

A Review of SWAT Applications, Performance and Future Needs for Simulation of Hydro-Climatic Extremes

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MOTIVATION 1



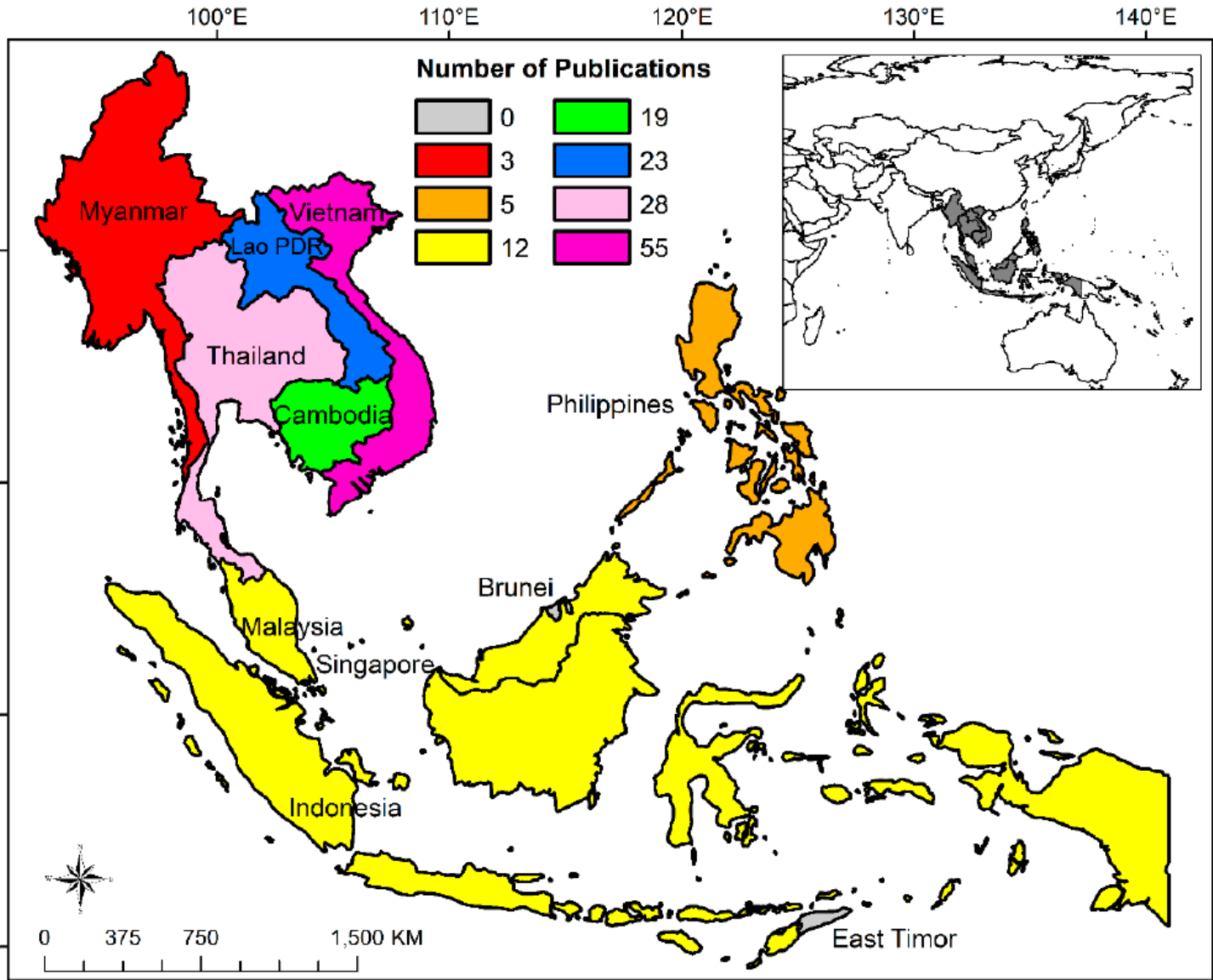
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Tan, M.L., Gassman, P.W., Srinivasan, R., Arnold, J.G. and Yang, X. (2019a) A Review of SWAT Studies in Southeast Asia: Applications, Challenges and Future Directions. *Water* 11(5), 914.

Various types of SWAT applications that have been reported for Southeast Asia.

Application	Transnational	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Thailand	Vietnam
Bioenergy crop impacts								•	
BMP assessment			•					•	
Climate and land use Change	•		•	•	•	•		•	•
Climate change	•			•	•	•		•	•
Climate data effects	•	•			•	•		•	•
Critical source area analysis								•	
DEM data resolution effects					•				
Evaporation assessment									•
Flood analysis								•	•
Groundwater analysis			•						
Impoundment effects	•	•		•				•	
Input uncertainty analysis					•				
Irrigation impact									•
Land use change	•		•		•		•	•	•
Model comparison								•	•
Nitrogen cycling and transport	•								•
Nutrient cycling and transport								•	
Pathogen fate and transport				•					
Pesticide fate and transport							•	•	
Regionalization of input parameters									•
Sediment loss and transport	•	•	•				•		•
Soil data resolution effects			•					•	
Uncertainty analysis	•								•

Tan, M.L., Gassman, P.W., Srinivasan, R., Arnold, J.G. and Yang, X. (2019) A Review of SWAT Studies in Southeast Asia: Applications, Challenges and Future Directions. *Water* 11(5), 914.

MOTIVATION 2



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Malaysia

NERC, ESRC and the Malaysia Ministry of Education are pleased to announce four joint projects:

Integrated modelling of landslides due to hydrometeorological impacts in Langat Basin, Peninsular Malaysia (iModelLandslides)

Lead organisations: Ashraf Osman (Durham University) and Mohd Raihan Taha (Universiti Kebangsaan Malaysia)

Understanding and managing the risk of water related diseases under hydrometeorological extremes

Lead organisations: Wouter Buytaert (Imperial College London) and Zed Diyana Zulkaflī (Universiti Putra Malaysia)

Impacts of precipitation from extreme storms - Malaysia (IMPRESS - Malaysia)

Lead organisations: James Haywood (University of Exeter) and Mou Leong Tan (Universiti Sains Malaysia)

Flood impacts across scales - informing models of flood exposure and vulnerability via an integrated multi-scale approach

Lead organisations: Nicholas Reynard (NERC Centre for Ecology & Hydrology) and Balqis Mohamed Rehan (Universiti Putra Malaysia)

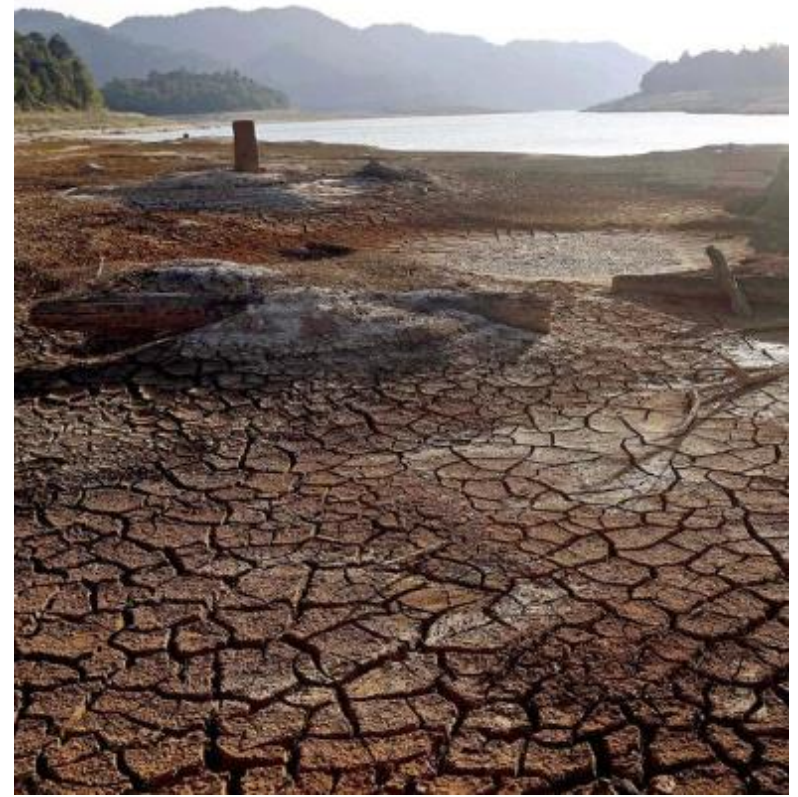
Hydro-climatic Extremes

“the occurrence of a hydro-climatic variable’s value higher (or lower) than a defined extremely high (or low) threshold value”.

Flood

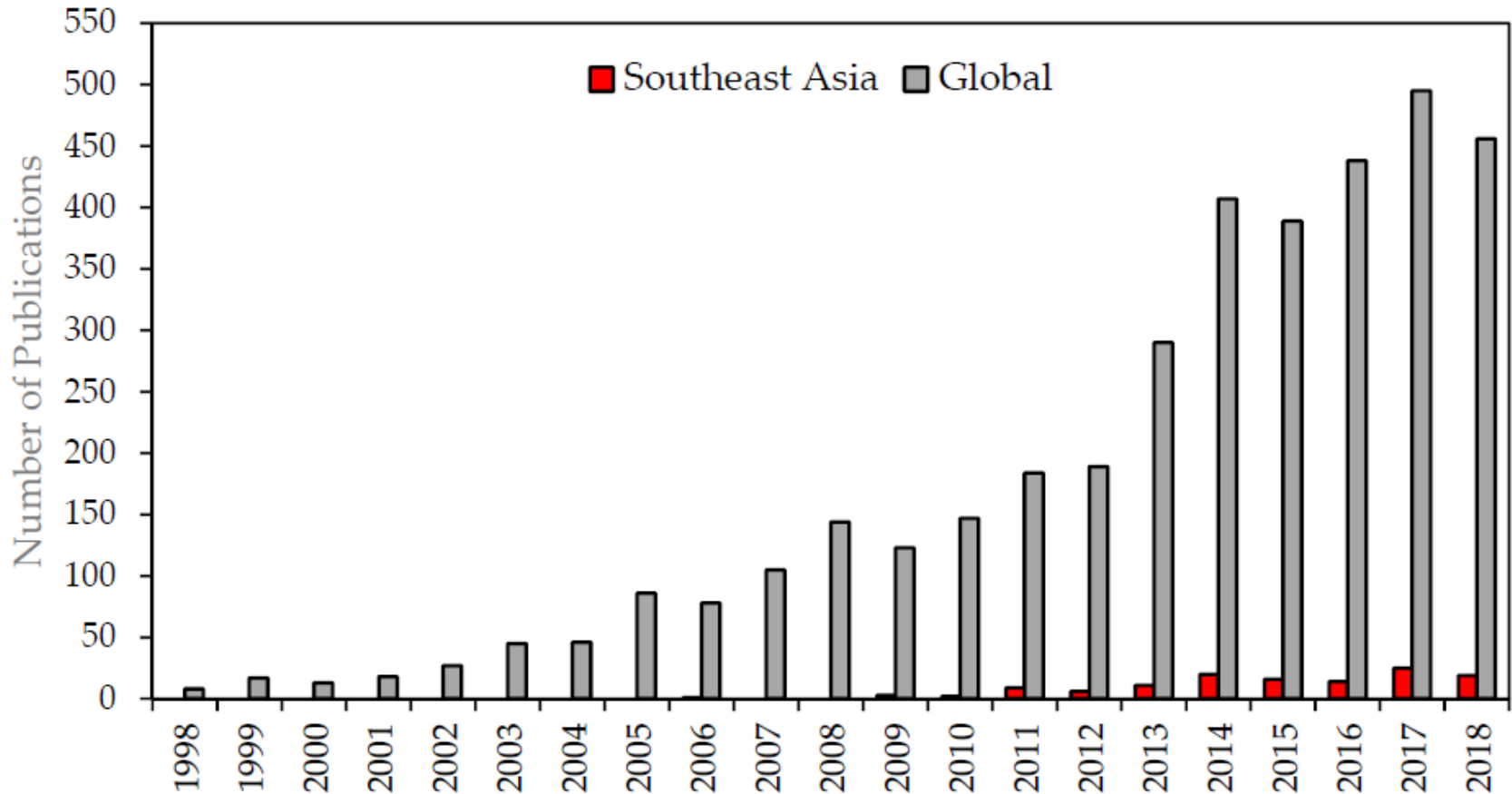


Drought



Why SWAT?

~4000 publications (CARD, 2019)



CARD 2019. SWAT Literature Database for Peer-Reviewed Journal Articles; Center for Agricultural and Rural Development: Iowa State University, Ames, IA, USA (accessed on 21 Oct 2019)

Research Gap



ELSEVIER

Journal of Hydrology
Volume 535, April 2016, Pages 625-636



=1.349
=1.267
=0.835

Review Paper

No SWAT Review on Hydro-climatic Extremes!!!

Quintero 

 Show more

<https://doi.org/10.1016/j.jhydrol.2016.01.034>

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Bressiani, D.A., Gassman, P.W., Fernandes, J.G., Garbosa, L.H.P., Srinivasan, R., Bonumá, N.B. and Mendiando, E.M. (2015) Review of Soil and Water Assessment Tool (SWAT) applications in Brazil: Challenges and prospects. *International Journal of Agricultural and Biological Engineering* 8(3), 9-35.

Francesconi, W., Srinivasan, R., Perez-Minana, E., Willcock, S.P. and Quintero, M. (2016) Using the Soil and Water Assessment Tool (SWAT) to model ecosystem services: A systematic review. *Journal of Hydrology* 535, 625-636.

Gassman, P.W., Reyes, M.R., Green, C.H. and Arnold, J.G. (2007) The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions. *Transactions of the ASABE* 50(4), 1211-1250.

Tan, M.L., Gassman, P.W., Srinivasan, R., Arnold, J.G. and Yang, X. (2019a) A Review of SWAT Studies in Southeast Asia: Applications, Challenges and Future Directions. *Water* 11(5), 914.

Objective

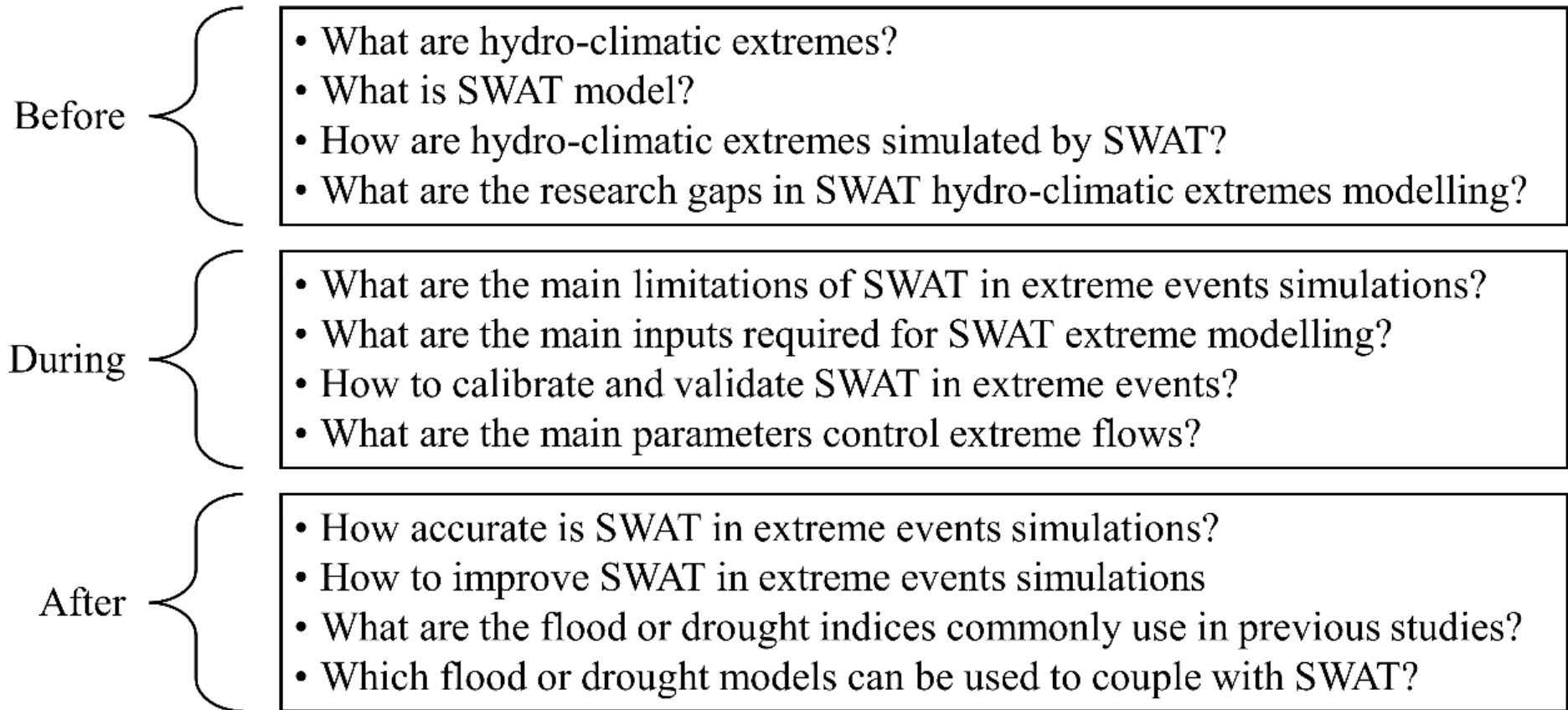
- This review aims to summarize the findings of existing SWAT-based hydro-climatic extremes studies.



I just need
the main ideas

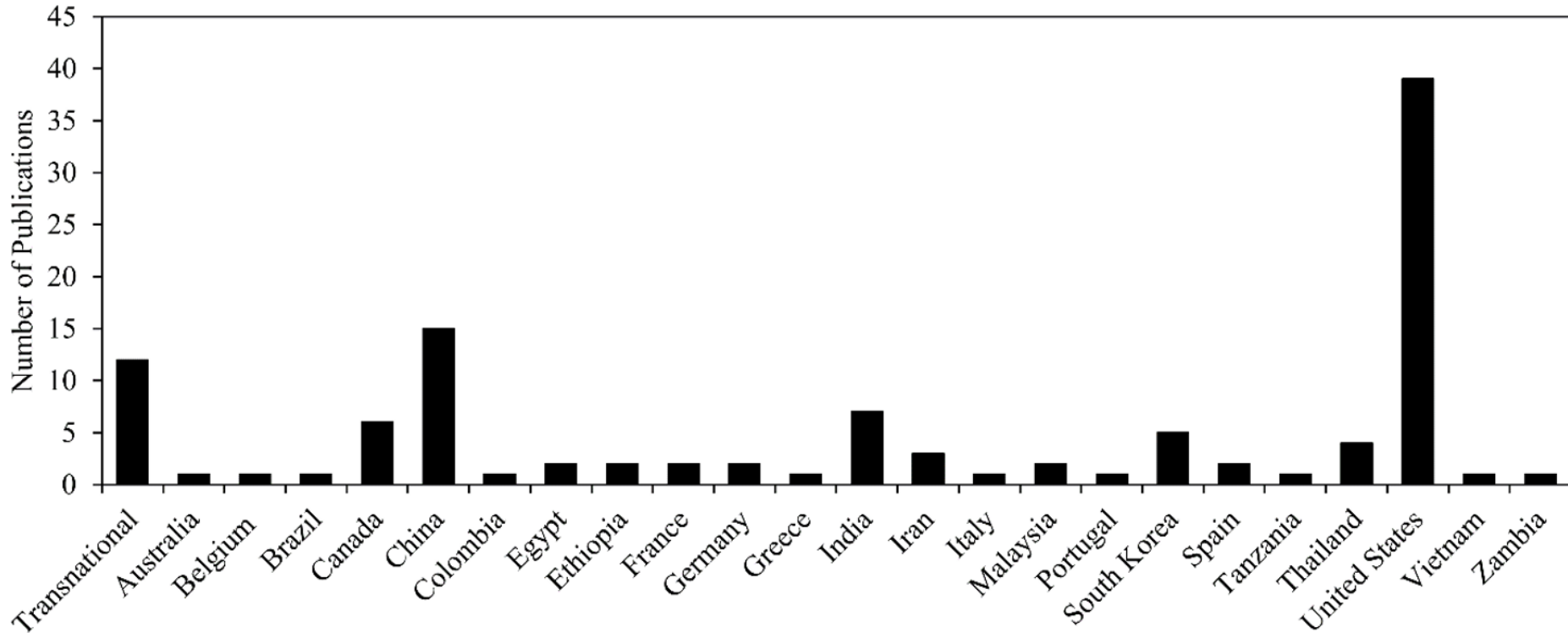


SWAT - Hydro-Climatic Extremes

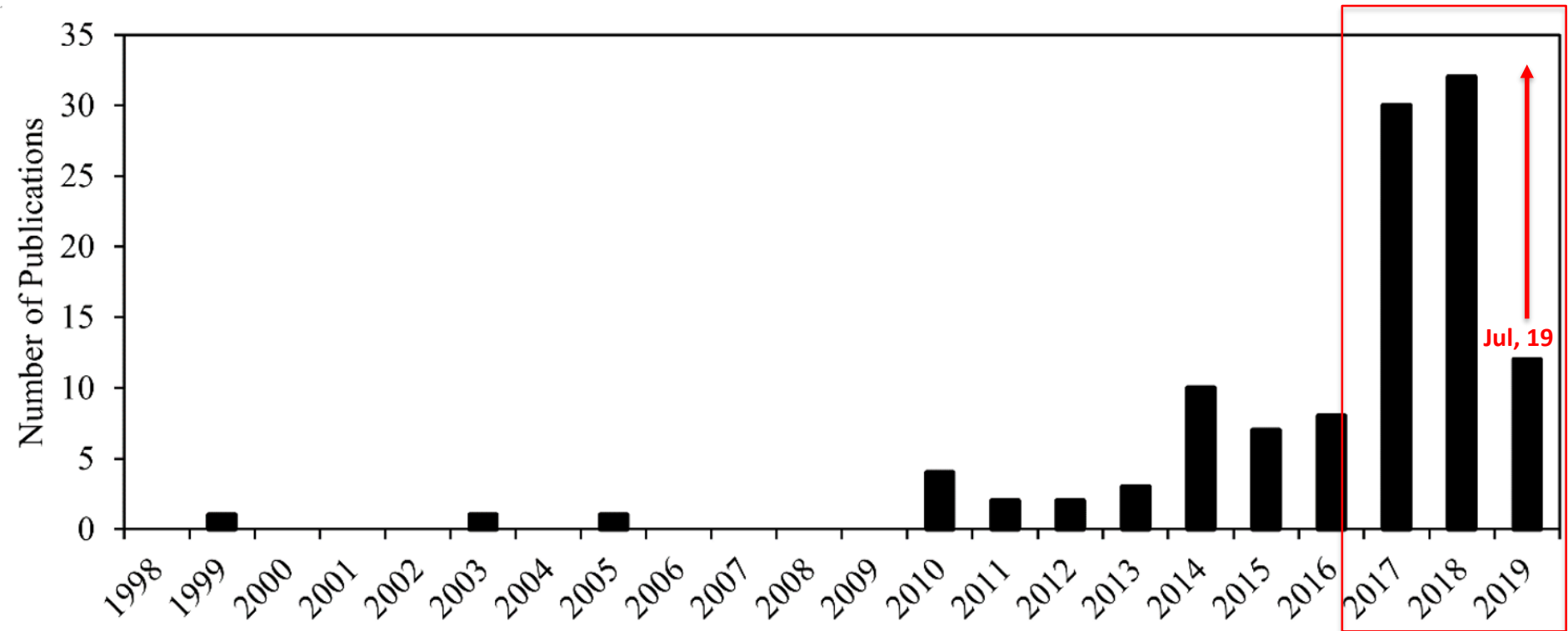


- The SWAT Literature Database (CARD, 2019) and Web of Science (WoS) database.
- Searching Keywords:
 - extreme, flood, drought, peak flow, high flow & low flow.
- Published from 1998 onward.
- Exclude grey literature, i.e. thesis, report, etc.
- Authors' experience & knowledge

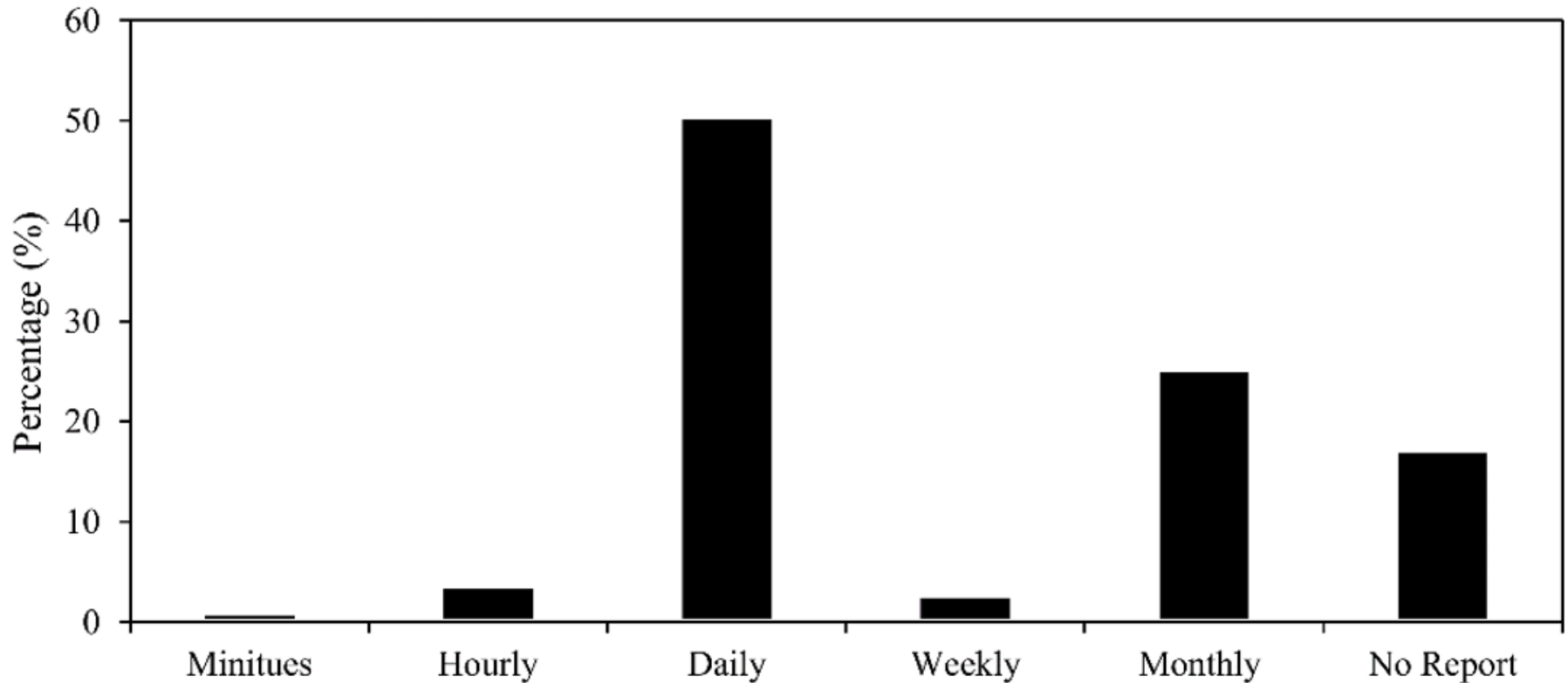
111 Articles



SWAT hydro-climatic extremes publications based on countries.



SWAT hydro-climatic extremes publications based on years



Finest streamflow calibration time-scale reported in the selected publications.

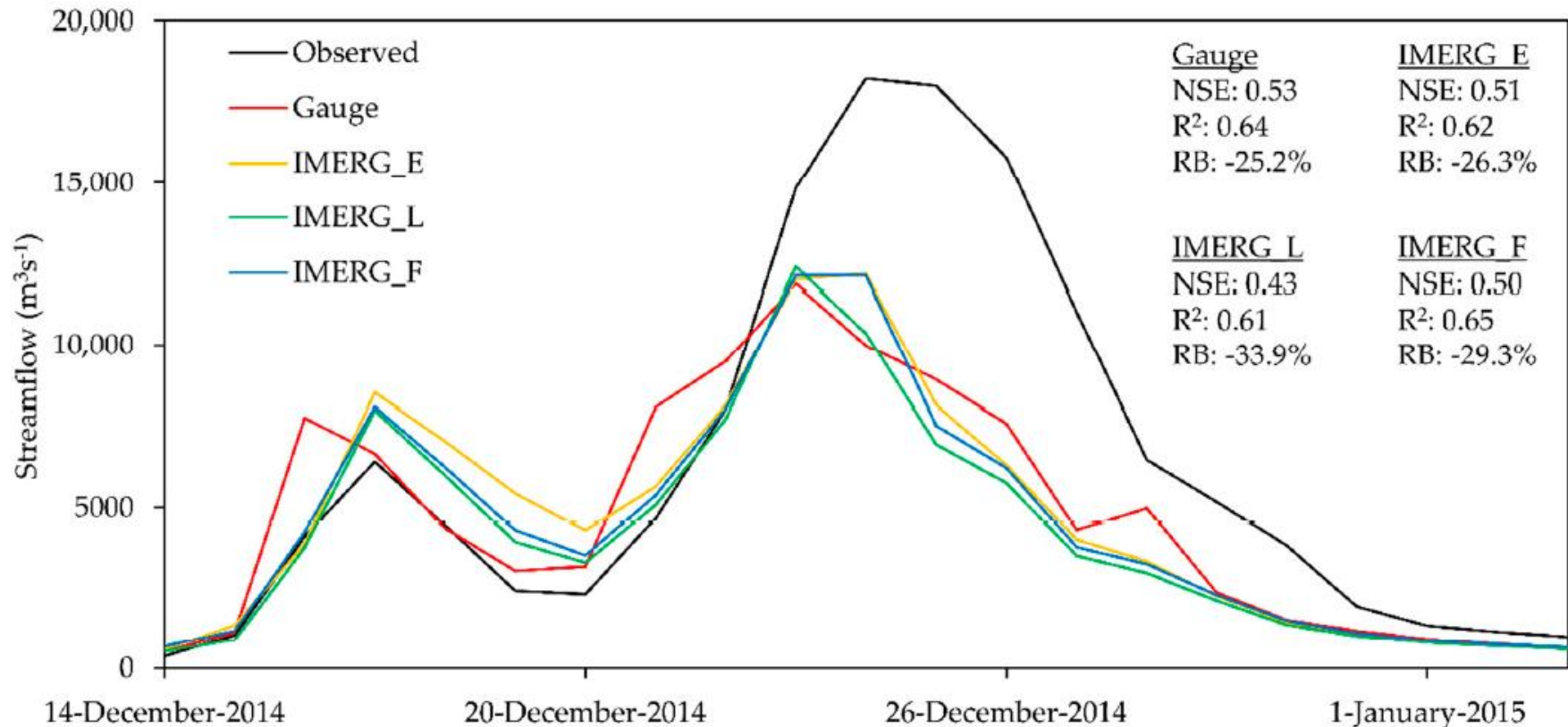
Overall SWAT performance of the selected 111 publications.

	Monthly				Daily				Sub-daily			
	Calibration		Validation		Calibration		Validation		Calibration		Validation	
	NSE	R ²	NSE	R ²	NSE	R ²	NSE	R ²	NSE	R ²	NSE	R ²
1-0.9	8	12	8	16	8	8	7	2	7	1	4	0
0.8-0.89	28	29	22	21	28	24	18	23	25	3	8	3
0.7-0.79	28	25	28	34	50	40	62	62	4	1	5	0
0.6-0.69	26	11	21	15	73	55	69	51	3	3	2	1
0.5-0.59	12	2	22	4	50	31	49	25	3	1	1	0
0.4-0.49	1	0	5	5	26	13	22	10	1	1	2	1
0.3-0.39	1	0	0	1	10	1	9	0	0	0	1	1
0.2-0.29	0	0	1	2	0	1	1	1	0	0	1	1
0.1-0.19	2	0	2	3	1	0	1	0	0	1	0	0
0-0.1	0	0	0	0	0	0	0	0	0	0	0	0
<0	0	0	1	0	1	0	2	0	1	0	0	0

Six Major Categories

- SWAT performance regarding replication of extreme flows.
- SWAT drought-related studies.
- SWAT flood-related studies.
- SWAT studies that incorporate both drought and flood analyses.
- SWAT coupling with other models.
- SWAT model applications featuring modifications, enhanced pre- or post-processing capabilities and some other improvement.

Selected Paper (Tan et al., 2018)



Daily SWAT streamflow simulations during the 2014–2015 flood by gauge and three GPM IMERG products at the Jambatan Guillermaid, Kelantan River Basin, Malaysia

Tan, M.L., Samat, N., Chan, N.W. and Roy, R. (2018) Hydro-Meteorological Assessment of Three GPM Satellite Precipitation Products in the Kelantan River Basin, Malaysia. *Remote Sensing* 10(7), 1011.



Future hydro-meteorological drought of the Johor River Basin, Malaysia, based on CORDEX-SEA projections

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ABSTRACT

Water scarcity issues in the Johor River Basin (JRB) could affect the populations of Malaysia and Singapore. This study provides an overview of future hydro-meteorological droughts using climate projections from an ensemble of four Coordinated Regional Climate Downscaling Experiments – Southeast Asia (CORDEX-SEA) domain outputs under the Representative Concentration Pathway (RCP) 4.5 and 8.5 scenarios for the 2021–2050 and 2071–2100 periods. The climate projections were bias corrected using the quantile mapping approach before being incorporated into the Soil and Water Assessment Tool (SWAT) hydrological model. The Standardized Precipitation Index (SPI) and Standardized Streamflow Index (SSI) were used to examine the meteorological and hydrological droughts, respectively. Overall, future annual precipitation, streamflow, and maximum and minimum temperatures are projected to change by about –44.2 to 24.3%, –88.7 to 42.2%, 0.8 to 3.7°C and 0.7 to 4.7°C, respectively. The results show that the JRB is likely to receive more frequent meteorological droughts in the future.

ARTICLE HISTORY

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EDITOR

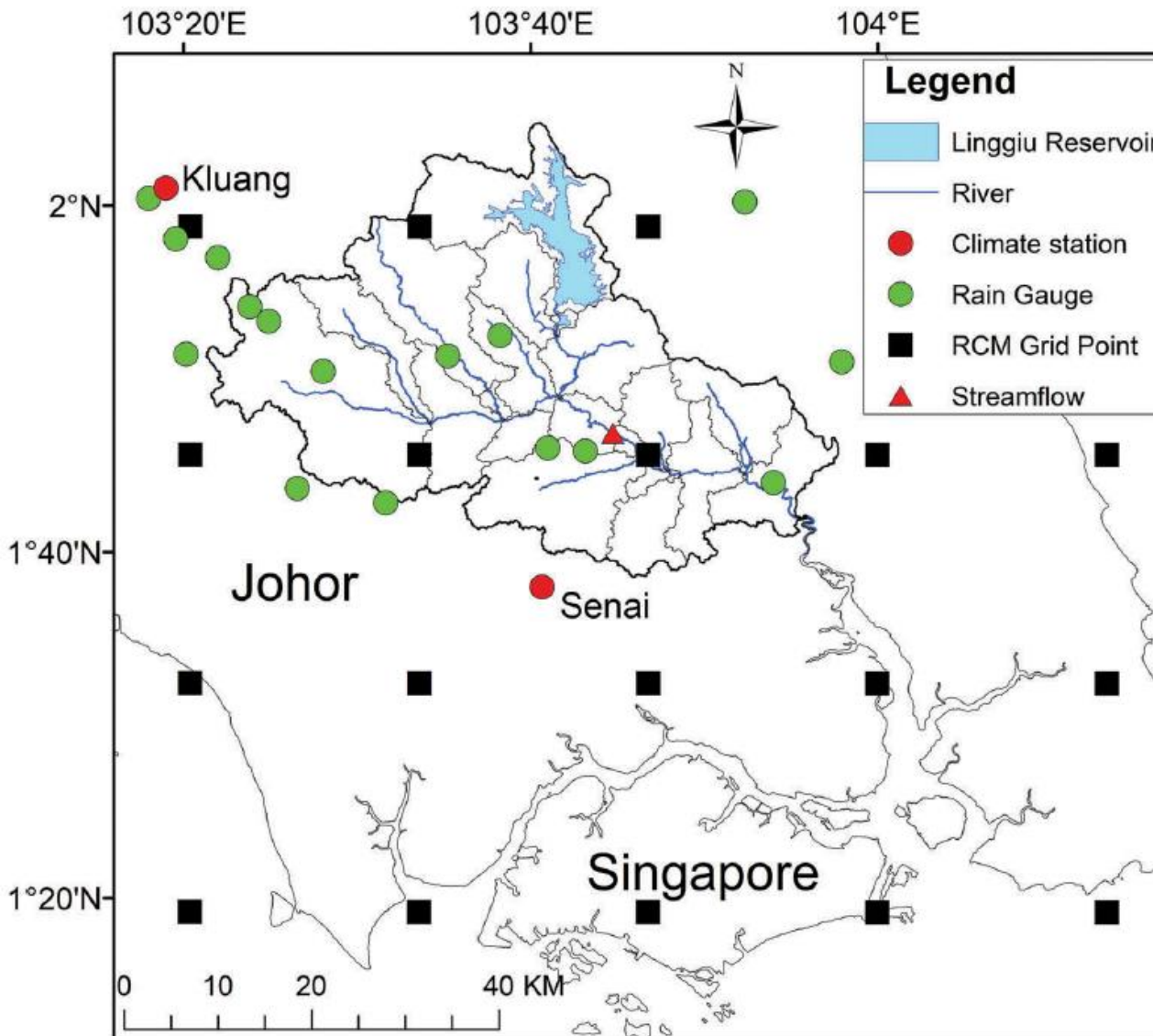
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ASSOCIATE EDITOR

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KEYWORDS

drought; water; climate change; CORDEX; SWAT; SPI; SSI; Malaysia; Singapore; Johor

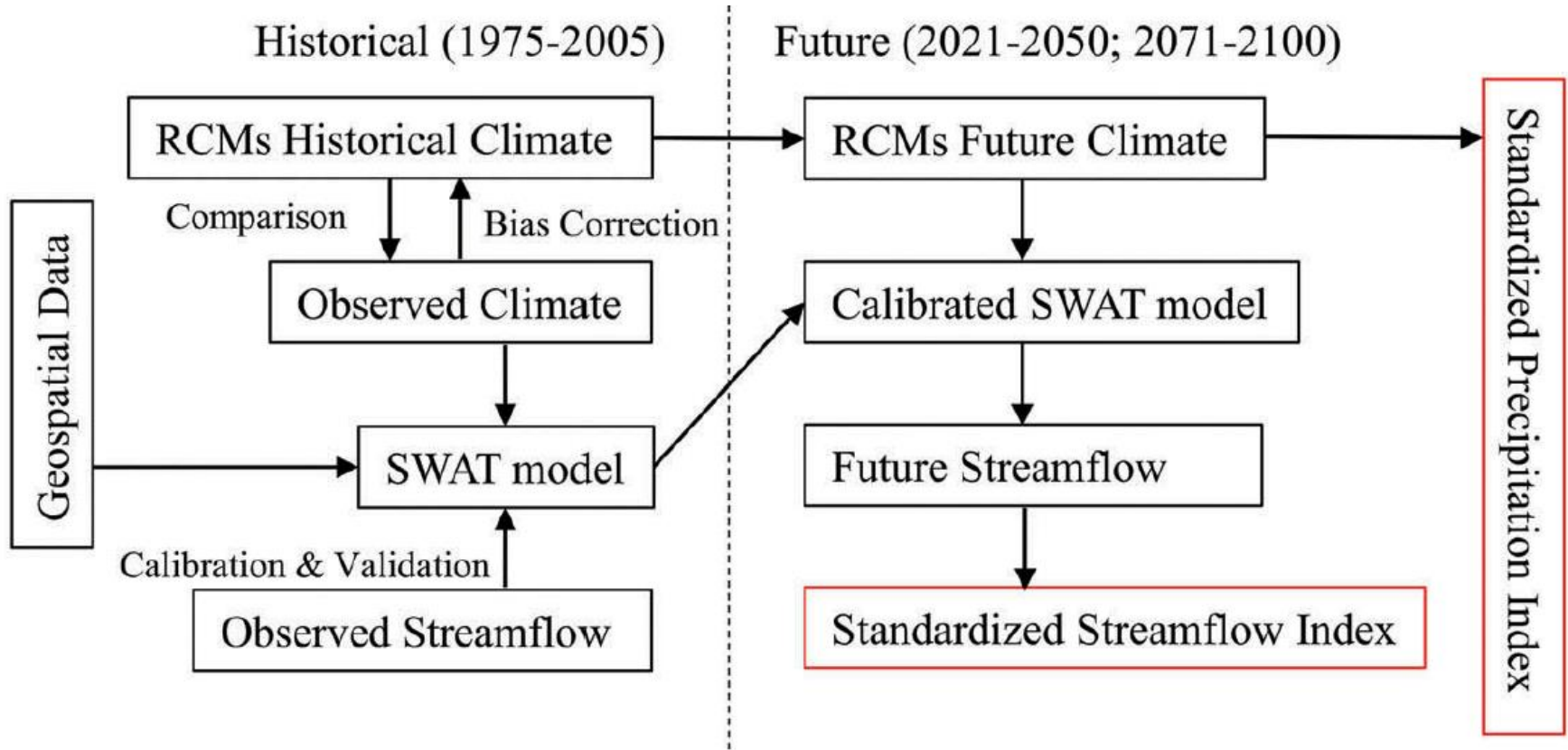


Area: 1652 km²

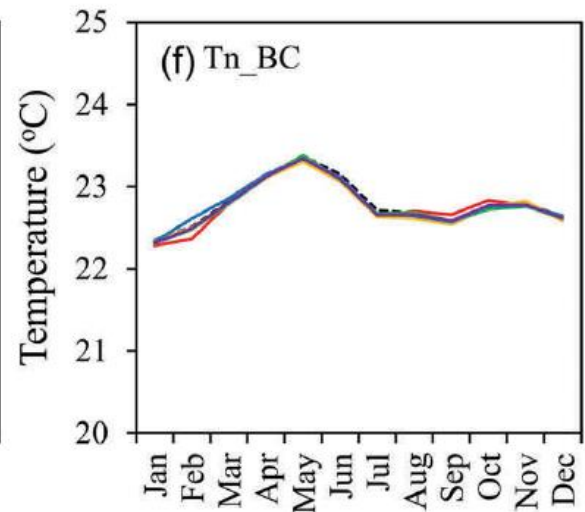
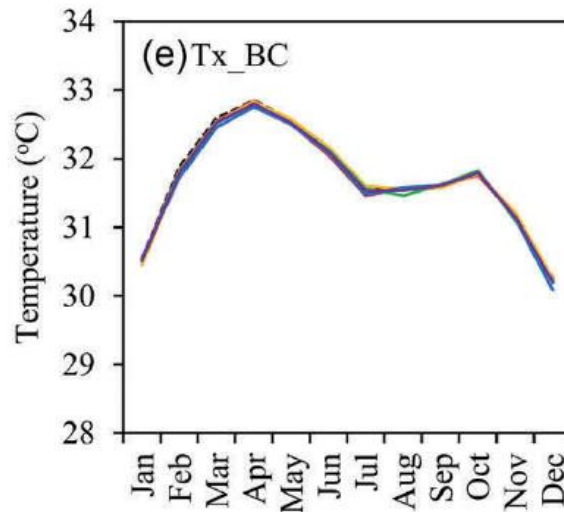
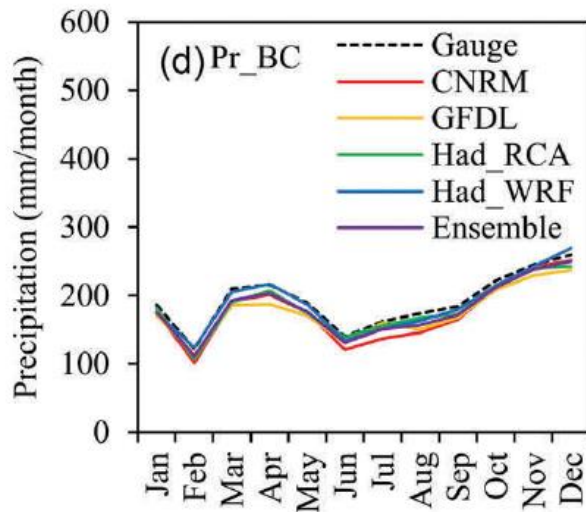
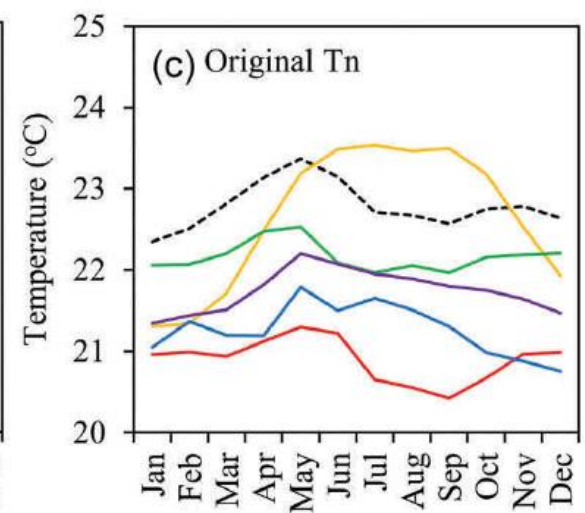
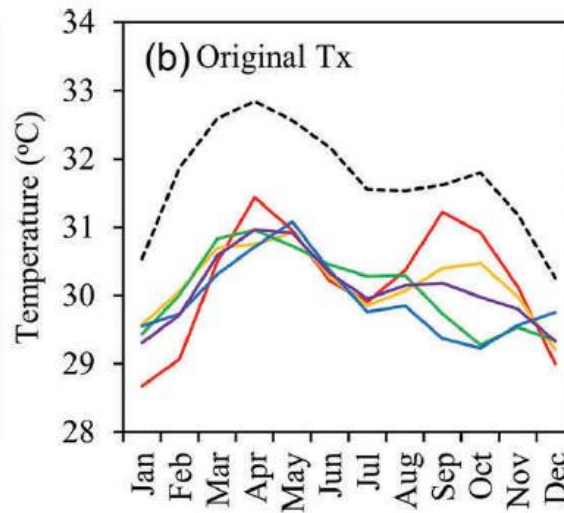
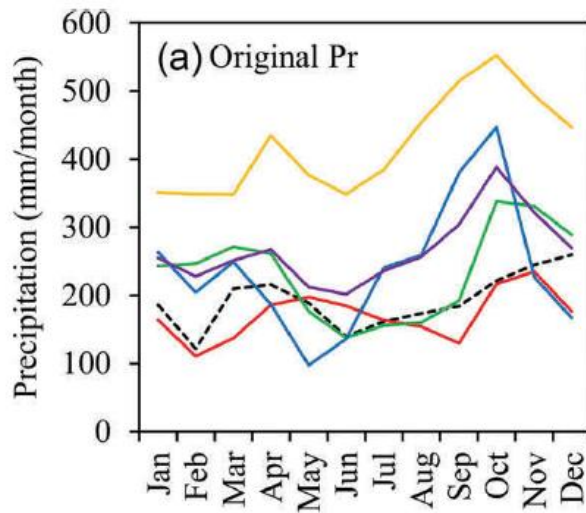
Precipitation :
~2500 mm/year

Temperature:
~26°C

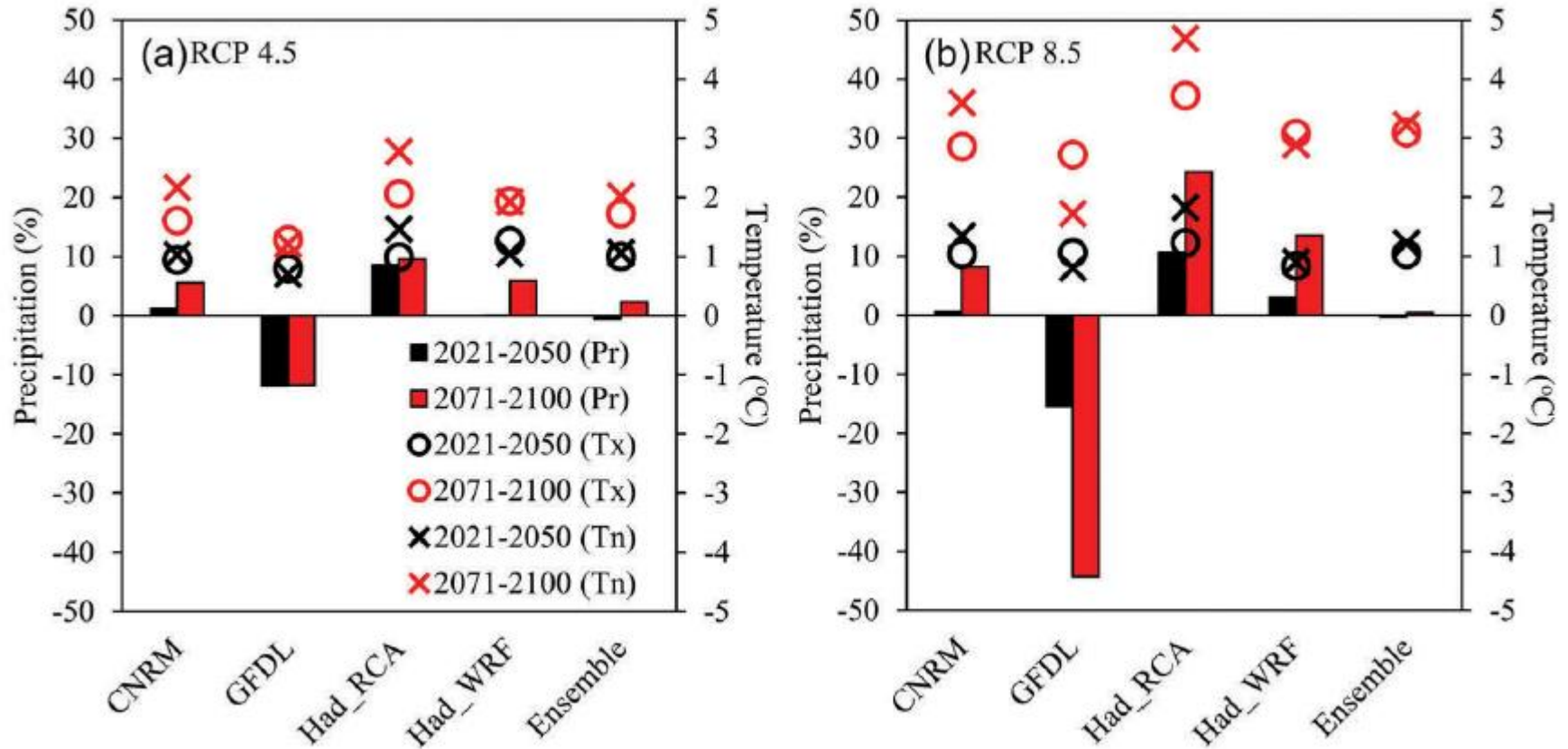
Freshwater for
~7 million people



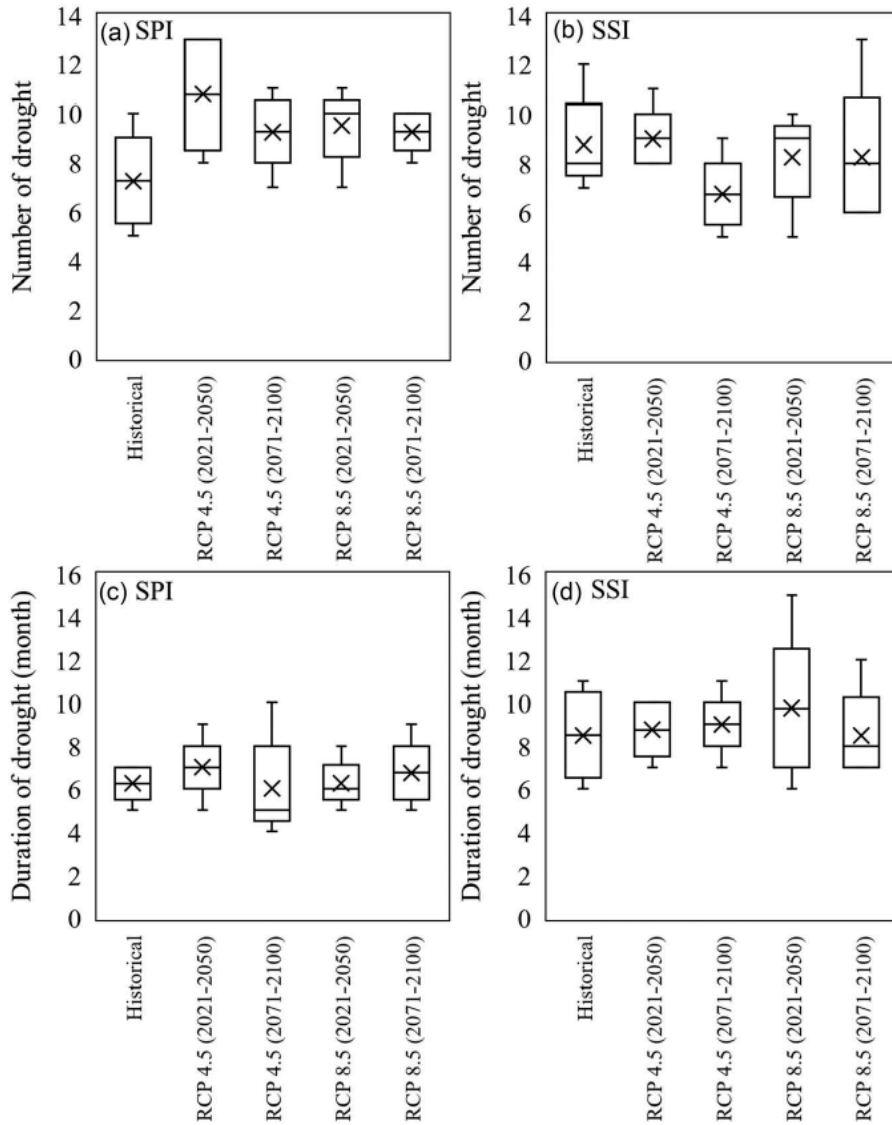
Framework of the study



Bias Correction of RCMs before incorporating into SWAT



Changes in annual precipitation, and maximum and minimum temperatures under (a) RCP4.5 and (b) RCP8.5 scenarios against the historical mean (1976–2005).



Comparison of the number and duration of the historical and future (a, c) meteorological and (b,d) hydrological droughts of the JRB under the RCP4.5 and RCP8.5 scenarios.

Some Useful Tools

- Water Engineering Time Series PROcessing tool (WETSPRO) & Indicators of Hydrologic Alteration (IHA) tool.
- Hydrologic Engineering Center's River Analysis System (HEC-RAS), MIKE FLOOD and SOBEK are some of the most widely used flood models to study potential future flood patterns via couplings with SWAT .

- SWAT low and high flows assessment framework.
- Improvement of simulated low and high flows in SWAT
- SWAT with other input data.
- Basin-based climate projections.

Conclusions

- Application of SWAT in hydro-climatic extreme studies has increased rapidly in the past few years, particularly since 2017.
- . A new unified SWAT-based extreme assessment framework that combines both the “traditional” and extreme flows or indices calculation should be developed for more reliable analysis and comparison.
- Application of CMIP6 GCMs in future SWAT hydro-climatic extreme studies.

