Overview of I-WRF Container Architecture

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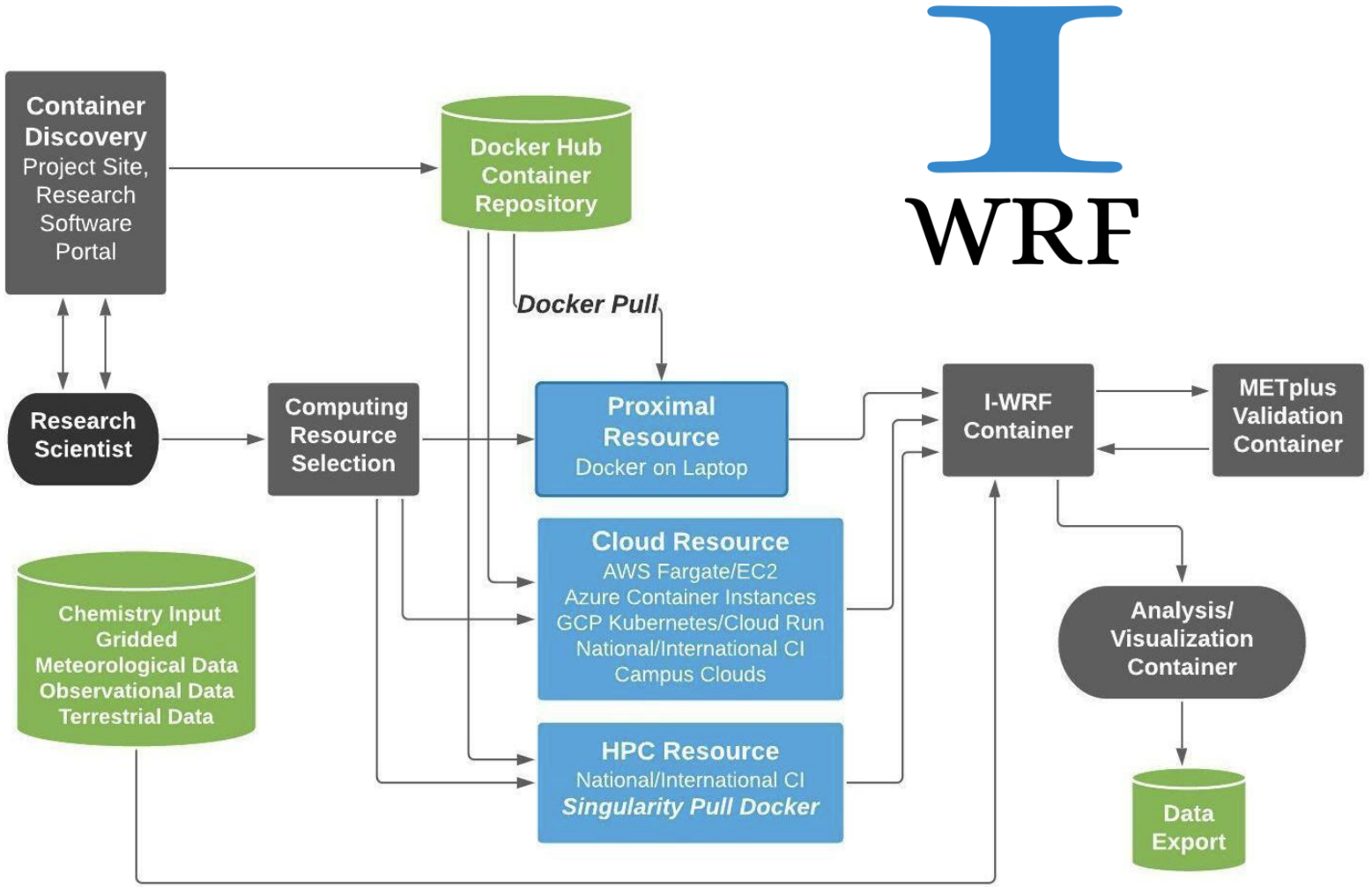
NSF National Center for Atmospheric Research

(On behalf of the entire project team from NSF NCAR & Cornell)

I-WRF Science Advisory Board Meeting
11 May 2026

I-WRF Conceptual Design



- The main change to this original concept diagram in our current implementation of I-WRF is that the visualization pieces are being done within the METplus validation container
- This way we only need to load in a Python environment in one container, not two

WRF Challenges

- Despite a large user base and deployment on many HPC systems, around *50% of users* attending tutorials at NSF NCAR report difficulty configuring the software for use on whichever computing platform they're using

- Compiling WRF software requires understanding multiple compiler frameworks, a set of required libraries to be built with the same compiler you select for WRF, and a wide range of WRF configuration options

- Need to know where to obtain data for initial conditions & lateral boundary conditions (ICs/LBCs), and observations for verification

- It usually requires some work to get verification and visualization tools configured to ingest WRF output

- These technical barriers mean that potential researchers and scholars run into hurdles before they can even get to the weather and climate stuff

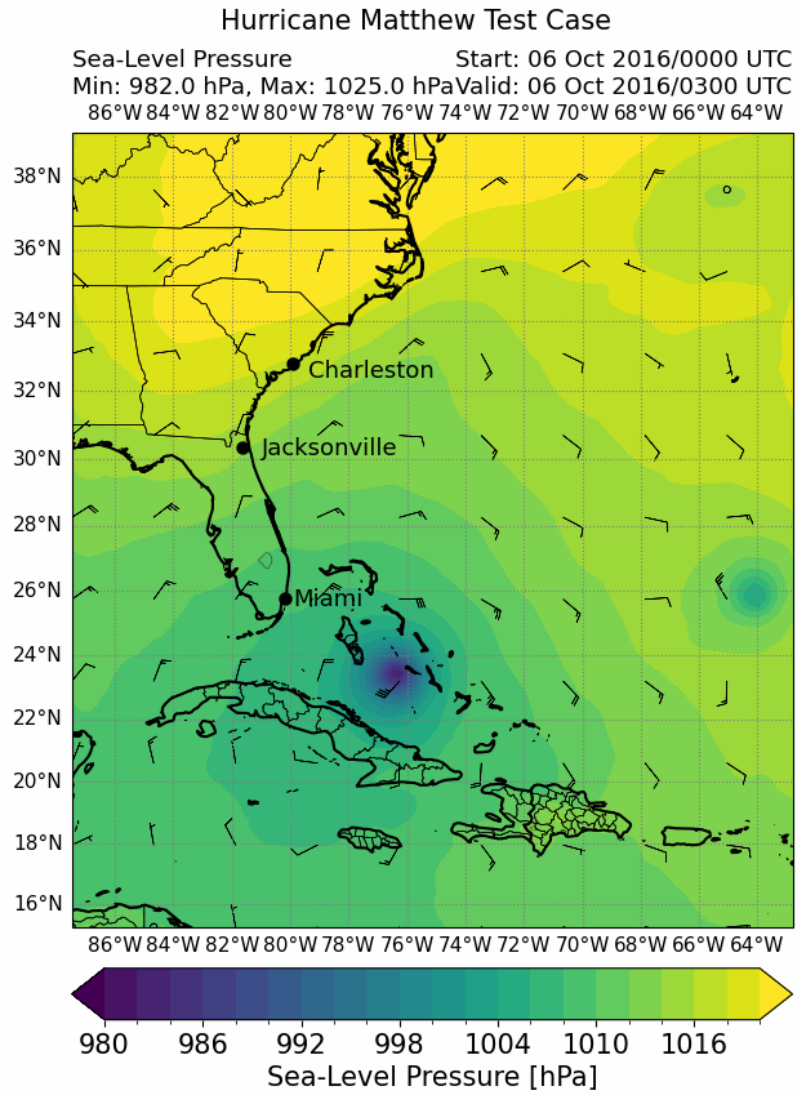
https://www.istockphoto.com/signature/photo/thats-it-im-done-gm936117884-256071691

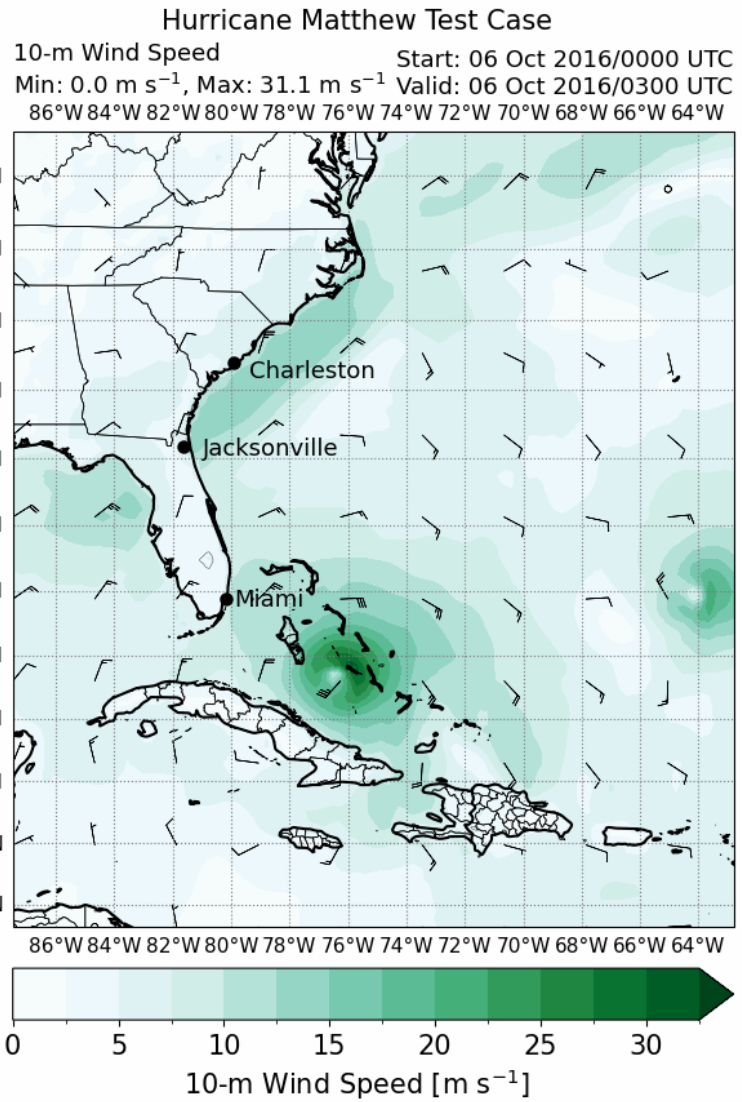
Verifying Model Output with METplus

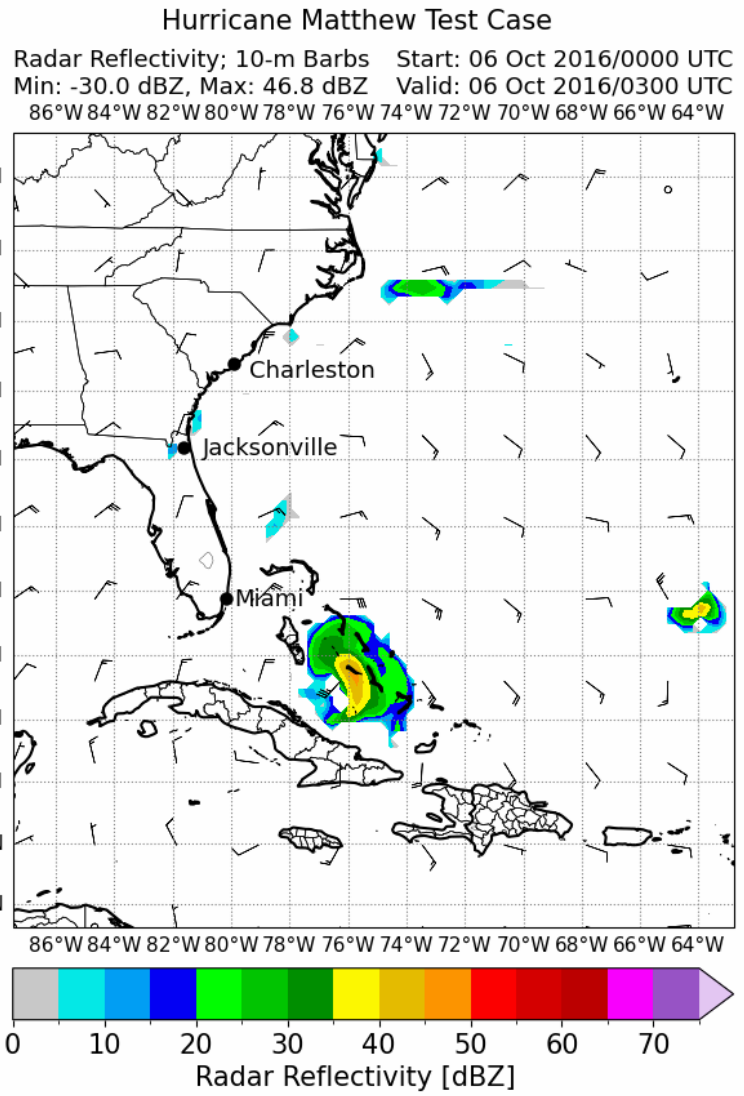
- Model Evaluation Tools (METplus) verification system
  - Community validation toolkit supported by NSF NCAR and largely developed by NSF NCAR
  - Developed through funding from the 557th Weather Wing of the U.S. Air Force, National Oceanic and Atmospheric Administration (NOAA), and NSF NCAR
  - Verification framework that spans a wide range of temporal (warn-on-forecast to climate) and spatial (storm to global) scales
  - Used operationally by NOAA, UK Met Office, Australian Bureau of Meteorology, and others
  - Large community of users & contributors
- METplus was already containerized
- I-WRF containerizes METplus configurations for doing some sample verification from the the various I-WRF use cases, and plots it

https://dtcenter.org/community-code/metplus

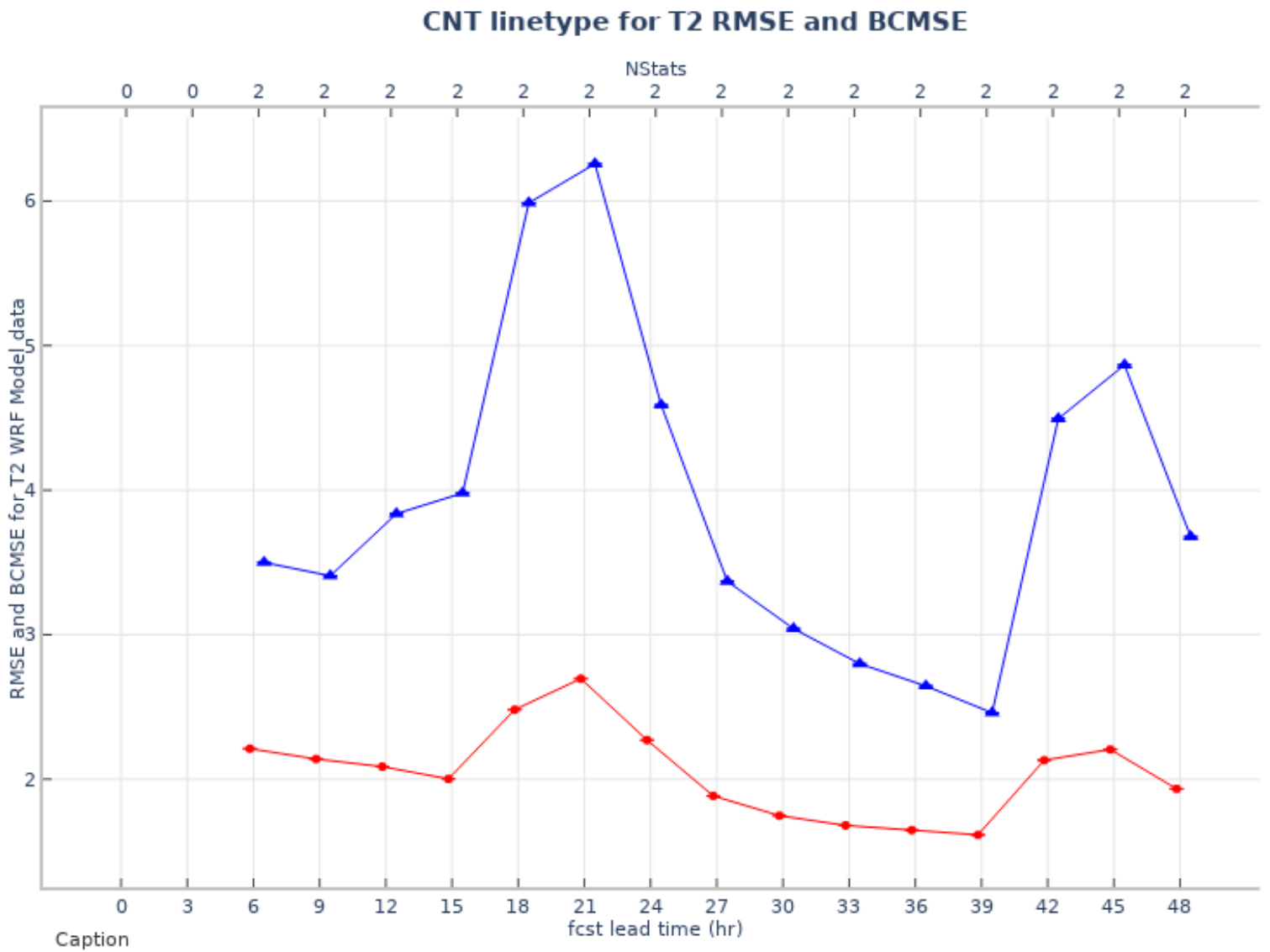
I-WRF Hurricane Matthew Test Case Python Visualization



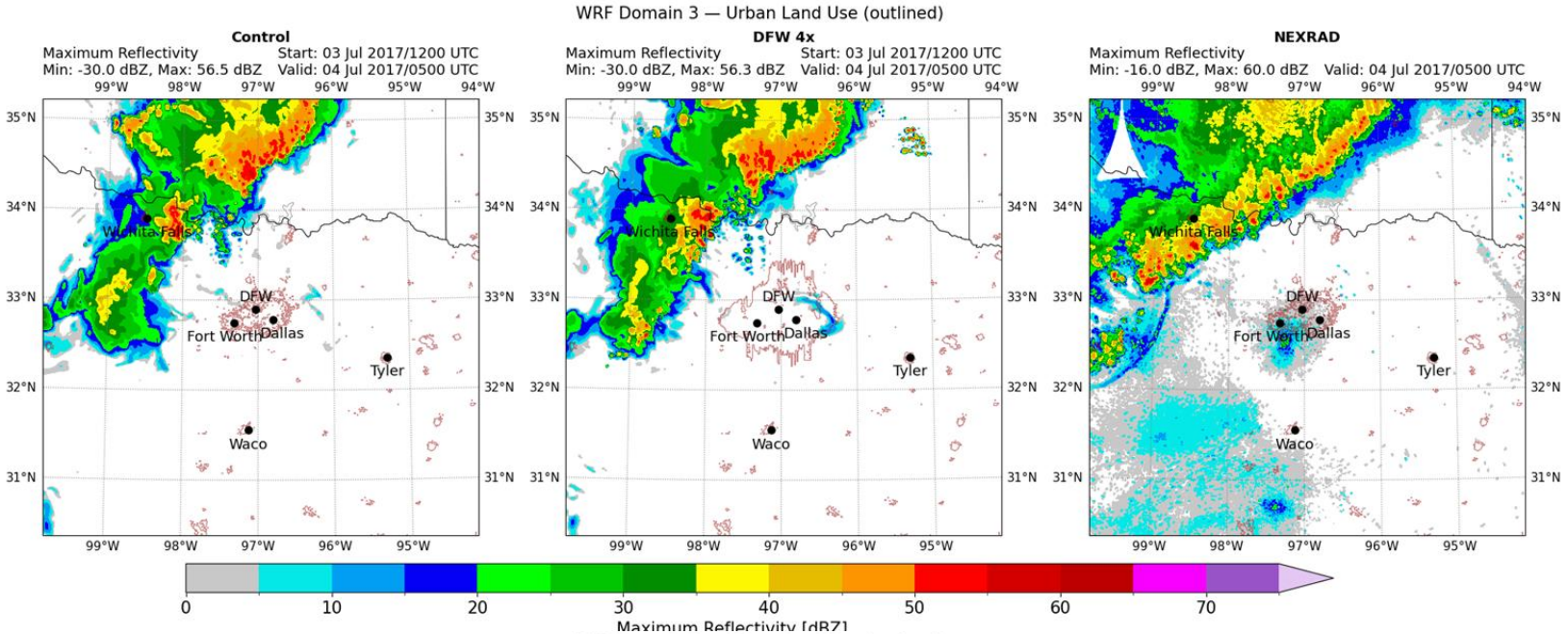


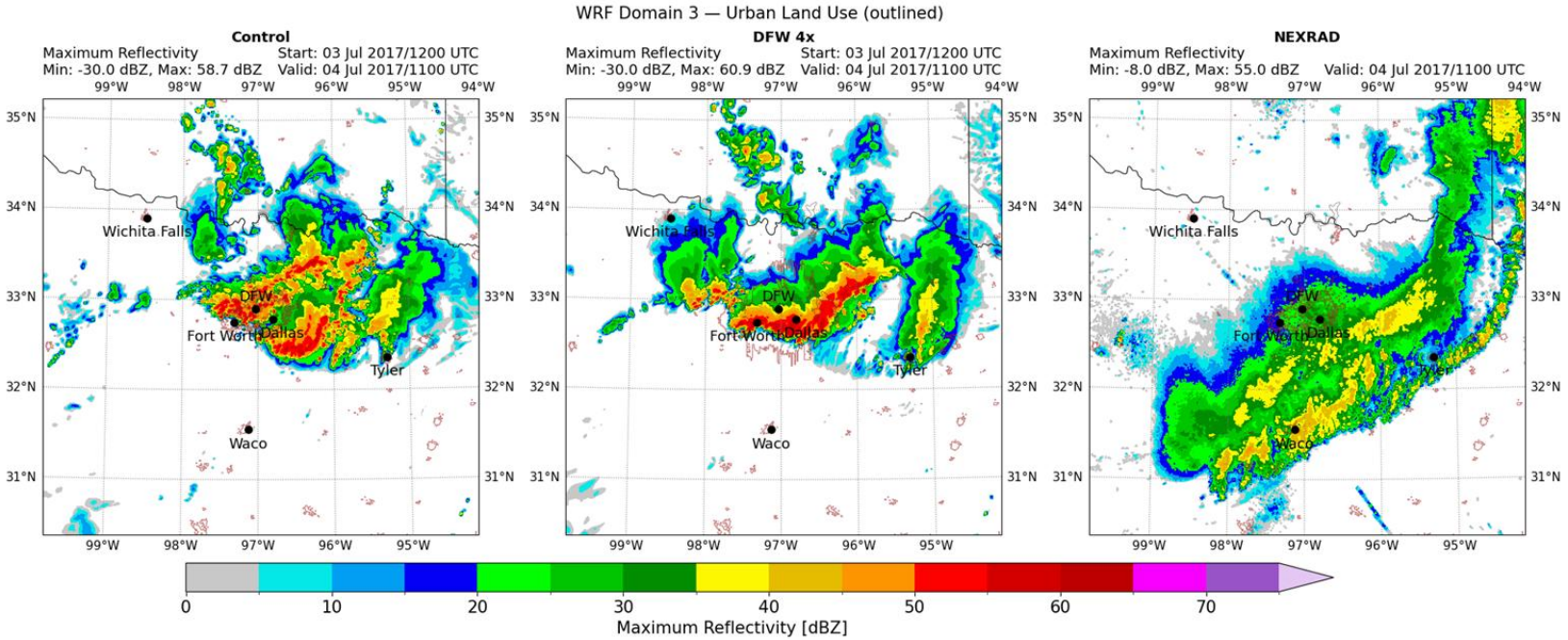


I-WRF Hurricane Matthew METplus Visualization

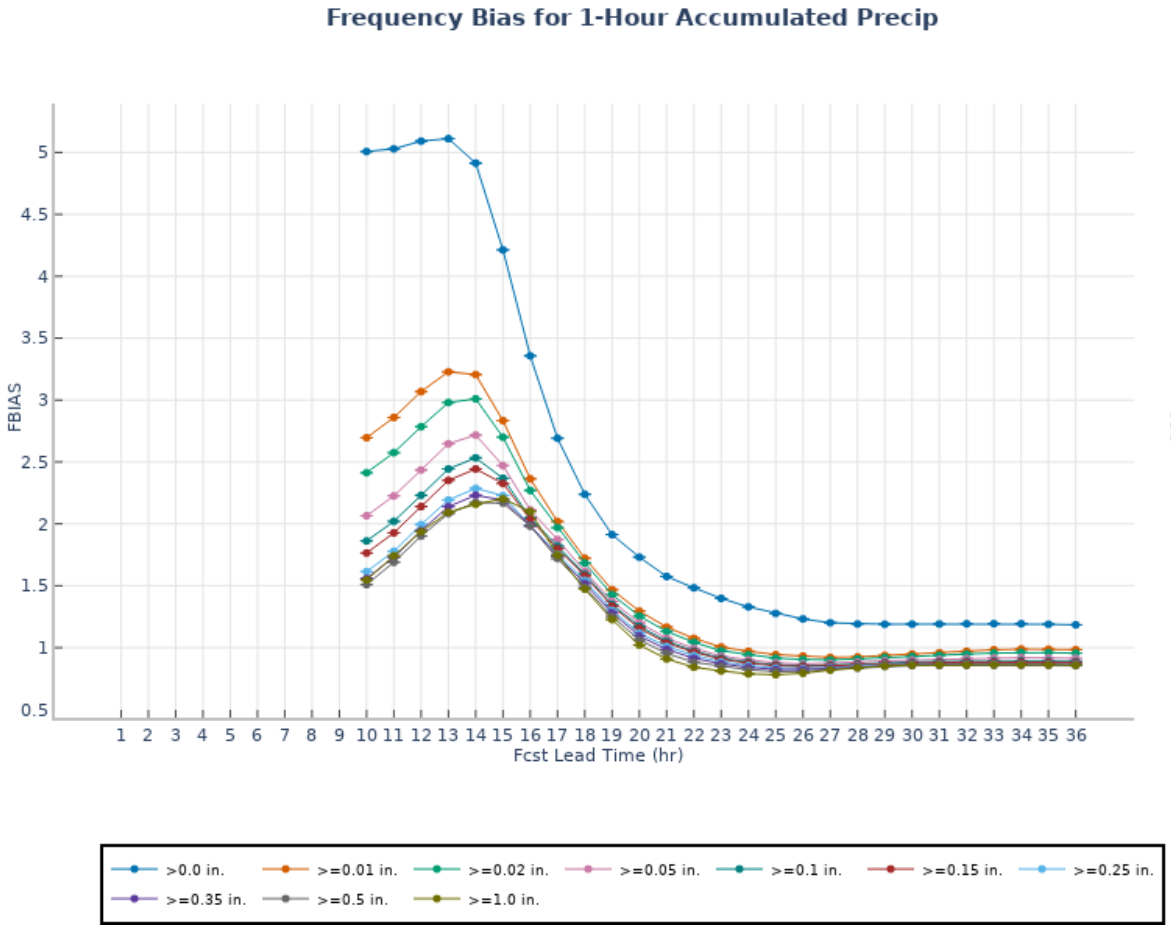


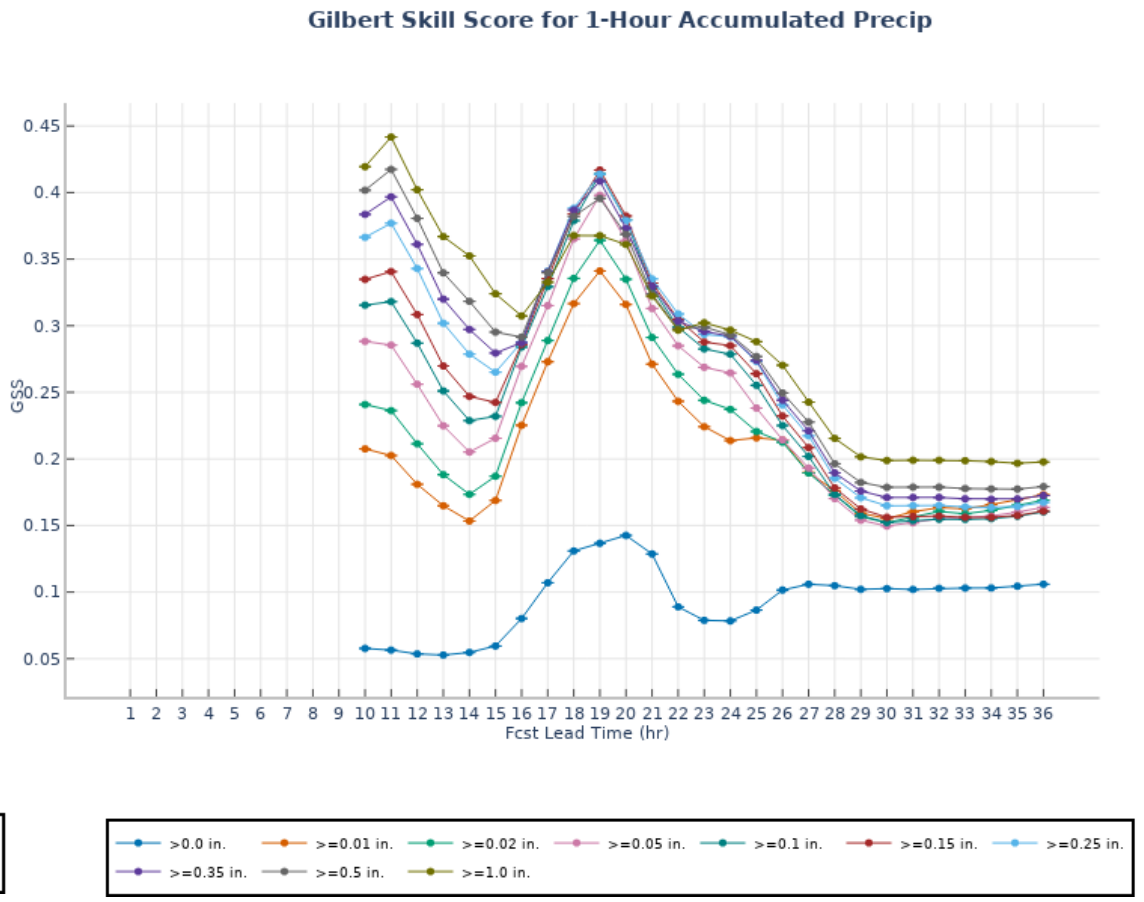
I-WRF LULC Test Case Python Visualization



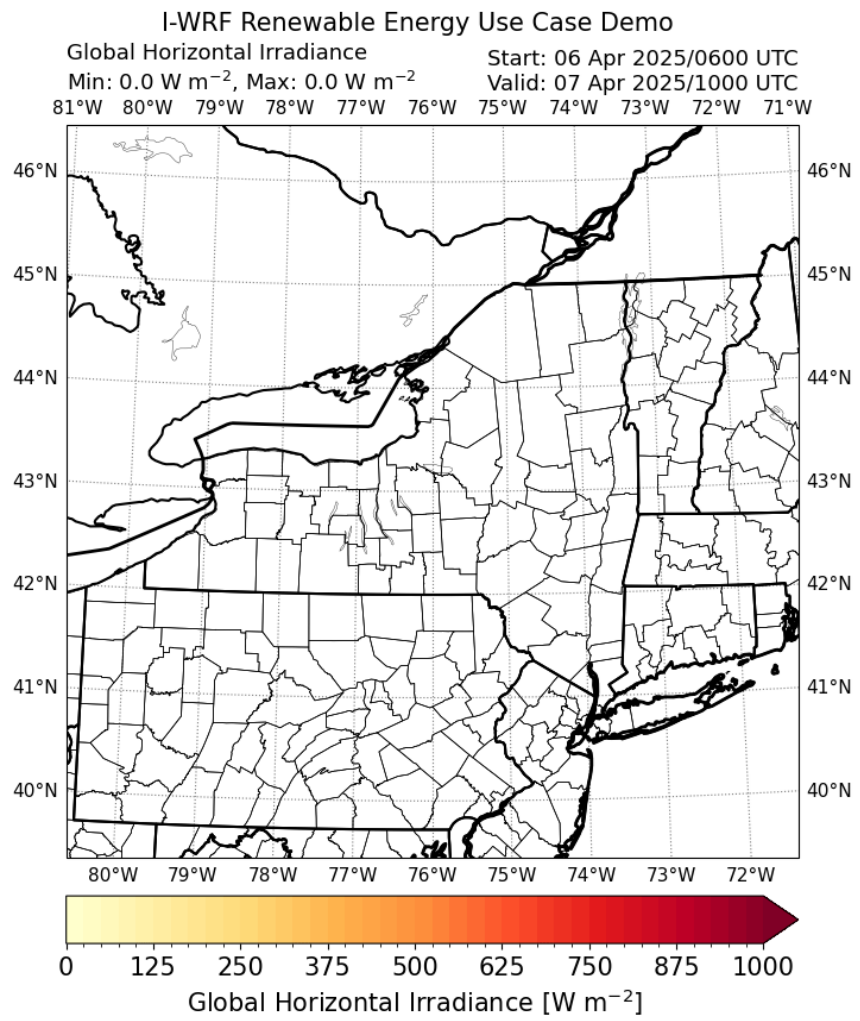


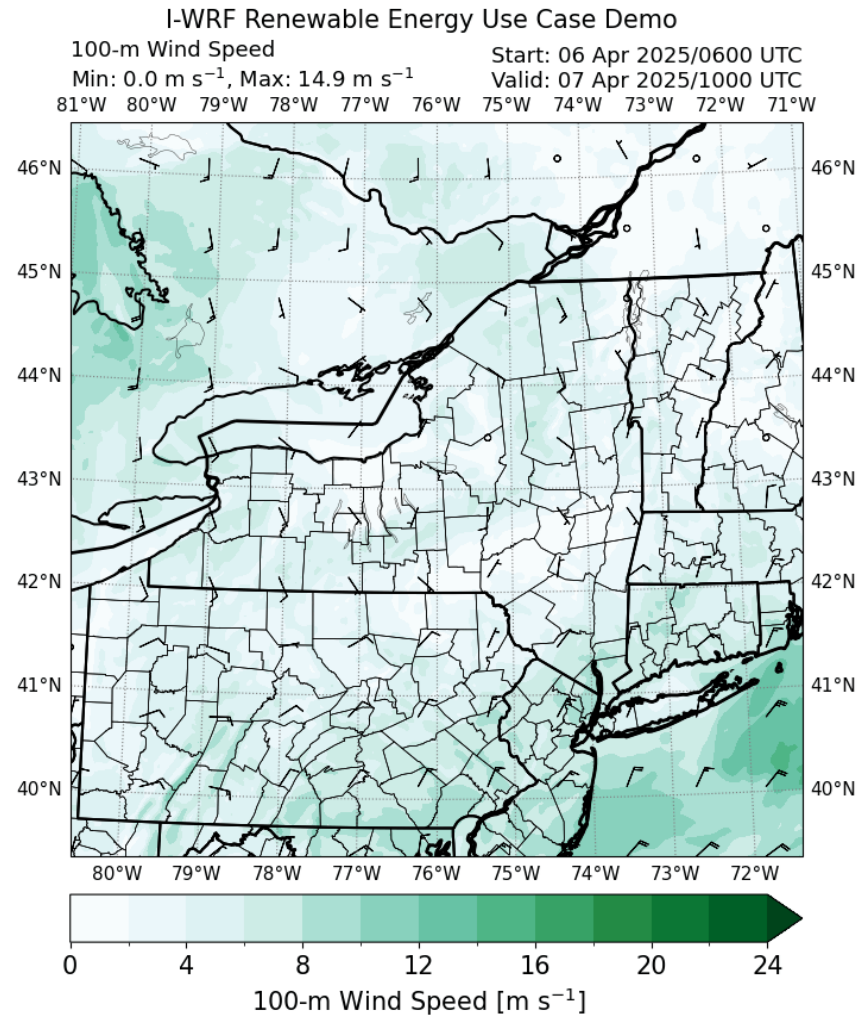
I-WRF LULC Test Case Python Visualization

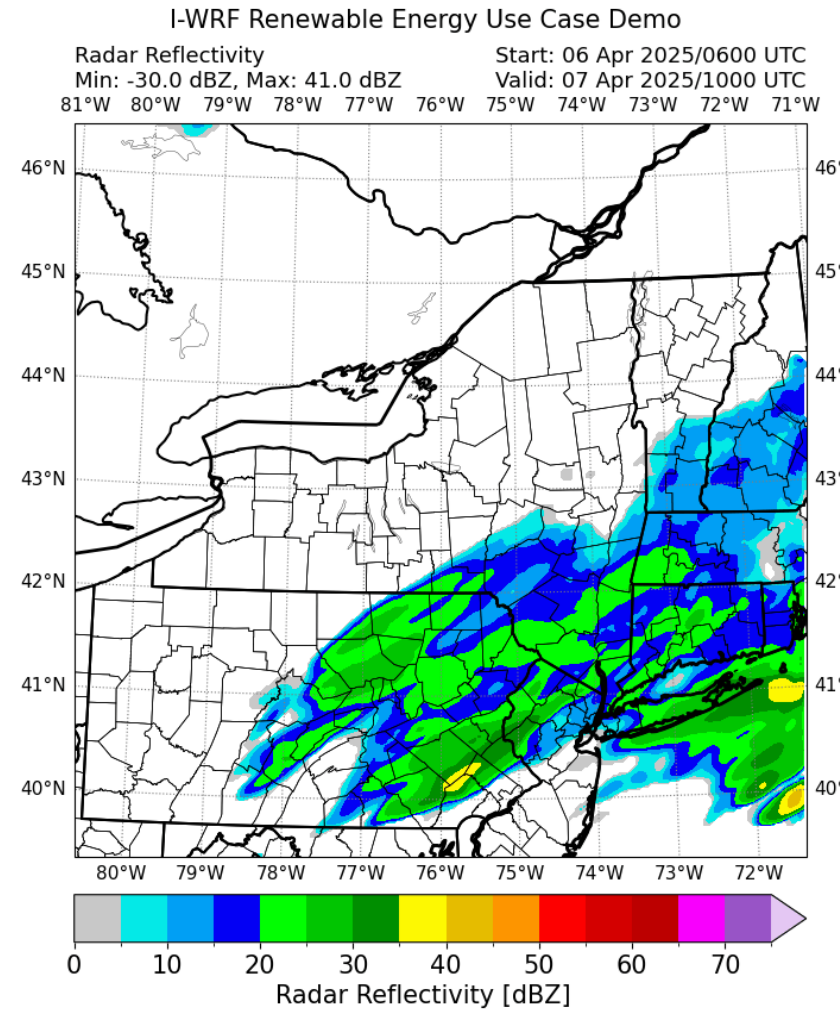




I-WRF Renewable Energy Test Case Python Visualization

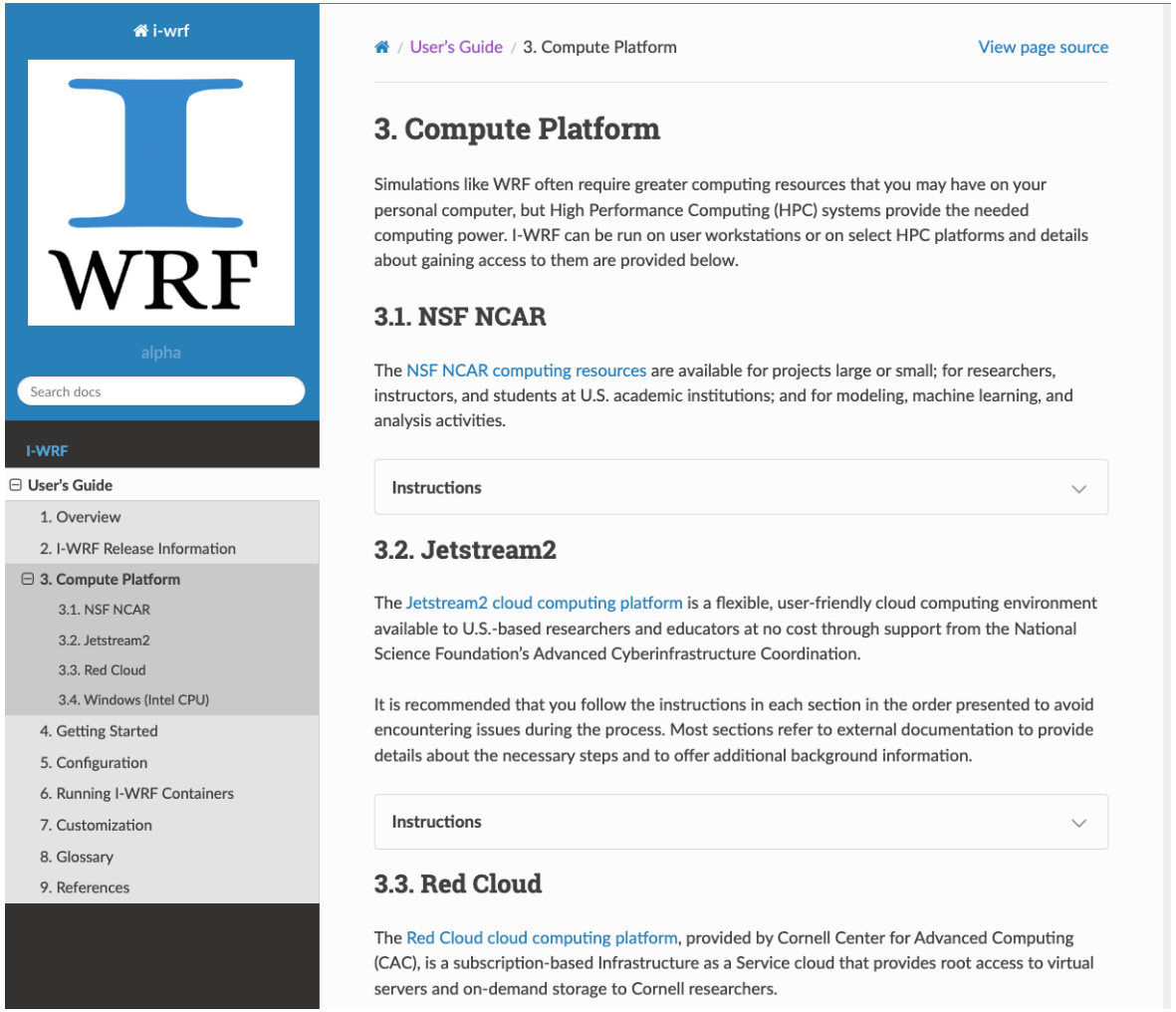




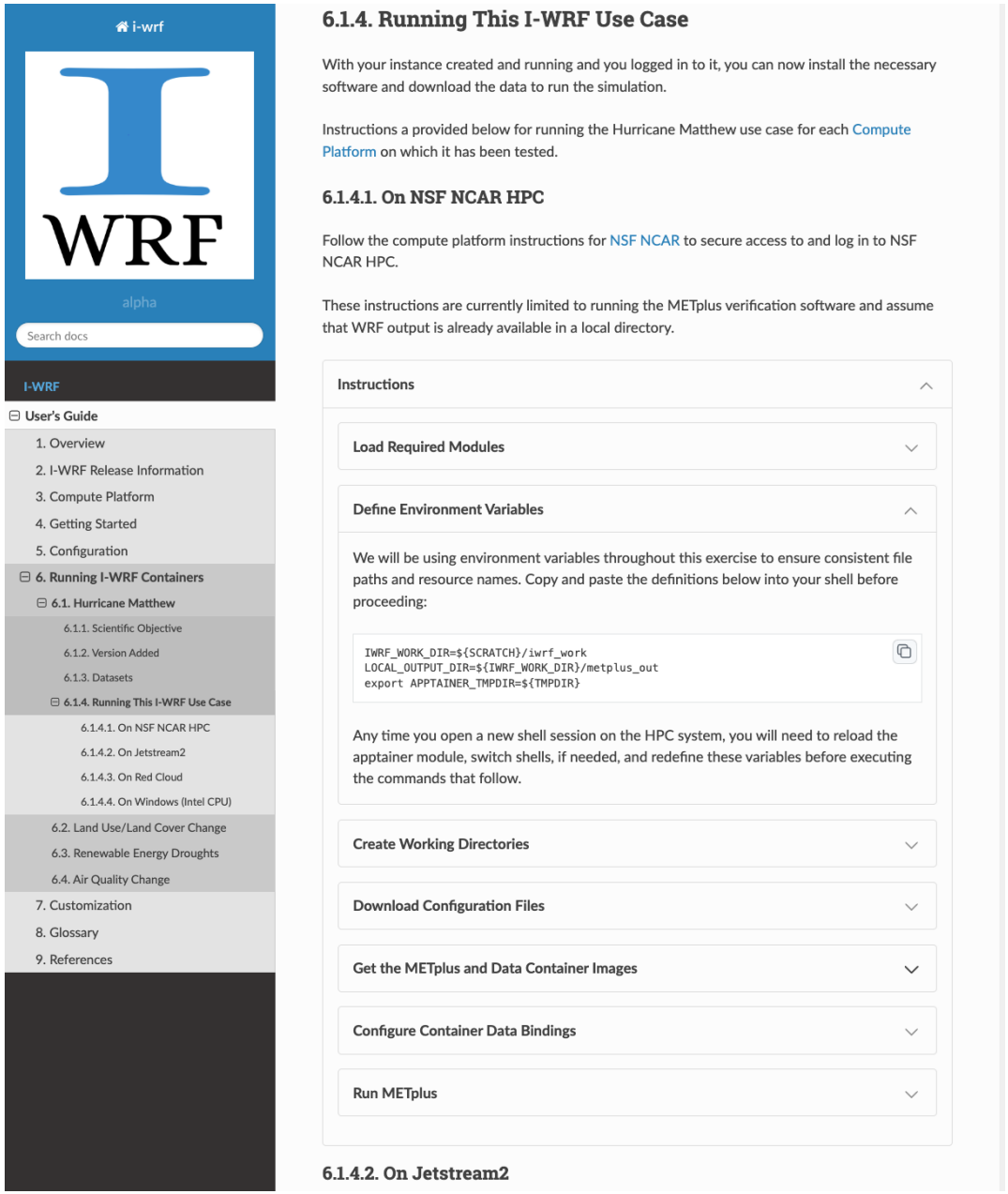


- Observations from New York State Mesonet will be used for verification for this case
  - 127 surface stations
  - 17 profiler stations (with lidars to verify 100-m wind forecasts)

I-WRF ReadTheDocs Documentation

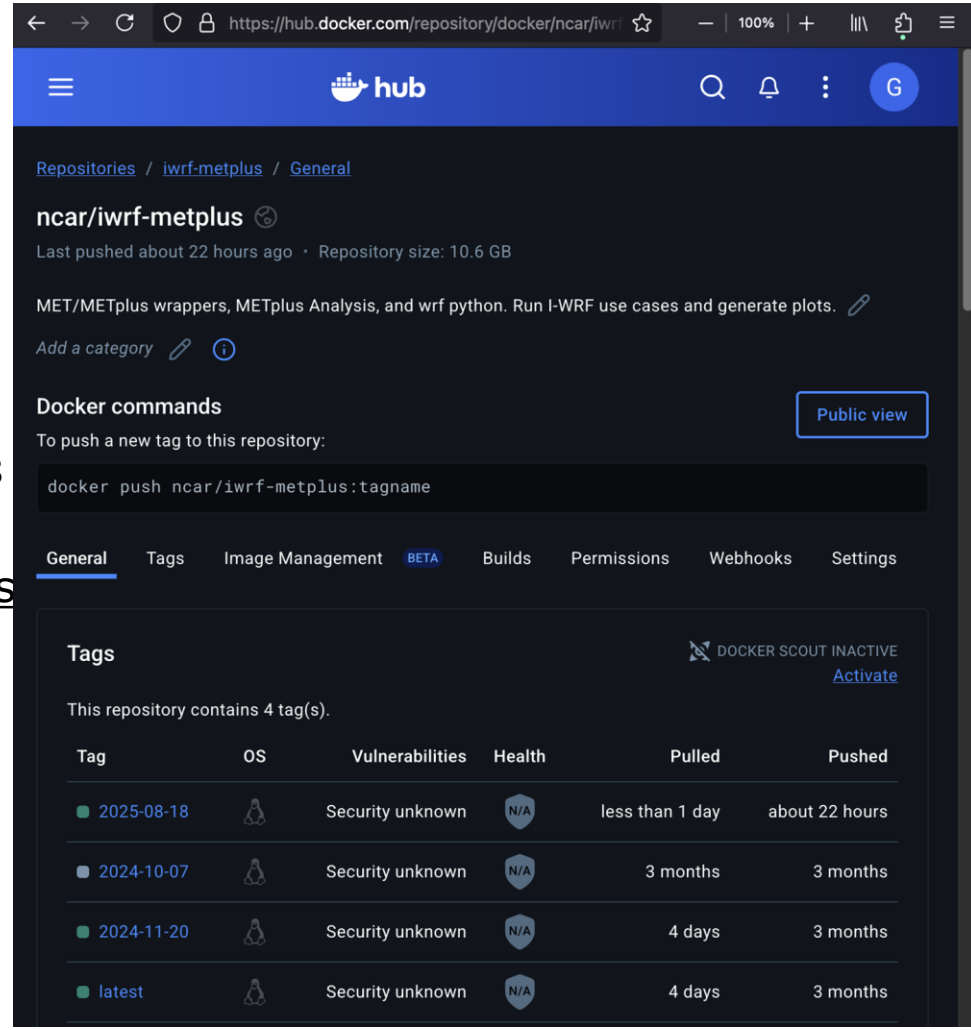


- User's Guide: https://i-wrf.readthedocs.io



I-WRF DockerHub Repositories

- ncar/iwrf : WRF Container
  - Contains software requires to run WRF
  - https://hub.docker.com/repository/docker/ncar/iwrf
- ncar/iwrf-metplus : METplus Container
  - Contains METplus wrappers, MET C++ executables, METplus Analysis plotting tools, and WRF-Python package
  - https://hub.docker.com/repository/docker/ncar/iwrf-metplus
- ncar/iwrf-data : Data Volumes
  - Contains input data used to run I-WRF use cases
  - https://hub.docker.com/repository/docker/ncar/iwrf-data

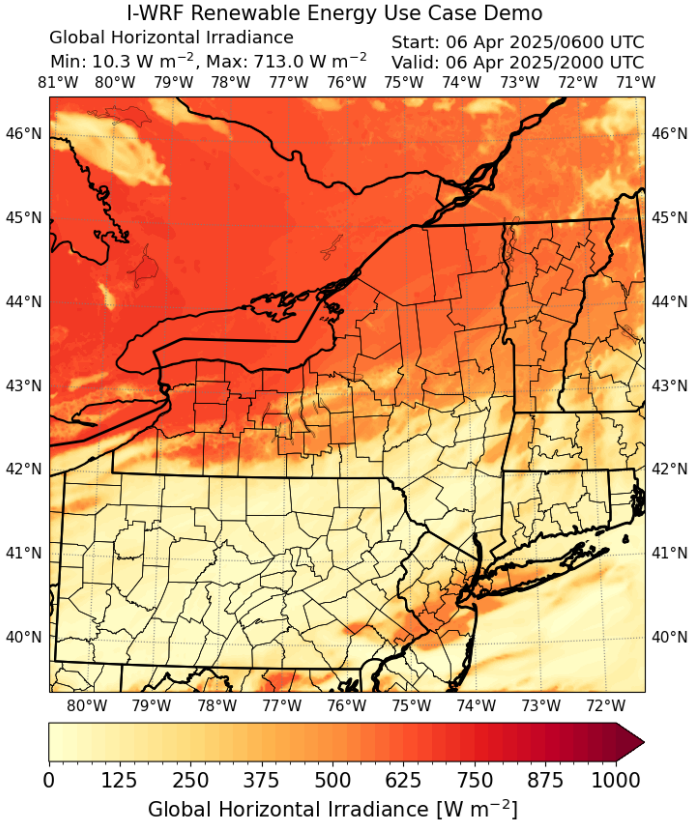


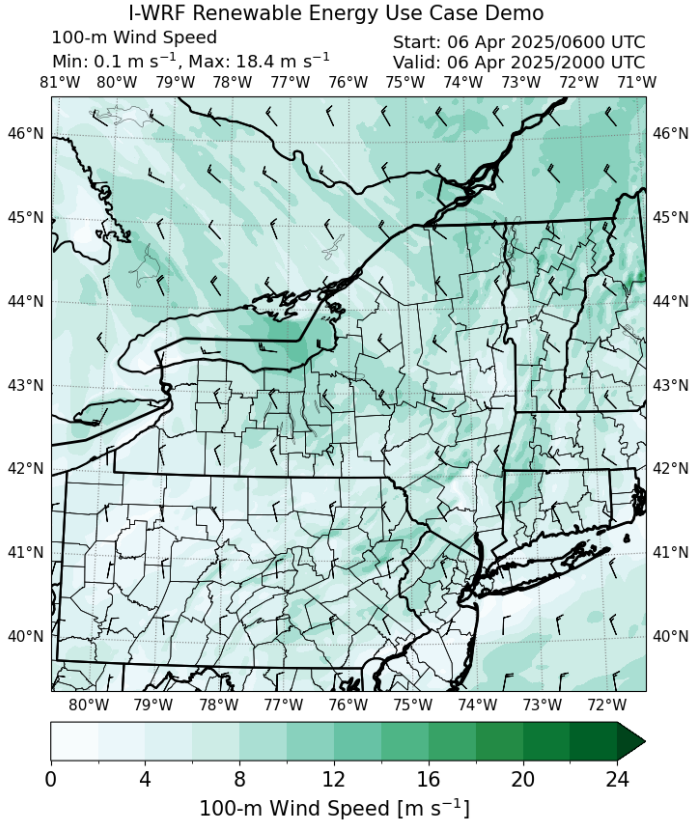
Major Technical Milestones Accomplished

- I-WRF v0.1
  - Hurricane Matthew demo with WRF & METplus containers (Oct 2024)
- I-WRF v0.2
  - Hurricane Matthew demo with visualization scripts added to METplus container (Dec 2024)
- I-WRF v0.3
  - LULC demo (Aug 2025, formally tagged as a release in Dec 2025)
  - Additional tasks in progress (v0.3.1):
    - Filling out METplus container instructions for Jetstream2, Red Cloud
    - Adding WRF visualization script to METplus container

Major Technical Milestones In Progress

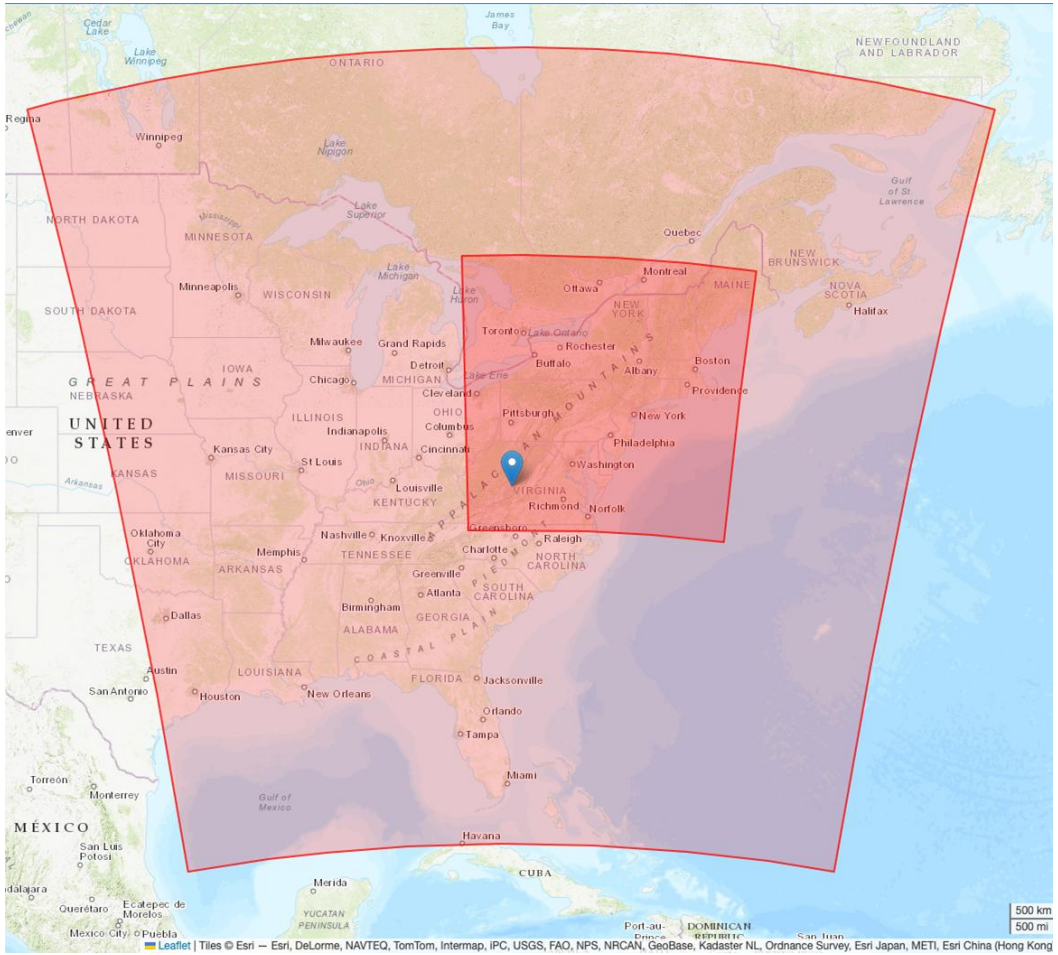
- I-WRF v0.4
  - Renewable Energy demo (in progress)
    - WRF case date/domain finalized, observations requested from NYS Mesonet
    - Adapting scripts from Hurricane Matthew demo for running WRF container
    - Configuring METplus container to verify WRF against NYS Mesonet obs
    - WRF visualization script for this demo mostly done





Major Technical Milestones In Progress

- I-WRF v0.5
  - Air quality change demo (in progress)
    - WRF-Chem containerized in Apptainer for Derecho and in Docker for Red Cloud and Jetstream2
    - WRF-Chem domain finalized (12/4-km domains over eastern U.S.)
    - Need to identify/obtain obs for METplus container demo
    - Need to adapt WRF visualization scripts



Major Technical Milestones In Progress

- I-WRF v1.0
  - User customization (in progress)
    - Add user exercises to change WRF physics, METplus stats, visualization
    - Add capability for user to select different date, triggering automatic retrieval of WRF ICs/LBCs and observations for that date
    - Add some level of guidance for users to create their own containers

```
&physics
 mp_physics                          = 28,    28,
 use_aero_icbc                       = .true.
 wif_fire_emit                       = .false.,
 do_radar_ref                        = 1,
 ra_lw_physics                       = 4,     4,
 ra_sw_physics                       = 4,     4,
 radt                                = 10,    10,
 swint_opt                           = 2,
 slope_rad                           = 1,     1,     1,
 topo_shading                        = 1,     1,     1,
 topo_wind                           = 0,     0,     0,
 sf_sfclay_physics                   = 5,     5,
 sf_surface_physics                  = 2,     2,
 sf_surface_mosaic                   = 1,
 mosaic_cat                          = 3,
 sf_lake_physics                     = 0,     0,
 bl_pbl_physics                      = 5,     5,
 bldt                                = 0,     0,
 tke_budget                          = 0,
 bl_mynn_tkeadvect                   = .false.,
 bl_mynn_cloudpdf                    = 1,
 bl_mynn_mixlength                   = 2,
 bl_mynn_edmf                        = 1,
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 bl_mynn_edmf_tke                    = 0,
 grav_settling                       = 0,
 scalar_pblmix                       = 1,
 cu_physics                          = 0,     0,
 cudt                                = 0,     0,
 isfflx                              = 1,
 ifsnow                              = 1,
 icloud                              = 3,
 icloud_bl                           = 1,
 insert_init_cloud                   = .true.,
 surface_input_source                = 1,
 num_soil_layers                     = 8,
 sf_urban_physics                    = 0,
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 mp_zero_out_thresh                  = 1.e-12,
 use_aero_icbc                       = .true.,
```
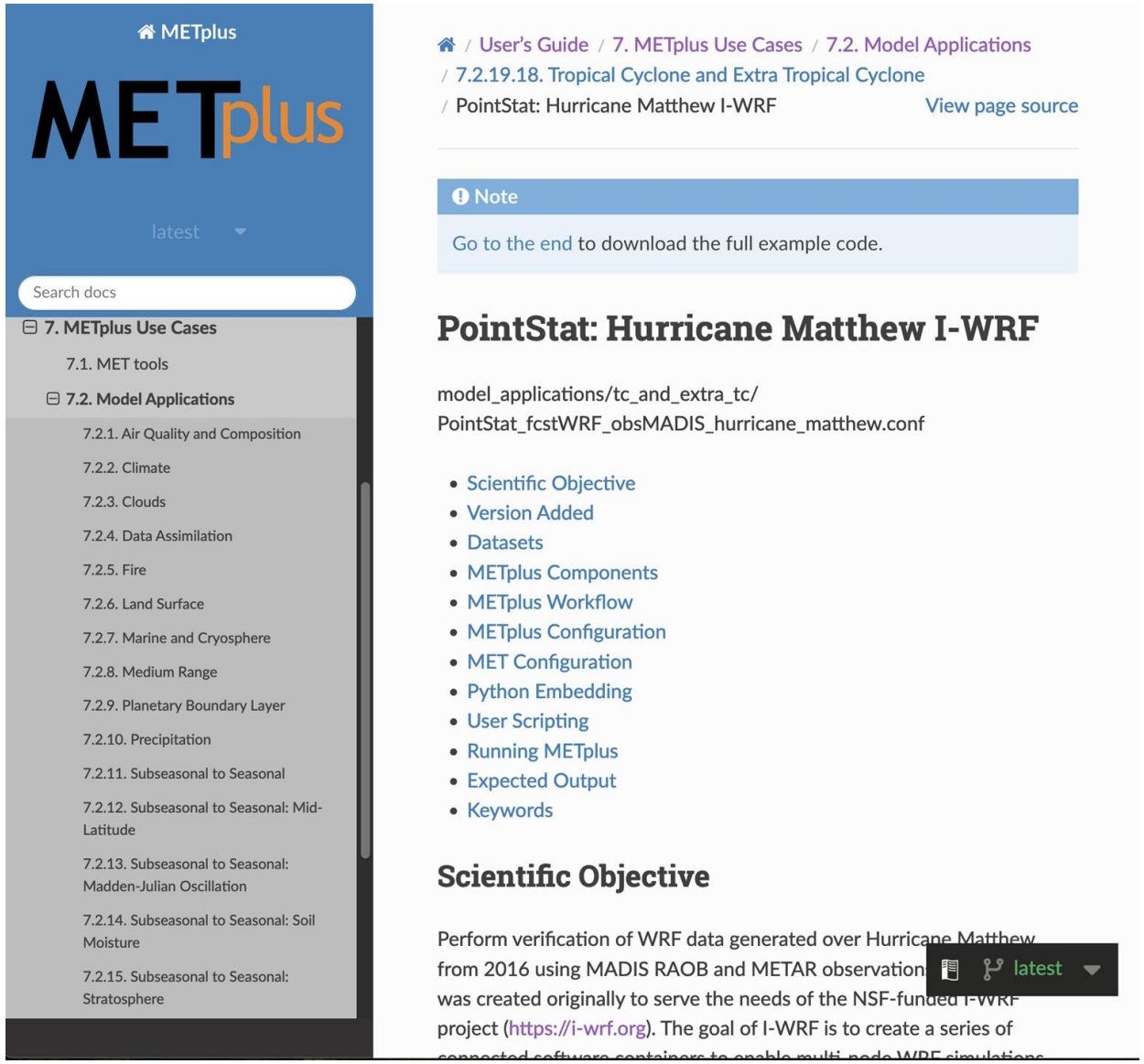

I-WRF GitHub Project Board – Demo

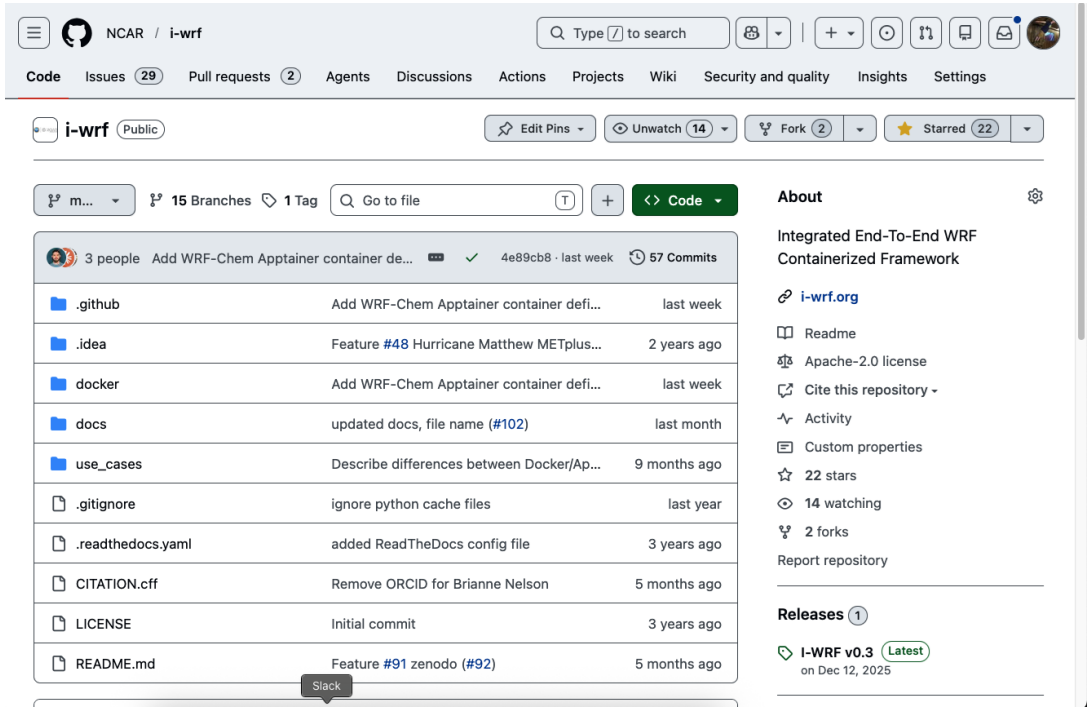
METplus Use Case

- METplus portion of the I-WRF Hurricane Matthew use case was added to the METplus use cases
- Contributes example of reading WRF into MET that is useful to the community
- Increases visibility of I-WRF project



I-WRF Useful Links

- Run it yourself
  - Hurricane Matthew demo: https://i-wrf.readthedocs.io/en/latest/Users_Guide/use-cases/matthew.html
  - LULC demo: https://i-wrf.readthedocs.io/en/latest/Users_Guide/use-cases/lulc.html
- Overview website: https://i-wrf.org
- User's Guide: https://i-wrf.readthedocs.io
- Github: https://github.com/NCAR/i-wrf



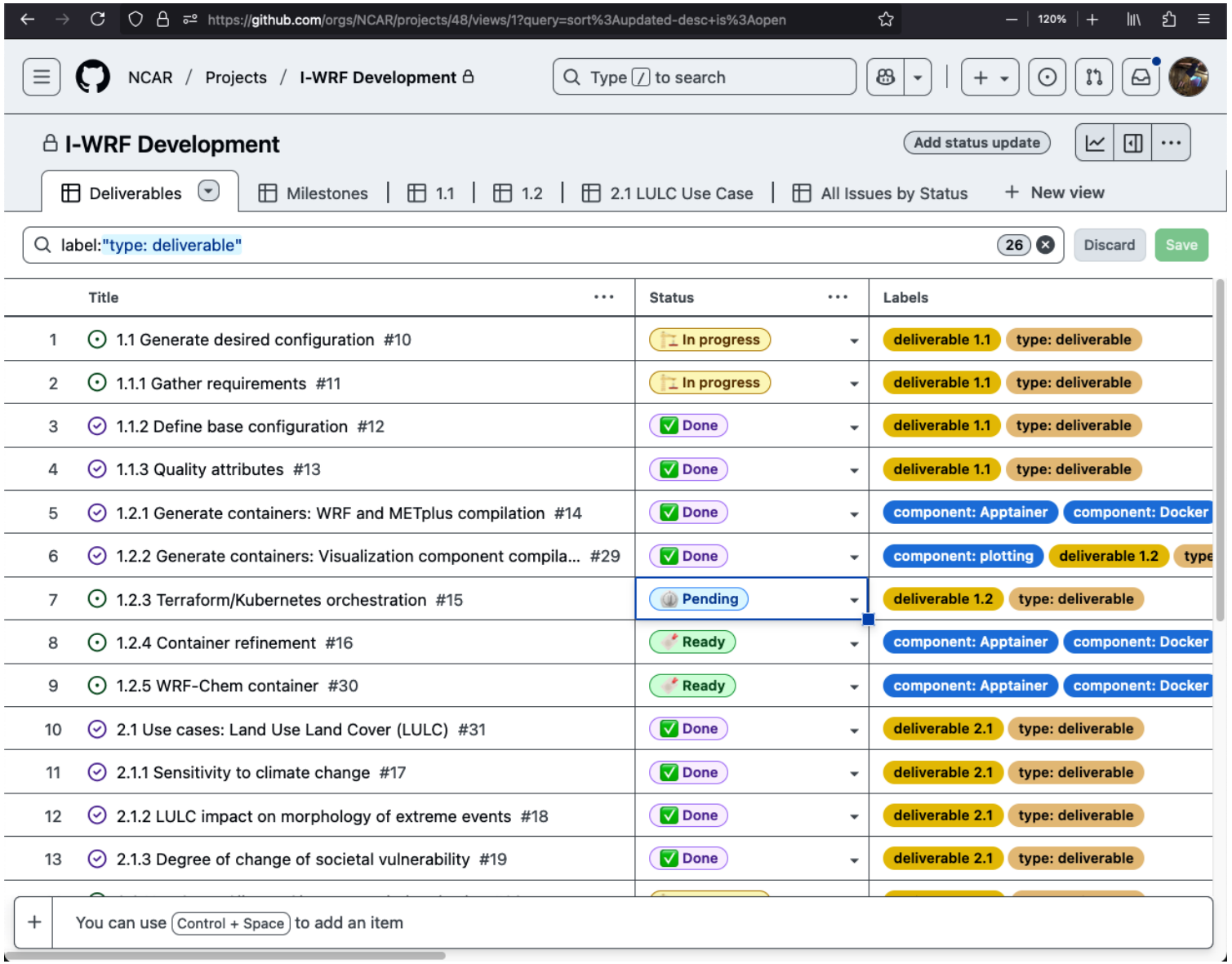
Github repository

Questions?

Supplemental material

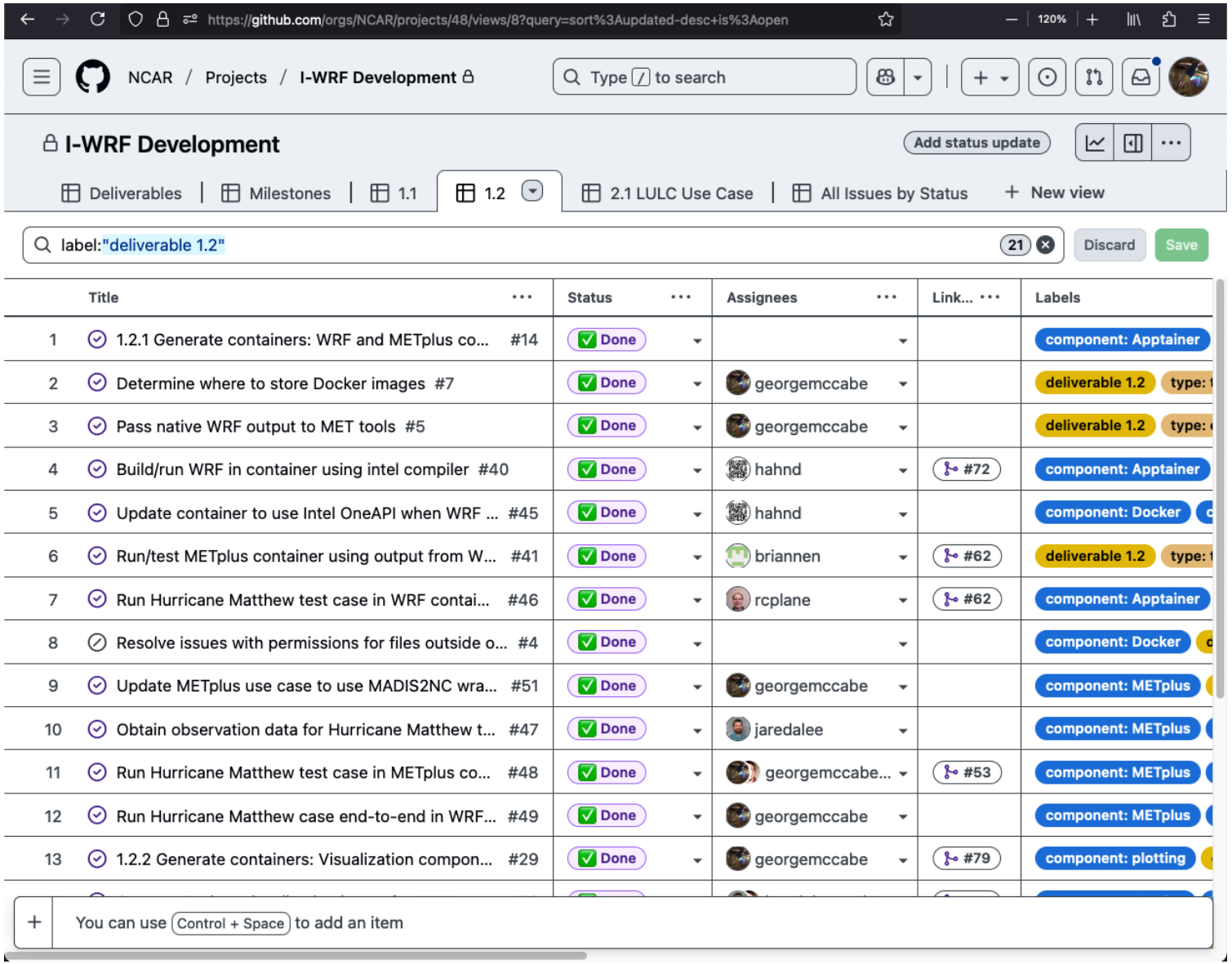
I-WRF GitHub Project Board – All Deliverables View

- Created an issue for each project deliverable
- Applied label type: deliverable to each issue
- Filtered issues with label type: deliverable



I-WRF GitHub Project Board – X.Y Deliverable View

- Created sub-issues for specific, assignable tasks
- Applied deliverable: X.Y label to related issues
- Quick view of status, assignee(s), relevant pull requests, labels, and other information

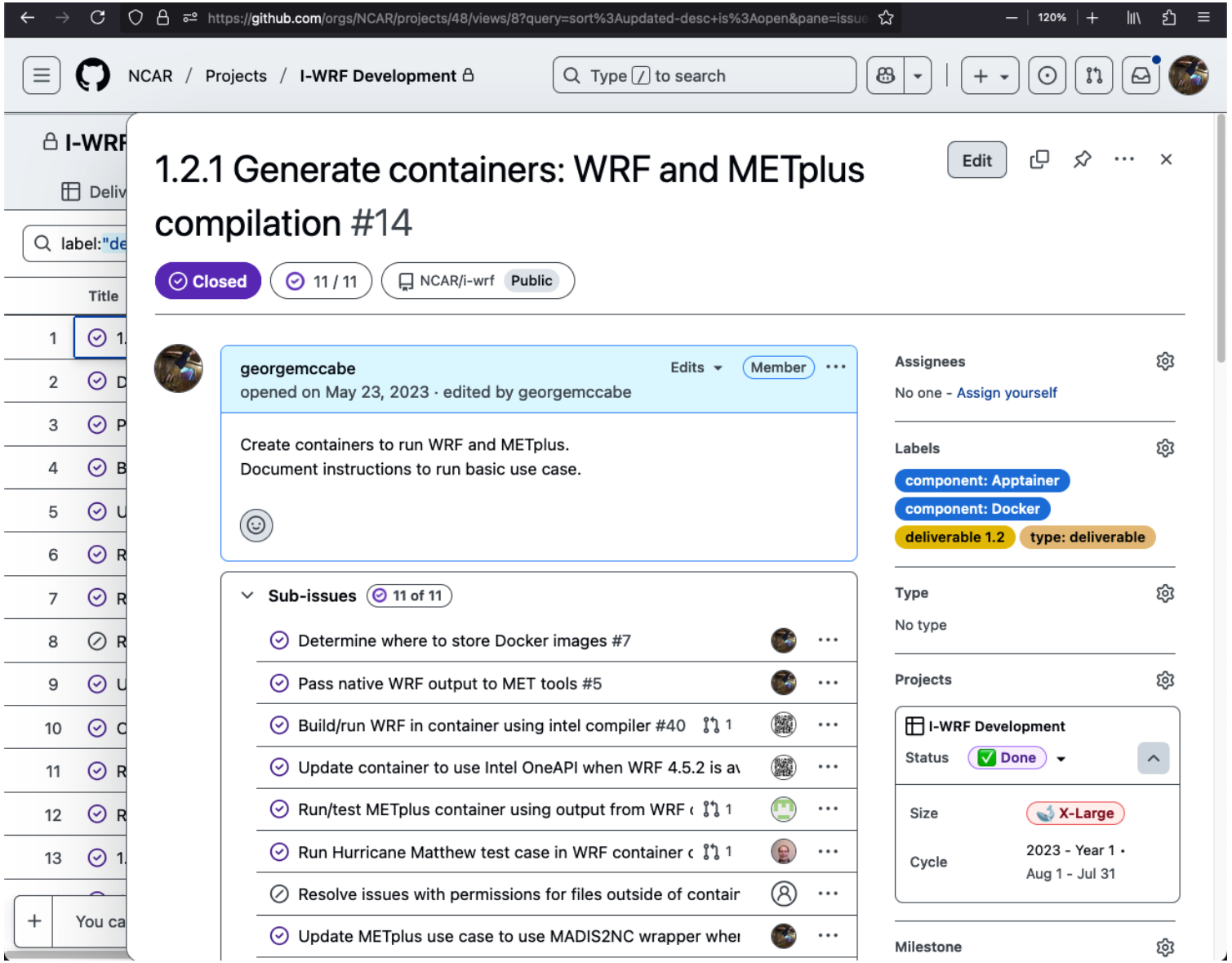


I-WRF GitHub Project Board – Deliverable Issue

1.2.1 Deliverable Issue:

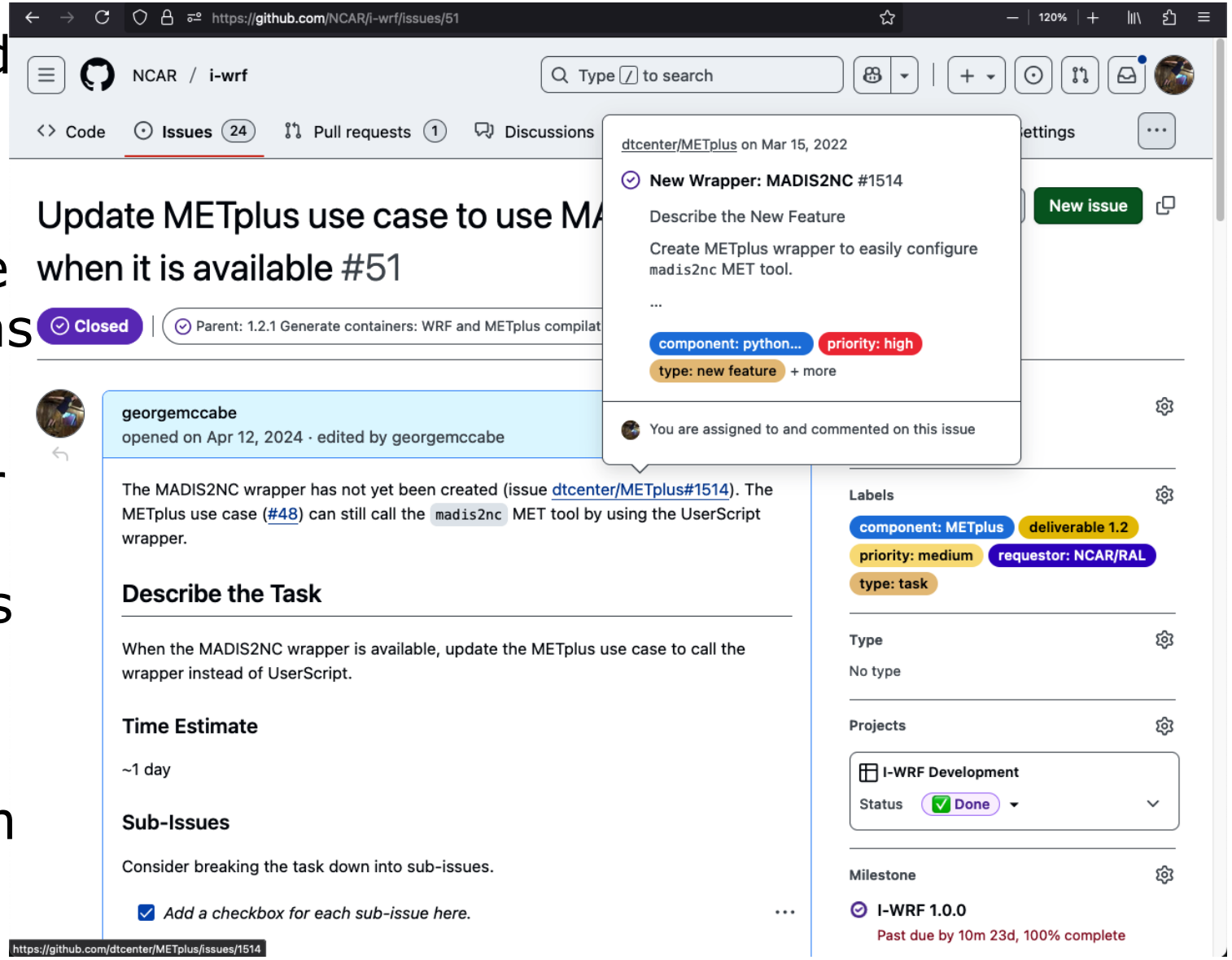
- Recently, GitHub added the ability to define issue "relationship" to officially relate parent and sub-issues

- Sub-issues can now be viewed from the parent issue



I-WRF GitHub Project Board – Sub-Issue

- Issue details are provided using an issue template
- Add comments to provide updates and ask questions
- Can include links to other I-WRF issues or issues from external repositories
- Status of external issue can be easily viewed from I-WRF issue by mousing over link



METplus Development

- MET was enhanced to support reading WRF output files directly without using a Python script

- An issue in the MET repository was created to track this work