Observed Sea-Level Trends and Variability from the Coast to Open Ocean: An Australian Case-Study

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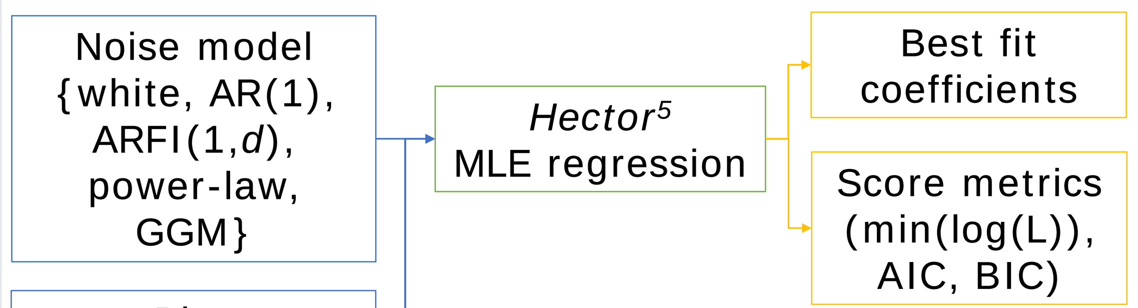
Introduction

We use these improved satellite altimetry data (altimeter range by waveform retrackers[1], wet tropospheric correction[2,3] and tidal models[e.g. 4]) to investigate the sensitivity of sea-level variability and trends in the coastal zone (50 km from the coast), to data treatment and we look for coherency with distance from the coast.

Method



A maximum likelihood estimation (MLE) linear regression is applied to sea surface height anomaly (SSHA) time series. The most appropriate noise model is determined from information criteria. With a coloured noise model, the trend and its formal error can be significantly different[6].

Linear sea-level trends from short observations can be affected by natural decadal variability[7]. We use the Pacific Decadal Oscillation[8] and Multi-variate El Niño Southern Oscillation Index[9] as proxies for Pacific climate variability and apply filters to separate a decadal climate index (DCI) from an inter-annual climate index (ICI).

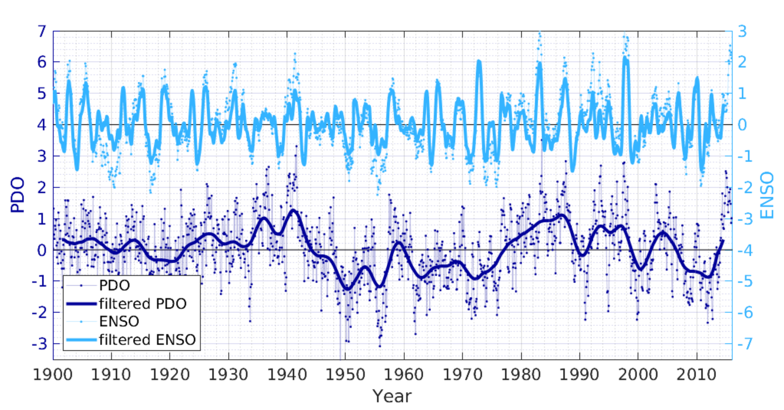


Figure 1 Climate indices: PDO and ENSO indices (dots) and the filtered DCI and ICI (solid lines) used in the multivariate regression

Data

SSHA time series for Jason-1 and Jason-2/OSTM missions (2002—2015) are derived for comparison points located every 5 km along the satellite reference groundtrack, using the RADS database[10]. The "coastal" time series (Table 1) substitutes the ALES range (J1,J2) and sea state bias correction (J1) and GPD+ wet tropospheric correction (J1,J2). Tide gauge data presented is monthly mean RLR data from PSMSL.

Data sets	Waveform retracking	Wet tropospheric correction	Tides
Standard	MLE4	Radiometer, models	GOT4.10c; FES2014
Coastal	ALES*	GPD+	GOT4.10c; FES2014

* ALES data only processed within 50 km of the coast

Table 1. Description of the different corrections used in this study

Data Sources

RADS: TUDelft rads.tudelft.nl/rads/rads.shtml ; github.com/remkos/rads
ALES: NASA PODAAC ftp://podaac-ftp.jpl.nasa.gov/allData/coastal_alt/L2/ALES/
GPD+: CTOH, AVISO www.aviso.altimetry.fr/en/data/products/auxiliary-products/wet-troposphere-correction.html
PSMSL: www.psmsl.org
PDO: ftp://ftp.atmos.washington.edu/mantua/pnw_impacts/INDICES/
MEI: www.esrl.noaa.gov/psd/enso

Thanks

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Results

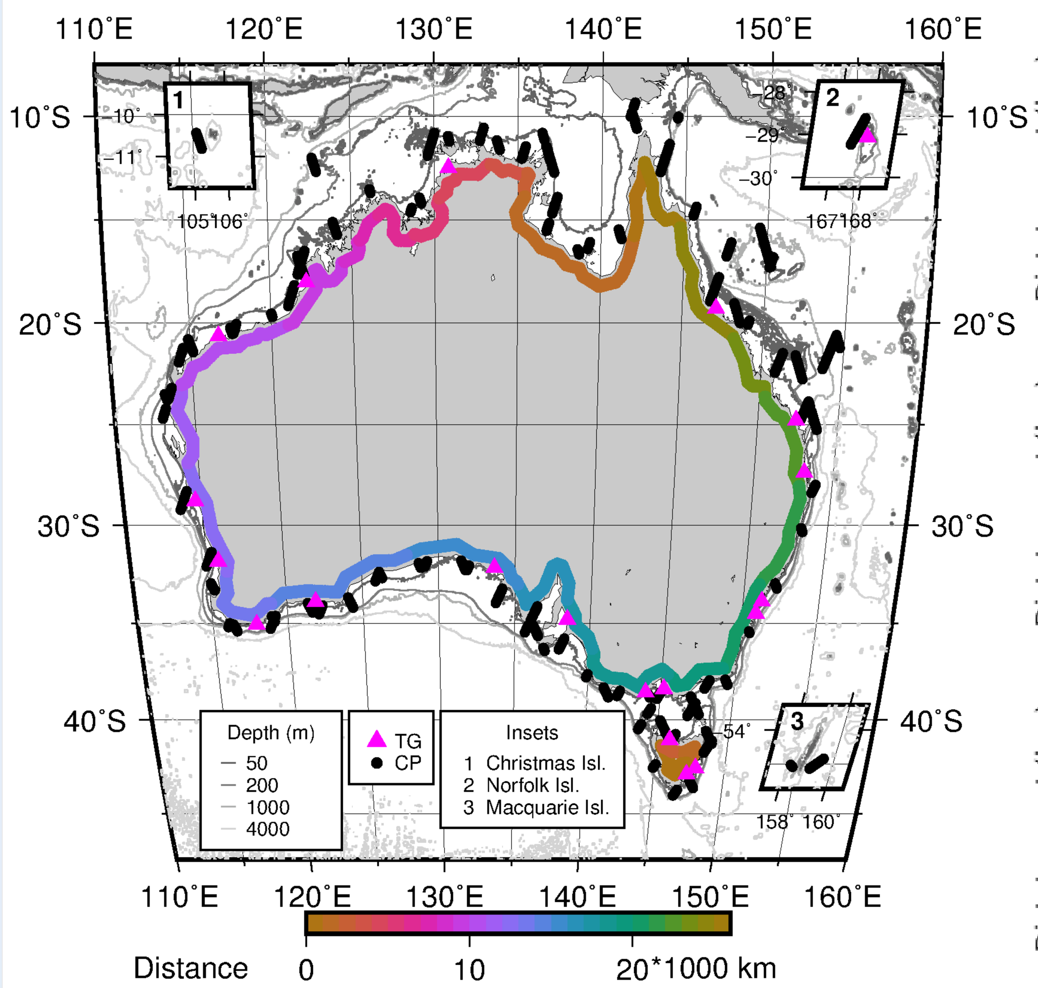

Figure 2. Context of "distance around coastline" in Figures, calculated counter-clockwise from Cape York (Torres Strait)

Sea-level trend from 2002—2015 around the Australian coast is spatially coherent, with highest trends on the west coast and lowest trends on the south-west shelf

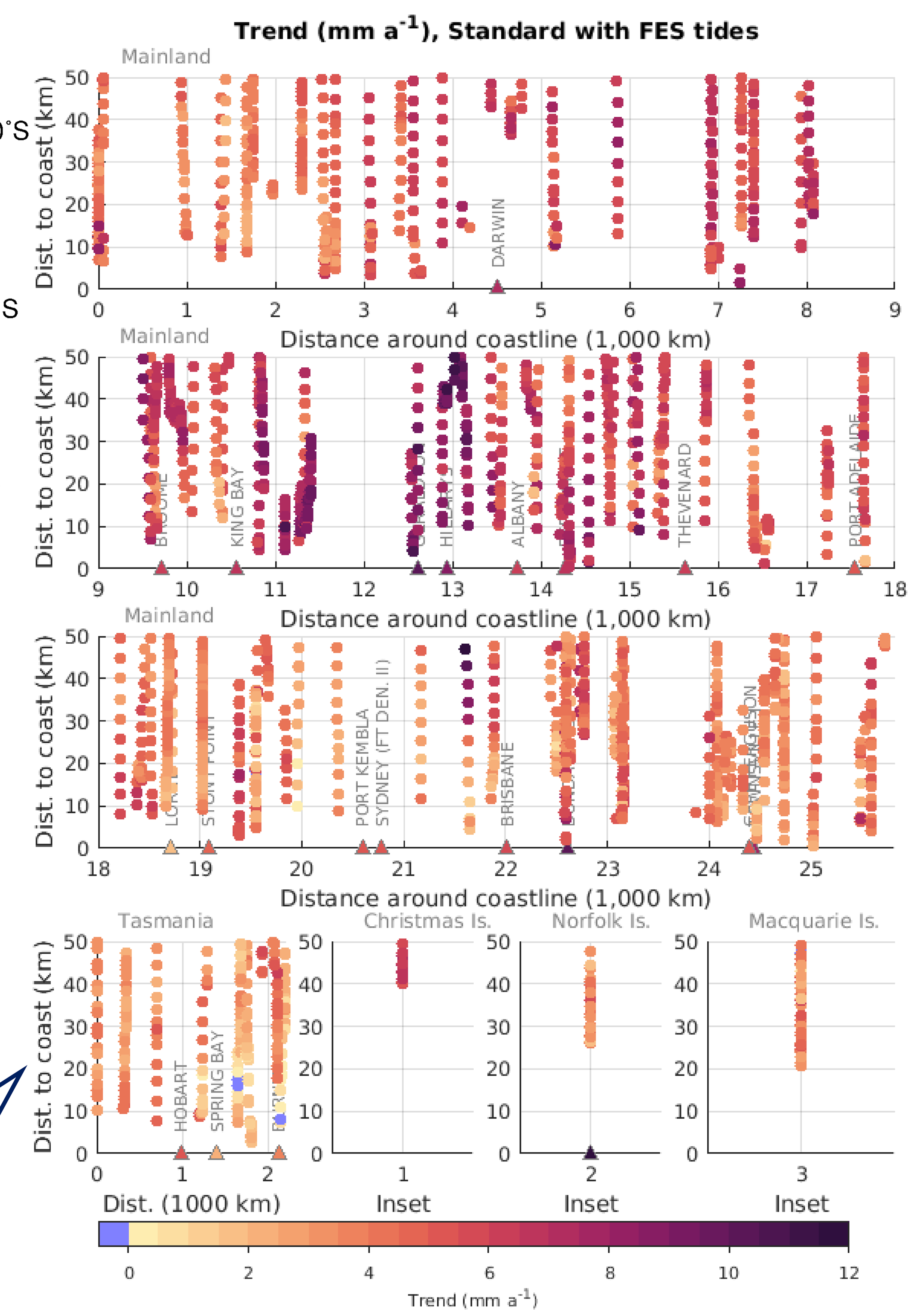

Figure 3. Trend (mm a^{-1}) around the Australian coast, from standard altimetry corrections, including climate indices in a multi-variate regression

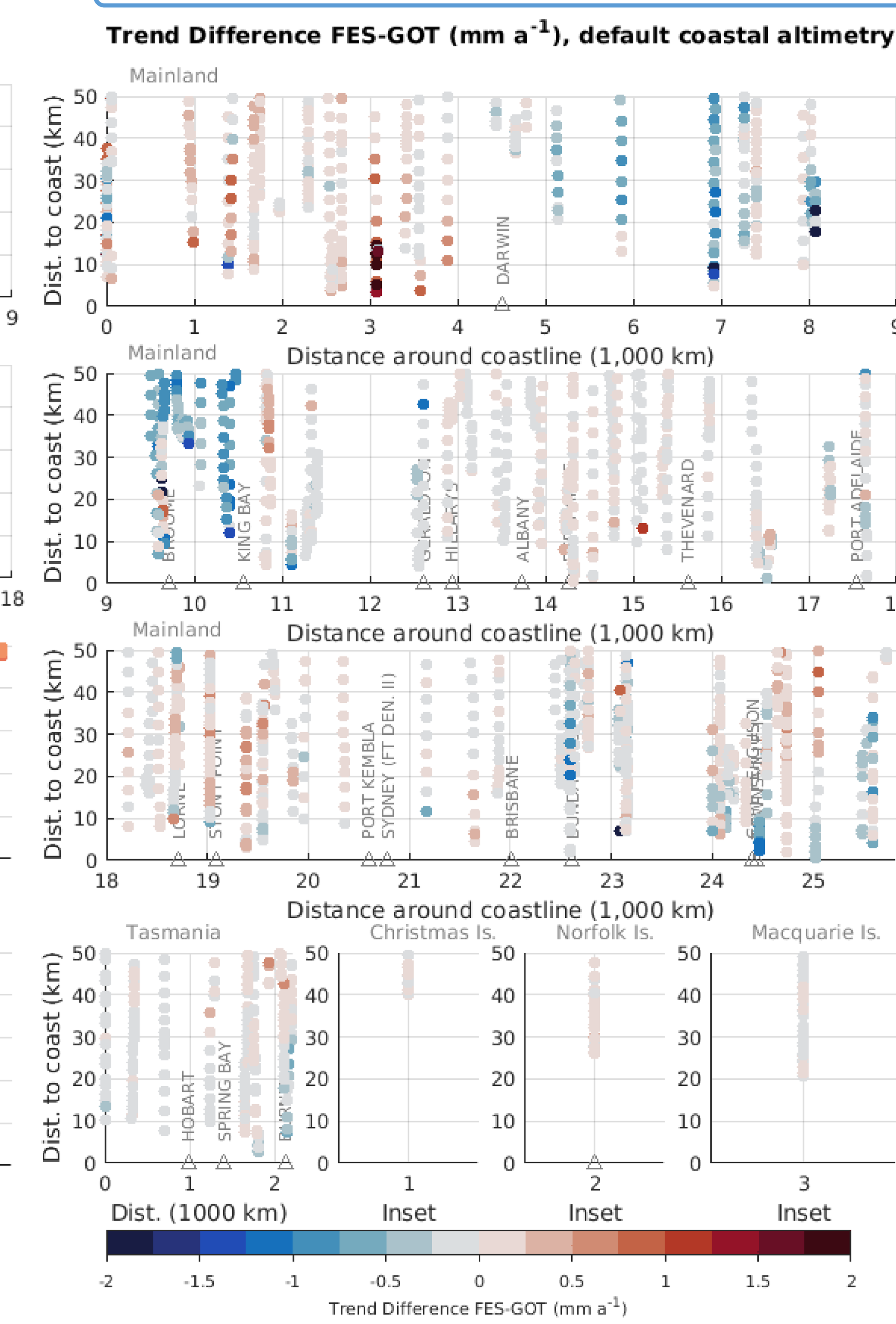

Figure 5. Difference in the trend (mm a^{-1}) due to the FES tide model, versus the standard GOT tide model. All other standard corrections applied and includes climate indices in the regression.

Effect of tidal corrections

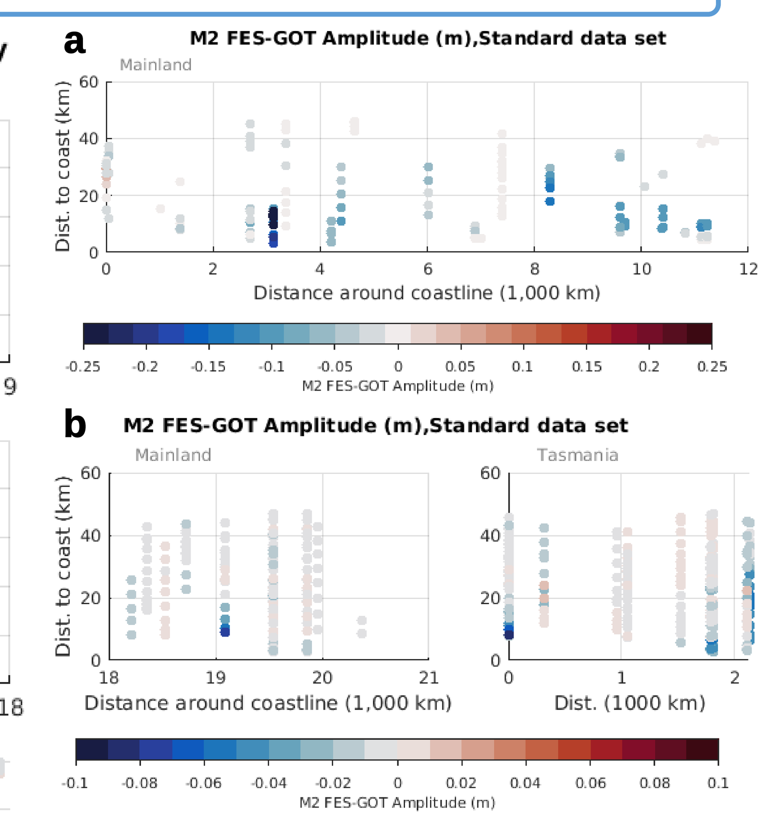

Figure 6. Difference in the amplitude (mm) of the aliased m2 tidal frequency between the FES and the standard GOT tide models (a) over the North West Shelf and (b) in Bass Strait.

FES2014b tide model reduces the variance of SSHA time series on wide shelves, within 20 km of coast. Both major and minor tidal constituents have lower amplitude in FES compared with GOT.

FES2014b tide model generally lowers trend (2002—2015) on wide shelves. There are regionally coherent changes, associated with reduced power at aliased tidal frequencies (c.f. GOT). The changes in the trend extend out more than 50 km from the coast.

Spatial mean of σ_{SSHA} (mm)	**Tide model sensitivity**	
	GOT 4.10c	FES 2014
Standard	126	111
Coastal	110	111

Table 2. Spatial mean of the standard deviation of each SSHA time series with >67% completeness in time (and coincident validity).

Spatial mean of trend (mm a^{-1})	**Tide model sensitivity**	
	GOT 4.10c	FES 2014
Standard	4.7 ± 2.1	4.7 ± 1.5
Coastal	5.0 ± 1.4	5.0 ± 1.5

Table 3. Spatial mean of the trend from each SSHA time series with >67% completeness in time (and coincident validity).

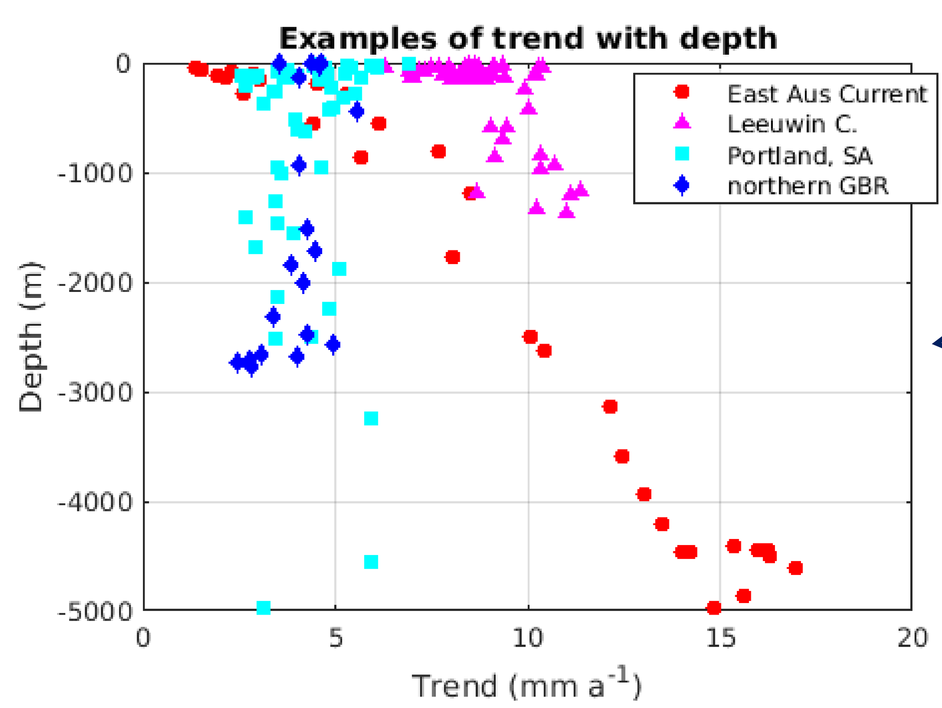

Figure 4. How sea-level trend (mm a^{-1}) changes across narrow continental shelves to the deep ocean. A comparison of regions with large mesoscale variability (EAC and Leeuwin in red and magenta) versus regions with high on-shelf variability (Portland and GBR in cyan and blue)

Sea-level trend does not change coherently with distance across the shelf. Sea-level trend increases in deep water in regions of large mesoscale variance. Elsewhere, there is no discernible difference in the trend with distance from the coast or bathymetry.

Effect of coastal range and wet troposphere corrections

GPD+ wet tropospheric correction makes minimal difference to the SSHA time series variability or trend for the Jason-1 and Jason-2/OSTM mission data around the Australian coast.

ALES range results in more valid SSHA in time close in to the coast (<10 km; c.f. standard MLE4 range).

ALES range gives a lower SSHA variance

ALES range generally increases the trend (c.f. standard MLE4 range), but there is no correlation with distance from coast or completeness

Conclusions and future work

When major climate modes (ENSO and PDO) and improved coastal altimetry corrections are applied, sea-level trends do not vary considerably with distance away from the coast. The exception to this is where mesoscale variability occurs off the shelf (e.g. East Australian and Leeuwin Currents). The trend is spatially coherent in regions around the coast, with highest trends occurring along the Australian west coast and lowest trends on the continental shelf along the south-east coast.

The FES2014 tide model leads to reduced variability in the SSHA time series within 20 km of the coast (compared with the standard GOT4.10c model). As a result of some tidal frequencies remaining in the SSHA time series, the GOT-corrected SSHA displays regionally-coherent differences in trends (2002—2015) that are consistent with distance away from the coast.

The ALES waveform re-tracker has better completeness near the coast. We find the linear trend over the short Jason-1/Jason-2 (2002—2015) time series is increased by 0.3 mm a^{-1} (from 4.7 mm a^{-1} to 5.0 mm a^{-1}) in the mean around the Australian coast.

Incorporating the Topex/Poseidon reference mission would increase the duration and therefore improve the formal errors on the trend estimates.

References

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