Comparisons of Satellite Altimeter data, Reconstructed Sea Level, and Tide Gauge Observations in the Indian Ocean

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Background

• Research goal that has been proposed:

Utilize the multiple satellite altimeter data (1992-present), in situ observations, reconstructed sea level (1950-2001) and model experiments to thoroughly investigate “the causes for the interannual variability and decadal change of thermocline depth and upper-ocean heat content in the Indian Ocean.”

As the first step: we validate satellite SLA (both GDR and gridded products), reconstructed sea level and the ocean model performance.
Here: comparisons of Satellite Altimeter, Reconstructed Sea Level, and Tide Gauge Observations

1. Compare hourly tide gauge data with:
   TOPEX/Poseidon MGDR generation B (481 cycles),
   Jason 1 GDR generation B (232 cycles),
   Jason 2 IGDR (26 cycles); retain tidal signals and atmospheric pressure effect.

2. Compare the gridded products: weekly, 1/3x1/3 degree TOPEX/Poseidon and Jason 1 (TPJ1) concatenated and AVISO Merged SLA, and monthly reconstructed SLA of Church et al. (2004).
1. Tide gauge versus TOPEX/Poseidon, Jason 1 and Jason 2
E. EQ, Langkawi (99.77E, 6.43N)

Descending

Black: Tide gauge

E. EQ, Ko Taphao Noi (98.43E, 7.83N)

Ascending
(a) Station 136a, Track# 53, min distance ~ 71.78km (T/P) and 72.64km (J1)

(b) Station 182a, Track# 183, min distance ~ 66.99km (T/P) and 68.54km (J1)
(a) Station 109a, Track# 79, min distance ~ 105.93km (T/P), 105.33km (J1), and 106.02km (J2)

![Graph with data points and trend lines showing sea level anomaly over time for Station 109a, Track# 79.](image)

- $r_{T/P} = 0.96$
- $e_{T/P} = 11.31 \text{ cm}$
- $r_{J1} = 0.94$
- $e_{J1} = 14.14 \text{ cm}$
- $r_{J2} = 0.87$
- $e_{J2} = 19.77 \text{ cm}$

Ascending

Central EQ, Gan (73.15E, 0.68S)

(b) Station 121a, Track# 131, min distance ~ 72.91km (T/P), 72.21km (J1), and 73.18km (J2)

![Graph with data points and trend lines showing sea level anomaly over time for Station 121a, Track# 131.](image)

- $r_{T/P} = 0.90$
- $e_{T/P} = 15.29 \text{ cm}$
- $r_{J1} = 0.95$
- $e_{J1} = 12.49 \text{ cm}$
- $r_{J2} = 0.87$
- $e_{J2} = 13.76 \text{ cm}$

Descending

Central W. EQ, Pt. La Rue (55.53E, 4.67S)
Satellite - Tide gauge comparison for all 12 stations

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<th>Station ID</th>
<th>Satellite Ascending Pass</th>
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2. T/P-Jason 1 (TPJ1) and AVISO: Oct 1992 - June 2008
Weekly, 1/3 x 1/3 degree

AVISO - TPJ1 RMSE

Correlation coefficient
Reconstructed, TPJ1, AVISO (1993-2001 monthly mean)
TPJ1, AVISO and reconstructed SLA

Reconstructed: 2.1 cm/decade
TPJ1: 1.392 cm/decade
AVISO: 1.395 cm/decade
Black: Tide gauge
Brown: Reconstructed

(a) Station 101a (in Church04)

(b) Station 142a (in Church04)

(c) Station 136a (not in Church04)
Summary

- T/P, J1 and J2 (GDR) data have comparable agreements with the tide gauge observations in the Indian Ocean, with correlation coefficients generally exceeding 0.84, except in the northern BOB and Persian Gulf, where correlation coefficients are low (~0.6) or even negative and RMSE is large (121cm at station 138a);

- The temporal variations and linear trends of basin-averaged SLA from AVISO and TPJ1 gridded data (1992-2008) agree very well; the RMSE of (AVISO-TPJ1), however, shows regular spatical patterns with large errors (~8cm) south (north) of 20S (10N) and near the western boundary;

- The reconstructed sea level reproduces the mean seasonal cycle well; its linear trend of basin-mean sea level, however, is much larger than that of the satellite data; its temporal variability and amplitude do not seem to agree well with the tide gauge data.
AVISO-TPJ1 Basin Mean, Indian Ocean

-0.0083 cm/decade
~0.6% of TPJ1 trend for 93-01

(b)
SLA Difference - Basin Mean, Indian Ocean

Church04-TPJ1
Church04-AVISO

SLA (cm)

93 94 95 96 97 98 99 00 01 02
Year