IDEQ Air Quality
Machine Learning Forecast System
Version 3

NW-AIRQUEST 2023 Annual Meeting

06/20/2023

Idaho DEQ

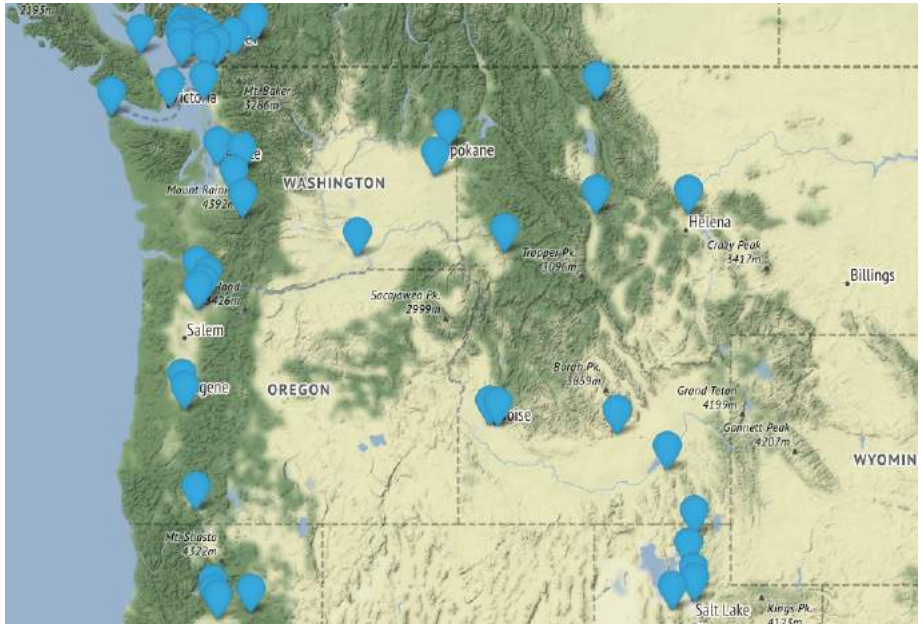
Acknowledgment

- David Ovens from University of Washington (UW) provided the extra met parameters we requested in the real time Meteorology Ensemble Models outputs

Overview of Forecast System

Spatial Coverage

O3 Sites (59, 5 in Idaho)

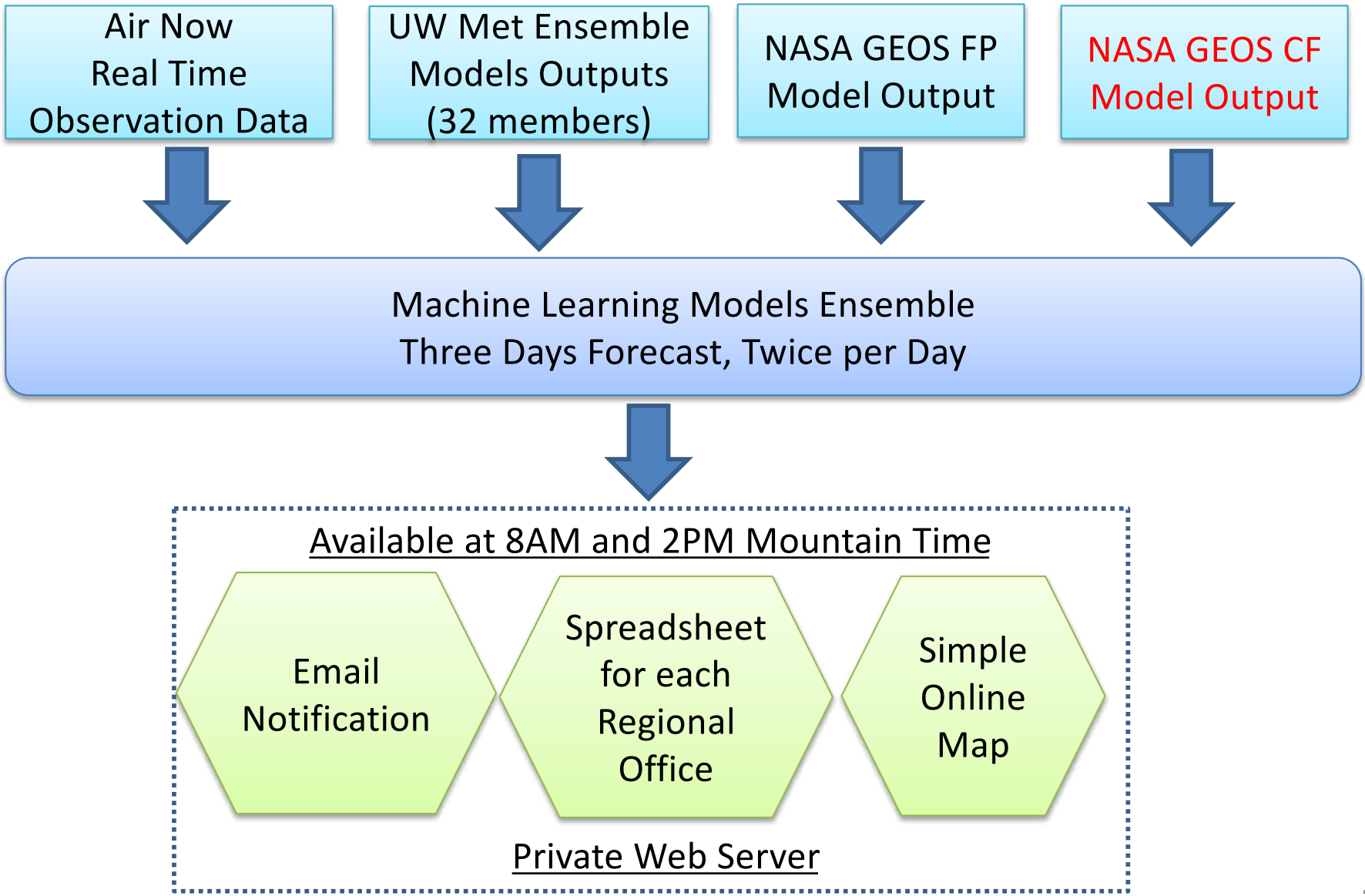


PM2.5 Sites (161, 32 in Idaho)

Site Selection Criteria: Having at least 3 years of data and continue to operate in the future

Overview of Forecast System

Data Process – In and Out



UW Meteorology Models

- Currently 32 ensemble members
- 4 km resolution except one is 1.3 km resolution
- Initialized at 00Z and 12Z
- Each forecasts 72 hours except production model forecasts 84 hours

- Time of arriving
  - 00Z forecast : ~09 - 12 MST
  - 12Z forecast : ~21 - 00 MST
- Utilization
  - Morning forecast : using previous day 12Z Met forecast (current day 00Z for production model)
  - Afternoon forecast : using current day 00Z Met forecast (current day 12Z for production model)

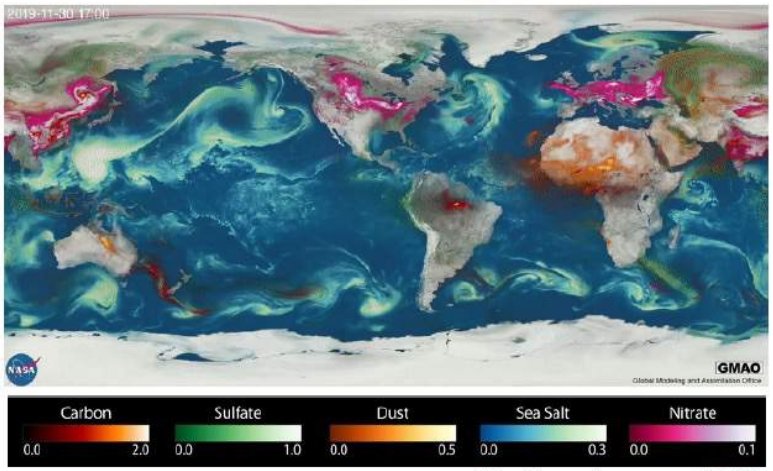
NASA GEOS-FP

GEOS FP

https://gmao.gsfc.nasa.gov/weather_prediction/

- GEOS FP analyses and forecasts support NASA field campaigns and provide a testbed for assimilation and forecast development
- Publicly available
- Includes weather, aerosols, and carbon monoxide (CO) on the same spatial scale
- State of the science forecast system – model physics or observing system updated every 6-12 months
  - Not suitable for trend analyses
- Meteorology used to drive chemistry models:
  - GEOSChem, Whole Atmosphere Community Climate Model (WACCM)
- When using FP meteorology fields to drive another model, must ensure your simulation does not span an update
  - GMAO NRT Product Page has updated details and dates

AOD (550 nm)



https://svs.gsfc.nasa.gov/31100

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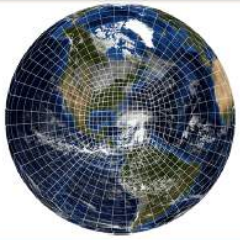
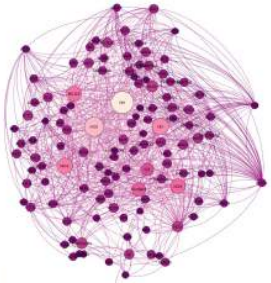
NASA GEOS-CF

NASA Composition Forecasts (GEOS-CF)

GEOS Meteorology



GEOS-Chem Chemistry



GEOS-CF

- GEOS-Chem: Global chemistry transport model driven by GEOS meteorology
- 1-day simulation of the previous day using the analysis from FP-IT
  - Uses a **replay** technique to force the meteorology towards the FP-IT analysis
  - FP-IT is a 'frozen' version of FP used for satellite retrievals, similar to the version used to make MERRA-2.
- 5-day forecast
- Two aerosol schemes:
  - GOCART – Radiatively coupled to AGCM
  - GEOS-Chem – No feedbacks to model physics
- Full description in Keller et al., 2021

ARSET - Introduction and Access to Global Air Quality Forecasting Data and Tools | NASA Applied Science

NASA Goddard Earth Observing System (GEOS) modeling and data assimilation systems

GEOS Output Quick Guide

	GEOS FP	GEOS-CF	MERRA-2
Type	Analysis + Forecast	Replay + Forecast	Reanalysis
Domain	Global	Global	Global
Spatial Resolution	Simulation: ~12 km Output: ~25 km (0.25°x0.312°)	~25 km (0.25°x0.312°)	~50km (0.5°x0.625°)
Temporal Resolution	2-D data: Hourly 3-D data: Every 3 h	15 min, Hourly	Hourly, Daily, Monthly
Vertical Levels	72 (near surface-0.1 hPa)	72 (near surface-0.1 hPa)	72 (near surface-0.1 hPa)
Output available	Analysis: 2014 – Present Forecast: ~20 days	Replay: 2018 – Present Forecast: 2019 – Present (aqc collection) ~14 days (all collections)	1980-Present
Initialization	Daily 10-day forecast at 00Z Daily 5-day forecast at 12Z	Daily 5-day forecast at 12Z	~1-2 months behind real time
Data Assimilation	Yes	No	Yes
File Specification Doc	https://gmao.gsfc.nasa.gov/pubs/docs/Lucchesi1203.pdf *	https://gmao.gsfc.nasa.gov/pubs/docs/Knowland1204.pdf *	https://gmao.gsfc.nasa.gov/pubs/docs/Bosilovich785.pdf *

NASA's Applied Remote Sensing Training Program * Find most current File Specification at https://gmao.gsfc.nasa.gov/pubs/office_notes.php 43

ARSET - Introduction and Access to Global Air Quality Forecasting Data and Tools | NASA Applied Science

O3 and PM2.5 Forecast Inputs Used

- Previous 24th hour O3/PM2.5
- T, P, RH, PBLH, WS, WDIR
- Deep Stable Layer (DSL) related
  - (dsl, dsl3hravg, dsl6hravg, dsl24hravg, dsl24hrmin1hr, dsl24hrmin3hravg, dsl24hrmin6hravg)
- Cloud fractions
- O3/PM2.5 hourly_mean (grouped by Month, Weekday/end, Hour)
- GOES FP PM2.5 Species: Dust, Organic Carbon, etc.
- GOES CF O3 and PM2.5
- Month (1-12), Weekday (0-1), Hour (0-23)

O3 and PM2.5 Forecast
Machine Learning Models Used

Neural Network Models

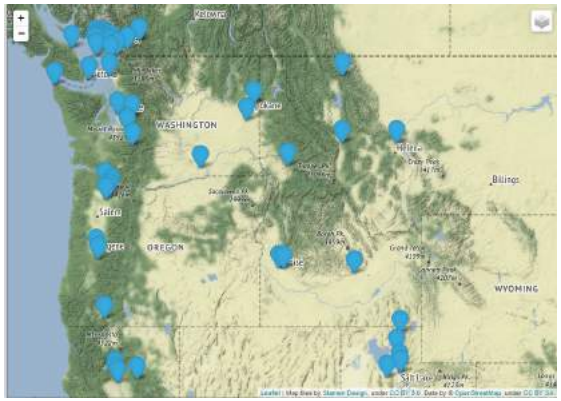
- Dense Neural Network Model
- 1D Convolutional Neural Network Model
- Recurrent Neural Network (LSTM)

Decision Tree Based Models

- Gradient Boosting
- Random Forest
- Boosted Random Forest

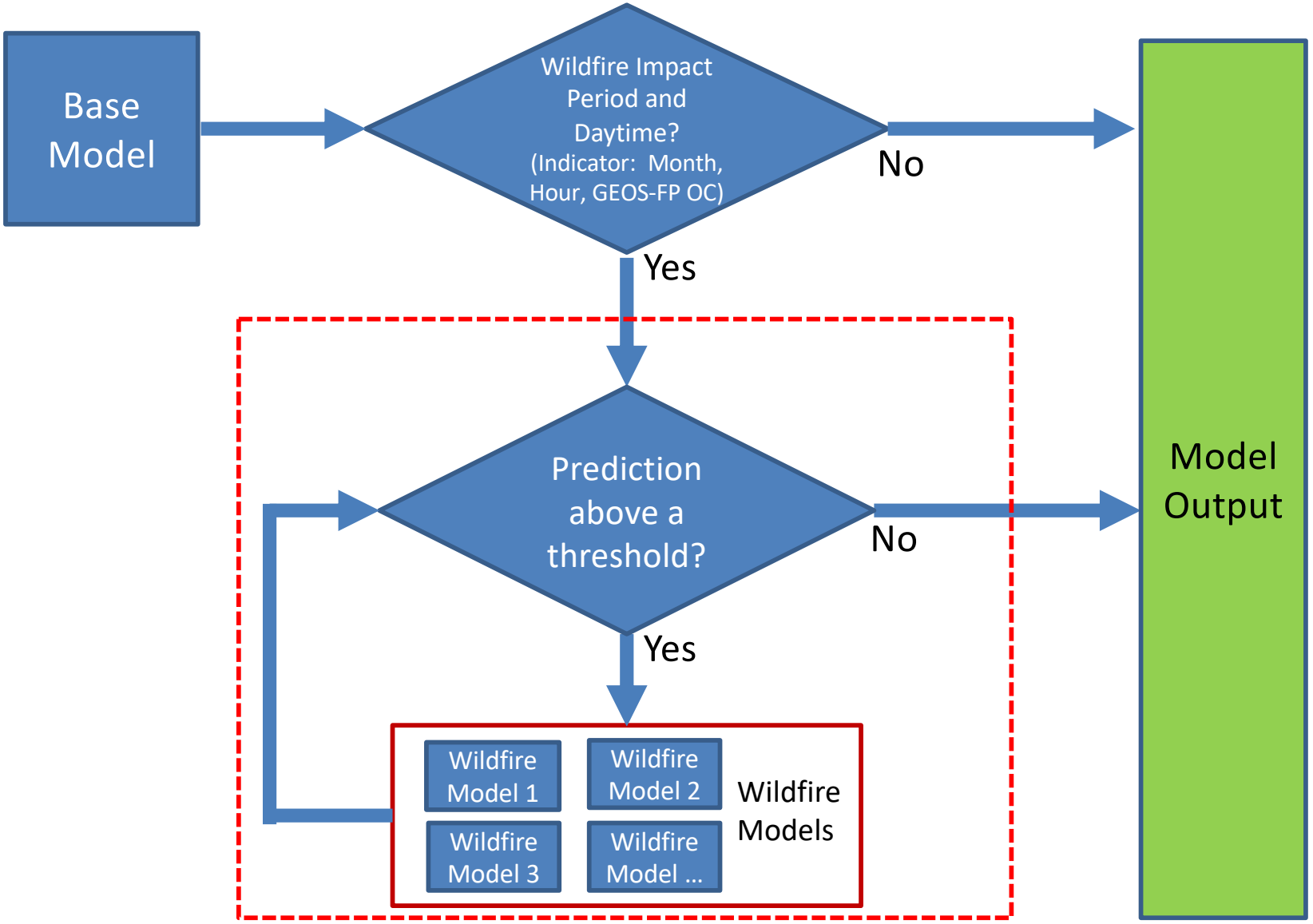
Baseline Model : Persistence

Wildfire Machine Learning Models



- Combine all sites together
  - Get adequate data set to train models
- Introduce site characteristic inputs
  - Elevation, Solar irradiance, Population, Land Use, Terrain Feature
- Limit to wildfire impact period and daytime
- Build models for different concentration ranges
  - Lessen Data imbalance issue
- Combine base model and wildfire models in an escalating fashion

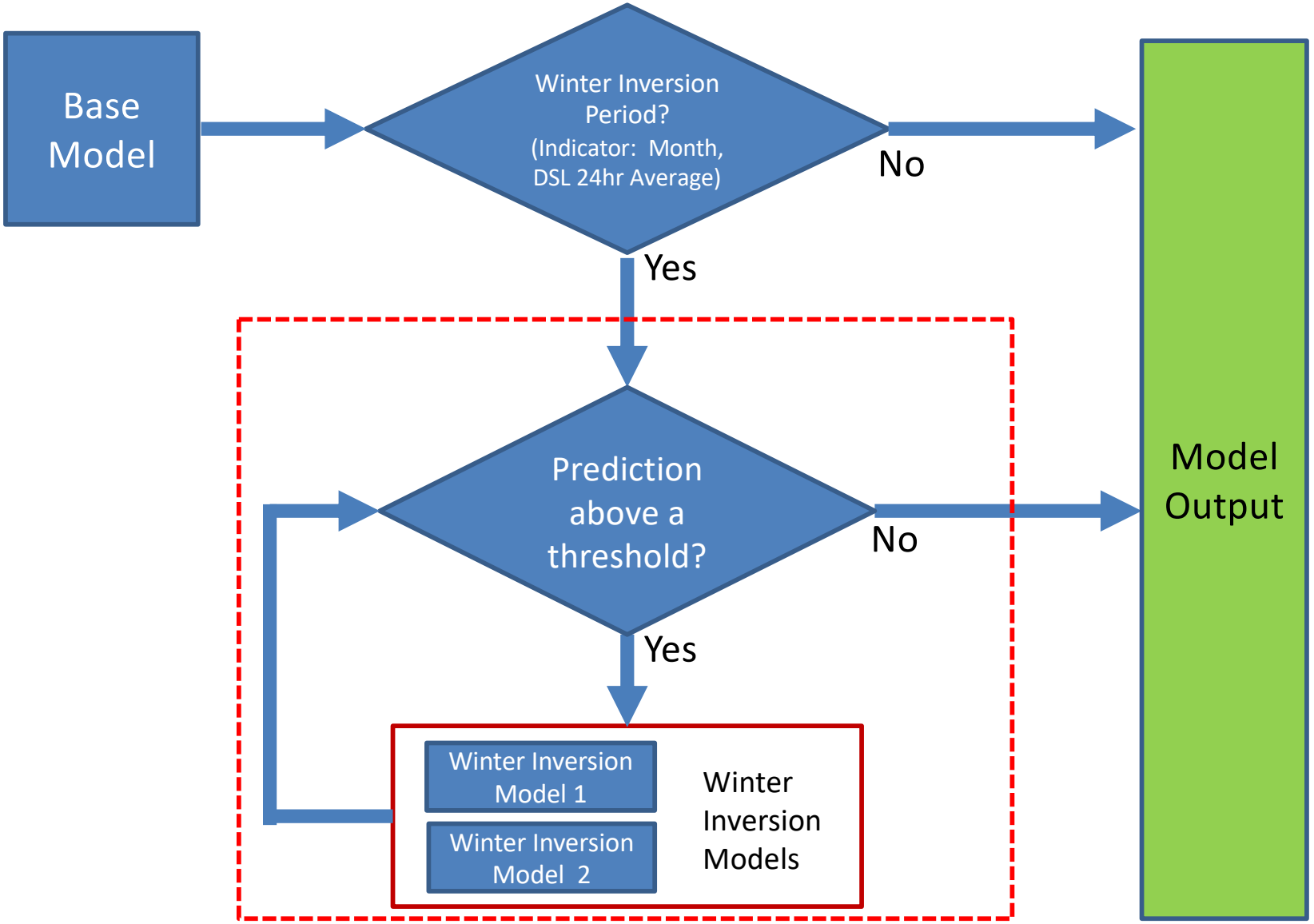
Enhanced Model Flow for Wildfire Season



Winter Inversion Machine Learning Models

- Combine all sites together
  - Get adequate data set to train models
- Introduce site characteristic inputs
  - Elevation, Solar irradiance, Population, Land Use, Terrain Feature
- Limit to winter inversion impact period
- Build models for different concentration ranges
  - Lessen Data imbalance issue
- Combine base model and winter inversion models in an escalating fashion

Enhanced Model Flow for Winter Season

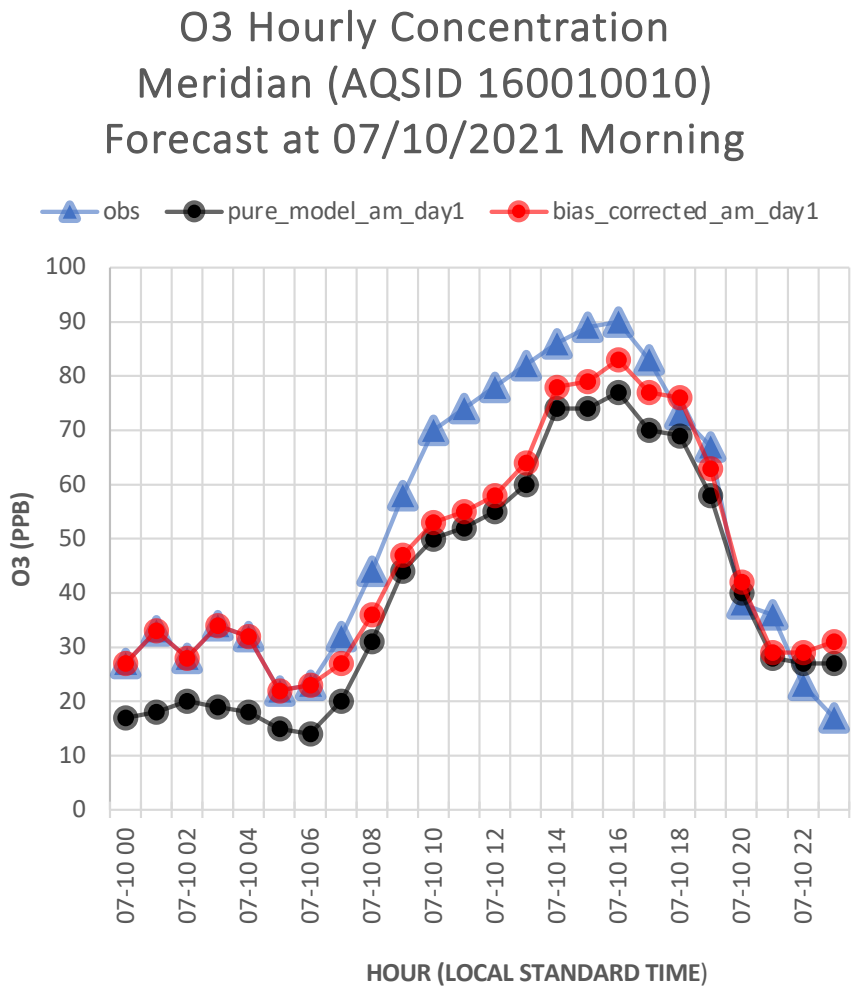


Ensemble

- Three layers of Ensemble
- Ensemble already employed in some Machine Learning Models, such as random forest
- Ensemble of Machine Learning Models:
  - Produce the final model output from multiple machine learning models for one set of input data
- Ensemble of Meteorology Models
  - The distribution of prediction

Bias Correction for Day 1

- Replace prediction with known observation
- Apply bias correction to directly following several hours based on known bias of previous 3 hours
- Apply bias correction for the rest hours based on previous day's 3-hour window hourly bias



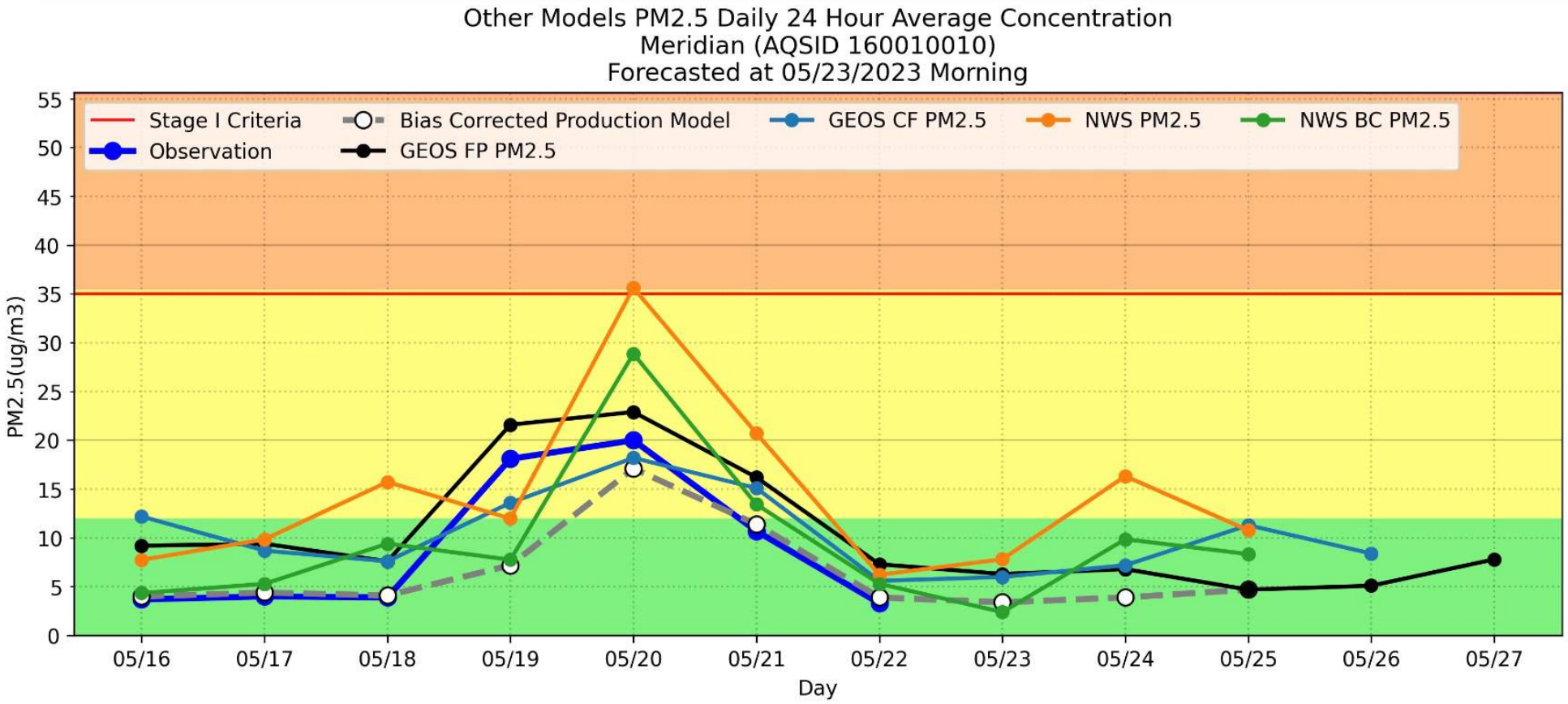
NWS Air Quality Guidance

- Community Multiscale Air Quality (CMAQ) model
- Driven by the NCEP Global Forecast System meteorological model (GFS)
- 12 km resolution
- Forecast 72 hours
- Model prediction and bias corrected

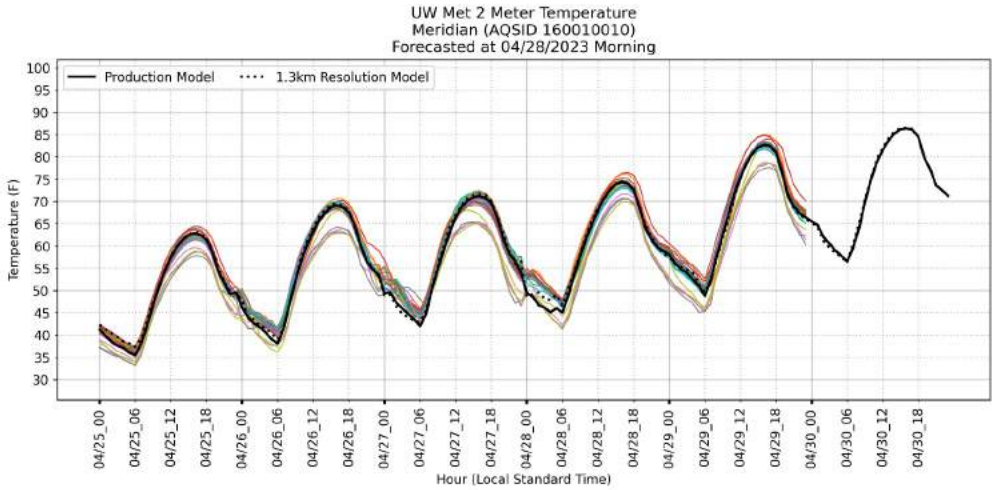
https://digital.mdl.nws.noaa.gov/airquality/?element=ozone01_bc&mapcenter=-96.00%2C40.00&mapzoom=5&subregion=CONUS&region=CONUS

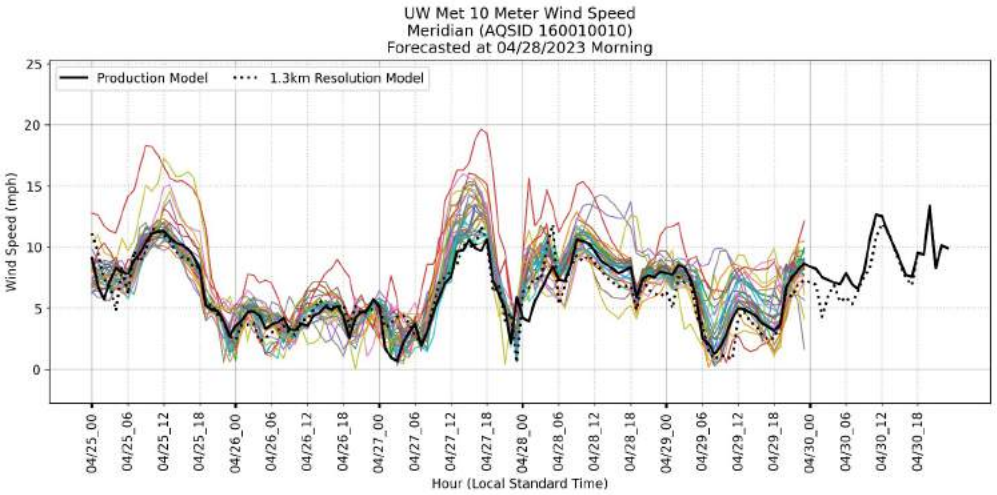
Display Outputs from Other Models

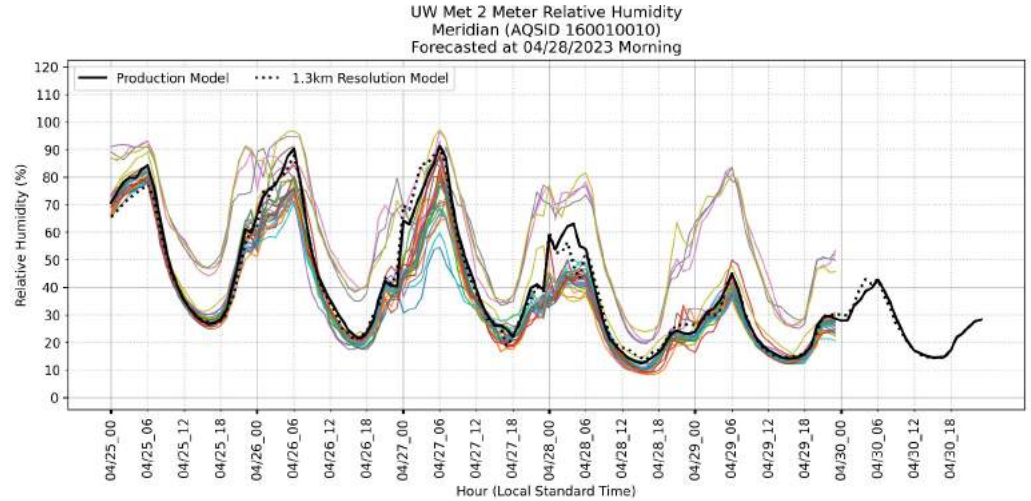
- GEOS FP
- GEOS CF
- NWS
  - NWS air quality guidance
- NWS BC
  - Bias corrected NWS air quality guidance

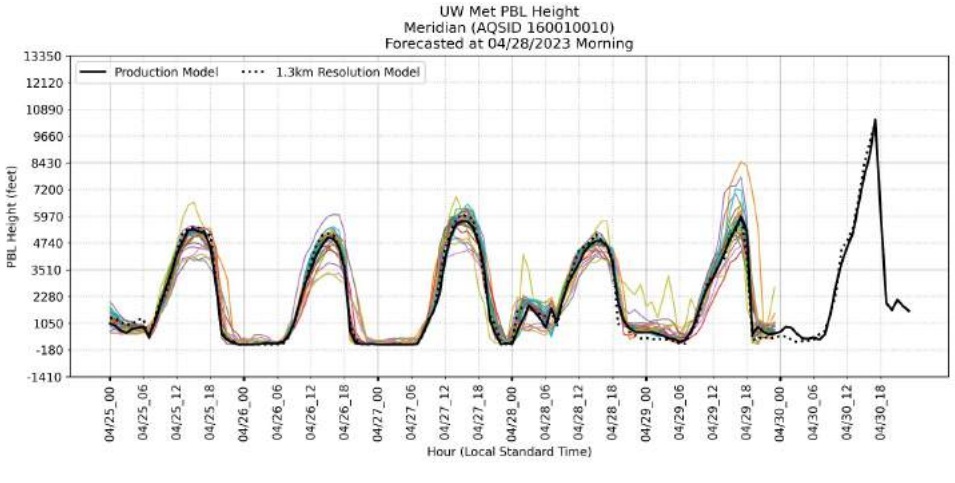


Display Meteorology parameters from Ensembles







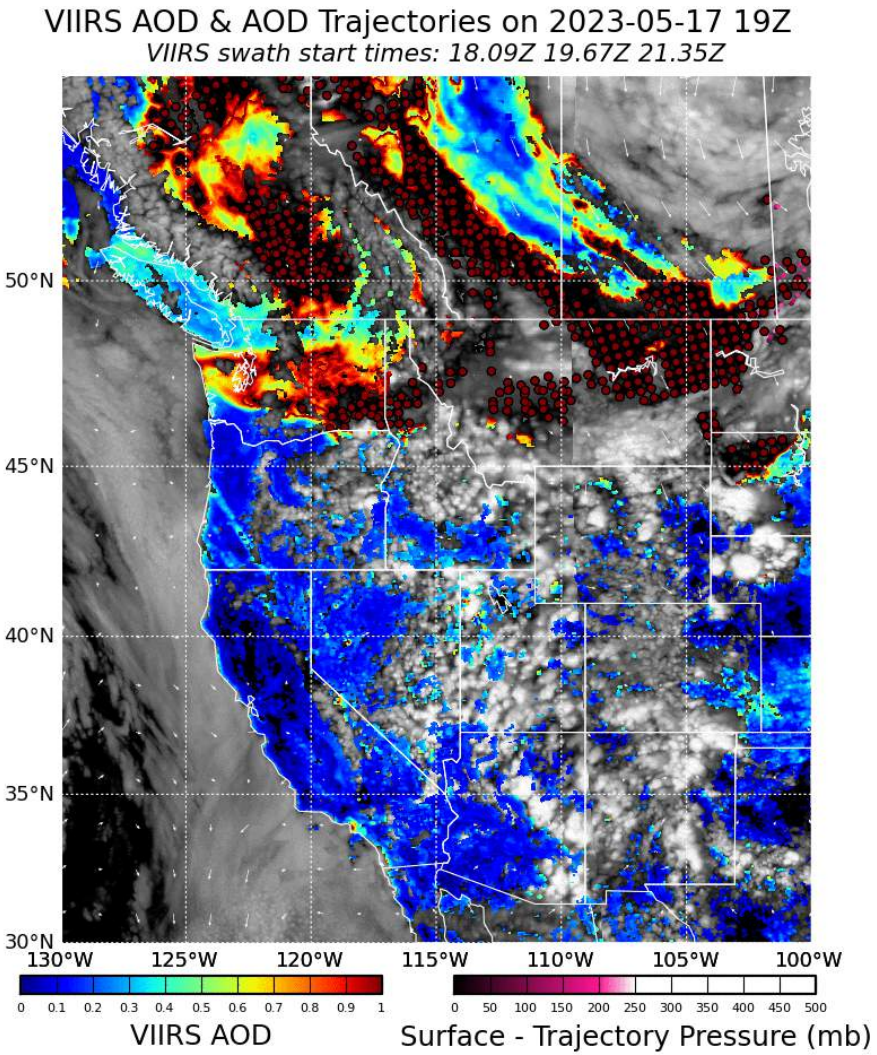


IDEA-I

- Stands for Infusing satellite Data into Environmental Applications – International
- Process:
  - Uses either Terra or Aqua MODIS Aerosol Optical Depth (AOD) and/or SNPP or JPSS VIIRS AOD to identify local regions of high aerosol loading from which trajectories are initialized
  - A trajectory model is then run which provides a forecast of the horizontal and vertical movement of the aerosols over the next 48 hours

- Initialized with yesterday's satellite AOD products
  - Aqua : NASA scientific research satellite
  - Terra : multi-national, NASA scientific research satellite
  - JPSS : Joint Polar Satellite System (NOAA-20)
  - SNPP : The Suomi National Polar-orbiting Partnership
- Driven by the NCEP Global Forecast System meteorological model (GFS)
- Cover 48 hours (today and tomorrow)

IDEA-I : JSPP
Shown on 05/18/2023



- Background image: AOD at initialization time
- Moving part : forwarding trajectories
  - Scale : surface pressure minus trajectory pressure
  - Darker is closer to surface

Summary of Improvements and New features

New meteorology parameters

- Deep Stable Layer (DSL) and cloud fractions

GEOS CF output

Winter inversion machine learning models

Display other air quality forecast model outputs

- GEOS FP
- GEOS CF
- NWS AQ, and bias correction NWS AQ

Display ensemble meteorology parameters

Display IDEA-I output

System stability

- Backup models without GEOS CF output

Model Performance
at
St. Lukes Meridian
for
O3 Models in Year 2022

St. Lukes Meridian O3 Site
Year 2022 Daily Regression Performance Metrics

Version 2 (Old)

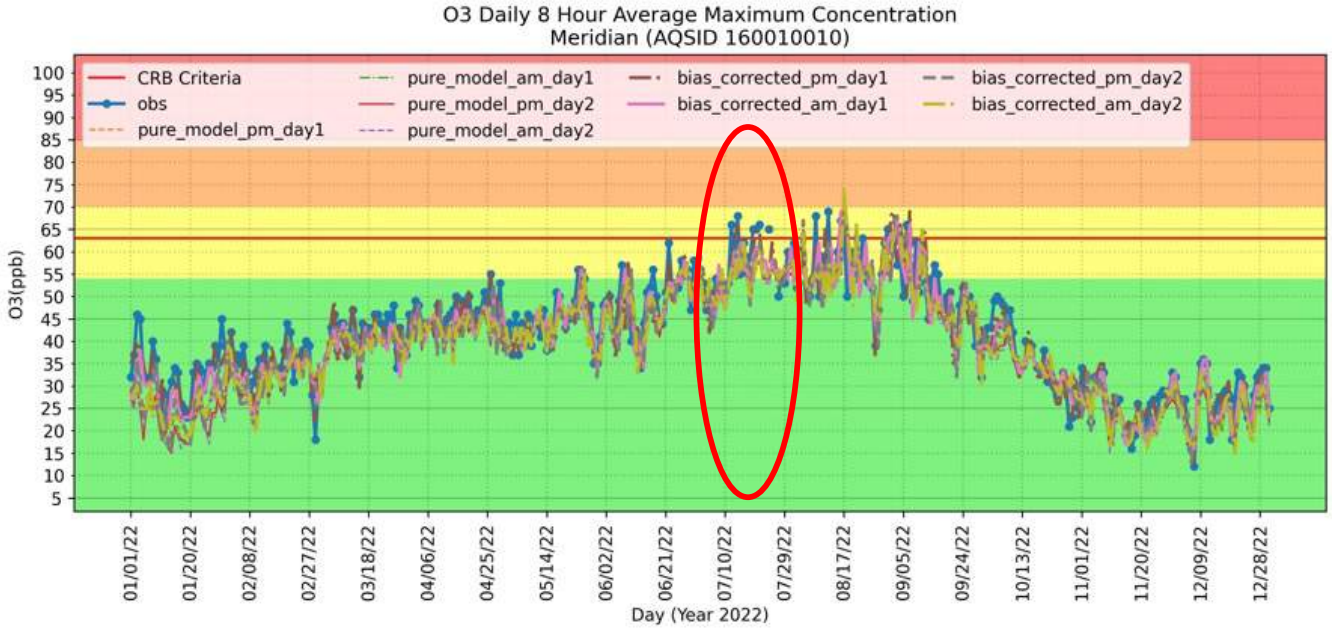
St. Lukes Meridian (AQSID 160010010)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	18	4.7	36.64	0	0.11	0.74	6.05
pure_model_am_day2	22	5.06	41.76	-0.08	0.12	0.7	6.46
pure_model_pm_day2	21	4.86	38.51	-0.07	0.12	0.72	6.21
pure_model_am_day1	20	4.87	38.53	-0.08	0.12	0.72	6.21
pure_model_pm_day1	20	4.85	37.92	-0.08	0.12	0.73	6.16
bias_corrected_am_day2	20	4.64	34.85	-0.06	0.11	0.75	5.9
bias_corrected_pm_day2	18	4.63	33.76	-0.06	0.11	0.76	5.81
bias_corrected_am_day1	16	3.99	26.93	-0.04	0.09	0.81	5.19
bias_corrected_pm_day1	16	2.76	14.85	-0.02	0.07	0.89	3.85

Version 3 (New)

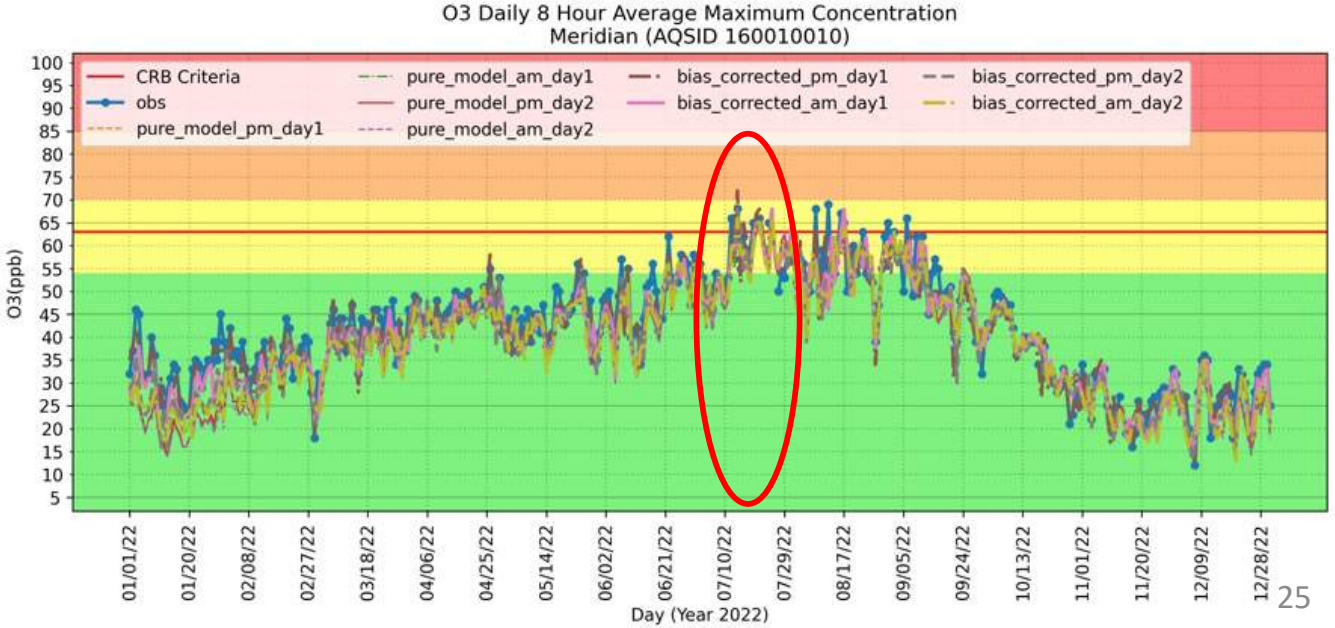
St. Lukes Meridian (AQSID 160010010)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	18	4.73	36.75	0	0.11	0.74	6.06
pure_model_am_day2	22	5.32	44.97	-0.09	0.13	0.68	6.71
pure_model_pm_day2	21	5.07	40.95	-0.09	0.12	0.71	6.4
pure_model_am_day1	22	5.1	40.81	-0.09	0.12	0.71	6.39
pure_model_pm_day1	22	5.04	40.07	-0.09	0.12	0.71	6.33
bias_corrected_am_day2	20	4.7	35.05	-0.08	0.11	0.75	5.92
bias_corrected_pm_day2	15	4.42	30.88	-0.07	0.11	0.78	5.56
bias_corrected_am_day1	23	3.7	23.67	-0.05	0.09	0.83	4.87
bias_corrected_pm_day1	13	2.49	11.48	-0.03	0.06	0.92	3.39

St. Lukes Meridian O3 Site
Year 2022 Time Series

Version 2 (Old)



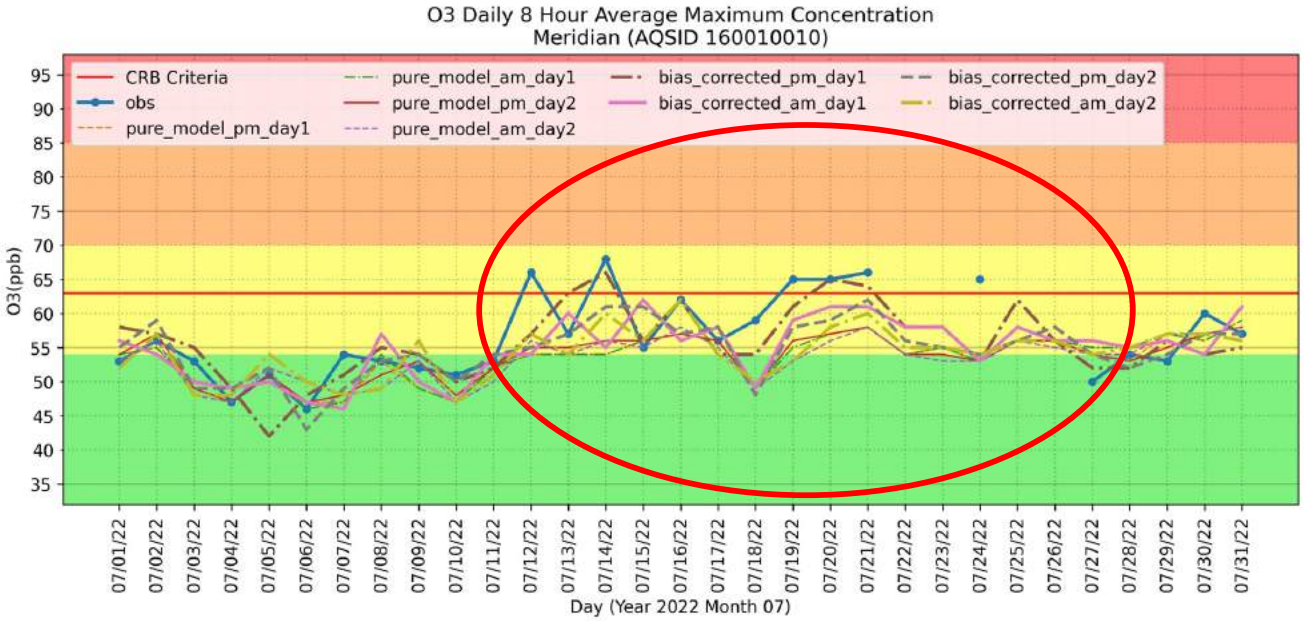
Version 3 (New)



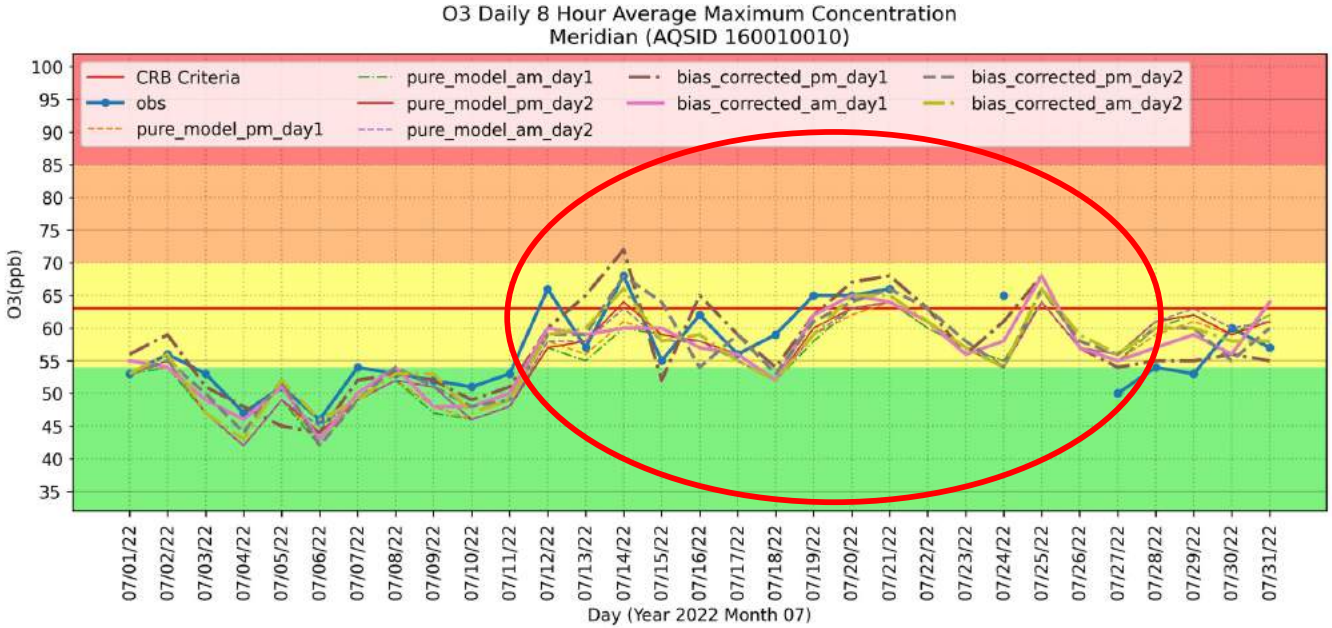
St. Lukes Meridian O3 Site

July 2022 Time Series

Version 2 (Old)



Version 3 (New)



Model Performance
at
St. Lukes Meridian
for
PM2.5 Models in Year 2022

St. Lukes Meridian PM2.5 Site
Year 2022 Daily Regression Performance Metrics

Version 2 (Old)

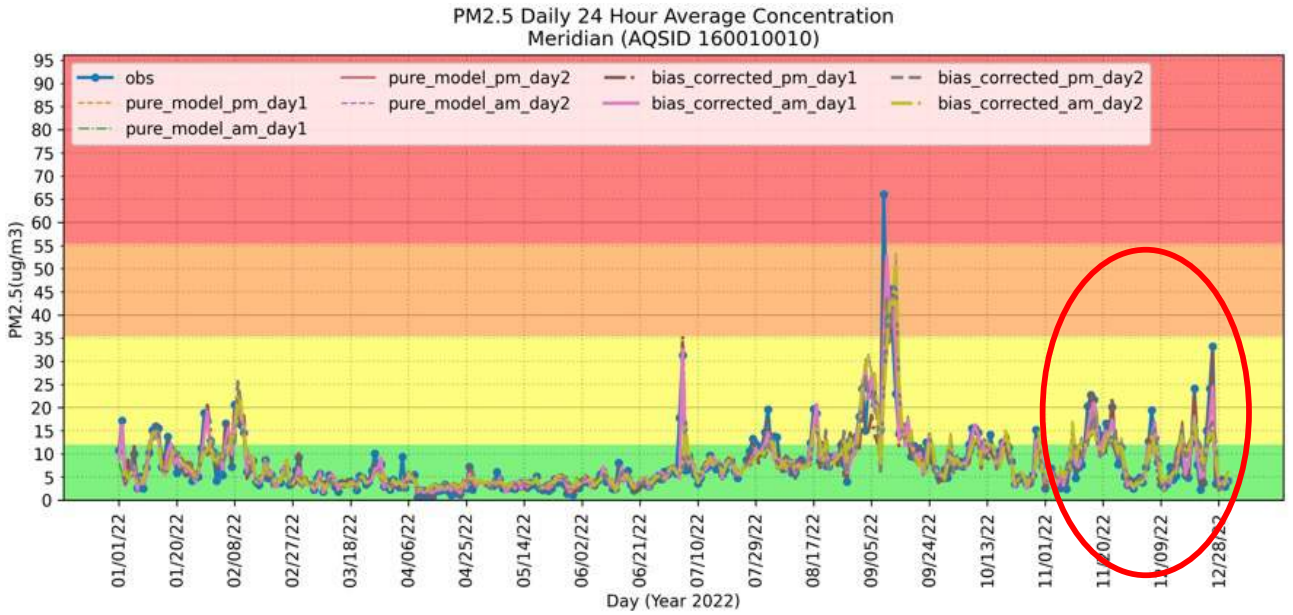
St. Lukes Meridian (AQSID 160010010)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	50.9	2.93	27.84	0	0.36	0.41	5.28
pure_model_am_day2	43.2	2.45	20.37	-0.01	0.3	0.57	4.51
pure_model_pm_day2	42.8	2.39	19.35	-0.01	0.29	0.59	4.4
pure_model_am_day1	40.9	2.26	16.59	-0.01	0.28	0.65	4.07
pure_model_pm_day1	44.1	2.23	16.5	-0.01	0.27	0.65	4.06
bias_corrected_am_day2	43.2	2.39	20.02	-0.02	0.29	0.58	4.47
bias_corrected_pm_day2	42.8	2.41	19.75	-0.03	0.3	0.59	4.44
bias_corrected_am_day1	32.4	1.55	8.66	-0.02	0.19	0.82	2.94
bias_corrected_pm_day1	15	1.16	4.03	-0.05	0.14	0.91	2.01

Version 3 (New)

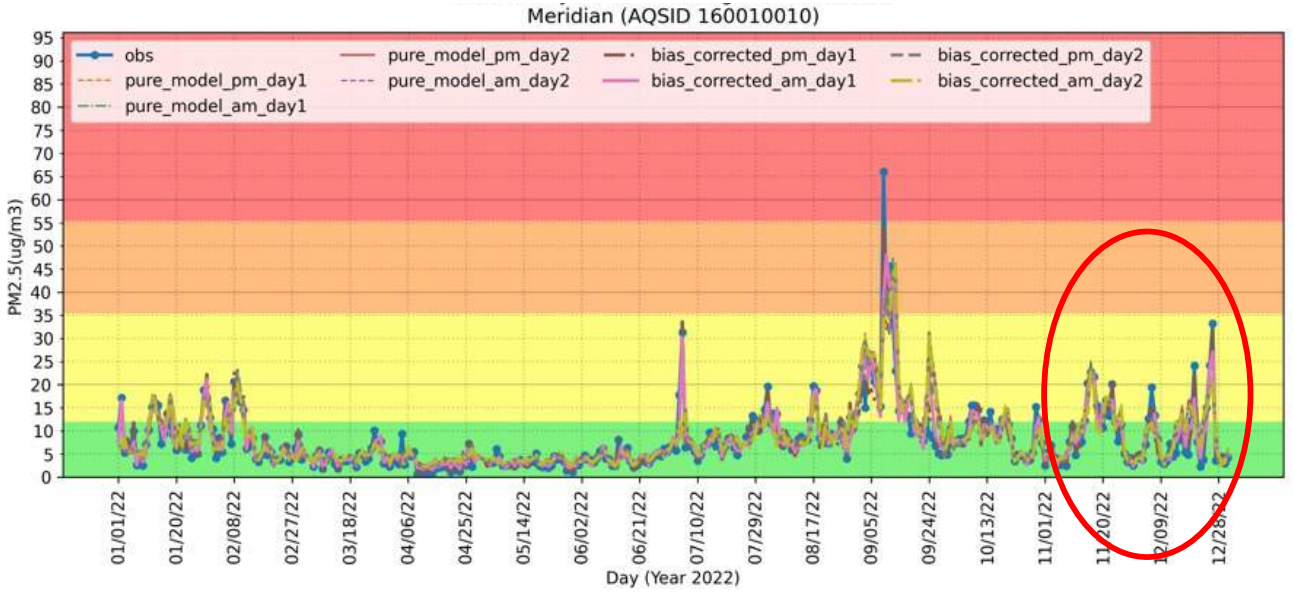
St. Lukes Meridian (AQSID 160010010)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	50.9	2.94	27.86	0	0.36	0.41	5.28
pure_model_am_day2	31.4	2.48	18.25	0.07	0.3	0.62	4.27
pure_model_pm_day2	31.3	2.43	17.55	0.06	0.3	0.63	4.19
pure_model_am_day1	33.5	2.28	15.79	0.05	0.28	0.67	3.97
pure_model_pm_day1	35	2.27	16.16	0.05	0.28	0.66	4.02
bias_corrected_am_day2	31.8	2.43	17.43	0.05	0.3	0.63	4.17
bias_corrected_pm_day2	32	2.39	16.85	0.04	0.29	0.65	4.11
bias_corrected_am_day1	27.8	1.52	7.44	0	0.19	0.84	2.73
bias_corrected_pm_day1	12.3	1.12	3.19	-0.01	0.14	0.93	1.79

St. Lukes Meridian PM2.5 Site
Year 2022 Time Series

Version 2 (Old)

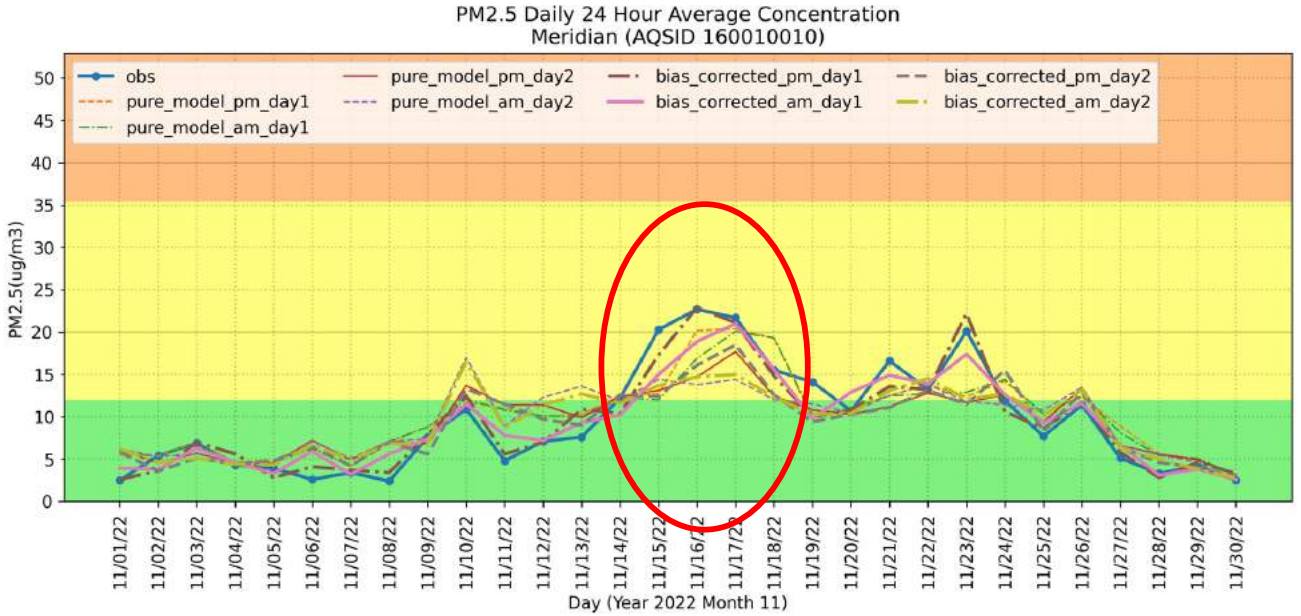


Version 3 (New)

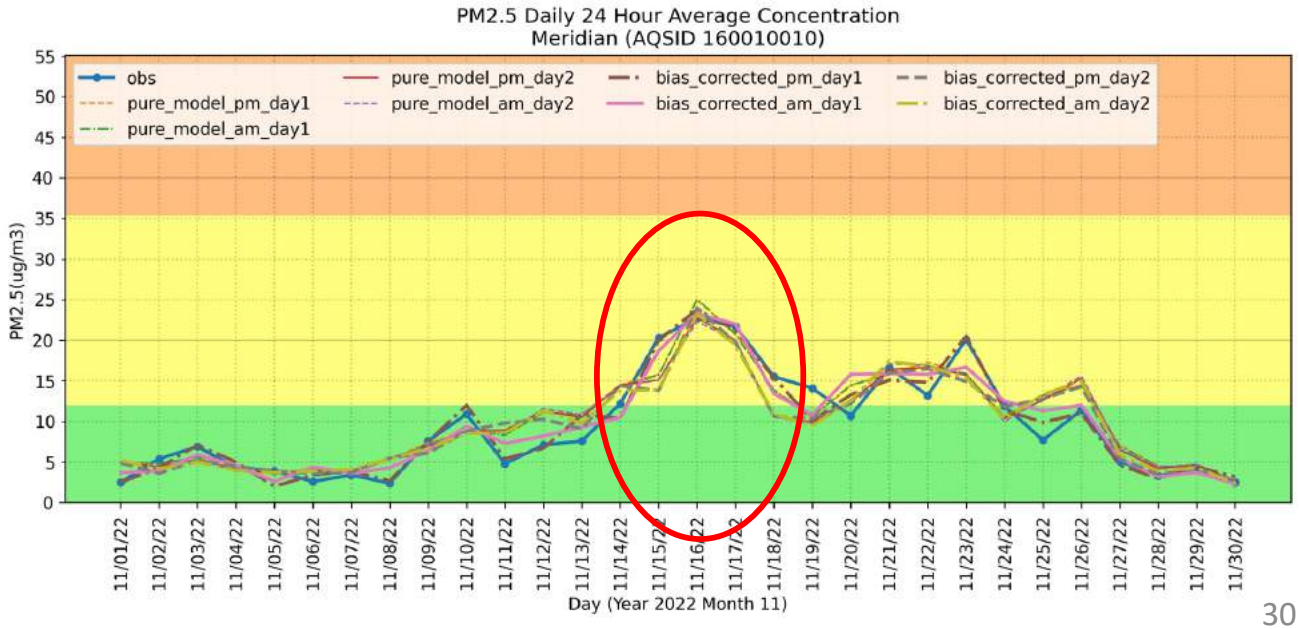


St. Lukes Meridian PM2.5 Site
November 2022 Time Series

Version 2 (Old)

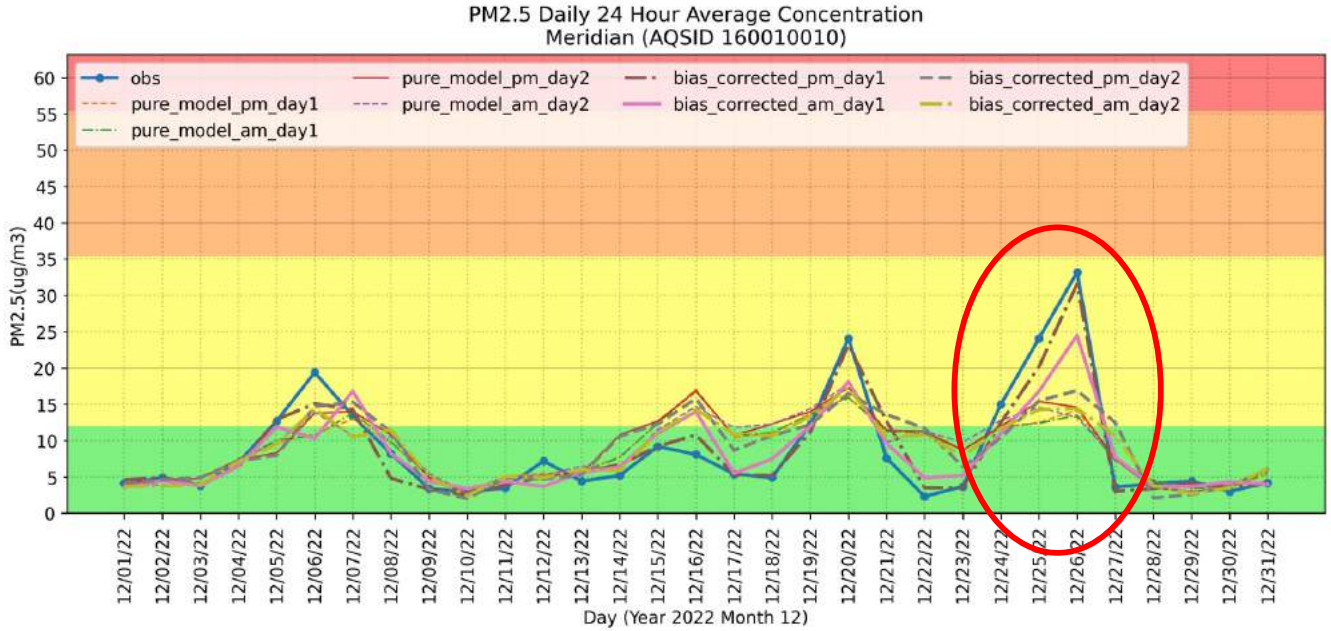


Version 3 (New)

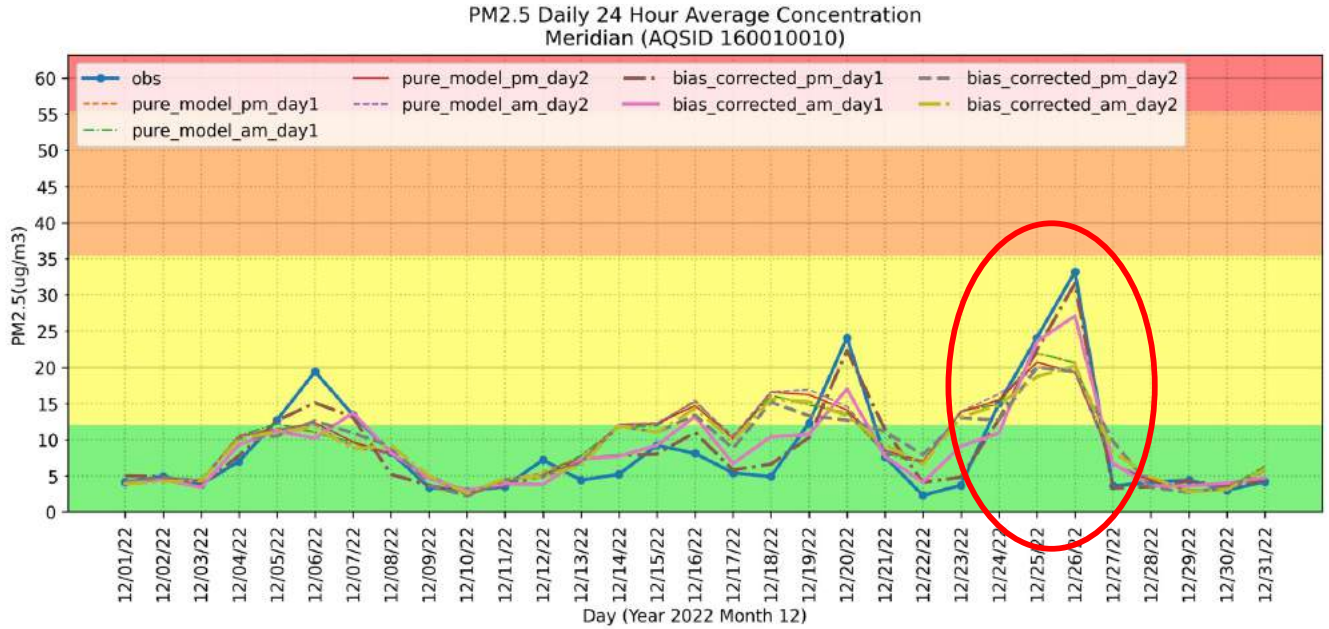


St. Lukes Meridian PM2.5 Site
December 2022 Time Series

Version 2 (Old)



Version 3 (New)



Model Performance
at
Nursery Rd. Coeur d'Alene
for
PM2.5 Models in Year 2022

Nursery Rd. Coeur d'Alene PM2.5 Site
Year 2022 Daily Regression Performance Metrics

Version 2 (Old)

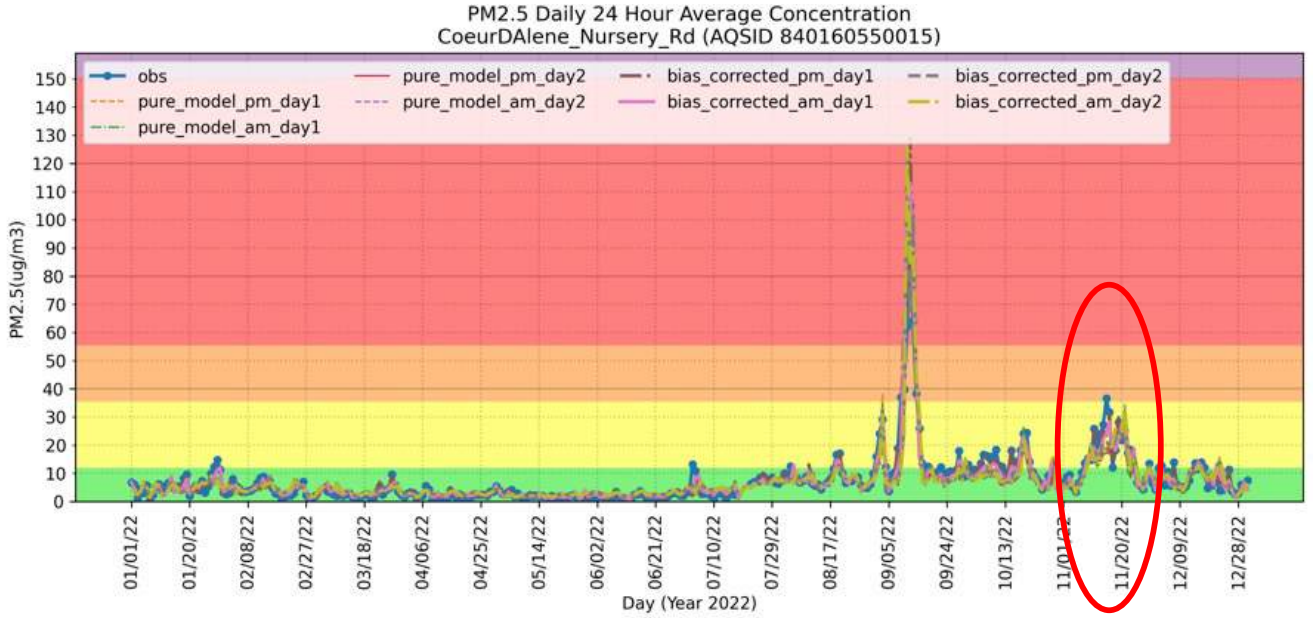
Nursery Rd. (AQSID 840160550015)							
Forecast	**max_error**	**mean_absolute_error**	**mean_squared_error**	**normalized_mean_bias**	**normalized_mean_error**	**r2_score**	**root_mean_squared_error**
persistence	42.7	2.61	25.7	0	0.35	0.71	5.07
pure_model_am_day2	61	2.82	29.03	-0.05	0.37	0.67	5.39
pure_model_pm_day2	59.4	2.79	29.38	-0.05	0.37	0.67	5.42
pure_model_am_day1	39.2	2.55	19.42	-0.04	0.34	0.78	4.41
pure_model_pm_day1	40.5	2.57	20.08	-0.05	0.34	0.77	4.48
bias_corrected_am_day2	64.5	2.72	28.75	-0.05	0.36	0.67	5.36
bias_corrected_pm_day2	64.8	2.64	31.62	-0.04	0.35	0.64	5.62
bias_corrected_am_day1	37.5	1.76	11.4	-0.03	0.23	0.87	3.38
bias_corrected_pm_day1	24.2	1.32	7.32	0	0.17	0.92	2.71

Version 3 (New)

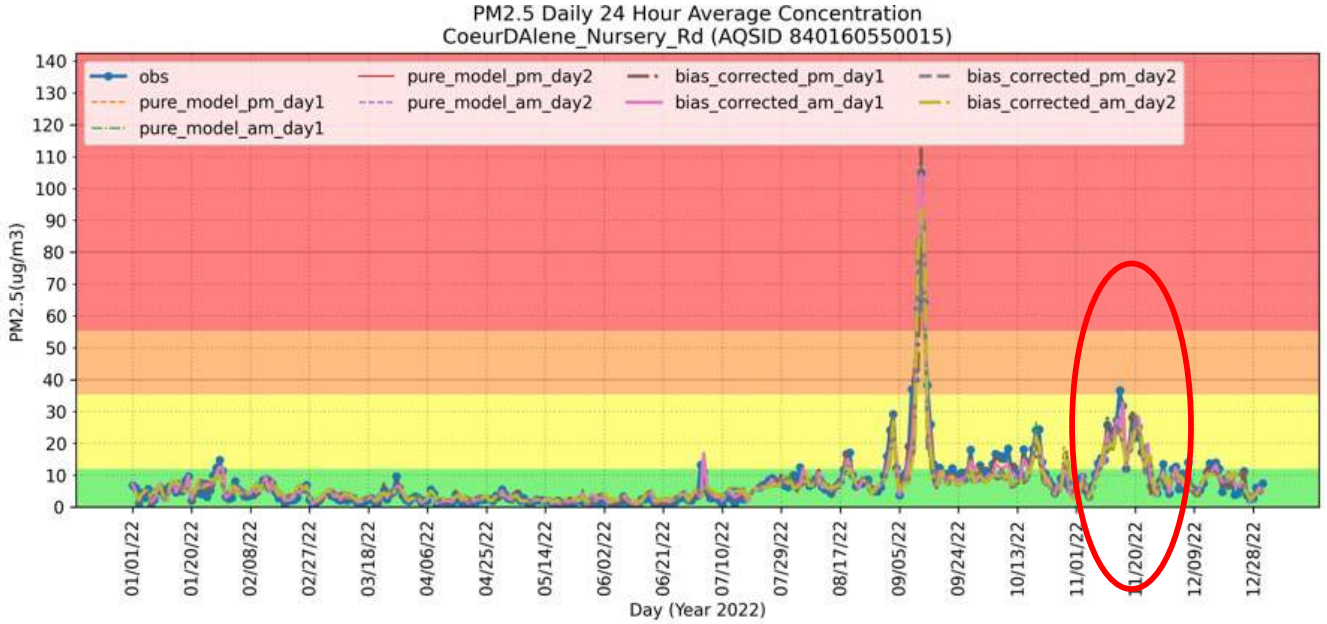
Nursery Rd. (AQSID 840160550015)							
Forecast	**max_error**	**mean_absolute_error**	**mean_squared_error**	**normalized_mean_bias**	**normalized_mean_error**	**r2_score**	**root_mean_squared_error**
persistence	42.7	2.61	25.65	0	0.34	0.71	5.06
pure_model_am_day2	24.9	2.49	15.29	-0.04	0.33	0.83	3.91
pure_model_pm_day2	33.4	2.56	18.46	-0.05	0.34	0.79	4.3
pure_model_am_day1	21.9	2.33	12.82	-0.03	0.31	0.85	3.58
pure_model_pm_day1	23.6	2.33	13.11	-0.03	0.31	0.85	3.62
bias_corrected_am_day2	23.1	2.35	14.13	-0.04	0.31	0.84	3.76
bias_corrected_pm_day2	42.8	2.39	19.76	-0.05	0.32	0.78	4.45
bias_corrected_am_day1	17.9	1.47	5.85	-0.02	0.19	0.93	2.42
bias_corrected_pm_day1	19.6	1.09	4.31	-0.02	0.14	0.95	2.08

Nursery Rd. Coeur d'Alene PM2.5 Site Year 2022 Time Series

Version 2 (Old)

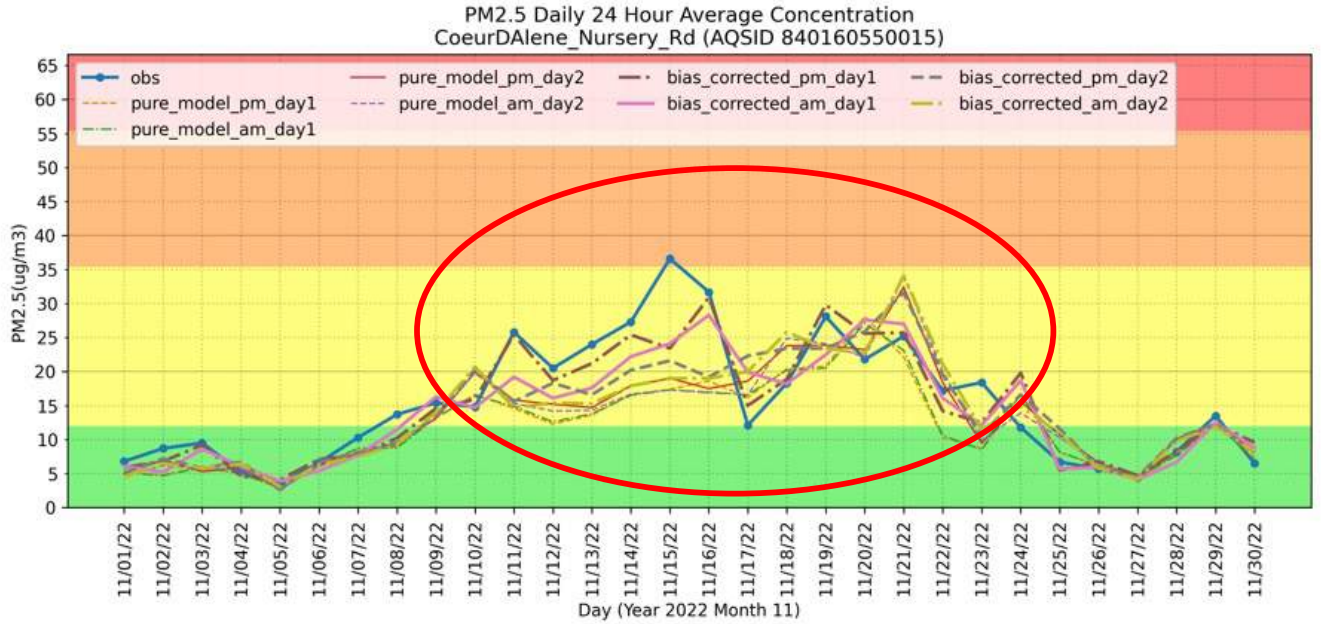


Version 3 (New)

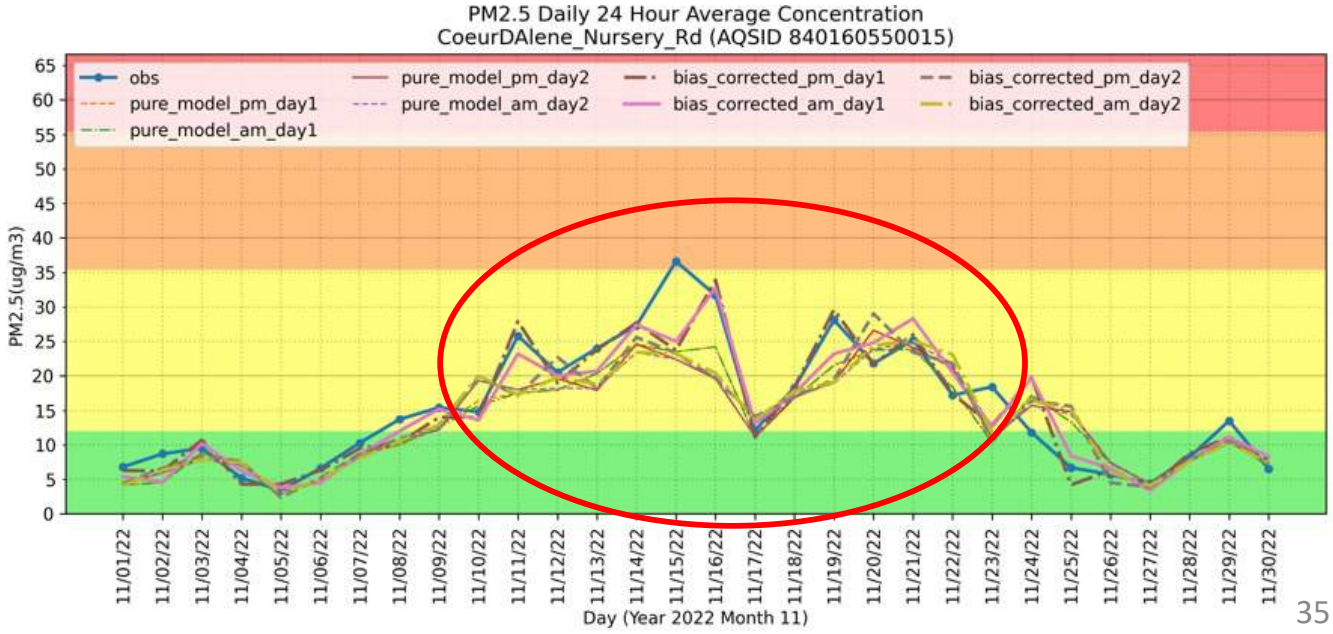


Nursery Rd. Coeur d'Alene PM2.5 Site November 2022 Time Series

Version 2 (Old)



Version 3 (New)



Model Performance
at
Salmon
for
PM2.5 Models in Year 2022

Salmon PM2.5 Site
Year 2022 Daily Regression Performance Metrics

Version 2 (Old)

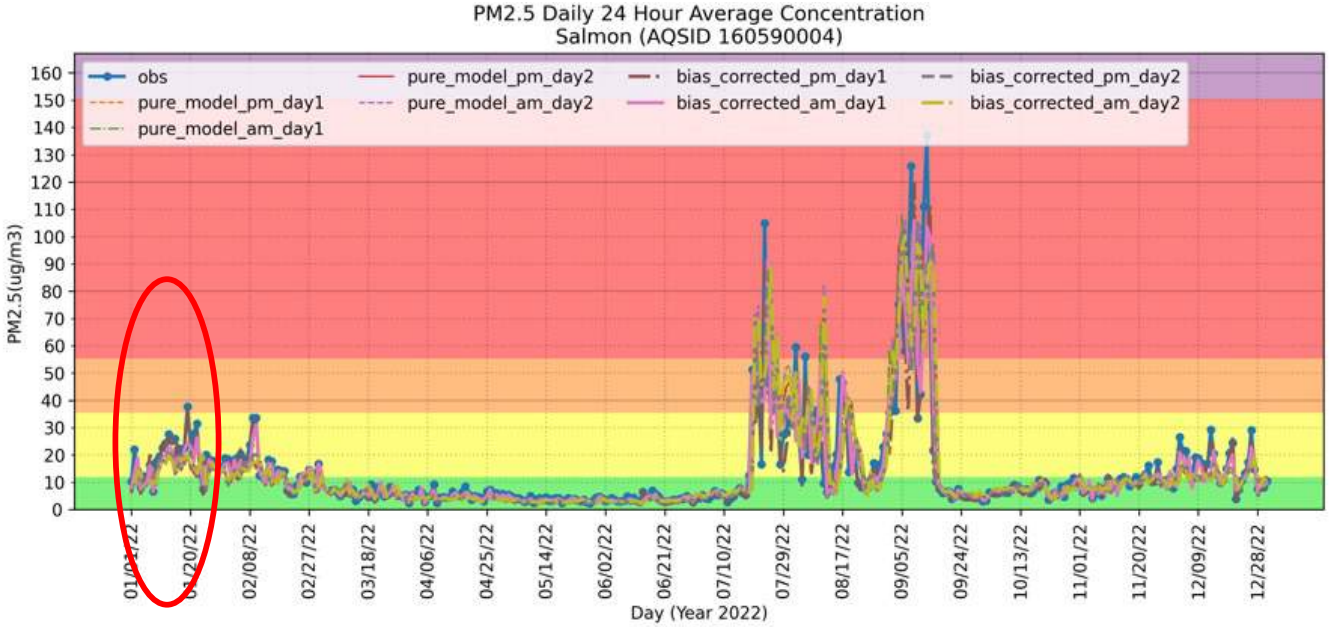
Salmon PM2.5 (AQSID 160590004)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	88.3	4.91	131.29	0	0.35	0.56	11.46
pure_model_am_day2	72.4	6.06	157.16	-0.01	0.43	0.47	12.54
pure_model_pm_day2	67.2	5.75	141.9	-0.04	0.41	0.53	11.91
pure_model_am_day1	54.4	5.17	109.1	-0.04	0.37	0.63	10.45
pure_model_pm_day1	54.2	5.04	102.92	-0.05	0.36	0.65	10.15
bias_corrected_am_day2	68.1	5.89	154.56	-0.02	0.42	0.48	12.43
bias_corrected_pm_day2	75.7	5.52	144.79	-0.05	0.39	0.52	12.03
bias_corrected_am_day1	64.4	3.74	71.45	-0.04	0.27	0.76	8.45
bias_corrected_pm_day1	55.9	2.85	47.02	-0.09	0.2	0.84	6.86

Version 3 (New)

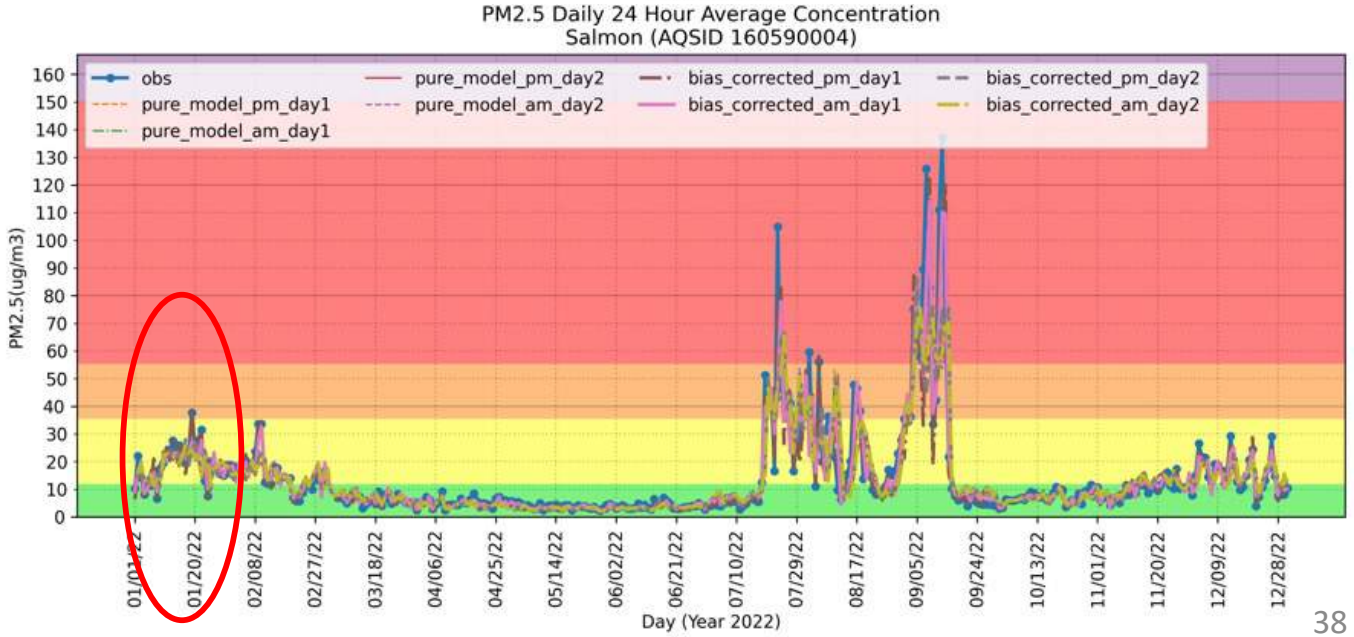
Salmon PM2.5 (AQSID 160590004)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	88.3	4.92	131.58	0	0.35	0.56	11.47
pure_model_am_day2	83.6	4.94	103.19	-0.04	0.35	0.65	10.16
pure_model_pm_day2	75.5	4.82	101.17	-0.05	0.34	0.66	10.06
pure_model_am_day1	62.8	4.51	82.27	-0.05	0.32	0.72	9.07
pure_model_pm_day1	71.3	4.49	85.43	-0.05	0.32	0.71	9.24
bias_corrected_am_day2	78.4	4.77	104.79	-0.04	0.34	0.65	10.24
bias_corrected_pm_day2	81.7	4.78	107.25	-0.06	0.34	0.64	10.36
bias_corrected_am_day1	58.2	3.32	56.67	-0.02	0.24	0.81	7.53
bias_corrected_pm_day1	56.5	2.63	43.53	-0.05	0.19	0.85	6.6

Salmon PM2.5 Site
Year 2022 Time Series

Version 2 (Old)

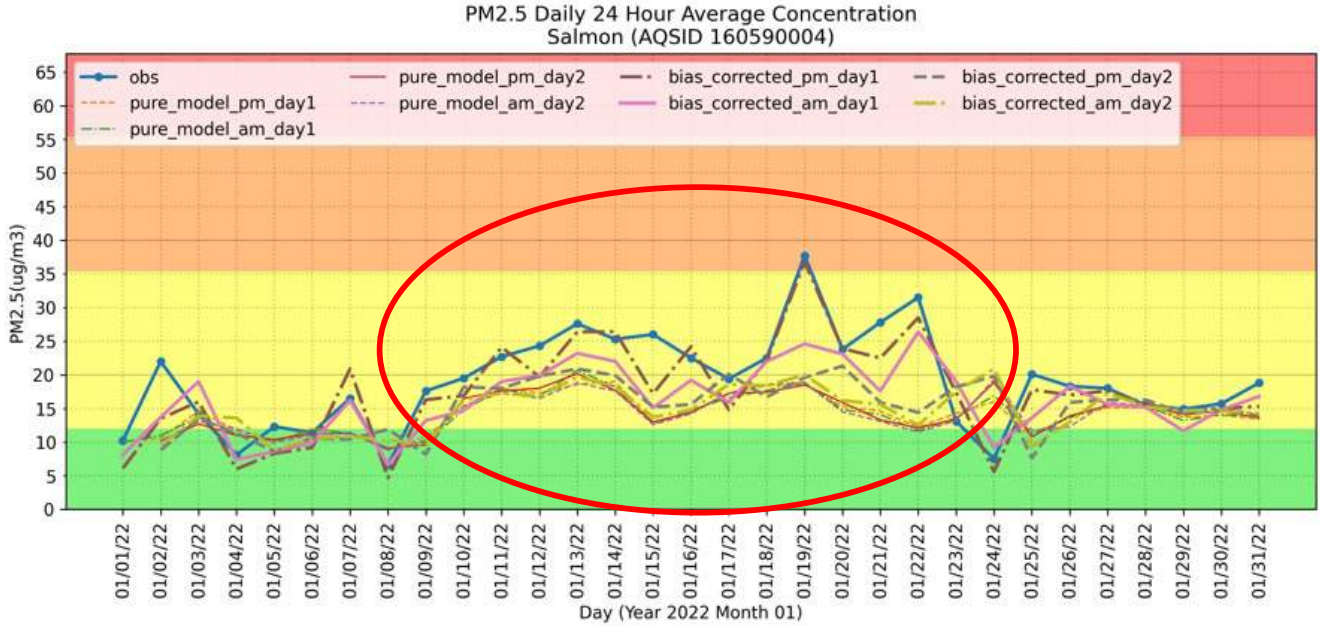


Version 3 (New)

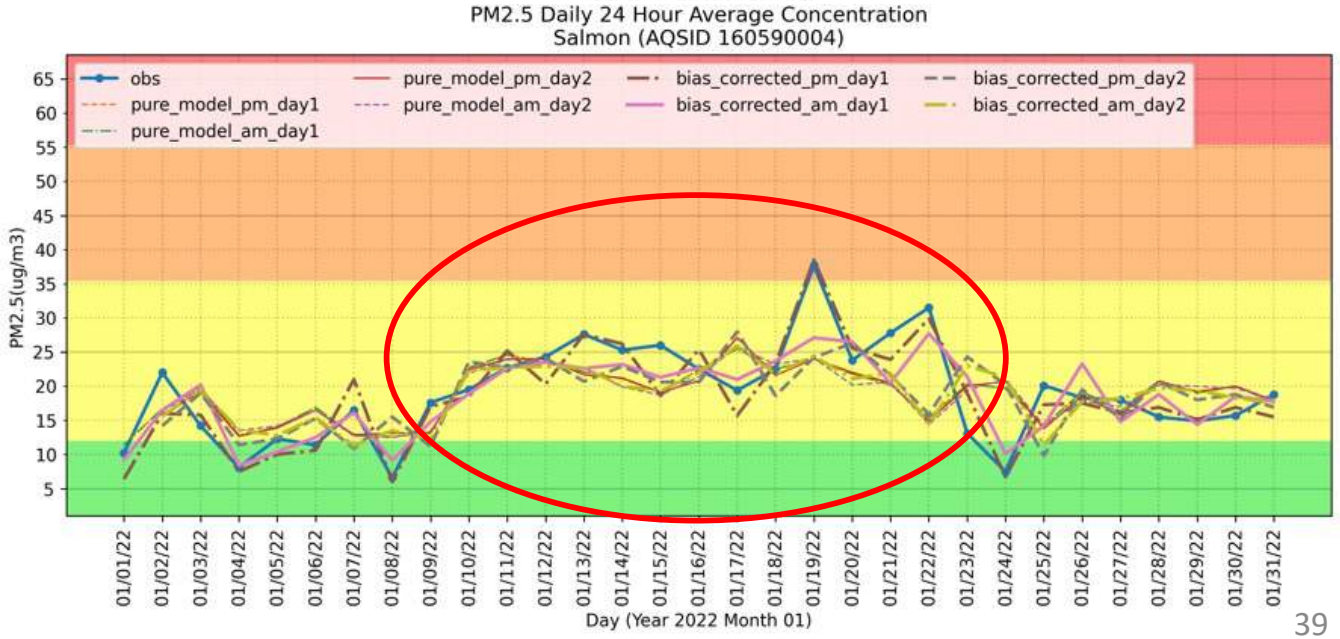


Salmon PM2.5 Site
January 2022 Time Series

Version 2 (Old)



Version 3 (New)



Model Performance
at
Preston
for
PM2.5 Models in Year 2022

Preston PM2.5 Site
Year 2022 Daily Regression Performance Metrics

Version 2 (Old)

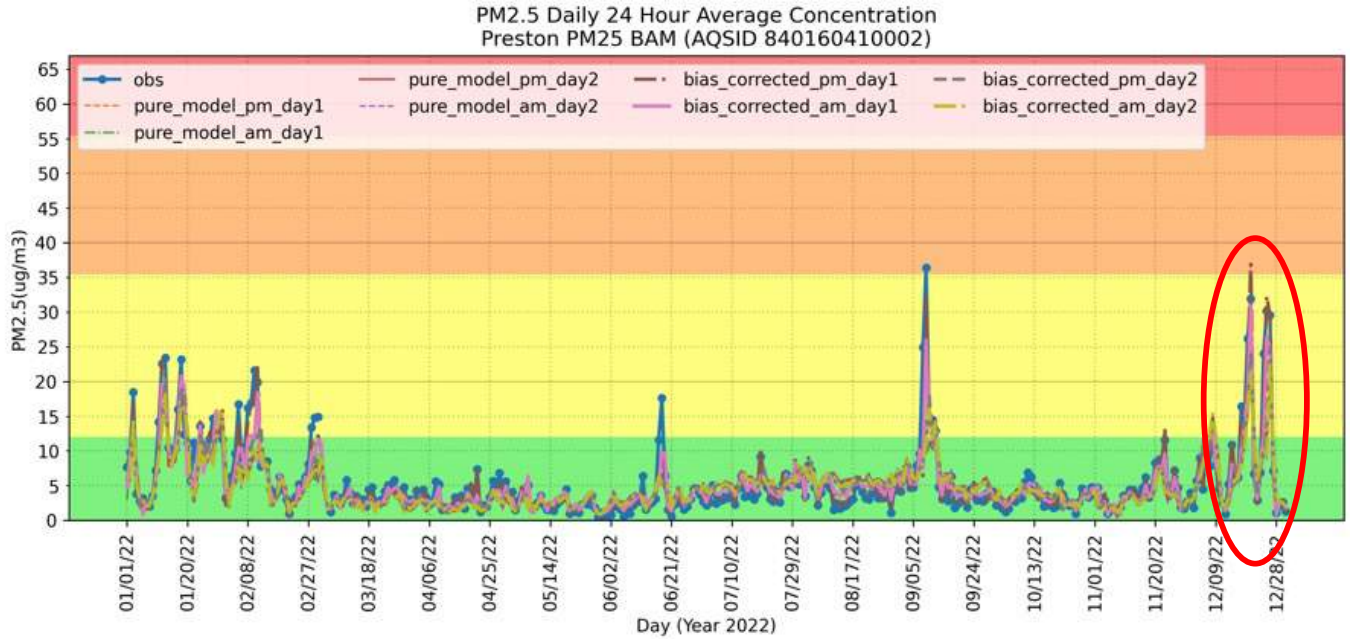
Preston PM25 BAM (AQSID 840160410002)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	25.2	2.21	15.01	-0.01	0.41	0.45	3.87
pure_model_am_day2	24.6	2.21	12.84	-0.11	0.41	0.53	3.58
pure_model_pm_day2	25	2.18	12.2	-0.11	0.4	0.55	3.49
pure_model_am_day1	26.8	2.08	11.23	-0.1	0.38	0.59	3.35
pure_model_pm_day1	26.8	2.06	11.29	-0.11	0.38	0.58	3.36
bias_corrected_am_day2	25.3	2.07	11.89	-0.1	0.38	0.56	3.45
bias_corrected_pm_day2	26.1	2.02	10.92	-0.09	0.37	0.6	3.3
bias_corrected_am_day1	17.4	1.29	4.8	-0.06	0.24	0.82	2.19
bias_corrected_pm_day1	18.5	0.88	2.64	-0.03	0.16	0.9	1.62

Version 3 (New)

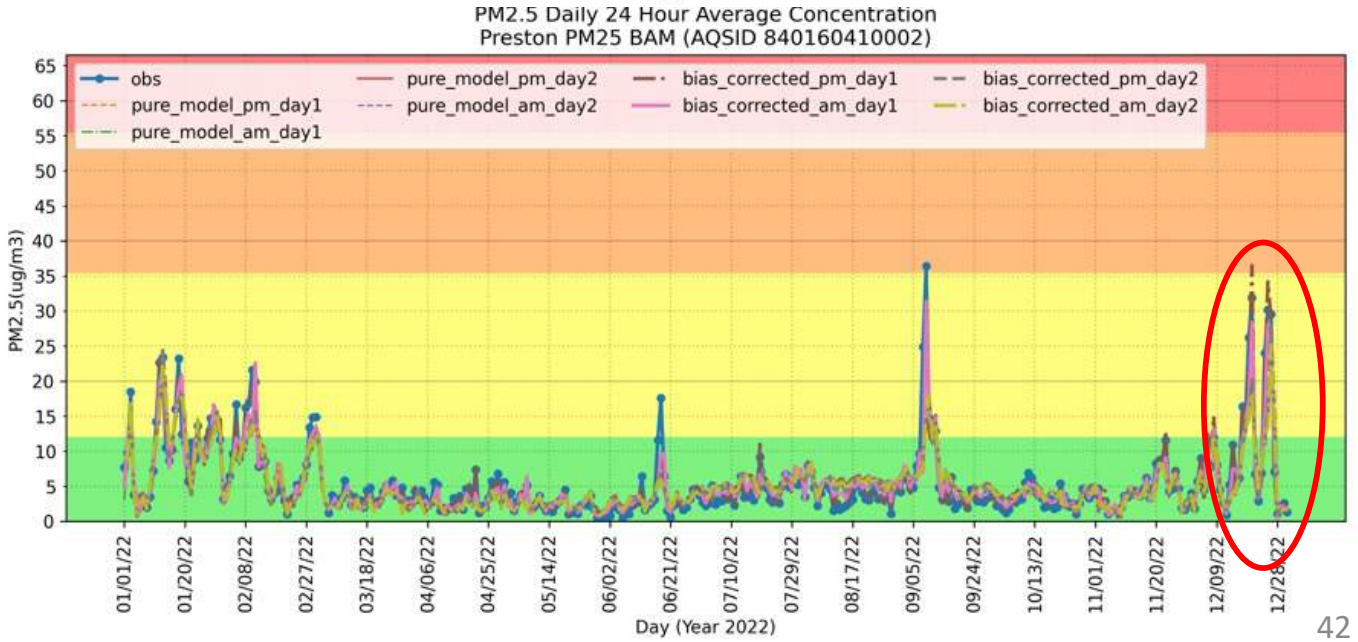
Preston PM25 BAM (AQSID 840160410002)							
Forecast	max_error	mean_absolute_error	mean_squared_error	normalized_mean_bias	normalized_mean_error	r2_score	root_mean_squared_error
persistence	25.2	2.21	15.02	-0.01	0.41	0.45	3.88
pure_model_am_day2	21	1.84	9.23	-0.05	0.34	0.66	3.04
pure_model_pm_day2	21	1.8	8.9	-0.05	0.33	0.67	2.98
pure_model_am_day1	22.3	1.77	8.61	-0.04	0.33	0.68	2.93
pure_model_pm_day1	22.4	1.77	8.62	-0.04	0.33	0.68	2.94
bias_corrected_am_day2	21.4	1.75	8.77	-0.05	0.32	0.68	2.96
bias_corrected_pm_day2	21.4	1.72	8.33	-0.05	0.32	0.69	2.89
bias_corrected_am_day1	17.9	1.16	3.94	-0.03	0.21	0.86	1.98
bias_corrected_pm_day1	17.8	0.81	2.44	-0.02	0.15	0.91	1.56

Preston PM2.5 Site
Year 2022 Time Series

Version 2 (Old)

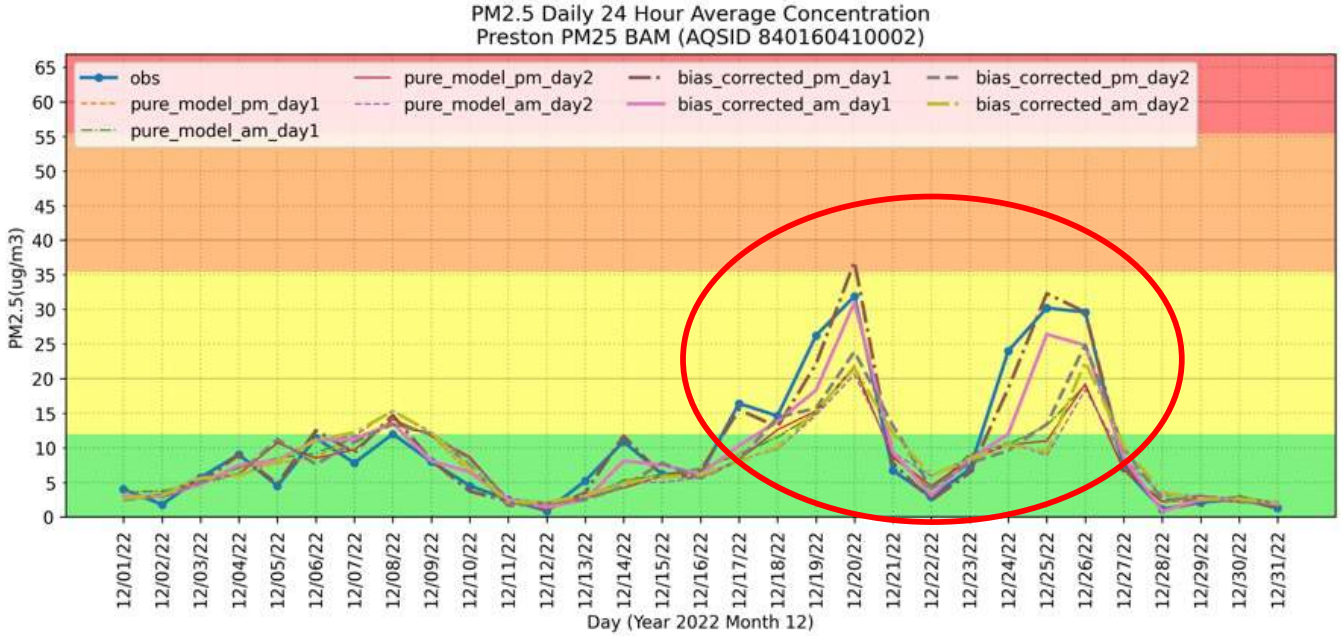


Version 3 (New)

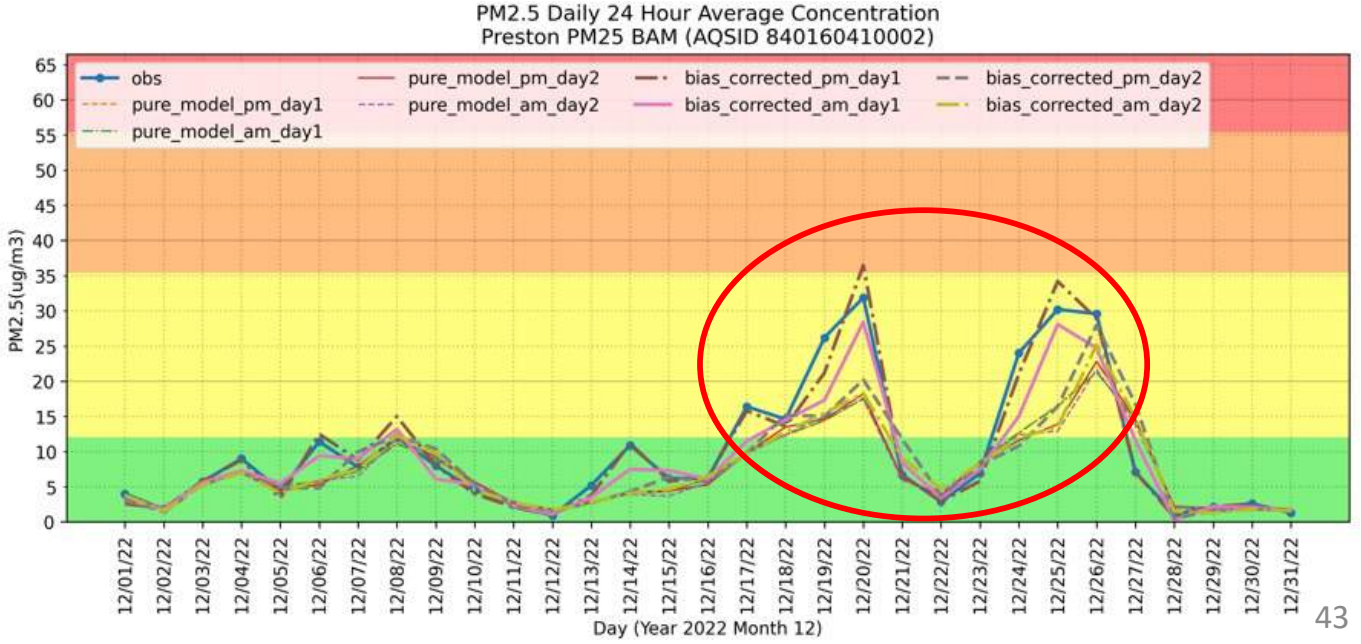


Preston PM2.5 Site
December 2022 Time Series

Version 2 (Old)



Version 3 (New)



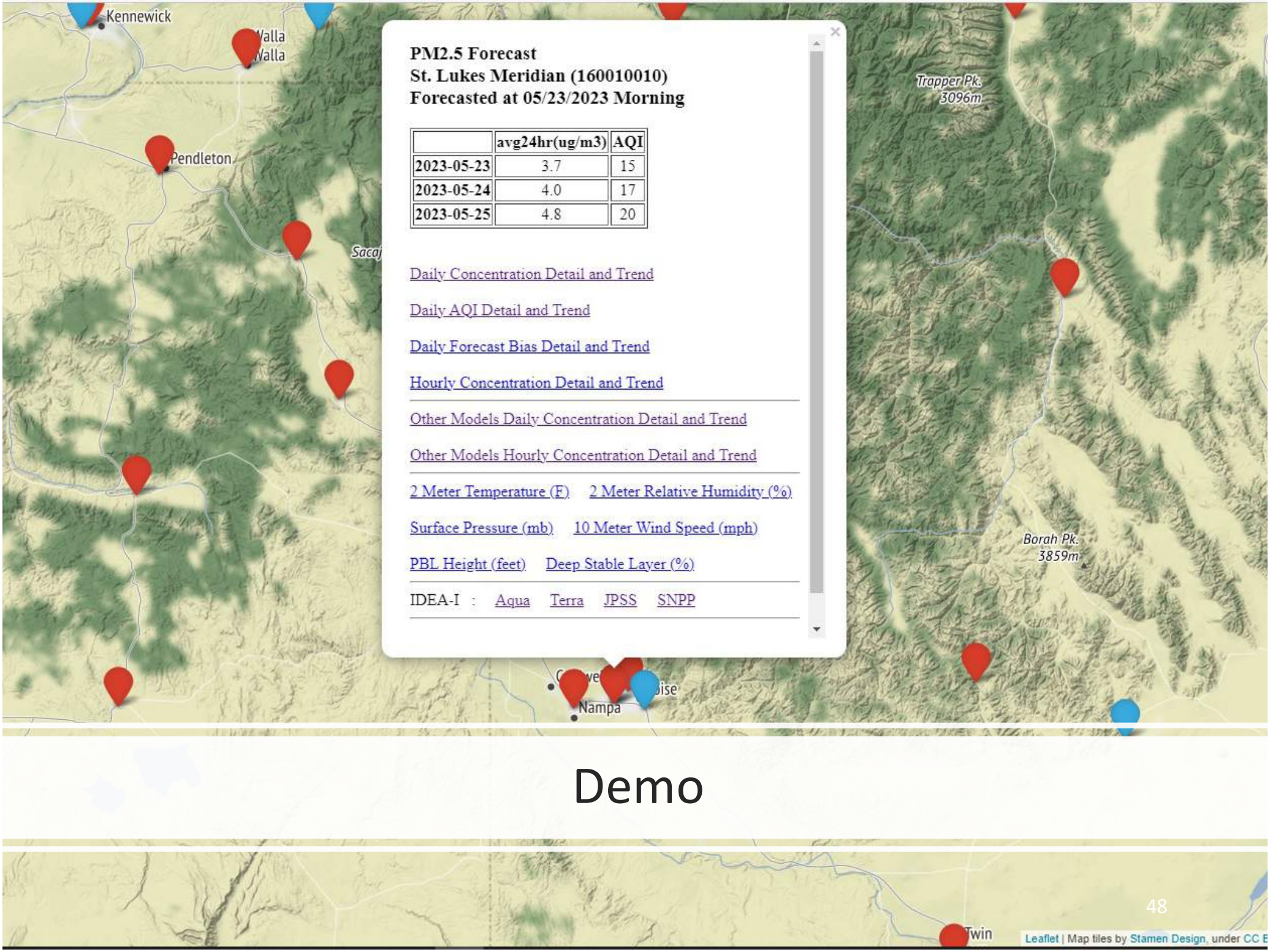
Path Forward

- Annual Maintenance
  - Evaluate the model performance in January of each year
  - Retrain the machine learning models with last year's data added in January of each year
- Display observation of meteorology parameters
- Test and bring in new inputs to improve model performance in the future

Questions and Discussion

The End

Supplemental Slides



PM2.5 Forecast
St. Lukes Meridian (160010010)
Forecasted at 05/23/2023 Morning

	avg24hr(ug/m3)	AQI
2023-05-23	3.7	15
2023-05-24	4.0	17
2023-05-25	4.8	20

Daily Concentration Detail and Trend

Daily AQI Detail and Trend

Daily Forecast Bias Detail and Trend

Hourly Concentration Detail and Trend

Other Models Daily Concentration Detail and Trend

Other Models Hourly Concentration Detail and Trend

2 Meter Temperature (F) 2 Meter Relative Humidity (%)

Surface Pressure (mb) 10 Meter Wind Speed (mph)

PBL Height (feet) Deep Stable Layer (%)

IDEA-I : Aqua Terra JPSS SNPP

Demo

Email Notification

Machine Learning Air Quality Forecast is here! (Forecasted at 05/23/2023 Morning)

Wei.Zhang@deq.idaho.gov
To Wei Zhang

Reply | Reply All | Forward

Tue 5/23/2023 7:44 AM

Wei,

This morning's forecast is here! The result can be found at:

http://tuxair5.deq.idaho.gov/ml_forecast_outputs/2023/20230523_am/

OR through simple online map http://tuxair5.deq.idaho.gov/ml_forecast_outputs/2023/20230523_am/20230523_am_forecast_0Map.html

To access forecasts for previous days, please go to:

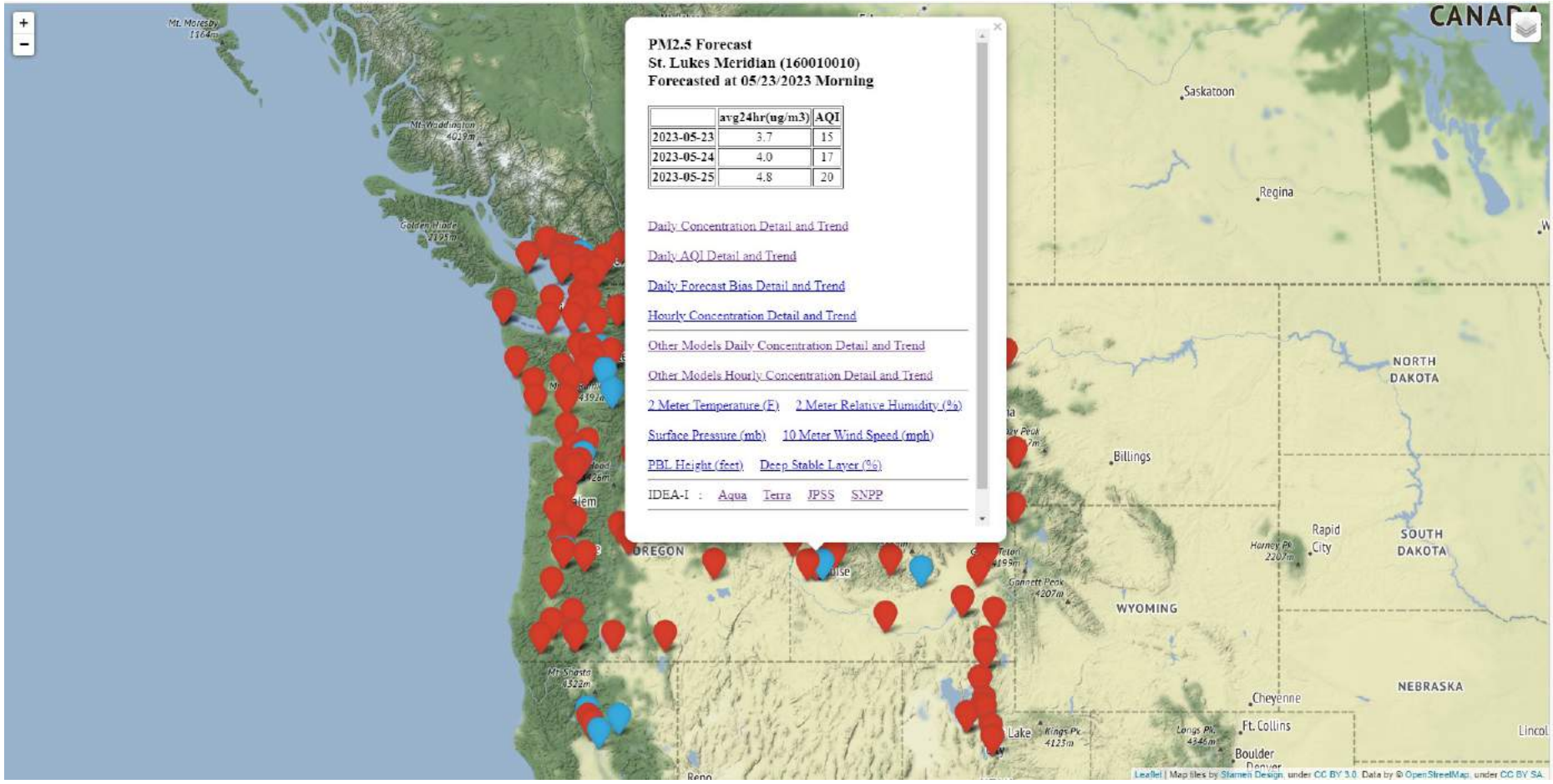
http://tuxair5.deq.idaho.gov/ml_forecast_outputs/

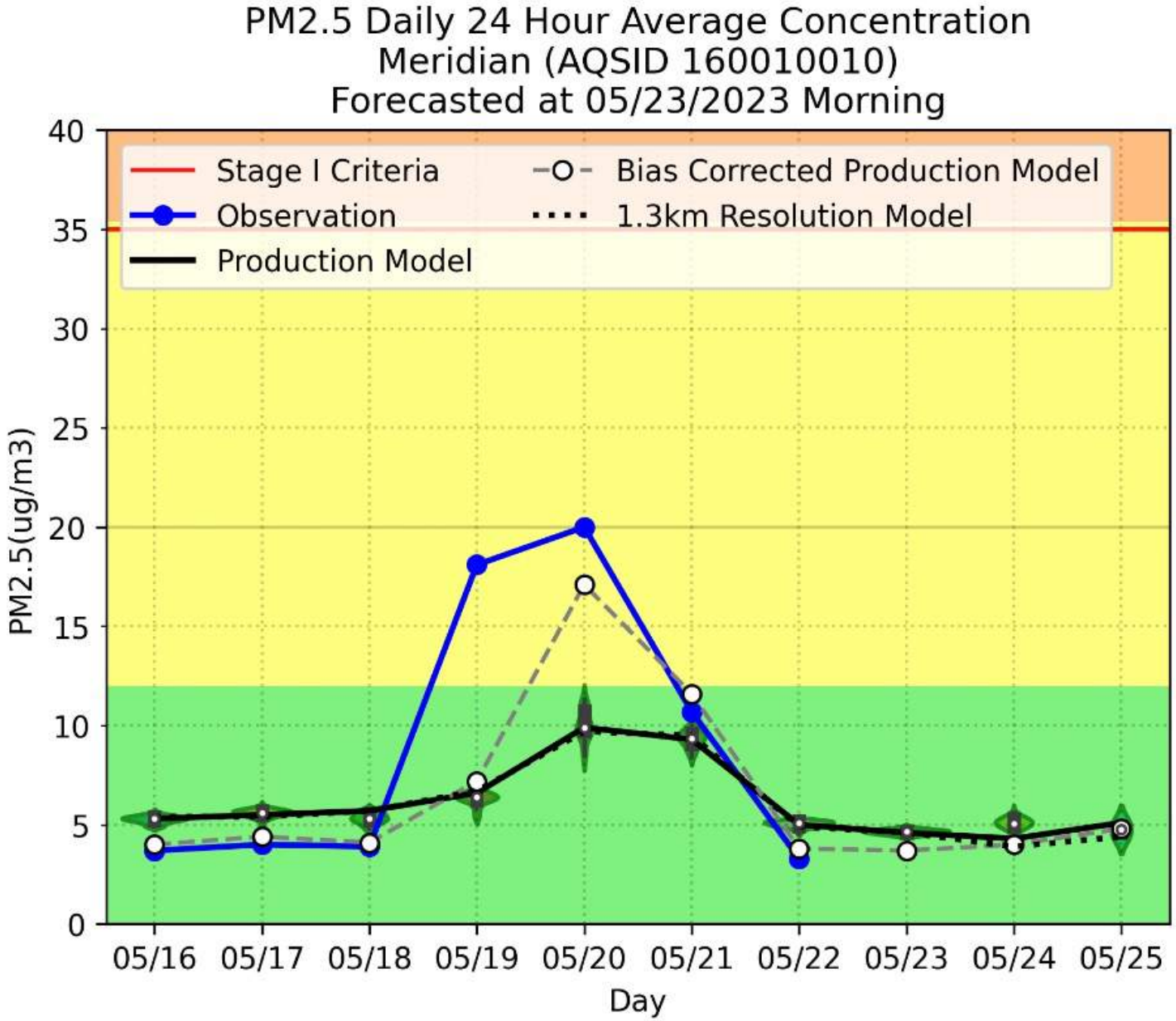
This forecast is based on a machine learning method utilizing modeled ensemble meteorological forecasts from the University of Washington. Local acute or event-based impacts are not considered in the model. This forecast should be used as a starting point and then adjusted based on local knowledge of these factors.

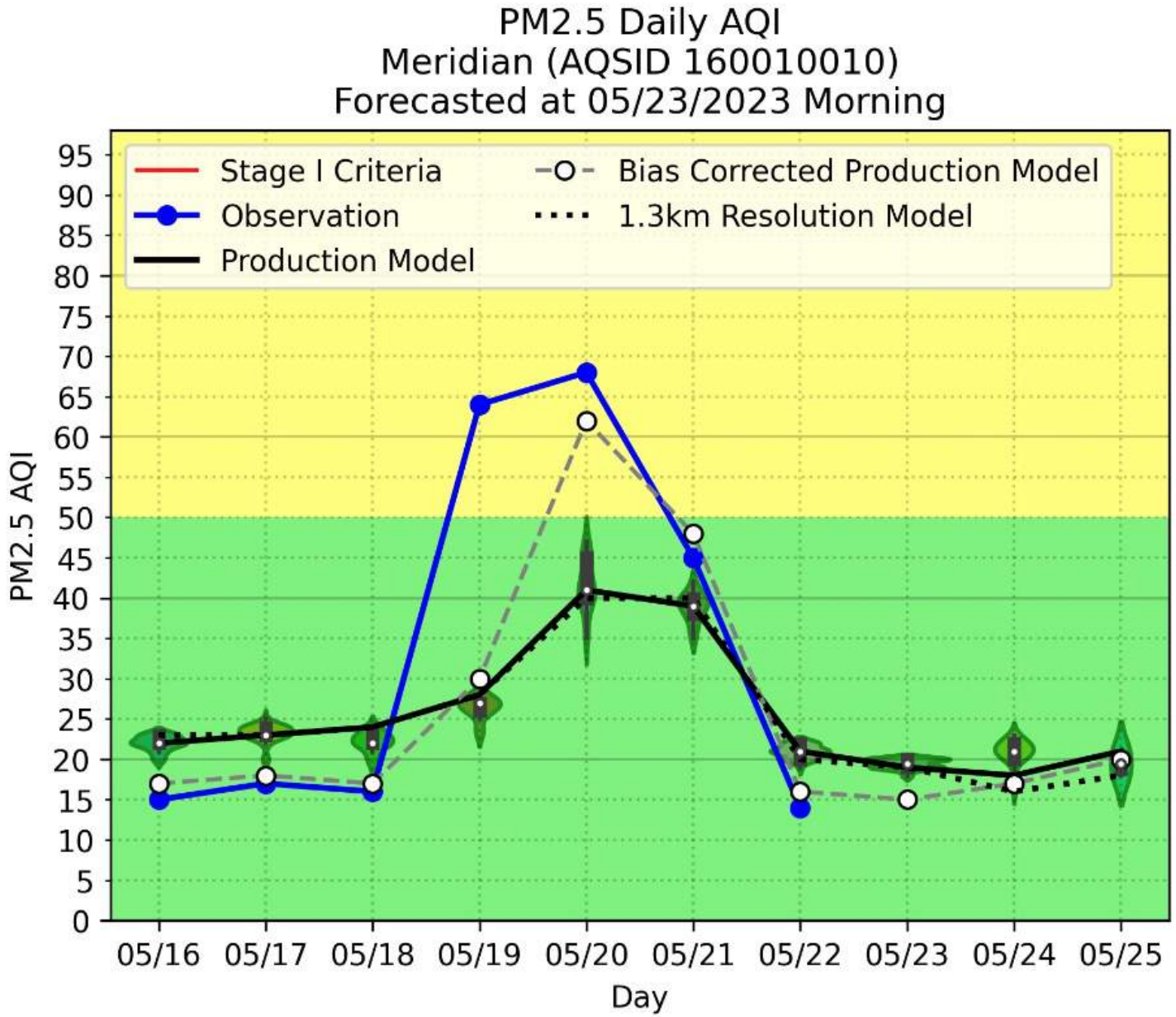
Hopefully this tool makes your life easier. Please provide us any feedback you may have.

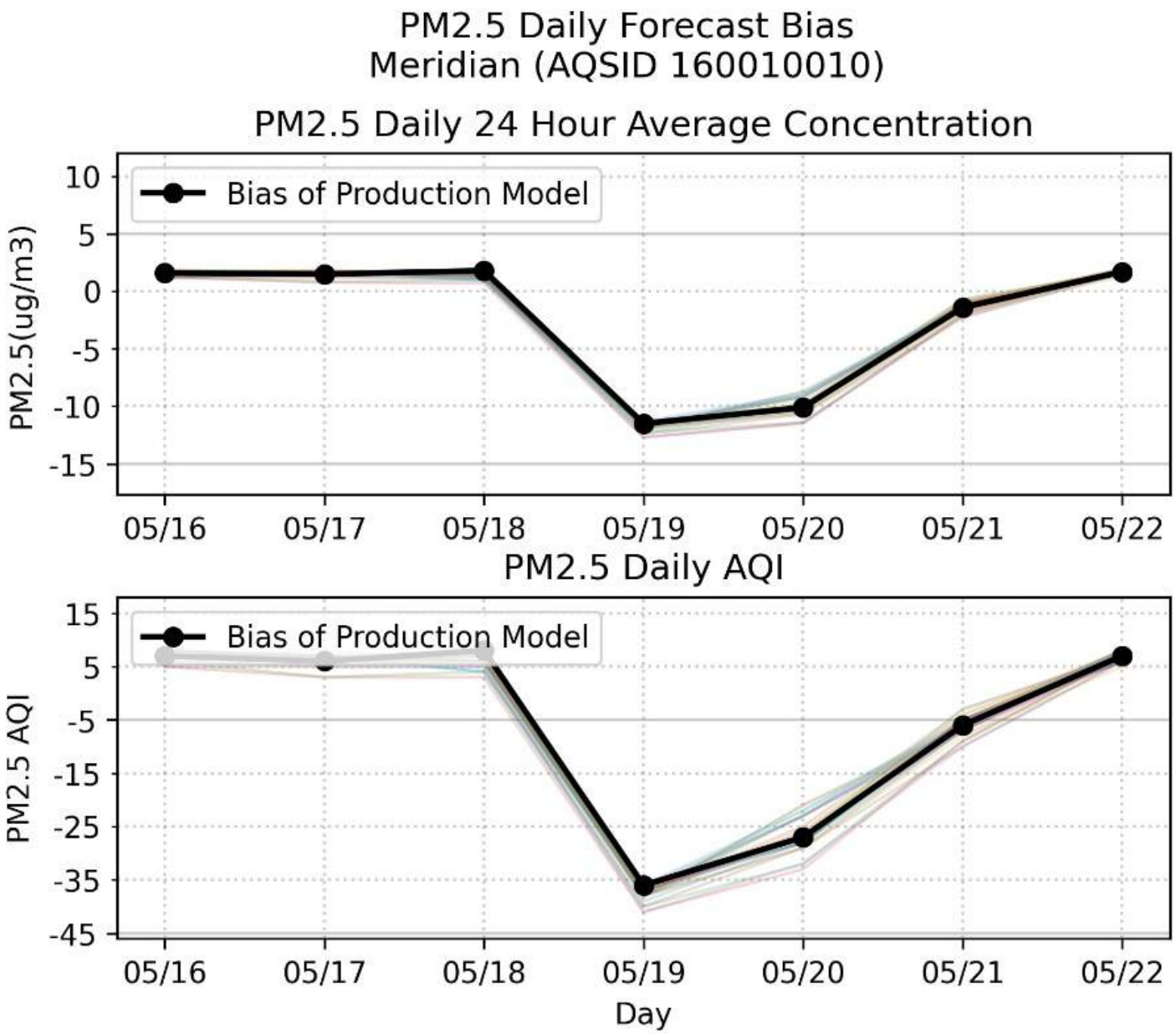
Technical Services Division
Idaho Department of Environmental Quality
Wei.Zhang@deq.idaho.gov

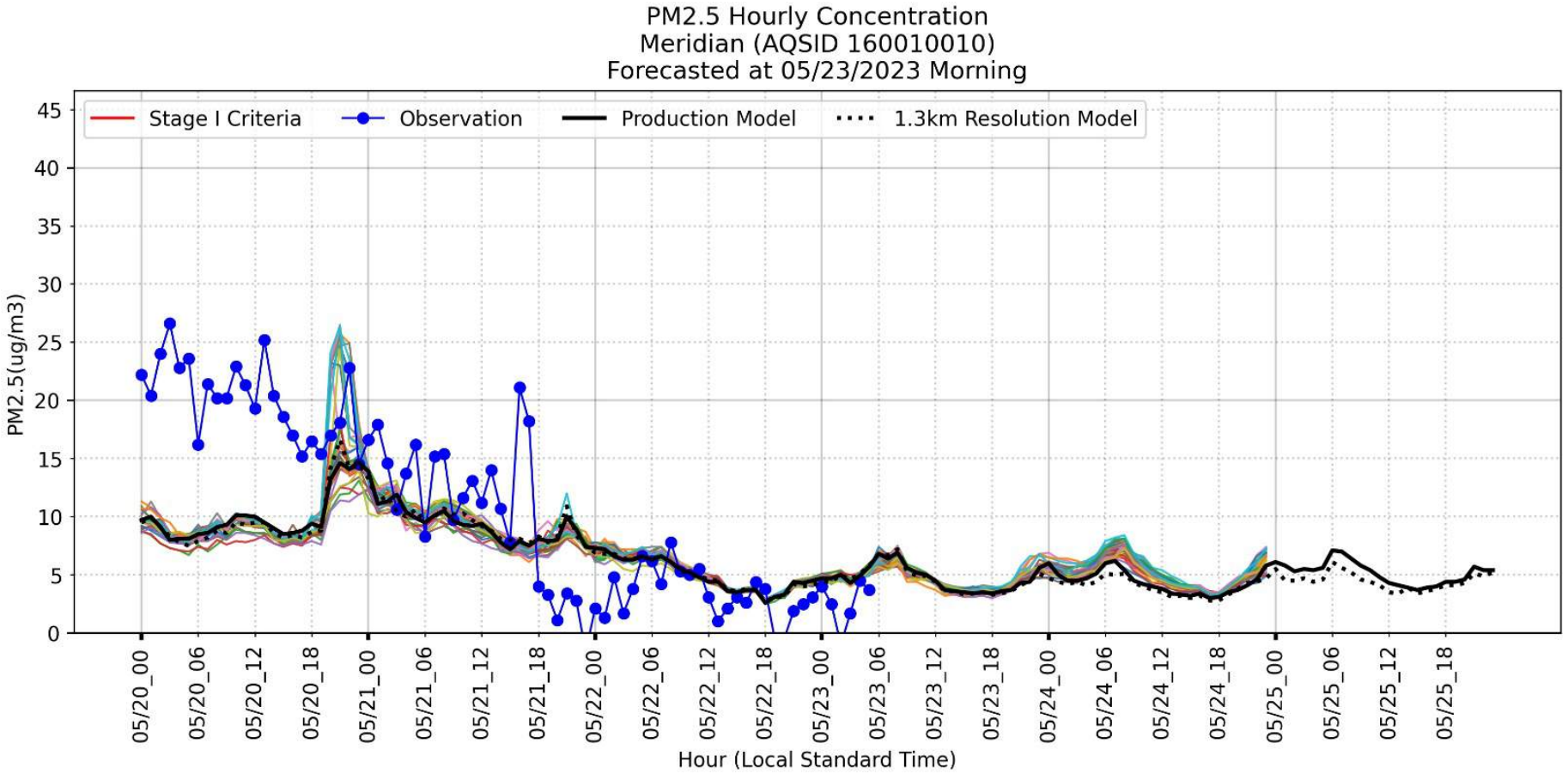
Simple Online Map

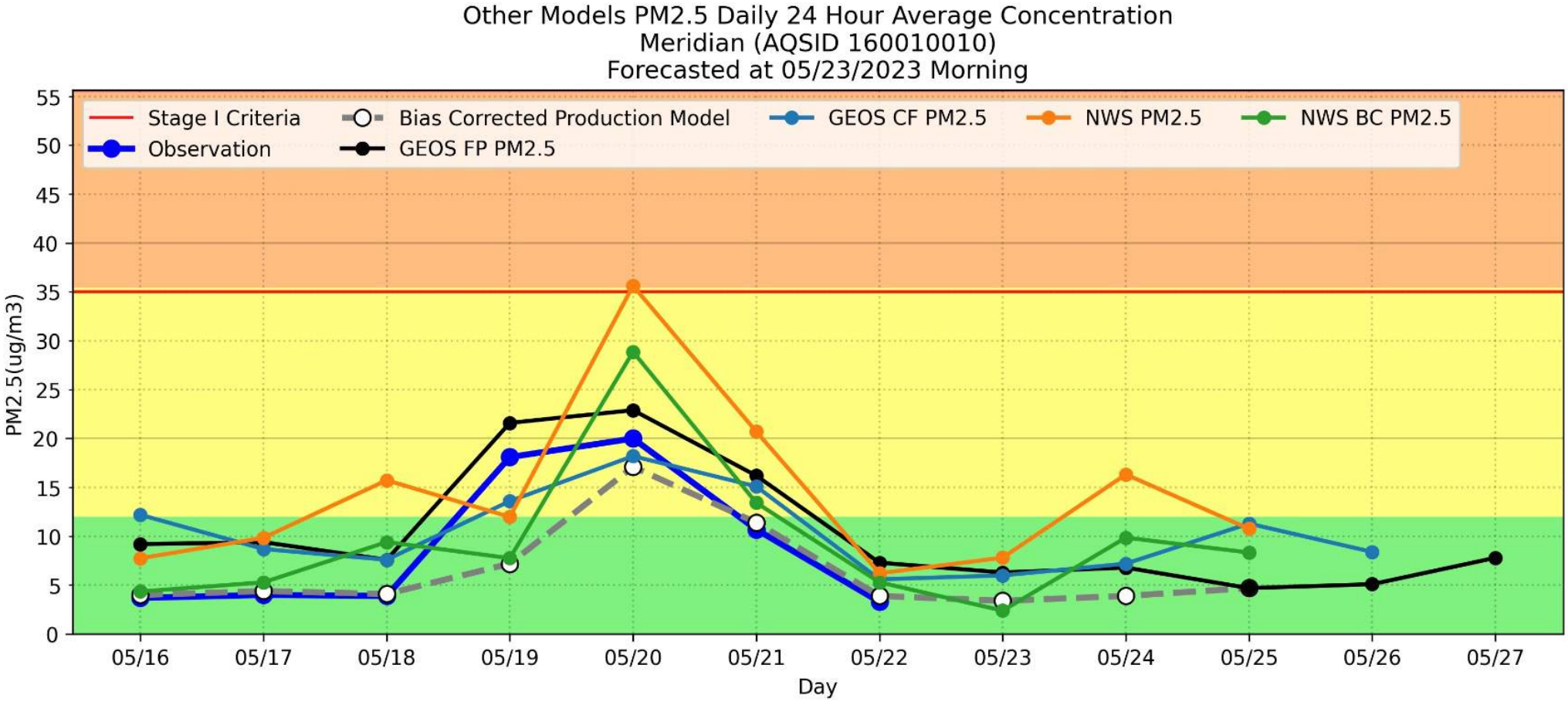


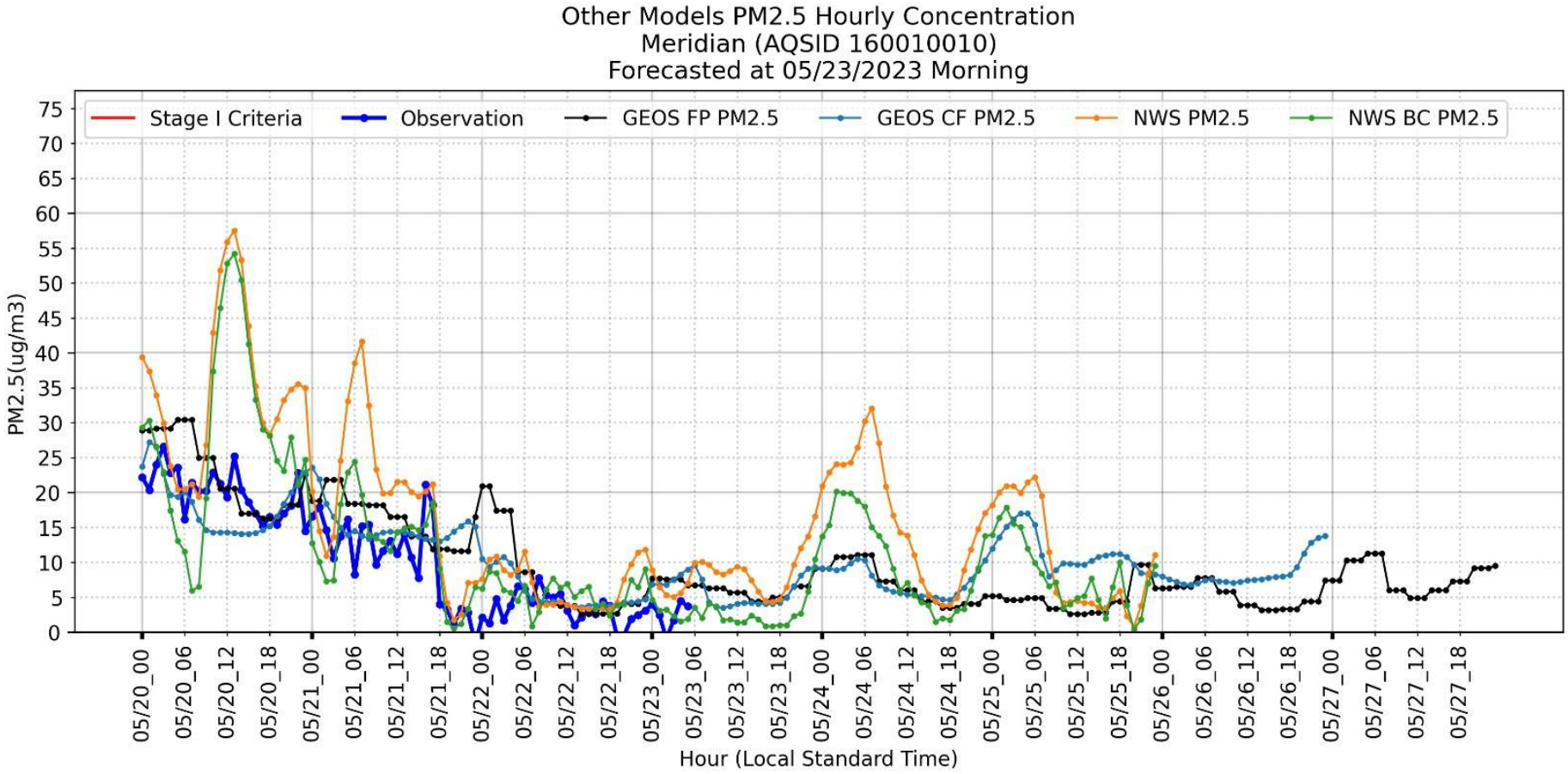

PM2.5 Daily 24 Hour Average Concentration
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Stage I Criteria
Observation
Production Model
Bias Corrected Production Model
1.3km Resolution Model
PM2.5(ug/m3)
0
5
10
15
20
25
30
35
40
05/16
05/17
05/18
05/19
05/20
05/21
05/22
05/23
05/24
05/25
Day

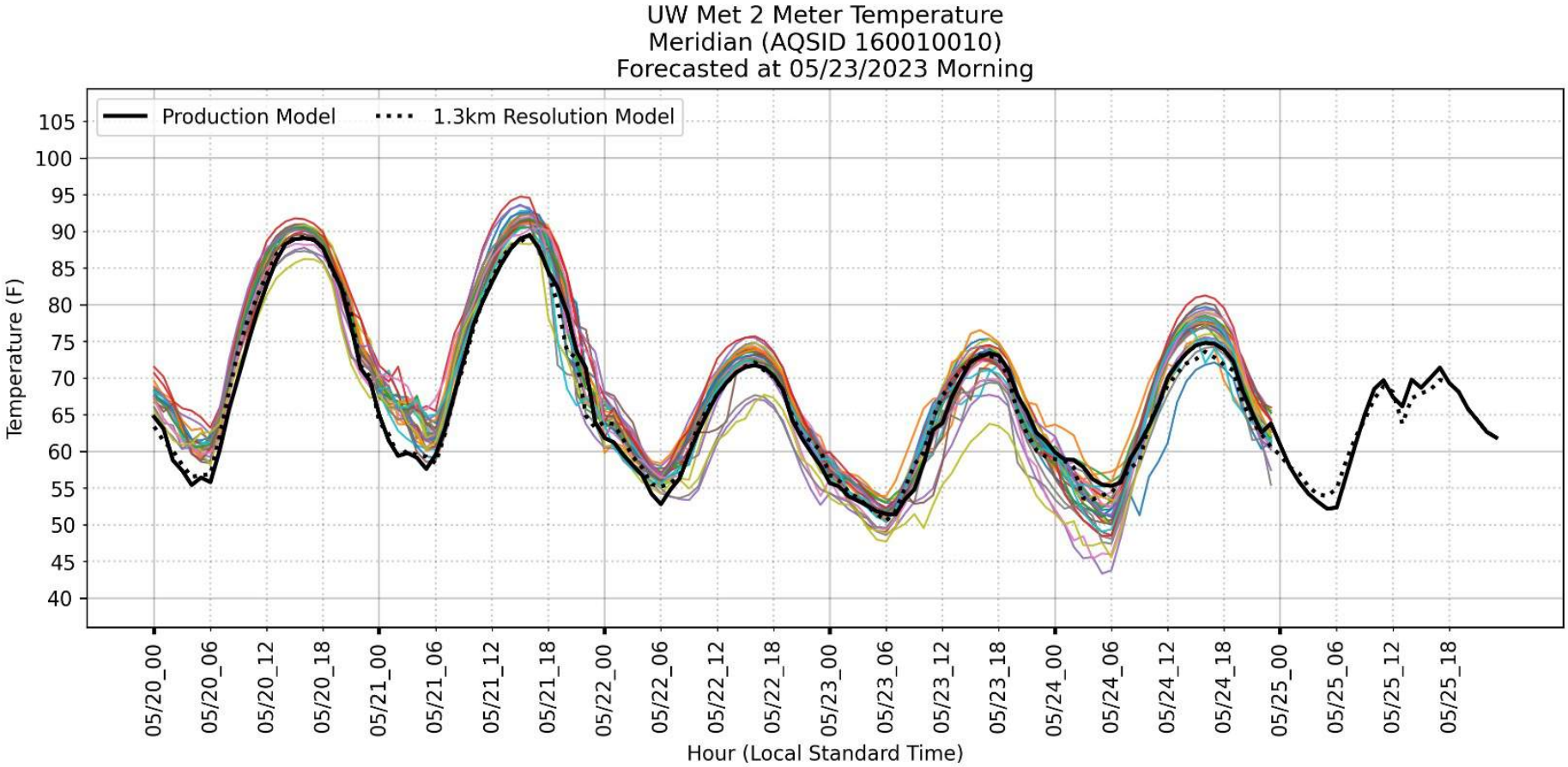

PM2.5 Daily AQI
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Stage I Criteria
Observation
Production Model
Bias Corrected Production Model
1.3km Resolution Model
PM2.5 AQI
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
05/16
05/17
05/18
05/19
05/20
05/21
05/22
05/23
05/24
05/25
Day

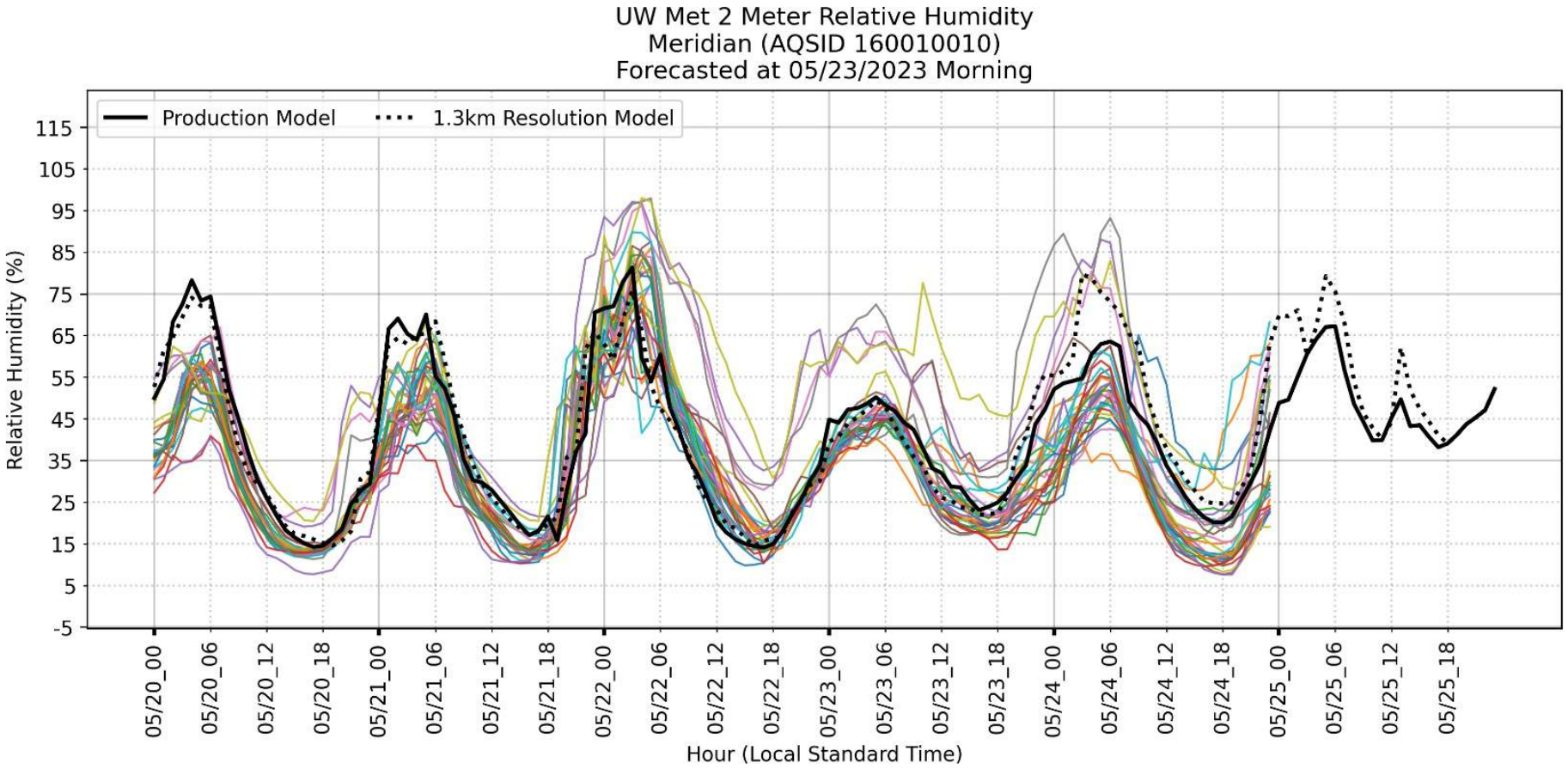

PM2.5 Daily Forecast Bias
Meridian (AQSID 160010010)
PM2.5 Daily 24 Hour Average Concentration
Bias of Production Model
PM2.5(ug/m3)
10
5
0
-5
-10
-15
05/16
05/17
05/18
05/19
05/20
05/21
05/22
PM2.5 Daily AQI
Bias of Production Model
PM2.5 AQI
15
5
-5
-15
-25
-35
-45
05/16
05/17
05/18
05/19
05/20
05/21
05/22
Day

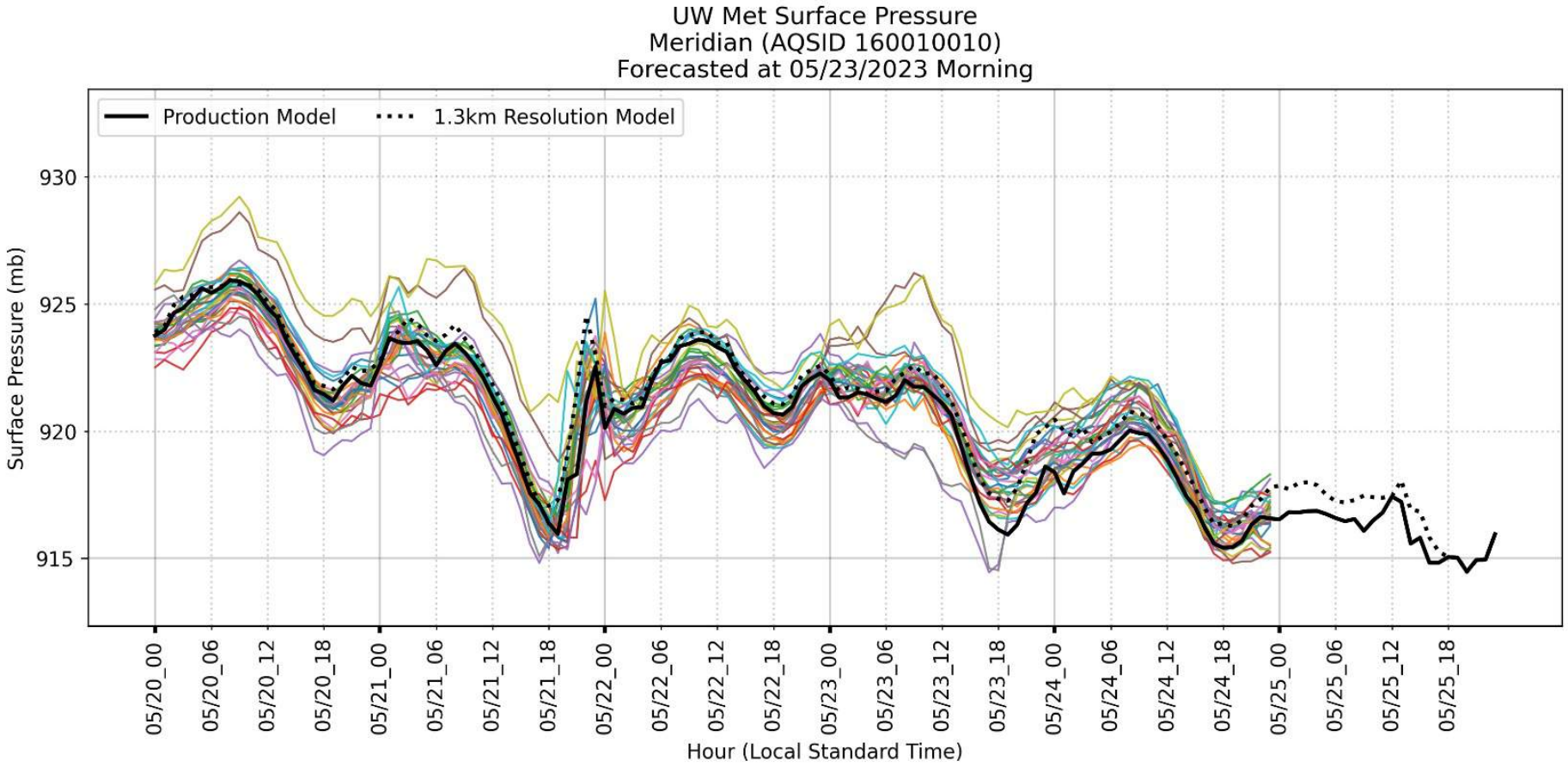

PM2.5 Hourly Concentration
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Stage I Criteria
Observation
Production Model
1.3km Resolution Model
PM2.5(ug/m3)
0
5
10
15
20
25
30
35
40
45
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)

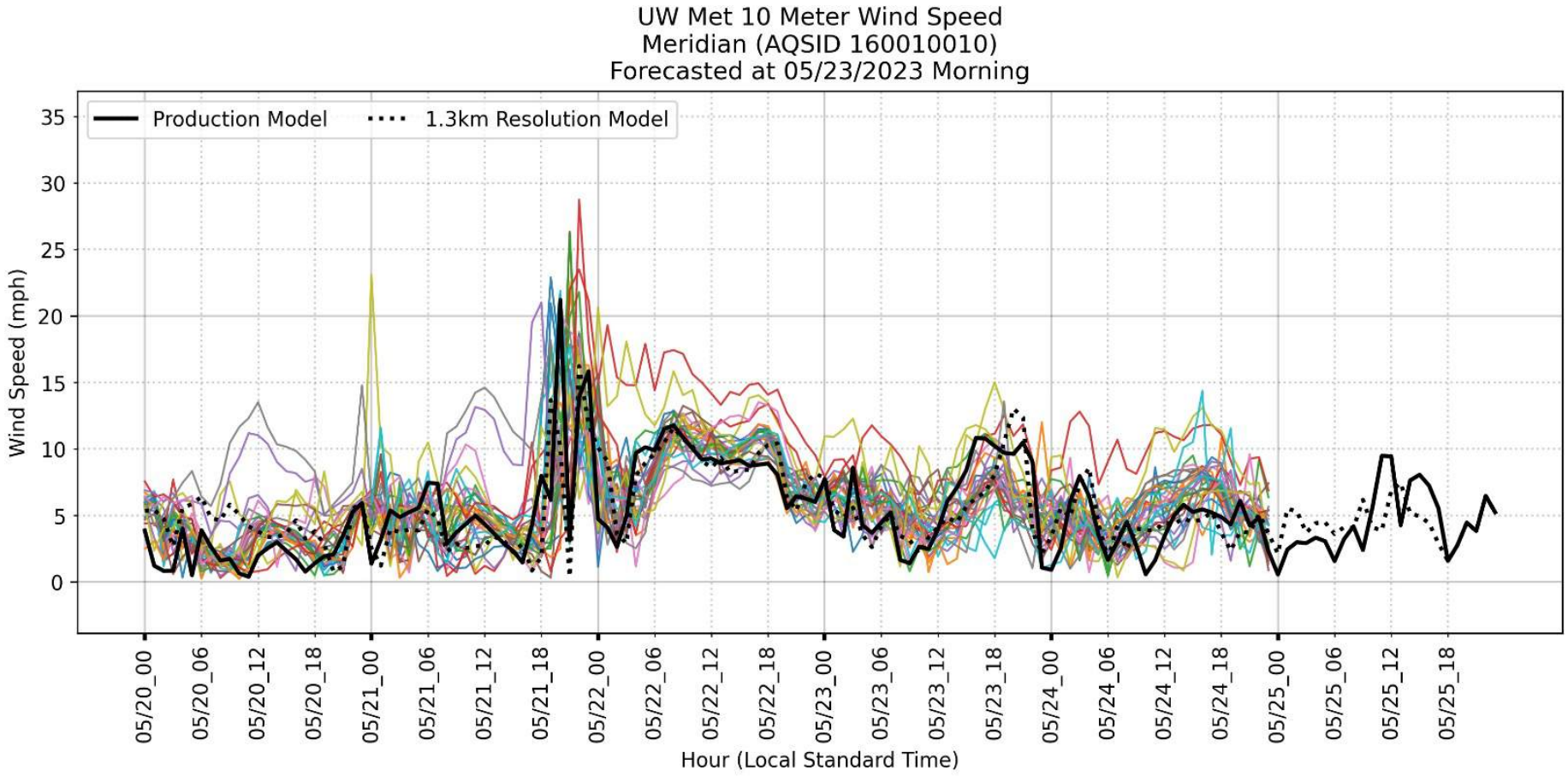

Other Models PM2.5 Daily 24 Hour Average Concentration
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Stage I Criteria
Observation
Bias Corrected Production Model
GEOS FP PM2.5
GEOS CF PM2.5
NWS PM2.5
NWS BC PM2.5
PM2.5(ug/m3)
0
5
10
15
20
25
30
35
40
45
50
55
05/16
05/17
05/18
05/19
05/20
05/21
05/22
05/23
05/24
05/25
05/26
05/27
Day

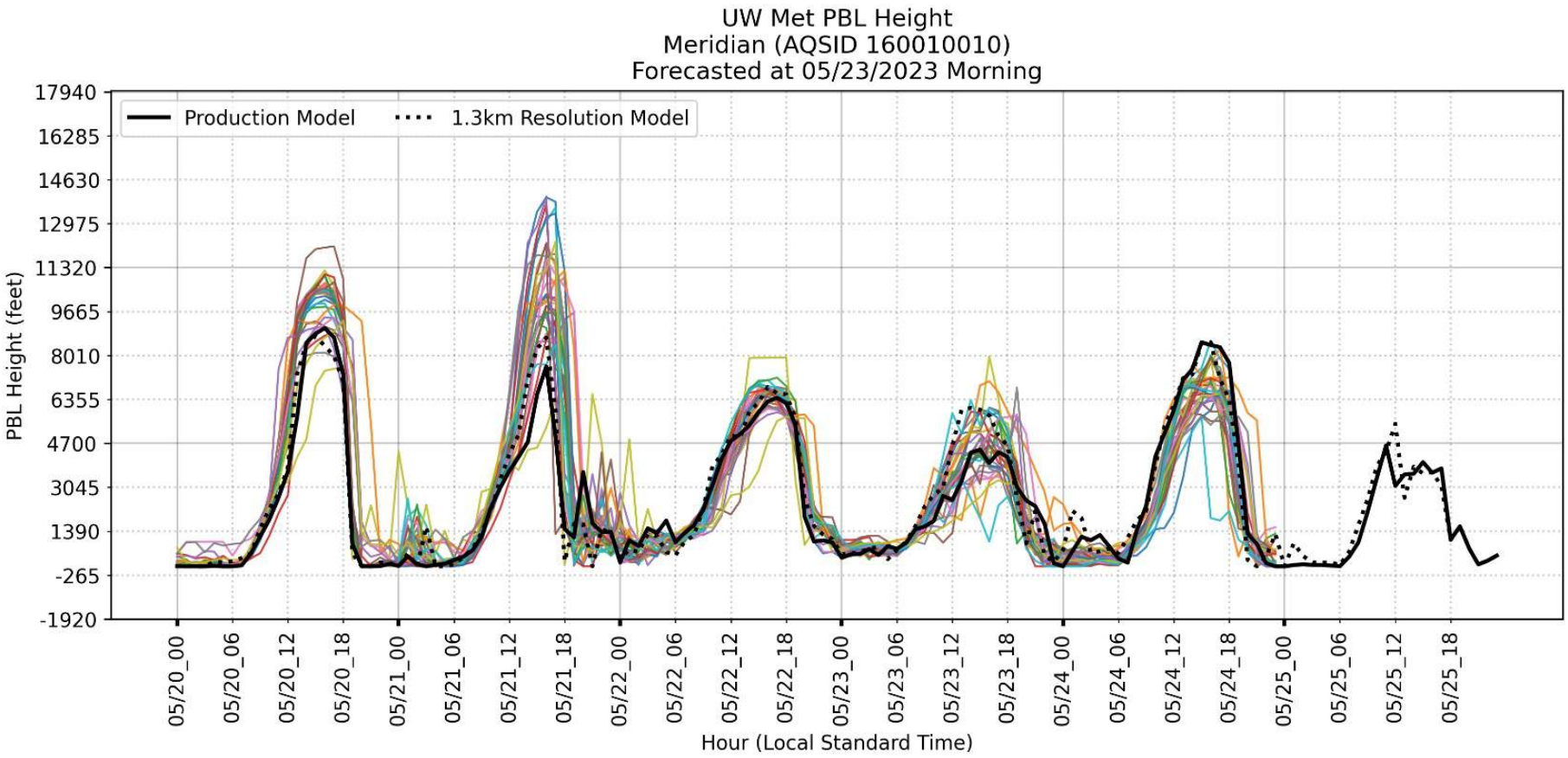

Other Models PM2.5 Hourly Concentration
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Stage I Criteria
Observation
GEOS FP PM2.5
GEOS CF PM2.5
NWS PM2.5
NWS BC PM2.5
PM2.5(ug/m3)
Hour (Local Standard Time)

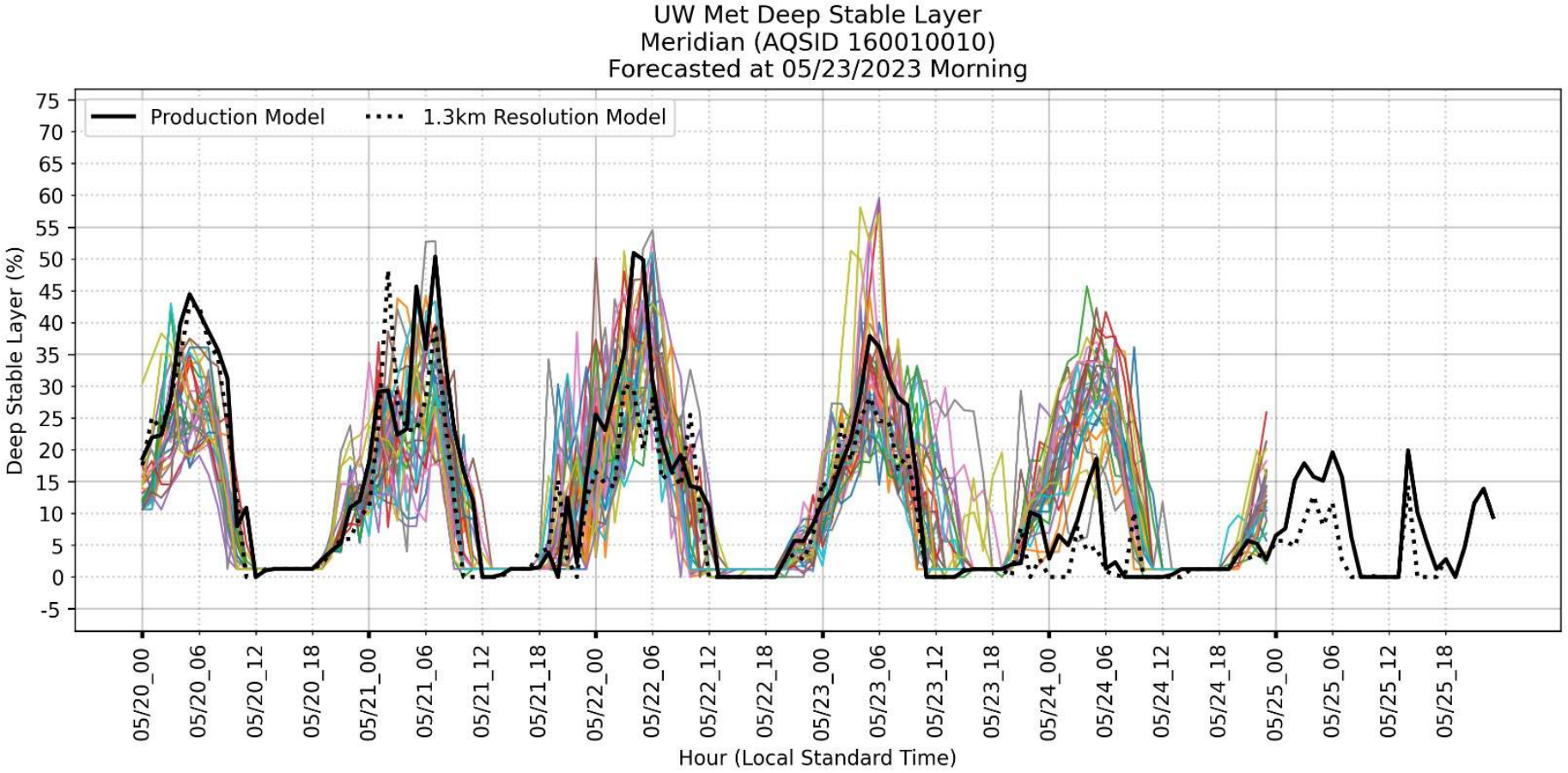

UW Met 2 Meter Temperature
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
Temperature (F)
105
100
95
90
85
80
75
70
65
60
55
50
45
40
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)

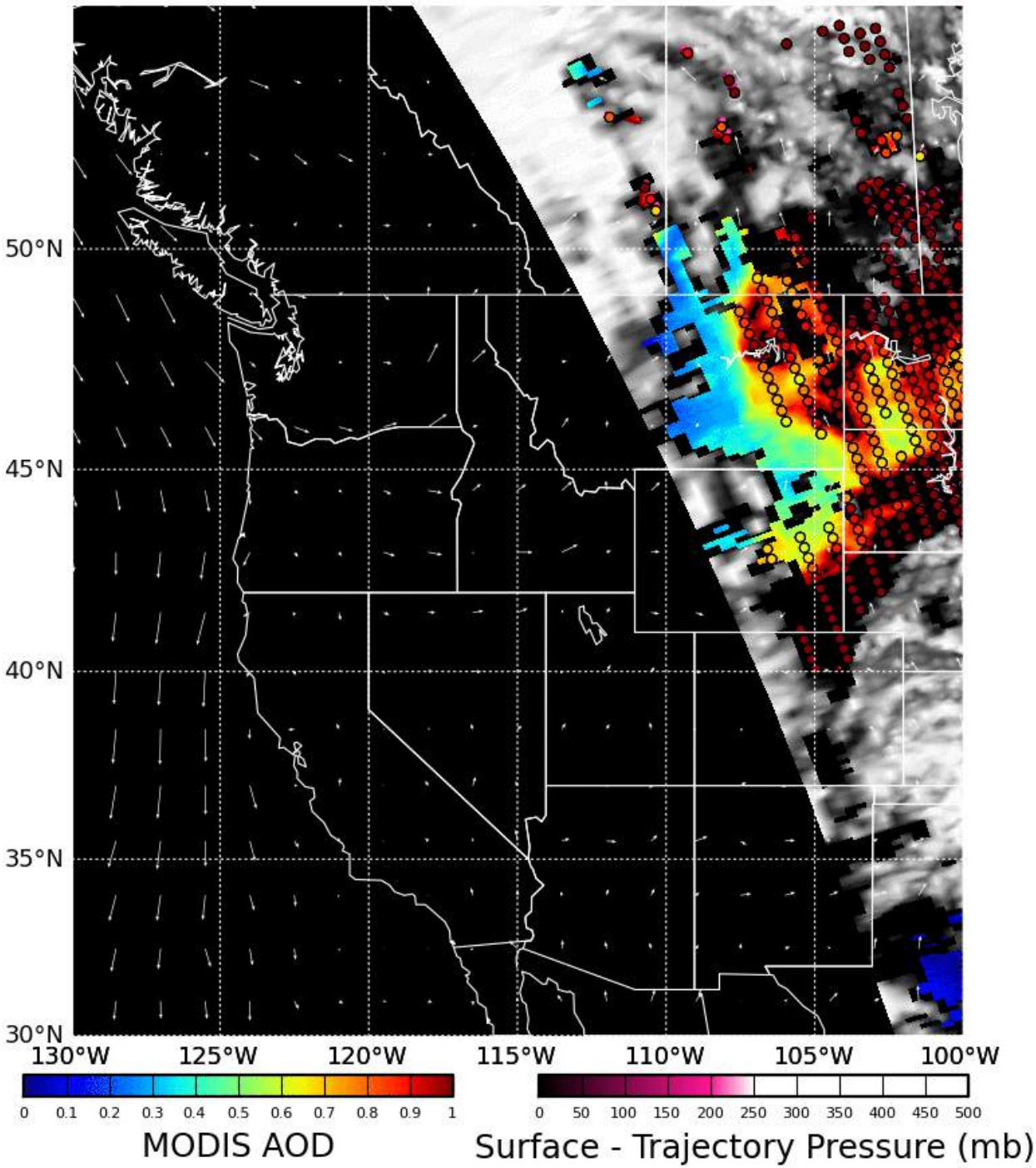

UW Met 2 Meter Relative Humidity
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
Relative Humidity (%)
115
105
95
85
75
65
55
45
35
25
15
5
-5
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)


UW Met Surface Pressure
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
Surface Pressure (mb)
930
925
920
915
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)

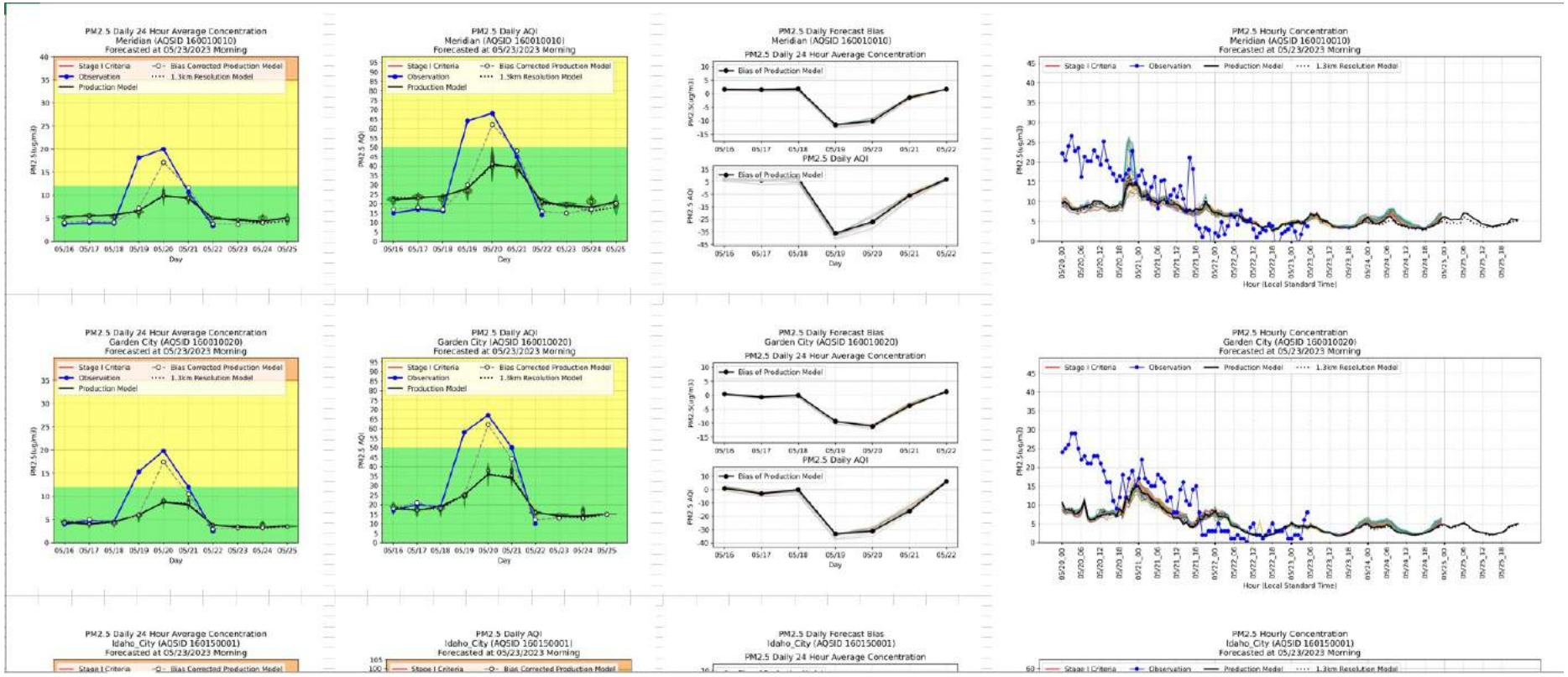

UW Met 10 Meter Wind Speed
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
Wind Speed (mph)
35
30
25
20
15
10
5
0
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)

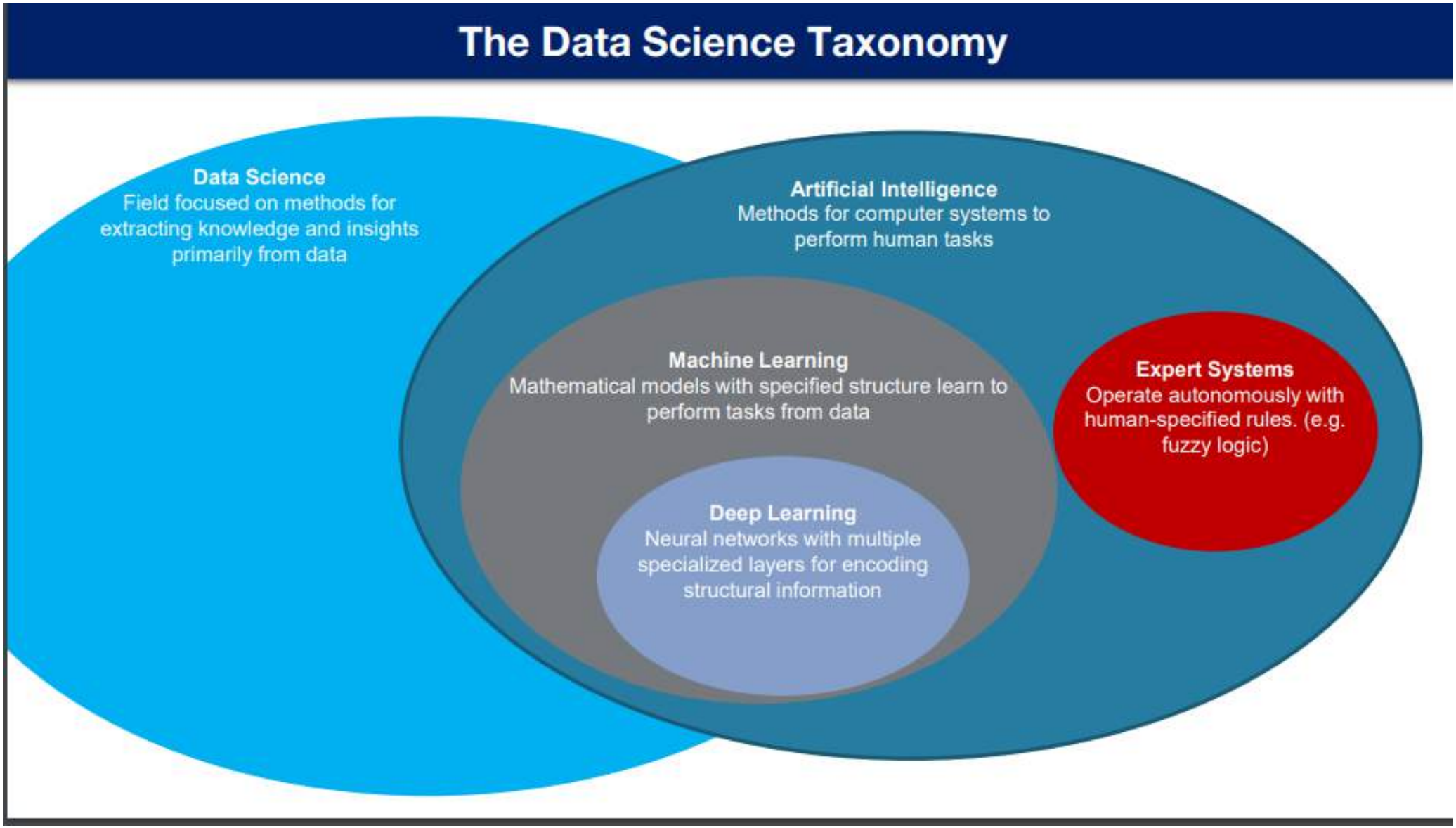

UW Met PBL Height
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
PBL Height (feet)
17940
16285
14630
12975
11320
9665
8010
6355
4700
3045
1390
-265
-1920
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)


UW Met Deep Stable Layer
Meridian (AQSID 160010010)
Forecasted at 05/23/2023 Morning
Production Model
1.3km Resolution Model
Deep Stable Layer (%)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
05/20_00
05/20_06
05/20_12
05/20_18
05/21_00
05/21_06
05/21_12
05/21_18
05/22_00
05/22_06
05/22_12
05/22_18
05/23_00
05/23_06
05/23_12
05/23_18
05/24_00
05/24_06
05/24_12
05/24_18
05/25_00
05/25_06
05/25_12
05/25_18
Hour (Local Standard Time)


MODIS AOD & AOD Trajectories on 2023-05-22 20Z
MODIS swath start times: 19.51Z
50°N
45°N
40°N
35°N
30°N
130°W
125°W
120°W
115°W
110°W
105°W
100°W
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
MODIS AOD
0 50 100 150 200 250 300 350 400 450 500
Surface - Trajectory Pressure (mb)

Spreadsheet per Regional Office

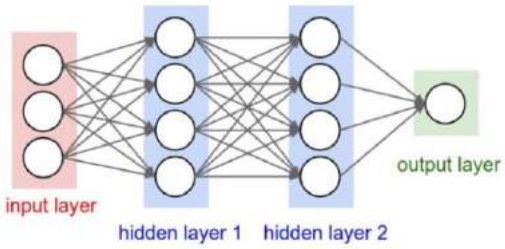


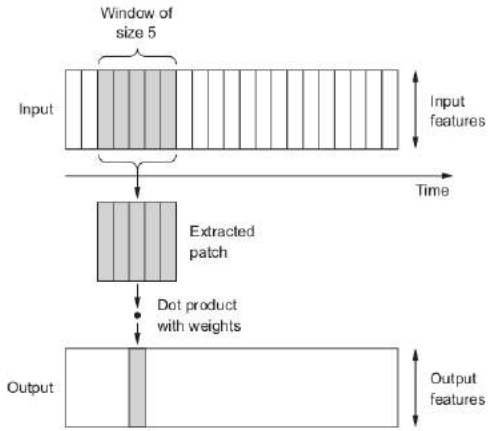


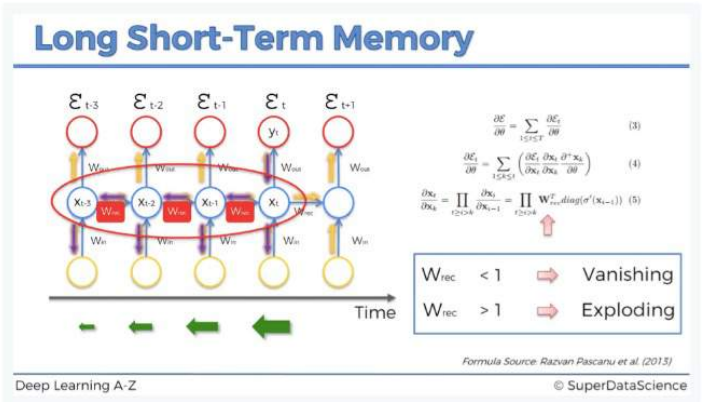
Source : Internet

Neural Network

- Dense Neural Network
- 1D Convolutional Neural Network
- Recurrent Neural Network (LSTM)

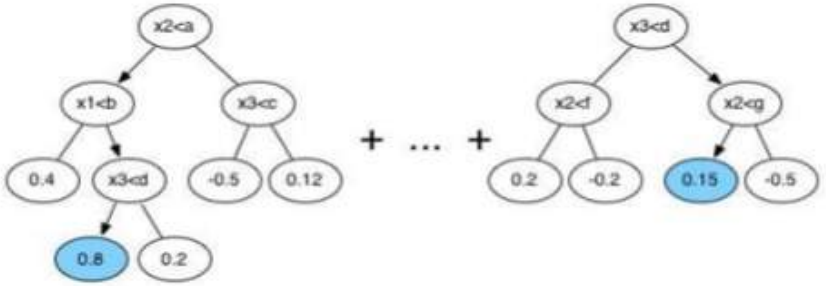


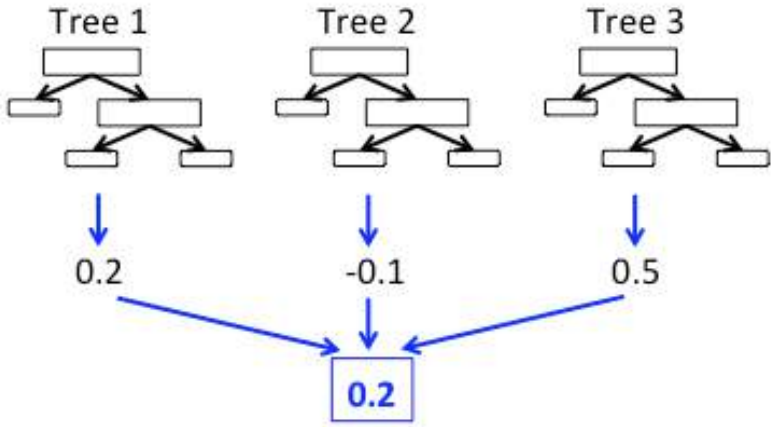


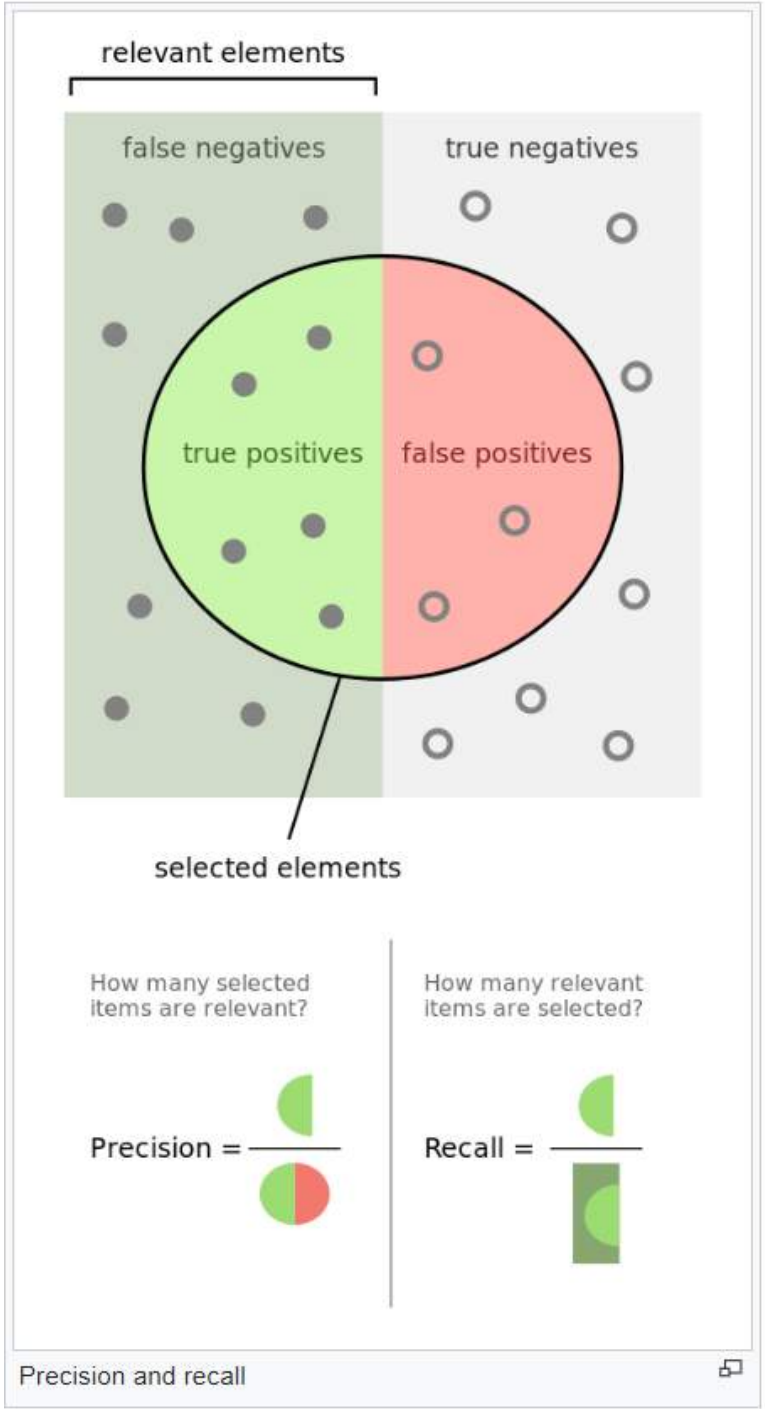


Tree based Methods

- XGBoost
  - XGBoost stands for e**X**treme **G**radient **B**oosting
  - Tree built sequentially by minimizing the residue (error) of the previous tree
- Random Forest
- Boosted Random Forest







Precision
Recall
F1 Score

$$F = 2 \cdot \frac{\mathrm{precision} \cdot \mathrm{recall}}{\mathrm{precision} + \mathrm{recall}}$$

A measure that combines precision and recall is the [harmonic mean](#) of precision and recall, the traditional F-measure or balanced F-score

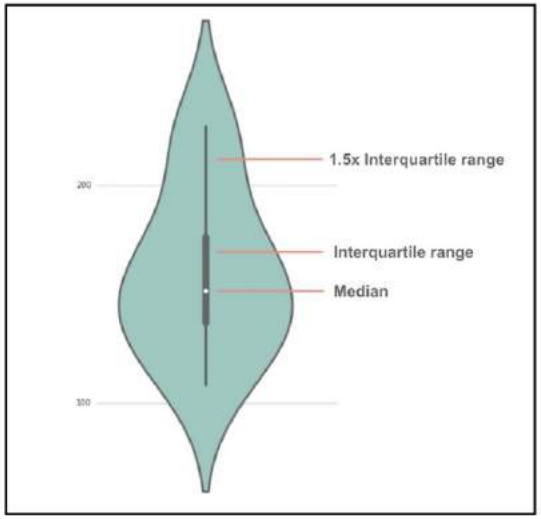
Source : Internet

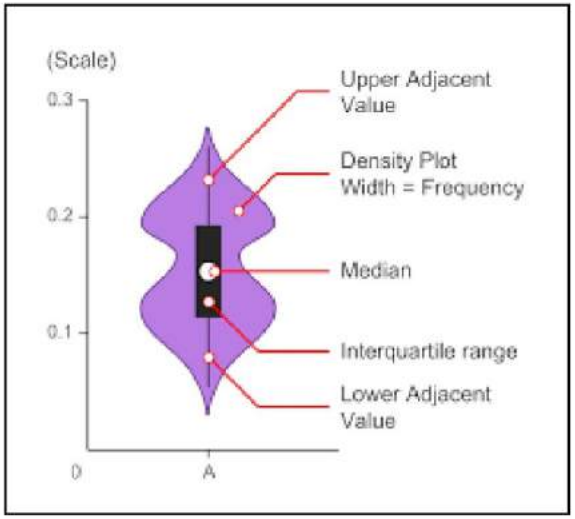
Heidke Skill Score (HSS) and Hanssen-Kuiper Skill Score (KSS)

- HSS represents the accuracy of the model prediction compared with a reference forecast, which is from the random guess that is statistically independent of the observations.
- The range of the HSS is from -inf to 1. A negative value means a random guess is better, 0 means no skill, and 1 means a perfect score.
- KSS measures the ability to separate different categories. The range is from -1 to 1 where 0 means no skill, and 1 means a perfect score.

Violin Plot Explained

Present Distribution of Model Ensemble Member Forecasts





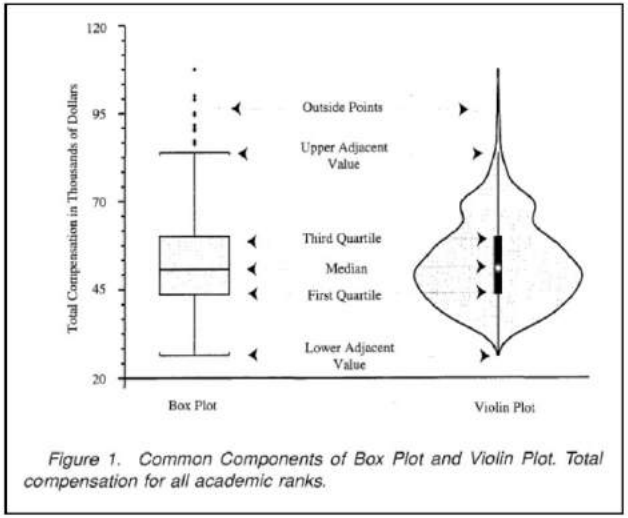
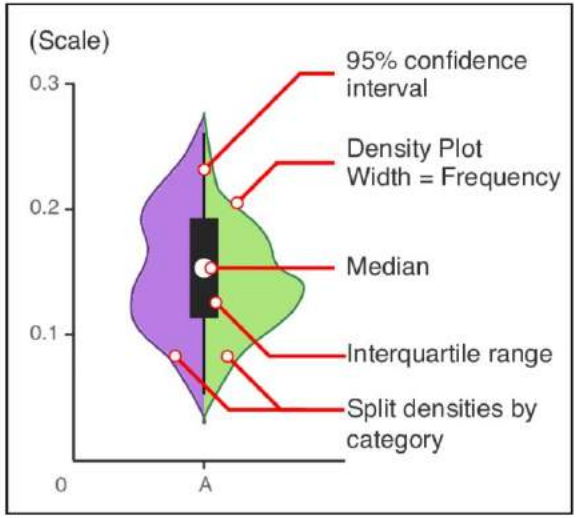


Figure 1. Common Components of Box Plot and Violin Plot. Total compensation for all academic ranks.

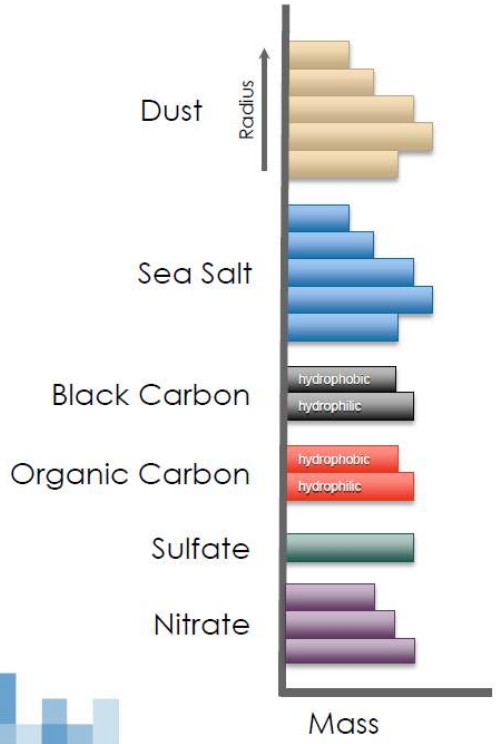


Source : Internet

GOCART

GOCART in GEOS

- Goddard Chemistry, Aerosol, Radiation and Transport Model (GOCART, Chin et al. 2002, Colarco et al. 2010)
- Sources and sinks for 6 non-interactive species
- Radiatively active



Wind and topographic sources, 5 mass bins

Wind-driven source, 5 mass bins

Anthropogenic and wildfire sources, mass hydrophobic & hydrophilic

Anthropogenic, biogenic, and fire sources, mass hydrophobic and hydrophilic

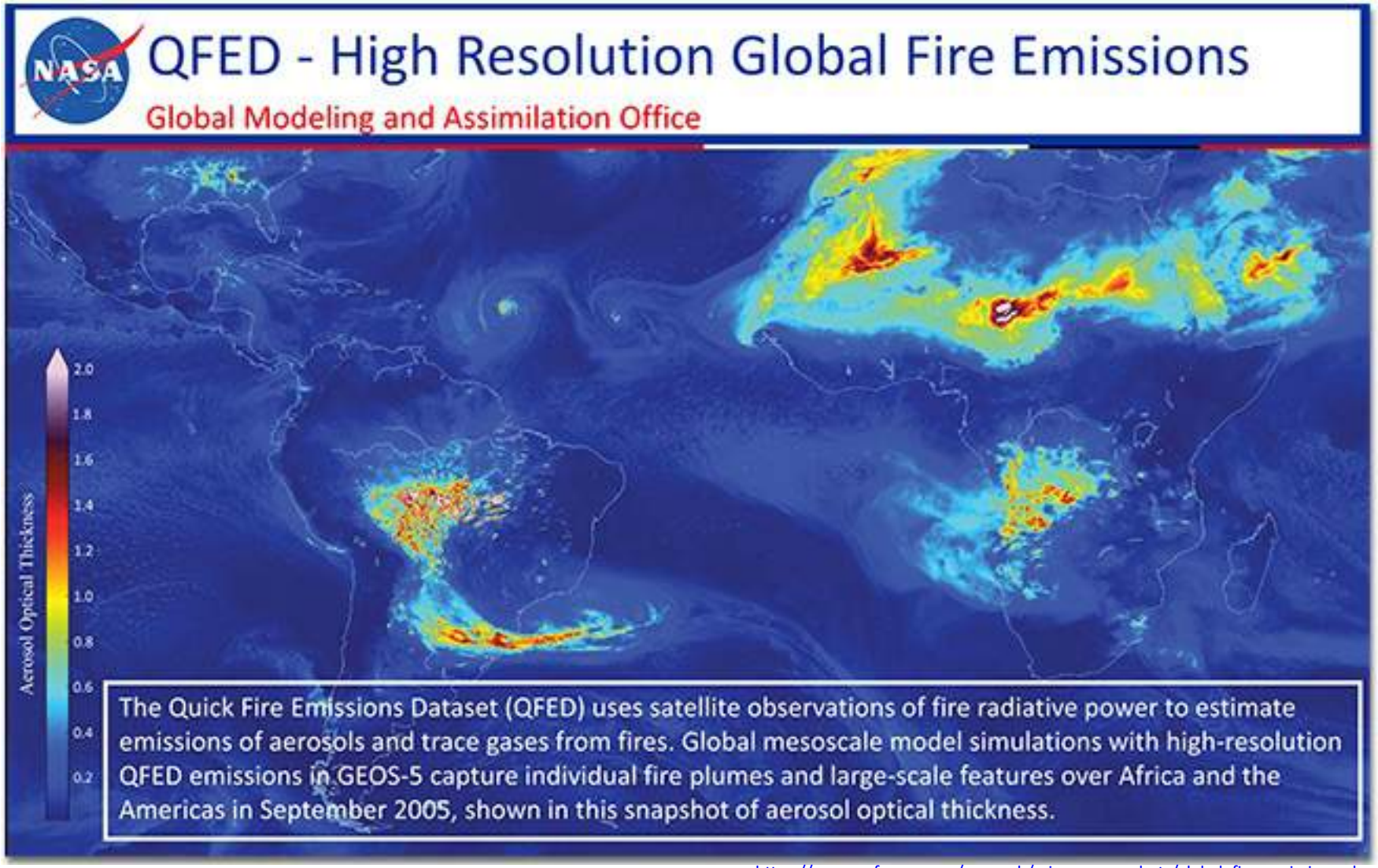
Anthropogenic, wildfire, and volcanic

Anthropogenic and wildfire sources

Future version of GOCART in GEOS FP will include Brown Carbon (BC)

ARSET - Introduction and Access to Global Air Quality Forecasting Data and Tools | NASA Applied Science

QFED - High Resolution Global Fire Emissions



https://gmao.gsfc.nasa.gov/research/science_snapshots/global_fire_emissions.php

Terrain Feature

- Source : Esri
- World Landforms - Improved Hammond Method
- 16 classes of landform types and regions
  - Nearly flat plains
  - Smooth plains with some local relief
  - Irregular plains with moderate relief
  - Irregular plains with low hills
  - Scattered moderate hills
  - Scattered high hills
  - Scattered low mountains
  - Scattered high mountains
  - Moderate hills
  - High hills
  - Tablelands with moderate relief
  - Tablelands with considerable relief
  - Tablelands with high relief
  - Tablelands with very high relief
  - Low mountains
  - High mountains

https://www.arcgis.com/home/item.html?id=cd817a746aa7437cbd72a6d39cdb4559

Wildfire Model Stairs

- Wildfire impact period
- Day time
- Upper end of concentration
- Lessen Data imbalance issue