Extraction and Analysis of Temperature data from COSMIC of Pacific Occultation

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Abstract. With the increase of human demand for natural climate research, climate monitoring technology has been greatly developed, and the occultation technology proposed in the field of surveying and mapping provides a more accurate and effective data source for meteorology research. With the destruction of the earth's ecosystem by pollution, the global climate change has a great impact on human life, so the research on meteorology has been paid more and more attention. The data obtained from GPS radio occultation observations have also become one of the key data sources to record the temperature changes of the atmosphere in tropical regions. The extraction and analysis of temperature data in the western Pacific are very essential. At the same time, it plays an crucial role in China's climate prediction and disaster warning. It is hoped that by reading the occultation data of the western Pacific in 12 months in 2014, and drawing the isoline map of the lunar season and seasonal temperature values, the change law of global and western Pacific temperature with longitude, latitude and altitude can be analysed.

1. Introduction

As the global temperature increases, people are paying more and more attention to the global climate. Changes in temperature on land, in the atmosphere, or at the surface of the ocean can be detected to test the effects of global warming. Sea surface temperature is also an essential indicator of global climate change. The traditional methods of measuring temperature and moisture content in the atmosphere, using weather forecasting models and microwave sonar, do not cover the entire globe. With the development of ground-based and space-based atmospheric remote sensing detection technology, the space-based GNSS (Global Navigation Satellite System), Radio Occultation (RO), including GPS of the United States, GLONASS of Russia, Galileo system of the European Union and Beidou system of China, has shown great potential in climate monitoring, weather forecast and ionospheric research. It breaks the regional limitation of the lack of data in the ocean and other remote areas by the conventional
exploration, which makes the in-depth understanding of the time-varying characteristics and spatial distribution of the earth's atmosphere free from the limitation of time and space. GNSS occultation technology inversions the vertical distribution of atmospheric parameters through the processing of GNSS radio wave signals\(^1\). The characteristics of high precision, stability and low cost of COSMIC (Constellation Observation System for Meteorology Ionosphere and Climate) have been widely concerned by many scholars at home and abroad. The occultation of meteorological, ionospheric and climatic constellation observation system has become a major research hotspot\(^2\).

Considering the convenience of data acquisition in the Western Pacific and the geographical location of the Western Pacific and its correlation with climate change in some regions of China, the Western Pacific region (Figure 1) (http://www.maps-of-the-world.net/) was selected for climate research, the Longitude from 120° E to 160° W. The vast and uniform water in the Pacific Ocean is conducive to the formation of the east-to-west Pacific Ocean Current and the formation of the Southern and Northern Equatorial Warm Current in the Pacific Ocean. The tropical western Pacific contains the most ocean heat around the tropics, also known as the “warm pool”\(^3\). Differences in its heat also influence global climate change, and differences in heat over land and sea can lead to the formation of monsoons and ocean currents. In addition, there are abundant ocean currents in the western Pacific, and the changes of ocean currents and monsoons will also have an impact on the temperature in the western Pacific. For example, the eastern coast of China, such as the Bohai Sea, belongs to the western Pacific, and it has an important impact on the climate, rainfall and other aspects of coastal cities and some inland cities\(^4\). The existing occultation data are used to invert the temperature values corresponding to different longitude and latitude in the world and the western Pacific Ocean, and the causes of temperature changes and temperature anomalies in a few areas are analysed, so as to predict the disasters caused by climate changes\(^5\).

![Figure 1 Location of the western Pacific Ocean](image)

2. Data source of COSMIC

COSMIC was launched in April 2006 as a cooperative project between Taiwan, China and the United States for the GNSS occultation sounding test\(^6\). The COSMETIC project consists of six LEO satellites. When the GPS satellite signal passes through the earth's atmosphere, the radio wave rays will be bent due to refraction. The signal received by the satellite will be processed according to the principle of geometry and optics to obtain the refractive index of each layer of the atmosphere, and finally the atmospheric meteorological data within the range of 0-60km will be reflected. And ionospheric data
ranging from 90 to 180 km. COSMIC data can provide 2000–3000 profiles of global temperature, pressure and humidity from high altitude to near ground every day. The data provided by COSMIC website and WETPRF (wet profile data) file in 2020 were selected for processing, and the global temperature corresponding to the same longitude and latitude at the pressure of 250 MB, 350 MB and 450 MB was obtained by interpolation method, and the final results were analysed and compared.

3. Analysis of temperature data results

Surfer 11.0 is used for grid processing of variable data documents. The processing method chosen here is to use Kriging interpolation method to fit the data and get a continuous temperature change trend chart. Effects due to temperature change of ocean currents and warm pool, according to the literature research results show that the largest convection centre is located in the western Pacific place, is the largest centre of precipitation years, location of the centre and the western Pacific warm pool is largely consistent. An ocean current is a relatively steady flow of water at the surface of the ocean in the same direction over a long period of time. Ocean currents are key to the regulation of land and sea surface energy. Ocean currents include warm currents and cold currents. Ocean current systems on the Earth's surface can enhance the heat exchange between water and land at high and low latitudes. Environmental characteristics such as temperature between different regions are changed by the flow of ocean currents. According to image analysis, the temperature change of the western Pacific region presents the temperature fell gradually from low latitude to high latitude, low latitude region of higher temperature may warm with Japan, south of the equator, the equatorial current and north equatorial current in other corresponding area has high absolute humidity value, this may be related to intertropical convergence zone (ITCZ) tropical convection system, it may lead Conveyor and transmission of strong vertical airflow. The temperature varies approximately constant over the same latitude and longitude. For the overall temperature change are relatively stable and relatively low latitudes in the temperature on the high side, the highest temperature was minus 10 degrees Celsius, roughly zero dispersion in low latitudes, the distribution of temperature of the high latitudes are generally lower, the lowest temperature is reached, near the polar temperature on the whole, shows the low-latitude high latitudes from declining trend. To make the comparison of the performance more intuitive, this paper selected the 250 MB, 350 MB and 450 MB of different pressure corresponding to the temperature contour map based on monthly or seasonal of horizontal and vertical to compare and analyse.

3.1. Temperature isolines at different pressures in each month

![Figure 2](image1)

Figure 2 Temperature isolines of 250MB(a), 350MB(b) and 450MB(c) in February.
As can be seen from the temperature isolines under different pressures in February, with the increase of pressure, the high-temperature areas become more concentrated. By comparing the temperature isolines of 450MB and 350MB, it is found that when the pressure is too high, the temperature in the edge zone decreases, but the temperature in the centre zone increases, and the high-temperature areas show continuity. The temperature decrease in the marginal zone may be related to the influence of seasonal winds and ocean currents.

The reason abnormal data are found during data grid processing is probably the area at a relatively high elevation and the complex cold and warm currents. Such as Antarctica is surrounded by cold currents and drifting westerly winds, which are not conducive to increasing temperatures in the region and the warm current near Mexico[8].

3.2. Temperature isolines at different pressures at seasons

According to the temperature isoline analysis under different pressures in each month, we can find the abnormal temperature change points in the month, and analyse the causes of climate change at this point. Considering the climate seasonality between different months, it is necessary to analyse the advanced seasonality of temperature isolines and further observe the climate change characteristics of abnormal data points.

The global occultation event of GPS2014 was extracted and the altitude layer was extracted, and Surfer11.0 was applied. The corresponding temperature values at different elevations at the same place in different months and seasons are plotted, so as to compare the temperature at different elevations at the same place and the temperature at different seasons at the same place[9].

Some data outliers are caused by problems in data processing (some uncoloured areas or red areas). Some outliers with high temperature may be caused by nearby heating or rapid cooling. Krikin interpolation is used in data grid processing to generate high temperature or abnormal data generated by interpolation. By comparing the temperature isoline maps of the four seasons in spring, summer, autumn and winter, it can be seen that the temperature changes in different seasons are quite different. The temperature changes in the marginal regions are more obvious than those in the central regions, and the changes of the high temperate zone in the central regions show continuity. What is remarkable is that autumn, as the transition zone between summer and winter, obviously reflects the increase of abnormal
points with the change of temperature, which also reflects the more obvious global climate anomalies in the alternating process of summer and winter, warm current and cold current.

4. Conclusions
Through data extraction and analysis, conclusions can be drawn as follows:

(1) The change in temperature with the change in pressure is also proportional to the change in pressure. The temperature range in the western Pacific is between -55 °C and -40 °C at 250 MB, between -50 °C and -20 °C at 350 MB, and between -20 °C and 0 °C at 450 MB.

(2) The temperature change shows a trend of decreasing with the increase of latitude, which may be determined by the difference in altitude from the ground and the distance from the refraction point of the sun. In the longitude direction, the temperature change trend is not obvious, and the temperature change at this time is mainly related to ocean current, monsoon and warm pool. This is also true in the western Pacific, where factors include currents and warm pools near the equator and monsoons, as well as whether or not an El Nino event occurs that year.

(3) Maximum temperature values vary with season in both hemispheres. In the winter of the southern hemisphere, the maximum absolute temperature in tropical areas is between -35°C and -45°C, and temperature anomalies appear in some areas. For example, there is a special case in December. The temperature anomaly points at (540°, W80°) is -25 °C, which is too high compared to the normal temperature of -50°C~40°C. However, in the southern hemisphere in summer, the highest temperature in the southern hemisphere is -40°C~45°C. Obviously, the area of high temperature in the tropical region is significantly larger in winter than in summer. And for the northern hemisphere, in summer, it's hot in the northern hemisphere. The highest temperature in the belt reaches -35°C~45°C, while in winter, the highest temperature in the northern hemisphere reaches -40°C~45°C, and the area of high temperature in the tropical region is significantly larger in summer than in winter. Obviously, that is, for the tropical parts of the southern hemisphere, the highest temperature occurs in winter and the lowest temperature occurs in summer. In contrast, for other tropical regions of the Northern Hemisphere, the highest temperature occurs in summer and the lowest temperature occurs in winter. In addition, the overall temperature of the southern hemisphere and the northern hemisphere varies little in winter and summer, while the temperature of the northern hemisphere varies greatly.

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