GC43K-1421: Evaluating Flood Forecasting System Performance in Cambodia During the 2019 Flood Season

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Objectives

Understand differences in performance
- of global , regional , and national flood forecasting systems
- at various forecast lead times
- between different station locations in Cambodia

Abstract

Every year, Cambodia experiences both flash and prolonged riverine flooding as a result of monsoon rains and typhoons. Floods occur frequently in various parts of the region, and result in significant economic cost. Flood forecasting systems are designed to mitigate economic and social impacts, enabling people to prepare for extreme events. However, in order for forecasts to be used effectively, an assessment of the available forecasting systems is needed. In addition, following the onset of flooding, satellite imagery is used to generate flood maps to aid in response efforts. This study demonstrates the performance of regional and global flood forecasting systems over the 2019 flood season. To do this, we assess the flood forecast accuracy at different forecast lead times through a series of forecast verification metrics at gauge locations in Cambodia. We then compare the flood forecast performance to Sentinel 1 flood maps produced by the Hydrological Remote Sensing Analysis of Floods (HYDRAFloods) tool currently being co-developed by SERVIR-Mekong in collaboration with the Myanmar Department of Disaster Management. This assessment of the flood forecasting systems' performance and comparison to generated flood maps helps provide context to forecasters and disaster managers as they make improvements to their models. Additionally, these results provide support to forecast users as they evaluate the strengths and weaknesses of different systems for taking action.

Datasets Used

Acronym	Dataset	Parameter	Spatial Extent	Range
MRC In Situ	Mekong River Commission In Situ Water Level Observations	Water Level	Regional	N/A
GloFAS	Global Flood Awareness System	Streamflow	Global	30 days
SPT	Streamflow Prediction Tool	Streamflow	Global / Regional	15 days
MRC Forecast	Mekong River Commission River Flood Forecasting System	Water Level	Regional	5 days
MOWRAM	Ministry of Water Resources & Meteorology Cambodia National Flood Forecasting System	Water Level	Country	5 days

Acknowledgements

Forecast Performance

Root Mean Square Error & Nash Sutcliffe at Kratie

| Lead Time (days)	GloFAS RMSE	GloFAS NSE	SPT RMSE	SPT NSE	MRC RMSE	MRC NSE	MOWRAM RMSE	MOWRAM NSE
1	1.52	0.88	5.00	-0.37	0.01	1.00	0.24	1.00
3	1.50	0.88	4.02	0.13	0.38	0.99	0.56	0.98
5	1.45	0.89	3.23	0.45	0.86	0.96	0.67	0.98
10	1.50	0.88	2.29	0.75	-	-	-	-
15	1.94	0.80	1.88	0.83	-	-	-	-
20	2.38	0.70	-	-	-	-	-	-
25	2.88	0.58	-	-	-	-	-	-
30	3.15	0.51	-	-	-	-	-	-

Fig. 1 Forecasts by MRC and MOWRAM show much higher accuracy than GloFAS and SPT at all lead times. While it might be expected that SPT would outperform GloFAS, given its higher resolution routing network, GloFAS shows consistently higher performance than SPT. Generally performance decreases as lead time increases, except for SPT, where performance improves as lead time increases.

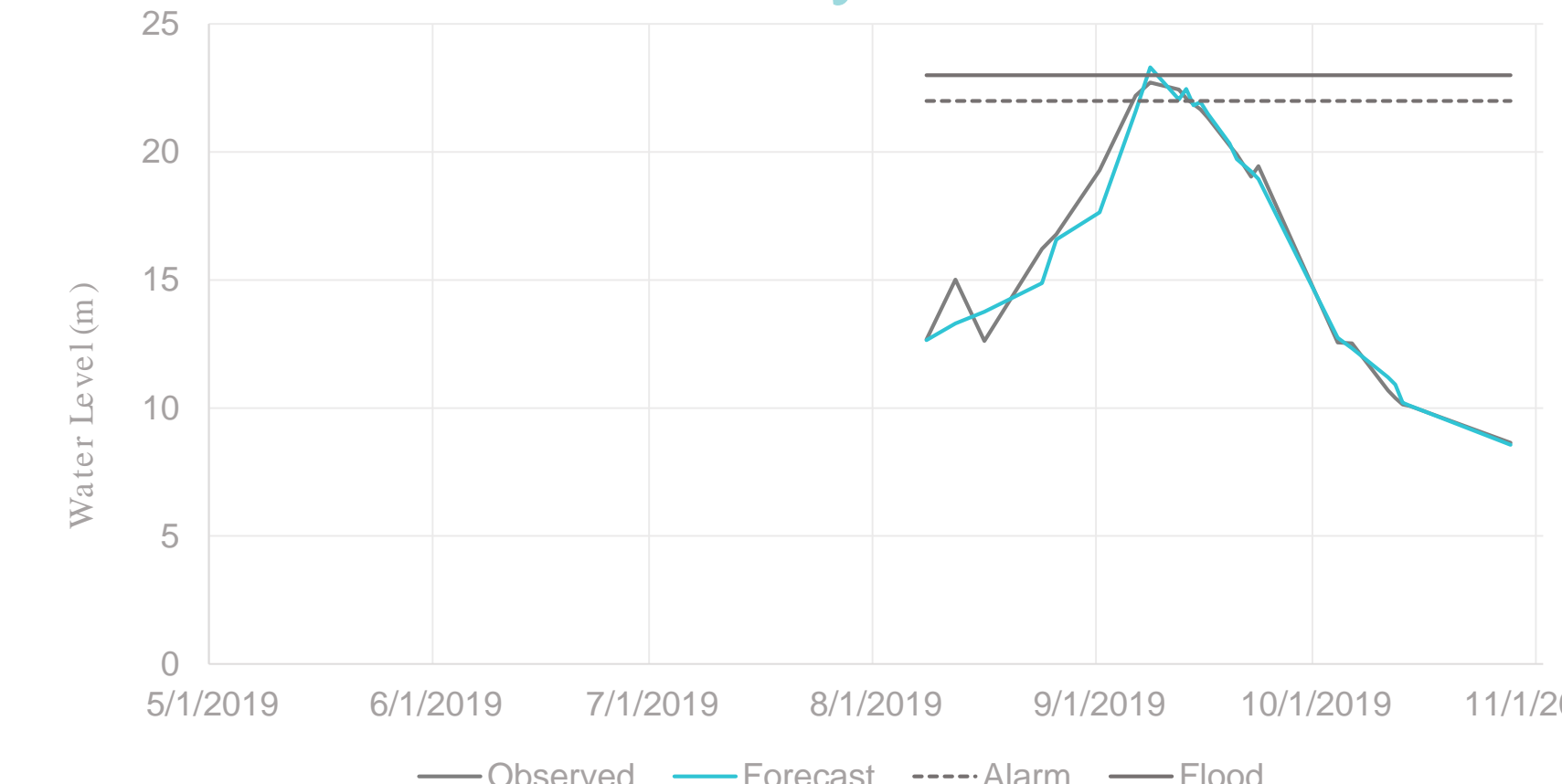### Root Mean Square Error & Nash Sutcliffe at 2 Day Lead Time

Station	GloFAS RMSE	GloFAS NSE	SPT RMSE	SPT NSE	MRC RMSE	MRC NSE	MOWRAM RMSE	MOWRAM NSE
Kratie	1.51	0.88	4.48	-0.09	0.16	1.00	0.39	0.99
Kompong Cham	3.08	0.77	6.92	-2.67	0.11	1.00	0.24	1.00
Phnom Penh Bassac	7.83	-9.39	1.93	0.33	0.06	1.00	0.09	1.00
Koh Khel	3.55	-2.38	3.15	-1.79	0.06	1.00	0.06	1.00

Fig. 2 Forecasts by MRC and MOWRAM show much higher accuracy than GloFAS and SPT at all locations. For MRC and MOWRAM, performance improves from upstream to downstream. For GloFAS, performance decreases from upstream to downstream until Koh Khel. The width of the channel at Koh Khel is about 1/7th the size of the channel upstream, which likely accounts for this departure from the trend. SPT performance varies widely between stations with no apparent trend.

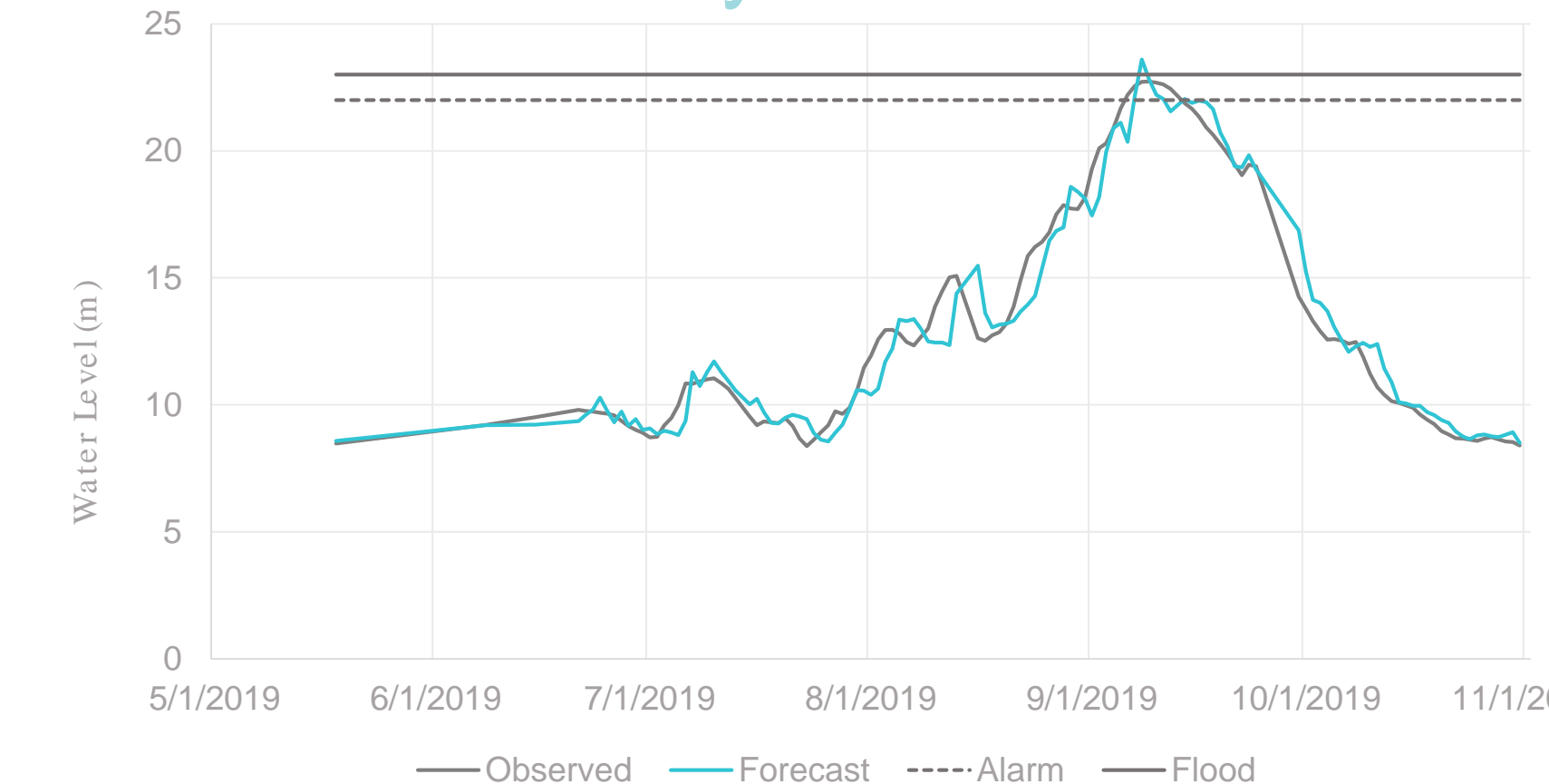### Mekong River Commission Water Level Observation Station Locations
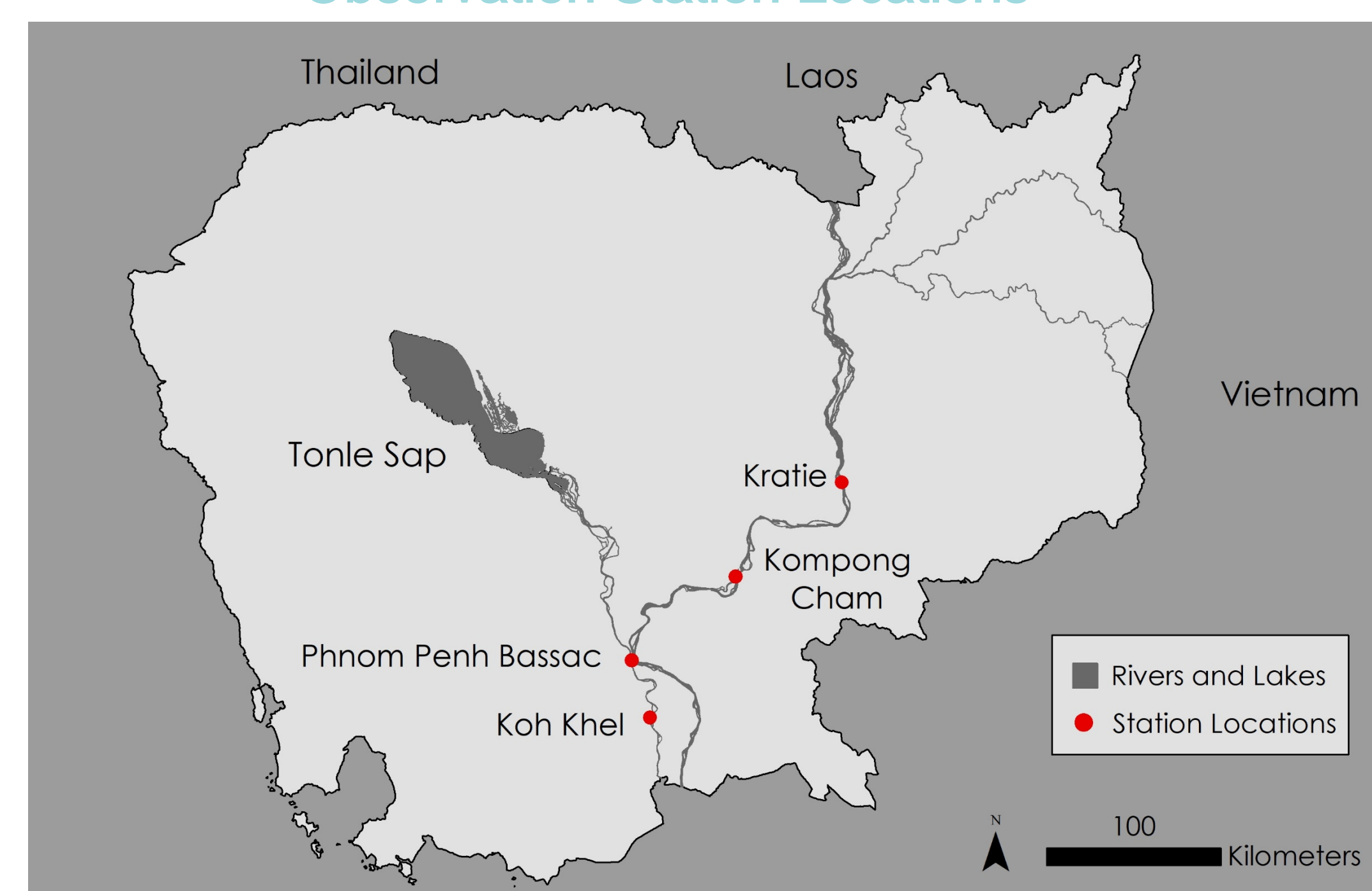
MOWRAM 5 Day Forecast vs Observed at Kratie

Date	Observed	Forecast
9/6/19	22.20	21.58
9/8/19	22.72	23.31
9/12/19	22.44	22.05
9/13/19	22.10	22.46

Fig. 3
Root Mean Square Error (RMSE): 0.67
Nash Sutcliffe (NSE): 0.98
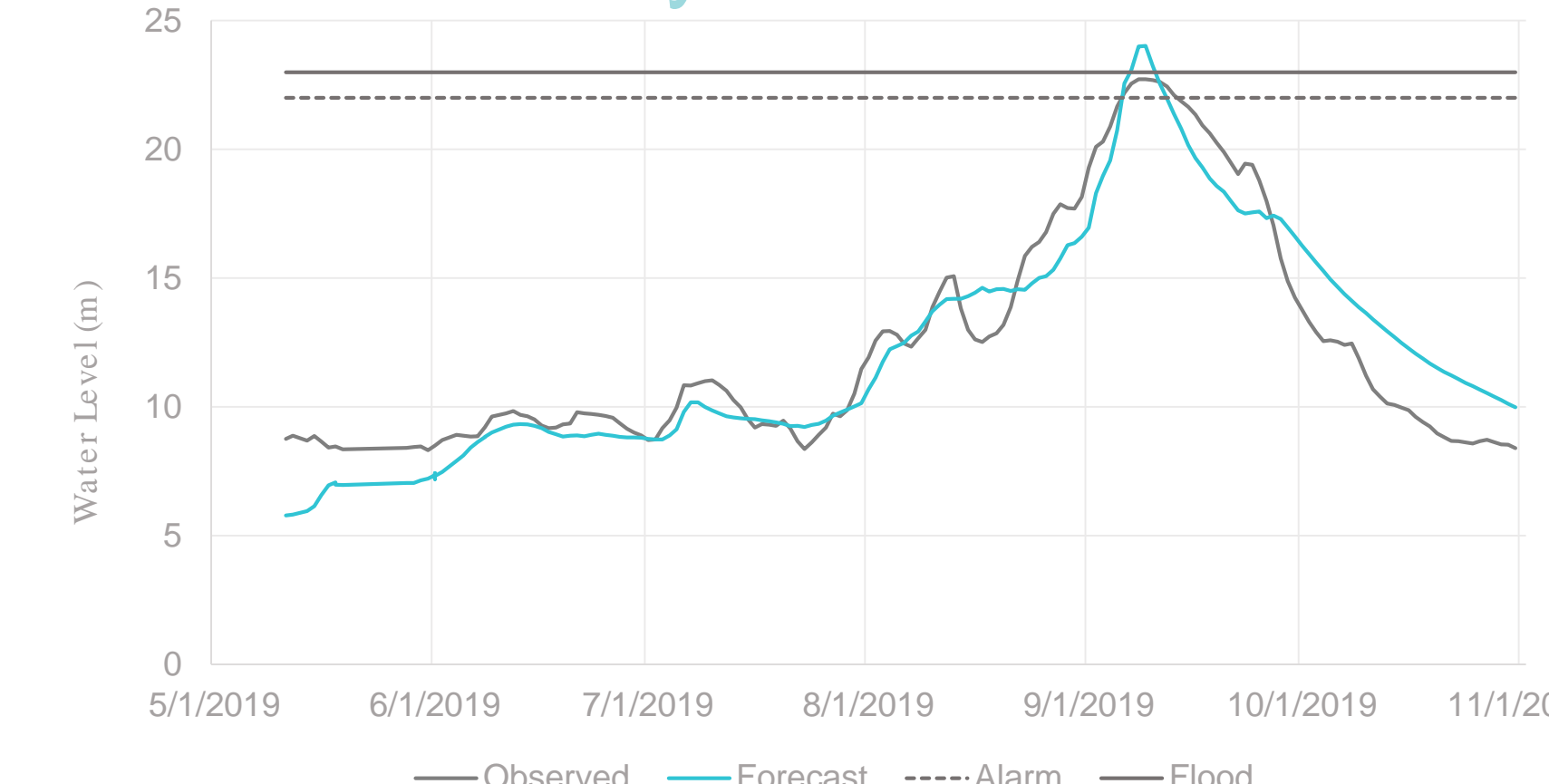Alarm threshold: 22m
Flood threshold: 23m

MRC 5 Day Forecast vs Observed at Kratie

Date	Observed	Forecast
9/6/19	22.20	20.35
9/7/19	22.56	22.17
9/8/19	22.72	23.60
9/9/19	22.73	22.82
9/10/19	22.69	22.21
9/11/19	22.62	22.04
9/12/19	22.44	21.55
9/14/19	21.87	22.05

Fig. 4
RMSE: 0.86, NSE: 0.96

GloFAS 5 Day Mean Forecast vs Observed at Kratie

Date	Observed	Forecast
9/6/19	22.20	22.00
9/7/19	22.56	22.76
9/8/19	22.72	23.70
9/9/19	22.73	23.94
9/10/19	22.69	23.18
9/11/19	22.62	22.48
9/12/19	22.44	21.87
9/13/19	22.1	21.29

Fig. 5
RMSE: 1.45, NSE: 0.89

SPT 5 Day Mean Forecast vs Observed at Kratie
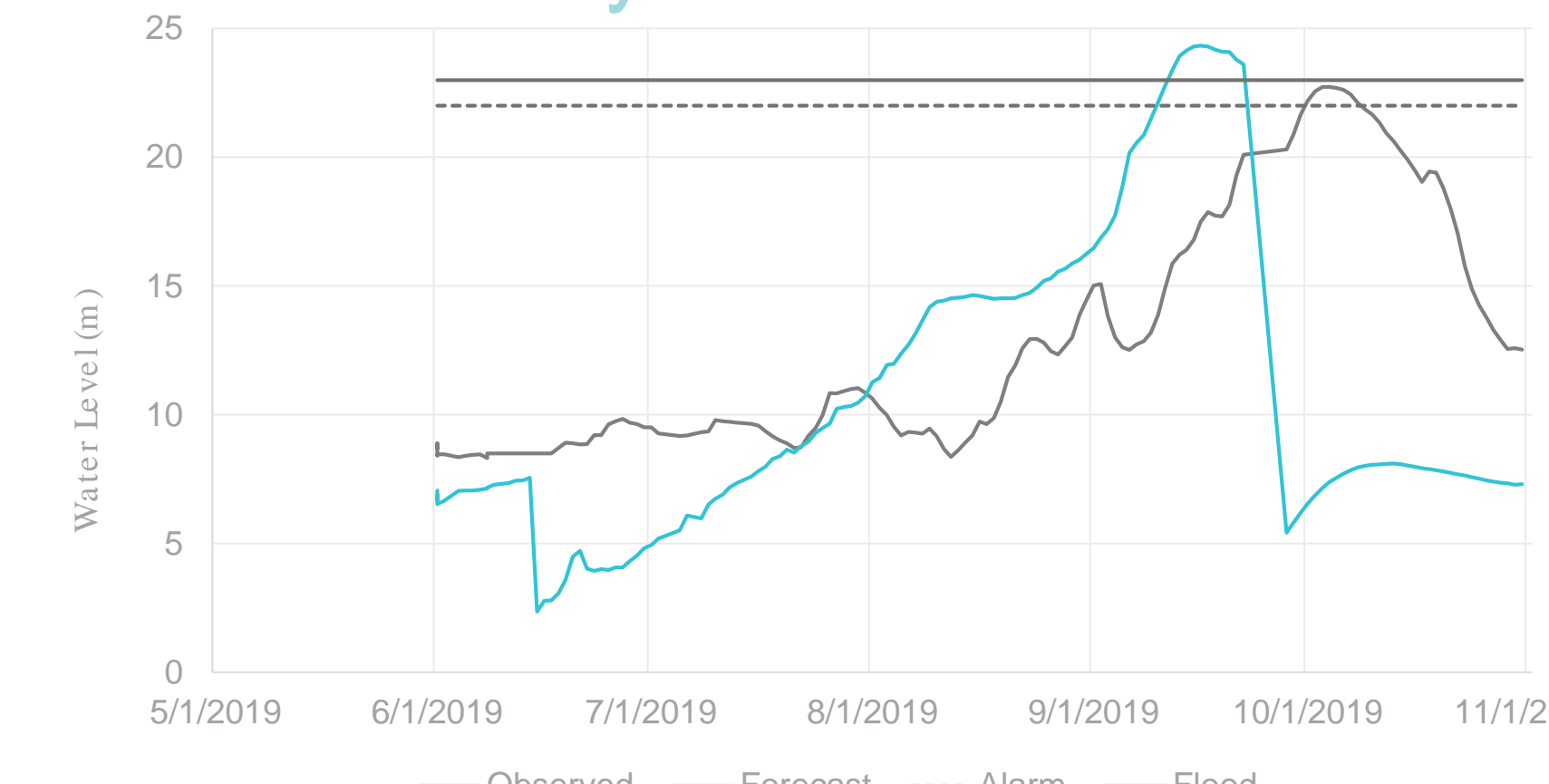
Date	Observed	Forecast
9/6/19	22.20	20.17
9/7/19	22.56	20.56
9/8/19	22.72	20.86
9/9/19	22.73	21.48
9/10/19	22.69	22.13
9/11/19	22.62	22.77
9/12/19	22.44	23.38
9/13/19	22.10	23.93
9/14/19	21.87	24.14
9/15/19	21.66	24.30
9/16/19	21.35	24.34
9/17/19	20.93	24.30
9/18/19	20.63	24.18
9/19/19	20.26	24.10
9/20/19	19.90	24.08
9/21/19	19.48	23.80
9/22/19	19.04	23.60

Fig. 6 RMSE: 3.23, NSE: 0.45

Fig. 3-6 Tables show water level (m) on days when either observed or forecast alarm threshold was crossed. For GloFAS and SPT, the mean of all ensembles is shown as the forecast and used to calculate metrics. For each plot, data are only shown for days when both forecast and observed values are available.

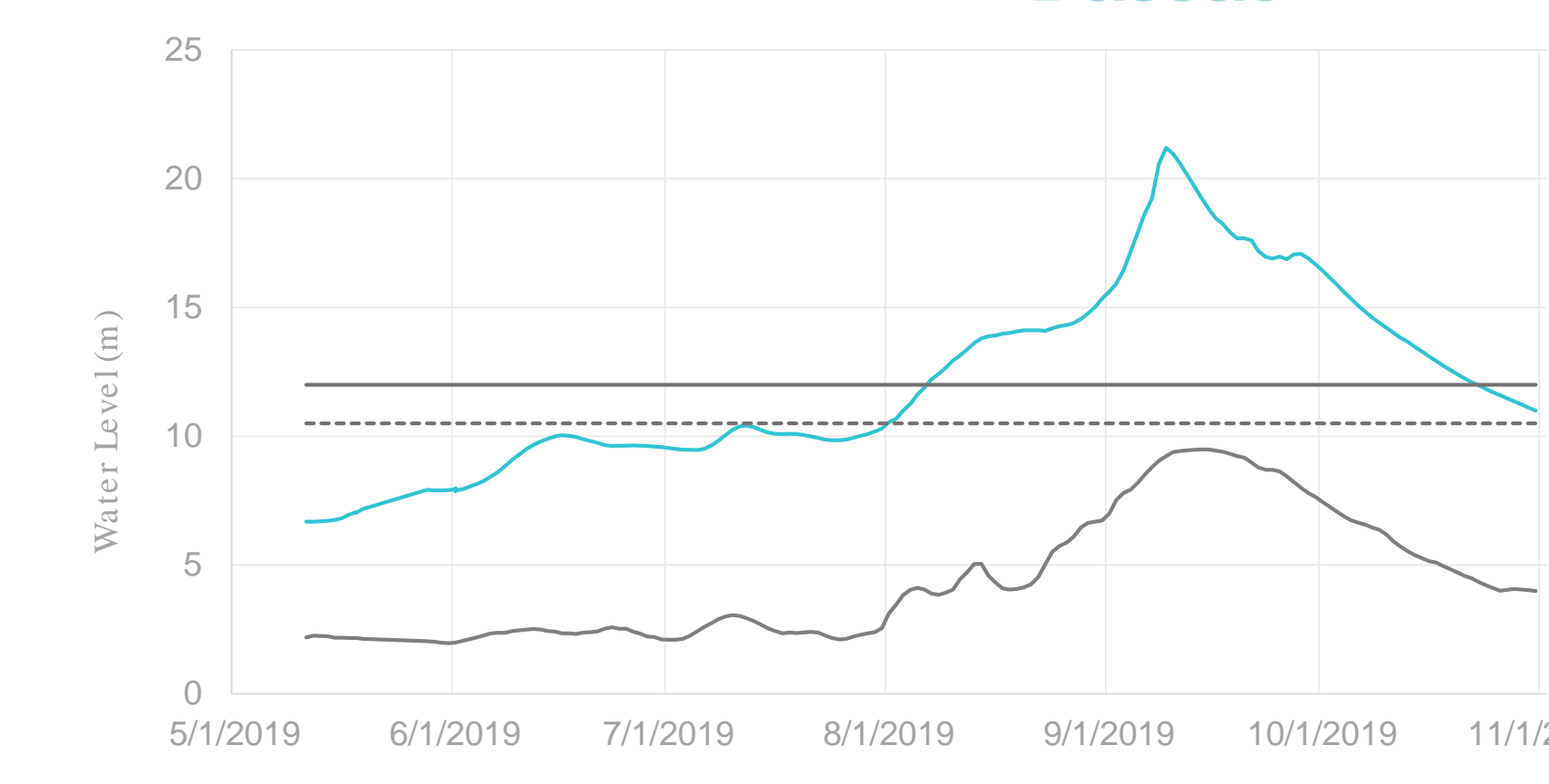## GloFAS 5 Day Mean Forecast vs Observed at Phnom Penh Bassac

Fig. 7-8
RMSE: 7.88, NSE: 9.5
The large difference in performance for GloFAS at different station locations can be seen by comparing Figures 5 and 7 (left). The coarse resolution of GloFAS (shown in Figure 8, right) offers a potential explanation for the poor performance at Phnom Penh.
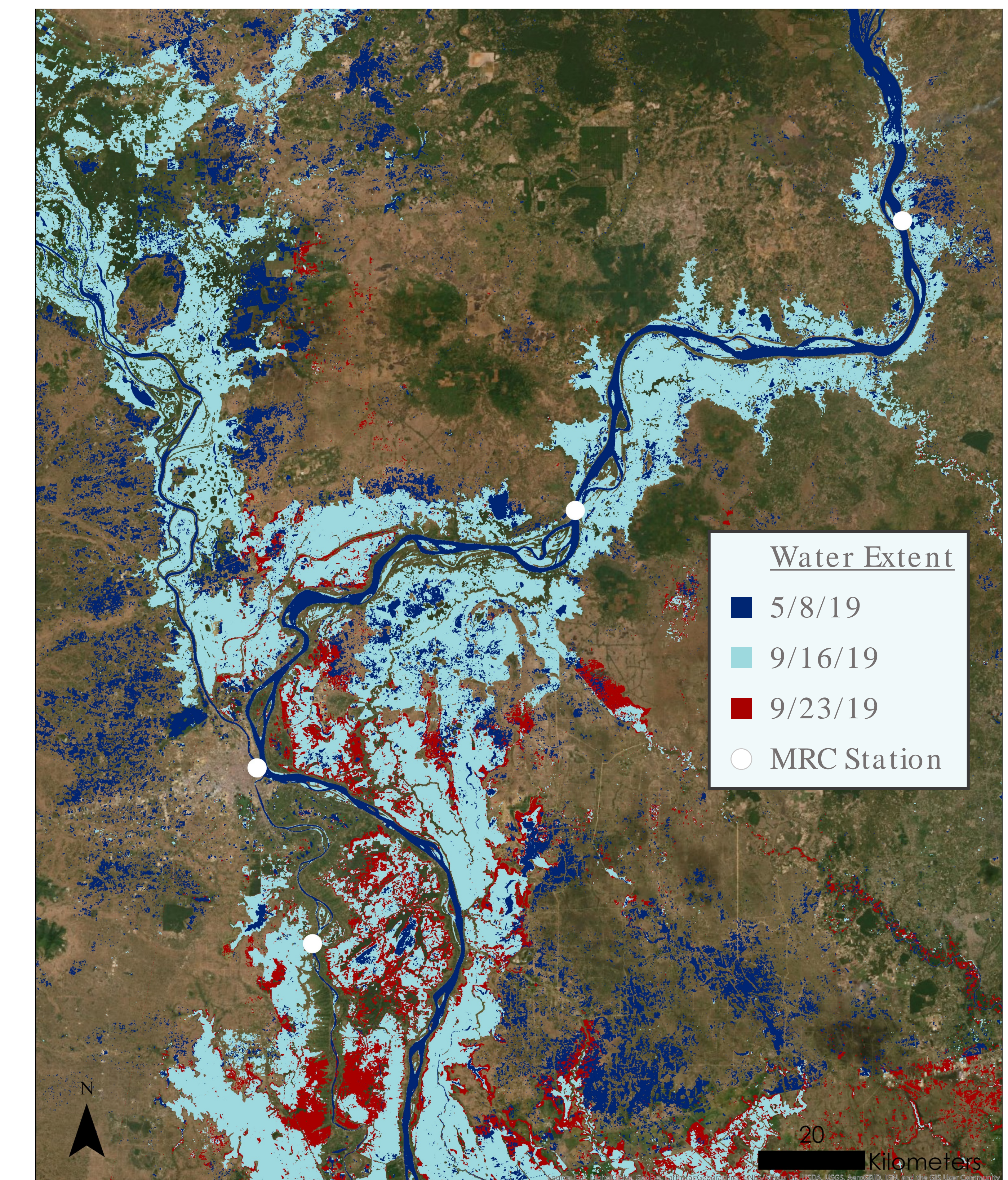
Flood Map

Water Extent
- 5/8/19
- 9/16/19
- 9/23/19
- MRC Station

Fig. 9 HYDRAFloods flood maps generated in Google Earth Engine from Sentinel 1 synthetic aperture radar data show the expansion of water extent around peak water level times. Although none of the stations observed water levels crossing the flood threshold during the 2019 flood season, areas around the river were inundated.

Conclusions

- Regional and national level systems outperform global systems at all lead times and all locations, but can only provide outlooks up to the next 5 days
- Performance varies widely between stations for global systems, but very little for regional and national systems
- Although no flood events occurred in the 2019 flood season according to water level thresholds, satellite based flood maps indicate large areas of flooding
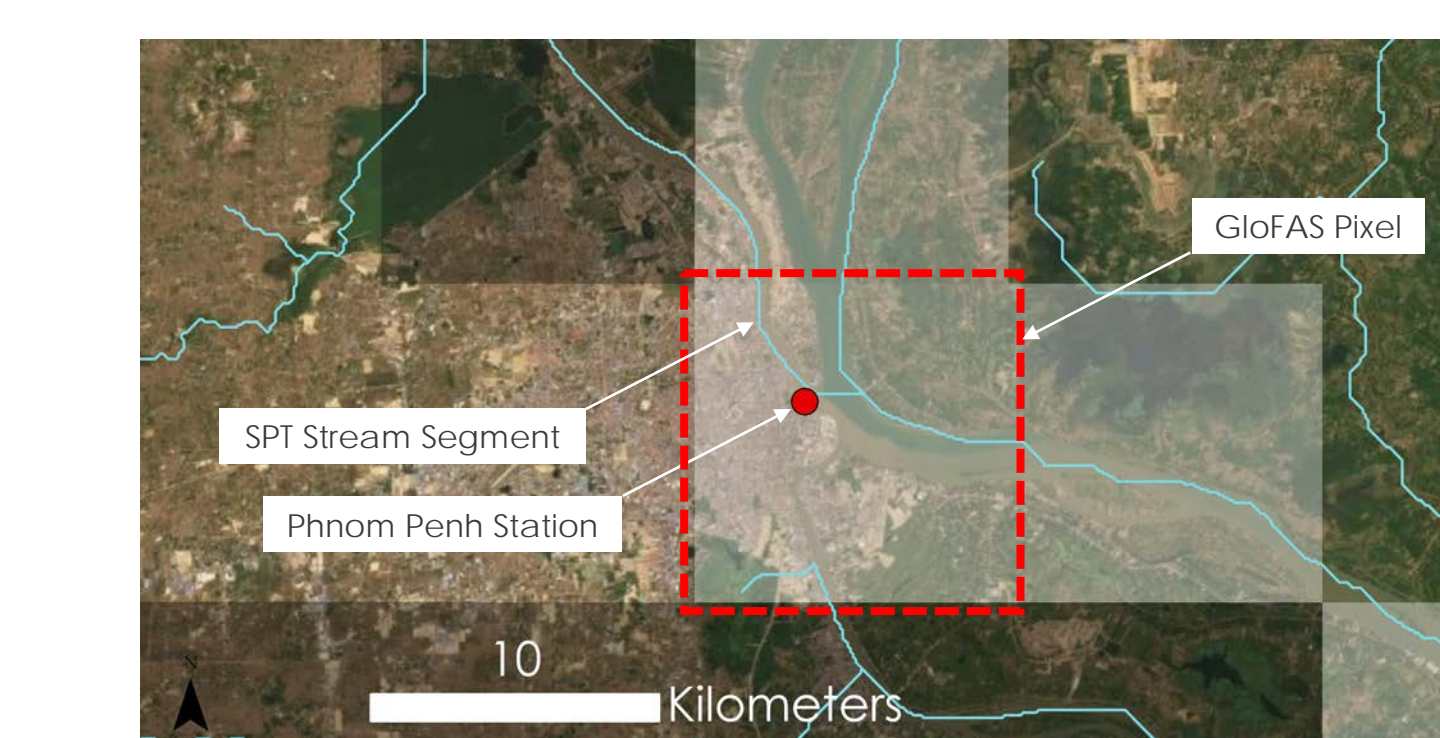
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