Assessment of Global and Regional Sea-Level Estimates based on Reprocessed TOPEX/Jason Altimetry

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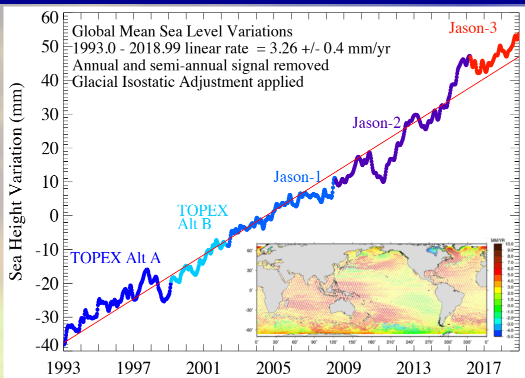
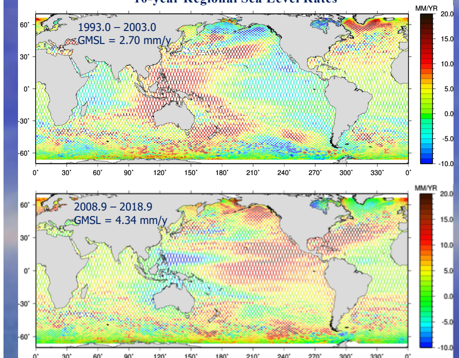
Abstract: Accurate sea-level projections based on global and regional rates derived from satellite altimetry warrants continuous improvements to the geocentric referenced sea surface height measurement. In the coastal zones signal-related problems and the degradation of geophysical and environmental range corrections pose challenges in determining local rates of sea-level rise. In this presentation we assess the efficacy of an adaptive iterative retracking procedure (ALES +) to improve the quality and retrieval rates of Jason-1 and Jason-2 range measurements. A status report is provided on the development of new POD standards which offers significant improvements in force and measurement modeling to further mitigate geographically correlated errors that translate directly into regional sea-level rates.

Current Global and Regional Mean Sea Level Estimates Referenced to ITRF2014

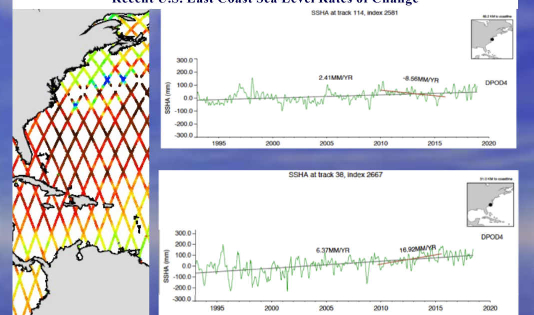


10-year Regional Sea Level Rates



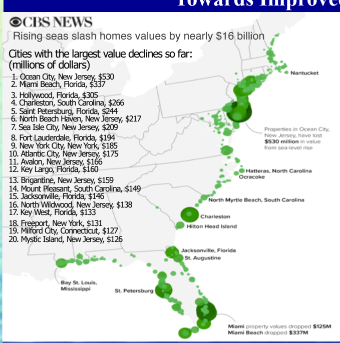
Left figure: Global mean sea level variations (and regional, inset) from 1993 through 2018 are estimated from NASA MEaSUREs v4.2 altimetry. The red line is the linear fit to the SSH variations after removal of annual and semi-annual signal and application of GIA. Regional sea level rates are shown above (middle figure) for the first and last 10-years of the T/P, Jason-1, 2, and 3 sea surface height time series. Two signatures of note are the reversal of the Pacific Decadal Oscillation (PDO) bringing significantly higher sea level rates to the U.S. west coast, and the rate reversal along southern Greenland coast as a result of ice mass loss post gravitational attraction effects.

Recent U.S. East Coast Sea Level Rates of Change

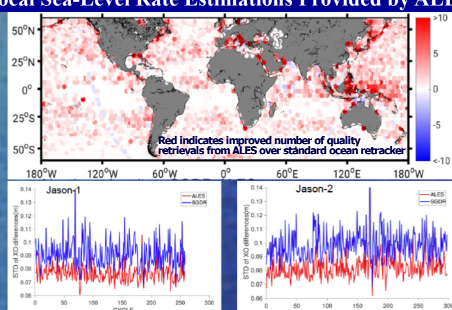


Local coastal dynamic mechanisms that contribute to sea level rate changes complicate projections particularly at short time scales. Recent work by Domingues et al., 2018 attributes accelerated sea level rates along the U.S. East coast south of Cape Hatteras to an ~ 1° C (0.2°/y) increase in the Florida Current from 2010-2015. In contrast rates fell sharply north of Hatteras during the same period which "was caused by an increase in atmospheric pressure combined with shifting wind patterns, with a small contribution from cooling of the water column over the continental shelf."

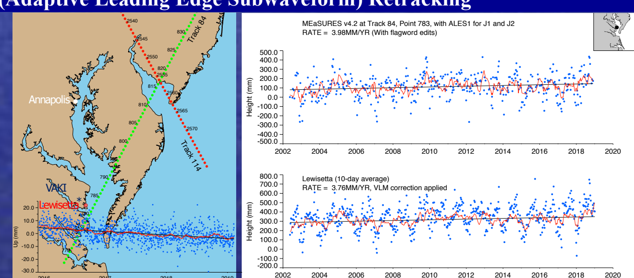
Towards Improved Local Sea-Level Rate Estimations Provided by ALES + (Adaptive Leading Edge Subwaveform) Retracking



Recent CBS news article reports current estimates of home devaluations along U.S. Gulf and East coast as a consequence of "rising seas" underscoring stakeholders concerns for accurate sea-level projections.



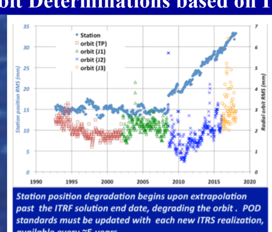
Jason-1 & 2 altimetry are reprocessed with ALES + retracking (Passaro et al., 2018) improving the fitting of peaky waveforms and mitigating noise in coastal and open ocean returns as well. Top image shows Jason-1 number of crossover residuals recovered with ALES+ versus standard mission ocean retracker. Plots above show variance reduction of crossover residuals of nearly 30% for Jason-1&2 in the coastal zone.

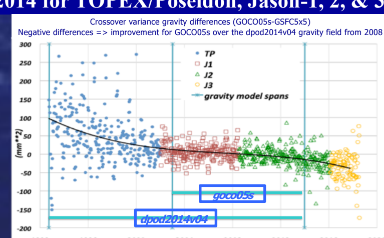


Local sea level is estimated near the entrance to the Chesapeake Bay from Jason-1 and Jason-2 altimetry reprocessed with ALES+ retracking (top right) at georeferenced index #783, ascending portion of revolution # 84. Good agreement is seen with sea level variations obtained from Lewisetta tide gauge after vertical land motion (VLM) correction (inset, left figure) is applied, estimated from GPS station VAKI from the NGL (Nevada Geodetic Laboratory) database (Blewitt et al., 2018).

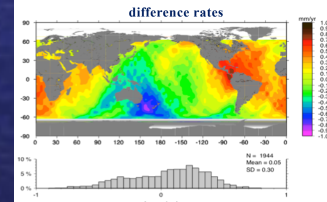
Improved Orbit Determinations based on ITRF2014 for TOPEX/Poseidon, Jason-1, 2, & 3 Altimetry

GSFC POD Developmental Updates		
Model	**dpod2014v04**	**std1808a**
GEODYN	1612	1802
gravity	GOCO02S +5x5 GSFC (1992-2014)	GOCO05S (2003-2014)
atmosphere gravity	ECMWF 50x50, 6-hour	GFZ 90X90 3-hour
mean pole	IERS2010	IERS2014 (linear)
integration step size	30 seconds	15 seconds
SRP	old TSI, Cr=0.945	new TSI, tuned SA+, X-, tuned Cr/arc
DPOD2014	Version 0.4	Version 2.0
LRA phase center	constant correction	constant + elevation
SLR bias template	gsfc2014 (ILRS_Data_Handling_File_2010.snx	gsfc2018 (ILRS_Data_Handling_File_2018-05-04.snx)
T2L2 SLR time bias	No	Yes
est. C31/S31 per arc	Yes	No



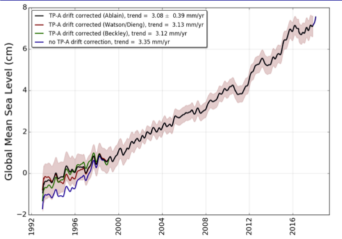


Jason-2/3 GSFC std1808a – JPl18a radial orbit difference rates

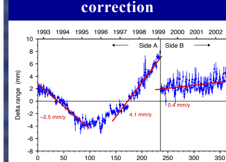


For altimetric satellite POD outside the "station solution interval" (1979 to 2008 for ITRF2008), the tracking station coordinates must be extrapolated. It is in this "extrapolation period" that we can see increasing degradation in tracking data fits and the resultant orbits based on ITRF2008, which can include potential drift error. We have evaluated ITRF2014 (Altamimi et al., 2016) and compared its performance to ITRF2008 (*Zelensky et al., 2017*). We see an improvement in the Satellite Laser Ranging Data RMS of fits per 10-day arc of 1-2 mm for ITRF2014 after 2010. This verification exercise will be repeated for the anticipated ITRF2020. GSFC is developing a new POD standard (left table), std1808, which offers significant improvements in force and measurement modeling over the previous dpod2014v04 standard. Even the intermediate std1808a version which is limited by the 2003-2014 gravity model definition span, shows improvement over all dpod2014v04 orbits from 2001. The non-gravity model updates offer orbit improvement over all the missions. GSFC is actively working to extend low order/degree GOCO05S-based coefficients to include the entire TOPEX period from 1992, and past 2014 to the present using SLR+DORIS satellite tracking data. Gravity updates past 2014 will serve to reduce current std1808a discrepancies with the JPL GPS-based orbits (right figure).

Revised estimates of GMSL based on reprocessed TOPEX altimetry

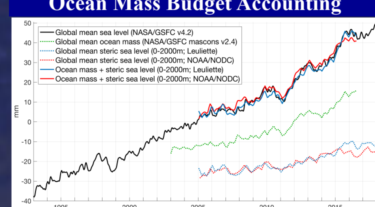


TOPEX cal-1 mode range correction



(Top left): Figure 2 from Cazenave et al., 2018: Evolution of ensemble mean GMSL time series (average of 6 GMSL products). On the black, red, and green curves, the TOPEX-A drift correction is applied respectively based on Ablain et al., 2017b, Watson et al., 2015, and Beckley et al., 2017 (cal-1 mode correction not applied). Uncertainties (90% confidence interval) of correlated errors over a 1-year period are superimposed for each individual measurement (shaded area). Top right: TOPEX cal-1 mode range correction.

Ocean Mass Budget Accounting



NASA MEaSUREs v4.2 GMSL variations based on GSFC std1808a orbits are compared to sum total of ocean mass+steric variations in an accounting towards mass budget closure. The above image shows the total ocean mass variations derived from GRACE GSFC Mascons v2.3 (*Luthcke et al., 2015*) and the steric component derived from two separate ARGO processing sources. The standard deviation of the GMSL minus (mass+steric) residuals is 1.52 mm.

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