



Estimating smoke emissions using bottom-up and top-down methods for improved smoke forecasting

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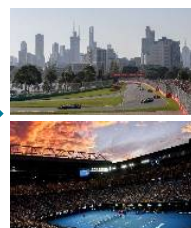
Australia's National Science Agency



AQFx - a tactical tool to aid decision-making



HEALTH



Impacts on public outdoor events



VISIBILITY



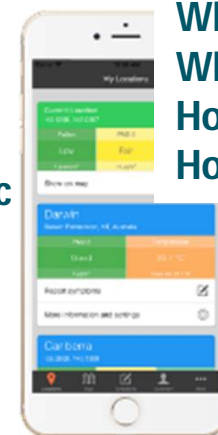
Impact on transport sector



VITICULTURE

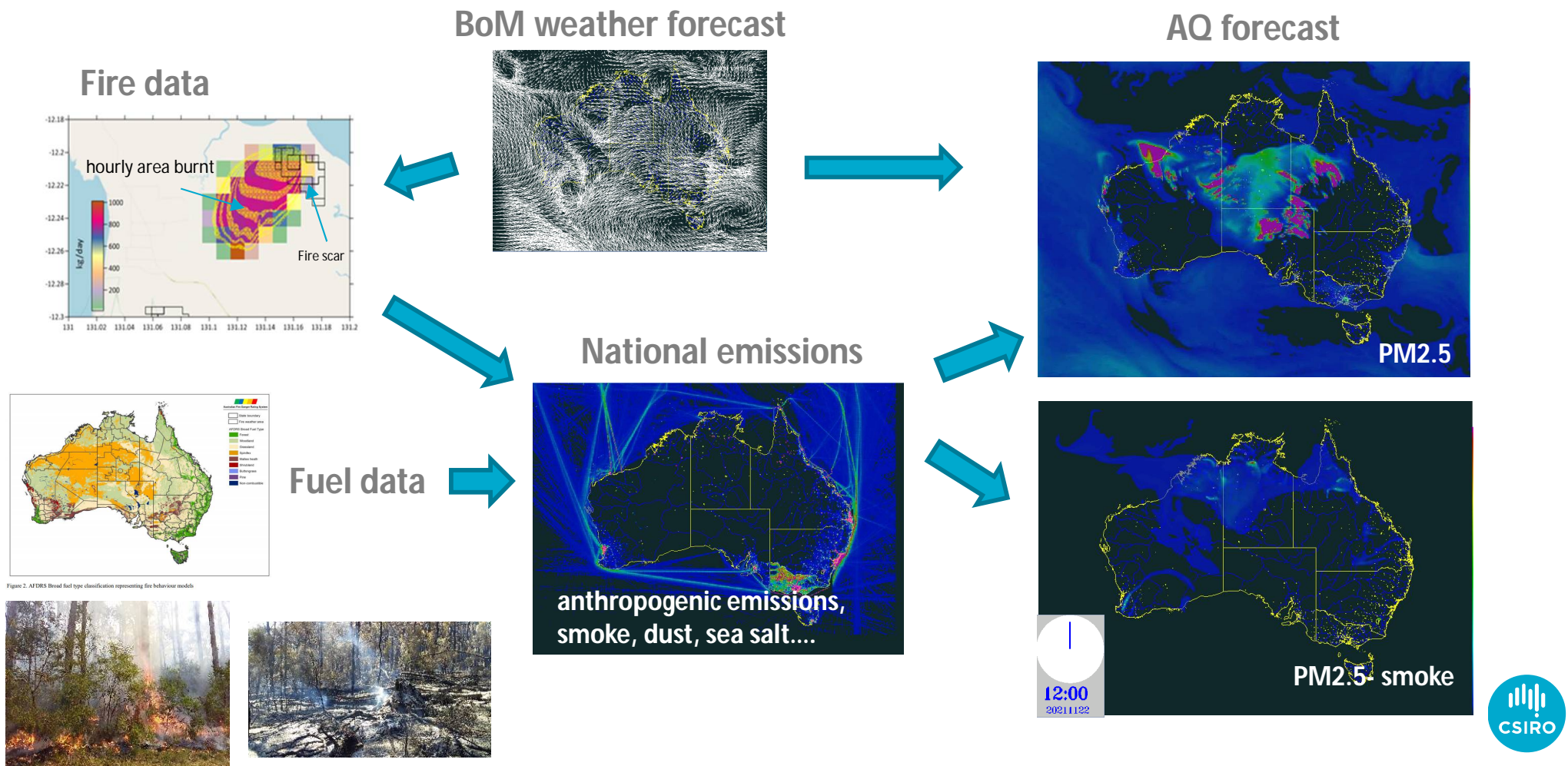


Likelihood of wine grape smoke taint risk



Where?
When?
How long?
How intense?

How forecasts are generated



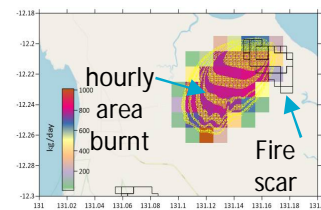
SMOKE EMISSION FLUXES

$$E = \text{Area} \times \text{fuel load} \times \text{burning efficiency} \times \text{EF}$$



Fuel consumption
↑
Fuel type/Fuel load

Temporal and spatial information on area burnt



Fuel load (fine & CWD) Burning efficiency

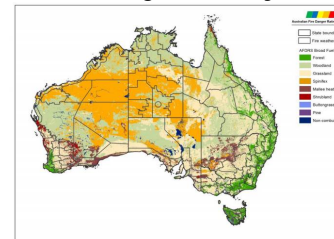
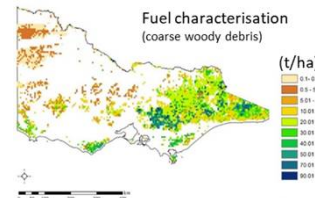
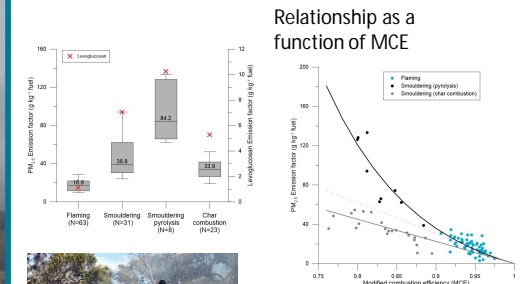


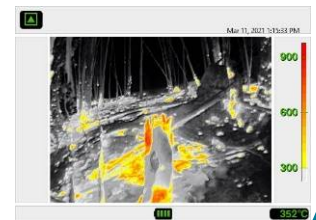
Figure 2. NFDIRS thermal fuel type classification representing fire behaviour models



Emission characterisation: Flaming & Smouldering



or combustion temperature



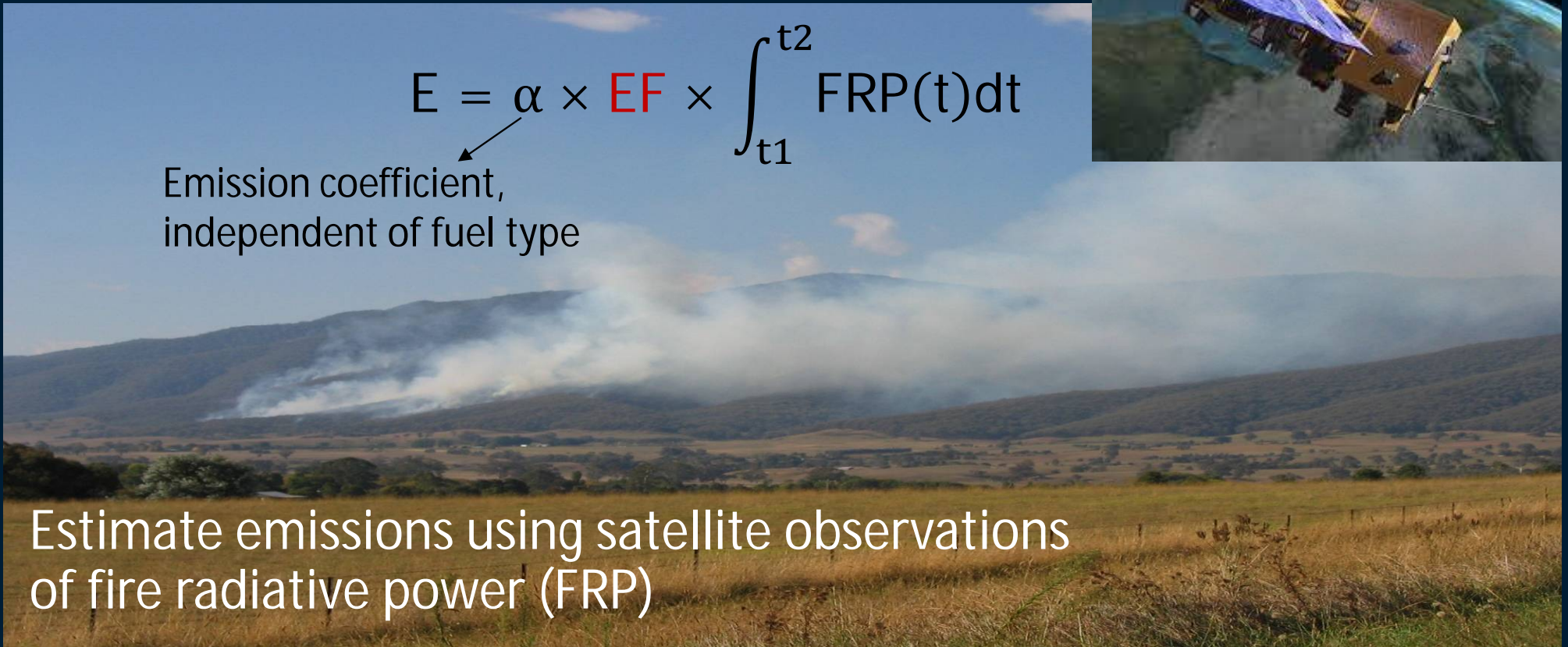
Smoke emissions - Bottom-up approach

Top-down approach

$$E = \alpha \times EF \times \int_{t1}^{t2} FRP(t)dt$$

Emission coefficient,
independent of fuel type

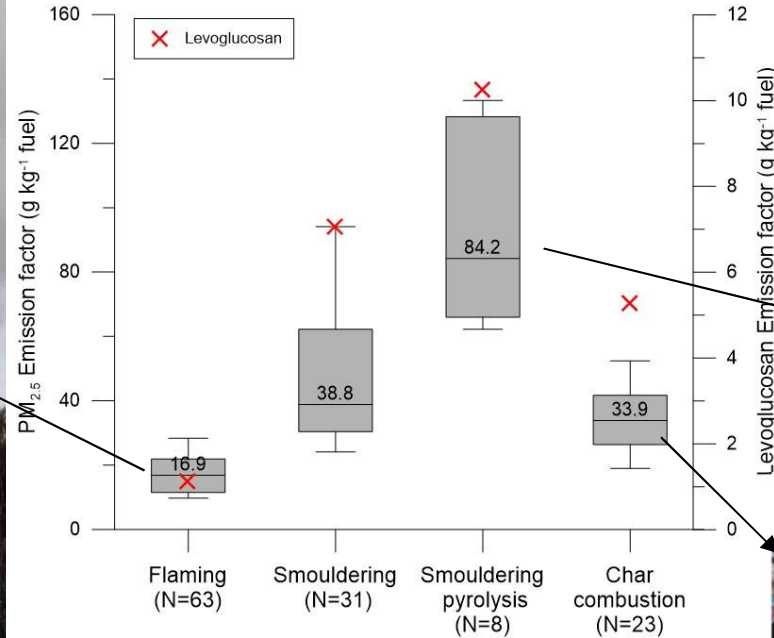
Estimate emissions using satellite observations
of fire radiative power (FRP)



Combustion conditions

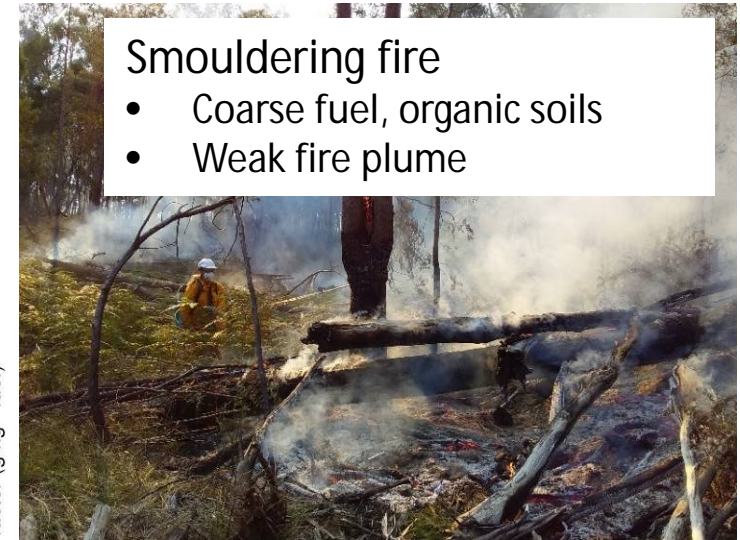
Flaming fire

- Fine fuel
- Strong fire plume

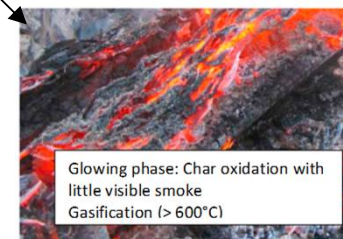


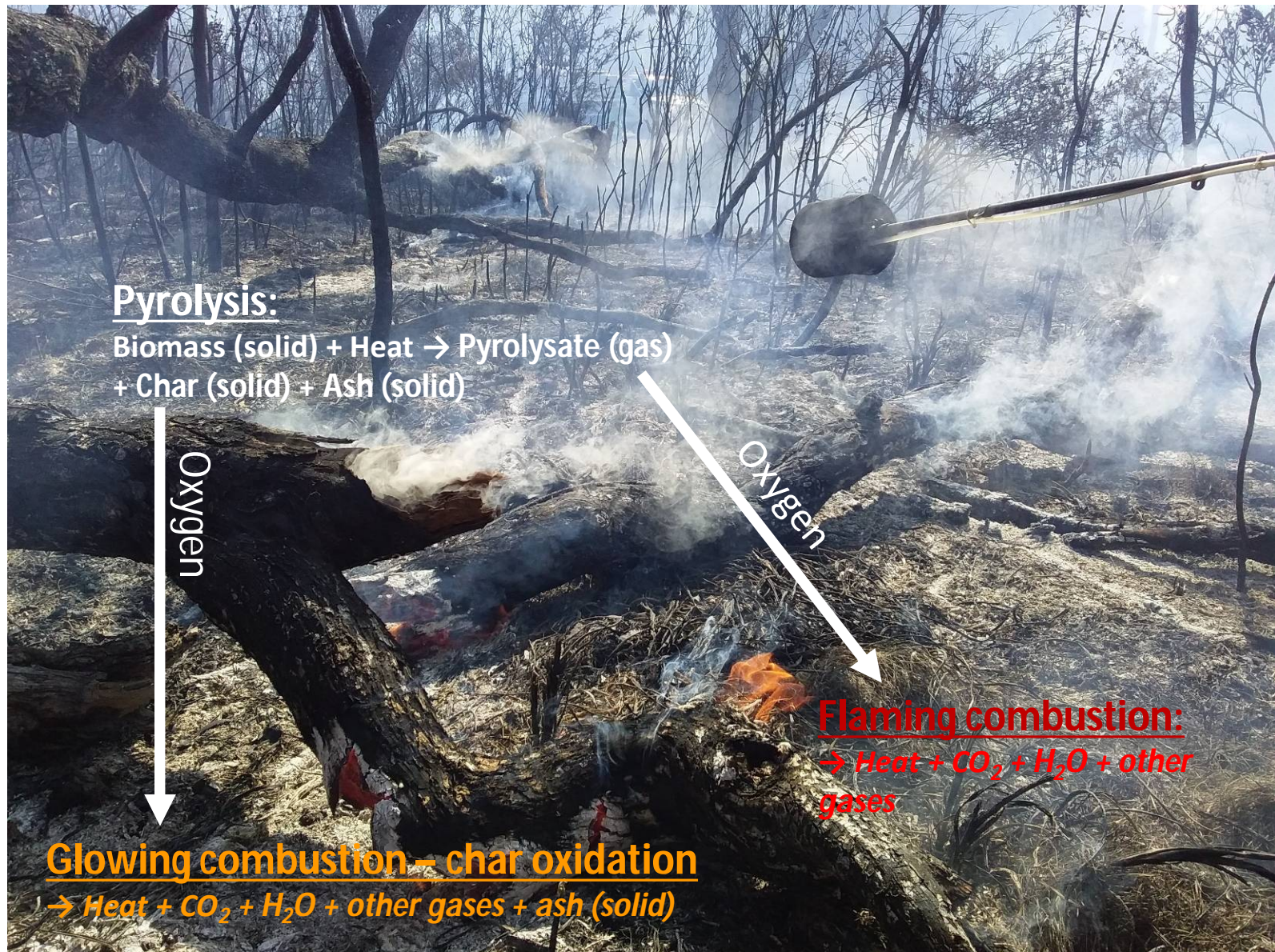
Smouldering fire

- Coarse fuel, organic soils
- Weak fire plume

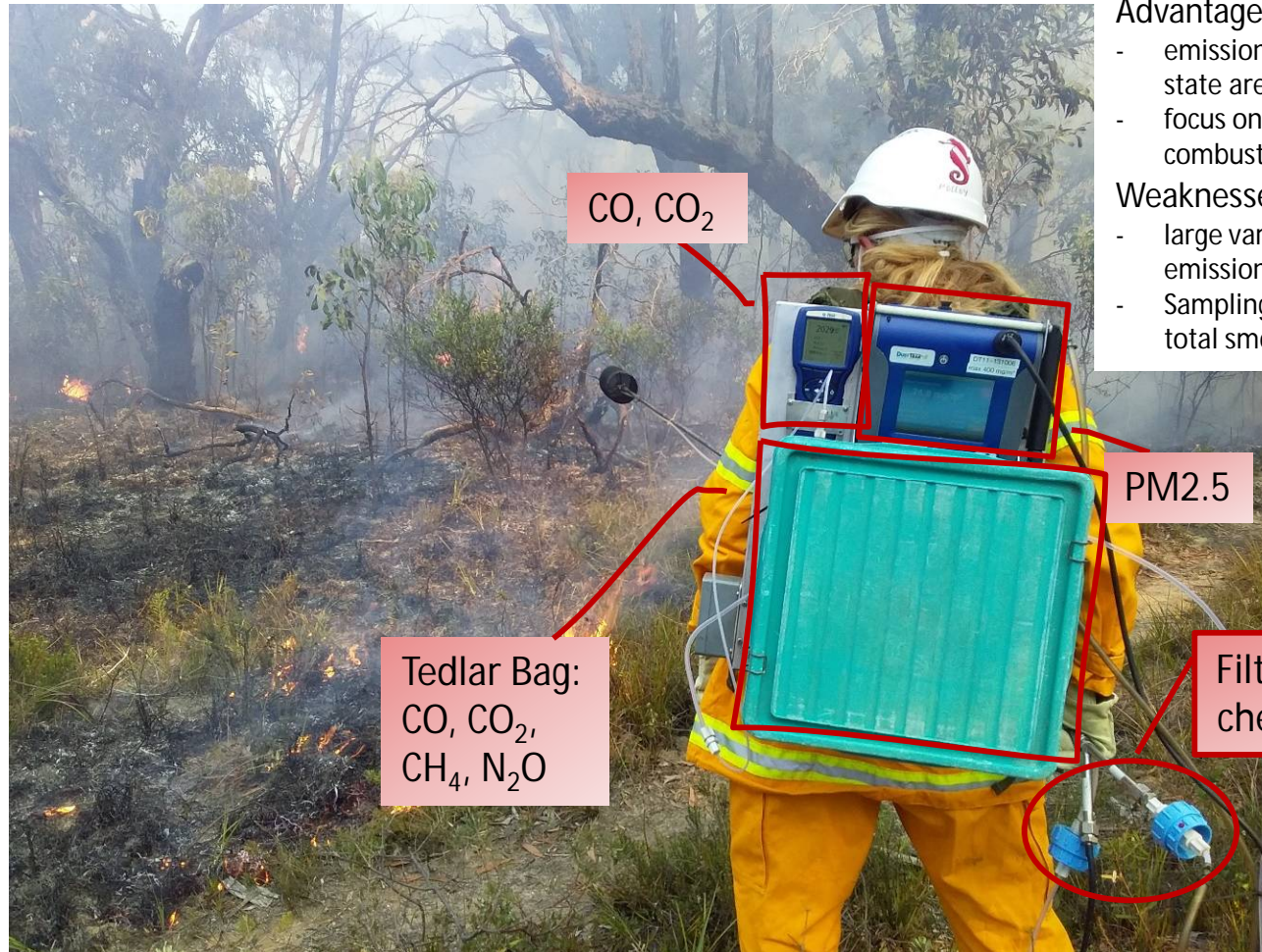
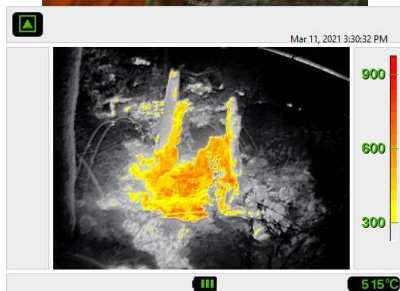


Smouldering coarse woody debris





Deriving emission factors



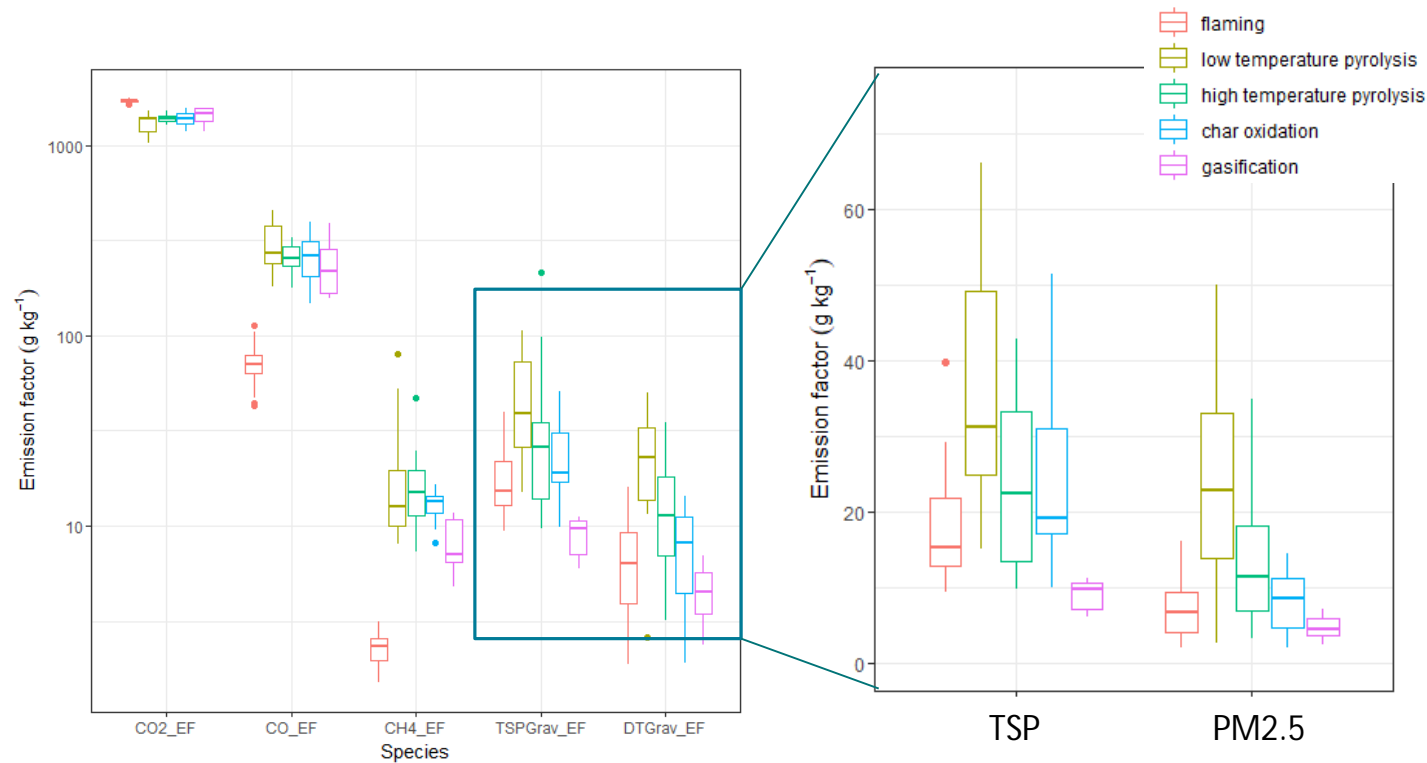
Advantages:

- emission source, and combustion state are known
- focus on flaming and smouldering combustion

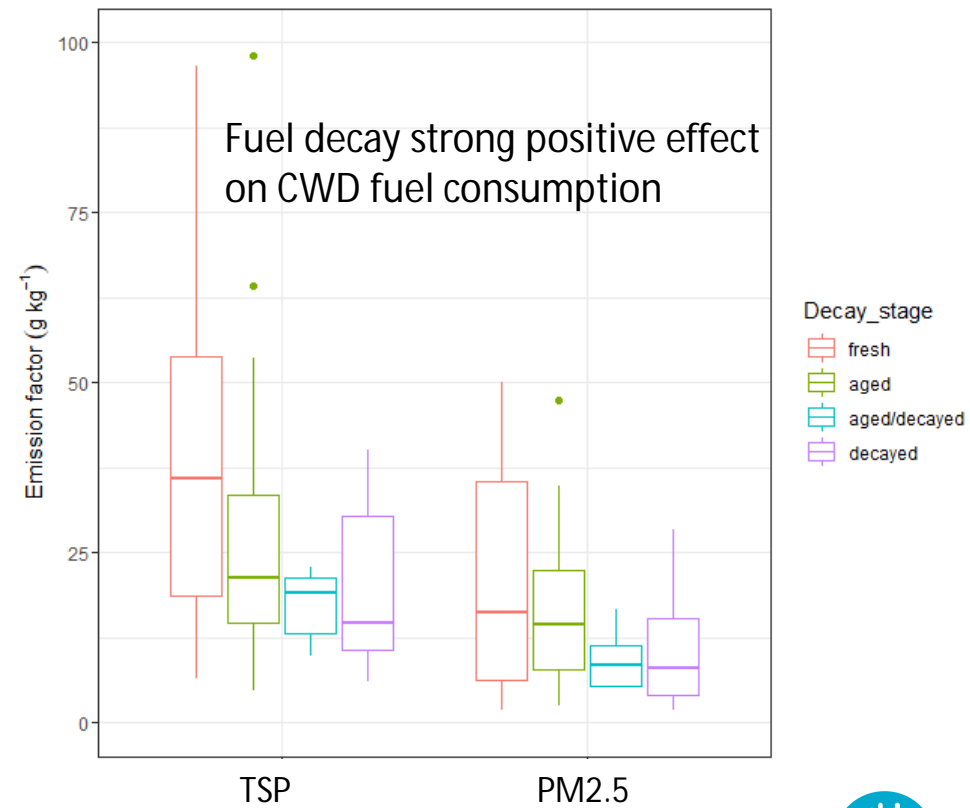
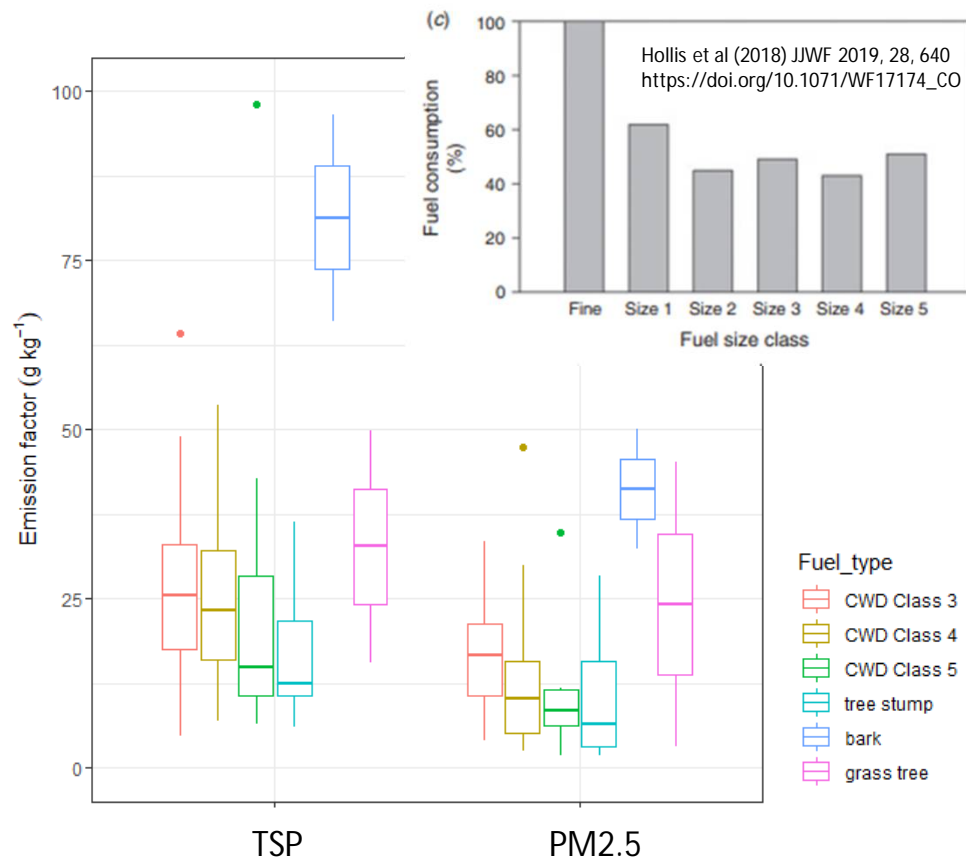
Weaknesses:

- large variability in point source emission rates
- Sampling of very small fraction of total smoke emitted by the fire

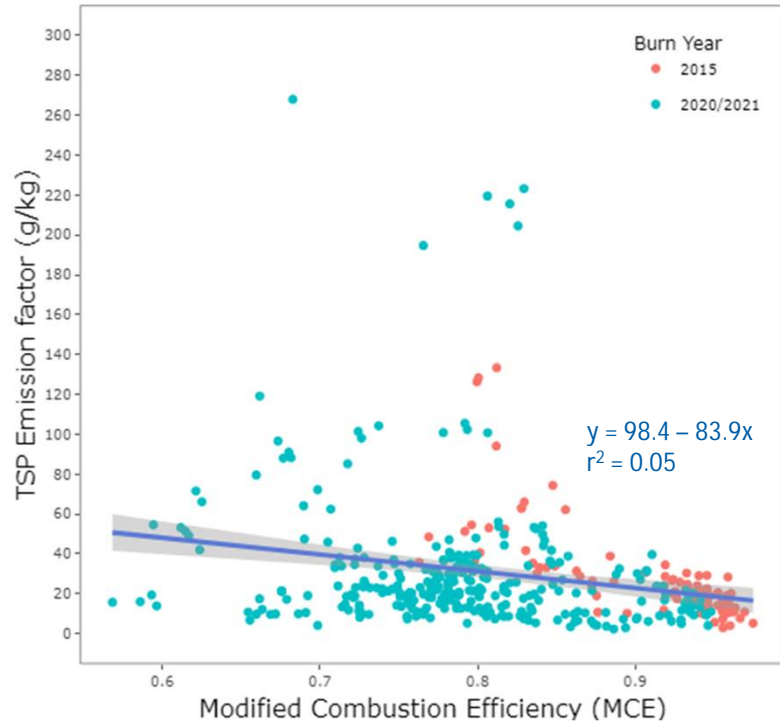
Emissions as a function of combustion process



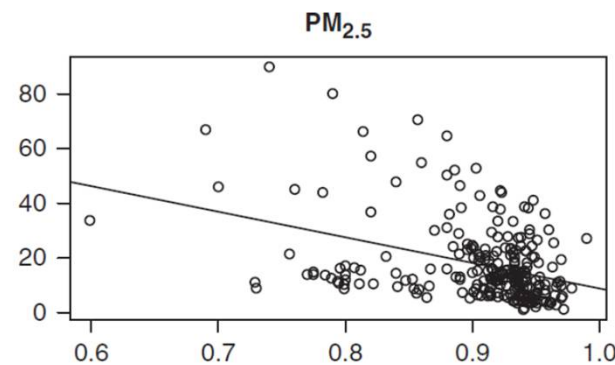
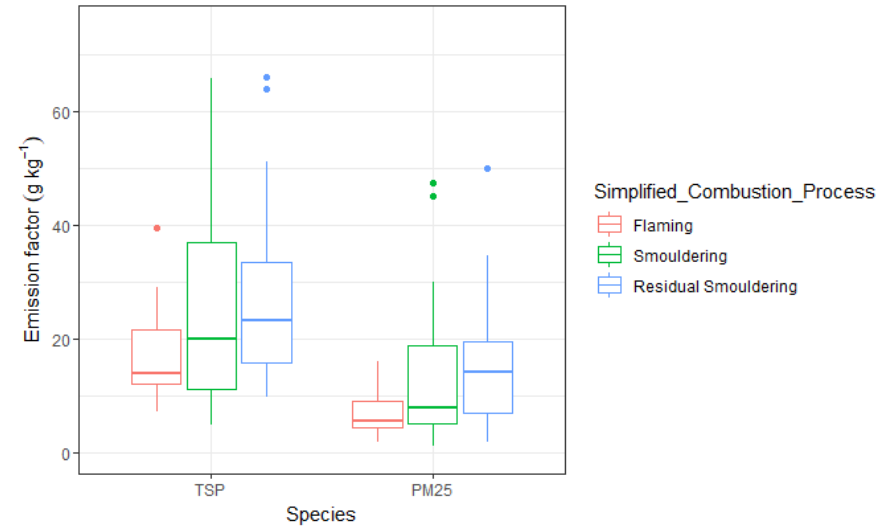
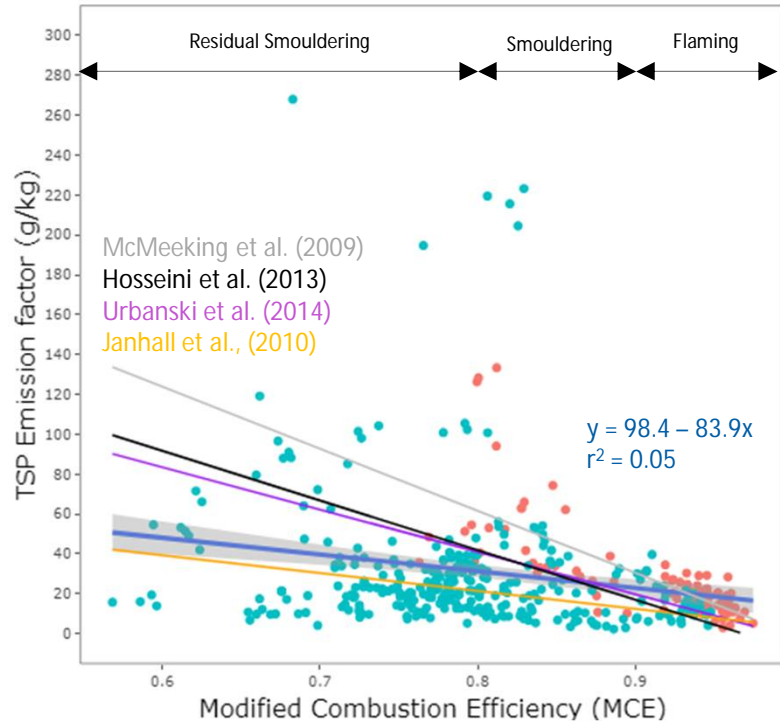
Emissions by fuel type and decay stage



Finding an explanatory variable to explain observed variation in particle EF

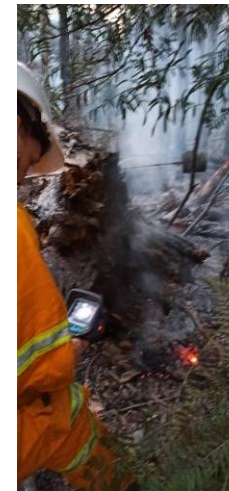
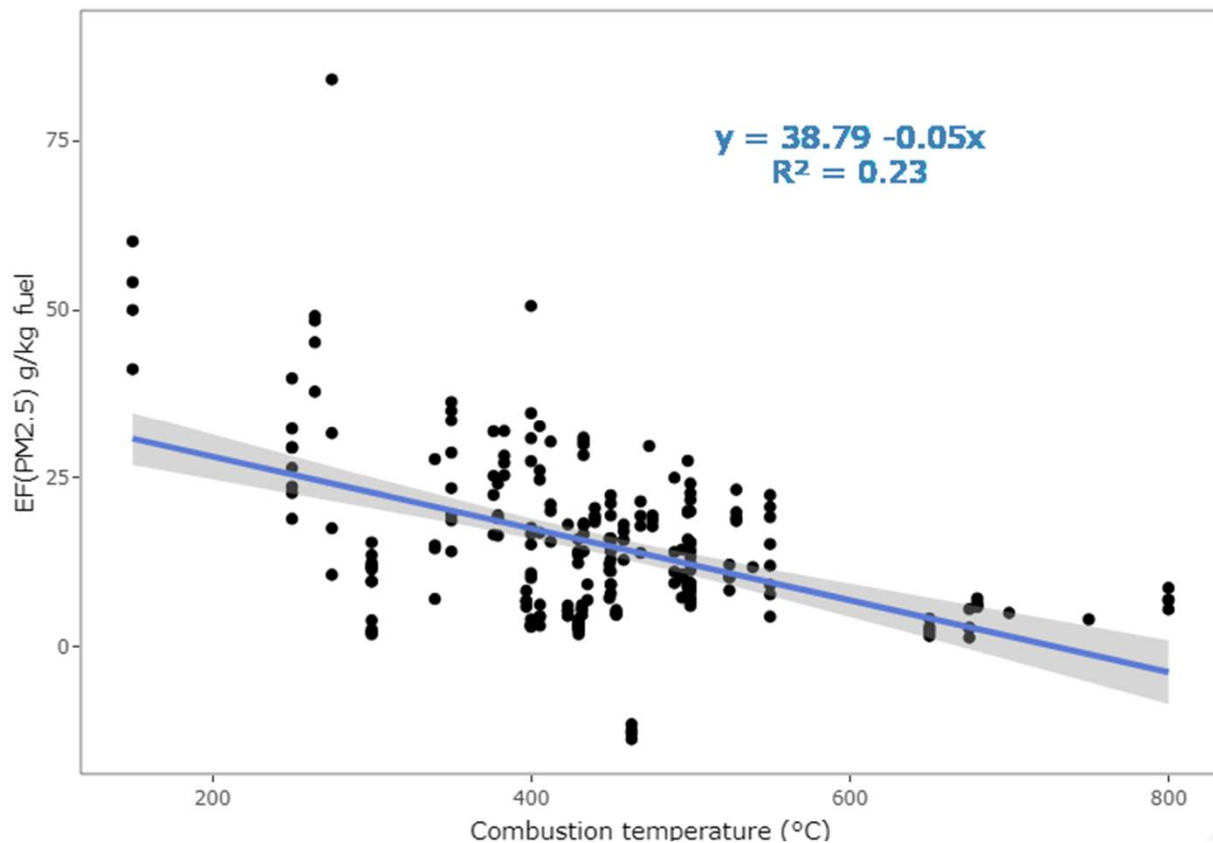


Finding an explanatory variable to explain observed variation in particle EF



Prichard et al (2020) *International Journal of Wildland Fire*, 29, 132–147
(<https://doi.org/10.1071/WF19066>)

Combustion temperature as an explanatory variable to explain observed variation in particle EF



Upscaling from individual log to burn area

Develop a distribution of combustion temperatures from smouldering CWD

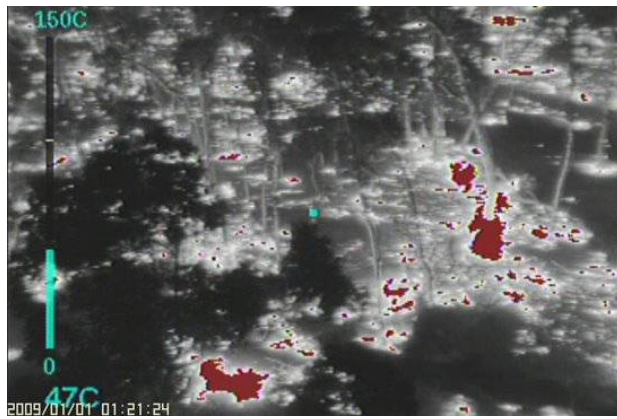
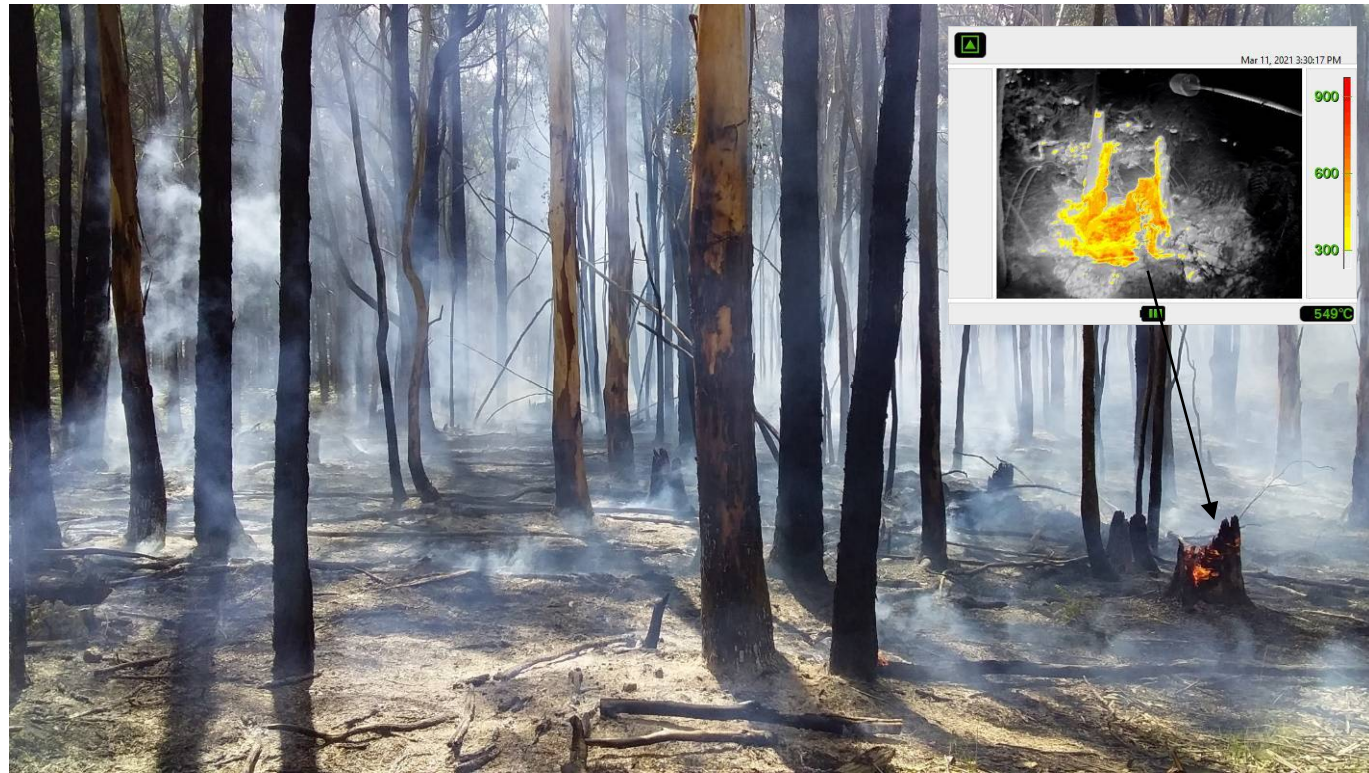


Photo: Aaron van Winden and Will Johnston
from DELWP Barwon South West

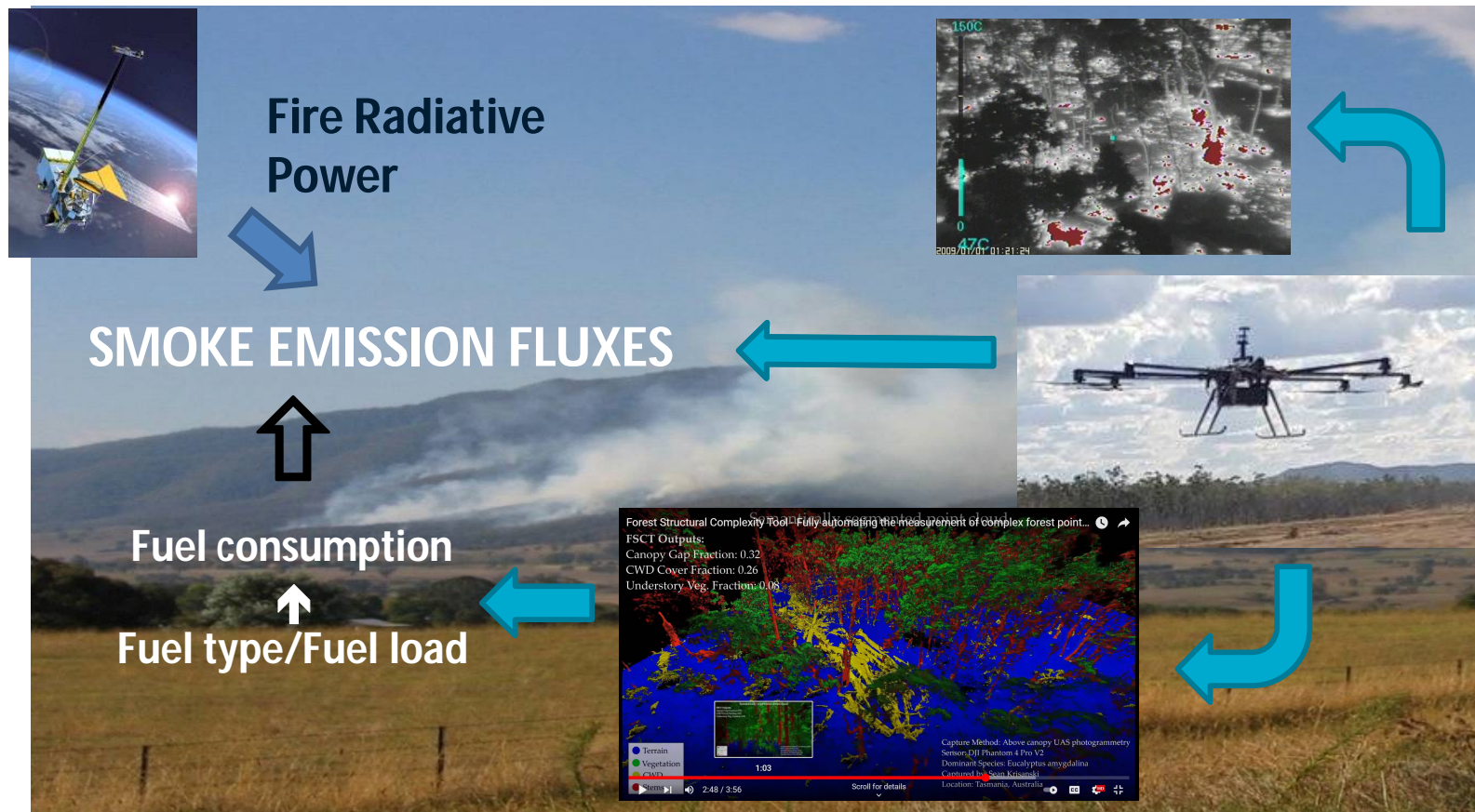


Improved forecasting for smouldering CWD

Refinement of emissions
based on observations
and inverse modelling



Combination of approaches to give us the most robust short-term smoke forecasting



Acknowledgements

We would like to thank FFMV, Parks Victoria and DELWP staff for their assistance during the smoke measurements at planned burns across Victoria and DELWP for funding of the project.



Thank you

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