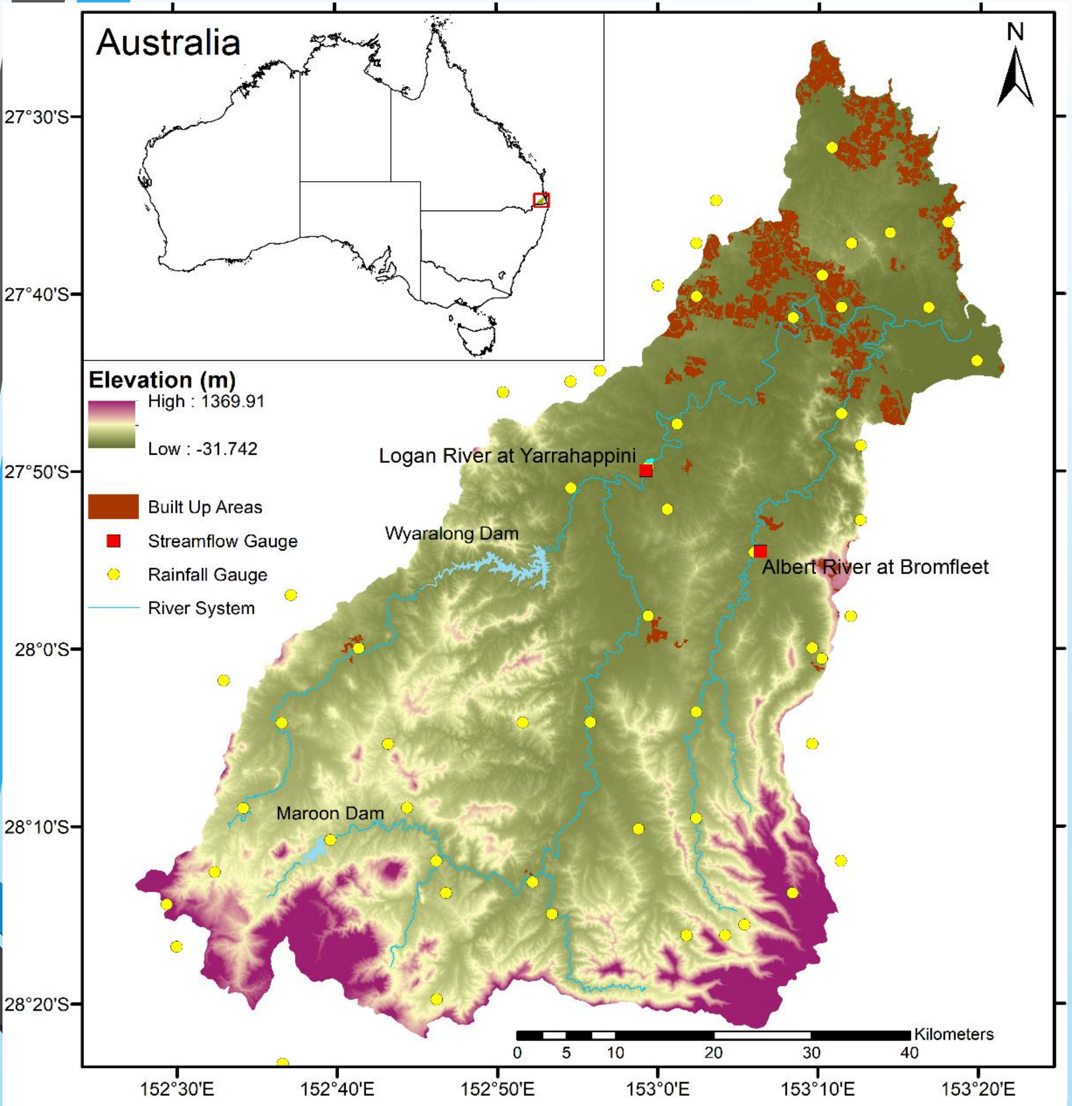
Impacts of climate change on river flooding in a subtropical Australian catchment

Rohan Eccles, Griffith School of Engineering and Built Environment
Prof Hong Zhang, Griffith School of Engineering and Built Environment
Prof David Hamilton, Australian Rivers Institute

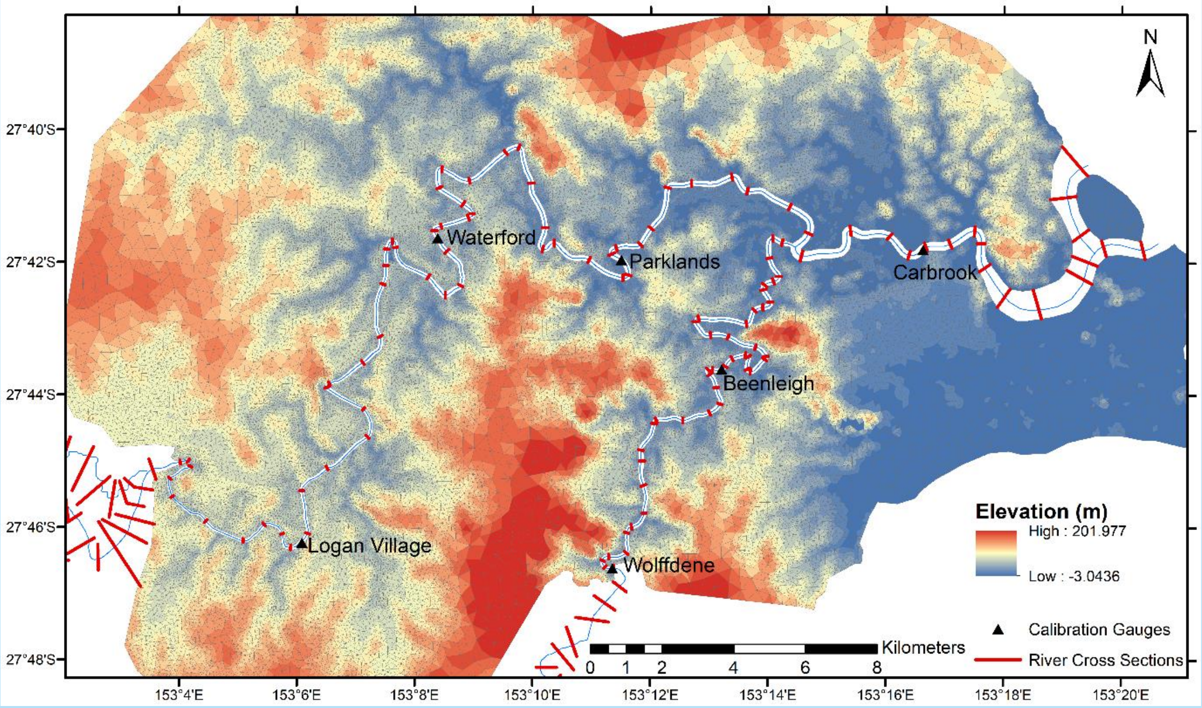
Griffith UNIVERSITY

Study area



Logan-Albert catchment, showing major dams, built up areas, major channels, rainfall and streamflow gauges used to calibrate the hydrological model.

- Second largest catchment to discharge into Moreton Bay
- Has experienced several large flooding events (e.g. 2013, 2017)
- Expected to undergo significant urbanisation in the coming decades



Coupled 1-D river and 2-D overland model for the lower Logan-Albert catchment showing cross-section locations, overland mesh size, topography, and the location of water level gauges used for calibration.

Climate data

Details of the 11 CMIP5 GCMs used in this study.

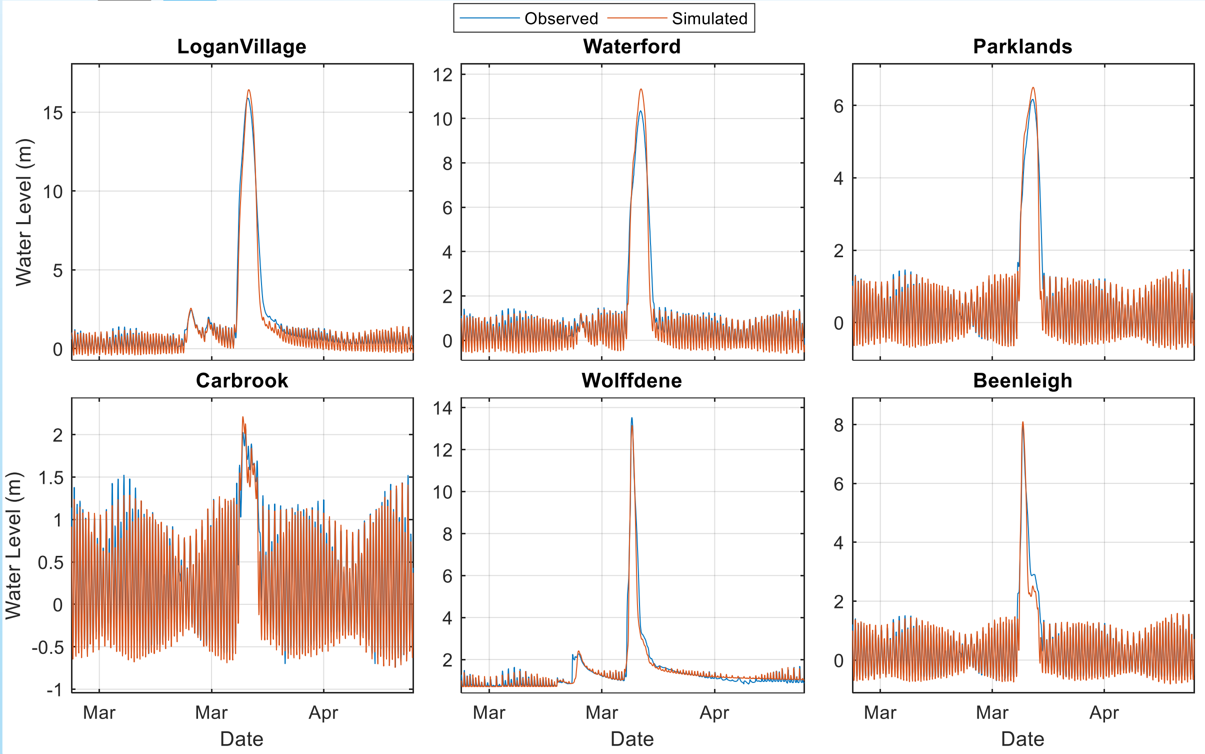
GCM	Model Name	Institution Name	Country
ACCESS1.0	Australian Community Climate and Earth-System Simulator, version 1.0	CSIRO & BOM	Australia
ACCESS1.3	Australian Community Climate and Earth-System Simulator, version 1.3	CSIRO & BOM	Australia
CCSM4	Community Climate System Model, version 4	NCAR	USA
CNRM-CM5	Centre National de Recherches Météorologiques Coupled Global Climate Model, version 5	CNRM-CERFACS	France
CSIRO-MK3.6	Commonwealth Scientific and Industrial Research Organisation Mark 3.6.0	CSIRO	Australia
GFDL-CM3	Geophysical Fluid Dynamics Laboratory Climate Model, version 3	GFDL NOAA	USA
GFDL-ESM-2M	Geophysical Fluid Dynamics Laboratory Earth System Model with Modular Ocean Model, version 4 component	GFDL NOAA	USA
HadGEM2	Hadley Centre Global Environmental Model, version 2	Met Office Hadley Centre	UK
MIROC5	Model for Interdisciplinary Research on Climate, version 5	AORI Japan	Japan
MPI-ESM-LR	Max Planck Institute Earth System Model, low resolution	Max Planck Institute	Germany
NorESM1-M	Norwegian Earth System Model, version 1 (intermediate resolution)	Norwegian Climate Centre	Norway

- Obtained high-resolution (10 km) daily climate data (1980-2099) from DES
- Run under the RCP8.5 emissions scenario (high emissions pathway)
- Sea level rise under the RCP8.5 scenario was also considered

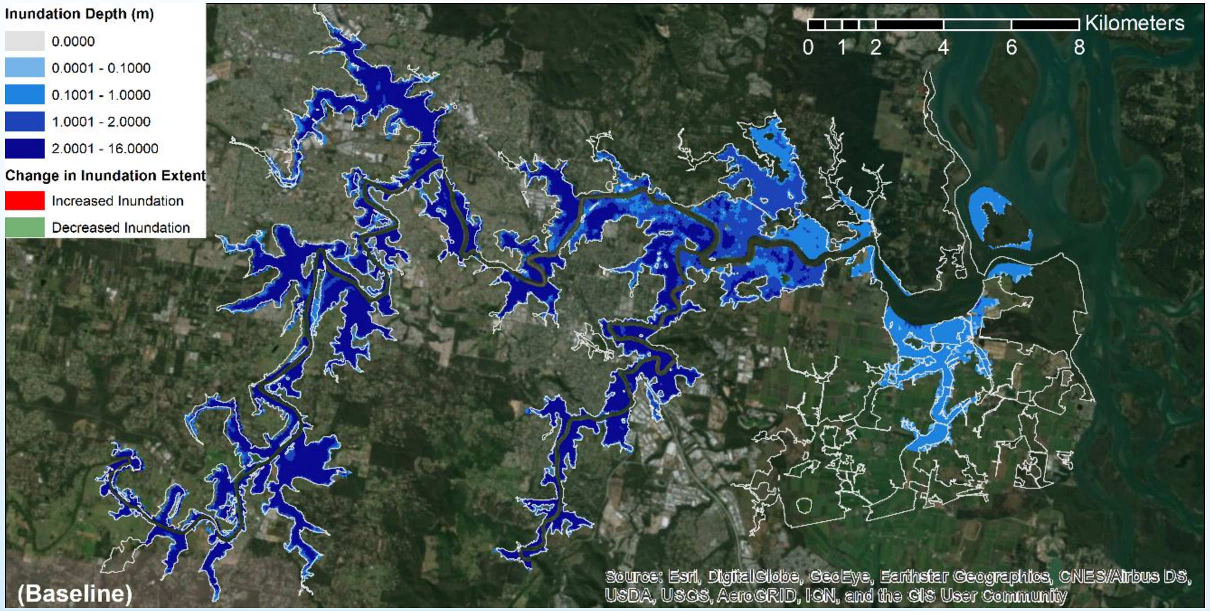
Calibration

Performance of NAM hydrological model during calibration and validation periods at downstream monitoring gauges along the Logan and Albert rivers.

Site		Calibration (2004-2014)			Validation (2015-2017)		
		NSE	RSR	PBIAS (%)	NSE	RSR	PBIAS (%)
Bromfleet	Overall	0.872	0.357	1.12	0.944	0.237	5.56
(Albert River)	High flows (1%)	0.823	0.417	-13.09	0.936	0.247	-6.67
Yarrahappini	Overall	0.860	0.375	5.95	0.916	0.290	2.53
(Logan River)	High flows (1%)	0.812	0.430	-4.18	0.897	0.313	2.55



Comparison between simulated and observed water level at the downstream gauges during the calibration period (2017).

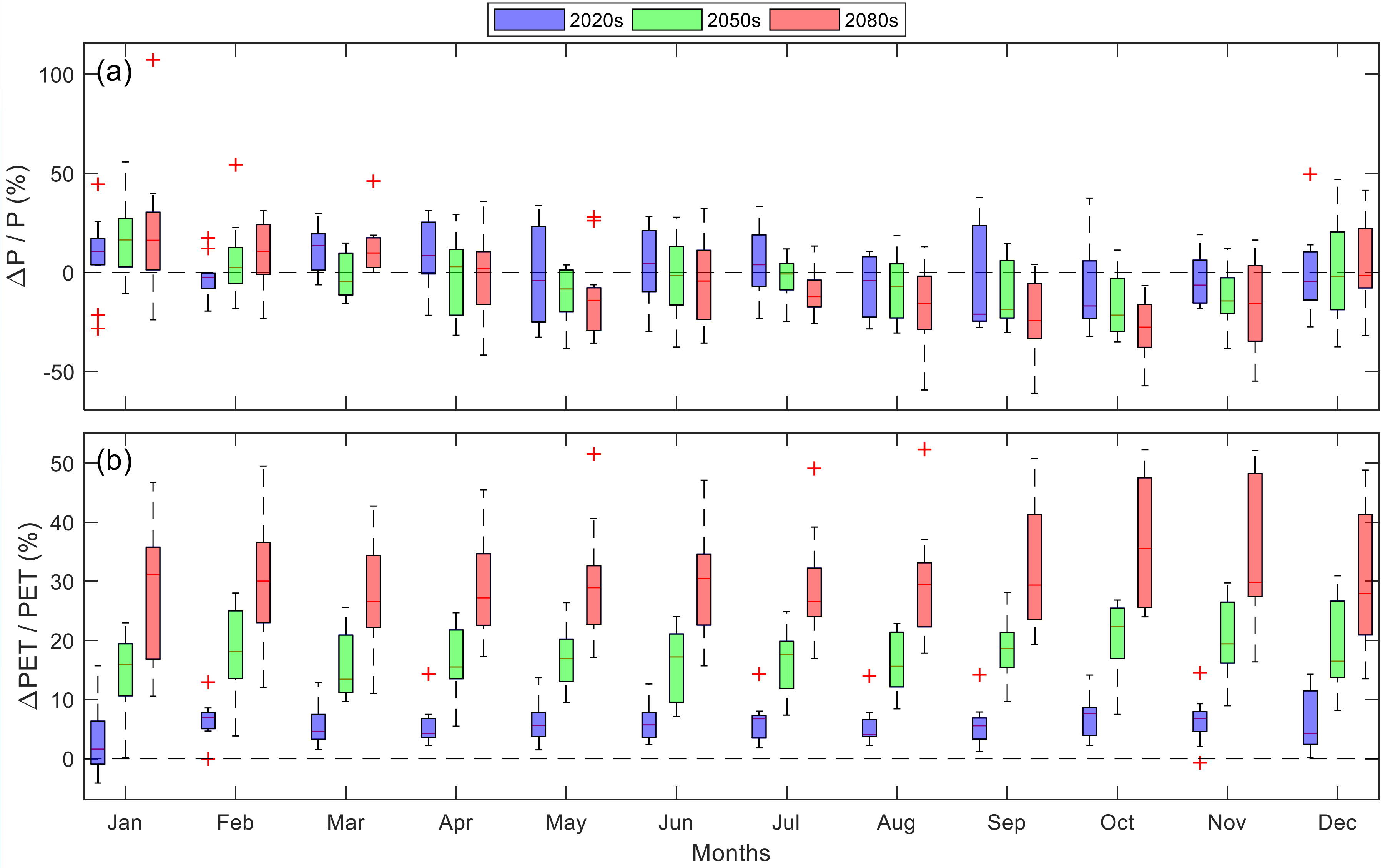


Maximum inundation maps from the coupled 1D-2D hydrodynamic model for the baseline period using an approximate 100-year flood event (white lines show actual measured flood extent).

- Calibrated NAM to daily streamflow values
- Coupled 1-D river model (MIKE Hydro) with a 2-D overland model (MIKE 21)
- Calibrated and validated model against flood events in 2017 and 2013
- Used the 2017 flood event as a baseline to compare with climate change scenarios

Changes to precipitation and PET

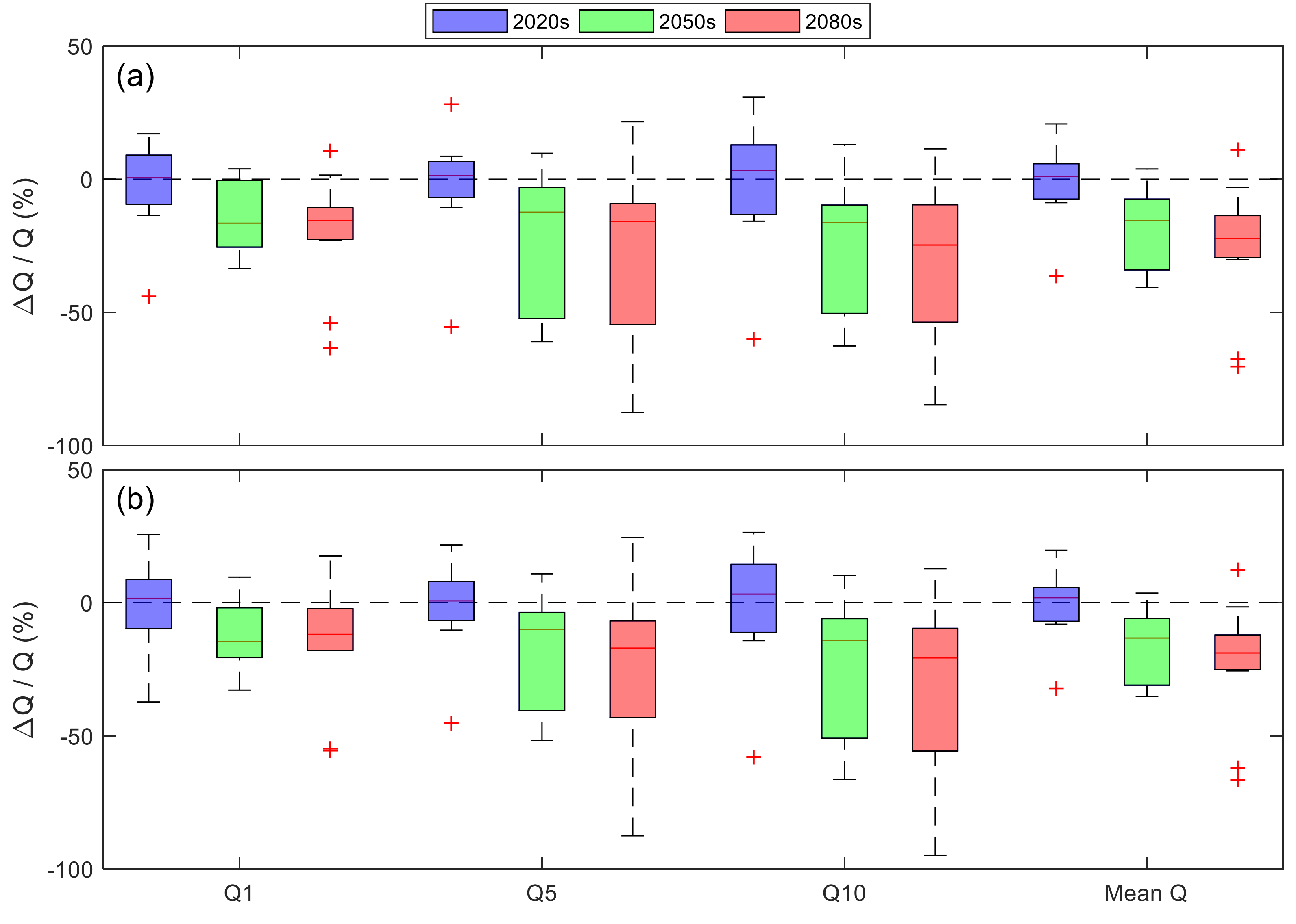
- Increased seasonality in precipitation
- Precipitation decreases in winter/spring and increases in summer
- PET increases at similar rates across all months
- Increases to PET by the late-century are the largest



Projected changes to monthly mean catchment averaged (a) precipitation and (b) PET for the 2020s, 2050s, and 2080s with respect to the baseline (1980-2010).

Changes to high and mean flows

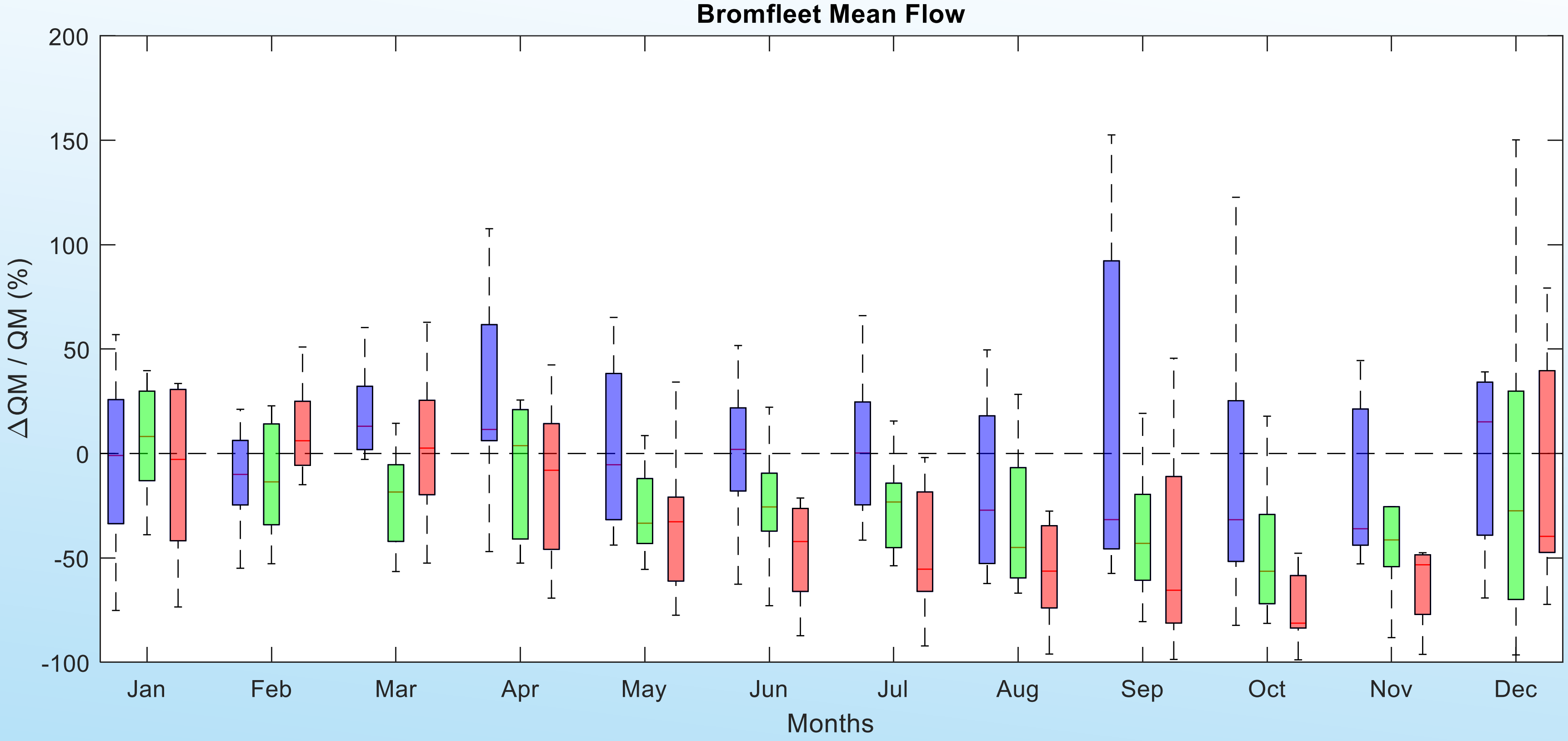
- Majority of climate models predict a decrease to high/mean flows by the 2050s and 2080s
- Flows decrease more as the models diverge further from the baseline



Projected changes to mean and high flows representing the top 10, 5, and 1% of flows relative to the baseline period at the (a) Albert River at Bromfleet and (b) Logan River at Yarrahappini gauge.

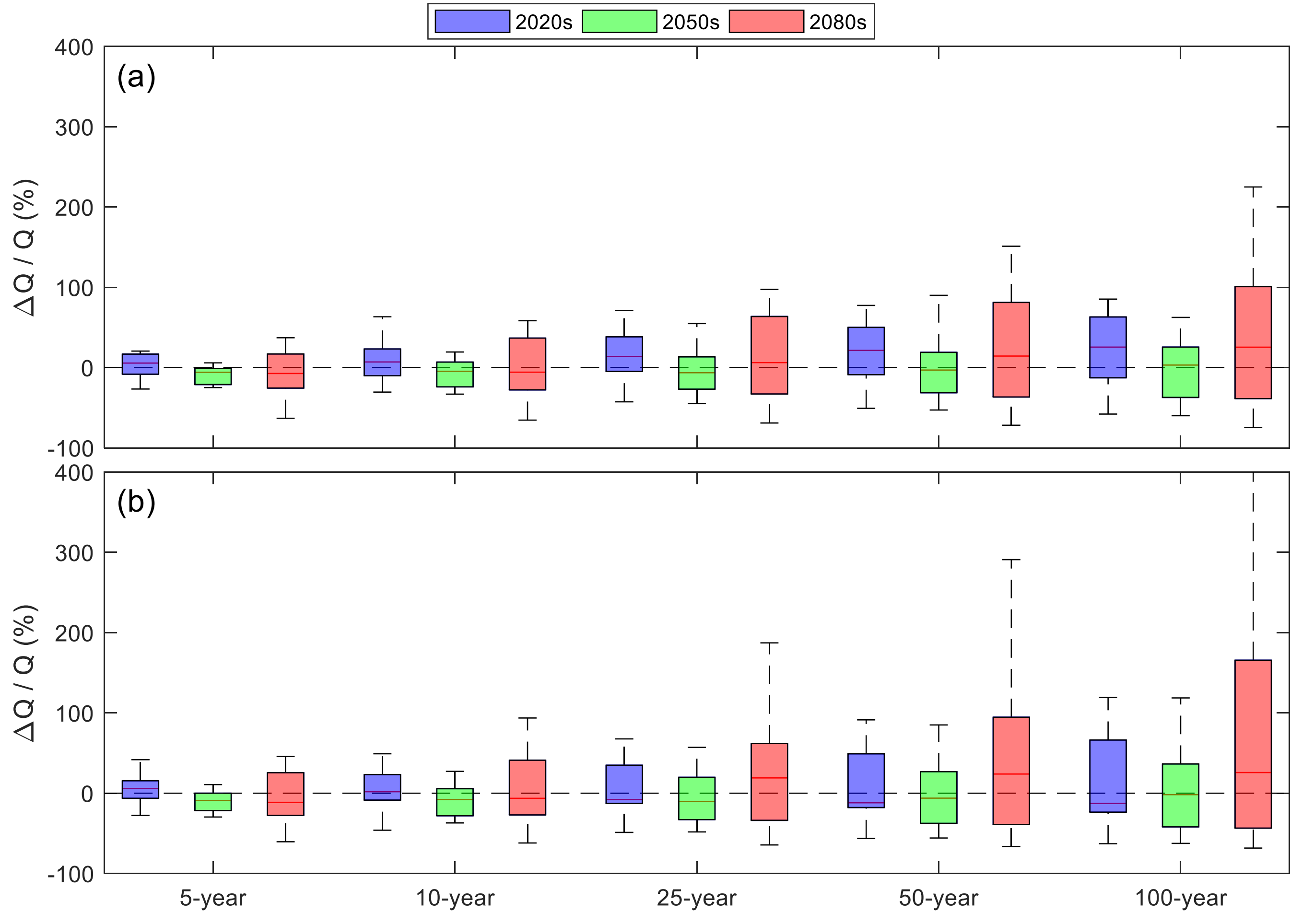
Seasonal changes

- Increased seasonality (reflects changes to precipitation)
- Increased PET diminishes the effects of increased precipitation in summer and amplifies the effects of reduced precipitation in winter/spring



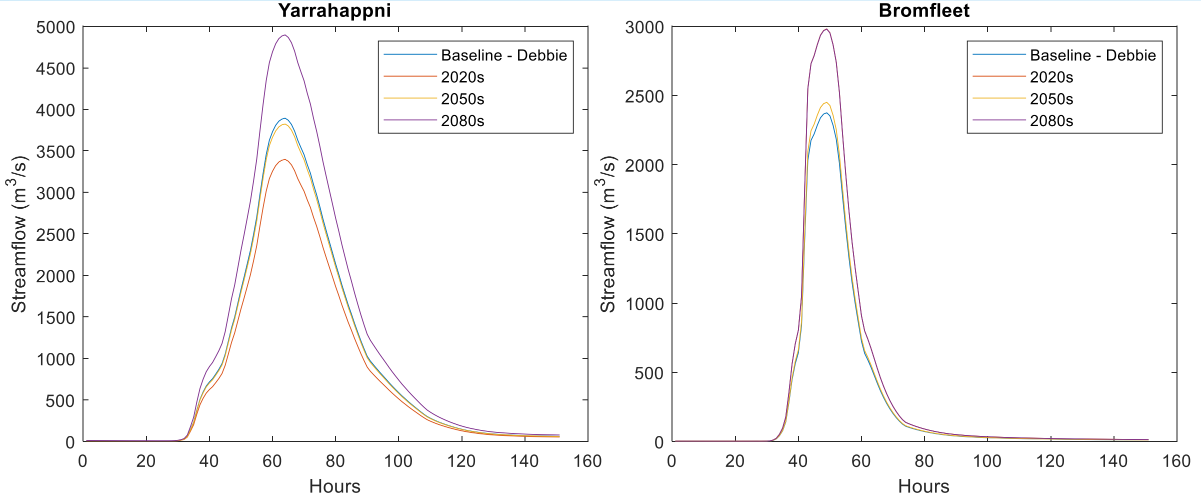
Multi-model ensemble changes to monthly mean flows (outliers removed) at the Albert River at Bromfleet gauge.

Changes to flood events



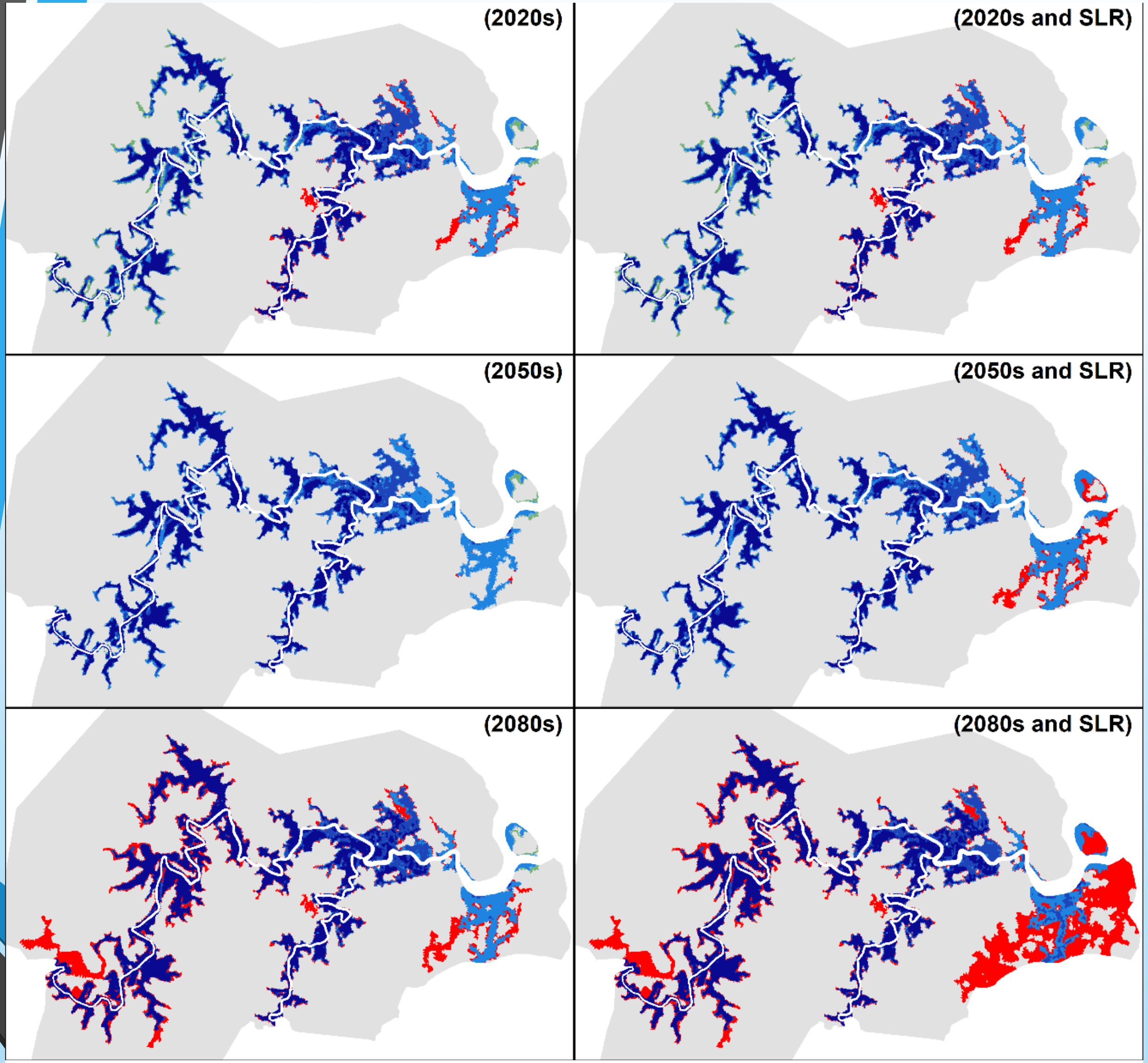
Multi-model ensemble changes to 5, 10, 25, 50, and 100-year flood events relative to the baseline period (outliers removed) at the (a) Albert River at Bromfleet and (b) Logan River at Yarrahappini gauges.

- Changes to floods are uncertain for all future periods
- Uncertainty is larger as the models diverge further from the baseline and for larger flood events
- Larger flood events appear to increase more than smaller flood events



Changes to the hydrograph of an approximate 100-year flood using the multi-model median change of a 100-year flood event for each future period and the 2017 flood event as a baseline.

Changes to inundation



Changes to maximum flood extent under climate change for three future time slices with and without sea level rise.

Future climate change scenarios considered for inundation modelling using the ex-tropical cyclone Debbie event of 2017 as a baseline.

Scenario	Time slice considered	Sea Level Rise year (rise compared to 2017)
1	2010-2039	-
2	2010-2039	(0.033 m)
3	2040-2069	-
4	2040-2069	(0.237 m)
5	2070-2099	-
6	2070-2099	(0.532 m)

Comparison of changes to inundation area for various depths and the relative total change to inundation relative to the baseline scenario.

Scenario	Area (km^2) of flood extent at various depth intervals (m)				Total Inundation (km^2)	Relative change to total inundation (%)
	< 0.1	0.1 - 1	1 - 2	> 2		
Baseline	1.934	19.231	15.486	29.147	65.798	-
2020s no SLR	2.035	19.713	15.834	27.297	64.879	**-0.87**
2020s SLR	2.082	20.180	15.829	27.358	65.449	**0.00**
2050s no SLR	1.821	18.842	15.522	28.697	64.882	**-0.87**
2050s SLR	2.246	23.583	15.886	28.853	70.568	**7.82**
2080s no SLR	2.447	23.591	16.467	42.177	84.682	**29.39**
2080s SLR	2.806	39.702	18.091	43.174	103.773	**58.56**

Summary

- Major increase in PET offsets increase to precipitation for high/mean flows
- Large decrease in high and mean flows predicted, particularly in winter/spring
- Changes to floods are uncertain, and may vary between different flood quantiles
- The consequences of sea level rise on inundation may outweigh those of rainfall

Thank you

Email: rohan.eccles@griffithuni.edu.au