Right data needs for a model: simple vs complex in catchment and agricultural settings

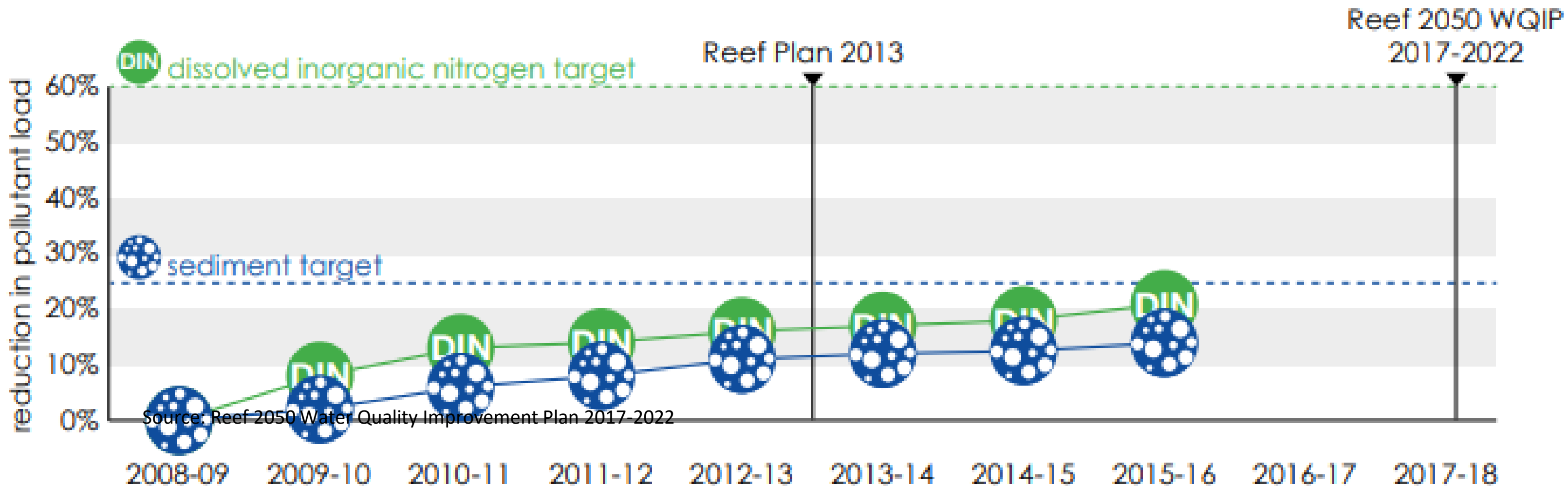
Afshin Ghahramani, David Freebairn

QWMN, Feb 2020

Data

Reef 2050 Water Quality Improvement Plan 2017-2022 **<u>Plan</u>**

Long-term progress towards 2025 water quality targets



Source: Reef 2050 Water Quality Improvement Plan 2017-2022

<u>Targets</u>

A robust and efficient methods of quantifying links between land management and water quality can help to tackle issues with <u>Deficit of Data linking on-farm land management to changes in environmental outcomes</u>.

In this presentation

UNIVERSITY OF SOUTHERN QUEENSLAND

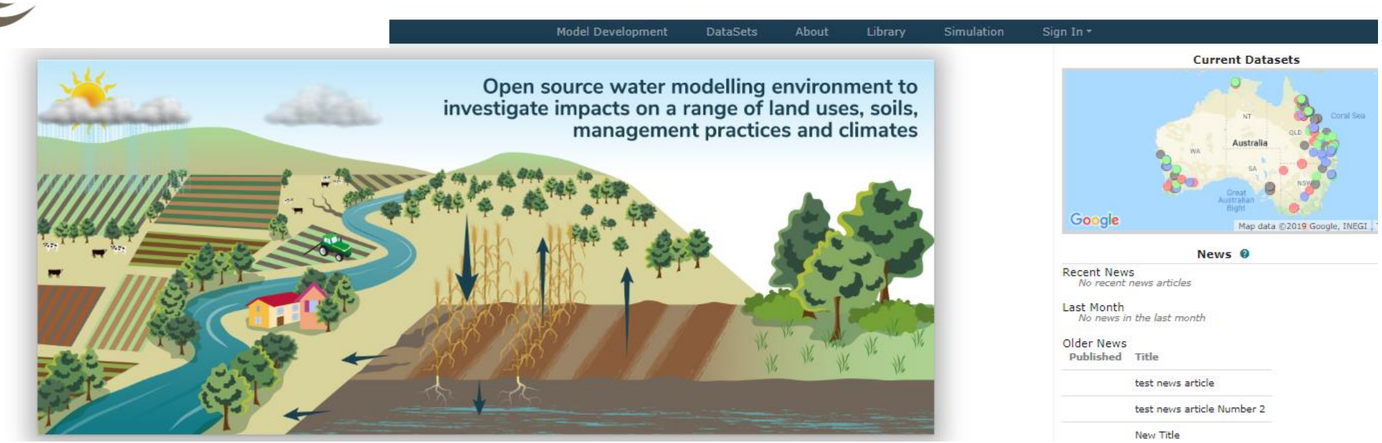
Quantifying links between land management and water quality across diverse environments

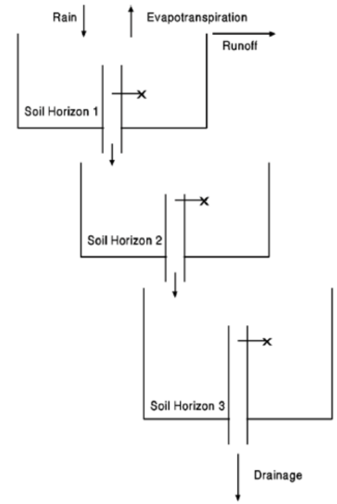
- To maximise the use of available data, regardless of completeness.
- To accommodate datasets that ranges from detailed daily records and site descriptions to sparse and incomplete data.

We explore: the use of a simple approach **for manual model parametrisation** and the impact of the level of **detail in system specification** on the model's ability to represent a range of paddock scale land use.

HOWLEAKY

UNIVERSITY OF SOUTHERN QUEENSLAND





One dimensional water balance model in agricultural systems to assess the impacts of land management, soil, climate-types on water balance and water quality

Applications

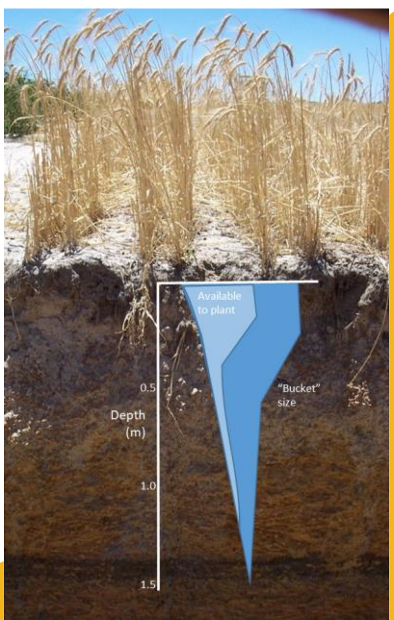
- Paddock modelling
- Catchment scale modelling
- Wide range of water modelling by consultants
- Developing DSS

Cost Effectiveness Calculator

SafeGauge

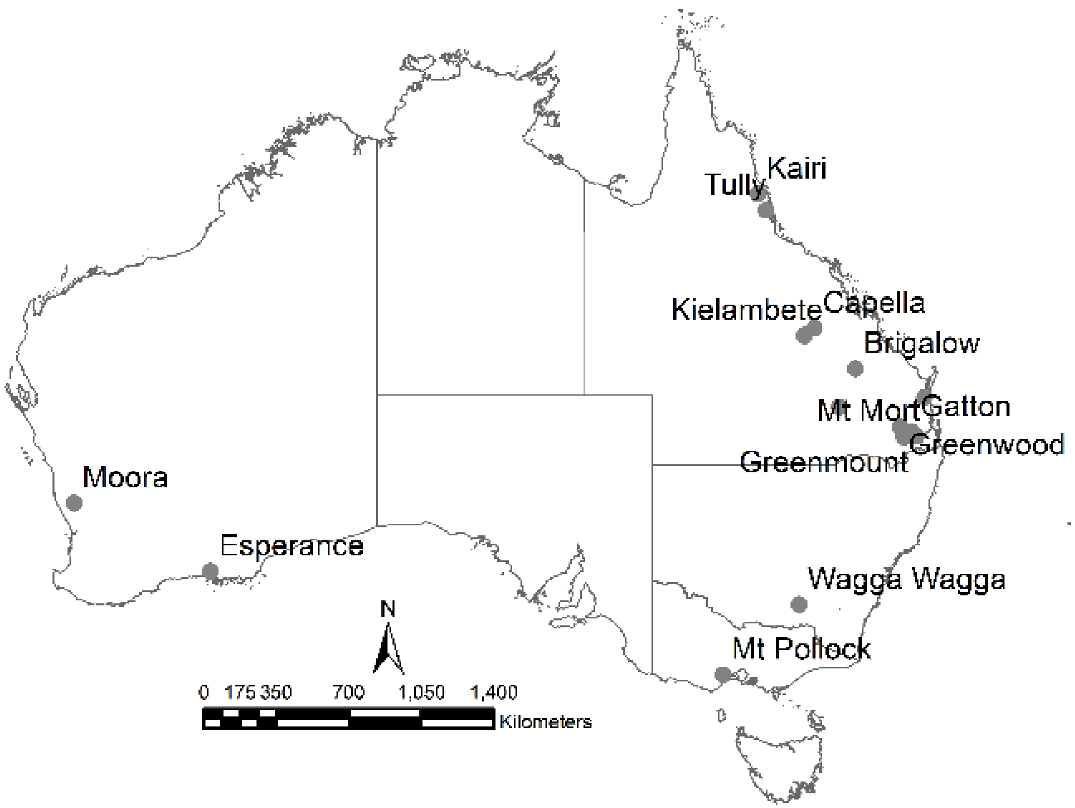
Capability

- Simplicity,
- computational efficient,
- Covering wide area from soil water balance to water quality



Datasets

Location of fifteen sites used in this paper



Approach to comparing detail in the model specification

UNIVERSITY OF SOUTHERN QUEENSLAND

Setup of the soil profile: Different layers

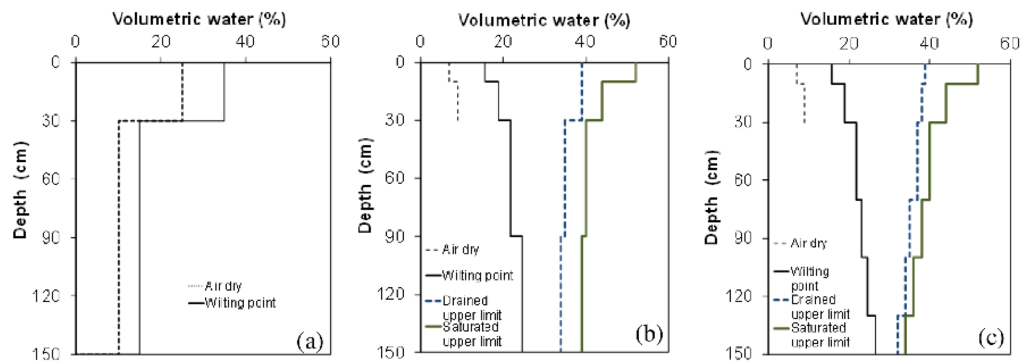
Three levels of soil water description

i. 2-layer using five soil water input variables (n=5);

ii. 4 layers (n=26), and

iii. six layers (n=32).

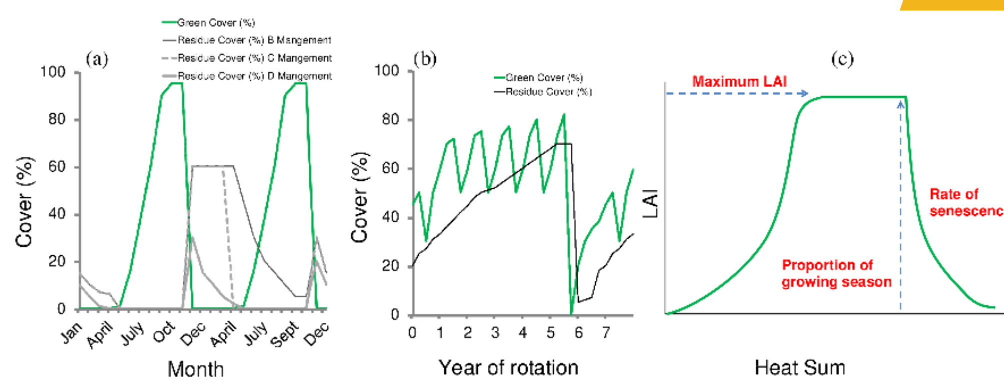
n is the number of variables describing water holding properties.



Vegetation growth model: Semi-static vs dynamic:

i) a simple, semi-static cover description, which typically is average monthly values of plant cover and dead and root depth

i) Leaf Area Index



Soil setup

UNIVERSITY OF SOUTHERN QUEENSLAND

Case study 1: Wallumbilla, SW Qld

- 3 land management practices: **pasture no grazing**, **grazed pasture** and **bare soil**.
- observed green and residue cover , soil profiles, soil erosion, runoff

Three levels of system specification

	Average Annual runoff (mm)				Average Annual soil erosion (t/ha)			
	Observed	Prediction			Observed	Prediction		
Soil resolution		2 layer	4 layer	6 layer		2 layer	4 layer	6 layer
Winter crop, tilled	55	44	54	57	3.3	2.5	3.4	3.6
Pasture, light grazing	14	27	18	17	0.3	0.2	0.2	0.2

5 ha catchments, 3-15 years data, Brown Sodosol Wallumbilla, Queensland (Freebairn et al. 2009).

Vegetation cover setup

UNIVERSITY OF SOUTHERN QUEENSLAND

Case study 2: tillage, Greenwood, South Qld

- a semi-static representation of green and residue cover;
- A dynamic LAI model where the model adjusts cover (green and residue) on a daily basis through feedbacks from soil water, temperature, crop growth and tillage.

Both models specify ~30-40 variables but the static model's input is more transparent to a non-specialist (i.e. non-modeller).

	Average Annual runoff (mm)			Average Annual soil erosion (t/ha)		
	Observed	Prediction		Observed	Prediction	
dynamic/semi-static		Static	Dynamic		Static	Dynamic
Stubble burnt	85	86	95	39	37	39
Disc tillage	71	80	81	10	15	24
Blade tillage	65	70	65	5	7	5
No tillage	66	63	60	3	3	4

0.8 ha catchments, 6 years data, winter crops with a range of stubble management: model specified as a) static annual cover pattern, and b) dynamics crop LAI and residue cover, tillage and planting dates specified (Freebairn and Wockner 1986a).

Contrasting environments and land uses

UNIVERSITY OF SOUTHERN QUEENSLAND

- **Sub-tropical landscapes (crops and pasture):** Kairi Research Station

four soil management conditions: bare soil; cropping aggressive tillage, cropping with reduced tillage; and pasture

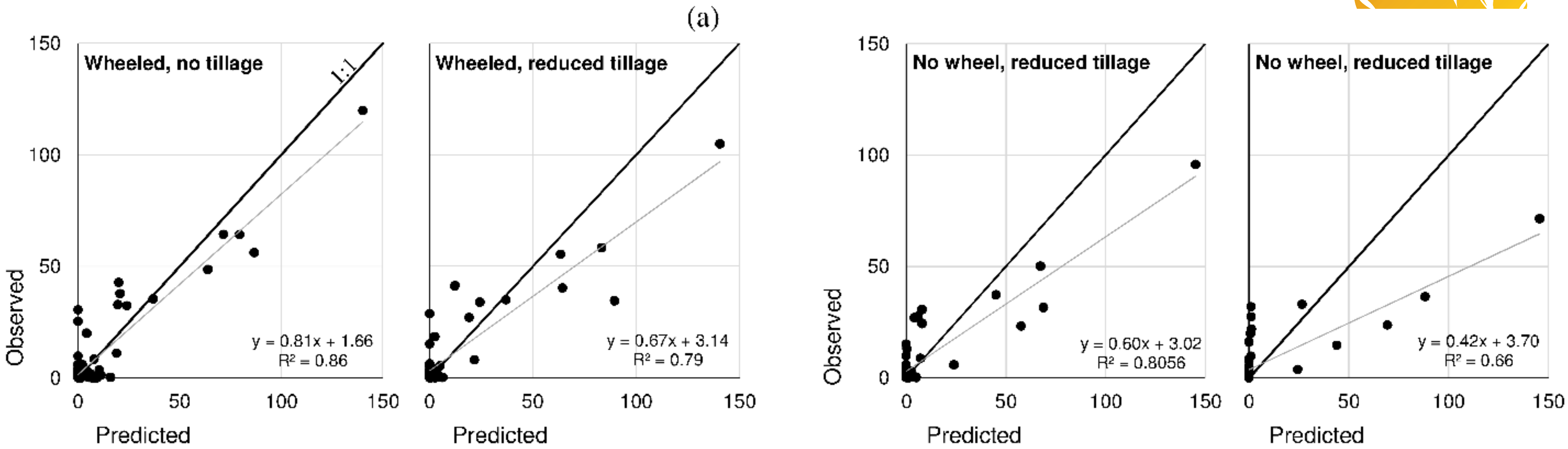
- **Cropping lands (Tillage, stubble, and compaction management):** Southern Queensland, Gatton Research Station

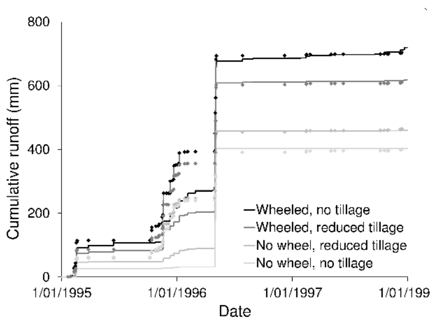
Three tillage systems: stubble mulch; minimum till and zero till; with and without wheel track compaction created a range of soil cover and compaction conditions on small plots.

Site and Management description	Runoff (mm)		Sediment (t/ha)		Phosphorus (kg/ha)	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
Crop, pasture, north Queensland, Kairi Research Station (Cogle et al, 2011)						
Bare soil	282	269	21	17	23	31
Cropped & tilled	116	93	5	4	7	8
Cropped & reduced tillage	93	91	3	3	6	6
Pasture, high cover	77	78	0.8	0.5	2	2
Crop, southern Queensland, Gatton Research Station (Tullberg et al. 2001)						
Wheeled, reduced tillage	237	240				
Wheeled, no tillage	217	206				
No wheel, reduced tillage	154	150				
No wheel, no-tillage	134	134				

Daily output

Gatton Research Station



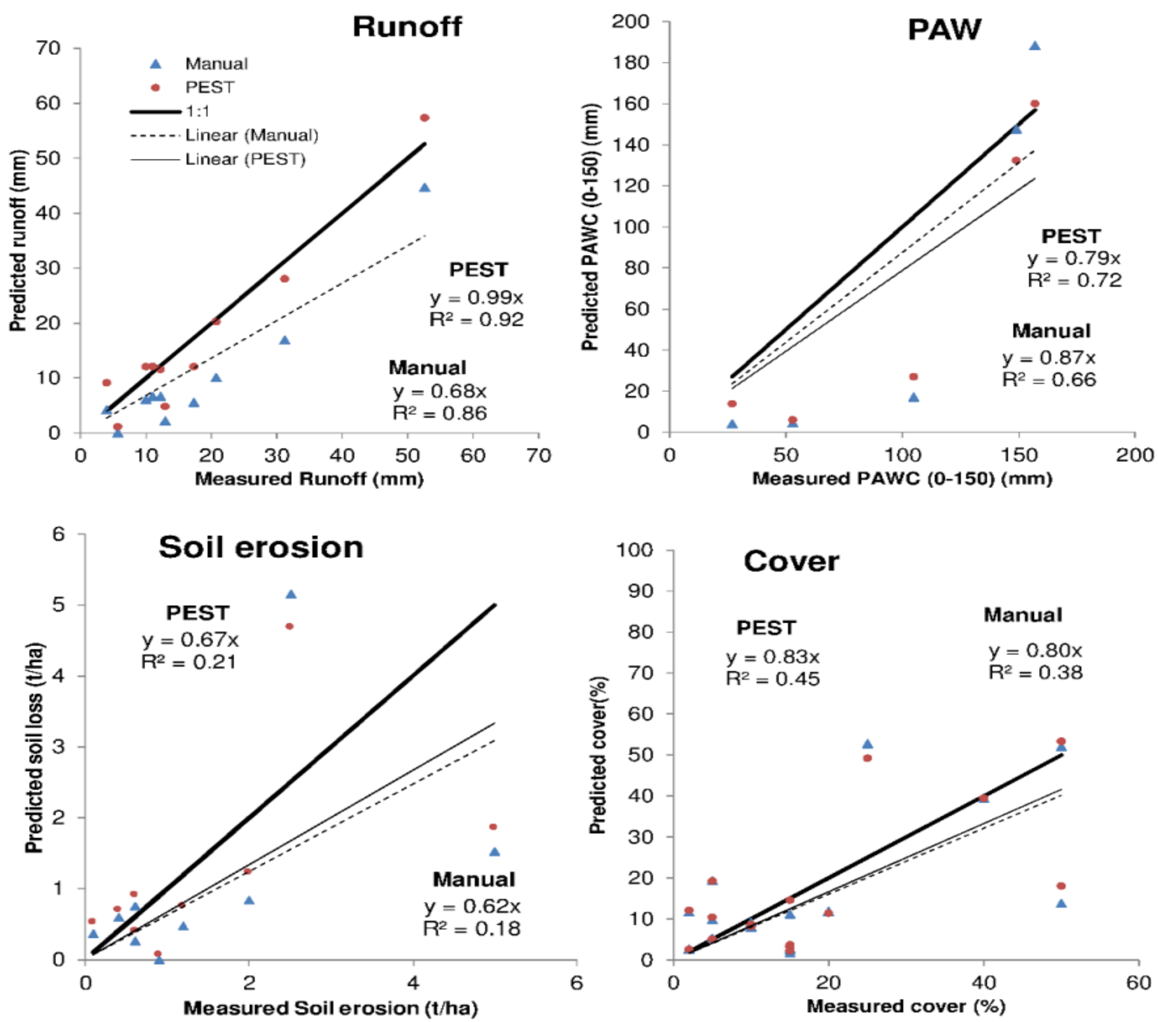


	Wheeled, no tillage		Wheeled, reduced tillage		No wheel, reduced tillage		No wheel, no tillage	
Method	Value	Agreement	Value	Agreement	Value	Agreement	value	Agreement
NSE	0.86	Very good	0.78	Very good	0.75	Very good	0.57	Satisfactory
PBIAS	-2.21	Very good	-1.39	Very good	0.27	Very good	-0.51	Very good

Manual Vs automatic calibration

UNIVERSITY OF SOUTHERN QUEENSLAND

Comparison between simulation results of manual calibration and automated PEST supported calibration at Wallumbilla (a difficult site to model).

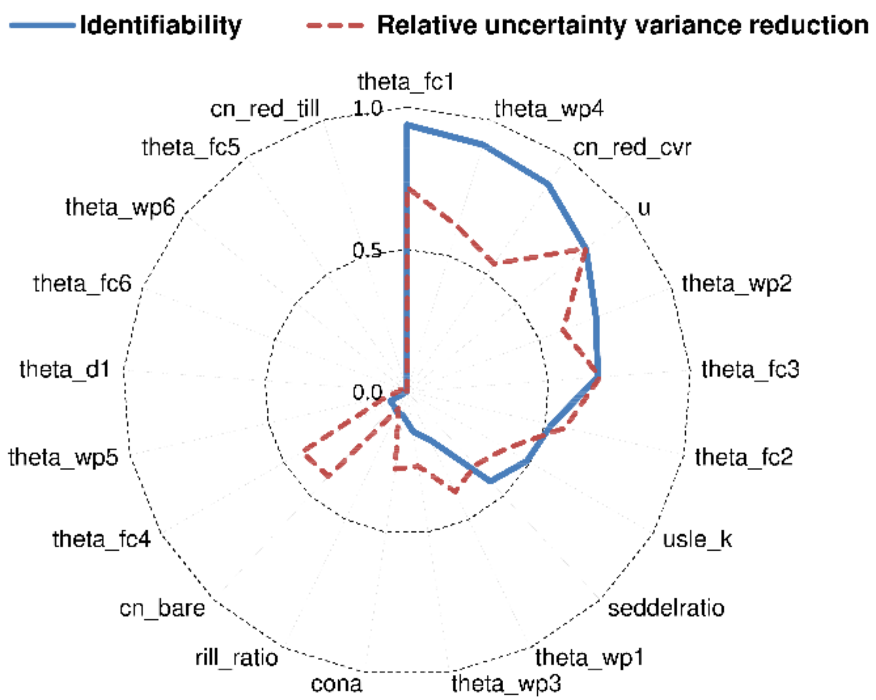


Calibration was performed for daily data during 1983-1991 and validations (this figure) for daily data of 1992-1995

Not a great improvement

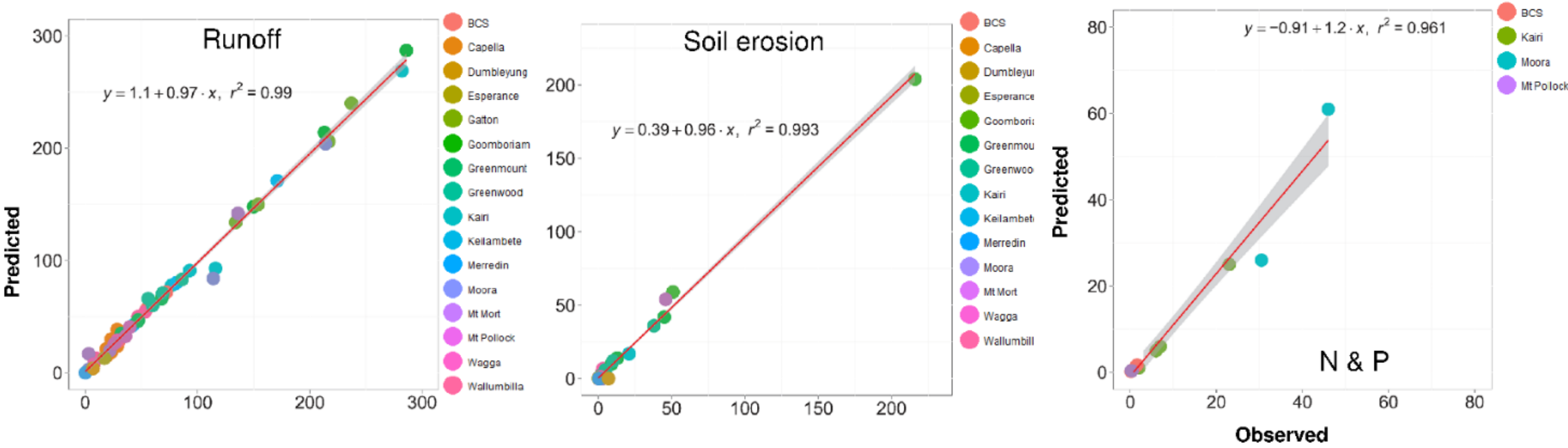
Manual Vs automatic calibration

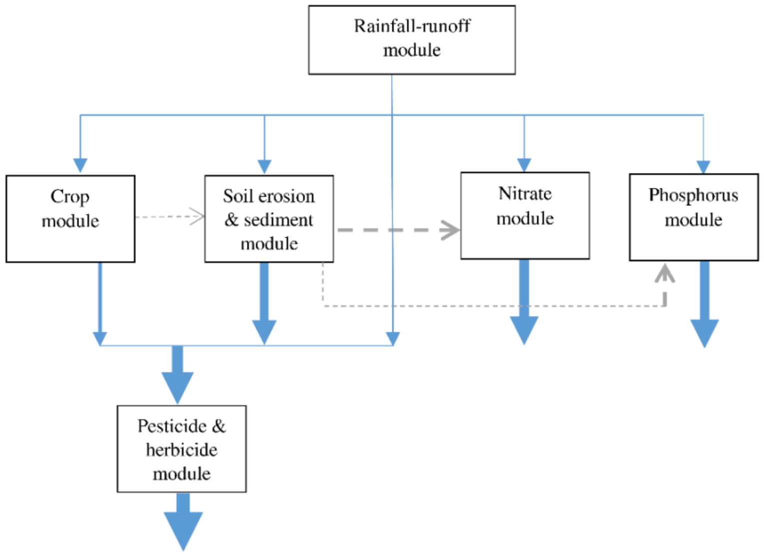
Sensitivity of the parameters, Identifiability, Uncertainty



Identifiability and uncertainty of the model parameters post automatic calibration.

Diverse environments; applying manual calibration at other locations





How pragmatic was an expert calibration?

A simple model worked to describe the general characteristics of the hydrology and water quality and importantly, the impact of management for a wide range of environments and management conditions.

- Daily and annual patterns of runoff for a wide range of climates (annual average rainfall of 1230 mm at Kairi catchment in north Queensland to 430 mm at Moora in Western Australia).

- Land use included annual crops, pastures, and horticulture, all with varying soil conditions while soil types ranged from heavy clays to deep sands.

This diversity of conditions was described using a simple and efficient process.

Summary

UNIVERSITY OF SOUTHERN QUEENSLAND

- We can quantifying links between land management and water quality

- Relying on existing, relatively simple, and familiar model can be sufficient for some of decision making, e.g. estimating water quality signatures in the Great Barrier Reef catchments.

- But a requirement for reducing uncertainties may push the user to a particular approach suited to the model i.e. a more complex parameter calibration procedure.

- This result does not reject requirements for complex modelling when complexities are unavoidable, e.g. mixed farming systems

Should note that Greater complexity may only increase the uncertainties related to the over-parametrisations or use of the models by people with insufficient skills (Jakeman et al., 2006) or not having enough data or suitable model.

Remaining Q

- Can we identify climate signals? and seperate effect of land use management and climate?
- If we had perfect data, would our models be any better?

Thank you very much

Afshin Ghahramani

University of Southern Queensland

Afshin.Ghahramani@usq.edu.au

Data

Shift in the culture to make government data more accessible and usable by public is a priority of the Australian Government (Paterson et al., 2016).

Accessible data & modelling results, model parameter sets to community?

Issues and solutions with data and models

General issues in model governance:

- Redundancy,
- Capability of integration with each other,
- Transparency,
- Reproducibility,
- On-going maintenance.

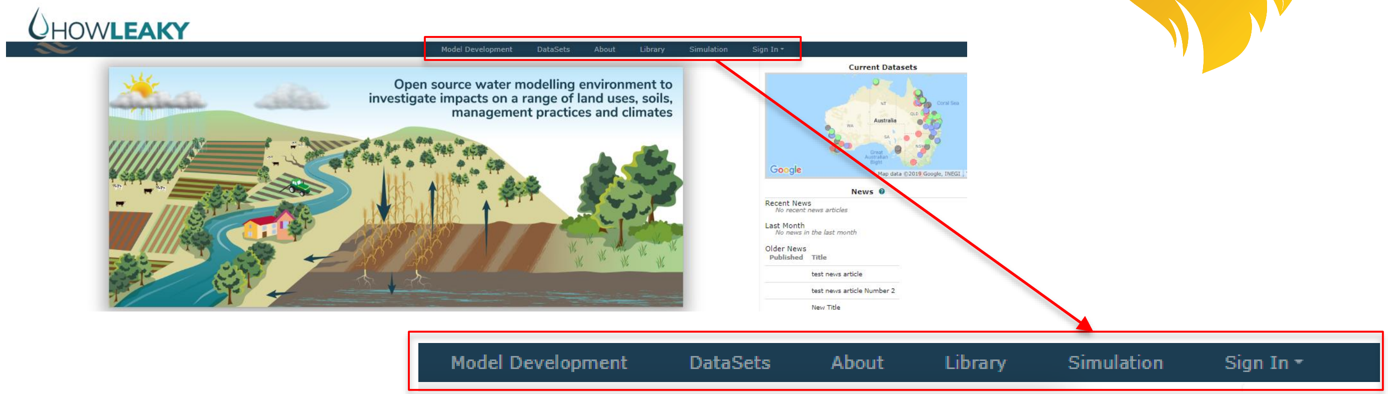
An open source and community driven platform integrates **capabilities of**

- **Model development,**
- **Dataset management,**

General issues in model governance:

One solution

Accessibility and governance; HowLeaky Platform



<u>Components</u>
Model development,
Dataset management,
Simulations

Datasets associated with models and parameters are a critical intellectual component of research platforms

Datasets are vital for
Transparent development and verification processes

Accessible data & model parameter sets to community

Model growth by community
Comparison of the models

Shift in the culture to make government data more accessible and usable by public is a priority of the Australian Government (Paterson et al., 2016).