



**NATIONAL  
WEATHER  
SERVICE**

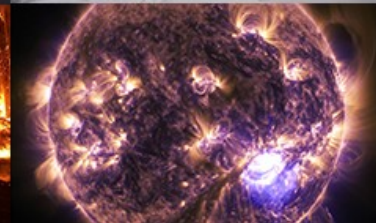
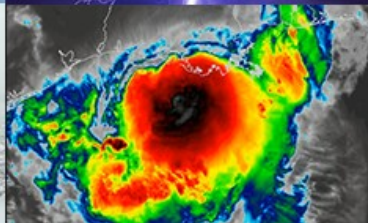
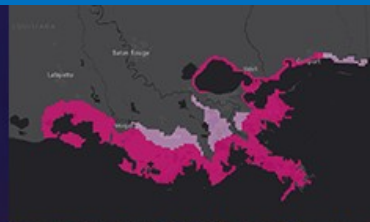
# NOAA Air Quality Program: National Air Quality Forecast Capability

**September 9, 2024**

Youngsun Jung<sup>1</sup> and Jack Kain<sup>1,2</sup>

<sup>1</sup>NOAA/National Weather Service/Office of Science and Technology Integration, <sup>2</sup>IBSS

Thanks to Alex Alder, Shira Francis, and the AQ model development team





# Outline

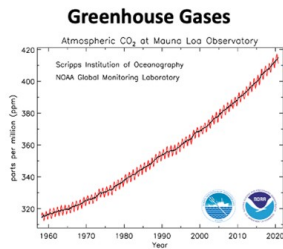
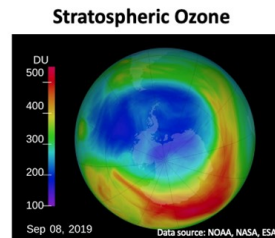
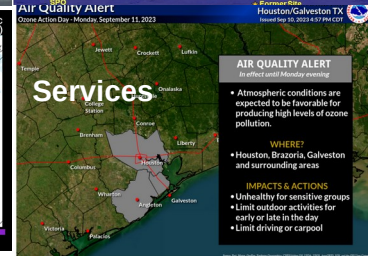
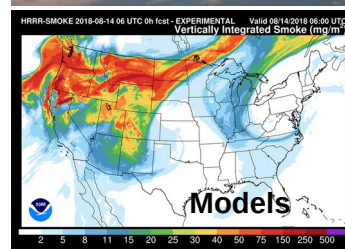
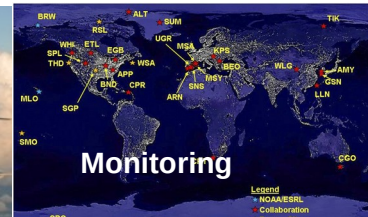


- NOAA's AQ/AC Research and Services
- Overview of NAQFC Program
- Recent Implementations
- Upcoming Model Upgrades
- Phased Transitioning to UFS



# NOAA's mandates for atmospheric composition research, operations, and products

- NOAA has numerous legislative, interagency, and international mandates for its research and operational predictions of atmospheric chemistry and composition for various hazardous weather conditions.
- NOAA's Atmospheric Composition research and operations support the agency's mission to **protect lives and property**.



Adapted from Kopacz et al. (2023)



# National Air Quality Forecast Capability

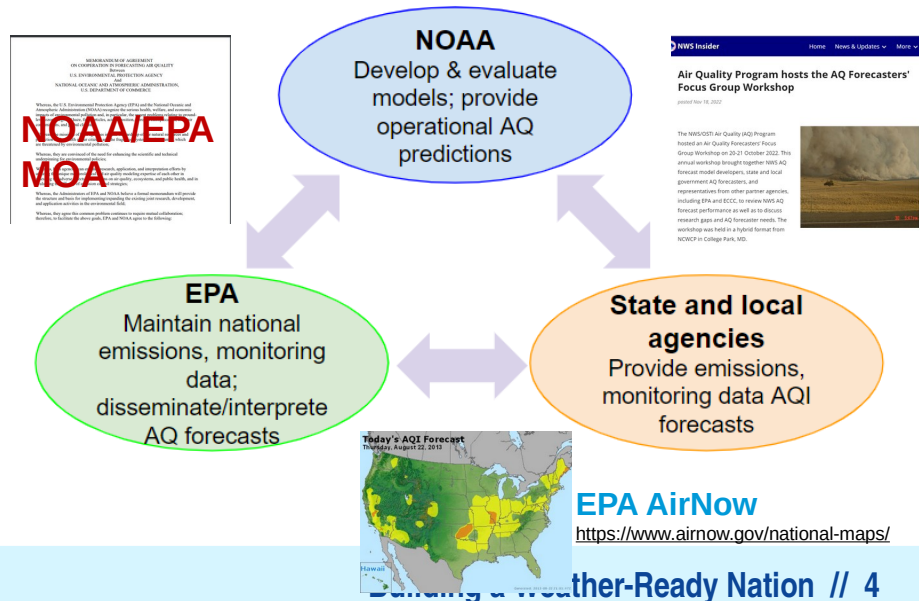
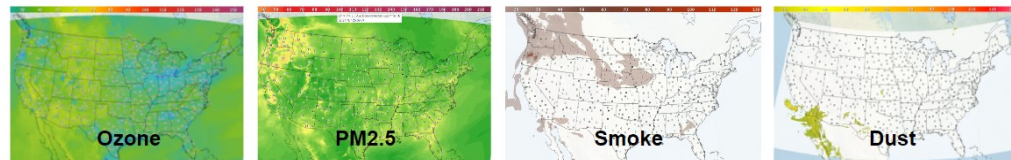
We improve the basis of air quality alerts and provide air quality information to people at risk to further NWS mission of protecting life and property and the enhancement of the national economy.

National Air Quality Forecast Capability (NAQFC) develops and implements operational air quality forecast guidance for the United States.

## Operational Forecast Products (72/48 hours):

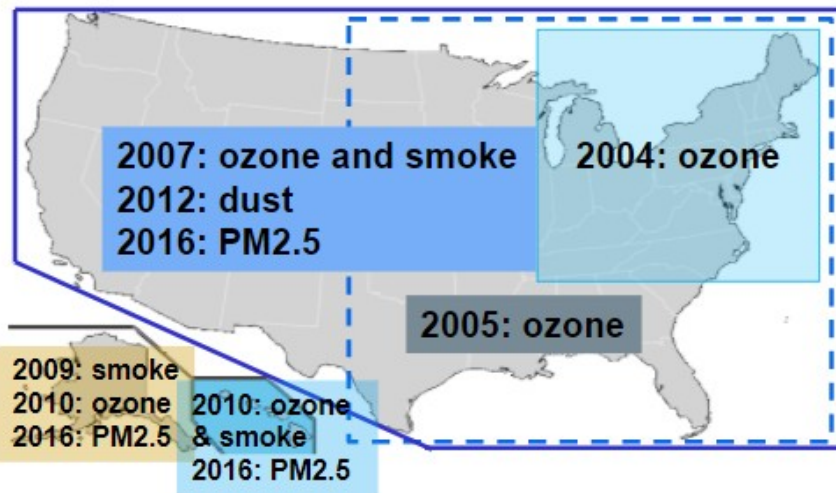
- Ozone nationwide (AQM with CMAQ)
- Fine particulate matter (PM2.5) nationwide (AQM with CMAQ)
- Smoke nationwide (RAP-Smoke)
- Dust over CONUS (HYSPLIT)

Air quality forecasting relies on a strategic partnership with the Environmental Protection Agency (EPA) and state and local air quality forecasters.





# Evolution of NAQFC Product Services



NWS Directives [10-516](#):  
Description on Issuance criteria, Contents,  
Product formats, etc

**2004:** 48-hour forecast guidance for ozone in Northeastern US

**2005:** Extend domain to Eastern US

**2007:** Extend domain to CONUS and add smoke forecast guidance

**2009:** Extend smoke prediction to Alaska

**2010:** Extend ozone prediction to nationwide

**2012:** Implement dust over CONUS

**2016:** Implement raw and bias-corrected PM2.5 predictions nationwide

**2018:** Add bias-corrected ozone in CONUS

**2021:** Extend ozone and PM2.5 forecast lengths to 72 hours



# Operational Models: Global



- GEFS-Aerosol (EMC, ARL, CSL, GSL, STAR)
  - One member of GEFSv12
  - Coupled atmosphere-wave-aerosol
  - Aerosol Optical Depth (AOD), Particulate Matter (PM), PM smaller than  $2.5\ \mu\text{m}$  for up to 5 days
  - Provide LBC to AQM
- Planned upgrade to GEFSv13 in FY26
  - Fully coupled: atmosphere-land-wave-ocean-ice-aerosol
  - Control member

## Long-range transportation of Saharan dust (July 2020)

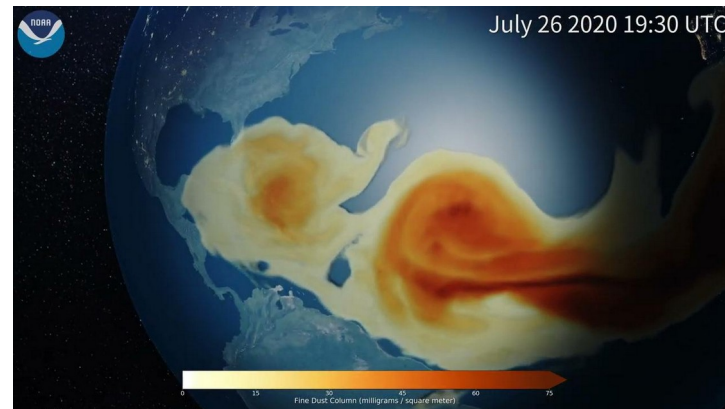


Image credit: Eric Hackathorn, NOAA Global Systems Laboratory

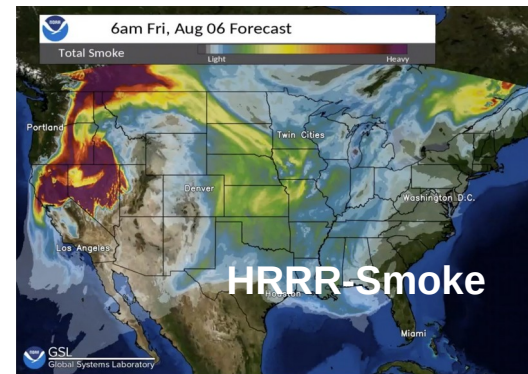
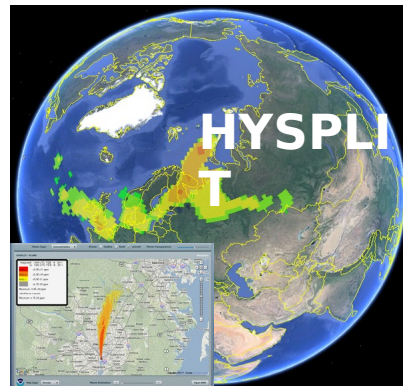
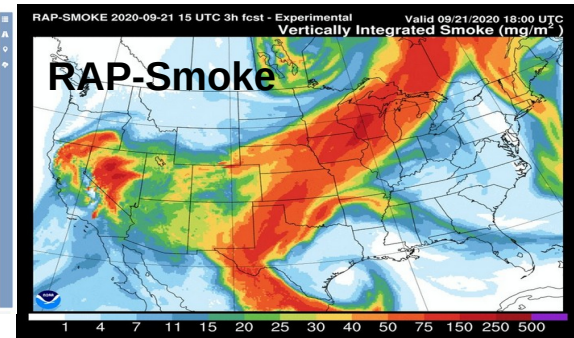
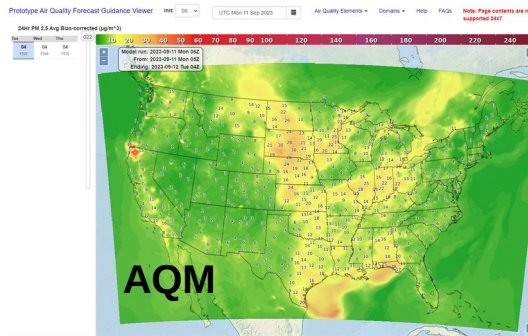




# Operational Models: Regional

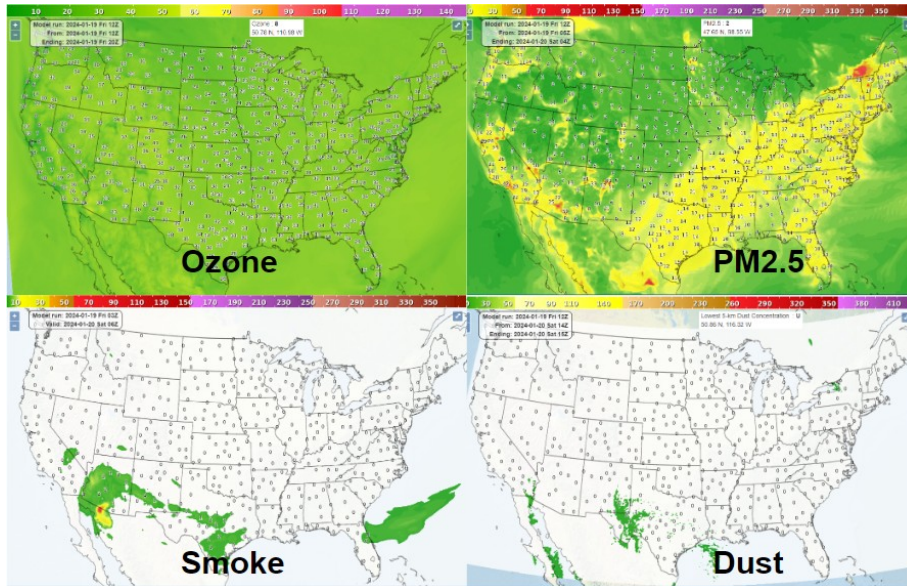


- AQM (EMC, ARL, PSL, STAR)
  - $O_3$  and PM2.5
- HYSPLIT-Dust
- RAP- and HRRR-Smoke
- On-demand HYSPLIT runs for radioactive/chemical events and volcanic ash ensemble

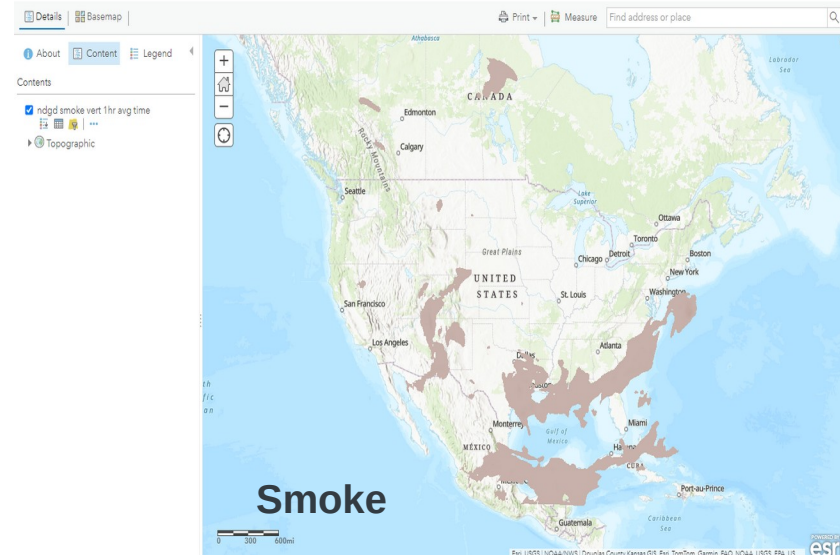


# Graphical Forecasts

NAQFC Graphics on AWS:  
<https://airquality.weather.gov>



GIS data on AWS:  
<https://www.weather.gov/gis/cloudgiswebservices>





# Gridded Binary File

ational Digital Guidance Database (NDGD)

ct Call Sign(s)

(05/30/2007 - 09/09/2023)

ct WMO Header(s) (sort by - WMO Header(s) / Description)

M - Administrative Messages

ct Start Date (YYYY/MM/DD)

13 / 09 / 09

ct End Date: (YYYY/MM/DD)

13 / 09 / 09

very Destination: FTP

mit Batch (skip file selection)? ☐ Yes ☒ No

il Address

Important Notes:

your data request will contain more than 2,000 files, you must select "Yes" the Submit Batch option above.  
here is a data volume limit of 250 Gigabytes per request.

ceed With Order

Reset Form

AWS S3 Explorer noaa-nws-naqfc-pds

Hide folder

50 entries per page

Object	Last Modified
AQMv5/	
AQMv6/	
AQMv7/	
Dust/	
Smoke/	
temp/	

Showing 1 to 6 of 6 entries

UVI (Ultraviolet Index)	daily	-	https	-
Regional Models				
ObsProc (Observations Processing)	variable	-	https	-
AQM Daily Maximum	06Z, 12Z	grib filter	https	OpenDAP
AQM Hourly Surface Ozone	06Z, 12Z	grib filter	https	OpenDAP
HIRESW Alaska	06Z, 18Z	grib filter	https	OpenDAP
HIRESW CONUS	00Z, 12Z	grib filter	https	OpenDAP
HIRESW Guam	00Z, 12Z	grib filter	https	OpenDAP
HIRESW Hawaii	00Z, 12Z	grib filter	https	OpenDAP
HIRESW Puerto Rico	06Z, 18Z	grib filter	https	OpenDAP
HREF Alaska	06Z, 18Z	grib filter	https	-
HREF CONUS	00Z, 12Z	grib filter	https	-
HREF Hawaii	00Z, 12Z	grib filter	https	-
HREF Puerto Rico	06Z, 18Z	grib filter	https	-
HRRR	hourly	grib filter	https	OpenDAP
HRRR Sub Hourly	hourly	grib filter	https	-

## NCEP Products Inventory

Air Quality Model (AQM) Products

Updated: 06/10/2021

Information about AQM Products

CC is the model cycle runtime (i.e. 00, 06, 12, 18)

FF is the model forecast time from 01-72

The Inventory links contain detailed model information.

Use as a guide when selecting specific parameters from NOMADS through the grib filter option

INVENTORY			Availability on NCEP FTP SERVER and NOMADS	Availability on NWS FTP SERVER
AQM				
Description	Filename	Inventory		
1hr Avg Ozone Conc	aqm.tCCz_ave_1hr_o3_227.grib2	FH		
8hr Avg Ozone Conc	aqm.tCCz_ave_8hr_o3_227.grib2	FH		
Daily Max from 1hr Ozone Conc	aqm.tCCz_max_1hr_o3_227.grib2	FH		
Daily Max from 8hr Ozone Conc	aqm.tCCz_max_8hr_o3_227.grib2	FH		
1hr Avg Ozone Conc (biased cor)	aqm.tCCz_ave_1hr_o3_bc_227.grib2	FH		
8hr Avg Ozone Conc (biased cor)	aqm.tCCz_ave_8hr_o3_bc_227.grib2	FH		
Daily Max from 1hr Ozone Conc (biased cor)	aqm.tCCz_max_1hr_o3_bc_227.grib2	FH		
Daily Max from 8hr Ozone Conc (biased cor)	aqm.tCCz_max_8hr_o3_bc_227.grib2	FH		
1hr Avg Particulate Matter	aqm.tCCz_ave_1hr_pm25_227.grib2	FH		
Daily Avg Particulate Matter	aqm.tCCz_ave_24hr_pm25_227.grib2	FH		
1hr Avg Particulate Matter (biased cor)	aqm.tCCz_ave_1hr_pm25_bc_227.grib2	FH		
Daily Avg Particulate Matter (biased cor)	aqm.tCCz_ave_24hr_pm25_bc_227.grib2	FH		
Daily Max from 1hr Particulate Matter	aqm.tCCz_max_1hr_pm25_227.grib2	FH		

GRI2 via ftp

GRI2 via https

Binary Format

## GRIB2 format

## NOAA Operational Model Archive and Distribution System (NOMADS) :

<https://nomads.ncep.noaa.gov/>

## TGFTP:

<https://www.nco.ncep.noaa.gov/pmb/products/aqm/>

## NOAA Open Data Dissemination (NODD)

<https://noaa-nws-naqfc-pds.s3.amazonaws.com/index.html>

## Historical database (National Digital Guidance Database):

[https://www.ncei.noaa.gov/has/HAS.FileAppRouter?datasetname=9950\\_01&subqueryby=STATION&applname=&outdest=FILE](https://www.ncei.noaa.gov/has/HAS.FileAppRouter?datasetname=9950_01&subqueryby=STATION&applname=&outdest=FILE)



Local forecast by  
"City, ST" or ZIP code

Enter location ...

Go

[Location Help](#)Customize  
Your  
Weather.gov

City, ST

Enter Your City, ST or  
ZIP Code☐ Remember Me

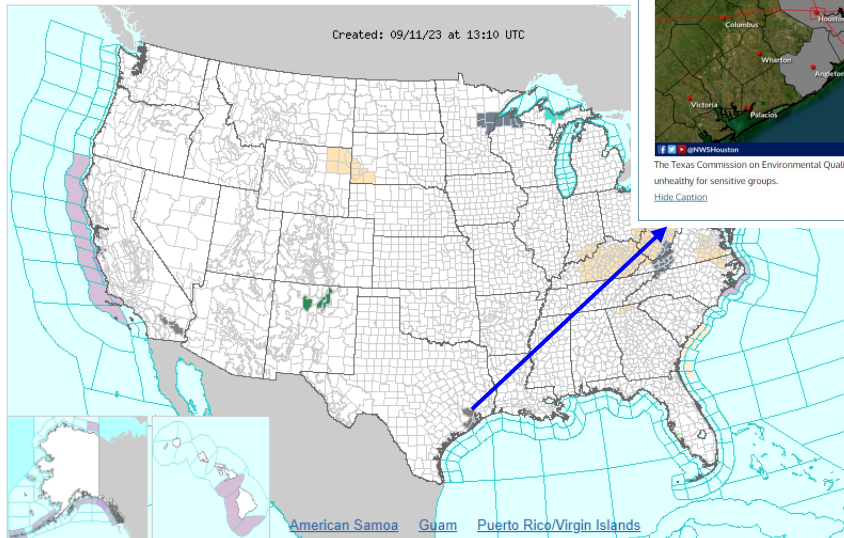
Get Weather

[Privacy Policy](#)

## Heavy Rainfall Potential; Monitoring Hurricane Lee

A frontal boundary along the East Coast, Gulf Coast into the Four Corners Region will focus shower could be locally heavy across these regions through the middle of the week. Hurricane Lee continue to the north of Puerto Rico. Dangerous surf and rip currents are expected along most of the U.S. Ea in size. [Read More >](#)

ACTIVE ALERTS FORECAST MAPS RADAR RIVERS, LAKES, RAINFALL AIR QUALITY SA

Click on the map above for detailed alerts or [Warnings By State](#)  [Public Alerts in XML/CAP v1.2 and ATOM Formats](#)

Hurricane Warning  
Tropical Storm Warning  
Flood Warning  
Gale Warning

Heat Advisory  
High Surf Advisory  
Dense Fog Advisory  
Small Craft Advisory

Rip Current Statement  
Beach Hazards Statement  
Flood Watch  
Special Weather Statement

Marine Weather  
**Air Quality Alert**

Current Hazards Current Conditions Radar Forecasts Rivers and Lakes Climate and Past Weather Local Programs

Air Quality Alert

Today

Tonight

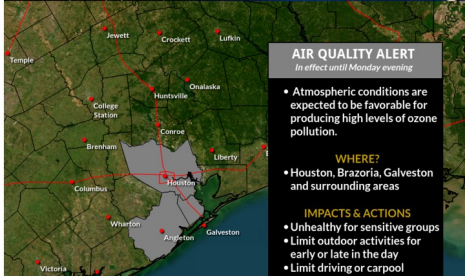
Five Day Outlook

## Air Quality Alert

Ozone Action Day - Monday, September 11, 2023

Weather Forecast Office  
Houston/Galveston TX

Issued Sep 10, 2023 4:57 PM CDT



@NWSHouston

weather.gov/hg

The Texas Commission on Environmental Quality has issued an Ozone Action Day for Monday, Air quality may be unhealthy for sensitive groups.

[Hide Caption](#)

## Alerts and Warnings



National Weather Service

Watches, Warnings &amp; Advisories

Local weather forecast by "City, ST" or zip code City, ST 

## Air Quality Alert

TXZ213-237-238-313-337-338-437x439-120100-

Air Quality Alert Message

Texas Commission on Environmental Quality

Relayed by National Weather Service Houston/Galveston TX

348 PM CDT Sun Sep 10 2023

...Ozone Action Day...

The Texas Commission on Environmental Quality (TCEQ) has issued an Ozone Action Day for the Houston, Galveston, and Brazoria area for Monday, September 11, 2023.

Atmospheric conditions are expected to be favorable for producing high levels of ozone pollution in the Houston, Galveston, and surrounding areas on Monday. You can help prevent ozone pollution by sharing a ride, walking, riding a bicycle, taking your lunch to work, avoiding drive through lanes, conserving energy and keeping your vehicle properly tuned.

For more information on ozone:

Ozone: The Facts [www.tceq.texas.gov/airquality/monops/ozonefacts.html](http://www.tceq.texas.gov/airquality/monops/ozonefacts.html)EPA AirNow: [www.airnow.gov/?city=Houston&state=TX&country=USA](http://www.airnow.gov/?city=Houston&state=TX&country=USA)

Take Care of Texas:

[www.takecareoftexas.org/conservation-tips/keep-our-air-clean](http://www.takecareoftexas.org/conservation-tips/keep-our-air-clean)

55

CAZ061-065-111400-  
Coachella Valley-San Geronimo Pass Near Banning-  
Including the cities of Indio, Palm Springs, Cathedral City,  
Palm Desert, Palm Desert Country, La Quinta, and Coachella  
152 PM PDT Sat Sep 9 2023

...AIR QUALITY ALERT DUE TO ELEVATED PARTICULATE MATTER LEVELS FROM

Buildi



# Air Quality Forecasters Workshop



**Date:** 12-13 October 2023

**Cadence:** Annual



**Location:** College Park, MD



**Purpose:** Bring together NWS AQ forecast model developers, state and local government AQ forecasters, and representatives from other partner agencies to review NWS AQ forecast performance as well as to discuss research gaps and AQ forecaster needs.



## Workshop Summary:

<https://vlab.noaa.gov/web/osti-modeling/aq-workshop-2023-summary>



## AQ WORKSHOP 2023 SUMMARY



*Workshop in-person attendees (October 2023)*

The National Oceanic and Atmospheric Administration National Weather Service (NOAA/NWS), under its air quality program, the National Air Quality Forecast Capability (NAQFC), hosted the annual Air Quality Forecasters' Focus Group Workshop on October 12-13, 2023. The NAQFC develops and implements operational air quality (AQ) prediction models to provide AQ forecast guidance for forecasters employed by local and state agencies. These agencies disseminate the forecasts to the public through NWS Forecast Offices and other outlets. This annual workshop provides a unique opportunity for AQ forecasters to share their experiences as end users of model guidance with model developers and AQ researchers from NOAA, the Environmental Protection Agency (EPA), and Environment and Climate Change Canada (ECCC). The purpose of the workshop is to review assessments of the strengths and weaknesses of the AQ model guidance, examine current model development and research initiatives, and use forecaster feedback to identify gaps and/or misalignment between model performance, current R&D initiatives, and forecasters' needs.

The workshop was conducted in a hybrid format, with 76 total participants, including 24 in-person attendees. It consisted of 4 distinct sessions. The first session included presentations on current methods and capabilities within the NWS, highlighting the meteorological and air-chemistry components of the operational AQ modeling systems, objective assessments of performance,



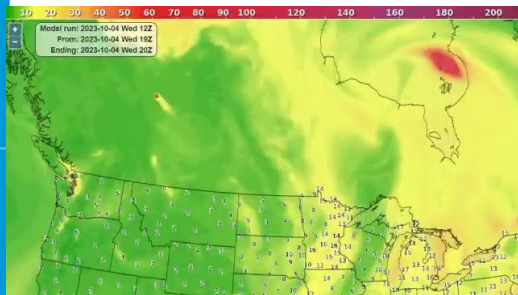




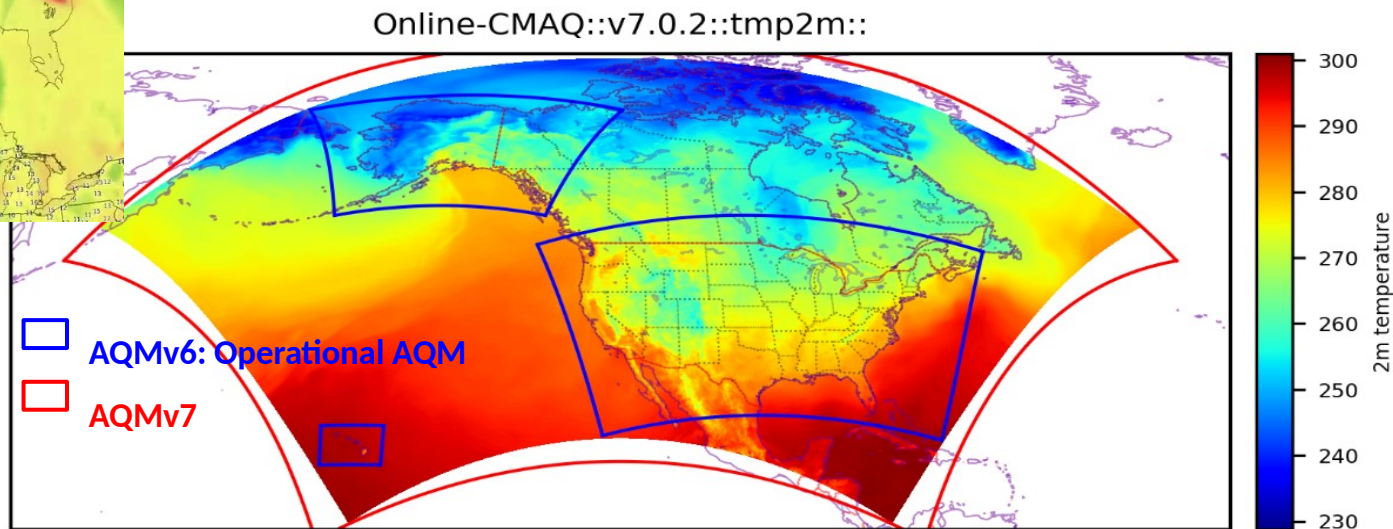
# AQM v7.0.7 Implementation (May 2024)



- Implemented on May 14, 2024
- First **online-coupled weather and chemistry model** in NOAA
- 13-km grid spacing over north America
- High-resolution hourly Regional ABI and VIIRS fire Emissions (**RAVE**)
- Sofiev plume-rise algorithm
- Updated LBC (AM4+GEFS-Aerosols) and wet deposition
- Fengsha dust module
- [Public Information Statement](https://www.weather.gov/notification/) (<https://www.weather.gov/notification/>)



Smoke intrusion from  
wildfires in Canada  
(Oct. 2023)



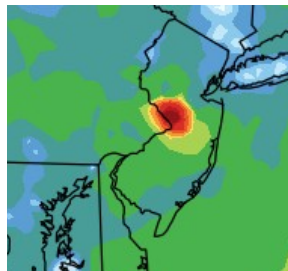
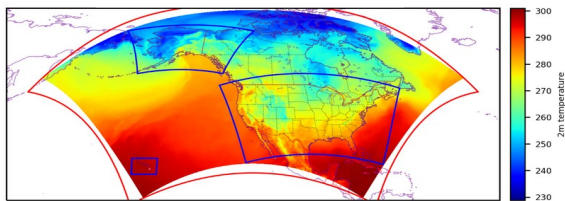




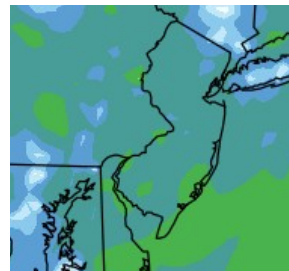
# AQM v7.0.8 Implementation (Oct 2024)



- “Non-Science” update, compelled by upgrades in RAVE\* fire emissions input data, also including these “changes of opportunity”:
  - Fix POC (primary organic carbon) emissions for wildfire and point sources
  - Fix to snow cover related dust emissions
  - Fix BC code for intermittently missing data from obs sites



BC code  
Bulls-eye fix



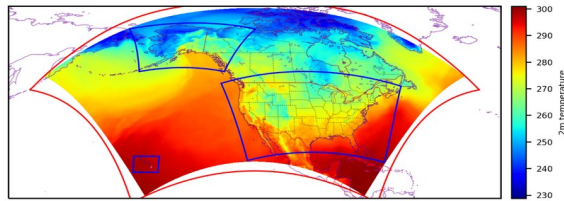
**\*RAVE = Regional Hourly Advanced Baseline Imager (ABI) and Visible Infrared Imaging Radiometer Suite (VIIRS) Emissions product**

- RAVEv2 upgrades:
  - changed primary satellite source from JPSS NOAA-20 to NOAA-21
  - Correct terrain-related parallax in ABI fire product
  - Application of calibrated scaling factors for PM2.5, black carbon and organic carbon



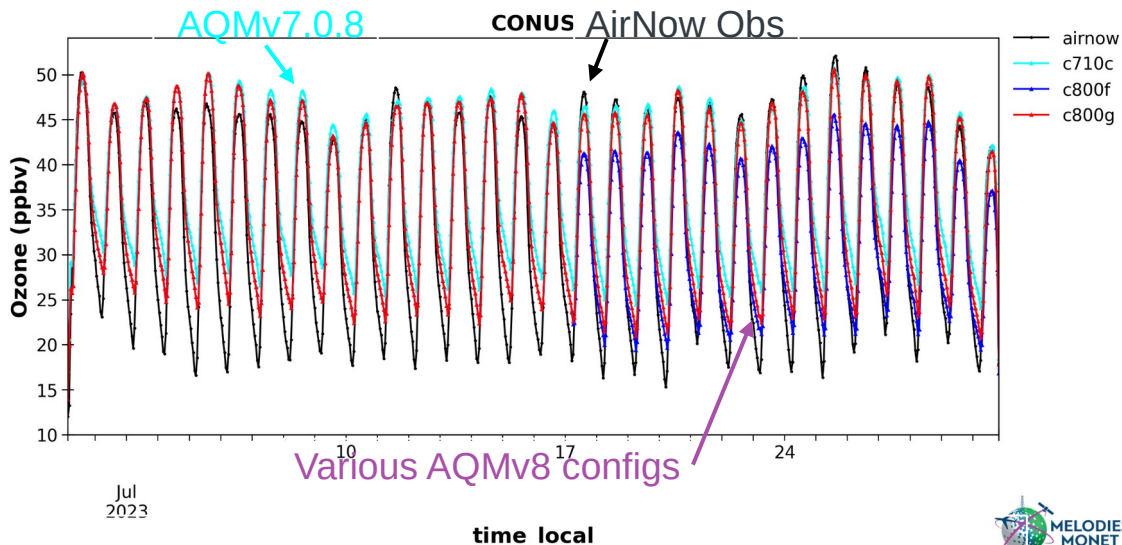


# AQM v8.0: Targeting December 2025 Implementation



## Planned Major Upgrades:

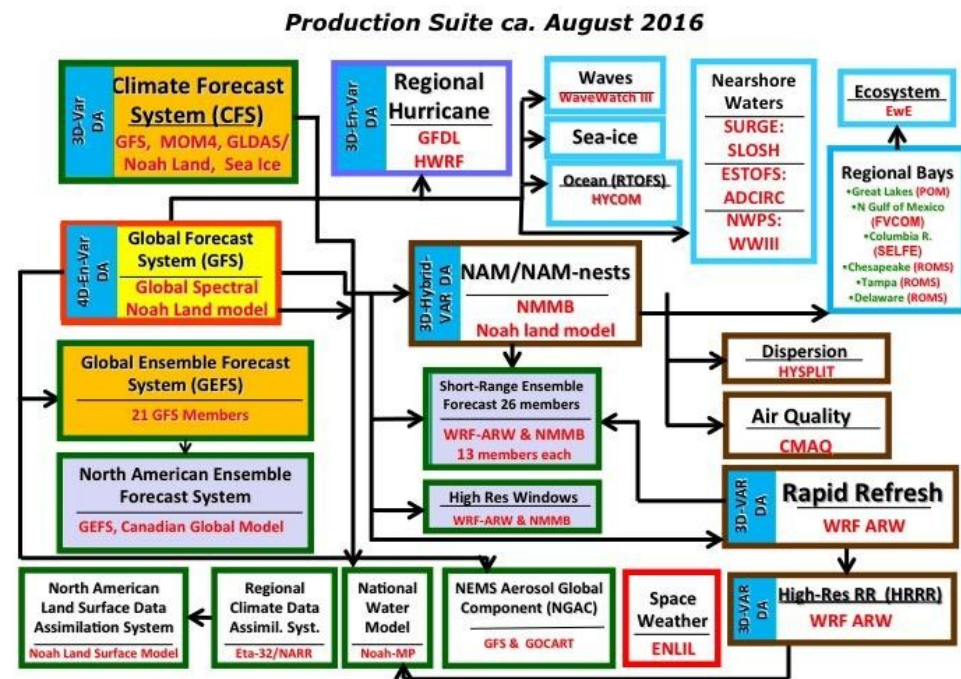
1. Resolution: 13km => 9km dx
2. UFS-Atmosphere model: GFSv16 => GFSv17
3. EPA air chemistry model: CMAQ v5.2 => CMAQ 5.4
4. National Emission Inventory (NEI): 2016 => 2019 base year
5. Bias correction code: Short training period for PM2.5?
6. Dust module calibration



## Prelim Results: Month of August 2023



# Simplifying NCEP Production Suites

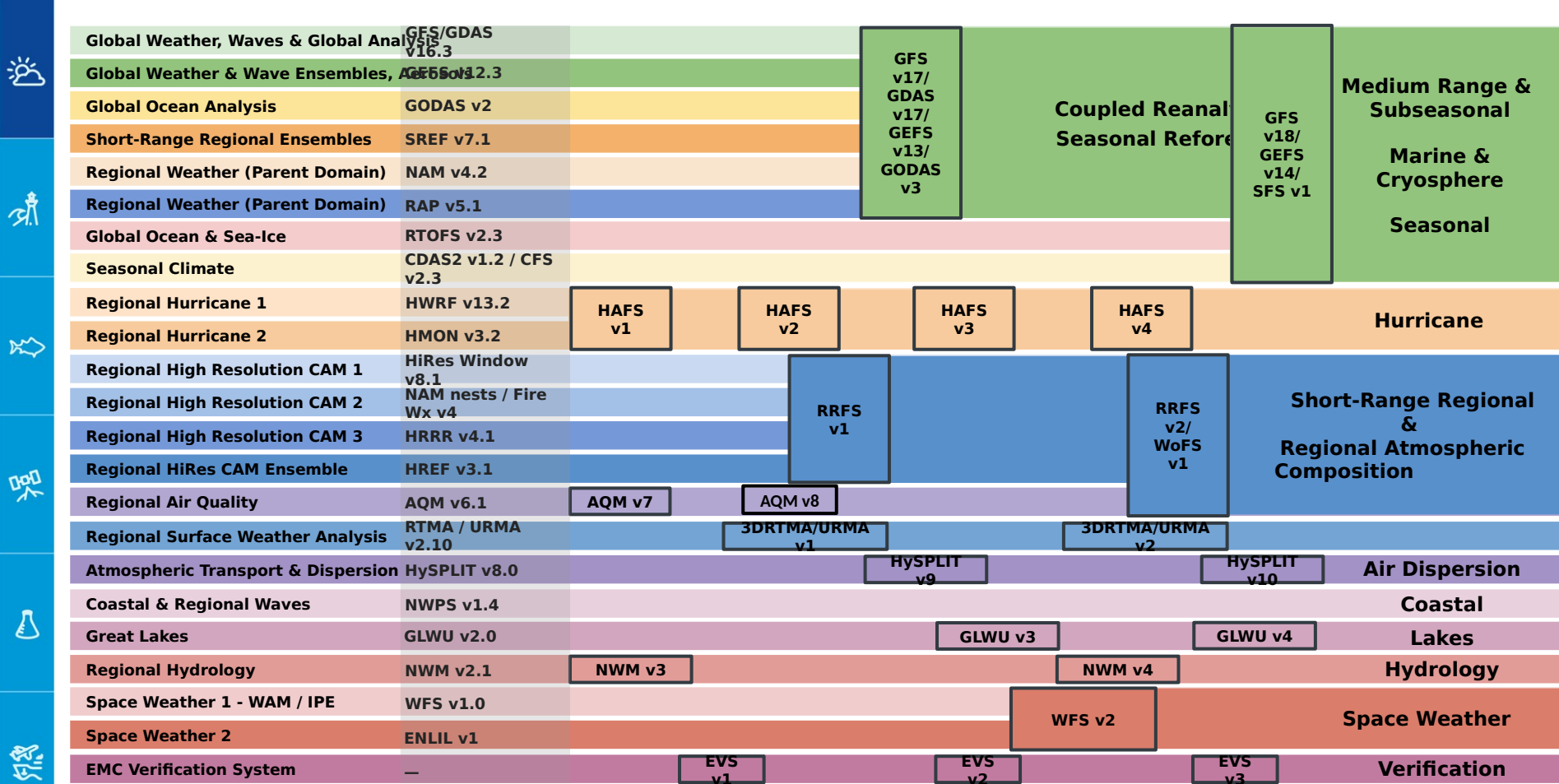


Courtesy Bill Lapenta

NCEP Modeling reviews by the UCAR Community Advisory Committee for NCEP (UCACN), 2015 - 2017: “Reduce the complexity of the NCEP Production Suite.”, “a unified, collaborative strategy for model development” and “better leverage the capabilities of the external community”

UCACN Reports (2015, 2016, 2017):  
<https://ufscommunity.org/documents/repository/>

→ Unified Forecast System (UFS):  
 community-based, fully-coupled,  
 comprehensive Earth Modeling System



## EMC Migration Plan to UFS-based Modeling Suites





# Transitioning to UFS



- RRFS-Smoke and Dust (RRFS-SD)
  - 3-km resolution smoke and dust forecast capability
  - Outperformed HRRR-smoke for many smoke cases
  - To be implemented in the RRFSv1 control member
- AQM to be merged to RRFSv2
  - Control member of RRFSv2 at 3-km resolution
  - Challenges:
    - available computational resources

