Rice monitoring using Earth Observation and ground data

Lesson being learned in the

GEORICE project

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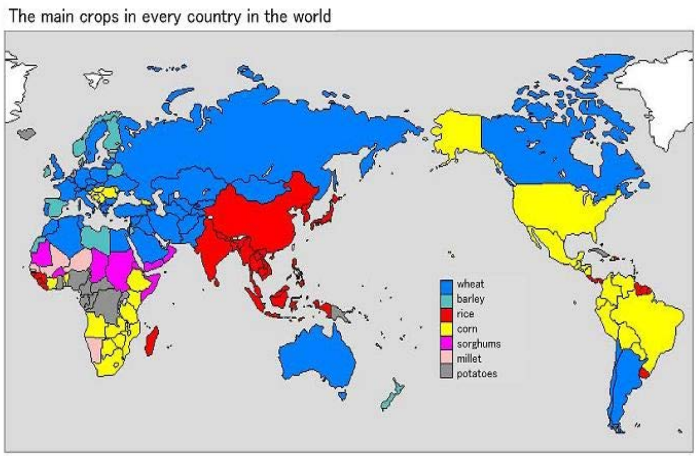
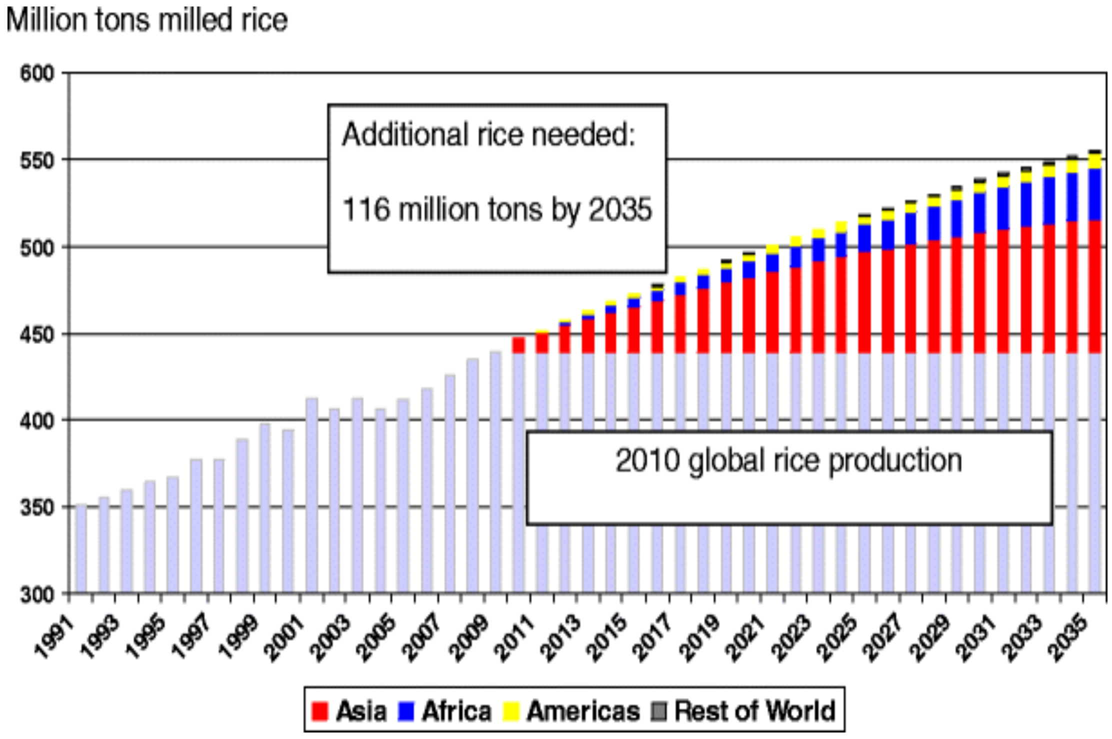
General background: Rice food demand is increasing

- Rice food demand continues to increase due to rapid population growth
- In Asia, where rice is the main crop , about additional 80 million tons will be needed in 2035 compared to 2010



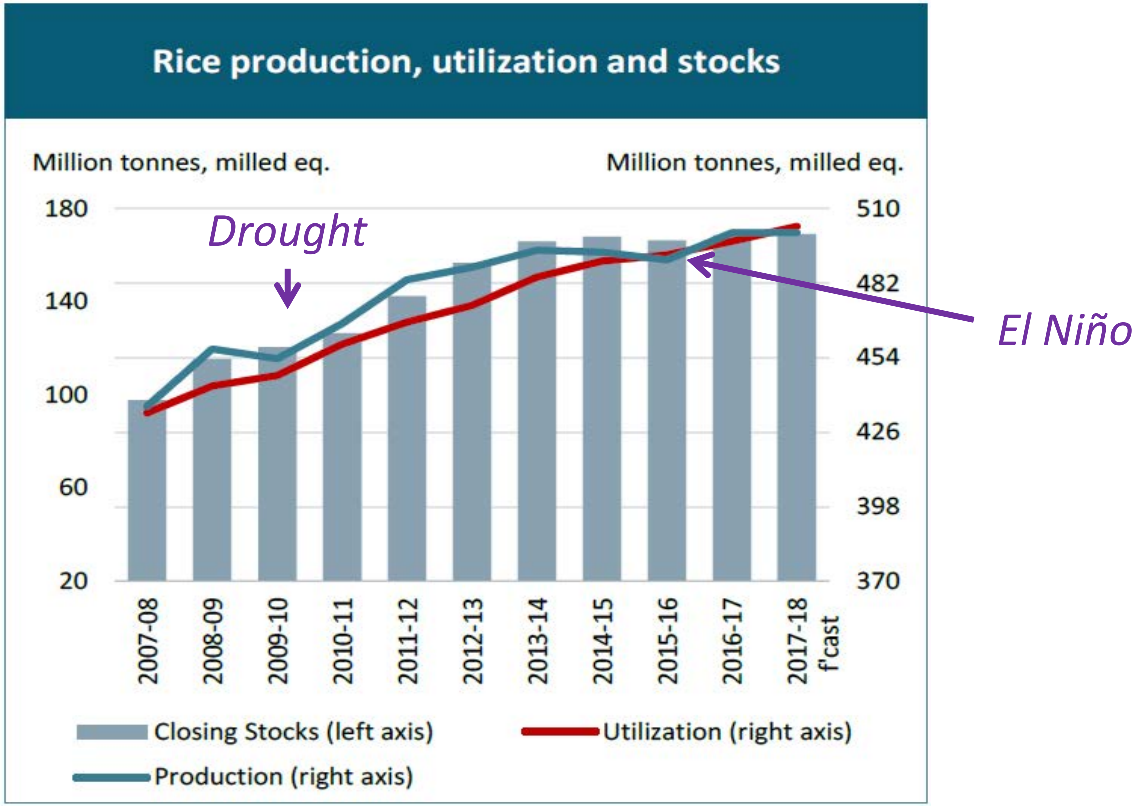


Rice production affected by climate change

- Increase of Rice production to meet the demand is threatened by adverse weather (flood and drought) under global warming

→ Fluctuation in rice production

→ No increase in the rice stocks in the past 5 years



Early rice production information is required for food security

Crop production= crop grown area x number of crop seasons per year x crop yield per season

Earth Observation is expected to provide timely and synoptic information on:

- crop grown area, for estimating rice grown area, the number of crops per year

- crop phenological stage, growth anomaly .. for early warning and for estimating the rice yield

Demonstration performed in Asia-RiCE

1. Demonstration at Technical demonstration sites (India, Japan, Malaysia, Philippines, Thailand , Taiwan (Chinese Taipei), Cambodia and Myanmar .

1. Demonstration at Regional/National scale: wall-to-wall Vietnam , and top 10 rice production provinces in Indonesia
   - APRSAF (Asia Pacific Regional Space Agency Forum) SAFE initiative in Cambodia, Indonesia, Myanmar and Vietnam (Mekong) using ALOS-2
   - ESA-GEORICE using Sentinel-1 for Mekong Delta Vietnam
   - ADB project using ALOS-2 for Lao, Philippine, Thailand and Vietnam (Red river)
   - Data and methods Implementation on the Vietnam Data Cube (CSIRO, USGS, JAXA, CESBIO/CNES, VNSC)

3. On going research for Rice Yield estimate and Methane Emission at test sites

Demonstration studies in Asia-RiCE

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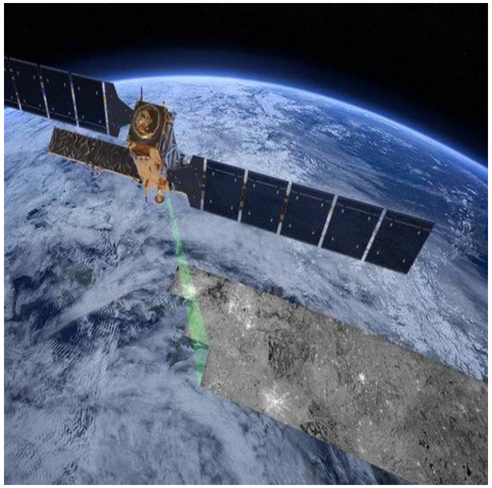
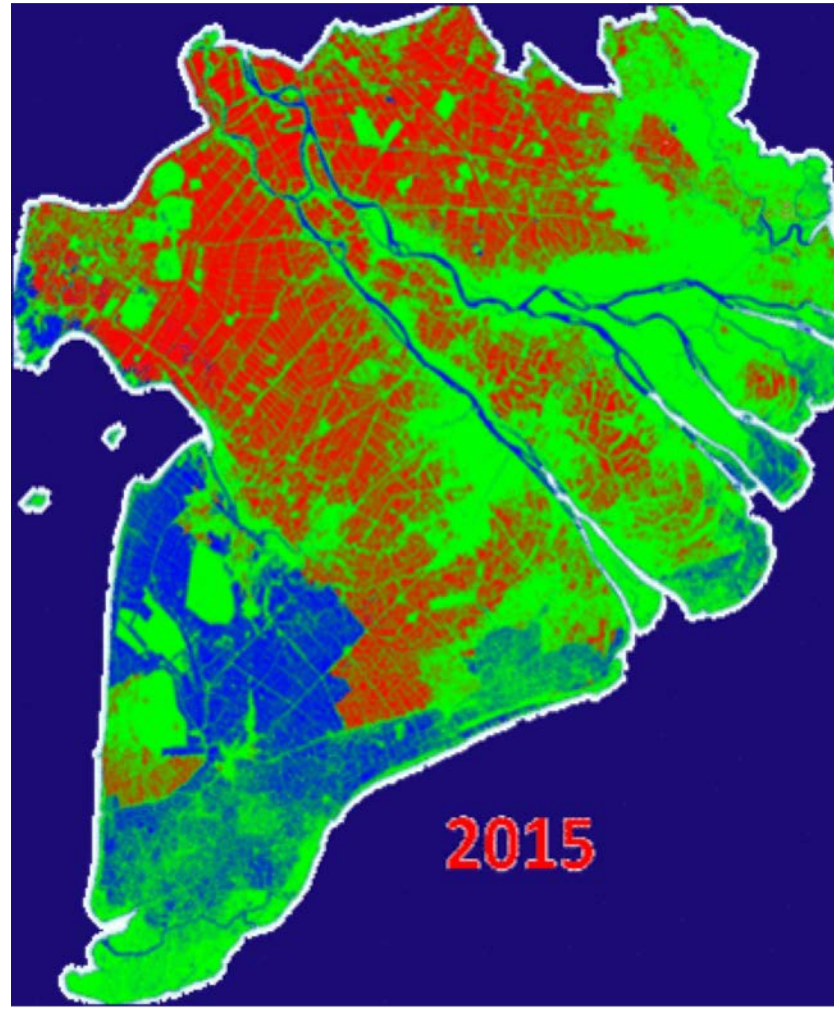
Sentinel-1 for Rice monitoring in Vietnam



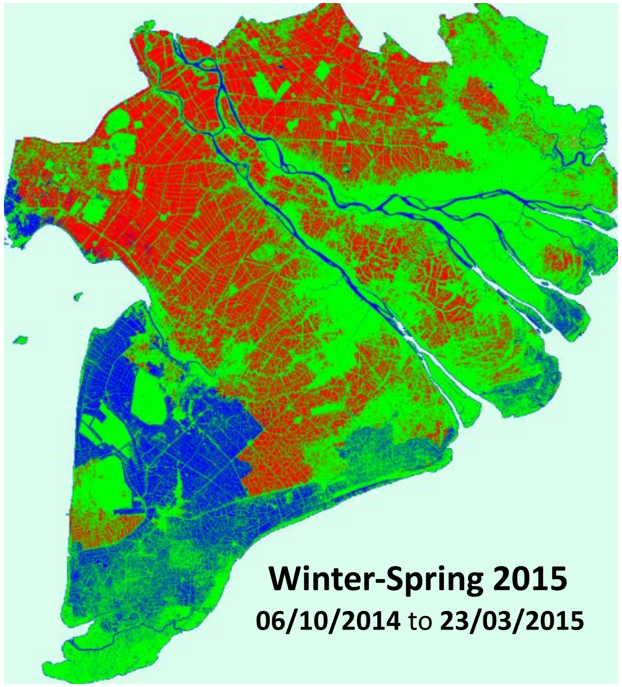
C-Band SAR data continuity

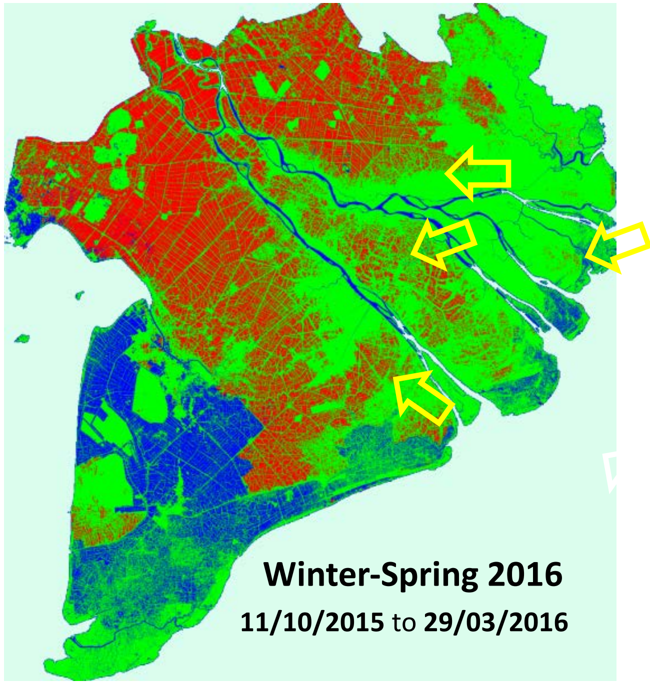
- Repeat Cycle: 12 days, 6 days with 1A & 1B
- Multimode, resolution 5-20m, swath width up to 250-400 km
- Open and Free access of data
- Preprocessing tools and Analysis Ready Data (ARD) available



Effect of El Niño on rice crop cultivation, 2015-2016-2017 in the Mekong Delta

Early estimate of variation in rice planted area





➡ **Decrease of 16.7%** of **Winter-Spring rice harvested area in Mekong River Delta 2016 compared to 2015 (**by March 2016**,** 1.39M ha estimated vs 1.67M ha in March 2015, or decrease of 276,000 ha) caused by **shortage of water** and **saline intrusion (El Niño effect)**

Other reportings:

- UNSCAP June 2016 : Damaged Winter-Spring paddy area in MRD of 234,260 ha
- VN Statistics Office 2017: **17,6%** of Winter 2016 rice planted area in MRD affected by drought and saline intrusion or 224, 552 ha

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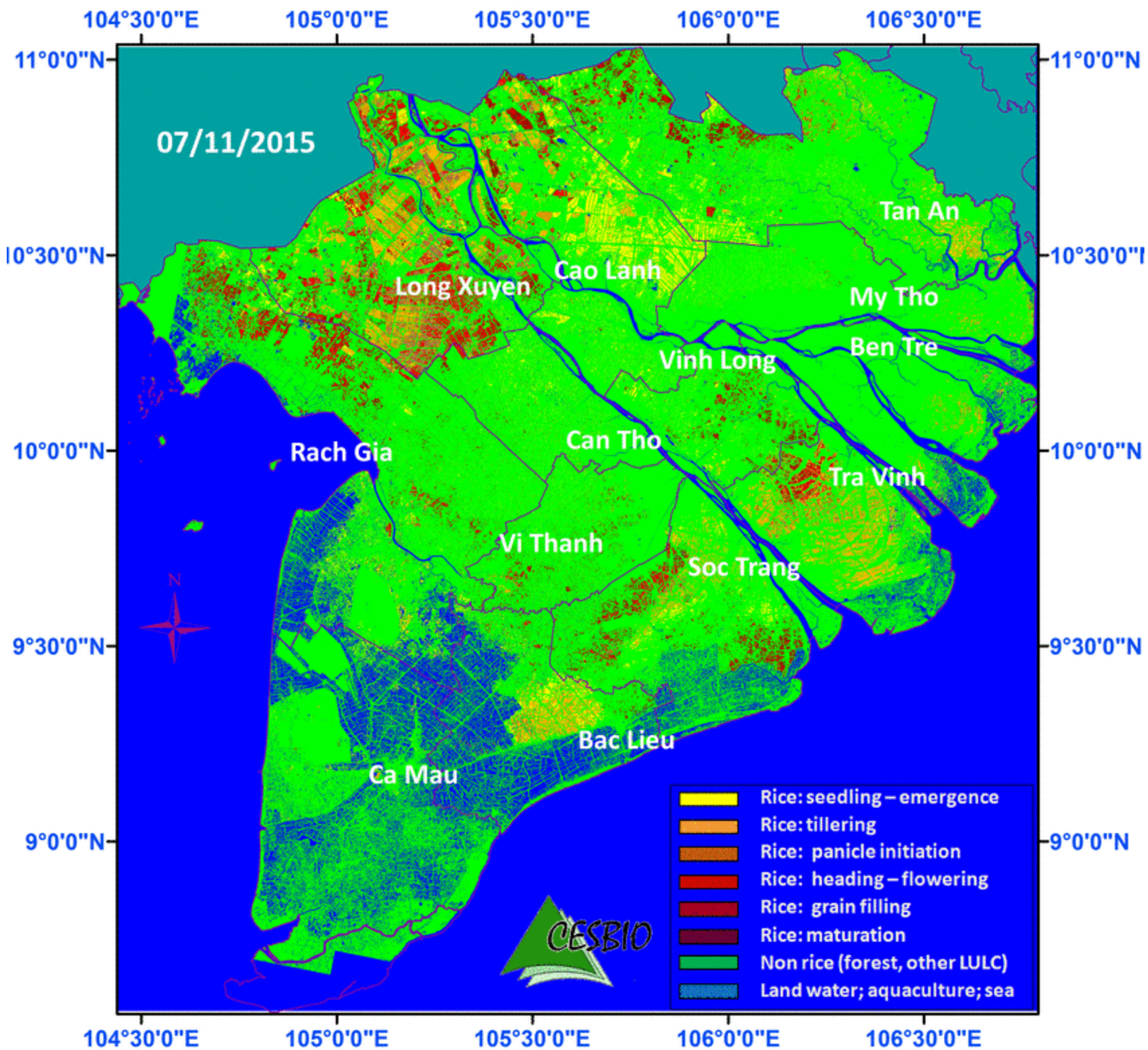
Rice growth stage monitored with Sentinel-1



esa

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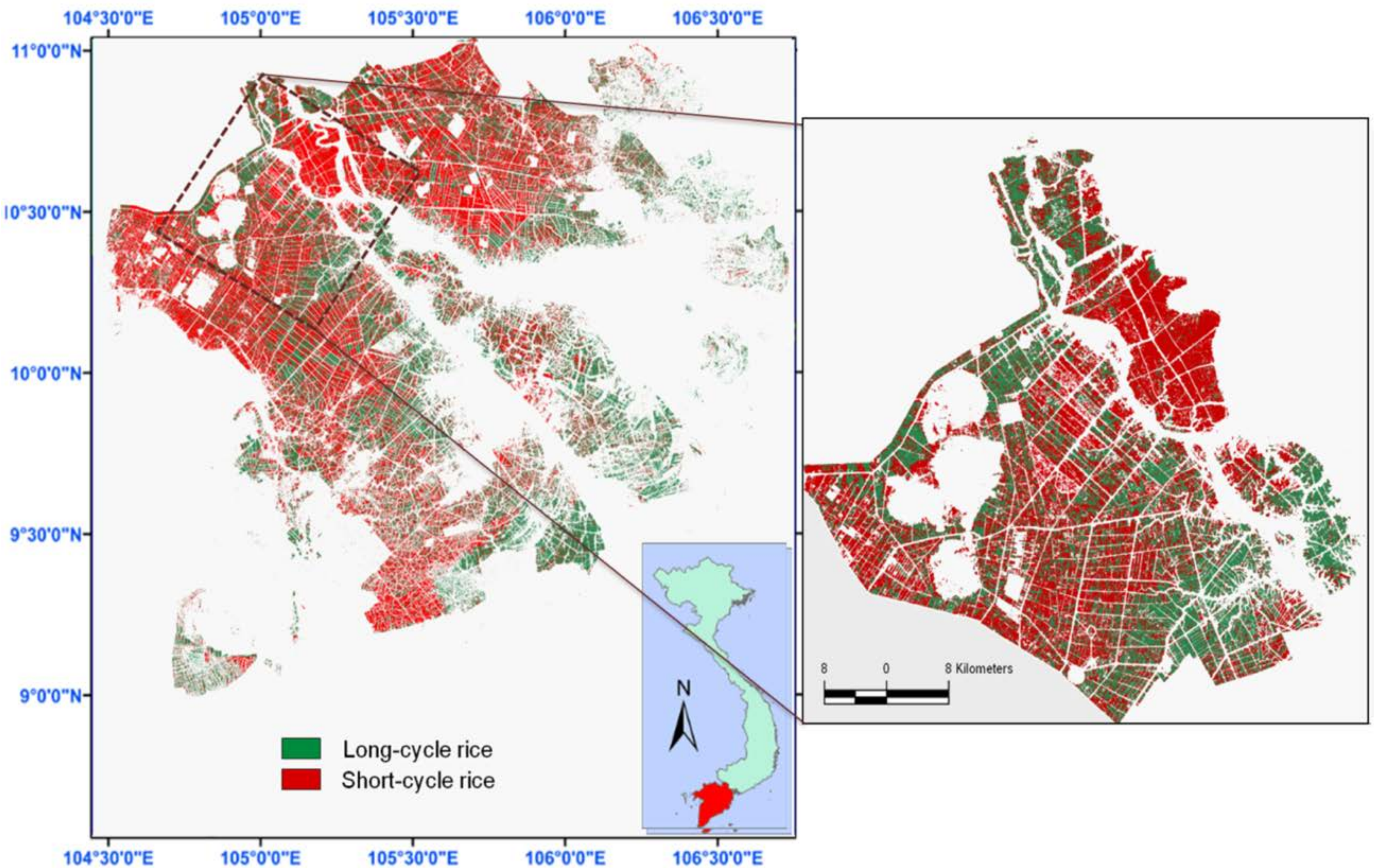
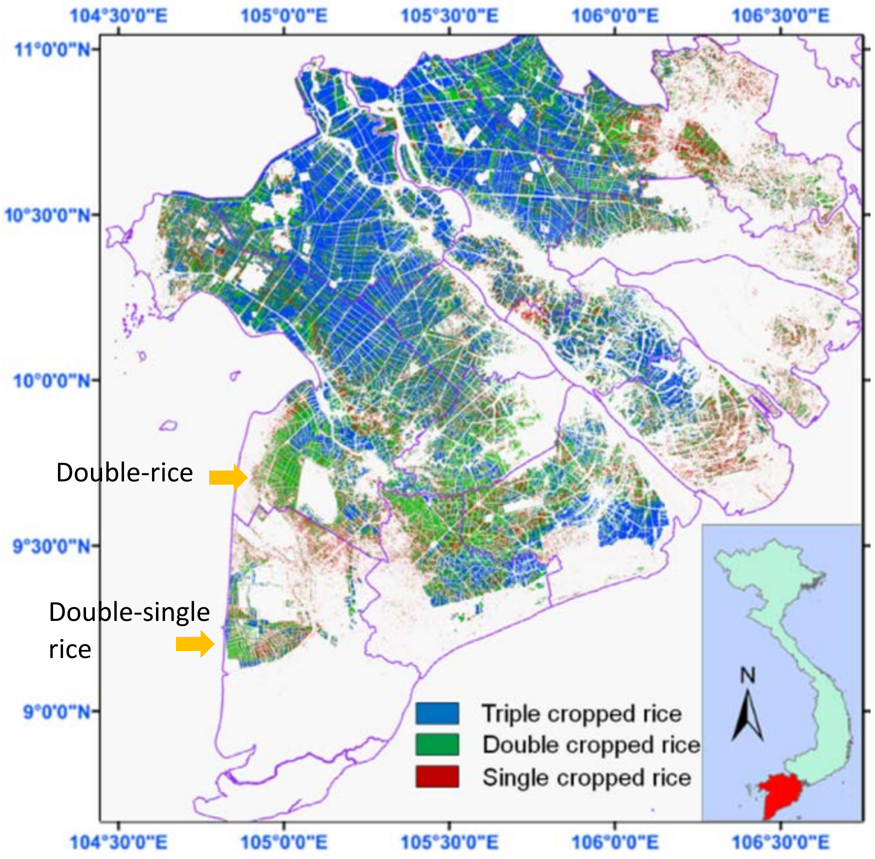
GEORICE- Mekong River Delta

Rice planted with short cycle and long cycle varieties: economical & environmental impacts

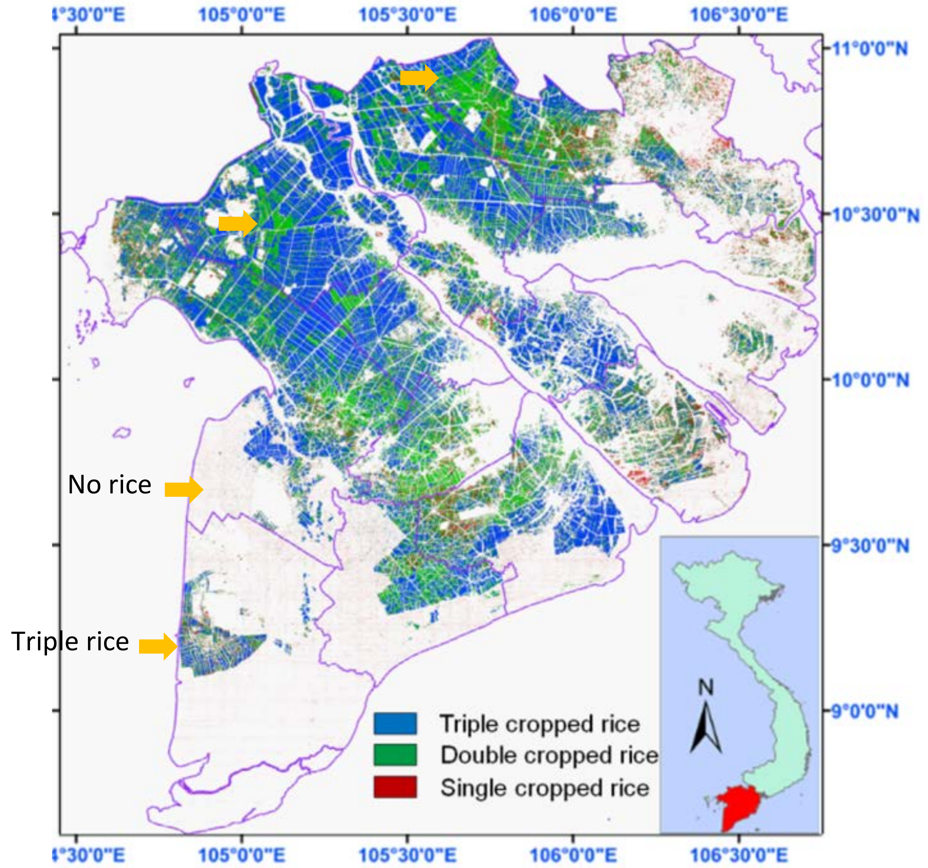


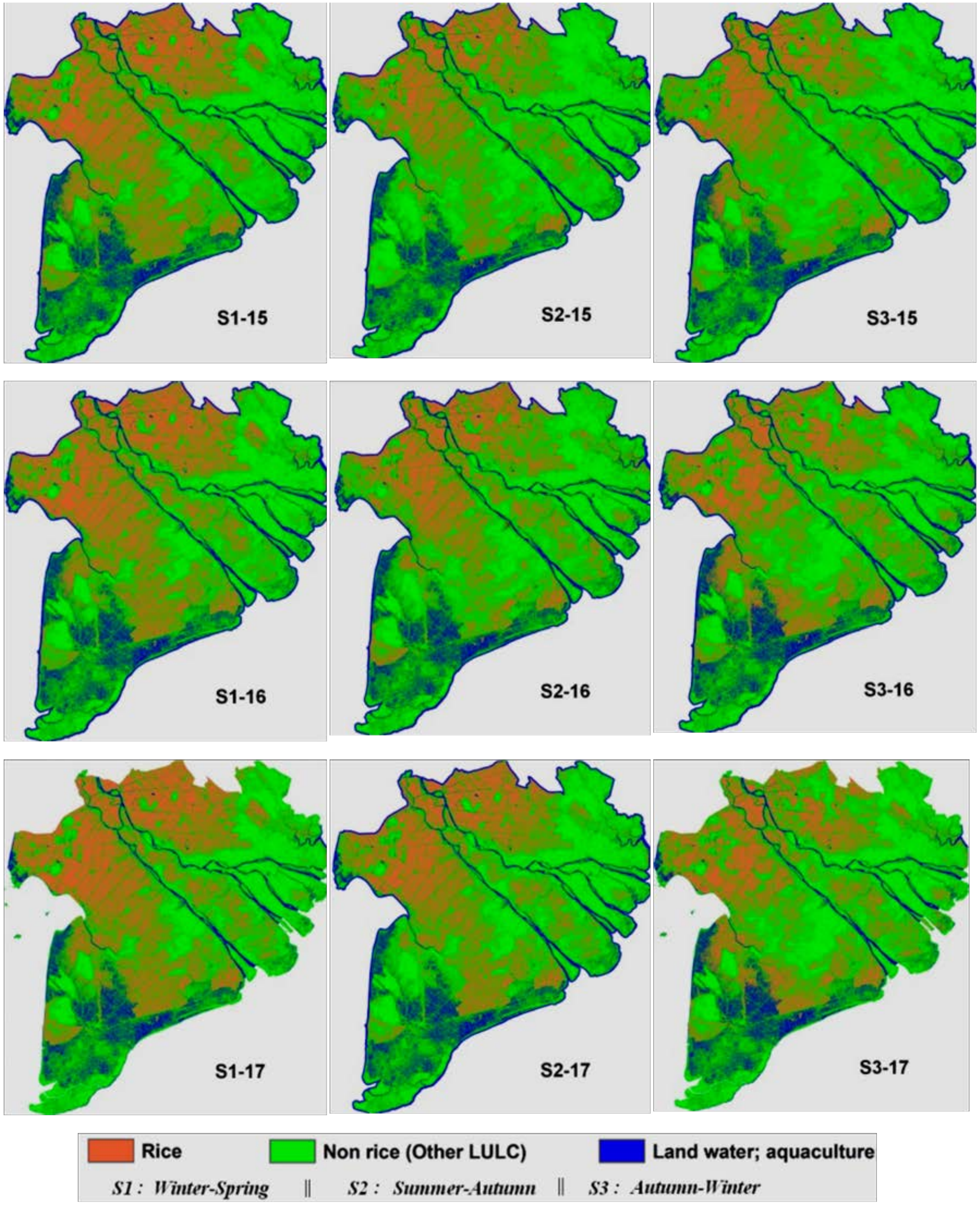
Year to year change in cropping density

2015

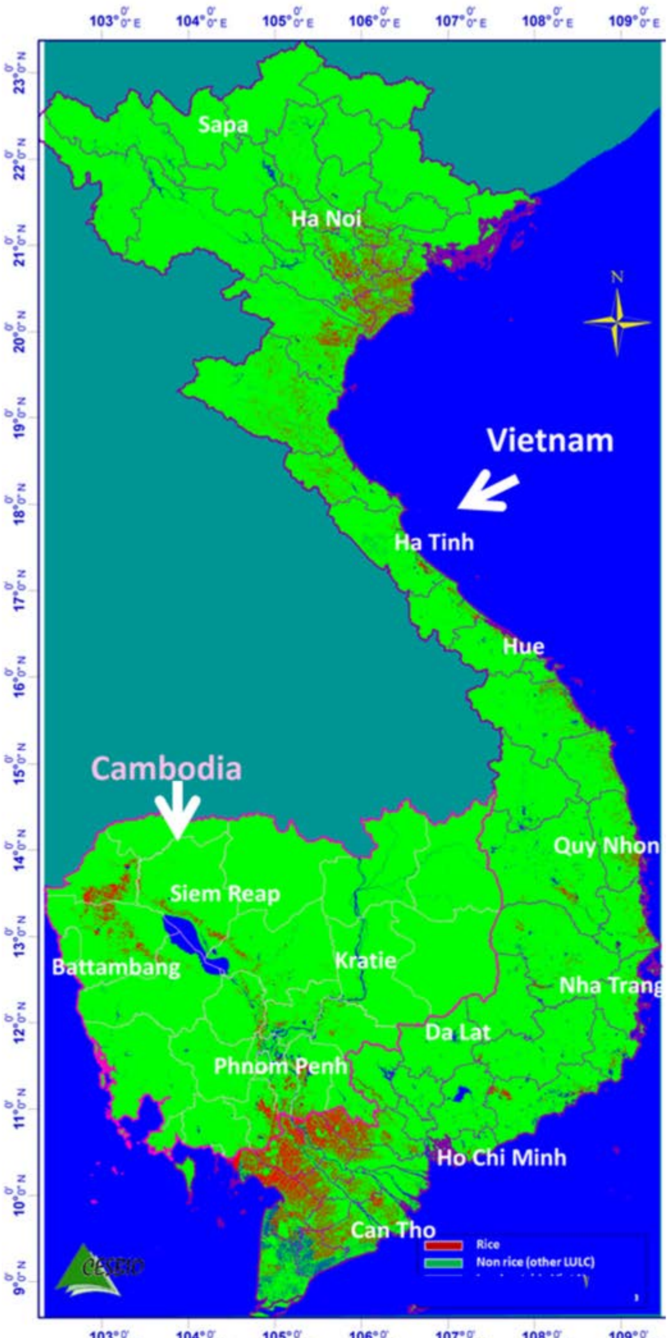


2016




S1-15
S2-15
S3-15
S1-16
S2-16
S3-16
S1-17
S2-17
S3-17
Rice
Non rice (Other LULC)
Land water; aquaculture
S1 : Winter-Spring
S2 : Summer-Autumn
S3 : Autumn-Winter

Test of wall-to-wall national mapping using Sentinel-1



Map of Winter-Spring 2016 rice in Vietnam and Cambodia

GEORICE phase 2: 5 countries
Vietam, Cambodia, Lao, Thailand, Myanmar
October 2018-March 2020

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In line with AOGEOSS pilot study

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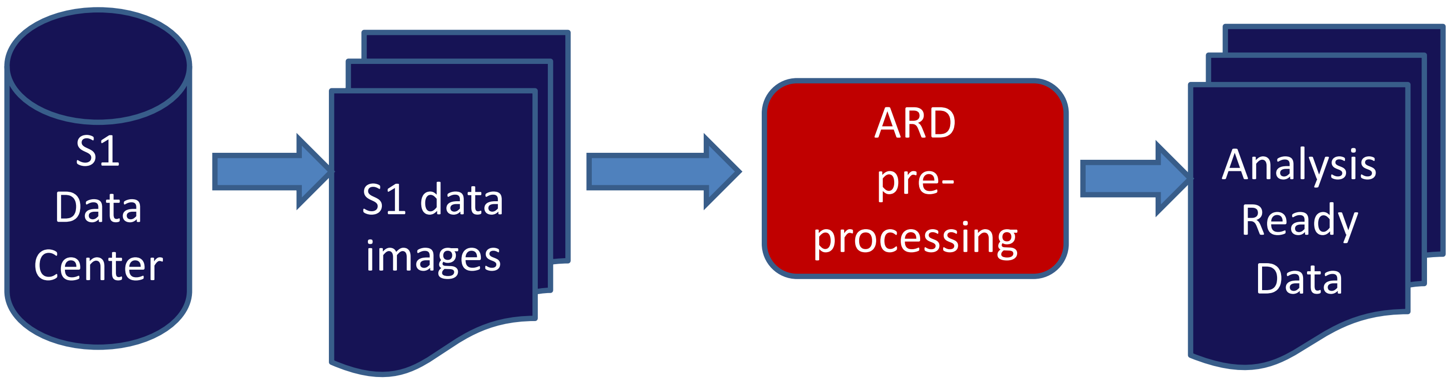
Building Analysis Ready Data (ARD) for Sentinel-1 on VN Datacube



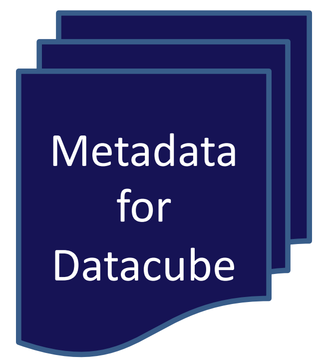
S1 images ready to use in Datacube

https://peps.cnes.fr

Ground projected image (GRD)
.SAFE format

Python script

S1toARD.py

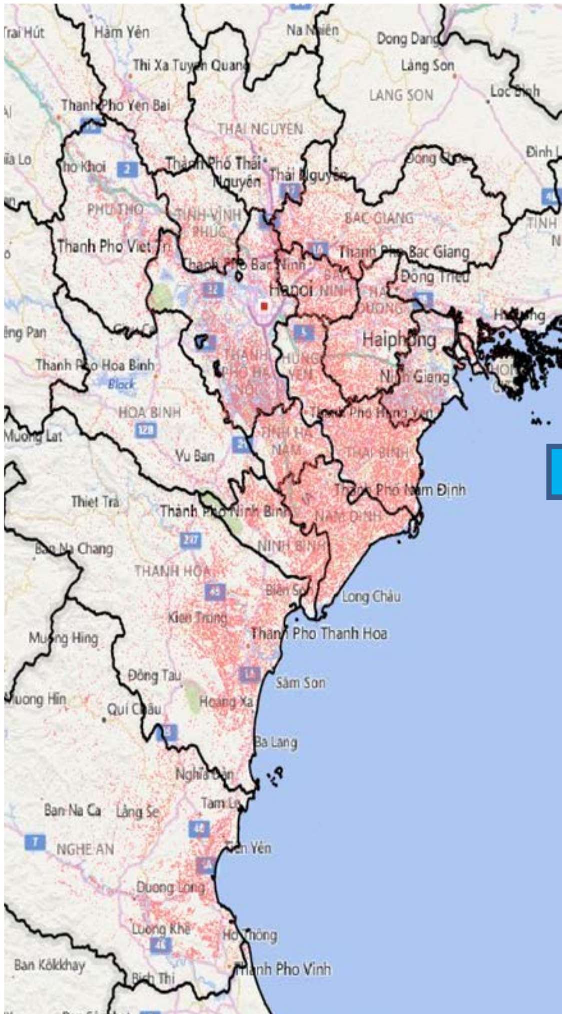


S1 images metadata for Datacube ingestion (.yaml file)

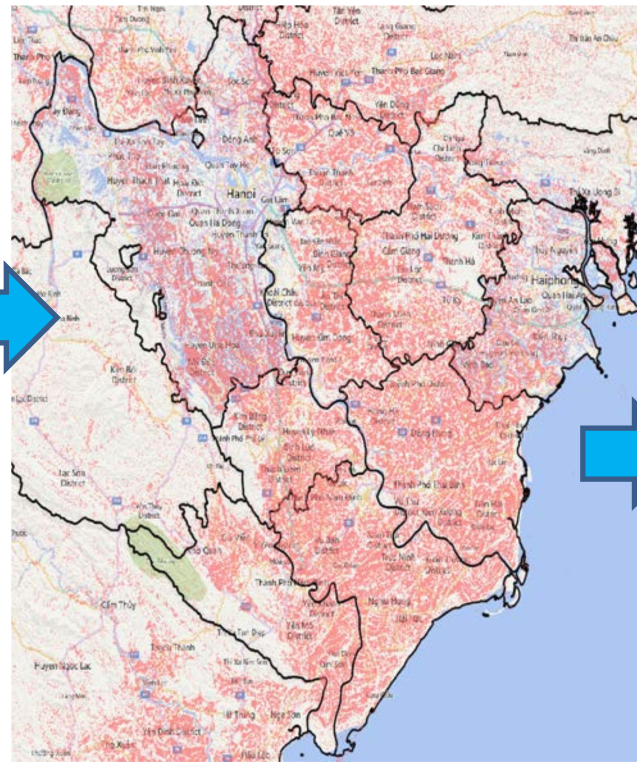
https://scihub.copernicus.eu

Demonstration of Rice mapping using VN Datacube

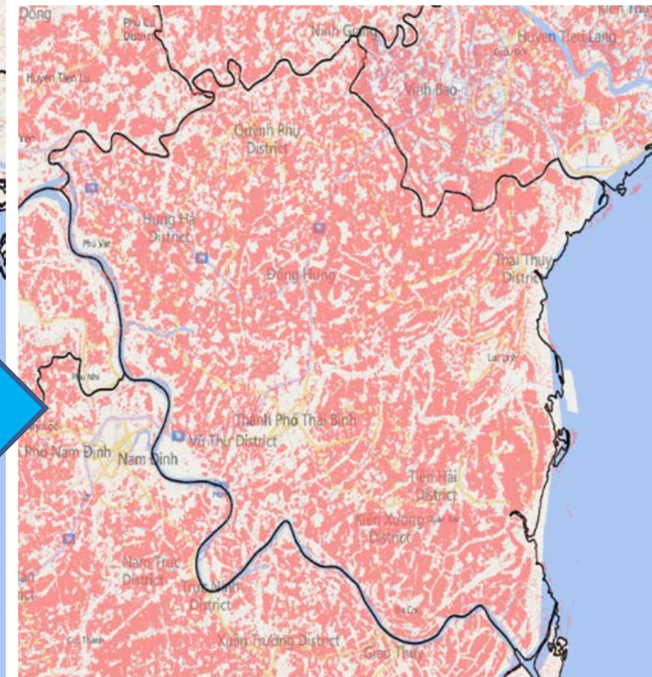
Northern Vietnam



Red River Delta



Thai Binh Province



Winter-Spring 2017 rice map generated from S1 data using VN DataCube

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Beyond food security, rice crop is closely linked to climate change, water and environment

Rice production is affected by climate change

- o Drought, which damage the crop at reproductive phase
- o Salinity intrusion, in particular in lowland South East Asia,
- o Floods and cyclones, in increasing number

Increase rice production → increases use of water resources

- o Irrigated rice receives an estimated 34−43% of the total world's irrigation water.
- increasing water scarcities in major river basins,
- retreating groundwater levels in areas where more water is being pumped for irrigation than can be replenished.

Beyond food security, rice crop is closely linked to climate change, water and environment

- **Rice fields are major generator of methane and nitrous oxide**, responsible for 25% of the total budget of global methane emissions from agriculture.
- **Environmental issues** increases with rice production :

Excessive use of fertilizers and pesticides that pollute waterways and kill beneficial wildlife,

As a task group, TG5 particularly addresses
SDG 2: *End hunger, achieve food security and improved nutrition and promote sustainable agriculture,* but also
SDG 6: *Clean and accessible water for all*
SDG 13 :*Take urgent action to combat climate change and its impacts*
SDG 15: *Protect, restore and promote sustainable use of terrestrial ecosystems*.

Questions to be addressed

How to increase rice production:

1. in conditions of climate change and reduced arable land

2. with reduced:

- water resources and chemical inputs

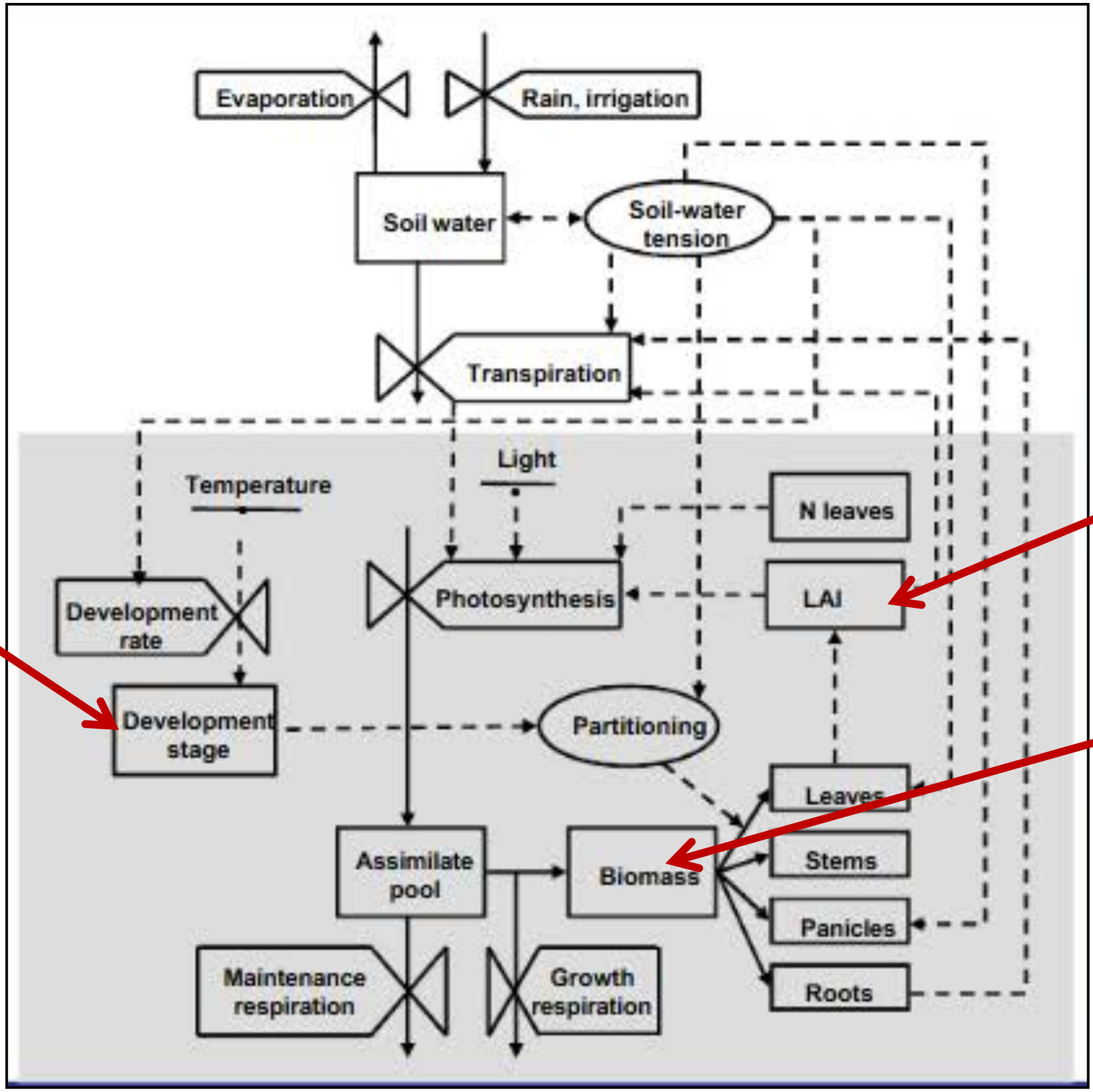
- methane and GHG and pollutant outputs

To address parts of these questions, one approach is to use models to simulate the effects of weather and cultural practices (inputs, water management..) on:

- rice yield (e.g. ORYZA2000)
- methane emissions and water used (e.g. DNDC)

The models used in situ data at experimental sites
The use of EO to provide a number of model inputs is assessed

Running OZYZA rice production model integrating Sentinel-1 data
Collaboration IRRI (Tri Deri Setiyono & Alice Laborte)



From Remote Sensing

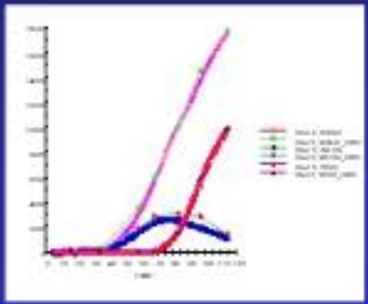
Simulation

Model input:

- Weather
- Crop properties
- Soil properties
- Management

Model output = calculated/predicted

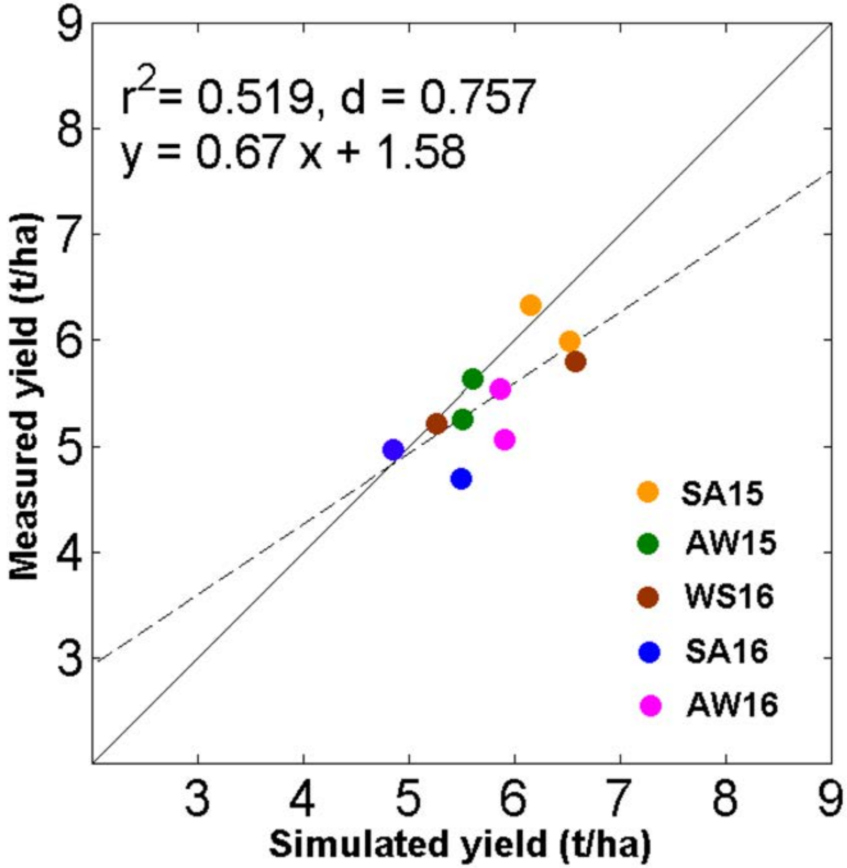
- Crop growth and development
- Yield
- Water requirements
- Nitrogen requirements
- ……



Real rice system

IRRI

Testing ORYZA2000 model with in situ data

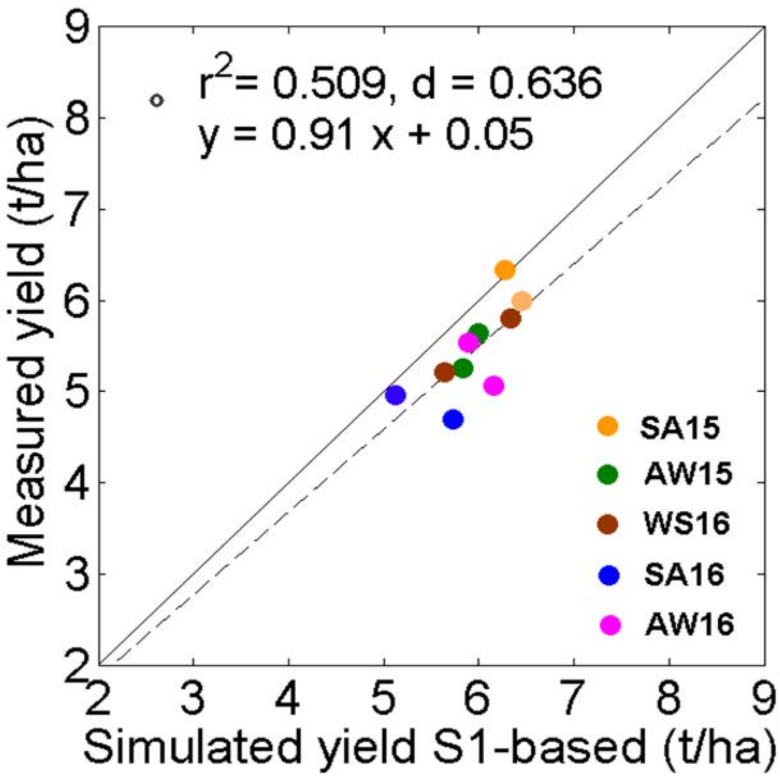


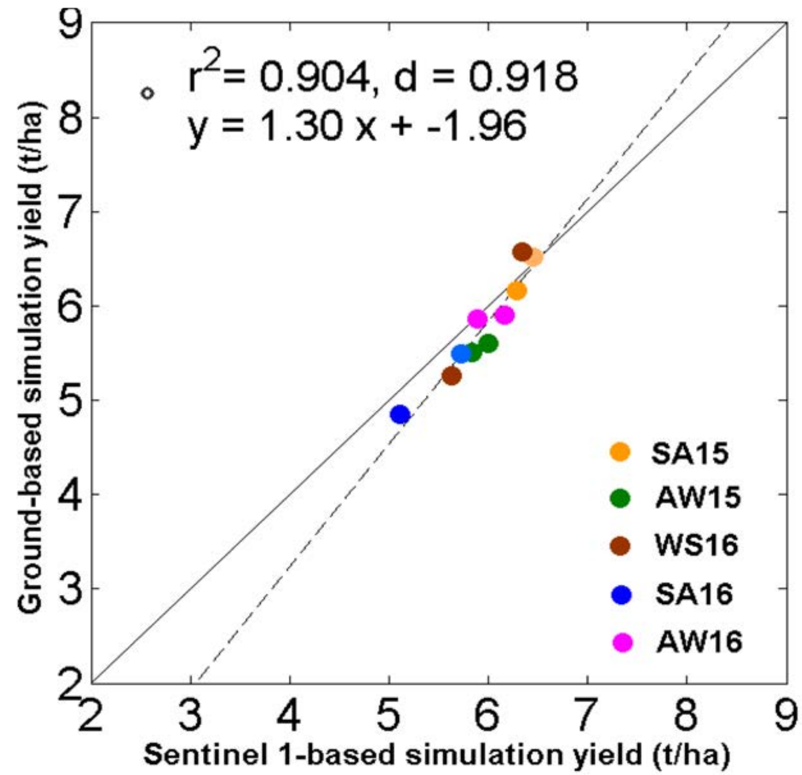
SA 2015 : highest : ~6 t/ha
SA 2016 : lowest , < 5 t/ha (El Niño)

Data for model inputs in collaboration with Dr. Horonori . Arai, The University of Tokyo

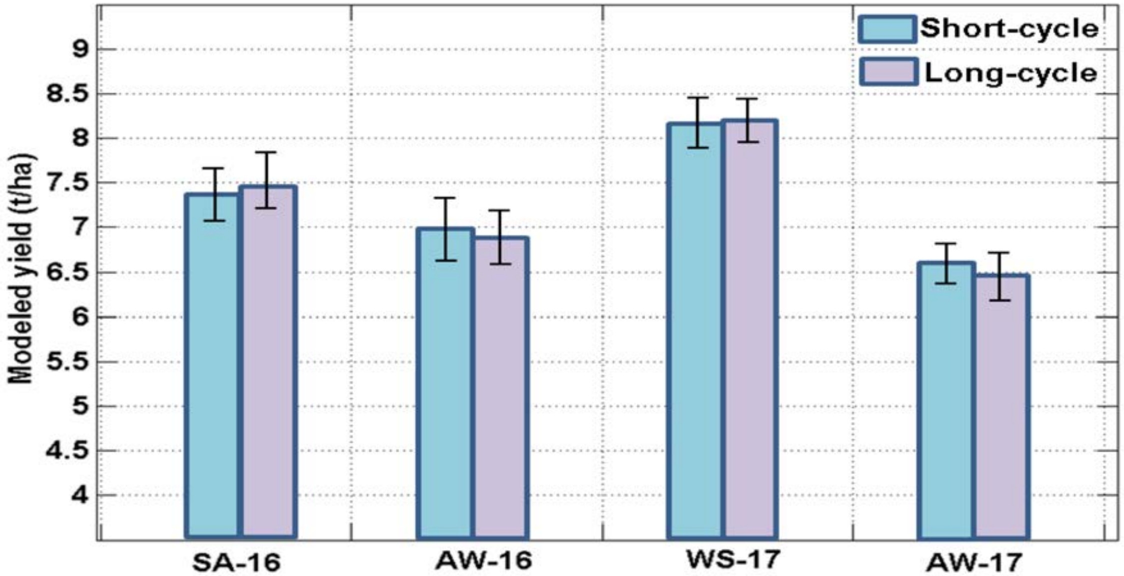
Testing ORYZA2000 model with inputs from EO data

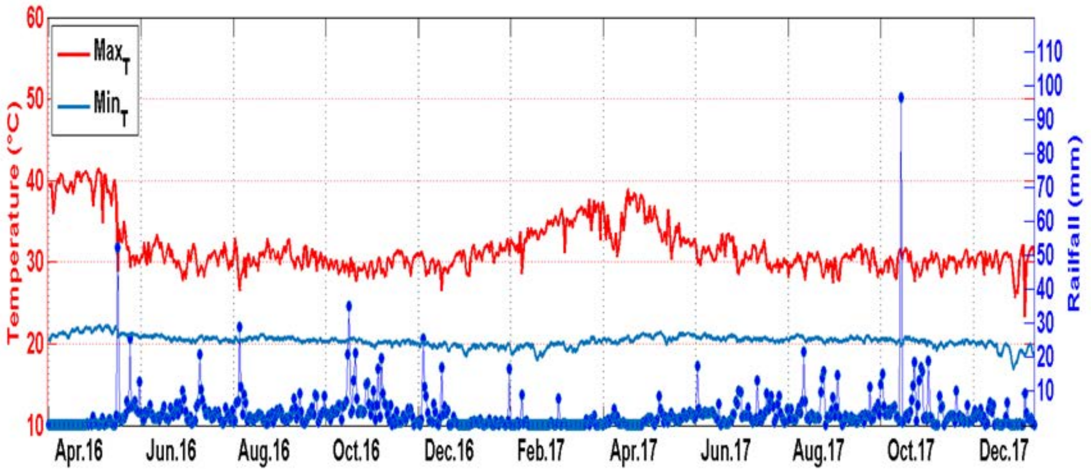
(start of season, season duration, phenological stages..)





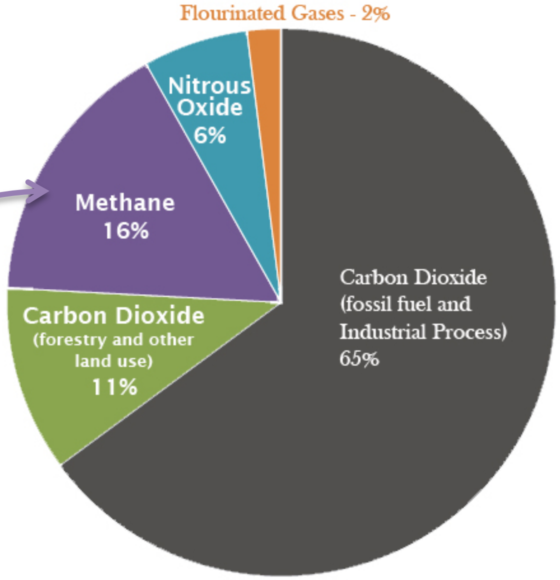
Model simulation provides similar yield for long and short cycle rice



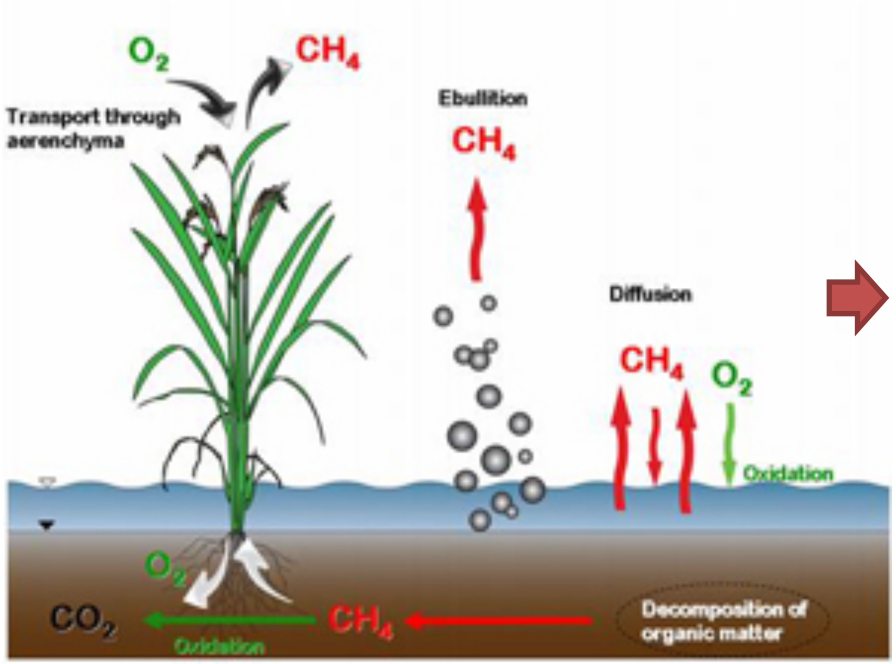


Rice fields, a major source of atmospheric methane

This process contributes about 25% of the total budget of global methane emissions



Greenhouse Gas Emission 2015



Feedback effect of rice production on climate change.

Rice is a major source of water consumption

Water management scenarios:

1. **Continuous flooding** (CF): 5-12 cm from initial flooding to 5 days prior to harvest
2. **Alternate wetting and drying** (AWD): Water table fluctuates ±5 -10 cm from soil surface.

AWD

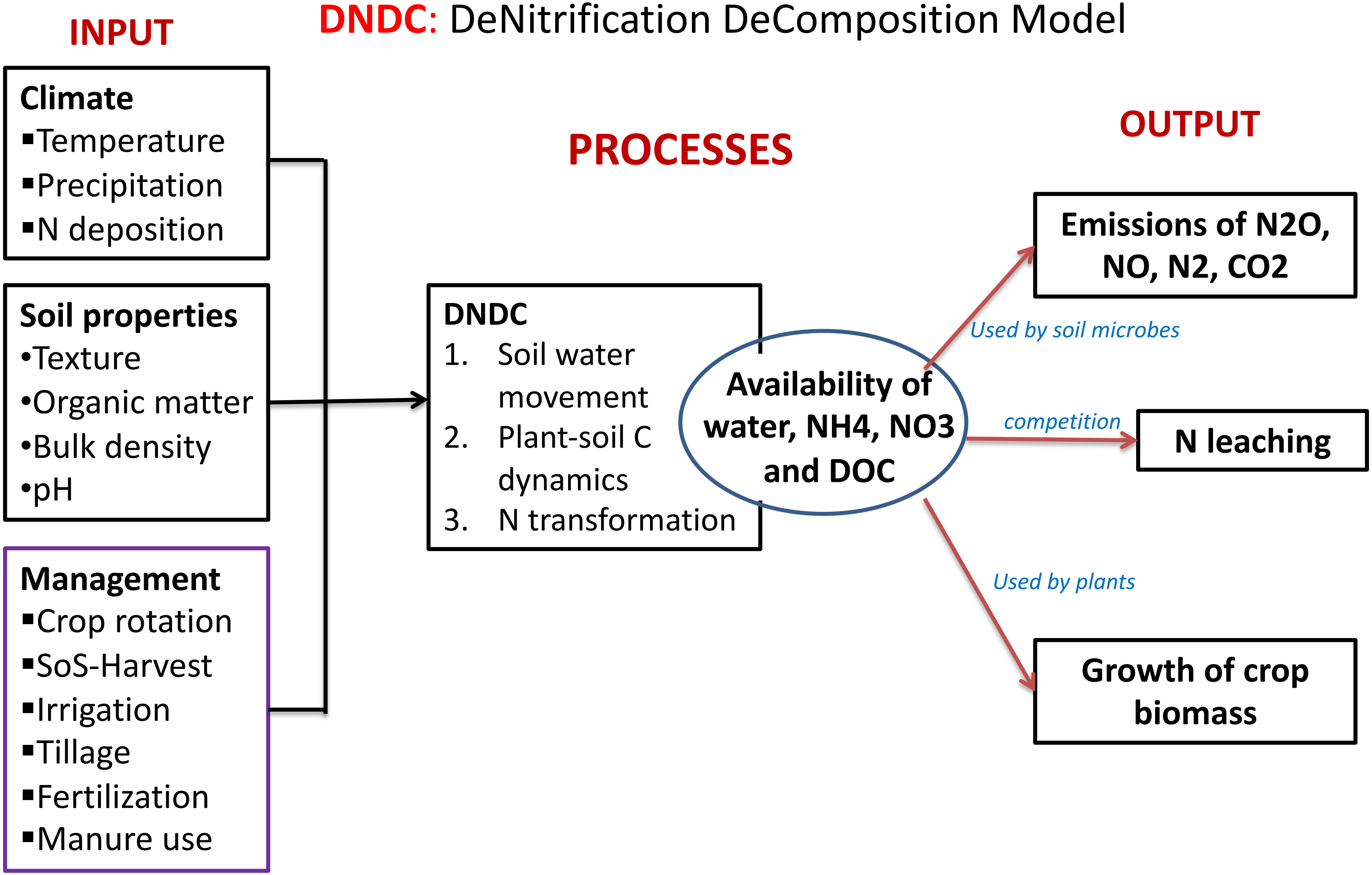
Biogeochemical Implications:

- Improve soil aeration;
- Stimulate root/shoot development;
- Increase soil mineralization.

Consequences:

- Increase crop yield;
- Decrease water consumption;
- Alter GHG emissions.

DNDC: DeNitrification DeComposition Model



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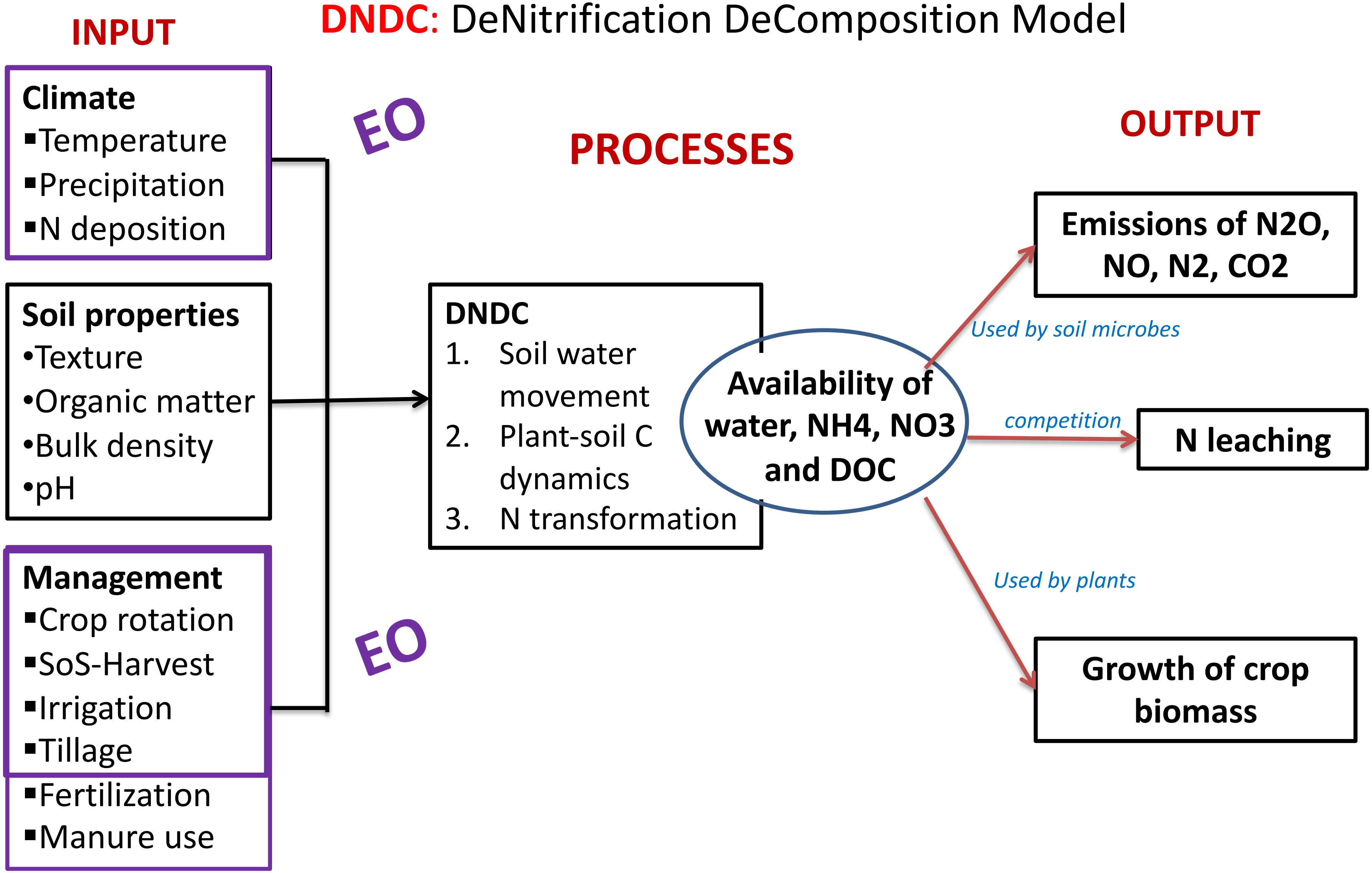
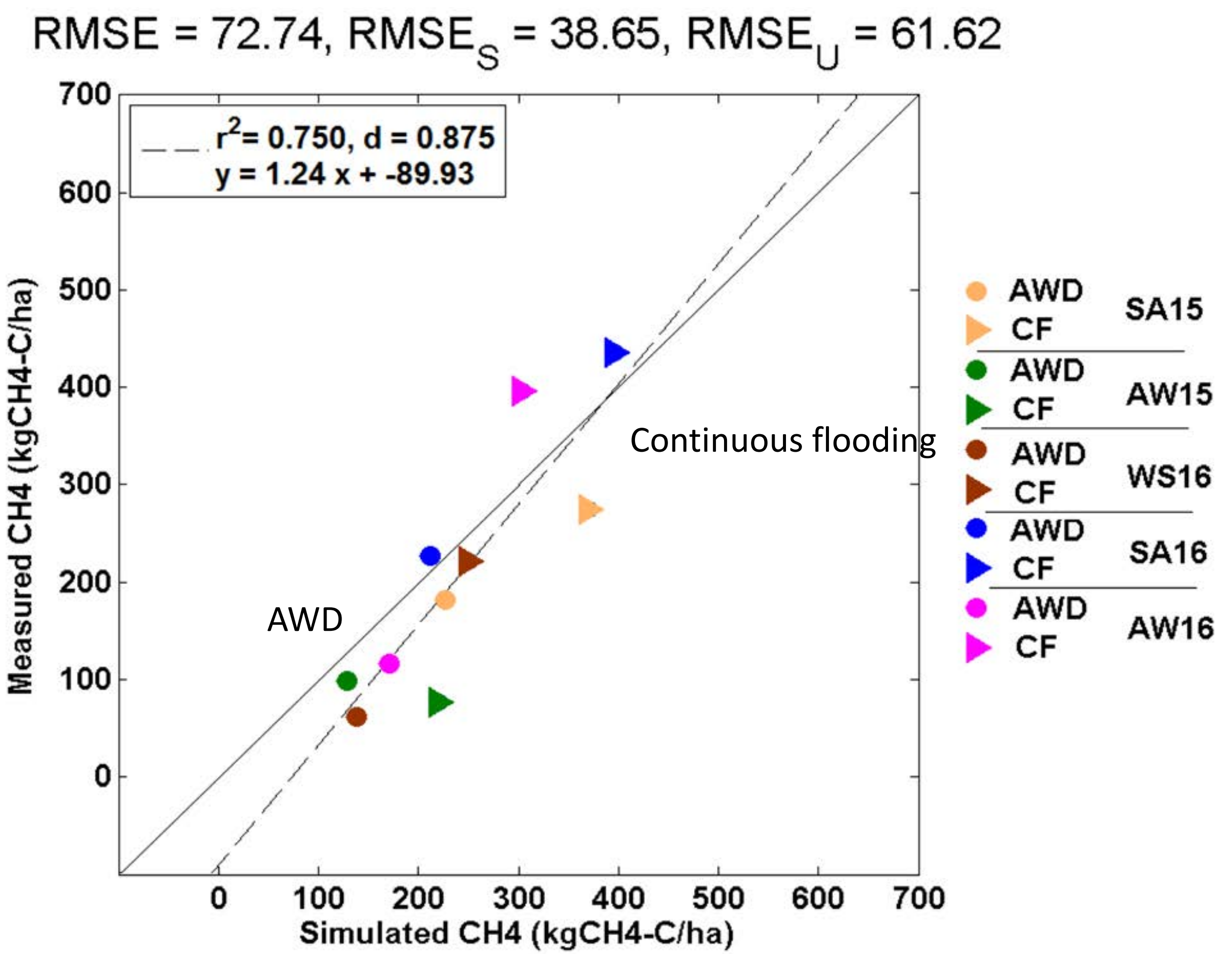
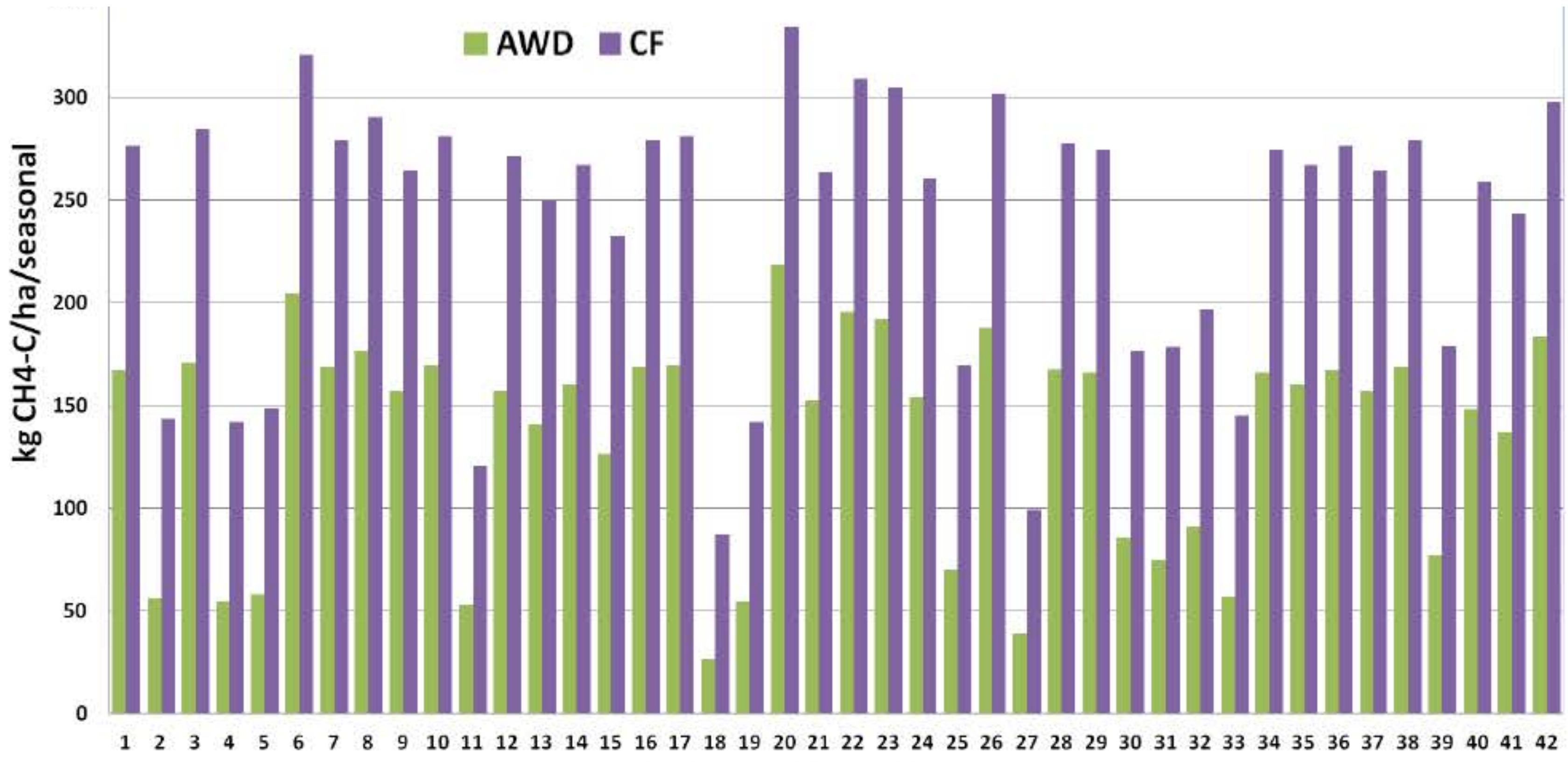


Testing CH4 emissions with DNDC



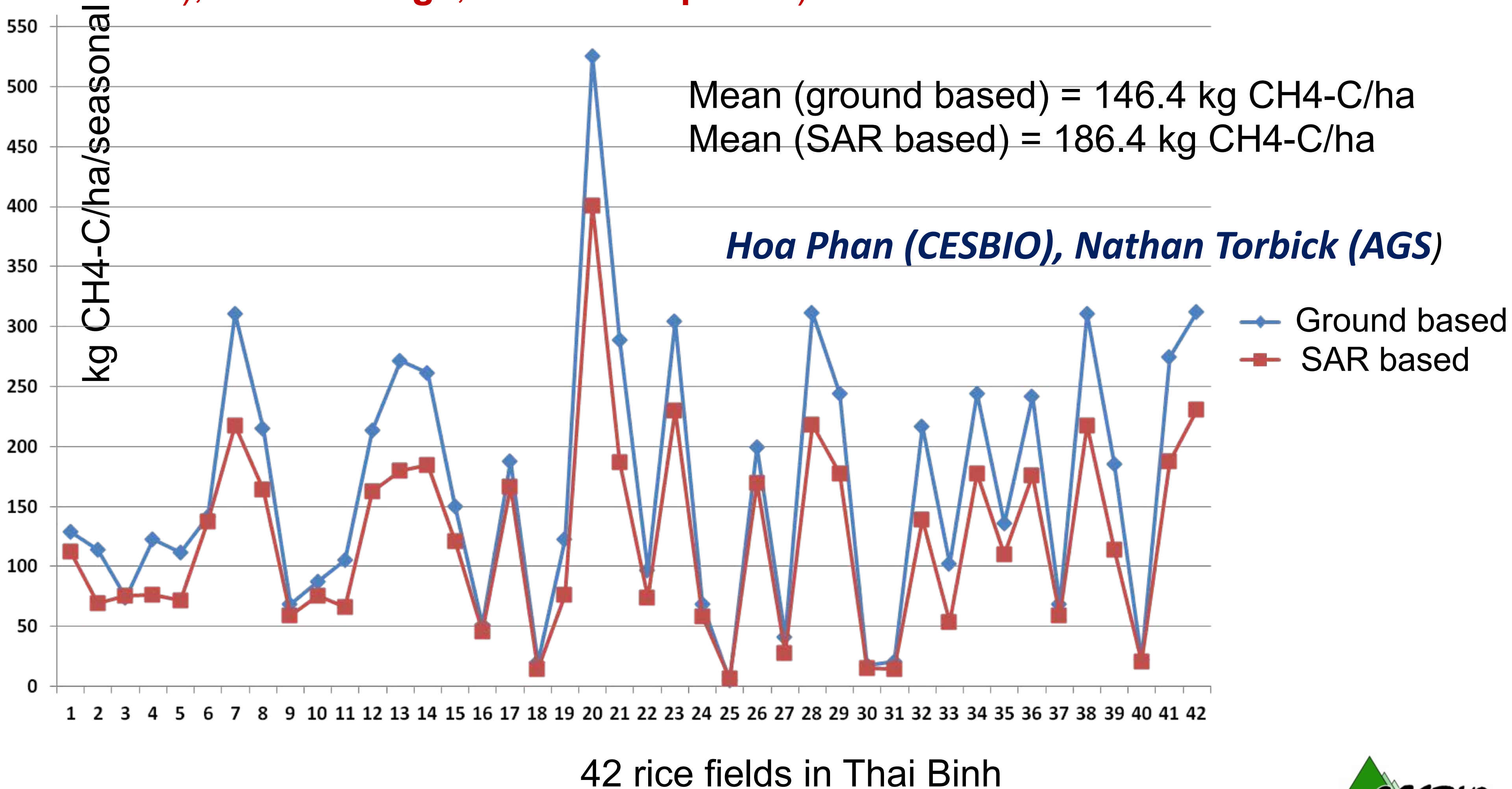


42 rice fields in Thai Binh

- Continuous flooding produces the highest CH4 fluxes
- AWD management practices contribute to reduce CH4 emissions

Estimation of seasonal CH4 emissions for 42 fields in Thai Binh

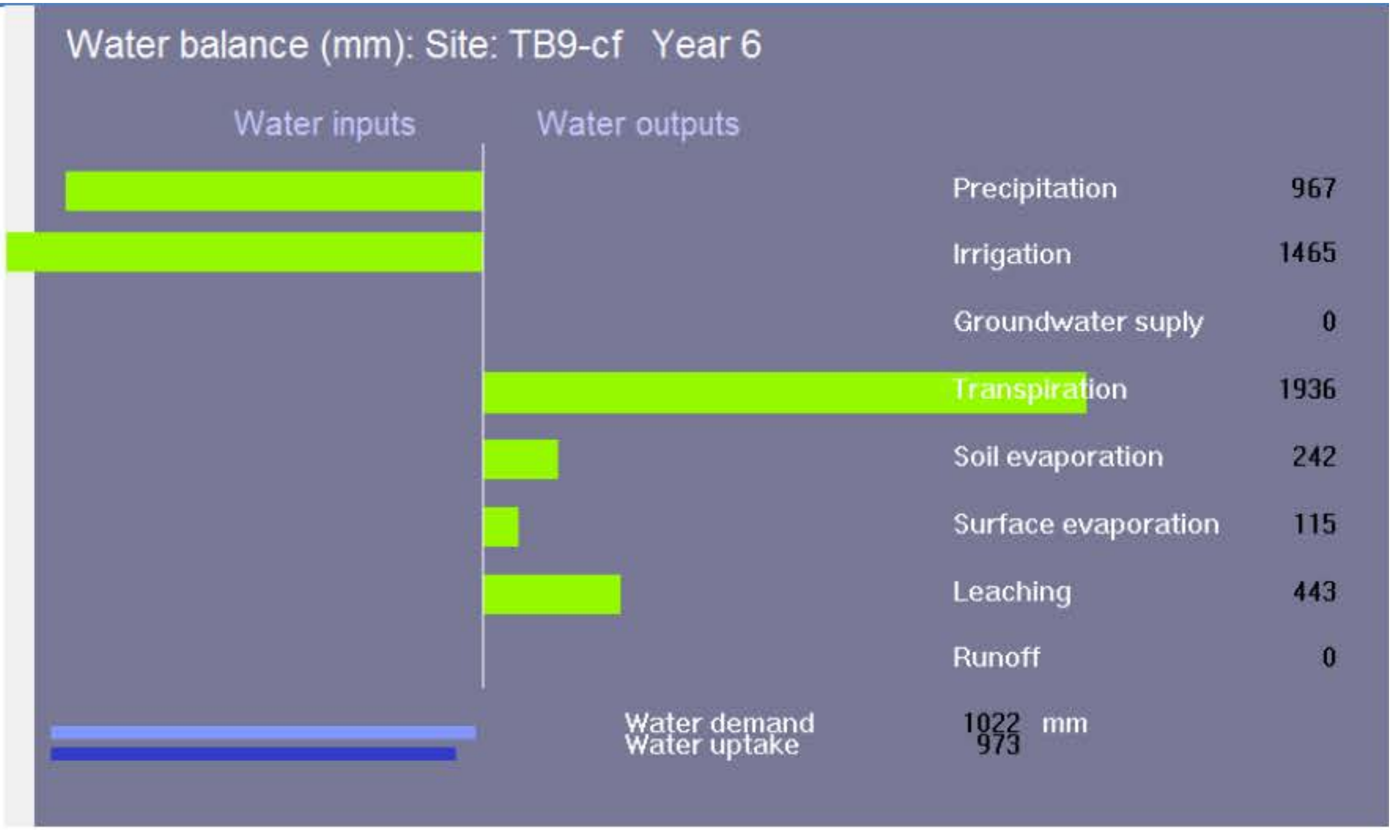
Comparison of simulations based on parameters collected by ground survey and detected using Sentinel-1(**Season rice maps**, **cropping density** (SoS and harvest), **Growth stage**, **Inundation period**)



Hoa Phan (CESBIO), Nathan Torbick (AGS)

CESBIO

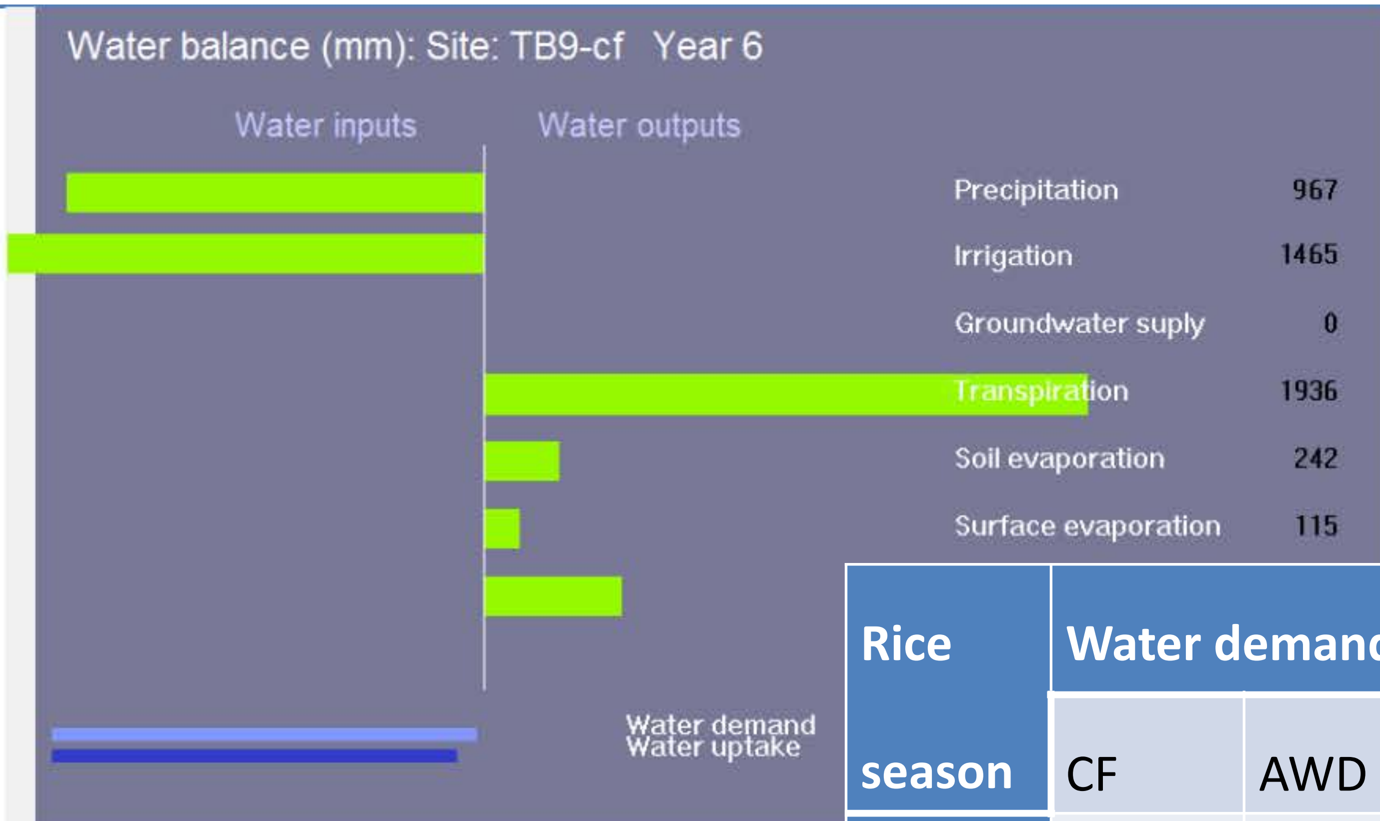
Test of water balance



Simulated of crop water budget:

→ Water uptake is higher in CF (973 mm) than AWD (742 mm)

Test of water balance



Rice season	Water demand		Water uptake	
	CF	AWD	CF	AWD
WS-16	1022	953	973	925
SA-16	1936	1210	1910	1198
AW-16	1407	1100	1380	1076

Simulated of crop water budget:

→ Water uptake is higher in CF (973 mm) tha

The remote sensing potential needs to go beyond the demonstration

1. To assess and harmonise remote sensing methods from Asia Rice partners ad to test the methods over rice ecosystems (rainfed, irrigated..)
2. To integrate satellite, ground-based data in multi-platform data base and models
3. To pursue integrated observations for food security, global change and environment

Collaboration among AO-GEOSS countries needed!

In spite of the progress, use of Earth Observation still limited in decision-support systems

TG5 will discuss the present status and perspectives of multi-platform observations for sustainable food security. (SDG 2)

- Output will go to GEOGLAM for G20 action plan
- Link with FAO and ASEAN Food Security System (AFSIS)

The multi-platform database and models will also be used to address issues related to SDG 6 clean water, SDG13, climate change, SDG15 ecosystems .

THANK YOU FOR YOUR ATTENTION!