

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

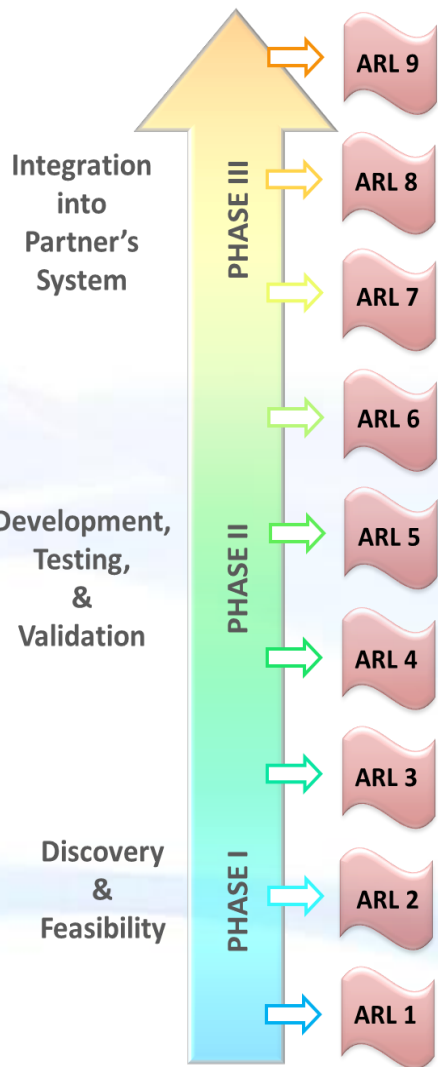


End-Users / Stakeholders

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.



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 (<i>Cloud EO Data Processing Costs</i>)	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 subset 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**).



DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome Import Earth Observations Imported Data Settings About

NASA Earth Observations for Health (NEOH)

Welcome to the **Earth observations data import wizard**.

This DHIS2 plugin will allow you import NASA Earth observation data such as precipitation, surface temperature, and vegetation health into DHIS2. To import NASA Earth Observations:

- Click the **Import Earth Observations** tab.
- Select the Earth observation you would like to import. You can choose between [precipitation](#), [surface temperature](#), and [vegetation health](#).
- Next, select the organizational unit to aggregate the data within those boundaries.
- Select the start date and end date.
- Select the "Request New Data" button.
- Your request and the progress will be displayed in the table.

Info
If the data elements for precipitation, temperature, and vegetation health have not been configured. Contact your system administrator. If you are an administrator select the **Settings** tab from the top menu to get started.

Acknowledgement
This work was funded by NASA's Earth Science Applied Sciences Program through their Health and Air Quality Program, grant #80NSSC19K0192 and performed by the University of Alabama in Huntsville (UAH). More information about this plugin can be found at the project's website [NASA Earth Observations for Health](#)


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

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DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome Import Earth Observations Imported Data Settings **About**

 **NASA Earth Observations for Health (NEOH)**

The **Earth Observations Data Import Wizard** was designed to request, retrieve, and import NASA Earth observations such as [precipitation](#), [surface temperature](#), and [vegetation health](#) into DHIS2.

Precipitation:
The precipitation data available with this plugin is NASA's IMERG Product. The Integrated Multi-satellitE Retrievals for GPM -- combines information from whatever constellation of satellites are operating in Earth orbit at a given time, to estimate precipitation over the majority of the Earth's surface.

Surface Temperatures:
The surface temperature data available with this plugin is NASA's MODIS Land Surface Temperature (LST) and Emissivity daily data which are retrieved at 1km pixels by the generalized split-window algorithm and at 6km grids by the day/night algorithm. In the split-window algorithm, emissivity's in bands 31 and 32 are estimated from land cover types, atmospheric column water vapor and lower boundary air surface temperature are separated into tractable sub-ranges for optimal retrieval. In the day/night algorithm, daytime and nighttime LSTs and surface emissivity's are retrieved from pairs of day and night MODIS observations in seven TIR bands. The product is comprised of LSTs, quality assessment, observation time, view angles, and emissivity's.

Vegetation Health:
The vegetation health data available with this plugin is NASA's MODIS Normalized Difference Vegetation Index (NDVI) product. MODIS NDVI, produced on 16-day intervals and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. The NDVI product is derived from atmospherically-corrected reflectance in the red, near-infrared, and blue wavebands, which provides continuity with NOAA's AVHRR NDVI time series record for historical and climate applications.

More information about this plugin can be found at the project's website [NASA Earth Observations for Health](#)

→ Click About tab to show more information about the dataset



DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome Import Earth Observations Imported Data **Settings** About

Data Element IDs Information

Precipitation Data Element ID

Temperature Data Element ID

Vegetation Data Element ID

DHIS2 district & Version

Generate **Store** **Show**

- 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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DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome **Import Earth Observations** Imported Data Settings About

Import Earth Observations

Earth Observation Datasets

Temperature

Organizational Unit Levels *

District

Start Date

01/01/2019

End Date

01/01/2019

Create New Request

*Disclaimer: Selecting an organizational unit level containing a large number of polygons may significantly increase processing time.

<input type="checkbox"/>	Dataset	Type	Status	Message	Date Created	View
<input type="checkbox"/>	temperature	aggregate	success	All requested files successfully aggregated	03-20-2023T20:31:24Z	See Results

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0 row(s) selected for deletion

Clear

- 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

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DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome Import Earth Observations Imported Data Settings About

Import Earth Observations

Earth Observation Datasets

Select Earth Observation Dataset

Organizational Unit Levels *

Select Organizational Unit Level

Start Date

mm/dd/yyyy

End Date

mm/dd/yyyy

Create New Request

*Disclaimer: Selecting an organizational unit level can significantly increase processing time.

Period	OrgUnit	Value (mm)
20190101	O6uvpzGd5pu	301.79597826086956
20190101	fdc6uOvgoji	303.5245112781955
20190101	lc3eMKXaEfw	301.1334453781513
20190101	jUb8gELQApI	300.445037037037
20190101	PMa2VCrupOd	303.0132
20190101	kJq2mPyFEHo	300.4309359605911
20190101	qhqaXpSTUXp	301.30705
20190101	Vth0fbpFcsO	301.77170454545455
20190101	jmlPBj66vD6	301.81300448430494
20190101	TEQlaapDQoK	302.69723076923077
20190101	bl4ooGhyHRQ	301.21918032786886
20190101	elQbndfxQMb	303.3109615384615
20190101	at6UHUQatSo	303.45454545454544

Download CSV X

Created: 2020-01-20 20:31:24Z

View

See Results

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→ 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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DHIS 2 Demo - Sierra Leone - Earth Observation Importer

Welcome Import Earth Observations **Imported Data** Settings About

Imported Data

* Data Refreshed Periodically

Earth Observation Datasets

Precipitation

Organizational Unit Levels

District

Start Year

2019

End Year

2020

Submit

Precipitation District (2019 - 2020)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
2019												
2020	X	X										

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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.