Climatology of anomalous propagation radar over Douala, Cameroon

By André Lenouo
Department of Physics, Faculty of Sciences, University of Douala BP 24157 Douala, Cameroon.
E-mail: lenouo@yahoo.fr

Using high-resolution radiosonde data, we have performed detailed analysis of surface ducts which determine the anomalous propagation days at the coastal site of Douala (4°N, 9.7°E; 5 m ASL) in Cameroon. We showed that the surface ducts were observed to occur less frequently in the dry season over the Gulf of Guinea. The median duct strength showed that the strongest ducts appear in summer and the weakest ones occur in winter. We found that the surface ducts also occur more frequently during the day than at night.

Introduction

Weather radar is a radar pulse and is used in meteorology to identify the position, intensity and movement of precipitation. One of the main utilities of weather radar is to remotely detect precipitation and approximate its intensity. For example, the inspection of the flow flood warming and other related purposes. Weather users need to know the amount of rain that falls over large areas. Radar network complements the rain gauge network because it covers larger area. The former can be used to calibrate the latter. It becomes important to know the refractive index for atmospheric use of radar and other meteorological applications or telecommunications. In certain meteorological conditions, low-tilt beams emitted from ground-based radar can become trapped and can even be deflected toward the surface, leading to spurious backscattered signals and hence erroneous interpretation (e.g., false precipitation echo). This phenomenon is referred to as anomalous propagation (AP), and the layer inside which the beam bends downward called the duct.

Data

Data used in this work are derived from regular radiosonde made by the technical division of ASECNA (Agency for the Safety of Air Navigation in Africa and Madagascar) for Douala. These data can also be downloaded from the African Monsoon Multidisciplinary Analyses (AMMA) database website. Douala (9.7°E, 4.0°N) is the economic capital of Cameroon. It is a city of just over 2.5 million (Fig.1).

Refractivity gradient and statistics

In Table 1, the percentage occurrence of the surface ducts, mean and median duct thickness are given for all radiosonde soundings, for the 0000 UTC and the 1200 UTC soundings. This table shows that the surface ducts over Douala occur mostly at the end of the dry season and during the summer months. We noticed that surface duct occurrence is more than 52% in May, June, July, August and September (MJJAS) which correspond to the rainy season in this region. The percentage of surface duct occurrence falls in the dry months to a value of around 24%. Here, we note that the dry season in this region starts with the month of November and ends in February. The annual average of the percentage occurrence is about 39.2%.

Figure 1: The satellite image of Cameroon, its neighbors, and the region of this study: Douala and the Gulf of Guinea. The reduced map of Africa also presents the region.

Table 1: Monthly percentage occurrence of surface ducts, mean and median duct thickness in Douala (9.7 ° E, 4.0 ° N) from 2006 to 2010 at 0000UTC (1200 UTC). The vertical gradient of the co-index of refraction is determined below 1500 m.

	Ducts frequency (%)			Mean duct thickness (m)		Median duct thickness (m)	
Months	0000 UTC	1200 UTC	Total	0000 UTC	1200 UTC	0000 UTC	1200 UTC
Jan	8	13	21	34.1	36.4	32.4	34.7
Feb	12	15	27	34.8	37.1	33.9	35.6
Mar	15	18	33	36.2	39.5	36.1	40.2
Apr	18	23	41	39.8	43.2	40.2	42.9
May	19	29	48	43.5	46.1	42.5	45.1
Jun	20	31	51	46.2	47.1	45.6	45.1
Jul	21	33	54	48.3	52.7	48.3	56.9
Aug	23	33	56	50.2	51.9	48.9	53.1
Sep	19	32	51	49.1	50.2	48.3	42.1
Oct	12	26	38	40.1	42.8	41.2	39.2
Nov	11	16	27	35.1	40.1	33.1	38.9
Dec	9	14	23	34.2	36.3	32.3	37.6
Ann	15.6	23.6	39.2	41.0	43.6	40.2	42.6

Figure 2 presents the variation twice daily for nighttime (0000 UTC, solid line) and daytime (1200 UTC, dotted line) of surface duct characteristics during the months of January and July. These two months correspond in Gulf of Guinea to the peak of dry and rain season respectively. We have chosen the duct thickness over duct height as terminology in our surface duct analysis. The duct strength ΔM defines the strength of the duct, which is the difference in modified refractivity between the base and the top of the trapping layer.

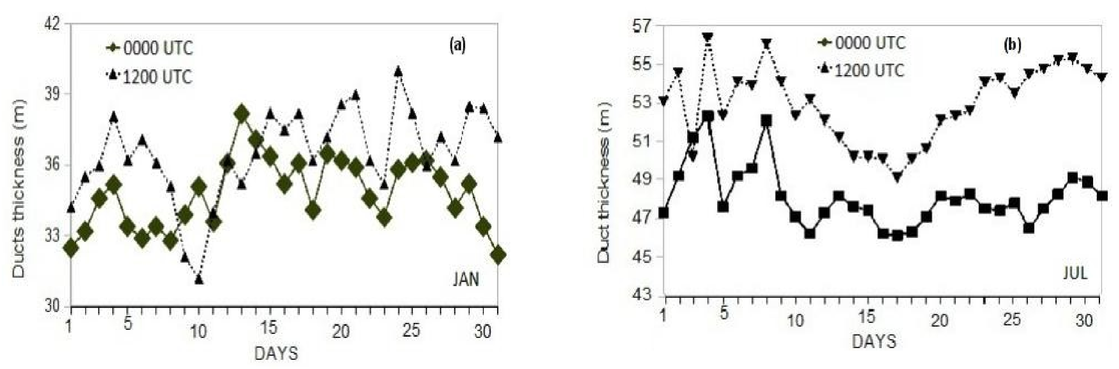

Figure 2: Daily variation of the nighttime (0000 UTC) and daytime (1200 UTC) of surface duct characteristics during the months of January and July. Graphs (a) and (b) correspond to the duct thickness and the duct strength for the month of January, whereas (c) and (d) are for July, respectively. The solid line with filled symbols represents the nighttime ducts, and the dotted line with open symbols represents the daytime ducts.

In this study, data from different clouds in Douala and neighboring areas during the days of 26 January 2009 at 23:35:25 UTC and 05 July 2009 at 23:35:52 UTC were used, due to the advantage that the satellite passes over this region. The corresponding cloudsat data are the granule 14630 and 16960 respectively for the segment 31 which moves from the geographical position (0N; 8.4E) to (11.6N; 10.9E) crossing Douala (4N, 9.7E). Figure 3 present the cloudsat data products recorded during these two days on January and July 2009.

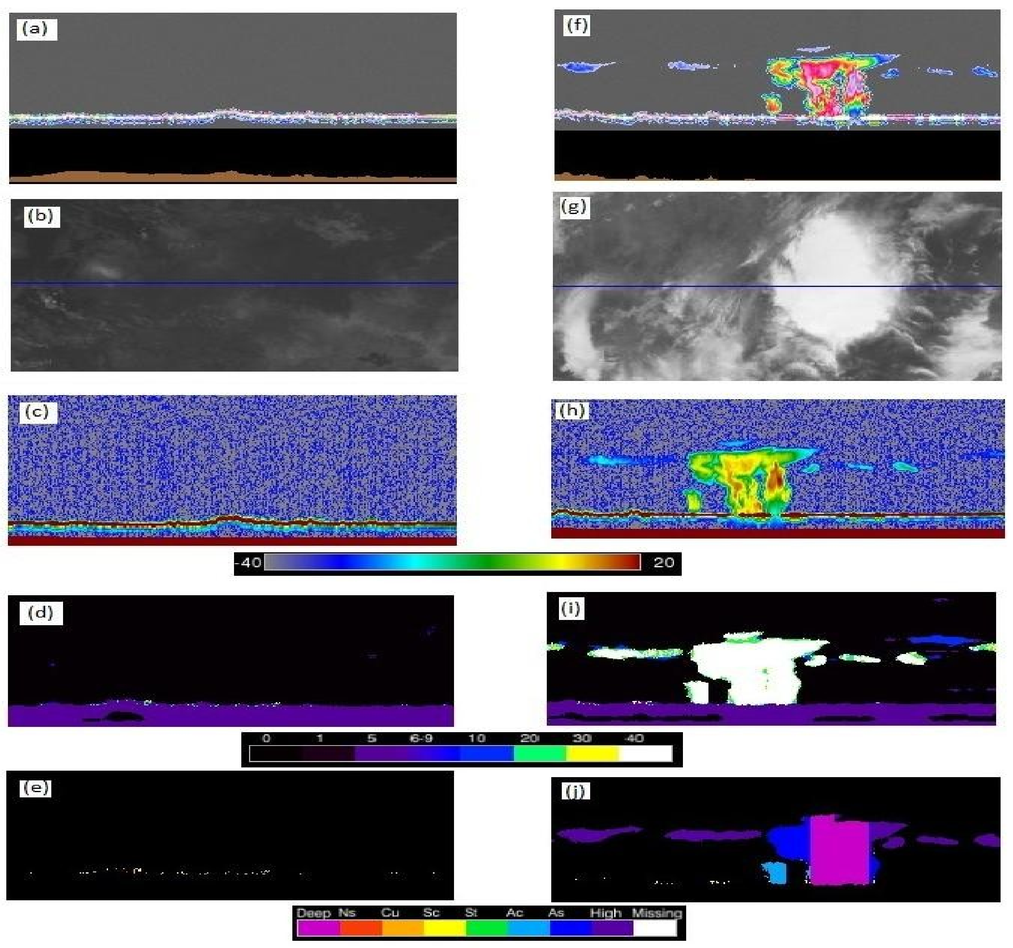

Figure 3: Cloudsat data products from the granule 14630 (left) and 16960 (right) for the segment 31 which move crossing Douala (4N, 9.7E) during the days 26 January 2009 at 23:35:25 UTC (left) and 05 July 2009 (right) at 23:35:52 UTC. (a), (f) cloud profile; (b), (g) MODIS 11µm channel; (c), (h) RADAR reflectivity; (d), (i) clod mark and (e), (j) cloud classification.

Conclusion

Using high-resolution radiosonde data, we have performed detailed analysis of surface ducts which determine the anomalous propagation days on the coastal site of Douala in Cameroon. We showed that the surface ducts were observed to occur less frequently in the dry season over the Gulf of Guinea. The median duct strength showed that the strongest ducts appear in summer and the weakest ones occur in winter. We found that the surface ducts also occur more frequently during the day than at night. Although the daytime ducts looks thicker than the nighttime ducts in general, the median difference is smallest in winter and greatest in summer. The variability of duct strength was also observed.

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