ACCESS-Fire: Coupled Fire-Atmosphere Modelling

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Presentation outline

Introduction

Recent progress in model development and evaluation

Future work

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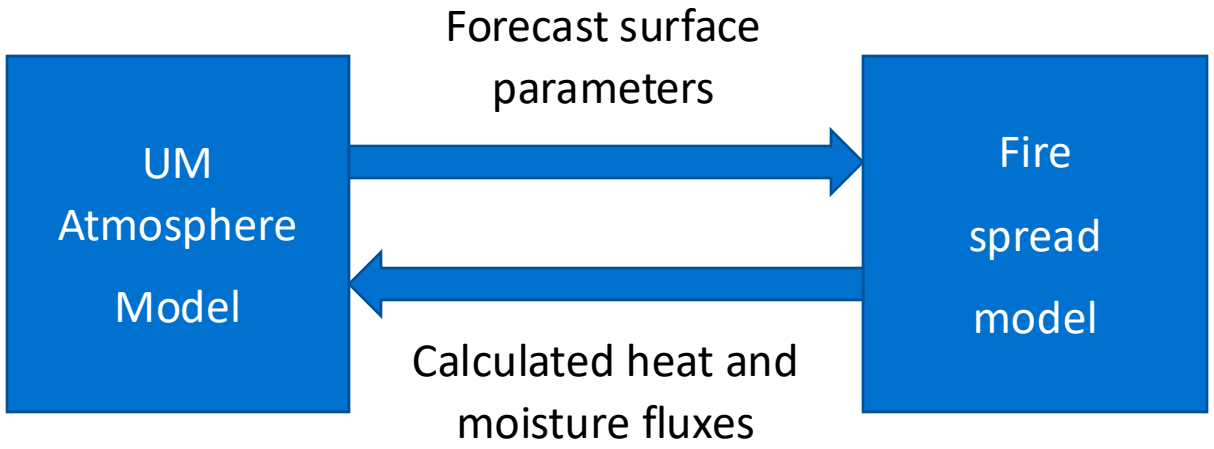
ACCESS-Fire basic configuration



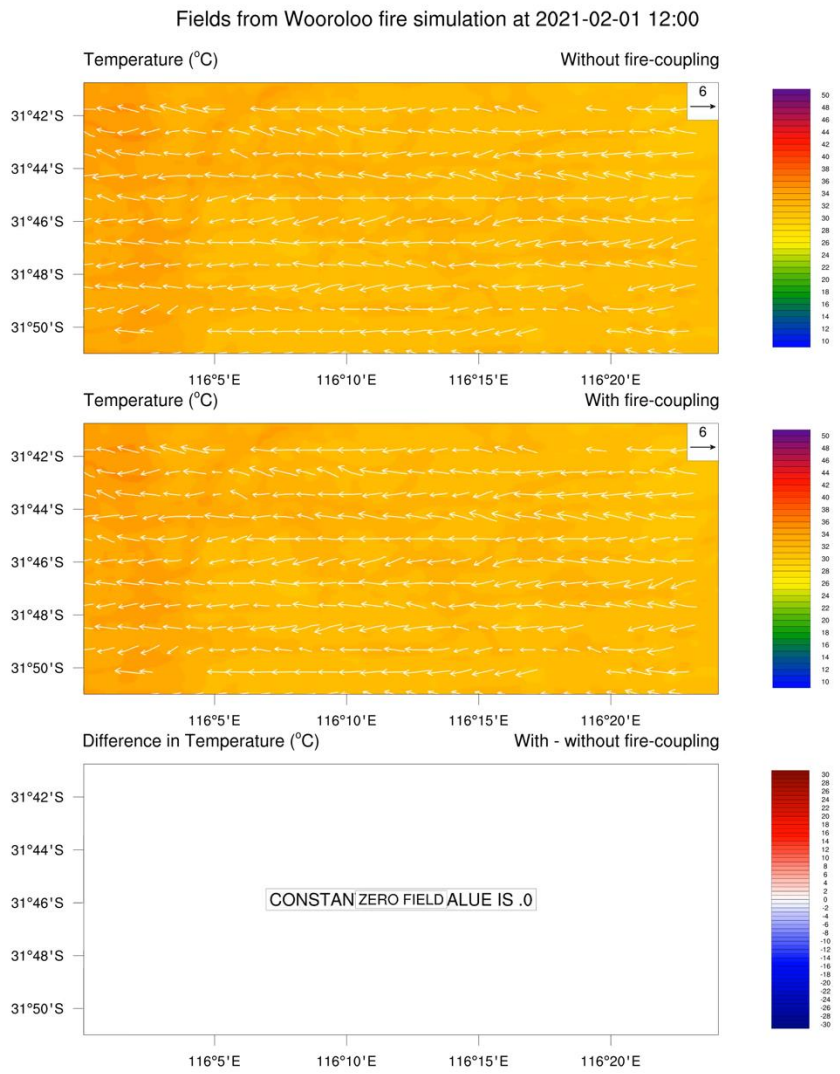
- Based on a standard nesting suite
- Fire spread model comprises a group of source code files embedded in JULES
- Nested domains to 300 m resolution (100 m if needed), 140 vertical levels
- The fire model is usually turned on in the innermost nest
- Fires can be initialized at any time from a single point or a polygon via a configuration file. This file also defines other aspects of fire model, e.g., the fire spread model to use, the fuel type and fuel load.

Case studies with ACCESS-Fire

- ACCESS-Fire has been run for 10 case studies:
  - Kilmore East (2009) – Black Saturday
  - Bushfire and Natural Hazards CRC project: Waroona (WA 2016) and Sir Ivan (NSW 2017)
  - Black Summer: Stanthorpe (QLD), Yanchep (WA), Corryong (VIC), Badja Forest (NSW), Kangaroo Island (SA)
  - NHRA Case Study project: Wooroloo (WA 2021) and Currowan (NSW 2019/20)
- Key fire-atmosphere interactions resolved:
  - PyroCb (fire-generated thunderstorms)
  - Fire Generated Vortices (fire whirls with tornado strength winds)
  - Low Level Jets (elevated wind descending to surface behind plume)

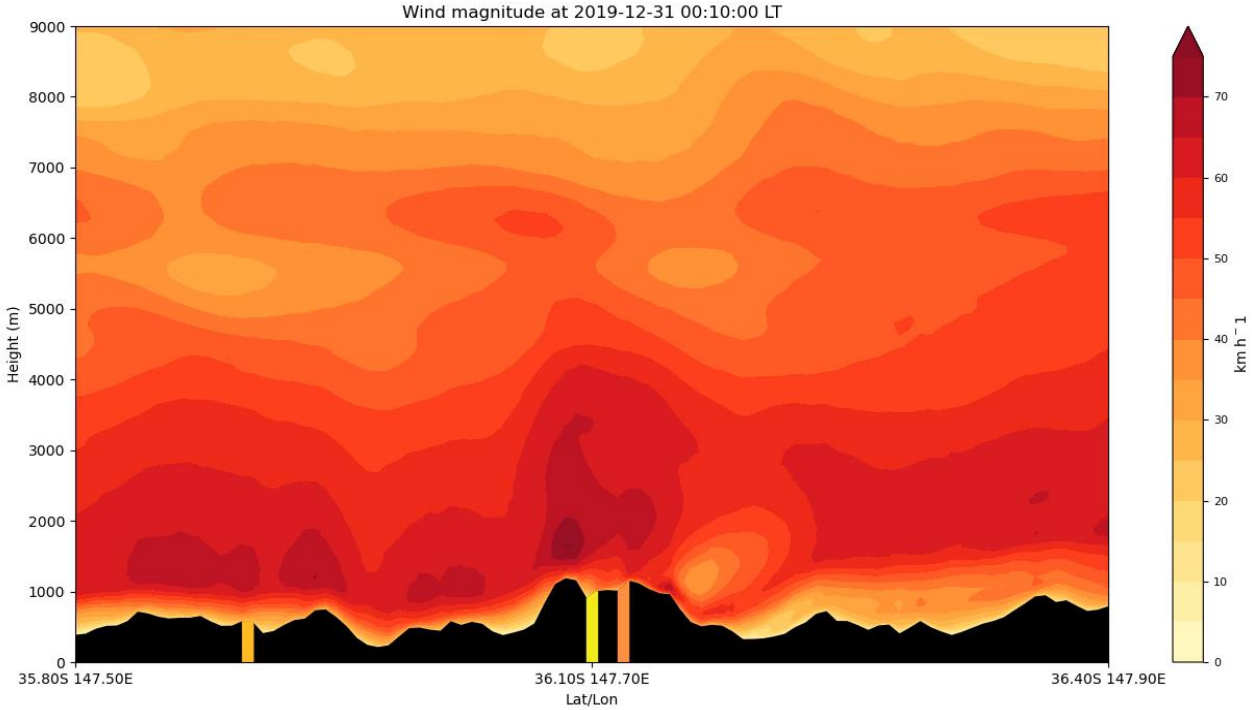
The coupling effects: surface

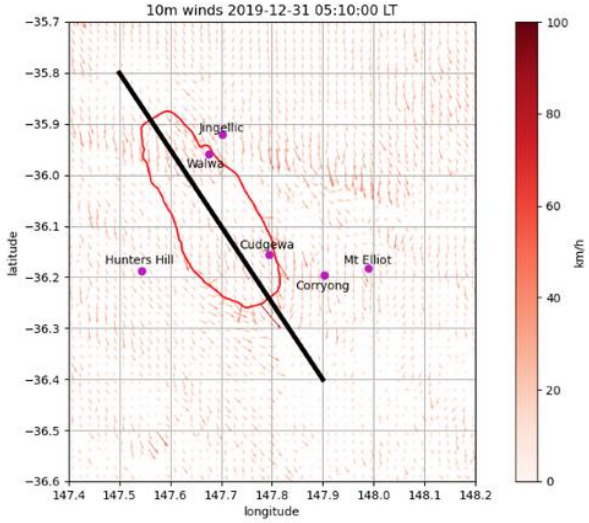
- Screen-level temperature and 10-m wind from ACCESS-Fire simulation of the Wooroloo fire:
  - Instantaneous values in 1-minute intervals
  - Hottest temperatures are generally where the fire front is
  - Wind modification can happen well ahead of the fire front
  - Winds behind the fire front tend to accelerate towards the fire (analogous to thunderstorm processes), making the fire spread more quickly than non-coupled run.
  - Overall, the coupled simulations are a good match with observations from fire fronts.



The coupling effects: 3D

Low Level Jets overnight in Corryong fire





- Vertical cross-section of wind speed in red/orange (m/s)
- Surface to 9km (black is topography, yellow/pink is fire) 10 minute time intervals
- Wind max 1000-2000 m elevation 80+km/h
- Extreme winds adjacent fire front (consistent with damage observations)
- Fire spread 36 km overnight

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The coupling effects: 3D

Low Level Jets in Corryong fire

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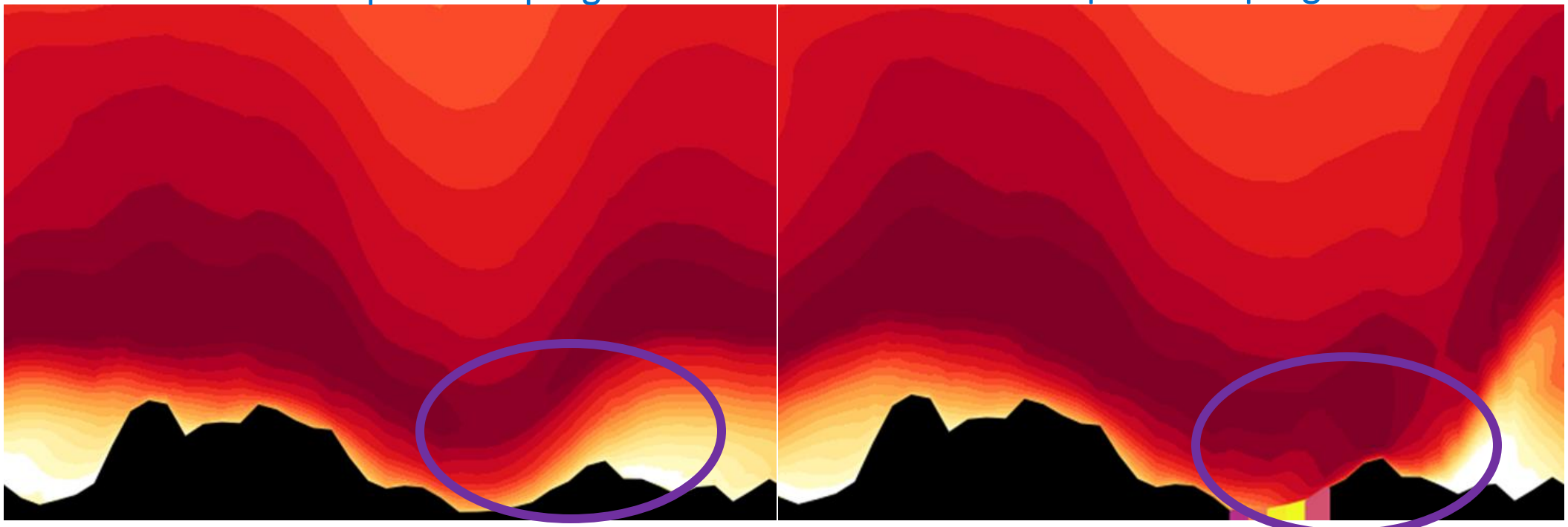
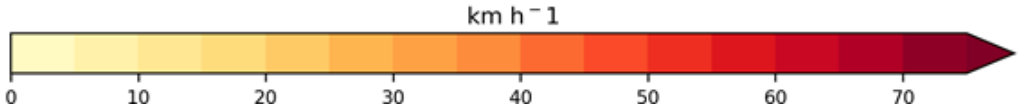
Fire-atmosphere coupling 'OFF'

Fire-atmosphere coupling 'ON'



Vertical scale = surface to ~4000m

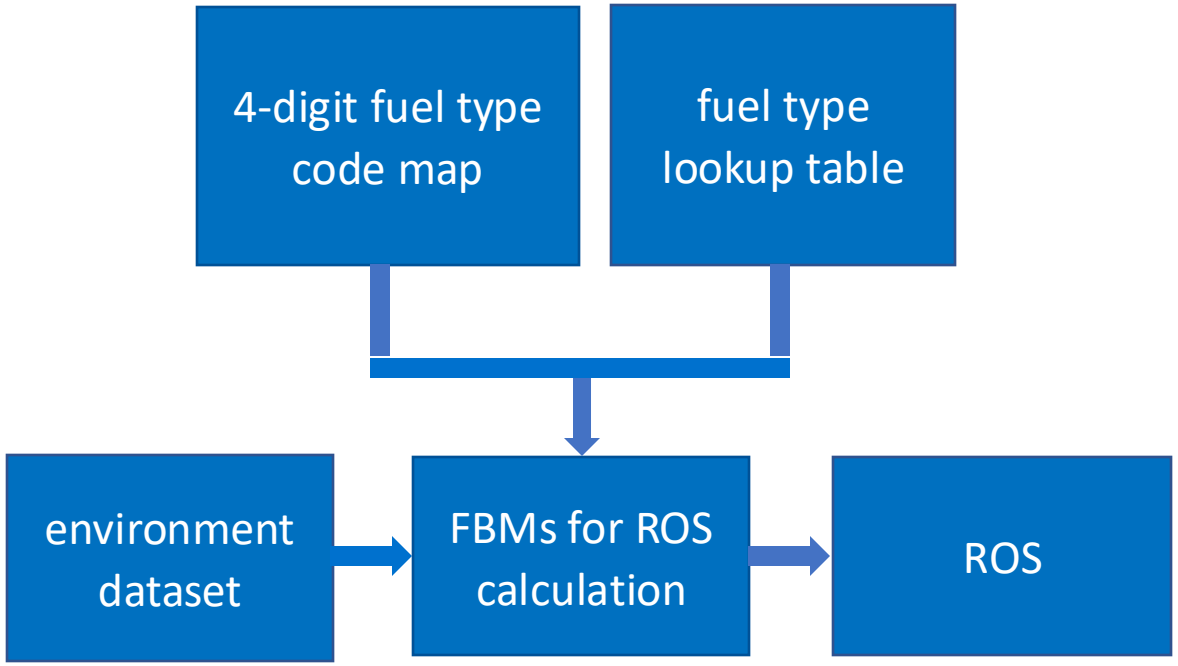


Implementing AFDRS

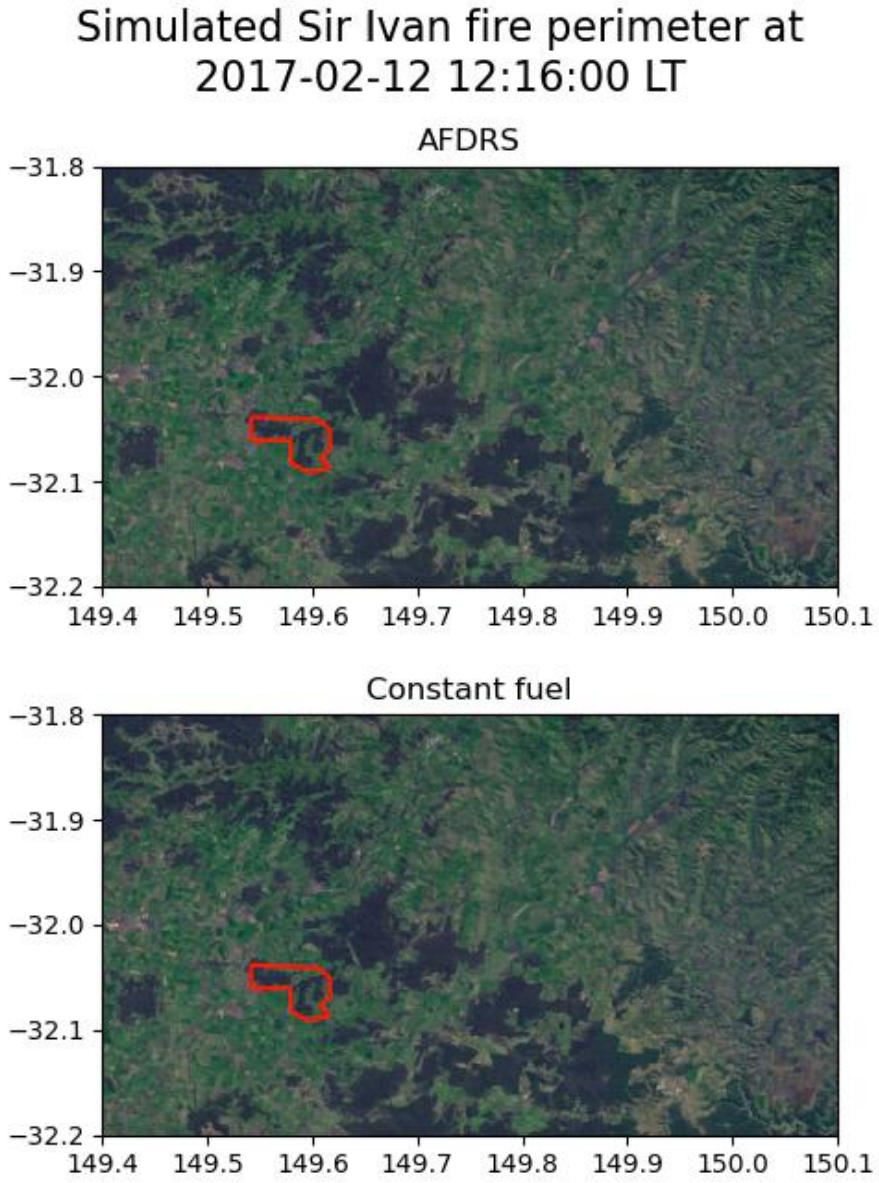
- In the original fire code, for a whole simulation, we can only use:
  - A single fuel type (e.g., dry forest) for entire domain
  - A single fire spread model (e.g., peak-time VESTA-1 for dry forest) to calculate the rate of fire spread (ROS)

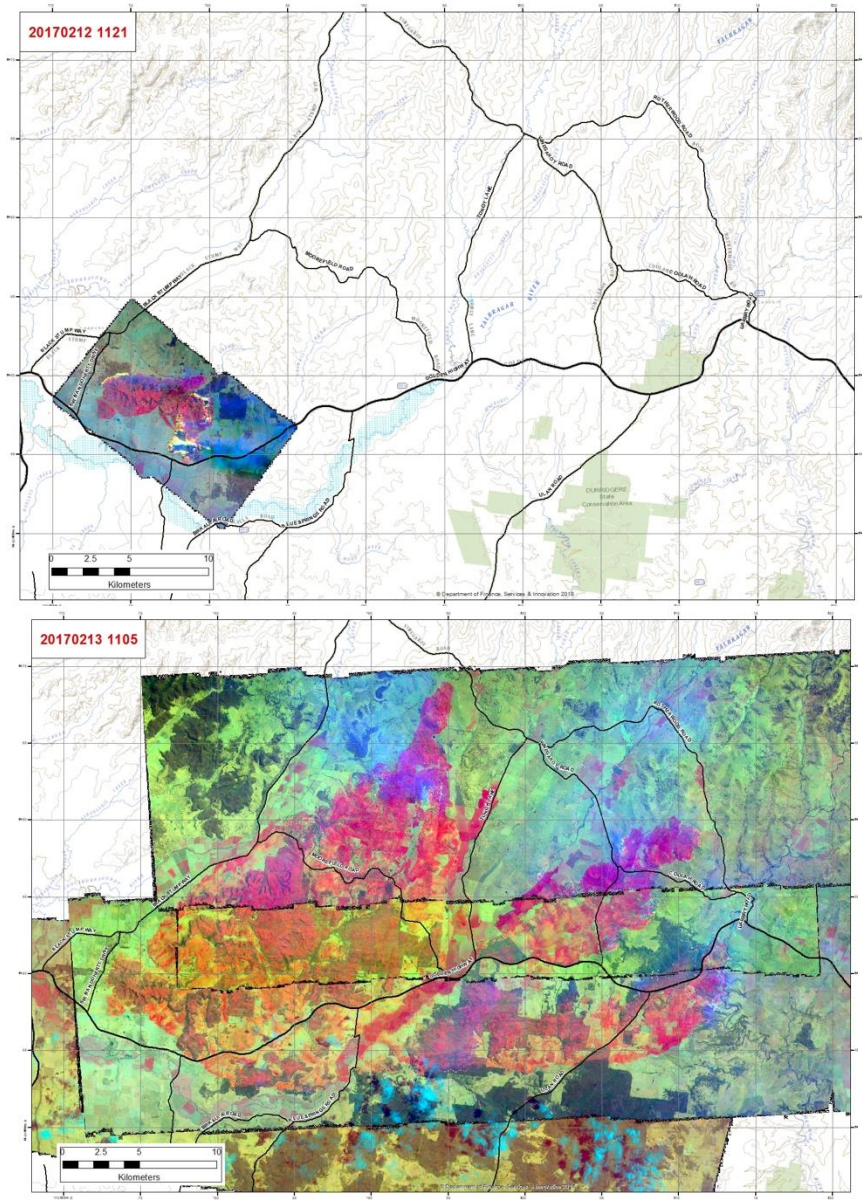
- Implementing AFDRS gives us:
  - Very high resolution (as high as ~ 30 m) information about the fuel type and the fuel condition.
  - The ability to use the matching fire spread model (or fire behaviour model – FBM) for the fuel type/condition.

Added functionality



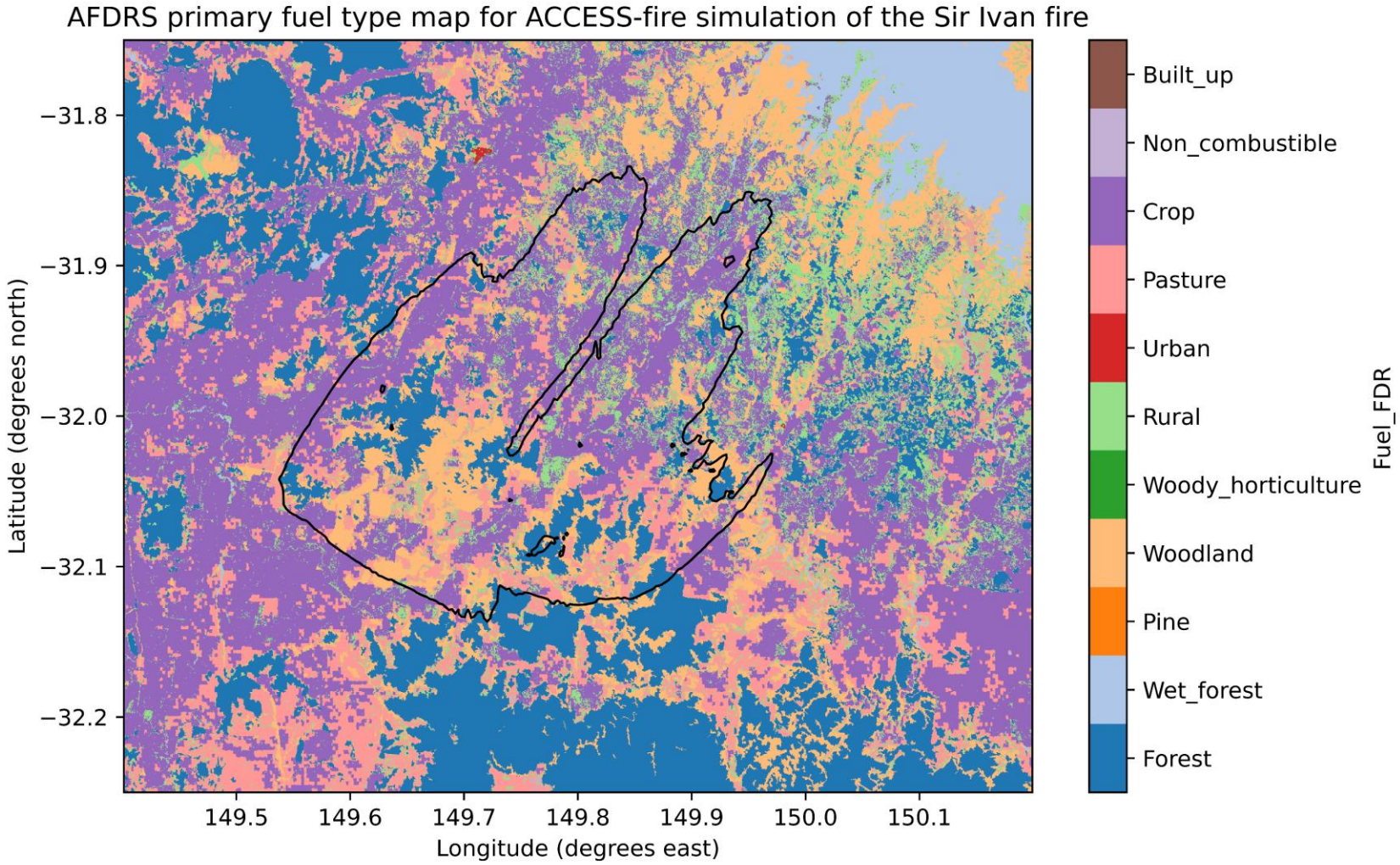
Implementing AFDRS: Sir Ivan fire



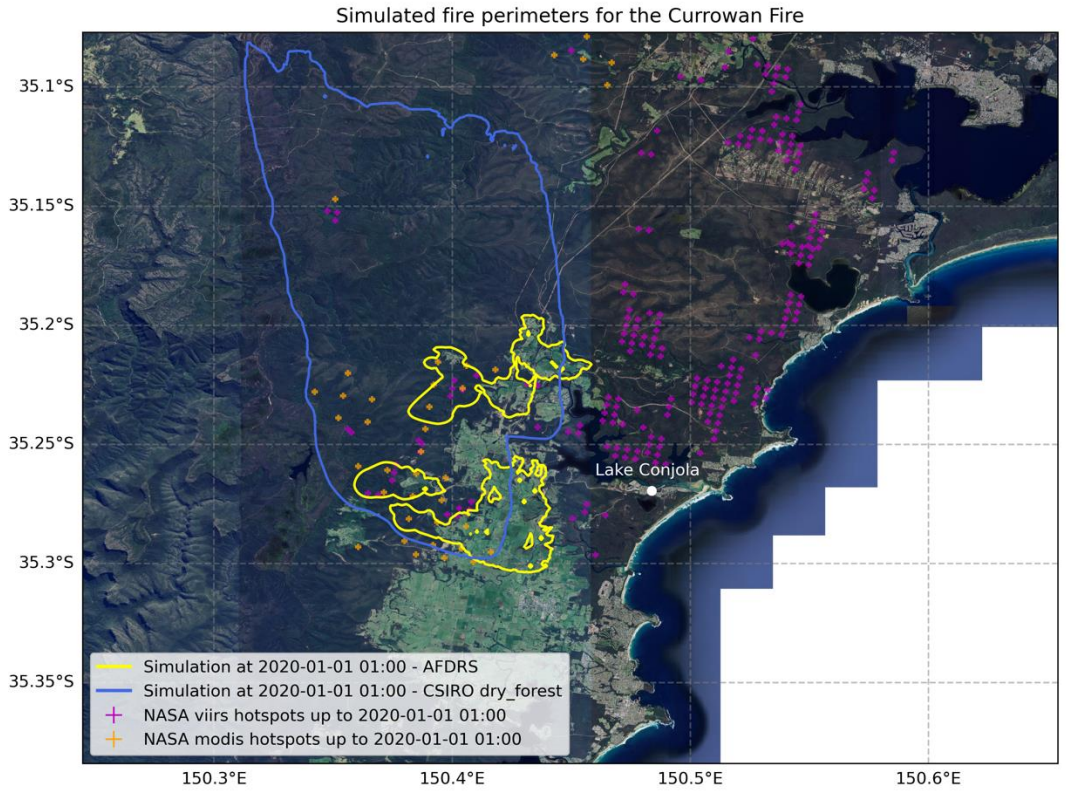


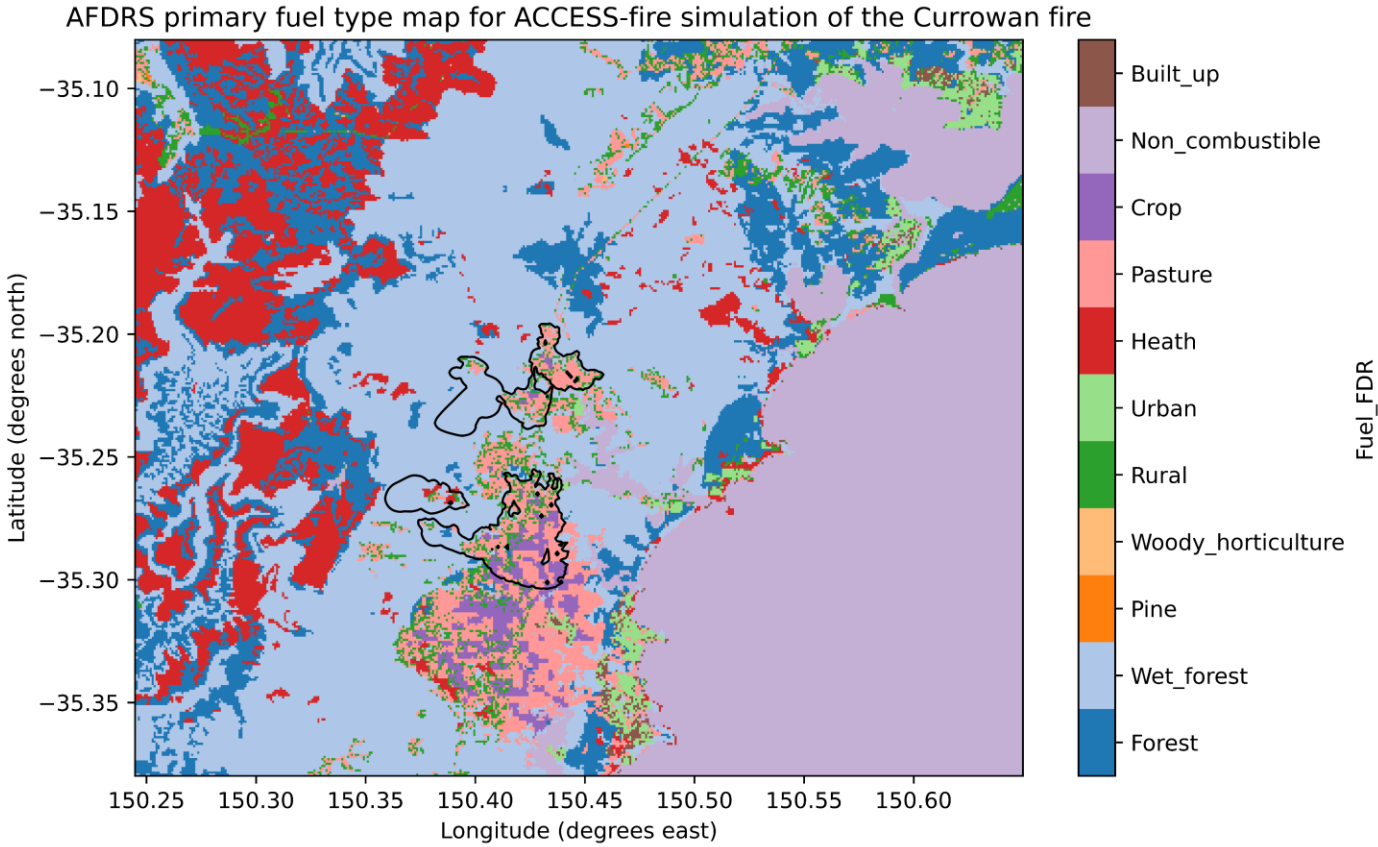
Implementing AFDRS: Sir Ivan fire

AFDRS fuel type map for Sir Ivan fire



AFDRS: Currowan fire





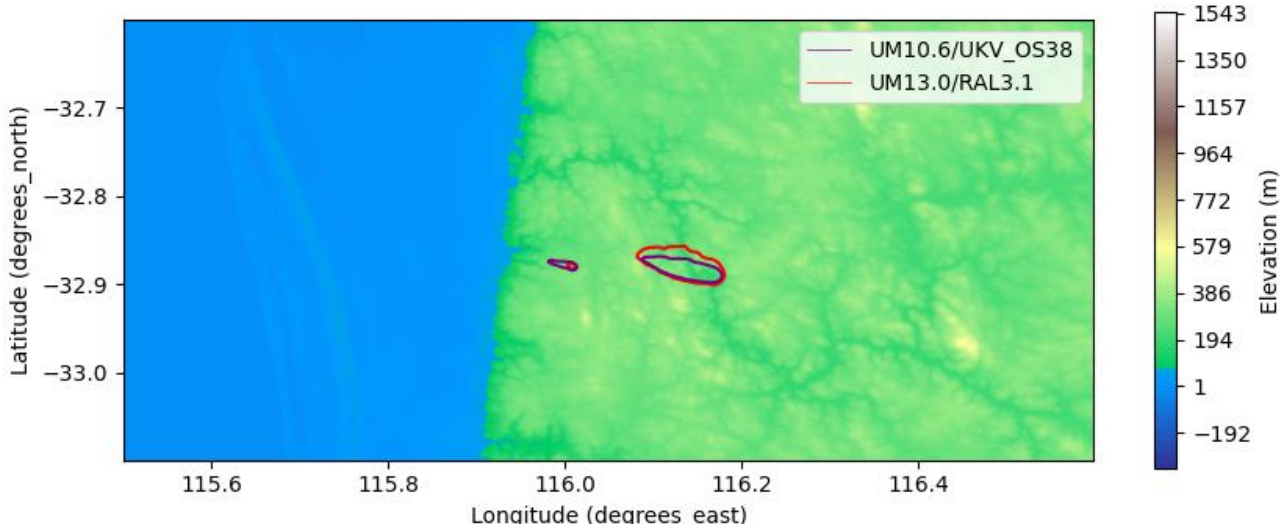
- AFDRS was not so accurate in this case – the fire had spread to Lake Conjola by this time.
- Possible issue with calculation of spread for wet forest (DF in NSW exceeded 10 in real time).
- There was also possibly spotting – we have a plan to try and resolve.

Upgrading the suite and source code

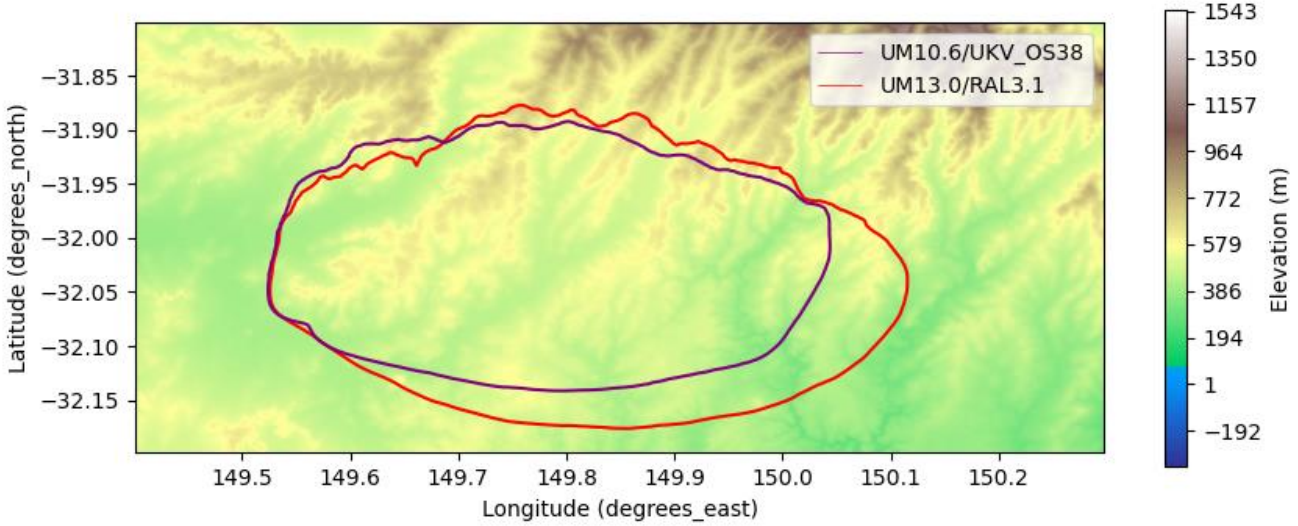
- Upgraded from UM10.6/UKV OS38 to UM13.0/RAL3.2
- Switched to the ACCESS-A style lsm and lct ancillary files
- Source code rewritten to be close to UM code standard
- Working on model stability issue.

Comparison between before and after the upgrade

Fire perimeter of Waroona after 19 hours burning



Fire perimeter of Sir Ivan after 20 hours burning



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Future work

- Effort to put ACCESS-Fire code on the JULES trunk.
- Explore including other processes, e.g. ember transport, smoke and chemical transport.
- Further model refinement in the NHRA Fire Case Study project. Closer to real-time (rapid post-event) simulations and event summaries for 2025-26 fire season, in collaboration with FHAQ
- Options for operational pathways (1) ACCESS-Fire is costly and bespoke to run in real time (2) integrate 3d processes in Spark (possible and favoured) (3) training of practitioners (valuable but can vary across individuals during extreme events)

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Summary

- ACCESS-Fire has been a small project funded by CRC and NHRA
- Has delivered (1) advanced modelling capability and (2) new knowledge on fire-atmosphere interactions
- Strongly supported by fire agencies and high community interest
- Future effort will transition the capability to operations to produce accurate fire predictions that integrate real-time data including radar, satellite and line scans
- Objective = optimal situational awareness and decision-making during bushfires.