Mapping Paddy Rice Agriculture in Monsoon Asia

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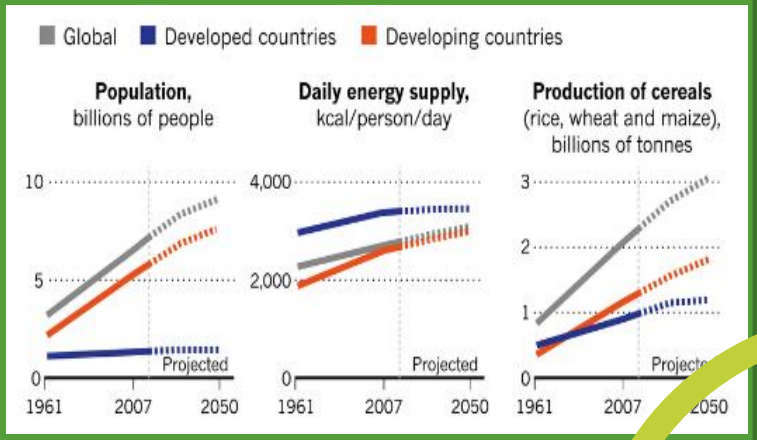
ICARDA
Science for resilient livelihoods in dry areas

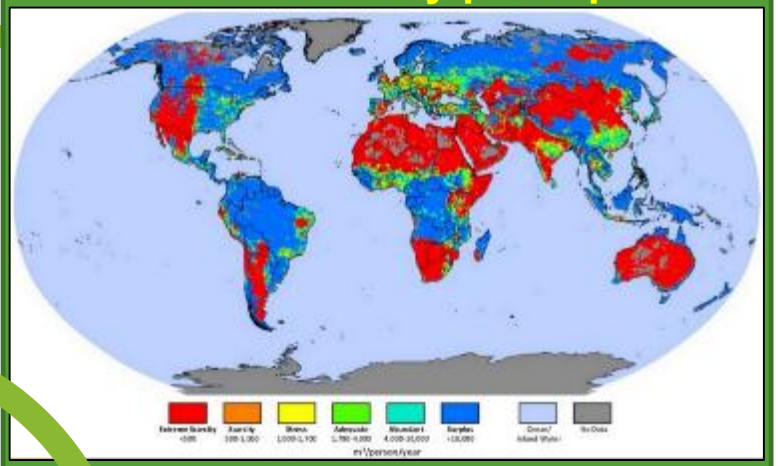
NASA LCLUC-SARI meeting 2019-07-23 Johor Bahru, Malaysia

Paddy rice: staple grain for people



(Elert, 2014 Nature Outlook)

Water availability per capita



(from S. Duttarganvi)

Paddy rice

Food

Water

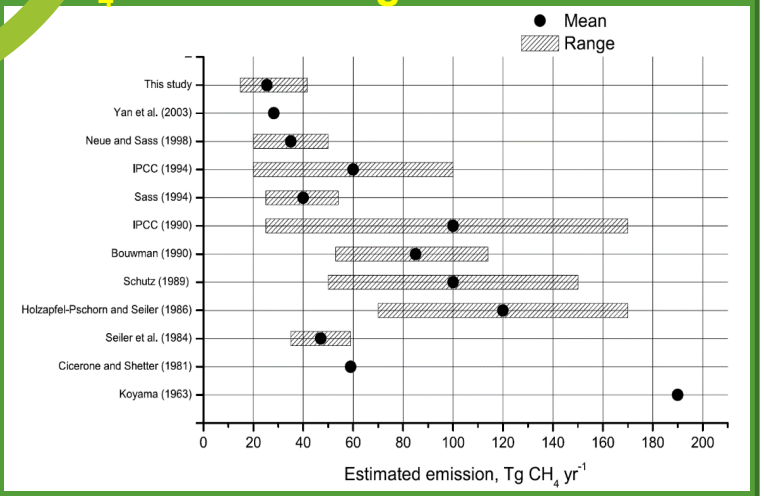
Climate

Disease

Paddy rice fields and avian influenza

(Gilbert, Xiao, et al., PNAS, 2008; Gilbert et al., 2014 Nature Comm.)

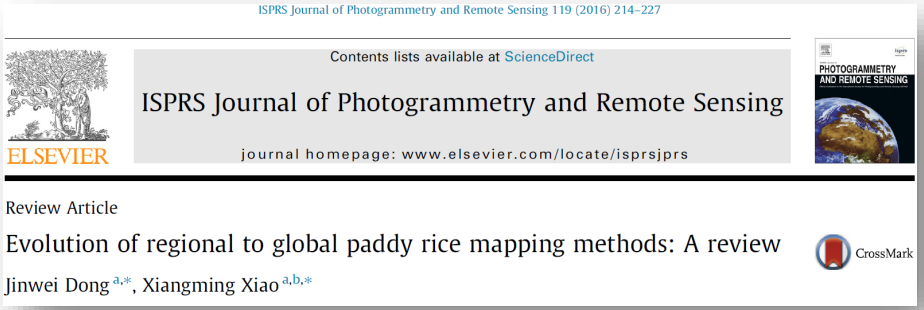
CH_4 emission of global rice fields



(Yan et al., 2009 GBC)

What is the best paddy rice mapping method in monsoon Asia?

Evolution of paddy rice mapping algorithms



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Review Article

Evolution of regional to global paddy rice mapping methods: A review

Jinwei Dong [a,*], Xiangming Xiao [a,b,*]

(Dong et al., 2016 ISPRS P&RS)

Band reflectance, Traditional classifiers

Spectral indices, Improved classifiers

Time series data/VIs, Improved classifiers

Time series data, Phenology-based approaches

Table 1
A literature summary of existed studies using the reflectanc

ID	Refs.	Sensor used	Variable used				
1	Mccloy et al. (1987)	Landsat MSS	Band reflecta				
2	Rao [illegible] (1987)	Landsat MSS	Band reflecta				
3	Panigrahy and Parihar (1992)	Landsat TM	Band reflectance				
4	Tennakoon et al. (1992)	Landsat TM	Band reflectance	Multi images from Seedling and Ripening stages	MLC	Case region in Thailand	>88%
5	Fang et al. (1998)	Landsat TM, NOAA AVHRR	Band reflectance	All available images, no phase specific	MLC	Hubei, China	91.6%
6	Fang (1998)	Landsat TM	Band reflectance	Single image in early growing season before transplanting	Unsupervised classification	Hubei, China	>81%
7	Turner and Congalton (1998)	SPOT XS	3 images (G/R/NIR)	Multi images from pre- and first half of flood	Hybrid classification	West Africa	70%
8	Kurosu et al. (1997)	ERS-1 C-band	σ^0	Multi images from June to September 1992	MLC	Ohgata-mura area, Japan	93%
9	Okamoto and [illegible]	Landsat, JERS-1	Reflectance	Landsat data in dry season, JERS-1 in planting	TS	Indramayu, Indonesia	–
						Two sites in Indonesia and Japan	–

Table 2
A literature summary of existed studies using the VI and enhanced image statistic-based paddy rice mapping approaches (Category Two).

ID	Refs.	Sensor u				area	Accuracy
11	Shao et al. (2001)	RADARS HH pola				ounties na	97%
12	Oguro et al. (2001)	Landsat5 SPOT4 H 1				hi- ima apan	–
13	Niel and McVicar (2003)	Landsat				ern New Wales	–
14	Chen and McNairn (2006)	RADARSAT-1 (C-band with HH polarization)	σ^0	Multi images in dry and wet seasons	NN, CD, CD + NN, MLC	Two areas in Philippine	>96%

Table 3
A literature summary of existed studies using the VI or RADAR backscatter-based temporal analysis approaches (Category Three).

ID	Refs.	Sensor used	Variables used	Phases of data used	Methods	Study area	Accuracy
20	J.S. Chen et al. (2011)	H					Kappa = 0.71
21	Oguro et al. (2003)	La					–
22	Son et al. (2013)	M					>80%
23	Nuarsa et al. (2012)	M					88%
24	Gumma et al. (2011)	M					80%
25	Gumma et al. (2014)	MODIS	NDVI	Time series images in entire year	A suite of methods (SMT, DT, etc.)	Bangladesh	>78%

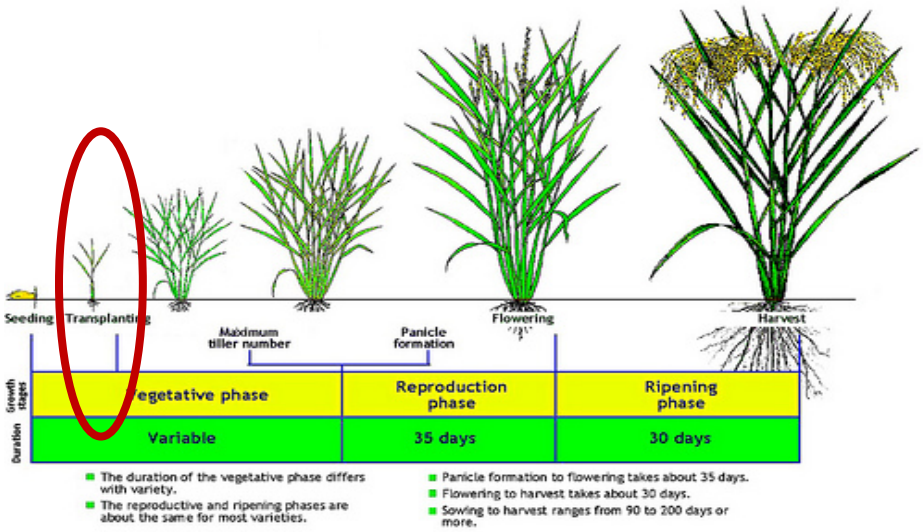
Table 4
A literature summary of existed studies using the phenology-based paddy rice mapping approaches, based on remote sensing recognition of key growth phases (Category Four).

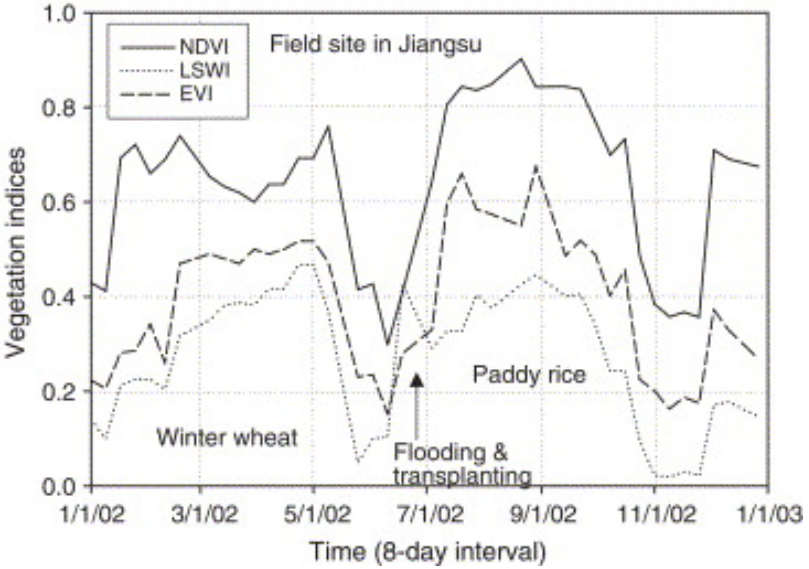
ID	Refs.	Sensor used	Variables used	Phases of data used	Methods	Study area	Accuracy
35	Xiao et al. (2005)	MODIS	NDVI, EVI, LSWI, NDSI	Time series images in entire	PA	Southern	–
36	Xiao et al. (20						
37	Feng et al. (20						
38	Sakamoto et a (2009)						
39	Sun et al. (200						
40	Bridhikitti and Overcamp (20						
41	Jeong et al. (2012)	MODIS, SAR	LSWI, EVI	Time series images in entire year	Variable TS	Yedang, Korea	–
42	Peng et al. (2011)	MODIS	LSWI, EVI	Time series images in entire year	PA	Hunan, China	>84%
43	Torbick et al. (2011)	PALSAR, ScanSAR, MODIS	σ^0, LSWI, EVI, NDVI	Multiple images in entire year	PA	Sacramento Valley, USA	95%
44	Shiu et al. (2012)	FORMOSAT-2	Band reflectance (R/G/B/NIR)	Multi images in transplanting and tillering stages	ISODATA + MLC, Object-based and pixel-based	Taiwan	>82%

	SVM	An area in China	>70%
ctive,	ED + SVM	An area in Malaysia	95%
vest	ISODATA	Shaoxing, China	>61%
	ISODATA	Mekong delta	94%
	SVM for pure rice, rice area fraction index for mixed pixels	Hunan, China	>97%

	13 footprints in Asia	>85% (OA)
l + EMD	Mekong Delta, Vietnam	71.6% (OA)
detector algorithm to separate ated rice	Thailand	89%
	Mekong Basin	>81%
	Guangdong, China	>77%
	Jiangsu, China	81% (OA)
	Guizhou, China	>91%
	Bangladesh	R^2 = 0.69–0.89
TMA, Peak method	Northwest and central India	–

Development of a phenology-based paddy rice mapping approach





(Xiao et al., 2005, 2006 RSE)

Seedling

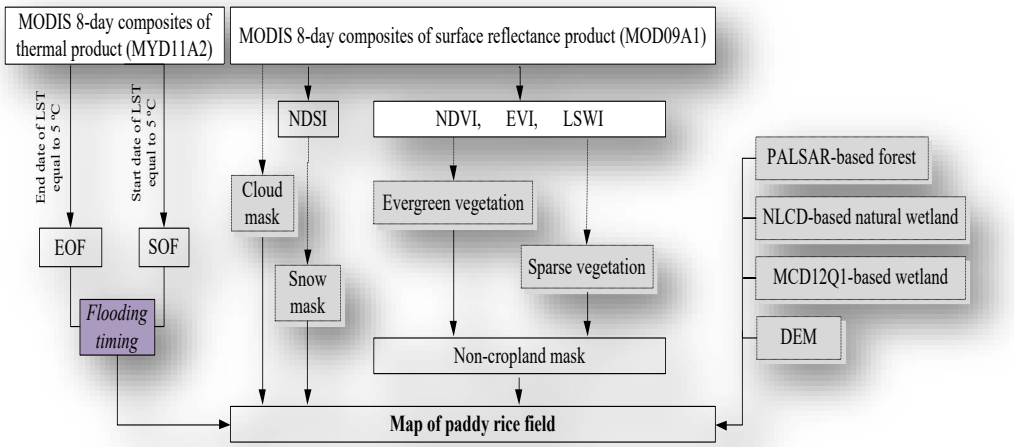
Transplanting

Reproduction

Mature/Harvest

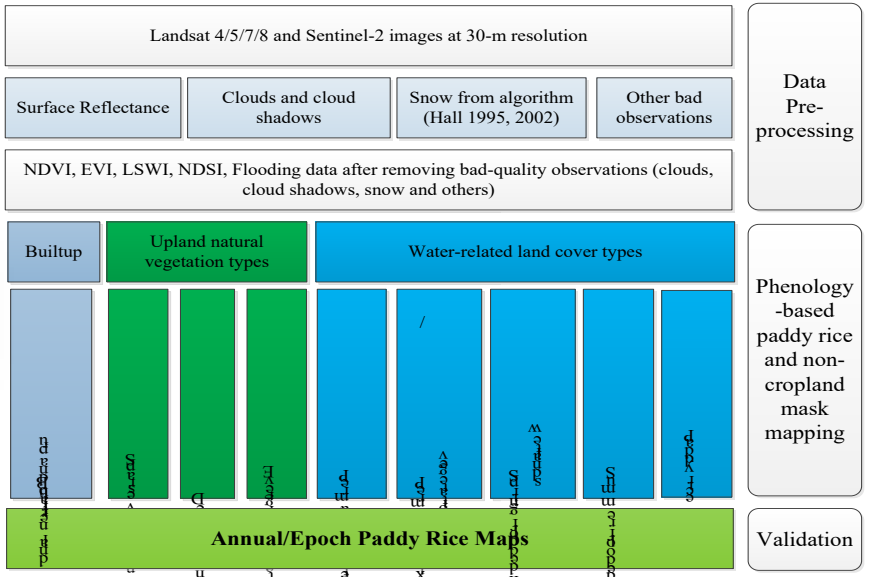
Paddy rice mapping packages:
RICE-Landsat and RICE-MODIS

RICE-MODIS



(Zhang et al. 2015, ISPRS P & RS)

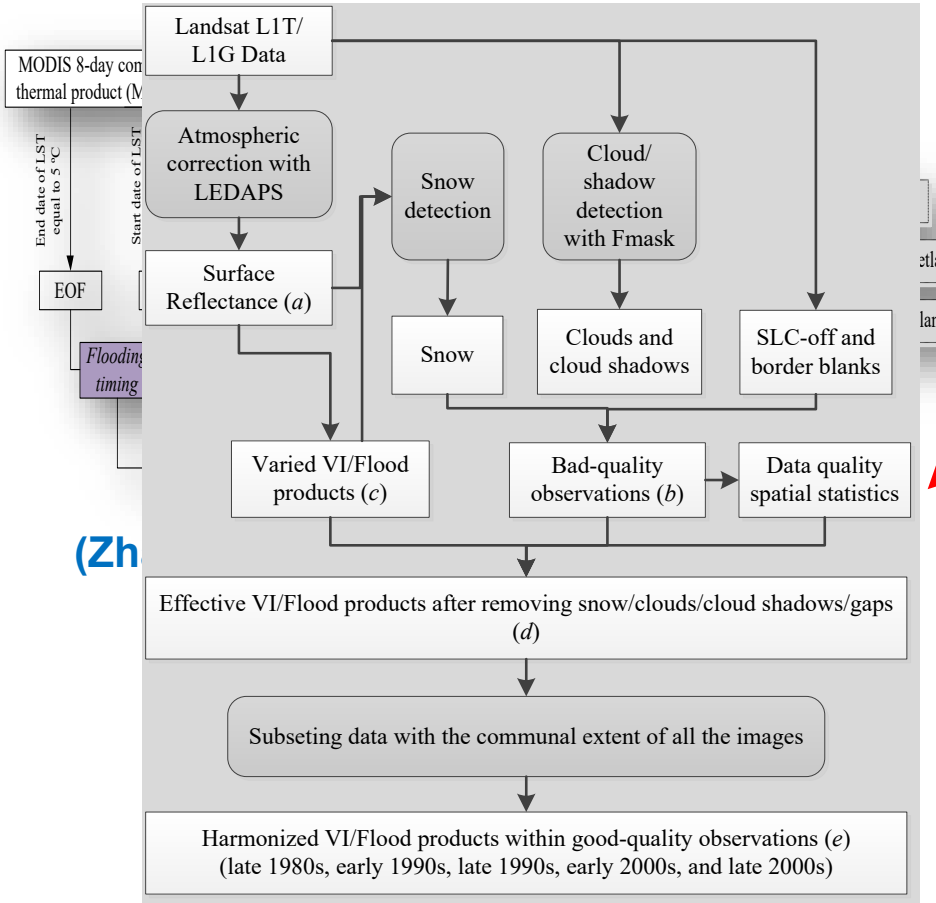
RICE-Landsat



(Dong et al., 2015 RSE)

Paddy rice mapping packages:
RICE-Landsat and RICE-MODIS

RICE-MODIS



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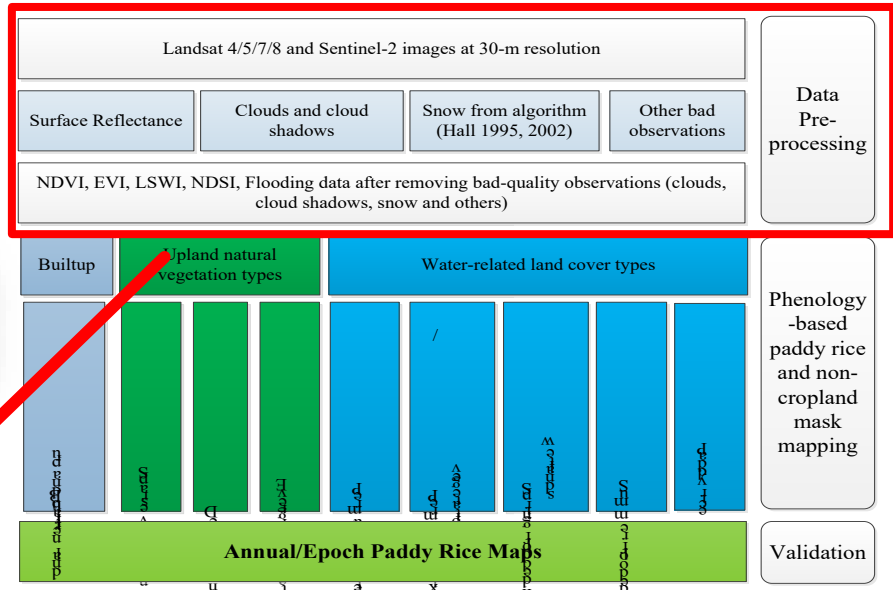
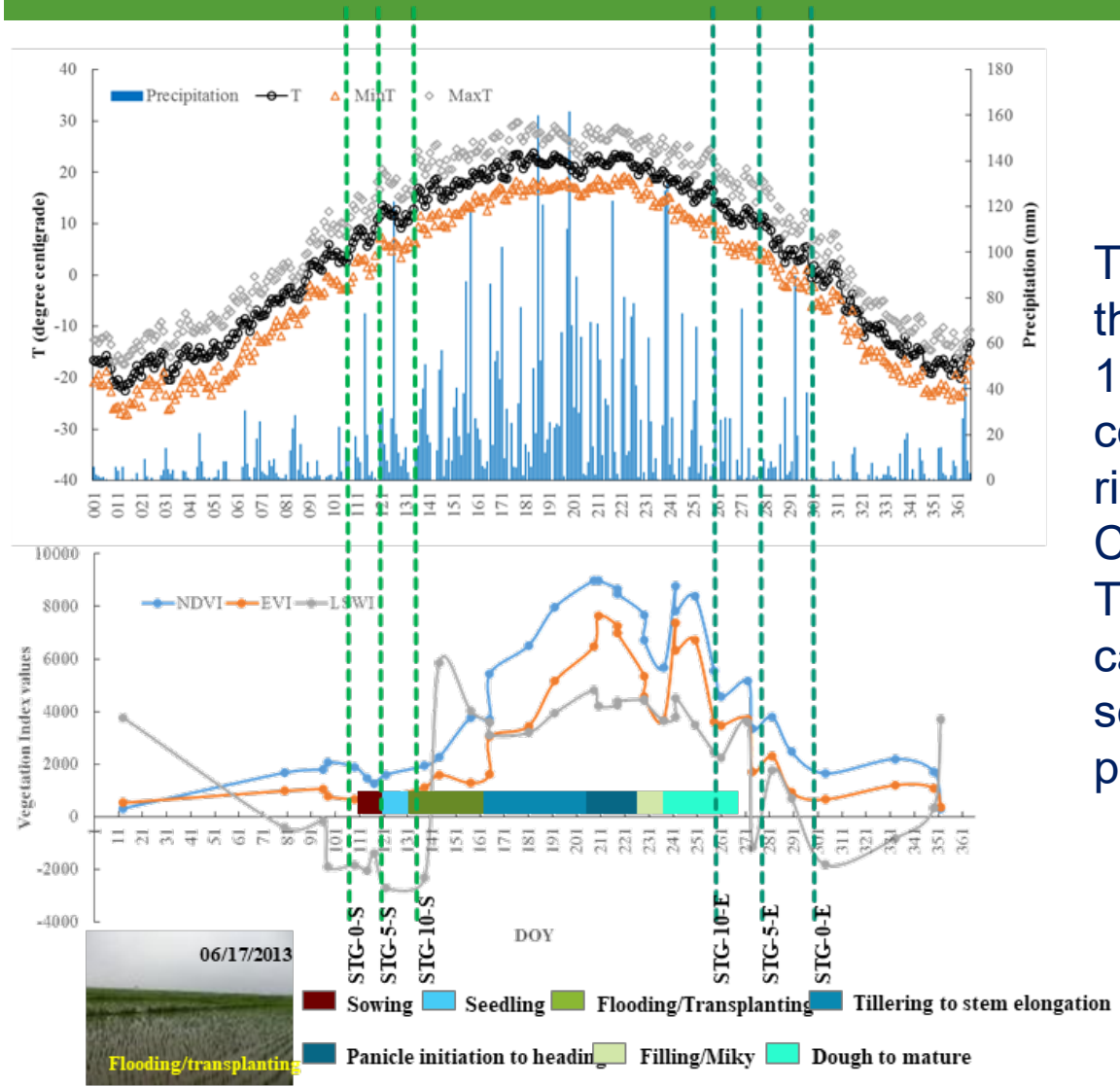
RICE-Landsat



(Dong et al., 2015 RSE)

Refining the phenology-based algorithm by setting time window using auxiliary data

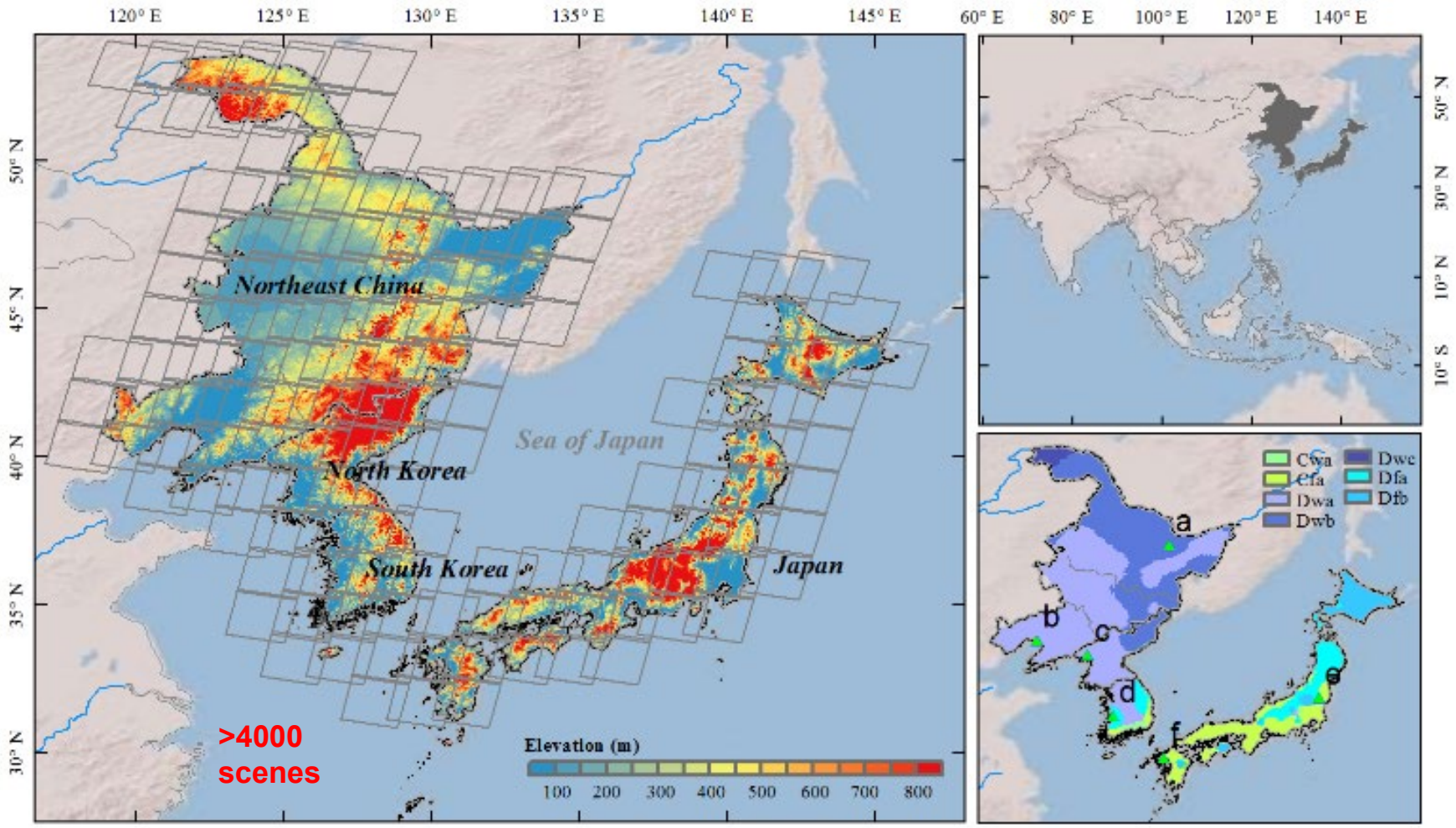


The start (TGS-10-S) date of thermal growing season above 10 °C of air temperature correspond to the start of paddy rice transplanting in Northeast China.

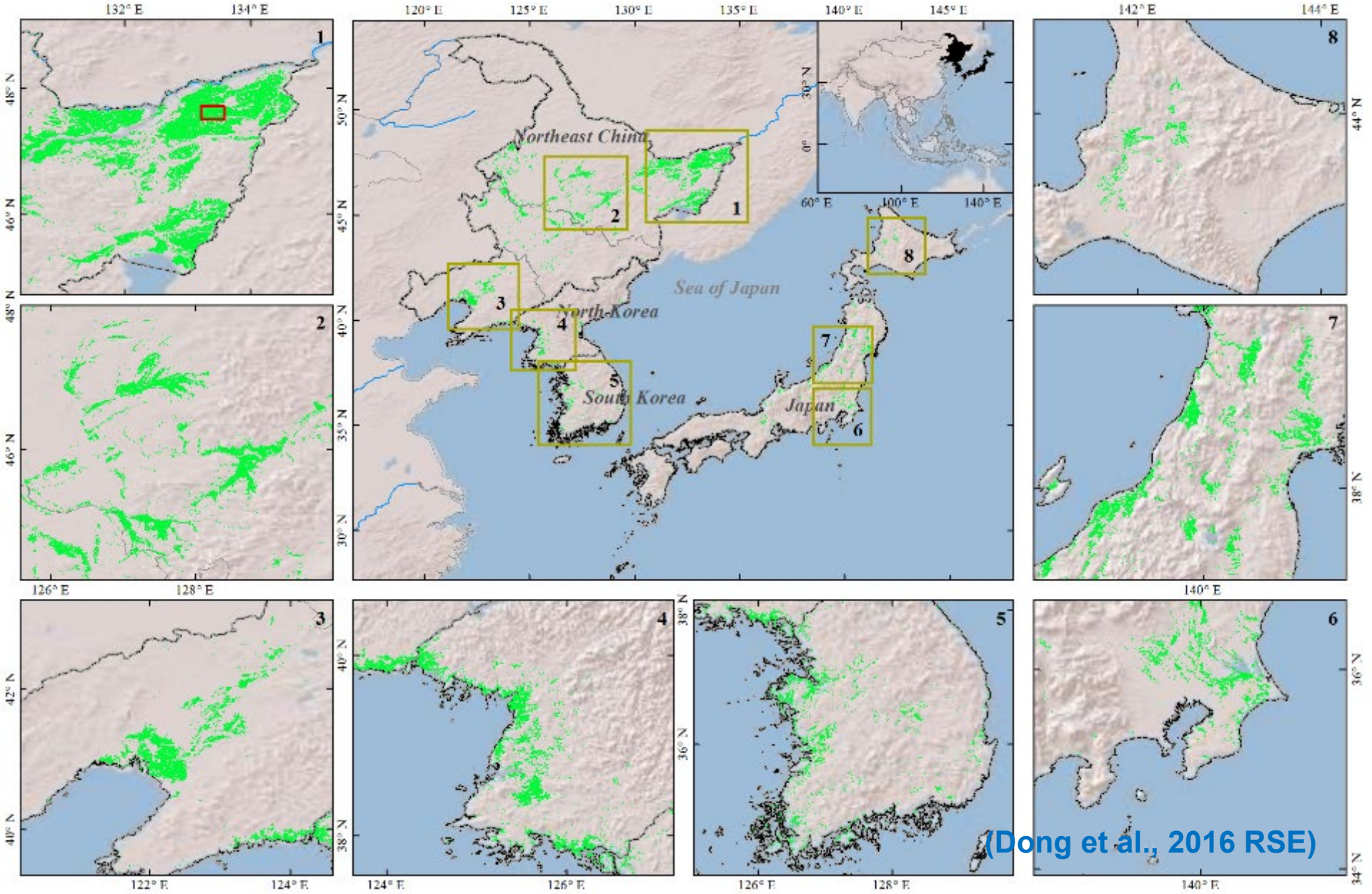
The transplanting time window can also be defined using time series LST or in-situ observed phenology data.

(Dong et al., 2015 RSE)

Mapping paddy rice in typical single-cropping area: northeastern Asia

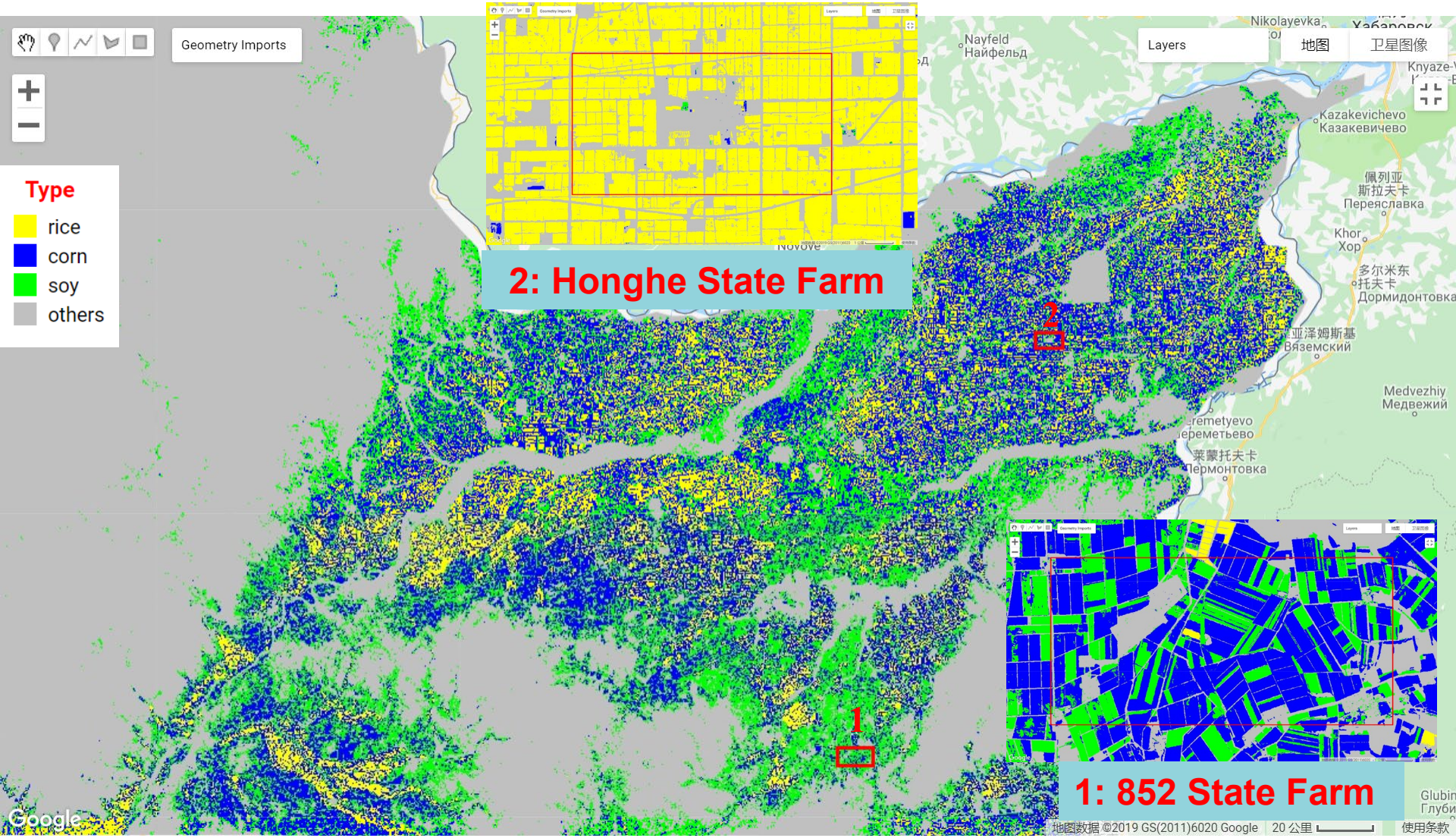


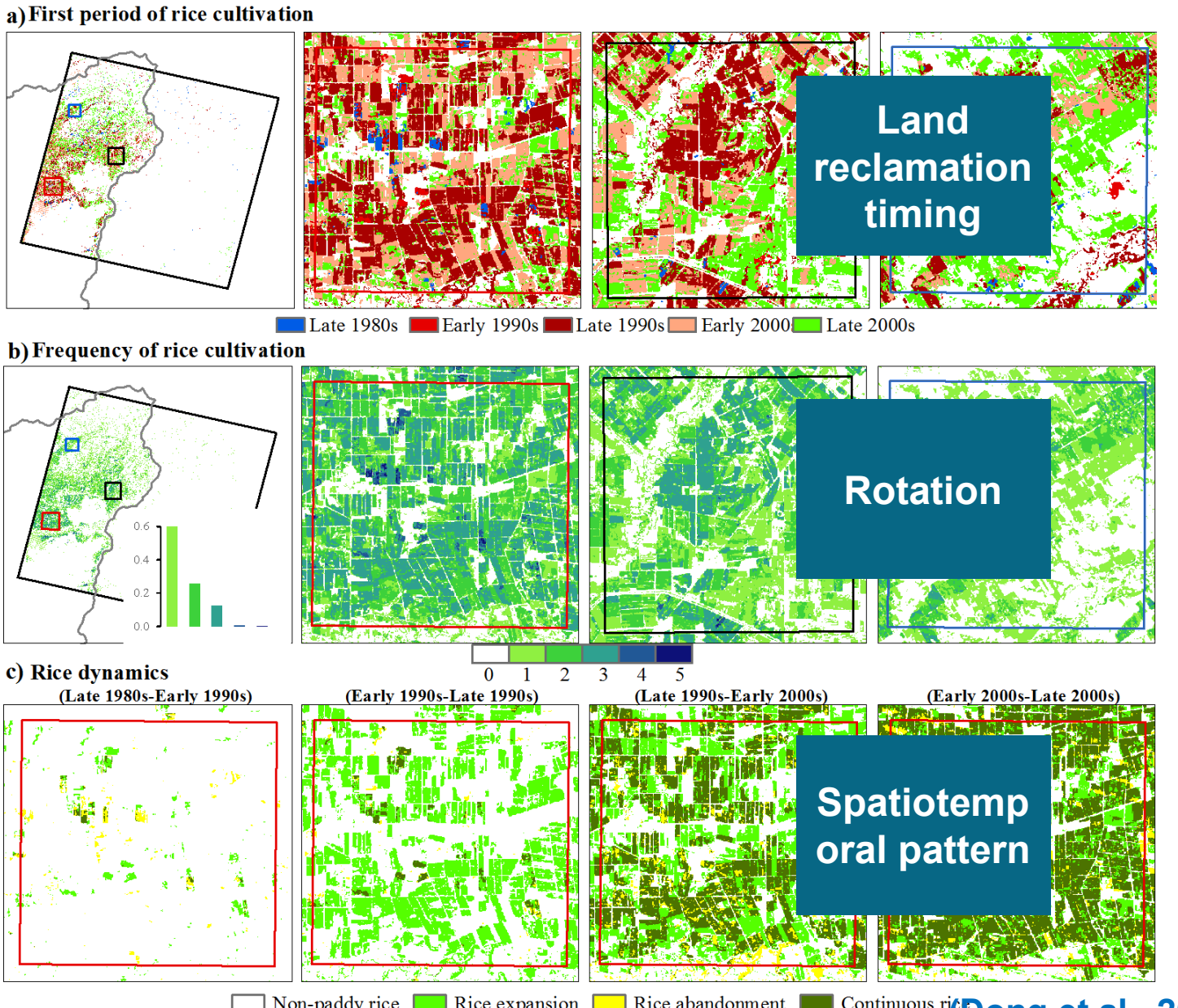
(Dong et al., 2016 RSE)



30m paddy rice map in the northeastern (NE) Asia in 2014 based on the phenology- and pixel-based paddy rice mapping (PPPM) algorithm, Landsat 8 imagery and the Google Earth Engine (GEE) platform.

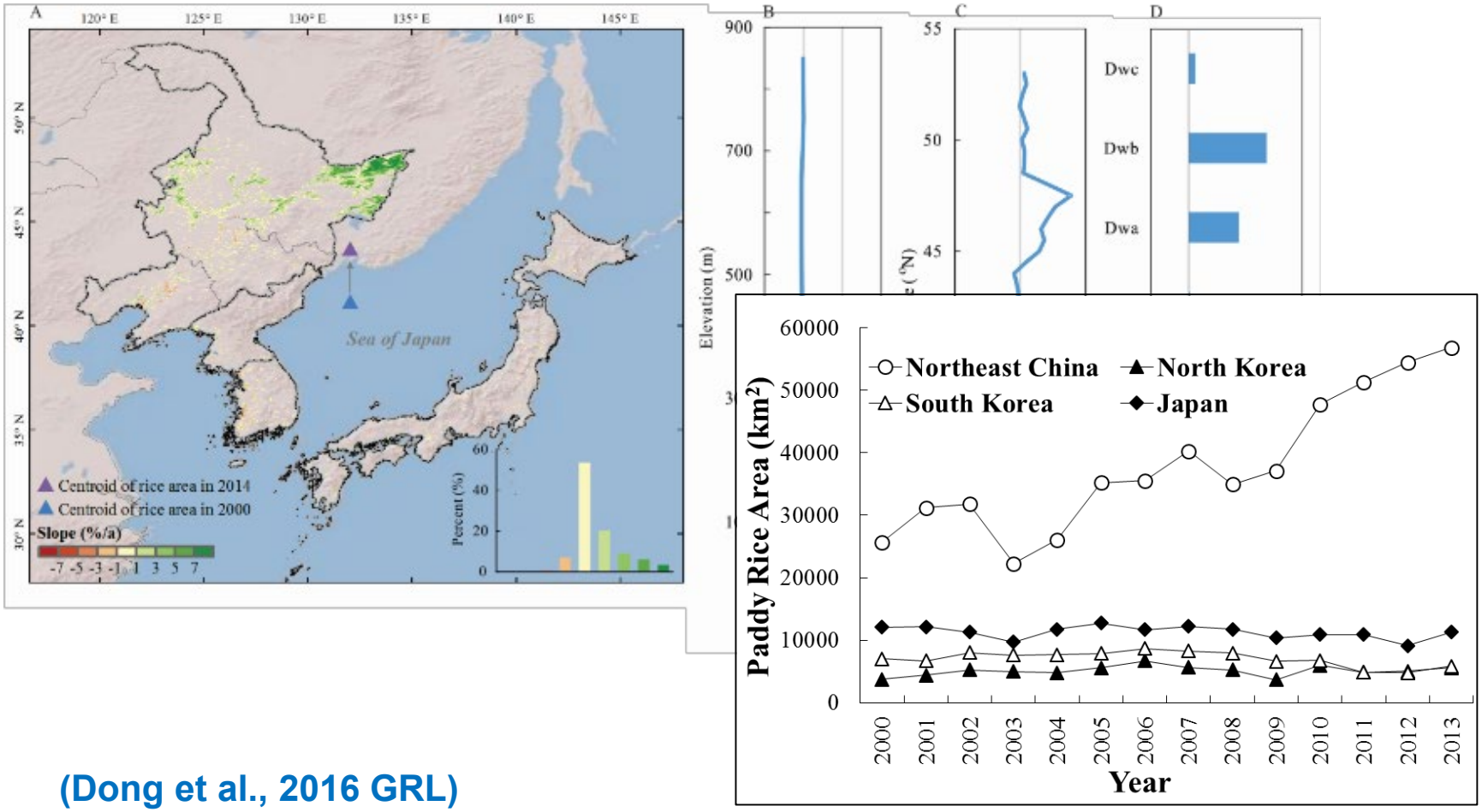
10m crop map in Northeast China in 2018





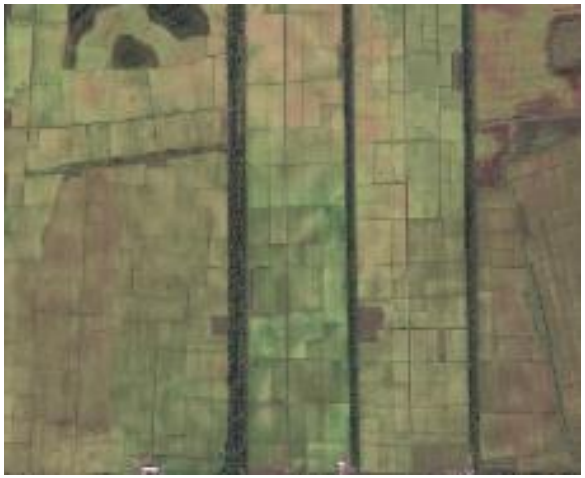
(Dong et al., 2015 RSE)

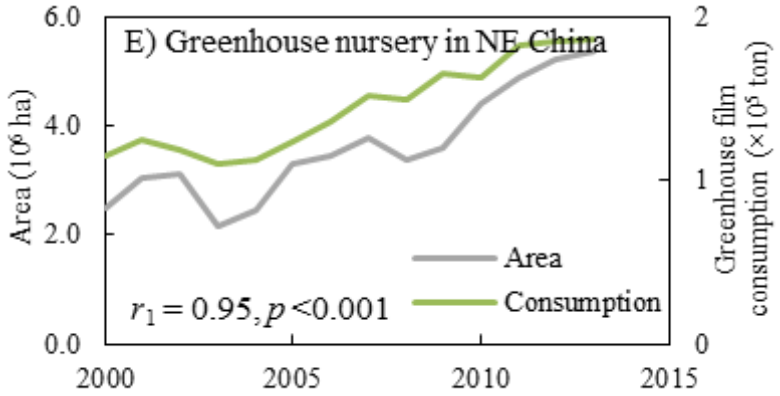
Rice expansion in northeastern Asia



(Dong et al., 2016 GRL)

Policy, market, technology, and climate together drove rice expansion in Northeast China

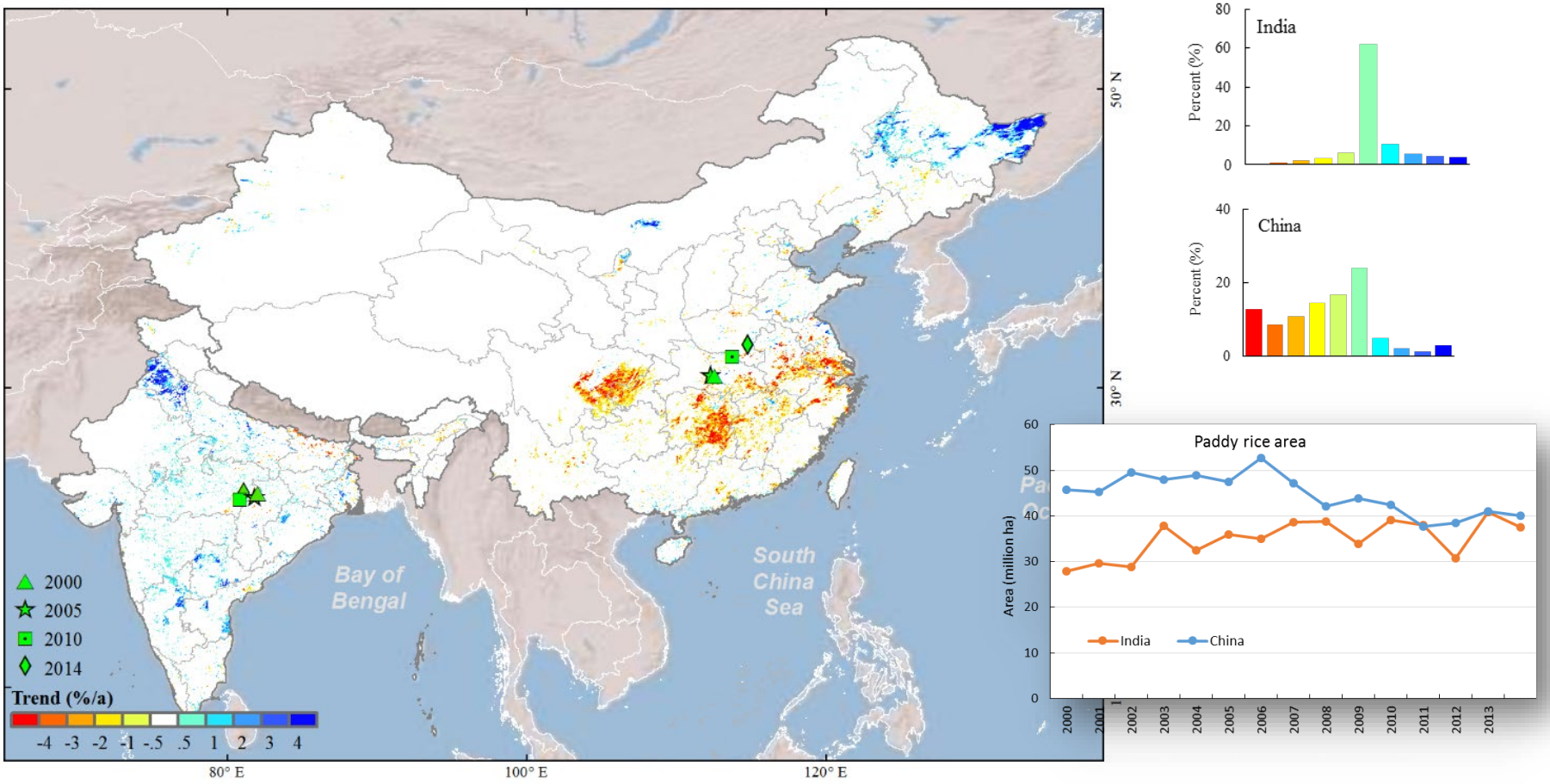




- AgriTech
- Cultivars
- Climate warming
- Market
- Policy

(Dong et al., 2016 GRL)

Pattern of paddy rice dynamics in China and India

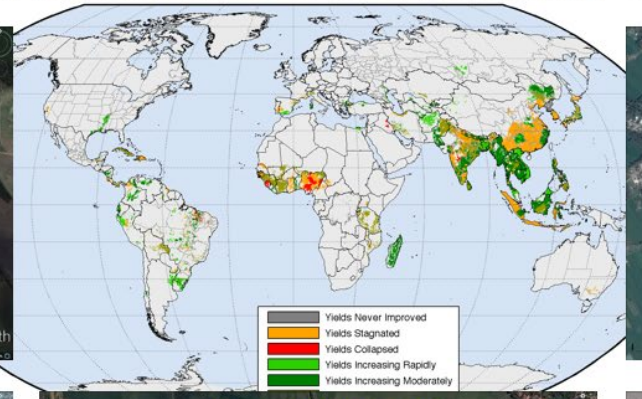


Variations of MODIS-based paddy rice area in China and India from 2000-2014

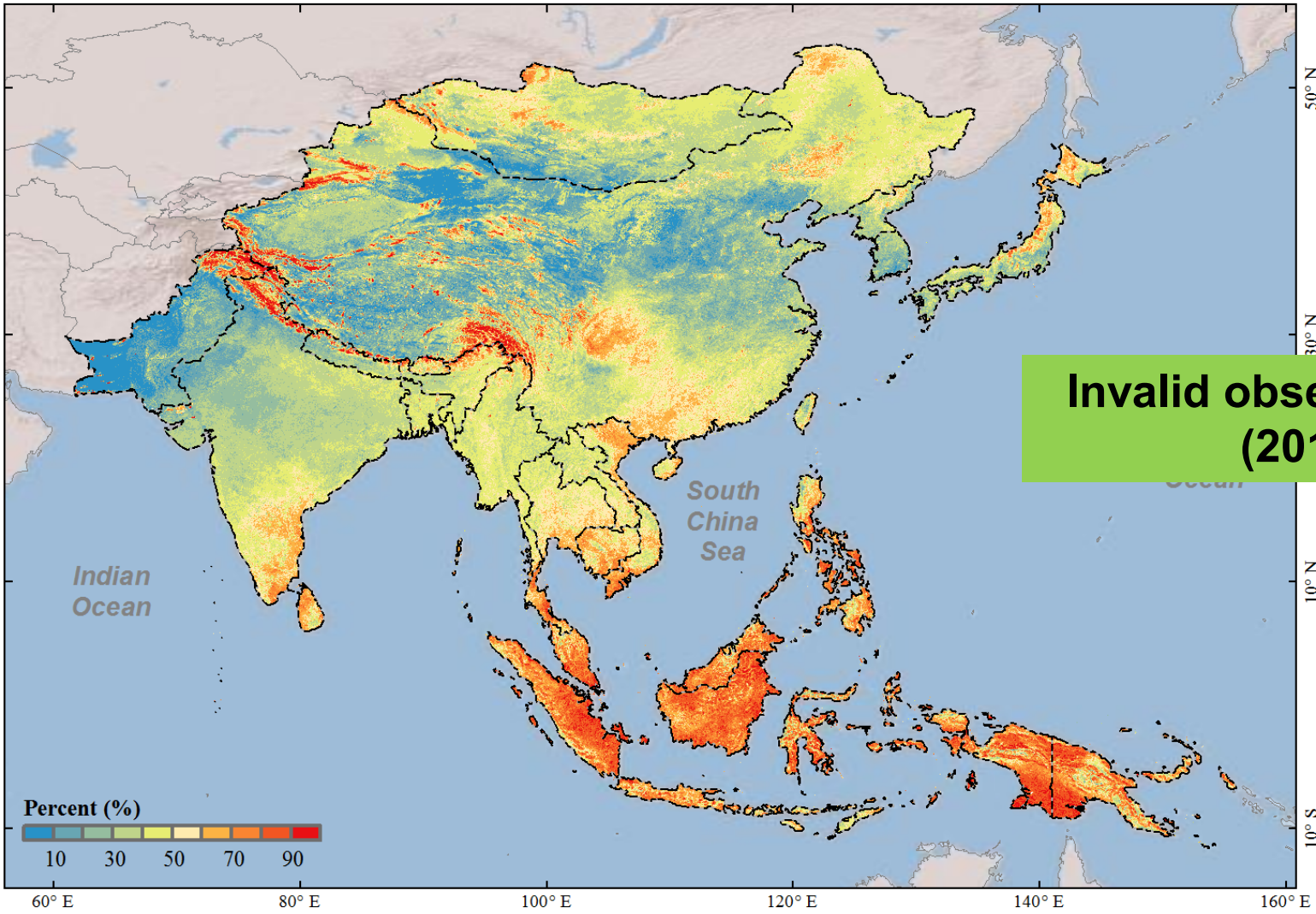
(Zhang et al., 2017 STE)

Can we apply the algorithm to the whole monsoon Asia?

Mapping paddy rice in monsoon Asia is challenging:
1. Small field sizes in many parts of Asia

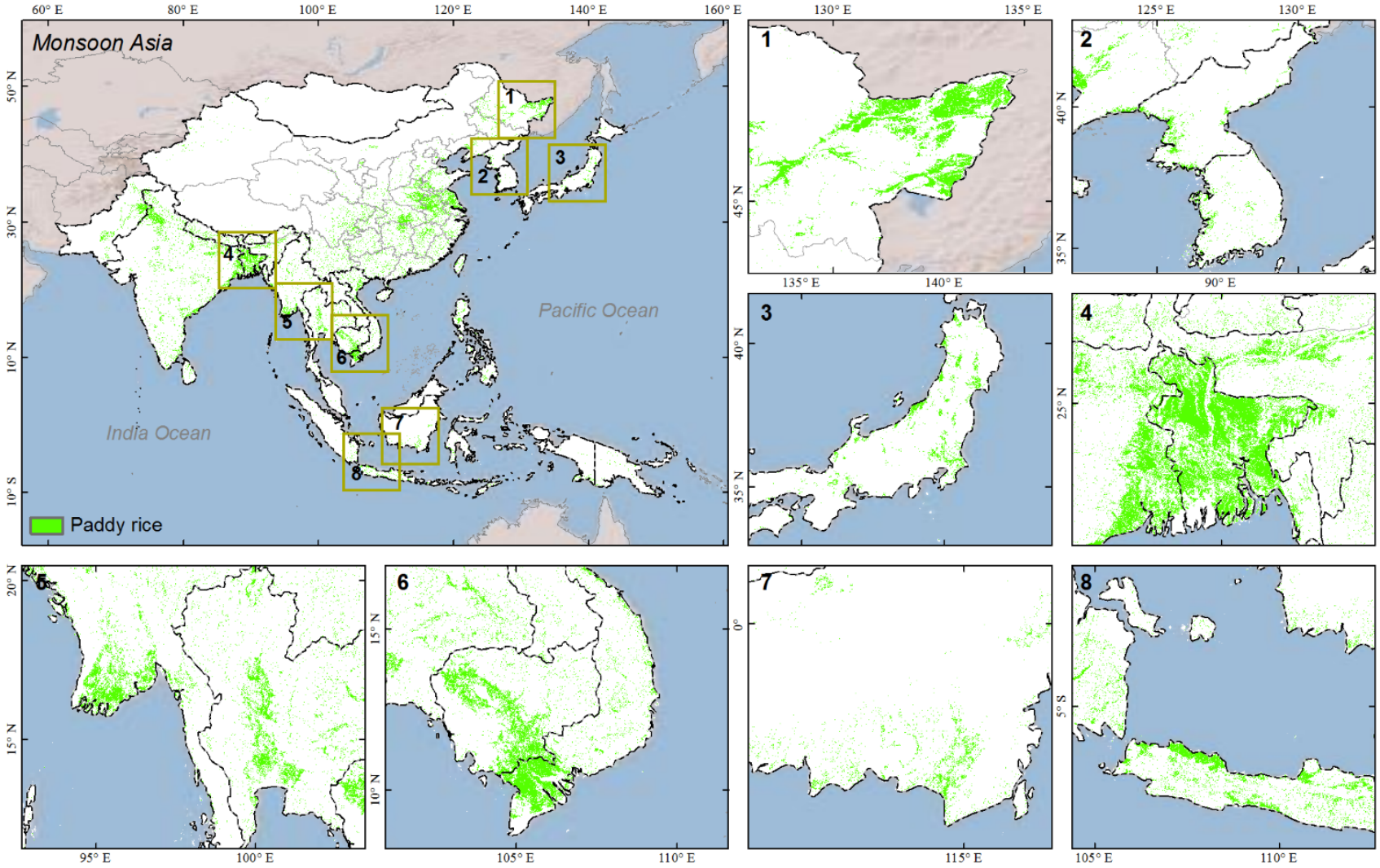


2. Persistent cloud coverage in tropical Asia



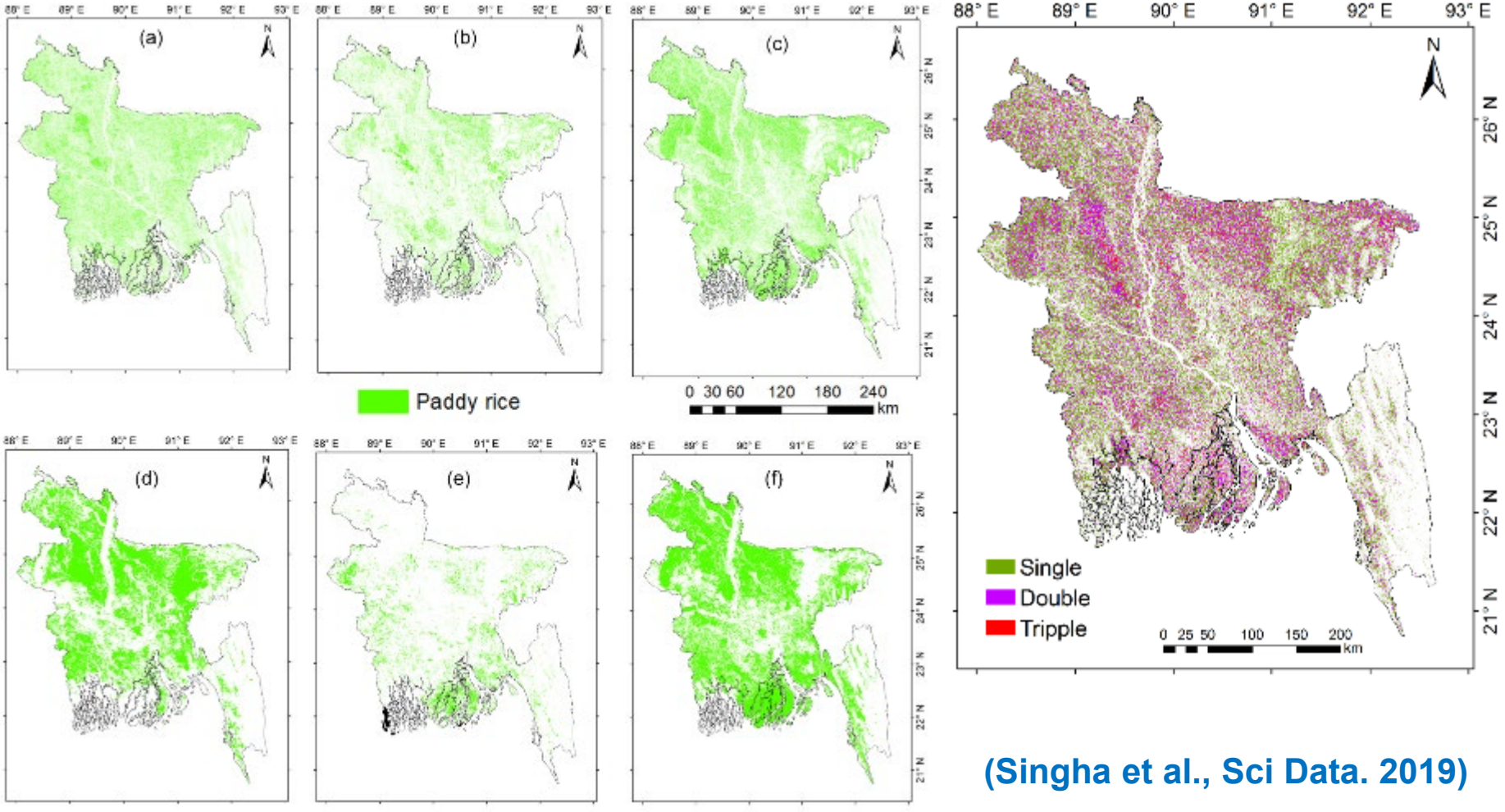
Invalid observation % (2010 MODIS)

MODIS-based paddy rice monitoring from 2000 to 2018



(Dong et al., In Prep.)

Mapping triple rice cropping system in Bangladesh using Sentinel-1 imagery



(Singha et al., Sci Data. 2019)

Summary

- It is not easy to map paddy rice for monsoon Asia, due to fragmented agricultural landscapes, cloud disturbances in tropical areas, and high cropping intensity, etc.
- Landsat and Sentinel-2 imagery can generally support retrospective paddy rice planting area change analyses for annual (2013-) or epoch (1980s-2013) scales in single rice cropping regions.
- Sentinel-1 is promising for mapping paddy rice in cloud-prone tropical areas in monsoon Asia with double or multiple cropping systems.
- While Sentinel-1 and 2 work well for regional rice mapping, MODIS and Landsat are the only source for tracking retrospective paddy rice dynamics before 2013, despite its uncertainty due to cloud disturbances.

Thanks for your attention!

For more questions, please contact
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