Influence of cloudiness on the incident shortwave radiation of Nevado Coropuna

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Proyecto CRYOPERU 144-2015

Motivation

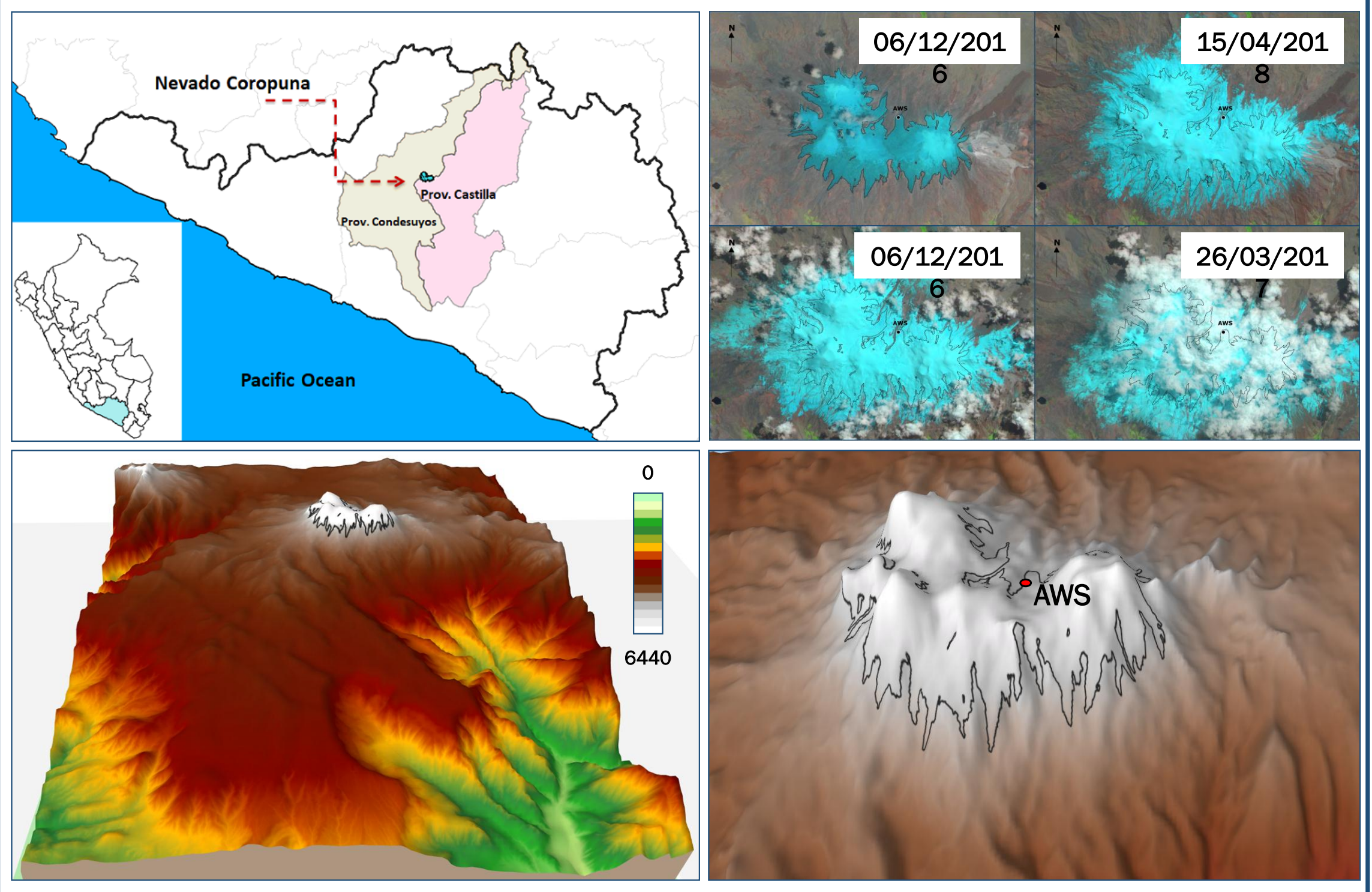

Figure 1: a) Localization of the Nevado Coropuna. b) Examples of the behavior of cloudiness. c) and d) Topography of the Nevado Coropuna.

- ➢ The study area is Nevado Coropuna, located in the volcanic Cordillera Ampato. The glaciers of these Nevado represent the most important freshwater for the Arequipa region, therefore the melting of these glaciers during the dry season is mainly important for farming activities and water supply to the cities. Nevertheless, the Nevado has decreased its area of 122.70 km2 (1955) to 49.02 km2 (2010) thus the total area lost is 63.68 km2.
- ➢ The presence of clouds has significant impacts in the budget energy, because the available energy depends from the balance radiation and this is influenced by the quantity of cloudiness.

Objective

The main objective of this work is to analyze the influence of cloud cover on shortwave radiation incident of the Nevado Coropuna during 2015-2016.

Data Source

For this study, it was used hourly radiation data from the Automatic Weather Station (AWS) installed in September of 2014 in the glacier Cavalca of the Nevado Coropuna, located in 15.53°S, 72.62°W and 5800 masl. Likewise, it was used cloudiness (octaves and cloud type) data from 14 conventional weather stations located around the study area at 00, 12 and 18 UTC.

Figure 2: AWS of the NC.

On the other hand, in order to estimate cloudiness, it was used meteorological satellite GOES-13 data which has a high temporal resolution (each 30 minutes and 4 km of spatial resolution). Besides, it takes data in two wavelengths: visible and infrared.

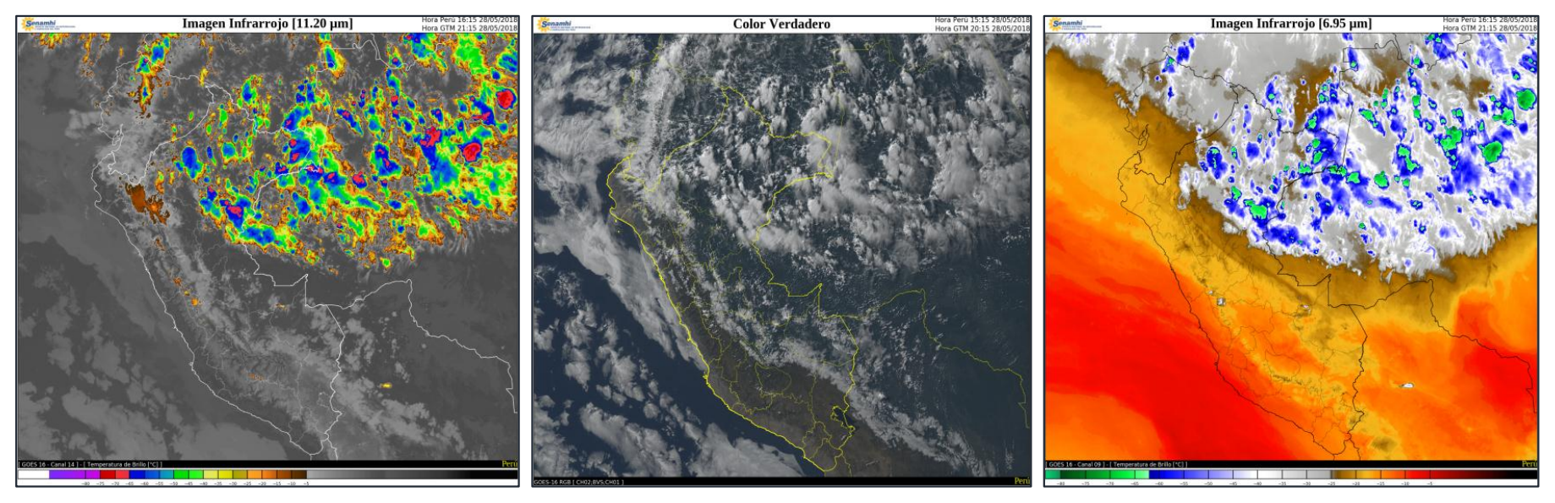

Figure 3: Channels of the GOES-13

Methodology

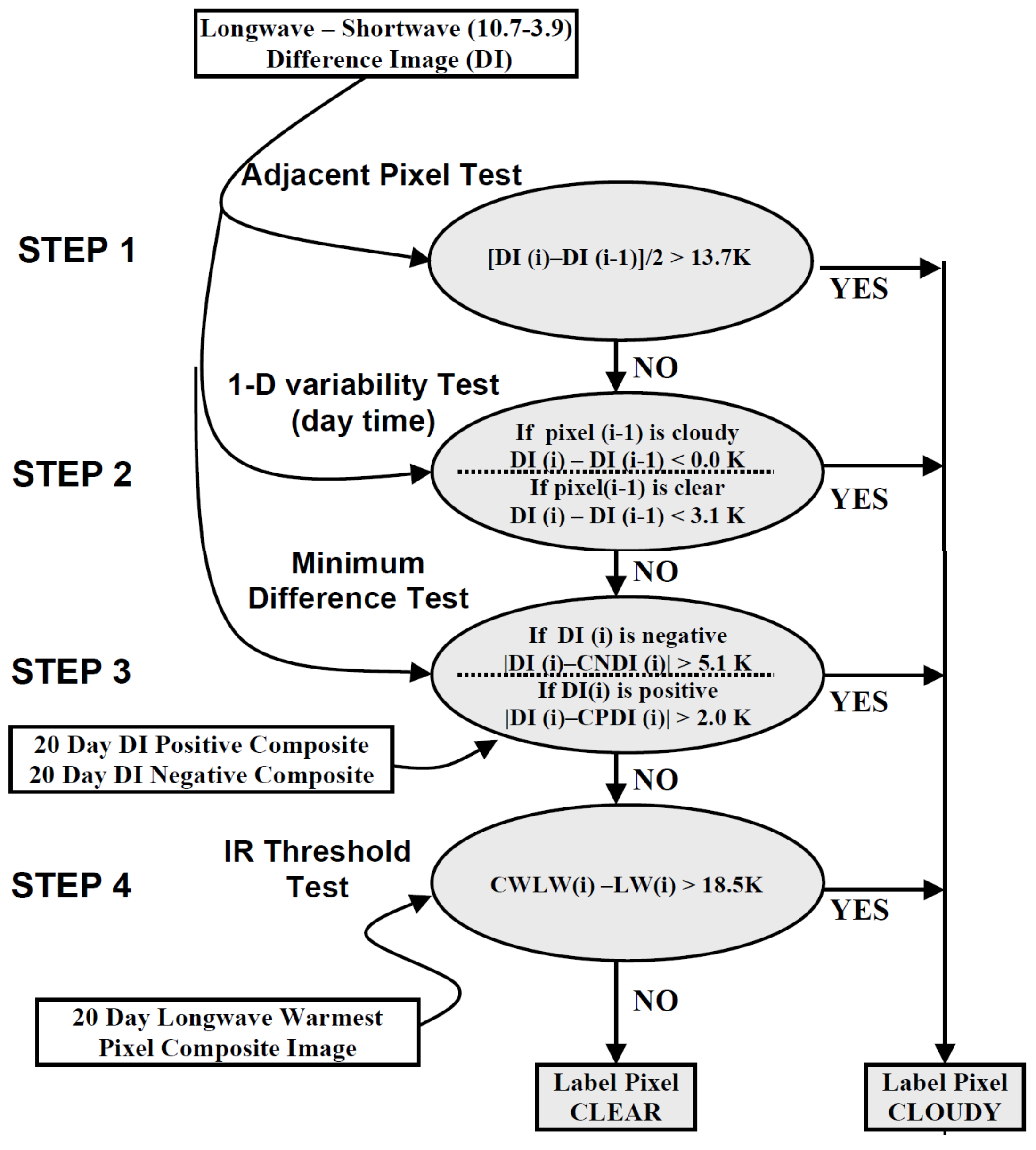

Figure 4: Cloud mask algorithm : The Bispectral Composite Threshold (BCT). Jedlovec, 2009.

To estimate the cloudiness, it was applied the Bispectral Composite Threshold – BCT (Jedlovec, 2009) to determine the cloud mask with the GOES 13 data since 2015 to 2017. This technique consists in 2 spatial and 2 spectral test and uses the 11 - 3.9 um difference imagery (DI). Likewise using 20-day composite of DI, with this step, spatially and temporarily varying thresholds are incorporated into de cloud detection process. Figure 4 describes all the steps and test.

Then, we obtain the cloud mask, and did hourly, daily, monthly, seasonal graphics to analyze the pattern of the cloudiness for the region Arequipa and the Nevado Coropuna. And reviewing the results of each test to check that accuracy with the observed data .

Finally, from the cloud mask we extract the data from one pixel near to the AWS and this was compared to radiation in clear and cloudy days. .

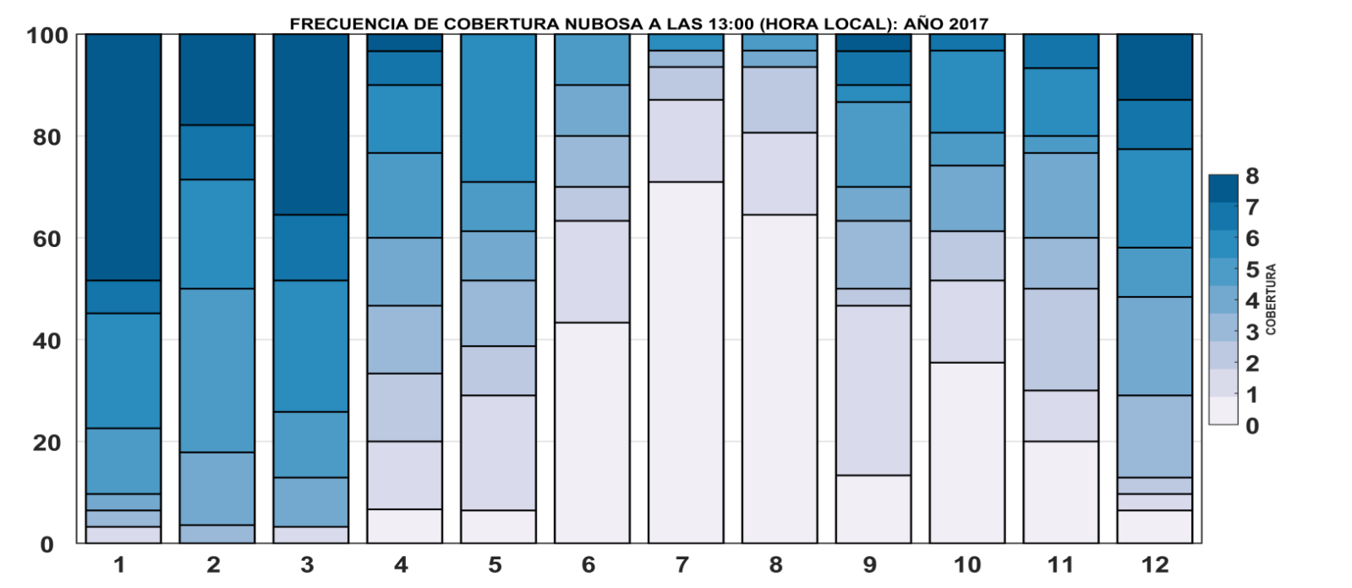

Figure 5: Frecuency of cloud in octaves of Machahuay Station for the 2017 at 18 UTC, located southwest of NC

Preliminary results

F R E Q U E N C Y C L O U D S

DAY

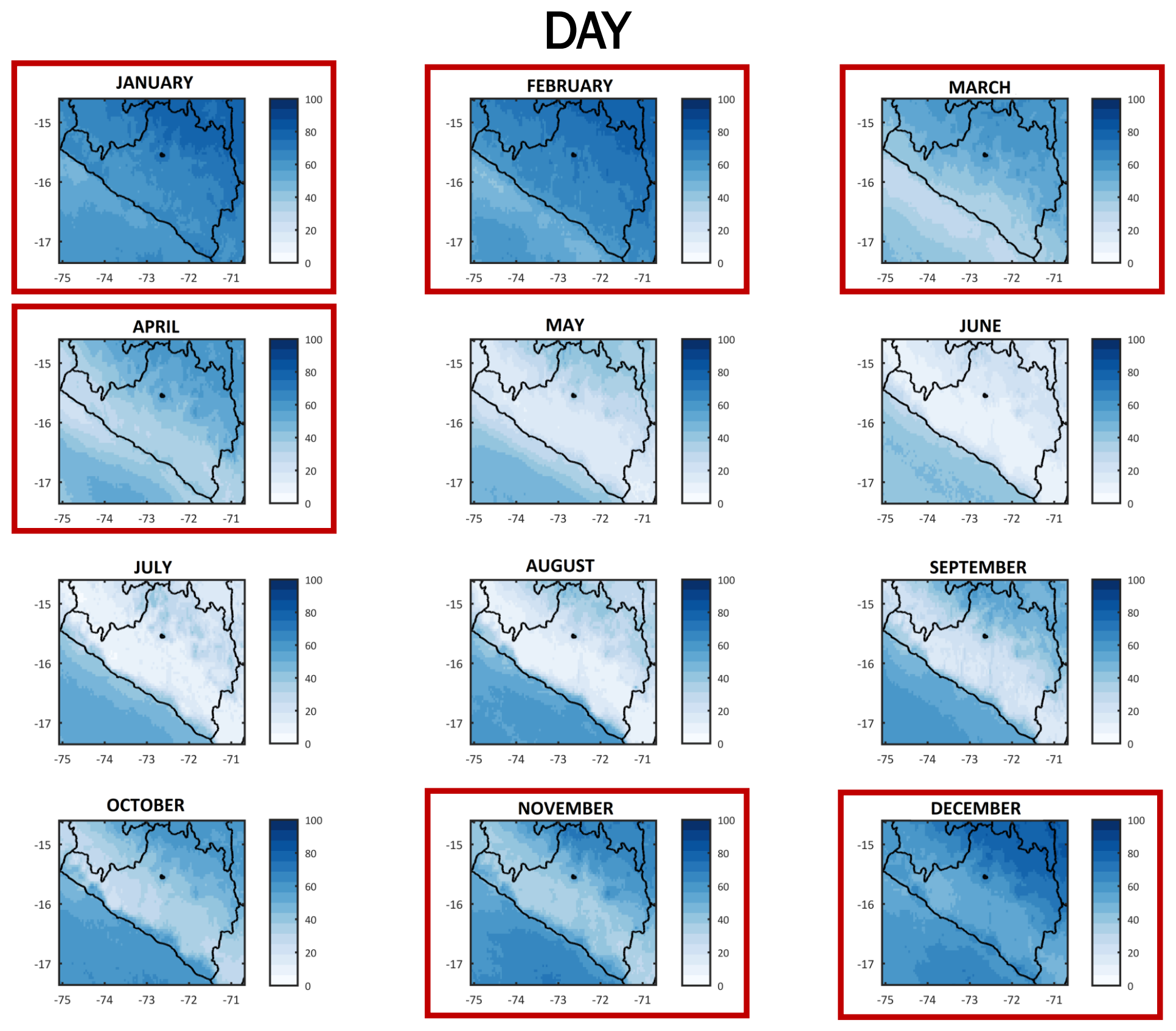

Figure 6: Cloud frequency during the day in Arequipa. Since November start formation cloud to April, the months with more hours with cloudy are January and February.

NIGHT

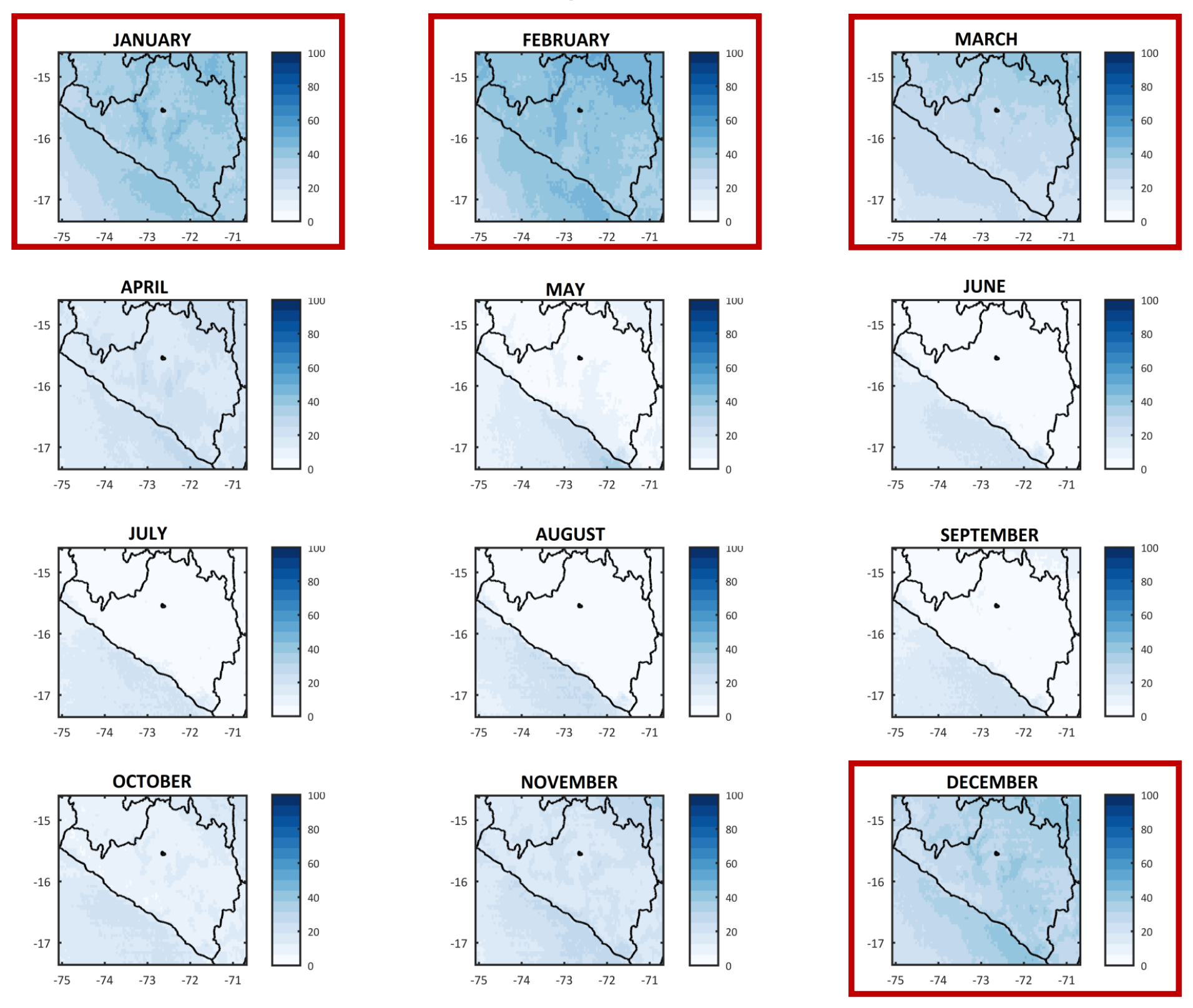

Figure 7: Cloud frequency during the night in Arequipa. In general, clouds are scarce at night, with the exception in the summer Austral months that there a more clouds .

DAY (NC)

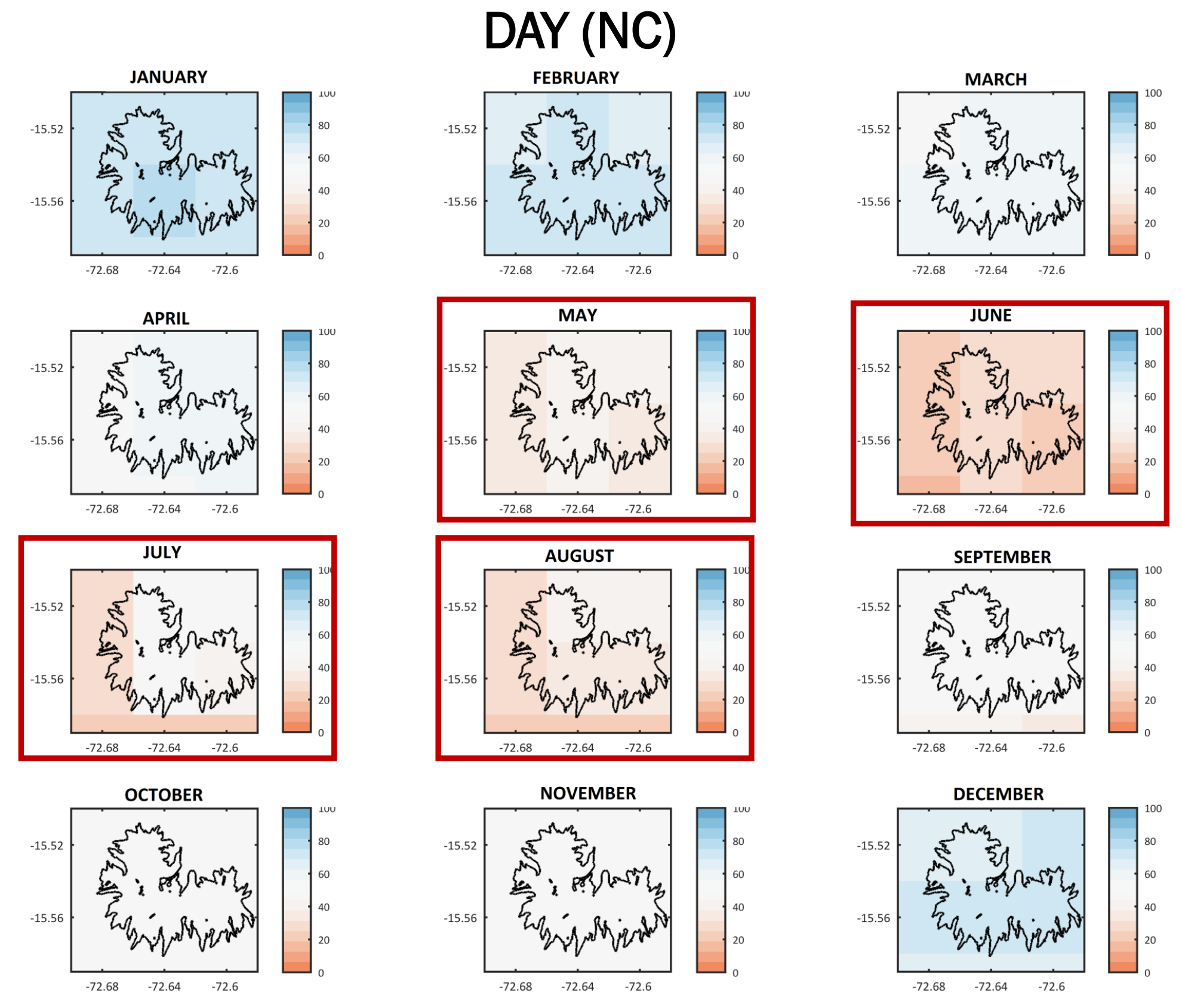

Figure 8: Cloud frequency during the day in Arequipa.NC is cover by 6 pixels of 4 km x 4 km, we can observed different frequency between the occidental and oriental side of the NC.

H O U R L Y C L O U D S

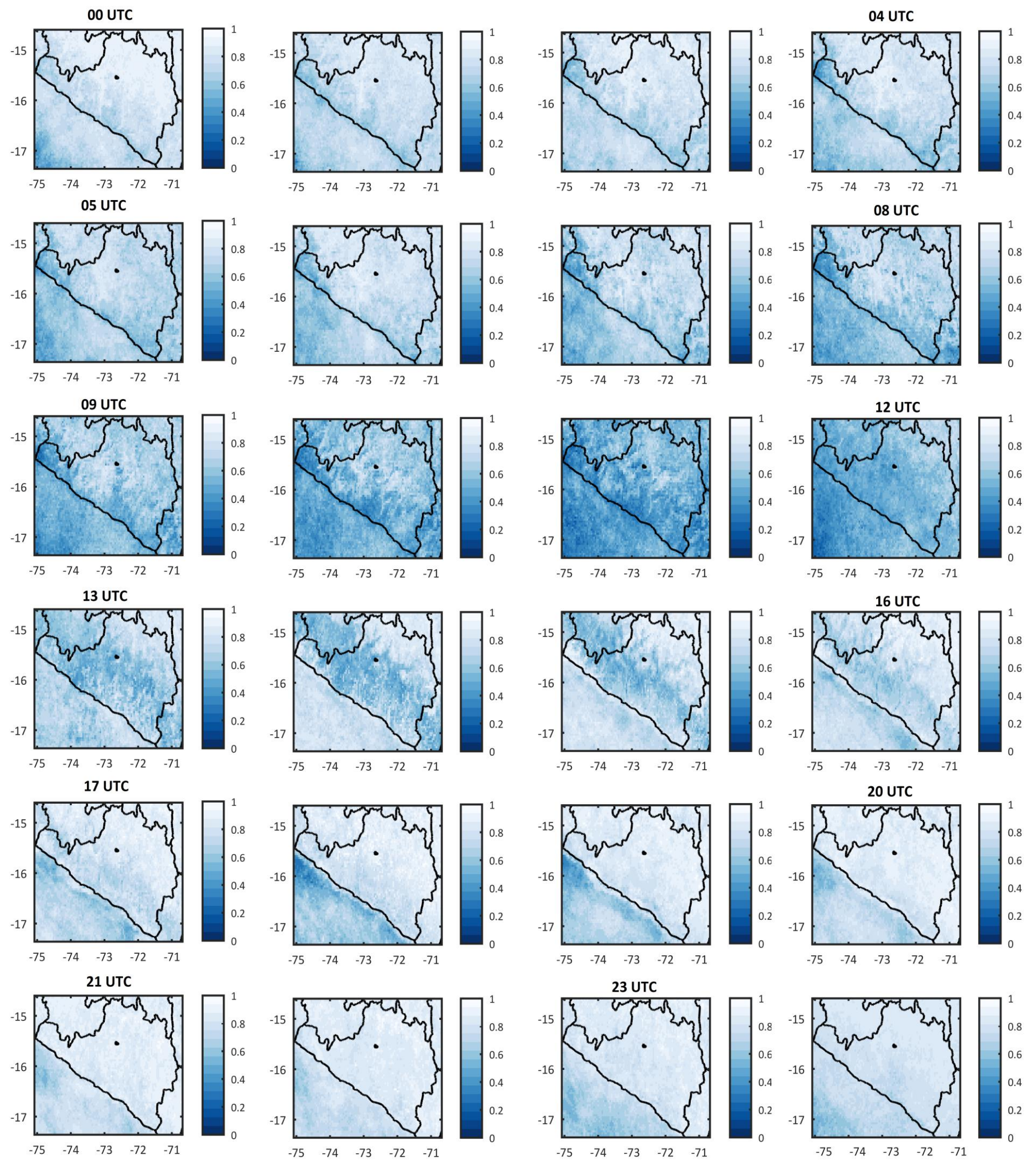

Figure 9: Diurnal and nocturnal variation of cloudiness in the summer of 2015, observe that in the early morning there no much cloud, but the afternoon and night is generally cloudy.

INCIDENT SHORTWAVE RADIATION AND CLOUDINESS

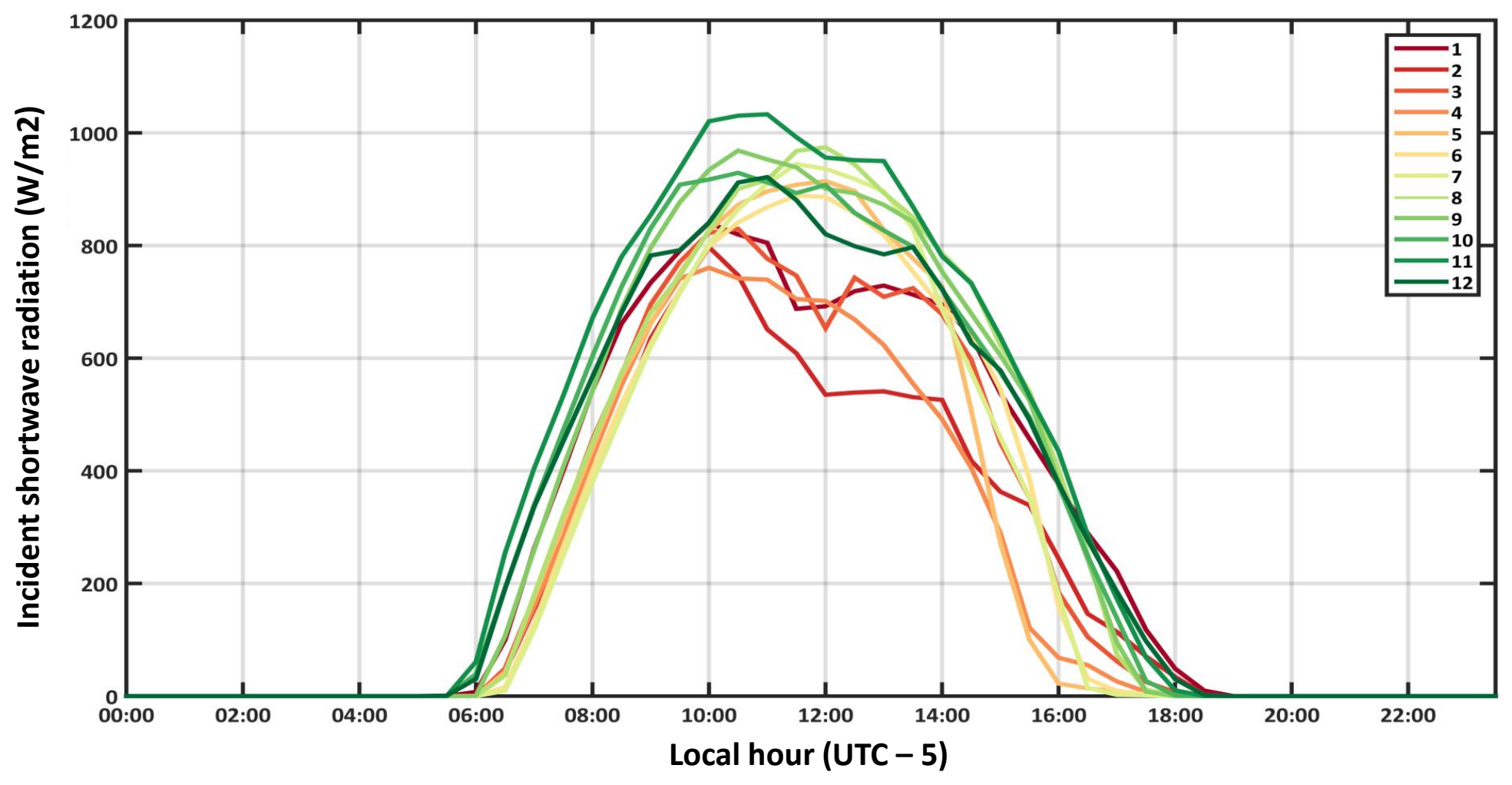

Figure 10: Diurnal variation of the radiation in all the months with a data of two years.

Since the data of the AWS, figure 10, it is observed the incident radiation above the NC occurred between the 11–23 UTC. The highest peaks occur among 15–19 UTC with values above 900 w/m2, besides the months with highest values are from September to December and the lowest from January to March.

In figure 11, during January and February (rainy period), we observed a significant difference between clear and cloudy days. In cloudy days, the radiation does not pass the 600 W / m2 whereas in the clear sky could, it reaches values close to 1200 W / m2. On the other hand, in July there are no differences, due to there are not clouds (just isolated cirrus) and the cloud estimation could not be accuracy in this month.

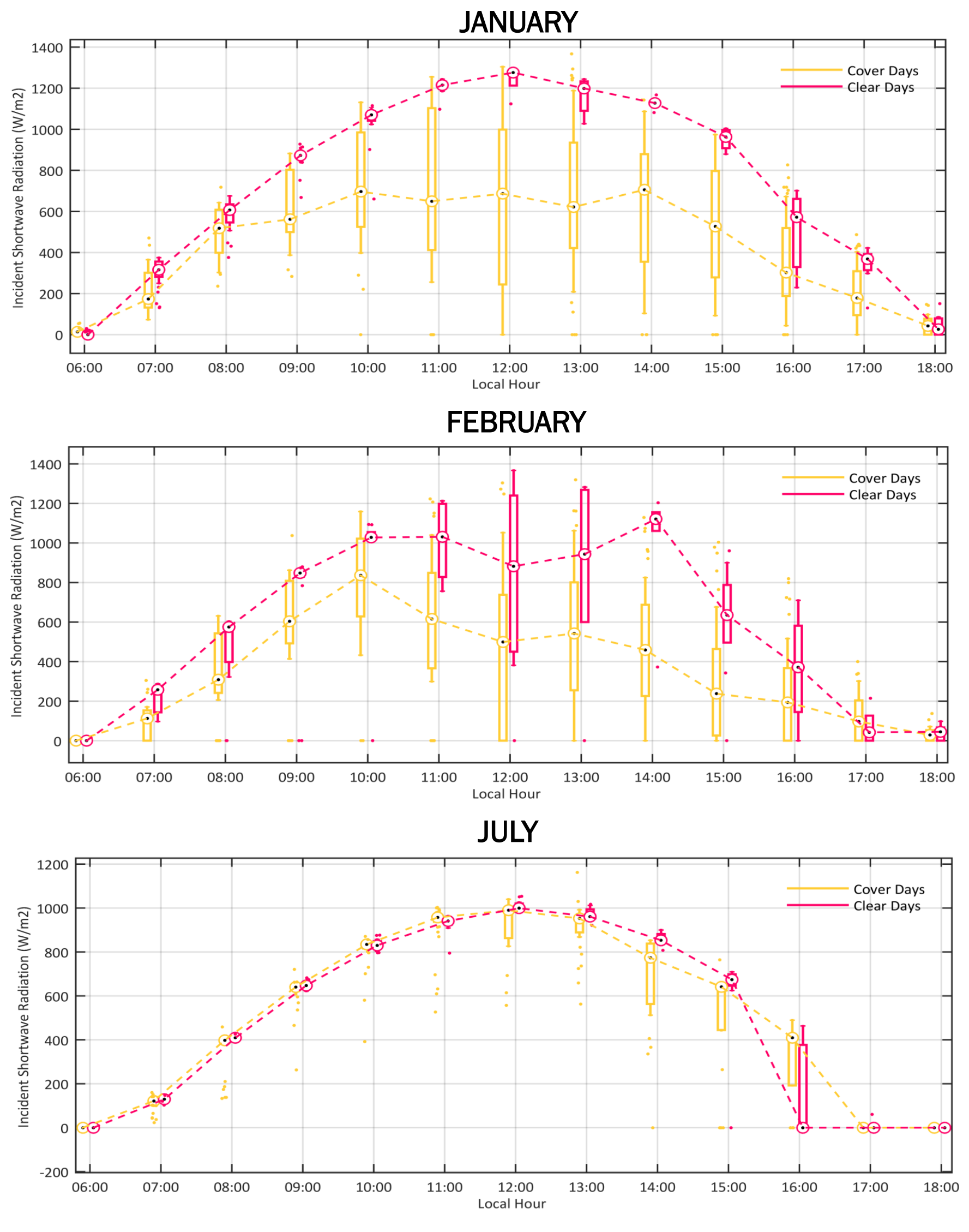

Figure 11: Box plot of the variation of the radiation in clear sky and cloudy to analyze the influence of cloudiness on the radiation.

Discussions

- The BCP estimates the daily and monthly cycle very coherent over Arequipa Region. Despite of this methond has not yet been validated over this region, Jedlovec et al (2009) made validations and determined that this method estimates successfully above 87% in the U.S.
- During the austral summer, Peru has the rainy period from December to March. So, the NC has the most humidity advection in those months, due to formation and intensification of the High Bolivia, and an income of the East flux, which it is come from the basin Amazon. Besides, during “Niño” or “Coastal Niño), anomalies positives of the sea surface temperature favors with income of humidity to the occidental side of NC.
- Arequipa, during the day, has more clouds between December to March above 80%. At night the cloudiness diminish significantly, hourly there are more clouds in the afternoon. The NC has a similar pattern, and there is a difference among the oriental and occidental side.
- The cloudiness radiation has a high impact in the incident shortwave, in clear moments the radiation could reach 1200 W/m2, meanwhile with cloudiness this does not pass the 600 W/m2. In the dry period, generally there are not clouds; in the conventional meteorological stations are found predominantly high clouds, cirrus.

Future works

- To validate the estimated cloudiness with observed values to measure the error, and to identify the regions where they overestimate or underestimate.
- Use other meteorological satellites, like the GOES 16. It has better spatial (0.5 and 2 km) and temporal (each 15’) resolution.
- To apply different methodologies to obtain cloud masks and determine the most accurate for the region.
- To replicate this analysis in other glaciers, like Quelcaya or Quisoquipina, both in Cusco due to they have radiation data.

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