Fire Impact on Atmospheric Chemistry

THE 26th CESM ANNUAL WORKSHOP
Fire cross -WG session

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Challenges in modeling the impacts of fires on air quality

- Emissions
- Chemistry
- Transport

About 80–90% of the emissions by mass from biomass fires are of CO_2

Of the non-CO_2 portion:

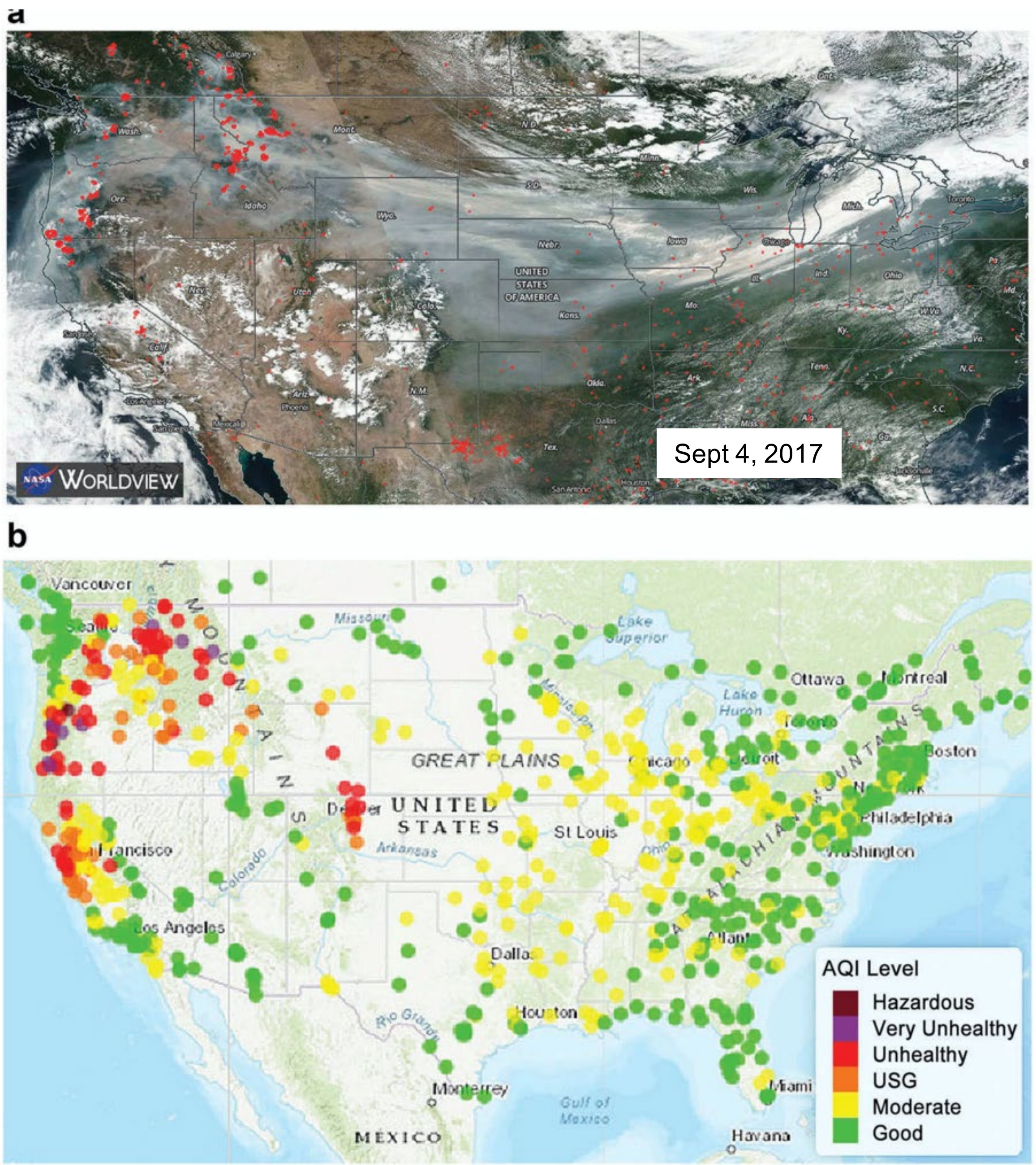
- CO (~60%),
- volatile organic compounds (VOC, ~15%)
- primary PM2.5 (~8%)
- CH_4 (~2%)

Both particles and gas-phase species emitted from fires impact atmospheric composition

Air quality pollutants:

PM2.5

ozone



Jaffe et al., JAWMA, 2020
doi:10.1080/10962247.2020.1749731

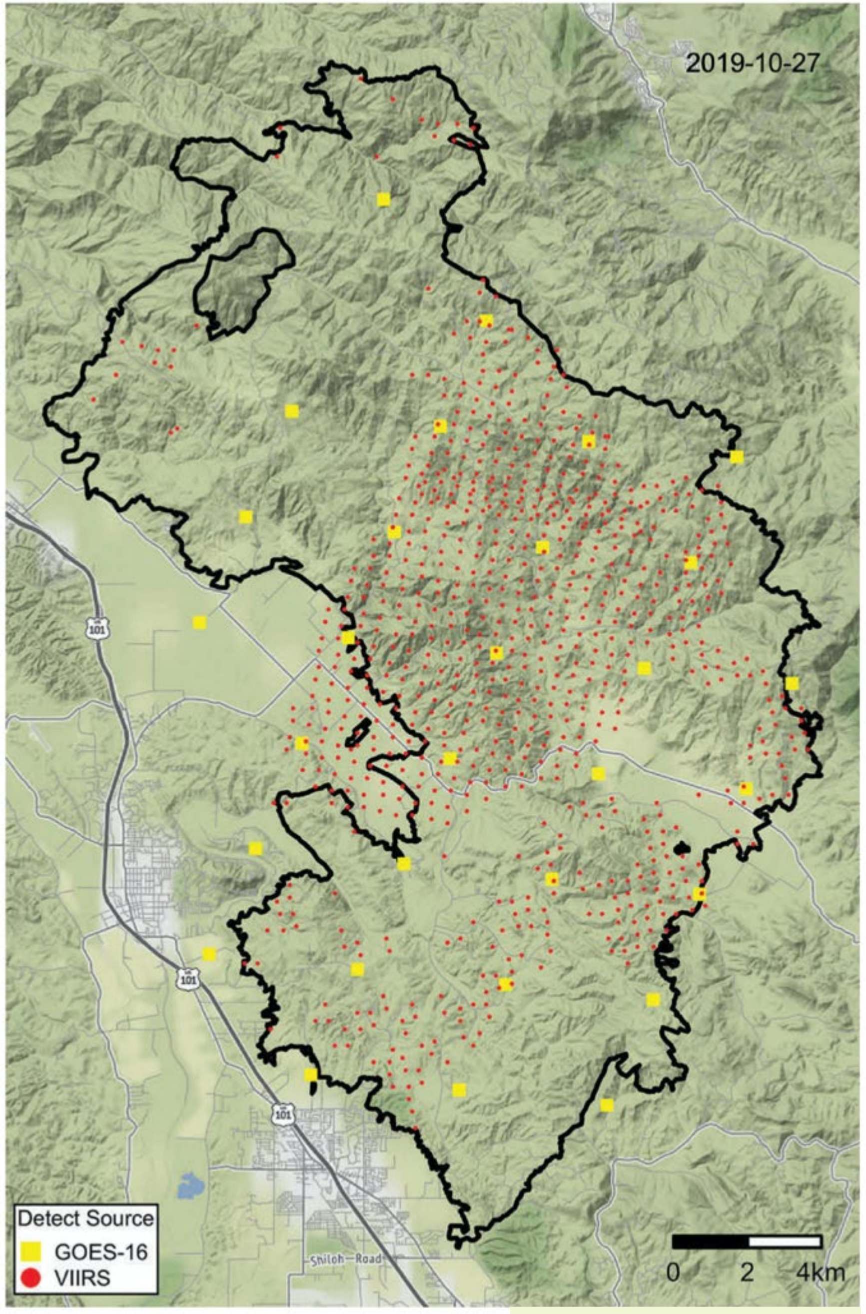
Emissions of compound x:

$$E(x) = A \times B \times FB \times EF(x)$$

A: Area burned
B: mass of biomass per unit area
FB: fraction of biomass consumed
EF(x): Emission Factor per unit fuel consumed for compound x

Sources of uncertainty:

- Detection or initiation of fire (clouds blocking satellite detection, small fires…)
- Identification of type of fuel burned
- Estimates of fuel consumed
- Emissions for each compound depend on fuel type burned and fire intensity



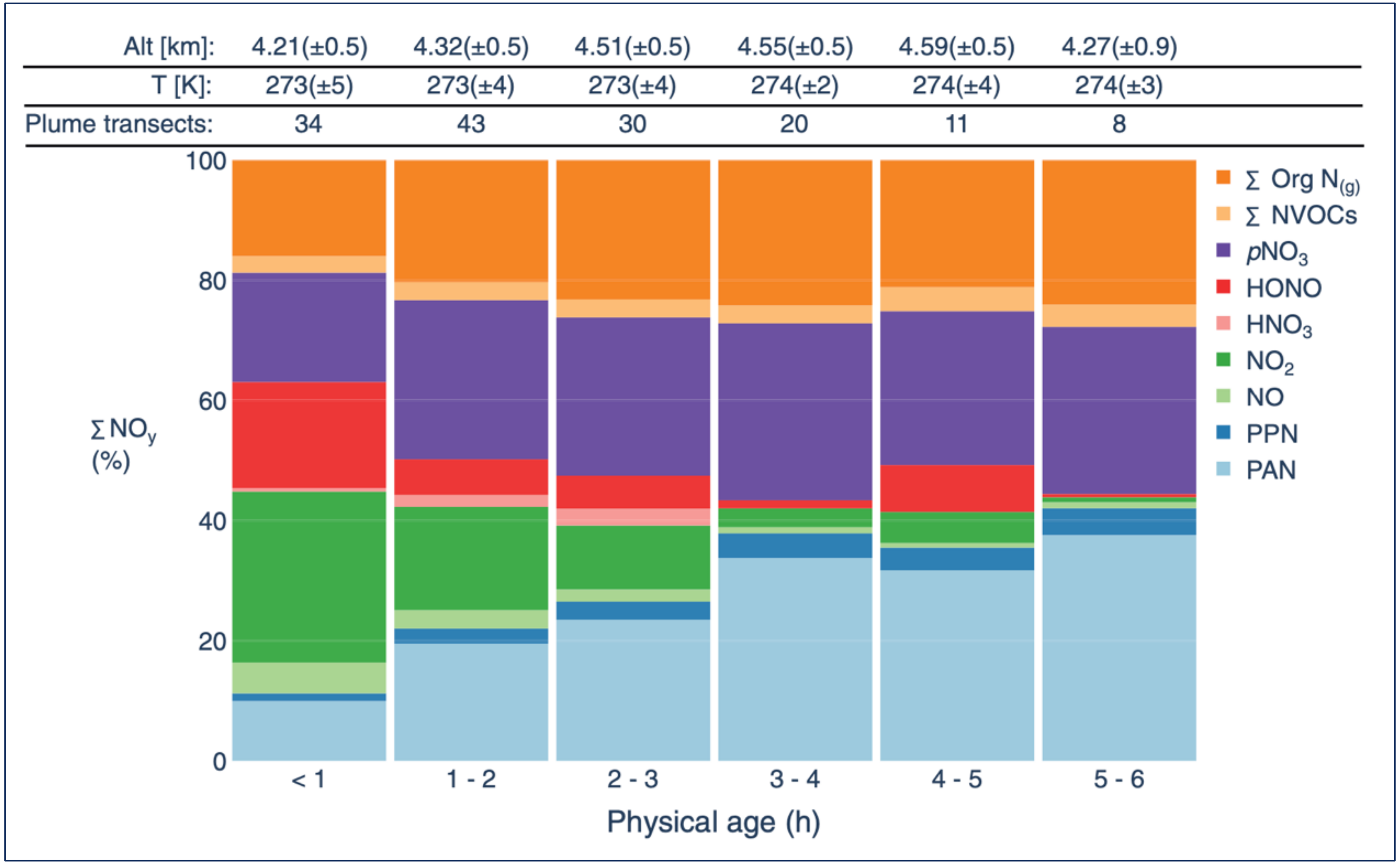
from Jaffe et al., 2020

Chemistry

Analysis of WE-CAN fire plume sampling

Partitioning of reactive Nitrogen compounds changes as the plume ages downwind

- NO & NO_2 decrease
- PAN, organic nitrates and particulate nitrate increase



Uncertainty in fire emissions of NO and VOCs result in uncertainty in ozone and secondary aerosols downwind

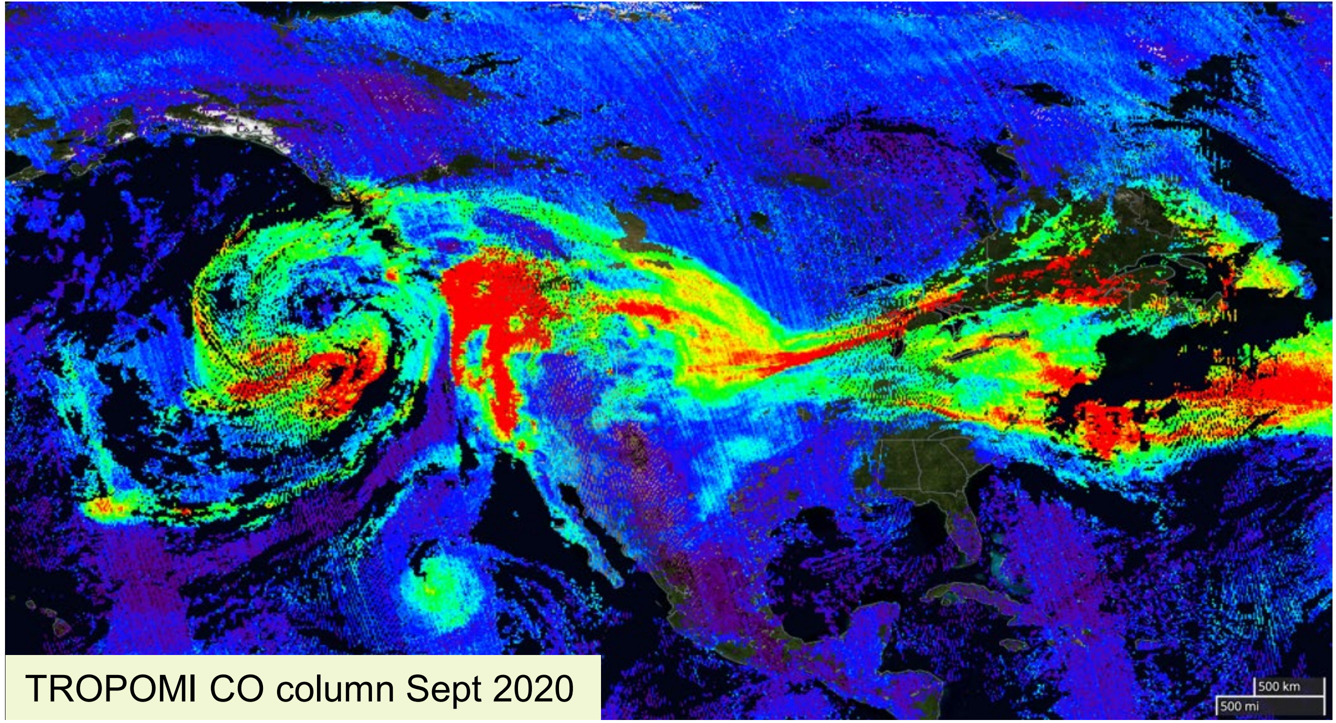
Many more VOCs are observed in fire plumes than are included in model chemical schemes

Model resolution (horizontal & vertical) impacts chemical regimes

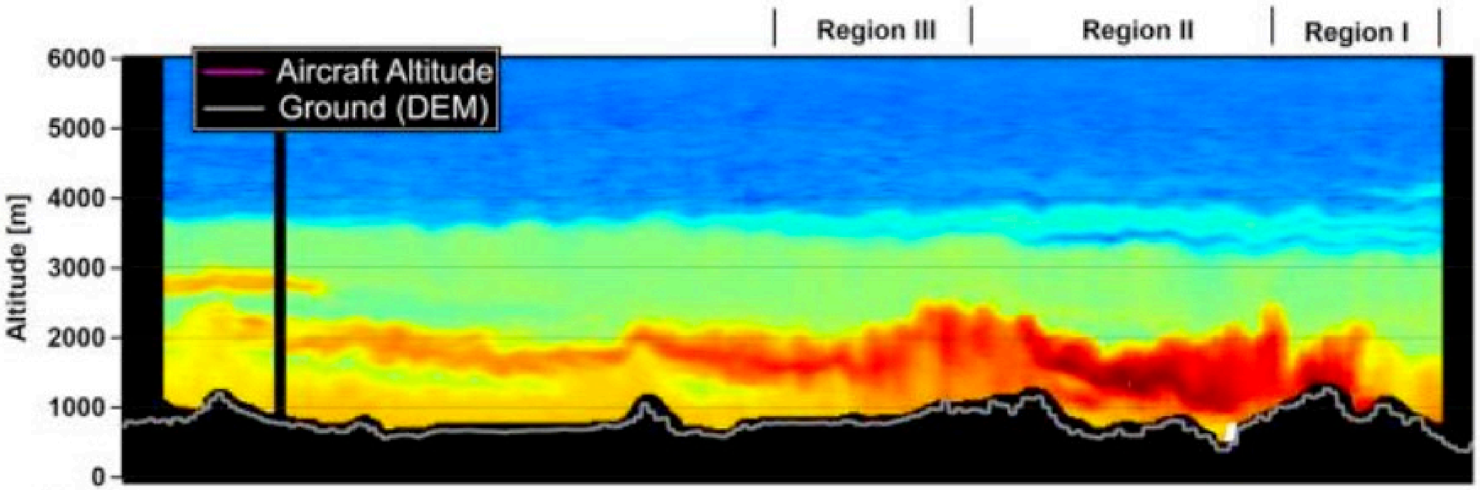
Juncosa Calahorrano et al., JGR, 2021
doi:10.1029/2020JD033484

Transport

- Plume-rise / Injection height of emissions
- Boundary layer –
  mixing, detrainment, entrainment
- Long-range transport –
  local to hemispheric



TROPOMI CO column Sept 2020



DIAL backscatter from DC-8 FIREX-AQ
[Junghenn Noyes et al., 2020]

Fire simulations with MUSICA -V0

MUSICA
Multiscale Infrastructure for Chemistry and Aerosols

CAM-chem with regional refinement: CONUS at 14 km

Analysis of WE-CAN (2018) and FIREX-AQ (2019) aircraft campaigns

Model grid is fine enough for direct comparison to aircraft observations and allows critical evaluation of emissions, chemistry, plume rise, transport, …