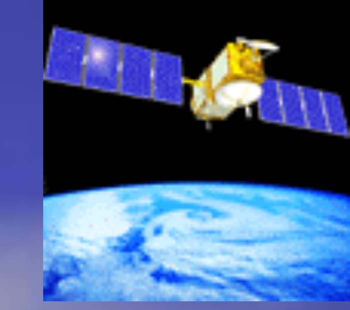

Impact of revised time variable gravity realizations on geocentric sea level estimates derived from the TOPEX/Poseidon/Jason Climate Data Record

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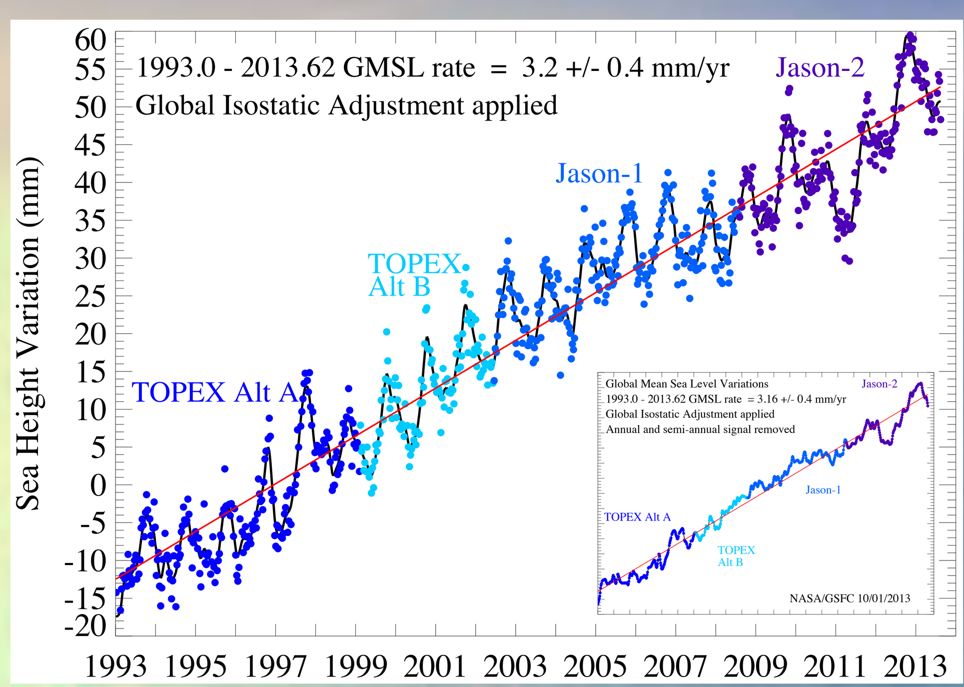
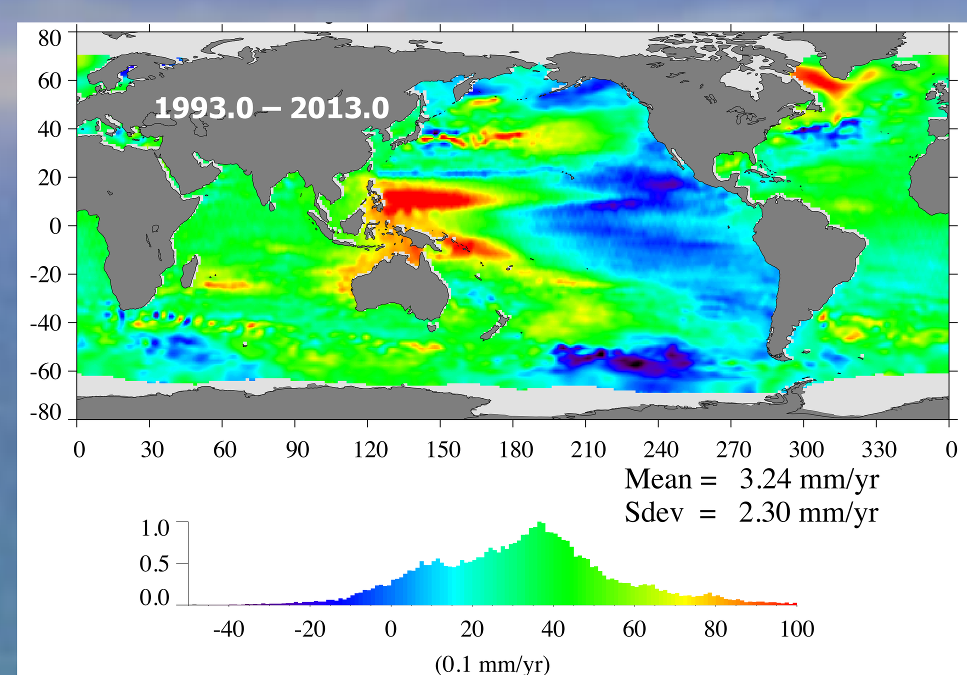
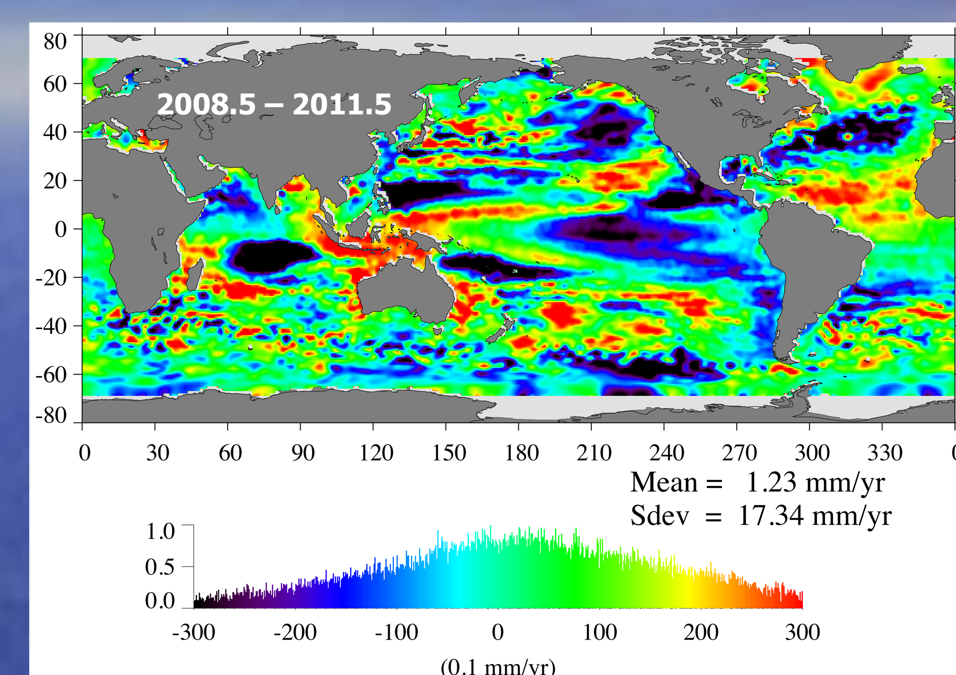
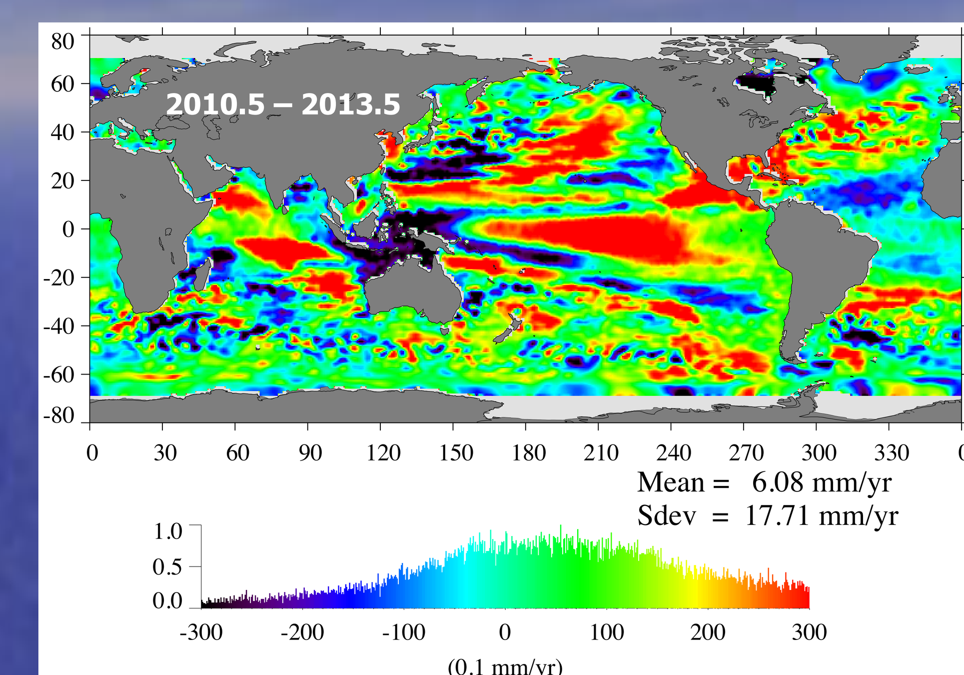
Abstract: Recent developments in Precise Orbit Determinations (POD) due to in particular to revisions to the terrestrial reference frame realization and the time variable gravity (TVG) continues to provide improvements to the accuracy and stability of the PO directly affecting mean sea level (MSL) estimates. 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. The stringent MSL acurracy requirements of a few tenths of a mm/yr are particularly essential for mass budget closure analysis over the relative short time period of Jason-1&2, GRACE, and Argo coincident measurements. In an effort to adhere to cross mission consistency, we have generated a full time series of experimental orbits (GSFC std1204) for TOPEX/Poseidon (TP), Jason-1, and OSTM based on the current ITRF2008 terrestrial reference frame (TRF) , and revised TVG (4x4) realization based on weekly SLR+DORIS snapshots that span the entire Climate Data Record . In this presentation we assess the TVG induced orbit error impact on Jason-2 regional MSL trends via inter-comparisons with the GSFC std1204 POD, the current GDR_D POD, the prior GDR_C, and the JPL GPS POD. Tide gauge verification results are shown to assess the current stability of the Jason-2 sea surface height time series as well as the 20+ year record.

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



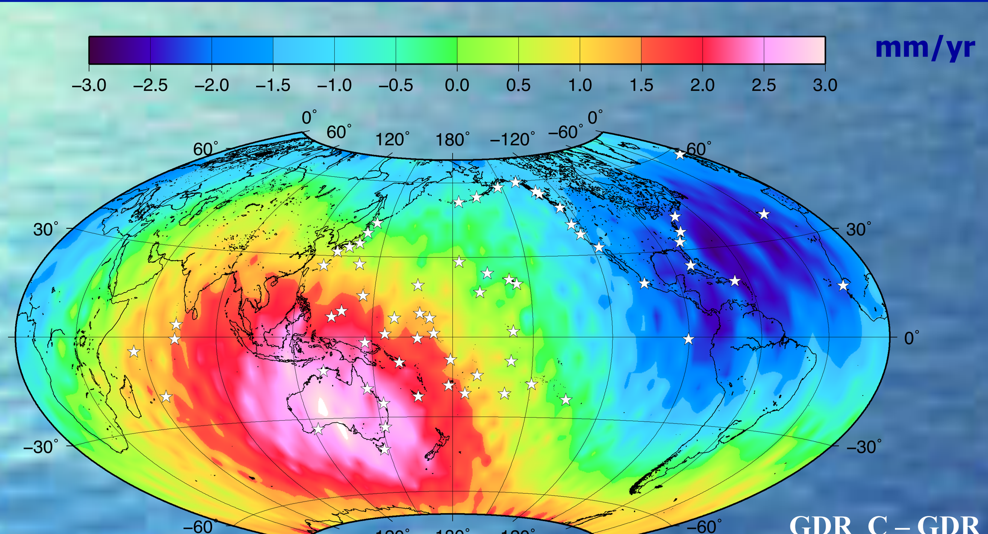




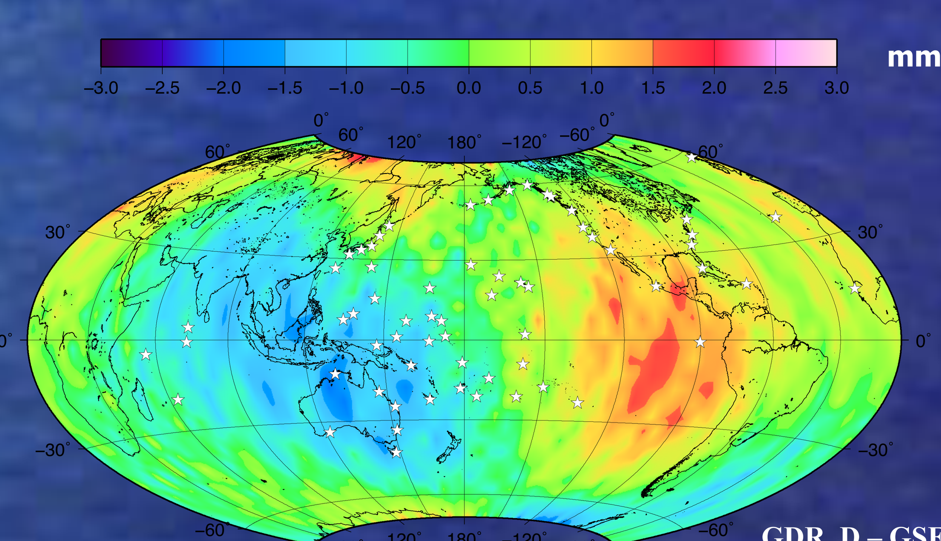


Global mean SSH variations (MEaSURE's TPJAOS v2) from TOPEX, Jason-1, and OSTM with respect to 1993 – 2002 mean are plotted every 10 days. The solid black line is the sea surface height variation with a 60-day Hanning filter applied revealing the annual cycle. Inset Image: The global mean sea level rate is estimated from linear fit (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 (GIA applied). SSH values throughout entire series are based on consistent GSFC std1204 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. In recent years during the Jason-2 period significant departures of global mean sea level variations with respect to the long term trend have been observed. These rapid departures are reflected in the regional mean sea level variations during the first three and last three years of the Jason-2 mission due in part to mass exchanges from ENSO transitions and mass influx from increased ice sheet melting, and underscores the need for improved time variable gravity realizations incorporated in the POD.

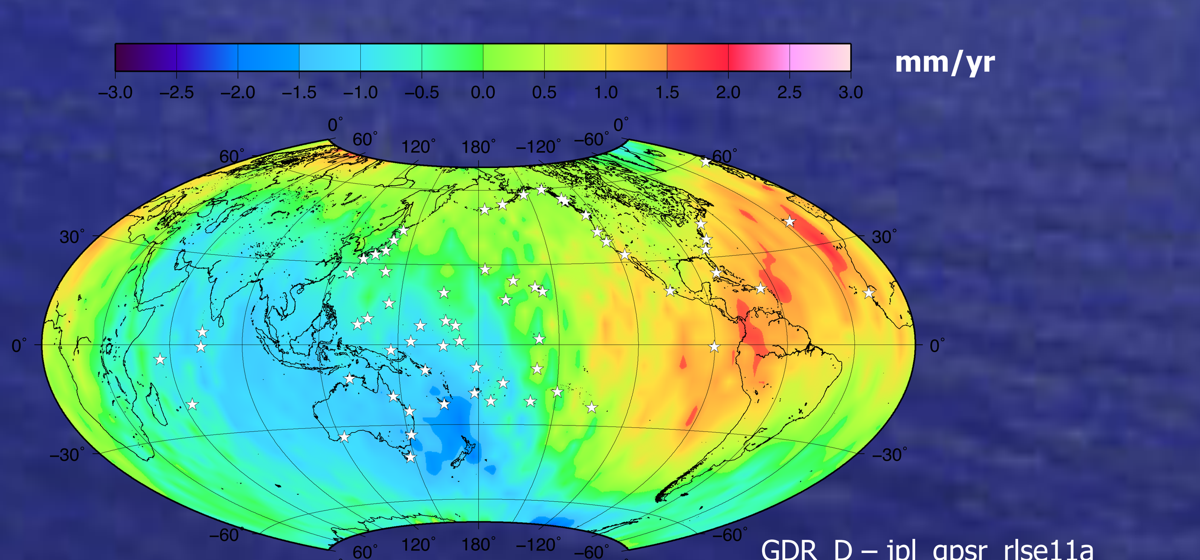
Impact of Time Variable Gravity realizations on Regional Mean Sea Level Estimated from OSTM Altimetry



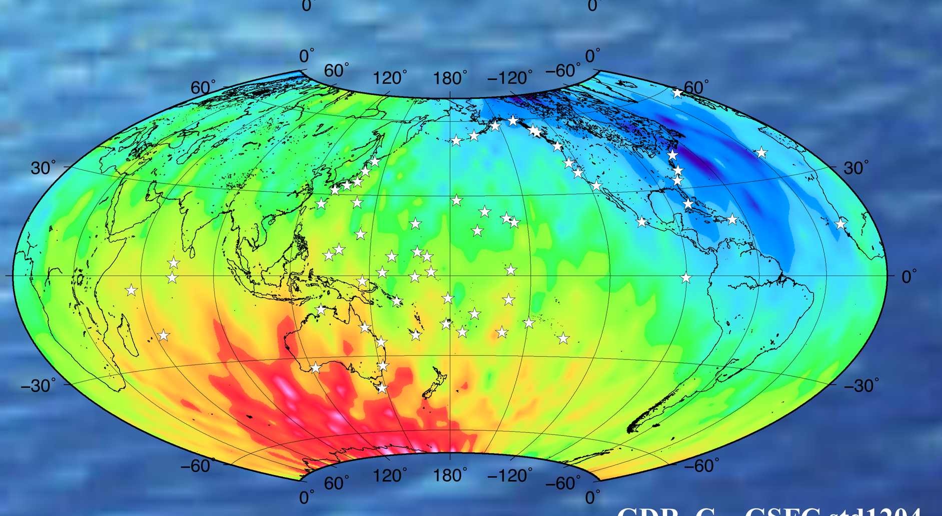
GDR_C – GDR_D



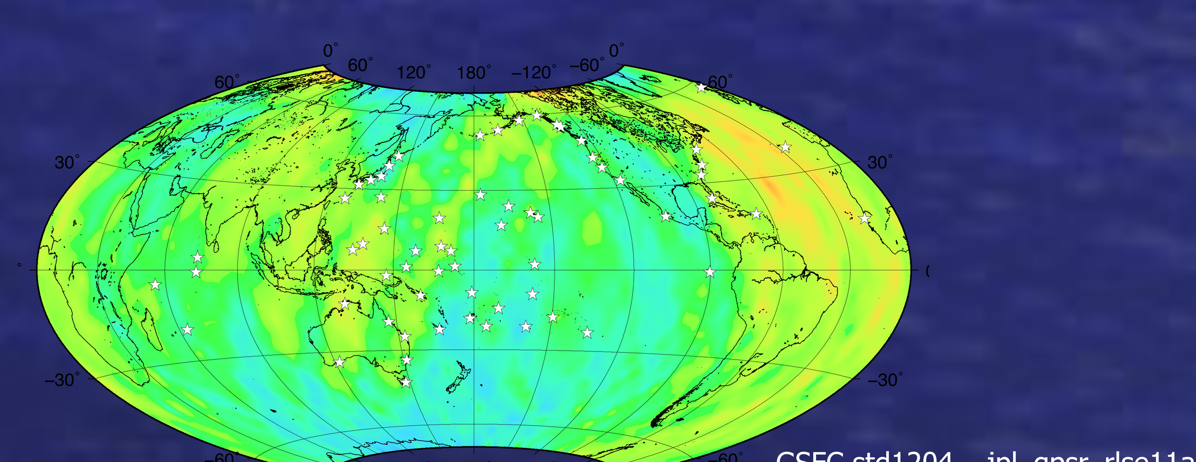
GDR_D – GSFC std1204



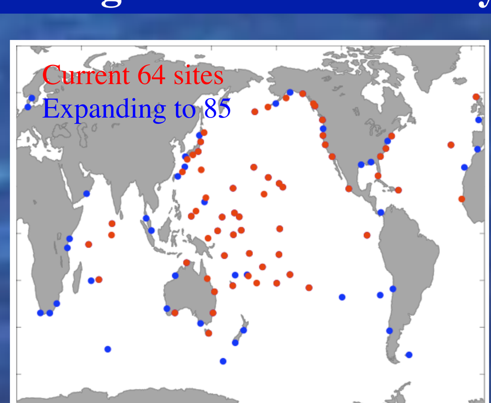
GDR_D – jpl_gpsr_rlse11a


GDR_C – GSFC std1204

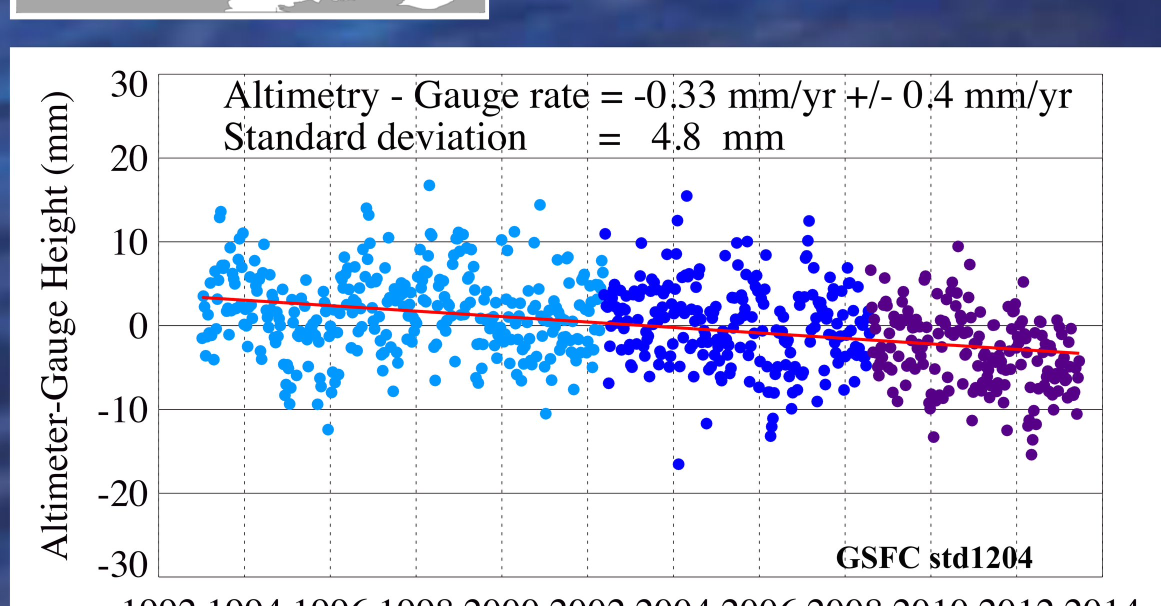
Impact on Jason-2 regional sea level trend estimates from TVG induced orbit error are shown via linear rates of orbit differences between various POD solutions. Significant regional trends with similar geographical correlated error signatures are observed for both the GDR_D and the GSFC std1204 PODs with respect to the initial GDR_t (version C standard) POD (left images). Note the white stars indicate the locations of the 64-site tide gauge network (Mitchum, 2000). The GSFC std1204 and GDR_D POD are based on improved TVG realizations derived from a much larger number of gravity coefficient linear rate terms as compared to the parsimonious accounting of TVG in earlier solutions (e.g. GSFC std1007 and the GDR_C). The GSFC std1204 tvg4x4 annual, semi-annual, and linear rate terms are derived from a fit to a 19.6-year tvg4x4 gravity coefficient time series estimated from weekly SLR/DORIS snapshots (Lemoine et al., 2012). The GDR_D tvg high-resolution (50x50) annual, semi-annual, and linear rate terms are derived from GRACE/LAGEOS over 2003-2010. Specifications of the individual POD strategies are detailed in Zelensky et al., poster. Some regional trend differences exist between the GDR_D and the GSFC std1204 POD (above figure). The alignment of these differences with the tide gauge network seem to have a cancelling effect on the tide gauge verification results shown below. An additional assessment is shown (right images) by comparing to the JPL GPS-only POD (jpl_gpsr_rlse11a) which is believed to be insensitive to TVG effects (Bertiger, et al., 2010).


GSFC std1204 – jpl_gpsr_rlse11a

Tide Gauge Verification Analyses

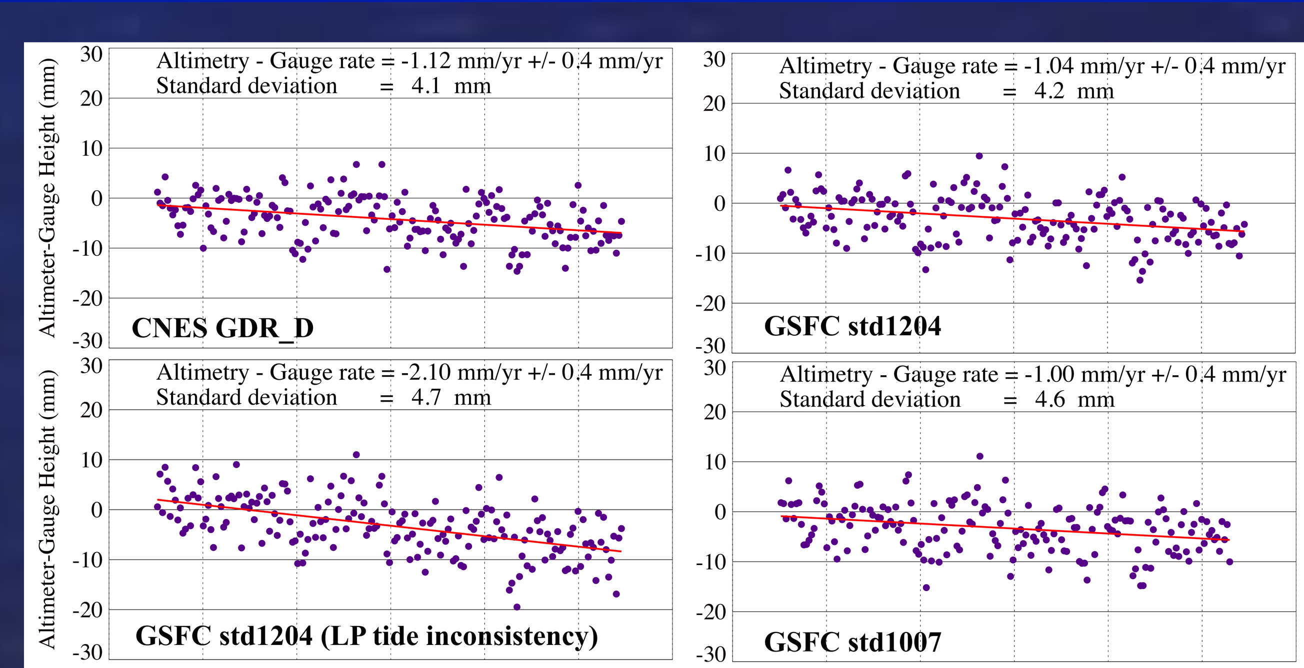


- *Prof. Gary Mitchum provides independent assessments of SSH time series for GSFC, NOAA, and U. of Colorado.*
- *Largest uncertainty in estimated rates arises from land motion at gauges.*
- *Vertical land motion corrections based on GPS series from Wöppelmann, et al., 2009.*



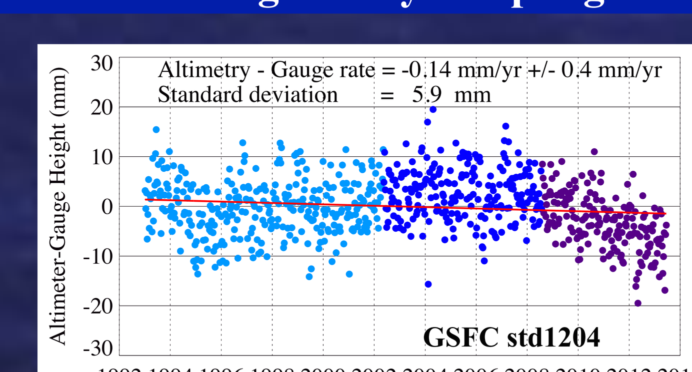
The above image shows the long-term drift estimate of the 20+ year SSH record (GSFC std1204) based on 10-day mean differences to a 62-site tide gauge network. Note the drift estimate is -0.11 mm/yr from 1993-2004, and -0.62 mm/yr from 2004-mid 2013.

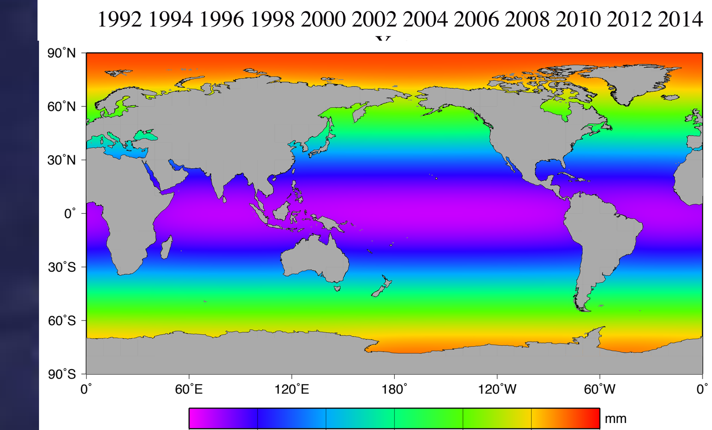
Jason-2 Drift Estimations

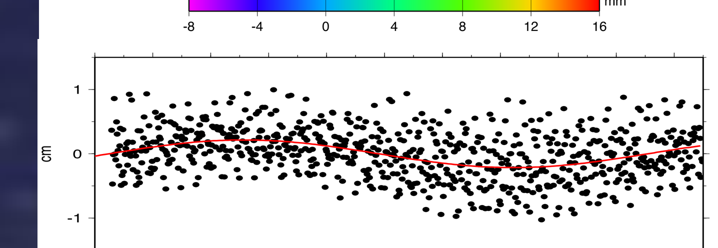


Jason-2 drift estimates are shown above for SSH time series based on the GDR_D and GSFC std1204 POD showing comparable stability, suggesting the tide gauge network geometry results in a cancelling effect of the geographically correlated TVG error. The lower figure shows an earlier GSFC std1204 based estimate compromised by an inconsistency in the application of the 18.6-yr Long Period (LP) tide. The drift estimate from an earlier GSFC std1007 solution is -1.00 mm/yr after resolving LP tide omission error.

Tide Gauge Analysis Epilogue







As the SSH time series approached 20+ years a long-period signal became more apparent in the altimetry/tide gauge mean height residuals (top figure). The 18.6-yr long-period tide was suspected. The middle image above shows the regional structure of the amplitude of the 18.6-yr node tide (self-consistent equilibrium) when nodal longitude N = 0° (Note: N = 0° during years …..1969, 1987, 2006…..). The above figure shows the expected signal that was removed from the altimeter SSH variations, but not the gauge height variations.

The authors acknowledge the University of Hawaii Sea Level Center for providing the most recent tide gauge data for comparisons against OSTM. This work is supported by NASA OSTM Science Working Team and MEaSURE' s funding.

Ocean Surface Topography Science Working Team Meeting, Oct. 8-11, 2013, Boulder, Colorado