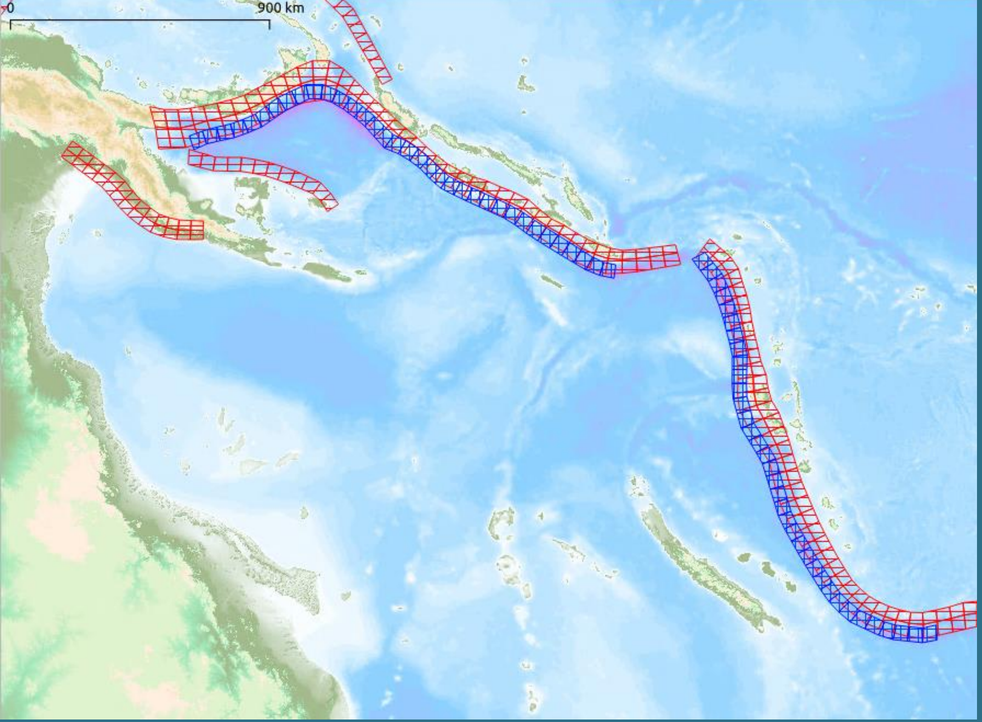
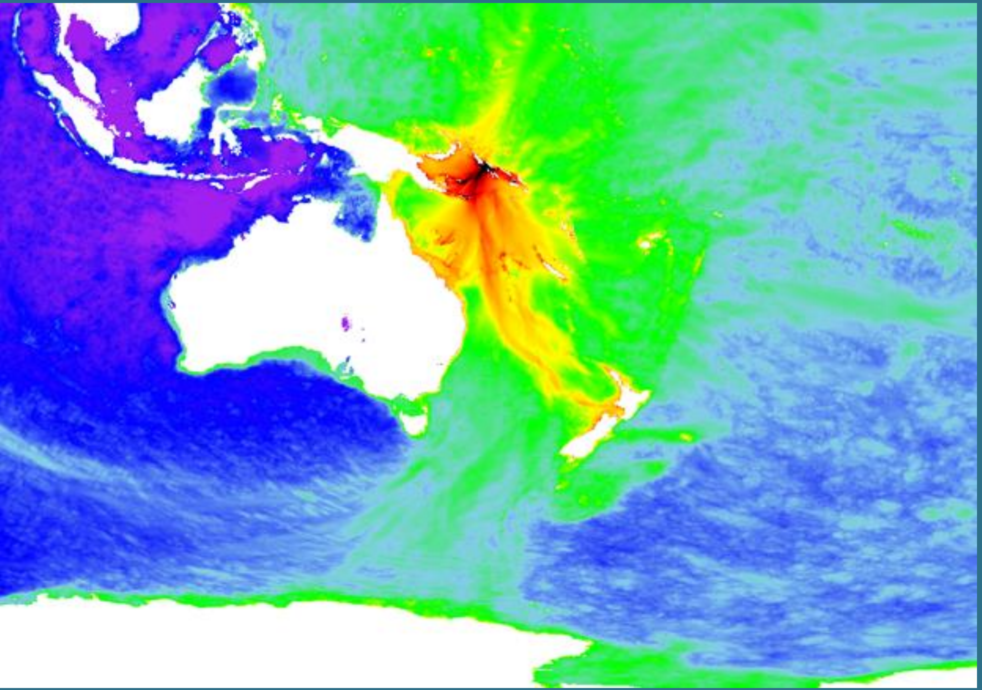
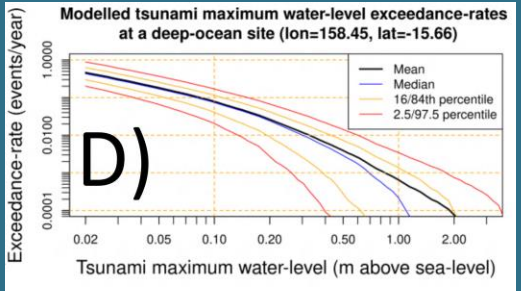




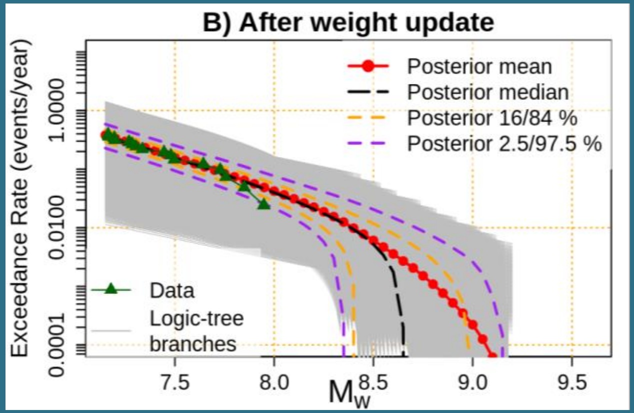


Australian Government
Geoscience Australia

Probabilistic seismic-tsunami hazard assessment options

ICG/PTWS Scientific meeting on the Vanuatu, San Cristobal and New Britain Subduction Zones

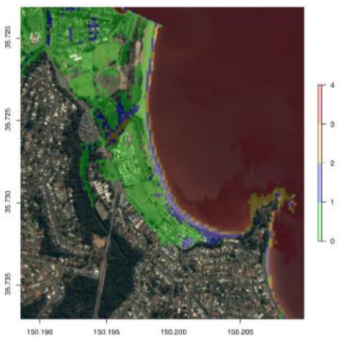
Gareth Davies



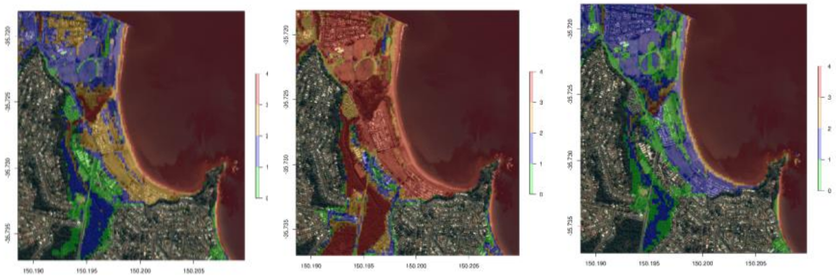
Approaches to tsunami inundation hazard assessment

Deterministic

- **Single scenario**

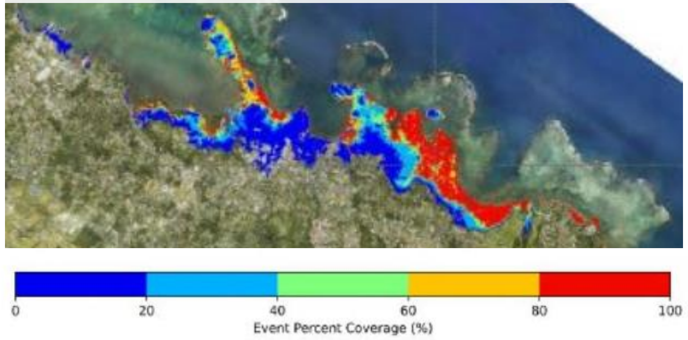


- **Set of scenarios**



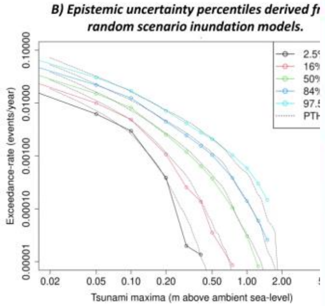
- **Set of scenarios informed by probabilistic analyses**
  - **Nominal average return period**, e.g.
    - 1/2500 wave height exceedance-rate at an offshore site
  - **Epistemic uncertainty**, e.g.
    - Likelihood that scenario is even possible (given M_w etc.)

7 scenarios with 1/1000 year offshore wave height: Giblin et al. 2022

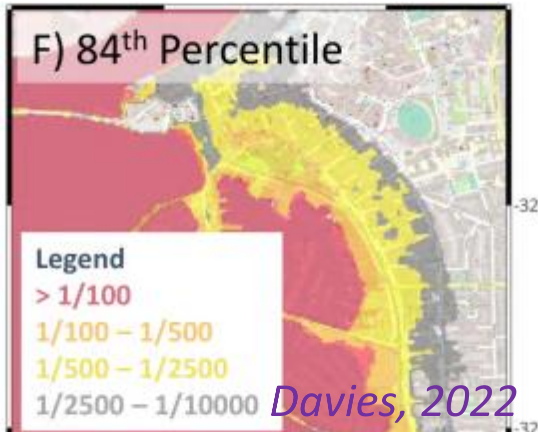


Probabilistic

- **Probabilistic tsunami inundation hazard assessment**
  - Integration over model of *all plausible scenarios & frequencies*
    - Tsunami intensity vs exceedance-rate [everywhere]
    - With epistemic uncertainty
  - Common for offshore PTHA from earthquakes
  - Increasingly possible for inundation hazard



Inundation events/year

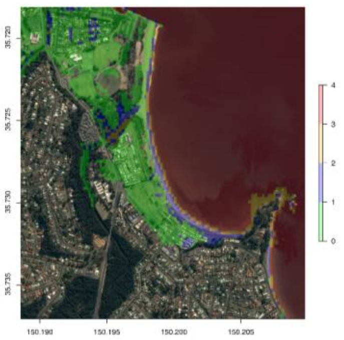


Davies, 2022

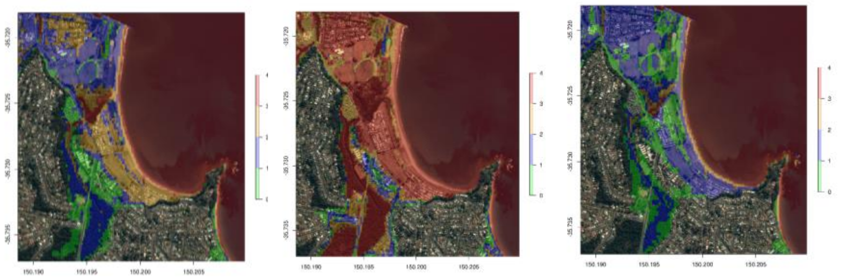
Approaches to tsunami inundation hazard assessment

Deterministic

- **Single scenario**



- **Set of scenarios**



- **Set of scenarios informed by probabilistic analyses**
  - **Nominal average return period**, e.g.
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  - **Epistemic uncertainty**, e.g.
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Probabilistic

- **Probabilistic tsunami inundation hazard assessment**
  - Integration over model of *all plausible scenarios & frequencies*
    - Tsunami intensity vs exceedance-rate [everywhere]
    - With epistemic uncertainty
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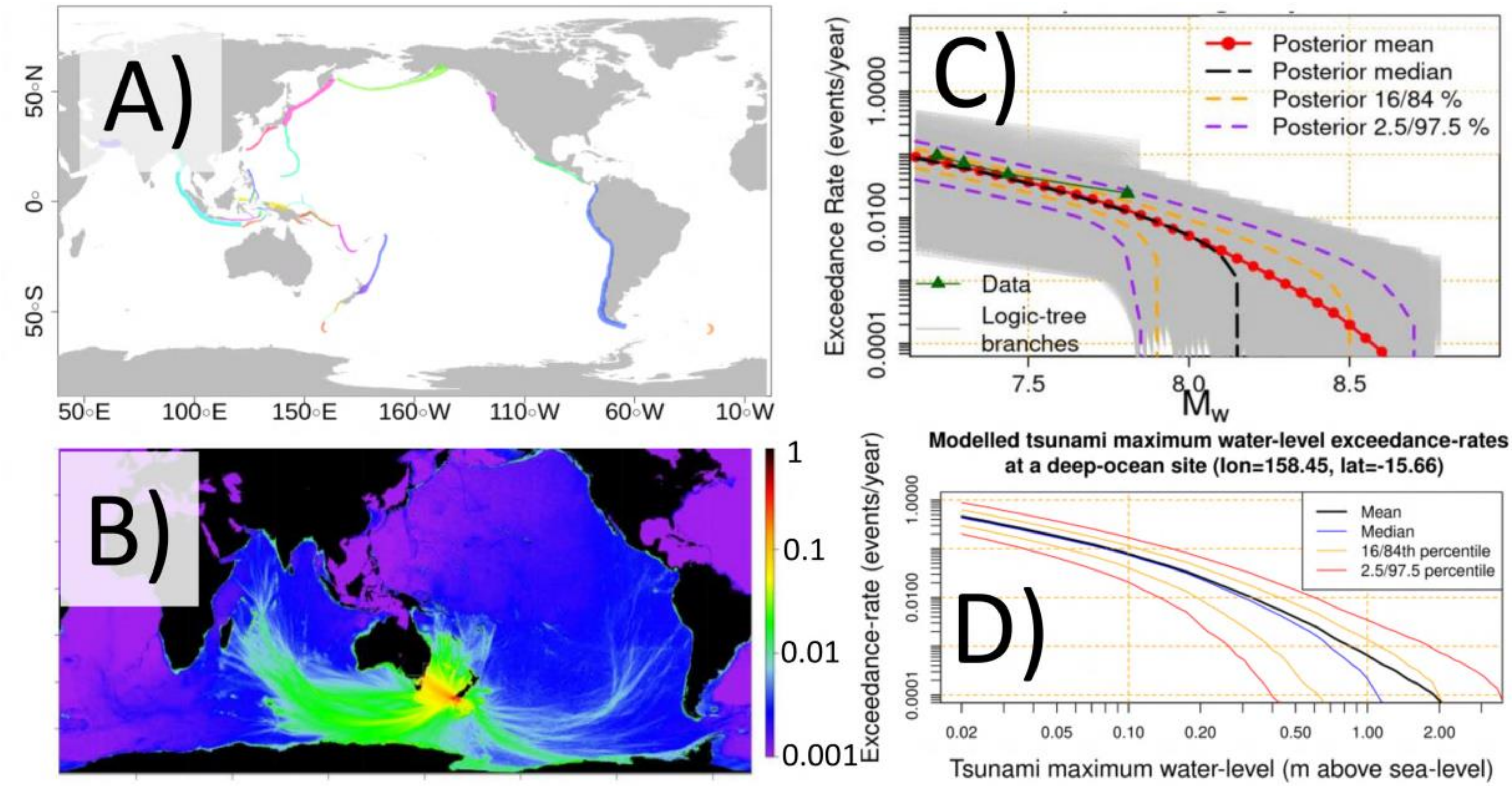
  - Increasingly possible for inundation hazard

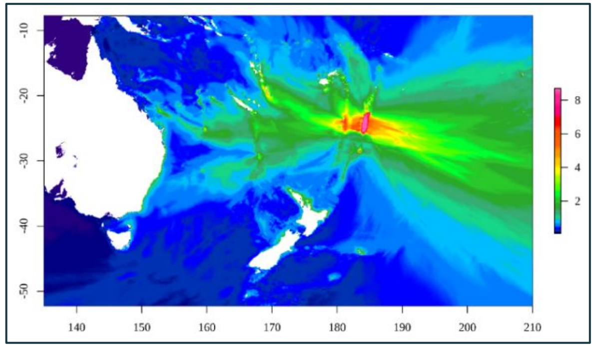
Leverage an Offshore Probabilistic Tsunami Hazard Assessment?

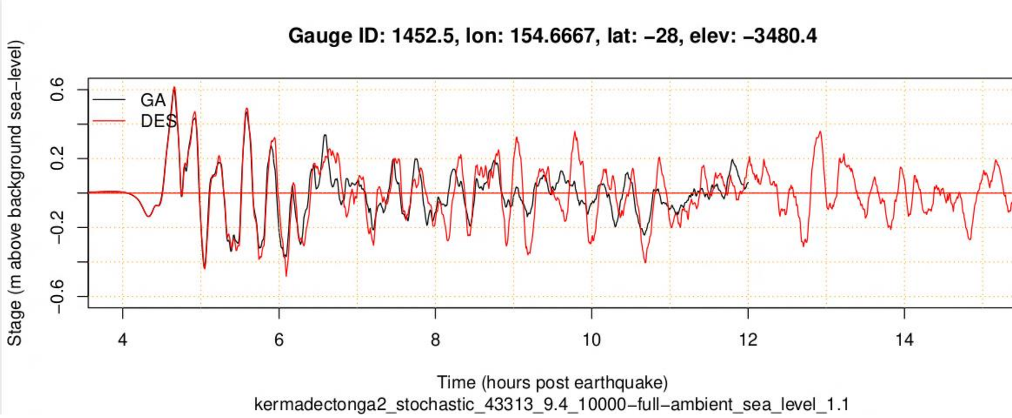
Offshore Probabilistic Tsunami Hazard Assessment: The basic idea



Offshore Probabilistic Tsunami Hazard Assessment: The basic idea

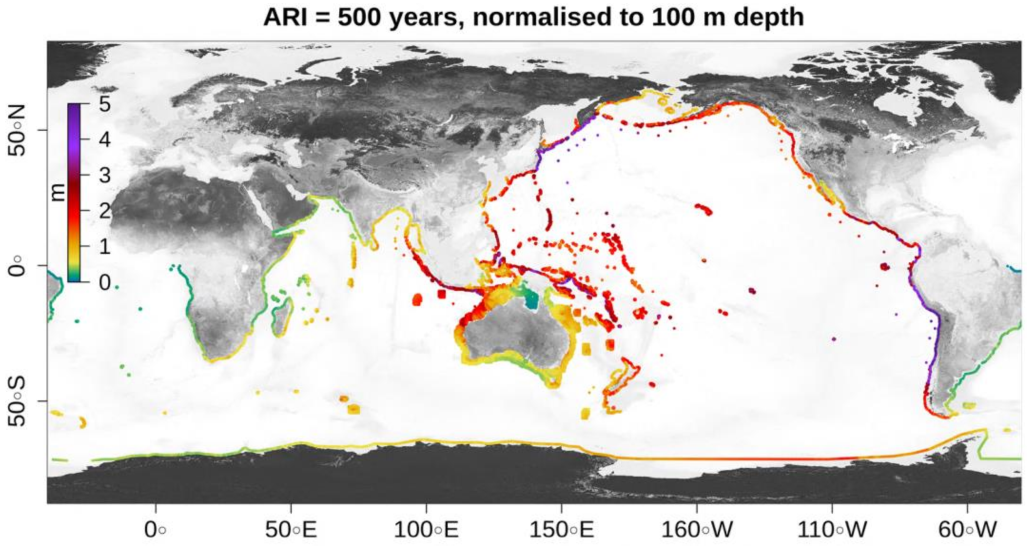
- ***Earthquake scenario database***
  - ***Tsunami initial conditions***
  - ***Linear wave time series***

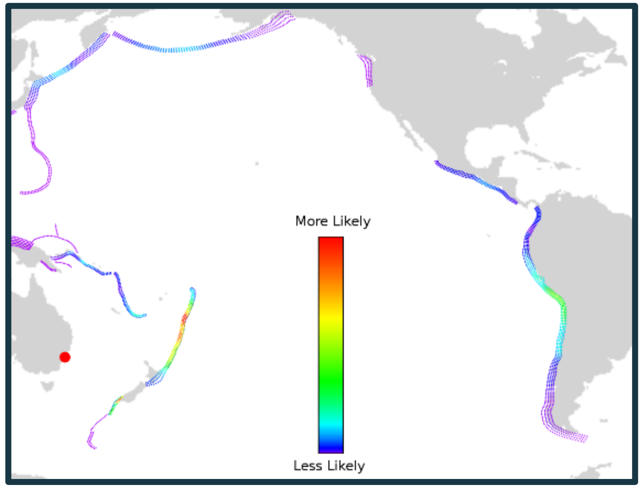




- ***Exceedance-rates with epistemic uncertainty***
  - ***Mw***
  - ***Wave size***

- ***Hazard deaggregation***





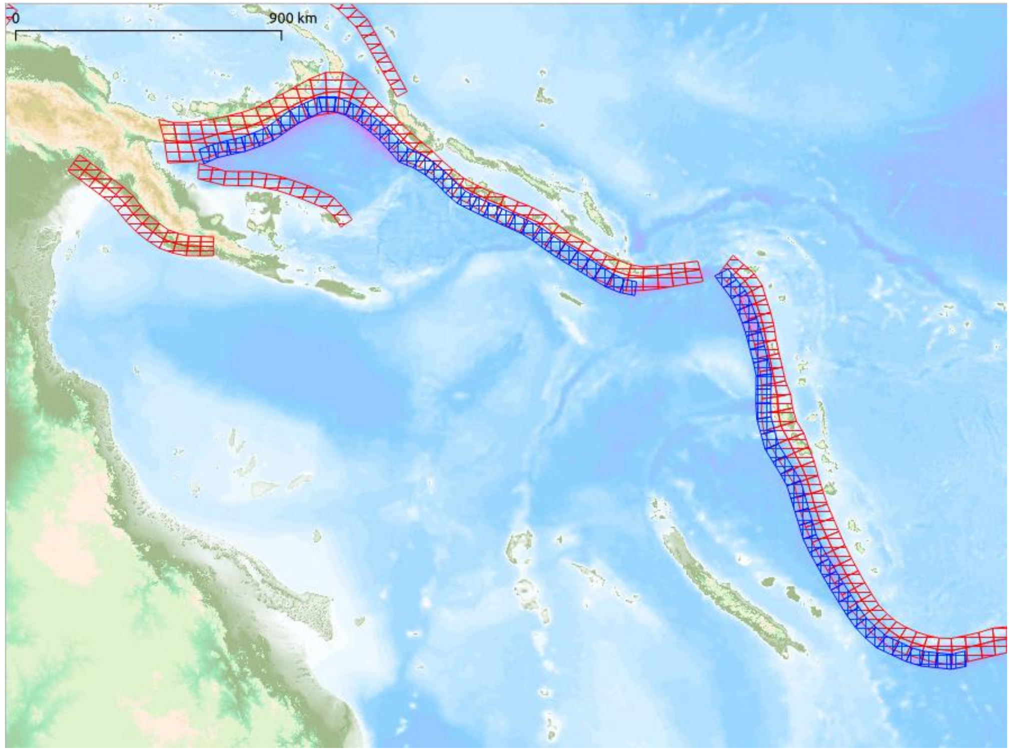
https://github.com/GeoscienceAustralia/ptha/tree/master/ptha_access

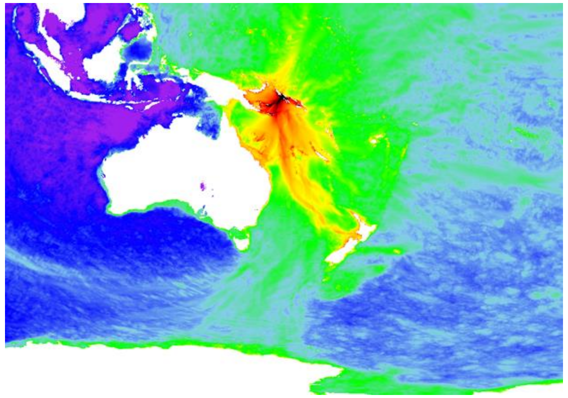
Probabilistic seismic tsunami inundation hazard assessment options

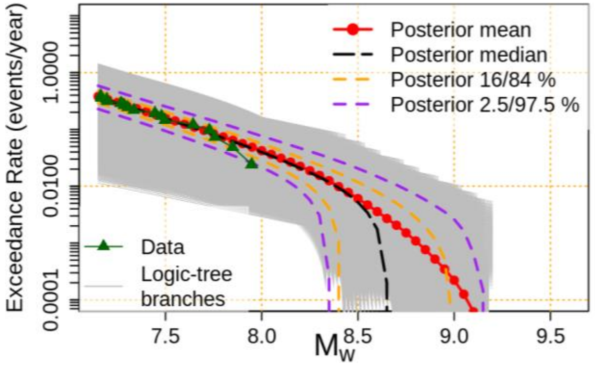
- **Leverage an existing offshore PTHA?**
  - 2018 Australian PTHA
  - New Zealand national PTHA
  - Many others in published literature & in development
  - **Others I am missing?**

- **Develop your own?**

- **Things to consider**
  - No option will be perfect
  - What will suit your end-users?
  - How well tested are the existing options?
    - Can you do better in the time you have?
  - Do existing PTHAs provide what you need?







SPC & GA guidelines on using offshore PTHA for inundation hazard

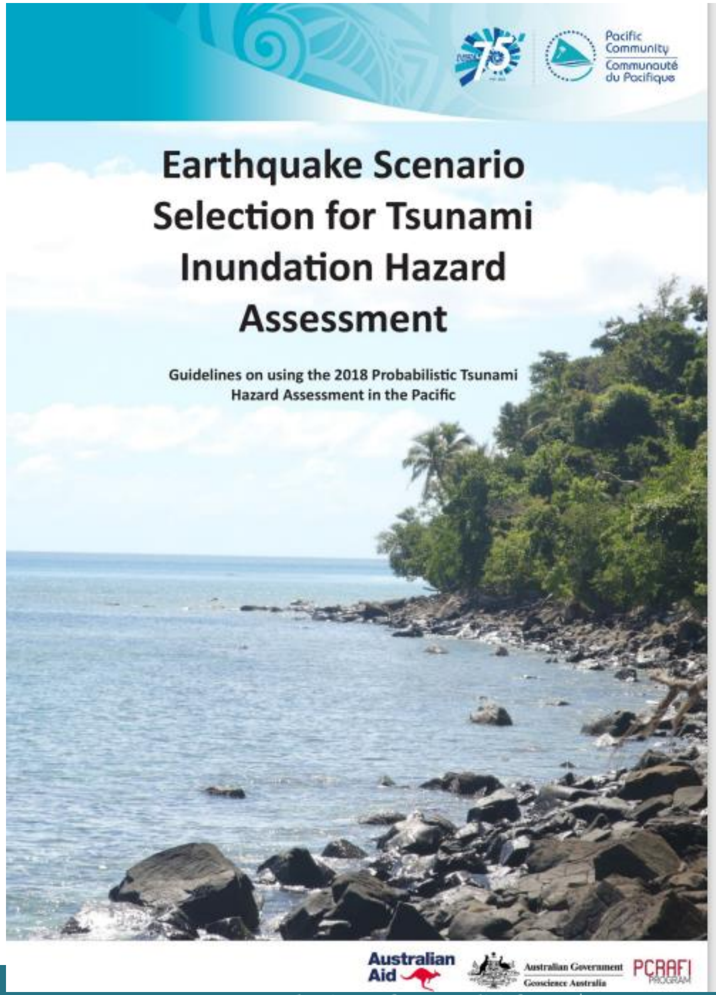
Deterministic

- **Single scenario**

https://repository.oceanbestpractices.org/handle/11329/2062

- **Set of scenarios**
- **Set of scenarios informed by probabilistic analyses**
- **Probabilistic tsunami inundation hazard assessment**
  - Ideal: Inundation for all offshore PTHA scenarios
    - Direct calculation of onshore hazards
  - Reality: Rigorous approximations of the ideal
    - e.g. Monte Carlo

Probabilistic

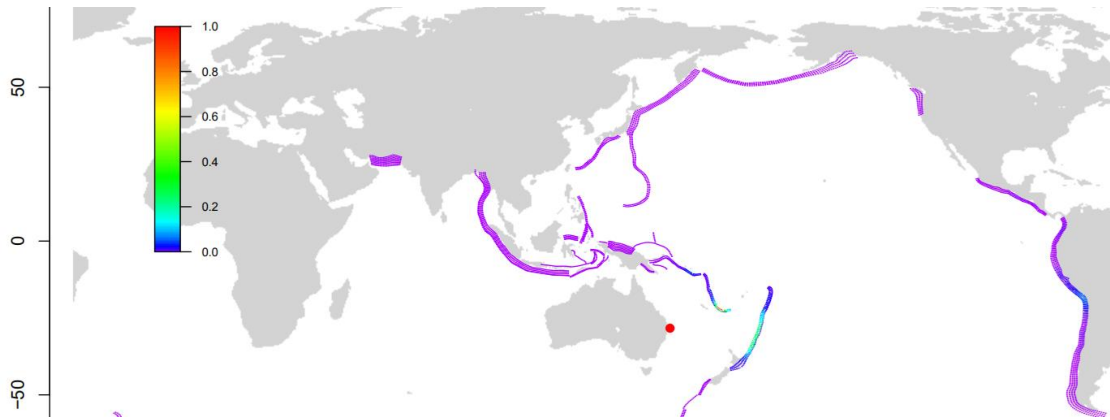


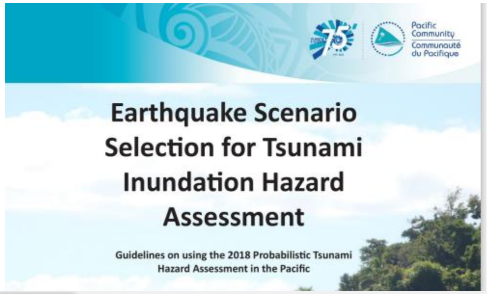
Examples of using offshore PTHA for inundation hazard assessment

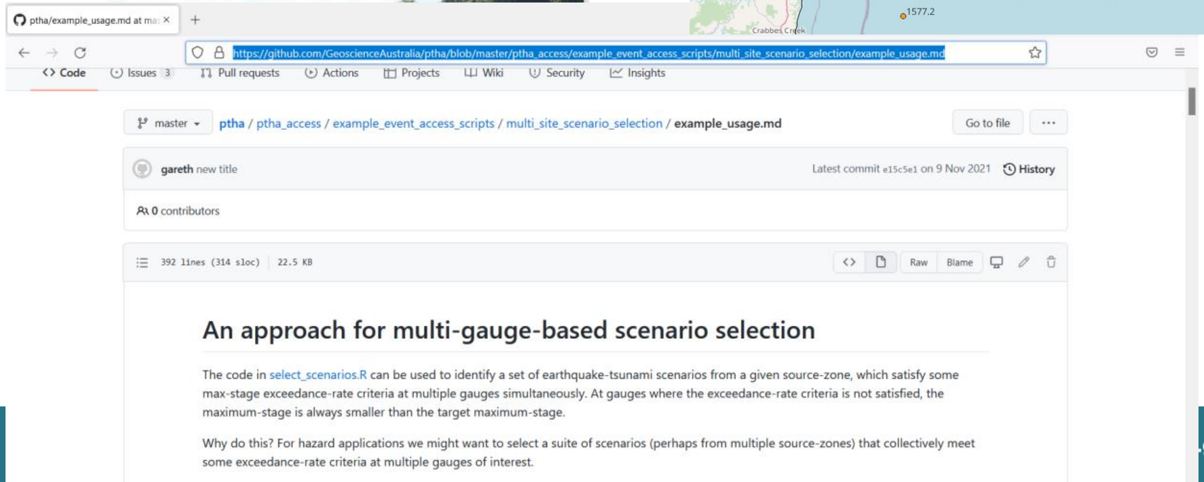
Example: Set of scenarios informed by probabilistic analyses

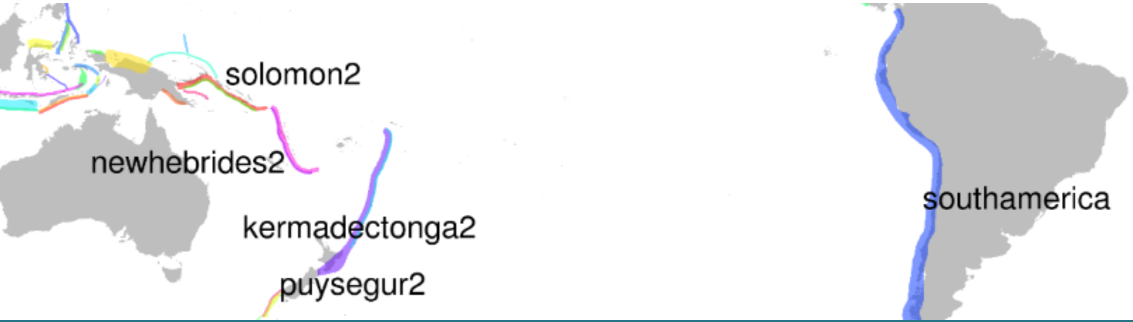
- **Tsunami inundation scenarios for Gold Coast, Australia**
  - QLD Department of Environment & Science

- **44 scenarios from 2018 Australian PTHA**
  - Informed by wave height exceedance-rates
    - 1/100 to 1/10000 @ multiple offshore sites
    - Logic-tree-mean
  - Many other subjective judgements, e.g.
    - Prefer a range of source-zones
    - Prefer "more likely" scenarios
  - See the guidelines for ideas & code

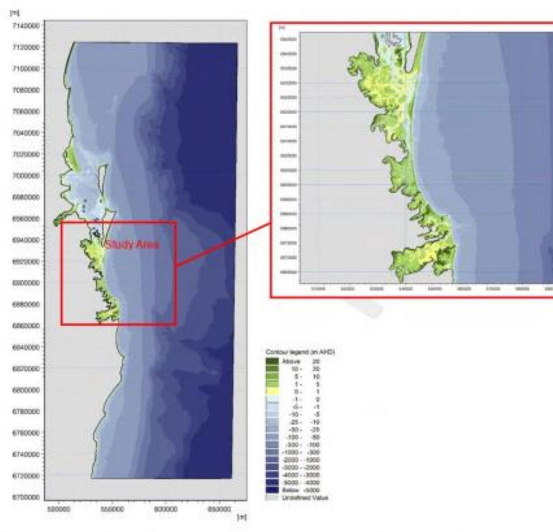








Example: Set of scenarios informed by probabilistic analyses



- **Tsunami inundation scenarios for Gold Coast, Australia**
  - QLD Department of Environment & Science

- **Inundation hazard maps by merging scenarios for each nominal exceedance-rate**
  - Onshore impacts vary for the same offshore wave height
  - Merging → likely conservative

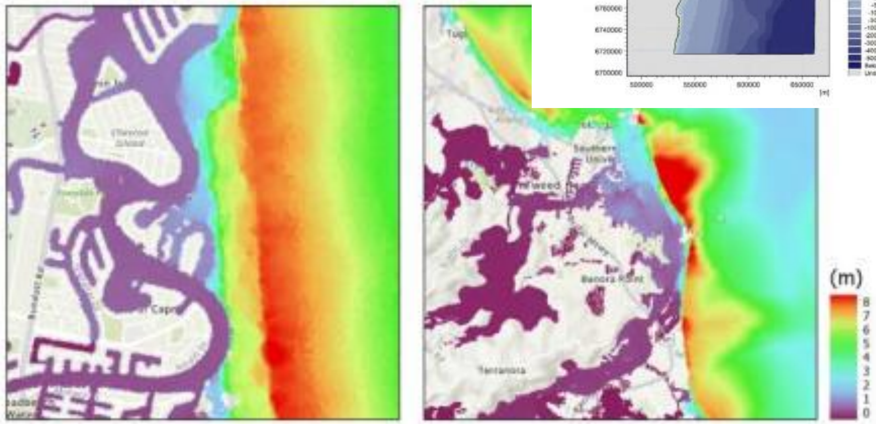


Figure 4 – Envelope of maximum water level for 10,000-yr ARI events at HAT. Left: Surfers Paradise; Right: Tweed Heads.

Figure 6 – Envelope of maximum inundation extents near Surfers Paradise for all ARIs at HAT.

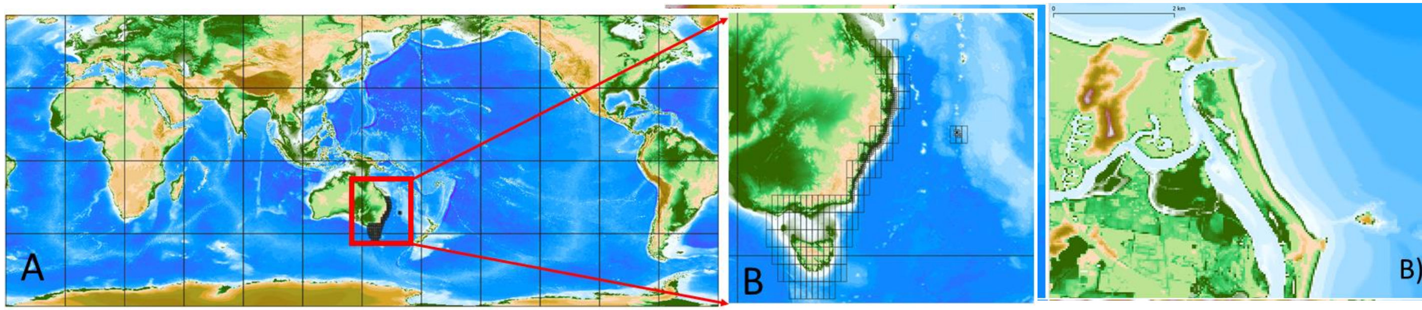
Australasian Coasts & Ports 2023 Conference – Sunshine Coast, QLD, 15 – 18 August 2023
Tsunami Inundation Modelling for City of Gold Coast, Australia
Neda Mardani, Paul K. Boswood, Youkai Li, Nick Naderi and Alex Atkinson

Tsunami Inundation Modelling for City of Gold Coast, Australia

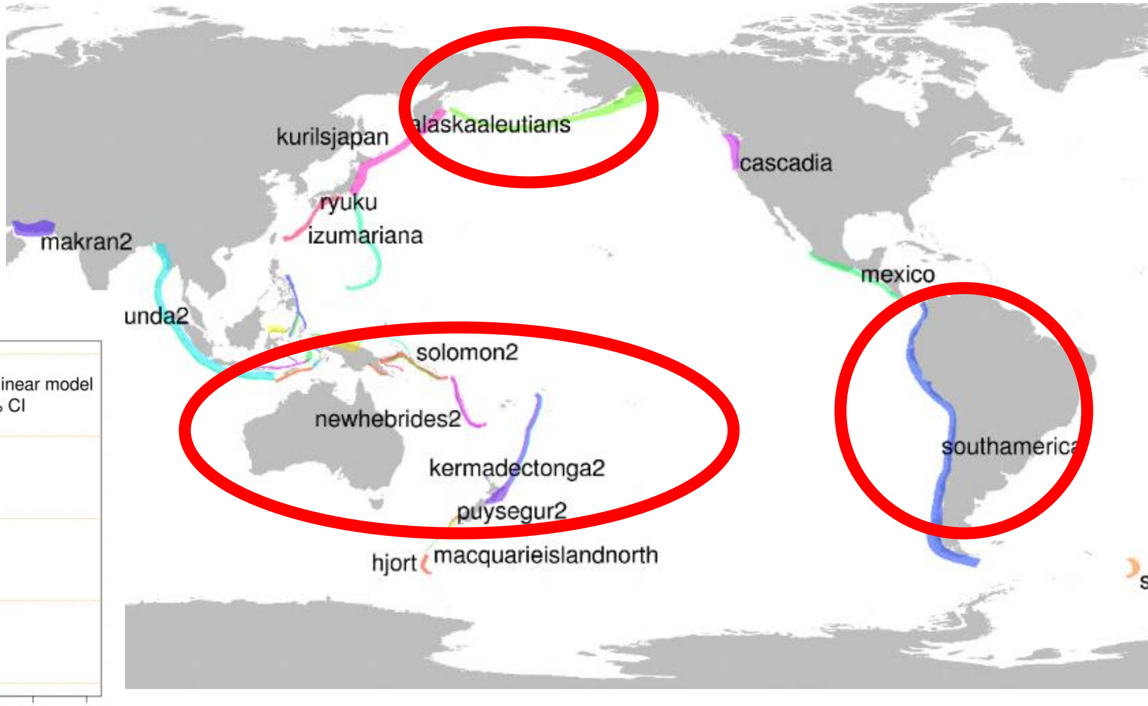
Neda Mardani[1], Paul K. Boswood[1], Youkai Li[1], Nick Naderi[1] and Alex Atkinson[1]
[1] Queensland Government Hydraulics Laboratory. Qld Department of Environment and Science, Brisbane, Queensland, Australia; Neda.Mardani@des.qld.gov.au

Example: Probabilistic tsunami inundation hazard assessment

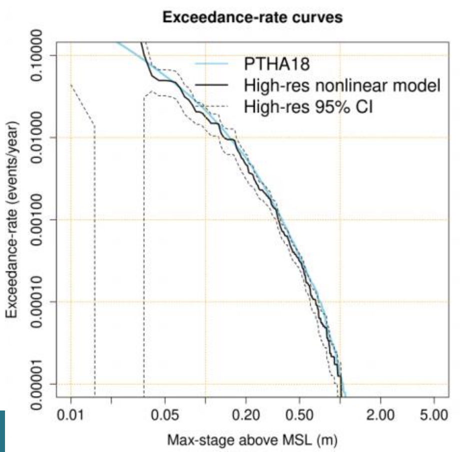
- **Inundation hazards for all NSW & Lord Howe Island, Australia**
  - ~1000 km coast @ ~33m res
  - In-process



- **Subset of PTHA18 source-zones**
  - Hazard deaggregation & judgement



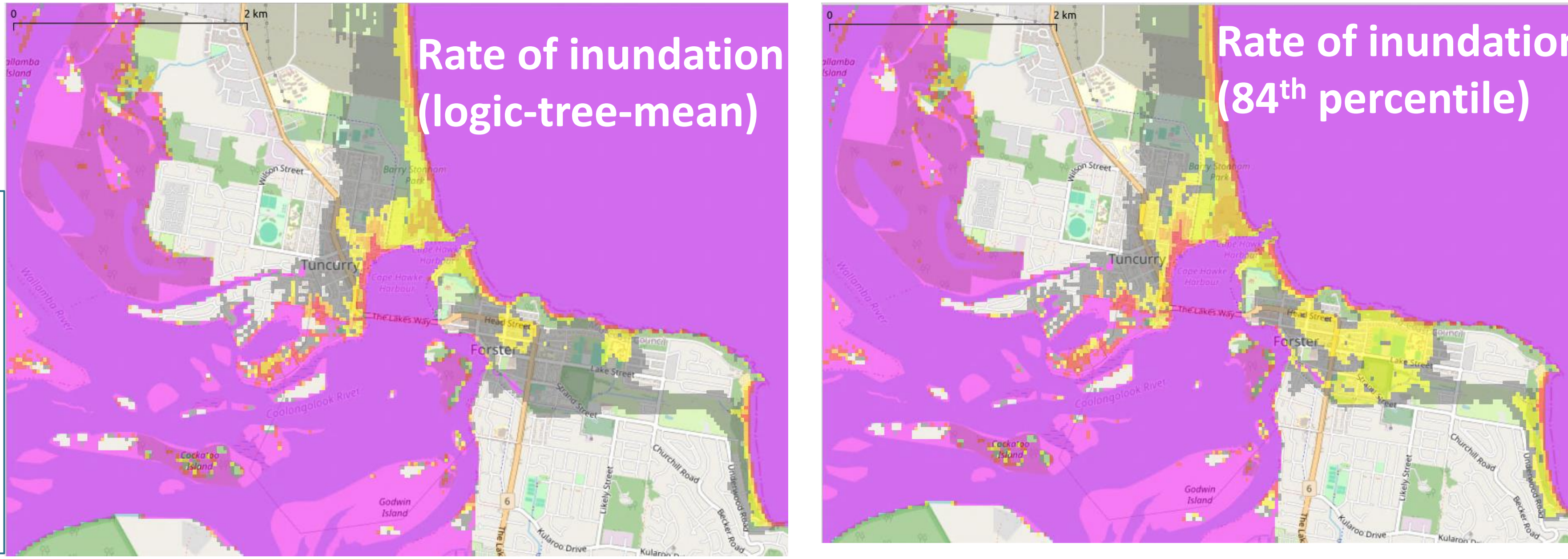
- **Monte Carlo approach**
  - Rigorously approximate the "all scenarios" solution
  - Importance sampling
    - Focus on hazardous waves
    - ~1000 inundation scenarios total



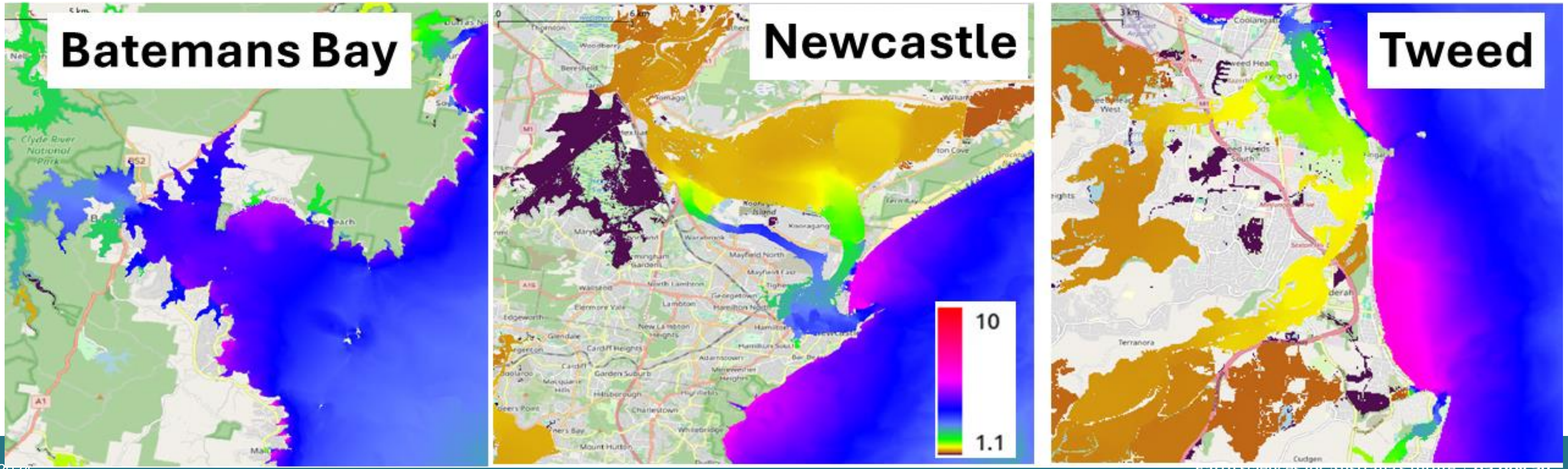
Example: Probabilistic tsunami inundation hazard assessment

- **PRELIMINARY!**
  - More scenarios to run

Rate of inundation events/yr
Purple: > 1
Red: 1 - 1/100
Orange: 1/100 – 1/500
Yellow: 1/500 – 1/2500
Grey: 1/2500 – 1/10000



Tsunami maxima (m above MSL), exceedance-rate 1/2500, 84 percentile



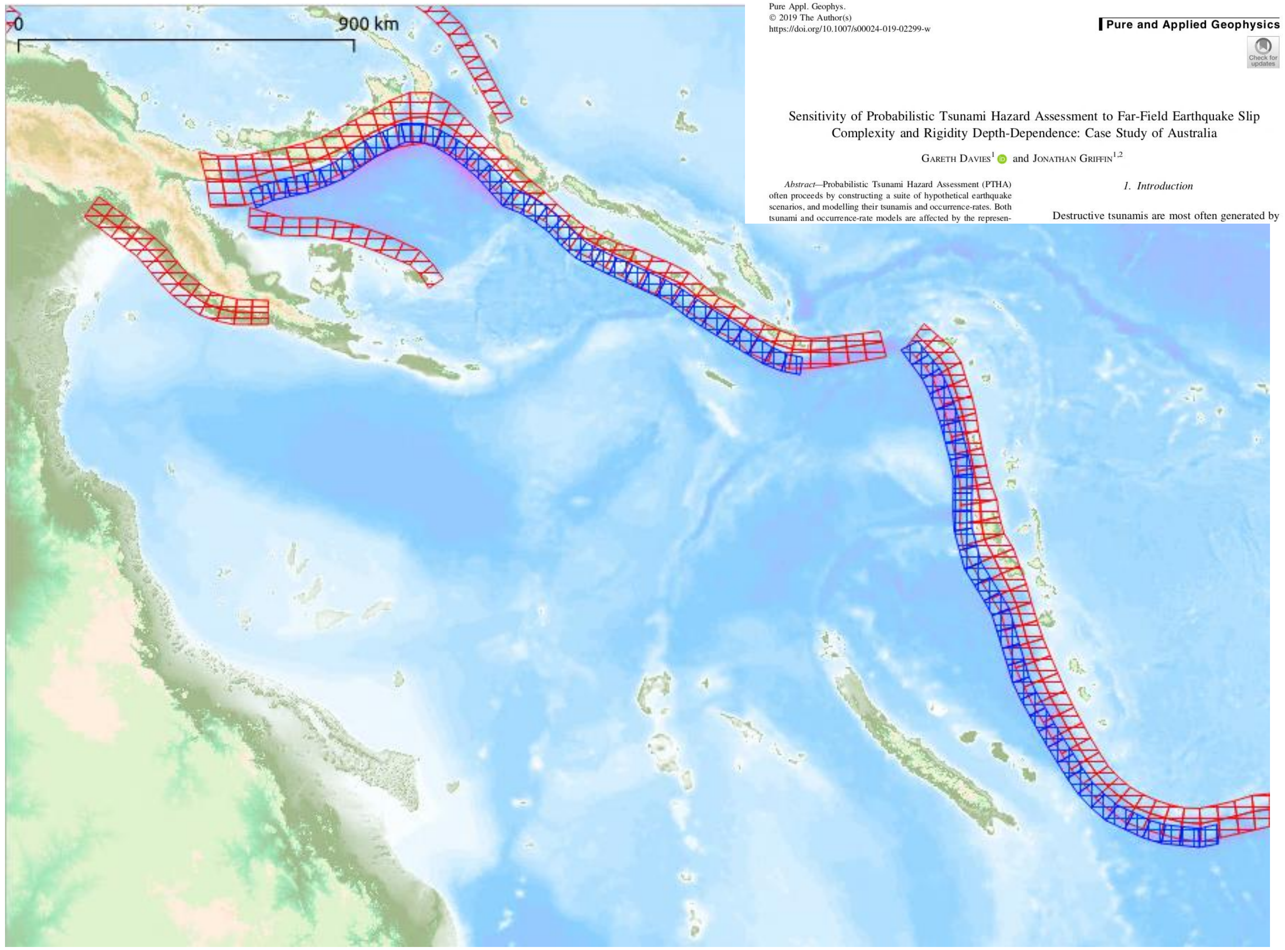
2018 Australian PTHA in the region from New Hebrides to New Britain

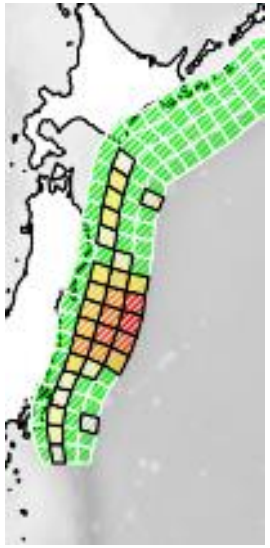
The region according to PTHA18

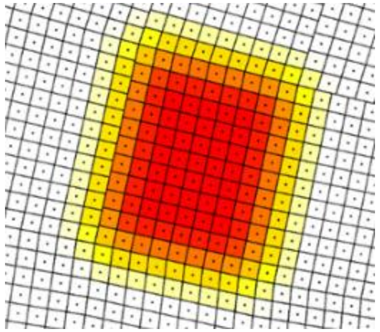
- **Globally uniform methodology**
  - Not tuned to this region
  - Davies and Griffin (2020)

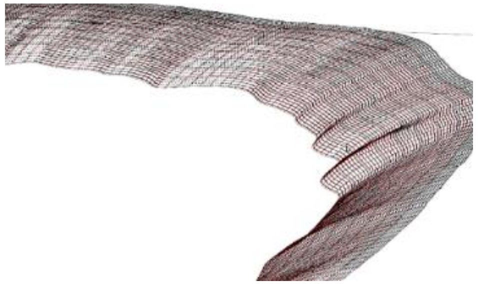
- **Two main subduction zones**
  - Solomon (inc. New Britain)
  - New Hebrides
  - 50% unsegmented, 50% segmented

- **Thrust and Outer-rise (normal)**
  - Separate (no mixed-mechanism scenarios)
  - Rigidity 30 GPA and 60 GPA
  - ~50x50 km^2 unit sources
    - Internal structure
  - Geometry from SLAB or other



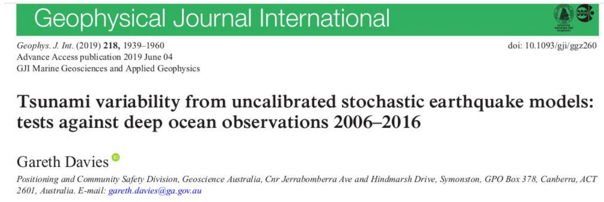






Historical tsunamis vs PTHA18 scenarios with “similar location & Mw”

- ***Data vs “similar” random scenarios***

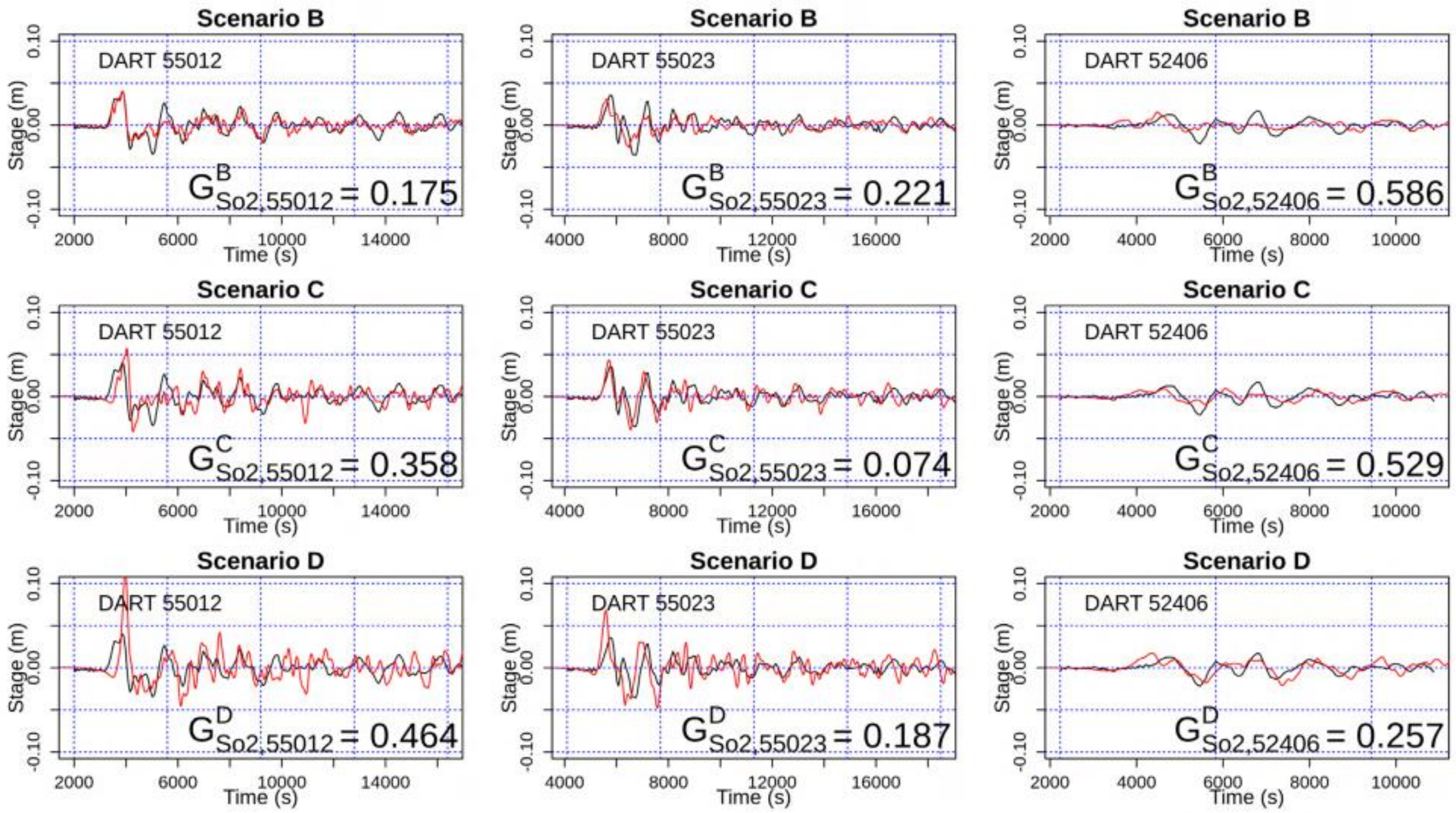


Geophysical Journal International
Geophys. J. Int. (2019) 218, 1939–1960 doi: 10.1093/gji/ggz260
Advance Access publication 2019 June 04
GJI Marine Geosciences and Applied Geophysics

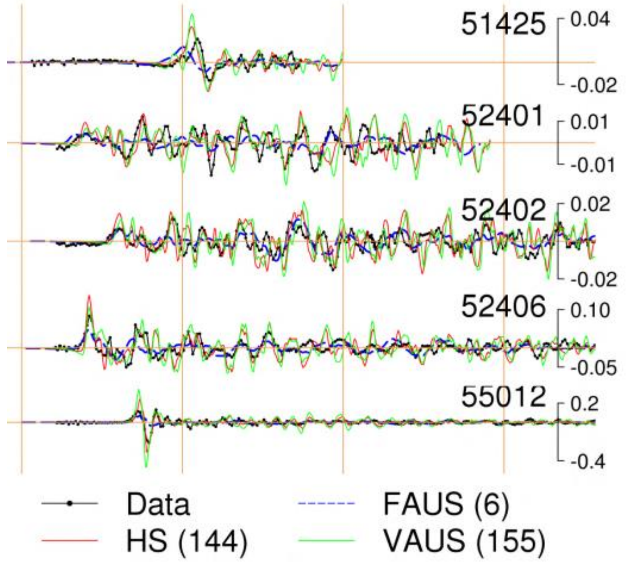
Tsunami variability from uncalibrated stochastic earthquake models: tests against deep ocean observations 2006–2016

Gareth Davies
Positioning and Community Safety Division, Geoscience Australia, Cnr Jerrabomberra Ave and Hindmarsh Drive, Symonston, GPO Box 378, Canberra, ACT 2601, Australia. E-mail: gareth.davies@ga.gov.au

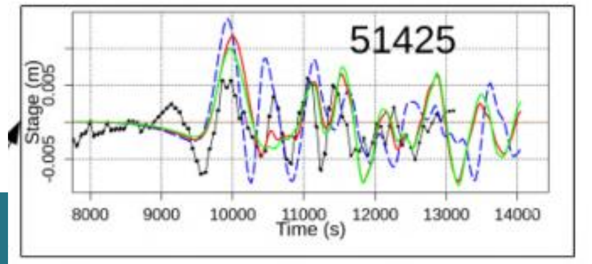
Solomon 2016/12/08 Mw 7.8



Santa Cruz 2013/02/06 Mw 7.9

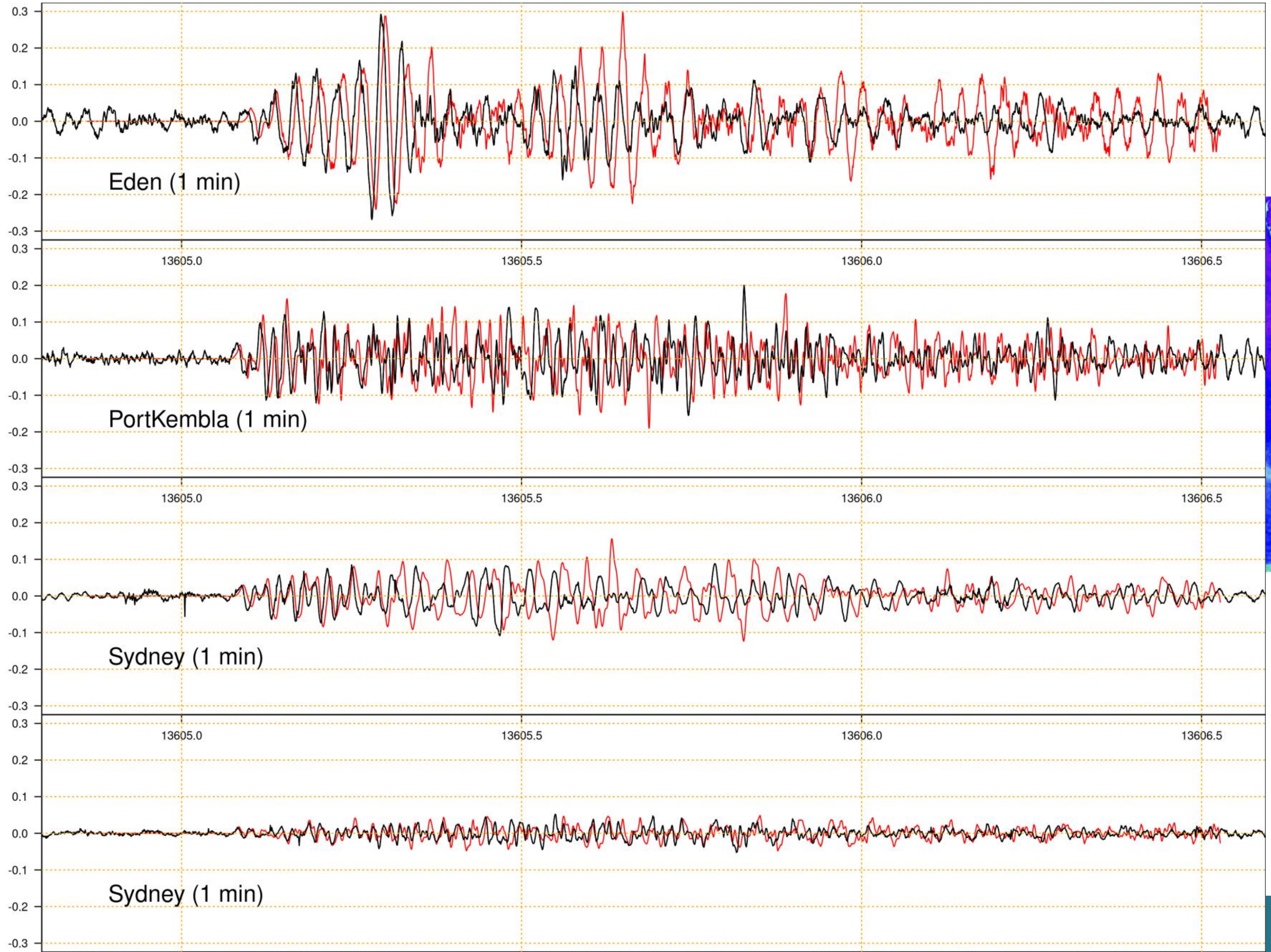


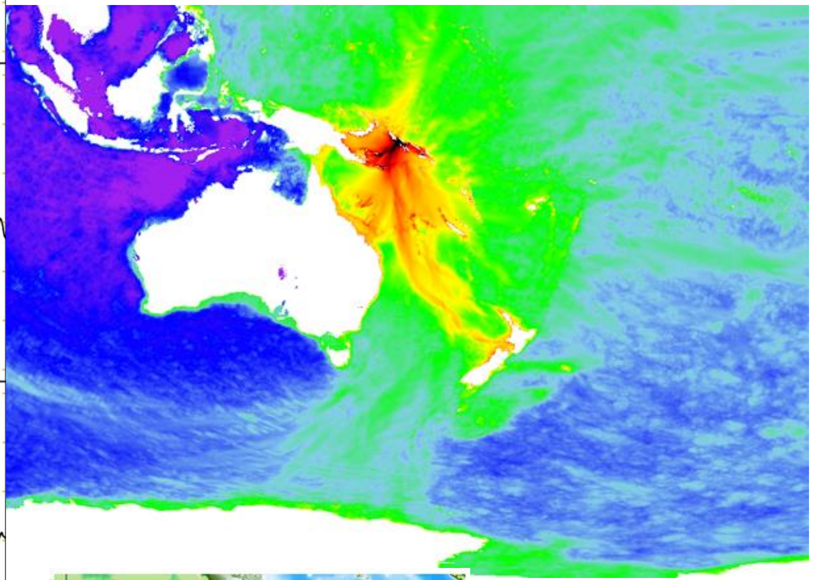
2009/02/06 Mw 7.8

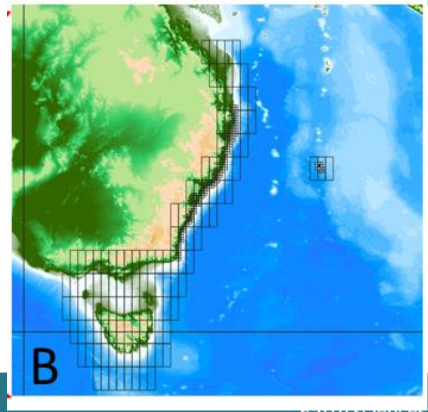


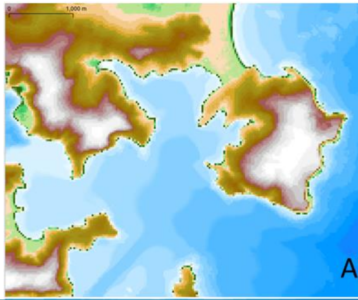
Nearshore tide-gauges in Australia

Solomon 2007/04/01
Mw 8.1
Observed
PTHA18 scenario







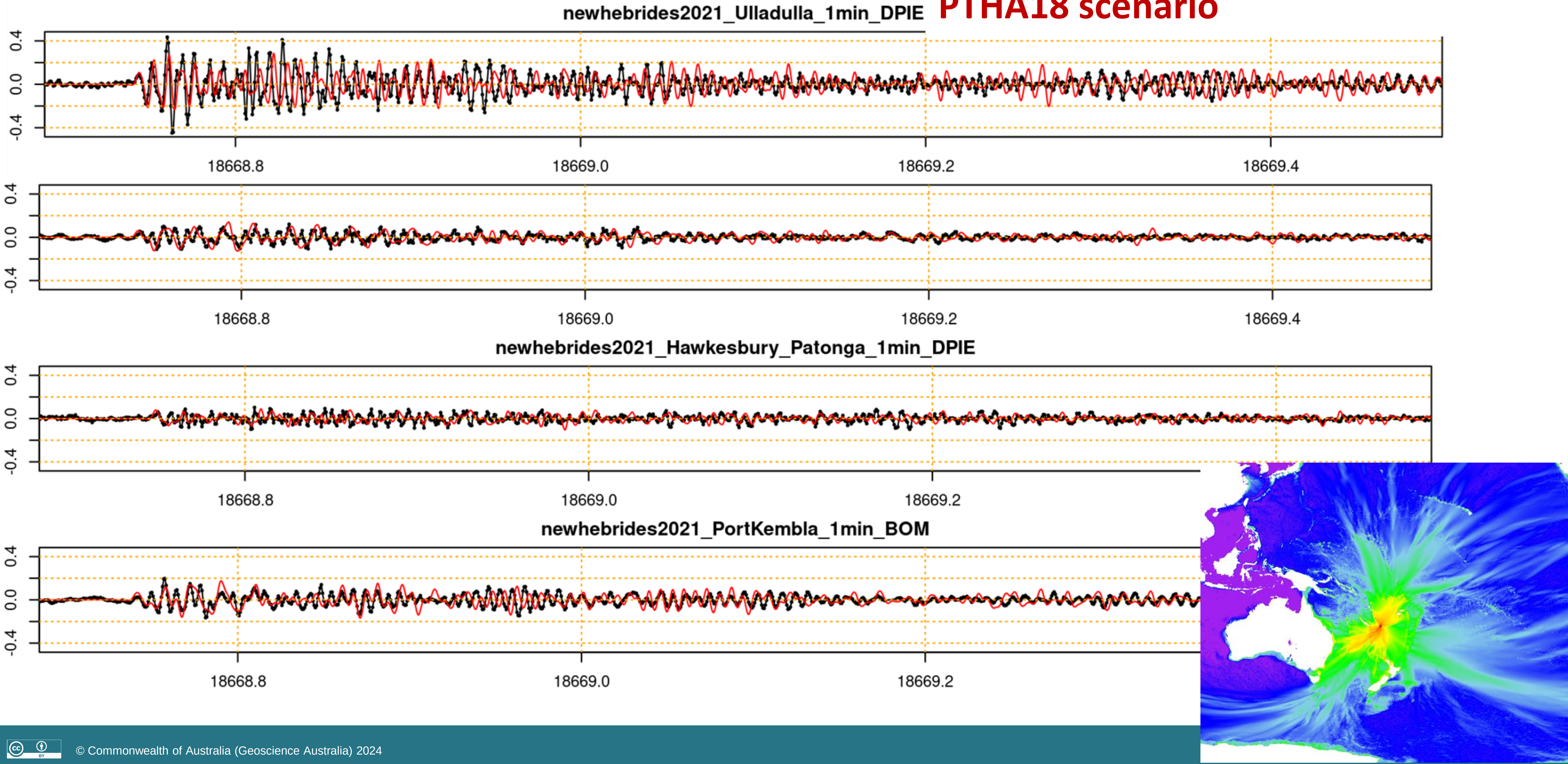


Nearshore tide-gauges in Australia

New Hebrides 2021/02/04 Mw 7.7

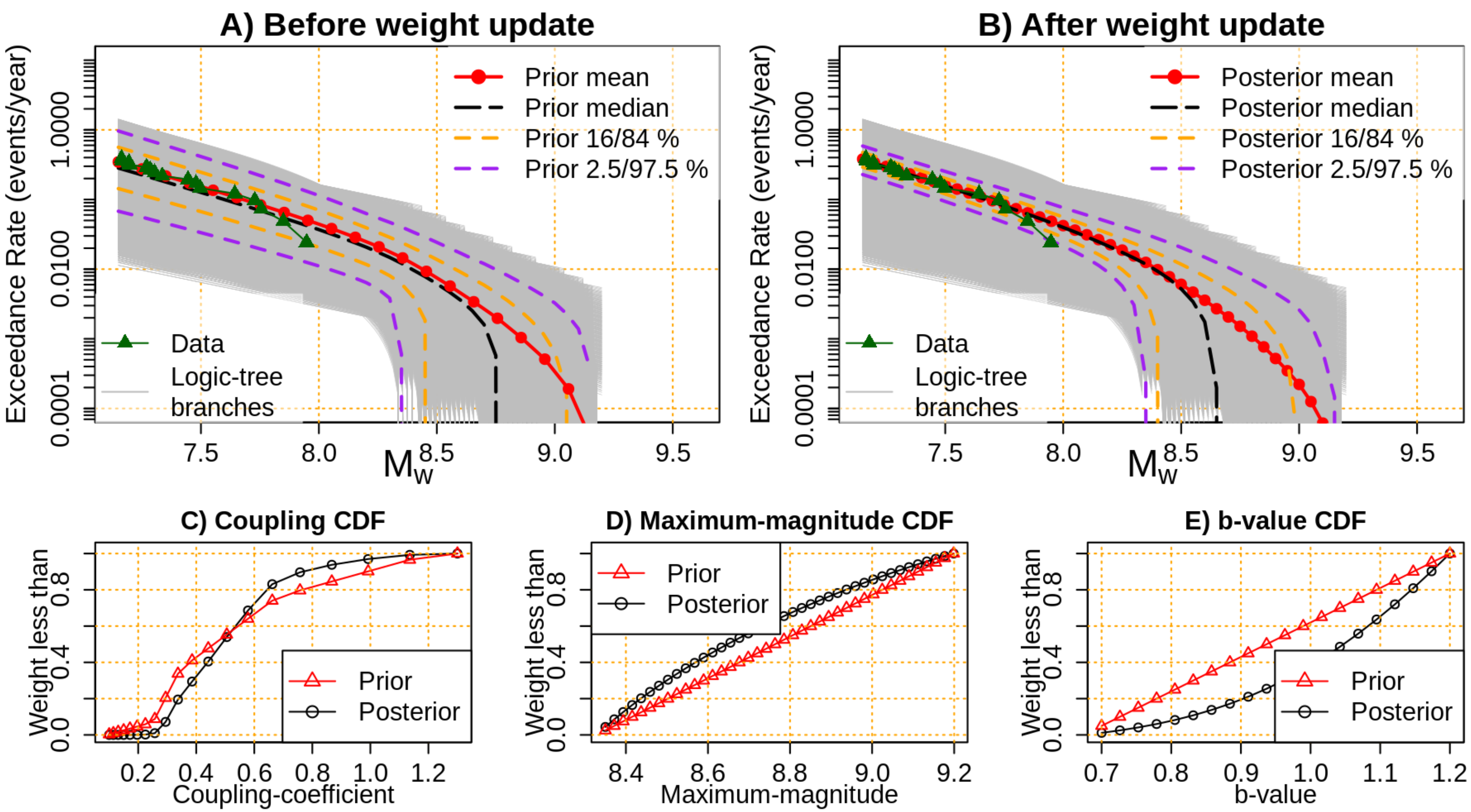
Observed

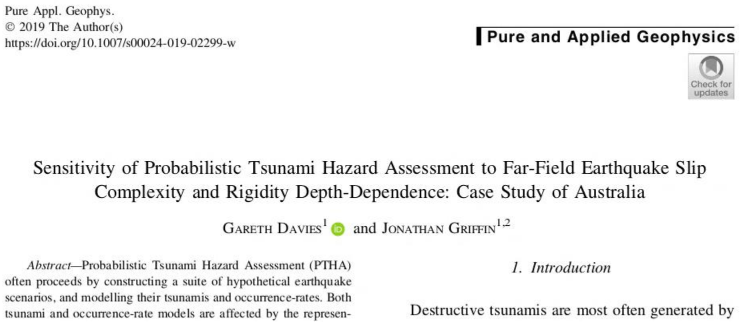
PTHA18 scenario



Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

New Hebrides thrust: Unsegmented

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https://doi.org/10.1007/s00024-019-02299-w

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Sensitivity of Probabilistic Tsunami Hazard Assessment to Far-Field Earthquake Slip Complexity and Rigidity Depth-Dependence: Case Study of Australia

Gareth Davies[1] and Jonathan Griffin[1,2]

Abstract—Probabilistic Tsunami Hazard Assessment (PTHA) often proceeds by constructing a suite of hypothetical earthquake scenarios, and modelling their tsunamis and occurrence-rates. Both tsunami and occurrence-rate models are affected by the represen-

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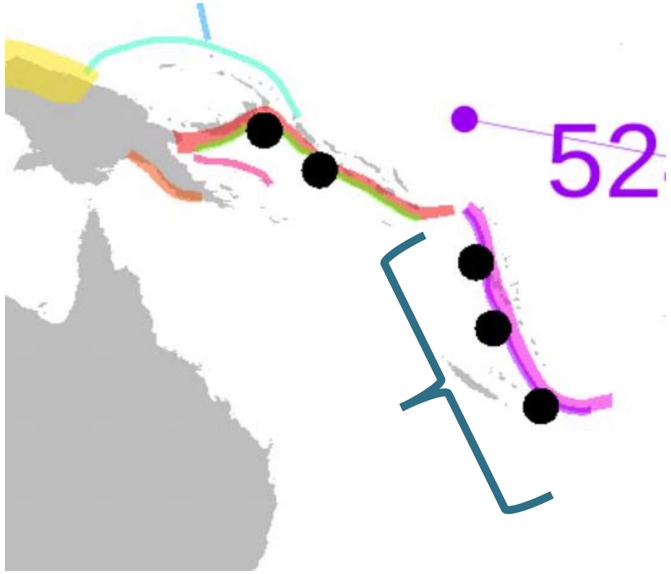
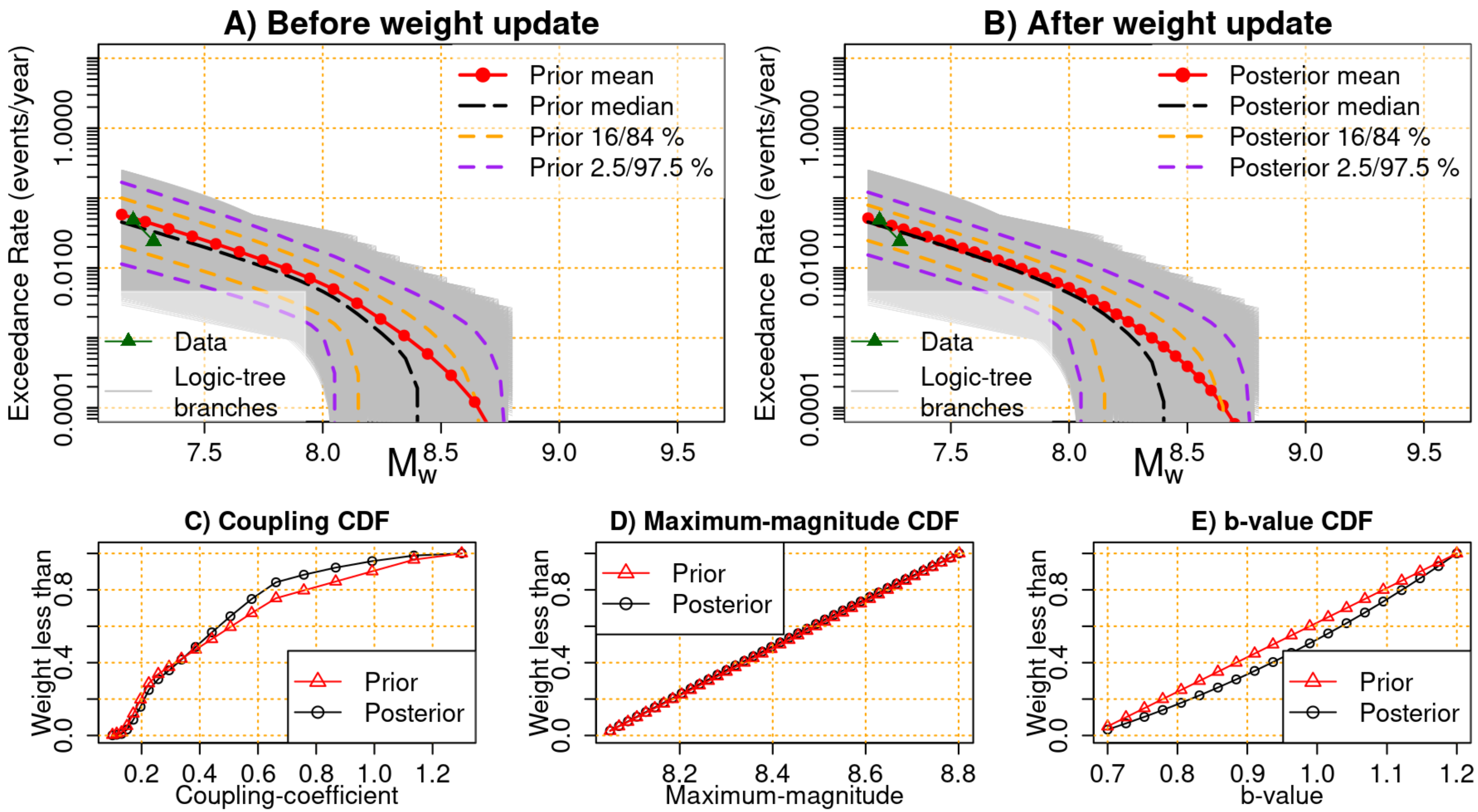
Destructive tsunamis are most often generated by



Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

New Hebrides thrust: Matthew Hunter segment



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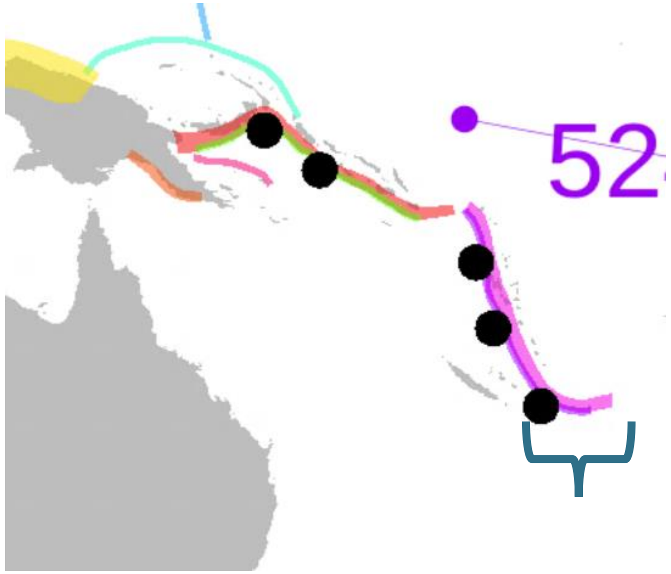
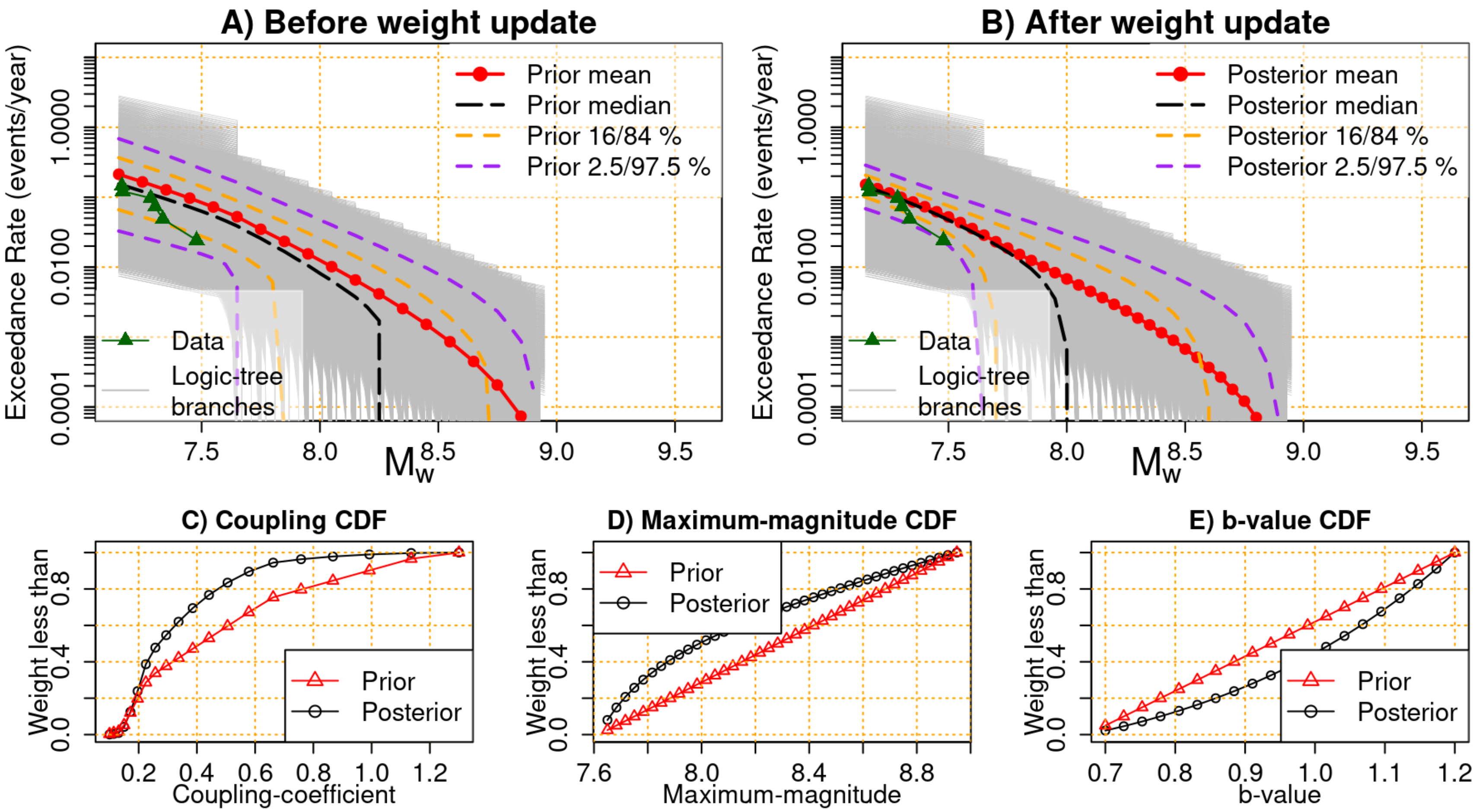
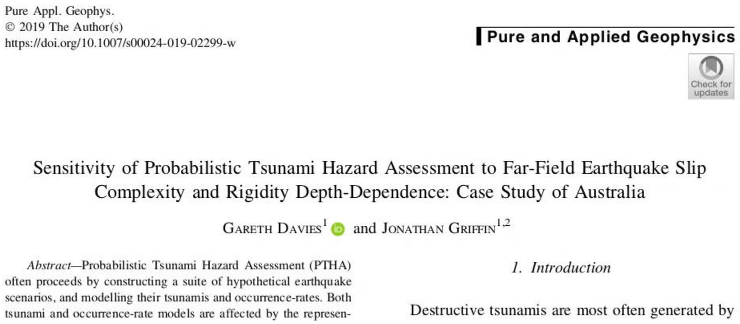


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

New Hebrides thrust: South segment





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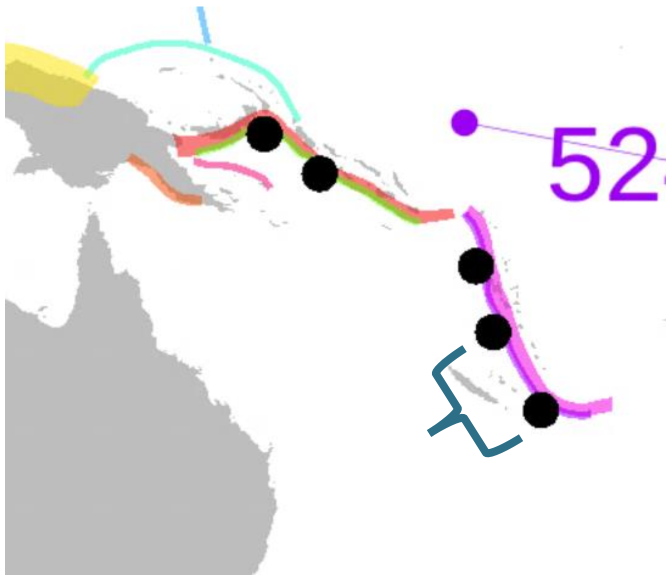
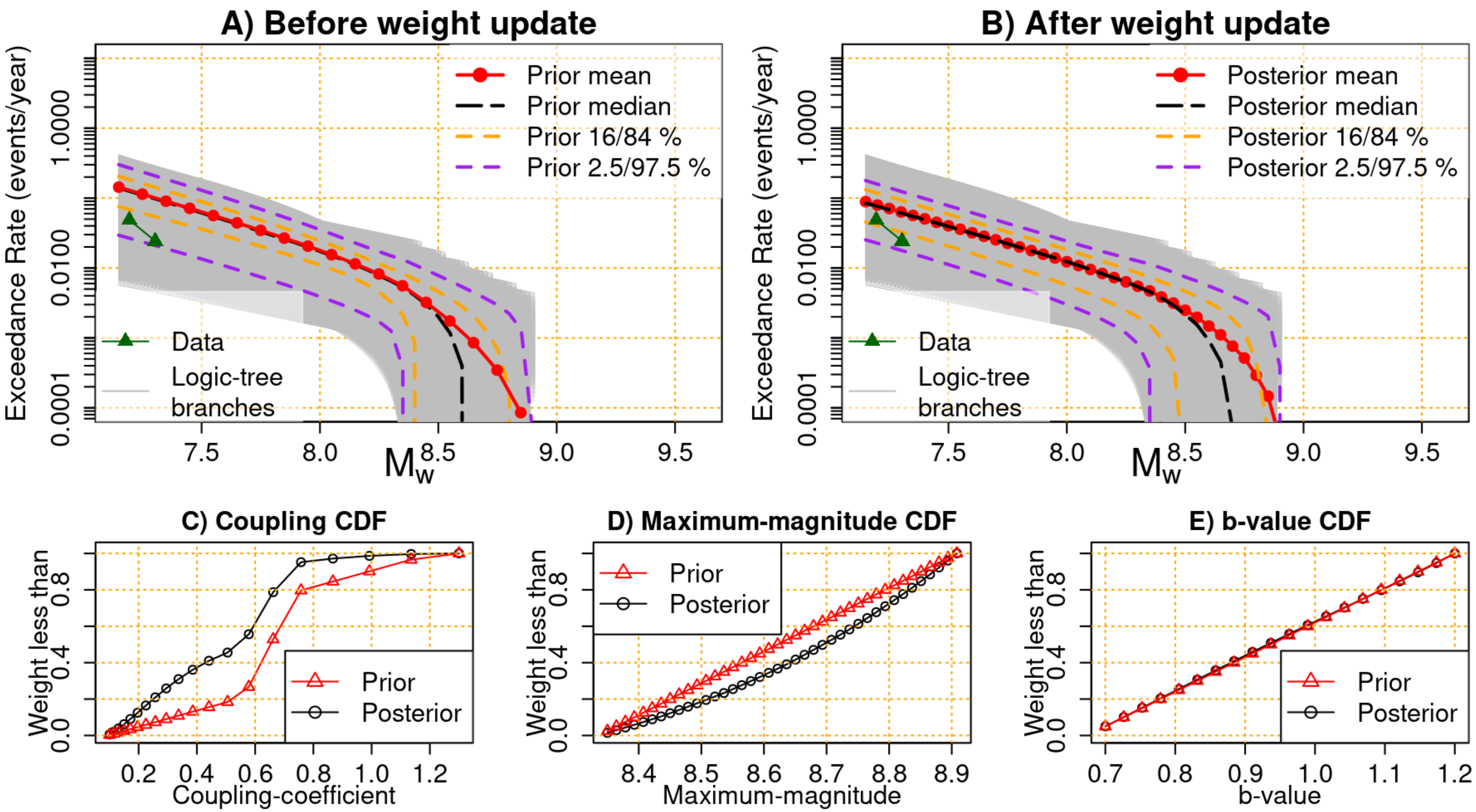
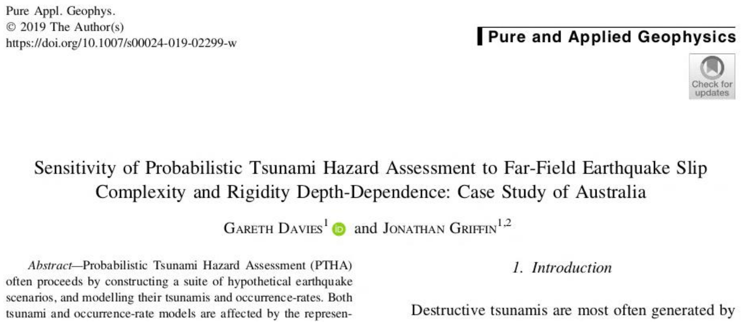


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

New Hebrides thrust: Central segment





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Pure and Applied Geophysics

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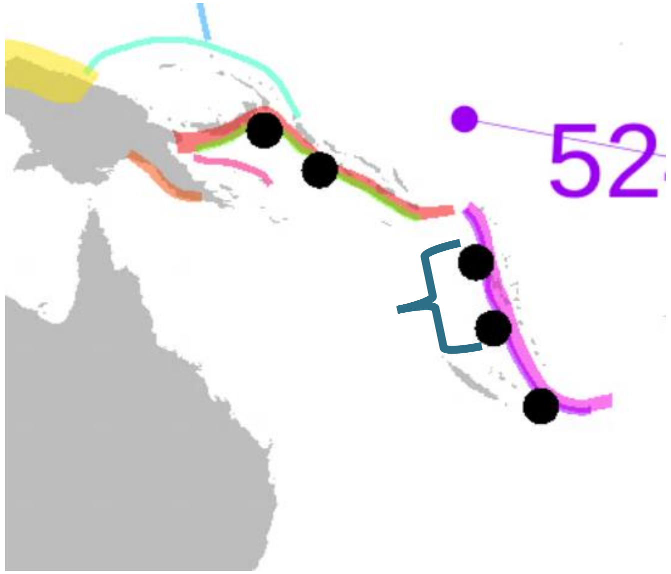
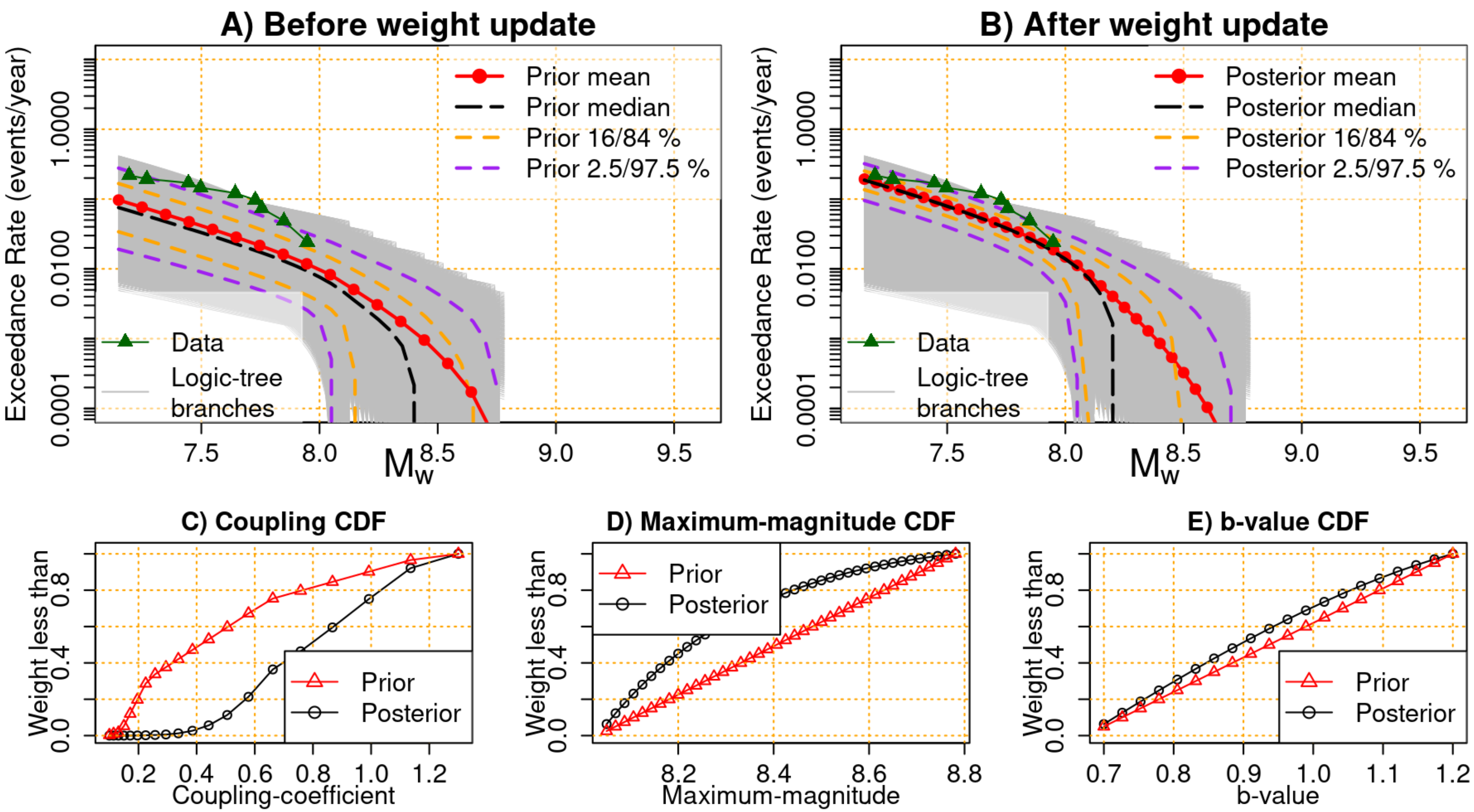
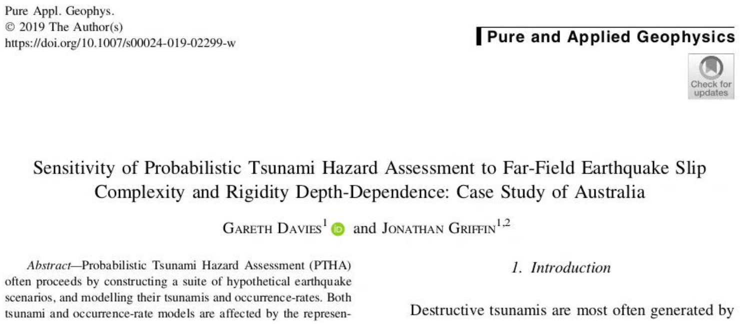


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

New Hebrides thrust: North segment





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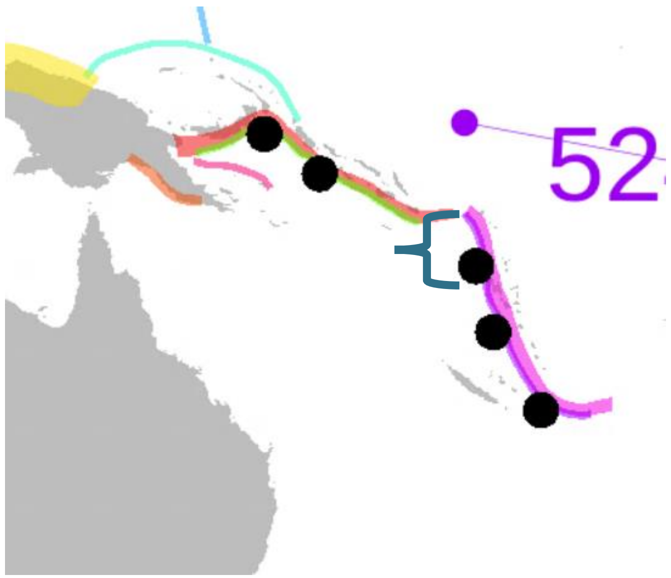
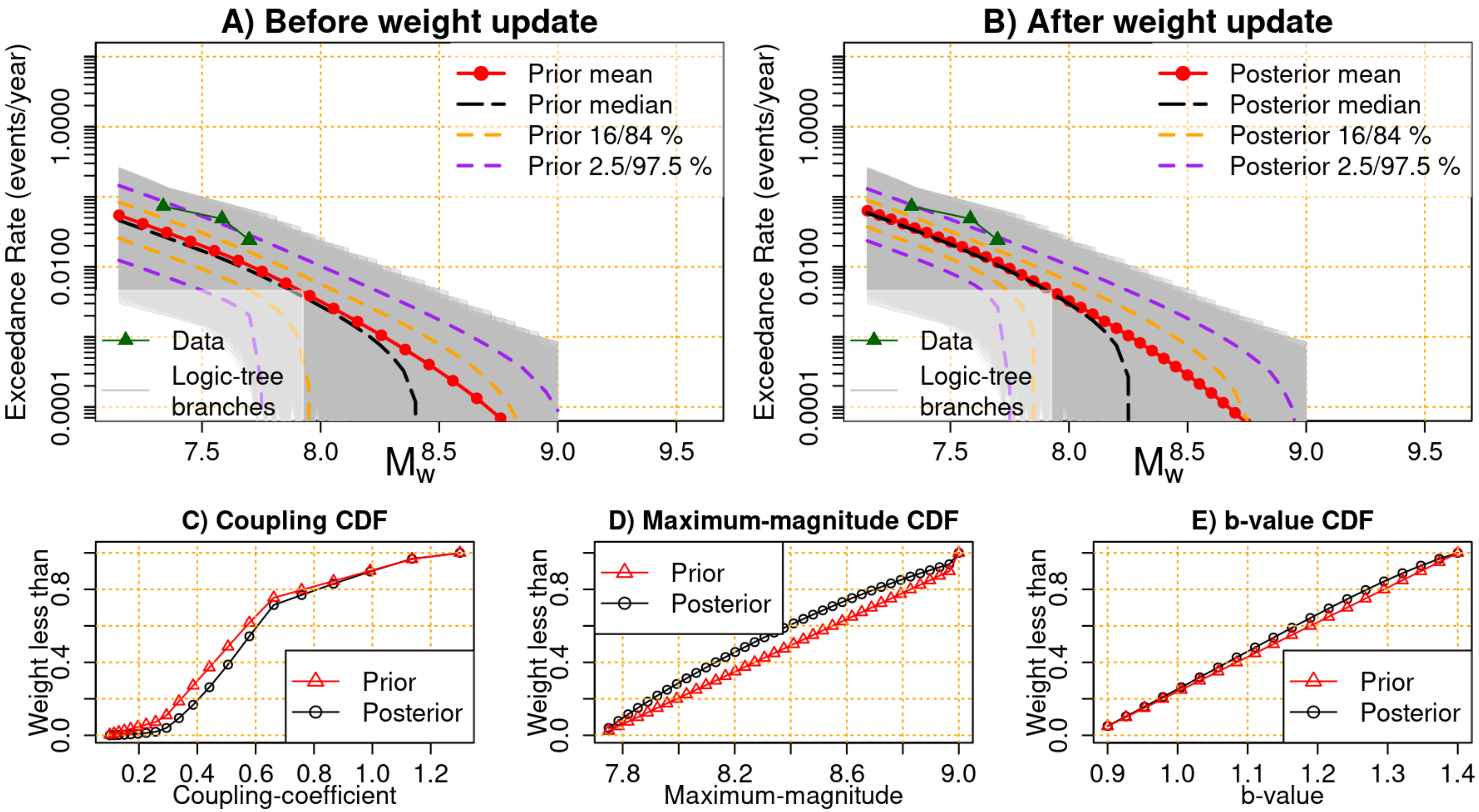


Mw-frequency models: outer rise

New Hebrides outer rise



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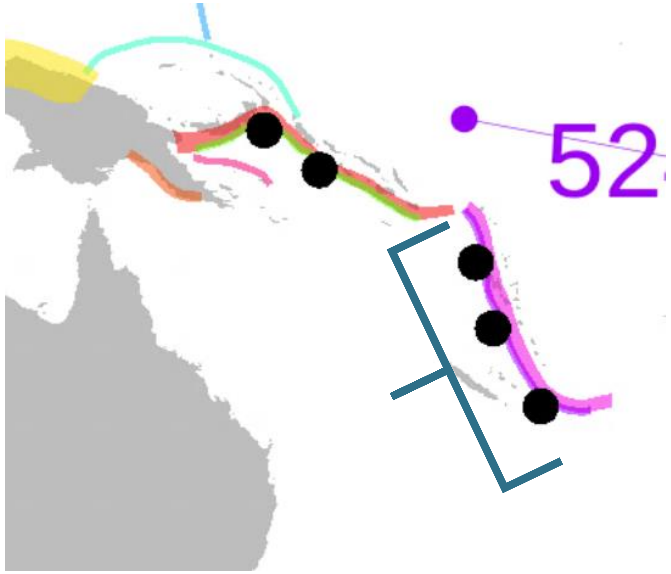
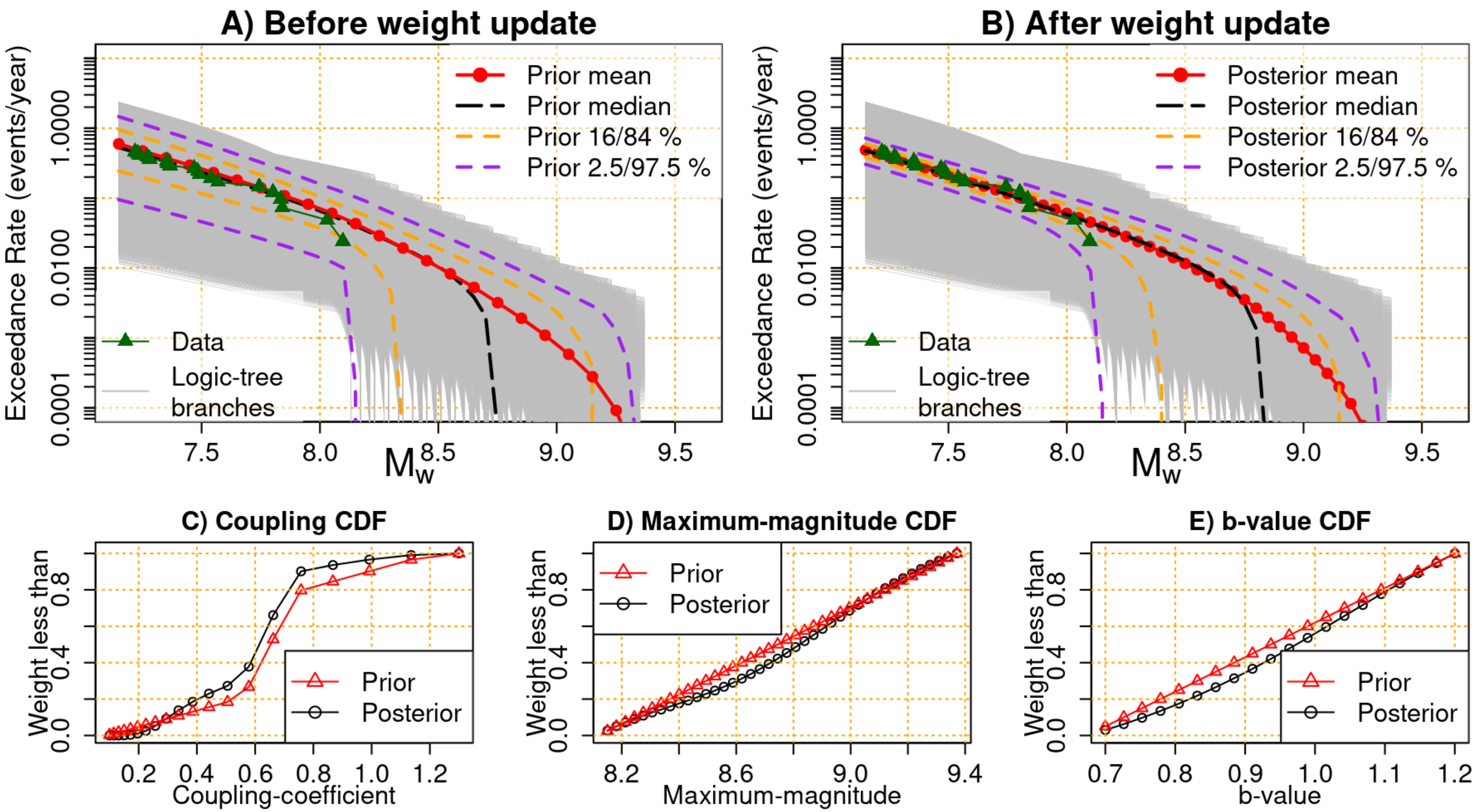
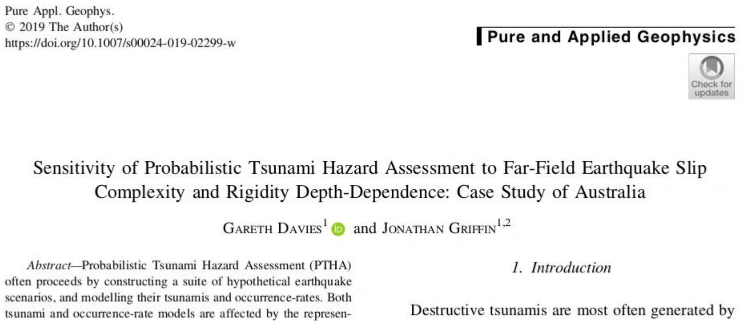


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

Solomon: Unsegmented





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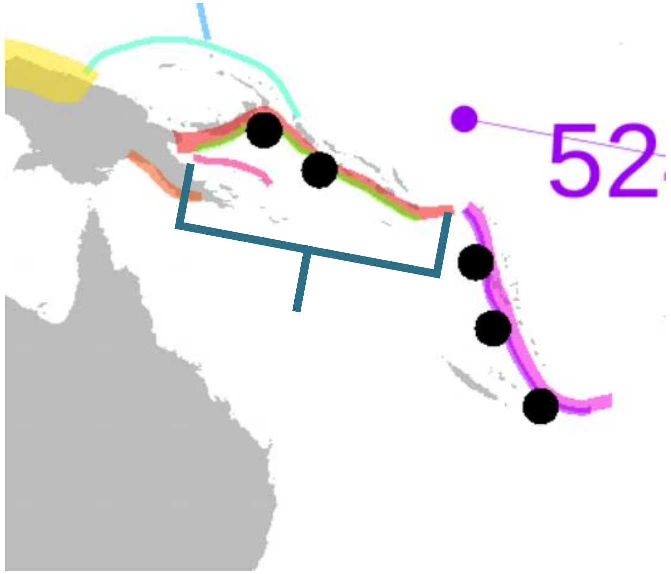
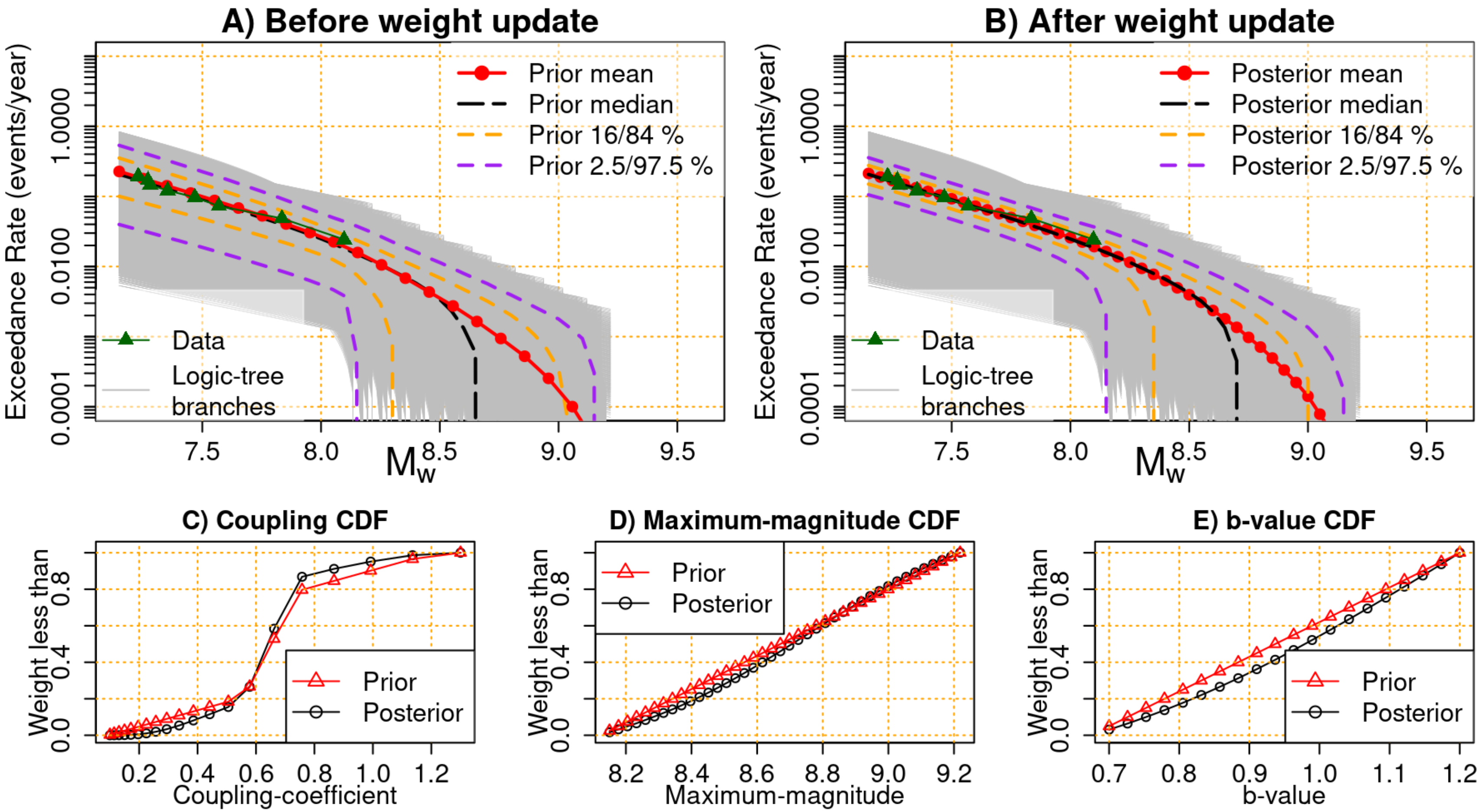
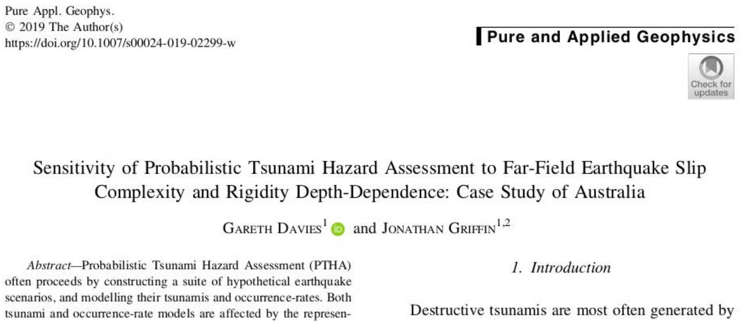


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

Solomon: Southeast segment

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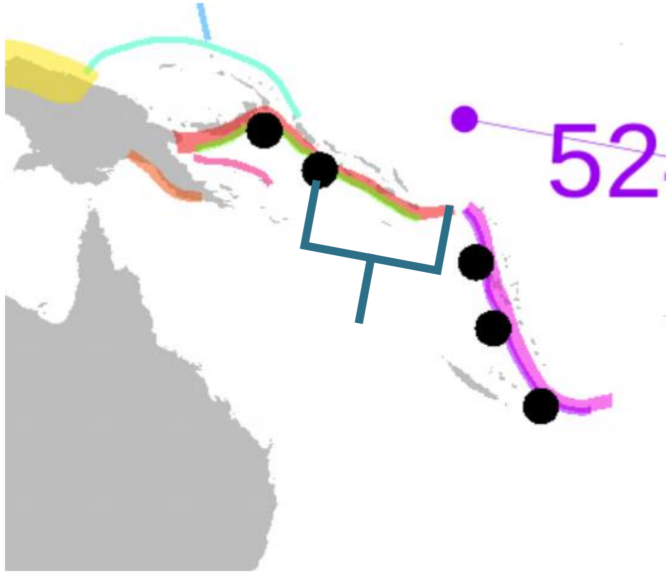
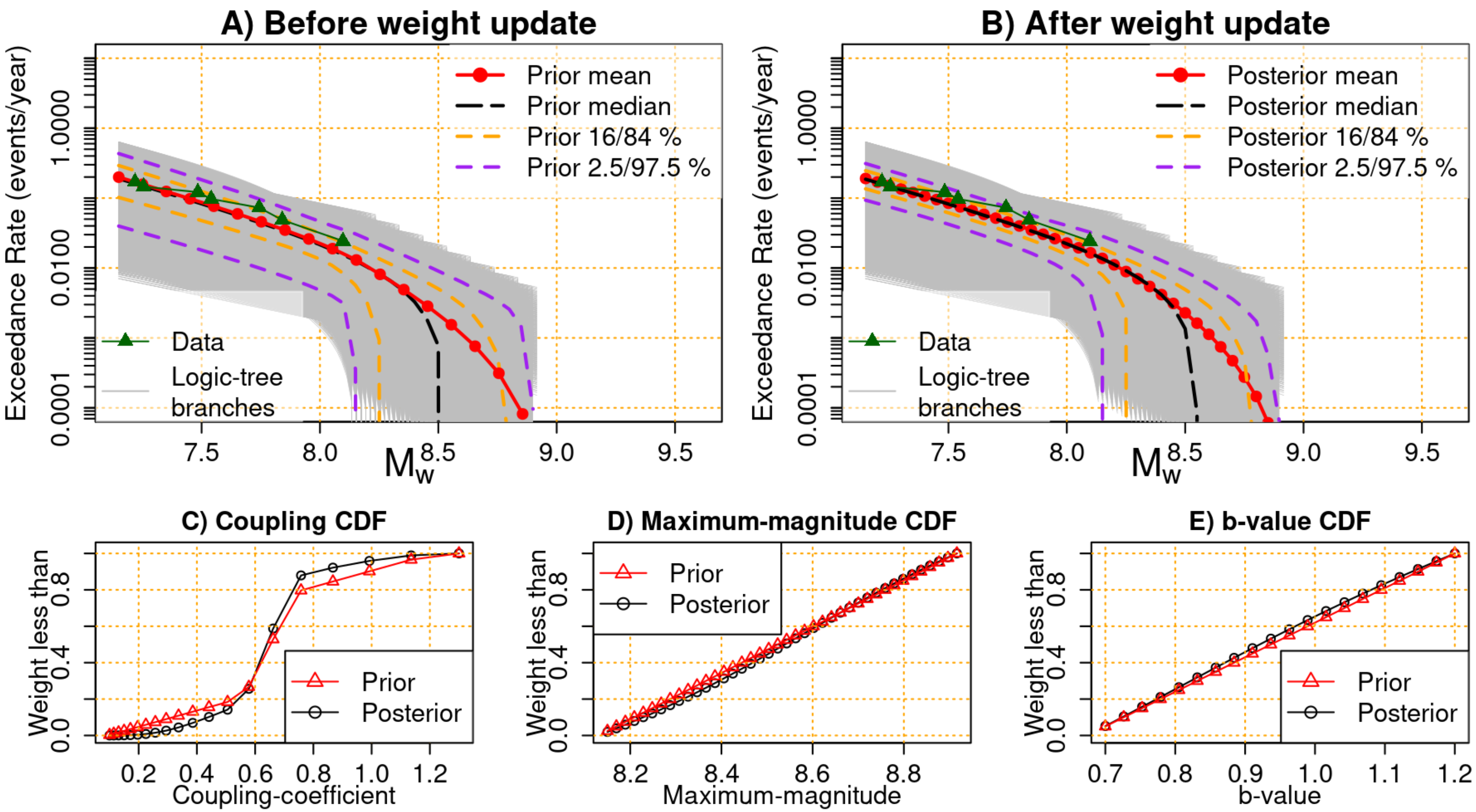
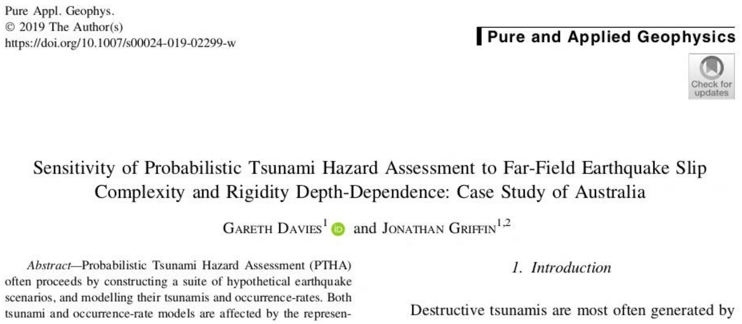


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

Solomon: Northwest segment





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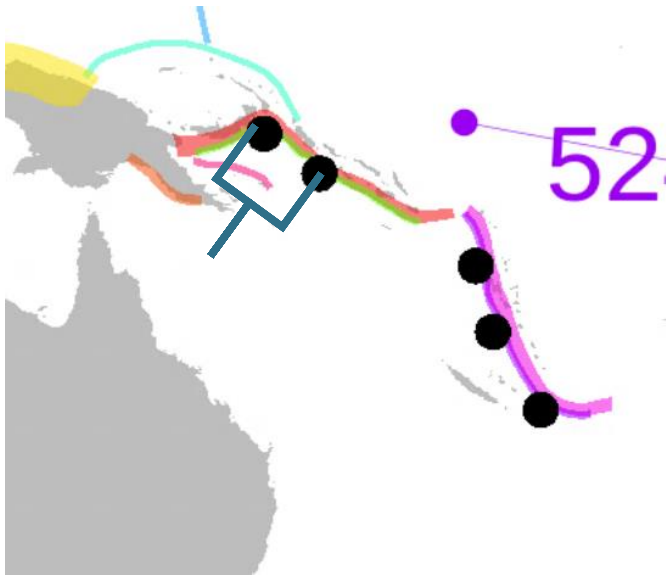
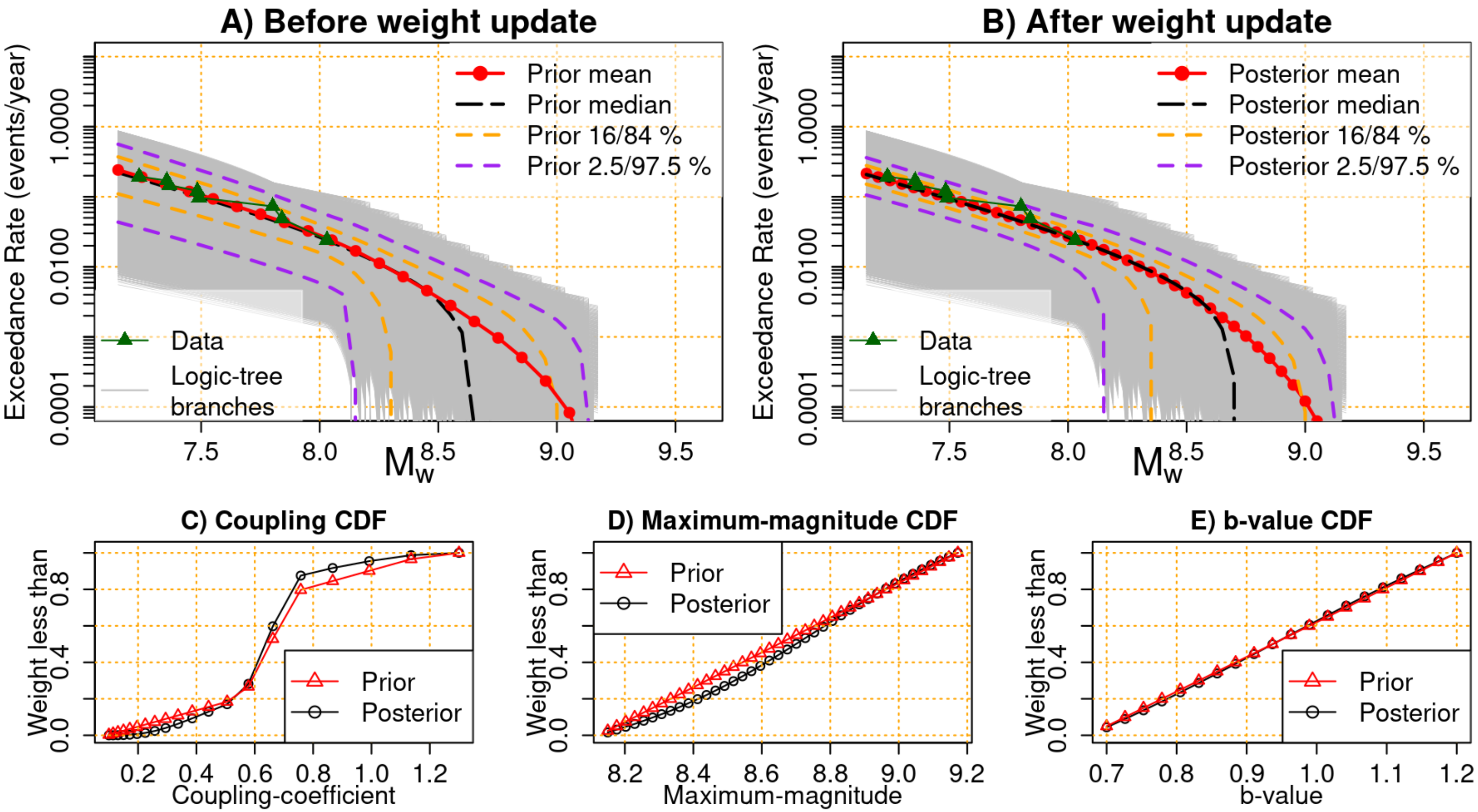
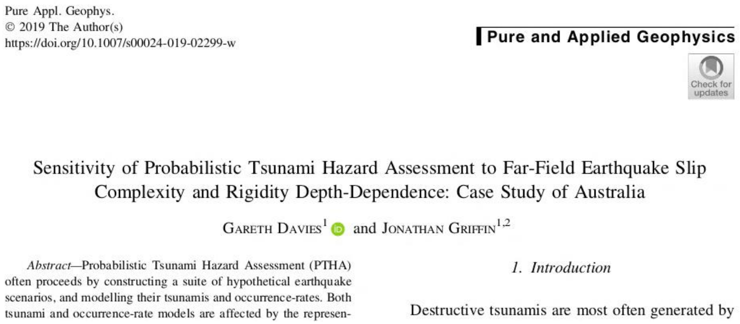


Mw-frequency models: 50:50 weight on unsegmented and union-of-segments

Solomon: New Britain segment





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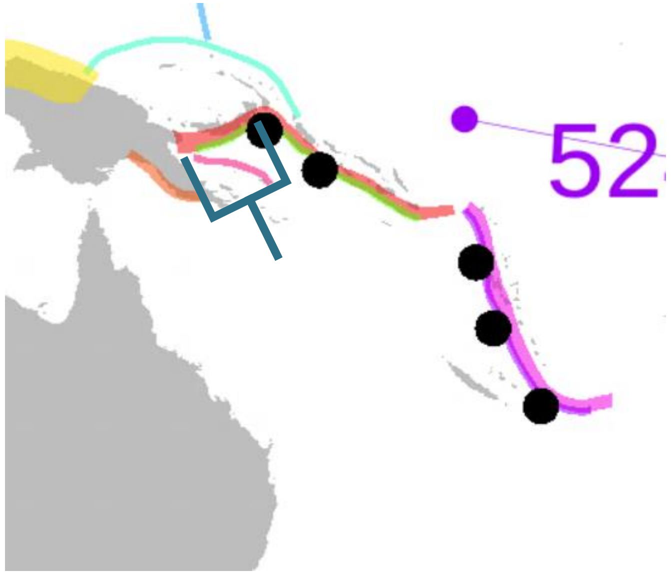

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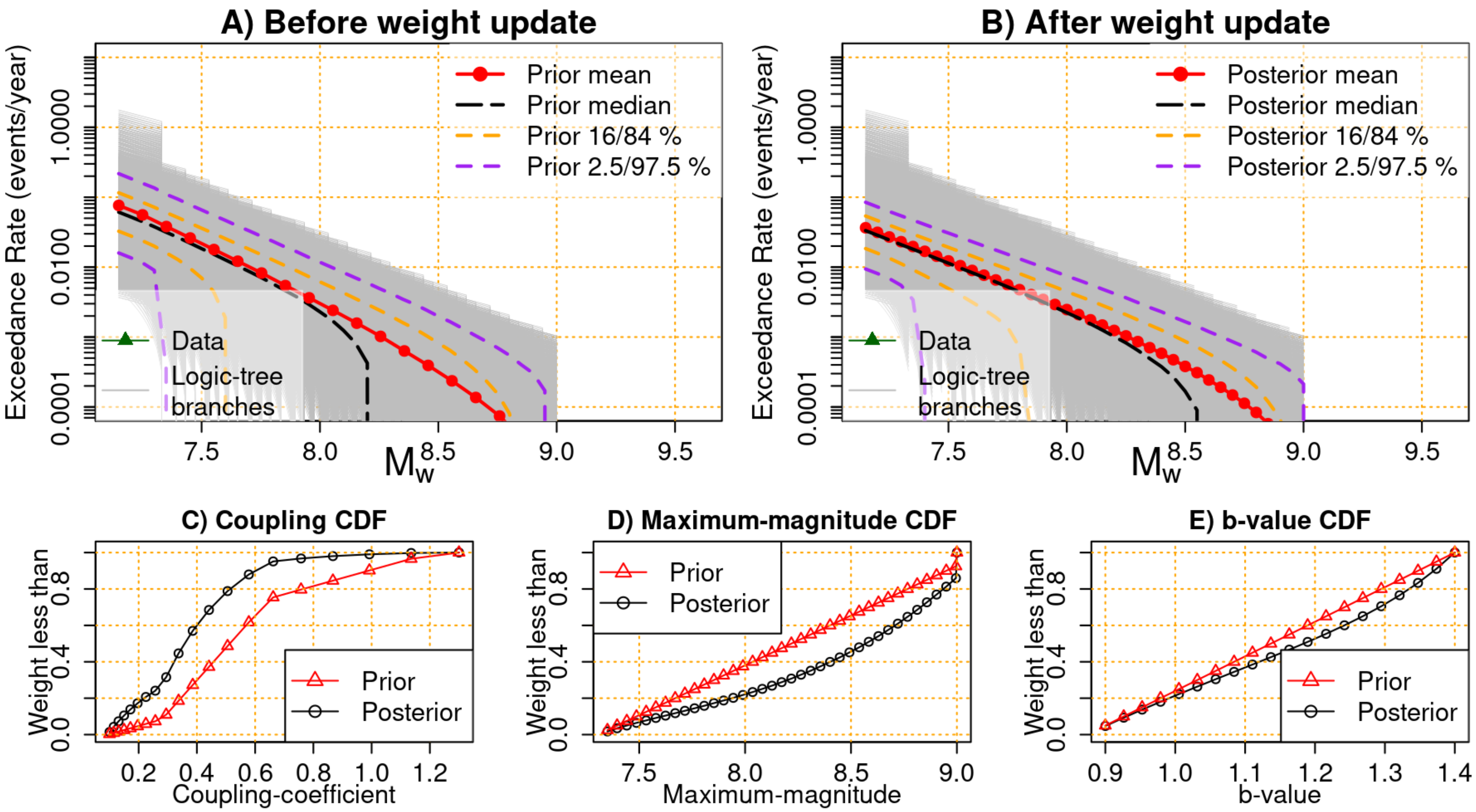

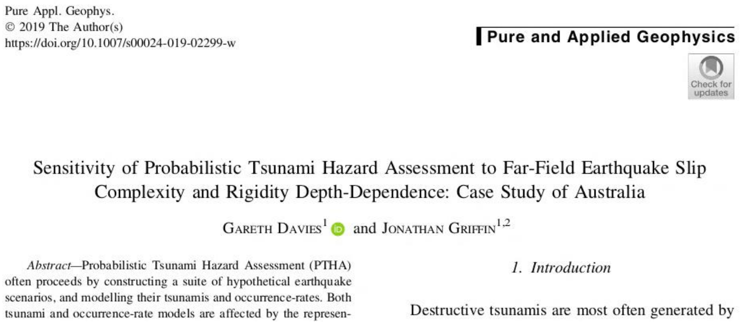

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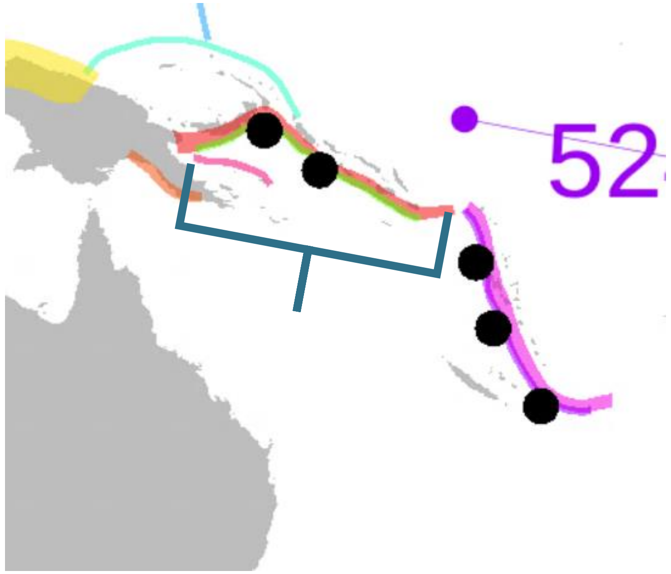

Thanks!

https://github.com/GeoscienceAustralia/ptha/tree/master/ptha_access