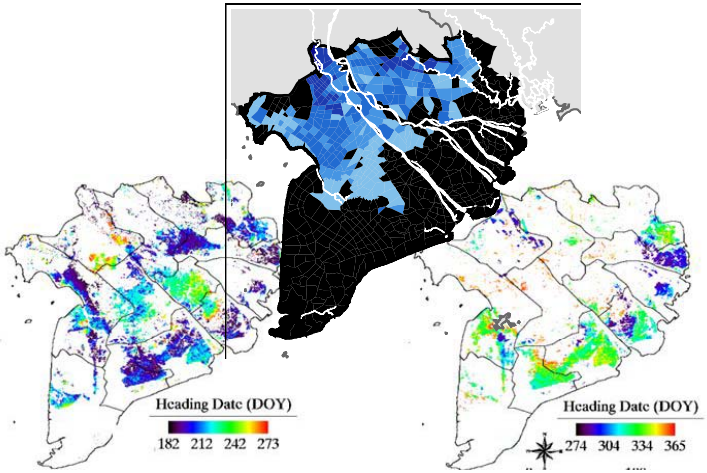
Water environment limits rice cropping patterns and areas



Jan, Feb, Mar　　Apr, May, Jun

Cropping pattern and Salinity
in the dry season

Satellite data (Sakamoto et al.2006)



Jul, Aug, Sep　　Oct, Nov, Dec

Cropping pattern and Flooding
in the wet season

Rice cropping pattern are designed to avoid damage of rice growth from seasonal change of negative water conditions.

Assuming the water resources condition change,
how will rice cropping pattern and harvest area change?

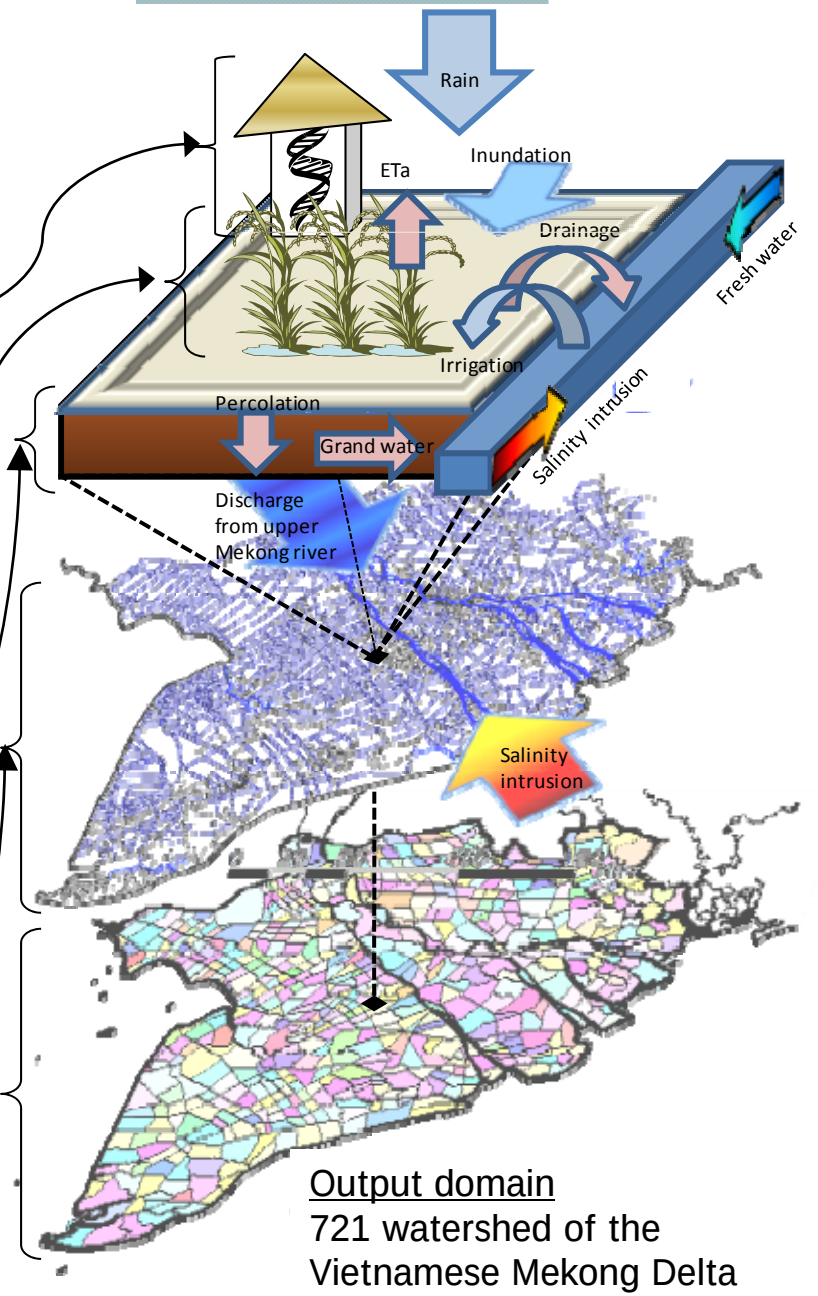
The model

Crop management (Self-adaptation)
Scheduling crop managements such as plowing, sowing, harvesting, and water management, based on paddy and channel water condition and rice growth.

Rice growth
Estimating rice phenology, growth and yield, based on daily weather condition and paddy water condition.

Paddy water balance
Estimating paddy water level, soil moisture and water requirement, based on precipitation, evapotranspiration and irrigation and drainage amounts.

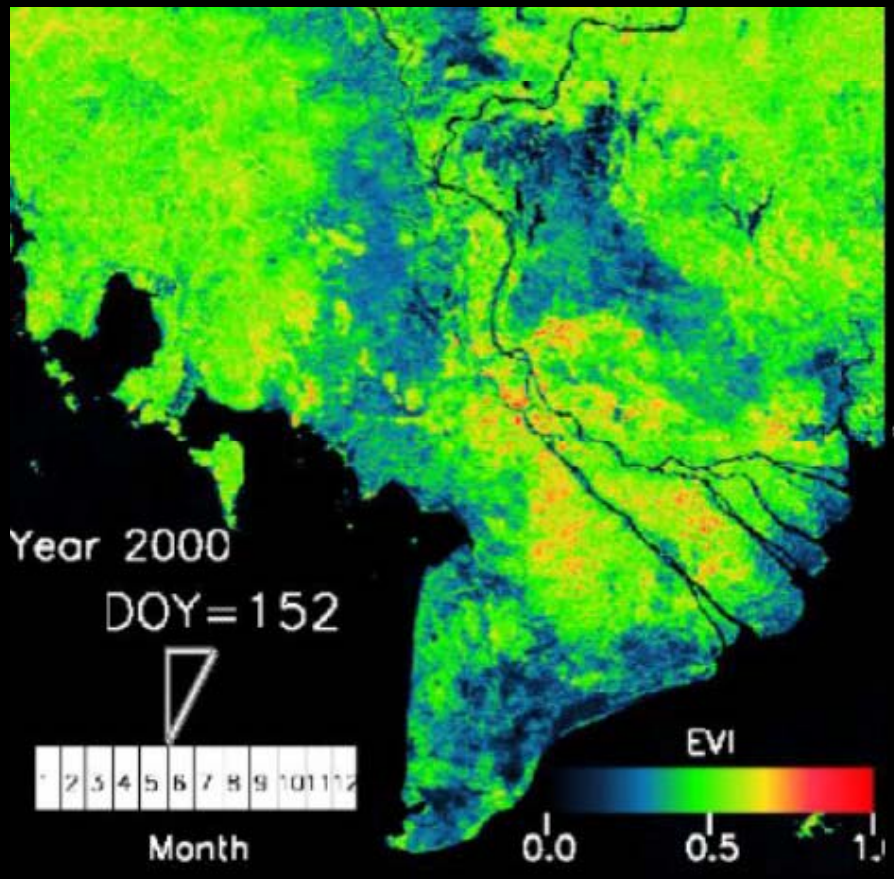
River and channel network
Estimating water discharge and salinity concentration in river and channel, based on discharge of the Mekong river, and tidal fluctuation.



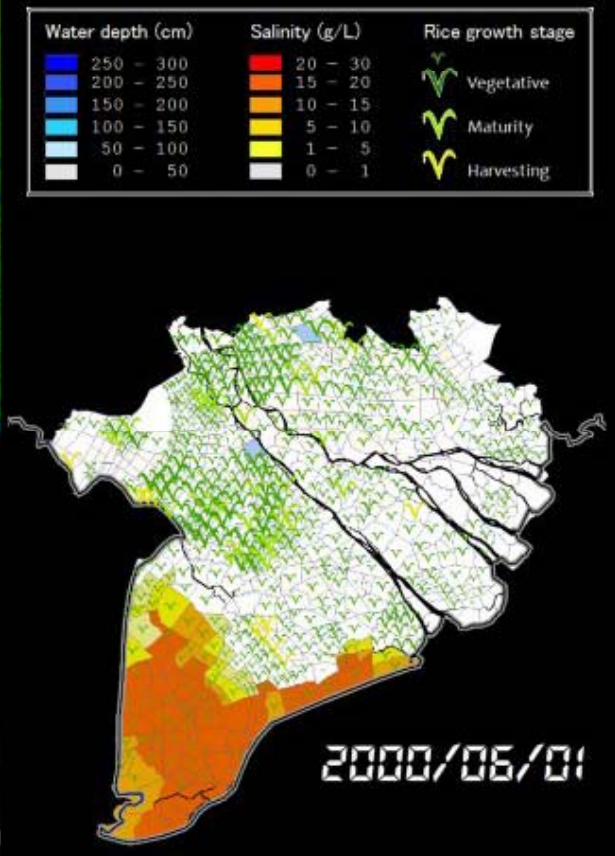
Output domain
721 watershed of the Vietnamese Mekong Delta

Example of the Model performance

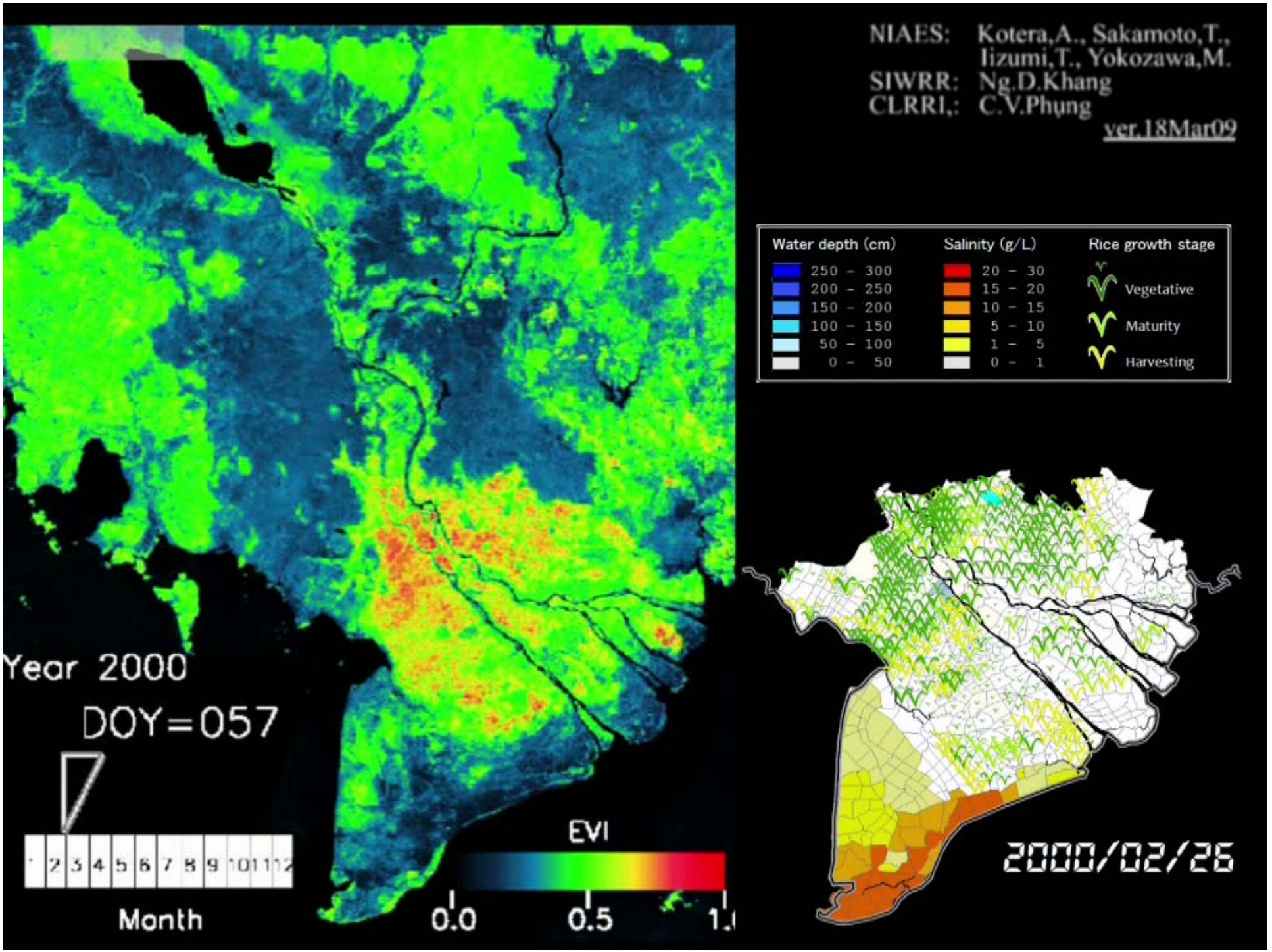
Comparison with satellite imagery



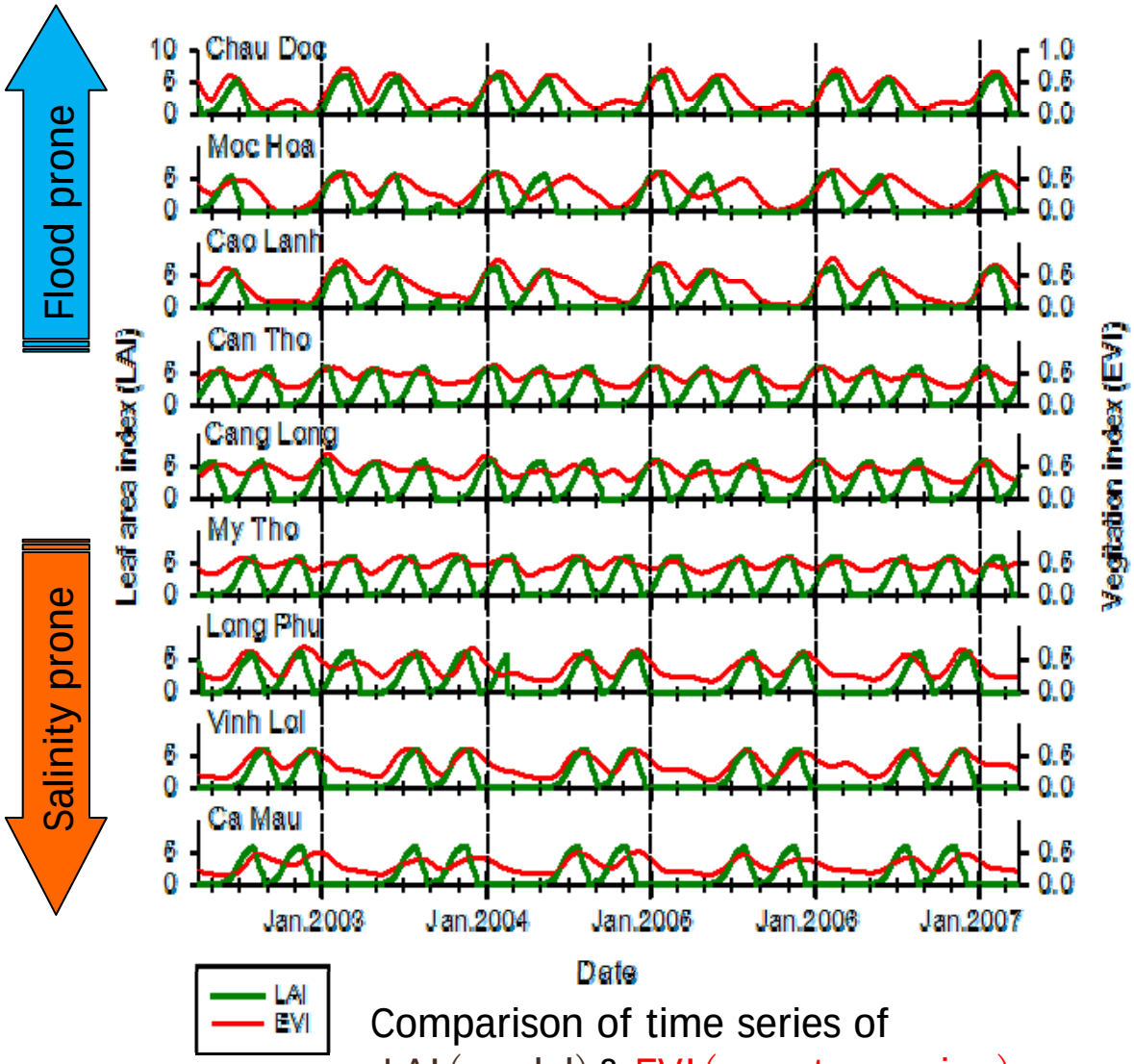
Vegetation (EVI) derived by satellite imageries (MODIS)
Produced by Sakamoto et al. 2006



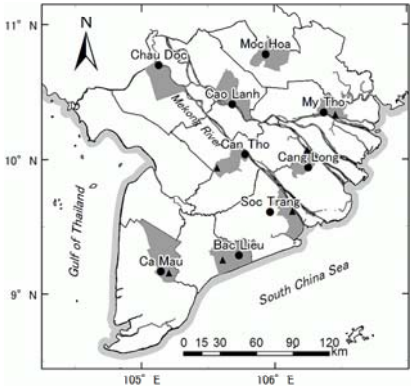
Inundation, salinity and rice growth simulated by the model


NIAES: Kotera,A., Sakamoto,T., Iizumi,T., Yokozawa,M.
SIWRR: Ng.D.Khang
CLRRI,: C.V.Phung
ver.18Mar09
Water depth (cm)
250 - 300
200 - 250
150 - 200
100 - 150
50 - 100
0 - 50
Salinity (g/L)
20 - 30
15 - 20
10 - 15
5 - 10
1 - 5
0 - 1
Rice growth stage
Vegetative
Maturity
Harvesting
Year 2000
DOY=057
1 2 3 4 5 6 7 8 9 10 11 12
Month
EVI
0.0
0.5
2000/02/26

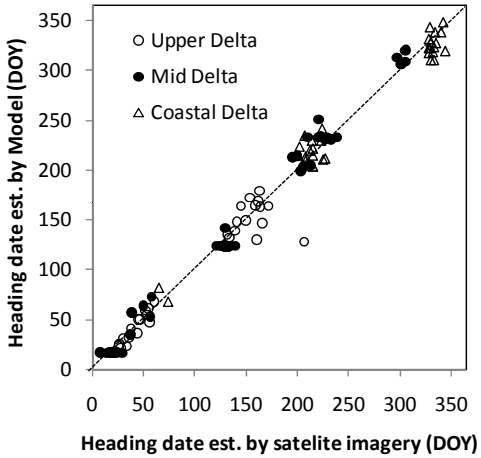
Validation of the model



Comparison of time series of
LAI (model) & EVI (remote sensing)



- Meteorological station
- Salinity observatory
- Target area of remote sensing



Comparison of flowering date
(X:Model,Y:MODIS)

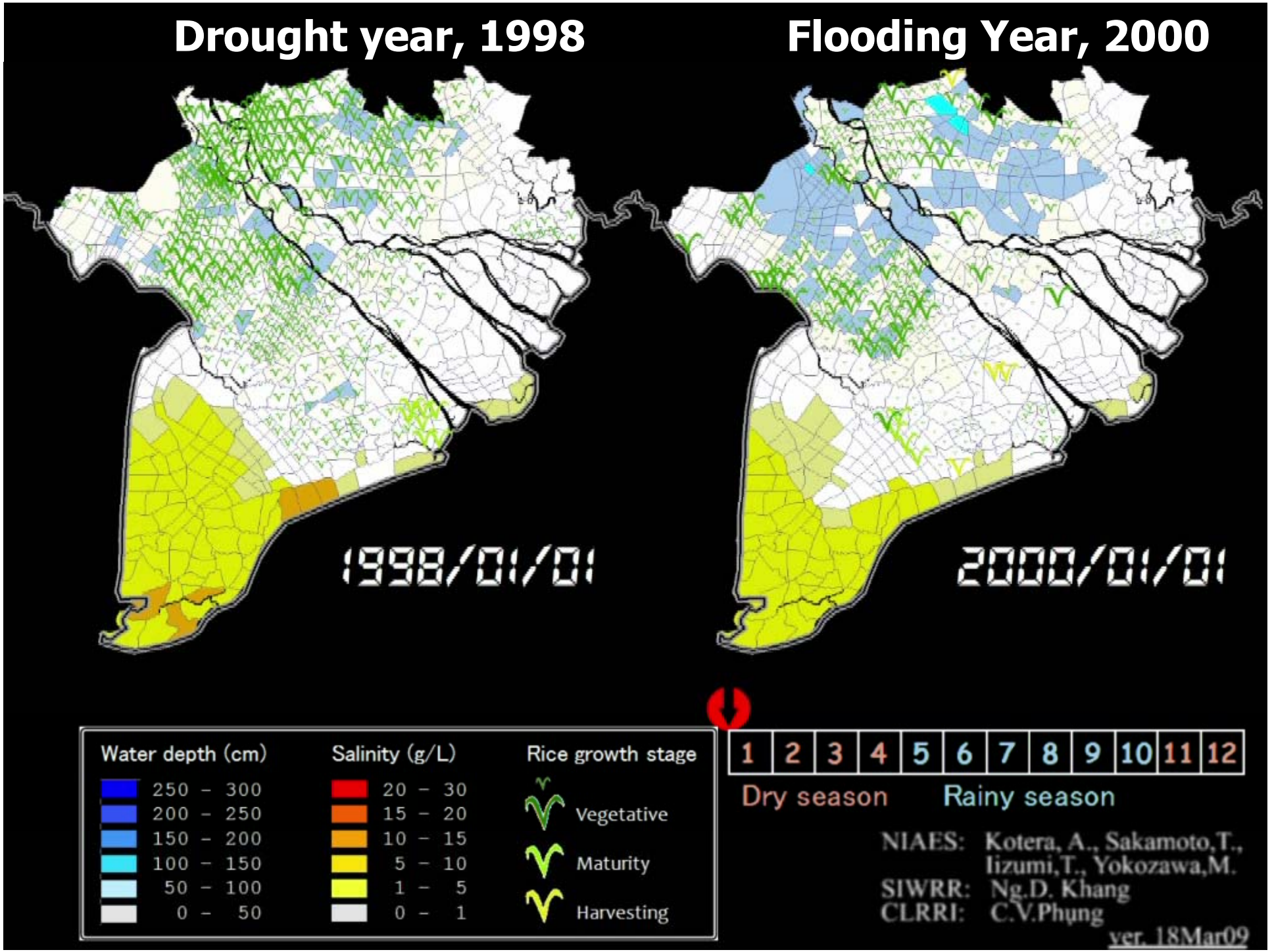
RMSE:
Upper area = 17.6 Days
Middle area = 11.2 Days
Coastal area = 13.0 Days

Analysis of impact of water resources change on cropping pattern

Drought year vs. Flooding year

	1998 Drought year	2000 Flooding year
Rainfall(mm)*	**1,746**	**1,921**
Monsoon onset	**Later**	**Earlier**
Max. flow discharge (m^3/s)**	**35,636**	**61,917**
Salinity intrusion	Large	Small
Inundated area	Small	Large
Historical scale	Extreme water condition in recent 20 years	

Observed in *Can Tho and **Kratie


Drought year, 1998
Flooding Year, 2000
1998/01/01
2000/01/01
Water depth (cm)
250 - 300
200 - 250
150 - 200
100 - 150
50 - 100
0 - 50
Salinity (g/L)
20 - 30
15 - 20
10 - 15
5 - 10
1 - 5
0 - 1
Rice growth stage
Vegetative
Maturity
Harvesting
1 2 3 4 5 6 7 8 9 10 11 12
Dry season
Rainy season
NIAES: Kotera, A., Sakamoto,T., Iizumi,T., Yokozawa,M.
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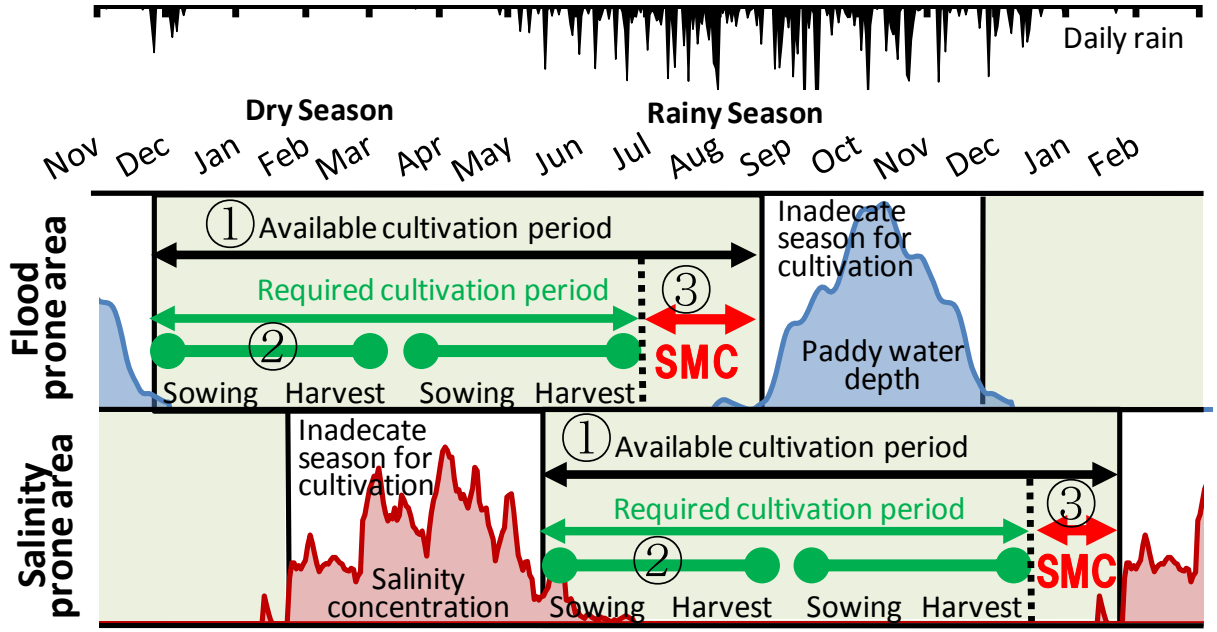
ver. 18Mar09

Evaluation indices



① **<u>Available cultivation period</u>** → Scale of threat

② **<u>Maximum cropping frequency</u>** → Quantity of influence on rice production

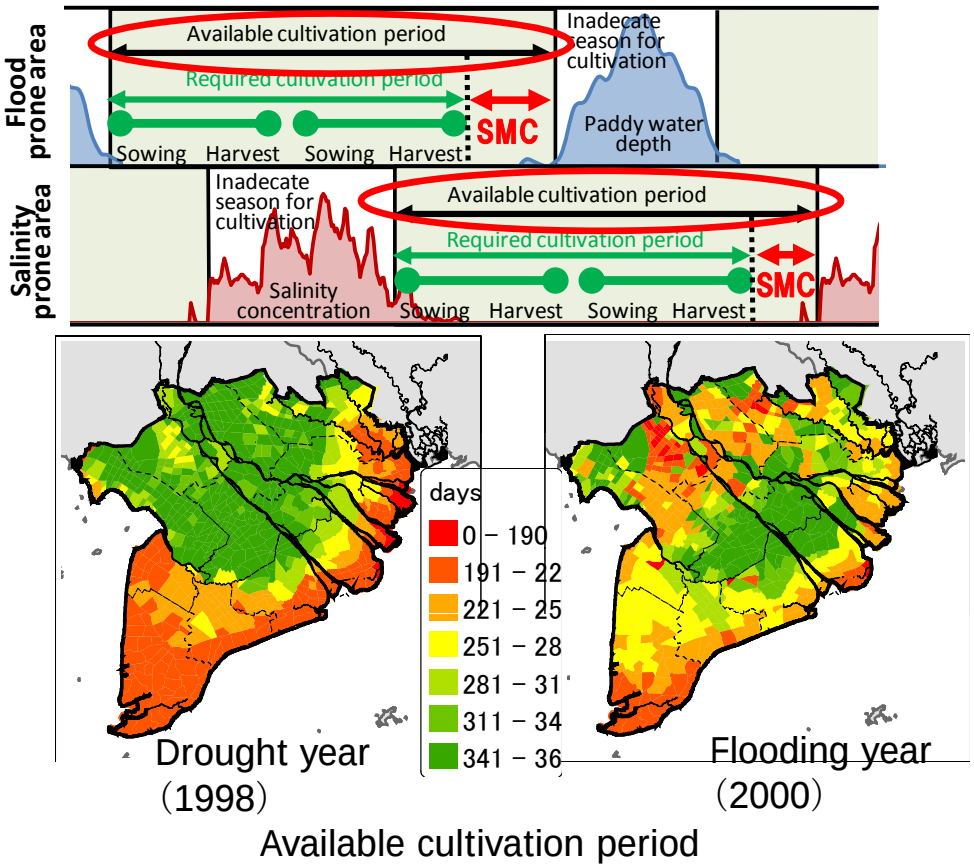
③ **<u>Safe Margin for Cropping (SMC)</u>** → Vulnerability to threat

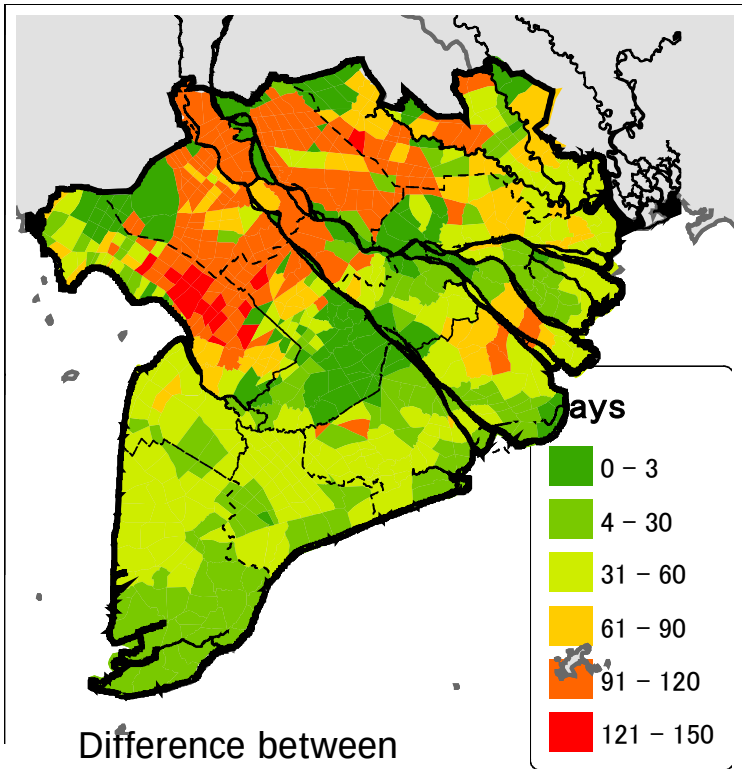
Time margin in the available cultivation period to the required period.

If SMC is short, the rice cropping would be easy to fail.

④ **<u>Rice productivity</u>** <u>(kg/km^2)</u> = **Σ Yield** in each harvest

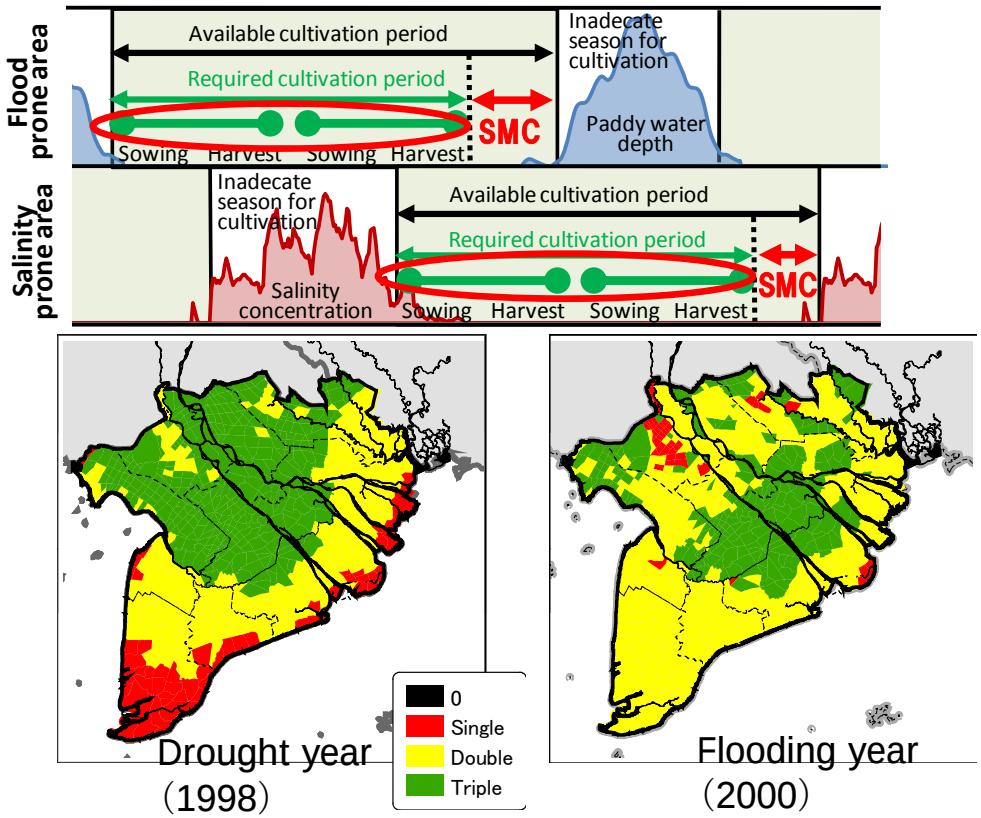
Change of available cultivation period



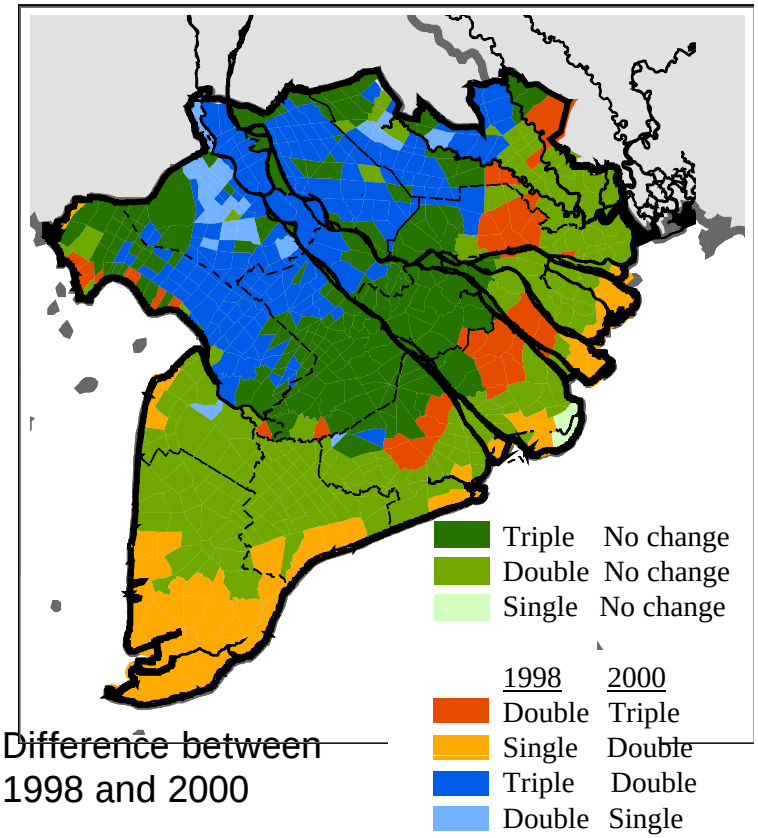


Range of available cultivation period was larger in the upper delta area with prone to flooding.

Change of cropping frequency



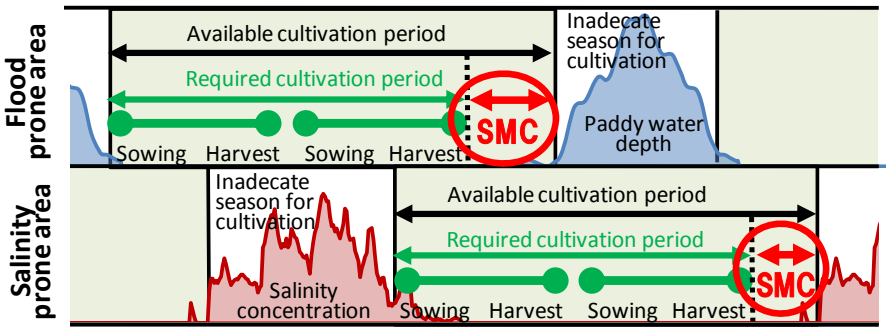
Maximum copping frequency (No./year)

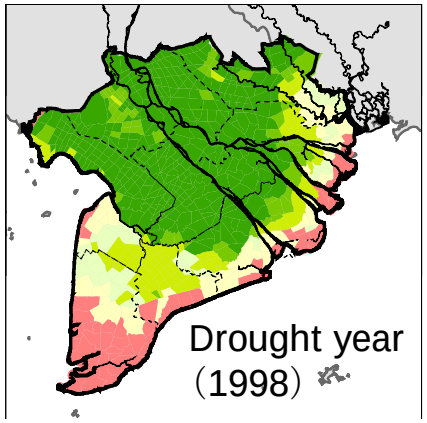


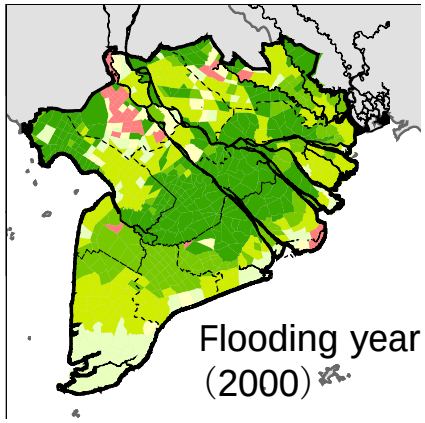
Difference between 1998 and 2000

The cropping frequencies were changed by years particularly in coastal area as well as in the upper area, though variation range of cultivation period in coastal area was small.

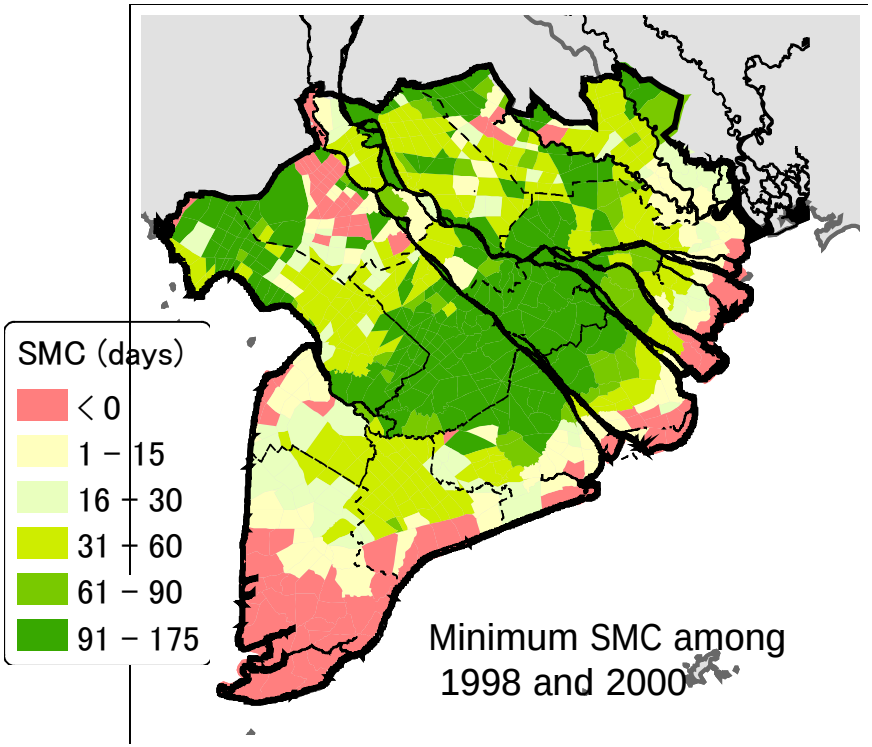
SMC: Safe Margin for Cropping







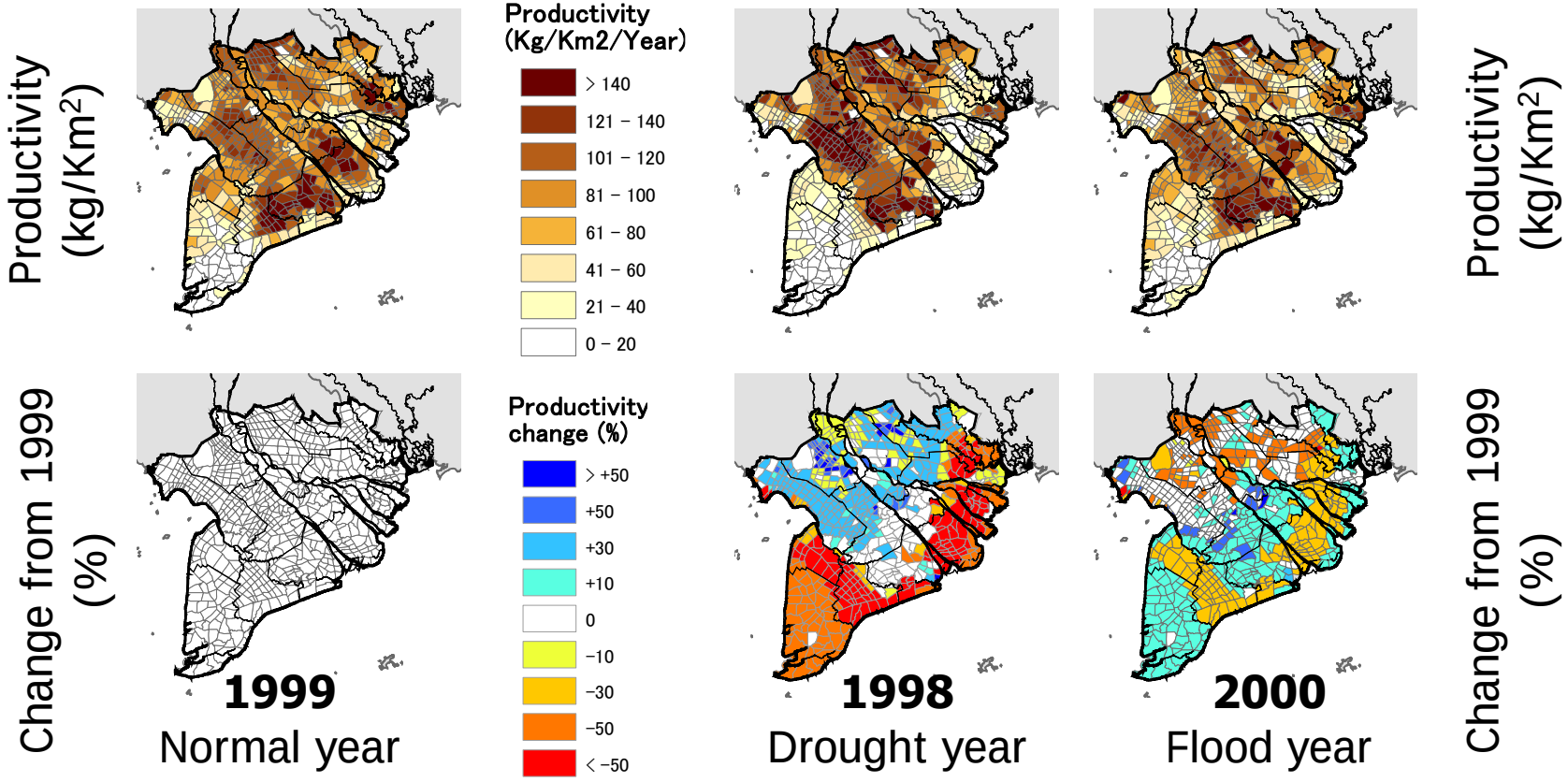
Safe margin for rice cropping (SMC)



The SMC in the coastal area were small, which imply that the **rice cropping system in the coastal area is vulnerable to the water resources changes**. Consequently, cropping frequency in the coastal area were easy to change even in small water resources change.

Change of annual rice productivity

Annual rice productivity (kg/km^2) = **Σ Yield** in each harvest



An inter-regional complementary alleviated serous reduction of total rice production of the whole delta.

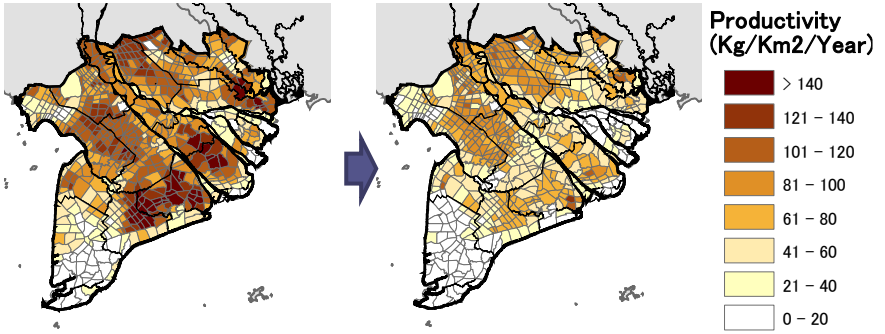
Rice productivity in 2030

	1999 Normal year	**2030*** MIROC hi A1B
Ave. Temp (℃)	26.7	27.9
Annual rain (mm)	1,905	1,564
Monsoon onset	-	Earlier
Max discharge(m^3/s)	51,665	59,256
Salinity intrusion	-	Smaller
Inundated area	-	Larger

(*Only single year projection)

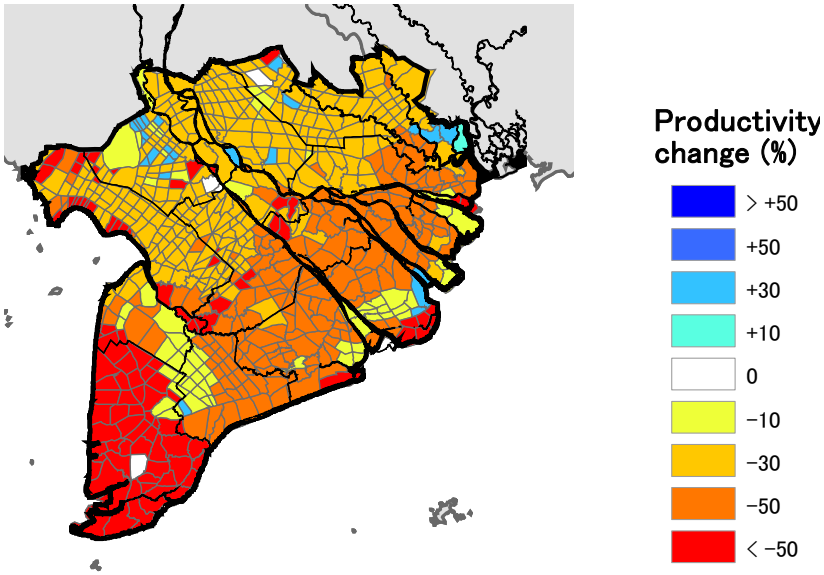
•Harvest areas decreased by severe inundation in the upper area and less rainfall in the coastal area.

•Yields decreased by higher temperature particularly in the wet season crops.



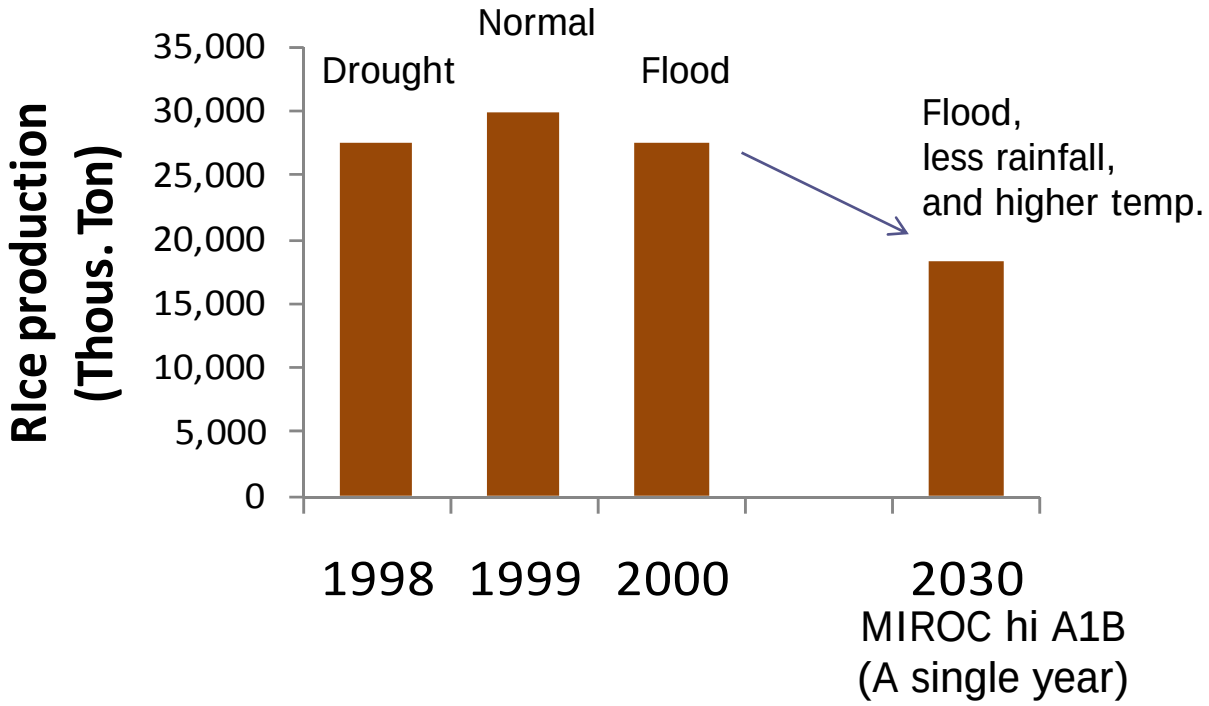
Productivity **1999** Normal year

Productivity **2030** MIROC hi A1B



Productivity change 1999-2030 (%)

Change of annual rice production in the whole Mekong Delta



Production = Annual productivity x Paddy area in 2001

Summary

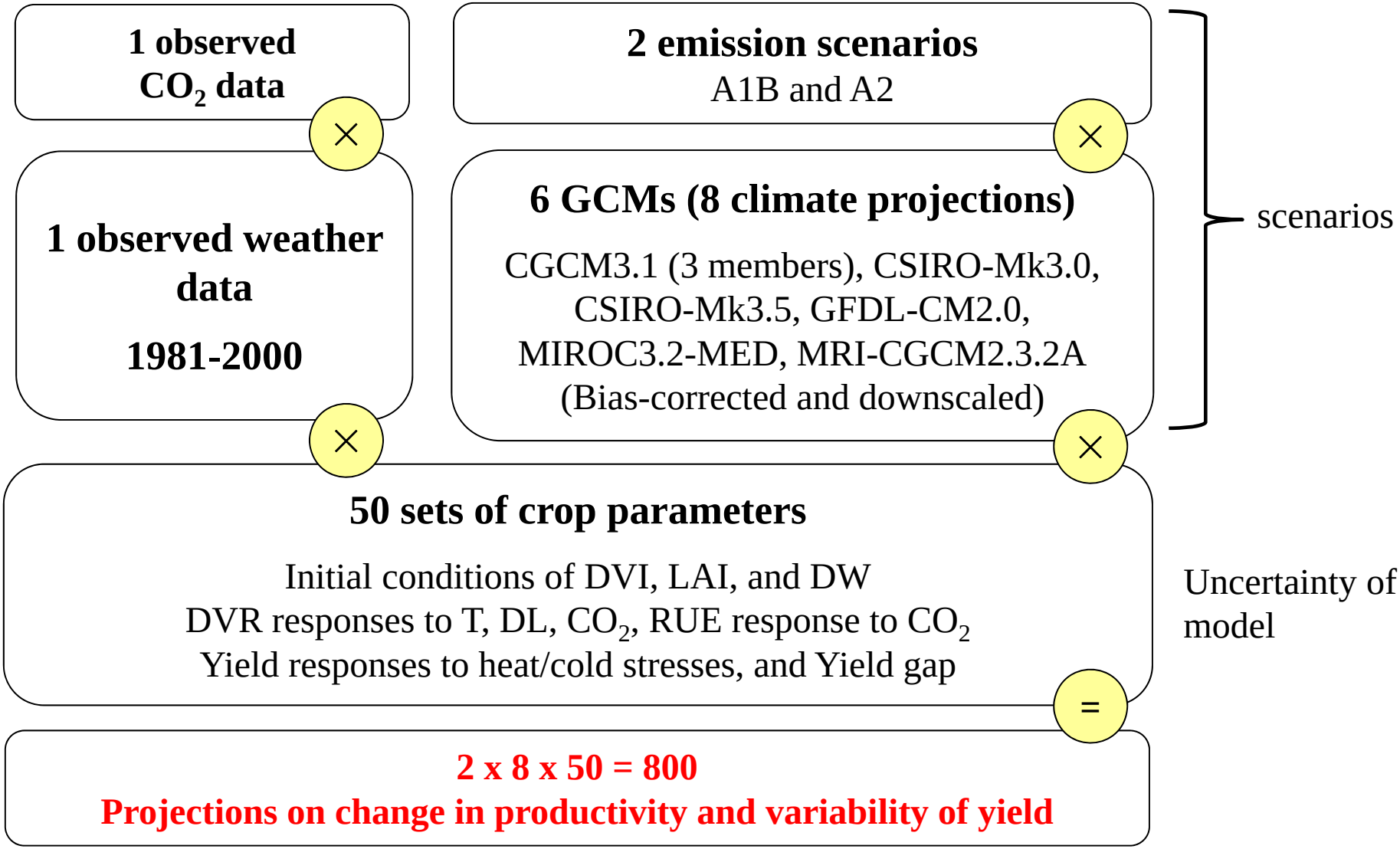
- **JAPAN**
  - Rice yield is projected to increase in northern area, but decrease in western and southern areas.
  - Yearly variation of rice yield would be magnified by temperature rise except in northern area.
- **The Mekong Delta, VIETNAM**
  - Change of threats scale would be larger in the upper area (inundation), but vulnerability in cropping system would be higher in the coastal area*.

    *Recently, land use in the coastal area is changing from paddy to shrimp pond etc.
  - Future rice production could considerably decrease by both decreasing of harvest area and yield.
    (We need farther study.)

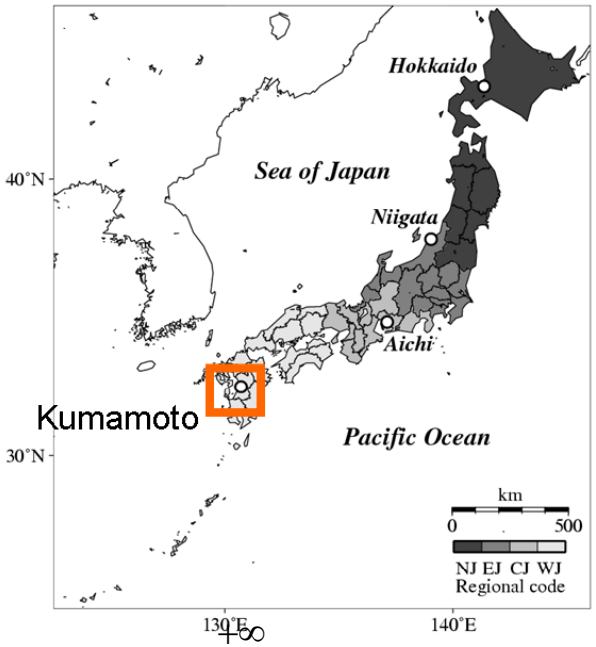
Expected adaptation measures

- **Yield**: Adapt to avoid the heat stress
  - Rice breeding
    - Heat tolerant cultivar, Phenology control...
  - Optimization of farming system
    - Crop scheduling, Early Warning System...
- **Harvest area**: Secure Safe Margin for Cropping
  - Protection engineering
    - Flooding, Salinity, SLR, Irrigation and drainage system...
  - Optimization farming system
    - Crop scheduling, Farm work, Land use...

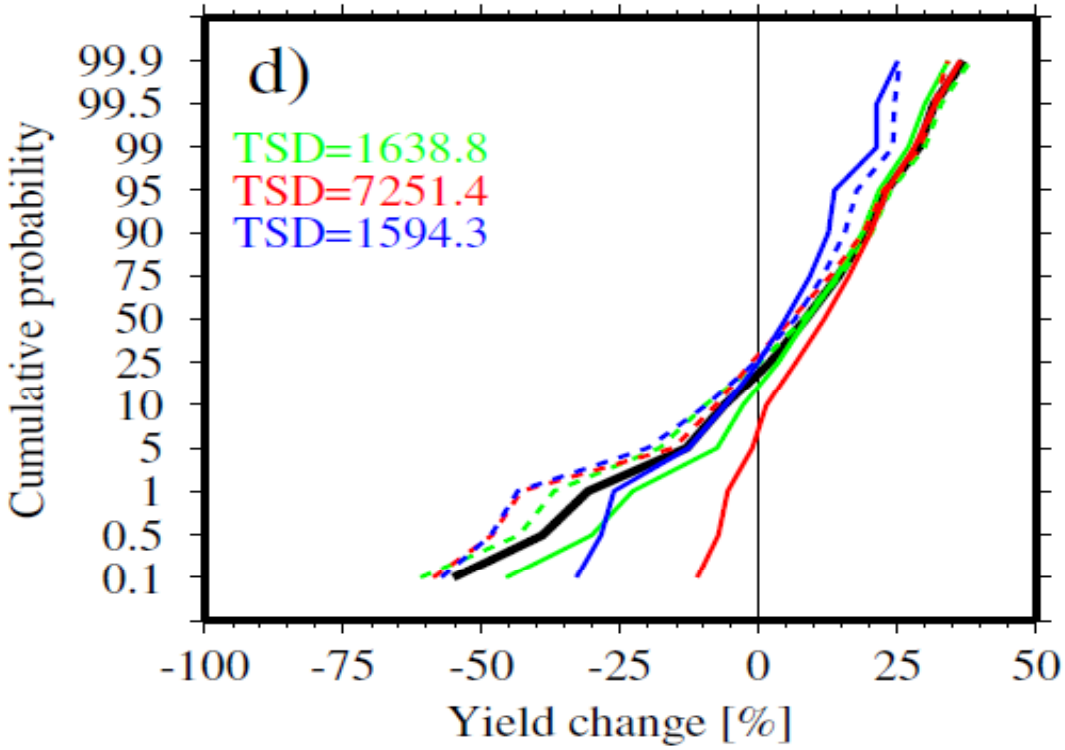
Uncertainty of projected impacts



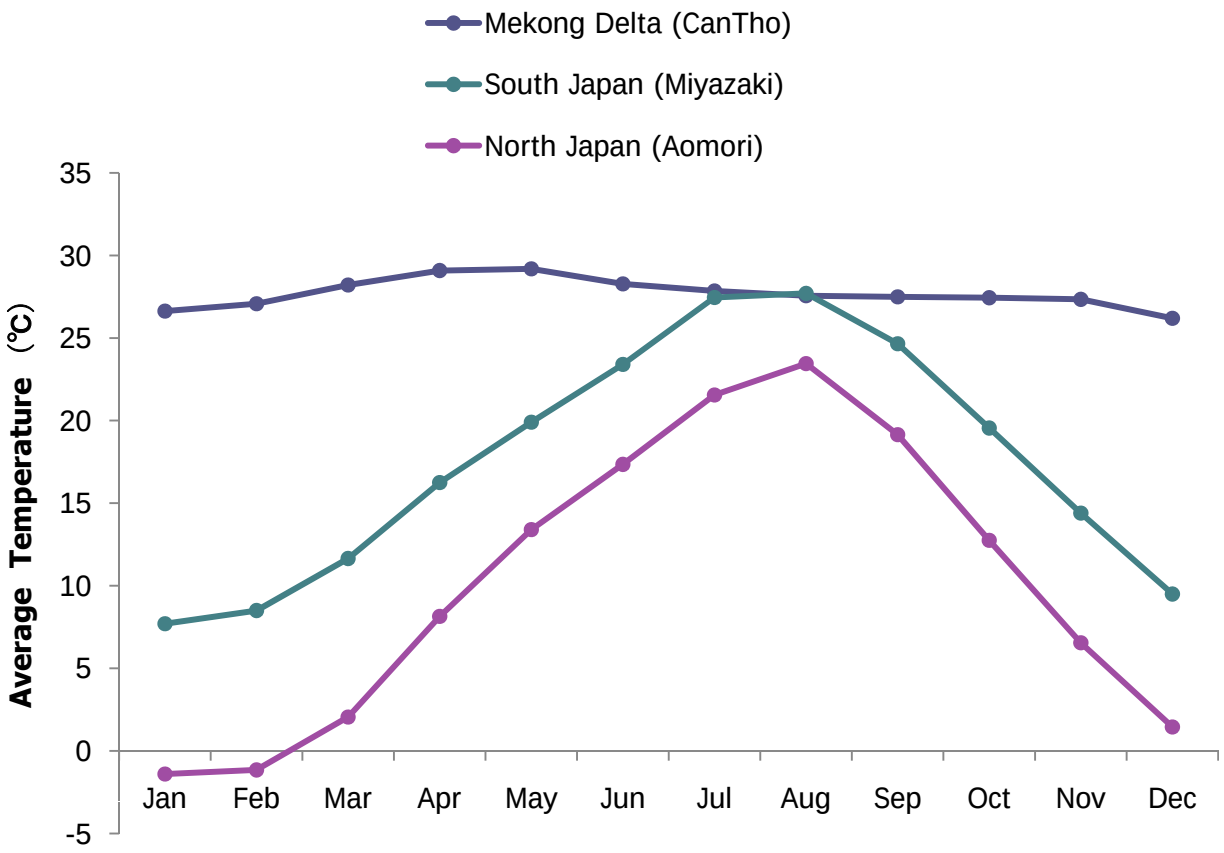
Uncertainty of projected impacts (parameter values)



$$TSD = \int_{-\infty}^{+\infty} [F_1(y) - F_2(y)]^2 \, dy$$

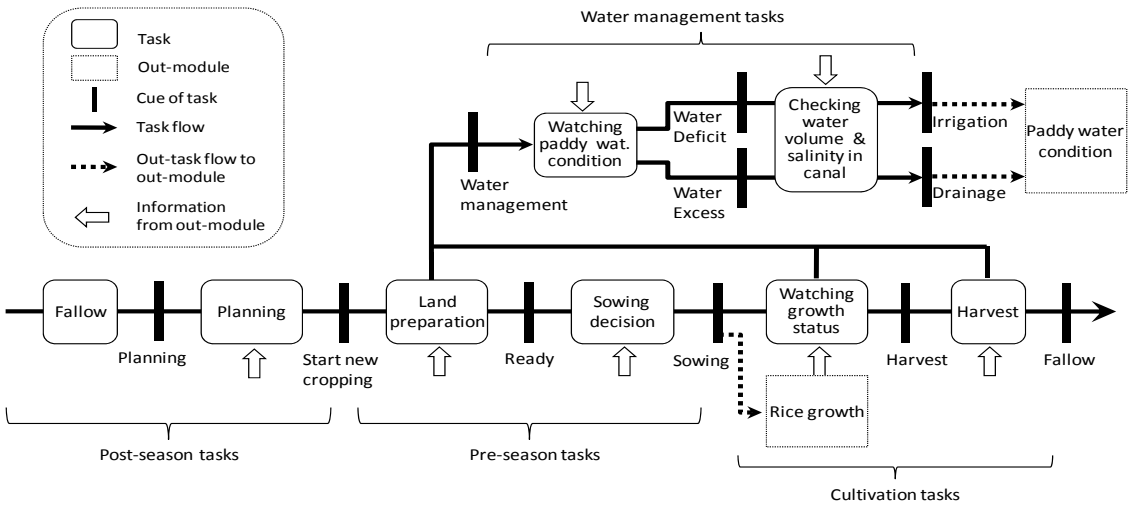


- 1 emission (A1B), 6 GCMs, and 50 sets of parameters
- 1 emission (A2), 6 GCMs, and 50 sets of parameters
- 1 GCM (CSIRO-Mk3.0), 2 emissions, and 50 sets of parameters
- 1 GCM (MIROC3.2-MEDRES), 2 emissions, and 50 sets of parameters
- 1 set of parameters (best), 2 emissions, and 6 GCMs
- 1 set of parameters (50th best), 2 emissions, and 6 GCMs
- 2 emissions, 6 GCMs, and 50 sets of parameters

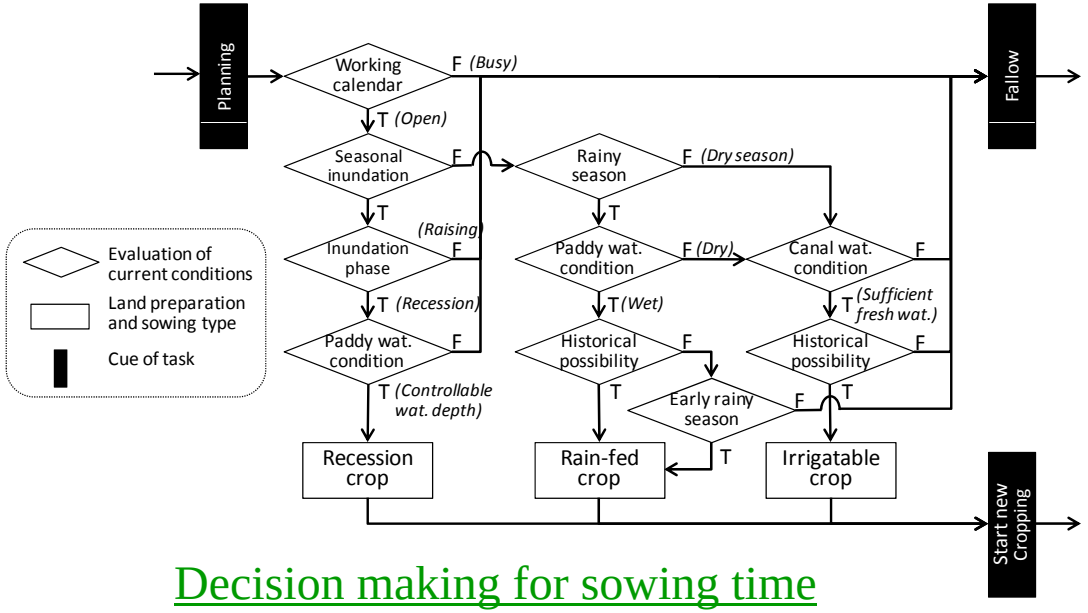

Mekong Delta (CanTho)
South Japan (Miyazaki)
North Japan (Aomori)
Average Temperature (℃)
35
30
25
20
15
10
5
0
-5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Cropping model

- Cropping calendars are developed with the record of progress of the cultivation process and rice growth.
- The model account for both the maximum land use and the minimum risk on harvest with the current environmental condition as well as the successful experiences of the cropping in the historical condition. The parameters of the decision criteria were given by empirical values according to the result of field survey in MRD.

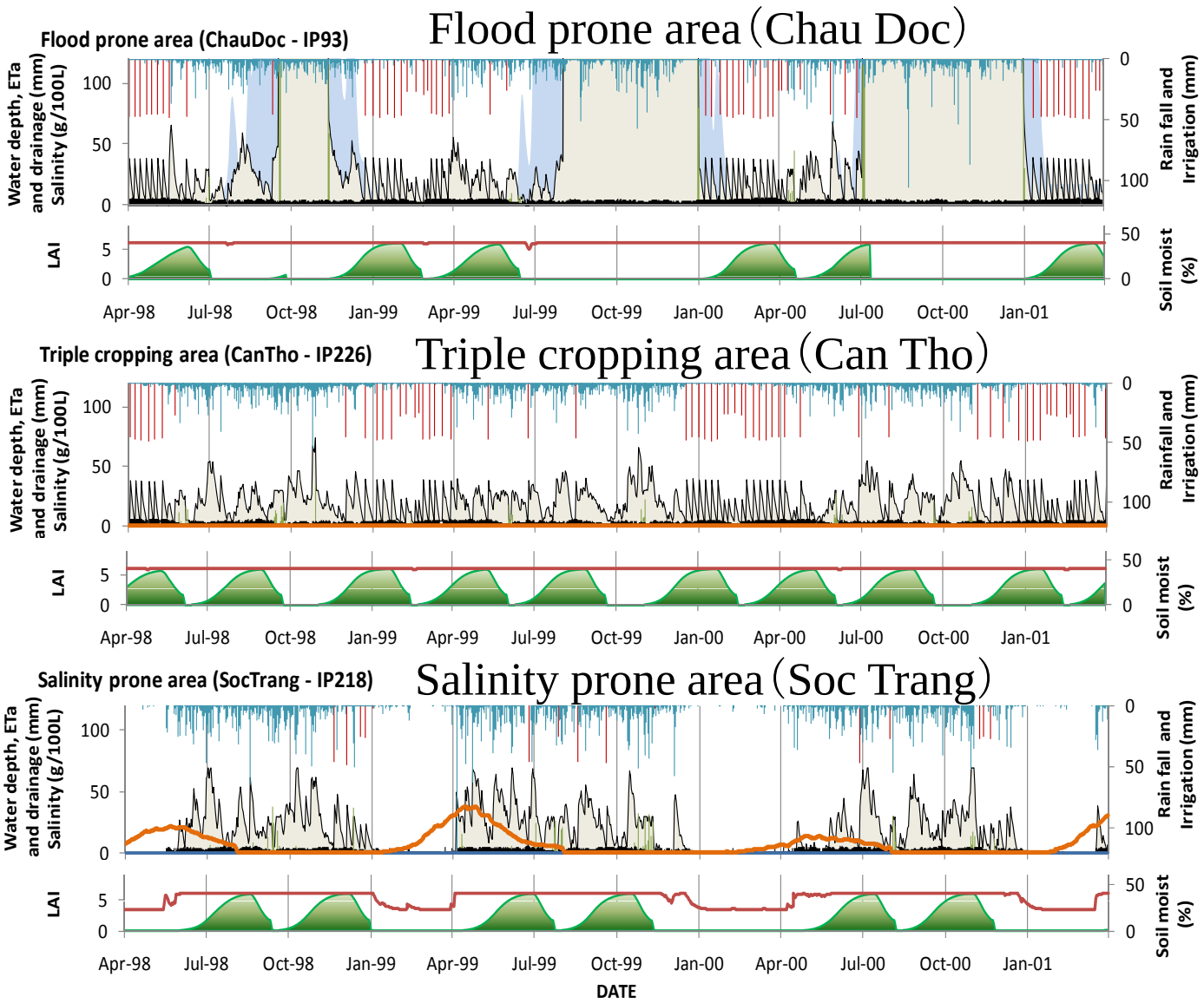


Sequence of cultivation work

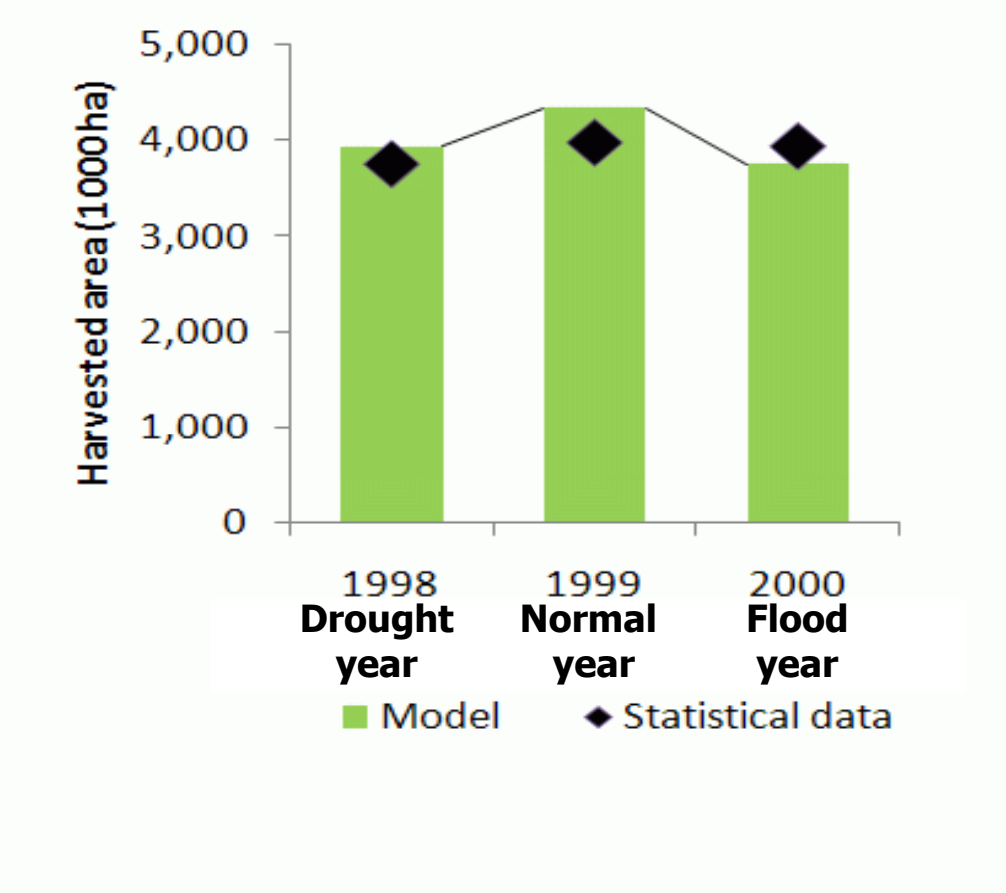


Decision making for sowing time

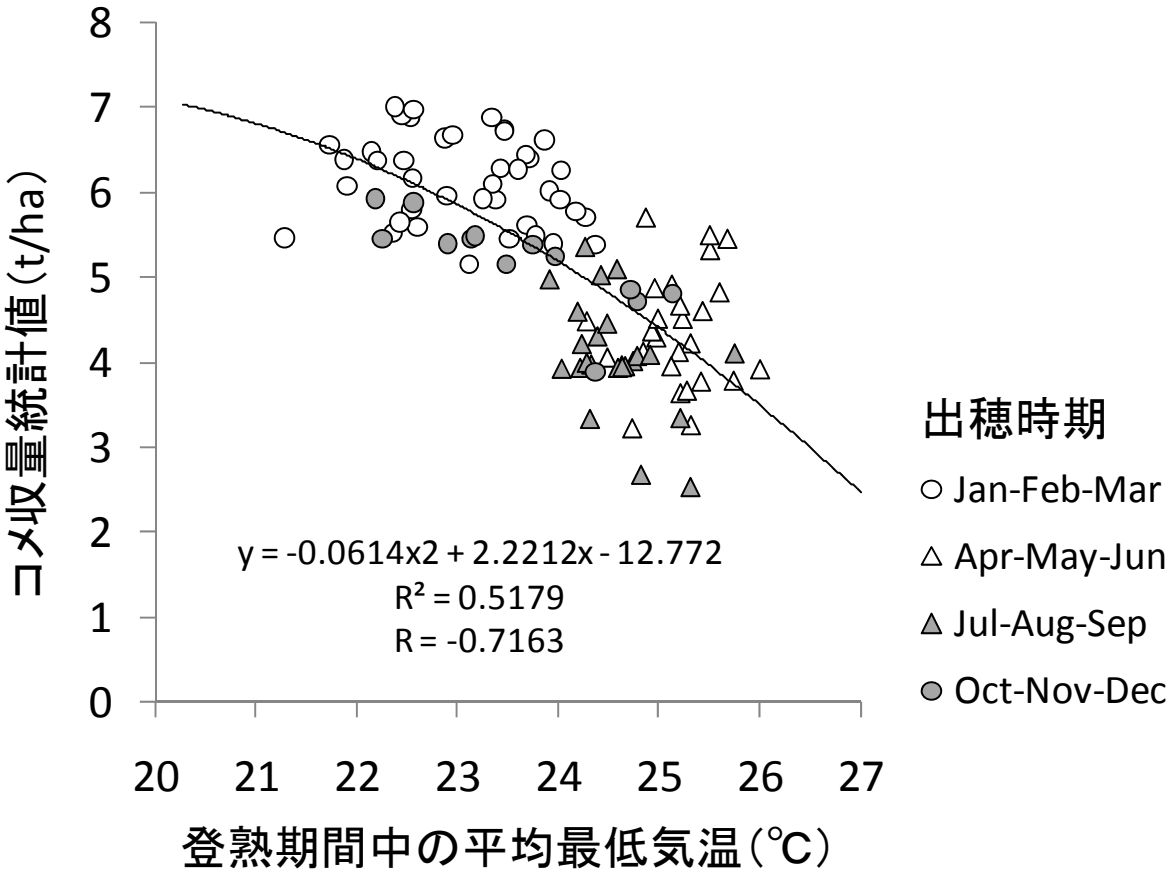
Model performance



Change of annual harvest area in the whole Delta



Rice yield vs. Night Temperature in the Mekong Delta



Yield and harvest area in quarterly period