Numerical Modelling of Wildland Fire-Atmosphere Interactions

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Background

Wildland fires are highly complex phenomena which can potentially have a devastating impact on both people and the environment. Fire behaviour is strongly associated with the conditions of the surrounding atmosphere, which can be both highly variable and difficult to predict, especially in complex terrain. In particular, the wind speed, wind direction, temperature and humidity play an important role in influencing the behaviour of a wildland fire. For example, a fire will typically spread faster under high wind speed conditions, and the direction of fire spread is often closely aligned to the wind direction. In addition to being influenced by atmospheric conditions, a fire can also influence the atmosphere through release of heat, water vapour and particulate matter through the chemical combustion of fuel. This two-way interaction between fire behaviour and atmospheric conditions often manifests itself through a number of different interaction processes. For example, wildland fires often generate strong convective plumes and towering pyrocumulous clouds above them, and frequently generate severe turbulence and vorticity. These interactions between fire processes and atmospheric conditions need to be incorporated in the development of improved modelling tools for predicting future fire behaviour.

Research Objectives

1. Develop a coupled fire-atmosphere computer model
2. Investigate the nature of fire-atmosphere interactions and how they affect fire behaviour using the newly developed coupled model
3. Develop new tools suitable for operational use by fire managers

Left: Firefighters look on at a fire whirl generated by a wildland fire
Top right: A wildland fire spreading across Mt. San Miguel in San Diego
Bottom right: A pyrocumulous cloud generated by the Station Fire in LA
References: http://www.flickr.com/photos/captlaz81b/3389728273/
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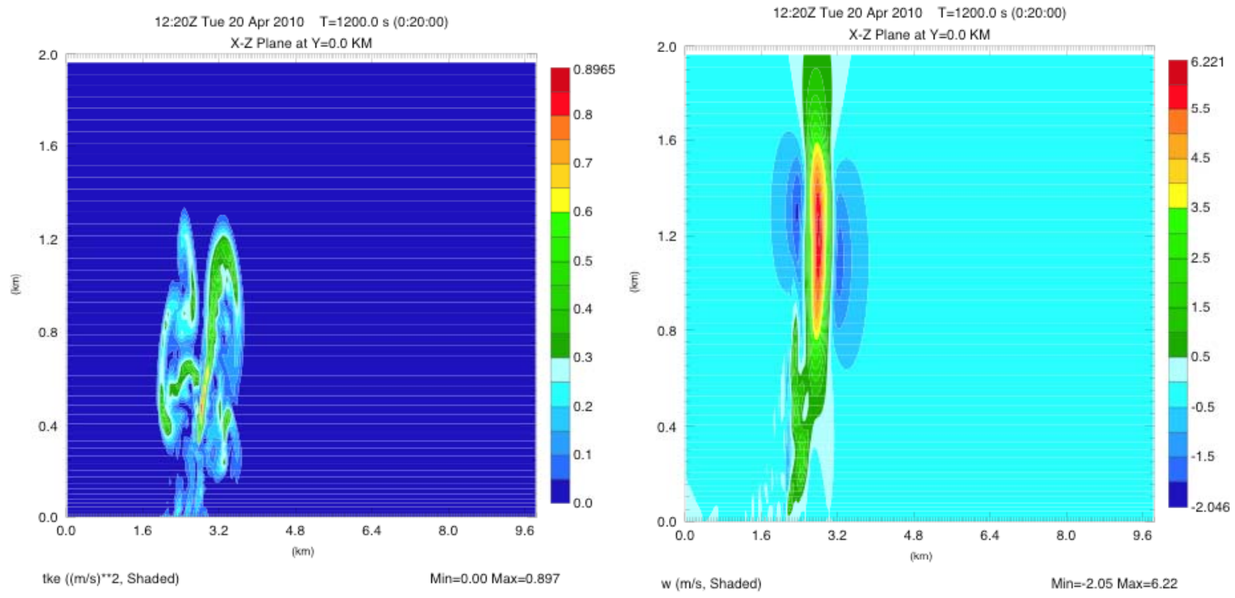

These diagrams show some results of an idealised simulation run using the ARPS model. Left: Turbulence generated above a patch of heated soil. Right: Vertical wind speeds show presence of convective plume above heated soil

Methodology

Due to the difficulty of obtaining high resolution observations of wildland fires, scientific researchers make extensive use of computer models to study fire behaviour. In order to study fire-atmosphere interactions, a coupled fire-atmosphere model is required. We intend to use idealised computer simulations to study these interactions at a horizontal scale of hundreds of metres over a period of many hours. We have opted to use a coupled fire-atmosphere based on the atmospheric model ARPS.

We have begun using this coupled model to set up idealised simulations that allow for investigations into the nature of fire-atmosphere interactions on small spatial scales. We are particularly interested to see how surface wind conditions are influenced by the presence of a fire, but are also interested in the generation of turbulence and vorticity by a simulated wildland fire. We are also interested in studying fire behaviour in areas of complex terrain.

Summary

The behaviour of a wildland fire is known to be strongly coupled to the conditions of its surrounding atmosphere. This coupling gives rise to a number of fire-atmosphere interaction processes. This research aims to use coupled fire-atmosphere computer models to perform idealised simulations that allow for an investigation into the fundamental nature of these interactions. A better understanding of these interactions will allow for development of more scientifically robust fire behaviour modelling tools, which will directly benefit fire management agencies.

References

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