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COMPARISON OF GLOBAL MEAN TEMPERATURE SERIES STRATEGIES FOR BEGINERS

Pro.Madhuraj Dravid[1]; Pro Mrigkshi Rajawat[1].

[1]faculty In Department Of Geography In University In Denver, Colorado.

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Corresponding Author:
Pro.Madhuraj Dravid[1]
[1]faculty In Department Of Geography In University In Denver,Colorado.
madhu.udf@gmail.com

ABSTRACT

Studies on the reconstruction of world mean temperature series are reviewed by introducing three series, Had- CRUT3, NCDC, and GISS thoroughly. Satellite data are used since 1982 in NCDC and GISS series. NCDC series has the foremost complete spatial coverage among the three by using the statistic interpolation technique. The weakened heating in 2000–2009 as revealed in HadCRUT3 data is possibly caused by the shortage of information coverage of this dataset over the Arctic.

Three series yielded almost the identical warming trend for 1910–2009 (0.70–0.75 C per 100 years).

KEYWORDS: Global Mean Temperature; HadCRUT3; NCDC; GISS

1. INTRODUCTION

The reconstruction of high-quality global mean surface air temperature data is prime to global climate change research. A more accurate assessment of world warming may be made with such data. Mean while, it is wont to determine the magnitudes of worldwide warming's, like the characteristics of its spatial patterns and temporal variations, which constitutes the idea for the research on global climate change causes. Therefore, it's of great importance to match the assorted global mean temperature series and analyze the info and methodologies in use. The research of worldwide mean temperature began in the late 19th century. Since then, more and more data sources and statistical methods became available and been incorporated into the reconstruction and improvement of worldwide mean temperature series [Wigleyet al., 1985; Ellsaesser et al., 1986; Hansen and Lebedeff, 1987].

The short history of worldwide mean temperature series research is roughly divided into three periods: before the 1970s, the 1980s–1990s, and therefore the 2000s. The primary two periods may be called the "classical" period, whereas the third is that the "modern" period. 2 Early studies A great deal of pioneering and innovative work was made within the playing period. to work out whether the worldwide climate had a warming or cooling trend, scientists began to study the world mean temperature within the late 19th century. Up till the mid-

20th century, there had been quite 30 scientists who had constructed their own global mean temperature series, among which the foremost representative was because of Mitchell [1961]. Since the full number of normal meteorological stations were only about 100–200 over land and islands, Mitchell had to divide the world into six 30◦ latitudinal belts to calculate the zonal mean temperature for every belt, then to mix them to estimate a world mean temperature.

Mitchell's work was a decent example showing that the study of world warming, from its very beginning, highly relied on meteorological observations. The number of in-situ stations significantly increased from the 1980s to the 1990s. As a result, within the second key period, Jones et al. [1990] independently developed three global temperature datasets. The numbers of accessible stations utilized in their studies are shown in Table 1.

Table 1 Numbers of meteorological stations used for the three global mean temperature series in 1980s

Author	Northern Hemisphere	Southern Hemisphere	Global
Jones et al. [1986a; 1986b]	2,666	610	3,276
Hansen and Lebedeff [1988]	1,902	738	2,640
Vinnikov et al. [1990]	301	265	566

In the 1980s, major sources of monthly mean temperature data were derived from World Weather Records and Monthly Climatic Data for the World. the main difference among the three authors' re- constructions was within the methods of processing ob- observational data. for instance, Jones et al. [1986a; 1986b] used the gridding method. They first interpolated the discrete station data into a 5◦ latitude by 10◦ longitude grid with the exception of the world south of 60◦S where there have been no observational data and so calculated the hemispheric and global mean temperature supported area-weighted grid point estimates. On the opposite hand, Hansen and Lebedeff [1988] divided the world into 80 equal-area regions. They established the temperature statistic for every region first then combined the 80 regional statistics to create the world mean temperature series. Vinnikov et al. [1990] used data from fewer stations. Although the numbers of stations wont to obtain the three series were vastly different and therefore the statistical methods employed weren't identical, the estimated series of worldwide mean temperatures were highly correlated with each other, with correlation coefficients between 0.94 and 0.95 [Jones et al., 1986b; Vin-nikov et al., 1990]. In general, the feature of the studies during this period is that mean temperature series representative of land areas were constructed but the observational data over the oceans weren't included. 3 Present global temperature datasets.

The key feature of the studies within the period of play is that the incorporation of oceanic observations for better representativeness. within the beginning, the scientists attempted to use the on-deck observations of air temperature. However, it had been found that the observations were largely suffering from the reflection of radiation over the deck of the ship.

Finally, Parker et al. [1994] and Rayner et al. [2003] showed that sea surface temperature (SST) should be wont to provide a better estimate of surface temperature over the oceans. Therefore, these global temperature datasets all use the mix of land surface temperature and SST observations to get a global mean temperature or earth surface temperature. Within the following, three global mean temperature series that are widely used are introduced and reviewed.

2. PRESENT GLOBAL TEMPERATURE DATASETS

The key feature of the studies within the period of play is that the incorporation of oceanic observations for better representativeness. within the beginning, the scientists attempted to use the on-deck observations of air temperature. However, it had been found that the observations were largely littered with the reflection of

Pro.Madhuraj Dravid[1]; *[1]faculty In Department Of Geography In University In Denver, Colorado madhu.udf@gmail.com*

radiation over the deck of the ship. Finally, Parker et al. [1994] and Rayner et al. [2003] showed that sea surface temperature (SST) should be accustomed provides a better estimate of surface temperature over the oceans. Therefore, the current global temperature datasets all use the mix of land surface temperature and SST observations to get global mean temperature or earth surface temperature. within the following, three global mean temperature series that are widely used are going to be introduced and reviewed. HadCRUT3 Climatic Research Unit (CRU) at the University of Geographical Area compiled a dataset [Jones and Moberg, 2001] of world land surface temperature by using 5,159 meteorological stations, among which 4,167 stations were wont to calculate the climatology of 1961–1990. Observations with anomalies above 5σ (standard de-variation) were removed. The 5◦×5◦ grid average temperatures weighted by grid area were accustomed to obtain hemisphere and hemisphere series, which were further combined to become a worldwide mean temperature series. Additionally, this land surface series was merged with the SST data from the Hadley Centre to create the worldwide surface temperature series named HadCRUT2. Cited within the latest Intergovernmental Panel on temperature change reports (IPCC AR4). Within the IPCC version of this dataset, there are over 4,500 land stations used. And therefore the spatial resolution is flexible instead of a set 5◦×5◦ grid, which is simple to match with model results.

Representative bias, including heat island effect. Specifically, the spatial coverage error is worth mentioning. to know the effect of the spatial coverage problem, NCEP/NCAR reanalysis dataset over 50 years, which has complete spatial coverage, maybe accustomed identify the difference between the mean temperature over the whole area which over the grids with land stations. Concerning the influence of urbanization in developing countries, emphasis has been placed mainly on the contrast between urban and rural areas. However, the classification of a district to be urban or rural affects the result of the contrast. In building HadCRUT3, some urban stations were explicitly excluded and some other ur- ban stations were corrected by applying internal control and normalization processing. Within the estimate of the full uncertainties, urban heat island contributes a typical error of 0.055 ◦C per 100 years since 1900. In all, the three styles of uncertainties can explain the long-term bias by ±0.1 ◦C, or 0.2 ◦C spread, with 95% confidence level.

NCDC National Climatic Data Center (NCDC) established a world temperature dataset with complete global coverage.

The processing of the SST data was characterized by not only taking into consideration changes in observational technologies but also assimilating satellite data [Smith and Reynolds, 2003; 2004]. For the SST data before 1941, a negative bias of 0.3 ◦C was consistently removed, because at that point seawater temperature was measured by taking a bucket of water onto the deck of the ship and a temperature drop was introduced with the evaporation of the water within the process. Since war II, the way of measuring sea-water temperature has been changed by pumping water onto the deck. For the SST data after 1982, satellite observations were incorporated to boost the standard of SST data [van den Dool et al., 2000]. The data of land surface temperature were derived from the worldwide Historical Climatology Network (GHCN) [Peterson and Vose, 1997], with over 4,400 stations and therefore the base period of 1961–1990. GISS [Hansen et al., 2010]. They also compared the GISS series with the HadCRUT3 and NCDC series. The land surface temperature within the updated version of GISS data was also derived from GHCN [Peterson and Vose, 1997], with quite 6,300 stations. gap between the 2 grid points. the worldwide gridded data were accustomed to calculate the zonal mean for four latitudinal belts (90◦–23.6◦S; 23.6◦S–0◦; 0◦–23.6◦N; 23.6◦– 90◦N), and so the world mean was estimated by averaging, within the latest version of GISS data, two improvements were made: 1) the entire area of every zonal belt, instead of the realm Figure 1

Pro.Madhuraj Dravid[1]; *[1]faculty In Department Of Geography In University In Denver, Colorado madhu.udf@gmail.com*

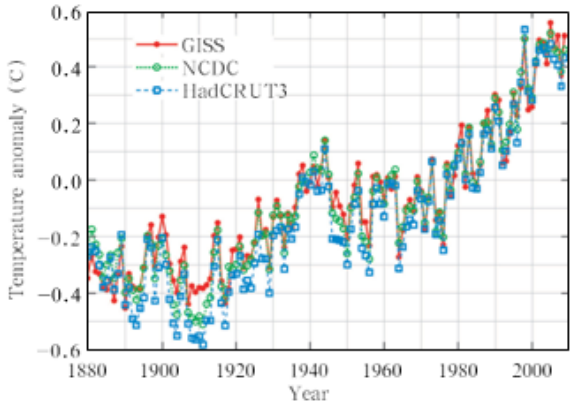

Figure 1 Global mean temperature anomalies for 1880–2009 relative to 1961–1990 [*Hansen et al.*, 2010]

Table 2 Global surface air temperature anomalies of Decadal average (°C) during 1880–2009 (relative to 1961–1990) and the trend for 1910–2009 (°C per 100 years)

Period	HadCRUT3	NCDC	GISS
1880s	–0.30	–0.26	–0.34
1890s	–0.39	–0.33	–0.32
1900s	–0.44	–0.38	–0.33
1910s	–0.43	–0.37	–0.34
1920s	–0.30	–0.25	–0.24
1930s	–0.13	–0.10	–0.11
1940s	–0.07	–0.02	–0.03
1950s	–0.16	–0.12	–0.09
1960s	–0.12	–0.07	–0.08
1970s	–0.09	–0.06	–0.07
1980s	0.08	0.10	0.11
1990s	0.24	0.27	0.25
2000s	0.41	0.44	0.45
1910–2009	0.75	0.72	0.70

Particularly, after 1982 the SST data are improved by incorporating satellite observations corrected by ship and buoy station data [Reynolds, et al., 2002], which are commonly stated as HadISST+OISST.

3 . INTER COMPARISONS

The statistic of the world means temperature from HadCRUT3, NCDC, and GISS, is shown in Figure 1 [Hansen et al., 2010].

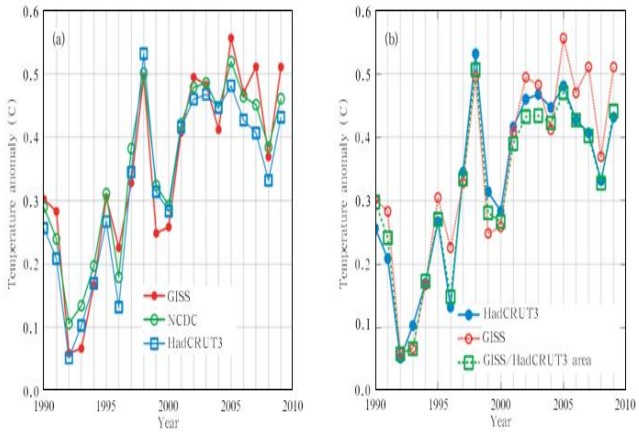

Figure 2 Global surface temperature anomalies for 1990–2009 relative to 1961–1990 (in the right plot, there are two GISS cases with one based on primitive definitions and another limited to HadCRUT3 area) [*Hansen et al.*, 2010]

From Figure 1 and Table 2, we will see all three-time series are very close. The differences among the 10- year mean temperature anomalies of those series are about 0.10 ◦C for the primary 40 years, are decreased to 0.05 ◦C by the 1950s, and fall below 0.05 ◦C within the past 50 years. The worldwide mean warming rate from 1910 to 2009 is 0.70–0.75 ◦C per 100 years. An interesting issue is found by comparing the three-time series very well.

Supported the weak warming trend in 1999–2008 calculated with the HadCRUT3 series, some scientists concluded that warming had come to a halt within the last 10 years [Knight et al., 2009; Kerr, 2009]. To investigate the change within the last 10 years, we calculated the warming trends in 2000–2009 with the three series.

It is obvious that GISS and NCDC, both of which incorporated observations over the pole, yielded higher warming rates than HadCRUT3. Hansen et al. [2010] recalculated the GISS series to mimic Had- CRUT3 grids and located they resulted in a very warming rate extremely just like that from the HadCRUT3. This further proved that the weak warming rate in Had- CRUT3 is primarily because of the sparse coverage of the info over the pole.

Pro.Madhuraj Dravid[1]; *[1]faculty In Department Of Geography In University In Denver, Colorado madhu.udf@gmail.com*

4. CONCLUSIONS

The global mean temperature series is a vital basis for detecting climate changes and finding their causes. From its time period when observations were only available from land and island stations, to the current when more oceanic and satellite observations are incorporated, the studies of worldwide mean temperature have experienced three periods. In these three periods, data quality, spatial coverage, and analysis methods are significantly improved and enhanced. During this paper, we reviewed and compared three popular datasets of worldwide mean temperature which are often employed by the international research community. And also the 100-year (1910–2009) warming trends from the three series are very close (0.70–0.75 ◦C). However, for the past 10 years (2000–2009), GISS and NCDC series showed a far stronger warming trend than HadCRUT3 did. this is often very likely because of the shortage of observations over the Arctic in HadCRUT3. This phenomenon not only shows the importance of the spatial coverage of the info, but it'd also to some extent explain the discrepancies among the three datasets within the early period.

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Pro.Madhuraj Dravid[1]; *[1]faculty In Department Of Geography In University In Denver, Colorado madhu.udf@gmail.com*

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Pro.Madhuraj Dravid[1]; *[1]faculty In Department Of Geography In University In Denver, Colorado madhu.udf@gmail.com*