The use of climate change projections and crop models for climate change impact assessment: TRF's Experiences in Thailand and Southeast Asia

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TCCIP, New Taipei City 231, Taiwan (R.O.C.)

Topics

- Short Introduction to IBSNAT, DSSAT, ICASA
- Introduction to TRF
- Situations in Agricultural Systems
- Assessing impacts of climate change on crops in Thailand
- Collaborative research agenda

Institutional Aspects: History

- ended in 1982: Soil Project, technology transfer via soil taxonomy
- 1982-93: IBSNAT Project
- 1983-86: Minimum Data Set Concept
  - Initial models were CERES-Maize, CERES-Wheat and SOYGRO soybean model.
- 1986, 1994: Data standards for compatibility of models
- 1986: DSSAT v2.1 released
- 1994: ICASA formed
- Fall 2002 – Spring 2003: ICASA Re-structured
- 1998: DSSAT v3.5 released (after project ended).
- 2003: DSSAT Cropping System Model, DSSAT v4 released
- 2015: DSSAT v4.6 released
- DSSAT.net

IBSNAT Project (1982-1993)

- Based at University of Hawaii (G. Uehara, PI; F. Beinroth, Co-PI)
- Funded by US-Aid
- H. Nix, Joe Ritchie, Barry Dent, Tony Hunt, Paul Teng, Juan Comerma on Technical Advisory Board
- International Network of Researchers Interested in Applying Systems Tools to Cropping Systems, and Systems Scientists
- Products:
  - DSSAT (Last Version Released in 1998, Version 3.5)
  - Data, Data Standards
  - Network of Trained Users (>2,000)
- DSSAT Version 4.6 in 2015

Rationale

- Increased demands for agricultural products
- Increased pressures on natural resources
- Rapid changes in technology, ...
- Globalization of trade, economies
- Information needed for decision making
- Gap between information needed and that created by disciplinary research
- Trial & Error approach to agricultural research is inadequate
- Integration of knowledge is essential

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Three connecting research efforts: A systems approach

Uehara, 1996 & 1998

TRF: Thailand Research Fund

- Research funding agency under PM office. One of six research funding agencies in Thailand.
- Est. in 1992, annual budget ~ 50-60 M USD.
- Three main mandates;
  - Research and Development,
  - Basic research and researcher development,
  - Strategic and special assignments.
- My interactions with TRF since 1994;
  - 1994-1998: Sugarcane simulation model to estimate yield in large areas.
  - 1997-2001:
    - DSS for Rural Community
    - DSS for Rice,
    - DSS for ARM.
  - 2002-2010:
    - TRF-DSS Research Network Coordinator,
    - MWCropDSS for the assessment of impacts of climate change on crops in Thailand.
  - 2014: TRF-DSS-ASEAN Research Network Coordinator
  - 2015-2017: TRF-PA (Precision Agriculture) Research Network Coordinator

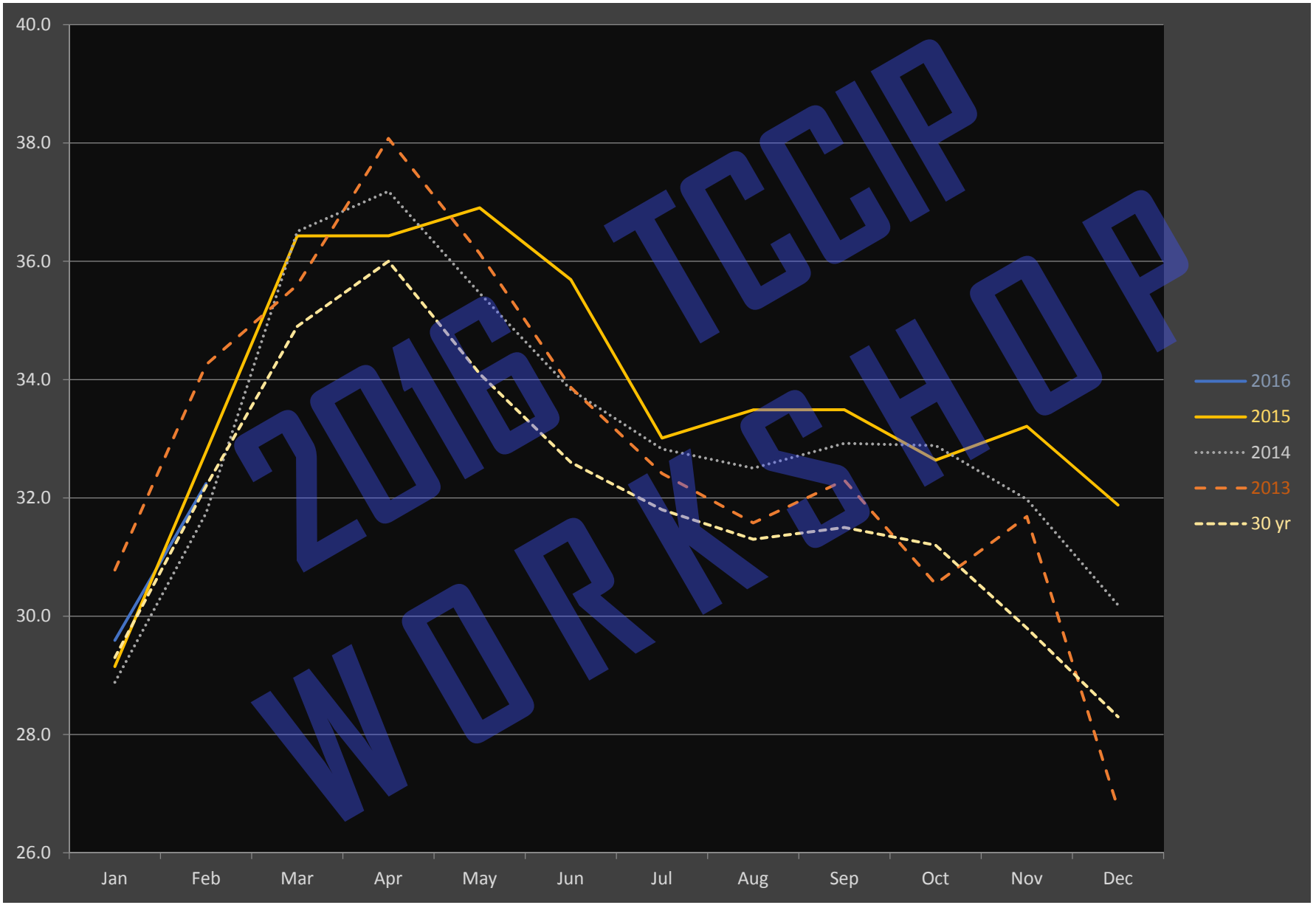
Situations of Agricultural Systems

- 50% of population is dependent on Agriculture.
- 35% of land area is under agricultural activities.

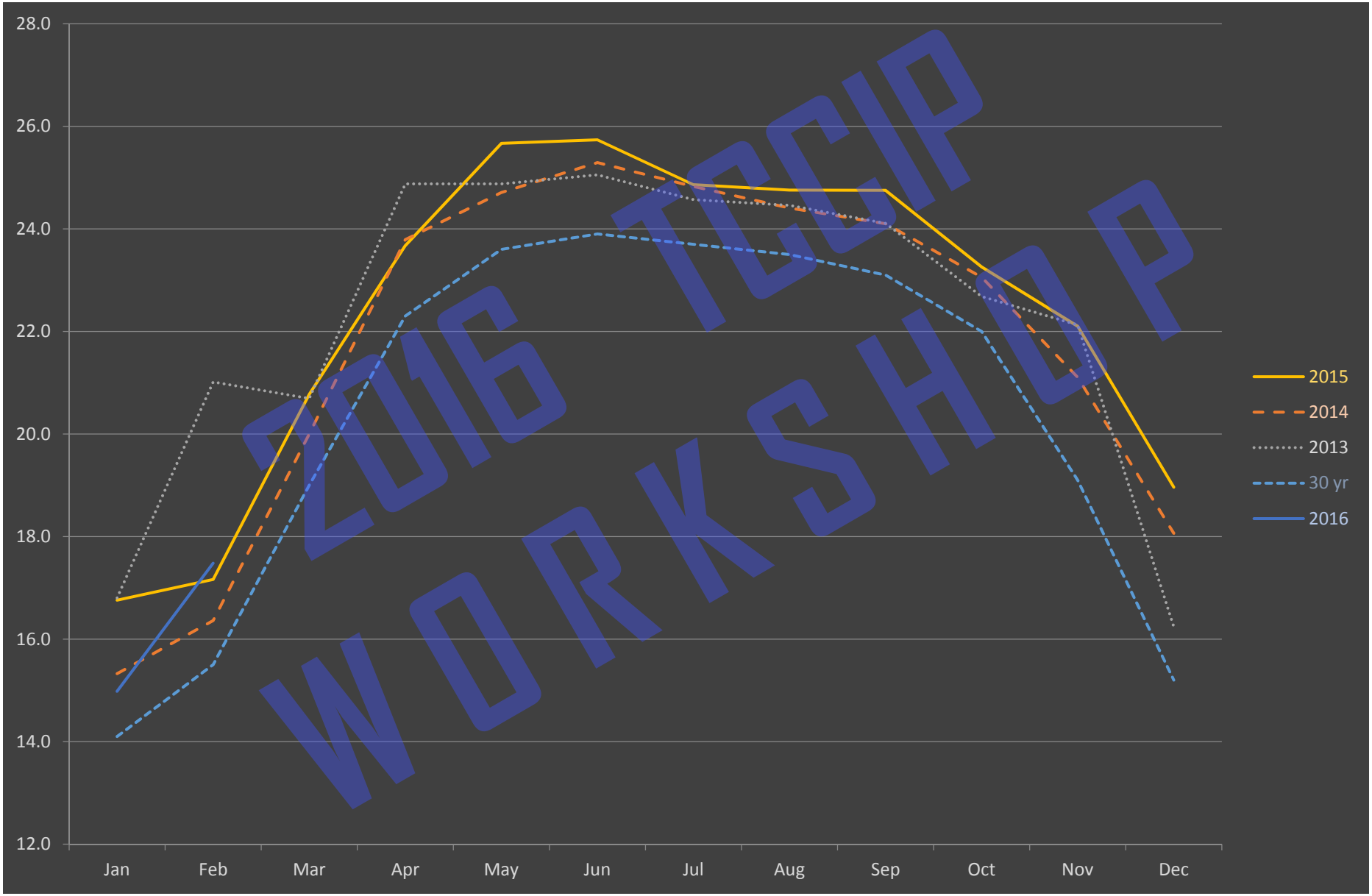
- Food grains production (Rice and Maize) approx. 30-35 Mt. at the national level.
- Provides about 20-80% of the Provincial GPP livelihood (NESDB, 2013).

- A risky business.
- Sensitive to weather & climate conditions.

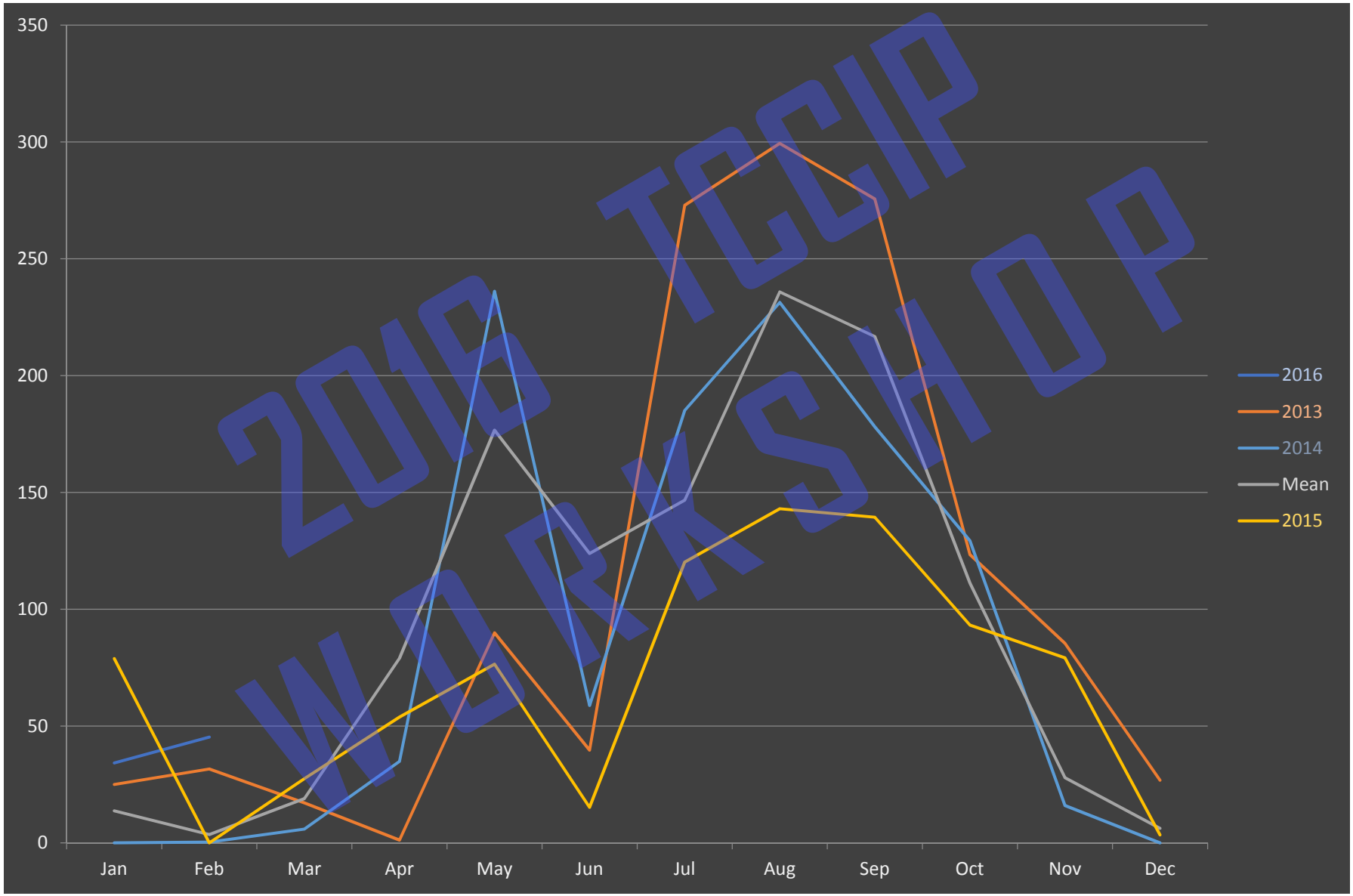
Chiang Mai maximum temperature (°C)



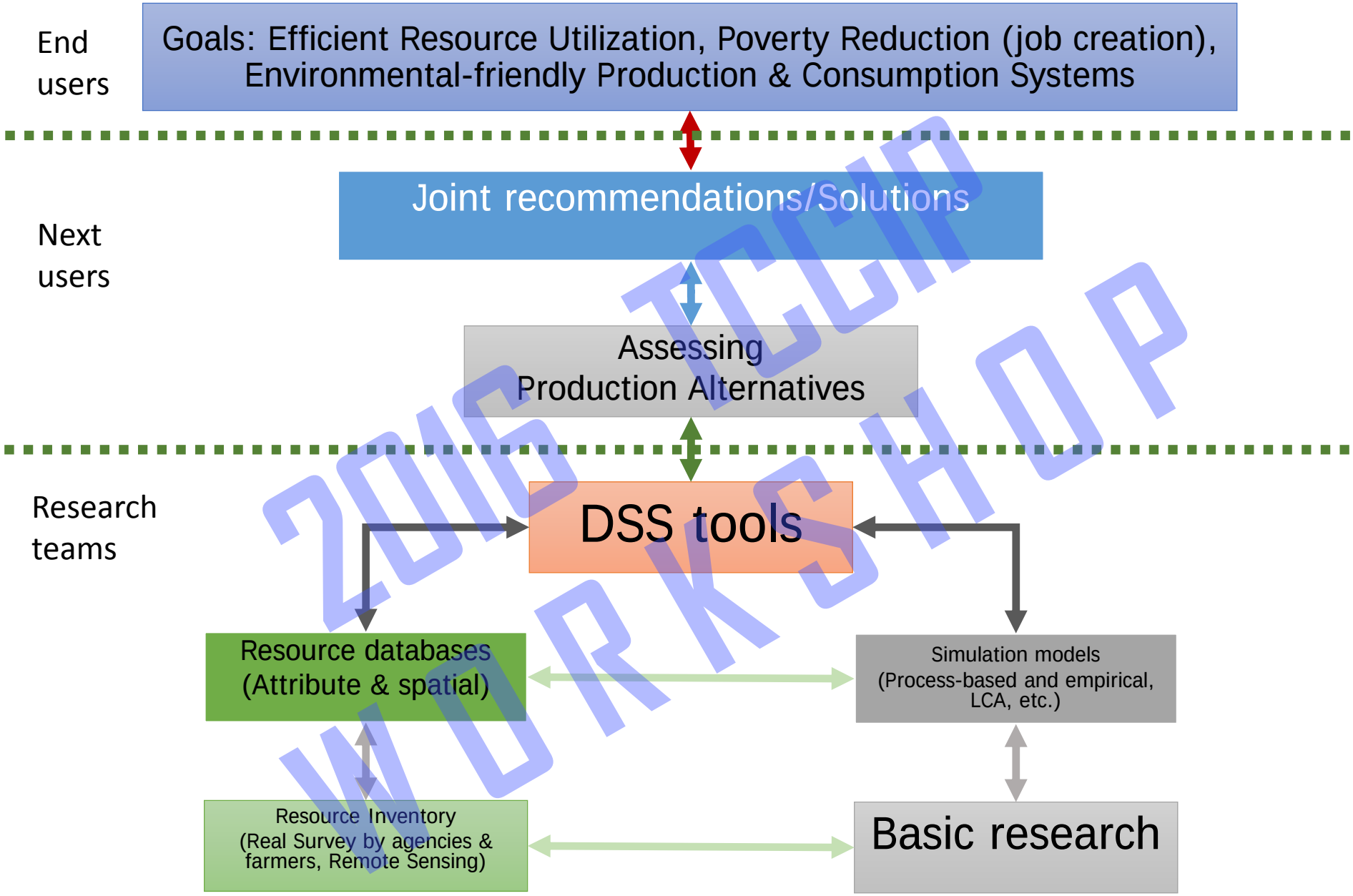
Chiang Mai minimum temperature (°C)



Chiang Mai monthly rainfall (mm)



Tools to assess impacts of climate change on crop production overtime and space



Uehara (1998); Kovanich (2009); Jintrawet *et al.* (2012)

Real world

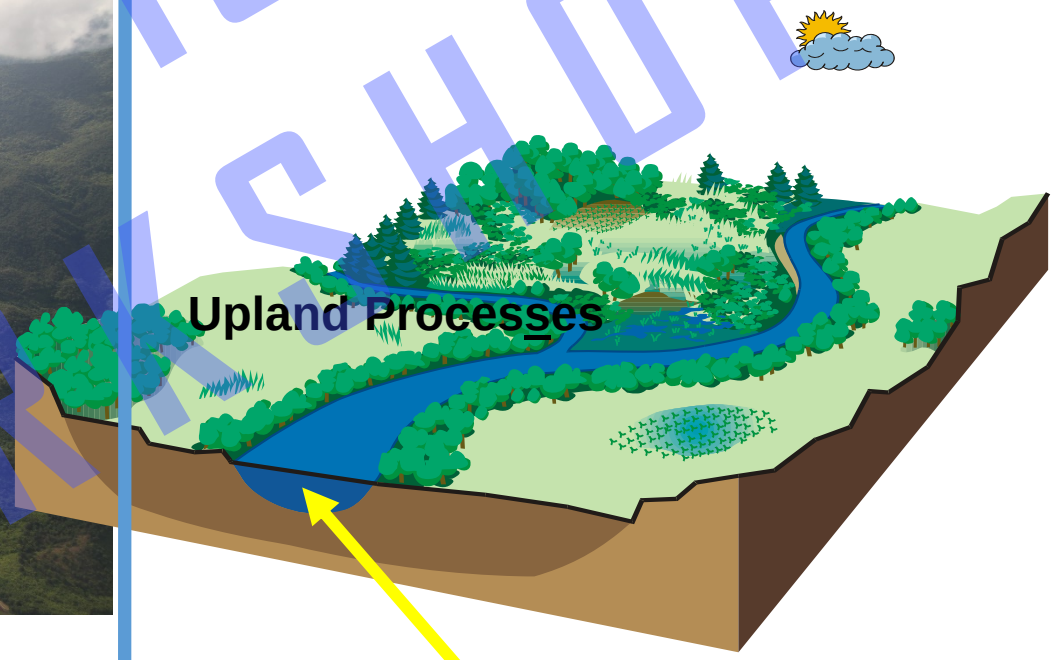
Natural and agro-ecosystems: Same photosynthesis process.

$6CO_2$	+	$6H_20$	Light	$C_6H_{12}O_6$	$6O_2$

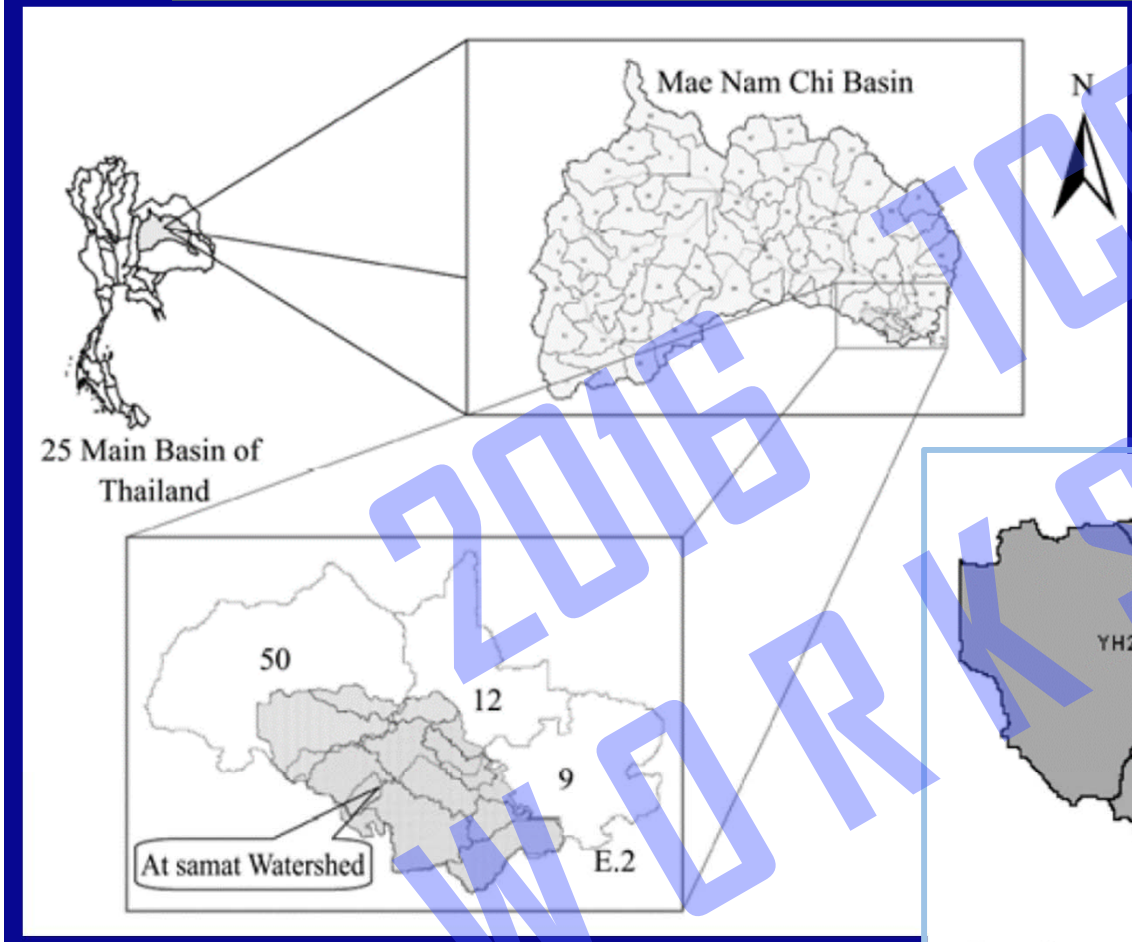
Model

System approach: Putting parts of rice production into one picture

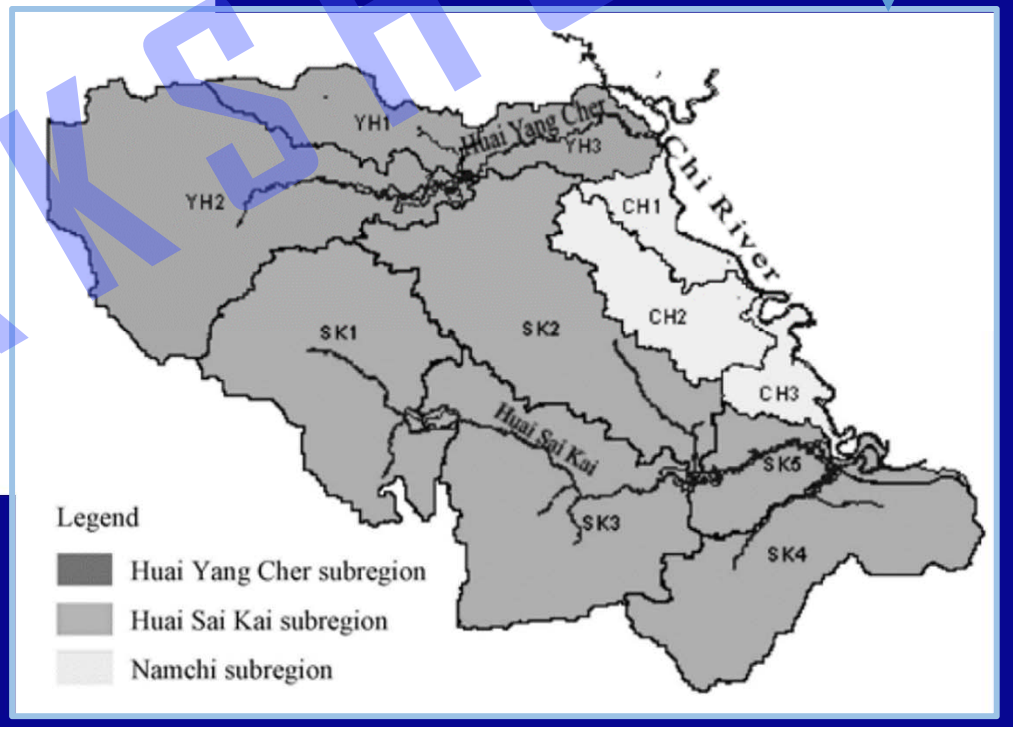
Soil Water Assessment Tool (SWAT Watershed System)



Applications



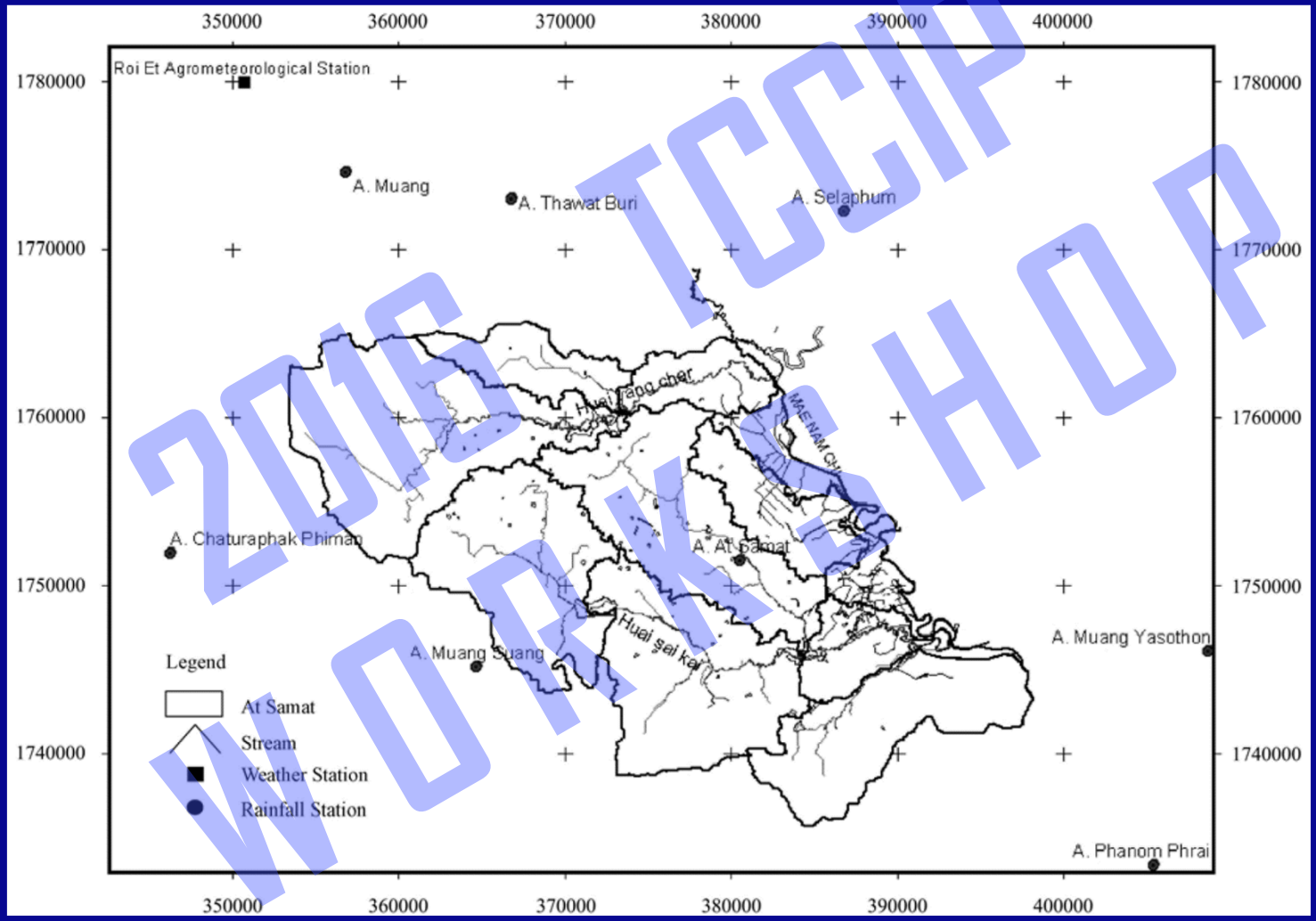
At samat watershed
- 732 km^2
- 1,356 - 1,659 mm/year
- Landuses
  - 79.9% Ag
  - 7.1% Forest
  - 4.3% Urban
  - 1.2% Water
  - 6.3% Other uses



Graiprab et al. (2010)

SWAT

Locations of the nine rainfall stations used for the At Samat SWAT simulation study



Graiprab et al. (2010)

Applications

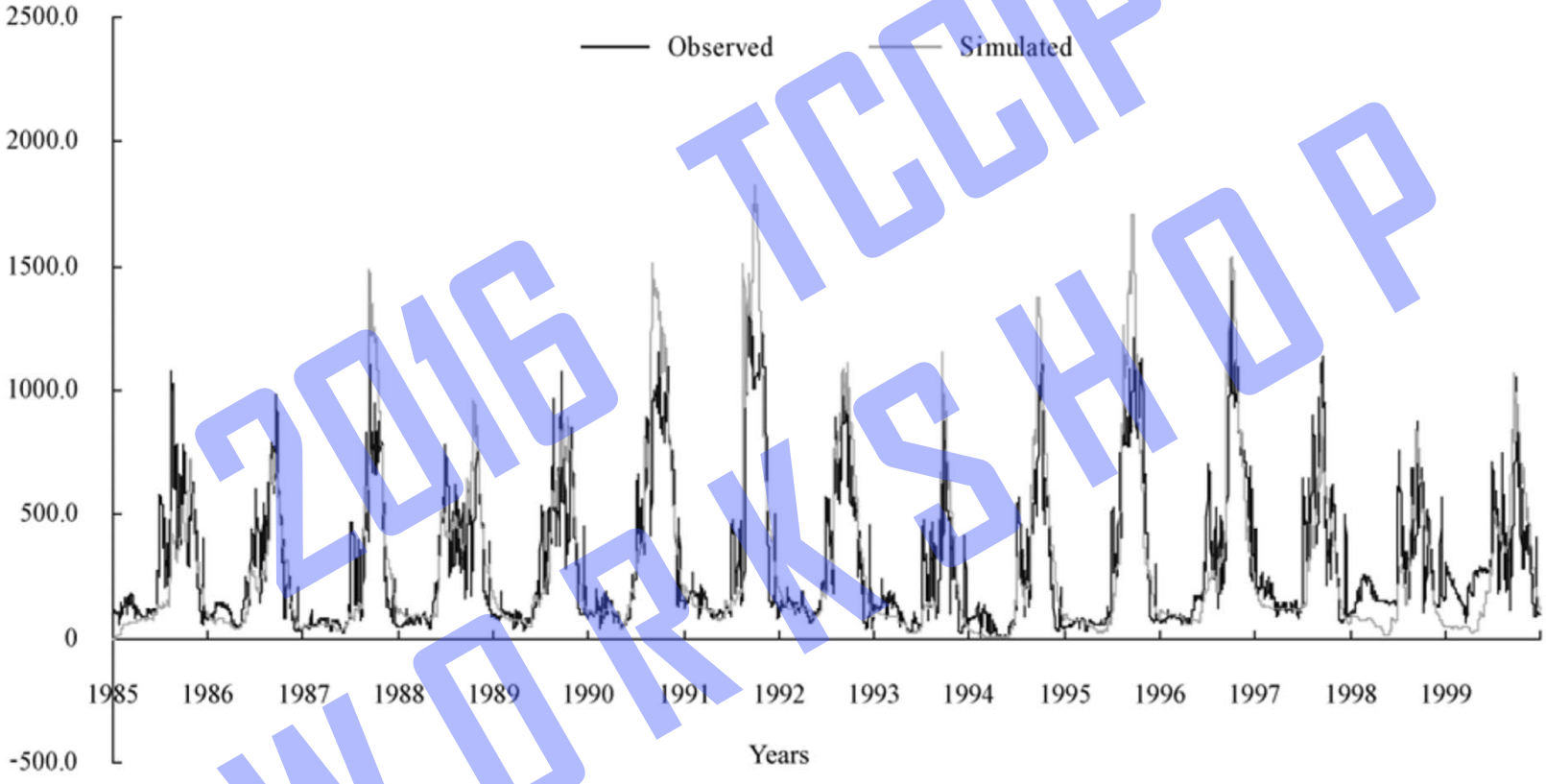


Figure 4 SWAT Calibration result for station E.2 located at Yasothon, at the outlet of the Mae Nam Chi River basin (Source: adapted from MRC, 2004)

Graiprab et al. (2010)

Applications

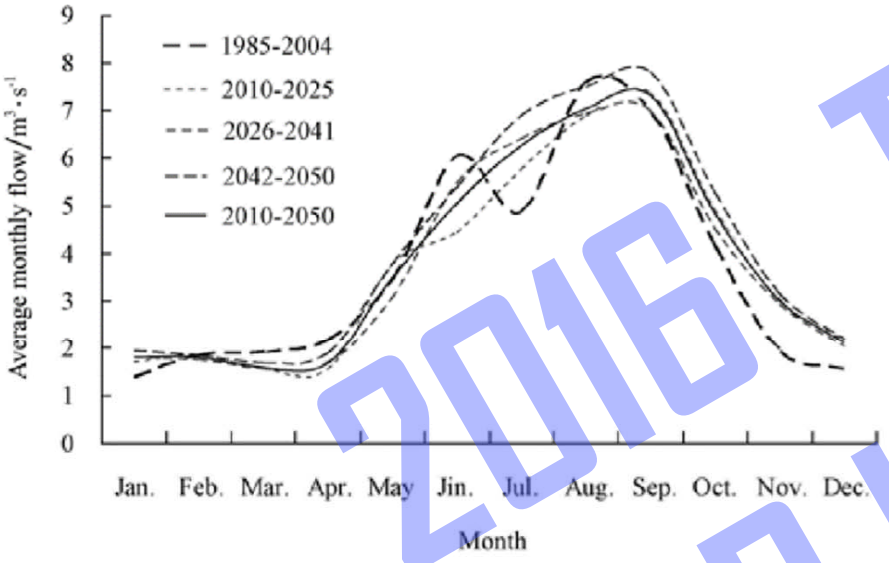


Figure 9 Average monthly flow change for Huai Yang Cher subregion

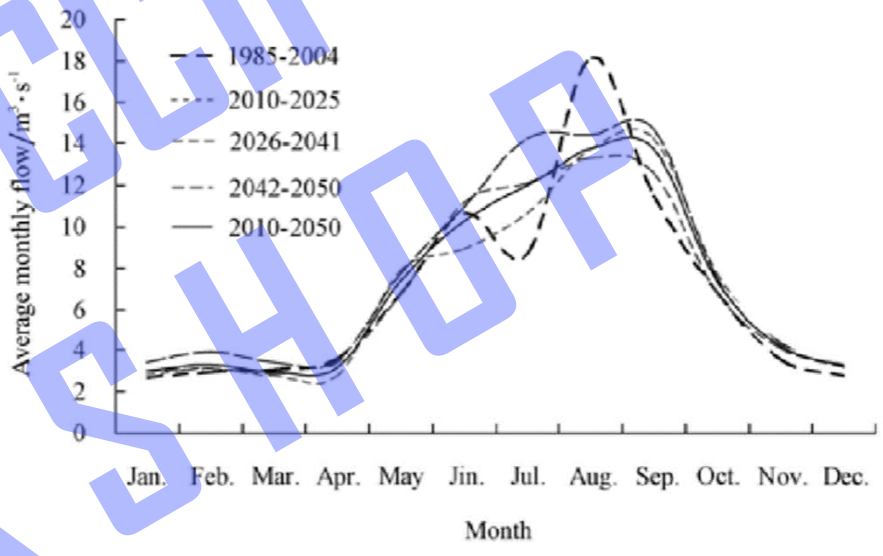
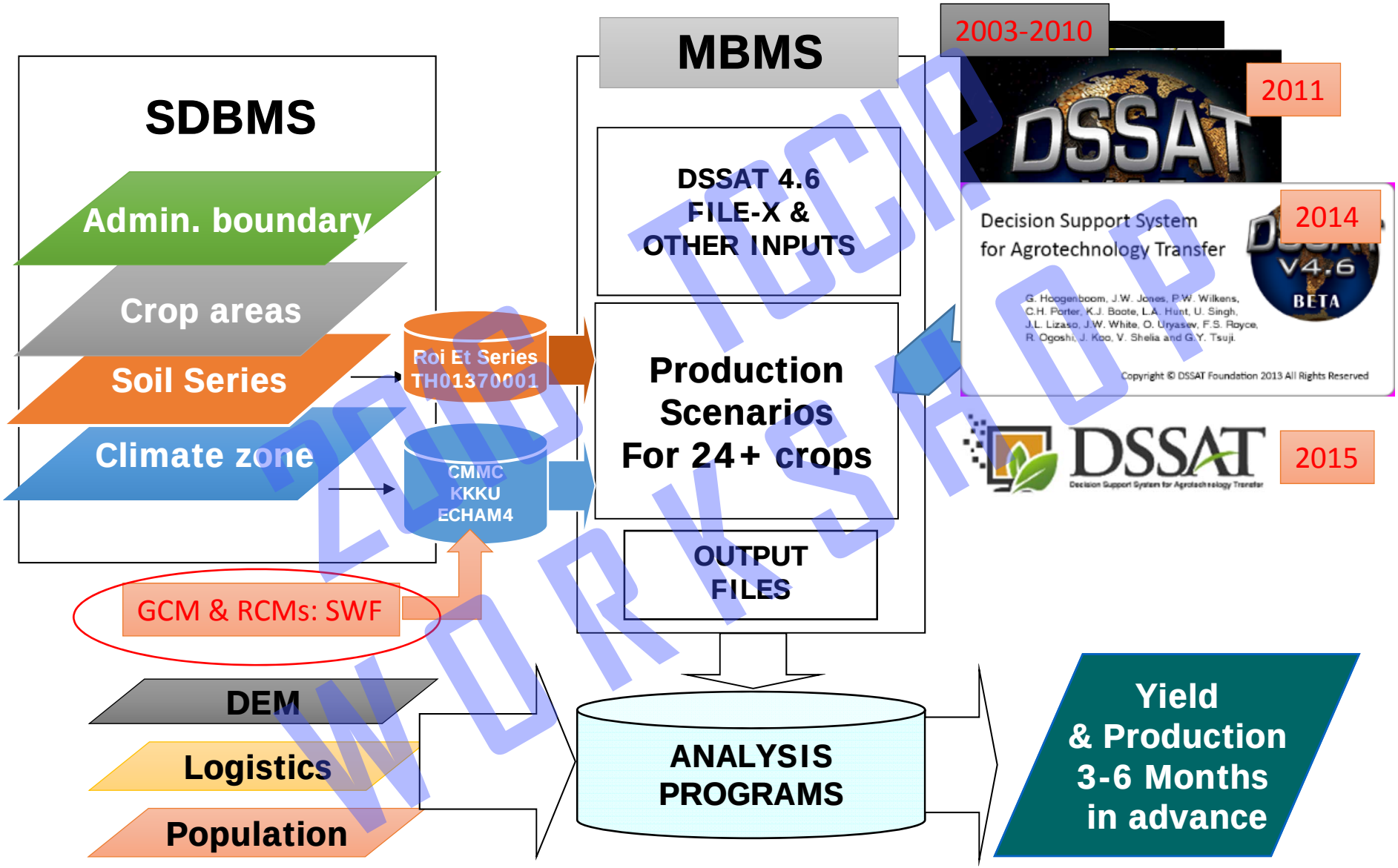


Figure 10 Average monthly flow change for Huai Sai Kai subregion

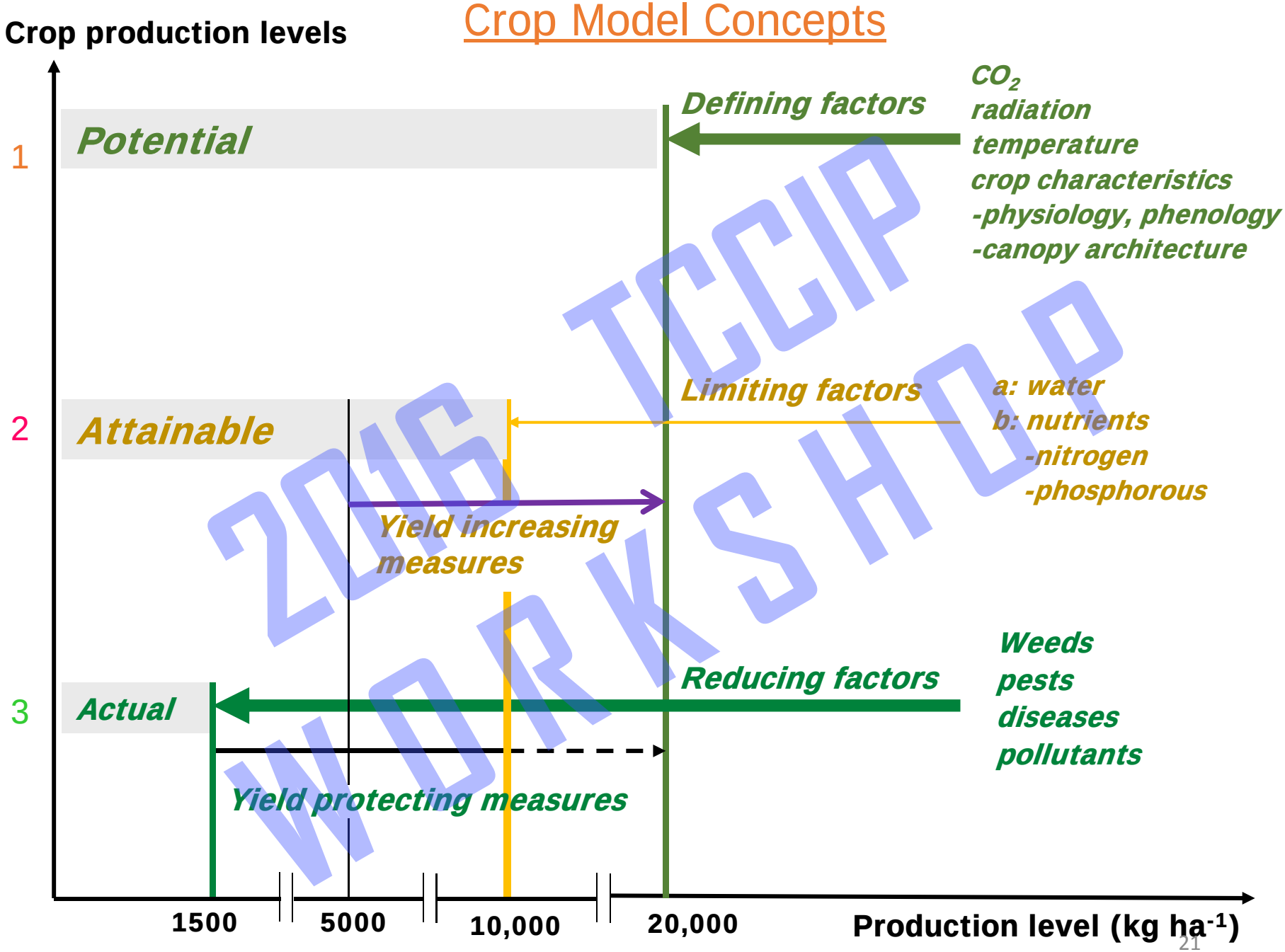
Graiprab et al. (2010)

MWCropDSS: A Framework for Seasonal Rice Yield Forecast in Thailand & AP



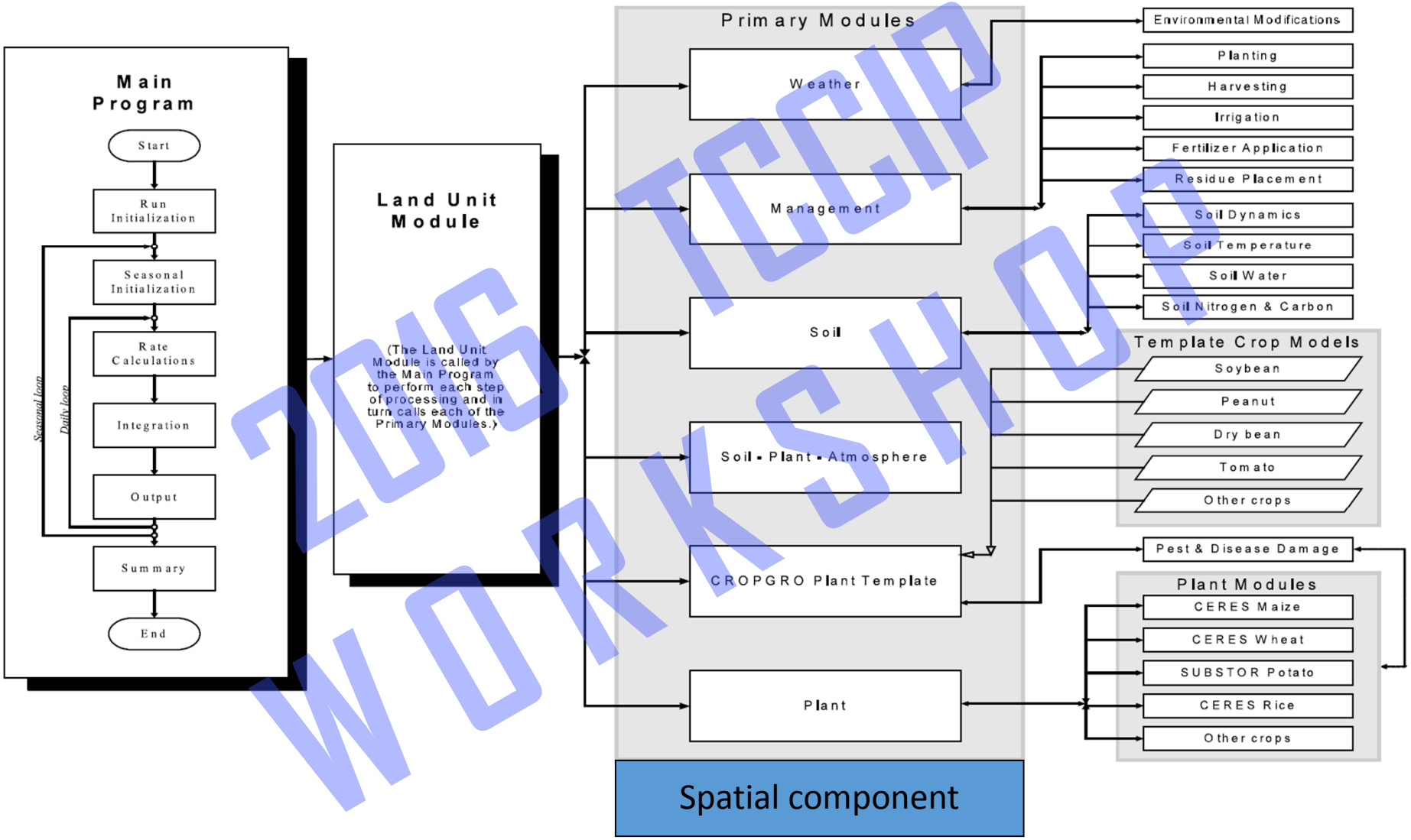
Jintrawet (2009); Morohn et al. (2013)

Crop Model Concepts



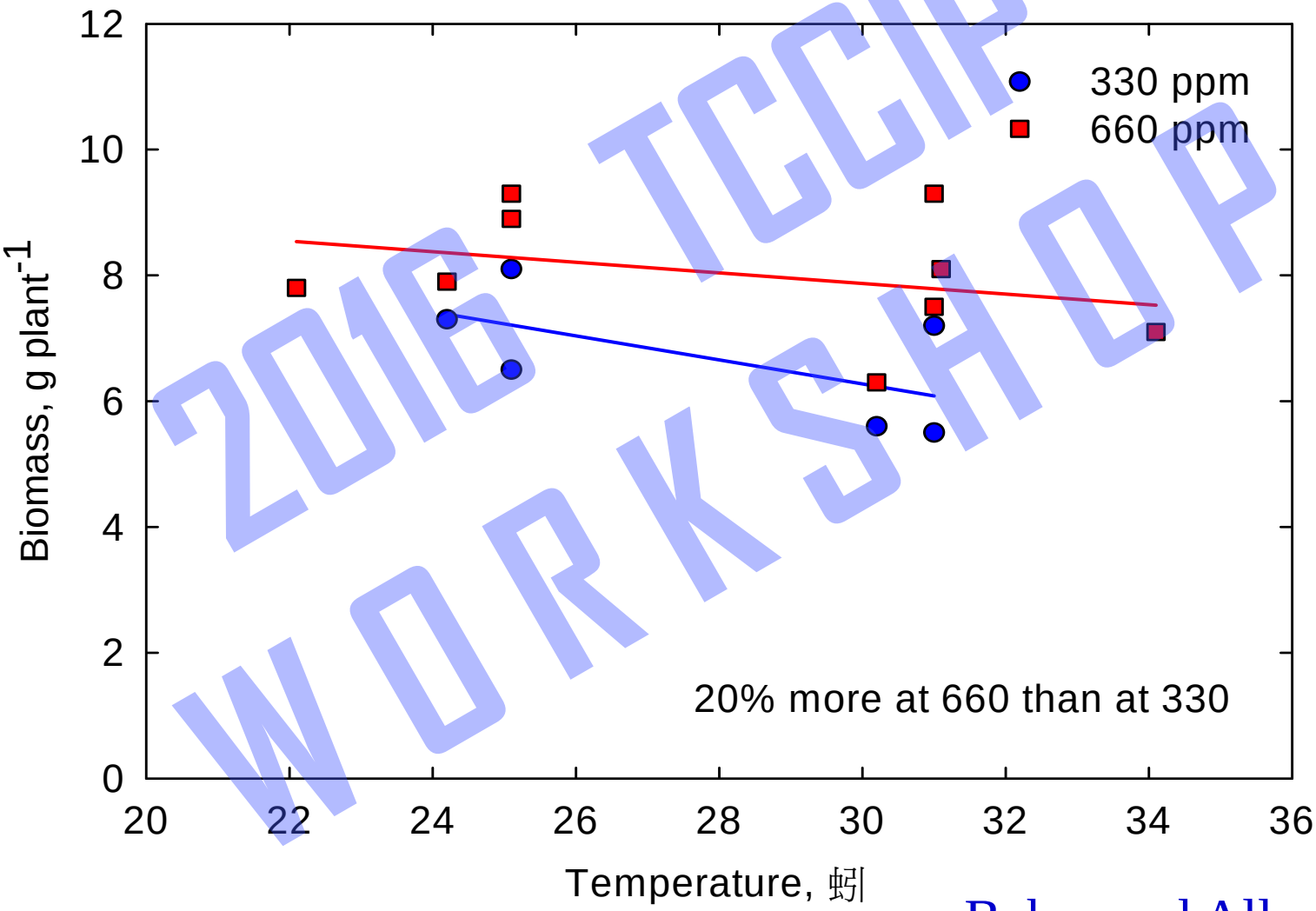
Source: World Food Production: Biophysical Factors of Agricultural Production, 1992; Bouman et al., 1996.

Overview of the components and modular structure of the DSSAT/CSM.



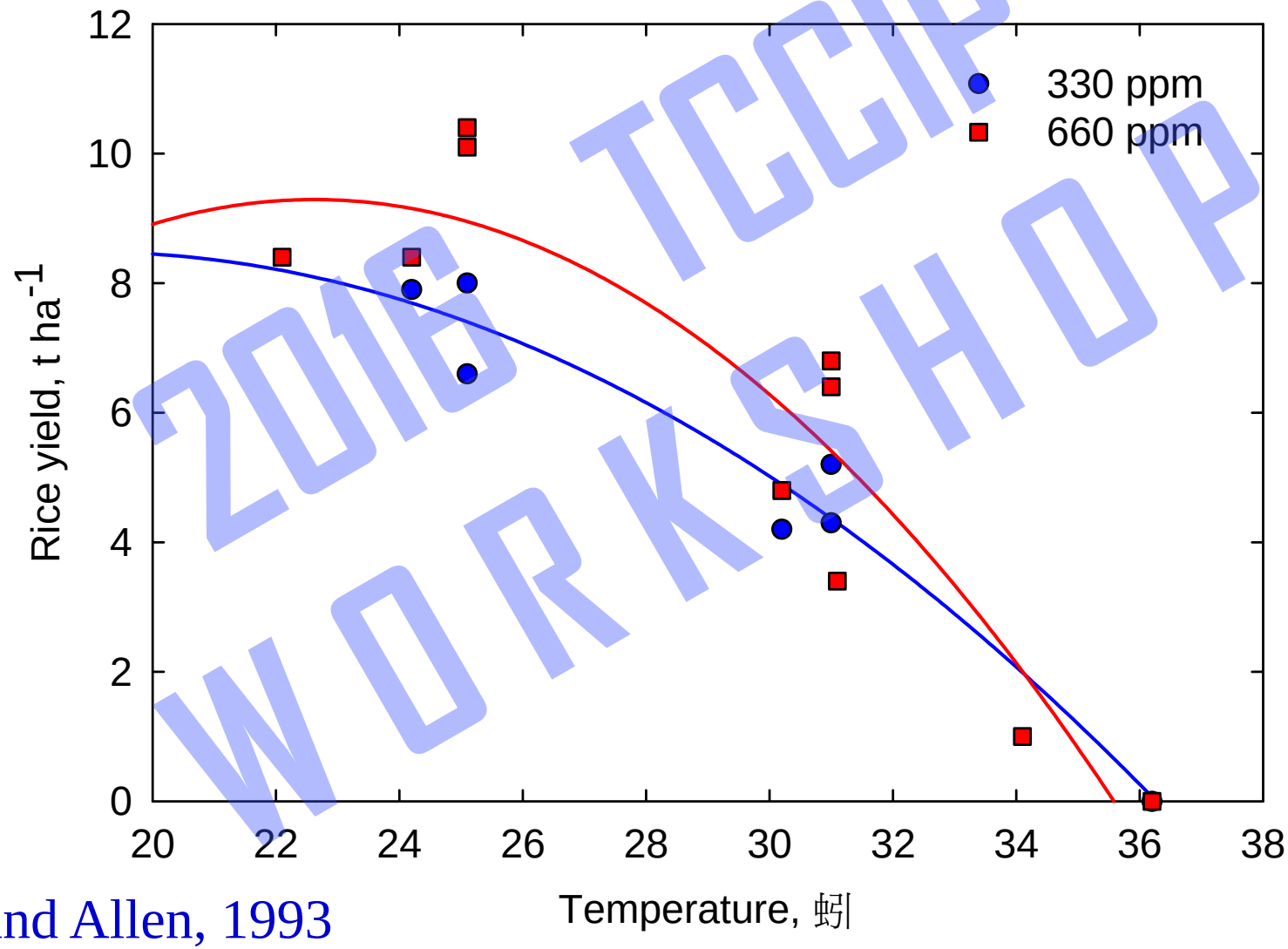
Jones al. (2003)

Climate Change and Crop Productivity
Temperature and CO_2 – Rice Growth



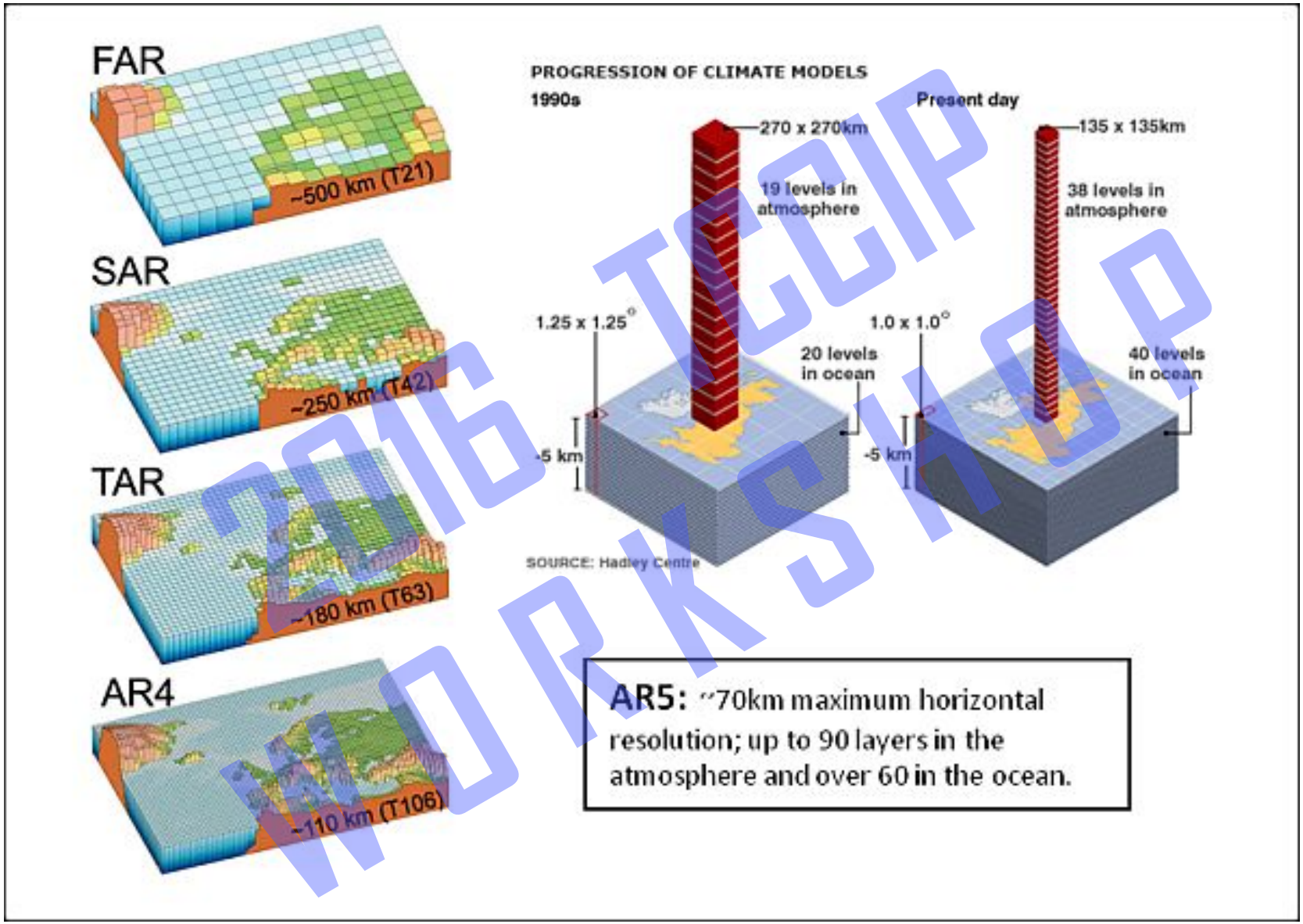
Baker and Allen, 1993

Climate Change and Crop Productivity
Temperature and CO_2 – Rice Yield

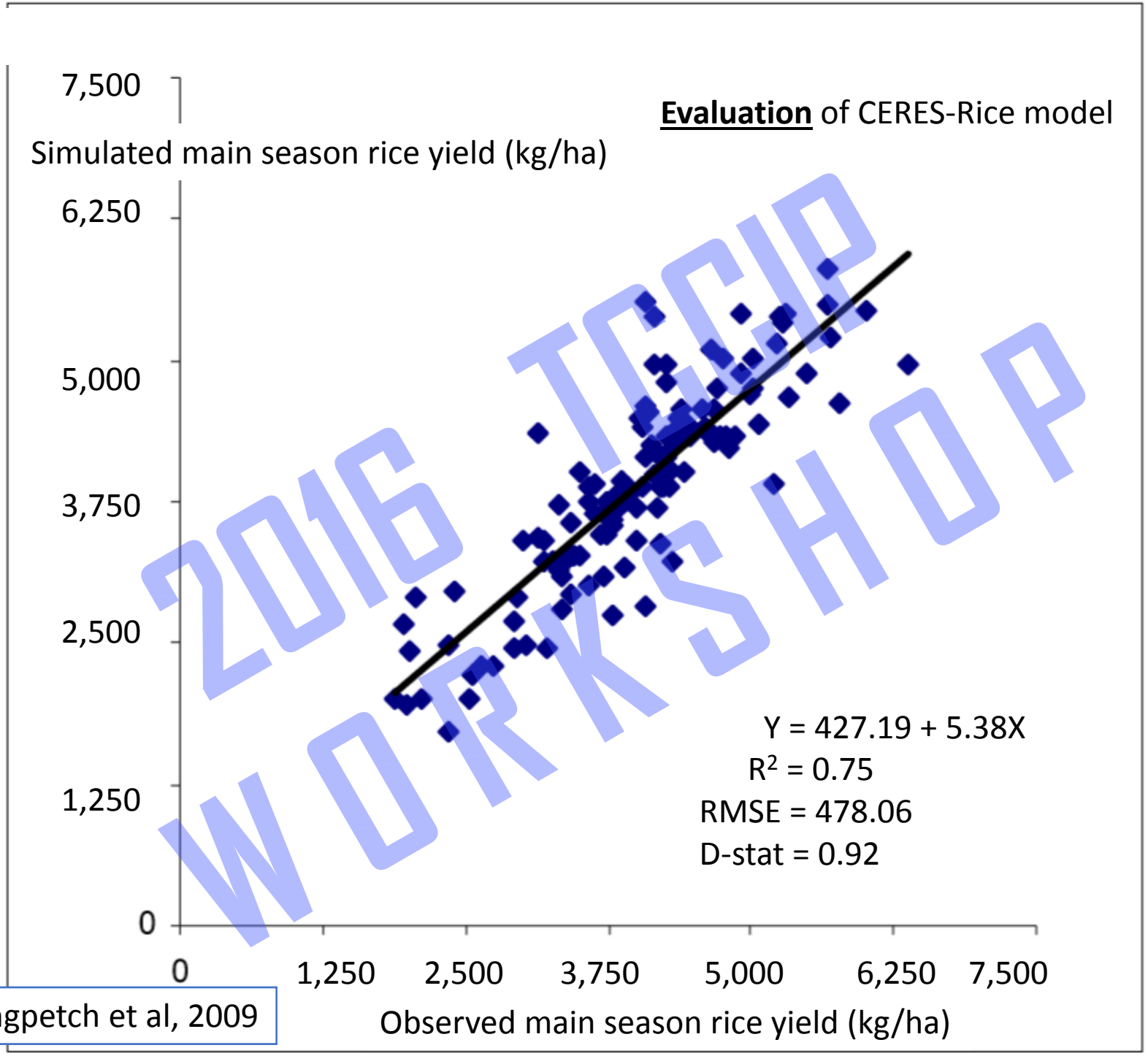


Baker and Allen, 1993

Climate Model Resolution

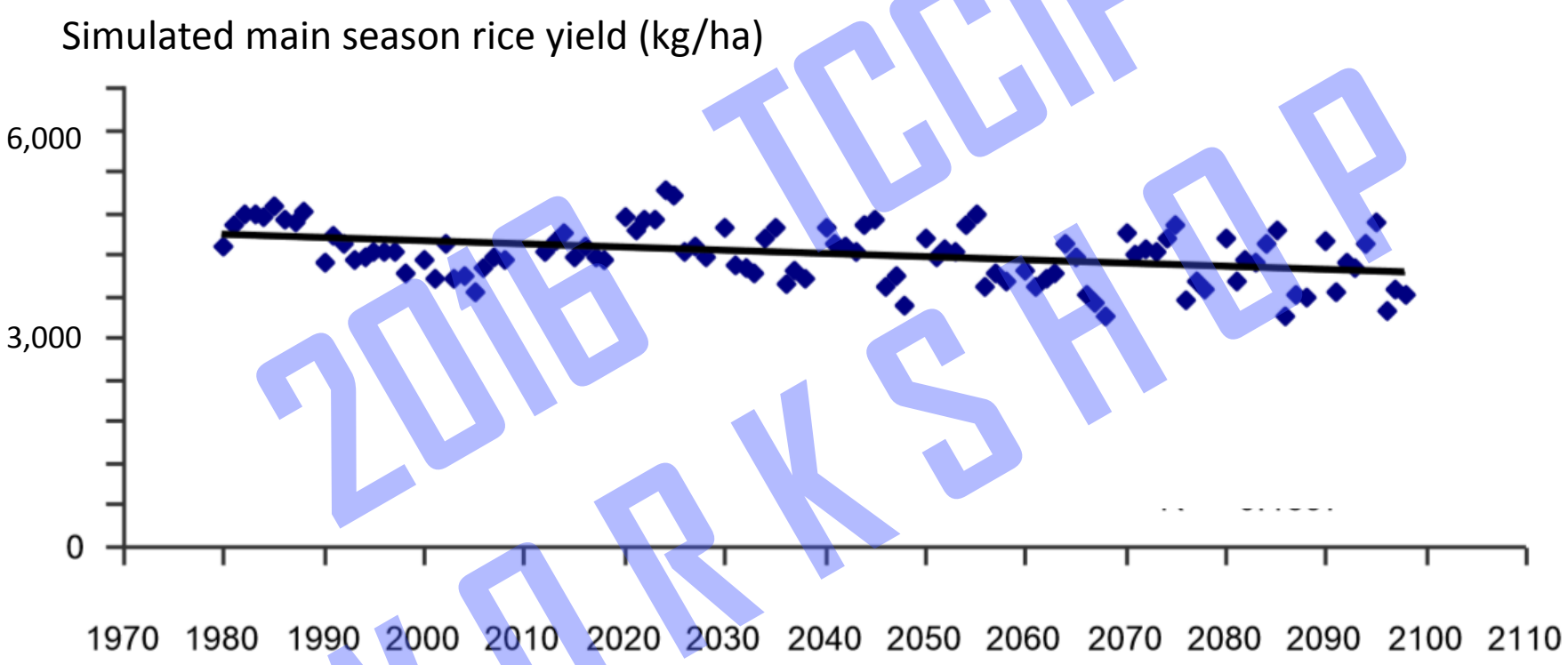


http://www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/climate-models/resolution/



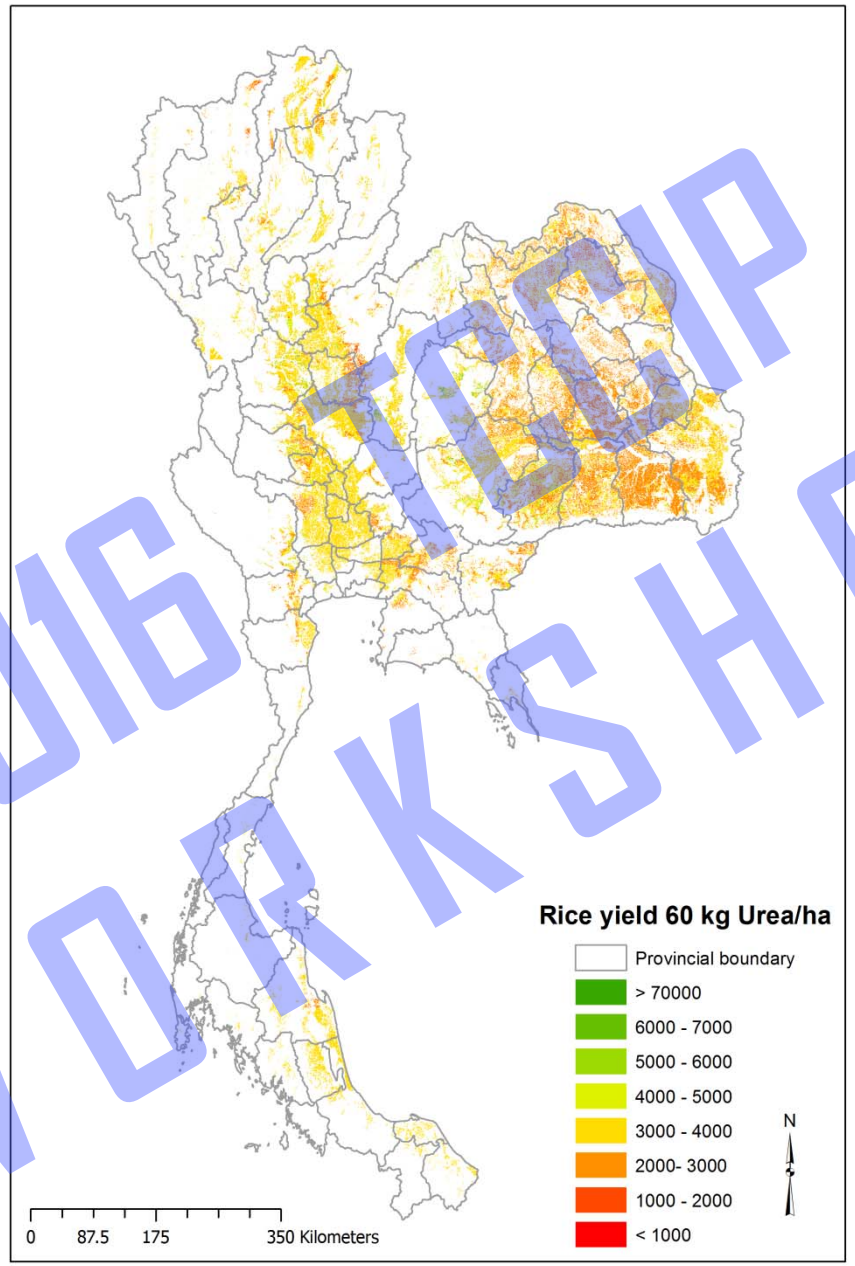
Pannangpetch et al, 2009

Rice under ECHAM4 A2



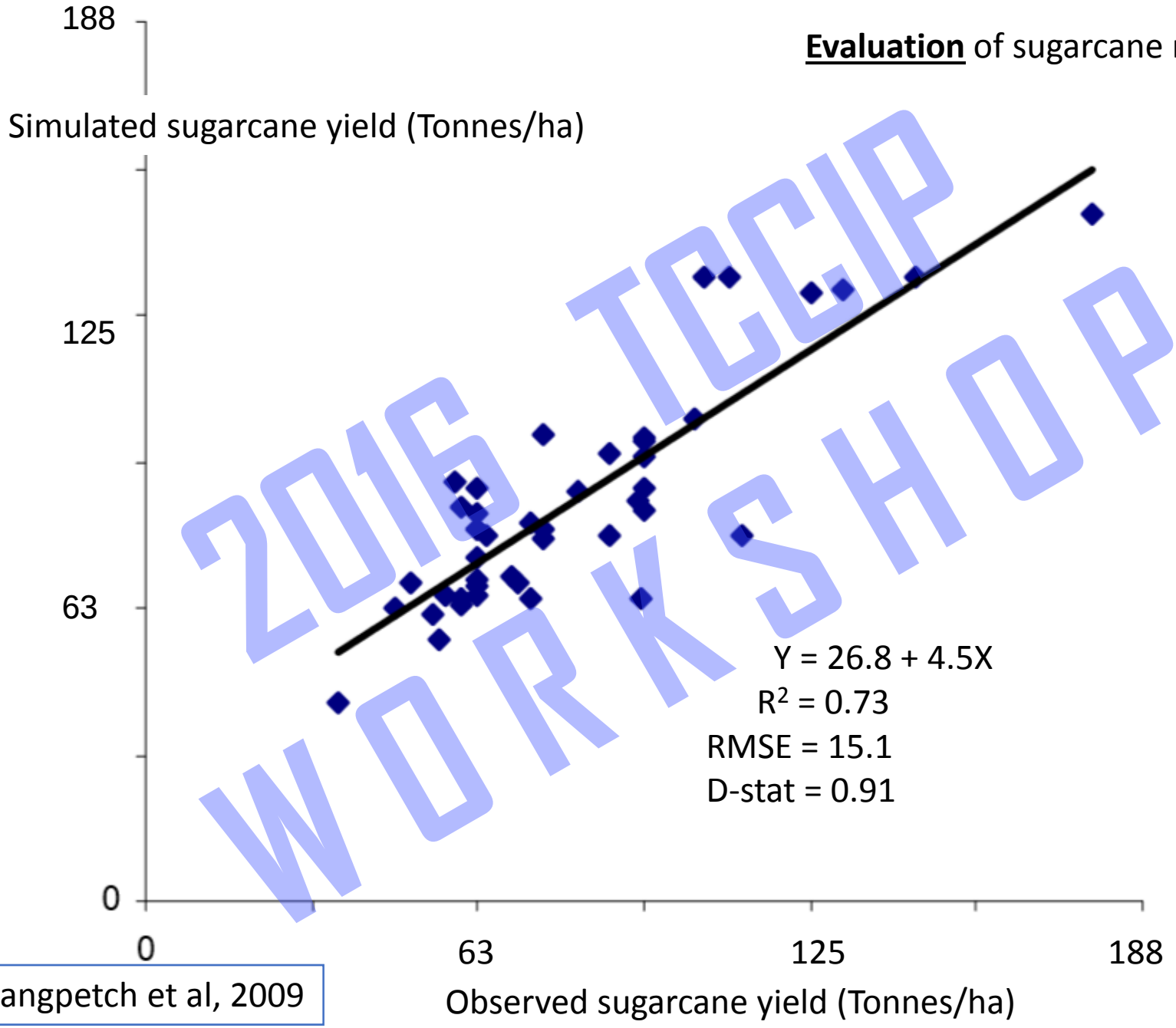
Pannangpetch et al, 2009

Rainfed, 60 kg of Urea per ha



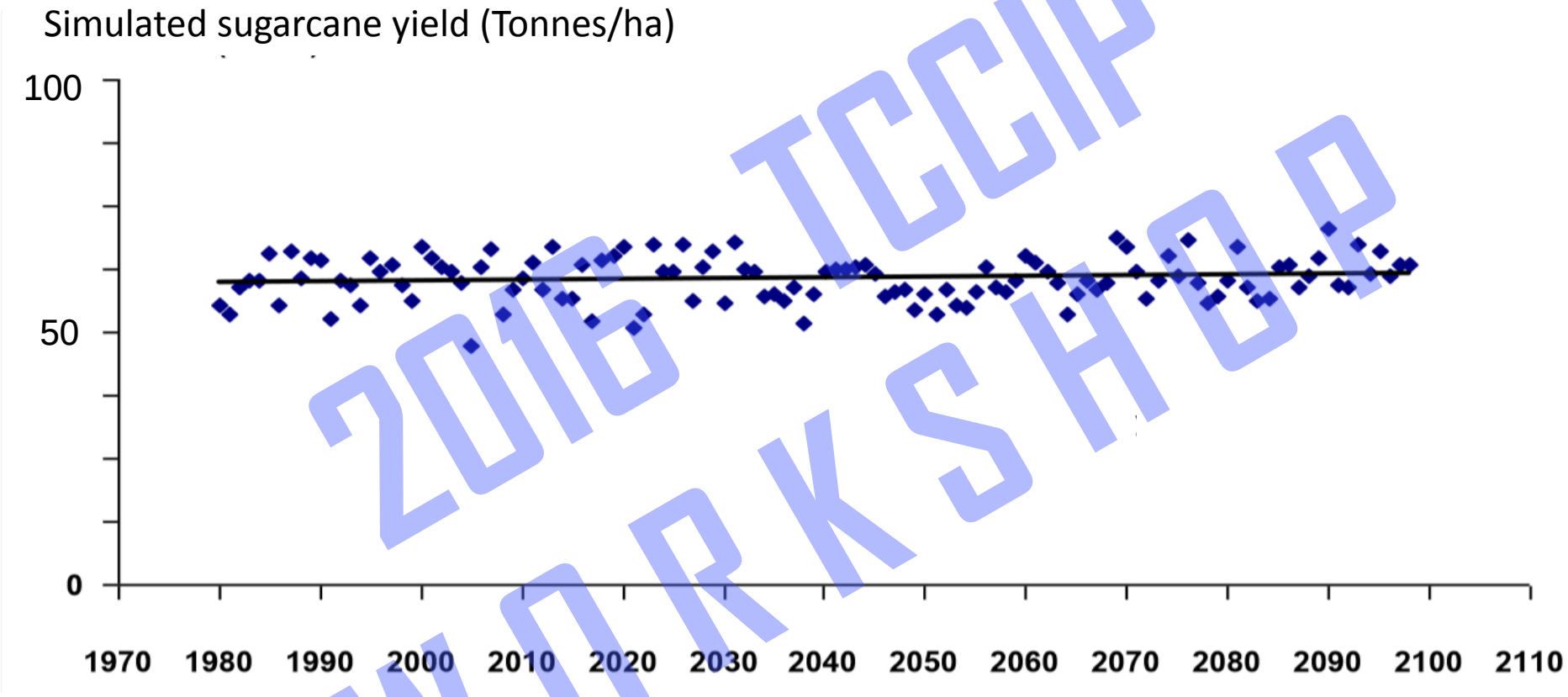
Jintrawet & Chinvanno, 2011

Evaluation of sugarcane model



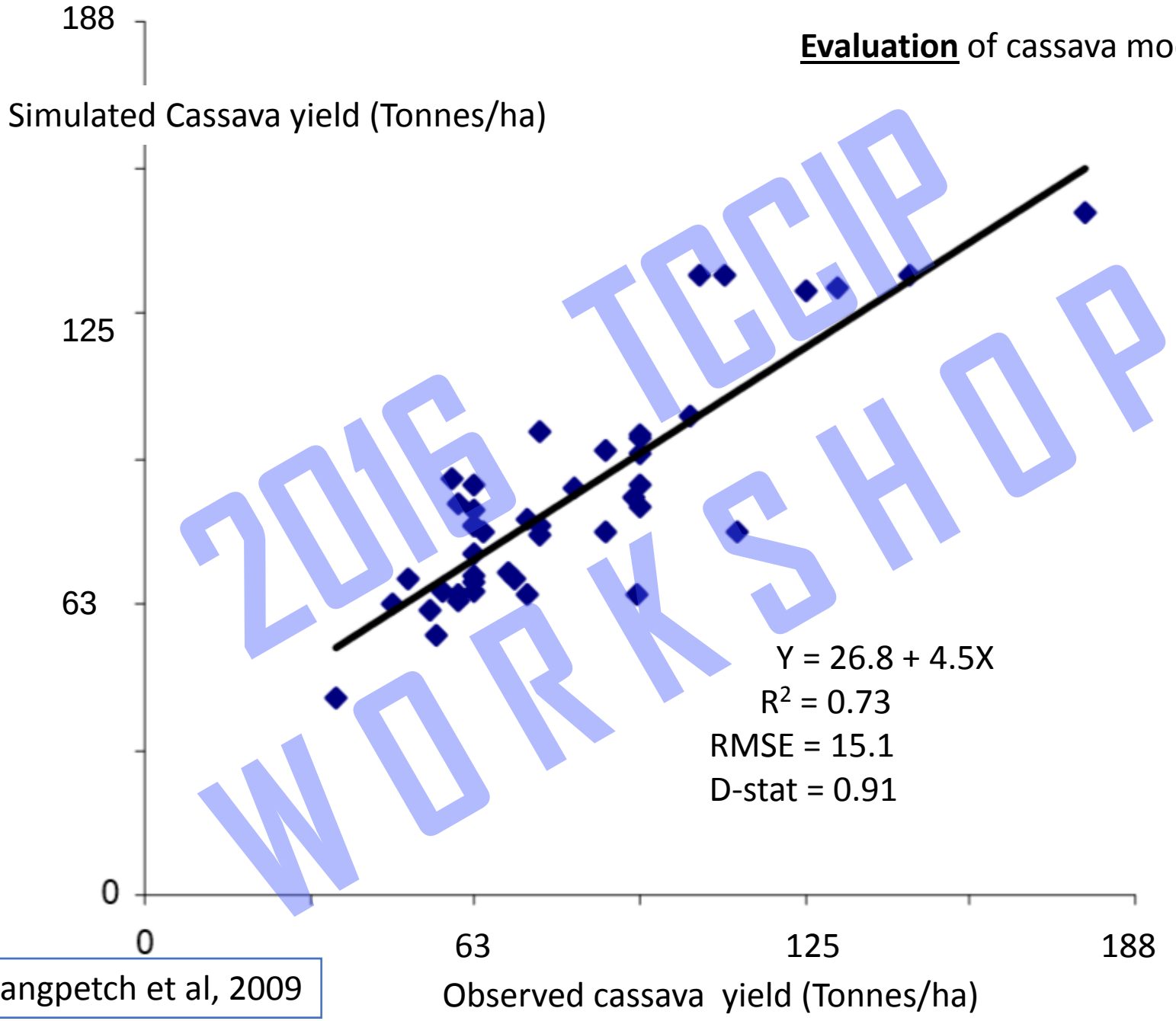
Pannangpetch et al, 2009

Sugarcane under ECHAM4 A2



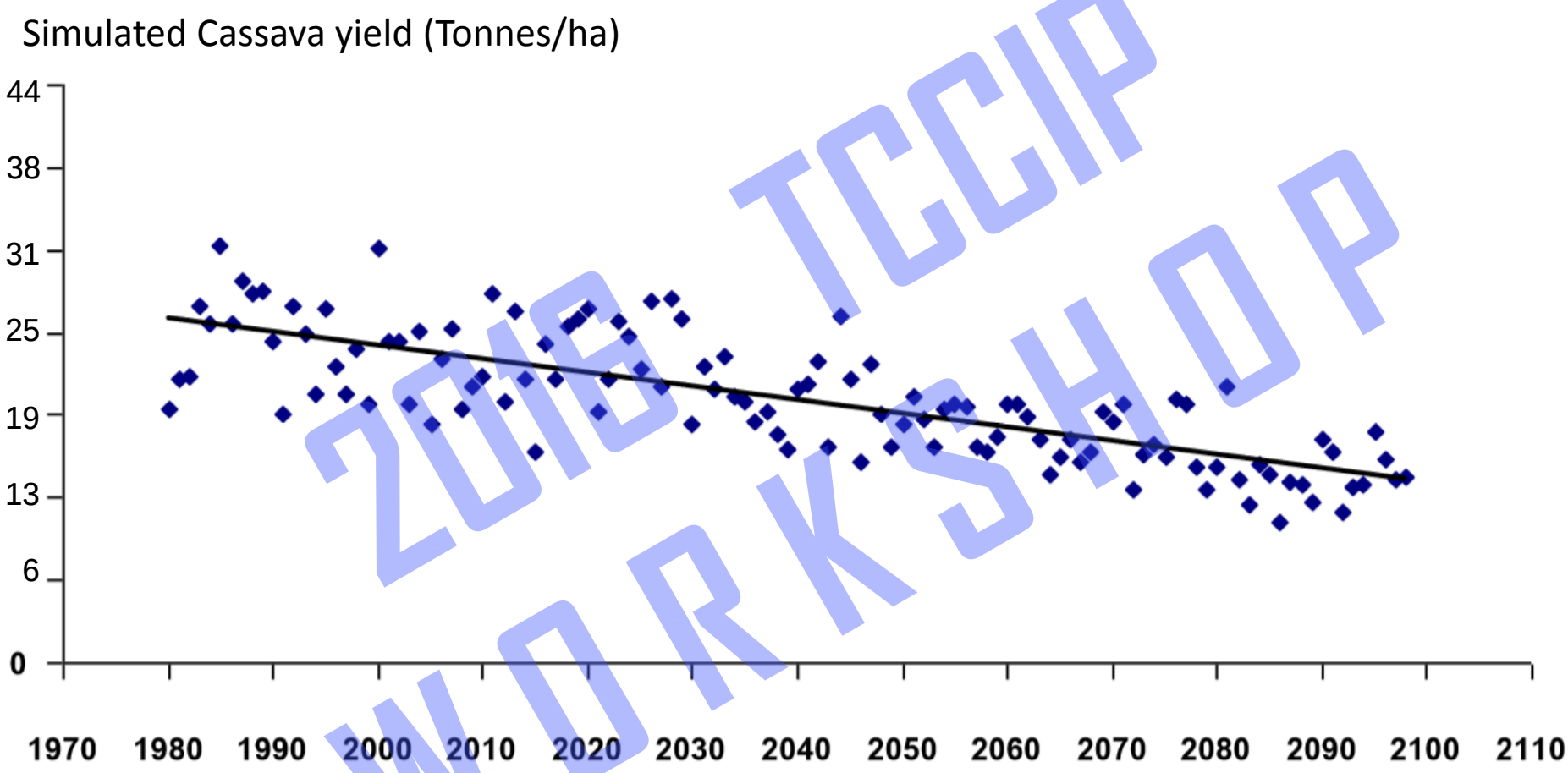
Pannangpetch et al, 2009

Evaluation of cassava model

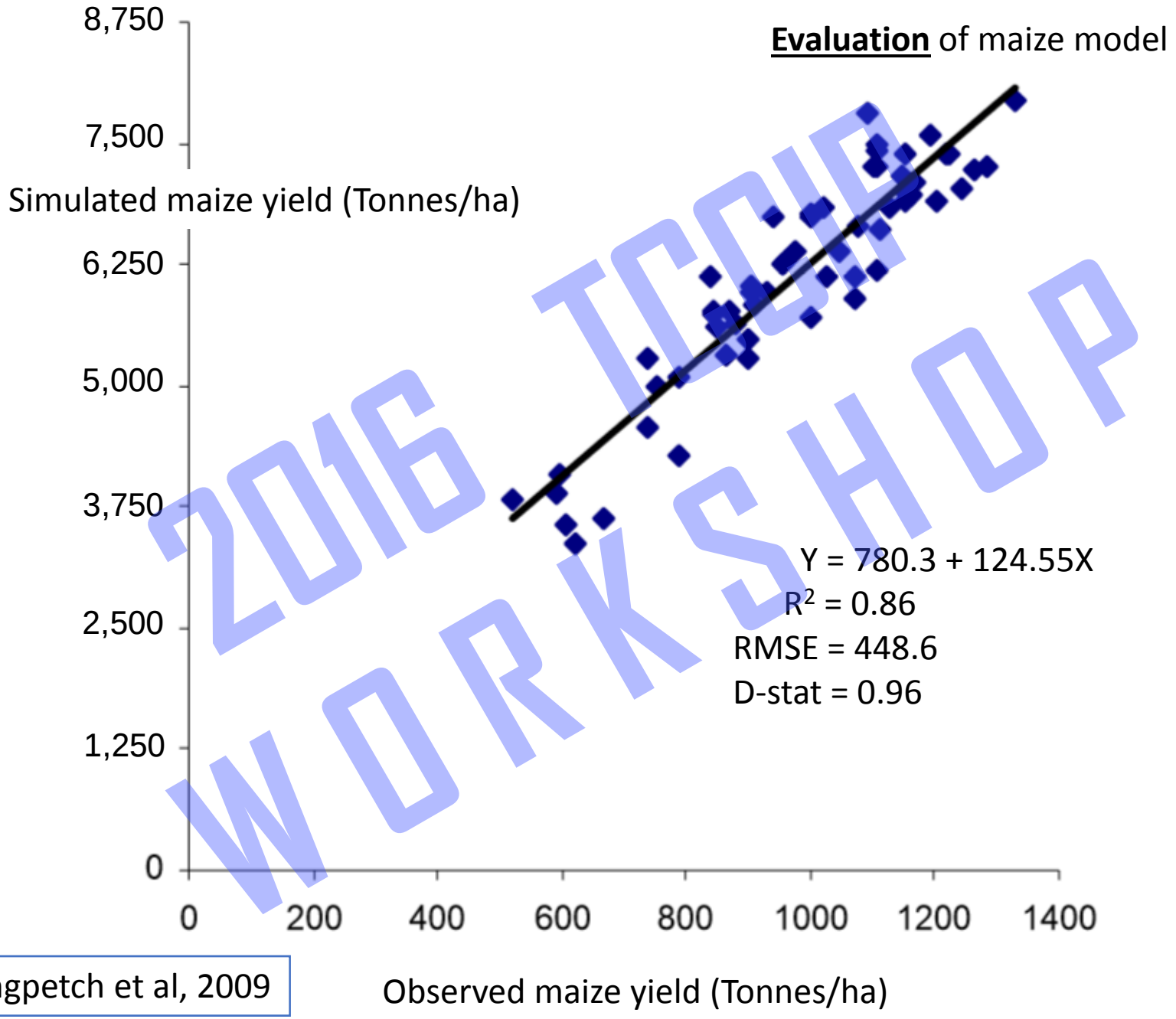


Pannangpetch et al, 2009

Cassava under ECHAM4 A2

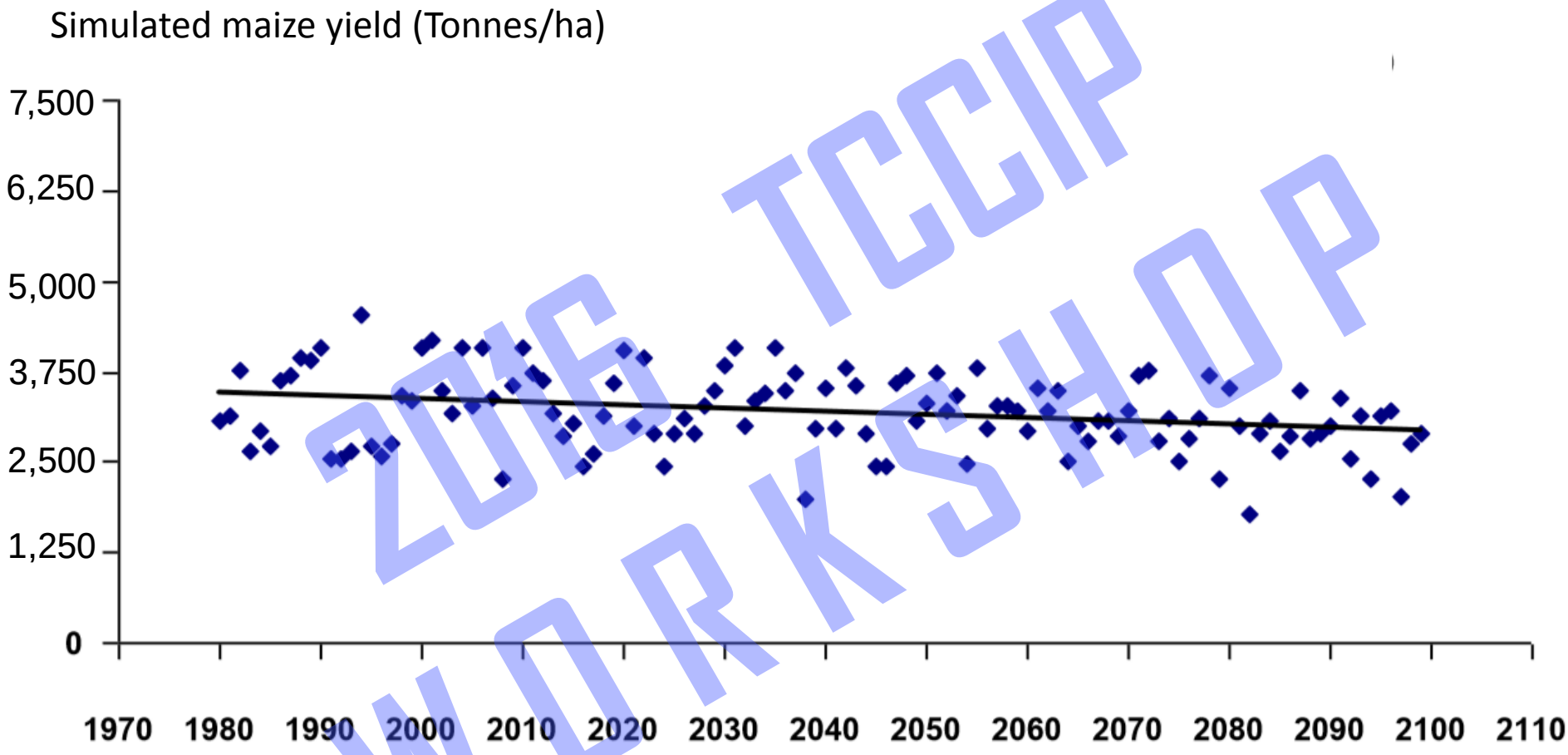


Pannangpetch et al, 2009



Pannangpetch et al, 2009

Maize under ECHAM4 A2



Pannangpetch et al, 2009

Mainstreaming workshop @CMU

May 23-28, 1993

21 Thai Participants

Mainstreaming workshop @CMU

Dec 1-11, 2003

30 Participants;
14 TRF-Funded (2 Cambodia, 2 Lao, 2 Vietnam, 8 Thai),

4 Bhutan,
1 Iran,
2 S. Korea,
1 Cambodia,
2 Vietnam,
2 Sri Lanka,
4 Thai

Mainstreaming workshop @CMU

June 28-July 9, 2004

21 Participants;
6 Bangladesh,
9 Pakistan,
6 Nepal

(APN-CAPaBLE

Program-Funded)

Mainstreaming workshop @CMU

Nov 26-Dec 7, 2007.

27 Participants;

2 Cambodia,
1 China,
1 Germany,
1 Indonesia,
9 Thai,
6 Vietnam
(RF &
Various sources)

Mainstreaming workshop @UKM

Mar 30-Apr 10, 2009.

30 Participants;

28 Malaysia,
1 Iran,
1 USA
(Malaysia
& Various source

Mainstreaming workshop @CMU

Feb 11-22, 2013.

27 Participants (21 TICA-funded);

Bangladesh, Egypt, Myanmar, Sri Lanka, Uganda (2 from each country)
Burundi, Eritrea, India, Jordan, Kenya, Pakistan, Paraguay, Philippines, Seychelles, Sudan (1 from each country)
And 7 from Thailand.

Mainstreaming workshop @CMU

Feb 10-21, 2014.

19 Participants (8 TICA-funded);

2 Nepal,
2 Egypt,
1 Sri Lanka,
1 Madagascar,
1 Jordan
1 El Salvador

2 Fiji, 1 India
4 Thai self-funded
MS student: 2 Germany, 1 Lao, 1 Thai

Mainstreaming workshop @PAFO, Luang Prabang, Lao PDR

Oct 20-24, 2014.

21 Lao Participants;

Mainstreaming workshop @Citeko Bogor

Nov 17-20, 2014.

35 Participants;

1 Cambodia,
4 Lao,
3 India,
13 Indonesia,
3 Malaysia,
4 Philippines,
3 Thailand,
4 Vietnam.

SEACLID

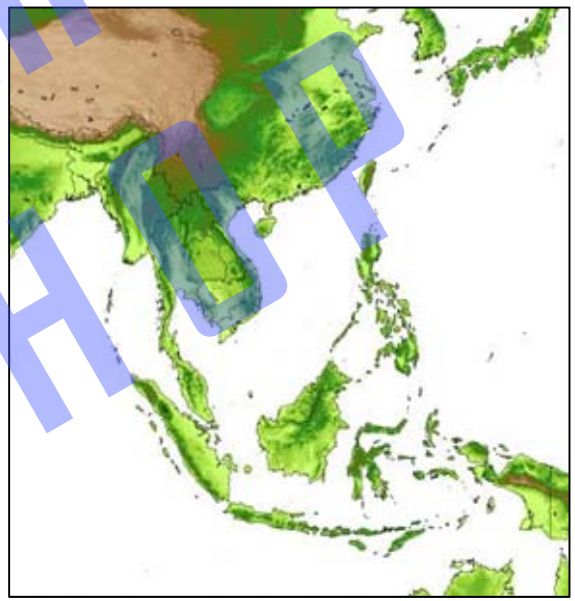
CORDEX-Southeast Asia

The Southeast Asia Regional Climate Downscaling (SEACLID) / CORDEX Southeast Asia Project

Fredolin Tangang

Coordinator
SEACLID/CORDEX SEA
The National University of Malaysia

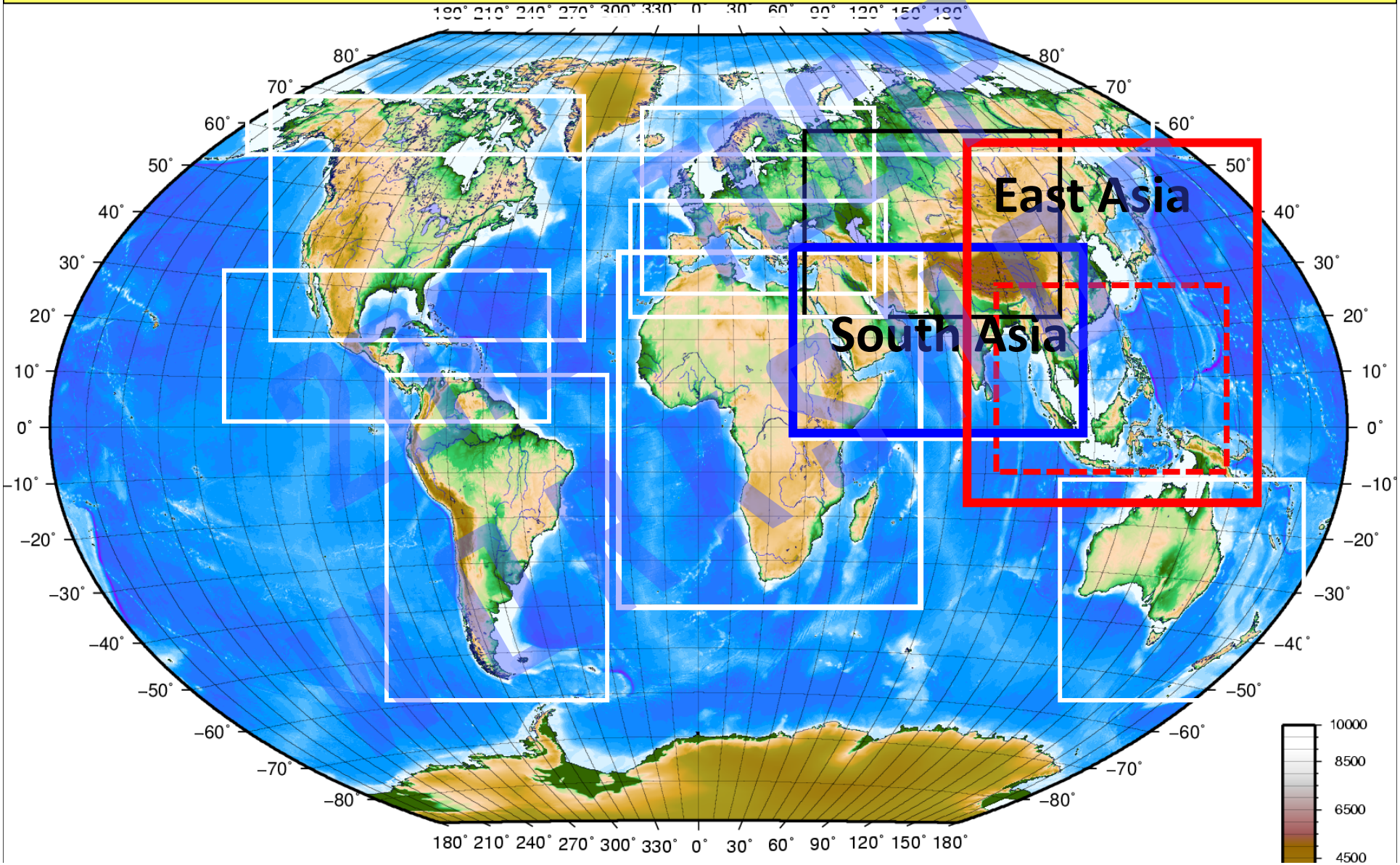
On behalf of colleagues involved in SEACLID/ CORDEX Southeast Asia



- **11 Countries, 15 Institutions involved in the project**
- **14 GCMs will be downscaled**
- ***October 2013-September 2016***

(http://www.ukm.edu.my/seaclid-cordex)

CORDEX domains

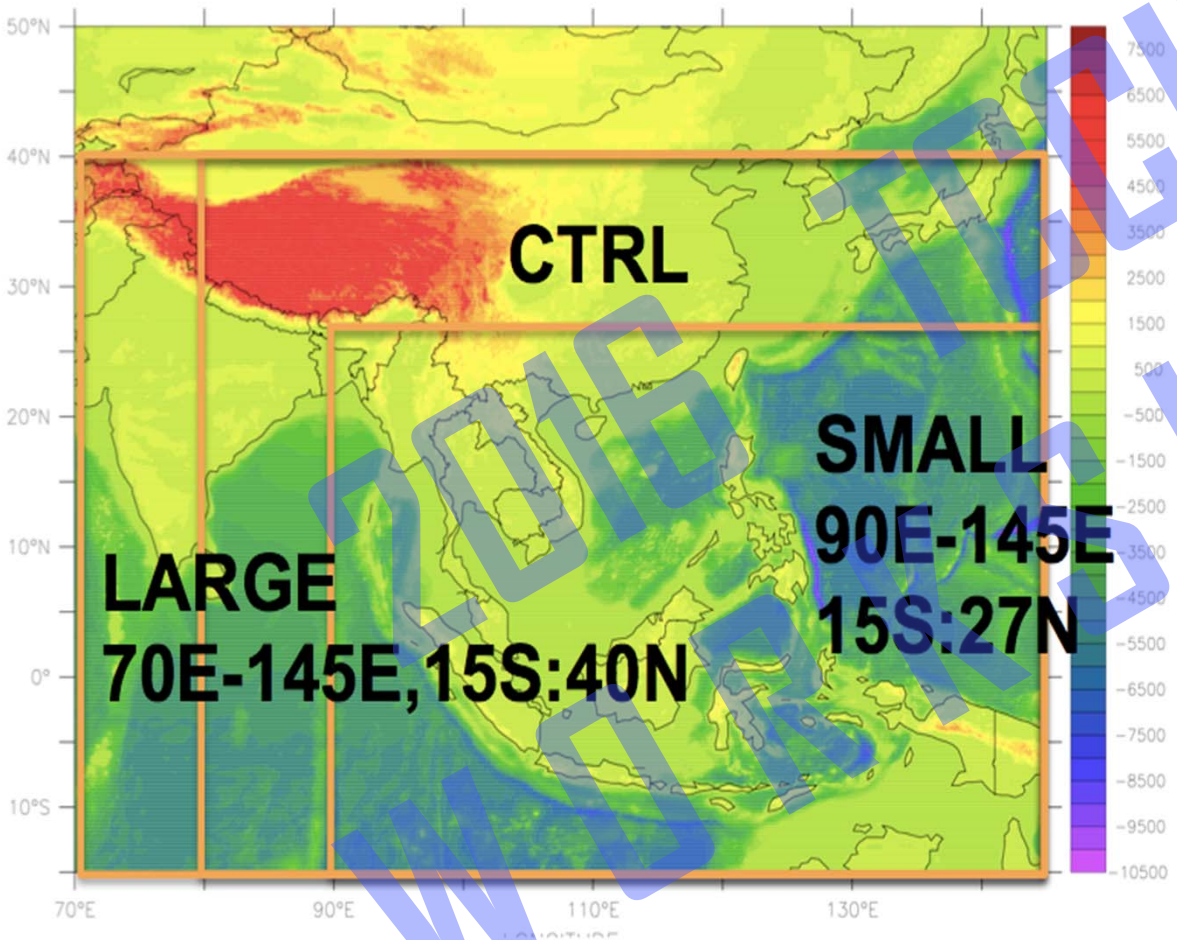


Southeast Asia Regional Climate Initiative (SEARCI)

Initial Member Countries: Malaysia, Indonesia, Vietnam, Philippines, Thailand

First Workshop hosted by Hanoi University of Science, Vietnam, 2-3 Aug 2012

CORDEX SEA Domain



Original plan:
Domain: 70E-145E, 15S-40N
Resolution: 36 km x 36 km

Revised plan :
Domain: 90E-145E, 15S-27N
Resolution: 25 km x 25 km

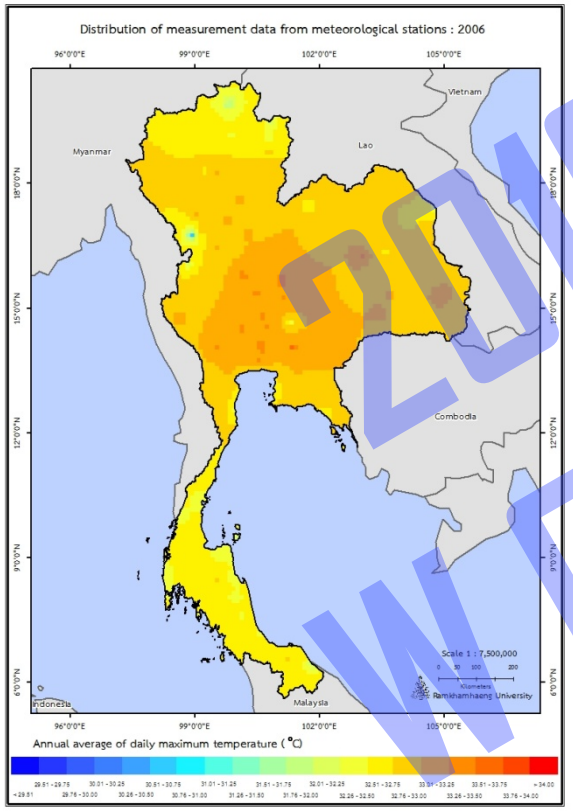
SEACLID team

Country	GCMs	Country and Institution developed the GCMs	RCPs	RCMs
Vietnam	CNRM-CM5	Centre national de Recherches Meteorologiques, France	RCP8.5, 4.5	RegCM4
Philippines	HadGEM2	Hadley Centre, UK	RCP8.5, 4.5	RegCM4
Thailand	MPI-ESM-MR	Max Planck Institute for Meteorology, Germany	RCP8.5, 4.55	RegCM4
Thailand	EC-Earth	EC-Earth consortium	RCP8.5, 4.5	RegCM4
Indonesia	CSIRO MK3.6	CSIRO, Australia	RCP8.5, 4.5	RegCM4
Malaysia	CanESM2	Canadian Centre for Climate Modeling and Analysis, Canada	RCP8.5, 4.5	RegCM4
Malaysia	IPSL-CM5A-LR	Institute Pierre-Simon Laplace, France	RCP8.5, 4.5	RegCM4
Malaysia	GFDL-ESM2M	GFDL, USA	RCP8.5, 4.5	RegCM4
Australia	CNRM-CM5	Centre national de Recherches Meteorologiques, France	RCP8.5	CCAM
Australia	CCSM4	NCAR, USA	RCP8.5	CCAM
Australia	ACCESS1.3	CSIRO, Australia	RCP8.5	CCAM
Hong Kong SAR	CCSM4 or CESM	NCAR, USA	RCP8.5, 4.5	WRF
United Kingdom	HadGEM2-ES	Hadley Centre, UKMO	RCP8.5, 4.5	PRECIS
South Korea	HadGEM2-AO	Hadley Centre, UKMO	RCP8.5, 4.5	WRF
Sweden	CNRM-CM5	Centre national de Recherches Meteorologiques, France	RCP8.5, 4.5	RCA3
Sweden	HadGEM2-ES	Hadley Centre, UKMO	RCP8.5, 4.5	RCA3
Germany	MPI-ESM-LR	Hadley Centre, UKMO	RCP8.5, 4.5	ROM

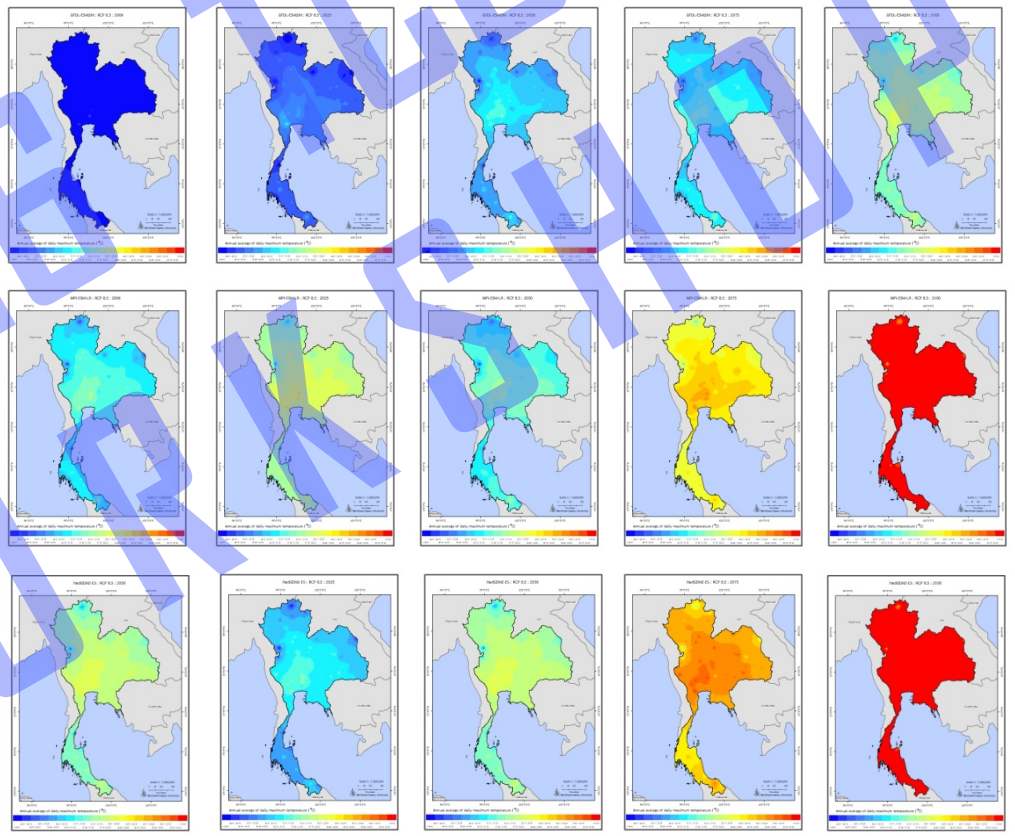
Dr. Jerasorn's team in Thailand

Future Max. Temperature : RCP8.5

Historical data 2006



2006 2025 2050 2075 2100



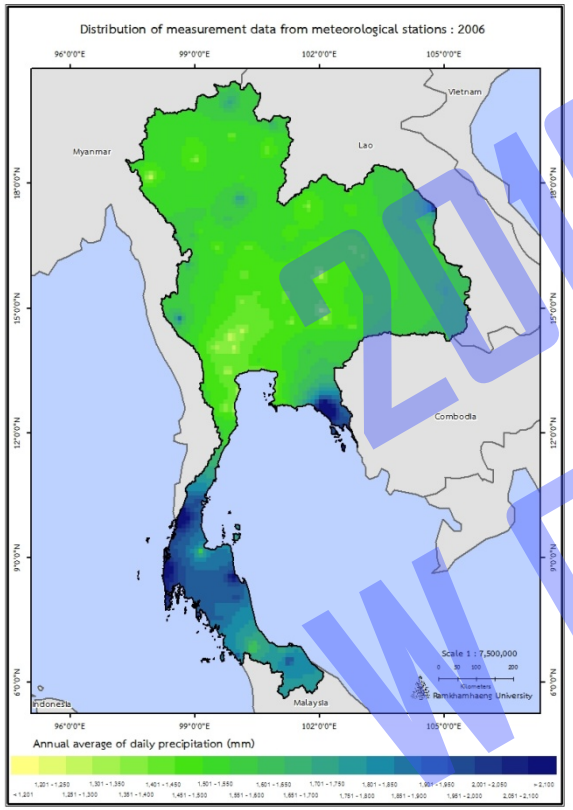
GFDL

MPI

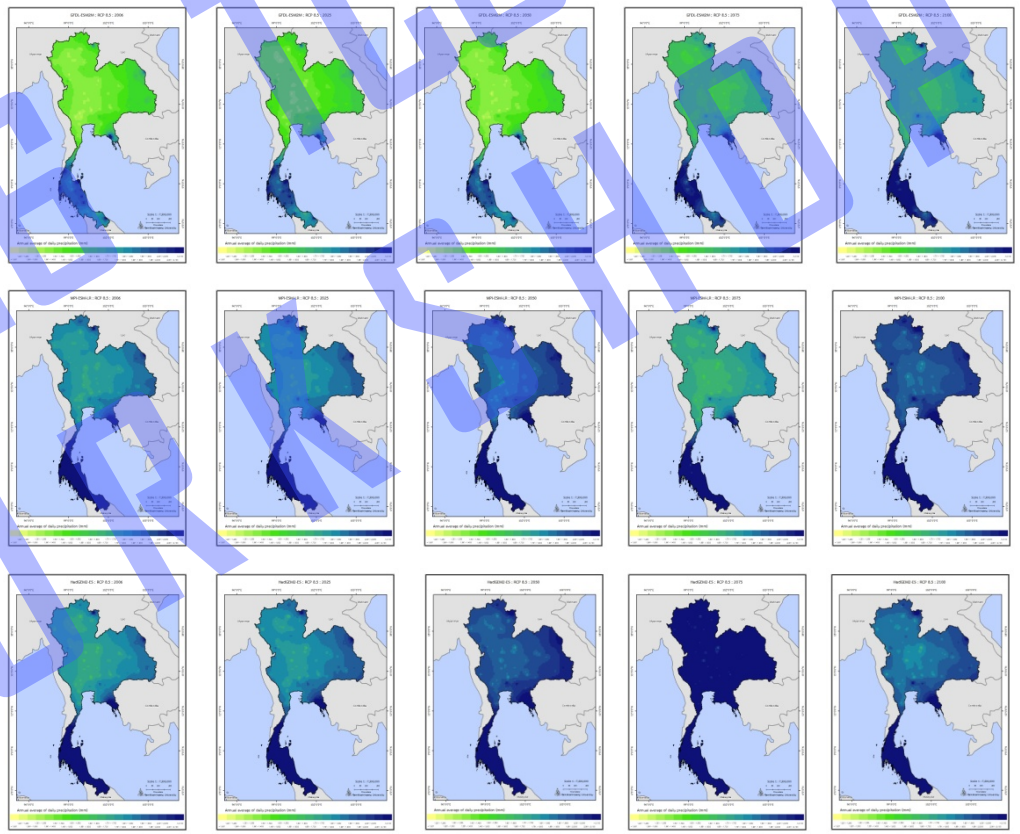
HadG

Future Precipitation : RCP8.5

Historical data 2006



2006 2025 2050 2075 2100



GFDL

MPI

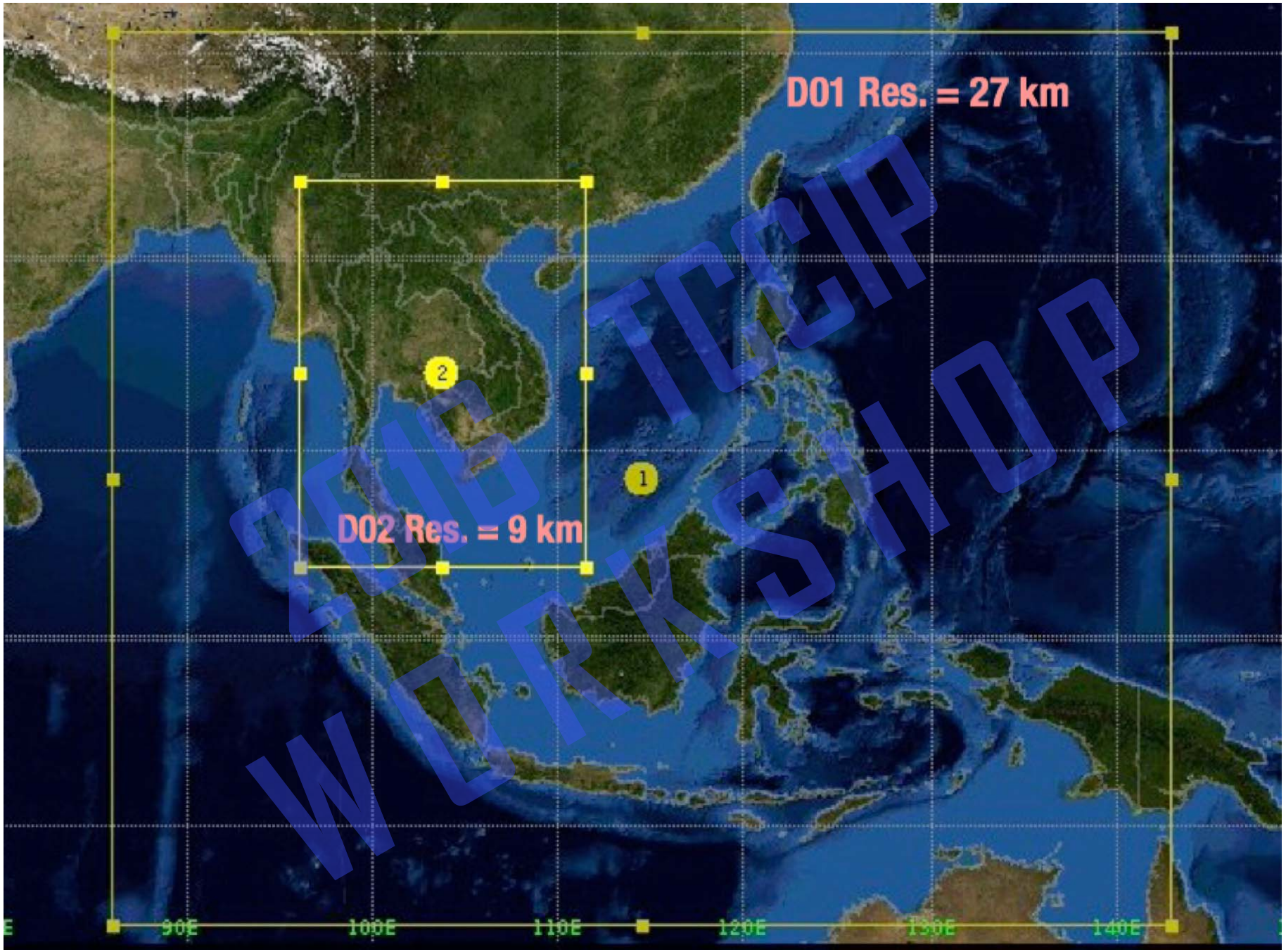
HadG

Future works

- Downscale CMIP4-GCM2 to 25 km × 25 km
  - SEACLID/CORDEX SEA output
- Further downscaling
  - Apply the statistical downscaling
  - 10 km × 10 km
  - Need high quality measurement data from the whole region

Dr. Chakrit's team in Thailand

- Dynamic downscaling


D01 Res. = 27 km
D02 Res. = 9 km
2
1
90E
100E
110E
120E
130E
140E

Future works

- Linking downscaled climate model data sets (10 km x 10 km) to assess impacts and evaluate adaptation options of major crop production systems in Thailand and beyond.

- HRD in climate change and variability for collective adaptation & mitigation.

On going works

1. Seasonal Rice Yield Forecast, 3-6 months in advance.
2. Precision Agriculture Research Network.

Network & Team's Mission *SEARY4cast*

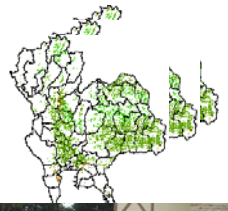
Rice production (kg) = Area planted & harvested (ha) x Averaged yield (kg/ha)

2. Rice & area planted & harvested (SMU)
- Small area from Drone
- Site-specific from Field survey/report

SMU

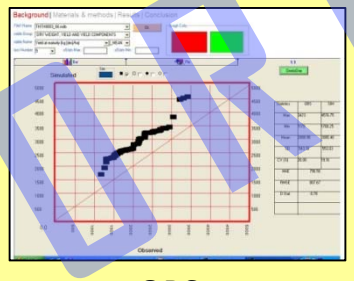
1. Seasonal Weather Forecast (SWF)
- 10x10 km
- Ensemble of GCMs & RCMs
- Stochastic by nature
- Report every month

Reporting & Consultation
- Reports as 3-6 months in advance of harvesting



5. Seasonal Rice Yield Forecast System: SRY4cast]

SIM



OBS

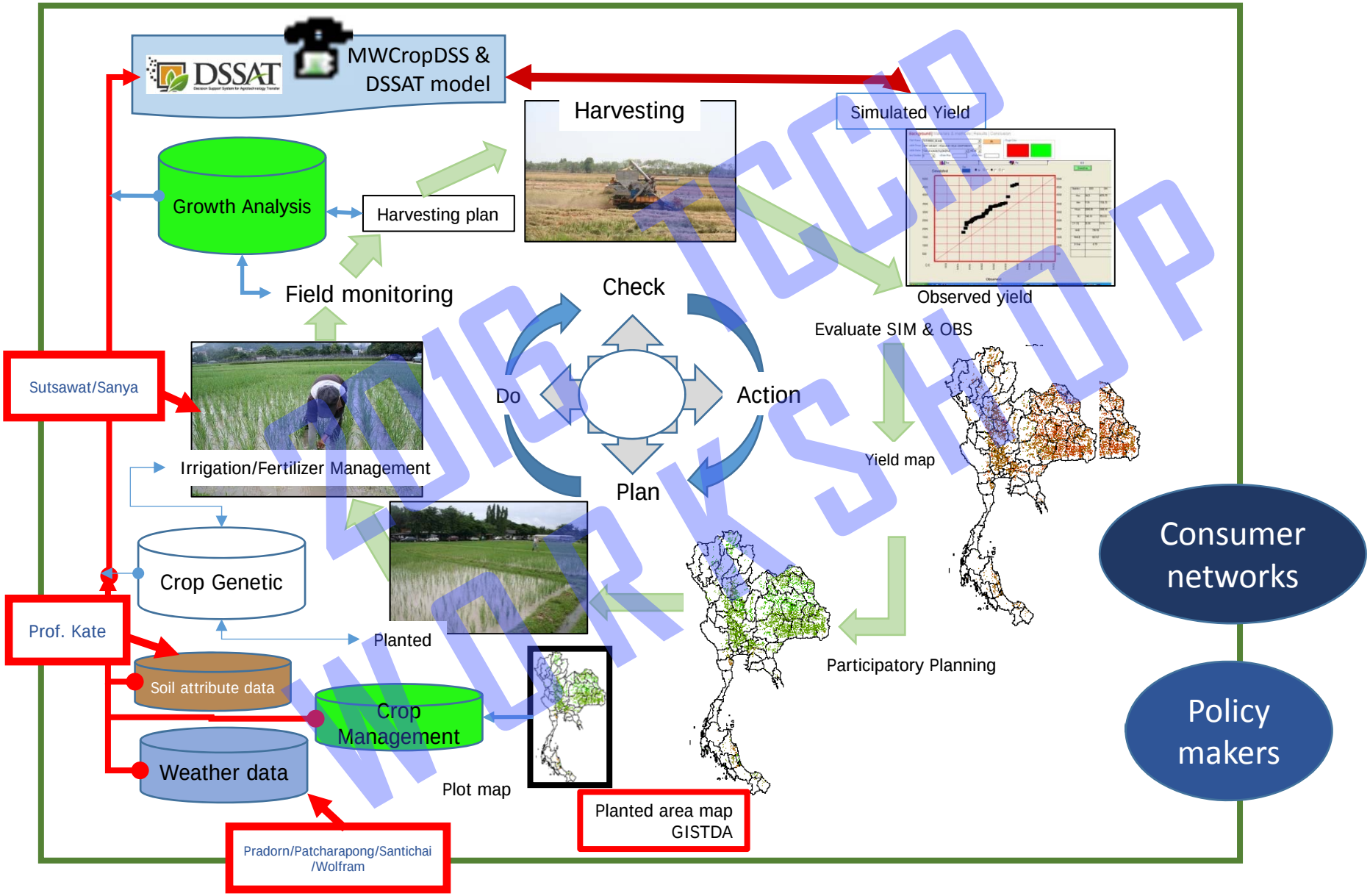
3. CSM-CERES-Rice model testing (SIM)
- Process-oriented & deterministic
- Laboratory works
- Calibration & Evaluation at field level
- Response to major inputs

4. Participatory Data Collection (Based on SMU)
- Site/HH participation
- Data on field operations, resource utilization and yield (OBS)
- Cost-Benefit Analysis

Jintrawet et al., 2014

DSS4cast work flow and data collection

Risk reduction @all steps/locations



Dimensions of PA-DSS (farm-policy = Production+Consumption)

Consumption=
- Good products
- Food security
- Fare prices

Cases
- Consumer networks
- Etc.

1. Brainstorming sessions with stakeholders

Rice, Longan, Sweet corn

i.e, on rice applied existing RTs with farmers to S2>S1 Riceland: 8 Mil. ha

Or to convert S3+N Riceland > other uses: 3 Mil. ha

Production =
- Precise inputs
- Precise decisions
- Reduce costs

Cases
- RRC
- Farmers markets
- University farms (CMU, MJU KKU)

Japan Farm Products, NHK

Loading up with a bunch of new toys without first establishing a well-defined need can be costly and counter-productive?

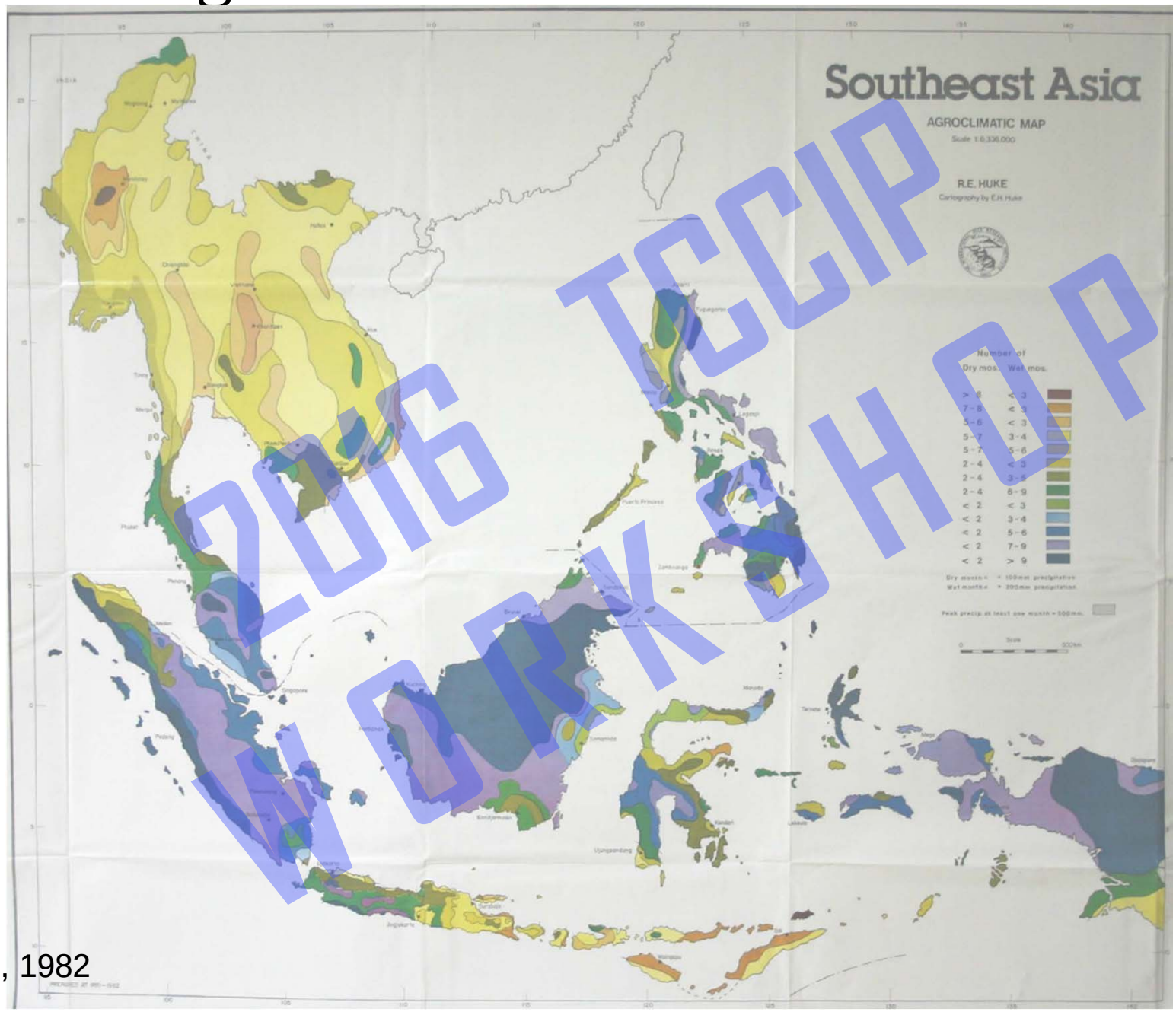
- Do you want to be more efficient with inputs?
- Do you want better on-farm record keeping?
- Do you have ideas for management changes that require additional knowledge about your farm?

4. Analysis/Synthesis/ Manipulation

October 2015 - March 2017

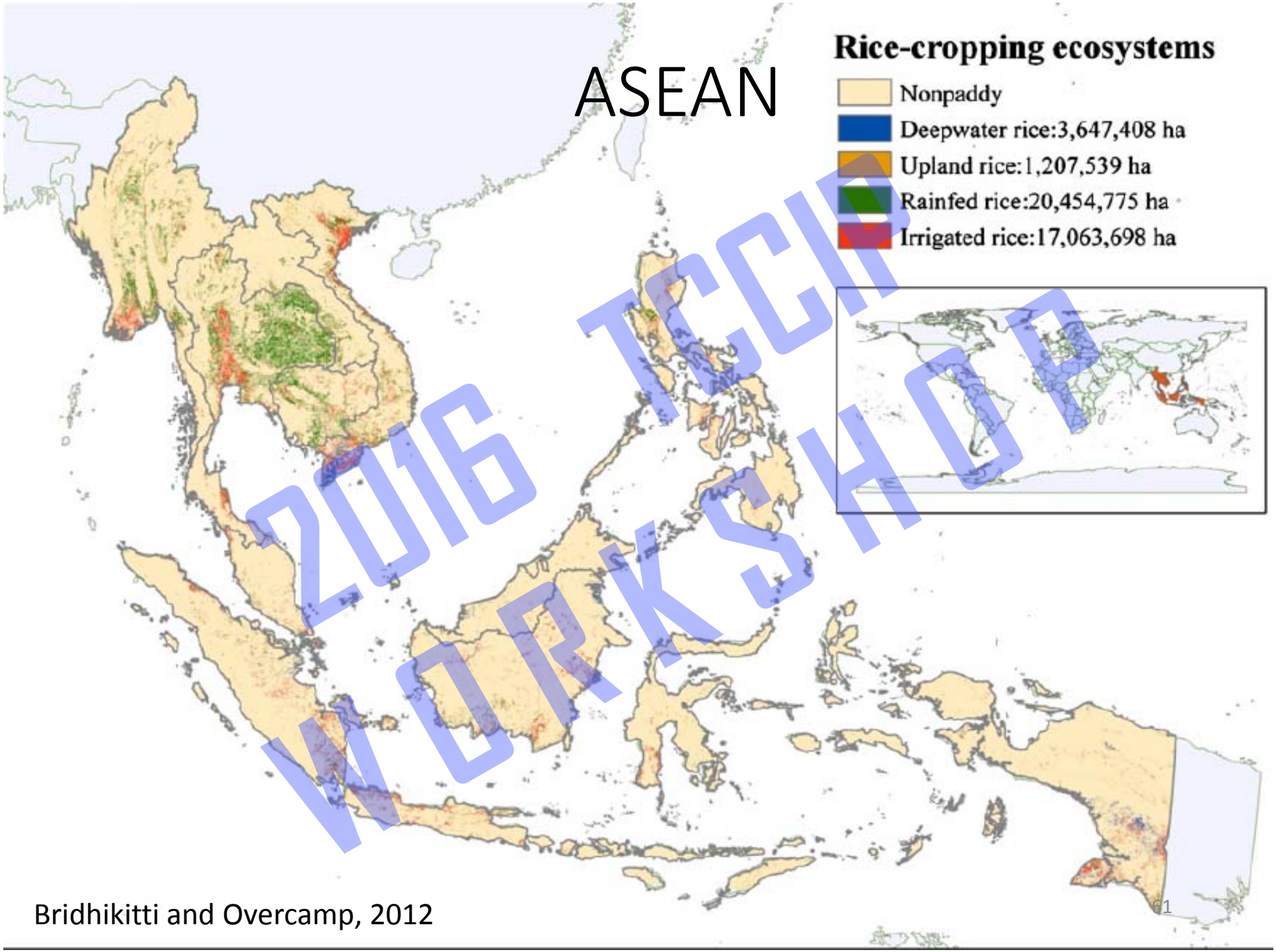
Modified from National Research Council, 1997; Srinivasan, 2006

SEA Agroclimatic Zone



Huke, 1982

ASEAN



Bridhikitti and Overcamp, 2012

Conclusion

- Climate projections, Models and DSS can be used as tools and frameworks for integrated natural and agricultural resource *assessment* & management.
- Need team work, networking & long-term commitment.
- A system is more than a sum of its parts.

Thank you TRF-DSS & TRF-PA teams

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