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RESEARCH ARTICLE

OCCURRENCES OF LOW CLOUDS OVER THE WESTERN MARGINS OF THE CONGO BASIN (SEPTEMBER TO DECEMBER 2021)

Ghislain Toli, Joëlle Claude Zou-Massengo and Gaston Samba
Centre de Recherche et d'Études sur l'Environnement (CREE), ÉcoleNormaleSupérieure, Marien Ngouabi University, Brazzaville, Congo.

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Abstract

This study aims to analyze the occurrence of low cumuliform clouds over the western margins of the Congo Basin from September to December 2021. The imagery of the Cloud Top Height product of Meteosat Second Generation set on synoptic hours (i.e. 00 hours, 06 hours, 12 hours and 18 hours) have been retained for this study. Through these data, we have developed an observation grid of 1° over the entire Congolese territory to make an inventory of low clouds identified at each 1°. The results obtained show that the low clouds appear most often between 00 hours and 12 hours. And the spatial distribution of the occurrences of clouds attests that the low cloud cover remains more pronounced in the Southern, Southwestern and Northern parts of the country.

Introduction:

The Congolese territory, located on the western margins of the Congo Basin between longitudes 11° and 19° East and latitudes 4° North and 5° South with altitudes not exceeding 900 m (Figure 1), remains an area of significant climatic fluctuations. It benefits from atmospheric or aerological conditions and surface states favorable to the formation of cumuliform clouds. The present work is part of a context of detection of climate change signals at the national or international scale. The detection of climate change signals requires an understanding of the behavior of climate elements. However, the analysis on the occurrence of low clouds is very little documented. Low clouds in their spatial distribution reflect an importance in the level of rainfall over the Congo Basin and its margins. The few works that exist to date on low clouds are those of Moron V., R. Aellig, L. Backita et al (2022, pp.1-7), Philippon N., Ouhechou A., Camberlin P. et al (2022, pp.185-201), Dommo A., Philippon N., Vondou A. et al (2021, pp1.-45), Philippon N., Cornu G., Monteil L. et al (2019, pp.1-11), Dommo A., Philippon N., Vondou A. et al (2018, pp.9585-9603), Philippon N., De Laparrent B., Gond V. et al (2016, pp.81-94) and De Lapparent B. (2014, pp.1-43). The climatic conditions of the Congo Basin, despite their complexity, determine the formation and diffusion of clouds over the Congolese part of the basin. Cumuliform clouds being rain carriers, researchers should focus their work on the mechanisms of cloud formation and diffusion.

Corresponding Author:- Ghislain Toli
Address**:-** Centre de Recherche et d'Études sur l'Environnement (CREE), ÉcoleNormaleSupérieure, Marien Ngouabi University, Brazzaville, Congo.

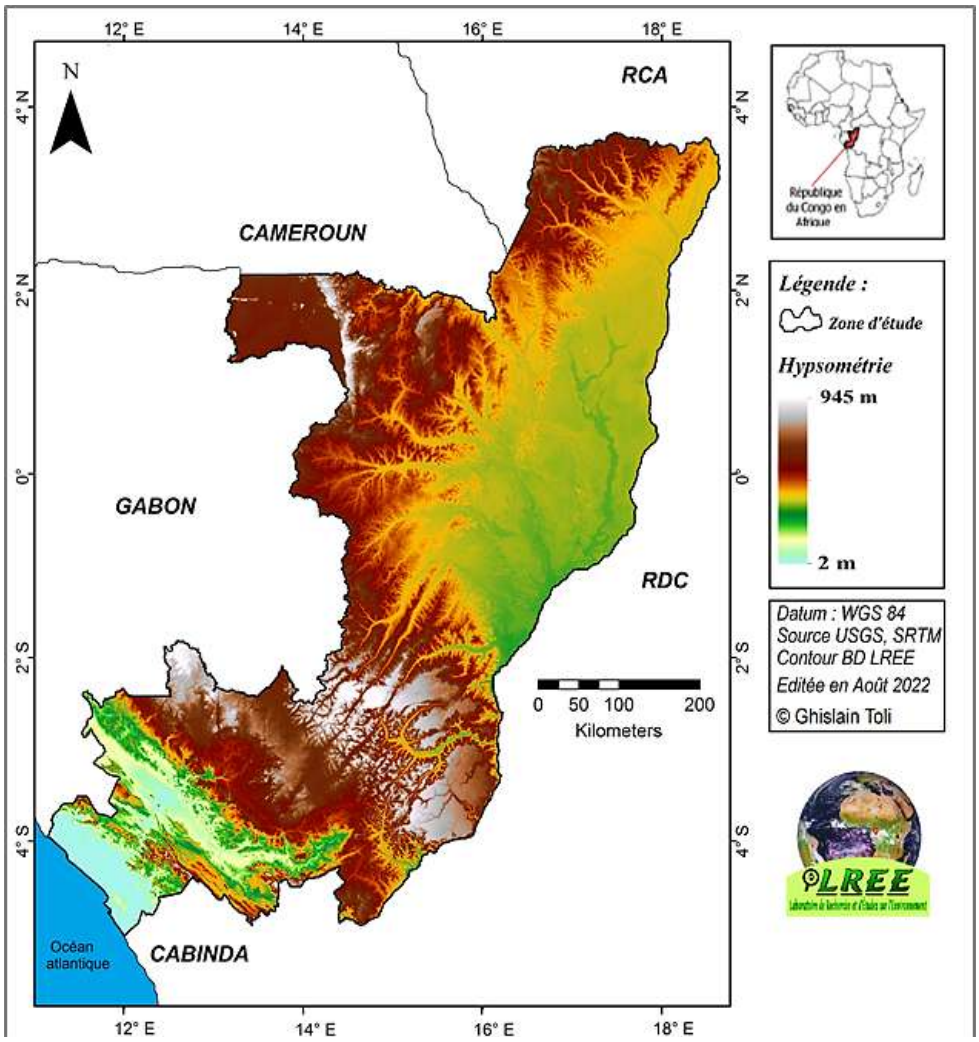

Figure 1:- Elevation of the study area.

Materials and Methods:-

Data

The satellite images used in this work are the Cloud Top Height product image sequences (Figure 2) from the Meteosat Second Generation (MSG) weather satellite. The image data selected are mainly for synoptic hours (00h, 06h, 12h and 18hUTC) from September to December 2021. The Cloud Top Height product indicates the height of the highest cloud. Based on a subset of information derived from scene and cloud analysis, but also uses other external weather data. It identifies the height of the top of clouds up to 16000 m altitude (i.e. 16 km). We were interested in clouds from 0 to 2 km (between 320 and 2560 m).

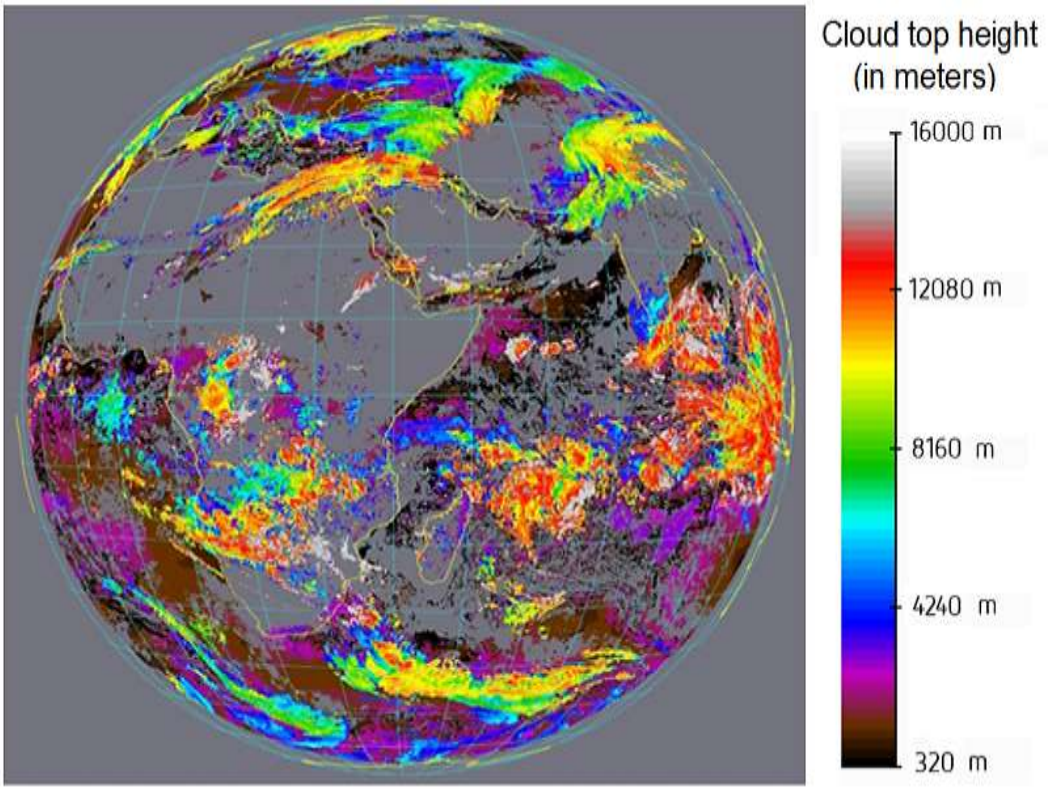

Figure 2:-Image of the product Cloud Top Height.
(source: eumetsat, 2021)

Methods:-

The analysis of precipitating clouds occurrences was done using the Meteosat Second Generation (MSG) Cloud Top Height product. We selected images set at synoptic times (00:00, 06:00, 12:00 and 18:00 UTC) over a 6-hour interval at universal time in order to have a wide coverage over a cloudy day. A grid of observation established on a mesh of 1° was set up in order to identify the occurrences of low clouds on the Congolese territory. Through this observation grid, we made calculations based on the inventory of low clouds identified at each 1°. The operation allowed us to identify the occurrences of low clouds appeared at the selected synoptichours.

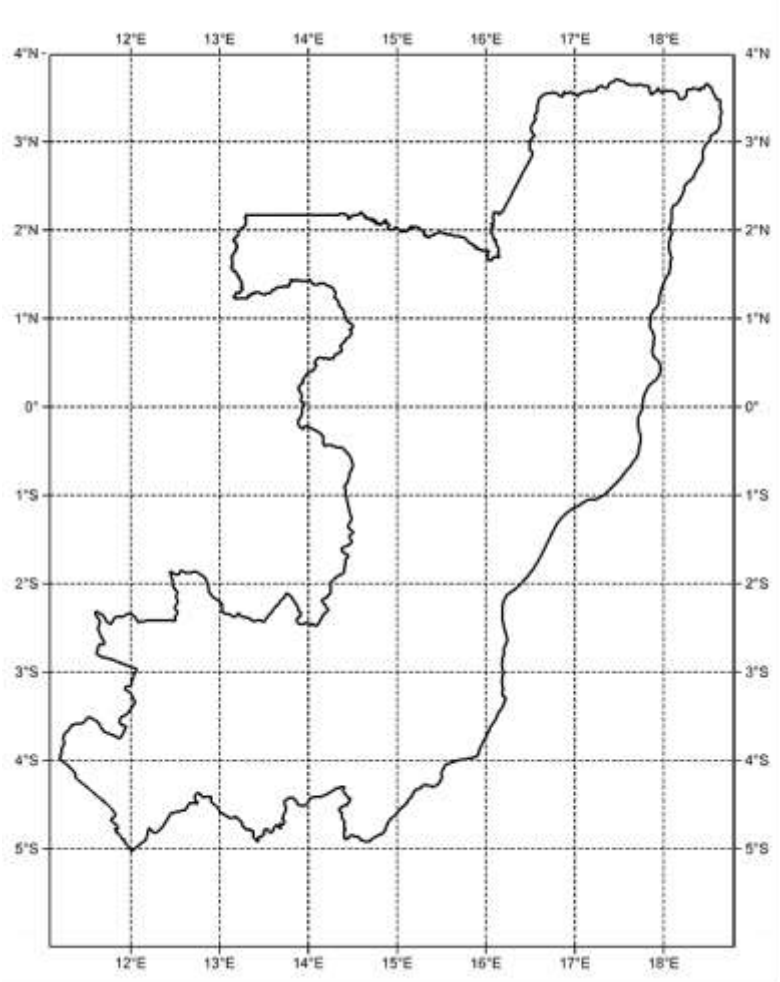

Figure 3:- Observation grid used.

Results and Discussion:-

Mechanisms of low cloud formation

The formation of low clouds can be explained by four main mechanisms: deep convection, orographic lifting, frontal lifting and base cooling.

Deep convection: the air in the vicinity of a warm ground warms up on contact with it and expands. lighter, it rises in the atmosphere before cooling at altitude to form clouds. these convection clouds appear all the more easily when there is cold air at altitude (unstable air mass). their base is horizontal, the altitude and the shape of their top evolve according to the temperature. they are frequent in summer on land, in winter over the sea.

Orographic lifting: when an air mass is pushed by the wind towards a relief, it is forced to rise along the slope. as it rises, its temperature drops and may reach the saturation point, meaning that some of the gaseous water it contains will condense. a cloud then forms on the windward side and dissipates on the leeward side. behind the mountain, the air warms up as it descends. if the cloud has lost some of its moisture in the form of precipitation, the air warms up more on the way down than it did on the way up. at equal altitude, it will be warmer downwind of the mountain than upwind. this is the foehn effect

The frontal lift : clouds can also form at the level of a front, i.e. at the interface between two air masses of different temperatures. in a moving disturbance, the warm air of the warm sector rises above the preceding cold air mass (warm front) and is rejected aloft by the faster progression of the cold air behind (cold front). this warm air cools at altitude and gives rise to clouds along the fronts.

Cooling from the base: this mechanism leads to the formation of low clouds or fog when a mass of mild air circulates above a colder surface. this mechanism is frequent over land in winter when a mild and humid air mass from the atlantic approaches. it can be observed at sea in summer when relatively mild air arrives over cold waters.

Couverture nuageuse basse de septembre à décembre 2021

Frequency of the hours of appearance of low clouds

The western margins of the Congo Basin benefit from favorable conditions for the daytime formation of cumuliform clouds. Data from the Meteosat Second Generation satellite show a pronounced appearance of low clouds, often of the cumulus type, between 00:00 and 12:00 UTC over the entire Congolese territory. Figure 4 shows the occurrences of low clouds from September to December 2021 between 00 hours and 18 hours UTC. We note more occurrences for the clouds appeared at 12 hours UTC with 831 occurrences (figure 4a). Low clouds appearing at 00:00 and 06:00 UTC showed 410 and 517 occurrences, respectively. Over the whole territory, November and December recorded more occurrences of low clouds with a high frequency of appearance around 12 o'clock (Figure 4b).

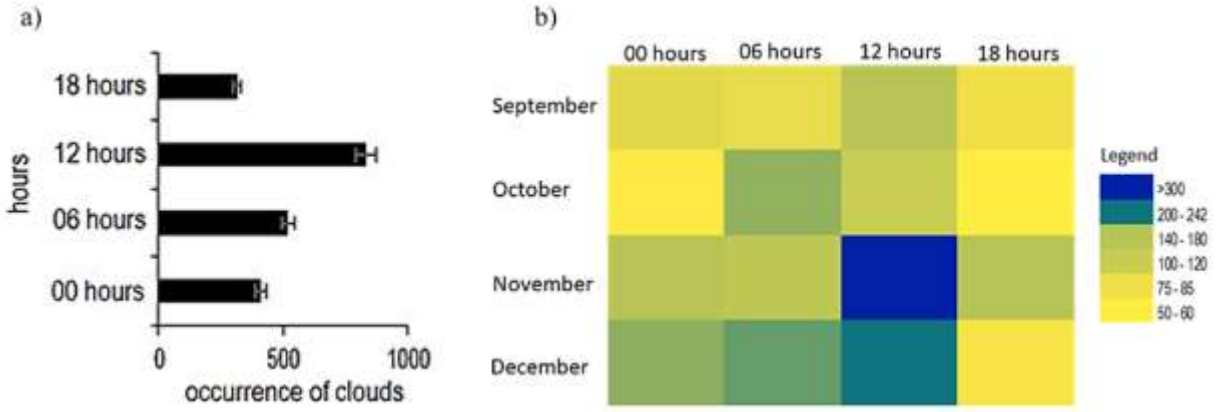

Figure 4:- Distribution of low cloud occurrences by hour between September and December 2021.

Spatial distribution of low cloud occurrences from September to December 2021

Figure 5 highlights the spatial pattern of occurrences of cumuliform clouds between September and December 2021 over the whole Congolese territory. The general observation remains the predominance of low cloud events in the southern, southwestern and northern parts of the country. Between September and October, there is a strong presence of low cloud occurrences in Lekoumou, Niari, Bouenza, Kouilou and southwestern Pool (Figure 5a and Figure 5b). The topography, the forest system and the activity of air masses from the Atlantic Ocean may be one of the explanatory factors for the formation of low cloud cover in this region of the country. The contrast remains almost the same throughout the season, however, in the heart of the season (late October to December), the analysis of the data suggests a low cloud cover over the entire territory with strong occurrences in the northern part (Figure 5c and Figure 5d).

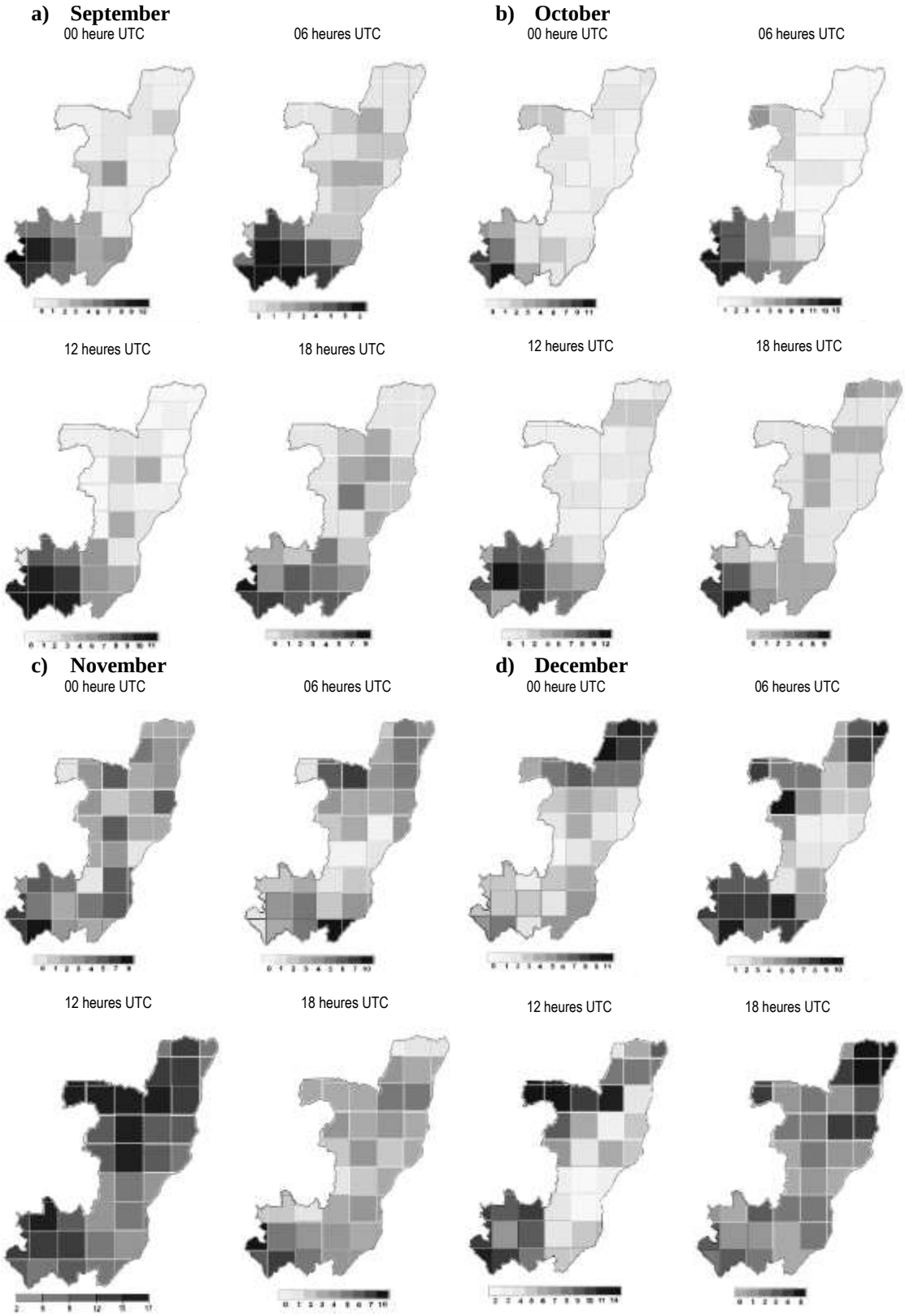

Figure 5:- Spatial distribution of low cloud occurrences over the western margins of the Congo Basin (September-December 2021).

Conclusion:-

The analysis of low cloud occurrences between September and December 2021 through the Meteosat Second Generation satellite data allowed to recognize the essential activity of the forest system and oceanic air masses on the western margins of the Congo Basin. The results show a frequent appearance of low clouds between 00:00 and 12:00 over the whole territory. The low cloud cover remains more pronounced in the southern, southwestern and northern parts of the country. The study placed particular emphasis on the analysis of low cloud cover during the rainy season in order to initiate solid research in a national context of climate change. This is in line with the study lines of the Center for Environmental Research and Studies, which has developed different research lines with the objective of identifying possible climate change signals on the western margins of the Congo Basin.

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