MONITOR CROPPING SYSTEM TRANSITION

Identifying Rice Crops in the Mekong Delta, Vietnam using Sentinel-1 Time Series Data

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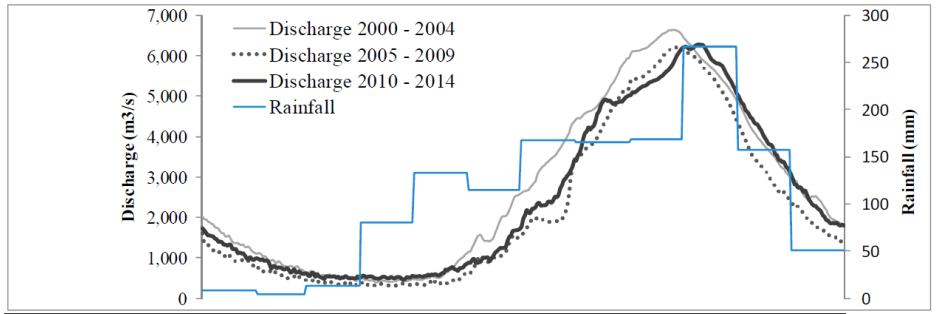
INTRODUCTION

- Triple-rice systems protected by high dikes from flooding during the wet season are common in the Mekong Delta, Vietnam (MD) due to their expected high yields.
- However, productivity for these systems is declining in the long term. New policies aim to reduce high-dikes and restore floodplain connectivity for ecosystem sustainability.
- Monitoring large areas for land-use changes is challenging. Traditional methods (e.g. field survey or in-person interview) are laborious and time-consuming. Analysis of single satellite images cannot deal with complexity of cropping system.
- **Objective: develop a workflow to monitor triple-rice system transitions in the MD using Sentinel-1 time series data.**

Adapted from Fujii, et al., 2013

RESEARCH BACKGROUND

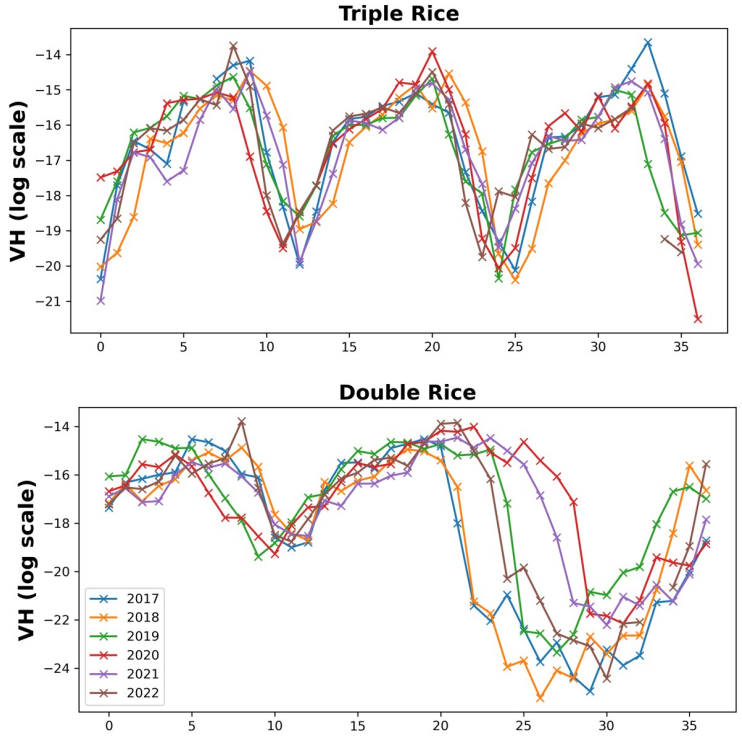
- Previous studies found seasonal variation of Sentinel-1 backscatter values can reflect the growing pattern of crop fields.
- Temporal profile can be treated as a signature to classify crop fields based on their land-use practises.



Month	1	2	3	4	5	6	7	8	9	10	11	12
Crop pattern/season	winter-spring			summer-autumn				autumn-winter				
Triple-rice crop												
Double-rice crop												
Single-rice crop												
Traditional-rice crop												

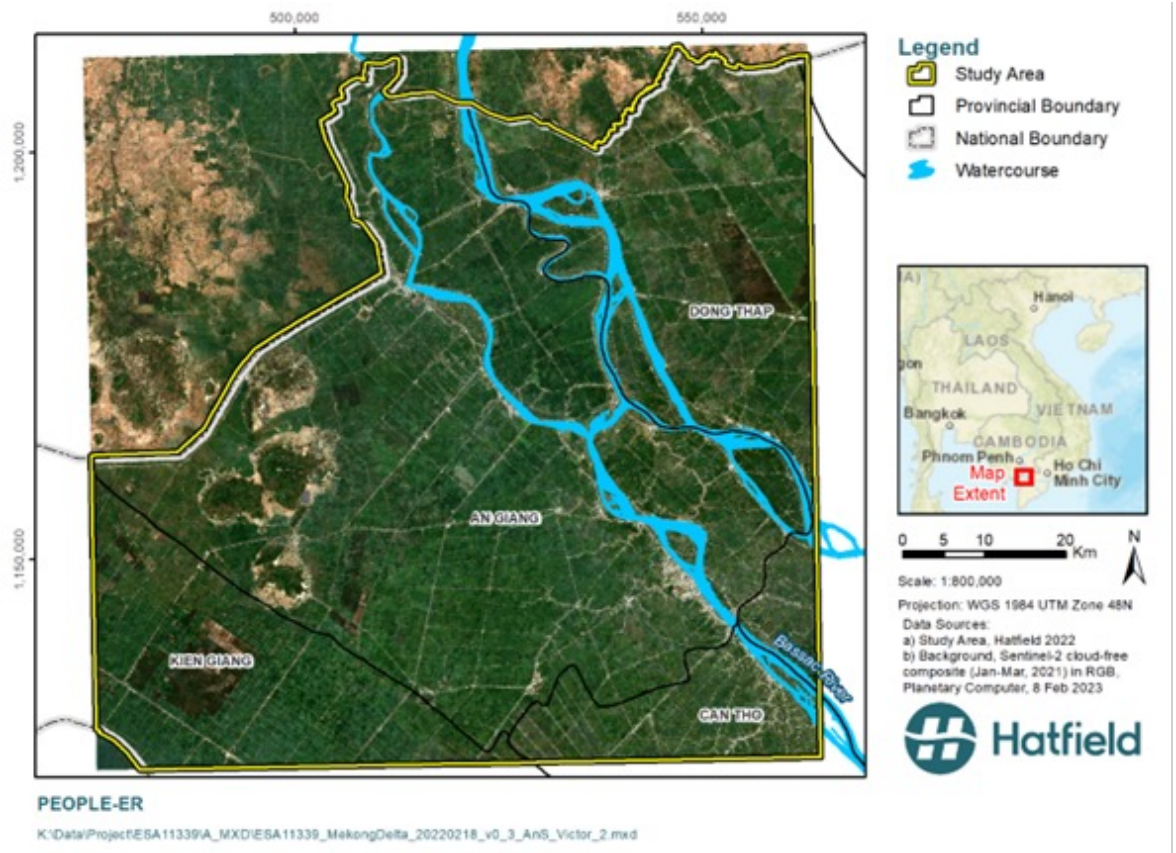
Rice
Vegetable

Adapted from Minh et al., 2019

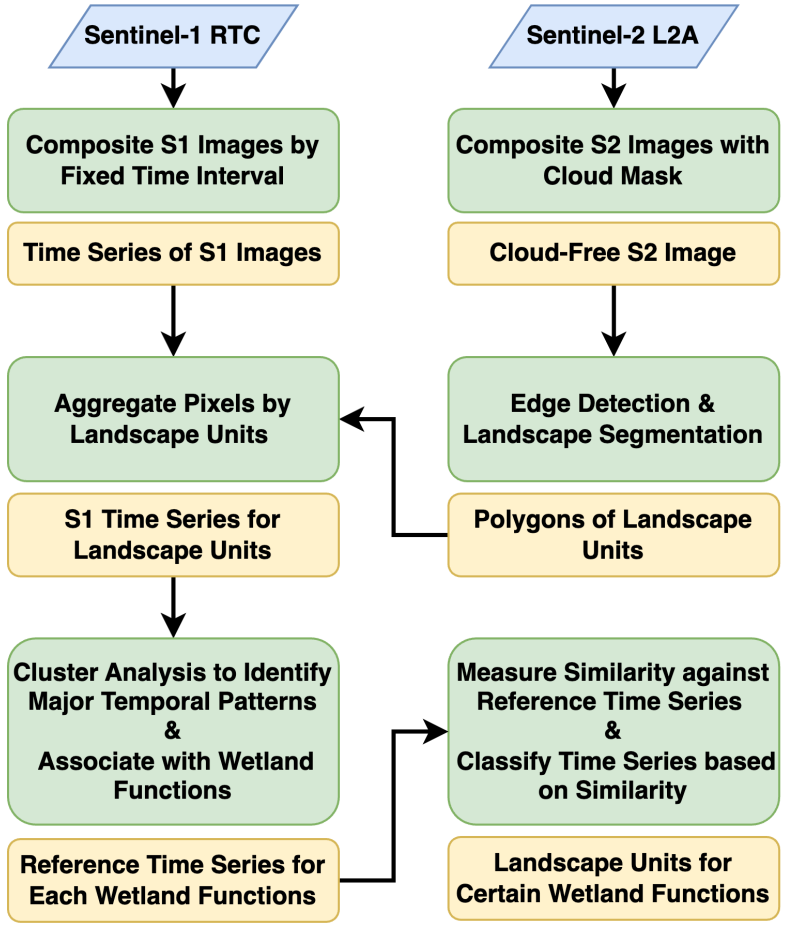


- In our exploratory analysis, we found the triple-rice and double-rice fields in the MD show distinct temporal profiles.

RESEARCH AREA & WORKFLOW



Research area mostly covers An Giang province with an area of ~6000 sq km

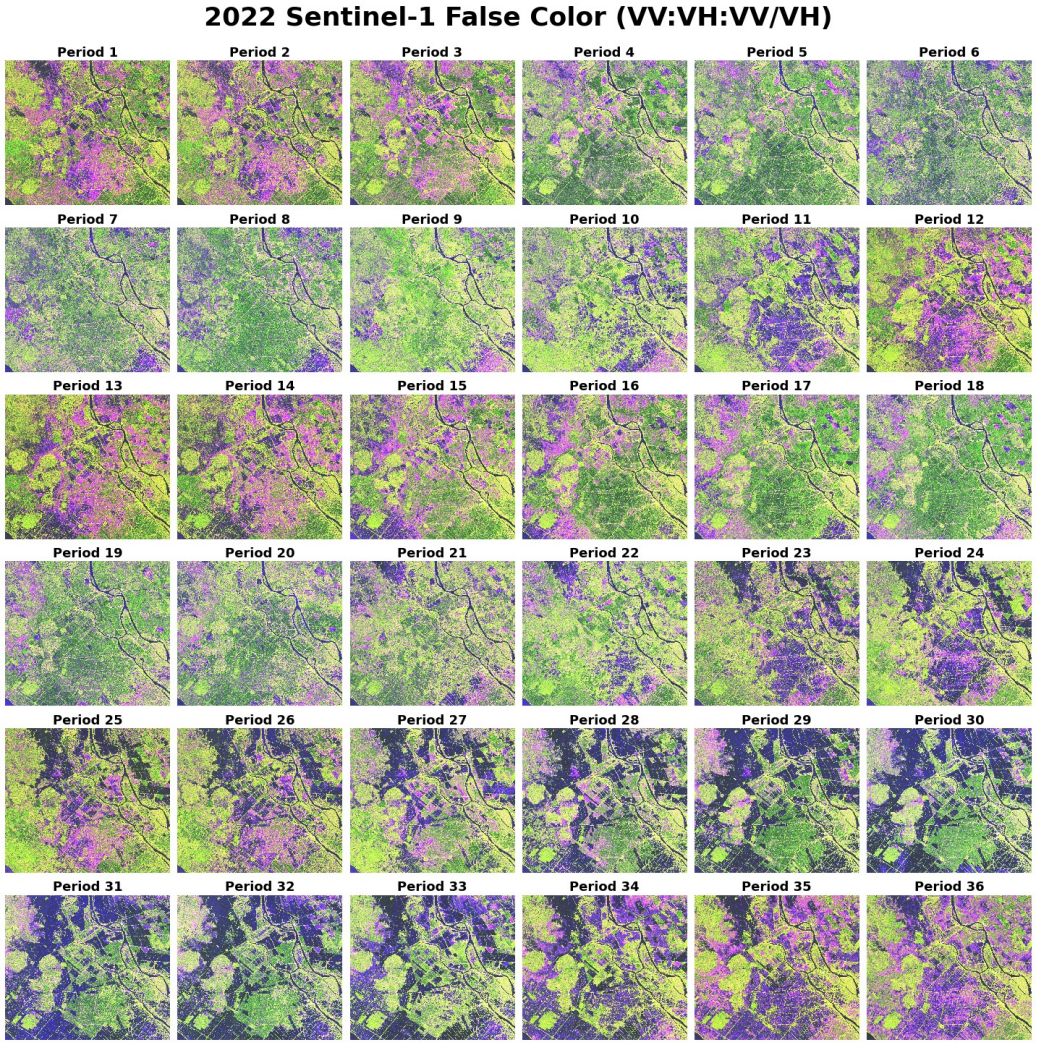


SENTINEL-1 IMAGE TIME SERIES

- Sentinal-1 SAR images were collected from 2018 Jan 1st to 2022 Dec 31st and separated by year to form annual S1 image stack

- S1 images were composited by 10 days to produced evenly spaced image time series

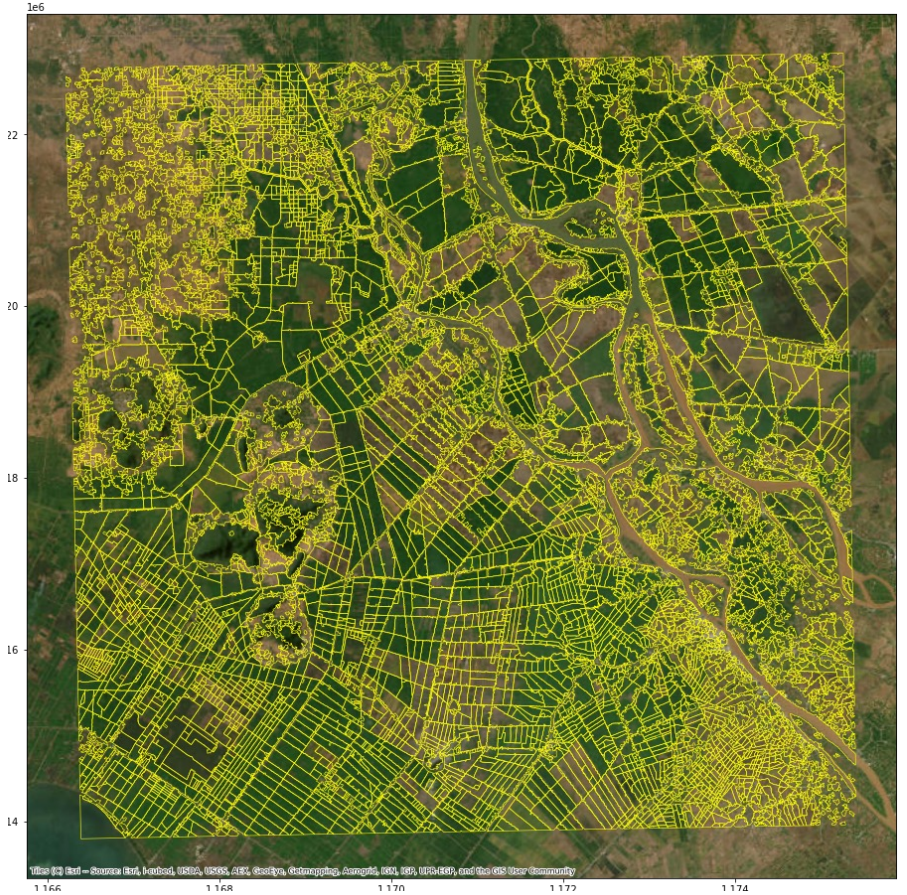
- Changes in color among the image time series clearly indicate strong temporal variation of backscatter values from flooding.



LANDSCAPE SEGMENTATION

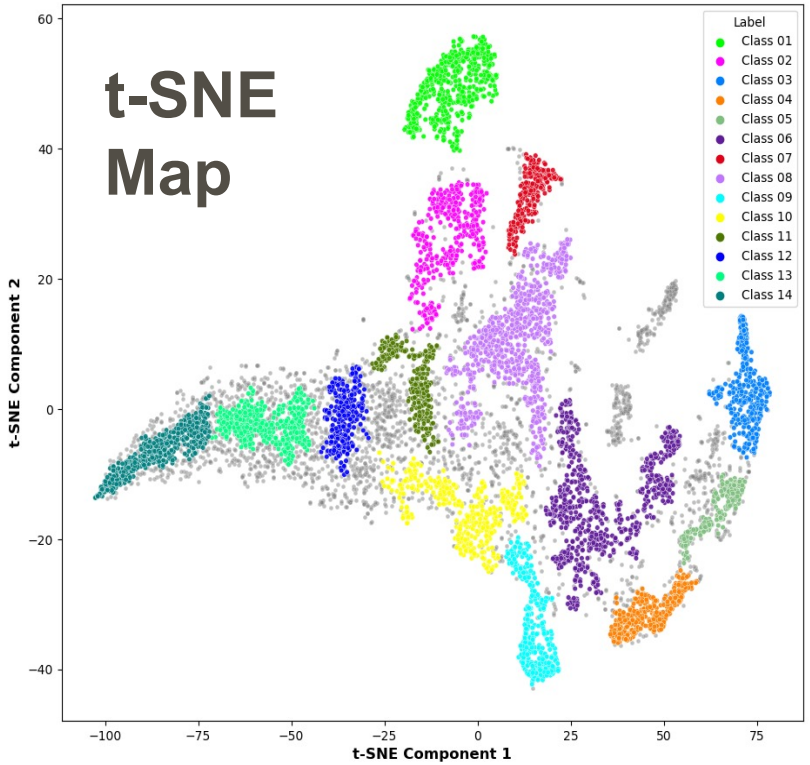
- Integrated multiple S2 images to enhance boundary information
- Scharr algorithm for edge detection
- Watershed algorithms for segmentation
- Aggregate pixels within landscape segment

```
# edge detection with scharr algorithm
edges_list = []
for i in tqdm(range(nb)):
    img = da[i, :, :]
    edges_list.append(scharr(img))

# stack edges of multiple images
edges = np.stack(edges_list, axis=0)
edges = np.nanmean(edges, axis=0)

# run watershed segmentation on edges
markers = morphology.binary_erosion(
    1 - edges, morphology.square(7)
)
markers, nf = ndi.label(markers)

segm = watershed(edges, markers)
```

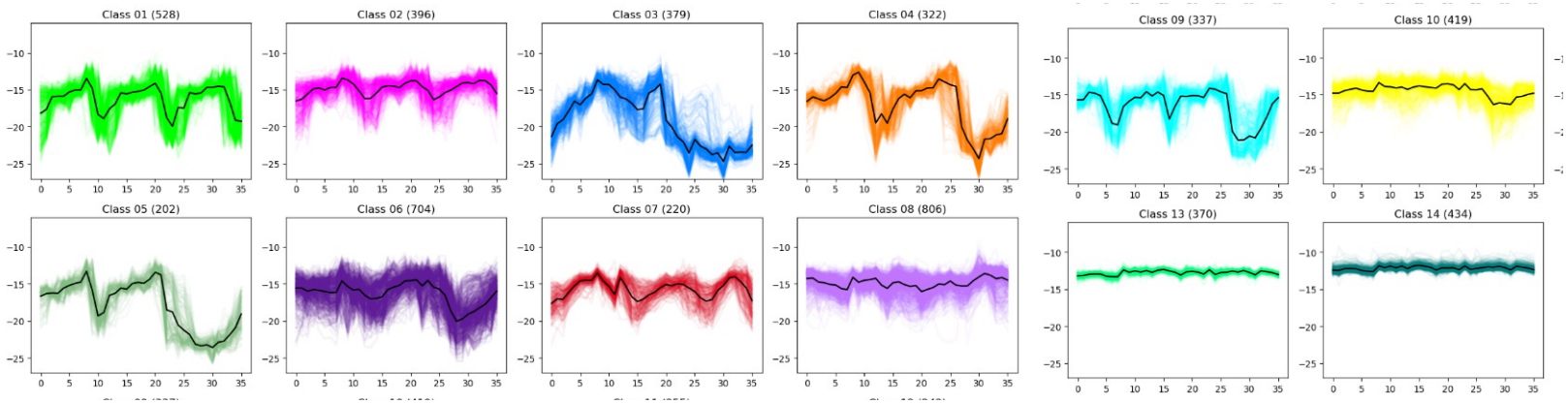


Sentinel-2 based image segmentation is developed based on the CEWS workflow proposed by Watkins & van Niekerk, 2019

CLUSTER ANALYSIS



- Perform t-SNE to project time series into 2D map for visualization
- Perform HDBSCAN to identify clusters on t-SNE map
- Associate those cluster to specific land-use types based on their temporal profile
- Average time series of each cluster were selected as the "**reference**" temporal profiles

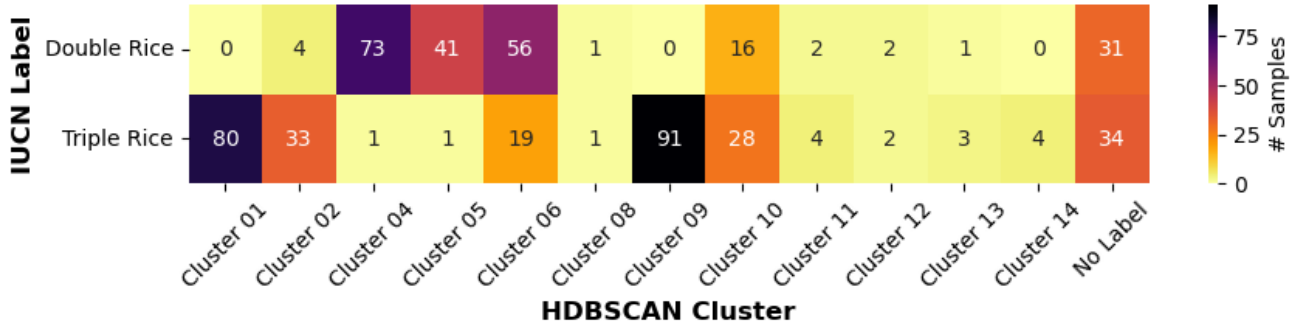


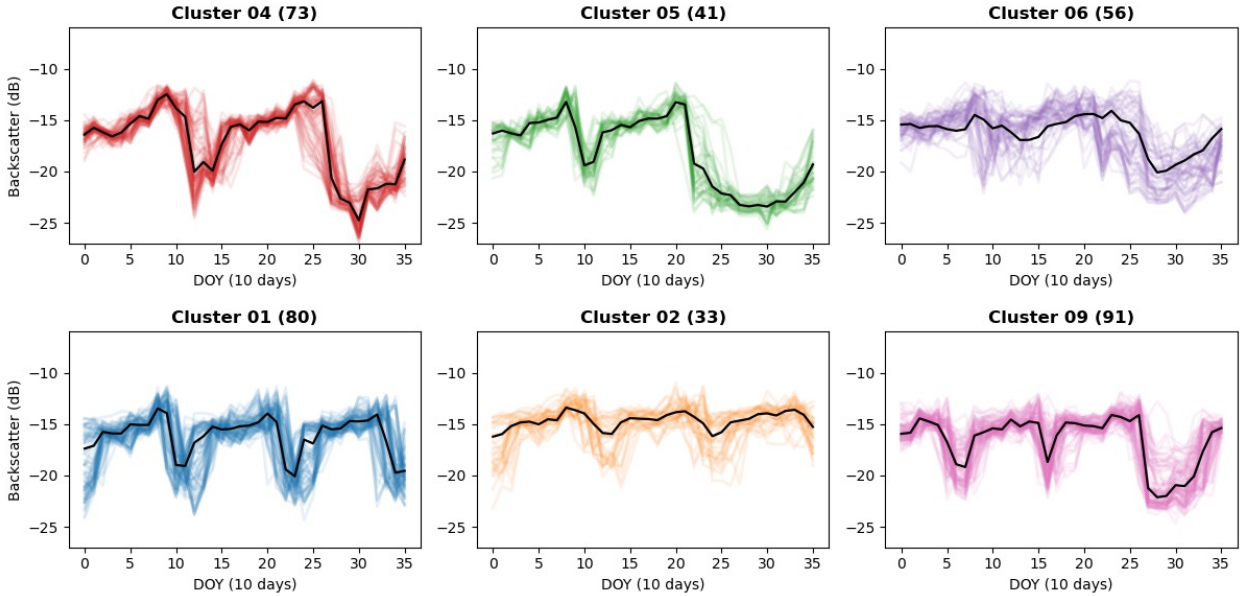
VALIDATION ASSESSMENT

- More than 600 landscape segments were labelled with landuse type
- Most belong to triple and double rice

Landuse 2022	Type
Annual Crops	26
Aquaculture	4
Built-Up Land	3
Mono Rice Crop	14
Perennial Trees	61
Rice - Shrimp	2
Double Rice	223
Double Rice-Vegetable	1
Triple Rice	303
Wetland	2

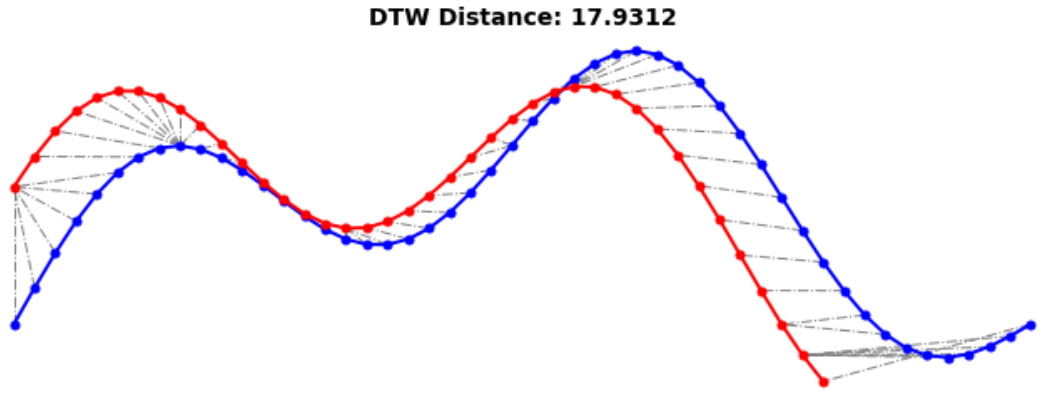
- Triple and double rice contains some subclasses
- IUCN labelled samples help to interpret HDBSCAN clusters
- Reference time series were identified for triple rice and double rice

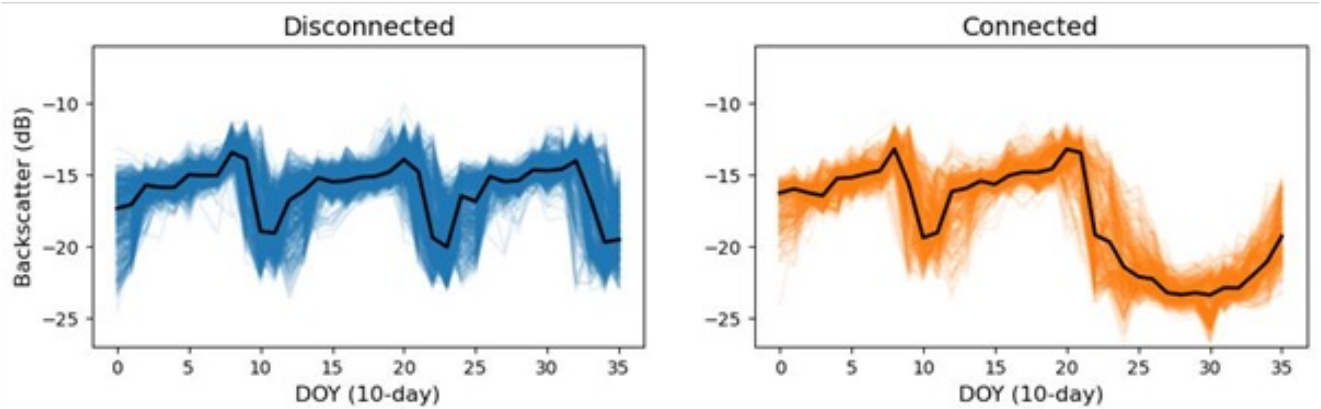




TIME SERIES SIMILARITY MEASUREMENT

- Dynamic Time Warping (DTW) is chosen to measure similarity between time series
  - advantage: tolerance in time lag
- DTW distances are calculated for landscape unit time series against reference time series
- DTW allows to select time series with similar temporal patterns to the reference ones
- Landscape segments are assigned to the land-use type with most similar temporal profile

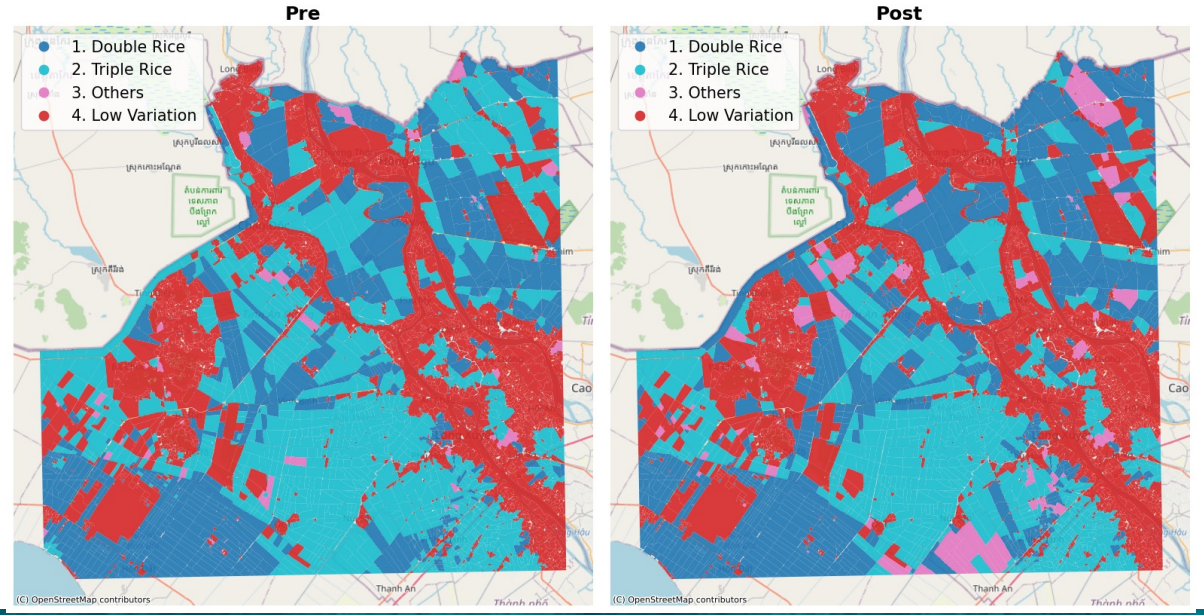




CLASSIFICATION & CHANGE DETECTION

- DTW was calculated between individual time series and reference temporal profiles that represent triple rice and double rice
- Segments were assigned to the classes with smallest DTW
  - If the smallest DTW > 275, then marked as ”Others”
  - If temporal variation < 2.0, then marked as “Low Temporal Variation”
- DTW-based classification achieved an overall accuracy of 86%.
- Comparison between the classification of 2019 and 2022 suggest ~20% decline in triple rice areas

Class_2022 / Class_2019	low variation	double rice	triple rice	others	2019 Total
low variation	2102.4	NaN	NaN	NaN	2102.40
double rice	NaN	1318.88	228.36	71.96	1619.21
triple rice	NaN	605.20	1519.46	194.92	2319.58
others	NaN	22.31	44.01	14.31	80.63
2022 Total	2102.4	1946.38	1791.83	281.19	6121.81

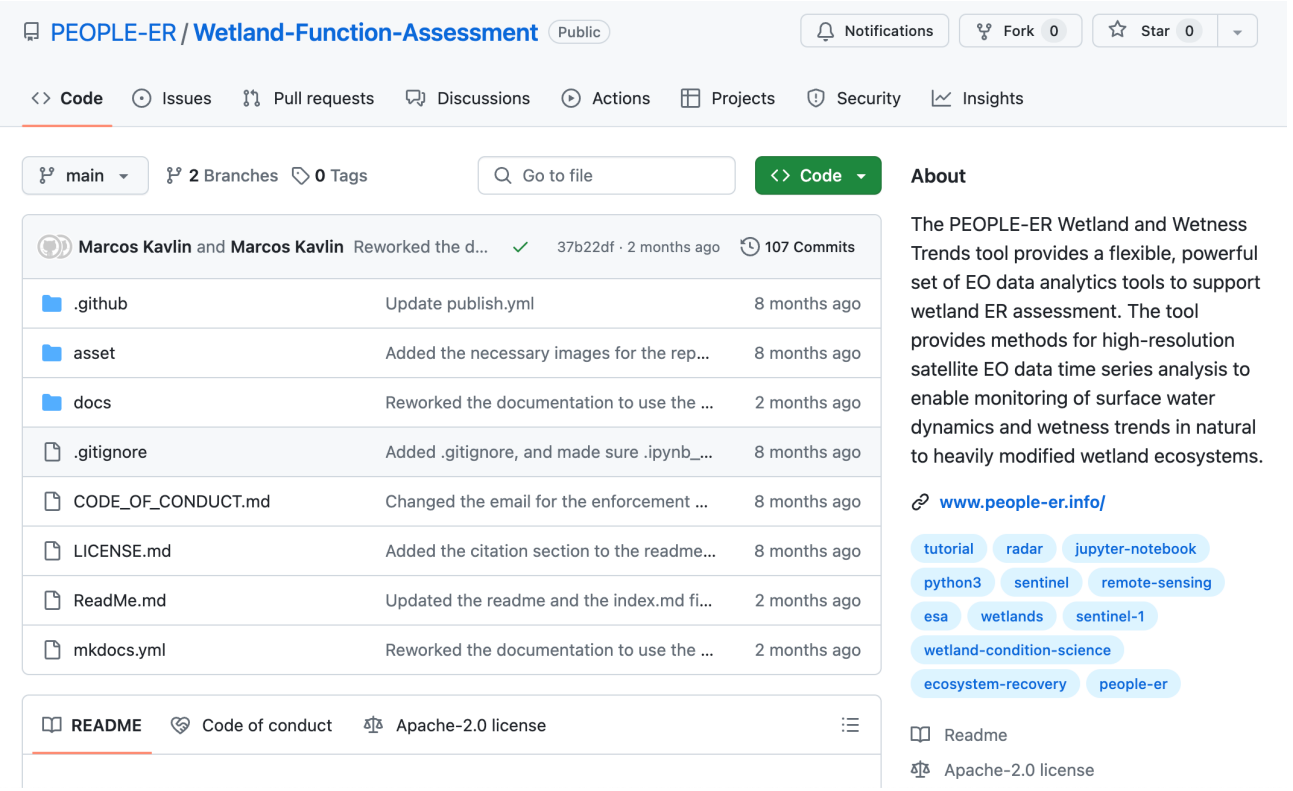


SUMMARY

- Sentinel-1 provides continuous observation even in cloudy areas (e.g. MD), enabling the identification of land-use types through backscatter temporal patterns.
- t-SNE-based cluster analysis allows for the identification of temporal patterns for predominant land-use practices across a given study area when the reference time series are unavailable.
- DTW is an effective similarity metric for time series dataset. Its tolerance to time lags accommodates the inter-annual variability of temporal patterns and disparity in flood timing between upper and lower floodplains.
- This novel workflow provides an efficient way to monitoring cropping systems transition in MD with minimal requirement for reference data.

MORE ABOUT PEOPLE-ER

https://www.people-er.info



https://github.com/PEOPLE-ER/Wetland-Function-Assessment


THANK YOU
QUESTIONS?