Improving flood forecast skill using remote sensing data

BNHCRC research forum **2019**

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Clarence catchment, Grafton, 2013 Jan 30th (Credits: Mr. Williamson)

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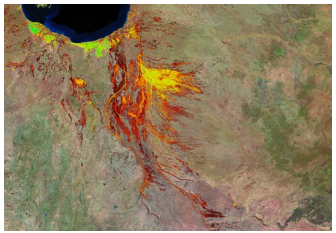
The impact of floods

Fig.1 Flooding in Condamine River. www.abc.net.au/news/2015-12-11/the-condamine-flooding/7020584

End-users

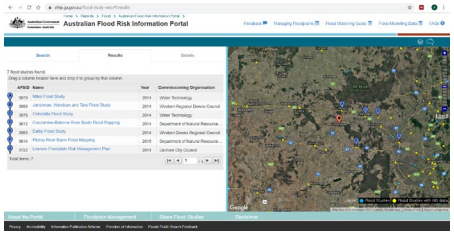
Australian Government
Geoscience Australia

WOfS



http://www.ga.gov.au/dea/products#wofs

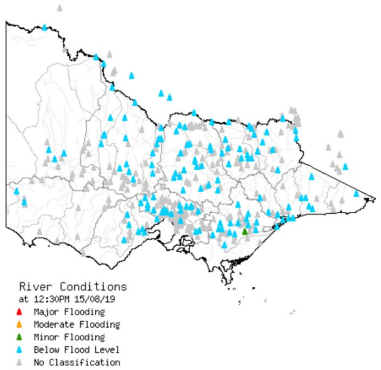
AFRIP



https://afrip.ga.gov.au/flood-study-web/#/results

Australian Government
Bureau of Meteorology

- Flood watch
- Flood Warning



http://www.bom.gov.au/vic/flood/

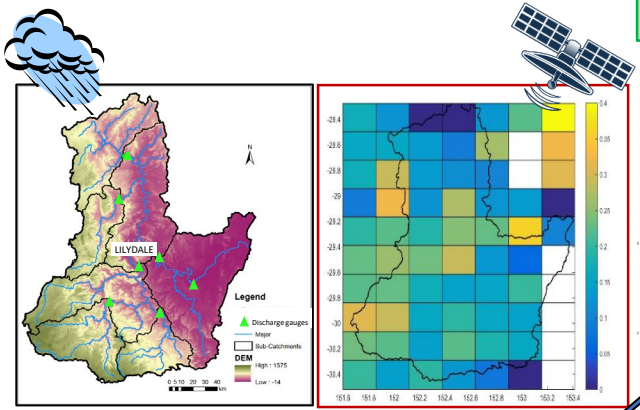
NSW STATE EMERGENCY SERVICE

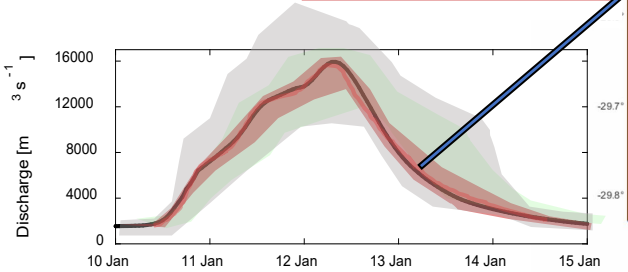
Respond to flood watch and flood warning

https://www.ses.nsw.gov.au/floodsafe/learn-more-about-floods/do-you-live-behind-a-levee/

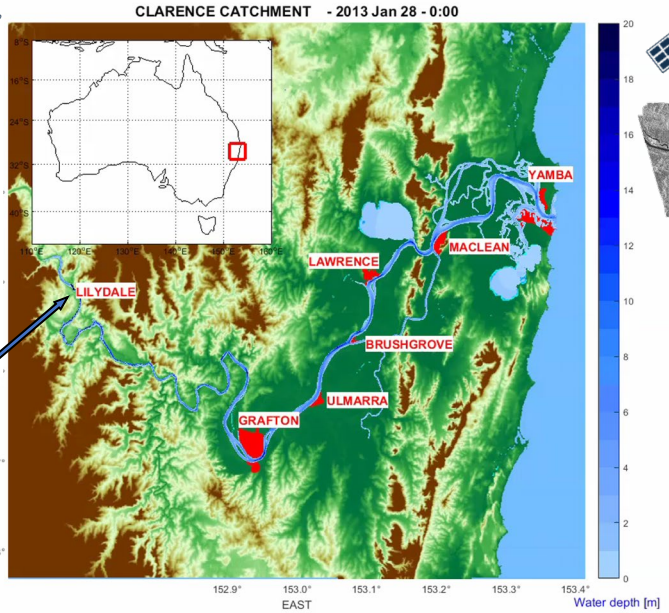
Project outline

1. Improved streamflow forecasts using remote sensing soil moisture

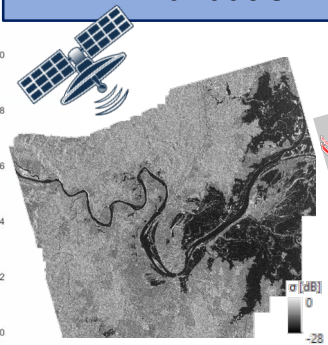




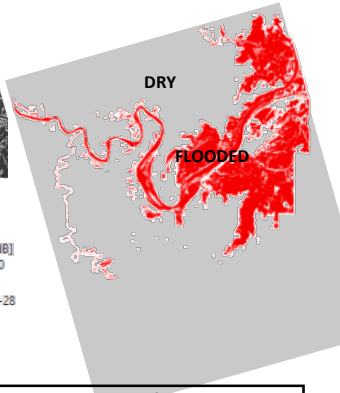
2. Improved floodplain inundation forecasts using remote sensing flood extent



3. Use of SAR (Synthetic Aperture Radar) for inundation monitoring



Clarence, CosmoSkyMed, Jan 12th 2011



Two test sites:
- Clarence
- Condamine-Balonne

Hydrologic model data fusion: A review

1. The ability of the modelled soil layer to represent the observed soil layer;
2. Bias between modelled and observed soil layer;
3. Strategies to use multiple observations and products; and
4. Correct specification of observed and modelled soil moisture errors.

Review

Application of Remote Sensing Data to Constrain Operational Rainfall-Driven Flood Forecasting: A Review

Yuan Li *, Stefania Grimaldi, Jeffrey P. Walker and Valentijn R. N. Pauwels

Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia; stefania.grimaldi@monash.edu (S.G.); jeff.walker@monash.edu (J.P.W.); valentijn.pauwels@monash.edu (V.R.N.P.)

Hydraulic model data fusion: A review

1. RS image processing algorithms;
2. Optimal use of RS-derived information for the implementation of hydraulic models for flood forecast;
3. Definition of the most appropriate RS-derived observation (e.g. inundation extent and/or level) for the effective evaluation of the accuracy of modelled floodplain inundation dynamics; and
4. Definition of RS-based protocols for the assessment of the parameter space of the hydraulic model to enable more accurate floodplain inundation predictions.

Surv Geophys (2016) 37:977–1034
DOI 10.1007/s10712-016-9378-y

CrossMark

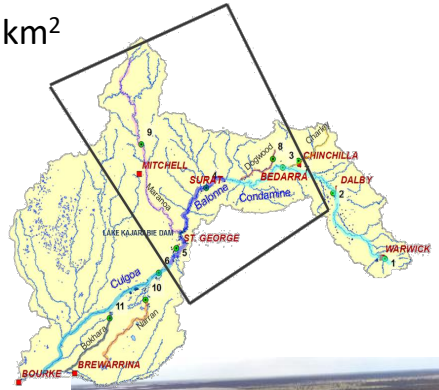
Remote Sensing-Derived Water Extent and Level to Constrain Hydraulic Flood Forecasting Models: Opportunities and Challenges

Stefania Grimaldi[1] · Yuan Li[1] · Valentijn R. N. Pauwels[1] · Jeffrey P. Walker[1]

Case studies

Condamine-Balonne

75370 km^2



Clarence

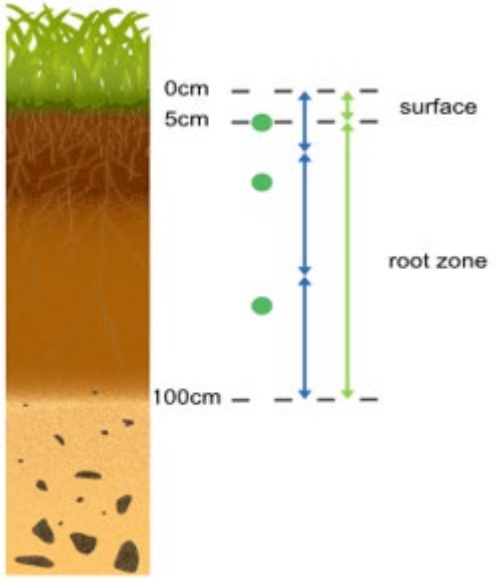
(20730 km^2

St. George, 2012 Feb 7th, http://www.abc.net.au

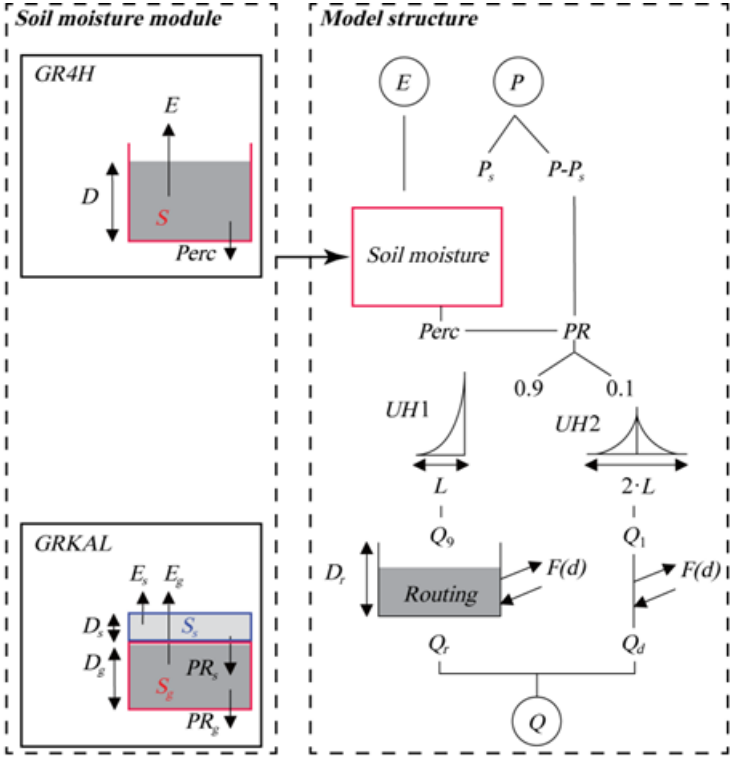
Grafton, 2013 Jan 30th, Mr. Williamson

Modelling the observed soil layer

- Model processes
- Model construction
- Data availability
- Computational requirement
- Soil moisture observations

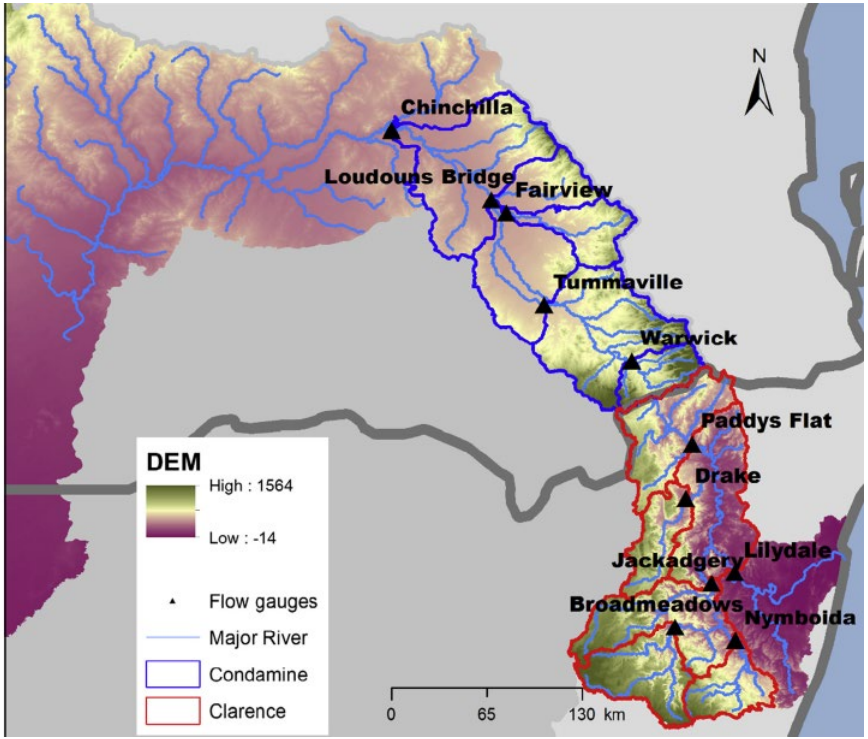


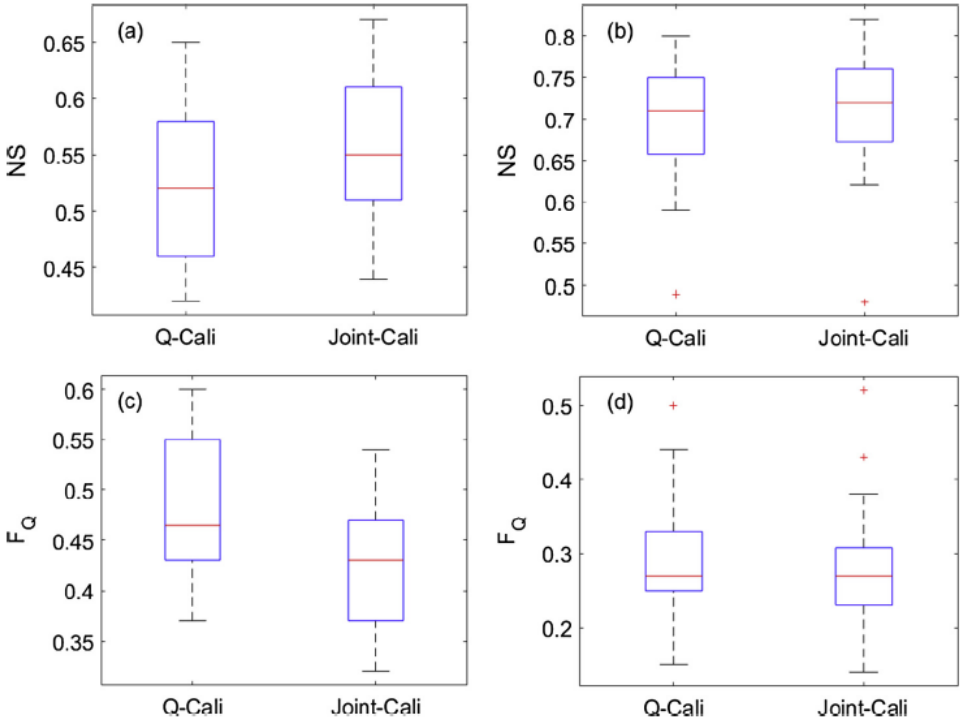
RS SM observations only capture surface soil moisture properties.
https://eos.org/science-updates/soil-moisture-data-sets-become-fertile-ground-for-applications



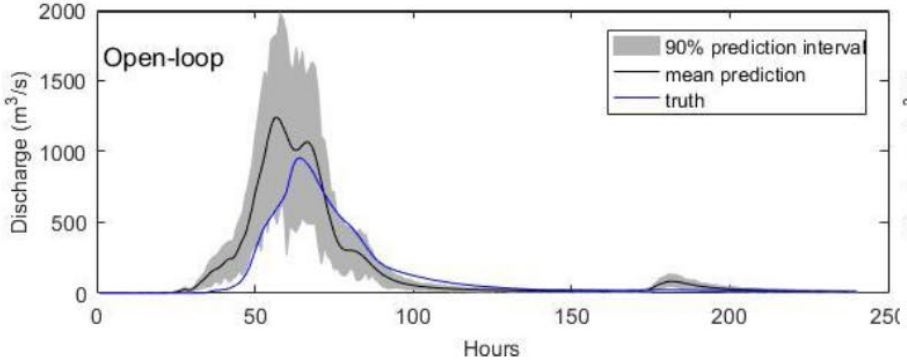
GR4H and GRKAL rainfall runoff models

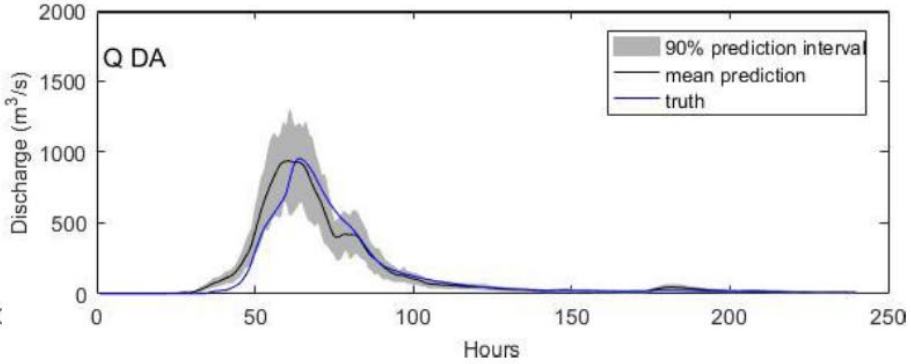
Addressing bias between modelled and observed soil layers

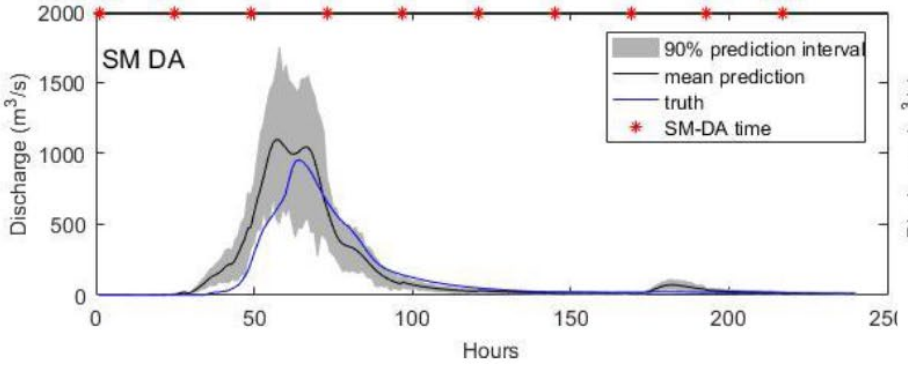


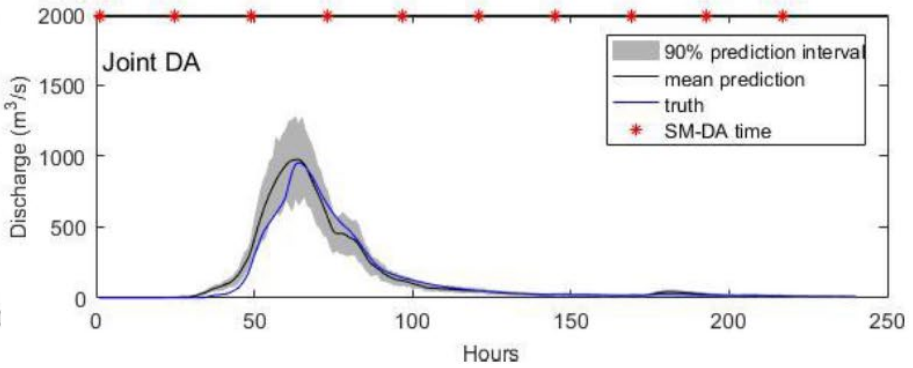


Strategies to use multiple observations and products









Correct specification of observed and modelled soil moisture errors

Conclusions

- EnKS has stronger impact on discharge when compared to EnKF.
- Synthetic experiments demonstrate that assimilating multiple products have benefits for extended forecasts.
- Assimilation of RS SM can both increase and reduce discharge errors.

Resulting questions

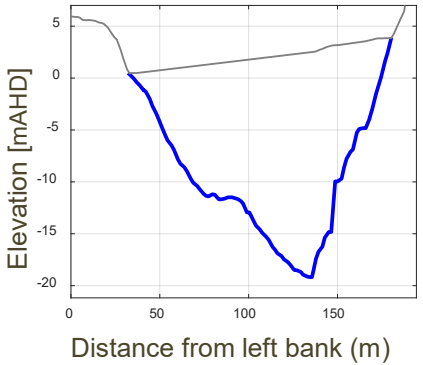
- How does the model calibration affect the results?
- How does quality of rainfall input affect the results?
- How can observed and modelled soil moisture errors be correctly specified to ensure consistent improvements in forecast skill?

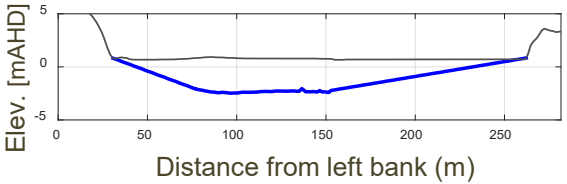
Hydraulic model implementation

In many catchments, information on **river bathymetry** is essential for the modelling of floodplain inundation.

- River width can be observed remotely; River **shape** and **depth** require **field data**.
- Field campaigns: Clarence (Nov.2015), Condamine-Balonne (May 2016).
- NUMERICAL EXPERIMENT BASED ON FIELD DATA

Measured cross sections

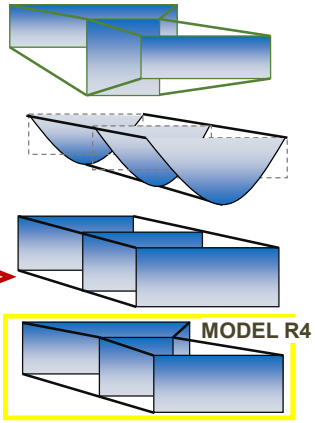


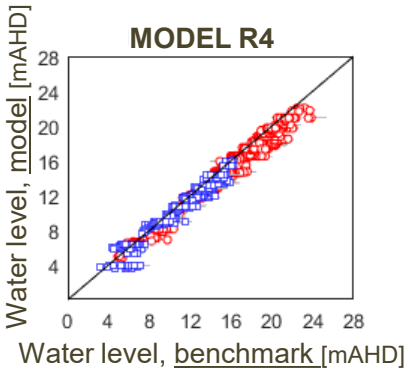


Simplified cross sections based on a combination of:

- a few measurements;
- Remote Sensing river width;
- global database.

Numerical experiment (Lisflood-FP)



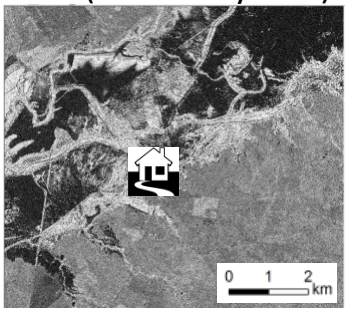


DATA PARSIMONIOUS IMPLEMENTATION METHOD:

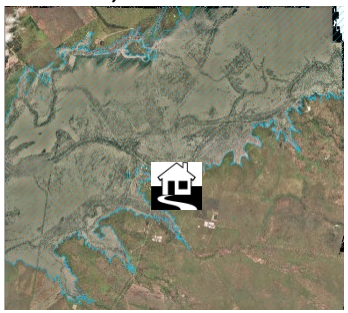
- Width varying rectangular shape with uniform longitudinal slope.
- Remote Sensing-derived river width combined with a few (3) measurements of river depth at strategic locations.

RS image processing algorithms

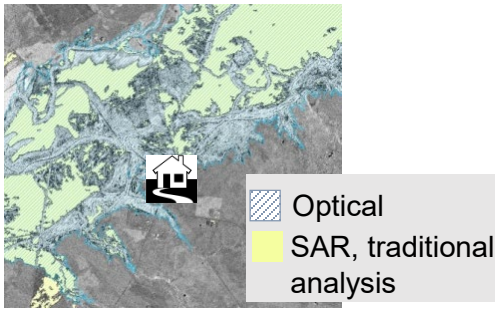
SAR (CosmoSkyMed)



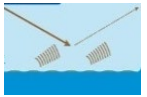
OPTICAL, evaluation data



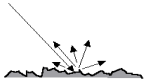
RS-derived flood extent



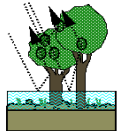
RADAR BACKSCATTER



Open water: LOW



Dry surface: HIGH

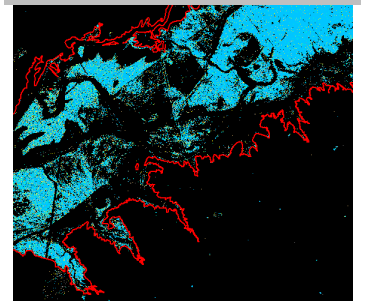


Flooded vegetation: even HIGHER

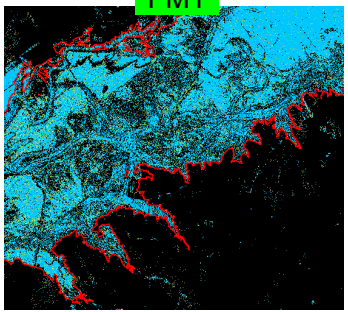
Flood mapping under vegetation using **single SAR** acquisitions and commonly **available ancillary data:**

- detection of open water areas → FM-OW
- statistical analysis of the backscatter response of wet and dry vegetation for different **land cover** types → FM1
- incorporation of information on **land use** and **morphology** within a fuzzy logic approach → FM2

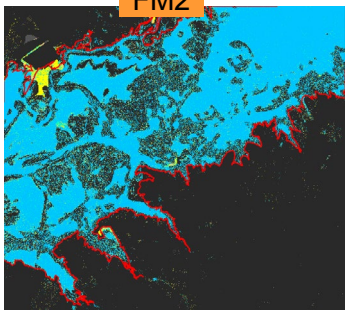
FM-OW = OPEN WATER



FM1



FM2



FM, value

0-0.02
0.02 - 0.1
0.1-0.3
0.3 - 0.5
0.5 - 0.8
0.8 - 1

Evaluation layer

Flood extent boundary

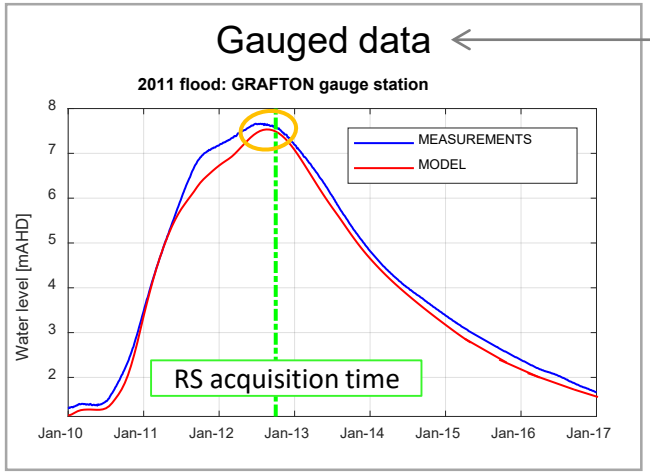
Inundation extent and/or level?

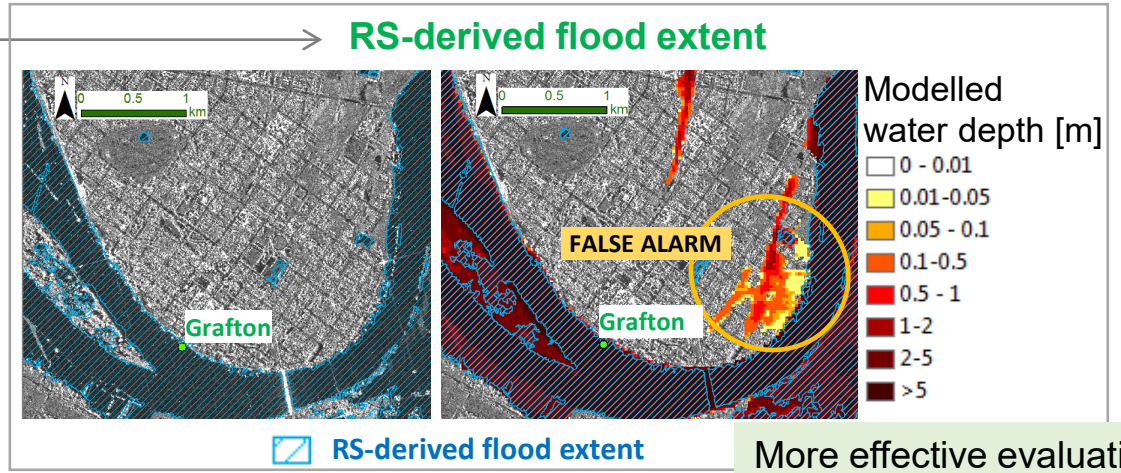
We are trying to determine how water flows throughout the floodplain

Typically models are calibrated to river level data at a small number of gauges

this means that the evaluation of predicted floodplain inundation dynamics exclusively relies on point-scale information from gauge stations

RS data provides the opportunity to calibrate models to inundation extent





More effective evaluation of model performances.

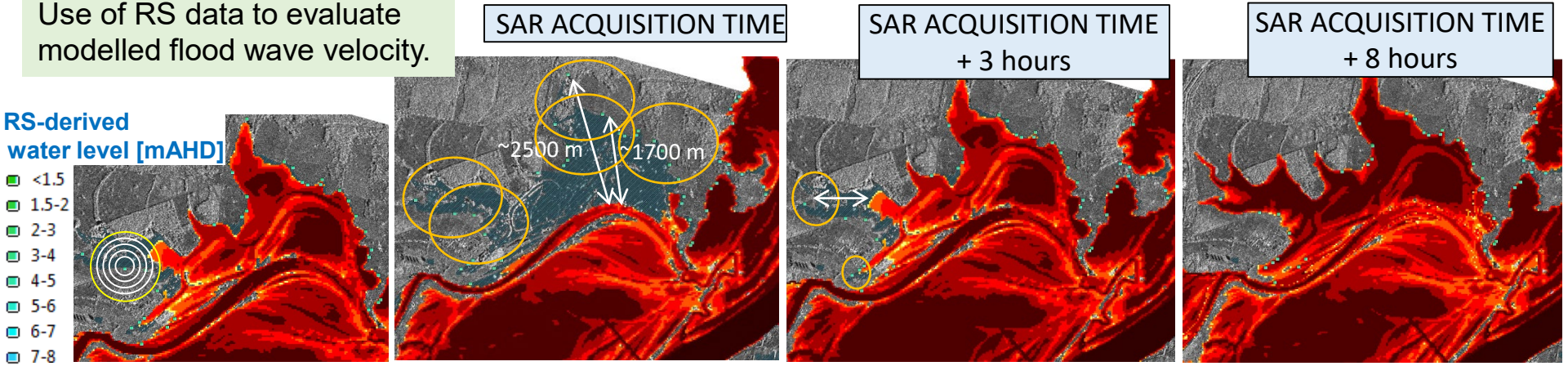
Optimal use of RS-derived information for hydraulic models for flood forecast

How do we include all of this additional information?

Identify critical points on the floodplain, determine if and when these points are inundated,

Compare modelled and observed wet/dry boundary points.

Use of RS data to evaluate modelled flood wave velocity.



Utilization

Recent flood events have shown the importance of flood forecasting to reducing damages to the community, and this research shows the potential of RS to improve flood forecasting across Australia.” – Chris Leahy (Australian Bureau of Meteorology)

“This project has developed an automated method to map flooded vegetation using single synthetic aperture radar acquisition and data products available for whole of Australia. This is a valuable step towards routine use of all-weather satellite observation for flood monitoring in Australia.” - Fang Yuan (Geoscience Australia)

RESEARCH TEAM

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Thanks for your kind attention!

Australian Government
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