Are global models skilful in forecasting floods, and their impacts in data scarce areas?

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Motivation

COPERNICUS
Emergency Management Service
European Commission
opernicus
Europe's eyes on Earth
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GLOFAS
Forecast Viewer
User Information
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ARGENTINA
Flood early detection up to 30 days in advance
(depending on the river basin size)
Visualisation of hydrographs at specific locations
Comparison with flood return periods derived from the climatology
Find out more
It couples state-of-the art weather fore
Global Flood Forecast
Deltares
INFO
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INTRODUCTION
CONDITIONS OF USE
Global Flood Forecast by Deltares
Floods are one of the main risks for coastal cities worldwide. To assist worldwide early warning for flood risk assessments and analyses Deltares presents this data viewer. This viewer presents the results of the GLObal Flood Forecasting Information System (GLOFFIS) and the GLObal Storm Surge Information System (GLOSSIS) of Deltares. These forecasts can be used for early warning in those areas currently lacking any forecasting capability, or can provide boundary conditions for more refined local models.
Frequency and lead time of forecasts
The models run operationally 2-4 times a day and provide forecasts for the upcoming 7-10 days on soil
eartH2Observe
Introduction
How to Use
Development
Data Services
About
Main eartH2Observe website »

Motivation

- Global models have potential for assessment and prediction of flood hazard in areas with insufficient data
  - Asymmetric availability of data (transboundary basins)
  - Period of record of consistent hydrological data short
- But…
  - How good are these models in predicting floods and their impacts?
  - What about scale (basin scale, resolution of hydrological model)?

Limpopo River at Xai Xai, Mozambique. Photo: Karel Prinsloo

Storm over Johannesburg. Photo: Dlala Nje

Approach

- Case Study: Limpopo Basin in Southern Africa
  - South Africa; Botswana; Zimbabwe; Mozambique

- Selection of global models from EartH2Observe Water Resources Reanalysis (WRR) that include simulated discharge
  - WRR1: Resolution 0.5 degrees; Daily; Forced by WFDEI Dataset; 1979-2012
  - WRR2: Resolution 0.25 degrees; Daily; Forced by MSWEP Dataset; 1980-2014

- Comparison against 2 Benchmarks

  A: Observed discharges at (reliable) discharge stations across basin

  B: Chronology of impacting flood events from disaster databases

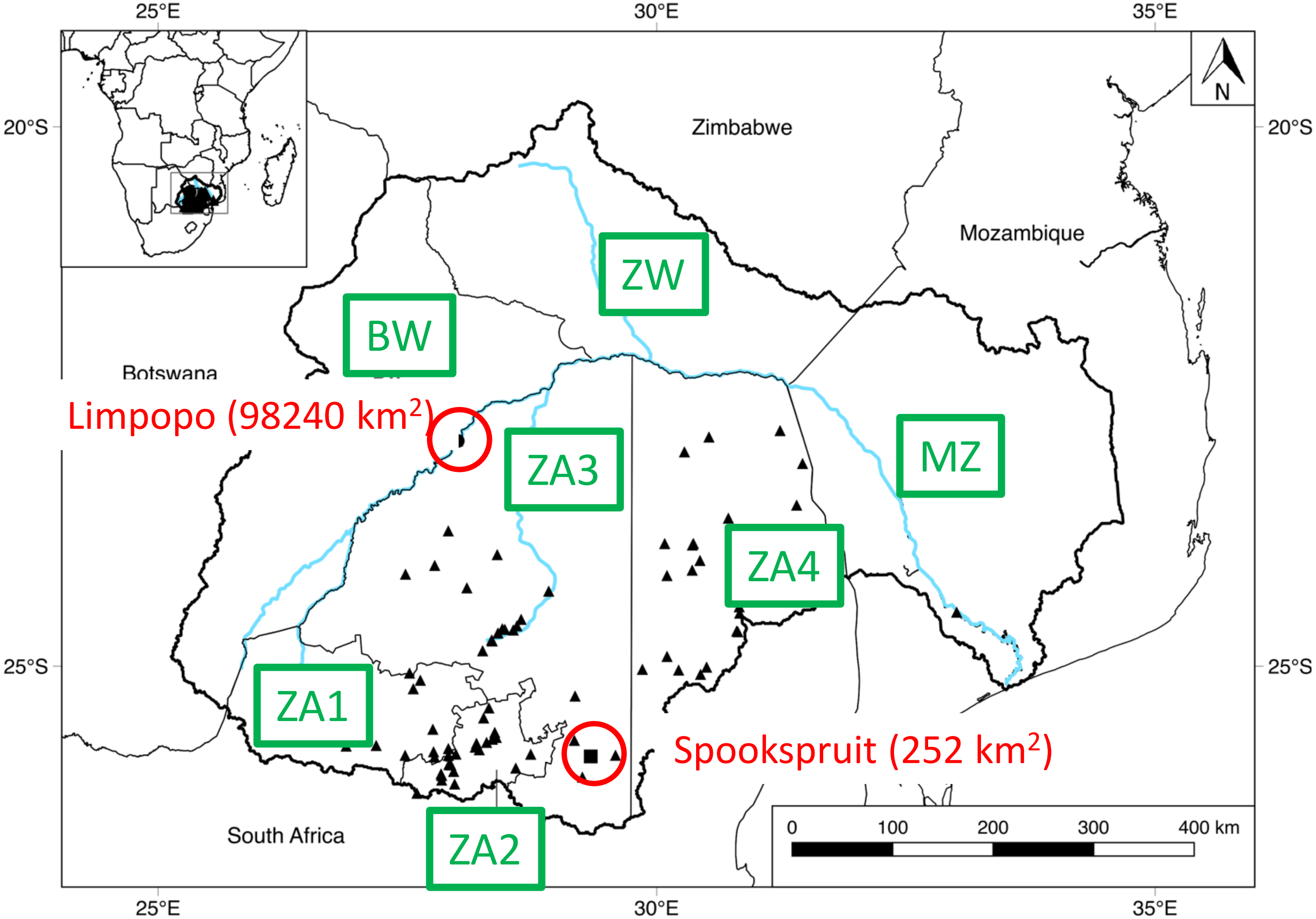
Approach

Table 1: Overview of the seven global models in the Water Resources Re-analysis dataset that include simulated discharge in rivers

Model	Model Type	Resolution (degrees)	Lakes-Reservoirs	Water use	Routing	Reference
HTESSEL-CaMa	LSM	0.5 & 0.25	No	No	CaMa-Flood	(Balsamo et al., 2009)
LISFLOOD	GHM	0.5 & 0.25	Yes	Yes	Double kinematic wave	(van der Knijff et al., 2008)
ORCHIDEE	LSM	0.5	No	No	Linear cascade of reservoirs	(Krinner et al., 2005)
PCR-GLOBWB	GHM	0.5	WRR1 only lakes	Not in WRR1	Travel time	(van Beek and Bierkens, 2009)
SURFEX-TRIP	LSM	0.5	No	No	TRIP with stream	(Decharme et al., 2010)
WaterGAP3	GHM	0.5 & 0.25	Yes	Yes	Manning-Strickler	(Flörke et al., 2013)
W3RA	GHM	0.5	No	No	Cascading linear reservoirs	(van Dijk et al., 2014)
Ensemble 7 models	GHM & LSM	0.5	Various	Various	Various	N/A

[*Source*: Schellekens et al. 2017; Dutra et al. 2015]

Benchmark A. Observed discharges



72 Stations

Performance of simulated discharge

Flood Severity Level

Flood Severity Level	Annual Exceedance Probability	Return Period [years]
0	≤ 0.303	≥ 2
1	≤ 0.164	≥ 5
2	≤ 0.090	≥ 10
3	≤ 0.038	≥ 25
4	≤ 0.010	≥ 100
5	≤ 0.005	≥ 200

Benchmark B. Reported impacting flood events

- EM-DAT – (CRED & Guha-Sapir, 2017)
- GAALFE – Dartmouth Flood Observatory (Brakenridge, 2017)
- NatCatSERVICE –Munich Re (Kron et al., 2012)
- Severity Level 0-5 based on NatCatSERVICE amended for no. of casualties / Basin Level

Database	Country or region	Start	Duration [days]	Fatalities	People displaced	People affected	Overall damages [million USD]	Severity level	Magnitude	Affected area [km2]	Lat	Lon
EM-DAT	BW	01/02/2000	29	3	-	138,776	5	-	-	-	-	-
EM-DAT	MZ	26/01/2000	62	800	-	4,500,000	419	-	-	-	-	-
EM-DAT	ZA	26/01/2000	62	83	-	200	160	-	-	-	-	-
EM-DAT	ZW	26/01/2000	62	70	-	266,000	73	-	-	-	-	-
GAALFE	MZ, ZA, BW, ZW, MW	26/01/2000	62	929	733,000	-	1,000	2	7.7	439,043	31.71	-27.82
NatCatSERVICE	BW	05/02/2000	5	8	10,000	-	-	2	-	-	-21.18	27.53
NatCatSERVICE	MZ	05/02/2000	45	700	544,000	-	300	4	-	-	-25.97	32.57
NatCatSERVICE	ZA	05/02/2000	25	83	200,000	-	160	3	-	-	-26	30
NatCatSERVICE	ZW	05/02/2000	49	100		-	55	4	-	-	-19	29
Other sources	Whole basin			700		2,000,000						
Thesis	Whole basin	05/02/2000	45	700	754,000	2,000,000	515	5				

Benchmark B. Reported impacting flood events

- EM-DAT – (CRED & Guha-Sapir, 2017)
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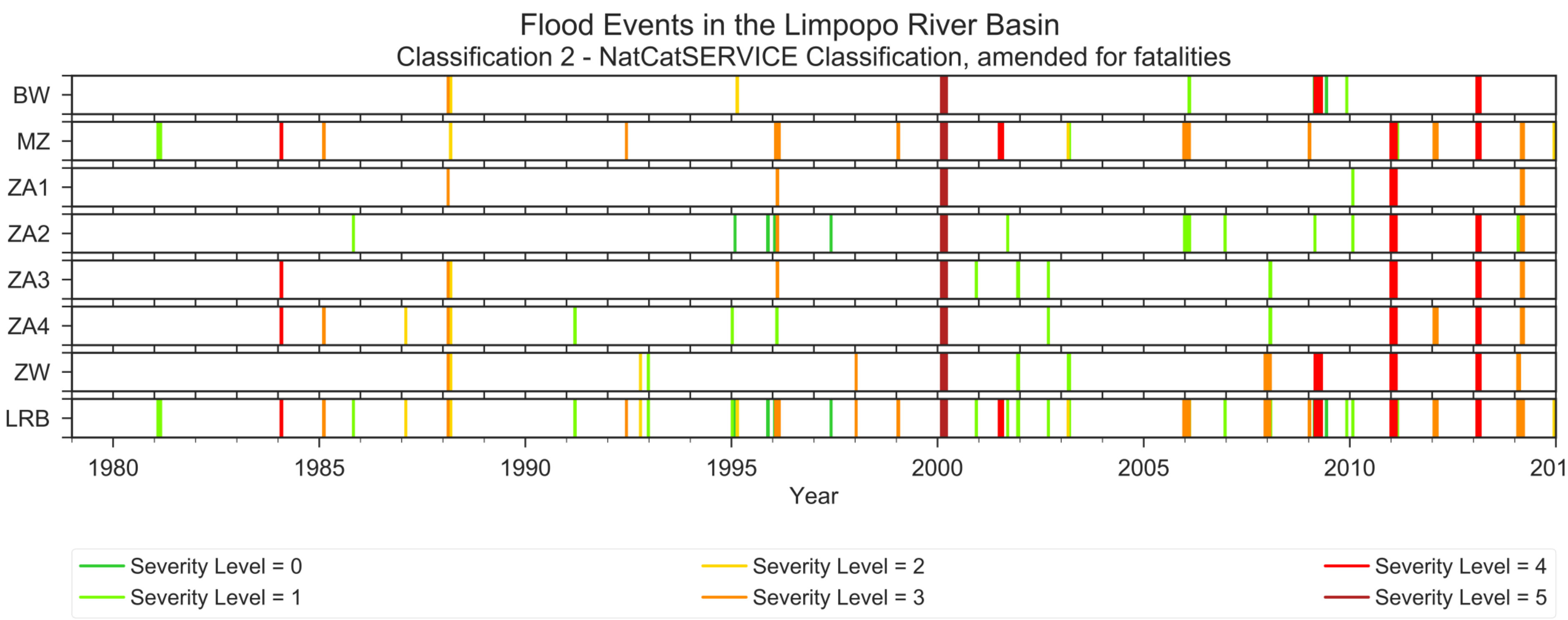
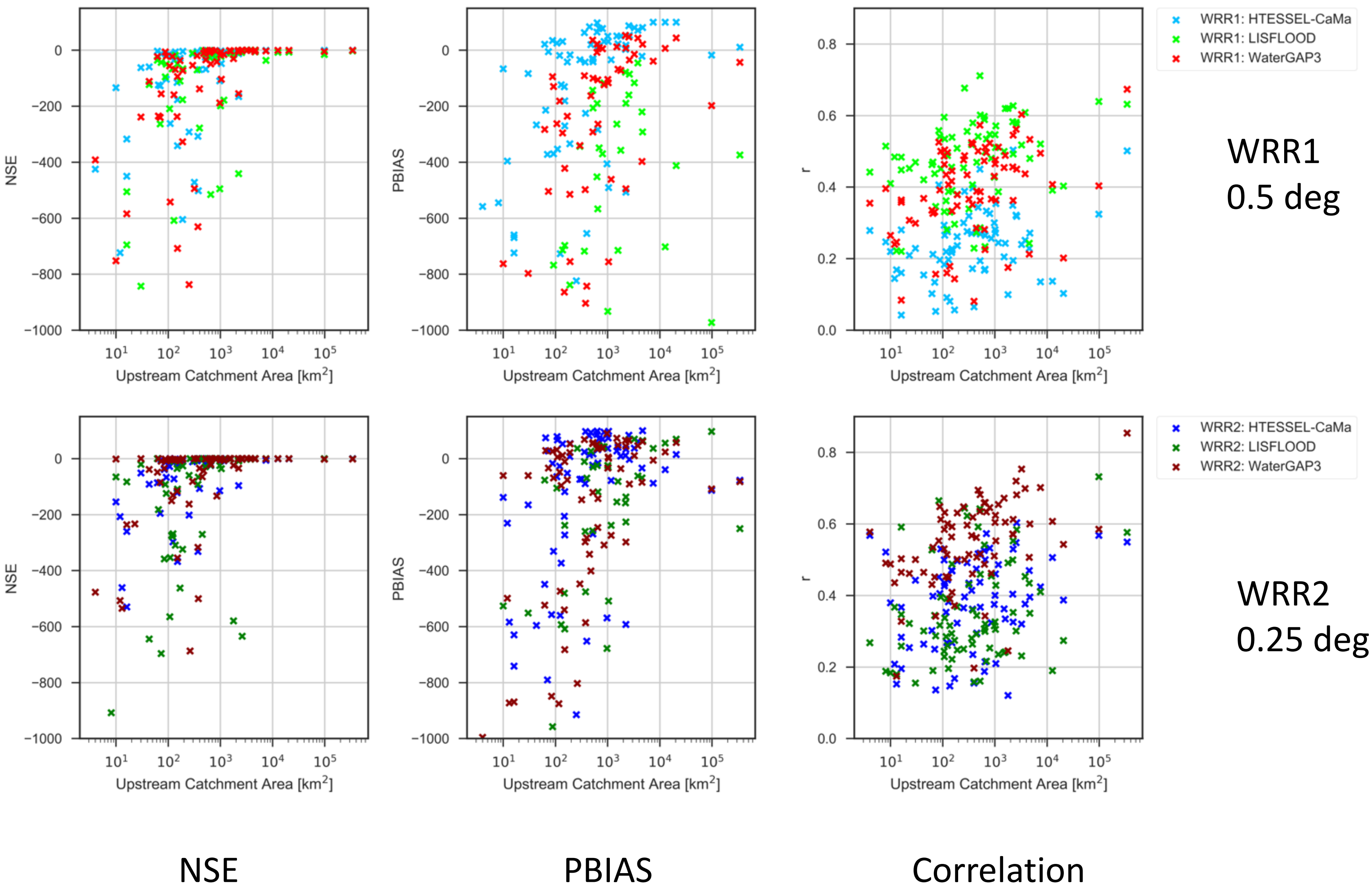
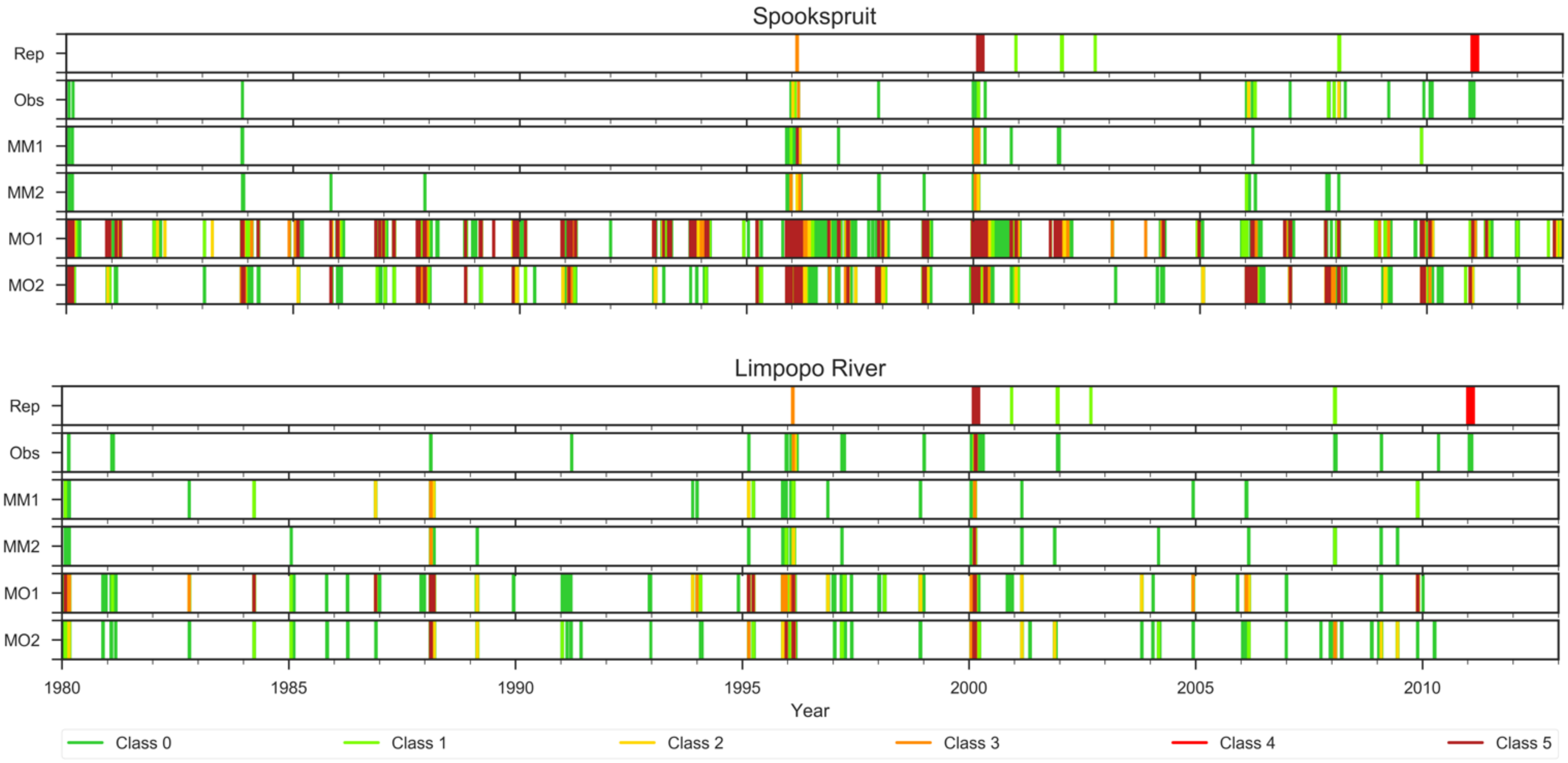
- NatCatSERVICE –Munich Re (Kron et al., 2012)
- Severity Level 0-5 based on NatCatSERVICE amended for no. of casualties
- Sub Basin/Country Level



Model performance



Occurrence of Flood Events



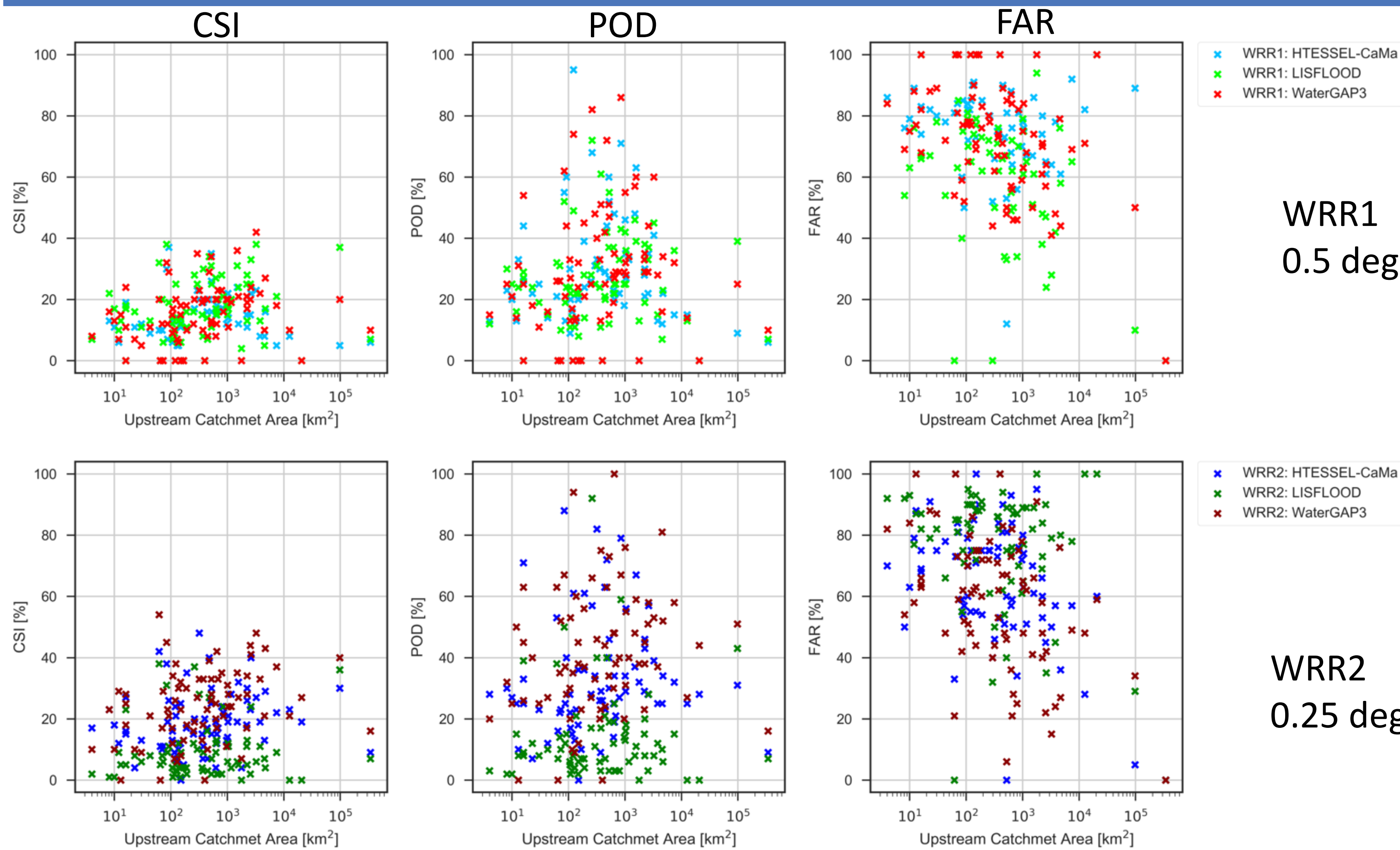
Example for WaterGAP model at Spookspruit & Limpopo gauges

Flood events identified using model climatology (MM1 & MM2)

Flood events identified using observed climatology (MO1 & MO2)

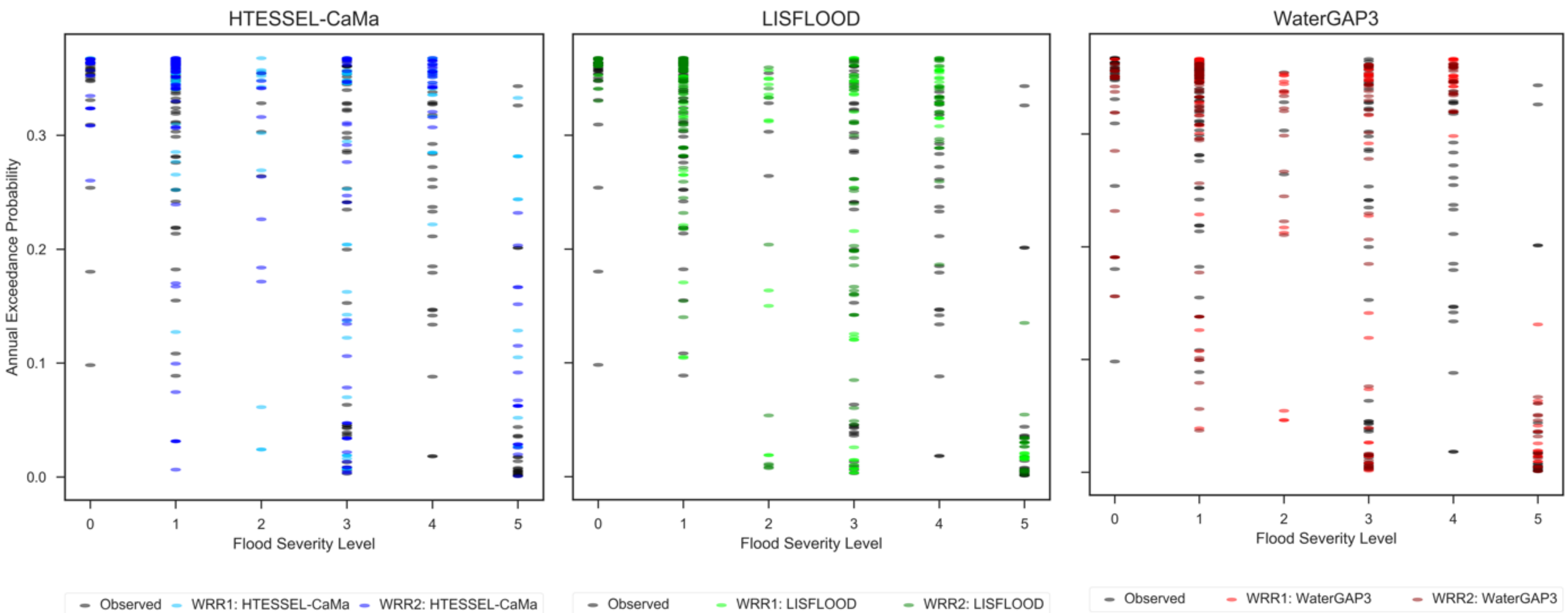
Digit indicates model resolution; 1 - WRR1 (0.5 degrees); 2 – WRR2 (0.25 degrees)

Occurrence of Flood Events (against observed)



CSI; POD & FAR using Annual exceedance probability threshold of 0.164 (5 years return period) for all gauging stations. WRR1 (upper panel) & WRR2 (lower panel).

Simulated return periods of reported flood events



The relationship of the flood event severity for the reported flood events, and the corresponding annual exceedance probabilities that were observed and modelled for (a) HTESSEL-CaMa, (b) LISFLOOD, and (c) WaterGAP3.

Discussion & Conclusions

- Overall performance of global models in simulating hydrological behaviour rather poor for smaller catchments
  - WRR1 basic representation of hydrological behaviour > ~2500 km2
  - WRR2 basic representation of hydrological behaviour > ~520 km2
- Skill of identifying observed flood events reasonable – but only when using model climatology.
- Models also show some skill in identifying flood events that cause impacts
  - important for their use in e.g. global forecasting systems
  - Improves for improved resolution WRR2 models (with exceptions)

- Global models provide information consistently – also for transboundary basins with asymmetric data availability
- Caveats: Inclusion of human influences in models and data; reliability of gauged discharges, particularly at peaks