Dynamic State Of Atmosphere On The Coast Of Benin From Radiosonde Data Of Cotonou

F.K. Guedje, B. E. Houngninou, T. Adanmitonde, A.J. Adechinan

Abstract: This study characterizes the dynamic state of the atmosphere on the Coast of Benin from the radiosonde data. The average monthly wind speeds were calculated. The main results of this study provide information about the dynamics of the atmosphere through the jets characteristics. Two peaks were identified respectively around 5 km and 16 km altitude. The maximum value of the speed of the horizontal wind for the first jet is recorded in September with 17.5 m/s, whereas the same value is noted in July and is 23 m/s for the second jet. The rose corresponding wind at these levels for each study month was represented. This has allowed us to identify the prevailing wind in different months concerned. Then the vertical profiles of pressure, temperature and humidity have been shown. This revealed that the air temperature and atmospheric pressure gradually decreases with altitude until the tropopause.

Keywords: atmospheric dynamics, radiosonde, wind rose, atmospherics parameters

1 Introduction

Climate variability leads to major threats to the environment and development [1]. Human, at the resurgence of extreme events due to climate change not just content to watch the weather and try to understand the processes behind its changes[2] . Rather, it seeks to predict or better predict major trends. This is what explains the fervor noted within the scientific community over the past decades on issues related to knowledge and climate change in all its forms. Many studies [3], [4], [5], [6] in this direction have led today to understand a little of the physical mechanisms of the essential climate variability to improve forecasting global, regional and local climate. In this area, very few studies on Africa and particularly on West Africa are made. The few studies [7, 8] related to winds in south of Benin have focused on surface winds. The interest of this work is based on the fact that the literature on the characterization of the altitude atmosphere in south of Benin is almost nonexistent. This study aims to fill this gap by characterizing the dynamic state of the atmosphere on the Benin coast from radiosonde observations made on the ASECNA station in Cotonou. It will specifically use the vertical profile of horizontal wind and identify the type of prevailing winds in the year and the period during which it was observed.

2 Data and Methods

The coastal zone is characterized by a succession of lakes and lagoons separated from the sea by a narrow coastal strip. It covers one hundred twenty five kilometers long and four kilometers wide on average [10]. Radiosonde date are used in this study. The technique use an ascending balloon with a radiosonde which carries and transmits the measurements of atmospheric parameters.

- *F.K. Guedje, Laboratory of Atmospheric Physics, Faculty of Science and Technology, University of Abomey-Calavi, Benin. E-mail: guedjefranco@yahoo.com*
- *T. Adanmitonde, B. E. Houngninou, A.J. Adechinan*
- *Laboratory of Atmospheric Physics, Faculty of Science and Technology, University of Abomey-Calavi, Benin.*

Radiosonde samples the atmosphere during their vertical ascent and rebroadcast directly measurements to down. The average speed of the ascent of the balloon is about 5 m/s [11]. The data used in this study were provided by the meteorological station of ASECNA based at the International Airport of Cotonou during the year 2008. These are daily data on the speed of zonal wind (m/s), the speed of the horizontal wind (m/s), the speed of the vertical wind (m/s), the wind direction (degree), relative humidity in (%) and the pressure (hPa) with a sampling interval in the order of one second. Throughout the year 2008, it is in February, March, April, May, July, September and October that the measures are carried out regularly. All the stripped data files indicate that the first steps of the radiosonde start from 140m above the ground. Different altitudes considered for measures vary from one shoot to another. Beyond 17 km altitude, the information returned by the radiosonde to the ground before it bursts is no longer reliable. Thus, the analyzes will only affect the altitude range between these two values. The processing of the collected data was done with Matlab. In order to harmonize pressure levels where different parameters were measured, the height of the radiosonde is interpolated for each 100m [12]. Thus the average monthly atmospheric parameters (horizontal wind speed, relative humidity, atmospheric pressure and temperature) was calculated and represented.

3 RESULTS

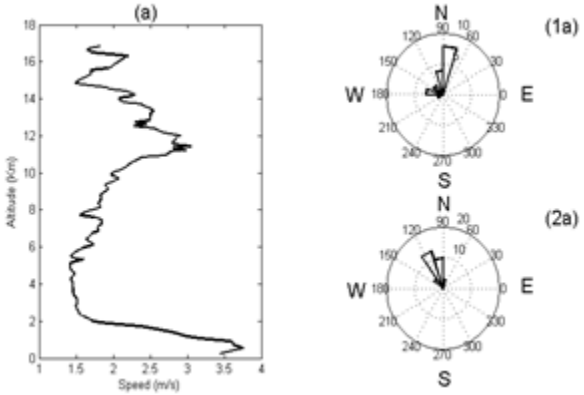

Figure 1 : *Wind speed and wind rose in May*

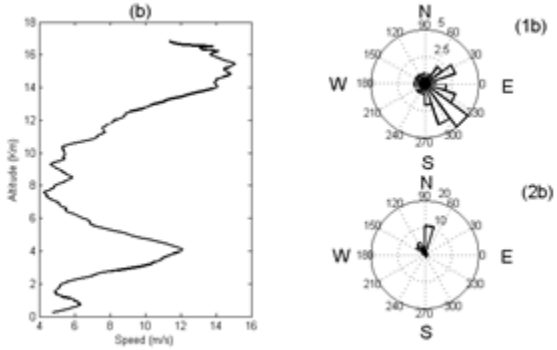

Figure 2 : *Wind speed and wind rose in June*

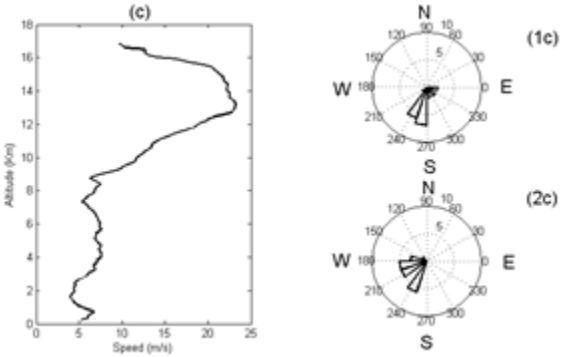

Figure 3 : *Wind speed and wind rose in July*

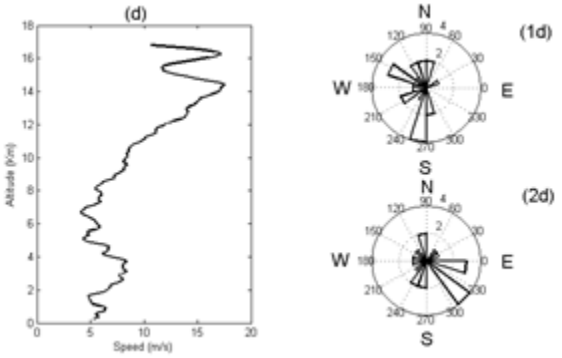

Figure 4 : *Wind speed and wind rose in September*

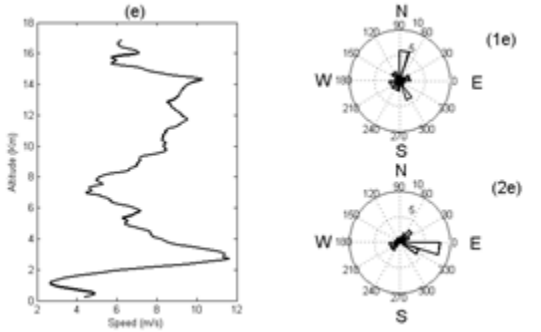

Figure 5 : *Wind speed and wind rose in October*

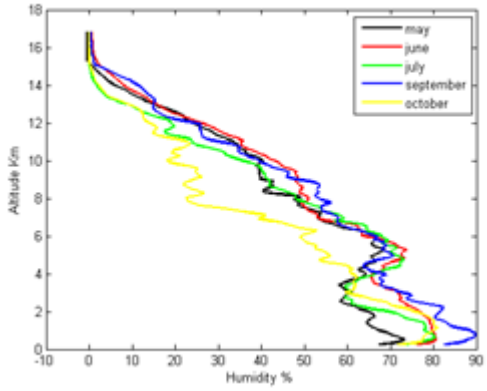

Figure 6 : *Vertical profile of humidity of the months of may, june, july, September and October.*

The curves (a), (b), (c), (e) and (d) of figures 1, 2, 3, 4 and 5 respectively show the variation of the average speed of the horizontal wind depending on the altitude of respectively May, June, July, September and October of the year. Through these different curves globally we can notice two clearly marked peaks as noticed from a VHF wind profiler radar in Djougou in the north of Benin [13]. The maximum value (17.5m/s) for the first peak is recorded in September while the minimum (3.7m/s) for the down peak is recorded in the month of May. With the exception of September, the first peak is observed in other months at an altitude of less than 5 km. This peak is experiencing a remarkable increase in the month of September and reaches its maximum value again before experiencing a decline in October. For the second peak (top), the maximum value (23m/s) is recorded in the month of July, the minimum (3m/s) is recorded in May. The average speed of the horizontal wind is minimum between 6 to 8 km altitude in the months of June and September, between 0.24 and 2 km in July and October. In May this value is obtained in the altitude range between 4 and 6 km. This value is respectively equal to 1.5, 4.2, 4.8, 4.5 and 2.5m/s in respectively May, June, July, September and October. Average speed is maximum horizontal wind between 14 and 16 km altitude in June, September and October; between 12 and 14 km in July and between 10 and 12 km in May. This value is respectively equal to 3, 15, 23, 17 and 10.5m/s in the months of May, June, July, September and October. The representations (1a), (1b), (1c), (1d), (1e) respectively from figures 1, 2, 3, 4 and 5 show the wind roses corresponding to the first peak observed at the vertical velocity profiles horizontal winds of May, June, July, September and October of the year of study. We see that from these roses winds, the winds towards North East are more dominant in May, the North West direction of winds are prevailing in June, the South West direction of winds are more dominant in the month of July, the south West direction of winds are dominant in the month of September and in October the north East direction of winds are dominant. The representations (2a), (2b), (2c), (2d), (2e) respectively from figures 1, 2, 3, 4 and 5 show the roses of the wind corresponding to the second peak observed at the vertical velocity profiles horizontal winds of May, June, July, September and October of the year of study. The winds of South East direction North East, South West, North West and North West are more dominant respectively in May, June, July, September and October. We note from the foregoing that the North East wind direction and North West more blown in

southern Benin during this study, followed by the South West wind direction and finally the South East wind direction [9]. The figure 6 below presents the vertical profile of humidity as a function of the altitude of May, June, July, September and October found that:

- The relative humidity decreases gradually as the altitude increases.
- It keeps almost the same change on all studied months. It oscillates between 70% and 90% on the coast of Benin [7]. The maximum value (90%) is obtained in September.
- A slight shift is observed at the vertical humidity profile on the month of October between 3 km and 12 km.

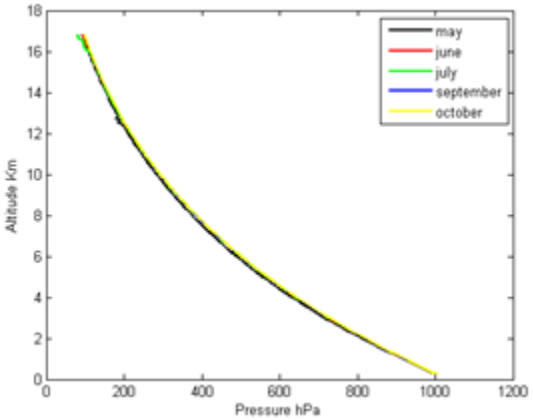

Figure 7 : *Vertical profile of pressure of the months of may, june, july, September and October.*

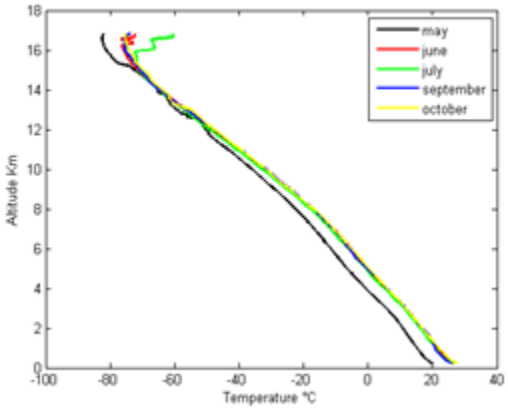

Figure 8 : *Vertical profile of temperature of the months of may, june, july, September and October.*

The figure 7 shows the vertical profile of pressure as a function of the altitude of May, June, July, September and October reveals that the atmospheric pressure decreases with altitude. The figure 8 shows the vertical profile of temperature as a function of the altitude of May, June, July, September and October reveals the same pattern for all studied months. It decreases with the altitude until around of 15 km before knowing an inversion. From this altitude the temperatures of May, June and July experiencing a slight increase while those of September and October decrease.

4 Conclusion

From this study, it appears that the Coast of Benin vertical profiles of horizontal wind speed of the surveyed month show two peaks. These two peaks are observed respectively around 5 and 16 km. The maximum value of the speed of the horizontal wind is obtained in July and is 23 m/s and the minimum value is obtained in the month of May and is 1.5 m/s. From wind rose, it appears that it is the North East wind direction and North West most dominant of this study period followed by the South West wind direction and finally wind South East direction. Contrary to the wind velocity, the pressure and the temperature studied vary almost in the same manner as in literature. They decrease gradually as the altitude increases. The maximum relative humidity is achieved in October.

5 References

[1] S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.), "IPCC, 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change", Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007.

[2] B. Bourles, R. Lumpkin, M.J. McPhaden, F. Hernandez, P. Nobre, E. Campos, L.Yu, S. Planton, A.J. Busalacchi, A.D. Moura, J. Servain, and J. Trotte, "The PIRATA program: history, accomplishments and future directions", pp. 1111-1125,2008,Bulletin of the American Meteorological Society, 89(8), doi/10.1175/2008BAMS2462.1.

[3] D. Jonathan, "Tropospheric Low-Level Temperature Inversions in the Canadian Arctic", Atmosphere-Ocean vol. 30, no.4, pp. 511-529, 1992.

[4] H. Conway, L.A. Rasmussen and P. Hayes, "On the use of radiosondes to model glacier ablation", Annual Glaciology, vol. 21, 1995.

[5] G. Krammi, F. Herbert, K. Bernhart, H. Muller, P. Were, T. Foken, and S. Richter, "Stability functions for momentum, Heat and water vapor and the erticle temperature transport of TEK and pressure fluctuations estimated from measured vertical profiles of wind speed temperature and humidity", Beitr. Physical Atmosphere, pp.464-475, 1996.

[6] S.M. Sempreviva and S.E. Gerying, "Mixing high over water and its role on the correlation between temperature and humidity fluctuations in the unstable surface layer", boundary layer Meteorology, vol. 97, pp. 273-291, 2000.

[7] A.A. Koukpemedji, B.B. Kounouhewa, E. Agoua, A. Houekpoheha, et J.B. Chabi Orou, "Influence de la temperature, de la pression et de l'humidite relative de l'air sur le potentiel eolien dans la zone côtière du Benin dans le Golfe de Guinee". Revue des Energies Renouvelables, Vol. 18, no.2 pp. 217 – 226, 2015.

[8] A.S. Bajamgnigni Gbambie, D.G Steyn, "Sea breezes at Cotonou and their interaction with the West African monsoon", Int. J. Climatol. vol. 33, no. 13, pp. 2889–2899, 2012.

[9] P.B.A. Chabi, I. Yabi et F. Afouda, "Etude de La typologie des pluies journalières en milieu subequatorial au Benin", XXVIIIe colloque de l'Association Internationale de Climatologie, Liège, 2015.

[10] E. Fiogbe, A. Dossou-Yovo, et E. Ogouwale, "Rapport national sur l'environnement marin et côtier du benin", Direction Generale de l'Environnement, CEDA, 2007, (unpublished manuscrit).

[11] F. Duruisseau, Analyse des vents dans la stratosphère à l'aide des trajectoires des ballons et estimations des biais dans les reanalyses era-interim, France, 158p, 2014.

[12] A.R.M. Bashair, "Vertical tropospheric characteristics over baghdad", International Journal of Application or Innovation in Engineering and Management, Vol. 2, no. 9, 2013.

[13] B. E. Houngninou, C.S.U. Alle, H. Kougbeagbede, S. Moumouni, K. F. Guedje, A. J. Adechinan, et T. E. Houngninou, "Caracterisation des saisons à partir des profils de vents observes par radar VHF en Afrique de l'Ouest", American Journal of Scientific research, vol. 11, pp. 105–115, 2014.