High-Resolution Smoke Simulation within NOAA's Rapid-Refresh Forecasting System: Verification for the 2019 Fire Season

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1. Rationale

NOAA is transitioning to the FV3[1] based high-resolution weather forecast model. Here, the smoke emissions, fire plume rise, dry and wet removal capabilities from the HRRR-Smoke[2] model are implemented into the RRFS model, hereafter, RRFS-Smoke. Preliminary results from the evaluation of the RRFS-Smoke system focusing on the 2019 FIREX-AQ field campaign and its comparison with the HRRR-Smoke model is presented

2. The Rapid Refresh Forecasting System: RRFS-Smoke

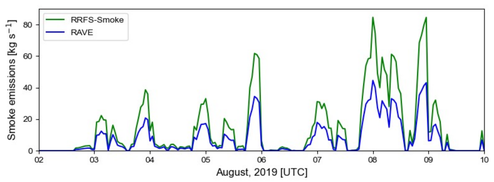
- Dynamical Core: Finite Volume Cubed-Sphere (FV3)
- Physics: Common Community Physics Package (CCPP)[3]
- Physics suite: MYNN PBL, Thompson microphysics, RUC LSM
- Domain: 3km resolution covering North and Central America, 65 vertical levels
- Two tracers: Smoke and dust
- Fire emissions: Based on the hourly FRP (GOES-16/17 and VIIRS)[4]
- Hourly Wildfire Potential diagnostic output

3. Hourly GOES-16/17 ABI and VIIRS FRP. PRELIMINARY

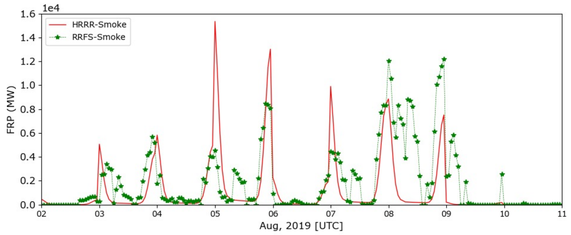
Fire emissions uses hourly FRP, VIIRS fractional land use[5], and emissions factors (EF) for flaming and smoldering

Emissions factors for flaming and smoldering based[4]. Units are in g kg^{-1}

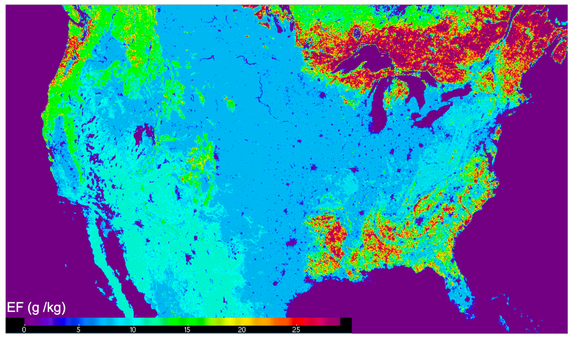
Ecosystem	EF flaming		EF smoldering	
	Mean	SD	Mean	SD
Forest	13.7	16.2	28.0	16.7
Hardwood	9.4	4.9	11.3	8.3
Mixed-wood	29.0	5	29.0	5
Shrubs	11.8	4.9	16.6	4.6
Shrubs + grasslands	10.8	4.9	20.3	9.3
Grasslands	7.4	2.9	39.1	0
Organic soil + mixed	10.8	4.9	20.7	10.1
Organic soil woody	11.8	4.9	23.3	11.3



Comparison total smoke emissions at WF fire (10 x 10 pixels) from RAVE and RRFS-Smoke

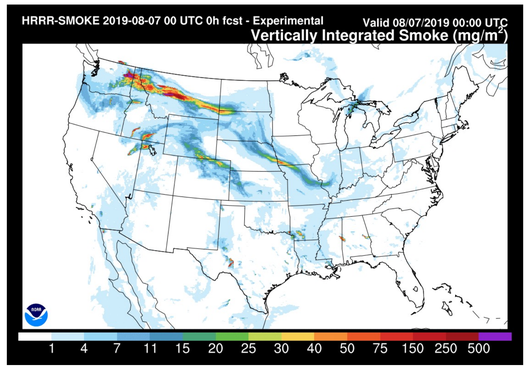


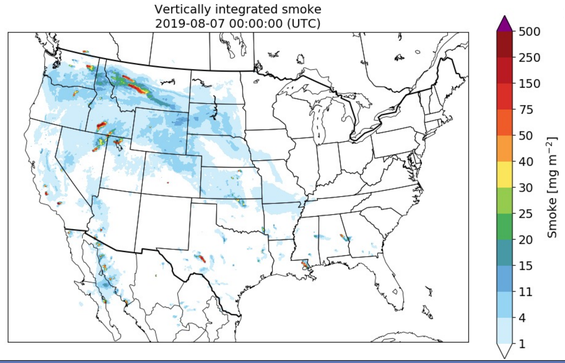
Comparison between total FRP used by HRRR-Smoke[6] (red) and RRFS-Smoke (green) for the Williams Flats fire. he HRRR-Smoke FRP time series is based on the VIIRS and MODIS data, and a climatological diurnal cycle



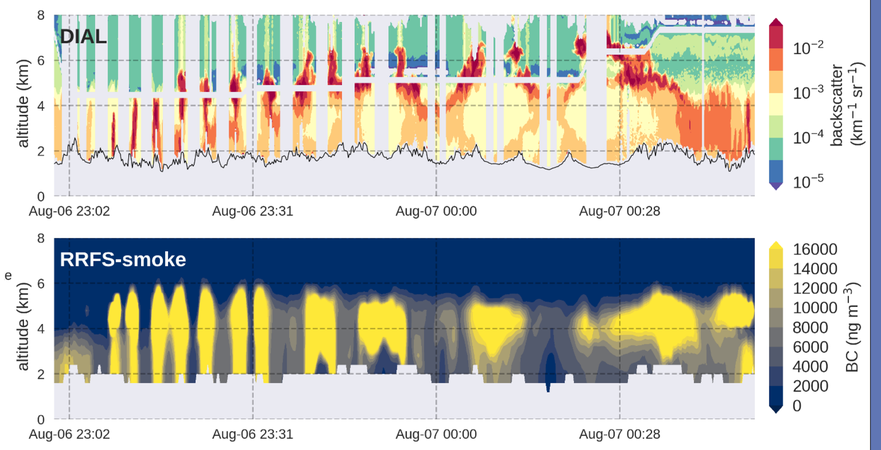
Spatial distribution of emissions factors using VIIRS vegetation fraction map.

4. RRFS-Smoke simulations for FIREX-AQ (CONUS domain). PRELIMINARY





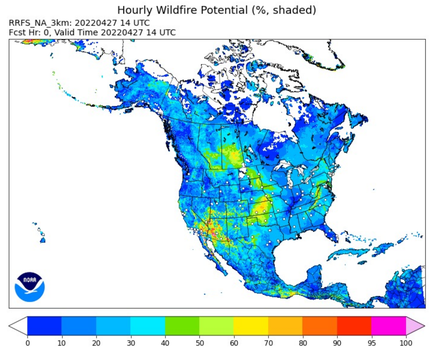
Differential Absorption Lidar (NASA Langley)

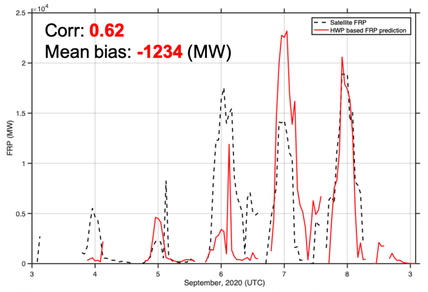


REMARKS:

- RRFS-Smoke captures the smoke spatial distribution (bottom-left-panel). However, the concentrations are lower than those predicted by HRRR-Smoke (top-left-panel)
- Comparison with observations from FIREX-AQ (top-right-panel) shows that the overall smoke vertical distribution is well capture by RRFS-Smoke (bottom-right-panel)

5. Hourly Wildfire Potential Index (HWP)[7]. PRELIMINARY





Comparison between satellite (black) and HWP forecasted FRP (red)

REMARKS:

- The HWP index relays on satellite detections.
- The algorithm, already included in the experimental RRFS (left-panel) and the RRFS-Smoke model, facilitates forecasting the evolution of large wildfires due to changing weather conditions
- Right-panel shows that HWP helps to predict changes in the fire behaviour due to windstorms (see peak in fire intensity on Sept 7 afternoon) and snowstorms (see Sep 8)
- Uncertainties in the analysis include: impact of fuel availability, the terrain and fire fighter operations

6. Future plans

Move to the RRFS North America domain

Implement PM2.5 and AOD data assimilation to improve the smoke prediction

Implementation of the HWP to predict FRP and so emissions for smoke forecasting

Test simulations in real-time

References

[1] https://www.gfdl.noaa.gov/fv3/
[2] Ahmadov, R., et al., 2017.Using VIIRS Fire Radiative Power data to simulate biomass burning emissions, plume rise and smoke transport in a real-time air quality modeling system. IGARSS, Ieee, New York, 2806-2808.
[3]https://dtcenter.org/community-code/common-community-physics-package-ccpp/documentation
[4] Li et al., 2019. https://doi.org/10.1016/j.atmosenv.2019.05.017
[5] https://viirsland.gsfc.nasa.gov/Products/NOAA/LandcoverEDR.html
[6]Prichard et al., 2018. https://doi.org/10.1071/WF19066
[7] https://rapidrefresh.noaa.gov/RRFS/

Acknowledgements
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Would you like to know more?

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