Development of decision support system for optimal agricultural production under global environment changes

Seishi Ninomiya1, Masaru Mizoguchi1, Tsuneo Kuwagata2, Hiroshi Nakagawa3, Taku Nishimura1, Takuji Kiura3, Chihiro Kato1, Ryoichi Doi1, Wei Guo1, Masayuki Hirafuji3, Toshiaki Iida1, Kenichi Inoue6, Yasushi Ishigooka2, Masaomi Kimura1, Yasuhiro Kominami3, Narutaka Kubo1, Megumi Minamiyama5, Hiroaki Miura8, Kou Nakazono3, Mikio Nomura5, Kazuhiro Nishida1, Ryuta Ohishi8, Hiroyuki Ohno3, Toyoiko Oida6, Hirotaka Saito7, Sho Shiozawa1, Wataru Takahashi5, Kei Tanaka3, Tadashi Tsukaguchi4, Satoshi Yonekawa1, Hiroe Yoshida3 and Shuichiro Yoshida1
• 12 sub-programs

- Develop Advanced Data Downscaling Methods
- Develop Data Assimilation Technology
- Develop Simulation Technology for Climate Change Adaptation
Implementation Framework

PD: Nobuo Mimura (Ibaraki University)

P0: Satoshi Takewaka (University of Tsukuba)
P0: Yousei Hayashi (University of Tsukuba)

Water
- Toshio Koike (The University of Tokyo)
- Fujio Kimura (Japan Agency for Marine-Earth Science and Technology)
- Tomohito Yamada (Hokkaido University)
- Motoki Nishimori (National Institute for Agro-Environment Sciences)

Urban
- Koji Dairaku (National Research Institute for Earth Science and Disaster Prevention)
- Keiko Takahashi (Japan Agency for Marine-Earth Science and Technology)
- Satoru Iizuka (Nagoya University)
- Seigo Nasu (Kochi University of Technology)
- Teruyuki Nakajima (The University of Tokyo)

Agriculture, Forestry and Fisheries
- Toshiki Iwasaki (Tohoku University)
- Seishi Ninomiya (The University of Tokyo)
- Toshiyuki Awaji (Japan Agency for Marine-Earth Science and Technology)

Principal Researcher (Affiliation)
“■” indicates Field Leaders
Objectives

• **To Develop a decision support system**
  – to realize robust, stable and profitable agriculture against long-term global warming and frequent extreme weather conditions

• **The system supports**
  – Optimal crop management, considering profitability
  – Optimal water management in an area of a watershed

• **Expected outcomes of studies**
  – Stable food supply
  – Stable farm profitability
  – Optimal usage of water resource
  – Sustainable agriculture
Outline of research

Climatic downscaling data

Weather model for high resolution data

High resolution data generation for local area

Local climatic data

Crop modeling
- Prediction of yield and quality

Soil condition and resource availability

Crop water demand

Soil and water modeling
- Estimation of water resource and soil condition

Monitoring data for assimilation and parameter tuning

Decision support system for optimal
- Farm base optimal cropping for productivity and profitability
- Guideline for local water management

Easy-to-use user interface

Integration of models

Systemization

Evaluation of system by ground
- Development of monitoring system

Evaluation at test beds
Weather model for locally useful high resolution data

Daily and hourly high resolution data

- Seasonal prediction
- Past to future Y1980-y2030
  - Temperature
  - Rainfall
  - Wind speed
  - Solar rad.
  - Snowfall
  - Humidity
  - Long-wave rad.

Uncertainty evaluation based on multiple climatic scenarios

- Reanalysis data
- Climatic Scenario data (CMIP 5)

Statistical and dynamic downscaling of climatic and weather data

High resolution data

Crop model  SW model

DIAS database
Crop model for productivity and quality

- Ground data for tuning and evaluation
- Climatic data
- Crop growth model
  - Crop growth
  - Yield and quality
  - Prediction of crop damage
- Soil/water model
  - For water supply and soil moisture
- Double cropping optimization against global warming
  - Optimal cropping timing, Optimal variety
  - Risk management, optimal land productivity
  - Optimal resource utilization
- Double cropping of rice and wheat
- Predictions of quality degrading
- Rice, Wheat and barley

Crop model for productivity and quality

Double cropping optimization against global warming

- Optimal cropping timing, Optimal variety
- Risk management, optimal land productivity
- Optimal resource utilization
Soil and water model for local circulation

- Demand prediction, optimal water management and usage plan
- Combination with crop model to make more accuracy
- Optimal reduction of environmental impact by material cycle model
Evaluation of system by ground monitoring

Ground monitoring data

Models

Data assimilation
Parameter tuning

Evaluation

Development of monitoring systems operational under poor network and power infrastructure

Evaluation of system based on productivity and profit performance
DSS for optimal crop production

- Farm base optimal cropping for productivity and profitability
  - Optimal amount and timing of fertilizer and irrigation, selection cropping period and variety, double cropping system
- Guideline for local water management
Expected outcomes of project

- Generation of high resolution climatic data useful for site-specific agriculture
- Crop model that also simulates quality
  - Mutual data exchange of crop model and soil/water model
    - Soil condition and water supply ability to contribute for crop model
    - Crop water demand to optimize water management
- Optimal crop managements can be suggested
  - Stable and profitable robust production even under global warming and unstable condition
  - Optimal amount and timing of fertilizer and irrigation, cropping period selection and optimal variety, double cropping system
- Guideline for optimal local water management
- System concept will not depend on local conditions and be usable in other places
Thank you very much