Impacts of Climate Change on Rice Production and Possible Adaptation Options

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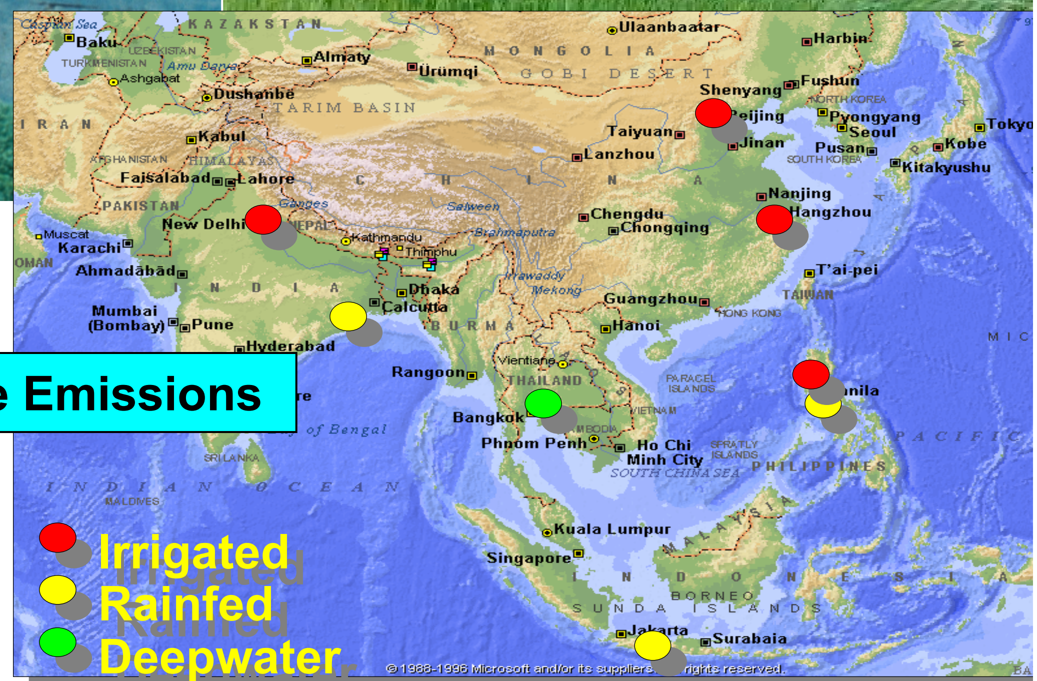
IRRI's Previous Projects on Climate/ Climate Change

- **In 1961-62, IRRI studied the effect of temperature on japonica and indica rice in the growth chamber.**
- **In 1971-72, IRRI studied the effect of CO_2 enrichment on rice plants in open-top chambers.**
- **Several projects on Methane Emissions from 1991-1999**
- **Open top chamber experiments on Temp./ CO2 effects and modeling (1991-1995)**

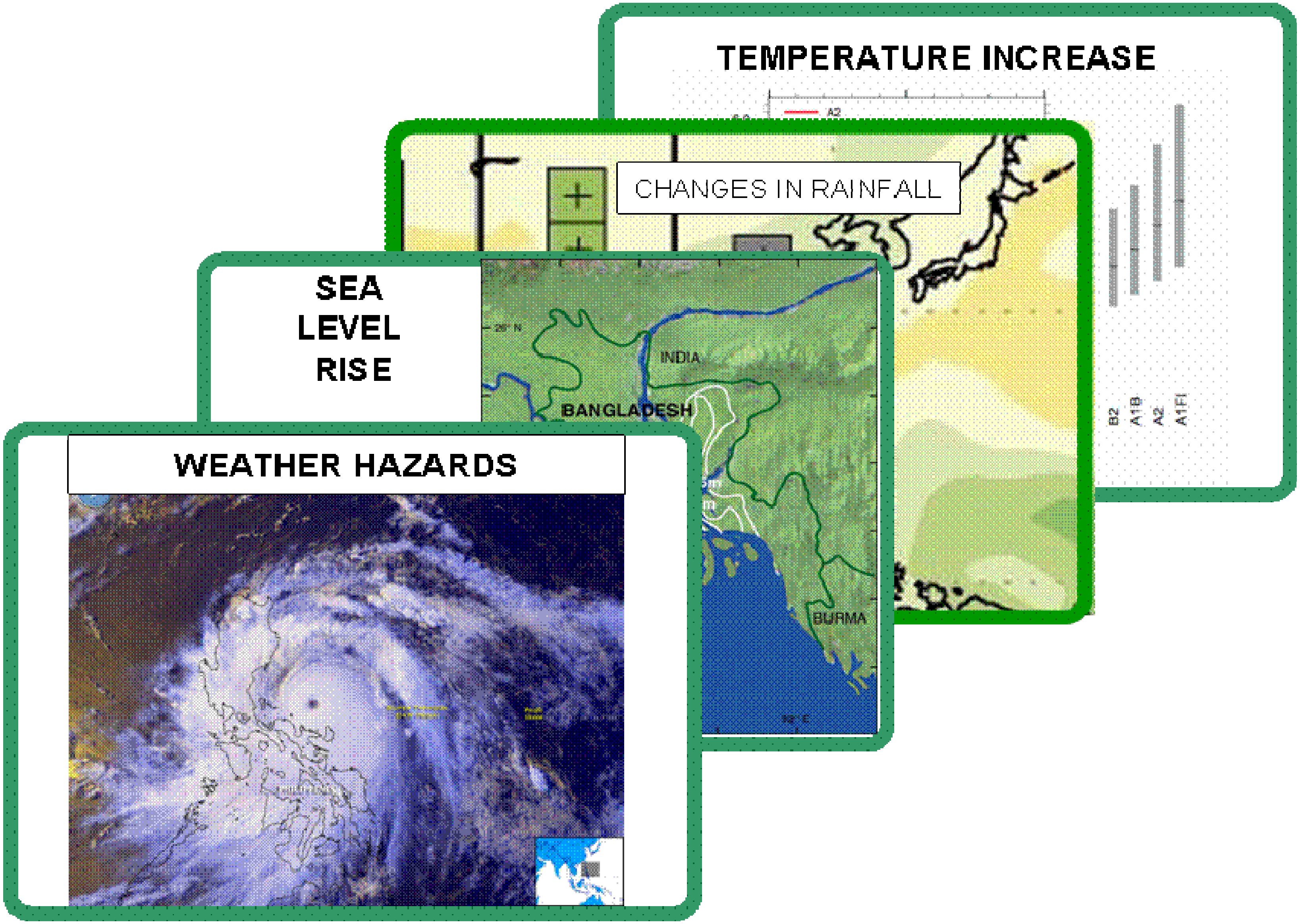
Research on ‘Rice and Climate Change’ in the 1990’s

Open Top Chambers and Automated Methane Emission Mesurements

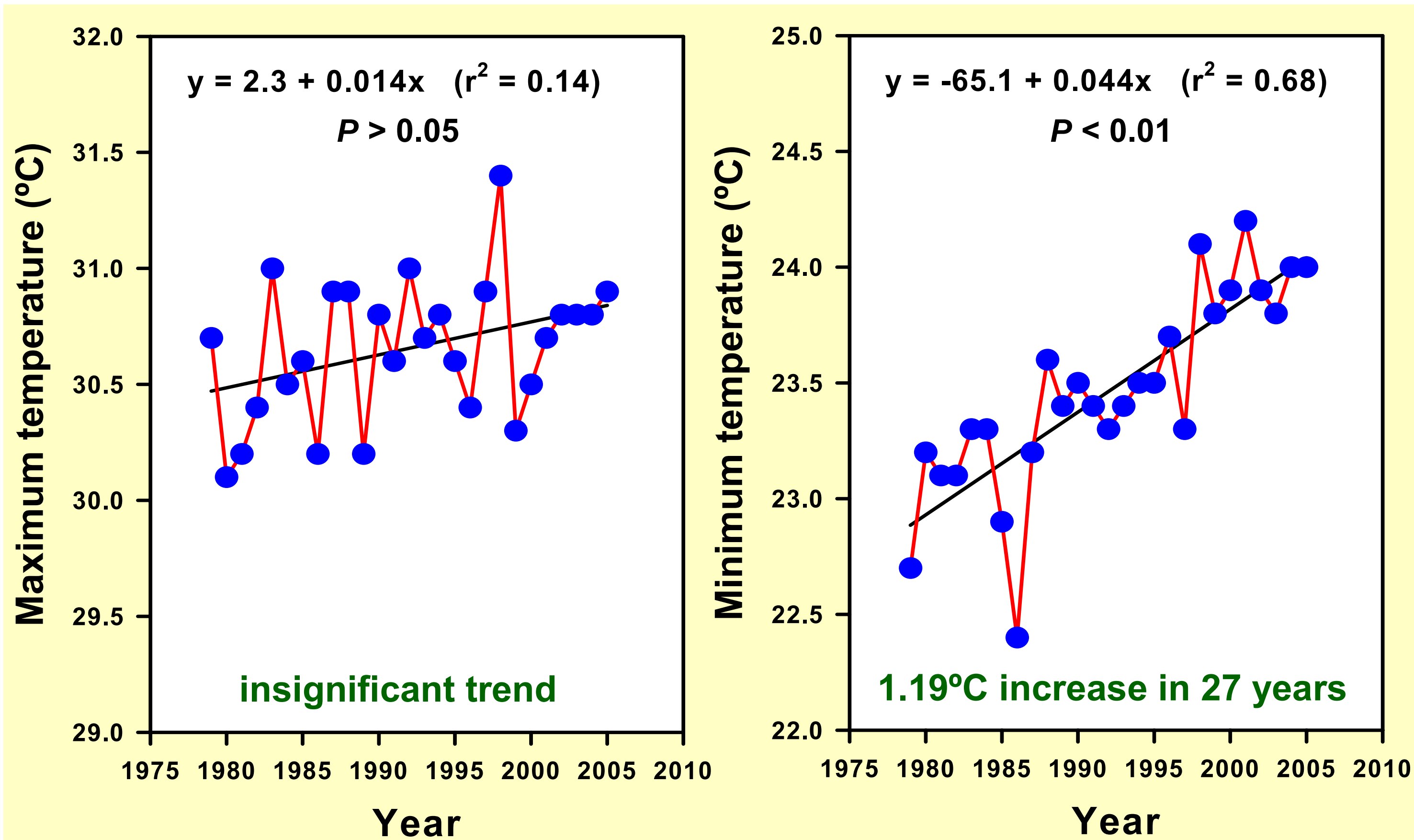
Network on Methane Emissions



Climate Change Effects Relevant for Rice Production

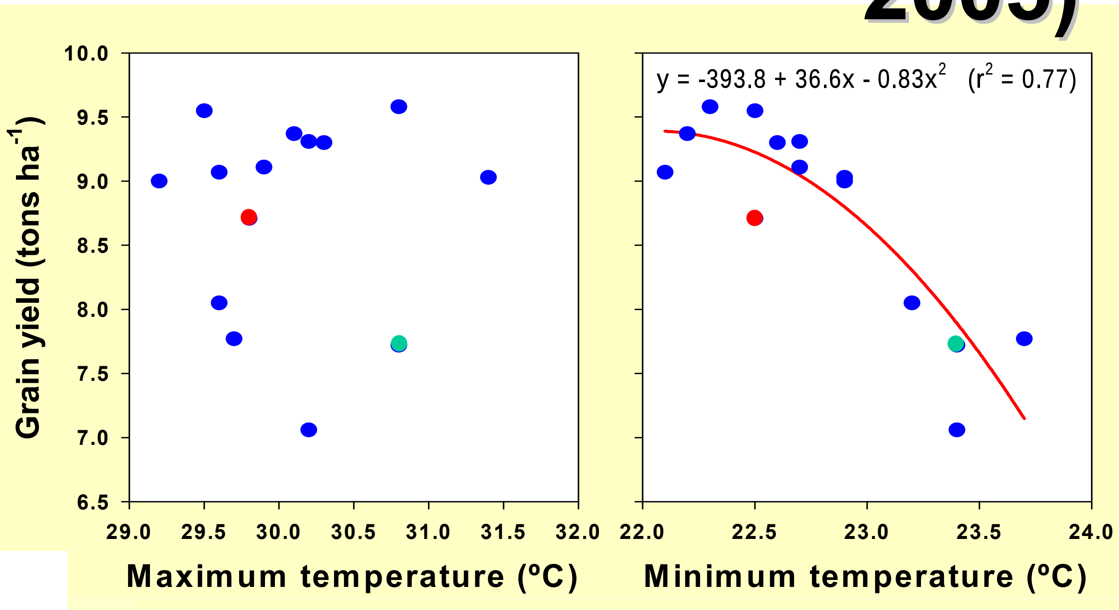


Annual means of daily max./ min. temperature, IRRI



Data from IRRI Climate Unit

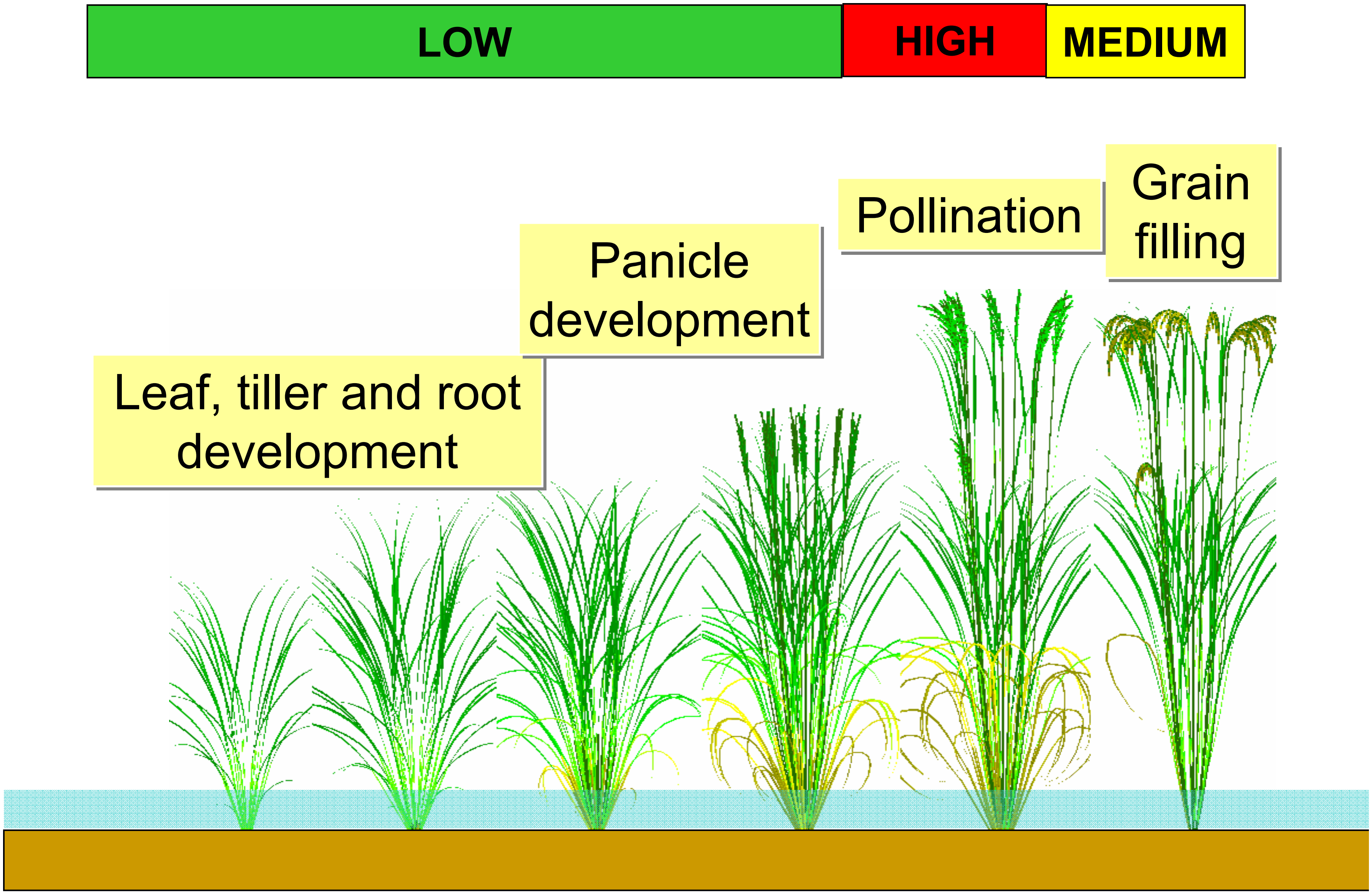
Long-term field experiment at IRRI (1975-2005)



Peng et al. 2004


23°C
25°C

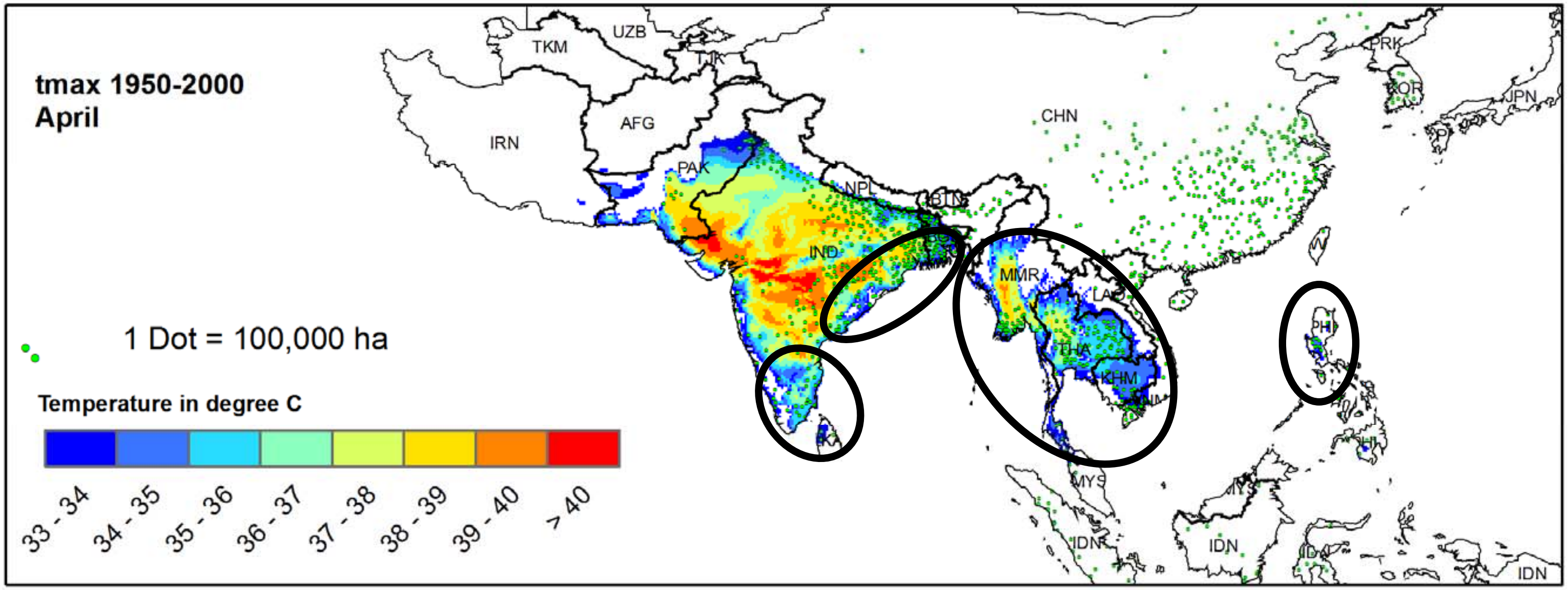
Sensitivity to Heat Stress

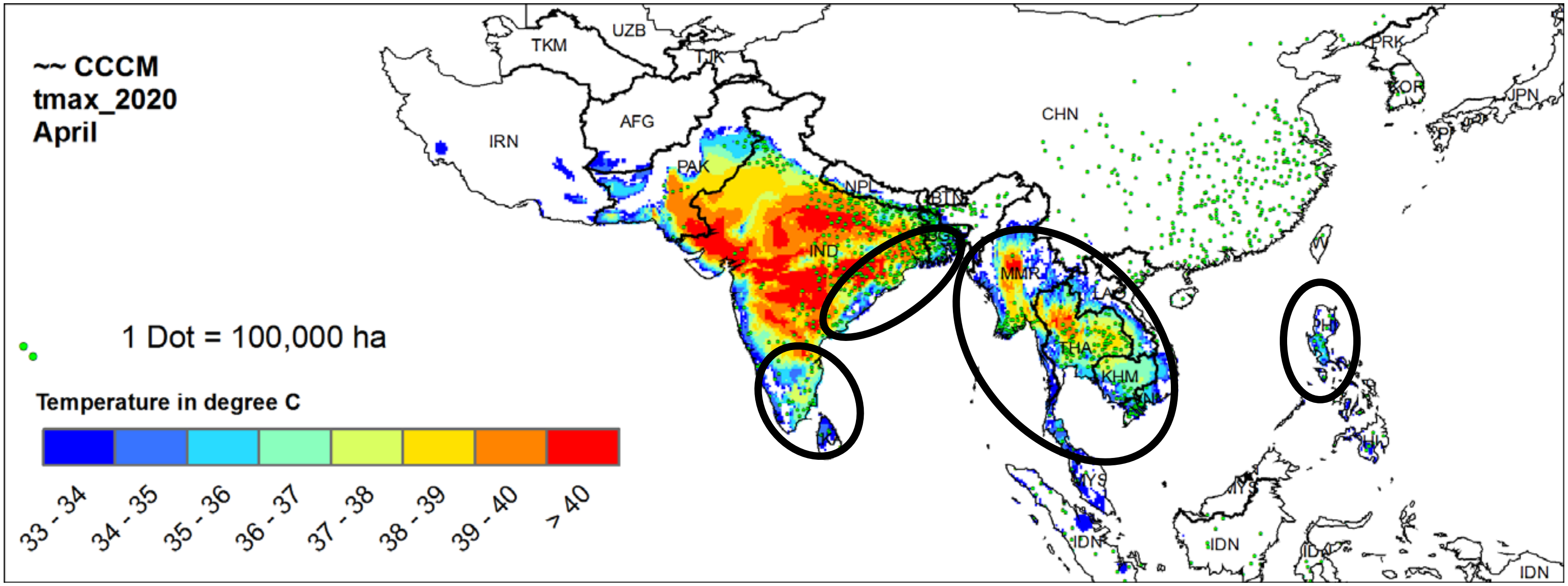


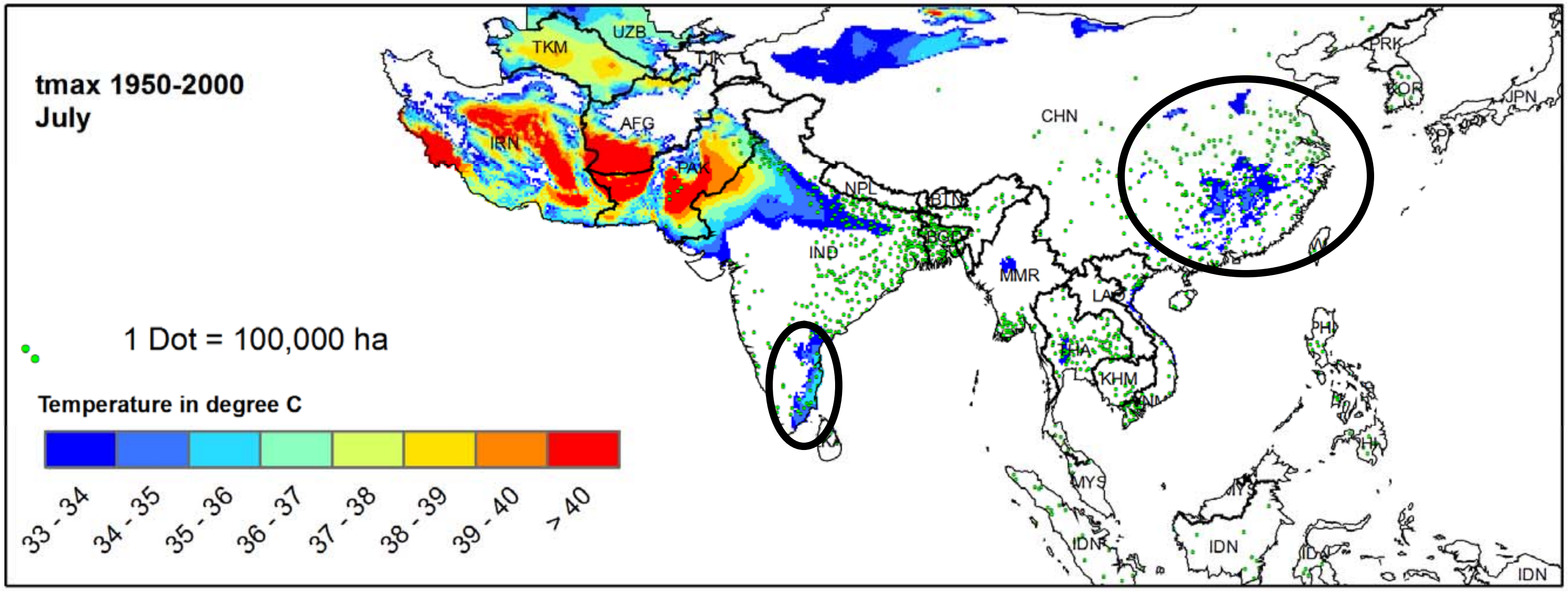
Spikelet sterility induced by high temperature at flowering

Temp. threshold depends on humidity (ca. 34-35ºC in humid tropics).

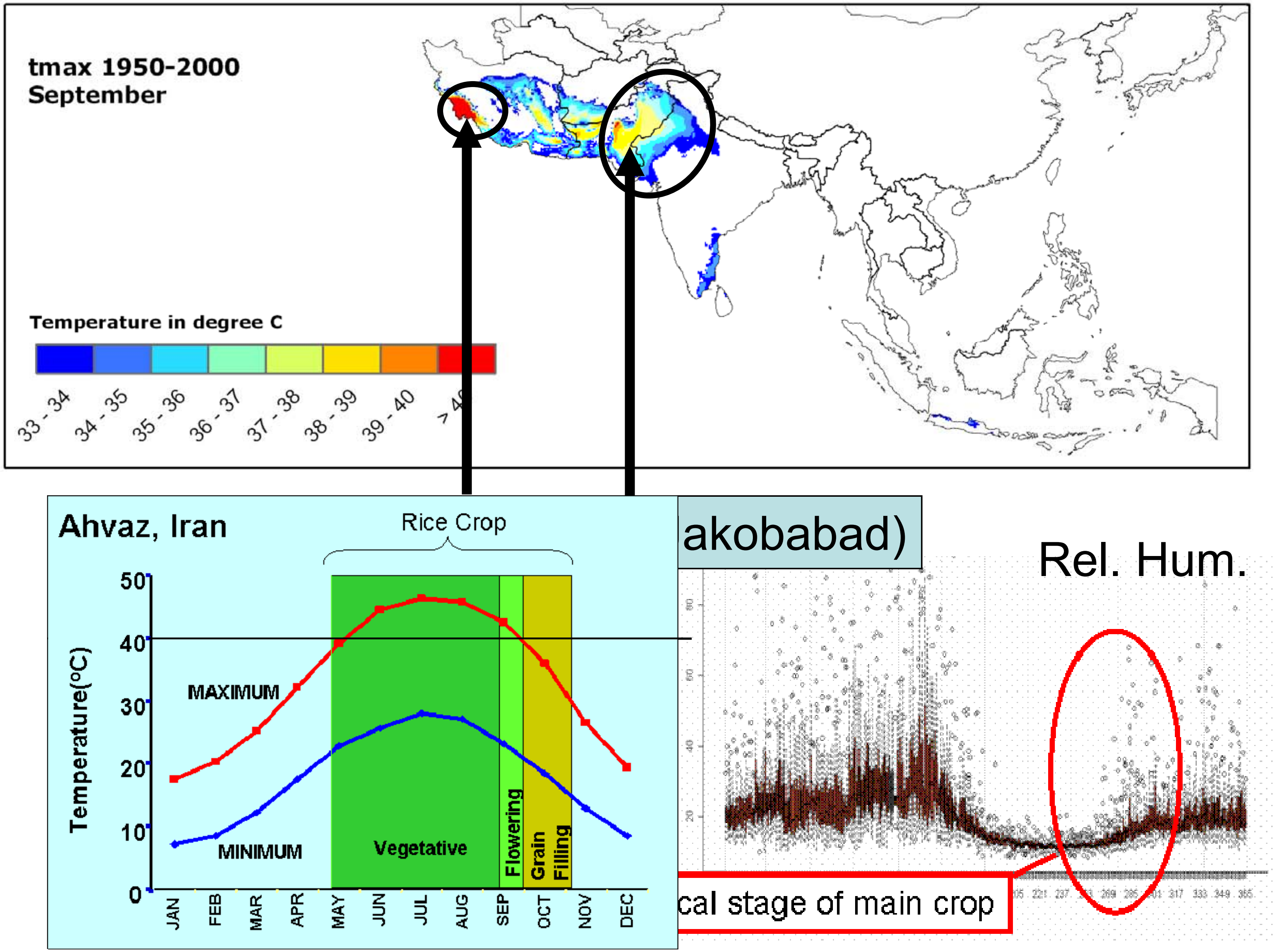
Sterility increases by 16% with a 1ºC increase above Temp. threshold


tmax 1950-2000
April
1 Dot = 100,000 ha
Temperature in degree C
33 - 34
34 - 35
35 - 36
36 - 37
37 - 38
38 - 39
39 - 40
> 40
TKM
UZB
IRN
AFG
PAK
NPL
IND
CHN
PRK
KOR
JPN
MMR
LAO
THA
KHM
PHI
MYS
IDN


~~ CCCM
tmax_2020
April
1 Dot = 100,000 ha
Temperature in degree C
33 - 34
34 - 35
35 - 36
36 - 37
37 - 38
38 - 39
39 - 40
> 40
TKM
UZB
TJK
AFG
IRN
PAK
NPL
BTN
IND
CHN
PRK
KOR
JPN
MMR
THA
KHM
IDN



tmax 1950-2000
July
1 Dot = 100,000 ha
Temperature in degree C
33 - 34
34 - 35
35 - 36
36 - 37
37 - 38
38 - 39
39 - 40
> 40
TKM
UZB
TJK
IRN
AFG
PAK
NPL
BTN
BGD
IND
CHN
PRK
KOR
JPN
MMR
LAO
THA
KHM
MYS
IDN
IDN
IDN

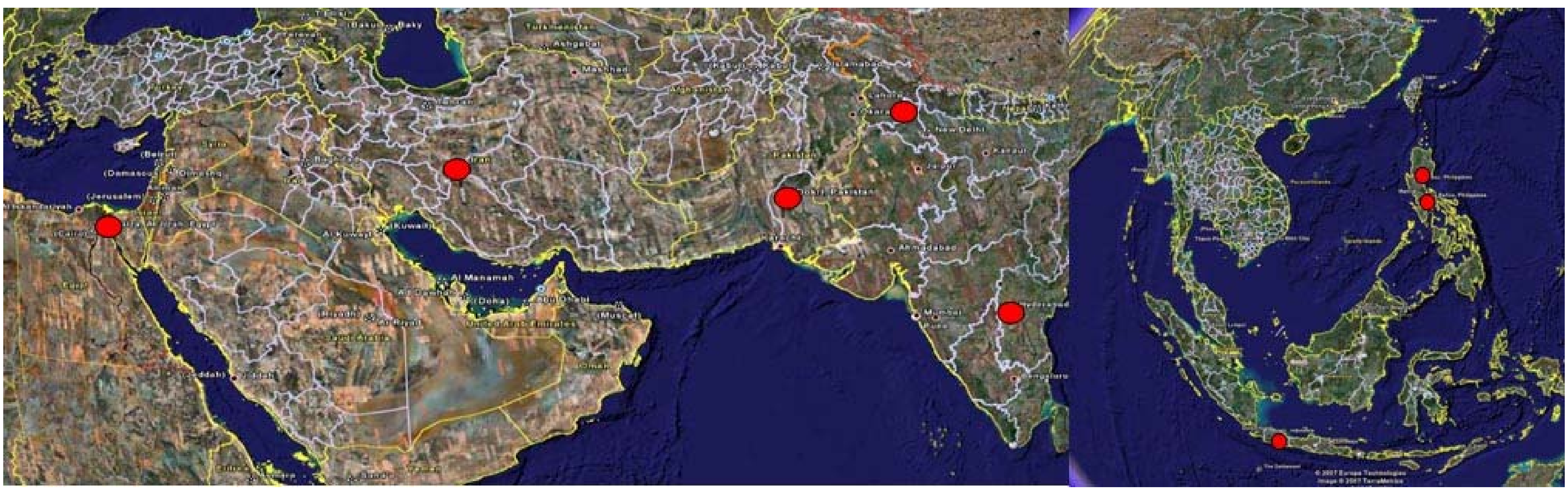


tmax 1950-2000
September
Temperature in degree C
33 - 34
34 - 35
35 - 36
36 - 37
37 - 38
38 - 39
39 - 40
> 40
Ahvaz, Iran
Rice Crop
Temperature(°C)
50
40
30
20
10
0
MAXIMUM
MINIMUM
Vegetative
Flowering
Grain Filling
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
akobabad)
Rel. Hum.
cal stage of main crop

Heat Tolerance Network

Crop data:
Spikelet fertility, seedling vigor, plant height, days to heading, time of day flowering, days to maturity, yield

Site data:
Daily maximum/minimum temperature, daily RH, monthly rainfall, solar radiation, sunshine hours



CO_2 and temperature effects on rice yields

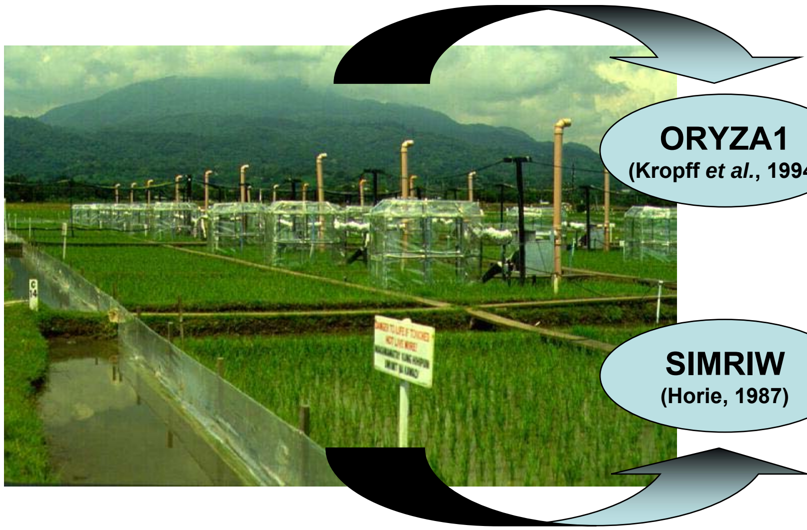
YIELD DIFFERENCES

Open top chamber experiment at IRRI

CO_2 Alone:	**+200 ppm**	**+300 ppm**
Wet Season	0.3 Mg ha^{-1}	0.9 Mg ha^{-1}
Dry Season	1.2 Mg ha^{-1}	1.4 Mg ha^{-1}

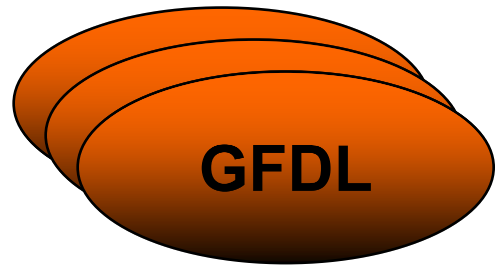
Ziska et al. 1997

Modeling CO_2/ temperature effects



IRRI project funded
by US-EPA (1991-1995)

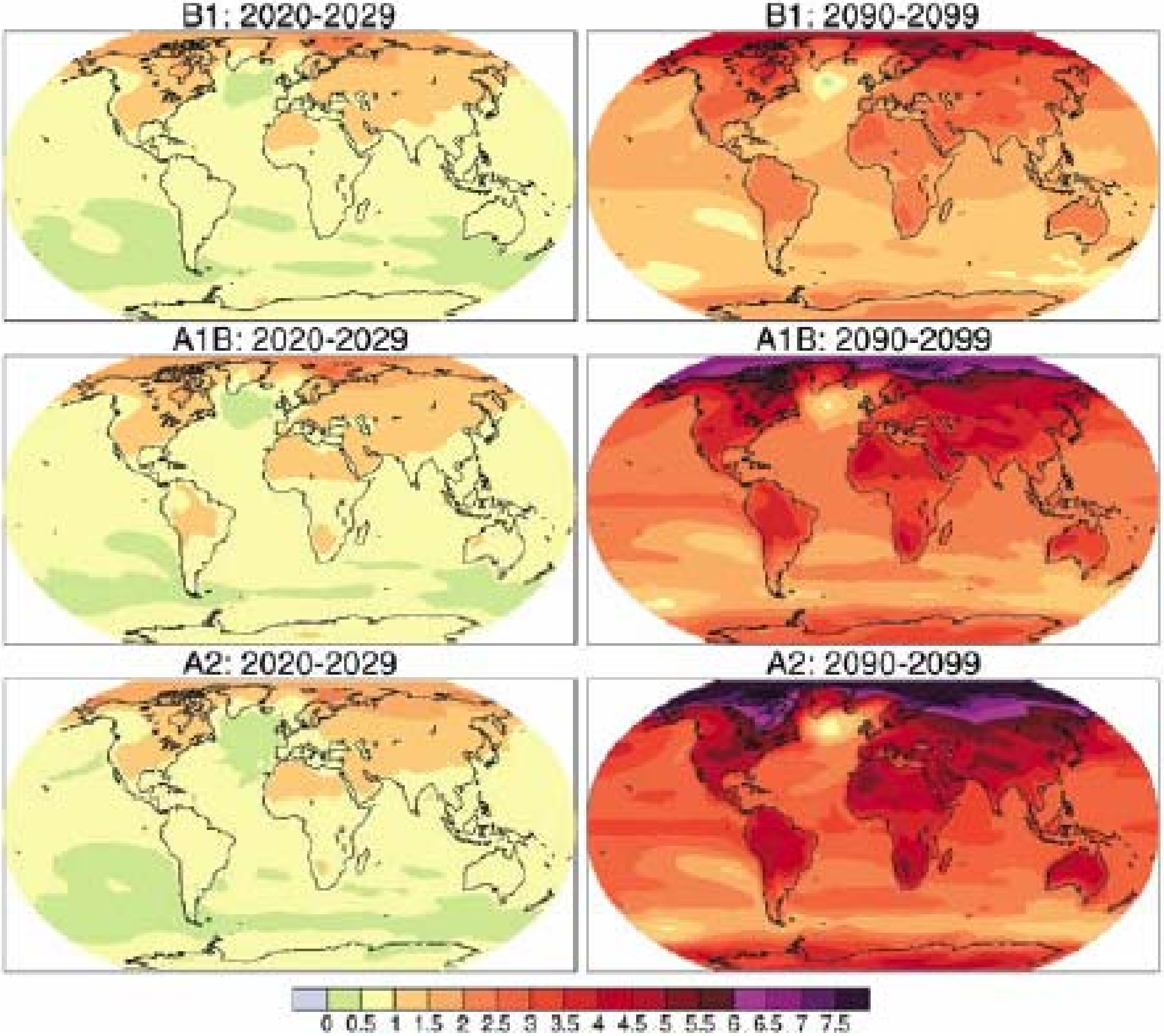
3 GCM scenarios



% change in regional rice production predicted by ORYZA1 and SIMRIW under different GCM scenarios

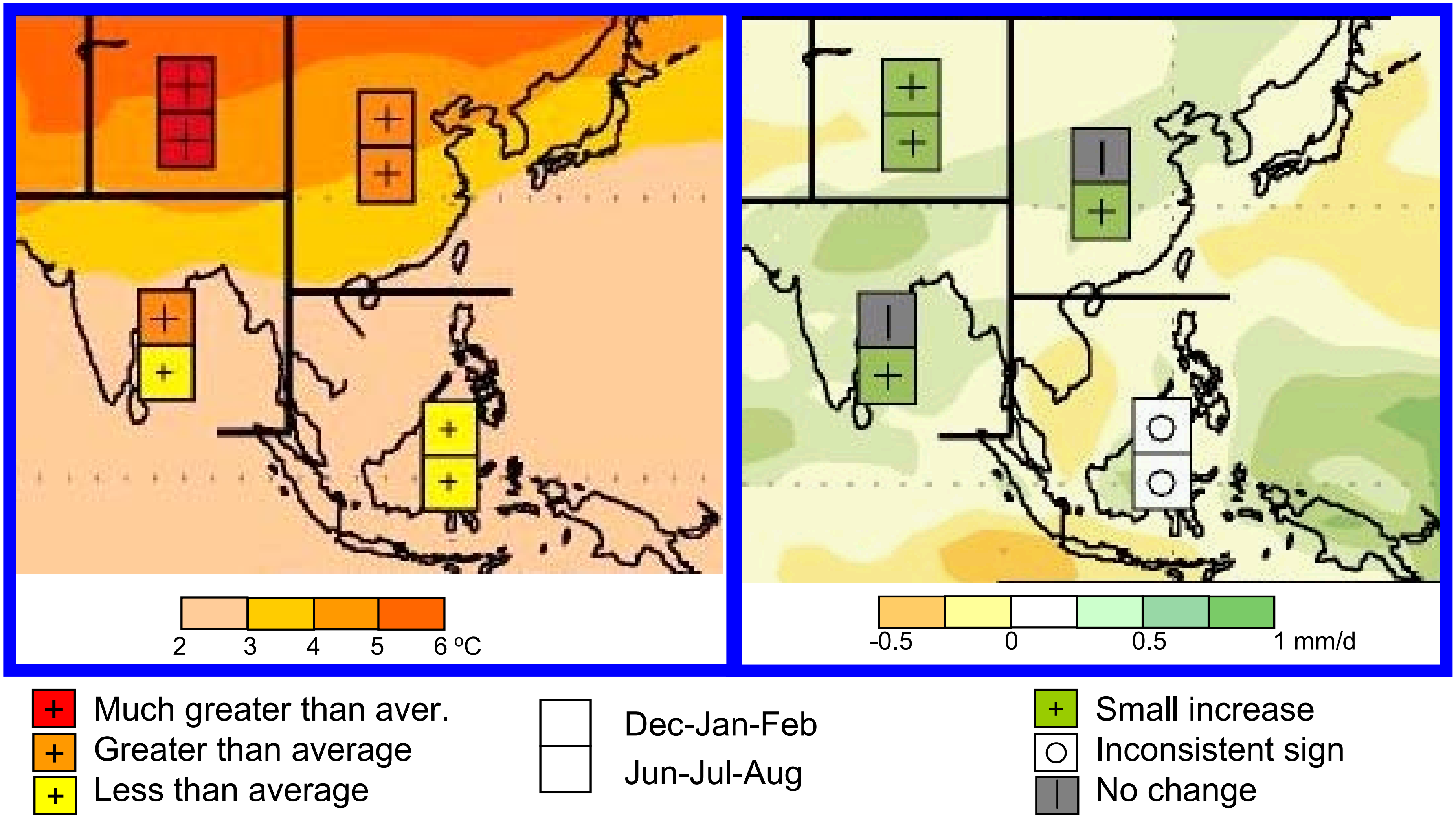
	GFDL	GISS	UKMO
ORYZA1	+6.5	-4.4	-5.6
SIMRIW	+4.2	-10.4	-12.8

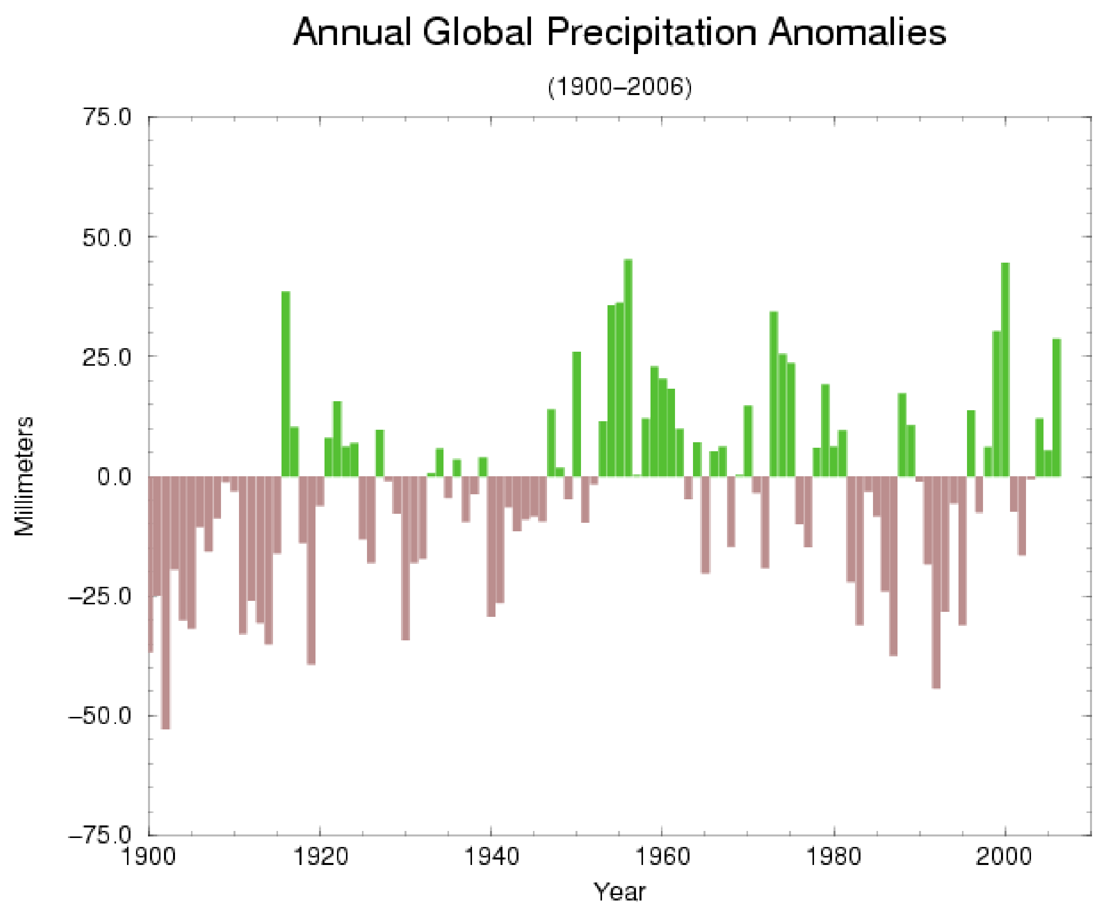
(Matthews et al., 1995)


B1: 2020-2029
B1: 2090-2099
A1B: 2020-2029
A1B: 2090-2099
A2: 2020-2029
A2: 2090-2099
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5

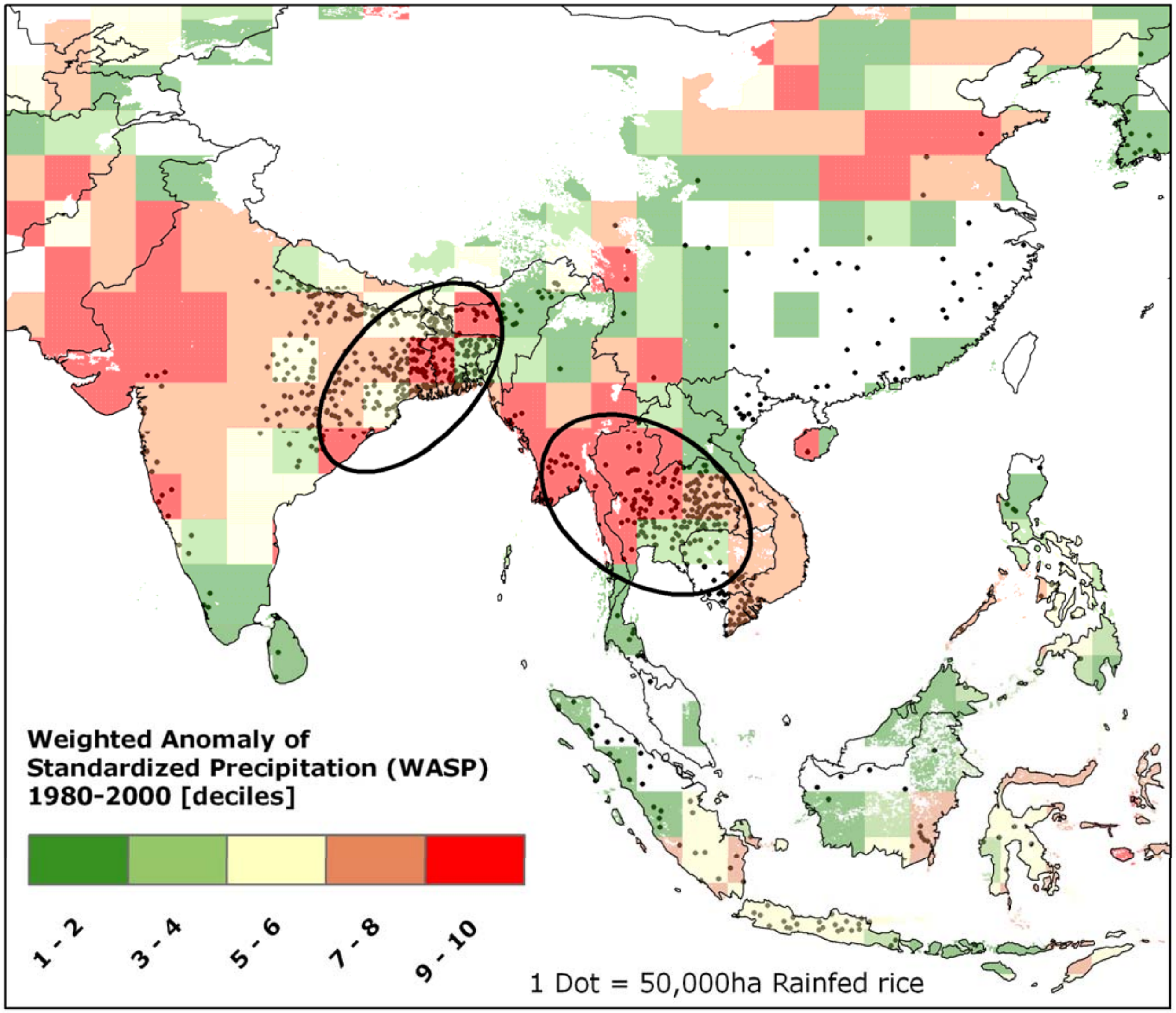
Regional Resolution of Global Climate Models

Temperature and rainfall in S, E, SE Asia under Sceanrio A2 (Δ**T** = 3.7 ^oC)



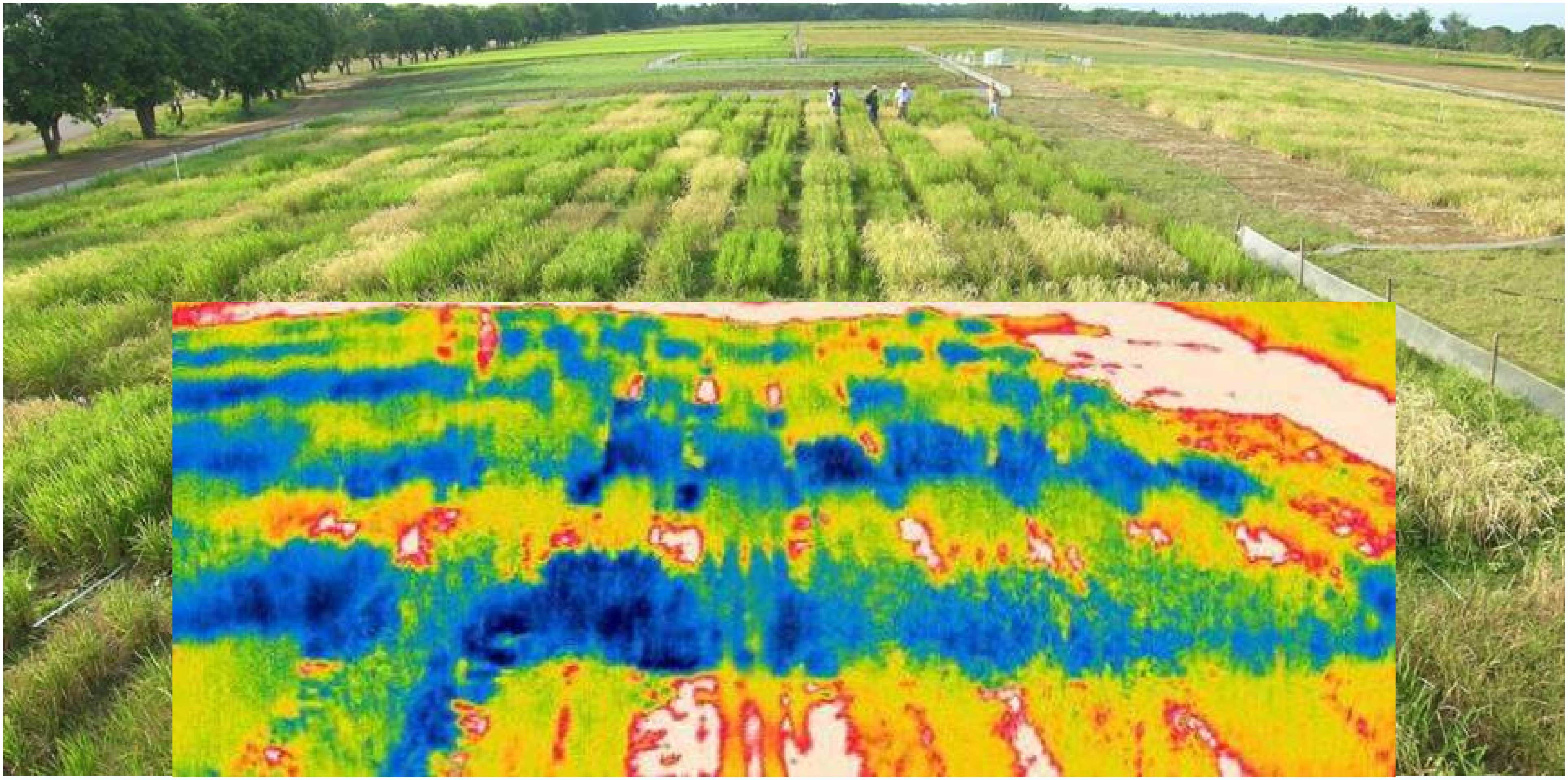


Annual Global Precipitation Anomalies
(1900–2006)
75.0
50.0
25.0
0.0
−25.0
−50.0
−75.0
Millimeters
1900
1920
1940
1960
1980
2000
Year

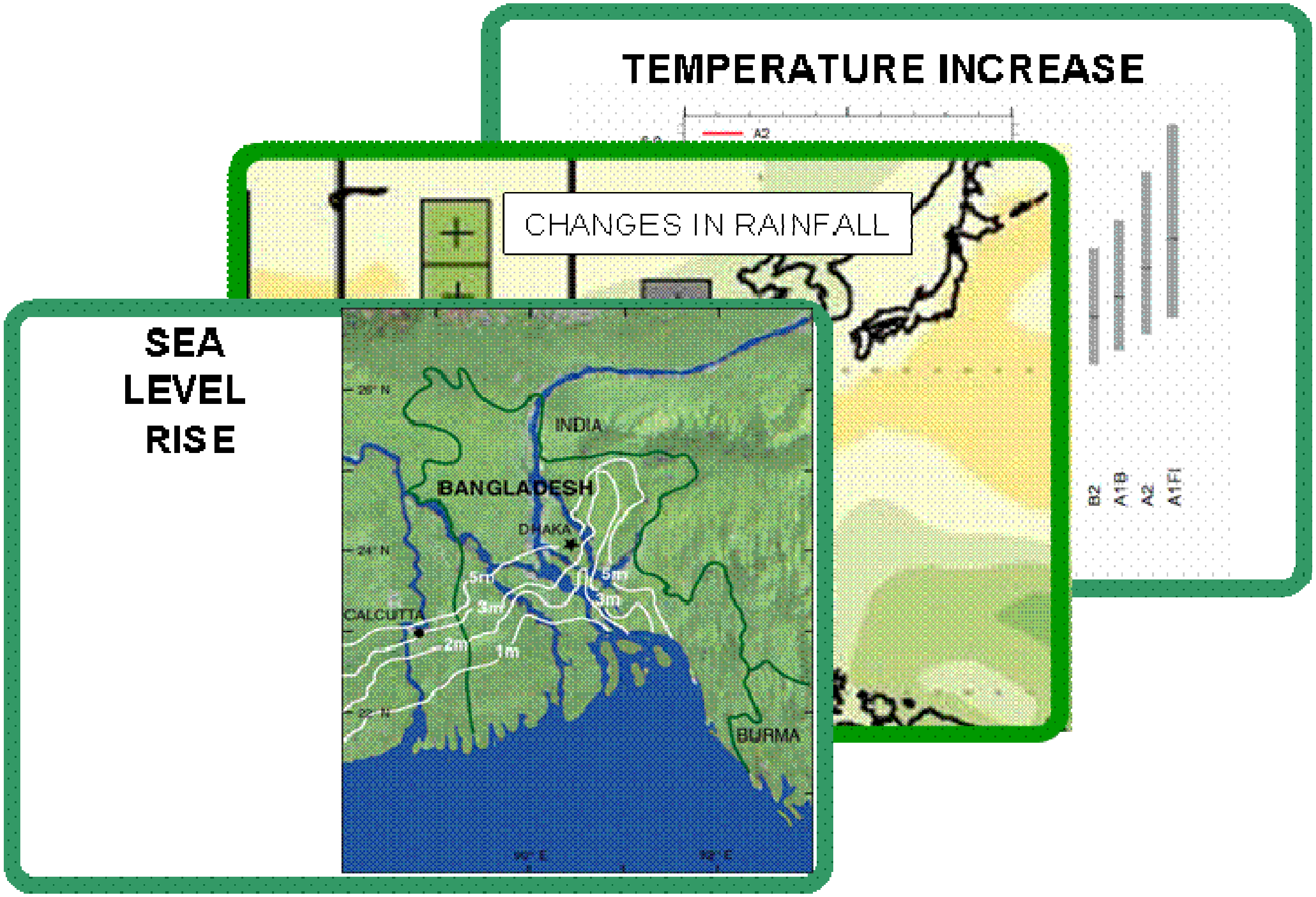


Weighted Anomaly of
Standardized Precipitation (WASP)
1980-2000 [deciles]
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
1 Dot = 50,000ha Rainfed rice

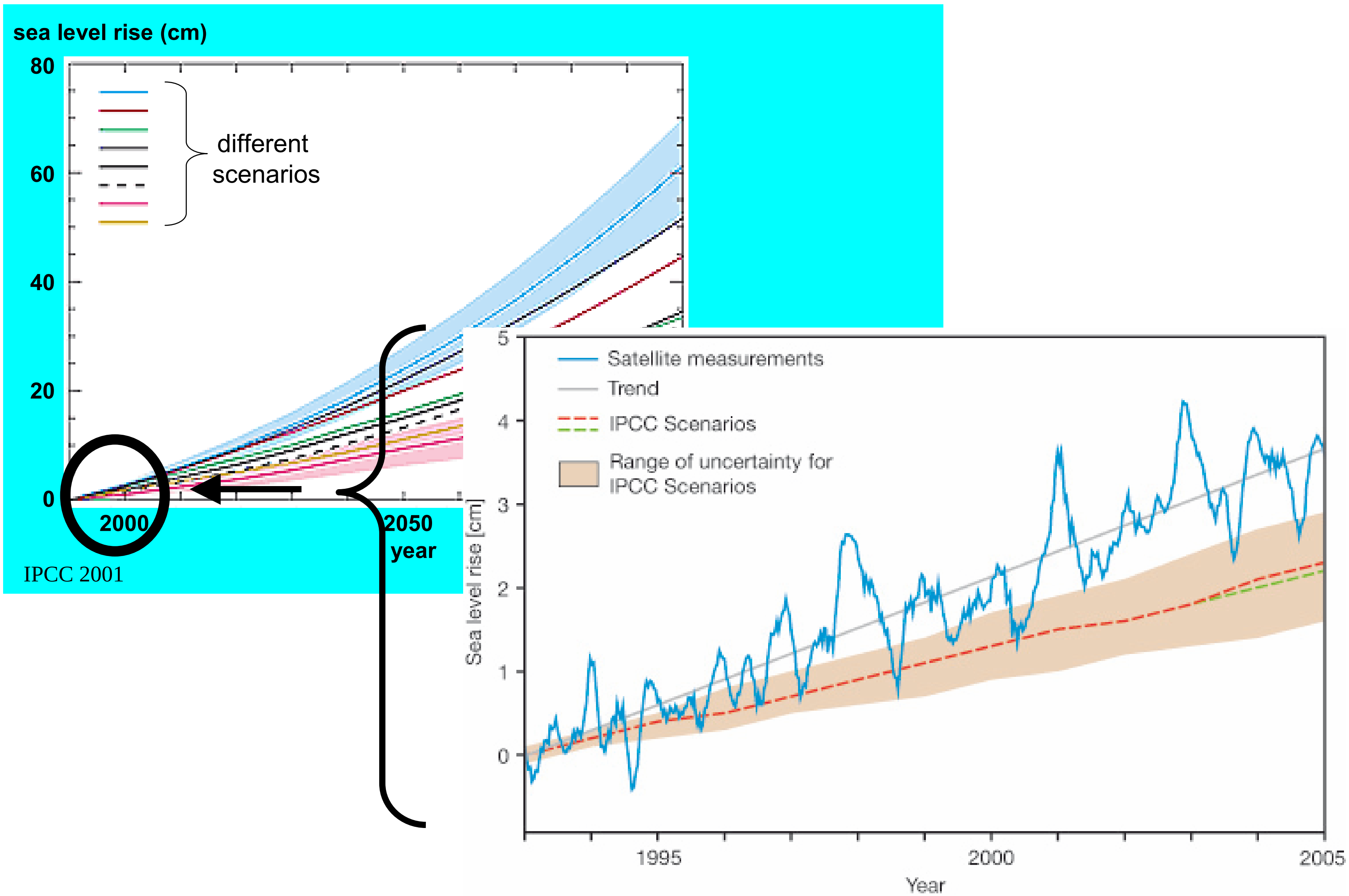
Drought Screening Field Arrays



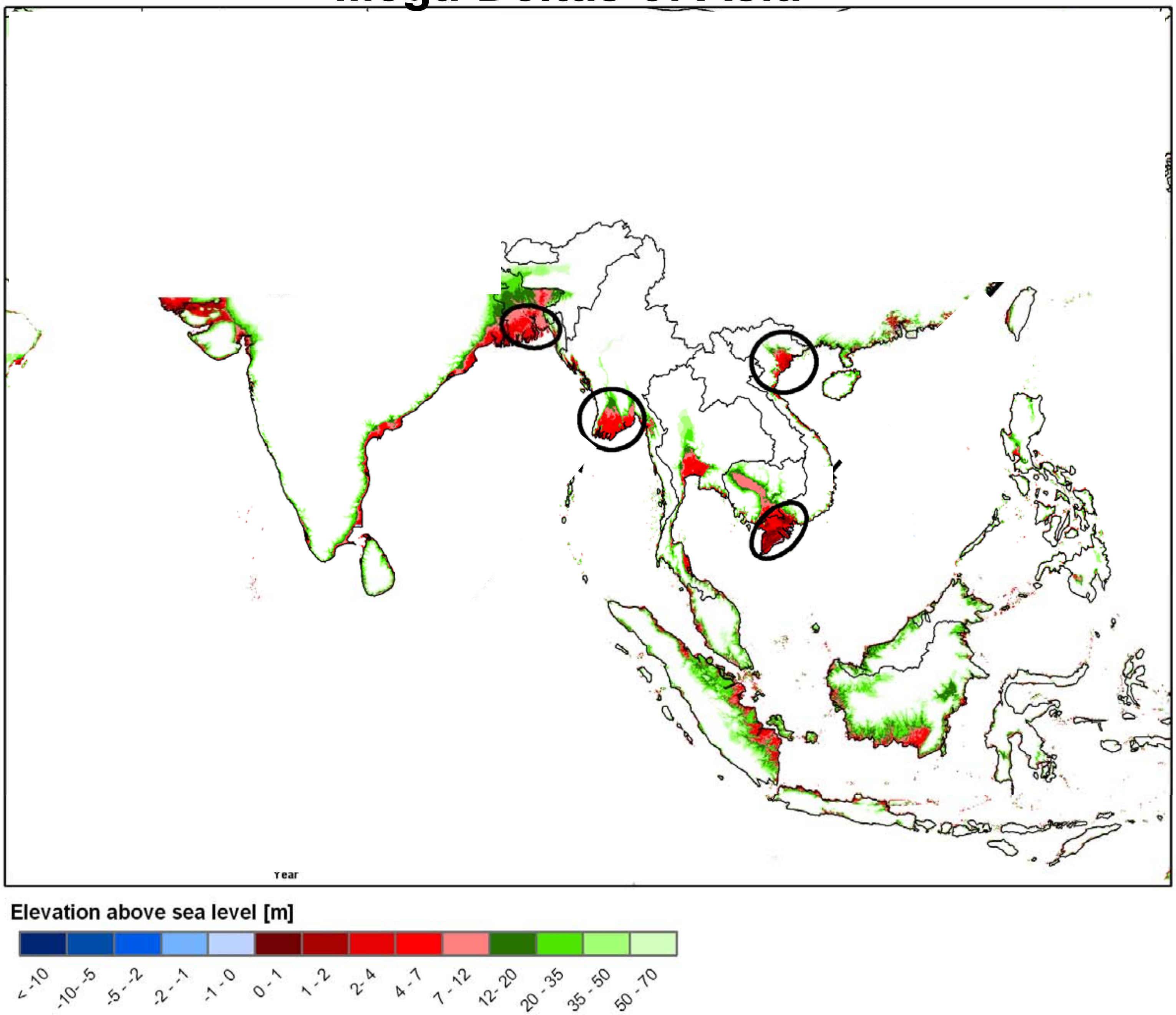
Climate Change Effects Relevant for Rice Production



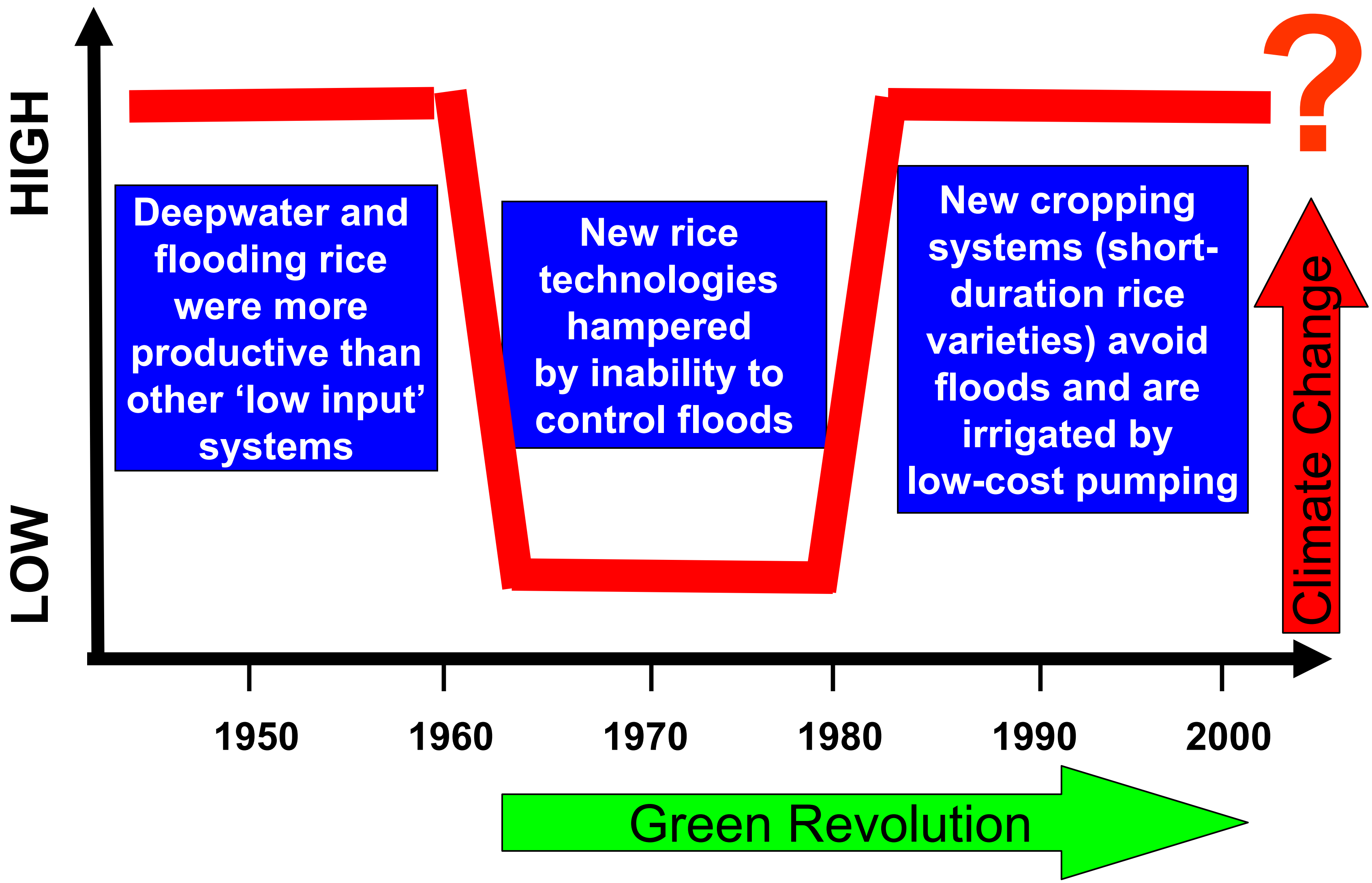
Sea Level Trends/ Future



Mega-Deltas of Asia



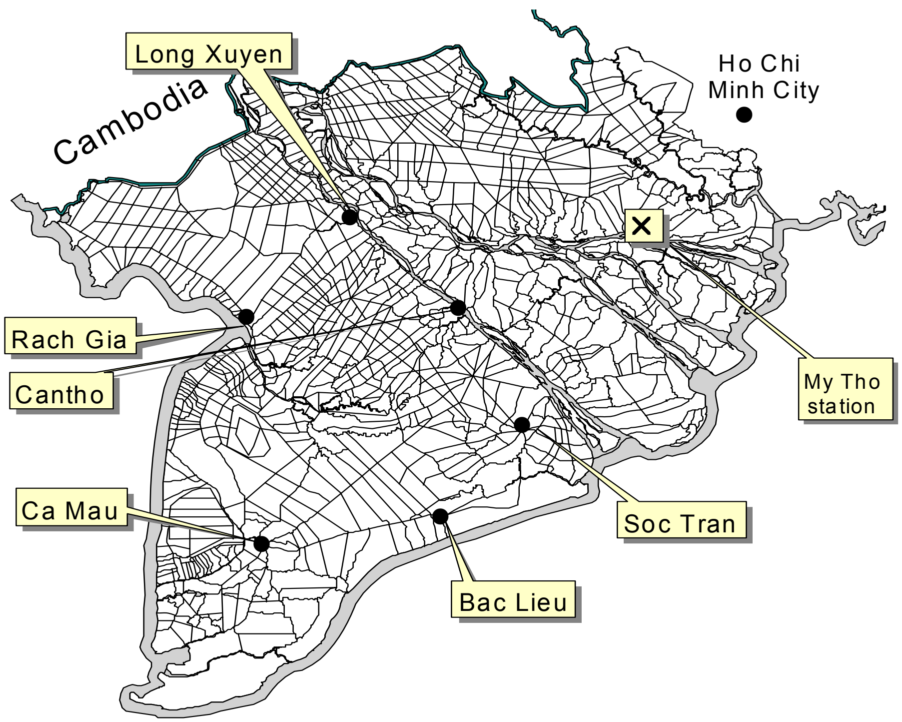
Comparative Advantage of Rice Production in Delta Regions



Drawn after Dawe (2005)

VRSAP (Vietnamese River System and Plains) **Model**

Southern Institute for Water Resource Planning, HCMC



Components:

- 2,111 segments,
- 1,505 nodes and
- 555 storage plains.

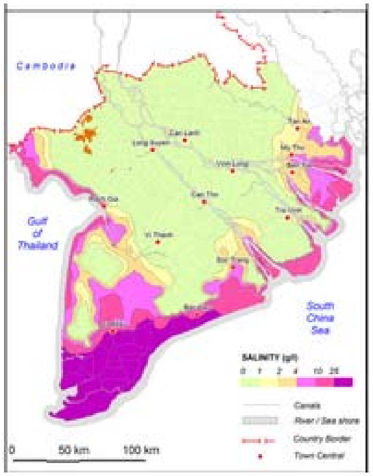
Boundaries:

- Cambodian stations
- Sea level

Maximum Water Levels of the Year 2000

Present Sea Level

Salinity in Dry Season under different Scenarios of Sea Level Rise



Present Sea Level

Salinity (g/l)

0 1 2 4 10 25

Canals

River/ Sea shore

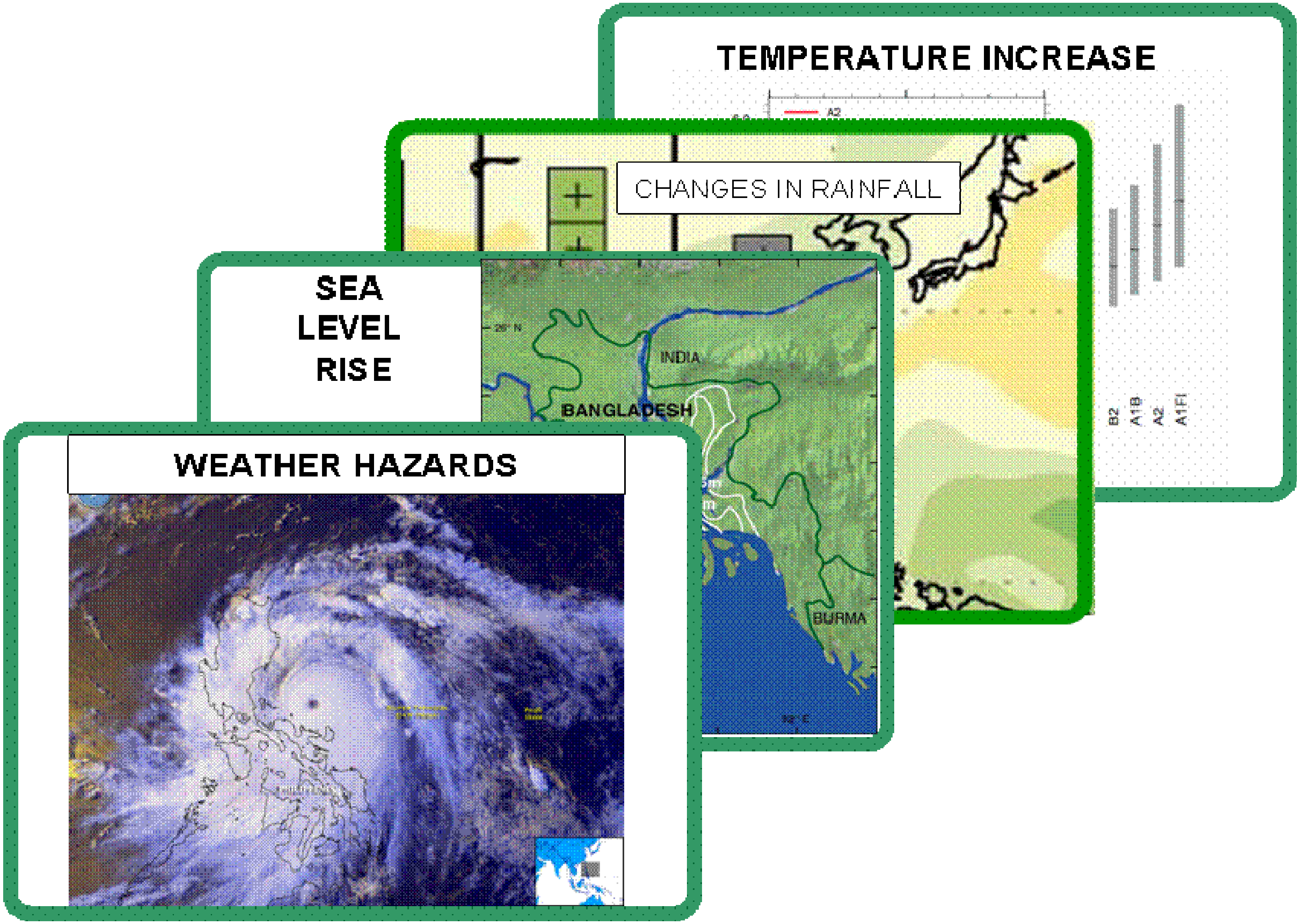
Country border

Central town

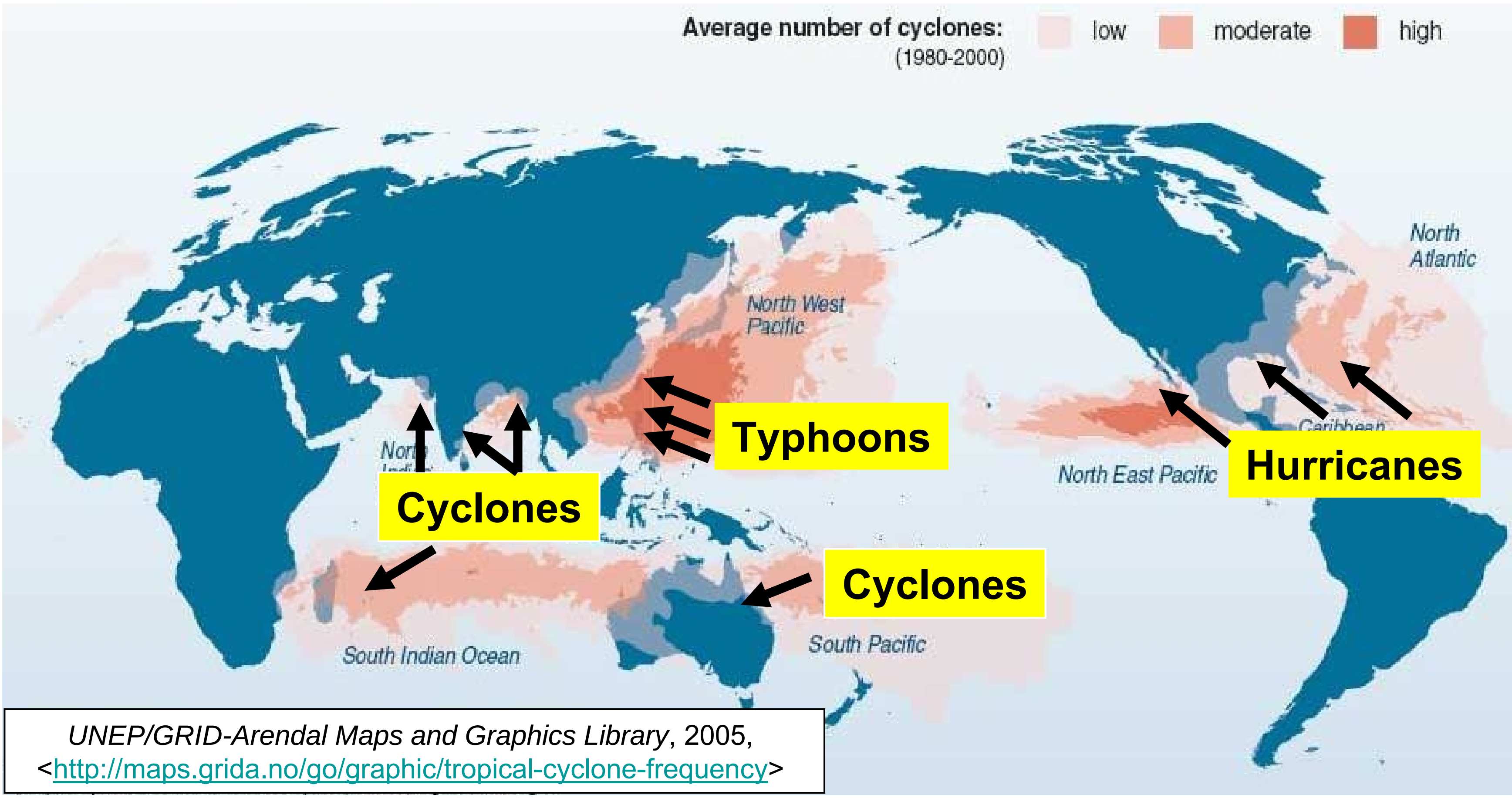
0 100 km

For March 2004

Climate Change Effects Relevant for Rice Production



Frequency of Tropical Cyclones



UNEP/GRID-Arendal Maps and Graphics Library, 2005,
<http://maps.grida.no/go/graphic/tropical-cyclone-frequency>

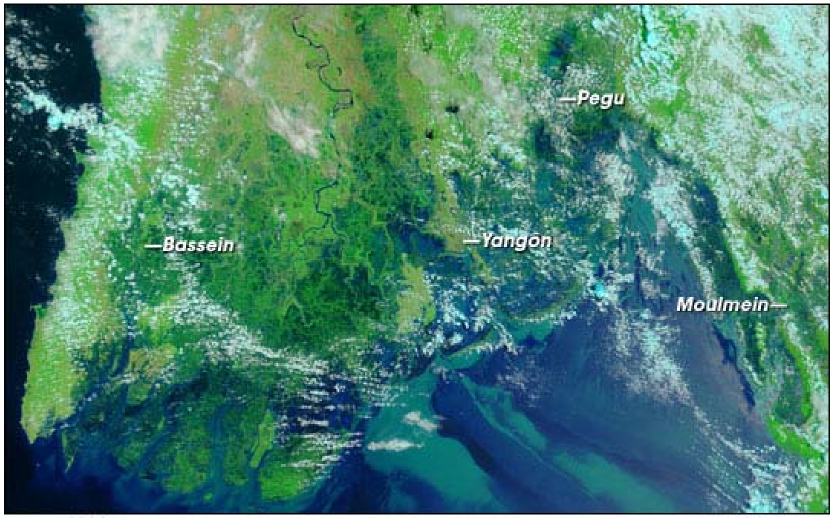
Tropical Cyclones and Climate Change

IPCC AR4 (2007):

- As of now, ‘*there is no clear trend in the annual numbers of tropical cyclones*’.
- Under ongoing global warming, however, ‘*it is likely that future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation…*’.

Impact of Cyclone Nargis in Myanmar (May 2008)

April 15, 2008



May 5, 2008

Satellite photography of the Irrawaddy Delta

Before Nargis

After Nargis

Typhoon Effects in Philippines vs. Myanmar

Xangsane (Sep. 06)

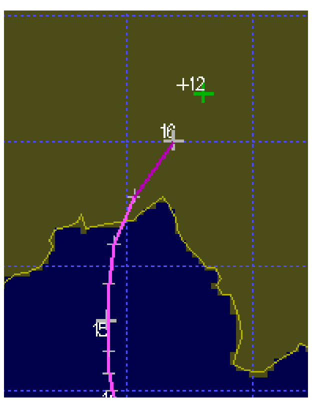
Track over land

- **> 150 km/h wind speed: 1022 km**
- **> 180 km/h wind speed: 365 km**

Area affected

- **Standing rice crop: 33,000 ha**
- **Salinity intrusion: ?**

Nargis (May 08)



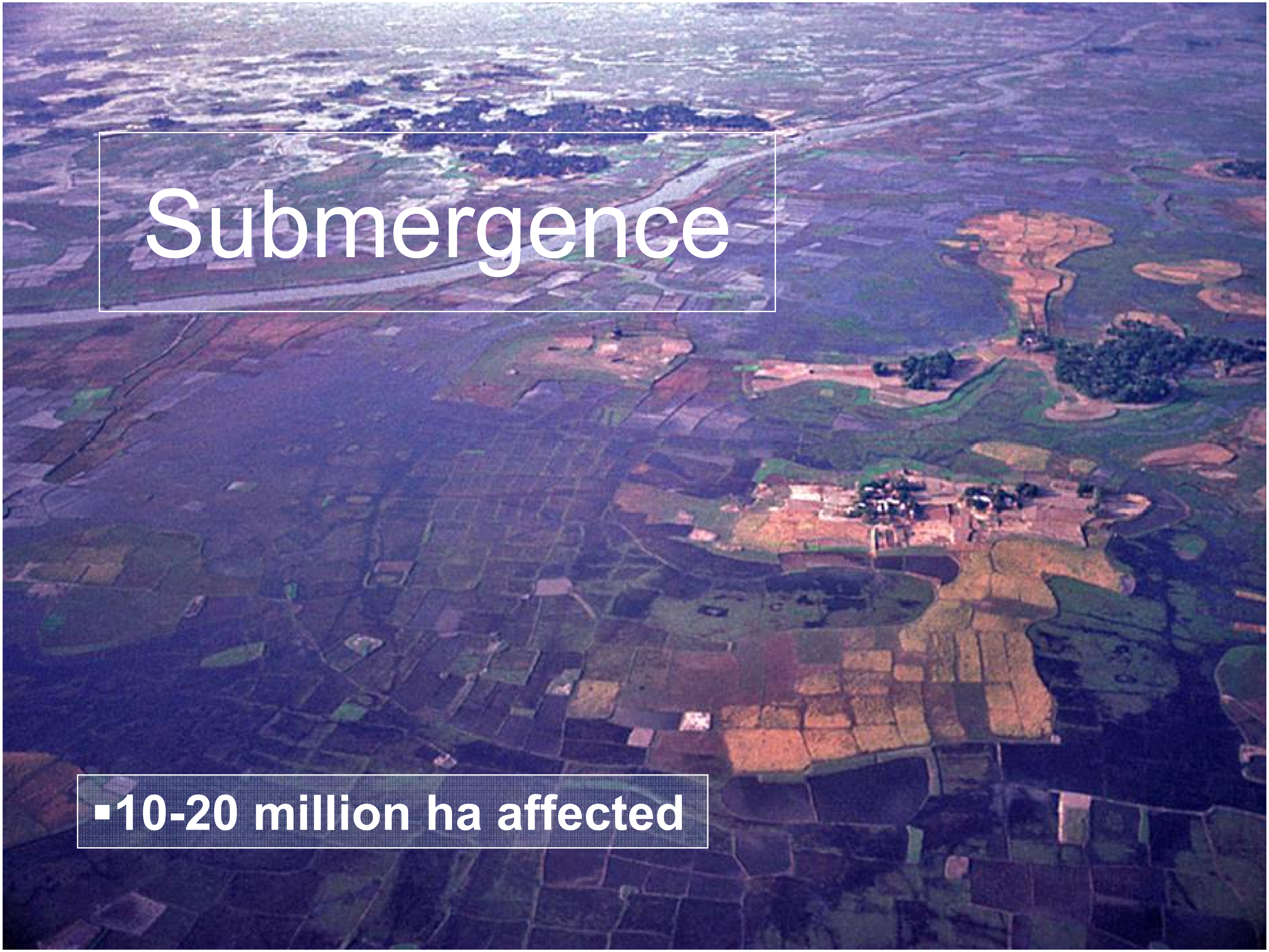
Track over land

- **> 150 km/h wind speed: 348 km**
- **> 180 km/h wind speed: 55 km**

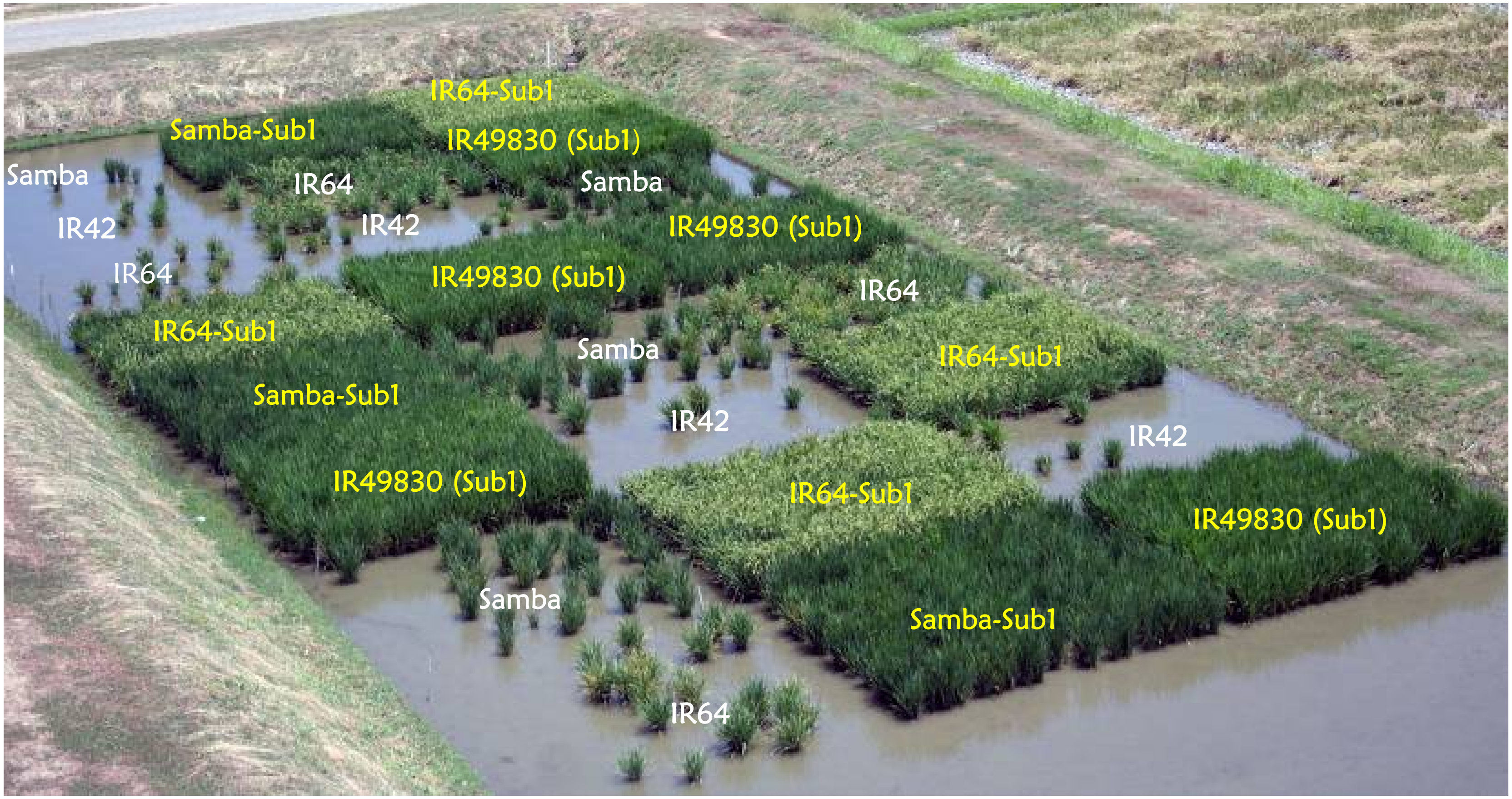
Area affected

- **Standing rice crop: 16,000 ha**
- **Salinity intrusion: 1,750,000 ha***

* http://www.pecad.fas.usda.gov/highlights/2008/05/Burma_Cyclone_Nargis_Rice_Impact


Submergence
▪10-20 million ha affected

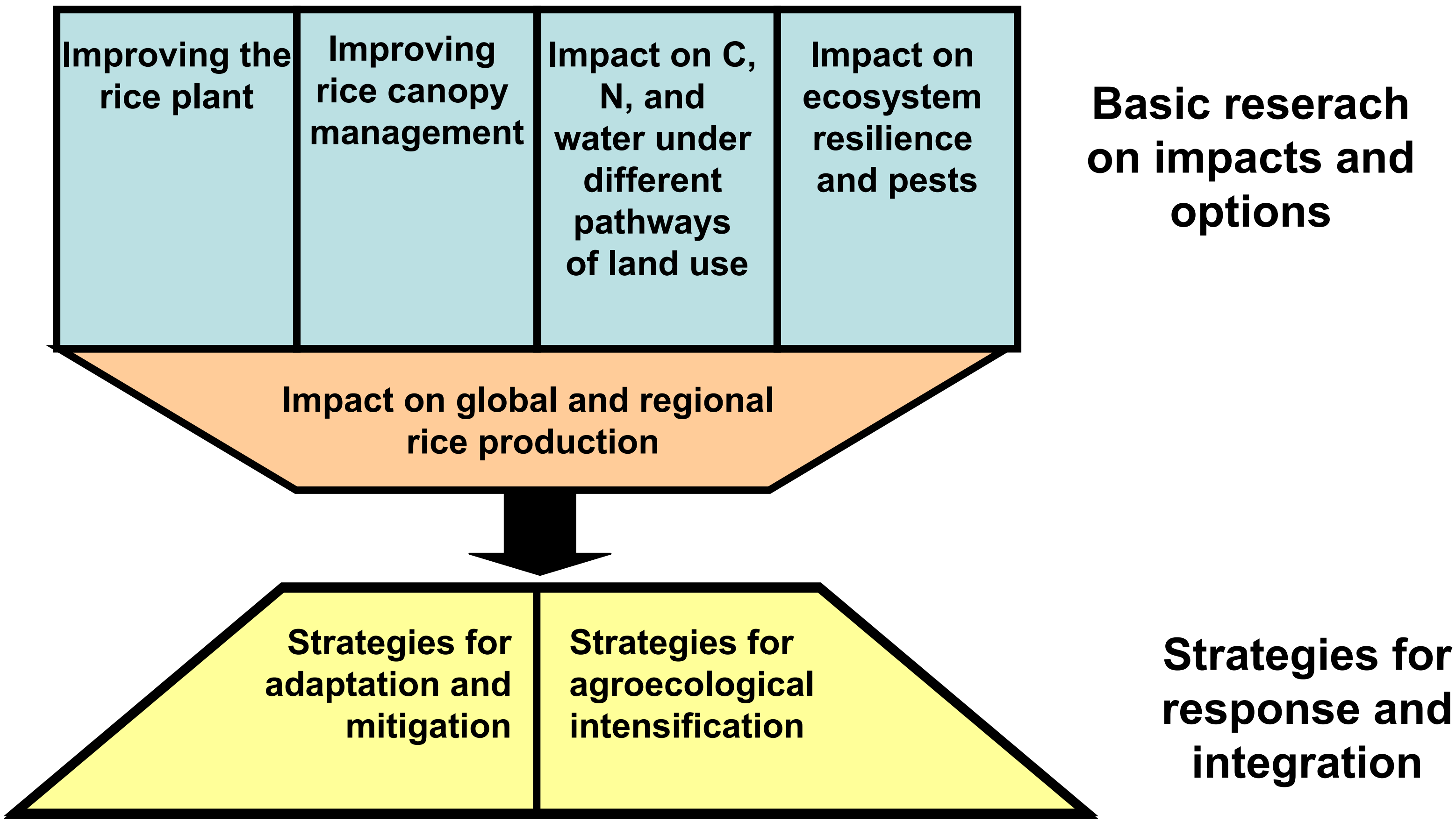
New *Sub1* lines after 17 days submergence in field at IRRI



Stress-tolerant rices CAN be developed

- Currently-grown varieties (mega varieties) are often intolerant of new climatic stresses
- Good donors for tolerance to abiotic stresses have been identified, but are low-yielding.
- Tolerance is usually controlled by a small set of genes.
- Transferring these genes into mega varieties is an effective strategy to develop rice varieties for the unfavorable rainfed areas.

The Rice Climate Change Consortium (RCCC)



The Rice Climate Change Consortium (RCCC)

- Work in an interdisciplinary consortium in collaboration with leading institutions and already existing global and regional networks

- Establish “integrated sites” for conducting long-term, interdisciplinary research on climate impact on rice and impact of rice on climate change under field conditions.

- Use regional case studies and transects along climatic gradients for addressing specific research questions

Prototype for Adaptation Projects on Rice Production at Country Scale/ Part 1

1. Selecting regional case studies (province/ county level) encompassing different rice growing environments

2. Detailed resource use analysis:
   * Data mining (statistics, soil maps etc.)
   * Farm surveys
   * Remote sensing

3. Climate Analysis:
   * Decadal trends
   * Downscaling of Climate Change Scenarios

Prototype for Adaptation Projects on Rice Production at Country Scale/ Part 2

4. Networking with local stakeholders
   * National and local government agencies
   * Existing networks and farmers association

5. Dissemination of improved technologies coping with climate extremes

6. Participatory Research on Breeding and Improved Resource Management

7. Upscaling for National Master Plans

Conclusion

Consequences of Climate Change :

Rice systems will experience more…

- **Drought**
- **Submergence**
- **Salinity**
- **Heat waves**

Challenges of Climate Change =
Challenges in unfavorable environments