dead (5)]. Genetically, it is an imperfect comparison of the two phenotypes. One can argue that the XP phenotype has been clinically selected for its severity. In contrast, the original mutant alleles of *SSL2* (which affect gene expression) have no increase in sensitivity to UV (5). If *ERCC3* functions in both transcription-coupled and general repair, many mutations in the gene may lead to an overall repair defect. However, it seems premature to state that there are no alleles of *ERCC3* that might specifically affect transcription-coupled repair.

In addition to proposing the model, I stated in my Perspective that *ERCC3* could simply be independently involved in repair and transcription. Experiments to test these two possibilities can now be planned. Should other subunits of TFIIH also be found to play a role in DNA repair, the idea that this complex acts as a transcription-repair coupling factor may warrant further consideration.

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Using Satellite Infrared Data in Studies of Variabilities of the Western Pacific Warm Pool

In their 1992 report, X.-H. Yan *et al.* (*1*) state that satellite multichannel observations of sea-surface temperature (SST) from 1982 to 1991 can be used to study SST response to solar irradiance variability, El Niño–Southern Oscillation events, volcanic activity, and global warming. However, analysis of in situ and satellite data has demonstrated that there are large biases in the satellite record that were caused by volcanic aerosol contamination and by satellite calibration errors (*2*). These biases appear to have been misinterpreted by Yan *et al.* as real changes in sea surface temperature.

The world's oceans serve as enormous reservoirs of heat and tend to moderate global atmospheric temperatures. Accurate observations of global SSTs are essential to detecting and monitoring climate change. Early attempts to measure SSTs from satellite were hampered by attenuation resulting from clouds. Beginning in 1981, satellite instruments viewed the sea surface with the use of infrared frequencies or channels. A basic assumption of the multichannel method (MCSST) is that only one gas (water vapor) varies significantly in its effect on the different channels being used. However, stratospheric sulfuric acid clouds, formed from the sulfur dioxide injected into the stratosphere by the large volcanic eruptions of El Chichón and Mount Pinatubo in the Philippines, violated this assumption and resulted in large biases in satellite-derived SST data.

One can compare the zonally averaged difference between the MCSST analysis and the Comprehensive Ocean-Atmosphere Data Set (COADS) (*3*, *4*) for 1982 to 1991 (Fig. 1). The COADS data consist of individual ship observations with typical one sigma noise levels of about 0.9°C. These random errors are further reduced because at least 100 independent observations are averaged around a latitude strip so that the random error is below 0.1°C. Large, nonrandom errors, or biases, remain and are critical to identify and understand.

El Chichón erupted in March 1982. The maximum bias of approximately 2°C occurs shortly after the major eruptions. The biases expanded latitudinally with the aerosol cloud. Negative biases of satellite data with magnitudes of 1°C remained throughout 1983. In March through June of 1991, there was a series of eruptions from Mount Pinatubo. In October 1991, a new multichannel algorithm was implemented in an attempt to correct for the volcanic aerosols, but small negative biases (about 0.5° to 1.0°C) still remained in data from the tropics.

A third, smaller bias occurred in the first half of 1987: the use of incorrect calibration tables for the satellite. This resulted in a temperature-dependent bias that had a zero crossing at about 15°C. Above 15°C there was a slight positive bias; below 15°C, there was a negative bias. A complete history of changes to the MCSST processing scheme is available (*5*).

The satellite SST record for the Western Pacific Warm Pool (as that region is defined by Yan *et al.*: 20°N to 20°S, 120°E to 150°W) shows negative biases with magnitudes greater than 1°C throughout 1983 and with magnitudes greater than 0.3°C throughout 1984.

Yan *et al.* attempt to compare the MCSST data with in situ expendable bathythermograph (XBT) data. XBT data, however, provide a poor measure of the surface temperature because the instruments have considerable thermal inertia when they first enter the water. To obtain an accurate surface temperature, the XBT temperature must be extrapolated from below the surface to the surface. The correlation coefficient between the MCSST and XBT data (figures 3b and 3c in the report by Yan *et al.*) is not statistically significant ($r = 0.36$ for nine samples). In addition, XBT coverage is sparse compared with MCSST data or that of the COADS.

Researchers should use the present satellite SST data with extreme caution. An effort to correct these biases, called Pathfinder, is sponsored by the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautic and Space Administration; consistent satellite data sets are being produced that account for calibration errors and volcanic aerosol

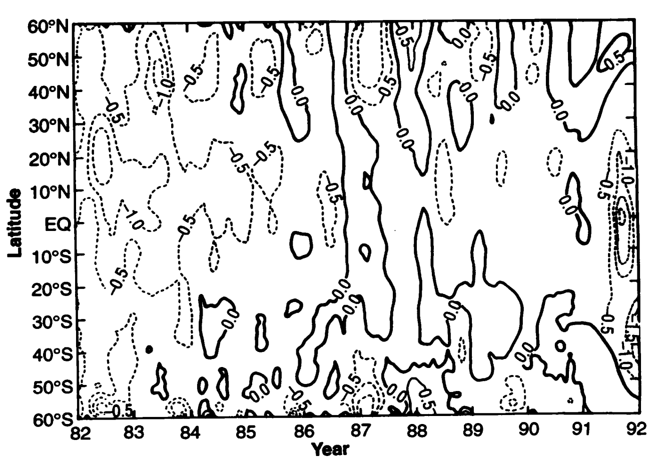

Fig. 1. Zonally averaged mean monthly difference between the MCSST satellite analysis of sea surface temperature and the COADS sea surface temperature for 1982 to 1991 (*6*).

biases. The first year of Pathfinder SST data should be available soon.

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Response: The purpose of our report (*1*) was to stimulate further consideration of satellite data in the study of global climate change, particularly in tracking the long-term fluctuations in the temperature and size of the Western Pacific Warm Pool (WPWP). Bates *et al.* identify some errors in sea-surface temperature (SST) observations from space. However, these errors in satellite data are well known in the scientific community (*2*). In addition, the use of MCSST data to study SST variability in the WPWP is not as problematic as Bates *et al.* indicate.

In our report we emphasized two basic points. The MCSSTs, as measured by the series satellites of the National Oceanic and Atmospheric Administration (NOAA), are a useful tool for tracking the variations in the WPWP temperature and size with a yearly resolution. This point has been verified by the consistency of yearly mean MCSST patterns with those of Levitus (*3*), which are widely used by the oceanographic community. Second, there is a monotonically increasing trend (specifically defined in our report) in yearly mean MCSST and size of the WPWP from 1983 to 1987, but with some fluctuation after 1987. This trend was observed by using 10 years of MCSST data (from 1982 to 1991), and it was also found in COADS and blended data. We speculated that possible causes of the observed variations might include solar irradiance variabilities, El Niño–Southern Oscillation (ENSO) events, volcanic activities, and global warming. These phenomena have been intensively discussed in recent years within the research community.

Figure 1 in the comment by Bates *et al.* shows the global zonally averaged difference between the MCSST analysis and COADS. This figure should not be compared with those in our report, which described the variation of SST and size for the WPWP only. The scales for this graph and for those in our study are very different. Also, the eastern and western equatorial Pacific have quite different dynamical processes—upwelling in the eastern equatorial Pacific and piling up of warm water in the western equatorial Pacific in normal, non–El Niño years. SST difference between the eastern and the western equatorial Pacific can be as large as 8°C or more (*3*). These complicated ocean phenomena appear to have been inappropriately combined by Bates *et al.* and misrepresented as real satellite errors in their zonally averaged plot. In addition, the COADS data used by Bates *et al.* are sparse and their spatial and temporal distributions are not uniform. Specific point SST in situ measurement, at a fixed time and location, may be considered as "sea truth" only for that time and point. In many cases, spatial and temporal interpolation, extrapolation, and gridding of the data, in addition to instrument error and calibration errors, can lead to more biases than are present in satellite images, which are much more uniformly sampled in both space and time. Therefore, the contour plot of the comparison in their figure 1 is not reliable. It should also be pointed out that their figure 1 and related explanations have already been published (*4*), which preempts their present comment.

Bates *et al.* also state that the satellite SST record for the WPWP as defined in our report shows negative biases, with magnitudes greater than 1°C throughout 1983 and greater than 0.3°C throughout 1984. We do not know how they arrived at such a conclusion. In our report, the WPWP was defined as an area in which SST was higher than 28°C inside a rectangular box from 120°E to 150°W and from 20°S to 20°N. As computed in the comment, however, the MCSSTs are consistently below 28°C. Even with this error in the comment, the same trend can also be found in COADS and the blended data (although the calculations are averaged in ways different from those in our study and the slopes of the trend are not exactly the same). This shows that the phenomena we discussed exist independently of observational techniques. Finding and reporting these variations, we hope, is a contribution to the studies of the WPWP and related problems.

As for errors in satellite MCSST, including those caused by volcanic eruption pointed out by Bates *et al.*, they were also well acknowledged in our report (*1*). However, we feel (and so does the remote sensing community, we believe) that it is no longer necessary for such continuous statements of error to appear in papers if these errors are obvious. Earlier papers using satellite data included much discussion about error sources in order to demonstrate that the researchers knew the subject thoroughly. Because of the frequent use of NOAA MCSST satellite data, researchers and readers are now familiar with the errors and such repeated emphasis on error sources is neither needed nor wanted. Satellite MSCCT is mainly dependent upon the physical temperature of the observed target. The large area and long-term mean contribution of radiation from atmospheric matter such as aerosols, water vapor, and CO_2 to the large area and long-term mean of the remotely sensed measurements is to the first order, a small quantity compared with the physical temperature of the target. Therefore, the large area and long-term mean MCSST time series must reflect variations in the sea surface temperature. Of course, sometimes these variations may be blurred by noise or errors in MCSST; that is why statistical techniques are often used for processing MCSST data. In our report, yearly mean MCSST of the WPWP was used in order to filter out high frequency noise and to reveal the slowly varying trend.

The importance of our report has also been demonstrated in part by the sufficient interest it has generated (*5*).

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