

NEXTGEN IN A BOX: NEXTGEN FRAMEWORK NATIONAL WATER MODEL COMMUNITY RELEASE

Unlock the potential for collaborative research



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DevOps Manager & Enterprise Architect
(#cloud, #devops, #infrastructure, #architect,...)



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CUAHSI Summer Institute '23



THE UNIVERSITY OF
ALABAMA | Alabama Water
Institute

AGENDA

- Introduction – CIROH and Team
- What is **National Water Model?**
- What is NOAA-OWP’s **NextGen?**
- What is **NextGen In A Box?**
- **Technology Stack Learning Session**
- Hands-on **demo of NextGen In A Box (local machine)**
- **Conclusion**
- **Q&A**



ABOUT CIROH

- The Cooperative Institute for Research to Operations in Hydrology (CIROH) is a **consortium of 28 institutions** to advance the National Oceanic and Atmospheric Administration's (**NOAA**) science and services capabilities to provide actionable water resources intelligence.
- CIROH's research aims to **improve water prediction** and supports **four broad themes**:
 - (1) **water resources prediction capabilities**;
 - (2) **community water resources modeling**;
 - (3) **hydroinformatics**; and
 - (4) application of **social, economic and behavioral science to water resources prediction**.
- CIROH outcomes will inform hydrological process understanding, operational forecasting techniques and workflows, community engagement in water modeling, open-source software development, translation of forecasts to actionable products, and use of predictions in decision making.



OUR TEAM

CIROH TEAM

The University of Alabama (UA) Team

- **Steve Burian, Ph.D.** - Executive Director of CIROH, Director of Science, AWI
- **James Halgren, Ph.D.** - Assistant Director of Science
- **Puri Bangalore, Ph.D.** - Professor in the Department of Computer Science
- **Jeff Carver, Ph.D.** - Professor in the Department of Computer Science
- **Arpita Patel** - DevOps Manager & Enterprise Architect
- **Benjamin Lee** - DevOps Engineer
- **Sepehr Karimi, Ph.D.** – Research Software Engineer, Data Scientist
- **Shahab Alam, Ph.D.** - Postdoc
- **Hari Jajula** – Student
- **Rohan Sunkarapalli** – Student

Lynker Team

- **Zach Wills** - Software Engineer
- **Nels Frazier** - Lead Technical Architect
- **Jordan Laser** - Software Engineer
- **Mike Johnson** – Hydrofabric Lead

RESEARCH TO OPERATIONS PATHWAY





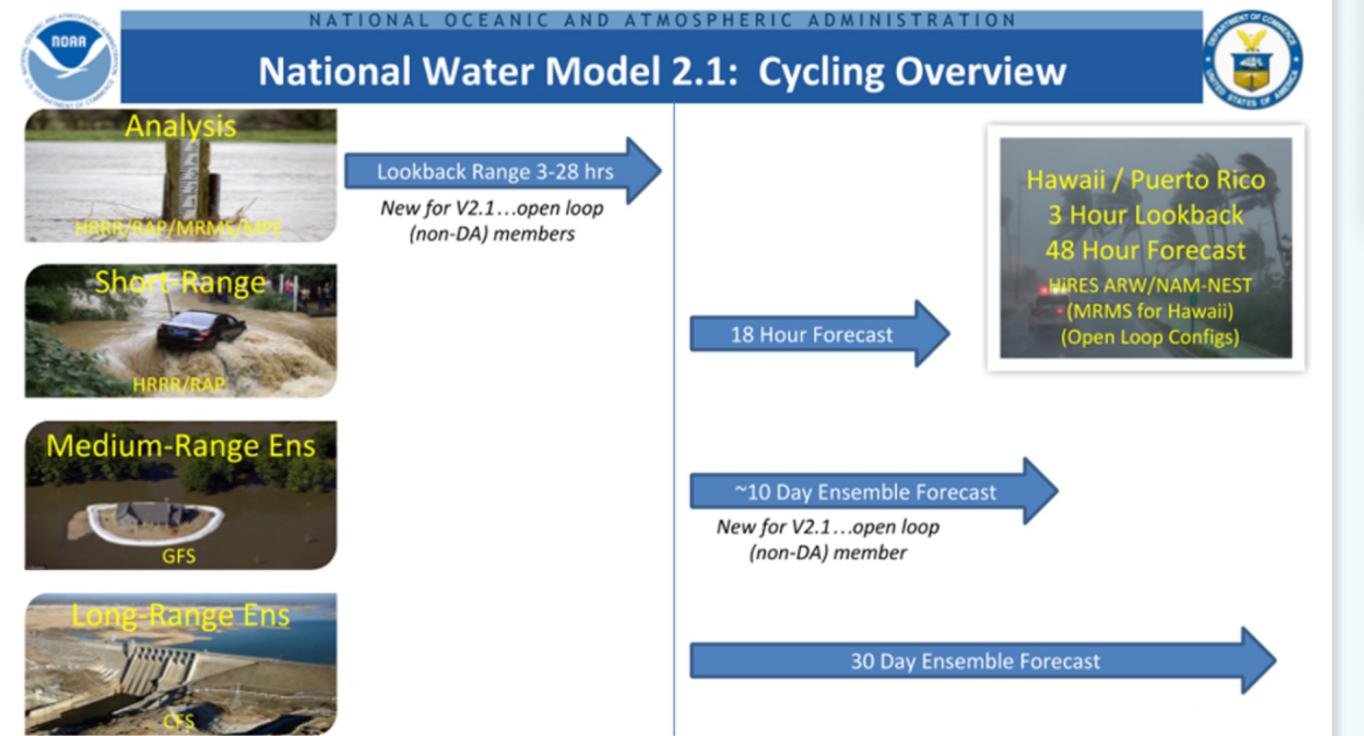
NWM AND NEXTGEN

WHAT IS THE NATIONAL WATER MODEL?

- The National Water Model (NWM) is a **hydrologic model developed by** the National Oceanic and Atmospheric Administration (**NOAA**) to simulate and forecast water conditions across the United States.
- This water prediction model creates forecast guidance for over 3.4 million miles of rivers and streams across the United States and its territories.
- The NWM supercomputer is fed nonstop data covering everything from current stream-flow to the snowpack in mountain ranges above.
- The job of the supercomputer is to take all of that data and produce stream flow forecasts for every stream and river in the continental United States and its territories. There are three different flavors of forecasts: short, medium, and long range.
- Just like how your local weather station can tell you what the weather will be like tomorrow, in 3 days, or a week from now; the NWM can tell you what the stream flow will be like in 18 hours, 10 days, or even up to 30 days from now.
- NOAA Central Library Seminar Recording from OWP (Next-Generation Water Resources Modeling):
<https://youtu.be/DLli3PruYxo>

NWM 2.1

- The NWM currently runs in four configurations:
 - Analysis and assimilation provides** a snapshot of current hydrologic conditions
 - Short-Range** produces hourly forecasts of streamflow and hydrologic states out to 15 hours
 - Medium-Range** produces 3-hourly forecasts out to 10 days
 - Long-Range** generates 30-day ensemble forecasts.



Source : <https://water.noaa.gov/about/nwm>

SO...WHAT IS NEXTGEN?

NextGen is a framework designed for building and integrating models rather than a model itself.

- Model agnostic!

The framework's focus is on a data-centric process that abstracts the addition of processes and data behind a standard.

- Data-centric standards

NextGen design allows for greater flexibility and standardization in model creation and integration.

Github URL: <https://github.com/NOAA-OWP/ngen>

ADDITIONAL NWM INFORMATION

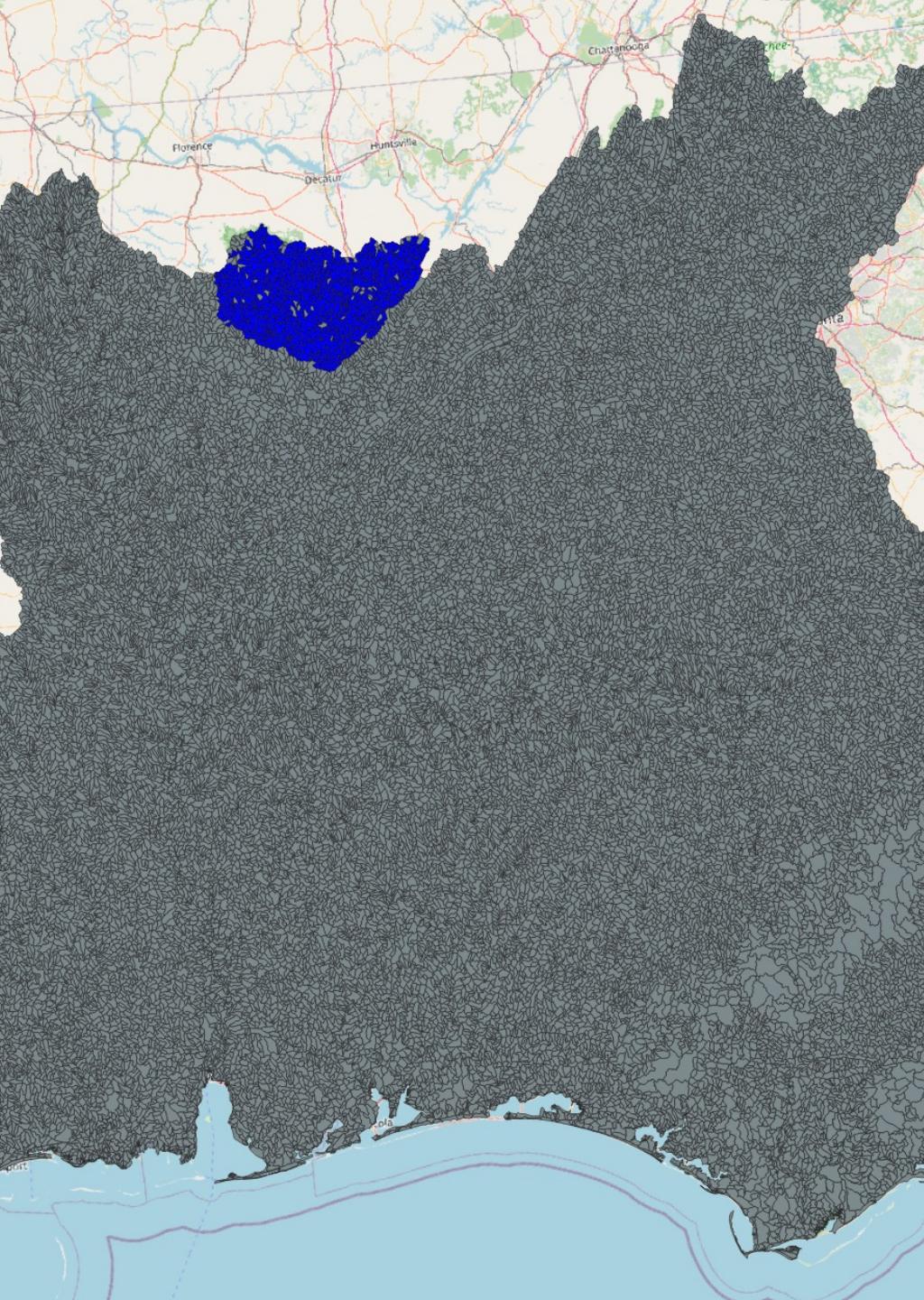


- Existing National Water Model basics course on HydroLearn:

<https://edx.hydrolearn.org/courses/course-v1:BYU+NWM101+2021/about>

NEXTGEN IN A BOX

- USE CASE
- OVERVIEW OF NEXTGEN
- OBJECTIVES AND BENEFITS OF NEXTGEN
- KEY FEATURES



USE CASE

- We are going to do a case study NWM run for Sipsey Fork, Black Warrior river
 - We don't want to run all of CONUS
 - We want to run NextGen locally
 - We want to have control over inputs / config.
 - How can we do it? Answer: **NextGen In A Box**
- Finally, - Generate outputs of the NextGen
 - NextGen currently outputs CSV at each catchment & nexus

OVERVIEW OF NEXTGEN IN A BOX COMMUNITY WATER MODEL FOR NWM

- Introducing the Nextgen In A Box community model for NWM to Academic community.
- Encouraging Academic researchers and developers to consider adopting this model in their own projects

OBJECTIVES AND BENEFITS OF THE COMMUNITY MODEL



To foster collaboration among academic researchers and developers in the Github repo community

This model provides a platform for individuals to share ideas, resources, and knowledge to advance research and development in the NWM. This model provides a platform for individuals to share ideas, resources, and knowledge to advance research and development in the NWM.



To enable rapid and efficient development of NWM repo-related tools and technologies

The model leverages the collective skills, expertise, and resources of the community to accelerate the development and deployment of NWM repo-related tools and technologies.



To promote open and transparent research practices

The model encourages open sharing of data, methods, and results to facilitate reproducibility and collaboration in the NWM repo field.



To facilitate adoption of NWM repo-related tools and technologies by the wider academic community

The model promotes the dissemination and adoption of NWM repo-related tools and technologies to enhance research efficiency and impact.

KEY FEATURES OF THE NEXTGEN IN A BOX COMMUNITY MODEL FOR NWM



Open and collaborative development process for all community members

Ensures that all members have a voice and can contribute to the development of the model



Flexible and modular structure that allows for customization

Enables users to adapt the NextGen workflow to fit their specific research and development needs



Reusable components that can be shared across multiple projects

Saves time and effort by avoiding the duplication of work and promoting knowledge sharing



Dedicated community support and resources

Provides documentation and guidance to users throughout the implementation and development process

NEXTGEN IN A BOX: INPUT

- INPUT DATA – CONFIG AND FORCINGS

SAMPLE INPUT DATA

Sipsey Fork, Black Warrior river

03W VPU (catchment-113060) Subset data:

Use Case: AWI 001 - Index file for sample data on S3 bucket: [AWI-001-index](#)

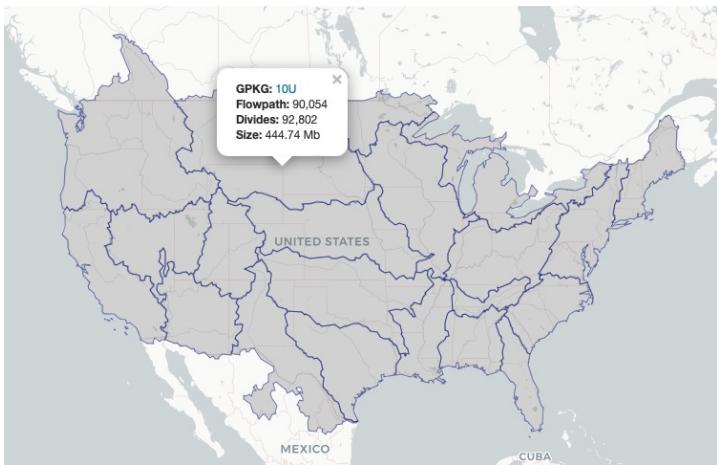
The screenshot shows the AWS S3 Explorer interface. The top navigation bar displays the URL: `ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com/index.html#AWI-001/AWI_03W_113060_001/`. Below the URL, the breadcrumb navigation shows: AWS S3 Explorer / [ciroh-ua-ngen-data](#) / [AWI-001](#) / [AWI_03W_113060_001](#). A dropdown menu indicates "Show 50 entries". The main content area is a table with two columns: "Object" and "Last Modified". The "Object" column lists two items: "config/" and "forcings/". The "Last Modified" column shows the last modified date for each item, which is not explicitly visible in the screenshot. At the bottom, a message states "Showing 1 to 2 of 2 entries".

Object	Last Modified
config/	
forcings/	

Showing 1 to 2 of 2 entries

NEXTGEN HYDROFABRIC

FILE REPRESENTATION OF THE PHYSICAL LAND AND FLOW PATHS OF WATER IN THE CONUS



The hydrofabric is a representation of the physical land and flow paths of water in the contiguous United States (CONUS).



Its files are the first argument to run ngen model.



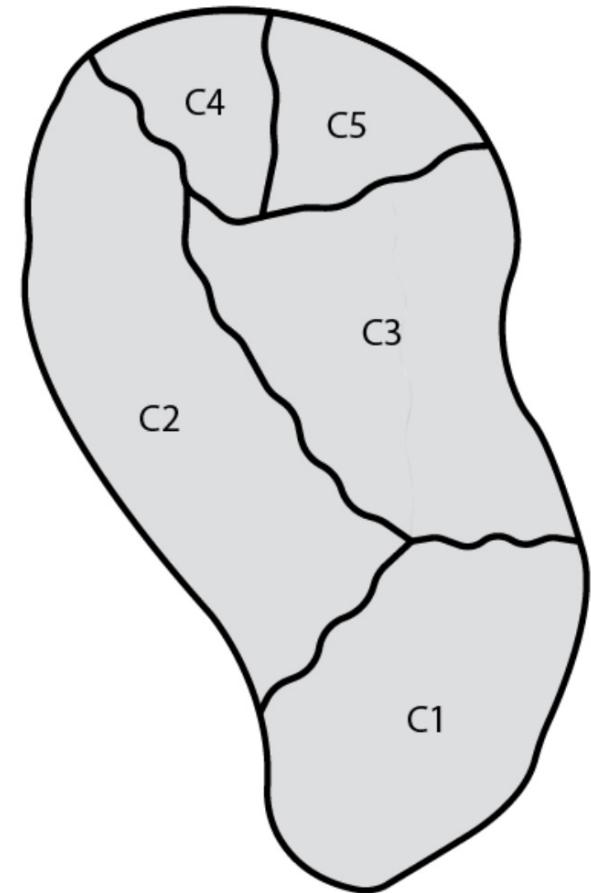
URL: <https://noaa-owp.github.io/hydrofabric/>



S3 bucket: <https://nextgen-hydrofabric.s3.amazonaws.com/index.html>

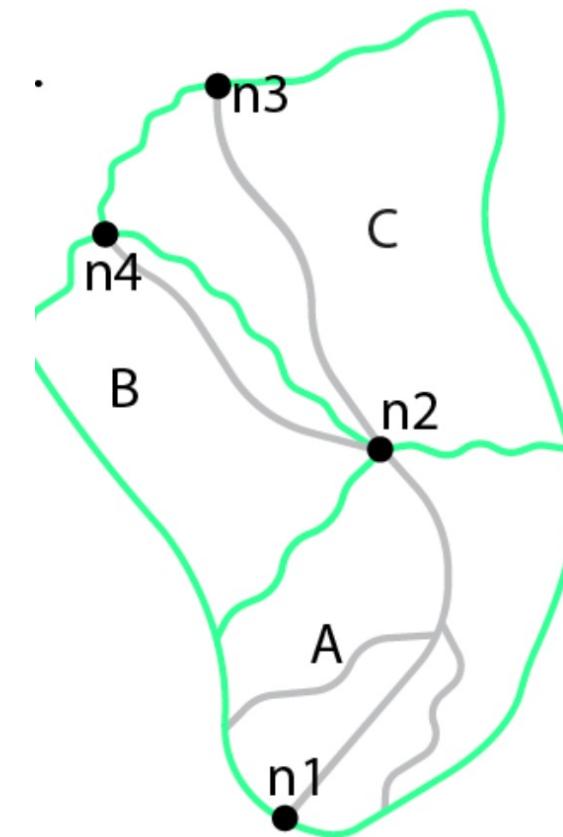
NEXTGEN CATCHMENT

- A catchment is a geographical area in which water drains into a common watercourse, such as a river or lake.
- The NextGen Hydrofabric divides the landscape into catchments, each of which is configured and parameterized then simulated independently by the model.
- More info: <https://github.com/NOAA-OWP/ngen/blob/master/data/README.md>

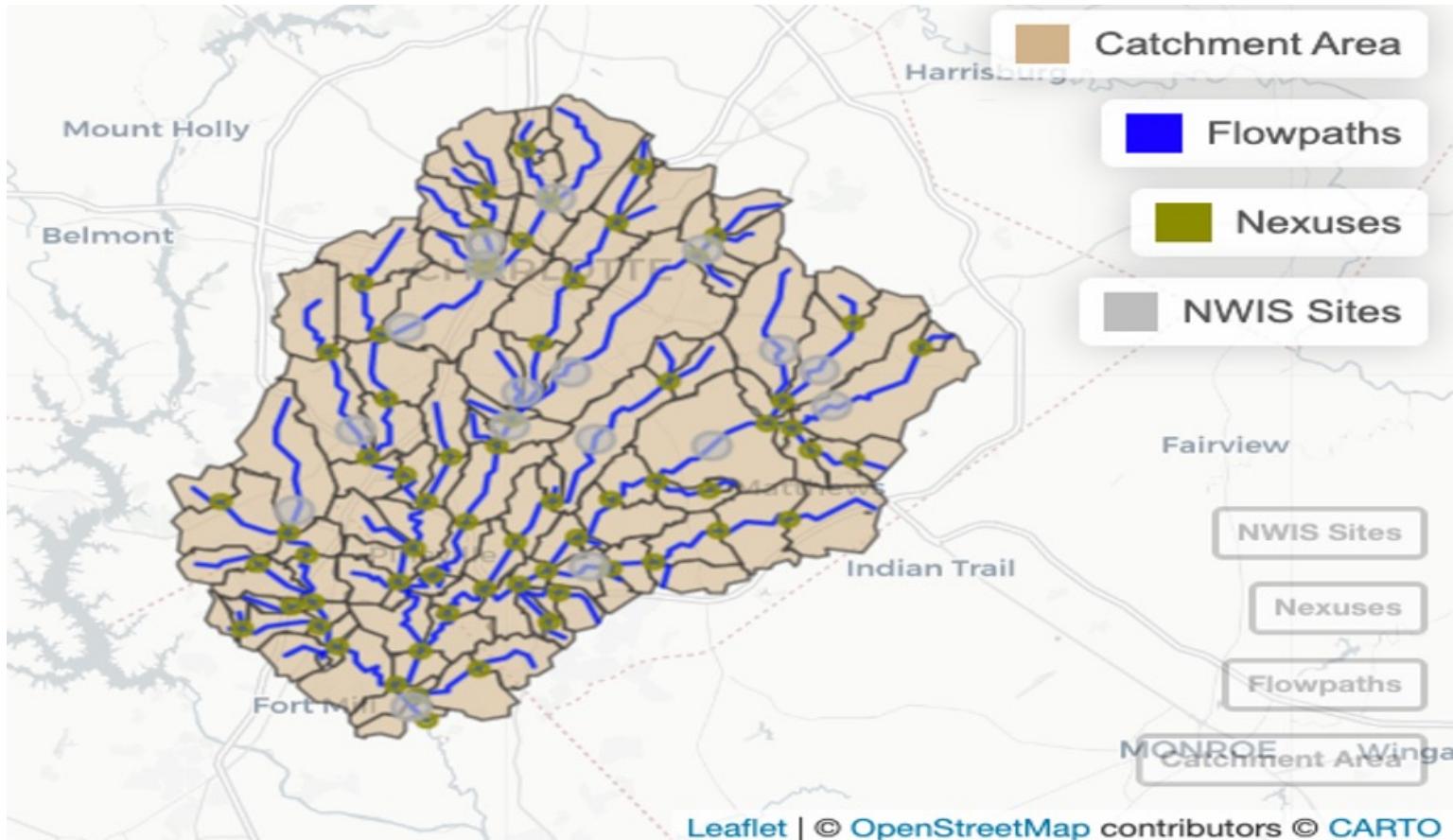


NEXTGEN NEXUSES

- The nexus is the connection between the surface and subsurface water systems within a catchment.
- It includes the movement of water through soil and rock, as well as the interactions between groundwater and surface water.
- The NextGen framework simulates these processes to estimate the amount of water at a nexus.
- It is a location where one or more nested models or groups of models are integrated.
- Nexuses are also planned be placed at hydrologically significant locations, (like at a known gauge) to output data for easier comparison.



CATCHMENT AND NEXUSES



REALIZATION FILES (CONFIG FILE)

```
{  
  "global": {  
    "formulations": [  
      {  
        "name": "bmi_multi",  
        "params": {  
          "name": "bmi_multi",  
          "model_type_name": "NoahOWP_CFE",  
          "main_output_variable": "Q_OUT",  
          "init_config": "",  
          "allow_exceed_end_time": false,  
          "fixed_time_step": false,  
          "uses_forcing_file": false,  
          "modules": [  
            {  
              "name": "bmi_c",  
              "params": {  
                "name": "bmi_c",  
                "model_type_name": "CFE",  
                "main_output_variable": "Q_OUT",  
                "init_config": "/nsgen/AWI_001/config/awi_config.ini",  
                "allow_exceed_end_time": true,  
                "fixed_time_step": false,  
                "uses_forcing_file": false,  
                "variables_names_map": {  
                  "atmosphere_water_liquid_equivalent_precipitation_rate": "precip_rate",  
                  "water_potential_evaporation_flux": "EVAPOTRANS",  
                  "ice_fraction_schaake": "sloth_ice_fraction_schaake",  
                  "ice_fraction_xinan": "sloth_ice_fraction_xinan",  
                  "soil_moisture_profile": "sloth_smp"  
                },  
                "model_params": {  
                  "b": 8.660529385231255,  
                  "satdk": 0.00011760880965802808,  
                  "maxsmc": 0.543673362985325,  
                  "refkdt": 3.6613440504586134,  
                  "slope": 0.8154788969461678,  
                  "max_gw_storage": 0.04021994414923359,  
                  "expon": 7.308820146231674,  
                  "Cgw": 0.0004609207383395736,  
                  "Klf": 0.1681695665829872,  
                  "Kn": 0.4017865685354076  
                }  
              }  
            ]  
          ]  
        }  
      ]  
    ]  
  ]  
}
```

- A realization is a set of inputs to the NWM that are used **to simulate the behavior of a catchment**. This includes meteorological data, such as **precipitation** and **temperature**, as well as information about the **land surface, such as soil moisture and vegetation cover**. The NWM uses realizations to forecast the water conditions in a catchment over time.
- Realizations provide a description of
 - the model(s) that run in catchments
 - Model parameters
 - Associated forcings
 - Model libraries

Realization files offer a powerful interface

- For automating model generation and calibration using machine-readable file formats
- which provide ability to support multi-model implementations, routing changes, and parameter variations.

```
2022-08-24 21:00:00,0.0,366.85886363636365,515.3281818181817,99616.97272727272,294.55954545454534,-1.4730909090909092,-2.742090909090909,0.0
2022-08-24 22:00:00,0.0,369.80590909090915,346.70995454545454,99594.3818181814,294.9004545454545,-2.3777272727272734,-2.38227272727273,0.0
2022-08-24 23:00:00,5.465763e-07,371.1136363636363,174.92749999999998,99608.5090909091,295.1936363636363,-1.95418181818185,-2.111181818181819,5.465763e-07
2022-08-25 00:00:00,6.7041565e-06,370.8944545454545,27.8396363636362,99634.64090909091,295.3190909090909,-0.7035,-2.5654090909090908,6.7041565e-06
2022-08-25 01:00:00,8.889083e-05,373.98027272727273,0.0,99668.03636363636,295.046818181814,-0.0520454545454534,-2.0010909090909093,8.889083e-05
2022-08-25 02:00:00,6.747035e-05,404.54200000000003,0.0,99688.96363636364,295.08454545454555,-0.968909090909091,-0.9149090909090912,6.747035e-05
2022-08-25 03:00:00,2.7146058e-07,387.6152727272727,0.0,99682.16363636364,294.980909090909,-1.3147272727272727,1.11568181818182,2.7146058e-07
2022-08-25 04:00:00,2.0956728e-07,405.59327272727273,0.0,99679.1,294.8190909090909,-1.3546363636363634,1.233409090909091,2.0956728e-07
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2022-08-25 06:00:00,4.2404034e-07,364.4026363636363,0.0,99692.88636363637,294.4031818181818,-1.02786363636362,0.2014999999999998,4.2404034e-07
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2022-08-25 08:00:00,4.348889e-07,361.8862272727273,0.0,99638.67272727274,293.834090909091,-1.4861818181818,1.2407727272727274,4.348889e-07
2022-08-25 09:00:00,2.1378277e-07,363.3771818181814,0.0,99628.05909090908,293.4740909090908,-1.64395454545454,1.550909090909091,2.1378277e-07
2022-08-25 10:00:00,1.0461959e-09,372.4043181818181,0.0,99611.3818181814,293.11227272727274,-1.46672727272727,2.35,1.0461959e-09
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2022-08-25 12:00:00,1.06891385e-07,377.8324090909091,89.2866363636366,99651.32727272726,292.62409090909097,-1.19936363636364,2.87595454545457,1.06891385e-07
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2022-08-25 15:00:00,1.7014056e-05,371.45863636363634,579.4265454545455,99678.868181818,292.4509090909091,-1.3245,1.78550000000000003,1.7014056e-05
2022-08-25 16:00:00,5.9881e-06,390.70981818182,489.1470909090909,99656.4,292.5909090909091,-0.23072727272727,1.77572727272722,5.9881e-06
2022-08-25 17:00:00,6.974531e-06,389.9126363636364,569.3464545454545,99598.58636363636,292.8409090909091,0.0614545454545456,1.4741363636363638,6.974531e-06
2022-08-25 18:00:00,7.915695e-05,387.3512727272727,575.4722727272728,99570.09545454546,293.023181818185,1.437090909090909,1.6983636363637,7.915695e-05
2022-08-25 19:00:00,5.2005063e-05,400.9825909090909,329.6197272727273,99490.45909090912,293.45409090909095,0.234,-0.85281818181817,5.2005063e-05
2022-08-25 20:00:00,0.00046328641,405.8560454545455,119.39481818182,99471.23636363637,294.23545454545456,1.85727272727276,-2.1581818181818,0.00046328641
2022-08-25 21:00:00,2.3808841e-05,403.60481818183,43.77959090909092,99448.34545454546,294.26045454545454,0.1495,-0.3169090909090909,2.3808841e-05
```

NEXTGEN FORCING

Per Catchment:
cat03w_cat-106885.csv

Link to forcing files in S3 bucket:
S3-bucket-forcing-files

TECHNICAL STACK: NEXTGEN IN A BOX

- OPENSOURCE TECHNOLOGY

“NEXTGEN IN A BOX” - TECHNOLOGY STACK

OPENSOURCE TECHNOLOGIES



Git – Distributed version control system that allows developers to track changes to their code over time and collaborate with other team members on code development.



Github – web-based central hub for Git repositories.



Github Actions - platform for automating software workflows, such as building, testing, and deploying code, directly within the GitHub repository



Docker – platform that allows developers to create, deploy and run applications in containers.



Terraform – Infrastructure as code tool that allows developers to provision and manage cloud infrastructure using declarative code.

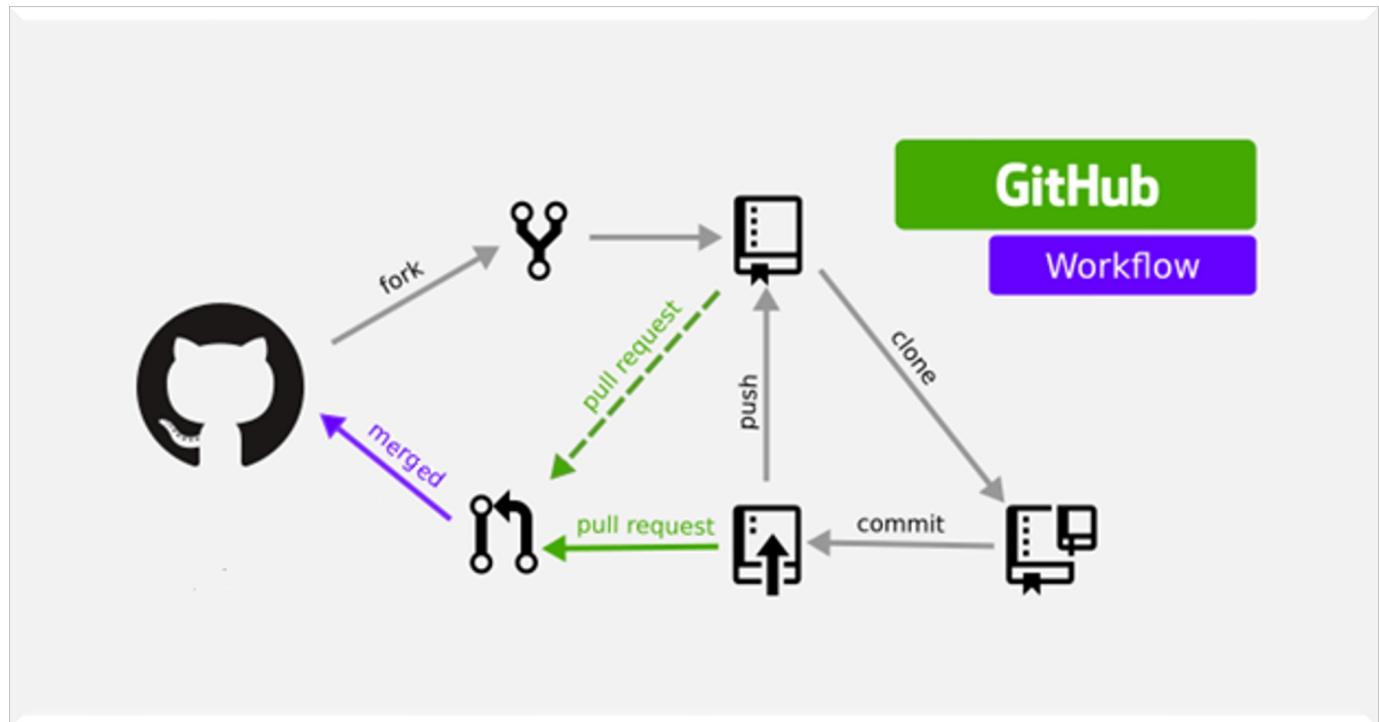


Cloud Infrastructure, Storage – Collection of hardware and software components that are used to provide cloud computing service, such as VM, storage and networking.

GIT BASICS!



- Git is a **version control system** for tracking the changes to the files and for **collaborating** work on those files among multiple people.
- Some basic **GIT commands** are:
 - ◆ **git init** -> Create a new git repo in the directory
 - ◆ **git clone**-> Clone the repository
 - ◆ **git branch** -> Create a new local branch
 - ◆ **git checkout** -> Switch branches
 - ◆ **git add** -> Add a new file to your staging area
 - ◆ **git commit** -> Adds staged changes to your local repository
 - ◆ **git pull** -> pull code from your remote repo to your local directory
 - ◆ **git push** -> Push local repository changes to your remote repo
 - ◆ **git status** -> Show which files are being tracked (and untracked)
 - ◆ **git diff** -> See the actual difference in code between your Working Directory and your Staging Area



GITHUB



- GitHub is a web-based **platform** for hosting and sharing Git repositories
 - GitHub makes it easier for teams to **collaborate** on code development, even when working remotely
 - GitHub provides **version control** and change tracking, so developers can easily see what changes have been made to the code over time
 - GitHub provides a platform for sharing and discovering **open source** projects
 - **Key features:**
 - Code hosting and version control
 - Collaboration tools, such as pull requests and code reviews
 - **Github Issues & Github projects** - Issue tracking and project management
 - Continuous integration and deployment (**CI/CD**) with **GitHub Actions**
-

NEXTGEN IN A BOX : GITHUB REPO



Repository location:

<https://github.com/CIROH-UA/CloudInfra>



Contains:

Dockerfiles

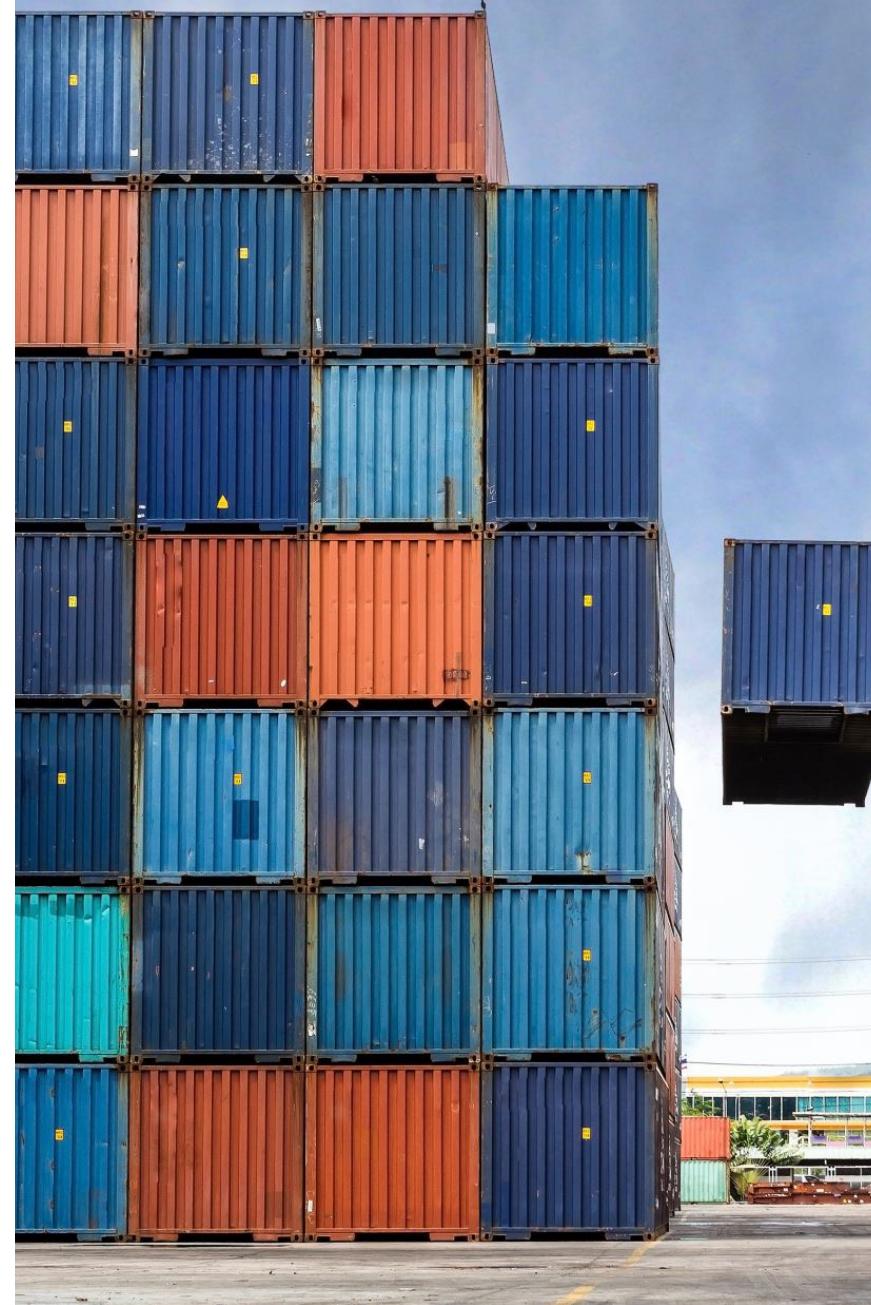
Terraform scripts

Github actions yaml files

Shell Scripts

DOCKER

- Standard unit of software
 - **Packages code and dependencies**
 - Can be shared as Docker **Images**
 - **Multiple** containers can be run simultaneously
 - **Portable**
 - **Lightweight** - Uses the host operating system
 - **Secure** - Strong default isolation features
 - Sometimes used in addition to VMs
 - Real world example :
<https://alabama.box.com/s/7fhd4lmkpcyrn2i0iajpj590sa77rvua>
-



WHY USE DOCKER?

- Develop **faster**
- Develop applications that work on **any OS**
- Easy to **share** applications among teams
- Easy to **scale** across multiple servers
- Large applications can be broken into **multiple** containers - one for each microservice
- Great solution for **Cloud Computing**
- Big community and **library** of Docker Images



DOCKERFILE COMMANDS

- **FROM:** Specifies the base image for the Docker image you're building.
 - **RUN:** Runs a command in the Docker image.
 - **COPY:** Copies files from your local machine to the Docker image.
 - **WORKDIR:** Sets the working directory for the Docker image.
 - **EXPOSE:** Specifies which ports should be exposed by the Docker image.
 - **CMD:** Specifies the command that should be run when the Docker container is started.
-

DOCKER COMMANDS:

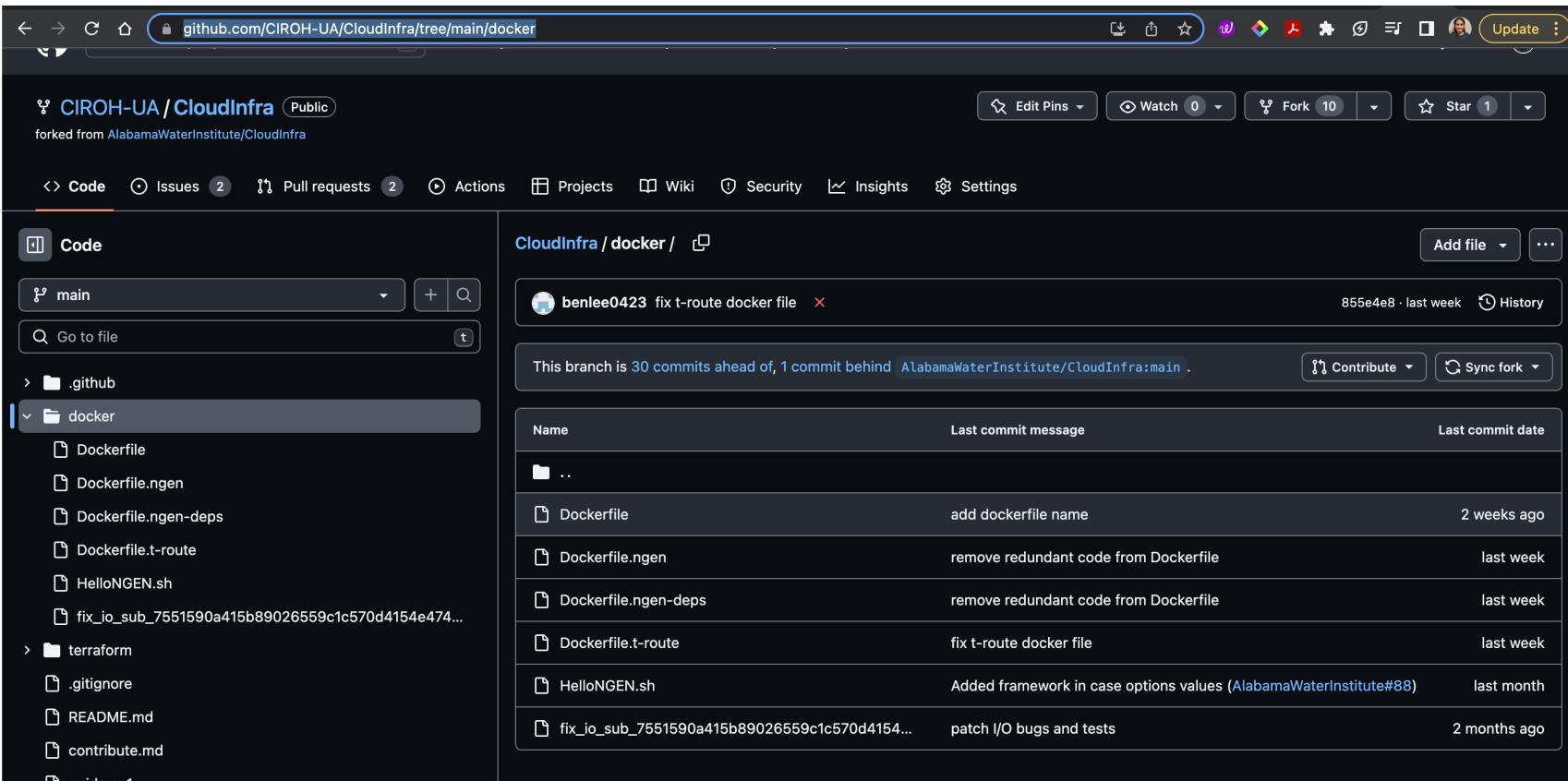
- **docker build**: Builds a Docker image from a Dockerfile.
 - **docker run**: Runs a Docker container from a Docker image.
 - **docker ps**: Lists the running Docker containers.
 - **docker stop**: Stops a running Docker container.
 - **docker rm**: Deletes a stopped Docker container.
 - **docker images**: Lists the Docker images on your machine.
 - **docker rmi**: Deletes a Docker image.
-

GETTING STARTED WITH DOCKER

- To get started with Docker, you need to install the **Docker engine** on your machine
 - Docker provides a range of **command-line tools and APIs** for working with containers and images
 - Docker also provides a range of services, such as **Docker Hub** and **Docker Store**, for finding and sharing container images
-

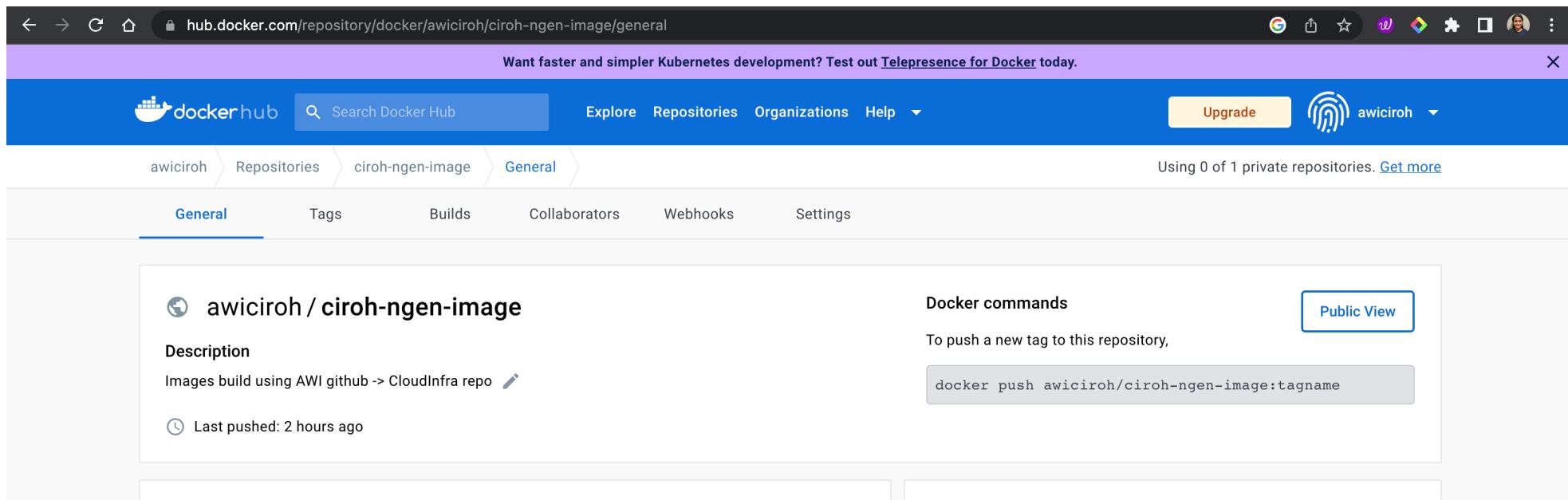
NGEN DOCKERFILE

- NextGen Dockerfile is available at
- <https://github.com/CIROH-UA/CloudInfra/tree/main/docker>



NEXTGEN IN A BOX: DOCKER HUB

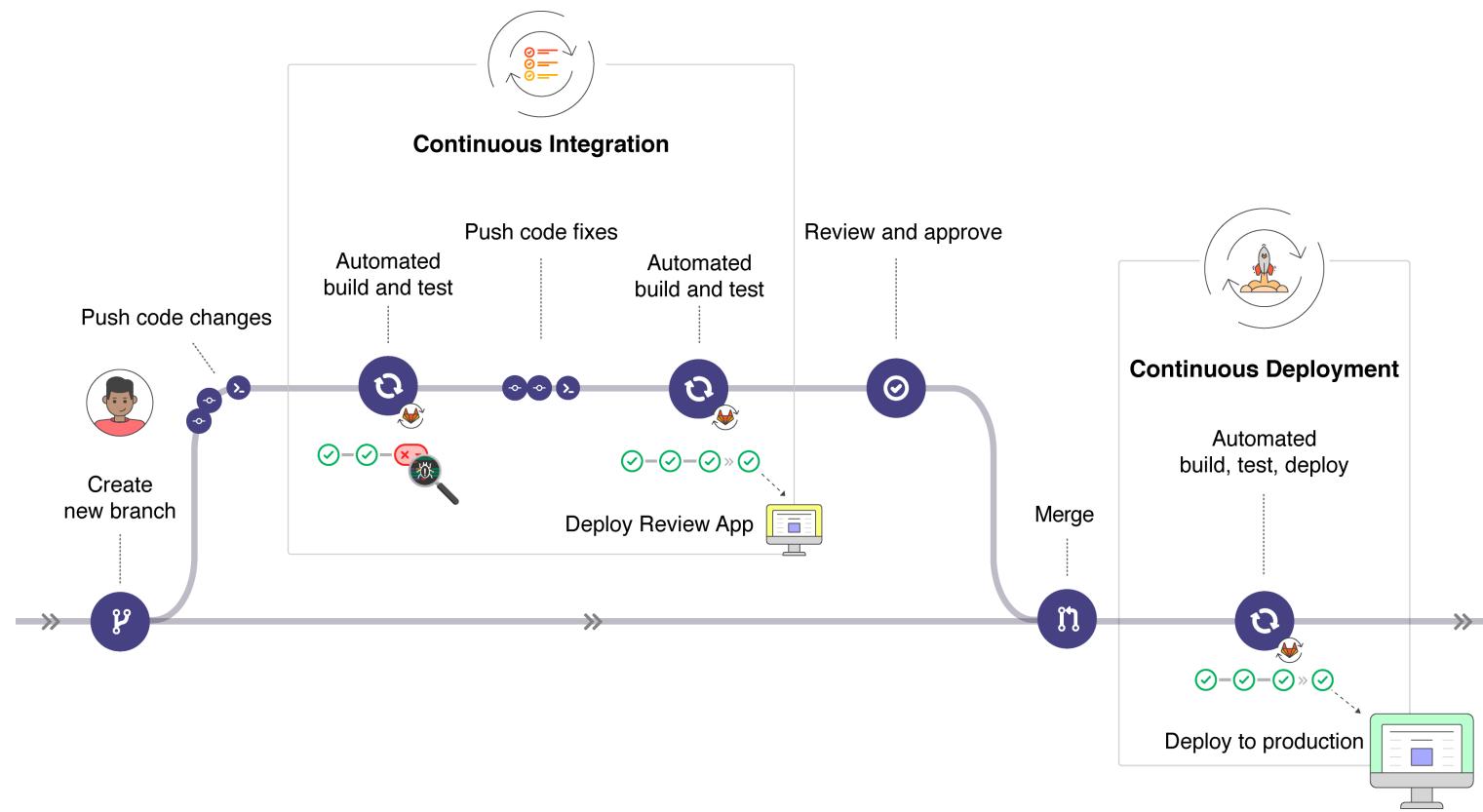
- **Dockerhub account :** awiciroh
- **Image name:** ciroh-ngen-image
- **Image tags:** latest_x86, latest_arm



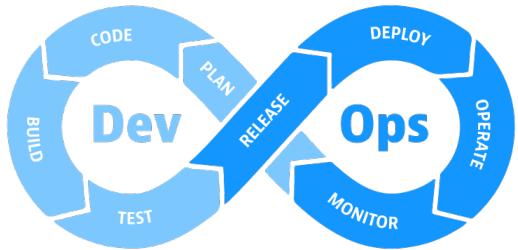
The screenshot shows a Docker Hub repository page for the user 'awiciroh'. The repository is named 'ciroh-ngen-image'. The 'General' tab is selected. The page displays basic information about the repository, including its name, a description stating 'Images build using AWI github -> CloudInfra repo', and the last push time ('2 hours ago'). On the right side, there is a 'Docker commands' section with a command box containing 'docker push awiciroh/ciroh-ngen-image:tagname' and a 'Public View' button. The top navigation bar includes links for 'Explore', 'Repositories', 'Organizations', 'Help', and a user profile for 'awiciroh'.

WHAT IS CI/CD?

- Continuous Integration & Continuous Deployment is an **automated process** for continuously integrating code changes in a small interval, testing them and releasing them out to the community.
- Real world example: <https://alabama.box.com/s/w1d1u5kd0f04nddtbnyb25culsjkouu2>



WHAT IS DEVOPS?



Real World Example:

<https://alabama.box.com/s/3j7d3zjk5b0kjgg22974toatrox6082>

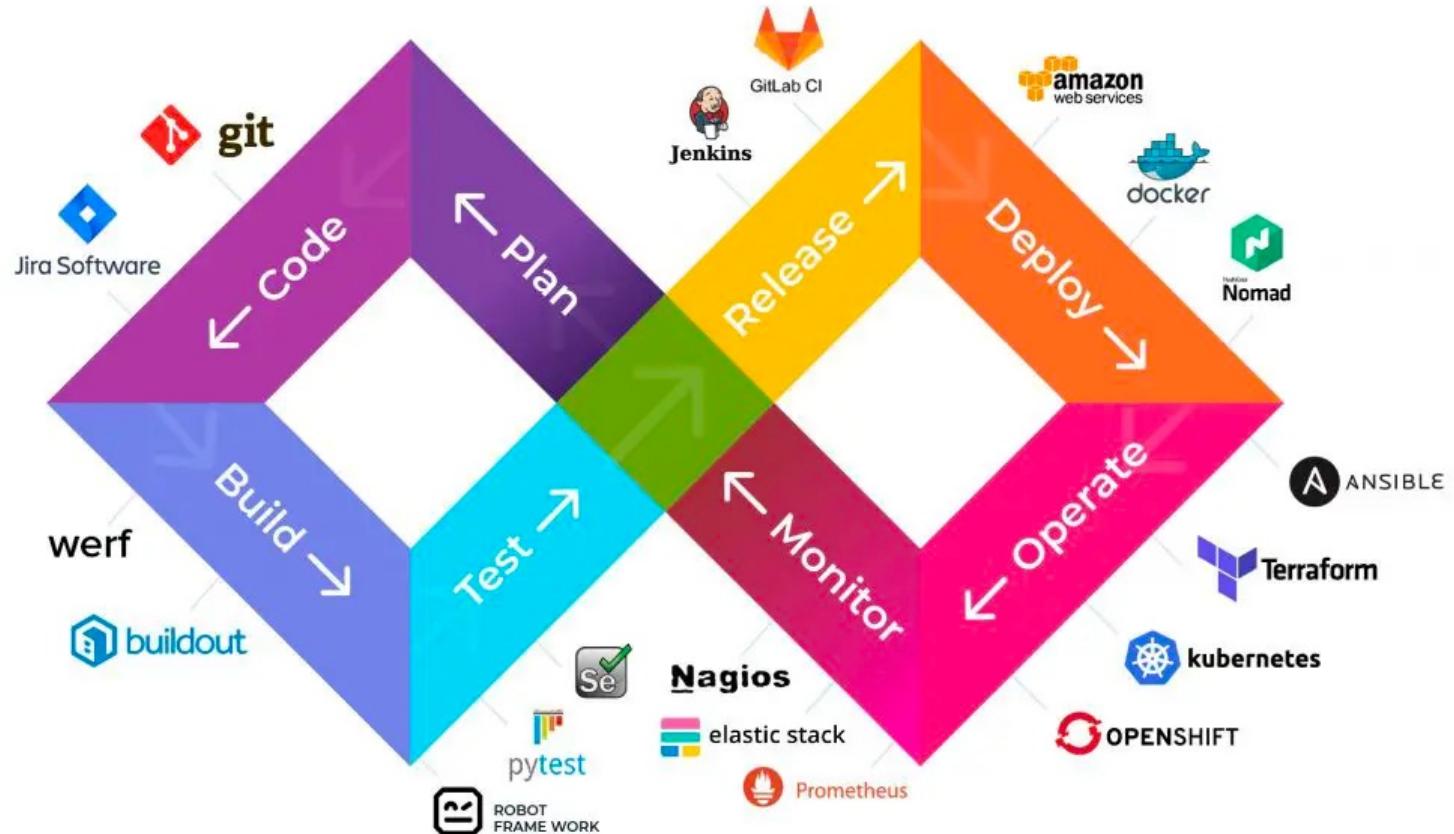
DevOps is a combination of software development (dev) and operations (ops).

It is defined as a software engineering methodology which aims to integrate the work of development teams and operations teams by facilitating a culture of collaboration and shared responsibility.

- DevOps is the union of **people, process, and products** to enable continuous delivery of value to your end users.
- Let's see life before DevOps and after DevOps using pit stops example: ([DevOps analogy](#))
- Some key benefits of using DevOps -
 - Better tasks & backlog tracking, **Reduce overall cost**
 - Continuous Integration, Delivery & Deployments (**CI/CD**)
 - Release **faster** and work smarter
 - Culture of **Collaboration**
 - **Scalability**
 - **Security** and monitoring (**DevSecOps**)

DEVOPS CONT.

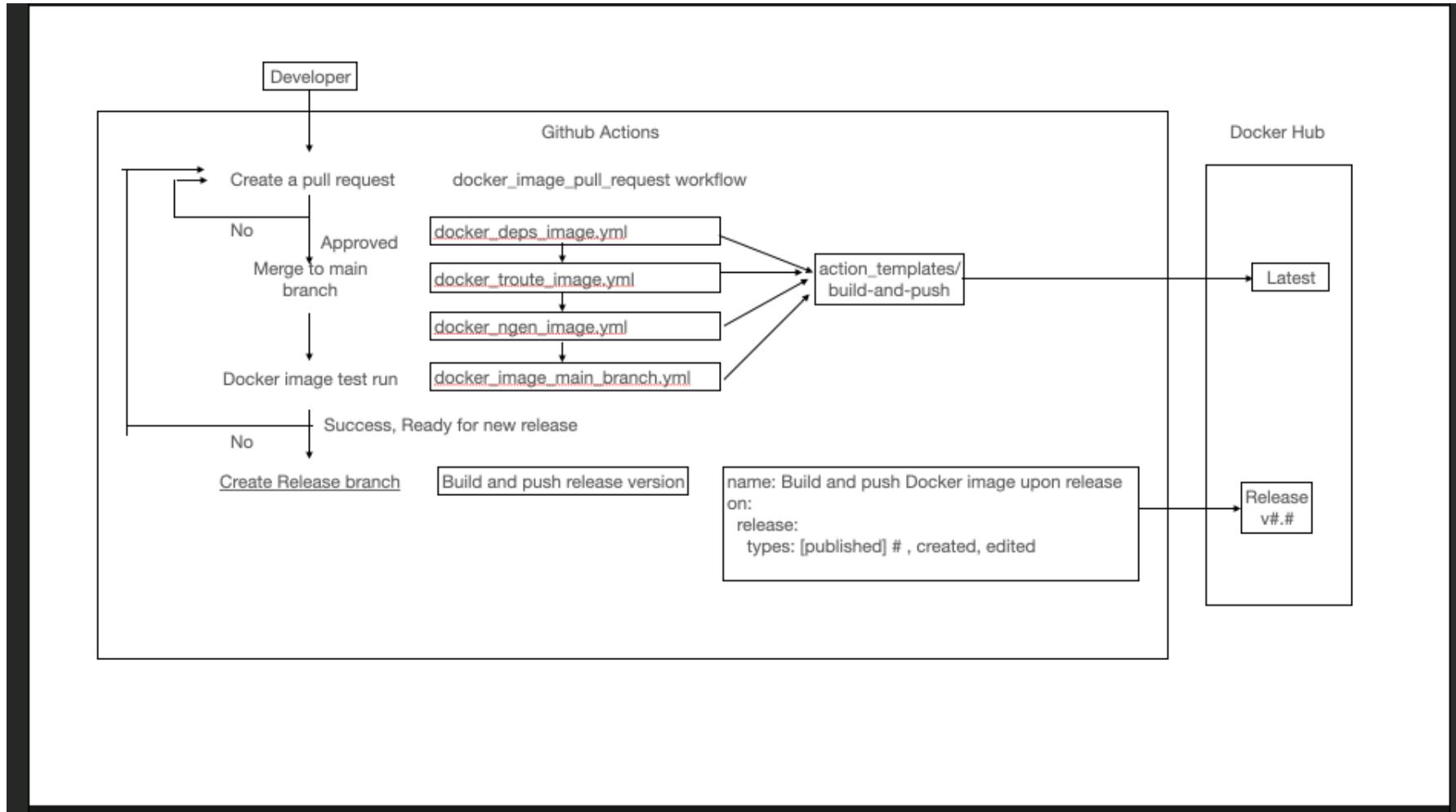
- Azure DevOps
- Git, Github, Github Issues
- Github Actions
- Terraform / K8s / ARM templates
- Docker
- AWS
- Prometheus / Grafana



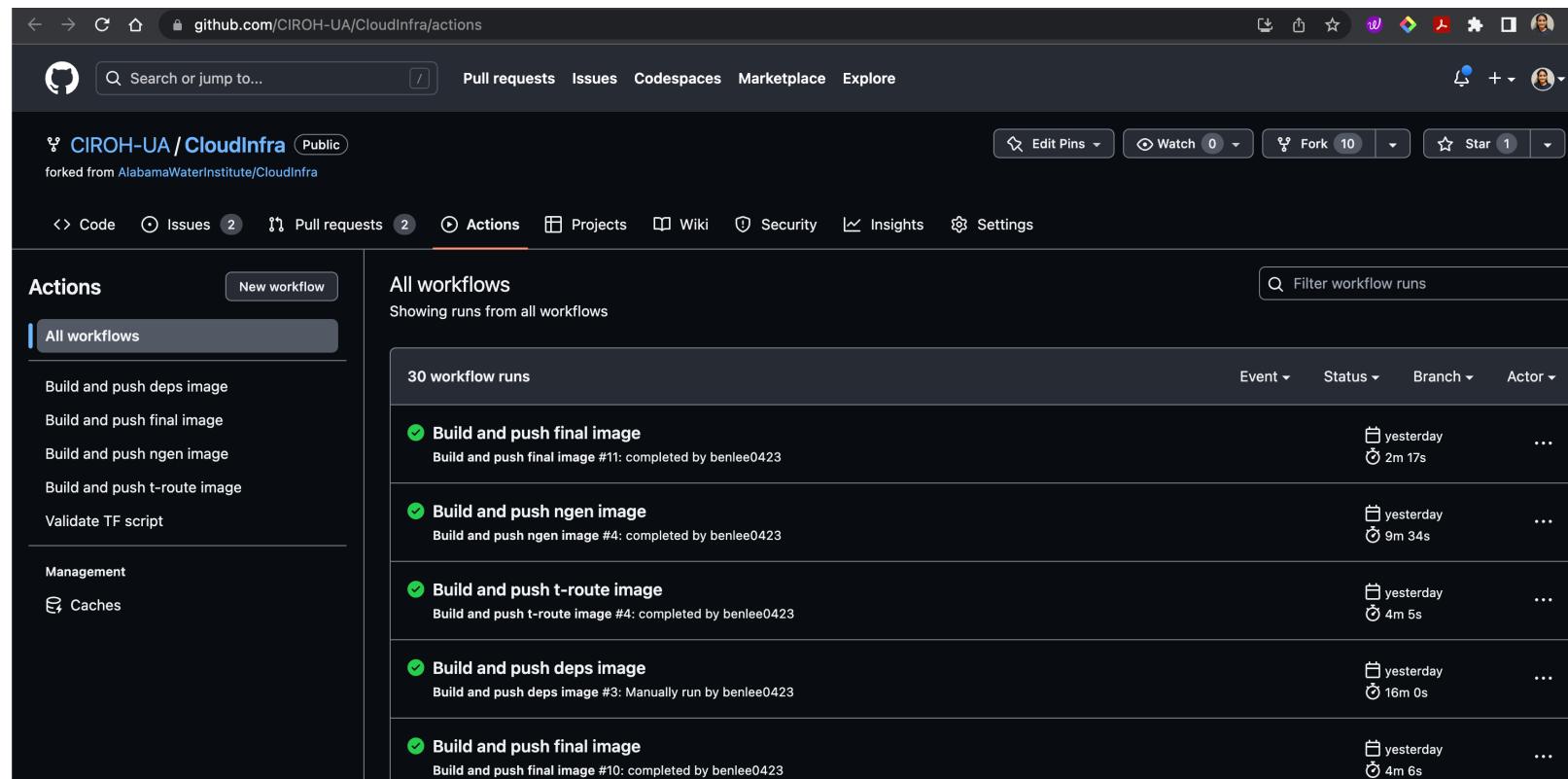
NEXTGEN IN A BOX : CI WORKFLOW

- Using **Github Actions** to run workflows.
- Automated flow to builds and push the docker image to Dockerhub once Pull Request is merged.
 - On Pull Request, triggers action workflow and validates changes.
 - On merge to main branch, triggers action, builds docker image and pushes to Dockerhub.

CI WORK FLOW



CI WORKFLOWS:



HANDS-ON DEMO

- RUNNING ON LOCAL MACHINE USING DOCKER

CIROH DOCUSITE:

- Docusite for National Water Model and NextGen In A Box:
- <https://docs.ciroh.org/docs/products/NextGen%20National%20Water%20Model/NGIAB>

The screenshot shows a web browser displaying a page from the CIROH Docusite website. The URL in the address bar is docs.ciroh.org/docs/products/NextGen%20National%20Water%20Model/NGIAB. The page title is "NextGen In A Box". The left sidebar has a "Products" section with "NextGen In A Box" highlighted. The main content area describes the NextGen Framework National Water Model Community Release and provides a bullet-point list of capabilities. To the right, there's a sidebar titled "We are doing a case study:" with options for "NWM run for Sipsey Fork,Black Warrior river", "Technologies", "Code", "More Information", "Slide's from Summer Institute - June 2023", "Slide's from CIROHDevCon1 - May 2023", "Bug and Issue Tracker", and "Team Members".

PREREQUISITES

- Make sure Prerequisites are installed on your local machine:
 - git
 - Docker (installed and started)

Make sure below is working in your instance:

```
$ docker ps
```

- Make sure input data is downloaded.



NEXTGEN IN A BOX: README.MD FILE

Open README file:

<https://github.com/CIROH-UA/CloudInfra#readme>

3 Steps:

1. Install docker
 2. Download sample data
 3. Run NextGen In A Box – guide.sh
-



STEP 1 : INSTALL DOCKER

On Windows:

Install Docker Desktop on Windows :
<https://docs.docker.com/desktop/install/windows-install/#install-docker-desktop-on-windows>

- Once docker is installed, start **Docker Desktop**.
- Open **powershell** -> right click and 'Run as an Administrator'
- Type `docker ps -a` to make sure docker is working.

On Mac:

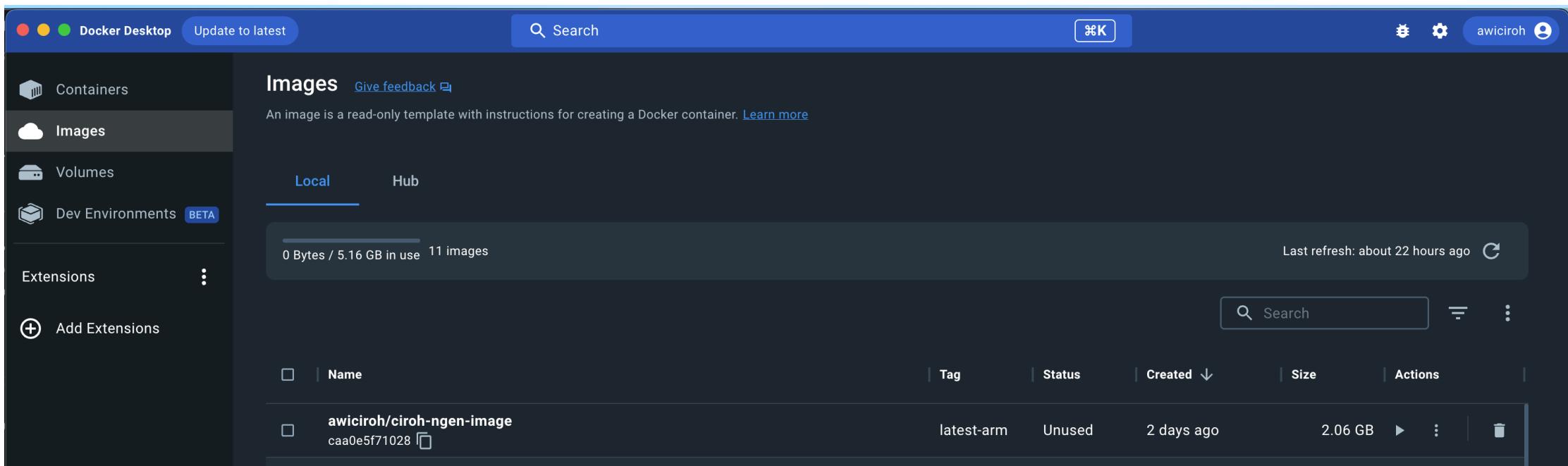
Install docker on Mac :
<https://docs.docker.com/desktop/install/mac-install>

- Once docker is installed, start **Docker Desktop**.
Open **terminal** app
Type `docker ps -a` to make sure docker is working.

On Linux:

Install docker on Linux :
<https://docs.docker.com/desktop/install/linux-install>

- Follow similar steps as Mac for starting Docker and verifying the installation



STEP 2 : DOWNLOAD DATA

Use Case: AWI 001 - Sipsey Fork, Black Warrior river - 03W VPU (catchment-113060) Subset data:

Index file for sample data on S3 bucket: [index.html](#)

Steps :

```
$ mkdir NextGen  
$ cd NextGen  
$ mkdir ngen-data  
$ cd ngen-data  
$ wget --no-parent https://ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com/AWI-001/AWI\_03W\_113060\_001.tar.gz  
$ tar -xf AWI_03W_113060_001.tar.gz  
$ cd AWI_03W_113060_001  
$ pwd
```

```
apatel54@UA-W2RP43G:~/NextGen/ngen-data|⇒ wget --no-parent https://ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com/AWI-001/AWI_03W_113060_001.tar.gz  
--2023-05-12 08:45:00-- https://ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com/AWI-001/AWI_03W_113060_001.tar.gz  
Resolving ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com (ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com)... 52.219.176.106  
Connecting to ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com (ciroh-ua-ngen-data.s3.us-east-2.amazonaws.com)|52.219.176.106|:443...  
connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 329467276 (314M) [application/x-tar]  
Saving to: 'AWI_03W_113060_001.tar.gz'  
  
AWI_03W_113060_001.tar.gz 100%[=====] 314.20M 23.0MB/s in 18s  
2023-05-12 08:45:19 (17.7 MB/s) - 'AWI_03W_113060_001.tar.gz' saved [329467276/329467276]  
apatel54@UA-W2RP43G:~/NextGen/ngen-data|⇒
```

```
apatel54@UA-W2RP43G:~/NextGen/ngen-data|⇒ ls -lart  
total 655952  
drwxr-xr-x 5 apatel54 staff 160 May 10 23:24 AWI_03W_113060_001  
-rw-r--r-- 1 apatel54 staff 329467276 May 11 10:51 AWI_03W_113060_001.tar.gz  
drwxr-xr-x 10 apatel54 staff 320 May 12 08:44 ..  
drwxr-xr-x 4 apatel54 staff 128 May 12 09:23 .
```

Please contact below for more info on how to prepare the dataset:

Preparing Data for NextGen-Based Simulations

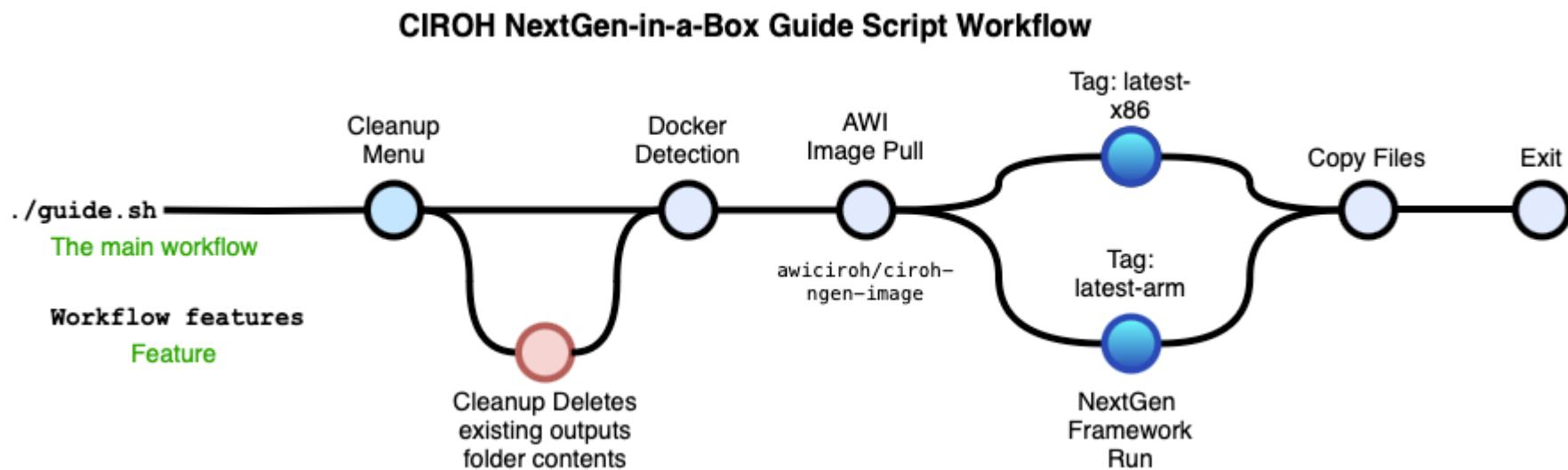
- Irene Garousi-Nejad, CUAHSI
- James Halgren, University of Alabama

STEP 3: NEXTGEN IN A BOX: GUIDE.SH WORKFLOW

Clone repo:

```
$ cd NextGen  
$ git clone https://github.com/CIROH-UA/CloudInfra.git  
$ cd CloudInfra
```

Latest guide.sh location: <https://github.com/CIROH-UA/CloudInfra/blob/main/guide.sh>



STEP 3: RUN GUIDE.SH

~/NextGen/CloudInfra => ./guide.sh

....

....

....

```
apatel54@UA-W2RP43G:~/NextGen/CloudInfra|main => ./guide.sh

=====
Welcome to CIROH-UA:NextGen National Water Model App!
=====

Looking for input data (a directory containing the following directories: forcings, config and outputs):
forcings is the hydrofabric input data for your model(s).
config folder has all the configuration related files for the model.
outputs is where the output files are copied to when the model finish the run

Enter your input data directory path (use absolute path): /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001|
```

Script will execute and prompt the user for entering the absolute path of input data.

Enter absolute input data path. (copied in notepad)

```
apatel54@UA-W2RP43G:~/NextGen/CloudInfra|main => ./guide.sh
=====
Welcome to CIROH-UA:NextGen National Water Model App!
=====

Looking for input data (a directory containing the following directories: forcings, config and outputs):
forcings is the hydrofabric input data for your model(s).
config folder has all the configuration related files for the model.
outputs is where the output files are copied to when the model finish the run

Enter your input data directory path (use absolute path): /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001
The Directory you've given is:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001
forcings exists.    30873 forcings found.
outputs exists.      0 outputs found.
config exists.     10 configs found.

Outputs directory is empty and model is ready for run.

[ Looking in the provided directory gives us:
Found these Catchment files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/catchments.geojson
Found these Nexus files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/nexus.geojson
Found these Realization files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/awi_simplified_realization.json

Detected ISA = Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM64_T6000 arm64
Docker version 20.10.22, build 3a2c30b
Docker found
[

1) Run NextGen Model using docker
2) Exit
Select an option (type a number): ]
```

~/NextGen/CloudInfra => ./guide.sh

....

....

Script will display catchment, nexus and realization files under input data.

Script will detect the OS architecture (arm vs x86) and make sure Docker is running.

Script will prompt user to enter "1" if ready to run the Model!

```
~/NextGen/CloudInfra => ./guide.sh
```

```
Detected ISA = Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM64_T6000 arm64
Docker version 20.10.22, build 3a2c30b
Docker found

1) Run NextGen Model using docker
2) Exit
Select an option (type a number): 1
Pulling NextGen docker image and running the model

Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM64_T6000 arm64
latest-arm: Pulling from awiciroh/ciroh-ngen-image
Digest: sha256:6401c31a91c3b1388e5793143c5a2df3c652e2d02e8a9d6ad8a3b1c7c84a0078
Status: Image is up to date for awiciroh/ciroh-ngen-image:latest-arm
docker.io/awiciroh/ciroh-ngen-image:latest-arm
Pulled awiciroh/ciroh-ngen-image:latest-arm image

Running NextGen docker container...
Mounting local host directory /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001 to /ngen/ngen/data within the container.
Working directory is :
/ngen/ngen/data

Found these Catchment files in /ngen/ngen/data/:
/ngen/ngen/data/config/catchments.geojson
Found these Nexus files in /ngen/ngen/data/:
/ngen/ngen/data/config/nexus.geojson
Found these Realization files in /ngen/ngen/data/:
/ngen/ngen/data/config/awi_simplified_realization.json

1) Run NextGen model in serial mode   3) Run Bash shell
2) Run NextGen model in parallel mode 4) Exit
Select an option (type a number): 1
```

-
- Script will pull docker image based on detected OS.
- Script will mount input data directory inside the container.
- Script will display paths of the files inside the container.
- The user is then prompted to select whether they want to run the model in serial mode (1) or parallel mode (2).

RUN SERIAL MODE

```
1) Run NextGen Model using docker
2) Exit
Select an option (type a number): 1
Pulling NextGen docker image and running the model

Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM64_T6000 arm64
latest-arm: Pulling from awiciroh/ciroh-ngen-image
Digest: sha256:6401c31a91c3b1388e5793143c5a2df3c652e2d02e8a9d6ad8a3b1c7c84a0078
Status: Image is up to date for awiciroh/ciroh-ngen-image:latest-arm
docker.io/awiciroh/ciroh-ngen-image:latest-arm
Pulled awiciroh/ciroh-ngen-image:latest-arm image

Running NextGen docker container...
Mounting local host directory /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001 to /ngen/ngen/data within the container.
Working directory is :
/ngen/ngen/data

Found these Catchment files in /ngen/ngen/data/:
/ngen/ngen/data/config/catchments.geojson
Found these Nexus files in /ngen/ngen/data/:
/ngen/ngen/data/config/nexus.geojson
Found these Realization files in /ngen/ngen/data/:
/ngen/ngen/data/config/awi_simplified_realization.json

1) Run NextGen model in serial mode   3) Run Bash shell
2) Run NextGen model in parallel mode 4) Exit
Select an option (type a number): 1

Enter the hydrofabric catchment file path from above: /ngen/ngen/data/config/catchments.geojson
/ngen/ngen/data/config/catchments.geojson selected
Enter the hydrofabric nexus file path from above: /ngen/ngen/data/config/nexus.geojson
/ngen/ngen/data/config/nexus.geojson selected
Enter the Realization file path from above: 
```

~/NextGen/CloudInfra => ./guide.sh

....

....

- Enter "1" for serial mode run.
- Copy and paste catchment, nexus and realization files path from above list.
- Model will run in serial mode.

```
CloudInfra — ./guide.sh — com.docker.cli - guide.sh — 133x46
./guide.sh
Config Value - Param: 'Cgw' | Value: '0.0018' | Units: 'm h-1'
Config Value - Param: 'expon' | Value: '6.0' | Units: ''
Config Value - Param: 'gw_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'alpha_fc' | Value: '0.33' | Units: '(null)'
Config Value - Param: 'soil_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'K_nash' | Value: '0.03' | Units: ''
Config Value - Param: 'K_lf' | Value: '0.01' | Units: ''
Config Value - Param: 'nash_storage' | Value: '0.0,0.0' | Units: '(null)'
Config Value - Param: 'num_timesteps' | Value: '1' | Units: '(null)'
Config Value - Param: 'verbosity' | Value: '1' | Units: '(null)'
Config Value - Param: 'DEBUG' | Value: '0' | Units: '(null)'
Config Value - Param: 'giuh_ordinates' | Value: '1.00,0.00' | Units: '(null)'
Found configured GIUH ordinate values ('1.00,0.00')
Config Value - Param: '' | Value: '(null)' | Units: '(null)'
Config Value - Param: '' | Value: '(null)' | Units: '(null)'
Schaake Magic Constant calculated
All CFE config params present
GIUH ordinates string value found in config ('1.00,0.00')
Counted number of GIUH ordinates (2)
Finished function parsing CFE config
At declaration of smc_profile_size, soil_reservoir.n_soil_layers = 0
Config file details - Line Count: 27 | Max Line Length 46
Config Value - Param: 'forcing_file' | Value: 'BMI' | Units: '(null)'
Config Value - Param: 'surface_partitioning_scheme' | Value: 'Schaake' | Units: '(null)'
Config Value - Param: 'soil_params.depth' | Value: '2.0' | Units: 'm'
Config Value - Param: 'soil_params.b' | Value: '8.93396282196045' | Units: ''
Config Value - Param: 'soil_params.satdk' | Value: '3.19069084890877e-05' | Units: 'm s-1'
Config Value - Param: 'soil_params.satpsi' | Value: '3.98730560956446' | Units: 'm'
Config Value - Param: 'soil_params.slop' | Value: '0.057029859113015' | Units: 'm/m'
Config Value - Param: 'soil_params.smcmx' | Value: '0.401686143900526' | Units: 'm/m'
Config Value - Param: 'soil_params.wltsme' | Value: '0.048334490431746' | Units: 'm/m'
Config Value - Param: 'soil_params.expon' | Value: '1.0' | Units: ''
Config Value - Param: 'soil_params.expon_secondary' | Value: '1.0' | Units: ''
Config Value - Param: 'refkdt' | Value: '3.72730851635058' | Units: '(null)'
Config Value - Param: 'max_gw_storage' | Value: '0.016' | Units: 'm'
Config Value - Param: 'Cgw' | Value: '0.0018' | Units: 'm h-1'
Config Value - Param: 'expon' | Value: '6.0' | Units: ''
Config Value - Param: 'gw_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'alpha_fc' | Value: '0.33' | Units: '(null)'
Config Value - Param: 'soil_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'K_nash' | Value: '0.03' | Units: ''
Config Value - Param: 'K_lf' | Value: '0.01' | Units: ''
Config Value - Param: 'nash_storage' | Value: '0.0,0.0' | Units: '(null)'
Config Value - Param: 'num_timesteps' | Value: '1' | Units: '(null)'
Config Value - Param: 'verbosity' | Value: '1' | Units: '(null)'
Config Value - Param: 'DEBUG' | Value: '0' | Units: '(null)'
```

~/NextGen/CloudInfra => ./guide.sh

....

....

- This output on console indicates script is running.
- This step will take 2-3 mins depending on hardware used.

~/NextGen/CloudInfra => ./guide.sh

```
2023-05-12 14:49:38,584 DEBUG [collection.py:678 -           close()): Flushed buffer
2023-05-12 14:49:38,585 DEBUG [collection.py:680 -           close()): Stopped session
supernetwork connections set complete
... in 0.7346653938293457 seconds.
2023-05-12 14:49:38,592 INFO [AbstractNetwork.py:476 - create_independent_networks(): organizing connections into reaches ...
2023-05-12 14:49:38,592 DEBUG [AbstractNetwork.py:505 - create_independent_networks(): reach organization complete in 0.0006887912
750244141 seconds.
2023-05-12 14:49:38,592 INFO [AbstractNetwork.py:598 - initial_warmstate_preprocess(): setting channel initial states ...
2023-05-12 14:49:38,593 DEBUG [AbstractNetwork.py:657 - initial_warmstate_preprocess(): channel initial states complete in 0.00099
70664978027344 seconds.
Reformatting qlat nexus files as hourly binary files...
.....
.....
.....
```

- This output on console indicates script is running.
 - This step will take 2-3 mins depending on hardware used. "SIP Water!!!" :)
-

```
2023-05-12 23:01:55,115 DEBUG [output.py:315 - nwm_output_generator(): writing CSV file took 4.577499628067017 seconds.
2023-05-12 23:01:55,115 DEBUG [output.py:370 - nwm_output_generator()]:          (θ, q)   (θ, v)   (θ, d) ... (2879, q) (2879, v) (28
113035 0.004222 0.077847 0.010080 ... 0.000120 0.018764 0.001184
113036 0.000000 0.000000 0.000000 ... 0.000747 0.040594 0.003430
113037 0.007119 0.049306 0.010021 ... 0.008429 0.066446 0.015711
113038 0.000000 0.000000 0.000000 ... 0.009002 0.121398 0.012910
113039 0.000000 0.000000 0.000000 ... 0.009086 0.118733 0.014489
...
125120 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000
125121 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000
125122 0.007620 0.094260 0.010146 ... 0.000174 0.024352 0.001323
125123 0.009853 0.086726 0.010178 ... 0.000193 0.028134 0.001865
125124 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000

[539 rows x 8640 columns]
2023-05-12 23:01:55,196 DEBUG [output.py:372 - nwm_output_generator(): output complete in 4.662291526794434 seconds.
2023-05-12 23:01:55,198 DEBUG [__main__.py:271 -      main_v04()): process complete in 119.47762989997864 seconds.
Finished routing
creating supernetwork connections set
supernetwork connections set complete
... in 1.8237299919128418 seconds.
Reformatting qlat nexus files as hourly binary files...
*****TIMING SUMMARY *****
-----
Network graph construction: 1.83 secs, 1.53 %
Forcing array construction: 112.31 secs, 94.0 %
Routing computations: 0.67 secs, 0.56 %
Output writing: 4.66 secs, 3.9 %
-----
Total execution time: 119.47 secs
Would you like to continue?
1) Interactive-Shell
2) Copy output data from container to local machine
3) Exit
Select an option (type a number): 2
997 new outputs created.
Any copied files can be found here: /home/ec2-user/NextGen/ngen-data/AWI_03W_113060_001/outputs
Thank you for running NextGen In A Box: National Water Model! Have a nice day!
```

~/NextGen/CloudInfra => ./guide.sh

....

....

....

- Timing summary is displayed.
- User is prompted if they want to exec into the container (1) or directly want to copy the output files to the local machine. (2)
- Select "2" to copy the output files.
- Output files are copied to path displayed.

RUN PARALLEL MODE

```
apatel54@UA-W2RP43G:~/NextGen/CloudInfra|main => ./guide.sh

-----
Welcome to CIROH-UA:NextGen National Water Model App!
-----

Looking for input data (a directory containing the following directories: forcings, config and outputs):

forcings is the hydrofabric input data for your model(s).
config folder has all the configuration related files for the model.
outputs is where the output files are copied to when the model finish the run

Enter your input data directory path (use absolute path): /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001
The Directory you've given is:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001
forcings exists. 30873 forcings found.
outputs exists. 996 outputs found.
config exists. 10 configs found.

Cleanup Process: This step will delete all files in the outputs folder: /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/outputs!
Be Careful.
1) Delete output files and run fresh 3) Exit
2) Continue without cleaning
Select an option (type a number):
```

~/NextGen/CloudInfra => ./guide.sh

....

....

....

- If outputs folder is not empty, script will prompt for cleaning outputs folder before rerunning new flow.
- Enter "1"

```
Cleanup Process: This step will delete all files in the outputs folder: /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/outputs!
Be Careful.
1) Delete output files and run fresh 3) Exit
2) Continue without cleaning
Select an option (type a number): 1
Cleaning Outputs folder for fresh run
Starting Cleanup of Files:      996

Looking in the provided directory gives us:
Found these Catchment files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/catchments.geojson
Found these Nexus files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/nexus.geojson
Found these Realization files:
/Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001/config/awi_simplified_realization.json

Detected ISA = Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM6
4_T6000 arm64
Docker version 20.10.22, build 3a2c30b
Docker found

1) Run NextGen Model using docker
2) Exit
Select an option (type a number): 1
```

~/NextGen/CloudInfra => ./guide.sh

....

....

- Follow same steps as for serial mode.
- Enter "1" for running NextGen Model.

```
Darwin UA-W2RP43G 22.3.0 Darwin Kernel Version 22.3.0: Mon Jan 30 20:38:37 PST 2023; root:xnu-8792.81.3~2/RELEASE_ARM64_T6000 arm64
latest-arm: Pulling from awiciroh/ciroh-ngen-image
Digest: sha256:6401c31a91c3b1388e5793143c5a2df3c652e2d02e8a9d6ad8a3b1c7c84a0078
Status: Image is up to date for awiciroh/ciroh-ngen-image:latest-arm
docker.io/awiciroh/ciroh-ngen-image:latest-arm
Pulled awiciroh/ciroh-ngen-image:latest-arm image

Running NextGen docker container...
Mounting local host directory /Users/apatel54/NextGen/ngen-data/AWI_03W_113060_001 to /ngen/ngen/data within the container.
Working directory is :
/ngen/ngen/data

Found these Catchment files in /ngen/ngen/data/:
/ngen/ngen/data/config/catchments.geojson
Found these Nexus files in /ngen/ngen/data/:
/ngen/ngen/data/config/nexus.geojson
Found these Realization files in /ngen/ngen/data/:
/ngen/ngen/data/config/awi_simplified_realization.json

1) Run NextGen model in serial mode 3) Run Bash shell
2) Run NextGen model in parallel mode 4) Exit
Select an option (type a number): 2

Enter the hydrofabric catchment file path: /ngen/ngen/data/config/catchments.geojson
/ngen/ngen/data/config/catchments.geojson selected
Enter the hydrofabric nexus file path: /ngen/ngen/data/config/nexus.geojson
/ngen/ngen/data/config/nexus.geojson selected
Enter the Realization file path: █
```

~/NextGen/CloudInfra => ./guide.sh

....

....

- Follow same steps as for serial mode.
- Enter "2" for running NextGen Model in parallel mode.
- Copy and paste catchment, nexus and realization files path.
- Model will run in parallel mode.

```
Config Value - Param: 'surface_partitioning_scheme' | Value: 'schaake' | Units: '(null)'
Config Value - Param: 'soil_params.depth' | Value: '2.0' | Units: 'm'
Config Value - Param: 'soil_params.b' | Value: '8.93396282196045' | Units: ''
Config Value - Param: 'soil_params.satdk' | Value: '3.19069084890877e-05' | Units: 'm s-1'
Config Value - Param: 'soil_params.satpsi' | Value: '3.98730560956446' | Units: 'm'
Config Value - Param: 'soil_params.slop' | Value: '0.057029859113015' | Units: 'm/m'
Config Value - Param: 'soil_params.smcmax' | Value: '0.401686143900526' | Units: 'm/m'
Config Value - Param: 'soil_params.wltsmc' | Value: '0.048334490431746' | Units: 'm/m'
Config Value - Param: 'soil_params.expon' | Value: '1.0' | Units: ''
Config Value - Param: 'soil_params.expon_secondary' | Value: '1.0' | Units: ''
Config Value - Param: 'refkdt' | Value: '3.72730851635058' | Units: '(null)'
Config Value - Param: 'max_gw_storage' | Value: '0.016' | Units: 'm'
Config Value - Param: 'Cgw' | Value: '0.0018' | Units: 'm h-1'
Config Value - Param: 'expon' | Value: '6.0' | Units: ''
Config Value - Param: 'gw_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'alpha_fc' | Value: '0.33' | Units: '(null)'
Config Value - Param: 'soil_storage' | Value: '0.05' | Units: 'm/m'
Config Value - Param: 'K_nash' | Value: '0.03' | Units: ''
Config Value - Param: 'K_lf' | Value: '0.01' | Units: ''
Config Value - Param: 'nash_storage' | Value: '0.0,0.0' | Units: '(null)'
Config Value - Param: 'num_timesteps' | Value: '1' | Units: '(null)'
Config Value - Param: 'verbosity' | Value: '1' | Units: '(null)'
Config Value - Param: 'DEBUG' | Value: '0' | Units: '(null)'
Config Value - Param: 'giuh_ordinates' | Value: '1.00,0.00' | Units: '(null)'
Found configured GIUH ordinate values ('1.00,0.00')
Config Value - Param: '' | Value: '(null)' | Units: '(null)'
Config Value - Param: '' | Value: '(null)' | Units: '(null)'
Schaake Magic Constant calculated
All CFE config params present
GIUH ordinates string value found in config ('1.00,0.00')
Counted number of GIUH ordinates (2)
Finished function parsing CFE config
At declaration of smc_profile size, soil_reservoir.n_soil_layers = 0
```

```
2023-05-12 15:29:07,997 DEBUG [collection.py:678 -] close()): Flushed buffer
2023-05-12 15:29:07,998 DEBUG [collection.py:680 -] close()): Stopped session
2023-05-12 15:29:08,006 INFO [AbstractNetwork.py:476 - create_independent_networks()]: organizing connections into reaches ...
2023-05-12 15:29:08,007 DEBUG [AbstractNetwork.py:505 - create_independent_networks()]: reach organization complete in 0.0006945133
209228516 seconds.
2023-05-12 15:29:08,007 INFO [AbstractNetwork.py:598 - initial_warmstate_preprocess()]: setting channel initial states ...
2023-05-12 15:29:08,008 DEBUG [AbstractNetwork.py:657 - initial_warmstate_preprocess()]: channel initial states complete in 0.00103
23524475097656 seconds.
```

~/NextGen/CloudInfra => ./guide.sh

....

....

....

- This output on console indicates script is running.
- This step will take few mins depending on hardware used. Please wait...

```
2023-05-14 02:15:13,517 DEBUG [output.py:315 - nwm_output_generator()]: writing CSV file took 4.583699703216553 seconds.
2023-05-14 02:15:13,517 DEBUG [output.py:370 - nwm_output_generator()]:          (0, q)  (0, v)  (0, d) ... (2879, q) (2879, v) (28
113035 0.004222 0.077847 0.010080 ... 0.000120 0.018764 0.001184
113036 0.000000 0.000000 0.000000 ... 0.000747 0.040594 0.003430
113037 0.007119 0.049306 0.010021 ... 0.008429 0.066446 0.015711
113038 0.000000 0.000000 0.000000 ... 0.009002 0.121398 0.012910
113039 0.000000 0.000000 0.000000 ... 0.009086 0.118733 0.014489
...
125120 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000
125121 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000
125122 0.007620 0.094260 0.010146 ... 0.000174 0.024352 0.001323
125123 0.009853 0.086726 0.010178 ... 0.000193 0.028134 0.001865
125124 0.000000 0.000000 0.000000 ... 0.000000 0.000000 0.000000

[539 rows x 8640 columns]
2023-05-14 02:15:13,600 DEBUG [output.py:372 - nwm_output_generator()]: output complete in 4.670687675476074 seconds.
2023-05-14 02:15:13,602 DEBUG [__main__.py:271 - main_v04()]: process complete in 120.44207549095154 seconds.
Finished routing
creating supernet connections set
supernet connections set complete
... in 1.7141664028167725 seconds.
Reformatting qlat nexus files as hourly binary files...
***** TIMING SUMMARY *****
-----
Network graph construction: 1.72 secs, 1.43 %
Forcing array construction: 113.37 secs, 94.13 %
Routing computations: 0.67 secs, 0.56 %
Output writing: 4.67 secs, 3.88 %
-----
Total execution time: 120.43 secs
Would you like to continue?
1) Interactive-Shell
2) Copy output data from container to local machine
3) Exit
Select an option (type a number): 2
997 new outputs created.
Any copied files can be found here: /home/ec2-user/NextGen/ngen-data/AWI_03W_113060_001/outputs
Thank you for running NextGen In A Box: National Water Model! Have a nice day!
```

~/NextGen/CloudInfra =>
./guide.sh

....

....

- Timing summary is displayed.
- User is prompted if want to exec into the container (1) or directly want to copy the output files to the local machine. (2)
- Select "2" to copy the output files.
- Output files are copied to path displayed.

202208292300NEXOUT.parquet	cat-114094.csv	cat-118207.csv	cat-122526.csv	nex-113954_output.csv	nex-118803_output.csv
202208300000NEXOUT.parquet	cat-114095.csv	cat-118208.csv	cat-122527.csv	nex-113055_output.csv	nex-118807_output.csv
202208300100NEXOUT.parquet	cat-114260.csv	cat-118209.csv	cat-122528.csv	nex-113056_output.csv	nex-118808_output.csv
202208300200NEXOUT.parquet	cat-114261.csv	cat-118210.csv	cat-122530.csv	nex-113057_output.csv	nex-118815_output.csv
202208300300NEXOUT.parquet	cat-114262.csv	cat-118211.csv	cat-122531.csv	nex-113058_output.csv	nex-118818_output.csv
202208300400NEXOUT.parquet	cat-114263.csv	cat-118212.csv	cat-122532.csv	nex-113059_output.csv	nex-118819_output.csv
202208300500NEXOUT.parquet	cat-114264.csv	cat-118213.csv	cat-122533.csv	nex-113060_output.csv	nex-118823_output.csv
202208300600NEXOUT.parquet	cat-114265.csv	cat-118214.csv	cat-122534.csv	nex-113061_output.csv	nex-119617_output.csv
202208300700NEXOUT.parquet	cat-114266.csv	cat-118215.csv	cat-122535.csv	nex-113729_output.csv	nex-119621_output.csv
202208300800NEXOUT.parquet	cat-114267.csv	cat-118216.csv	cat-122537.csv	nex-113730_output.csv	nex-119625_output.csv
202208300900NEXOUT.parquet	cat-114268.csv	cat-118217.csv	cat-122538.csv	nex-113731_output.csv	nex-119626_output.csv
202208301000NEXOUT.parquet	cat-114269.csv	cat-118218.csv	cat-122539.csv	nex-113732_output.csv	nex-119630_output.csv
202208301100NEXOUT.parquet	cat-114270.csv	cat-118219.csv	cat-122540.csv	nex-113733_output.csv	nex-119632_output.csv
202208301200NEXOUT.parquet	cat-114271.csv	cat-118220.csv	cat-122541.csv	nex-113734_output.csv	nex-119643_output.csv
202208301300NEXOUT.parquet	cat-114272.csv	cat-118221.csv	cat-122542.csv	nex-113735_output.csv	nex-119654_output.csv
202208301400NEXOUT.parquet	cat-114273.csv	cat-118222.csv	cat-122543.csv	nex-113736_output.csv	nex-119660_output.csv
202208301500NEXOUT.parquet	cat-114274.csv	cat-118223.csv	cat-122546.csv	nex-113737_output.csv	nex-119661_output.csv
202208301600NEXOUT.parquet	cat-114275.csv	cat-118790.csv	cat-122547.csv	nex-113738_output.csv	nex-120777_output.csv
202208301700NEXOUT.parquet	cat-114276.csv	cat-118791.csv	cat-122548.csv	nex-113739_output.csv	nex-120778_output.csv
202208301800NEXOUT.parquet	cat-114277.csv	cat-118792.csv	cat-122549.csv	nex-113740_output.csv	nex-120785_output.csv
202208301900NEXOUT.parquet	cat-114394.csv	cat-118793.csv	cat-122551.csv	nex-113741_output.csv	nex-120817_output.csv
202208302000NEXOUT.parquet	cat-114395.csv	cat-118794.csv	cat-122552.csv	nex-113742_output.csv	nex-120852_output.csv
202208302100NEXOUT.parquet	cat-114396.csv	cat-118795.csv	cat-122553.csv	nex-113743_output.csv	nex-120853_output.csv
202208302200NEXOUT.parquet	cat-114397.csv	cat-118796.csv	cat-122554.csv	nex-113744_output.csv	nex-120859_output.csv
202208302300NEXOUT.parquet	cat-114398.csv	cat-118798.csv	cat-122555.csv	nex-113745_output.csv	nex-122552_output.csv
202208310000NEXOUT.parquet	cat-114399.csv	cat-118799.csv	cat-122556.csv	nex-113746_output.csv	nex-122557_output.csv
202208310100NEXOUT.parquet	cat-114400.csv	cat-118800.csv	cat-122557.csv	nex-113747_output.csv	nex-122588_output.csv
202208310200NEXOUT.parquet	cat-114401.csv	cat-118802.csv	cat-122559.csv	nex-113748_output.csv	nex-122615_output.csv
202208310300NEXOUT.parquet	cat-114402.csv	cat-118803.csv	cat-122561.csv	nex-113749_output.csv	nex-122629_output.csv
202208310400NEXOUT.parquet	cat-114403.csv	cat-118804.csv	cat-122566.csv	nex-114085_output.csv	nex-122631_output.csv
202208310500NEXOUT.parquet	cat-114426.csv	cat-118805.csv	cat-122567.csv	nex-114086_output.csv	nex-125118_output.csv
202208310600NEXOUT.parquet	cat-114427.csv	cat-118806.csv	cat-122568.csv	nex-114087_output.csv	partitions_2.json
202208310700NEXOUT.parquet	cat-114428.csv	cat-118807.csv	cat-122569.csv	nex-114088_output.csv	
202208310800NEXOUT.parquet	cat-114429.csv	cat-118808.csv	cat-122570.csv	nex-114089_output.csv	
202208310900NEXOUT.parquet	cat-114430.csv	cat-118809.csv	cat-122572.csv	nex-114090_output.csv	
202208311000NEXOUT.parquet	cat-114431.csv	cat-118814.csv	cat-122574.csv	nex-114091_output.csv	
202208311100NEXOUT.parquet	cat-114432.csv	cat-118815.csv	cat-122575.csv	nex-114092_output.csv	

[ec2-user@ip-172-0-1-26 outputs]\$ █

- **Nexus output file** - volumetric flow (m^3/s) from the catchment to the nexus
- Time series of volumetric flow at each nexus can be used as inputs for other hydrologic models like FIM (Flood Inundation Mapping) to create user facing products like flood risk maps, which are extremely valuable to emergency managers and others
- **Catchment output file** – They can be used as inputs for other models (e.g. weather models where evapotrans can be critically important).

NEXTGEN IN A BOX – OUTPUT FILES

- e.g: **nex-113731_output.csv**
 - 0, 2022-08-24 13:00:00, 0.897584
 - 1, 2022-08-24 14:00:00, 0.814954
 - 2, 2022-08-24 15:00:00, 0.73377
 - 3, 2022-08-24 16:00:00, 0.686156
 - 4, 2022-08-24 17:00:00, 0.633547
- **Catchment output file:**
 - e.g : **cat-114432.csv**
 - Time
 - Step,Time,EVAPOTRANS,sloth_ice_fraction_schaake ,sloth_ice_fraction_xinan,sloth_smp
 - 0,2022-08-24
13:00:00,0.000000,0.000000,0.000000,0.000000

CONCLUSION

- FUTURE PLANS
- ISSUE TEMPLATE
- CONTRIBUTION GUIDE
- SUPPORT QUESTIONS

FUTURE PLANS FOR NEXTGEN-IN-A-BOX

- Implement "**CIROH Research to Operations Hybrid Cloud – R2OHC**" a flexible computational platform to support collaborative hydrology research surrounding the NextGen framework. – This will be CIROH-supported, community-accessible resource for supporting NextGen framework development in the hybrid cloud.
- **Cloud Migration, Automation, Infrastructure as Code.**
- Collaborate with researchers across CIROH to create **a series of case studies that demonstrate the value of a shared cloud computing environment in hydrology research**
- **GOALS:**
 - Promote **reproducible hydrologic computing experiments** with the NextGen Water Resource Modeling Framework;
 - Provide support for, and reduce the barrier to entry for performing NextGen-related **experiments at various scales**; and
 - Accelerate the interconnection and **integration of research products** and hydroinformatics innovations from the various ongoing CIROH experiments.

CONTRIBUTION GUIDE & BUG REPORT

- **Contribution Guide:**

<https://github.com/CIROH-UA/CloudInfra/blob/main/contribute.md>

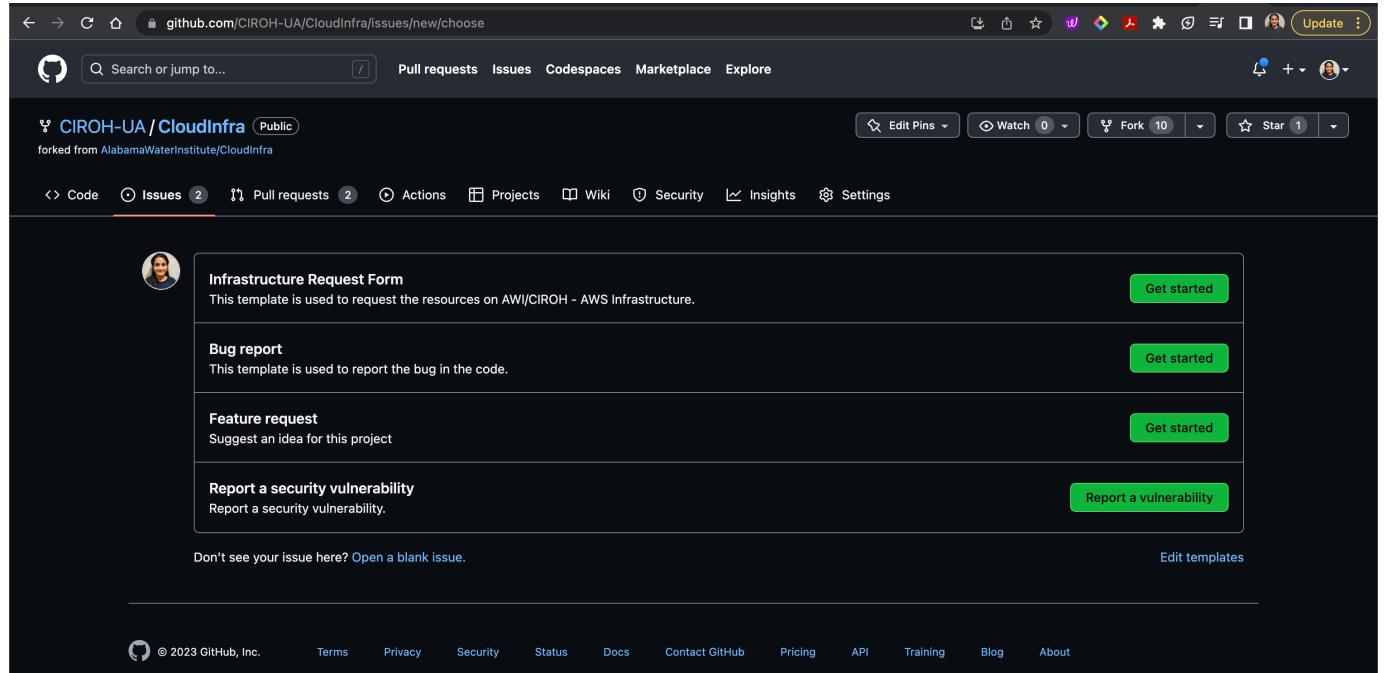
- **Report an issue:**

<https://github.com/CIROH-UA/CloudInfra/issues>

- Together, let's drive innovation and advance academic research through the power of NextGen In a Box
-

FEATURE REQUEST

- Github -> Issues -> New Issues
- If you have a feature request, please open a new issue so we can discuss it and prioritize it accordingly.
- https://github.com/CIROH-UA/CloudInfra/issues/new?assignees=&labels=enhancement&projects=&template=feature_request.md&title=



AWS INFRASTRUCTURE REQUEST FORM

- AWS Infrastructure Request Form
 - https://github.com/CIROH-UA/CloudInfra/issues/new?assignees=&labels=infrastructure&projects=&template=aws_infrastructure_request.md&title=
-

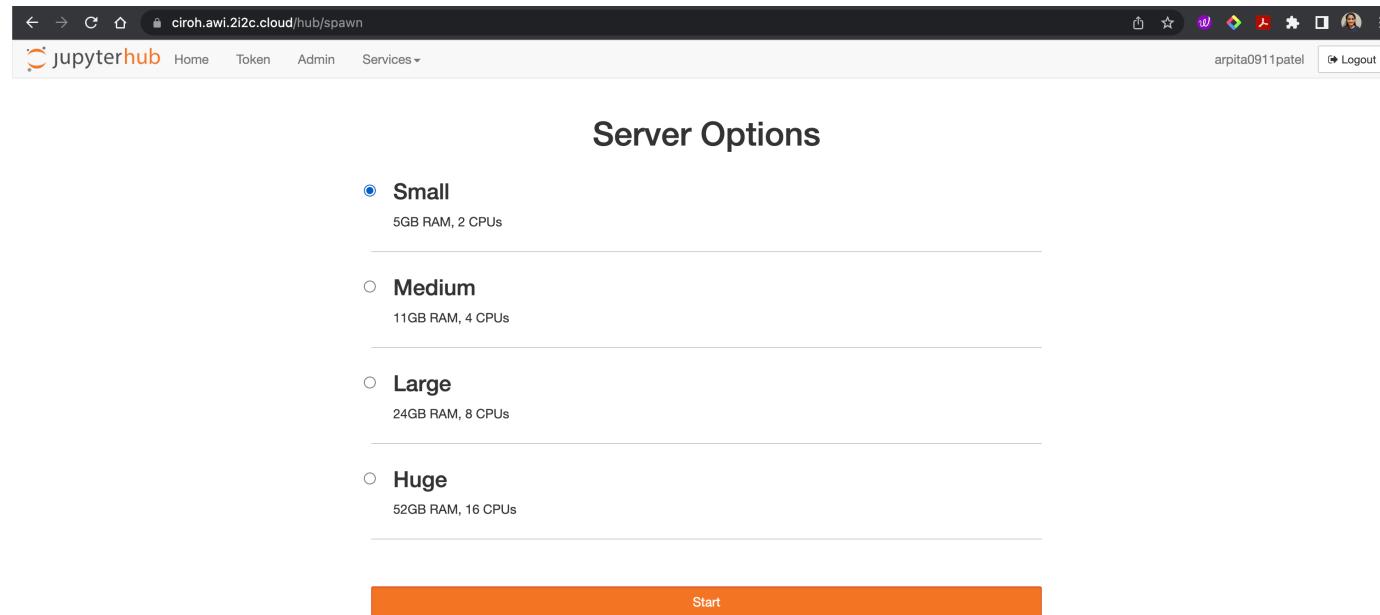
CIROH AWS ORGANIZATION

The screenshot shows a web browser window for ciroh.awsapps.com/start#/. The top navigation bar includes standard browser controls, a search bar, and user information for Arpita. The main content area displays a list of AWS accounts under a heading "AWS Account (4)". Each account entry consists of a small orange cube icon, the account name, and a unique identifier.

AWS Account	Identifier	Email
BYU_AWS_Admin	#456531024327	byu_aws_admin@ciroh.org
LynkerAWSAdmin	#857712214391	lynker_aws_admin@ciroh.org
RTIAWSAdmin	#935462133478	rti_aws_admin@ciroh.org
UA_AWS_Users	#858933856877	ua_aws_users@ciroh.org

At the bottom of the page, there is a link to "Terms of Use".

GOOGLE (VIA 2I2C) - CIROH-UA JUPYTERHUB

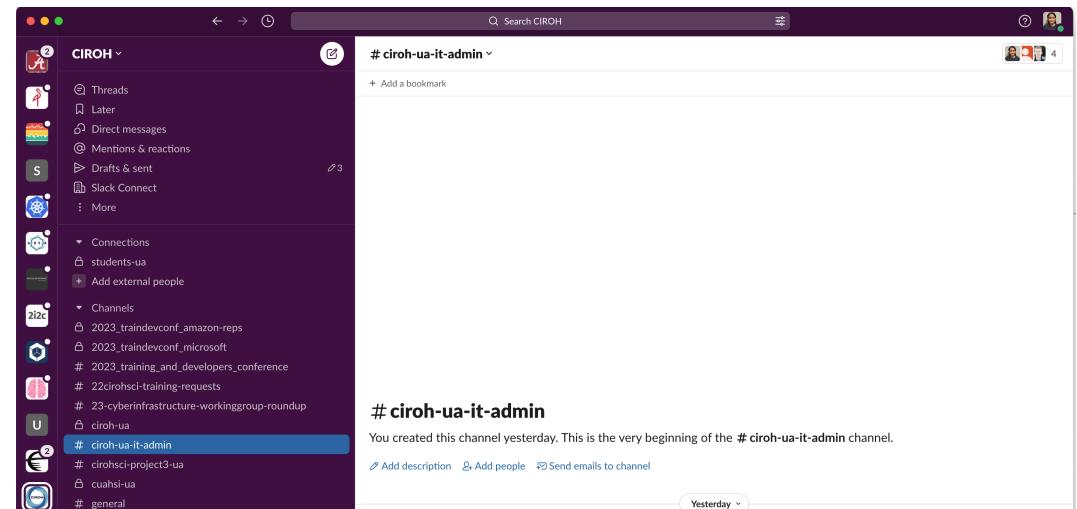


SUPPORT

- For any questions, comments or issues:

Email us at : ciroh-it-admin@ciroh.org

Contact us on CIROH Slack: #ciroh-ua-it-admin





Q&A?



Thank you for your time and attention 😊

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