Sea Level Rise Projections / Local Government Implications

Sea Level variability in Western Australia

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The University of Western Australia

Coastal Oceanography

NOT Climate change but TIDES

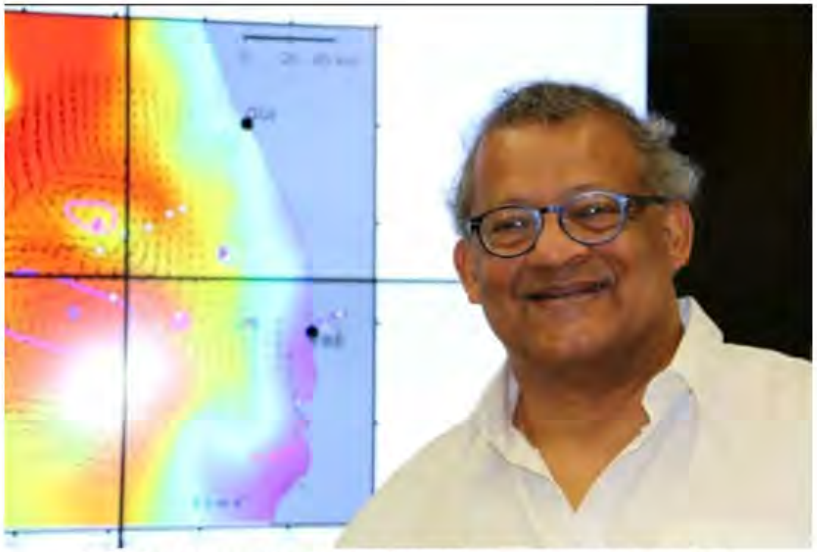
"In the next eight years our water level is going to increase by about 25 cm, which is much higher than the mean water level increase for the last 115 years."

Home › Current News › Actual Tidal Data Proves Australian Universities Lie About Sea Level Rises

Actual Tidal Data Proves Australian Universities Lie About Sea Level Rises

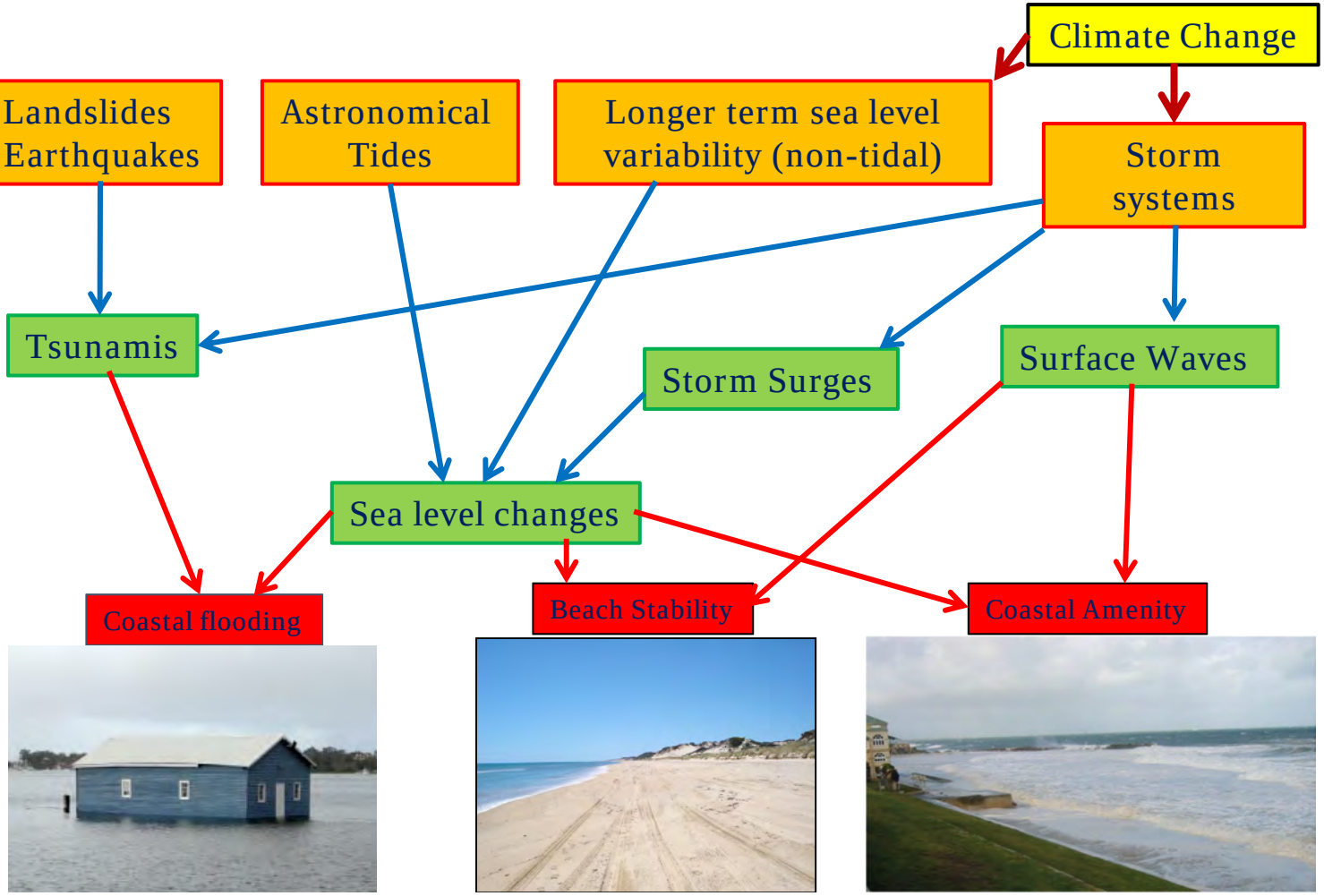
Published on June 8, 2018

Written by PSI Contributor

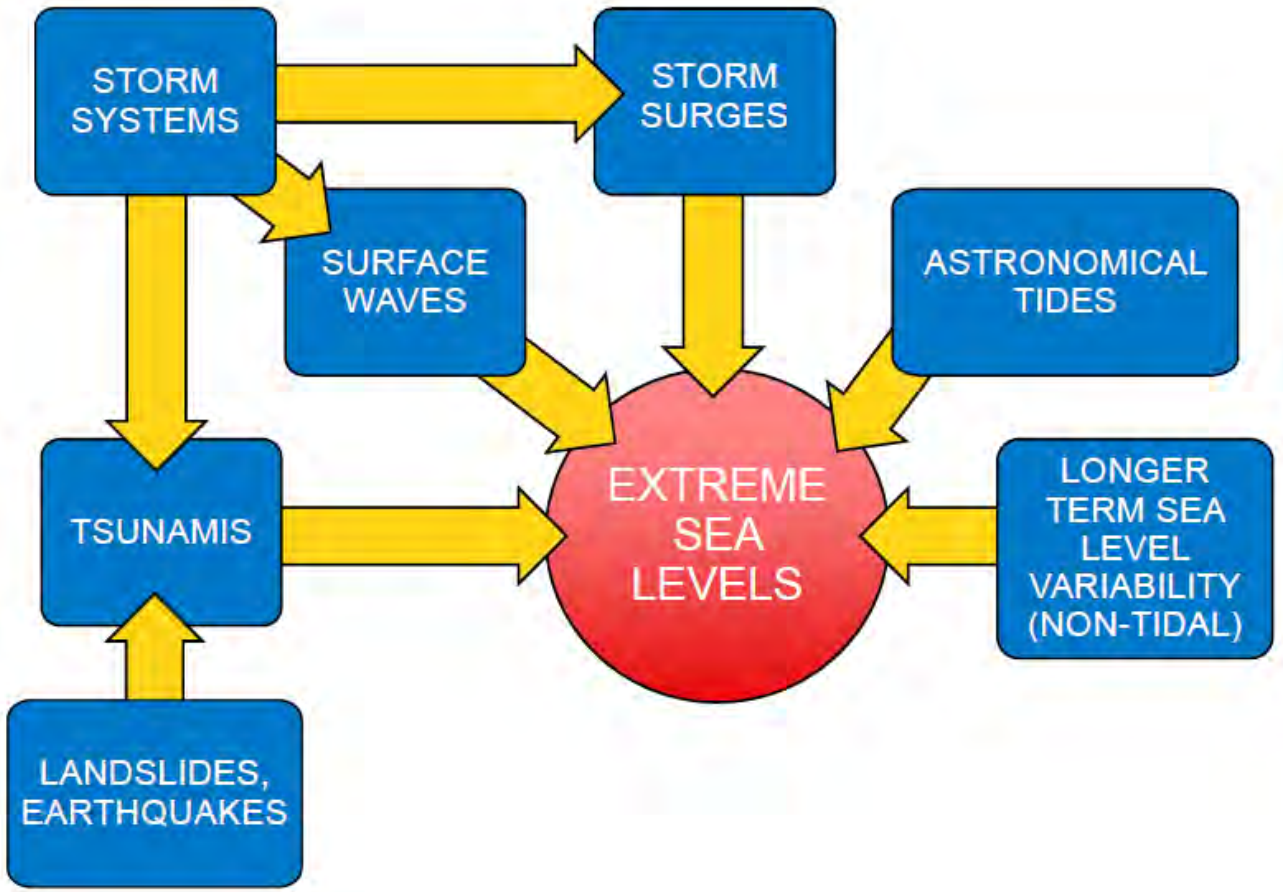


UWA Professor Charitha Pattiaratchi - ocean data fraudster?

Coastal Hazards

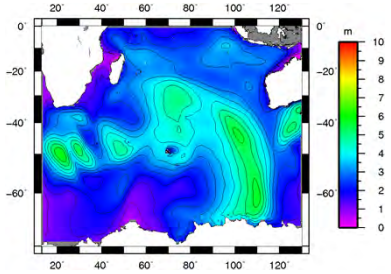


Extreme sea levels

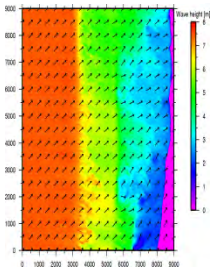


‘Energy’ @ Beach

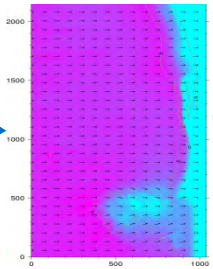
Basin Scale



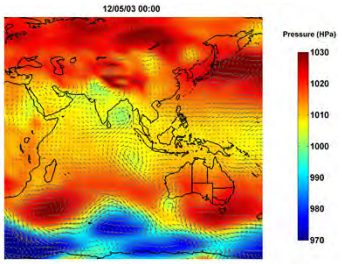
Shelf Scale

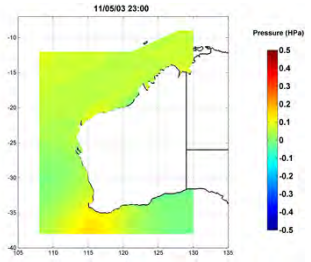


‘Beach’ Scale



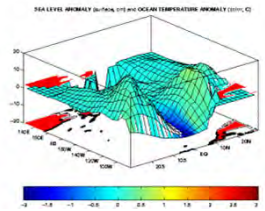
Wave Climate



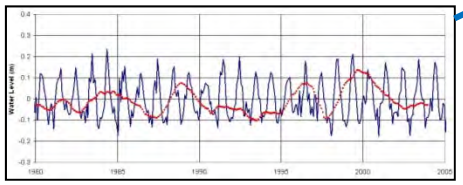


Storm Surges

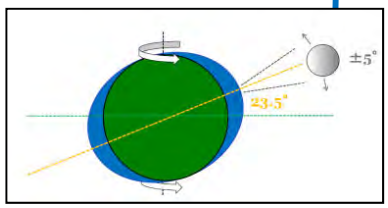
Mean sea level



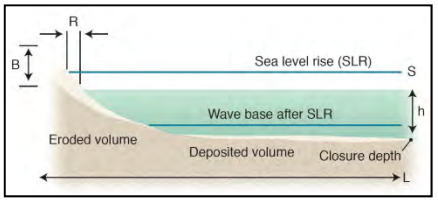
ENSO (El Nin0/La Nina)



Seasonal + Inter-annual

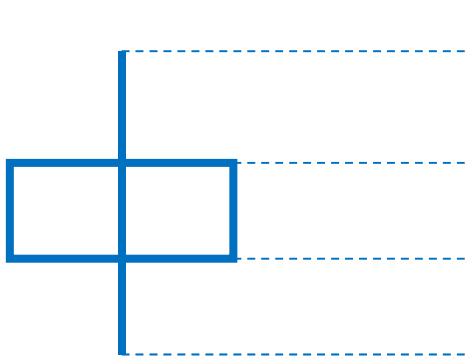


Nodal tides



Relative MSL

Sea Level Fluctuations

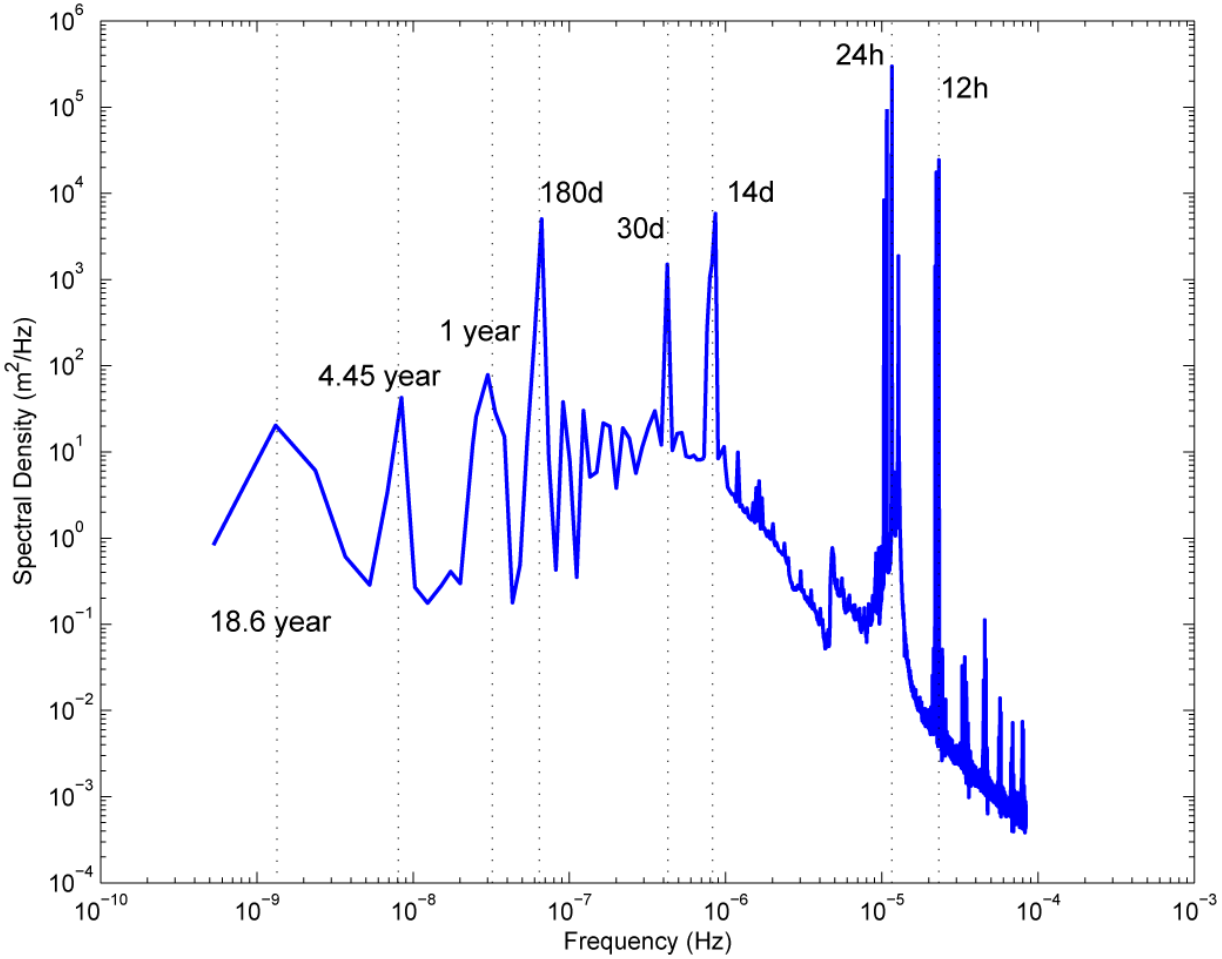


Range = 2m

$$\text{Sea Level}(t) = \text{Tide}(t) + \text{Surge}(t) + \text{Mean Sea Level}(t)$$

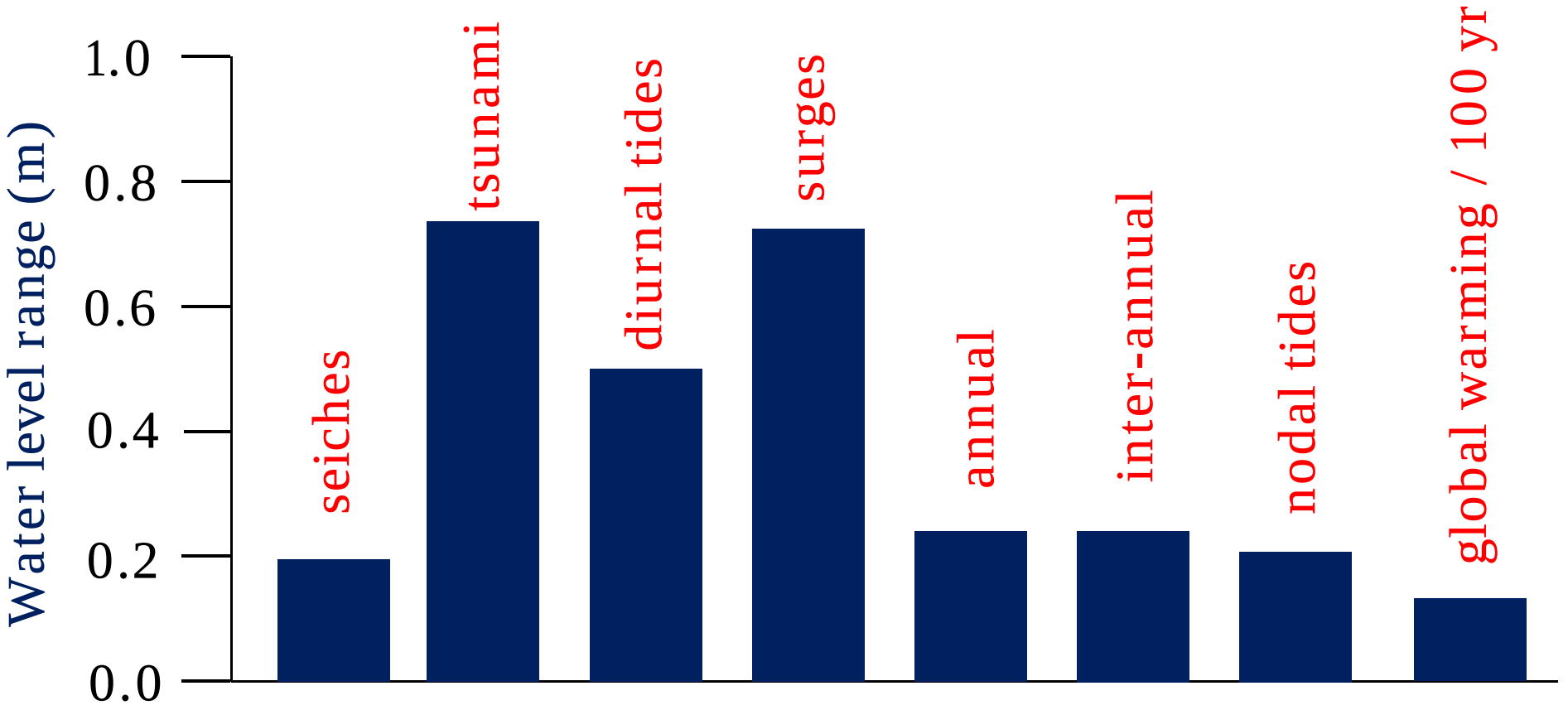
Fremantle Tide Spectrum

THE UNIVERSITY OF WESTERN AUSTRALIA

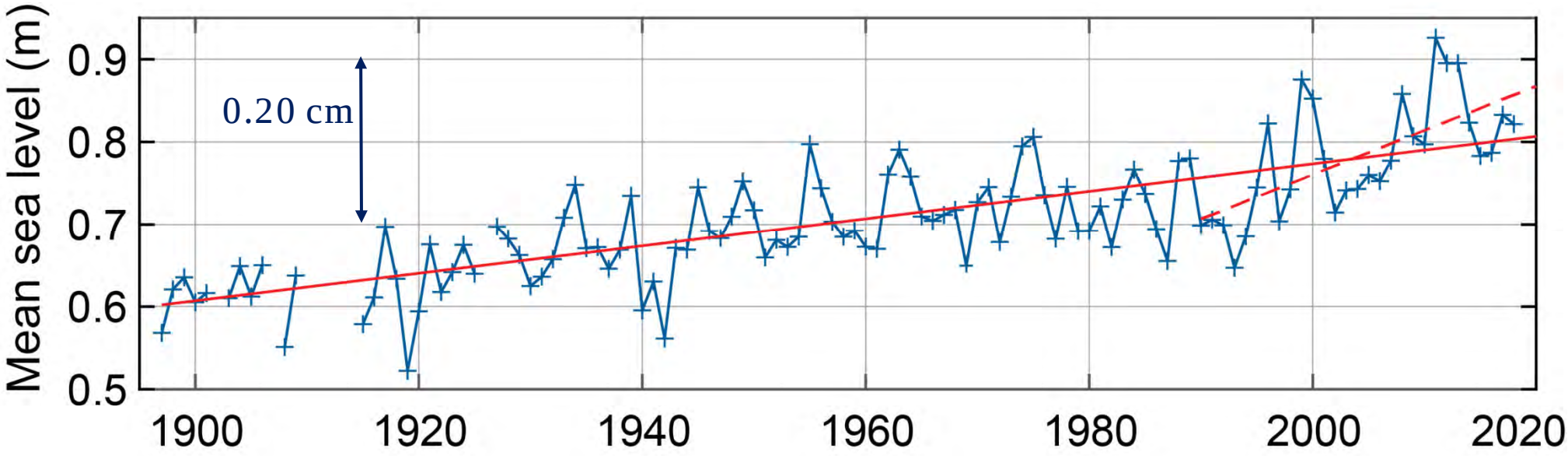


1950-2010

Water level variability at Fremantle

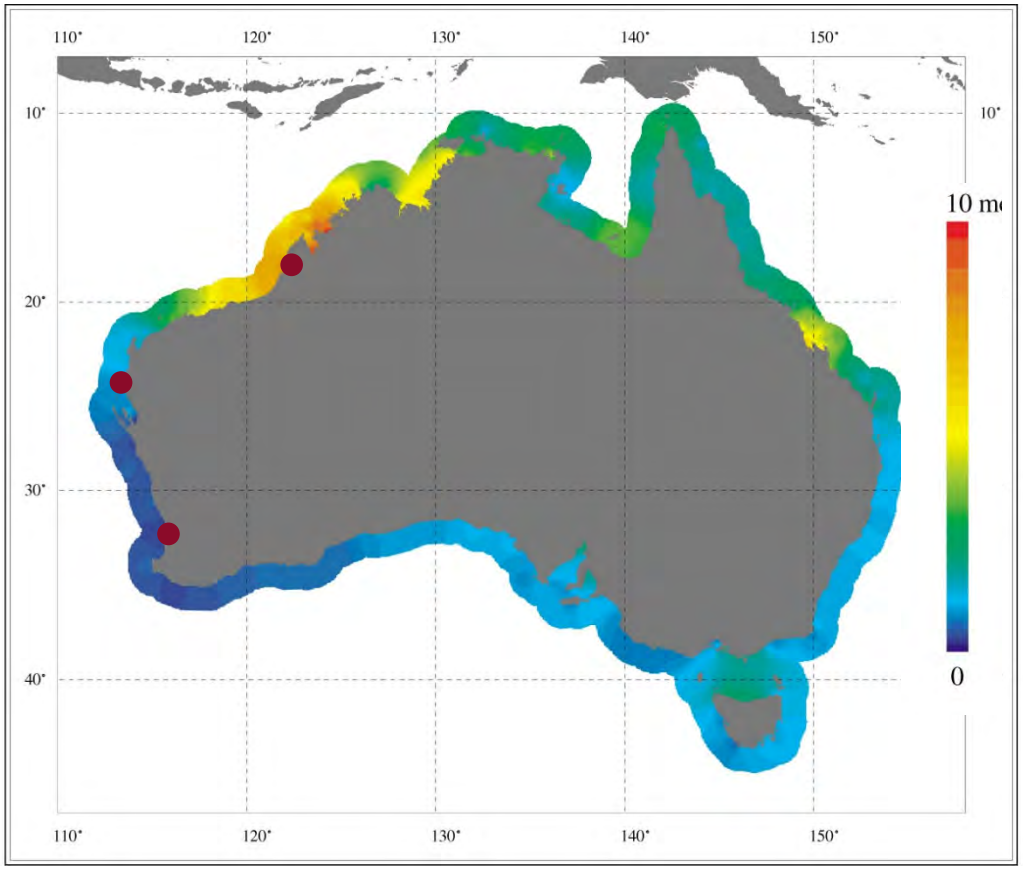


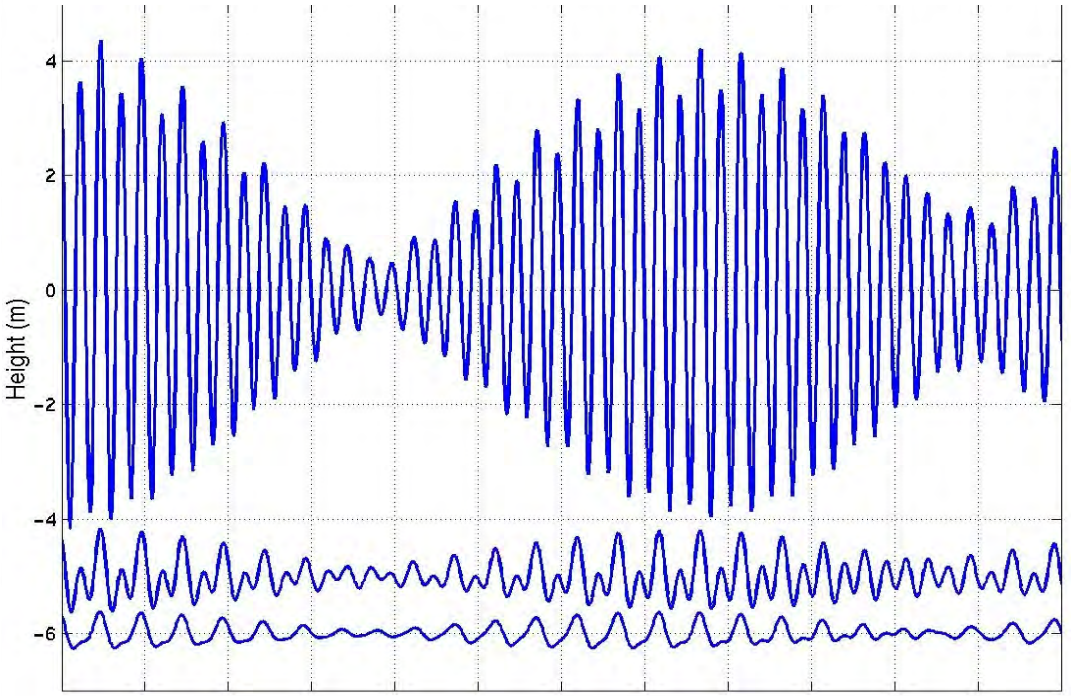
Fremantle: mean sea level



Mean rate of increase: 1.7 mm/year (1897-2018)= 20.7 cm

Australian tides





Fundamental Tidal Frequencies

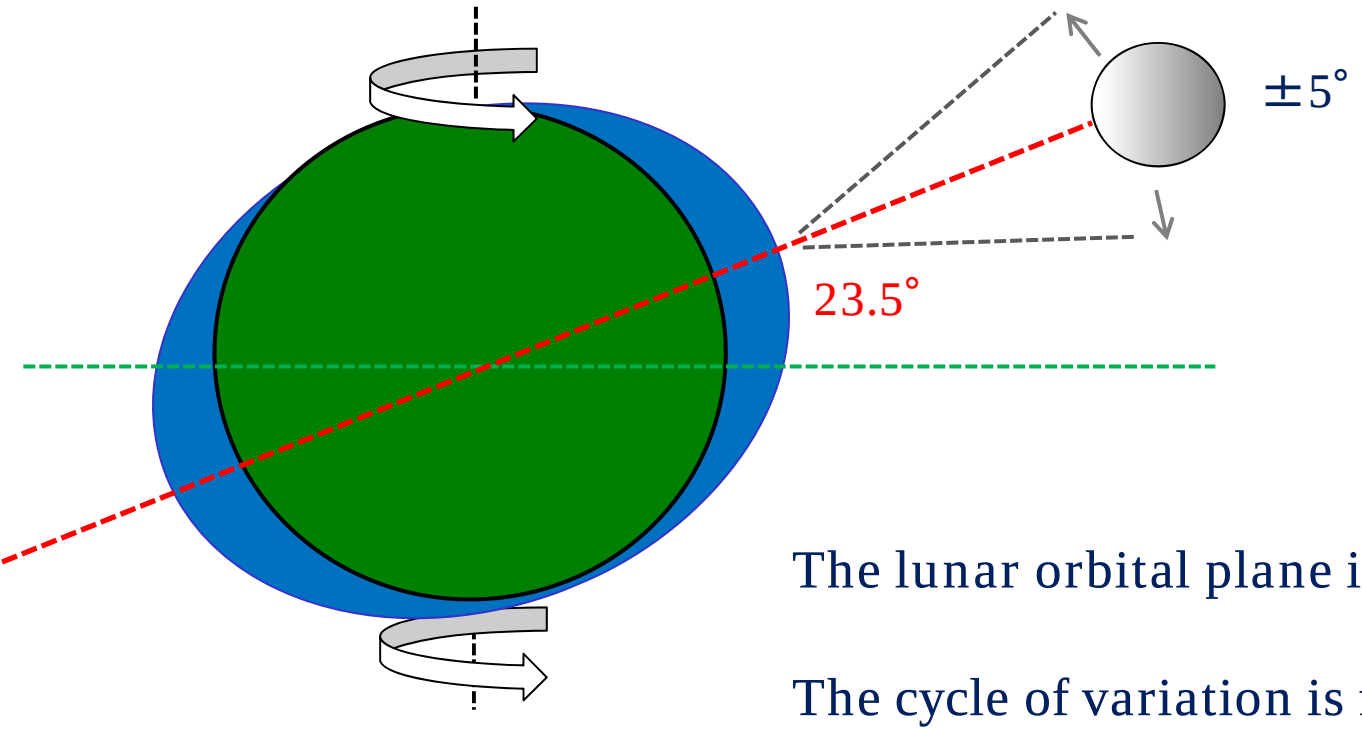
All tidal frequencies are linear combination of 6 fundamental frequencies

$$f = n_1 f_1 + n_2 f_2 + n_2 f_2 + n_3 f_3 + n_4 f_4 + n_5 f_5 + n_6 f_6$$

n_i are positive/negative integers

	Period		Source
f_1	1	Lunar day	Local mean lunar time
f_2	1	month	Moon's mean longitude
f_3	1	year	Suns' mean longitude
f_4	8.847	years	Longitude of the moon's perigee
f_5	18.613	years	Longitude of the moon's ascending node
f_6	20,940	years	Longitude of the sun's perigee

Long-period tides: 18.6 yr nodal cycle

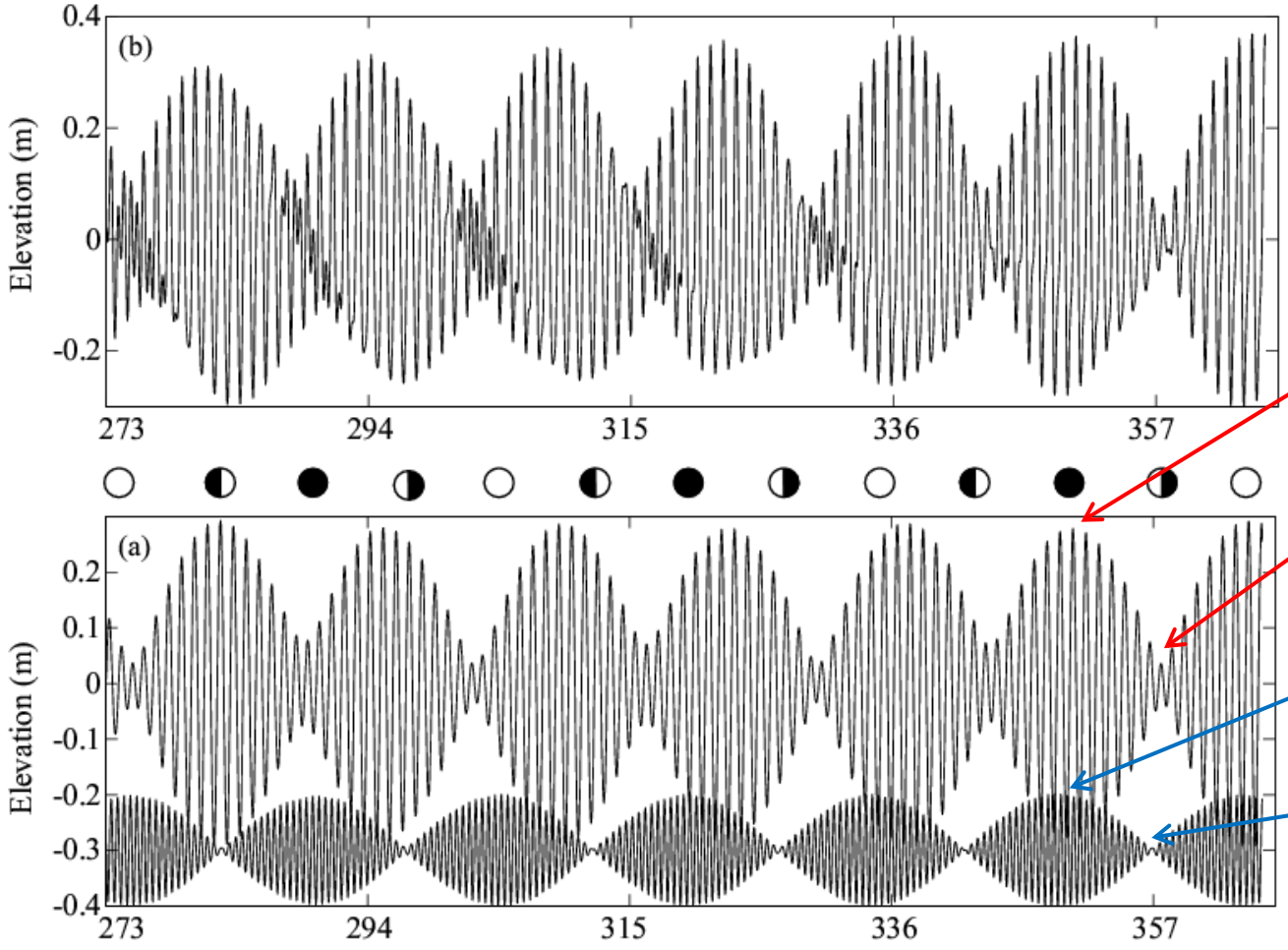


The lunar orbital plane is (23.5 ± 5º) of the equator

The cycle of variation is from
18.5º (23.5º-5º) to 28.5º (23.5º+5º)
and is defined as the nodal cycle

Haigh et al., 2011

Diurnal tides: characteristics



Tropic tides
(moon: max declination)

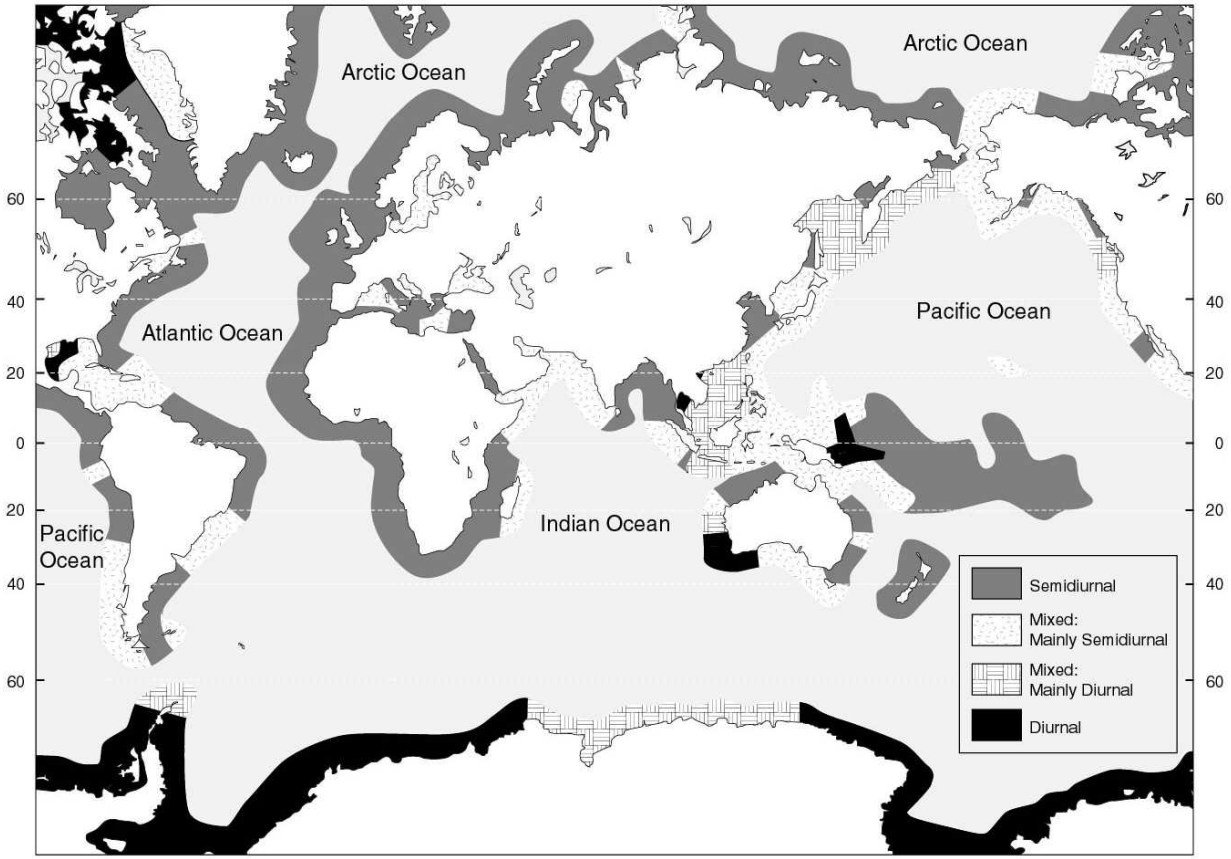
Equatorial tides
(moon: min declination)

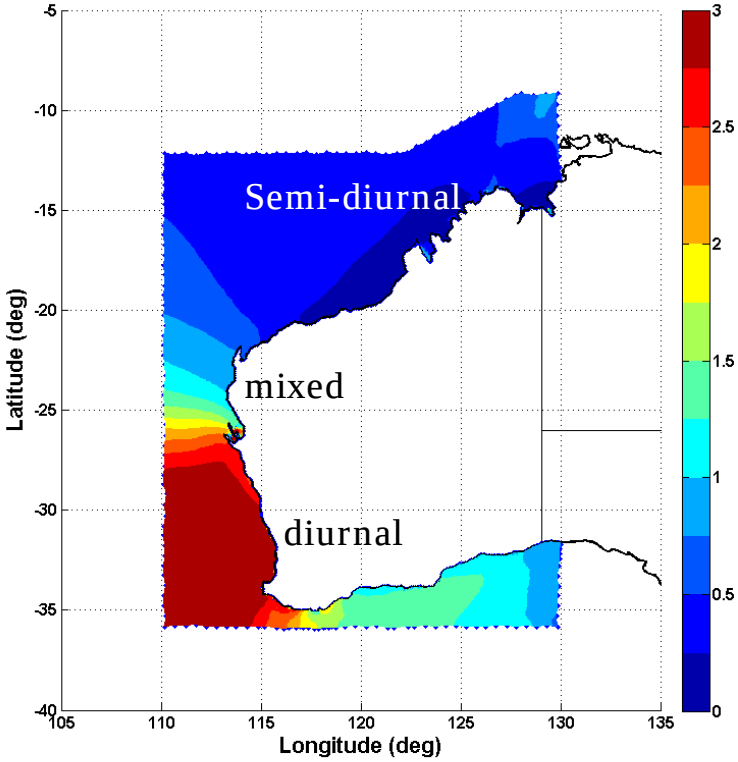
Spring tides
(moon-sun: syzygy)

Neap tides
(moon-sun : quadrature)

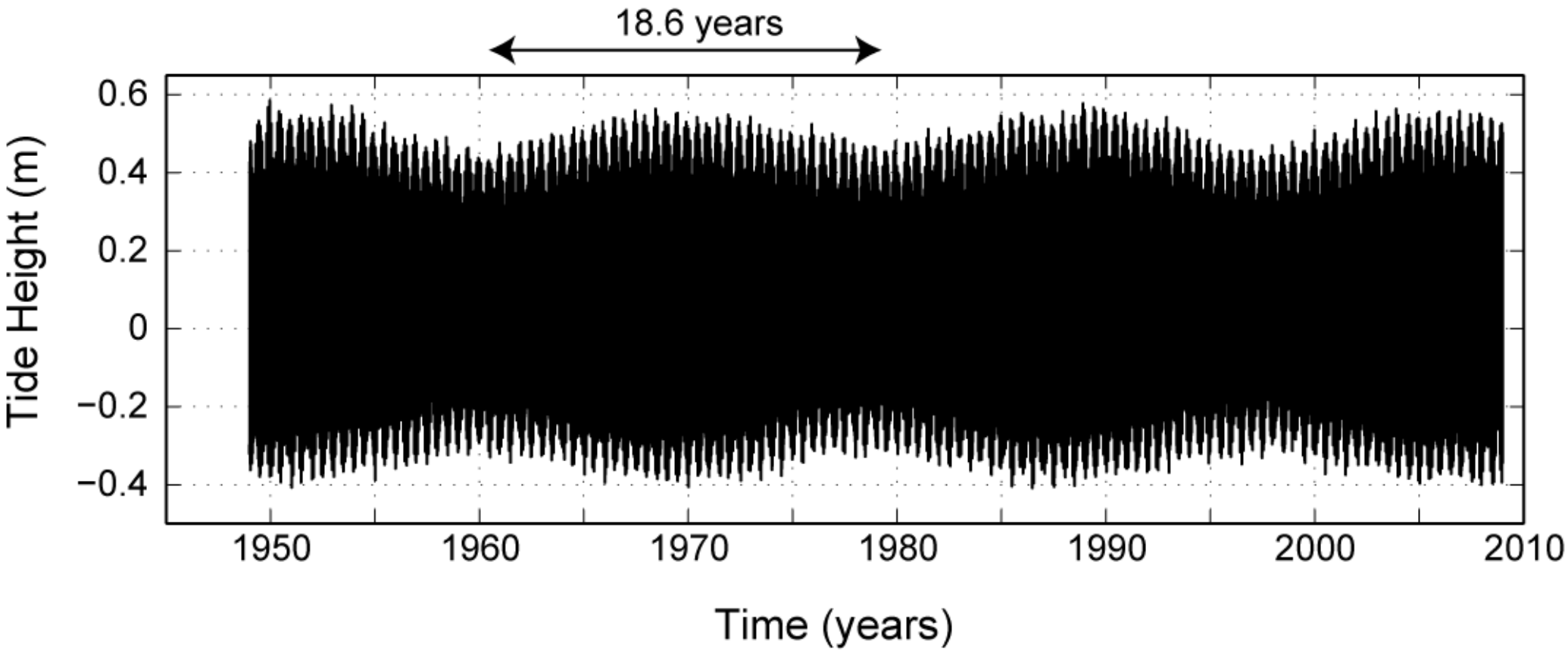
O'Callaghan, Pattiaratchi & Hamilton, 2010

Global distribution of tidal conditions



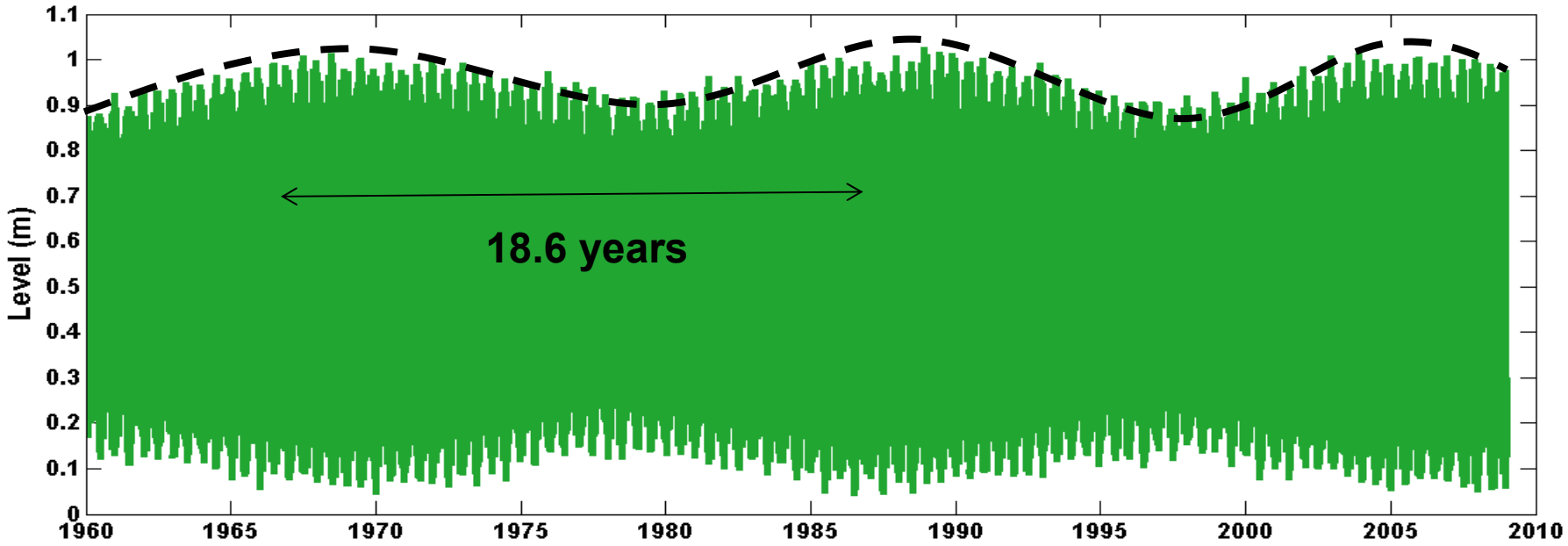


Fremantle Tides 1948-2008



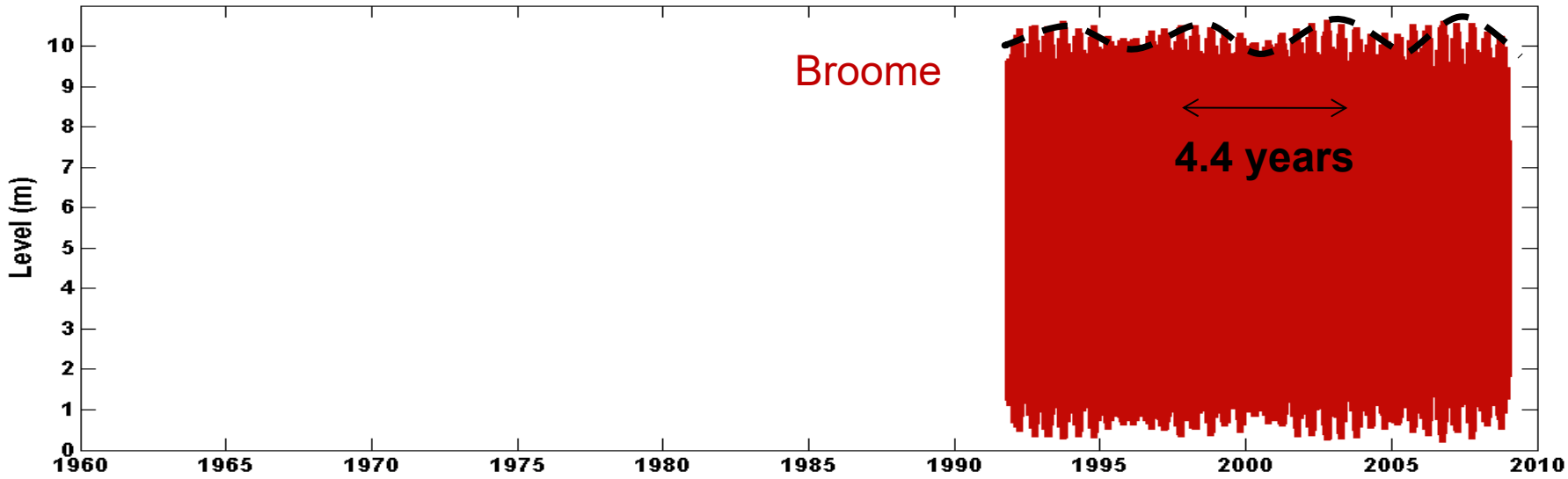
Measurements: Fremantle

Measurements: Fremantle



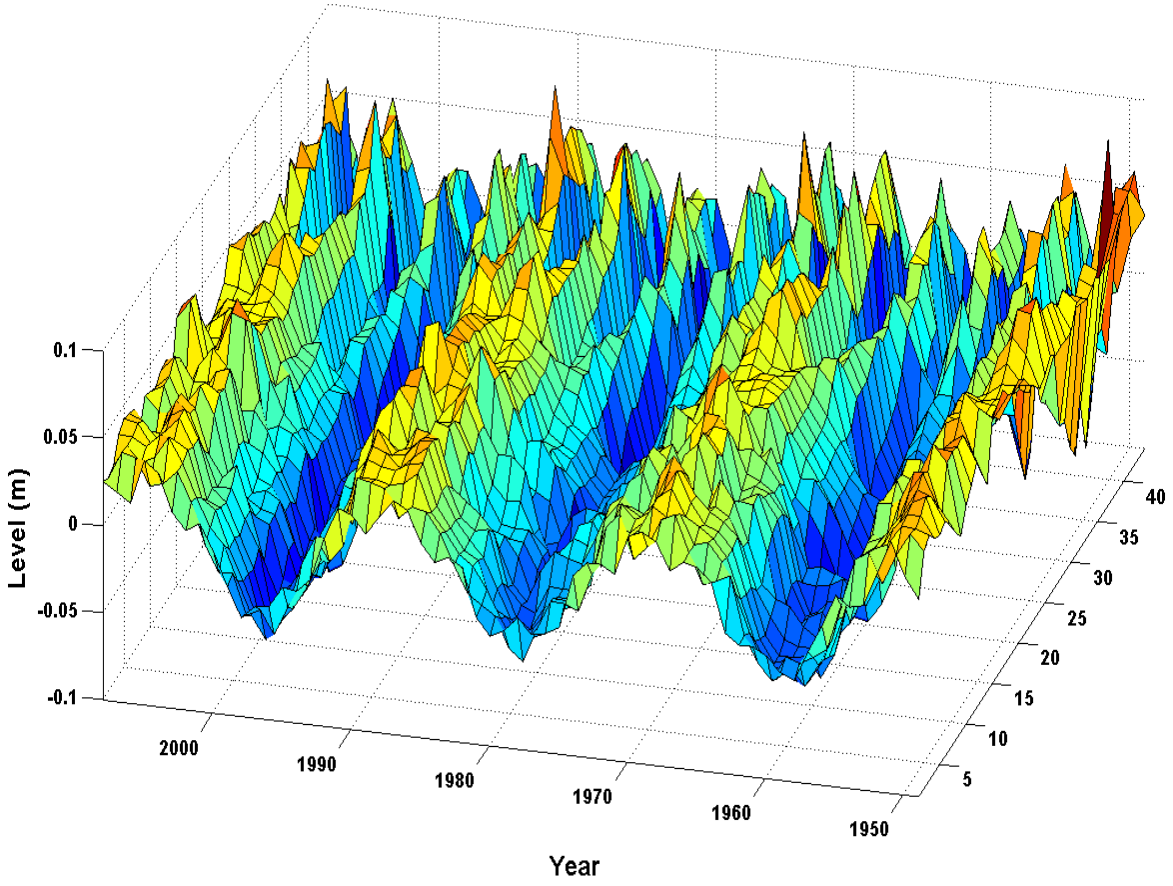
Ivan Haigh

Measurements: Broome



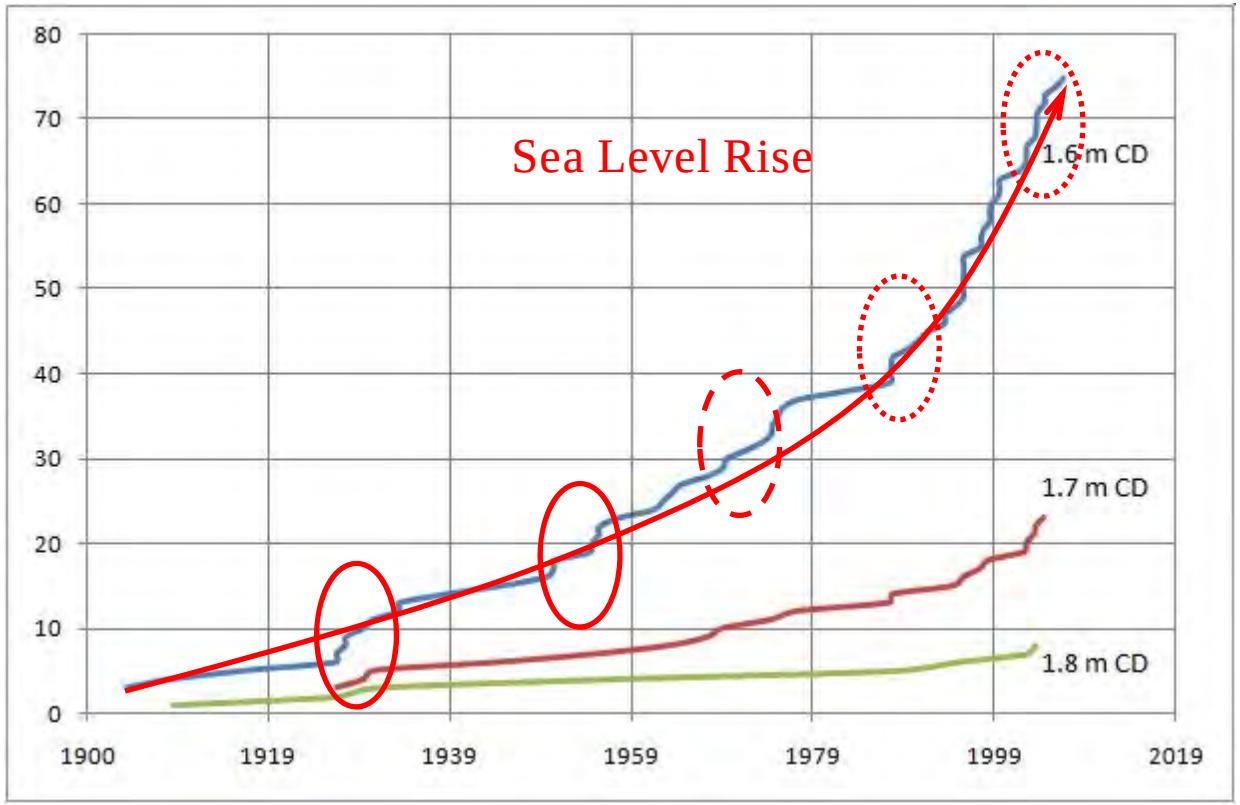
Ivan Haigh

Latitudinal variation



Ivan Haigh

Fremantle High WL Exceedance



Next high water years:

2025 2043 2062

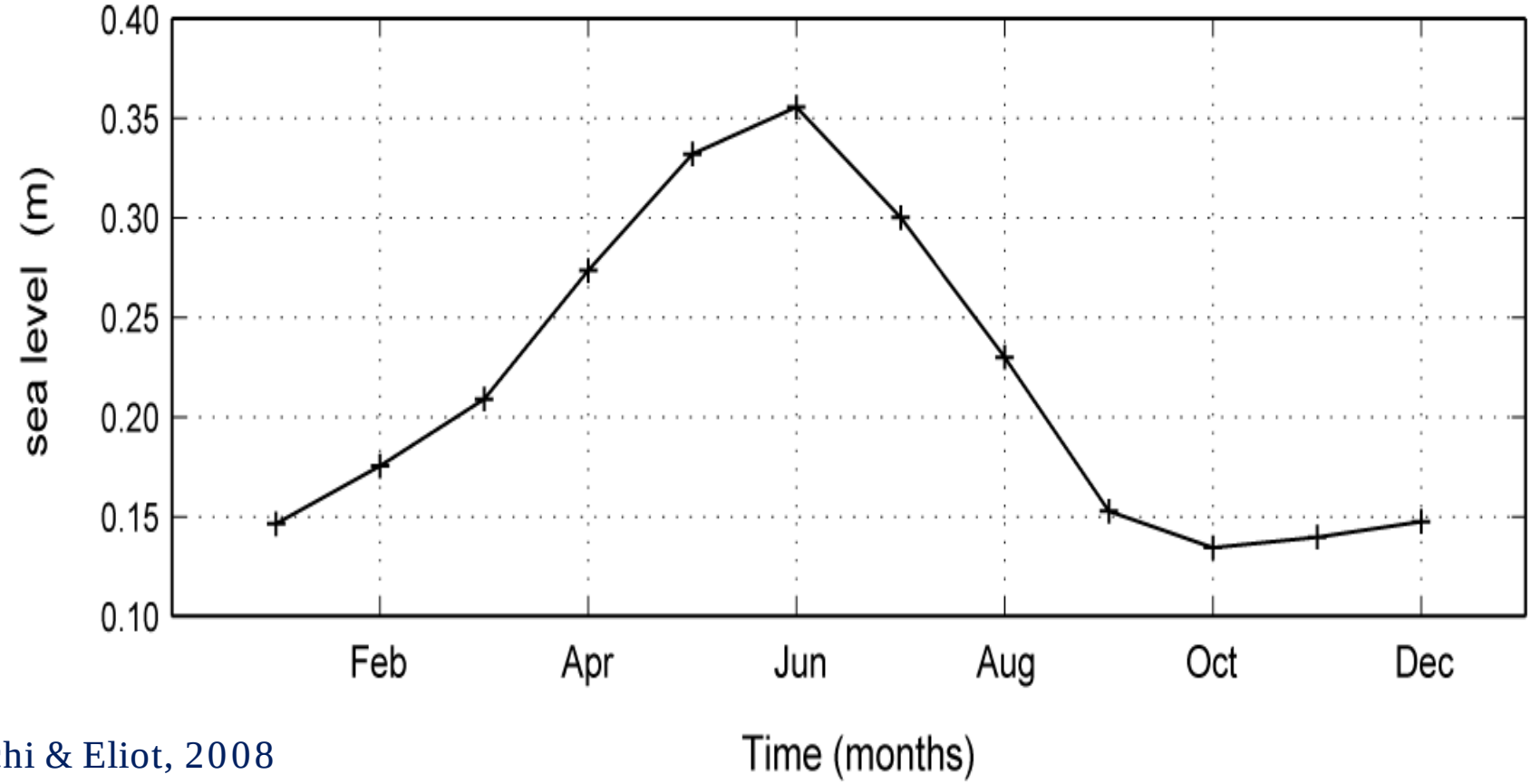
Shows bursts of activity, and progressive change

Eliot, 2012

Seasonal Changes: steric height

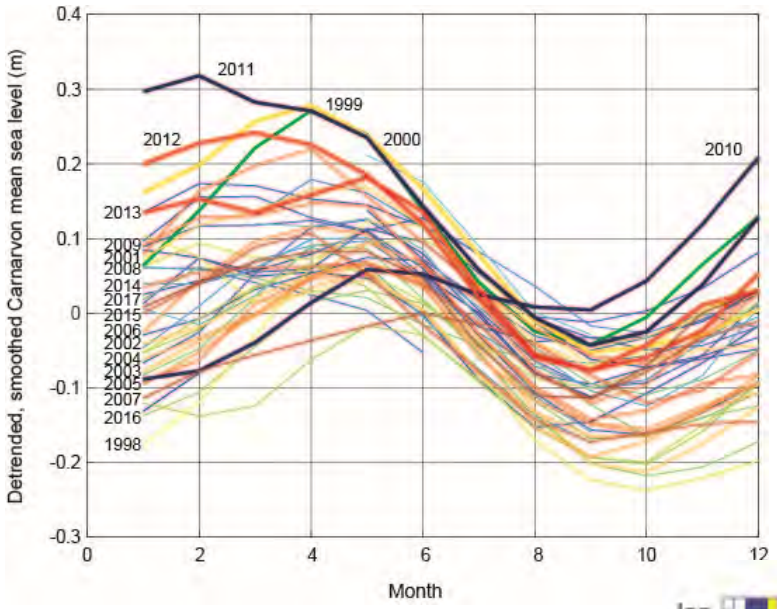
Ocean currents

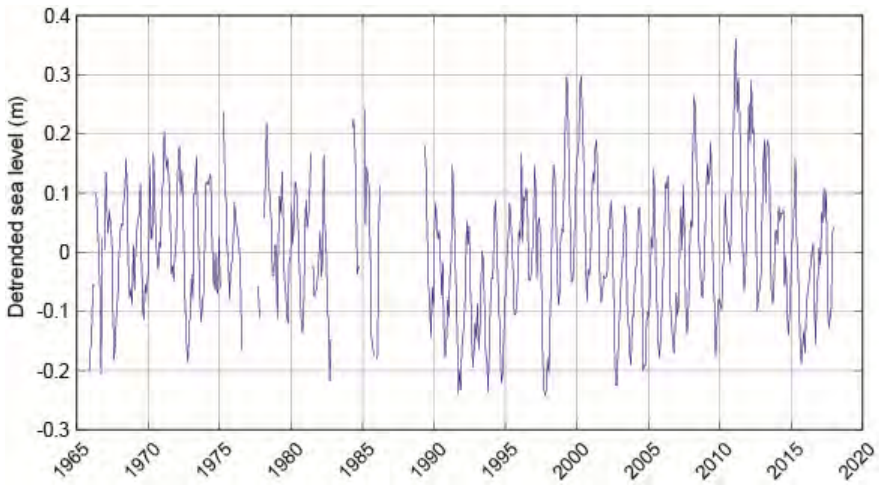
Max: 0.20m

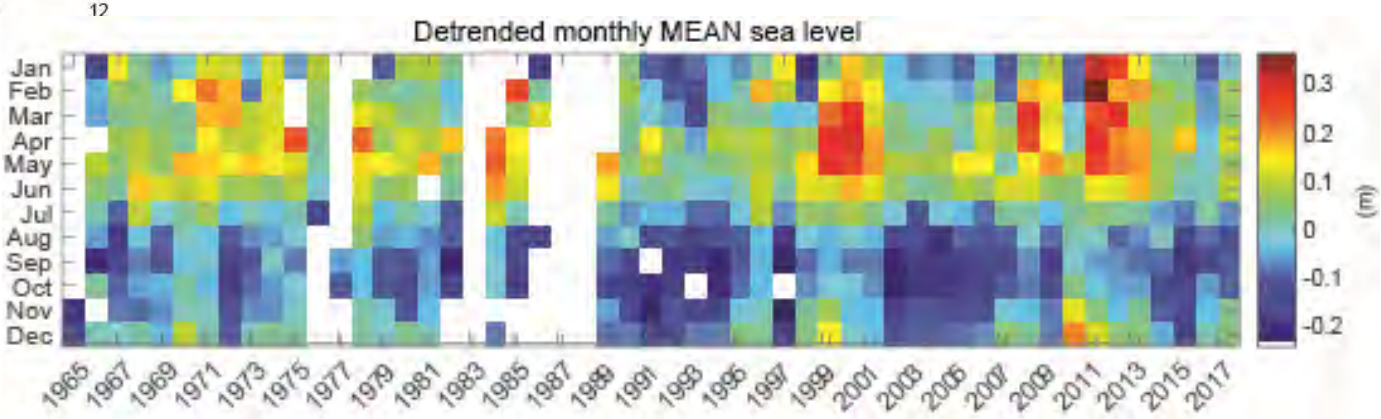


Pattiaratchi & Eliot, 2008

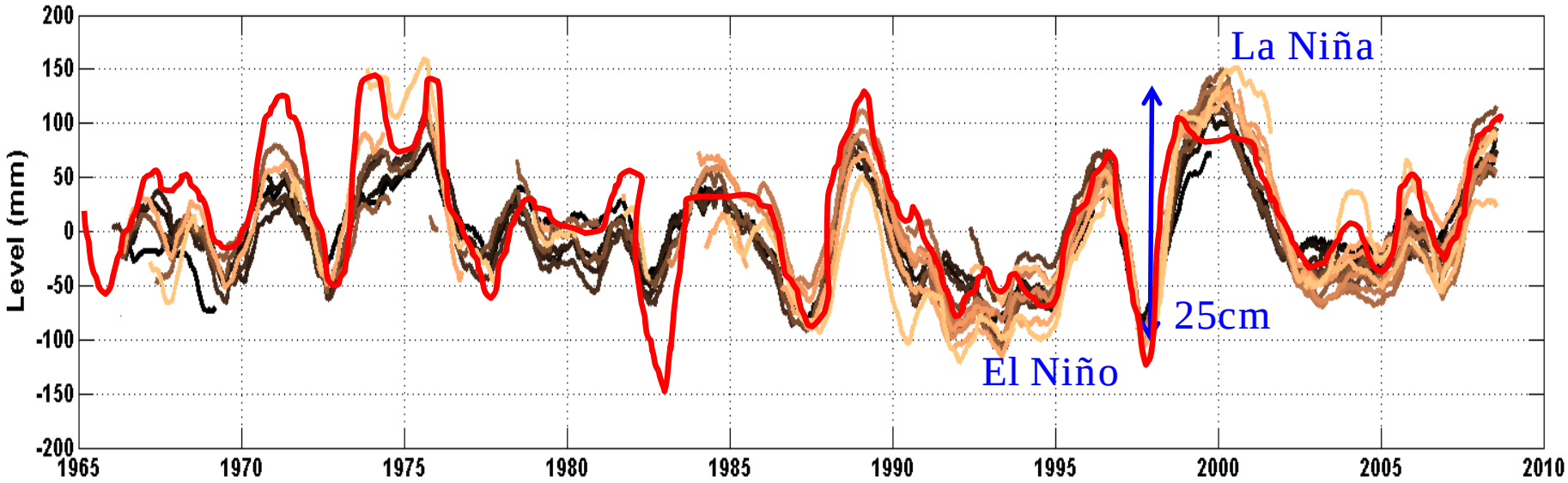
Carnarvon


Detrended, smoothed Carnarvon mean sea level (m)
Month
2011
1999
2012
2000
2010
2013
2009
2001
2008
2014
2017
2015
2006
2002
2004
2003
2005
2007
2016
1998


Detrended sea level (m)

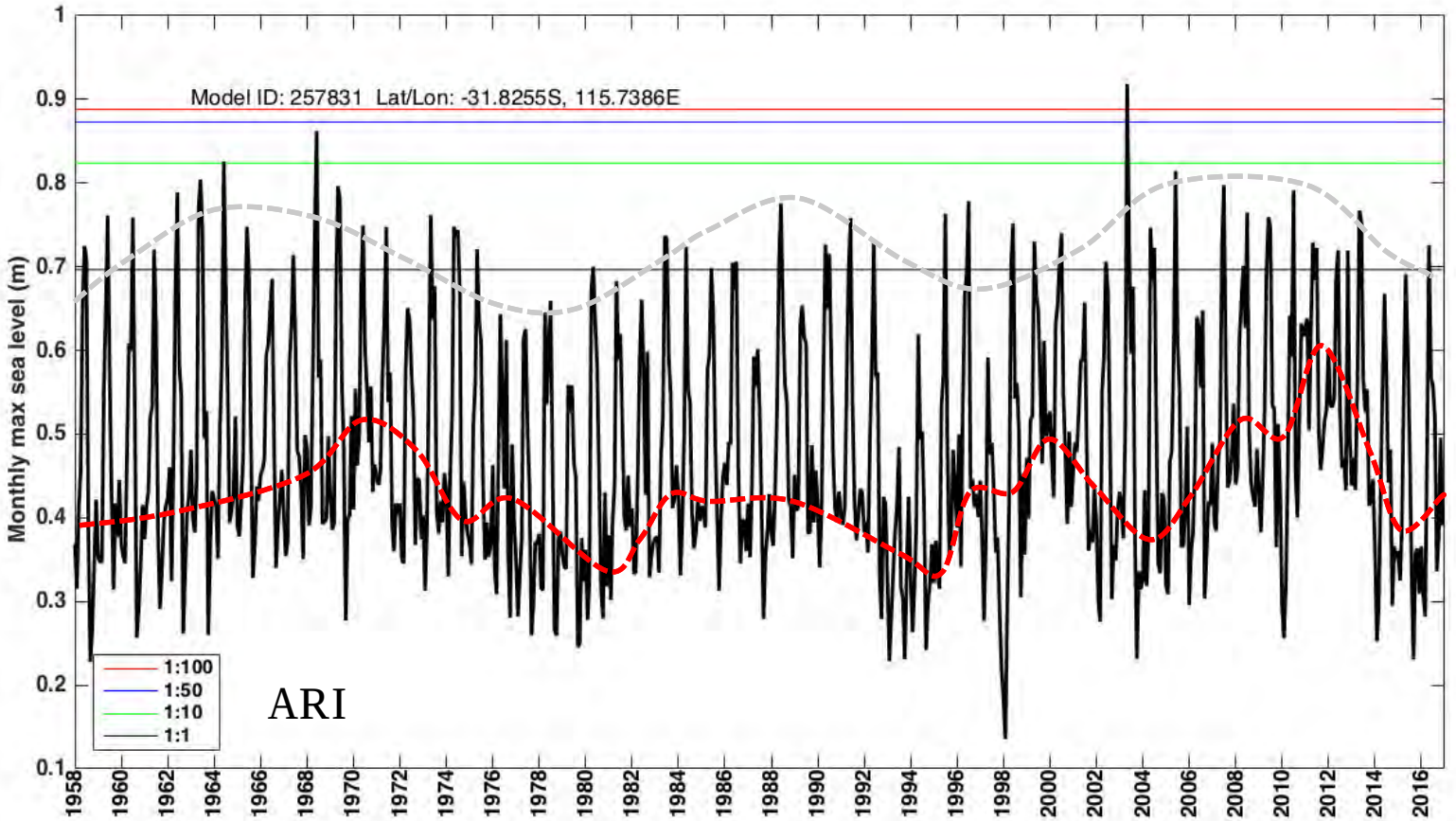

Detrended monthly MEAN sea level
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
(m)

Inter-annual Variability



Post 1966: 1 unit SOI = ~13 mm mean sea level.
No relationship prior to 1966

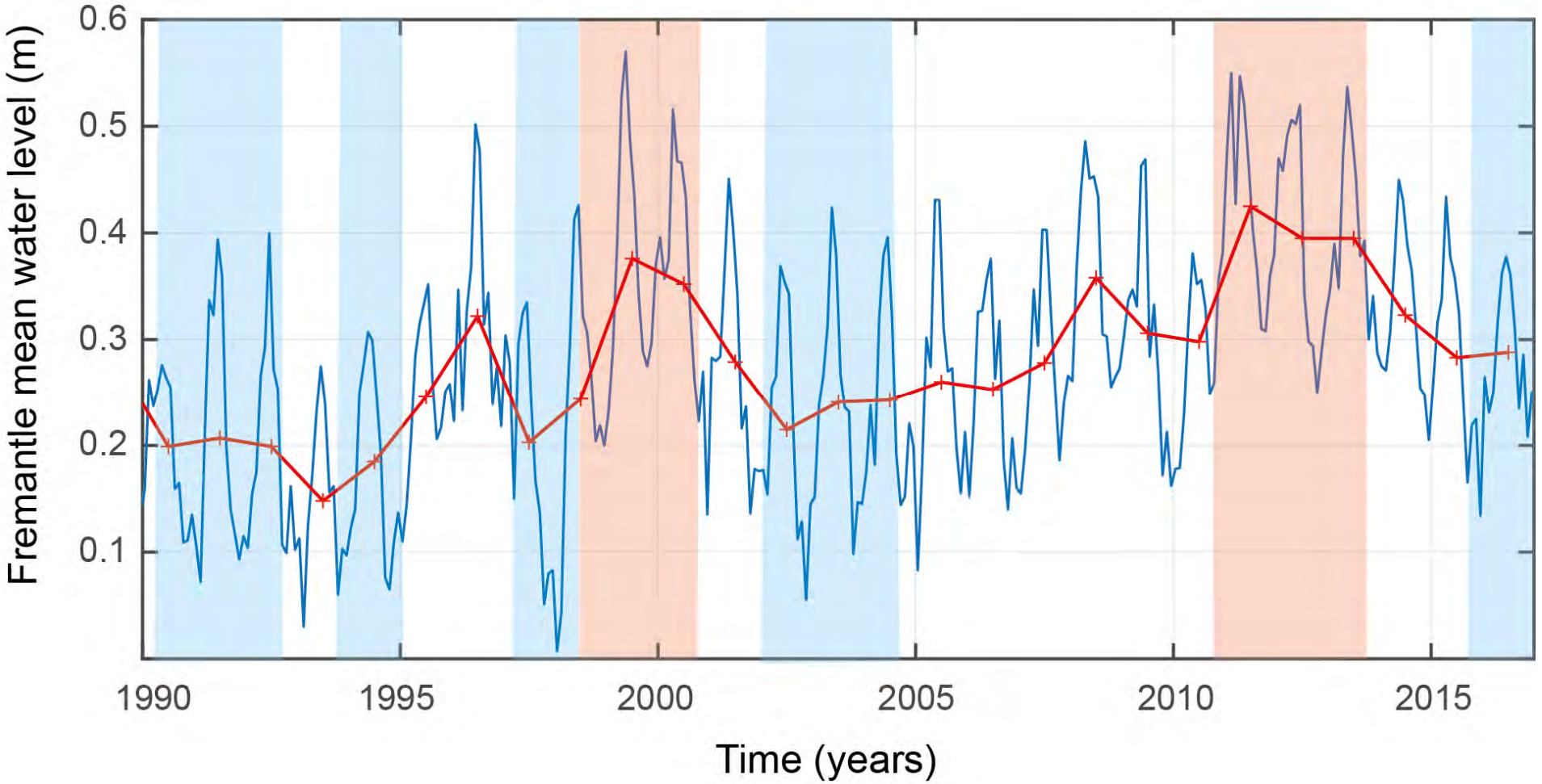
Extreme sea levels: a range of processes



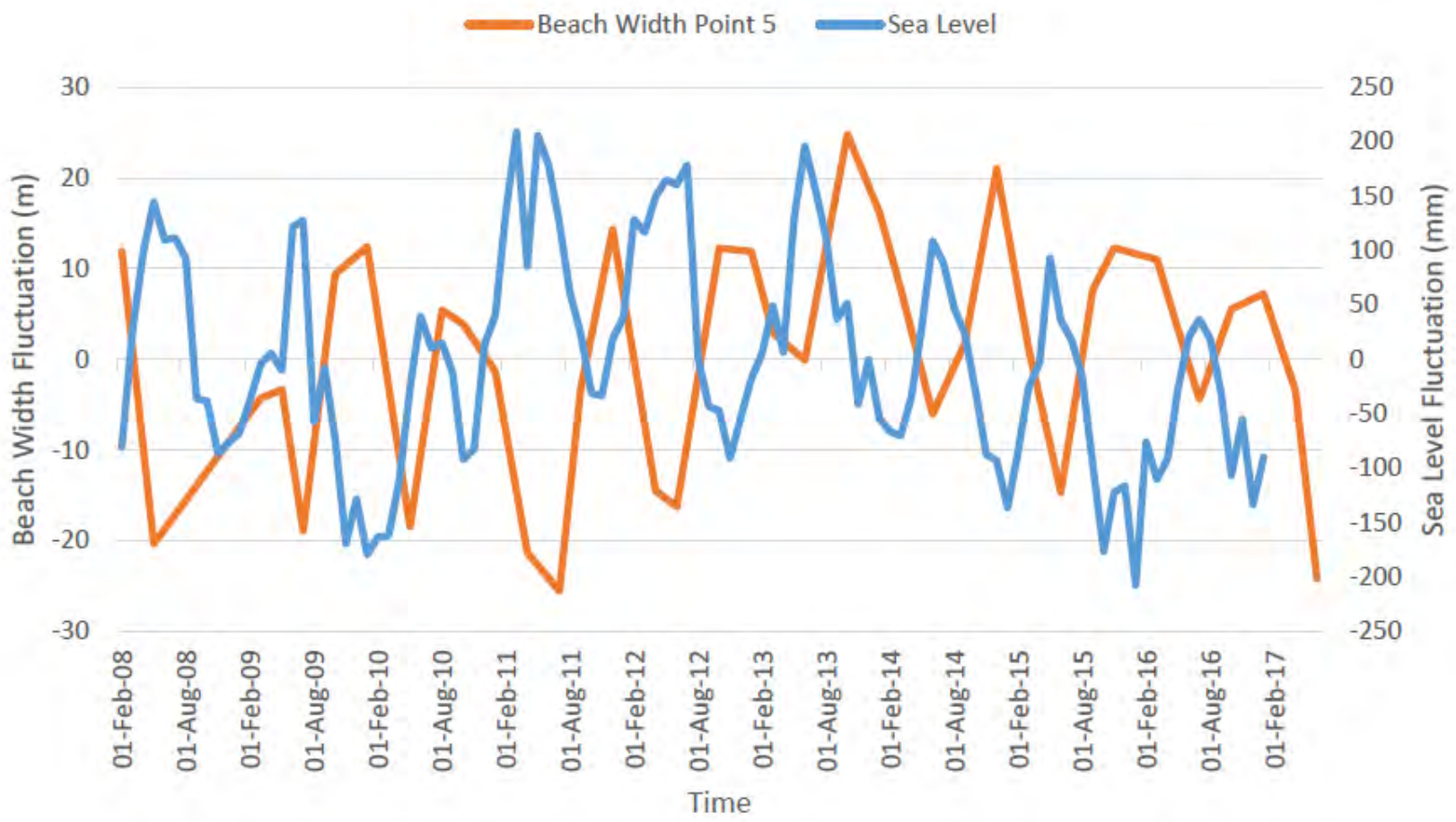
18.6 yr nodal tidal cycle

ENSO

Inter-annual Variability

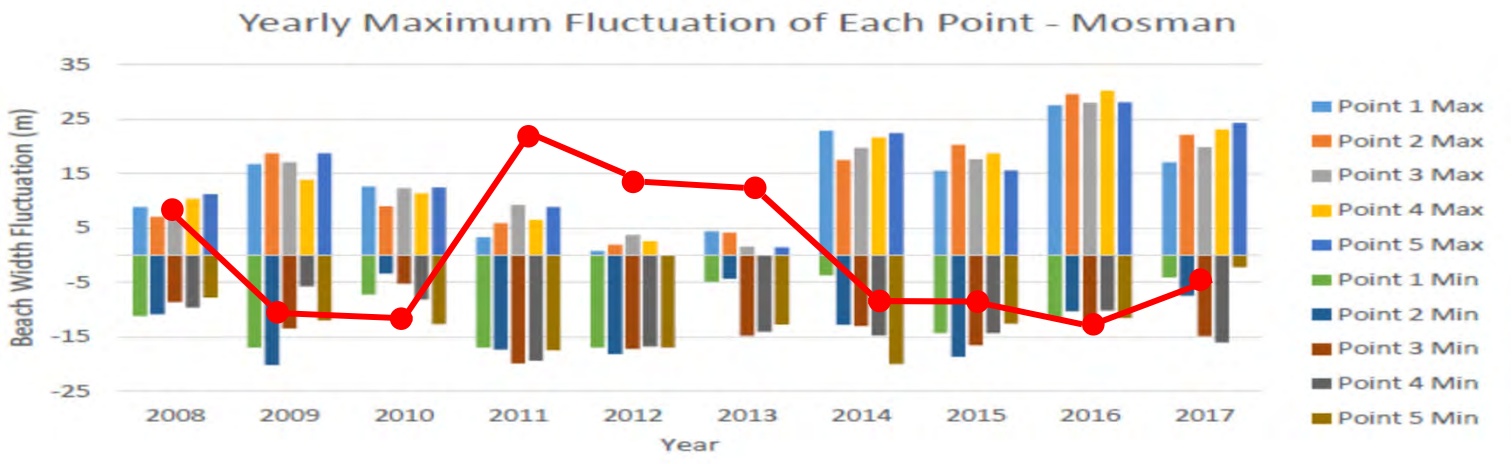


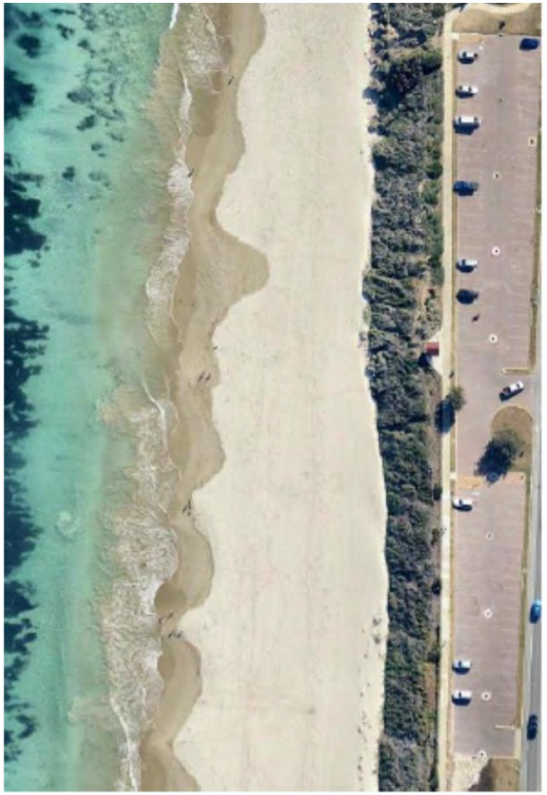
Sea level & beach width: Cottesloe



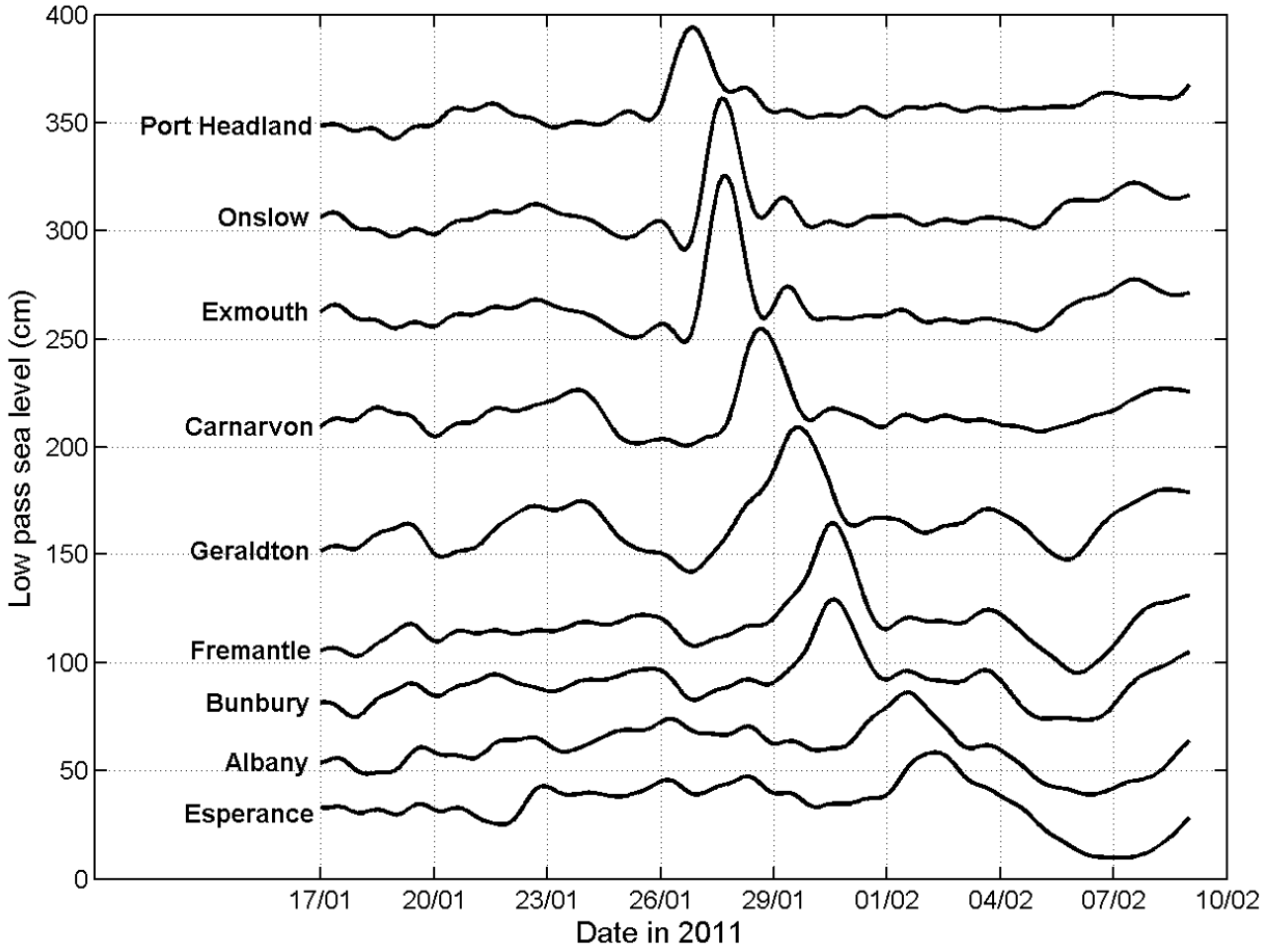
Lake, 2018

Sea level & beach width: Mosman



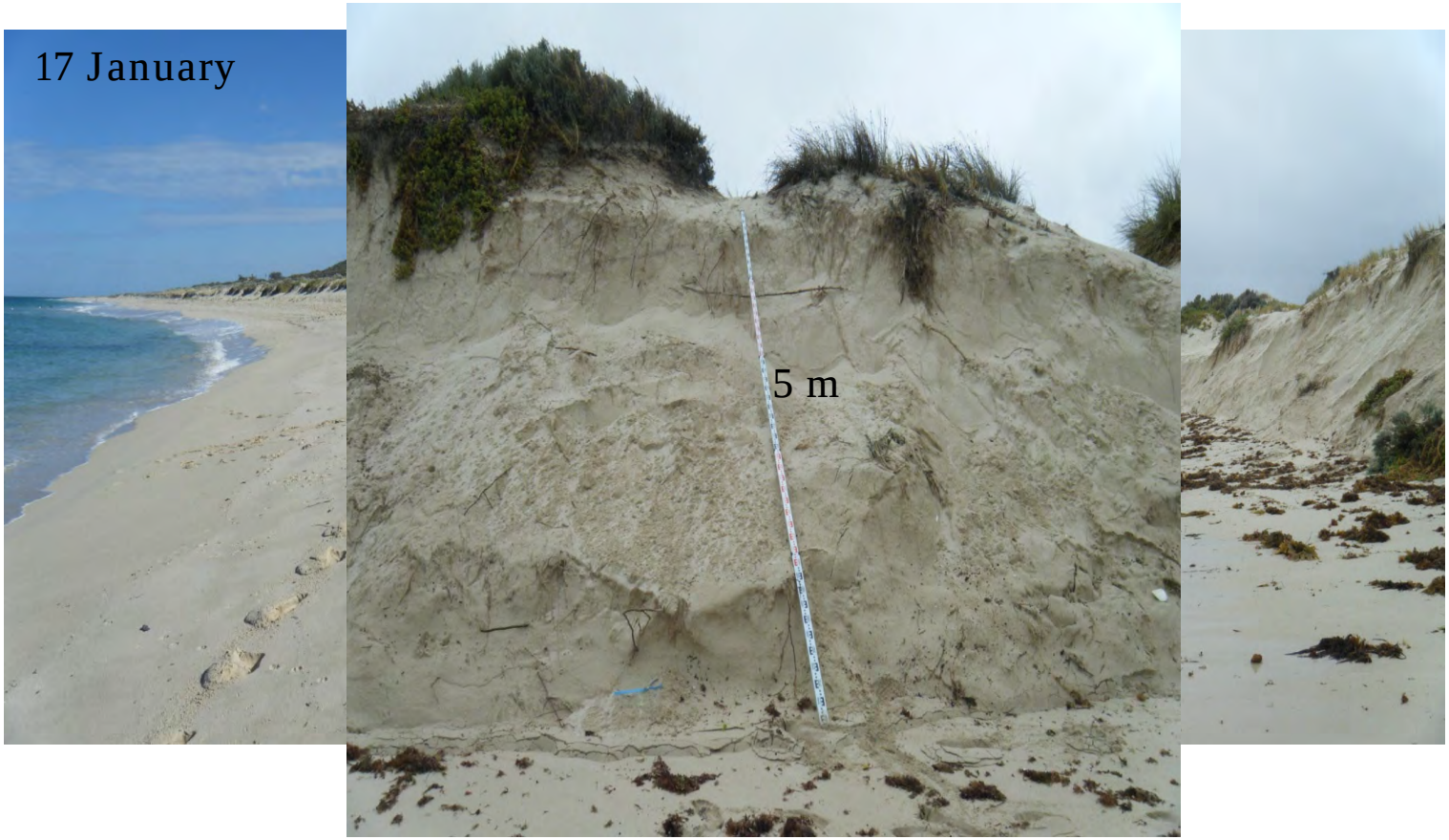


Continental Shelf Waves (TC Bianca)

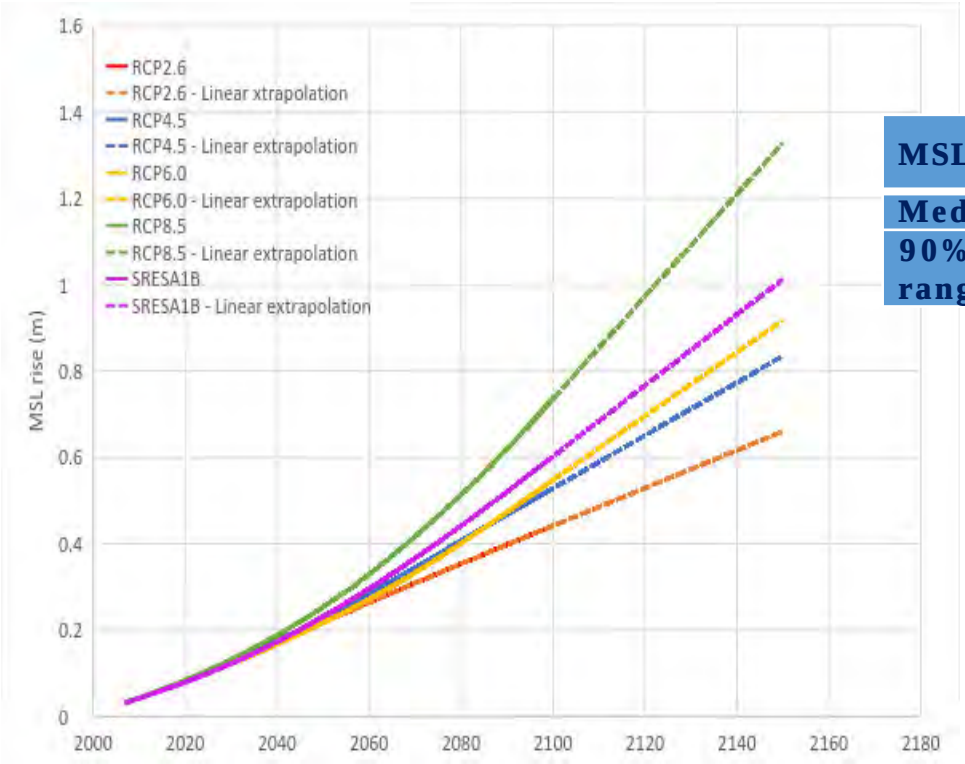


Tropical Cyclone Bianca

Impacts @ Yanchep Beach



Global mean sea level rise



Projected global MSLR (m) in period 2081-2100
Relative to levels averaged over period 1986-2005

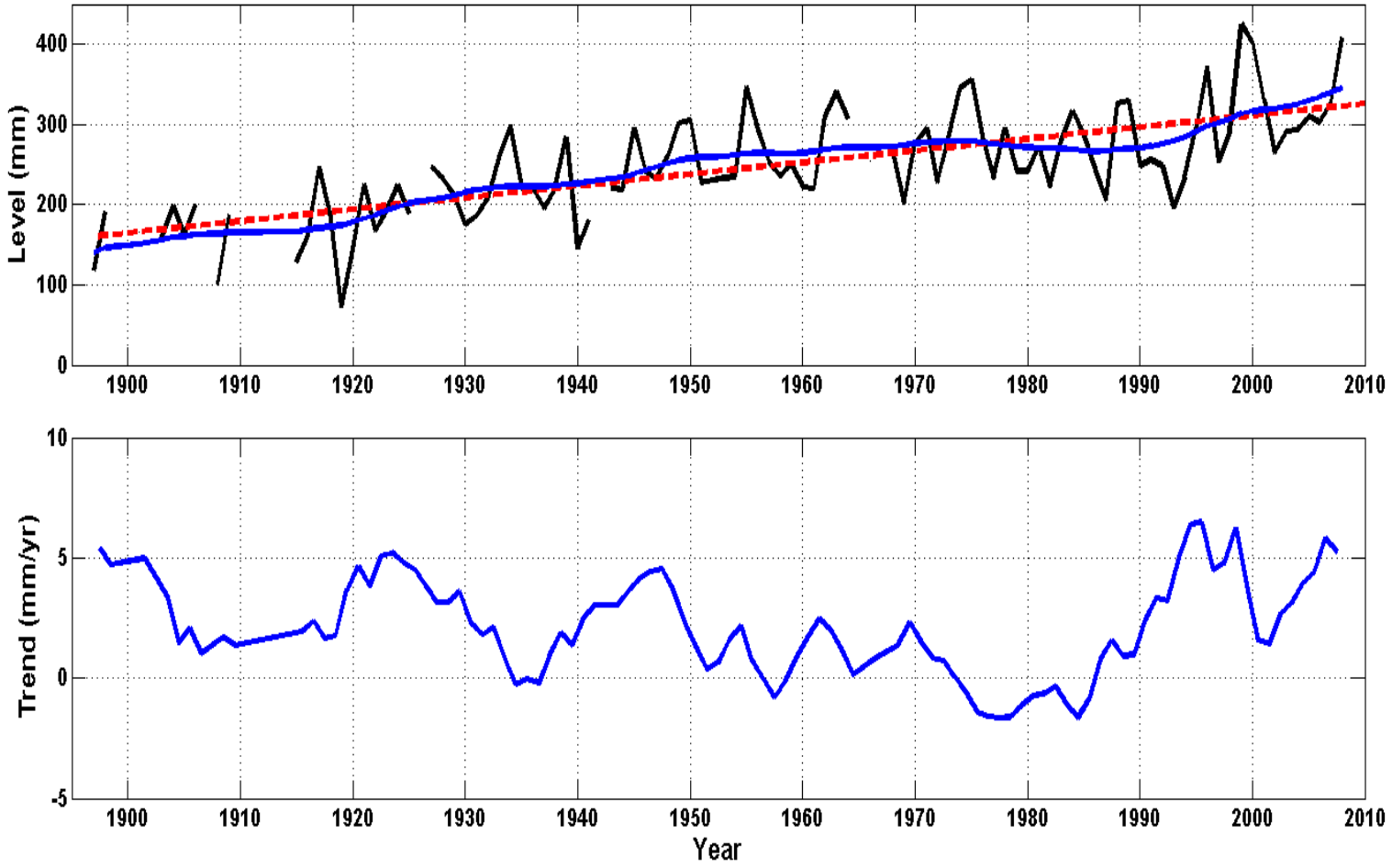
MSLR (m)	RCP Scenarios			
	RCP2.5	RCP4.5	RCP6.0	RCP8.5
Median	0.40	0.47	0.48	0.63
90%likely range	[-0.1 - 0.16]	[0.32 - 0.63]	[0.33 - 0.63]	[0.45 - 0.82]

(Church et al., 2013).

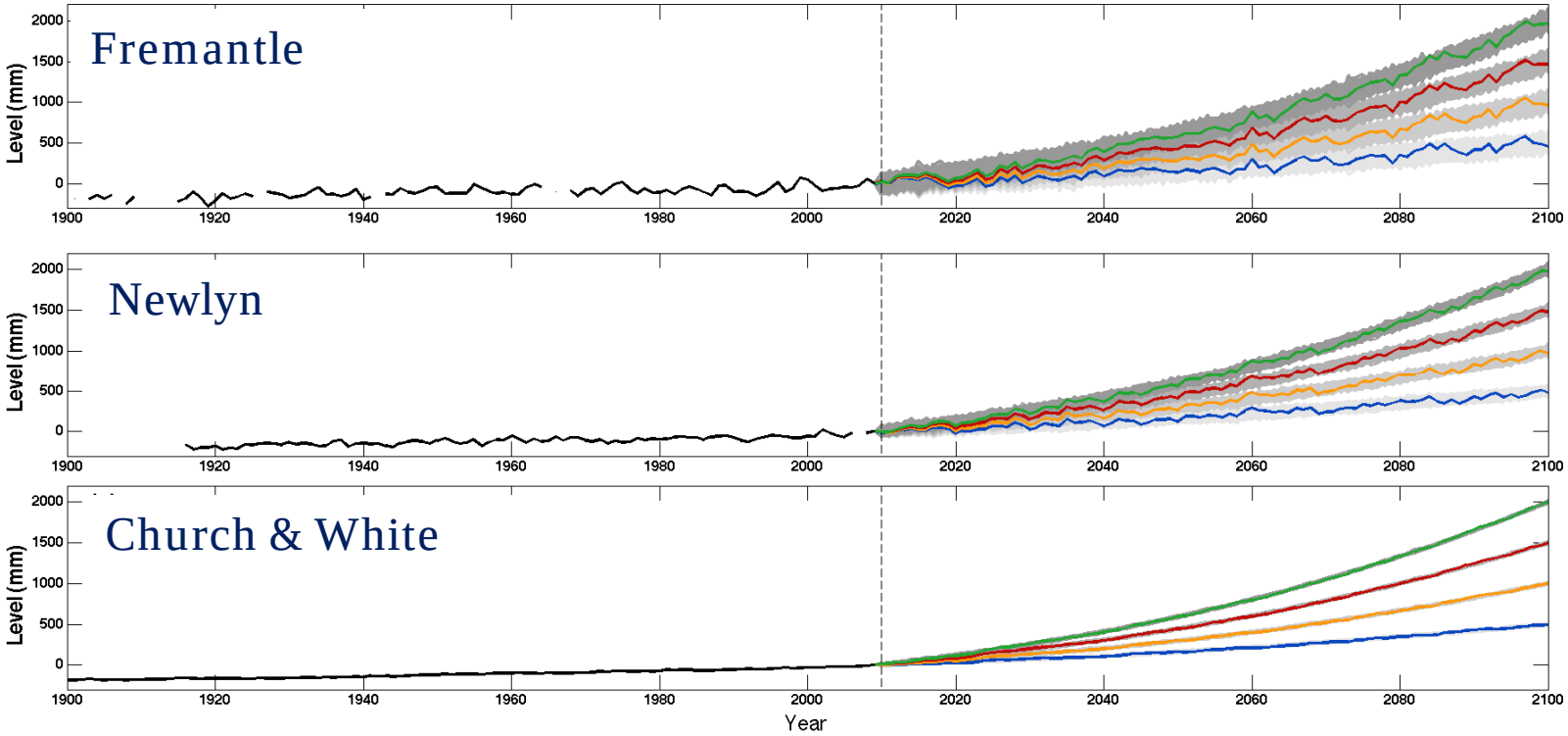
Projected Fremantle MSLR (m) in period 2081-2100

MSLR (m)	RCP Scenarios		
	RCP2.6	RCP4.5	RCP8.5
2030	0.12	0.12	0.12
2090	0.38 [0.22 - 0.55]	0.46 [0.30 - 0.64]	0.61 [0.40 - 0.84]

Fremantle Sea Level: Acceleration ?



Global Mean Sea Level



It will be several decades before a discernable sea level rise acceleration in individual TG records are detected due mainly to inter-annual to multi-decadal variability

EXTREME SEA LEVELS IN AUSTRALIA

bushfire&natural HAZARDSCRC

THE UNIVERSITY OF WESTERN AUSTRALIA

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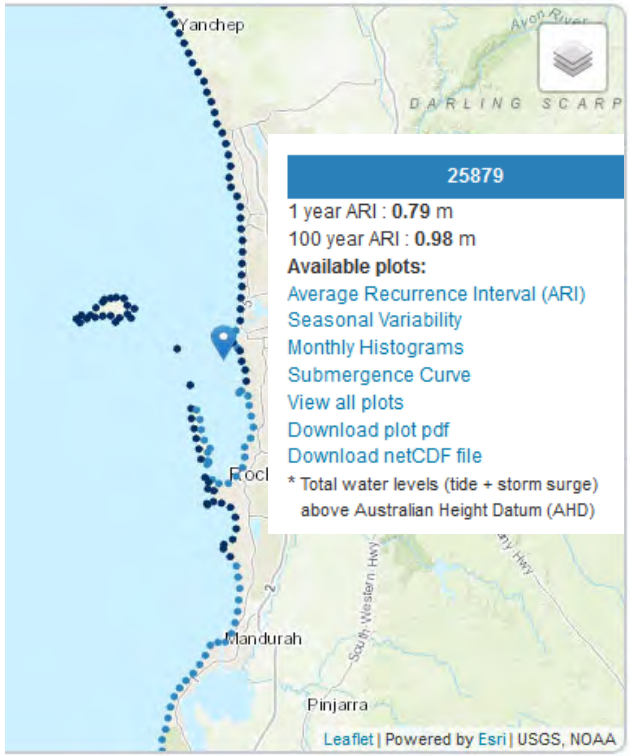
http://sealevelx.ems.uwa.edu.au/

Colour scale: 100 year ARI in metres above Australian Height Datum (AHD)

Predicted extreme sea level statistics around Australia

Click on coastal data points to access the statistics, including present day 100 year Average Recurrence Interval (ARI) levels, historical and seasonal variability derived from the numerical model. Blue markers contain data derived from measurements at 29 tide gauge sites.



Overview

Present day extreme sea level statistics available on this website were calculated from a 59 year (1958-2016) hindcast of sea levels around Australia. The high-resolution numerical model included the effects of astronomical tides, storm surges due to wind and pressure, and seasonal and interannual mean sea level (MSL) variability. The project was undertaken by the Coastal Oceanography Group at the University of Western Australia, funded by the Bushfire and Natural Hazard CRC .

EXTREME SEA LEVELS IN AUSTRALIA

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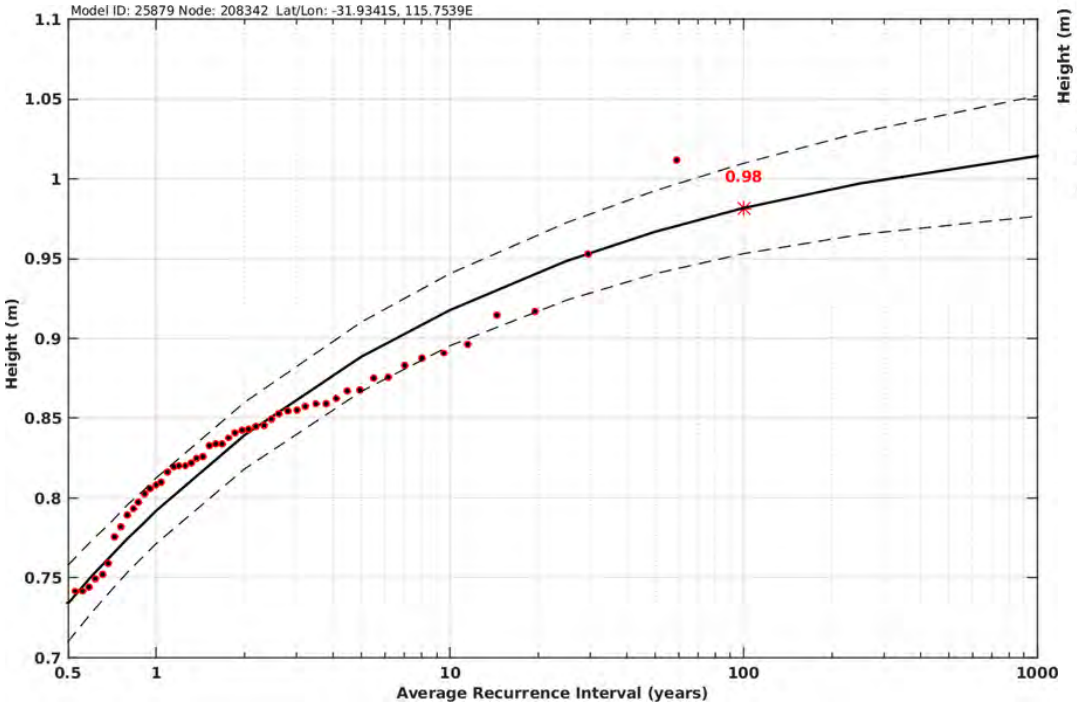
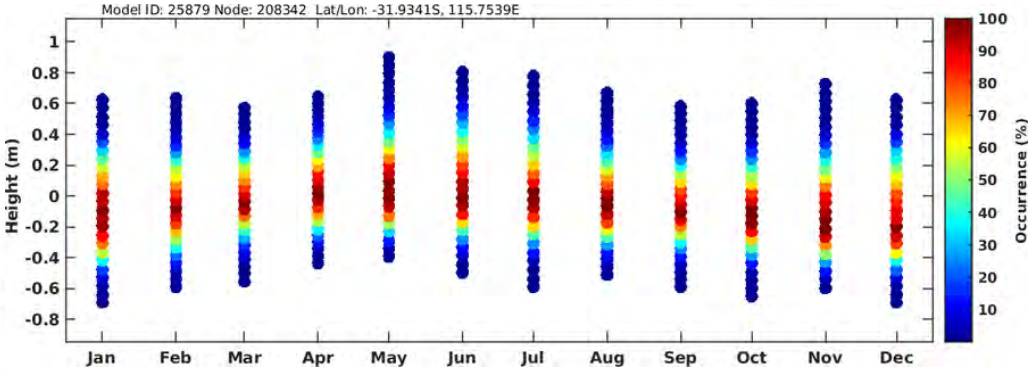
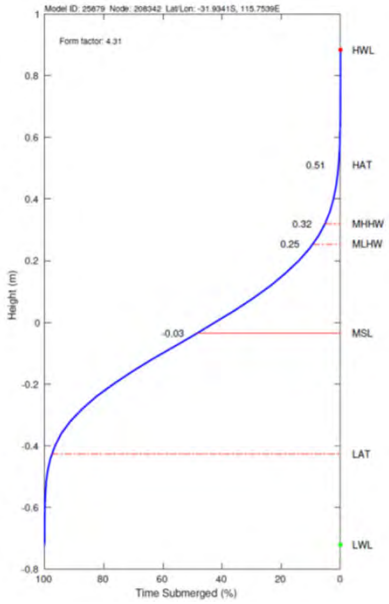
http://sealevelx.ems.uwa.edu.au/







Conclusions

- Mean sea level has many components. It is important to understand local processes contributing to sea level.
- Expect an increase in mean water levels over next 8 years due to tidal effects
- Implications for coastal flooding, beach stability and coastal infrastructure

Low	High
1960	1969
1979	1988
1998	2006
2016	2025
2035	2043

OCEANS GRADUATE SCHOOL

An introductory level course that is aimed at professionals who are working in the coastal zone but have had no formal training in coastal engineering. It is best suited to practising engineers, coastal planners and to those who are wanting to develop knowledge on coastal engineering.

Participants will learn how to better interpret observed coastal changes in relation to coastal forcing and gain an improved understanding of the technical methods used for coastal engineering and coastal hazard assessment.

Thank You

Hazard Observer (USA)