Global 1 degree monthly sea surface temperature comparisons

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Abstract- **Comprehensive global comparisons have been made between two satellite-based sea surface temperature (SST) products and related blended satellite/in situ SST products. The satellite SST data sets were those derived from advanced very high resolution radiometer (AVHRR) data using the modified Pathfinder SST (MPSST) and operational NOAA SST (ONSST) algorithms (collectively referred to as satellite SST data). The blended satellite/in situ data included the NOAA Optimal Interpolation (OI) [1] and 2-dimensional variational analysis (2DVAR) SST data sets, and the UK Meteorological Hadley Center Global Sea-Ice and Sea Surface Temperature (HADISST) data set (collectively refereed to analysis SST data). Global monthly comparisons for co-located 1 degree squares using standard statistics were computed. Only data from each SST data set from 1985-1997 were used in these comparisons and the satellite data were separated into day/night time periods.**

Statistics for each comparison set (e.g., MPSST/OI, ONSST/OI etc.) were then generated to determine the global mean bias, RMS differences, standard deviation of bias, and correlation values. These statistics were examined to determine how well the MPSST product performs with respect to the ONSST on a monthly and seasonal basis. Preliminary results indicate that with respect to the mean bias, the ONSST comparisons generally have a lower bias in the low variability central ocean basin region while the MPSST has the significantly lower bias in high variability areas (e.g., western boundary currents). The RMS difference comparisons indicate that the ONSST to be on average lower during the nighttime while the MPSST performs better during the daytime.

INTRODUCTION

Satellite SST time series are now of sufficient length that they can be used for preliminary insights into decadal global and regional climatic variability [2] as well as used in the construction of global high resolution SST climatologies [3,4]. This paper examines two popular satellite AVHRR SST time series data sets, the ONSST and MPSST, and investigates how they perform at climate scales and identifies significant characteristics and differences of each. One of the limitations to determining the overall accuracy and robustness of satellite SST time series is the lack of a comprehensive independent SST data set to use as a reference. Instead, satellite SST time series data are often compared to analysis SST time series products such as the OI, 2DVAR and HADSST with the assumption that the analysis SST products are weighted highly towards in situ SST observations. However, due to blended nature of the analysis SST products they are never completely independent from the satellite data. This is especially true of the ONSST since all the analysis SST products used in this study incorporate the ONSST observations in some manner.

The satellite data were formatted to be spatial and temporally compatible with the analysis SST data sets, which are produced natively on a 1 degree grid at monthly intervals. In the case of the MPSST data, 1 degree monthly products were derived from highest quality spatially regridded and averaged daily 9 km MPSST data. The ONSST were similarly derived from operational 1/2 degree or higher resolution products. It is important to point out that the ONSST came from several sources: NOAA, U.S. Navy and the University of Miami. Future work will focus on obtaining the operational SST from a single source. In the comparison processing, statistics were gathered over all common 1 degree squares using a monthly temporal time scale. Daytime and nighttime satellite retrievals were compared separately to address SST algorithm differences as well as issues regarding the skin/bulk and diurnal temperature variability.

RESULTS AND DISCUSSION

Based on the number of comparison permutations there were a large number of results generated and only a small representative subset can be presented here. Fig. 1 shows the bias between daytime and nighttime MPSST-ONSST results as 1 degree maps for July. Clearly the MPSST is generally biased cool with respect to the ONSST especially at night where the largest negative biases are found. During both periods the area of lowest bias appears to be in the mid-latitude southern hemisphere. Although only the results from July are presented here other monthly maps are similar. Biases comparisons using the OI SST reveal a similar story (Fig. 2). Ignoring differences above 60N latitude where the ONSST product has limited data, the nighttime MPSST is generally cooler overall. Both comparisons indicate the satellite data is cooler off the northwest coast of Africa as compared to the OI data possibly indicating that aerosol contamination in the remotely sensed SST signal has not been fully accounted for.

RMS maps of satellite vs. OI SST differences, indicating the spatial and temporal variability component of these biases, are presented in Fig. 3. Considering only the data between 60N-60S, the ONSST minus OI RMS differences indicate low values in the center of the ocean basins with larger RMS values in regions of strong western boundary currents and other high SST variability areas such as in the Circumpolar Current region. The MPSST results indicate reduced RMS differences in these high variability regions while slightly larger RMS differences in the central ocean basin regions. However, the ONSST-OI comparison lacks a degree of data independence since the OI SST incorporates some the very ONSST observations used in the comparison, while the MPSST comparison does not. Thus the ONSST-OI SST RMS comparison could be expected to have regions with low RMS differences especially in the southern hemisphere where there is very limited in situ data available for the OI analysis. The comparison maps using the daytime satellite SST values (not shown) indicate that over the entire globe the MPSST-OI SST RMS differences are significantly lower than the ONSST-OI SST RMS differences. The time series of all satellite vs. analysis SST RMS differences, indicate that the ONSST comparisons have a lower RMS difference during the nighttime while the MPSST comparisons fare better during the daytime comparisons (Fig. 4). Maps of these comparisons (not shown) again indicate that ONSST comparisons are characterized by lower RMS differences over regions in the central ocean basis, while MPSST comparisons perform better in high variability regions of western boundary currents etc. However, as with the OI SST analysis, these other analysis SST data sets also incorporate ONSST observations (and not MPSST) and thus the non-independence may be significant.

A final note regards the bias differences. Using the monthly 1 degree WOA98 (World Ocean Atlas 1998) climatological SST observations [5], a monthly anomaly time series (SST minus climatology SST) was created for nighttime satellite observations and the Reynolds OI SST (Fig. 5). An inspection of the results indicate that a 0.1- 0.2°C cool bias of the MPSST anomaly time series is very evident. Also noteworthy is that the variability of the MPSST fluctuations is less than the ONSST anomaly time series especially in the early years of 1985-1987, perhaps indicating that the MPSST processing has minimized climatic noise in the AVHRR satellite time series. However, if MPSST are to be assimilated into a blended satellite and in situ SST product such as the OI or 2DVAR analysis, the cool bias that is most noticeable during the nighttime period must be systematically accounted for.

CONCLUSIONS

The results of these global comparisons offer a glimpse as to how the MPSST and ONSST time series compare to one another and how each potentially performs at climate scale. The MPSST data appear to have a negative cool bias during nighttime comparisons while having a higher overall nighttime RMS than the ONSST comparisons. However, it is noteworthy that the MPSST RMS differences are significantly lower than ONSST RMS differences in high temperature variability regions important for heat transport and ocean circulation. Daytime results are even more encouraging, with the MPSST comparisons having lower bias and RMS when using any of the analysis SST data sets as a comparison set. The positive behavior of the ONSST/analysis SST comparisons during the nighttime period may in part be due the non-independence of the data used in these comparisons.

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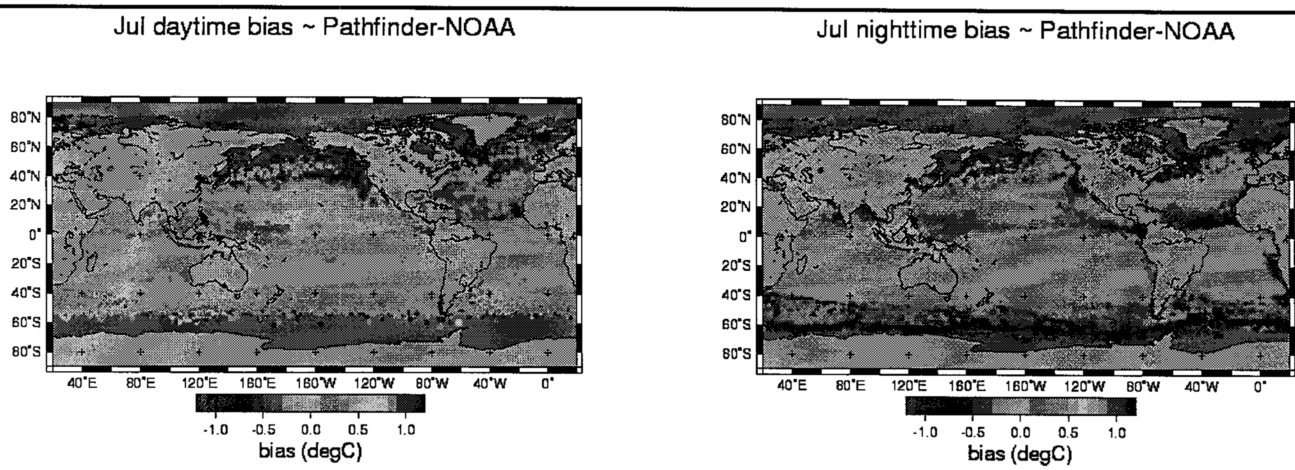

Fig 1. Mean July global daytime and nighttime bias maps for the MPSST-ONSST comparison.

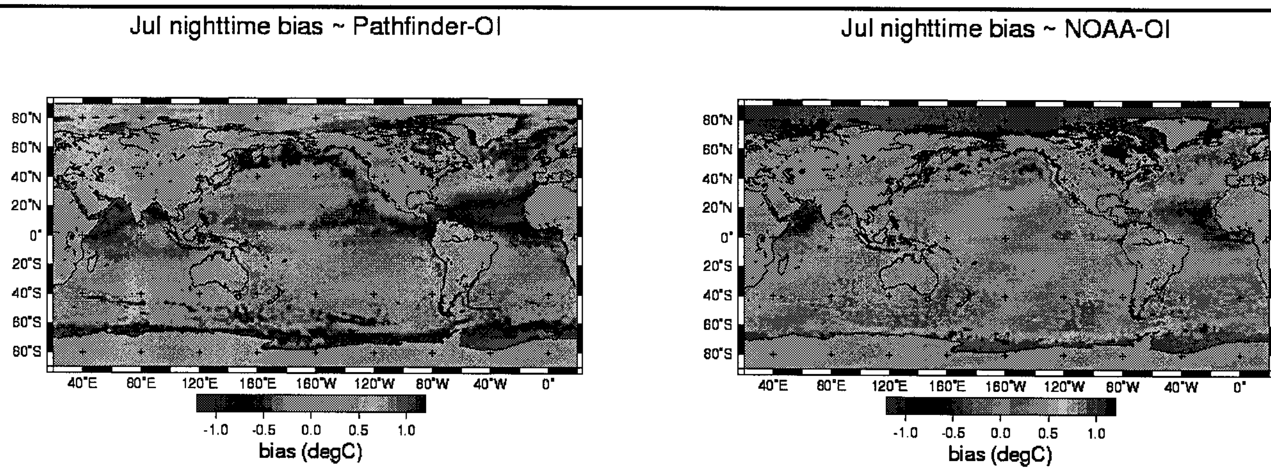

Fig 2. Mean July nighttime only bias maps for the satellite SST (MPSST and ONSST) vs. OI SST comparisons.

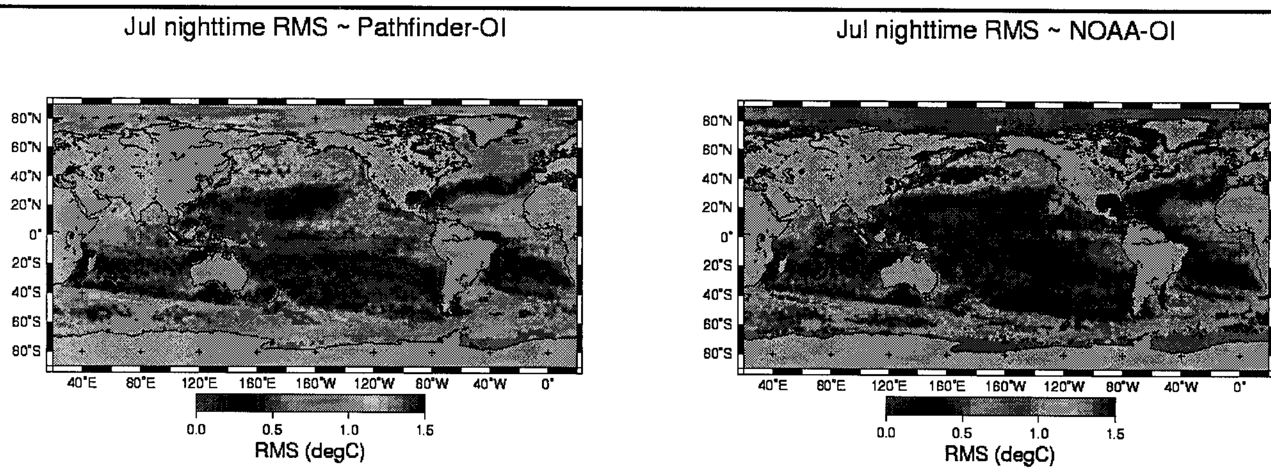

Fig 3. As in Fig. 2, but for the RMS differences.

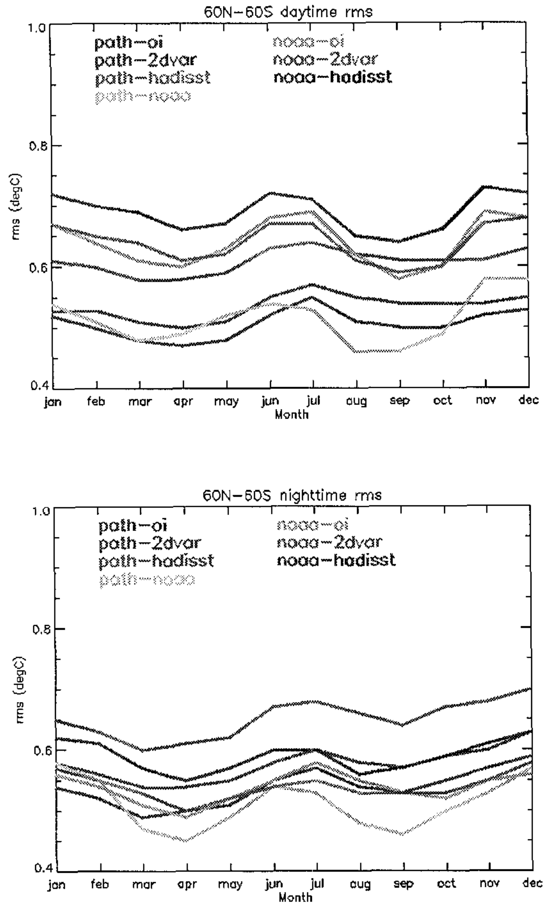

Fig 4. Average monthly daytime and nighttime comparison RMS values between the satellite SST and analysis SST data sets. Only data in 60N-60S area is considered.

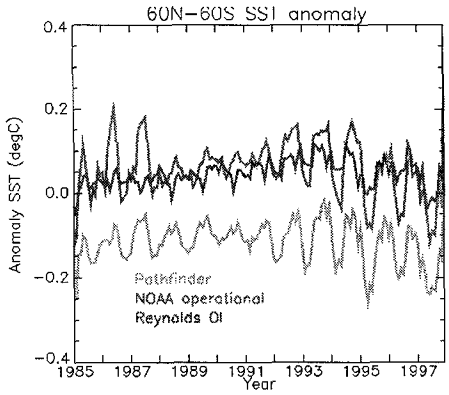

Fig 5. Monthly anomaly time series from 1985-1997 of MPSST, ONSST, and OI SST minus WOA98 climatological values. Satellite data are nighttime values.

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