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Introduction

In the atmosphere, generally clouds cover more than half of the earth surface. Clouds play crucial roles on climatic change and constitute natural filter of ultraviolet radiation (UVR), clouds can increase UVR due to multiple scattering phenomena (Sabburg, 2003, Brogniez et al., 2016). Clouds were sometimes sources of climatic model uncertainty, because they rapidly change in time and space, but their property can also change depending cloud classes that change according to their altitude, all of that make clouds one complex parameter to study in the atmosphere. Two different technics can be used to estimate cloud cover, the first using satellite data which most often have an excellent spatial coverage, but a low resolution. The second is a ground-based technic using camera which takes images permanently with a good resolution but low spatial dimension. The two methods are complementary.

The aim of our study is to understand cloud variability in Indian Ocean, where very few studies have been carried out yet. News observation stations have been installed recently by UV-Indien network (Lamy et al., 2021) to monitor long-term variation of UV radiation and nebulosity in the Indian Ocean.

Methods

In this study we will evaluate performance of Reuniwatt an algorithm developed by Reuniwatt society which processes images taken from all sky camera (Cadet et al., 2020) for measuring cloud cover with another algorithm named Elifan originally developed by CNRS actually use by ACTRIS – France community (Lothon et al., 2019). Reuniwatt and Elifan algorithms are based on red over blue ratio (R/B) obtained from the images which we will call later RBR. Elifan exploits thresholding criteria applied on RBR to discriminate clouds from blue sky. It uses two thresholding technics (absolute and differential), the last one takes into account clear sky image library. Reuniwatt perform image segmentation then do classification using Random Forest algorithm (Cadet et al., 2020). Both algorithms provide Cloud Fraction (CF) as output. Cloud fraction obtained by the cameras can be used as a new data source if we want to compare with satellite data to ensure consistency. In this study, we compared two different satellites measurements with camera data. The first is METEOSAT a geostationary satellite which takes images each 15 mn, and provides cloud mask output data. Additional process is required to calculate cloud fraction, we take a square window of 3x3 pixels centered on each station to calculate number of pixels of cloud divided by total number of pixels include in this window. The second one is MODIS that provides 2 daily diurnal images of cloud fraction in the Indian Ocean, we are just extract values of CF corresponding to studded station. From all of these data, we calculate climatology for each ground-based, and satellite cloud fraction data to understand cloud variability of some sites.

Interpretations / Discussions

We compared CF measurements (Meteosat, Elifan, and Reuniwatt) at St Denis Réunion station 31/08/2020 (fig 5), and Antananarivo Madagascar 20/05/2020 (fig 6). We found maximum difference of 10% between Elifan and Reuniwatt. This difference happens when the sun is not hidden by clouds, solar disk (area near the sun) present a lot of saturation in the images caused by solar radiation scattering. Difference can also occur when solar zenith angle is near by zero, around solar noon. Elifan uses additional solar masks during the process to reduce overestimation of measurements. When we compared CF from Elifan and Reuniwatt with Meteosat, we found maximum difference of 20% because of some parts of areas covered by Meteosat, and not covered by camera. These differences were sometimes caused by presence of haze. Lowest value of bias was found in summer season from October to March. In fig 7, we found mean bias (Meteosat and Elifan) -4.86%, and -6.43% (Meteosat and Reuniwatt). Maximum bias was found in winter season between April and September around -10%. Green lines represent mean values of CF obtained each month, vertical lines (standard deviation) represent data dispersion around mean values, orange shaded surface represents limits of first and third quartile. We got first results of climatology at two stations St Denis La Réunion (fig 8) using Reuniwatt output, and Antananarivo (fig 9) obtained from Meteosat. At St Denis we found low quantity of cloud cover in the morning (40%), and grow up during the day around 60%. At Antananarivo, we have a strong cover at the beginning of the day (55%), decreases towards noon around 30%, then increases in the afternoon (40%).

Conclusion

- We found a good agreement of cloud fraction from camera and satellite sensors even if their spatial dimension and field of view are very different.
- The climatology presented here is not really representative because the depth of our archive is not sufficient but it can provide some overview of cloud cover variation on very poorly known sites. This climatology will be consolidated in the future. But we can see particularity of each site, here St Denis and Antananarivo, due to environmental and geographics difference.
- These first results will help us to understand the influence of nebulosity on ultraviolet radiation on the surface.

Acknowledgment

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Data and instrument (Meteosat / Modis / Elifan / Reuniwatt)

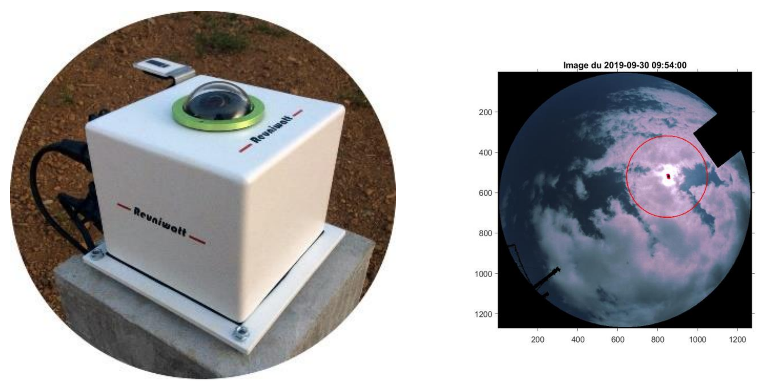

Fig 1: Reuniwatt Sky Cam Vision

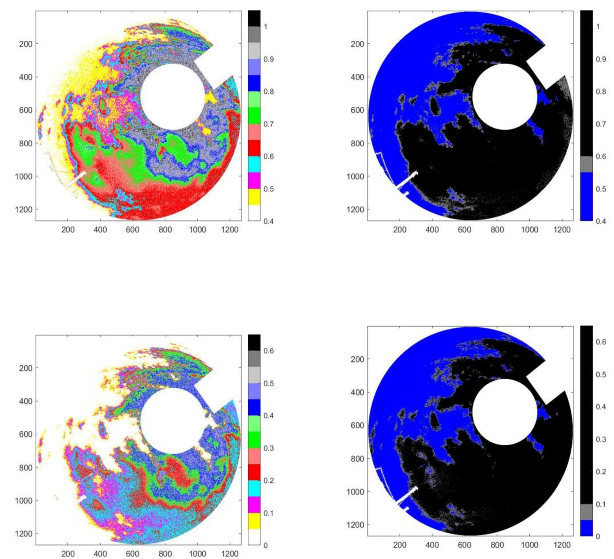

Fig 2: Intermediate images obtained from Elifan algorithm

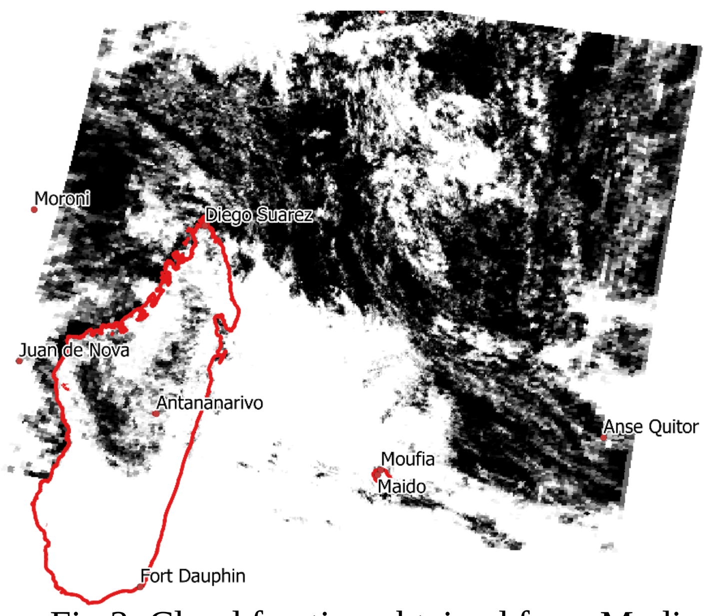

Fig 3: Cloud fraction obtained from Modis

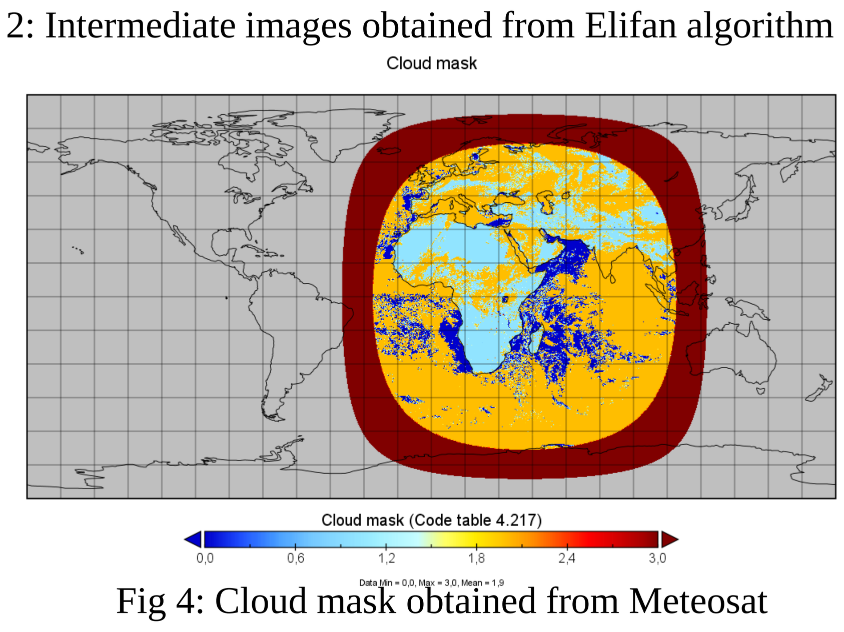

Fig 4: Cloud mask obtained from Meteosat

Results

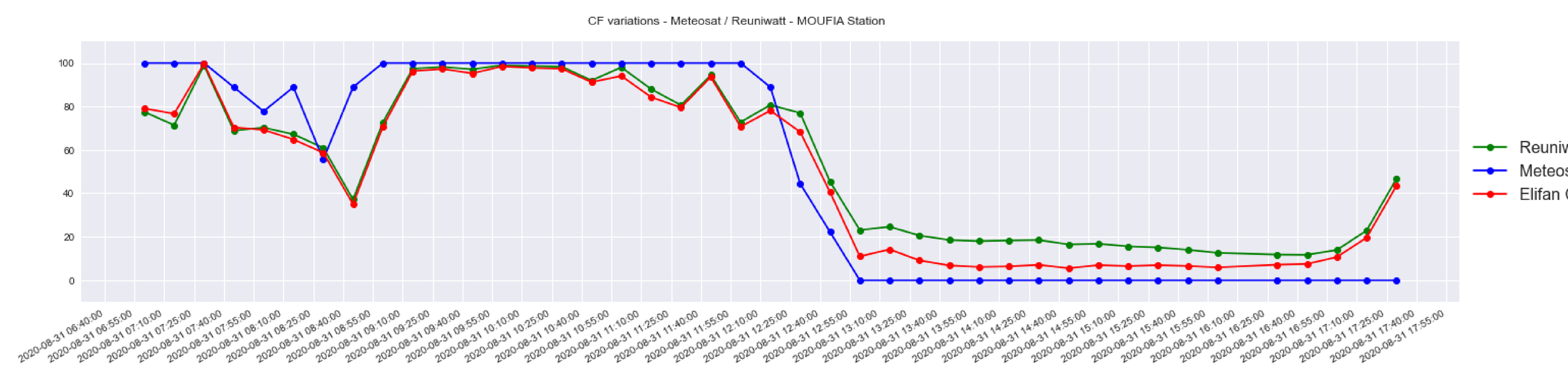

Fig 5: Comparison of Cloud Fraction – Meteosat – Elifan - Reuniwatt (St Denis – La Réunion)

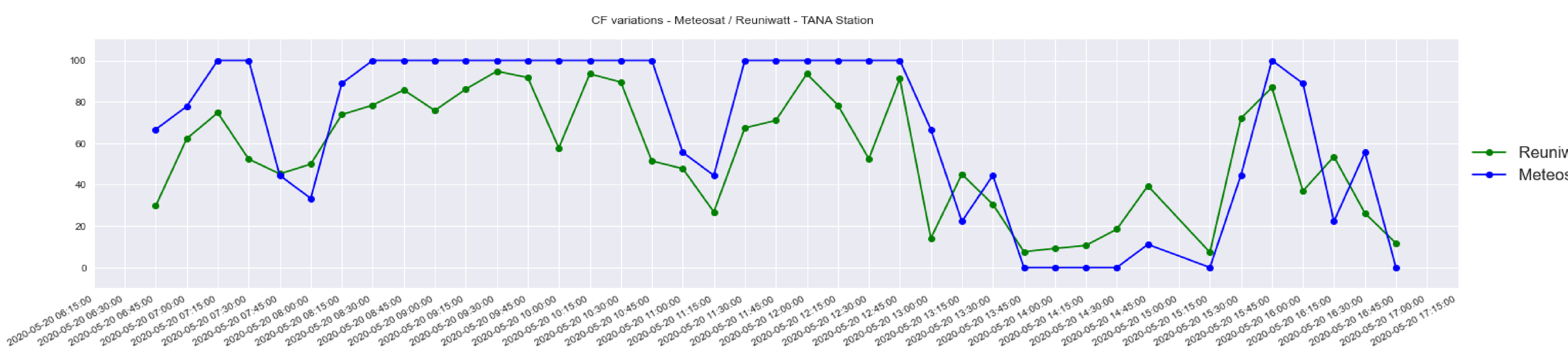

Fig 6: Comparison of Cloud Fraction – Meteosat – Reuniwatt (Antananarivo – Madagascar)

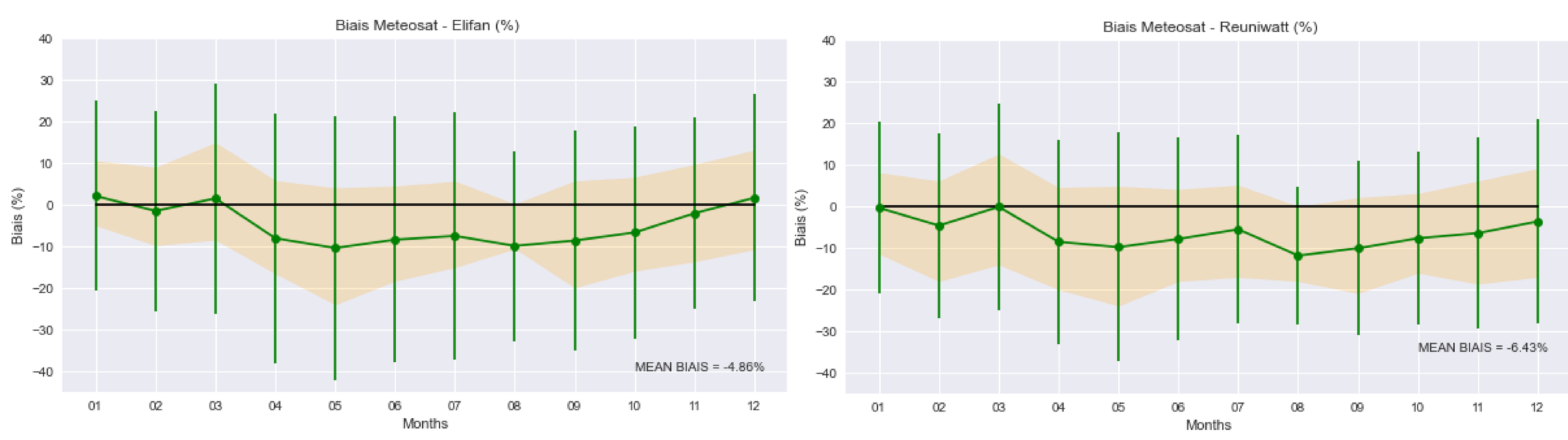

Fig 7: Bias of Cloud Fraction (Meteosat and Elifan / Reuniwatt) - St Denis – La Réunion

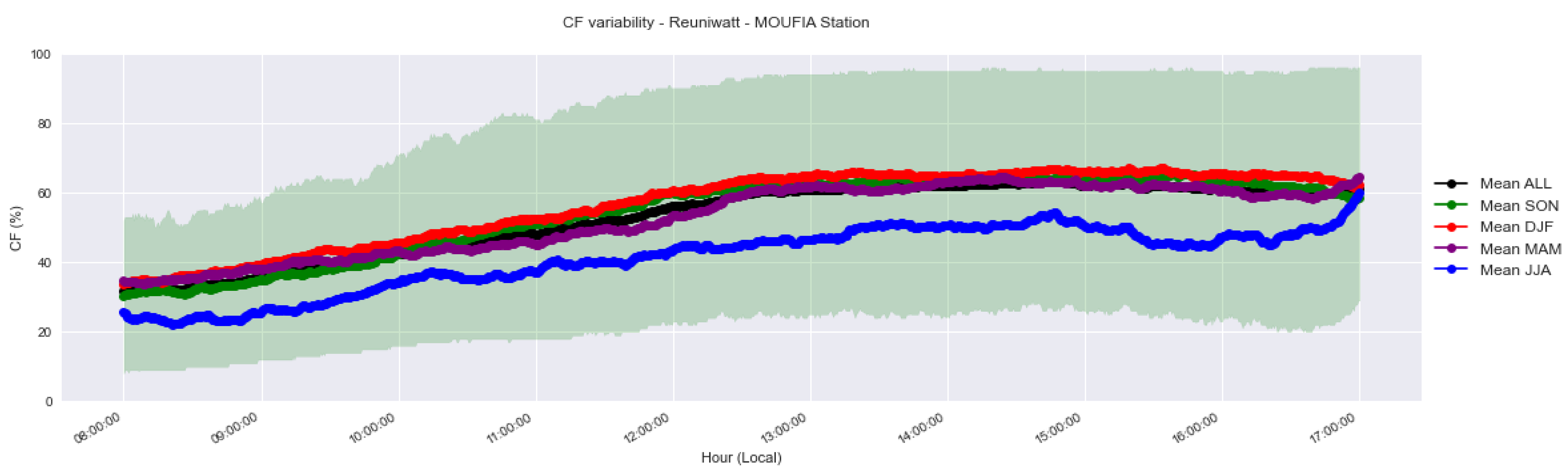

Fig 8: Cloud variability - Reuniwatt - Saint Denis - La Réunion (Sept 2019 - Dec 2021)

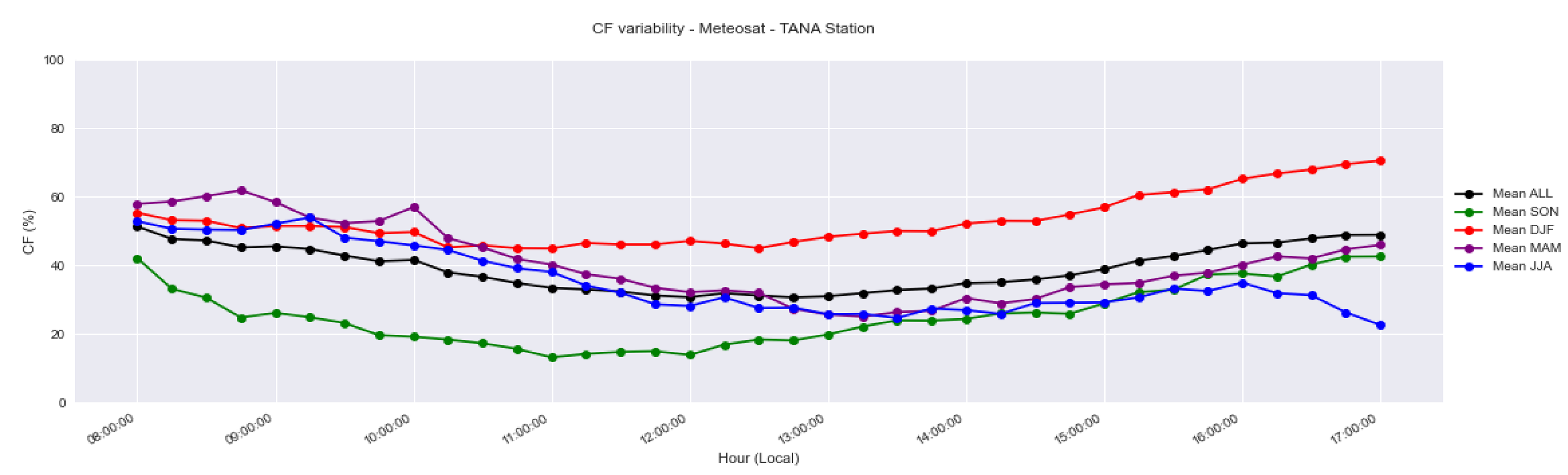

Fig 9: Cloud variability - Meteosat – Antananarivo - Madagascar (Sep 2019 - Mar 2021)