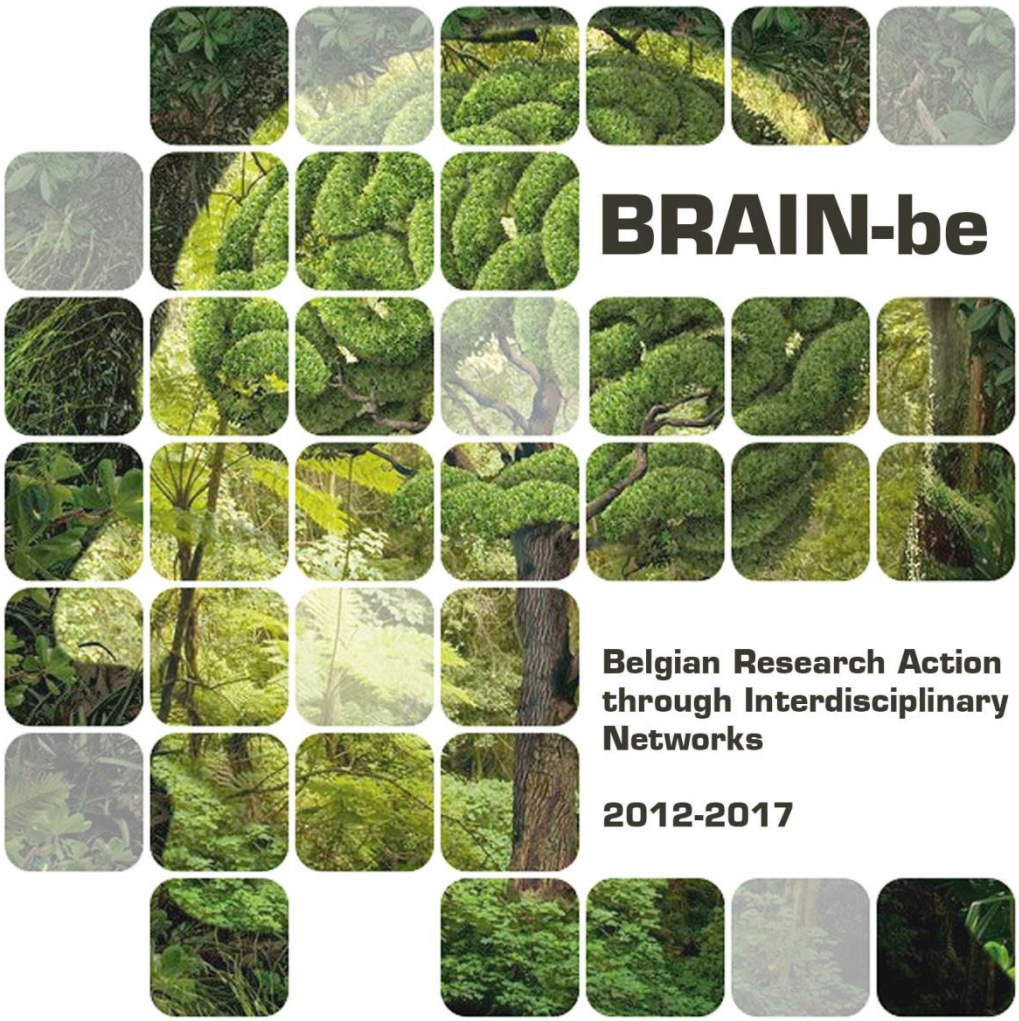

COBECORE

Congo basin eco-climatological data recovery and valorisation

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Axis 3: Cultural, historical and scientific heritage

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NETWORK PROJECT

COBECORE

Congo basin eco-climatological data recovery and valorisation

Contract - BR/175/A3/COBECORE

FINAL REPORT

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TABLE OF CONTENTS

ABSTRACT

The Congo Basin rainforest covers more than 600 million ha, stores up to 66 Pg of carbon and is a persistent carbon sink (0.34 Pg C yr-1). The African rainforests also contribute significantly to GDP through the forestry sector. Despite this relevance, predictions regarding forest resilience under climate change remain uncertain, in part due to a lack of long-term data. Much of the necessary baseline information is available in historic paper archives from the colonial period, yet practically inaccessible for contemporary research reliant on accessibility through digital data repositories.

The COBECORE project aimed to establish baseline measurements necessary for long-term (retrospective) ecological and climatological research in the Congo Basin. Through the development of a multi-faceted database, including three data streams (aerial photography, climate data and leaf trait data), COBECORE contributed to the digital accessibility of the analogue archives of the Institut National pour l'Etude Agronomique du Congo Belge (INEAC).

The COBECORE project implemented state-of-the-art digitization techniques, including machine learning, citizen science and several European collaborations, resulting in practical insights for future digitization projects, outreach for secondary schools and public interest, and numerous publications in A1 scientific journals. The data recovered during COBECORE continues to inspire new research opportunities and remains a valuable reference for contemporary research.

Keywords: data recovery, digitization, historical data, climate change, Congo basin, tropical forests, forest resilience

1. INTRODUCTION

The African rainforest is the second largest on Earth. It covers ~630 million ha and stores up to 66 Pg of carbon. It is presently a persistent carbon sink (0.34Pg C yr^{-1}). In addition, African rainforests support the forestry sector, which contributes 3-6% of the gross domestic product (GDP) across the Congo Basin with most foreign export directed to Europe. As such, the African rainforest currently represents both a local and foreign (EU) economic driver.

Our understanding of forest ecosystem responses to climate change relies on consistent long-term observations to provide baseline measurements. However, observing and measuring tropical plant species in their natural habitat is demanding, particularly in the central Congo Basin. Consequently, established long-term observation programs are rare. For example in terms of meteorological observations, the central Congo Basin is currently represented by only a few rain gauges, seriously limiting climate forecasts across the Congo Basin. Similarly, few long-term forest inventory plots exist for the central Congo Basin limiting the accuracy of biomass estimates and our understanding of forest structure and function. Leaf traits stored in herbarium collections, such as leaf area, stomatal density and stomatal size, provide information on species' life cycle strategy, habitat and climate. This lack of digitally accessible long-term (historical) eco-climatological data leaves the central Congo Basin spatially and temporally under-represented in most contemporary analyses.

Five decades worth of pre-1960 ecological and climatological data exists on paper as unexplored heritage, stored in various federal archives and collections. Within this context key archives include the Institut National d'Etudes Agronomique du Congo Belge (INEAC) at the State Archives (SA, INEAC March 2013, I 546, National Archives), publications and aerial photographs stored at the Royal Museum for Central Africa (RMCA) and the herbarium collections of the Meise Botanic Garden (Meise BG), with its large collection of tropical African plant specimens and complementary legacy data. The inventory of these archives include historic forestry, climatological, ecological, biodiversity data and aerial photographs, with great potential and relevance for current and future basic and applied forestry research in the central Congo Basin, particularly within the context of climate change.

The need for a comprehensive digitally accessible dataset of long-term eco-climatological legacy data for the central Congo Basin was evident. To this end, the Congo basin eco-climatological data recovery and valorisation project (COBECORE) united an interdisciplinary network of partners, i.e Ghent University (UGent), the Royal Museum for Central Africa (RMCA), the State Archives (ARCH) and Meise Botanic Garden (Meise BG), with the objective to establish baseline measurements necessary for (retrospective) eco-climatological research by valorising unexplored historical data.

2. OBJECTIVES

The project harnessed a wide array of new technology, generating three data streams through the completion of it's four objectives: (1) a historical climate record for the central Congo basin; (2) historic metrics of forest structure through digitization of aerial photographs; (3) historic leaf traits from herbarium specimens; and (4) data integration and dissemination. The tasks completed in order to obtain these objectives are listed in Table 1.

3. METHODOLOGY

The tasks completed during the COBECORE project are listed in Table 1. A description of these tasks is provided in the text below.

Table 1: Overview of work packages of the COBECORE project and associated tasks

Work package	Task
WP 1: Identification and organization of complementary sources of ecological, climatic and land use change (meta)data	Task 1.1: Preliminary identification of (meta)data sources from the INEAC and related archives Task 1.2 Selective sampling of data from the INEAC archives at the State Archives, RMCA and in the federal collections of BGM following COBECORE
WP 2: digitization, registration and validation of (meta)data	Task 2.1 Registration of meta-data related to information extracted from the INEAC archives, such as corroborative research within the INEAC archives and in complementary archives and validation of meta-data types. Task 2.2 Digitization of legacy aerial photographs. Task 2.3 Digitization from the INEAC archives at the State Archives, RMCA and in the federal collections of BGM (Digitization INEAC data). Task 2.4 Digitization of herbarium specimens for stomatal density analysis + additional leaf trait parameters (Microscope digitization of herbarium specimen).
WP 3: Valorization of digitized data	Task 3.1 Transcription of digitized meteorological records and ecologically relevant forest inventory data as well as stomatal density counts inventory data as well as stomatal counts and size measurements. (Meteorological record transcription) Task 3.2 Geo-referencing of legacy aerial photography, as well as analysis of Land Use and Land Cover Change (LULCC) and textural metrics of canopy structure
WP 4: Enhancing the accessibility of the INEAC archives and valorizing their potential within a scientific and international context	Task 4.6 Internal review and reporting Task 4.7 Public awareness and public relations (PR outreach)

3.1 Identification of main sources of data

This activity included exploratory visits to the State Archives (I-546, the INEAC archives), the RMCA (central library, archives stored by the Geology department, INEAC publications stored at the Wood Biology section), and the Botanic Garden Meise (visits to the library, identification of relevant herbarium collection pieces in the Herbarium Africanum). After an initial mapping of existing materials (climate data, aerial photographs, herbarium specimens), additional searches targeted specific protocols and other complementary documentation (Bulletin Agricole, documents describing protocol and sampling equipment used during colonial times, etc). In this way we were able to locate for

example the flight plans describing when and how aerial photography data was acquired (Figure 1) and the protocols used for climate data collection, including a list of sites of the climatological stations at various points in time throughout the Congo Basin (see: http://cobecore.org/map/).

3.2 Creation of a digital archive

3.2.1 Aerial photographs

COBECORE prioritized regions under study within the context of past (eg. COBIMFO, FORETS) and on-going projects (eg. FORETS2) projects as a means to increase the impact for contemporary research initiatives. Therefore digitization of aerial photographs focussed on the Yangambi region. High-resolution digital images were created with the help of a volunteer (Thales D'Hauville). The scans are stored on the UGent network shares (S:\shares\cobecore_aerial_photo) and consist of 378GB, 403 files and 11 folders, whereby each folder corresponds with a flight path (Fig 1).

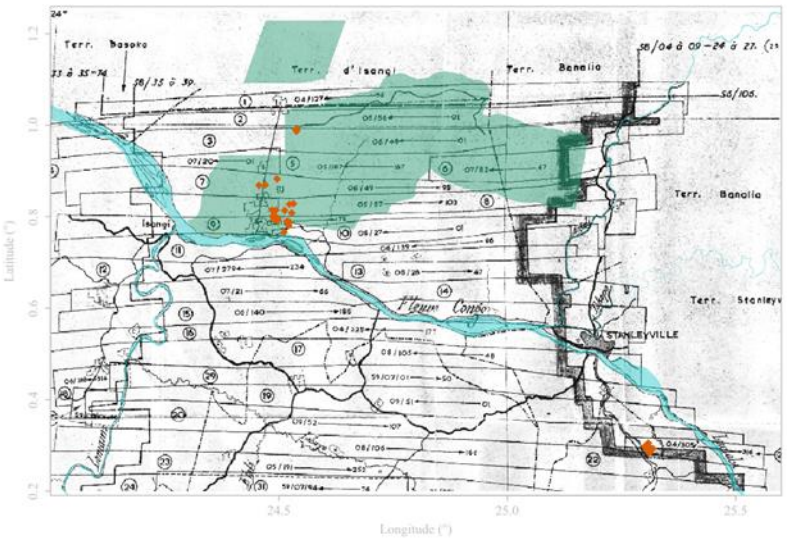

Figure 1: a geo-referenced historical map of the Kisangani region outlining the flight paths of various aerial photography mapping campaigns.

3.2.2 Climate data

COBECORE focussed on data collected by INEAC, the colonial weather service and airports (stored in the National Archives of Belgium, I-546). Several complementary protocol publications at the state archives and in the library collections at the RMCA were also scanned. COBECORE selected only stations that collected at least precipitation and temperature data.

At the State Archives a digitization setup was installed (Figure 2). The basic hardware setup consisted of a reproduction stand, digital camera and laptop for data storage. We were able to scan at a rate of around 700 scans/day. Digitization was initially carried out by Kim Jacobsen and Koen Hufkens, later they provided supervision for digitization. An UGent MSc student from the DRC, Innocent Banzi Ngulu-Kulu digitized sub-daily data at Yangambi for his Masters thesis. Afterwards a new staff member was

recruited at the State Archives, Leen Van Hirtum (Niv. C, full-time) to help with digitization activities. (NB: she continued to work in association with COBECORE at the Africamuseum and is currently pursuing a PhD at the UGent at the Faculty of Arts and Philosophy on the topic "INEAC: Agricultural science and development in the Belgian Congo" under supervision of Prof Felicitas Becker).

Raw image scans of the climatological records were stored locally and remotely via a VPN connection to the servers at UGent. The RAW image scans of the climate data sheets from the INEAC archives are stored on the UGent network shares (S:\shares\cobecore\raw_image_data). They consist of 554 GB, 83741 files in 1244 folders, whereby each folder is identified by the inventory label which can be found in the inventory of the INEAC archives, I-546, see: https://search.arch.be/ead/pdf/BE-A0510_003812_005470_DUT.ead.pdf, p567-769. This identifier links to the file/folder name used by the State Archives to hold the climate data.

The climate data scans represent data from +500 station locations, for stations holding at least temperature and rainfall data. The additional files in the RAW image folder are scans concerning protocols and complementary files (see below). A detailed description of all climate data (raw and derived) can be found in the README file in the annex (COBECORE-climate-README.txt). Both offline and online copies are retained at Ugent, with additional copies distributed to all project partners in order to provide offline backups and easy (local) access to all project material.

Figure 2: Digitization set-up including reproduction stand, lights, computer for direct image transfer and a background mask

With so many **climate data** sheets scanned (+73 000 scans), climate data transcription is a formidable task. For the two parameters temperature and rainfall alone, at least 4 200 000 individual values must be transcribed.

For this reason, COBECORE explored different methods to achieve its goal:

1) **Manual transcription** of temperature and rainfall for two stations (Eala and Yangambi) was carried out by a Congolese **MSc** student (Innocent Banzy Ngulu Kulu) for his **thesis**. From this exercise it became clear that the transcription, data cleaning and analysis could not be feasibly completed by experts or a few staff alone during the short time span of the COBECORE project. For a full description of the methodology used, please see his thesis: https://lib.ugent.be/en/catalog/rug01:002785179/files/0

2) **Manual transcription** of temperature, rainfall and surface pressure data for stations that hold surface pressure data. Job students employed by Jürg Luterbacher of the Section Climatology, Climate Dynamics and Climate Change, Dept. Geography at the Justus-Liebig Universitat Giessen in Germany. This **collaboration** was facilitated by Rob Allan (COBECORE Follow-up committee)

3) **Manual transcription** of climate **data "availability"**: as a fail-safe, this dataset is being created to assist with prioritization of the transcription activities by creating a database that lists the availability of climate data parameters, for a given time frame and location. Since COBECORE started, we have received several queries regarding data availability. This database is currently being created with the assistance of volunteer help at the RMCA. We have so far inventoried approximately 15-20% of the scans.

4) Exploring **automated transcription of tabular handwritten data**: Collaboration was initiated with Gunter Mühlberger of the READ (Recognition and Enrichment of Archival Documents) project (an EU-funded H2020 project) and the Dept German Language and Literature, University of Innsbruck, Austria. **Transkribus** aims to develop a prototype tool for Optical Character Recognition of table data. Although much progress has been made with this HTR software, we are not yet at the stage where fully automated transcription yields qualitatively high results.

5) **Transcription via crowdsourcing**: The Zooniverse **citizen science** project "Jungle Weather". Scans were ordered into 24 different formats to facilitate post processing. The bulk of these are represented by three formats, which cover well over half of the scans. Ten thousand scans were formatted to support transcription through a citizen science project on the Zooniverse platform (https://www.zooniverse.org/projects/khufkens/jungle-weather/classify). Data sheets were matched with a known template to accurately extract individual cells in the data sheets. Subsequently, a custom Deep Learning algorithm was applied to detect if cells are empty or not. The model used in this Deep Learning framework was acquired by transfer learning of an existing classifier. An accuracy of 98% was attained with little or no commission errors on identifying empty cells. This workflow allowed us to accurately extract completed cells of the table. As a final step these images were presented to citizen scientists for transcription. A basic workflow was presented to Zooniverse review before release. In 2020, COBECORE completed this citizen science effort, with the Zooniverse project "Jungle Weather". More than 2300 volunteers from around the world registered (with additional unregistered volunteers participating). Together they annotated over 350 000 data cells, equivalent to roughly 10% of the temperature and precipitation data. Each data cell was looked at 1.8 million times to ensure quality control. The entire dataset will require the

annotation of over 4 million values. Part of the success of this effort was probably due to the covid-19 lockdown situation, leaving many volunteers searching for distraction online. The next step will attempt to use this data to train a machine learning algorithm enabling automatic transcription of the remaining scans (https://www.zooniverse.org/projects/khufkens/jungle-weather/classify). Resulting data was deposited in a public Zenodo archive (Hufkens & Jacobsen 2022 https://doi.org/10.5281/zenodo.7104838).

6) A new R package ECMWF was developed at the Richardson lab in Arizona (USA), by Koen Hufkens (https://khufkens.github.io/ecmwfr/). This package can query European Centre for Medium-Range Weather Forecasts (ECMWF) climate data & allows also for easy querying of ECMWF climate reanalysis data for use in data comparisons and description upon completion of climate data transcription. Other software was generated to support transcription efforts and deposited in publicly accessible repositories, e.g. the JungleWeather processing workflow is documented in https://github.com/khufkens/jungleweather (Hufkens 2019).

7) At the time of this report, MSc student Justine Luca is working on the compilation of a **comprehensive dataset** for the Yangambi region, and additional description of the climate datasets generated during the COBECORE project.

3.2.3 Herbarium data

The leaf traits of stomatal density, stomatal size, specific leaf area (the ratio of leaf area to dry mass) and leaf surface area, are important parameters in ecosystem models and indicators of adaptation to climate change in their own right. These data were extracted from about 1385 specimens representing 125 species. Specimens for data extraction were selected based on three research questions: (1) photosynthetic response to changing climate conditions in the Congo basin, (2) functional trait evolution of the economically important Coffea genus and (3) functional trait evolution of tropical rainforest trees.

Six thousand leaf scans (number of specimens x 5 leaves per specimen) have been made for surface area measurements, while a total of 5430 photos (number of specimens x 5 leaves x 3 pictures) have been produced for stomata counts. Visualizing of stomata on the dried leaf material was carried out using the nail varnish method. The use of dried material in the herbaria posed particular problems (eg. quality decreases after drying & stomata shrink). To quantify this shrinkage by drying stomata size from 12 tropical tree species from the living collection were compared before and after drying. This showed an average shrinkage of almost 2 microns (2 - 20%), which is something to consider when we use these data for research.

Although the objectives written in the research were obtained, the extraction of leaf trait data from herbarium specimens was continued by two volunteers working at Meise Botanic Garden, internship students at Meise, and a CIFOR funded Congolese MSc student, Yves Hatangi, who focuses on the relationship between leaf functional traits and climate change in the understory of the Congo basin rainforest.

Students, volunteers and scientists contributed to the extraction of leaf functional trait data of tropical African herbarium specimens. In order to standardize measurements, a protocol was written and distributed to collaborators. Still, in particular cases, deviating from this protocol was necessary for reasons related to the nature of the herbarium specimens (e.g. very small or very large leaves). For some species it was very challenging to obtain stomata prints, e.g. due to the presence of hairs on the leaves, and alternative protocols should be developed. Some of the measurements were quite destructive for the valuable herbarium specimens, and care should be taken to apply a methodology that keeps the specimens as much as possible intact.

3.2.4 Protocols and complementary documentation

- Additional digitisations at the RMCA: Digitization of certain key publications stored at the Africamuseum. Specifically, *The Bulletin Agricole du Congo Belge et du Ruanda-Urundi* & the *Bulletin d'Information de l'INEAC* were scanned and uploaded to the **Agricultural Research Archive for the DRC, Rwanda and Burundi, 1885-1960 (beta version)**. These key publications are now accessible online from a server located in Belgium (http://ineac.africamuseum.be/) and also from a mirror server located at the CRGM in the Democratic Republic of Congo. (http://ineac.rdcmirrorsmrac.org/); this answers a need expressed in 2016 by the DG of INERA to the director of the RMCA to provide documentation on research carried out by INEAC during colonial times. An ever-increasing number of publications is available, and searchability is increased through character recognition techniques and additional meta-data. This work was carried out with additional funding provided by the Framework agreement between the RMCA and Belgian Development Cooperation (DGD).

- Additional digitisations at the State Archives (climate data): Additional documents, photographs and reports that augment the interpretation of the climate data or that hold particular historical value have also been digitized and are now accessible through the website of the State Archives: (https://search.arch.be/en/zoeken-naar-archieven/zoekresultaat/ead/rabscans/zoekterm/ineac/eadid/BE-A0510_003812_005470_DUT).

- Additional digitisations at the State Archives (forestry data): Contemporary research on tropical forests benefits from access to the historical grey literature, such as reports from study visits at the start of the *Forestry Division* of INEAC, which are stored in the archives of the National Archives of Belgium. Reports and relevant complementary information stored in the INEAC archives for the forestry division (focus on Yangambi and Luki) was also scanned and is available on the Ugent servers in the raw image data folder under "Division Forestiere" (52,6GB; 8291 files, 333 folders). A descriptive README text is provided in annex (Luki en Yangambi reservaten INEAC-archief.odt). Other metadata and complementary information regarding climate data can be found in the folder raw image data under "congo maps" and "Documentation_feb2018.

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

*Note: The **Results** of COBECORE are a reflection of the objectives: "to make available eco-climatological data (digitally) accessible for contemporary research". As such, we present in this section the results of the digitisation operation. The data that was transcribed from the scanned documents and digital images made from aerial photographs and herbarium specimens. **Recommendations** focus on the digitisation process.*
*The **Valorisation** section (below) refers to scientific observations and conclusions made from this data, and is best reflected in the publication record.*

4.1 Aerial photographs

The high-resolution scans of historical aerial photographs can be considered big data (~300 GB). Compositing these data was constrained by computational power, but resolved by employing a graphics card with accelerated optimization techniques during image matching. This allowed for acceptable processing times and high-resolution results.

A subset of the photographs was geo-referenced in the context of the FORETS project (an EU-funded project, with RMCA as partner) to look at land use and land cover change around the Yangambi region. The interaction with FORETS highlights the relevance of this data for contemporary research. The geo-referenced photographs were compared with drone footage taken by the FORETS project.

A full composite is visualized here: http://cobecore.org/aerial_photo_map/. This large orthomosaic (~93,431 ha) was geo-referenced to ~4.7 ± 4.3 m at submeter resolution and served as a basis of a **land use land cover (LULC) change analysis**. A scrollable and zoomable map shows an orthomosaic composite of aerial photos taken at the beginning of 1958, covering much of the village of Yangambi and the ongoing agricultural research at the time (at ¼ of the true resolution for visualization purposes). The full flight paths were composited into geoTIFF files, with most of these files georeferenced. Some images throughout flight paths could not be composited in full due to the lack of clear landscape features (due to the self-similar nature of the forest). However, more than 90% of the scanned data was used in the final composites.

Although the data is roughly georeferenced, there remains a consistent offset throughout the dataset. Since the final use cases of the data are not known we opted to retain the globally consistent data, not further pursuing locally accurate referencing. We can provide instructions to users to accurately geo-reference the data for their particular purpose. In doing so, workload and usability of the data across research domains remains balanced. The scanned data from the aerial photographs is accessible via a zenodo archive (cfr Publications, below), where it can be directly downloaded and used as such.

To further assist in valorization (eg. Analysis of land use, land cover change and forestry components using the historical images and contemporary satellite imagery), Koen Hufkens developed the FOTO R package, available through his github (see : https://github.com/bluegreen-labs/foto). The FOTO (Fourier Transform Textural Ordination) method uses a principal component analysis (PCA) on radially averaged 2D Fourier spectra to characterize (grayscale) image texture. The package has been peer-reviewed and is hosted on the Comprehensive R Archive Network (CRAN)

The pre-processing and compositing of the aerial photographs to a publication standard was partially automated, using Structure from Motion. A workflow with historical data precludes a fully automated

approach. The final published results required intervention and manual parameter tuning to gain satisfactory results. Although we are ultimately satisfied, the lack of an automated workflow limits the scalability and usability of older aerial photography archives without the necessary time budgeted for manual processing.

A comparison of the historical aerial photographs with contemporary LULC data showed a shift from previously highly regular industrial deforestation of large areas to discrete smallholder farming clearing, increasing landscape fragmentation and providing opportunities for substantial forest regrowth. We estimated aboveground carbon gains through reforestation to range from 811 to 1592 Gg C, partially offsetting historical deforestation (2416 Gg C), in the study area. This manuscript was published in Remote Sensing (Hufkens et al., 2020)

4.2 Climate data

The **climate data** currently available in digital form consists of:

- +73 000 scans from the **original analog climate data** archive, from +500 locations. This dataset is stored on a secure server at Ghent University (S:\shares\cobecore\raw_image_data), under the supervision of Prof Hans Verbeeck (CAVELab). Total size of the COBECORE data folder: 554 GB, 83741 jpeg files in 1244 folders (these are the climate data sheets including additional metadata and scans from the Division Forestière)

- **Climate data availability**: this dataset provides an overview of the parameters that were measured each month at each location, currently +250 locations have been covered (dataset creation ongoing on volunteer staff time). This dataset is stored on a secure server at Ghent University (S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\climate_data_availability), under the supervision of Prof Hans Verbeeck (CAVELab). Size: 5,77Mb, 305 xlsx files, 1 folder, 1 README.txt file. Automated transcription of climate data “availability” is underway. An automated methodology to determine data coverage from the scans has been implemented in order to provide meta-data on the coverage of parameters in the scanned data. This allows for easier selection of priority sites. This work is on-going

- **Surface pressure data**: 6 stations (Yangambi, Eala, Stanleyville, Tshibinda, Sangaie, Mobwasa) were selected for manual transcription (collaboration with Jürg Luterbacher (Justus Liebig University, Germany & World Meteorological Organization (WMO) in Geneva, Switzerland) because of the long-term (+10y) surface pressure data time series and its relevance for climate re-analysis. This dataset is stored on a secure server at Ghent University (S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\SurfacePressure-Luterbacher-collaboration), under the supervision of Prof Hans Verbeeck (CAVELab). Size: 9,91Mb, 6 xlsx files, 1 README.txt file

- **Temperature and rainfall data for Yangambi and Eala**: This dataset contains manually transcribed data by the MSc thesis student Innocent Banzy Ngulu-Kulu. The data concerns temperature and rainfall for the stations Eala and Yangambi during the first half of the 20th century. It consists of multiple files and folders of input data and output from the RClimdex-package. This dataset is stored on a secure server at Ghent University

(S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\Temp-Prcp-Eala-Yangambi-MSc-Innocent), under the supervision of Prof Hans Verbeeck (CAVELab). Size: 59,4Mb, 428 files, 62 folders, 1 README.txt file

- **Citizen science (temperature and rainfall)**: +350 000 data cells were transcribed during the the citizen science project "Jungle Weather" on the Zooniverse platform, equivalent to 10% of the available data. These data were observed over 1,8 million times by more than 2300 registered volunteers, ensuring quality control. In the coming year this dataset will be cleaned in an effort towards additional transcription using machine learning algorithms. A MSc student (Justine Luca) will compile a comprehensive dataset for the Yangambi region (from ~1910 until the present day; a combination of recovered historical data from pre- and post-colonial times (COBECORE & Kasongo et al. Data), and fluxtower data (CongoFlux)

- **Future automated transcription** of climate data using the Transkribus HTR software is being explored as a potential solution for transcription of the remaining climate data (contact Günther Mühlberger (Universität Innsbruck)).

- **A comprehensive dataset for Yangambi** (pre- and post-colonial climate data, linked also to the CongoFlux project) will be described and documented by a MSc thesis student (Justine Luca) in 2023

Through our digitization activities, we gained considerable insight into the (time) requirements of a successful data recovery project. For example, with modest means, using a simple reproduction stand and camera, we were able to digitize the +73 000 pages of climate data from the State archives in less than 12 months, at a speed of an estimated 700 scans per day. We also learned that when the data consists of printed tables, image processing and machine learning techniques can speed up pre-processing. For example writing the pre-processing code only took approximately two weeks, while the pre-processing of 10K scans for crowdsourcing takes roughly a day. These experiences allow us to provide informed advice on the feasibility and duration of future data recovery projects.
Collaboration with Jürg Luterbacher (Justus Liebig University, Germany & World Meteorological Organization (WMO) in Geneva, Switzerland) also allowed us to track time requirements for data transcription from scanned climate data sheets: eg. for temperature, rainfall and surface pressure data, digitization and quality control for data

- from Yangambi covering the 1950-1955 period: 30 hours
- from Sangaie 1927-1937: 45 hours
- from Kongo Mobwasa 1914-1917: 17 hours

The recovered data represents a sizable data volume, ~1000GB of scans and associated data, or Big Data. Although some key tasks have been automated, such as template matching of tables for the extraction and screening of table cells, much remains very labour intensive. For example, all recovered data needs to be sorted by table format in order for further automation to be possible. The latter translated in sorting +70K images by unique table format (i.e. 24 in total). However, time required for sorting data was largely offset by the automation of certain processes once the data was properly cleaned.

Currently, we roughly estimate 24K images (represented by 3 distinct table formats) can be automatically processed with few errors. Cursory checks for errors teach us that if they occur they are due to misclassified table formats, which influence the accuracy of the cell extraction. Of the remaining ~35K images, ~25K images are represented by a singular format. All these data combined represent the bulk of the data to be transcribed, the remaining 10K images represent various formats but also hand formatted tables. The latter can't be automated.
We hope collaborations with the Transkribus-READ project might provide solutions to deal with these disparate data streams.

4.3 Herbarium data

A collaboration was set up with Prof. Francis Wyffels (Department of Electronics and Information systems-UGent) and Prof. Jan Van den Bulcke (Department of Environment-UGent) to automate the counting and measuring of stomata and their anatomical features using pattern recognition with deep learning. Additional funding was obtained via an IMEC Smart Education@Schools project (https://www.aiopschool.be/kiks/).

The leaf trait data is accessible through the Zenodo data repository (CC-BY license): From leaf to label: A robust automated workflow for stomata detection: Light microscope images of stomata. DOI: 10.5281/zenodo.3579227. This includes all light microscope images used for training and testing of the deep learning model developed in the study: Meeus S., Van den Bulcke J., wyffels F. (2020) From leaf to label: A robust automated workflow for stomata detection. Ecol. Evol. https://doi.org/10.1002/ece3.6571.

The dataset contains 1154 images of 94 specimens (461,8 MB) and has since its publication on October 27, 2020, been downloaded 3733 times. For additional details about the dataset, species and specimens, please see supplementary material from the Ecology & Evolution paper. All details, including barcodes of the specimens visible in the online botanical collections site (www.botanicalcollections.be) See: http://www.botanicalcollections.be/#/en/specimen/*barcode*

In order to validate conclusions drawn from stomatal density counts in relation to climate change, δ13C, δ18O and δ15N **isotope contents** were determined from leafs of 203 specimens (23 species, 3 time frames and 3 replicates per time frame) for which stomata data are also available. The evolution of water use efficiency and its causes (increased photosynthetic rate versus reduced stomatal conductance) and nitrogen availability can be approximated by analysing the concentration of three stable isotopes: δ13C, δ18O and δ15N. We used historical as well as recent herbarium material and available tree ring data for δ13C, δ18O and δ15N isotope analysis and stomatal trait analysis. δ13C will be used as a proxy for WUE change over time, δ18O as a proxy for stomatal conductance change over time and δ15N as a proxy for nitrogen availability. Additional analyses on Mg, P, and K are currently under way to support some of the patterns found. Analyses were performed in collaboration with Marijn Bauters and Pascal Boeckx at the ISOFYS lab (UGent). A manuscript was published in Global Change Biology: Bauters, M., Meeus, S., Barthel, M., Stoffelen, P., De Deurwaerder, H., Meunier, F., ... & Boeckx, P. (2020). Century-long apparent decrease in iWUE with no evidence of progressive nutrient limitation in African tropical forests. *GLOBAL CHANGE BIOLOGY*, *26*(8), 4449-4461 (https://doi.org/10.1111/gcb.1514) and leaf functional trait data are publicly available through the supplementary information.

4.4 General recommendations on digitization

Overall the COBECORE project greatly benefitted from the recent advances in deep learning. Both the processing of the historical aerial photographs into a land use map, the automated generation of data coverage statistics on the scanned climatological data and the counting of stomata on herbarium specimens all leveraged deep learning. We would therefore like to underscore the importance of these new techniques in the valorization of historical collections. These findings should be considered in the planning of future projects. Automation benefits many parts of the project, however some parts still require manual input. As a rule, **the time allocations have been underestimated**. In future projects the **allocation for manual tasks should be higher**. For now, extra hours were put to the task.

5. DISSEMINATION AND VALORISATION

5.1 Dissemination of results

Besides the COBECORE website, the project created 5 associated **websites**

1) **The Agricultural Research Archive for DRC, Rwanda and Burundi** is a beta-version website that provides access to the pdf's of the *Bulletin Agricole du Congo Belge* and the *Bulletin d'INEAC*. Via a search function, the user is now able to find specific information on research carried out during the Colonial period (1885 – 1960). At present all volumes of these journals have been scanned. Quality control is ongoing and we expect updates of the website, further improving functionality during the coming year. Additional scans of complementary journals such as the *Serie Scientifique et Technique d'INEAC*; *Flore du Congo Belge et du Ruanda-Urundi, Atlas anatomique des Bois du Congo* Belge and others, can be expected later on.

   - http://ineac.africamuseum.be/: available via a server located in Belgium at the Royal Museum for Central Africa
   - http://ineac.rdcmirrorsmrac.org/: available via a server located in the DRC; this answers a need expressed in 2016 by the DG of INERA to the director of the RMCA to provide documentation on research carried out by INEAC during colonial times

2) Two citizen science projects were launched on the Zooniverse platform: (1) to assist with the transcription of climate data (https://www.zooniverse.org/projects/khufkens/jungle-weather) and, (2) to assist with the measurement of leaf trait data on images made of herbarium specimens (https://www.zooniverse.org/projects/sofie-dot-meeus/leaf-prints).

3) The Kunstmatige intelligentie, Klimaatverandering, Stomata (KIKS) project, a spinoff of the COBECORE project related to leaf traits, was funded and launched. This project aims to teach high school kids the use of deep learning methods using stomata recognition as a worked example. Lesson plans are freely available online at https://www.aiopschool.be/kiks/ .

4) Other websites related to the herbarium samples include the Botanical Collections website, managed by the Meise Botanic Garden, which includes more than 490 000 digitized specimens from the DRC, of which +310 000 date from the colonial period

5) The State archives now provide access to a selection of archival pieces from the REPCO-INEAC-SERDAT archives via their website, this collection is steadily growing each year. (https://search.arch.be/en/zoeken-naar-archieven/zoekresultaat/ead/index/eadid/BE-A0510_003812_005470_DUT). Copies of these documents are available online for free after creating an account: http://www.arch.be/index.php?l=nl&m=archieven-online&r=19de-en-20ste-eeuw

6) The Inventory of the REPCO-INEAC-SERDAT archives (I 546), by Guy Coppieters was **translated from Dutch to English** by Leen Van Hirtum. This greatly increases the accessibility of these archives for international research. The translation is in its final quality control phase (estimated completion for early 2023). Until then, the English translation is available upon request via Michael Amara at the State Archives.

7) In September 2022 a **Joint 6th Annual Meeting on Plant Ecology and Evolution & final COBECORE symposium** was held at the Botanic Garden Meise. AMPEE, an initiative of the Royal Botanical Society of Belgium and Meise Botanic Garden, jointly organised the event with the final meeting of the COBECORE project. See also: https://sites.google.com/plantentuinmeise.be/ampee6/

   The lively meeting was attended by 115 participants who came from more than 25 institutions in Belgium, plus France, UK, South Africa, China, and the Democratic Republic of the Congo. The packed two-day programme started with a keynote by Marijn Bauters (UGent) on understanding tropical forest ecology through biogeochemistry, followed by talks on tropical forest ecosystems. Parallel afternoon sessions focused on the results of the COBECORE project, plus talks ranging from lichen diversity to plant genomics.

   During the second day, two COBECORE workshops were held with about 20 participants; a hands-on introduction to automatic stomata detection using deep learning, and a workshop on applications for macroscopic wood anatomy and timber identification. The event concluded with the closing meeting of the COBECORE project. During the closing meeting Dr Ingrid Jonckheere and Emmanuel Kasongo of the COBECORE follow-up committee were present and future opportunities for further valorization of data and techniques developed in the framework of COBECORE were discussed, such as e.g. AI-for-Good and integration in future Belspo projects, e.g. FOURCAST (Brain 2.0). It was also decided that early 2023, the data-sets compiled by the different project partners will be gathered on external hard-drives and distributed to the different partner institutes to be included in the archives.

5.2 Valorisation

The **valorisation** of the COBECORE project is perhaps best reflected in the publication record (see below): 8 publications in Conference proceedings, 5 publications in A1-journals, 1 MSc thesis, 1 training manual (outreach) and 6 datasets. With more publications to come as a result of the digitization efforts completed during the COBECORE project. We also receive regular requests for data and access to the research archives that are now more easily accessible than before the start of the COBECORE project.

Leen Van Hirtum is carrying out **historical research** into INEAC as a result of her involvement with COBECORE. Her current PhD project focuses on agricultural science and development in the

Belgian Congo from the 1930s until the 1960s. This research was funded as an FWO project in collaboration with Prof Felicitas Becker (UGent). The INEAC archives are central to this research; the project hopes to give valuable insight into the historical context of the scientific work of the institute. This can help interpret the COBECORE data and give more information on the scientific processes used for gathering that data. Completion of the project is expected in 2024.

KIKS is a **STEM project on artificial intelligence (AI) for the third grade of secondary education** in Flanders (BE). Students learn to understand AI, with possibilities and limitations; they learn how to have an impact on it. The relationship between plant stomata and climate change offers a unique framework for working with deep neural networks. The Python programming language is also very accessible as a tool to study the fundamentals of neural networks. An asset of the KIKS project is the collaboration between researchers and teachers. After all, the KIKS teaching material is being developed in parallel with the results of ongoing scientific research at Ghent University and the Botanic Garden Meise (https://www.aiopschool.be/kiks/)

Although the COBECORE project officially ended in October 2022, **several activities are ongoing**, including: (1) additional quality control and update of the INEAC publications website, (2) several publications and data papers are in preparation (phenology data, climate data); (3) we foresee the publication of datasets in dedicated repositories after publication - particularly with regards to the climate data; (4) continued efforts to transcribe large subsets of climate data leveraging technological advances in Handwritten Text Recognition (HTR) technology or opportunities in collaboration with interested research groups.

6. PUBLICATIONS

Conference proceedings

1. Jacobsen, K., Hufkens, K., De Mil, T., Beeckman, H., Vandelook, F., Stoffelen, P., Van den Bulcke, J., Meeus, S., Van Hirtum, L., Amara, M. & Verbeeck, H. 2018. 'Forestry research from the Belgian Colonial period in the Democratic Republic of Congo'. *Scientific Side event to the 18th Meeting of Parties of the Congo Basin Forest Partnership, Tervuren, 27/11/2018*. Book of abstracts. p. 25. https://www.africamuseum.be/fr/research/discover/publications/repository/pub_view?pubid=5447

2. Jacobsen, K., Van Hirtum, L., Amara , M., Beeckman, H., Meeus, S., Vandelook, F., Van den Bulcke, J., Stoffelen, P., Verbeeck, H. & Hufkens, K. 2018. 'Climate data rescue from the Belgian colonial archives : helping to close the data-gap over Central Africa'. *Early Instrumental Meteorological Series*. Book of abstracts. http://hdl.handle.net/1854/LU-8587593

3. Jacobsen, K., Meeus, S., Stoffelen, P., Mergen, P., Beeckman, H., Vandelook, F., Van de Bulcke, J., Amara, M., Verbeeck, H. & Hufkens, K. 2018. 'Contributions of the Belgian Congo archives to contemporary research questions'. *Archives that Matter*. Book of abstracts. Copenhagen : DARIAH-EU. http://hdl.handle.net/1854/LU-8587601

4. Jacobsen, K., Hufkens, K., Beeckman, H., Vandelook, F., Stoffelen, P., Van den Bulcke, J., Meeus, S., et al. (2018). Historical forestry research from the Belgian colonial period in the Democratic Republic of Congo. *Tropentag 2018: Global food security and food safety : the role of universities, Abstracts*. Presented at the Tropentag 2018: Global food security and food safety : the role of universities. http://hdl.handle.net/1854/LU-8587590

5. Hufkens K, Jacobsen K, Van Hirtum L, Amara M, Beeckman B, Meeus S, Stoffelen P, Vandelook P, van den Bulcke J and Verbeek. Climate data rescue from the Belgian colonial archives : helping to close the data-gap for Central Africa. Chapman Conference on Hydrologic Research in the Congo Basin, Washington, DC, USA, 2018 https://www.agu.org/Plan-for-a-Meeting/AGUMeetings/Chapman-Conferences

6. Meeus S, Vandelook F, Stoffelen P, Janssens S, Jacobsen K, Hufkens K, Beeckman H, Van den Bulcke J, Amara M, Verbeeck H. Herbaria as functional trait databases. SPNHC 2018, Dunedin, New Zealand. doi: 10.3897/biss.2.25766 https://biss.pensoft.net/article/25766/

7. Meeus S, Bauters M, Vandelook F, Stoffelen P, Boeckx P. Tracking the effects of global change on central Africa's tropical forest: a triple isotope approach. EGU General assembly, Vienna, 7-12 April 2018 https://egu2018.eu/home.html

8. Meeus, S., Wyffels, F., Van den Bulcke, J. 2019. From Leaf to Label : Robust Automated Workflow for Stomata Detection. In: Biodiversity Information Science and Standards vol. 3. Proceedings of Biodiversity Next 2019: Building a global infrastructure for biodiversity data, together. https://doi.org/10.3897/biss.3.37504

A1-publications

9. Brönniman, S., Allan, R., Ashcroft, L., Baer, S., Barriendos, M., Brázdil, R., Brugnara, Y., Brunet, M., Brunetti, M., Chimani, B., Cornes, R., Dominguez-Castro, F., Filipiak, J., Founda, D., Garcia Herrera, R., Gergis, J., Grab, S., Hannak, L., Huhtamaa, H., Jacobsen, K., Jones, P., Jourdain, S., Kiss, A., Lin, KE., Lorrey, A., Lundstad, E., Luterbacher, J., Mauelshagen, F., Maugeri, M., Maughan, N., Moberg, A., Neukom, R., Nicholson, S., Noone, S., Nordli, O., Olafsdottir, KB., Pearce, PR., Pfister, L., Pribyl, K., Przybylak, R., Pudmenzky, C., Rasol, D., Reichenbach, D., Reznickova, L., Rodrigo, FS., Rohr, C., Skrynyk, O., Slonosky, V., Thorne, P., Valente, MA., Vaquero, JM., Westcott, NE., Williamson, F. & Wyzynski, P. 2019. 'Unlocking pre-1850 instrumental meteorological records: A global inventory'. Bulletin of the American Meteorological Society. DOI: 10.1175/BAMS-D-19-0040.1. https://biblio.ugent.be/publication/8630341/file/8630344.pdf

10. Hufkens, K., de Haulleville, T., Kearsley, E., Jacobsen, K., Beeckman, H., Stoffelen, P., Vandelook, F., Meeus, S., Amara, M., Van Hirtum, L., Van den Bulcke, J., Verbeeck, H., Wingate, L. 2020. "Historical Aerial Surveys Map Long-Term Changes of Forest Cover and Structure in the Central Congo Basin." *REMOTE SENSING* 12 (4). doi:10.3390/rs12040638 https://biblio.ugent.be/publication/8655405/file/8655406.pdf

11. Kafuti, C., Bourland, N., De Mil, T., Meeus, S., Rousseau, M., Toirambe, B., Bolaluembe, B-C., Ndjele, L., Beeckman, H. 2020. "Foliar and Wood Traits Covary along a Vertical Gradient within the Crown of Long-Lived Light-Demanding Species of the Congo Basin Semi-Deciduous Forest." FORESTS 11 (1). https://biblio.ugent.be/publication/8640762

12. Meeus, S., Van den Bulcke, J., wyffels, F. 2020. "From Leaf to Label : A Robust Automated Workflow for Stomata Detection." ECOLOGY AND EVOLUTION 10 (17): 9178–9191. doi:10.1002/ece3.6571. https://pubmed.ncbi.nlm.nih.gov/32953053/

13. Bauters, M., Meeus, S., Barthel, M., Stoffelen, P., De Deurwaerder, H., Meunier, F., Drake, T.W., Ponette, Q., Ebuy, J., Vermeir, P., Beeckman, H., wyffels, F., Bodé, S., Verbeeck, H., Vandelook, F., Boeckx,P. 2020. "Century-long Apparent Decrease in IWUE with No Evidence of Progressive Nutrient Limitation in African Tropical Forests." GLOBAL CHANGE BIOLOGY 26 (8): 4449–4461. doi:10.1111/gcb.15145. https://onlinelibrary.wiley.com/doi/10.1111/gcb.15145

MSc thesis

14. Banzi Ngulu-kulu, I. (2019). Changes In Temperature and Precipitation Extremes In Yangambi and Eala (Democratic Republic of Congo) In the First Half of the 20th Century. Thesis submitted for MSc Environmental Sanitation; Promotors: Koen Hufkens and Jan Van den Bulcke, tutor: Kim Jacobsen; 64p. https://lib.ugent.be/en/catalog/rug01:002785179

Training manual (outreach)

15. Gesquière, N., Meeus, S., Van den Bulcke, J., wyffels, F. 2020. *Kunstmatige Intelligentie, Klimaatverandering, Stomata : KIKS : Lerarenhandleiding*. Dwengo https://biblio.ugent.be/publication/8681893

Datasets

16. Meeus, S. (2020). From leaf to label: A robust automated workflow for stomata detection: Light microscope images of stomata. Ecology and Evolution (Vol. 10, pp. 9178–9191). Zenodo. http://doi.org/10.5281/zenodo.3579227

17. Hufkens, K., Jacobsen, K. (2022). Unprocessed data from the Jungle Weather Zooniverse citizen science project [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7104838

18. Hufkens, K. (2019). A curated dataset of aerial survey images over the central Congo Basin, 1958 [Data set]. In Remote Sensing (1.0). Zenodo. https://doi.org/10.5281/zenodo.3547767

19. Hufkens, K.. (2019). khufkens/jungleweather: The Jungle Weather data recovery workflow v1.0.0 (v1.0.0). Zenodo. https://doi.org/10.5281/zenodo.3378865

20. Hufkens, K.. (2019). khufkens/foto: an R implementation of the "fourier transform textural ordination (foto)" method (v1.0.2). Zenodo. https://doi.org/10.5281/zenodo.3337933

21. Hufkens, K., Campitelli, E., Stauffer, R., Hereñú, D. (2022). bluegreen-labs/ecmwfr: ecmwfr (v1.4.0). Zenodo. https://doi.org/10.5281/zenodo.7004985

7. ACKNOWLEDGEMENTS

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ANNEXES

ANNEX 1 - COBECORE-climate-README.txt

*RAW image data

S:\shares\cobecore\raw_image_data

The RAW image scans of the climate data sheets from the INEAC archves at the State Archives (Rijksarchief, Rue de Ruysbroeck 2, 1000 Bruxelles, www.arch.be) are stored on the shares.
Size: 554 GB, 83741 files in 1244 folders

The folders are named using the identifier found in the inventory of the INEAC archives, I-1546, see: https://search.arch.be/ead/pdf/BE-A0510_003812_005470_DUT.ead.pdf, p567-769. This identifier links to the file/folder name used in the State Archives to hold the climate data.

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*Climate data availability

S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\climate_data_availability

**Methodology

Climate data availability gives an overview of the available data. For each inventory folder holding climate data that was scanned during the Belspo project COBECORE in the State archives, a file was created in excel, using the same number code as that in the inventory I 546. Each scan within an inventory folder is equivalent to a month of daily climate data observations. Within each excel spreadsheet, each row represents a month of climate data (= one scan). Columns represent the parameters measured (see data dictionary), whereby 0 = parameter was not measured and 1 = parameter was measured.

**Data dictionary

inventory nr: Folder number as mentioned in the inventory I 546
name Location name written on the scan
month Month when the observation was carried out
year Year when the observation was carried out
temp_min Minimum temperature (Â°C) on the day of observation
temp_max Maximum temperature (Â°C) on the day of observation
precip Precipitation (mm) on the day of pbservation
psychrometer_temp_dry Psychrometer dry bulb temperature (Â°C)
psychrometer_temp_wet Psychrometer wet bulb temperature (Â°C)
relative_humidity Relative humidity (%)
evapometre_de_piche Atmometer or Evaporimeter (mm)(
temp du bar Temperature (Â°C) on baromete
haut bar. Luc Height on a mercury barometer (mm)
t1 If temperature was recorded only once a day
t2 Two observations (sub-daily temperature)
t3 Three observations (sub-daily) temperature
actino Actinometer readings
hygro (Relative) humidity (% or mm/cmÂ³)
Long Longitude

Lat Latitude
Alt Altitude (m)
nebulosite Cloud cover
forme des nuages Cloud shape
Orage Storms
Lucimetre Light intensity measurements

---

*Surface pressure (Yangambi, Eala, ...)

S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\SurfacePressure-Luterbacher-collaboration

**Methodology

Climate stations holding +10 yearsâ€™ worth of surface pressure data were identified from the climate data scans taken at the National Archives in Brussels (source I 546, INEAC archives). The scans were shared with JÃ¼rg Luterbacher for transcription. Data was transcribed manually with help from volunteer students at the University of Giessen, Germany (supervised by JÃ¼rg Luterbacher). Digitization and quality control took approximately 45 hours for a total of 2093 scans of climate data from stations holding +10y of surface pressure data.

**Data tables

Six files were created in Excel:

Congo-Eala(1908-1952).xlsx
CountryCongo, Territory Coquilhaville, Station Eala (1590 scans)
Years 1908-1952
Times 8 a.m. 1 p.m. 6 p.m.
Lat 00° 40' 00'' N / 0.066667 Derived from Google
Long 18° 17' 00'' E / 18.283333

Congo-Stanleyville(1908-1952).xlsx
CountryCongo, Province Orientale, Station Stanleyville (189 scans)
Years 1908-1939
Times 8 a.m. 1 p.m. 6 p.m.
Lat 2° 30' 00'' N / 2.5 Derived from Google
Long 27° 00' 00'' E / 27

Congo-Tshibinda(1930-1939).xlsx
CountryCongo, District Kivu, Station Tshibinda (124 scans)
Years 1930-1939
Times 8 a.m. 2 p.m. 6 p.m.
Altitude2070m
Lat 7° 15' 0'' S Derived from Google
Long 20° 53' 60'' E

Kongo_Sangaie(1927-1937).xlsx
CountryCongo, Province Kasai, District Sankuru, Territory Lusambo, Station Sangaie (122 scans)
Years 1927-1937

Times 8 a.m., 12 p.m., 6 p.m.

Kongo_Mobwasa(1914-1917).xlsx
CountryCongo, District Bangala, Station Mobwasa (117 scans)
Years 1914-1917
Times 8 a.m., 12 p.m., 6 p.m.

Kongo_Yangambi (1950-1955).xlsx
CountryCongo, Station Yangambi (73 scans)
Years 1950-1955
Times 24h
Lat 0°46'3.18"N / 0.76755 Derived from Google
Long 24°26'23.03"E / 24.43973

Data dictionary
PRESSION ATMOSPHERIQUE EN MB (Barometre 900+): surface pressure (millibars, mb ; 1hPa = 1mb = 100 Pa)
Temp. & Haut. Bar: temperature and height of barometer
Eau tombée: rainfall (mm)

---

*Temp-Prcp-Eala-Yangambi-MSc-Innocent

S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\Temp-Prcp-Eala-Yangambi-MSc-Innocent

**Methodology

Described in detail in the MSc thesis of Innocent Banzy Ngulu-Kulu (https://lib.ugent.be/en/catalog/rug01:002785179) ; RClimdex 1.0 package ETCCDI (2018) was used for quality control. This dataset includes raw data and some duplication of data sheets may occur within this folder. Data coverage, quality control methods, R-package and script are all described in detail within the MSc thesis.

**Data dictionary (see thesis)

**Data tables

FOLDER - 00-Cobecore_Keyed_Data-Original-layout

=> this folder includes the original COBECORE climate data, keyed into excel worksheets using the following techniques (WMO, 2011; Daly C., et al., 2007; see also p15 of the MSc thesis) to reduce errors.

FOLDER - bili
FOLDER - bongabo
FOLDER - eala
FOLDER - ec
FOLDER - km5
FOLDER - lokele

FOLDER - pics
FOLDER - plantation
FOLDER - yapehe

=> these station folders include output from the RCLimdex R-package, and also the input data

Bili.xlsx
Bongabo.xlsx
COBECORE_Yangambi&Eala_DATABASE.xlsx
COBECORE_Yangambi&Eala_DATABASE1.xlsx
E.C.xlsx
Eala.xlsx
Jan.docx
Km5.xlsx
Lokele.xlsx
Plantation.xlsx
Stations_Loc_Conver.txt
Stations_Location.xlsx
yangambi_Tmaxtseries.docx
Yapehe.xlsx
=> input data for each station (the same data is also in each station folder, see above)
=> location data

=> compiled data for Yangambi & Eala
rclimdex.R
rhtest.txt
rhtest1.txt
rhtests.R
RHtests_dlyPrcp4.txt
RHtests_Koen.txt
=> RClimdex
---
*Citizen science (temperature and rainfall) â€“ ask Koen Hufkens

S:\shares\cavelab_data\CAVELab-Data\Africa\Democratic Republic Congo\COBECORE-climate\Temp-Prcp-CitizenScience

**Methodology: contact koen.hufkens@gmail.com and also see project page at Zonniverse: https://www.zooniverse.org/projects/khufkens/jungle-weather/about/research

**Data dictionary

(To be completed)

ANNEX 2 - Luki en Yangambi reservaten INEAC-archief.odt

LUKI & YANGAMBI DIVISION FORESTIERE

3224-3242: Afdeling bosbouw Yangambi

- **3224**: Inspectierapporten 1937-1946
  - Namen en hoofdonderzoeken van aanwezige wetenschappers, 18/5/1946
  - Inspectierapport van F. Jurion 4/7/1939: Afdeling Bosbouw. O.a. problemen met het Arboretum (fouten bij aanplanting, bij keuze locatie, e.d.), over het Parc Forestier.
  - Inspectierapport van A. Ringoet 5/4/1937: beginnende Afdeling Bosbouw.
- **3225**: Jaarrapport 1938
  - Rapport over de Afdeling Bosbouw en het Arboretum/andere plaatsen waar men metingen op de bomen deed in Yangambi. Enkele tabellen met eerste resultaten.
- **3226**: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 1- 47bis 1940 – sep. 1950
  - Eerste document is een inhoudsopgave.
  - Semestrieel rapport 1940 Afdeling Bosbouw
  - Jaarrapport 1944 Afdeling Bosbouw
  - Jaarrapport 1940 Afdeling Bosbouw
  - Programma Afdeling Bosbouw 1942
  - Jaarrapport 1942 Afdeling Bosbouw
  - Inspectierapport 2/1943 Afdeling Bosbouw
  - Jaarrapport 1943 Afdeling Bosbouw
  - Jaarrapport 1944 Afdeling Bosbouw
  - Jaarrapport 1944 Afdeling Bosbouw (veel uitgebreider)
  - Programma Afdeling Bosbouw 1945
  - Jaarrapport 1945 Afdeling Bosbouw: bevat ook nota over bosreservaat in Luki, opmerkingen bij het jaarrapport (drievoud: handgeschreven en twee getypte versies)
  - Handgeschreven jaarrapport 1945 Afdeling Bosbouw
  - Programma Afdeling Bosbouw 1946
  - Documentatie van de Afdeling Bosbouw: index van de aanwezige dossiers en registers in Yangambi
  - Programma Afdeling Bosbouw 1947
  - Programma voor Bosbouw van de Kolonie en INEAC: opdeling in het wetenschappelijke aspect (INEAC) en het administratieve (Kolonie)
  - Kort rapport over het *Partie Sylvicole*: bevat meetresultaten per boomsoort
  - Extract uit reisverslag 1939
  - Reisverslag van G. Gilbert door Laag- en Midden-Congo jan.-apr. 1940: Gilbert is het hoofd van de Afdeling Bosbouw in Yangambi. Hij bezocht en maakte notas over verschillende plantages, herbebossingsprojecten en bosreservaten. Hij bezocht ook het reservaat in Luki en de Plantentuin in Eala.
  - Jaarrapport 1946 Afdeling Bosbouw: handgeschreven
  - Overzicht van het programma van de Afdeling Bosbouw

- ‘*Rapport de stage a la station de Yangambi*’, Franz Smeyers. 28/10/1947 – 07/04/1948. : Afdelingen Bosbouw, Bodemkunde en Botanie. Bevat verschillende tekeningen van boomsoorten, tabellen en grafieken.
- ‘*Visites de la Division Forestiere les 28 Aout, 4 et 25 Septembre 1947*’: bespreekt boomsoorten.
- Jaarrapport 1947 Afdeling Bosbouw
- Jaarrapport 1947 Afdeling Bosbouw: licht andere versie
- Handgeschreven nota’s
- Programma 1949 Afdeling Bosbouw: met programma’s voor verschillende onderzoeksvelden.
- Verslag van topografische prospecties voor de installatie van een visteeltstation in de Bohonde
- Programma 1950 Afdeling Bosbouw: met middelen gevraagd voor uitvoering van het programma van 1950
- Programma 1950 Afdeling Bosbouw: met middelen gevraagd voor uitvoering van het programma van 1950: enigszins geannoteerde versie
- Lijst van stations met een Afdeling Bosbouw, met per station het beoogde programma. O.a. Yangambi en Luki
- Nota over de Afdelingen Bosbouw en Botanie en het bodemkundig laboratorium
- Jaarrapport 1950 Afdeling Bosbouw en Hydrobiologie

- **3227**: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 48 – 68 Mei 1950 – juni 1953
  - Er staat een inhoudsopgave op de binnenflap van de roze map: gaat tot en met 69, maar 69 zit in de volgende map
  - Jaarrapport 1950 Afdeling Bosbouw
  - Programma 1951 Afdeling Bosbouw: twee exemplaren
  - Programma 1952 Afdeling Bosbouw: twee exemplaren
  - Correspondentie over de Afdeling Bosbouw en haar onderafdelingen, tussen INEAC en de koloniale overheid: bevat o.a. protocol voor savanneproeven
  - Programma 1952 Afdeling Bosbouw
  - Correspondentie met de grote lijnen van de activiteiten rond bosbouw in Kivu
  - Programma 1951 Onderzoek Bosbouw: met briefwisseling over programma
  - Inspectierapport Bosbouwwerkzaamheden te Vuazi
  - Programma 1952 Groep Bosbouw te M’vuazi: bevat ook correspondentie
  - Programma 1953 Afdeling Bosbouw: geannoteerd
  - Studie naar de namen van de belangrijkste boomsoorten in Yangambi in de plaatselijke talen
  - Jaarrapport 1951 Afdeling Bosbouw: bevat aantekeningen en opmerkingen, vooral rapporten over Keyberg bij Elizabethstad
  - Correspondentie: bevat een ‘*Protocole “essais antichambres” pour les essences exotiques*’ en een brief over een rapport over Luki
- 3228: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 70 – 84 Apr. 1953 – Nov. 1954.
  - Inhoudsopgave op de binnenflap van de roze map
  - Jaarrapport 1952 Afdeling Bosbouw
  - Rapport van het centrum voor bosonderzoek in Yangambi
  - Jaarrapport 1952 van de Groep Bosbouw van het station van Bambesa: twee

exemplaren
- Jaarrapport 1952 van de Groep Bosbouw van het station van Vuazi
- Jaarrapport 1952 van de Groep Bosbouw van het station van Mulungu
- Opmerkingen bij de jaarrapporten van 1952: soms handgeschreven
- Jaarrapport Afdeling Bosbouw 1952: opmerkingen per station
- Jaarrapport 1952 van de Groep Bosbouw van het station van Luki
- Jaarrapport 1952 van de Groep Bosbouw van het station van Keyberg
- Jaarrapport 1952 van de Groep Bosbouw van het station van Luki-Kiobo
- Jaarrapport 1952 van de Groep Bosbouw van het station van Nioka: twee exemplaren
- Programma 1954 Afdeling Bosbouw: met handgeschreven toevoegingen
- 'Amenagement d'une serie de Foret heterogene' : met uitleg over voorbereidende werken, jaarlijkse taken, onderhoud en exploitatie, en voorbeeld met prijsberekening. Twee exemplaren en handgeschreven nota
- Jaarrapport 1953 Afdeling Bosbouw: met opmerkingen
- Jaarrapport 1953 Afdeling Bosbouw te Yangambi: twee exemplaren,met opmerking
- Jaarrapport 1954 Afdeling Bosbouw te Yangambi: drie exemplaren, met opmerkingen
- Programma 1955 Afdeling Bosbouw te Yangambi: twee exemplaren, een geannoteerd
- 'Reunion du personnel universitaire, Jeudi 4 novembre 1954: La foret dense et l'etat actuel de sa sylviculture, par C. Donis' : verslag.

• 3229: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 86 – 104 Apr. 1955 – Mei 1956.
- NIET IN JUISTE DOOS (3227-3231)

• 3230: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 111 – 122 Okt. 1956 – Aug. 1958.
- Inhoudsopgave op binnenflap groene map: begint al bij nr. 107, pas vanaf nr. 111 aanwezig in de map.
- Rapport Mr. Lebrun, Afdeling Bosbouw, 17/7-24/10/1956
- Bijlages bij C.C.R. 1957: 'Equipe 1.2b. Sortie d'eau evapotranspiration sous foret amenagee' door A. Pieters, en 'Situation actuelle du bloc de foret empoisonne a l'arsenite de soude a la presqu'ile Lokele' door Ant. Craet,
- Jaarrapport 1956 Afdeling Bosbouw met commentaren: twee exemplaren
- Programma 1958 Afdeling Bosbouw: twee exemplaren
- Programma 1959-1960 Afdeling Bosbouw: met commentaren, meerdere exemplaren
- Jaarrapport 1957 Afdeling Bosbouw: zeer uitgebreid, met commentaren

• 3231: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Nrs. 124 – 143 Sept. 1957 – Feb. 1961.
- Inhoudsopgave op binnenflap groene map begint bij nr. 123, pas vanaf nr. 124 aanwezig in de map.
- Reisverslag Maudoux 1957: Reis naar Maniema en de zuidelijke rand van het regenwoud, 23/7-2/9/1957, met opmerkingen.
- Jaarrapport 1958 Afdeling Bosbouw: met commentaren, samenvatting in het Nederlands en het Frans, twee exemplaren

- Jaarprogramma 1960 Afdeling Bosbouw: met commentaren
- Verslag van de vergadering van de Commission de coordination Agri-Ineac over het werk rond bosverrijking, 16/3/1959 te Leopoldville: met bijlagen
- Jaarrapport 1959 Afdeling Bosbouw: drie exemplaren
- Rapport van het bezoek aan de Afdeling Bosbouw, 10/11/1960
- 'La multiplication des bambous', door P. Abeels
- Programma 1961 Afdeling Bosbouw: twee exemplaren, met commentaren
- Verslag van de voorbereidende vergadering voor de programma's van 1960

• 3232: Verzameldossier, genummerd 1 tot 143. 1940- feb. 1961: Diverse nrs. 58-143 juni 1952 – juni 1956.

- Lijst van soortnamen van bomen in het dialect Turumbu
- Map klimaatkaarten van Congo
- Programma 1953 Afdeling Bosbouw
- Rapport studiereis over eucalyptus in Australie: door de V.N. en Australie, sept.-okt. 1952
- Protocol voor het gebruik van landbouwexplosieven: opvolging na een inspectiebezoek in Vuazi, 1953
- Memorandum over de samenwerking tussen de diensten die betrokken zijn bij bosexploitatie in Yangambi, 30/6/1951
- Programma 1955 Afdeling Bosbouw: met bijlagen
- Programma 1956 Afdeling Bosbouw: met bijlagen, document over korte termijn-experimenten, twee exemplaren
- Artikel te verschijnen in het Bulletin Agricole: 'Un outil forestier peu connu, le dendrometre "Christen"' van Roman Gutzwiller
- Programma 1957 Afdeling Bosbouw: twee exemplaren
- 'Considerations pratiques sur l'elimination des arbres' door E. Maudoux
- Schema voor het opstellen van de programma's van de Afdelingen Bosbouw in de verschillende stations
- Programma 1959 Afdeling Bosbouw: met commentaren
- Rapport bezoek aan Bas-Uele 23-26/5/1959: met commentaar
- Correspondentie over de publicatie van 'La multiplication des bambous', door P. Abeels: opmerkingen, correspondentie rond een Engelse vertaling voor een Indisch tijdschrift
- Documenten over de werking en onderzoeksprojecten in de verschillende bosbouwstations: examen de l'activite, uiteenzetting principes voor toekomstige werking
- Prijsberekening van de producten van bosexploitatie te Yangambi
- Verslag voorbereidende vergadering voor het programma 1960 van de Afdeling Bosbouw
- Programma 1961 Afdeling Bosbouw

• 3233: Ingebonden jaarverslagen 1945-1955

- Dikke rode band met op de rug '13. Rapports annuels – forestiere 1945-1955 I'

• 3234: Ingebonden jaarverslagen 1956-1959.

- Dikke rode band met op de rug '14. Rapports annuels – forestiere 1956-1959 II'

• **3235:** Maandverslagen. 1946-1953.

- Maandverslagen Yangambi Afdeling Bosbouw 1953: januari t.e.m. december
- Maandverslagen Yangambi Afdeling Bosbouw 1952: januari t.e.m. december

- Maandverslagen Yangambi Afdeling Bosbouw 1951: januari t.e.m. december
- Maandverslagen Yangambi Afdeling Bosbouw 1950: januari t.e.m. december
- Maandverslagen Yangambi Afdeling Bosbouw 1949: januari t.e.m. december
- Maandverslagen Yangambi Afdeling Bosbouw 1948: januari t.e.m. november
- Maandverslagen Yangambi Afdeling Bosbouw 1947: april t.e.m. december
- Maandverslagen Yangambi Afdeling Bosbouw 1946: enkel juli

- **3236:** Inventaris van het patrimonium en bijhorende stukken. 1947-1958.: 1947-1953.
  - Grote getekende kaart van onderzoekscentrum Yangambi: vooral aanduidingen van de verschillende percelen en onderdelen van de Afdeling Bosbouw
  - Parcellaire de la division: bevat gedetailleerde beschrijving van alle onderdelen van de Afdeling Bosbouw in Yangambi, met kaarten in bijlage.
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1948
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1949
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1950: met parcellaire van 31 december 1949
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1951
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1952
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1953: met uitgaven en inkomstem van het voorbije jaar
  - Uitgaven en inkomsten van Afdeling Bosbouw te Yangambi: tot en met 31 december 1953
- 3237: Inventaris van het patrimonium en bijhorende stukken. 1947-1958.: 1953-1958.
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1954
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1955
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1956
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1957
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1958
  - Uitgebreide inventaris van de bezittingen van de Afdeling Bosbouw te Yangambi op 1 januari 1959
- 3238:Documents Techniques, ingebonden verzameling van technische documenten. 1947-1961: 1947-1953.
  - Inhoudsopgave op de binnenkant van het boek. Dikke rode band met op de rug ‘103. Documents techniques – Div. Forestiere 1947-1953 I’
  - *Protocol experimental de la Division Forestiere*
  - *Visites de la Division Forestiere les 28/8, 4 et 25/9/47*
  - *Detail de la situation des parcelles d’experiences de la Division au Ier janvier 1949*
  - Essais de carbonisation au four tranchant, J. Wagemans
  - Rapport preliminaire de la Mission Pedobotanique de M’Vuazi, I. Denisoff en R.

Devred
- Rapport provisoire de Prospection dans la region de Ntampa, R. Devred
- Rapport de voyage en Ituri du 24-5-1950 au 5.6.1950, C. Donis
- Rapport de voyage au Katanga du 5 au 25/7/1950, C. Donis
- Sur quelques elements de politique forestiere tropicale, C. Donis
- Rapport d'inspection des travaux forestiers de M'Vuazi, C. Donis
- Protocole dressais en savane, C. Donis
- Le Pinus merkusii Jungh. et De Vr. - Monographie et etude critique de son introduction au Congo belge, J. Dubois
- Reponse au questionnaire relatif au projet de legislation pour la conservation des sols, A. Schmitz
- EUCALYPTUS et reboisement au Kivu, R. Pierlot
- Tests d'homogeneite appliques a de jeunes boisementsequiennes d'Eucalyptus, R. Pierlot
- Les Eucalyptus au Congo belge (Est et Sud-Est) et au Ruanda-Urundi, R.Pierlot
- *Essais d'utilisation des "Tempil Pellets" pour les observations ecologiques sur feux de brousse*
- *Protocole d'essai de plantation de Podocarpus usambarensis, propose a Cada-Kavumu*
- Rapport d'inspection de la Station forestiere du Mayumbe a Luki (3 au 10.2.1953), C. Donis
- Rapport d'execution du protocole "Explosifs agricoles", R. Devred
- Rapport sur des essais du sous-solage a la dynamite executes dans la parcelle de collection d'avocatiers a la Station de M'Vuazi, J. Philippe
- Notes sure les variations de quelques facteurs microclimatique en foret dense equatoriale, E. Maudoux
- Activite du Groupe forestier de Keyberg, A. Schmitz

• 3239: Documents Techniques, ingebonden verzameling van technische documenten. 1947-1961: 1954 – 1961.
- Inhoudsopgave op de binnenkant van het boek. Dikke rode band met op de rug '104. Documents techniques – Div. Forestiere 1954 – 1961 II'
- Stageverslag van de proeftijd in het onderzoekscentrum te Yangambi, A. Deville
- *Enquete relative aux Galles du Chlorophora*
- Un aspect de l'influence de la foret sur le sol, P. Gerard
- Ueber die Bedeutung der schweizerischen waldbaulehre fur die Bewirtschaftung der tropischen Regenwalder, Roman Gutzwiller
- Plantes fourrageres de l'Okapi (Okapia Johnstoni Sclat.), Roman Gutzwiller
- Rapport d'inspection du Centre de Recherches forestieres des Yangambi, C. Donis
- Un outil forestier peu connu, le dendrometre "Christen", Roman Gutzwiller
- Consideration pratiques sur l'elimination des arbres, E. Maudoux
- Rapport general sur l'etat des recherches forestieres au Congo belge, E. Maudoux
- Nouvelle technique d'enrichissement des forets denses heterogenes. La plantation par placeaux denses espaces, E. Maudoux
- *Premieres observations sur le cleistopholis glauca en plantation industrielle a Yangambi*, E. Maudoux et P. Abeels
- Annelation et empoisonnements des arbres, E. Maudoux et A. Craet
- Voyage d'information au Maniema et sur la lisiere Sud de la foret equatoriale 23/7

– 2/9/1957, E. Maudoux
- *Moyens chimiques pour la preservation des bois*
- Visite des chantiers forestiers de la Brigade du Bas-Uele (23-26/5/1959), E. Maudoux
- Etude de l'amenagement des forets a Gilbertiodendron Dewevrei. Rapport de mission a Rubi (Bas-Uele), A. Pieters
- Etude preliminaire de l'amenagement des forets a Gilbertiodendron Dewevrei, F. Noyen en A. Pieters
- La multiplication des bambous, P. Abeels
- Quelques plantes interessantes comme engrais verts dans les pepinieres forestieres, A. Craet
- *La bambusiculture en region de forets denses humides*
- Activites de Centre de Recherches forestieres de Yangambi, E. Maudoux
- Note complementaire au rapport "Eucalyptus" remis par le gouvernement de la republique federative du Congo au Congres F.A.O. de Sao Paulo (Bresil) – juillet 1960, M. Moyaux
- Etude de l'amenagement des boisements de l'Eucalyptus, M. Reynders
- Observations sur les Essences forestieres introduites a l'Arboretum de Ruhande (Astrida) 1934 – 1960, M. Reynders
- *Deuxieme Conference Mondiale de l'Eucalyptus – Rapport national d'activite*
- Premiers resultats des essais comparatifs Eucalyptus au Rwanda et au Burundi, M. Reynders

- 3240: Jaarverslag 1949
  - Drie exemplaren, met bijlagen.
- 3241: Inventaris van het patrimonium en bijhorende stukken. 1953 – 1958.
  - Inventaris 1953
  - Inventaris 1954
  - Inventaris 1955
  - Inventaris 1956
  - Inventaris 1957
  - Inventaris 1958
- 3242: Jaarverslagen 1953, 1958 en 1960. 1953 - januari 1960.
  - Betreft onder meer ontwerpversies met aantekeningen.
  - Jaarverslag 1953 Afdeling Bosbouw: met aantekeningen en bijlagen
  - Jaarverslag 1958 Afdeling Bosbouw: zeer uitgebreid, met verschillende tabellen en grafieken
  - Jaarverslag 1959 Afdeling Bosbouw: zeer uitgebreid, met verschillende tabellen en grafieken

3752 – 3769: Bosbouwkundig station van Luki
- 3752: Driemaandelijkse en tussentijdse activiteitsverslagen. 1937.
  - Derde rapport Mayumbe, M'Vuazi, 27/05/1937: twee exemplaren, met opmerkingen.
  - Tweede rapport Mayumbe, M'Vuazi, 25/02/1937.
  - Driemaandelijks rapport – eerste trimester 1937: twee exemplaren.
- 3753: Jaarverslag voor het dienstjaar 1937. Januari 1938.
- 3754: Werkprogramma voor het dienstjaar 1939. Juni 1938.

- Zeer uitgebreid, met aantekeningen.

- 3755: Verzameldossier, genummerd 1 tot 87. Sep. 1940 – jan. 1961: nrs. 1 – 44. Sep. 1940 – okt. 1955.
  - Rapport van het bezoek van Jurion aan het bosreservaat in Luki, 1/09/1940: met opmerkingen.
  - Jaarrapport 1942 Bosreservaat Luki.
  - Zesmaandelijks rapport Bosreservaat Luki – eerste semester 1943.
  - Nota over het bezoek van Jurion aan het bosreservaat in Luki, 16/08/1943.
  - Jaarrapport 1943 Bosreservaat Luki.
  - Nota over het bezoek van Jurion aan het bosreservaat in Luki, 04/1944.
  - Zesmaandelijks rapport Bosreservaat Luki – eerste semester 1944.
  - Becommentarieerde nota over het reservaat in Luki, 04/1945: bevat plannen voor de uitwerking van het reservaat en een budget.
  - Zesmaandelijks rapport Bosreservaat Luki – eerste semester 1945.
  - Nota van Donis aan Jurion over het reservaat in Luki, met kaart, 16/09/1945.
  - Rapport van Gilbert over het reservaat in Luki: bevat inspectieverslag en plannen op korte en lange termijn.
  - Jaarrapport 1946 Bosreservaat Luki: ook brief met samenvatting.
  - Stagerapport R. Devred, 27/09/1947.
  - Jaarrapport 1947 Bosreservaat Luki.
  - Programma 1949 Bosreservaat Luki.
  - Nota over bezoek van Jurion aan het reservaat in Luki, 04/1946.
  - Nota over bezoek van Jurion aan het reservaat in Luki, 30/09/1947.
  - Nota over de inspectie van het bosbouwstation in Luki, 7 – 8/03/1949.
  - Programma 1951 Bosreservaat Luki.
  - Inspectierapport van het bosbouwstation Mayumbe, 20/02/1951.
  - Inspectierapport van het bosbouwstation Mayumbe, 2 – 8/02/1952.
  - Opmerkingen bij het jaarrapport 1951 van Mayumbe.
  - Rapport over bezoek aan het station in Luki, 7/11/1953.
  - Inspectierapport van het bosbouwstation Mayumbe, 20/05/1953: met briefwisseling met opmerkingen.
  - Briefwisseling met opmerkingen bij het jaarrapport 1952.
  - Inspectierapport van het bosbouwstation Mayumbe, 12 – 16/8/1953: met briefwisseling.
  - Programma 1954 Bosreservaat Luki.
  - Inspectierapport van het bosbouwstation Mayumbe, 13 – 19/2/1954.
  - Jaarrapport 1953 Bosreservaat Luki: met ontwerpversies en commentaren.
  - Programma 1955 Bosreservaat Luki: meerdere versies met opmerkingen.
  - Nota over cacao in Luki, 24/6/1954.
  - Rapport van bezoek aan station Luki, 2 – 3/5/1954.
  - Inspectierapport van het bosbouwstation van Luki, 9 – 13/7/1954.
- 3756: Verzameldossier, genummerd 1 tot 87. Sep. 1940 – jan. 1961: nrs. 45 – 66. Dec. 1954 – okt. 1957.
  - Briefwisseling rond het programma 1956 van de Afdeling Bosbouw in Luki.
  - Inspectierapport Bosreservaat Luki, 5 – 9/2/1955: met briefwisseling.
  - Jaarrapport 1954 Bosreservaat Luki: met briefwisseling, meerdere exemplaren.
  - Programma 1956 Afdeling Bosbouw Luki: met verschillende versies, briefwisseling

en bijlagen.
- Inspectierapport van het bosbouwstation Mayumbe, 25/4 – 5/5/1995.
- Inspectierapport van het bosbouwstation Luki, 13 – 17/8/1955.
- Inspectierapport van het bosbouwstation Luki, 13 – 18/1/1956.
- Briefwisseling over een Technisch Rapport "Etude comparative de diverses methodes de calcul de l'accroissement moyen annuel. Exposition d'une nouvelle methode.".
- Jaarrapport 1955 Bosbouwstation Mayumbe: met bijlagen, verschillende versies en opmerkingen.
- Programma 1957 Afdeling Bosbouw Luki: met briefwisseling en opmerkingen.
- Inspectierapport van het Bosbouwstation van Luki, 7 – 14/7/1956: met briefwisseling.
- Rapport over bezoek aan Luki, 8 – 9/2/1956.
- Rapport over bezoek aan Luki, 23/9/1956.
- Inspectierapport van het Bosbouwstation Luki, 15 – 18/1/1957: met opmerkingen.
- Briefwisseling en rapport over herbebossingsexperimenten in Luki, 1957.
- Jaarrapport 1956 Bosbouwstation Luki: meerdere exemplaren, verschillende versies, met opmerkingen en briefwisseling.
- Inspectierapport van het Bosbouwstation Luki, 5 – 11/3/1957.
- Programma 1958 Bosbouwstation Luki: meerdere exemplaren, verschillende versies, met opmerkingen en briefwisseling.

• 3757: Verzameldossier, genummerd 1 tot 87. Sep. 1940 – jan. 1961: nrs. 67 – 87. Feb. 1958 – jan. 1961.
- Inspectierapport van het bosbouwstation Luki, 14 – 18/9/1957.
- Inspectierapport van het bosbouwstation Luki, 2 – 6/05/1958: met brief.
- Programma 1959 van het Bosbouwstation Mayumbe in Luki: meerdere versies.
- Brieven en documenten over papierindustrie in Mayumbe.
- Jaarrapport 1957 Bosbouwstation Mayumbe: 6 exemplaren, commentaren, briefwisseling, verschillende versies, bijlagen. Bevat ook een kaart van het station.
- Inspectierapport van het bosbouwstation Luki, 5 – 7/10/1958.
- Inspectierapport van het bosbouwstation Luki, 22 – 29/04/1959.
- Inspectierapport van de Algemene Diensten van het station Luki, 13 – 14/02/1959.
- Inspectierapport van het bosbouwstation Luki, 18 – 25/03/1959: met briefwisseling en opmerkingen.
- Jaarrapport 1958 Bosbouwstation Mayumbe: verschillende exemplaren, commentaren, briefwisseling.
- Programma 1960 van het Bosbouwstation Mayumbe in Luki: briefwisseling, verschillende versies, commentaar.
- "Proces-verbal de remise-reprise des fonctions de Directeur de la Station forestiere du Maymbe entre MM. J. Wagemans en J. Hombert", 29/06/1959.
- Rapport van bezoek aan het station van Luki, 24 – 26/09/1959.
- Begeleidende brieven bij ontbrekende rapporten.
- Opmerkingen bij een bezoek aan het bosbouwstation Luki.
- Rapport over experimenten met het uitzetten van vis in Luki, 1957: herwerking en verbetering van een deel van het Technisch Rapport 1957.
- Rapport van de missie van Jean Dubois te Luki, jan. 1961.

- Briefwisseling.
- 3758: Ingebonden jaarverslagen. 1945 – 1958.
- Dikke rode band met op de rug '31. Rapports annuels – Luki 1945-1958'
- 3759: Maandverslagen. Jan. 1947 – dec. 1956.
- Maandverslagen Luki Afdeling Bosbouw 1947: jan. - maa.
- Maandverslagen Luki Afdeling Bosbouw 1948: feb. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1949: jan. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1950: jan. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1951: jan. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1952: jan. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1953: jan. - dec.
- Maandverslagen Luki Afdeling Bosbouw 1954: jan. - okt., dec.
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