Fire Light Detection Algorithm-2 (FILDA-2): A New VIIRS Product to Advance Fire Emission Estimates

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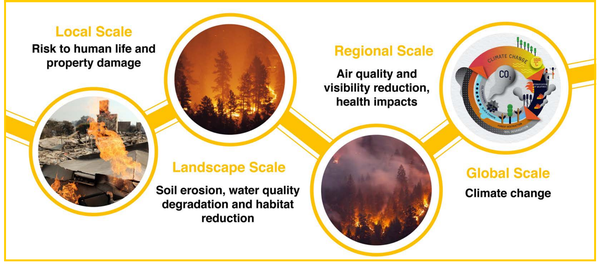
Motivation and Research Goal

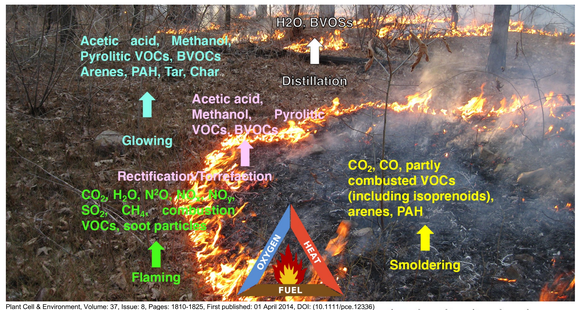
Biomass burning plays a significant role in both Earth's system and human society. The modified combustion efficiency (MCE) posts great impacts on the microphysical and optical properties of the trace gas and aerosol. It is a key parameter in determine the emissions of the chemical transport model for air quality and climate change studies. While most of the fire emission inventories assume a fixed MCE and consequently fixed emission factors (EF) for different species, a dynamic MCE is expected to advance the model skills for the fire modeling.

In this research, we developed the nighttime Fire Light Detection Algorithm (FILDA-2) by utilizing the Visible Infrared Imaging Radiometer Suite (VIIRS) Day-night band (DNB), the moderate band (M-band), and the image band (I-band) to detect the active fire and estimate the MCE. The MCE will provide valuable information for building a dynamic fire emission inventories for the modeling communities for better representation of fire in the model.

Wildfire poses risks to all levels of the Earth System



Combustion phase greatly impacts the fire emission



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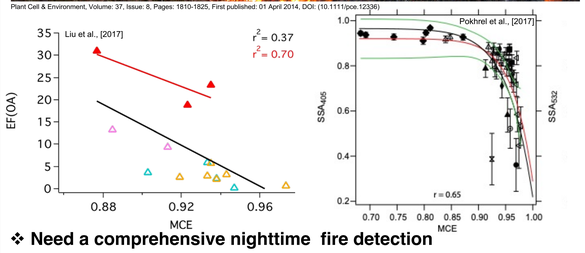
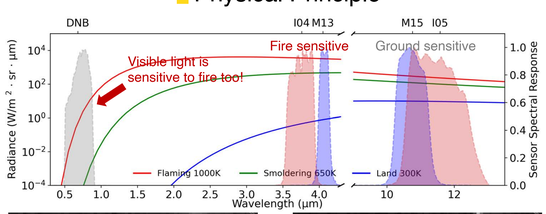
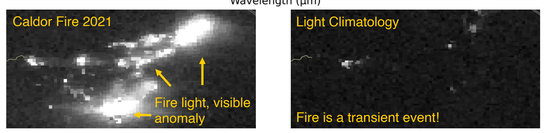


- **Need a comprehensive nighttime fire detection**
- **Need information for characterizing the MCE and EF of fire**

Methodology

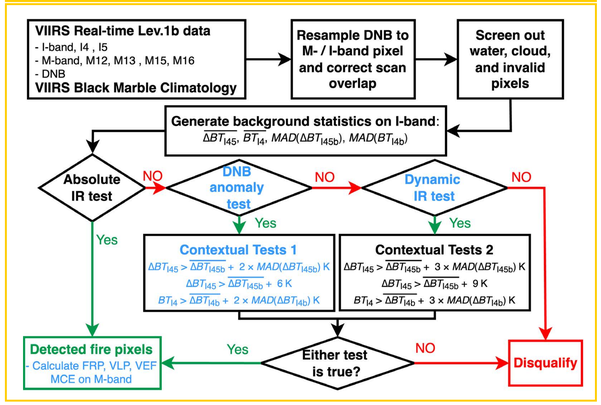
Physical Principle



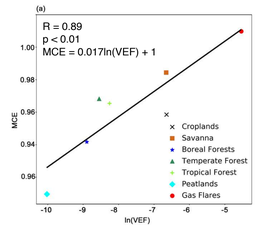


- Visible anomaly at night is a good indicator of fire
- Ratio between visible light power to total fire radiation power is sensitive to fire temperature (combustion efficiency)

Flowchart of the detection algorithm



Retrieval of fire information



$$FRP = \frac{A\sigma(L_{13} - L_{13B})}{C}$$

$$VLP = \pi A(L_{DNB} - L_{DNB\_B})$$

$$VEF = \frac{VLP}{FRP}$$

$$MCE = 0.017 \ln VEF + 1$$

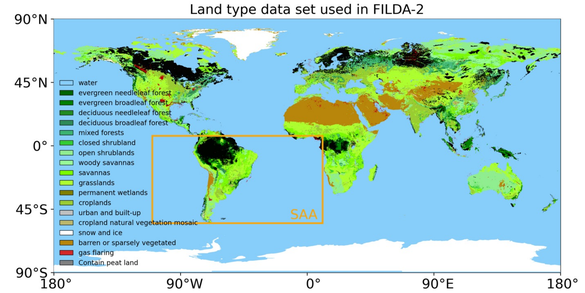
FRP: Fire Radiative power VLP: Visible Light Power
VEF: Visible Energy Fraction MCE: Modified Combustion Efficiency

Wang, W. and Cao, C., 2019. NOAA-20 VIIRS DNB aggregation mode change: Prelaunch efforts and on-orbit Verification/Validation results. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 12*(7), pp.2015-2023.

Data source

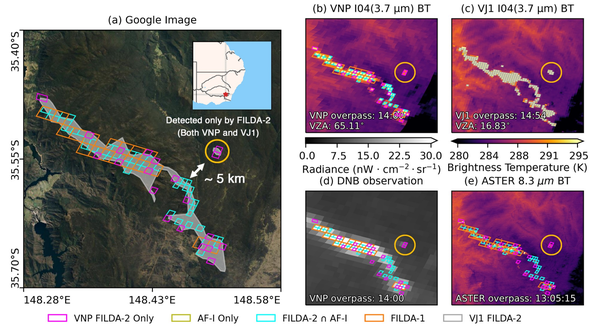
- Suomi-NPP, NOAA-20 VIIRS Nighttime Observation:
  - DNB [0.5 ~ 0.9 μm], Panchromatic Band, 750 m
  - M-band [4.05], Monochromatic band, 750 m
  - I-band [3.74, 11.45], Monochromatic band, 375 m
- VIIRS Black Marble product (VNP46A1)
- MODIS Terra and Aqua combined land cover product
- PEATMAP global peatland database
- Global gas flaring dataset

Land type data set used in FILDA-2



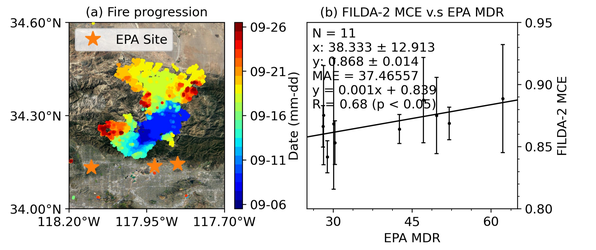
Case Study & Global Assessment

Case study I: 19/20 Australia Bushfire



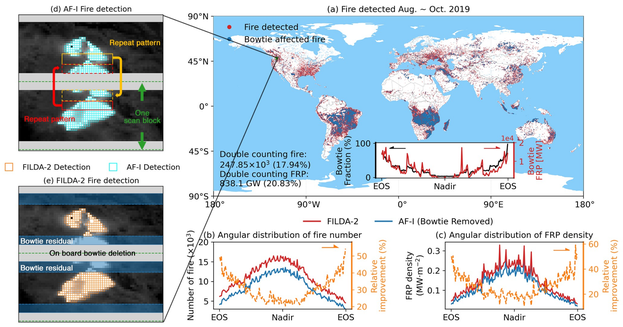
- Multiband and multi-sensor view of the Black summer bushfire on 8th Jan. 2020 by VIIRS AND ASTER. (a) Google image of the fire events; (b) VNP I-band 3.7 μm brightness temperature at 14:00 UTC; the averaged view zenith angle for this scene is around 65 degrees; (c) Same as (b), but for VJ1 at 14:54 UTC with the view zenith angle of 16 degrees; (d) Same as (b) but for resampled M-band resolution DNB image; (e) ASTER 8.3 μm image overpass at 13:05 UTC. The orange circle indicates an isolated fire event that are around 5 km away from the fire front.

Validation of the MCE derivation



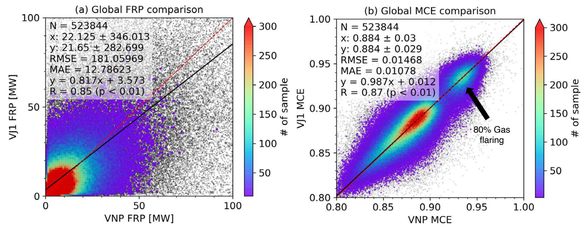
- Validation of the FILDA MCE against EPA CO and NO2 for Bobcat fire in Angeles National Forest, CA, 2020. (a) Fire progression map of the Bobcat in CA 2020; (b) Scatter plot of the EPA MDR vs. FILDA MCE.
- Mole density ratio: $MDR = \frac{\Delta X\ NO_2}{\Delta X\ CO}$

Better identification of double counted fire



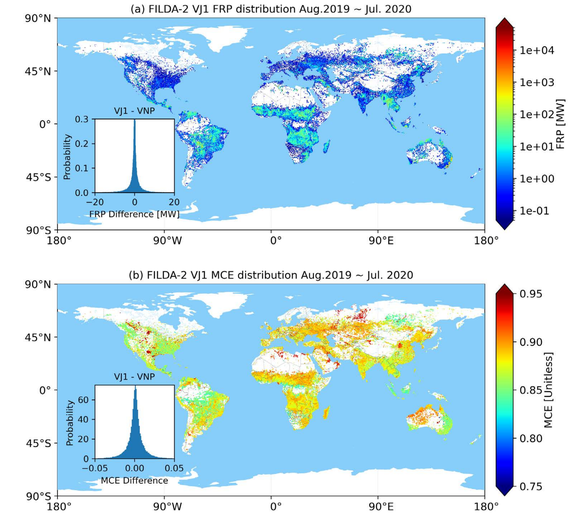
- Illustration of bowtie-effect caused double counting of fire spot and corresponding impact on FRP. (a) Global view of the AF-I fire detection, note in FILDA-2 the bowtie affected fire pixels are well recognized and removed; (b) An example of double counting of fire spot in AF-I, two repeated patterns are highlighted by the dash boxes; (c) Same area as (d) but for FILDA-2 product.

Intercomparison of VJ1 and VNP



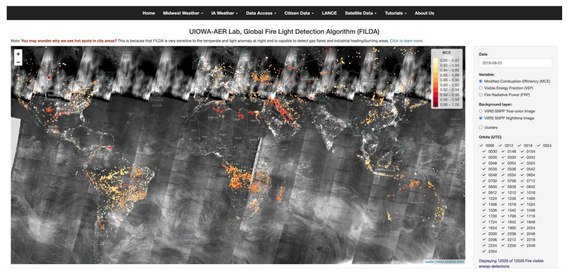
- Fire data were resampled into 0.25-degree CMG for point-by-point compassion.

Global Map of FRP and MCE



FILDA-2 Product

- FILDA-2 (Level 2, 6 minutes swath product) is operational globally at http://esmc.uiowa.edu:3838/fires_detection/, data will be shared upon request.
- FILDA-2 will be delivered to NASA MODIS/VIIRS Land team as a new near real time (NRT) experimental Level-2 (L2) VIIRS nighttime active fire combustion efficiency product (VNP47/VJ147) next year.



Acknowledgement

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