# Understanding the contributions of different types of biomass combustion to ambient $PM_{2.5}$ in the U.S. using CMAQv5.3.3

Jiaoyan (Joey) Huang, PhD, Shih-Ying Chang, PhD, ShihMing Huang, and Fred Lurmann
Sonoma Technology, Petaluma, CA, USA

STi | Sonoma Technology

Contact Us
707.665.9900 | sonomatech.com
Poster presented by Joey Huang
jhuang@sonomatech.com

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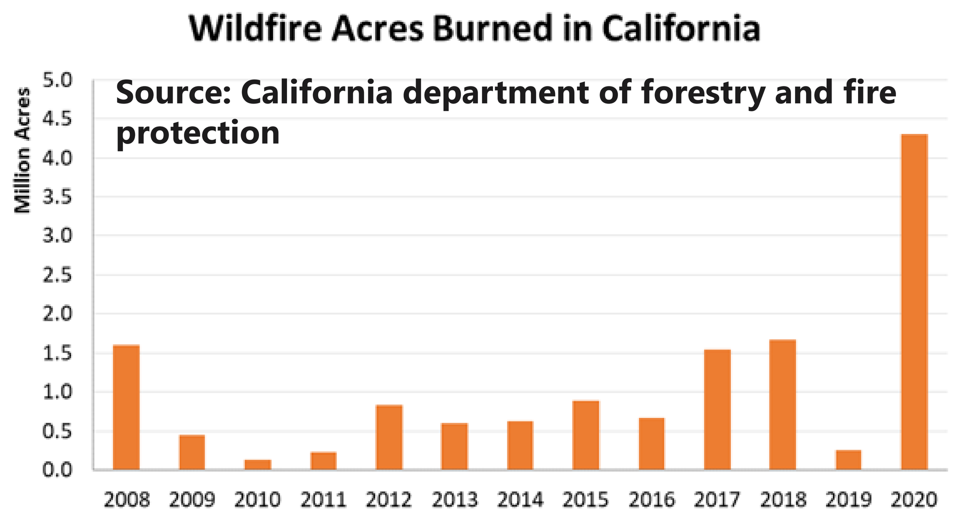
This smoke modeling work is part of an NIH-funded study titled "Wildfires and intentional biomass burning in California and Preterm Birth" led by Amy Padula at the University of California, San Francisco

## Background

The increasing frequency and intensity of large California wildfire events in recent years have caused major concern regarding public health impacts from wildfire smoke exposure. A recent study estimated that ozone ($O_3$) and fine particulate matter ($PM_{2.5}$) impacts from wildfire emission exposure caused between 9,900 and 25,000 premature deaths in 2016 in the United States (Fann et al., 2018).




Fann N., Alman B., Broome R.A., Morgan G.G., Johnston F.H., Pouliot G., and Rappold A.G. (2018) *Science of The Total Environment*, 610-611, 802-809. Available at https://www.sciencedirect.com/science/article/pii/S0048969717320223.

## Models

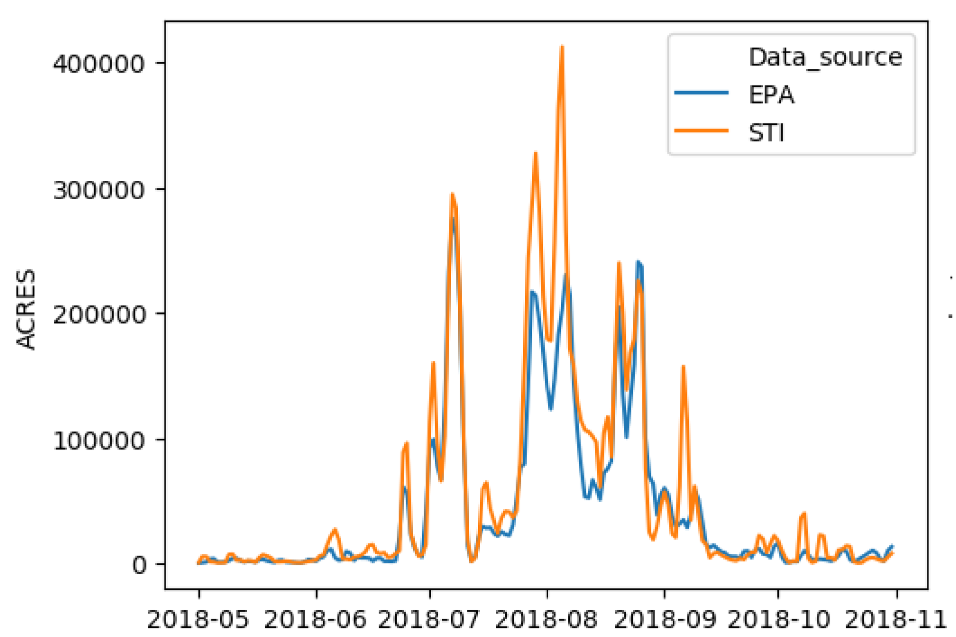
Model configuration:

- Modeling period: 2018
- Photochemical model: Community Multiscale Air Quality Modeling (CMAQ) v5.3.3
- Meteorology-Chemistry Interface Processor (MCIP), emission, boundary, and initial conditions: 2018 U.S. EPA data
- Biomass emissions:
  - Wildfire emissions (WF): Estimated based on merged satellite (MODIS) and agency (GeoMAC, ICS-209, FIRESTAT, CAL FIRE) fire activity data using the USFS BlueSky Smoke Modeling Framework
  - Prescribed fire emissions (Rx): Estimated based on satellite (MODIS) and merged agency (CAL FIRE, USFS FACTS, CARB PFIRS) fire activity data using BlueSky
  - Agricultural fire emissions (AG): 2018 U.S. EPA data
  - Residential wood combustion (RWC): 2018 Nation Emission Inventory (NEI) data
- AG, Rx, and WF emissions data were modeled as point sources and the actual emissions were calculated in-line with the CMAQ plume rise option
- CMAQ was run without implementing potential secondary organic aerosol form combustion emissions (PcSOA) for these biomass emission sectors
- Base scenario model performance: the normalized mean bias ranges from 30% to 35% for hourly total $PM_{2.5}$ concentrations and from 0% to 15% for hourly ozone concentrations.

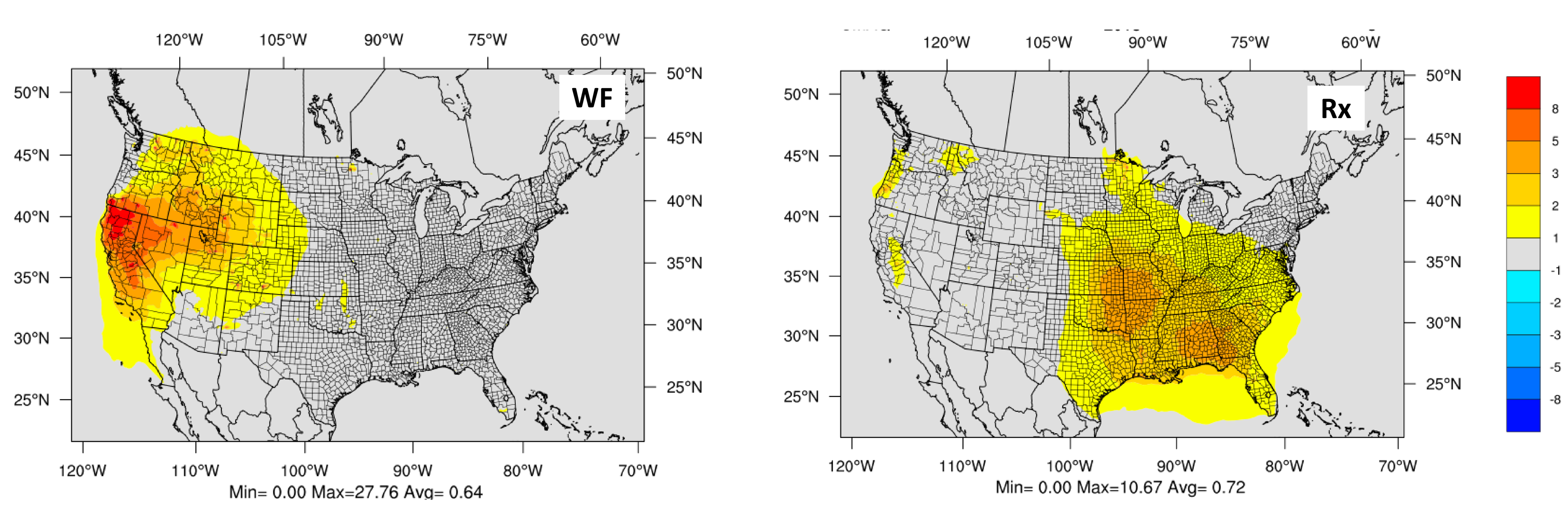
**Model Scenarios**

| Scenario | Description |
|---|---|
| Base case | With all emissions |
| Sens case 1 | Without ag fire emissions |
| Sens case 2 | Without wildfire emissions |
| Sens case 3 | Without prescribed fire emissions |
| Sens case 4 | Without RWC |

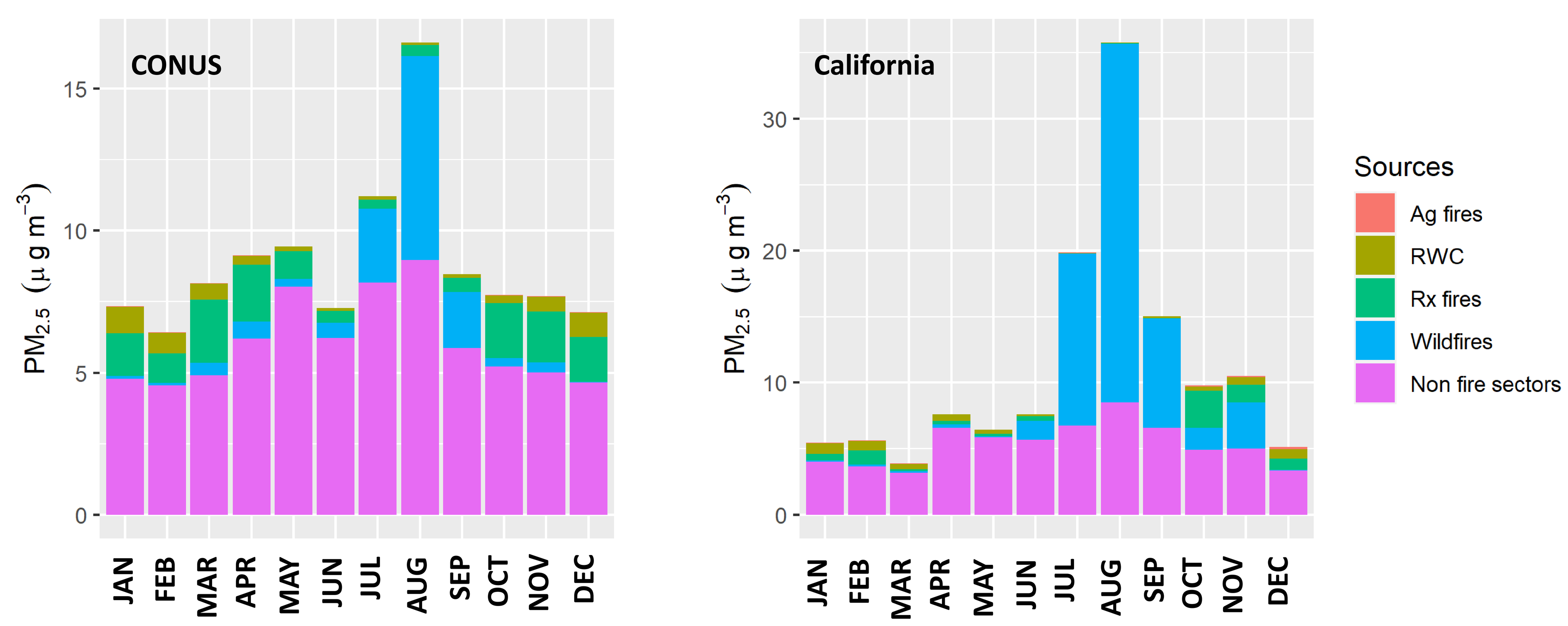
**Comparison of U.S. EPA and Sonoma Technology (STI) Monthly Wildfire Acres Burned in California**



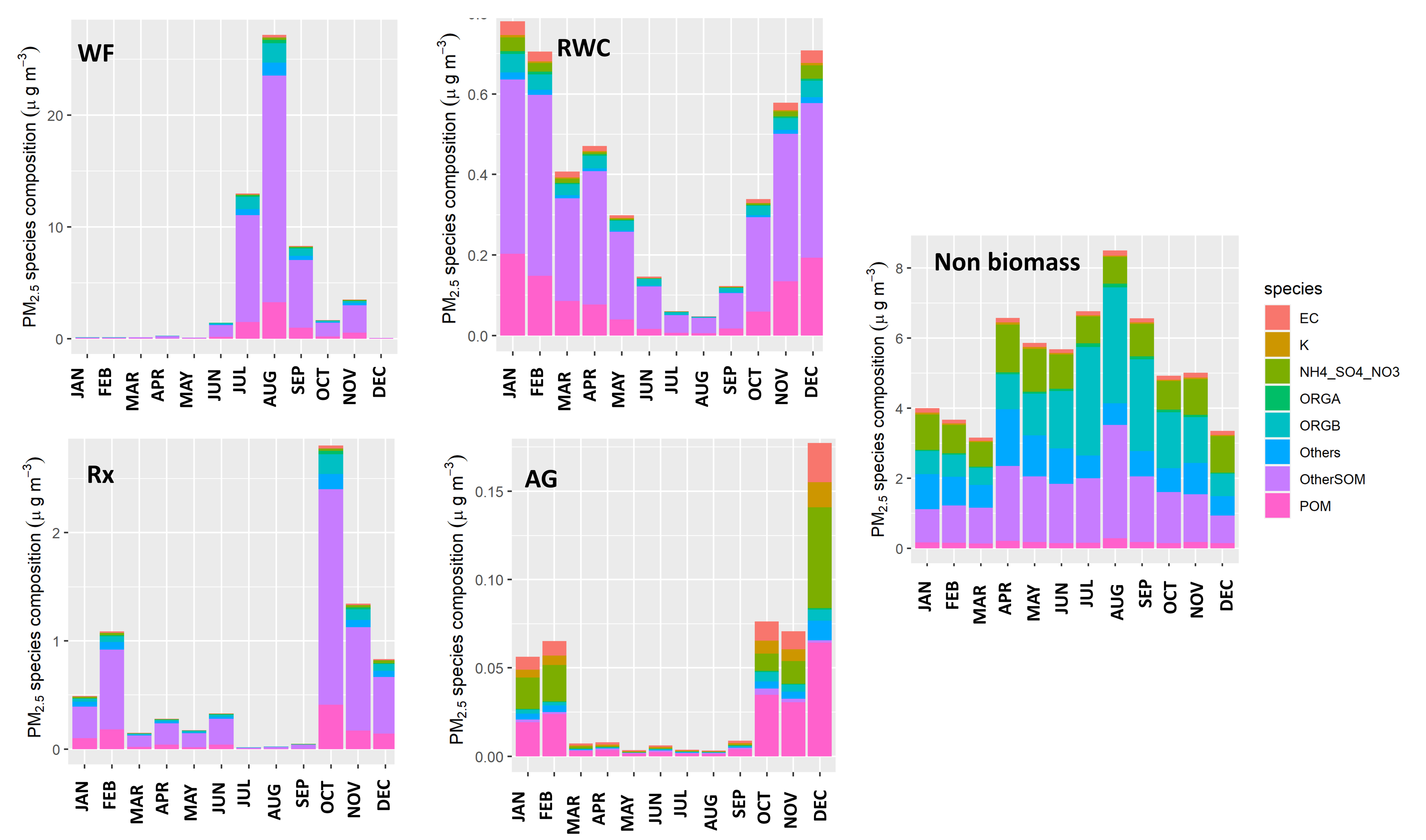

## Spatial Variation: Wildfire (WF) and Prescribed Fire (Rx) Contributable $PM_{2.5}$ (µg/m³) in 2018




## 2018 $PM_{2.5}$ Biomass Source Apportionment in CONUS and California by Month




## 2018 $PM_{2.5}$ Chemical Component Related to Biomass Emissions in California by Month




## Conclusions

- WF is the most important biomass emission source of $PM_{2.5}$ from July through September in California, with monthly average contributions ranging from 50% to 75%.
- The second largest biomass contributor of $PM_{2.5}$ is Rx emissions, with monthly contribution ranging from >5% to 25% from October to April.
- WF, Rx, and RWC have similar impacts on $PM_{2.5}$ chemical component with high other secondary organic matter. However, for AG emissions, the most import species are $SO_4$, $NO_3$, $NH_4$ aerosols and primary organic matter.

## Future Work

- Investigate the differences between wildfire contributable $PM_{2.5}$ using the EPA inventory and Sonoma Technology's inventory. This will help us understand the impacts on accuracy of the CMAQ simulation from accuracy of emissions.
- Explore biomass combustion-related chemistry in CMAQ. Currently, primary organic and secondary organic aerosol formations near emission sources in CMAQ are not well predicted.
- To analyze ambient $PM_{2.5}$ from wildfires and to prescribe fires from an environmental justice perspective.

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