Differences in Simulated Fire Spread Over Askervein Hill Using Two Advanced Wind Models and a Traditional Uniform Wind Field

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Abstract*—A computational fluid dynamics (CFD) model and a mass-consistent model were used to simulate winds on simulated fire spread over a simple, low hill. The results suggest that the CFD wind field could significantly change simulated fire spread compared to traditional uniform winds. The CFD fire spread case may match reality better because the winds used in the fire simulation were more accurate.*

Introduction

The influence of wind simulations from two microscale wind models on simulated fire spread over a simple, low hill was investigated. The models were a computational fluid dynamics (CFD) model and a mass-consistent model (Forthofer in prep.). The hill, called Askervein Hill, had previously been the site of a detailed field study of wind flow over isolated hills (Taylor and Teunissen 1983, 1985). The simulated winds were compared to these data. The mass-consistent model and the CFD model were able to accurately simulate the wind flow on the upwind side and top of the hill. On the downwind side of the hill, the CFD model showed lower wind speeds than the mass-consistent model. These lower speeds matched the measured data better. The simulated winds were then used in FARSITE (Finney 1998) simulations to identify how the different wind fields affected fire spread. For reference, the traditional method of using a spatially uniform wind field was also used in the fire spread simulations. The resulting fire progressions showed that the mass-consistent wind field produced fire spread similar to the uniform wind field case, but the CFD simulation was noticeably different. The uniform and mass-consistent wind based fire growth simulations did not show appreciable effects of reduced wind speed on the lee side of the hill. These results suggest that the CFD wind fields could significantly change simulated fire spread compared to traditional uniform winds. Also, the CFD fire spread case may match reality better because the winds used in the fire simulation were more accurate.

Discussion

Askervein Hill was the site of a large wind measurement field campaign in 1982 and 1983 (Taylor and Teunissen 1983, 1985). More than 50 wind measurement towers were placed in the hill area to characterize the surface

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flow field. The hill was 116 m tall and surrounded by flat ground. Towers were placed along three lines running over the hill, as shown in figure 1. We have compared simulations from two types of microscale wind models, a CFD model and a mass-consistent model, to the measured winds to evaluate their ability to reproduce the flow field.

Comparisons of the simulated and measured winds are shown in figure 2 for sensors placed along lines A, AA, and B. Both models predicted the flow on the upwind side of the hill and at the top of the hill well. The CFD model compared better on the lee side of the hill than the mass-consistent model. The noticeable overprediction here of the mass-consistent model is probably due to the model's inadequate representation of momentum, which becomes important on the lee side of the hill.

With the accuracy of the simulated flow fields assessed, hypothetical fire spread over the hill was computed using FARSITE (Finney 1998) with the two simulated wind fields and a traditional spatially uniform wind field. Table 1 shows the settings used in FARSITE for the spread simulations. As seen in Figure 3, the CFD fire progression was markedly different than the mass-consistent and uniform wind cases. It appears that the low wind speeds on the lee side of the hill had a significant impact on the simulated fire spread. These low speeds were reproduced by the CFD model, but not well by the mass-consistent model and not accounted for by the uniform wind field (of course).

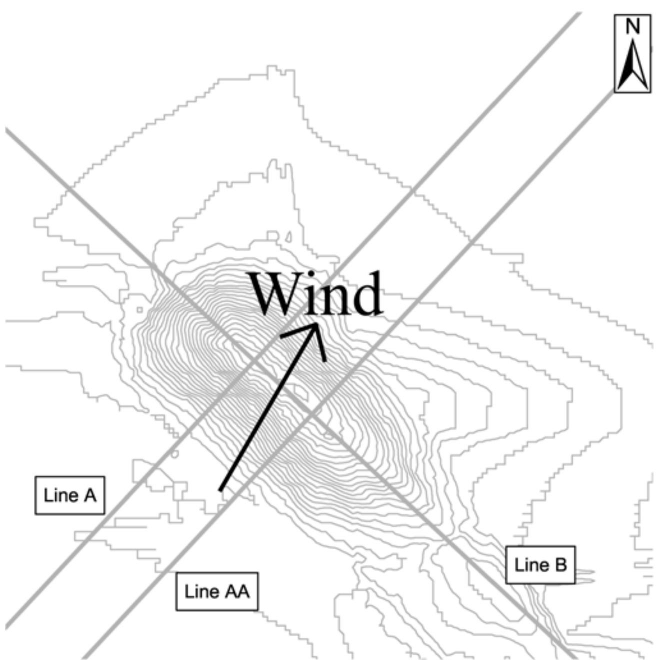


Figure 1—Contour map of Askervein Hill showing locations of lines A, AA, and B. The wind measuring devices were placed along these lines. The contour interval is 5 m.

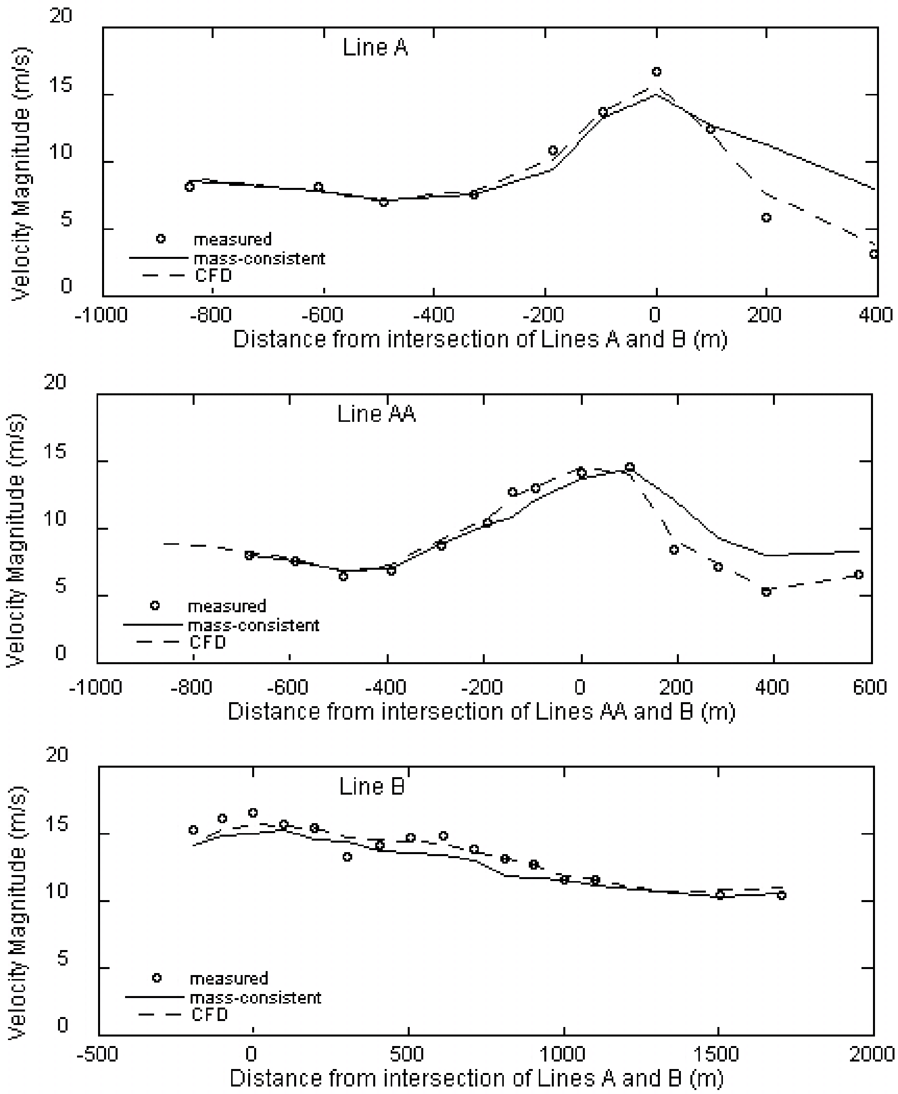


Figure 2—Simulated wind speeds from the mass-consistent and CFD models compared with measured wind speeds along lines A, AA, and B over Askervein Hill. The reported winds are 10 m above the ground.

Table 1—Inputs for FARSITE fire spread simulations.

Fuel model	2
Canopy cover	0 percent
Temperature	80 degrees F
Relative humidity	20 percent
1 hour fuel moisture	5 percent
10 hour fuel moisture	6 percent
100 hour fuel moisture	7 percent
Live herbaceous fuel moisture	100 percent
Live woody fuel moisture	100 percent
Fire spread rate adjustments	1
Time step	10 min
Perimeter resolution	25 m
Distance resolution	25 m
Only surface fire, no spotting	

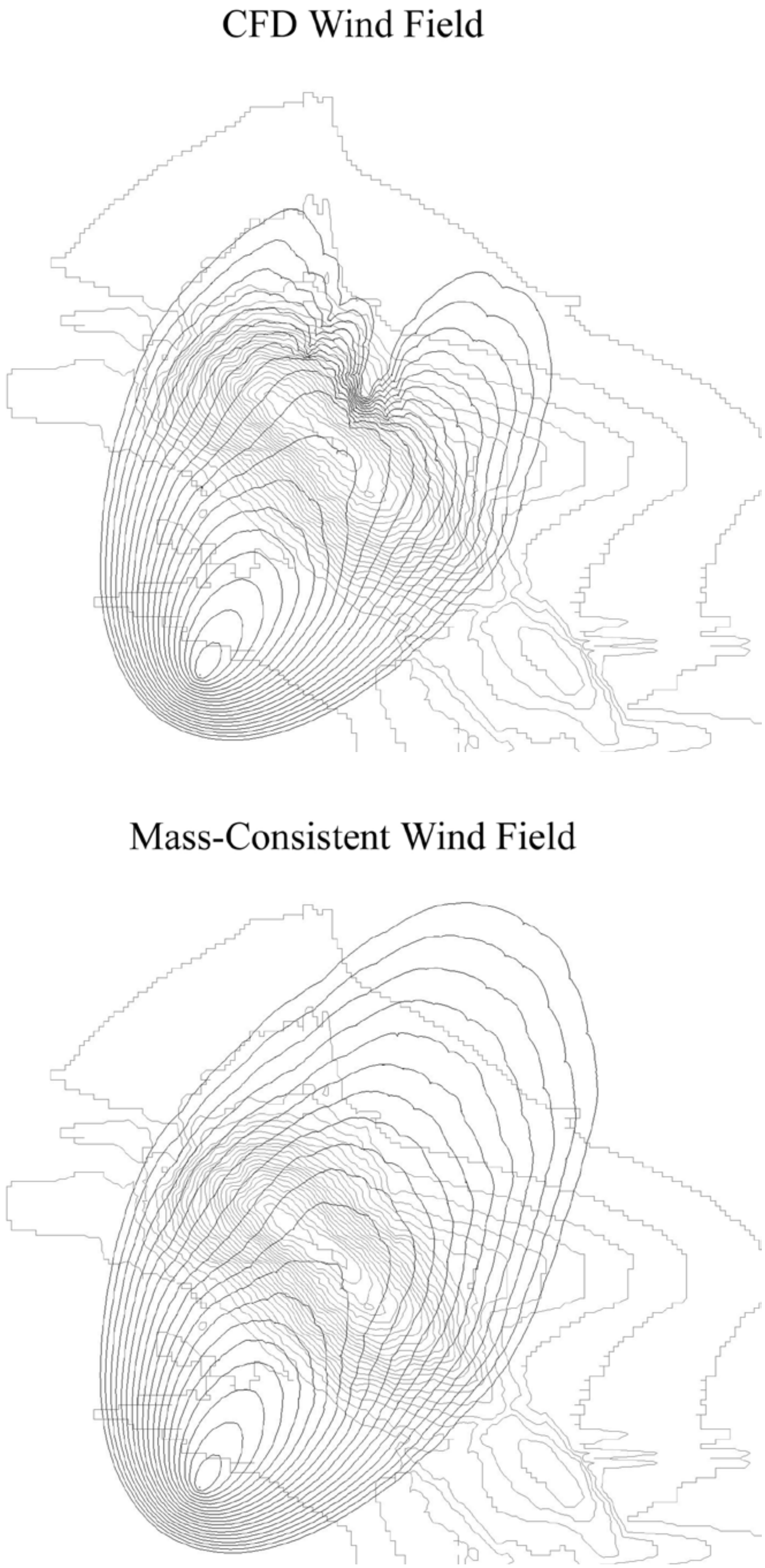
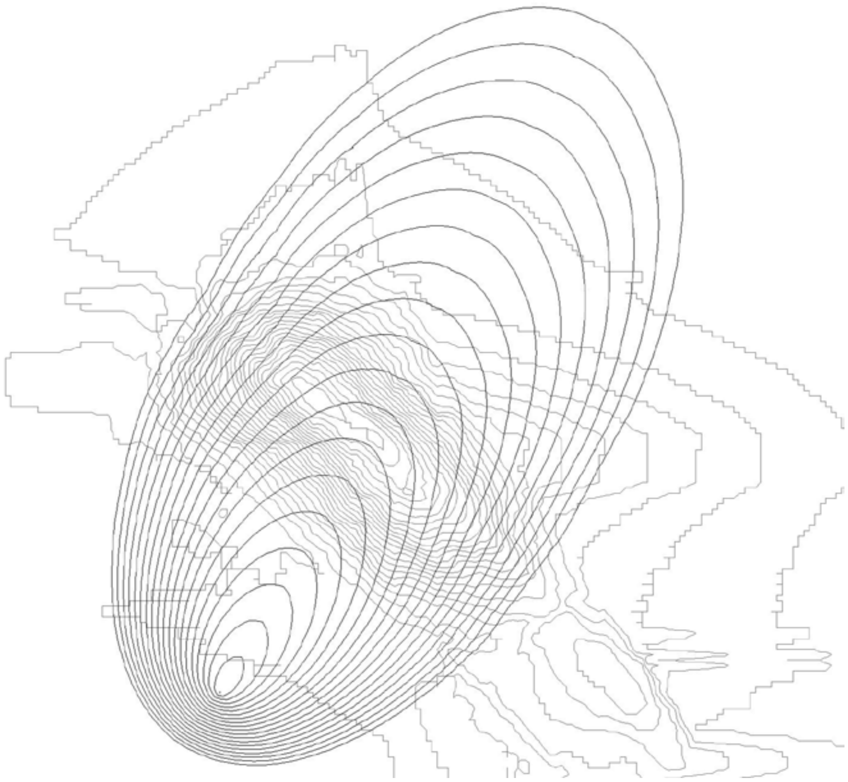


Figure 3—Comparison of three fire spread simulations for the Askervein Hill area using different wind fields. Dark lines denote the fire progression spaced 10 min. apart, light lines are the 5 m elevation contour lines.

Uniform Wind Field



Conclusions

This study indicates that spatially varying wind flow occurring from terrain modification can have a large impact on simulated fire spread. Accurate simulations of surface influenced wind flow are improved when the simulation model includes both mass and momentum conservation. It appears that this may be true even in cases of relatively simple, gently sloping terrains such as Askervein Hill. Because wind often has such a large impact on the behavior of a spreading wildland fire, a significant increase in the accuracy of fire spread predictions might be obtained by incorporating a wind model such as the CFD model into fire behavior prediction systems.

References

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