Response to Reviewer 2's comments:

The article documents, recovers and analyses historical weather records of Congo basin in present-day DRC. The weather records considered in this analysis are primarily from 1960s to 1990s, some records extending into early 2000s. The study undertakes digitalisation (imaging) of 9,885 sheets of paper from 37 weather stations in DRC. Using previously developed ML-based data transcription python-module 'Meteosaver' to recover more than one million observations of temperature and precipitation. The resulting dataset consists of daily maximum, minimum, and average temperatures (dry bulb and wet bulb) measured three times a day, and daily precipitation.

The analysis was shown to have marked warming in daily maximum, minimum, and average temperatures, corresponding to approximately 0.7°C, 0.3°C, and 0.5°C, respectively, of warming during the 1961–1990 period. It was also reported that increasing frequency of hot days and fewer cold days as compared to earlier decades in the dataset. Due to limited rainfall data, only two stations were found to experience increased frequency of heavy rainfall. Though the changes inferred from this study can not be applied to whole of DRC due to limited spatial coverage, but this study enhances our understanding of changes in climate in DRC, one of the most data sparse region in the world.

Specific comments:

The article is generally well-written and undertakes substantial data-rescue work to produce climate dataset and analyse past climate of Congo basin. The authors describe the current state of data (un)availability in Central Africa for understanding climate change in the region. They use numerous paper records archived in DRC and Belgium to fill in the data gap, and the sources and paper format is described in sufficient detail to understand background of the work being undertaken. The dataset produced has potential to answer many questions regarding scale and impact of climate change in the equatorial Africa.

This paper presents historical climate dataset for DRC, using ML-based transcription process and using statistical QC/QA steps to ensure data accuracy. While ML-based transcriptions have been researched in number of fields, using it to produce a published climate dataset of this size is probably first documented case. This attempt opens a realistic possibility of using ML-based transcriptions to extract historical observations from elsewhere.

The region's climate has been quantitatively assessed by analyzing long-term in-situ weather observations for the first time. The analysis performed within the limited spatiotemporal dataset shows that the climate has gotten warmer and maybe wetter as well. The results based on limited data support conclusions drawn, subject to further investigations.

Though the paper transcribes and analyses historical weather observations, discussion on observation techniques or instrument metadata has been largely absent. As the biases and offsets are often strongly linked to weather measurement techniques, e.g. how temperature scale was read, was a correction scale was provided/used, bucket size of rain gauge etc. The instrument make and model can also be helpful in assessing systematic biases and can be used to perform QA/QC checks and corrections.

Some discussion on why we expect to find these temperature or rainfall trends in Central Africa will be helpful. Has any earlier studies found similar trends either in observational data or model data?

We thank the reviewer for their time and valuable suggestions to improve the manuscript. Below, we respond to the individual comments and illustrate modifications to the manuscript to accommodate the concerns raised. We believe that the manuscript will benefit from these modifications. The following convention is used in this document to illustrate proposed text modifications in the original manuscript: modified text.

Individual comments:

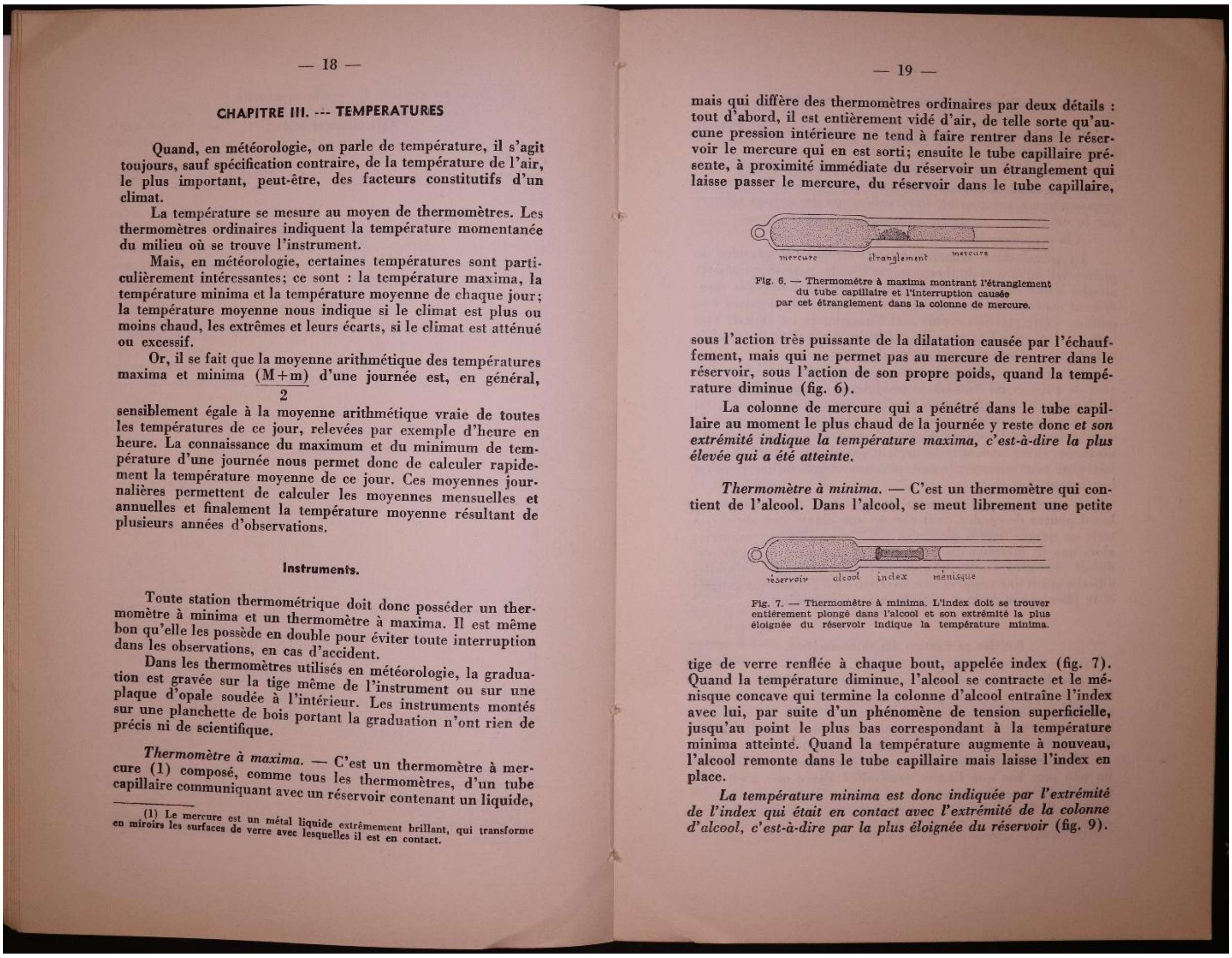
1. Though the paper transcribes and analyses historical weather observations, discussion on observation techniques or instrument metadata has been largely absent. As the biases and offsets are often strongly linked to weather measurement techniques, e.g. how temperature scale was read, was a correction scale was provided/used, bucket size of rain gauge etc. The instrument make and model can also be helpful in assessing systematic biases and can be used to perform QA/QC checks and corrections.

Response:

We agree that information on the instrumentation used at the stations, as well as measurement techniques, measurement precision, and observing practices, is important for assessing potential systematic biases in historical weather records. Some ancillary documents from *Instructions aux observateurs – INEAC* and *Guide pratique à l'usage des observateurs – Réseau Météorologique du Congo Belge* describe some of the instruments and observation procedures prescribed for use at the stations, including thermometer types, measurement techniques, and rain-gauge information. These documents are available through the COBECORE records (Jacobsen et al., 2018; Coppieters. G., 2013). In the revised manuscript, we propose updated text referring to these records in Section 2.1 and include examples in the Appendix Figs. B4–B5. However, these available metadata are not sufficiently complete to reconstruct station-specific histories of instrument changes, calibration procedures, measurement precision, station relocations, or observing practices over the full observational period. Therefore, they could not be used to perform a formal homogenisation or systematic bias correction. We therefore also propose to clarify this limitation in the revised manuscript and explicitly discuss how such non-climatic inhomogeneities may affect the magnitude of individual station trends and part of the observed distributional shifts. At the same time, we note that the widespread warming signal across multiple stations, together with its consistency with previous regional-scale assessments, supports the robustness of the broad regional warming pattern.

To this end, we propose to add this paragraph to the Data description in **Section 2.1**:

> In addition to the weather data sheets, additional archive documents available through the COBECORE records (Jacobsen et al., 2018; Coppieters. G., 2013), namely *Instructions aux observateurs – INEAC* and *Guide pratique à l'usage des observateurs – Réseau Météorologique du Congo Belge,* provide information on some of the instruments and observation procedures prescribed for use at the stations, including thermometer types, measurement techniques, and rain-gauge information. These documents demonstrate that standardised instrumentation and observation procedures were prescribed to ensure rigorous and consistent measurements across the INEAC/INERA observational network. Examples of these documents are shown in Appendix Figures B4-B5.



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CHAPITRE III. --- TEMPERATURES

Quand, en météorologie, on parle de température, il s'agit toujours, sauf spécification contraire, de la température de l'air, le plus important, peut-être, des facteurs constitutifs d'un climat.

La température se mesure au moyen de thermomètres. Les thermomètres ordinaires indiquent la température momentanée du milieu où se trouve l'instrument.

Mais, en météorologie, certaines températures sont particulièrement intéressantes; ce sont : la température maxima, la température minima et la température moyenne de chaque jour; la température moyenne nous indique si le climat est plus ou moins chaud, les extrêmes et leurs écarts, si le climat est atténué ou excessif.

Or, il se fait que la moyenne arithmétique des températures maxima et minima $\frac{(M+m)}{2}$ d'une journée est, en général, sensiblement égale à la moyenne arithmétique vraie de toutes les températures de ce jour, relevées par exemple d'heure en heure. La connaissance du maximum et du minimum de température d'une journée nous permet donc de calculer rapidement la température moyenne de ce jour. Ces moyennes journalières permettent de calculer les moyennes mensuelles et annuelles et finalement la température moyenne résultant de plusieurs années d'observations.

Instruments.

Toute station thermométrique doit donc posséder un thermomètre à minima et un thermomètre à maxima. Il est même bon qu'elle les possède en double pour éviter toute interruption dans les observations, en cas d'accident.

Dans les thermomètres utilisés en météorologie, la graduation est gravée sur la tige même de l'instrument ou sur une plaque d'opale soudée à l'intérieur. Les instruments montés sur une planchette de bois portant la graduation n'ont rien de précis ni de scientifique.

Thermomètre à maxima. — C'est un thermomètre à mercure (1) composé, comme tous les thermomètres, d'un tube capillaire communiquant avec un réservoir contenant un liquide,

(1) Le mercure est un métal liquide extrêmement brillant, qui transforme en miroirs les surfaces de verre avec lesquelles il est en contact.

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mais qui diffère des thermomètres ordinaires par deux détails : tout d'abord, il est entièrement vidé d'air, de telle sorte qu'aucune pression intérieure ne tend à faire rentrer dans le réservoir le mercure qui en est sorti; ensuite le tube capillaire présente, à proximité immédiate du réservoir un étranglement qui laisse passer le mercure, du réservoir dans le tube capillaire,

Fig. 6. — Thermomètre à maxima montrant l'étranglement du tube capillaire et l'interruption causée par cet étranglement dans la colonne de mercure.

sous l'action très puissante de la dilatation causée par l'échauffement, mais qui ne permet pas au mercure de rentrer dans le réservoir, sous l'action de son propre poids, quand la température diminue (fig. 6).

La colonne de mercure qui a pénétré dans le tube capillaire au moment le plus chaud de la journée y reste donc *et son extrémité indique la température maxima, c'est-à-dire la plus élevée qui a été atteinte.*

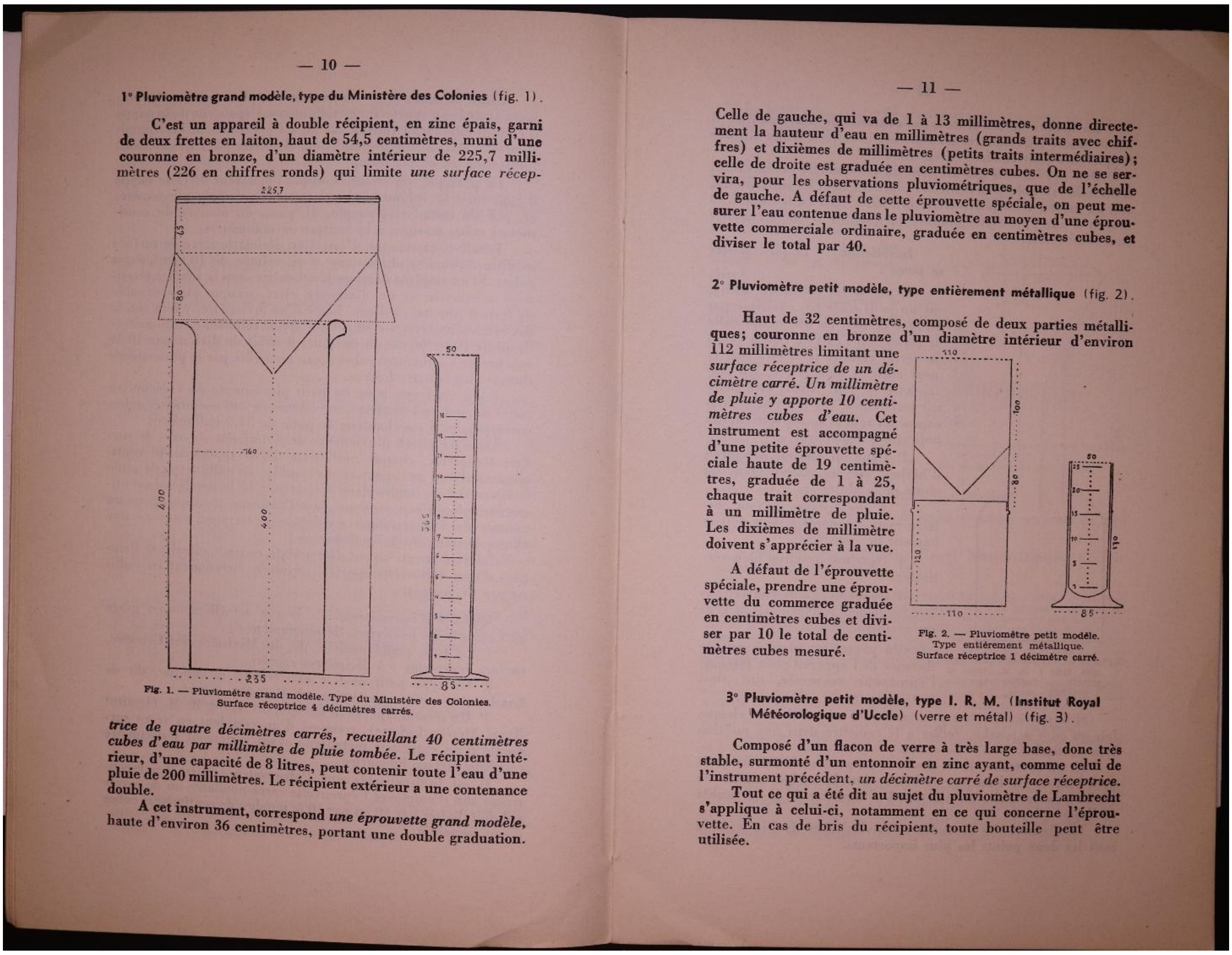
Thermomètre à minima. — C'est un thermomètre qui contient de l'alcool. Dans l'alcool, se meut librement une petite

Fig. 7. — Thermomètre à minima. L'index doit se trouver entièrement plongé dans l'alcool et son extrémité la plus éloignée du réservoir indique la température minima.

tige de verre renflée à chaque bout, appelée index (fig. 7). Quand la température diminue, l'alcool se contracte et le ménisque concave qui termine la colonne d'alcool entraîne l'index avec lui, par suite d'un phénomène de tension superficielle, jusqu'au point le plus bas correspondant à la température minima atteinte. Quand la température augmente à nouveau, l'alcool remonte dans le tube capillaire mais laisse l'index en place.

La température minima est donc indiquée par l'extrémité de l'index qui était en contact avec l'extrémité de la colonne d'alcool, c'est-à-dire par la plus éloignée du réservoir (fig. 9).

Appendix Figure B4: Example of COBECORE archive documents describing thermometers used to measure daily maximum and minimum temperatures and observation procedures used at INEAC/INERA stations. These documents provide useful contextual metadata and demonstrate that standardised instrumentation and observation procedures were prescribed across the INEAC/INERA observational network. However, they do not constitute complete station-specific histories of instrument changes, calibration procedures, relocations, or observing practices over the full observational period (Source: *Guide pratique à l'usage des observateurs – Réseau Météorologique du Congo Belge*; available in the COBECORE records (Jacobsen et al., 2018; Coppieters. G., 2013).



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1° Pluviomètre grand modèle, type du Ministère des Colonies (fig. 1).

C'est un appareil à double récipient, en zinc épais, garni de deux frettes en laiton, haut de 54,5 centimètres, muni d'une couronne en bronze, d'un diamètre intérieur de 225,7 millimètres (226 en chiffres ronds) qui limite *une surface réceptrice de quatre décimètres carrés, recueillant 40 centimètres cubes d'eau par millimètre de pluie tombée.* Le récipient intérieur, d'une capacité de 8 litres, peut contenir toute l'eau d'une pluie de 200 millimètres. Le récipient extérieur a une contenance double.

Fig. 1. — Pluviomètre grand modèle. Type du Ministère des Colonies. Surface réceptrice 4 décimètres carrés.

A cet instrument, correspond *une éprouvette grand modèle*, haute d'environ 36 centimètres, portant une double graduation.

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Celle de gauche, qui va de 1 à 13 millimètres, donne directement la hauteur d'eau en millimètres (grands traits avec chiffres) et dixièmes de millimètres (petits traits intermédiaires); celle de droite est graduée en centimètres cubes. On ne se servira, pour les observations pluviométriques, que de l'échelle de gauche. A défaut de cette éprouvette spéciale, on peut mesurer l'eau contenue dans le pluviomètre au moyen d'une éprouvette commerciale ordinaire, graduée en centimètres cubes, et diviser le total par 40.

2° Pluviomètre petit modèle, type entièrement métallique (fig. 2).

Haut de 32 centimètres, composé de deux parties métalliques; couronne en bronze d'un diamètre intérieur d'environ 112 millimètres limitant une *surface réceptrice de un décimètre carré. Un millimètre de pluie y apporte 10 centimètres cubes d'eau.* Cet instrument est accompagné d'une petite éprouvette spéciale haute de 19 centimètres, graduée de 1 à 25, chaque trait correspondant à un millimètre de pluie. Les dixièmes de millimètre doivent s'apprécier à la vue.

A défaut de l'éprouvette spéciale, prendre une éprouvette du commerce graduée en centimètres cubes et diviser par 10 le total de centimètres cubes mesuré.

Fig. 2. — Pluviomètre petit modèle. Type entièrement métallique. Surface réceptrice 1 décimètre carré.

3° Pluviomètre petit modèle, type I. R. M. (Institut Royal Météorologique d'Uccle) (verre et métal) (fig. 3).

Composé d'un flacon de verre à très large base, donc très stable, surmonté d'un entonnoir en zinc ayant, comme celui de l'instrument précédent, *un décimètre carré de surface réceptrice.*

Tout ce qui a été dit au sujet du pluviomètre de Lambrecht s'applique à celui-ci, notamment en ce qui concerne l'éprouvette. En cas de bris du récipient, toute bouteille peut être utilisée.

Appendix Figure B5: Example of COBECORE archive documents describing rain gauges used to measure daily precipitation and observation procedures used at INEAC/INERA stations. These documents provide useful contextual metadata and demonstrate that standardised instrumentation and observation procedures were prescribed across the INEAC/INERA observational network. However, they do not constitute complete station-specific histories of instrument changes, calibration procedures, relocations, or observing practices over the full observational period (Source: *Guide pratique à l'usage des observateurs – Réseau Météorologique du Congo Belge*; available in the COBECORE records (Jacobsen et al., 2018; Coppieters. G., 2013).

We also propose the following updates to the text in the **Discussion Section 4.2:**

> However, it is important to note that, while QA/QC checks were applied to identify and correct transcription errors and physically inconsistent values, homogenisation was not performed to detect and adjust for potential non-climatic inhomogeneities in the station records. Such inhomogeneities, well-rehearsed throughout the literature, may arise from changes in station location, instruments, calibration procedures, measurement precision, observation times or practices, and could introduce artificial (non-climatic) shifts in the temperature time series (Williams et al. 2012; Peterson et al., 1998). While digitized records documenting the types of instruments used and some measurement procedures

are available in the COBECORE records (Appendix Figures B4-B5 ; Jacobsen et al., 2018; Coppieters. G., 2013), the available metadata are not sufficiently complete to reconstruct station-specific histories of such changes throughout the full observational period.

Possible physical contributors may also have influenced differences among the station records. These include differences in elevation (Hock et al. 2019), changes in the immediate station environment, proximity to forests or water bodies, and local and remote land-use or land-cover change (Zeppetello et al., 2020). For instance, Mangaza et al. (2026) report a loss of approximately 9.7% of tropical forest in the Tshopo province, where three stations in our dataset are located (Yangambi-Km.5, Yaekama, and Gazi; the former two analysed), over the period 1900-2023 due to deforestation for agriculture and settlement. Within Yangambi alone, approximately 24 ha of primary forest was lost between 2002 and 2025, accounting for only about 2% of the total tree-cover loss in the area recorded over the same period (Global Nature Watch, 2026; Turubanova, S. et al. 2018; Hansen, M. C. et al. 2013). Between 2001 and 2025, permanent agriculture was associated with approximately 19% of the tree-cover loss in Yangambi (Global Nature Watch, 2026; Sims, M.J. et al. 2025; Hansen, M. C. et al. 2013). Such changes can lead to localised warming effects (Zeppetello et al., 2020).

More generally, differences in trend magnitude and sign among stations may reflect a combination of large-scale climate variability, local environmental conditions, and station-specific non-climatic effects. However, because this study did not perform a formal attribution analysis, we could not quantify the relative contributions of such possible drivers to the observed station-level trends. Therefore, part of the distribution changes may reflect these local physical and/or non-climatic influences from one or more stations, although the consistency with previous regional assessments suggests that the broad warming pattern is robust.

2. Some discussion on why we expect to find these temperature or rainfall trends in Central Africa will be helpful. Has any earlier studies found similar trends either in observational data or model data?

Response:

We thank the reviewer for this suggestion. We agree that, although the original manuscript already compared our temperature results with previous regional assessments, the discussion could more clearly place our findings in the context of earlier studies of temperature trends and extremes in Central Africa. In the revised manuscript, we will expand Sect. 4.2 by adding, in addition to the regional assessment by Doherty et al. (2022), a comparison with Aguilar et al. (2009) who reported similar warming trends in temperature extremes in Central Africa, namely trends in the warmest day, warmest night, coldest day, and coldest night temperatures during the period 1955 to 2003, additional stations in the DRC that are distinct from those analysed in this study. We keep the discussion of precipitation more cautious because, as already stated in Sects. 3.1, 3.3.3, and 4.4, only three stations have sufficiently complete QA/QC-confirmed daily precipitation records for the precipitation analysis. We therefore avoid drawing broader conclusions about rainfall trends across the DRC. We propose the following modifications to the text in **Discussions Section 4.2**:

Twenty of the 21 stations considered in this study show an increasing trend in at least one of the Tx, Tn, or Tavg values. The median warming trends are 0.22°C, 0.10°C, and 0.15°C per decade for Tx, Tn, and Tavg, respectively, which correspond to approximately 0.7°C, 0.3°C, and 0.5°C of warming over 30 years. When scaled to multi-decadal periods, these station-based trends are of similar magnitude to the reported warming of 0.75-1.05°C since 1960 for Central Africa (Doherty et al., 2022), indicating consistency between in-situ observations and prior regional-scale assessments that did not have access to these data.

These station-based trends are also consistent with the broader expectation of warmer temperature distributions under a warming climate. Similarly, Aguilar et al. (2009) reported warming trends in Central African temperature-extreme indices, including the warmest day, warmest night, coldest day, and coldest night, of 0.25°C, 0.21°C, 0.13°C, and 0.23°C per decade, respectively, over the period 1955-2006, based on station observations from countries in the region, including additional stations in the DRC that are distinct from those analysed in this study.