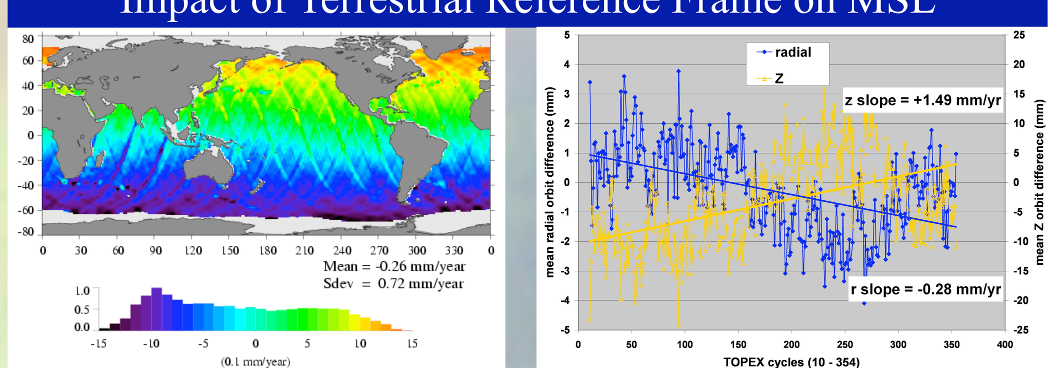
Assessment of Global and Regional Mean Sea Level Estimates Based on ITRF2008

B. Beckley, N. Zelensky, S. Holmes - SGT, Inc.
F. Lemoine, S. Luthcke, R. Ray – NASA/GSFC
S. Desai, S. Brown – JPL
G. Mitchum – Univ. of S. Florida
N. Tran - CLS

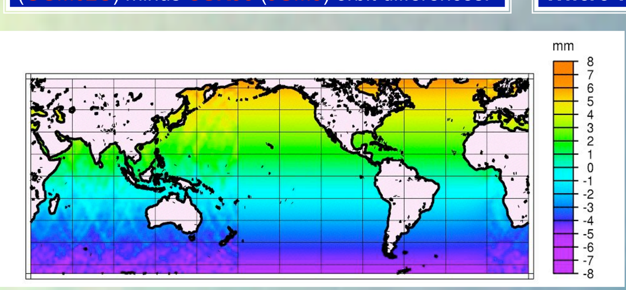
The measurement of mean sea-level change from satellite altimetry requires extreme stability of the altimeter measurement system. Reference frame accuracy and stability directly affect mean sea level (MSL) estimates. Long -term credible MSL estimates require the development and continued maintenance of a stable reference frame, along with vigilant monitoring of the performance of the independent tracking systems used to calculate the orbits for altimeter spacecrafts. In an effort to adhere to cross mission consistency, we have generated a full time series of experimental orbits (GSFC std1007) for TOPEX/ Poseidon (TP), Jason-1, and OSTM based on an improved terrestrial reference frame (TRF) realization (ITRF2008). In this presentation we assess the impact of the revised TRF on inter-mission bias estimates, and resultant global and regional MSL trends.

Impact of Terrestrial Reference Frame on MSL



Regional TOPEX (1993-2002) SSH trend differences from direct impact of the ITRF2005 (GGM02C) minus CSR95 (JGM3) orbit differences.

R slope / Z slope = -0.28 mm/yr / 1.49 mm/yr
MSL rate error = - 0.19 x TZ (mm/yr)
Where TZ is the mean orbit rate error in Z.



Regional mean sea level errors resulting from a 10 mm Z-translation of the Terrestrial Reference Frame (DORIS station coordinates). *From Morel L., and Willis, P., 2005.*
Mean sea level= -0.12 x TZ (mm)
where TZ is the TRF error in Z.

Improving T/P, Jason-1&2 SLR/DORIS orbits with ITRF2008

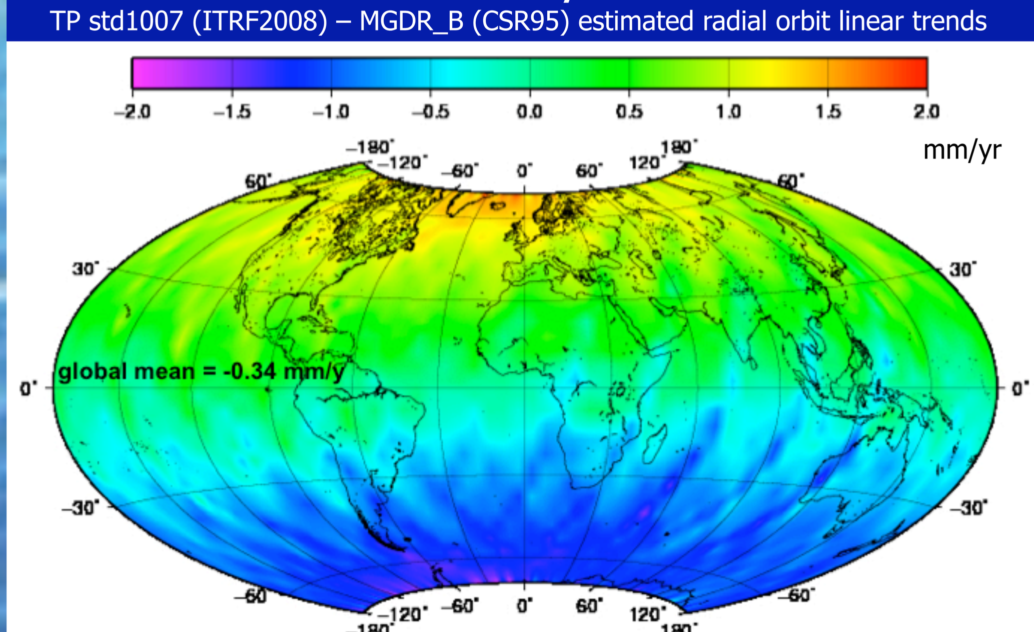
Evaluate ITRF2008 SLR/DORIS orbit performance for TP, J1, J2 [1]

Mission	dynamic orbit test	average RMS tracking data residuals: DORIS (mm/s)	SLR (cm)	Crossover (cm) (independent)
TP cycles 1-446 xover: 30 cycles	std0905 (itrf2005)	0.4989	1.751	5.482
	std1007 (itrf2008)	0.4985	1.663	5.477
J1 cycles 1-259	std0905 (itrf2005)	0.3857	1.076	5.460
	std1007 (itrf2008)	0.3851	1.055	5.457
J2 cycles 1-75 xover cycles 1-52	std0905 (itrf2005)	0.3618	1.095	5.564
	std1007 (itrf2008)	0.3609	1.032	5.550

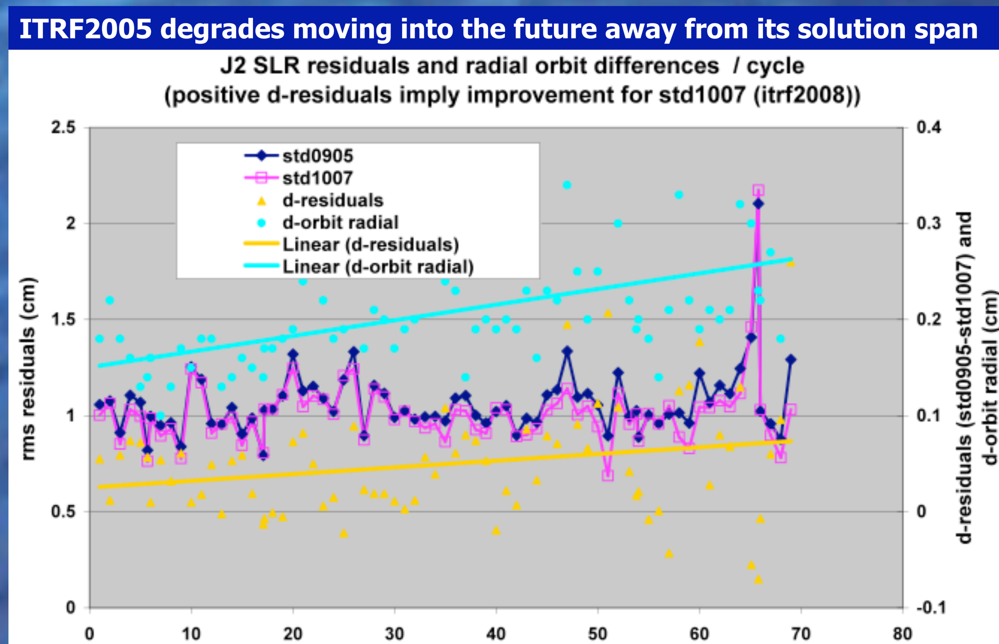
1) the std0905 (itrf2005) dynamic orbit accuracies have been accessed at about 1.5 cm (Lemoine et al. 2010 , ASR, Towards development of a consistent orbit series for TOPEX, Jason-1, and Jason-2)

Source of orbit instability – TRF realization

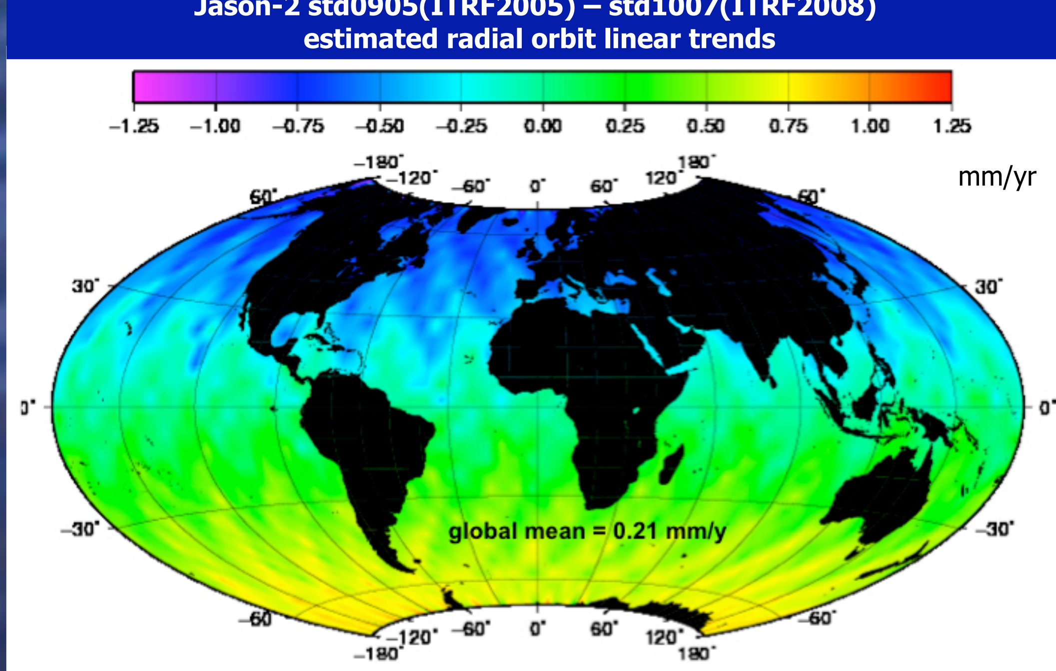
TP std1007 (ITRF2008) – MGDR_B (CSR95) estimated radial orbit linear trends



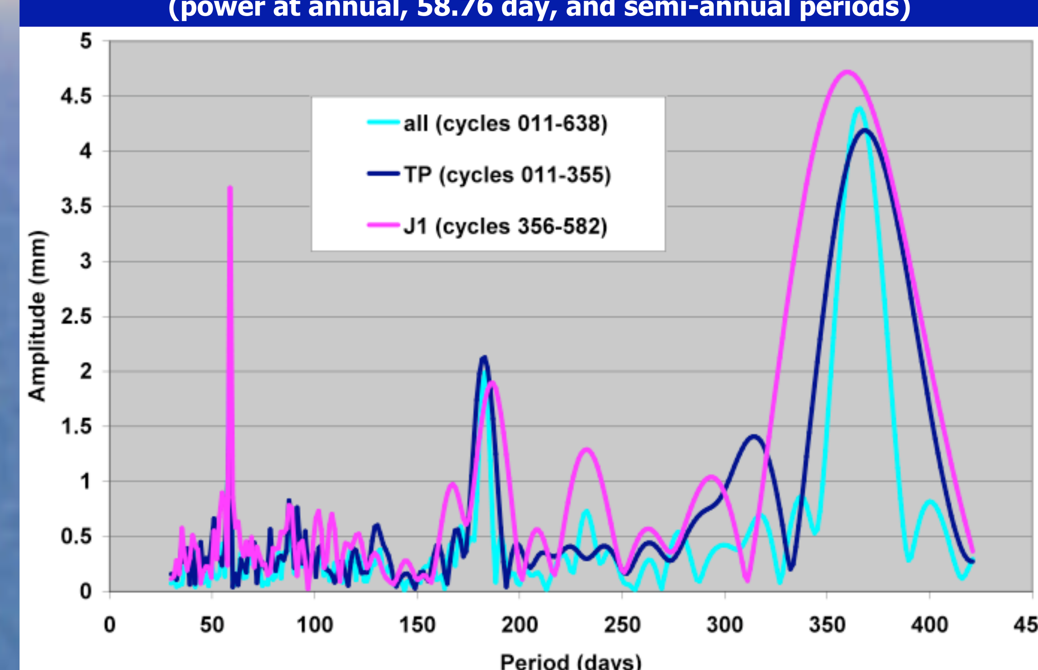
ITRF2005 degrades moving into the future away from its solution span



Jason-2 std0905(ITRF2005) – std1007(ITRF2008) estimated radial orbit linear trends



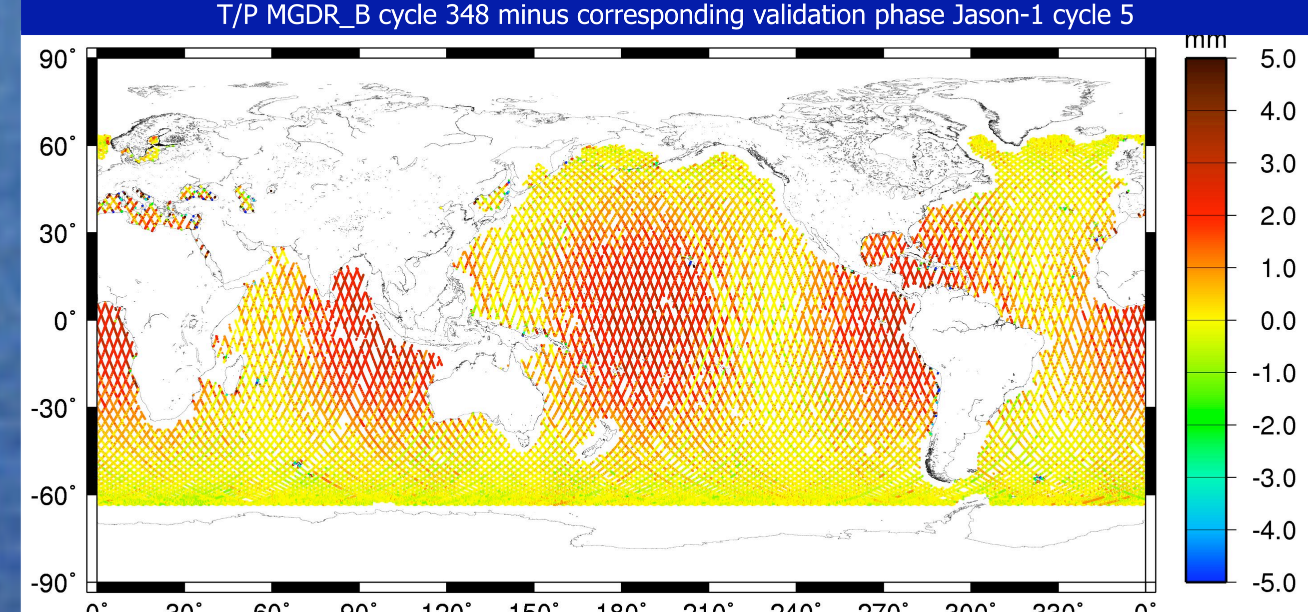
Periodogram of MSL Variations 1993-2009 (power at annual, 58.76 day, and semi-annual periods)



Residual signature shown at ~59 day period is correlated to solar effects on the satellite as the percent illumination from the sun changes corresponding to the angle between the sun and the orbital plane. Efforts to better understand it's mission-specific source and amplitude and provide a proper correction strategy to reduce it's power are on-going.

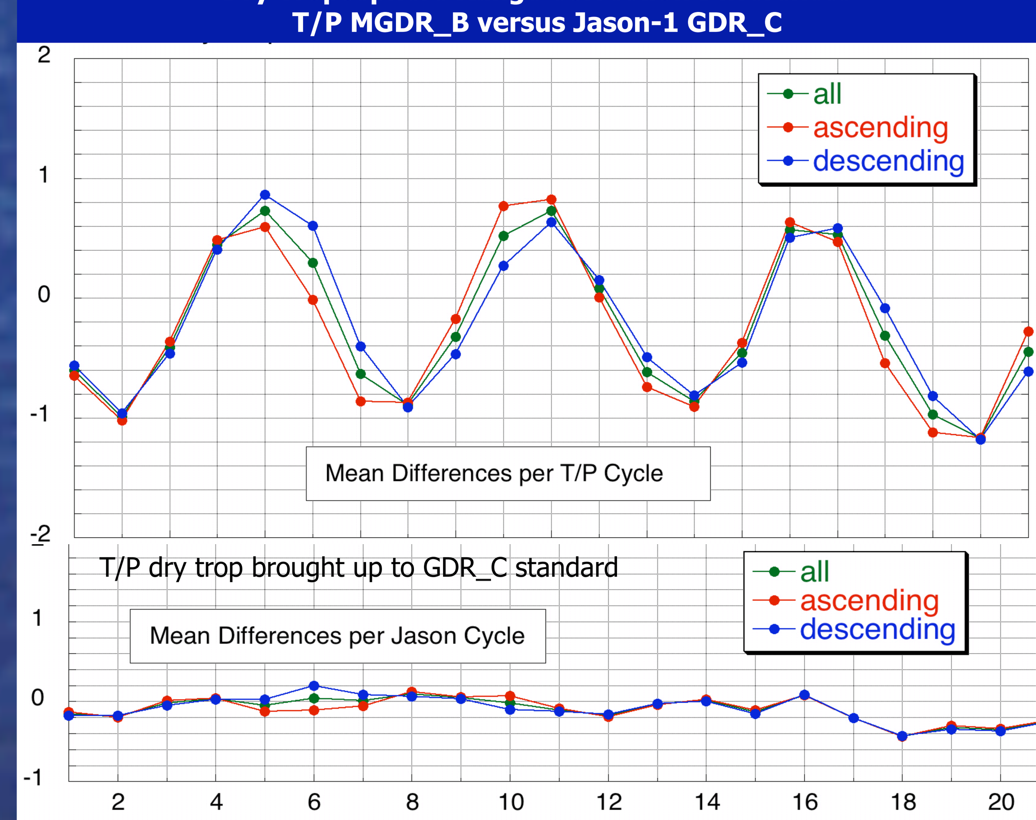
Dry Troposphere Path Delay Range Correction Differences

T/P MGDR_B cycle 348 minus corresponding validation phase Jason-1 cycle 5



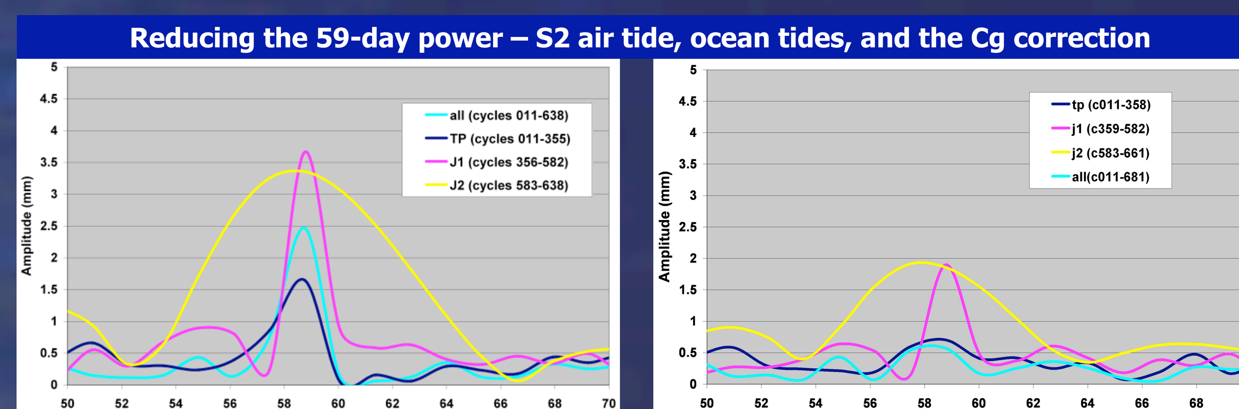
Regional differences in the dry troposphere correction depict the regional pattern of the S2 air-tide standing wave; an omission error that exists in the current MGDR_B. Revisions to the T/P dry troposphere correction to better account for S2 air-tide were performed employing the ECMWF Re-analysis Interim product.

Dry Troposphere Range Correction Differences T/P MGDR_B versus Jason-1 GDR_C



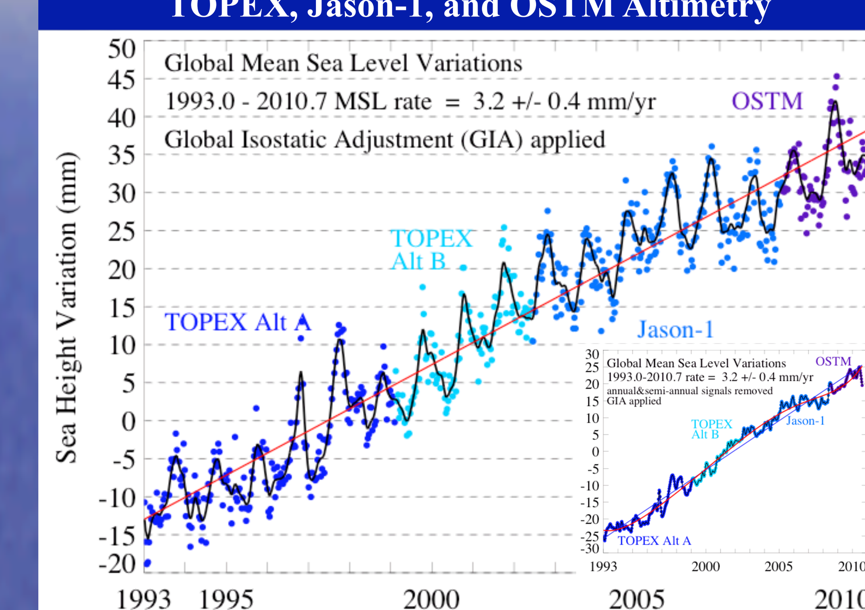
One possible source of 59-day power is the S2 air-tide in the T/P dry troposphere correction is not properly accounted for as in the Jason GDR_C standard. The above plot shows the better agreement after recovery of the S2 air-tide contribution to the T/P dry tropospheric range path delay.

Reducing the 59-day power – S2 air tide, ocean tides, and the Cg correction



The periodogram in the ***left figure*** is derived from MSL variations that were estimated by applying the original MGDR_B dry trop, the GOT4.7 tide model, and without the application of the Cg correction. The ***right figure*** is derived from MSL variations in which the SSH had the revised T/P dry trop applied, the Cg correction (sign convention as stated in MGDR_B handbook), and with a revised GOT4.9 ocean tide model which has the S2 constituent updated from revised T/P altimetry. Sorting out the correct sign convention of the Cg correction, and the proper accounting of the S2 contributions in the empirical derivation of the ocean tides has resulted in an on-going "enthusiastic" exchange resulting in a special session devoted to these issues.

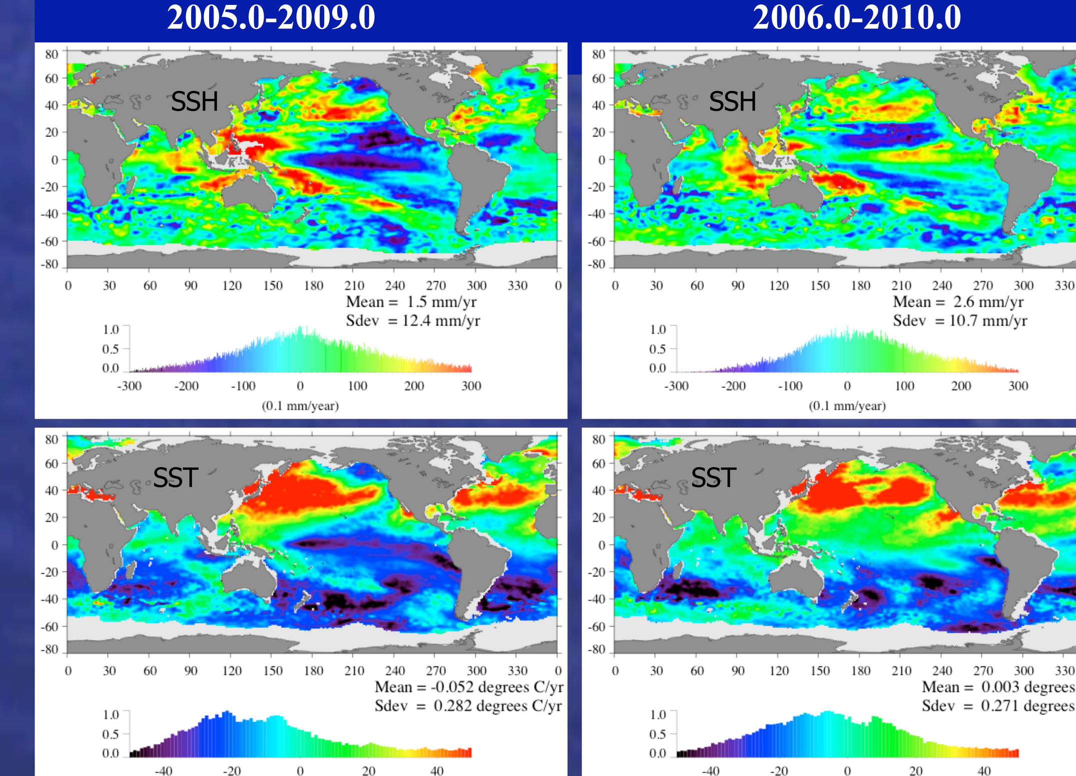
Global Mean Sea Level Estimated from TOPEX, Jason-1, and OSTM Altimetry



Global mean SSH variations from TOPEX, Jason-1, and OSTM with respect to 1993 – 2002 mean are plotted every 10 days. The solid black line is the sea surface height variation with a 60-day Hanning filter applied revealing the annual cycle. ***Inset Image***: The global mean sea level rate is estimated from linear fit (bold red line) after removal of annual and semi-annual signal. The MSL rate over the entire time span is **3.2 ± 0.41 mm/yr**. SSH values throughout entire series are based on consistent GSFC std1007 (ITRF2008) replacement orbit. MSL rate error reported above is the root-square sum of the tide gauge precision and the variance of the global mean SSH variations about the linear fit.

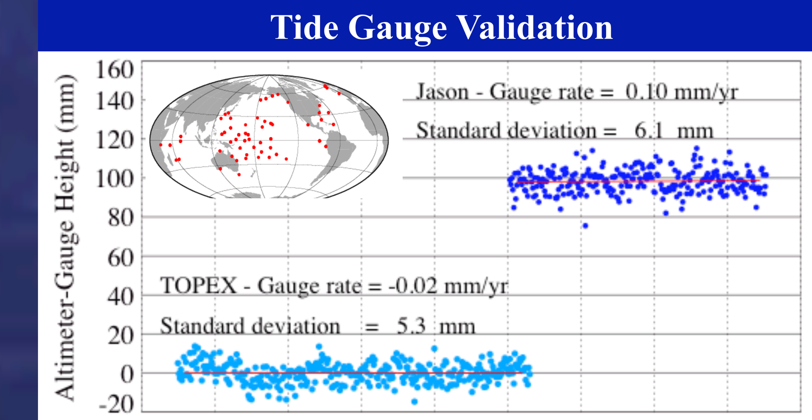
Recent Mean Sea Level and SST Trends

2005.0-2009.0 — 2006.0-2010.0



Over the last several years global mean sea level trends had "leveled off" due in part due an extended La Nina period, with a negative global mean SST trend. The transition over the past year revealed from the SSH and SST (sea surface temperature from AVHRR) trends shows the breakdown of this persistent event.

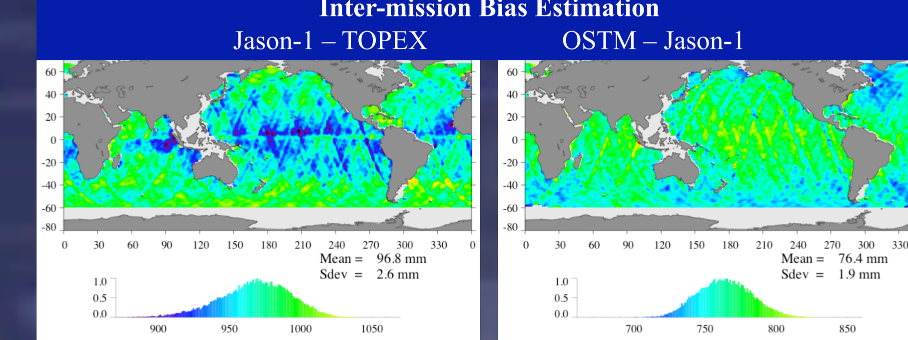
Tide Gauge Validation



TOPEX and Jason-1 sea surface height variations are compared to tide gauge variations from 64 sites. Altimeter SSH values are based on GSFC std1007 (ITRF2008) orbits, and most recent recalibrated TMR and JMR wet troposphere range corrections. Estimated instrument bias derived from tide gauge comparisons are consistent with global mean collinear differences during the verification phases.

Inter-mission Bias Estimation

Jason-1 – TOPEX — OSTM – Jason-1



Inter-mission biases are estimated from collinear SSH residuals during the Jason-1 and OSTM verification phases.

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