Climate Change Detection with the Global GPS Information System

Kuo-ying WANG

Department of Atmospheric Sciences, National Central University, No. 300, Chung-Da Road, 320 Chung-Li District, Tao-Yuan City, Taiwan

Keywords: Climate change, GPS, Radio occultation, Formosta-3/COSMIC.

Abstract. The Intergovernmental Panel on Climate Change (IPCC) has predicted a persistent and wide-spread warming of temperatures close to the surface over the entire globe in the 21st century, due to the continuously increases in the concentrations of anthropogenic greenhouse gases in the atmosphere. How realistic are the predictions made by the IPCC models, especially over the polar region where the highest increases in temperatures were predicted? Due to the lack of accurate temperature measurements over polar region, the estimate of temperature trends over the polar region remains to be determined. The polar region is also one of the regions where temperature trends remain uncertain. In this work we use profiles of temperature measurements from the FORMOSAT-3/COSMIC (F3C) to determine global temperature trends during the period 2006-2016. The radio occultation (RO) technique gives the F3C a unique and accurate temperature measurement when verified against radiosonde measurements, and when compared with other passive-based temperature measurements using the thermal infra-red emission method. The RO methods use known sources from the radio waves provided by the Global Positioning System (GPS). With a good global coverage by the F3C, we can work out temperature trends on a global scale. Our analysis shows following main results. The distinctive warming over the northern hemisphere polar regions. This warming in the polar region, identified by the F3C observations, confirms the predictions made by the IPCC models. As warming trends in the polar region are the most worried concerns for the global warming, which is likely to lead to progressive reduction in sea ice content, melting glaciers, etc. Our work with the F3C data proves this is terrifying picture is actually happening now. Our analysis also shows distinctive warming over the southern hemisphere polar regions. Again, this proves significant warming during the cold season in the polar region which is consistent with what we have found in the northern hemisphere polar regions. In conclusion, the F3C data demonstrates that significant warming has occurred during the period 2007-2013, and most pronounced warming areas have occurred over the polar region. The pronounced warming over the polar region likely to have worsen effects on sea ice lost, and melting glaciers.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) reports has made predictions of a persistent and wide-spread warming of temperatures close to the surface over the entire globe in the 21st century [1]. How realistic are the predictions made by the IPCC models, especially over the polar region where the highest increases in temperatures were predicted? Due to the lack of accurate temperature measurements over polar region, the estimate of temperature trends over the polar region remains to be determined.

Since the successful launched of the FORMOSAT-3/COSMIC (F3C) satellite on 14 April 2006, the F3C satellite has provide very consistent monitoring of atmospheric temperatures below 40 km altitude for more than 7 years [2-7]. In this work use this 7 years of good temperature measurements to construct atmospheric temperature trends from surface to the 40-km altitude, covering troposphere and most of the stratosphere; and from the South Pole to the North Pole. We expect to see things that are unexpected, especially when compared with published results using conventional methods (ground-based monitoring stations, radiosonde measurements, and satellite IR radiance methods). We will also compare temperature trends from F3C with temperature trends from model reanalysis data,
which have been heavily used and taken for granted as representative of the state of atmospheric flows.

**Methods**

In this work we use profiles of temperature measurements from the F3C data to determine global temperature trends during the period 2006-2016. Based on known sources from the radio waves provided by the Global Positioning System (GPS), the F3C uses radio occultation (RO) technique to obtain profiles of atmospheric temperatures from surface to 40-km altitudes (Figure 1). With a good global coverage by the F3C, we can work out temperature trends on a global scale.

![Figure 1. A cartoon showing GPS radio occultation method used by the F3C constellation.](image)

**Results**

Distinctive warming over the northern hemisphere polar regions is shown from the F3C data (Figure 1). This warming in the polar region, identified by the F3C observations, confirms the predictions made by the IPCC models. The continuously warming trends in the polar region can lead to progressive reduction in sea ice extent, melting glaciers, etc. Our work with the F3C data proves that this terrifying picture is actually happening now.

![Figure 2. Global surface temperature trends in March (K/10 years) determined from F3C for the 10-year period of 2007-1016.](image)

**Summary**

The F3C data demonstrates that significant warming has occurred during the period 2007-2016, and most pronounced warming areas have occurred over the polar region. The pronounced warming over
the polar region are exacerbating sea ice lost, and melting glaciers. Satellite measurements are keys for mankind to continuously observe what have occurred over the polar region.

Acknowledgement
This research was financially supported by the Ministry of Science and Technology, Taiwan.

References


