Lessons learned from coupled fire-atmosphere research and implications for operational fire modelling

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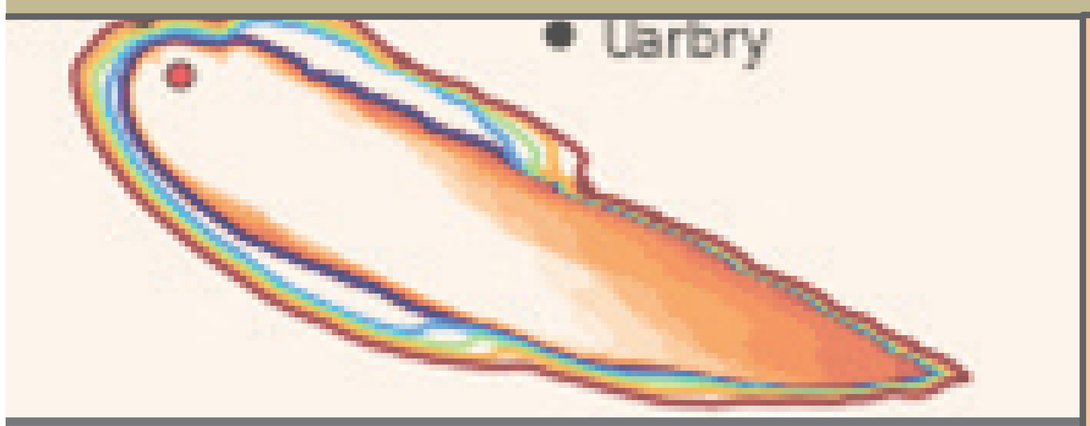
WHAT ARE COUPLED FIRE-ATMOSPHERE MODELS?

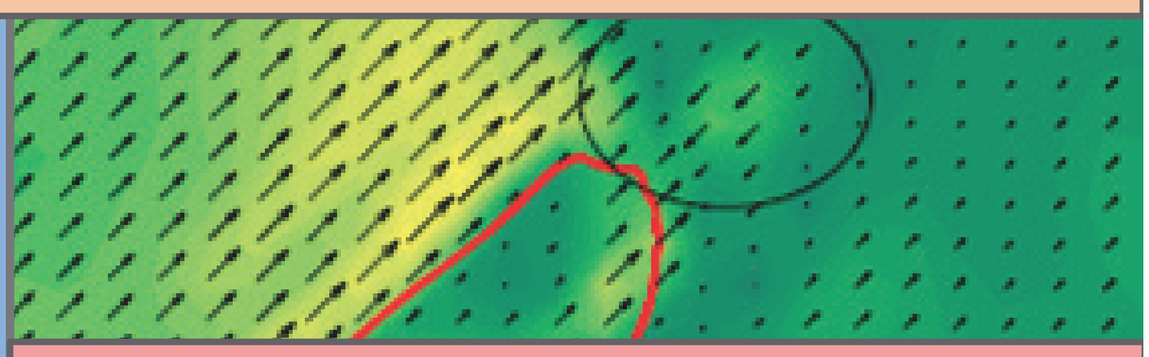
Coupled models are a class of fire prediction models that combine fire and atmospheric components. The objective is to resolve how the energy released by a fire modifies the surrounding atmosphere and how the feedbacks manifest on fire behaviour. Fire-atmosphere interactions can be particularly dramatic and hazardous at large, intense fires burning in complex terrain within unstable atmospheric conditions.



FIRE–MODIFIED WINDS

Energy released by a fire into the atmospheric model changes the wind flow near the fire front. The example below shows a fire front (red) driven by southwesterly winds, with a wind direction reversal (circled) ahead of the fire.

Observations from radar and weather stations confirm this effect, which can extend several kilometres from the fire front. Coupled simulations have shown that the elliptical shape of fires is due to the fire modified winds.



COUPLED FIRE-ATMOSPHERE MODELS IN USE:

CAWFE: The world-first coupled fire-atmosphere model, run at the US National Centre for Atmospheric Research. Uses Rothermel's empirical fire model linked to a high-resolution weather model.

WRF-FIRE: Similar fire code to CAWFE, but linked to the extensively used Weather Research and Forecasting model. WRF-Fire contains a smoke and chemistry transport scheme.

ACCESS-FIRE: The Australian coupled model, which links some Australian fire behavior models to the BoM weather prediction model. Currently under development as a BNHCRC project.

FIRETEC/HIGRAD: A physical model used at Los Alamos Laboratory. The equations capture very fine-scale combustion processes. FIRETEC provides insights into physical processes, but is suitable for research applications only, not landscape scale fires.

WFDS: Physics based model with an emphasis on combustion and heat transport. Grass fuels only, not intended as a landscape model.

MESO-NH AND FOREFIRE: French model, fire component not as advanced as the USA models.

WHAT IS THE DIFFERENCE BETWEEN EMPIRICAL AND PHYSICALLY BASED MODELS?

Physical models capture the physics and chemistry of combustion processes through the basic laws of physics, like conservation of mass, momentum and energy.

Empirical fire behaviour models (almost all of them) are derived through statistical analysis of outdoor-experimental fires or laboratory based experiments.

Empirical models can work well in many circumstances, but are limited when conditions are outside the range they were developed on. Physical models can predict situations they have not seen before, but are computationally expensive.

FUTURE OPERATIONAL USE?

Coupled models in Australia are not sufficiently mature to be used in operations.

In the US, WRF-Fire has been run in an operational trial with the Colorado Fire Prediction System.

Australian agencies are monitoring the Colorado trial with interest.

WHAT DOES THE FUTURE HOLD FOR COUPLED MODELS?

Small and medium sized fires are often predicted pretty well by the current empirical models.

Coupled models may be needed to predict large powerful fires that change the weather around them.

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