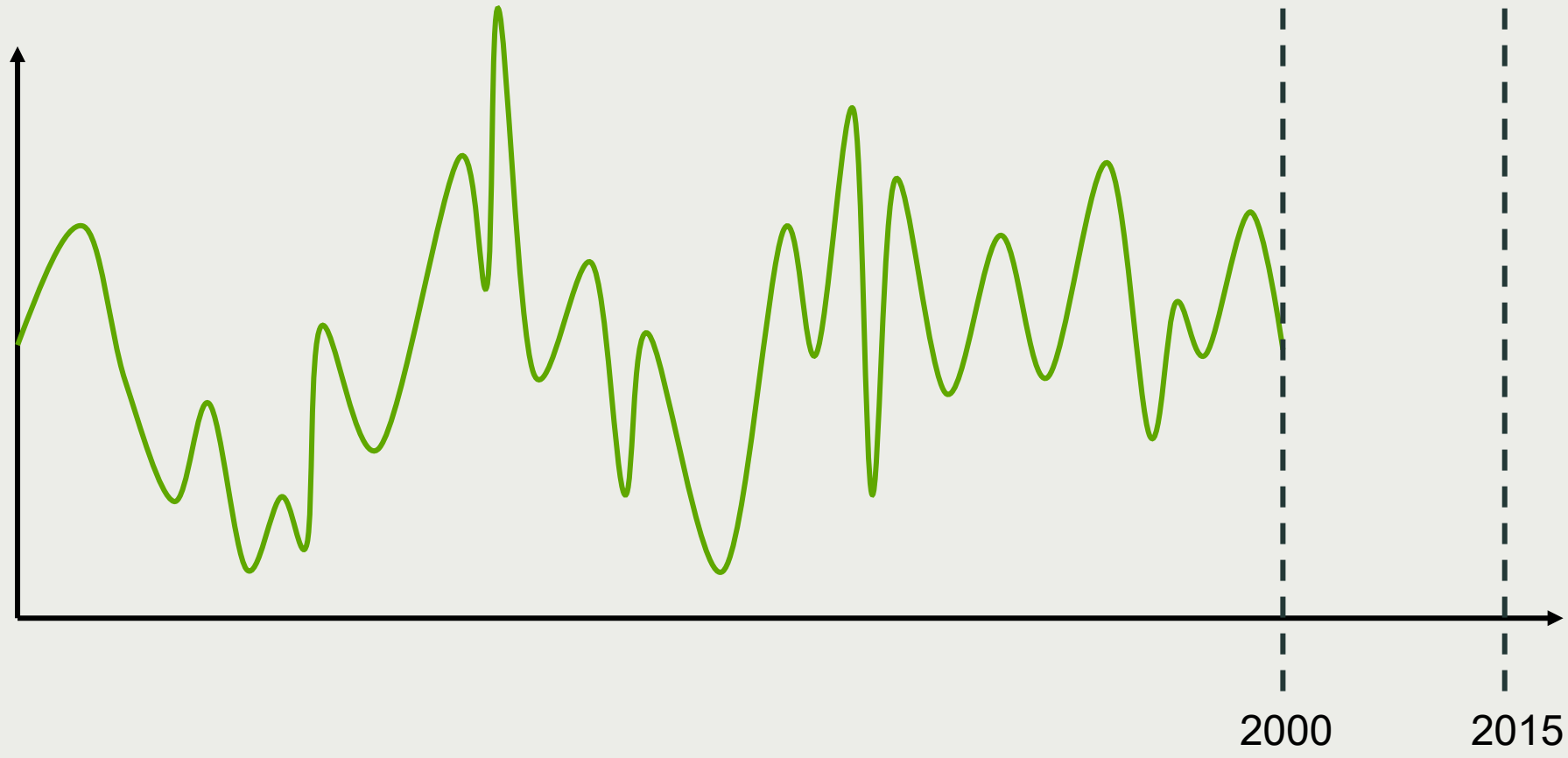
The benefit of perfect knowledge……



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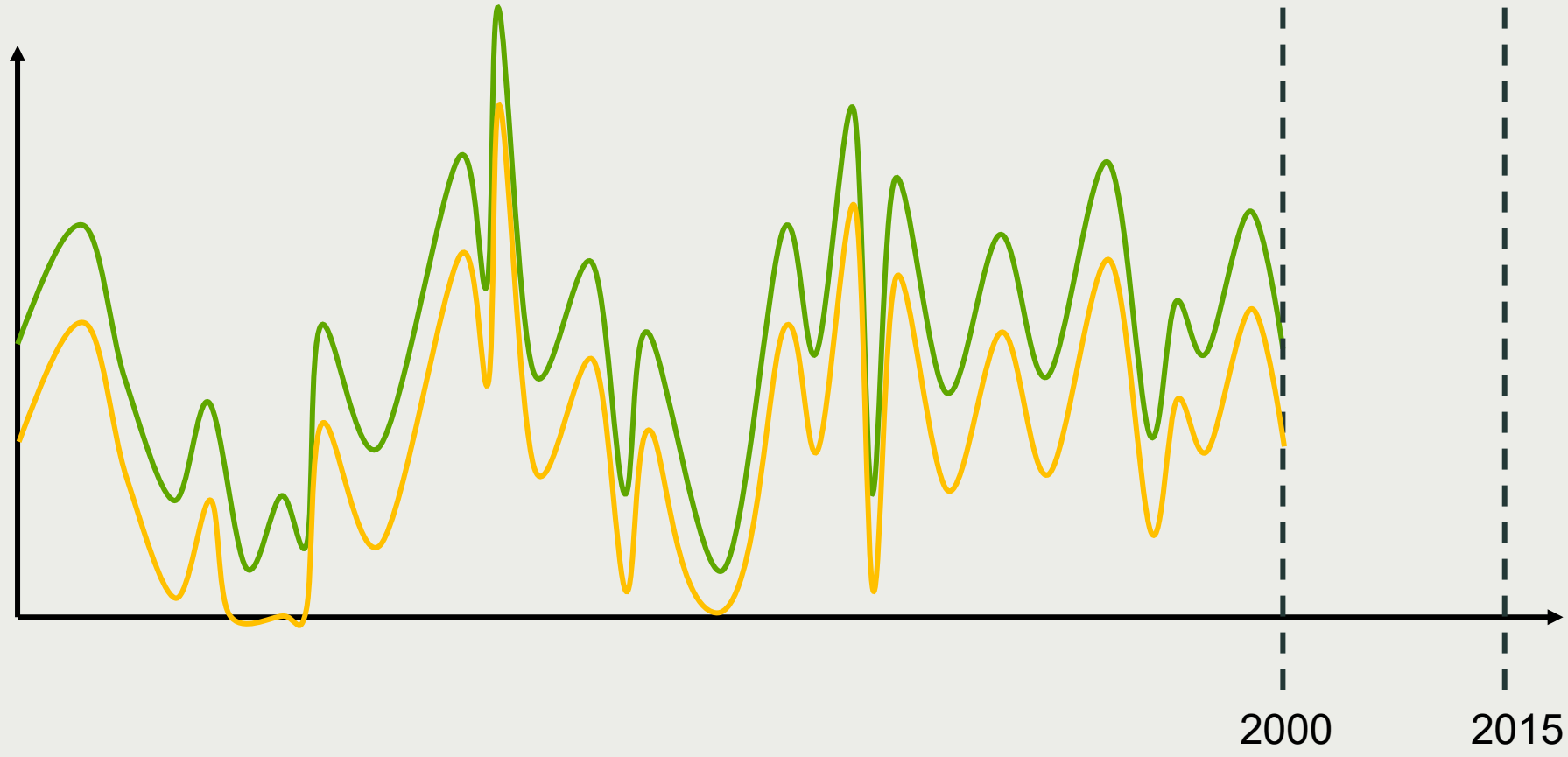

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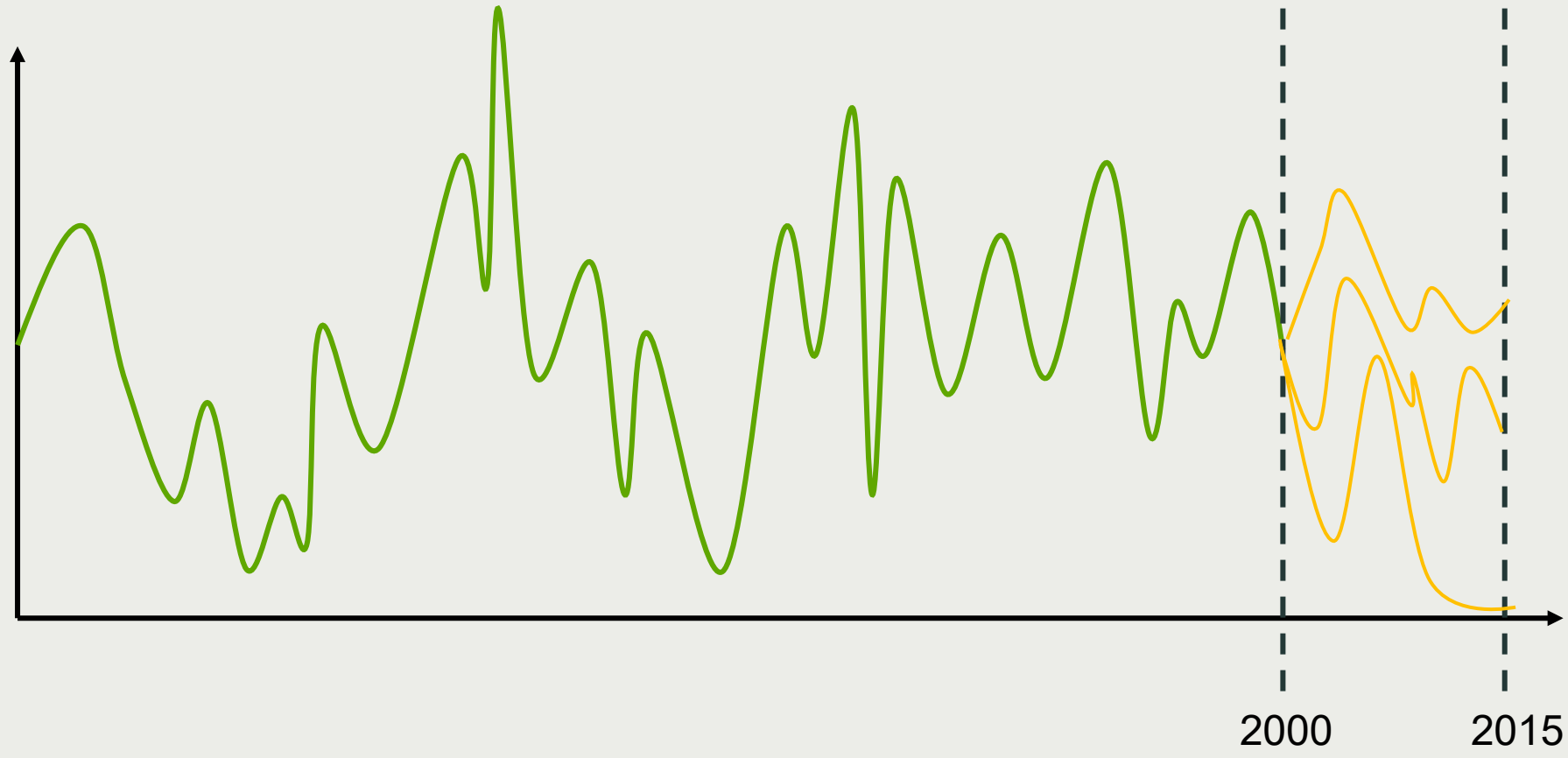

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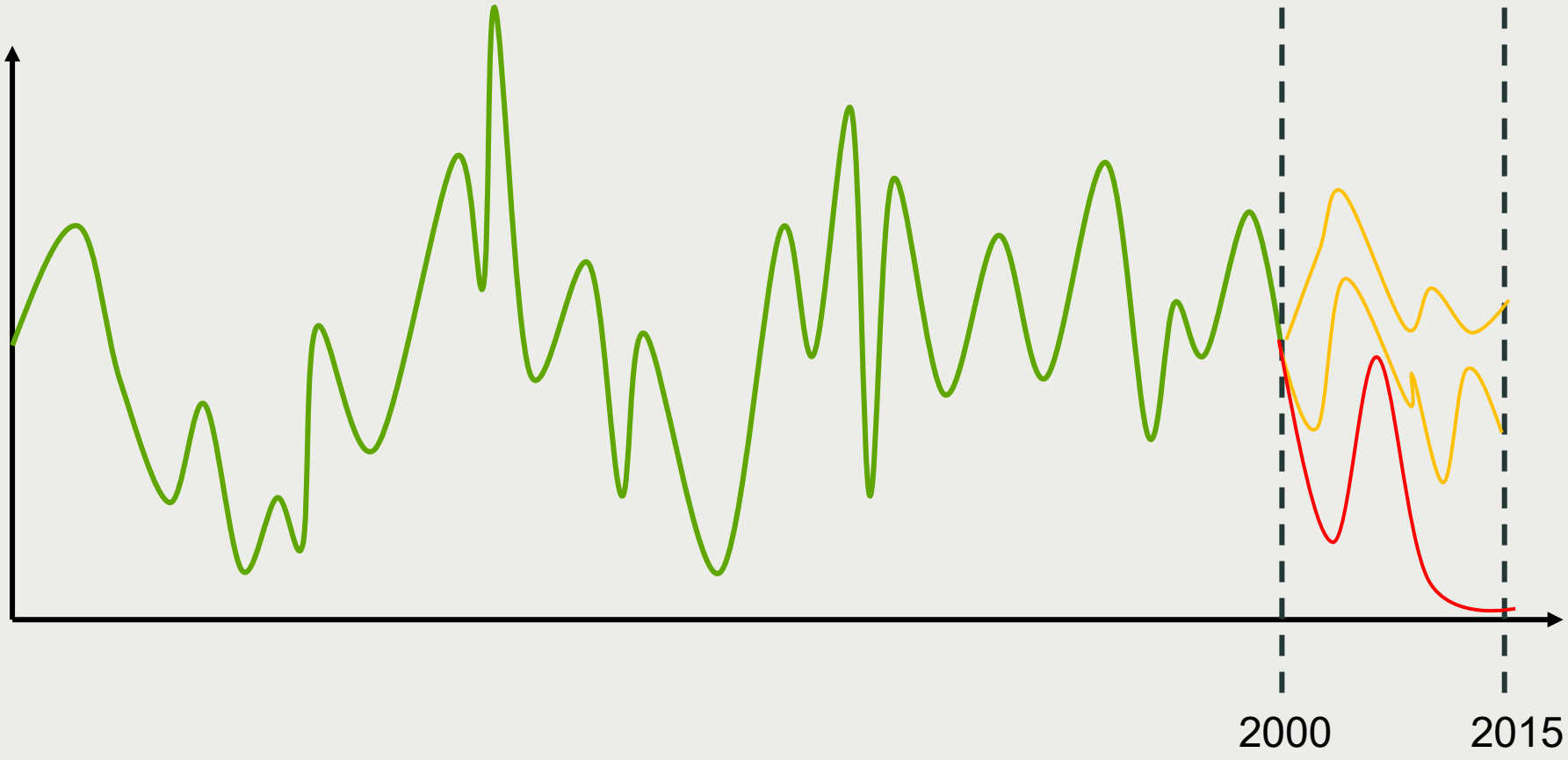
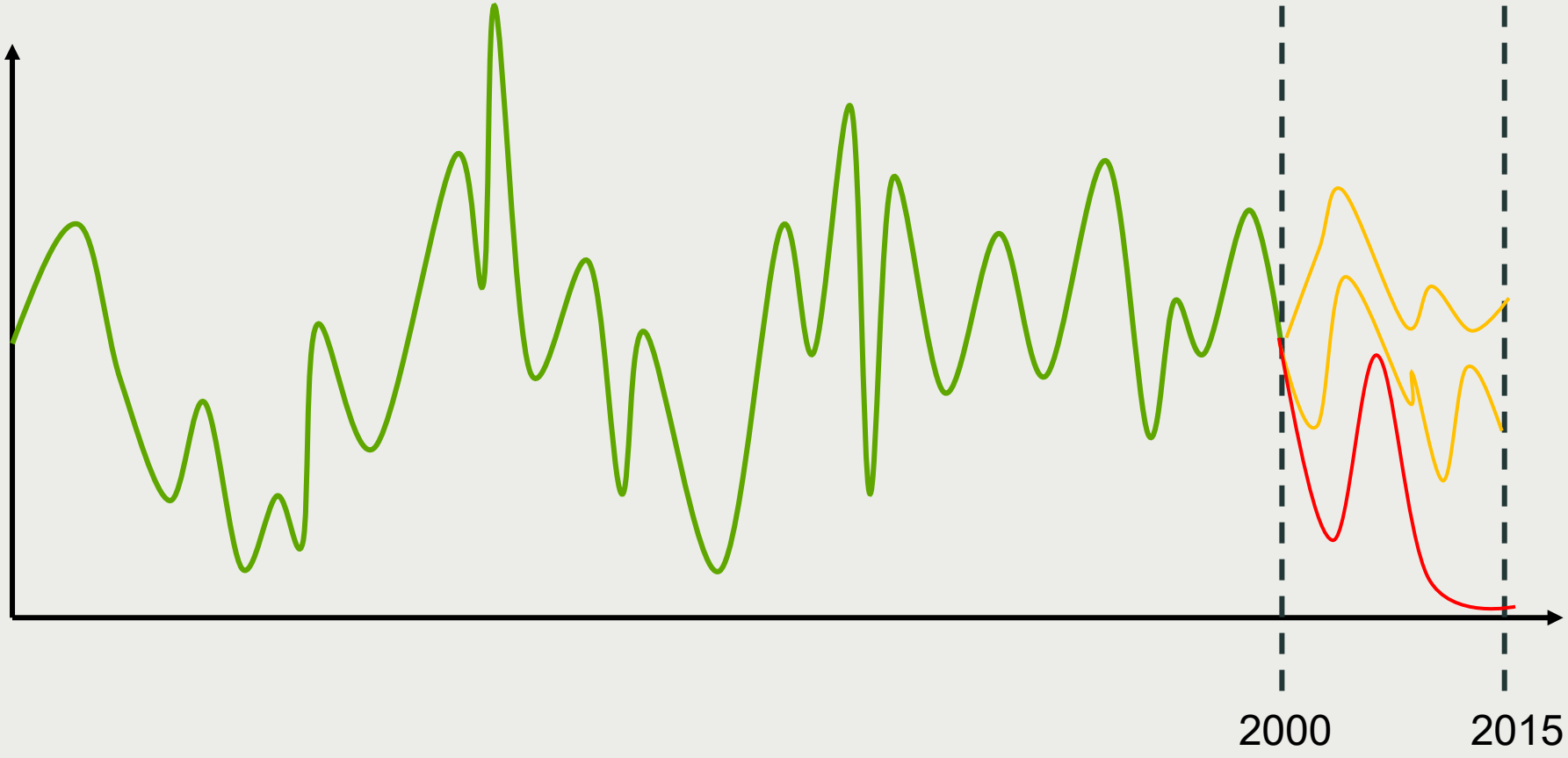


The benefit of perfect knowledge.



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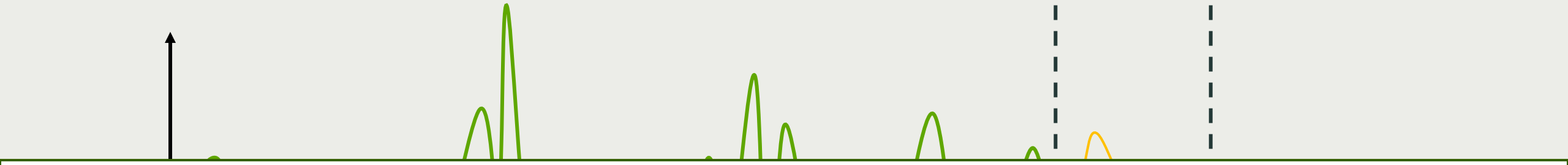


We want to understand

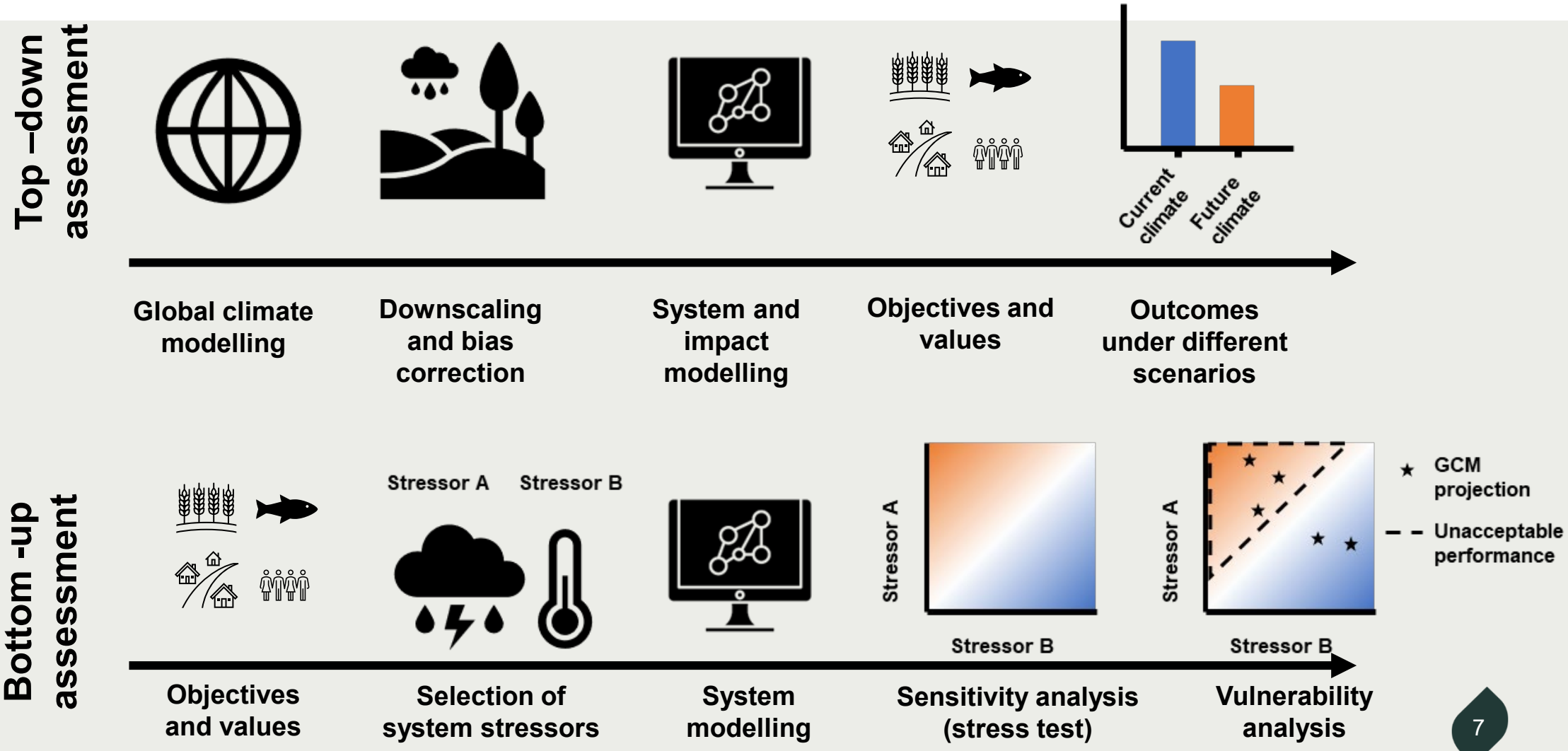
Robustness

Can a system cope with a wide range of conditions? Are the benefits of a management intervention also seen across a range of possible future conditions?

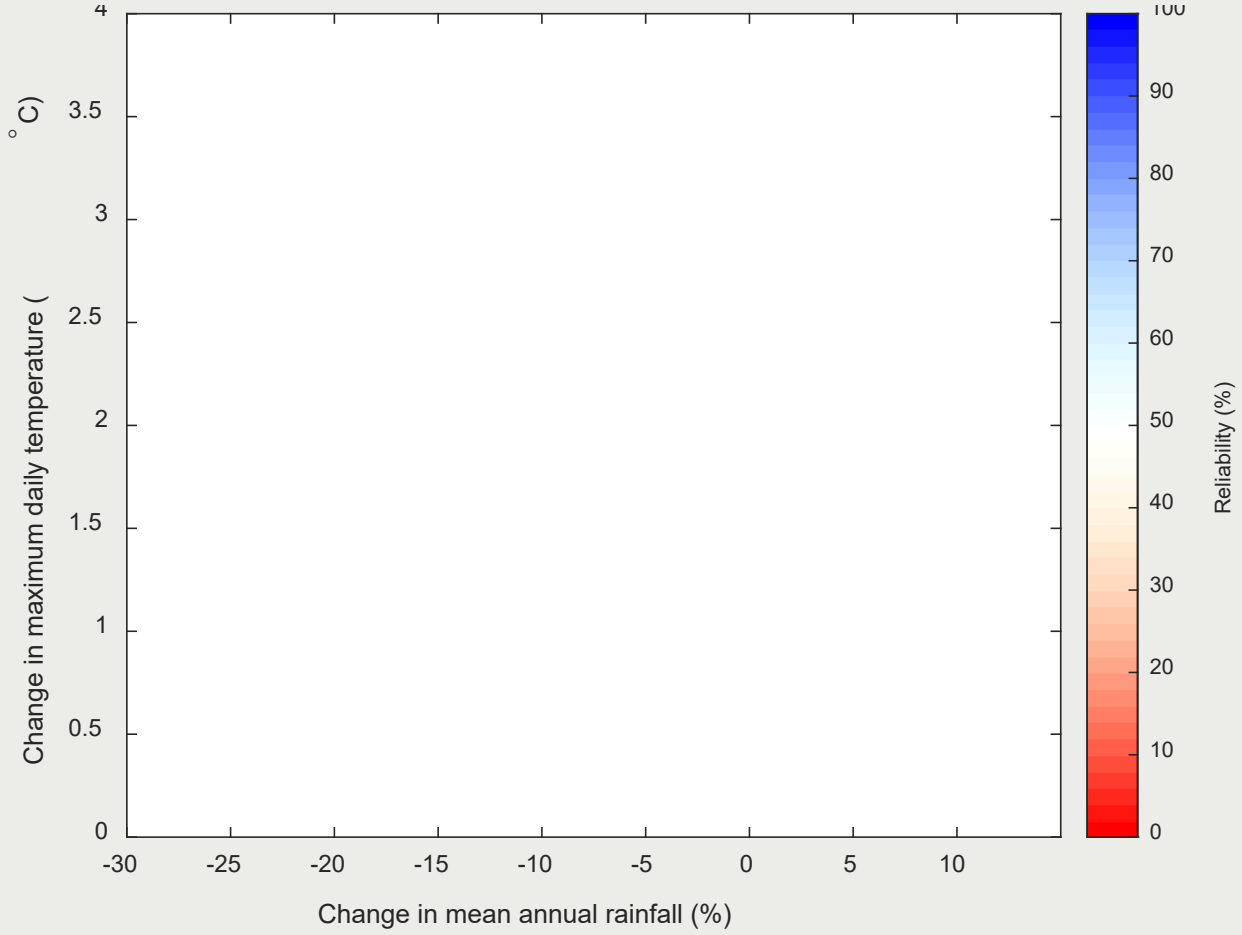
Sensitivity

How does a system respond to changes in inputs? What are the most important changes?

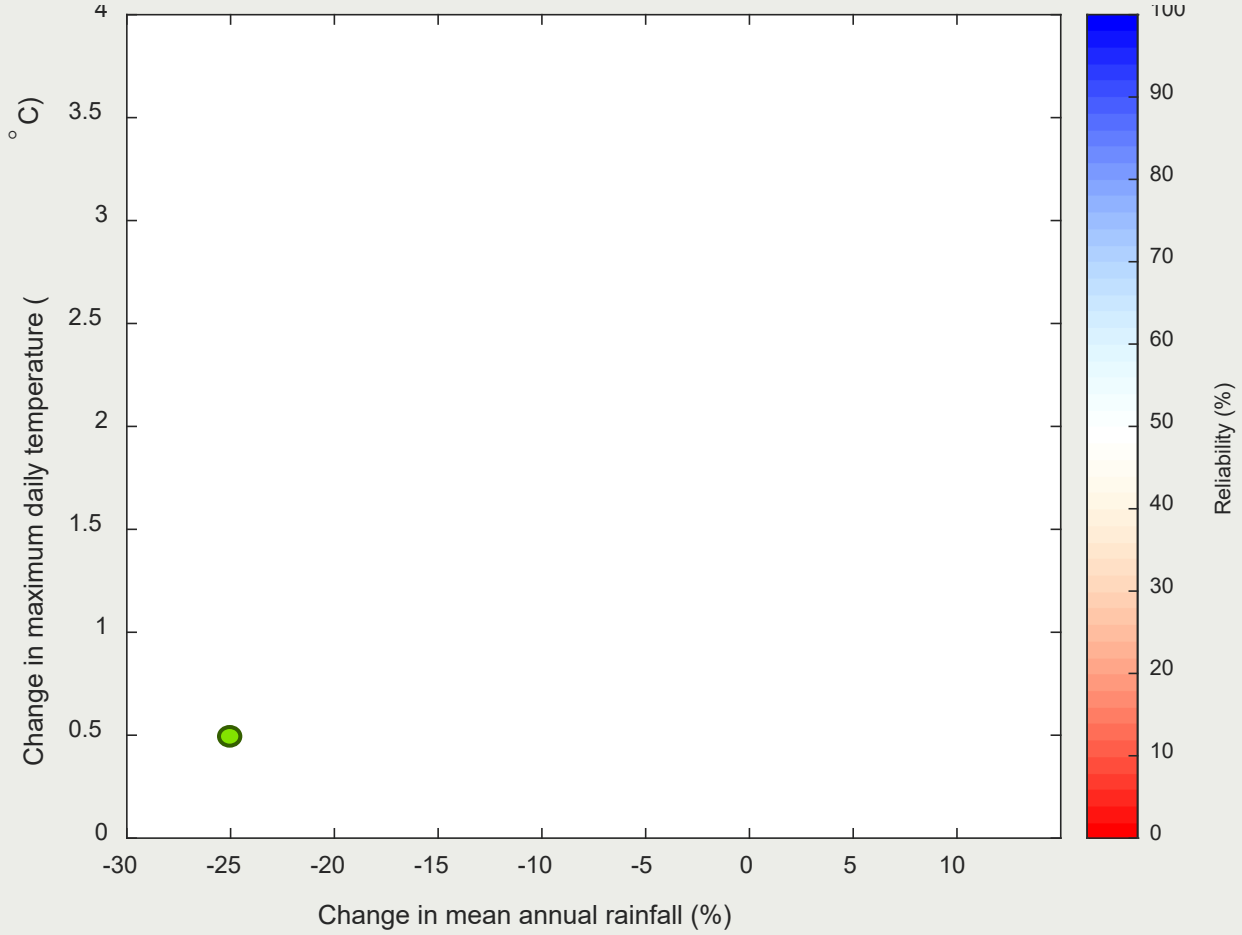
What is stress testing and why would we do it?



Stress test


Change in maximum daily temperature (°C)
4
3.5
3
2.5
2
1.5
1
0.5
0
-30
-25
-20
-15
-10
-5
0
5
10
Change in mean annual rainfall (%)
100
90
80
70
60
50
40
30
20
10
0
Reliability (%)

Stress test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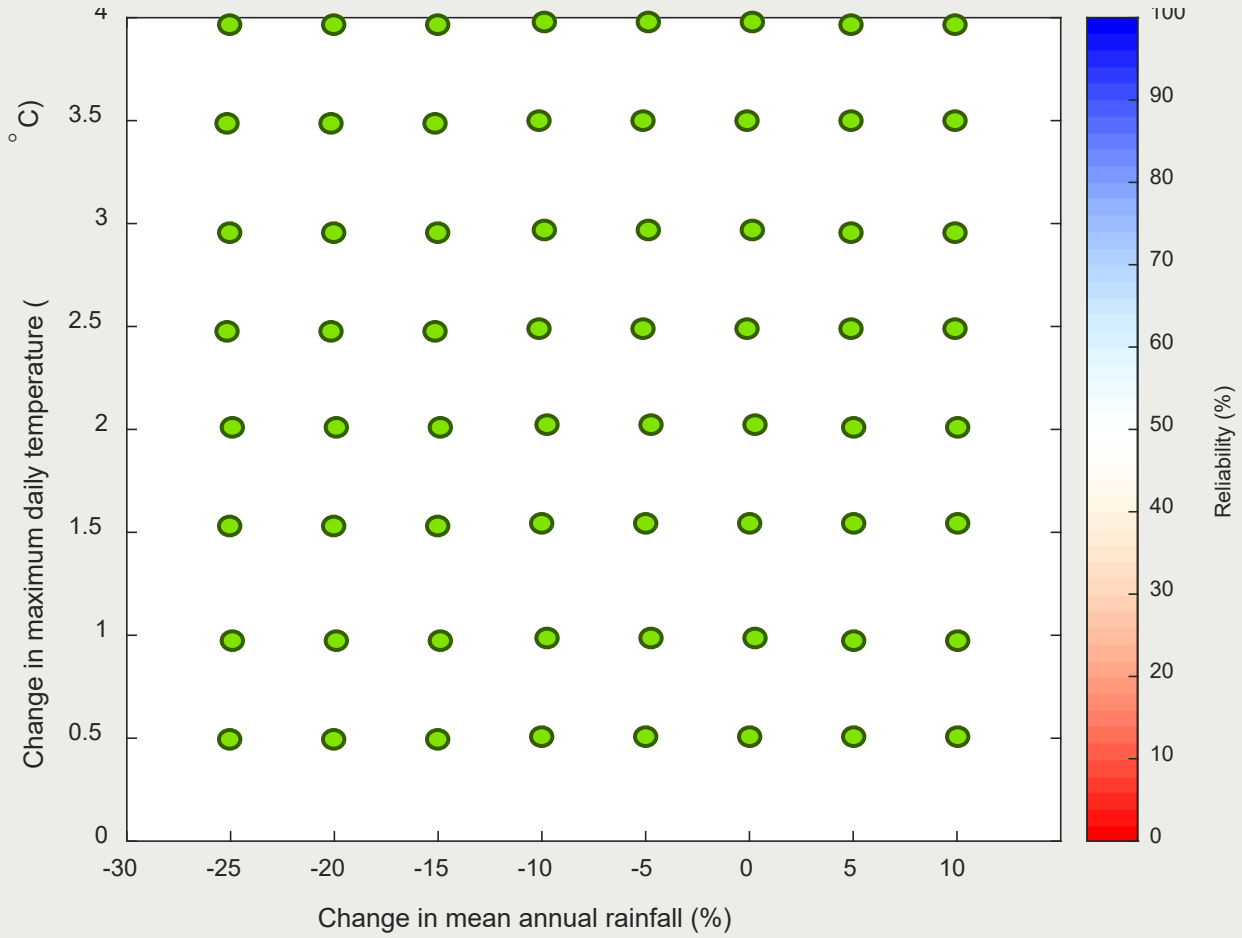
Stress test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Change in mean annual rainfall (%)
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80
70
60
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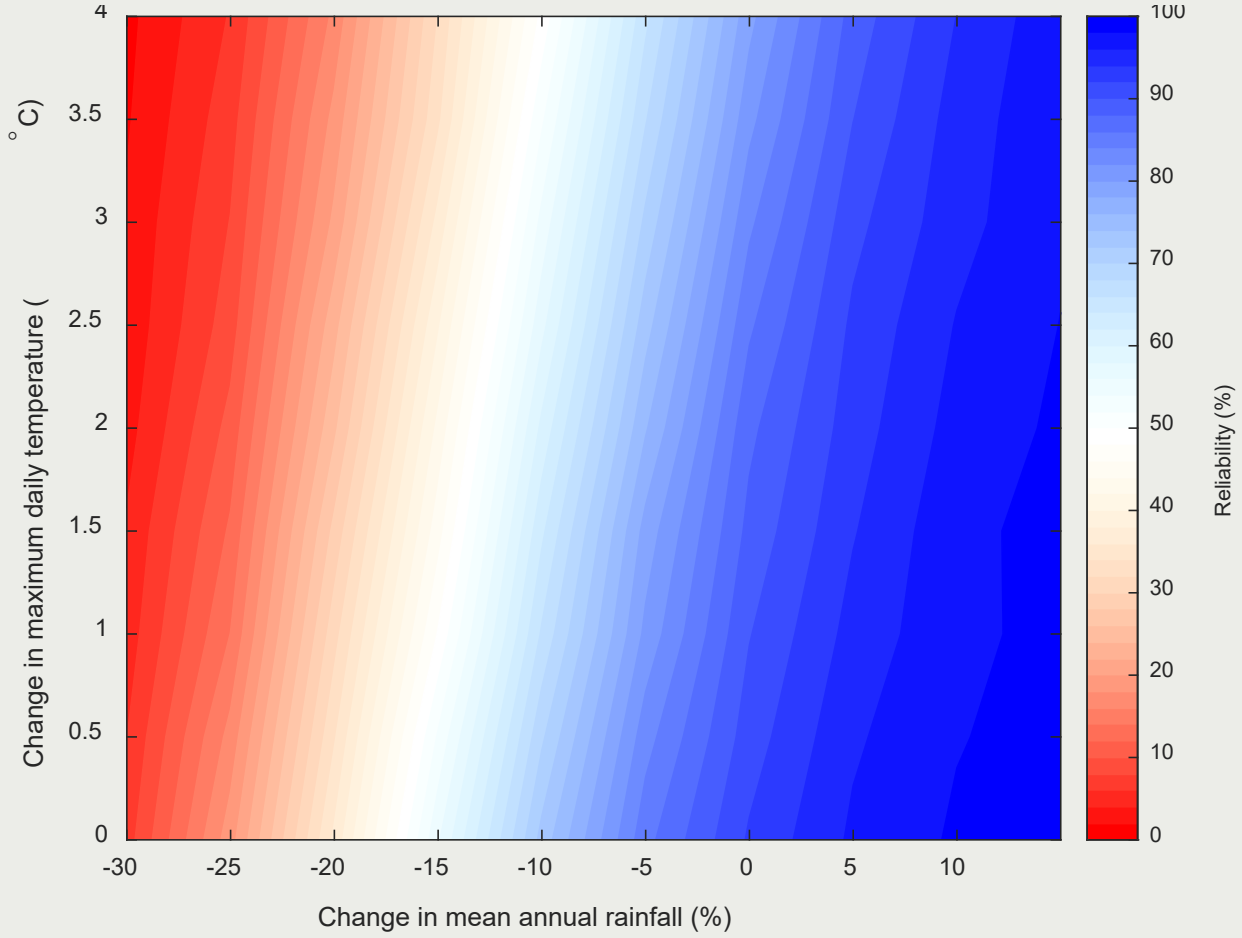
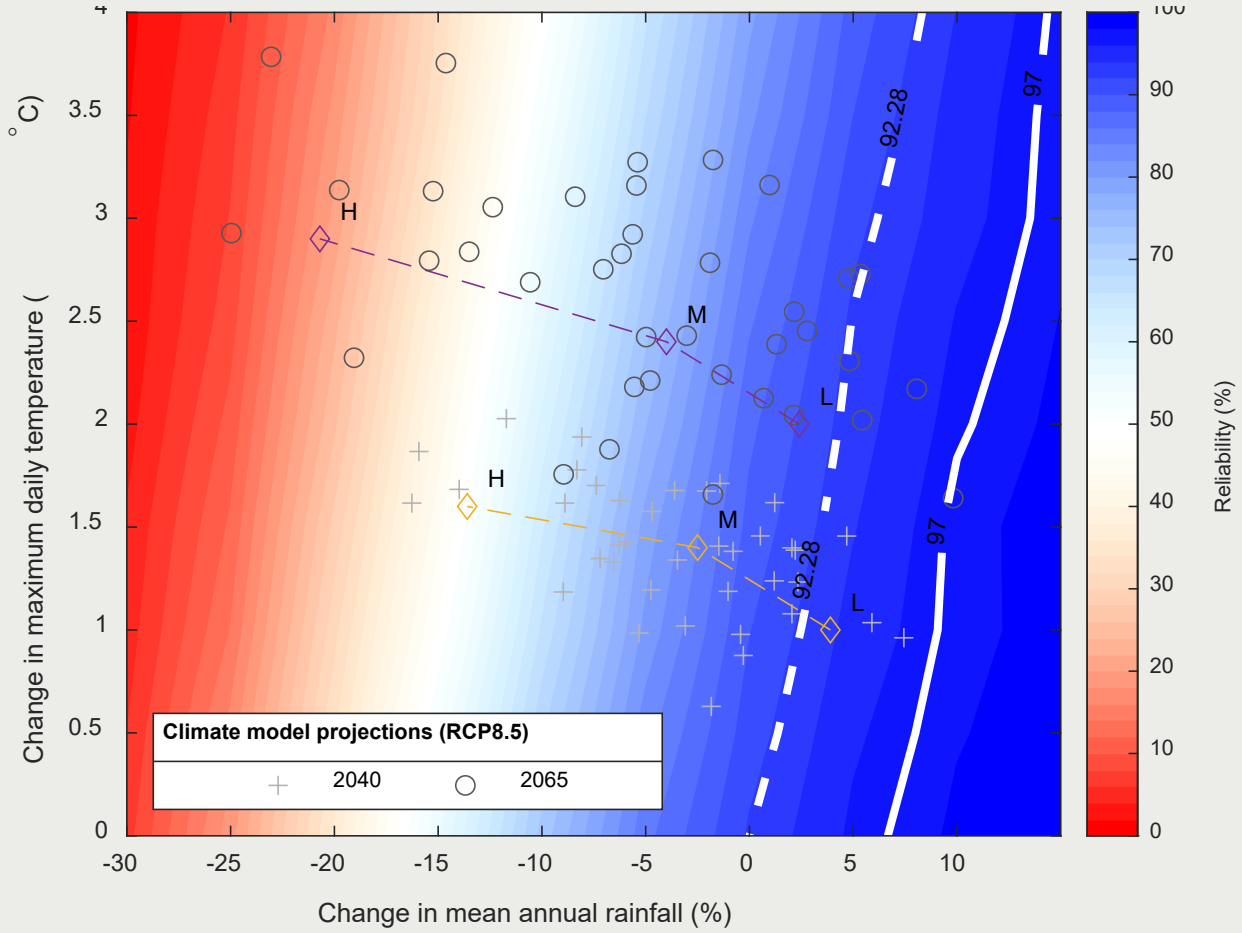
10
0

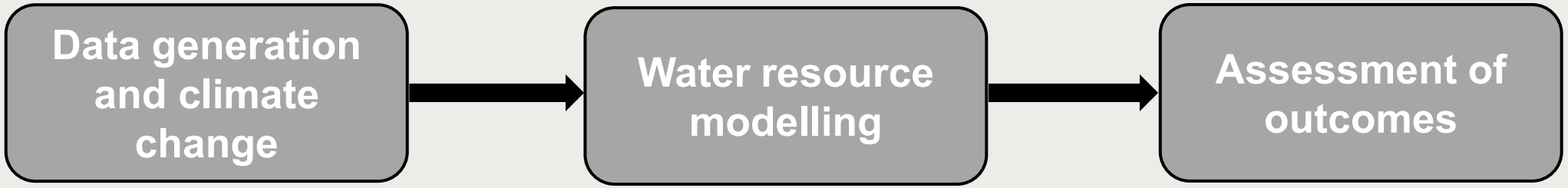
Concept of a vulnerability surface



Concept of a vulnerability surface



But how do we do it?



Climate and runoff inputs

- For multiple dimensions
- At many increments of change
- Spatially and temporally consistent at scale
- Stochastic data for sequences and high impact events

Able to support very large scenario analysis

- Right level of detail
- Represent regulated system management
- Current decision making

Tailored to risk assessment

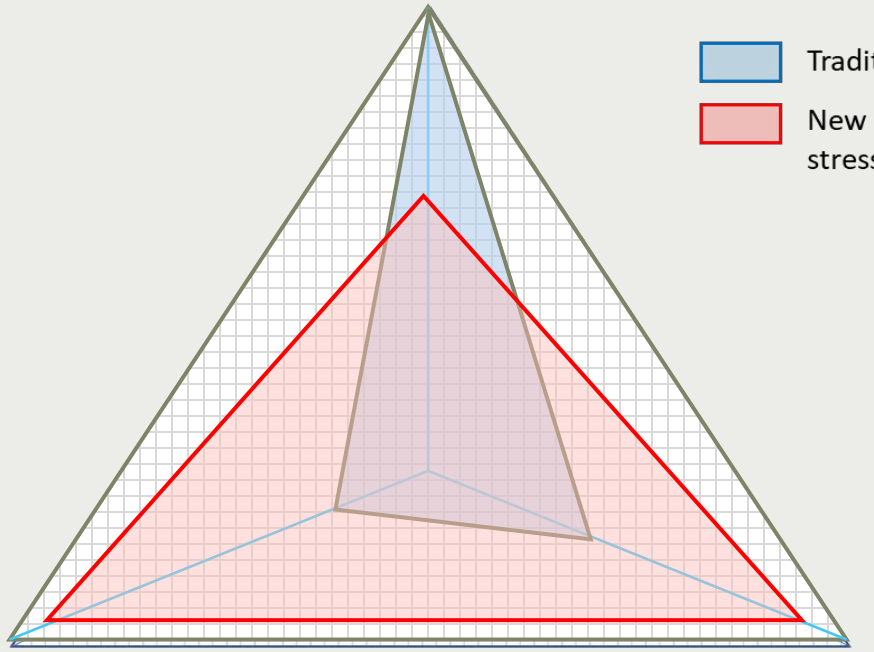
- What is success or failure?
- Economic, social or environmental impact models?

Commensurate complexity

But how do we do it?

Precision:

Spatial and temporal resolution, comprehensiveness



Traditional approaches

New approaches suited to stress testing and uncertainty

Speed:

Computational efficiency

Uncertainty analysis

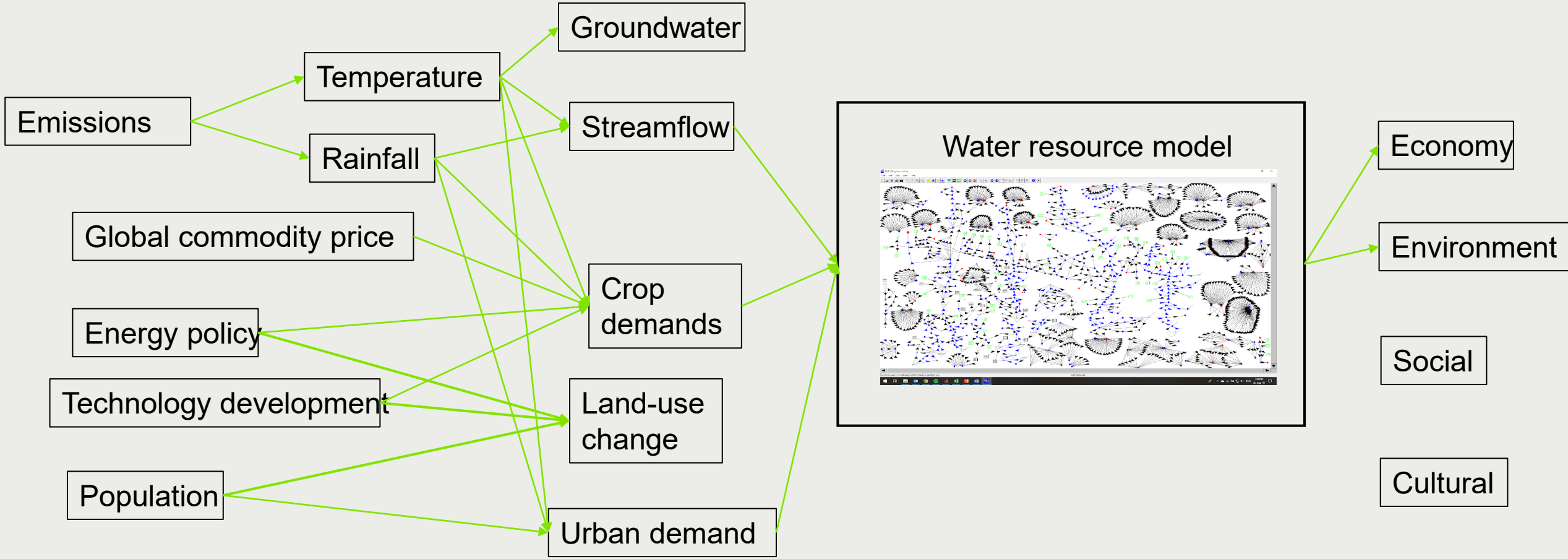
Flexibility:

Ease of making changes/interventions

Contemporary questions

Assess interactions and dependencies

But how do we do it?



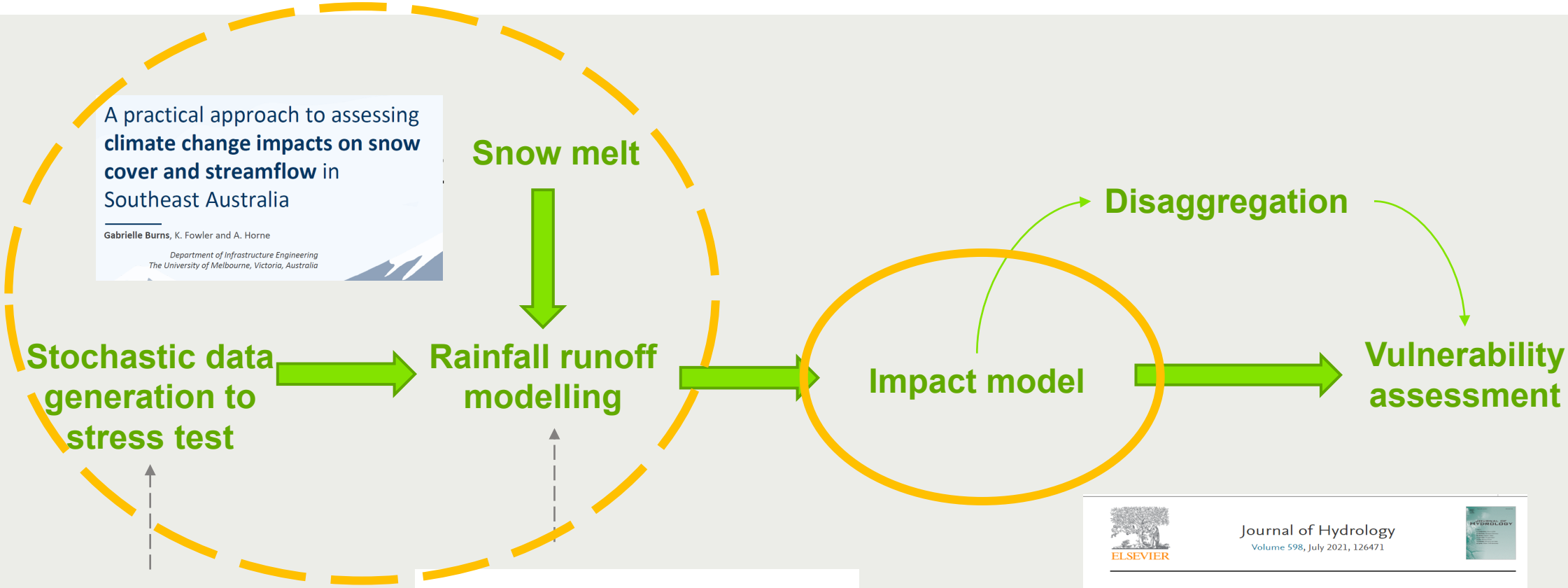
Our approach

- Generating stochastic climate impacted inflow data across the Murray Darling Basin

- Novel methods for rapid impact modelling
    - Statistical models for water allocations in sMDB
    - Machine learning emulator models for instream flow at indicator sites

Making use of existing water resource modelling efforts
Providing complementary analysis and outputs

Our approach



Integrated framework for rapid climate stress testing on a monthly timestep

Keirnan Fowler, Natasha Ballis, Avril Horne, Andrew John, Rory Nathan, Murray Peel

Water Resources Research

Research Article | Open Access

Simulating Runoff Under Changing Climatic Conditions: A Framework for Model Improvement

Keirnan Fowler, Gemma Coxon, Jim Freer, Murray Peel, Thorsten Wagener, Andrew Western, Ross Woods, Lu Zhang

ELSEVIER

Journal of Hydrology

Volume 598, July 2021, 126471

Research papers

Disaggregated monthly hydrological models can outperform daily models in providing daily flow statistics and extrapolate well to a drying climate

Andrew John, Keirnan Fowler, Rory Nathan, Avril Horne, Michael Stewardson

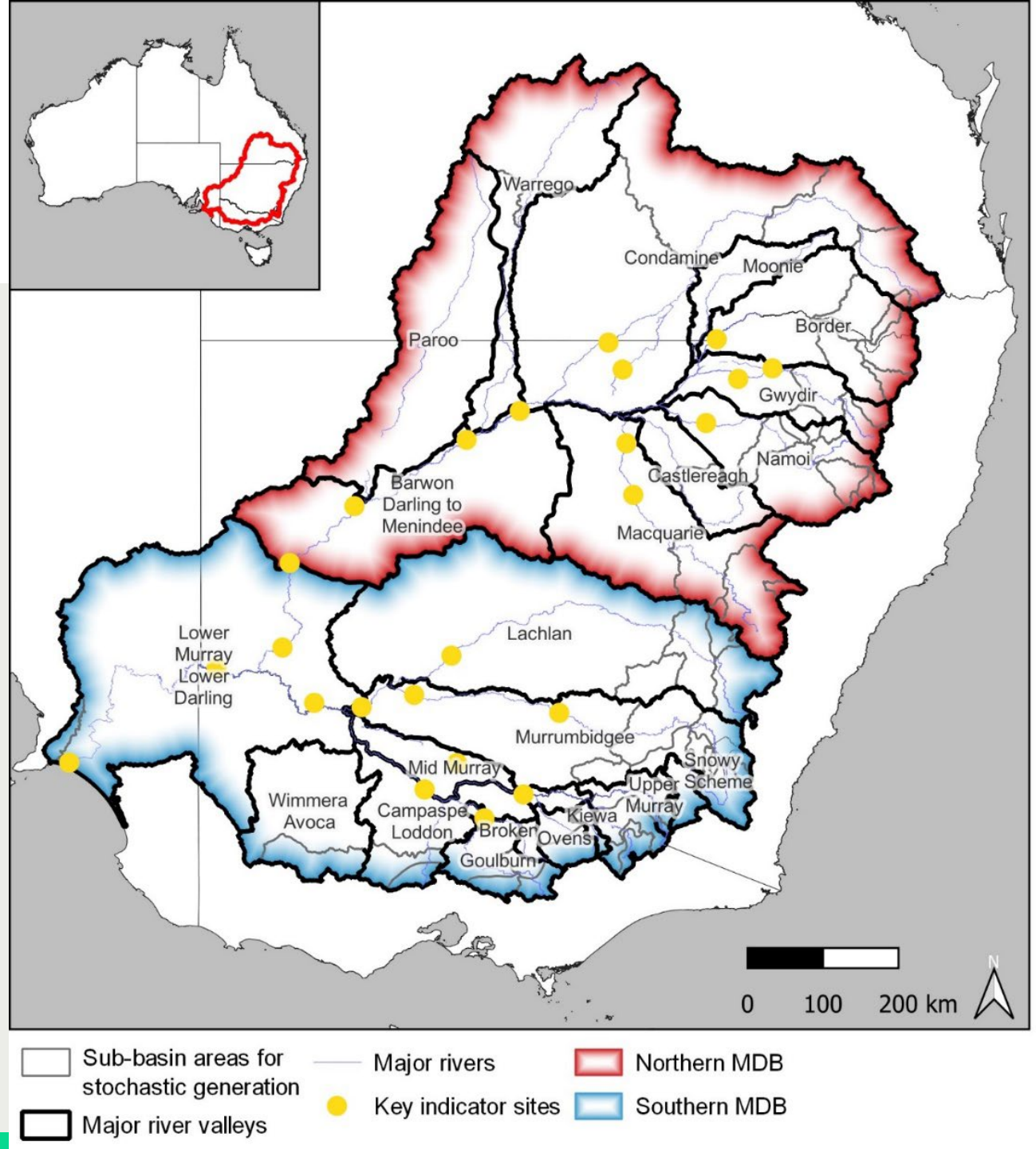
Stochastic inflows - Generating data across the Basin

21 major river valleys

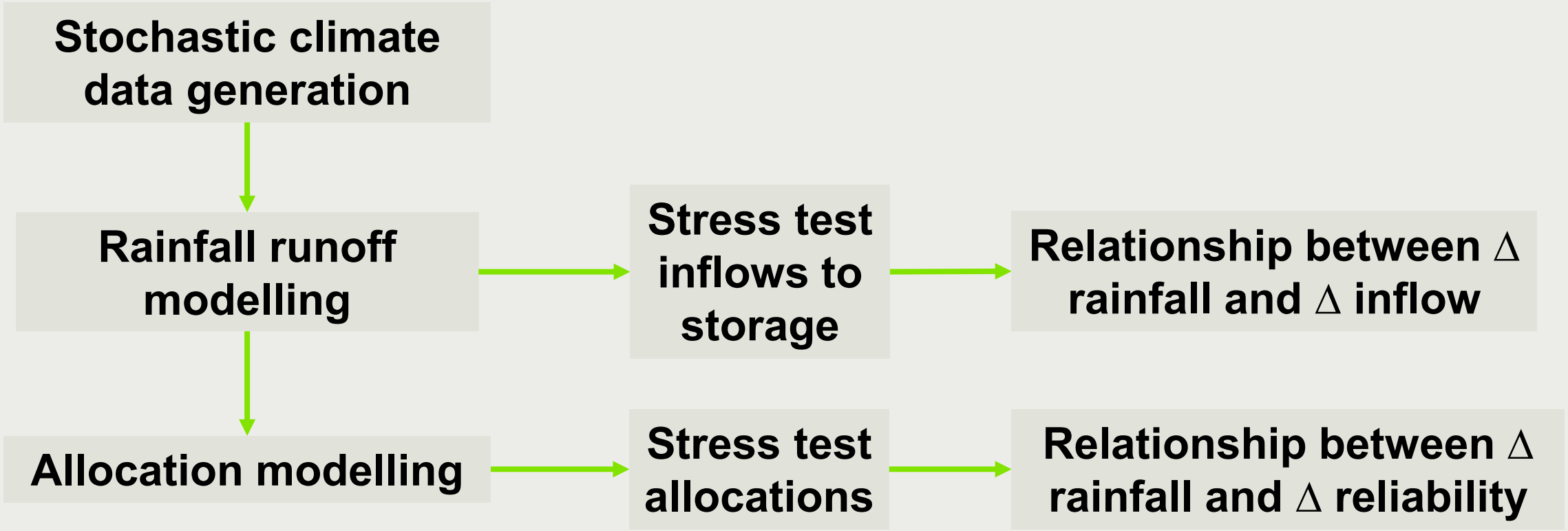
77 sub-areas for data generation

Allocation modelling uses inflows to major storages in ScMDB to estimate HRWS (Vic) and General (NSW)

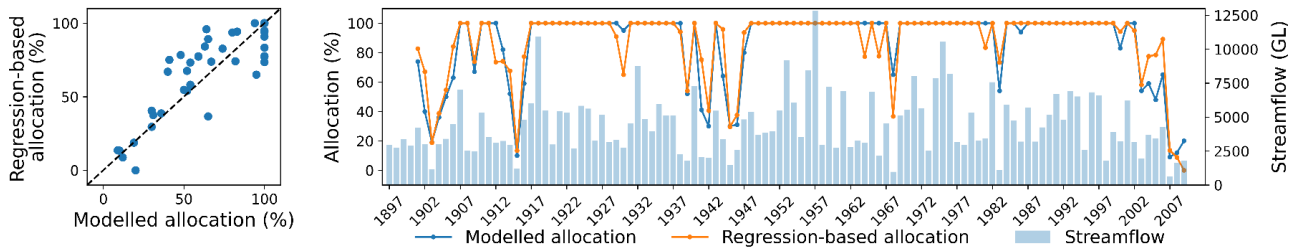
Instream flow indicator modelling uses upstream inflows to estimate outcomes at 24 indicator sites



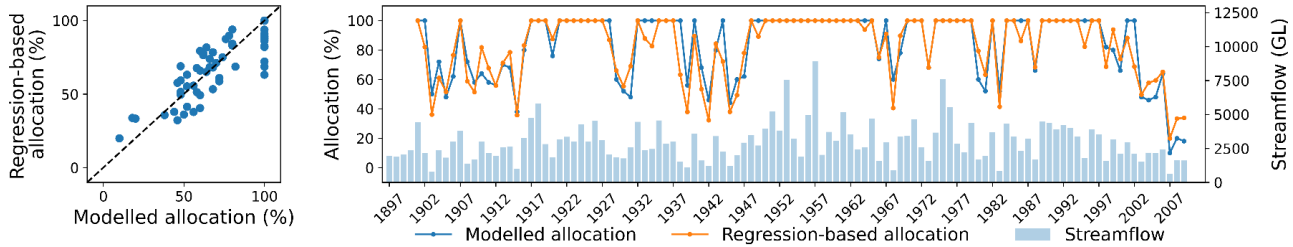
Allocation modelling using a statistical model



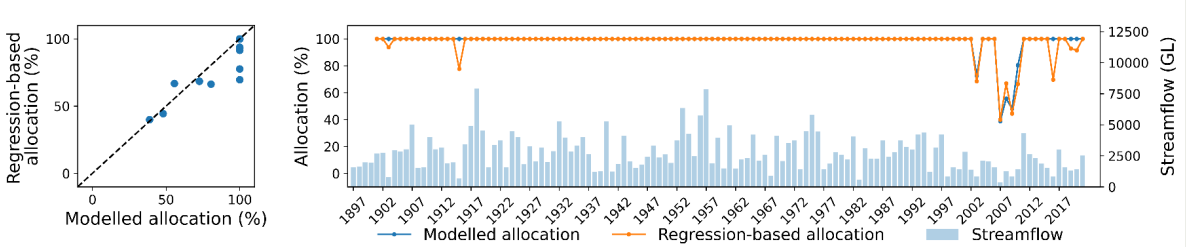
Impact model



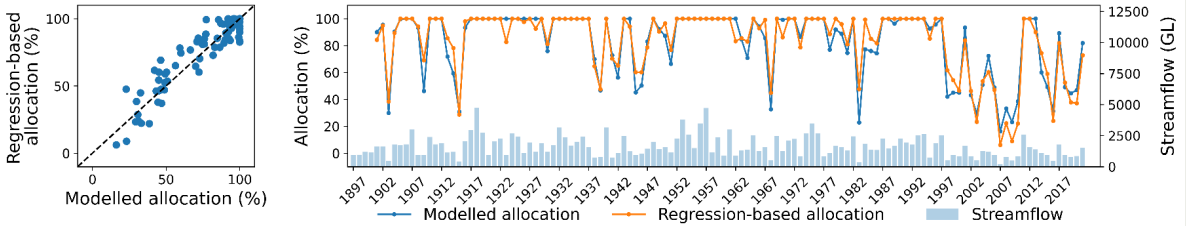
(a) General Security for NSW Murray (Historic Scenario)



(b) General Security for Murrumbidgee (Historic Scenario)

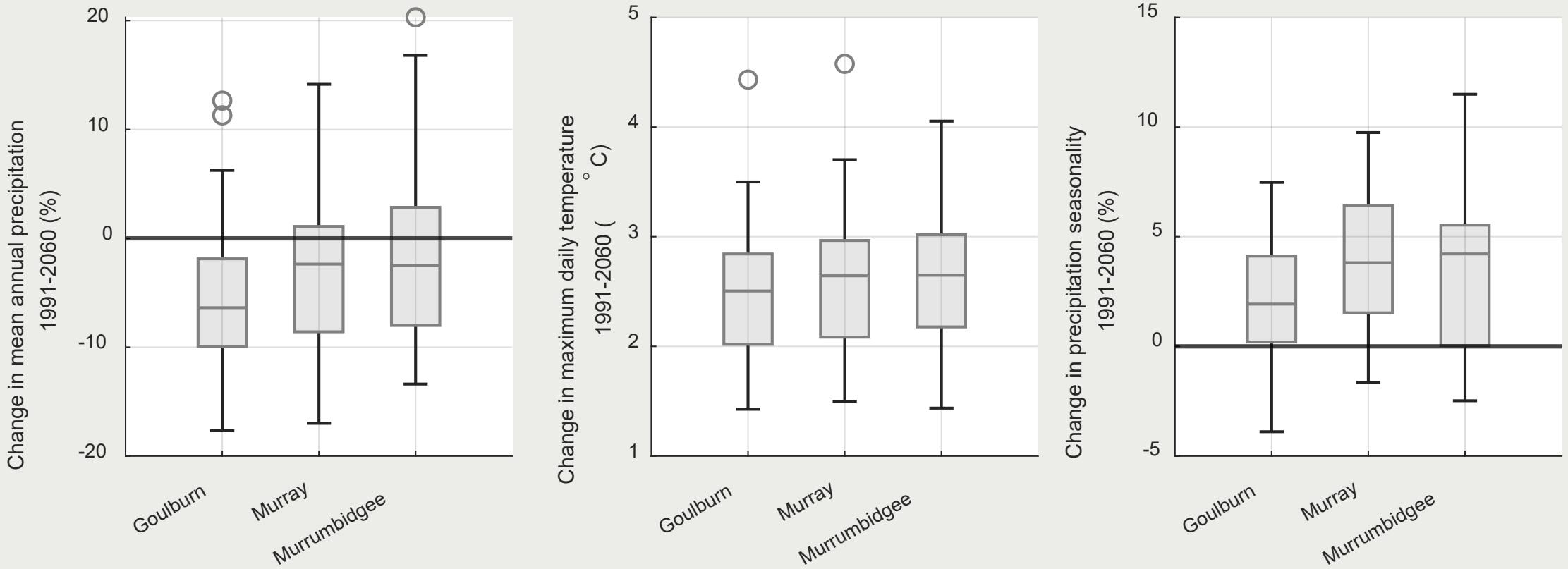


(e) High Reliability for Goulburn (Historic Scenario)



(f) High Reliability for Goulburn (Dry Scenario)

1. Climate Projections

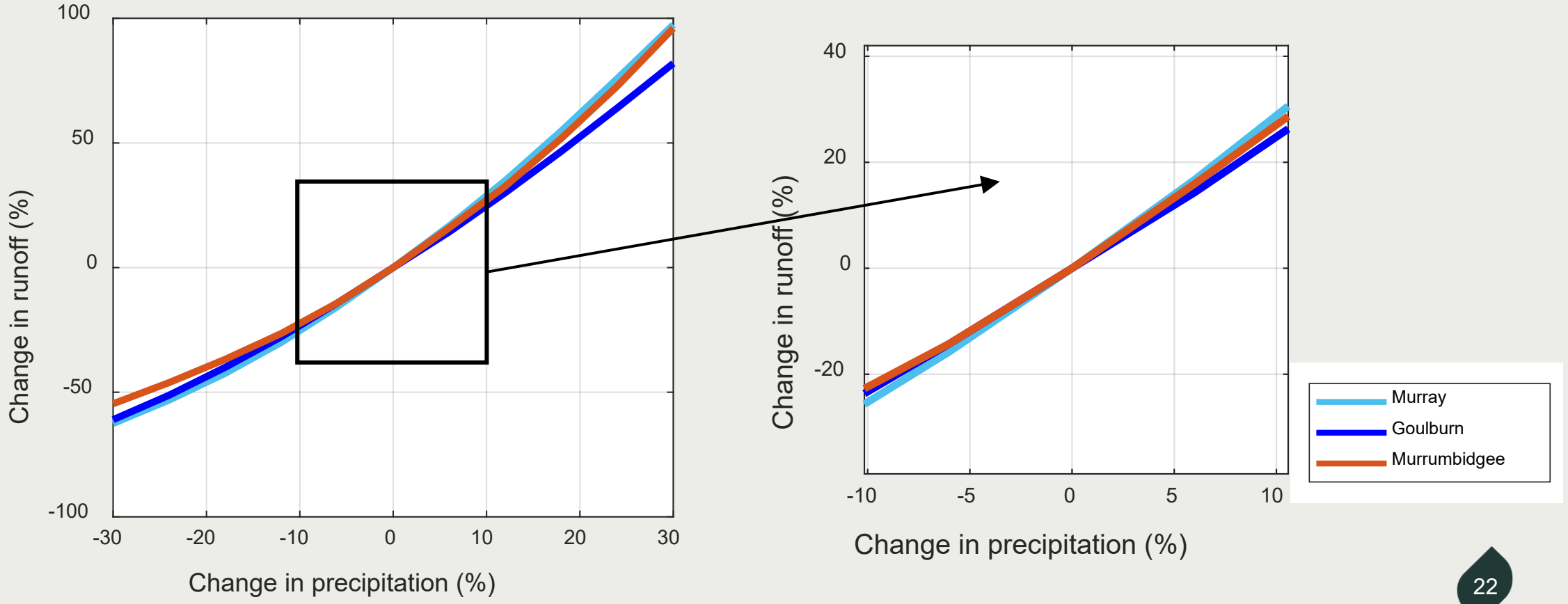


37 General Circulation Model (GCM)s projections

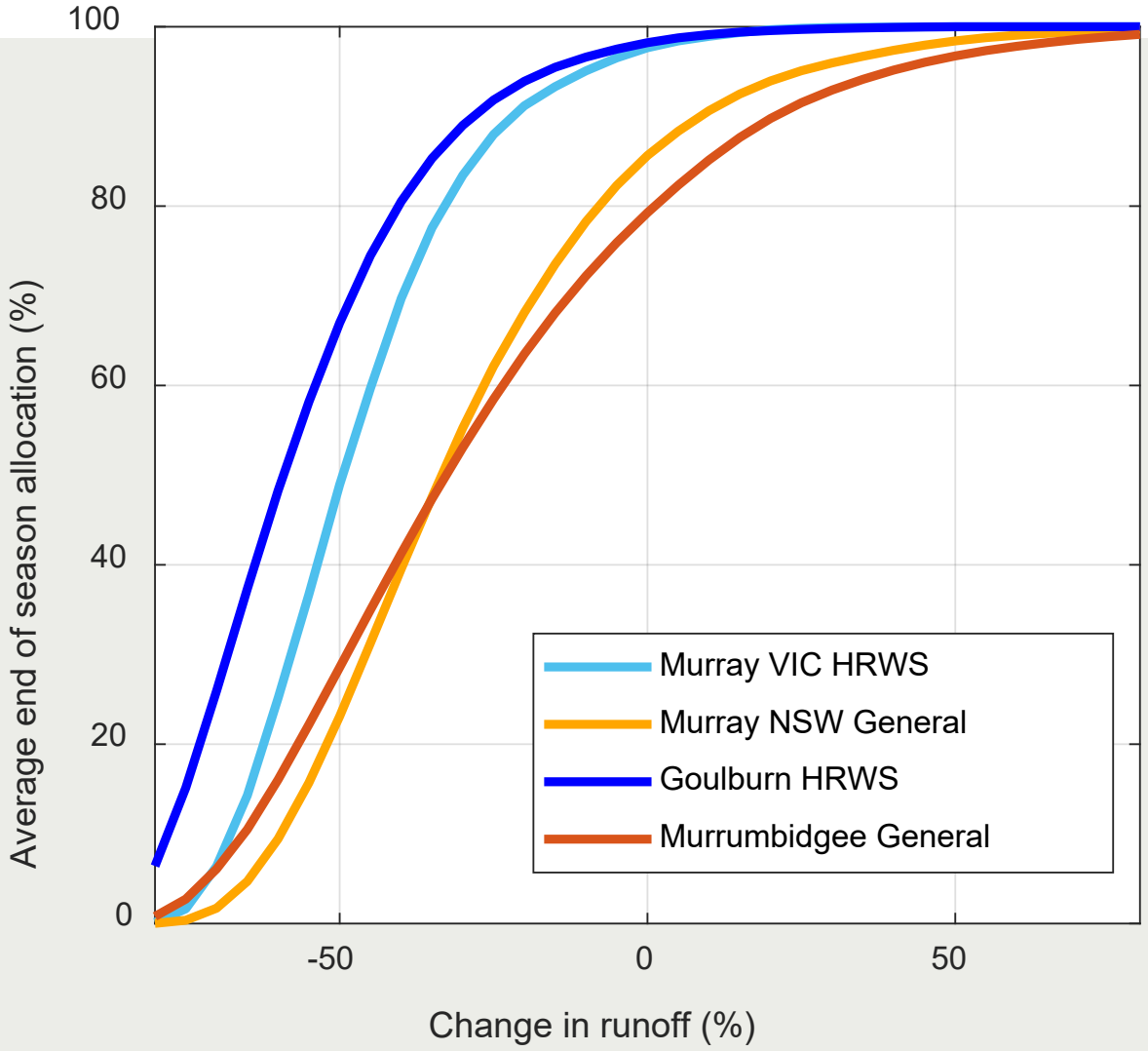
SSP5-8.5 2060

2. Streamflow sensitivity to rainfall

Investigated in a controlled manner to build a relationship comparable across major storage inflows

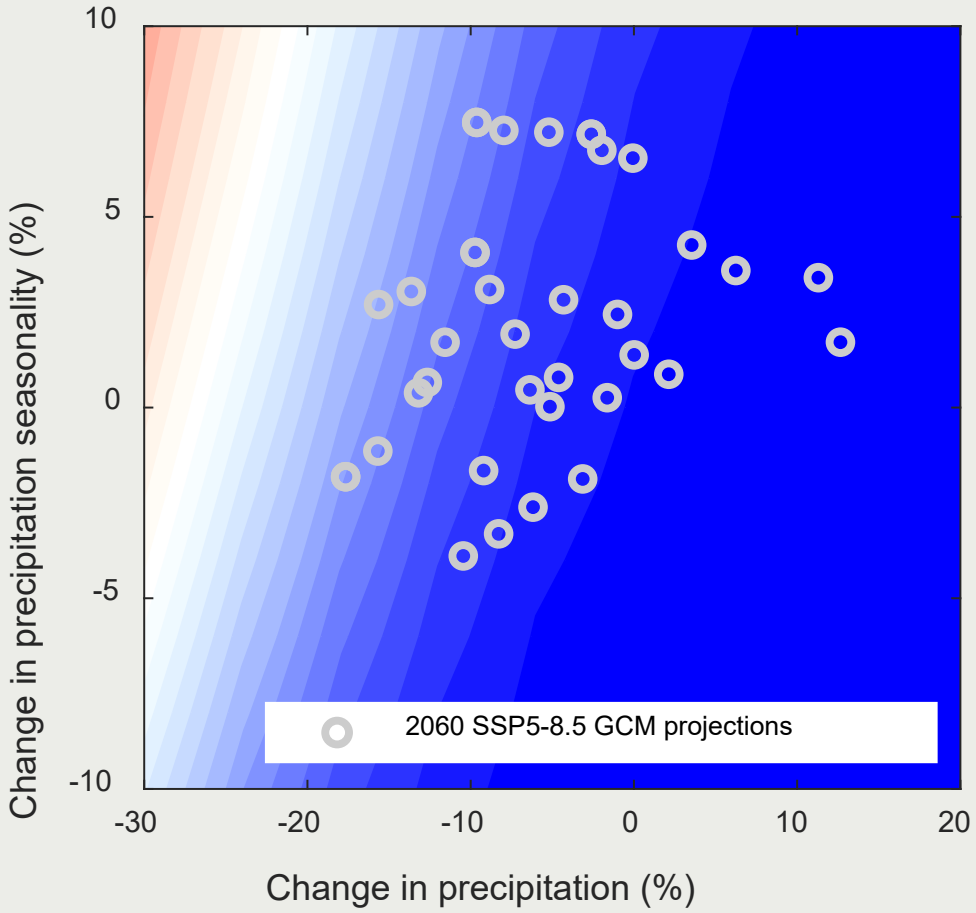


3. Allocation sensitivity to streamflow

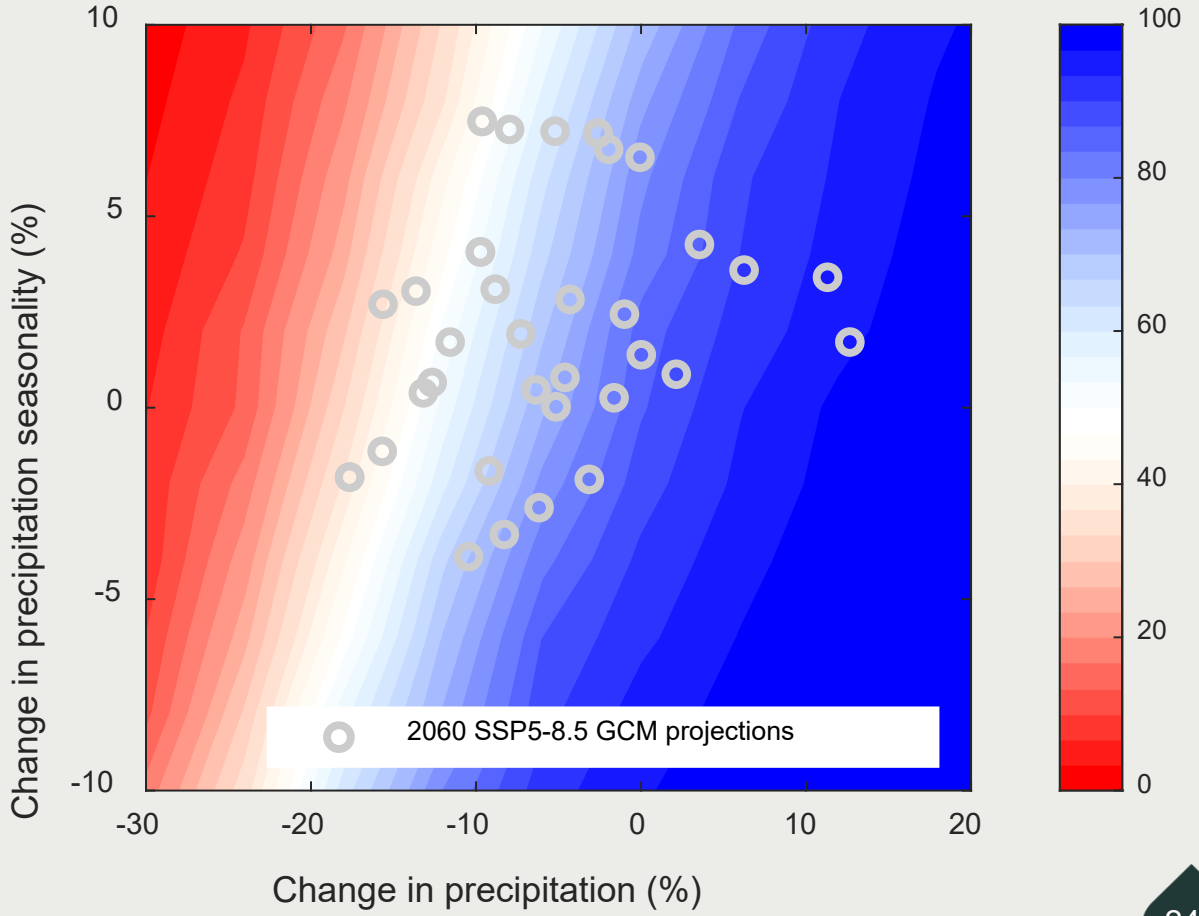


Bringing it all together

Goulburn HRWS average end of season allocation



Goulburn HRWS reliability



Allocation modelling using regressions

We can stress test and understand sensitivity, robustness and relative impact on different systems using a relatively efficient approach

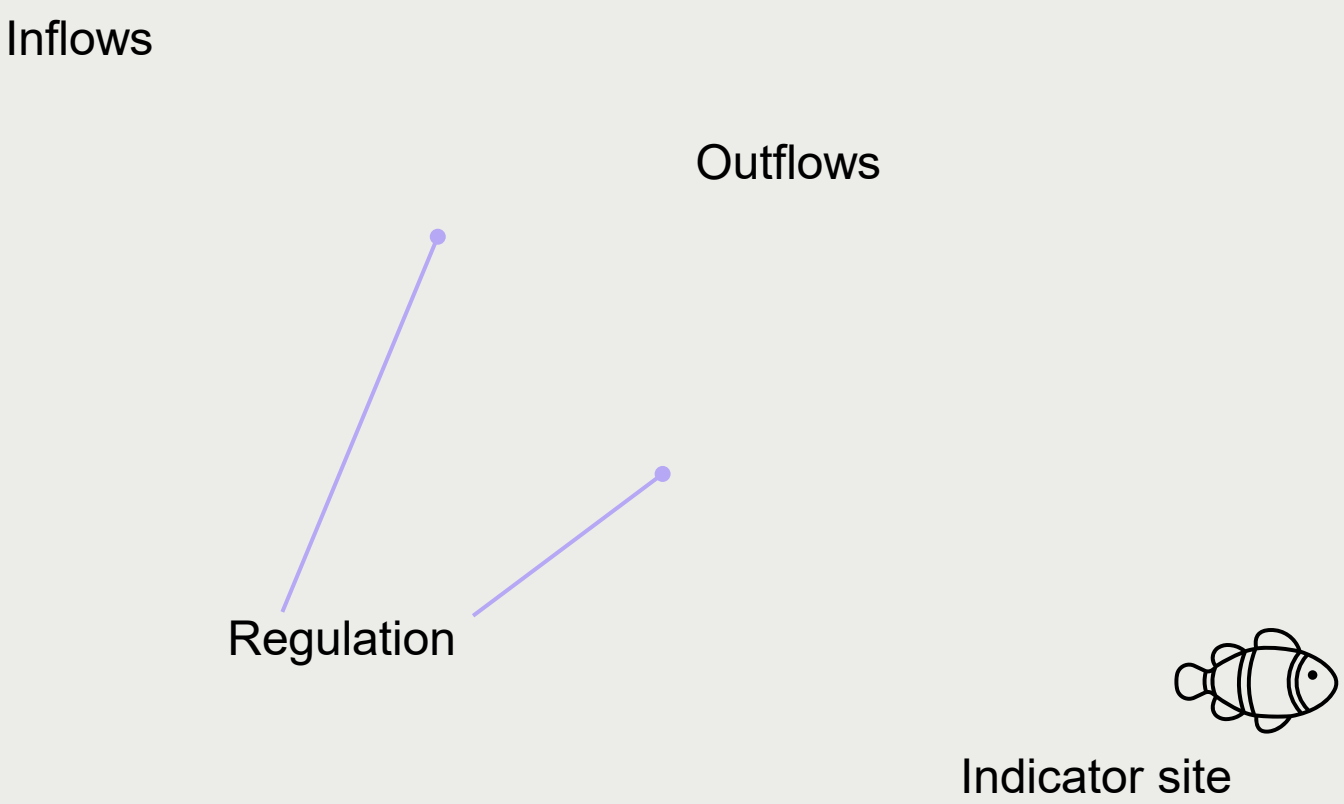
- Package to rapidly generate monthly stochastic data for stress testing (transferable)
- Package to generate rainfall runoff modelling and link stochastic data (transferable)

For the Southern Connected MDB:

- Climate projections show rainfall in Goulburn likely to decrease more than in Murray and Murrumbidgee
- But the biggest differences are due to the way the different allocation products are structured
  - NSW systems are more sensitive to reductions in streamflow
  - VIC systems can take moderate change to climate, but rapid drop off when runoff change > 25%

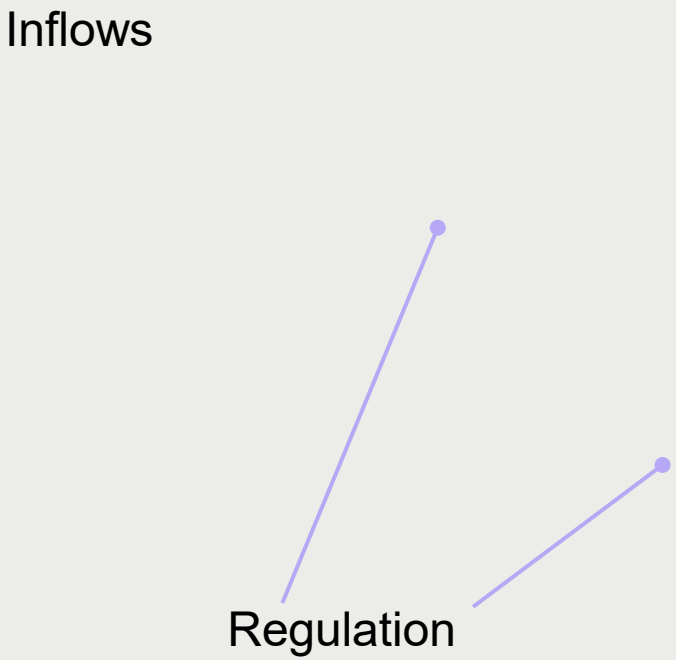
Implications for trade and movement of water (delivery and eflows) throughout the basin where there are differential impacts on allocations

Using emulator models for stress testing flow indicators across the MDB



Emulator models mimic the regulated parts of the system by training on water resource model outputs

Using emulator models for stress testing flow indicators across the MDB



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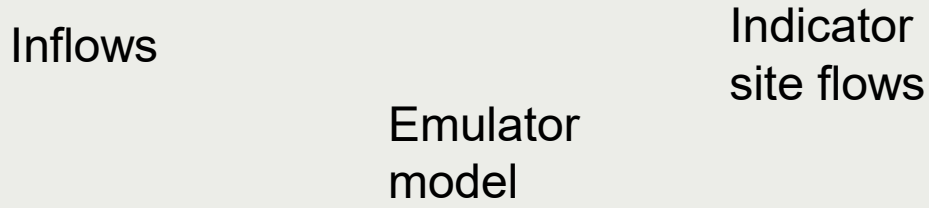
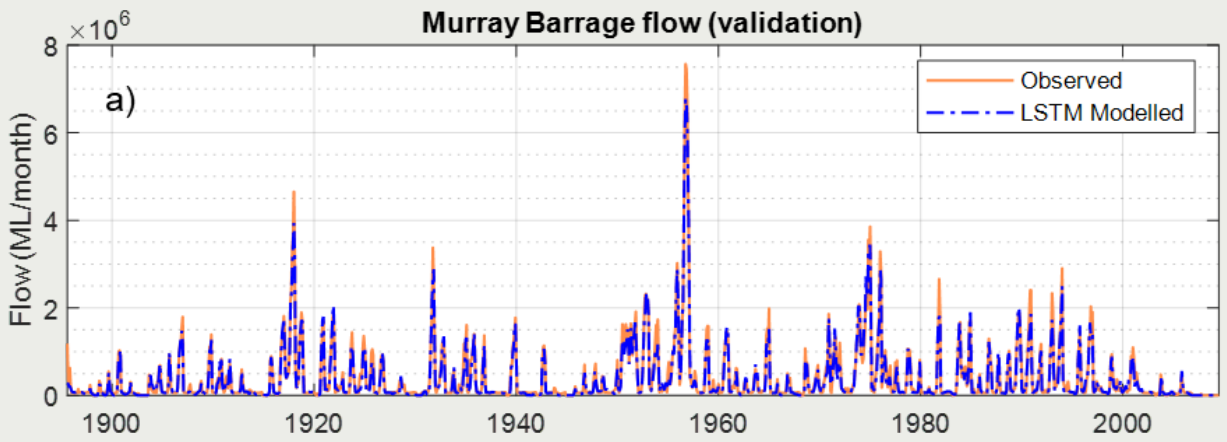
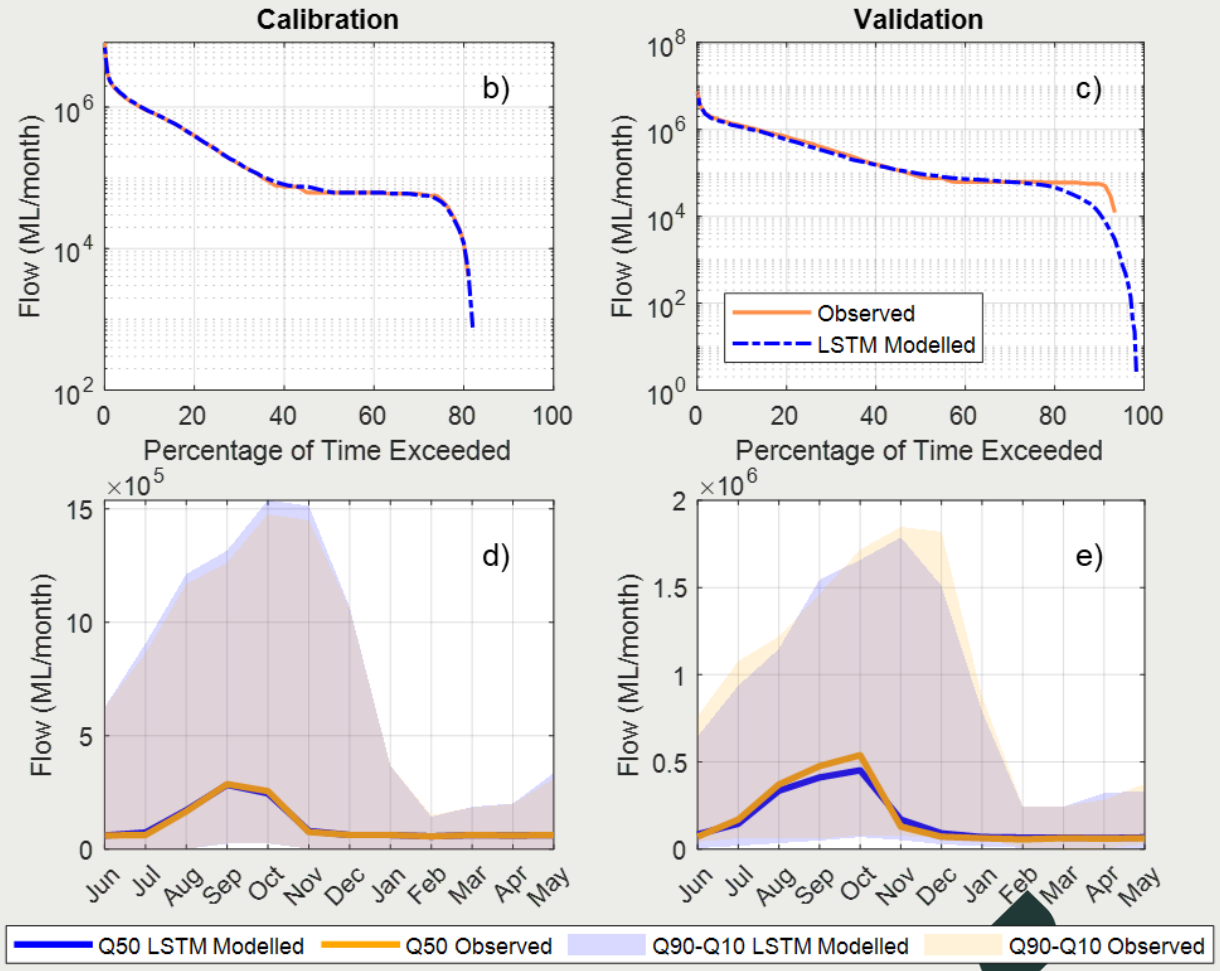


Emulator modelling for hydrological indicators

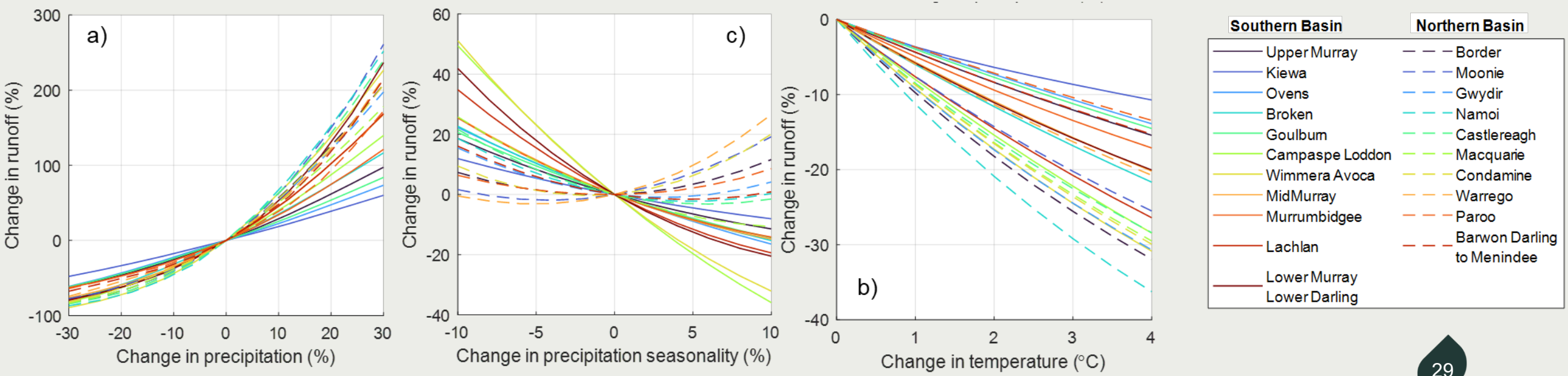




Emulator models mimic the complex models well when trained over a long sequence of alternate climate scenarios

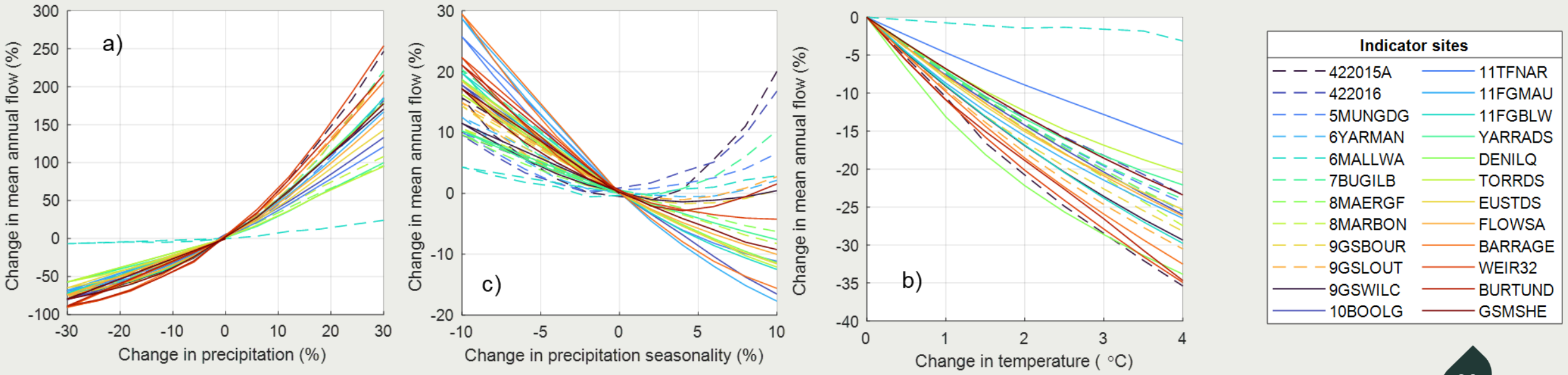
Sensitivity of MDB inflows

Large differences in catchment response to climate change across the basin
Northern basin shows higher sensitivity

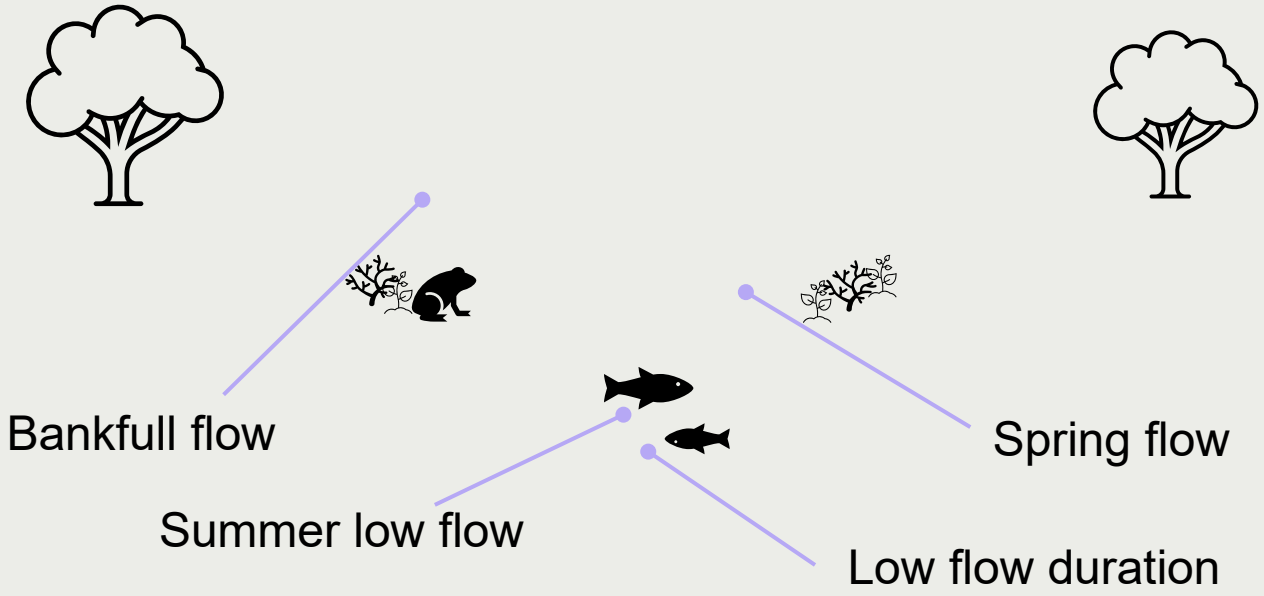


Sensitivity of river indicator sites

Similar pattern of responses at river indicator sites
Northern basin and drier rivers show higher sensitivity



Flow metrics



Transferable across sites

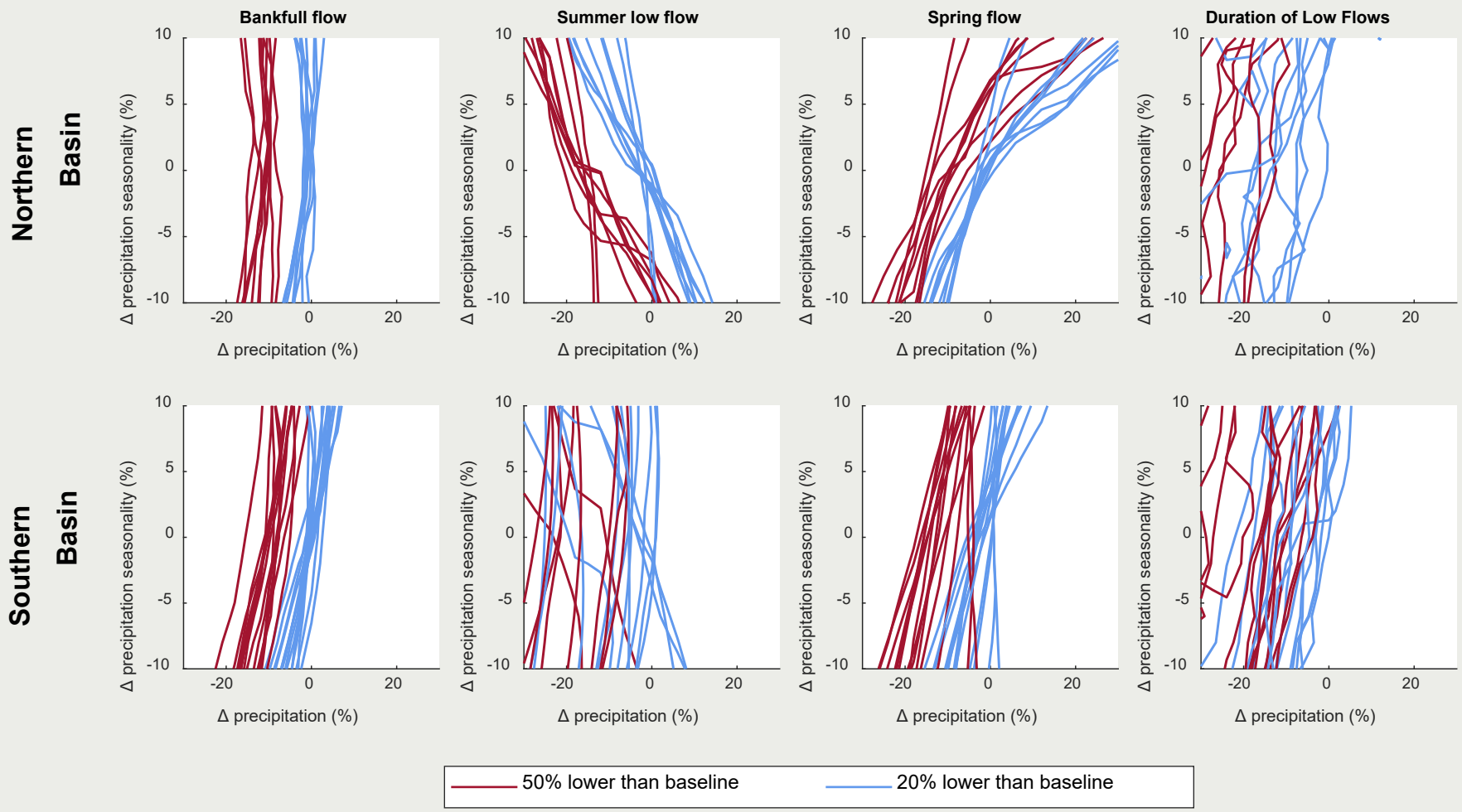
SFIs at indicator sites
104 total, ~5 per site
Flow component with timing, magnitude, frequency

2 additional indicators at Murray Barrages in Basin Plan

Success assessed each year
Each has a long-term target

Site specific

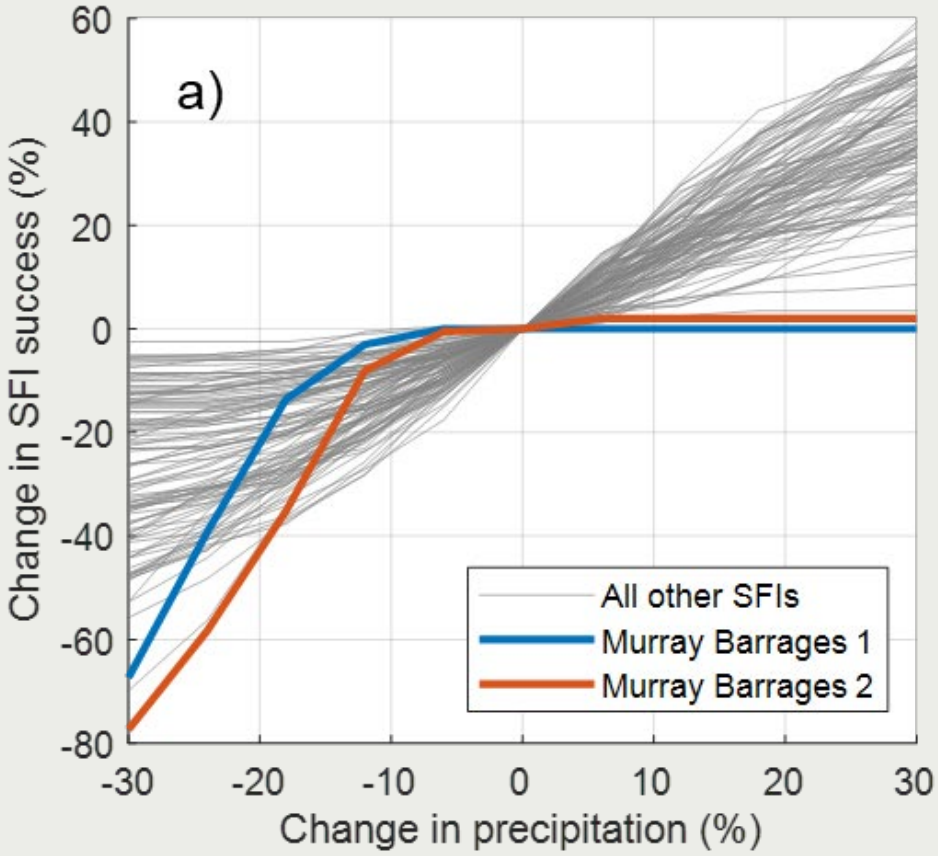
Sensitivity of site flow metrics

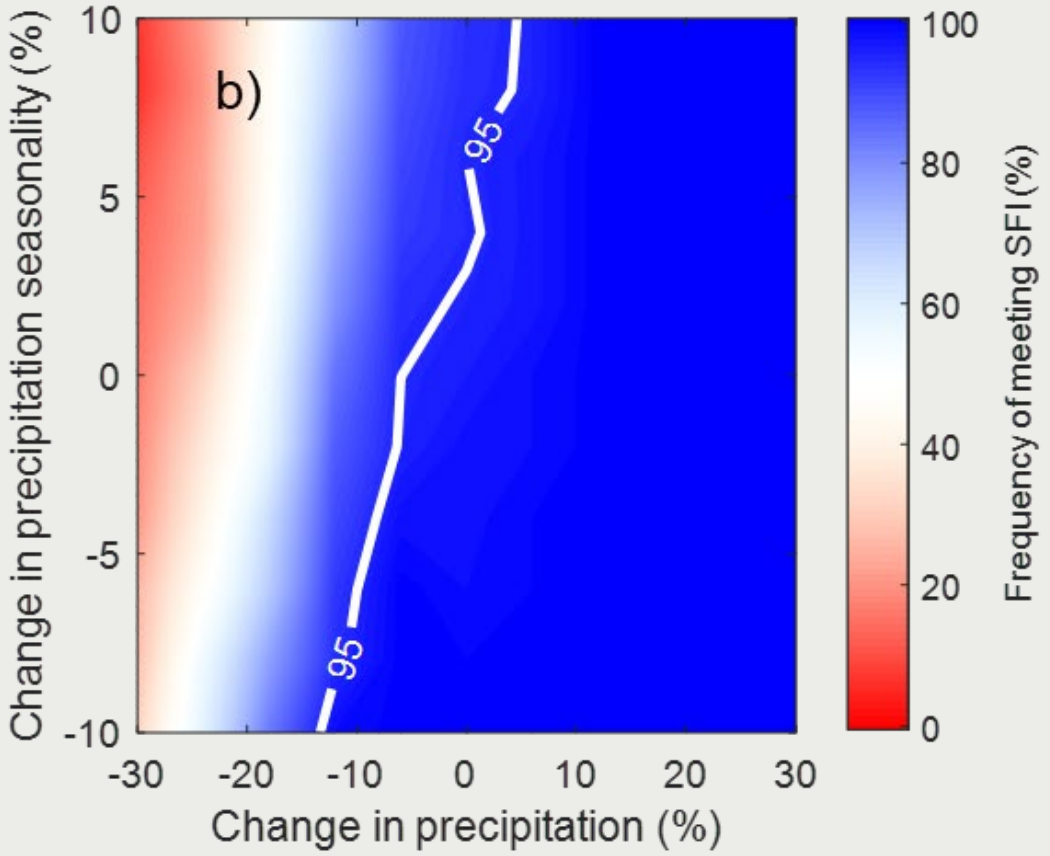


Similar thresholds for high flows at river indicator sites

More variable low flow responses across the basin

Long-term targets for indicators





Why use these approaches?

Learn about system behaviour and response

Find threshold or non-linear behaviour

Parameterise complex models to explore vulnerability and uncertainty

Support storylines or scenario development

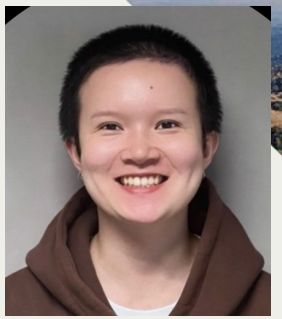
Many minds

Keirnan Fowler

Leah Traill (HARC)

Rory Nathan

Gabrielle Burns



Ziqi Zhang

Thank you

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A short 1-minute survey will pop up at the webinar's conclusion *or complete it on your phone now by scanning the QR code.*

Enjoyed the webinar today?
See you at the next month's One Basin Webinar:

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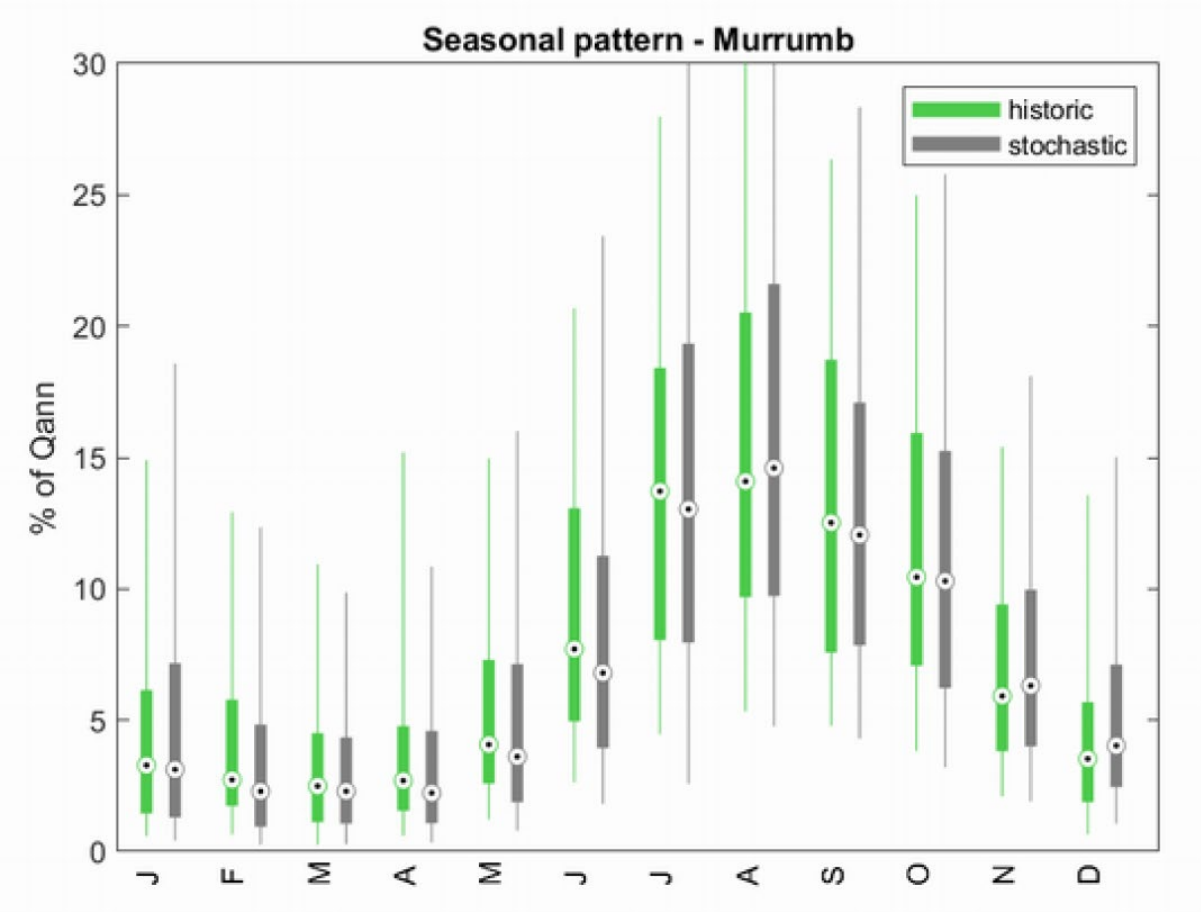
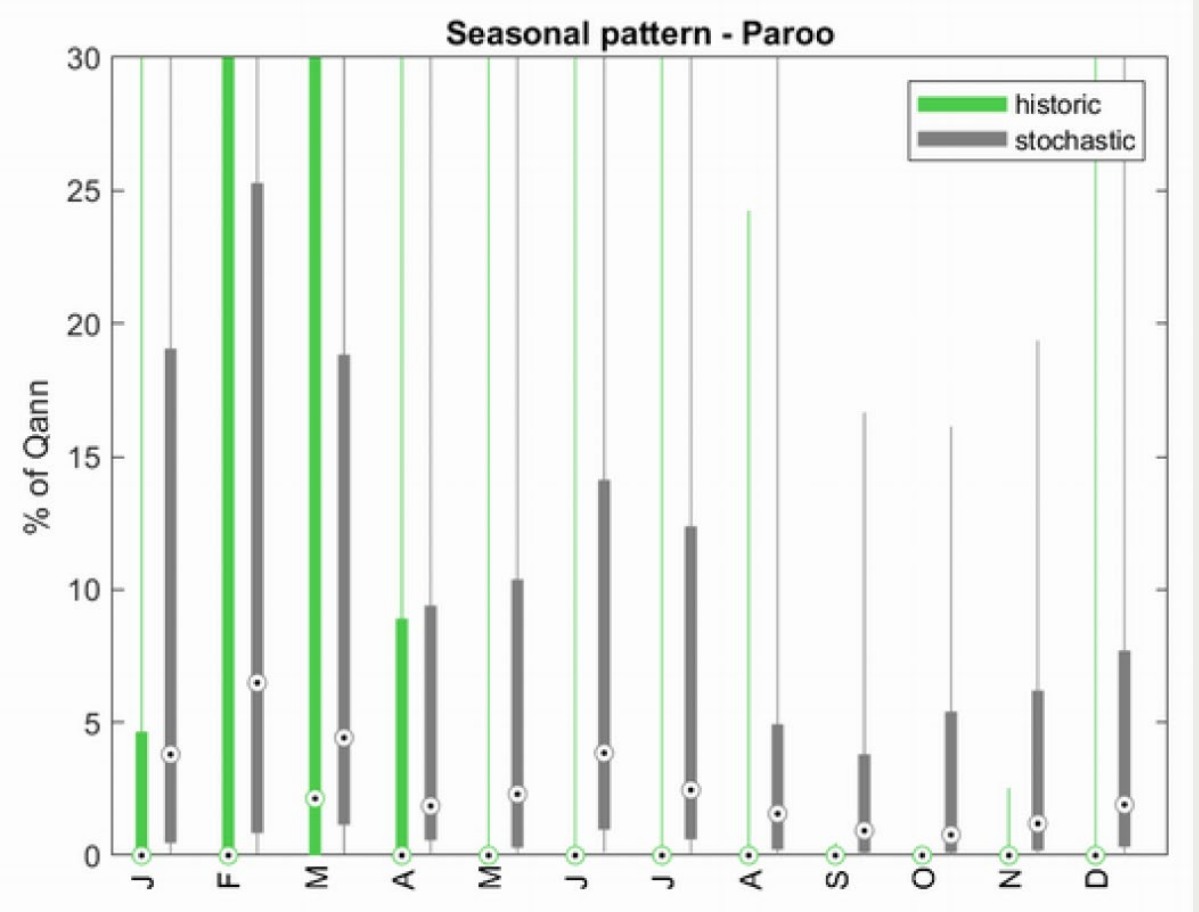
Stochastic inflows





Stochastic inflows