



Global surface temperature change analysis based on MODIS data in recent twelve years

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Received 3 December 2015; received in revised form 25 October 2016; accepted 4 November 2016

Abstract

Global surface temperature change is one of the most important aspects in global climate change research. In this study, in order to overcome shortcomings of traditional observation methods in meteorology, a new method is proposed to calculate global mean surface temperature based on remote sensing data. We found that (1) the global mean surface temperature was close to 14.35 °C from 2001 to 2012, and the warmest and coldest surface temperatures of the global in the recent twelve years occurred in 2005 and 2008, respectively; (2) the warmest and coldest surface temperatures on the global land surface occurred in 2005 and 2001, respectively, and on the global ocean surface in 2010 and 2008, respectively; and (3) in recent twelve years, although most regions (especially the Southern Hemisphere) are warming, global warming is yet controversial because it is cooling in the central and eastern regions of Pacific Ocean, northern regions of the Atlantic Ocean, northern regions of China, Mongolia, southern regions of Russia, western regions of Canada and America, the eastern and northern regions of Australia, and the southern tip of Africa. The analysis of daily and seasonal temperature change indicates that the temperature change is mainly caused by the variation of orbit of celestial body. A big data model based on orbit position and gravitational-magnetic change of celestial body with the solar or the galactic system should be built and taken into account for climate and ecosystems change at a large spatial-temporal scale.

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Keywords: Surface temperature; Global; Climate change

1. Introduction

Many reports suggest that extreme floods, heat waves, droughts, and wildfires that occurred on a global scale over

the past decade might be increased by climate change (Rahmstorf and Coumou, 2011). For instance, the heat wave affecting Australia in the summer of 2013 brought extreme temperatures to most part of the Australian continent over a prolonged period. Climate change was a major driving force behind many extreme weather events that alternately scorched and soaked many countries in recent years. People often guessed “this year is the warmest” or “this year is the coldest”. Numerous studies have been

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carried out to quantify the global temperature, which are usually based on data from meteorological stations (Hansen et al., 2010; Brohan et al., 2006; Smith et al., 2008; Ishihara, 2006; Rahmstorf and Coumou, 2011). There are four major global temperature indices that incorporate station data. These efforts are led, respectively, by NOAA's National Climate Data Center (NOAA NCDC), NASA's Goddard Institute of Space Sciences (NASA GISS), a collaboration between the University of East Anglia's Climatic Research Unit, the UK Met Office's Hadley Centre (CRU), and the Berkeley Earth Surface Temperature group. These groups individually utilize different averaging techniques, quality control procedures, homogenization techniques, and datasets, but all primarily rely on the Global Historical Climatology Network (GHCN) for their input data. The GHCN data collects data from about 7000 stations (Hansen et al., 1988, 1999, 2001, 2006; Rayner et al., 2003; Fan and Dool, 2008; Jones et al., 1999). The GISS achieved temperature show some differences. For example, GISS and NCDC indicate 2005 as the warmest year in their analyses, while HadCRUT has 1998 as the warmest year. The differences might be caused by two main factors: (1) the way that temperature anomalies are extrapolated, or not extrapolated, into regions without observing stations and (2) the ocean data sets that are employed different by different studies. The detail analysis can be referred to reference (Hansen et al., 2010).

Most analysis concerns only temperature anomalies, not magnitude temperature. Temperature anomalies are computed relative to the base period 1951–1980 (Hansen et al., 2006, 2012). The reason for the focus on anomalies rather than absolute temperature is because absolute temperature varies markedly in space, while monthly or annual temperature anomalies are representative of a much larger region. It is very difficult to determine the annual mean of absolute temperature because temperature variations are different in different regions. The number of ground observation sites is insufficient, especially in mountainous regions, ocean regions, and the Polar regions. Hansen and Lebedeff have shown that surface air temperature anomalies are strongly correlated to distances of the order of 1000 km (Hansen and Lebedeff, 1987). To compensate for sea temperature observations, the surface temperature from satellite sensors (NOAA/AVHRR) is used as a supplement (Hansen et al., 1999). Additional *in situ* and satellite data improve the accuracy of a blended (*in situ* and satellite) sea-surface temperature (SST) (Brohan et al., 2006; Smith et al., 2008; Reynolds et al., 2005). The surface temperature retrieved from satellites is different from near surface air temperature. The surface brightness temperature is influenced by surface emissivity far more than near surface air temperature. Generally speaking, surface temperature varies from point to point on the ground, and ground measurements are generally point measurements. The location of observation sites therefore, has some influence on the measurements. Hansen et al. (2010) tested

alternative choices for the ocean data, and showed how global temperature changes were sensitive to estimated temperature changes in polar region where observations are limited. For some meteorological observations, it is difficult to guarantee consistent data recording and proof-reading because meteorological observations are made different in many nations. For a more detailed discussion, we can find more information from the The Elusive Absolute Surface Air Temperature (http://data.giss.nasa.gov/gistemp/abs_temp.html).

The history of surface temperature retrieval from remotely sensed thermal infrared (TIR) data dates back to the 1970s (McMillin, 1975). To improve the estimating surface temperature from satellite thermal data, many studies have been carried out, and different algorithms have been proposed to eliminate the influence of emissivity and atmospheric (Becker and Li, 1990; Gillespie et al., 1998; Hook et al., 1992; Kealy and Hook, 1993; Kerr et al., 1992; Pozo et al., 1997; Price, 1983, 1984; Qin et al., 2001; Susskind et al., 1984; Wan and Dozier, 1996; Jiménez-Muñoz and Sobrino, 2003; Mao et al., 2005, 2007). Li et al. (2013a,b) evaluated the advantage and disadvantage of different algorithms in details. NASA has two polar-orbiting Earth Observing System (EOS) satellites (Terra and Aqua) with one satellite passing the equator in the morning (10:30) and evening (22:30) and the other passing the equator in the afternoon (13:30) and late morning (1:30). The reason to have them is on a sun-synchronous, and near-polar orbit is that they can travel from the North Pole to the South Pole on the sunlit side as the Earth rotates below it. As result, they pass over Earth at approximately the same local time each day to ensure comparable daylight conditions during a day. Moderate Resolution Imaging Spectroradiometer (MODIS) instruments are on board these two satellites, with 36 bands available including 8 thermal infrared bands designed for retrieving of sea surface temperature (SST) and land surface temperature (LST). Two algorithms are used by NASA officially for global surface temperature retrieval from MODIS data (Wan and Dozier, 1996; Wan and Li, 1997), which in total provide four daily global surface temperature coverages. NOAA has two similar meteorological satellites AVHRR with two thermal bands which can accurately retrieve sea surface temperature. Thus people tend to use the SST obtained from AVHRR to supplement ocean surface temperature in previous studies (Hansen et al., 1999; Brohan et al., 2006; Fan and Dool, 2008).

Remote sensing can quickly obtain surface temperature over large area, and it has been standardized to keep consistency and ensure accuracy. MODIS can provide highly accurate estimation of land and sea surface temperatures (Wan et al., 2004; Peter et al., 2006; Wan, 1999), which overcome disadvantages of Combined Land-Surface Air and Sea-Surface Water Temperature Index (Land-Ocean Temperature Index). Therefore the surface temperature obtained from MODIS can help us to accurately determine the surface temperature at different regional scale, which is

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