



A Sample Spatiotemporal Generation Method Using Optical-SAR Fusion For Crop Classification In Cloudy And Rainy Regions

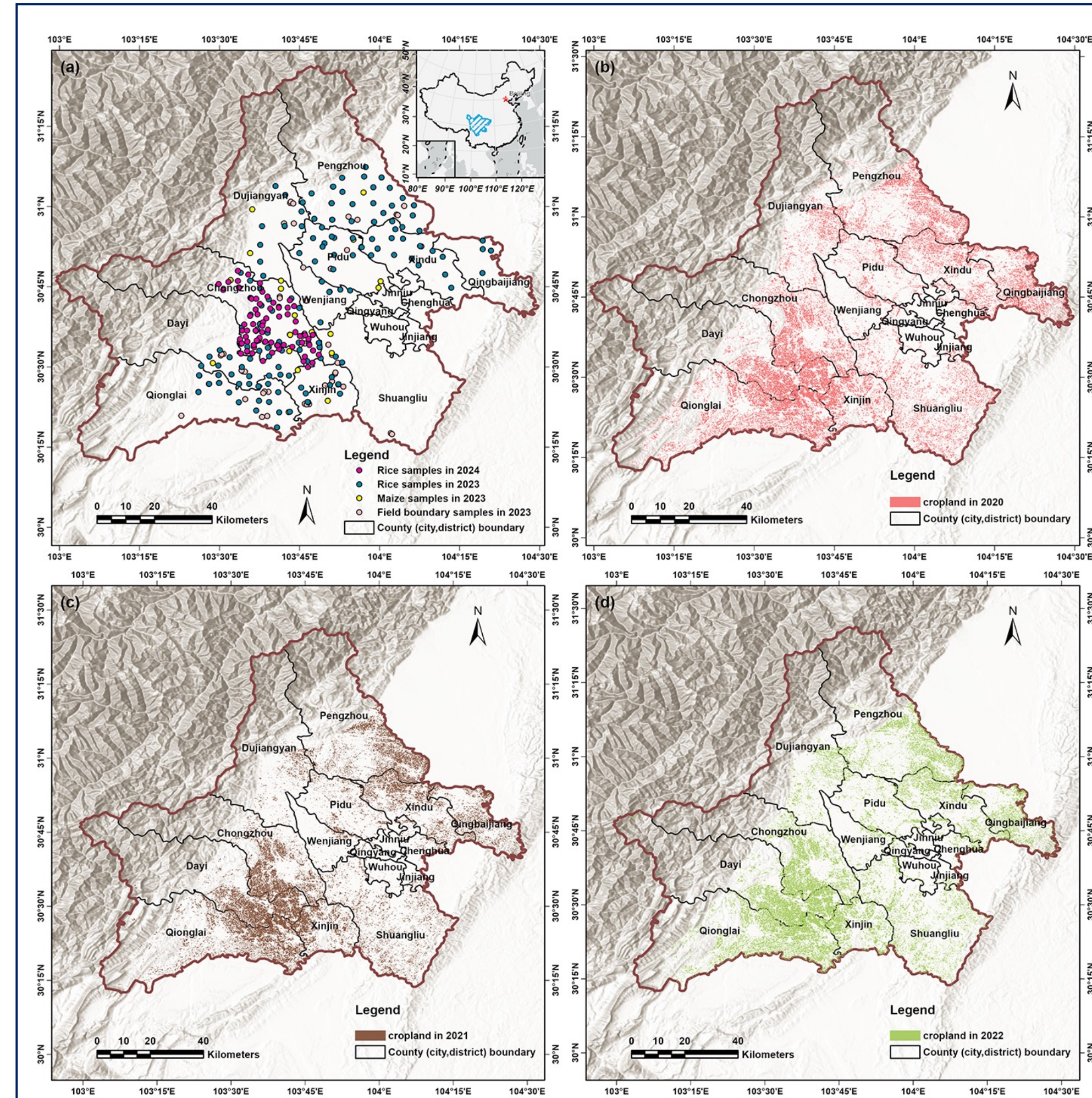
Ruonan Gao, Timo Balz*, Yuyan Yan, Boshen Chang, Qingwei Zhuang

State Key Laboratory of Information Engineering in Surveying, Mapping, and Remote Sensing (LIESMARS), Wuhan University, China; balz@whu.edu.cn

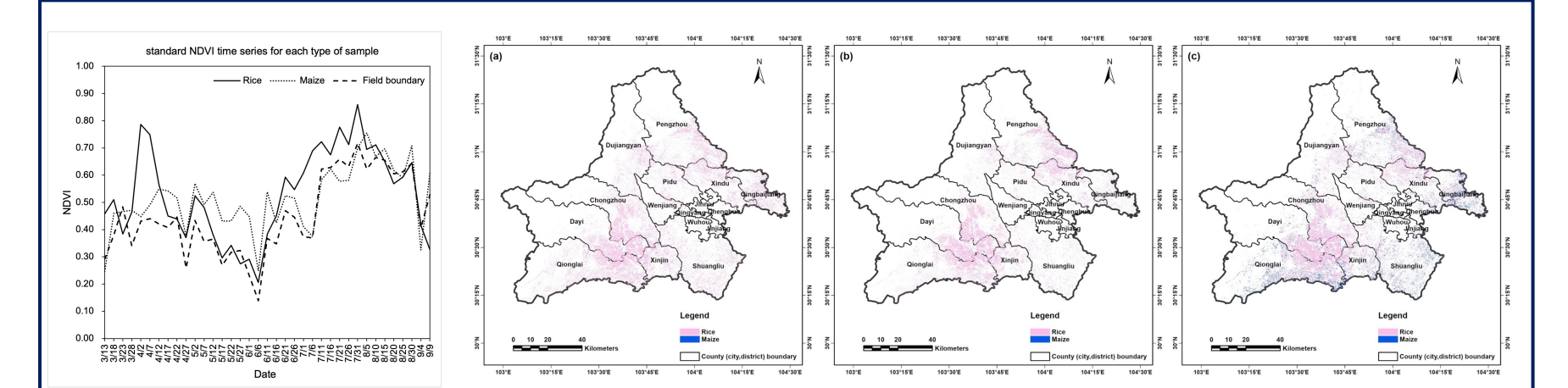


Abstract

Crop classification in cloudy and rainy regions faces the dual challenges of insufficient high-quality remote sensing images and limited samples. To address this, we propose a method that integrates optical and synthetic aperture radar (SAR) data to generate spatiotemporal samples. This approach enables the estimation of crop distribution in other years based on field survey samples from a single year. The method reconstructs vegetation index time series through pixel-level optical-SAR fusion and identifies crop types of generated spatiotemporal samples using time-weighted dynamic time warping and sample refinement. These samples support rapid and large-scale crop classification, achieving an accuracy of 67%-82% with random forest. Compared to methods relying solely on optical satellite data, the proposed approach demonstrates the potential of SAR in addressing data gaps. The results highlight the potential of training machine learning with spatiotemporal samples generated from optical-SAR fusion to enhance crop classification accuracy in similar climates.



Overview of the study area and cropland distribution in the Chengdu Plain. (a) Location of the Chengdu Plain and field survey sample distribution. Cropland distribution in (b) 2020, (c) 2021, and (d) 2022.



Standard NDVI time series for each type of sample and classification results of rice and maize in the Chengdu Plain in (a) samples in 2023, (b) 2020, (c) 2021, (d) 2022

Discussion

We compared this approach with the method that relies solely on optical remote sensing images for sample generation [5]. The two methods differ only in time series reconstruction approach, while all other procedures remain consistent.

Classification accuracy evaluation

Year	Overall accuracy	Method	Rice	Maize	Field boundary	Accuracy
2020	0.67	Optical - SAR	38	10	25	0.52
2021	0.72	Optical	48	7	18	0.66
2022	0.82	Optical				

Conclusion

In this study, we investigated the use of optical-SAR fusion for reconstructing NDVI time series and assessed its effectiveness in crop type determination and classification in cloudy and rainy regions. It showcased the potential of SAR to address data gaps caused by persistent cloud cover, ensuring data continuity across the crop growth cycle. The findings also highlighted key challenges, such as the misclassification of poorly grown crops as field boundaries and the cumulative accuracy losses during the spatiotemporal sample generation process. Future research will focus on improving reconstruction algorithms, integrating advanced cropland masks, and exploring the synergistic use of optical and SAR data to fully leverage their combined strengths. These efforts aim to provide more reliable and comprehensive solutions for crop monitoring in complex environmental conditions.

References

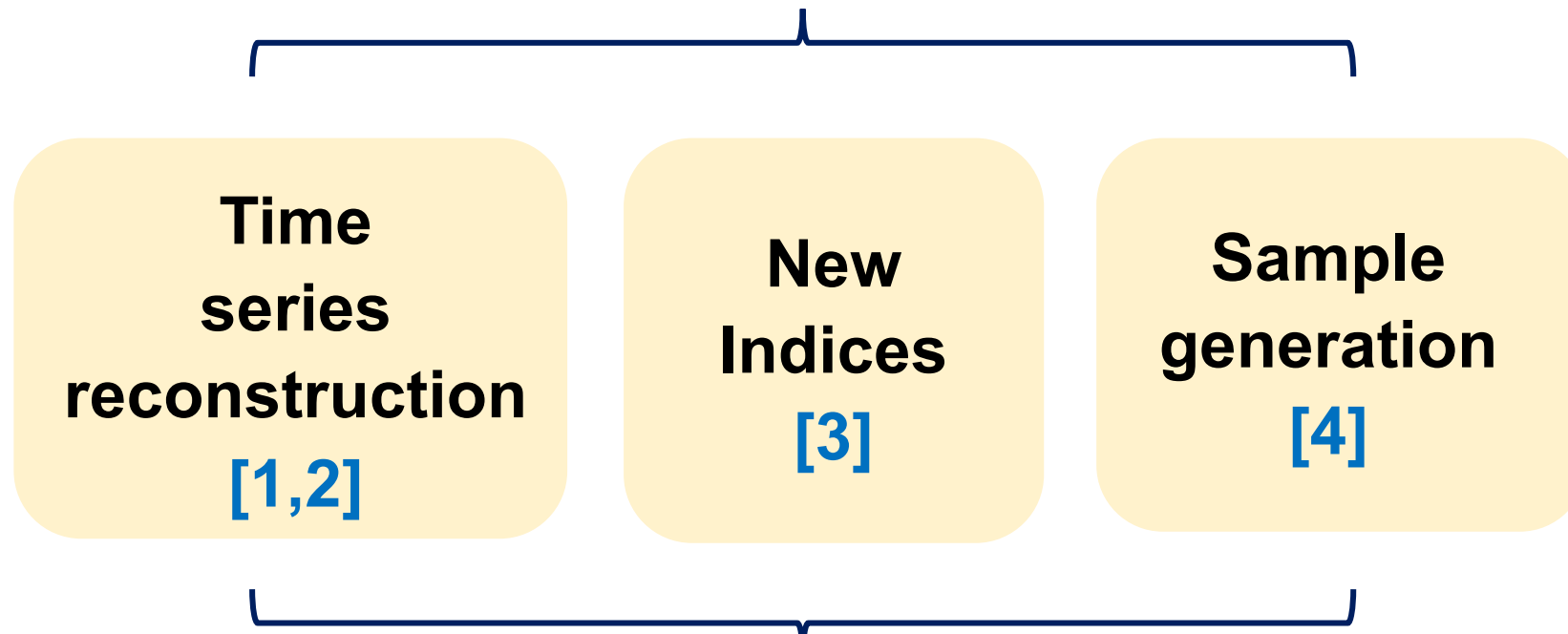
- [1] F. Feng, M. Gao, R. Liu, S. Yao, and G. Yang, "A deep learning framework for crop mapping with reconstructed Sentinel-2 time series images," *Comput. Electron. Agric.*, vol. 213, p. 108227, Oct. 2023.
- [2] X. Liu, S. Xie, J. Yang, L. Sun, L. Liu, Q. Zhang et al., "Comparisons between temporal statistical metrics, time series stacks and phenological features derived from NASA Harmonized Landsat Sentinel-2 data for crop type mapping," *Comput. Electron. Agric.*, vol. 211, p. 108015, Aug. 2023.
- [3] W. Zhou, H. Wei, Y. Chen, X. Zhang, J. Hu, Z. Cai et al., "Monitoring intra-annual and interannual variability in spatial distribution of plastic-mulched citrus in cloudy and rainy areas using multisource remote sensing data," *Eur. J. Agron.*, vol. 151, p. 126981, Nov. 2023.
- [4] J. Yang, Q. Hu, W. Li, Q. Song, Z. Cai, X. Zhang et al., "An automated sample generation method by integrating phenology domain optical-SAR features in rice cropping pattern mapping," *Remote Sens. Environ.*, vol. 314, p. 114387, Dec. 2024.
- [5] R. Gao, T. Balz, and Z. Shao, "Enhancing Crop Mapping Through a Spatial Expansion Approach," in *IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium*, pp. 10062-10066, Jul. 2024.

Acknowledgement

This work was conducted as part of the Dragon 6 cooperation programme between the European Space Agency (ESA) and the Ministry of Science and Technology (MOST) of China. The authors acknowledge the support and coordination provided by the Dragon Programme Office.

Introduction

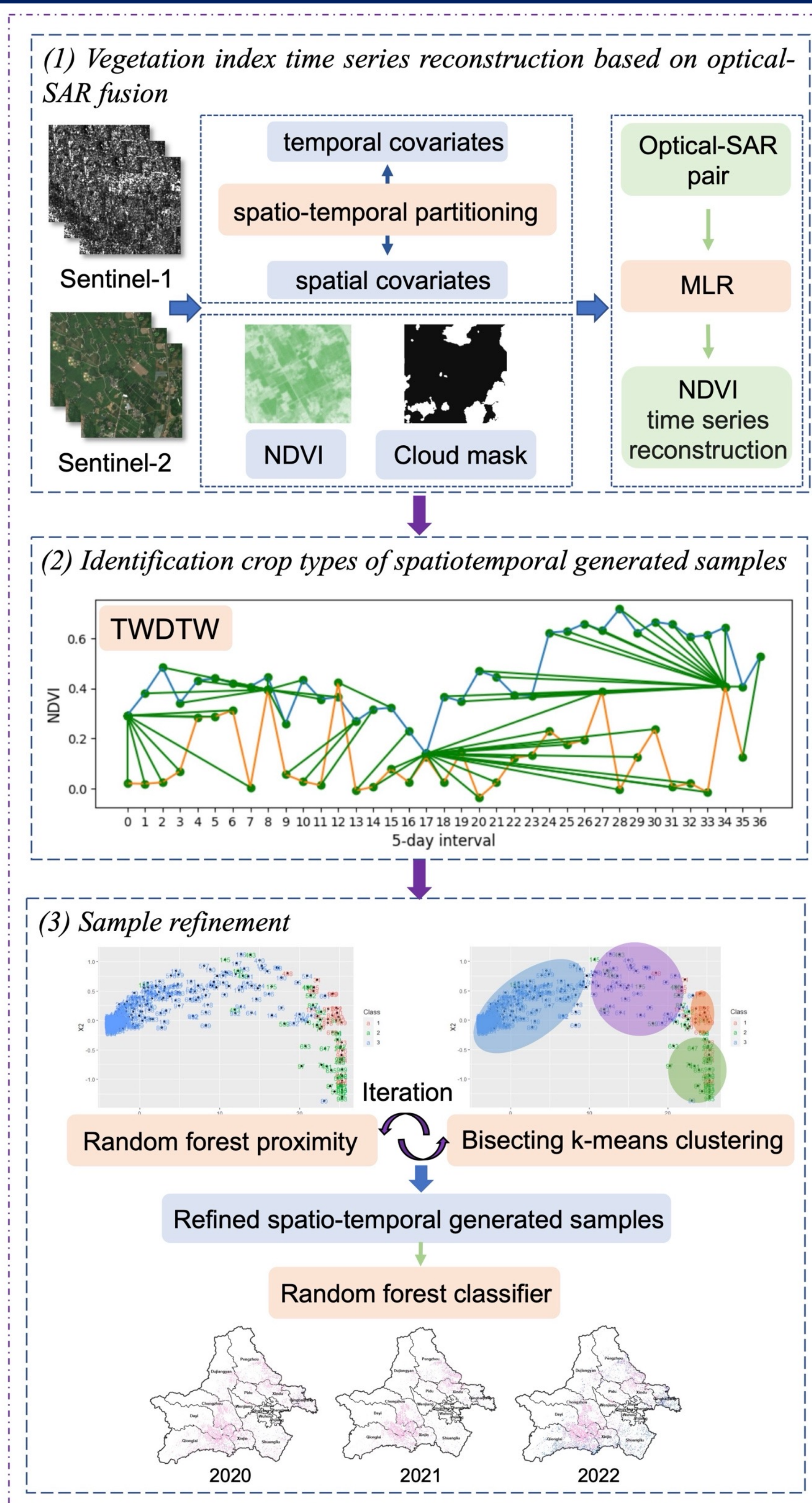
Current crop classification methods in cloudy and rainy regions



fail to address the simultaneous lack of high-quality images and samples

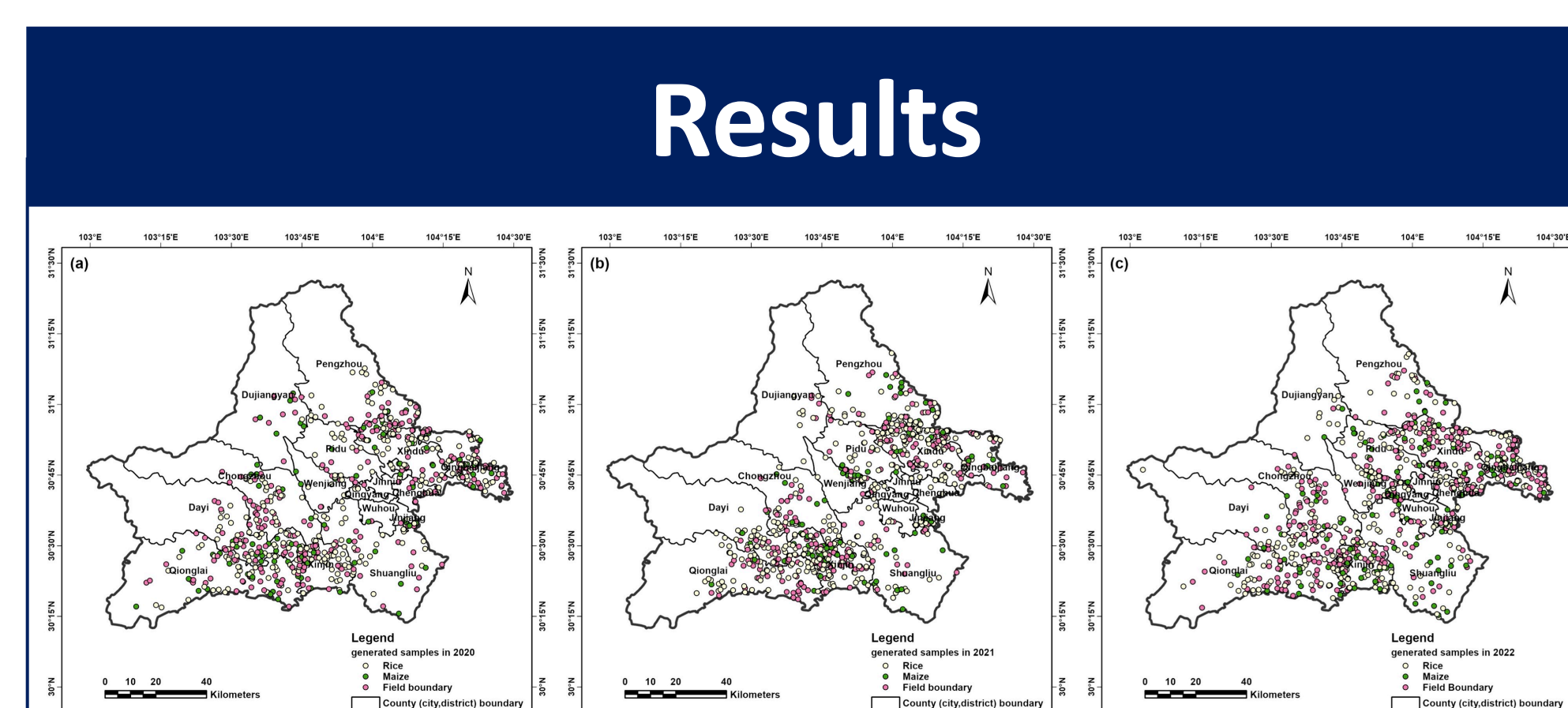
How to expand existing field survey samples across temporal and spatial scales and achieve large-scale, rapid crop classification in cloudy and rainy regions using remote sensing image time series that combine optical and SAR data?

Methods



Workflow of the proposed method

Results



Spatial distribution of spatiotemporal generation samples in (a) 2020, (b) 2021, (c) 2022

Study Area and Datasets

•Study Area:

Chengdu Plain, Sichuan Province

•Crops:

Rice and maize, with rice transplanted in mid-May and harvested in early September, while maize is sown in mid-March and harvested in mid-August

•Dataset:

- (1) Satellite image data: Sentinel-1 and Sentinel-2
- (2) Cropland mask data: "Dynamic World V1"

•Sample Points:

- (1) 247 crop type samples collected in 2023, (165 rice samples, 31 maize samples, and 51 field boundary
- (2) 73 rice samples collected in 2024 for accuracy validation