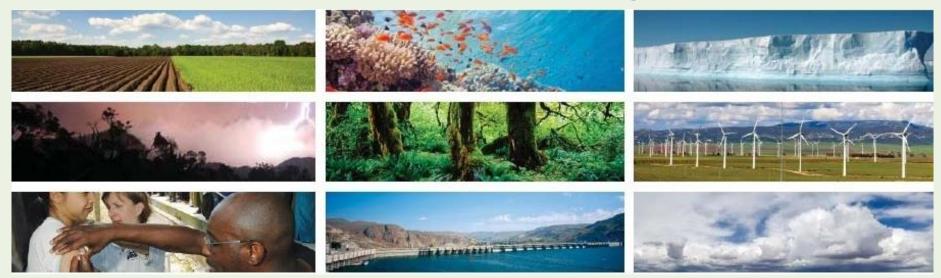# NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Improving Malaria Decision Support with Earth Observations

NASA Award # 80NSSC19K0192

Program Area (Health and Air Quality)

Final Report– March 30, 2023

Applied Sciences– Project Summary

- Project Title: Improving Malaria Decision Support with Earth Observations

- Project PI: John Beck

- Solicitation: ROSES 2017 A.39 Health and Air Quality

- **Project Summary:** Researchers at UAH in collaboration with the CDC and NASA are helping to improve malaria control decision making in Africa by developing and deploying a technology for incorporating the latest NASA Earth observations for surface temperatures, precipitation, and vegetation health into a widely used health management platform titled District Health Information Software 2 (DHIS2).

- Geographic Scope: Global

- Geographic Focus: sub-Saharan Africa

- Societal Benefit Area(s): Human Health

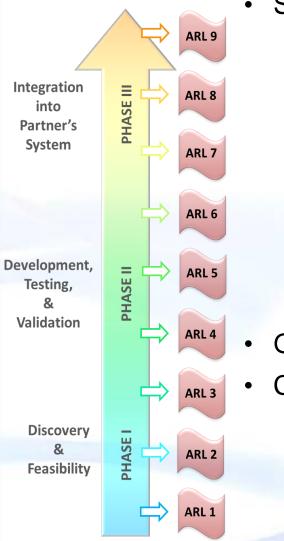- Earth observations / models / technologies applied: Surface temperatures, precipitation, and vegetation health.

Project Partners

Role	Name	Affiliation Organization	Organization Type
Co-I	Jeffrey Luvall	NASA/MSFC	Federal Agency
Co-I	John Painter	CDC	Federal Agency
Co-I	Udaysankar Nair	UAH	State Agency
Co-I	Todd Berendes	UAH	State Agency

End-Users / Stakeholders

Organization Name	Organization Type
World Health Organization (WHO)	Global Organization
Centers for Disease Control and Prevention (CDC)	Federal Agency
Africa Country Ministries of Health	Other
University of Oslo	Education
University of South Carolina	Education

Performance/ARL

- Start-of-Project ARL = 3 *(11/16/2018)*

  - **We estimated that the starting ARL for this project was a 3**. We based this evaluation on three factors: 1) Components of DHIS2 had been tested and validated by independent users, 2) we conducted a simple feasibility study that assessed the potential viability of modifying the DHIS2 software and we established a proof a concept for the application, and 3) we have a convincing case for the viability of our concept.

- Goal ARL = 9 (sustained use)

- Current ARL = 8 *(03/30/2023)*

  - We have completed version 2.0 of the web application and version 1.0 of the Docker image for the backend services. We have successfully tested the application. The software is working as expected and the user documentation is completed.

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Project Challenges & Risks

Rank	Type*	Risk	Mitigation Action
1	PM/B/ES	Overseas travel restrictions due to COVID-19.	UAH team members and the CDC implemented alternative outreach methods to demonstrate and deploy the technology to partner countries in Africa. We developed a demonstration video and attended the DHIS2 conferences.
2	PM	Sustainability *(Cloud EO Data Processing Costs)*	We developed a Docker Image for local deployment of backend services.
3	T	DHIS2 Software and Web Browsers Updates	We are working diligently to maintain software integrity with regard to software versions and web browsers updates. User documentation is key to success. Utilizing GitHub open-source repository.

* Please designate risk type as: Technical (T), Budget (B), End-User/Stakeholder (ES), or Project Management (PM)

Major Accomplishments / Results

- Developed a **cloud-based system** for retrieving, aggregating, and ingesting **Earth Observations (EO)** such as IMERG precipitation, MODIS surface temperatures, ECOSTRESS surface temperatures, and MODIS vegetation health data from NASA repositories over input health districts boundaries into DHIS2's database.
- Developed a Earth Observation Web Application DHIS2 Plugin for **requesting, importing, and managing** the NASA EO data.
- Updated the Graphic User Interface (GUI) for the Web App to include adding an administration section and updated security features.
- Developed an **API for the backend services** to expose EO data outside of DHIS2.
- Developed packaging procedures for distribution among partners using a **Docker Image** for local or network deployment.
- Worked with the NASA AppEEARS team at the LP DAAC to negotiate better connections with their system for many of the datasets.
- Worked closely with the developers of DHIS2 at the University of Oslo to demonstrate the need for ***EO data ingestion as a future core function.***
- Created a video demonstrating the web application and its functionality.
- Developed a project's webpage on UAH/ITSC research page.
- Completed user documentation and installation procedures.

Major Accomplishments / Results

- Established a GitHub Page for the Web Application and Docker Image.
    - https://github.com/UAH-NEOH/neoh-docker
    - https://github.com/UAH-NEOH/neoh-webapp

- Held several meetings with the developers of DHIS2. The DHIS development team is very impressed with our application and they demonstrated the concept to users at a recent meeting in Nairobi. They want to build a catalogue of available Earth observation layers to include within the core functions of DHIS2. There are many sources of data that many countries will find useful but they are spread out across too many locations to be accessible. DHIS has suggested to build a core application that will bring all of the layers under one roof so that countries can simply select from that list what they want to have available in their application. It will probably mean that DHIS will set up their own host so there is a single repository for the data. All of this is a direct result of our project.

Recent Improvements

- Using Docker and Fast API, instead of using AWS Services.
- Web-app is configured to use Docker App (local) by default.
- Added a functionality to bulk download NASA Earth observation data (year worth of request at once, able to make more on NASA server availability).
- Eliminated 5 minute timeouts (Limitations of AWS Lambda).
- Able to access process logs and data via Docker CLI (Helps to debug)
- Allows parallel requests (Make asynchronous request, not waiting for the first request to finish).
- Three endpoints available. Start process, Get status, and Get result.
- The Docker container can be deployed to a cloud provider. If a cloud-based solution is preferred.
- Users have option to modify and update the source file/Docker to tailor it to their individual needs.
- Using OPeNDAP (https://www.opendap.org/) services to request and sub-set NASA Earth observation data for faster access.

End-User / Stakeholder Engagement

- Conducted a visit to the CDC. This visit included a capabilities and project briefing to members of the CDC Malaria Branch.
- Received positive feedback from the poster presentations at AGU (2019, 2020, 2021, 2022) and AMS Conferences (2020, 2021, 2022, 2023).
- Gave a presentation at the BAO DHIS2 Symposium on September 15th, 2020.
- Gave a presentation at the 2022 American Mosquito Control Association Annual Conference in Jacksonville, FL on March 3, 2022.
- Co-I Dr. Luvall gave a presentation at the 2022 NASA ECOSTRESS Science Team Meeting about incorporating ECOSTRESS Temperature data into DHIS2 using our application.
- This project was highlighted in the NASA Health and Air Quality Newsletter for the October – December 2021 Issue.
- Participated in Video Tele-Conferences (VTC) with members from the Bill and Melinda Gates Foundation with regards to Malaria elimination.
- Working on writing and submitting a Journal Article. A possible journal would be the Journal of Infectious Diseases of Poverty. We plan to submit in mid April.
- Attended DHIS Annual Conference **(won Web App Honorable Mention)**.

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→ When the app is loaded, user will be shown the Welcome tab with instructions

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→ Click About tab to show more information about the dataset

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→ For the first time, user needs to set up the Data Elements in DHIS2.

→ Click "Generate" button and then "Store" button to save the values into DHIS2 instance.

→ User is ready to import data.

→ If you are a returning user, Click the "Show" button to look at the existing Data Elements IDs

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→ Click "Import Earth Observations" tab.

→ Select the dataset, Organizational unit levels, start date, and end date. Click " Create New Request" button to submit the request for processing.

→ The progress can be tracked (on the right side) on a table view. On a successful request, The data will be published to DHIS2

→ On a success, Click "See Results" on a table to view the data. User can also Download the data in CSV format

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→ Click "Imported Data" tab to view the existing data in DHIS2 instance
→ Select the dataset, Organizational unit levels, start year, and end year. Click "Submit".
→ The available data will be shown on the table in right side.
→ Note: Must run the Analytics Table in DHIS2 instance to view the latest data.