Combination of TOPEX, JASON and Tide Gauge Data to Reconstruct Long Periodic Changes in the Global Sea Level

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1 Introduction

On December 7, 2001 the JASON-1 mission was launched to replace its predecessor TOPEX/POSEIDON (T/P). Purpose of this poster is to demonstrate that the tandem mission concept can link both systems. Absolute calibration with the help of tide gauges is necessary to be able to estimate global and local sea level changes. Oceanographic climatology of Levitus is used to explain the thermosteric part of the observed sea level variations. Post glacial rebound corrections are used to compensate for land motion at tide gauges.

2 Linking T/P and Jason

Both systems have operated in tandem during the first half of 2002 so that differencing of observed sea levels results in a relative altimeter bias. Table 1 shows the results from our relative calibration procedure from which we conclude that it is possible to calibrate T/P and Jason to about 0.5 mm which is sufficient for sea level change studies. This value is obtained by computing the rms of a mean sea level anomaly difference as 19 / sqrt(N) mm where N is the number of passes used in the computation of table 1.

observation type	acronym	units	mean	rms
sea level anomaly	SLA	mm	-93	19
significant wave height	SWH	mm	68	29
microwave radiometer	MWR	mm	-5	3
ionospheric delay	ION	mm	-3	1
radar backscatter	sigma_0	dB	0.25	0.04

Table 1: Altimeter bias statistics obtained from the relative calibration experiment. The mean and the rms values refer to value estimated by altimeter pass (a half orbit in RADS). The statistics are then computed from 4534 passes.

3 Absolute calibration

Formation flying takes care of the relative calibration of both altimeters; to accomplish absolute calibration we use a network of tide gauges. We follow the method described in (Mitchum,1998) and have used 41 tide gauges. The tide gauge data are corrected for a land motion correction due to post glacial rebound (PGR) using the ICE-3G model developed by (Tushingham and Peltier,1991). The results are shown in figure 1.

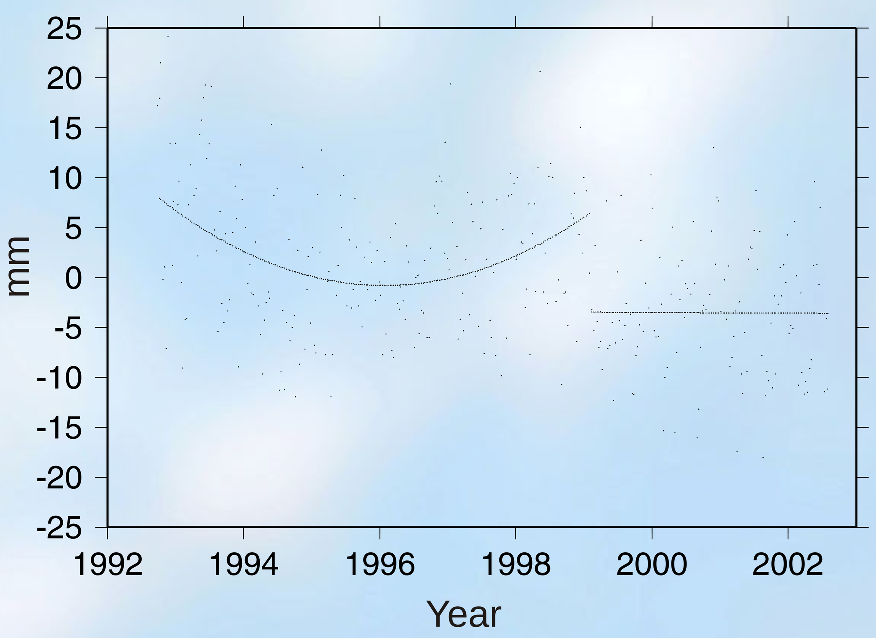

Figure 1: Altimeter bias estimates for TOPEX cycles 2 till 364, or August 1992 till July 2002. At cycle 233 side A was switched off and side B took over at cycle 235. The individual points represent the mean difference between altimeter observed sea level heights and neighboring tide gauge records. The continuous lines represent best fitting polynomials.

4 Sea Level change.

The combination of both calibration procedures enables satellite altimetry to observe the global sea level (GSL) trend. A number of estimates are shown in figure 2 and table 2 based upon different versions of the inverse barometer correction algorithm and selected data subsets. Our average GSL trend recovered by altimetry is currently 1.94 +/- 0.15 mm/yr. This number is based on the average of 4 cases displayed in table 2.

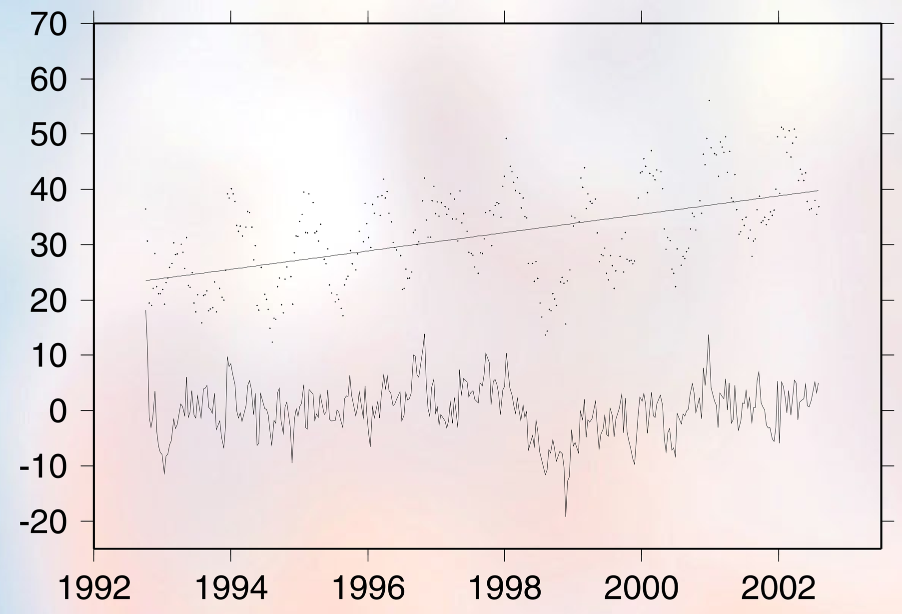

Figure 2: Global mean sea level [mm] against date estimated from T/P side A and B. Dots represent a GSL by cycle, the solid line is a residual after subtraction of an annual correction curve and a linear trend of 1.77 mm/yr

case	slr mm/yr	cos mm	sin mm	rms mm
IB, full period	2.06	-5.19	-4.84	5.12
IB, excluding 97-98	2.10	-4.86	-5.15	4.89
no IB, full period	1.77	5.98	5.37	4.75
no IB, excluding 97-98	1.83	6.00	5.06	4.23

Table 2: estimates of the global sea level change with consideration of different versions of the IB correction and inclusion or exclusion of the 1997-1998 ENSO.

4 Local Sea Level Change

More difficult to interpret are altimeter estimates of the local sea level change. While the GSL values converge around 2 mm/yr the local sea level (LSL) changes occur in the range -20 to +20 mm/yr. Our estimate from 10 years of T/P data is shown in figure 3. An estimate from the Levitus climatology between 1945-1996 is shown in figure 4. The average thermosteric GSL trend from climatology is 0.35 mm/yr so that 1.55 mm/yr remains for other terms in the budget such as meltwater input, post glacial rebound and other non-steric processes.

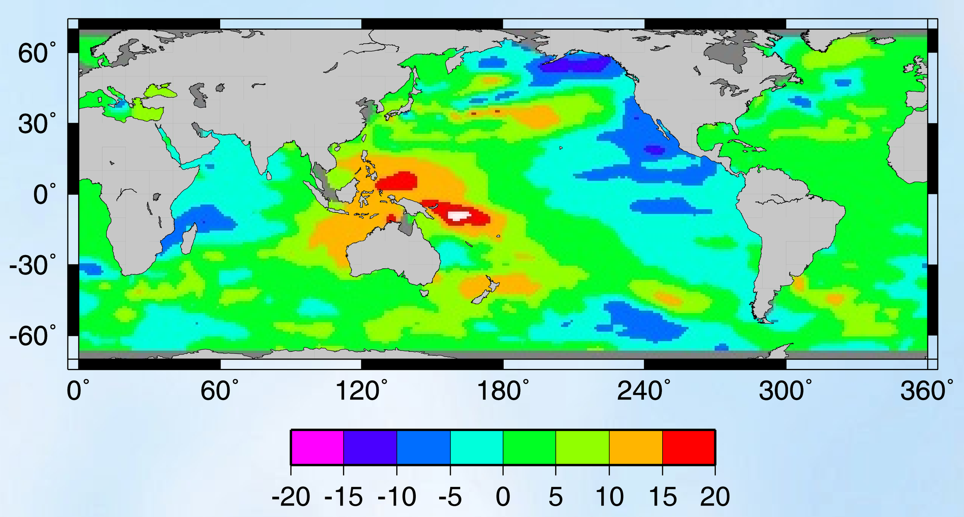

Figure 3: Local sea level change (mm/yr) observed by satellite altimetry.

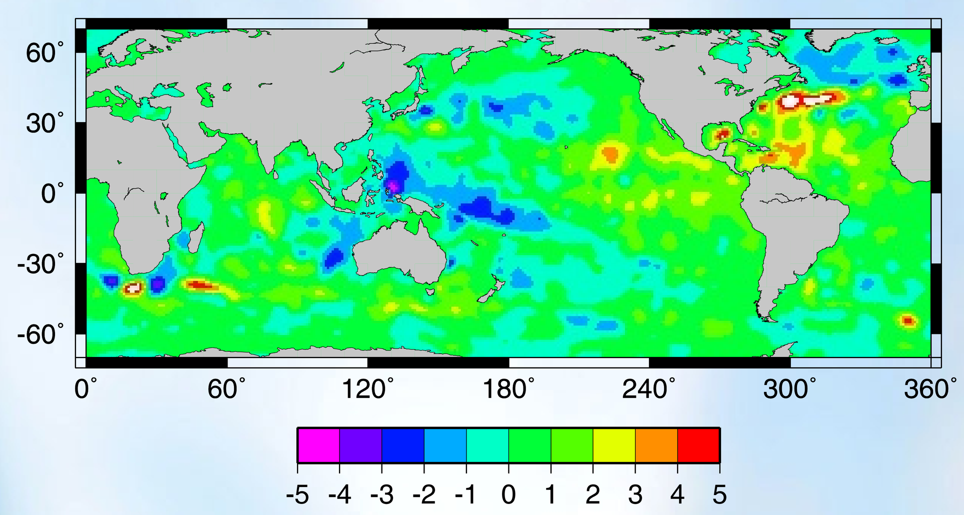

Figure 4: Local sea level change (mm/yr) from Levitus climatology for 1945-1996

5 Annual Cycle

Figures 5a-c show a verification of the algorithm that computes steric sea level variations. Essentially monthly densities in a water column are computed relative to a mean, this information is translated to height information and an annual cycle is extracted. Figures 5a and 5b show the altimeter estimate, figure 5c shows the difference to the annual cycle predicted by climatology.

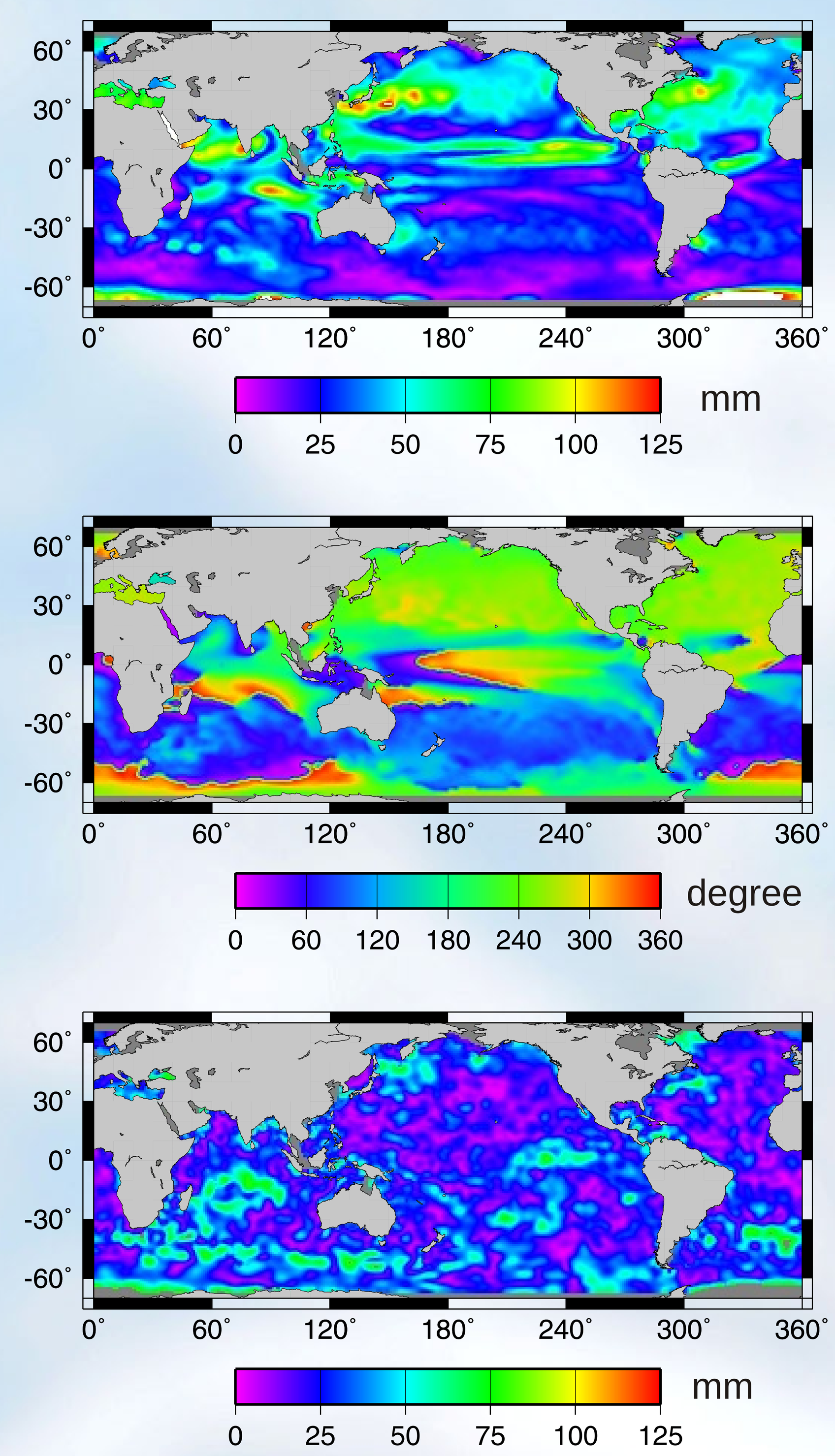

Figure 5a-c: Top/middle annual amplitude and phase from altimetry, bottom, difference to monthly Levitus climatology.

6 Effect 1997-1998 ENSO

This phenomenon had a global impact and its remnants are clearly visible in our LSL trend estimates (see also figures 3 and 4). Here we display the result of a least squares estimation procedure where the sea level is modeled as a linear trend, an annual cycle and an extra regression variable being the NINO 3.4 index.

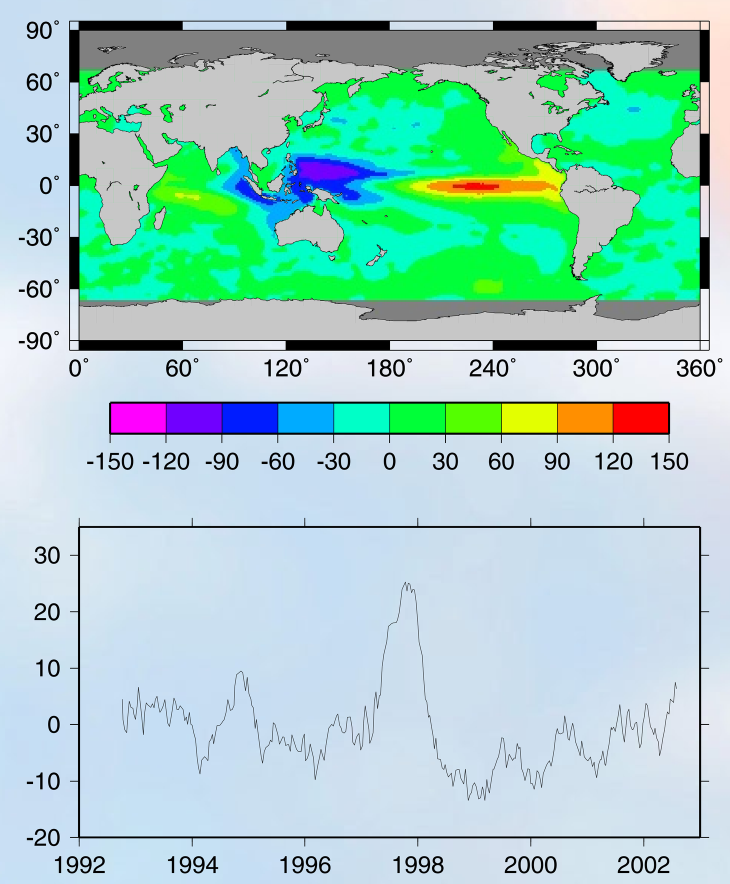

Figure 6: The top panel shows a geographic regression variable, the bottom panel the corresponding NINO3.4 index in units of cm. To obtain sea level variations divide the top panel by 100 and multiply times the bottom panel.

7 Conclusions

The T/P Jason combination enables continuation of sea level change monitoring with satellite altimetry. We observe about 1.94 mm/yr with this technique, while Levitus climatology explains about 0.35 mm/yr as a thermosteric signal. These statements refer to global sea level change, regional sea level change processes vary over a much wider range and depend more heavily on the selected time window.

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