NOTES AND CORRESPONDENCE

A High-Resolution Global Sea Surface Temperature Climatology for the 1961–90 Base Period

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ABSTRACT

In an earlier study (Reynolds and Smith), a monthly 1° SST climatology was produced for the 1950–79 base period. This climatology was constructed from two intermediate climatologies: a 2° SST climatology developed from in situ data for the period 1950–79, and a 1° SST climatology for the period 1982–93 derived from an optimum interpolation SST analysis that uses in situ and satellite data. Since then a new 2° spatial resolution near-global SST analysis has been developed, which can produce a similar high-resolution climatology for any base period within the analysis period (1950–92). In this note the procedure is utilized to change the base period to 1961–90, which is the climatological base period suggested by the World Meteorological Organization. The method is nearly identical to that used in the earlier study except for the formation of the 2° climatology from new analyses. The results show that the change in the climatology is generally small with absolute differences usually less than 0.2°C. As with the earlier climatology, in regions where insufficient in situ observations are available prior to 1982 there is no adjustment. In those regions, which include the Southern Ocean, the climatology base period is 1982–96.

1. Introduction

In Reynolds and Smith (1995, hereafter RS) we produced a 1° spatial resolution monthly climatology. The climatology was constructed from two intermediate climatologies: a 2° SST climatology developed from in situ data for the period 1950–79, and a 1° SST climatology derived from the optimum interpolation (OI) SST analysis (1982–93) of Reynolds and Smith (1994). The final climatology was a combination of these two products so that a 1° resolution was maintained and the base period was adjusted to the 1950–79 period wherever there were sufficient in situ data (approximately between 40°S and 60°N). Compared to the 2° climatology, the 1° climatology resolved equatorial upwelling and fronts much better, which leads to a better matching of the scales of the OI analysis and climatology. Although the climatological base period south of 40°S and north of 60°N was reduced to 1982–93, the use of the satellite data in the OI allowed resolution of oceanic features, for example, the fronts near the northern boundary of the Antarctic Circumpolar Current, that could not be resolved without satellite data.

When the RS climatology was computed, we decided to maintain the same operational base period (1950–79) as had previously used (Reynolds 1988) for more consistent monitoring and analysis of SST anomalies. Since then we decided to change the base period of our high-resolution SST climatology to 1961–90, to match that suggested by the World Meteorological Organization and used by the Intergovernmental Panel on Climate Change (Houghton et al. 1996).

The new climatology is similar to that of RS but contains some refinements. There are three more years of OI analysis (1994–96) available since the construction of the RS climatology in 1994. The Smith et al. (1996) 2° resolution in situ analysis for 1950–92 gives an improved near-global SST climatology, which is augmented with additional in situ data in some inland seas. In the Smith et al. (1996) analysis spatial empirical orthogonal functions (EOF) were computed from the OI analysis. The 2° analysis was then obtained by fitting the dominant EOF modes, in a least squares sense, to the monthly in situ data. In the sections that follow we discuss the input analysis, the new adjusted climatology, and differences between the 1961–90 and the 1950–79 base period climatologies.

This adjusted climatology is designed to assist monitoring and analysis of SST anomalies primarily on interannual and shorter timescales. Because the climatology adjustments are a few tenths of a degree or less, larger anomalies will be minimally affected by the change in climatology. However, caution should be exercised in interpretation of small anomalies occurring across boundaries between regions where the 1961–90

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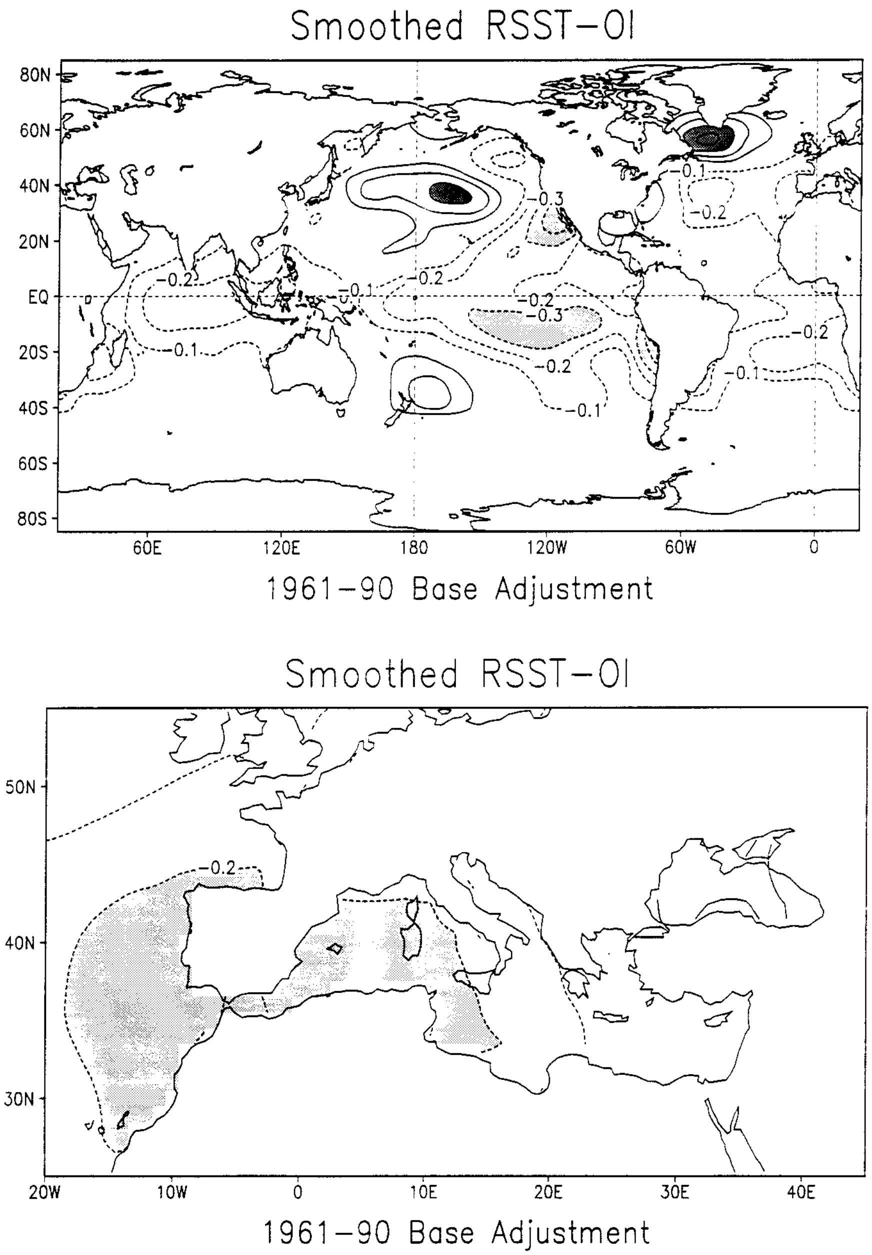

FIG. 1. Annual average of the adjustment for the OI climatology. Contour interval is 0.1°C, the zero contour is omitted. In (a) values less than −0.3°C and greater than 0.3°C are shaded, and in (b) values less than −0.2°C and greater than 0.2°C are shaded.

2° climatology is defined and regions where the climatology relaxes to the 1982–96 base period. For analysis of small anomalies in those regions, the 1982–96 OI-based climatology could be used instead to avoid differences associated with the merging of climatologies that have different base periods.

2. Input analysis

To make the adjusted SST climatology, we first compute a 1° spatial resolution climatology from the OI analysis of Reynolds and Smith (1994). The OI uses global satellite and all available in situ data to produce a global, high-resolution SST analysis for the period in which satellite observations are available (November 1981–present). To form the OI climatology for a calendar month we average all analyses for that month over the 1982–96 period. The three extra years of OI analysis available since the construction of the RS climatology do not substantially change the OI-based climatology, but they should give slightly more stability to a climatology because of the longer base period.

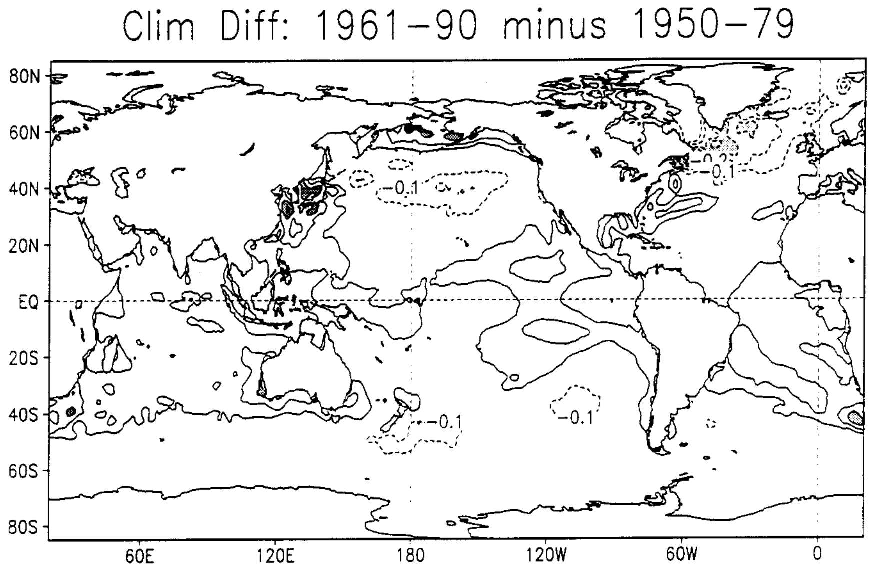

FIG. 2. Annual average difference in the climatologies, 1961–90 climatology minus the 1950–79 climatology of RS. Contour interval is 0.1°C, the zero contour is omitted and values less than −0.3°C and greater than 0.3°C are shaded.

We next compute a monthly climatology for the desired base period, 1961–90, using the SST analyses of Smith et al. (1996) augmented by in situ data in some inland seas, which are described below. This climatology, which we will refer to as the in situ climatology, is again computed by averaging the appropriate months for the 1961–90 period. Although the in situ climatology is computed from analyses done on a 2° resolution grid, the actual resolution is somewhat less because the EOF fitting tends to smooth out the data in these analyses. In addition, because the Smith et al. (1996) analyses are confined to oceanic regions where there are sufficient observations to perform the analysis, roughly 45°S–70°N, the in situ climatology cannot be defined everywhere.

In situ SST from the Comprehensive Ocean–Atmosphere Data Set (COADS; Woodruff et al. 1987) are combined with the reconstructed SST of Smith et al. (1996) to fill the Mediterranean Sea, the Baltic Sea, the Black Sea, the Red Sea, and the Persian Gulf. Those inland seas are not included in the reconstructed SST but have sufficient sampling for construction of a climatology. For each month in the 1961–90 period a near-global 2° SST field is formed using the Smith et al. (1996) analysis where available and filling inland seas with the COADS data. The COADS data are checked against the 15-yr OI climatology, and data that differ from the OI climatology by ± 2 standard deviations are not used. At each spatial location for each calender month, the in situ climatology is then computed by averaging all available data for that month, with the requirement that there must be data for at least three years for COADS-filled locations. Since we only use COADS to fill well-sampled regions, the climatology is well defined in those regions without decadal bias. At those few COADS-filled locations where there are insufficient data and at high latitudes where the in situ analysis is not defined, the in situ climatology is set equal to the 15-yr OI climatology.

This climatology is similar to the 1950–79 climatology used by RS. However, that product was formed by averaging observations over the period rather than from analyses. Because the number of in situ observations has increased with time, the climatology used by RS is not exactly centered on the 1950–79 period. This is not the case for the in situ climatology used here, apart from those inland seas filled using COADS data.

3. Adjusted OI climatology

Computation of an adjusted climatology is discussed in detail in RS, and the method described here is almost identical. First the OI climatology is averaged to the 2° grid of the in situ climatology and the difference between the two climatologies is computed for each month. In regions where there is no in situ climatology, the difference is zero. The difference is then smoothed spatially using a moving area average. We smooth over a moving area with a radius of 1000 km in order to resolve only the large-scale differences. That smoothed difference defines the base-period monthly adjustment for the OI climatology (see RS for details). To further reduce temporal noise in the smoothed difference, it is temporally smoothed by fitting to a Fourier series and retaining only the mean and first two harmonics of the difference. The average of the 12 monthly adjustments reflects low-frequency SST variations (Fig. 1a), and is typically a few tenths of a degree with negative ad-

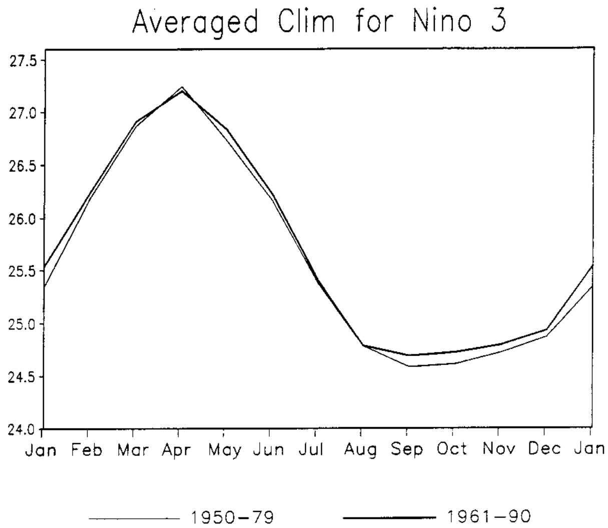

FIG. 3. Annual cycle of the 1961–90 climatology and the 1950–79 climatology, averaged in the Niño3 region (5°S–5°N, 150°–90°W), in °C.

justments over most of the oceans except in the midlatitude North Pacific, the northwest North Atlantic, and in a small part of the Southern Hemisphere centered near the date line at 40°S. For the region including the Mediterranean Sea (Fig. 1b) the adjustment is a smooth continuation of the adjustments in the Atlantic. The individual monthly adjustments each show similar patterns for the oceans. In most inland seas the seasonal cycle of the adjustment has an amplitude of 0.3°C or less, but in the Black Sea the amplitude exceeds 0.5°C. Since that sea is relatively small and is situated deep within the Eurasian landmass, its temperatures can fluctuate more easily than the oceanic temperature and thus it is not unreasonable for its difference to have a greater range.

The adjusted monthly climatology is computed by adding the appropriate smoothed monthly difference to the monthly OI climatology. The annual average difference between the 1961–90 climatology and the RS 1950–79 climatology (Fig. 2) shows that differences are small over most of the oceans, typically 0.1°–0.2°C, with a global mean of 0.06°C. Differences between the two climatologies reflect changes in the base periods and, to a lesser extent, changes in our computation of the intermediate products.

The annual cycle of the 1961–90 adjusted climatology and the 1950–79 adjusted climatology of RS, for the Niño3 region (5°S–5°N, 150°–90°W), shows that the phase and amplitude of each is roughly the same (Fig. 3). The main difference is that the RS climatology is slightly cooler in the boreal fall and winter. Anomalies computed with respect to either climatology would show major climatic anomalies, such as strong warm or cool episodes in the tropical Pacific. However, the climatology differences may be large enough to obscure more subtle variations in anomalies. This is especially true in the North Pacific and North Atlantic between 30°N and 70°N.

4. Summary

We used the methods of RS to produce a 1° resolution climatology with a 1961–90 base period. This new climatology is needed to make the base period compatible with that used by Houghton et al. (1996) and with that used for other National Centers of Environmental Prediction products. The new SST climatology is similar to the 1950–79 base climatology of RS, with differences that are mostly due to the change of the base period.

Because the in situ climatology (computed from the analysis of Smith et al. 1996) is not defined everywhere, the base period of the new climatology relaxes to 1982–96 at high latitudes where the in situ analysis is not defined (south of 45°S and north of 70°N).

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