Comparison of Decadal Trends in Surface Temperature in Different Data Sets

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1. Introduction

A comparative study of the decadal trends in different surface temperature data sets has been undertaken. One objective was to determine what the differences were in paired marine surface temperature based on ship measurements (both sea surface and air temperature) along most of the globe's coastal regions with surface air temperature measured at coastal stations. We also wished to determine how the rate of change of surface temperature varied over two sets of time intervals for the various data sources. The data sets used are described in the section that follows.

For the period since 1950 all the data sets agree fairly closely. For longer periods, although known biases in COADS affect the results, it is clear that sampling biases can also significantly affect the linear trend values obtained under different spatial coverages. No acceleration in temperature trend is evident from the analysis.

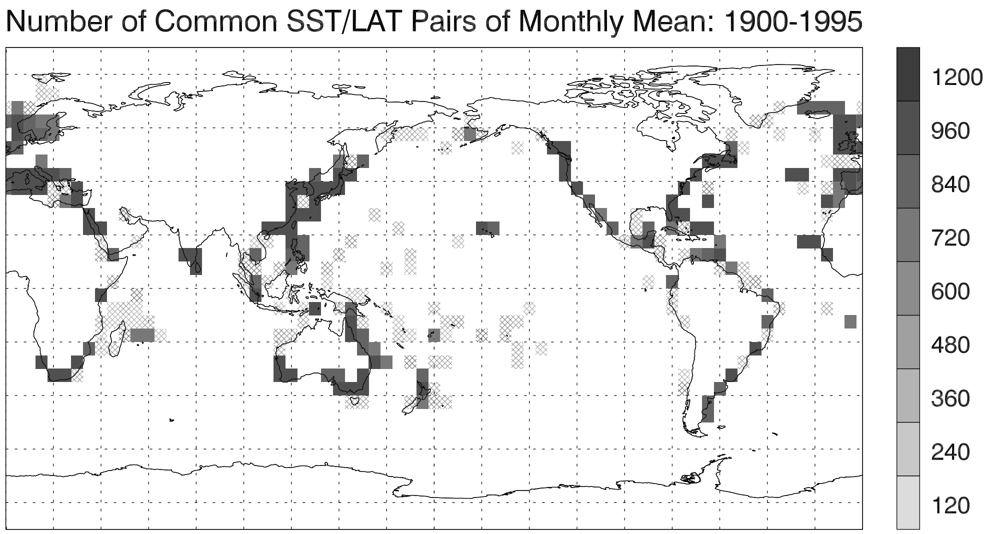
2. Data and Method

Sea surface temperature (SST), marine air temperature (MAT), and night marine air temperature (NMAT) from following data sets are examined: (1) Standard and enhanced versions of Comprehensive Ocean-Atmosphere Data Set (COADS, Slutz et al., 1985; Woodruff etal., 1987). In the standard version, COADS (std), only ship-observations are included and data are trimmed with 3.5σ. In the enhanced version, COADS (enh), observations from a variety of marine platform types are included and data are trimmed with relaxed limits (all variables are trimmed with 4.5σ (Wolter, 1997) except the NMAT which is not trimmed for the period from 1854-1979); (2) UK Meteorological Office Historical SST Version 6 (MOHSST6); (3) UK Meteorological Office Historical NMAT Version 4 (MOHMAT4N; and (4) Global sea-Ice SST Version 2.3b (GISST2.3b) created by the UK Meteorology Office.

In COADS, the data are original: only the trimming, if any, was applied as quality control. The MOHSST6 is a version of an adjusted SST data set: adjustments were made to correct the systematic difference between measurements by buckets and those by engine intakes (Folland and Parker, 1995). The MOHMAT4N is also a version of an adjusted data set: adjustments were made to eliminate the effect of increases in deck-elevation and inhomogeneities during 1856-85 and 1942-45 (Bottomley et al., 1990). The GISST2.3b is a derived version of MOHSST6, in which spatial and temporal gaps of missing values were filled with interpolations (Rayner et al., 1996).

Land air temperature (LAT) from a grid global air temperature data set created in the NOAA-CIRES Climate Diagnostic Center (CDCLAT) is used as independent verification. A blend of LAT by Jones et al. (1994) and SST from MOHSST6

(MOHSST6+LAT) is also used as an additional sample. Monthly means of each of the variables from all data sets are processed to have a same 5 degree longitude by 5 degree latitude grid format. In order to have a consistent sampling, in each of the 5-degree boxes a monthly mean is taken into account only when all the considered variables are not missing for the same month. Spatial averages of monthly mean



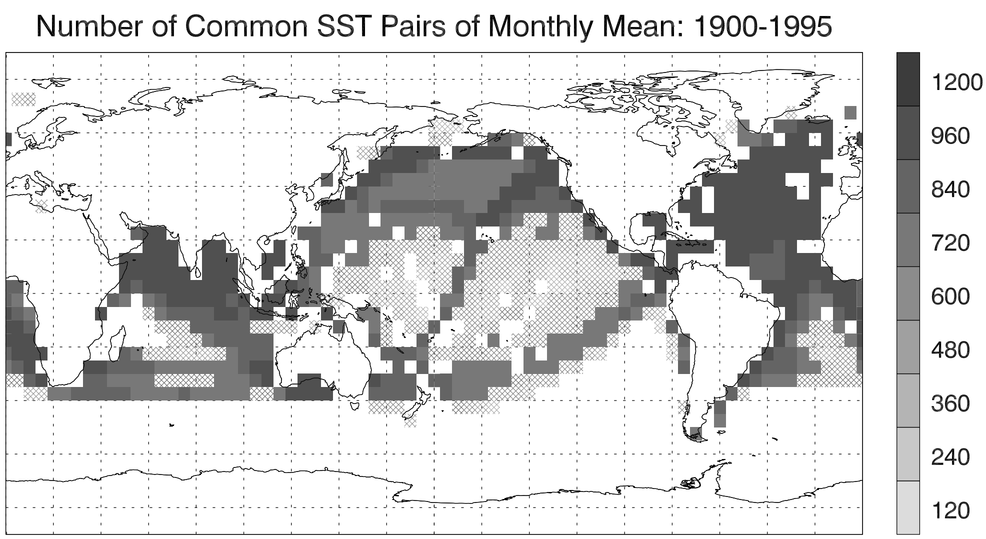


Figure 1: Spatial distribution of the 5 by 5 degree boxes used in the calculation. Solid shades indicate boxes that have more than 720 non-missing monthly means during the 1900-95 period. Hatched shading indicate boxes that contain more than 360 monthly means during the 1950-95 period.

anomalies are made for global marine-land and open ocean respectively. We define marine-land area as those 5 degree boxes which contain monthly mean of both marine and land-station observations. The open ocean includes all the oceanic 5-degree boxes except those marine-land boxes

Figure 1 shows the number of months when all considered variables are not missing for each 5-degree boxes of the global marine-land (upper panel) and the open ocean (bottom panel). Linear trends in the time series of monthly mean anomalies are calculated for two periods: 1950-95 and 1900-95. And, two spatial/temporal sampling schemes are used for each period to examine the sensitivity of the trends to the sampling: (1) spatial average of the boxes in which the monthly means were not missing in at least 720 months during the 1900-95 period, i.e. the solid boxes in Fig.1; and (2) spatial average of the boxes in which the monthly means were available in at least 360 months during the 1950-95 period, i.e. the solid and hatched boxes in Fig.1. Number of observations for each box/month is not taken into account because this information is only available in COADS.

3. Results

The linear trends are listed in Table-1 and our interpretation can be summarized as the following:

3.1 For the period from 1950 to 1995:

Over the global marine-land, a trend of about 0.4 C/100 years is seen in all the sea surface temperature (SST) and night marine air temperature (NMAT) in both the COADS and MOH data. The trend in GISST2.3b SST is about half: 0.23 C/100 years. Different trimming limits in COADS do not have significant impact in the trend. Both land air temperature (LAT) and day-and-night marine air temperature (MAT) show a higher trend of about 0.6 C/100 years. The higher trend in LAT and MAT indicates that day-time temperature has increased faster than night-time temperature during the 46-year period.

Over the global open ocean, a trend of about 0.6 C/100 years is seen in all the SST in COADS, MOHSST6 and GISST2.3b, and NMAT in COADS and MOHMAT4N. A higher trend of 0.9 C/100 years is seen in the COADS MAT indicating a faster increase in day-time temperature.

The difference between the trend (0.4 C/100 years) over the global marine-land and the trend (0.6 C/100 years) over the global open ocean during the recent four decades suggests that one must include sufficient data in the tropical Pacific Ocean to appropriately estimate the trend for the global ocean.

3.2 For the period from 1900 to 1995:

Over the global marine-land, one observes an acceleration in the warming-rate in the records of land-station observed surface temperature. The warming trend (0.6 C/100 years) during the recent four decades (1950-95) is twice as large as the trend (0.3 C/100 years) during the past century (1900-95). The land-station data provide an independent verification to the quality of ship-observed surface temperature over the global marine-land area.

Over the global marine-land, however, the acceleration in the surface warming is not seen in all the archives of marine observations examined in this study. In all the archives of marine observations, one actually sees reversed sign of change, a decrease in the warming-rate over the global marine-land. The trends reduced from the range of about 0.5 to 1.2 C/100 years during the past century (1900-95) to the range of 0.2 to 0.5 C/100 years during the recent four decades. The larger warming trend in the records of marine observations during the centennial period is mainly attributed to much colder surface temperature during the decades from 1900s to 1940s in the records of ship-observations. And these strong cold anomalies in the ship data are associated with a suspicious abrupt decrease around 1900. The abrupt change makes the time series discontinu

Table 1. Linear Trend in Surface Temperature

	Trend ± 95% confidence interval [Celsius / 100 years]			
Time	1900-95		1950-95	
Sampling Scheme	Box-60yr	Box-30yr	Box-60yr	Box-30yr
Marine-Land:				
CDCLAT	**.34** ± .03	**.29** ± .02	**.83** ± .08	**.64** ± .08
MOHSST6+LAT	**.66** ± .02	**.63** ± .02	**.48** ± .07	**.48** ± .06
COADS-MAT	**.75** ± .03	**.77** ± .03	**.53** ± .06	**.57** ± .05
COADS-NMAT	**.75** ± .04	**.75** ± .04	**.37** ± .06	**.37** ± .05
MOHMAT4N	**.69** ± .03	**.68** ± .02	**.41** ± .06	**.41** ± .06
COADS-SST	**1.2** ± .03	**1.2** ± .03	**.31** ± .05	**.38** ± .05
MOHSST6	**.66** ± .02	**.67** ± .02	**.32** ± .06	**.34** ± .06
GISST-2.3b	**.48** ± .02	**.47** ± .02	**.19** ± .06	**.23** ± .06
Open Ocean :				
COADS-MAT	**.72** ± .03	**.65** ± .03	**.83** ± .05	**.93** ± .06
COADS-NMAT	**.66** ± .04	**.66** ± .04	**.53** ± .06	**.63** ± .05
MOHMAT4N	**.63** ± .02	**.62** ± .03	**.50** ± .05	**.60** ± .06
COADS-SST	**1.1** ± .03	**1.1** ± .03	**.49** ± .04	**.62** ± .05
MOHSST6	**.56** ± .02	**.54** ± .02	**.44** ± .06	**.58** ± .06
GISST-2.3b	**.54** ± .02	**.50** ± .03	**.48** ± .07	**.62** ± .08

ous in all the data sets of the marine observed surface temperature. The absence of recent increase in the warming-rate and the discontinuity around 1900 in the ship data over marine-land indicate systematic biases in the historical records of ship-observations. The adjustments that had been made in the UK Meteorology Office's marine surface data sets have reduced many of the biases. Magnitude of the spurious discontinuous change is largest in COADS, smaller in MOHSST6 and smallest in GISST2.3b. The discontinuity around the 1900 is not seen in the land-station observed surface temperature. Assuming that there is no systematic bias in the records of land-station surface temperature, the remaining discontinuity in MOHSST6 and GISST2.3b suggest that more adjustments are still needed.

Over the open ocean, some increase in warming-rate after 1950 can be seen in the MAT in COADS, the SST in MOHSST6 and GISST-2.3b. However, the acceleration in the warming-rate in the open ocean is much weaker than that exhibited in the land-observed surface temperature over the global marine-land. And, again, the spurious discontinuity around 1900 is seen in all the archives of marine observations.

It is also important to notice that the trends over the open ocean are very close to the trends over the marine-land for the centennial period, which is in contrast to the large difference between the open ocean and marine-land shown in the recent four decades. The similar trends in the open ocean and marine-land for the centennial period represents another difficulty in making an accurate estimation of the surface temperature trend for the global ocean because the similarity results indeed from lacking observations in vast area of the open ocean during early decades.

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