Effect of Recent Volcanic Eruptions on Satellite-Derived Sea Surface Temperatures

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1. Introduction

Volcanic aerosols interfere with sea surface temperature (SST) retrievals from the advanced very high resolution radiometer (AVHRR). Reynolds et al. (1989) compared in situ and satellite data for the period 1982 through 1989. They showed that the biases with the largest magnitudes were negative and were due to stratospheric aerosols from the April 1982 volcanic eruptions of El Chichón. During June 1991, Mt. Pinatubo, located in the Philippines (15°N, 120°E), produced new stratospheric aerosols with a volume more than twice as great as the volume from El Chichón (Stowe et al., 1992). By the middle of July, the aerosol cloud encircled the earth although it was confined to the tropics. In August 1991, the eruption of Mt. Hudson in Chile (46°S, 73°W) contributed additional stratospheric aerosols in the zonal band between 30°S and 50°S.

2. Effect of the aerosols on satellite SST retrievals

The presence of an aerosol cloud not only affects the bias but also affects the number of retrievals. Normally satellite retrievals in cloud covered regions are discarded. The present daytime algorithm can detect the aerosol cloud; the nighttime algorithm cannot. Thus, in the aerosol contaminated regions, the number of daytime retrievals dropped to almost zero while the number of nighttime retrievals was unaffected. Further details on the satellite algorithms can be found in McClain et al. (1985) and Walton (1988).

To examine the effect of the aerosols on the SSTs, all weekly in situ and nighttime satellite observations were separately averaged onto a 1° grid. Gridded values were converted into anomalies by subtracting the climatology of Reynolds (1988). Weekly averages were then computed for the two data types along 200 wide zonal bands for a 30 week period from the beginning of June 1991 to the end of December 1991. Figure 1 shows the difference between these two zonal averages during the period. The figure shows two major maxima. Both maxima show that the nighttime satellite SSTs are negatively biased relative to the in situ observations. (A similar result, not shown, was obtained between the in situ and daytime satellite data.)

The first maximum occurs in the 0° to 20°S band from the beginning of July to the end of September and is due to the presence of the Pinatubo aerosols. On October 3, 1991 NESDIS implemented a new global algorithm to correct for the Pinatubo aerosols (Walton, 1991, personal communication). This correction reduced the negative biases from over 1°C to approximately 0.5°C. Although the Pinatubo bias was not completely, eliminated, it can be expected to weaken as the Pinatubo aerosols are dispersed over time.

The second maximum occurs in the 40° to 20°S band from mid-October through the end of December. This maximum is partially due to the relatively weak aerosols from Mt. Hudson. It is important to note that these biases are not corrected by the Pinatubo correction algorithm. The remaining biases are caused by other quality control problems which affect high latitude nighttime retrievals in the summer hemisphere (Walton, 1992, personal communication).

3. Effect of satellite biases on SST analyses

The U.S. National Meteorological Center (NMC) routinely produces a l° gridded SST analysis using optimum interpolation (OI) (e.g. see Gandin, 1966, and Thiébaux and Pedder, 1987). The analysis is produced both daily and weekly following the method of Lorenc (1981). It uses in situ and satellite SST data as well as SSTs estimated from sea ice coverage. Complete documentation for the OI is being prepared.

The OI method assumes that the data are unbiased. Because strong satellite biases are now evident, a preliminary step was added before performing the OI to correct any large scale satellite biases. This adjustment uses the Poisson technique of Reynolds (1988) to provide smooth correction fields (with a 12° resolution) for both daytime and nighttime satellite observations. The weekly OI analysis has been run with and without these corrections to the satellite data.

Figure 2 shows the difference between the OI with and without the bias correction for the week of September 22-28, 1991. This period was selected to demonstrate the effect of the Pinatubo biases (first maximum in Fig. 1). The figure shows that the uncorrected OI is negatively biased throughout the tropics as expected. The maximum difference occurs in the tropical Atlantic. There, the effects of the Pinatubo aerosols are augmented by the normal seasonal tropospheric dust from the Sahara desert to produce negative biases of more than 2°C.

Figure 3 shows the difference between the two versions of the OI for the week of December 22-28, 1991. This period represents the second maximum in Fig. 1 and illustrates that much of the tropical bias from Pinatubo has been corrected. However, as shown in Fig. 1, the uncorrected analysis shows important negative biases between roughly 25°S and 45°S.

4. Discussion

The results presented here demonstrate that uncorrected satellite SST data should not be used to monitor changes in SST. This is clearly shown by the spurious signal in the satellite data in Fig. 1. However, once the satellite data are corrected, they are extremely useful in extending the spatial resolution defined by in situ data alone. This is particularly true in the Southern Hemisphere where the in situ data are sparse.

References

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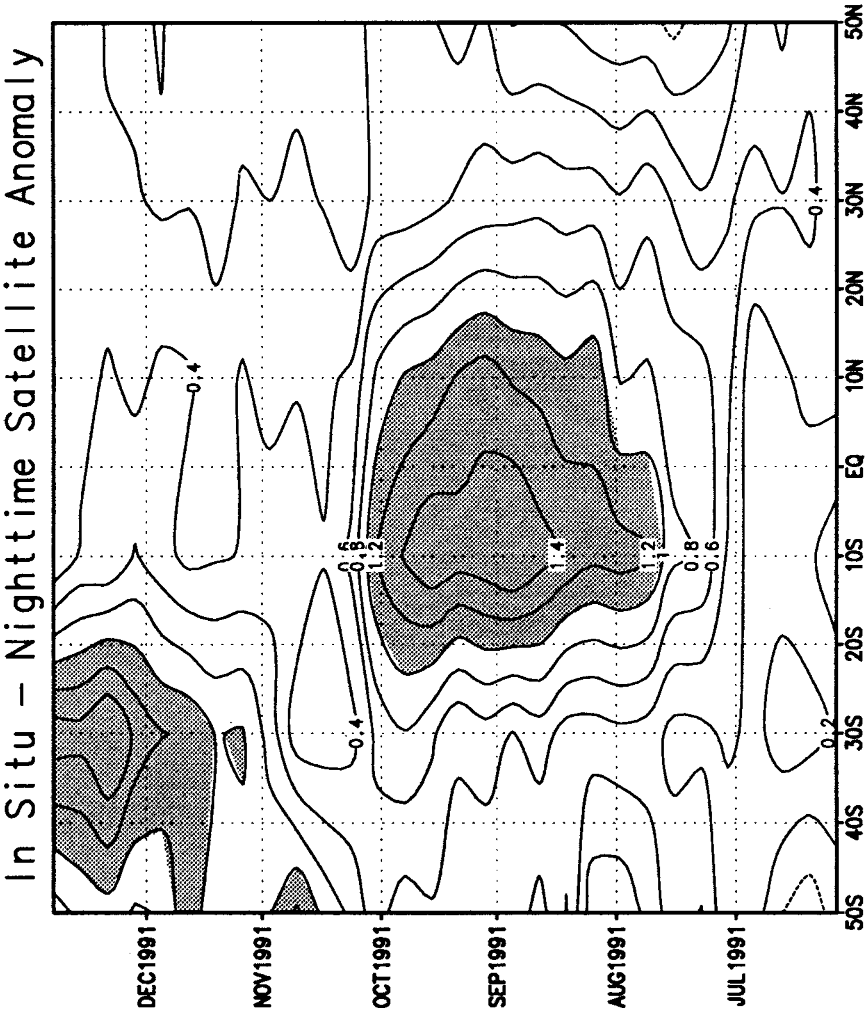

Figure 1. Difference between weekly <u>in situ</u> and nighttime satellite SST anomalies. The anomalies were averaged in 20° zonal bands whose centers ranged from 50°S to 50°N. The period ranges from the week of June 2-8, 1991 to December 22-28, 1991. The ordinate is labeled on the first day of the month with month and year. The contour interval is 0.2°C. Differences greater than 1°C are shaded. The sign of the difference is defined as "<u>in situ</u>" minus "nighttime satellite".

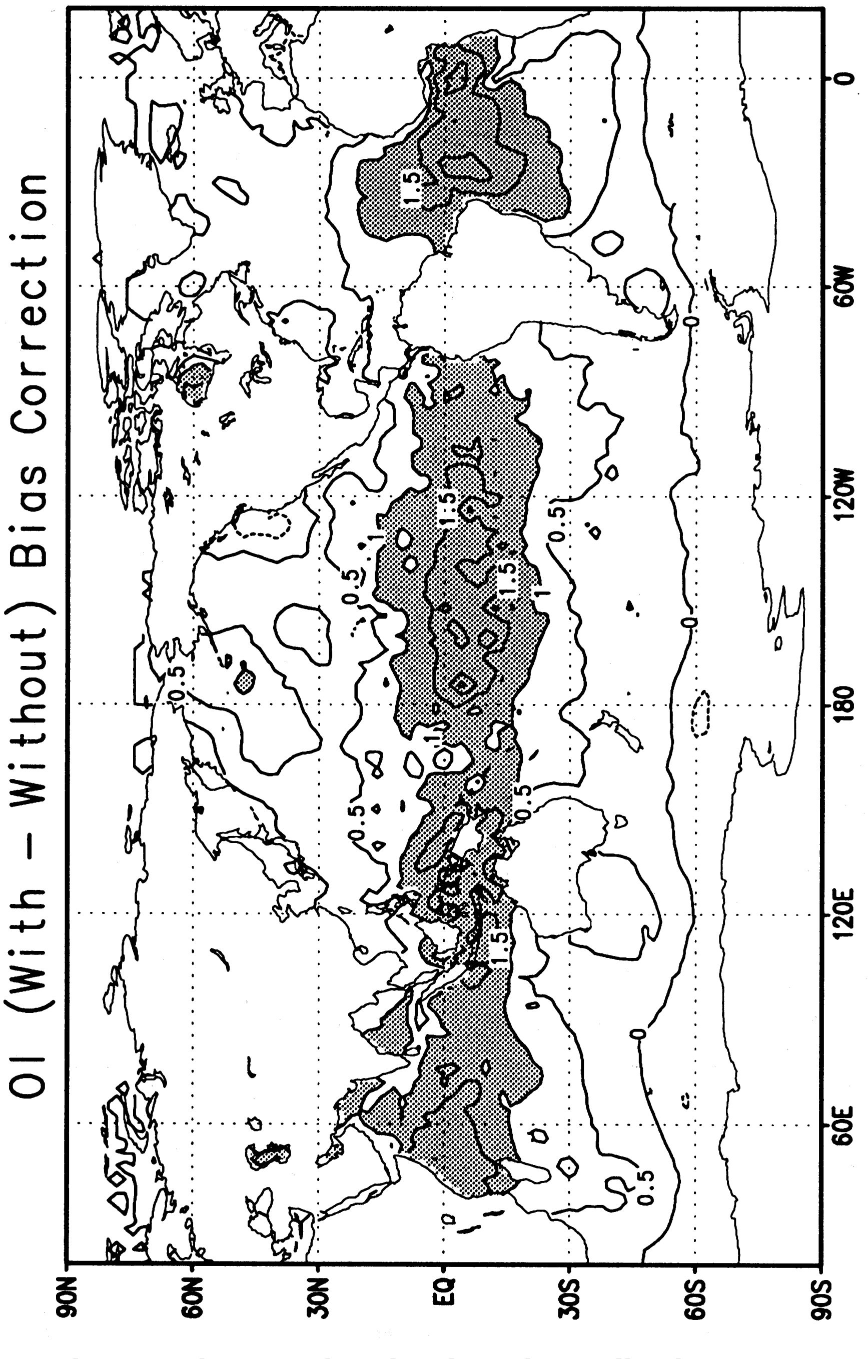

Figure 2. Difference between the OI with and without the satellite bias correction for the seven day period: September 22-28, 1991. the contour interval is 0.5°C. Differences greater than 1°C are shaded. The sign of the difference is defined as “with” minus “without”.

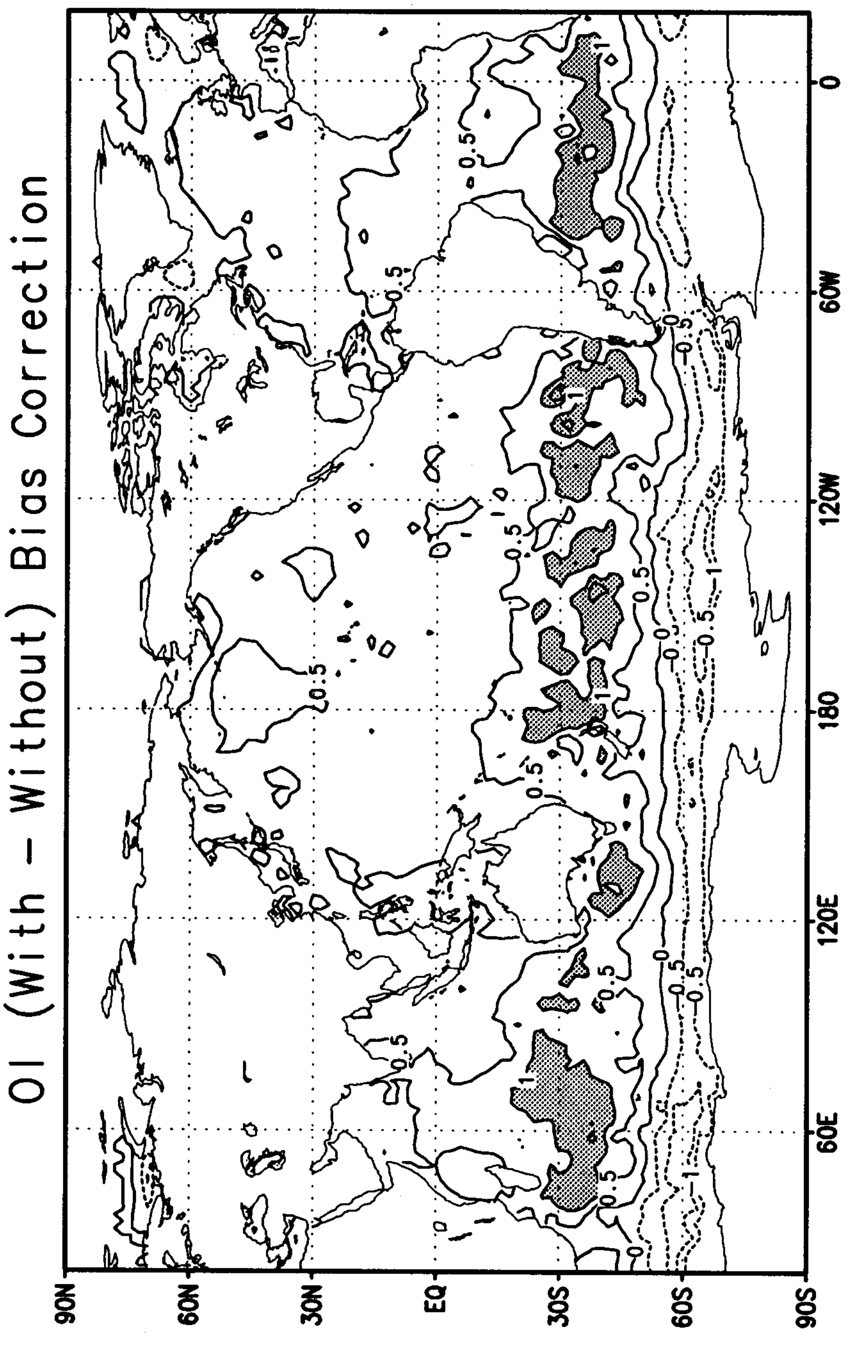

Figure 3. Difference between the OI with and without the satellite bias correction for the seven day period: December 22-28, 1991. The contour interval is 0.5°C. Differences greater than 1°C are shaded. The sign of the difference is defined as "with" minus "without".