Final Report: BIG-ACE

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# Applicable Documents

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| Document | Date | Comments |
| BIG data Archetypes for Crops from EO | 16th November 2022 | Project Proposal In response to 2022-23 call by ESA EO AFRICA R&D Facility in collaboration with AUC |
| Collaboration Agreement: Document: 7258820 - EO AFRICA COLLABORATION AGREEMENT UT AFRICAN EUROPEAN- UoT-UCL-UoW-FEA, | 20th February 2023 | University of the Witwatersrand, Johannesburg; University College London; Universiteit of Twente |
| Progress Report: BIG-ACE | 4th October 2023 | Progress report, file: EO AFRICA Progress Report Sept2023 UCL-Wits.docx |

# 2.0 Introduction

Global food security is of vital and increasing importance to our world and is a direct component of several UN SDGs. Monitoring crop information from Earth Observation (EO) plays a key role in supporting formation for this, for example, yield predictions and early warning systems. But current efforts such as NASA Harvest or GEOGLAM cropwatch[[1]](#footnote-1) are mainly limited to resolution anomaly detection and broad crop status indicators to get the temporal sampling needed for crops. The project “BIG data Archetypes for Crops from EO” funded through the ESA/AU EO Africa R&D Facility is a joint undertaking by researchers at University College London (UCL), UK and the University of The Witwatersrand, South Africa.

The main aim of the project was to improve the information available for such monitoring by directly targeting the ‘full set’ of crop biophysical parameters for this task, moving away from the previous empirical basis to inherent crop characteristics that are physically measurable and more fully exploit the full spectral signal available in modern EO systems. The UCL team had developed this approach using a ‘big data’ analysis of EO data over US croplands, and tested the portability of the approach by validation against a suite of temporal biophysical ground measurements in Germany. A paper was in production for that work. In this project, we would test the application of the approach to an African environment by collecting a new field dataset in South Africa, to be combined with one collected under other funding the previous year. These data then used to further test the approach and provide practical codes and data that other can use in further studies.

The approach is novel, in providing an (empirical) model of the temporal development of each of crop biophysical parameters, in coordination, the parameters of which summarise the total information on crop development available from a time series of optical EO data. We call the basis functions for the parameter development ‘archetypes’ as they express the typical development of the parameters in temporal coordination. Such a model allows this full set of biophysical crop parameters to be linked to EO measurements of bidirectional reflectance factor (BRF) via physically-based radiative transfer models. This, in turn allows for approaches to estimate the archetype model parameters from a series of EO data. Note that the EO data can, in theory, come from a set of heterogeneous sensors, although in this study we will limit ourselves to Copernicus Sentinel-2 data.

Code for the project, along with the test datasets from the South African fields measurements has been placed in an open access GitHub repository, with an example notebook to instruct users in the approach and allow them to conduct other experiments. This will be detailed below.

This report is the ‘final report’ D2, due at KO+12 months, with reference to the “Public open-source research code repository” D3. A copy of the draft ‘open-access peer-reviewed scientific publication’ (D4) will be submitted as a separate document The project task list from the project proposal is included for reference in Figure 1, with the planned publications in Figure 2 and deliverables in Figure 3.

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Figure 1. Project task list

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Figure 2. Planned publication list, from proposal

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Figure 3. List of deliverables

# 3.0 Progress

## 3.1 Fieldwork logistics and farmers' meeting

The first project task is completed. The data collection for this project for 2023 is to take place at Syngenta's Marné Research Farm, situated on Kaallaagte Road in Meets, Bethlehem, South Africa. This location is approximately 290 kilometres away from Wits University in Johannesburg. The primary focus of the study is rainfed wheat cultivation, with the planting season commencing on September 1st.

## 3.2 Field data collection and processing

As of now, two site visits have been completed. During the first visit, we placed and marked the plot samples. Each plot is 50x50 m and has five subplot (10x10m). We also recorded GPS coordinates for the central points of the subplots and collected soil spectral measurements from these subplots to support data interpretation. The second field visit took place on September 22, 2023, during which we measured the biophysical and biochemical parameters of the crops in accordance with the research proposal. Fieldwork will continue at 15-day intervals until the crop is ready for harvest. We expect harvest to be in November or December 2023, just giving us time for processing within the project timeframe. The protocols are mature and readily implemented.

We trialled the measurement approaches during 2022, funded under a small bilateral seed corn project funding, and have been processing these data under this project. Unfortunately, the African PI was hijacked and held hostage in early September 2022, before he had passed the processed results to the UCL team. His computer was stolen, and all of the processed data lost. We have been able to reconstruct much of the data (for Chlorophyll concentration (Cab) and Leaf Area Index (LAI)) directly from the field instruments, and now have this in a form ready for comparison with the archetype parameters. Figure 2 shows the mean values of the field measurements for 2022 for Cab and LAI, averaged over 5 sub-plots, with 5 subplots as noted above. The initial estimate of LAI derived from the archetypes derived from Sentinel-2 data over the field is shown in Figure 3. We are in the process of matching up the plots and sub-plots to compare between the field data and EO estimates. The new data collected for 2023 will provide a similar dataset, but with a wider range of biophysical parameter for testing.

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Figure 4. Crop field measurements for 2022 season (mean)

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Figure 5. LAI derived from archetypes over the field site for 2022

## 3.3. European PI visit to South Africa

The proposed visit of the European PI to the field site was been delayed due to the later than expected crop season start, complicated by issues relating to the UCL PI taking early retirement during the timeframe of this project, and finally not possible. Instead, we have kept in touch with on-line meetings, and were able to fund a visit for the African PI to the UK for detailed project planning from other sources.

## 3.4 EO Acquisition and pre-processing

Acquisition and processing of EO data over the site is completed for 2022 as noted above, and has been used for archetype validation. Datasets for 2023 have been collected and processed to surface reflectance over the field site. A version of these data are made available to users via GoogleEarth Engine in the project notebook.

## 3.5 Modelling crop parameters using archetypes

As noted above, field dataset for 2022 and 2023 has been processed. Data are available to users via the project notebook. There have been some issues with the collection of the datasets that are outlined below.

## 3.6 Stakeholder engagement

**Elhadi: can we say anything about stakeholders?**

## 3.7 Writing

The UCL team submitted a paper to a special issue of Remote Sensing of Environment on the Archetype approach in November 2023. That paper is still undergoing peer review, but scientifically, since it describes the method, we need that paper to be published (or at least accepted) before we can submit validation/application papers using the South African data. The November 2023 paper contains a small amount of parameters validation, over a test site in Germany. We are continuing work on the main paper coming from this work, a fuller validation study using the 2022 dataset using the new data which we will submit as Deliverable D4. All datasets we collect here and previous ones we have directly collected will be made available via a zenodo site. They are also directly available via the GitHub site that contains the project notebooks.

# 4. Results

## 4.1 Field Data

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| A aerial view of a farm  Description automatically generated | A green squares in a circle  Description automatically generated |

# 5. Other matters

## 5.1 Finance

There was a delay in setting up the transfer process between UCL and Wits that has complicated the financial process. A customer number was finally created for the Geography Department at UCL, but invoices for fieldwork and other were greatly delayed as a result. **Elhadi: details?**

## 5.2 Training and workshops

Elhadi Adam attended the EO AFRICA F2F Training: Cloud Computing and Algorithms for EO Analyses in Kigali, 16 to 22 October 2023, and reported back to the group on what was learned.

**Anything else to say?. Any workshops that you can claim are part of this?**

## 5.3 Financial expenditure

Partly because of the delay in the financial transfer process, not all of the money has been spent from the Wits end. Further, since the UCL partner was unable to attend the delayed field trails in Soth Africa, the UK travel money has not been spent. Funds for training for the African PI were deployed in October, to attend the EO AFRICA F2F Training: Cloud Computing and Algorithms workshop.

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Figure 6. Proposal expenditure plan

1. <https://nasaharvest.org>; <http://www.cropwatch.com.cn/htm/en/index.shtml> [↑](#footnote-ref-1)