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."***

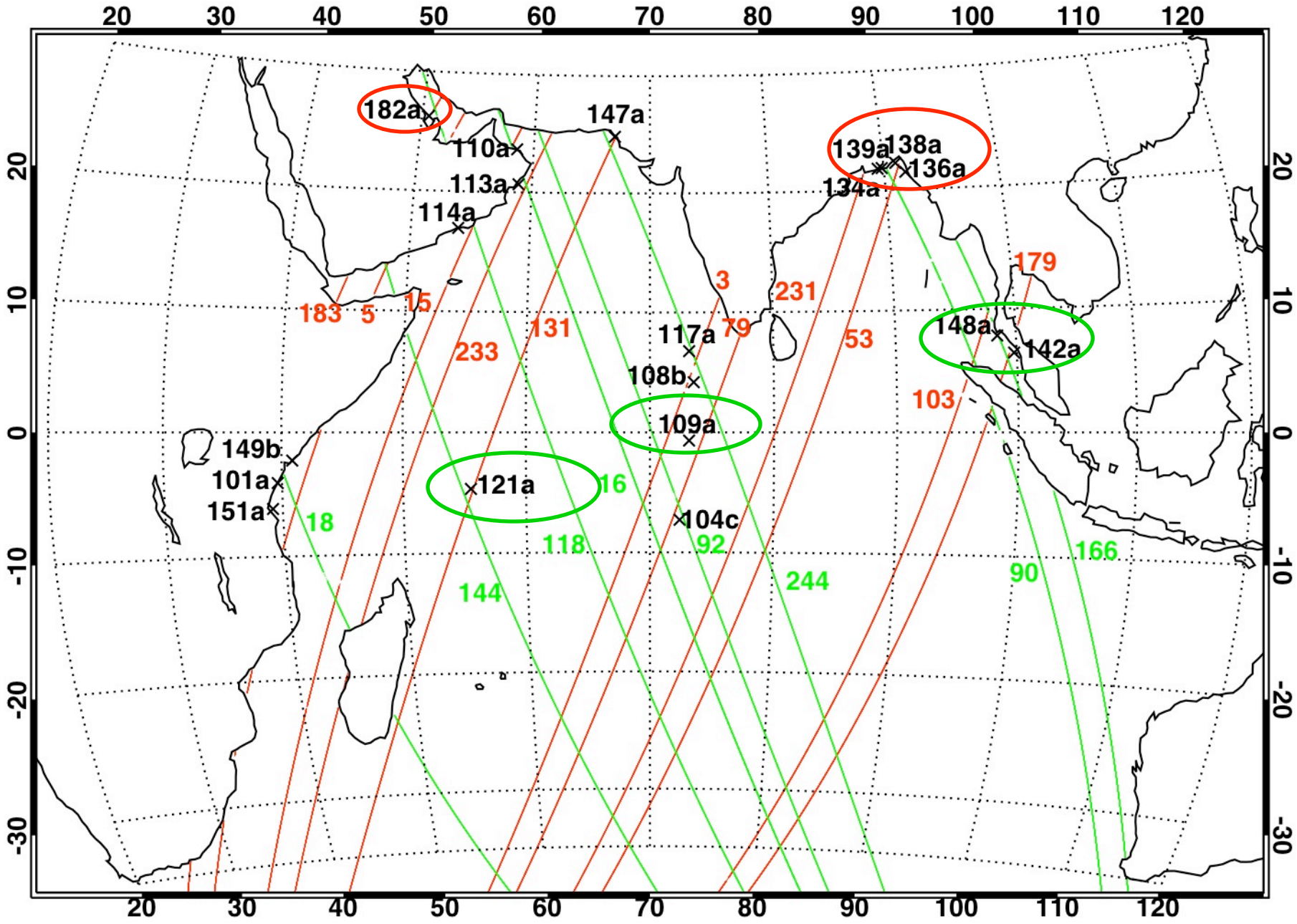
  As the first step: we ***validate satellite SLA (both GDR and gridded products), reconstructed sea level and the ocean model performance.***

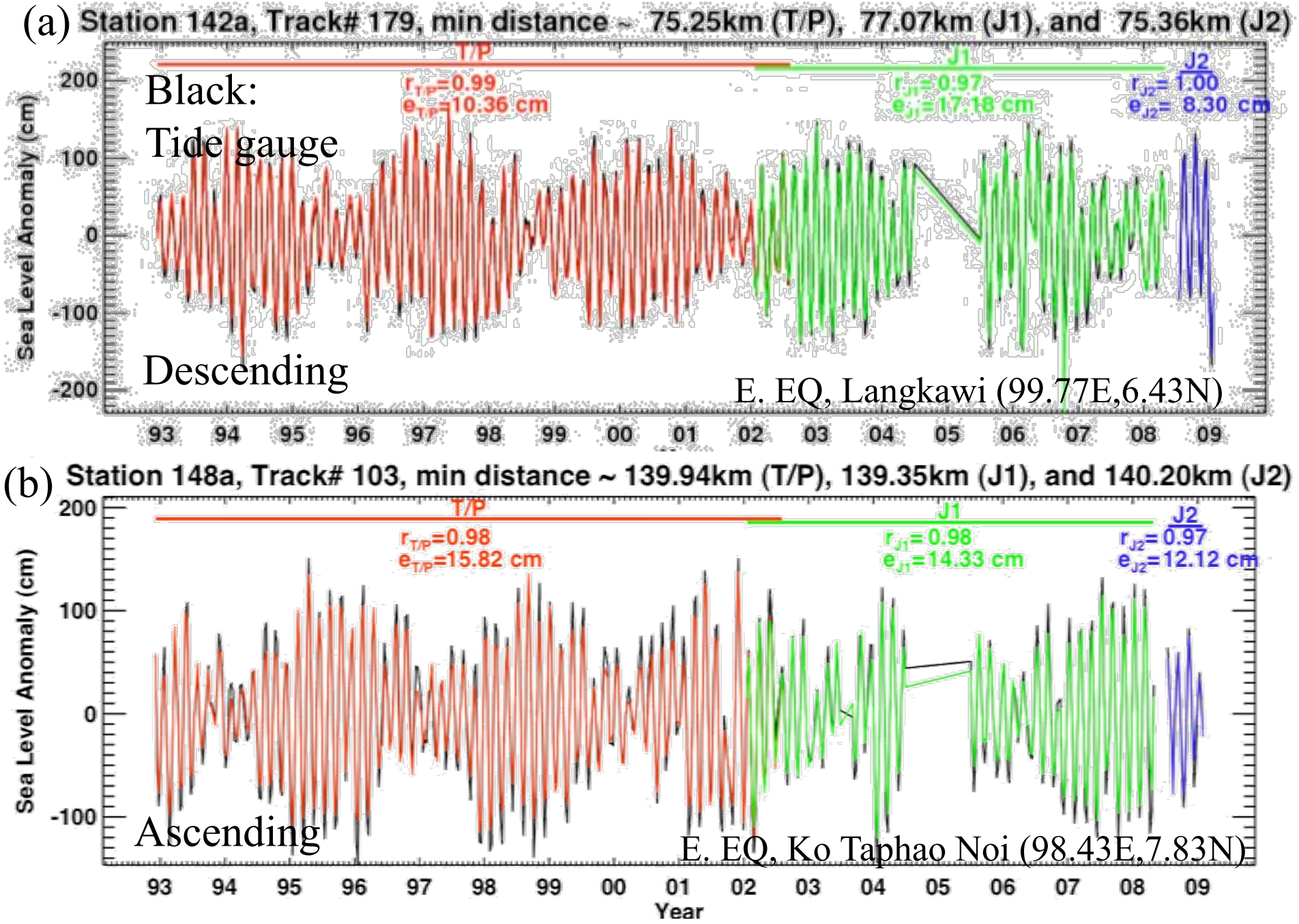
Here: comparisons of Satellite Altimeter, Reconstructed Sea Level, and Tide Gauge Observations

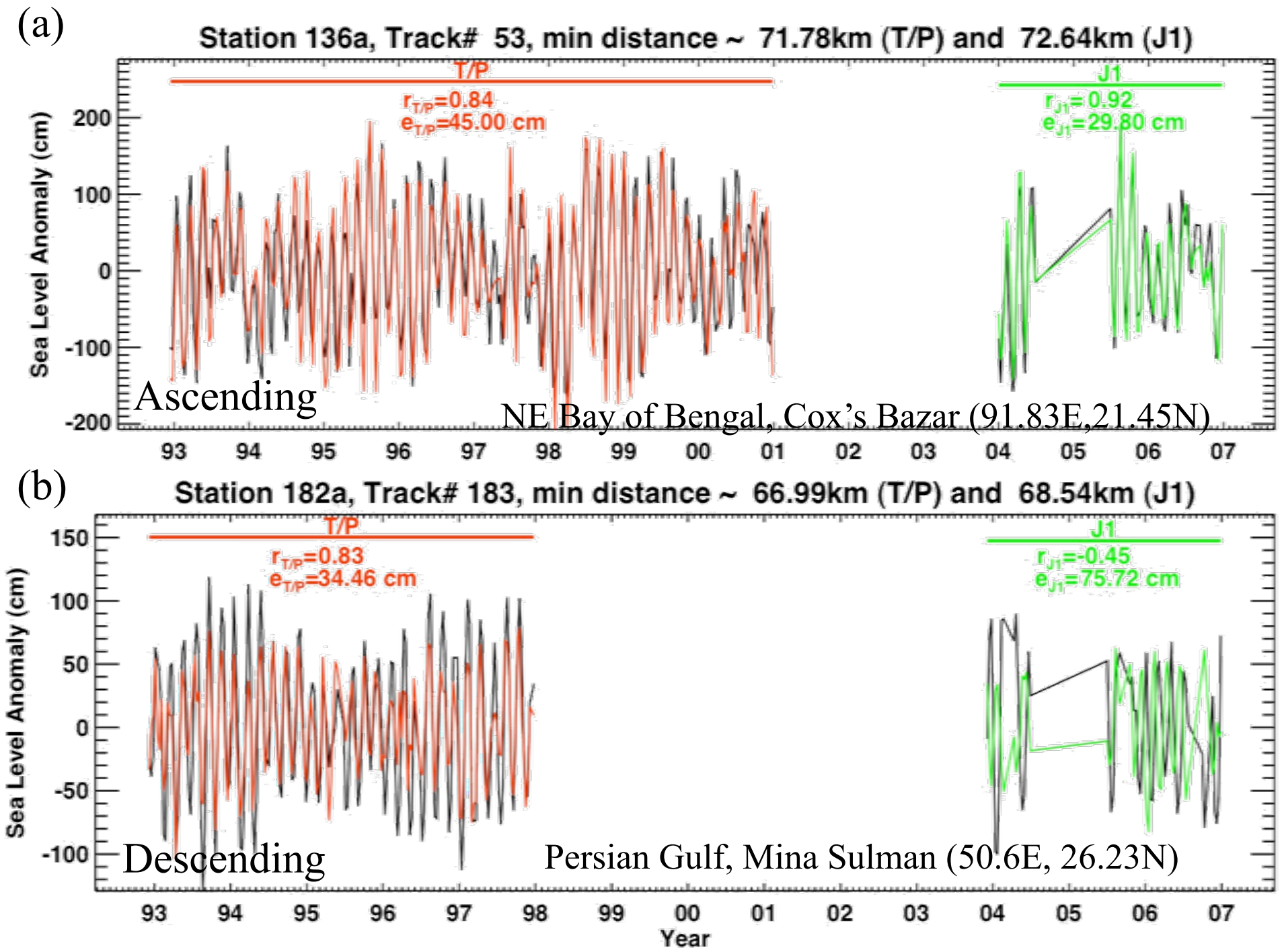
1. Compare hourly tide gauge data with:
   TOPEX/Poseidon MGDR generation B (481 cycles),
   Jason 1 GDR generation B (232 cycles),
   Jason 2 IGDR (26 cycles); retain tidal signals and atmospheric pressure effect.

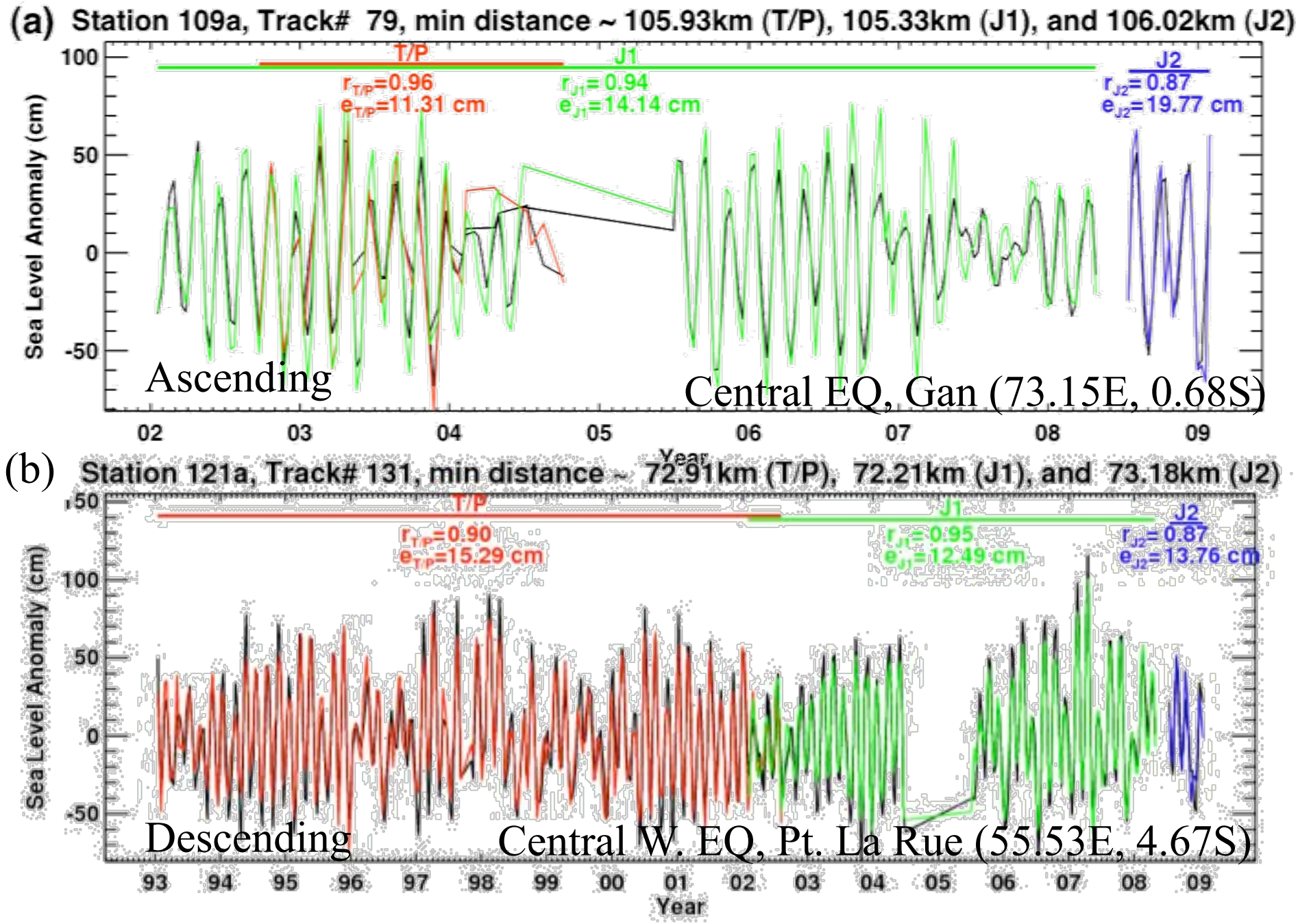
2. Compare the gridded products: weekly, 1/3x1/3 degree TOPEX/Poseidon and Jason 1 (TPJ1) concatenated and AVISO Merged SLA, and monthly reconstructed SLA of Church et al. (2004).

1. Tide gauge versus TOPEX/Poseidon, Jason 1 and Jason 2




(a) Station 142a, Track# 179, min distance ~ 75.25km (T/P), 77.07km (J1), and 75.36km (J2)
T/P
J1
J2
$r_{T/P}$=0.99
$e_{T/P}$=10.36 cm
r_{J1}=0.97
e_{J1}=17.18 cm
r_{J2}=1.00
e_{J2}= 8.30 cm
Black:
Tide gauge
Descending
E. EQ, Langkawi (99.77E,6.43N)
Sea Level Anomaly (cm)
200
100
0
-100
-200
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09
(b) Station 148a, Track# 103, min distance ~ 139.94km (T/P), 139.35km (J1), and 140.20km (J2)
T/P
J1
J2
$r_{T/P}$=0.98
$e_{T/P}$=15.82 cm
r_{J1}=0.98
e_{J1}=14.33 cm
r_{J2}=0.97
e_{J2}=12.12 cm
Ascending
E. EQ, Ko Taphao Noi (98.43E,7.83N)
Sea Level Anomaly (cm)
200
100
0
-100
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09
Year


(a)
Station 136a, Track# 53, min distance ~ 71.78km (T/P) and 72.64km (J1)
T/P
$r_{T/P}$=0.84
$e_{T/P}$=45.00 cm
J1
r_{J1}=0.92
e_{J1}=29.80 cm
Sea Level Anomaly (cm)
200
100
0
-100
-200
Ascending
NE Bay of Bengal, Cox's Bazar (91.83E,21.45N)
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
(b)
Station 182a, Track# 183, min distance ~ 66.99km (T/P) and 68.54km (J1)
T/P
$r_{T/P}$=0.83
$e_{T/P}$=34.46 cm
J1
r_{J1}=-0.45
e_{J1}=75.72 cm
Sea Level Anomaly (cm)
150
100
50
0
-50
-100
Descending
Persian Gulf, Mina Sulman (50.6E, 26.23N)
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
Year

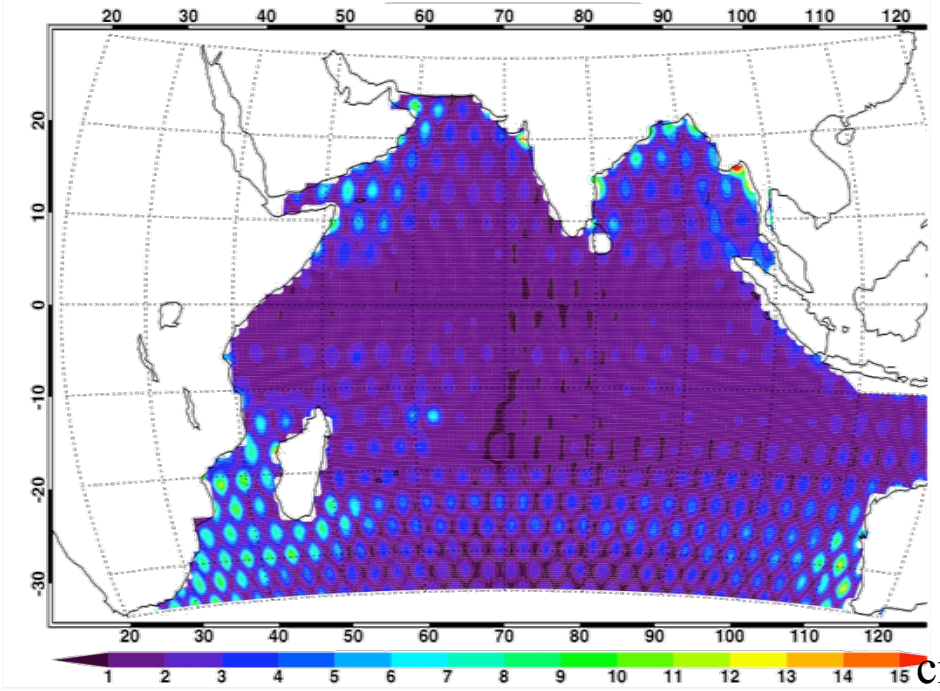

(a) Station 109a, Track# 79, min distance ~ 105.93km (T/P), 105.33km (J1), and 106.02km (J2)
T/P
J1
J2
$r_{T/P}$=0.96
$e_{T/P}$=11.31 cm
r_{J1}=0.94
e_{J1}=14.14 cm
r_{J2}=0.87
e_{J2}=19.77 cm
Sea Level Anomaly (cm)
100
50
0
-50
Ascending
Central EQ, Gan (73.15E, 0.68S)
02
03
04
05
06
07
08
09
Year
(b) Station 121a, Track# 131, min distance ~ 72.91km (T/P), 72.21km (J1), and 73.18km (J2)
T/P
J1
J2
$r_{T/P}$=0.90
$e_{T/P}$=15.29 cm
r_{J1}=0.95
e_{J1}=12.49 cm
r_{J2}=0.87
e_{J2}=13.76 cm
Sea Level Anomaly (cm)
150
100
50
0
-50
Descending
Central W. EQ, Pt. La Rue (55l53E, 4.67S)
93
94
95
96
97
98
99
00
01
02
03
04
05
06
07
08
09
Year

Satellite - Tide gauge comparison for all 12 stations

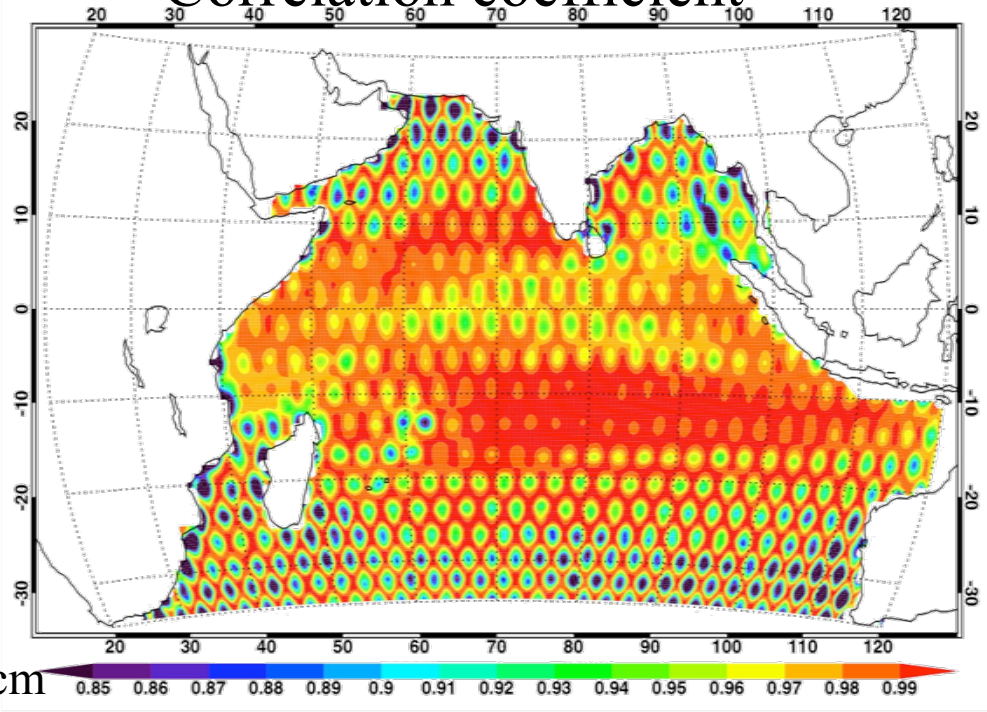
Station ID	Satellite Ascending Pass						Satellite Descending Pass					
	r_{ter}	e_{ter}	r_{ti}	e_{ti}	r_{tr}*	e_{tr}*	r_{ter}	e_{ter}	r_{ti}	e_{ti}	r_{tr}*	e_{tr}*
101a	0.97	23.07				]	0.97	22.68			0.99	17.88
104c	0.96	14.57			0.95	16.87	0.97	13.80			0.98	9.64
108b	0.93	13.11	0.89	12.81					0.90	10.47		
109a	0.96	11.31	0.97	12.20	0.87	19.77			0.84	23.63	0.84	34.51
113a	0.97	14.64	0.97	15.10	0.99	13.55	0.97	13.67	0.98	12.07	0.99	10.69
114a			0.88	17.85	0.96	13.17			0.90	18.45	0.93	14.15
117a	0.92	14.21			0.95	9.76	0.93	14.82			0.44	53.90
121a	0.86	17.45	0.91	15.61	0.79	13.43	0.90	15.29	0.93	13.23	0.87	13.76
134a			0.91	34.22			0.82	42.48	0.80	41.71		
136a	0.84	45.00	0.92	29.80			0.64	62.82	0.69	64.43		
138a	0.66	86.34					-0.18	121.93				
139a	0.85	40.70					0.82	41.78				
142a	0.99	9.99	0.99	12.11	0.98	18.05	0.99	10.36	0.97	18.36	1.00	8.30
147a					0.99	10.29					0.99	10.20
148a	0.98	15.82	0.99	13.20	0.97	12.12			0.99	11.88	0.99	11.58
149b			0.96	24.00	0.98	22.58			0.96	22.25	0.98	22.35
151a	0.98	24.85	0.99	25.93			0.98	25.11	0.99	28.41		
182a			-0.36	73.51			0.83	34.46	-0.45	75.72		

2. T/P-Jason 1 (TPJ1) and AVISO: Oct 1992 - June 2008
Weekly, 1/3 x 1/3 degree

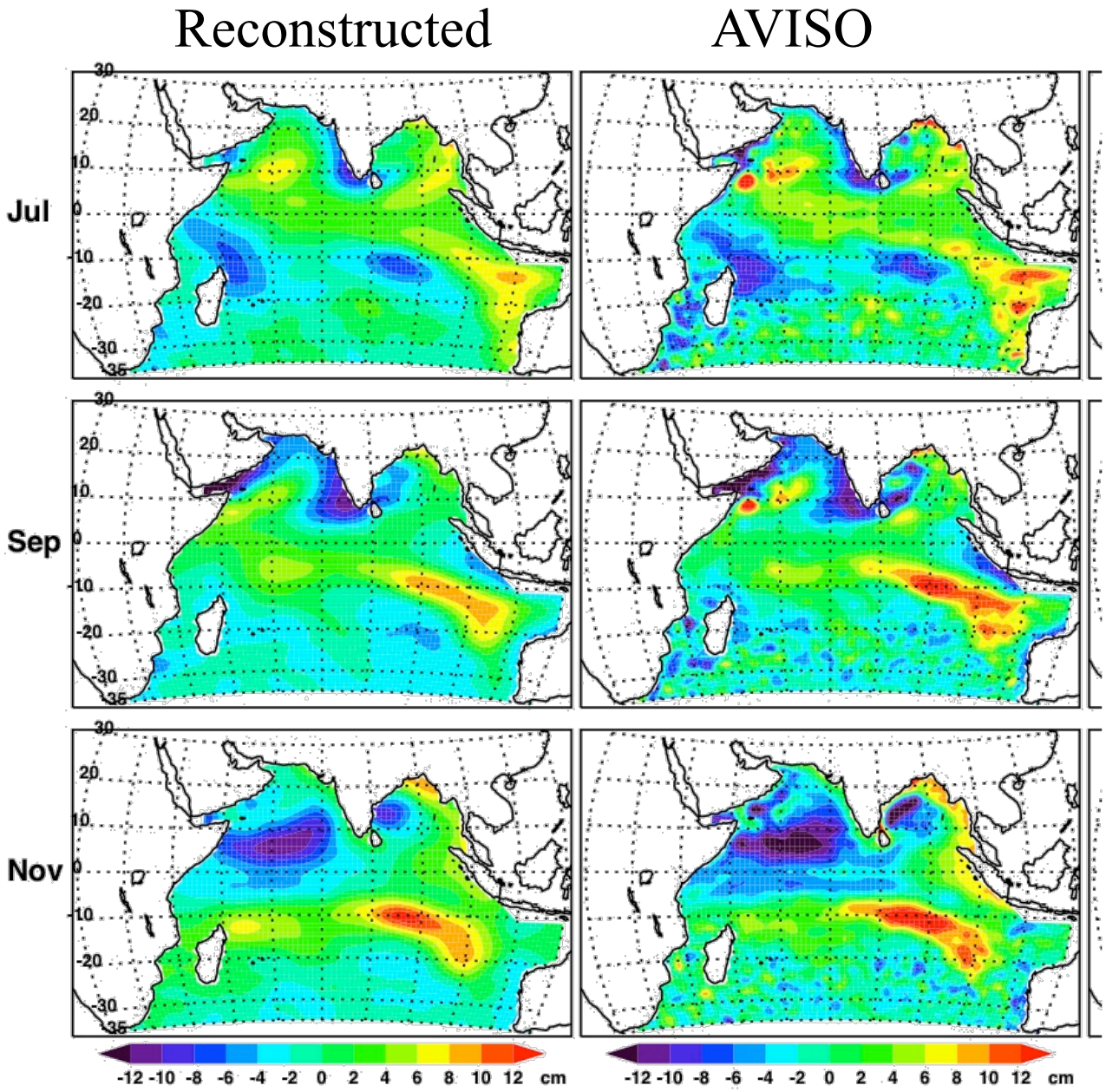
AVISO - TPJ1 RMSE



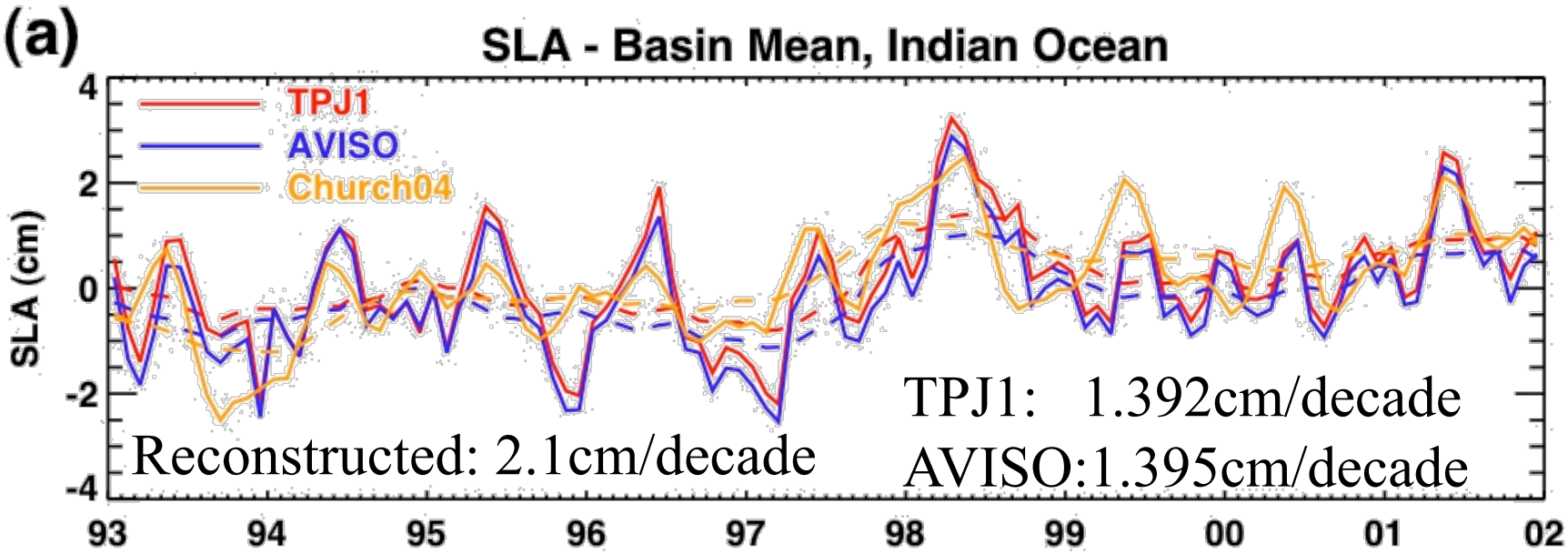
Correlation coefficient

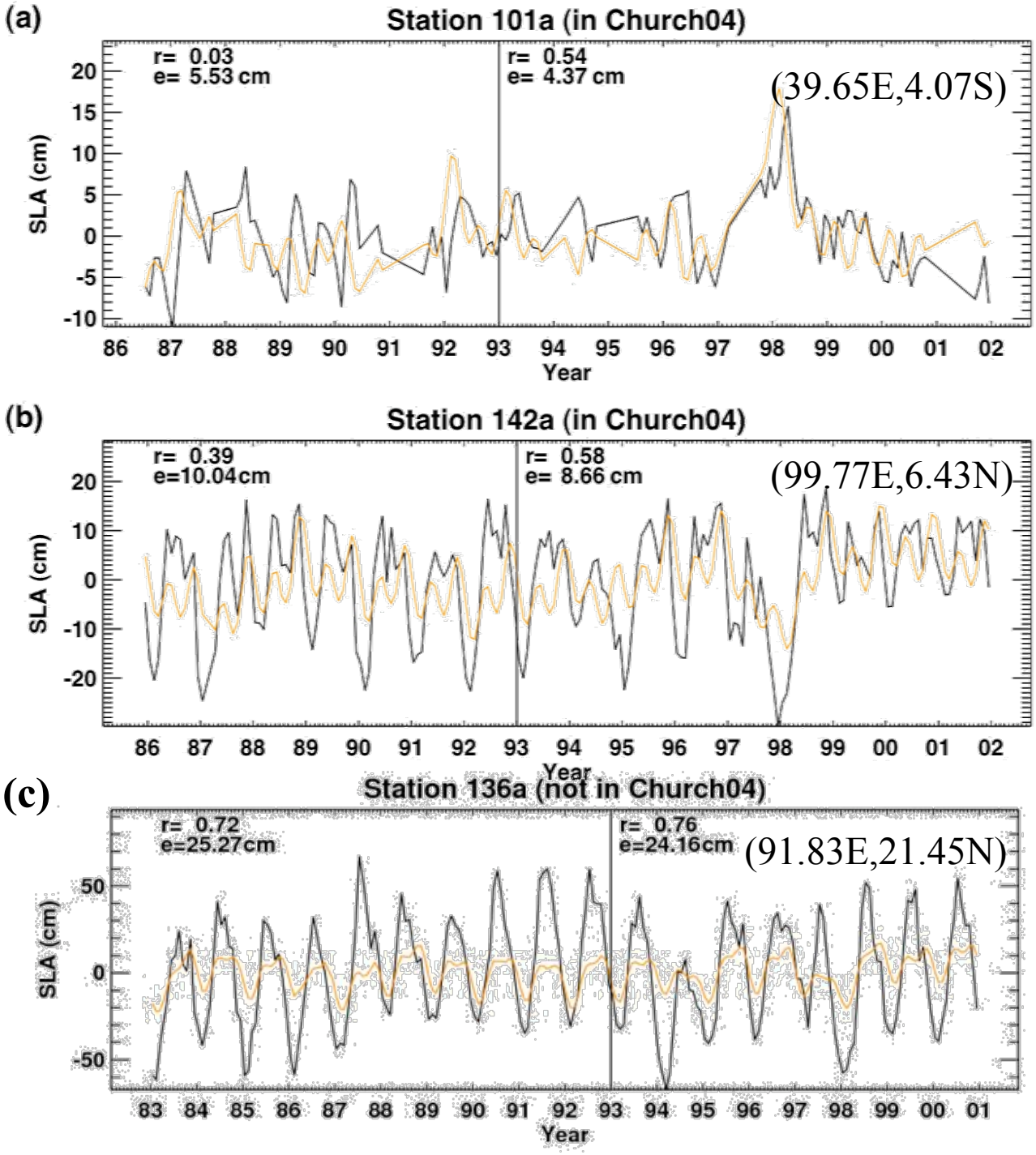


Reconstructed, TPJ1, AVISO (1993-2001 monthly mean)



TPJ1, AVISO and reconstructed SLA

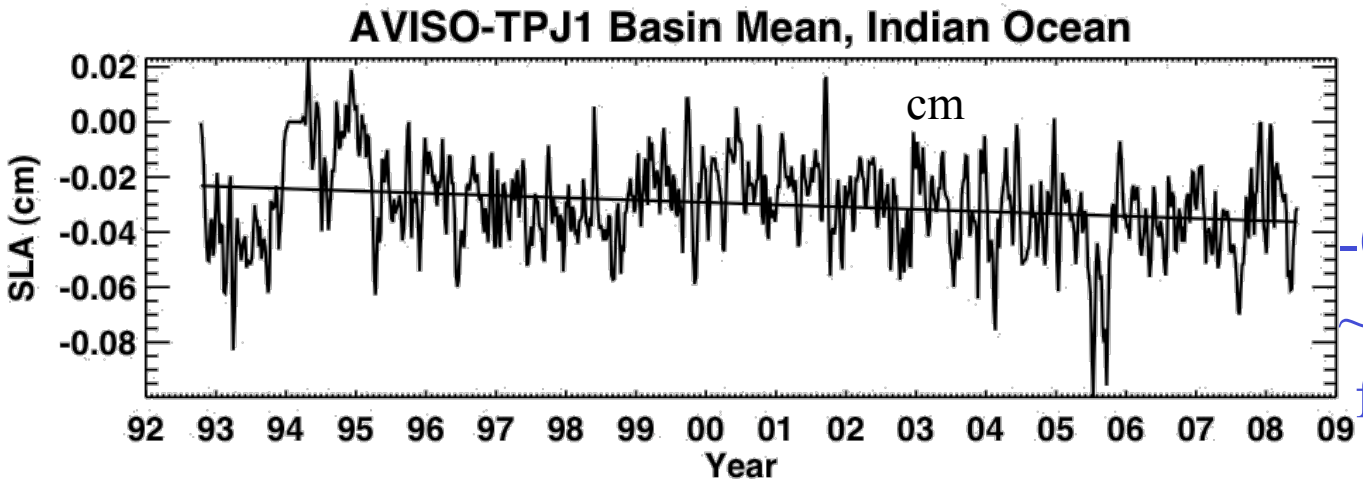




Black: Tide gauge
Brown: Reconstructed

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.



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