Wave driven sea-level anomaly at Midway Atoll

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Australian Government

photo: Scott Smithers

Wave set-up at Pacific atolls and islands

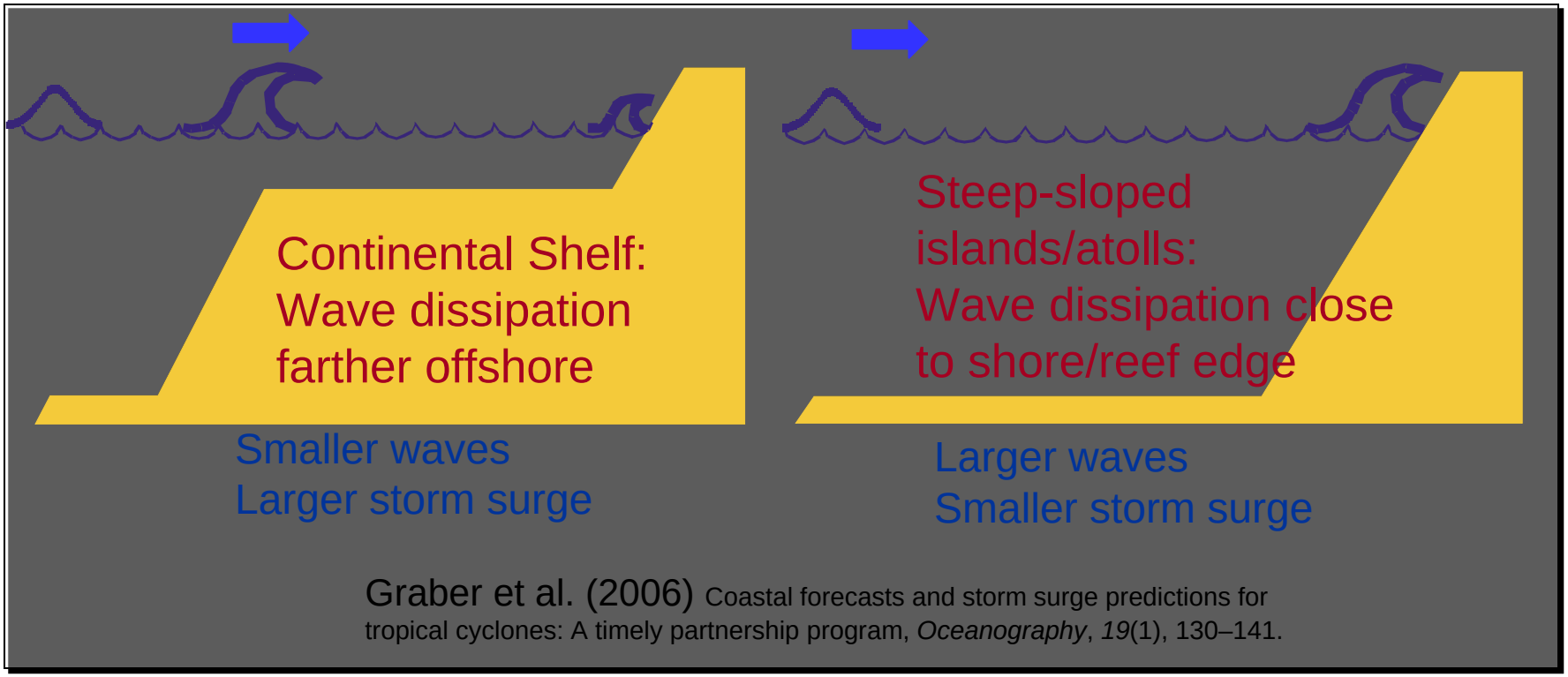
"..the power of the breaking waves is utilized to maintain a water level just inside the surf zone about 1.5 ft above sea level."

Munk and Sargent (1948) **Adjustment of Bikini Atoll to waves**, *Transactions, Am. Geo. Union*, *29*(6), 855-860.

Wave set-up may be "as much as 20% of the incident wave height."

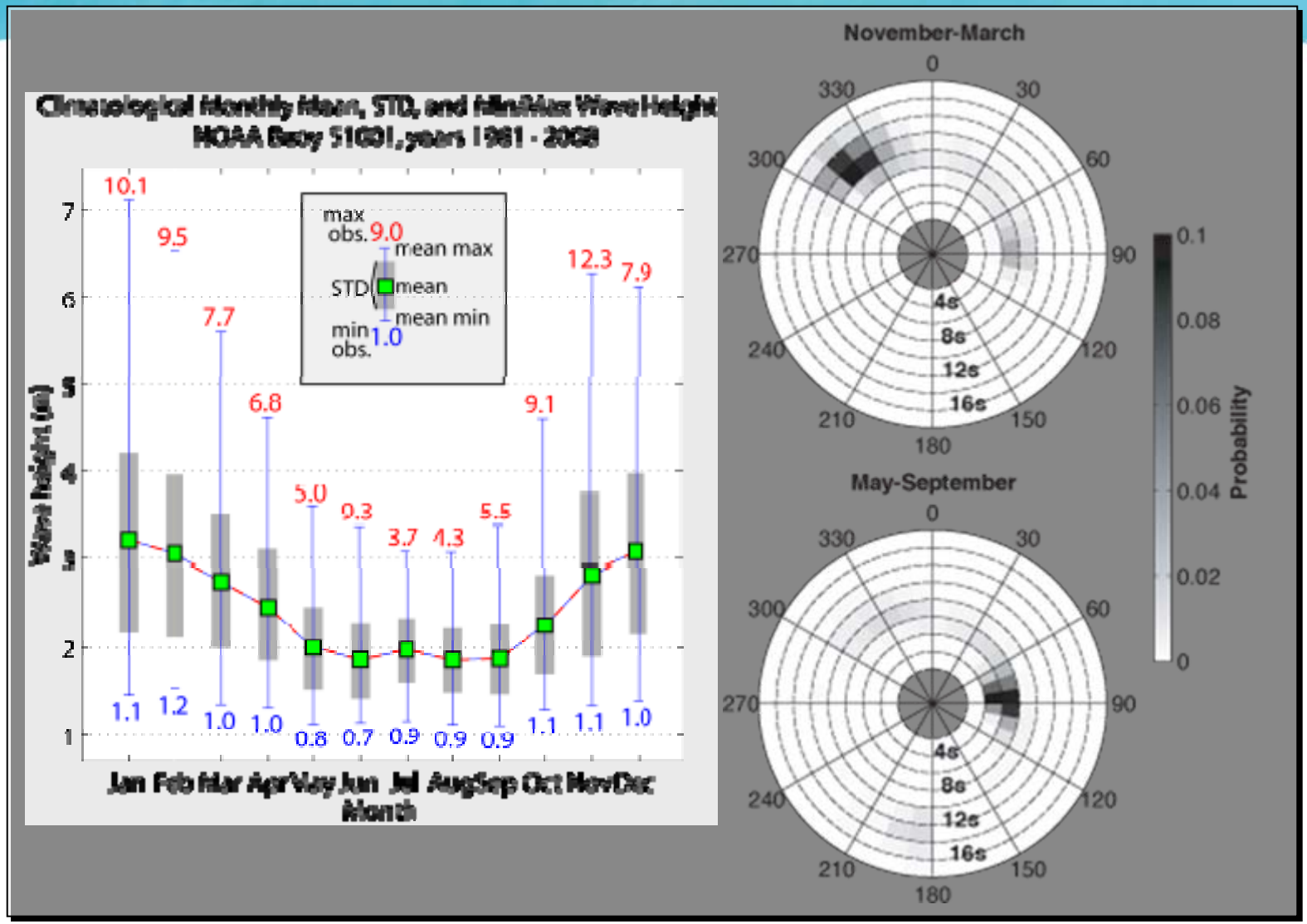
Tait, R. J. (1972) **Wave Set-Up on Coral Reefs**, *J. Geophys. Res.*, *77*(12).

Wave set-up at Pacific atolls and islands



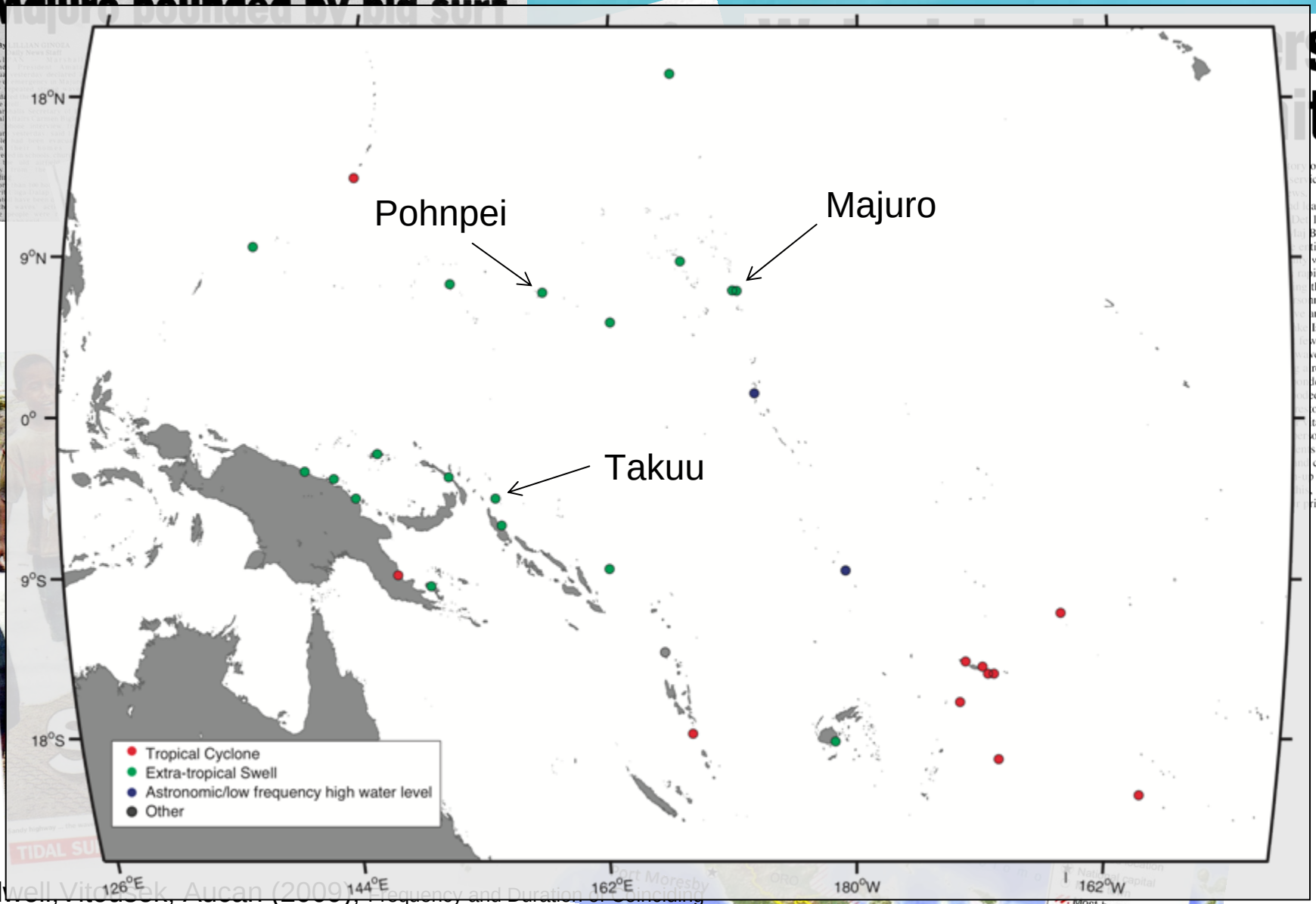
Graber et al. (2006) Coastal forecasts and storm surge predictions for tropical cyclones: A timely partnership program, *Oceanography*, *19*(1), 130–141.

Pacific wave climate



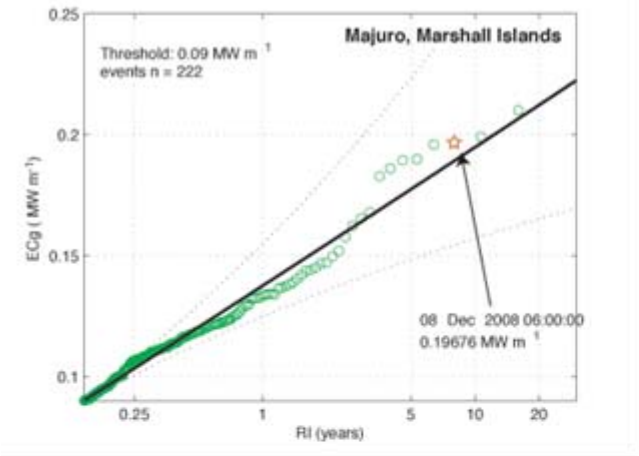
Hoeke et al. (2011) *J. Geophys. Res.*, *116*(C4), C04018.

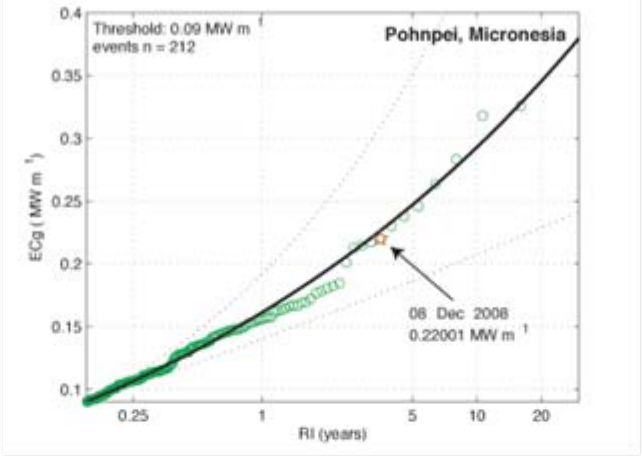
Wave set-up inundation events

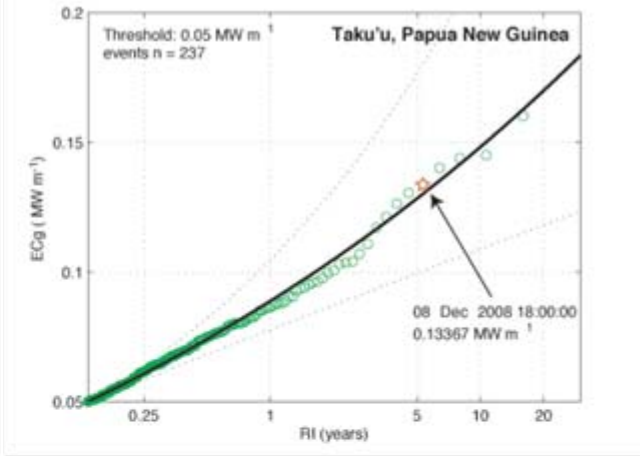


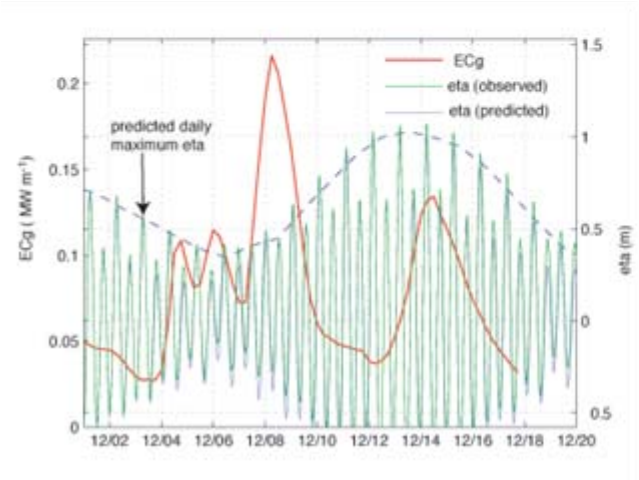
Caldwell, Vitousek, Aucan (2009), Frequency and Duration of Coinciding High Surf and Tides along the North Shore of Oahu, Hawaii, 1981-2007, *J. Coastal Res.*, *25*(3).

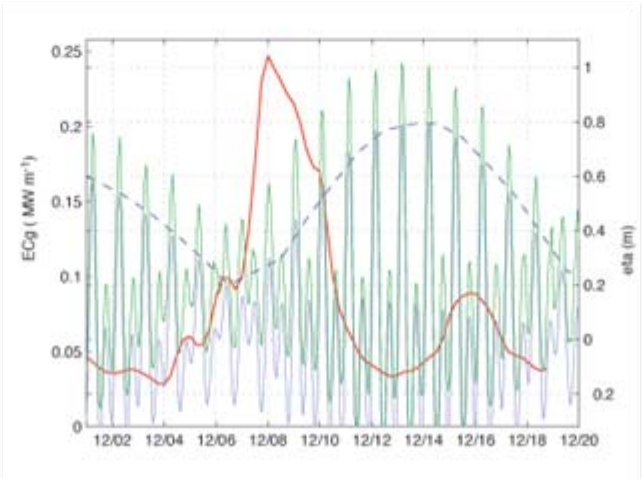
Wave set-up inundation events

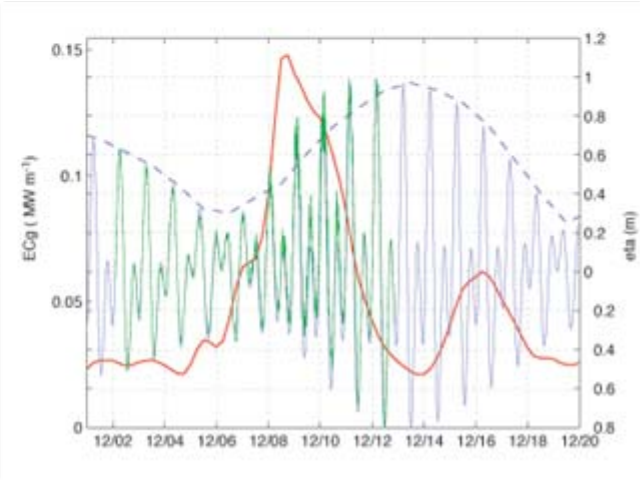












*Wave hindcast data provided by Mark Hemer (CSIRO)
**Taku'u water level data provided by John Hunter (U. Tas)

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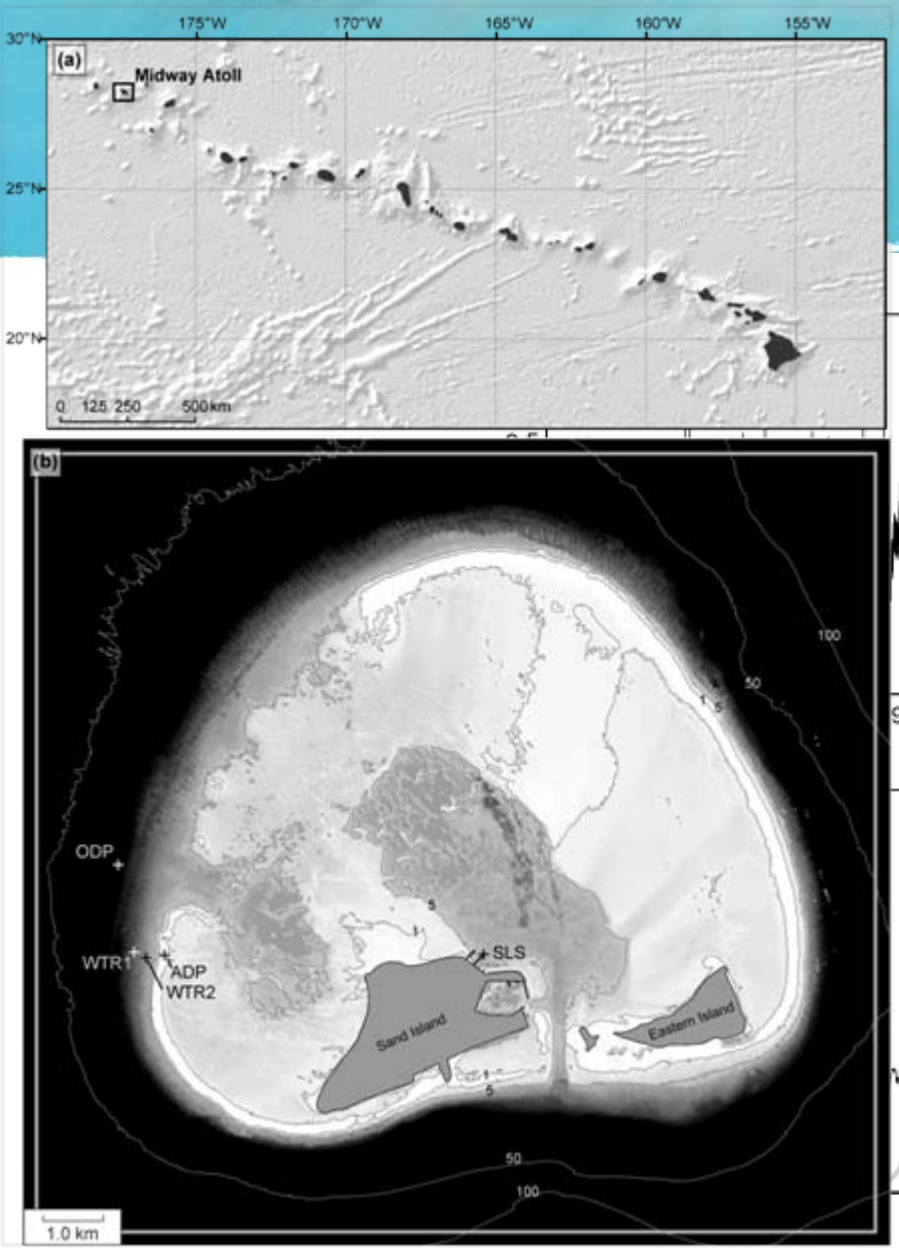

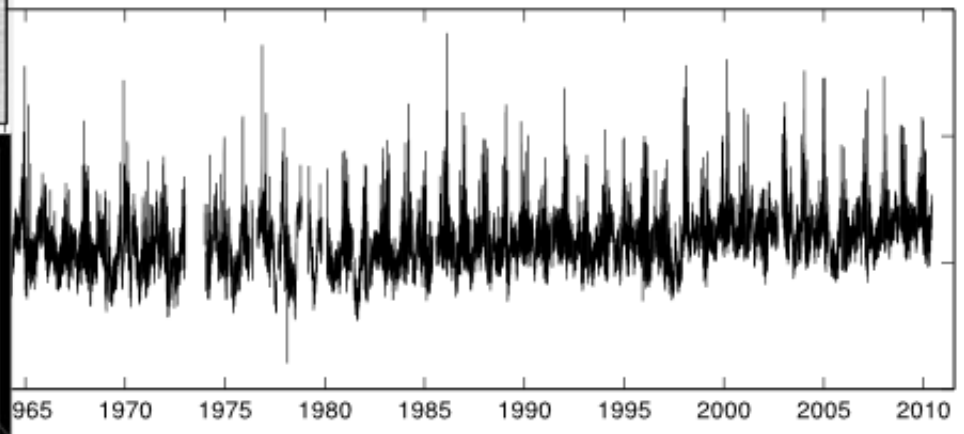

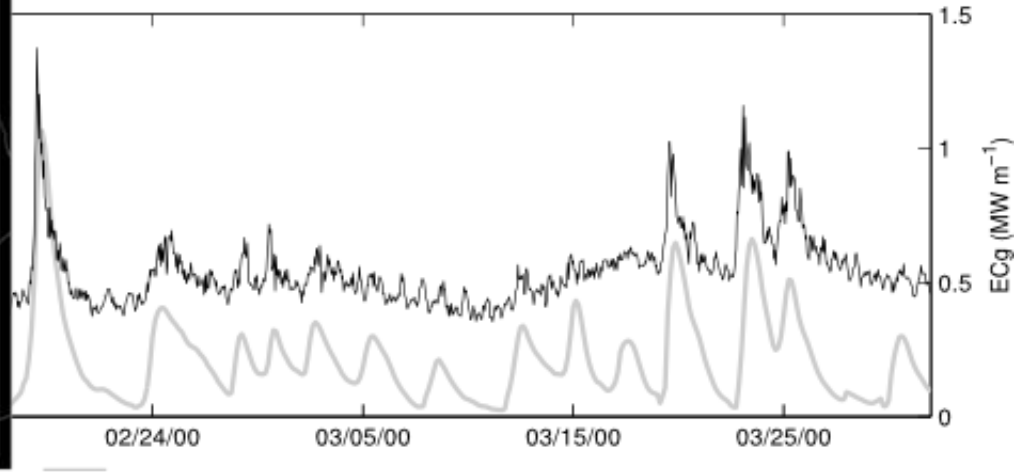

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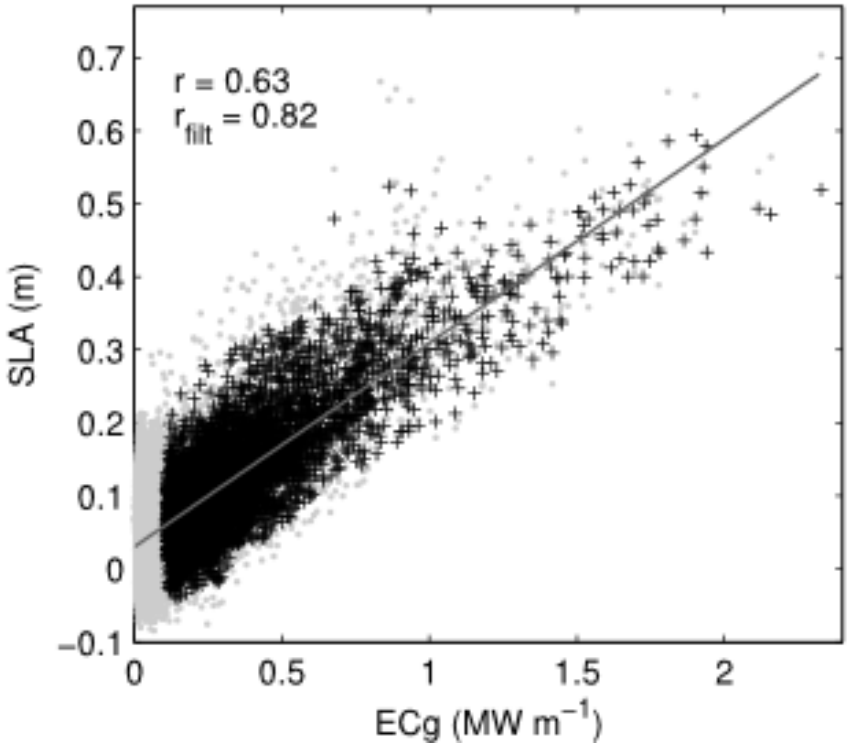

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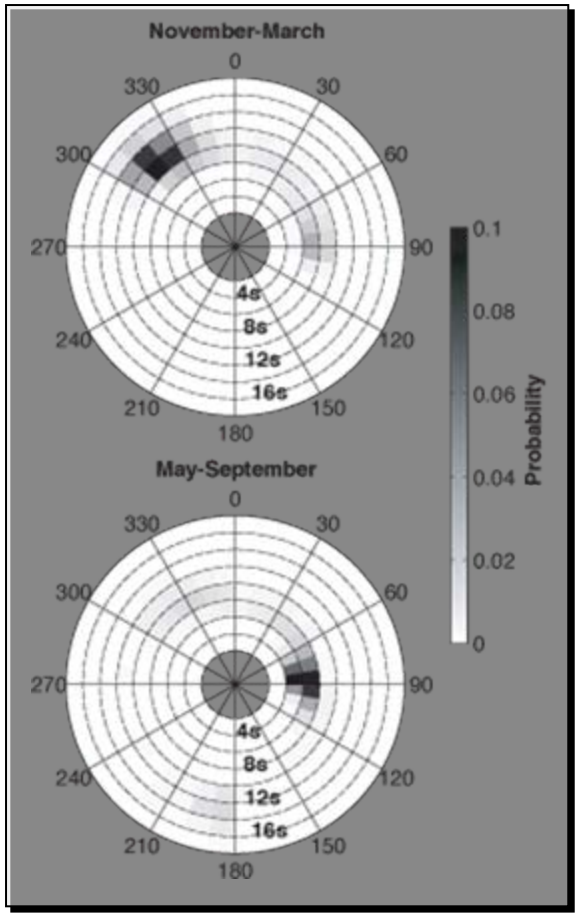

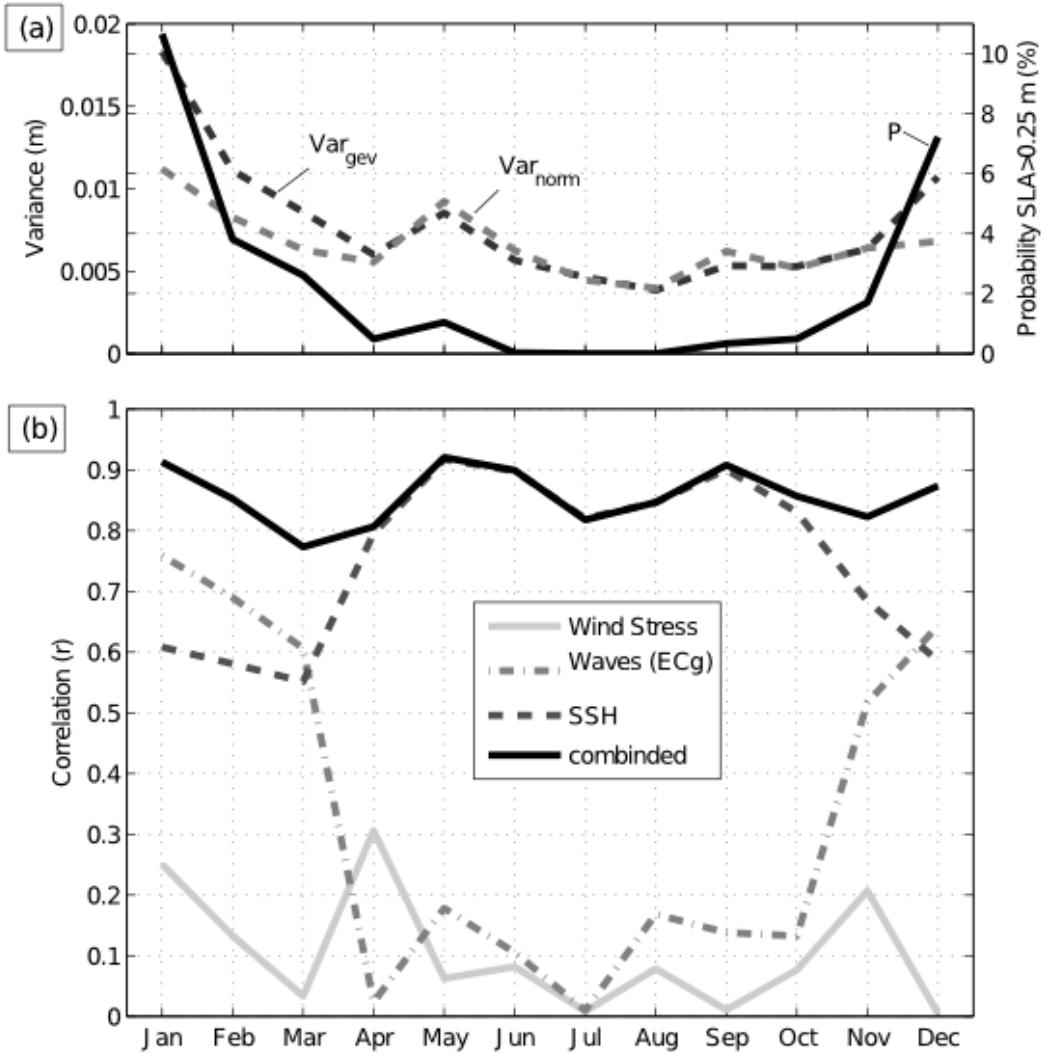

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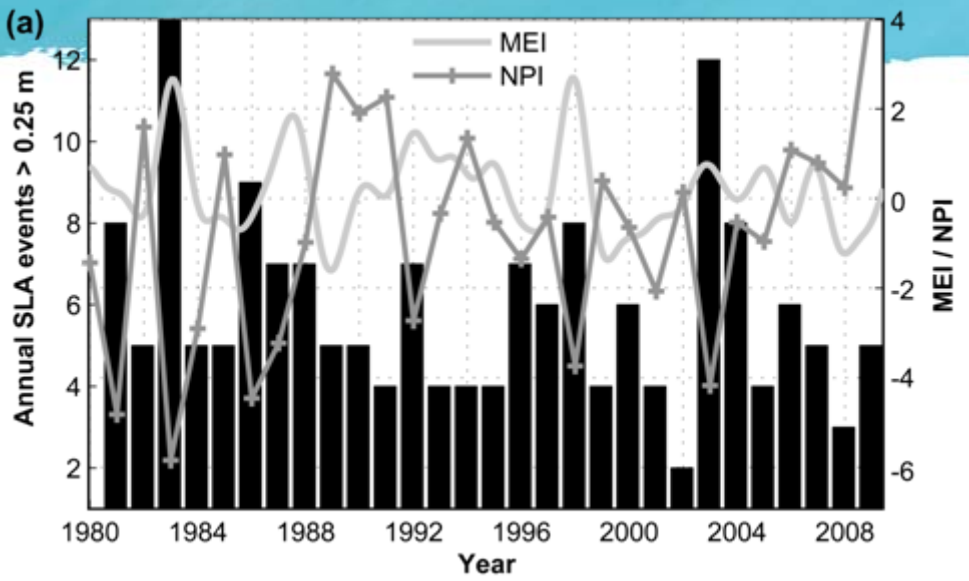
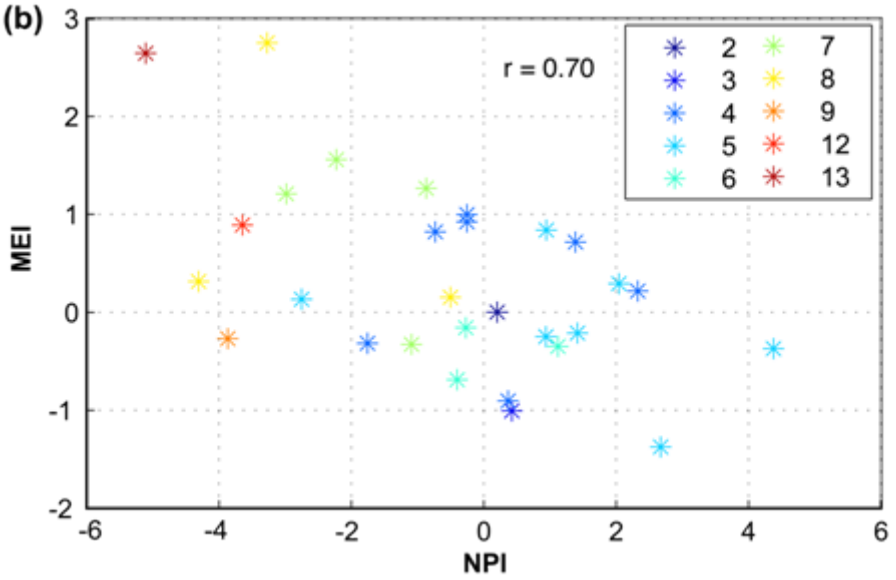


Multi-variate ENSO Index (MEI)
Wolter and Timlin (1998)

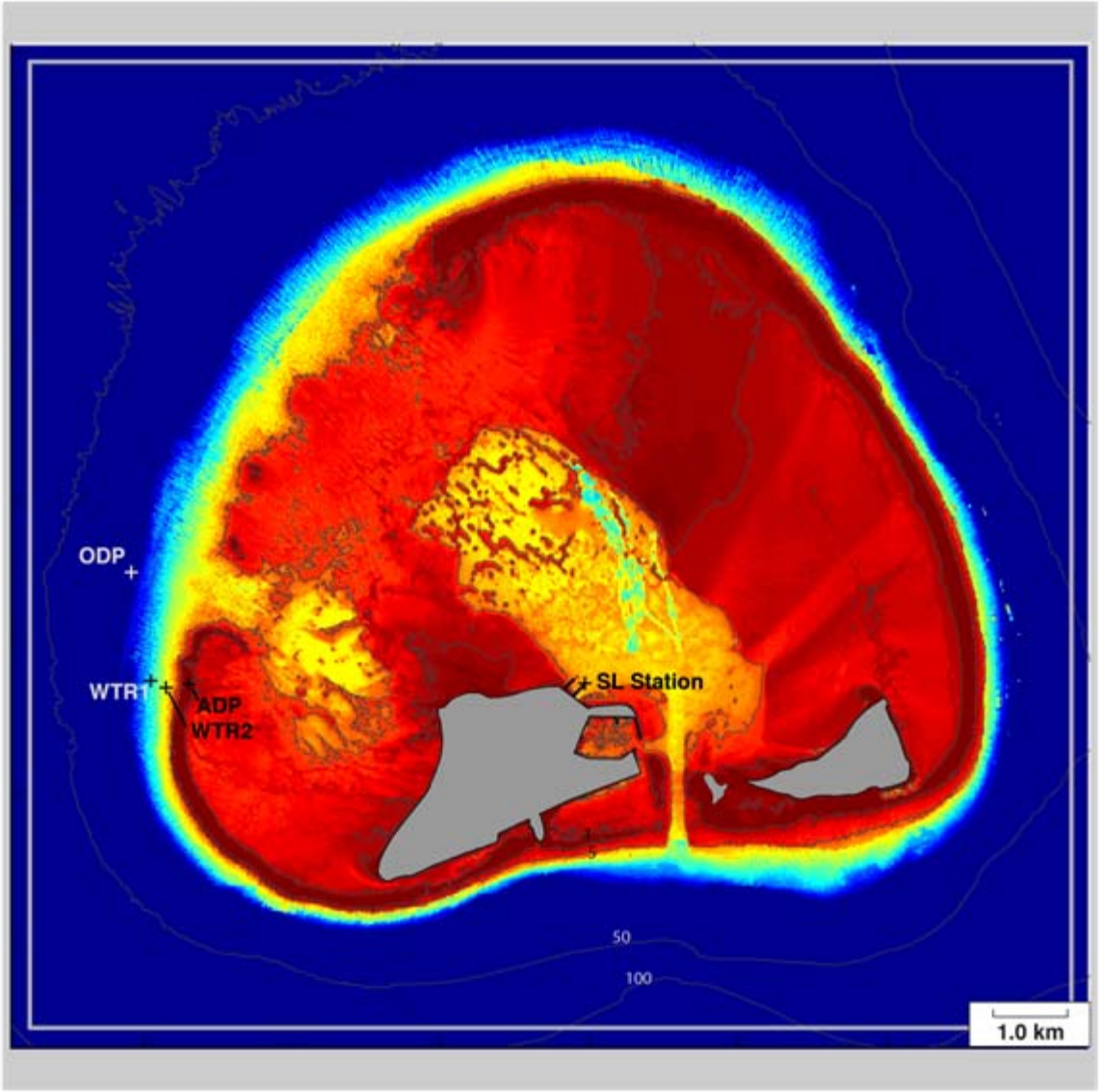
NDJFM North Pacific Anomalies Index (NPI)
*Trenberth and Hurrell (*1994)



Coupled numerical wave/flow model

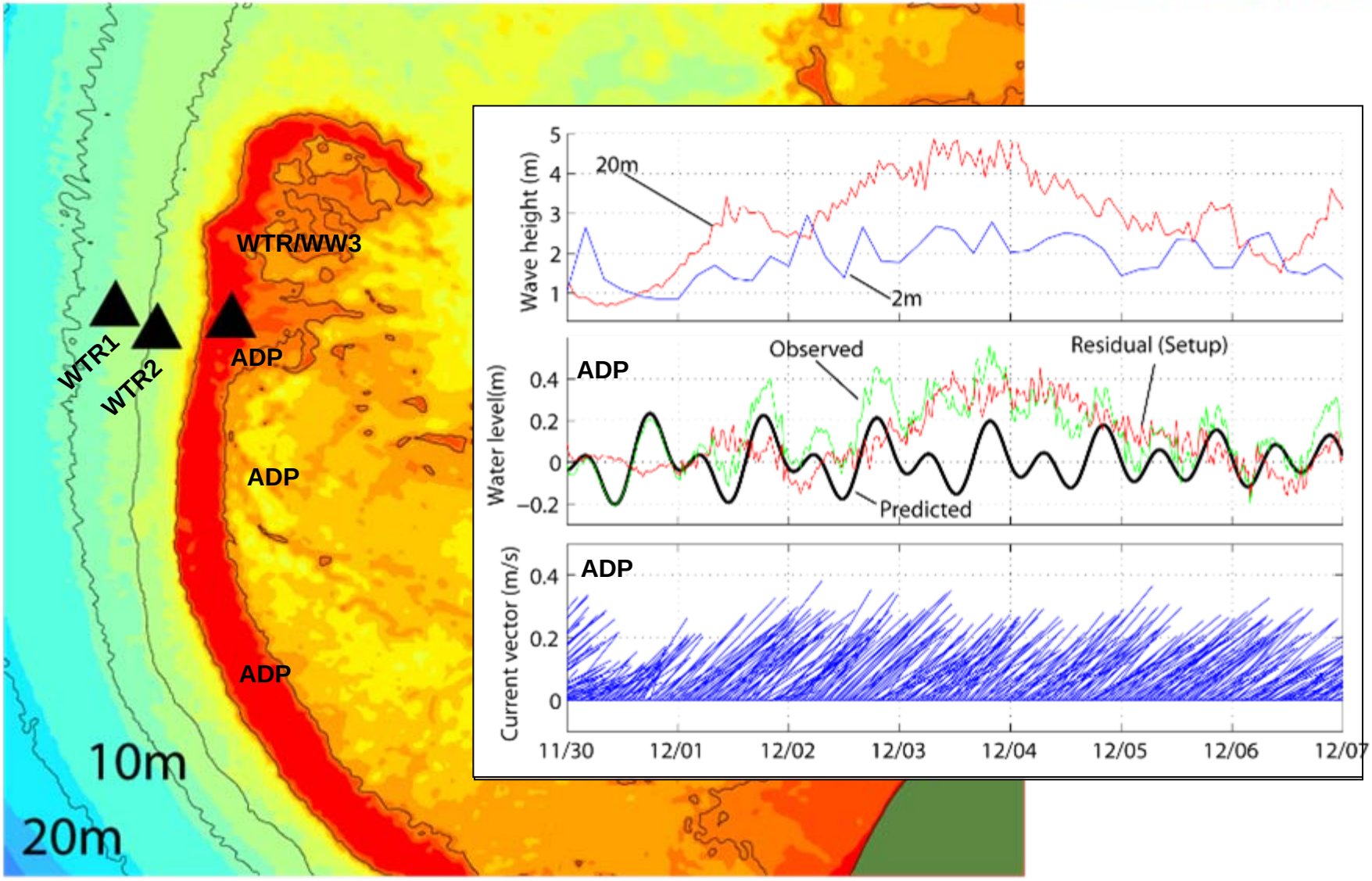
SWAN Wave Model: phase-averaged solution of the discrete spectral balance of wave action density

Delft3D Circulation Model: finite - difference coupled wave/flow numerical solution to Navier-Stokes equations (non-steady, incompressible, continuity, hydrostatic)



Bathymetry: NOAA Technical Memorandum NESDIS NGDC-33

In situ observations



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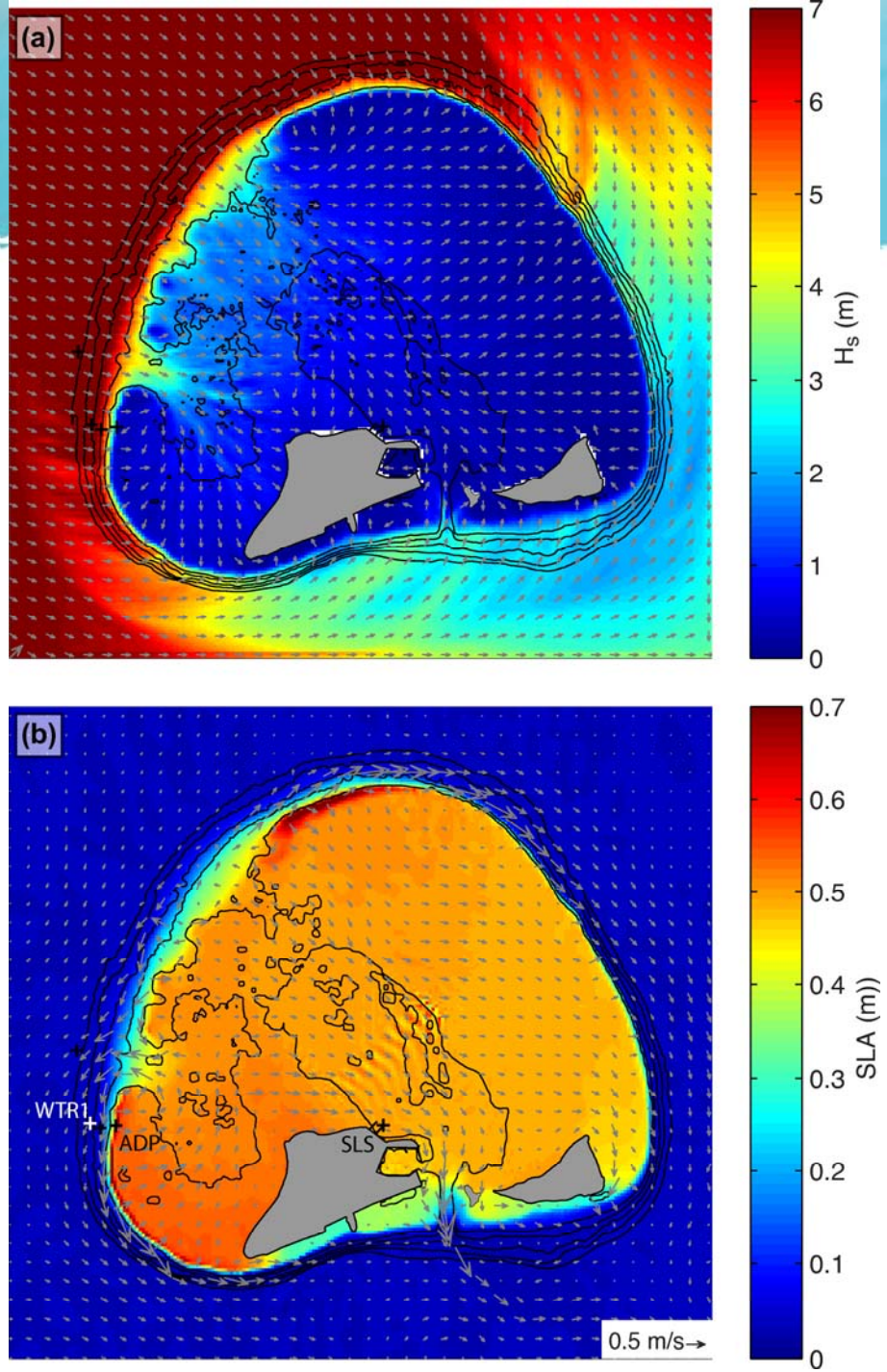

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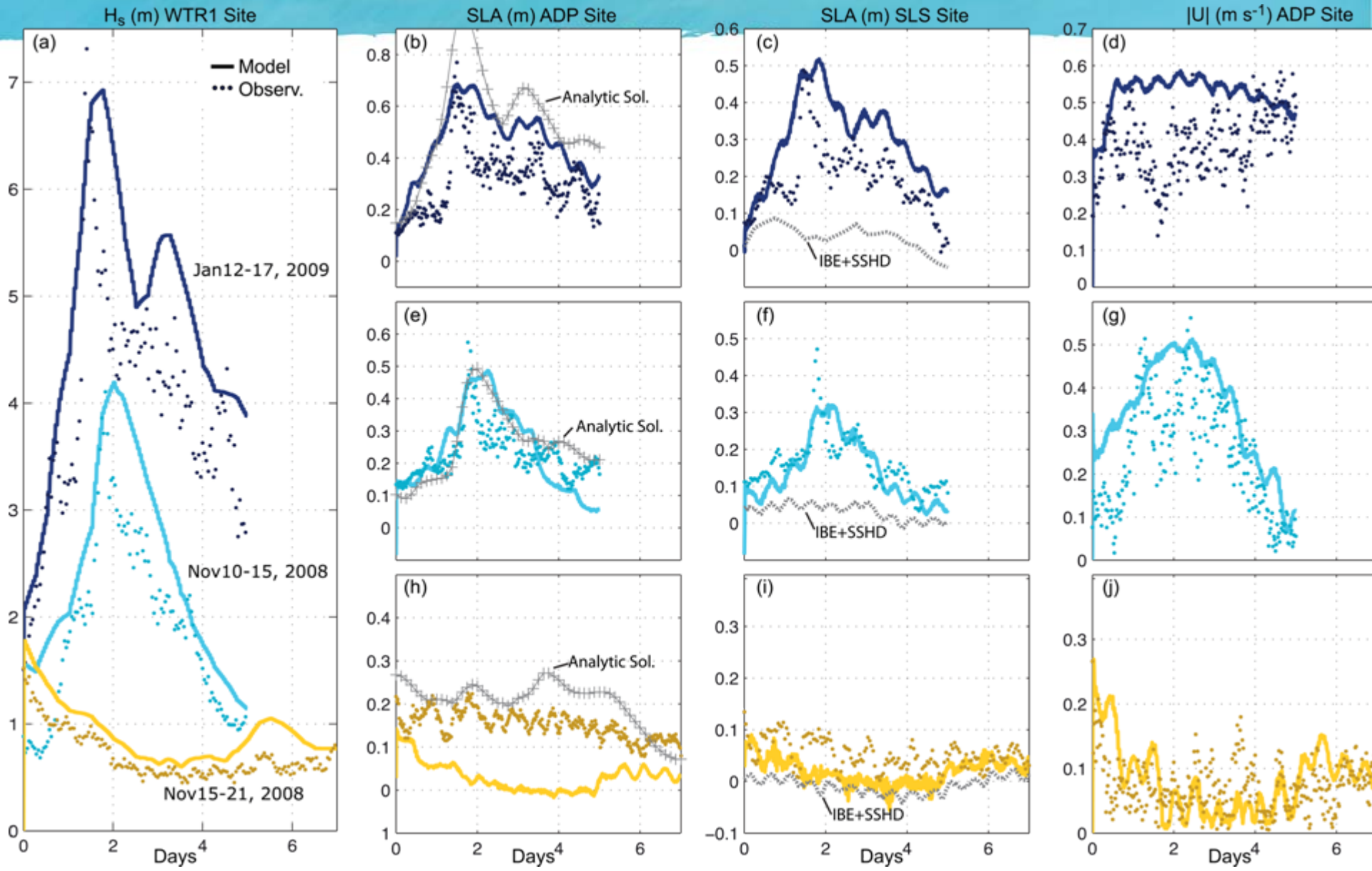
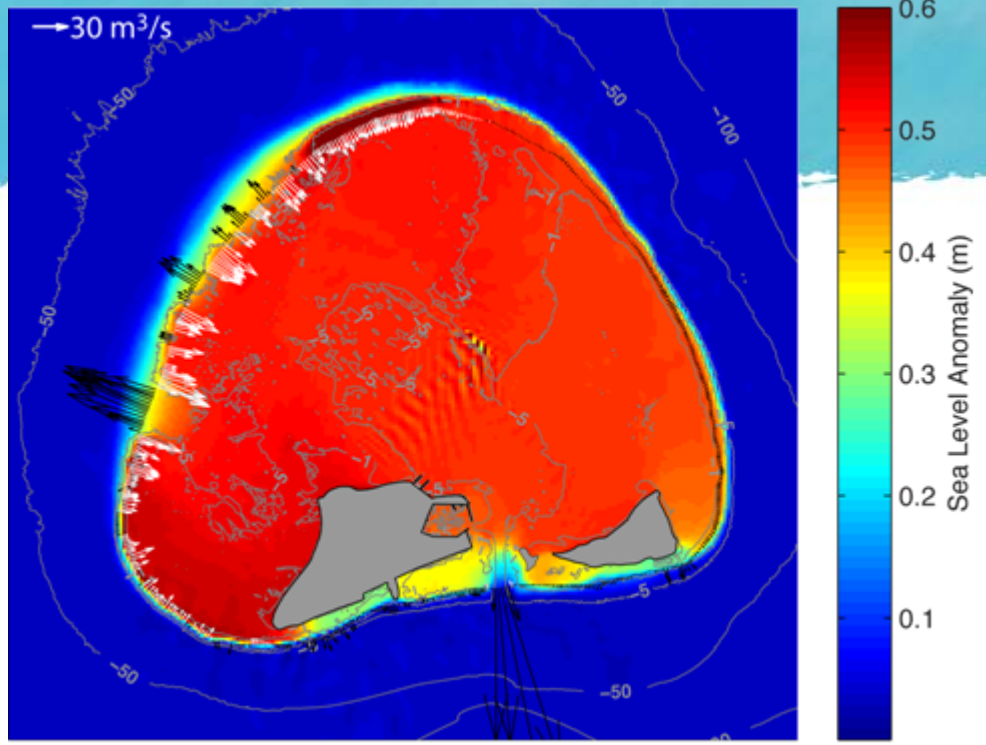


Coupled numerical wave/flow model



$$\text{Model Skill} = \frac{\sum (x_m - x_o)^2}{\sum \left(\left| x_m - \overline{x_o} \right| + \left| x_o - \overline{x_o} \right| \right)^2}$$

model period	max H_s (m)	max T_p (s)	max D_p (°)	Max SLA: ADP site (m) model	Max SLA: ADP site (m) obs.	Max SLA: ADP site (m) analy.	Max SLA: SLS site (m) model	Max SLA: SLS site (m) obs.	Flushing time (hours) min	Flushing time (hours) max	Model skill
Jan12 -17, 2009	8.3	15.9	305.8	0.686	0.769	0.973	0.518	0.488	3.5	13.0	0.73
Nov10 -15, 2008	5.1	14.2	314.0	0.487	0.574	0.492	0.321	0.471	5.0	18.3	0.91
Nov15 -21, 2008	3.8	8.5	99.6	0.141	0.225	0.271	0.090	0.134	16.6	36.3	0.82

Wave driven sea-level anomaly at Midway Atoll: Conclusions

Midway Atoll's tidal gauge record presents a unique dataset to examine wave setup.

A proxy record of north Pacific storm activity back to 1947?

Water level (tide gauge) data + numerical modeling is needed to help better understand and predict inundation events at reefs and islands in the Pacific and Indian Oceans

Wave driven sea-level anomaly at Midway Atoll: Future Work

Explore wave height -> reef rim depth -> reef channels -> wave setup relationship (implications for extreme swell events and sea level rise)

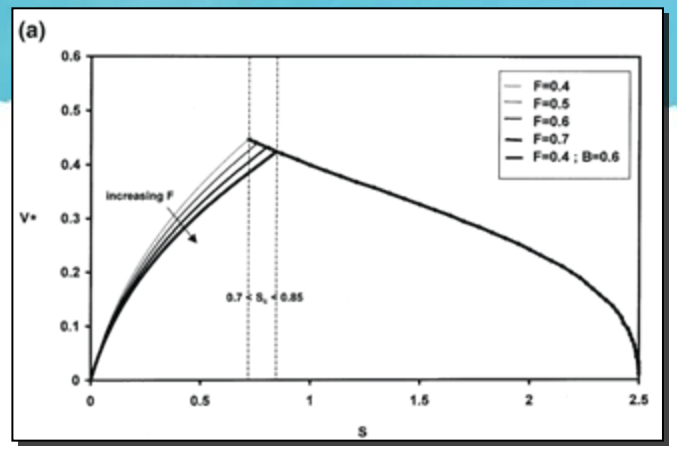
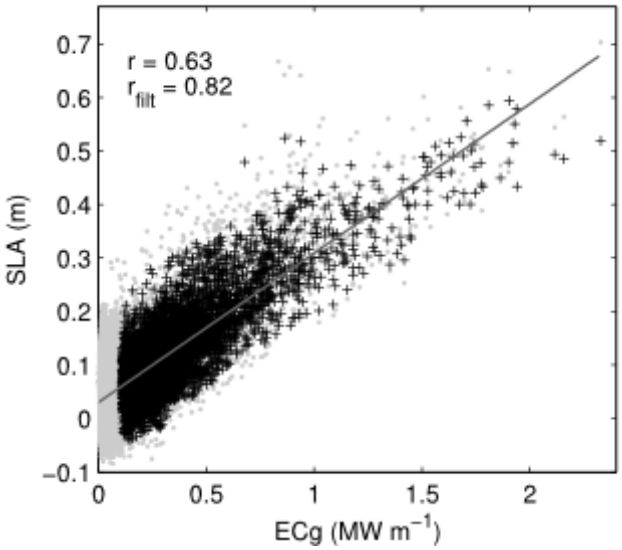


Figure 7a: Gourlay and Colleter (2005)
Wave-generated flow on coral reefs--an analysis for two-dimensional horizontal reef-tops with steep faces, *Coastal Engineering*, *52*(4), 353-387.



Apply model to other Pacific Atolls (Funafuti, Tuvalu and Majuro, Marshall Islands)

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