Estimates of Rainfall Intensity using Ground-Based Dual-Frequency Passive Microwave Radiometer Measurements

Speaker：Nan-Ching Yeh, CCIT, NDU
Coauthors：Wann-Jin Chen, Jian-Liang Wang,
Jen-Chi Hu, Gin-Rong Liu

Outline

- Introduction
- Data collection and processing
- Theory and research methods
- Results and discussion
- Conclusion and future work

Introduction

- The time span, spacial distribution, and the amount of precipitation have always been deeply concerned with human life. It is also closely related to global energy transportation, atmospheric circulation, and climate change.
- The rainfall data provided by the traditional weather observation station cannot satisfy the need of weather operation units and people's livelihood in aspects of both time and space.
- The precipitation estimation from satellite remote observation recovers the shortage in space.

- In the early time, satellite IR and VIS channels were used to estimate precipitation.
  - The major error source of the IR channel is that it cannot get any information under the top of clouds
  - The limitation of the VIS channel is that it is not suitable for use at night.

- The microwave channel is more suitable for estimating the intensity of precipitation because it is not affected by clouds obviously and it can get the information under the top of clouds.

- In the past, the precipitation estimated is often compared with the actually observed values to evaluate the accuracy of these algorithm methods.

- Liu et al. (2001) indicated the downward radiation intensity obtained by the ground-based radiometer has only little inhomogeneity.
  - Most radiation signals are provided by liquid particles in the atmosphere

- The ground-based radiometer is more suitable than satellite microwave data to investigate the relationship between brightness temperature (Tb) and precipitation.

- The purpose of this research is to discuss the relationship between Tb obtained from the ground-based radiometer and the precipitation observed by the traditional tipping bucket rain gauge to derive formulas of Tb and precipitation of channels 18.7-GHz and 36.5-GHz.

Data collection and processing

- Tb and rainfall rate (RR) data used in this study were observed from the ground based dual polarization radiometer and tipping bucket rain gauge, respectively. The direction and speed of wind were observed from AWOS.
  - Ground-based Dual Polarization Radiometer Observation Data
  - Rainfall Data
  - Data of Wind Direction and Speed

Ground-based Dual Polarization Radiometer

Frequencies of two channels are 18.7 GHz and 36.5 GHz, both including vertical and horizontal linear polarized channels, and the time resolution is 1 second.

Data used in this study is from March to May 2009.

The regression was established using 2 month data (3 & 5), and verified using 1 month data (4).

Data of rainfall and wind

- The rainfall data used in this article is acquired from the rain gauge on the housetop of NDU's Science Building. It has time resolution of 1 record per minute, and its minimum unit of measurement is 0.5 mm.

- The data of wind direction and speed are acquired from the AWOS on the housetop of NDU's Science Building, and it has time resolution of 1 record per minute.

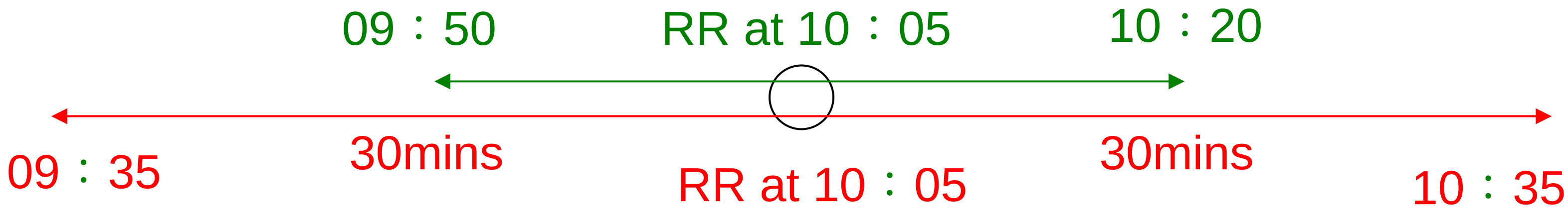
THEORY AND RESEARCH METHODS

- The emission of rain drops (~0.9) is much higher than that of a clear sky.
- When it rains, Tb increases with RR and they seems to have linear relationship with each other.
- Kutuza et al. (1998) indicated when there were rain drops in the observation space, the difference of vertical and horizontal polarizations ($PD \equiv TB_V - TB_H$) would be negative.

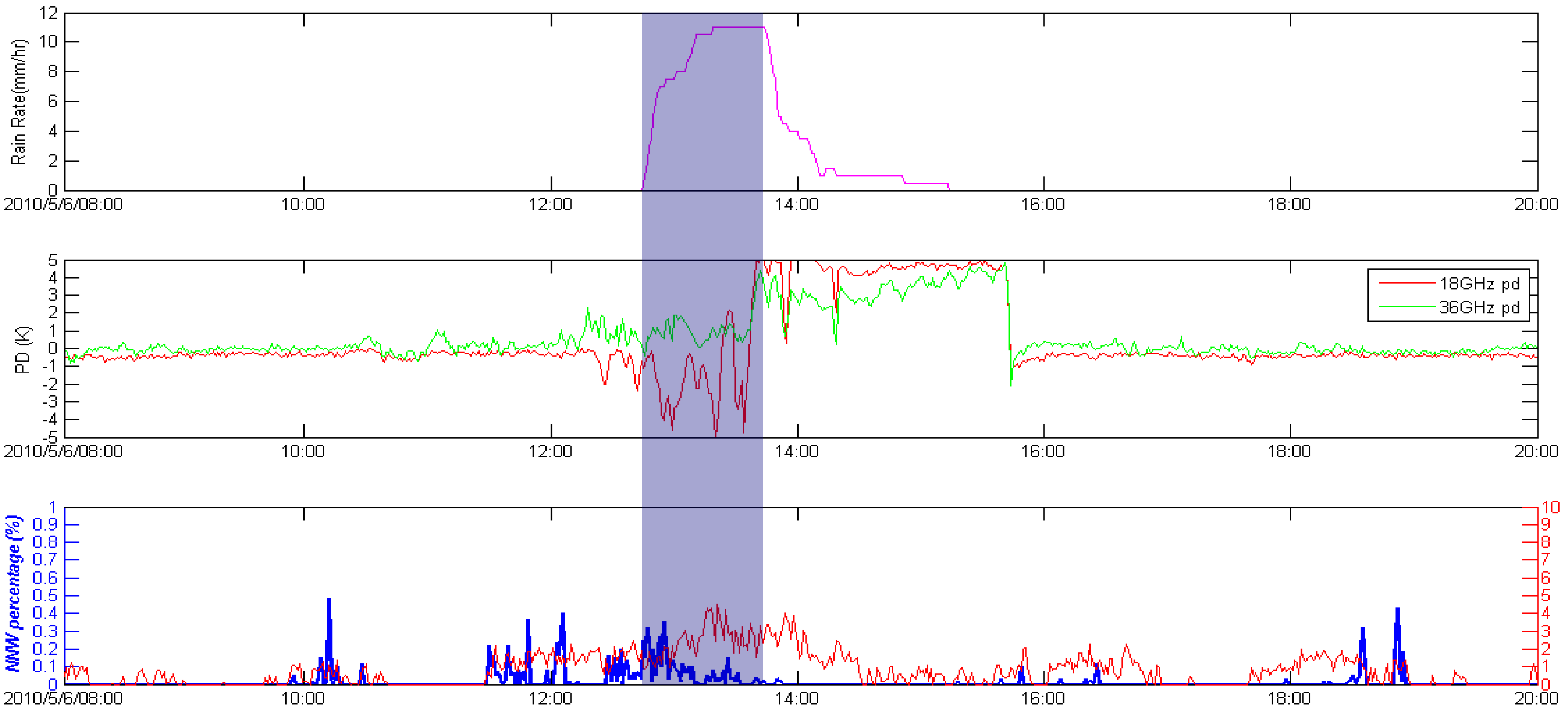
- We can clearly identify the existence of liquid water by using the fact that rain drop makes Tb increase and causes the variation of PD.
- The elevation angle of observation is set as 30° and the azimuth angle is 341.5° in this study.

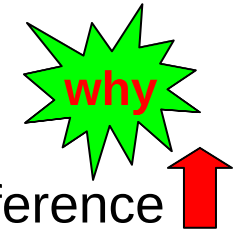
- The RR at each minute has to be defined so that it can be used to analyze its correlation with the Tb at that minute.

- The definition of the RR at each minute is that the value of precipitation within the same forward and backward time interval at that minute.



Quality Control (1)Bad data were filtered out





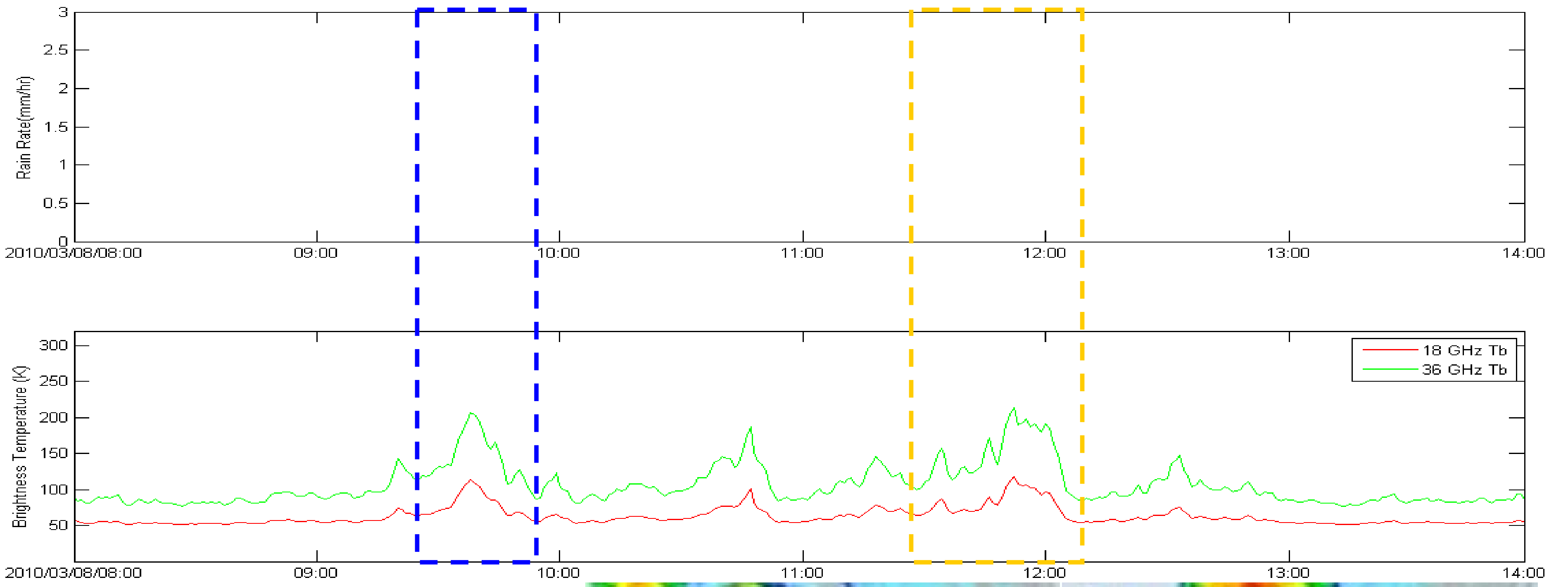
polarization difference

The wind directions were north north-west.

The wind speed was changed to 2-4 m/s.

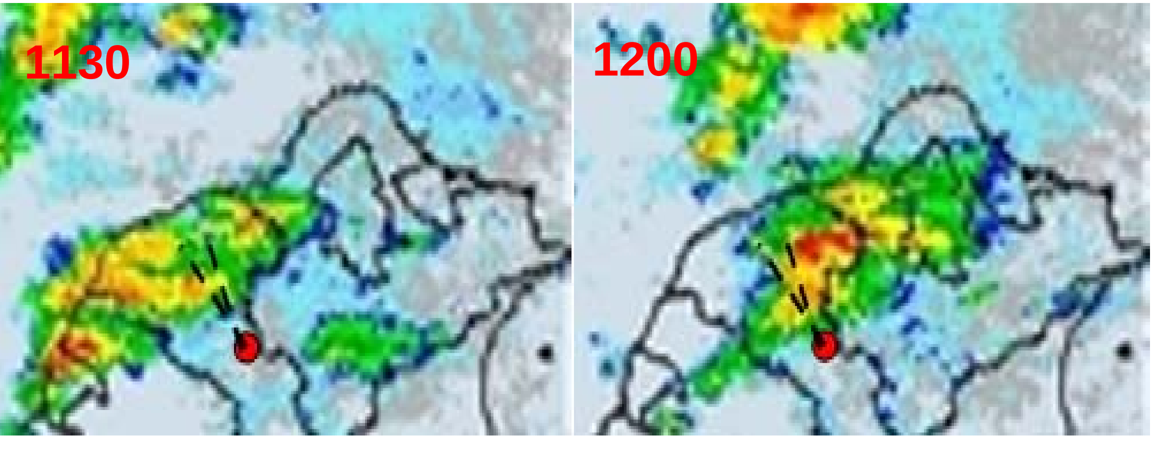
It is apt to make the sensor wet by droplets.

Quality Control (2) source of bad signals (filtered out).



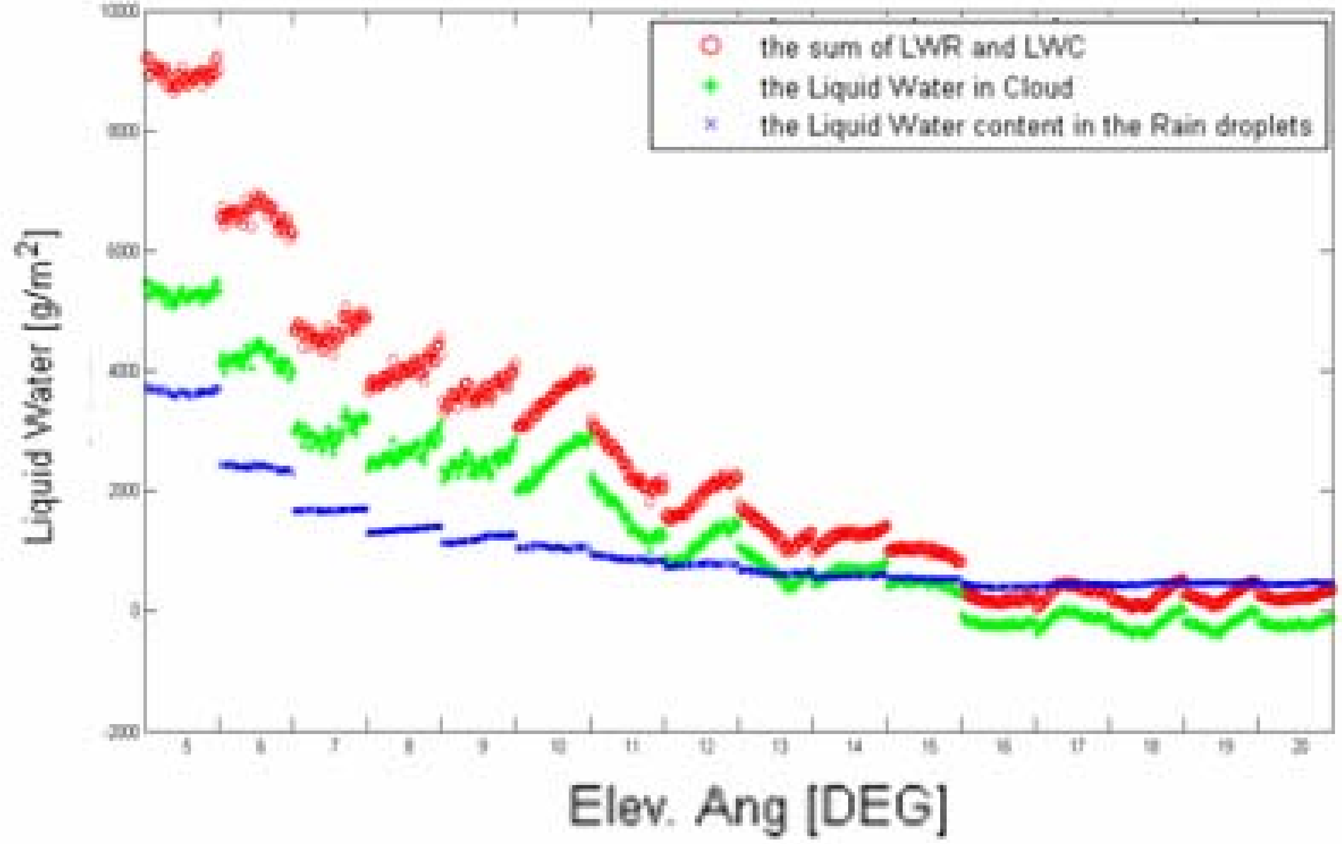
brightness temperatures

why



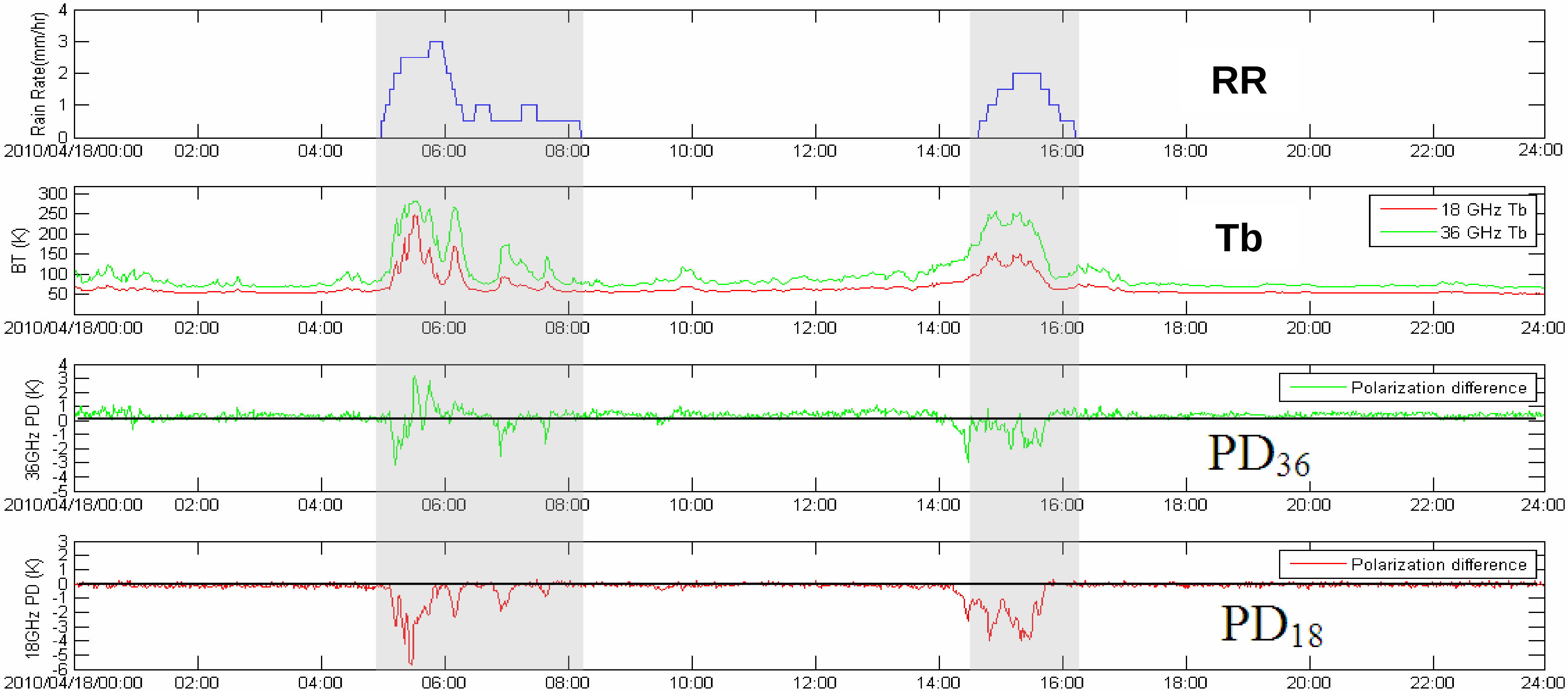
radar reflectivity image

RESULTS AND DISCUSSION



The variation of liquid water content in the atmosphere.

This picture shows that the liquid water content exponentially decays with height.

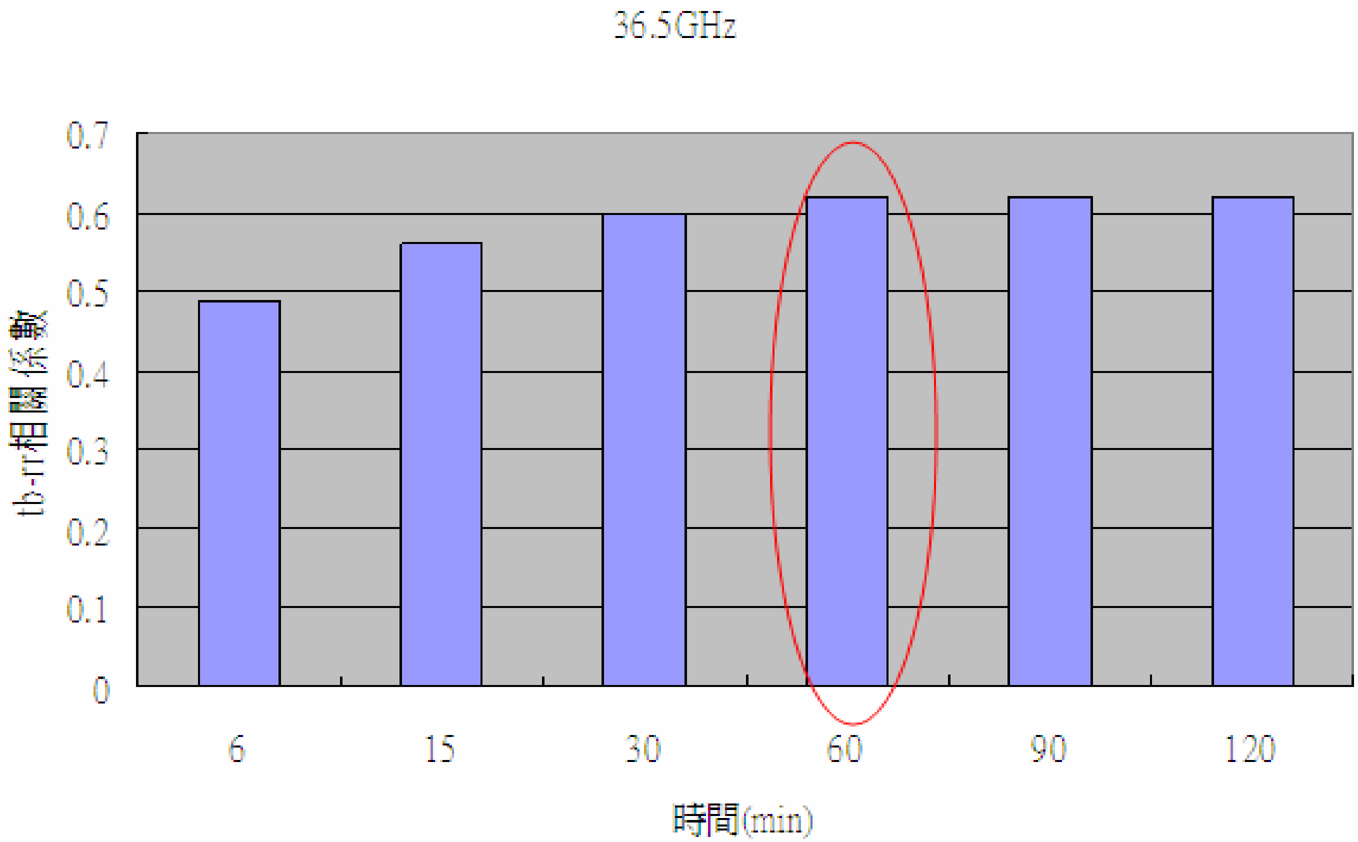


rainfall → Tb of two channels increased

rainfall → PD of two channels were negative

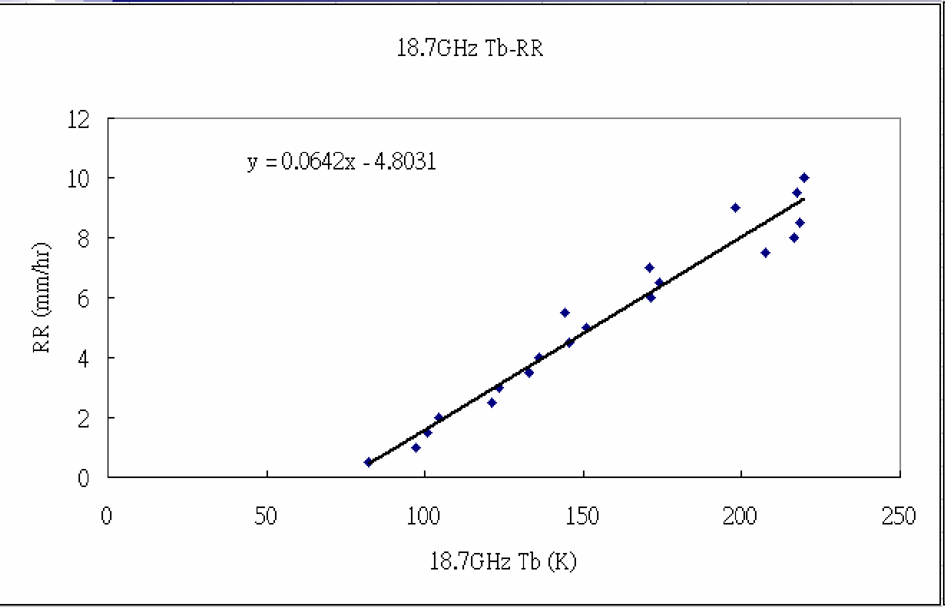
without rainfall → Tb 55K±3K, 70K±3K

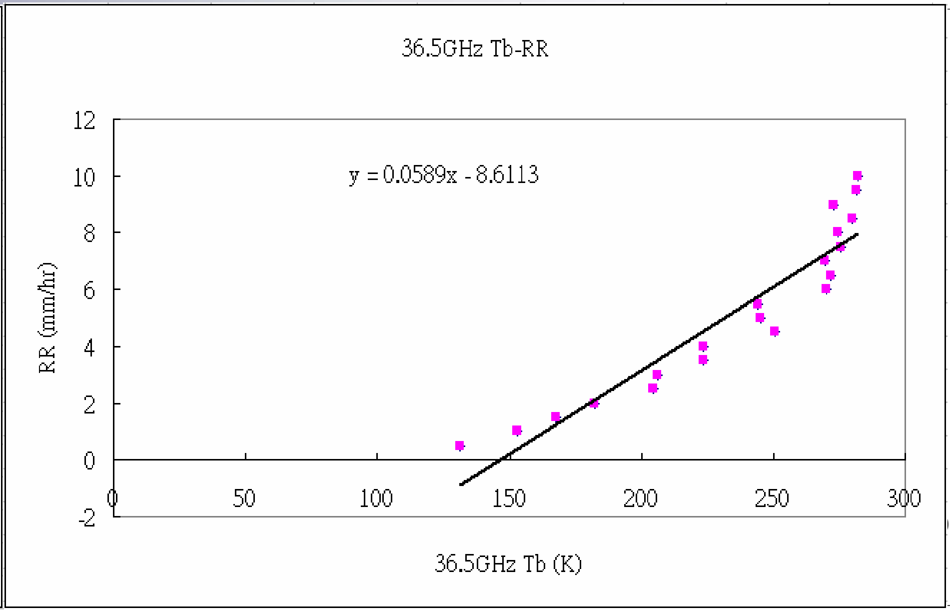
without rainfall → PD ≈ 0



The correlation coefficients between Tb and RR of different duration (from 6 minutes to 2 hours).

From these analyses, the 60 minute accumulative rainfall will be used to calculate the rainfall intensity for deriving the relationship between RR and Tb.



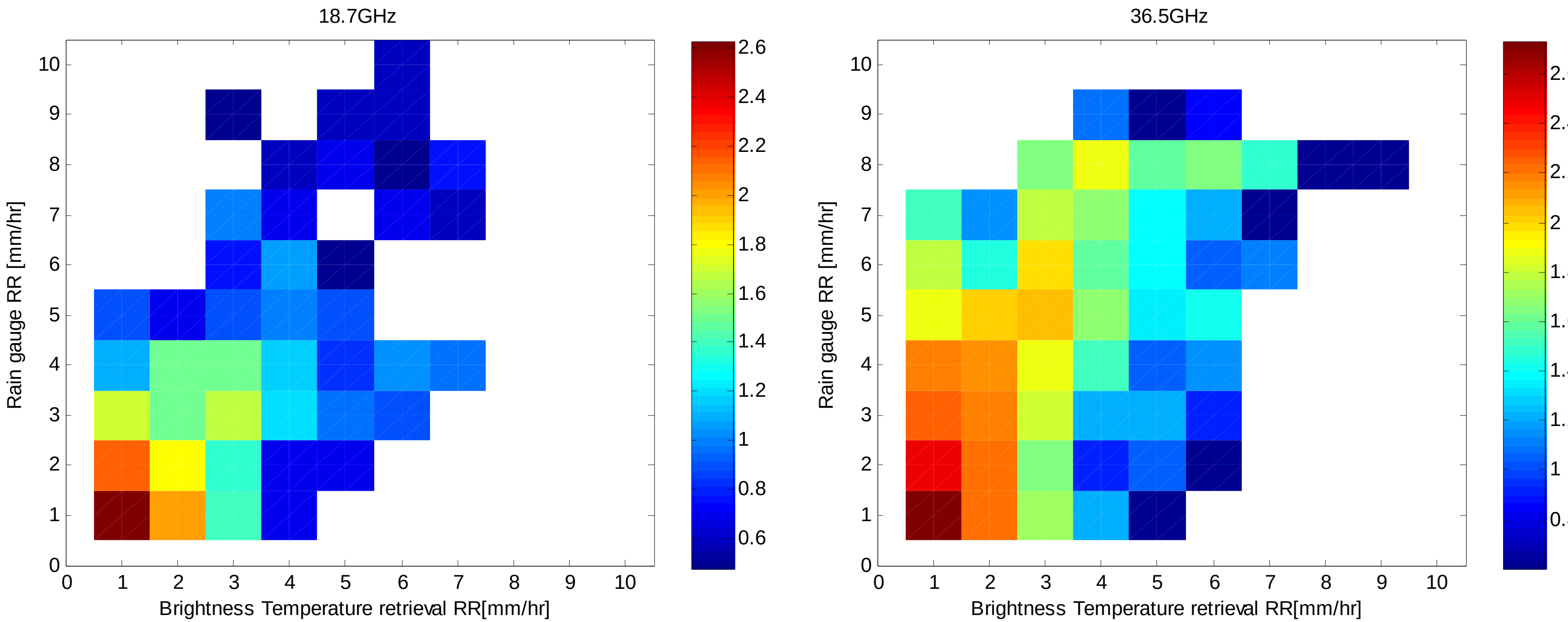


The relation of the RR and Tb.

Tb does not increase much with RR when it is greater than 10 mm/hr but even decreases with RR.

RR can only be estimated with passive microwave remote sensing technology before the saturation of all channels.

The independent data (April) were utilized to verify RR retrievals from Tb with rainfall observed by rain gauge.



The RMSEs of 18.7 GHz and 36.5 GHz are 1.52 and 2.1 respectively.

Conclusion and future work

- There are two reasons for bad signals to happen.
  - When the wind direction is north north- west (toward the sensor) and the wind speed reaches 2 4 m/s, it is apt to make the sensor wet by droplet.
  - When there are rain drops in the observing range of radiometer, but the rainfall area is not above the radiometer (rain gauge).

- The rainfall represented by accumulating 1 hour has the highest correlation with Tb of ground-based radiometer.

- Correlation coefficients between Tb and RR are 0.69 and 0.62 for 18.7-GHz and 36.5-GHz, respectively.
- RMSEs of 18.7-GHz and 36.5-GHz of the verified results are 1.52 and 2.1 respectively.
- Tb and PD will be used to establish their regression with RR in the future.

Thank you for your attention