Effect of new USO and SPTR tables on ERS-1 and ERS-2 range

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1 Introduction

Since 15 December 2000 new USO and SPTR correction tables are available from ESRIN (`http://pcswww.esrin.esa.it/ra`). For the USO tables the difference is only in format (two separate files are available in stead of one for both satellites). The SPTR tables, however, have completely changed. A new method has been devised to determine the correction [*Martini and Féménias*, 2000]. These new SPTR values are nicknamed SPTR2K.

The old SPTR tables are no longer made available by ESRIN since 24 January 2001. As from 30 January 2001 the new SPTR and USO tables are used by all DEOS software through the subroutine altbias.

2 Downloading

The old SPTR and USO correction tables were available on an FTP site. The new tables are available by HTTP protocol only. To avoid manual downloading using a web browser, an HTTP-compatible FTP client software (lftp) has been installed. This program now daily mirrors the SPTR and USO tables and a symbolic link is created in the directory `$ALTIM/data/bias` to always point to the most recent files.

3 New implementation

The new tables have been implemented in the subroutine altbias, along with the old corrections. This routine returns the USO and SPTR correction for a given ERS-1 or ERS-2 data product at a given time. The routine searches in the USO and SPTR tables (which are loaded into memory at the first call) and returns the correct values to the user. These corrections are to be **added** to the altimeter range.

3.1 SPTR correction

The implementation of the SPTR correction in altbias is quite simple. The routine searches the to time tags in between which the requested epoch lies. Because the SPTR correction changes stepwise, the value belonging to the first time tag is reported to the user. If the requested epoch is beyond the last entry in the table, the last value in the table is reported.

In case the SPTR correction for a certain interval between two altimeter switch-offs could not be determined, a value 0 is reported in the SPTR correction file. The routine altbias, however, returns the average SPTR correction for the given satellite. This is +20 mm for ERS-1 and –20 mm for ERS-2.

Figure 1 shows the impact of the change in the SPTR tables for ERS-1 and ERS-2. The red and green line correspond to the old and new corrections. There are noticeable differences between the two (indicated by the blue line). The new SPTR correction will decrease the sea level heights for ERS-1 by about 15 mm. ERS-2 sea level measurements will rise by an average of about 12 mm. The bias between ERS-1 and ERS-2 will thus change by about 27 mm, lowering ERS-1 sea levels with respect to ERS-2.

Note that there is also a negative trend in the difference between the new and the old SPTR correction for ERS-1. This means that when the new SPTR correction is applied the sea level trend for ERS-1 will likely increase by approximately 2 mm/year.

3.2 USO correction

Although the USO values have not changed, the implementation in altbias has been changed on two points. In the older implementation all time tags were taken to be at 00:00 UTC of the date given in the table. In reality, the time tags vary between 10:00 and 12:00 UTC. The subroutine altibias now correctly registers the time tags. In the earlier years, however, the exact time was not given. When this is the case, 11:00 UTC is assumed.

The second change concerns the interpolation of the values from the table. This used to be done with stepwise changes, like the SPTR correction. Currently, linear interpolation is implemented. If the requested epoch is beyond the last entry in the table, linear extrapolation is performed using the last two entries.

Effects of both changes are marginal, as can be seen in Figure 2. The only during long intervals wihout USO measurements differences of a few millimeters are noticeable.

4 Evaluation

Because of the new retrieval algorithm of the SPTR values, the new corrections are suggested to be more precise. Particularly any remaining jumps in the (apparent) bias of the ERS-1 and ERS-2 radar altimeters should be reduced. An obvious way to analyse the improvement of the bias stability is by comparision of collinear ERS-1 and ERS-2 tracks with a 1-day interval. This has been done in the report by *Martini and Féménias* [2000]. Unfortunately, this analysis only applies to the Tandem Mission and not the the periods before (ERS-1) and after (ERS-2).

In this report we will analyse the **full** period of operation of ERS-1 and ERS-2 by means of crossover height differences with TOPEX and through comparison with a mean sea surface model. All altimeter data stem from the RADS database [*Schrama et al.*, 2000].

4.1 Dual-satellite crossovers

First, all crossover locations between ERS-1 and TOPEX were searched for which the time interval between the measurements is less than 5 days. Second, the fully-corrected sea surface heights along the tracks are interpolated to the crossover location and differenced, creating crossover height differences. This was repeated for the combinations ERS-1/Poseidon,

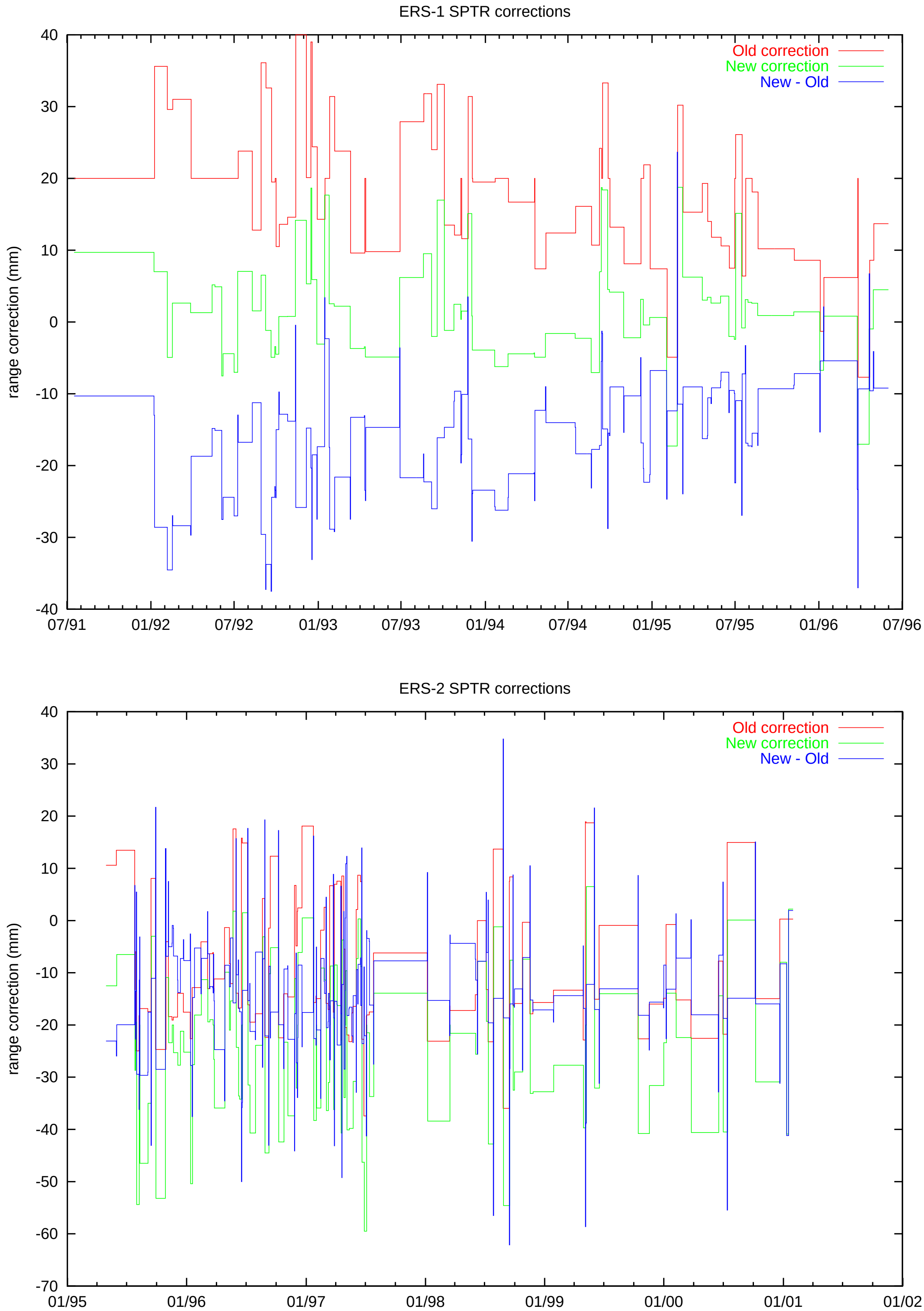

Figure 1. Old and new SPTR correction and their differences for ERS-1 (top) and ERS-2 (bottom).

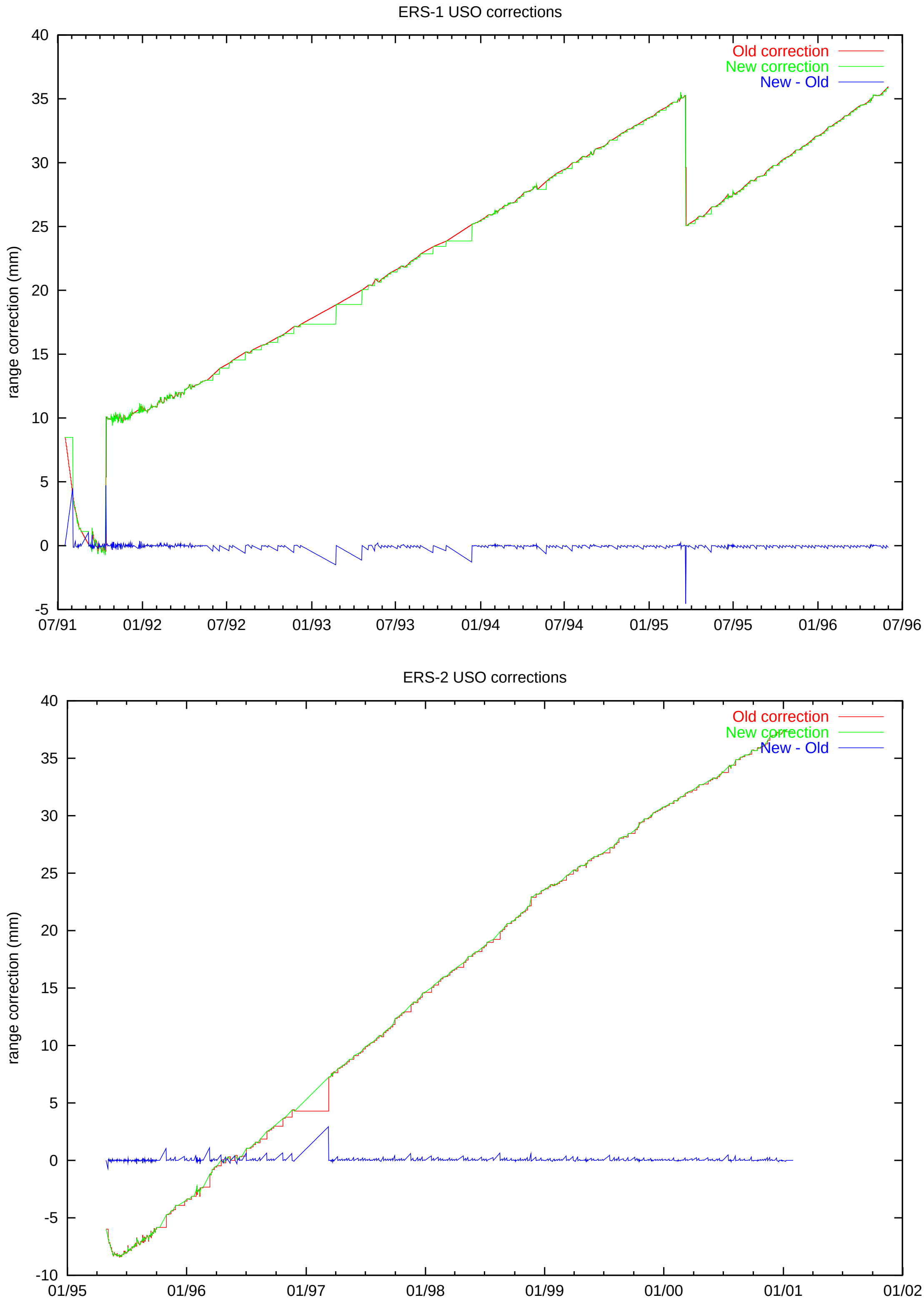

Figure 2. Old and new USO correction and their differences for ERS-1 (top) and ERS-2 (bottom).

ERS-2/TOPEX, ERS-2/Poseidon, and ERS-1/ERS-2 (in the later case the time interval was limitted to 17.5 days).

All crossover height differences were averaged in weekly and monthly bins. This was done for data corrected with the old SPTR correction and repeated for data corrected with the new SPTR correction. The results are shown in Figure 3: weekly averages are portrayed in the top graph, monthly averages in the lower graph.

Most evident is the improvement of the crossover height differences between ERS-1 and ERS-2. With the old SPTR corrections (grey line) a clear trend is visible, which is completely removed when using the new SPTR corrections (black line). This is mainly due to changes in ERS-2 sea height measurements.

In the comparison of ERS-1 and TOPEX sea level we see no dramatic improvement when going from the old (magenta line) to the new (red line) SPTR corrections. The ERS-1 sea heights dropped by a bit less than 2 cm, as expected, and the sea level trend slightly increases.

Many erratic changes in the sea height difference between ERS-2 and TOPEX are visible when the old SPTR corrections were used (cyan line). They are largely removed when the new SPTR corrections are applied (blue line) and sea level for ERS-2 is increased by an average of about 1 cm. However, the sudden drop in the sea level differences after the beginning of the year 2000 is visible in both cases. It is not clear whether the 2 cm drop is related to the drop of sigma naught occurring in January 2000. We can rule TOPEX out as a rule since TOPEX/Poseidon crossovers (green crosses) show no such behaviour.

4.2 Sea level anomalies

For each pass (half orbit) the average height difference with the OSU MSS95 mean sea surface model is computed. These sea level anomalies can be caused by many sources, among which are orbit errors, geophysical correction errors, seasonal sea level change, and altimeter bias changes. We assume that the orbit and geophysical correction errors average out over a period of a month. What remains are seasonal sea level changes (most likely exhibiting a yearly cycle) and bias changes.

Figure 4 shows the monthly average anomalies obtained for ERS-1 (red line), ERS-2 (blue line), TOPEX (magenta line) and Poseidon (green crosses). The straight inclined lines indicate a sea level trend fitted to the monthly averages. The seasonal cycle is clearly visible in the TOPEX data. The sea level trend for ERS-1 is evidently too large, but for TOPEX and Poseidon it is quite realistic. The ERS-2 sea level trend would have been similar if not for the data after January 2000. Again, TOPEX and Poseidon data show no such behaviour.

5 Conclusion

When the new SPTR corrections are applied the variations in sea level differences between ERS-1, ERS-2 and TOPEX appear to reduce. However, the trend in ERS-1 sea level is still irrealistically high. It is also not clear what causes the sudden drop in ERS-2 sea level since early 2000.

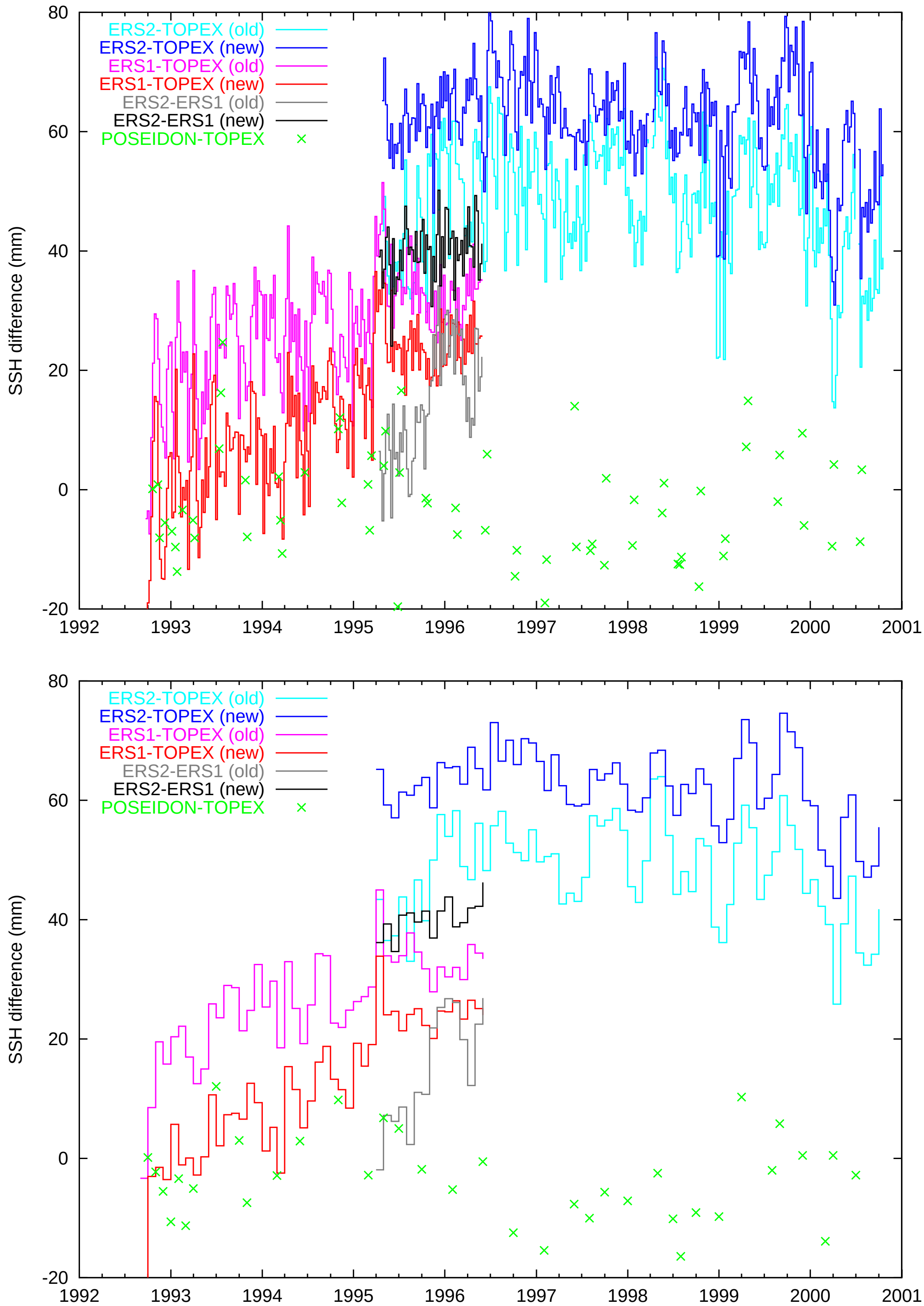

Figure 3. Comparison between ERS-1, ERS-2, TOPEX and Poseidon sea surface heights at crossovers. The crossover height differences are averaged per week (top) and per month (bottom).

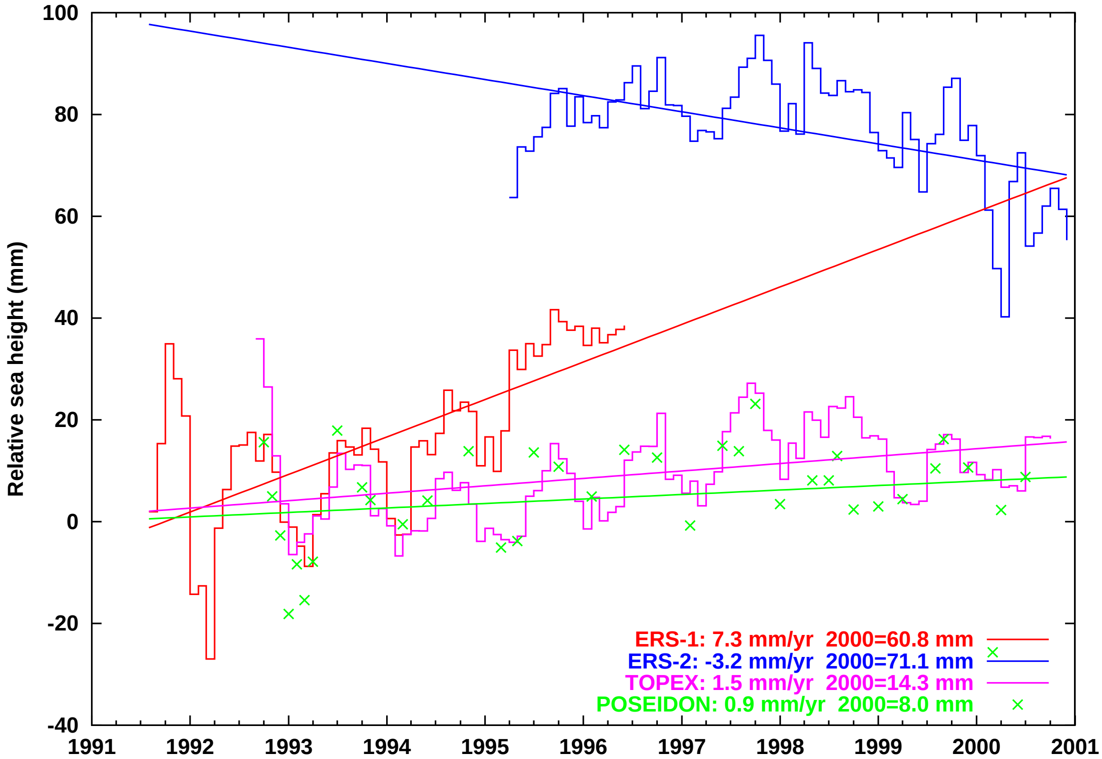

Figure 4. Comparison of ERS-1, ERS-2, TOPEX and Poseidon sea surface heights with the OSU MSS95 mean sea surface model. Sea level anomalies have been averaged per month.

References

Martini, A., and P. Féménias (2000), The ERS SPTR2000 altimeric range correction: Results and validation, *Technical Note ERE–TN–ADQ–GSO–6001*, ESA/ESRIN, Frascati, Italy, November 2000.

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