bnhcrc.com.au

IMPROVING FLOOD FORECAST SKILL USING REMOTE SENSING DATA

Non-peer reviewed research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference
Brisbane, 30 August – 1 September 2016

Yuan Li[1,2], Stefania Grimaldi[1,2], Ashley Wright[1,2], Jeffrey Walker[1,2], Valentijn Pauwels[1,2]

1. Monash University
2. Bushfire and Natural Hazards CRC

Corresponding author: yuan.li2@monash.edu

Version	Release history	Date
1.0	Initial release of document	30/08/2016

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Publisher:
Bushfire and Natural Hazards CRC

August 2016

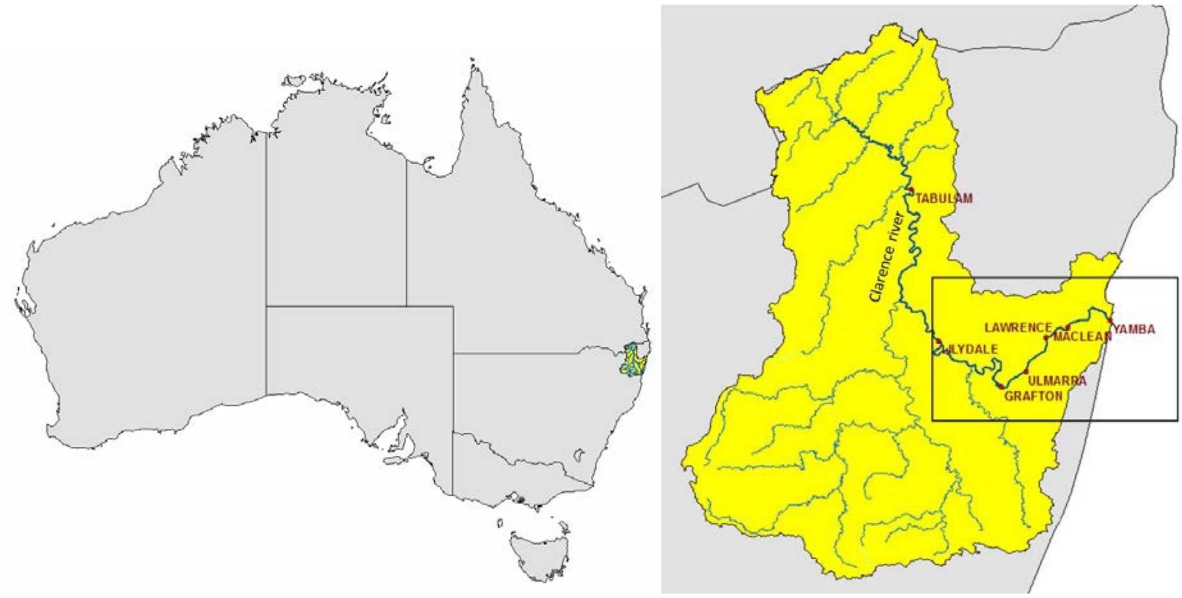
ABSTRACT

Floods are among the most important natural disasters in Australia. The average annual cost of floods in the last 40 years has been estimated to amount to $377 million, with the 2010–2011 Brisbane and south-east Queensland floods alone leading to $2.38 billion in economic damage and 35 confirmed deaths. Flood forecasting systems are the most important tools to limit this damage but are prone to a considerable degree of uncertainty.

During the last decades, significant research focusing on the monitoring of the global water cycle through satellite remote sensing has been performed. The strength of remote sensing is the opportunity to provide information at large spatial scales including areas that are difficult or impossible to monitor using on-ground techniques. For these reasons it is believed that the use of remote sensing data can improve the quality of operational flood forecasts.

Operational flood forecasting systems typically consist of a hydrologic model, which estimates the amount of water entering a river system, and a hydraulic model, which models the flow of water inside the river system. Remotely sensed soil moisture data is being used to improve the hydrologic model results (i.e. the modeled hydrograph into the river network), while remotely sensed water levels and/or flood extent data are being used to improve the hydraulic model results (i.e. the modeled water velocities, depths, and floodplain extents).

The project focusses on two test sites, the Clarence River in New South Wales and the Condamine-Balonne River in Queensland. Figure 1 shows an overview of these test sites.



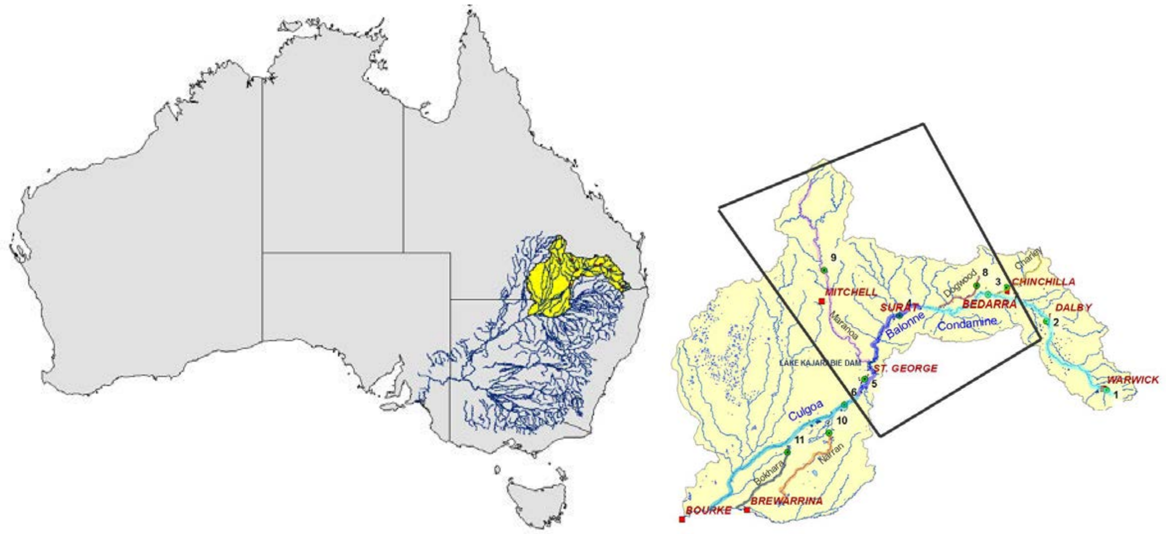


FIGURE 1. OVERVIEW OF THE TEST SITES. TOP LEFT HAND SIDE: LOCATION OF THE CLARENCE RIVER BASIN. TOP RIGHT HAND SIDE: DETAILED OVERVIEW OF THE CLARENCE RIVER BASIN. BOTTOM LEFT HAND SIDE: LOCATION OF THE CONDAMINE-BALONNE RIVER BASIN. BOTTOM RIGHT HAND SIDE: DETAILED OVERVIEW OF THE CONDAMINE-BALONNE RIVER BASIN.

This presentation will provide an overview of our preliminary analysis on the effectiveness of using RS data to calibrate and validate hydrologic and hydraulic models for flood forecasting. In particular, the impact of using RS soil moisture and RS water extents on the accuracy of the calibration and validation of a hydrologic and of a hydraulic model, respectively, will be discussed using the Clarence catchment as study site.

A preliminary streamflow simulation experiment has been conducted in the Clarence River basin upstream of Lilydale. The study basin was delineated into six sub-catchments and the streamflow was simulated at the outlets of the six sub-catchments through a semi-distributed hydrologic model based on the GRKAL rainfall-runoff model and the linear Muskingum flow routing model. The model parameters were estimated using two calibration schemes: 1) a single-objective calibration using streamflow measurements and 2) a multi-objective calibration using both remotely sensed surface soil moisture (SMOS) and streamflow measurements. Only discharge at Lilydale (outlet of the study basin) was used for calibration, while the other five internal gauges were only used for validation. Data from 2010 to 2011 was used for calibration while data from 2012 to 2014 was used for validation.

The result at Lilydale indicates that the calibration with soil moisture data results in a slight degradation in streamflow simulation during the calibration period compared with the calibration without soil moisture data, e.g. the NS decreases from 0.81 to 0.76. However, during the validation period, calibration with soil moisture data gives slightly better forecasts, e.g. the NS increases from 0.70 to 0.71. This means that minimising errors in soil moisture may lead to sub-optimal streamflow simulation in calibration period, but can lead to a more robust parameter set which has the potential to improve the future forecasts. The results at the five internal locations indicate a potential to improve forecasts in ‘ungauged’ areas. Four of the five locations were improved through incorporating remote sensing soil moisture data in the calibration period, and the improvements were retained at three locations. Figure 2 gives an example of simulated hydrographs at Lilydale and two upstream gauges in both calibration and validation periods.

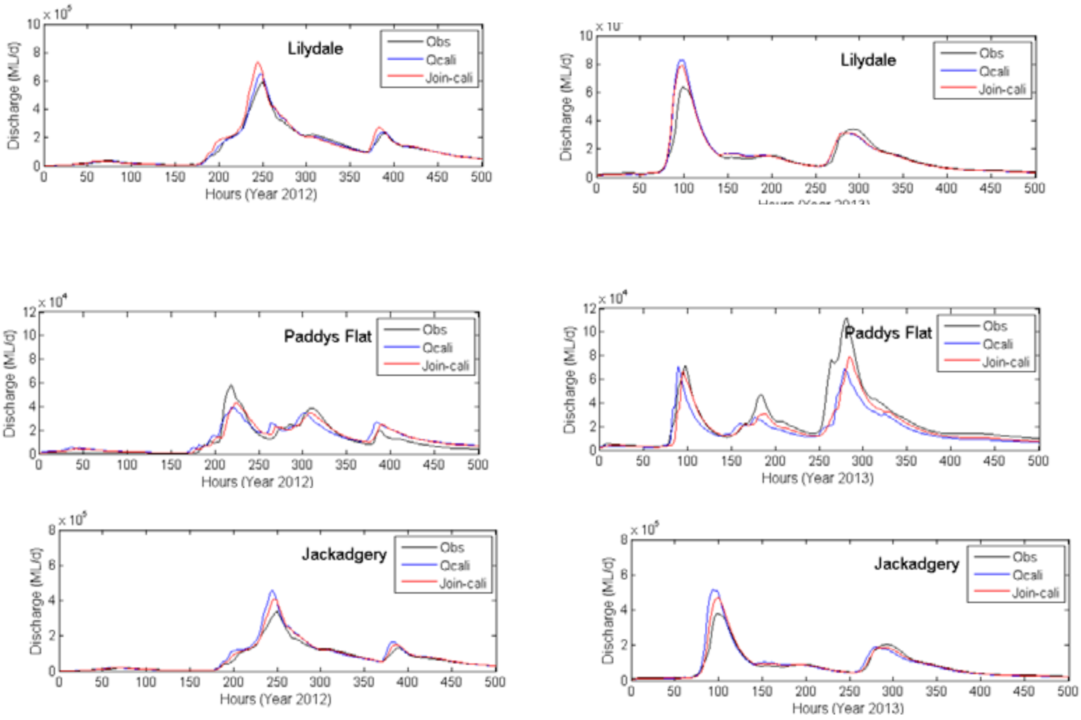


FIGURE 2. STREAMFLOW SIMULATIONS AT THREE LOCATIONS. THE LEFT ONES ARE IN CALIBRATION PERIOD AND THE RIGHT ONES ARE IN VALIDATION PERIOD.

A preliminary comparison on the use of field and RS data for the calibration and validation of hydraulic models for flood forecasting has been completed using the January 2013 flood event in the Clarence catchment as case study.

The hydraulic model is based on LISFLOOD-FP (Bates et al., 2010) and it uses the finite difference method to solve the inertial approximation of the shallow water equations. The measured discharge hydrograph at Lilydale and tidal levels at Yamba were used as upstream and downstream boundary conditions respectively.

The results of the model were firstly compared with the water levels measured by ten gauging stations. The RMSE, when averaged over the ten gauging stations, was 0.30 m. As an example, Figure 3 shows the measured and modelled water level hydrographs at Grafton and Maclean. Despite providing rather satisfactory results at local level, a comparison with RS-derived flood extent observations pointed out that the model failed the prediction of the flood extent in the relevant urban area of Grafton. Figure 4 shows the modelled and observed flood extent at Grafton on January 29th at 12pm.

These results underlined the limits of a punctual model-measurements comparison and highlighted that more coherent and explicative modalities of comparison are possible thanks to the intrinsically two dimensional features of RS observations.

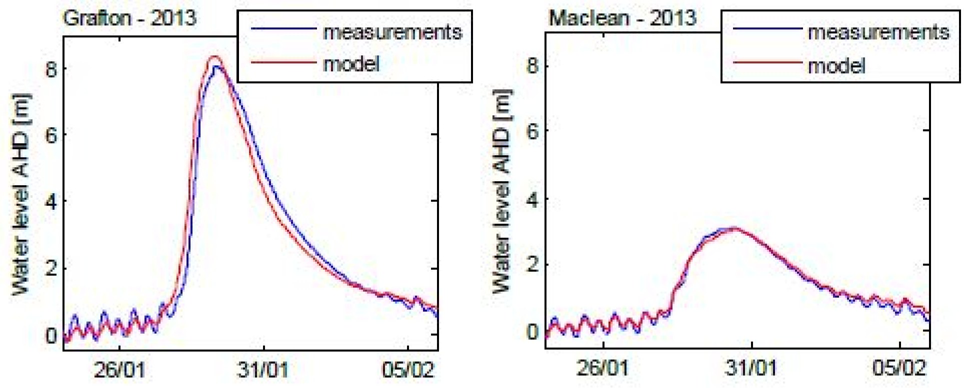


FIGURE 3. EXAMPLES OF MODELLED AND MEASURED WATER LEVEL HYDROGRAPHS.

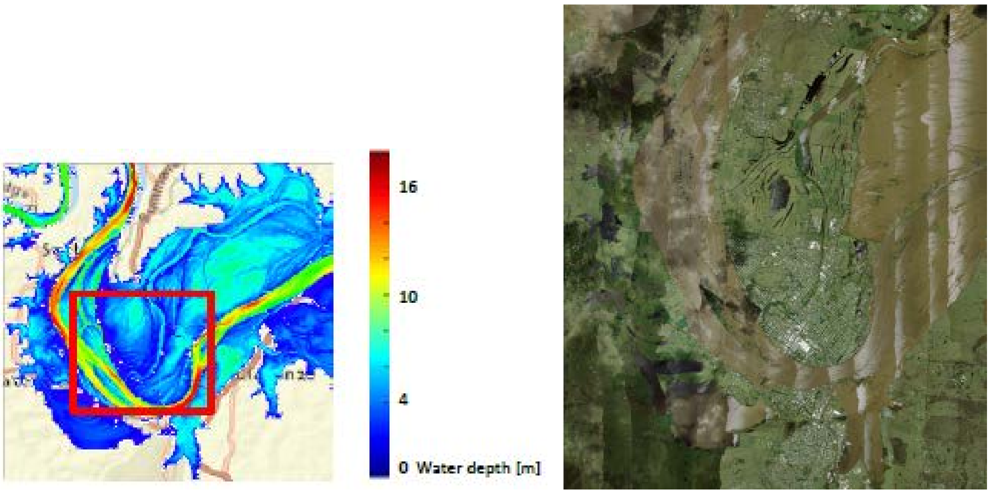


FIGURE 4. MODELLED AND OBSERVED FLOOD EXTENT: GRAFTON, JAN 29TH, 12PM.

REFERENCES

Bates PD, Horritt MS, Fewtrell TJ. 2010. A simple inertial formulation of the shallow water equations for efficient two-dimensional flood inundation modelling. Journal of Hydrology, 387: 33-45. DOI: http://dx.doi.org/10.1016/j.jhydrol.2010.03.027.