Remote Sensing based
Crop Yield Monitoring & Forecasting

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Presentation Outline

• Background
• RIICE Service Platform
• The tools:
  – Radar remote-sensing
  – Crop growth model
• Integrated RS & crop modeling
• Yield forecasting
• Summary
Background

Rice in South East & South Asia:
Small holder farmers, vulnerable to climate uncertainties

2011 Thai Flood (Chao Phraya Basin)
Remote sensing-based Information and Insurance for Crops in Emerging economies

Project Targets:
- 7 countries, 5 million farmers, in 5 years.

1. Reduce the vulnerability of 5 million rice farmers in Asia and beyond to flood and drought over the next 5 years.

2. Help Governments and NGOs to better plan for food crises through better crop growth monitoring.

3. Increase efficiency and effectiveness of crop insurance solutions and turn it into a viable business also in emerging markets.

RIICE Service Platform

- MAPscape-Rice processing & product generation
- Earth Observation data
- Crop calendar
- Crop practices
- Administrative units
- Leaf Area Index in situ point data
- Oryza2000 rice growth simulation model
- Meteo data
- Soil data
- Phenological data
- Management data
- Yield estimation
- Production

www.riice.org
Rice from optical and radar RS
Space-born Earth Observation

- Software: MAPscape-Rice (Sarmap SA)
- Radar Data: Cosmo-SkyMed (40 x 40 km, 3 m, X-band) (Italian Space Agency/e-GEOS)

Leyte, Philippines

Rice extent, 1 ha resolution
ASAR wide swath
2004 to 2012
Single season rice area; 3m CSK; June to September 2012
© Cosmo-SkyMed data ASI distributed by e-GEOS,

Data processed using MAPscape-Rice.
**Leyte, Philippines**

**Rice field phenology**

**Wet season 2012**

Inferred from SAR product.

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**Remote Sensing based Crop Yield Estimation**

Expert Meeting on 'Crop Monitoring for Improved Food Security'

17 February 2014, Vientiane, Lao PDR

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**IRRI**

International Rice Research Institute

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**30 Sep 2012**

End September, the area is a mixture of green crops (green), maturing (yellow), and already harvested fields (brown).
**Red River Delta, Vietnam**

Rice extent (1 ha), ASAR WS (2003 to 2010). Seasonal rice, 3m Cosmo-Sykmed (SM) January to May 2013. Different colors correspond to the different dates of start of season (SoS).

**Cambodia**

Rice extent (1 ha), ASAR WS (2005 to 2010). Seasonal rice area for short duration (green) and medium-long duration (green) in sample area near Takeo, Cambodia based on 3m Cosmo-SkyMed SM (September 2012 to March 2013).

© Cosmo-SkyMed data ASI distributed by e-GEOS, processed using MAPscape-Rice.

Data processed using MAPscape-Rice.

**Tamil Nadu, India**

Rice area (15m), ASAR IM (2011), Cauvery Delta, India Seasonal rice area, Thanjavur, TN, India, Cosmo-Sykmed (Sep 2012 to Feb 2013). Colors – start of season (SoS).

© Cosmo-SkyMed data ASI distributed by e-GEOS, processed using MAPscape-Rice.

Data processed using MAPscape-Rice.
**Damage Assessments**

Flooding Muang Yang, Thailand, Oct 2013
(image provided by GISTDA)
Oct 2 – blue; Oct 6 – cyan

Taiphon Haiyan (Yolanda),
Leyte Philippines, Nov 2013

Areas flooded on February 9th are in blue.

The red box borders the area where some floods could have occurred in between February 5th and 9th.

Subang, Indonesia, Feb 2014

CSK images provided by e-geos.
CSK images processed by sarmap.
Crop Growth Model: ORYZA2000

ORYZA2000: a rice growth simulation model

- Potential, water-limited, and/or nitrogen-limited conditions
- Lowland & upland/aerobic rice
- Weather, irrigation, nitrogen fertilizer, general management, variety characteristics, soil properties

Weather Data
- Daily Time Step
- Variables:
  - Solar Radiation
  - Min Temperature
  - Max Temperature
  - Relative Humidity
  - Wind Speed
  - Precipitation
Performance of ORYZA2000 in simulating rice yield

Experimental plots
Potential, water-, or nitrogen-limited environments

ORYZA2000
Rice Crop Growth Simulation Model

Irrigated Rice Yield (2009 Dry Season)

Source: BAS
Simulated (ORYZA2000)

BAS - Philippines Bureau of Agricultural Statistics
Yield trends in long-term continuous rice cropping

- Actual measured yield in dry seasons, 1992 to 2010
- 6.5 to 9.5 tons/ha
- Measured yield depends on weather and management

- Potential yield is the maximum plausible yield of a variety under certain climatic conditions
- Potential yield is obtained using crop simulation models (ORYZA2000)
- Potential yield varies according to weather

Slide: Courtesy of Roland Buresh (IRRI)
### Integrated RS & Crop Growth Model

**Leyte West, Philippines, Wet Season 2012**

**Yield accuracy at barangay level**

Preliminary accuracy assessment of RS-based rice yield estimation

<table>
<thead>
<tr>
<th>Barangay</th>
<th>Yield (ton/ha)</th>
<th>RMSE (kg/ha)</th>
<th>Accuracy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ARBY CCE</td>
<td>RS estimate</td>
<td></td>
</tr>
<tr>
<td>Amahit</td>
<td>2.96</td>
<td>1.94</td>
<td></td>
</tr>
<tr>
<td>Cuta</td>
<td>3.79</td>
<td>4.32</td>
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<tr>
<td>Liloan</td>
<td>5.96</td>
<td>5.04</td>
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<tr>
<td>Matica-a</td>
<td>5.14</td>
<td>5.69</td>
<td></td>
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<tr>
<td>Sabang Ba-o</td>
<td>4.99</td>
<td>4.94</td>
<td></td>
</tr>
</tbody>
</table>

National Province Municipal Barangay
## Insurance & RS-based Yield Estimates

Comparison of ARBY* yield and Remote Sensing yield for 2012 WS

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Yield trigger at 95% (ton/ha)</th>
<th>Yield (ton/ha)</th>
<th>ARBY</th>
<th>RS estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barugo</td>
<td>3.62</td>
<td>5.12</td>
<td>5.63</td>
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<tr>
<td>Ormoc City</td>
<td>3.74</td>
<td>5.31</td>
<td>5.56</td>
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</tr>
</tbody>
</table>

Agreement between ARBY and RS yield estimates

**No payout in WS 2012**

*ARBY – Area Based Yield Crop Insurance Policy

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**Integrated RS & Crop Growth Model**

**Leyte West, Philippines, Wet Season 2012**

**www.riice.org**

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**International Rice Research Institute**
Reducing uncertainties in yield forecast
Integrated RS & Crop Growth Model
- RS -> in-season crop status
- CSM -> weather + crop status = yield

Hansen et al. 2006

LAI estimate from RS
55 days before harvest
Corrects the forecast &
get closer to actual yield
of 5.2 Mg/ha

• Incorporation of remote sensing products (SAR) into
  crop model is essential:
  • Reduces non-remote sensing parameters, e.g. SAR derived LAI
capture the response of rice plants to environmental conditions over
large areas
  • Includes rice phenology to initialize the model
  • Improves yield estimation for actual yields, allowing reliable
application such as in a crop insurance system

• National partners involvements are crucial:
  • The only way to sustain, promote and validate operational crop
monitoring system
  • Terrestrial data collection for calibration and validation & provision of
knowledge on rice types and practices that are essential for product
generation

Summary