Regional rice monitoring in South East Asia using Sentinel-1 data - The GeoRice project

Thuy Le Toan, Hoa Phan, Thierry Koleck, Alexandre Bouvet, Stephane Mermoz, Wenceslas Marie Sainte, CESBIO, Toulouse, France

Nguyen Lam Dao
VNSC/VAST, Ho Chi Minh City, Vietnam

Benjamin Koetz
ESA-ESRIN, Frascati, Italy

Land Use/Cover Changes, Environment and Emissions in South/Southeast Asia
An International Regional Science Meeting, 22-24 July, 2019, Johor Bahru, Malaysia
Rice is the most critical staple food for more than half of humanity, with the majority in developing world (90% in Asia).

Global rice production increases needed to meet demand by 2035 (source IRRI)

Sustainable Development Goal 2
More than 90% of the world’s rice production is from irrigated or rainfed lowland rice fields.

Total water input to rice fields is 2-3 times more than other cereals

Irrigated rice receives 34–43% of the total world’s irrigation water.

Worldwide, water for agriculture is increasingly scarce. It is estimated that, by 2025, 15–20 million ha of irrigated rice will suffer some degree of water scarcity.

Sustainable Development Goal 6
More irrigated rice generates more GHG

Rice fields: sources of methane

Atmospheric methane by Sentinel-5P mission - March 2019

Increase since 2010

Sustainable Development Goal 13
Need Earth Observation for Rice monitoring to support:

- Food Security: For Rice production estimates and Early warning (Asia-Rice/ GEOGLAM objectives) at local, national, global scale

- For the trade-off between productivity, water resources, GHG emission at regional and global scale

In support of Sustainable Development Goals
Objective
To develop and generate Rice monitoring products using Sentinel-1, from local to regional scale
- Rice area,
- Rice cropping density,
- Phenology, growth stage,
- Seasonal and interannual variations

Achievements of the GeoRice phase 1 (2016-2018)
1. Demonstration in the Mekong Delta
2. Implantation of rice mapping in DataCube Vietnam
3. Monthly rice map currently tested in VN Ministry of Agriculture
   Link with GEOGLAM crop monitor on going
GeoRice

Sentinel-1 to monitor rice growth

07/11/2015
GeoRice

Multi season, multi year mapping and statistics
El Niño event reduced rice harvested area

276000 ha less in 2016 compared to 2015, 1.39 M ha vs 1.67 M ha (16.7%)
## Change in rice crop calendar (2016, VN Mekong Delta)

<table>
<thead>
<tr>
<th>Province</th>
<th>Summer-Autumn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Tre</td>
<td></td>
</tr>
<tr>
<td>Vinh Long</td>
<td></td>
</tr>
<tr>
<td>Can Tho</td>
<td>22/3</td>
</tr>
<tr>
<td>Tien Giang</td>
<td></td>
</tr>
<tr>
<td>Long An</td>
<td></td>
</tr>
<tr>
<td><strong>Hau Giang</strong></td>
<td>9/2</td>
</tr>
<tr>
<td><strong>Hau Giang 2016</strong></td>
<td>10/8</td>
</tr>
<tr>
<td>An Giang</td>
<td></td>
</tr>
<tr>
<td>Ca Mau</td>
<td>1/5</td>
</tr>
<tr>
<td><strong>Dong Thap</strong></td>
<td>15/1</td>
</tr>
<tr>
<td><strong>Dong Thap 2015</strong></td>
<td>15/5</td>
</tr>
<tr>
<td><strong>Dong Thap 2016</strong></td>
<td>30/8</td>
</tr>
<tr>
<td>Tra Vinh 2015</td>
<td></td>
</tr>
<tr>
<td>Tra Vinh 2016</td>
<td></td>
</tr>
<tr>
<td>Bac Lieu</td>
<td>1/6</td>
</tr>
<tr>
<td>Kien Giang</td>
<td></td>
</tr>
<tr>
<td>Soc Trang</td>
<td></td>
</tr>
</tbody>
</table>

**Traditional sowing date**
GeoRice
Adaptation measures by provinces

Change in cropping density

2015

2016
Alternate Wetting Drying reduces water demand, reduces methane emission, without significant change in yield
The Regional GeoRice objective is to up-scale the proof-of-concept for rice monitoring in the Mekong delta to larger regions.

GeoRice extension main objectives are to:

• Demonstrate in five countries in South-East Asia (Vietnam, Lao, Cambodia, Thailand, Myanmar)

• Update and maintain the GeoRice processing system in a cloud computing environment

• Make the GeoRice processing system available as open source

Many of the climate change issues impacting rice cultivation are transboundary: water use, flood, drought, salinity intrusion... As well as the market price. These requires harmonized observations over large regions.
Challenges:
1. Big data: from Mekong Delta to 5 countries in SE Asia
2. Diversity of rice cropping systems
GeoRice  Diversity in rice ecosystems & cultural practices

Rice Varieties / Method of sowing

- **Long cycle**: transplanting
- **Short cycle**: direct seeding

Water management

1. **Continuous flooding (CF):**

   5-12 cm during growing cycle

2. **Alternate wetting and drying (AWD):**

   ±5-10 cm at certain dates
Issues: Determination of the S1 time series period including the start and end of a rice season. Automation of the processes.
Two major steps:

1. S1 data pre-processing
   Building the calibrated, orthorectified, speckle filtered time series over the area of interest (as in datacube)

2. Time series analysis (pixel-based) for product generation
GeoRice

Data Preprocessing

S1 database

Data request

S1 GRD image dataset

Calibration, Projection, Concatenation

Projected Images

Filtered time series

Region of interest

Multi-image filtering

GeoRice
• Calibration
• Orthorectification with terrain correction
• Mask generation
• Images concatenation
Building the calibrated, orthorectified, speckle filtered time series over the area of interest (as in datacube)
GeoRice

Time series analysis: irrigated rice

Every 6 days

From Proba-V
Irrigated Rice

THAILAND: Wet Season Rice Production

Wet Season Rice Tons (2014)

- 0 - 20,000
- 20,001 - 200,000
- 200,001 - 500,000
- 500,001 - 1,000,000
- 1,000,001 - 1,415,000

% = Percent of Total Production
Source: Office of Agricultural Economics (OAE)
USDA Foreign Agricultural Service
International Production Assessment Division

DESCENDING - 40°
Temporal variation of S1 over rice seasons - 47PPS
All field, 100 dates

VH

VV

VH/VV

2016

GSMAP Rain data 98% of the hits
Rainfed Rice

THAILAND: Wet Season Rice Production

Wet Season Rice
Tons (2014)
- 0 - 20,000
- 20,001 - 200,000
- 200,001 - 500,000
- 500,001 - 1,000,000
- 1,000,001 - 1,415,000

% of Total Production
Source: Office of Agricultural Economics (OAE)
Thailand Provincial 2014 data

DESCENDING (34-35°)
Temporal variation of S1 over rice seasons - 48PWB
All field, 104 dates

VH

VV

VH/VV

GSMAPI Rain data 98% of the history

mm/day
Time series analysis: cropping density

1 rice crop/year
(rice-shrimp)

2 rice crops/year
(rice-rice-vegetable)

3 rice crops/year

Change from rice to other type
GEORICE first rice map covering 4 countries
High resolution rice mapping at large scale in SE Asia demonstrated. Result validation on going.

Rice growth status every 12 days: big challenges at large scale
Possible regional solutions by rice ecosystems

Contact with effective users to be consolidated
Bokchoy
Cabbage
Eggplant
Temporal variation of S1 over rice seasons - 4BQXH
Field id: #21, 3 pixels, 112 dates, | 35.0deg

VH

VW

VH/VV

DB

GSMAP Rain data 98% of the histo
Morningglory
Temporal variation of S1 over rice seasons - 4BQXH
Field id: #14, 19 pixels, 112 dates, | 35.0 deg

VH

VV

VH/VV

GSMAP Rain data 98% of the histo