Global Carbon Consumption Database for Wildland Fire

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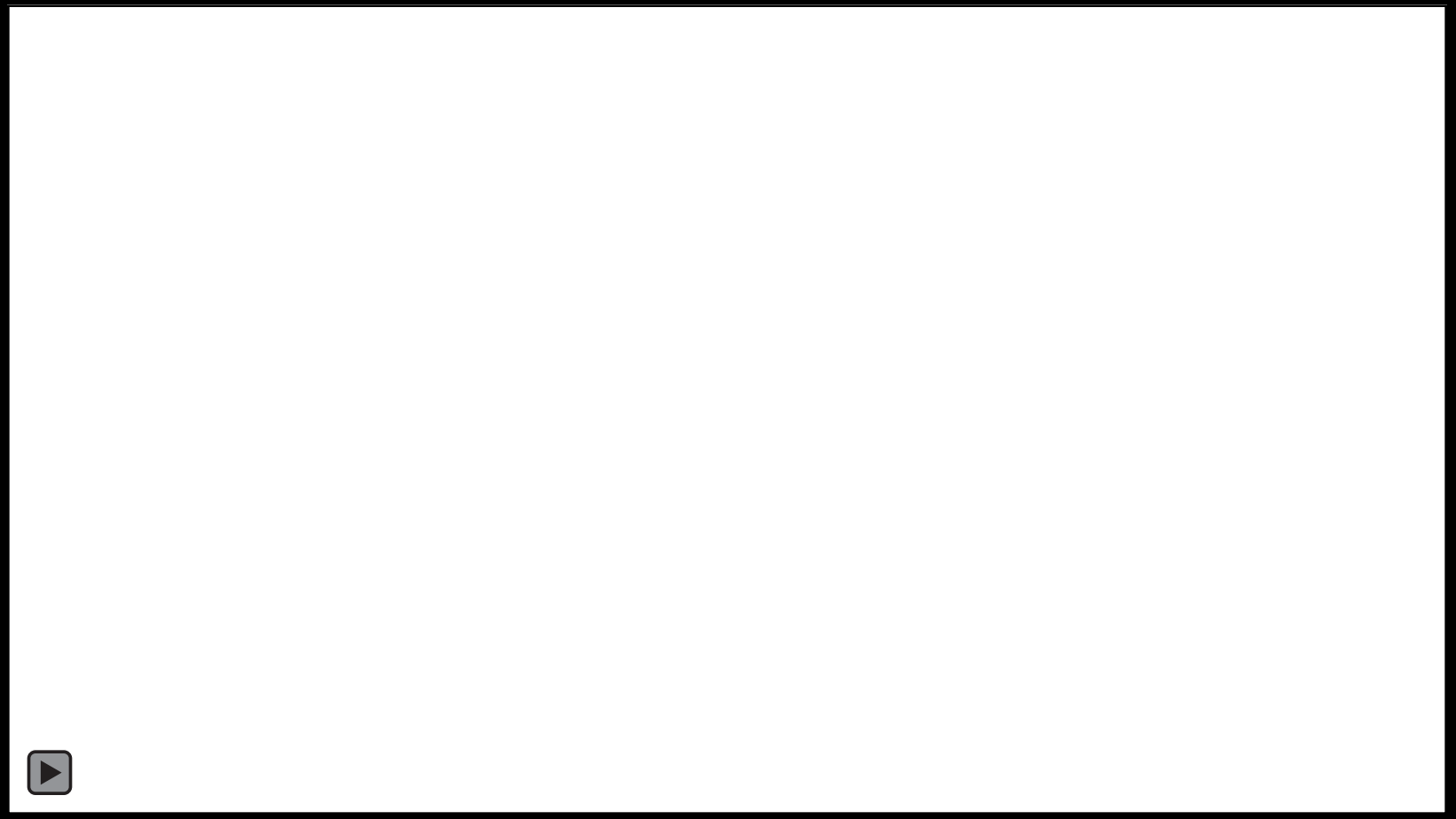


NATIONAL INSTITUTE OF AEROSPACE

Fuel2Fire

NASA

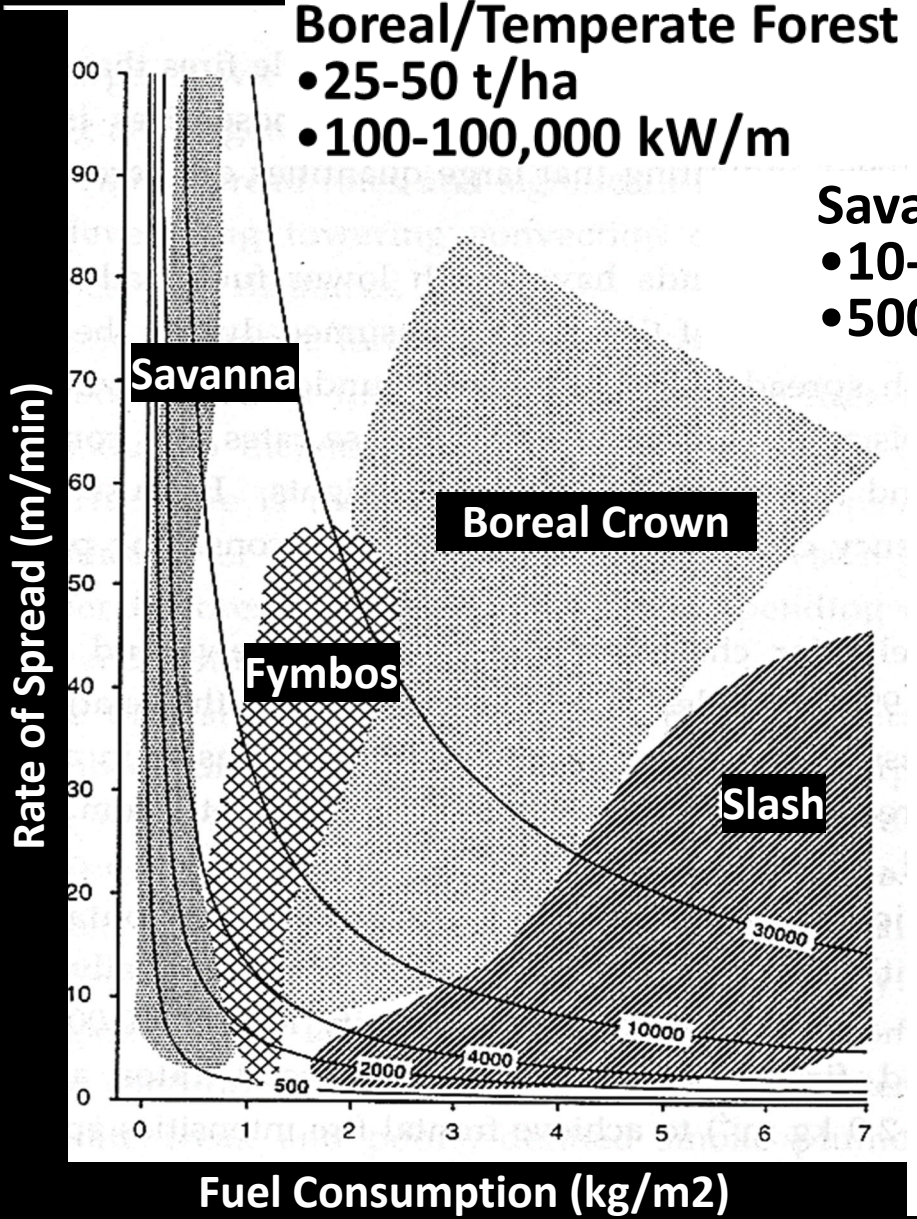
Global Connections: Fire, Smoke, Air Quality

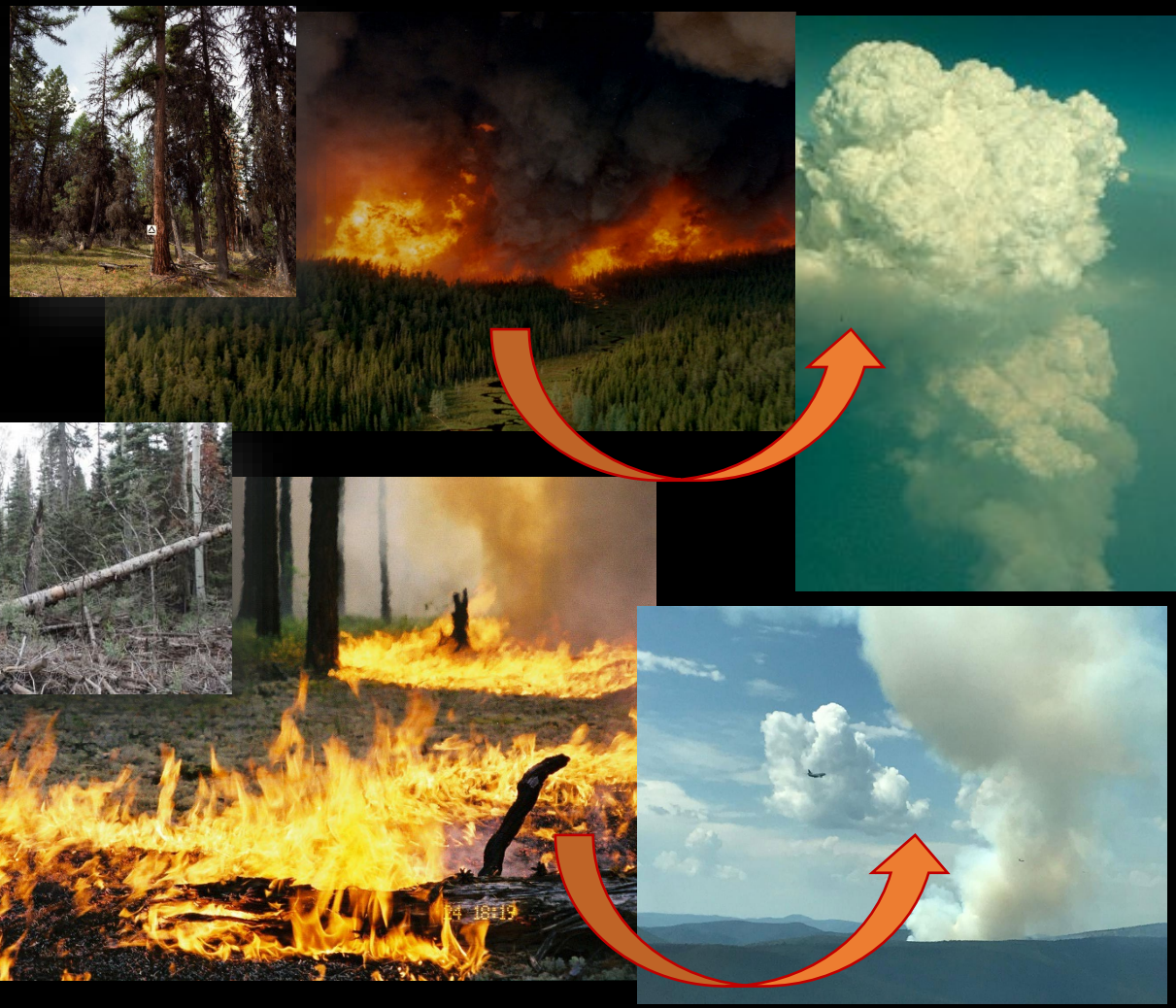


Fuel Characteristics- Fire Intensity- Energy Release- Emissions

Boreal/Temperate Forest Fire:
- 25-50 t/ha
- 100-100,000 kW/m

Savanna Fire:
- 10-12 t/ha
- 500-10,000 kW/m





Driving force: Fire Weather & Available Fuel

Building a Global Carbon Consumption Database for Wildland Fire

We use the Pettinari, M. Lucrecia (2015) Global Fuelbed database as a base for fuel

- a global fuel map with standardized Fuel Characteristic Classification System (FCCS) biomass parameters
  - Includes variables such as canopy biomass, ladder fuels, shrub, duff, etc
- ~300m resolution
- 274 main fuelbeds, 359 when sub-fuelbeds considered

Source: Pettinari, M Lucrecia (2015): *Global Fuelbed Dataset [dataset]. Department of Geology, Geography and Environment, University of Alcala, Spain, PANGAEA, https://doi.pangaea.de/10.1594/PANGAEA.849808*

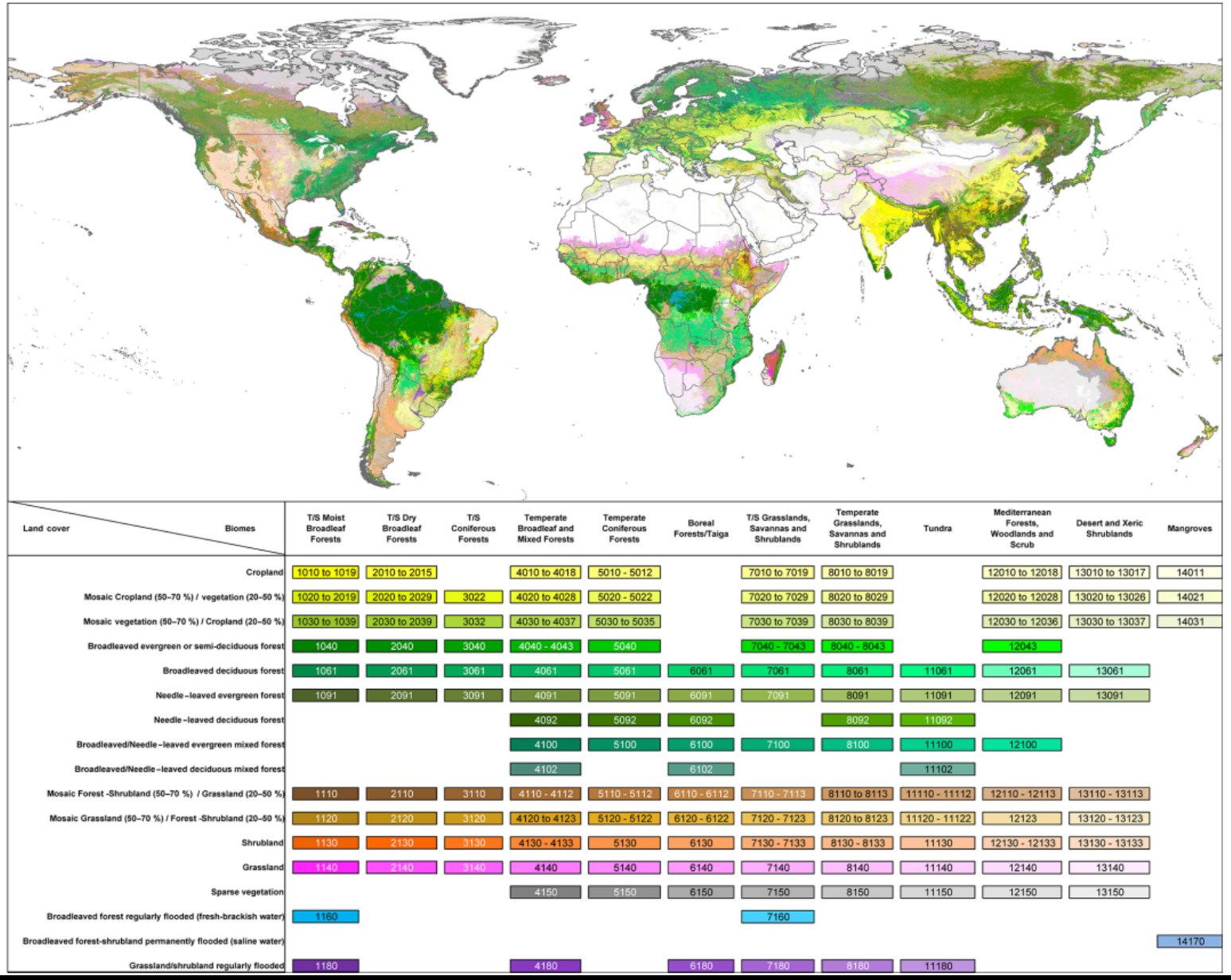


Figure Credit: Pettinari, M. L. and Chuvieco, E.: Generation of a global fuel data set using the Fuel Characteristic Classification System, Biogeosciences, 13, 2061–2076, https://doi.org/10.5194/bg-13-2061-2016, 2016.

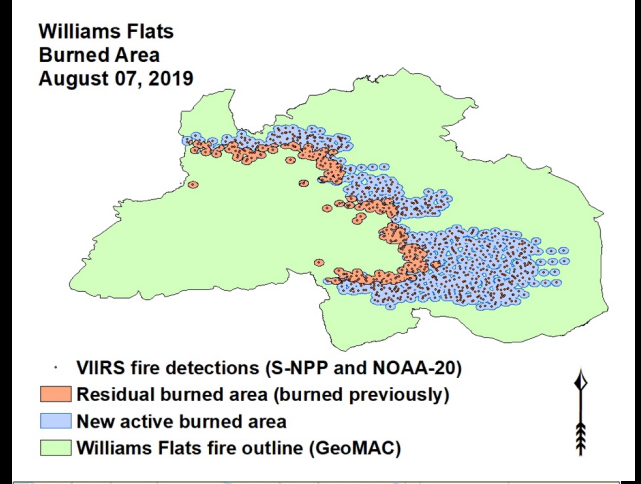
Proof of concept

FIREX-AQ Daily Fire Emissions Methodology

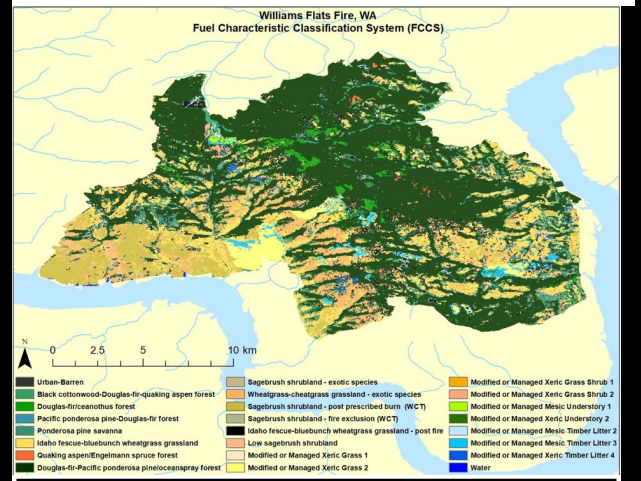
$$C_t = A \times B \times F_c \times C_b$$ [Seiler and Crutzen, 1980]

A = Area Burned (VIIRS/MODIS)
B = Biomass Density (FCCS)
F_c = 0.5 (Assumed biomass carbon)
C_b = Fraction of biomass consumed (Weather)

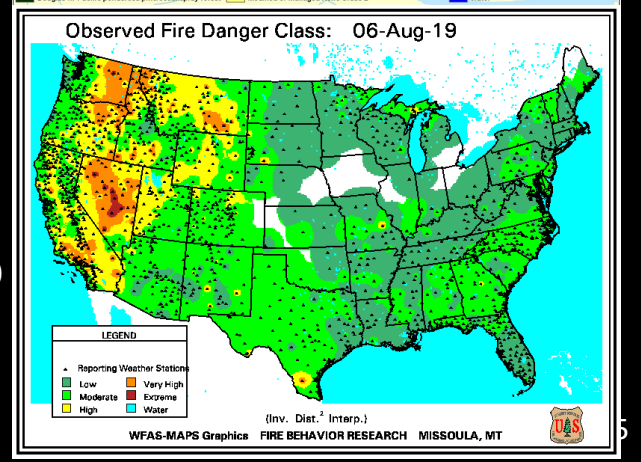
[Soja et al., 2004; Pierce et al., 2007; Pierce et al., 2009; Wiedinmyer et al., 2011]



A

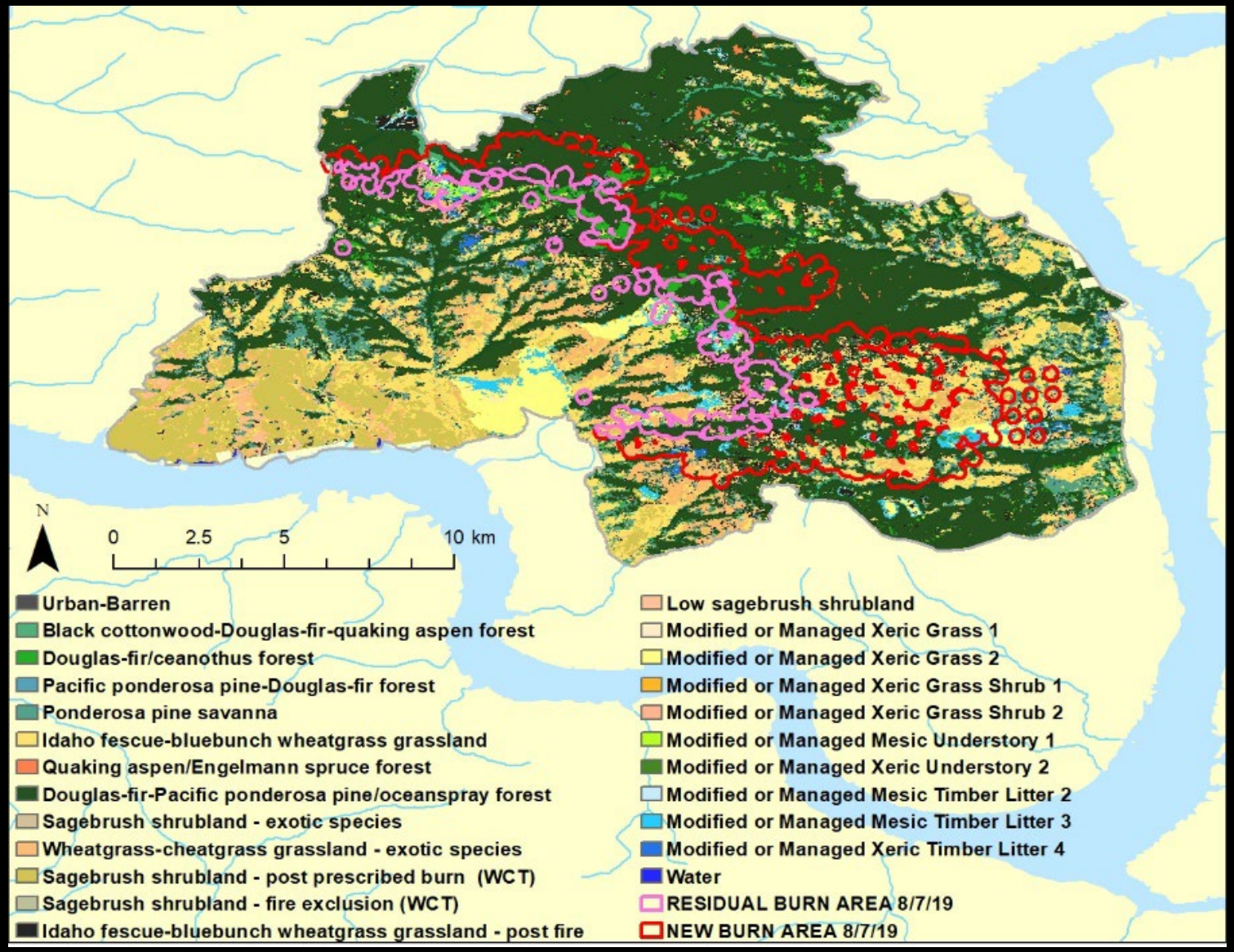


B



C_b

Fueled from below: FCCS Fuels and burned area

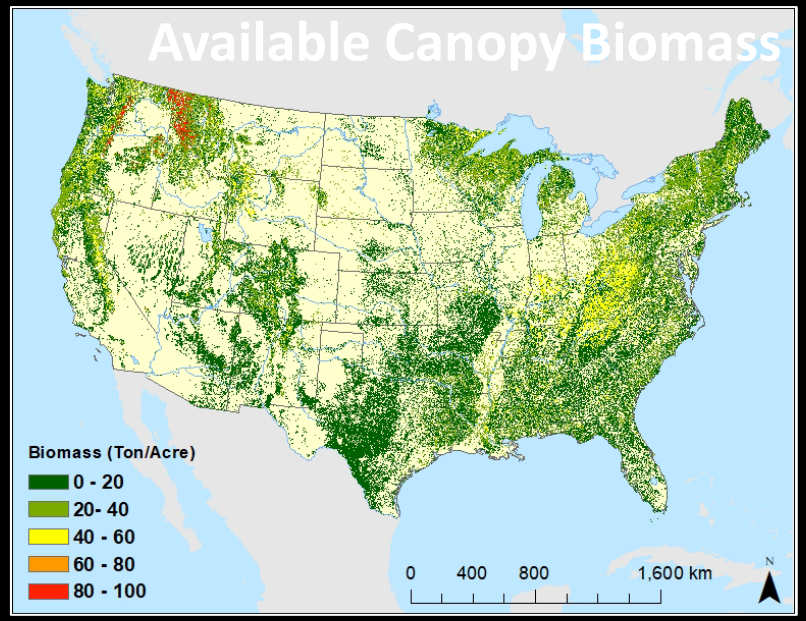


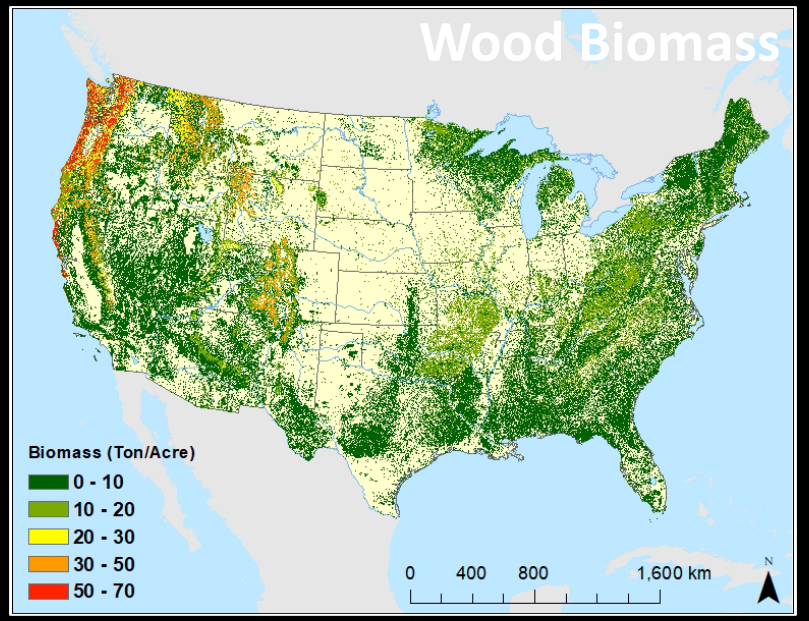
FCCS 30 m fuels

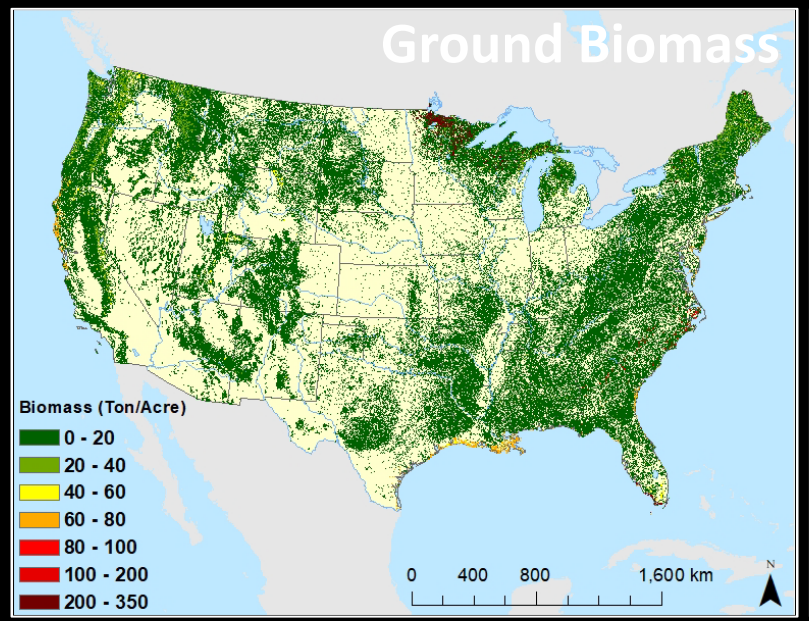
Burned area outlines
VIIRS 375m buffered area

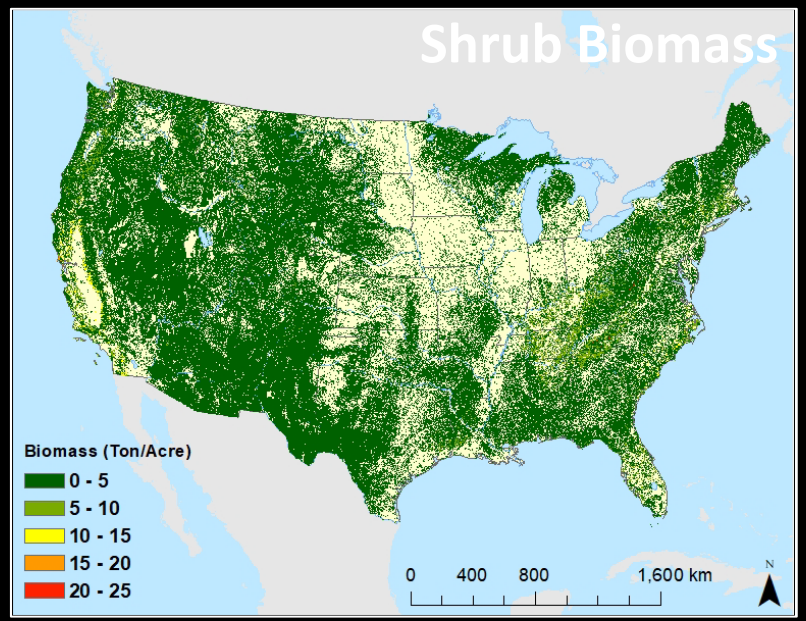
New burned area
in red and
Residual or
previously burned areas
in pink-purple

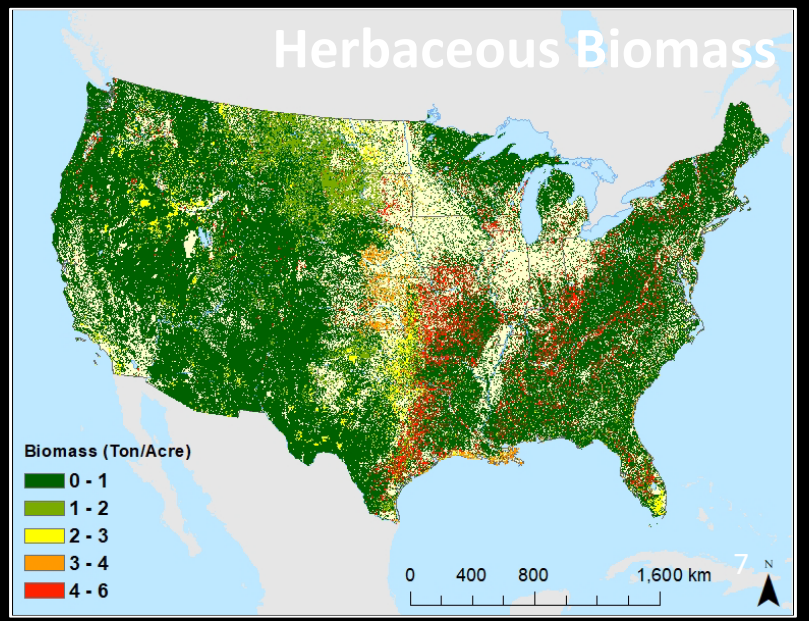
CONUS Fuel Characteristic Classification System (FCCS) Fuelbeds- 30 m











Fuel Decision Table: Allocation of New:Residual

Percentage of Fuel Burned in each Fire Weather Category					
New (N) burned area / previously burned Residual (R) area					
Variable	**Extreme N/R**	**Very High N/R**	**High N/R**	**Moderate N/R**	**Low N/R**
Canopy_avai_load	90 / 5	80 / 5	60 / 5	10 / 0	0 / 0
Shrub_tpa_biomass	100 / 0	80 / 5	60 / 5	40 / 5	20 / 5
Herb_tpa_biomass	100 / 0	80 / 5	60 / 5	40 / 5	20 / 5
Wood_tpa_biomass	20 / 40	10 / 20	10 / 20	10 / 10	10 / 5
LLM_tpa_biomass	100 / 0	80 / 5	60 / 5	40 / 5	20 / 5
Ground_tpa_fuel	20 / 40	10 / 20	10 / 20	10 / 10	10 / 5

Total available fuel loading of canopy fuels, including tree crowns, C2 and C3 snags, and ladder fuels. Does not include tree boles or C1 snag wood.

Total aboveground shrub and herbaceous biomass

Total combustible wood, including downed wood, rotten and lightered stumps, and piled wood.

Litter, lichen and moss biomass

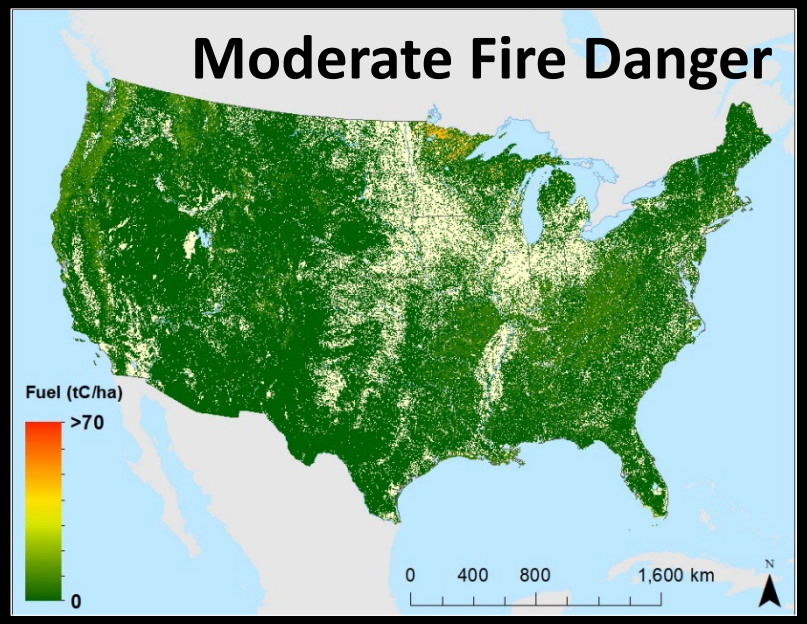
Ground fuels including duff, basal accumulations and squirrel middens

Soja et al., 2004
Pierce et al., 2007
Petrenko et al., 2012

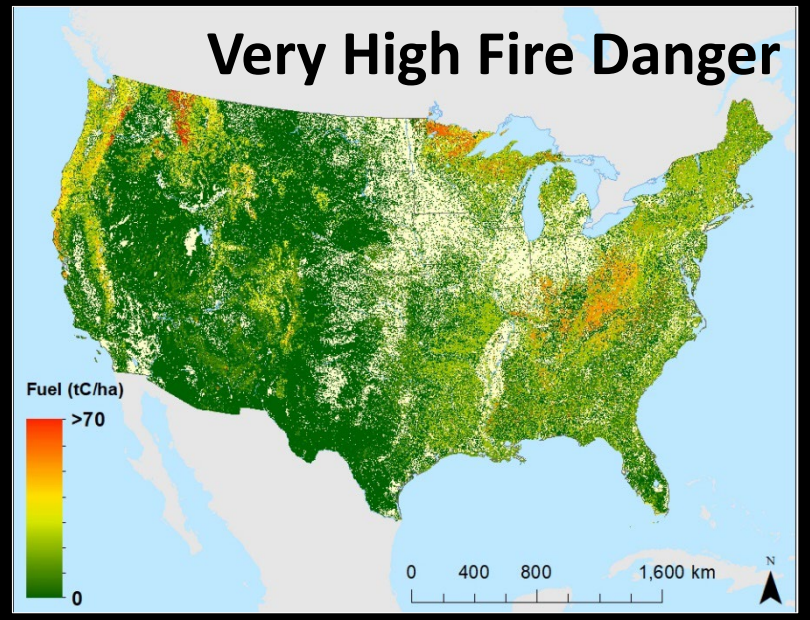
Fuel Available for New Burn

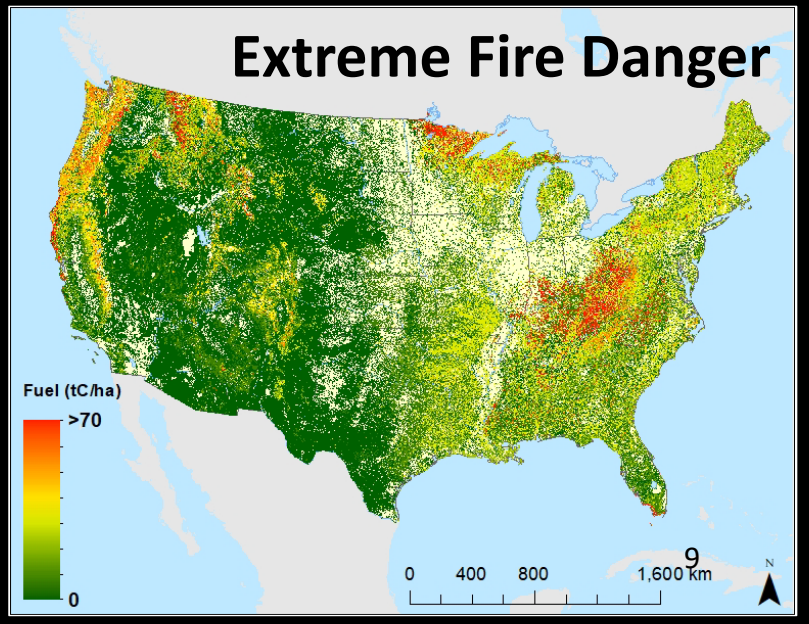
FCCS-based Fuel











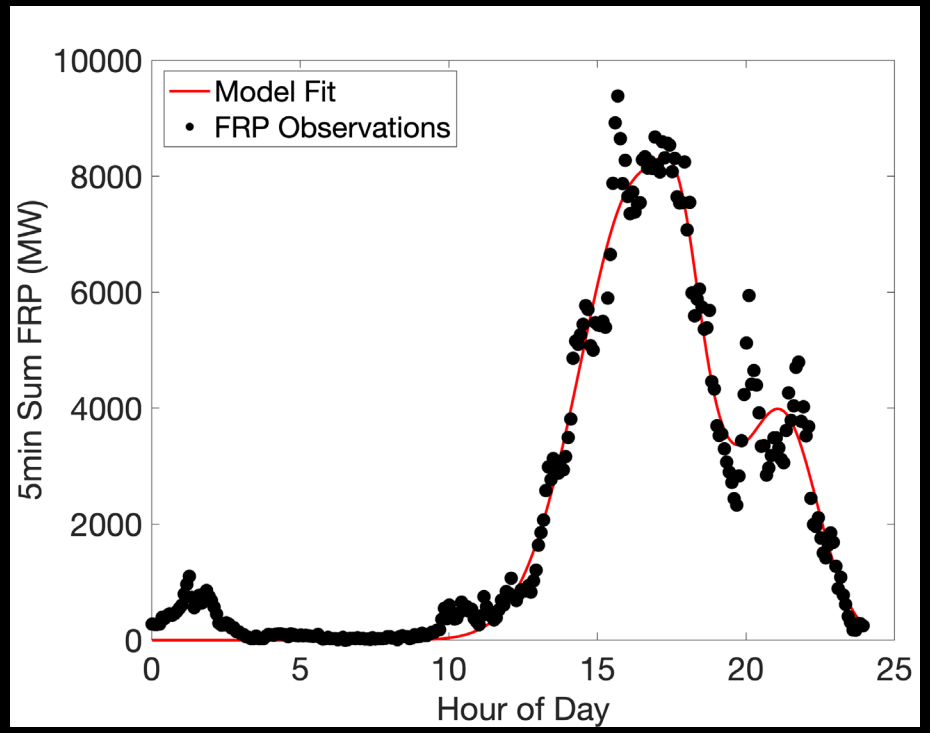
Emissions Model

$$C_t = A \times B \times F_c \times C_b$$

A = Area Burned (VIIRS/MODIS)
B = Biomass Density (FCCS)
F_c = 0.5 (Assumed biomass carbon fraction)
C_b = Fraction of biomass consumed (Weather)

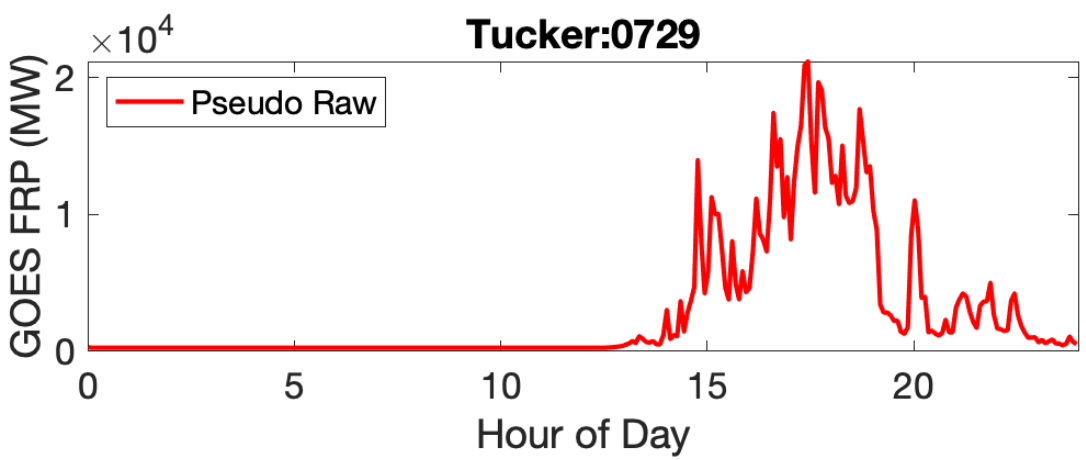
Flaming/Smoldering Allocation

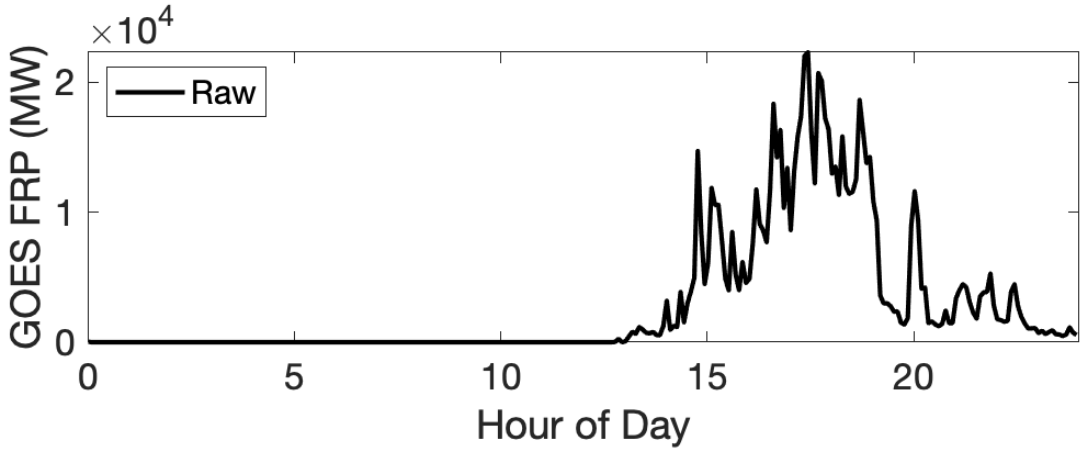
Diurnal Cycle Derived from 5-min GOES FRP Observation

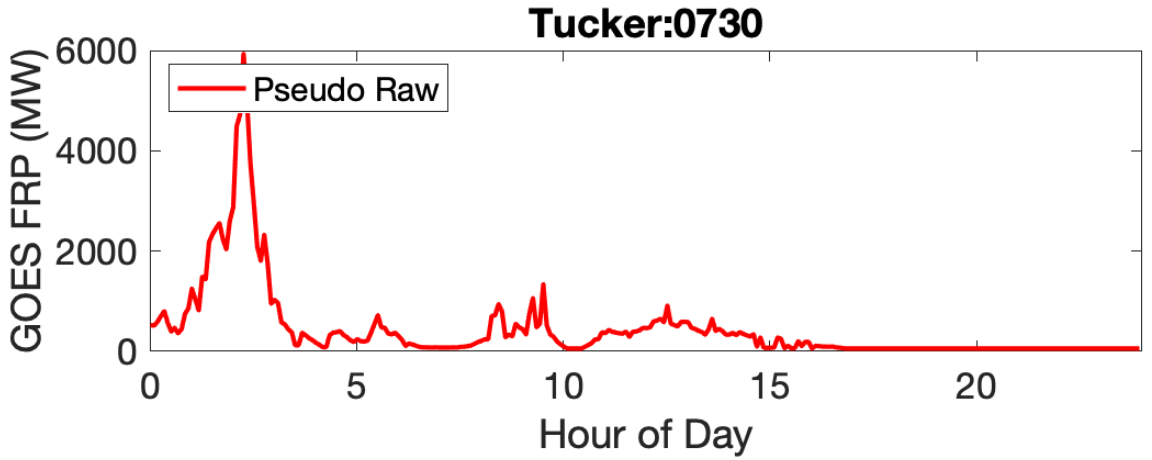


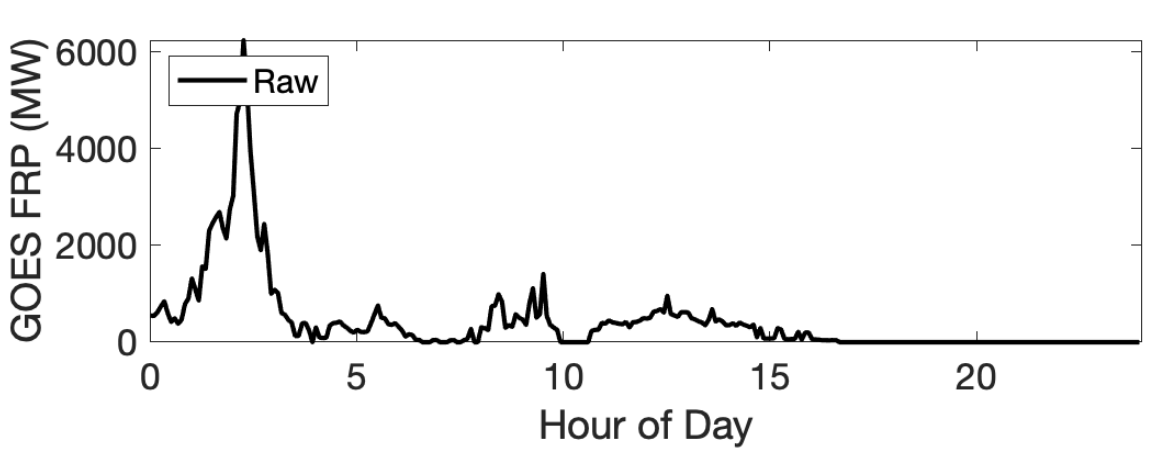
1-Sec Emissions

When GOES data are not available (smoldering fire, cloud cover inhibiting detections), a mean of each fire is used to define the diurnal cycle


Tucker:0729
×10^4
GOES FRP (MW)
Pseudo Raw
0
1
2
0
5
10
15
20
Hour of Day

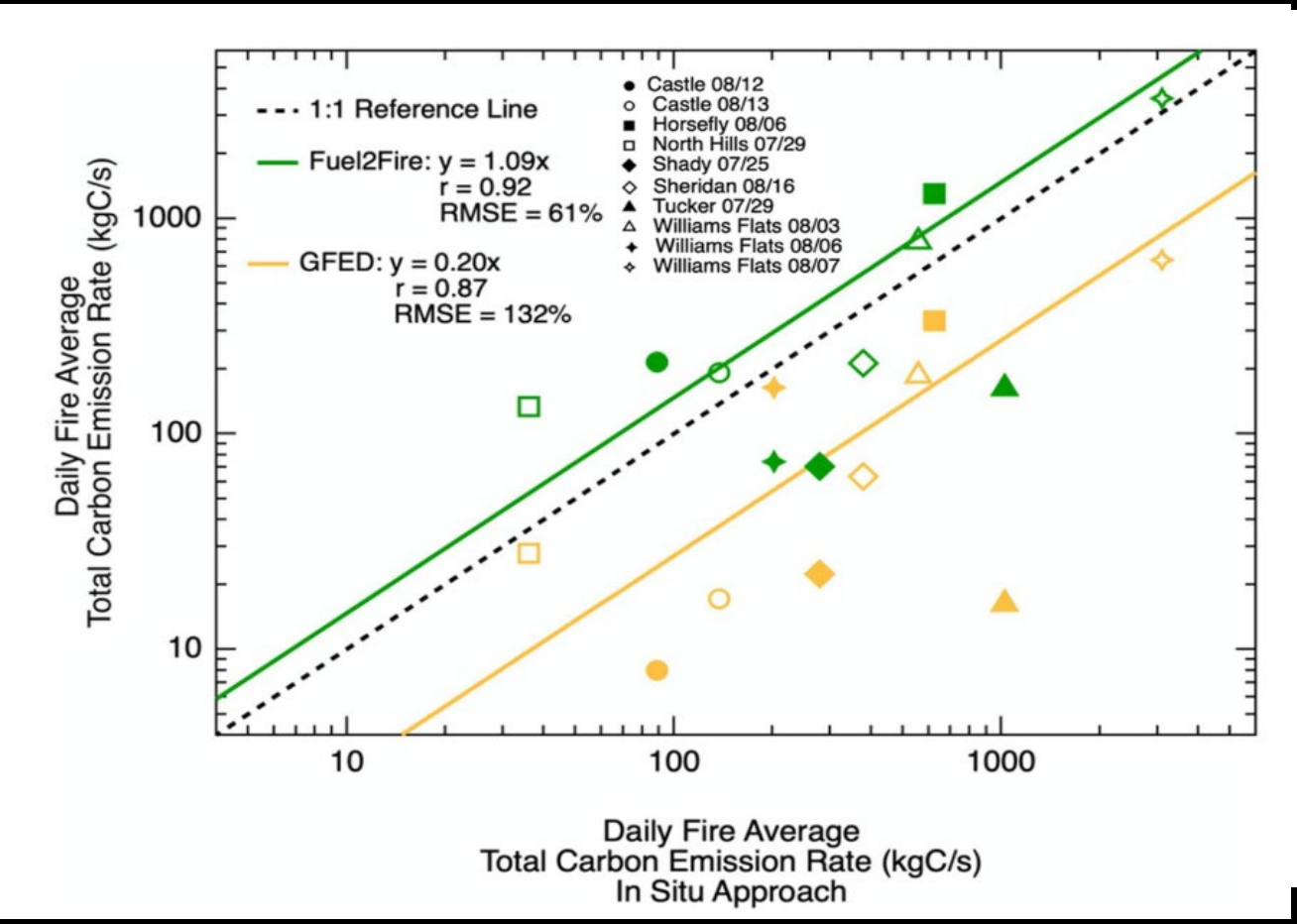

×10^4
GOES FRP (MW)
Raw
0
1
2
0
5
10
15
20
Hour of Day


Tucker:0730
GOES FRP (MW)
Pseudo Raw
0
2000
4000
6000
0
5
10
15
20
Hour of Day

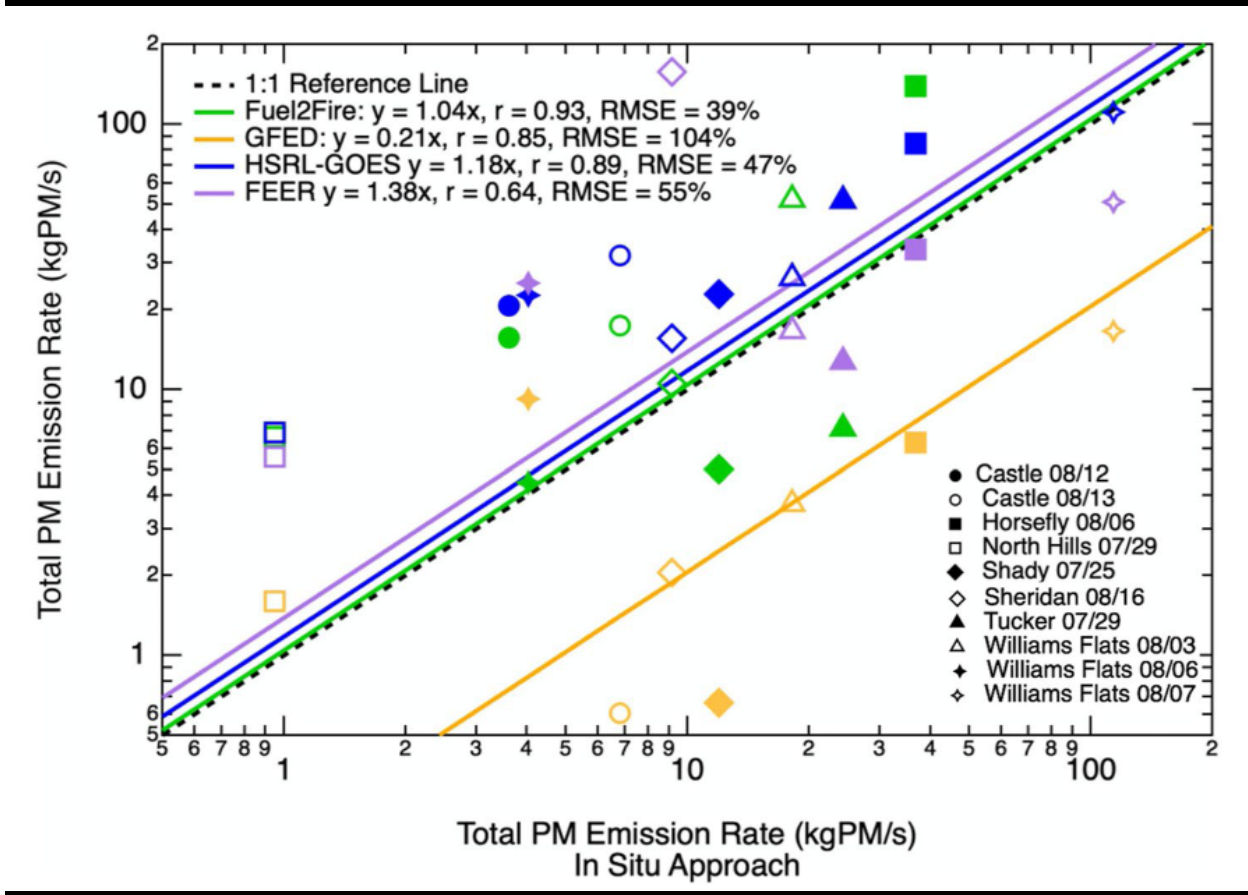

GOES FRP (MW)
Raw
0
2000
4000
6000
0
5
10
15
20
Hour of Day

Emissions Comparisons with in-situ aircraft data

Wiggins et al., GRL 2020; Wiggins et al., JGR 2021



Daily fire average total carbon emissions rate



Total Particulate Matter emissions rate

Global Product

- Pettinari, M. Lucrecia (2015) Global Fuelbed database as a base for fuel
- We will apply the same Fuel Decision Table for Allocation of New:Residual percentages for each biomass variable
- Final 300 m product will contain tC released under each of 5 fire danger levels and for new vs residual burning
- Global product will be made publicly available