On the use of remote sensing-derived river width and water level in hydraulic flood forecast models

S. Grimaldi, Y. Li, J. Walker, and V. Pauwels

MONASH University
EGU 2018
GROUP OF EIGHT AUSTRALIA
bushfire&natural HAZARDS CRC
Australian Government Bureau of Meteorology
Australian Government Geoscience Australia
SES NSW STATE EMERGENCY SERVICE

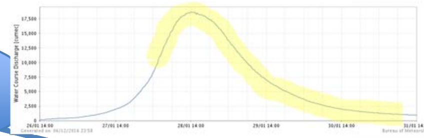
Introduction: flood forecast and river bathymetry

- **Floods** are the most frequent and disastrous natural hazards of the world *(CRED & UNISDR, 2015)*.
- Floods might impact two billion people by 2050 (*De Groeve et al. 2015*).

Accurate and reliable **flood forecasts** provide **vital information** for emergency and land management.

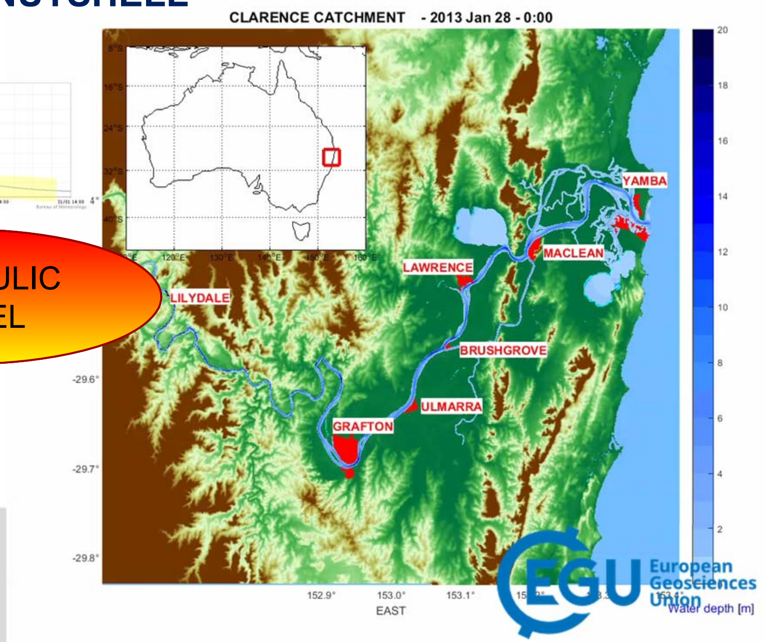
FLOOD FORECASTING CHAIN IN A NUTSHELL

WEATHER and CLIMATE MODEL → HYDROLOGIC MODEL → HYDRAULIC MODEL



HYDRAULIC MODEL → Water level and velocity in the river network and, when the storage capacity of the river is exceeded, in the floodplain.

Bathymetric data are critical input to hydraulic models.



Assessment of river bathymetry

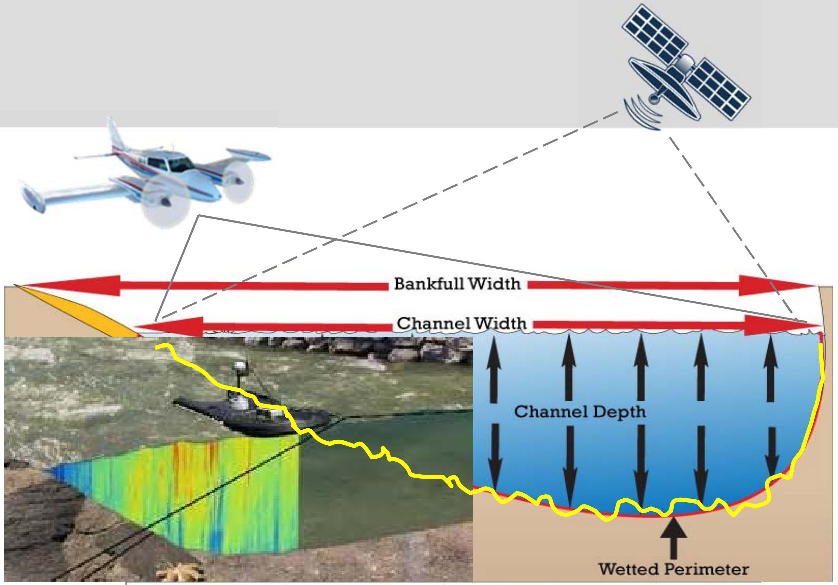
- River width can be systematically observed remotely.
  River shape and depth require costly field measurements.

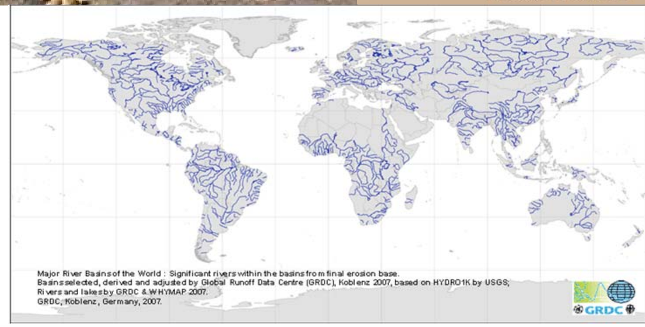
- In numerical modelling of river flow, river shape and friction can compensate for each other (equifinality).

✓ Approximated knowledge of river bathymetry can provide a more robust model setup.

A **numerical experiment** based on **detailed field data** was used to investigate:

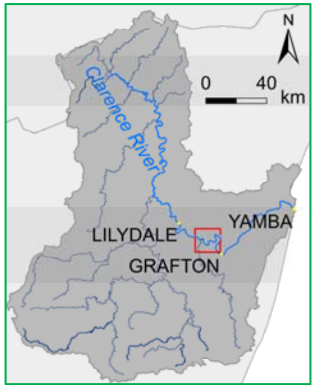
- A **data parsimonious** methodology for effective **preliminary representation** of river bathymetry.
- A method to **identify errors** in the preliminary representation.

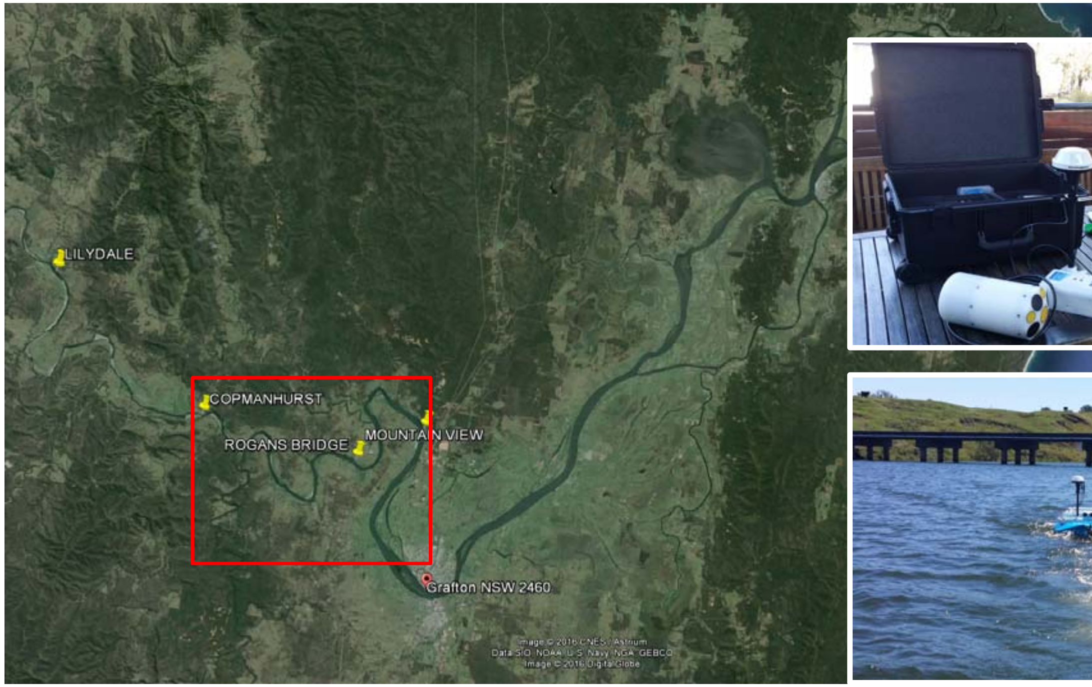


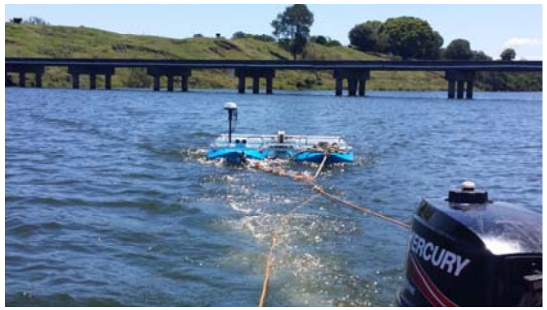


Numerical experiment: field data

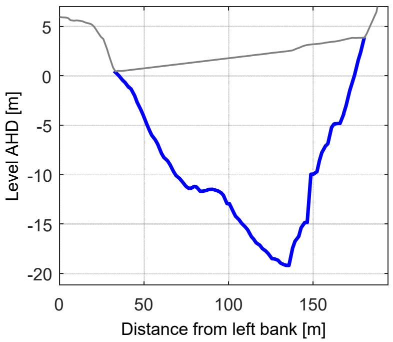
Upper Clarence catchment (NSW, Australia), field campaign in November 2015: 65 cross sections (20 km)

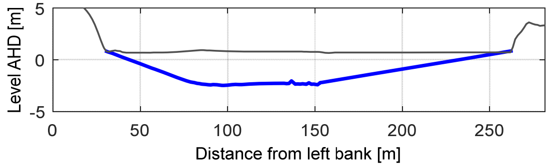


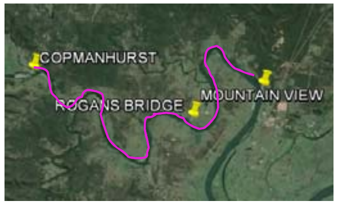


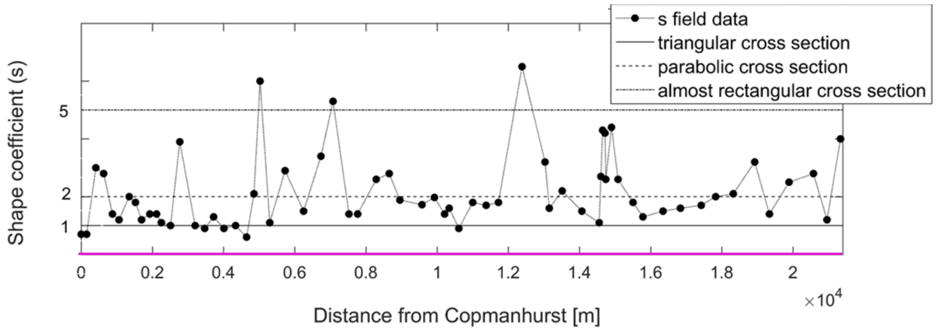


Numerical experiment: field data and numerical model









NUMERICAL EXPERIMENT

Model: LISFLOOD-FP (Bates et al., 2010)

Objectives:

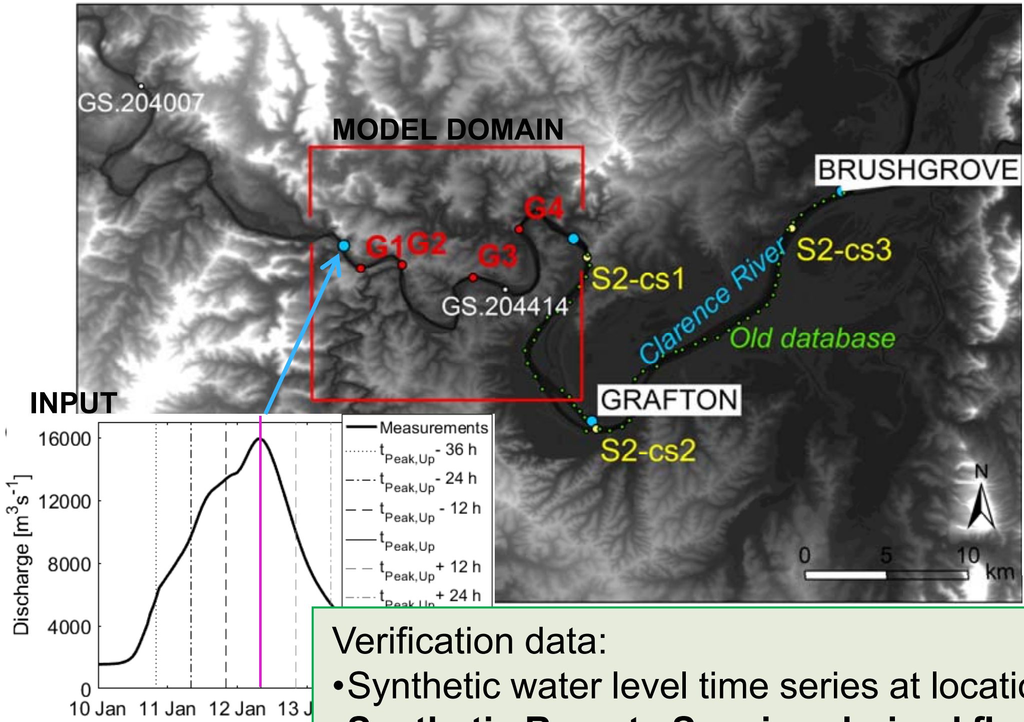
(Obj.1) Identification of the level of **geometrical complexity** required for the representation of river bathymetry in hydraulic flood forecasting models.

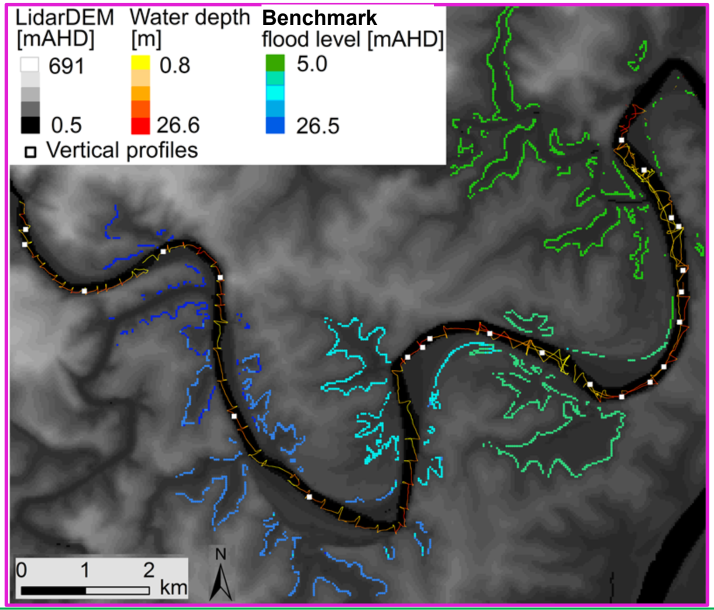
(Obj.2) Definition of a methodology for the **preliminary assessment of river bathymetry** in data scarce areas.

(Obj.3) Testing of a strategy to **identify errors** in the preliminary assessment of river bathymetry.

Numerical experiment: benchmark model

A **high resolution (5m)** model based on **bathymetric field data** has been used to benchmark **coarse models** based on **simplified** representations of river geometry.





Verification data:

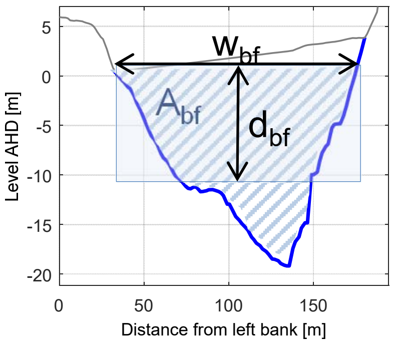
- Synthetic water level time series at locations G1, G2, G3, and G4.
- **Synthetic Remote Sensing-derived flood extent and level** at peak time -24h, -12h, +0, +12h

Results: identification of simplified geometry

BENCHMARK

High resolution (5m grid size) model based on bathymetric field data

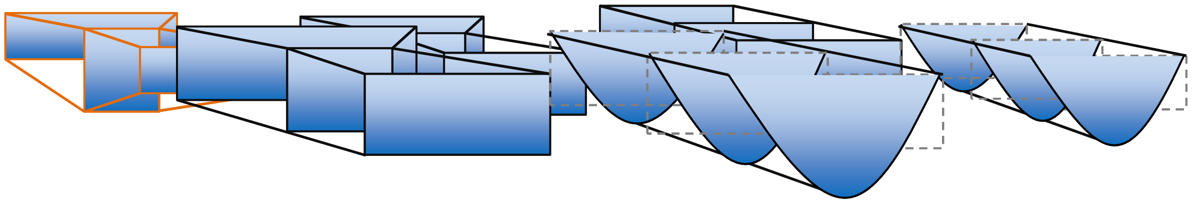
Synthetic time series of water level (1D) and maps of inundation extent and water level (2D)



Larger grid size for operational purposes → 30m

(Obj.1) Geometrical complexity required for the representation of river bathymetry

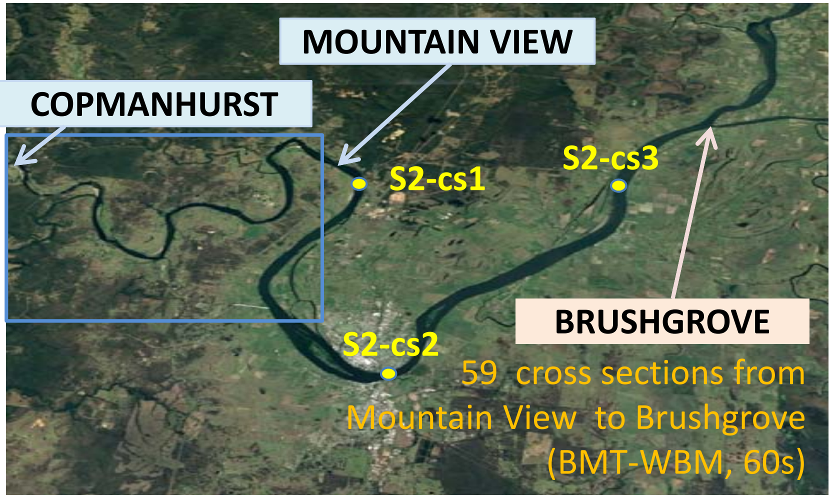
Simplified geometries derived from field data



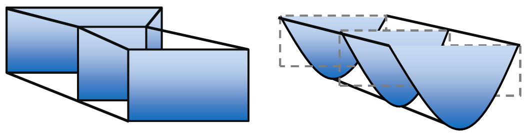
(Obj.2) Preliminary assessment of river bathymetry in data scarce areas.

Simplified geometries derived from a combination of limited field data, global database, and RS-derived river width.

Results: preliminary assessment of river bathymetry in data scarce areas



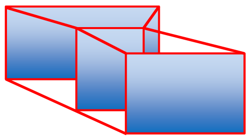
HYPOTHESIS of DATA SCARCE SCENARIOS	
S1	**All the available cross sections** from Mountain View to Brushgrove.
S2	**3 cross sections sampled at strategic locations** from Mountain View to Brushgrove.

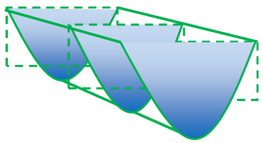


Few (min. 3) measured cross sections & empirical formulations (at-a-station equations) &/or **Remote Sensing-derived river width** database.

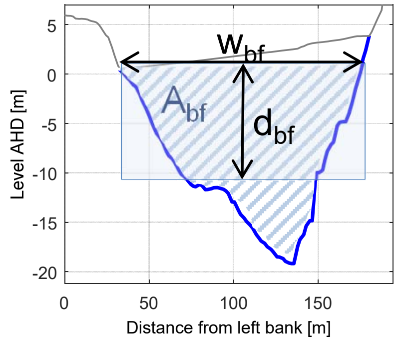
→ **Preliminary assessment** of river geometry from Copmanhurst to Mountain View

Results: preliminary assessment of river bathymetry in data scarce areas



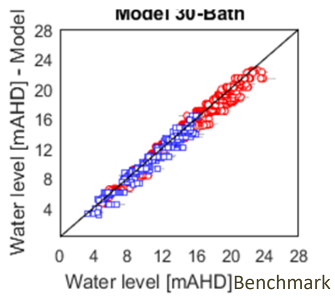


	w_{bf}	d_{bf}	A_{bf}
	PBIAS	PBIAS	PBIAS
S2 – R; **RS-derived river width**	-3.21	-23.64	-24.54
S2 – E; Global database of river width	117.87	-23.65	28.94



(Obj.3) Testing of a strategy to **identify errors** in the preliminary assessment of river bathymetry.

COMPARISON OF BENCHMARK AND MODELLED WATER LEVELS at THE CATCHMENT SCALE, and at DIFFERENT LEAD TIMES (flood peak time -24h, -12h, +0h, +12h)

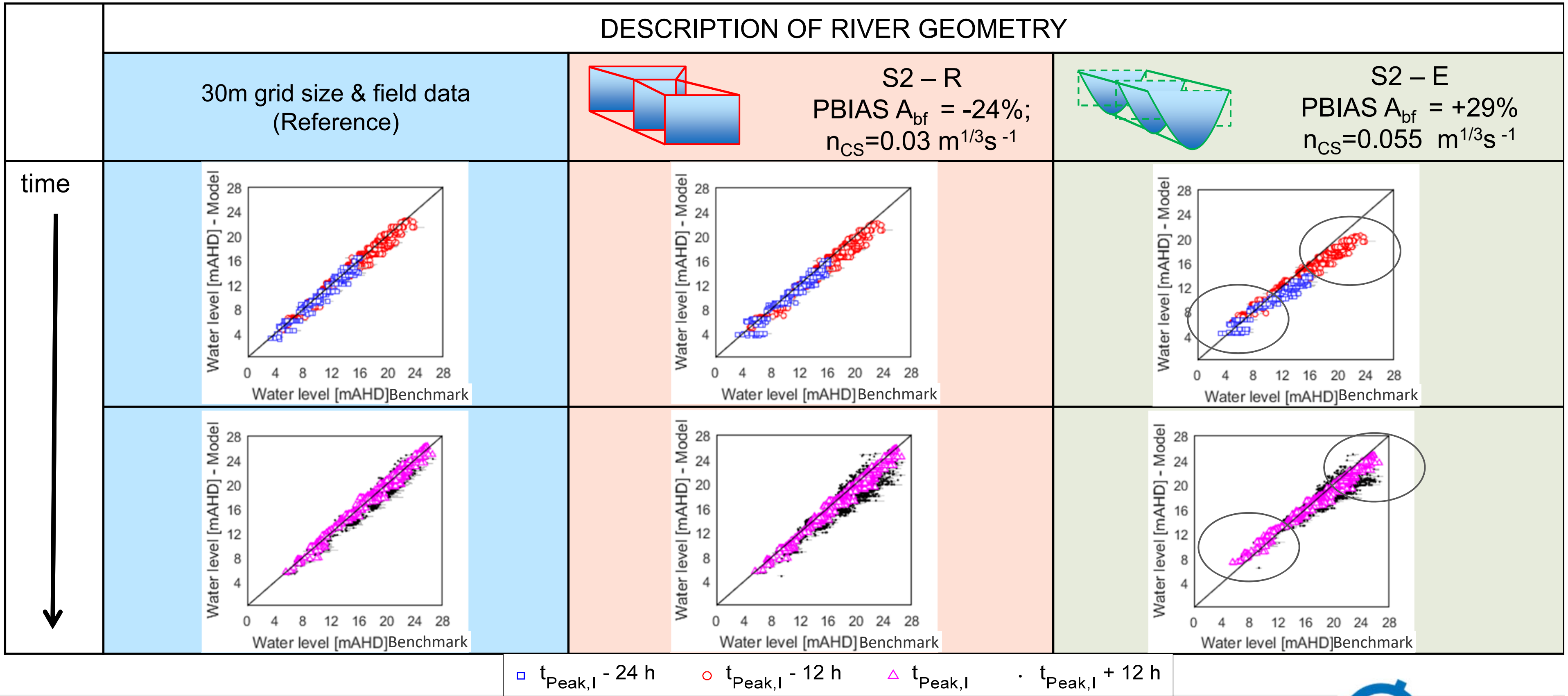


MONASH University

bushfire&natural HAZARDSCRC

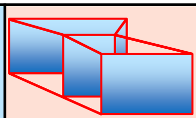
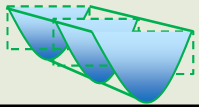
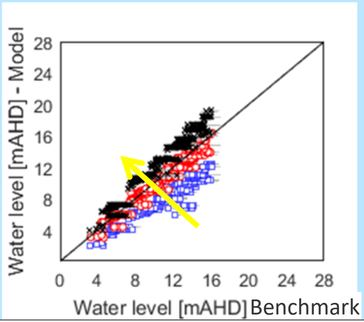
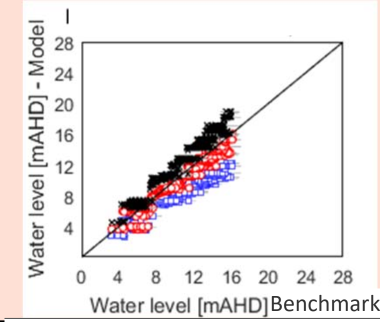
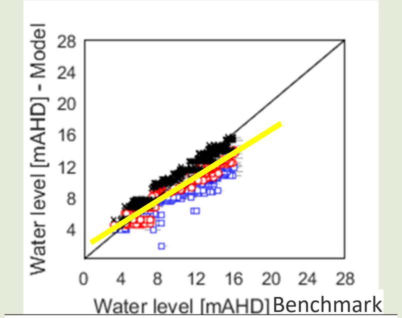
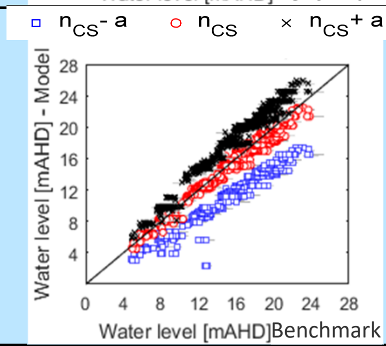
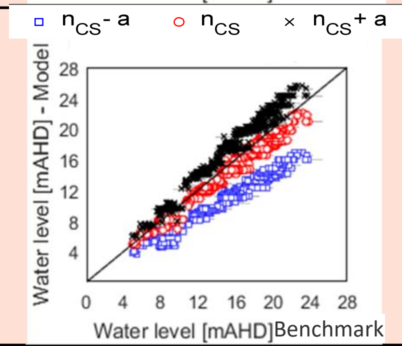
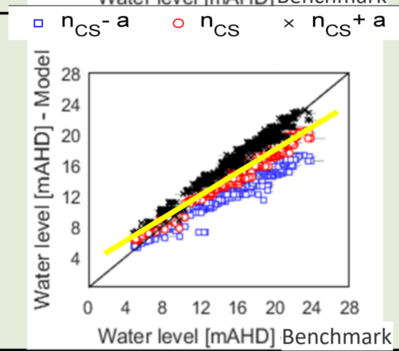
European Geosciences Union

Results: use of Remote Sensing-derived water level for model verification



In this study area, Remote Sensing-derived river width values allowed appropriate representation of river geometry.

Results: use of Remote Sensing-derived water level for model verification

	DESCRIPTION OF RIVER GEOMETRY		
	30m grid size & field data (Reference) $n_{CS}=0.03\ m^{1/3}s^{-1}$	 S2 – R PBIAS A_{bf} = -24%; $n_{CS}=0.03\ m^{1/3}s^{-1}$	 S2 – E PBIAS A_{bf} = +29% $n_{CS}=0.055\ m^{1/3}s^{-1}$
24h before the flood peak			
12h before the flood peak			

Analysis of Remote Sensing-derived water level at the catchment scale can support timely diagnosis of errors in the representation of river geometry.

European Geosciences Union

Conclusions

- A **data-parsimonious** method for the preliminary assessment of river geometry was proposed. In this study area, **Remote Sensing-derived river width** combined with few measurements of river depth provided adequate representation of river geometry.

- In this numerical experiment, **Remote Sensing-derived water level acquired as early as 24 hours before the flood peak allowed identification of errors in the representation of river geometry.**

- The results of this numerical experiment should be tested in a real case study.

Manuscript:

Grimaldi, S., Li, Y., Walker, J. P., & Pauwels, V. R. N. (2018). Effective representation of river geometry in hydraulic flood forecast models. *Water Resources Research*, 54. https://doi.org/10.1002/2017WR021765

THANKS FOR YOUR KIND ATTENTION!

ACKNOWLEDGEMENTS:
The authors would like to express their gratitude to the Clarence Valley Council, BMT-WBM Ltd., the Australian Bureau of Meteorology, Geoscience Australia and the Commonwealth Scientific and Industrial Research Organisation for their advice and support during the collection of the remote sensing and field database.