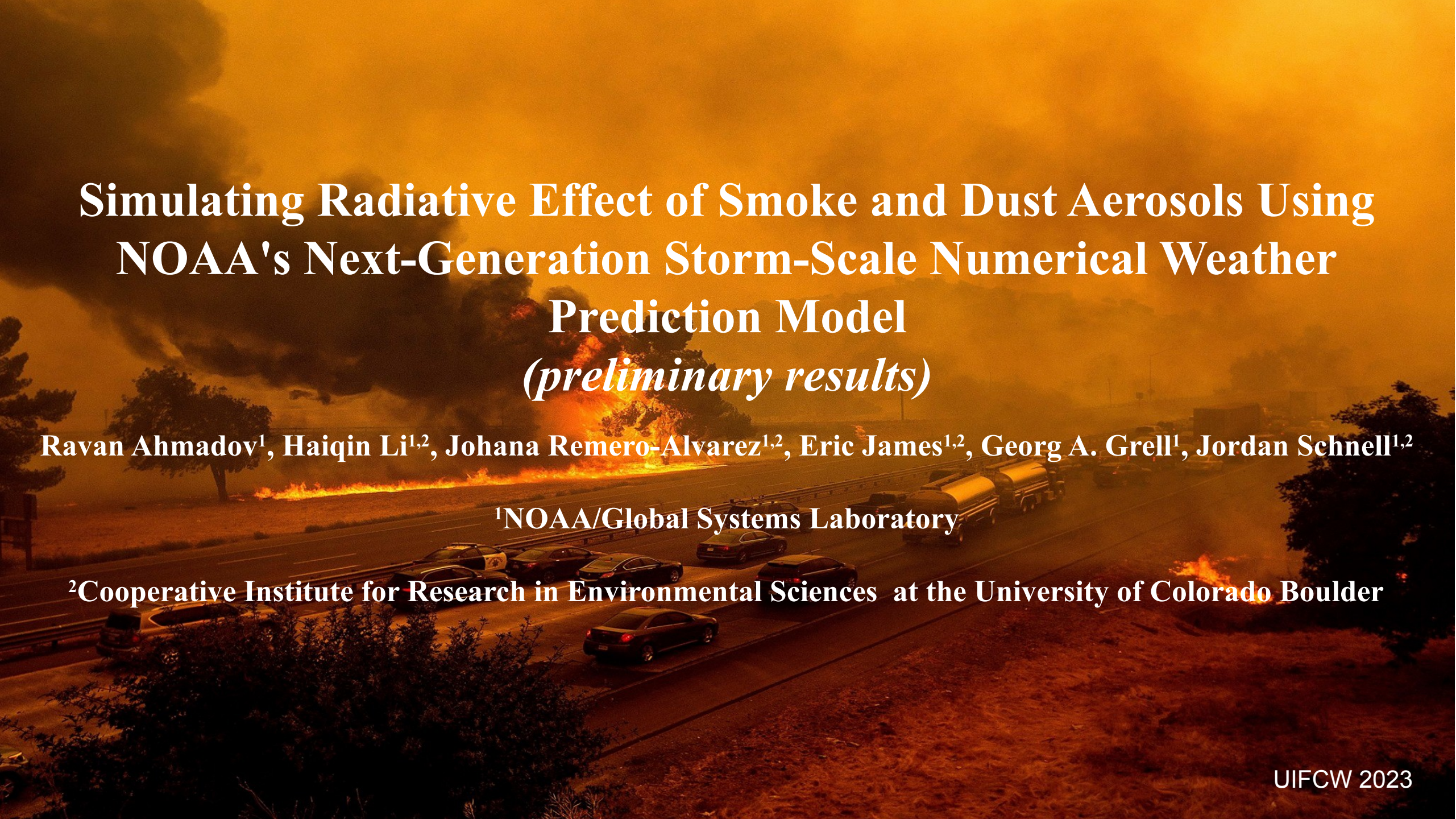

Simulating Radiative Effect of Smoke and Dust Aerosols Using NOAA's Next-Generation Storm-Scale Numerical Weather Prediction Model

(preliminary results)

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[2]Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder

UIFCW 2023

3.1 An introduction to the Rapid Refresh Forecast System - Smoke and Dust (RRFS-SD)

- **The host model: Rapid Refresh Forecast System (RRFS)**

-- dynamics core: Finite Volume Cubed-Sphere (FV3)

-- physics: Common Community Physics Package (CCPP) FV3 HRRR physics suite (MYNN PBL, Thompson microphysics, RUC LSM)

- **Coupling smoke and dust modules into RRFS through CCPP**

-- Plume rising: 1D cloud model is used to calculate injection heights and plume rise emission rates

-- Fire Emission: hourly Advanced Baseline Imager and Visible Infrared Imaging Radiometer Suite Emissions (RAVE)

-- Dust: FENGSHA dust scheme

-- Sea-salt: NASA GEOS-5 GOCART sea salt scheme

-- Fire Weather Index: Hourly Wildfire Potential diagnostic output

- **This is a simple aerosol model with 3 tracers of smoke, fine dust and coarsepm. Anthropogenic and biogenic emissions, gas or aerosol chemistry are NOT included.**

3.2 The method of direct and indirect feedback in RRFS-SD

- **In the global and regional scale NOAA United Forecast System (UFS) Weather Models, the MERRA2 climatology (2003-2013) is used as the background aerosols for the radiation process.**
- **We add the smoke and dust from RRFS-SD on top of the MERRA2 climatology for radiation.**
- **The same approach of aerosol indirect feedback in global modeling is also applied in RRFS-SD.**

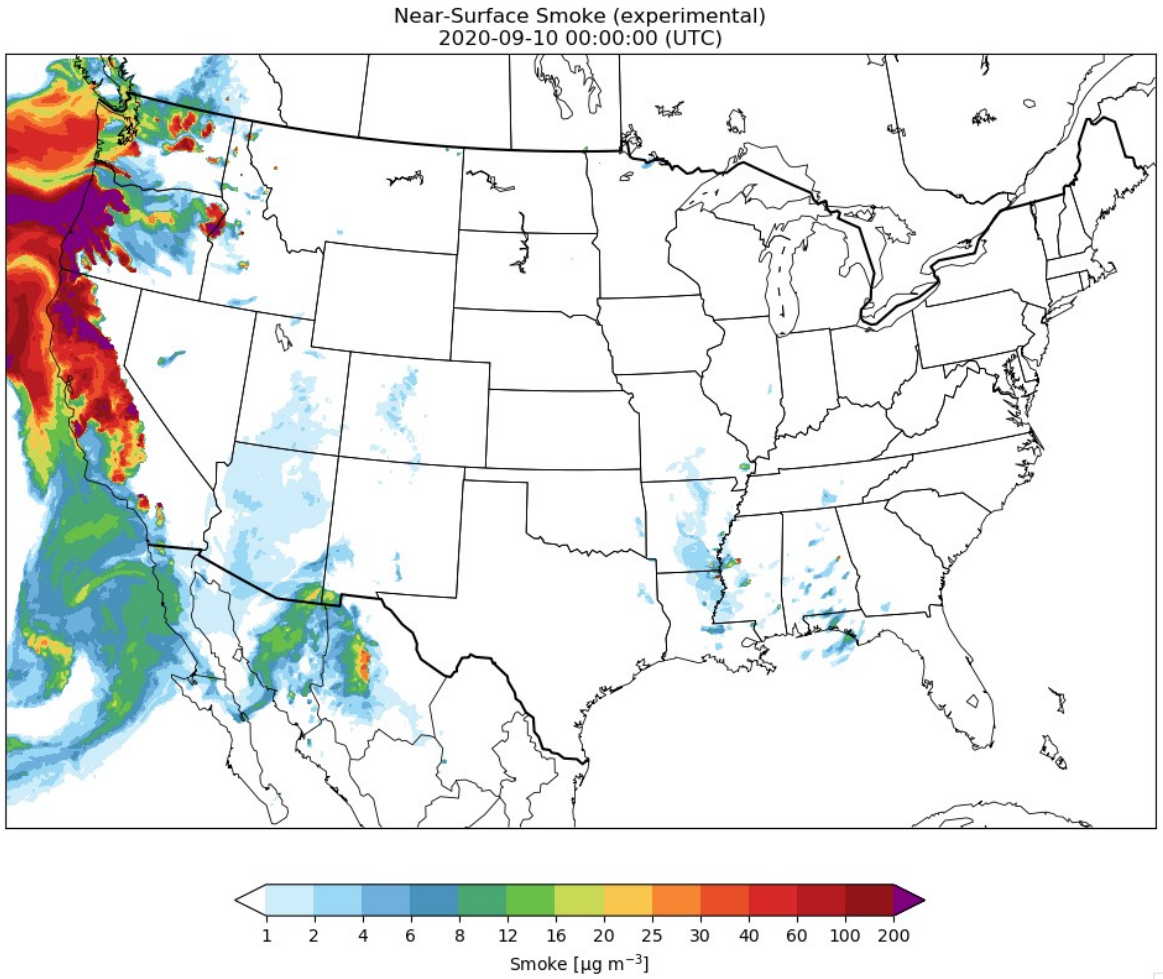
3.3 Experimental design of aerosol direct/indirect feedback in RRFS-SD

	CTL	fdb_dir	fdb_indir
Smoke/dust direct feedback to radiation	NO	YES	NO
Smoke/dust indirect feedback to cloud physics	NO	NO	YES
physics	FV3 HRRR physics suite	FV3 HRRR physics suite	FV3 HRRR physics suite
RRFS Initial/Boundary Conditions	Rapid Refresh (RAP) Analysis (2020090100~2020091523)	Rapid Refresh (RAP) Analysis (2020090100~2020091523)	Rapid Refresh (RAP) Analysis (2020090100~2020091523)
RRFS domain	Contiguous United States (CONUS)	Contiguous United States (CONUS)	Contiguous United States (CONUS)
Horizontal resolution	3km	3km	3km
Vertical resolution	64 layers	64 layers	64 layers
Integration length	24h with hourly output	24h with hourly output	24h with hourly output
Smoke/dust start	Cold-start cycling (smoke & dust are cycled)	Cold-start cycling (smoke & dust are cycled)	Cold-start cycling (smoke & dust are cycled)

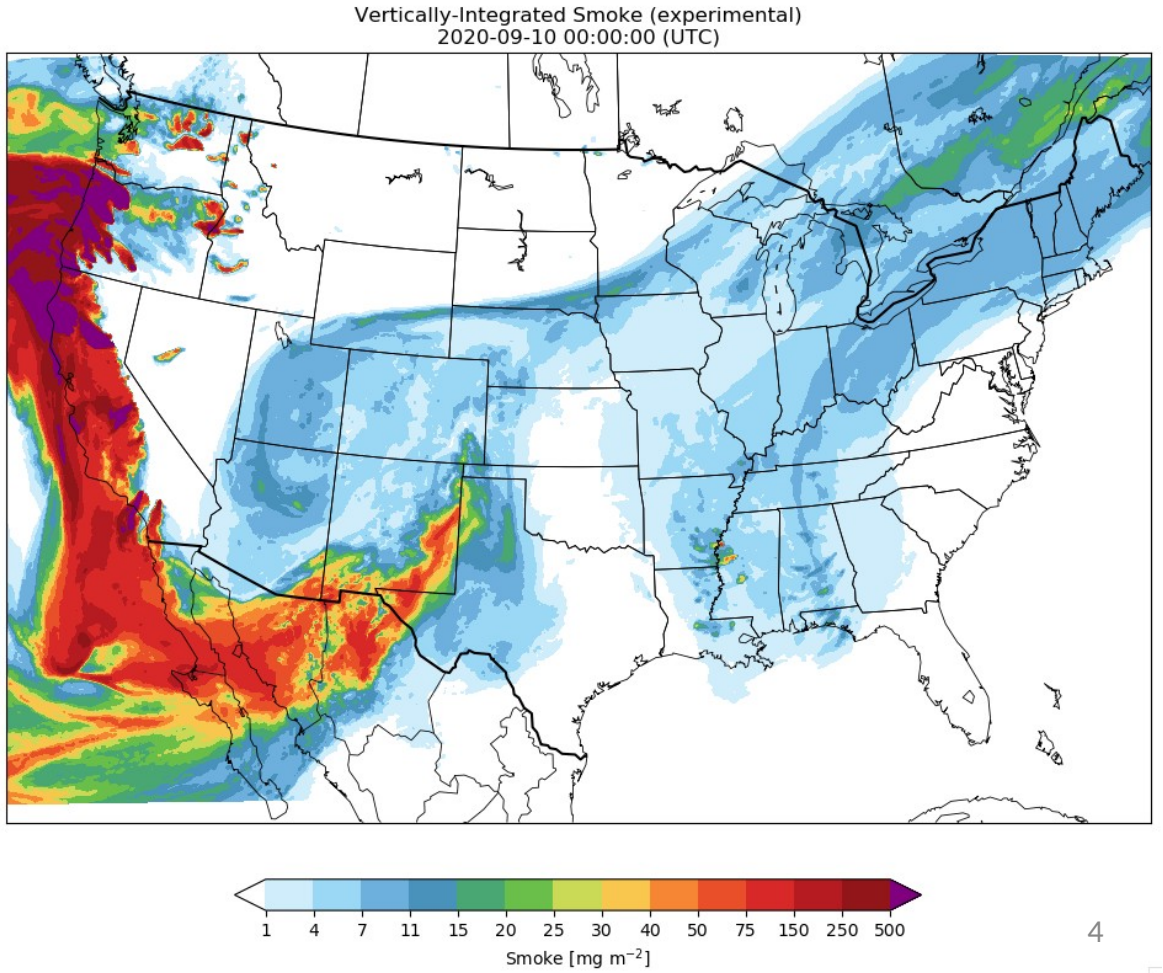
RRFS-Smoke simulation on the 3km resolution CONUS domain

September 10, 2020

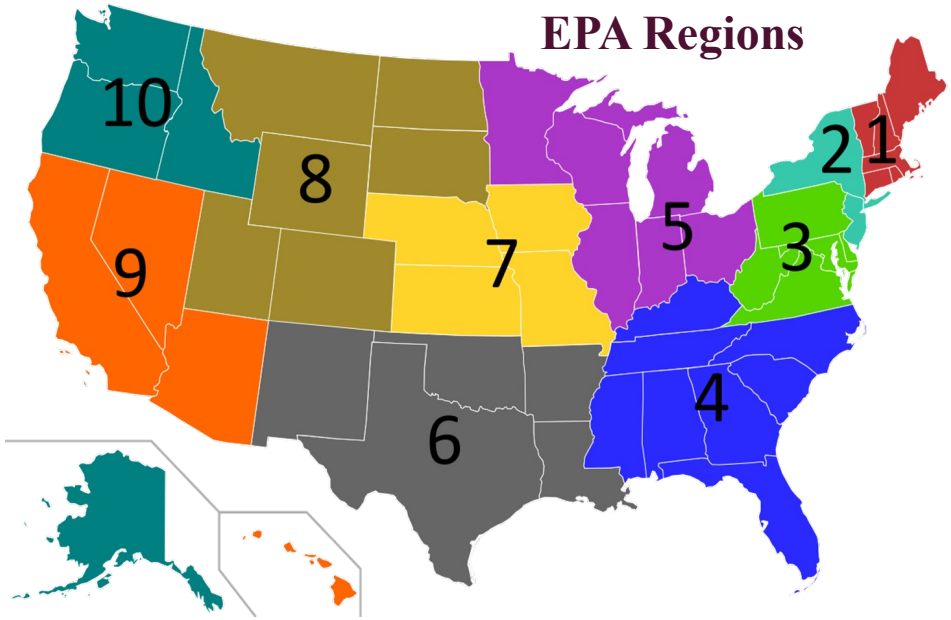
Near-Surface Smoke (ug m^{-3})

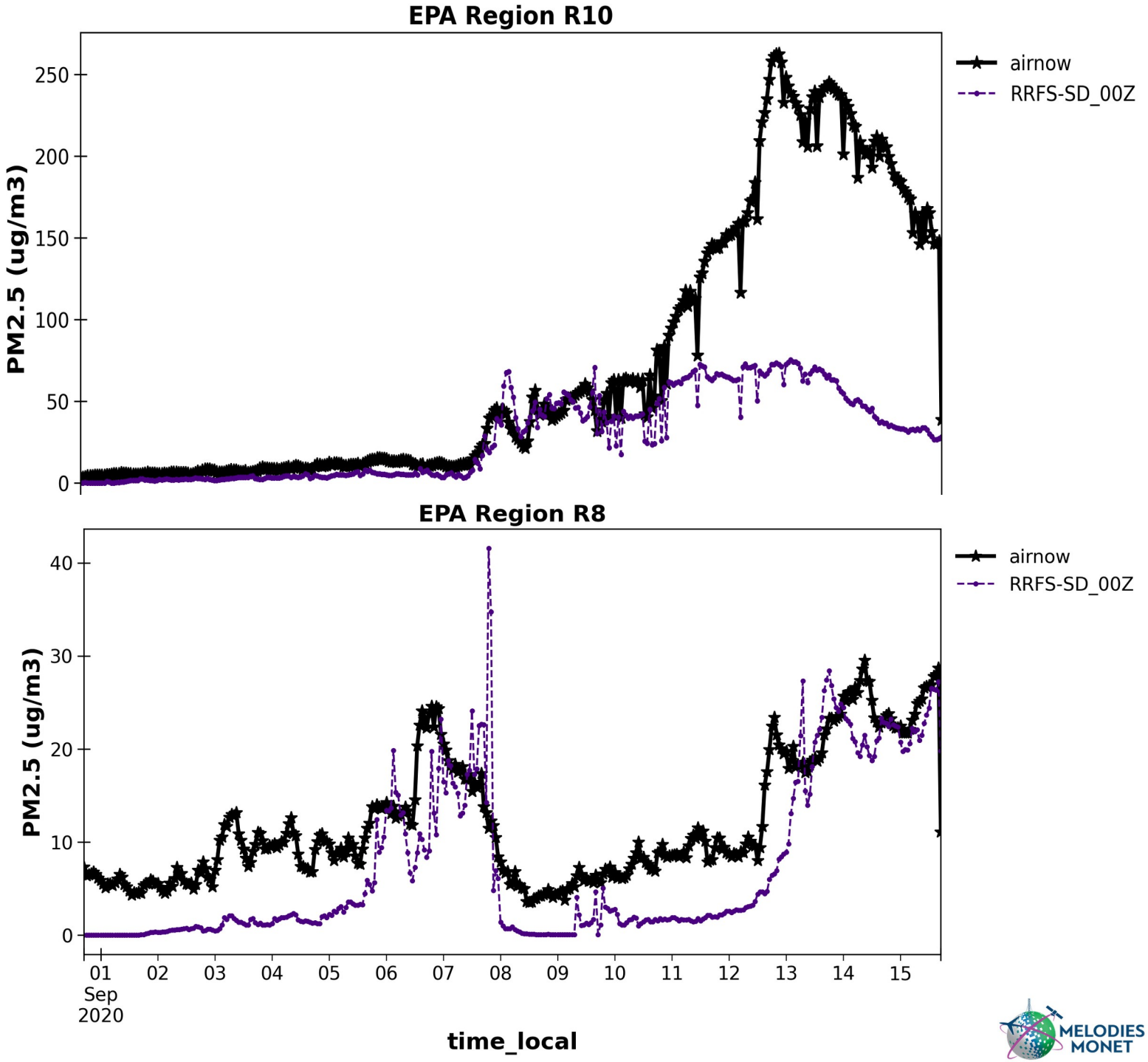


Vertically-Integrated Smoke (mg m^{-2})

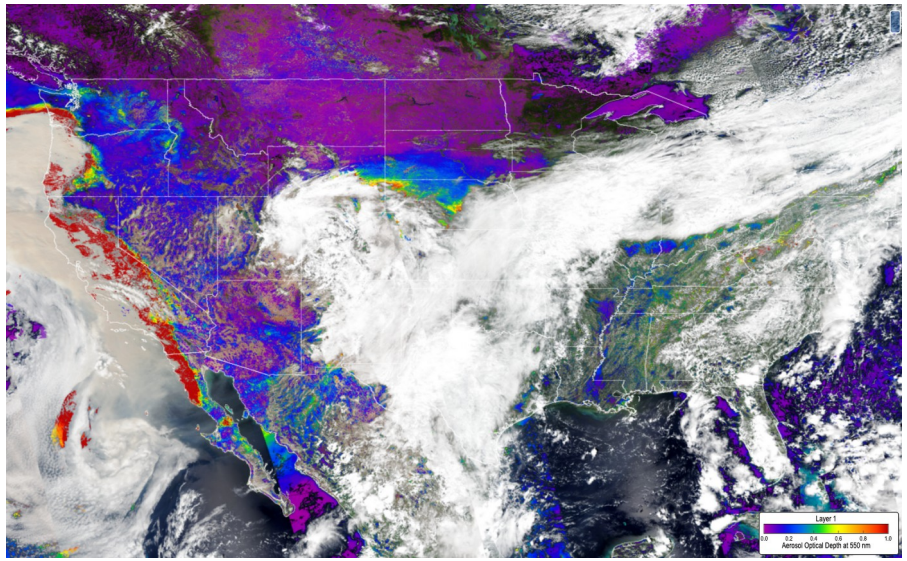


Evaluation of the RRFS-Smoke simulations using the AirNow PM2.5 observations for September, 2020

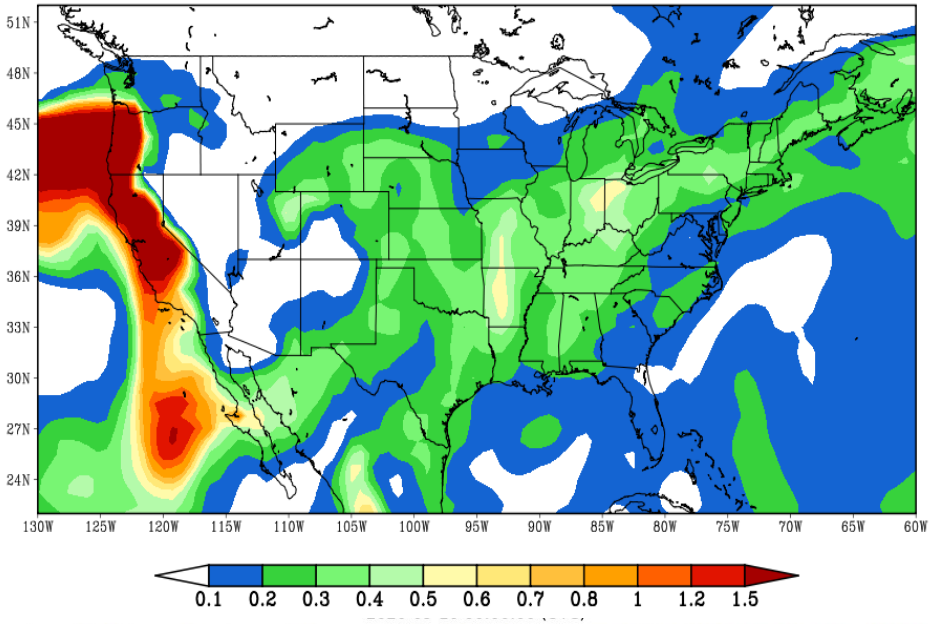




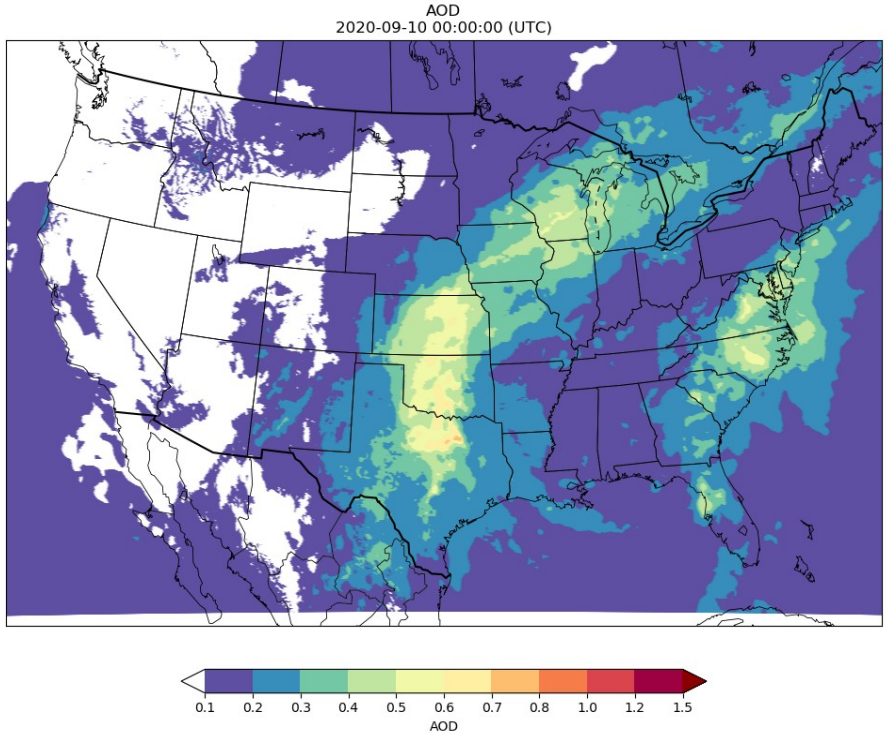
Aerosol Optical Depth (AOD) valid for September 10, 2020



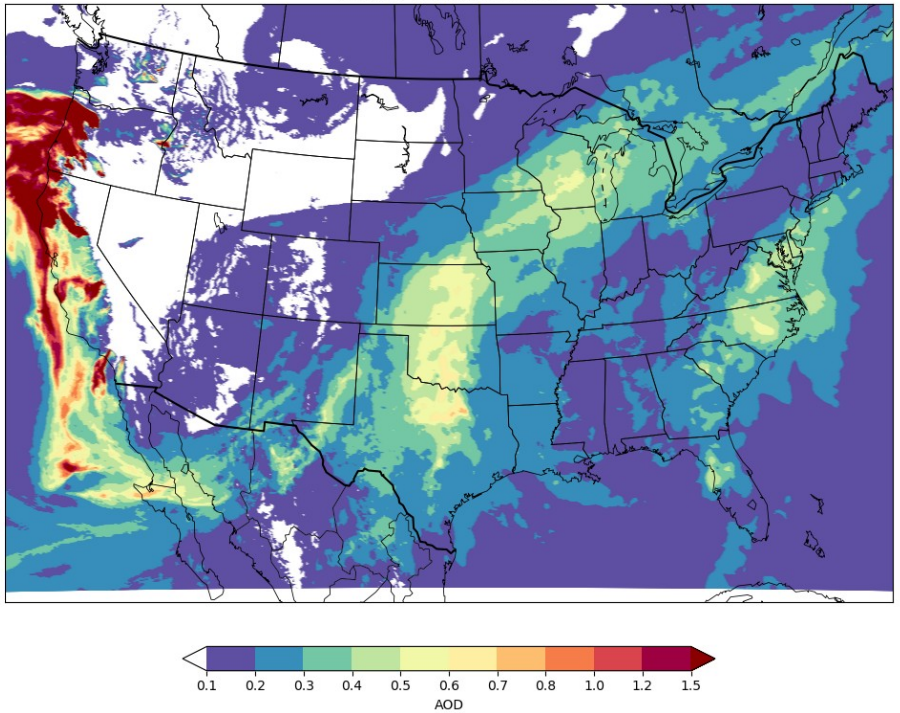
NOAA-20 satellite



ECMWF Aerosol analysis



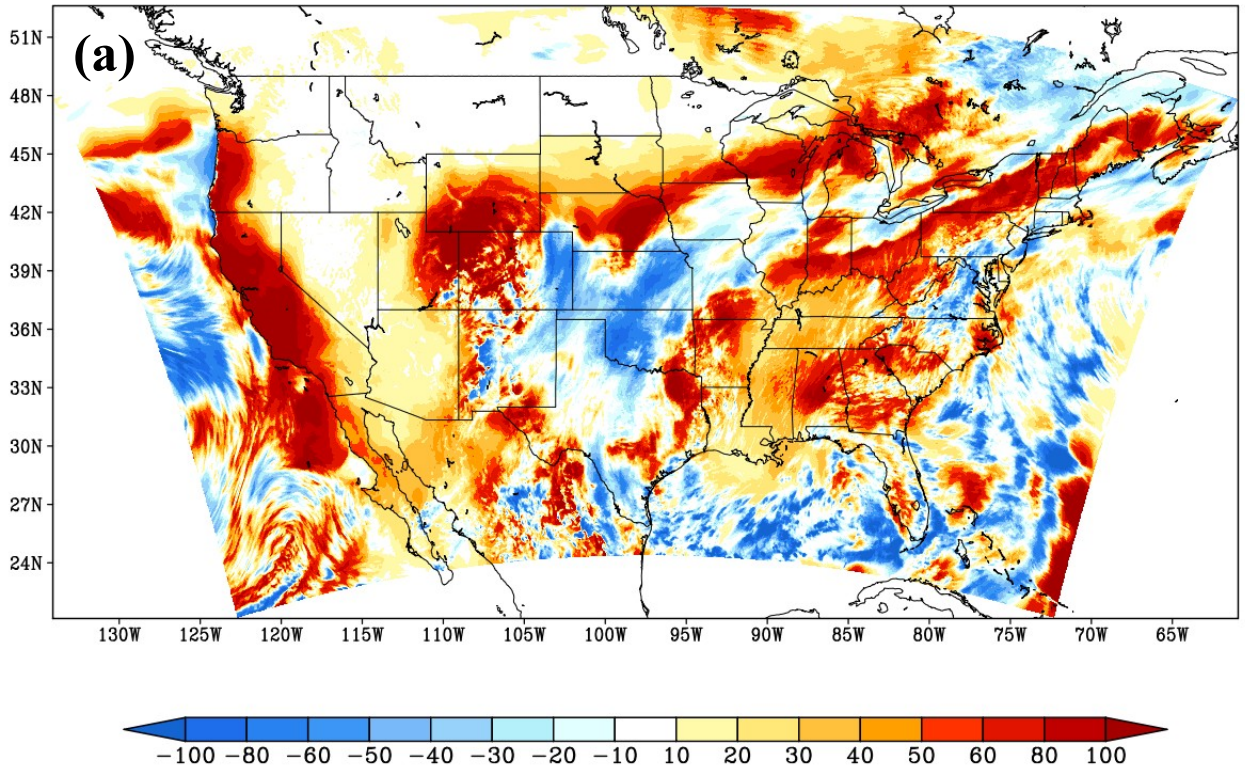
Model AOD Climatological Aerosols only



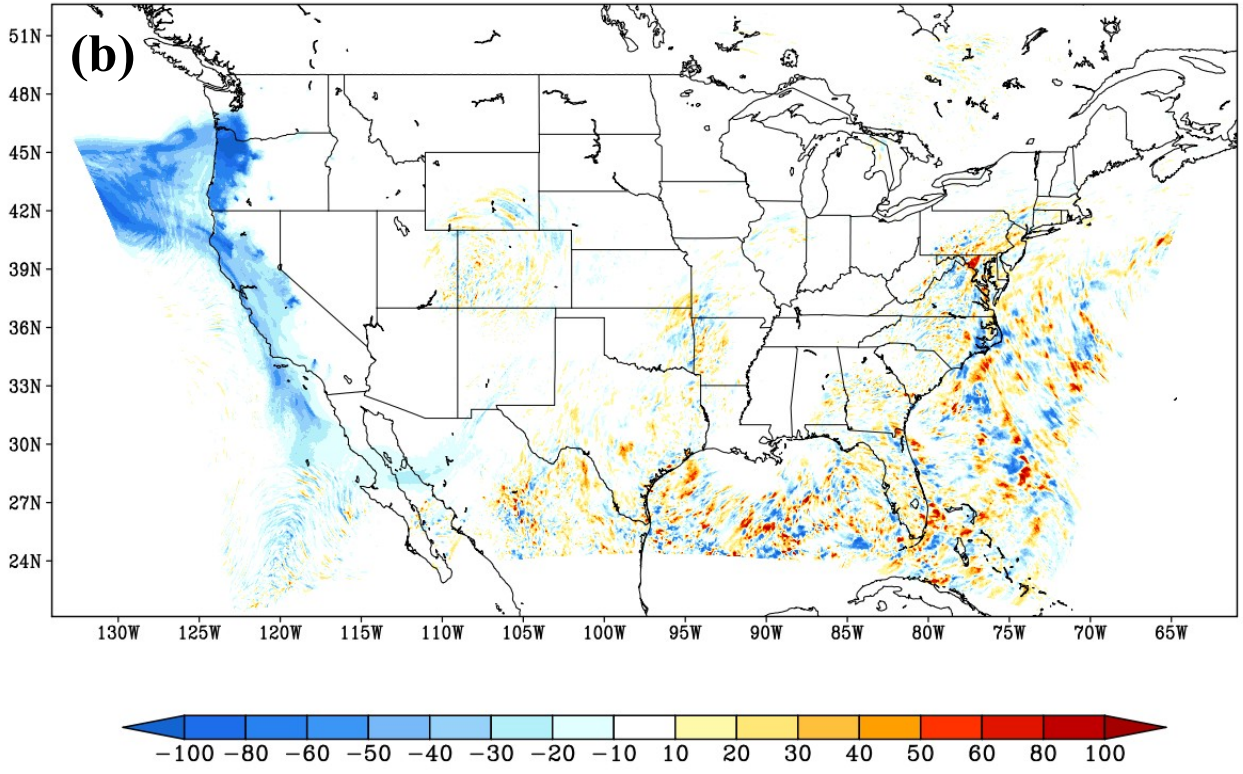
Model AOD smoke+climatological aerosols

Surface downward shortwave radiation flux (W/m²)

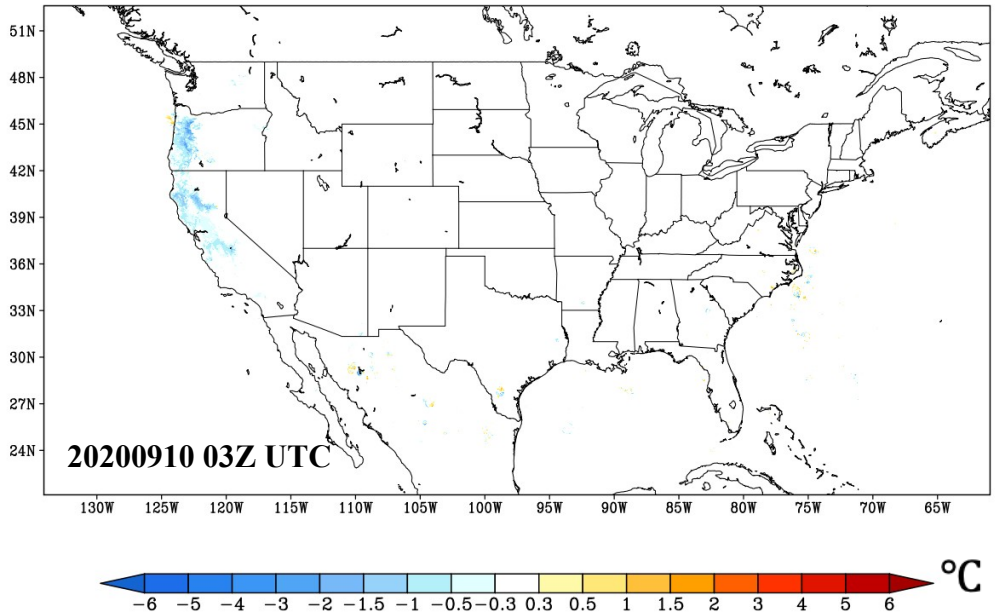
20200910 daily mean
CTL .minus. CERES Observation

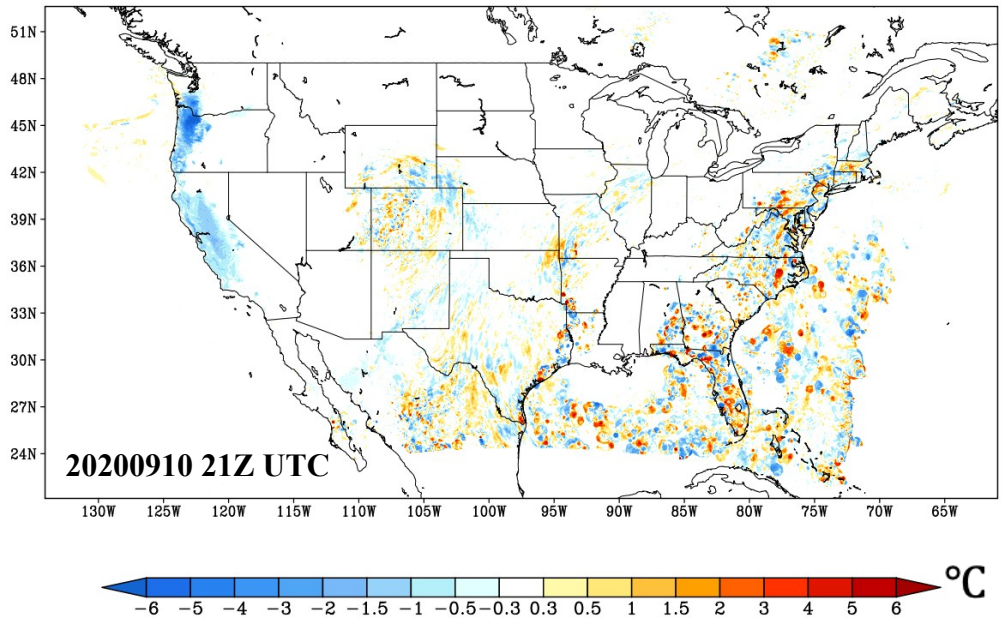


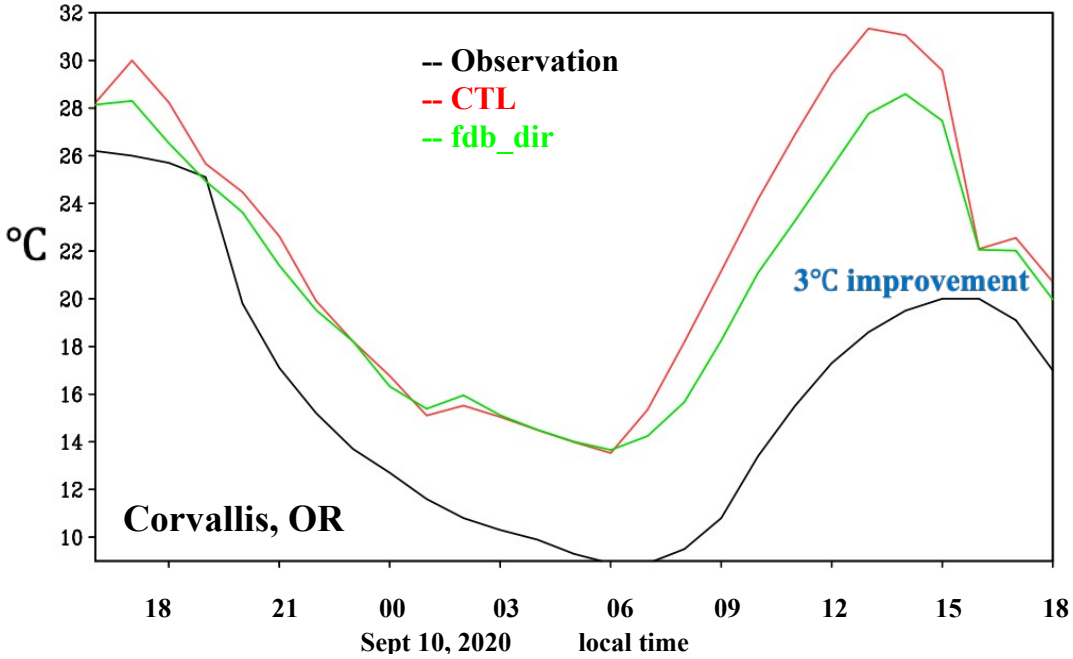
20200910 daily mean
fdb_dir .minus. CTL

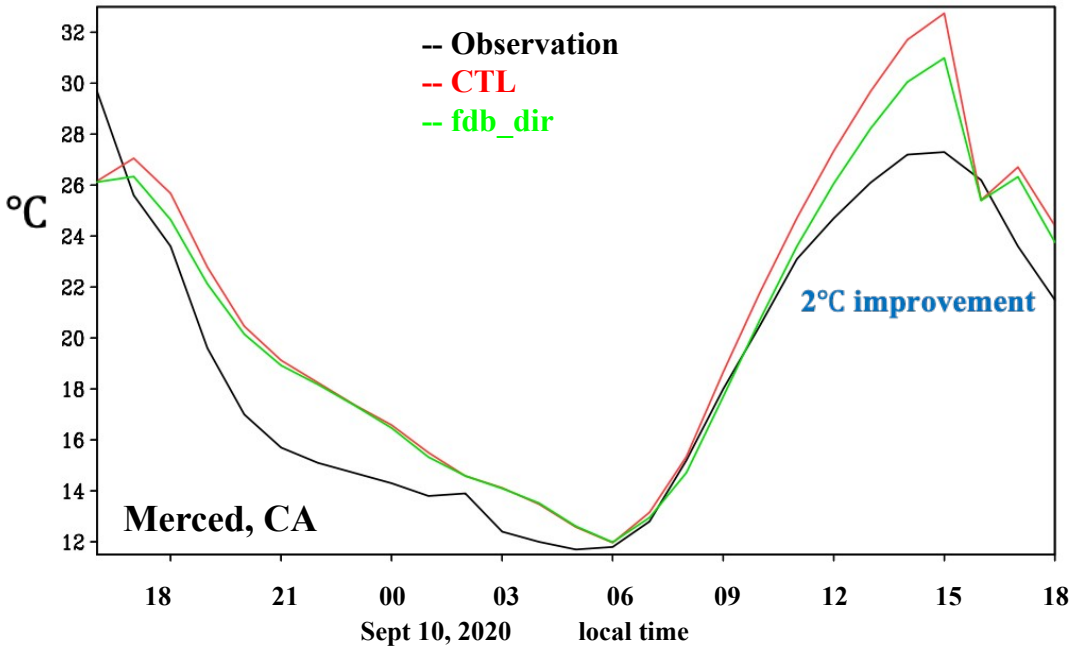


2m air temperature forecast difference (℃) due to the radiative feedback in RRFS-SD (September 10, 2020)

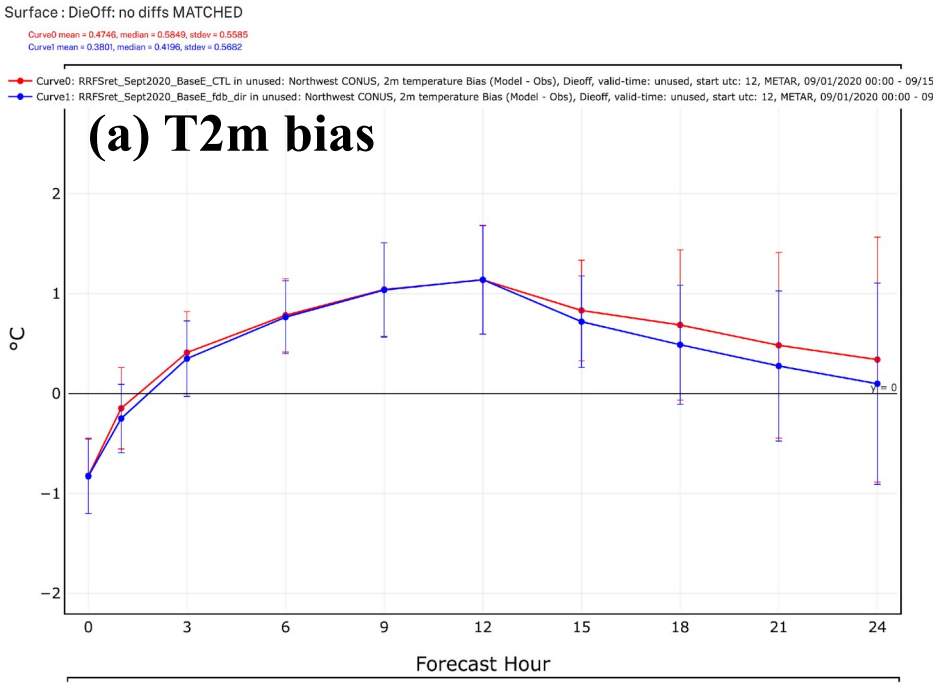


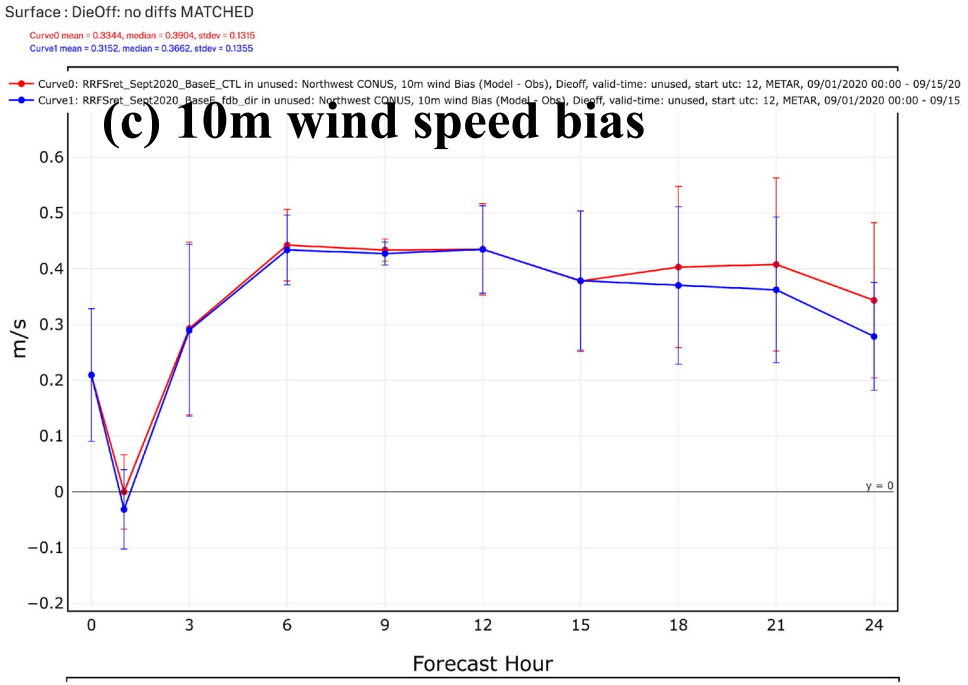


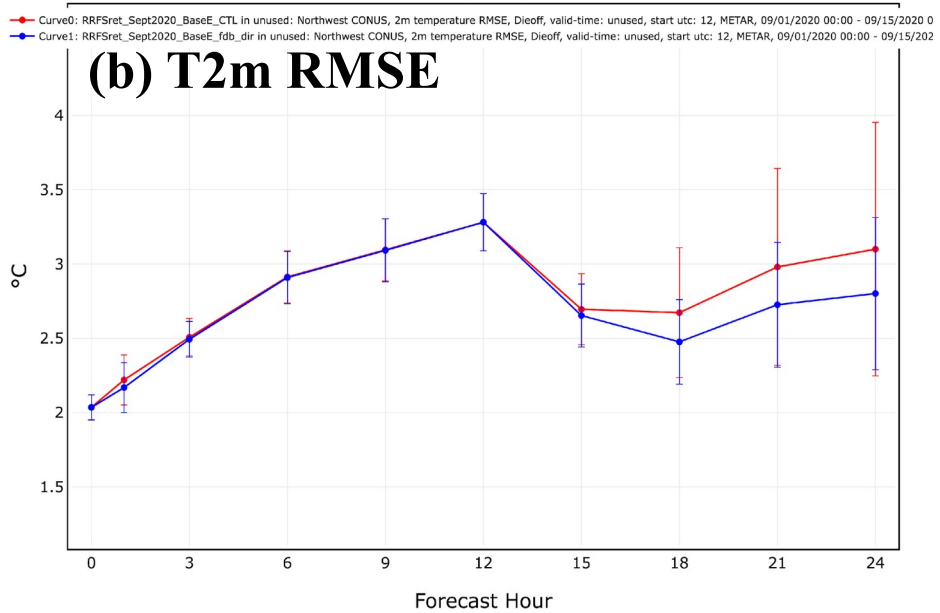


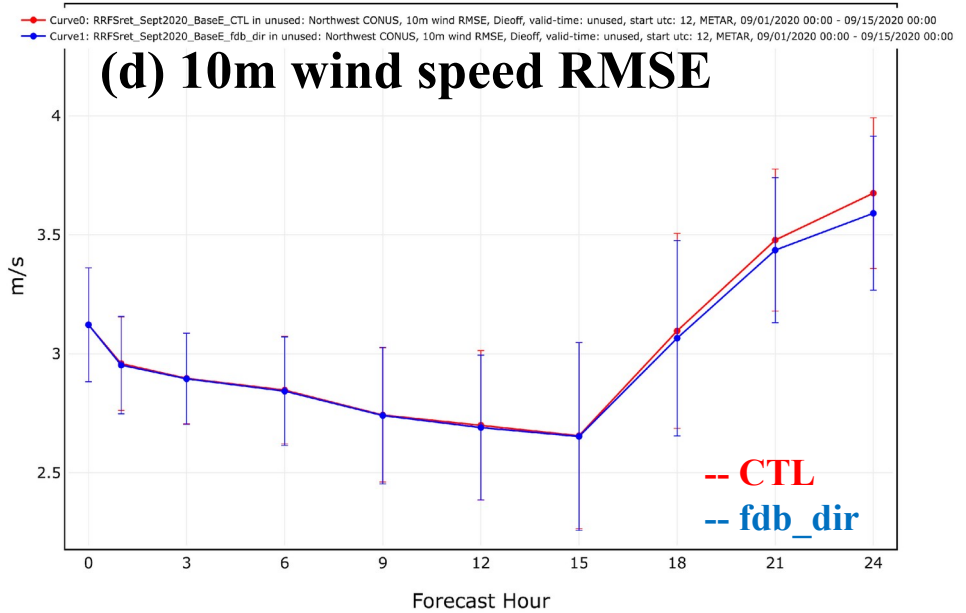


RRFS-Smoke verification over the northwestern CONUS region

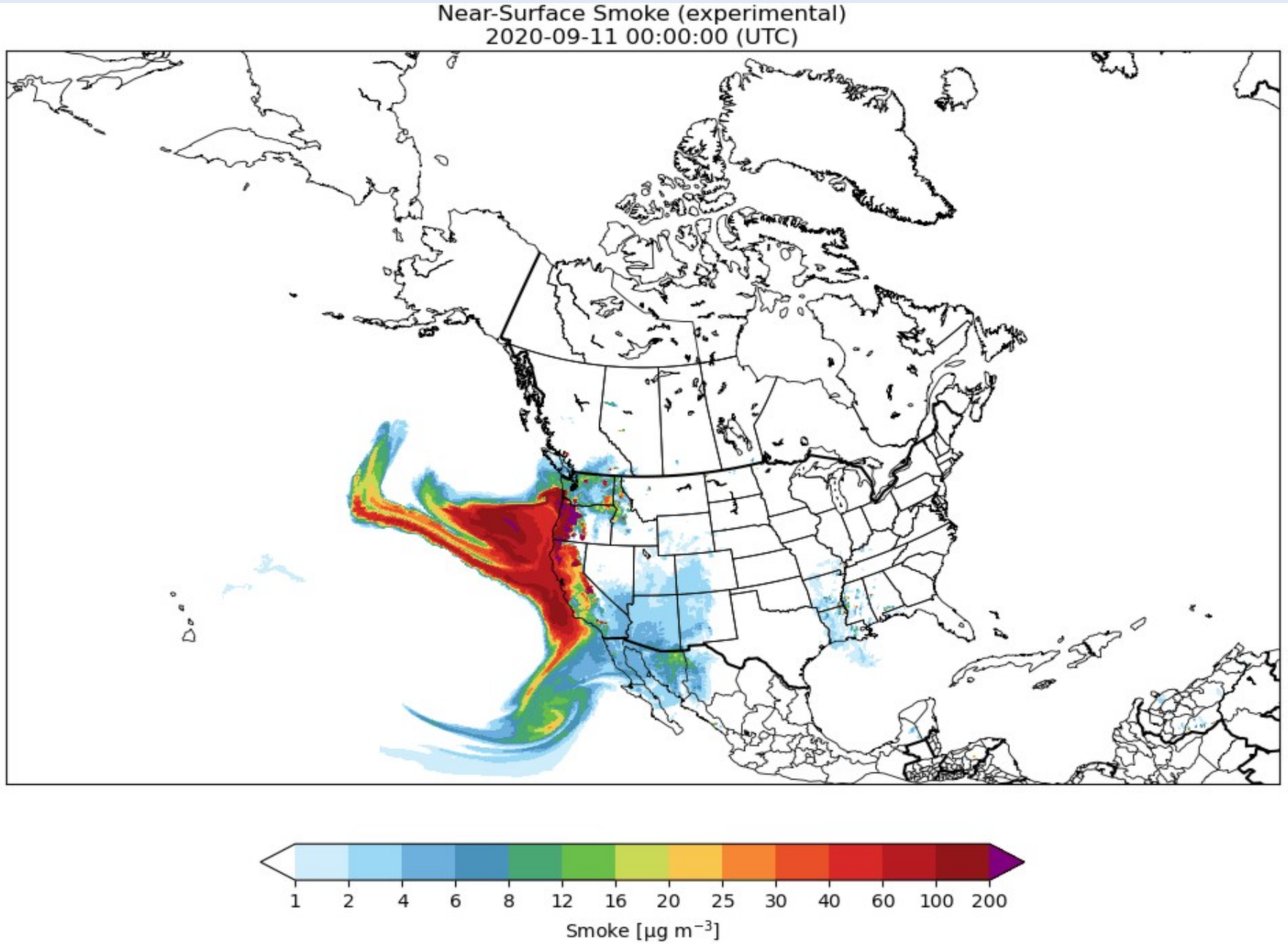




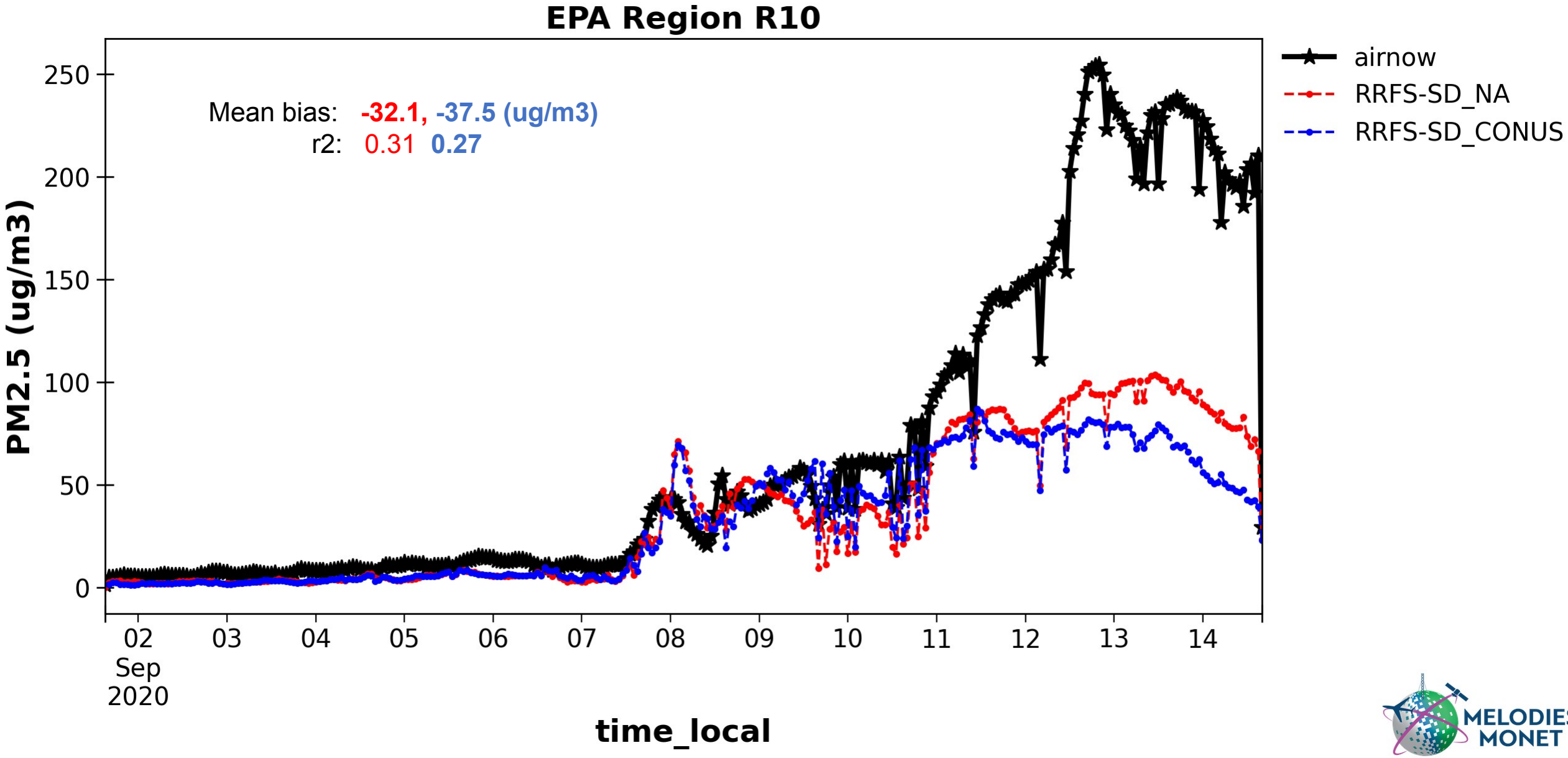




RRFS-Smoke simulation on the 3km res. NA domain



Verification of the RRFS-Smoke simulation on the 3km res. North American domain



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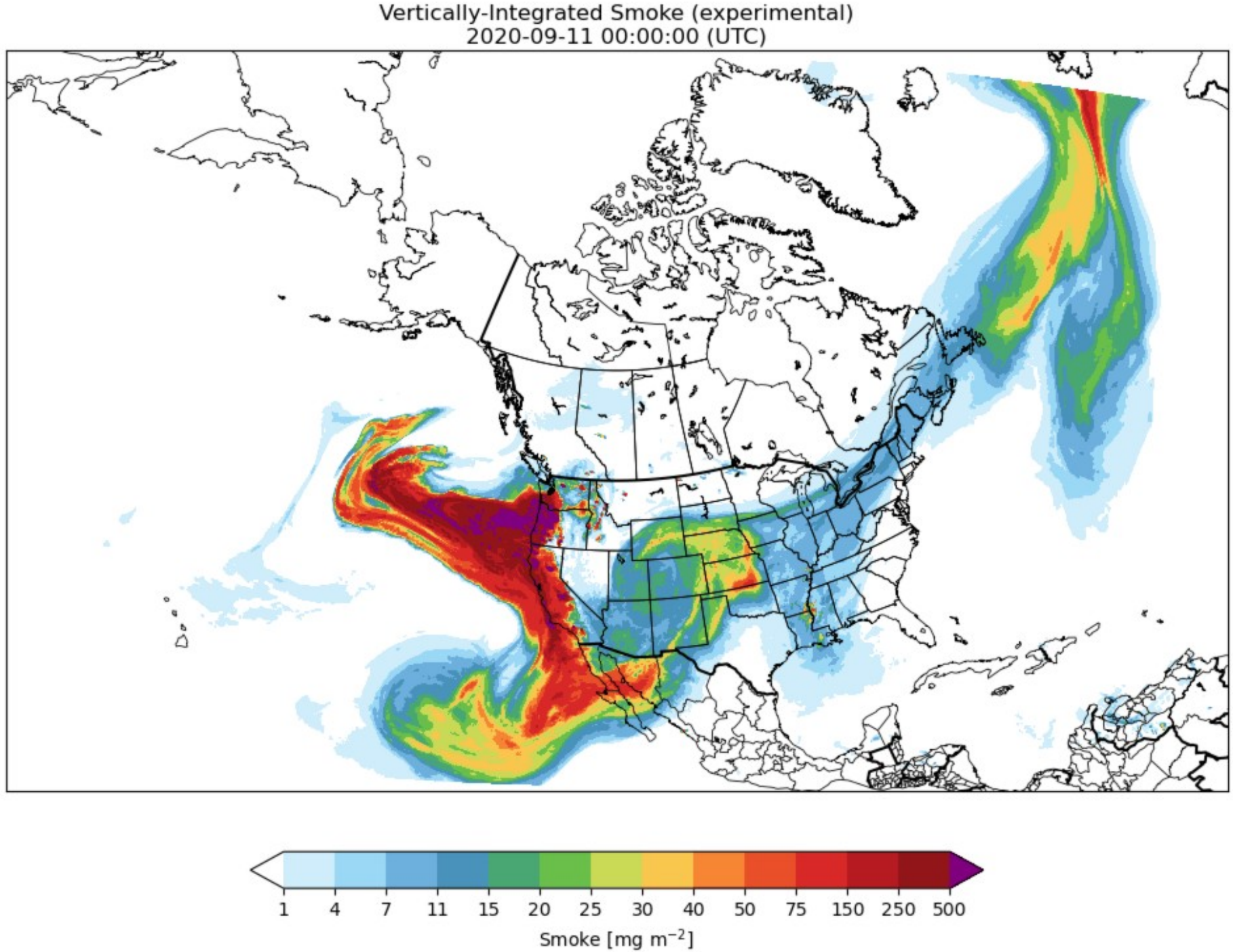
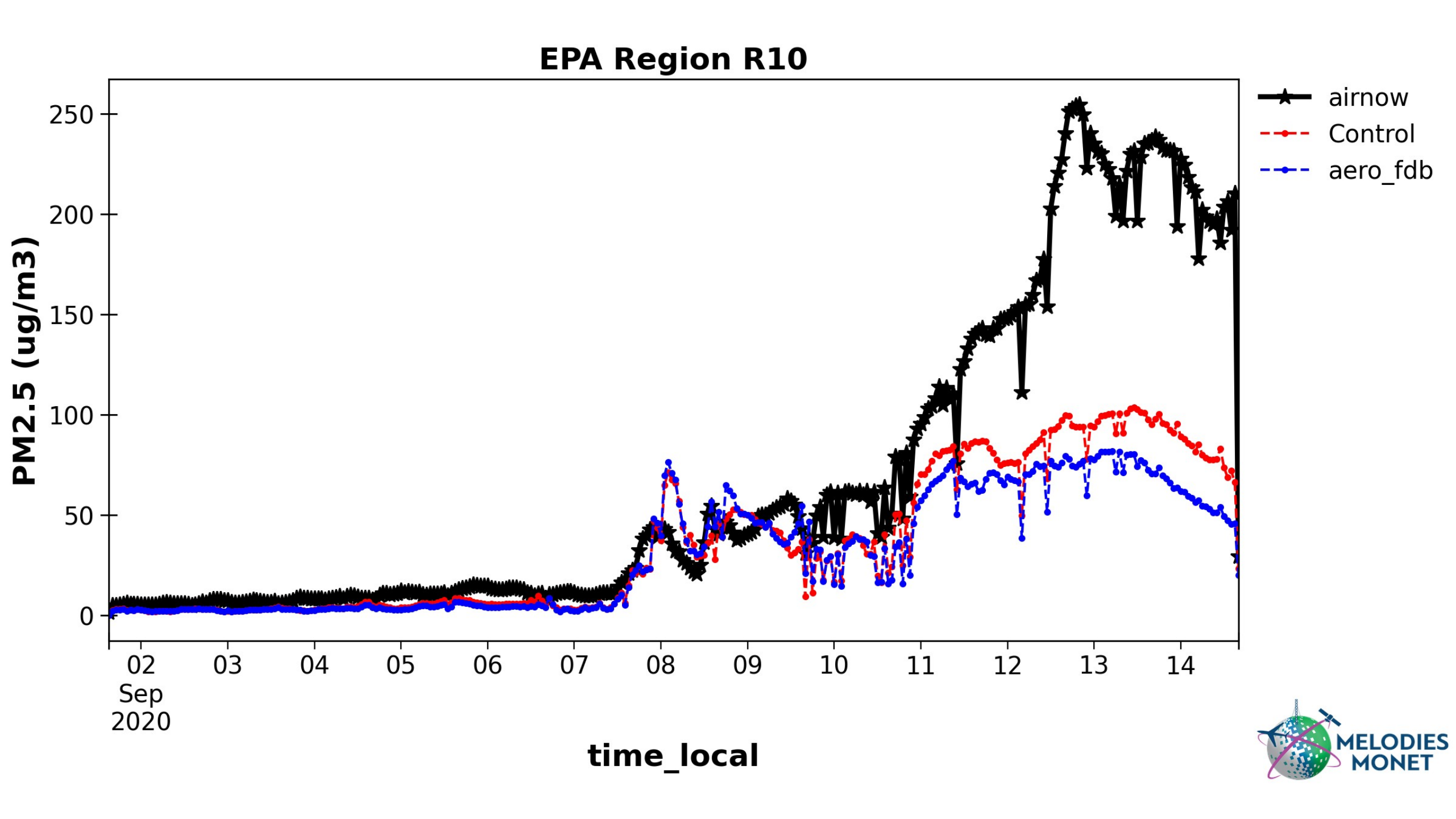
Summary and future plans

- RRFS-Smoke simulations are conducted for September, 2020 during the extreme fire season in the western US.
- Smoke simulations are conducted on the 3km resolution domains covering the CONUS and NA regions, with and without radiative feedback of smoke.
- Incorporating smoke direct feedback into RRFS helps to improve the weather forecast skill of the model noticeably.
- Next step is to conduct RRFS-Smoke simulations on the NA3km domain with meteorological and aerosol data assimilation.


Vertically-Integrated Smoke (experimental)
2020-09-11 00:00:00 (UTC)
1
4
7
11
15
20
25
30
40
50
75
150
250
500
Smoke [mg m^{-2}]


EPA Region R10
airnow
Control
aero_fdb
PM2.5 (ug/m3)
250
200
150
100
50
0
02
Sep
2020
03
04
05
06
07
08
09
10
11
12
13
14
time_local
MELODIES
MONET