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NASA Ocean Altimeter Pathfinder Project Report 2: Data Set Validation

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Abstract

The NOAA/NASA Pathfinder program was created by the Earth Observing System (EOS) Program Office to determine how existing satellite-based data sets can be processed and used to study global change. The data sets are designed to be long time-series data processed with stable calibration and community consensus algorithms to better assist the research community. The Ocean Altimeter Pathfinder Project involves the reprocessing of all altimeter observations with a consistent set of improved algorithms, based on the results from TOPEX/POSEIDON (T/P), into easy-to-use data sets for the oceanographic community for climate research.

Details are currently presented in two technical reports:
Report #1: Data Processing Handbook
Report #2: Data Set Validation

This report describes the validation of the data sets against a global network of high quality tide gauge measurements and provides an estimate of the error budget. The first report describes the processing schemes used to produce the geodetic consistent data set comprised of SEASAT, GEOSAT, ERS-1, TOPEX/POSEIDON, and ERS-2 satellite observations.

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1. Introduction

The Earth Observing System (EOS) Program Office created the NOAA/NASA Pathfinder program to determine how existing satellite-based data sets can be processed and used to study global change. The data sets are designed to be long time-series data processed with stable calibration and community consensus algorithms to better assist the research community.

The use of satellite altimetry for earth observations was proposed in the early 1960s ("Williamstown Report," MIT, 1970). The first successful space based radar altimeter experiment was flown on SkyLab in 1974 (McGoogan, et al., 1974). The first successful satellite radar altimeter was flown aboard the Geos-3 spacecraft between 1975 and 1978 (Geos-3 Project, 1979). While a useful data set was collected from this mission for geophysical studies, the noise in the radar measurement and incomplete global coverage precluded it from inclusion in the Ocean Altimeter Pathfinder program. This program initiated its analysis with the Seasat mission, which was the first satellite radar altimeter flown for oceanography (Seasat, 1982). This mission was followed by the U.S. Navy's Geosat satellite in 1985 to 1989 (Geosat, 1987, 1990). The European Space Agency's ERS-1 spacecraft was flown from 1991 to 1996 (ERS-1 System, 1992). ERS-1 was followed by the joint U.S. and French T/P mission from 1992 to the present (TOPEX/Poseidon, 1994, 1995) and ESA's ERS-2 spacecraft in 1996 (ERS-2 Spacecraft, 1995). Table A.1 summarizes the dates of these missions, the data coverage, and the length of time for which a Pathfinder data set has been constructed.

The Ocean Altimeter Pathfinder Project involves the reprocessing of all altimeter observations with a consistent set of improved algorithms, based on the results from TOPEX/POSEIDON (T/P), into easy-to-use data sets for the oceanographic community for climate research. Two data sets have been produced and are described in detail in Report #1: Data Processing Handbook (Koblinsky et al., 1998). This report describes the validation of these data sets against a worldwide set of high quality tide gauge measurements.

The first product is the collinear time series of sea surface height at fixed locations along the track of the spacecraft. In these data only minimal interpolation and smoothing has been done to the altimeter measurement. The second product is the grid data set which consists of monthly anomalies relative to an annual reference surface from all missions to provide a near decade long data set of sea level anomalies. In this data set substantial smoothing and interpolation has been done to create equally spaced consistent grids across all missions.

Tide gauge measurements have been acquired over many years for a variety of purposes. The data sets utilized in validating the Pathfinder data products were obtained from the ftp site of the University of Hawaii Sea Level Center (UHSLC) see http://uhslc.soest.hawaii.edu. Especially intended for altimeter calibration, the WOCE (World Ocean Circulation Experiment) "fast" Sea Level Data were used for the collinear data validation. These data include hourly and daily values at selected stations. For the validation of the grid data set the monthly Sea Level Deviations provided by UHSLC under IGOSS (Integrated Global Ocean Services System) were used. These data are monthly anomalies with respect to a twenty-year average and

have been pressure corrected. The inventory of the sites and data record span for each data set is given in the Appendix.

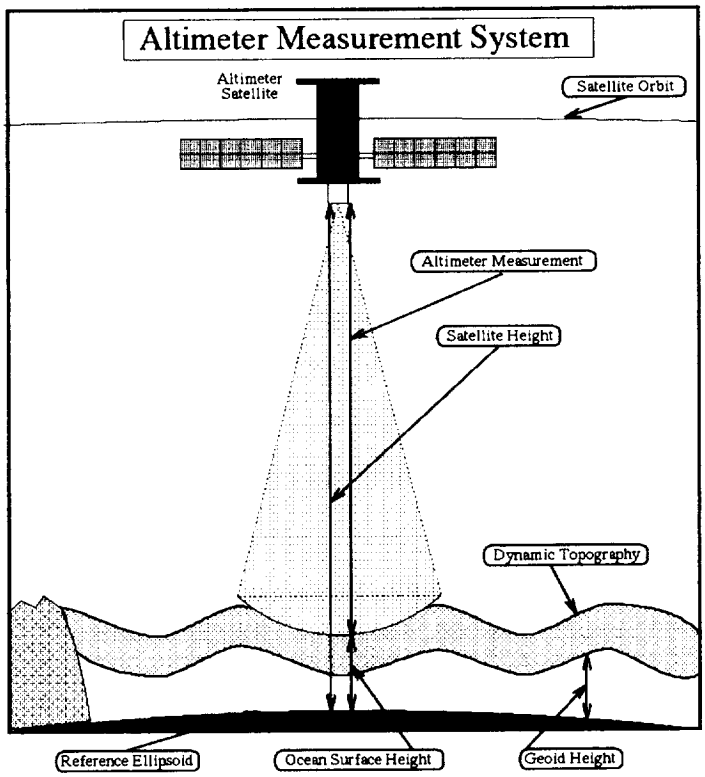
The second section of this report describes the algorithms that are used to compare these data sets for validating the altimeter product accuracy. The third section describes the comparisons between the Pathfinder collinear data set and the tide gauges. The fourth section describes the comparisons between the Pathfinder grid data set and the tide gauge data.

2. Comparison Algorithms

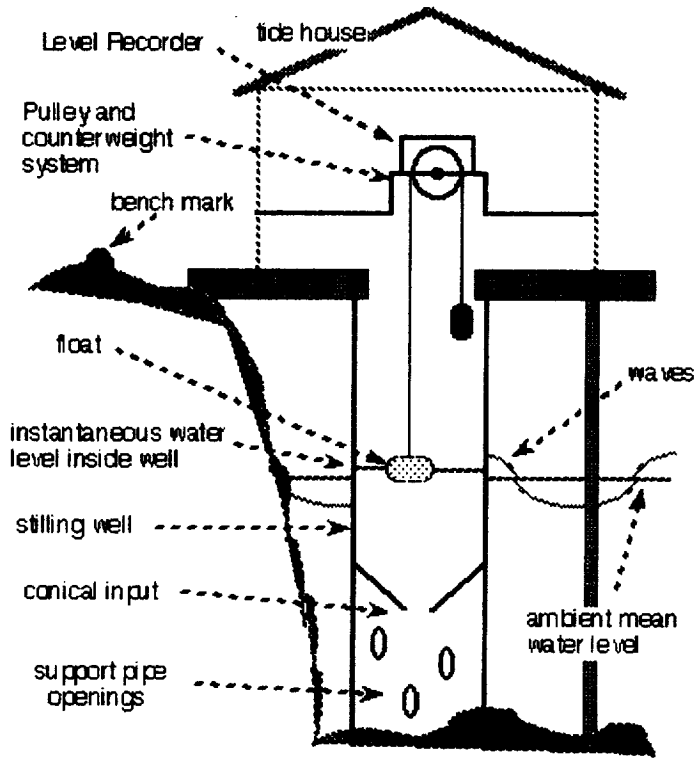
The satellite altimeter measurement of surface height is observed by merging two complicated measurements, the radial position of the space based ranging instrument relative to the center of the planet, and the round-trip travel time of a radar or light pulse sent from the spacecraft (see Figure 1). To transform satellite altimeter range and orbit measurements into accurate sea-surface elevation data, a variety of models, algorithms, and corrections need to be adopted and applied. These include the determination of the satellite position within a consistent geodetic reference frame, the correction for atmospheric range refraction and radar ranging corrections, and the removal of unwanted geophysical effects, such as tides and atmospheric loading. Most of the adopted PATHFINDER corrections and algorithms are consistent across satellite missions, but some are specific to an individual mission. Pathfinder Report #1 describes the algorithms applied to the Pathfinder altimeter data (Koblinsky et al, 1998).

Tide gauge measurements are made with a variety of instruments (Pugh, 1987., Gill and Mero, 1990.) that measure the level of the water relative to a fixed benchmark on land (See Figure 2). Gravity and surface tension waves are filtered out by the measurement transducer or through the use of a "stilling well". The observations are collected at a high frequency and filtered to minutes or hourly rates. (Caldwell and Merrifield, 1996).

- ***Figure 1 A schematic of the satellite altimeter measurement of sea surface topography.***



- ***Figure 2 A schematic of the tide gauge measurement of sea level.***



2.1. Collinear Comparison Algorithms

The purpose of the comparison between the collinear altimeter sea surface height variations and the tide gauge measurements is to evaluate the total measurement differences as close in space and time as possible.

2.2.1. Data preparation

The time periods and sources of data are listed in the Appendix. In the comparisons described in this report the tides have been removed from both the tide gauge and altimeter data sets. For the altimeter the tide is removed using the models described in Report #1. For the tide gauges daily sea level values from the WOCE "Fast Delivery" Sea Level Center were employed. The daily sea level values have been low pass filtered to remove diurnal and semi-diurnal tide signals (Mitchum, 1994). For the collinear comparisons the atmospheric load has not been removed from either data set. For all the collinear data sets, no adjustments have been performed to remove systematic orbit errors.

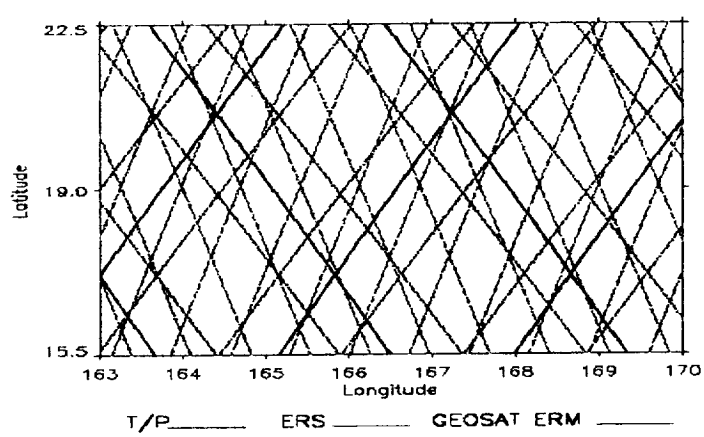
2.2.2. Temporal and spatial alignment

Tide gauge data sets come with a variety of sampling intervals depending on the purpose of the data. Time intervals are typically: minutes (raw data), hourly, daily (tide removed), monthly (tide removed), and annual average. In order to study the impact of these sample frequencies on the altimeter collinear comparison a thorough analysis should evaluate the impact of each step of the processing. However, for the current version of the report we only consider:

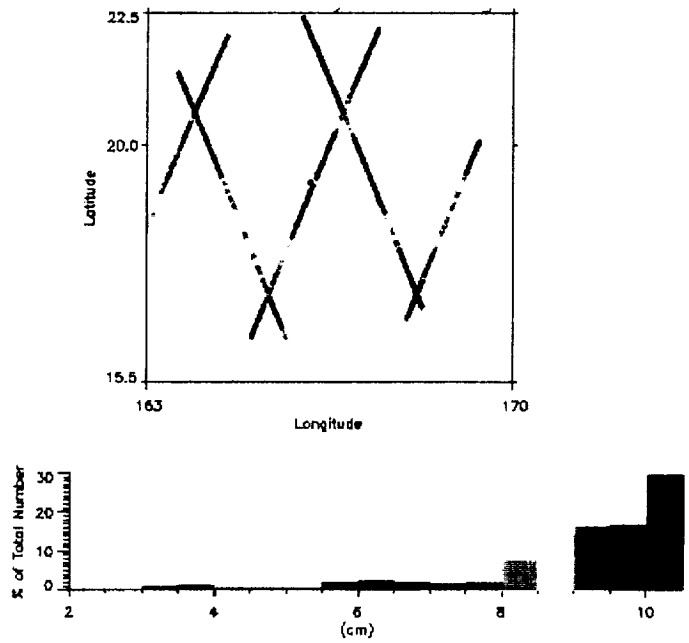
- Closest point in time and space, tides removed, using daily tide gauge data and collinear altimetry.

The spatial alignment between the altimeter measurement and the tide gauges varies among satellites and tide gauges. Figure 3 shows a sample map of the ground tracks for the GEOSAT ERM, ERS-1 35-day repeat, and the T/P 10-day repeat missions relative to the tide gauge at Wake Island. The distance between the tide gauge and the satellite measurement is extremely variable. In order to evaluate the impact of this difference, we extracted all collinear altimeter data within a 3°x3° region around each gauge and compared all data in this region. Figure 4a shows the sharp reduction in the sea surface height rms with increased proximity of the T/P alongtrack altimeter observations with the tide gauge at Wake Island. Fortuitously, the T/P groundtrack runs nearly adjacent to the Wake Island station. In contrast, the Majuro Island station lies nearly 100 km from the closest along-track location (Figure 4d). Despite the location of the Majuro station with respect to the T/P groundtrack geometry, it compares to the T/P altimetry to a precision of less than 4 cm RMS over a period of 5 years (Figure 4e). Though as expected, most stations consistently exhibited improved statistics with along-track locations of closest proximity.

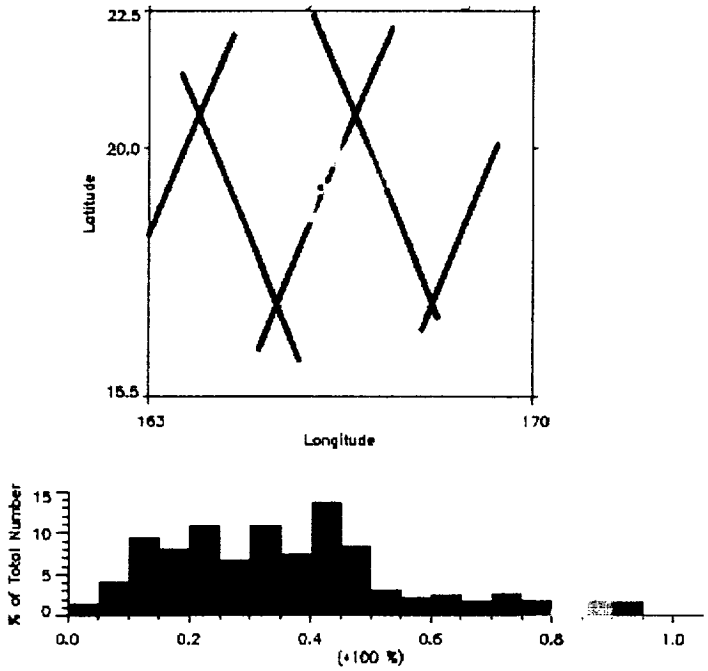
- ***Figure 3 Groundtrack geometry about Wake Island Tide Gauge Station (19° 17'N, 166° 37'E).***



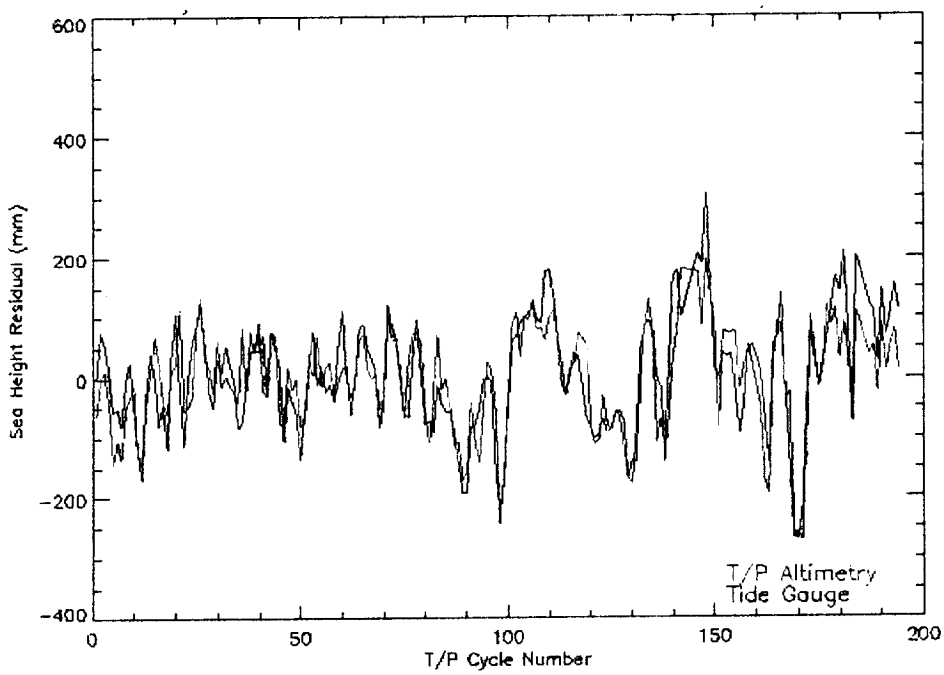
- ***Figure 4a RMS Differences between daily tide gauge values at Wake Island station (19° 17'N, 166° 37'E) and T/P collinear observations.***



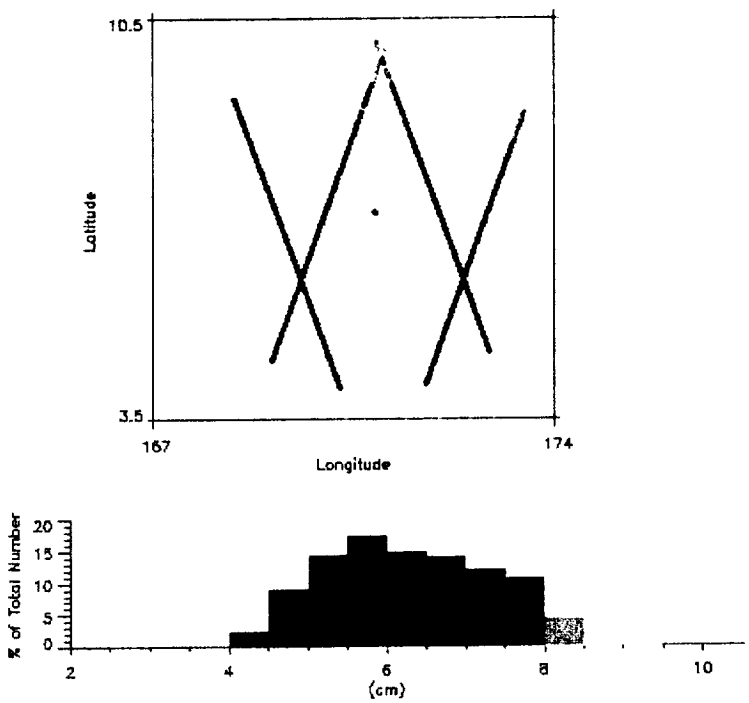
- ***Figure 4b Correlation between daily tide gauge values at Wake Island station (19° 17'N, 166° 37'E) and T/P collinear observations.***



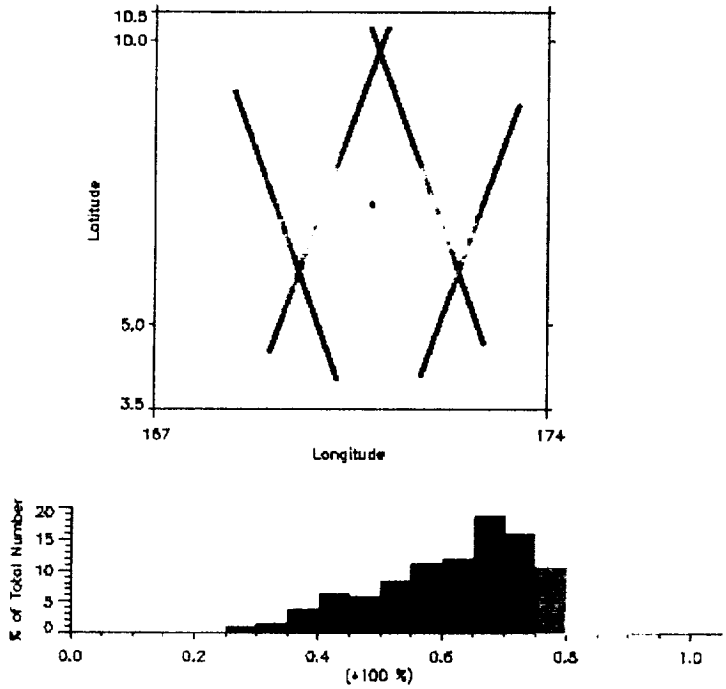
- ***Figure 4c Time series between daily tide gauge values at Wake Island station (19° 17'N, 166° 37'E) and T/P collinear observations. RMS=53 mm, CC=0.88.***



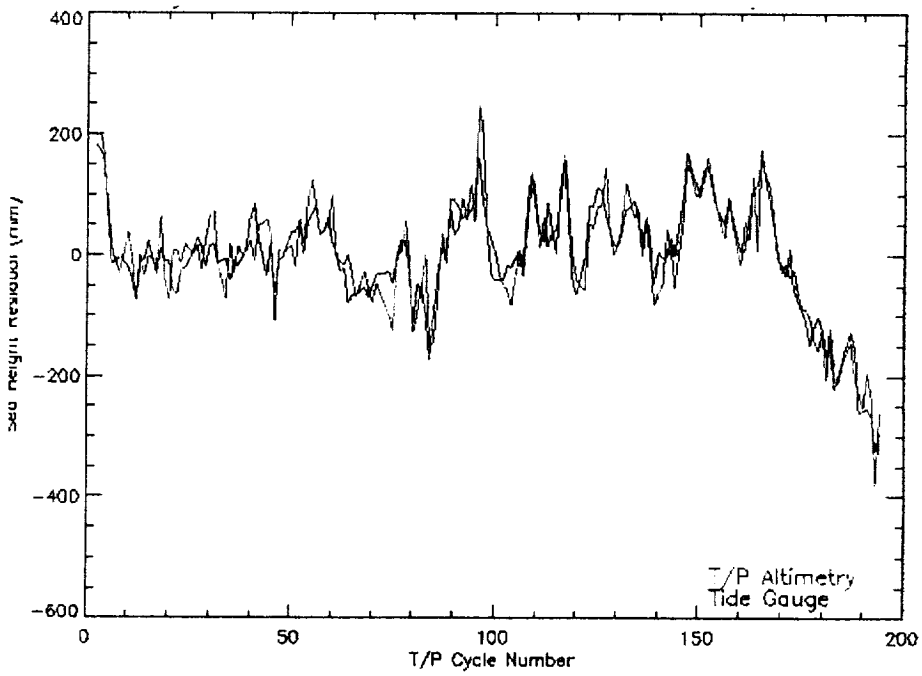
- ***Figure 4d RMS Differences between daily tide gauge values at Majuro station (07° 06'N, 171° 22'E) and T/P collinear observations.***



- ***Figure 4e Correlation between daily tide gauge values at Majuro station (07° 06'N, 171° 22'E) and T/P collinear observations.***



- ***Figure 4f Time series between daily tide gauge values at Majuro station (07° 06'N, 171° 22'E) and T/P collinear observations. RMS = 35mm; CC = 0.94.***



2.2.3. Comparison tools

We have computed three parameters in our comparison of the collinear data sets. The point-to-point root-mean-square difference (rms) between the tide gauge and altimeter time series. The point-to-point correlation (Cor) between the tide gauge and altimeter time series. The point-to-point signal-to-noise ratio (SNR) between the tide gauge and altimeter time series, where the signal-to-noise is defined as the rms of the tide gauge measurement divided by the rms difference between the altimeter and tide gauge measurements at a point. Comparisons are made between all altimeter data within the 3°x3° region surrounding the tide gauge to examine the variation in these variables.

2.3. Grid Comparison Algorithms

The purpose of the comparison between the gridded altimeter sea surface height variations and the tide gauge measurements is to evaluate the utility of the multiple altimeter measurement set for studying long term climate variability. In this comparison the grids from all satellites are examined against the tide gauge time series.

2.3.1. Data preparation

The time periods and sources of data are listed in the Appendix. In the comparisons described in this report the tides and the atmospheric load have been removed from both the tide gauge and altimeter data sets. For the altimeter the tide and atmospheric load is removed using the models described in Report #1. For the tide gauges monthly sea level anomalies were provided by the IGOSS Sea Level Program in the Pacific (ISLP-Pac). The sea level anomalies are with respect to the 1975 – 1995 mean annual cycle of sea level. These anomalies are corrected for the inverted barometer effect using the atmospheric pressure fields computed at the National Meteorological Center (Mitchum, 1994).

2.3.2. Temporal and spatial alignment

The spatial alignment between the altimeter measurement and the tide gauges varies among satellite ground tracks and tide gauge locations. Monthly sea surface height grids from altimeter observations were derived by estimating at each node on a 1° x 1° regular grid, a weighted average of cross over or collinear differences (within a 3° radius) with respect to the mean 1993 reference surface. The gridding algorithm is fully described in Report 1: Data Processing Handbook. Regardless of the tide gauge location relative to the grid cell, the grid value is assumed to be constant across the grid node and so the comparison is the same anywhere within the cell.

3. Evaluation of Product 1: The Collinear Data Set

3.1. Description

The Pathfinder Project began its work by reproducing all GDRs for each mission with revisions based upon the corrections described in Report #1. These new GDRs formed a basis for the formation of 'easy-to-use' products. The first product created from these data and distributed to the community was the simplified collinear data set. This data set consists of files containing regularly spaced, spatially indexed, collinear sea surface heights with respect to a reference mean sea surface. These data were derived from collinear mission data only. For the temporal coverage of the collinear missions see Table 1.

- ***Table 1 Collinear data coverage.***

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
86											Geosat	Geosat
87	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat
88	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat
89	——	——	——	——	——	——	——	——	——	——	——	——
90												
91								——	——	——	——	——
92	——	——	——	——	ERS-1	ERS-1	ERS-1	ERS-1	ERS-1	ERS-TP	ERS-TP	ERS-TP
93	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP
94	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP	TP
95	TP	TP	TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP
96	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP
97	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP	ERS-TP

Altimeter satellites that are maintained in a repeating orbit facilitate the separation of sea height variations from the geoid. The term 'collinear' refers to sea surface heights for a particular 'exact repeat orbit' mission that have been georeferenced to a specific groundtrack. The collinear data file contains sea surface heights for each orbit cycle at fixed locations thus allowing for the direct analysis of Sea Surface Height (SSH) variability with tide gauge time series.

3.2. Comparisons

These data sets were compared against the tide gauges described in the Appendix. A series of tests were carried out to determine the indexed alongtrack locations which best represented sea surface variations as monitored by the tide gauges. The primary determining factors were proximity of the indexed along-track locations to the tide gauge and the number of cycles containing valid altimeter measurements. A secondary factor considered locations that were identified as those where anomalous sea surface height variations were believed to be due to highly localized ocean dynamics. Daily tide gauge measurements

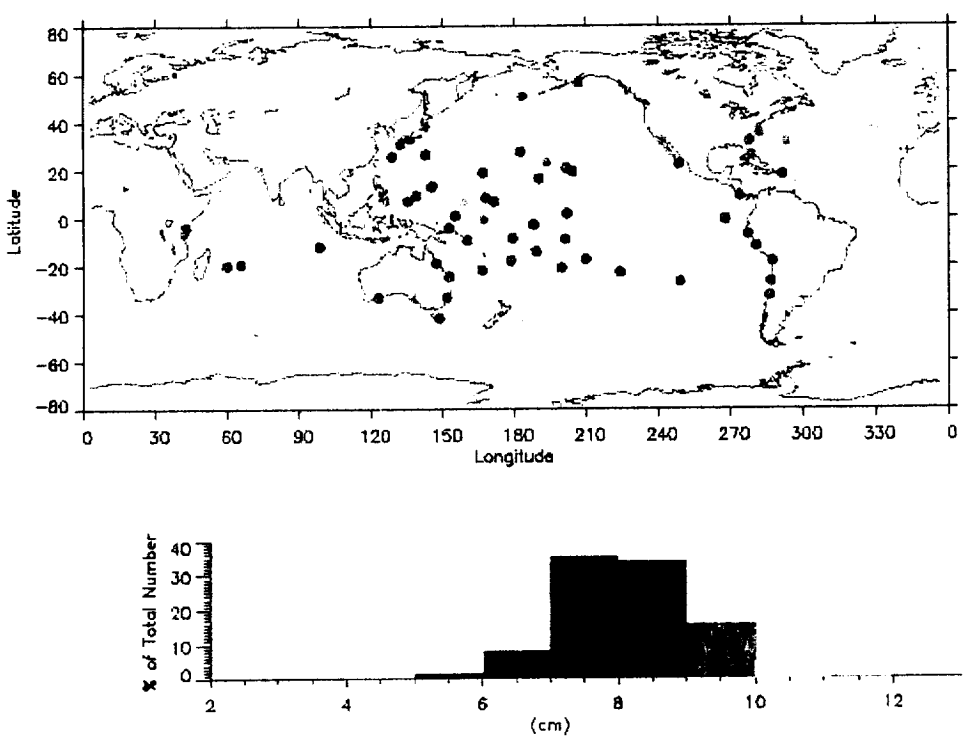
were linearly interpolated to the altimeter observation time. Sea surface height variations were then computed for the tide gauge and altimetry time series about their respective means. Figures 5 through 9 show the rms differences between the daily tide gauge measurements and the collinear altimetry for the GEOSAT, ERS, and TOPEX/POSEIDON repeat missions. The correlations for each mission are shown in Appendix B, Tables B.1 to B.5. Each color-coded dot represents a bulk statistic for each individual tide gauge comparison. Sea surface height variation profiles as illustrated in Figure 4f for each station are not provided in this report, but can be viewed on the Ocean Pathfinder website at:

http://neptune.gsfc.nasa.gov/ocean.html

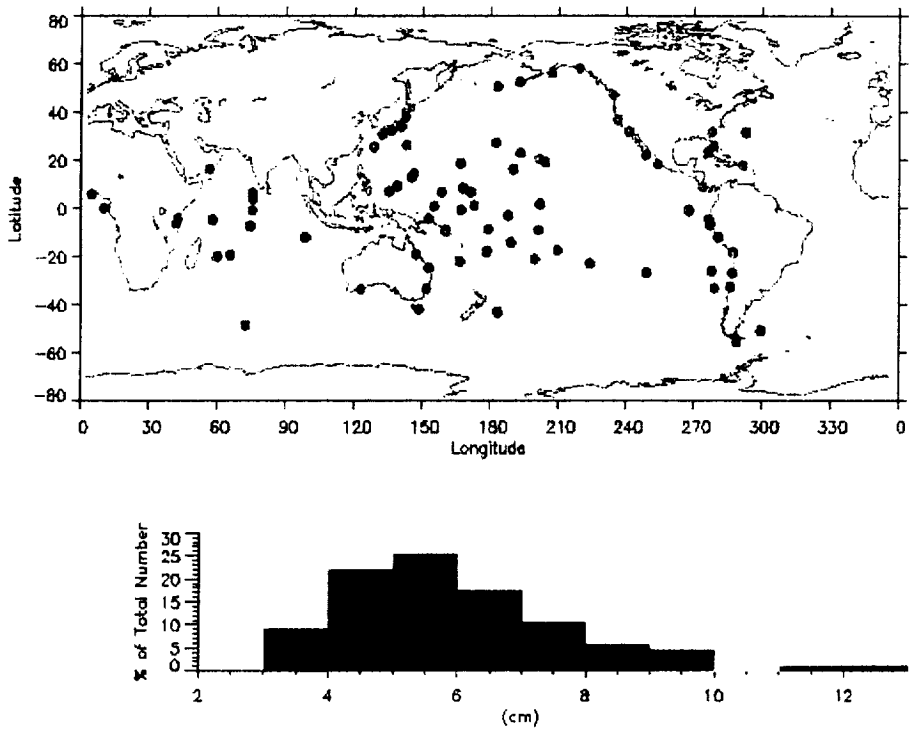
Summary tide gauge station statistics for each mission are listed in Table 3.2, and the individual station statistics are compiled in Appendix B. Globally averaged statistics listed in Table 3.2 show ERS mean rms differences to be consistent though slightly lower than TOPEX/POSEIDON. This probably can be attributed to the groundtrack resolution of the ERS 35-day repeat period.

All of the tide gauge data were not used in each tests. For most, a sub-sample was used based on experience.

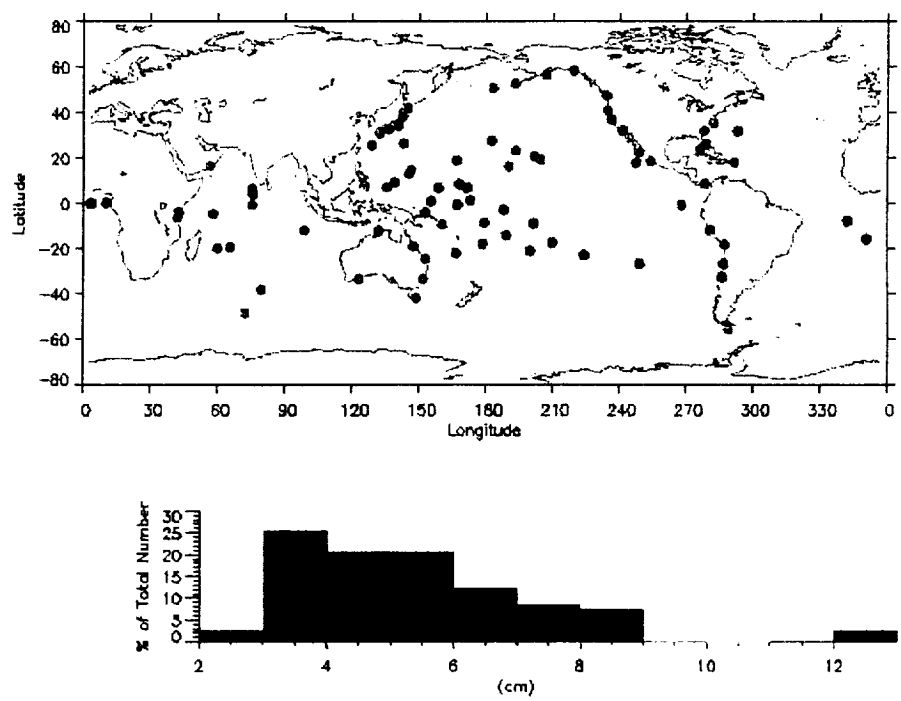
- ***Figure 5 RMS differences between daily tide gauge values and collinear Geosat data.***



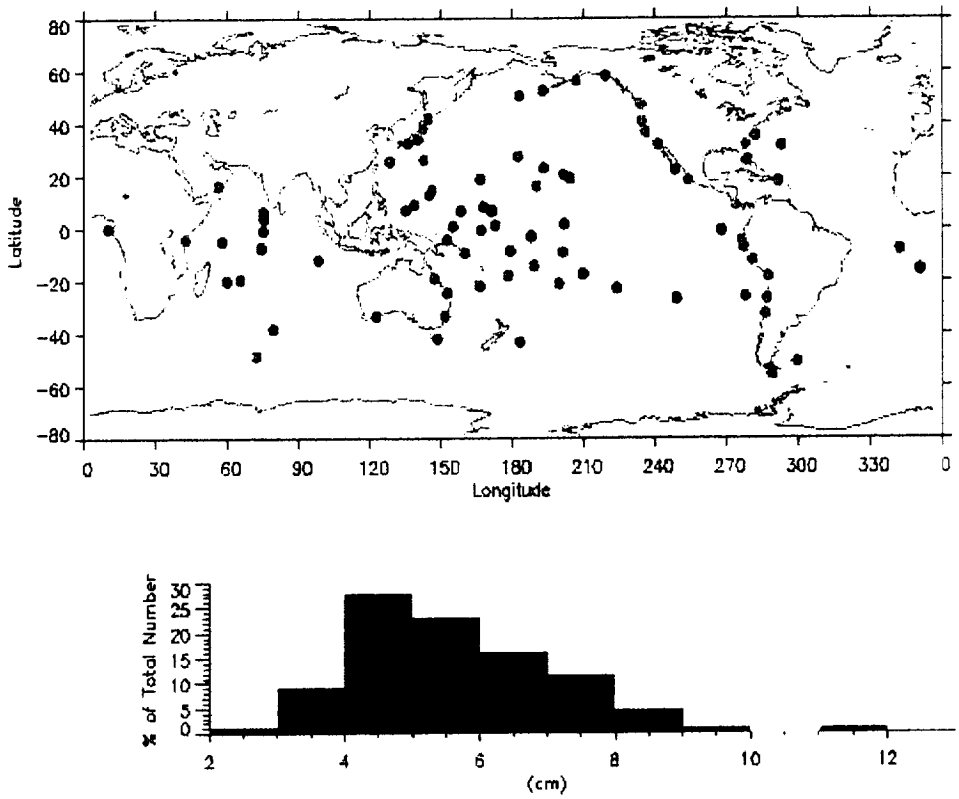
- ***Figure 6 RMS difference between daily tide gauge values and collinear ERS-1 Phase C data.***



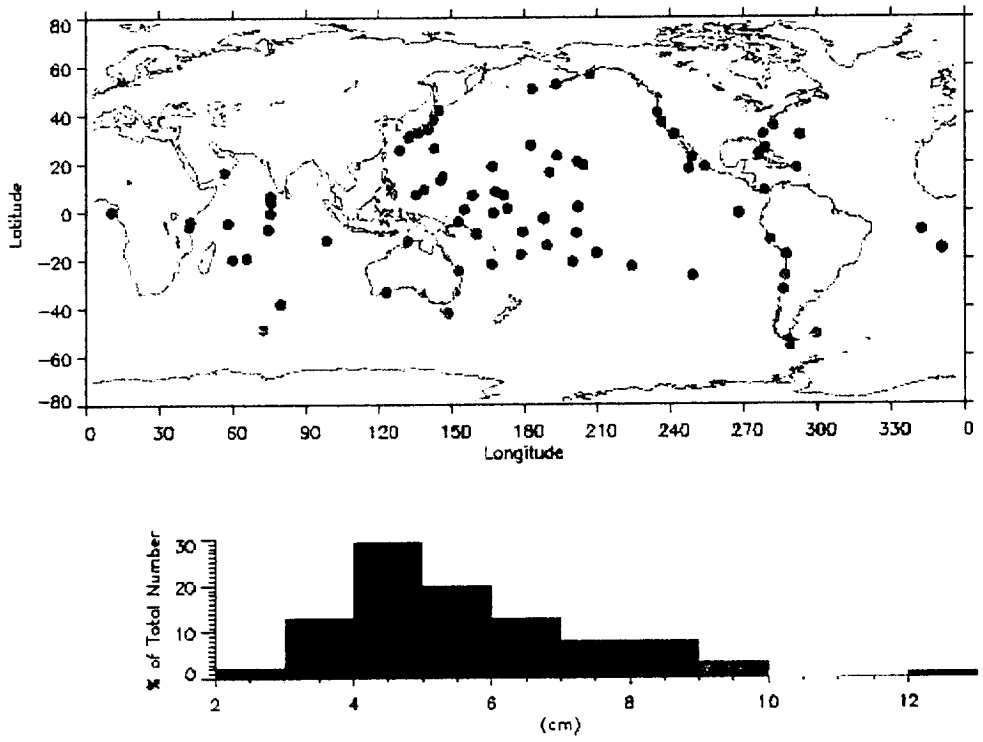
- ***Figure 7 RMS difference between daily tide gauge values and collinear ERS-1 Phase G data.***



- ***Figure 8 RMS differences between daily tide gauge values and collinear T/P data.***



- ***Figure 9 RMS differences between daily tide gauge values and collinear ERS-2 data.***



- ***Table 2 Global Statistical Summary of Daily Tide Gauge Comparisons with Collinear Altimetry.***

	RMS (cm)				
Satellite	Mean	Median	Maximum Likelihood	Mean Correlation	Number of Tide Gauges
GEOSAT ERM	8.1	7.8	8.	0.64	62
ERS-1 Phase C	6.1	5.5	5.	0.73	86
T/P	5.9	4.6	5.	0.78	86
ERS-1 Phase G	5.3	5.0	5.	0.75	82
ERS-2	5.7	4.5	5.	0.78	85

3.3 Summary

The summary statistics in Table 2 show the major points of the collinear comparison. First, the Geosat comparison is about 40% worse than the ERS or T/P comparisons. This is not unexpected because of the poorer quality orbit and corrections available for Geosat.

Second, the ERS and T/P comparisons are about the same. For ERS-1, ERS-2, and T/P the most likely difference between collinear height differences from the satellite and the tide gauge variations is 5. ± 0.5 cm. This measure is a composite that includes continental, as well as open ocean islands. In addition, there is no distinction made depending on the distance from the gauge to the collinear estimate. However, Figures 5 - 9 show that the best comparisons are found with deep-water open ocean island tide gauges in the tropics. Comparisons at individual sites in the form of time series can be examined at the Pathfinder web site (http://neptune.gsfc.nasa.gov/ocean.html).

The composite statistics of mean, median and maximum likelihood are probably all biased high because of the influence of geophysical noise in the comparisons. The minimum difference for all satellites tends to be much lower than these numbers. The minimum differences are less than 4 cm rms for ERS and T/P, whereas for Geosat it is 5.9 cm rms. The difference between the minimum value and the most likely value is probably a reasonable approximation for the measurement noise. Consequently, for Geosat we have found a noise level of 6 to 8 cm rms for the collinear data set, for ERS-1 we find 3 to 5 cm rms, for ERS-2 the noise is 3 to 5 cm rms, and also 3 to 5 cm rms for T/P.

4. Evaluation of Product 2: The Grid Data Set

4.1. Description

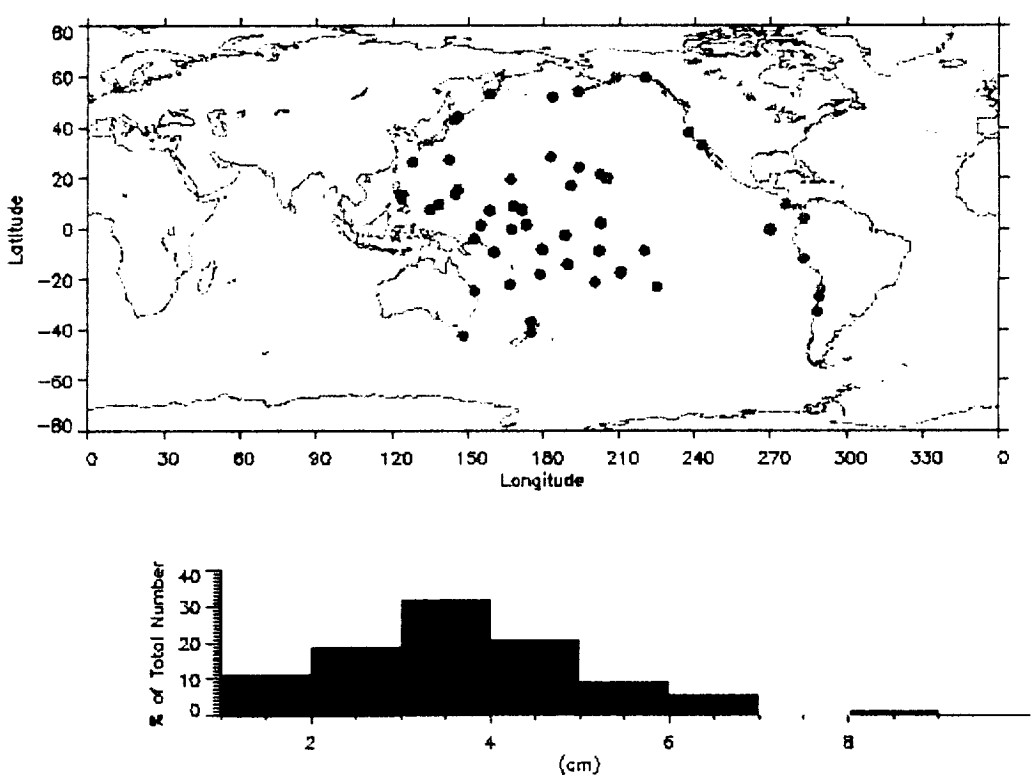
A time series of gridded monthly sea surface height variations with respect to a 1993 mean reference has been generated from all available altimeter observations provided by SEASAT, GEOSAT, ERS-1, and T/P. The grids are created from height anomalies of cross over or collinear data relative to a mean reference set of collinear ground tracks. The reference field are the annual mean heights from T/P and ERS-1 for 1993, where the ERS-1 mean ground track height has been adjusted through least squares at the cross-over locations with the T/P mean. The gridding algorithm and grid parameters are fully described in Report #1. The time period for these grids is described in Table 3.

Our comparisons of the grids with tide gauge measurements focused on monthly averaged values. We started by evaluating the impact of using monthly average tide gauge data versus using averages of daily values in the month for whatever days the altimeter sampled in a close proximity. Evaluation of the monthly grid solutions for individual missions and phases have been performed and are shown in figures 10 to 20. For comparison purposes, the T/P monthly grids were evaluated over the same time span for each coincident ERS Phase. Tests were performed to evaluate gridded sea surface height variations from blended ERS-1 and T/P altimetry. Figures 21 to 25 show results for the individual and combined solutions. Tests were also performed to evaluate the blended T/P + ERS-1 monthly grids employing various gridding parameters. Statistics in Table 5 show the grid solutions were not significantly sensitive to various grid node weights and observation search radii at the 1°x1° spatial resolution.

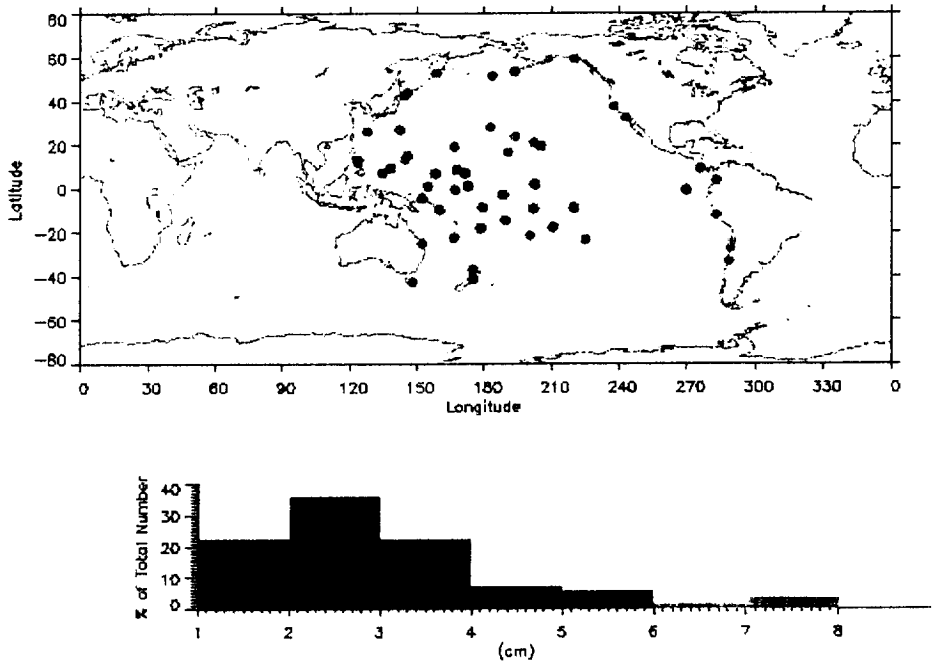
- ***Table 3 Summary of Coverage of Monthly Grids.***

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
78							Seasat	Seasat				
79												
80												
81												
82												
83												
84												
85				Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat
86	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat		Geosat	Geosat
87	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat
88	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat	Geosat
89	——	——	——	——	——	——	——	——	——	——	——	——
90												
91								——	——	——	——	——
92	——	——	——	——	ERS-1	ERS-1	ERS-1	ERS-1	ERS-1	T/P	T/P	T/P
93	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P
94	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P
95	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P
96	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P
97	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P

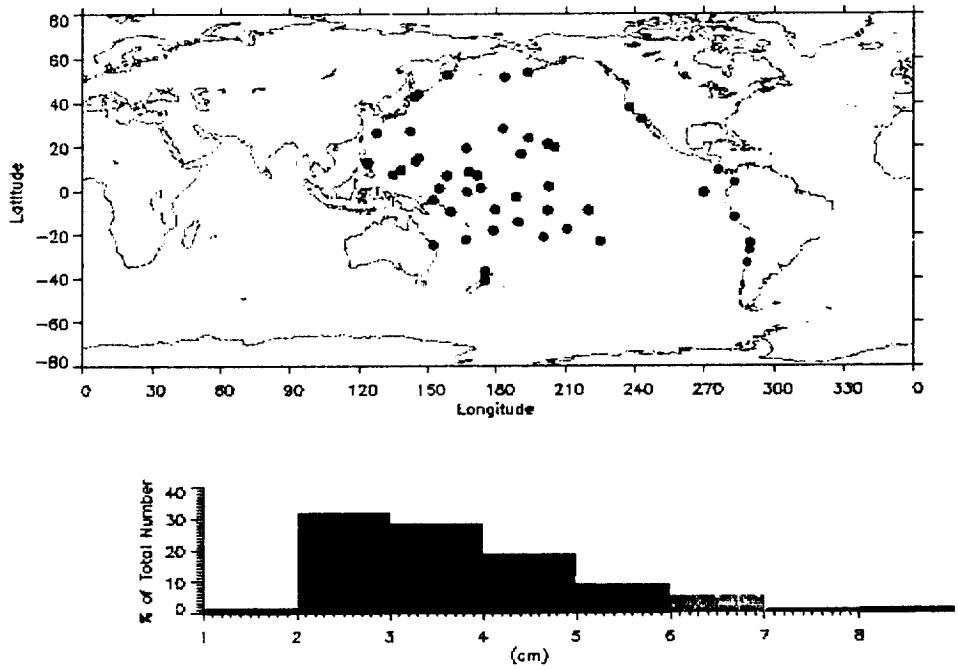
- ***Figure 10 RMS differences of T/P vs. monthly tide gauge data (October 1992- December 1997).***



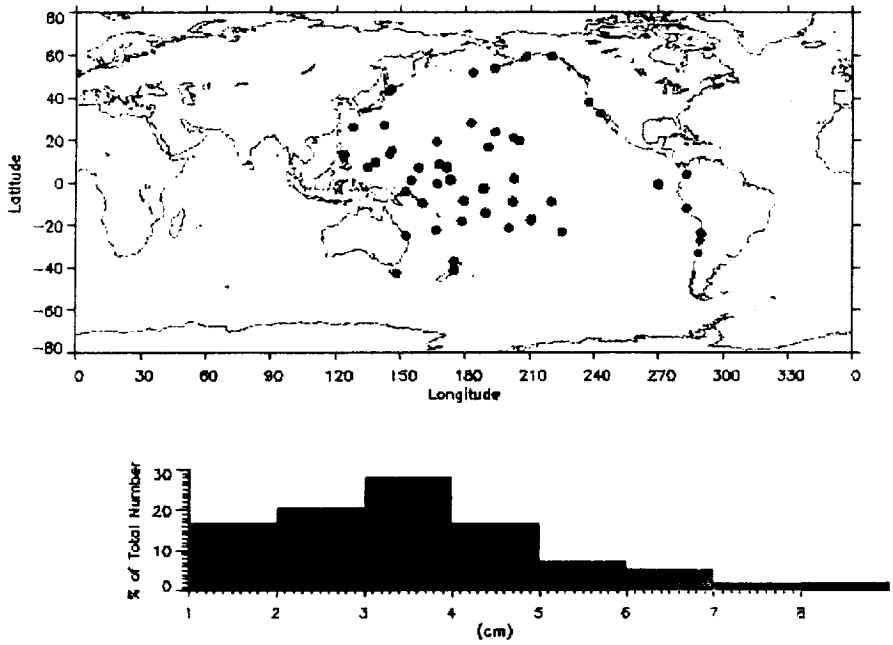
- ***Figure11 RMS differences of T/P vs. monthly tide gauge data (October 1992 – December 1993).***



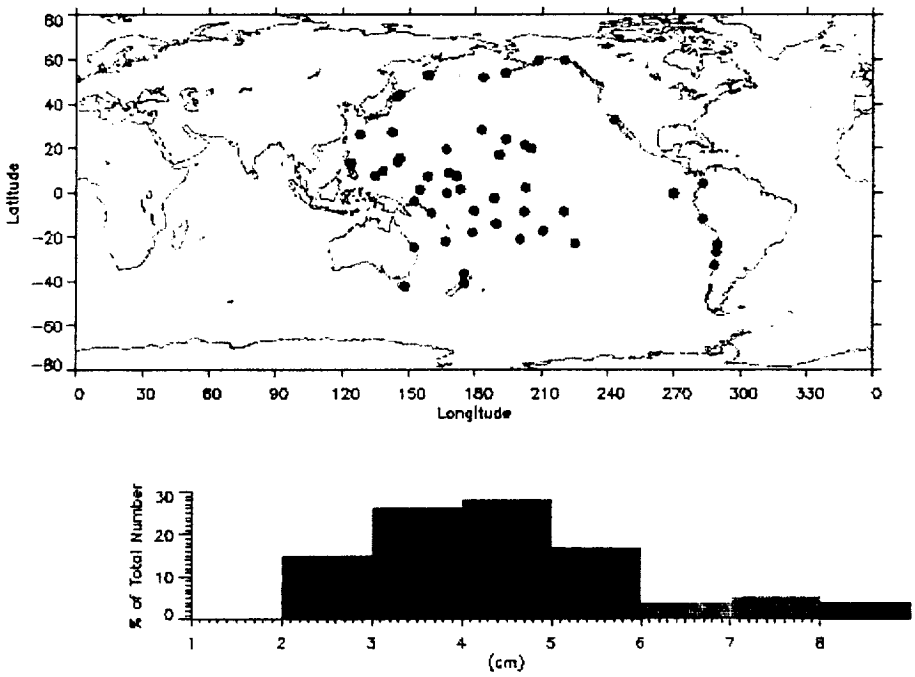
- ***Figure 12 RMS differences of ERS-1 Phase C vs. monthly tide gauge data (October 1992 - December 1993)***



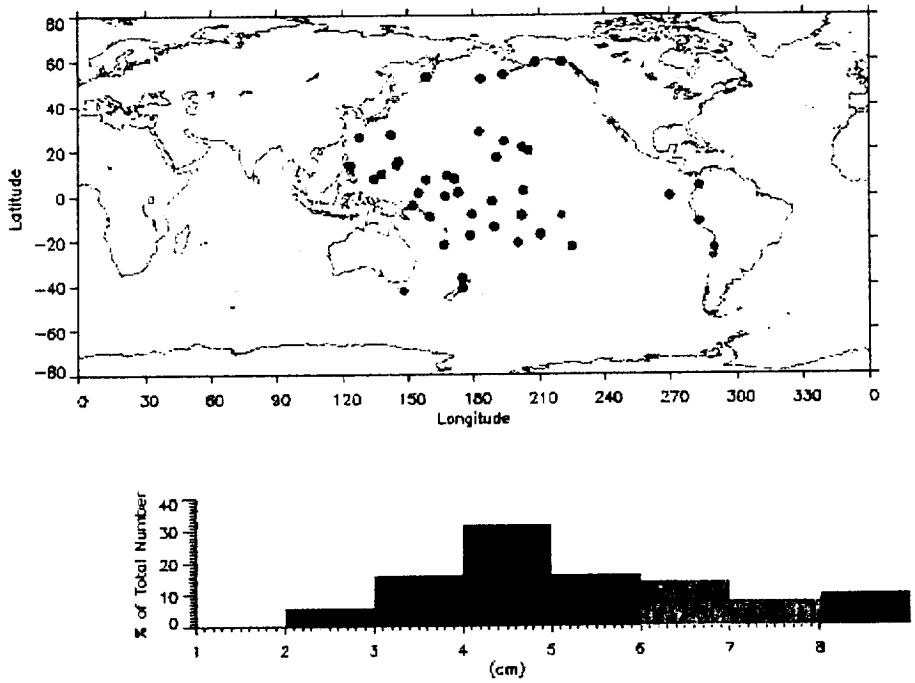
- ***Figure 13 RMS differences of T/P vs. tide gauge monthly data (April 1994 - March 1995).***



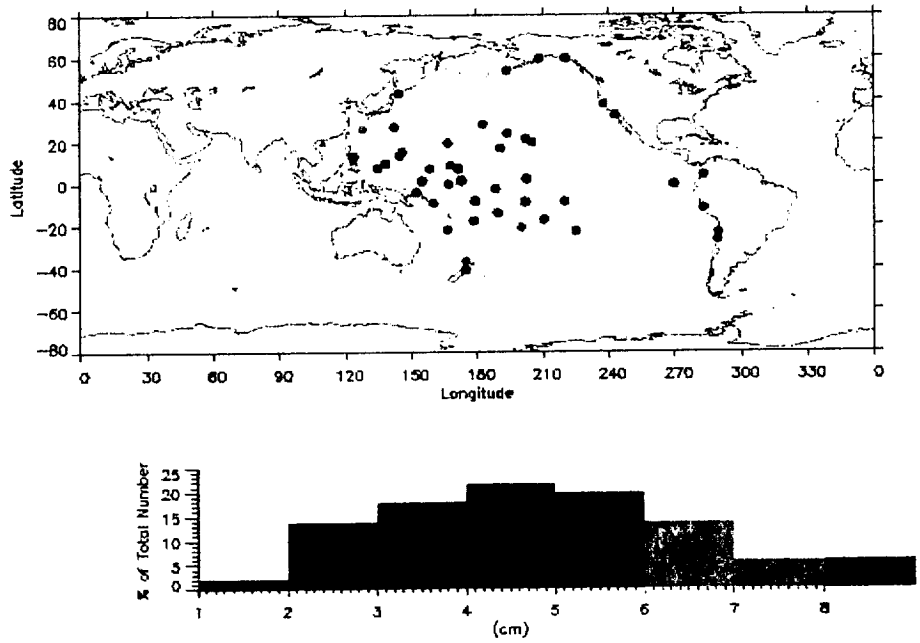
- ***Figure 14 RMS differences of ERS-1 Phase E,F vs. tide gauge monthly data (April 1994 - March 1995).***



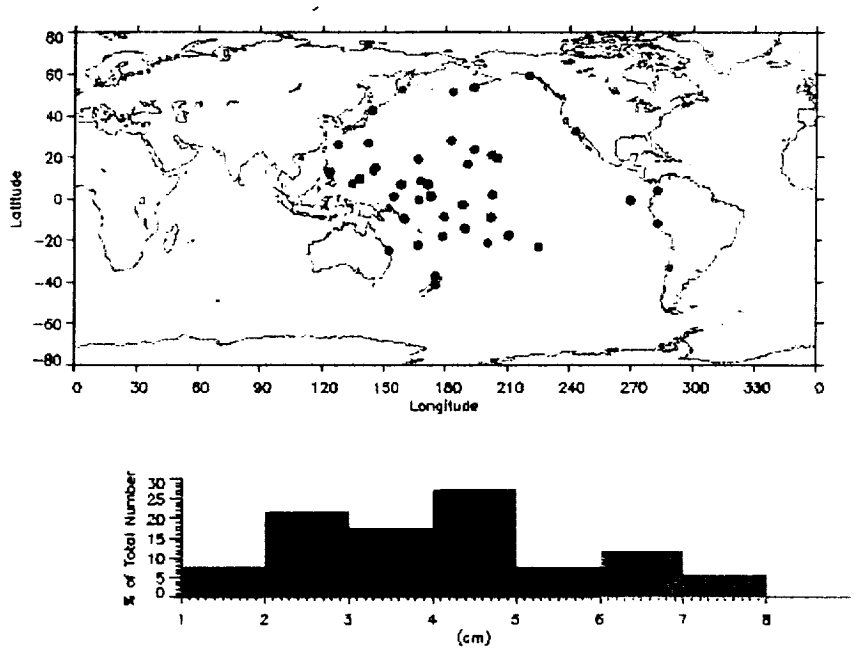
- ***Figure 15 RMS differences of T/P vs. monthly tide gauge data (April 1995 – May 1996).***



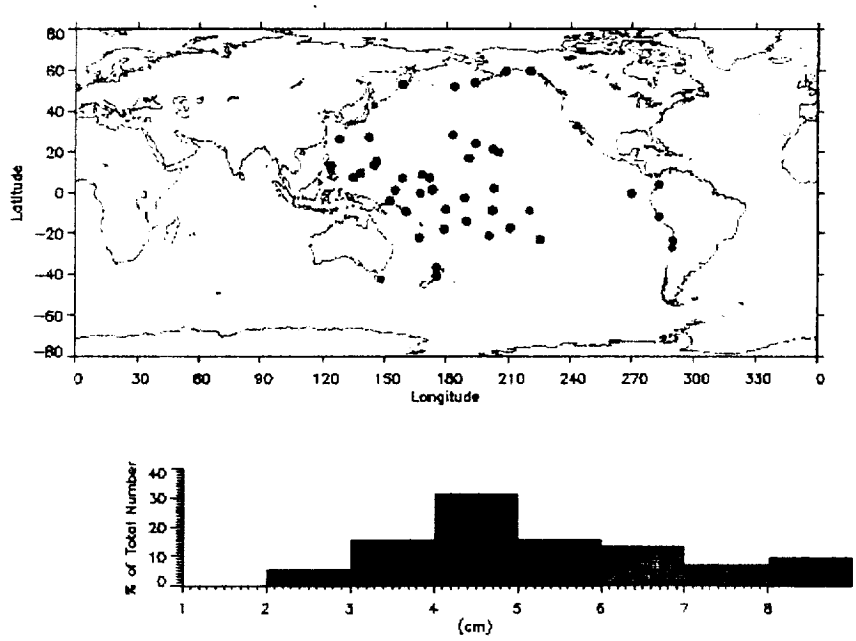
- ***Figure 16 RMS differences of ERS-1 Phase G vs. tide gauge monthly data (April 1995 - June 1996).***



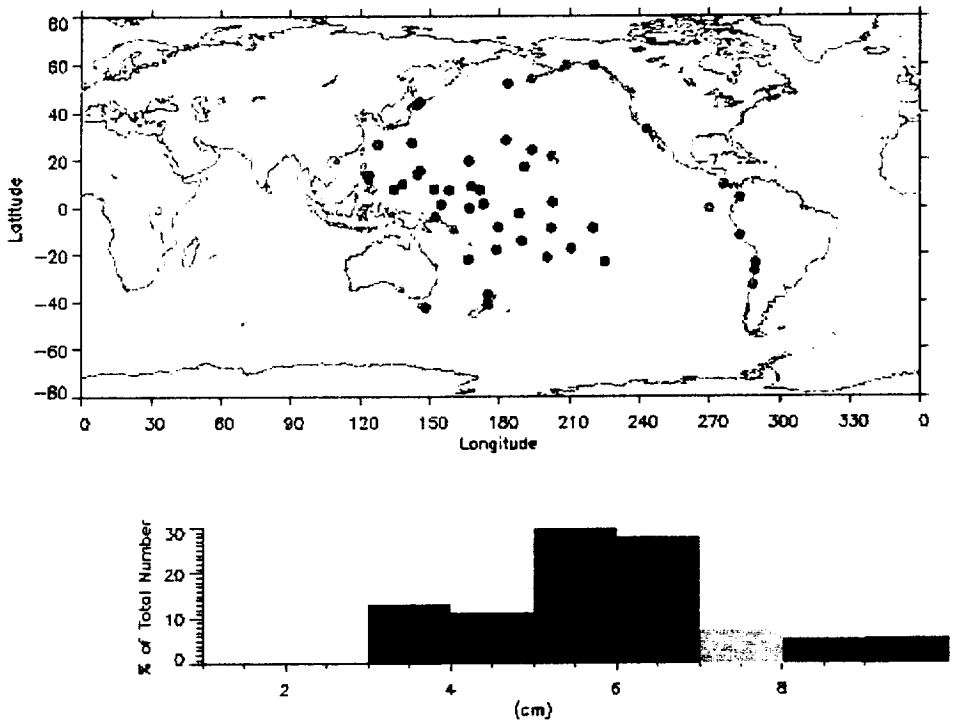
- *Figure 17 RMS differences of T/P vs. monthly tide gauge data (May 1995 - June 1997).*



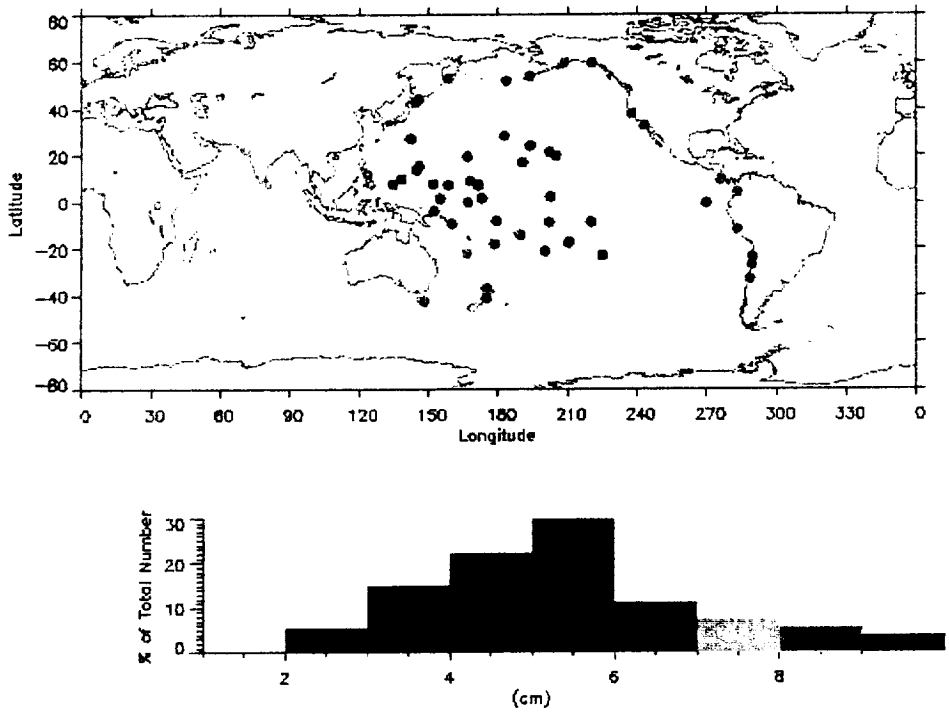
- *Figure 18 RMS differences of ERS-2 vs. monthly tide gauge data (May 1995 - June 1997).*



- ***Figure 19 RMS differences of GEOSAT ERM vs. monthly tide gauge data.***



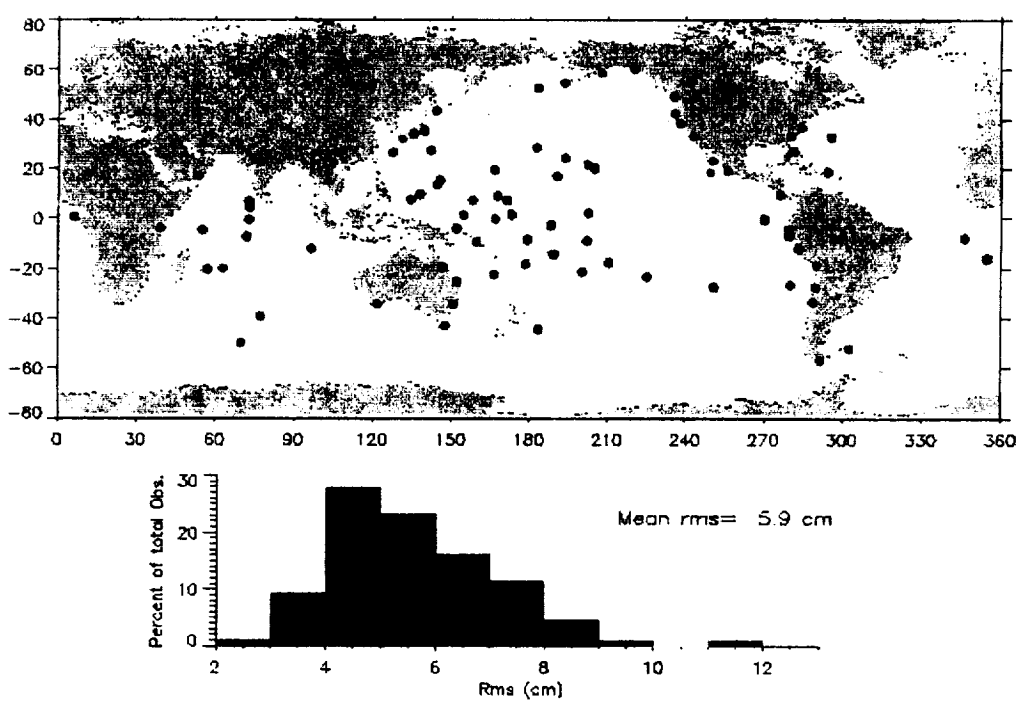
- ***Figure 20 RMS differences of GEOSAT GM vs. monthly tide gauge data.***



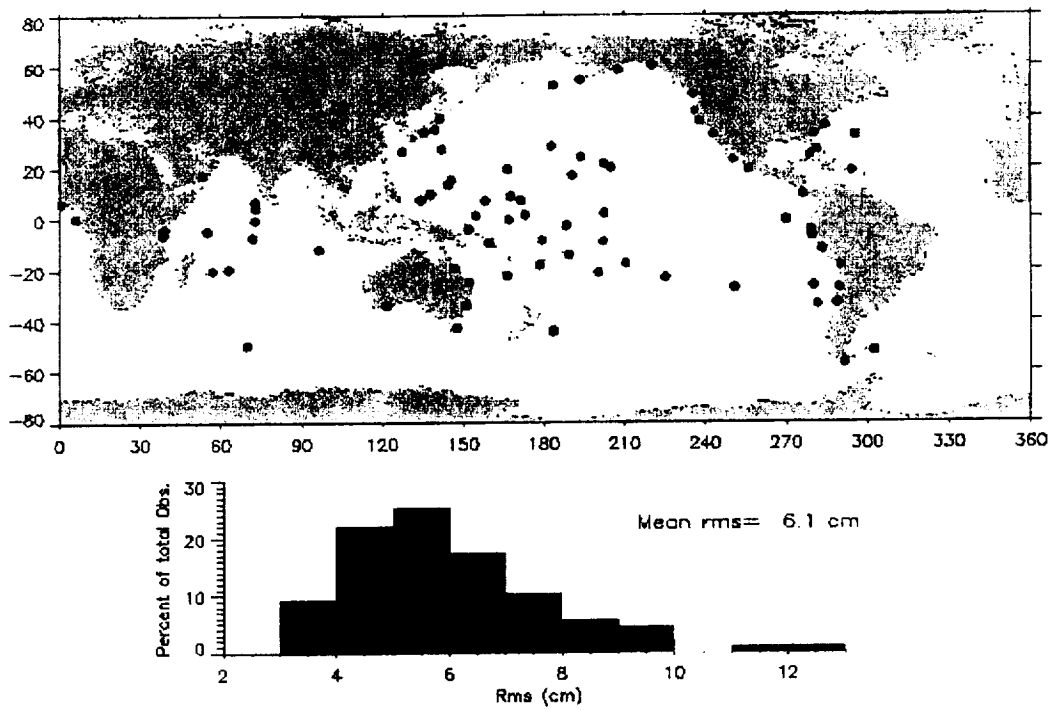
- ***Table 4 Global Statistical Summary of Monthly Tide Gauge Comparisons with Altimetry Grids.***

		RMS (cm)				
Satellites	Dates	Mean	Median	Maximum Likelihood	Number of Gauges	Mean Correlation
T/P	10/92 - 06/97	3.7	3.8	2.	53	
T/P	10/92 - 12/93	3.2			53	.67
ERS-1 C	10/92 - 12/93	4.1	3.7	3.	53	.58
T/P	04/94 - 03/95	3.7			53	.72
ERS-1 E&F	04/94 - 03/95	4.5	4.3	4.	53	.61
T/P	04/95 - 05/96	3.8			51	.71
ERS-1 G	04/95 - 05/96	4.9	4.8	4.	51	.56
T/P	05/95 - 06/97	4.1			51	.75
ERS-2	05/95 - 06/97	5.3	4.9	5.	51	.61
GEOSAT ERM	11/86 - 12/88	6.0	5.9	6.	54	.59
GEOSAT GM	04/85 - 09/86	5.5	5.2	5.	54	.60

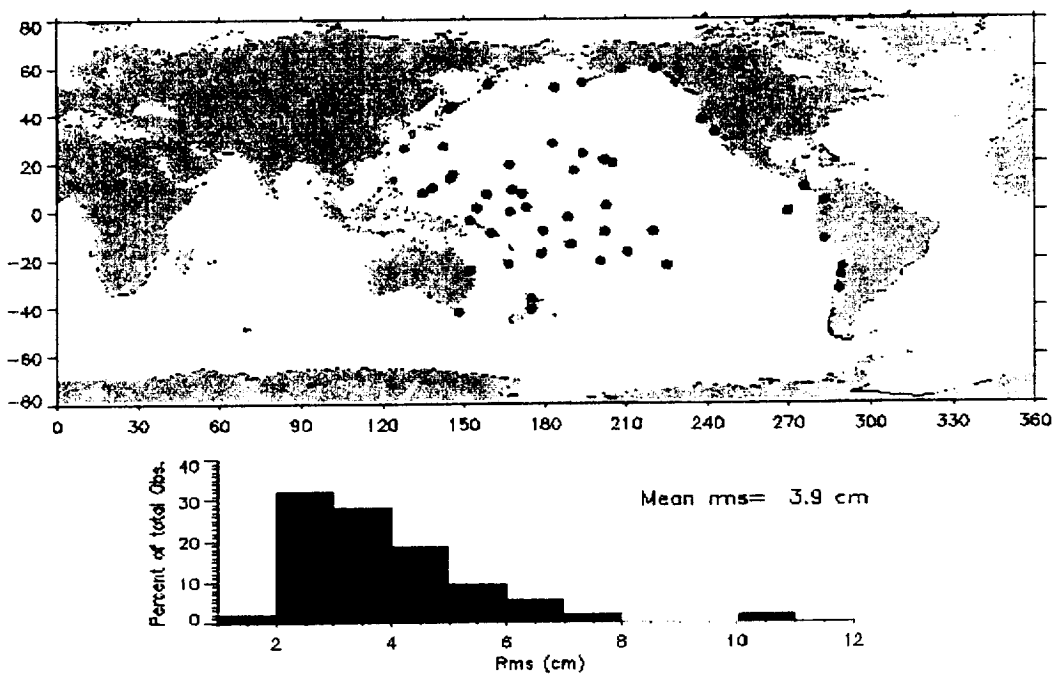
- ***Figure 21 Sea surface height variations from T/P collinear altimetry at "closest" georeferenced locations to tide gauge stations vs. daily averaged sea level variations as monitored by WOCE tide gauge network.***



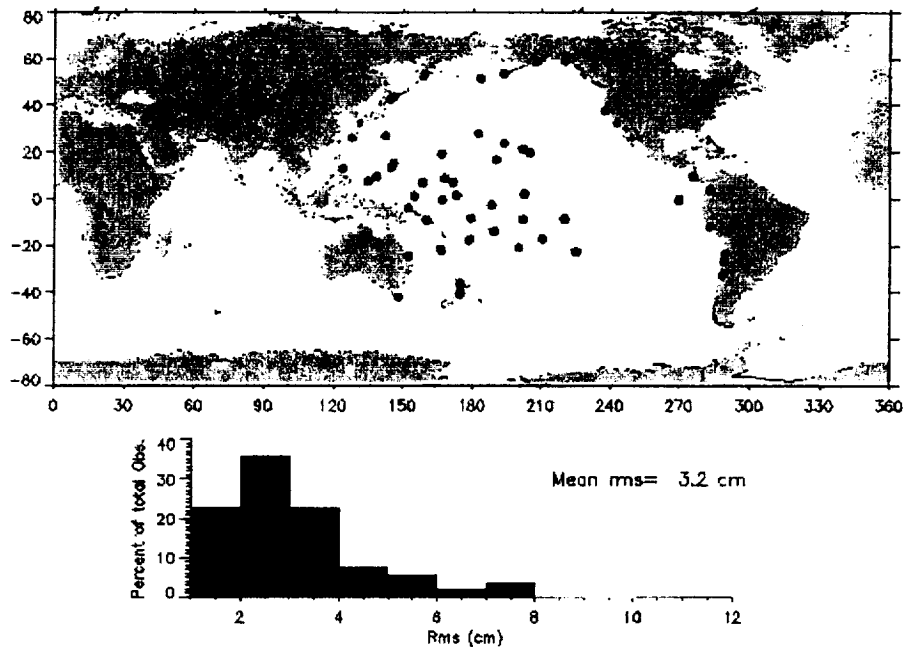
- ***Figure 22 Sea surface height variations from the unadjusted ERS-1 Phase C collinear altimetry vs. daily averaged tide gauge measurements. The dense spatial ground-track of ERS-1 provides closer proximity to tide gauge locations resulting in improved statistics.***



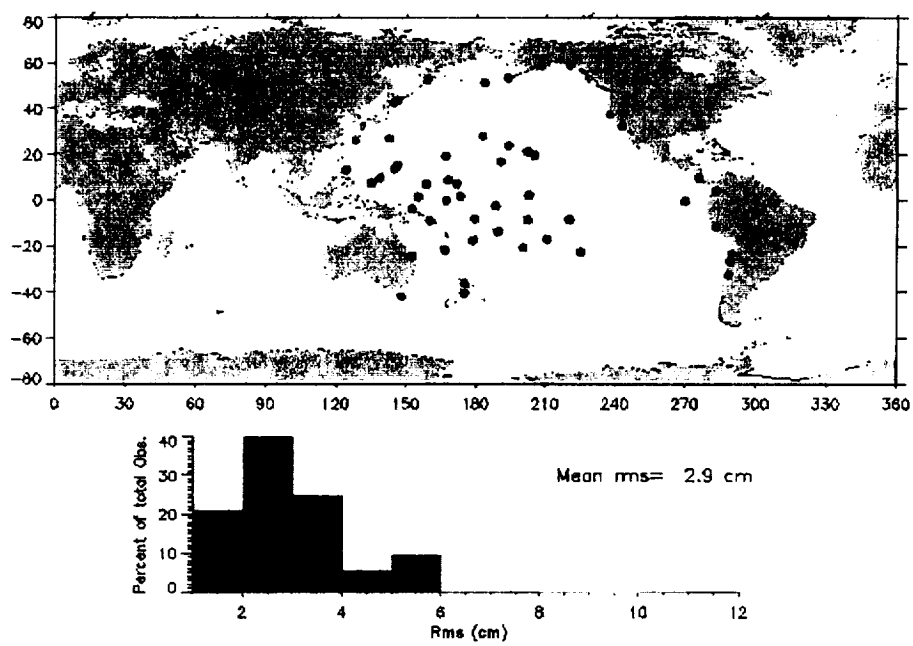
- ***Figure 23 Monthly gridded sea surface height anomalies derived from adjusted ERS-1 Phase C altimetry vs. tide gauge network. The higher rms of the ERS gridded height fields as compared to T/P can be attributed to the temporal characteristics of the 35-day repeat ground-track.***



- ***Figure 24 Monthly gridded sea surface height anomalies derived from T/P altimetry vs. monthly averaged sea level variations from WOCE tide gauge network.***



- ***Figure 25 ERS-1 and T/P altimetry are "blended" and sea surface height anomaly grids are generated employing identical gridding parameters as above. The mean rms difference when compared to the tide gauge network is reduced as a result of the combined spatial resolution of ERS and the temporal resolution of T/P.***



- ***Table 5 "Blended" T/P + ERS-1 Monthly Grids vs. Tide Gauge Monthly Data Statistics for Various Gridding Parameters.***

τ (degrees)	Radius (degrees)	T/P Mean (cm)	Blended Mean (cm)	Tide Gauges Numbers
1.0	3.0	3.1	2.9	53
1.5	3.0	3.3	3.0	53
.75	3.0	3.1	2.9	53
.75	2.0	3.1	2.9	53
.50	2.0	3.5	3.2	53
.50	3.0	3.5	3.3	53

4.2. Summary

The monthly grids compare more favorably with the tide gauge measurements because the time/space smoothing removes some of the noise from the system. In these comparisons, if we use the lower bound range between the minimum and most likely comparison as a measure of the noise in the grid then the Geosat data have noise of 3 to 6 cm rms, the ERS-1 data have a noise of 2 to 4 cm rms, the ERS-2 data have a noise of 2 to 5 cm rms, and T/P has a noise of 1 to 2 cm rms. In this comparison, the T/P data are substantially better than the ERS data, perhaps because of the longer time series or the lower instrument noise in the averaging process of making the grid.

In Table 5 we have shown the impact of blending the T/P and ERS data sets into a composite grid. In this analysis we find that the ERS data set reduces the noise in the T/P grid by about 10%. As discussed by Greenslade, Chelton and Schlax (1998), for these gridded products the ERS data set does not add a lot of information to the T/P data set because of the sampling period differences between the two satellites. In addition, Table 5 examines the impact of various radii of influence in the grid process. It is determined that the best grid algorithm should have a search radius of 3 degrees and a radius of influence of 1 degree. It is seen that reducing these values can be done to 2 degrees and 0.75 degrees, respectively without harm.

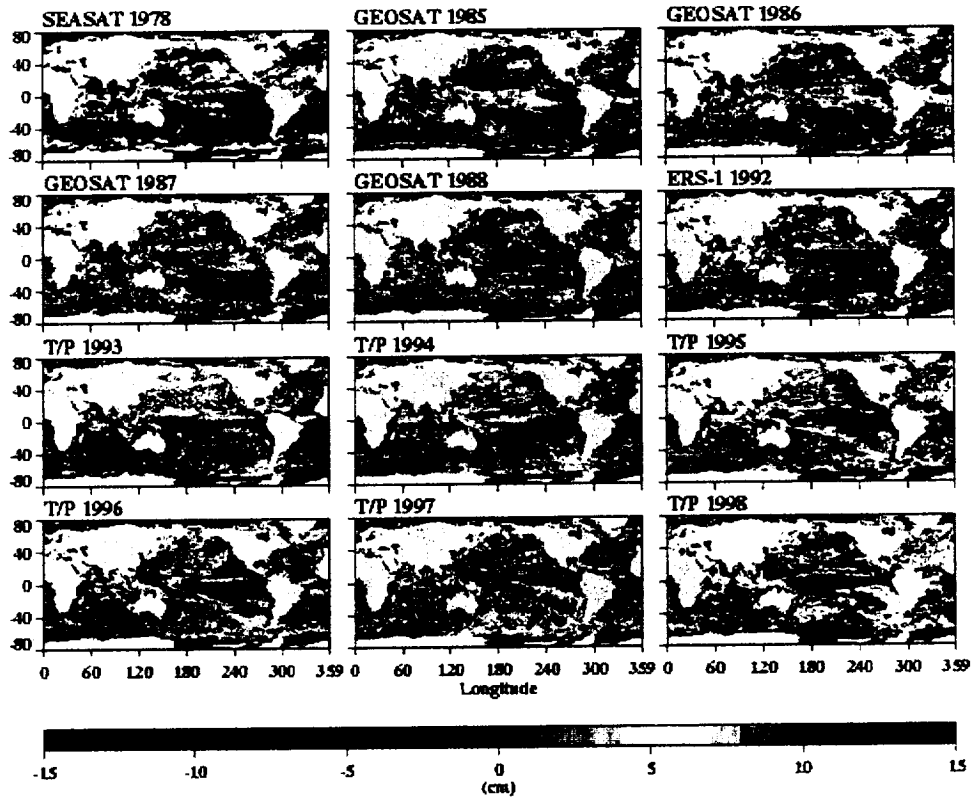
5. SUMMARY

The primary objective of the NASA Ocean Altimeter Pathfinder Project is to reprocess all available radar altimetry observations of sea surface topography into a consistent data set using the latest, community consensus algorithms. This report details the most recent validation of this data set against a global set of high quality tide gauges. The summary of the validation can be shown in three figures. The first figure (26) shows that a consistent data set has been processed. The summer sea surface topography anomalies relative to a 1993 mean for 1978 through 1998 from Seasat, Geosat, ERS-1, ERS-2, and TOPEX/POSEIDON suggest that there are no major errors in any of the individual data sets. A multi-decadal view is possible.

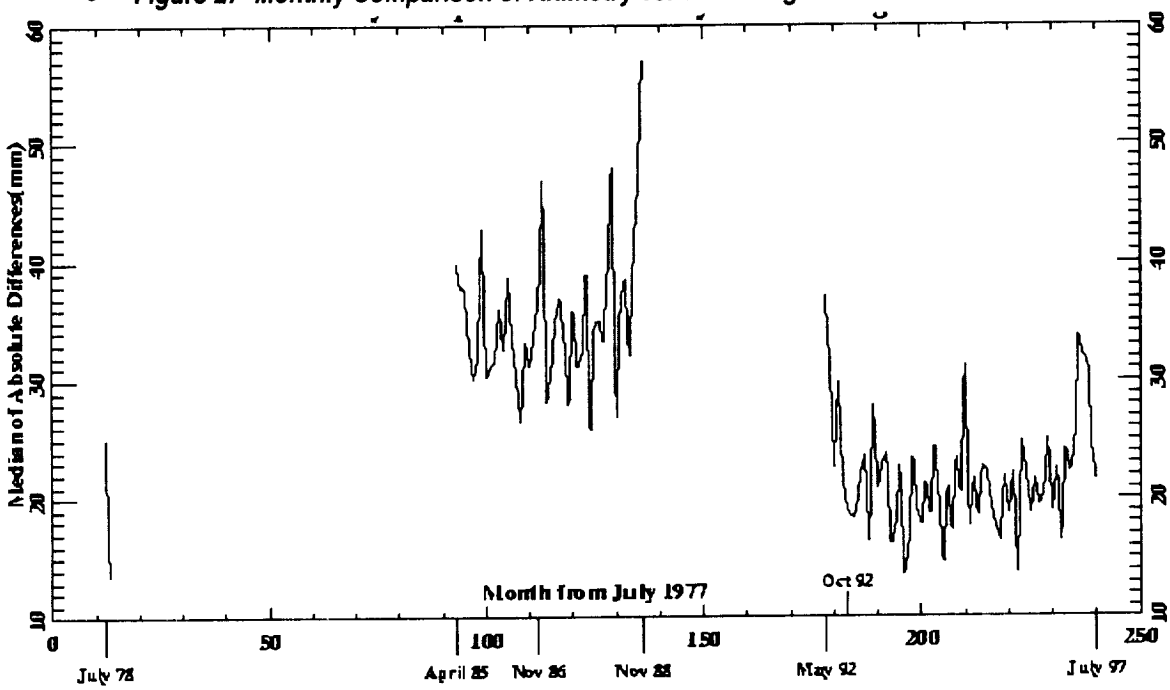
The next figure (27) shows a summary of the tide gauge comparisons across the entire data set. In this figure the median value of the absolute value of all tide gauge comparisons for each month is plotted as a function of time for all months. A remarkable consistency is found and the median comparison is less than 5 cm for all months except late 1988 when Geosat was rapidly deteriorating. It can be seen that the Geosat data set has about twice as much error as the more recent measurements. TOPEX/POSEIDON data provide the best accuracy with comparisons at 2 cm or better for each month. The final figure (28) shows the geographic distribution of this composite comparison with tide gauges throughout the Pacific. The rms comparison of monthly values from this data set versus the Pacific tide gauges shows a mean rms difference of 4.7 cm.

The conclusion of this validation exercise is that the Pathfinder Project has met its primary objective. A new, improved and consistent radar altimeter data set has been compiled. Over the next few years we will continue to improve upon these data and distribute them. If you have any comments or questions regarding this project, please contact us through our homepage at ***http://neptune.gsfc.nasa.gov/ocean.html***.

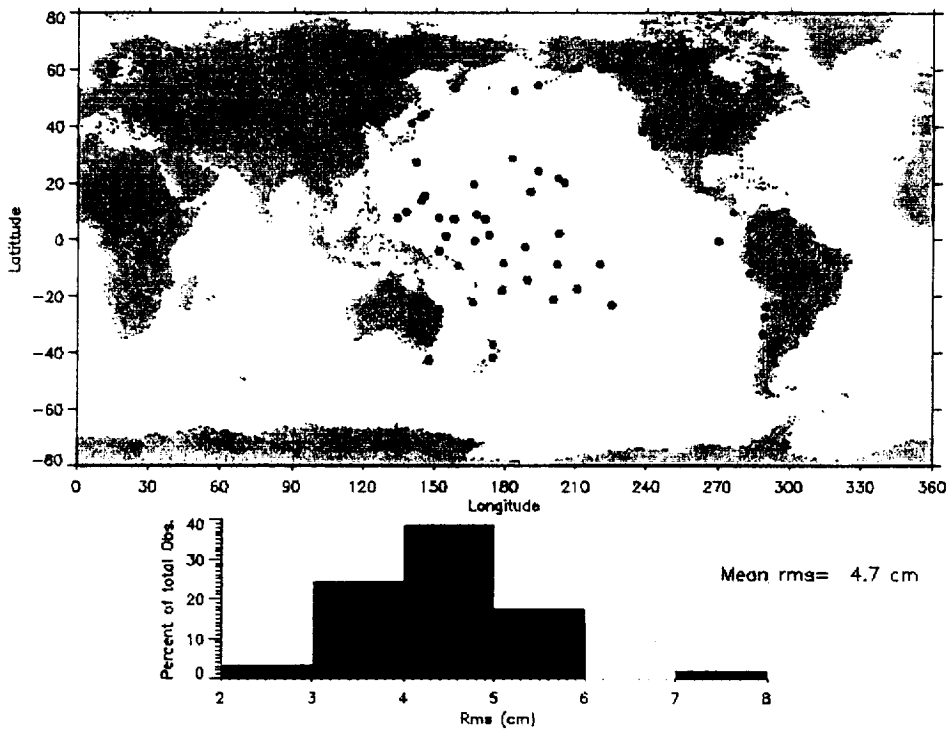
- *Figure 26 The reprocessing of all ocean related mission altimetry employing the latest algorithms from the TOPEX/POSEIDON experience has resulted in a geodetically consistent data set for climate research.*



- *Figure 27 Monthly Comparison of Altimetry vs. Tide Gauges.*



- ***Figure 28 RMS Differences between monthly tide gauge values and altimetry (July 1978 - July 1997).***



6. APPENDIX A: OBSERVATIONS

- ***Table A.1 The Ocean Altimeter Pathfinder data sets.***

Satellite	Mission Dates	Collinear Data Set	Grid Data Set
Seasat	06/26/78 – 10/10/78	N/A	07/78 – 09/78
Geosat	03/12/85 – 12/31/89	11/08/86 – 12/31/89	04/85 – 09/86 11/08/86 – 12/88
ERS-1	07/17/91 – 02/06/96	04/14/92 – 12/20/93	05/92 – 12/93
TOPEX/POSEIDON	08/10/92 - Present	09/23/92 – 12/28/97	10/92 – 12/97
ERS-2	04/20/95 - Present	04/20/95 – 06/23/97	05/95 - 06/97

- ***Table A.2 The Tide Gauge Data Set***

The data used in this validation are the WOCE "fast" Sea Level Data distributed as hourly, daily and monthly values by the University of Hawaii Sea Level Center (ftp site : kia.soest.hawaii.edu, subdirectory : woce). For each station there are three data types: hourly data, daily values (centered on the 12 hour GMT of the day) and monthly values calculated as daily means (if 7 days or less are missing).

30	SANTA CRUZ	ECUADOR	0-45S	090-19W
3	BALTRA	ECUADOR	00-26S	090-17W
19	NOUMEA	NEW CALEDONIA	22-18S	166-26E
28	SAIPAN	NORTH MARIANA	15-14N	145-45E
8	YAP	F.S. M.	9-31N	138-08E
7	MALAKAL	BELAU	7-20N	134-28E
1	POHNPEI	F.S.M.	6-59N	158-15E
29	KAPINGAMARANGI	F.S.M.	1-06N	154-47E
4	NAURU	NAURU	0-32S	166-54E
2	TARAWA	KIRIBATI	1-22N	172-56E
5	MAJURO	MARSHALL	7-06N	171-22E
14	FRENCH FRIGATE SH	HAWAII	23-52N	166-17W
57	HONOLULU	HAWAII	21-18N	157-52W
23	RAROTONGA	COOK ISL.	21-12S	159-47W
13	KANTON	KIRIBATI	2-49S	171-43W
24	PENRHYN	COOK ISL	8-59S	158-03W
11	CHRISTMAS	KIRIBATI	1-59N	157-29W
15	PAPEETE	FREN POLYNESIA	17-32S	149-34W
25	FUNAFUTI	TUVALU	8-32S	179-13E
16	RIKITEA	FREN POLYNESIA	23-08S	134-57W
18	SUVA	FIJI	18-08S	178-26E
22	EASTER	CHILE	27-09S	109-27W
9	HONIARA	SOLOMONS	09-26S	159-57E
10	RABAUL	P. N.G.	04-12S	152-11E
31	NUKU HIVA	FREN POLYNESIA	08-56S	140-05W
91	LA LIBERTAD	ECUADOR	2-12S	080-55W
93	CALLAO	PERU	12-03S	077-09W
371	LEGASPI	PHILIPPINES	13-09N	123-45E
372	DAVAO	PHILIPPINES	07-05N	125-38E
70	AUCKLAND	NEW ZEALAND	36-51S	174-46E
71	WELLINGTON	NEW ZEALAND	41-17S	174-47E
540	PRINCE RUPERT	CANADA	54-19N	130-20W
542	TOFINO	CANADA	49-09N	125-55W
541	BAMFIELD	CANADA	48-50N	125-08W
350	KUSHIRO	JAPAN	42-58N	144-23E
351	OFUNATO	JAPAN	39-04N	141-43E
352	MERA	JAPAN	34-55N	139-50E
353	KUSHIMOTO	JAPAN	33-28N	135-47E
354	ABURATSU	JAPAN	31-34N	131-25E
355	NAHA	JAPAN	26-13N	127-40E
47	CHICHIJIMA	JAPAN	27-06N	142-11E

360	WAKKANAI	JAPAN	45-25N	141-41E
361	FUKAURA	JAPAN	40-39N	139-56E
334	TOWNSVILLE	AUSTRALIA	19-15S	146-50E
332	BUNDABERG	AUSTRALIA	24-50S	152-21E
333	SYDNEY	AUSTRALIA	33-51S	151-14E
168	DARWIN	AUSTRALIA	12-28S	130-51E
394	SALINA CRUZ	MEXICO	16-10N	095-12W
316	ACAPULCO	MEXICO	16-50N	099-55W
303	TUMACO	COLOMBIA	01-50N	078-44W
85	BUENAVENTURA	COLOMBIA	03-54N	077-06W
80	ANTOFAGASTA-BM45	CHILE	23-39S	070-24W
88	CALDERA	CHILE	27-04S	070-50W
81	VALPARAISO	CHILE	33-02S	071-38W
597	TALCAHUANO	CHILE	36-42S	073-06W
40	ADAK	ALASKA	51-52N	176-38W
41	UNALASKA	ALASKA	53-54N	166-30W
561	SELDOVIA	ALASKA	59-26N	151-43W
559	SITKA	ALASKA	57-03N	135-20W
558	NEAH BAY	WASHINGTON	48-22N	124-37W
556	CRESCENT CITY	CALIFORNIA	41-45N	124-12W
551	SAN FRANCISCO	CALIFORNIA	37-48N	122-28W
569	SAN DIEGO	CALIFORNIA	32-43N	117-10W
51	WAKE	USA TRUST	19-17N	166-37E
52	JOHNSTON	USA TRUST	16-45N	169-31W
50	MIDWAY	USA TRUST	28-13N	177-22W
620	KADOK-TO	KOREA	35-01N	128-49E
621	TAEHUKSAN-DO	KOREA	34-41N	125-27E
622	KUNSAN	KOREA	35-58N	126-38E
623	INCHON	KOREA	37-28N	126-36E
630	DALIAN	CHINA	38-52N	121-41E
633	LUSI	CHINA	32-08N	121-37E
632	KANMEN	CHINA	28-05N	121-17E
635	ZHAPO	CHINA	21-35N	111-49E
376	XIAMEN	CHINA	24-27N	118-04E
393	PUERTO VALLARTA	MEXICO	20-37N	105-15W
305	ISLA CEDROS	MEXICO	28-11N	115-13W
34	CABO SAN LUCAS.	MEXICO	22-53N	109-54W
327	KEPPEL+TANJONG	SINGAPORE	01-16N	103-49E
624	PETROPAVLOVSK	RUSSIA	53-01N	158-38E
625	YUZHNO KURILSK	RUSSIA	44-01N	145-52E
54	TRUK MOEN	F. S. M.	7-27N	151-51E
55	KWAJALEIN	MARSHALL	8-44N	167-44E
53	GUAM	MARIANAS	13-26N	144-39E
56	PAGO PAGO	SAMOA	14-17S	170-41W
60	HILO	HAWAII	19-44N	155-04W
560	SEWARD	ALASKA	60-05N	149-27W
570	YAKUTAT	ALASKA	59-33N	139-44W
87	QUEPOS	Costa Rica	09-24N	084-10W
320	CENDERING	Malaysia	05-16N	103-11E
142	LANGKAWI	Malaysia	06-26N	099-46E
300	PANAMA	PANAMA	08-55N	079-32W

Appendix B: Collinear Tide Gauge/Altimeter Comparison Details

- ***Table B.1 Summary of daily tide gauge comparisons with GEOSAT ERM Altimetry***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
BALTRA	-0.4350	269.7150	80.42	1.1	1.6	0.77	97.50	42
NAURU	-0.5283	166.9050	94.52	0.9	0.9	0.40	16.11	41
MAJURO	7.1067	171.3733	84.25	1.0	1.3	0.64	46.55	41
MALAKAI	7.3300	134.4633	72.02	2.1	2.1	0.89	87.75	36
YAP	9.5083	138.1283	71.53	1.5	1.7	0.82	90.65	33
HONIARA	-9.4250	159.9567	68.81	1.5	1.6	0.79	138.31	37
RABAUL	-4.2000	152.1750	66.86	1.3	1.6	0.78	139.90	40
CHRISTMA	1.9850	202.5233	86.93	1.5	1.9	0.85	17.75	40
KANTON	-2.8100	188.2817	81.91	1.0	1.2	0.60	29.92	42
FRENCH_F	23.8667	193.7100	94.87	0.9	1.4	0.69	88.23	43
PAPEETE	-17.5250	210.4333	71.17	0.7	1.2	0.52	132.66	42
RIKITEA	-23.1250	225.0467	78.93	0.7	1.1	0.44	35.32	42
SUVA	-18.1317	178.4267	74.60	1.0	1.0	0.52	124.18	38
NOUMEA	-22.2950	166.4333	67.30	0.7	1.3	0.61	156.00	32
EASTER_I	-27.1500	250.5517	89.03	0.7	1.0	0.41	60.76	38
RAROTONG	-21.1983	200.2300	86.73	0.9	1.1	0.55	88.15	41
PENHRYN	-9.0133	201.9383	73.16	0.8	1.2	0.54	39.07	42
FUNAFUTI	-8.5250	179.2083	83.35	1.1	1.5	0.76	83.71	41
SAIPAN	15.2267	145.7417	97.58	1.1	0.9	0.52	106.97	35
KAPINGAM	1.0983	154.7767	82.38	0.8	1.2	0.59	106.76	40
SANTA_CR	-0.7533	269.6883	73.70	1.1	1.6	0.80	74.01	42
CABO_SAN	22.8833	250.0833	77.73	0.7	1.0	0.41	106.55	40
KODIAK_I	57.8000	207.6000	79.29	1.6	2.0	0.87	75.97	39
ADAK_ISL	51.8500	183.3500	108.53	1.2	1.6	0.77	72.25	38
CHICHIJI	27.1000	142.1833	81.84	1.2	1.6	0.77	75.79	37
MIDWAY_I	28.2167	182.6333	78.76	1.1	1.2	0.63	72.69	42
WAKE_ISL	19.2833	166.6167	81.67	1.1	1.4	0.68	54.63	38
JOHNSTON	16.7500	190.4833	86.04	0.9	1.2	0.56	22.19	43
GUAM	13.4333	144.6500	77.41	1.3	1.3	0.72	56.07	34
KWAJALEI	8.7333	167.7333	80.37	1.0	1.4	0.72	85.38	42
PAGO_PAG	-14.2833	189.3167	72.86	0.8	1.4	0.71	76.22	42
HONOLULU	21.3067	202.1333	80.84	0.7	1.3	0.66	42.32	39
HILO	19.7333	204.9333	77.80	0.7	1.2	0.54	41.13	38
VALPARAI	-33.0333	288.3667	90.14	0.8	1.1	0.49	99.63	39
ARICA	-18.4667	289.6667	75.64	1.0	1.2	0.61	75.93	28
LOBOS	-6.9333	279.2833	71.29	1.1	1.2	0.64	90.36	28
QUEPOS	9.4000	275.8333	80.00	1.0	1.4	0.71	126.96	33
CALDERA	-27.0667	289.1667	81.80	0.8	0.9	0.34	80.87	42
CALLAO	-12.0500	282.8500	78.84	0.7	1.0	0.33	127.09	40
MOMBASA	-4.0700	39.6567	86.01	0.8	0.9	0.35	138.05	28
PORT_LOU	-20.1550	57.4950	63.99	1.5	1.7	0.82	49.53	41
RODRIGUE	-19.6683	63.4183	70.03	1.4	1.5	0.77	46.52	43

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
ZANZIBAR	-6.1550	39.1900	94.30	0.6	1.0	0.31	118.69	37
COCOS_IS	-12.1167	96.9000	84.62	1.2	1.4	0.71	32.04	37
ESPERANC	-33.8667	121.9000	71.88	2.0	2.3	0.90	49.51	35
KEY_WEST	24.5533	278.1917	86.35	0.9	1.0	0.47	79.50	22
SAN_JUAN	18.4600	293.8833	73.43	0.8	1.1	0.44	122.92	37
SETTLEME	26.7100	281.0033	91.56	0.9	1.2	0.58	86.93	21
Bermuda	32.3700	295.3033	94.55	1.0	1.2	0.61	114.14	28
DUCK_PIE	36.1833	284.2600	92.14	1.3	1.2	0.66	113.40	26
CHARLEST	32.7817	280.0750	81.60	1.6	1.9	0.85	34.63	25
BUNDABER	-24.8333	152.3500	82.81	0.9	1.3	0.63	118.04	40
FORT_DEN	-33.8500	151.2333	70.27	1.1	1.5	0.76	46.19	42
TOWNSVIL	-19.2500	146.8333	75.01	1.3	1.7	0.81	111.35	35
SPRING_B	-42.5500	147.9333	74.97	1.8	2.1	0.88	39.15	42
OFUNATO	39.0667	141.7167	89.34	1.0	1.3	0.63	42.32	38
MERA	34.9167	139.8333	100.08	0.9	1.5	0.74	44.67	37
KUSHIMOT	33.4667	135.7833	107.15	0.8	1.2	0.59	89.55	33
ABURATSU	31.5667	131.4167	62.85	2.0	2.0	0.87	39.34	35
NAHA	26.2167	127.6667	59.34	2.1	1.9	0.88	87.44	25
SAN_DIEG	32.7150	242.8267	94.97	0.8	1.0	0.41	82.91	42

- ***Table B.2 Summary of daily tide gauge comparisons with ERS-1 Phase C Altimetry***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Dist. (km)	# of Cycles
POHNPEI	6.9867	158.2433	52.84	1.0	1.7	0.84	91.55	18
BETIO	1.3617	172.9300	48.92	1.5	1.5	0.79	71.45	17
BALTRA	-0.4350	269.7150	72.85	0.9	1.2	0.57	65.36	15
NAURU	-0.5283	166.9050	68.58	1.0	0.7	0.37	73.51	18
MAJURO	7.1067	171.3733	50.40	1.1	1.1	0.60	49.94	17
MALAKAI	7.3300	134.4633	37.37	2.5	2.3	0.92	99.15	17
YAP	9.5083	138.1283	42.15	1.1	1.5	0.76	71.53	18
HONIARA	-9.4250	159.9567	38.53	2.1	2.0	0.88	117.94	18
RABAUL	-4.2000	152.1750	78.22	0.8	1.0	0.40	128.57	16
CHRISTMA	1.9850	202.5233	43.69	1.1	1.5	0.74	59.92	17
KANTON	-2.8100	188.2817	51.51	1.0	1.5	0.76	79.40	18
FRENCH_F	23.8667	193.7100	65.07	0.8	1.3	0.63	56.96	18
PAPEETE	-17.5250	210.4333	63.52	0.6	1.0	0.26	99.76	17
RIKITEA	-23.1250	225.0467	50.03	1.1	1.4	0.72	54.14	18
SUVA	-18.1317	178.4267	41.16	1.0	1.1	0.57	99.11	15
NOUMEA	-22.2950	166.4333	44.70	1.5	1.7	0.80	94.22	17
JUAN_FER	-33.6217	281.1667	64.56	1.1	1.2	0.63	66.87	18
EASTER_I	-27.1500	250.5517	42.43	1.6	1.6	0.81	52.17	17
RAROTONG	-21.1983	200.2300	64.41	1.3	1.4	0.72	68.93	18
PENHRYN	-9.0133	201.9383	67.24	0.9	0.8	0.36	20.22	17
FUNAFUTI	-8.5250	179.2083	62.18	1.4	1.6	0.78	92.46	18
SAIPAN	15.2267	145.7417	58.31	1.2	1.7	0.81	143.29	18
KAPINGAM	1.0983	154.7767	53.06	1.5	1.3	0.75	35.13	18
SANTA_CR	-0.7533	269.6883	42.97	1.4	1.8	0.82	102.72	16
CABO_SAN	22.8833	250.0833	57.57	1.2	1.8	0.86	105.62	18
SAN_FELI	-26.2833	279.8667	52.41	1.1	1.3	0.66	53.14	11

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
KODIAK_I	57.8000	207.6000	48.10	2.8	3.3	0.96	90.78	17
ADAK_ISL	51.8500	183.3500	76.66	1.3	1.4	0.73	94.86	17
DUTCH_HA	53.9000	193.5000	76.02	2.0	2.4	0.91	93.17	16
CHICHIJI	27.1000	142.1833	61.18	1.9	2.1	0.88	101.48	18
MIDWAY_I	28.2167	182.6333	57.74	1.3	1.4	0.72	78.54	18
WAKE_ISL	19.2833	166.6167	47.38	1.8	1.9	0.86	19.25	18
JOHNSTON	16.7500	190.4833	51.12	1.5	1.8	0.83	102.73	18
GUAM	13.4333	144.6500	36.91	2.3	2.6	0.92	56.74	17
KWAJALEI	8.7333	167.7333	45.71	1.3	2.0	0.90	97.01	18
PAGO_PAG	-14.2833	189.3167	51.85	1.0	1.3	0.64	87.65	18
HONOLULU	21.3067	202.1333	60.04	0.7	1.3	0.63	139.18	18
HILO	19.7333	204.9333	55.63	1.2	1.4	0.72	89.65	17
CHATHAM	-43.9467	183.4383	35.77	1.8	1.4	0.83	79.58	18
VALPARAI	-33.0333	288.3667	50.18	1.2	1.3	0.67	78.98	18
ARICA	-18.4667	289.6667	66.40	0.6	1.2	0.61	62.70	16
LOBOS	-6.9333	279.2833	45.56	1.3	1.9	0.86	60.83	17
QUEPOS	9.4000	275.8333	53.00	1.3	1.2	0.69	78.17	15
CALDERA	-27.0667	289.1667	67.65	0.7	1.0	0.29	114.99	17
TALARA	-4.5833	278.7167	42.99	1.3	1.2	0.68	86.08	17
CALLAO	-12.0500	282.8500	45.21	1.2	1.5	0.76	57.22	18
MOMBASA	-4.0700	39.6567	44.05	0.9	1.5	0.76	98.82	18
PORT_LOU	-20.1550	57.4950	77.68	1.5	1.7	0.82	84.74	18
DIEGO_GA	-7.2900	72.3933	33.31	1.4	1.8	0.83	98.57	18
RODRIGUE	-19.6683	63.4183	47.06	2.3	2.4	0.91	65.85	18
HULHULE	4.1833	73.5333	52.01	0.7	1.0	0.36	90.07	17
GAN	-0.6867	73.1517	63.10	0.8	1.2	0.57	110.49	18
SALALAH	16.9350	54.0067	89.19	0.9	1.2	0.57	81.44	18
HANIMAAD	6.7667	73.1667	77.63	0.8	1.5	0.80	100.29	16
POINT_LA	-4.6717	55.5283	40.57	2.0	2.4	0.92	83.99	10
ZANZIBAR	-6.1550	39.1900	38.43	1.3	1.5	0.76	118.76	18
COCOS_IS	-12.1167	96.9000	48.91	1.7	1.8	0.83	48.33	18
ESPERANC	-33.8667	121.9000	65.65	2.3	2.1	0.90	75.20	18
KERGUELE	-49.3450	70.2200	64.37	1.4	1.8	0.82	77.55	8
LOME	6.1333	1.2833	51.35	1.4	1.6	0.77	78.03	17
SAO_TOME	0.3500	6.7500	48.08	1.5	1.3	0.76	66.27	18
KEY_WEST	24.5533	278.1917	59.59	1.6	1.6	0.80	58.37	18
SAN_JUAN	18.4600	293.8833	64.38	1.0	1.4	0.67	49.43	18
SETTLEME	26.7100	281.0033	55.54	1.2	1.6	0.79	34.64	17
Bermuda	32.3700	295.3033	38.05	2.6	2.6	0.93	34.03	17
DUCK_PIE	36.1833	284.2600	95.36	1.2	1.0	0.62	56.31	18
CHARLEST	32.7817	280.0750	58.92	1.9	2.0	0.87	74.64	18
PORT_STA	-51.7000	302.1500	35.60	2.7	2.6	0.93	58.56	13
NAOS_ISL	8.9167	280.4667	102.63	0.8	1.3	0.61	107.00	14
BUNDABER	-24.8333	152.3500	73.96	0.9	1.3	0.67	101.75	16
FORT_DEN	-33.8500	151.2333	77.41	0.8	1.1	0.52	67.18	17
TOWNSVIL	-19.2500	146.8333	77.62	1.2	1.4	0.71	98.01	17
SPRING_B	-42.5500	147.9333	88.69	1.3	1.4	0.74	88.69	17
KUSHIRO	42.9667	144.3833	106.19	0.8	1.2	0.57	56.90	18
OFUNATO	39.0667	141.7167	82.06	0.6	0.9	0.17	99.76	18

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
MERA	34.9167	139.8333	120.84	0.7	1.4	0.73	89.66	16
KUSHIMOT	33.4667	135.7833	82.44	1.3	1.8	0.84	60.11	17
ABURATSU	31.5667	131.4167	115.71	1.1	1.8	0.88	57.70	17
NAHA	26.2167	127.6667	52.27	1.3	1.9	0.88	137.20	18
MANZANIL	19.0500	255.6667	59.08	1.1	1.4	0.70	46.62	11
FORT_POI	37.8067	237.5350	59.13	2.0	1.5	0.87	73.39	17
CRESCENT	41.7450	235.8167	98.59	0.8	1.1	0.50	106.67	18
NEAH_BAY	48.3683	235.3833	92.17	1.6	1.1	0.77	86.22	14
SAN_DIEG	32.7150	242.8267	47.13	1.4	1.9	0.86	45.83	16
YAKUTAT	59.5467	220.2650	91.36	1.8	2.1	0.88	46.42	18
DIEGO_RA	-56.5083	291.2850	87.36	1.2	1.7	0.81	29.68	9

- ***Table B.3 Summary of daily tide gauge comparisons with ERS-1 Phase G Altimetry***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Dist. (km)	# of Cycles
POHNPEI	6.9867	158.2433	30.49	2.1	2.2	0.90	91.55	9
BETIO	1.3617	172.9300	30.24	1.1	1.3	0.67	70.42	11
BALTRA	-0.4350	269.7150	63.02	0.5	0.8	-0.01	65.36	12
NAURU	-0.5283	166.9050	31.49	1.3	1.5	0.75	96.18	10
MAJURO	7.1067	171.3733	31.30	1.7	1.9	0.85	49.94	9
MALAKAI	7.3300	134.4633	43.83	1.4	1.7	0.80	96.27	10
YAP	9.5083	138.1283	51.10	1.2	1.6	0.78	58.01	9
HONIARA	-9.4250	159.9567	64.84	1.0	1.9	0.96	84.88	11
RABAUL	-4.2000	152.1750	36.27	1.1	1.4	0.69	117.74	11
KANTON	-2.8100	188.2817	31.94	0.8	1.3	0.61	76.28	13
FRENCH_F	23.8667	193.7100	51.93	1.3	1.6	0.78	61.77	11
PAPEETE	-17.5250	210.4333	41.78	1.0	1.1	0.51	96.91	12
RIKITEA	-23.1250	225.0467	35.48	1.8	2.1	0.88	54.14	12
SUVA	-18.1317	178.4267	47.20	1.8	1.3	0.85	106.90	9
NOUMEA	-22.2950	166.4333	41.67	1.7	1.3	0.82	94.22	11
EASTER_I	-27.1500	250.5517	32.35	2.0	2.3	0.90	57.80	10
RAROTONG	-21.1983	200.2300	40.59	1.7	2.0	0.86	54.32	13
PENHRYN	-9.0133	201.9383	31.29	1.3	1.9	0.88	9.42	10
FUNAFUTI	-8.5250	179.2083	48.67	1.3	1.6	0.77	92.20	12
SAIPAN	15.2267	145.7417	51.90	1.4	1.3	0.74	141.89	11
KAPINGAM	1.0983	154.7767	43.70	1.1	1.0	0.56	42.69	11
SANTA_CR	-0.7533	269.6883	48.77	0.8	1.0	0.38	102.72	11
CABO_SAN	22.8833	250.0833	62.26	1.4	1.3	0.72	98.87	13
KODIAK_I	57.8000	207.6000	51.31	2.6	2.9	0.94	97.87	12
ADAK_ISL	51.8500	183.3500	63.17	2.1	2.3	0.90	71.54	10
DUTCH_HA	53.9000	193.5000	66.60	2.5	3.1	0.96	93.57	12
CHICHIJI	27.1000	142.1833	77.17	1.4	1.6	0.79	100.51	11
MIDWAY_I	28.2167	182.6333	38.55	1.3	1.5	0.76	78.83	11
WAKE_ISL	19.2833	166.6167	32.20	2.7	2.8	0.94	18.82	10
JOHNSTON	16.7500	190.4833	50.98	1.6	1.9	0.86	100.60	13
GUAM	13.4333	144.6500	47.82	1.4	1.4	0.74	56.74	13
KWAJALEI	8.7333	167.7333	33.98	1.3	2.0	0.88	97.01	11
PAGO_PAG	-14.2833	189.3167	45.13	1.1	1.3	0.67	93.86	13
HONOLULU	21.3067	202.1333	75.59	0.9	1.6	0.82	135.41	13
HILO	19.7333	204.9333	53.27	1.2	1.6	0.79	89.65	12
VALPARAI	-33.0333	288.3667	33.30	1.6	1.5	0.79	73.45	12
ARICA	-18.4667	289.6667	48.31	0.8	1.6	0.87	85.10	7
CALDERA	-27.0667	289.1667	30.96	1.3	1.6	0.78	104.24	10
SOCORRO	18.2333	248.9500	50.89	1.1	1.2	0.63	109.43	13
CALLAO	-12.0500	282.8500	34.00	1.2	1.6	0.77	55.89	12
MOMBASA	-4.0700	39.6567	33.24	1.0	1.6	0.81	96.35	12
PORT_LOU	-20.1550	57.4950	65.51	1.2	1.1	0.63	84.74	12
RODRIGUE	-19.6683	63.4183	46.84	1.7	2.2	0.90	65.04	10
HULHULE	4.1833	73.5333	45.16	1.3	1.5	0.76	90.49	12
GAN	-0.6867	73.1517	56.53	0.8	1.5	0.79	110.49	7
SALALAH	16.9350	54.0067	89.37	0.8	1.1	0.50	66.04	11
HANIMAAD	6.7667	73.1667	50.53	1.3	1.7	0.80	91.06	13

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
POINT_LA	-4.6717	55.5283	87.09	1.0	1.4	0.72	83.99	12
ZANZIBAR	-6.1550	39.1900	54.97	0.6	1.1	0.46	118.98	12
DARWIN	-12.4667	130.8500	85.00	0.9	1.3	0.63	97.74	11
COCOS_IS	-12.1167	96.9000	65.19	1.0	1.1	0.57	48.33	7
ESPERANC	-33.8667	121.9000	44.05	2.8	3.3	0.96	75.20	11
ST._PAUL	-38.7117	77.5383	64.01	1.2	1.5	0.76	10.58	10
KERGUELE	-49.3450	70.2200	74.29	1.5	2.0	0.87	89.53	11
SAO_TOME	0.3500	6.7500	31.83	2.1	1.9	0.88	72.58	10
KEY_WEST	24.5533	278.1917	50.58	1.0	1.5	0.75	58.37	9
SAN_JUAN	18.4600	293.8833	72.02	0.6	1.3	0.63	49.43	13
SETTLEME	26.7100	281.0033	33.69	2.5	2.6	0.92	34.64	11
Bermuda	32.3700	295.3033	35.33	4.3	4.1	0.97	36.01	11
DUCK_PIE	36.1833	284.2600	44.69	3.8	3.5	0.97	56.57	10
CHARLEST	32.7817	280.0750	45.05	3.5	3.5	0.96	68.21	13
ASCENSIO	-7.9000	345.6167	38.81	0.6	1.2	0.50	62.44	13
ST._HELE	-15.9667	354.3000	38.81	1.2	1.5	0.76	15.02	11
NAOS_ISL	8.9167	280.4667	55.61	1.8	1.6	0.83	107.00	11
BUNDABER	-24.8333	152.3500	59.59	1.4	1.2	0.73	101.75	13
FORT_DEN	-33.8500	151.2333	60.95	1.6	1.7	0.82	67.18	12
TOWNSVIL	-19.2500	146.8333	44.62	1.4	1.5	0.76	139.96	11
SPRING_B	-42.5500	147.9333	83.72	1.3	1.6	0.78	91.14	12
KUSHIRO	42.9667	144.3833	51.52	1.5	1.7	0.81	36.88	12
OFUNATO	39.0667	141.7167	81.76	1.2	1.1	0.62	91.67	11
MERA	34.9167	139.8333	141.43	1.0	1.3	0.63	94.15	12
KUSHIMOT	33.4667	135.7833	71.50	2.0	2.1	0.89	46.65	10
ABURATSU	31.5667	131.4167	125.46	0.8	1.2	0.54	57.70	10
NAHA	26.2167	127.6667	50.84	1.8	1.8	0.85	134.60	11
MANZANIL	19.0500	255.6667	52.32	1.6	2.1	0.89	49.50	8
FORT_POI	37.8067	237.5350	57.44	1.0	1.0	0.54	87.86	13
CRESCENT	41.7450	235.8167	68.59	0.8	1.1	0.46	106.67	9
NEAH_BAY	48.3683	235.3833	82.10	1.2	1.6	0.79	86.22	9
SAN_DIEG	32.7150	242.8267	28.90	2.6	2.1	0.93	56.63	8
YAKUTAT	59.5467	220.2650	77.82	2.1	2.1	0.89	57.78	11
DIEGO_RA	-56.5083	291.2850	79.46	1.9	2.3	0.91	19.14	8

- ***Table B.4 Summary of daily tide gauge comparisons with TOPEX/POSEIDON Altimetry***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
POHNPEI	6.9867	158.2433	44.64	2.4	2.6	0.93	96.36	172
BETIO	1.3617	172.9300	38.46	1.7	2.0	0.87	128.18	168
BALTRA	-0.4350	269.7150	42.53	2.3	2.5	0.92	17.39	174
NAURU	-0.5283	166.9050	59.41	1.4	1.2	0.73	33.28	132
MAJURO	7.1067	171.3733	34.51	2.7	2.8	0.94	90.53	177
MALAKAI	7.3300	134.4633	46.43	2.0	2.2	0.89	78.03	174
YAP	9.5083	138.1283	43.99	2.2	2.3	0.90	55.80	168
HONIARA	-9.4250	159.9567	58.21	1.9	2.3	0.91	139.91	178
RABAUL	-4.2000	152.1750	64.88	1.7	1.7	0.83	119.69	144
CHRISTMA	1.9850	202.5233	52.68	1.7	1.4	0.80	84.28	185
KANTON	-2.8100	188.2817	40.06	1.5	1.7	0.82	145.76	138

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
FRENCH_F	23.8667	193.7100	78.23	1.2	1.4	0.71	43.83	177
PAPEETE	-17.5250	210.4333	36.45	1.1	1.5	0.74	52.55	166
RIKITEA	-23.1250	225.0467	45.04	1.5	1.7	0.81	75.73	184
SUVA	-18.1317	178.4267	49.04	1.6	1.6	0.80	78.04	181
NOUMEA	-22.2950	166.4333	47.95	1.4	1.5	0.76	128.26	170
EASTER_I	-27.1500	250.5517	38.24	1.7	1.6	0.82	43.60	175
RAROTONG	-21.1983	200.2300	51.81	1.6	1.6	0.81	55.07	188
PENHRYN	-9.0133	201.9383	44.79	1.4	1.5	0.75	39.97	175
FUNAFUTI	-8.5250	179.2083	40.24	2.0	2.0	0.87	62.00	168
SAIPAN	15.2267	145.7417	54.37	1.8	1.9	0.85	53.58	176
KAPINGAM	1.0983	154.7767	63.86	1.5	1.5	0.79	77.50	170
SANTA_CR	-0.7533	269.6883	47.30	2.2	2.2	0.89	45.29	174
CABO_SAN	22.8833	250.0833	70.57	1.3	1.3	0.72	115.07	172
SAN_FELI	-26.2833	279.8667	74.60	0.9	0.8	0.29	86.69	82
KODIAK_I	57.8000	207.6000	63.19	2.2	2.3	0.90	100.55	182
ADAK_ISL	51.8500	183.3500	85.22	1.6	1.8	0.83	94.83	184
DUTCH_HA	53.9000	193.5000	84.60	1.9	2.1	0.87	96.09	189
CHICHIJI	27.1000	142.1833	61.35	2.1	2.2	0.89	53.90	178
MIDWAY_I	28.2167	182.6333	57.86	1.4	1.5	0.77	51.00	184
WAKE_ISL	19.2833	166.6167	53.32	1.9	2.1	0.88	48.50	183
JOHNSTON	16.7500	190.4833	54.51	1.6	1.9	0.84	68.19	186
GUAM	13.4333	144.6500	51.39	2.1	2.0	0.88	29.48	179
KWAJALEI	8.7333	167.7333	45.09	1.7	1.8	0.84	85.11	173
PAGO_PAG	-14.2833	189.3167	39.72	1.2	1.5	0.76	56.98	177
HONOLULU	21.3067	202.1333	66.83	0.8	1.2	0.59	113.20	187
HILO	19.7333	204.9333	40.82	1.5	1.5	0.77	119.77	185
CHATHAM	-43.9467	183.4383	50.95	2.2	2.4	0.91	95.04	68
VALPARAI	-33.0333	288.3667	65.79	1.0	0.9	0.48	86.55	176
ARICA	-18.4667	289.6667	58.54	1.2	1.0	0.60	106.78	152
LOBOS	-6.9333	279.2833	41.27	1.6	1.5	0.78	65.68	97
QUEPOS	9.4000	275.8333	61.84	1.6	1.3	0.77	68.86	60
CALDERA	-27.0667	289.1667	67.68	0.8	1.0	0.41	124.39	172
SOCORRO	18.2333	248.9500	99.94	0.8	0.7	0.14	132.84	170
TALARA	-4.5833	278.7167	53.05	1.1	1.1	0.60	74.24	121
CALLAO	-12.0500	282.8500	46.69	1.9	2.1	0.88	22.99	151
MOMBASA	-4.0700	39.6567	54.67	0.9	1.1	0.53	81.51	186
PORT_LOU	-20.1550	57.4950	41.65	2.2	2.3	0.90	53.13	184
DIEGO_GA	-7.2900	72.3933	37.89	2.4	2.5	0.92	43.51	173
RODRIGUE	-19.6683	63.4183	56.51	1.7	1.9	0.86	73.53	180
HULHULE	4.1833	73.5333	44.95	1.1	1.5	0.76	84.35	170
GAN	-0.6867	73.1517	46.00	1.2	1.2	0.64	106.84	169
SALALAH	16.9350	54.0067	66.47	1.2	1.4	0.73	120.27	171
HANIMAAD	6.7667	73.1667	49.37	1.4	1.8	0.83	29.30	160
POINT_LA	-4.6717	55.5283	43.16	2.1	2.0	0.88	76.33	127
COCOS_IS	-12.1167	96.9000	56.07	2.0	2.0	0.88	38.80	180
ESPERANC	-33.8667	121.9000	62.58	2.3	1.8	0.90	66.05	187
ST._PAUL	-38.7117	77.5383	55.37	1.7	1.8	0.83	51.12	111
KERGUELE	-49.3450	70.2200	74.91	1.2	1.6	0.78	78.56	162
SAO_TOME	0.3500	6.7500	48.58	1.3	1.4	0.72	96.69	121

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
KEY_WEST	24.5533	278.1917	103.04	0.9	1.3	0.62	93.92	179
SAN_JUAN	18.4600	293.8833	39.52	1.7	1.8	0.84	85.40	181
SETTLEME	26.7100	281.0033	38.47	2.1	2.3	0.90	27.10	168
Bermuda	32.3700	295.3033	43.03	2.8	3.0	0.94	57.42	181
DUCK_PIE	36.1833	284.2600	118.18	1.3	1.1	0.66	118.13	167
CHARLEST	32.7817	280.0750	66.68	2.3	2.0	0.90	72.14	181
PORT_STA	-51.7000	302.1500	73.23	1.5	1.6	0.80	44.26	116
ASCENSIO	-7.9000	345.6167	40.23	0.9	1.2	0.59	94.74	140
ST._HELE	-15.9667	354.3000	28.19	1.5	1.7	0.81	46.92	120
BUNDABER	-24.8333	152.3500	59.30	1.3	1.6	0.77	109.73	183
FORT_DEN	-33.8500	151.2333	69.26	1.2	1.5	0.74	109.59	146
TOWNSVIL	-19.2500	146.8333	75.10	1.4	1.3	0.72	139.49	181
SPRING_B	-42.5500	147.9333	54.19	2.0	2.4	0.92	99.25	179
KUSHIRO	42.9667	144.3833	69.27	1.2	1.5	0.74	110.33	147
OFUNATO	39.0667	141.7167	109.90	0.8	1.2	0.54	101.89	181
MERA	34.9167	139.8333	62.23	1.4	1.4	0.75	66.21	176
KUSHIMOT	33.4667	135.7833	88.47	1.4	1.6	0.79	69.39	179
ABURATSU	31.5667	131.4167	100.90	1.3	1.4	0.72	107.79	170
NAHA	26.2167	127.6667	50.71	2.3	2.5	0.91	81.98	180
MANZANIL	19.0500	255.6667	58.96	1.9	2.0	0.87	114.97	157
FORT_POI	37.8067	237.5350	74.21	1.5	1.1	0.73	139.64	139
CRESCENT	41.7450	235.8167	70.49	1.7	1.4	0.81	37.87	169
NEAH_BAY	48.3683	235.3833	89.26	1.7	1.5	0.82	50.63	166
SAN_DIEG	32.7150	242.8267	46.86	1.8	1.6	0.83	142.48	146
YAKUTAT	59.5467	220.2650	71.86	2.3	2.3	0.91	81.12	172
DIEGO_RA	-56.5083	291.2850	75.13	1.9	2.1	0.88	42.22	172

- ***Table B.5 Summary of daily tide gauge comparisons with ERS-2 Altimetry***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
POHNPEI	6.9867	158.2433	46.22	1.9	2.3	0.91	91.55	19
BETIO	1.3617	172.9300	33.39	1.5	2.1	0.88	71.45	22
BALTRA	-0.4350	269.7150	43.56	2.5	2.7	0.93	65.36	22
NAURU	-0.5283	166.9050	43.71	1.8	1.9	0.85	73.51	20
MAJURO	7.1067	171.3733	49.72	1.3	1.6	0.79	49.94	21
MALAKAI	7.3300	134.4633	51.69	1.4	1.7	0.81	106.45	18
YAP	9.5083	138.1283	65.41	1.6	1.6	0.80	71.53	22
HONIARA	-9.4250	159.9567	33.75	2.2	2.0	0.89	117.72	17
RABAUL	-4.2000	152.1750	47.39	1.4	1.6	0.79	122.46	21
CHRISTMA	1.9850	202.5233	32.45	2.1	2.3	0.90	53.16	13
KANTON	-2.8100	188.2817	23.84	1.7	2.1	0.88	79.40	22
FRENCH_F	23.8667	193.7100	60.83	1.1	1.5	0.73	61.77	21
PAPEETE	-17.5250	210.4333	35.56	1.3	1.4	0.72	96.91	21
RIKITEA	-23.1250	225.0467	49.13	1.4	1.7	0.81	54.14	20
SUVA	-18.1317	178.4267	55.31	1.7	1.8	0.84	106.90	24
NOUMEA	-22.2950	166.4333	50.91	1.3	1.3	0.71	94.22	22
EASTER_I	-27.1500	250.5517	45.06	1.4	1.5	0.75	58.51	17
RAROTONG	-21.1983	200.2300	48.99	1.5	1.7	0.82	68.93	19
PENHRYN	-9.0133	201.9383	42.94	1.3	1.4	0.72	20.22	17
FUNAFUTI	-8.5250	179.2083	48.87	1.6	1.9	0.85	92.20	20
SAIPAN	15.2267	145.7417	59.47	1.4	1.1	0.70	141.89	18
KAPINGAM	1.0983	154.7767	69.59	1.6	0.8	0.85	61.06	20
SANTA_CR	-0.7533	269.6883	37.32	1.9	2.4	0.93	93.19	16
CABO_SAN	22.8833	250.0833	54.84	1.7	1.4	0.81	109.60	21
KODIAK_I	57.8000	207.6000	67.67	1.9	1.9	0.87	97.87	21
ADAK_ISL	51.8500	183.3500	82.03	1.7	2.2	0.91	71.54	19
DUTCH_HA	53.9000	193.5000	85.57	1.8	1.8	0.85	93.57	22
CHICHIJI	27.1000	142.1833	70.94	1.5	1.6	0.80	100.51	22
MIDWAY_I	28.2167	182.6333	37.30	2.2	2.1	0.89	78.83	21
WAKE_ISL	19.2833	166.6167	50.21	2.3	2.3	0.91	20.71	20
JOHNSTON	16.7500	190.4833	54.01	1.6	1.8	0.83	104.03	22
GUAM	13.4333	144.6500	52.96	1.7	1.9	0.86	74.98	20
KWAJALEI	8.7333	167.7333	47.31	1.2	1.3	0.69	97.01	22
PAGO_PAG	-14.2833	189.3167	49.02	1.1	1.4	0.71	91.61	22
HONOLULU	21.3067	202.1333	73.66	0.8	1.3	0.64	136.21	22
HILO	19.7333	204.9333	73.23	0.8	1.3	0.67	89.65	21
VALPARAI	-33.0333	288.3667	70.02	1.4	1.0	0.70	73.56	21
ARICA	-18.4667	289.6667	48.08	1.5	1.6	0.79	85.10	18
CALDERA	-27.0667	289.1667	54.34	0.9	1.2	0.59	136.44	14
SOCORRO	18.2333	248.9500	46.37	1.3	1.6	0.79	109.38	22
CALLAO	-12.0500	282.8500	44.05	2.5	2.4	0.92	55.89	22
MOMBASA	-4.0700	39.6567	45.58	1.1	1.4	0.69	98.82	22
PORT_LOU	-20.1550	57.4950	81.46	1.0	0.9	0.44	96.99	20
DIEGO_GA	-7.2900	72.3933	33.36	1.1	1.6	0.78	98.57	19
RODRIGUE	-19.6683	63.4183	47.75	1.7	2.1	0.88	65.04	17
HULHULE	4.1833	73.5333	57.92	0.9	1.3	0.62	90.07	12
GAN	-0.6867	73.1517	46.66	1.1	1.7	0.81	110.49	21

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt	Corr	Distance (km)	# of Cycles
SALALAH	16.9350	54.0067	69.29	1.1	1.6	0.80	81.44	21
HANIMAAD	6.7667	73.1667	49.80	1.3	1.7	0.82	91.06	13
POINT_LA	-4.6717	55.5283	48.50	1.8	2.1	0.88	83.99	21
ZANZIBAR	-6.1550	39.1900	47.43	0.8	1.0	0.38	118.76	22
DARWIN	-12.4667	130.8500	68.52	1.8	2.1	0.88	94.04	17
COCOS_IS	-12.1167	96.9000	51.36	2.4	2.7	0.93	48.38	17
ESPERANC	-33.8667	121.9000	50.02	2.2	2.1	0.90	75.20	19
ST._PAUL	-38.7117	77.5383	36.52	2.3	2.3	0.91	10.58	14
KERGUELE	-49.3450	70.2200	60.47	1.8	1.7	0.84	86.93	16
SAO_TOME	0.3500	6.7500	43.92	1.6	2.3	0.93	78.97	9
KEY_WEST	24.5533	278.1917	45.62	1.7	1.8	0.84	58.37	19
SAN_JUAN	18.4600	293.8833	59.17	1.0	1.3	0.67	49.43	22
SETTLEME	26.7100	281.0033	30.78	1.9	2.1	0.88	40.10	18
Bermuda	32.3700	295.3033	33.76	4.1	3.7	0.97	36.01	19
DUCK_PIE	36.1833	284.2600	81.52	1.9	1.7	0.85	56.57	21
CHARLEST	32.7817	280.0750	67.08	2.2	2.0	0.89	68.21	24
PORT_STA	-51.7000	302.1500	70.77	1.3	1.6	0.77	58.56	12
ASCENSIO	-7.9000	345.6167	43.33	0.6	1.0	0.27	64.21	19
ASCENSIO	-7.9000	345.6167	43.33	0.6	1.0	0.27	64.21	19
ST._HELE	-15.9667	354.3000	26.34	1.4	1.9	0.85	37.34	15
NAOS_ISL	8.9167	280.4667	59.18	2.0	2.1	0.88	107.00	21
BUNDABER	-24.8333	152.3500	70.95	1.1	1.2	0.62	101.75	22
FORT_DEN	-33.8500	151.2333	93.41	1.0	1.4	0.69	68.00	21
TOWNSVIL	-19.2500	146.8333	97.38	0.9	0.7	0.26	93.15	15
SPRING_B	-42.5500	147.9333	85.78	1.5	1.4	0.77	93.99	21
KUSHIRO	42.9677	144.3833	58.22	1.7	1.5	0.81	36.88	20
OFUNATO	39.0667	141.7167	86.54	1.2	1.4	0.70	91.61	21
MERA	34.9167	139.8333	61.83	2.1	2.6	0.93	87.05	15
KUSHIMOT	33.4667	135.7833	78.19	1.7	1.7	0.83	61.18	15
ABURATSU	31.5667	131.4167	138.37	0.7	1.1	0.48	57.58	18
NAHA	26.2167	127.6667	54.29	1.9	1.8	0.86	134.79	20
MANZANIL	19.0500	255.6667	51.66	2.5	2.5	0.92	49.50	20
FORT_POI	37.8067	237.5350	62.89	1.4	1.5	0.76	73.39	19
CRESCENT	41.7450	235.8167	87.04	1.0	1.0	0.49	106.67	21
NEAH_BAY	48.3683	235.3833	100.91	1.4	1.0	0.71	98.52	20
SAN_DIEG	32.7150	242.8267	34.42	2.0	2.0	0.87	56.85	18
YAKUTAT	59.5467	220.2650	99.45	1.6	1.9	0.84	49.67	17
DIEGO_RA	-56.5083	291.2850	61.77	2.5	2.5	0.92	29.68	13

APPENDIX C: Grid Tide Gauge/Altimeter Comparison Details

- ***Table C.1 Summary of grid vs. monthly tide gauge comparisons for GEOSAT GM***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-0.7500	269.6833	55.31	1.4	0.5	0.80	18
BALTRA	-0.4333	269.7167	83.51	1.3	0.4	0.87	18
NOUMEA	-22.3000	166.4333	69.03	0.8	1.4	0.70	18
SAIPAN	15.2333	145.7500	45.17	1.2	1.2	0.68	16
YAP	9.5167	138.1333	43.49	1.9	1.6	0.85	17
MALAKAL	7.3333	134.4667	56.69	1.9	1.6	0.85	18
POHNPEI	6.9833	158.2500	45.87	1.6	1.4	0.78	18
KAPINGAMAR	1.1000	154.7833	35.08	2.2	2.0	0.89	18
NAURU	-0.5333	166.9000	49.11	1.4	1.3	0.72	18
TARAWA	1.3667	172.9333	39.29	1.0	1.4	0.70	18
MAJURO	7.1000	171.3667	26.01	2.2	1.9	0.89	17
FRENCH_FRI	23.8667	193.7167	36.42	1.8	1.5	0.82	15
HONOLULU	21.3000	202.1333	54.15	1.3	1.5	0.74	18
RAROTONGA	-21.2000	200.2167	37.76	1.6	1.2	0.78	18
KANTON	-2.8167	188.2833	74.23	0.7	0.8	0.16	18
PENRHYN	-8.9833	201.9500	58.62	0.9	1.0	0.47	16
CHRISTMAS	1.9833	202.5333	39.29	1.3	1.5	0.76	18
PAPEETE	-17.5333	210.4333	28.72	1.0	1.1	0.57	17
FUNAFUTI	-8.5333	179.2167	48.73	2.1	1.8	0.88	18
RIKITEA	-23.1333	225.0500	29.0	2.7	2.6	0.93	18
SUVA	-18.1333	178.4333	56.85	1.0	1.1	0.56	18
HONIARA	-9.4333	159.9500	62.78	3.4	2.6	0.98	17
RABAUL	-4.2000	152.1833	60.77	2.1	1.4	0.90	18
NUKU_HIVA	-8.9333	219.9167	36.86	1.2	1.3	0.67	8
CALLAO	-12.0500	282.8500	43.61	0.8	1.0	0.39	18
LEGASPI	13.1500	123.7500	74.48	0.9	0.9	0.37	18
AUCKLAND	-36.8500	174.7667	58.83	1.4	0.9	0.72	18
WELLINGTON	-41.2833	174.7833	61.05	1.3	0.5	0.67	18
KUSHIRO	42.9667	144.3833	90.13	0.5	0.8	-0.23	18
NAHA	26.2167	127.6667	76.95	1.3	1.5	0.75	18
CHICHIJIMA	27.1000	142.1833	52.68	2.8	2.3	0.94	18
BUNDABERG	-24.8333	152.3500	77.42	0.6	1.2	0.60	17
BUENAVENTU	3.9000	282.9000	49.15	2.1	2.3	0.90	18
ANTOFAGAST	-23.6500	289.6000	53.25	0.7	0.7	0.07	18
CALDERA	-27.0667	289.1667	46.44	0.6	0.9	0.07	18
VALPARAISO	-33.0333	288.3667	46.46	0.9	0.6	0.13	17
ADAK	51.8667	183.3667	51.67	0.7	0.5	-0.43	17
UNALASKA	53.9000	193.5000	67.20	0.6	0.9	0.21	18
SELDOVIA	59.4333	208.2833	81.76	1.2	0.8	0.53	18
SAN_FRANCI	37.8000	237.5333	58.93	1.5	0.7	0.80	18
SAN_DIEGO	32.7167	242.8333	51.31	1.6	1.3	0.78	17

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
WAKE	19.2833	166.6167	50.96	1.6	1.4	0.78	18
JOHNSTON	16.7500	190.4833	57.45	1.6	1.0	0.79	17
MIDWAY	28.2167	182.6333	48.08	1.1	0.7	0.49	16
PETROPAVLO	53.0167	158.6333	67.95	0.9	1.1	0.49	17
YUZHNO_KUR	44.0167	145.8667	58.35	1.0	0.5	0.28	18
TRUK_MOEN	7.4500	151.8500	32.19	1.4	2.0	0.89	18
KWAJALEIN	8.7333	167.7333	37.31	1.1	1.3	0.66	18
GUAM	13.4333	144.6500	40.25	1.0	1.3	0.64	15
HILO	19.7333	204.9333	55.81	2.0	1.7	0.87	18
YAKUTAT	59.5500	220.2667	52.37	1.6	1.0	0.80	18
QUEPOS	9.4000	275.8333	123.35	0.8	0.7	0.06	16
SPRING_BAY	-42.5500	147.9333	86.29	0.7	0.6	-0.22	16
PAGO_PAGO	-14.2833	189.3167	43.72	1.6	1.2	0.78	18

- ***Table C.2 Summary of grid vs. monthly tide gauge comparisons for GEOSAT ERM***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-0.7500	269.6833	53.14	1.6	1.1	0.78	25
BALTRA	-0.4333	269.7167	69.08	1.5	0.9	0.79	23
NOUMEA	-22.3000	166.4333	56.61	0.9	1.2	0.57	25
SAIPAN	15.2333	145.7500	63.38	1.4	1.0	0.70	22
YAP	9.5167	138.1333	64.32	1.7	1.1	0.84	25
MALAKAL	7.3333	134.4667	91.37	1.5	0.8	0.75	24
POHNPEI	6.9833	158.2500	58.65	2.0	1.5	0.86	25
KAPINGAMAR	1.1000	154.7833	37.49	1.6	1.4	0.79	25
NAURU	-0.5333	166.9000	61.21	1.1	1.0	0.56	25
TARAWA	1.3667	172.9333	31.82	2.3	2.4	0.91	25
MAJURO	7.1000	171.3667	49.70	1.8	1.6	0.83	25
FRENCH_FRI	23.8667	193.7167	52.14	2.1	1.6	0.89	23
HONOLULU	21.3000	202.1333	39.63	1.5	1.8	0.82	25
RAROTONGA	-21.2000	200.2167	41.16	1.8	1.3	0.83	23
KANTON	-2.8167	188.2833	119.51	1.1	0.5	0.45	25
PENRHYN	-8.9833	201.9500	49.58	1.0	1.1	0.52	24
CHRISTMAS	1.9833	202.5333	59.20	2.1	1.9	0.88	25
PAPEETE	-17.5333	210.4333	38.10	1.3	1.6	0.78	25
FUNAFUTI	-8.5333	179.2167	51.62	1.6	1.5	0.80	25
RIKITEA	-23.1333	225.0500	35.44	1.3	1.3	0.70	24
SUVA	-18.1333	178.4333	64.71	0.8	0.8	0.26	20
HONIARA	-9.4333	159.9500	80.68	1.6	0.9	0.84	25
RABAUL	-4.2000	152.1833	46.23	1.9	1.6	0.86	25
NUKU_HIVA	-8.9333	219.9167	32.89	1.6	1.8	0.84	25
CALLAO	-12.0500	282.8500	51.51	1.0	1.0	0.50	25
LEGASPI	13.1500	123.7500	94.44	1.0	0.7	0.37	25
AUCKLAND	-36.8500	174.7667	45.29	0.8	0.8	0.24	25
WELLINGTON	-41.2833	174.7833	36.84	0.9	1.0	0.46	23
KUSHIRO	42.9667	144.3833	66.65	0.6	0.7	-0.08	25
NAHA	26.2167	127.6667	89.77	0.8	0.9	0.34	25
CHICHIJIMA	27.1000	142.1833	56.00	1.6	1.5	0.79	23
BUNDABERG	-24.8333	152.3500	71.86	0.7	1.1	0.50	25
BUENAVENTU	3.9000	282.9000	53.88	1.4	1.2	0.70	21
ANTOFAGAST	-23.6500	289.6000	61.15	0.9	1.0	0.45	23
CALDERA	-27.0667	289.1667	54.90	1.0	0.8	0.39	24
VALPARAISO	-33.0333	288.3667	53.19	0.7	0.7	-0.05	25
ADAK	51.8667	183.3667	62.76	0.8	0.8	0.23	23
UNALASKA	53.9000	193.5000	68.56	0.3	0.8	-0.32	15
SELDOVIA	59.4333	208.2833	60.88	1.0	1.0	0.49	25
SAN_FRANCI	37.8000	237.5333	70.70	1.1	0.8	0.49	25
SAN_DIEGO	32.7167	242.8333	66.56	1.2	1.0	0.59	25
WAKE	19.2833	166.6167	64.08	1.3	0.9	0.64	25
JOHNSTON	16.7500	190.4833	52.32	1.6	1.7	0.82	25
MIDWAY	28.2167	182.6333	58.88	0.9	1.1	0.51	25
PETROPAVLO	53.0167	158.6333	78.51	0.7	1.1	0.41	25
YUZHNO_KUR	44.0167	145.8667	58.32	0.9	0.8	0.32	24
TRUK_MOEN	7.4500	151.8500	60.27	2.0	1.5	0.87	20
KWAJALEIN	8.7333	167.7333	56.19	1.6	1.5	0.78	25

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
GUAM	13.4333	144.6500	83.32	1.3	1.0	0.63	24
HILO	19.7333	204.9333	75.89	0.7	0.9	0.16	24
YAKUTAT	59.5500	220.2667	55.79	1.1	0.6	0.47	24
QUEPOS	9.4000	275.8333	60.34	1.4	1.4	0.74	25
SPRING_BAY	-42.5500	147.9333	60.38	1.0	0.9	0.47	22
PAGO_PAGO	-14.2833	189.3167	41.45	1.7	1.8	0.84	24

- ***Table C.3 Summary of grid vs. monthly tide gauge comparisons for ERS-1 Phase C***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-.750	269.683	22.9	2.1	2.1	.89	19
BALTRA	-.433	269.717	29.7	1.9	1.5	.86	18
NOUMEA	-22.300	166.433	45.0	1.0	.8	.43	20
SAIPAN	15.233	145.750	38.7	1.4	1.8	.84	15
YAP	9.517	138.133	33.1	1.3	1.6	.78	20
MALAKAL	7.333	134.467	36.8	2.4	2.3	.91	20
POHNPEI	6.983	158.250	25.1	1.5	2.1	.91	20
KAPINGAMAR	1.100	154.783	33.4	1.6	1.2	.79	20
NAURU	-.533	166.900	49.1	1.2	.7	.57	18
TARAWA	1.367	172.933	35.8	1.4	1.0	.68	20
MAJURO	7.100	171.367	31.2	1.6	1.5	.80	20
FRENCH_FRI	23.867	193.717	37.4	1.5	1.1	.76	20
HONOLULU	21.300	202.133	33.8	1.2	1.2	.64	20
RAROTONGA	-21.200	200.217	52.4	1.2	.7	.57	20
KANTON	-2.817	188.283	28.0	1.3	1.7	.81	20
PENRHYN	-8.983	201.950	22.6	1.4	.9	.69	20
CHRISTMAS	1.983	202.533	25.3	1.7	1.7	.83	19
PAPEETE	-17.533	210.433	35.1	.8	1.1	.48	20
FUNAFUTI	-8.533	179.217	27.9	2.5	1.8	.93	20
RIKITEA	-23.133	225.050	31.0	1.7	1.3	.81	20
SUVA	-18.133	178.433	28.0	1.1	1.2	.62	20
HONIARA	-9.433	159.950	30.2	2.1	1.7	.89	20
RABAUL	-4.200	152.183	27.4	1.6	1.4	.78	20
NUKU_HIVA	-8.933	219.917	21.5	1.0	1.0	.49	20
CALLAO	-12.050	282.850	46.1	1.0	.9	.45	18
LEGASPI	13.150	123.750	92.9	.8	.8	.17	18
AUCKLAND	-36.850	174.767	38.7	1.3	1.0	.65	14
WELLINGTON	-41.283	174.783	28.5	1.2	1.3	.69	20
KUSHIRO	42.967	144.383	45.8	1.0	.7	.29	19
NAHA	26.217	127.667	64.3	.6	.9	.20	20
CHICHIJIMA	27.100	142.183	53.0	2.0	1.2	.94	20
BUNDABERG	-24.833	152.350	35.6	1.2	1.2	.63	20
BUENAVENTU	3.900	282.900	47.4	1.2	1.3	.69	17
ANTOFAGAST	-23.650	289.600	50.1	.7	.8	.18	19
CALDERA	-27.067	289.167	46.6	.5	.9	-.06	19
VALPARAISO	-33.033	288.367	53.4	.5	.7	-.41	20
ADAK	51.867	183.367	25.7	1.1	.7	.45	19
UNALASKA	53.900	193.500	34.4	.9	.9	.44	19
SELDOVIA	59.433	208.283	67.3	.9	.7	.24	14
SAN_FRANCI	37.800	237.533	41.2	1.2	1.2	.63	20
SAN_DIEGO	32.717	242.833	33.5	1.5	1.3	.75	20
WAKE	19.283	166.617	61.8	1.2	.9	.56	20
JOHNSTON	16.750	190.483	47.8	1.4	1.3	.71	20
MIDWAY	28.217	182.633	44.3	1.2	.5	.63	20
PETROPAVLO	53.017	158.633	76.1	.4	.9	-.17	20
YUZHNO_KUR	44.017	145.867	46.3	1.0	.8	.34	17
KWAJALEIN	8.733	167.733	26.5	1.8	1.6	.83	20
GUAM	13.433	144.650	51.0	1.7	1.8	.85	18

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
PAGO_PAGO	-14.283	189.317	30.4	1.2	1.0	.60	20
YAKUTAT	59.550	220.267	65.8	.8	.8	.17	19
QUEPOS	9.400	275.833	41.6	1.1	1.0	.51	19
HILO	19.733	204.933	32.8	1.1	1.3	.68	20
SPRING_BAY	-42.550	147.933	66.3	.9	.6	.16	20

- ***Table C.4 Summary of grid vs. monthly tide gauge comparisons for ERS-1 Phase E&F***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-.750	269.683	20.9	2.3	2.5	.92	12
BALTRA	-.433	269.717	30.2	2.0	2.2	.89	10
NOUMEA	-22.300	166.433	54.3	.4	1.0	.23	12
SAIPAN	15.233	145.750	20.0	5.3	5.0	.98	12
YAP	9.517	138.133	39.7	1.8	1.3	.85	12
MALAKAL	7.333	134.467	29.6	2.8	3.5	.97	11
POHNPEI	6.983	158.250	26.8	2.6	2.2	.93	12
KAPINGAMAR	1.100	154.783	40.3	1.5	1.5	.79	12
NAURU	-.533	166.900	41.9	1.6	1.4	.79	9
TARAWA	1.367	172.933	38.3	1.6	1.8	.83	12
MAJURO	7.100	171.367	29.0	2.0	1.9	.87	12
FRENCH_FRI	23.867	193.717	35.7	2.0	1.8	.86	12
HONOLULU	21.300	202.133	45.4	.9	.4	.06	12
RAROTONGA	-21.200	200.217	46.1	1.0	.7	.35	12
KANTON	-2.817	188.283	30.0	2.2	1.6	.90	12
PENRHYN	-8.983	201.950	27.0	2.4	1.9	.92	11
CHRISTMAS	1.983	202.533	31.6	2.3	1.9	.91	12
PAPEETE	-17.533	210.433	32.2	1.1	.9	.53	11
FUNAFUTI	-8.533	179.217	32.0	2.1	1.8	.88	12
RIKITEA	-23.133	225.050	43.8	1.8	1.2	.86	12
SUVA	-18.133	178.433	59.0	.8	.7	.12	12
HONIARA	-9.433	159.950	37.8	3.3	3.2	.95	12
RABAUL	-4.200	152.183	31.1	3.5	3.1	.96	11
NUKU_HIVA	-8.933	219.917	45.0	1.2	.7	.59	5
CALLAO	-12.050	282.850	38.6	.8	1.0	.36	10
LEGASPI	13.150	123.750	46.5	1.2	1.3	.68	12
AUCKLAND	-36.850	174.767	30.1	2.2	1.5	.91	12
WELLINGTON	-41.283	174.783	43.3	1.2	.8	.56	10
KUSHIRO	42.967	144.383	42.8	.8	.9	.29	12
NAHA	26.217	127.667	76.4	1.4	1.7	.81	12
CHICHIJIMA	27.100	142.183	50.7	2.2	1.4	.94	12
BUNDABERG	-24.833	152.350	50.1	.9	1.0	.50	12
BUENAVENTU	3.900	282.900	46.4	1.9	2.2	.89	12
ANTOFAGAST	-23.650	289.600	93.3	.8	.4	-.42	11
CALDERA	-27.067	289.167	25.1	1.1	.9	.48	11
VALPARAISO	-33.033	288.367	55.6	.7	.5	-.24	12
ADAK	51.867	183.367	47.9	.8	.7	.04	12
UNALASKA	53.900	193.500	44.0	.5	.8	-.16	12
SELDOVIA	59.433	208.283	55.6	1.0	.8	.34	9
SAN_FRANCI	37.800	237.533	66.0	1.4	.7	.77	12
SAN_DIEGO	32.717	242.833	78.0	.8	.7	.14	12
WAKE	19.283	166.617	41.1	1.6	1.7	.82	12
JOHNSTON	16.750	190.483	48.8	1.9	1.4	.85	12
MIDWAY	28.217	182.633	37.8	1.5	1.7	.81	12
PETROPAVLO	53.017	158.633	79.2	.9	.9	.34	11
YUZHNO_KUR	44.017	145.867	50.3	.9	1.0	.45	7
KWAJALEIN	8.733	167.733	23.8	2.5	2.4	.92	12
GUAM	13.433	144.650	44.4	2.2	2.2	.90	12

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
PAGO_PAGO	-14.283	189.317	30.1	1.0	1.2	.60	12
YAKUTAT	59.550	220.267	59.6	1.0	1.0	.50	12
QUEPOS	9.400	275.833	63.2	1.6	.9	.84	10
SPRING_BAY	-42.550	147.933	104.5	.6	.6	-.37	12
HILO	19.733	204.933	53.5	1.2	1.0	.58	12

- ***Table C.5 Summary of grid vs. monthly tide gauge comparisons for ERS-1 Phase G***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-.750	269.683	28.0	2.3	1.9	.91	14
BALTRA	-.433	269.717	34.9	2.2	1.8	.90	14
NOUMEA	-22.300	166.433	49.0	.9	1.4	.71	14
SAIPAN	15.233	145.750	42.5	1.5	1.5	.78	14
YAP	9.517	138.133	48.2	1.5	.7	.84	14
MALAKAL	7.333	134.467	43.5	2.4	1.9	.92	14
POHNPEI	6.983	158.250	41.9	2.5	1.7	.96	14
KAPINGAMAR	1.100	154.783	26.2	3.4	3.2	.96	14
NAURU	-.533	166.900	42.1	1.0	.7	.30	11
TARAWA	1.367	172.933	19.6	1.9	1.9	.86	14
MAJURO	7.100	171.367	25.8	2.6	1.8	.96	14
FRENCH_FRI	23.867	193.717	45.9	2.5	1.8	.94	14
HONOLULU	21.300	202.133	52.2	1.2	.8	.58	14
RAROTONGA	-21.200	200.217	41.9	1.5	.9	.75	14
KANTON	-2.817	188.283	32.5	1.3	2.2	.96	14
PENRHYN	-8.983	201.950	20.6	1.5	1.6	.79	14
CHRISTMAS	1.983	202.533	25.2	2.4	3.0	.96	14
PAPEETE	-17.533	210.433	30.7	1.2	.6	.50	14
FUNAFUTI	-8.533	179.217	21.7	5.9	5.4	.99	14
RIKITEA	-23.133	225.050	32.1	2.2	1.3	.95	11
SUVA	-18.133	178.433	57.3	1.1	.9	.54	14
HONIARA	-9.433	159.950	38.8	6.0	5.4	.99	14
RABAUL	-4.200	152.183	80.1	2.8	1.9	.99	14
NUKU_HIVA	-8.933	219.917	50.7	.9	.6	.20	14
CALLAO	-12.050	282.850	27.0	1.3	1.2	.68	14
LEGASPI	13.150	123.750	50.8	.8	1.1	.46	14
AUCKLAND	-36.850	174.767	60.9	1.3	.7	.67	11
WELLINGTON	-41.283	174.783	76.1	1.2	.4	.53	13
KUSHIRO	42.967	144.383	59.3	.7	.6	-.23	14
NAHA	26.217	127.667	61.7	1.2	1.2	.64	14
CHICHIJIMA	27.100	142.183	54.2	1.4	1.1	.68	14
BUNDABERG	-24.833	152.350	65.0	.7	1.0	.32	13
BUENAVENTU	3.900	282.900	46.6	1.5	1.4	.76	13
ANTOFAGAST	-23.650	289.600	57.3	.7	.5	-.23	13
CALDERA	-27.067	289.167	56.6	.7	.6	-.25	14
VALPARAISO	-33.033	288.367	62.5	.8	.4	-.26	13
ADAK	51.867	183.367	63.9	.5	.7	-.30	14
UNALASKA	53.900	193.500	74.7	.5	.6	-.45	14
SELDOVIA	59.433	208.283	100.2	.7	.5	-.25	14
SAN_FRANCI	37.800	237.533	55.3	1.1	.9	.51	14
SAN_DIEGO	32.717	242.833	77.8	1.1	.6	.42	14
WAKE	19.283	166.617	48.1	1.7	1.1	.83	14
JOHNSTON	16.750	190.483	42.9	1.7	.8	.88	14
MIDWAY	28.217	182.633	36.0	1.4	.8	.68	14
PETROPAVLO	53.017	158.633	67.3	1.0	.6	.35	13
KWAJALEIN	8.733	167.733	38.2	1.8	1.4	.83	14
GUAM	13.433	144.650	54.8	1.6	1.0	.79	14
PAGO_PAGO	-14.283	189.317	33.2	2.3	1.6	.94	14

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
HILO	19.733	204.933	39.2	1.1	1.1	.57	14
YAKUTAT	59.550	220.267	87.2	.8	.5	-.20	14

- ***Table C.6 Summary of grid vs. monthly tide gauge comparisons for T/P (Oct. 1992 - July 1997)***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-.750	269.683	16.6	4.6	4.4	.98	57
BALTRA	.433	69.717	5.7	3.1	3.0	.95	53
NOUMEA	-22.300	166.433	28.7	1.3	1.1	.66	57
SAIPAN	15.233	145.750	36.9	2.2	2.2	.90	54
YAP	9.517	138.133	16.8	4.8	4.6	.98	58
MALAKAL	7.333	134.467	33.8	2.6	2.5	.92	57
POHNPEI	6.983	158.250	20.0	4.3	4.2	.97	58
KAPINGAMAR	1.100	154.783	33.6	2.3	2.6	.93	58
NAURU	-.533	166.900	36.3	1.9	1.3	.87	49
TARAWA	1.367	172.933	18.5	2.9	2.7	.94	58
MAJURO	7.100	171.367	19.5	3.5	3.2	.96	58
FRENCH_FRI	23.867	193.717	37.9	2.4	2.1	.91	58
HONOLULU	21.300	202.133	38.7	1.3	1.2	.70	58
RAROTONGA	-21.200	200.217	39.3	1.9	1.6	.85	58
KANTON	-2.817	188.283	17.9	2.6	2.6	.93	58
PENRHYN	-8.983	201.950	17.9	2.7	2.3	.93	57
CHRISTMAS	1.983	202.533	23.2	2.6	2.4	.92	57
PAPEETE	-17.533	210.433	21.0	1.6	1.5	.79	57
FUNAFUTI	-8.533	179.217	24.8	3.6	3.4	.96	58
RIKITEA	-23.133	225.050	40.5	1.7	1.2	.82	46
SUVA	-18.133	178.433	37.4	1.5	1.4	.75	58
HONIARA	-9.433	159.950	22.8	7.2	7.3	.99	57
RABAUL	-4.200	152.183	51.6	3.2	2.4	.98	56
NUKU_HIVA	-8.933	219.917	47.2	.9	.7	.19	42
CALLAO	-12.050	282.850	40.2	1.8	1.2	.84	54
LEGASPI	13.150	123.750	47.4	1.3	1.6	.77	54
AUCKLAND	-36.850	174.767	36.7	1.8	1.5	.83	48
WELLINGTON	-41.283	174.783	45.1	1.3	1.0	.63	54
KUSHIRO	42.967	144.383	45.3	.7	.9	.27	57
NAHA	26.217	127.667	38.4	2.1	2.1	.89	58
CHICHIJIMA	27.100	142.183	38.9	2.6	2.2	.93	58
BUNDABERG	-24.833	152.350	36.5	1.2	1.3	.69	57
BUENAVENTU	3.900	282.900	34.3	2.5	2.7	.93	56
ANTOFAGAST	-23.650	289.600	80.9	.7	.8	.08	53
CALDERA	-27.067	289.167	53.2	.8	.9	.30	55
VALPARAISO	-33.033	288.367	53.5	1.0	.8	.40	57
ADAK	51.867	183.367	34.4	1.0	1.3	.64	58
UNALASKA	53.900	193.500	40.6	.8	.9	.27	56
SELDOVIA	59.433	208.283	60.7	1.0	.6	.23	52
SAN_FRANCI	37.800	237.533	58.3	1.2	.8	.58	58
SAN_DIEGO	32.717	242.833	41.3	1.5	1.6	.80	58
WAKE	19.283	166.617	43.6	1.7	1.2	.82	58
JOHNSTON	16.750	190.483	39.0	1.9	1.4	.87	58
MIDWAY	28.217	182.633	48.1	1.2	1.2	.64	58
PETROPAVLO	53.017	158.633	64.1	1.0	.7	.34	55
YUZHNO_KUR	44.017	145.867	35.9	1.0	.7	.38	20
KWAJALEIN	8.733	167.733	24.6	2.5	2.1	.92	58
GUAM	13.433	144.650	39.8	2.3	2.3	.91	58

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
PAGO_PAGO	-14.283	189.317	23.7	2.6	2.2	.92	58
YAKUTAT	59.550	220.267	52.9	1.1	.7	.48	57
QUEPOS	9.400	275.833	43.3	2.0	1.6	.87	27
HILO	19.733	204.933	24.6	1.9	1.4	.85	58
SPRING_BAY	-42.550	147.933	61.6	.9	1.0	.42	58

- ***Table C.7 Summary of grid vs. monthly tide gauge comparisons for ERS-2***

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
SANTA_CRUZ	-.750	269.683	35.0	2.6	1.8	.96	26
BALTRA	-.433	269.717	39.2	2.3	1.7	.92	25
NOUMEA	-22.300	166.433	44.3	1.0	1.5	.76	26
SAIPAN	15.233	145.750	51.0	1.5	1.1	.73	26
YAP	9.517	138.133	50.1	2.0	1.4	.89	26
MALAKAL	7.333	134.467	52.2	2.0	1.4	.90	26
POHNPEI	6.983	158.250	46.7	2.3	1.6	.94	26
KAPINGAMAR	1.100	154.783	38.7	2.6	2.3	.92	26
NAURU	-.533	166.900	41.3	2.0	1.3	.90	23
TARAWA	1.367	172.933	29.7	1.9	1.7	.86	26
MAJURO	7.100	171.367	40.0	1.9	1.1	.91	26
FRENCH_FRI	23.867	193.717	58.8	1.9	1.2	.89	26
HONOLULU	21.300	202.133	48.7	1.2	.8	.57	26
RAROTONGA	-21.200	200.217	46.1	1.8	1.5	.84	26
KANTON	-2.817	188.283	45.0	1.0	1.5	.76	26
PENRHYN	-8.983	201.950	22.8	1.7	1.6	.82	26
CHRISTMAS	1.983	202.533	30.5	2.0	1.9	.87	25
PAPEETE	-17.533	210.433	26.2	1.3	1.2	.67	26
FUNAFUTI	-8.533	179.217	34.3	3.0	2.5	.95	26
RIKITEA	-23.133	225.050	35.7	2.1	1.5	.90	14
SUVA	-18.133	178.433	46.8	1.5	1.4	.75	26
HONIARA	-9.433	159.950	31.6	6.7	6.3	.99	26
RABAUL	-4.200	152.183	86.6	2.6	1.7	.98	25
NUKU_HIVA	-8.933	219.917	60.3	.8	.6	-.11	18
CALLAO	-12.050	282.850	47.9	1.7	1.1	.83	26
LEGASPI	13.150	123.750	47.6	1.2	1.3	.68	26
AUCKLAND	-36.850	174.767	49.2	1.5	.9	.77	23
WELLINGTON	-41.283	174.783	74.1	1.0	.5	.18	25
KUSHIRO	42.967	144.383	62.8	.6	.7	-.14	26
NAHA	26.217	127.667	73.8	1.1	1.1	.57	26
CHICHIJIMA	27.100	142.183	53.6	1.8	1.3	.86	26
BUNDABERG	-24.833	152.350	64.8	.7	1.0	.36	25
BUENAVENTU	3.900	282.900	45.0	1.7	1.5	.81	25
ANTOFAGAST	-23.650	289.600	58.8	1.0	.7	.38	25
CALDERA	-27.067	289.167	60.2	.8	.7	.17	26
VALPARAISO	-33.033	288.367	67.9	1.0	.5	.19	25
ADAK	51.867	183.367	54.0	.7	.8	.02	26
UNALASKA	53.900	193.500	94.8	.4	.9	-.20	25
SELDOVIA	59.433	208.283	82.0	.8	.6	-.03	26
SAN_FRANCI	37.800	237.533	66.8	1.1	.7	.44	26
SAN_DIEGO	32.717	242.833	72.4	1.0	.6	.21	26
WAKE	19.283	166.617	67.7	1.4	.9	.71	26
JOHNSTON	16.750	190.483	49.8	1.5	.8	.82	26
MIDWAY	28.217	182.633	43.4	1.5	1.1	.74	26
PETROPAVLO	53.017	158.633	83.0	.9	.6	.22	25
KWAJALEIN	8.733	167.733	47.1	1.5	1.0	.76	26
GUAM	13.433	144.650	57.5	1.7	1.2	.81	26
PAGO_PAGO	-14.283	189.317	45.3	1.8	1.2	.86	26

Tide Gauge	Latitude	Longitude	RMS (mm)	SNR Gauge	SNR Alt.	Corr	Available Months
HILO	19.733	204.933	39.6	1.1	1.2	.60	26
YAKUTAT	59.550	220.267	82.3	.7	.6	-.12	26

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13. ABSTRACT *(Maximum 200 words)*

The NOAA/NASA Pathfinder program was created by the Earth Observing System (EOS) Program Office to determine how existing satellite-based data sets can be processed and used to study global change. The data sets are designed to be long time-series data processed with stable calibration and community consensus algorithms to better assist the research community. The Ocean Altimeter Pathfinder Project involves the reprocessing of all altimeter observations with a consistent set of improved algorithms, based on the results from TOPEX/POSEIDON (T/P), into easy-to-use data sets for the oceanographic community for climate research.

Details are currently presented in two technical reports:
Report #1: Data Processing Handbook
Report #2: Data Set Validation

This report describes the validation of the data sets against a global network of high quality tide guage measurements and provides an estimate of the error budget. The first report describes the processing schemes used to produce the geodetic consistent data set comprised of SEASAT, GEOSAT, ERS–1, TOPEX/POSEIDON, and ERS–2 satellite observations.

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