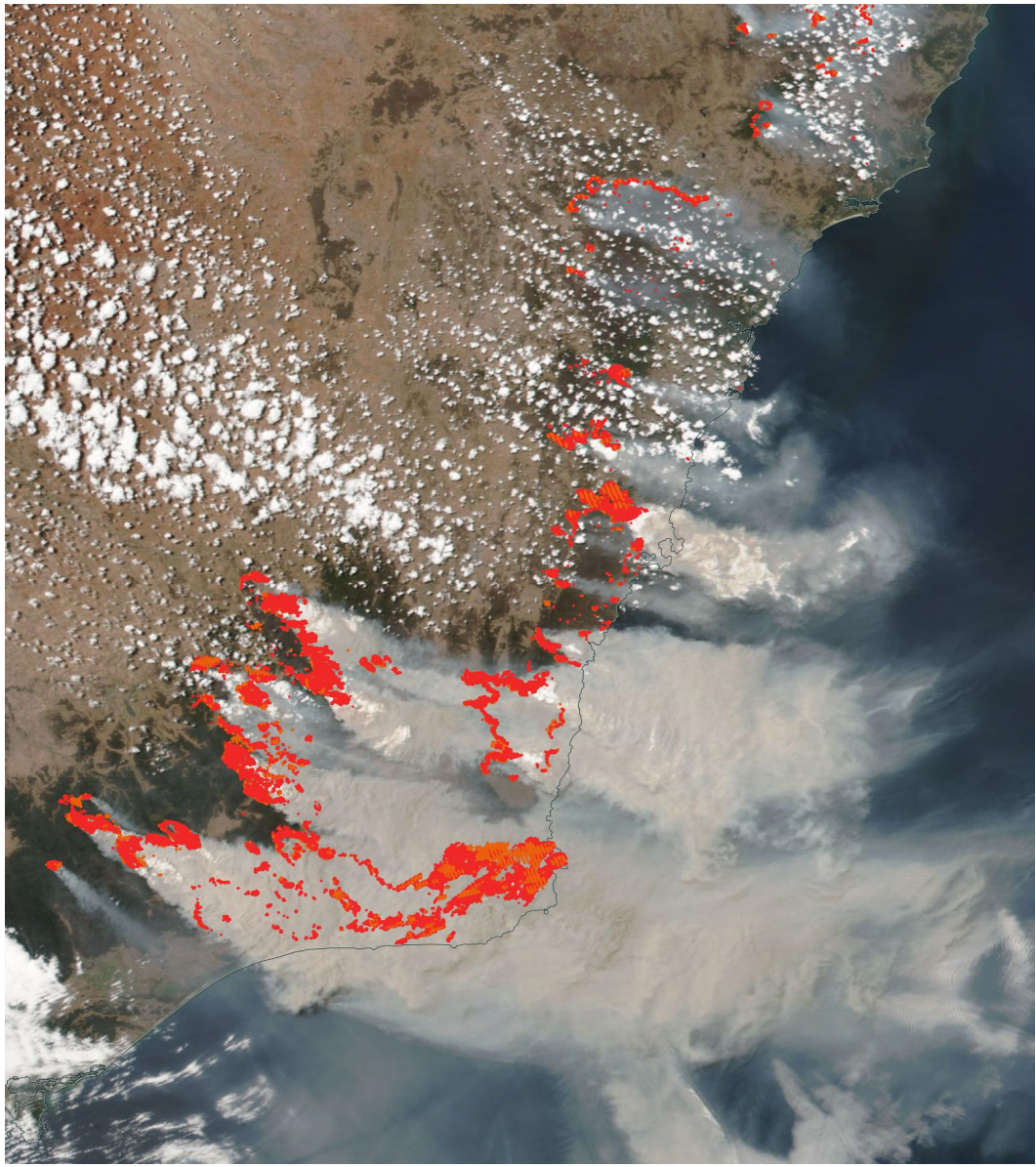
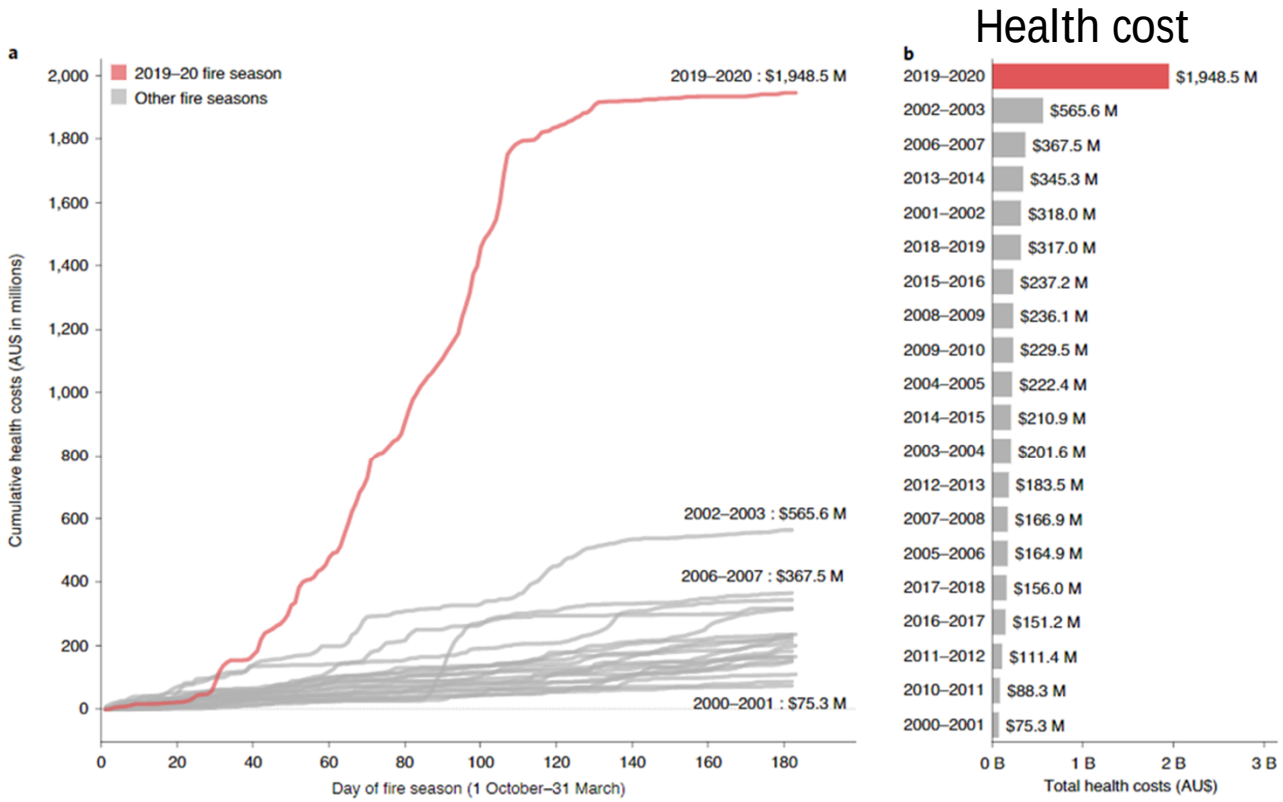
Smoke forecasting using AQFx for the 2019-2020 summer bushfires

Fabienne Reisen, Julie Noonan, Martin Cope, Stuart Young, Kerryn McTaggart, Amelia Tandy, Alan Wain

AFAC22 23-25 August 2022, Adelaide



2019-2020 Australian Bushfire Season Impacts



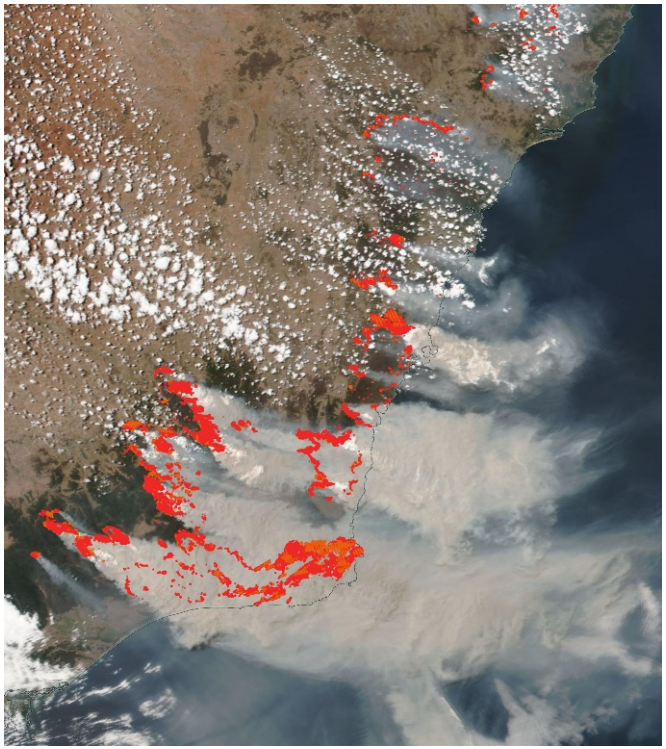


Fig. 2 | Smoke-related health costs for Australian fire seasons (1 October to 31 March) between 2000 and 2020. a, Cumulative daily costs. **b**, Ranked total costs by season. M, million; B, billion.

Johnston *et al. Nat Sustain* **4,** 42–47 (2021). https://doi.org/10.1038/s41893-020-00610-5

National smoke forecasting capability

- Alignment to Royal Commission recommendation 14.2 National Air Quality Forecasting Capability:

  Australian, state and territory governments should develop national air quality forecasting capabilities, which include broad coverage of population centres and apply to smoke and other airborne pollutants, such as dust and pollen, to predict plume behaviour.

Provide forecast advisories of when smoke will impact communities

→

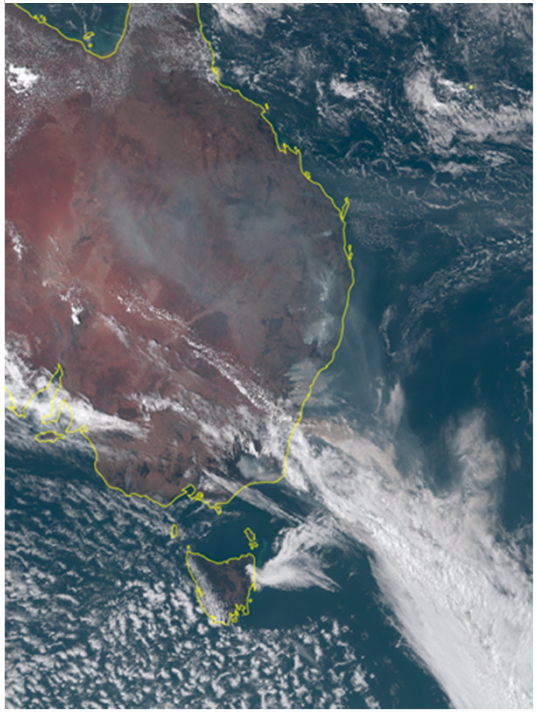
Enable preventative actions

Better planning for burn-offs

→

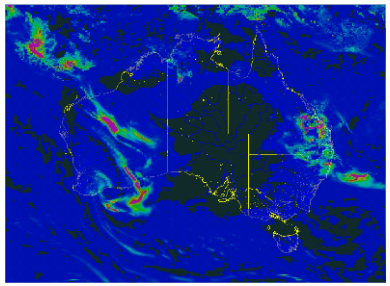
Reduce population health risk from smoke exposure

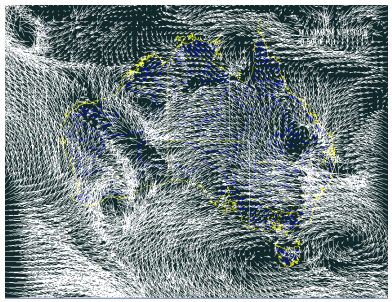
The extent of the 2019/20 bushfires highlighted the urgent need for a national smoke forecasting capability to protect health across Australia.

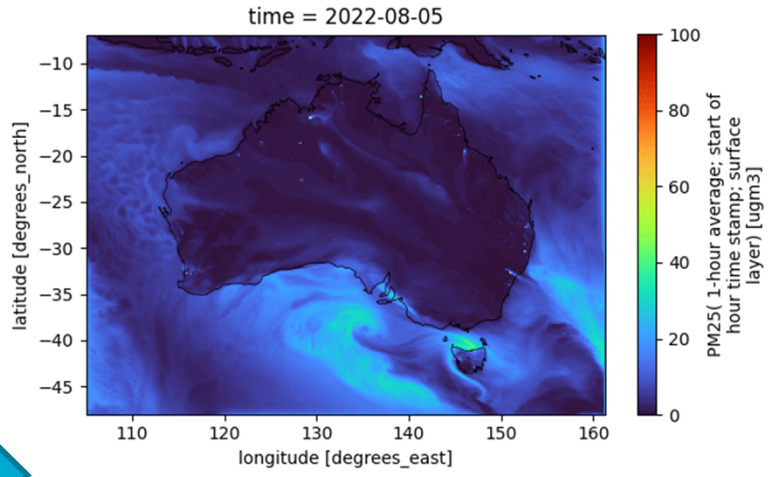


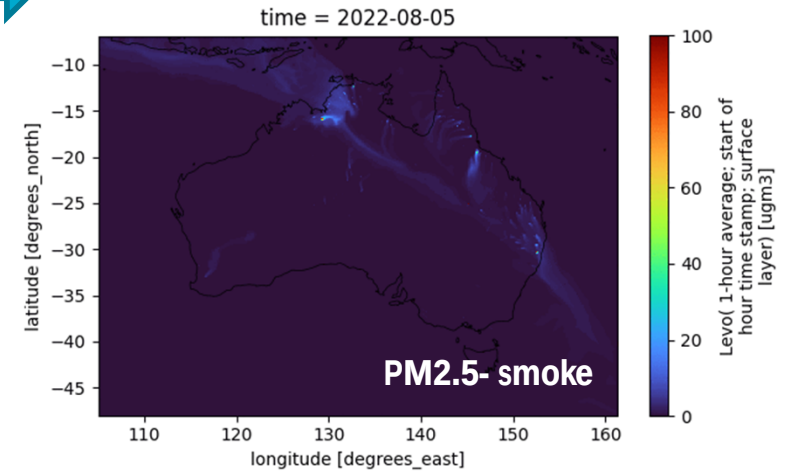
How forecasts are generated

BoM weather forecast

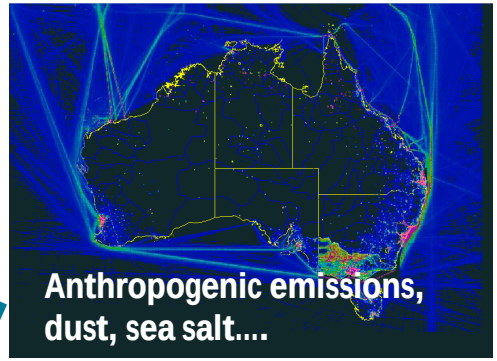








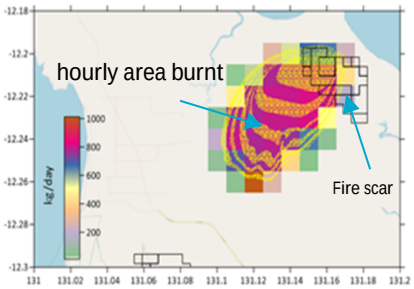
National emissions



Towards development of a forecast system that provides relevant information to key stakeholders

Assessing different components of AQFx to understand uncertainties and make improvements

- Fire emissions
  - Fire input data
  - Fuel layer maps
  - Fuel consumption
- Plume dynamics



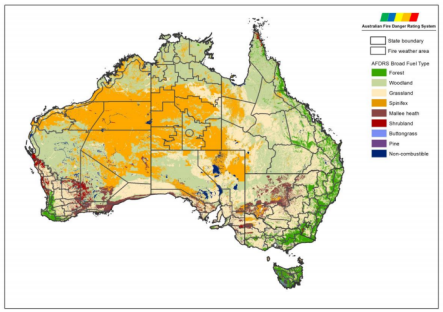
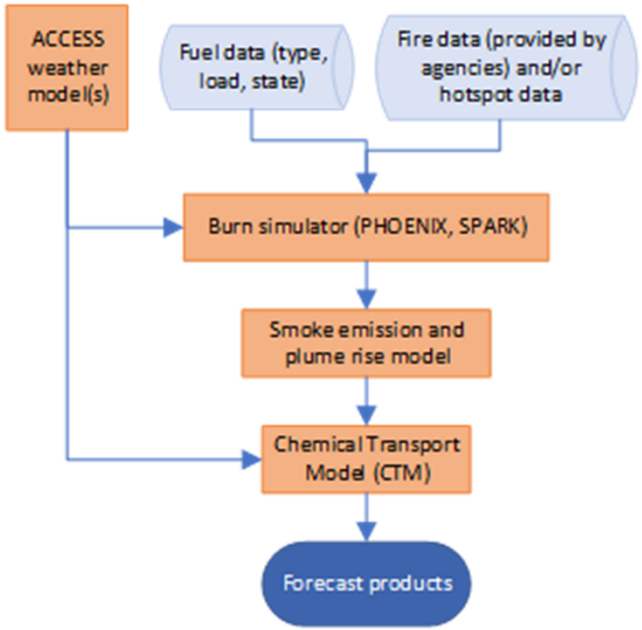
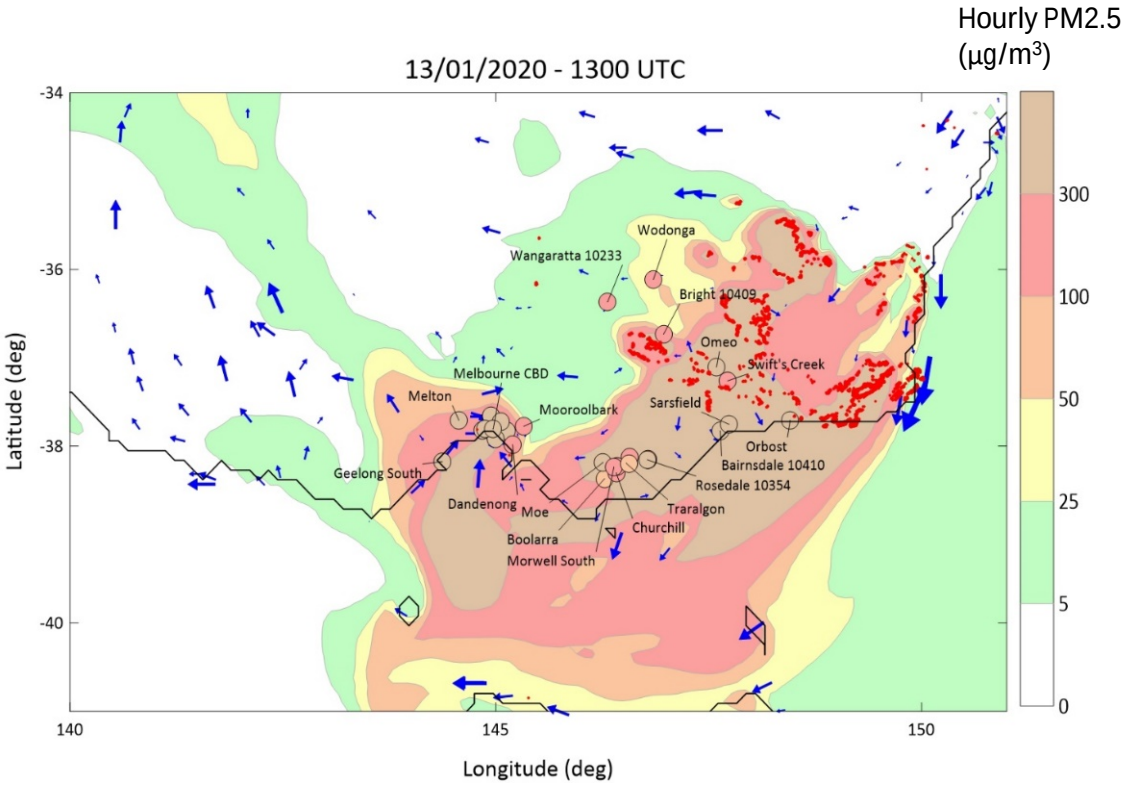


Figure 2. AFDRS Broad fuel type classification representing fire behaviour models



A deep dive into an AQFx forecast for 12-16 January 2020 for Victoria

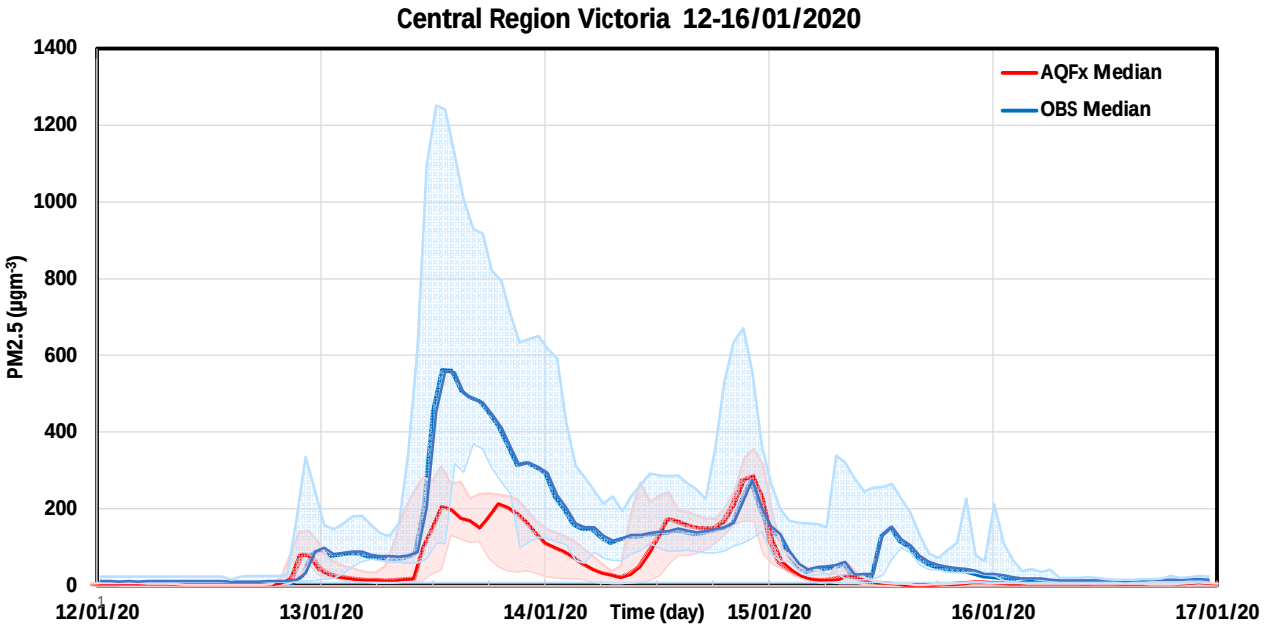


Source: The Guardian (14th Jan 2020)

Challenge:
Robust forecasting of complicated wind patterns which can affect the onset and duration of smoke events

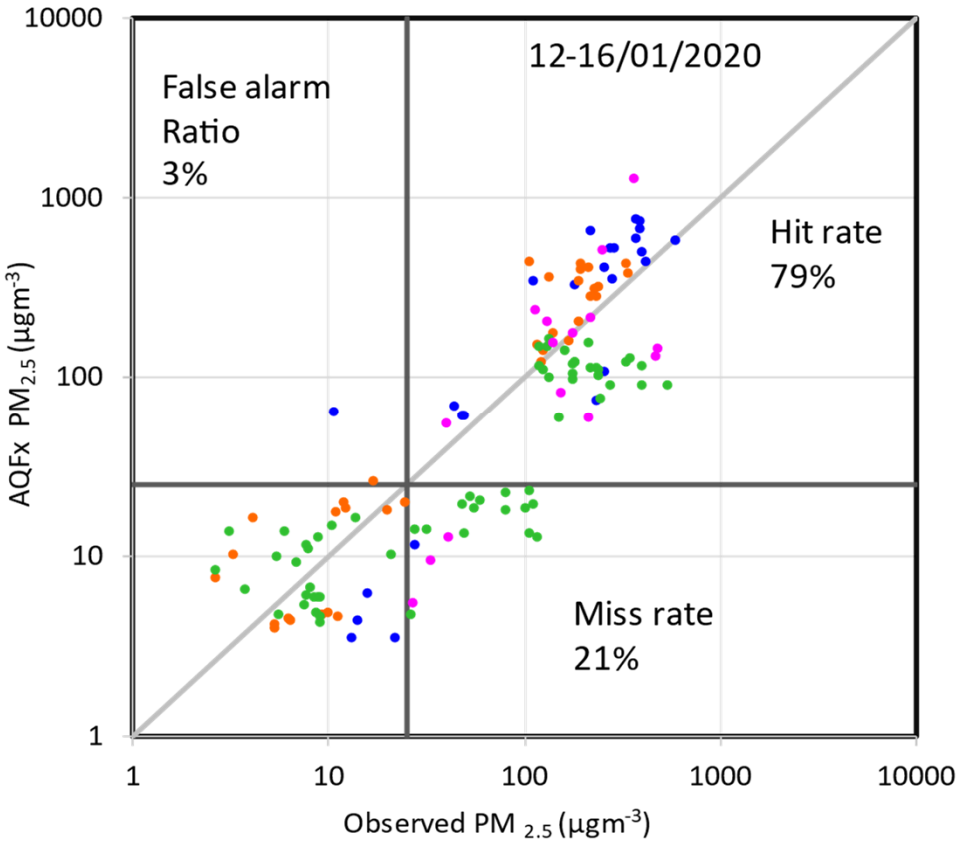
⇨Run 2 forecasts per day during summer 2022/23 initiated with different weather forecasts

Time series plots to assess onset and duration of smoke plume events



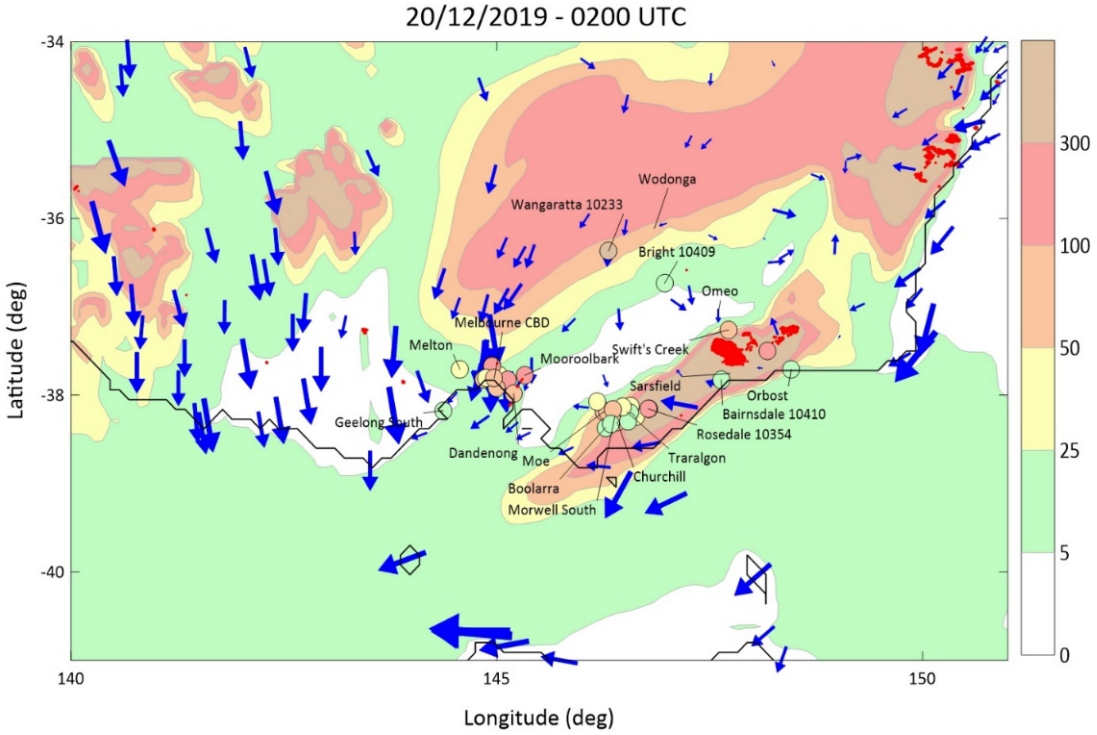
- Onset and duration of smoke plume event well captured
- Difference in magnitude
  - ⇨ Emissions
  - ⇨ Plume dynamics
  - ⇨ Atmospheric rxns

Categorical evaluation of PM2.5 forecasts



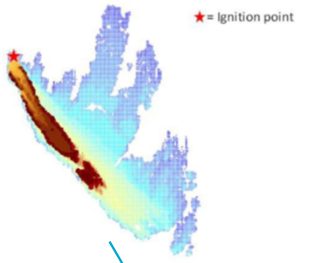
Quantify the skill with which AQFx can predict the onset of smoke impacts in populated areas, and the subsequent duration and magnitude of the exposure.

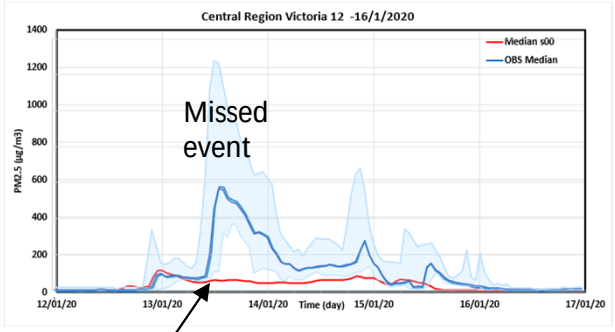
Victorian Alps forming a physical barrier to the smoke plumes from fires in the north and south of Victoria

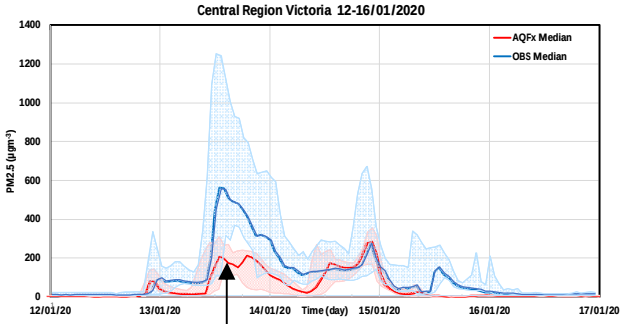


Smoke plume event on 13 January 2020 forecasted using different fire emissions

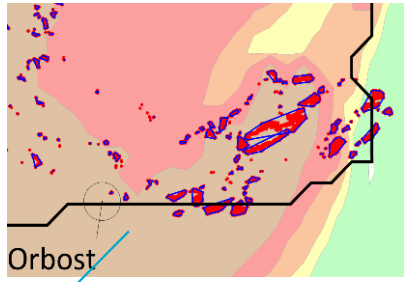
PHOENIX simulation

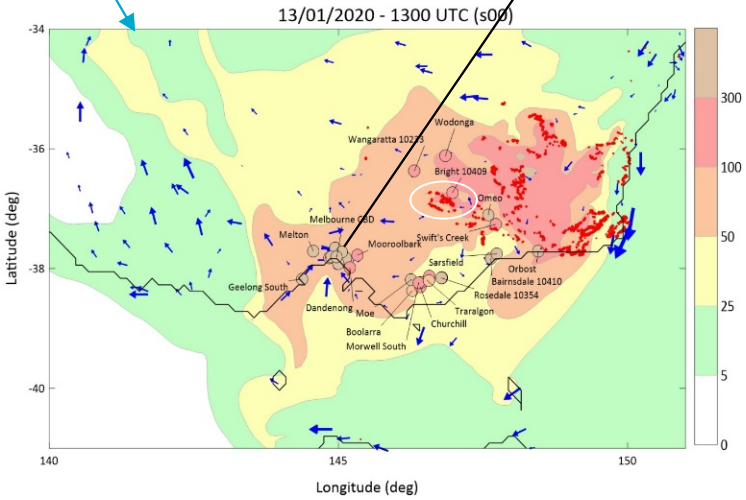


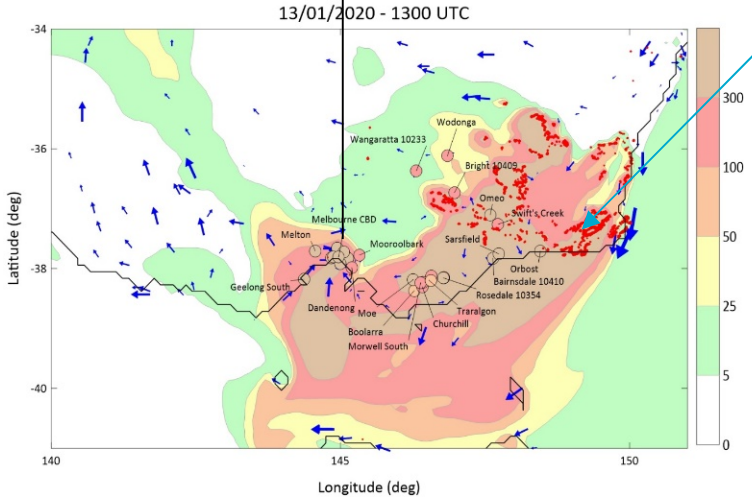




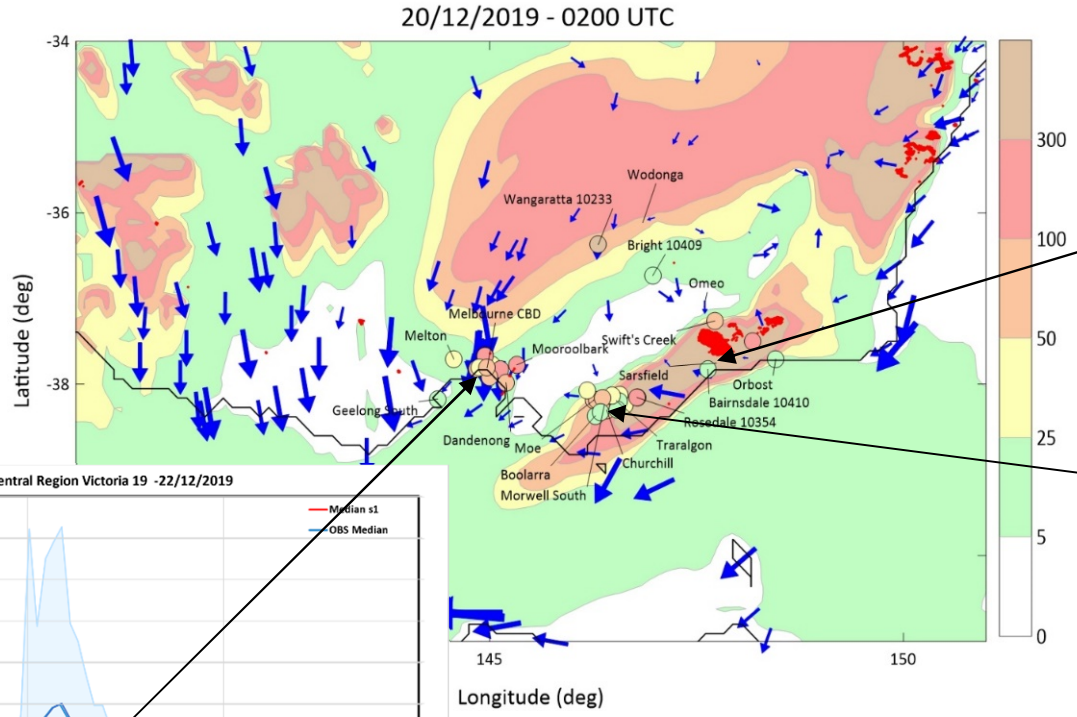
VIIRS/MODIS hotspot cluster analysis

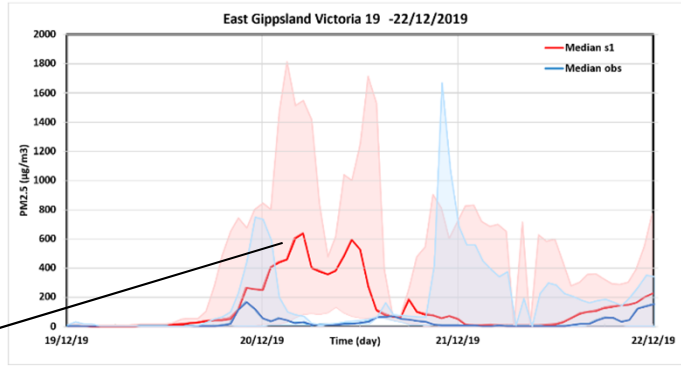


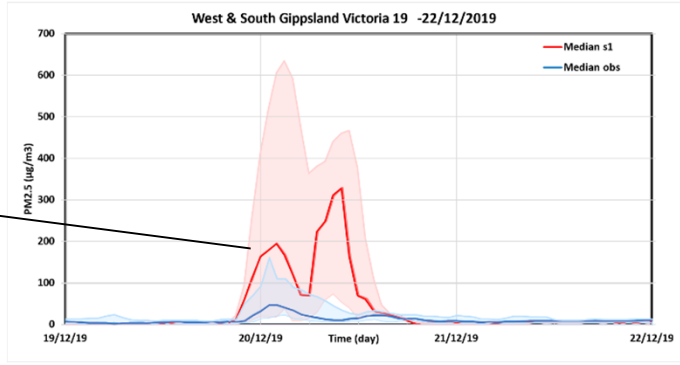


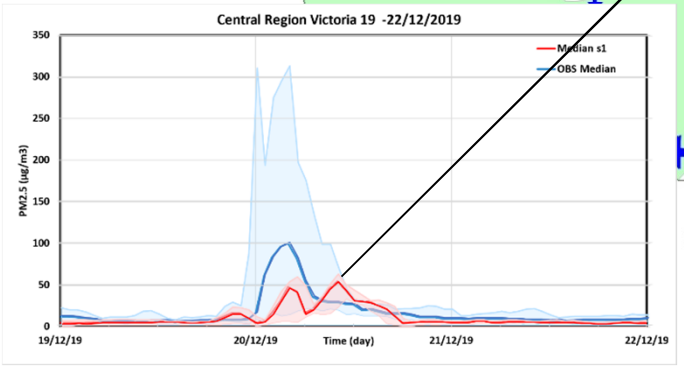


Smoke plume event on 20 December 2019 and its impact on Melbourne







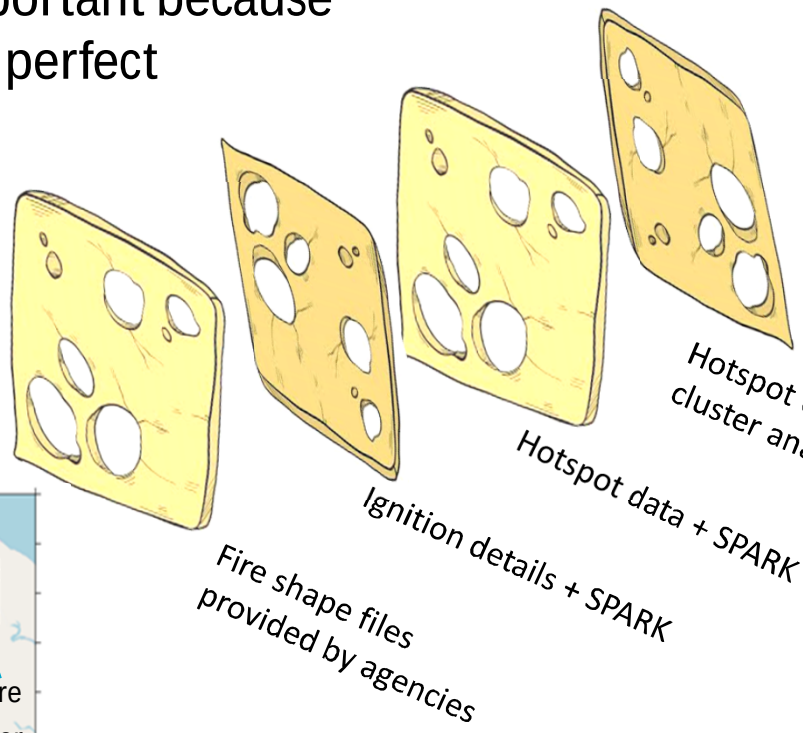


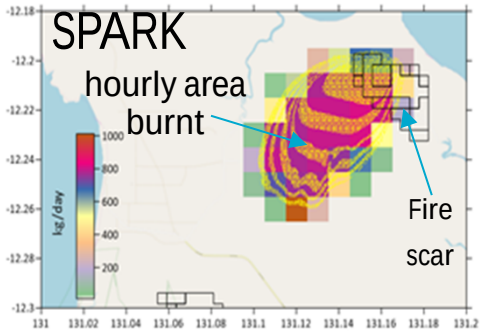
Forecast overestimated PM2.5 concentrations close to fire source and underestimated around Greater Melbourne

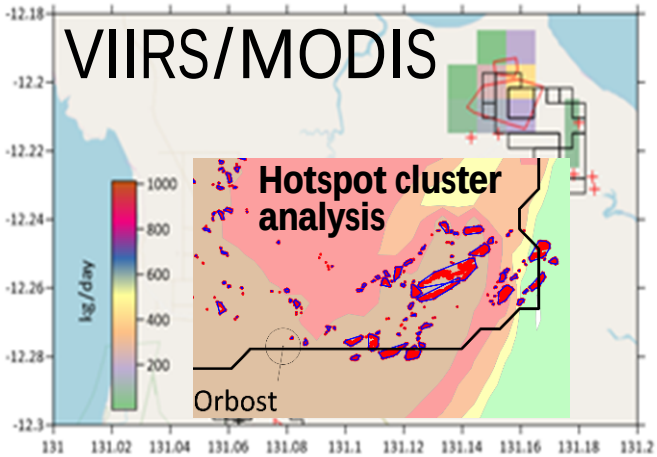
⇨ driven by smouldering emissions ?

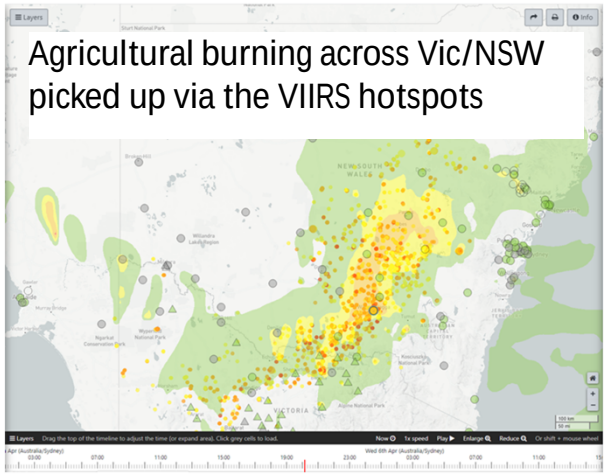
Applying the Swiss Cheese Model to fire input data

All layers are important because each layer is not perfect







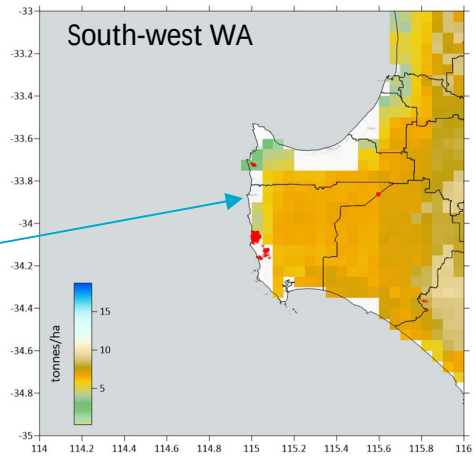


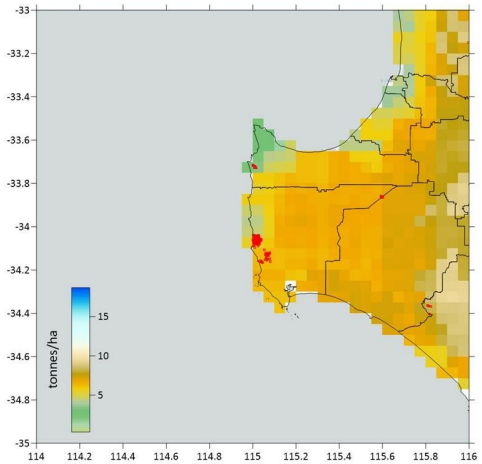
Fuel consumption another source of uncertainty in forecast model

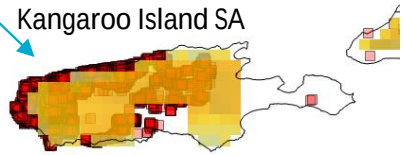
- Empirical fuel load data sets [fine; cwd]
- Semi-empirical model VAST (Barrett, 2002)

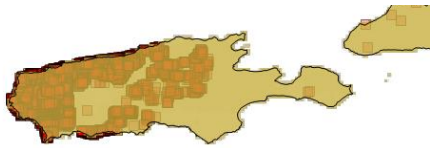
- AFDRS fuel maps [fine]
- Process-based carbon cycle model BIOS2 [cwd]

coarse resolution of VAST fuel load data sets
⇨ areas close to the coast with zero fuel load

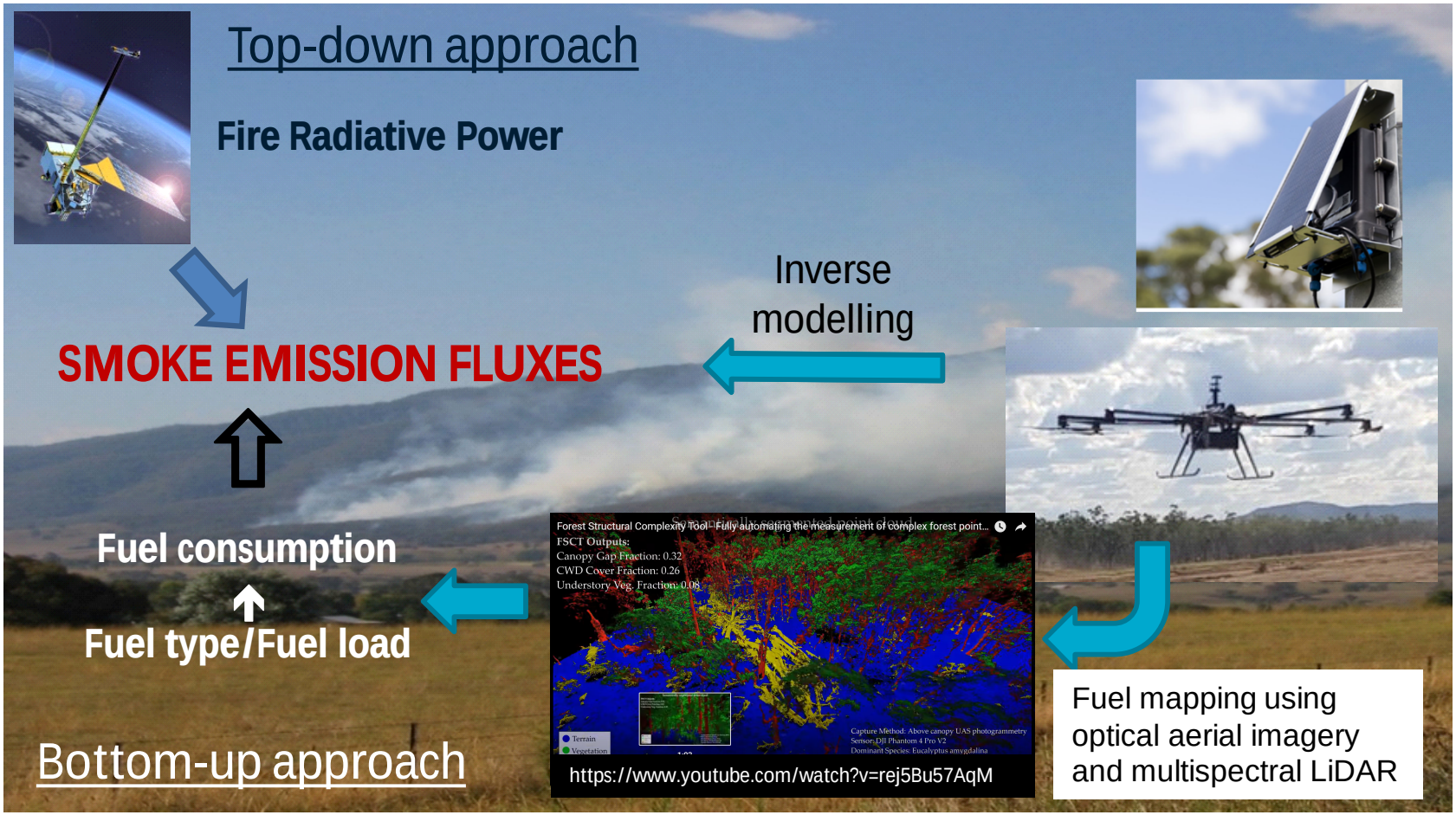




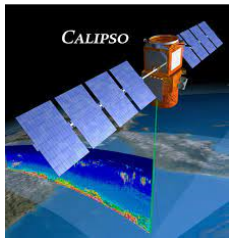


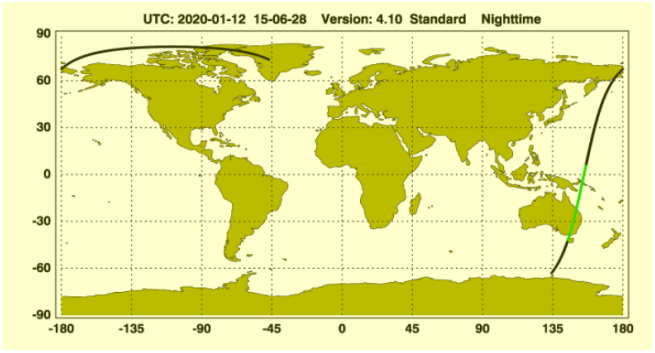


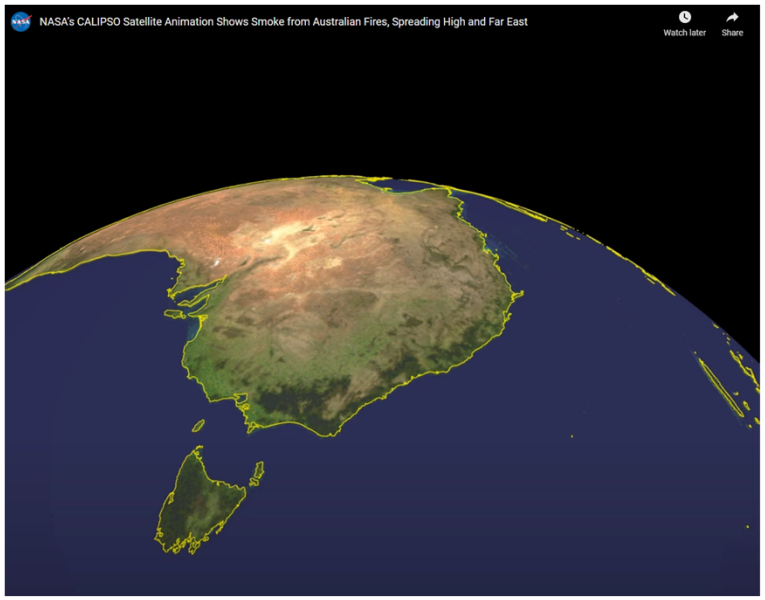
Combination of approaches to give us the most robust short-term smoke forecasting

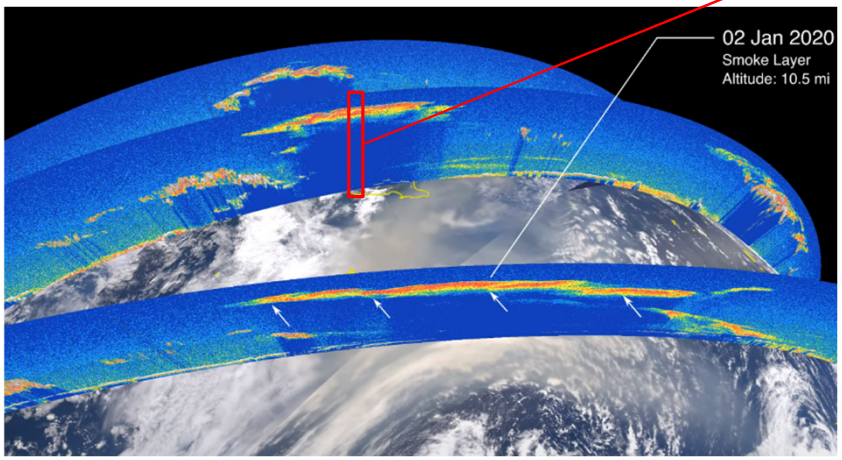


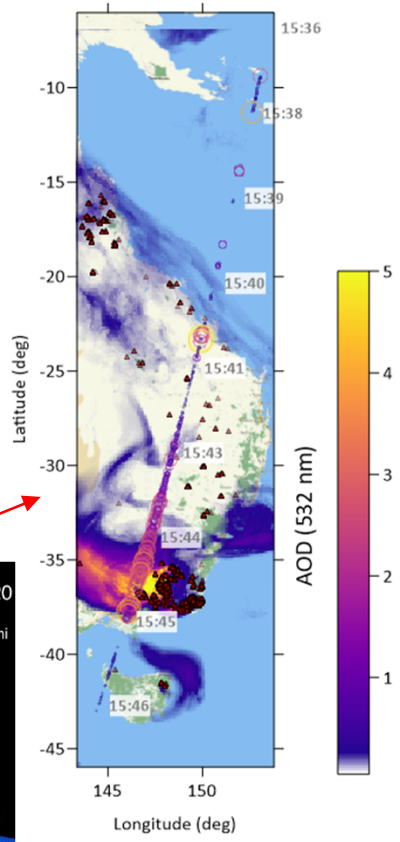
Use of satellite remote sensing data for atmospheric composition



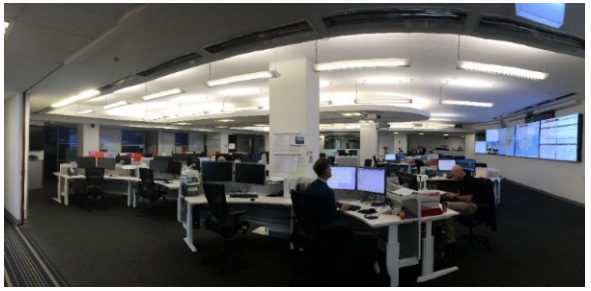


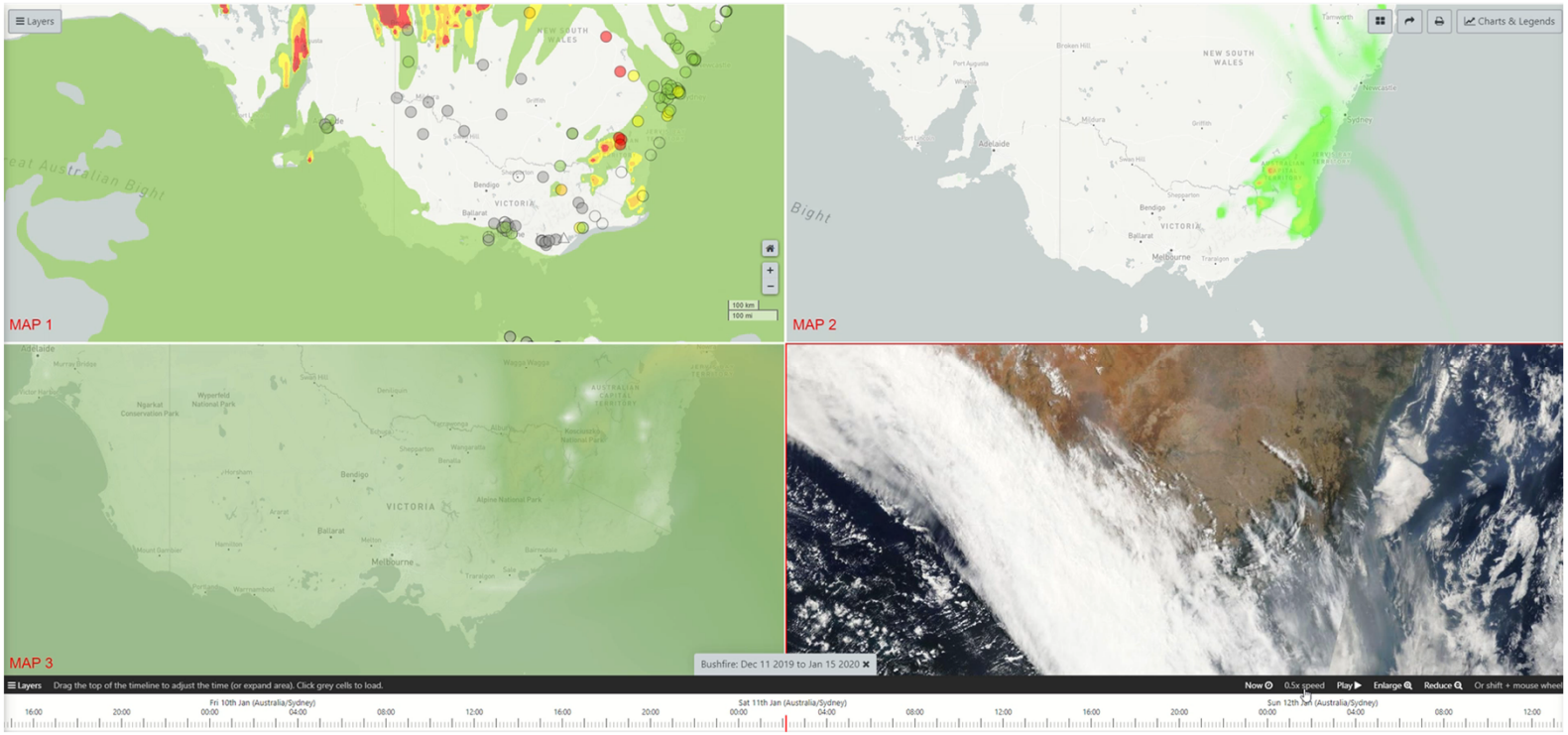






Building a tactical AQ analysis tool





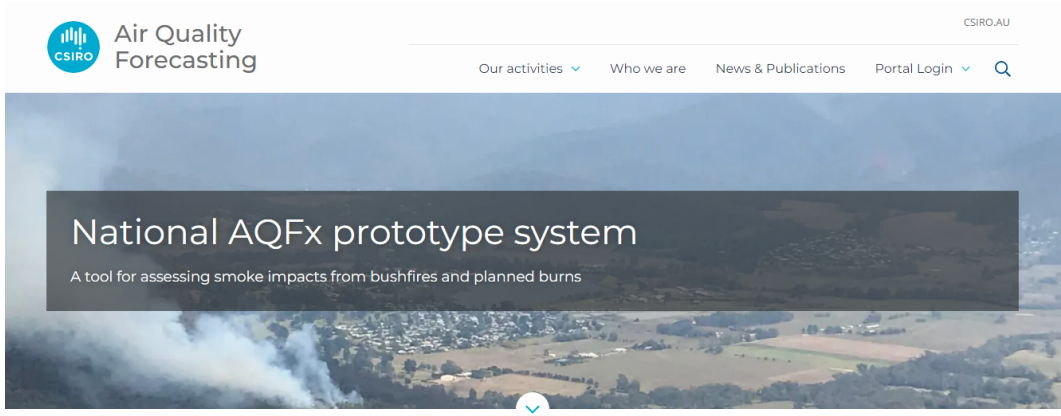
Thank you

Oceans & Atmosphere
Fabienne Reisen
Principal Research Scientist

+61 3 9239 4435
fabienne.reisen@csiro.au
https://research.csiro.au/aqfx/

Oceans & Atmosphere
Martin Cope
Principal Research Scientist

+61 3 9239 4647
martin.cope@csiro.au



The extent of the 2019/2020 bushfires highlighted the urgent need for a national smoke forecasting system to protect the health of Australians. In response, the Australian Government has provided funding to develop a national prototype smoke forecasting system. The project will test potential extensions to the current operational AQFx system. AQFx is run by the Bureau of Meteorology in Victoria for the Department of Environment, Land, Water and Planning (DELWP), and in NSW for the Rural Fire Service (RFS).

The prototype system will be developed through a research collaboration between CSIRO, Bureau of Meteorology, the University of Tasmania, the University of Sydney, the University of Melbourne and DELWP.

https://research.csiro.au/aqfx/