

The investigation of temperature trend in the Antarctic using GPS radio occultation technique

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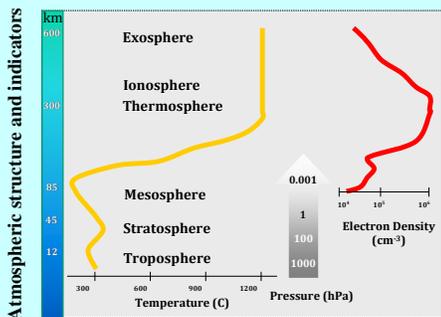


Fig 1. Atmospheric structure and indicators, and the map of Radiosonde Network

Atmospheric Observation

The Antarctic plays a vital role in the global atmospheric and oceanic systems and circulations because of its unique geographical and meteorological features. Recent abnormal melting of Antarctica ice sheet has been considered as a strong evidence of global warming. Climate change in the Antarctic and its impacts on global climate have drawn more attention of climatologists.

Studies of these weather phenomena and climate change heavily relies on atmospheric upper air information that is predominantly from the global radiosonde weather network of about 2000 stations (Fig 1). The Antarctic has 18 stations and all of these stations locate along the coastline. Due to the extreme conditions, data from only seven stations are reliable for climatologic studies.

The radiosonde network has a limited number of stations and heterogeneous geographical distribution, and high operation costs. Atmospheric information derived from the station-based observation can not represent the dynamics (in both space and time) of the Earth's atmosphere status and processes properly.

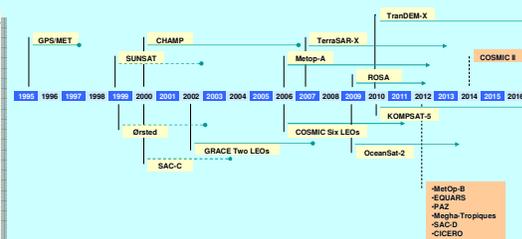
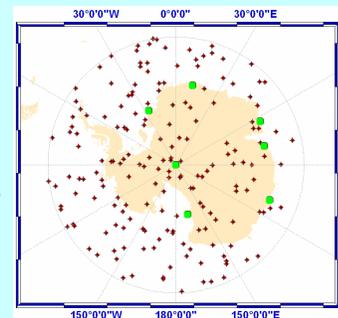


Fig 3. Past and current GPS RO missions

Fig 4. Distributions of the radiosonde stations (green dots) & 1-day COSMIC RO events (red dots) in the Antarctic.



Evaluation of RO and Climate Case Study

Comprehensive and detailed evaluation of the new RO data is the interest of meteorological communities. The characteristics of the datasets must be studied carefully to maximise the advantages of the new technology and to avoid/reduce problems that might be introduced into the current systems and models. Therefore, evaluation study designed to access the retrieved atmospheric profiles from CHAMP and COSMIC missions.

The Antarctic plays important role in the global and Australian weather and climate. Space-based GNSS RO technique provide very important upper air atmospheric information for remote areas like Australasian and the Polar regions. The key aim of this research is then to investigate of the Antarctic temperature trends using the seven years CHAMP data. Temperature trends at different pressure levels and in different seasons in the Antarctic were estimated.

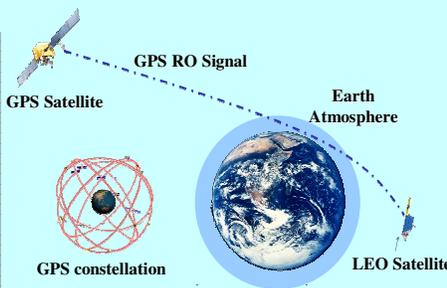


Fig 2. GPS RO event concept map

The keys of the technology are the satellites' orbits precise determination and the GPS RO signal retrieval process.

GNSS RO Introduction and Missions

Global Navigation Satellite System (GNSS) Radio Occultation (RO) is an emerging atmospheric observation technology to overcome limitations of radiosonde. The technology is to utilize GPS RO receiver onboard Low Earth Orbit (LEO) satellites to capture the GPS signals while the GPS satellites setting or rising behind the Earth's limb as viewed by the LEO (Fig 2). Its advantageous include its global coverage, high vertical resolution, high accuracy, all weather capability and calibration-free.

Since promising results found in the pioneering GPS/MET experiment in 1996, a number LEO with RO receivers have been launched, such as German CHAMP, European's MetOp and ACE, South Africa's Sunsat and Taiwan and USA's COSMIC (Fig 3). With the new launch of COSMIC in 2006, about 200 daily RO events can be expected for the Antarctic region, that is significant increasing upper air observations to the Antarctic meteorology comparing the seven regular radiosonde stations (Fig 4).

Result Discussion

Fig 5 shows a evaluation of COSMIC retrievals (in the Antarctic and the Australasian) using radiosonde data. Significant statistical agreement between the two data sets was found. Radiosonde obtains warmer temperature than RO in the lower atmosphere but cooler in the upper atmosphere.

Fig 6 is the spatial representation of the mean and STD of pressure differences between COSMIC and radiosonde. It can be seen that both the inland and high latitude areas have smaller values since these areas are relatively dry. Fig 7 shows comparison of CHAMP and radiosonde (temperature and pressure) and the 95% confidence intervals.

Fig 8 and Fig 9 presents Antarctica temperature trend analysis using 8-year CHAMP data. Fig 8 shows the trends derived at different pressure levels and Fig 9 presents the annual and seasonal trends at 500 hPa level.

Conclusion

- Three notable findings are
1. GPS RO retrieved atmospheric profiles agree well with radiosonde measurements and weather model data,
 2. General cooling trends in the stratosphere and warming trends in the troposphere,
 3. General warming in the West Antarctic and Peninsula and cooling in east Antarctic,
 4. Warming trend cross all the continent in Winter but cooling in Summer.

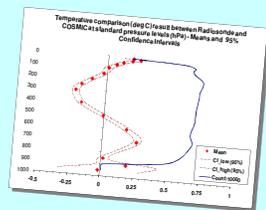


Fig 5. Comparison of COSMIC and Radiosonde (Temperature)

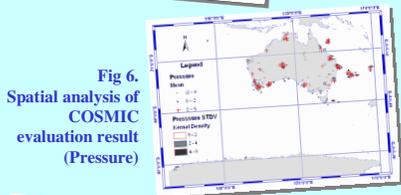


Fig 6. Spatial analysis of COSMIC evaluation result (Pressure)

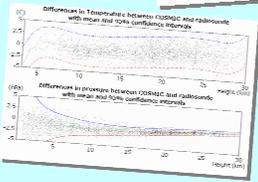


Fig 7. Comparison of CHAMP and Radiosonde (Temperature and pressure), and the 95% confidence interval analysis

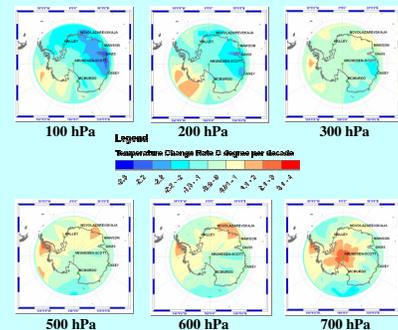


Fig 8. Antarctic Temperature trends analysis using CHAMP RO data at different pressure levels

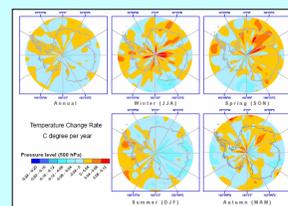


Fig 9. Antarctic Temperature trends (annual and seasonal) analysis using CHAMP RO data at 500 hPa pressure level

