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Nansen-Tutu Centre
for Marine Environmental Research

Time scales of Sea Level variability along the east and south coast of southern Africa based on monthly tide gauge records

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1. Introduction

- This study aimed to determine the range of time scales of sea level variability and so identify corresponding drivers. It is part of the PhD work entitled "Does the variation in strength and position of the Agulhas Current contribute to coastal sea level variability?"
- The overall aim of the thesis is to discover whether the Agulhas Current (AC) has a measurable impact on coastal sea level (SL) around the coast of southern Africa; if so, how does this process operate?
- In order to achieve this aim, we will investigate the trends of SL and the relation between this and the AC position and strength variations. This will be done using a combination of *in situ* and satellite altimetry observations of the south and east coast of southern Africa SL, and as well as climate-model simulations in order to identify a distinct spatial pattern of SL and AC transport along the same region.

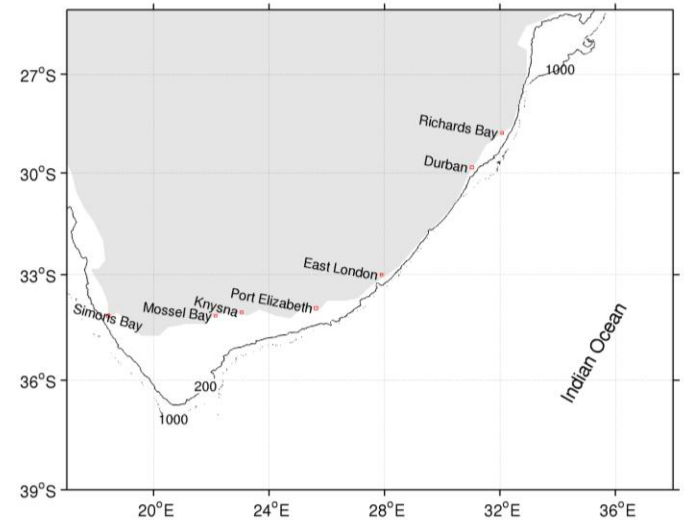

Fig. 1: The location of the tide gauges under consideration (stations are labelled with their names) and bathymetry (200 and 1000 m) of southern Africa.

2. Data and Analysis Methods

- The data consisted of all available tide gauge monthly mean records until December 2015, from 7 sites along the east and south coast of southern Africa (see Fig. 1). The data was obtained from the Permanent Service for Mean Sea Level (PSMSL, http://www.psmsl.org/).
- The Empirical Mode Decomposition/Hilbert - Huang Transformation (EMD/HHT) method (Huang et al., 1998; Huang and Wu, 2008; Ezer and Corlett, 2012; Ezer et al., 2013) was applied for the first time for southern Africa tide gauge records.

3. Results

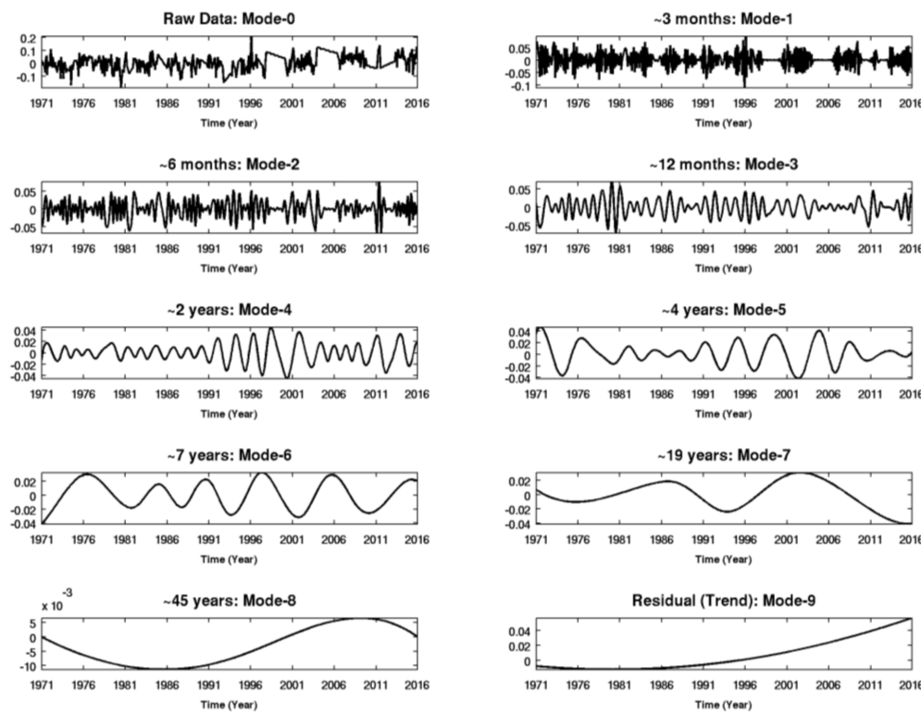

Fig. 2: Monthly sea level records at Durban (in m) when decomposed with the EMD/HHT analysis. As result, nine modes were found, mode 0 is the raw data, mode 1 - 8 are the oscillating modes, the remaining residual mode is the trend (mode-9).

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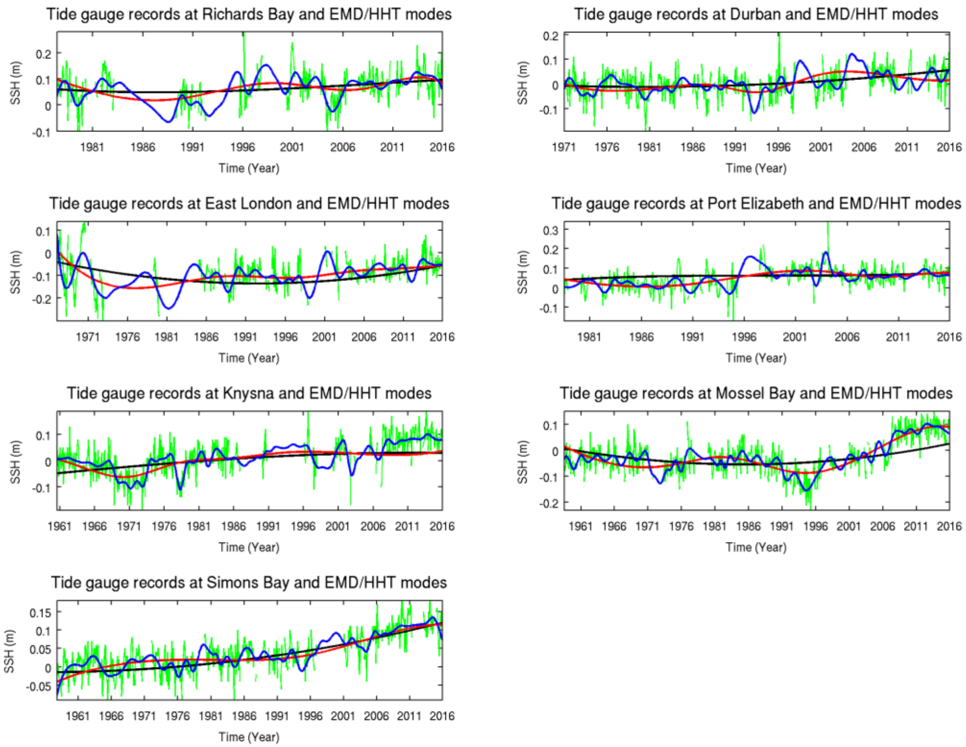

Fig. 3: Monthly tide gauge records at each site (green line) and the ensemble mean of the modes. Where blue line (modes 4 to 9) represent the “interannual-to-decadal” variability, red line (modes 7 to 9) indicate the “multi-decadal” (~25 year periods) variability and black line (mode 9) is the remaining residual or “trend”, which also shows some evidence of a non-linear change.

4. Conclusion

- Due to our limited knowledge of how sea level is linked to the drivers, it is still challenging interpreting a single oscillatory mode (see Fig. 2).
- Therefore, the timescales revealed were grouped as sub-annual, interannual and long-term low-frequency components of sea level variability (see Fig. 3, the sub-annual component is not shown):
  - The sub-annual component indicates how sea level responds to the weather disturbances in the annual cycle, including seasonal and annual large-scale wind and atmospheric pressure pattern changes.
  - The interannual component indicates an association with El Niño-Southern Oscillation (ENSO) through large-scale sea surface temperature patterns and large-scale wind patterns.
  - Lastly, the low-frequency component may be associated to bi-decadal ocean dynamics or climate variability drivers, such as the 18.6 year lunar nodal cycle.
- The remaining mode, which is considered as the increasing trend, showed that along the study region sea level is rising at all sites mainly from the 1990s onwards, at a pattern similar to the global mean increase (see Fig. 4).

5. Way forward

- Test the impacts of the gaps on the EMD/HHT analysis by applying the method to an artificial data set and then, artificially locate data gaps of similar lengths to the tide gauge;
- Have some critical discussion on tide gauge data quality for suggesting new advancing data corrections at each site;
- Undertake correlation analyses between tide gauge records, altimetry observations and model ocean data, in order to fill the gaps;

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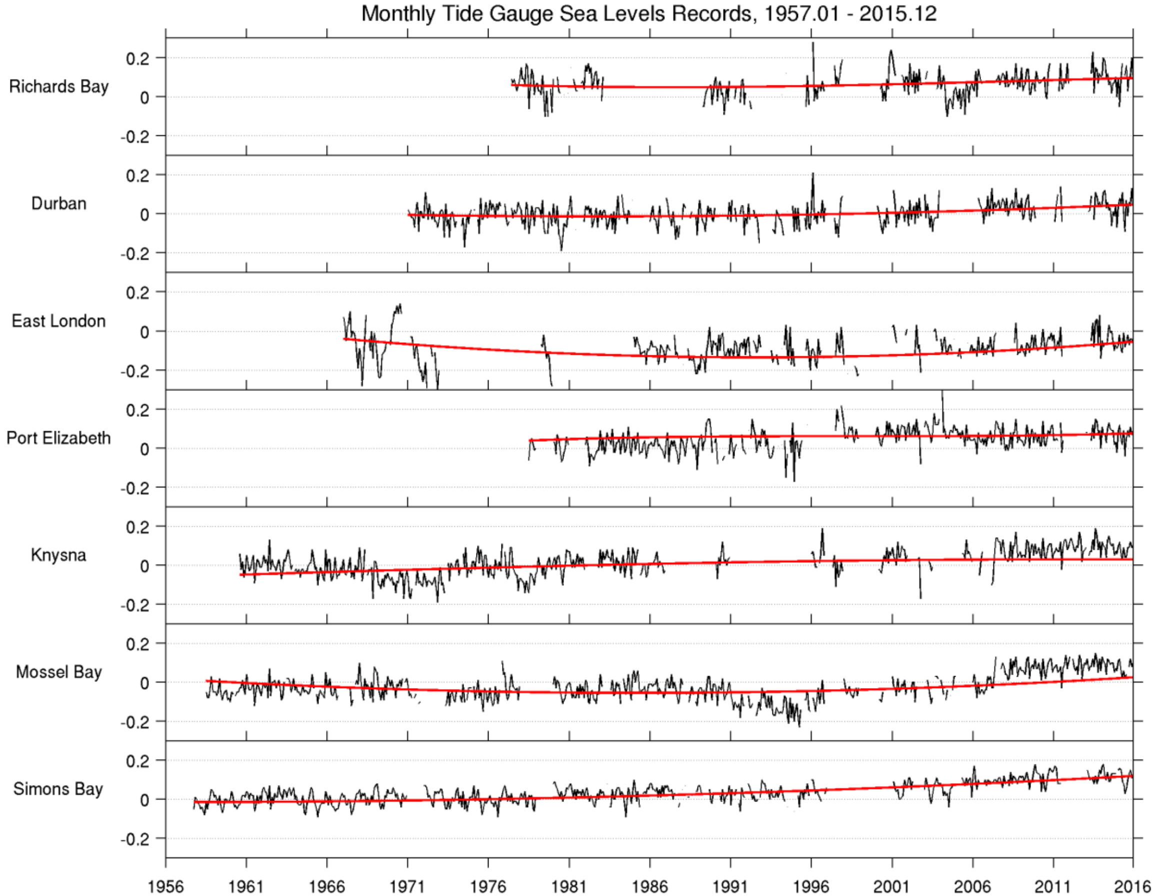

Fig. 4: Monthly sea level records (m) at tide gauges under consideration and its respective residual (red solid line).

6. Future research

- Does the Agulhas Current drive coastal Sea Level and how?
- How the offshore AC core changing position impacts the coastal SL?
- Where the AC has a clear influence/impact on the coastal sea level?

References

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Thank you

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