Forecasting wind direction variability using numerical weather prediction

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Introduction

Wind direction variability in the atmospheric boundary layer contributes to lateral fire spread by broadening the fire front. This broadening increases the fire front propagation speed, makes the fire more difficult to suppress and results in a larger area of damage.

Here we present results from a high resolution (0.004°) simulation of the atmosphere on Black Saturday, 7th February 2009, using the Australian Community Climate and Earth-System Simulator (ACCESS).

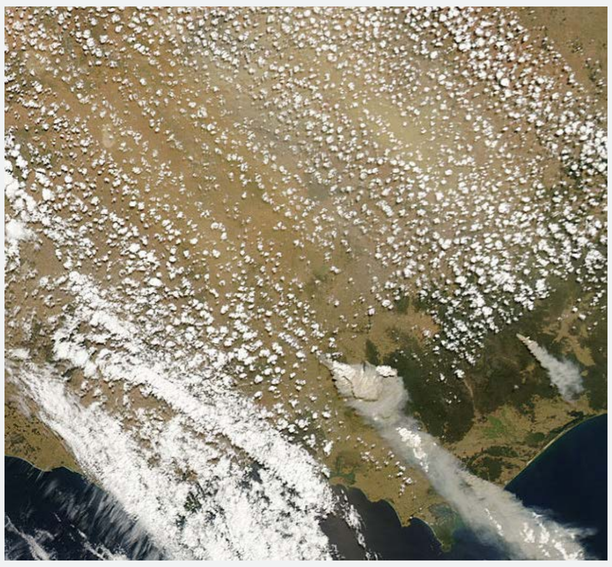

Fig. 1. MODIS satellite image, Victoria 15:50 EDT, 7th February 2009.

Observations

Satellite imagery (Fig. 1) indicates that linear organised convection, known as boundary-layer rolls, covered a substantial area of Victoria during the afternoon of 7th February 2009. The effects of this convection at the surface are evident in the observations at Yarrawonga (Fig. 2). Wind speed and direction fluctuations of approximately 20 kmh^{-1} and 60°, respectively, are seen over timescales of a few minutes.

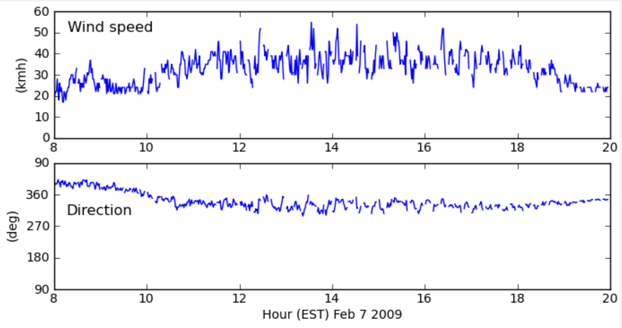

Fig. 2. Observed 10 m wind speed and direction at Yarrawonga AWS.

Model results

Vertical velocity at 980 m above ground level (AGL) and wind streamlines at 10 m AGL for a 60 x 60 km subregion are presented in Fig. 3. Successful simulation of the linear organised convection of boundary-layer rolls is evident. Alternate “strips” of updraft and downdraft are reproduced, above regions of surface convergence and divergence, respectively. The alternating convergence and divergence results in variations in surface wind direction of larger than 50 ° over a distance of a few kilometres.

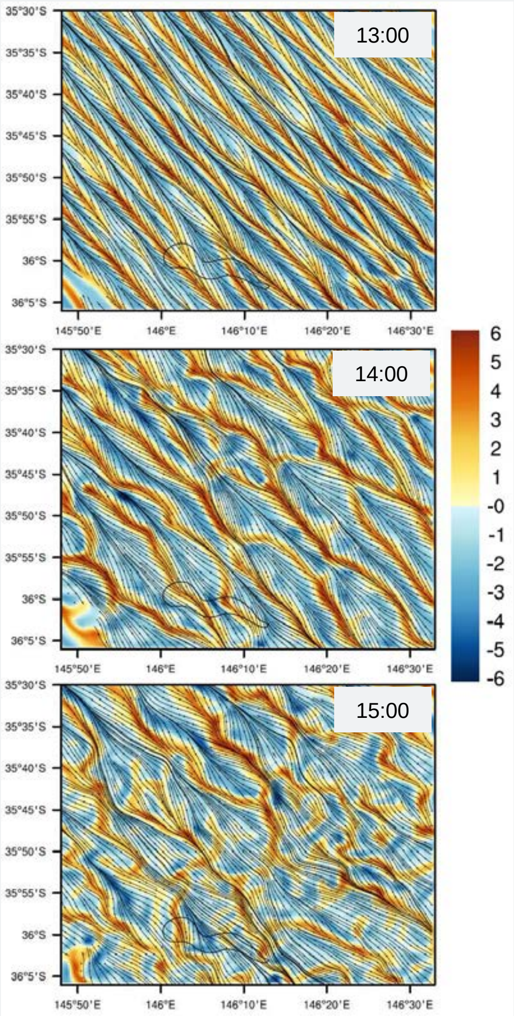

Fig. 3. Simulated 10-m wind streamlines overlaid on simulated vertical velocity (ms^{-1}) at 980 m AGL. Times in EDT, 7th February 2009.

Throughout the afternoon the convection develops, and both the magnitude and the horizontal spacing between the updrafts increases. Later in the afternoon the convection becomes less linear and more cellular in nature. Updrafts exceed 6 ms^{-1}, a typical fall velocity for firebrands, indicating that the rolls are strong enough to loft firebrands.

Potential fire impacts

Instantaneous Forest Fire Danger Index (FFDI) values from the ACCESS output are shown in Fig 4. Initially strips of depressed FFDI are superimposed on a constant FFDI background. These low FFDI regions are located beneath the roll updrafts and caused by low surface wind speed around the area of convergence. As the convection develops, patches of elevated FFDI are seen. Variations of the order 50 FFDI units can occur over a distance less than 5 km.

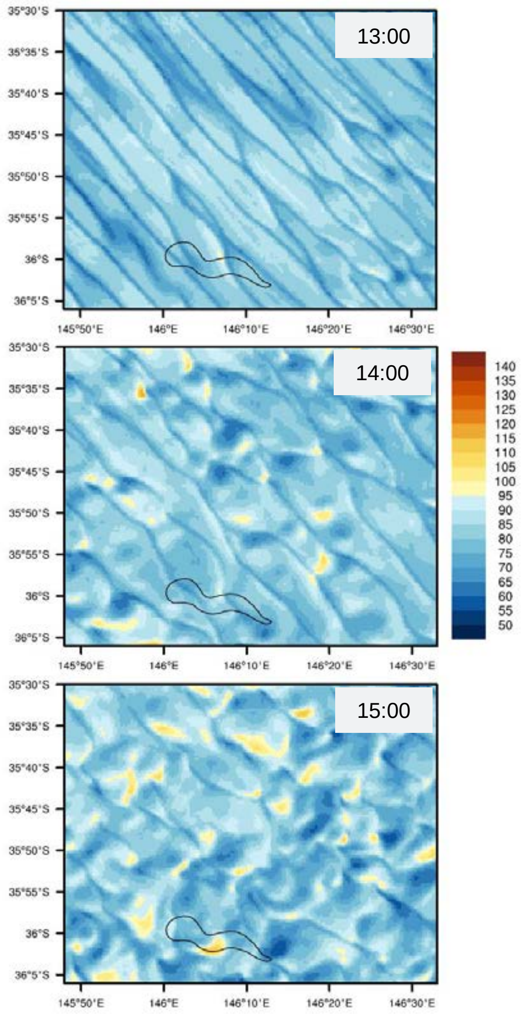

Fig. 4. Instantaneous FFDI calculated from simulated wind speed, relative humidity, temperature and using a drought factor of 10. Times in EDT, 7th February 2009.

Summary

The ACCESS model has been successfully used to reproduce boundary-layer rolls and their associated surface wind variability. Variation in direction leads to faster fire spread and variation in speed leads to large FFDI differences over small distances.

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