Atmospheric Water

Winter Semester 2022

Understand the types of clouds and precipitation at the location Huaraz in South America were based on drop size distribution, liquid water content, rain rate and terminal fall velocity.

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1. Introduction

Nowadays clouds play a dominated role in the climate discussion. Clouds are made up of thousands of small water and ice droplets.[1] When air temperature rises, water condenses from microscopic droplets, forming ice particles, and this individual development process is known as cloud microphysics.[2] Clouds are divided into three categories. Low cloud which polar regions is below 2 km and temperate region is below 2 km, tropical regions is below 2 km. Middle cloud polar regions is 2-4 km, temperate regions is 2-7 km, tropical regions is 2-8 km. High cloud polar region is 3-8 km, temperate regions is 5-13 km, tropical regions is 6-18 km.[1-4]Brightness temperature rises in a monotonous manner and is connected to precipitation rate; as brightness temperature rises and rain rate reaches its maximum, it begins to decline.[4]

2. Aim

This research examines two years' worth of data to determine cloud types and precipitation. Between these two years, we used reflectance, liquid water content, rain rate, and terminal fall velocity to better understand the climate in that location. Remote sensing is used to examine cloud development. Data on rainfall rates aids our understanding of the many forms of precipitation.

3. Study Area

Study area location is Huaraz which is situated in the South America. In this area high speed of moist wind is found. This area is a tropical rain forest area and most of the rain events occurred in this study area due to the Amazon.

4. Materials and Methods

In this study we used micro- rain radar to detect clouds and analyse the precipitation. The radar is installed in the highest level of Andean chain. We collected the two years of data 2017 and 2018. For the analysis purpose Spyder (anaconda 3) is used. Methods is compared the rain rate between these two years and identified the reflectivity, liquid water content in the cloud.

5. Result and Analysis

5.1 Stratiform vs Convective

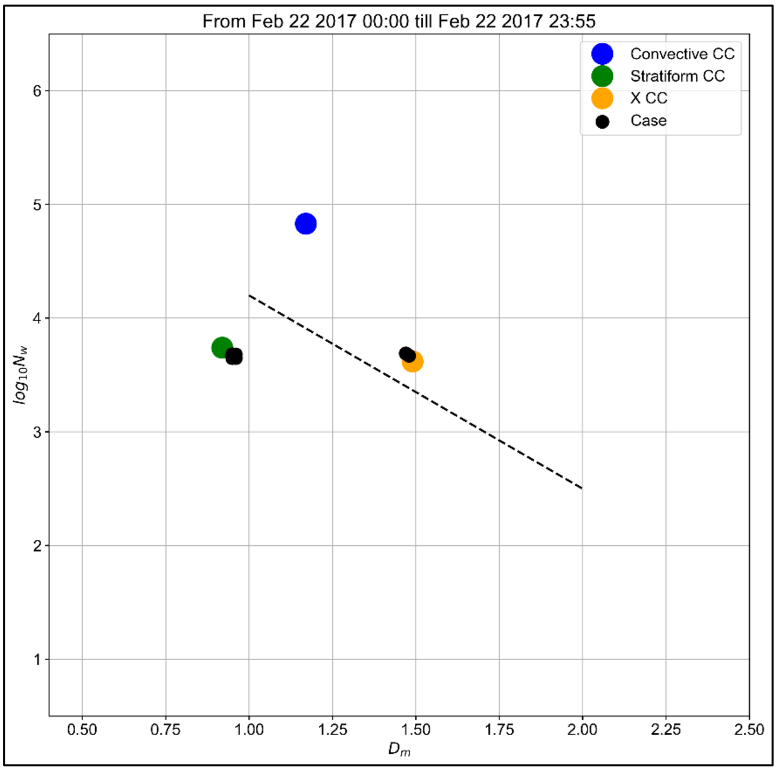

Figure 1: Cloud show in February 22, 2017

Latent heat was released into the atmosphere by convective clouds. Convective clouds can reach the highest section of the atmosphere thanks to solar heating and warm waters.[1] The energy created when the positive charge flows from the lowest level to the troposphere and out of the cloud powers the convective cloud. At the top of the cloud base, a negative charge layer forms quickly.[2]

Stratiform clouds are sheets of clouds that have little or no vertical movement of air.[4] The lifespan of stratiform clouds is longer, but the updrafts are weaker.Figure 1 shows the three types of clouds.

The image depicts three different types of clouds. On February 22, 2017, no convective clouds were observed, as shown in Figure 1. However, stratiform and X clouds could be seen in the sky.

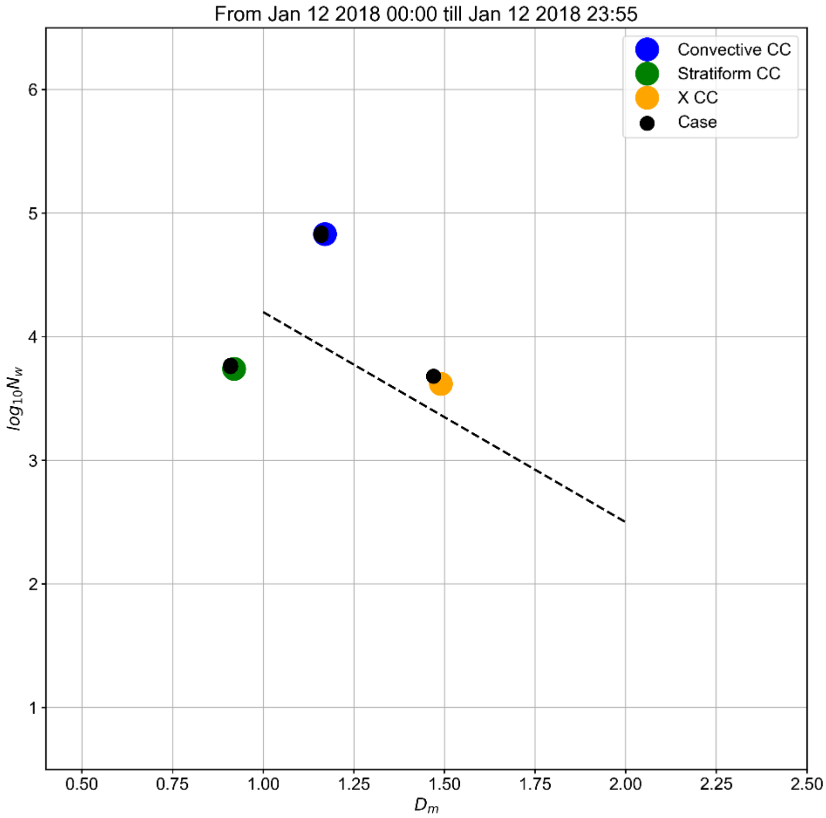

Figure 2: Cloud shows in January 12, 2018

Convective clouds were seen on January 12, 2018, as illustrated in Figure 2. Stratiform clouds are seen in the sky, although there are few X CC clouds visible on that day.

5.2 Micro Rain Radar Data(MRR)

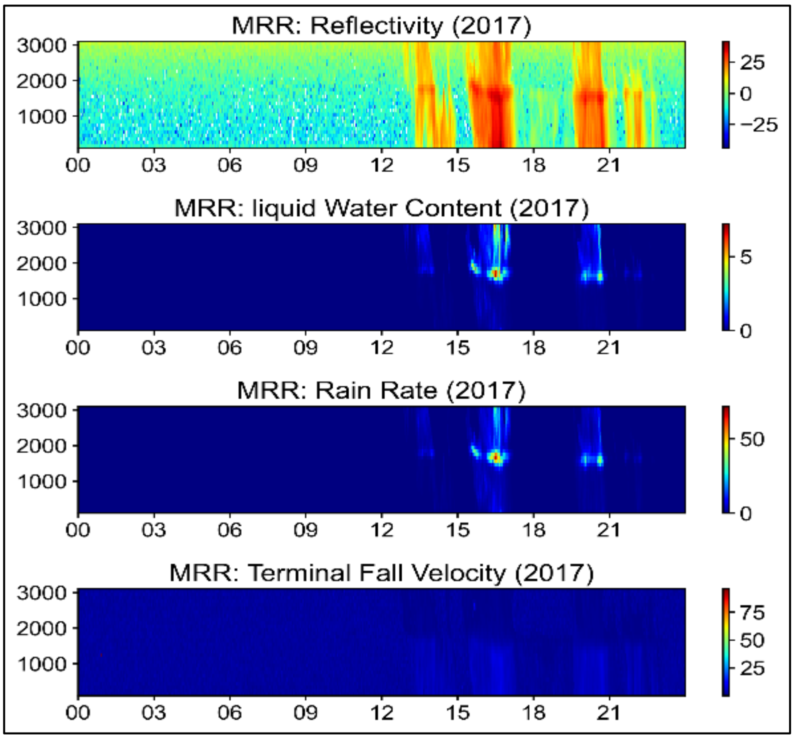

Figure 3: MRR readings are shown in a panel (2017)

Liquid water content estimates the mass liquid amount in the clouds.[1] Reflectivity and velocity observed the precipitation in different locations and times.[1] The mass liquid quantity in the clouds is estimated using liquid water content.[5] The precipitation was detected using reflectivity and velocity at various places and times.

Figure 3 demonstrates that there was much greater precipitation in 2017 between the 13 and 24. The unit is measured as decible (dBZ). From 13 to 24 there are several times the reflectivity fluctuated between 30 dBZ. That indicates there are more particles in the cloud at that moment, and there is a lot more reflection. Because of the high rain rate, this statistic also shows that there is a lot more water. As the amount of liquid water in the atmosphere increases, precipitation and speed increases.

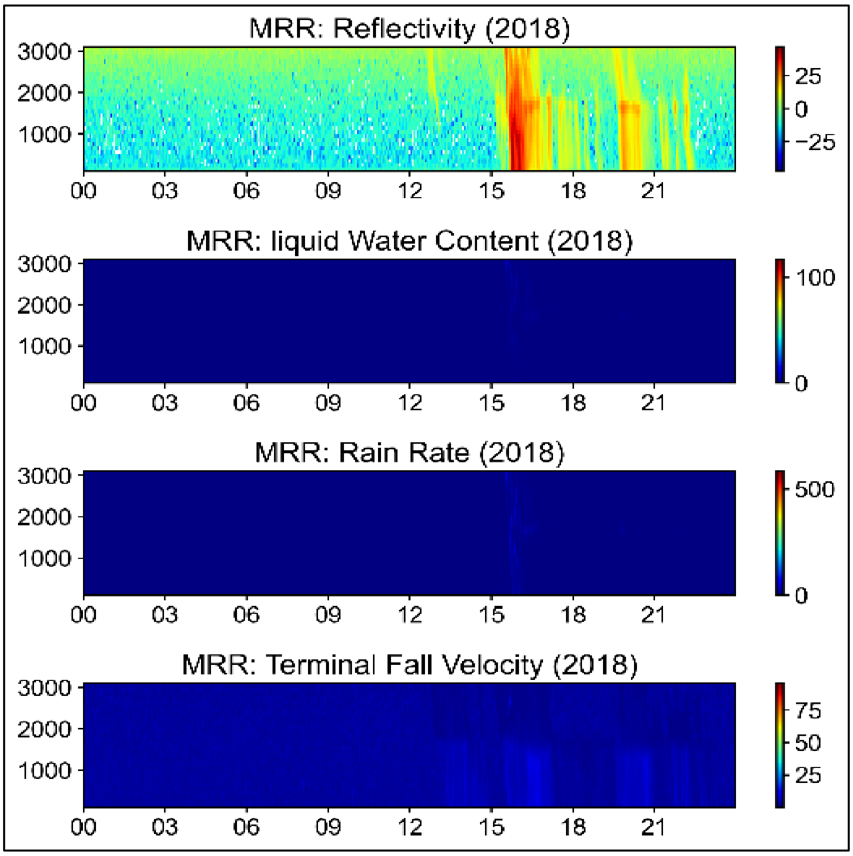

Figure 4: MRR readings are shown in a panel (2018)

Depending on the sixth power particle and its formation strongly increase the radar reflectivity.[1] The higher reflectivity value means the case for large snow and large raindrops.[1] The changes in the rader reflectivity between levels are associated with melting, height, and raindrops falling. Figure 4 shows that there was less precipitation in the range of 0 to 14 in 2018. Between 15 and 21, the reflectance climbed many times between 20 dBZ. But from the liquid water and terminal fall velocity indicates there are fewer particles and less liquid water in the atmosphere, and the rain rate isn't significantly higher.

5.3 Rain Rate and Brightness Temperature

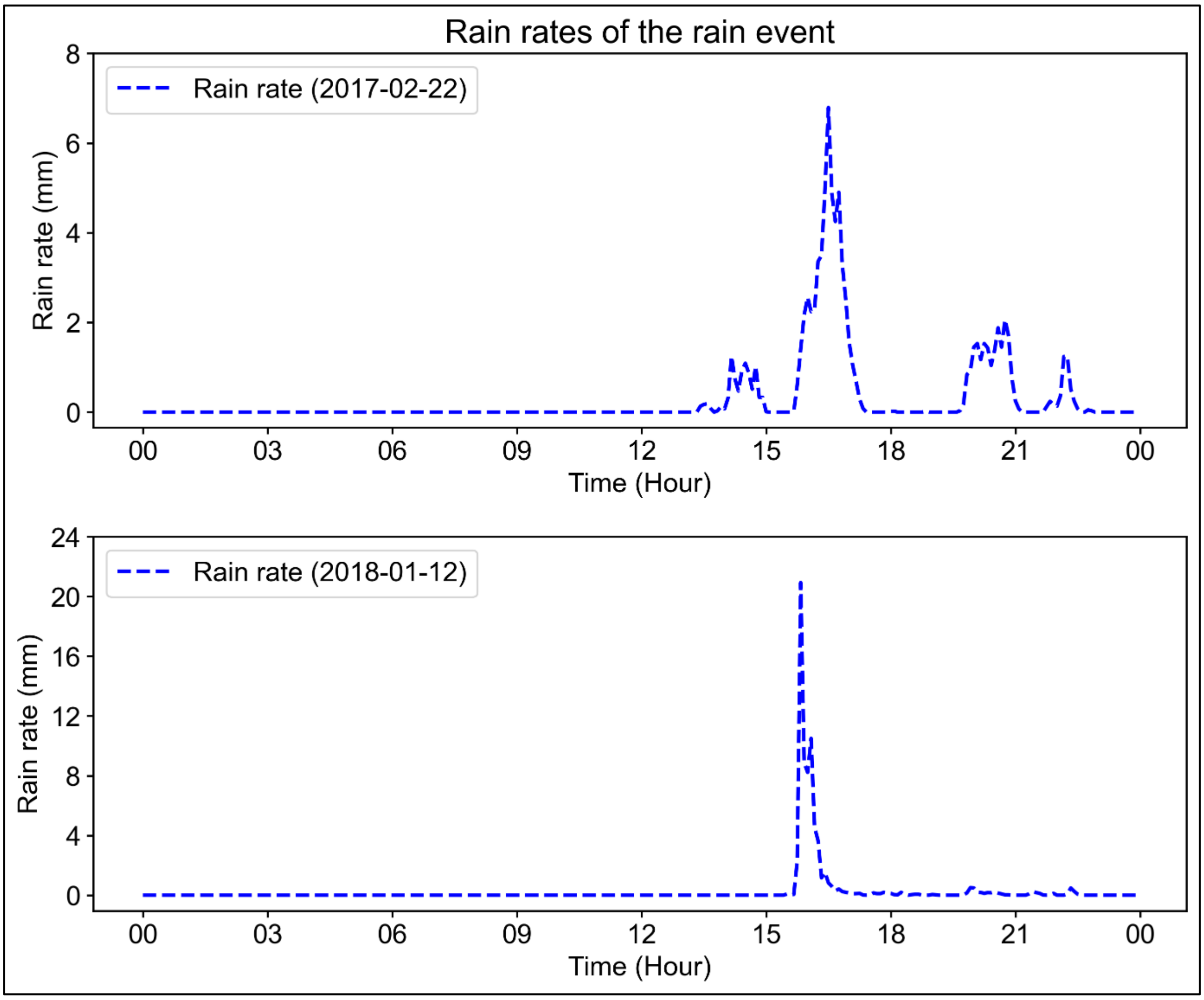

Figure 5: 2017 and 2018 rain rate comparison

The two dates of the rain rate event are compared in Figure 5. The higher precipitation occurred on February 22, 2017, during a time between 15 and 18 a.m., as seen in the image. Rainfall rates of more than 6 millimetres per hour were recorded. After then, it appears that little additional precipitation occurred between 20 and 24 hours, at a rate of less than 2mm/hour. On the other hand, greater rainfall occurred on January 12, 2018, between 15 and 19, with a precipitation rate of more than 20mm/hour. There was no precipitation for the majority of the day. As a result, the lowest rain rate recorded was 0 millimetres per hour.

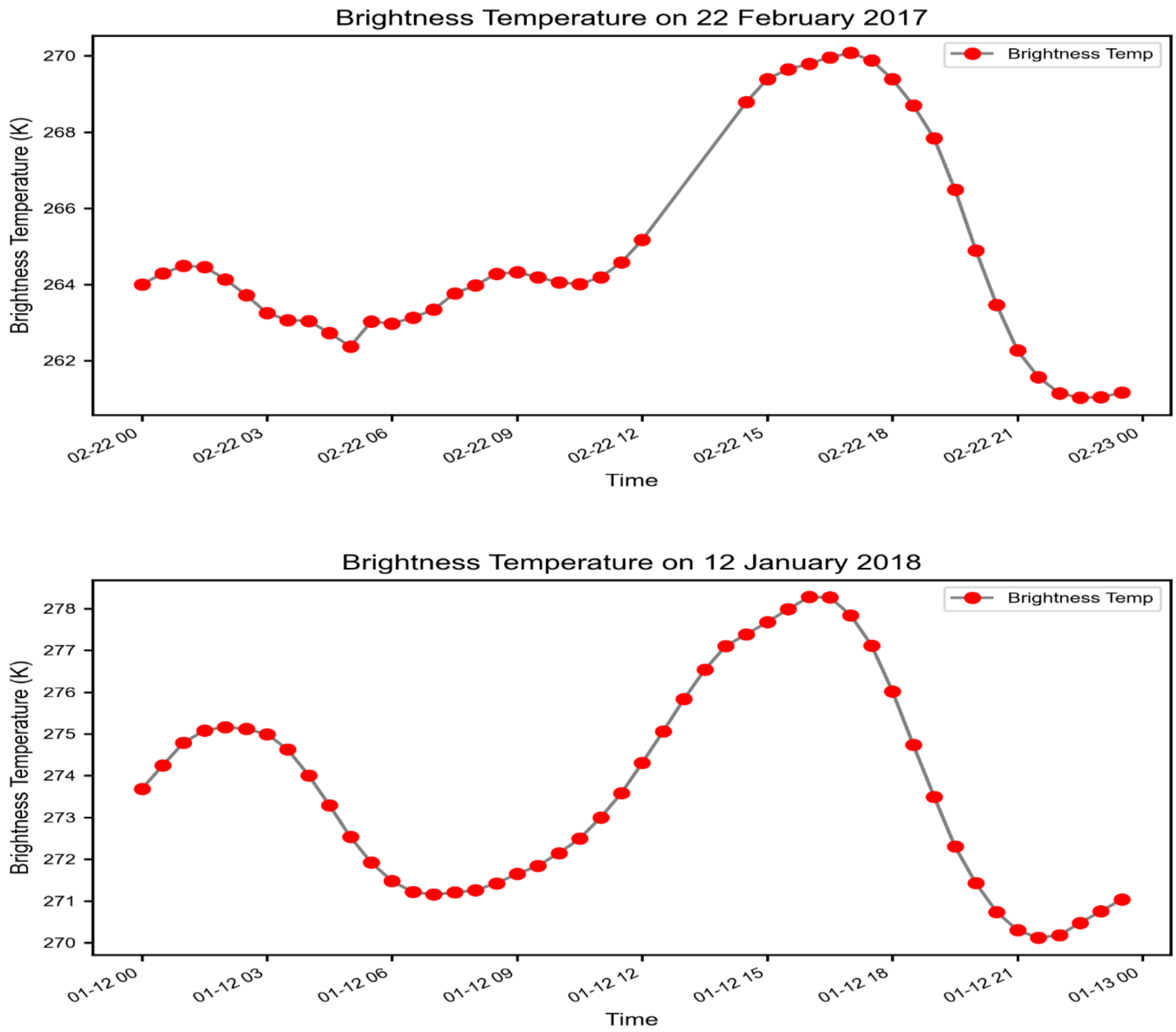

Figure 6: 2017 and 2018 brightness temperature comparison

Nowadays, brightness temperature is beneficial for the analysis of rainfall. We use a remote sensing radiometer to capture the radiation of the earth's surface, and this radiation moves upward to the atmosphere captured by the satellite. The brightness temperature at the top of the rain layer is related to the rain rate. Downwelling and upwelling are two ways to communicate brightness temperature.[3] Figure 6 illustrates that brightness temperature rises in lockstep with rain rate until it reaches a maximum, after which it begins to fall. The lowest brightness temperature was below 262k from 21.00 to 23.00 hours on February 22, 2017, while the maximum temperature was greater than 270k from 15.00 to 18.00 hours. However, as seen in the image below, from 06.00 hours to 18.00 hours on January 12, 2018, the brightness temperature was substantially higher, reaching 270k to over 278k. Then it dropped precipitously. It dropped below 270k around 21:00 a.m. Figures 5 and 6 show that as the rain rate increases, so does the brightness temperature, and as the rain rate falls, so does the brightness temperature.

5.4 Trajectory Analysis

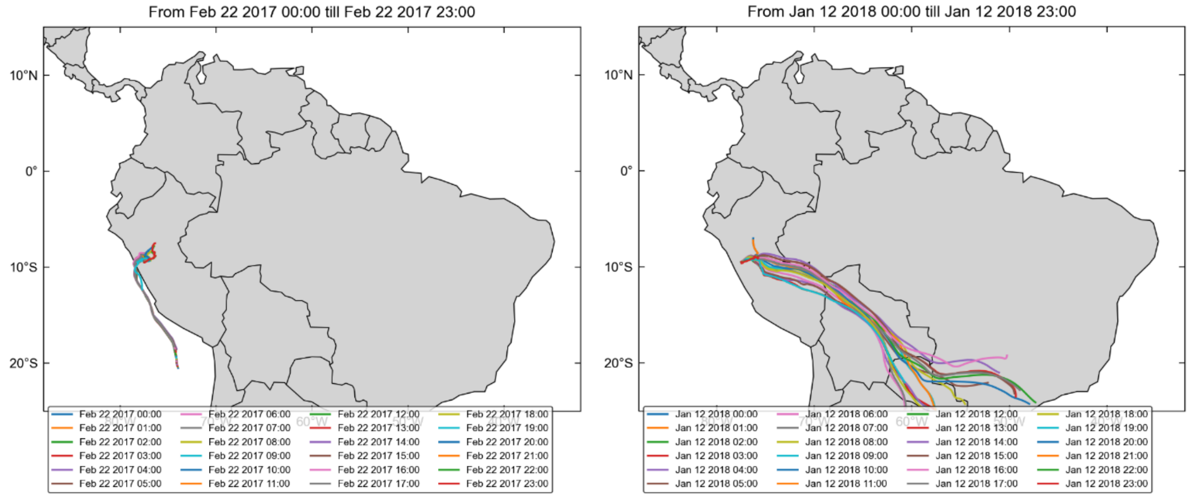

Figure 7: Comparison two rain events trajectories

There are several approaches for analysing fluid parcels and how they flow. It evaluates itself in terms of time and space.[2] Trajectories are the paths along which fluid parcels travel. Figure 7 illustrates a comparison of the two rain event trajectories, with the trajectory moving ahead to the Southern Pacific area on February 22, 2017. It might be claimed that the wind was blowing forward at the moment, and clouds were moving in the direction of the wind. On the other hand, the precipitation on 12 January 2018 was on a downward trend, as shown on the right side of Figure 7. The region's trajectory shifted to the Southern Atlantic. It might be claimed that the wind and clouds have a strong influence on the direction. As a result, a big travel trajectory could be seen on the right side of the image.

5.5 Qvapor vs Altitude

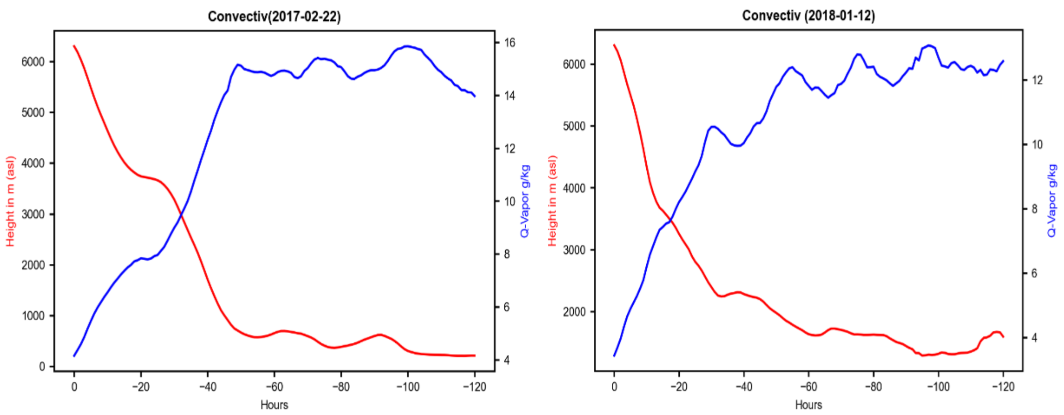

Figure 8: Qvapor vs altitude during two rain events

Qvapour is the quantity of water vapor that mixes a given amount of volume in the air mass, but it does not participate in the atmospheric process.[3] It aids in the movement of air parcels in the atmosphere, and so may be considered a trajectory. The link between sea level and Qvapor is seen in Figure 8. According to the graph, as the height grew, Qvapour fell dramatically. When a cold temperature turns more liquid water into the sea level, Qvapor is lowered because the amount of liquid water is reduced.

6. References

1. Karstens, U., et al. “Remote Sensing of Cloud Liquid Water.” *Meteorology and Atmospheric Physics*, no. 1–4, Springer Science and Business Media LLC, 1994.

2. Rollenbeck, Rütger, and Jörg Bendix. “Rainfall Distribution in the Andes of Southern Ecuador Derived from Blending Weather Radar Data and Meteorological Field Observations.” *Atmospheric Research*, no. 2, Elsevier BV, Feb. 2011.

3. Schneider, Christoph, et al. *Climate Impacts on Glaciers and Biosphere in Fuego-Patagonia*. Frontiers Media SA, 2020.

4. Espinoza, Jhan Carlo, et al. “Rainfall Hotspots over the Southern Tropical Andes: Spatial Distribution, Rainfall Intensity, and Relations with Large-Scale Atmospheric Circulation.” *Water Resources Research*, no. 5, American Geophysical Union (AGU), May 2015.

5. Seo, Bong-Chul, et al. “Utility of Vertically Integrated Liquid Water Content for Radar-Rainfall Estimation: Quality Control and Precipitation Type Classification.” *Atmospheric Research*, Elsevier BV, May 2020.