Climatic Changes and Evaluation of Their Effects on Agriculture in Asian Monsoon Regions

Green Network of Excellence Program (GRENE) Environmental Information - Achievement Report –

Content

Objective of the study

INTRODUCTION

More than 60% of the world's population live in Asian monsoon regions containing many agricultural countries. Therefore, it is important to properly predict climate change and to assess its impact on agriculture in Asian monsoon regions. We will build an information infrastructure that contributes to adaptation and mitigation measures in agriculture in the Southeast Asian countries.

■Objective

Climate change will affect seasonal changes, creating a pattern of rainfall and temperature different from conventional patterns. This effect is a serious problem for the countries in the Asian monsoon region where traditional agriculture is practiced.

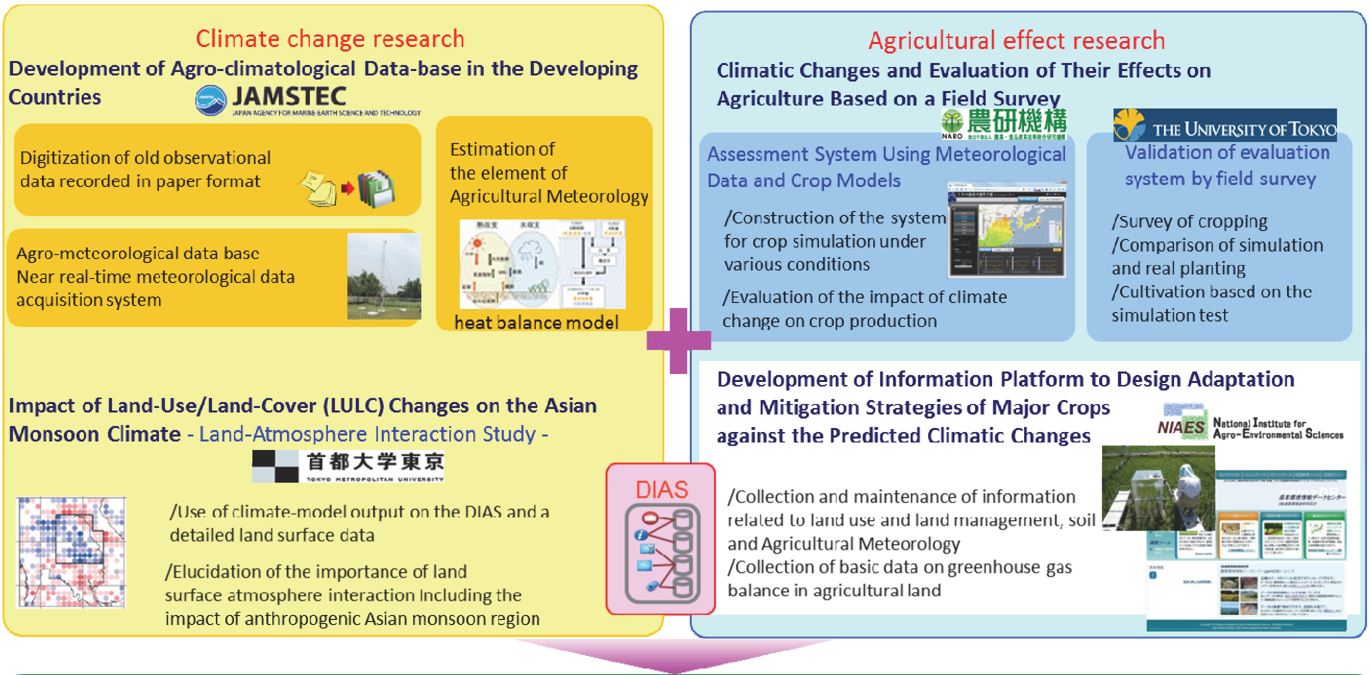
The goal of this research project is to build a basic information database that is useful to properly predict climate change and to assess the impact on the agriculture, then contributing to the policy making of adaptation and mitigation measures.

■Uniqueness of this research

In cooperation with the climate change and agricultural impact research groups, this research project was conducted effectively in several common fields in Southeast Asia.

■Four Southeast Asia countries plus Japan

We select four countries, Thailand, Vietnam, Philippines and Indonesia, which are susceptible to the Asian monsoon, and built a basic information database to contribute to the adaptation and mitigation measures with local researchers.



1. Development of basic environmental information and its application to decision-making in the Asian monsoon region
2. Training of young researchers to lead the study of global warming mitigation measures and adaptation research and climate change
3. Construction of information infrastructure for the realization of global warming adaptation and mitigation measures for agricultural sectors

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■Cooperation with DIAS

This research project has been promoted under the cooperation of DIAS (Data Integration Analysis System) which was started in 2006 as a project in the national key technology in the third Science and Technology Basic Plan.

DIAS
Data Integration & Analysis System

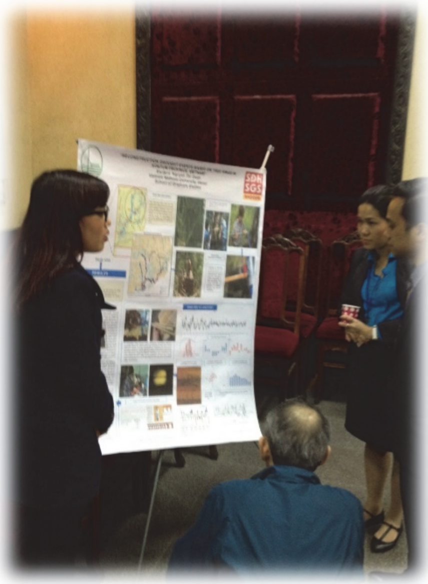
■International workshops

We held workshops to discuss the research results at the end of every fiscal year for the effective research promotion and human resource development of the young.

March 3-5, 2012 in Bangkok, Thailand
March 4-6, 2013 in Baguio, Philippines
March 17-19, 2014 in Bali, Indonesia
March 10-12, 2015 in Hanoi, Vietnam
March 6-8, 2016 in Fukushima, Japan

■Capacity building

Along with Southeast Asian students, we promoted local Meteorological Organization, the joint research with Agriculture Organization. As a result, we developed human resources with deep knowledge on climate change and agricultural impact. The research results worked to establish a human network that can be shared regionally.



Poster Session in Vietnam

The Fourth International Workshop of Climatic Changes and Their Effects on Agriculture in Asian Monsoon Region

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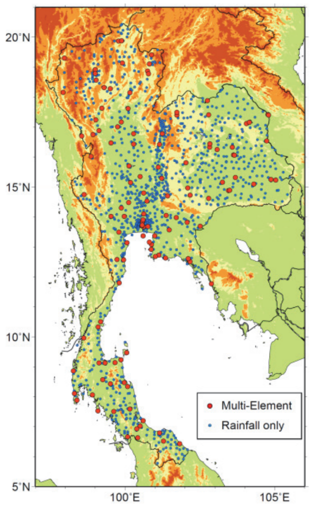
Climatic change information for agriculture in Thailand

Development of meteorological database and analysis of climatic changes

- Meteorological database in Thailand (daily, 1979-2013) was developed.
- A high-resolution gridded daily rainfall dataset was created and released.
- Correlation between pre-monsoon rain in northeast Thailand and ENSO has become stronger.

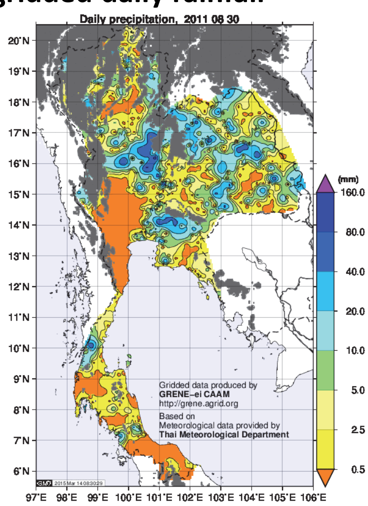
■Development of meteorological databases

Meteorological databases in Thailand were developed from surface daily meteorological observation data obtained from the Thai Meteorological Department. Multi-element observations at 123 stations, and additional rainfall data at 1081 stations are available for the period 1979-2013. The elements contained in the database are rainfall, temperature, sunshine duration, sea level pressure, relative humidity, surface wind speed etc.



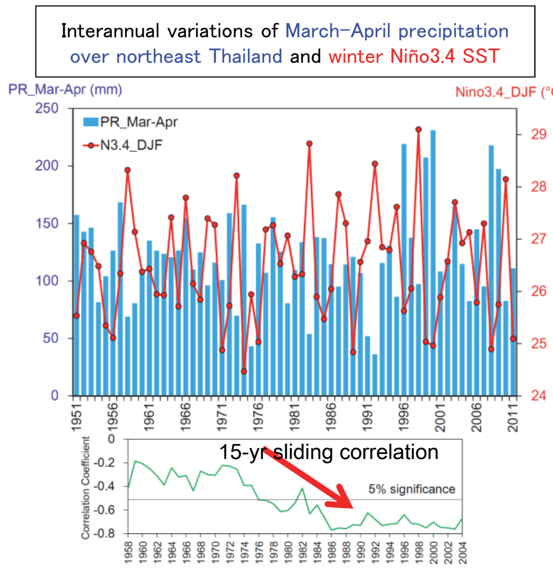
■High-resolution gridded daily rainfall

From the above-mentioned meteorological database, a high-resolution (0.05°×0.05°) gridded daily rainfall dataset in the lowland areas in Thailand was created, and released on the DIAS website.



■Rainfall-ENSO relationship in NE Thailand

Pre-monsoon rainfall is important for dry-to-wet season crops over northeast Thailand. Our analysis shows that correlation between rainfall amount in March-April and El Niño Southern Oscillation (ENSO) in the preceding boreal winter has become stronger since the 1980s. This implies that ENSO information has become more important for the local climate and agriculture.



■Website of gridded daily rainfall

GRENE-ei CAAM 0.05° ×0.05° Grid Daily Precipitation in Thailand

http://dias-dmg.tkl.iis.u-tokyo.ac.jp/dmm/doc/GRENE_ei_CAAM_Thai_Grid_DailyRain-DIAS-en.html

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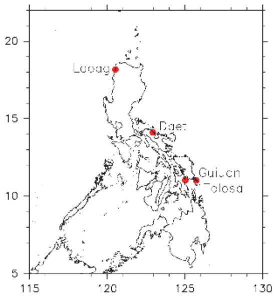
Long-term Asian monsoon variability and rice yield in Japan

Meteorological observations in the Philippines and the relationship between Asian summer monsoon activity and rice yield in Japan

- Surface meteorological observations were conducted in the Philippines and real time data were displayed.
- Collecting historical surface meteorological data from the 19th century in the Philippines.
- Asian summer monsoon index (PJ pattern) correlates Philippines rainfall and Japan rice yield.

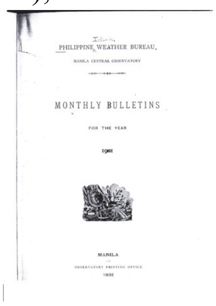
■Surface observation in Philippines

We have installed four automatic weather systems (AWS) in the Philippines. Meteorological observation data obtained are temperature, humidity, pressure, wind, rainfall and radiation. All the data are automatically sent to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and real time data aredisplayed on the PAGASA website.



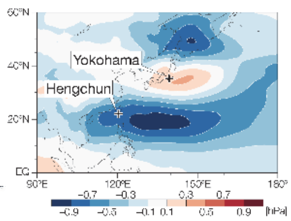
■Collecting historical meteorological data

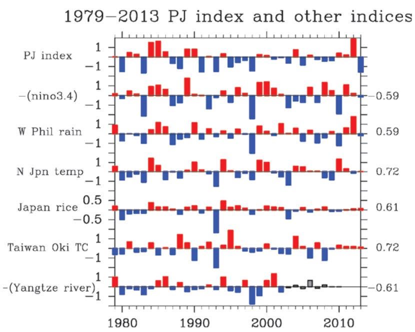
Meteorological observation in the Philippines started in 1865. We have collected historical station-based meteorological data around the world which was lost in the Philippines observed by Spanish (1866-1900), American (1901-1940), Japanese (1940-1944) and Philippine (1949-2013) meteorologists. We have created a long-term rainfall dataset.



■Asian monsoon and Japan rice yield

Pacific-Japan (PJ) teleconnection pattern is a dominant pattern of interannual variability in the East and Southeast Asian summer monsoon. PJ pattern is an anomalous dipole of low troposphere circulation centered in the Philippine Sea and around Japan. We choose Yokohama and Hengchun for each pole, and defined new PJ pattern index (left Fig.). PJ pattern index correlated widely to climate variables (ENSO, Philippine rain, Japan temperature, typhoon in Taiwan and Yangtze river flow) including Japan rice yield (right Fig.; numerals are correlation coefficient). When PJ pattern index is negative (blue bars), it tends to be preceded by El Niño. Weak summer monsoon in the Philippines, and cold summer in Japan, which leads to low rice yield are accompanied. These relationships show multi-decadal variations during the past 117 years.





■References

Kubota, H., Y. Kosaka, and S.-P. Xie, 2015: A 117-year long index of the Pacific-Japan pattern with application to interdecadal variability, *Int. J. Climatol*, in press.

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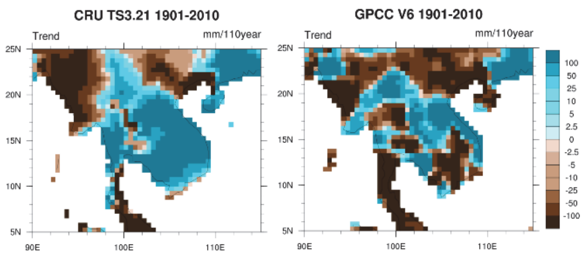
Long-term climate variations in the Asian rice cultivation regions

Data rescue of rainfall and rainfall variability in the Mekong River Basin during the 20th century

- We collected historical meteorological data reports in French Indochina.
- Rainfall data in the Mekong River basin were digitized from these data reports.
- Rainfall variability in the Mekong River basin during the twentieth century were analyzed.

■Rainfall trends in the Indochina Peninsula

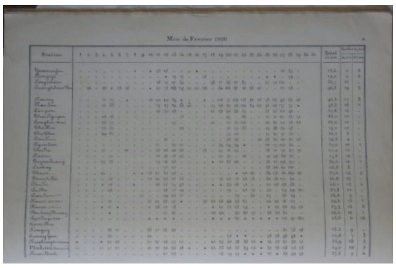
Annual rainfall trends over the Indochina Peninsula during the 20th century were analyzed using with CRU and GPCC datasets. Spatial distribution of trends are shown below.



It is obvious that annual precipitation trends in the lower Mekong River basin were different between CRU and GPCC data sets.

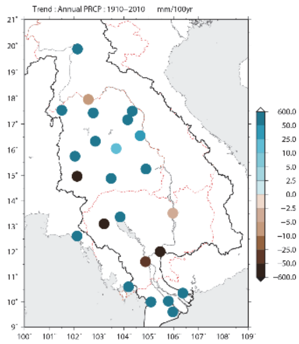
■Collection of historical rainfall data

Examination of long-term rainfall variations using historical meteorological data is very crucial because rice cultivation is a major economic sector in this region. We prepared images of historical meteorological data reports published by the meteorological services in this region.

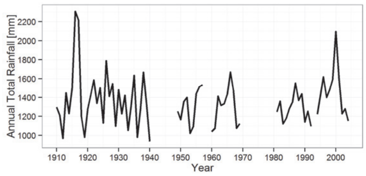


■Trends and variability of rainfall

We digitized rainfall information using the historical meteorological data reports from 1910 to the mid-1970s.

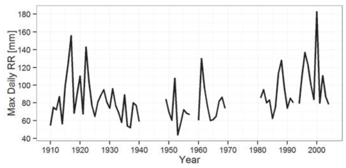


Trends in annual rainfall in the Mekong River basin are shown to the right. Increasing trends were observed in the northeastern Thailand. On the contrary, decreasing trends were found in Cambodia. Time series of annual rainfall at Phnom Penh is shown in below figure. Long-term decreasing trends at Phnom Penh shown above



are due to the existence of heavy rainfall in 1916 and 1917. It is clearly observed that the dominant time scale of inter-annual variation was smaller in the early 20th century than that of recent decades.

Although heavy rainfall events were frequently observed in the period 1915-1925, heavy rainfall frequency tended to increase in the later half of the 20th century.



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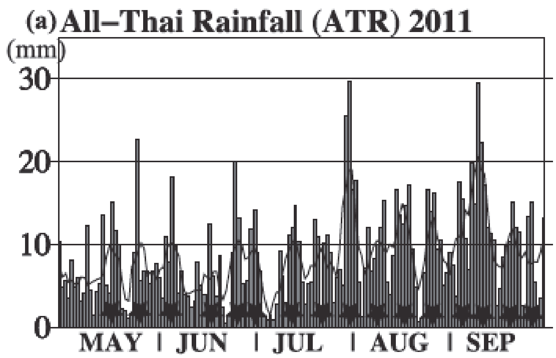
Severe meteorological disasters over Southeast Asia

The 2011 Thai flood caused by vigorous activity of tropical cyclones and interannual variability

- In 2011, a severe flood occurred in Thailand.
- The severe flood was caused by vigorous activity of tropical cyclones(TCs) across Indochina.
- In the last 30 years, TC activity has controled the interannual variation of precipitation of Indochina.

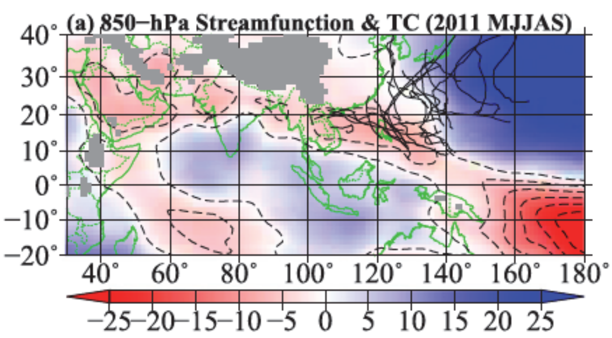
■Time-series of precipitation over Thailand

The time-series of precipitation averaged over Thailand showed repeatable precipitation events were observed. The time-scale of precipitation events were approximately 10 days. This indicates the TCs, which is the main cause of precipitation, has repeatedly brought precipitation to Thailand.



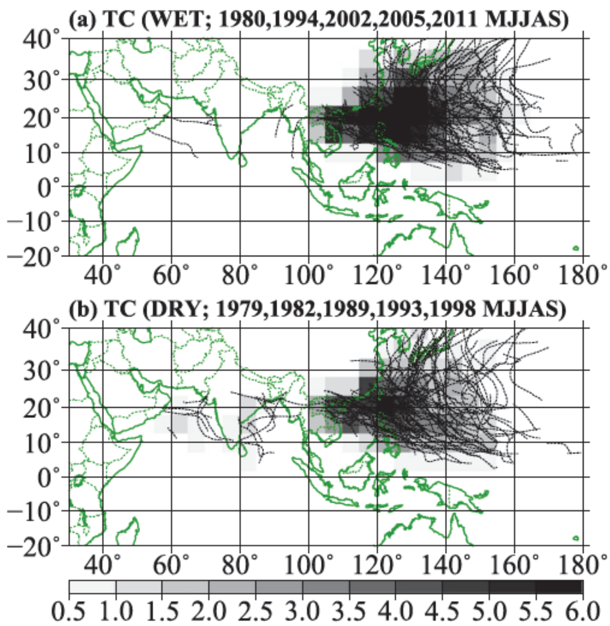
■Atmospheric circulation in the 2011 summer monsoon season

Several TCs were observed around Indochina, which showed TC activity were more active in 2011 than climatological conditions.



■TC activity and summer monsoon rainfall

In above-normal precipitation years, the number of TCs (including weaker tropical cyclones) was more than neutral and below-normal precipitation years. This tendency was common in the last 30 years. In addition, the simultaneous impact of ENSO on the summer monsoon in Indochina was unclear over the last 30 years.



■References

Takahashi H.G., H. Fujinami, T. Yasunari, J. Matsumoto, and S. Baimoung, 2015: Role of tropical cyclones along the monsoon trough in the 2011 Thai flood and interannual variability, Journal of Climate. 28, 1465–1476.

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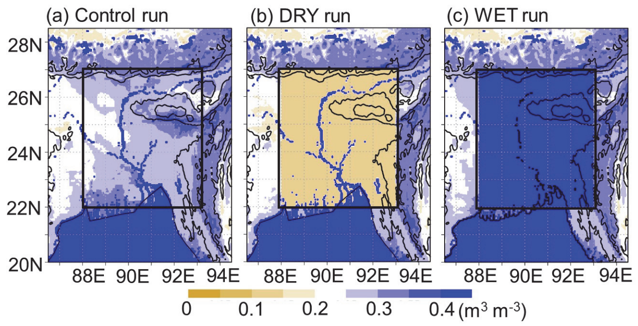
Numerical evaluation of precipitation sensitivity to land-surface wetness

Soil moisture impact on precipitation in South Asian regions

- Numerical experiments were conducted to evaluate land-atmosphere coupling in South Asia.
- The numerical model successfully simulated seasonal variation in precipitation.
- Land-surface wetness has a possibility to control precipitation intensity and frequency.

■ Numerical experiment in South Asia

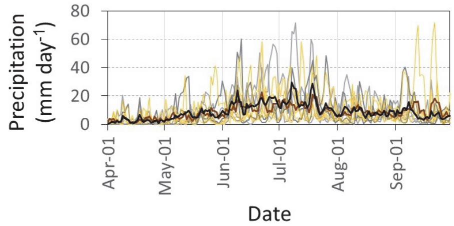
We calculated precipitation characteristics in South Asian countries for 5 years: from 2003 to 2007 using a regional climate model (Control run). Ideal experiments with dry/wet land-surface were also conducted. A comparison between control and ideal experiments can evaluate the impact of land-surface wetness on precipitation.



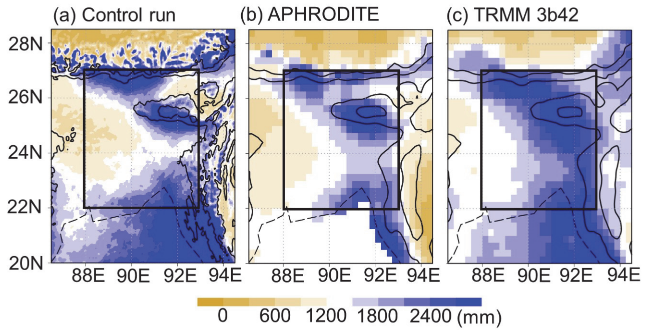
Soil moisture calculated in the numerical experiments
Open rectangle : area modified land-surface wetness

■ Simulated precipitation in control run

The control runs simulated seasonal variation in precipitation. Furthermore, spatial distribution of precipitation were quite similar to that in observations.



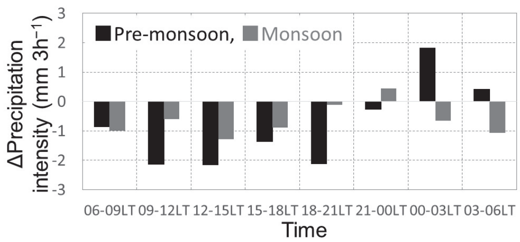
Seasonal variation in area-averaged precipitaiton
Black & gray : Control runs, Brown & yellow: Observation



Spatial distribution of precipitation integrated between Apr. and Sep.
Open rectangle : area modified land-surface wetness

■ Precipitation sensitivity to soil moisture

In South Asian regions, wet land-surface may enhance daytime precipitation intensity relative to the dry land-surface. Precipitation frequency may decrease/increase in pre-monsoon/mature monsoon seasons. This result suggests that consecutive land-surface modification (e.g., flood and land-use change) is likely to change precipitation characteristics in South Asian countries.



Difference of area-averaged precipitation intensity between wet and dry experiments

■ References

Sugimoto, S. and H. G. Takahashi (2015): submitted to Journal of Climate.

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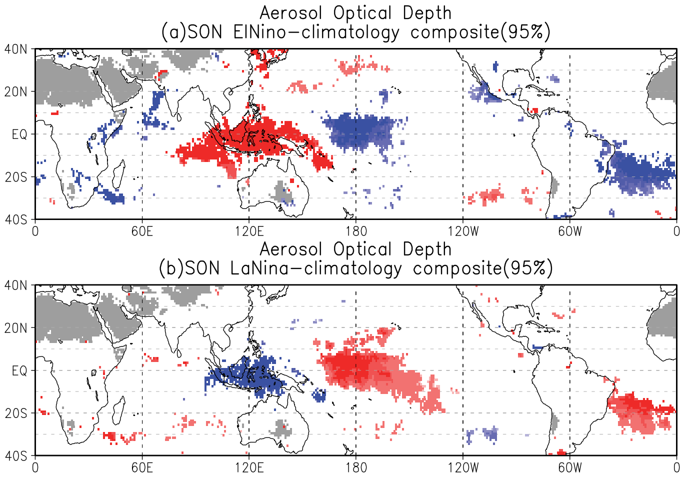
Asymmetrical interannual variation in aerosol optical depth: Aerosol-cloud-precipitation-surface feedback

- Interannual variations in aerosol optical depth (AOD) were statistically investigated.
- Aerosol increased (decreased) during El Niño (La Niña) over the Maritime Continent.
- Interannual variations in AOD was more dominant during dry phase than wet one.

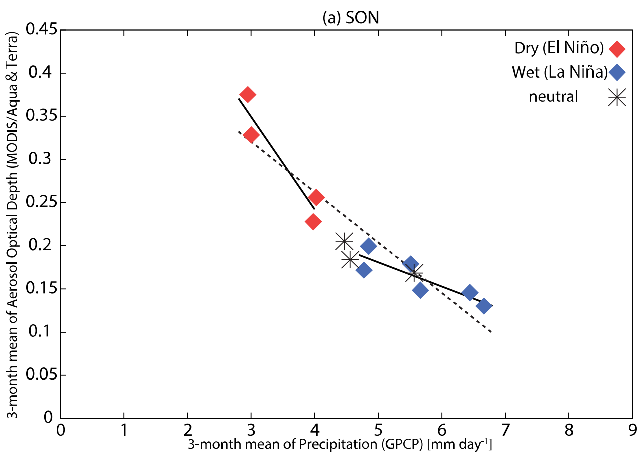
■Interannual variations in aerosol optical depth over the tropics

We statistically investigated an interannual co-variation among aerosol optical depth (AOD), cloud effective radius (CER), and precipitation, focusing on aerosol-cloud interaction over the tropics. A three-month composite analysis based on El Niño-Southern Oscillation (ENSO) phases during September–October–November (SON) and December–January–February shows that an increase (decrease) in AOD in the El Niño (La Niña) years was associated with a decrease (increase) in precipitation, particularly in SON over the Maritime Continent.



■The Role of aerosol-cloud-precipitation-surface condition feedback on asymmetrical interannual variations

Interannual variation in AOD and CER in SON in the Maritime Continent was asymmetrical, which can be explained by stronger aerosol-cloud interactions under drier conditions. Specifically, large amounts of aerosols suppressed cloud and precipitation formation, which leads to decreases in wet deposition and increases in emission under warmer and drier surface conditions. This feedback results in asymmetrical variation.



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Yamaji M. and H.G. Takahashi, 2014: Asymmetrical interannual variation in aerosol optical depth over the tropics in terms of aerosol-cloud interaction, SOLA (Scientific Online Letters on the Atmosphere), 10, 185-189, doi:10.2151/sola.2014-039.

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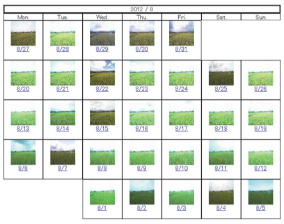
Real time monitoring of agricultural field

Auto-collection of information on crop growth and its environment from fields overseas

- Image, weather, soil data come automatically from agricultural field in Asian monsoon regions.
- Collected data can be shared among stakeholders in Asian monsoon regions.
- The status of monitoring equipment set in oversea agricultural fields is checked from Japan.

■Auto-collection of data from oversea field

We have developed a ground monitoring device that runs by only solar power. Once we install the device, we can collect the data at the same time from several data loggers that are installed around the device. By installing this unit in the field, various types of sensor data including images are now automatically collected from the field all over the world without commercial power supply. Users can easily check the data on weather and crop growth, etc. while looking at the image to be displayed in a calendar format.



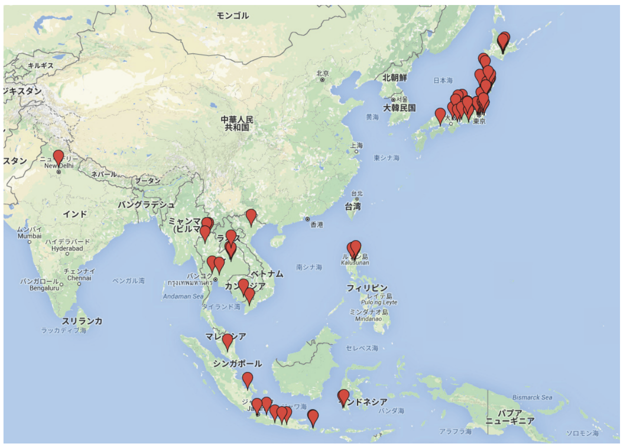
■Easy check of monitoring sensors

The consumption situation of the battery or the abnormality of the sensors, such as the fixed point camera, weather, soil and flooding water depth sensor, can be effectively managed in a plurality of the ground monitoring site. As a result, the maintenance of the equipment of the site now has become dramatically easier.

	Toyama	Ishikawa	Fukui	Nishi-Tokyo
2011/03/31	M S	I M S	I S	I M S
2011/03/30	I M S	I M S	I M S	I M S
2011/03/29	I M S	I M S	I M S	I M S
2011/03/28	I S	I M S		
2011/03/27	I S	I M S	I M S	M S

■For the field research around the world

Developed technology is used in not only this research project but also with a number of researchers in the fields all over the world. As a result, a large amount of data continues to be updated every day. Maintenance management and the specific use of these data will become a future challenge in DIAS project.



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M.Mizoguchi&T.Ito (2015) Field monitoring technology to change the agriculture and rural areas, Water, Land and Environ. Eng., 83 (2), 3-6

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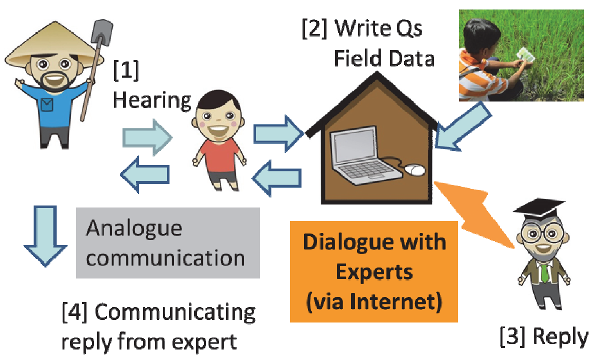
Real time monitoring of agricultural field

Field monitoring by youths

- Youths supported field data collections as a part of YMC model demonstrations.
- Youths between 9 and 14 of age were sufficiently able to collect field data.
- The data collection by youths was fully useful to help remote experts to provide local farmers decision supports and expected to be promising in developing countries.

■YMC model and youth sensors

YMC (Youth Mediation Communication) is a model to transfer knowledge to illiterate local farmers through their children being educated, utilizing mobile phones, the Internet etc. As a part of the demonstration of YMC, field data collection by youths were conducted to help remote experts to give the local farmers decision supports in Vinh Long District, Vietnam.



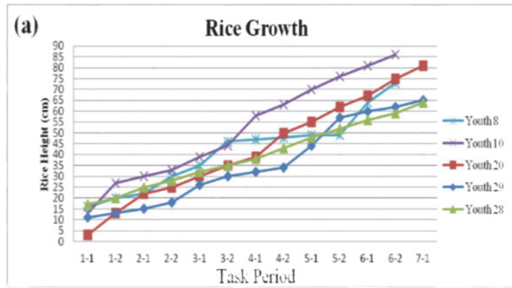
■Data measurements by youths

Youths measured daily temperature, humidity and weather and visited their parents' fields twice a week to measure crop height, leaf color and check anomaly such as diseases and insects. They utilized mobile phones for data transfer and photographing.

Mobile phone, leaf color chart, insect plate, temp-humidity meter, measurement

■Efficiency of data collections by youths

The data collection trials were conducted for 4 paddy rice crops from 2011 to 2014 in 3 villages of Vinh Long District, Vietnam. In total, 85 children (age 9 -14) of 84 households selected based on the nominations by the Vietnamese Local Governments participated in the field data collection trials. The data collected such as temperature, crop height and leaf color were acceptably accurate and useful enough to support the decision by the remote experts. The images of diseases, insects etc. taken by mobile phones were particularly useful. The approach of the data collection will be promising in field data collection in developing countries.



■References

S. Ninomiya, et al (2012) Children as Field Sensors to Support Site-specific Decisions in Rural Asia under Climatic Change, Proc. MARCO Symposium 2012, 61-63.

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Crop yield prediction for the Asian monsoon regions

Prediction system for the influence of the climate change on agriculture

- Prediction system was developed to simulate crop yield cultivated in the Asian monsoon region.
- The effects of climate change on agriculture can be estimated by using the meteorological data that reflects the influence of climate change.

■Prediction system

The crop yield prediction system has four main components: (1) A meteorological data acquisition function and a weather data generator that reflects the effects of climate change; (2) a crop model (Decision Support System for Agrotechnology Transfer : DSSAT) and a crop model execution engine that executes them; (3) save and display functions for the resulting data (crop yield, growth period, etc.) and a comparison function to validate the system; (4) a Web application to show the result data designed based on the assumption that it would be used by a farmer in the field with a 7-inch tablet.

■Double cropping rice and cassava

The system was applied to optimize double cropping of rice and cassava as a concrete application for the GRENE-ei project. We created this system to identify and recommend crops that can be grown during a dry season, and to simulate the effects of climate change in Thailand's farming areas by inputting meteorological data that reflect the influence of climate change (Fig. 2).

■References

Tanaka, K., T. Kiura (2015) A Web Application to Estimate the Climate Change Effects on Agriculture in Thailand, Journal of Agricultural Informatics, 6(4)22-29.

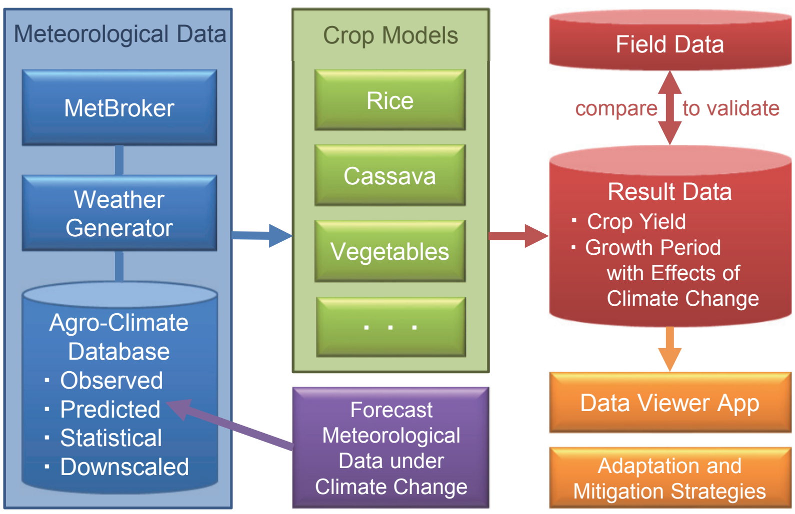

Fig. 1 Structure of the Crop Yield Prediction System

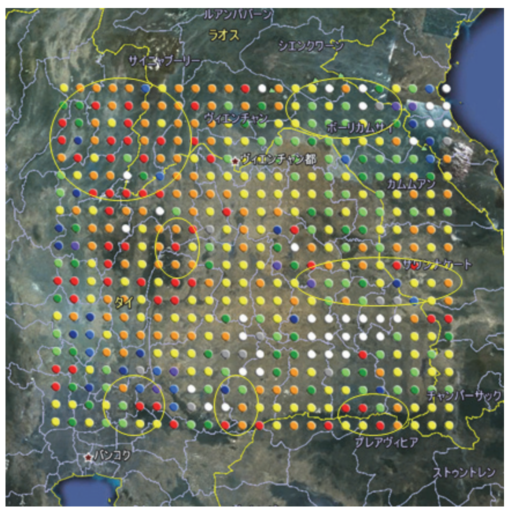

Fig. 2 Results of the prediction system for double cropping optimization

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Crop yield prediction for the Asian monsoon regions

Data display application for predictions of crop models

- WebAPI wrapping existing weather data generators and sample UI.
- Web application displays mesh data, predicted by crop models, with other maps.
- Source codes are available as Open Source codes.

■Weather Generator Service

To use results from weather model simulation models under scenarios for the future, weather generators are used to obtain a reasonable daily/hourly weather data required by crop models. There are now many weather generators available. To hide differences among weather generators a WebAPI is defined. Three weather generator services are implemented as reference codes and a simple Web User Interface is developed. Each generated data has an UUID, and applications can access the same data by specifying the UUID.

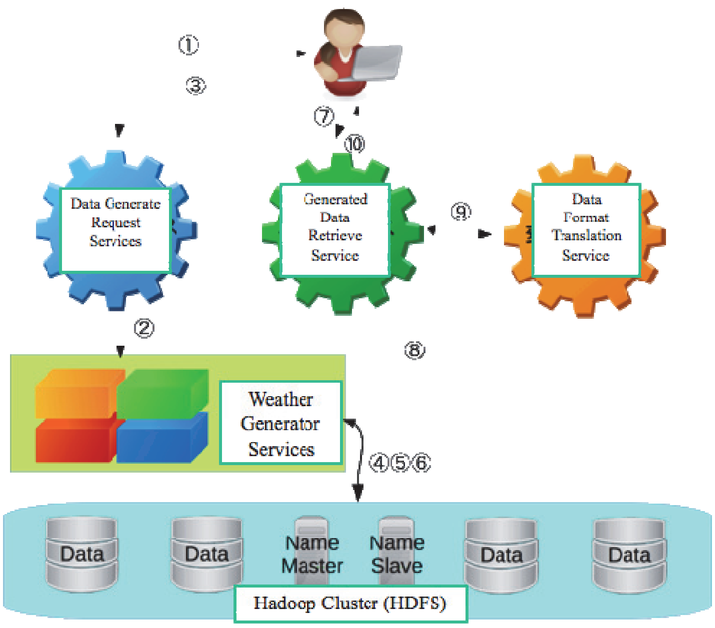

Fig. 1 Image Generator Service Application

■Display application for model results

Existing applications developed by another project were internationalized.

It contains data loaders to read model results and put into the PostGIS database. A Web Application is access the open geo-referenced maps and overlay model results accessing database. If grid point are selected, related graphs are displayed to understand the results.

In this implementation the OpenWeatherMap is used as background map.

■URLs

Weather Generator Service:
https://github.com/TKiura/WedGenS/
Results display application
https://github.com/TKiura/cost/ (soon)
GRENE-ie CAAM Demonstrations
http://agrid.diasjp.net/

Fig. 2 Web Application to display results of crop model predictions

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Development of basic information for agriculture

Estimation of daily mean soil temperature and moisture of agricultural field

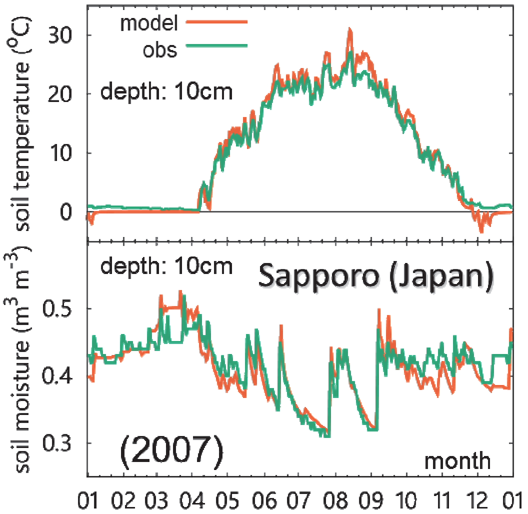
- We developed the process based mode for estimating soil temperature and moisture of agricultural field.
- Daily mean soil temperature and moisture at any depths are evaluated from meteorological data.
- The estimated data by this model can be used as the basic information for agriculture.

■Model description

We have developed the process based model (revised from that developed by Kondo and Xu (1997)), which evaluate daily mean soil temperature and moisture by solving both the heat and water balances between air and soil surface, and their transfer into the soil. The input data to the model are daily mean meteorological data (temperature, humidity, and etc.) and the physical properties of soil.

■Validation of the model

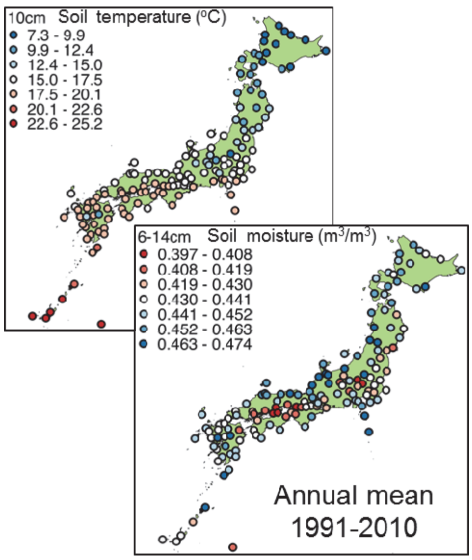
We validated the model by using observation data at several sites. The model simulated the seasonal change in daily mean soil temperature and moisture (depth of 10 cm) observed at experimental field of NARO Hokkaido Agricultural Research Center (Sapporo, Japan, Sameshima *et al*., 2009), with the accuracies of about 1.5 °C and 0.03 m^3/m^3, respectively.



■Example of estimation results

We estimated daily mean soil temperature and moisture of agricultural field at the 152 sites in Japan. Figure shows the annual mean values averaged for 1991 to 2010. For this estimation, the daily meteorological data at the surface meteorological observatories of the Japan Meteorological Agency were used, and the physical properties of soil were determined on the basis of 'Soil Information Web Viewer' (http://agrimesh.dc.affrc.go.jp/soil_db/).

The estimated data by this model can be used as the basic information for agriculture in Asian monsoon region.



■References

Kondo, J., and Xu, J., 1997, *J. Appl. Meteor*., 36, 1676-1695.

Sameshima *et al*., 2009, *Misc. Publ. Natl. Agric. Res. Cent. Hokkaido Reg*., 67, 1-8.

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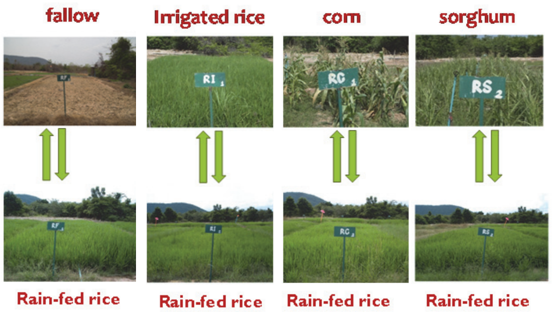
Continuous measurement of GHG emissions and soil organic carbon stocks from managed rice cultivation in Thailand

- Measurement of methane (CH_4) and nitrous oxide (N_2O) emissions can be continuously monitor throughout the rice growing season using "AGSS" where differentiation of rice seasons effect on GHG emissions can be found.
- Soil organic carbon (SOC) stocks can be continuously monitor in all treatments and found the trends of SOC stock changes.

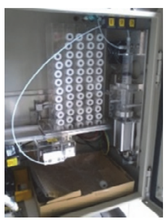
FIELD EXPERIMENT

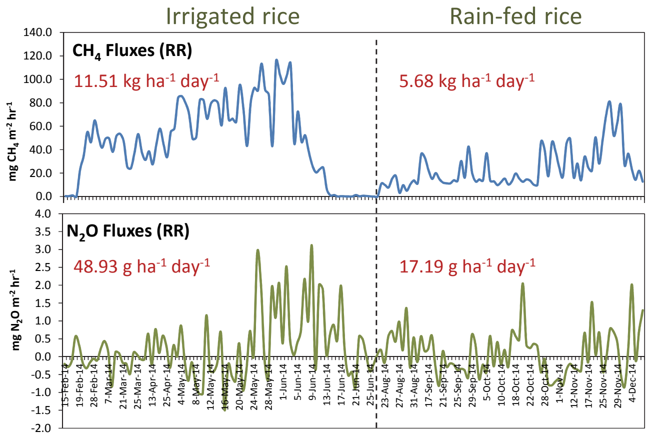
The field experiment was established at King Mongkut's University of Technology Thonburi, Ratchaburi Campus, Ratchaburi Province, Thailand (13°35′ N, 99°30′ E). We designed the rice for main crop in the rainy season (Aug-Dec) and rotation with irrigated rice and energy crops in the dry season (Feb-Jun). Corn and sweet sorghum were selected for rotation in rice field. The rotation systems were designed in four treatments, including: 1) fallow land+ rice (RF), 2) rice+rice (RR), corn+rice (RC), and sweet sorghum+rice (RS).



CONTINUOUS GHG EMISSION MONITORING

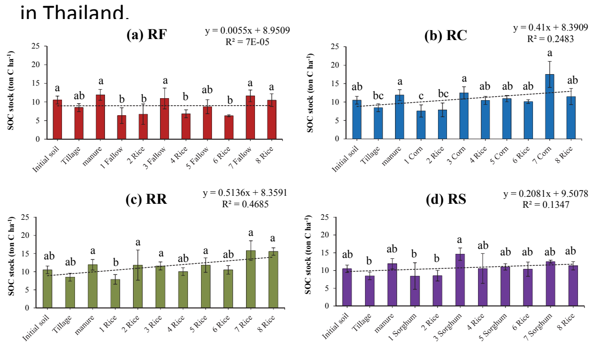
The chamber of automated gas sampling system (AGSS) permanently installed during the rice growing season for two crops. The sampling schedules were controlled by specific software. The gas samples were analyzed by gas chromatography (GC) (Shimadzu GC-2014, Japan) with a flame ionization detector (FID) for CH_4 and Electron capture detector (ECD) for N_2O. Continuous of CH_4 and N_2O fluxes measurement in irrigated and rain-fed rice were clearly observed.





SOIL ORGANIC CARBON STOCK CHANGE

Soil samples were collected from the experimental site at soil depths of 0-15 cm after crop activities and each crop harvest (2009-2013). The soil samples were analyzed for organic matter (OM) by wet digestion method (Walkley and Black, 1934). The soil organic carbon stock was estimated by the equivalent soil mass method (ESM) (Lee *et al.*, 2009). Continuous measurement found increasing trends of SOC stocks in different managed rice cultivation in Thailand.



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Lee, J. *et al*., 2009. Agri Ecosyst & Environ, 134, 251-256.

Walkley, A. & Black, I.A., 1934. Soil Science, 37, 29-38.

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Future prediction of CH_4 emission from irrigated rice paddies in central Thailand

Paddy water management helps to delay global warming

- A mathematical model to simulate the emission of CH_4, a potent greenhouse gas, from rice paddies has been calibrated and validated for irrigated areas in central Thailand.
- The CH_4 emission enhanced by future global warming can be negated by an appropriate water management practice.

■ Future climate enhances the CH_4 emission

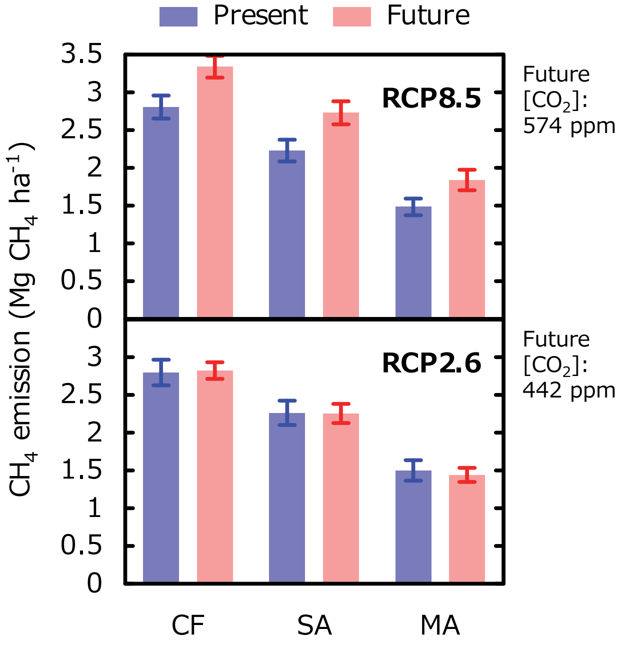
The rise in air temperature and in atmospheric CO_2 concentration can enhance CH_4 emission from rice paddies[1]. Water management is being available in Thailand, thanks to the spread of irrigation systems. It supplies O_2 into the soil during drainage, so that CH_4 production by anaerobic microbes is inhibited. We analyzed the effect of water management on the enhanced CH_4 emission from future irrigated rice paddies in central Thailand using a mathematical model, DNDC-Rice[2].

■ Method of model simulation

First, we calibrated and validated the model using observed CH_4 emission data at 7 sites there. Then, we estimated the CH_4 emission from each site with double cropping under 3 water management practices (CF, continuous flooding; SA, single aeration; MA, multiple aeration) from 2001 to 2060. Future climate change scenarios consisting of 4 emission scenarios (RCPs) and 7 global climate models (GCMs) were generated by a statistical downscaling method[3].

■ Example of simulation results

Here we show the results at Chainat site based on the selected scenarios (RCP: 2.6 and 8.5, GCM: GFDL-ESM2M). The CH_4 emission in the future (2051-2060) was higher than that in the present (2001-2010, [CO_2]: 380 ppm) by -4 to 24%. The future CH_4 emission under SA and MA was 18-21% and 45-49% lower than that under CF, respectively. The effect of water management on the reduction of CH_4 emission was still high in the future climate, the model predicted.



(Error bar for 95% confidence interval)

■References

(1) Tokida et al. 2010. Biogeosciences, 7, 2639–2653.
(2) Fumoto et al. 2008. Glob. Change Biol., 14, 382–402.
(3) Iizumi et al. 2010. J Agric. Meteorol., 66, 131–143.

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Optimizing SRI Water Management for Greenhouse Gas Mitigation Strategy Based on Monitored Data

- Different water status in the SRI paddy fields has affected the dynamic changes of environmental biophysics parameters in the soil that caused released greenhouse gas emission at different levels
- Some environmental biophysics parameters are well monitored by field monitoring system
- Dry regime is the best strategy to mitigate greenhouse gas emissions, particularly for methane emission

■Objective

- Find optimal water regime to mitigate greenhouse gas emission from SRI paddy fields

■Field Experiments:

Time and Location: Bogor, 26 March to 23 June 2015

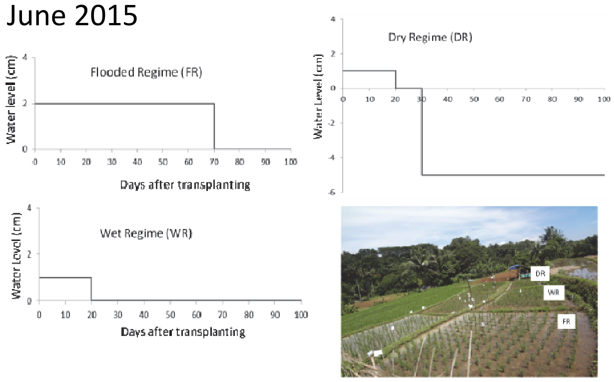

Figure 1. Water management regimes in each plot

■Field Monitoring System:

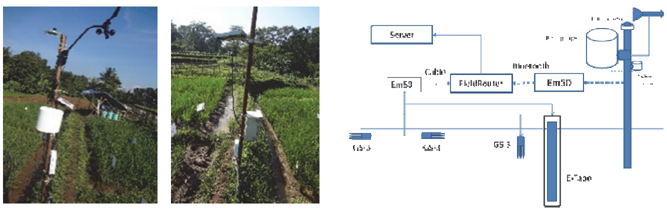

Figure 2. Field measurement networks

■Greenhouse Gas Emission Measurements :

Figure 3. Greenhouse gasses measurements

$$E=\frac{\delta C}{\delta t}\times\frac{Vch}{Ach}\times\frac{mW}{mV}\times\frac{273.2}{273.2+T}$$

Total fluxes:

$$\int_a^b f(x)dx \approx \frac{b-a}{6}\left[f(a)+4f\left(\frac{a+b}{2}\right)+f(b)\right]$$

■ Results: Methane Emission

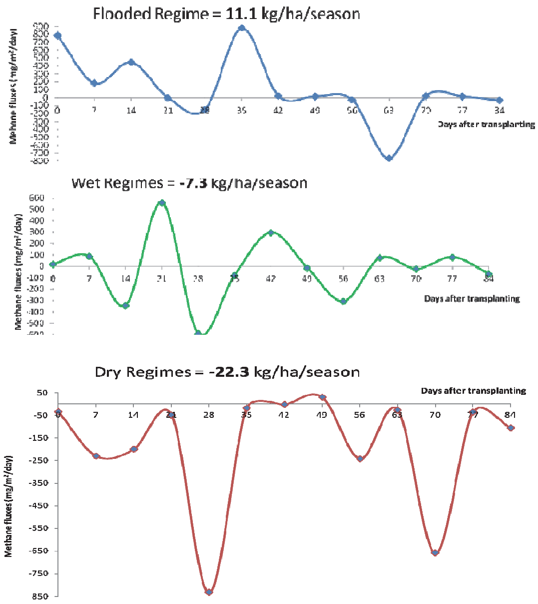

Figure 4. Methane fluxes during planting season

■Remarks:

- Greenhouse gas emission, particularly methane emission is affected by environmental biophysics parameters, i.e., soil moisture, soil temperature, soil pH and soil redox potential.
- Dry regime is the best regime to mitigate methane emission
- In this regime, dry field is conditioned 30 days after transplanting

■Reference:

Arif et al. 2015. Development of artificial neural network to predict greenhouse gas emissions from rice fields with different water regimes. Jurnal Irigasi Vol. 10(1): 1-10 (in Bahasa)

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Establishing a local crop weather network for localized adaptation

FMS-based weather monitoring for local climate change adaptation for agriculture

- Pioneering work to model a localized FMS-based crop weather monitoring network.
- Highlighting the importance of partnership with local governments for climate change adaptation.
- Institutionalization of the project to ensure sustainability.

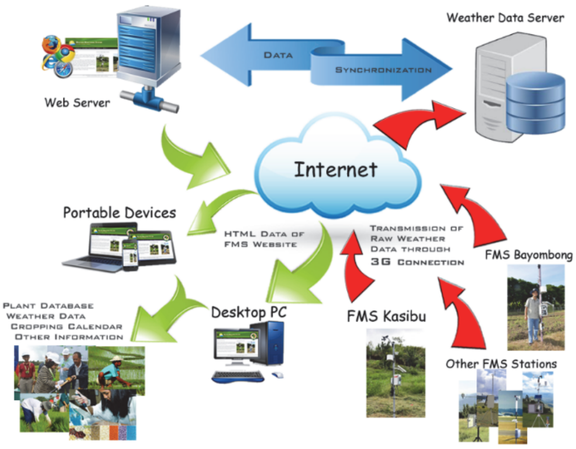
■ Partnership with local government units (LGUs) in the operation of field monitoring systems (FMS)

To ensure sustainability, Memoranda of agreements (MOA) between the Nueva Vizcaya State University (NVSU) and LGUs were formalized. Six weather monitoring zones in six municipalities were established – Bayombong, Kasibu, Santa Fe, Dupax del Sur, Kayapa, and Diadi.

■ Database management and data parsing

In order to organize the datasets obtained from the FMS, we have created a data parsing software designed for organizing and visualizing measured data from FMS sensors.

THE FMS DATA TRANSMISSION SCHEMA



■ Weather monitoring website

The project designed a weather monitoring website at http://fms.nvsu.edu.ph. This website allows multi-sectoral users to access FMS data, which include temperature, rainfall, humidity, wind speed and direction, solar radiation, among others. The website has two vital components: (1) Query window to view weather information; and (2) cropping calendar for major crops which compare the ideal weather requirements of the crop with the actual field data.

■ Sustainability of the weather monitoring system

In December, 2014, Nueva Vizcaya State University (NVSU) has institutionalized the Nueva Vizcaya Climate Change Center (NVCCC). NVCCC is a Center attached to the office of the Director for R and D of NVSU and is headed by a "Center Director".

Director for R & D
Center Director, NVCCC
Project Leader
- Research Assistant
- Administrative Support (NVSU)
- LGU (linkages)

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Real time monitoring of agricultural field

Downscaling Seasonal Climate Forecasts for Agricultural Risk Management in the Philippines

- Seasonal rainfall forecasts from a coupled GCM (global climate model), CFSv2 (Climate Forecasting System version 2), were used to evaluate the utility of MJJA (May-June-July-August) rainfall forecasts in Northern Philippines. Daily mean soil temperature and moisture at any depths are evaluated from meteorological data.
- Our sensitivity analysis showed that planting rice and maize earlier than the usual planting windows practiced by farmers could improve the resilience to climate risks. .

■Downscaling and Crop Simulations

Fig. 1 shows the general framework of the study. Here, we present only the use of dynamic seasonal climate forecasts and crop models for informing agricultural risk management at the farmers' and policy level.

The core of the study is the Climate Informed-Crop Monitoring and Forecasting System (CI-CMFS), which consists of developed crop and statistical models for crop yield forecasts leading to farming advisories for risk management at the farm level. Essential prerequisite for the development of the CI-CMFS are seasonal climate forecasts (SCF) generated from general circulation model-climate forecasting system v2 (GCM-CFSv2) outputs.

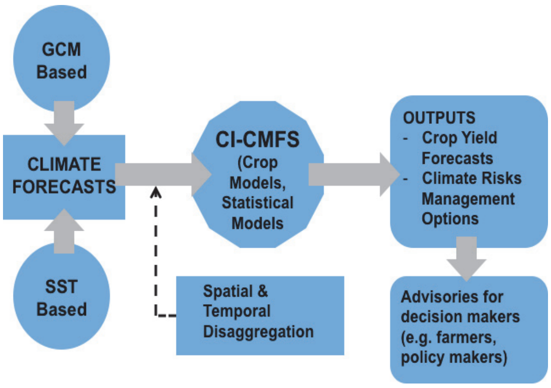

Fig. 1. Schematic of the Study

The CI-CMFS, in conjunction with the HMMTool, consists of a dynamic crop model that is flexible to be updated when climate information ahead growing season is available.

The developed CI-CMFS components enable the translation of available advanced climate information into realistic expected crop outcomes.

■Results

Stochastic simulations reveal that NHMM is able to recover the inter-annual variability of station scale rainfall modestly (seasonal r = 0.41, monthly r = 0.50). This indicates a reasonable "downscalability" of GCM-CFSv2 regional-scale rainfall to the station scale given the predictive nature of the predictor data set as well as the imperfect capability of the NHMM. Diagnostics of the NHMM show a maximum r = 0.93 which maybe attributed to unpredictable station scale noise as theorized by Moron et. al., 2006.

Climatologically and in consideration of the rainfall states found in this study, the best planting and sowing windows for rice and maize in the study areas are on the first week and last week of May, respectively. Relative hereto, SCF for an incoming season is a rolling and moving target that is acquired by driving the developed models with available advance climate information.

■References

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Hansen, J.W., Ines, A.V.M., 2005. Stochastic disaggregation of monthly rainfall data for crop simulation studies. *Agric. For. Meteorol.* 131: 233-246.

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Real time monitoring of agricultural field

Predictability of May to August (MJJA) Seasonal Rainfall in Northern Philippines

- The skill of a probabilistic climate forecast three months ahead of the rice and maize growing season to inform better agricultural management was examined. Our sensitivity analysis showed that planting rice and maize earlier than the usual planting windows practiced by farmers could improve the resilience to climate risks.
- The skill of seasonal climate forecast provides a basis on the utility of the advanced climate information for assessing and managing climate related risks in crop production using agricultural impact models.

■Predictability of Rainfall

In this study, the Climate Predictability Tool (CPT) was used to perform canonical correlation analysis (CCA) between the pre-determined set of predictors (SSTs) and predictands (MJJA station rainfall).

CPT was executed to determine the probabilistic rainfall forecast with 3-months lead-time onto the MJJA season. Both the model with observed and GCM SSTs were time-lagged to represent a predictive relationship with the predictand. In this study, the predictor was the February-May (FMA) SST initialized in January and the predictand covered the MJJA season. Experiments were done to determine which of the three SST predictors (i.e., observed and GCM-based) tend to result in the greatest cross-validated hindcast skill and which predictor shows the strongest SST-versus-rainfall relationships.

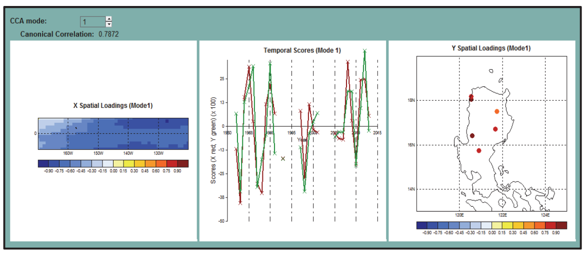

Fig. 1. Spatial loading of the predictor and predictand

■Results

Overall findings suggest that MJJA seasonal rainfall predictions were favorable and skillful (GI = 0.63 and CC = 0.79) enough for decision support in farming activities to be able to substantially reduce economic losses associated with excessive rain and drought in the study area. Generally, skill levels may provide considerable basis to reasonably link the probabilistic rainfall forecasts with crop models for decision support in rice and maize production.

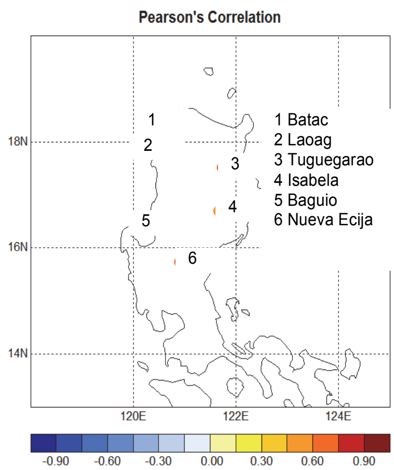

Figure 2. Skill map of the CFSv2 SST predictor

■References

Hardle, W., Simar, L. 2007. "Canonical Correlation Analysis". *Applied Multivariate Statistical Analysis*. pp. 321–330.

Mason, S.J. 2014. Seasonal Forecasting Using the Climate Predictability Tool (CPT). International Research Institute for Climate and Society, The Earth Institute of Columbia University, Palisades, NY

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Real time monitoring of agricultural field

Environment factors affect Field Monitoring System (FMS) & the Vietnam Gridded Precipitation Dataset

- Environment factors, such as rain, insects may result in damage FMS device and losing data.
- Understanding rainfall characteristics is very important for monitoring and mitigating water-related disasters around the world. Thus gridded rainfall dataset is needed.

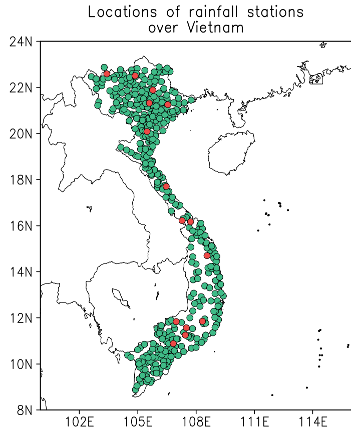
■Introduction of Field Monitoring System (FMS)

FMS is an automatic monitoring system that collects pictures, soil, and meteorological data, and then send them to the web server where all data are shown as visual graphs and can be downloaded as raw data. These data are necessary not only for climate change researches, but also for agricultural management. The stability of this system is an important issue, which needs to be considered. The stability of FMS depends on the field's solar power supply and the internet connection. In addition, because the device is placed outside, environment conditions must be taken into account.

■ Environment factors affect Field Monitoring System

These environment factors can result in equipment damages and lead to problems with data. Electrical components of can be wet and stop working in heavy rain, although they are waterproof devices; ants and bees built their nests inside the device, etc. FMS users should check the system periodically to ensure that it is working well.

■VnGP: A new gridded rainfall dataset for Vietnam



Location of 481 rainfall stations used for building the new dataset

The use of data from a dense observation network helps improve the quality of rainfall gridded datasets. Among the interpolation methods, Spheremap [2] shows relatively better results. Consequently, we have generated two versions of the final Spheremap daily products, called Vietnam Gridded Precipitation 0.25 (VnGP_0.25) and 0.1 (VnGP_0.1), with the resolution of 0.25° and 0.1°, respectively [3]. VnGP covers the period 1980-2010 and will be shared through the Data Integration and Analysis System (DIAS).

■References

[1] M.Mizoguchi, et al. (2011) Quasi Real-Time Field Network System for Monitoring Remote Agricultural Fields. SICE Annual Conference 2011, Waseda University, Tokyo, Japan, 1586-1589.

[2] Willmott, C.J. et al. 1985. Small-scale climate maps: a sensitivity analysis of some common assumptions associated with grid-point interpolation and contouring, *American Cartographer*, 12: 5-16.

[3] Nguyen, X.T. et al., 2016: A new gridded rainfall dataset for Vietnam, in preparation.

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Monitoring of Local Climate and Soil in Rain-fed Cultivation for Farmers Coping with Climate Change in Northeast Thailand

- Field monitoring has been conducted to obtain climatic and soil moisture data in rice-cassava fields under rain-fed conditions in Northeast Thailand.
- Quasi real-time monitoring is useful for predicting the optimum planting dates of cassava after rice.
- Monitoring of soil moisture and temperature is profitable on improve yields in cassava fields.

■ Automatic data collection by FMS

Since 2011, field monitoring has been conducted to obtain climatic parameters (rainfall, air temperature, solar radiation, etc.) continuously in rice-cassava fields under two rain-fed fields in Khon Kaen, northeast Thailand using FMS (Field Monitoring System).

■ Data sharing with local farmers

The data obtained in quasi real-time is helpful for local farmers to know the optimum planting and harvesting dates of cassava after rice. The detection of abrupt increase in soil moisture under ground, which was predicted by FMS, prevented the moisture damage of cassava in advance and saved the farmers from economic loss.

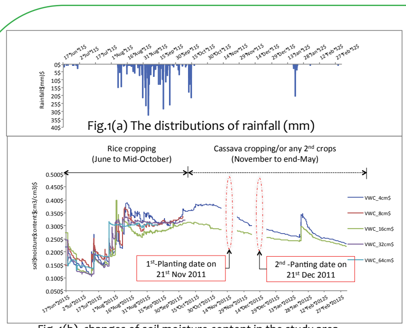


Fig.1(a) The distributions of rainfall (mm)

Fig. 1(b) changes of soil moisture content in the study area (from June 17th,2011 to February 2012)

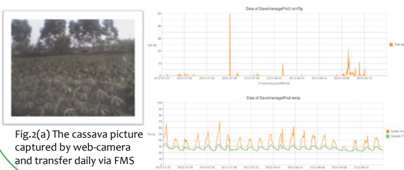


Fig.2(a) The cassava picture captured by web-camera and transfer daily via FMS

Fig.2(b) Real-time monitoring data in cassava field by using FMS

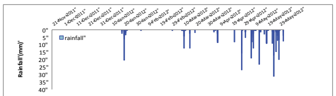


Fig. 3(a) The fluctuations of rainfall (mm) in cassava field

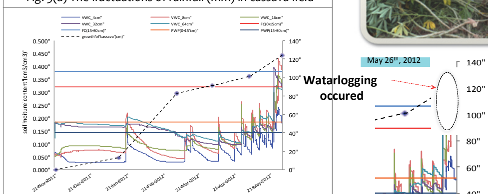


Fig. 3(b) changes of soil moisture, growth of cassava and waterlogging occurred in the areas of the first -planting date

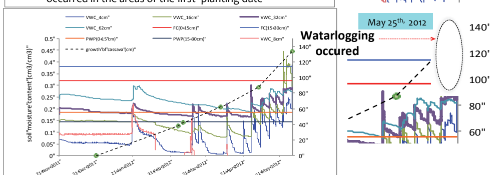
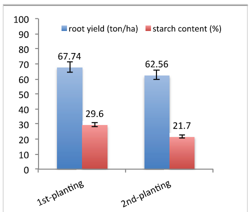


Fig.3(c) changes of soil moisture, growth of cassava and waterlogging occurred in the areas of the second-planting date

Harvesting date on May 31st, 2012



- 1st- Planting date : 67.74 ton/ha
  starch content 29.6 %
- 2nd-Planting date: 62.56 ton/ha
  starch content 21.7 %

Yield & Starch Content & Harvest Index (HI)

Treatment	Experiment 1 Yield (t/ha)	Experiment 1 Starch (%)	Experiment 1 HI	Experiment 2 Yield (t/ha)	Experiment 2 Starch (%)	Experiment 2 HI
Tillage practices						
Tied ridges	12.18	18.1	0.62	20.65	17.32	0.46
Flat	15.8	17.63	0.64	19	17.12	0.5
F - test	*	ns	ns	*	ns	**
Mulching						
Mulches	11.43	20.55	0.6	19.91	17.04	0.46
Non-mulched	16.55	15.18	0.66	19.42	17.16	0.5
F - test	*	*	***	ns	ns	*
Cultivars						
KU-50	17.24	18.03	0.6	20.65	17.32	0.54
RY-11	10.75	17.7	0.66	19	17.12	0.4
F - test	**	ns	***	**	ns	***
F - test (interaction)						
A x B	ns	ns	ns	ns	ns	ns
A x C	ns	ns	ns	ns	ns	ns
B x C	ns	ns	.	ns	ns	ns
A x B x C	ns	ns	ns	ns	ns	*

■ Cropping practices using Cassava as an adaptation measure against climate change

As a result of several field tests under different soil cultivation practices, harvested cassava was found to contain starch of good quality and to have market value in Thailand where cassava production decreases. In conclusion, the cropping practices using cassava proved to be an effective adaptation strategy against climate change in the northeast Thailand.

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■Organizations which participated in this project

The University of Tokyo (UTokyo)
Tokyo Metropolitan University (TMU)
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
National Agriculture and Food Research Organization (NARO)
National Institute for Agro-Environmental Sciences (NIAES)

Overseas research cooperation institutions

Thailand: Kohn Kaen University(KKU), King Mongkut's University of Technology Thonburi (KMUTT), Thai Meteorological Department (TMD), Land development department (LDD)

Vietnam: Vietnam National University (VNU), Can Tho University (CTU), National Hydro-Meteorological Service (NHMS)

Philippines: Nueva Vizcaya State University (NVSU), Mariano Marcos State University (MMSU), Ateneo de Manila University (AMU), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

Indonesea:Bogor Agricultural University (IPB), Badan Pengkajian dan Penerapan Teknologi (BPPT)

■ The study period (2011 – 2016)

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It should be noted that the present research project had mutual cooperation with DIAS as well as the following projects:

RECCA: construction of agricultural production optimization support system under global environmental change (research leader Ninomiya Masashi)

MAHASRI (Monsoon Asian Hydro-Atmosphere Scientific Research and Prediction Initiative)

ANY (Asian Monsoon Years 2008-2012)

MARCO: The Monsoon Asia Agro-Environmental Research Consortium

■ More information

The details of this research project is available from the following website.

https://grene.agrid.org/htdocs/

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Climatic Changes and Evaluation of Their Effects on Agriculture in Asian Monsoon Region

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