# Extreme Weather Monitoring Based on GNSS Radio Occultation Sounding - A Case Study in China

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## 1 Introduction

Extreme weather events due to the climate changing (e.g. snow storms in UK and USA, flooding in Indonesia and drought and torrential rain in China occurred almost concurrently) have disastrous impacts on environment, society and economy worldwide. However, monitoring and prediction of these extreme weather events have been challenging tasks due to limited atmospheric information from conventional meteorological observation systems. Due to unprecedented high vertical resolution, high accuracy, global coverage and long-term stability, the Global Navigation Satellite System (GNSS) radio occultation (RO) technique has a great potential to complement other meteorological observation systems and improve extreme weather monitoring and forecasting. This research investigates a methods of extreme weather monitoring using GNSS RO sounding. The profiles from COSMIC GNSS RO mission are used to investigate the flood in Guangxi Province, China in 2009 and the drought in Yunnan Province, China during 2009- 2010, respectively.

## 2 Flood in Guangxi

Heavy rains had hit the south of China since the middle of June 2009. The high rainfall leaded to severe flood in 12 provinces. The floods resulted in about 3.9 million people afflicted, thereinto about 1 million people displaced, and a direct economic loss of 13 billion Chinese Yuan. In the worst-hit province, Guangxi, there were 9 major cities, 63 countries and 3.69 million people afflicted by the flood. The direct economic loss has reached 1.5 billion Chinese Yuan.

Fig. 1: Flood in Guangxi Province in 2009.

### 2.1 Datasets

☞COSMIC atmospheric profiles (wetPrf)
☞Location: Guangxi Province (Lon: 105-115 degree, Lat: 20-30 degree)
☞Date: Jun. 1st - Jul. 15th (2007, 2008, & 2009)

### 2.2 Preliminary Results

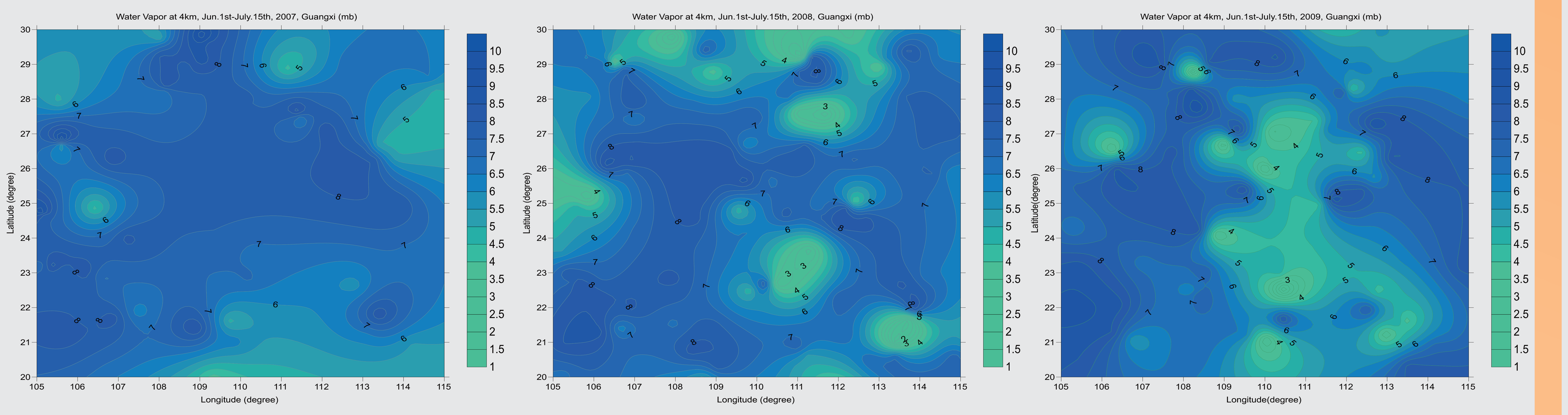


Fig. 2: Spatial variations of water vapor over Guangxi Province from Jun. 1st - Jul. 15th, in 2007 (left), 2008 (middle), & 2009 (right), respectively.

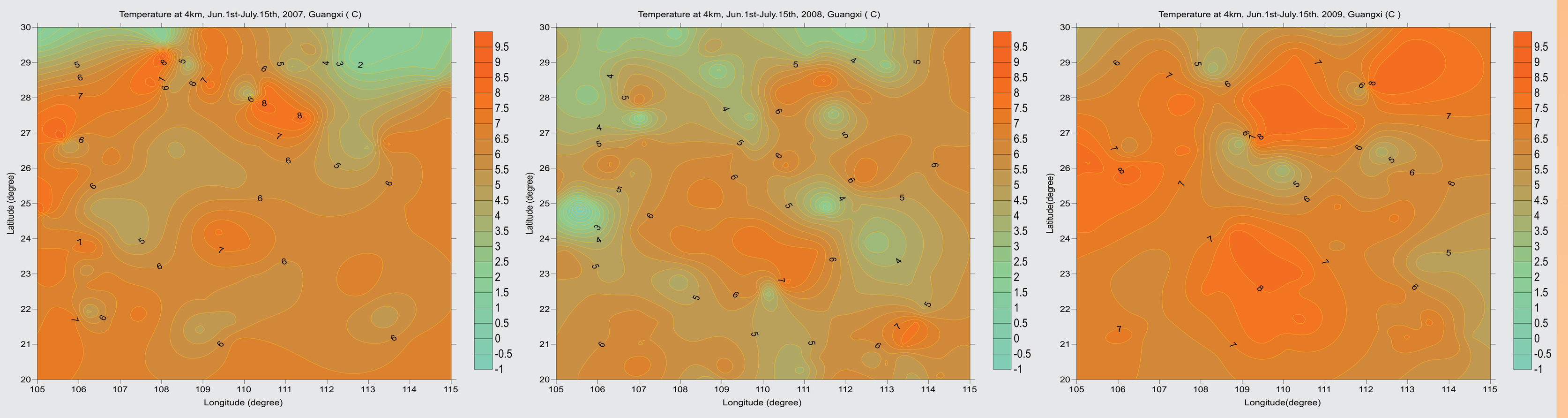


Fig. 3: Spatial variations of temperature over Guangxi Province from Jun. 1st - Jul. 15th, in 2007 (left), 2008 (middle), & 2009 (right), respectively.

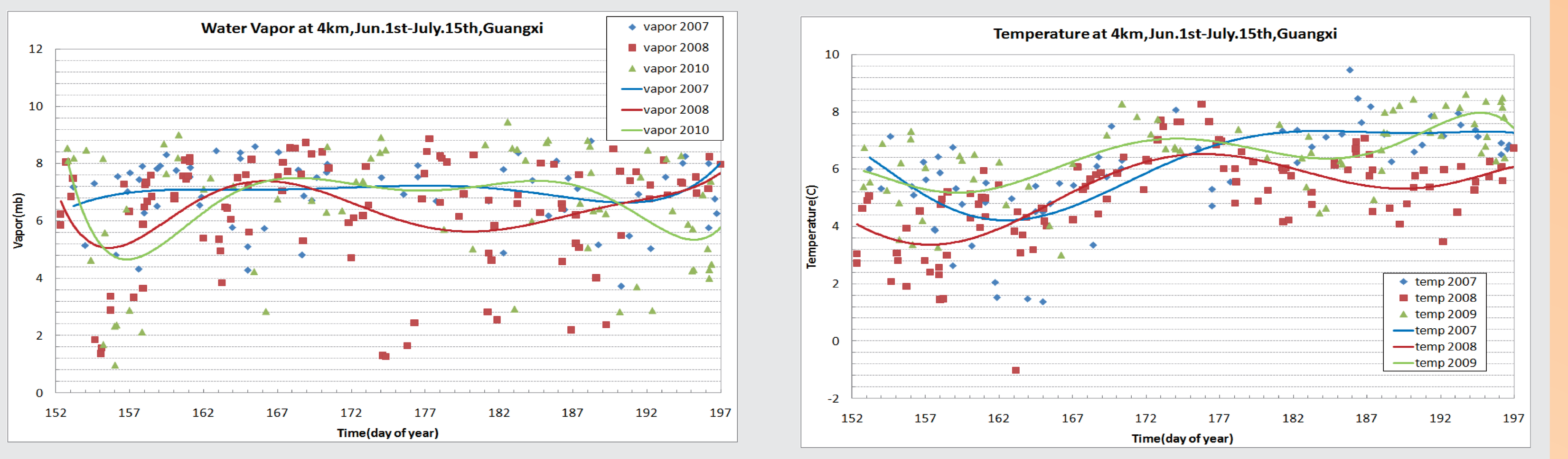


Fig. 4: Temporal variations of water vapor (left) and temperature (right) over Guangxi Province from Jun. 1st - Jul. 15th, in 2007, 2008, & 2009, respectively.

Tab. 1: Comparison of water vapor and temperature from Jun. 1st - Jul. 15th, 2007, 2008, & 2009 (Altitude: less than 4 km).

| Average / Standard deviation | 2007 | 2008 | 2009 |
|---|---|---|---|
| Water vapor (mb) | 13.76 / 5.40 | 12.92 / 5.55 | 13.03 / 5.72 |
| Temperature (C) | 14.20 / 5.54 | 13.58 / 5.60 | 14.86 / 5.50 |

☞The water vapor of 2009 at an altitude of 4 km is lower than year 2008 & 2007 (Fig. 2). The temperature of 2009 at an altitude of 4 km is higher than year 2008 & 2007 (Fig. 3).
☞The temperature of 2009 is about one degree Celsius higher than year 2008.

## 3 Drought in Yuannan

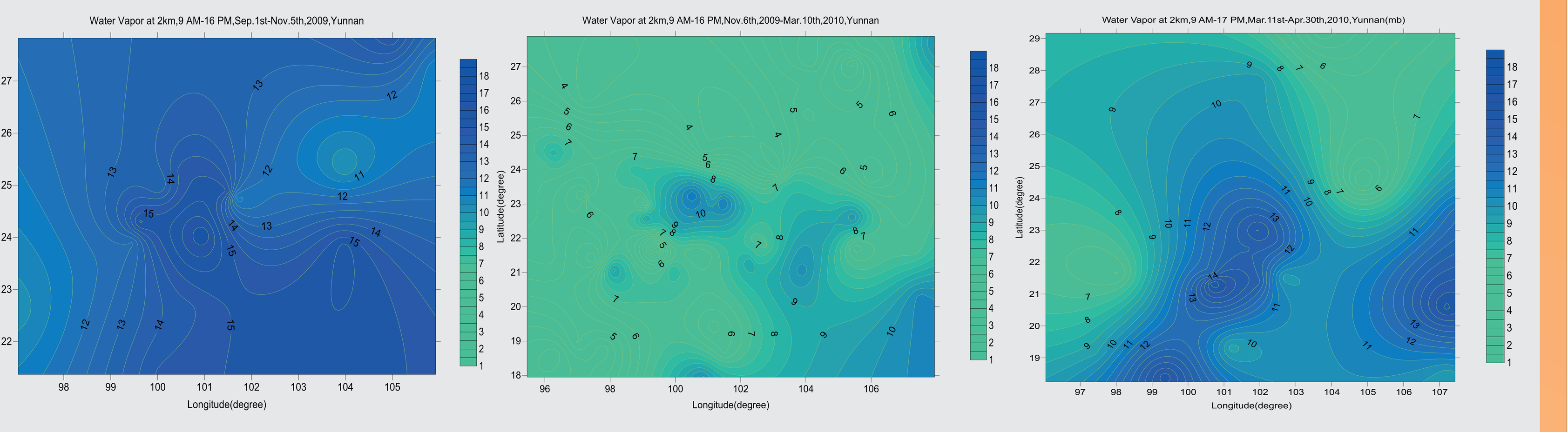
The precipitation of the southwest of China was only half its average annual amount since autumn 2009, and the drought was one of the worst in decades. The Yunnan Province was hit hardest by the drought from February to April, 2010, with more than 20 million people and 12 million livestock suffered from drinking water shortages. The drought resulted in a direct economic loss of 17.2 billion Chinese Yuan to the Yunnan Province's agriculture.

Fig. 5: Drought in Yunnan Province during2009-2010.

### 3.1 Datasets

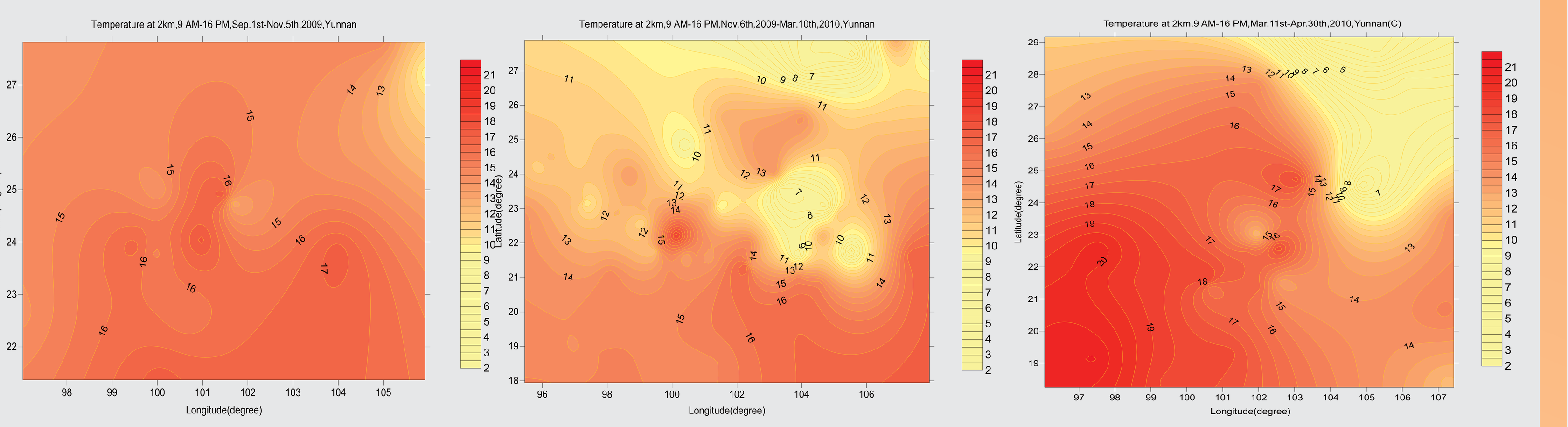
☞COSMIC atmospheric profiles (wetPrf)
☞Location: Yunnan Province (Lon: 97-106 degree, Lat: 21-28 degree)
☞Date: Sep.1st, 2009 - Apr. 30th, 2010

### 3.2 Preliminary Results



(a) Early period (b) Middle period (c) Late period

Figure 6: Spatial variations of water vapor for different periods of drought (9 AM - 16 AM) from Sep.1st, 2009-April.30th, 2010.



(a) Early period (b) Middle period (c)Late period

Figure 7: Spatial variations of temperature for different periods of drought (9 AM - 16 PM) from Sep.1st, 2009-April.30th, 2010.

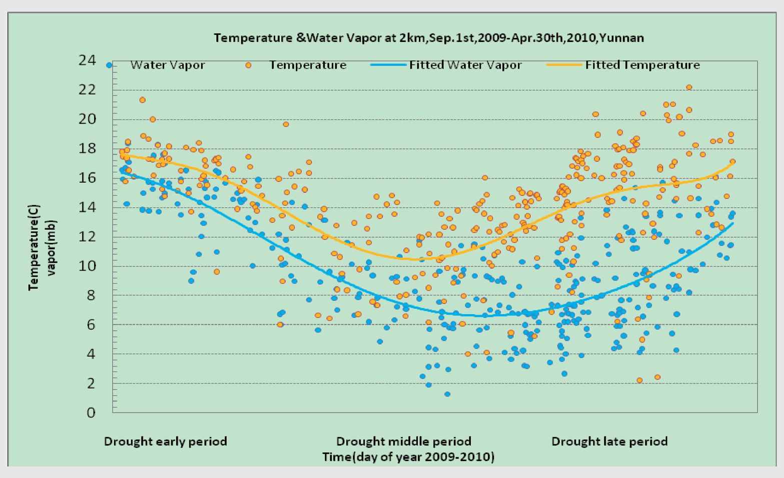


Fig. 8: Temporal variations of water vapor and temperature over Yunnan Province from Sep.1st, 2009-April.30th, 2010.

Tab. 2: Comparison of water vapor and temperature from Sep.1st,2009 - Apr. 30th, 2010 (Altitude: less than 2 km).

| Average / Standard deviation | Early | Middle | Late |
|---|---|---|---|
| Water vapor (mb) | 13.62/ 2.82 | 6.83/ 3.06 | 10.38/ 3.94 |
| Temperature (C) | 15.25/ 5.99 | 12.22/ 5.74 | 14.39/ 6.26 |

☞The water vapor of middle period of drought at an altitude of 2 km is about 3-7mb lower than the early and late period of drought (Tab. 2).
☞The temperature of middle period of drought which is in the winter is about 2-3 degree Celsius lower than the early and late period which are in the autumn and spring respectively(Tab 2).

## 4 Summary

☞The atmospheric profiles from COSMIC GNSS RO mission for extreme weather monitoring in China has been investigated. The results demonstrate the great potential of GNSS RO technique to extreme weather events monitoring.
☞The GNSS RO products should be assimilated into Numerical Weather Prediction Models and General Circulation Model for extreme weather monitoring.

## Acknowledgments

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