

# DEVELOPMENT OF COMPUTATIONAL TOOLS AND EDUCATIONAL RESOURCES TO SUPPORT PI-WRF COMMUNITY DRIVEN LEARNING MODULES

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# Outline

- **Background**
- **Goal**
- **Development**
- **Result**
- **Future work**

# Background: Motivation



Weather forecasting provides information that help communities prevent weather-related losses and make smart choices.



Weather forecasting can be both complex and complicated, involving large amount of data, modeling and use of supercomputers.

*How can you create a weather forecast?*



*Water, earth, air, fire*

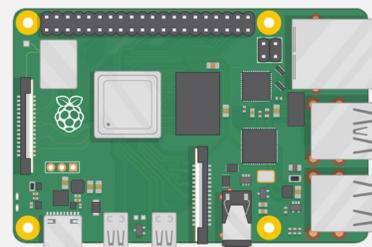


Few people understand the process and many lack access to resources to make their own forecast.

# Background: Goal

Facilitate community understanding of the concept and process of weather forecasting.

*Raspberry pi + WRF Model*

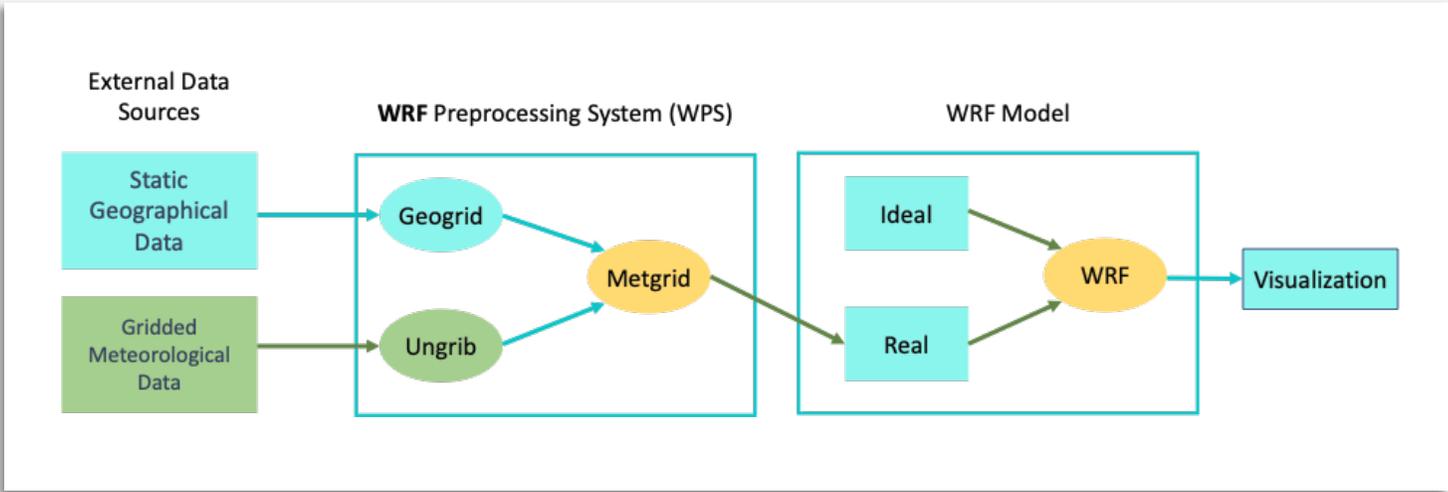


Facilitate the creation and sharing of weather-related content among educators and other community members.

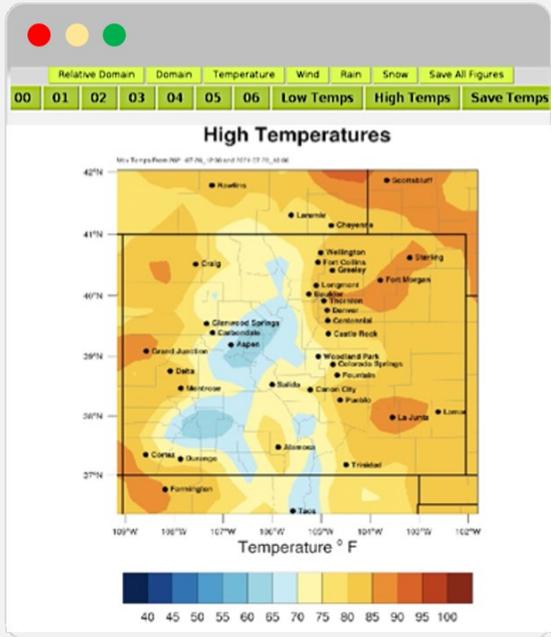


# Background: WRF Model

- Numerical Weather Prediction System.
- Atmospheric research and operation forecasting.
- Actual and Idealized atmospheric conditions modeling.

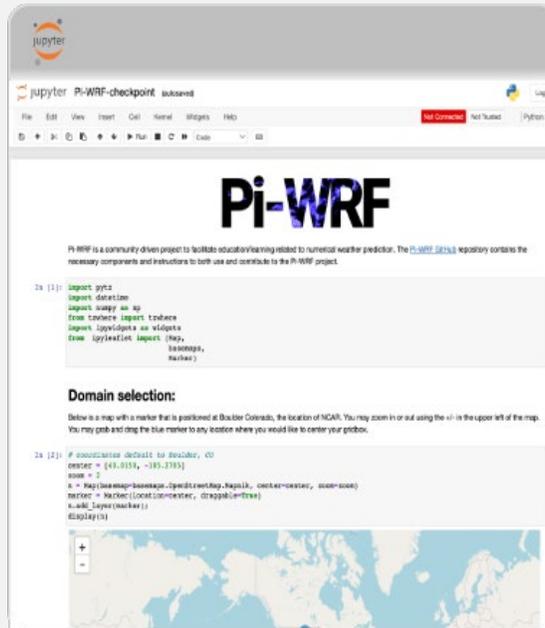


# Background: Previous Iterations



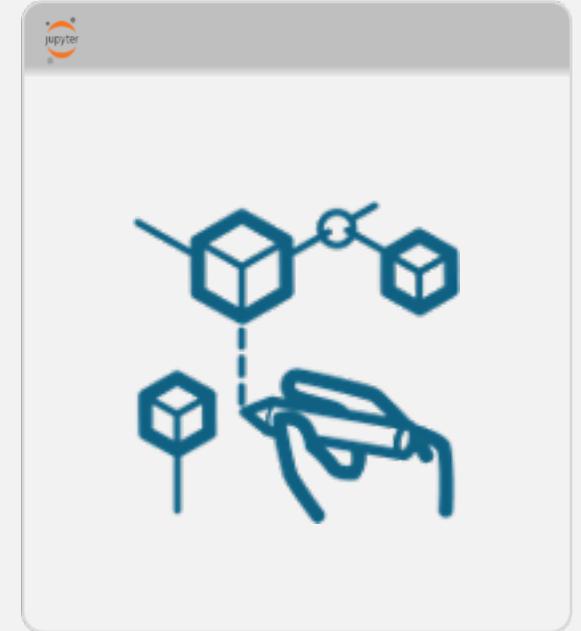
Python-based GUI

- Run WRF on a Raspberry Pi
- Output series of plots



Jupyter Notebook

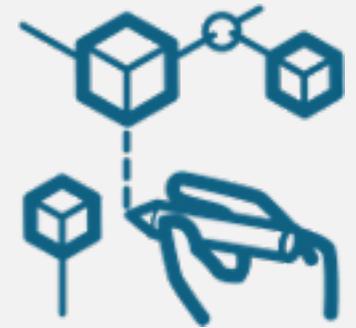
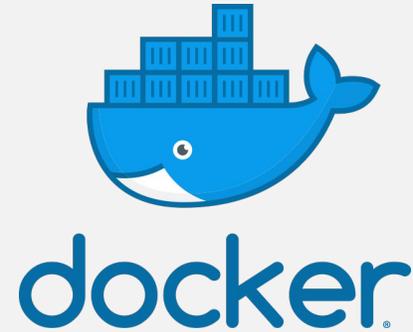
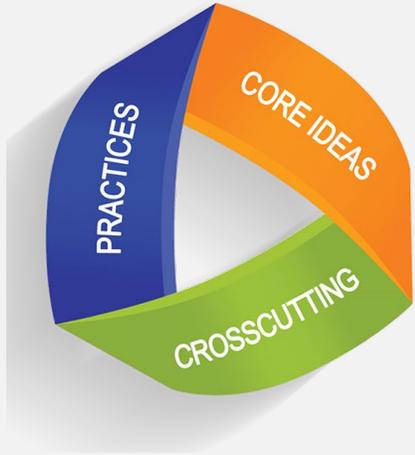
- Docker Stacks
- Transition to community effort



Community Framework

- Educational Modules
- Pi-WRF Extension
- Support Framework

# Background: Summer Goal



Develop educational modules that address NGSS standards

Extend existing technologies to facilitate community contribution

Build framework and materials to encourage community contribution of modules.

# Development: Educational Module

Using Pi-WRF to facilitate science education by targeting relevant NGSS standards.

Earth's Systems (ESS2) | Earth and Human Activity (ESS3)



Design of sample activities and lesson templates to support teacher's creation of Pi -WRF contents.



Development of learning activities demonstrating real-world application of Pi -WRF and weather forecasting.

<https://oluwajobs.github.io/myweatherstory/>



# Pi-WRF

## My Weather Story

Search this book...

**Introduction**

Lesson Overview

Scenario:

Using Pi-WRF To Answer Our Driving Question

Vocabulary:

[Github Version](#)

# My Weather Story

Date: July 8 2022

A picture story of the different clothes that I will be putting on based on my weather forecast using Pi-WRF

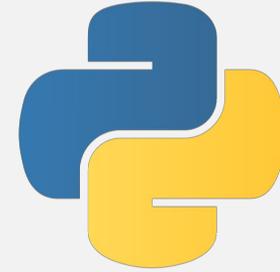
 84°F Hour 1	 70°F Hour 2	 69°F Hour 3	 78°F Hour 4
It is going to be very hot ☀️ so I will be putting on a hat to protect my eyes.	My forecast says it is going to be a nice weather. Not that sunny! I might visit the beach!	It is probably going to be sunny at first before it cools off. I will be wearing a cloth that fits both weaather condition.	It is going to be very hot at this time! I'm plan to put on shorts ☀️.

Figure 1: A Jupyter book showing a sample Pi-WRF Activity

# Development: Pi -WRF Extension

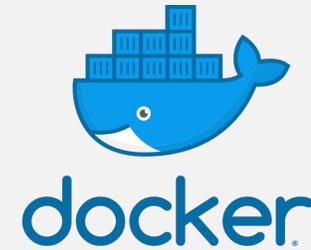
Added new libraries to support independent analysis and visualization of weather data.

*PyNGL, Xarray, FFmpeg, hvPlot...*



Rebuilt Pi-WRF to support multiple architectures:

*AMD, ARM, ARM/v7*



Web-based Interactive application of WRF for weather forecasting using Jupyter notebook.

<https://github.com/NCAR/pi-wrf>



# Development: Pi -WRF Extension

## Domain selection:

Below is a map with a marker that is positioned at Boulder Colorado, the location of NCAR. You may zoom in or out using the +/- in the upper left of the map. You may grab and drag the blue marker to any location where you would like to center your gridbox.

```
In [2]: # coordinates default to Boulder, CO
center = [40.0150, -105.2705]
zoom = 2
n = Map(basemap=basemaps.OpenStreetMap.Mapnik, center=center, zoom=zoom)
marker = Marker(location=center, draggable=True)
n.add_layer(marker);
display(n)
```



## Datetime range selection:

The cell below automatically generates a datetime range based on the current time of the timezone for the map marker. The times are rounded according to the model's expected input. Current times are rounded down to the most recent appropriate hour for a start time. The end time adds six hours to the start time. It is possible to manually set the start and end times at the end of the cell if desired.

```
In [3]: # function for rounding times
def round_hour(x, base=6):
    return x // base * base
# time range is generated automatically based on current time at time zone of map marker
from tzwhere import tzwhere
tzwhere = tzwhere.tzwhere()
timezone_str = tzwhere.tzNameAt(marker.location[0], marker.location[1])
```

## Initiate model

The model is initiated from the cell below. The above cells should have already been executed so the appropriate inputs will be available for the model. The model will take a few minutes to run. You should wait until it finishes running before proceeding to the following cells. The cell's number will show an asterisk '\*' while it is still running.

```
In [7]: %%bash
cd ../pi-wrf/pi_wrf/pi_wrf
```

# Result: Pi -WRF Extension

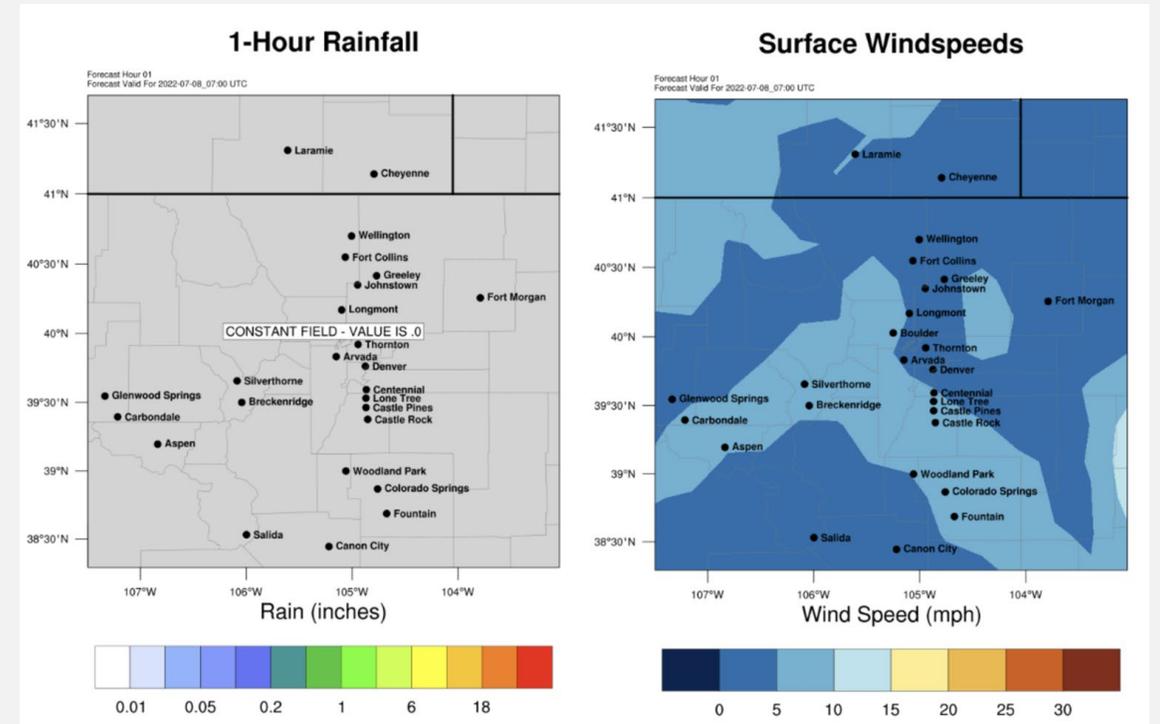
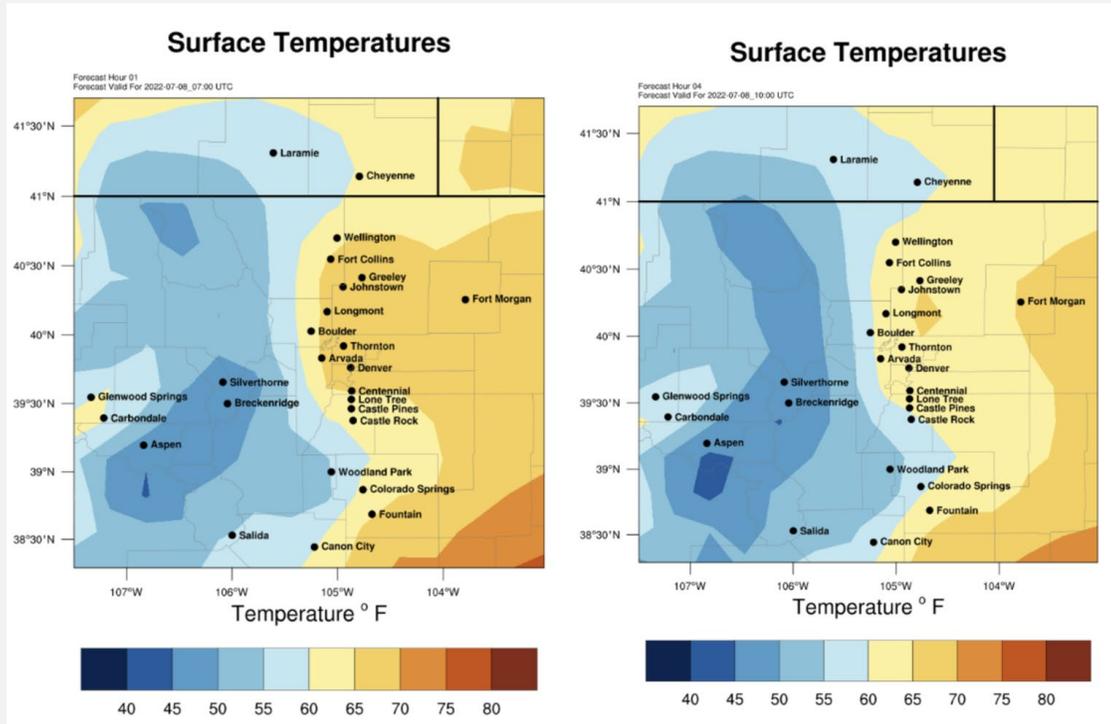
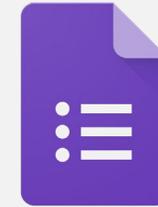


Figure 3: Plot showing the temperature for areas around Boulder for July 8, 2022 at 0700hr and 1000hrs respectively.

Figure 4: Plot showing rainfall and windspeed forecast for Boulder area on July 8, 2022 at 0700hrs.

# Development: Teaching Box Contribution

Development of a contributor guide to foster creation of teaching boxes among teachers with varying experience.



Google Forms

Creation of web pages to lower barriers to contribution among teachers with little to no programming expertise.

[Teaching Boxes Page](#)



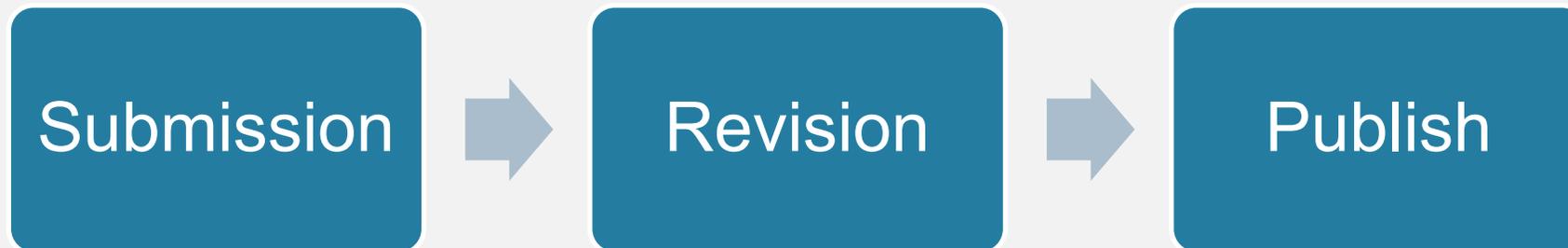
Lesson template, sample problems.



# Result: Teaching Box Contribution Process

The screenshot shows the top navigation bar with 'TEACHING BOXES', 'ABOUT PIWRF', 'CONTRIBUTE MODULES', 'PI-WRF & NGSS', and 'FAQ'. The main heading is 'CONTRIBUTE TEACHING BOXES'. The text explains the goal of the project: to facilitate the development and sharing of instructional modules. It encourages educators to contribute lessons, concepts, or activities. A 'Begin Submission' button is visible at the bottom.

The screenshot shows the 'OVERVIEW' page. The navigation bar includes 'TEACHING BOXES', 'ABOUT PIWRF', 'CONTRIBUTE MODULES', 'PI-WRF & NGSS', and 'FAQ'. The 'OVERVIEW' button is highlighted. Below the navigation, there are radio buttons for 'Middle School' and 'High School'. The main text describes the concept of weather and climate across science disciplines and the design of Pi-WRF teaching boxes around NGSS performance expectations and 3D learning. A circular diagram on the right shows 'PRACTICES', 'CORE IDEAS', and 'CROSSCUTTING'. The bottom text describes the Pi-WRF application interface for integrating and analyzing weather data.



- Pi-WRF Teaching Boxes
- Improved libraries and Multi-architecture Pi-WRF Application
- Contributor's guide and template
- Submission page and form to support sharing

## Next Steps

- Usability: Focus Groups Feedback
- Development of more educational modules
- Optimizing the Pi-WRF application: Docker Multistage
- Persistence of WRF outputs in Docker Containers

# Acknowledgements

## Mentors

Agbeli Ameko

Keith Maull

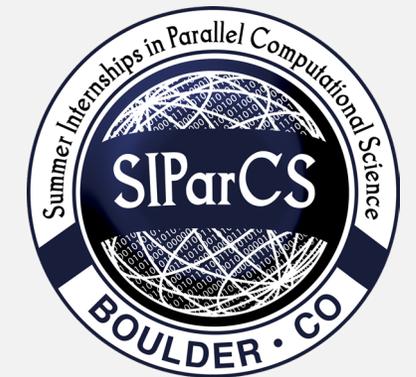
## SIParCS & NCAR Team

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Jerry Cyccone

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# Thank You

Questions & Feedback

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## In-Progress Template