Large Eddy Simulation of Fire Behaviour in Landscapes

Md. Mahfuz Sarwar[1] (PhD Candidate), Khalid Moinuddin[1], Graham Thorpe[1] and Matthew Cleary[2]

[1]Centre for Environmental Safety and Risk Engineering (CESARE)
Victoria University, Victoria, Australia
[2]Department of Aerospace Engineering, University of Sydney, NSW, Australia
Contact: mdmahfuz.sarwar@live.vu.edu.au

bushfire CRC

Introduction

In this research project, Wildland-urban Interface Fire Dynamic Simulator (WFDS)/ Fire Dynamic Simulator (FDS) will be used to conduct the numerical simulation of the landscapes fire modeling. WFDS/FDS is the state of the art physics based fire model for non-prescribed fires. To make WFDS/FDS a reliable predictive tool, it is important to reduce grid sensitivity which means the result will not change with the change of grid cell size even with sufficiently coarse grid. A grid independent result of WFDS/FDS is important to simulate real life fire scenario and for the validation of simulated model with experimental results (Fig. 1). One of the major problems in large eddy simulation (LES) based CFD fire models including WFDS/FDS are, their solutions are grid sensitive. This research will concentrate on altering the LES sub-model in WFDS/FDS to reduce the grid sensitivity.

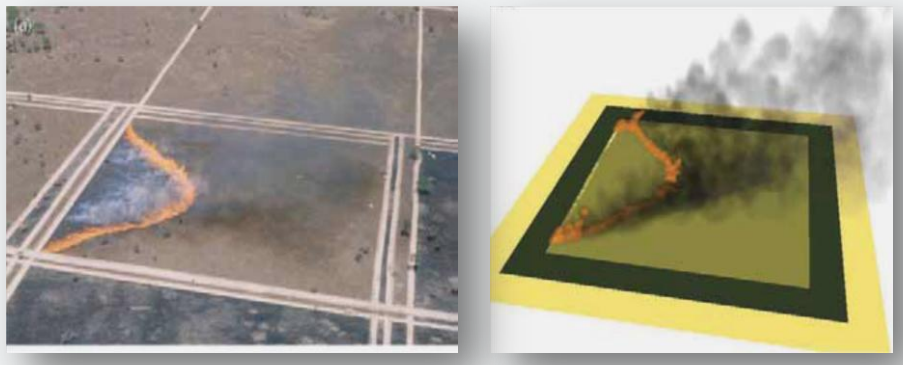

Figure 1. Photograph of experimental fire (left) and fire simulation using WFDS (right) of a (200mX200m area) grassland

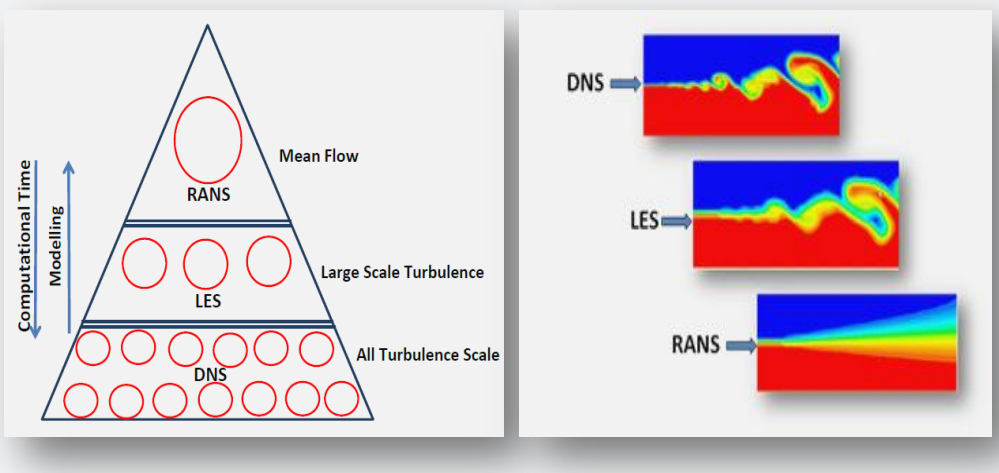

Figure 2. Comparison between DNS, RANS and LES

Background

For the fire simulation, it is important to account for turbulence to describe the fire behaviour properly. Direct Numerical Simulation (DNS), Reynolds-Averaged Navier-Stokes Simulation (RANS) and LES are widely used CFD methods to simulate the turbulence involved in fire phenomena. However, LES lies between DNS and RANS in terms of computational cost and time. In addition, LES is able to capture acceptable results on turbulence phenomena adequately by using filtering techniques with less computational resource (Fig. 2). It is to be noted that DNS results are considered to be accurate and LES is showing almost identical nature like DNS with less computational resources for the same fluid flow phenomena.

Research Question

Grid sensitivity in LES model (such as WFDS/FDS) is known to be attributed to implicit filtering technique. If external filtering (explicit) system is added in WFDS/FDS, whether the grid sensitivity will be reduced or grid independent results can be easily obtained?

Research Methodology

The proposed research project will be accomplished by concentrating on these following steps:

Investigation of the contribution of filtering processes

The first step of the research will be exploring the effect of implicit and explicit filtering techniques of the LES method in simple CFD benchmark cases like pipe flow and backward facing steps.

Implementation of new filter in WFDS/FDS

Explicit filtering techniques can be added in LES sub-model of WFDS/FDS for grid independent solution.

Validation of WFDS/FDS

For the model validation, more complex cases will be considered, like simulation of some simple buoyancy driven flow in heated room environment by the modified FDS for grid sensitivity study. Afterwards, two sets of Douglas Fir tree (Fig. 3) and Grassland (Fig. 4)simulation will be done with the modified WFDS. As experimental data are readily available for these fire simulation, then simulation results and experimental results will be compared for the model validation. The degree of grid sensitivity will also be analysed.

Significance

CFD Based Fire Model WFDS/FDS is a promising model to simulate bush or wildland fires with a reasonable degree of accuracy. However, its results are highly dependent on grid sizes and making it almost impossible to carry out validation studies. The research is aimed at reducing the grid dependency so that reliable validation studies of WFDS/FDS can be carried in order to use them as a predictive tool for early warning systems.

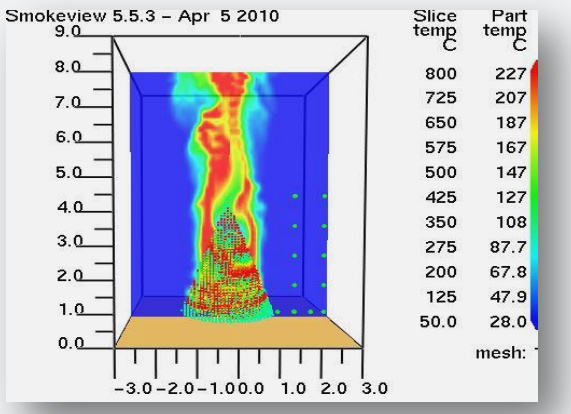

Figure 3. Fire simulation using WFDS (Douglass Fir Tree)

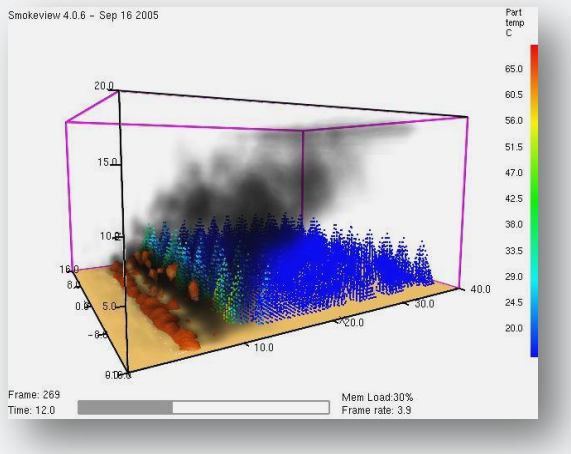

Figure 4. Fire simulation using WFDS (Grassland)