An integrated system for Early detection and suppression of bushfires

Bushfire Research
Centre of Excellence

Prof. Marta YEBRA
Director Bushfire Research Centre of Excellence

The Gospers Mountain fire

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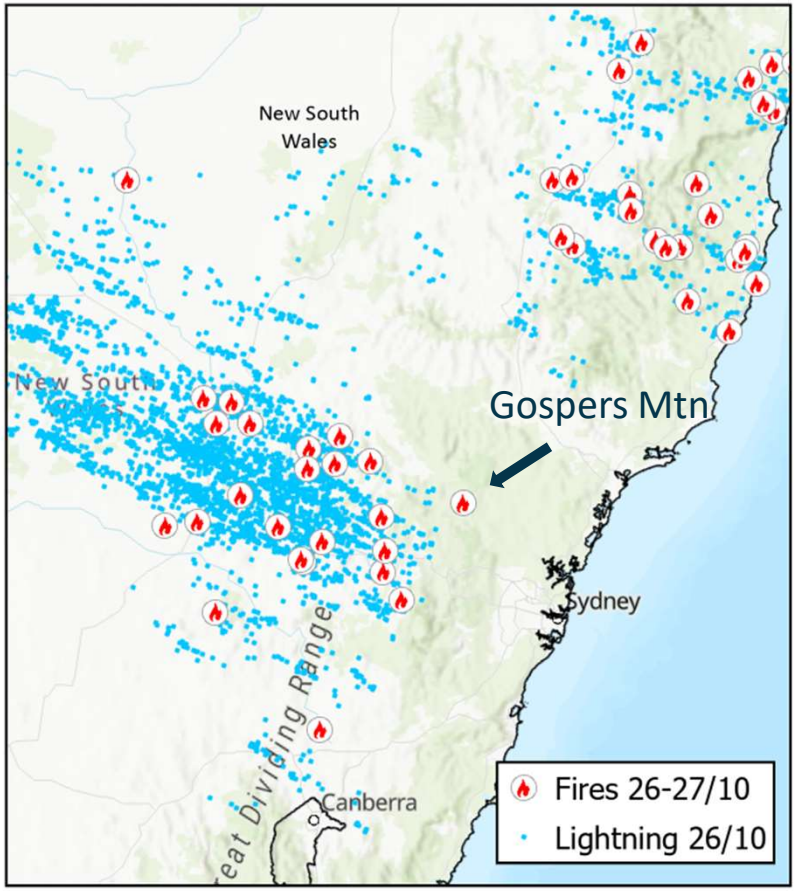
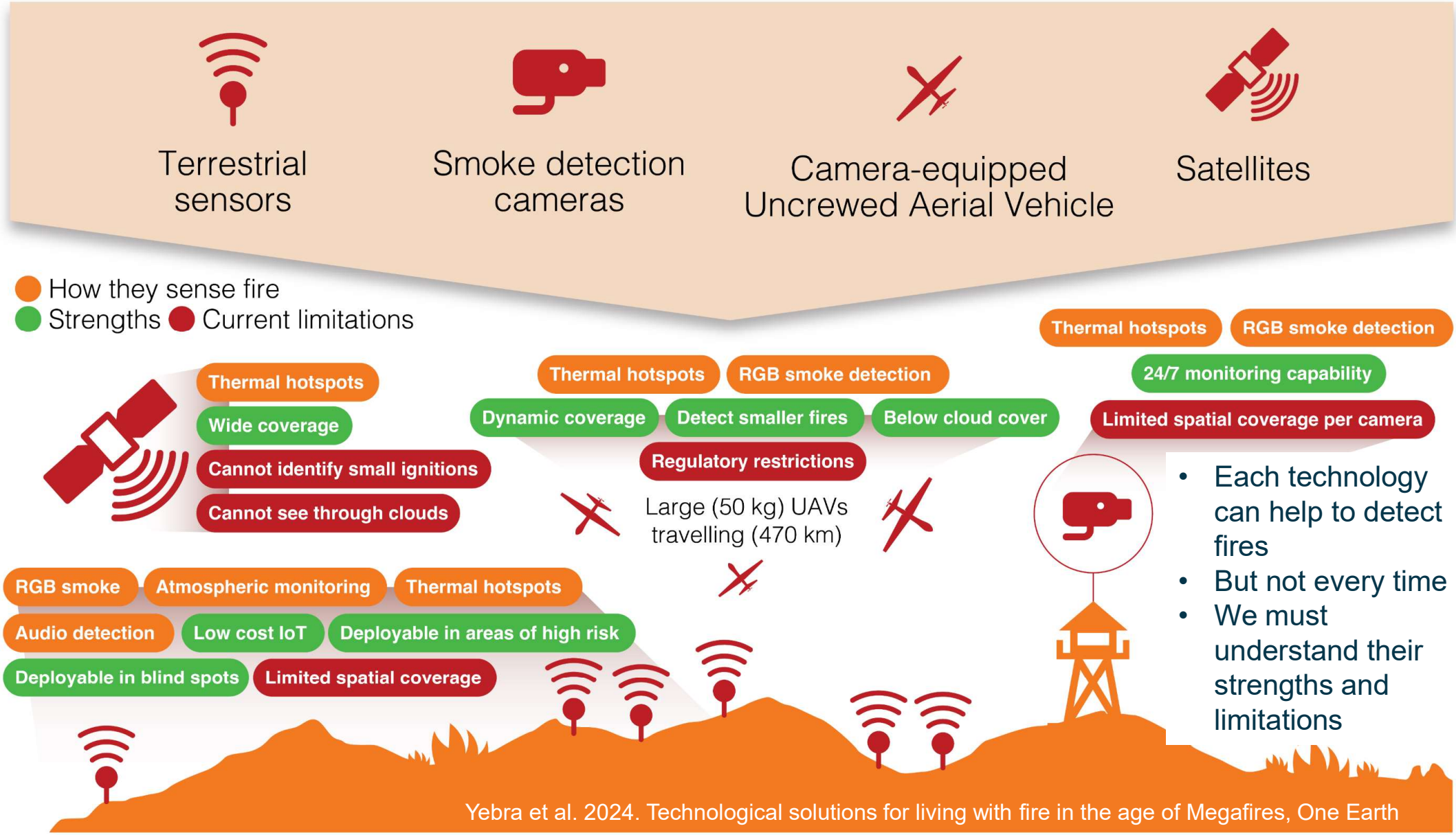
The largest bushfire in Australia (>1M ha)



@ABC, 2020

Fire detection: a tricky scenario

- How can we improve on existing detection capabilities?
  - Particularly in remote areas
  - Or when resources are already stretched


Terrestrial sensors
Smoke detection cameras
Camera-equipped Uncrewed Aerial Vehicle
Satellites
How they sense fire
Strengths
Current limitations
Thermal hotspots
Wide coverage
Cannot identify small ignitions
Cannot see through clouds
Thermal hotspots
RGB smoke detection
Dynamic coverage
Detect smaller fires
Below cloud cover
Regulatory restrictions
Large (50 kg) UAVs travelling (470 km)
Thermal hotspots
RGB smoke detection
24/7 monitoring capability
Limited spatial coverage per camera
RGB smoke
Atmospheric monitoring
Thermal hotspots
Audio detection
Low cost IoT
Deployable in areas of high risk
Deployable in blind spots
Limited spatial coverage
• Each technology can help to detect fires
• But not every time
• We must understand their strengths and limitations
Yebra et al. 2024. Technological solutions for living with fire in the age of Megafires, One Earth

Evaluation

- Quantify detection efficacy of:
  - Satellite
  - Scout drones
  - Tower camera AI smoke image detection
  - IoT terrestrial sensor networks
- Using several experimental methods
  - Artificial signals
  - Experimental burns
  - Planned burns
  - Unplanned fires

Artificial fire signals

Experimental Burns

Planned burns (ACT PCS)

Layers of Technology for ignition detection

- Which strikes caused an ignition?
- How accurately are the strikes geolocated?

Lightning detectors

Radom forest model for Lightning ignitions

- Dry lightning (temperature and humidity at levels above the surface and between 1,000 and 500 hPa)
- Climate and vegetation types
- Temperature and humidity at the time of ignition
- DEM and soil moisture

	Accuracy	Precision	Recall	AUC
Validation set	0.88	0.89	0.84	0.95
Test set	0.76	0.80	0.66	0.85

Layers of Technology for ignition detection

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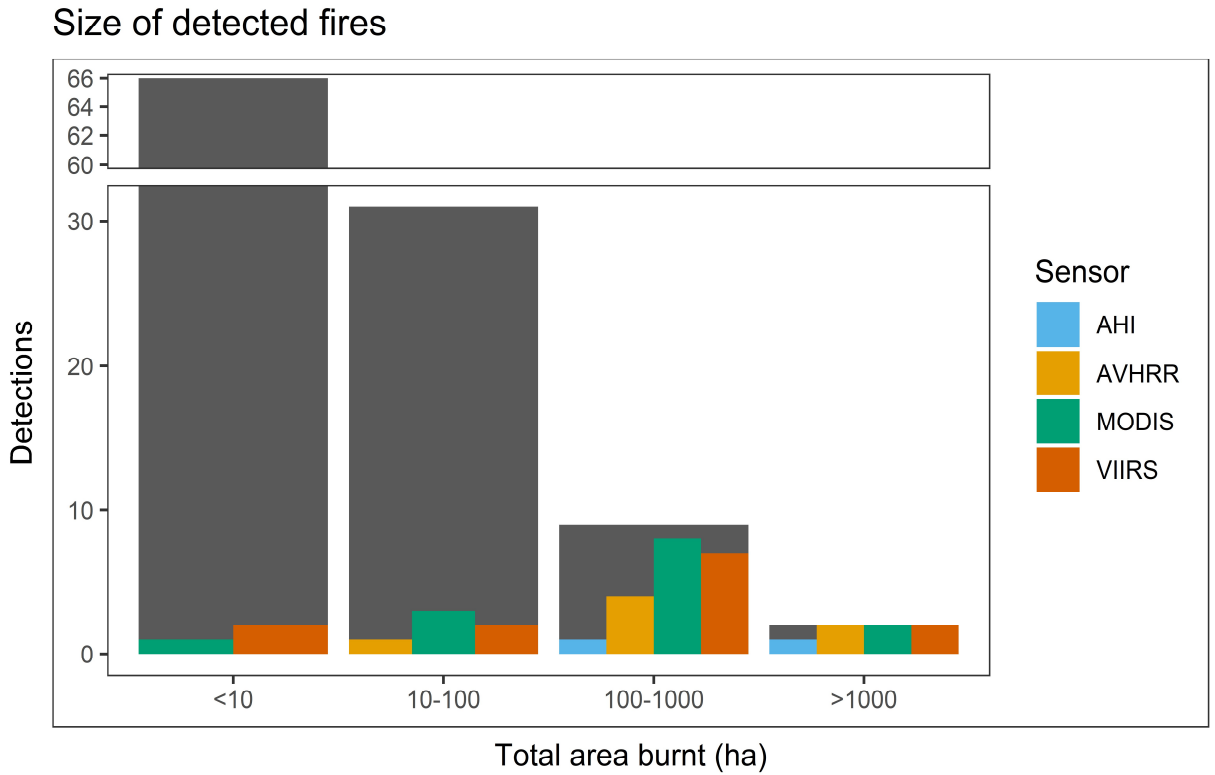
Satellite

- Is the fire big enough to see?
- Is the satellite sensitive to changes in fuel condition?
- Is there cloud or smoke?
- When does it overpass?

Current satellite capability for early fire detection

- ~ 5,000 fires in NSW where we know the date of detection (and likely ignition)
- Effects of temporal and spatial resolution but also algorithms



Higher temporal resolution

Higher spatial resolution

Wilson et al. In preparation

Fuel Moisture Content monitoring

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Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Sub-daily live fuel moisture content estimation from Himawari-8 data

Xingwen Quan[a,b,*], Rui Chen[a], Marta Yebra[c,d], David Riaño[e,f], Víctor Resco de Dios[g,h], Xing Li[i], Binbin He[a], Rachael H. Nolan[j], Anne Griebel[j,k], Matthias M. Boer[j], Yuanqi Sun[a]

Examining the Transferability of Remote-Sensing-Based Models of Live Fuel Moisture Content for Predicting Wildfire Characteristics

Edna Guk, Avi Bar-Massada, Marta Yebra, Gianluca Scortechini, and Noam Levin

scientific **data**

OPEN

DATA DESCRIPTOR

Globe-LFMC 2.0, an enhanced and updated dataset for live fuel moisture content research

Marta Yebra *et al.*#

(presenting at the EARSEL)

fire

A Review of Leaf-Level Flammability Traits in Eucalypt Trees

by Nicolas Younes [1,2,*], Marta Yebra [1,2,3], Matthias M. Boer [4], Anne Griebel [4,5] and Rachael H. Nolan [4]

Global Change Biology WILEY

RESEARCH ARTICLE

Tree species explain only half of explained spatial variability in plant water sensitivity

Alexandra G. Konings[1] | Krishna Rao[1,2] | Erica L. McCormick[1] | Anna T. Trugman[3] | A. Park Williams[4] | Noah S. Diffenbaugh[1] | Marta Yebra[5,6] | Meng Zhao[7]

FMC at global and continental scale

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Working on a literature review and comparison paper

Product	Region	Sensors	Res.	Approach
Quan et al., 2021	Global	Optical	500 m	Physical algorithm
Forkel et al., 2023	Global	Optical + Pas. MW	0.25 º	Random forests
Miller et al., 2023	CONUS	Optical	500 m	Neural networks
McCandless et al., 2020	CONUS	Optical	1 km	Random forests
Rao et al., 2020	West US	Optical + Act. MW	250 m	Neural networks
Chaparro et al., 2024	West US	Optical + LIDAR + Pas. MW + Act. MW	0.25º	Semi-physical algorithm
Yebra et al., 2018	Australia	Optical	500 m	Physical algorithm
Cunill et al., 2021	Mediterranean Basin	Optical	500 m	Random forests

Chaparro et al., In Preparation

Tailored EO Mission to monitor fire fuel Flammability

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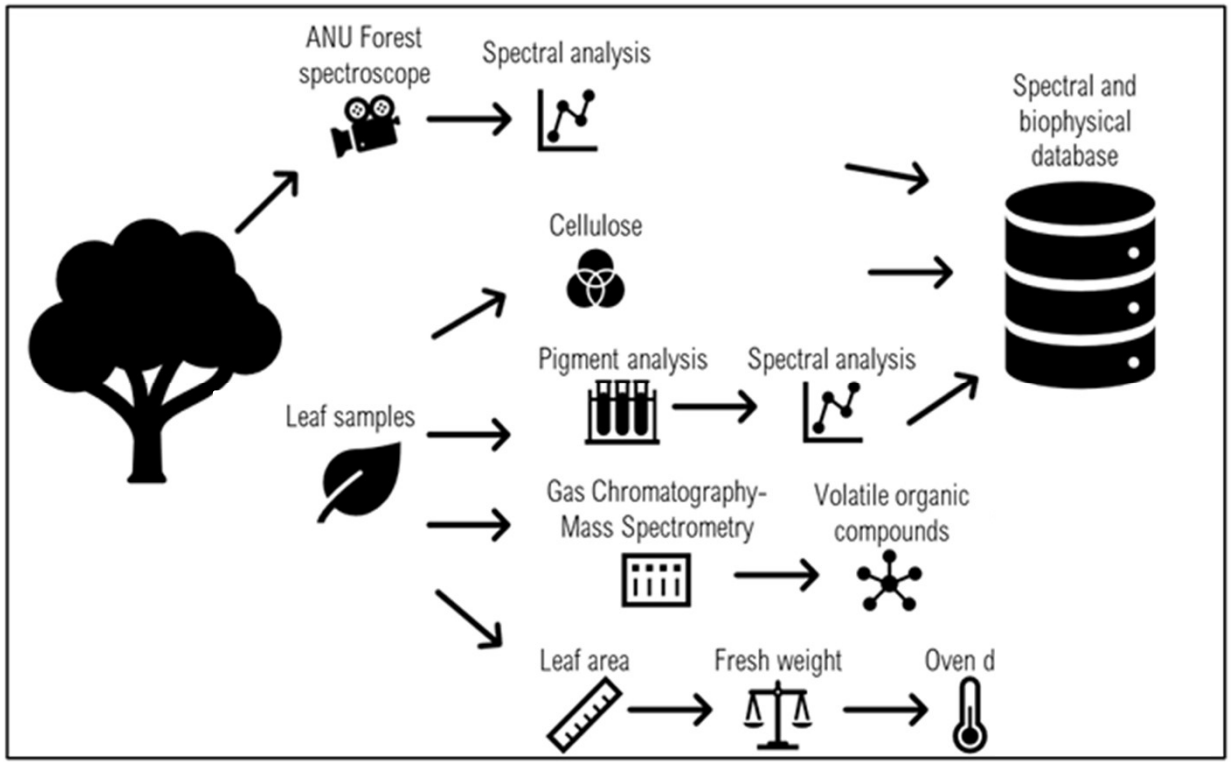
OzFuel



EUCFlamm 1.0
(presenting at the EARSEL)

Indigenous pathways to EO technologies

- Interface Aboriginal knowledge with modern scientific research.
- Use satellite data to create "life maps" for reading landscapes and fuel flammability.
- Cross-validate traditional assessments with satellite-derived data on vegetation moisture.

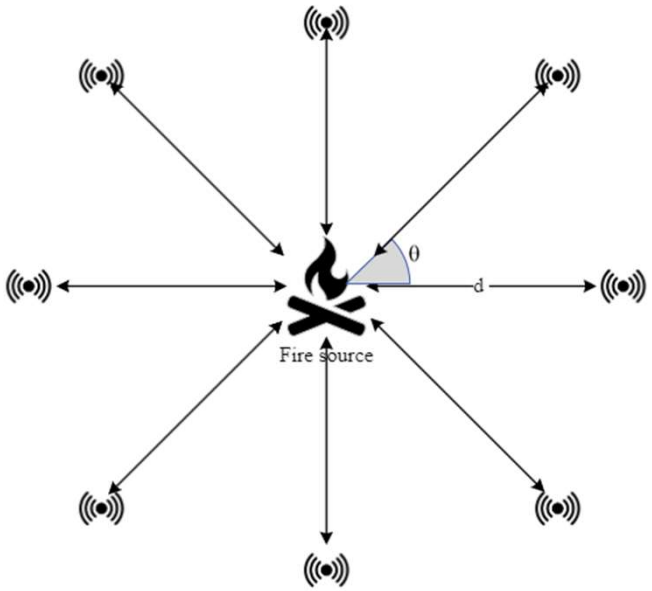
Layers of Technology for ignition detection

- Are they close enough to the fire?
- Are they downwind from the fire?

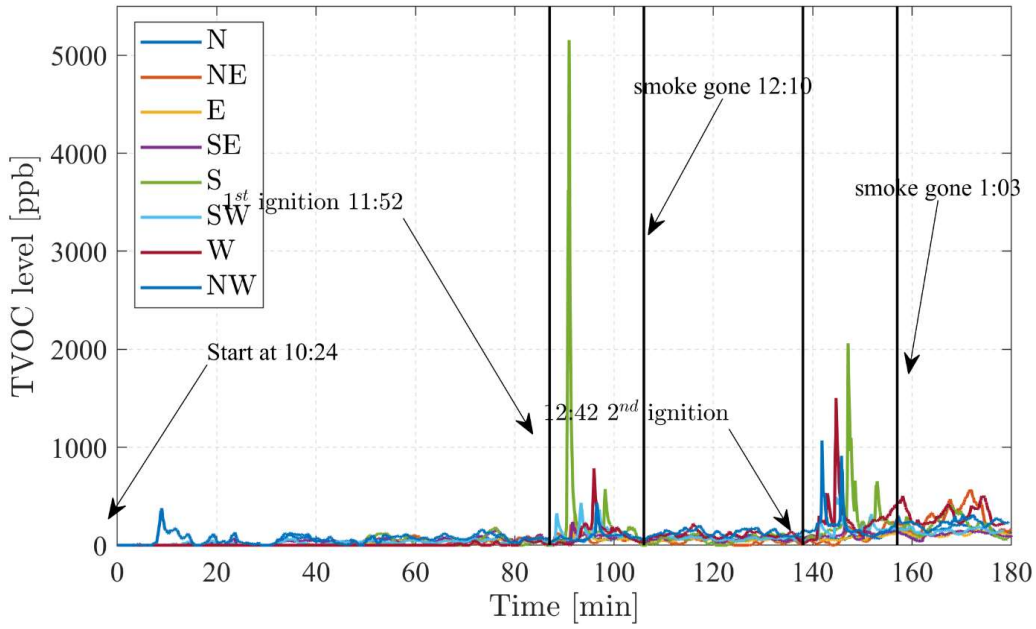
IoT Ground sensor network

IoT Ground Sensor Networks

- Position relative to wind direction strongly affects signal strength
- Smoke dispersal modelling to quantify how quickly sensor in different locations might affect fire detection



Measurements of sensor nodes
at 30 m from the fire source



Layers of Technology for ignition detection

- Is the smoke too far away?
- Is there occlusion/blind spots?
- Is there enough light to see smoke?
- Is it a false positive?

Camera-based smoke detection

Camera-based fire detection

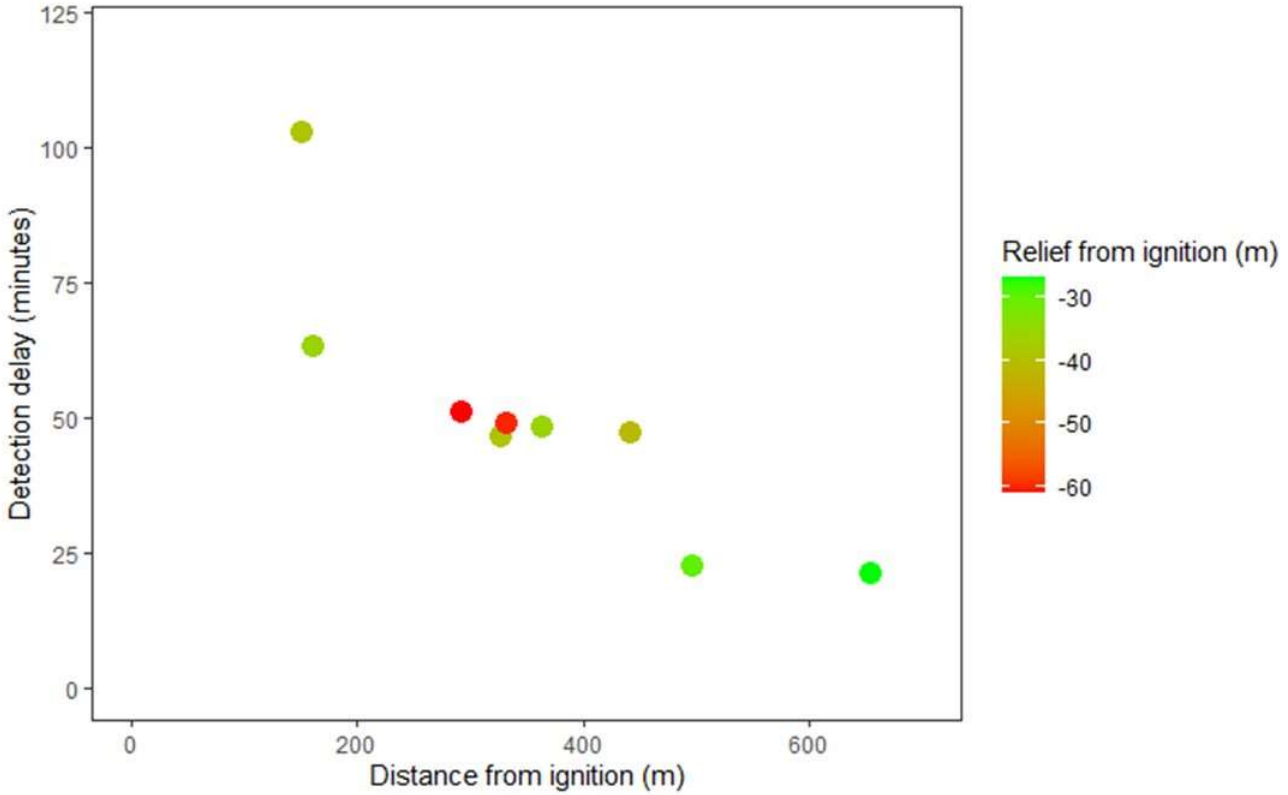
- Successfully built detection/segmentation models to detect fires

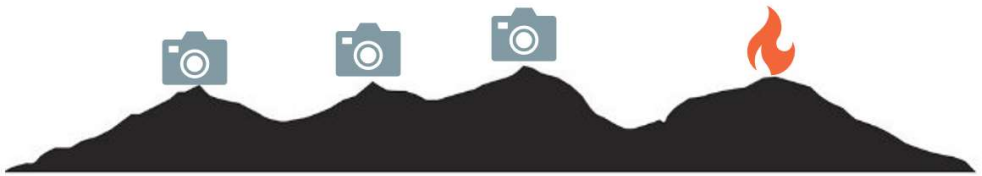
- Need to generate a publicly available dataset of smoke-detecting camera imagery (AusSmoke project- under funding application)

Yan et al. 2022

Camera-based fire detection

- Distance not always increases time to detection as we must account for terrain and wind direction





Wilson et al. In preparation

Layers of Technology for ignition detection

Scout drones

- How close do we need to fly to the fire?
- What if there is a dense canopy?

Scout drones

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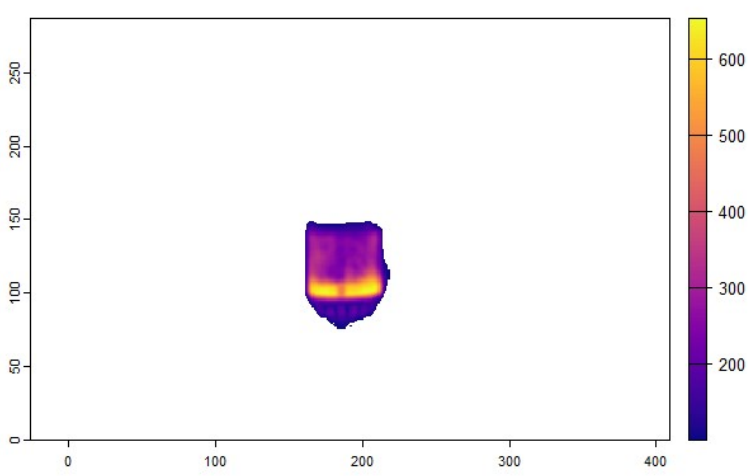
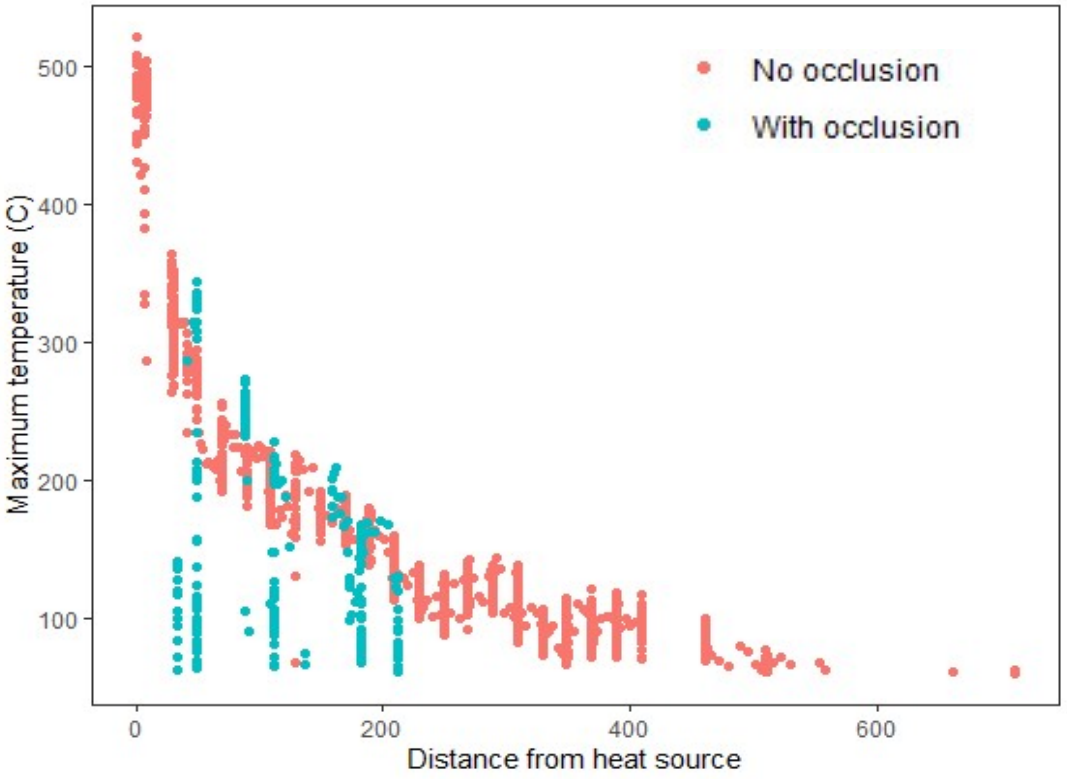
- Ongoing development of capability of Ottano platform working with Carbonix.
- Evaluation of thermal SIYI ZT30 camera and gimbal in flight conditions for small fires and heaters
- Development of manuals and procedures for EVLOS
- Obtained accreditation with CASA for EVLOS and BVLOS

Carbonix Ottano drone during tech demo in Oct.

Scout drones





Strategic roadmap for drone implementation

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- Reviewing and assessing current drone technologies for bushfire management (capabilities, limitations, and operational effectiveness)
- Guide Australian federal decision-makers in strengthening national capabilities across all phases of bushfire management: prevention, preparedness, response, and recovery → Recommendations
- Collaborating with key stakeholders to develop and rigorously test an implementation roadmap

FIRETECH CONNECT

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Australian Government
National Emergency Management Agency

https://www.drones.gov.au/drones-and-bushfire-capability

Wildfire Prediction at global scale

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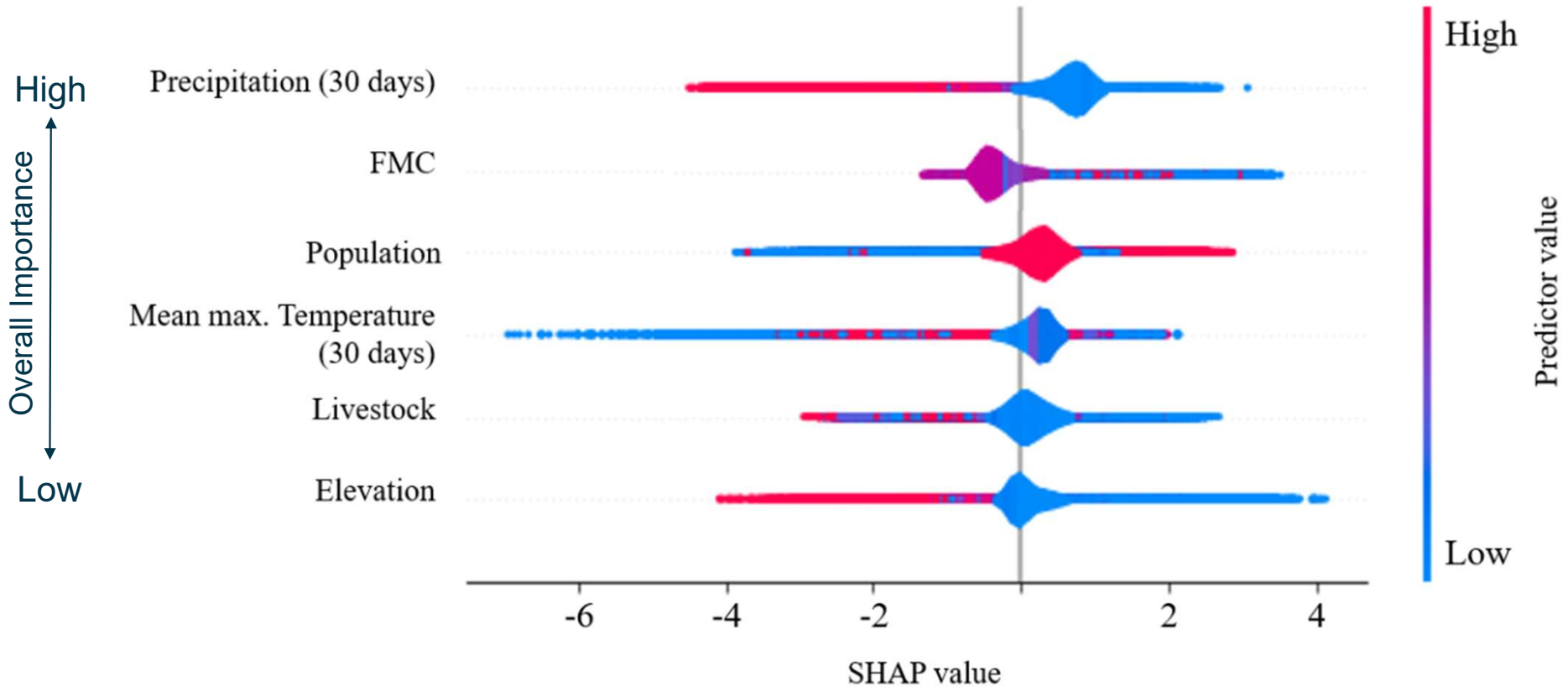

77.82 Model Accuracy

Impact of each variable on the model's predictors

Marquez-Torres et al, Under review in Global Change Biology. AI in Wildfire Prediction: A Global High-Resolution Approach.

Thank you

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OPTUS

CARBONIX

Australian Government
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

NSW RURAL FIRE SERVICE

ACT PARKS AND CONSERVATION SERVICE

indicium dynamics

FIRETECH CONNECT

FIRE NEURAL NETWORK

VICTORIA State Government

TECHNISCHE UNIVERSITÄT DRESDEN

A.C.T. RURAL FIRE SERVICE

ORORA TECHNOLOGIES

BUSHFIRE & NATURAL HAZARDS RESEARCH CENTRE

WESTERN SYDNEY UNIVERSITY

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Sustainable Timber Tasmania

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Stanford University

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