Integration of Remote Sensing and Crop Model for Yield Estimation

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and
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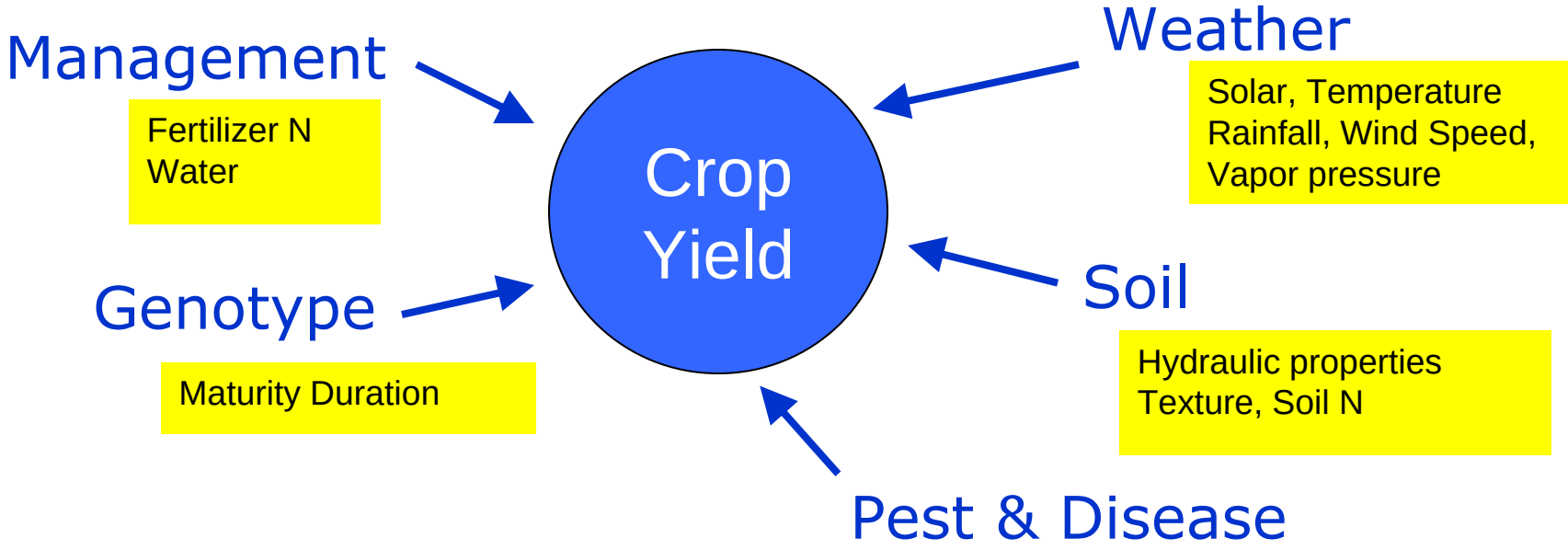
Why do we need to model yield?

- Yield estimates is useful to anticipate production, market dynamics, plan for food export/import and local and regional policy support.
- Ability to make yield estimates before or after harvest using remote sensing data can be of paramount importance for timely decision making
- Using frequent remote sensing data, there is now a potential to provide quantitative, spatially detailed, and timely information on yields over large areas which can be used for
  - damage estimates in the event of flood or drought
  - better statistics (area, yield, production)
  - developing crop insurance products that need good yield data
  - research and development

Crop growth simulation models (CGSM)

- Crop growth simulation models (CGSM) like ORYZA , DSSAT, APSIM are explanatory models that estimate the growth rate of the crop at every crop stage based on rate and state variables (G), weather and soil (E), water and nutrients (M).
- **ORYZA**, is an ecophysiological model which simulates growth and development of rice including water, C, and N balance in lowland, upland, and aerobic rice ecosystems. It works in potential, water-limited, nitrogen-limited, and NxW-limited conditions.
- Point based (field level) models that estimate the yield for a rice plant accurately when many of the above variables are known or well defined.
- Needs a lot of information for just one point.
- Not spatial, and almost impossible to get all that information for every field and farmer.

Crop growth simulation models (CGSM)



Crop Simulation Model (CSM). e.g. ORYZA

…more variables to consider than the human mind can reasonably organized (Whisler et al 1999)

Assimilation of RS data into CGSM Assimilation means combining a model with observations.

- RS data is an indirect measure or proxy of crop growth, LAI or biomass over a large area, with good spatial detail.
- RS data has been used many times to calibrate CGSM to generate better and/or more spatially detailed yield estimates.
- What is **new in this method** is that we are linking three pieces of software together (**MAPscape-RICE, ORYZA, RiceYES**) to make spatial yield estimation

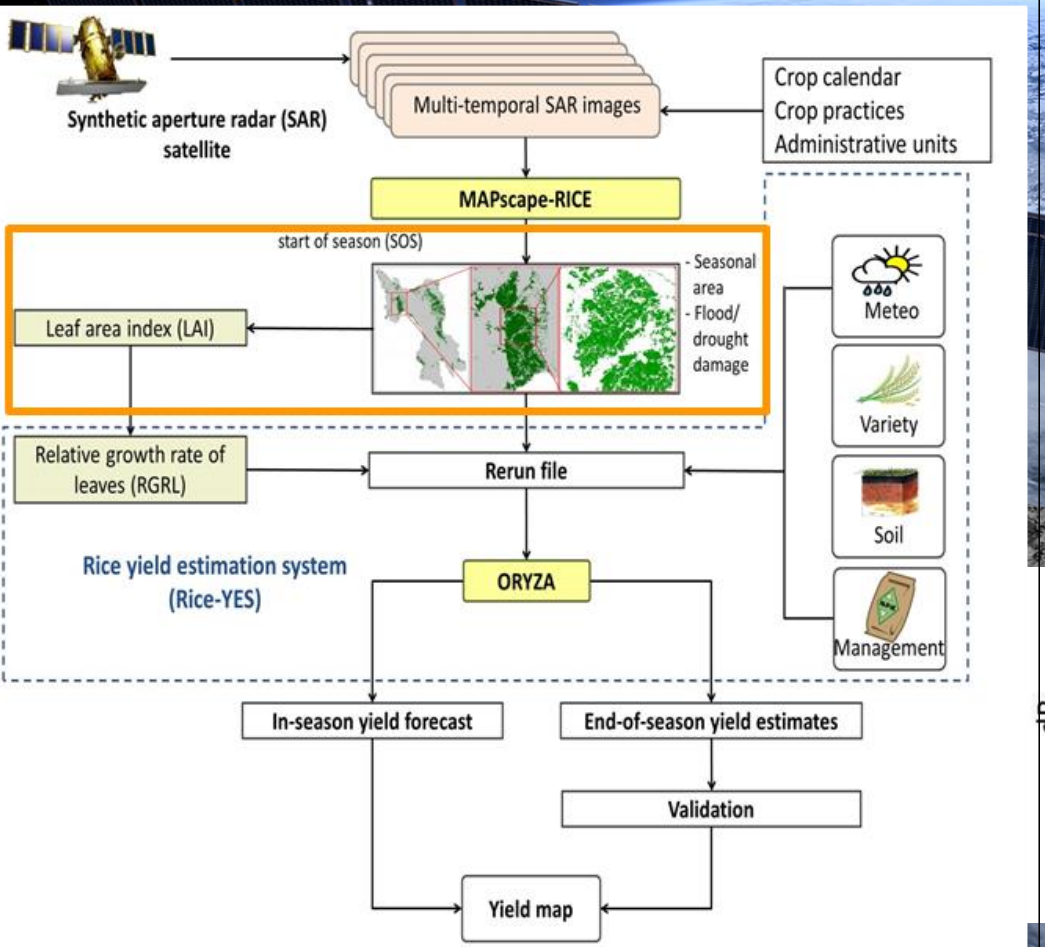
❑ more user friendly

❑ more robust over different GxExM interactions that represent the many different rice systems in Asia.

❑ faster and more efficient

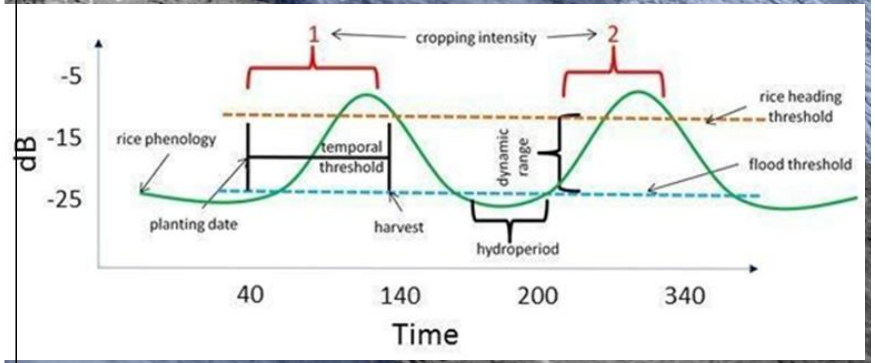
❑ possible for mid-season forecast as well as end-of-season

Integration of rice and crop models



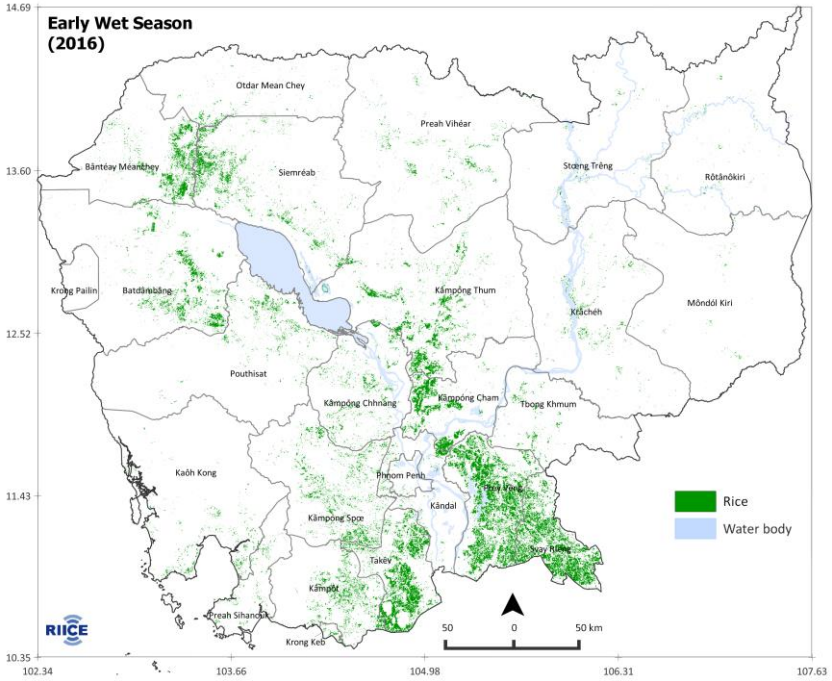
Sentinel-1a & 1b (European Space Agency)

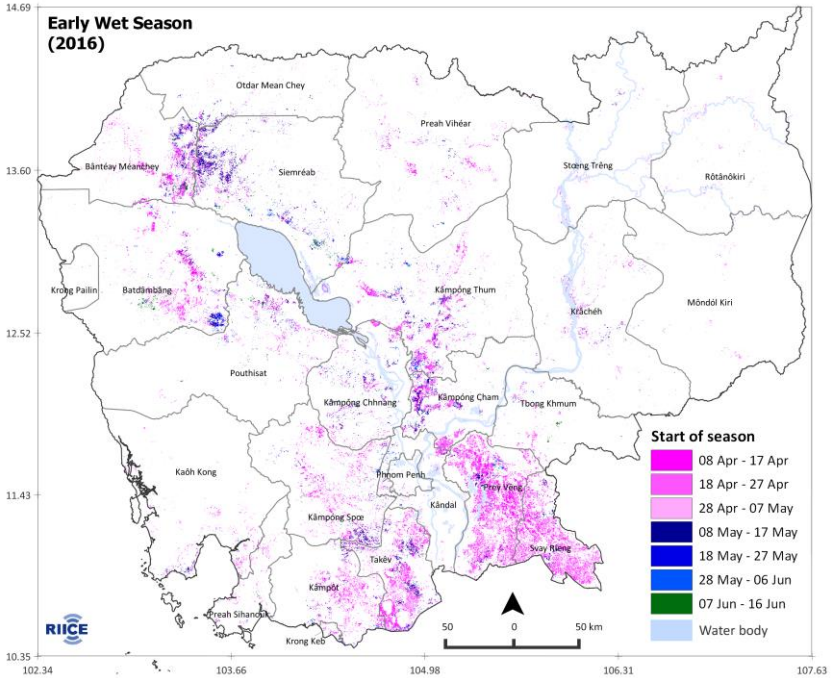
- Launched 3rd/April/2014 by ESA
- Non-cloud sensitive
- Up to 6 days
- C-Band (5.405 GHz)
- Dual polarization: VV+VH
- Free and open access to imagery



Operational diagram of **yield** estimation

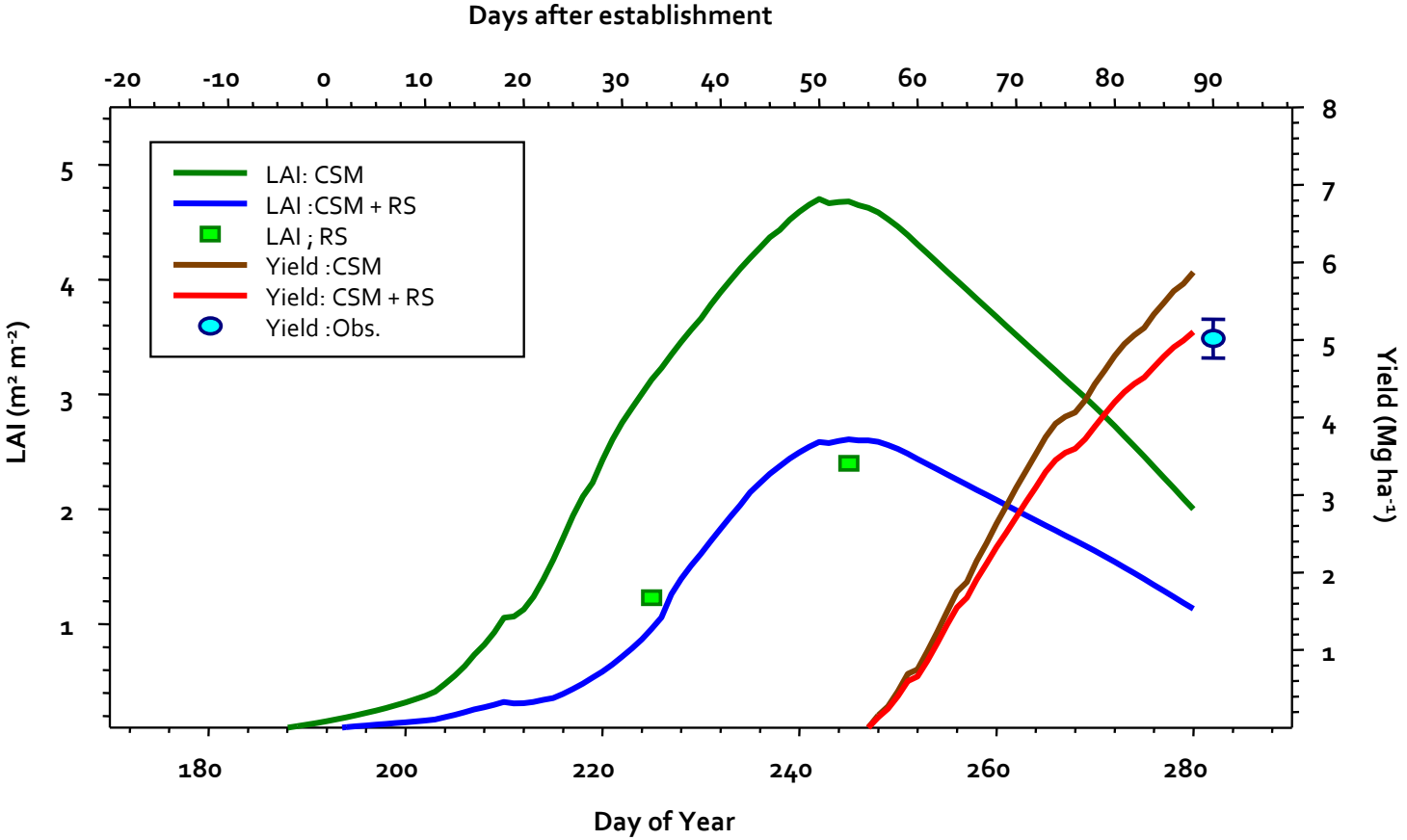
Generated products from SAR





Rice area and Start of season maps are important inputs in yield estimation

SAR & Crop Model based Rice Yield Estimation



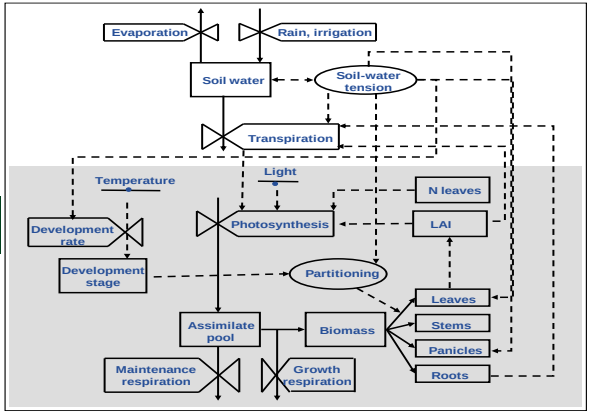
CSM– Crop Sim. Model; RS – Remote Sensing; Obs. - Observed

Rice Yield Estimation

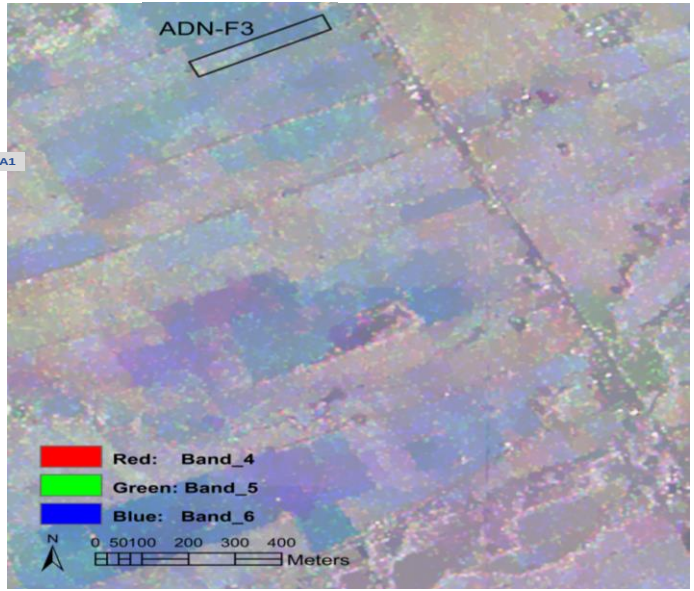
Scale: Field

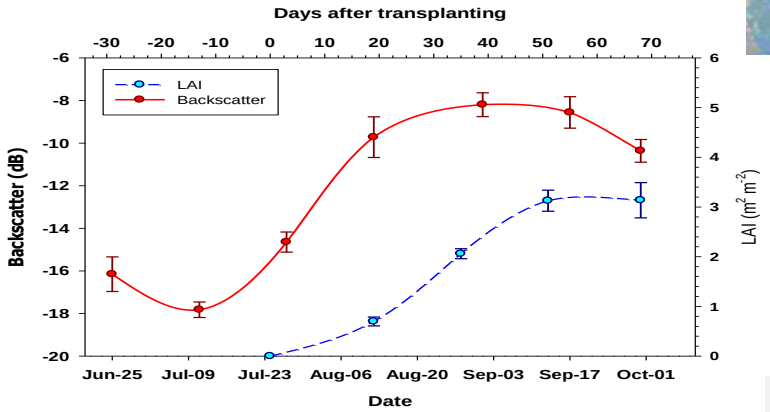
RS

Scale: Spatial



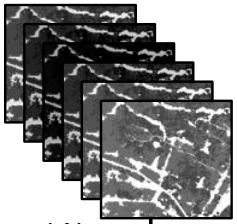
ORYZA1





SAR & Crop Model based Rice Yield Estimation

Multi-temporal σ°

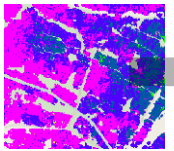


LAI

WeatherID
453300
454742
454741
454744

LAI
1.65-3.50
1.45-1.65
1.41-1.45
1.38-1.41
1.34-1.38

SoS
2015297
2015309
2015321
2015333



Start of Season (SoS)

MAPscape-RICE

Input for Crop Yield Model

CYM

Rice-YES

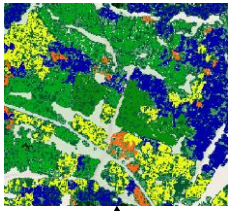
ORYZA

LUTID	Yield
1	5847
2	5748
3	5183
4	4240
5	2153

remapping

MAPscape-RICE

Yield Raster

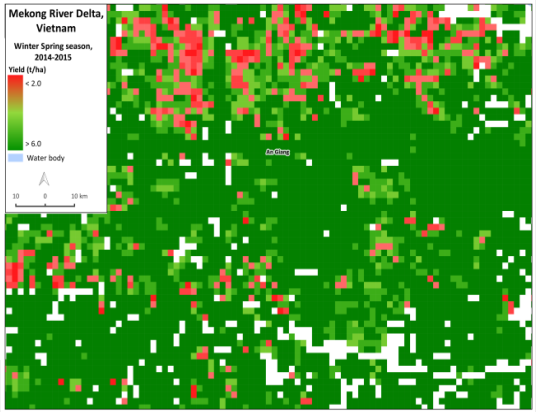


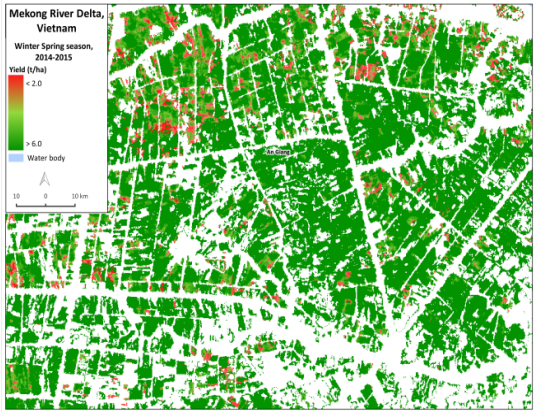
Setiyono *et al*, 2019
IJRS 40 (21): 8093-8124
https://doi.org/10.1080/01431161.2018.1547457

Processing Time for Dong-Xuan (Winter Spring) Rice in Mekong River Delta, Vietnam

30 h

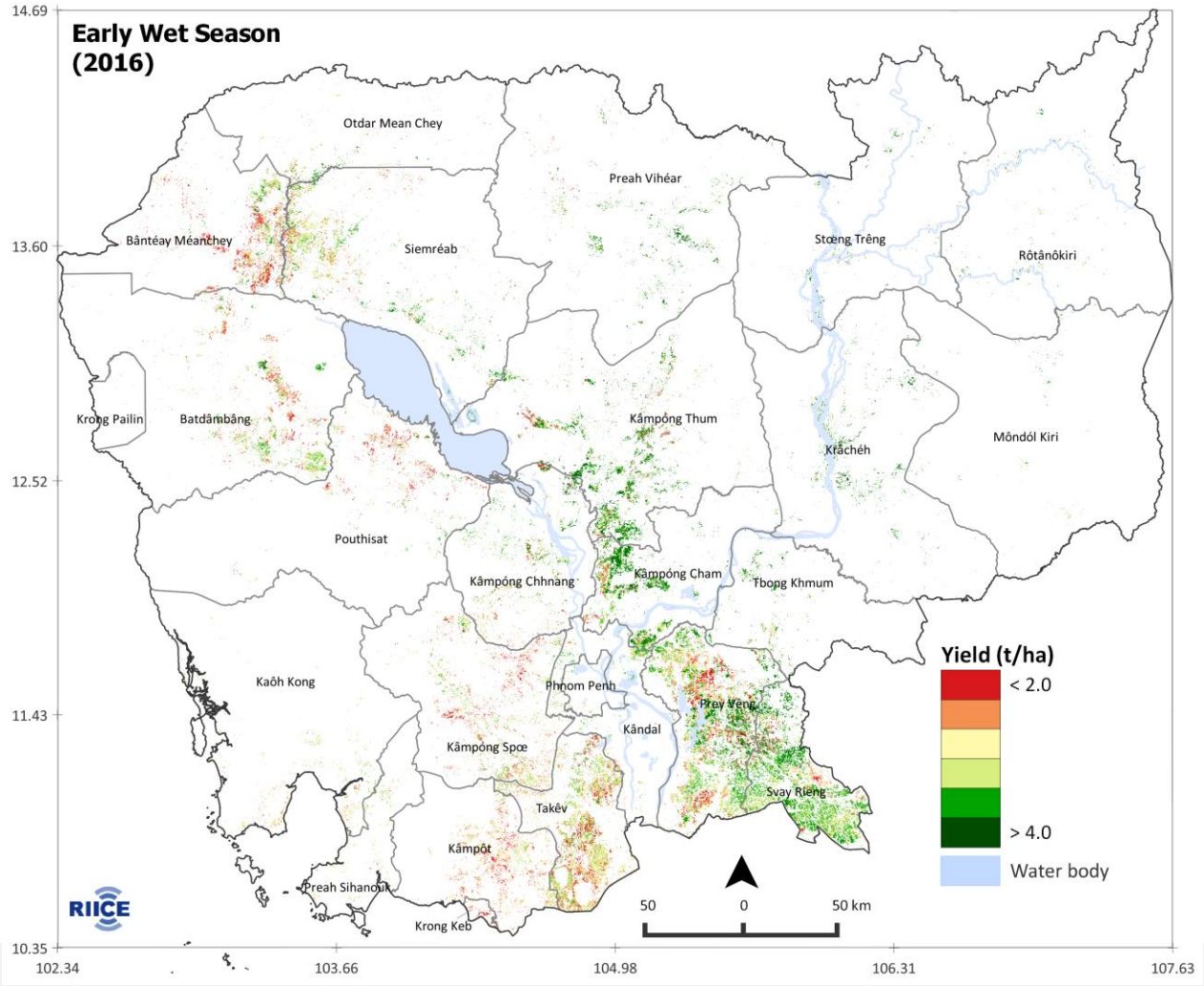
5 h



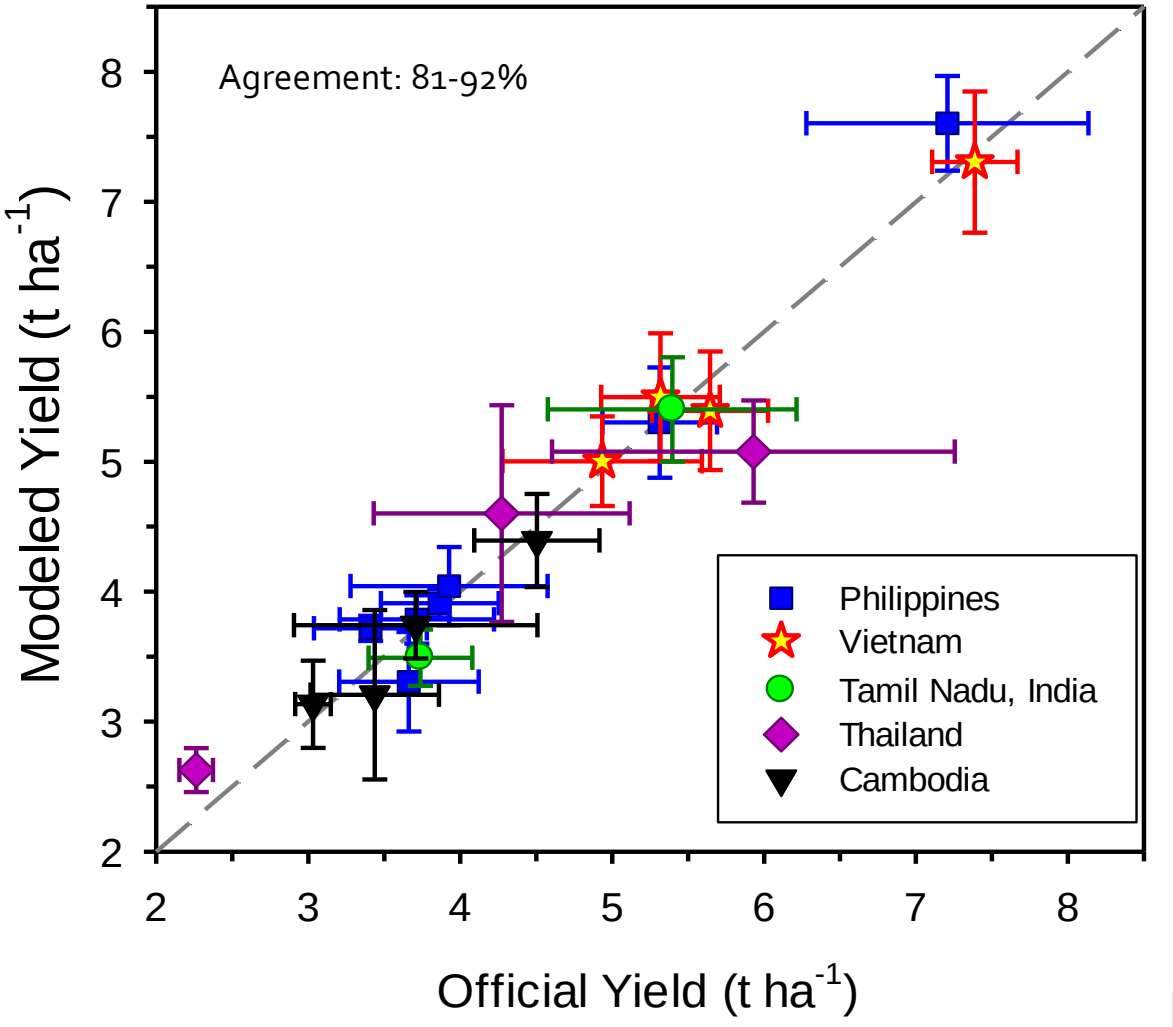


IRRI

Generated yield map

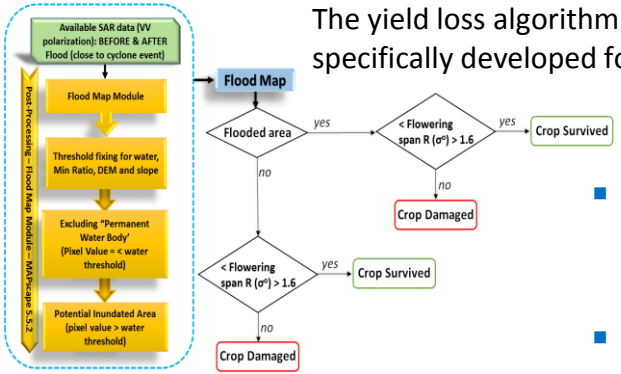


RIICE yield estimates Validation in Multiple Sites (2012-2016)

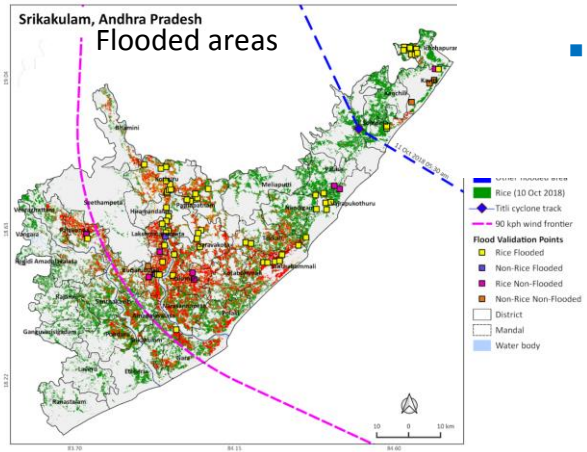


Yield Loss Assessment (Impact of Cyclone and Flood)

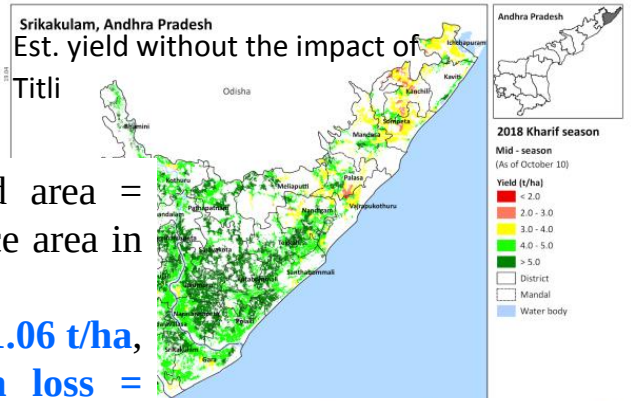
Rice crop damage assessment due to 'Titli' cyclone in Srikakulam, 12 Oct 2018

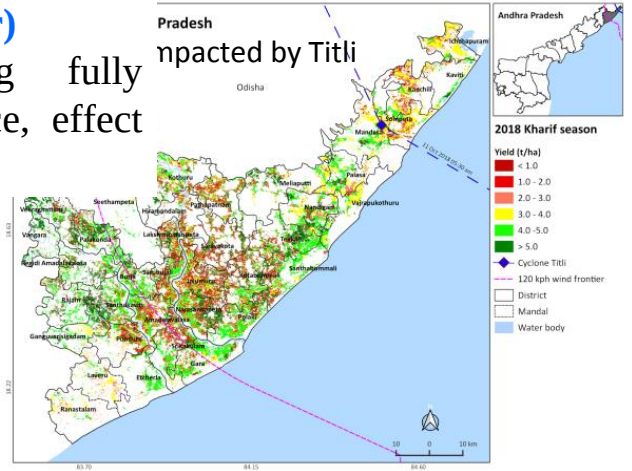


The yield loss algorithm was specifically developed for A.P.



- Overall estimated rice flooded area = **69,306 ha** or **33.8%** of total rice area in Srikakulam
- Estimated average **yield loss = 1.06 t/ha**, whereas estimated **production loss = 245,908 t (33% of normal year)**
- Include all loss including fully inundation, partial submergence, effect of storm surge, wind





RIICE yield products for rice crop insurances

- Vietnam:
  - RIICE pilot ongoing for implementation of yield-based rice crop insurances for 7 provinces in Vietnam in collaboration with SwissRe. Mapping implemented by NIAPP/MARD and funding from SDC.
- Cambodia:
  - RIICE dry run insurance test planned for monsoon season 2020 to support development of national crop insurance programme in collaboration with SCOR and Forte. Mapping implemented by GDA-DPS/MAFF and funding from SDC.
- Tamil Nadu State, India:
  - Tamil Nadu initiated several policy level measures in alleviating the losses in the aftermath of the 2015 devastating floods based on a timely assessment report of RIICE flood maps and yield data
- Andhra Pradesh State, India:
  - Remote sensing-based rice monitoring system developed and demonstrated for the state (including yield); crop insurance companies engaged for PMFBY implementation in paddy areas.

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2019, VOL. 40, NO. 21, 8093–8124
https://doi.org/10.1080/01431161.2018.1547457

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Rice yield estimation using synthetic aperture the ORYZA crop growth model: development of the system in South and South-east Asian

T. D. Setiyono[a], E. D. Quicho[a], F. H. Holecz[b], N. I. Khan[a], G. Ror
C. Garcia[a], A. Rala[a], J. Raviz[a], F. Collivignarelli[b], L. Gatti[b], M. Bar
V. Q. Minh[d], Q. T. Vo[d], A. Intrman[e], P. Rakwatin[f], M. Sothy[g], T.
S. Pazhanivelan[i] and M. R. O. Mabalay[j]

remote sensing

Article

Spatial Rice Yield Estimation Based on M and Sentinel-1 SAR Data and ORYZA C Growth Model

Tri D. Setiyono [1,*], Emma D. Quicho [1], Luca Gatti [2], Manuel Campos-Tal
Lorenzo Busetto [4], Francesco Collivignarelli [2], Francisco Javier García-Haro [
Mirco Boschetti [4], Nasreen Islam Khan [1] and Francesco Holecz [2]

Remote Sens. **2014**, *6*, 10773-10812; doi:10.3390/rs61110773

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Article

Towards an Operational SAR-Based Rice Monitoring System in Asia: Examples from 13 Demonstration Sites across Asia in the RIICE Project

Andrew Nelson [1,*], Tri Setiyono [1,*], Arnel B. Rala [1], Emma D. Quicho [1], Jeny V. Raviz [1], Prosperidad J. Abonete [1], Aileen A. Maunahan [1], Cornelia A. Garcia [1], Hannah Zarah M. Bhatti [1], Lorena S. Villano [1], Pongmanee Thongbai [1], Francesco Holecz [2], Massimo Barbieri [2], Francesco Collivignarelli [2], Luca Gatti [2], Eduardo Jimmy P. Quilang [3], Mary Rose O. Mabalay [3], Pristine E. Mabalot [3], Mabel I. Barroga [3], Alfie P. Bacong [3], Norlyn T. Detoito [3], Glorie Belle Berja [3], Frenciso Varquez [3], Wahyunto [4], Dwi Kuntjoro [4], Sri Retno Murdiyati [4], Sellaperumal Pazhanivelan [5], Pandian Kannan [5], Petchimuthu Christy Nirmala Mary [5], Elangovan Subramanian [5], Preesan Rakwatin [6], Amornrat Intrman [7], Thana Setapayak [7], Sommai Lertna [7], Vo Quang Minh [8], Vo Quoc Tuan [8], Trinh Hoang Duong [9], Nguyen Huu Quyen [9], Duong Van Kham [9], Sarith Hin [10], Touch Veasna [10], Manoj Yadav [11], Chharom Chin [12] and Nguyen Hong Ninh [13]


Thanks for listening!