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Seasonal & non-seasonal SSH variations within the Makassar Strait

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1. Introduction

- Southward flow in the Makassar Strait accounts approximately 80% of the Indonesian throughflow from the Pcacific Ocean to the Indian Ocean (*e.g.* [1])
- Its variations have been related to the sea level difference between the Celebes Sea and the Java Sea (*e.g.* [2,3]), but sea surface height (SSH) within the Strait has not studied due to difficulty of altimeter observations.
- In this study, along-track coastal altimetry data are used to investigate SSH variations inside the Makassar Strait, accounting temporal scale dependencies.

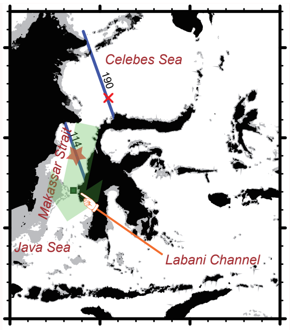

Fig.1: Study area and locations of SSH points

2. Materials and Method

- We use Jason-2 20Hz SSH data (from 2008.06 to 2016.09) along tracks 114 and 190 (Fig. 1) processed with a coastal retracker [4]. Data are smoothed spatially (25 km) and temporally (90 days).
- Monthly SST, Net Heat Flux (NHF) and Momentum Flux (τ) data are obtained from J-OFURO3 ver 1.1 data set[5]. They are also smoothed over 3 months with Gaussian filter.
- Volume transport variations at narrow Labani Channel (Fig.1) are obtained from [1].

- All data are separated into 1: Long-term variations (>3 yrs), 2: Interannual variations (>1-3 yr), 3: Repeated annual variations (=1 yr) and 4: Residual variations (3-12 months). Amplitude modurations of seasonal signals by ENSO/IOD will be included in #4.

3. Results

- SSH variations at 1°S along Track114 (Makassar Strait) and 2°N along Track 190 (Celebes Sea; Fig.1) are shown in Fig. 2, with four time scales.
- Both SSHs are in phase with similar amplitudes, except in repeated seasonal variations (#3). **Seasonal SSH variations in the Makassar Strait is significantly larger.**

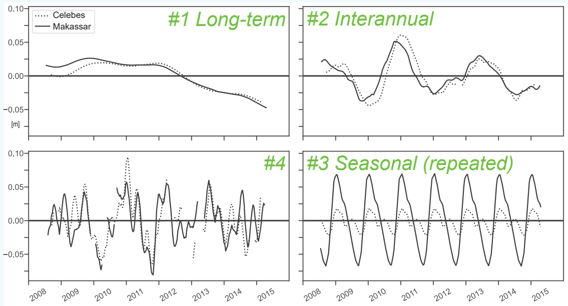

Fig.2: SSH variations in four time scales

3.1 Seasonal Variatoins

- Seasonal SST and SSH behave significantly different (Fig.3), suggesting that seasonal SSH has no baroclinic nature.
- Temporal changes of seasonal SST is simply explained by phase-shifted NHF (Fig.4).
- SSH difference and along-strait wind stress τ are in phase with volume transport (Fig.5), **not** with its temporal acceleration.
- They would be consistent if the bottom friction balances with the pressure gradient. Note that the southern end of the Strait is shallow, except narrow Labini Channel.

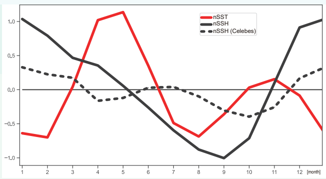

Fig.3: Seasonal SST and SSH. For comparisons, SST and SSH are normalized by 0.31°C and 0.07 m.

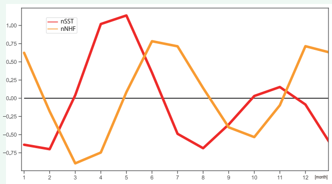

Fig.4: Seasonal SST and NHF, normalized by 0.31°C and 23 W/m^2.

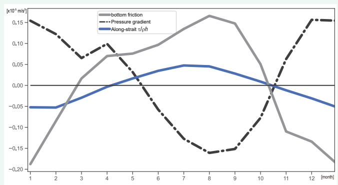

Fig.5: Seasonal SST difference (1°S-2°N), τ, and southward volume transport. Values are arranged to be in ms^{-2} unit, assuming that the water depth h=50m and the Newtonian bottom friction coefficient 7.5x10^{-5} ms^{-1}

3.2 non-Seasonal Variatoins

- Different SST and SSH behaviors are found in other time scales (Fig.6).
- In #4, however, SSHs occasionally become in-phase with SSTs (e.g., in no-ENSO years, 2012-2013). Wind stress in #4 scales were weak in these periods.

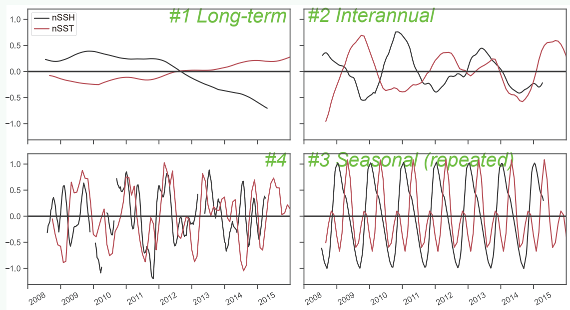

Fig.6: normalized SSH and SST variations in four time scales

4. Summary

- SSH variations within the Makassar Strait is significantly amplified w.r.t. the upstream Celebes Sea only in the repeated seasonal cycle.
- They are independent from SST but related with winds, suggesting barotropic response to the winds
- Shallow southern end of the Strait would act as a semi-enclosed chanel that enhances wind-induced SSH variations, and also increase bottom stress
- SSH could be in-phase with SST in response with the upper-layer heat content, when winds are weak.

References

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3: Pujana et al. (2019) JGR, 124, 3737-3754
4: Wang et al. (2019) Rem. Sens., 11, 1274.
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