

# InletTracker: 30+ years of entrance dynamics of NSW ICOLLs from satellite data

Valentin Heimhuber, Oscar Garratt, William Glamore

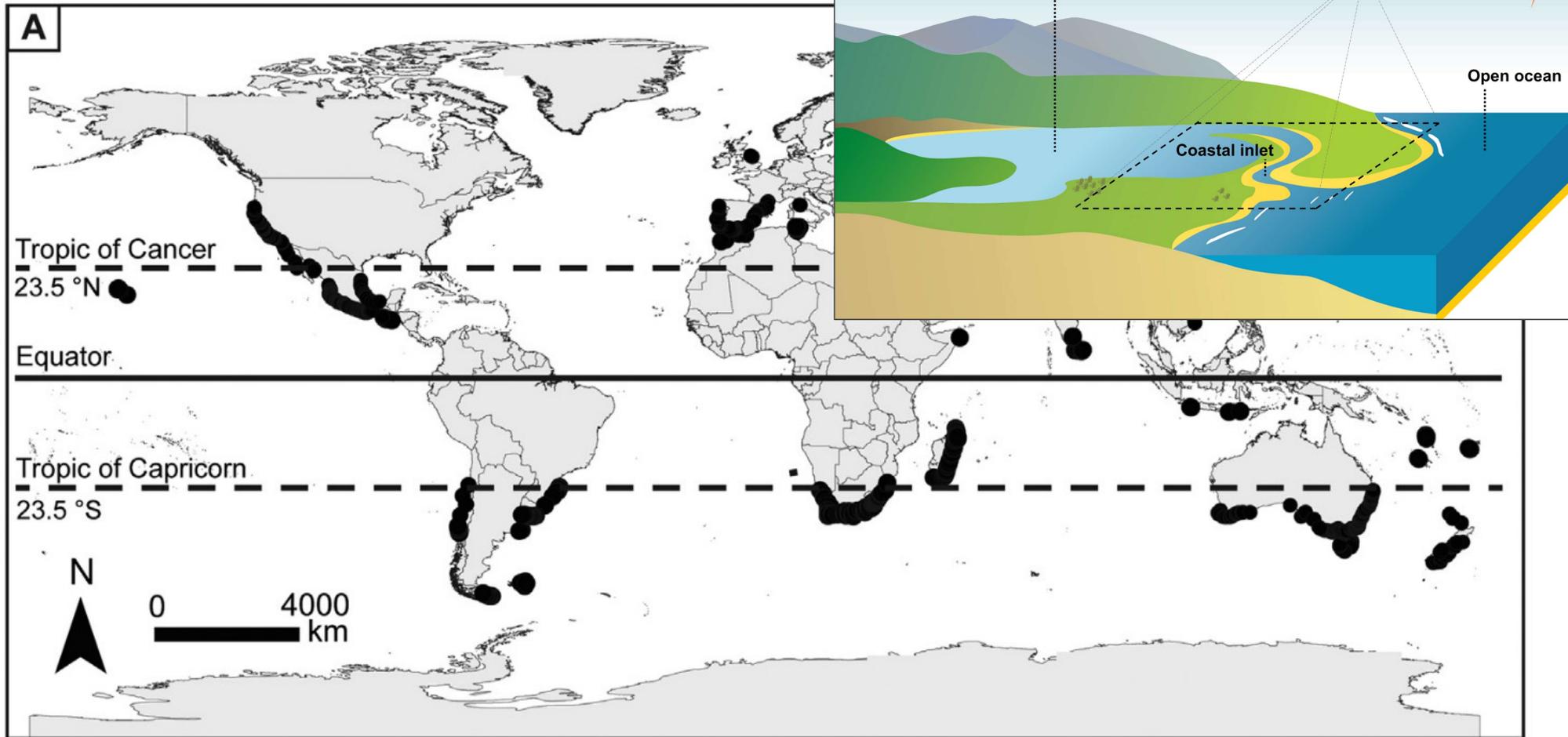


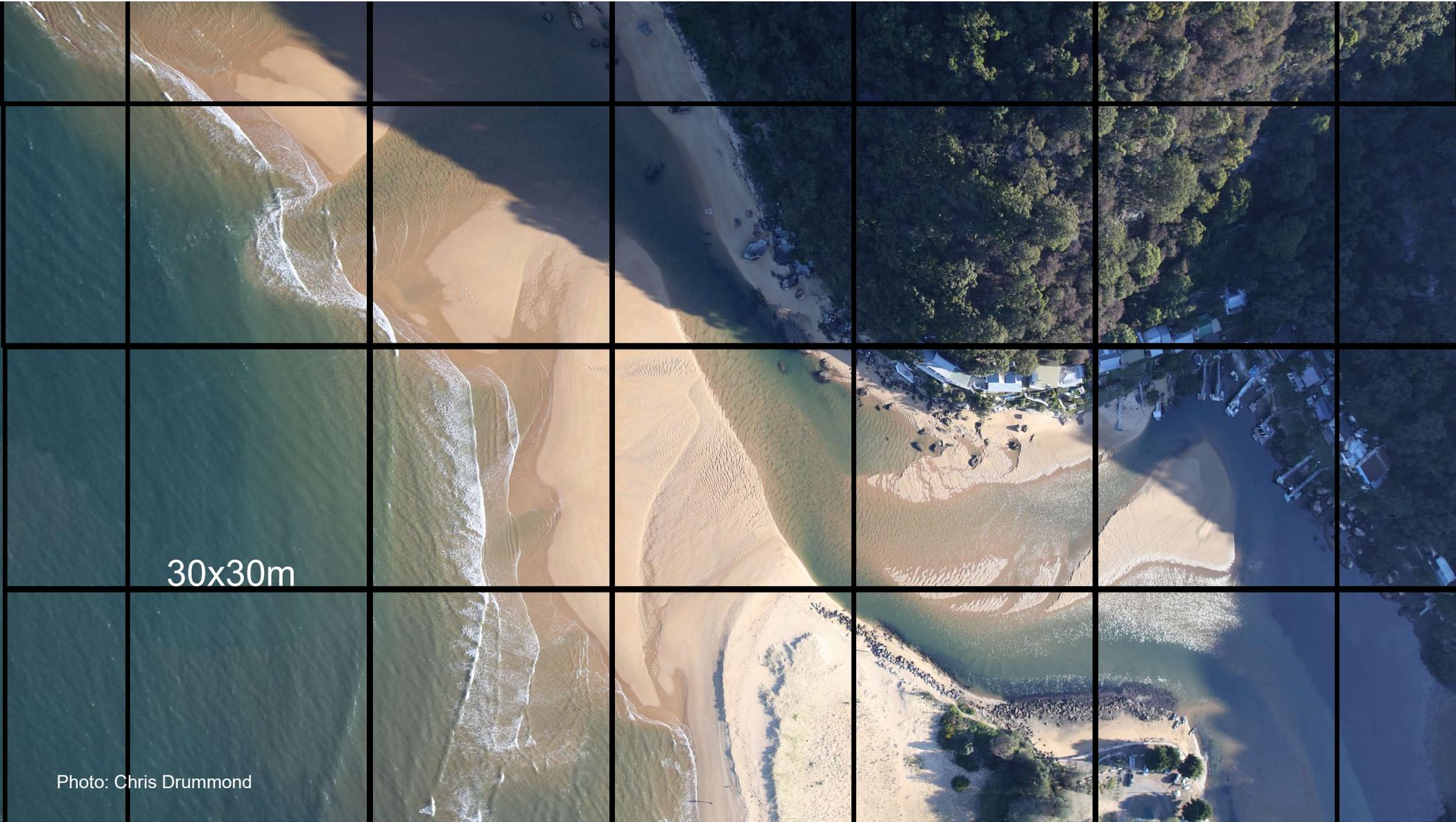
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# Motivation

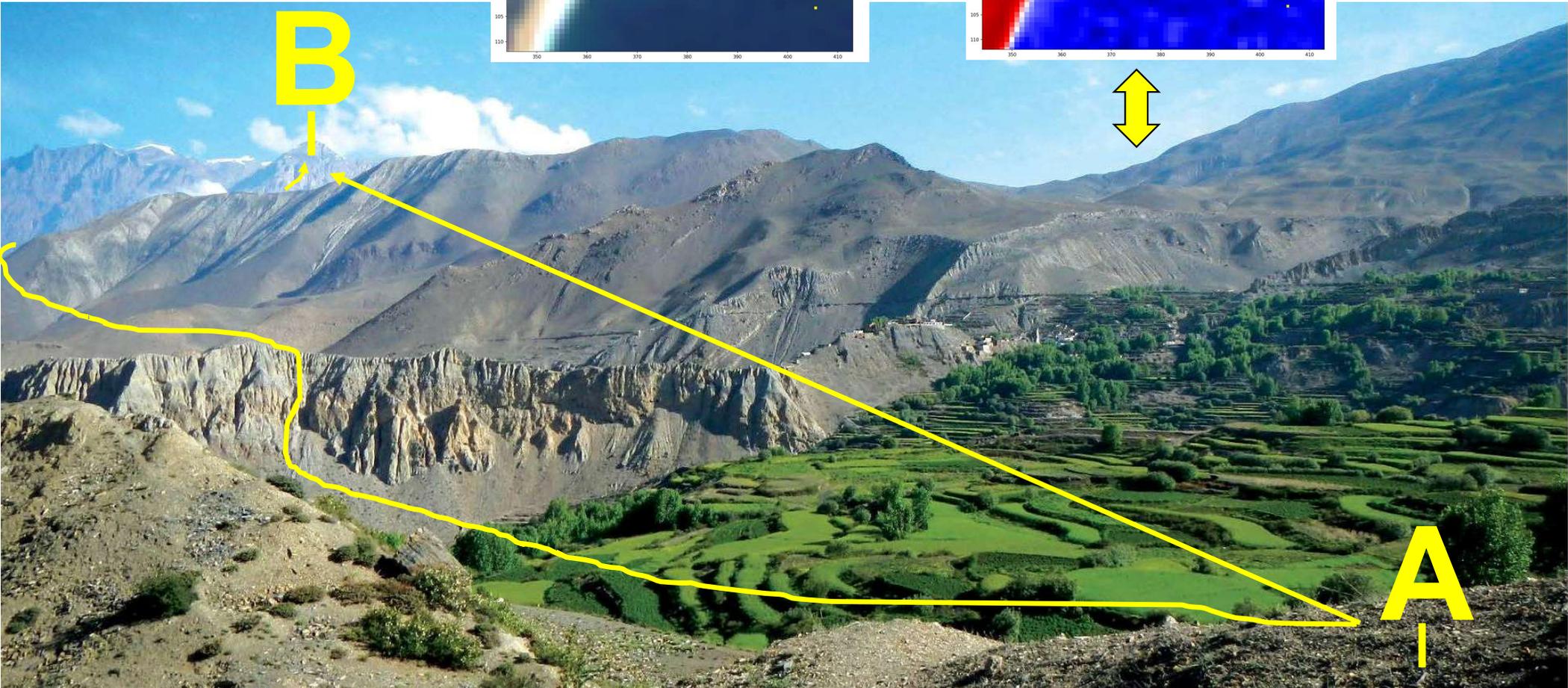
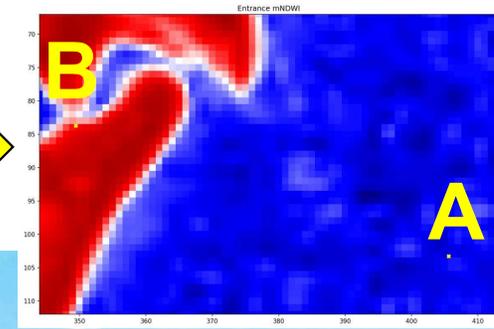
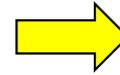
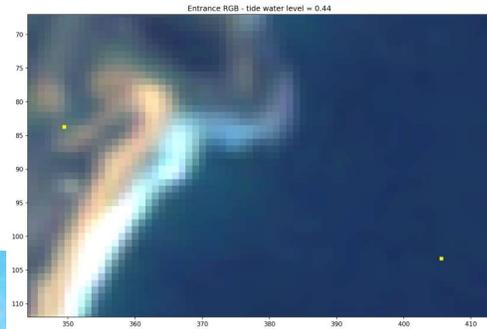




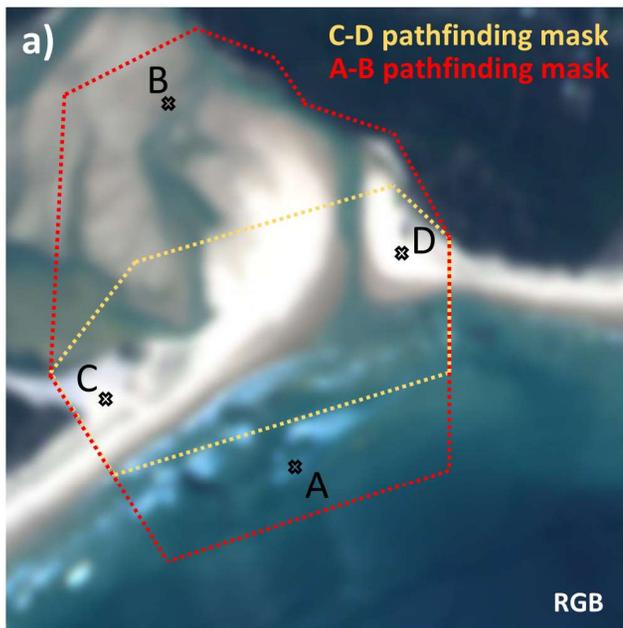
30x30m

Photo: Chris Drummond

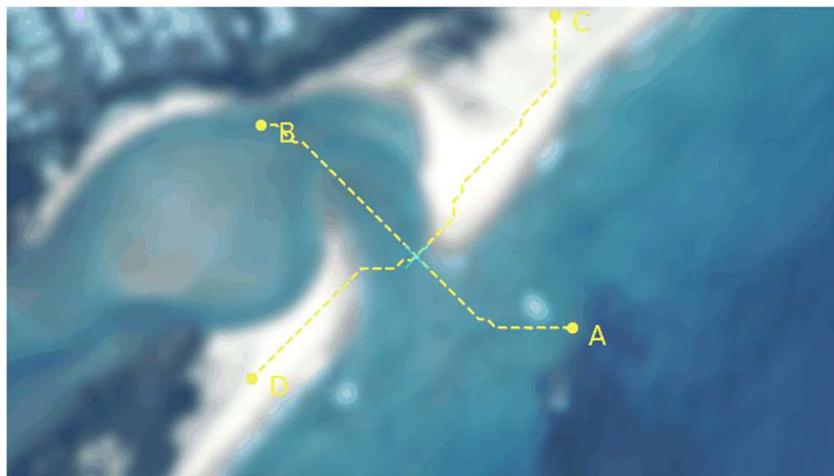
How it works:



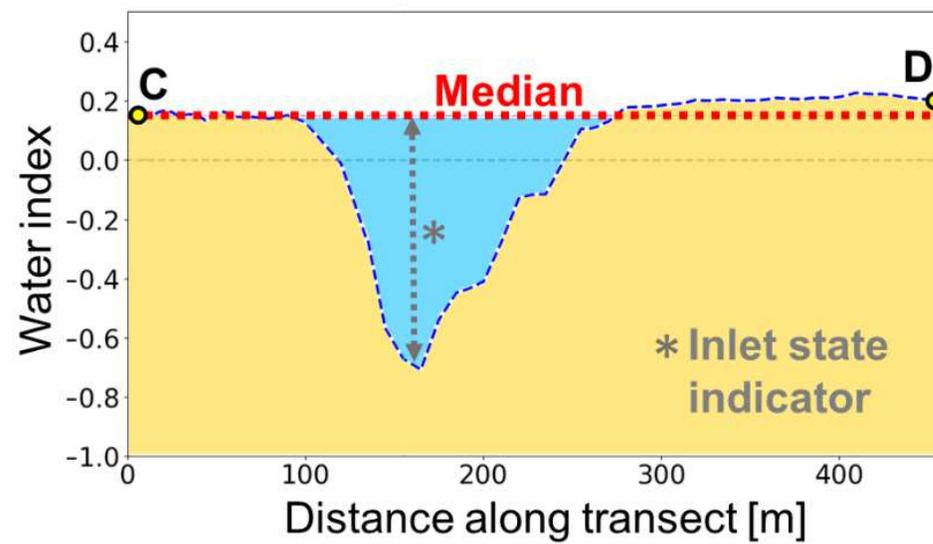
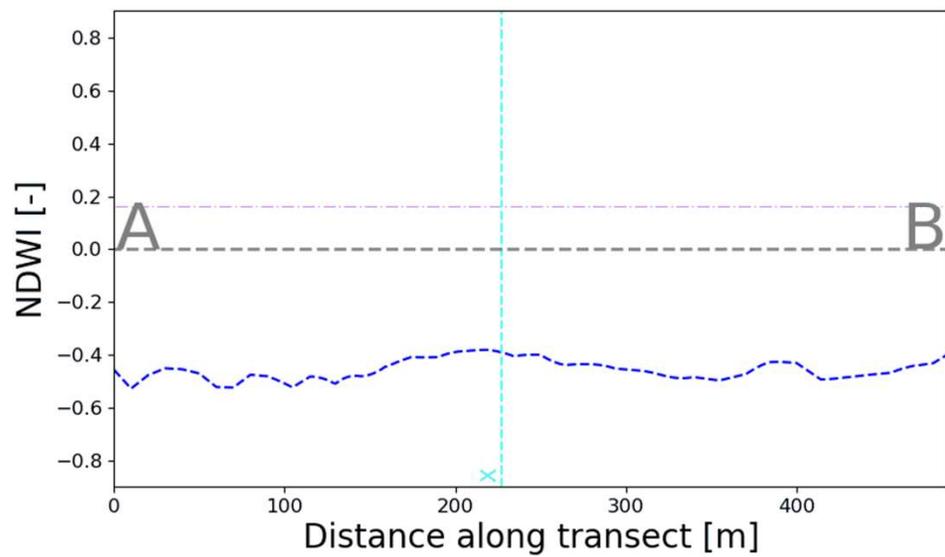
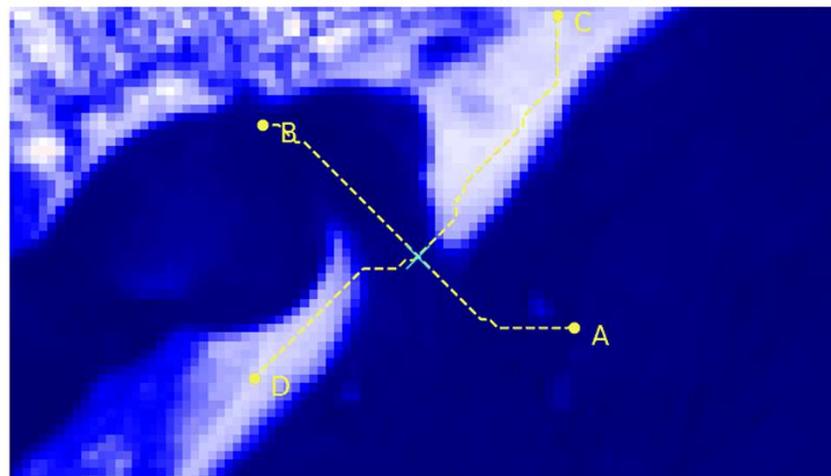
# How it works:



S2 2018-01-05



NIR

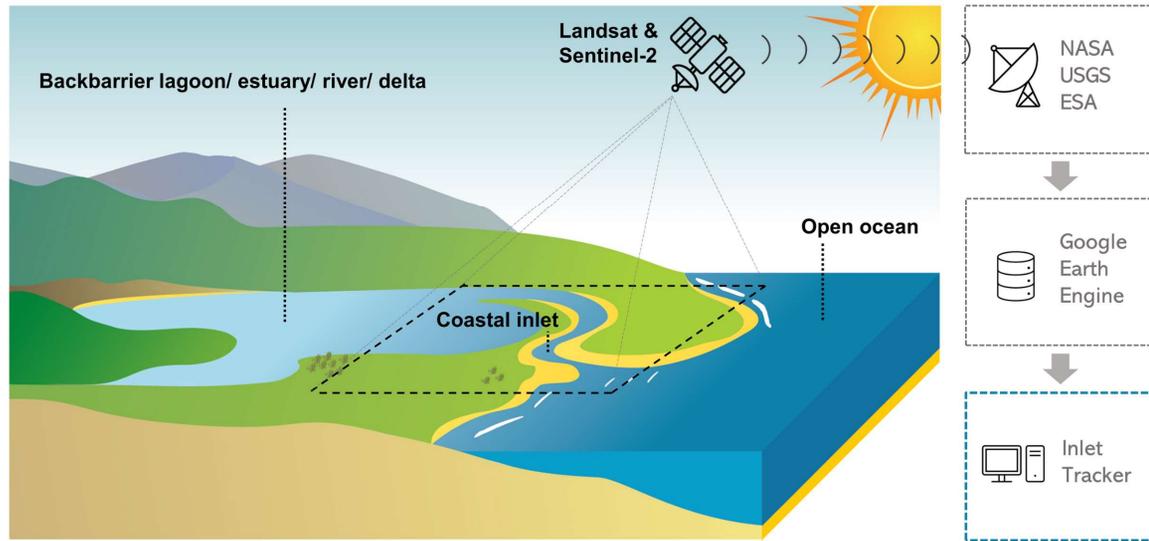




Google Earth  
Data SIO, NOAA, U.S. Navy

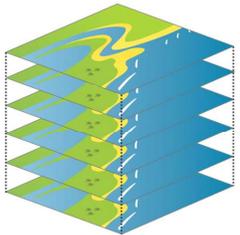
#Waterfromspaceweekly

# InletTracker: A toolkit for monitoring dynamic inlets

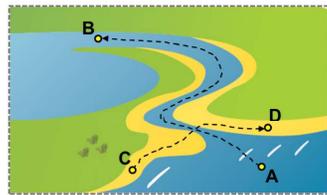


## Python

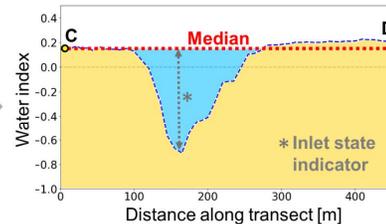
User-friendly image download and pre-processing (1986-present) via CoastSat functionality.

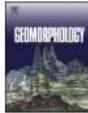


Automated tracing of along-berm (C to D) and across-berm (A to B) paths via least-cost path finding on water sensitive bands/indices.



Automated detection of open vs. closed inlet states via transect analysis on water sensitive indices.





# InletTracker: An open-source Python toolkit for historic and near real-time monitoring of coastal inlets from Landsat and Sentinel-2

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 Least-cost pathfinding

## ABSTRACT

Despite their global abundance and high ecological and socio-economic significance, the dynamics of coastal inlets often remain poorly quantified at multi-decadal time scales. Here, we introduce InletTracker (<https://github.com/VHeimhuber/InletTracker>), a new tool that reconstructs the time-evolving state of dynamic coastal inlets over the last 30+ years from publicly available Landsat 5, 7 and 8 and Sentinel-2 satellite imagery. InletTracker is a Google Earth Engine enabled python toolkit that uses a novel least-cost pathfinding approach to trace inlets along and across the berm (i.e., barrier, bar), and then analyses the resulting transects to infer whether an inlet is open or closed. To evaluate the performance of InletTracker, we applied the tool at 12 intermittent coastal inlets with different maximum inlet widths ( $\leq 30\text{--}200\text{ m}$ ), geomorphological setting and opening frequency located across Southeastern and Southwestern Australia. This exercise involved 6363 unique binary inlet state predictions (i.e., open vs. closed) that were validated against visually inferred inlet states (from the satellite imagery itself), on-ground observational records, and in-situ water levels from inside the inlets. InletTracker reproduced the visually inferred inlet states with an average accuracy across all sites of 89% for the combined Landsat and Sentinel-2 record (15–30 m resolution) and 94% for the Sentinel-2 record only (10 m resolution). Overall, we found good agreement between the predictions of the tool and the three independent validation datasets for all but the smallest sites. Our results demonstrate that InletTracker will enable coastal engineers, managers, and researchers to gain new insights into the dynamics and drivers of coastal inlets or similar shallow water landforms such as river mouths, tidal flats, floodplains, wetlands or delta channel networks. Further, the high spatial (i.e., 10 m) and temporal (i.e., 5-daily) resolution provided by Sentinel-2 makes InletTracker a viable option for near real-time monitoring of even relatively small inlets with a minimum channel width of around 10 m and frequent, short-duration, openings.

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## 1. Introduction

### 1.1. Background

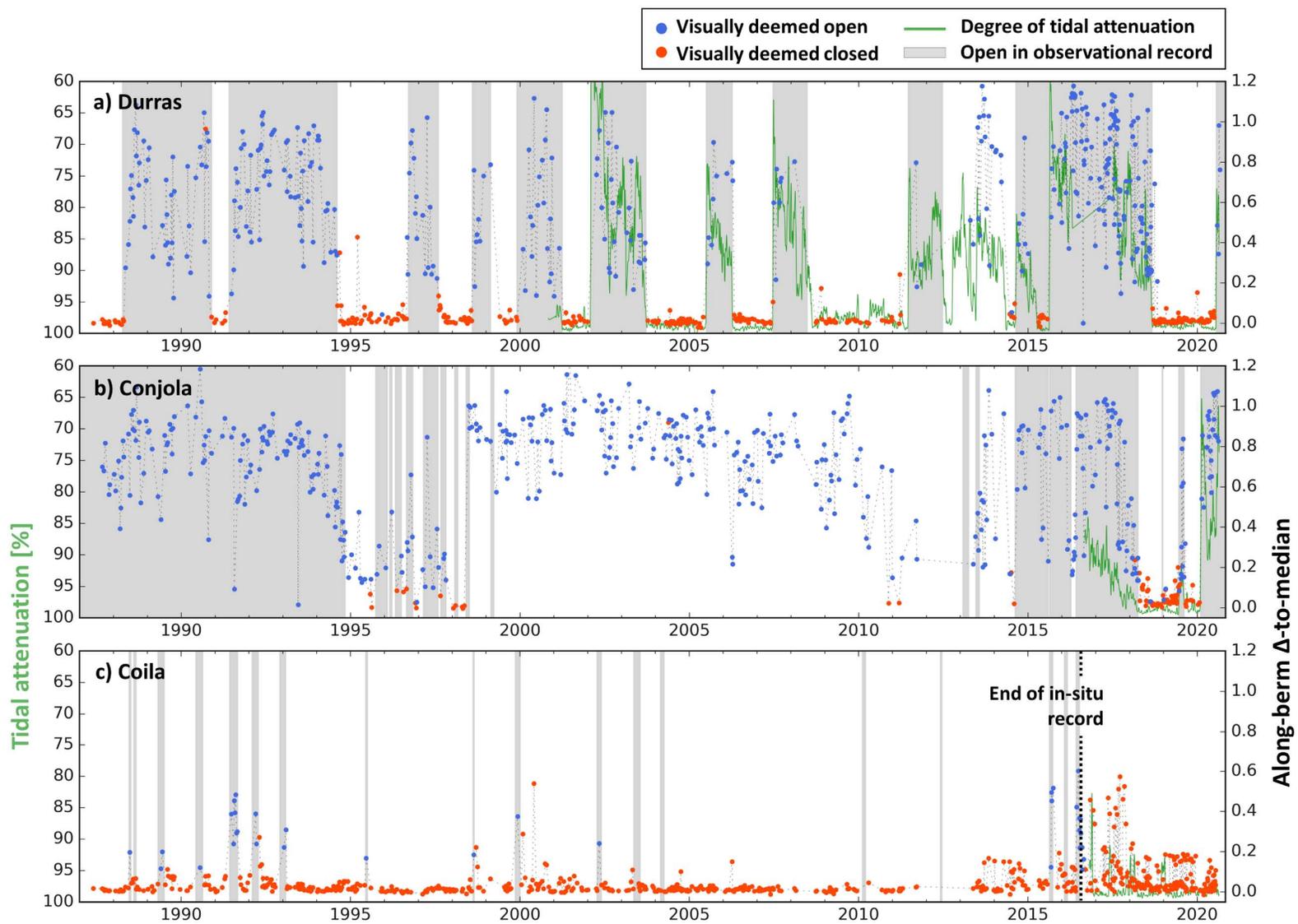
Many of the world's coastlines feature highly dynamic intermittent/ephemeral coastal inlets (also referred to as tidal inlets, intermittent estuaries, entrances, mouths) that close when fluvial or tidal flows are insufficient to prevent coastal sediments from infilling the inlet channel via longshore drift, aeolian transport, and wave processes (Haines et al., 2006; Hayes and FitzGerald, 2013; McSweeney et al., 2017; Moore and Murray, 2018; Orvos, 2020; Roy et al., 2001; van Ormondt et al., 2020). These intermittent coastal inlets can substantially influence the hydrodynamics, morphology and ecology of often extensive sheltered estuarine/lagoon environments on the landward side of the inlet (Velasquez Montoya et al., 2018), which provide numerous ecosystem services including storm protection, carbon sequestration, recreation

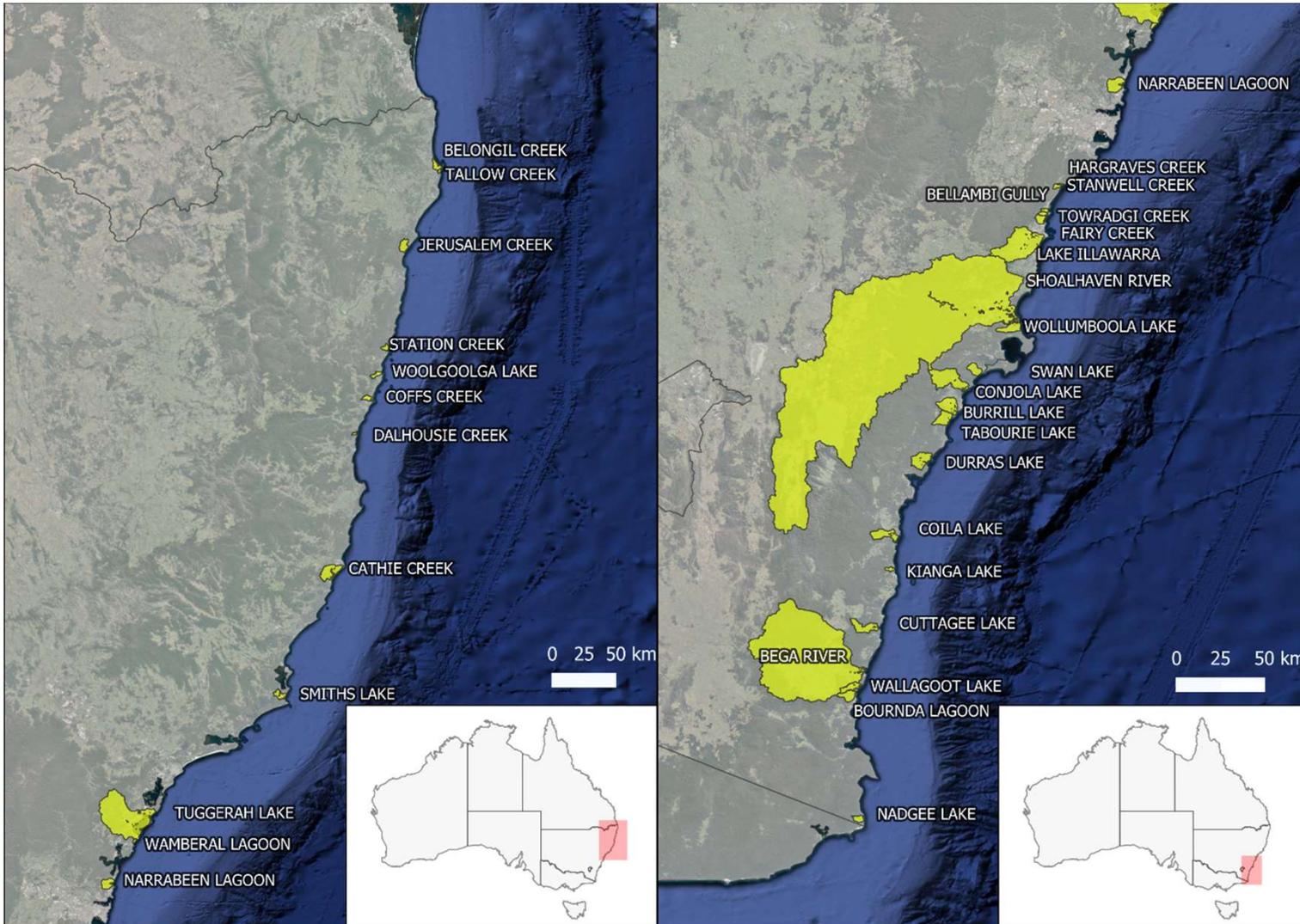
and fisheries productivity (Moore and Murray, 2018; Newton et al., 2018; Scanes et al., 2020). Examples of intermittent coastal inlets include those found at the downstream end of over 1477+ documented intermittent estuaries worldwide (McSweeney et al., 2017) or those that form after major coastal storms at barrier island systems, such as the Outer Banks of North Carolina, U.S. (Moore and Murray, 2018; van Ormondt et al., 2020; Velasquez Montoya et al., 2018).

Due to the often sporadic and erratic nature of intermittent coastal inlets, they remain less understood than more mature and permanent coastal inlets (Behrens et al., 2013; McSweeney et al., 2018; Velasquez Montoya et al., 2018), pose a challenge for coastal management (Alluvium, 2012; Gordon and Nielsen, 2020; Stephens and Murtagh, 2012) and sometimes feature a heated socio-political debate around management interventions such as mechanical inlet openings/closures (Gladstone et al., 2006; Gordon and Nielsen, 2020; Stephens and Murtagh, 2012; Young et al., 2014). These concerns can be compounded by a lack of datasets on historic inlet states (open vs. closed), which, apart from a few targeted coastal monitoring programs (e.g., DPIE (2020a)), do not exist for many inlets around the globe. To this end,



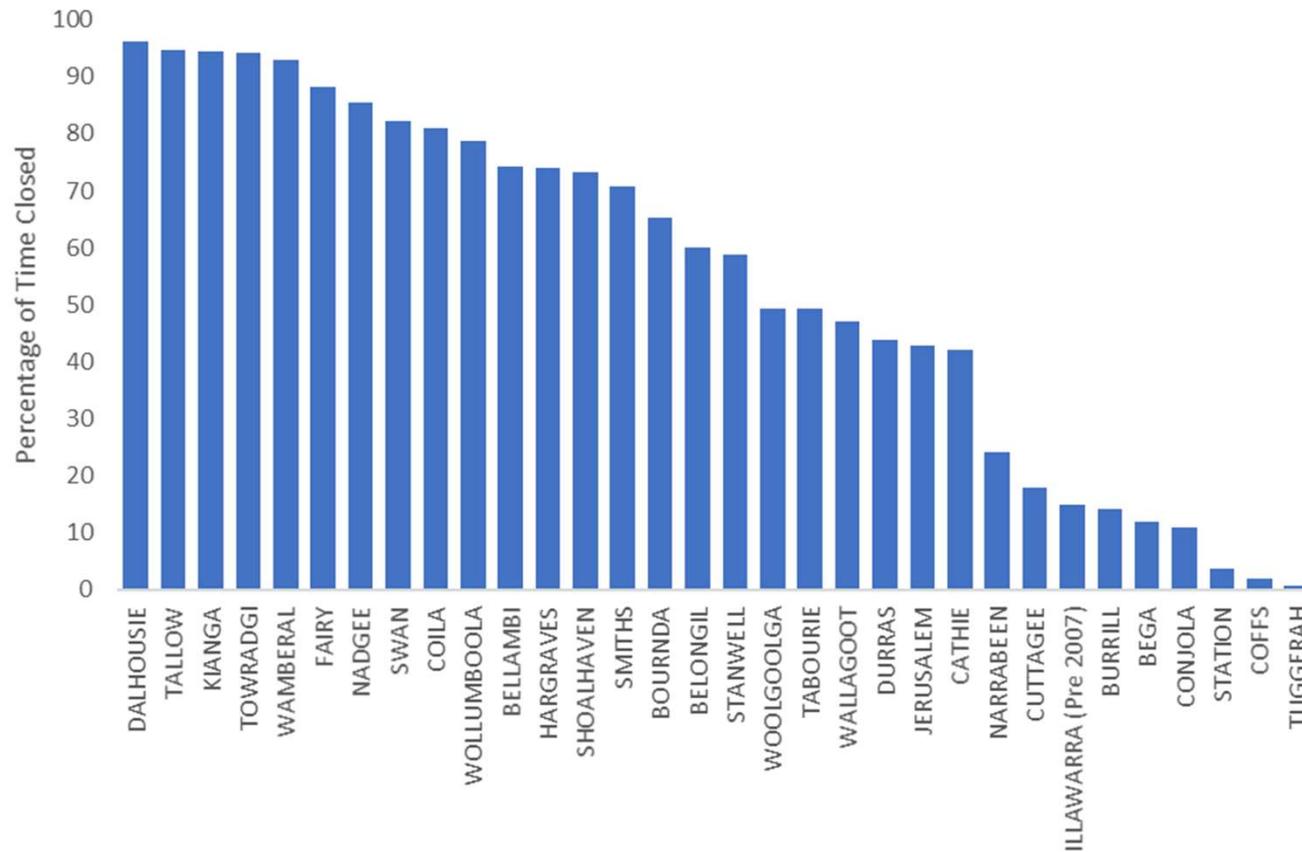
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 E-mail address: [v.heimhuber@unsw.edu.au](mailto:v.heimhuber@unsw.edu.au) (V. Heimhuber).



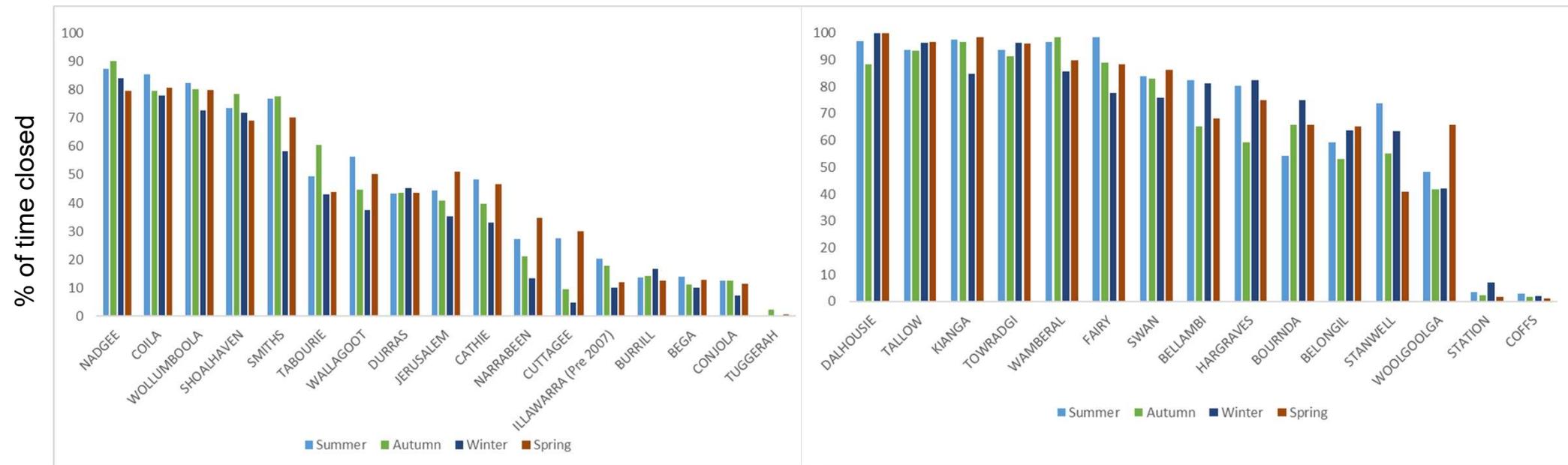


Oscar Garratt  
Senior Engineer at Rhelm

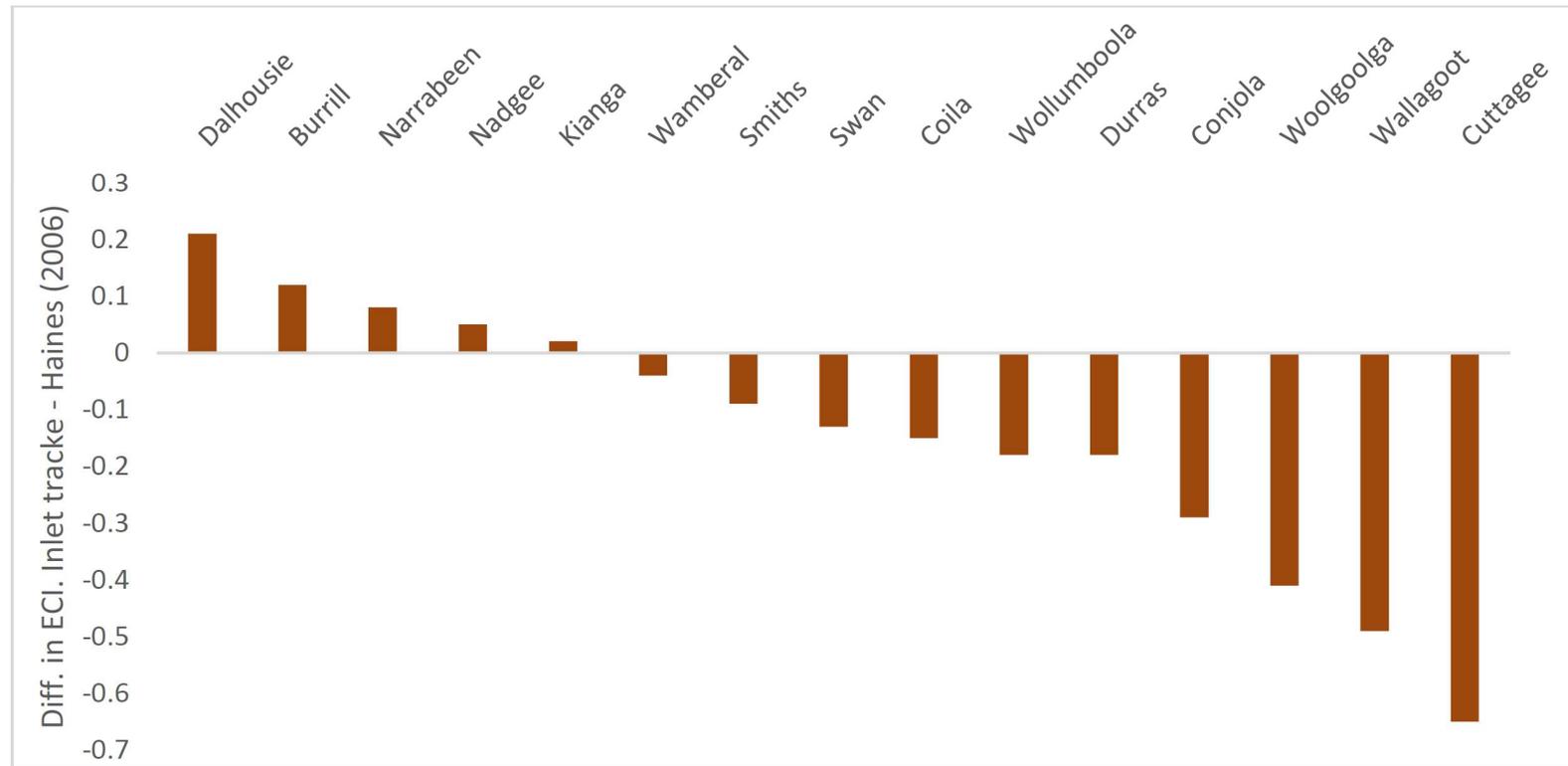
# Results - % closed between 1987-2021



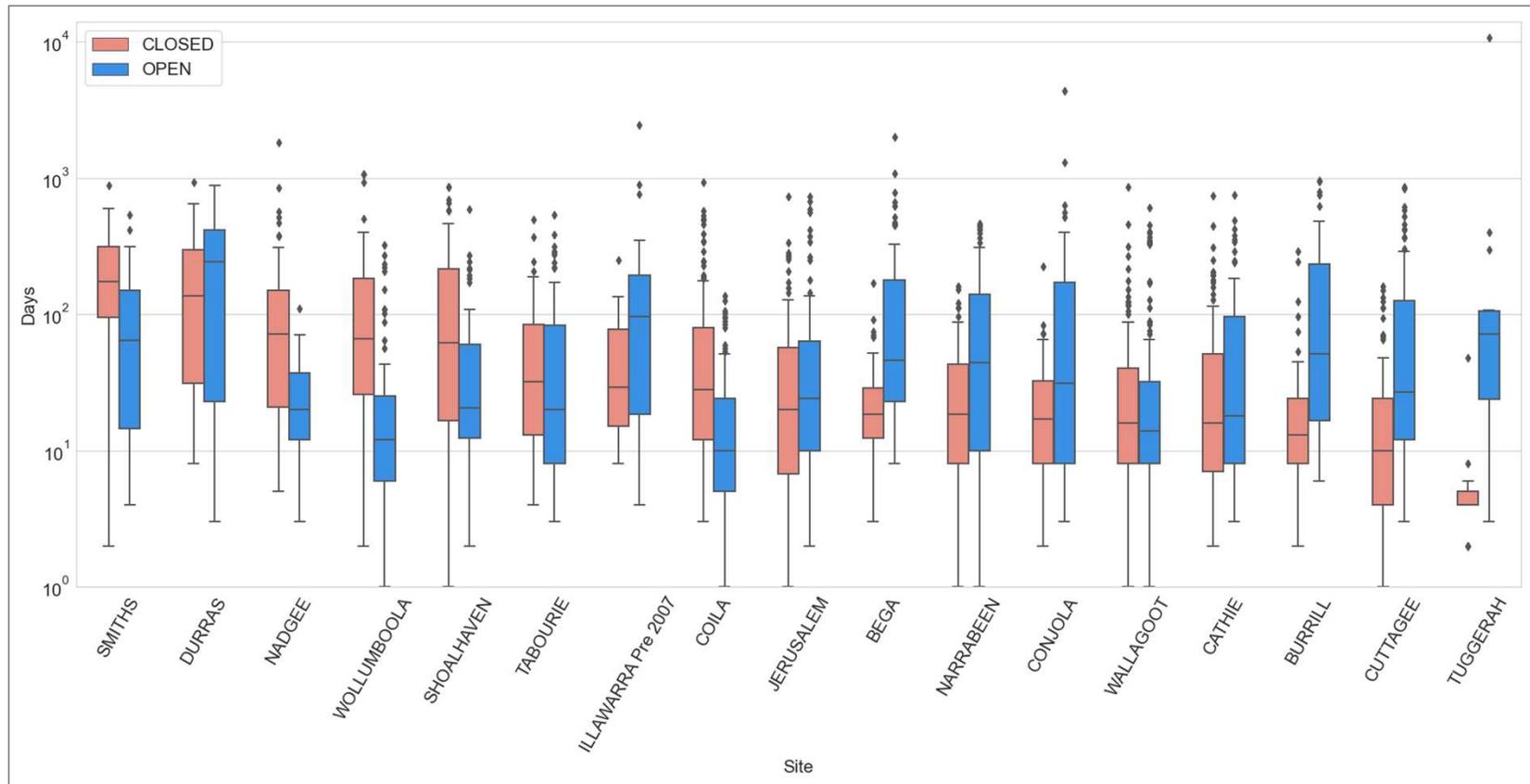
# Results - % closed between 1987-2021



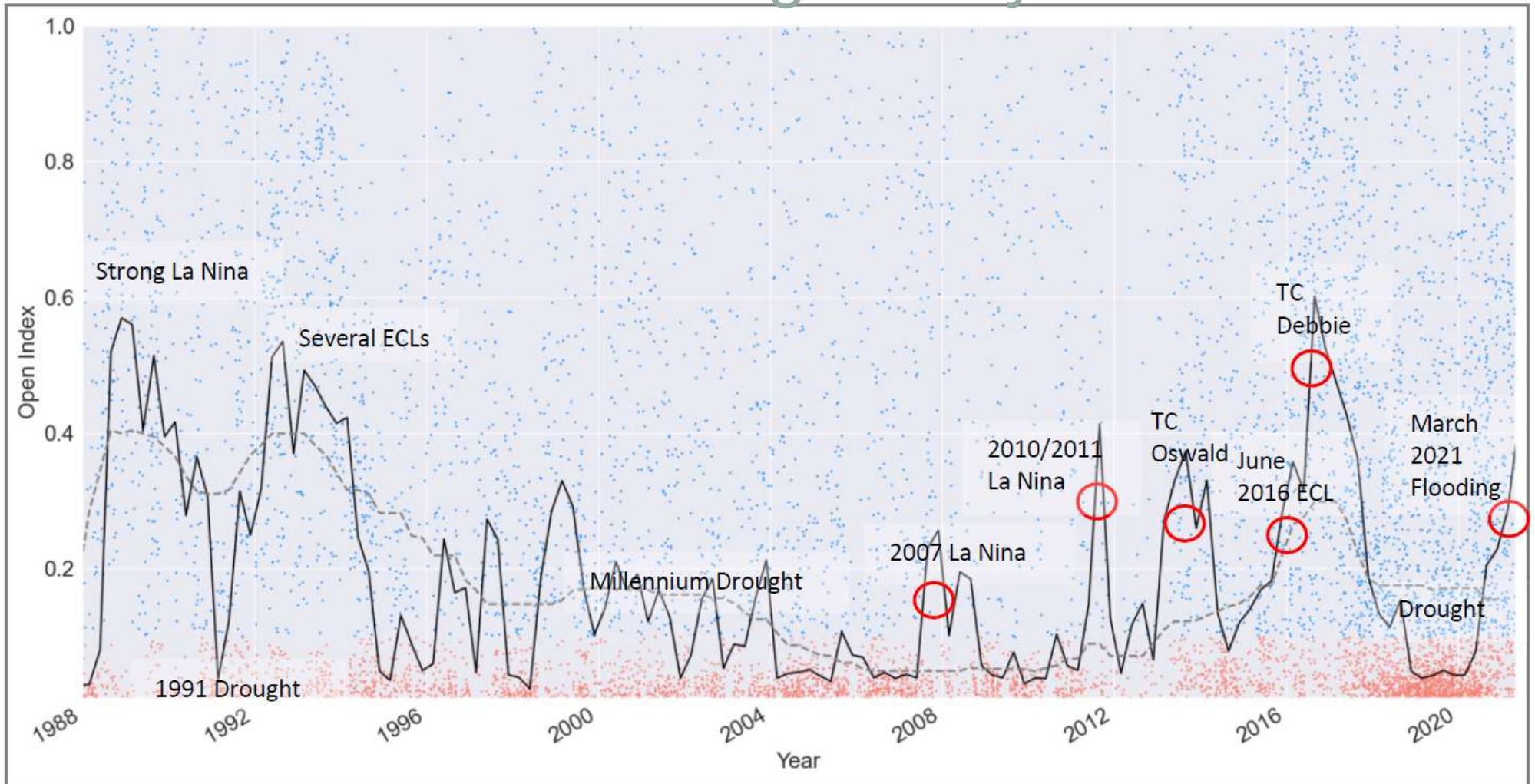
# Results – comparison with previous work:



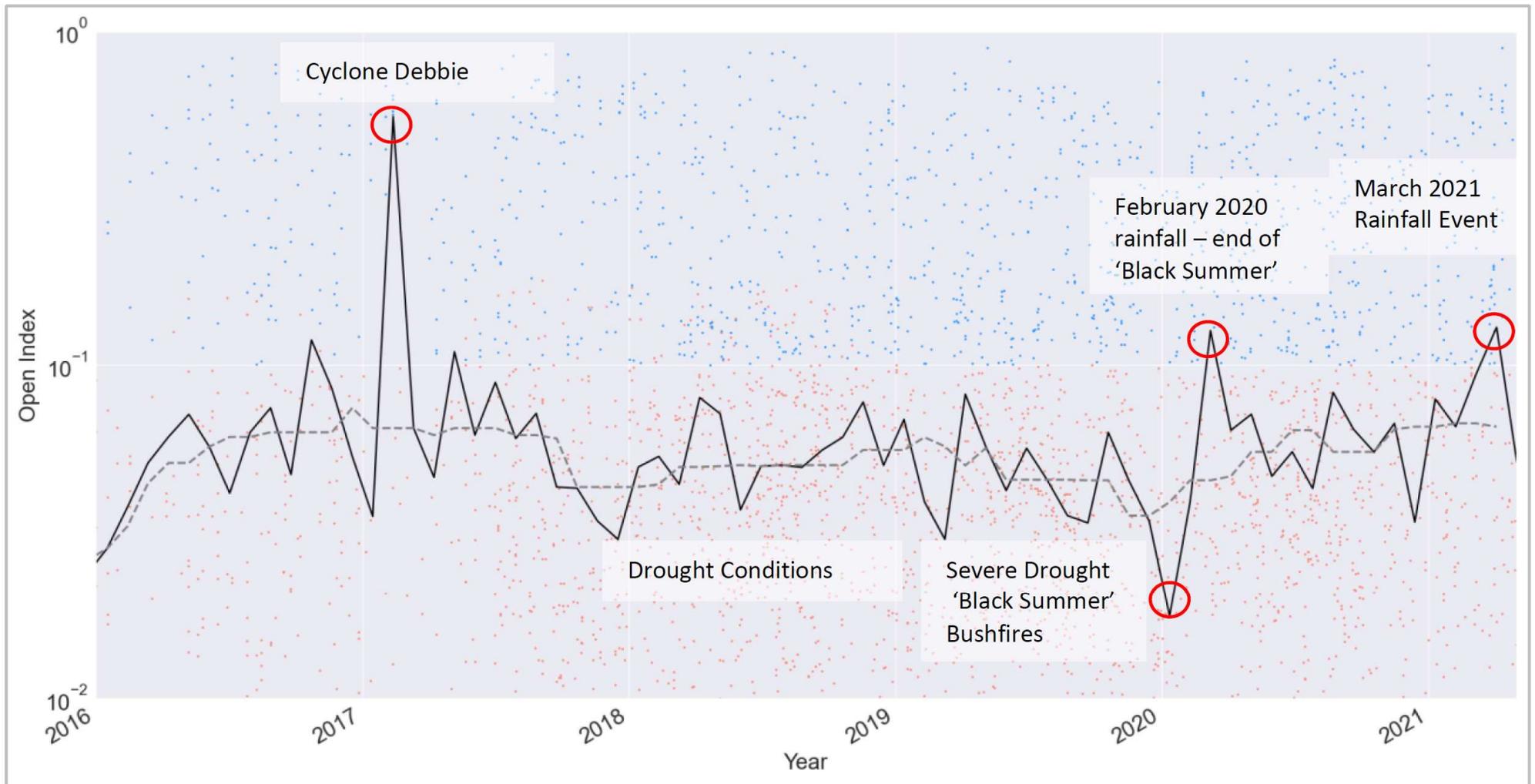
# Results - 1987-2021

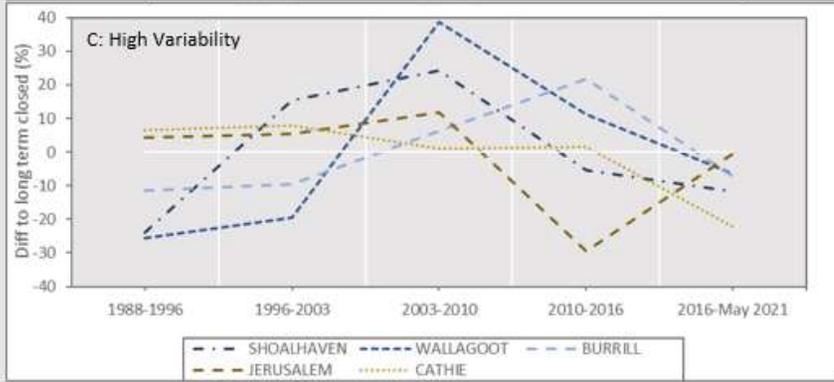
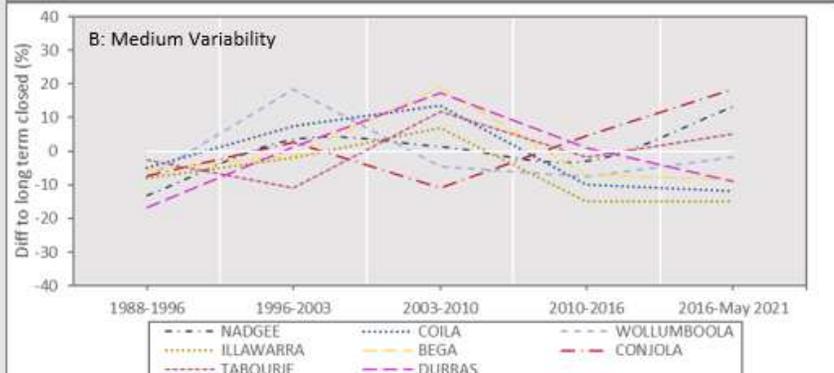
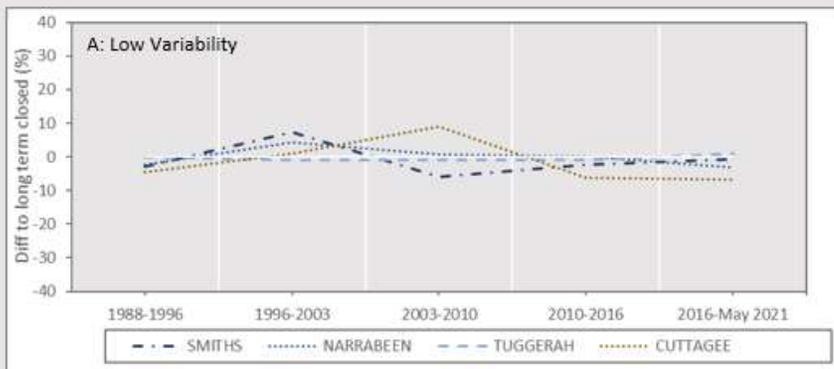


# Results – multidecadal regional dynamics.

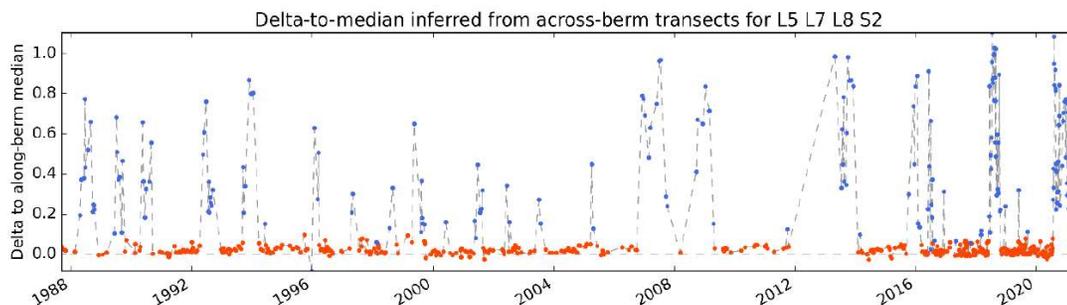


# Results – regional dynamics.





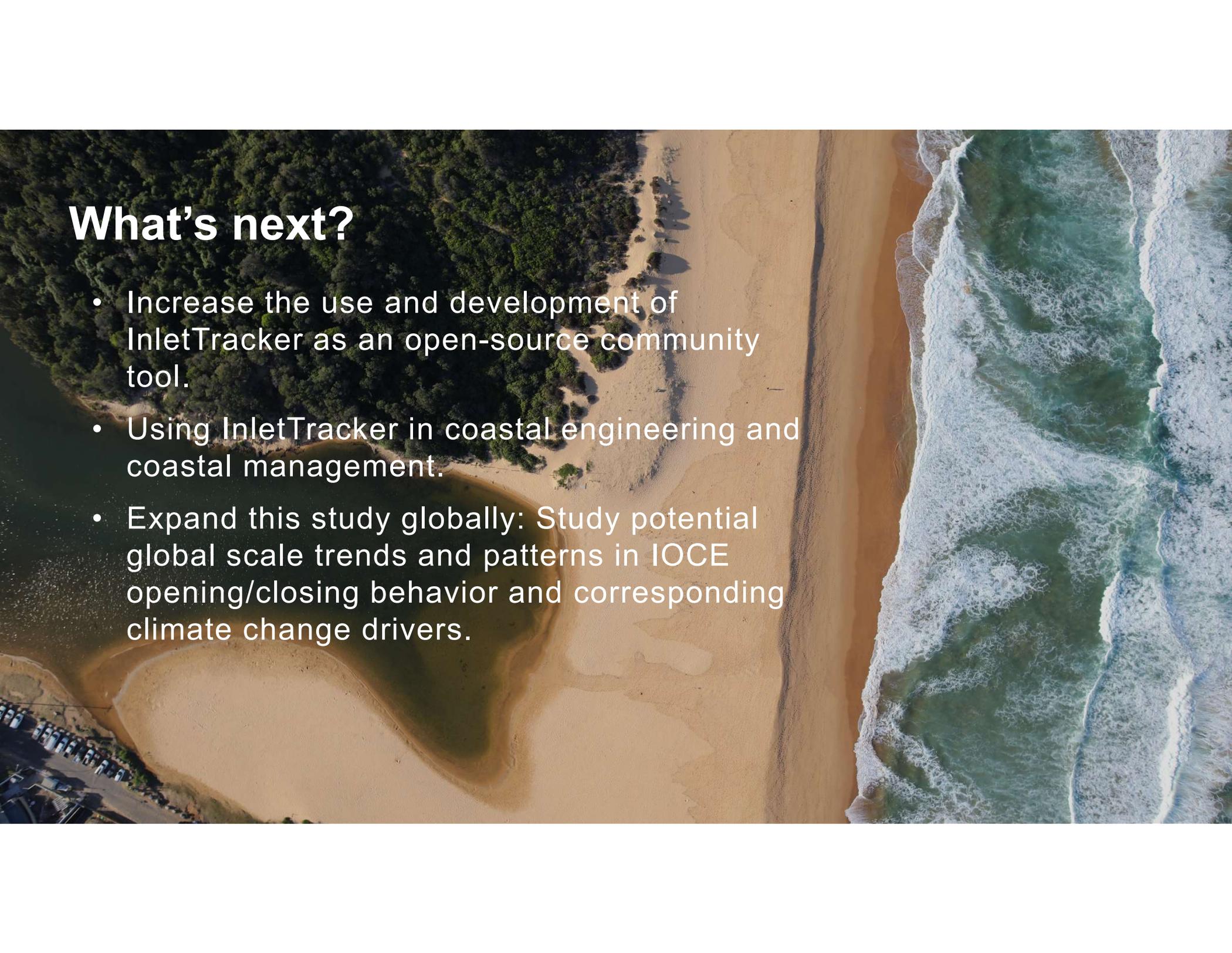
## Smiths Lake:



## Hypothesis:

|                                | Relative Inlet State Variability                   |                                                    |                                                  |
|--------------------------------|----------------------------------------------------|----------------------------------------------------|--------------------------------------------------|
|                                | Low                                                | Medium                                             | High                                             |
| <b>Mostly Closed (&gt;60%)</b> | Smith's Lake                                       | Nadgee Lake<br>Lake Coila<br>Lake Wollumboola      | Shoalhaven River                                 |
| <b>Even (40-60%)</b>           |                                                    | Tabourie<br>Durras                                 | Wallagoot Lake<br>Lake Cathie<br>Jerusalem River |
| <b>Mostly Open (&lt;40%)</b>   | Narrabeen Lagoon<br>Tuggerah Lake<br>Cuttagee Lake | Lake Illawarra (Pre 2007)<br>Bega River<br>Conjola | Burrill Lake                                     |

Increasing sensitivity to climate variability

An aerial photograph of a coastal inlet. The image shows a sandy beach on the left, a dense green forest in the upper left, and a large body of water in the center. The water is a mix of green and brown, indicating sediment. The right side of the image shows the ocean with white-capped waves breaking onto the shore. The overall scene is a natural coastal environment.

## What's next?

- Increase the use and development of InletTracker as an open-source community tool.
- Using InletTracker in coastal engineering and coastal management.
- Expand this study globally: Study potential global scale trends and patterns in IOCE opening/closing behavior and corresponding climate change drivers.



# InletTracker: Free Online Tutorial

8<sup>th</sup> of July 2022: 8am-12am AEST

Participants will learn:

- how to download the tool from GitHub (<https://github.com/VHeimhuber/InletTracker>),
- how to get it running on computer,
- how to setup new coastal inlet or ICOLL sites for automated processing,
- how to process sites effectively and how to interpret the results.
- Email [v.heimhuber@unsw.edu.au](mailto:v.heimhuber@unsw.edu.au) for more info.



Please register your interest here!



## Inaugural International Workshop on Intermittent Estuaries in a Changing Climate | 15<sup>th</sup>–18<sup>th</sup> of June 2021

**Part I** - Key drivers of land-sea connectivity and conceptual/numerical models of inlet behavior.

**Part II** - Innovative change detecting methods of inlet behavior - satellite imagery, drones, and stationary systems.

**Part III** - Physical responses of IOCEs to a changing climate

**Part IV** - Biological responses of IOCEs to a changing climate

**Part V** - Policy frameworks, public datasets, and novel management approaches



Global Forum on Intermittent Estuaries

73 Abonnenten



Übersicht

Videos

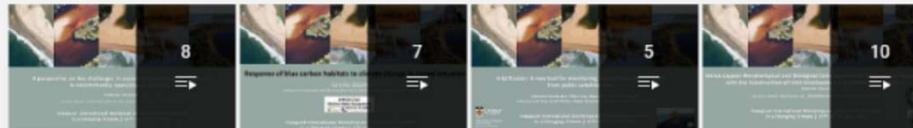
Playlists

Kanäle

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Videos grouped by workshop sessions I - V



Session I - Key drivers of land-sea connectivity and...

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Sessions II & III - Physical and biological responses of...

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Session IV - Innovative change detecting methods of inlet...

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Session V - Policy frameworks, community datasets, and...

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### Key statistics:

Number of presentations: **30**

Number of registered attendees: **380 ppl.**

Average attendance during sessions: **110-130 ppl.**

Registered attendees by country:

**Australia: 148 ppl**

**South Africa: 78 ppl**

**USA: 56 ppl**

**New Zealand: 13 ppl**

**Chile: 5 ppl**

**UK: 3 ppl**

**Other countries: 77**