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WHACS: A new global **Wave Hindcast** for the **Australian Climate Service**

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I would like to begin by acknowledging the Traditional Owners of the Land and Sea Countries represented in this talk and dataset, and pay my respect to their Elders past and present.

‘Eternal Wisdom, Infinite Innovation’
artwork by Rachael Sarra, working with Gilimbaa.

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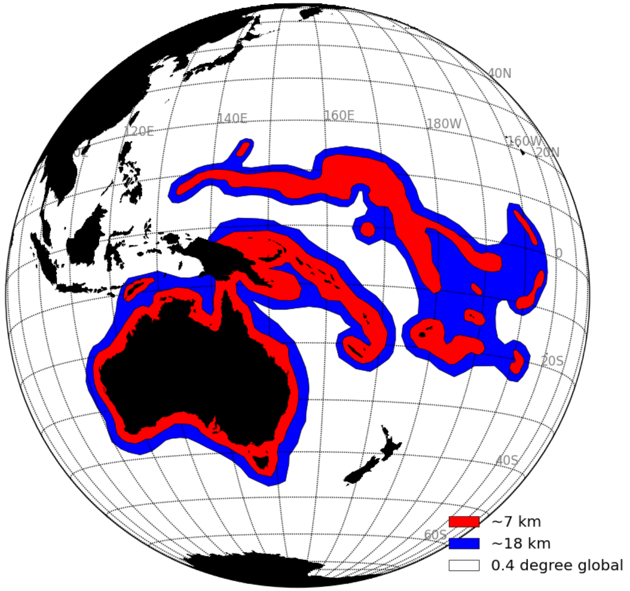
A replacement for the CAWCR Wave Hindcast…

- The CAWCR Wave Hindcast (http://hdl.handle.net/102.100.100/137152) was created in 2011 using a previous version of WAVEWATCH III (WW3), with higher resolution nested grids in the Australian and Pacific regions, but poor resolution globally.
- Dataset has inhomogeneous variable names when the model version was changed in 2014
- Data is poorly chunked for reuse and time series analyses
- The model is forced with CFSR/CFSv2 winds, pressure and sea ice.



Desire to:

- enhance coastal resolution globally utilizing the SMC grid,
- Upgrade model physics using ST6 formulation
- Use ERA5 forcing data

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The Wave Hindcast for the Australian Climate Service (WHACS)

- Generate **historical wave boundary conditions** for CSIRO's coupled wave-hydrodynamic model for extreme water levels (CCHaPS)
- **Align** model with the Bureau of Meteorology's operational forecast wave model **AUSWAVE-G3** by using the same physics and Spherical Multi-cell Grid (SMC).
- Provide **historical wave outputs** for existing customers and partner organizations (Defence, NIWA, Oil & Gas, Pacific)
- Serve as an **upgrade** of the existing wave CAWCR hindcast with the latest WW3 version 6.07 (upgrade from version 4.08) and **improved** global and regional **resolution**

NOAA-EMC/**WW3**

WAVEWATCH III

NATIONAL WEATHER SERVICE

Geoscience Data Journal | Open Access | RMetS

DATA PAPER | Open Access

Global wave hindcast with Australian and Pacific Island Focus: From past to present

Grant A. Smith, Mark Hemer, Diana Greenslade, Claire Trenham, Stefan Zieger, Tom Durrant

First published: 14 August 2020 | https://doi.org/10.1002/gdj3.104 | Citations: 5

The Wave Hindcast for the Australian Climate Service (WHACS)

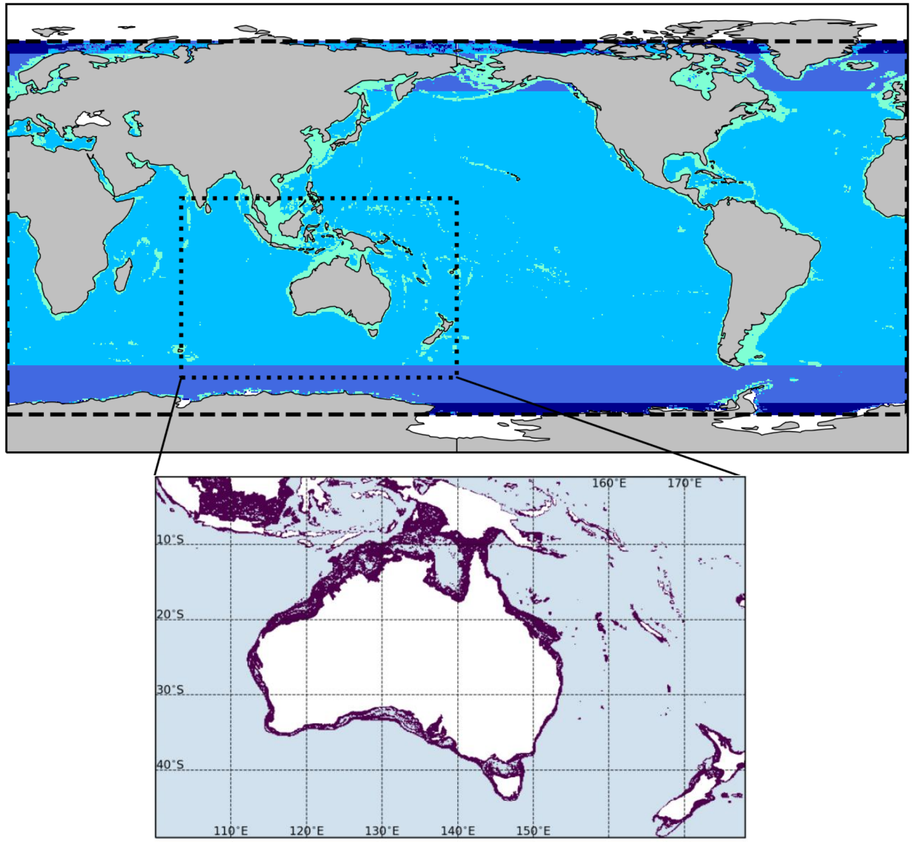
Physics
- **ST6** parametrization
- DIA
- No currents

Sea ice
- <25% open ocean
- 25% < SI < 75% ln decay
- >75% land

SMC grid

I. 1/16° (~7km)
II. 1/8° (~10 to ~14 km)
III. Relaxing to 1/4° from 55° to 70° lat. and 1/2° beyond 70°

(Smith et al., 2025, in prep.)



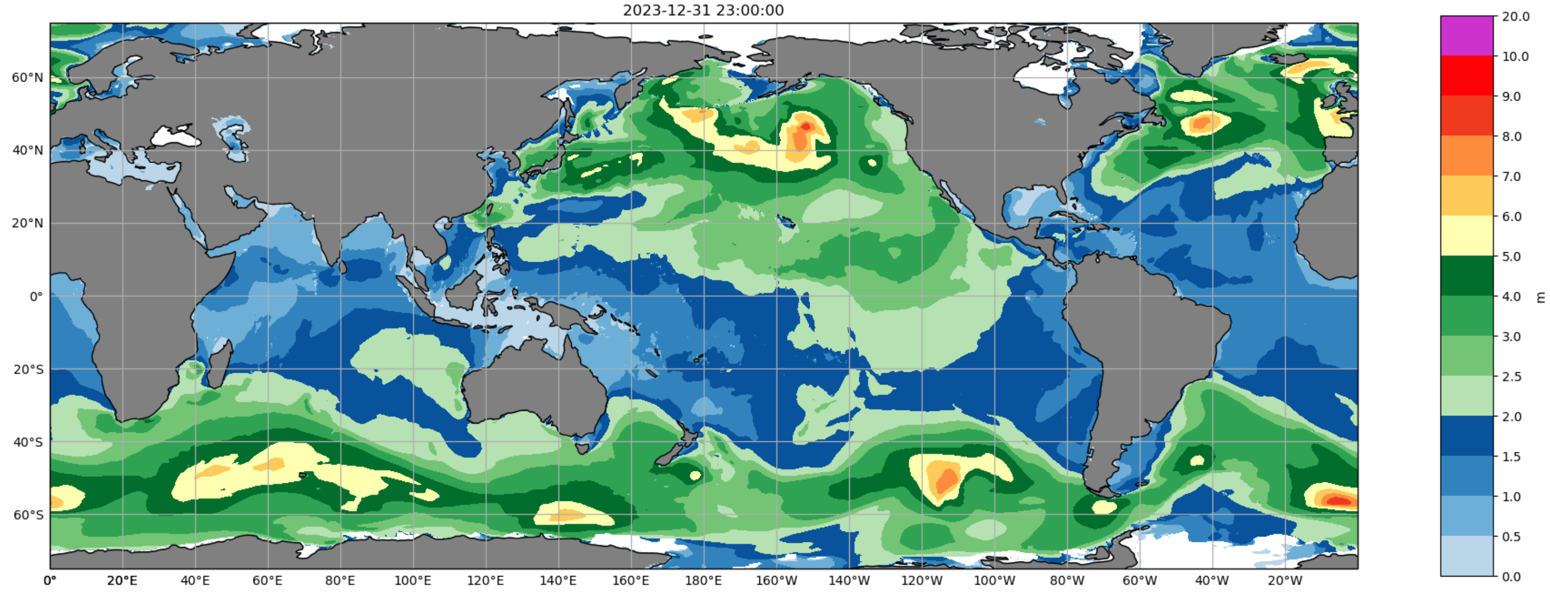
Spectral res.
- 28 freq. (0.0412 – 0.524 Hz)
- 30 dir. ($\Delta\theta = 12^\circ$)

WHACS: Output Types

- Bulk wave parameters at every grid point, both SMC grid and regridded rectilinear grids
- Spectral wave output at **>11k** select locations and geographic regions
- WW3 format boundary conditions to accommodate a wide range of users (Defence, Pacific, NIWA)

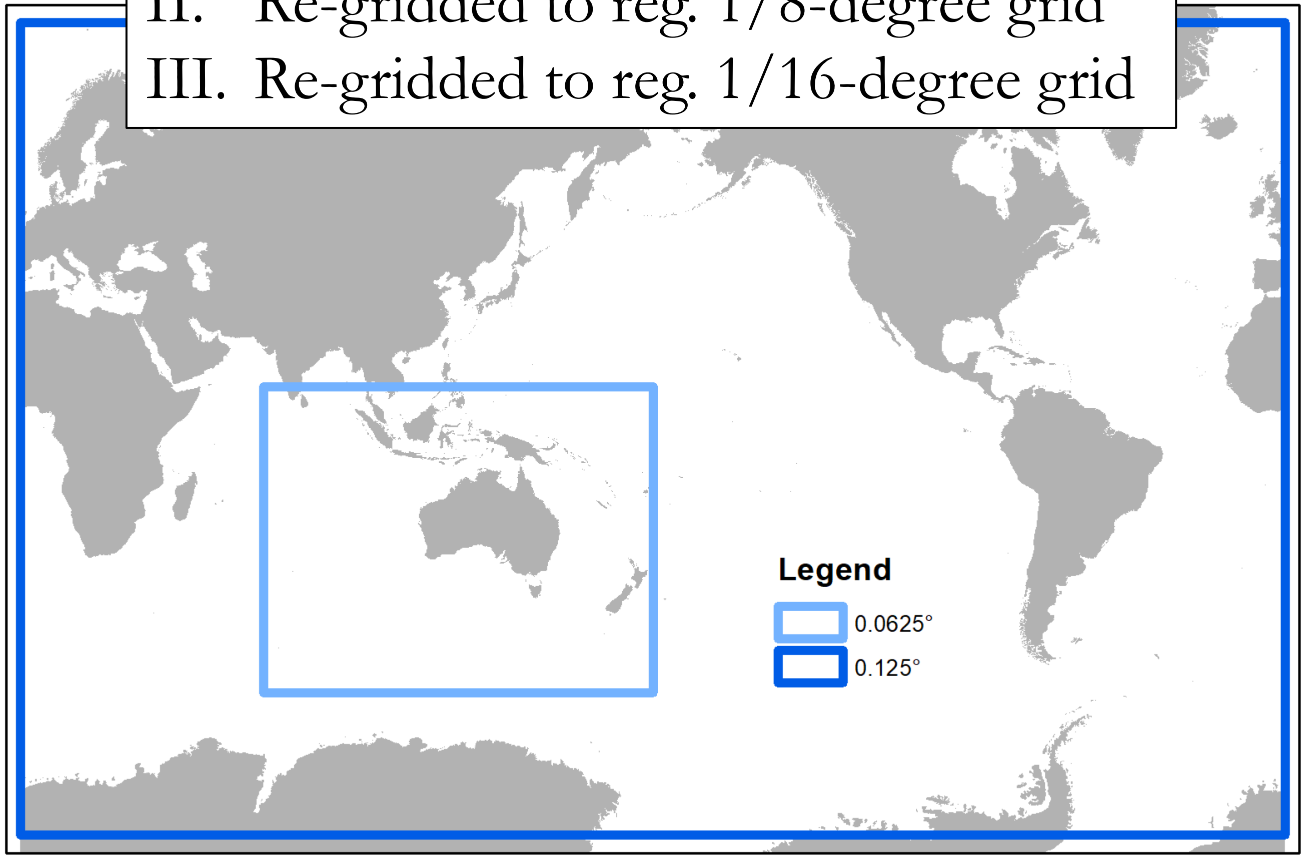
Applications:

- Pacific modelling of coastal hazards
- Wave climatology & statistics
- Renewable energy assessments
- Boundary conditions for many downscaling projects
- Near Real-Time Verification of the operational forecast model
- Put events into context (extreme value analysis)



Gridded Bulk Output Parameters

I. SMC-grid output
II. Re-gridded to reg. 1/8-degree grid
III. Re-gridded to reg. 1/16-degree grid



- Standard output parameters
- Parameters for Spectral reconstruction

<u>Same spectral 'reconstruction' used for ROAM-Wave and ROAM-Littoral can be applied!</u>

WWIII Name	Description	Variable Name	units
HS	Significant Height of Wind and Swell Wave	hs	m
WND	Eastward Wind	uwnd	m/s
	Northward Wind	vwnd	m/s
T01	Mean Period (T01)	t01	s
T02	Mean Period (T02)	t02	s
T0M1	Mean Period (T0m1)	t0m1	s
FP	Peak Wave Frequency	fp	Hz
DIR	Mean Wave Direction	dir	degree
DP	Peak Direction	dp	
SPR	Directional Spread	spr	degree
PQP	Peakedness Partition [0-3]	pqp[0-3]	
PHS	Wave Significant Height Partition [0-3]	phs[0-3]	m
PTP	Peak Period Partition [0-3]	ptp[0-3]	s
PDIR	Wave Direction Partition [0-3]	pdir[0-3]	degree
PDP	Peak Direction Partition [0-3]	pdp[0-3]	degree
PPE	Peak Enhancement Factor [0-3]	ppe[0-3]	
PSPR	Directional Spread Partition [0-3]	pspr[0-3]	degree
CGE	Wave Energy Flux	cge	kW/m

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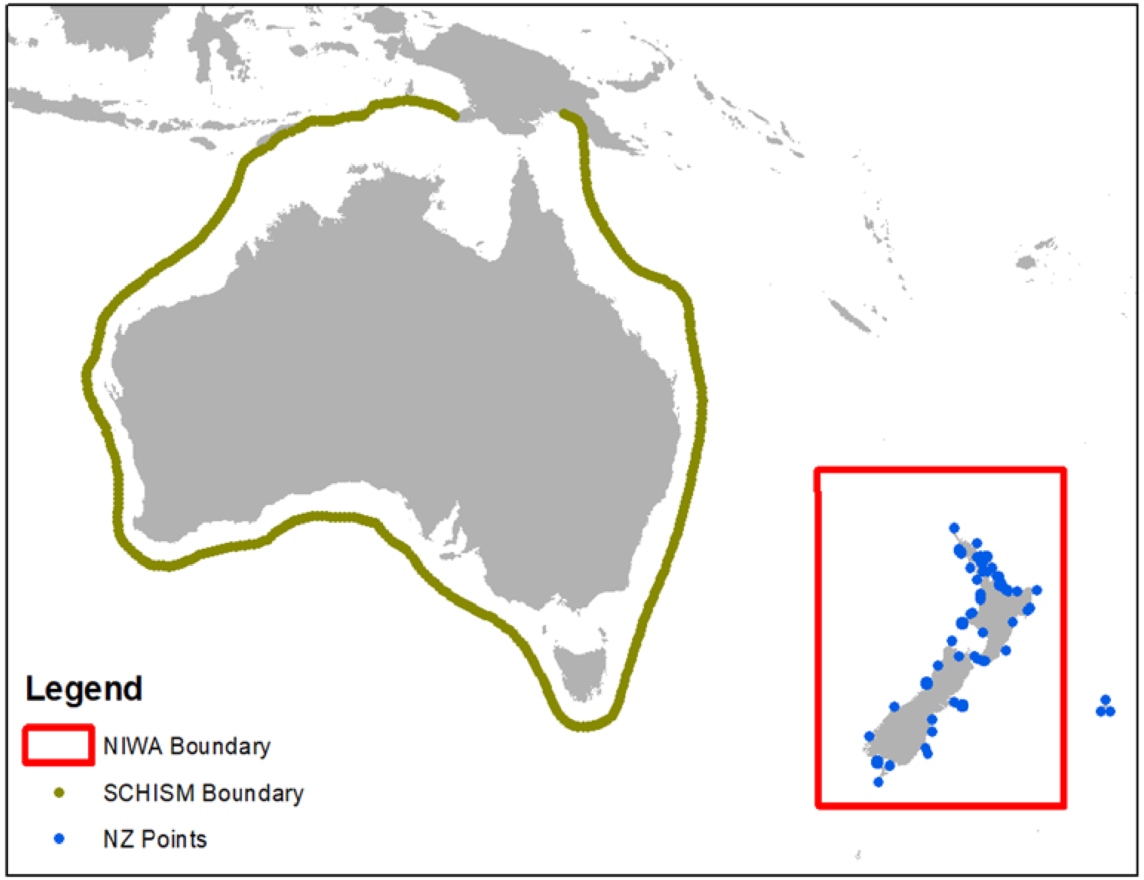
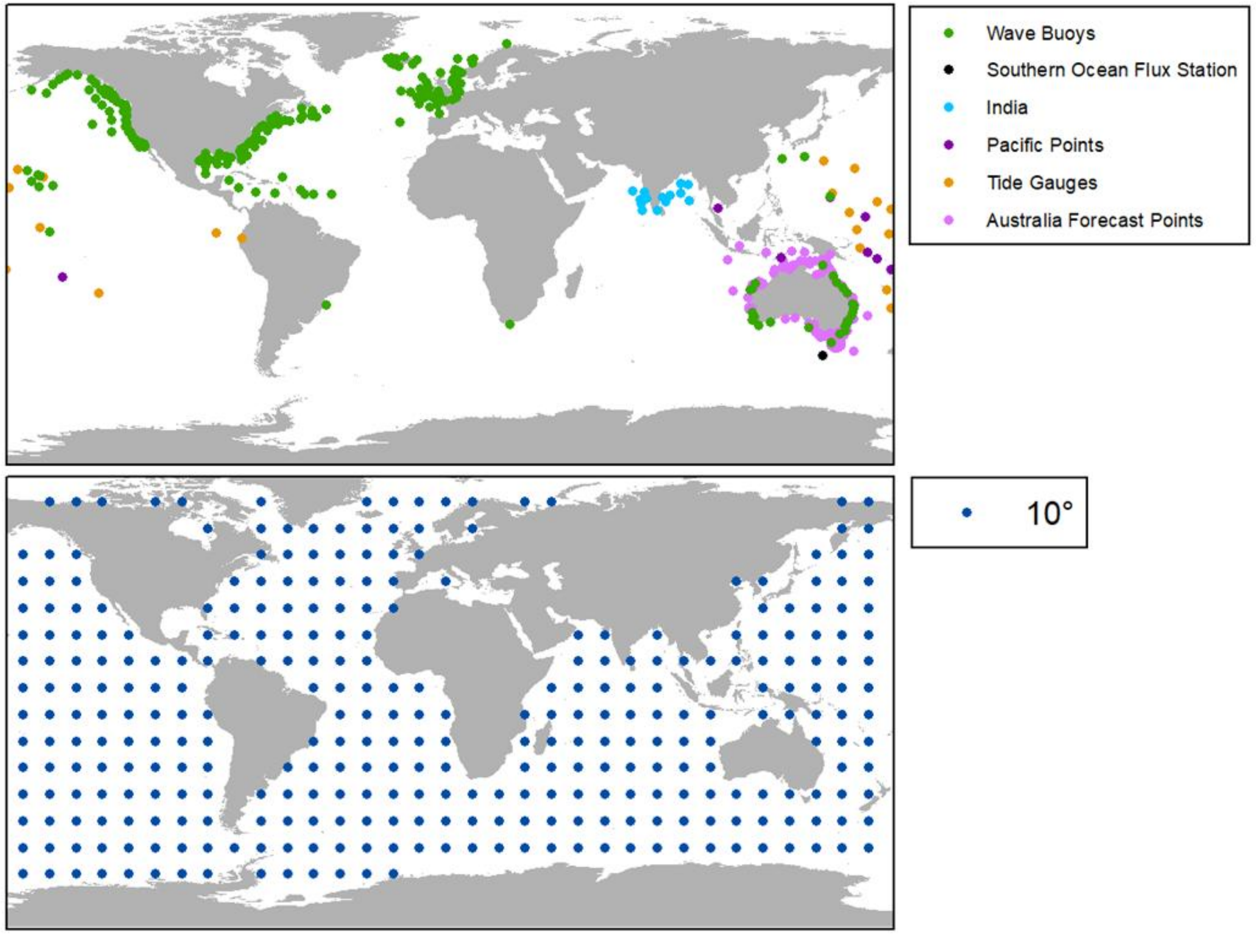
Spectral Output Point Locations

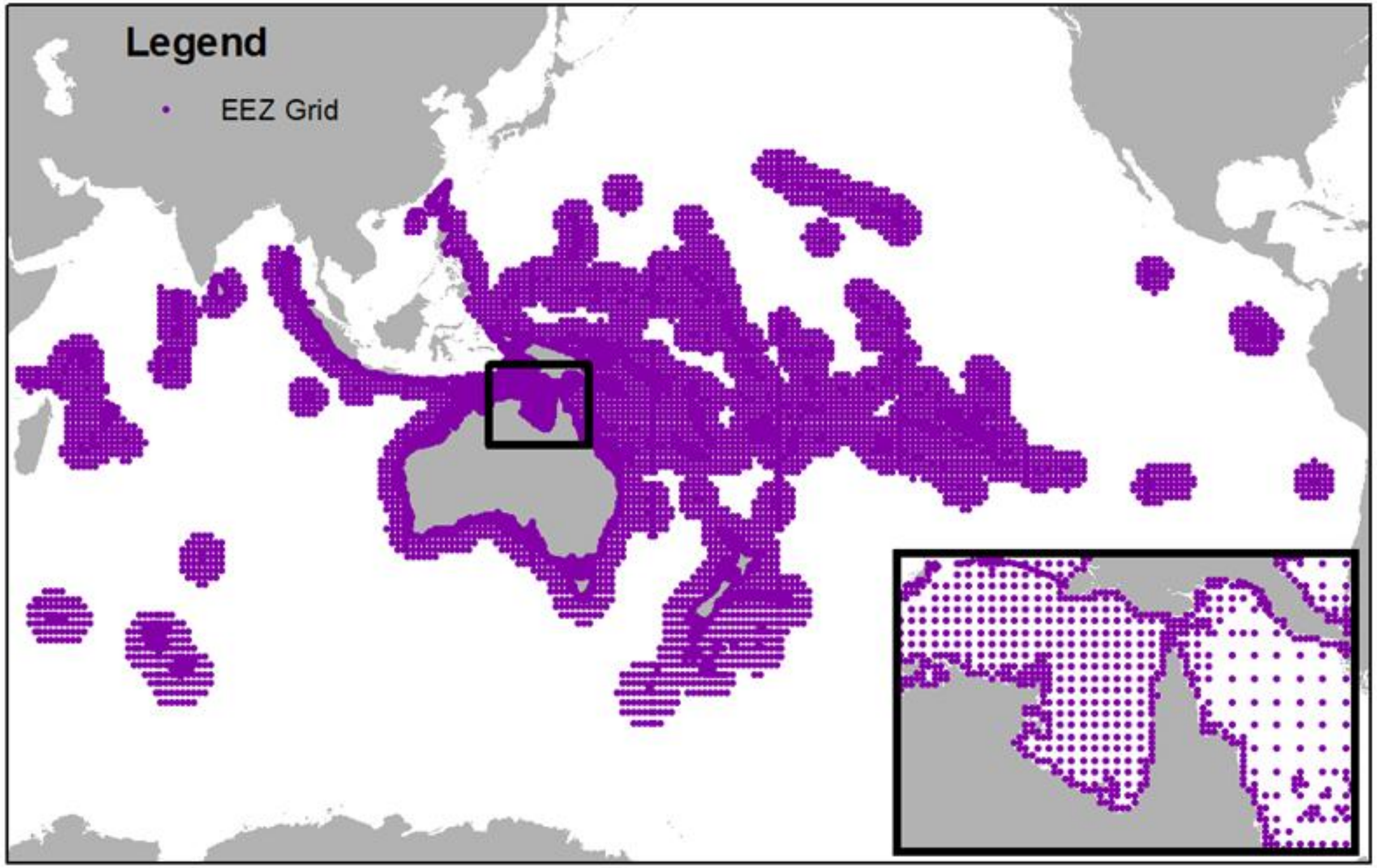




Spectral Output Point Locations

Primarily for creating spectral boundaries for downscaling:

- 1 degree spacing for selected EEZ in Pacific and Indian Ocean
- 30 min spacing for depths shallower than -500m
- 15 min spacing within 25 km of major land masses (larger than $1km^2$)



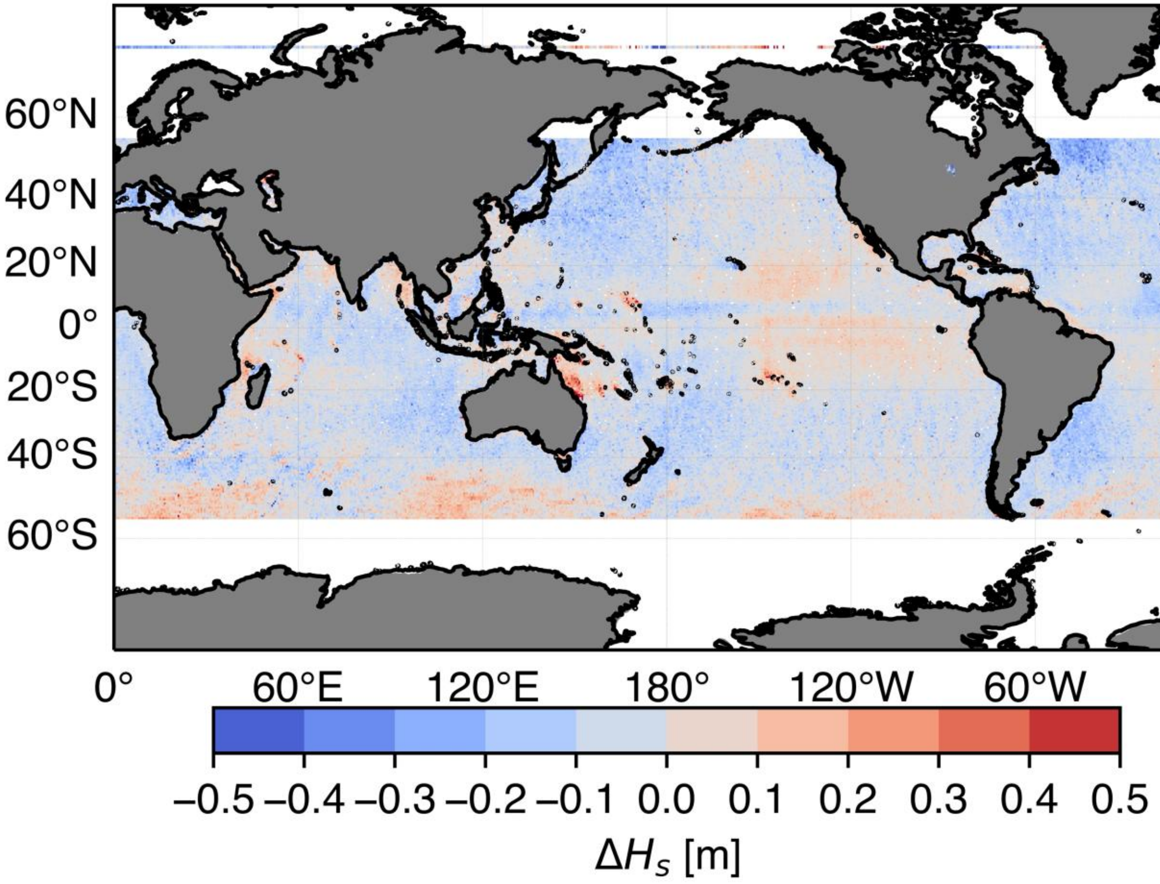
(Alday et al., 2021) (Campos et al., 2022)

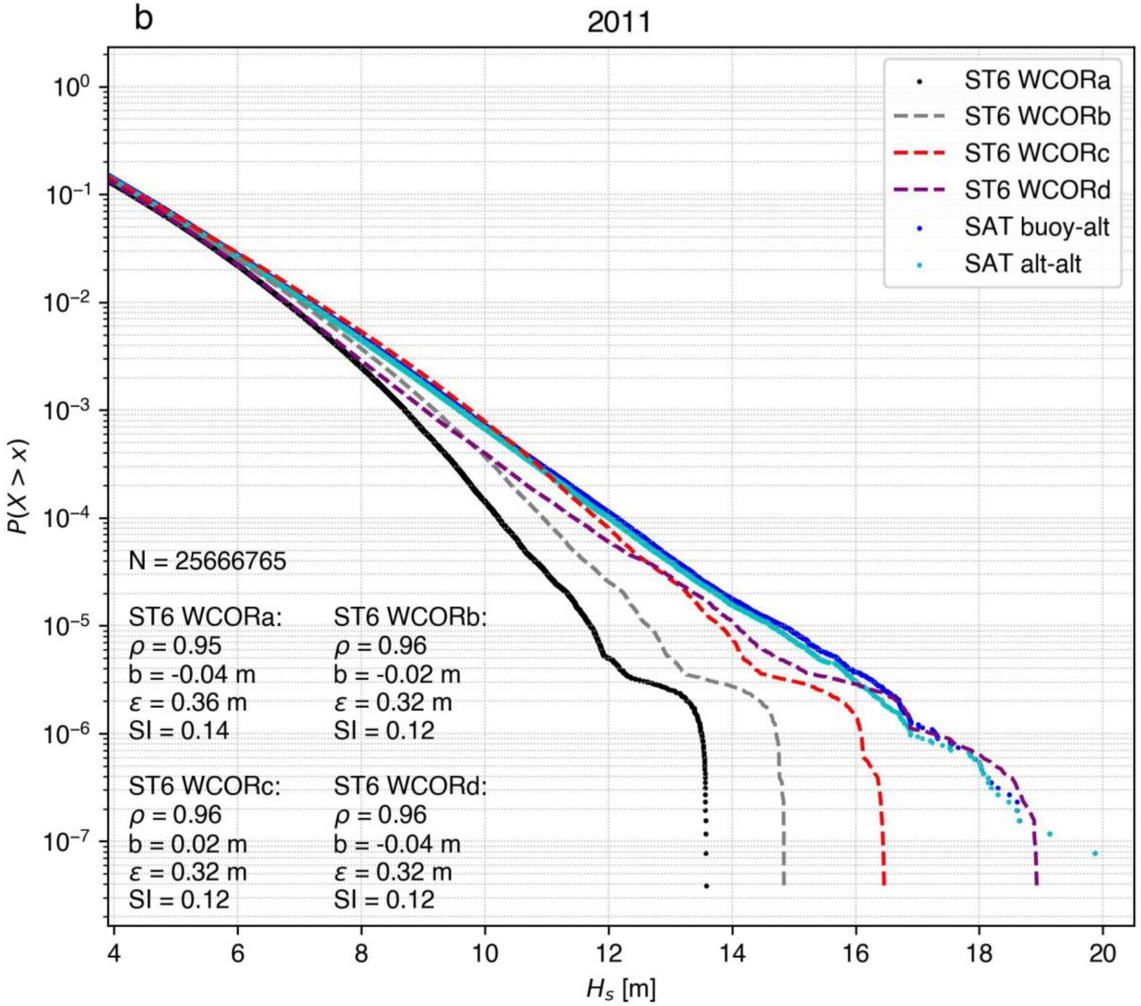
$$U_{10,\text{corr}} = U_{10,\text{raw}} + x_c \max\{U_{10,\text{raw}} - U_c, 0\}$$

Wind Calibration against AODN satellite altimeter

WCOR2 WCOR1

25+ million wave model/altimeter collocations at 1/8-degree res.





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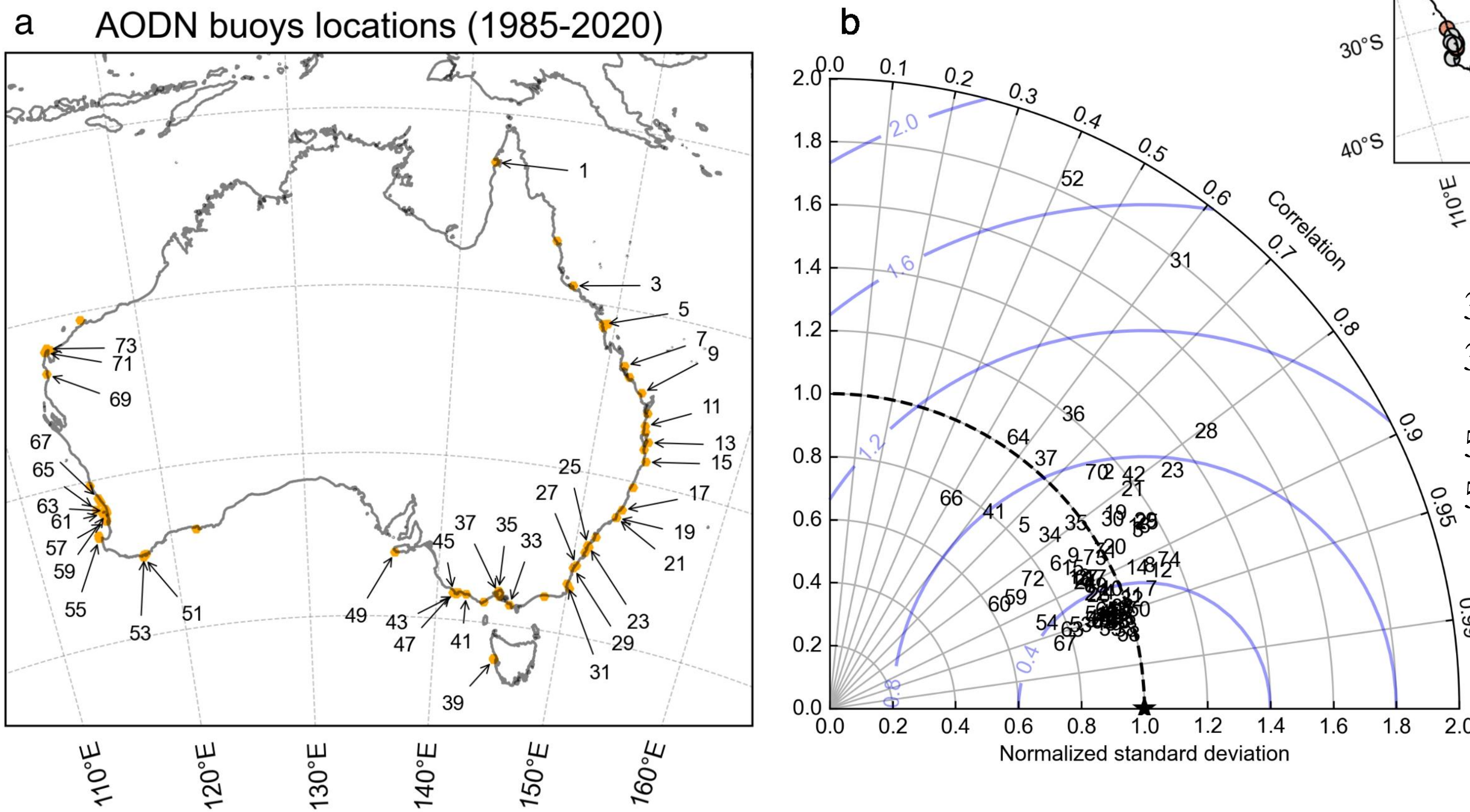
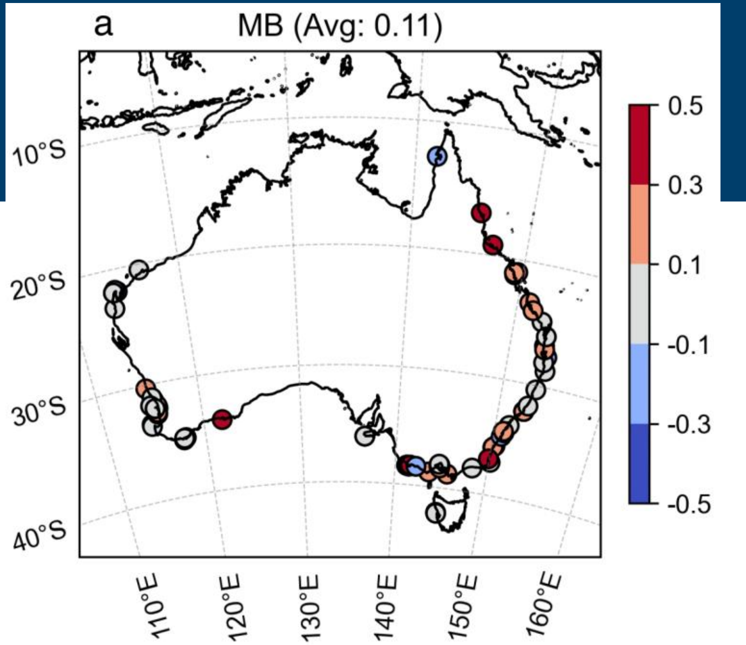
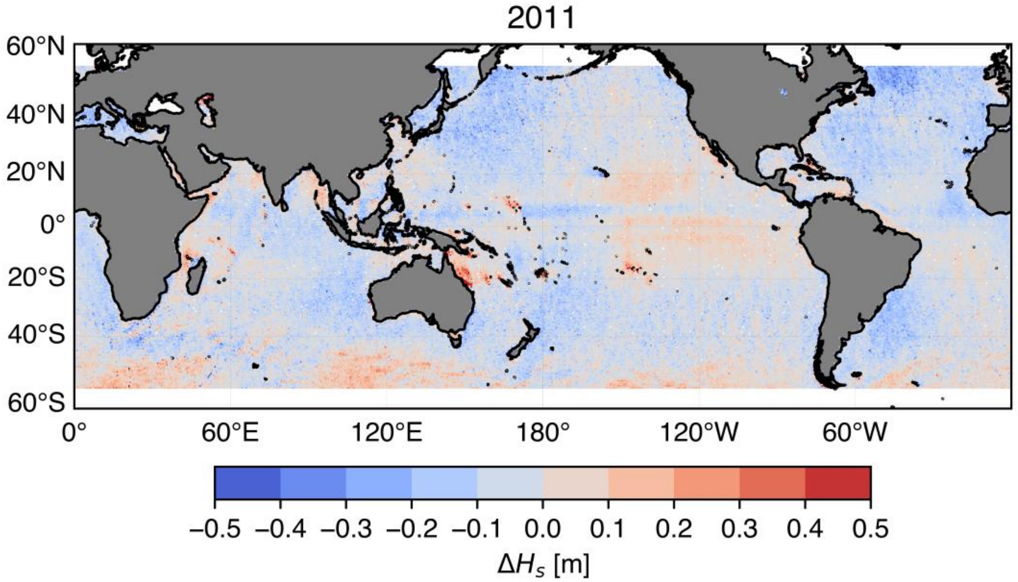
WHACS vs AODN buoys – 1985-2020

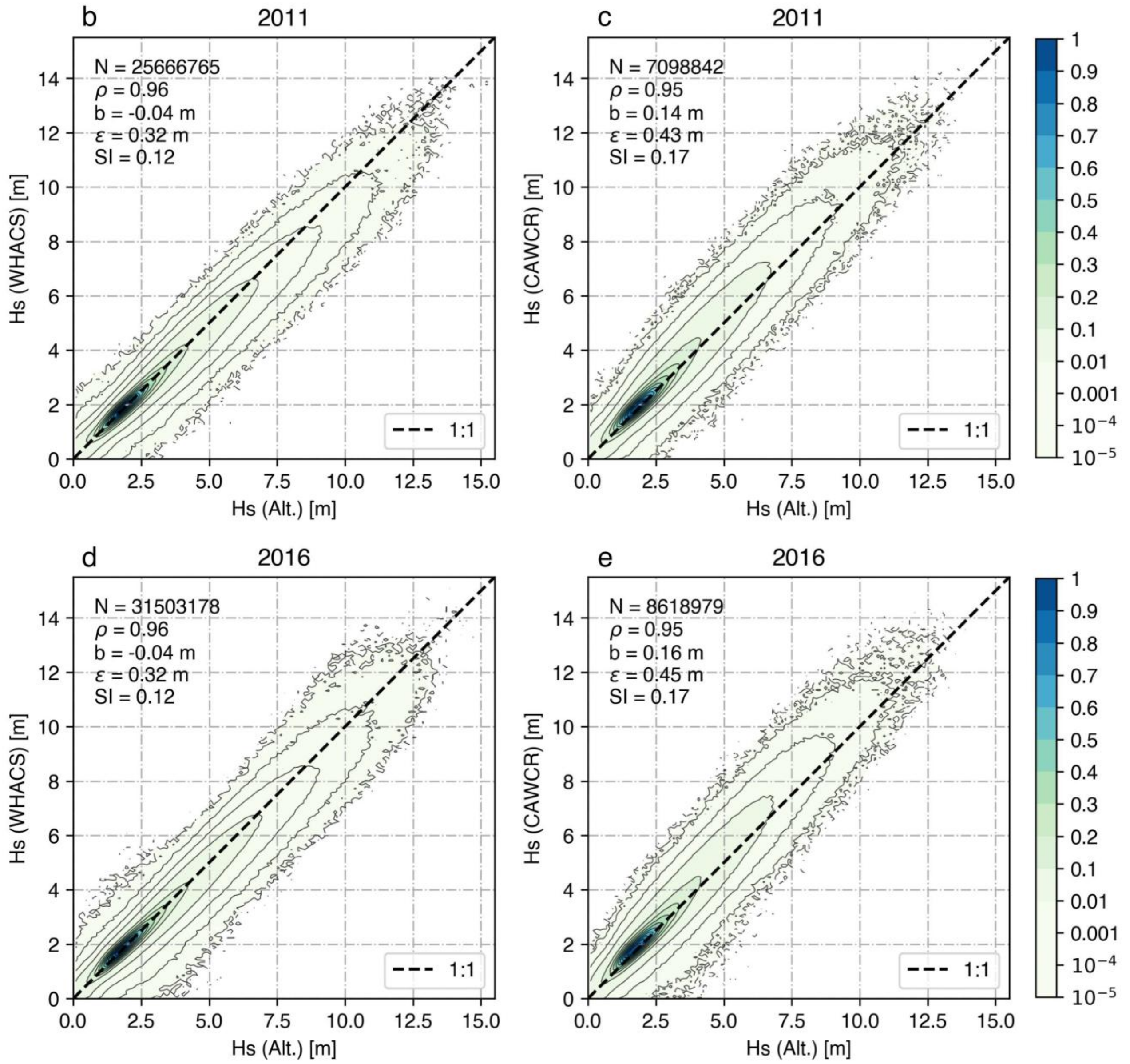




30	Eden	27 years
31	Merimbula	3 months
51	Albany 04	14 years
52	Albany 02	6 months

CAWCR vs WHACS comparison





Improved data performance

- Data has been post-processed prior to publication to improve computational performance and storage space
- Compliant with all relevant metadata standards
- Data is rechunked to optimize order of point storage and balance performance of access for timeseries or spatial analyses (e.g. validation against buoy data, or creation of maps of Tropical Cyclones)
  - This permits previously intractable problems like timeseries operations over all space, like calculating extreme value indices at all spatial points.
- This has been done for 3 gridded datasets: SMC, global 1/8°, and Australian region 1/16°; spectral data were also rechunked to improve performance.
- Data is made available for direct download from CSIRO's Data Access Portal or via THREDDS
- Smith, Grant; Meucci, Alberto; Zieger, Stefan; Trenham, Claire; Hally, Bryan; Seers, Blake; Spillman, Claire; & Hoeke, Ron (2024): WHACS: Wave Hindcast for the Australian Climate Service. v6. CSIRO. Data Collection. https://doi.org/10.25919/yp77-v026

WHACS Key Takeaways – https://doi.org/10.25919/yp77-v026

- **New data product** – can be used to replace CAWCR (1979-2023 presently*)
- **Enhanced extreme wind calibration** – Supports robust Extreme Value Analyses (EVA) for improved risk assessment.
- **Superior wave model physics** – Advances beyond CAWCR's capabilities
- **Improved accuracy** – Demonstrates better correlation, lower RMSE, and reduced bias for significant wave height and peak period compared to CAWCR.
- **Increased spectral outputs** – Provides a much higher number of spectral parameters, enhancing decision-making for defence and maritime operations.
- **Higher global coastline resolution** – Extends high-resolution forecasting beyond Australia and the Pacific to all global coastlines, crucial for strategic planning.
- **Cutting-edge spectral reconstruction** – Enables out-of-the-box application of spectral reconstruction, unlocking new capabilities.

*planning to operationalise and bring up to date as CAWCR is in the next ~year.

Thank you for listening!

- Please feel free to use and cite our data!
  https://doi.org/10.25919/yp77-v026

- If you have any questions, please contact
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