

WRF Cloud

FORECASTING MADE EASY

WRF Cloud User's Guide

version 1.0.0

Jun 26, 2023

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Foreword: A note to WRF Cloud users

WRF Cloud TERMS OF USE - IMPORTANT!

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Citations

The citation for this User's Guide should be:

Fossell, K., D. Hahn, G. McCabe, J. Halley Gotway, P. Kucera, M. Harrold, M. Kavlich,, 2023: WRF Cloud Version 1.0.0 User's Guide. UCAR/UCP/COMET and UCAR/NCAR/RAL. Available at: <https://github.com/NCAR/wrfcloud/releases>

Acknowledgments

Chapters

Chapter 1

Overview of WRF Cloud

The WRF Cloud framework is a cloud-based forecasting system that was designed to easily facilitate cost-effective state-of-the-art numerical weather prediction system forecasts in communities that lack the large computational resources. It is a self-managed software-as-a-service, meaning users install and manage the system independently in their own cloud accounts.

1.1 Purpose and organization of the User's Guide

The goal of this User's Guide is to document the procedures required to install the WRF Cloud framework and to serve as a reference for using and adapting the system to an organization's own needs. As features are added to the framework, this User's Guide will continue to be expanded to document new capabilities.

The User Guide is organized by first providing an overview of the system, followed steps to install the framework and adminstartion details to manage the system. Finally the user interface is documented along with details about the graphical outputs produced by the system.

1.2 UCAR/UCP/COMET and UCAR/NCAR/RAL

This project is made possible by [UCAR/UCP/COMET](#) and collaborations with [UCAR/NCAR/RAL/MMM](#).

1.3 WRF Cloud goals and design philosophy

The primary goal of this projec is to provide easy access to powerful NWP forecasts to communities lacking financial or computation resources to maintain baremetal forecasting platforms. The aim for this framework is to be:

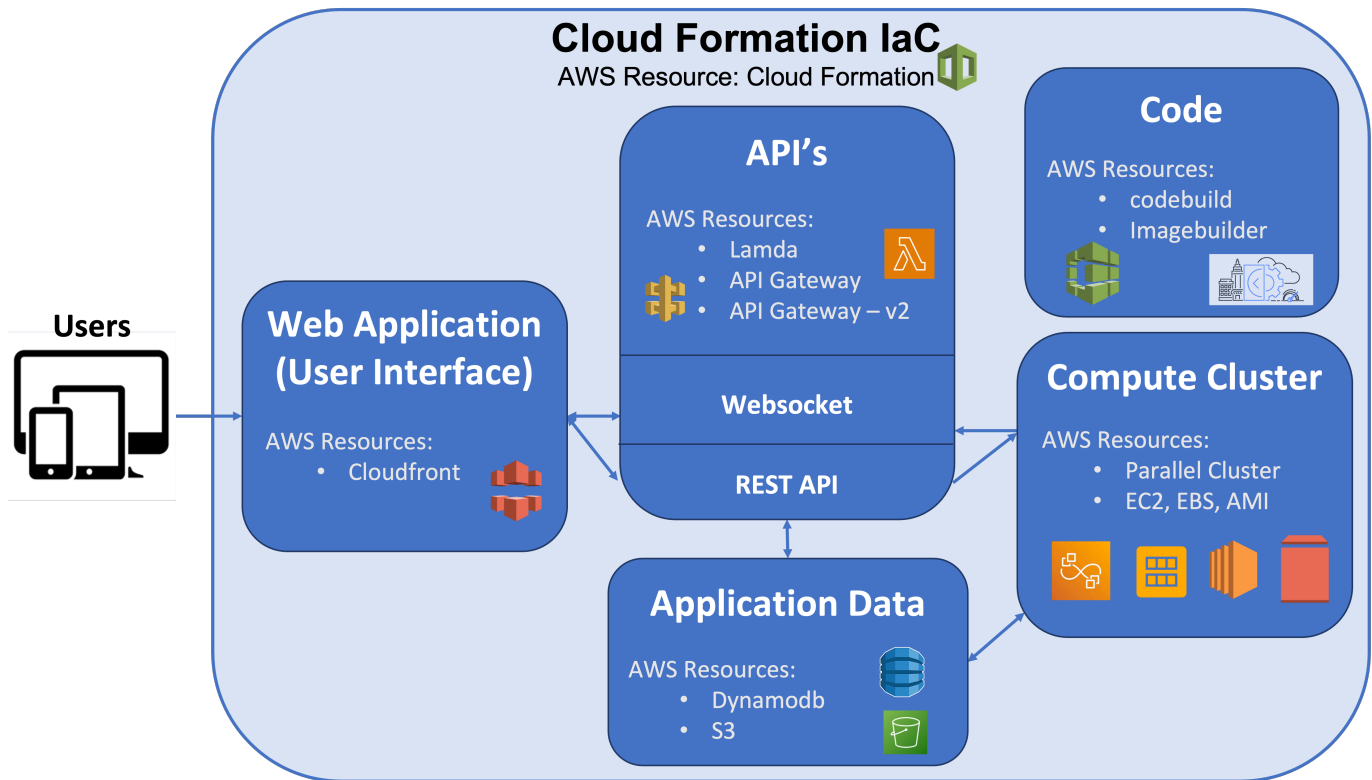
- Flexibility and customizable
- Efficeint and cost-effective
- Easy to setup, use, and manage
- Useful and accessible

1.4 WRF Cloud components

The WRF Cloud framework primarily consists of a web application and a python package that were developed to orchestrate all of the necessary components of the end-to-end system from the web application to the user authentication and authorization, as well as the numerical weather software and forecast management. It leverages serverless architecture, meaning that there are no dedicated web servers required to host the APIs, website or database, and makes running the system more cost-efficient. Amazon Web Services (AWS) is used for the cloud service provider and several AWS resources are used to construct the entire system.

1.4.1 System overview

The main components of the framework and how they interact with each other are shown in the overview schematic below. Details about each of the components follows.



1.4.2 Cloud Formation

AWS's Cloud Formation is used to configure and manage all AWS resources by treating them as Infrastructure as Code (IAC).

1.4.3 Web Application (User Interface)

The web application consists of single page application and progressive web application and is the primary place users interact with the system. The website itself was implemented using Angular, and AWS's CloudFront is used to deliver the website content anywhere with low latency. The web application communicates with the APIs and allows users to login and change or recover passwords, manage users, as well as forecasts including launching, monitoring, cancelling new runs and viewing forecast output. In addition, the web application was implemented with responsive design to support mobile devices, such as tablets and smartphones.

1.4.4 APIs

The application interfaces leverage AWS's Lambda functions for the code execution and API Gateway to provide a standard HTTP request and forward to the Lambda function for processing, plus API Gateway version 2 to handle the websocket protocol) Together these three services coordinate a user's request from the web application or user interface and performs authentication and execution of the requested action.

1.4.5 Compute Cluster

The compute cluster component is where the bulk of the computing is done, including running the numerical weather prediction software and producing the graphical outputs. Care is taken to ensure these resources are only provisioned when necessary and that they are shut down when the jobs are complete as this component is the most expensive part of the framework. AWS's Parallel Cluster is used to deploy and manage the cluster resources which include launching an AWS EC2 instance from an AMI developed specifically for this framework.

The weather forecasts use initial conditions from the Global Forecast System (GFS) and are pulled from AWS's S3 on demand for each forecast. The numerical weather prediction software used for making the forecasts is the Weather Research and Forecasting version 4.4.1 (WRF) system, including its pre-processor WPS. The WRF model output is then post-processed using the [wrf-python](#) package version v1.3.2, and the Unified Post Processor version 4.0.1 (UPP) and from there the data are processed for plotting and served up to the system's user interface and forecast viewer.

1.4.6 Application Data

Certain information needs to persist for the system to function properly. This component uses AWS's dynamodb service to maintain its document database. Information that is collected and stored falls into four categories: Users, Audit Log, WRF Jobs, Model Data, and Scheduled Jobs. Users information stored includes that which is required for authentication and authorization with the API. The Audit Log contains useful information about actions requested. The WRF Jobs category contains information about a certain forecast that was run, such as the initialization time, configuration name, user email, forecast length, status, archive location, and deletion information. Model data consists of the forecast output, graphics, and any other products desired to archive. Finally, Scheduled Jobs includes information from regular scheduled jobs much like the WRF Jobs, but also including scheduling information.

Certain static information specific to a model configuration (e.g. namelists, geo_em* files) are stored on S3 for access by the cluster when a forecast is run. Additionally, model data and geojson plotting files are stored on S3 when the forecast is complete.

1.4.7 Code

The python code used to build and manage the entire system is available on GitHub. AWS's CodeBuild has been incorporated to make sure the code within the package is regularly tested with coverage reports generated to identify untested features.

AWS's Imagebuilder is used to create an Amazon Machine Image (AMI) that contains the hardware and software needed to run the system. This AMI is automatically created during the setup of this system.

1.5 WRF Cloud Release Notes

When applicable, release notes are followed by the GitHub issue number which describes the bugfix, enhancement, or new feature ([WRF Cloud GitHub issues](#)). Important issues are listed **in bold** for emphasis.

1.5.1 WRF Cloud Version 1.0.0 release notes (20230403)

Goal: Ability for others to be able to install and use the package on their AWS account and create/run model configuration of their choosing.

Target Audience: Friendly users, general public w/o dedicated support

Key Features:

- Automated installation
- Customizable model configurations
- Updated forecast products

Details can be viewed on the [GitHub v1.0 milestone](#) page for this release.

1.5.2 WRF Cloud Version 0.1.0 release notes (20221212)

*****This is an alpha release to be used by development team only.*****

Goal: Develop all necessary pieces to launch a preconfigured test case forecast and view a sample of forecast plots, all from the user interface on the website.

Target Audience: Development team only; no public use capabilities

Key Features:

- Website/User Interface
- CI testing

- UG Documentation (overviews, running forecasts, output products. No installation or advanced options)
- From the website user interface, ability to launch the pre-configured test forecasts, monitor status, view output products.

Details can be viewed on the [GitHub v0.1.0 milestone](#) page for this release.

1.6 Future development plans

New features being considered for future releases:

- Verification capabilities
- Enhanced User Interface plotting features
- New plot types, e.g. vertical cross sections and Skew T - Log P plots
- Increased customizability of configuration

1.7 Code support

Questions may be posted on the [GitHub Discussions page](#).

Chapter 2

System Installation

2.1 Introduction

The WRF Cloud framework can be installed in any AWS account via [CloudShell](#).

If you encounter issues related to your AWS account, please work with your AWS account administrator. For issues related to the WRF Cloud installation, please post to [WRF Cloud GitHub Discussions](#).

2.2 Required Permissions

The user installing WRF Cloud must have sufficient administrative permissions within their AWS account. It is recommended to install with **AdministratorAccess**, **SystemAdministrator**, or root privileges. Please work with your AWS account administrator to secure the required permissions or find another user with sufficient permissions to perform the installation.

Check existing permissions:

- In the **AWS Management Console**, use the top-level search bar to find and launch the AWS **IAM** (Identity and Access Management) Service.
 - If you are unable to launch the AWS **IAM** Service, you do not have sufficient permissions.
- In **Access management > Users**, find and select your user name, and inspect the **Permissions policies**.
 - Ensure that you have **AdministratorAccess**, **SystemAdministrator**, or higher permissions.

If any of the following installation steps fail due to insufficient permissions, please contact your AWS account administrator for assistance.

2.3 Prerequisites

There are 4 prerequisites for installing WRF Cloud in an AWS account:

- **Web Domain:** This is the web domain (hosted zone) where the WRF Cloud system is accessed. AWS's [Route 53](#) Domain Naming Service (DNS) is used to create and host the domain for the system. This service has an annual cost associated with it.
- **Adequate Instance Limits:** On-demand HPC instance limits must be set to a minimum of 96 vCPUs. By default, the AWS account may be less than this. A request should be made to increase this limit for full functionality of the system.
- **Enable Simple Email Service (SES):** This facilitates AWS emailing within the system. By default the SES is limited to testing with verified identities. A request must be made to lift these limits and make it a production service.
- **Access to us-east-2 region:** The hpc6a instances that the system uses are only available in the us-east-2 region. This is typically available by default for regular AWS accounts.


The procedures for ensuring the prerequisites are fulfilled are described below.

1. Login to the [AWS Management Console](#) for your account as a user with sufficient permissions (see [Section 2.2](#)).
2. Check [Route 53](#) domain name.
 - Use the top-level search bar to find and launch the AWS **Route 53** Service.
 - Check for at least one **Hosted zone** or create a new one with an annual fee.
3. Check account limits.
 - Use the top-level search bar to find and launch the AWS **EC2** Service.
 - **Select the US East (Ohio) / us-east-2 region from the top-right dropdown navigation.**
 - Access to us-east-2 region is required. This is likely enabled by default, per AWS documentation for standard AWS accounts. In the event that you do not see us-east-2 region as an option when going through the procedures, contact your AWS account administrator, or AWS directly, to inquire about enabling it.
 - Select **Limits** from the left navigation menu and search for **HPC** to find **Running On-Demand HPC instances**.
 - If the **Current limit** is less than **96 vCPUs**, select the radio button and click **Request limit increase**.
 - **AWS Support Center** will followup via email with the AWS account owner.
 - See details about contacting [AWS Support Center](#), as needed.
4. Check Simple Email Service (SES).
 - Use the top-level search bar to find and launch the AWS **SES** Service.
 - Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
 - If you registered a new **Route 53** domain above, you'll need to create a new verified identity.

- Select **Configuration** > **Verified identities** from the left navigation menu.
- If the newly added domain is not listed, select the **Create identity** button, select the **Domain** radio button, and enter the newly added domain.
- [AWS Support Center](#) will followup via email with the AWS account owner.
- Confirm that the newly added domain appears in the **Verified identities** list.
- If you see a banner message warning that **Your Amazon SES account is in the sandbox in US East (Ohio)**, contact AWS to **Request production access**.
 - Prior to requesting production access, be sure that you have at least one verified identity (see above).
 - [AWS Support Center](#) will followup via email with the AWS account owner.
 - If AWS requires further justification for this change, note that this email service is needed by WRF Cloud to send users emails when WRF jobs finish running and to facilitate password recovery. We also recommend that your AWS account administrators subscribe to an SNS topic that is configured to accept bounce and complaint messages.

2.4 Procedures to Install

Once the AWS account prerequisites are satisfied (see [Section 2.3](#)), follow these instructions to install WRF Cloud.

1. Login to the [AWS Management Console](#) for your account as a user with sufficient permissions (see [Section 2.2](#)).
2. Select the **US East (Ohio)** / **us-east-2** region from the top-right dropdown navigation.
3. Click the **CloudShell** button () at the top of the screen to launch a terminal window.
4. The WRF Cloud installation requires at least 512MB of space. Run the following command to check the disk usage of your home directory and confirm that at least 512MB of space are available, as listed in the **Avail** column.

```
df -kh ~/
```

If you do not have sufficient space, you can either manually remove unneeded files (especially from the hidden **.cache** directory) or run **Actions** > **Delete AWS CloudShell home directory** to remove everything. Prior to deleting everything, please confirm that nothing in your home directory should be retained.

5. Define the GitHub branch name (e.g. develop) or release name (e.g. v1.0) to be installed.

```
export GITHUB_NAME=develop
```

6. Copy and paste the following into the CloudShell terminal to clone the repository:

```
git clone --branch ${GITHUB_NAME} https://github.com/NCAR/wrfcloud
```

7. Copy and paste the following into the CloudShell terminal to start the installation:

```
./wrfcloud/install_bootstrap.sh ${GITHUB_NAME}
```

This bootstrap script takes about 25 minutes to run. It is followed by a series of interactive questions that must be completed prior to WRF Cloud being installed. For each question, the default option (if applicable) is provided in square braces. Simply hit enter to accept the default or modify the setting as needed. These questions include:

- Would you like to enable autocompletion?
 - If this question appears during the installation of Angular, answer *Yes*. However, this setting has no impact on the installation of WRF Cloud.
- Which domain name would you like to use? [[Route 53](#) domain(s) from [Section 2.3](#)]
 - Note: This is used for {DOMAIN} in the following questions.
- Enter host name for web application: [e.g. app.{DOMAIN}]
- Enter host name for REST API: [e.g. api.{DOMAIN}]
- Enter host name for websocket API: [e.g. ws.{DOMAIN}]
- Enter administrator's full name:
 - Note: This is your name, you are the administrator installing WRF Cloud on your AWS account.
- Enter email address for application administrator:
 - Note: This is your email, you are the administrator installing WRF Cloud on your AWS account and you will use this email to login to WRF Cloud.
- Enter administrator's new password:
 - Note: You will use this to login into WRF Cloud.
- Do you want to install example model configurations? [*Recommend Yes*]
- Do you want to upload an SSH public key for an admin? [*Recommend Yes*]
 - Note: This is not necessary, but we recommend it because administrators may need to login to clusters directly for advanced troubleshooting, this allows you to do so.
- Paste your public key, often found at \${HOME}/.ssh/id_rsa.pub:
 - Copy and paste the output of this command into the CloudShell terminal:

```
cat ${HOME}/.ssh/id_rsa.pub
```

If this file does not exist, refer to [this documentation](#) to generate a public key.

8. After completing these steps, check the email address provided above to verify it. It takes approximately 10-20 minutes for the website to become available.
9. Monitor the installation progress:
 - Launch a new [AWS Management Console](#) window, and use the top-level search bar to find and launch the AWS **CloudFormation** Service.

- Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
 - Select **Stacks** from the left navigation menu.
 - Click an item (**WrfIntelImageBuilder**, **WrfCloudApiData**, or **WrfCloudWebApp**) listed in the **Stack name** column and select the **Events** tab to monitor progress.
10. When installation completes, a log message in the CloudShell terminal directs you to the newly created WRF Cloud URL.

```
WRF Cloud installation is complete.  
Open your browser to https://app.{DOMAIN}
```

11. Confirm that you can login.
- Open a web browser and clear the cache to ensure a clean test environment.
 - Navigate to <https://app.{DOMAIN}>.
 - If directed to the **WRF Cloud Login** page, use the administrator email address and password defined above to login and proceed to the next step.
12. Confirm that the WRF Amazon Machine Image (AMI) has finished building.
- Use the top-level search bar to find and launch the **AWS EC2** Service.
 - Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
 - Select **Images > AMIs** from the left navigation menu and search for **wrf**.
 - Confirm that an AMI that includes **wrf** in the **AMI name** column.
 - Note that it may take several hours for this AMI to finish building. You may need to refresh the page occasionally to see the new image appear in the list. While you can add new users and configurations via the WRF Cloud user interface, you will not be able to actually launch a run until the WRF AMI is available.
13. After completing these installation steps, proceed to System Administration ([Section 3](#)).

2.5 Procedures to Uninstall

The steps for uninstalling WRF Cloud from an AWS account are described below.

1. Login to the [AWS Management Console](#) for your account as a user with sufficient permissions (see [Section 2.2](#)).
2. Remove data from S3.
 - Use the top-level search bar to find and launch the **AWS S3** Service.
 - Select **Buckets** from the left navigation menu and search for **wrfcloud**.
 - Select the **wrfcloud-XXXXXXX** S3 bucket and click **Empty** to remove its contents.
 - Do not **Delete** this bucket, as CloudFormation will handle that step.

3. Remove IAM policy.

- Use the top-level search bar to find and launch the AWS **IAM** Service.
- Select **Access Management > Policies** from the left navigation menu and search for **wrfcloud**.
- Click the **wrfcloud_parallelcluster** radio button and select **Actions > Delete**.
 - Any other **wrfcloud** policies do not need to be removed.

4. Modify EC2 settings.

- Use the top-level search bar to find and launch the AWS **EC2** Service.
- Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
- Remove the wrfcloud Amazon Machine Image (AMI).
 - Select **Images > AMIs** from the left navigation menu and search for **wrf**.
 - Make note of the **AMI ID** for the **wrf** AMI.
 - Select that AMI followed by **Actions > Deregister AMI**.
- Remove any AMI Snapshots.
 - Select **Elastic Block Store > Snapshots** from the left navigation menu.
 - Select any entries for which the **AMI ID** noted above appears in the **Description** column.
 - Select **Actions > Delete snapshot** to remove them.
- Remove the SSH key.
 - Select **Network & Security > Key Pairs** from the left navigation menu.
 - Select the **wrfcloud-admin** key pair followed by **Actions > Delete**.

5. Modify SES settings.

- Use the top-level search bar to find and launch the AWS **SES** Service.
- Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
- Select **Configuration > Verified Identities** from the left navigation menu.
- Select and **Delete** the email identity for your administrator's email address.

6. Delete CloudFormation stacks.

- Use the top-level search bar to find and launch the AWS **CloudFormation** Service.
- Select the **US East (Ohio) / us-east-2** region from the top-right dropdown navigation.
- Select **Stacks** from the left navigation menu.
- Select and **Delete** each of the following stacks: **WrfIntelImageBuilder**, **WrfCloudWebApp**
- Wait for **WrfCloudWebApp** to be completely deleted. If a delete fails, delete it again, and **DO NOT** retain the resources.
- Select and **Delete** the following stack: **WrfCloudApiData**

- Switch to the **US East (N. Virginia)** / **us-east-1** region and **Delete** the following stack: **WrfCloudWebCertificate**

You have now finished uninstalling WRF Cloud from your AWS account.

Chapter 3

System Administration Overview

System Administration can be broken down into two pieces: administration within AWS and administration of the WRF Cloud system. The primary administrator is the person who installed WRF Cloud on their AWS account.

WRF Cloud is designed to be run and managed in a self-contained way, largely negating the need for accessing AWS itself. Following a successful installation of WRF Cloud, the primary administrator adds a user(s) to their WRF Cloud system with admin permissions. These admin users can then manage the access to WRF Cloud, without needing to access AWS. The system administration of WRF Cloud is described in the first section below.

There may be times when the primary administrator may need to access AWS resources related to WRF Cloud to debug issues. The second section below includes some cursory information about AWS resources that may be helpful.

3.1 WRF Cloud Administration

3.1.1 User Roles & Permissions

The following definitions and table describe the user roles and corresponding permissions for each role that exist in this framework.

- **readonly:** Active user who will view forecasts only
- **regular:** Active user who will schedule, launch, manage, and view forecasts
- **maintainer:** Active user in the system with permissions of a regular user and can also create or update new model configurations
- **admin:** Active user with permissions of a maintainer and also admin permissions to manage users and the system

Table 3.1: Roles and Permissions

	admin	maintainer	regular	readonly
Change Password	X	X	X	X
View Forecasts	X	X	X	X
List jobs	X	X	X	X
Run and Schedule Forecasts	X	X	X	
Cancel and Delete Jobs	X	X	X	
Create and Update Model Configurations	X	X		
Manage Users	X			

3.1.2 Managing Users

Users with the **Admin** role have permission to manage the users on their system. Admin users will see the menu option “Manage Users” on their User Interface, which allows the admin to add new users, update active user roles, or delete users. Select the “Manage Users” menu option to view a current list of users.

Add a New User

Select the “Manage Users” menu option and click on the “Add User” option at the top of the page. A pop-up box will appear to fill in the new user’s email address and name. Select the Role for that user and click “Create”. An email will be sent to the new user asking them to activate their account and setup a new password.

Update Roles

Select the “Manage Users” menu option to view a current list of users. Click on the user you wish to update. A pop-box box with the user’s information will appear. Select the new role you wish to assign and click “Update”. The user will automatically be given permissions associated with this new role.

Delete a User

Select the “Manage Users” menu option to view a current list of users. Click on the user you wish to remove. A pop-box box with the user’s information will appear. Click “Remove” to delete the user from the system.

3.2 AWS Administration

3.2.1 Audit Logs

The API component will keep an audit log of every request received and store it in the DynamoDB database table. There is currently no plan to make these logs accessible via the web application, but the log entries can be viewed via the AWS DynamoDB console at: <https://console.aws.amazon.com/dynamodb>.

There are three main purposes for this audit log: 1) Help users to debug any problems they may encounter. If an action fails, the reference ID and any errors will be presented to the user. The reference ID can help an administrator to find the request details and the log output from the request handler. 2) Keep a history of system activity. This can help to inform how the system is used and which users launched model jobs in the account. 3) The audit logs can help to identify suspicious activity and from what IP the requests originate.

Each audit log entry represents a single API request and contains the following fields:

Reference ID: A unique ID for each request. Entries can be found quickly by the reference ID.

Action: The name of the action requested, which helps understand what the user was trying to do.

Authenticated: A boolean flag that indicates if the request was from an authenticated user.

Username: The username or email address of the user that made the request, if authenticated.

Client IP: The IP address of the client that sent the request.

Start Time: The time that the request was received as seconds since 1970-01-01 00:00:00 UTC.

End Time: The time that the request handling finished.

Duration: The total amount of time in milliseconds that it took to handle the request.

Action Success: A boolean flat that indicates if the request was successful or failed.

3.2.2 CloudWatch Logs

The reference ID can be used to search the CloudWatch Logs to find logs leading up to an error, which may be useful to when debugging failures.

3.3 Troubleshooting WRF Failures

A full set of log files is saved when a WRF job either finishes or fails to complete. The log files are stored as a zip file in the system's S3 bucket. To find the zip file, look for `s3://wrfcloud-XXXXXXXXX/jobs/<job-id>/logs.zip`

Chapter 4

User Interface

Users access the WRF cloud system through a web browser and domain name unique to each organization. In this documentation, app.wrfcloud.com may be used as an example. This website serves as the primary user interface (UI) through which users are able to view, launch, and monitor forecasts as well as manage user accounts, depending on each user's role and corresponding permissions (see System Administration Roles and Permissions [Section 3.1.1](#)). Users can navigate the site using the Menu options. The Menu options are described below.

4.1 Homepage

The main home pages contains brief information about the system and is an access point to Login to the system.

4.1.1 Login / Logout

To Login to the system, click on the blue Login button on the Homepage. This will take you to a prompt to enter your Email Address and Password, and then you can click the blue Login button. If your credentials are properly validated, you'll be taken to the main system page. Once logged into the system, you can logout by clicking the "Logout" button.

4.1.2 Forgot / Reset password

If you forgot your password, you can click on the "I forgot my password" button on the Login page. You'll be prompted to enter your email address. Check your email from instructions to reset your password.

4.2 Run WRF

The Run WRF tab is where you can launch a new WRF run. There are several parameters described below that need to be selected in order to setup and launch a new forecast.

- **Model Configuration:** Name of the model configuration. The list of available model configurations will appear in the dropdown menu. These are created using the WRF Config Menu option (see below).
- **Job Name:** This is an optional name to give your run to help describe its purpose or meaning.
- **Cycle Date:** The initial date of the forecast. Select from the calendar or enter manually in MM/DD/YYYY format. (Please see note below)
- **Cycle Hour:** The initial cycle hour. Options are 00, 06, 12, 18 UTC.
- **Forecast Length:** The forecast length in hours.
- **Output Frequency:** The frequency of forecast output.

After the parameters are set, check or uncheck the “Notify when finished” box. Then click the Launch button. You will be automatically taken to the WRF Jobs status page after the system initializes the cluster.

Note: The initialization data currently used is the Global Forecasting System (GFS) at 3-hourly intervals. Currently GFS data availability is limited to roughly the last two years. In addition, users running close to real-time cycles should allow a 6-hour buffer to ensure that cycle is available on the server. Data can be retrieved from two sources: NOAA's GFS archive on [AWS's S3](#), and the [NOMADS](#) server if requested data is within 10 days.

Remember that longer forecast length and greater the output frequency, the more the forecast will cost.

4.3 WRF Configs

A model configuration is a combination of user-defined parameters that together define the computational domain, grid extents and projection, resolution, model dynamics and model physics. These parameters are defined in the namelist.wps and namelist.input that are used by WRF to run its forecasts.

4.3.1 Configuration Parameters

The following information is needed to create a new model configuration:

Name: Name of the model configuration. This should ideally be a shorter character string, but it is helpful to provide a meaningful name to describe the model configuration details. For example, “6km_caribbean_trop” may be a name given to describe a configuration of the Caribbean Sea with 6km grid spacing that uses the tropical physics suite.

Description: Additional description to provide more information about the model configuration. In the example above, “6km_caribbean_trop”, the description might be “6km Caribbean Domain with standard tropical physics suite”.

WPS Namelist: The information contained in namelist.wps. Users will primarily be interested in modifying the &geogrid section of the namelist.wps to customize their region of interest. Note that currently the system only support single domains, so max_dom must be set to 1. Additional information about these settings can be found in the [WRF Users Guide](#).

WRF Namelist: The information contained in namelist.input. Users will primarily be interested in modifying the &domains section to match their namelist.wps, and &physics section to change physics options. Note that currently the system only support single domains, so max_dom must be set to 1. Additional information about these settings can be found in the [WRF Users Guide](#). As quick start, WRF provides two sample physics suites, which include settings for two typical applications: convection-permitting weather over the contiguous U.S. and tropical storms/convection. Information can be found [here](#), but the settings are shown below for quick reference and use in defining a new model configuration.

Table 4.1: CONUS convection-permitting suite

Microphysics	Thompson	mp_physics= 8
Cumulus	Tiedtke	cu_physics= 6
Longwave radiation	RRTMG	ra_lw_physics= 4
Shortwave radiation	RRTMG	ra_sw_physics= 4
Boundary layer	MYJ	bl_pbl_physics= 2
Surface layer	MYJ	sf_sfclay_physics= 2
Land surface	Noah LSM	sf_surface_physics= 2

Table 4.2: tropical weather/convection suite

Microphysics	WSM6	mp_physics= 6
Cumulus	new Tiedtke	cu_physics= 16
Longwave radiation	RRTMG	ra_lw_physics= 4
Shortwave radiation	RRTMG	ra_sw_physics= 4
Boundary layer	YSU	bl_pbl_physics= 1
Surface layer	MM5	sf_sfclay_physics= 91
Land surface	Noah LSM	sf_surface_physics= 2

Core Count: By default the system uses 96 cores. But for smaller or coarser configurations, using too many cores will over-decompose the grid and result in model failure. WRF provides some information in this [FAQ](#) as a guide to set the appropriate number of cores. In the future, this will be automated.

4.3.2 Limitations of Model Configuration Options

- Currently the system only supports single domains.
- Initialization data is limited to GFS at a 3-hourly interval and the date range of availability is generally within about the last 2 years.
- Regional WRF resolutions may range from about 1km to 12km.
- There are many options in WRF, choosing new configurations requires some knowledge of WRF to be successful.

4.3.3 Managing Model Configurations

Create new config

To create a new model configuration, users can either do so from scratch or duplicate an existing config and save as new.

Option 1. From scratch:

Click on the “Add Config” button and the Create WRF Configuration window will pop up. Enter a new name and description. The user can populate the WPS Namelist and WRF Namelist sections by either copy and paste from local file, enter the text manually, or uploading a file from their local computer using the “Load File” button. Set the appropriate number of cores. Then click “Save”.

Option 2. From existing config (duplicate and save as new):

As an alternative to avoid needing a local file, users can start with an existing configuration and duplicate it to use it as a guide or template, then modify the settings, and save it as a new model configuration name. To duplicate an existing model configuration, click on the Configuration name and a new Edit window will pop up. Click on the “Duplicate” button and a fresh editing window will appear with a copy of the configuration. You can then enter a new Name, make changes to the namelist, and click save. The new configuration will then appear in your list.

Update existing config

To update an existing model configuration, click on the Configuration name and a new Edit window will pop up. Make the desired changes and click the “Update” button.

Remove config

To remove an existing model configuration completely, click on the Configuration name and a new Edit window will pop up. Click the “Remove” button to remove.

4.4 WRF Jobs

A table of jobs that have been launched can be found under the WRF Jobs menu option.

- **Job ID:** Unique job ID for the forecast. This is automatically generated by the system and used for advanced debugging.
- **Name:** If a Job Name was provided in the previous step when Launching a new forecast, it will appear in this column. (Note: this is optional)
- **Configuration:** Name of model configuration.
- **Cycle Time:** The initialization date and time of the forecast.
- **Forecast Length:** The total forecast length in hours.
- **Status:** The current status and progress of the forecast.

4.4.1 Managing a WRF Job

Clicking on the row of a particular job will pop up a window with complete job information along with status information and links to the forecast viewer.

Cancel or Delete a Job

There is also a “Delete” button if the user wants to remove a completed job, or there a “Cancel” button if the user wants to cancel and in-progress job.

The status column will display information about the progress and processing step of that particular forecast. When a run is finished, this column will display a button called “Open Viewer” which can be clicked to go to the forecast viewer to look at forecast plots.

4.5 Manage Users (Admins only)

For users with Admin privileges, the users of the system can be managed in this menu option. Click on any user name to change their role and permissions or remove from system access. To add new users, click on the “Add user” button and enter their email, Name, and select a role for permissions. (see System Administration Roles and Permissions [Section 3.1.1](#))

4.6 Preferences

Users may manage their own preferences in this tab. Currently the only option is to change your password.

4.7 Forecast Viewer

The forecast plots can be accessed by clicking on the Job ID or Status of a run in the WRF Jobs tab. See Graphics page for more information.

Chapter 5

Graphical Outputs

5.1 Forecast Viewer

The forecast plots can be accessed by clicking on the “WRF Jobs” menu option. When the model has finished, an “Open Viewer” button will appear. The button is also available in the pop-up box if you click on a job to see its details. Each available product will be listed in the right-hand menu and can be toggled on/off with the checkmark. Each product also has a transparency slider bar to adjust the field’s transparency. Additionally, there is a Political Boundaries selector at the top of the products list that can be toggled on/off depending on preference. Automation play/pause/advance buttons and slider can be found at the bottom of the map. On the left, a vertical slider bar allows users to select different vertical pressure levels for appropriate products.

Current products available for viewing include:

- 2-meter Temperature
- 2-meter Dew Point
- 10-meter Wind Speed
- 10-meter Wind (Speed/Direction vectors)
- Mean Sea Level Pressure
- 2-m Relative Humidity
- CAPE
- CIN
- Composite Reflectivity
- Precipitation Accumulation
- Low-level Cloud Cover
- Mid-level Cloud Cover
- High-level Cloud Cover
- Precipitable Water

- Temperature on Pressure Levels (1000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa, 100 hPa)
- Relative Humidity on Pressure Levels (1000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa, 100 hPa)
- Vertical Velocity on Pressure Levels (1000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa, 100 hPa)
- Wind Speed on Pressure Levels (1000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa, 100 hPa)
- Wind (Speed/Direction vectors) on Pressure Levels (1000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 300 hPa, 250 hPa, 100 hPa)

More to come!

Chapter 6

References

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