A Comparison of Sentinel-1 Approaches to Map the May-June 2022 Floods in Sylhet, Bangladesh

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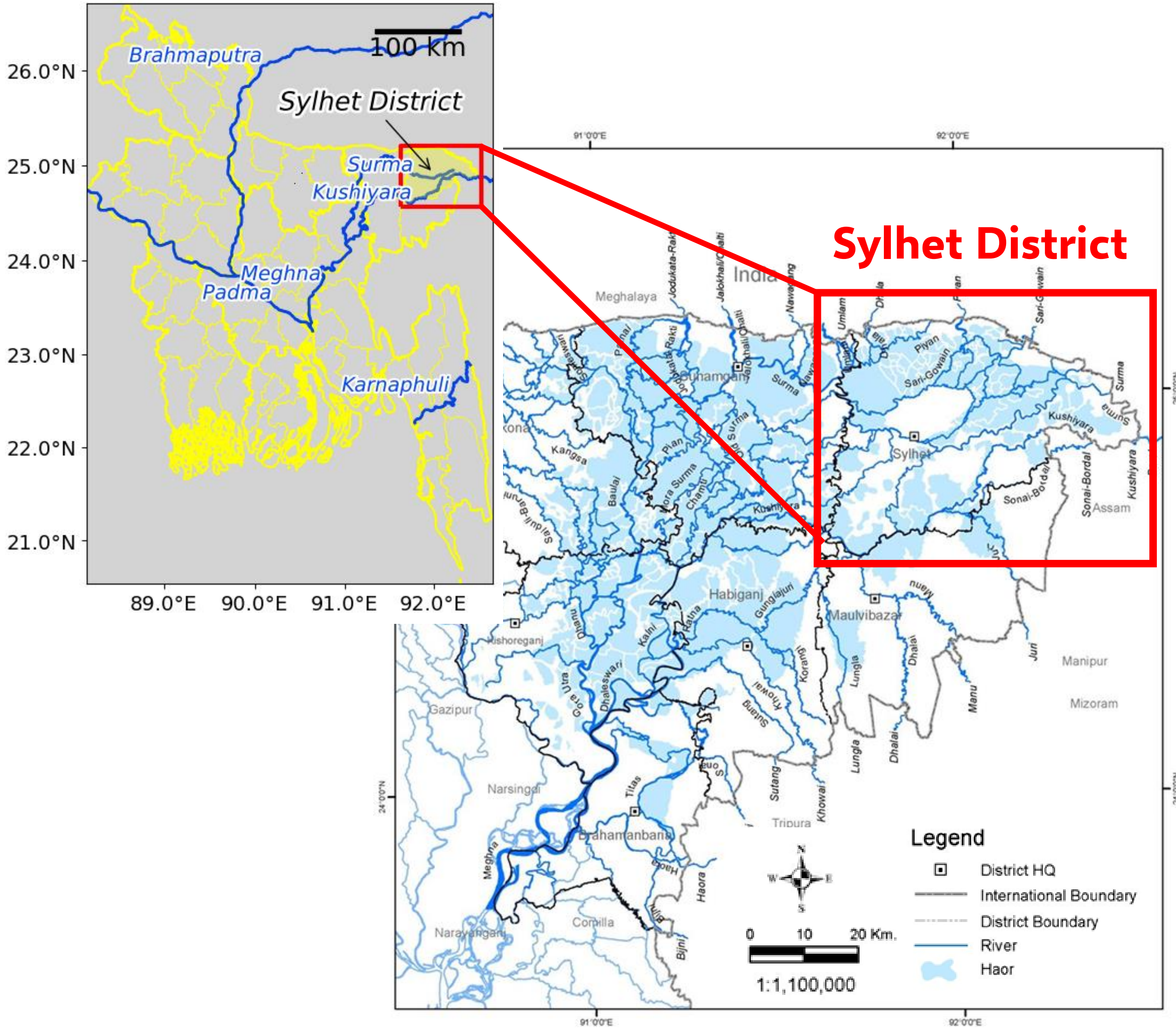
Getty images via NY Times

Sylhet experienced extreme flooding in May-June 2022



Bangladesh Haor and Wetland Development Board

2022 floods

Getty images via NY Times

Sylhet experienced extreme flooding in May-June 2022

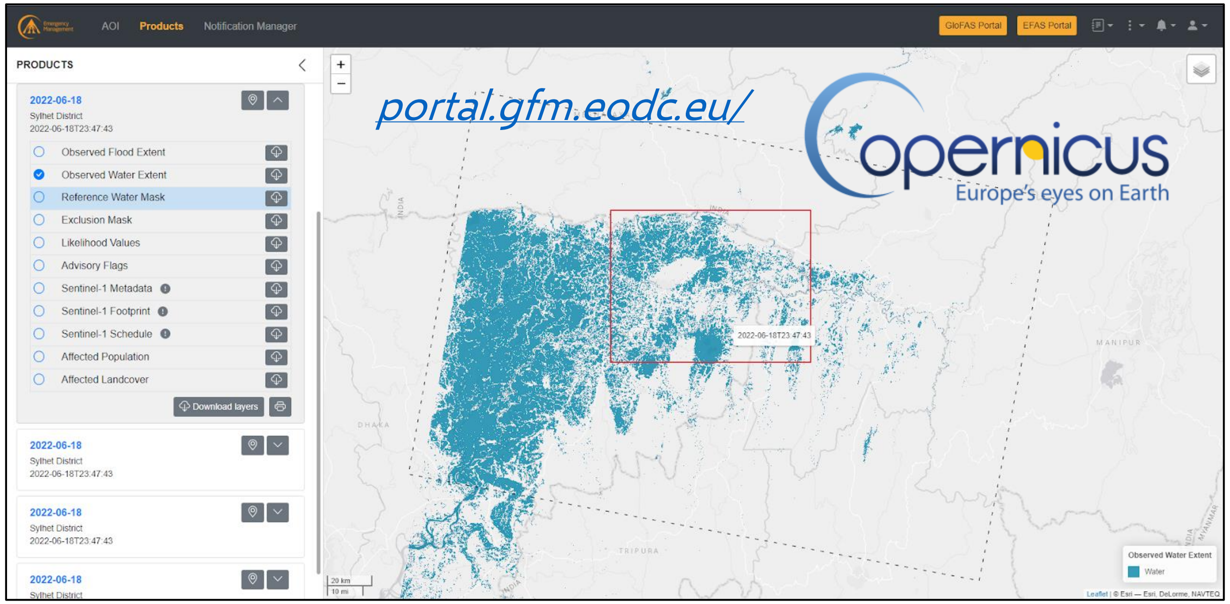
Gowainghat, Sylhet Division

Companiganj, Sylhet Division

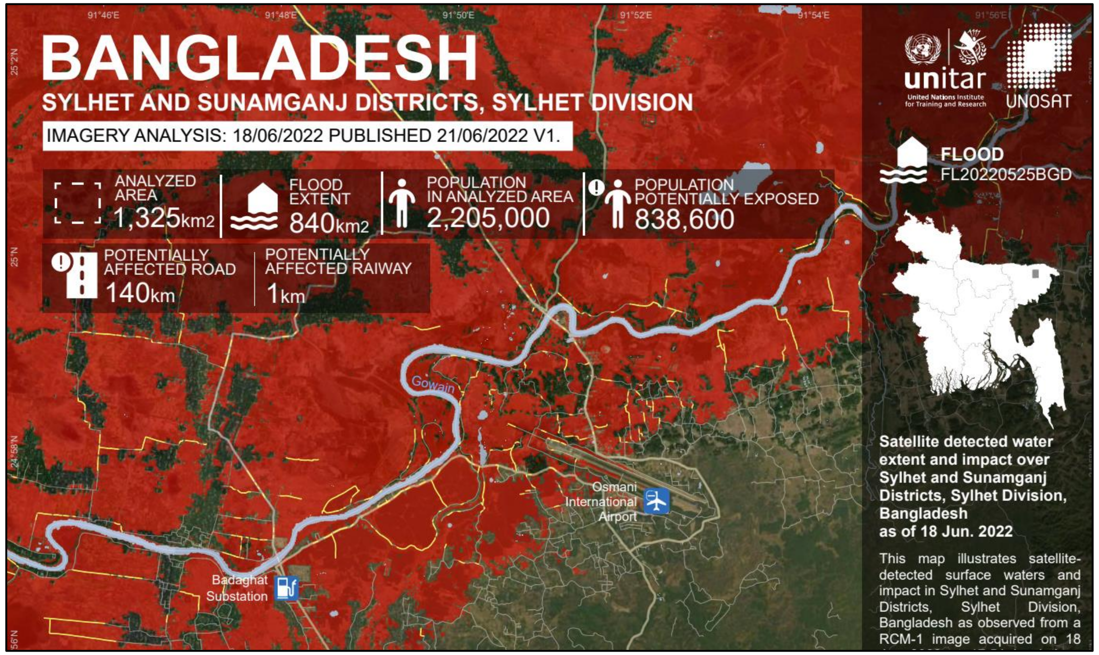
Why create remotely sensed maps after the floods?

- Assess accuracy of commonly used mapping methods and products
- Compare "local" vs "global" approaches
- Compare machine learning (ML) vs "traditional" non-ML approaches

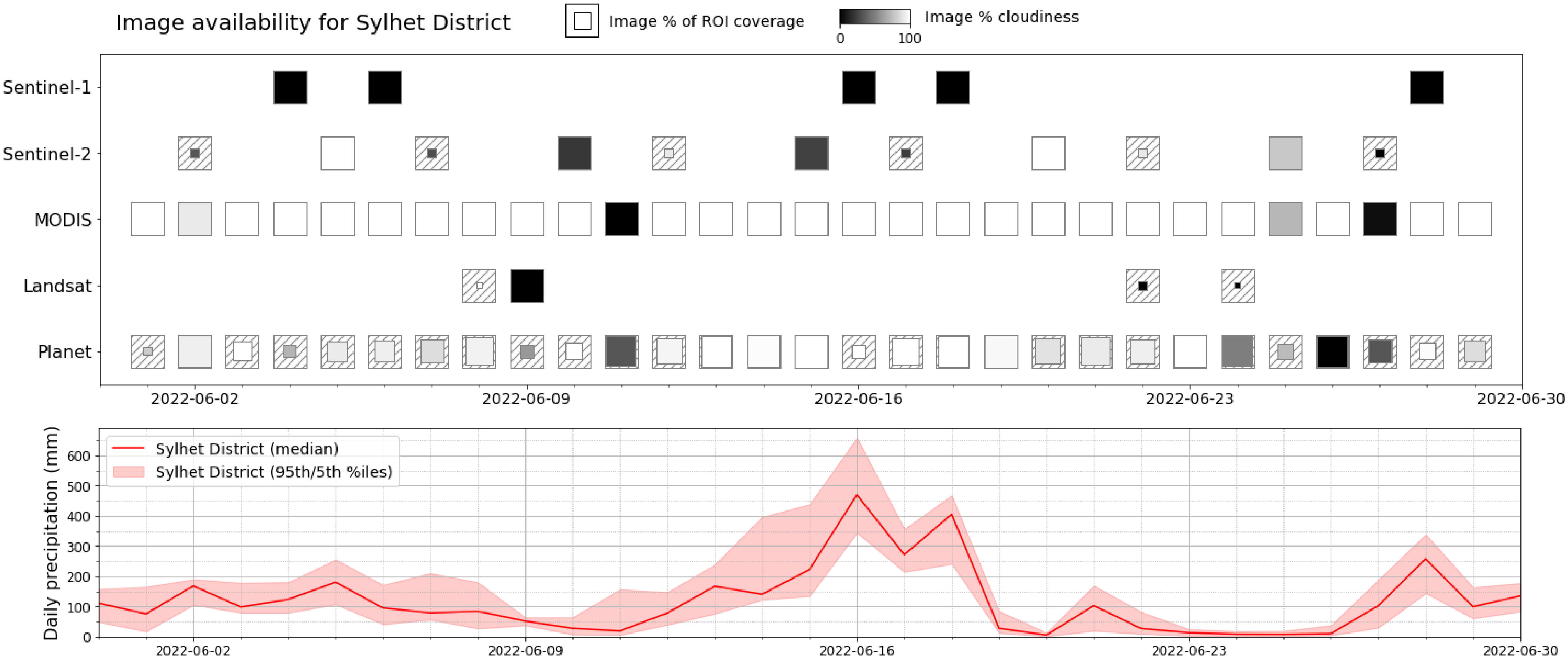
Copernicus Global Flood Monitoring



UNOSAT Analysis



Synthetic Aperture Radar gives us the chance to map the May-June 2022 floods



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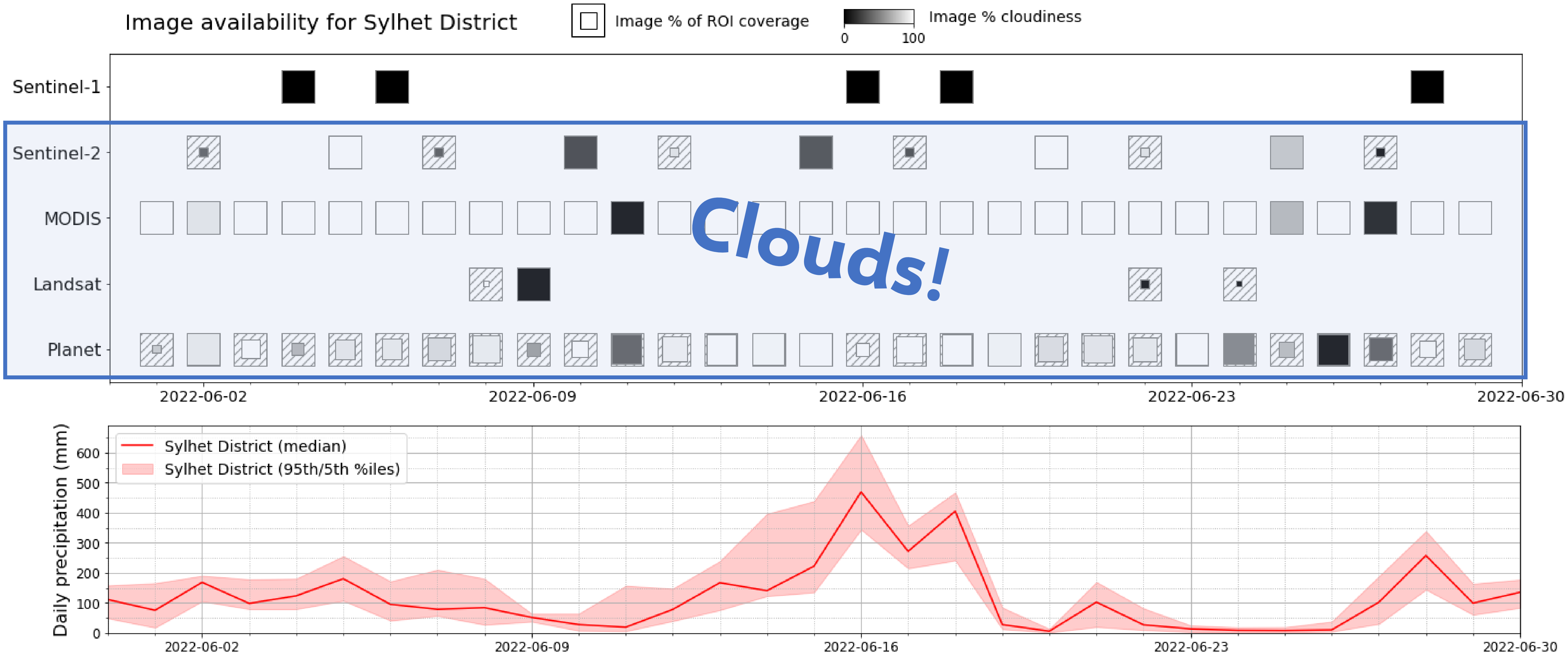


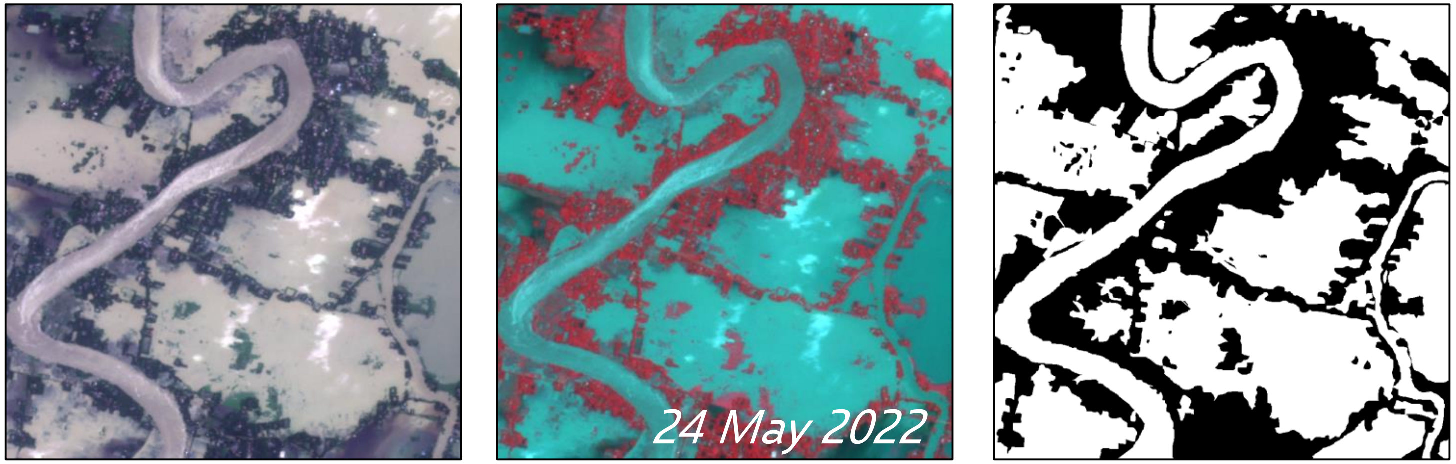
We compared three Sentinel-1 algorithms / datasets

Method / dataset	Description	Sensor	Resolution
Thomas et al., 2023	**"Local"** change detection, developed for Bangladesh	Sentinel-1	2-10 days, 10 m
Paul & Ganju, 2021	Pre-trained **"global" machine learning** (CNN)	Sentinel-1	2-10 days, 10 m
Copernicus Global Flood Monitoring "GFM"	**Automated "global"** emergency mapping product	Sentinel-1	2-10 days, 10 m

We hand labeled Planet images for validation

- **1024x1024 pixels @ 3 m** resolution
- **36 labels** across three cloud-free dates

True color (RGB) ***False color (NIR-B-G)*** ***Hand label***



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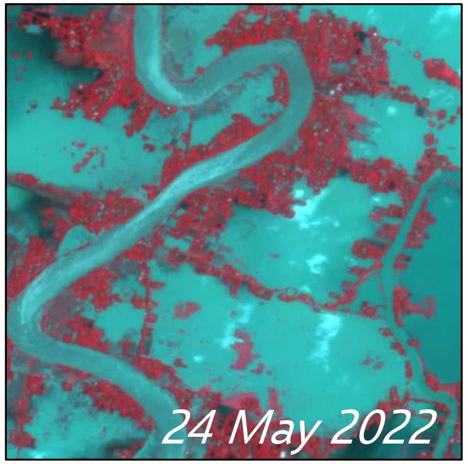

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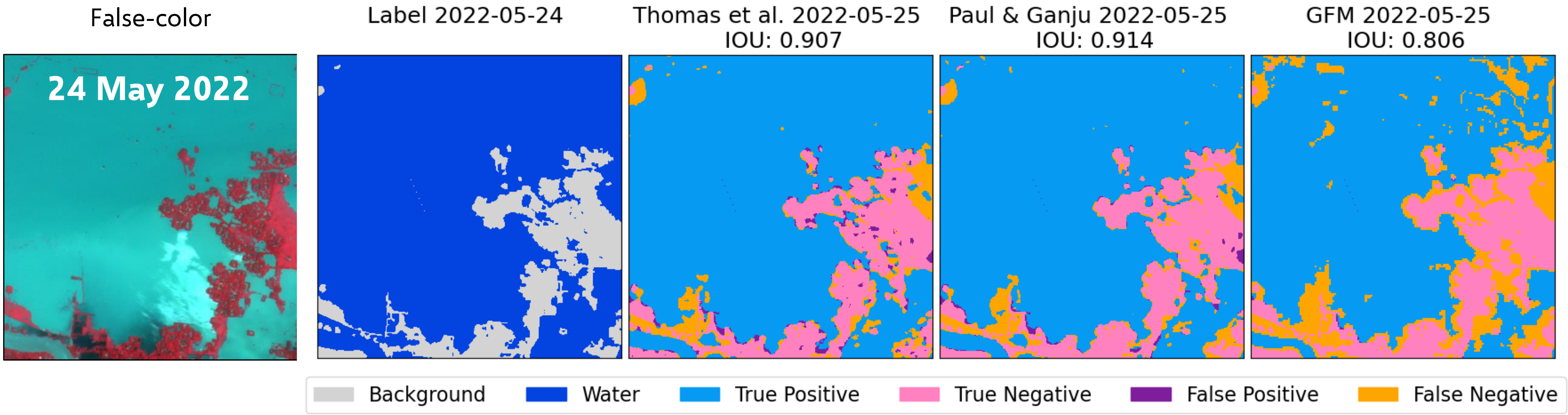
Local non-ML and global ML algorithms give higher accuracy than GFM



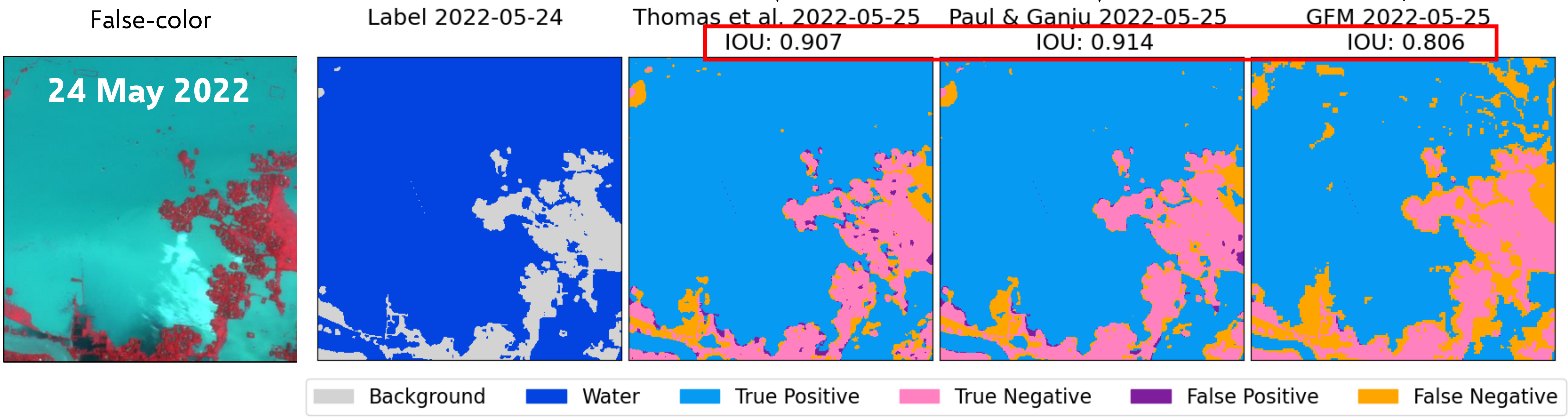
Local non-ML and global ML algorithms give higher accuracy than GFM

**IoU = intersection over union*

Local, non-ML

Global, ML

Global automated, non-ML



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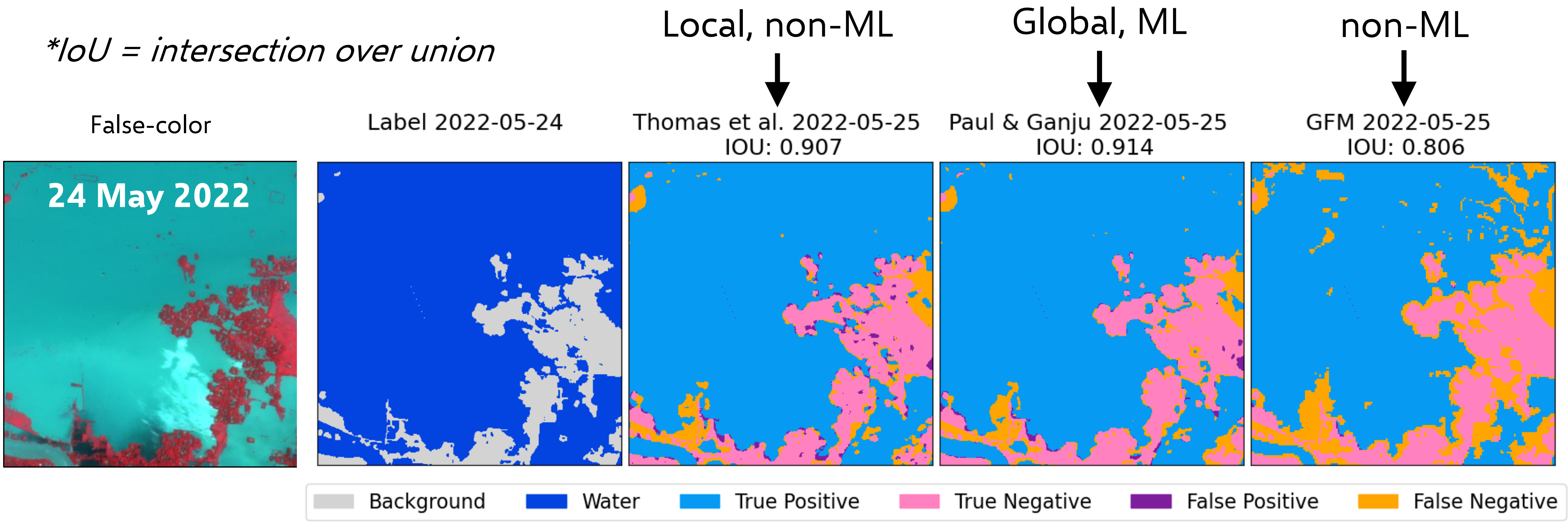

Accuracy over 36 tiles over 3 dates

Model	Precision	Recall	Accuracy	IoU
Thomas et al.	85.2%	75.4%	82.0%	67.9%
Paul & Ganju	93.4%	70.0%	82.4%	66.6%
Copernicus GFM	93.1%	52.7%	73.4%	51.7%

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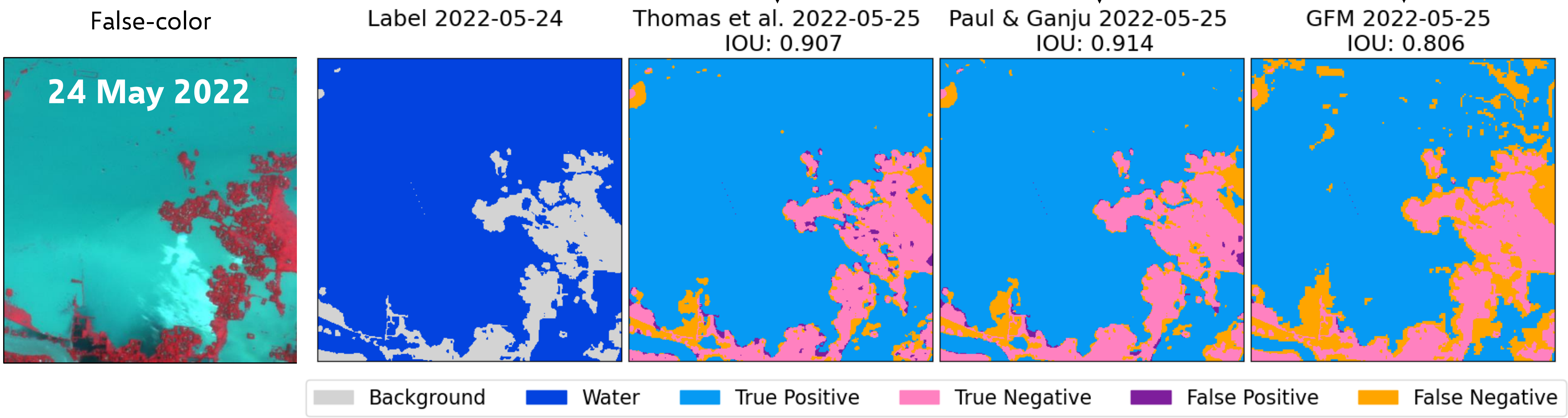

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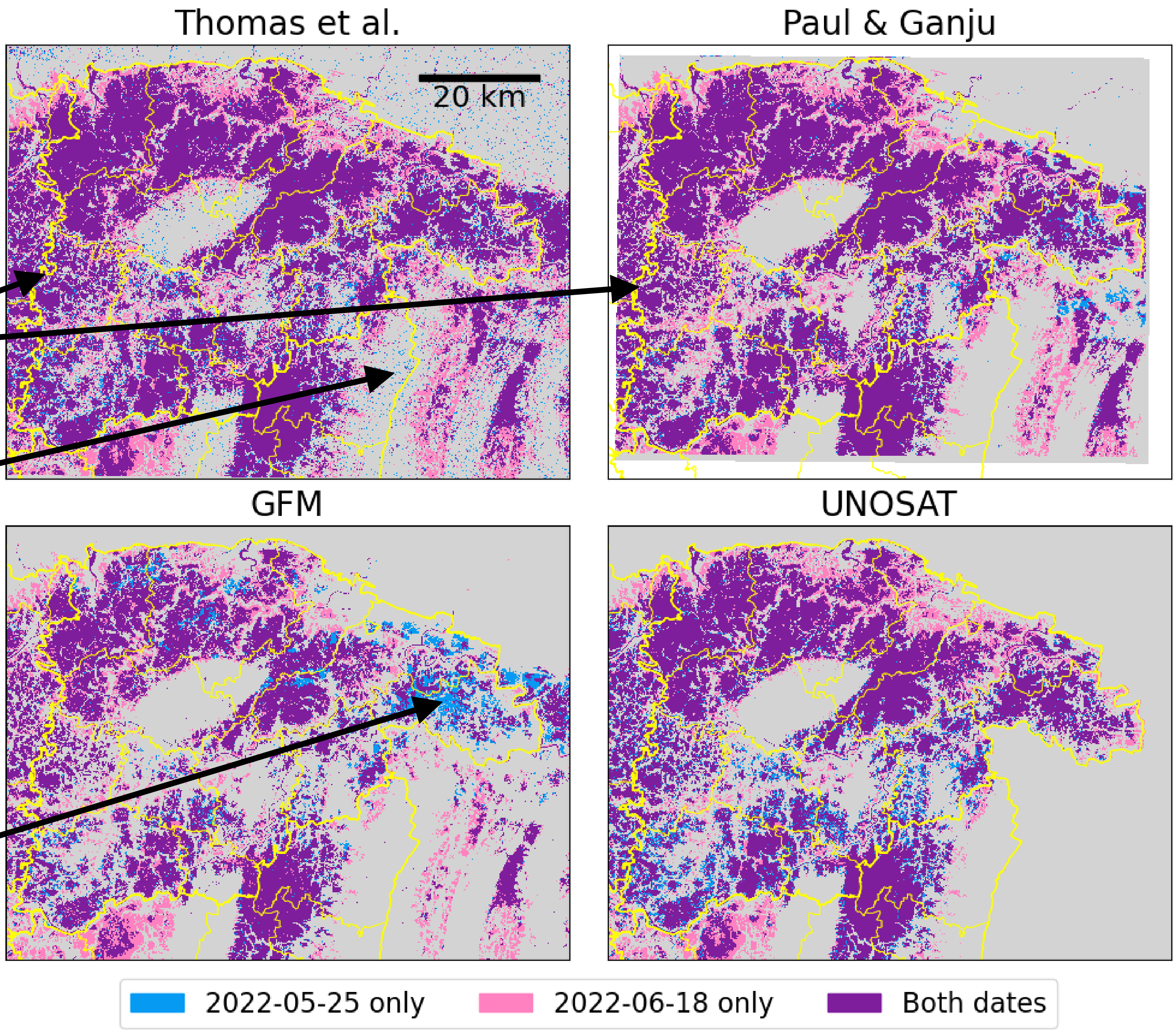
Spatial comparison of inundation extent

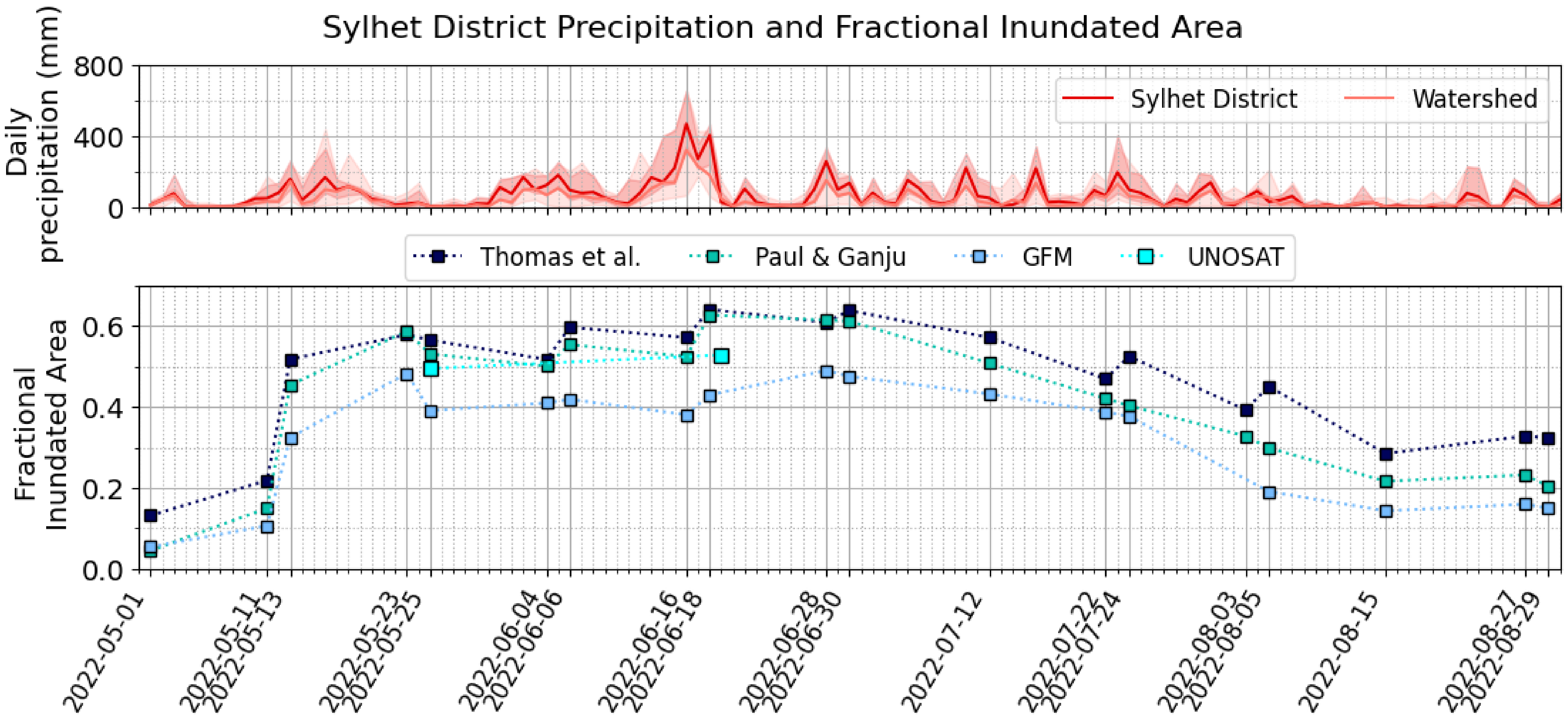
Largely in agreement

Speckle due to thresholding approach?

Areas where water receded between the two dates?



Temporal comparison of inundation extent



Takeaways

1. Local algorithm and global ML algorithm give equally high accuracy – *ML generalizes well, but had advantage of training on other Bangladesh data*
2. GFM shows lower accuracy – *tradeoff for global coverage and ready-to-use maps? Underprediction due to ensemble method?*

Future work: more studies to understand utility of emergency mapping products in different contexts

References

Paul, S., Ganju, S., 2021. Flood Segmentation on Sentinel-1 SAR Imagery with Semi-Supervised Learning. https://doi.org/10.48550/arXiv.2107.08369

Thomas et al. 2023. A framework to assess remote sensing algorithms for satellite-based flood index insurance. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 1–17. https://doi.org/10.1109/JSTARS.2023.3244098

Thank you for listening!

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Access the code and data →

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THE UNIVERSITY OF ARIZONA

Getty images via NY Times

Appendices

SAR surface water mapping algorithm recently developed for Bangladesh

- Sentinel-1 backscatter thresholding developed by Thomas et al. (2023)
    - Regional dry baseline from soil moisture
    - Additional VH condition
    - Additional smoothing
- Improved accuracy across four recent events

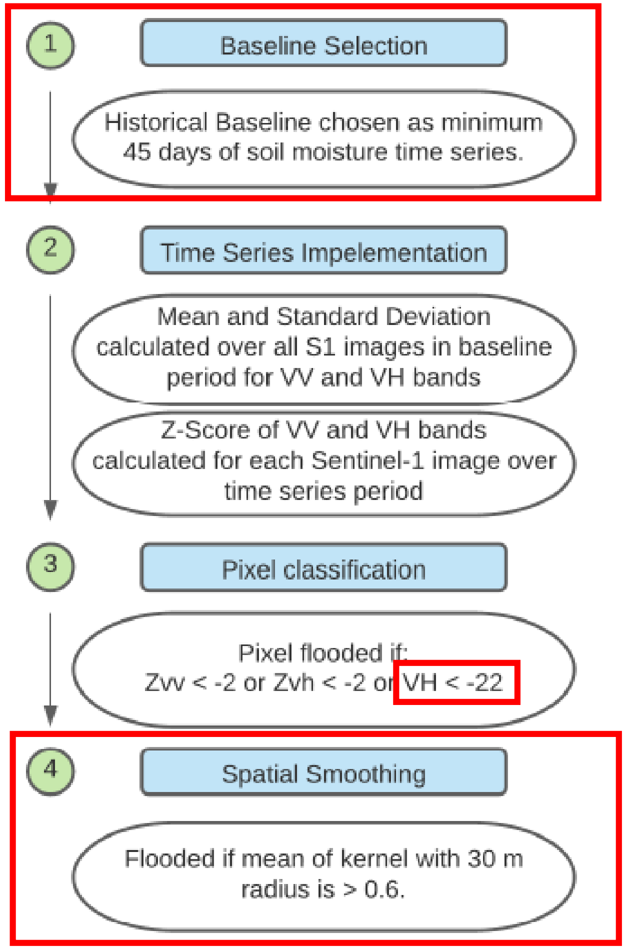
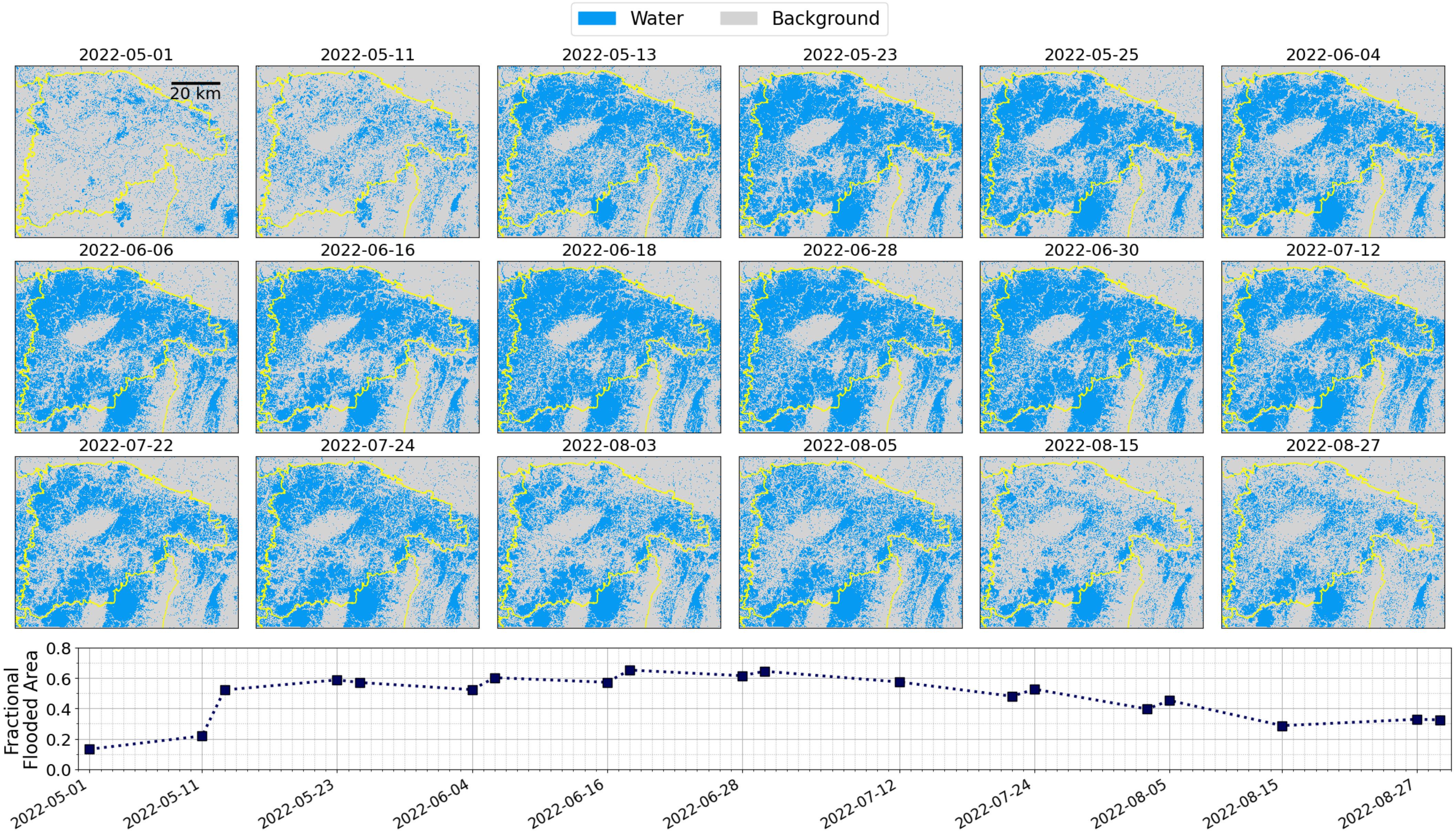


TABLE III
ACCURACY METRICS FOR THE PROPOSED SENTINEL-1 ALGORITHM, THE PREVIOUS SENTINEL-1 ALGORITHM, AND THE MODIS ALGORITHM.

	Proposed Sentinel-1 Algorithm		Sentinel-1, DeVries *et al.* [31]		MODIS, Islam *et al.* [76]	
Event	F1	Bias	F1	Bias	F1	Bias
1. Sylhet	0.901	1.043	0.818	0.908	0.737	2.535
2. Natore/ Naogoan	0.970	1.047	0.953	0.887	0.931	1.100
3. Sirajganj/ Pabna	0.930	0.875	0.822	0.590	0.849	1.527
4. Jamalpur	0.897	1.293	0.873	0.727	0.835	1.871
Average	0.925	1.065	0.867	0.778	0.838	1.758
Standard Deviation	0.034	0.172	0.063	0.149	0.080	0.606

Thomas et al. (2023)

Peak water extent occurred around 18 June



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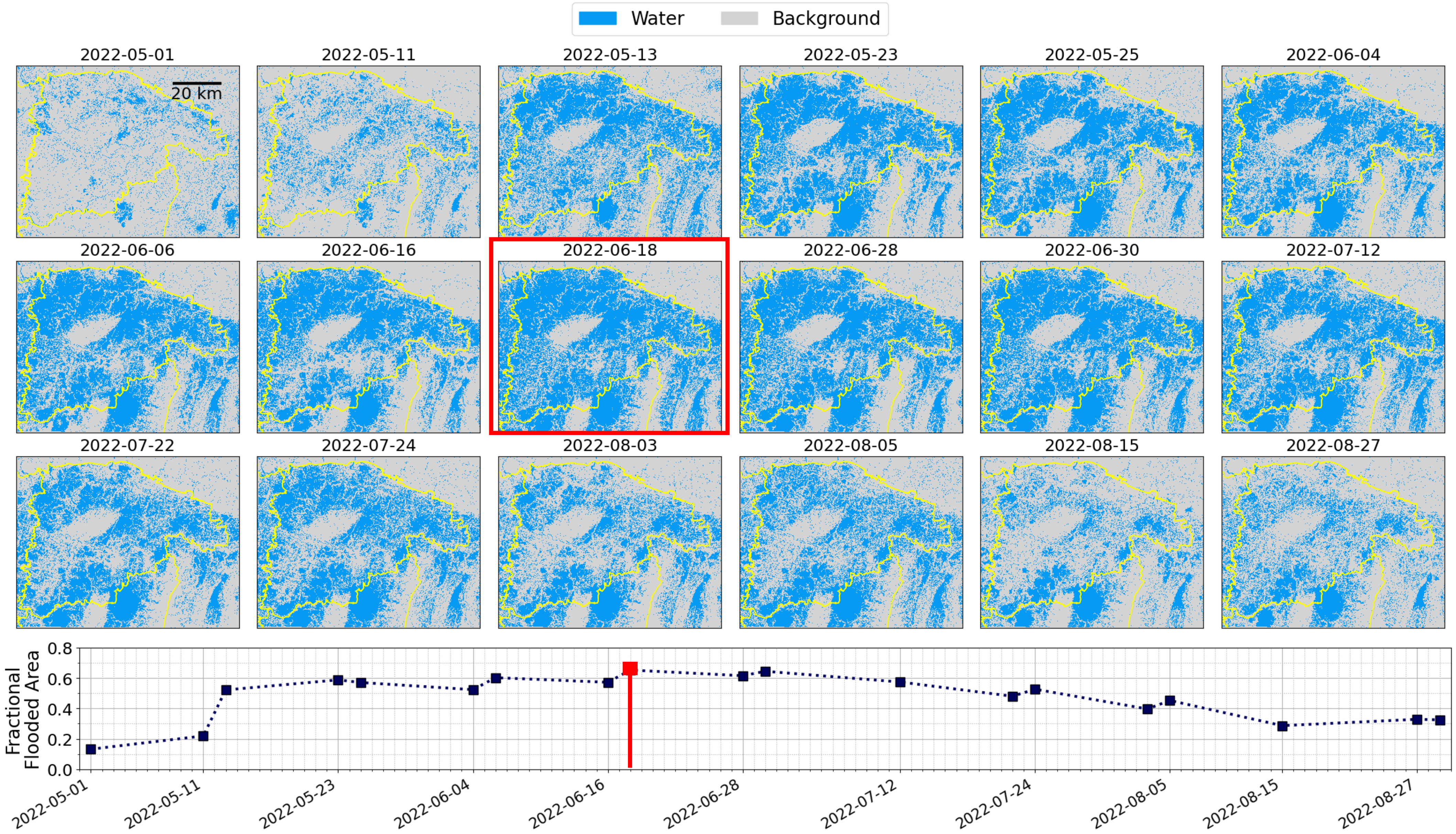
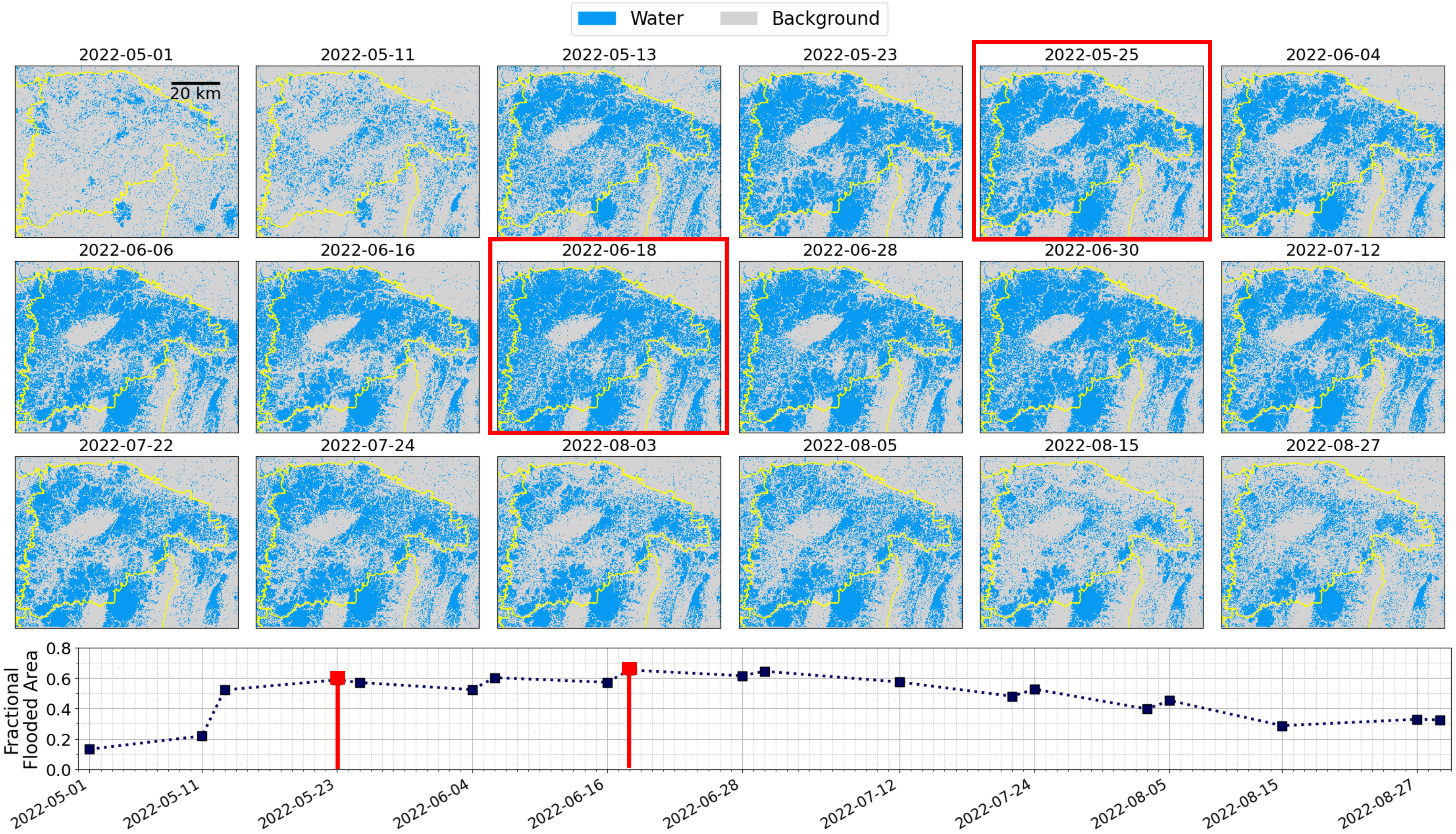
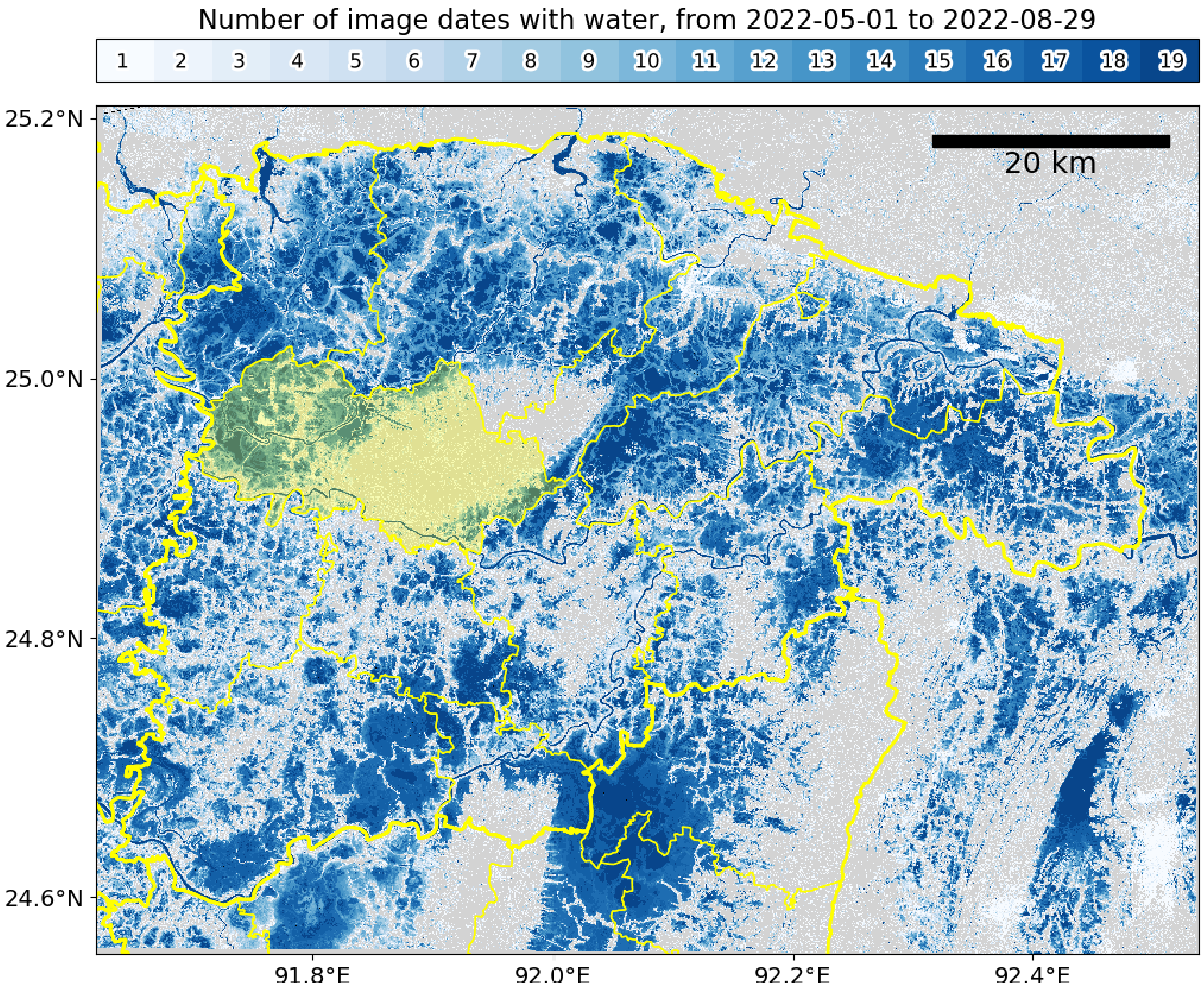


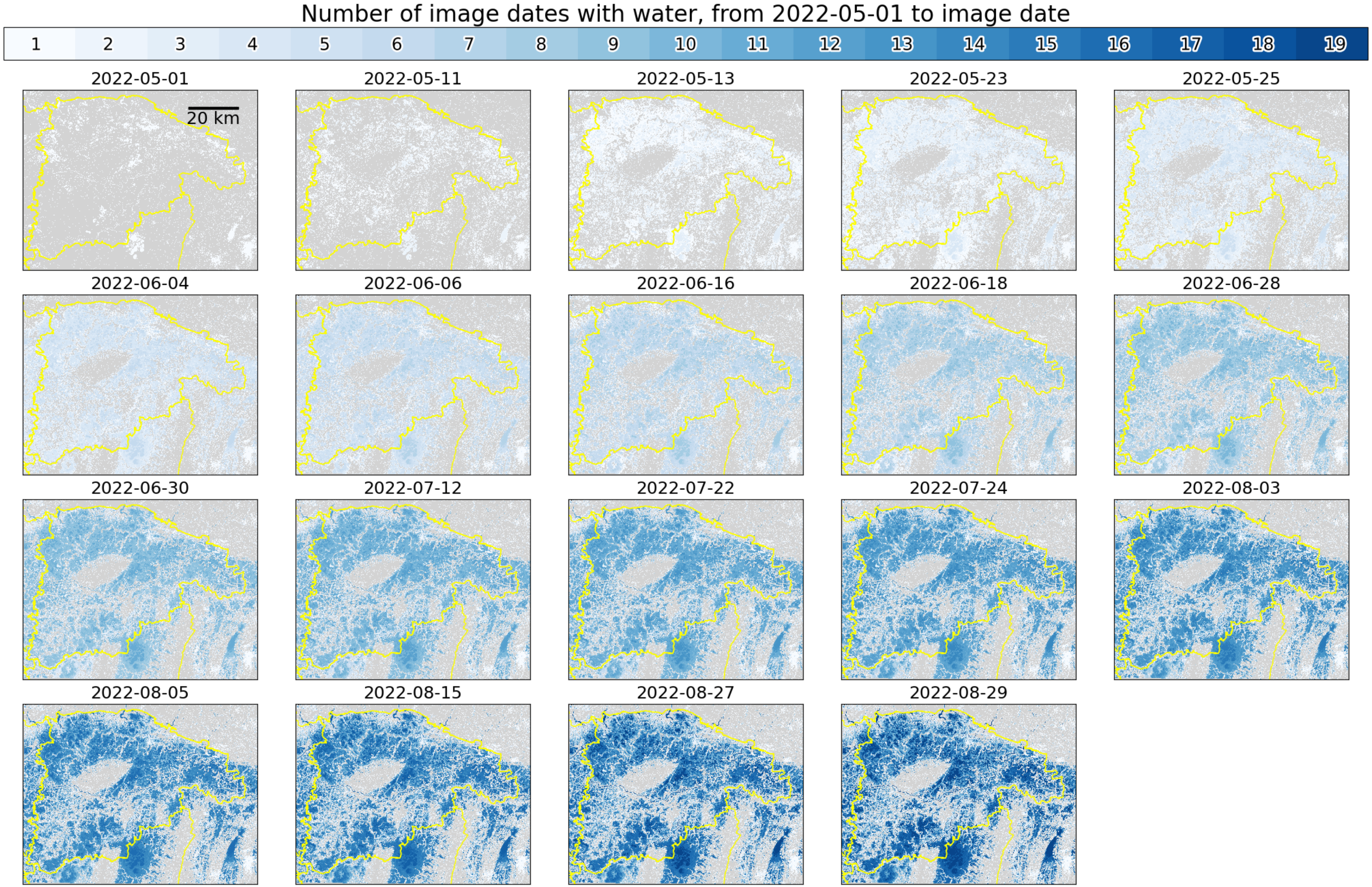
But most water accumulated during May



Large parts remained flooded for up to several months



- Deepest depressions in the Haor Basin remained inundated throughout May-August
- *Was duration an important factor in the severity of impacts?*



Number of image dates with water, from 2022-05-01 to image date
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
2022-05-01
20 km
2022-05-11
2022-05-13
2022-05-23
2022-05-25
2022-06-04
2022-06-06
2022-06-16
2022-06-18
2022-06-28
2022-06-30
2022-07-12
2022-07-22
2022-07-24
2022-08-03
2022-08-05
2022-08-15
2022-08-27
2022-08-29