Improving flood forecast skill using Remote Sensing data

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This project investigates the use of remotely sensed soil moisture and inundation extent/level to improve the accuracy of operational flood forecast.

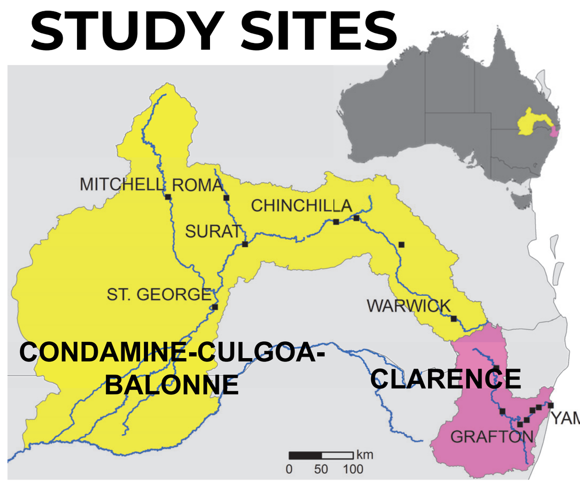
Floods are among the most common and deadliest natural disasters in Australia.

Coupled hydrologic-hydraulic forecasting models are essential tools in managing floods. Hydrologic models predict the flow volume in the river system; hydraulic models convert this flow volume into inundation extents and levels.

Hydrologic and hydraulic models are affected by large uncertainties (e.g. model structure, parameters, input data).

Satellite remote sensing (RS) **soil moisture** and **flood extent/level** can be used to constrain the **hydrologic** and **hydraulic** models.

STUDY SITES

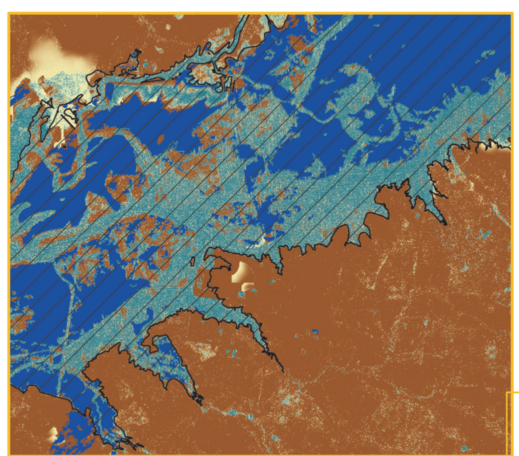


The Clarence and the Condamine-Culgoa-Balonne were affected by floods in 2011-12-13.

Fig 1. Study sites.

DATA ANALYSIS

Remote Sensing-derived inundation extent and level



An algorithm is being developed to improve the accuracy of RS-derived flood extent in densely vegetated areas.

Fig 2 – RS-derived flood extent (Surat, 2011).

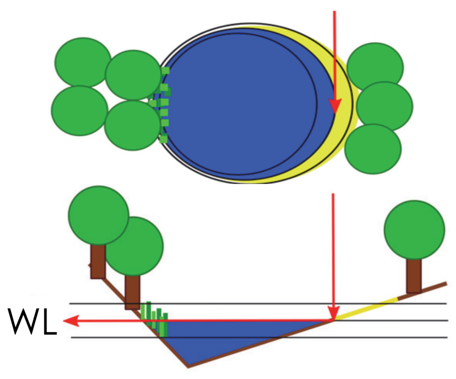


Fig 3 – RS-derived WL.

Flood extents are overlaid on terrain data to provide RS-derived water level (RS-WL). RS-data: Synthetic Aperture Radar (SAR).

HYDROLOGIC MODELLING (GRKAL)

Assimilation of gauged data and RS soil moisture for streamflow forecast

A set of synthetic experiments was conducted in the Condamine-Culgoa-Balonne catchment upstream of Warwick.

A data assimilation (DA) approach based on a fixed-lag ensemble Kalman smoother was implemented to constrain the hydrologic streamflow forecasts using:

a) RS Soil Moisture data (RS-SM DA);
b) gauged discharge data (Q DA);
c) RS-SM and Q data (Joint DA). GP

Results

Nash-Sutcliffe efficiency	Lead time		
	1-h	24-h	72-h
Open Loop	0.68		
a) RS-SM DA	0.83	0.75	0.69
b) Q DA	0.93	0.78	0.72
c) Joint DA	0.93	0.84	0.75

Table 1 – Nash-Sutcliffe efficiency coefficient of stream-flow predictions for an event in 2011 (optimal value: 1)

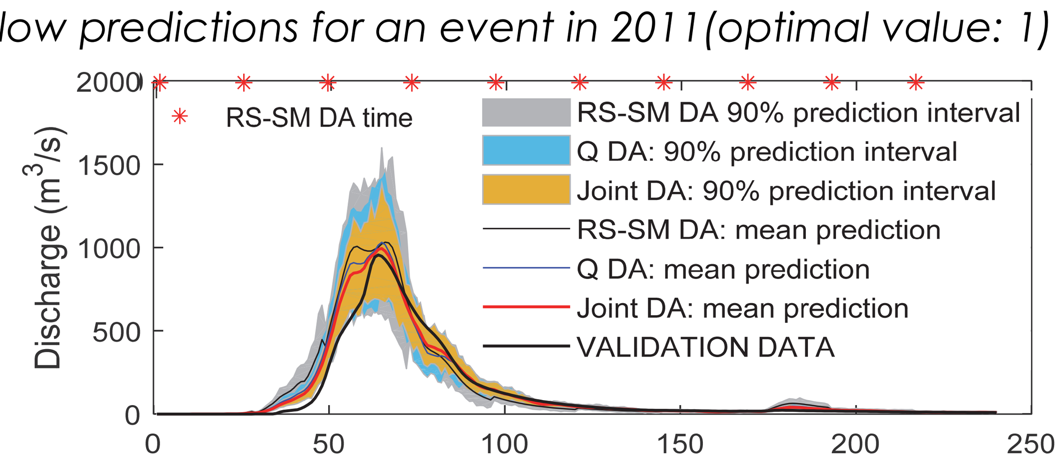


Fig.4 – Ensemble streamflow prediction for an event in 2011 (24 hours lead time).

The results indicate that:

- Q DA has larger impact than RS-SM DA in improving the accuracy of streamflow forecasting;
- **Joint DA outperforms** the single variable assimilation schemes (i.e. Q DA and RS-SM DA) for longer lead times.

Conclusion (1)
Including **RS-SM** information **adds value** to constrain hydrologic streamflow forecasting.

HYDRAULIC MODELLING (LISFLOOD-FP)

Use of gauged data or RS-derived water level for model verification

The 2011 flood in the Clarence catchment was used as a case study.

The results of the hydraulic model were verified using:

a) 10 gauged water level time series;
b) RS-derived water level (RS-WL) from 1 image acquired close to the flood peak.

Results

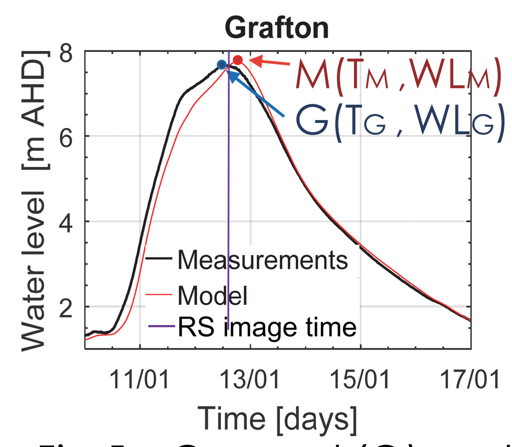


Fig 5 – Gauged (G) and modelled (M) water level.

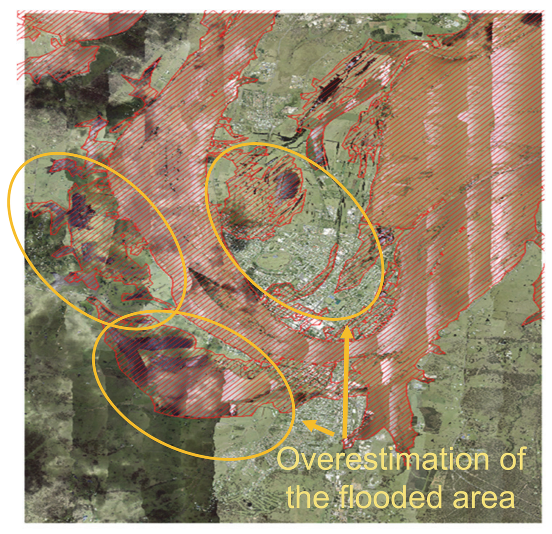
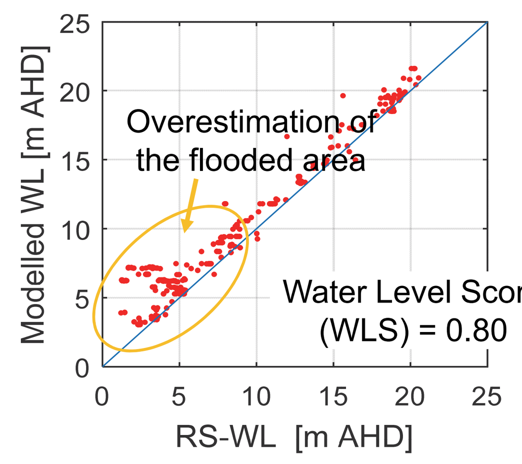


Fig 6 –Modelled flood extent (red dashes).



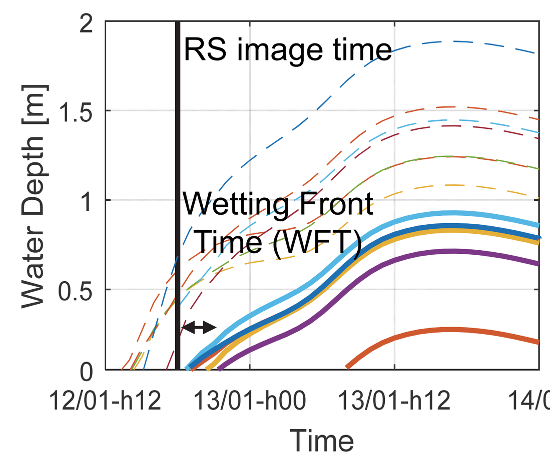


Fig 7, 8 – Modelled and RS-WL and flood arrival time.

Gauged data (Grafton)				RS-WL	
NS	RMSE	PR=WL_M/WL_G	$\Delta t=T_M-T_G$	WLS	WFT
0.97	0.26 m	1.036	3 h	**0.80**	**>0**

Table 2 – Performance metrics for the 2011 flood. Target values: NS = 1; RMSE = 0; PR =1; Δt = 0; WLS =0; WBT=0.

The results indicate that:

- **RS-WL** are pivotal for the detection erroneous predictions of **flooded area**;
- RS-WL can be used to verify predicted flood wave **arrival time**.

Conclusion (2)
RS-WL provide **more coherent and explicative** ways of comparison than gauged data.

END-USERS STATEMENTS

*"The outcomes from this research will provide information for us to use remotely sensed data to improve our flood forecasting service. This work will support the development of both probabilistic flood forecasts, and flood forecasts that provide much more detailed information on the impact of floods." **– Chris Leahy (Australian Bureau of Meteorology)***

*"This project makes use of Synthetic Aperture Radar data, that are increasingly used in flood mapping and becoming routinely available over Australia from new satellite sensors. Outcome of this project will not only assist near real time flood monitoring and modelling but also inform effective use of SAR data systematically across Australia." **– Yuan Fang (Geoscience Australia)***

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