3.3 Evaluation of Dust and Smoke Forecasts from NOAA's High Resolution Rapid Refresh Forecast System (RRFSSD)

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NATIONAL WEATHER SERVICE

Outline

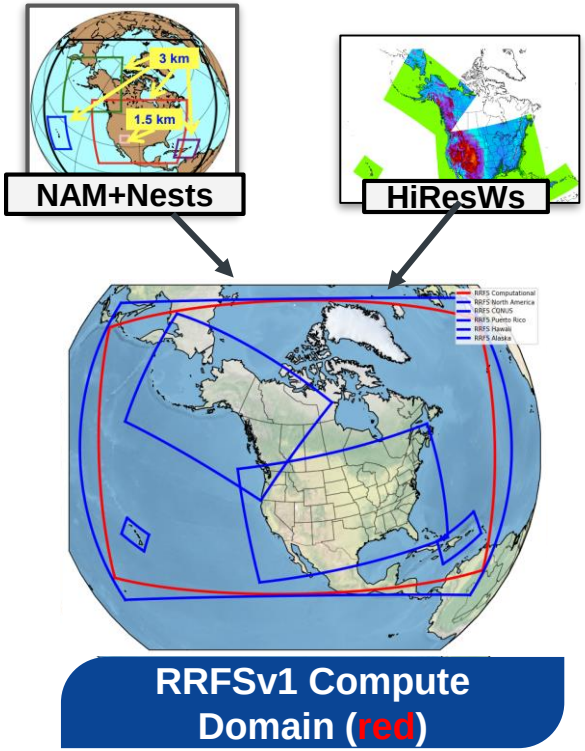
- Model Configuration: overview of RRFS and SD part
- Near-real time experimental run
- Results from retro case studies using RRFS-SD
- Summary and next steps

RRFS-SD related talk in AMS
Barry Baker on dust input in RRFS : https://ams.confex.com/ams/104ANNUAL/meetingapp.cgi/Paper/435472

The Rapid Refresh Forecast System version 1

RRFS is collaboration between GSL, NCEP/EMC and other partners and is based on :

- FV3-Limited Area Model (LAM)
- Physics : CCPP
- Physics suite: MYNN PBL, Thompson microphysics, Noah-MP; GF and saSAS deep convection in different ensemble members
- Rapidly updated
- Convection-allowing (~3km)
- Hybrid 3dEnVar assimilation (30 members)
- Ensemble Forecasts (~10 members) with stochastic and multi-physics suite
- Forecasts up to 60 hours for 00, 06,12 and 18z cycles
- Implementation : **Q2FY25**



Smoke and Dust in RRFS

- RRFS-SD simulates advection, turbulent mixing, dry and wet deposition of smoke (PM2.5) and dust (PM2.5 and PM10) aerosol species. Smoke and dust is included only in the control member.
- It estimates wildland fire emissions in real-time by ingesting hourly fire radiative energy from ABI and VIIRS fire emissions from RAVE (Regional Hourly Advanced Baseline Imager (ABI) and Visible Infrared Imaging Radiometer Suite (VIIRS) Emissions) dataset provided by NESDIS.
- The model fire plume rise is estimated using RAVE fire radiative power data.
- RRFSS-SD uses FENGSHA dust parametrization (Dong et al., 2016, provided by ARL) to simulate dust fluxes in real time.
- Plan to use dust from NOAA's global aerosol model (GEFS-Aerosols) for LBCs in RRFS
- No Anthropogenic and secondary aerosol formations included in RRFS-SD.
- MERRA2 climatological AOD and prognostic dust and smoke extinctions are combined to provide AOD for RRFS-SD.
- Radiative feedback of aerosols on meteorology is turned on.

Smoke and Dust test cases

Number of retro case studies were conducted to finalize parameters

Next slides will discuss

- **2 dust cases in south-western USA**
- **California smoke case (with and without radiative feedback)**

We have used Airnow (surface PM2.5 and PM10), Satellite AOD and Aeronet measurements to evaluate model performance

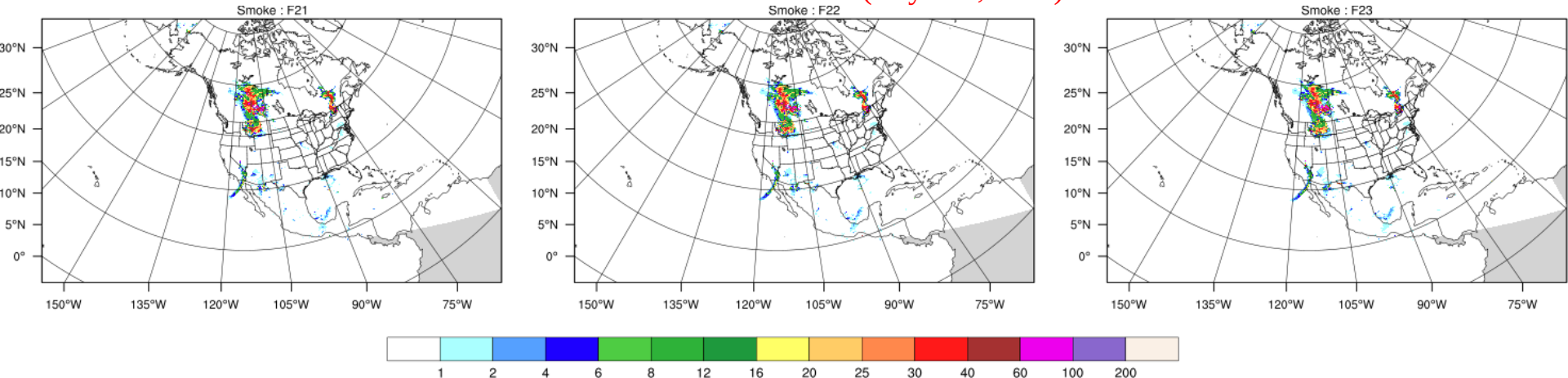
For verification, DTC METplus and MELODIES MONET tools are used

Near-real time monitoring of RRFSSD forecasts

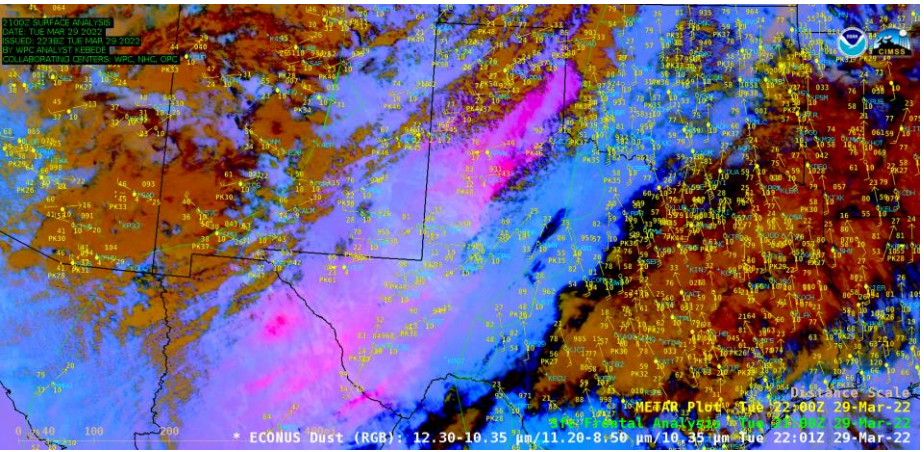
Not official products , but experimental sites to monitor RRFS runs :

- Smoke and dust field plots : https://rapidrefresh.noaa.gov/RRFS-SD/
- Verification of surface PM, AOD, meteorological fields : https://rapidrefresh.noaa.gov/AQverification/
- Satellite AOD evaluation :
  https://www.emc.ncep.noaa.gov/gc_wmb/parthab/RRFSSD_WCOSS2/html/fv3_rrfsstat_png.html
  and comparison of surface PM2.5 against HRRR-Smoke (all cycles and forecast hours):
  https://www.emc.ncep.noaa.gov/gc_wmb/parthab/RRFSSD_WCOSS2/html/fv3_hrrrsmconc_png.html

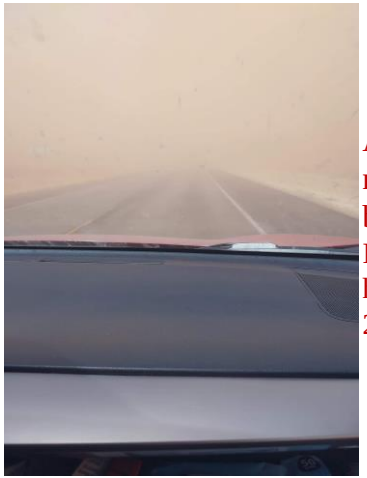
Canadian Smoke intrusion (July 17th, 2023)



28th and 29th March, 2022 dust case over Chihuahua, Mexico and parts of Texas, New Mexico and Oklahoma

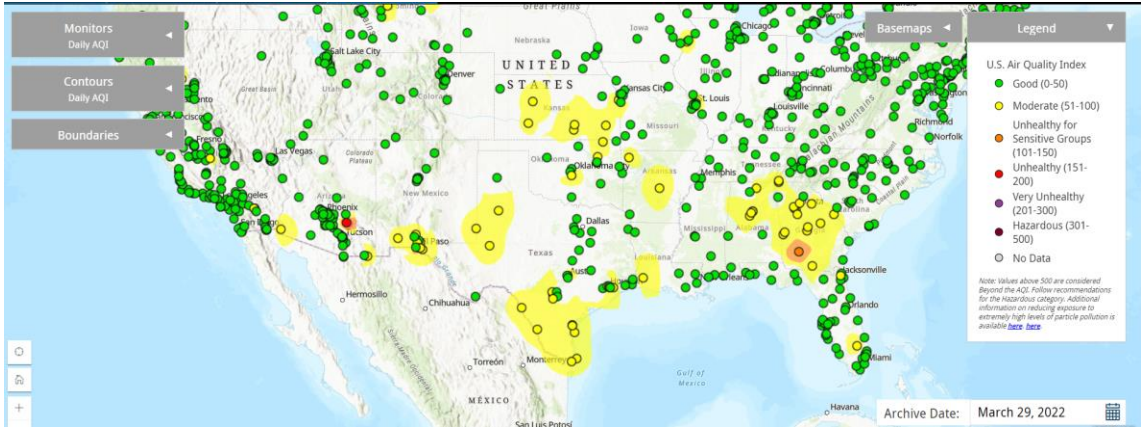


GOES-16 RGB image highlighted the development of widespread blowing dust (brighter shades of pink/magenta)

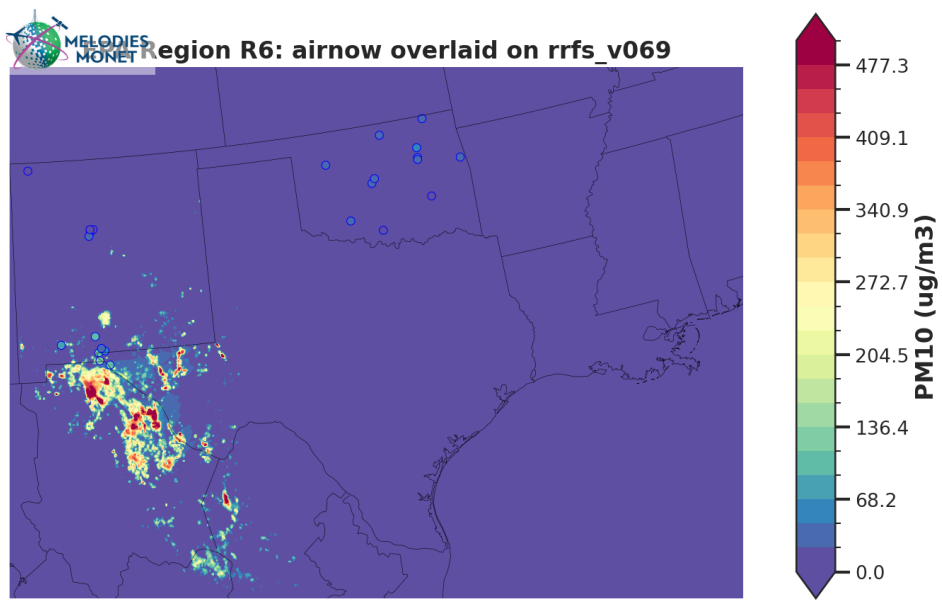


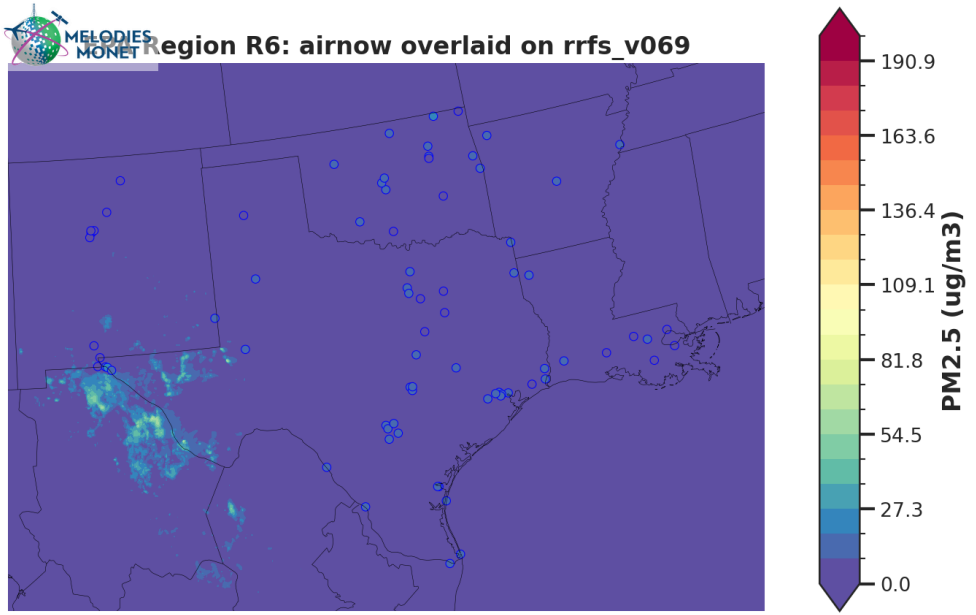
Accompanied by strong wind, blowing dust reduced the visibility at places to 4 miles between 5-9pm
Image source : https://www.weather.gov/lub/events-2022-20220329-wind

EPA Airnow surface observation PM map showing high PM in southern and eastern Texas

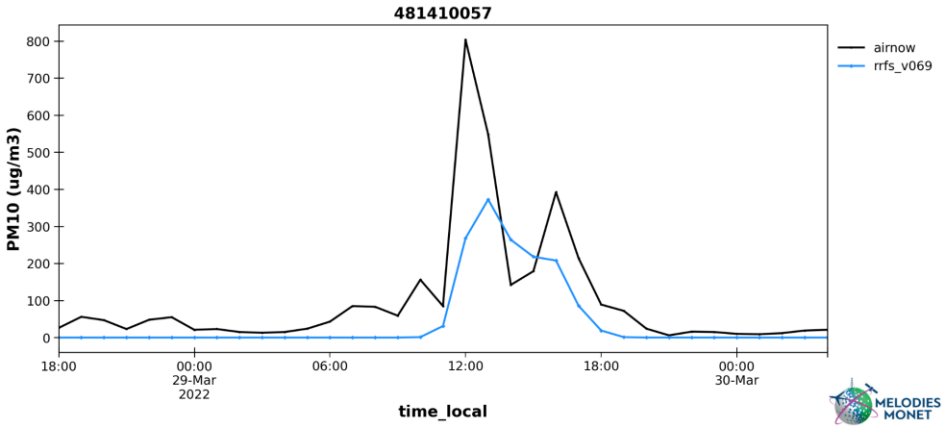


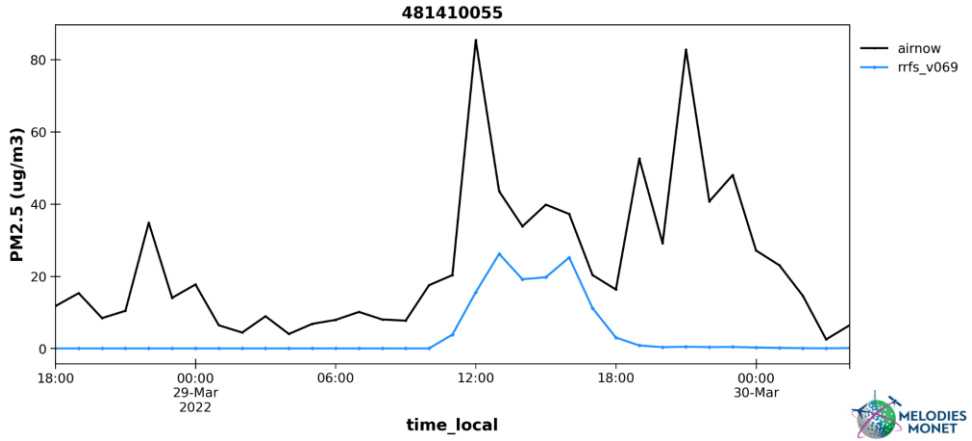
- RRFSSD initialized on 28th March using GFS boundary condition for 24-hrs forecast for next 2 days



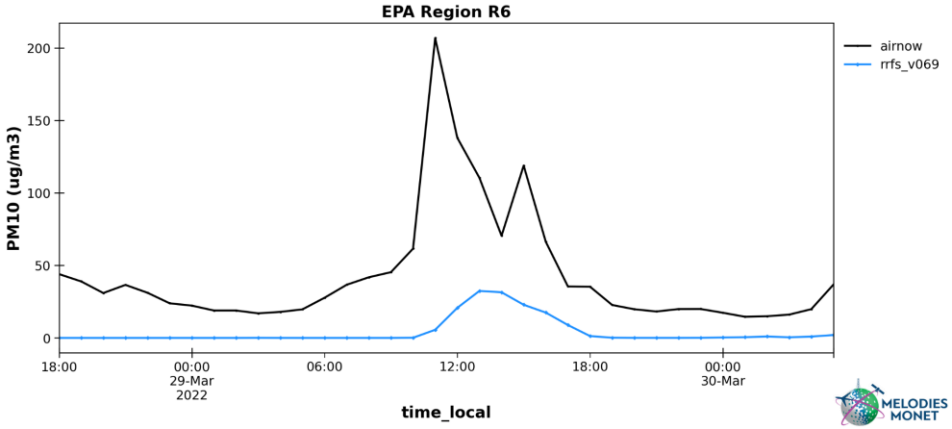


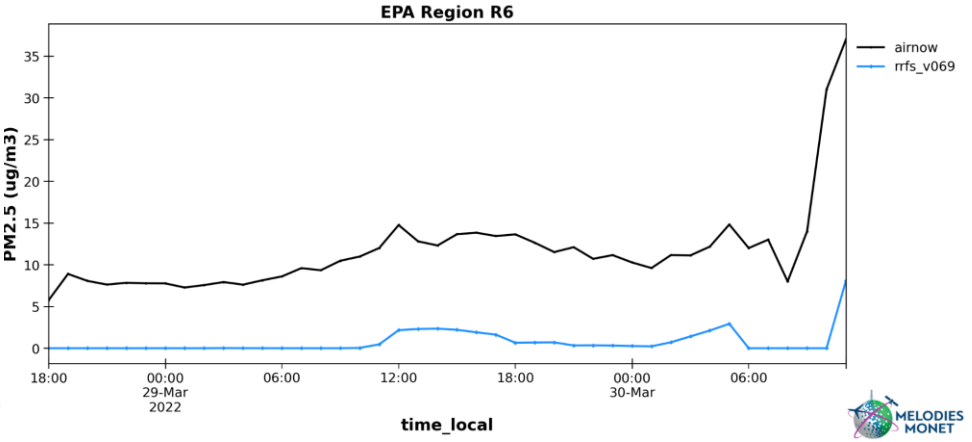
Average of 0-23hrs forecast for both PM2.5 and PM10



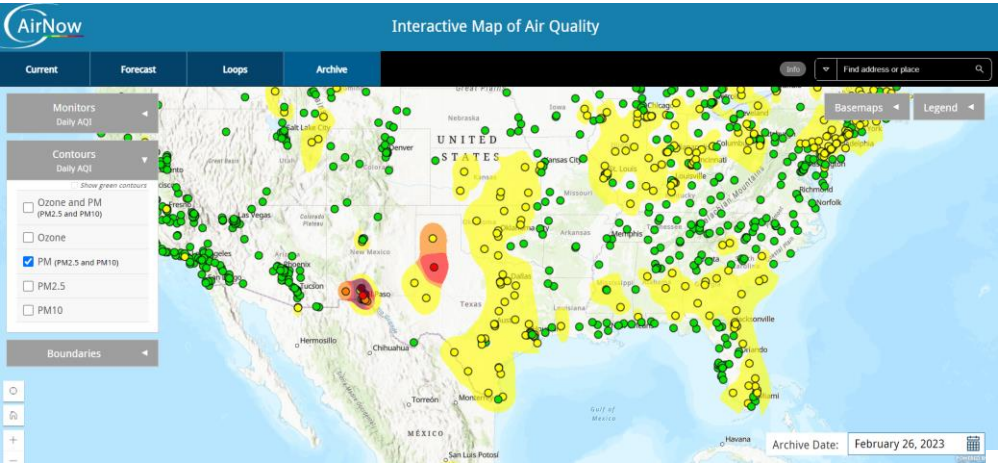


Peak dust intensity is less than the observed, but the stations near the dust plume able to simulate the event





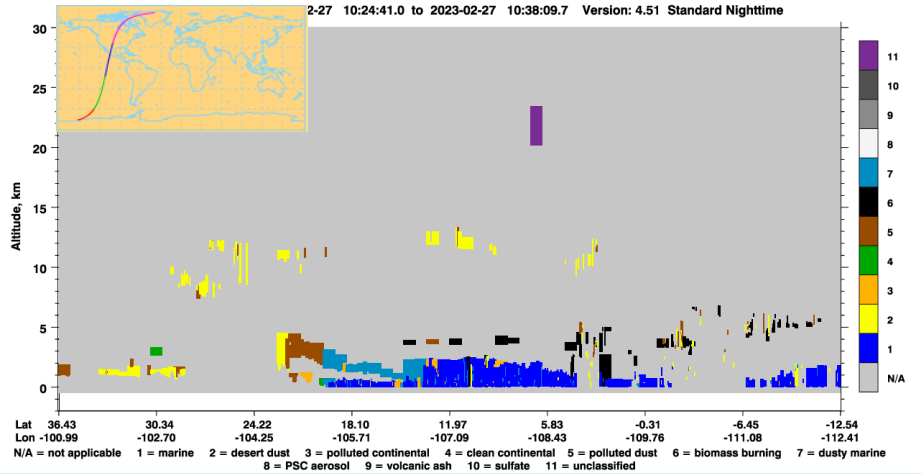
26th February, 2023 dust event over Western Texas and New Mexico

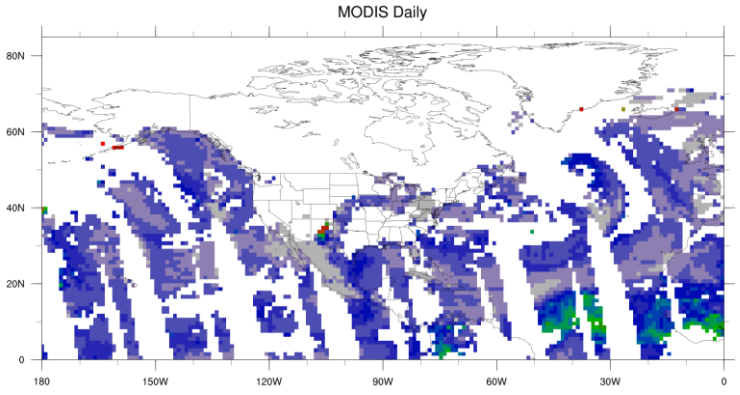


EPA Airnow surface observation PM map showing high PM over El Paso

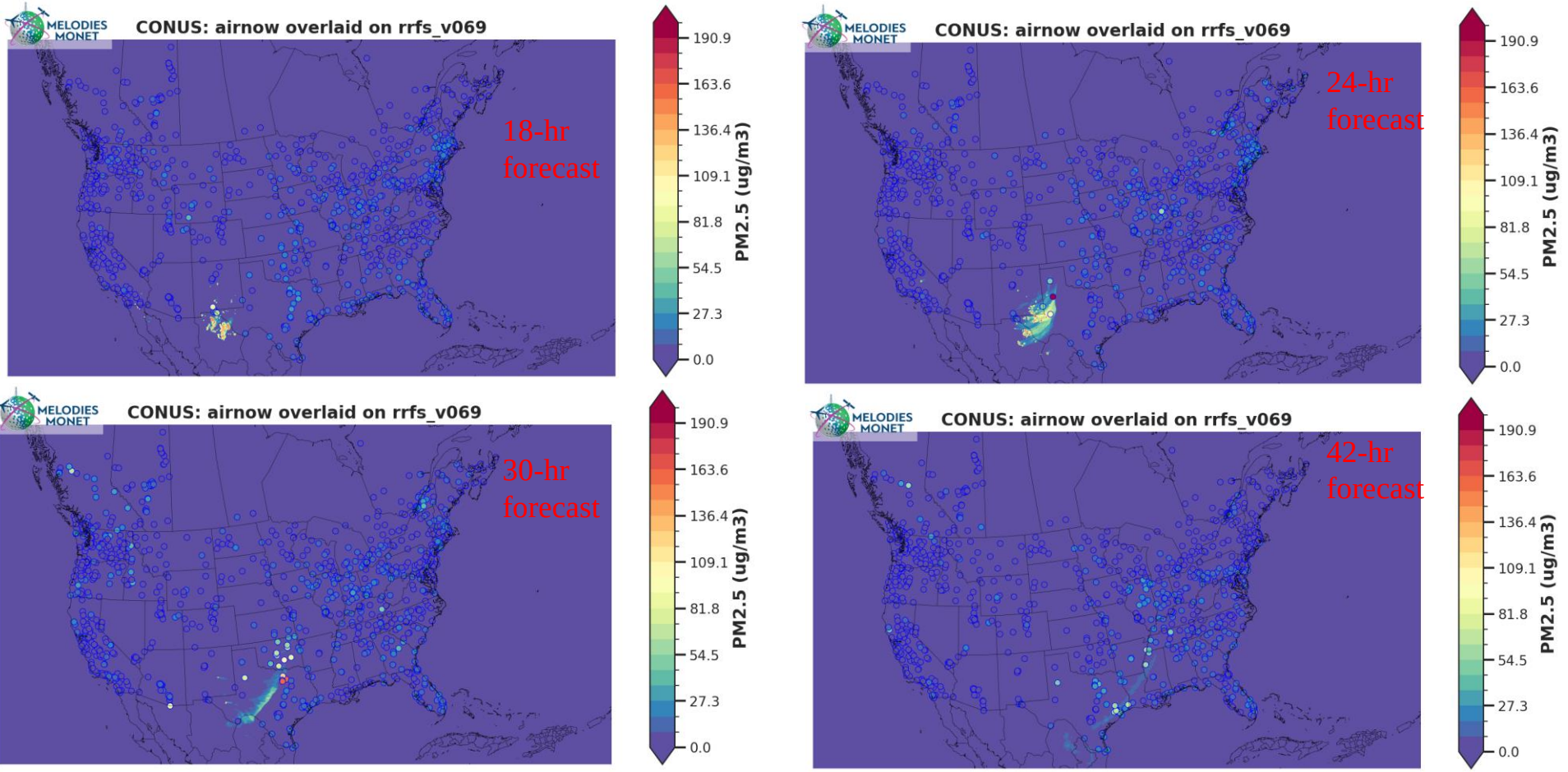
Thick blowing dust blowing approaching Lake Alan Henry, Western Texas.
Image source : https://www.weather.gov/lub/events-2023-2023026-wind

CALIPSO vertical profile shows transported dust over southern region

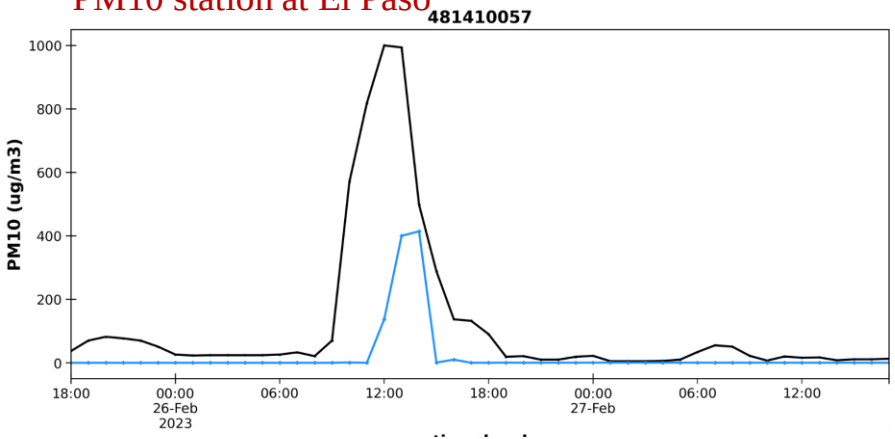




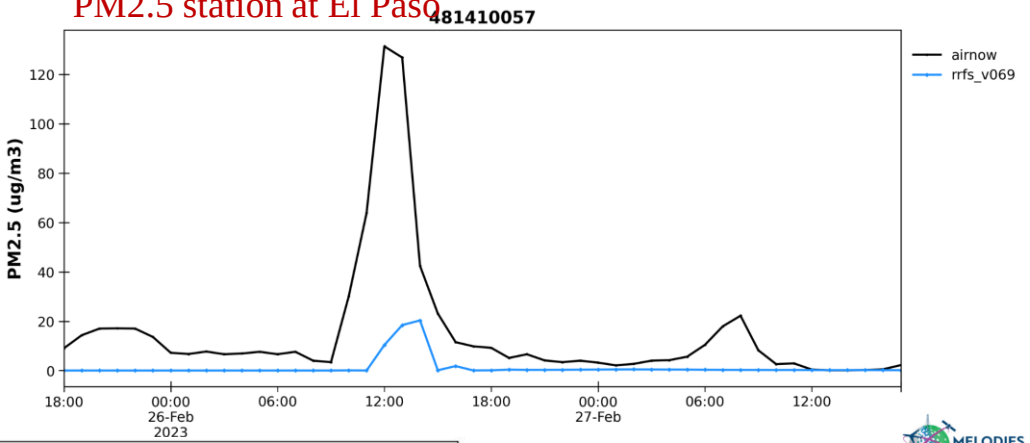
- RRFSSD initialized on 26th February using GFS boundary condition for 48-hrs forecast to simulate dust transport



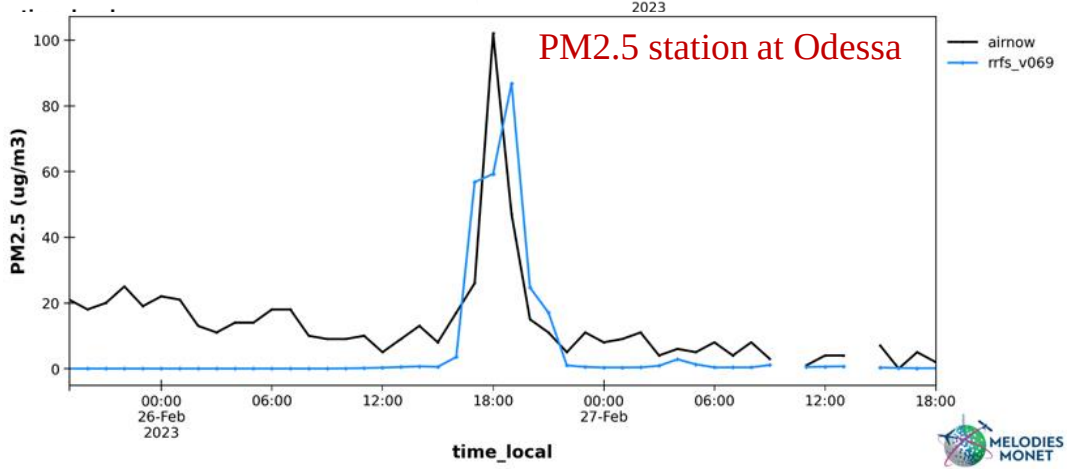
PM10 station at El Paso



PM2.5 station at El Paso



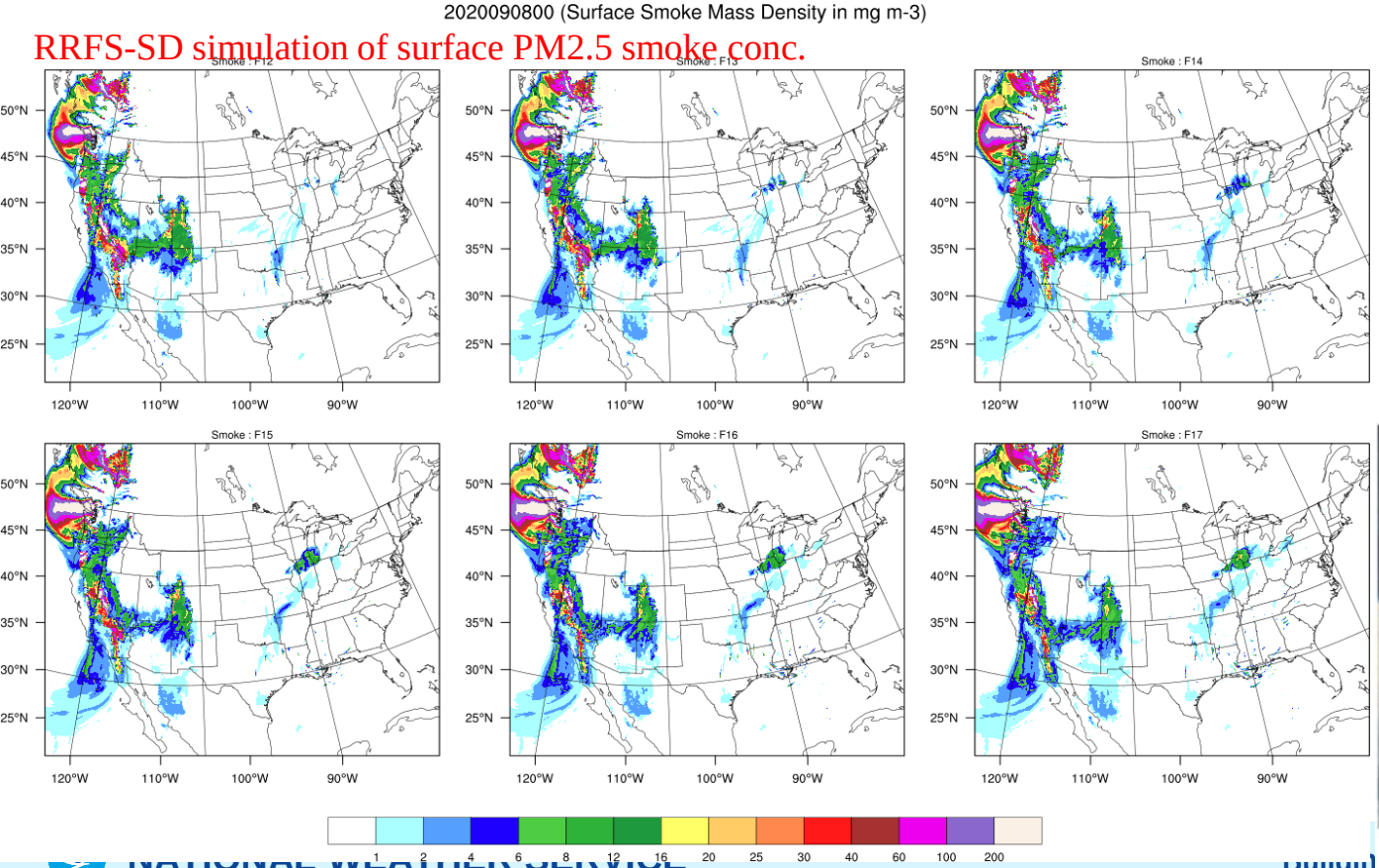
PM2.5 station at Odessa



California Smoke case : September 1-10th, 2020

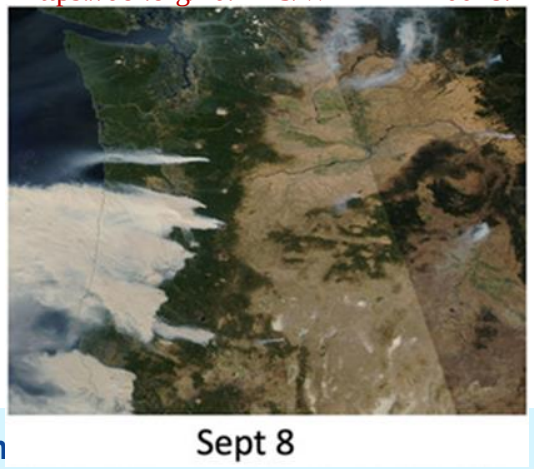
- 2 sets of simulations – one with radiation feedback turned on and one without it.
- Both simulations run for 10 days, forecasting upto 24 hours each day (00z cycle)

RRFS-SD simulation of surface PM2.5 smoke conc.



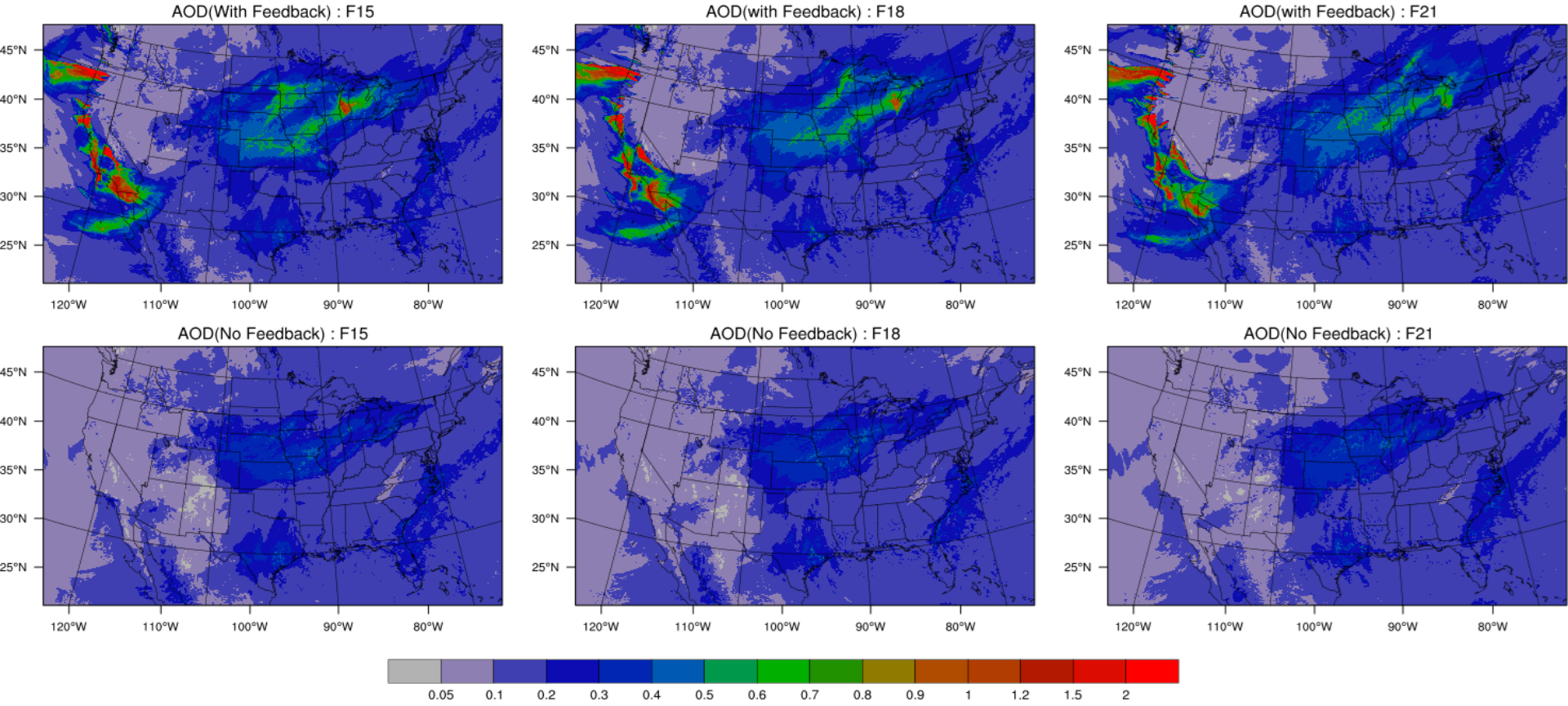
Airnow and MODIS Aqua AOD

https://doi.org/10.1175/WAF-D-21-0028.1



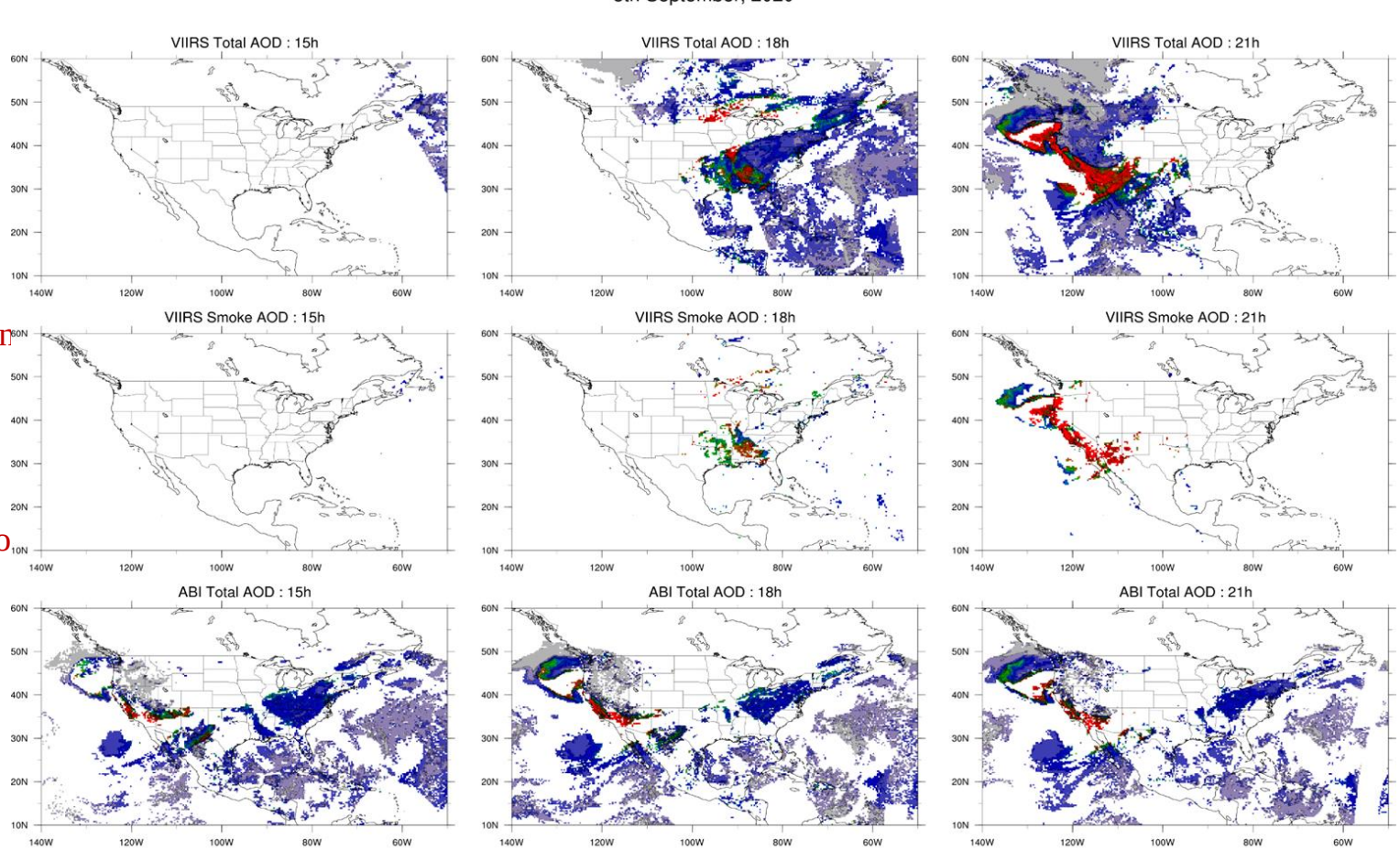
AOD simulation of RRFS-SD

8th September,2020 (Total AOD)



Satellite observation of total and smoke AOD

Simulation with feedback on shows less bias against observation compared to the simulation witho feedback.



Summary of RRFSSD findings

- Smoke and dust in RRFSv1 capable of capturing events
- More ongoing tests are underway over larger NA domain
- Improvement of smoke prediction in RRFSSD compared to HRRR-Smoke
- RRFS-SD adds dust which is not included in HRRR-Smoke
- Final updates before science freeze (End of March)