SUSTAINABLE DEVELOPMENT GOALS

RESPONSIBLE CONSUMPTION AND PRODUCTION

CLIMATE ACTION

Satellite data based transparent MRV system of GHGs emission from Asian agricultural ecosystems

Hironori Arai[1,3], Wataru Takeuchi[1], Kei Oyoshi[2], Lam Dao Nguyen[4], Towa Tachibana[5], Ryuta Uozumi, Koji Terasaki[3], Takemasa Miyoshi[3], Hisashi Yashiro[3], Kazuyuki Inubushi[5]

RSED

JAXA

AICS

VNSC Lift off your Dream

IPCC Methodologis

Tier 1

- Simplest method
- Activity data available to all countries

Tier 2

- Technology-specific emission factor

Tier 3

- More detailed or country-specific methods

From IPCC methodologies and reporting principles by Kristin Rypdal, CICERO & IPCC author

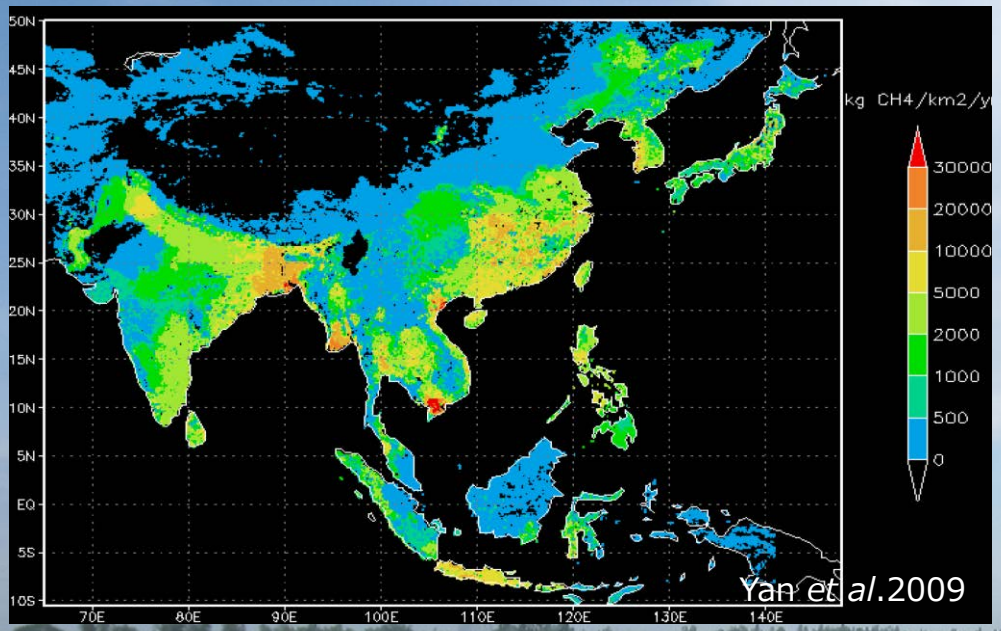
Each country must submit INDC (Intended Nationally Determined Contributions) to UNFCCC before 2020

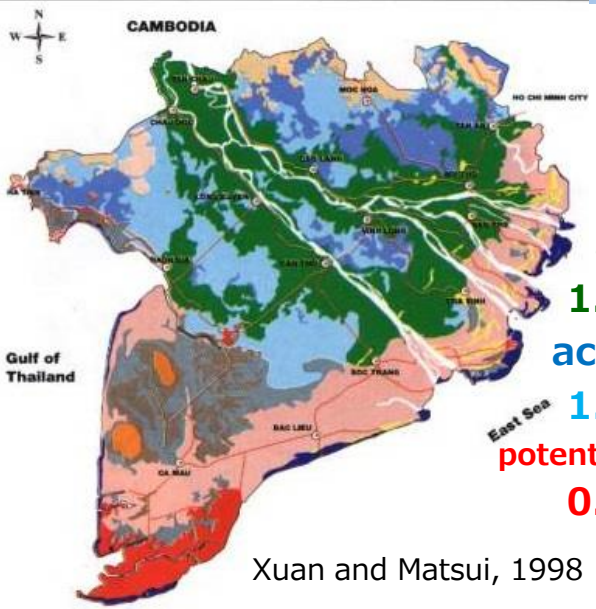
Outline

1. Background & Objective

2. Ground observation of greenhouse gas emission and semi-empirical modeling

3. Satellite remote sensing of GHG emitters
   - Cropping calendar & the adjacent fallow length
   - Paddy soil/water covered by rice plants
   - Top down verification with GOSAT





alluvial soil
1.1 Mha, 28%
acid sulfate so
1.1 Mha, 28%
potentially acid sulfat
0.5 Mha, 13%

Xuan and Matsui, 1998

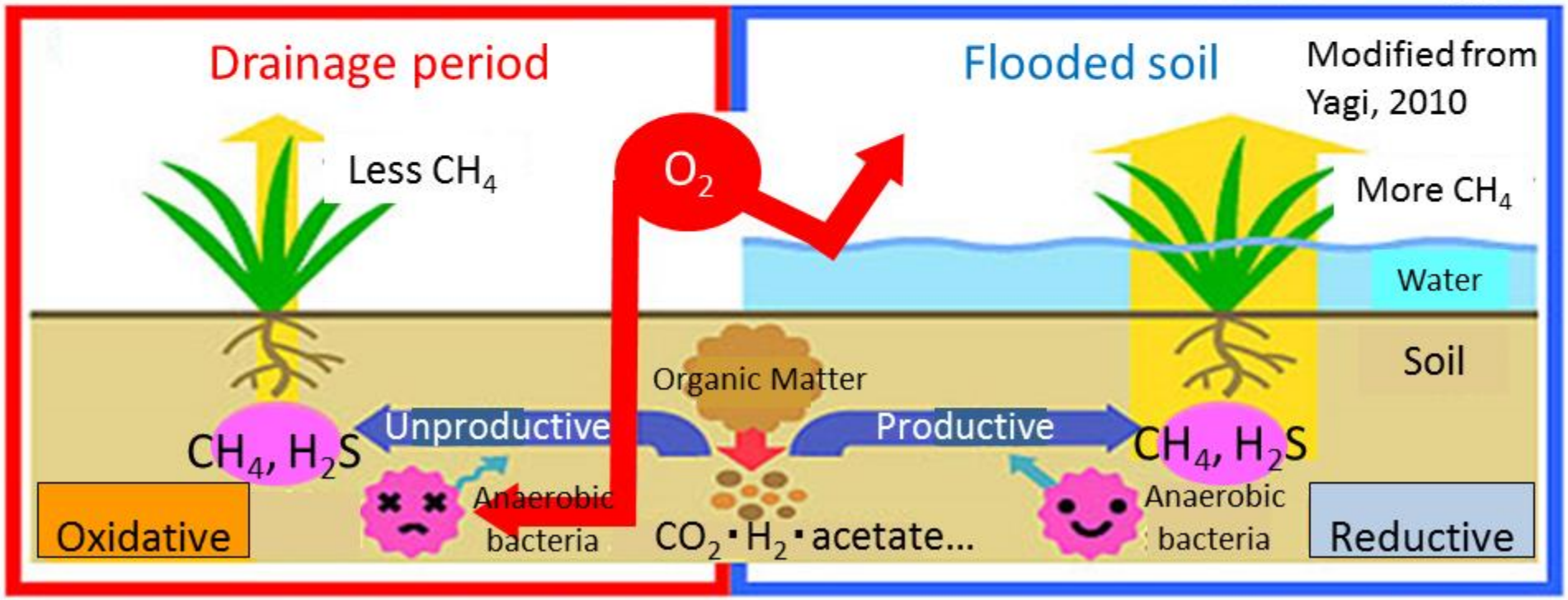
- **Continuously flooded nearly through a year**
  +
- **High straw production**

- **Anaerobic stress for rice production**
- **High GHGs emission**

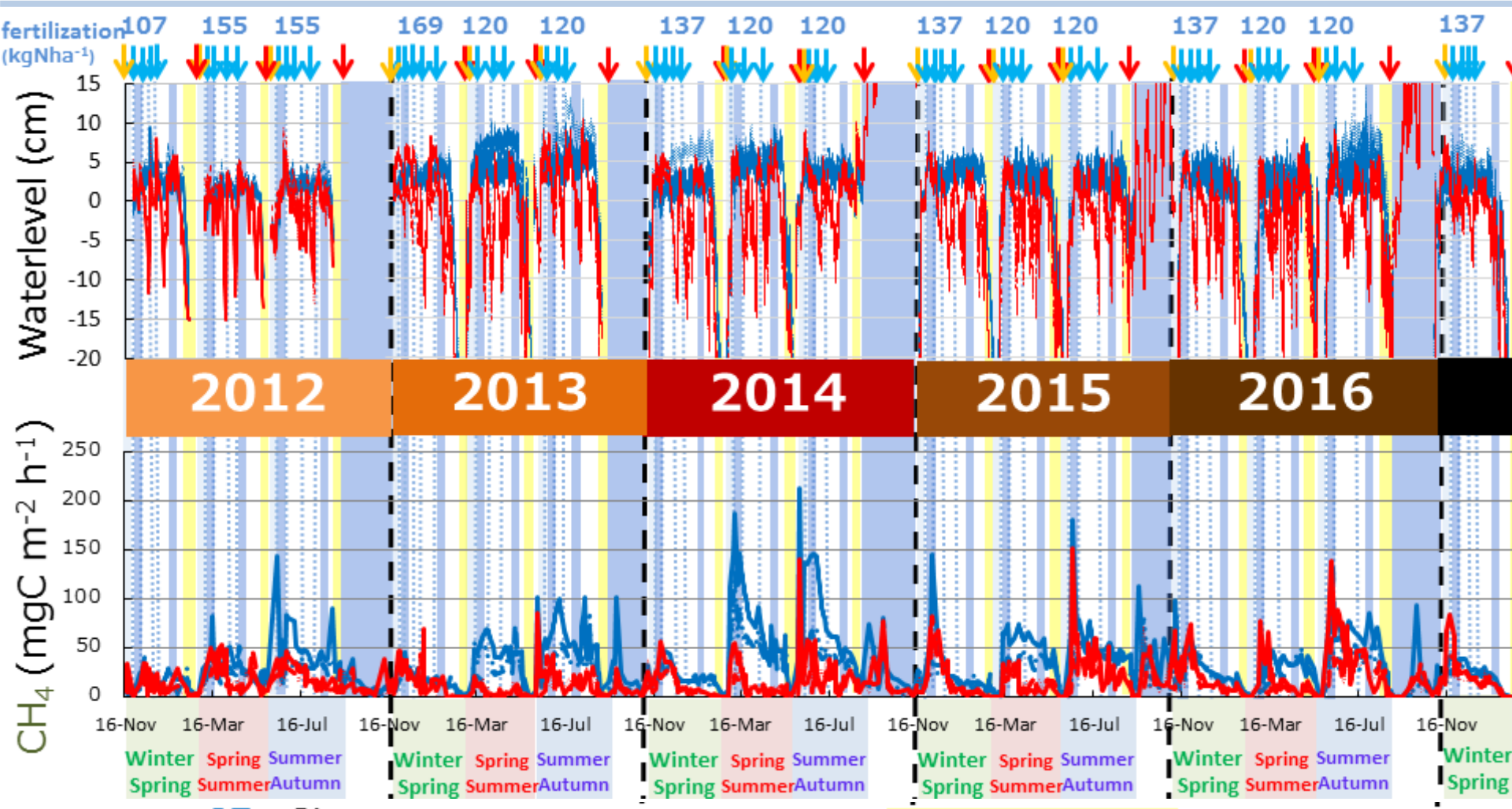
AWD

(**A**lternate **W**etting and **D**rying)

- Irrigation-water saving
- Anaerobic-stress mitigation
- GHGs mitigation

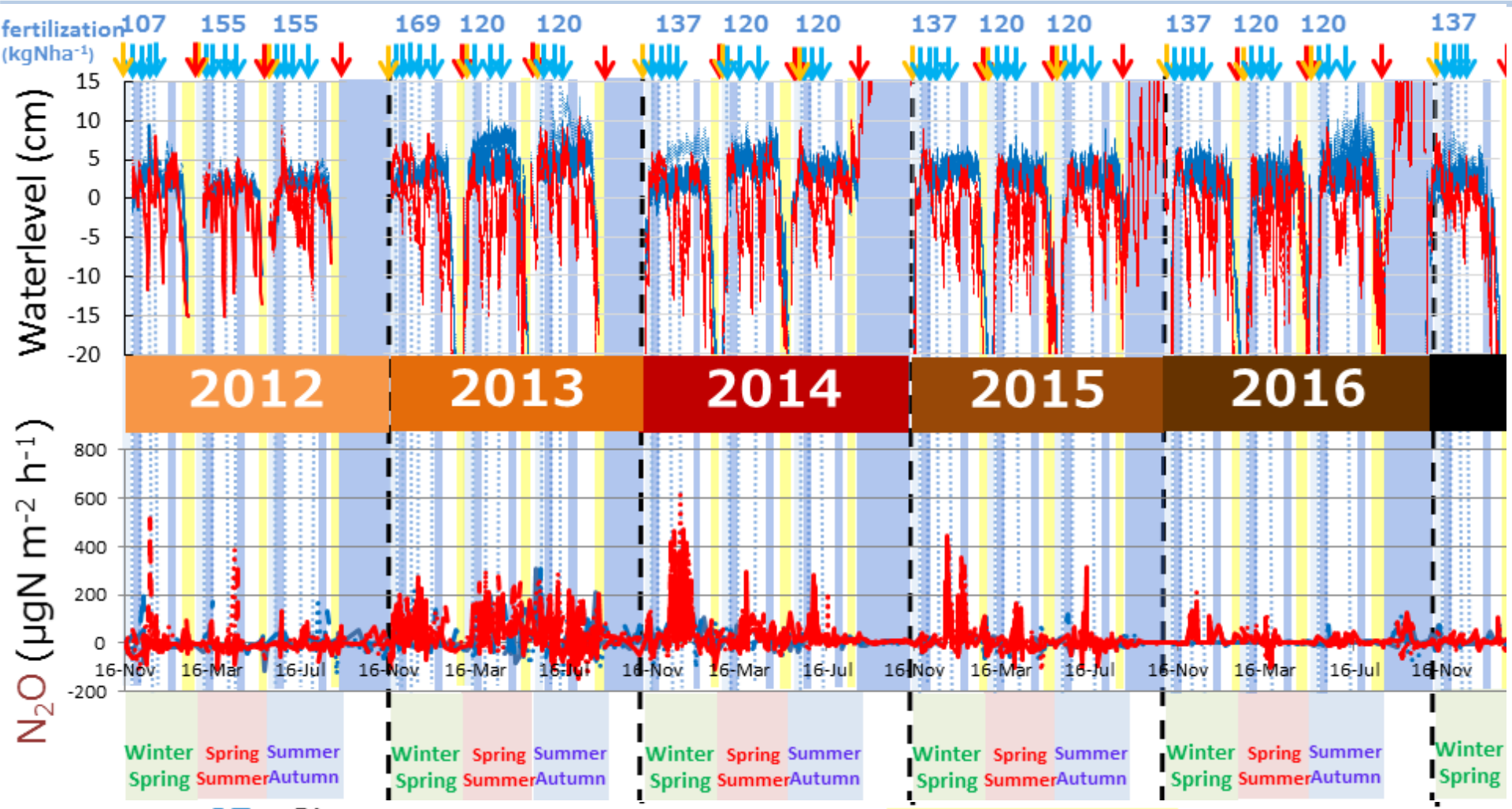


Characteristics of the Mekong delta



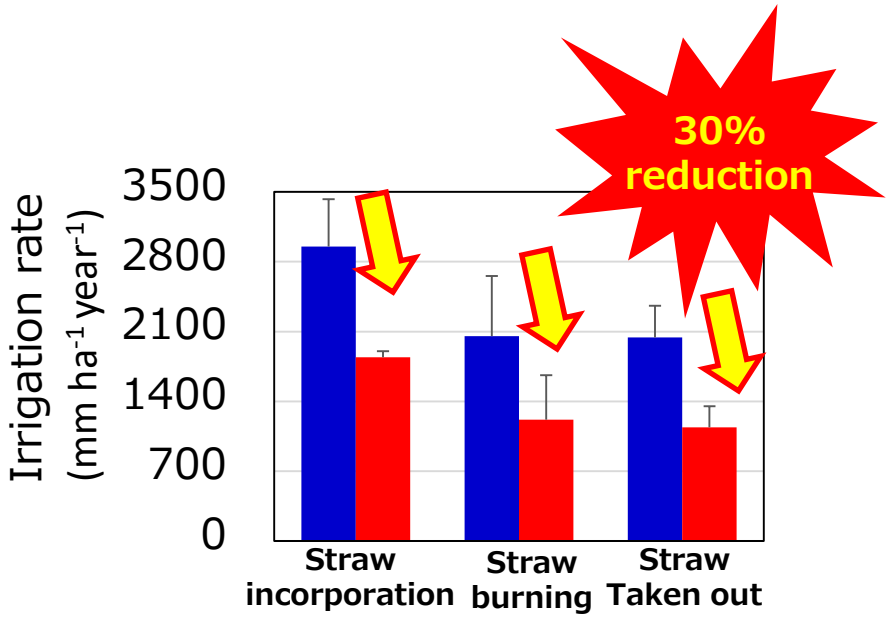
Arai et al., 2018

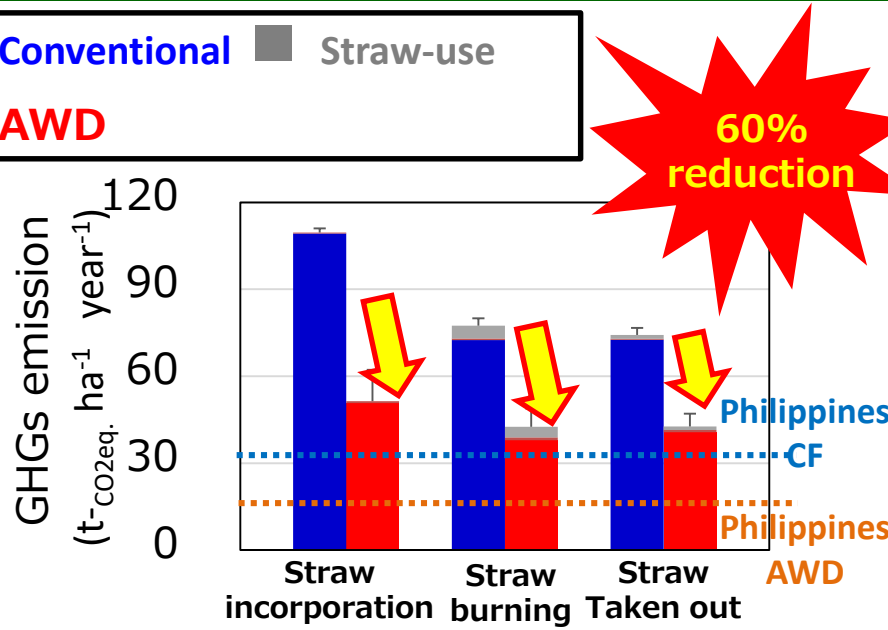
Characteristics of the Mekong delta

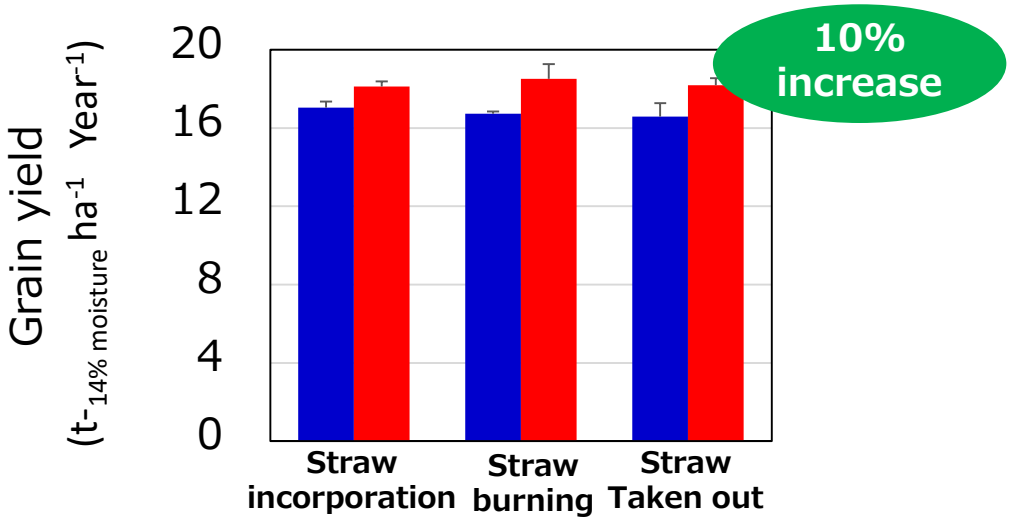


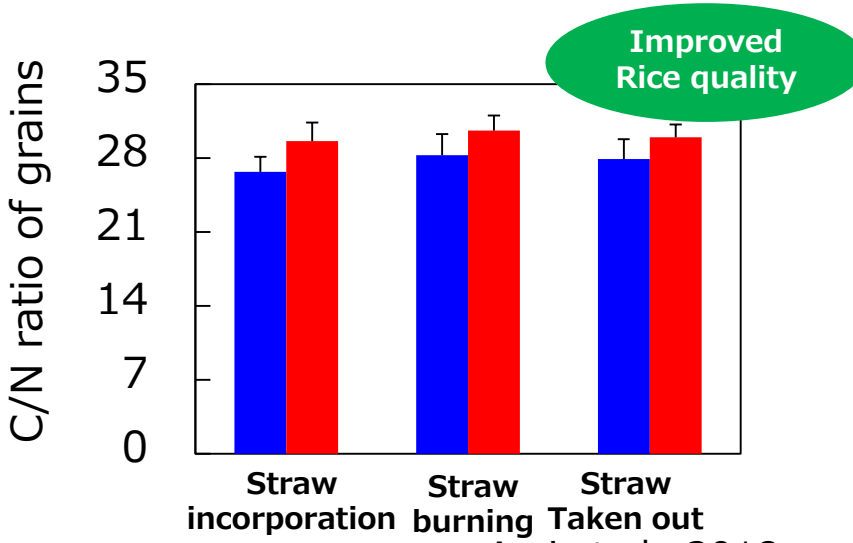
Arai et al., 2018

- Reduction of irrigation rate & GHGs (2012-2016)
- Increase of rice grains and its quality



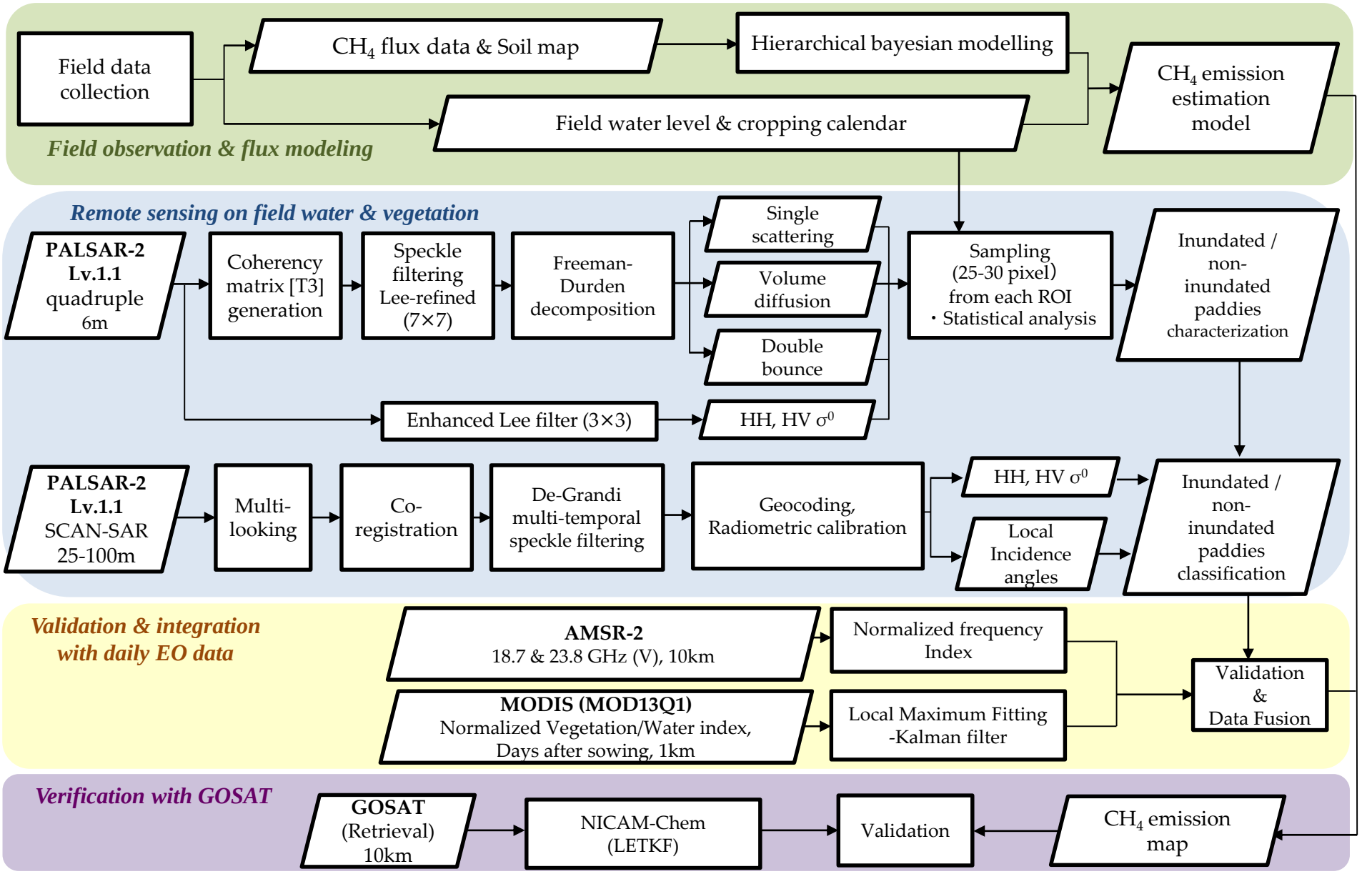






Arai et al., 2018

Flow chart


Field data collection
CH_4 flux data & Soil map
Hierarchical bayesian modelling
Field water level & cropping calendar
CH_4 emission estimation model
Field observation & flux modeling
Remote sensing on field water & vegetation
PALSAR-2 Lv.1.1 quadruple 6m
Coherency matrix [T3] generation
Speckle filtering Lee-refined (7×7)
Freeman-Durden decomposition
Single scattering
Volume diffusion
Double bounce
Sampling (25-30 pixel) from each ROI
・Statistical analysis
Inundated / non-inundated paddies characterization
Enhanced Lee filter (3×3)
HH, HV σ^0
PALSAR-2 Lv.1.1 SCAN-SAR 25-100m
Multi-looking
Co-registration
De-Grandi multi-temporal speckle filtering
Geocoding, Radiometric calibration
HH, HV σ^0
Local Incidence angles
Inundated / non-inundated paddies classification
Validation & integration with daily EO data
AMSR-2
18.7 & 23.8 GHz (V), 10km
Normalized frequency Index
MODIS (MOD13Q1)
Normalized Vegetation/Water index, Days after sowing, 1km
Local Maximum Fitting -Kalman filter
Validation & Data Fusion
Verification with GOSAT
GOSAT (Retrieval) 10km
NICAM-Chem (LETKF)
Validation
CH_4 emission map

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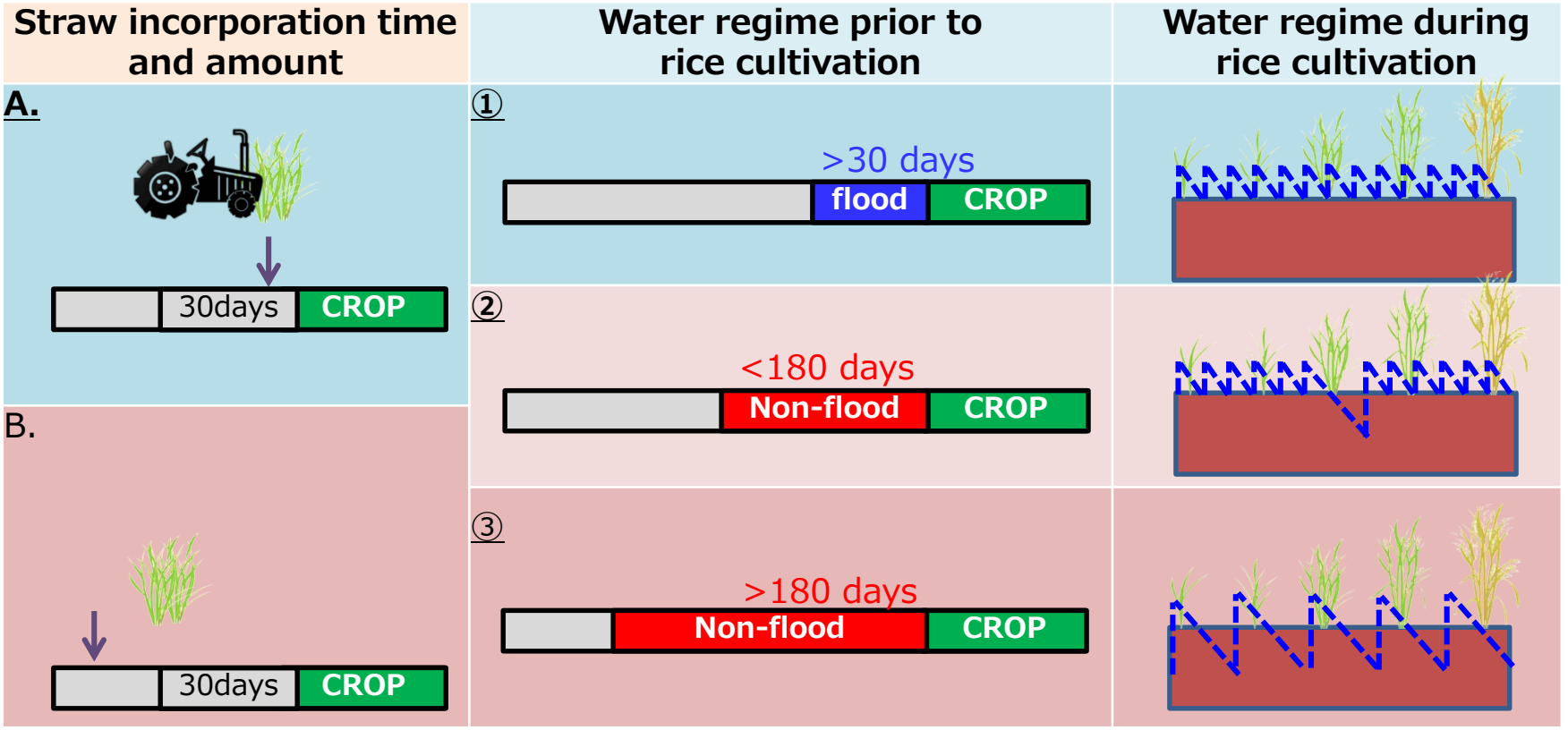
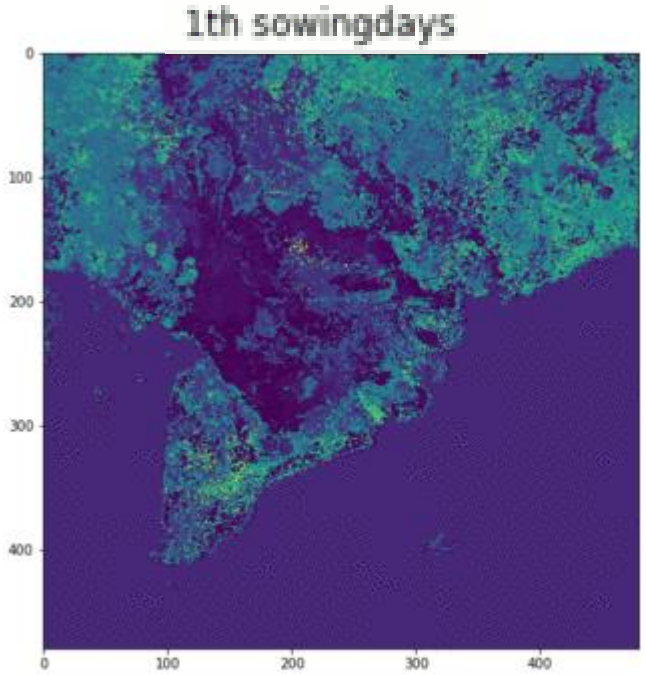
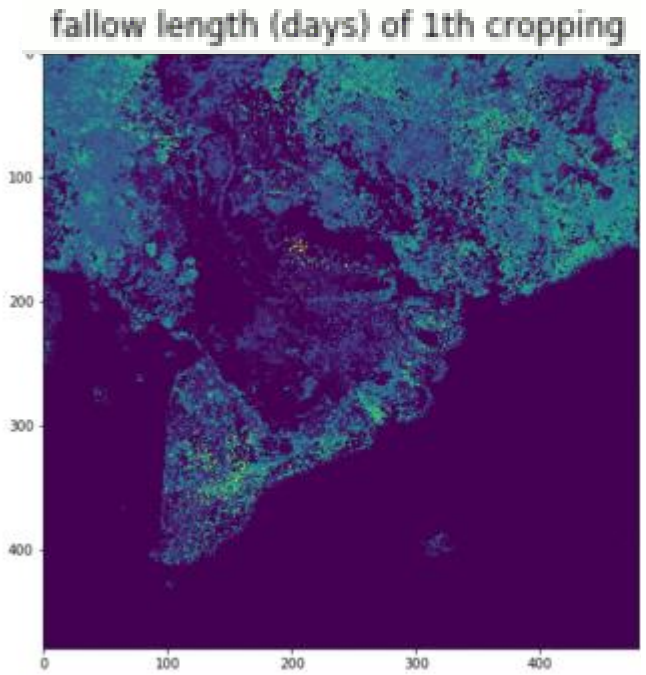
IPCC guideline (Tier1)
[Emission factor × Scaling factor in IPCC guideline]



Cropping calendar evaluation with MODIS-NDVI (LMF-KF) for GCOM-C

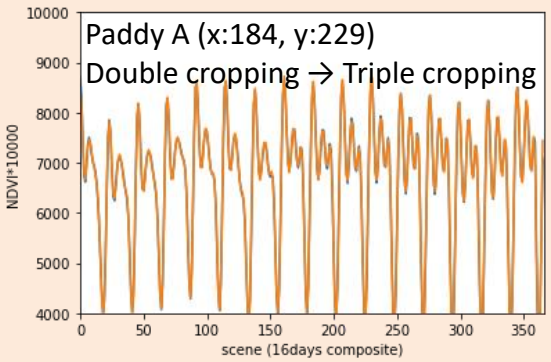
Sowing days (days after 2001/01/08)

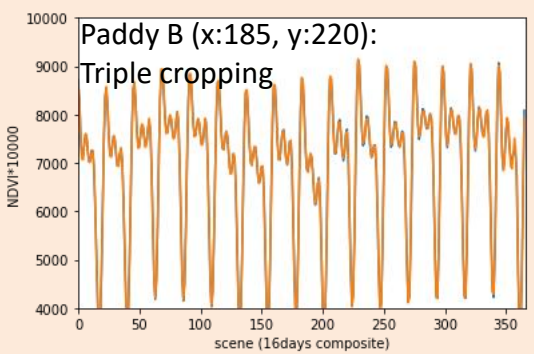




The adjacent fallow's length (days)

Samples of paddies





Arai et al., 2018

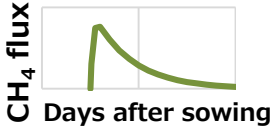
Semi-empirical **daily** CH_4 flux (mg C m^{-2} hr^{-1}) Model

CH_4 emission on a specific date

= γ * *carbon_management* / *non-inundated_fallow* / *inundated_fallow* * *water_management* *α*β

carbon_management (Michaelis-Menten KINETICS)

=[exp(-***DAS****δ)-exp(-***DAS****(δ+ω))+κ]



non-inundated_fallow (OXYDATION CAPACITY)

= [1+EXP(-1* ζ *(***DAS** – ι* **days of nonflooding days of the former fallow))]

inundated_fallow

= EXP(ε * **days of flooding days of the former fallow**)

water_management

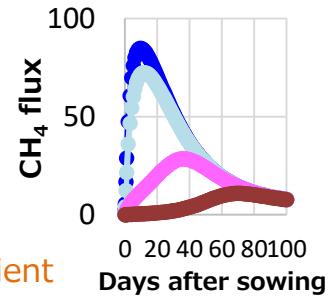
= EXP(η * **inundated days during the last 10days**)

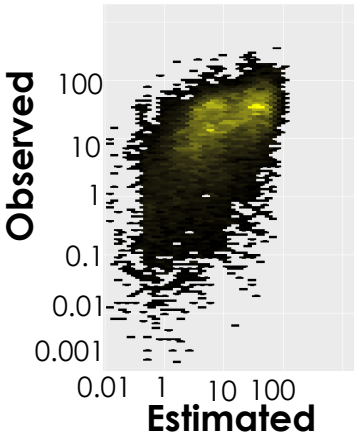
DAS←days after sowing

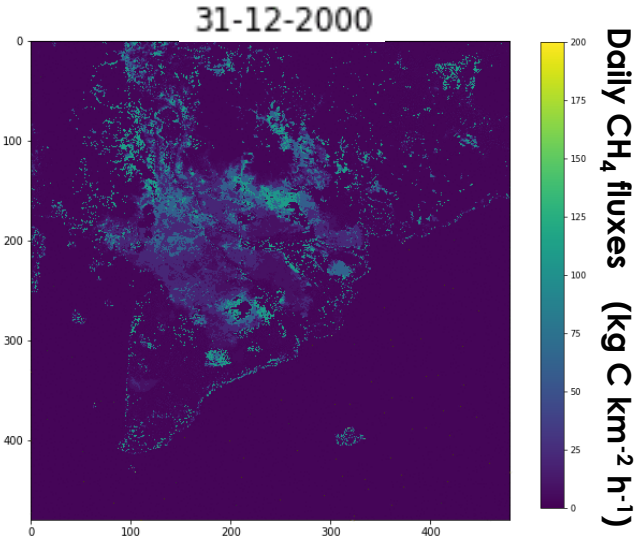
α ←straw incorporation coefficient

β ←acid sulfate・coastal sandy soil coefficient

γ, η, δ, ε , ω , ζ , ι, κ←constant (>0)



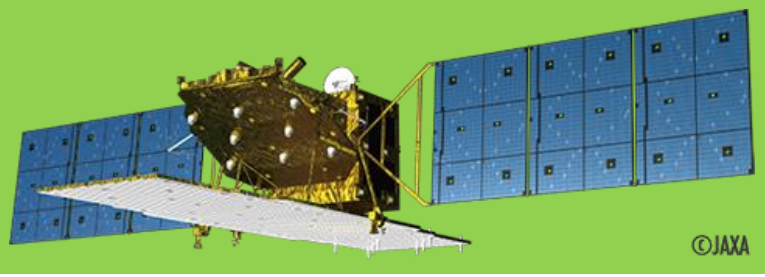


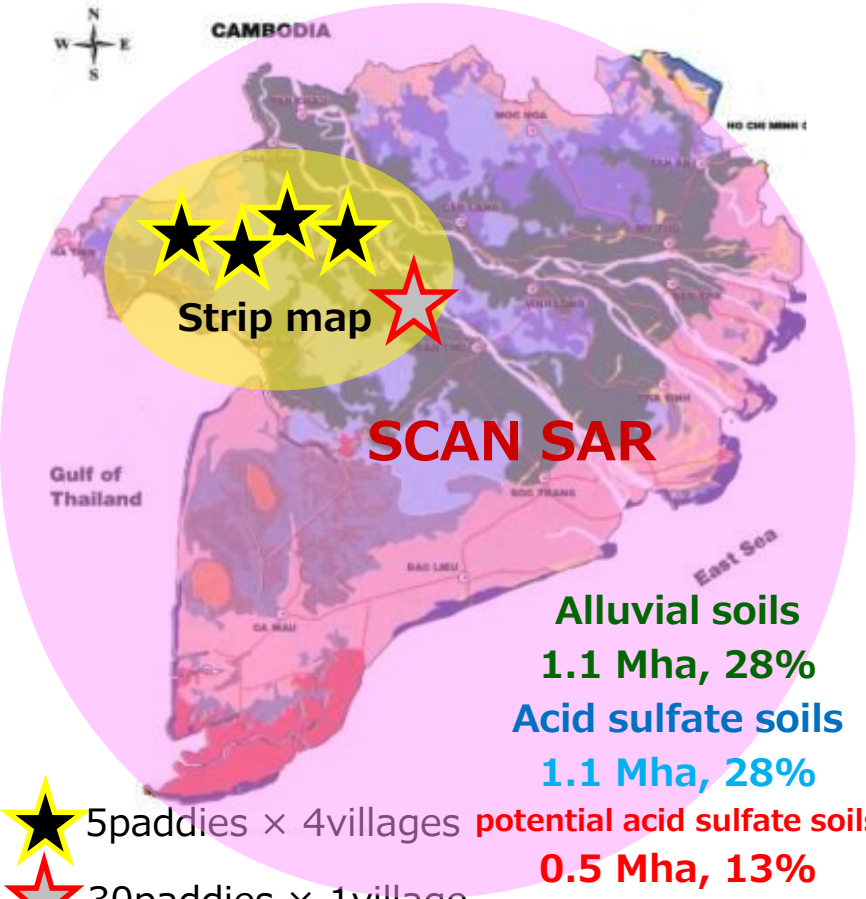


Arai et al., 2018

ALOS-2/PALSAR-2

– **L**band-**S**ynthetic **A**perture **R**adar –





Xuan and Matsui, 1998

PALSAR-2 Lv.1.1 (quad. CEOS) 23 scenes

- Coherency matrix [T3] generation
- Speckle filtering LEE refined (7×7)
- **Polarimetric decomposition**: Freeman-Durden; Cloud-Pottier
- Sampling (25-30pixel) from each ROI & Statistical analysis

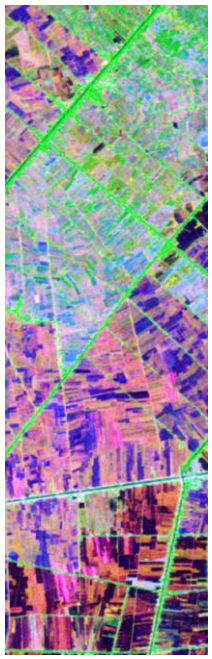
PALSAR-2 Lv.1.1 (SCANSAR CEOS) 105 scenes

- Multilooking
- Co-registration
- De Grandi multi-temporal filtering
- Geocoding & Radiometric calibration — HH; HV; Incidence angle
- Rice paddy masking & Statistical analysis

Classification of inundated paddies and non-inundated paddies which is covered by rice plants

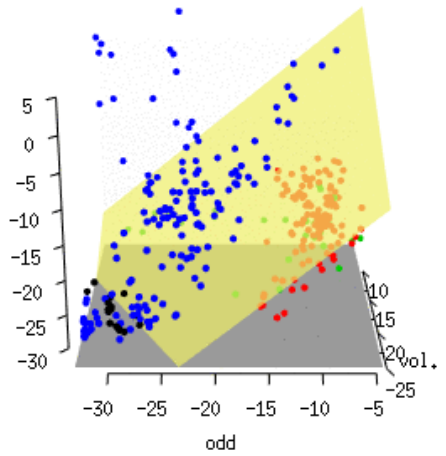
Modified from Avtar *et al*. 2012

-Freeman-Durden decomposition-



Inundated (cropping)

Inundated (fallow)

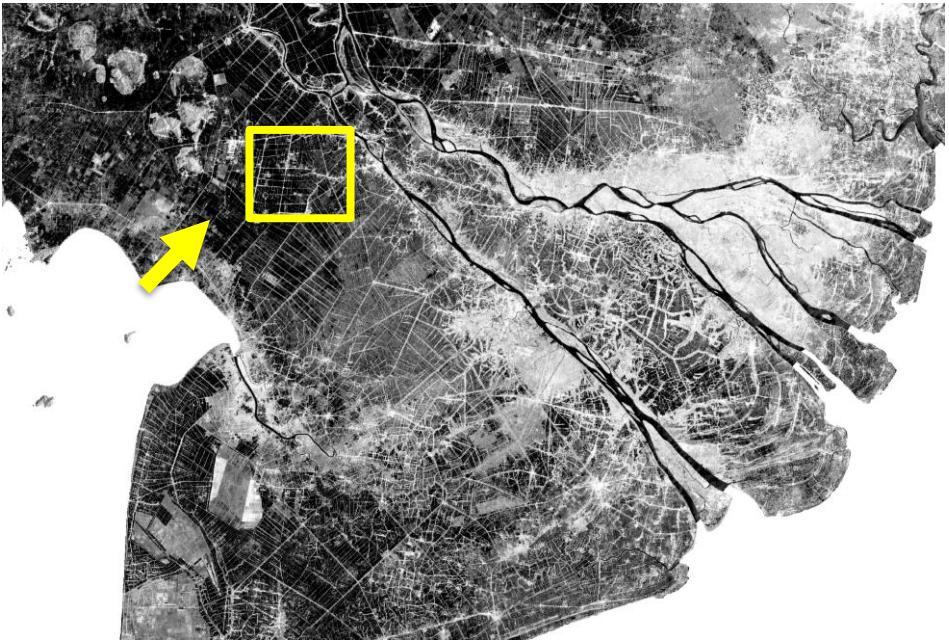


Non-inundated (cropping)

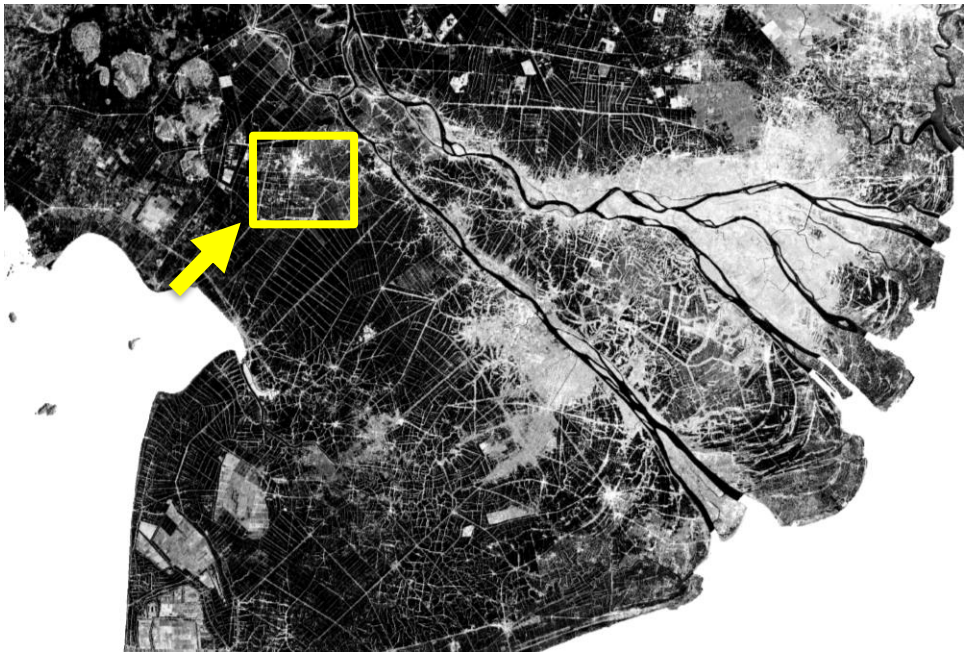
Non-inundated (fallow)

SCANSAR (intensity - HHσ^0)

Dry season (2015 Apr. 10)

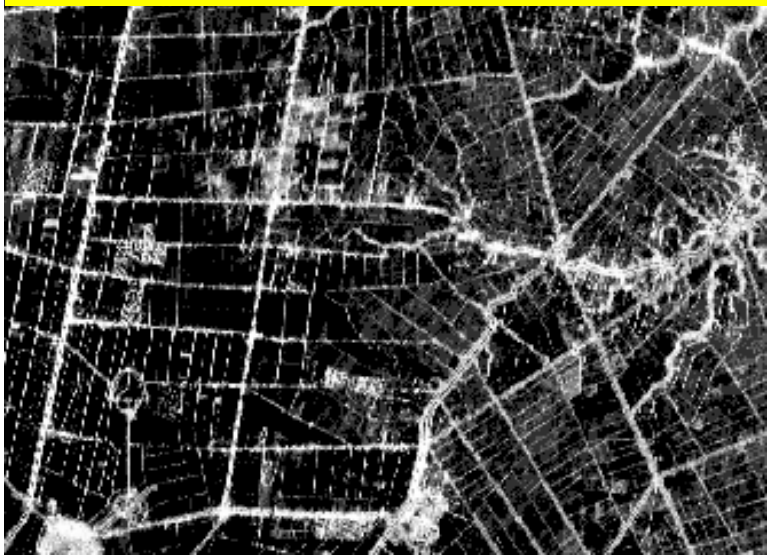


Flooding season (2015 Oct. 23)



Double bounce detection by SCANSAR (intensity - HHσ^0)

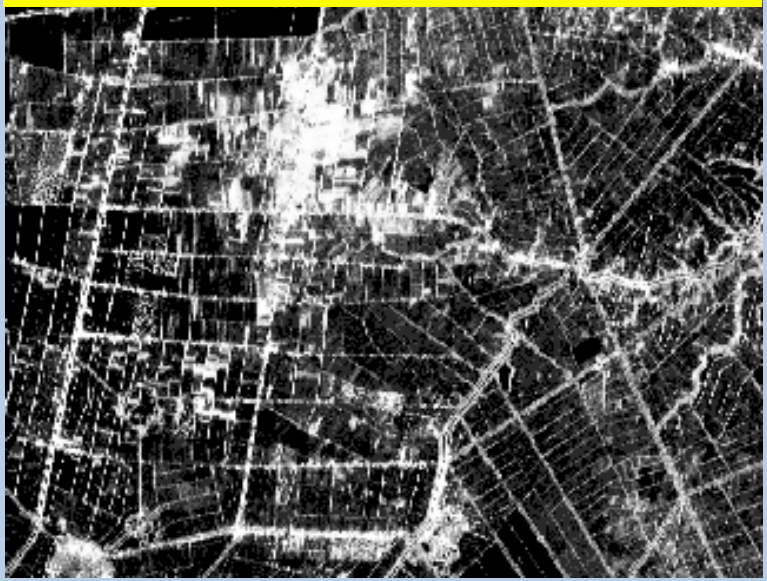
Dry season (2015 Apr. 10)



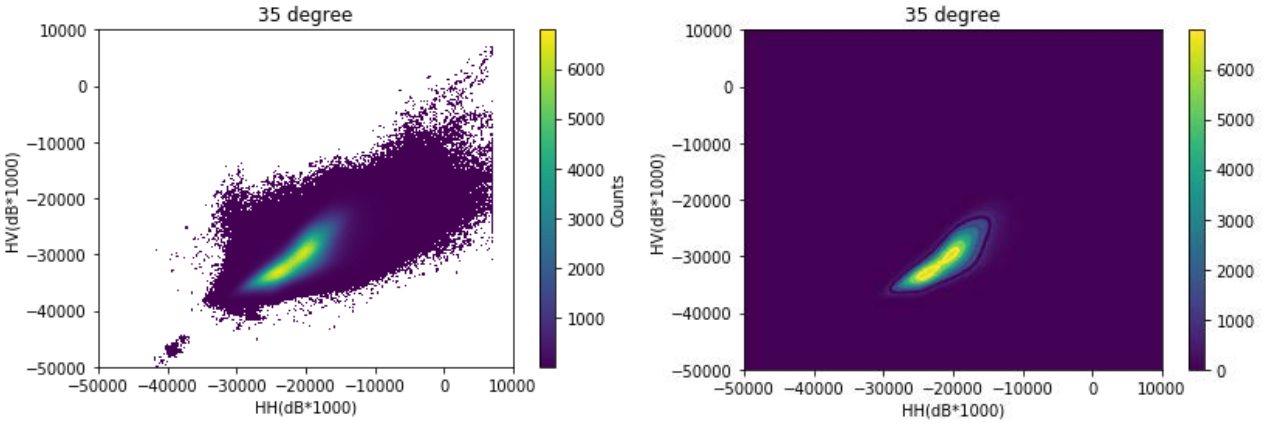
Rainy season (2015 Jul. 03)

Flooding season (2015 Oct. 30) **-LANDSAT-8-**

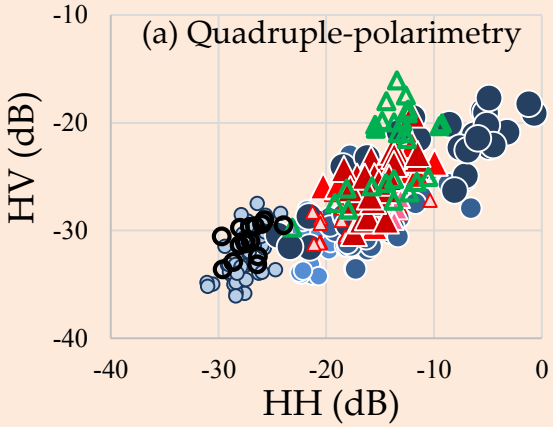
Flooding season (2015 Oct. 23)



SCAN-SAR (25m)



Full-polarimetry (3m)



Inundated Non-inundated

0-20 days after sowing

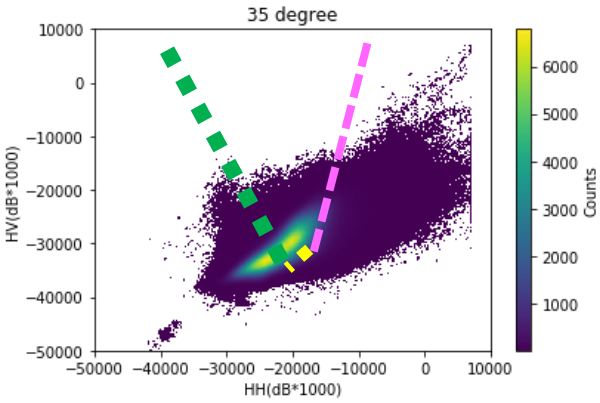
21-40 days after sowing

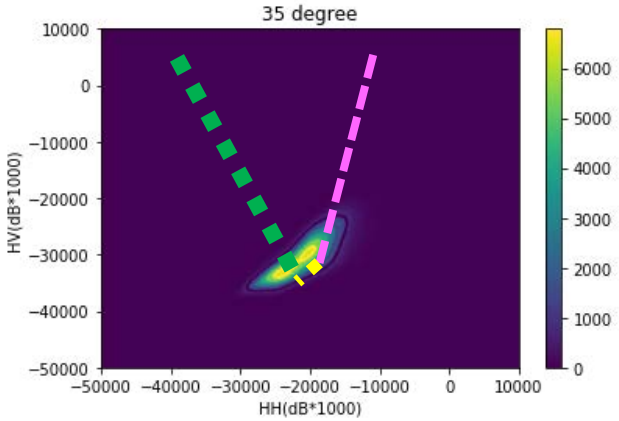
41-60 days after sowing

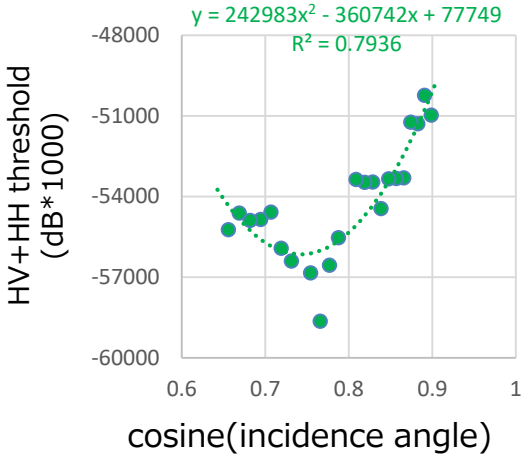
61-100 days after sowing

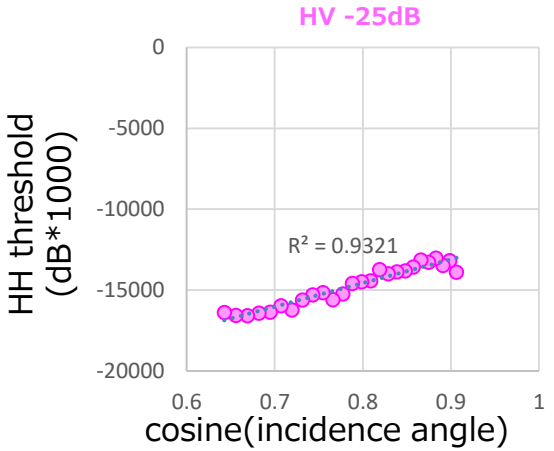
Fallow paddies

Arai et al., 2018







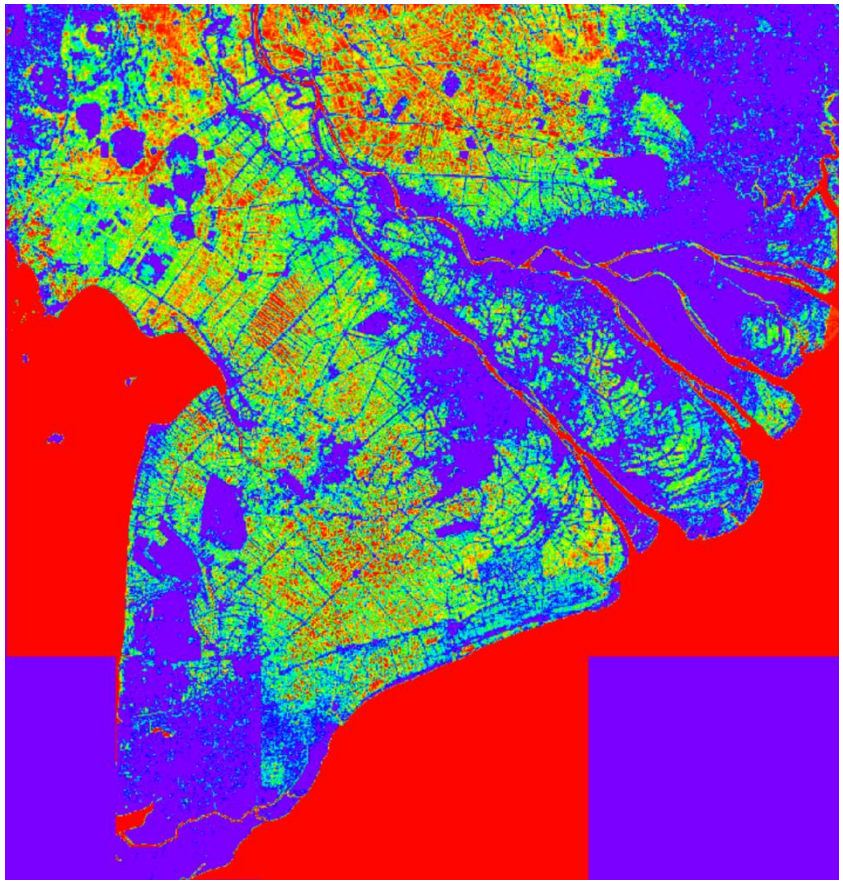


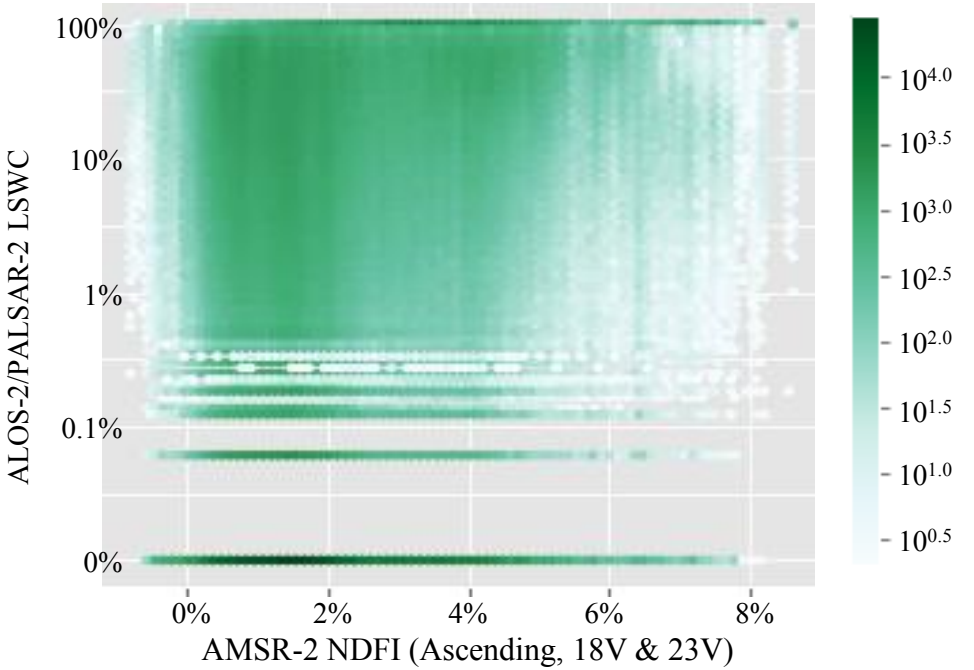
HH threshold (dB) = 0.550*HV
+12.9*cosine(IA)
-11.2

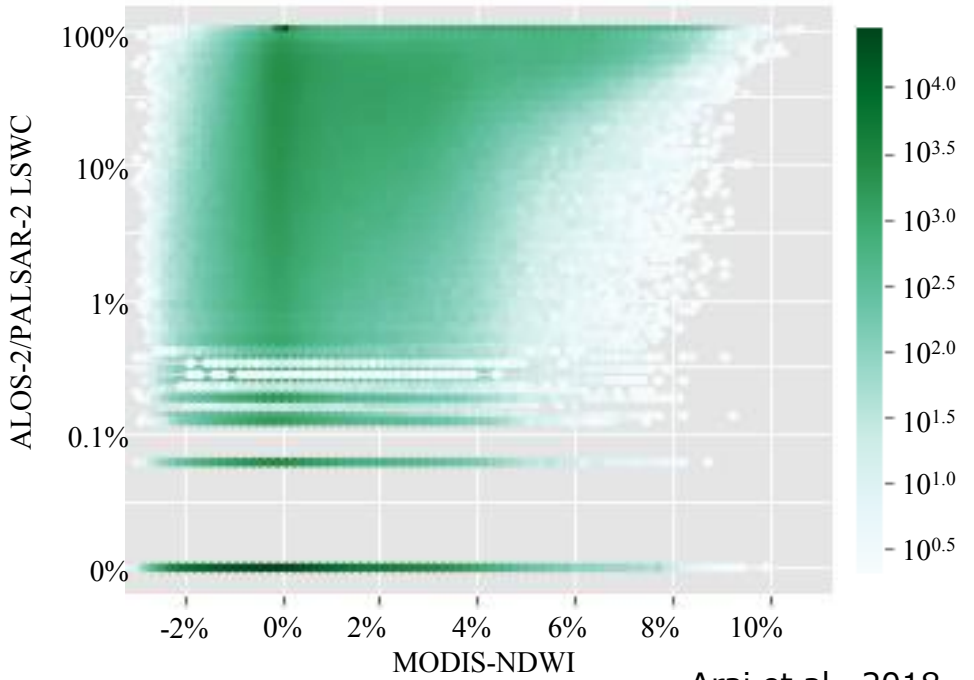
Arai et al., 2018

Floodability analysis

(Cumulative LSWC/
observation scenes)



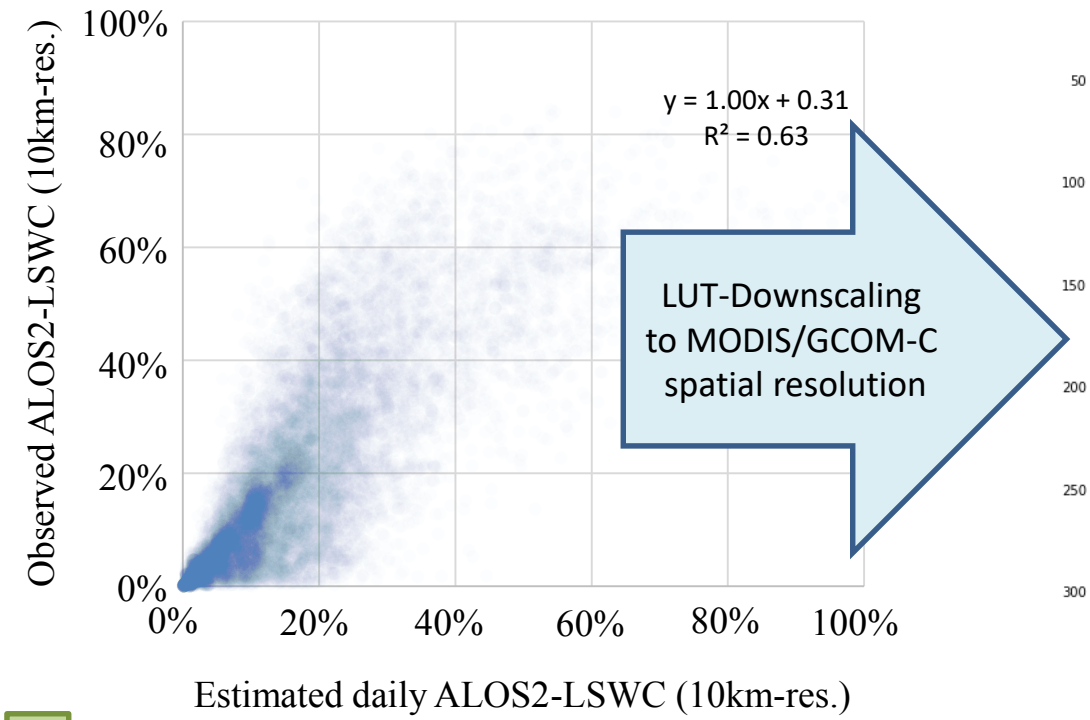




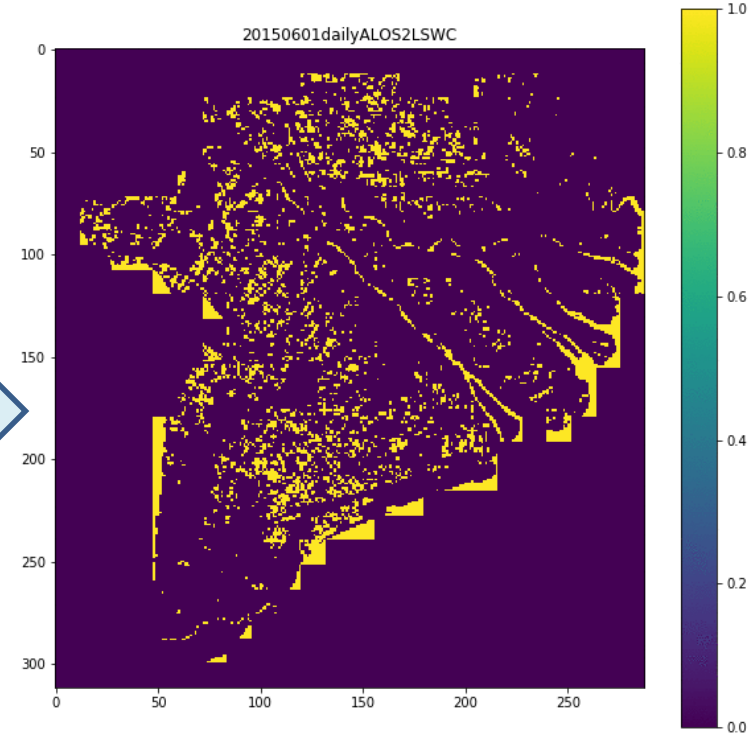
Arai et al., 2018

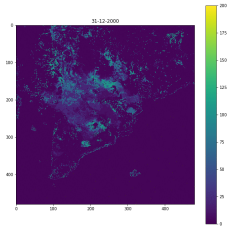
Daily ALOS2-LandSurfaceWaterCoverage estimation with floodability, GCOM-W & GCOM-C (MODIS)

$$= (ALOS2floodability*\omega + \zeta)* \exp(AMSRNDFI*\delta - MODISLSVC*\delta)$$



LUT-Downscaling to MODIS/GCOM-C spatial resolution



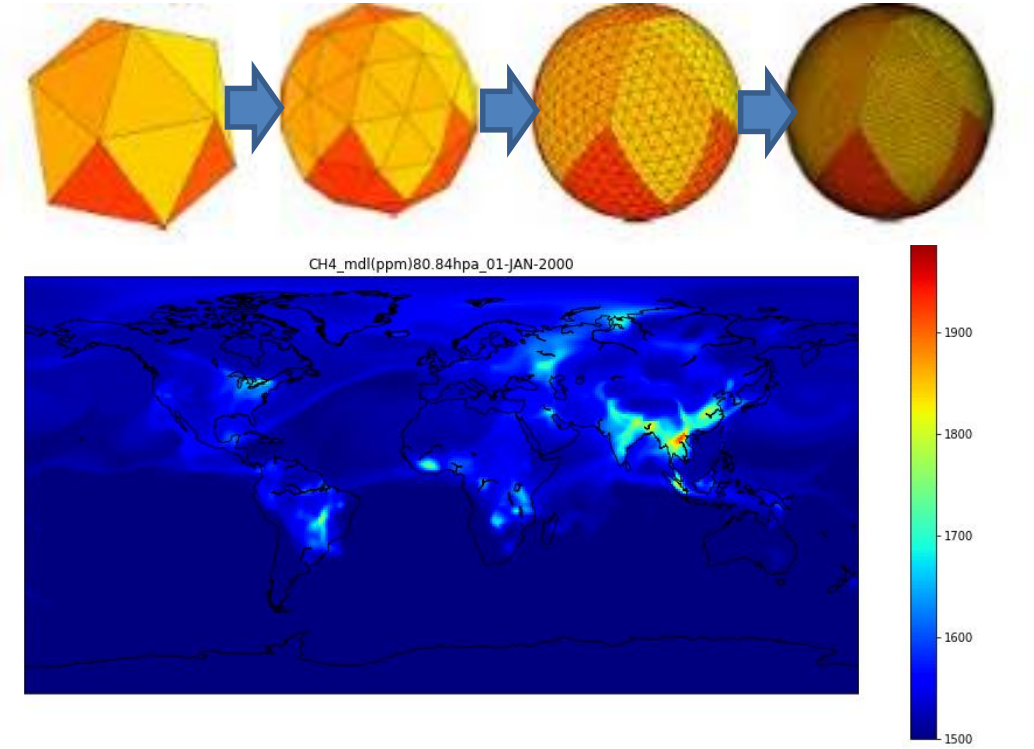


Estimate daily CH_4 emission with sowing date data and paddy-mask (MODIS, GCOM-C) (250m res., 2002-)

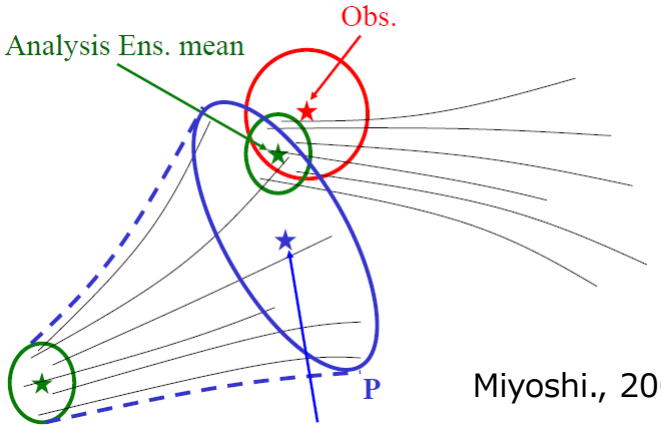
Need to be **VERIFIED** with GOSAT!

Inverse estimation of the emission using **NICAM-TM(Chem)-LETKF** with AMSU, PREPBUFR and **GOSAT** data

Nonhydrostatic **IC**osahedral **A**tmospheric **M**odel-**TM(Chem)**

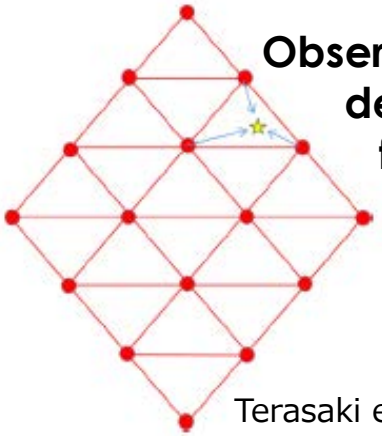


Local **E**nsemble **T**ransform **K**alman **F**ilter



Miyoshi., 2005

Observation operator development for GOSAT



Terasaki et al., 2014

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, D09110, doi:10.1029/2010JD014673, 2011

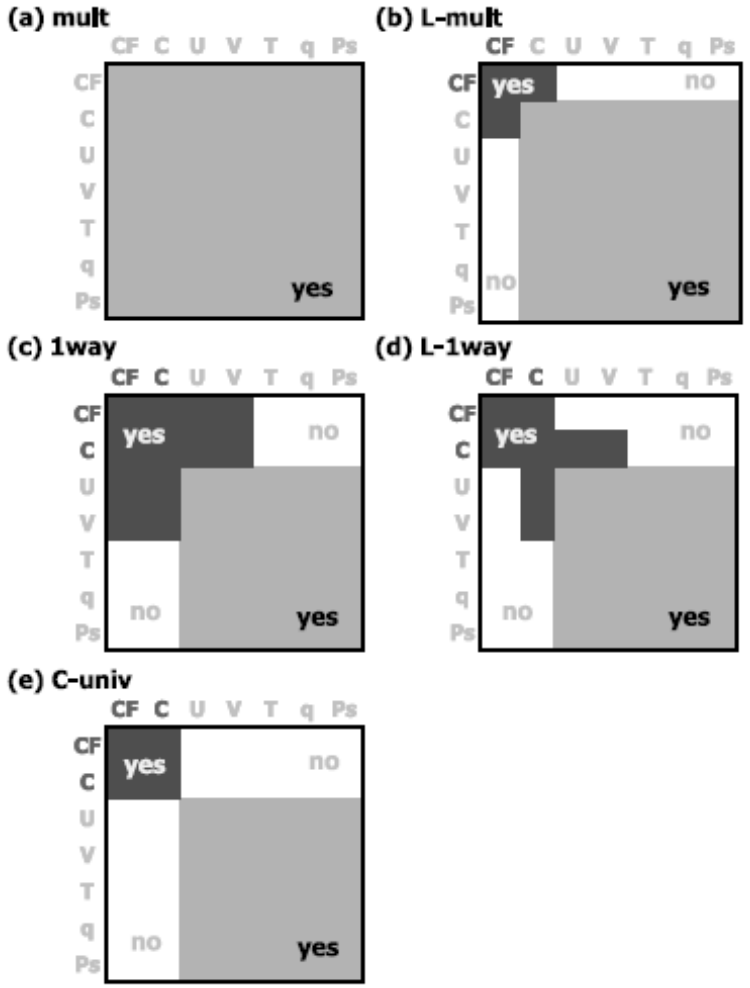
"Variable localization" in an ensemble Kalman filter: Application to the carbon cycle data assimilation

Ji-Sun Kang,[1] Eugenia Kalnay,[1] Junjie Liu,[2] Inez Fung,[2] Takemasa Miyoshi,[1] and Kayo Ide[1]

Flux estimation from atmospheric concentration by omitting multi-collinearity

- **No direct emission or apriori info. is required!**

Transparent MR**V**!!



Back ground covariance matrices

Thank you
for your attention