POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Evaluation of river flood extent simulated with multiple global hydrological models and climate forcings

Cross-sectoral ISIMIP and PROCLIAS online Workshop – 12.01.2021

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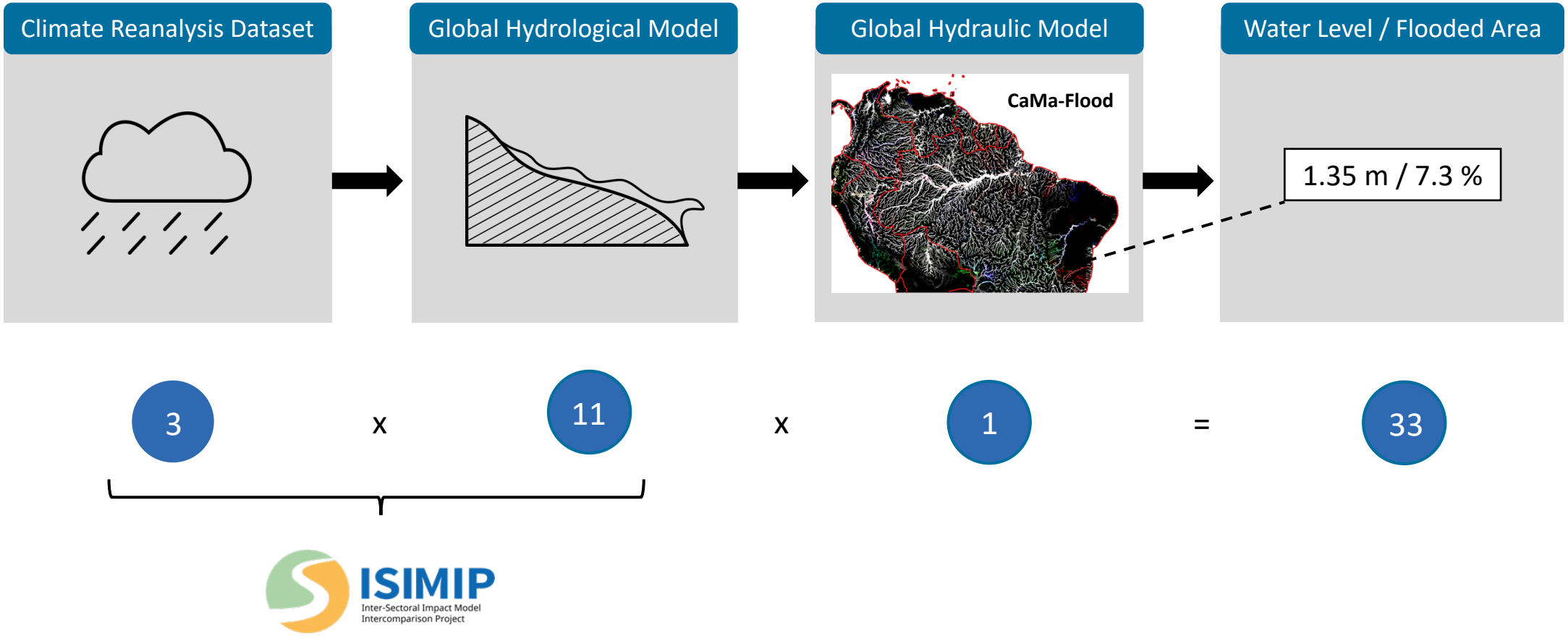
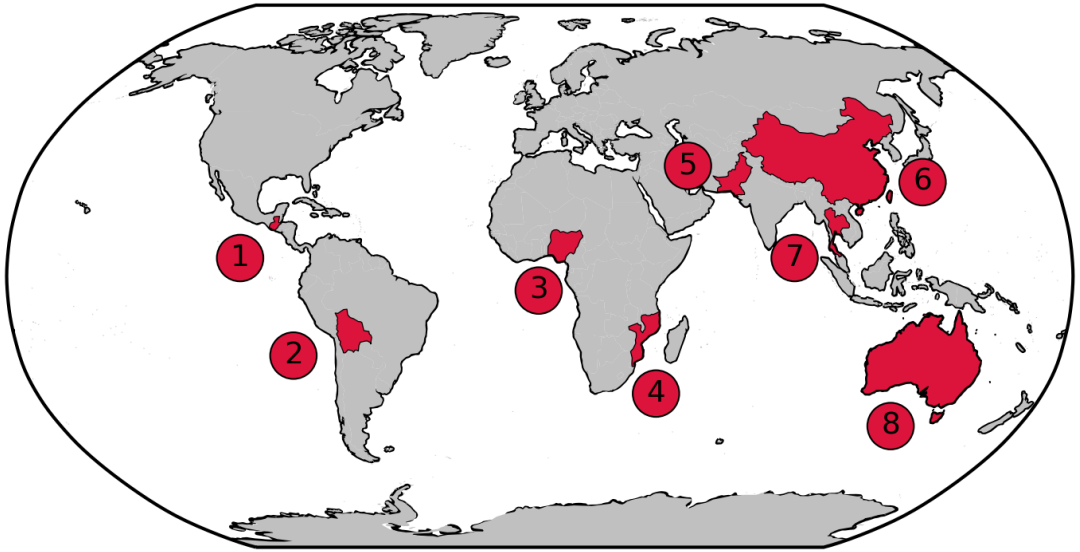
Leibniz Association

1. Global Flood-Modelling Chain



2. Case Study - Overview

- Eight major floods on four continents, covering a variety of climates and hydraulic characteristics
- Evaluation using model agreement maps and spatial performance metrics
- Testing the effect of a flood-volume adjustment procedure („adjust“) (Kim et., 2009; Hirabayashi et al., 2013) and the inclusion of spatially explicit flood protection levels („protect“) (Scussolini et al., 2016)



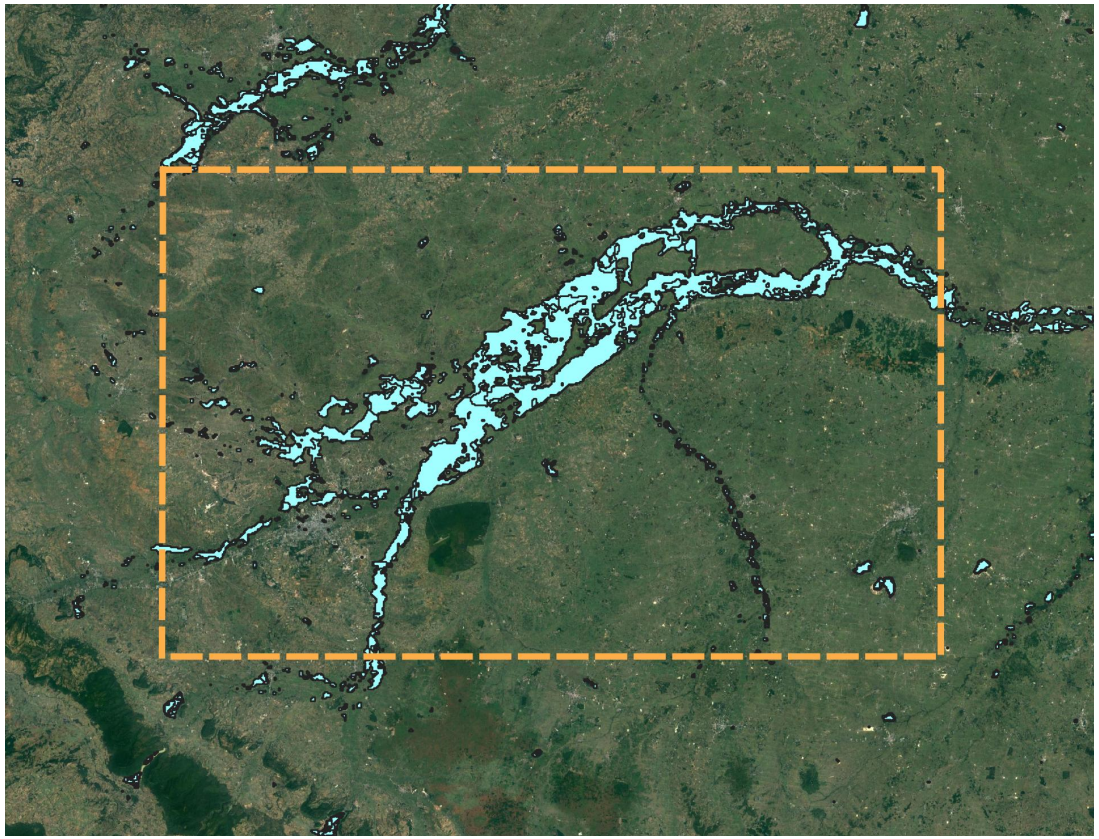
3. Case Study - Validation with MODIS satellite imagery

Example:

Flooding in the Mun River Basin, Thailand (2010)

turquoise = flooded area

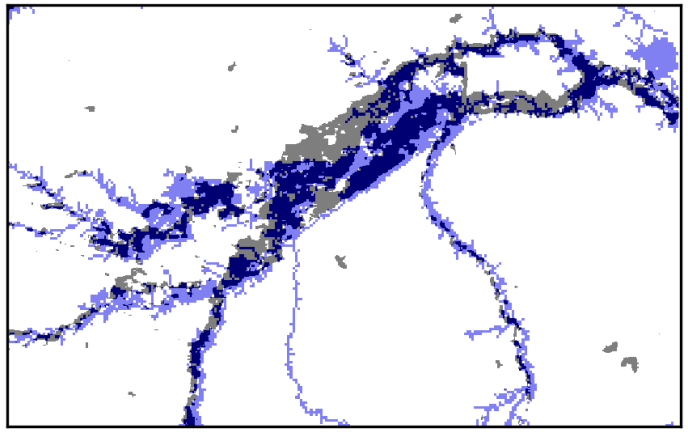
yellow = area of interest



4. Results – Model Agreement Maps

Thailand (Mun River, 2010) – Model agreement of 1 x hydrological model with „PGFv2“ forcing:

PGFv2

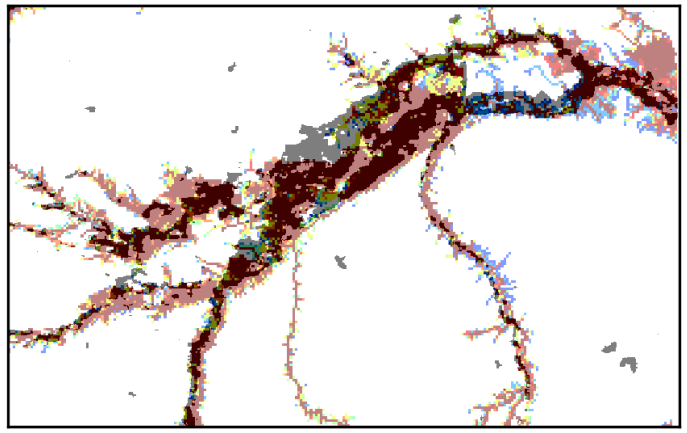


Mester et al., in prep.

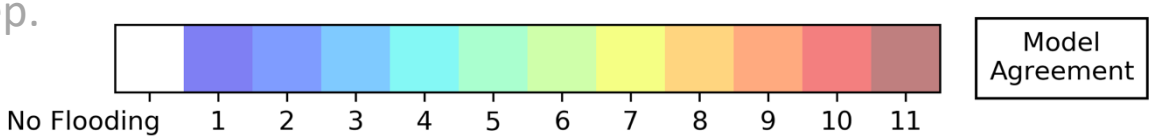
4. Results – Model Agreement Maps

Thailand (Mun River, 2010) – Model agreement of 11 x hydrological models with „PGFv2“ forcing :

PGFv2

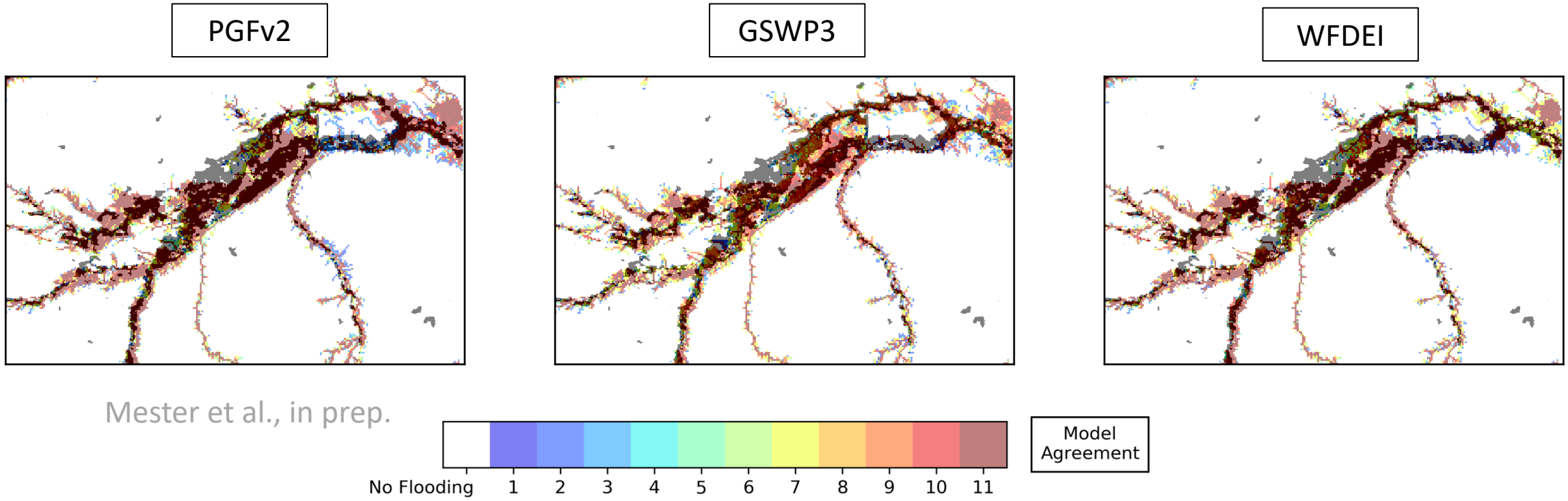


Mester et al., in prep.



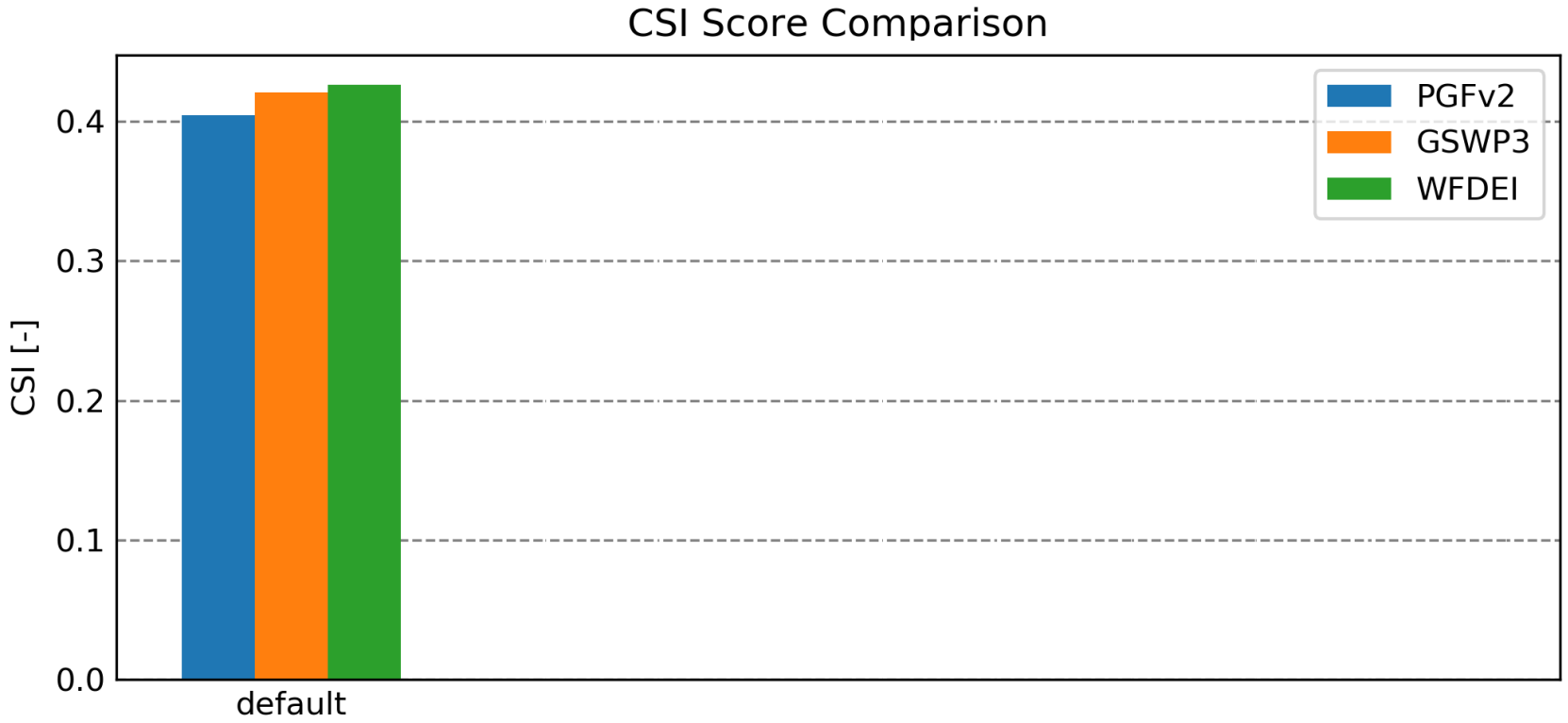
4. Results – Model Agreement Maps

Thailand (Mun River, 2010) – Model agreement of 11 x hydrological models with three forcings:



Mester et al., in prep.

4. Results – Spatial Performance Metrics



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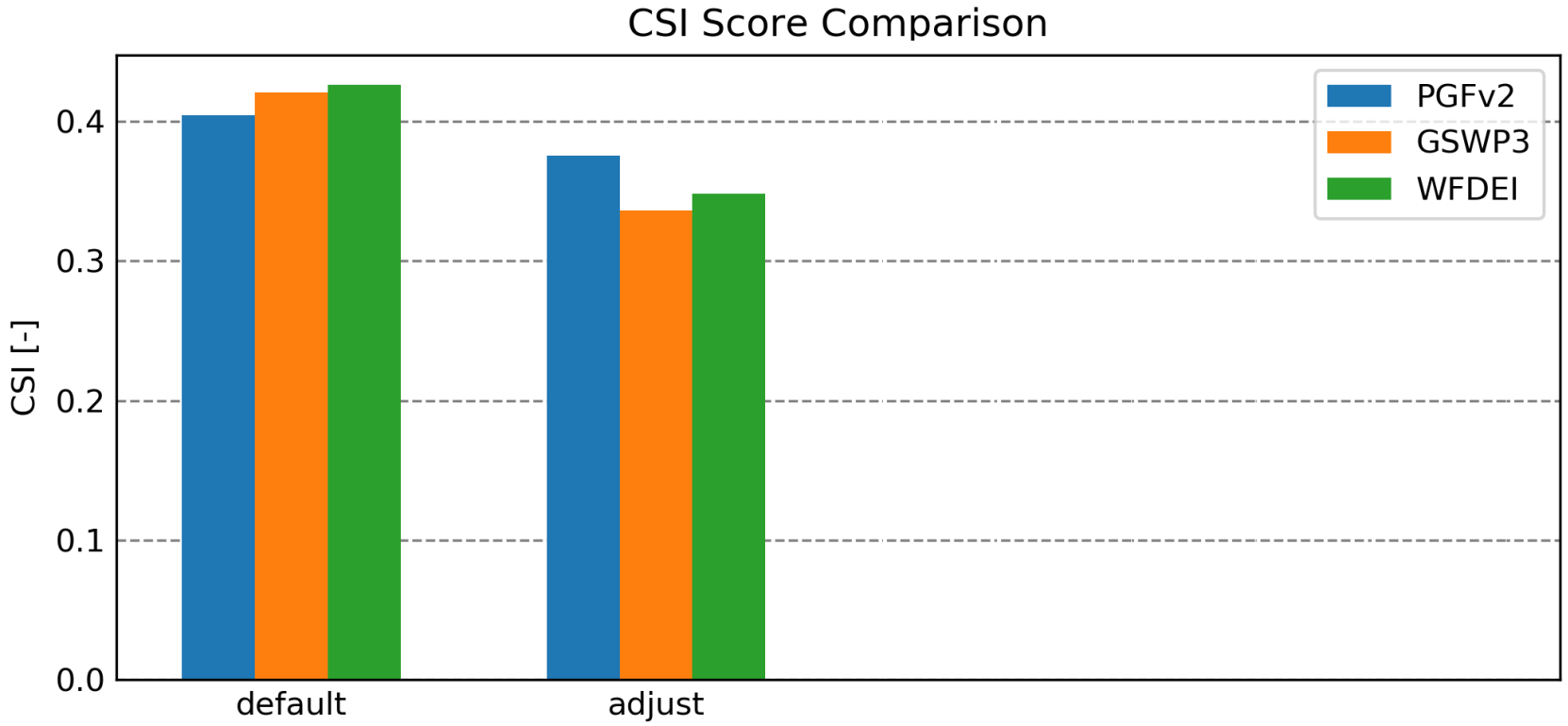

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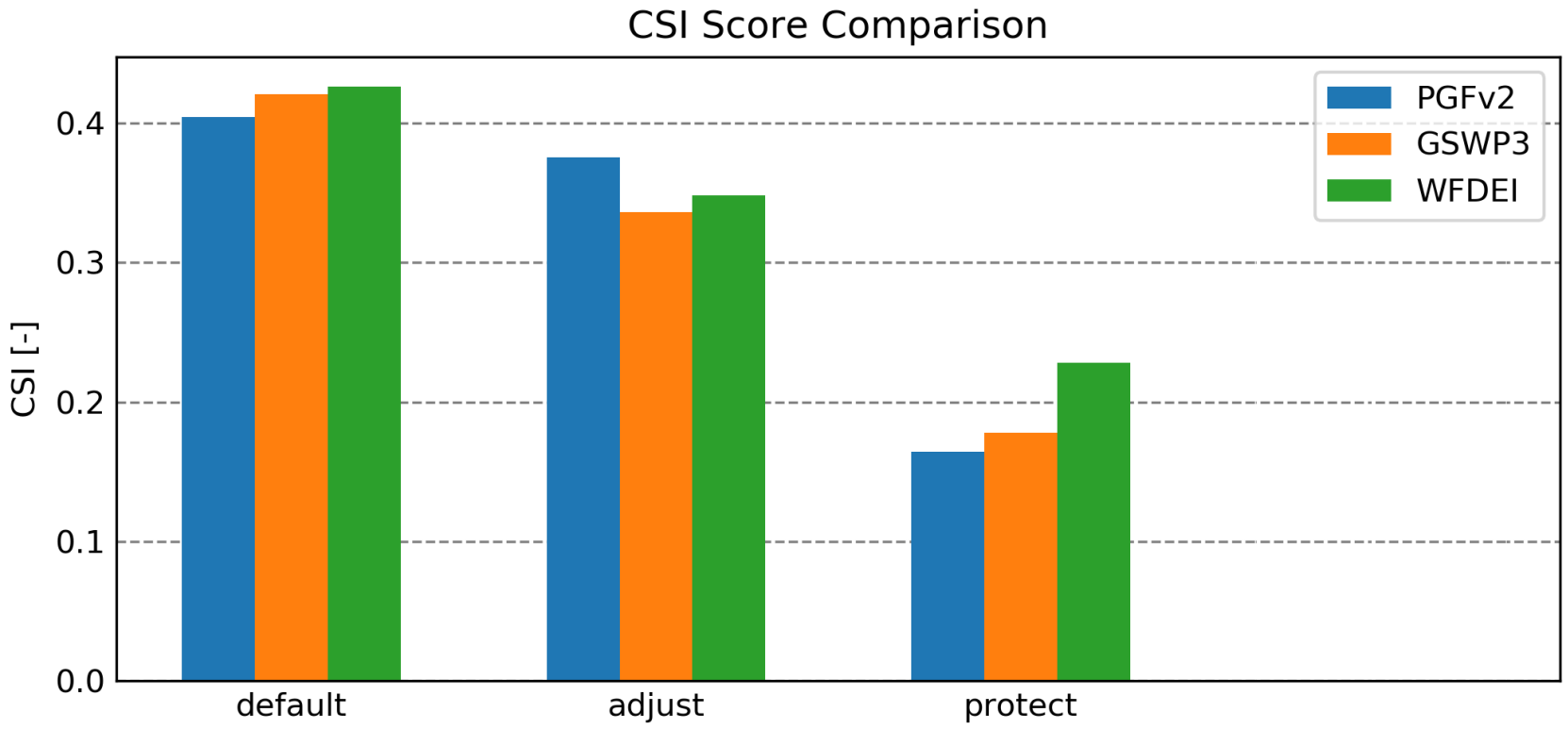

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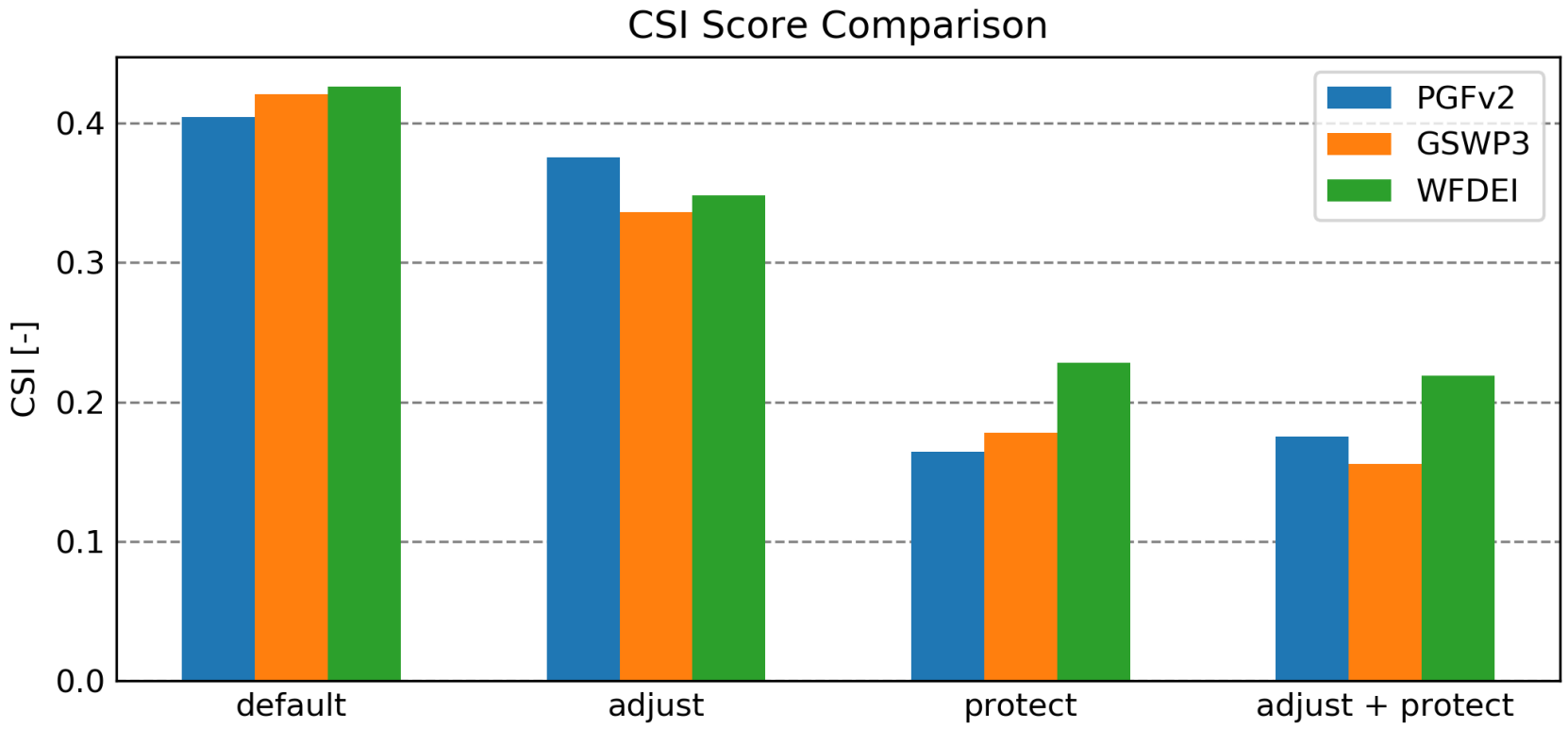

5. Conclusion

- The performance differs considerably between events
- The choice of GHM and climate forcing has mutually dependent effects
- Neither a flood volume adjustment procedure, nor accounting for flood protection, lead to clear improvements
- Bias Scores: Overestimation („default“) and underestimation („adjust“ and/or „protect“) of flood extent translate into high differences of simulated affected people

→ A multi-model, multi-forcing ensemble approach (such as ours) is recommended when there is no prior knowledge about a certain combination’s performance for the specific type of region

References

Kim H, Yeh P J-F, Oki T and Kanae S 2009 Role of rivers in the seasonal variations of terrestrial water storage over global basins Geophys. Res. Lett. 36 Online: https://doi.org/10.1029/2009GL039006

Hirabayashi Y, Mahendran R, Koirala S, Konoshima L, Yamazaki D, Watanabe S, Kim H and Kanae S 2013 Global flood risk under climate change Nat. Clim. Chang. 3 816–21

Scussolini P, Aerts J C J H, Jongman B, Bouwer L M, Winsemius H C, De Moel H and Ward P J 2016 FLOPROS: an evolving global database of flood protection standards Nat. Hazards Earth Syst. Sci. 16 1049–61

Questions & Answers

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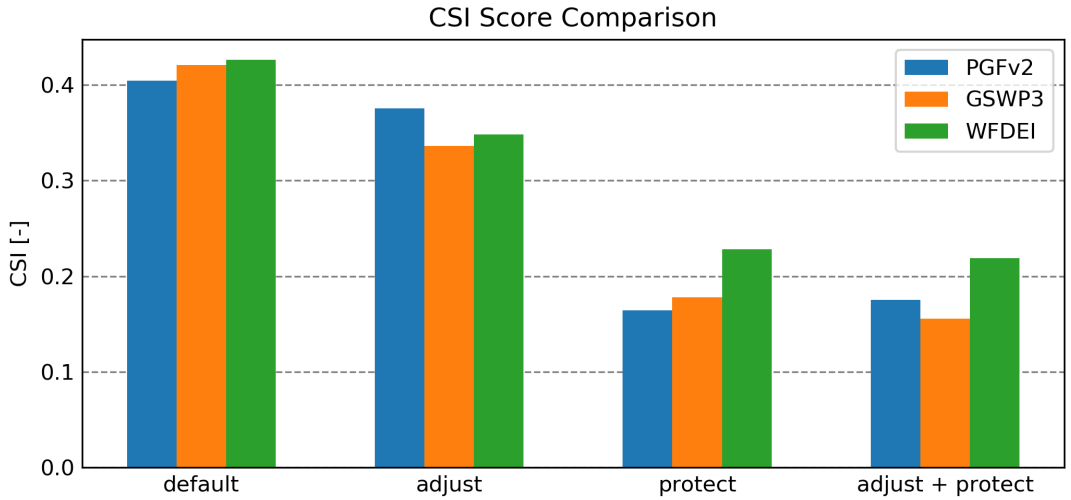
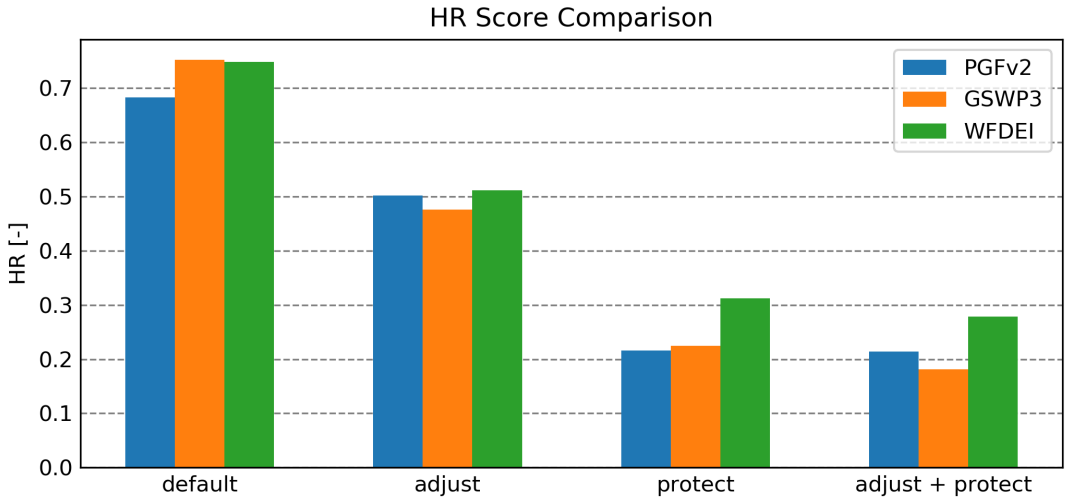
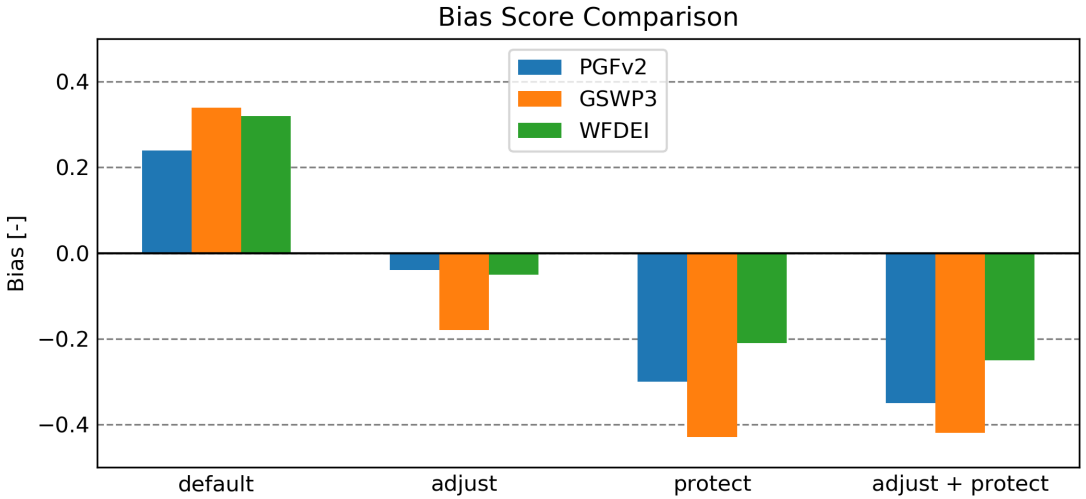
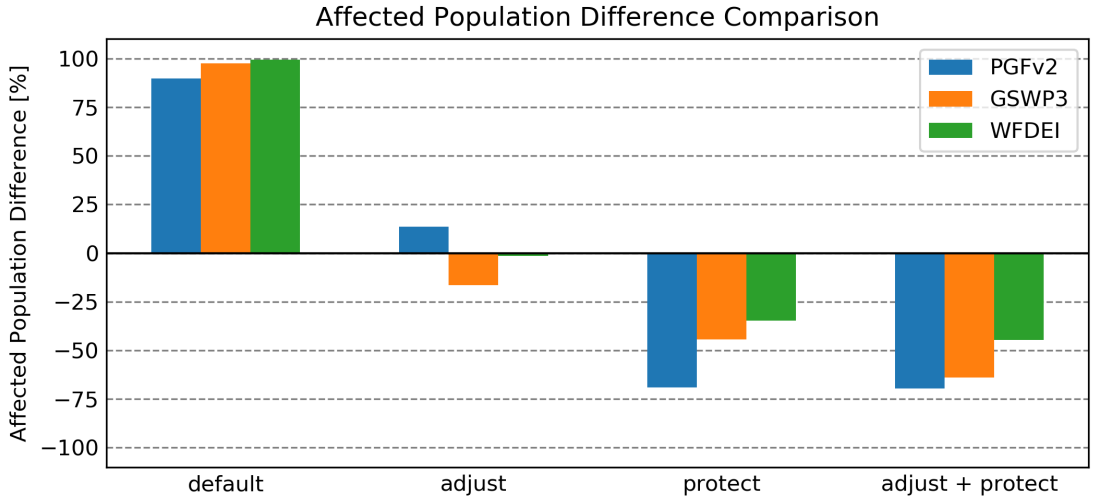
Extra Slides

4. Results – Spatial Performance Metrics









Extra Slides

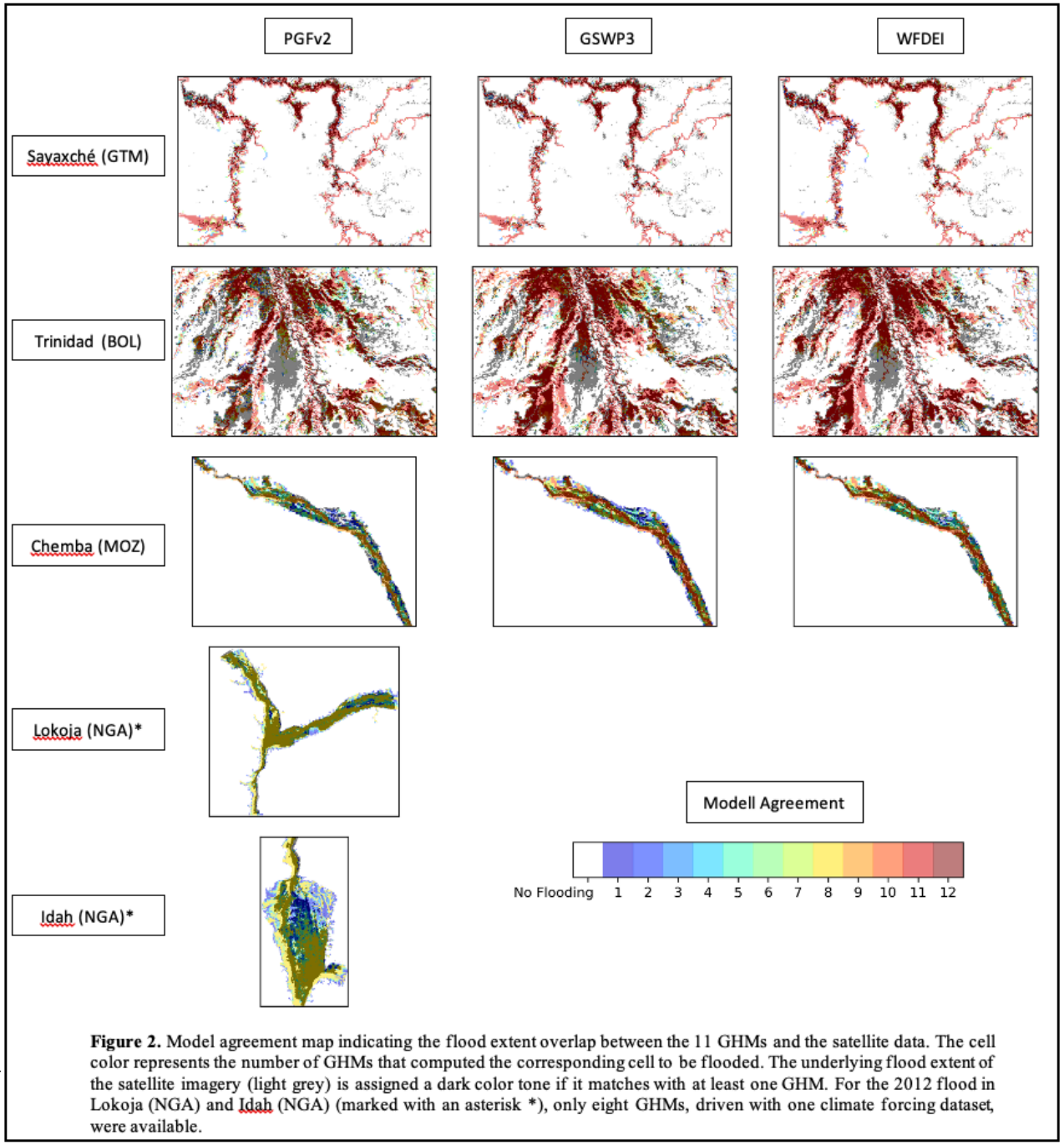


Figure 2. Model agreement map indicating the flood extent overlap between the 11 GHMs and the satellite data. The cell color represents the number of GHMs that computed the corresponding cell to be flooded. The underlying flood extent of the satellite imagery (light grey) is assigned a dark color tone if it matches with at least one GHM. For the 2012 flood in Lokoja (NGA) and Idah (NGA) (marked with an asterisk *), only eight GHMs, driven with one climate forcing dataset, were available.

Extra Slides

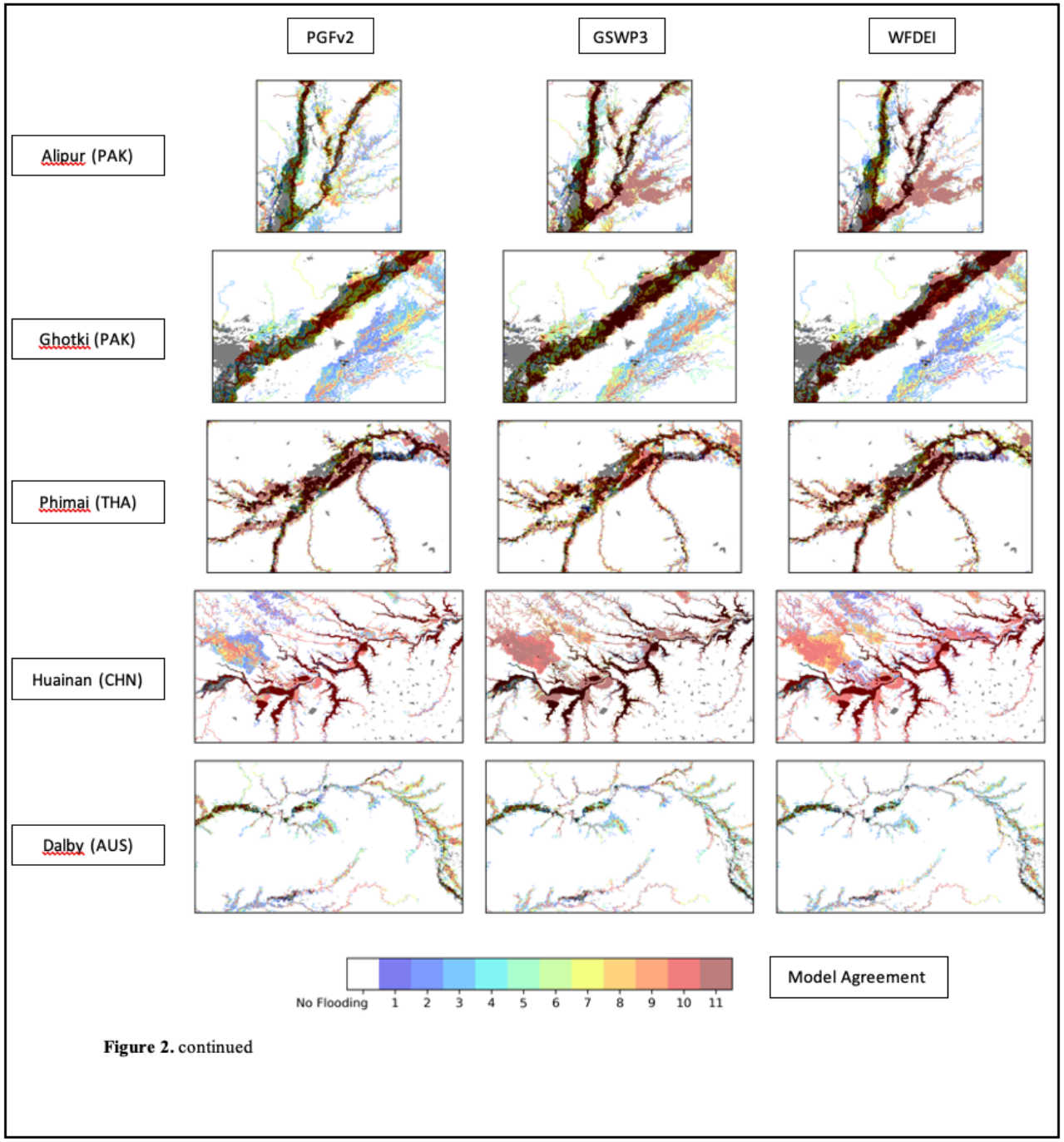


Figure 2. continued

Extra Slides

$$CSI = \frac{F_m \cap F_o}{F_m \cup F_o}$$

$$HR = \frac{F_m \cap F_o}{F_o}$$

$$Bias = \frac{(F_m \cap F_o) + F_m}{(F_m \cap F_o) + F_o} - 1$$

Extra Slides

Princeton

	CLM	DBH	H08	JULES-W1	LPJmL	MATSIRO	MPI-HM	ORCHIDEE	PCR-GLOBWB	VIC	WaterGAP2	Mean GHMs	Min. GHMs	Max. GHMs	Spread GHMs
Sayaxché	0.52	0.55	0.52	0.53	0.53	0.56	0.52	0.52	0.54	0.53	0.56	0.53	0.52	0.56	0.04
Trinidad	0.47	0.51	0.52	0.50	0.51	0.34	0.52	0.51	0.48	0.43	0.51	0.48	0.34	0.52	0.18
Chemba	0.43	0.71	0.68	0.67	0.67	0.00	0.40	0.71	0.53	0.00	0.56	0.49	0.00	0.71	0.71
Alipur	0.23	0.37	0.39	0.35	0.40	0.11	0.34	0.36	0.44	0.39	0.38	0.34	0.11	0.44	0.33
Ghotki	0.20	0.34	0.42	0.34	0.35	0.11	0.34	0.32	0.43	0.38	0.41	0.33	0.11	0.43	0.32
Phimai	0.44	0.46	0.41	0.50	0.47	0.49	0.45	0.45	0.44	0.43	0.50	0.46	0.41	0.50	0.09
Huainan	0.38	0.34	0.39	0.38	0.39	0.46	0.43	0.42	0.32	0.39	0.40	0.39	0.32	0.46	0.14
Dalby	0.24	0.17	0.22	0.16	0.19	0.24	0.24	0.20	0.21	0.26	0.26	0.22	0.16	0.26	0.10
Lokoja*	-	-	0.73	0.74	0.74	0.74	0.76	0.68	0.72	-	0.75	0.73	0.68	0.76	0.08
Idah*	-	-	0.66	0.70	0.69	0.60	0.70	0.60	0.60	-	0.69	0.66	0.60	0.70	0.10
Mean Region	0.36	0.43	0.44	0.43	0.44	0.29	0.40	0.44	0.42	0.35	0.45	0.40	0.29	0.45	0.16

GSWP3

	CLM	DBH	H08	JULES-W1	LPJmL	MATSIRO	MPI-HM	ORCHIDEE	PCR-GLOBWB	VIC	WaterGAP2	Mean GHMs	Min. GHMs	Max. GHMs	Spread GHMs
Sayaxché	0.53	0.56	0.54	0.56	0.55	0.58	0.54	0.54	0.56	0.55	0.56	0.55	0.53	0.58	0.05
Trinidad	0.53	0.54	0.54	0.53	0.54	0.49	0.53	0.54	0.53	0.46	0.53	0.52	0.46	0.54	0.08
Chemba	0.69	0.71	0.70	0.60	0.71	0.53	0.70	0.62	0.71	0.00	0.53	0.59	0.00	0.71	0.71
Alipur	0.32	0.33	0.36	0.33	0.35	0.33	0.35	0.35	0.36	0.35	0.37	0.35	0.32	0.37	0.05
Ghotki	0.34	0.40	0.44	0.35	0.35	0.42	0.43	0.34	0.42	0.40	0.34	0.38	0.34	0.44	0.10
Phimai	0.46	0.45	0.42	0.50	0.47	0.41	0.47	0.46	0.45	0.43	0.46	0.45	0.41	0.50	0.09
Huainan	0.28	0.28	0.29	0.33	0.30	0.38	0.31	0.31	0.28	0.31	0.32	0.31	0.28	0.38	0.10
Dalby	0.23	0.18	0.24	0.18	0.20	0.23	0.25	0.22	0.22	0.26	0.25	0.22	0.18	0.26	0.08
Mean Region	0.42	0.43	0.44	0.42	0.43	0.42	0.45	0.42	0.44	0.34	0.42	0.42	0.34	0.45	0.11

WFDEI

	CLM	DBH	H08	JULES-W1	LPJmL	MATSIRO	MPI-HM	ORCHIDEE	PCR-GLOBWB	VIC	WaterGAP2	Mean GHMs	Min. GHMs	Max. GHMs	Spread GHMs
Sayaxché	0.52	0.53	0.50	0.51	0.51	0.53	0.50	0.51	0.53	0.51	0.52	0.52	0.50	0.53	0.03
Trinidad	0.53	0.53	0.54	0.54	0.54	0.53	0.54	0.54	0.54	0.51	0.53	0.53	0.51	0.54	0.03
Chemba	0.65	0.71	0.70	0.61	0.71	0.55	0.66	0.71	0.71	0.00	0.49	0.59	0.00	0.71	0.71
Alipur	0.27	0.36	0.37	0.38	0.36	0.30	0.36	0.34	0.37	0.31	0.38	0.35	0.27	0.38	0.11
Ghotki	0.37	0.34	0.48	0.40	0.35	0.47	0.47	0.37	0.44	0.42	0.41	0.41	0.34	0.48	0.14
Phimai	0.47	0.46	0.41	0.50	0.47	0.49	0.47	0.47	0.46	0.45	0.49	0.47	0.41	0.50	0.09
Huainan	0.29	0.28	0.30	0.32	0.31	0.37	0.33	0.32	0.27	0.31	0.31	0.31	0.27	0.37	0.10
Dalby	0.25	0.18	0.24	0.20	0.20	0.27	0.25	0.25	0.22	0.26	0.27	0.24	0.18	0.27	0.09
Mean Region	0.42	0.42	0.44	0.43	0.43	0.44	0.45	0.44	0.44	0.35	0.43	0.43	0.35	0.45	0.10

Figure 3. Critical success index (CSI) scores for all combinations of GHMs and PGFv2, GSWP3, and WFDEI. Lokoja (NGA) and Idah (NGA) were excluded from the computation of the regional mean. "-" means no input data was available.