bushfire&natural HAZARDS CRC

FIRE SPREAD PREDICTION ACROSS FUEL TYPES BY PHYSICS-BASED MODELLING

Research Advisory Forum

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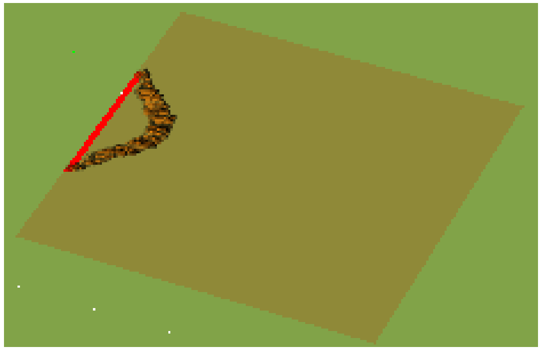
Australian Government
Department of Industry, Innovation and Science

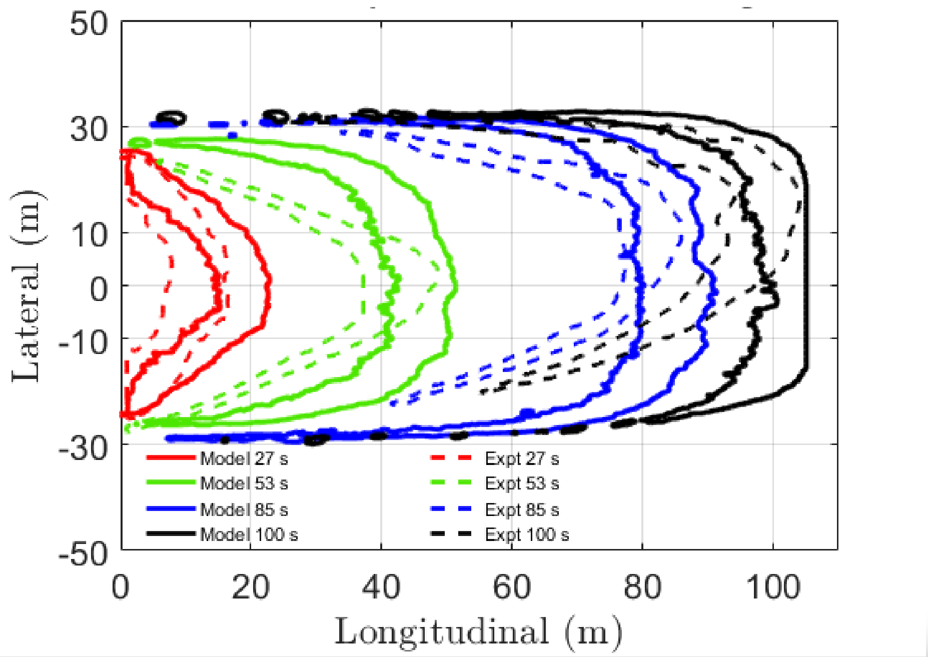
Business
Cooperative Research Centres Programme

PROGRESS REPORT

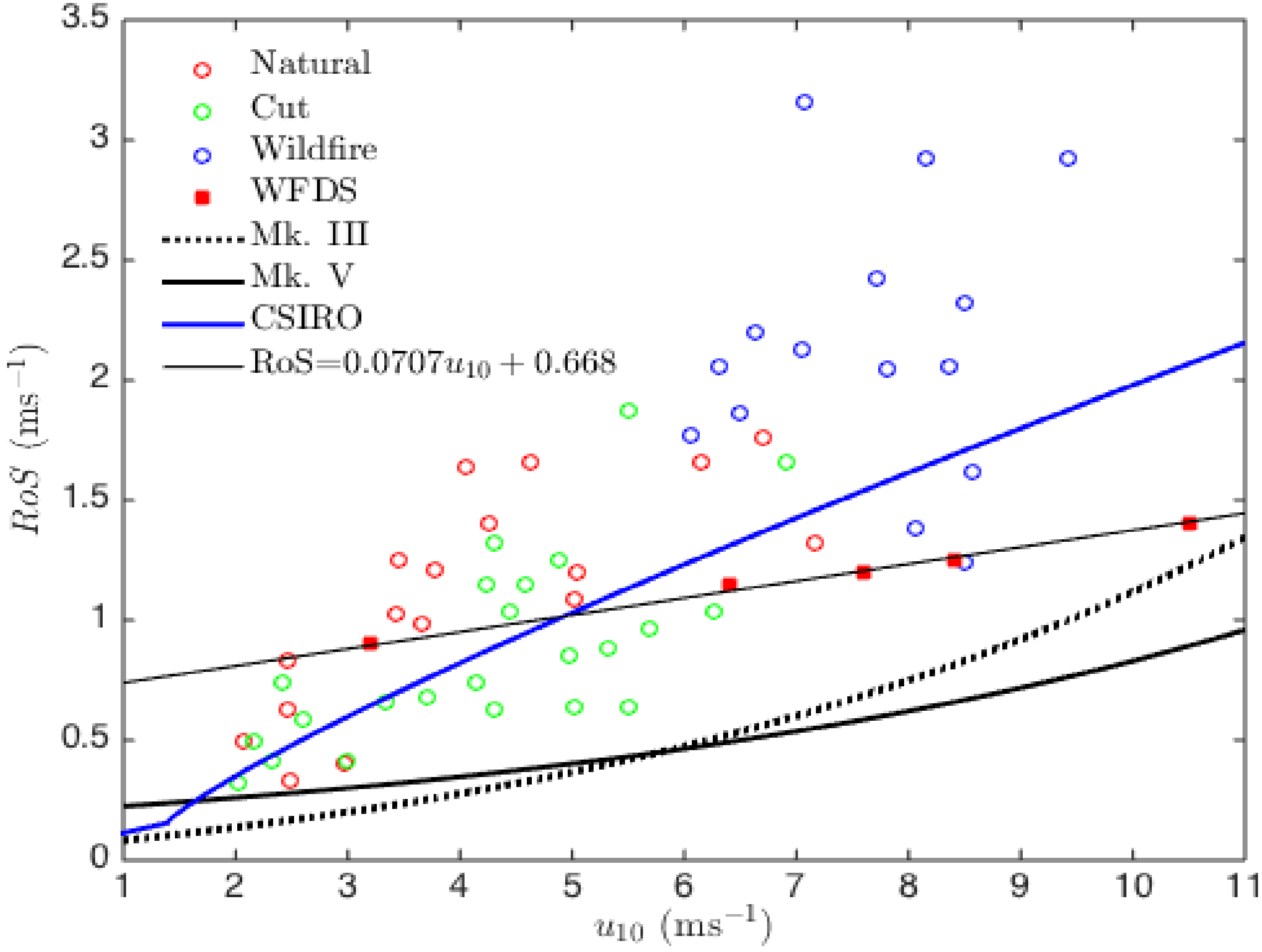
1) **Grassfires simulation**
   a) **Published online Int. J. Wildland Fire**
2) Simulation of flow through vertically heterogeneous canopies
   a) Presented at AFAC 2018
3) **Validation of a firebrand transport model**
   a) Published in Fire Safety Journal 2017
   b) Further progress subject of breakout session
4) Initialise wind fields for physics-based simulations
   a) To be presented at AFMC 2018
5) Assess ability for surface-to-crown fire transition
   a) A paper submitted to Mathematics & Computers in Simulation
6) Investigate aspects of confined plumes

GRASSFIRE RATE OF SPREAD (ROS) – VALIDATION C064 CHENEY ET AL (1993)

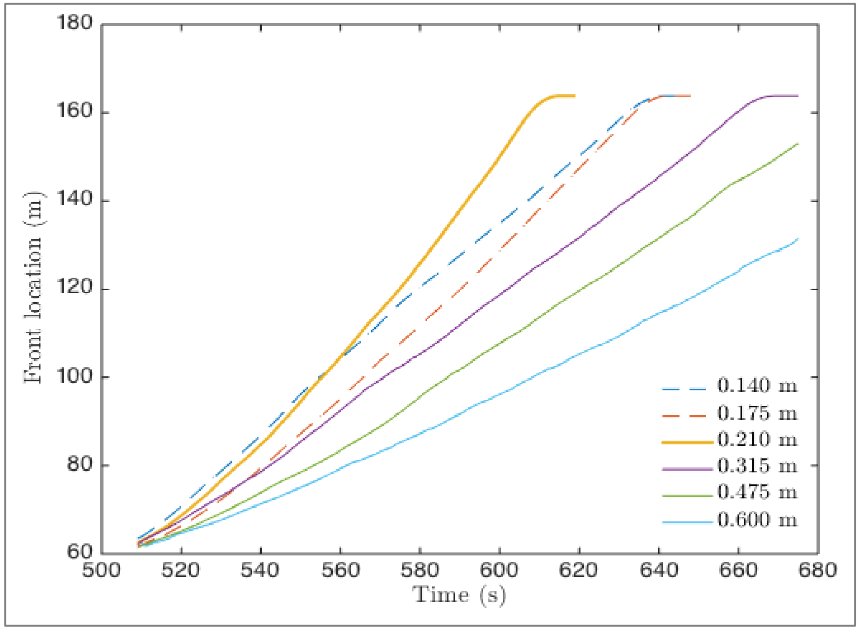


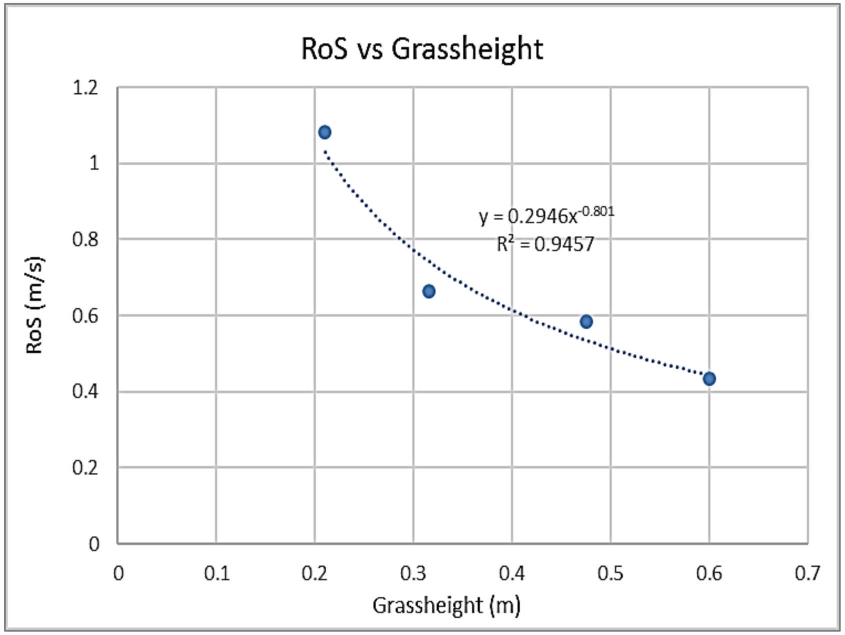


GRASSFIRE ROS VS WIND SPEED – COMPARISON WITH EMPIRICAL MODEL



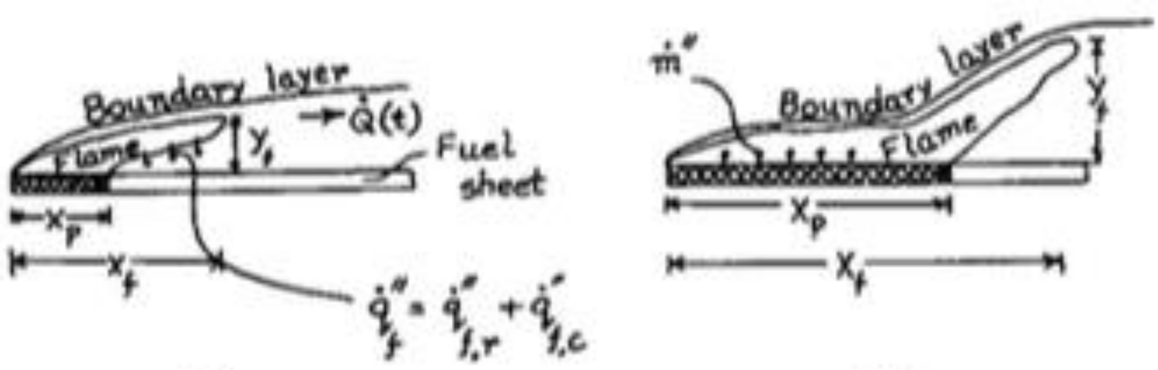
GRASSFIRE ROS– EFFECT OF GRASSHEIGHT





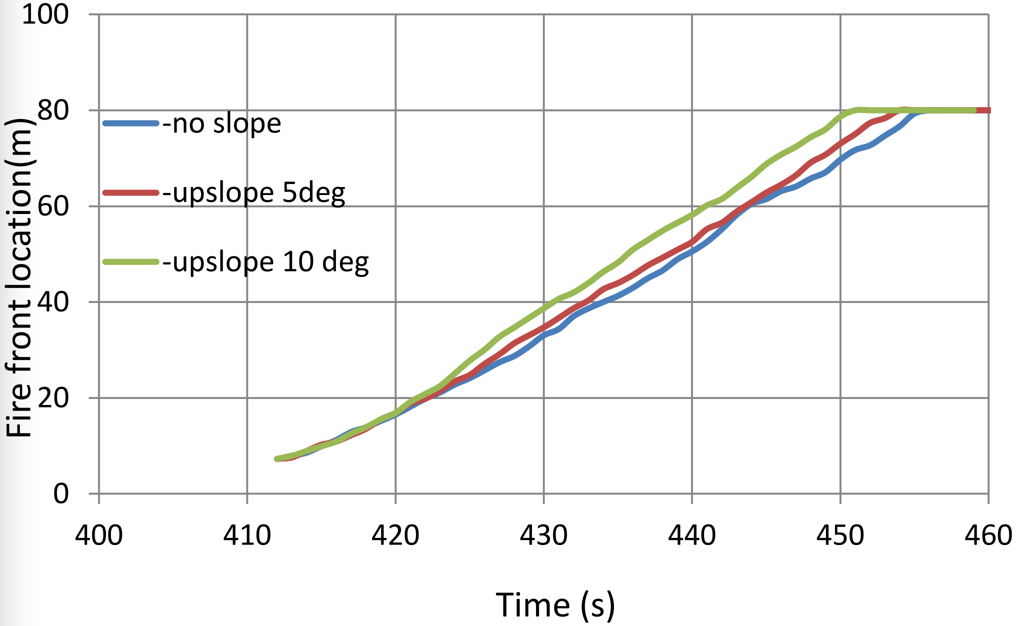
Dashed: Boundary layer mode; Solid: Plume mode

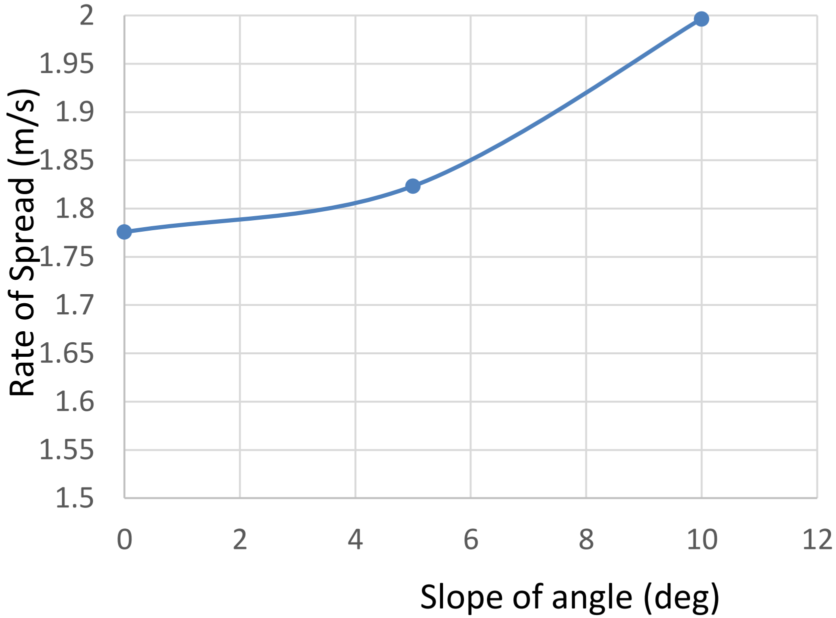
Plume dominated fire



(a) (b)

GRASSFIRE- EFFECT OF SLOPE





RoS doubles for every ten degrees of slope is not supported

- More upslope cases will be simulated; Same number of downslope cases
- Currently modelling heat load on a house from an approaching fire (AS3959)
- Patchy grass – soon to start

EXTENSION OF GRASSFIRE

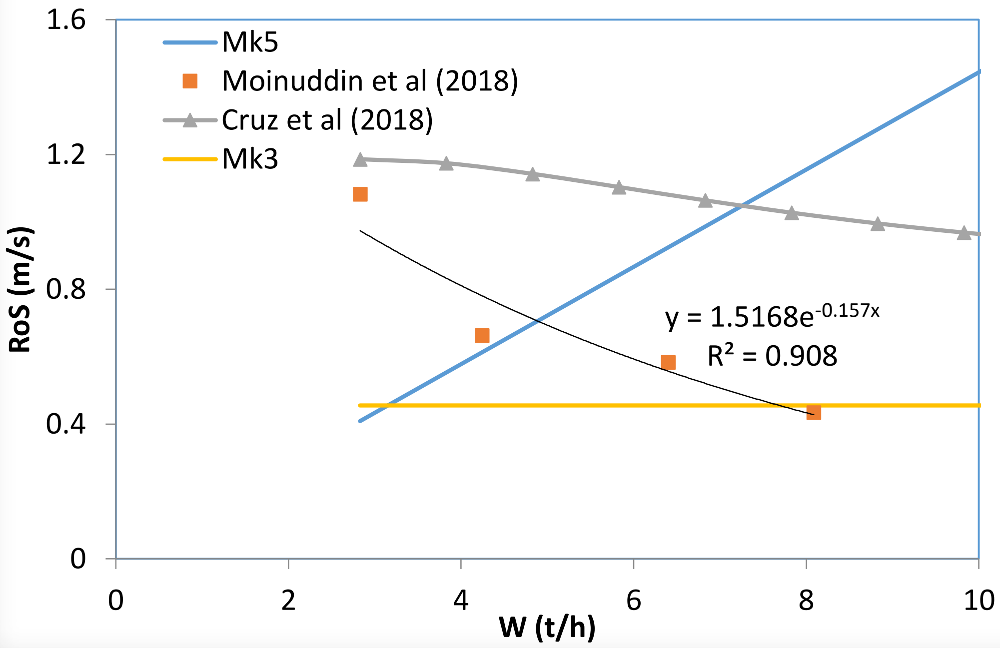
Cruz et al (2018) the effect of fuel load (weight) and moisture content

-for Fuel load, primarily bulk density variation, not grass height variation

-Different ignition protocol

$$R = \begin{cases} (0.054 + 0.269\,U_{10})\Phi(M)\Phi(C)\Phi(W), U_{10} \leq 5\,\mathrm{km\,h^{-1}} \\ (1.4 + 0.838(U_{10} - 5)^{0.844})\Phi(M)\Phi(C)\Phi(W), U_{10} > 5\,km\,\mathrm{h^{-1}} \end{cases}$$

Natural



Sharples and McRae (2009):

Simple index model for FDI

temperature, wind speed & humidity

$$MC = \frac{97.7+4.06H}{T+6} - 0.00854H + \frac{3000}{C} - 30$$

Our extension work :

- Fuel load
- Humidity (proxy for moisture)
- Ignition protocol

EXTENSION OF GRASSFIRE

$$MC = \frac{97.7+4.06H}{T+6} - 0.00854H + \frac{3000}{C} - 30$$

U_{10} (m/s)	Grass height (m)	Bulk density	Moisture(%) (H)
3	0.14	3-4 for each grass height	3.55 (10)
6.5	0.175		4.5 (20)
7.5	0.21		6.3 (40)
8.5	0.315		7.5 (50)
10.5	0.475		10 (75)
	0.6		12.4 (100)

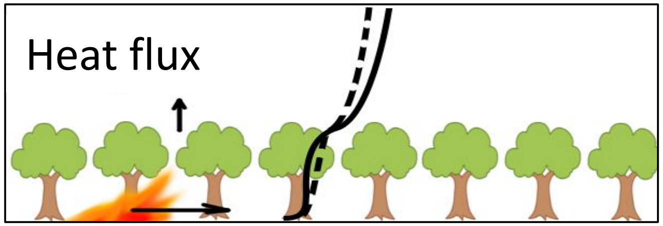
Use of non-dimensional parameter to determine number of simulations

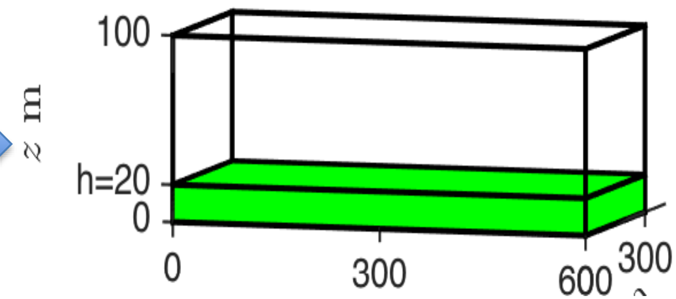
Main aim to understand boundary layer / plume mode threshold, sub aim correlations

WIND REDUCTION FACTOR

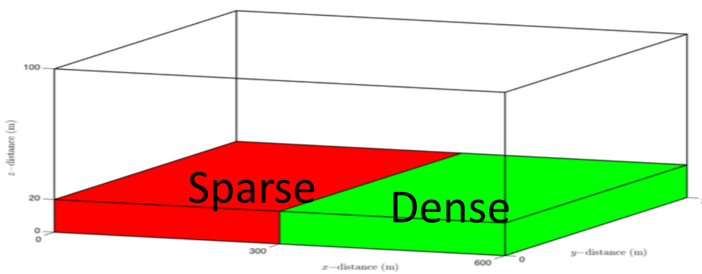
Works done and in progress

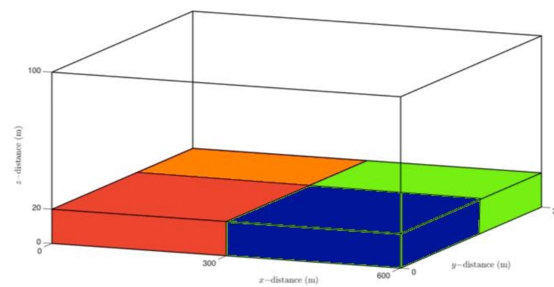
- One shaped LAD (does not vary horizontally), variation of canopy length (first only wind flow, then with surface fire



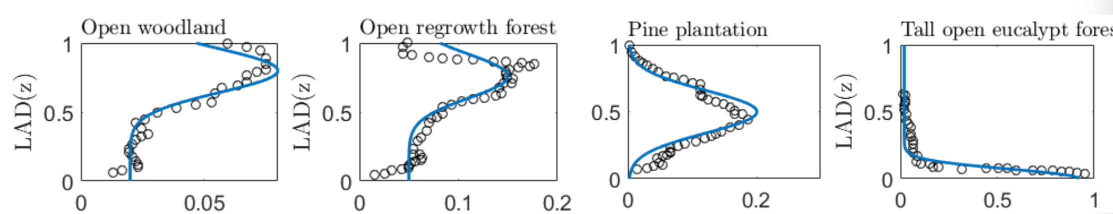


- LAD varies horizontally





- Various vertical shaped LAD

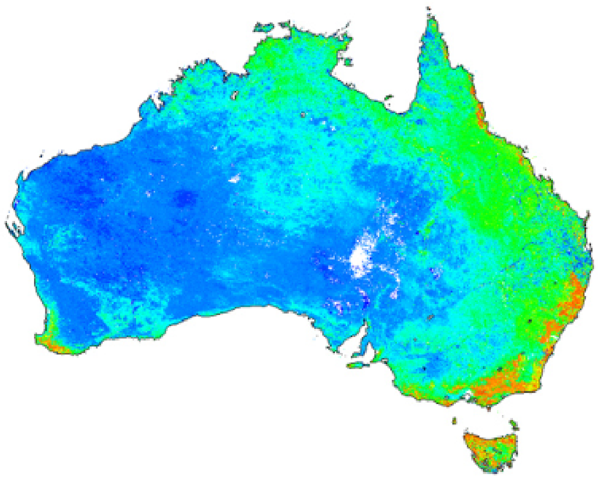


Utilization

- Recruiting Research Assistant for apps development for Fire Behaviour Analysts

FUTURE AMBITION -WIND REDUCTION FACTOR MAP

Leaf area index (LAI) and Fraction of photosynthetically active radiation (fPAR) - MODIS, MOD15A2(c5) mosaic



LAI defines the number of equivalent layers of leaves relative to a unit of ground area, while fPAR measures the proportion of available radiation in the photosynthetically active wavelengths that is absorbed by a canopy.

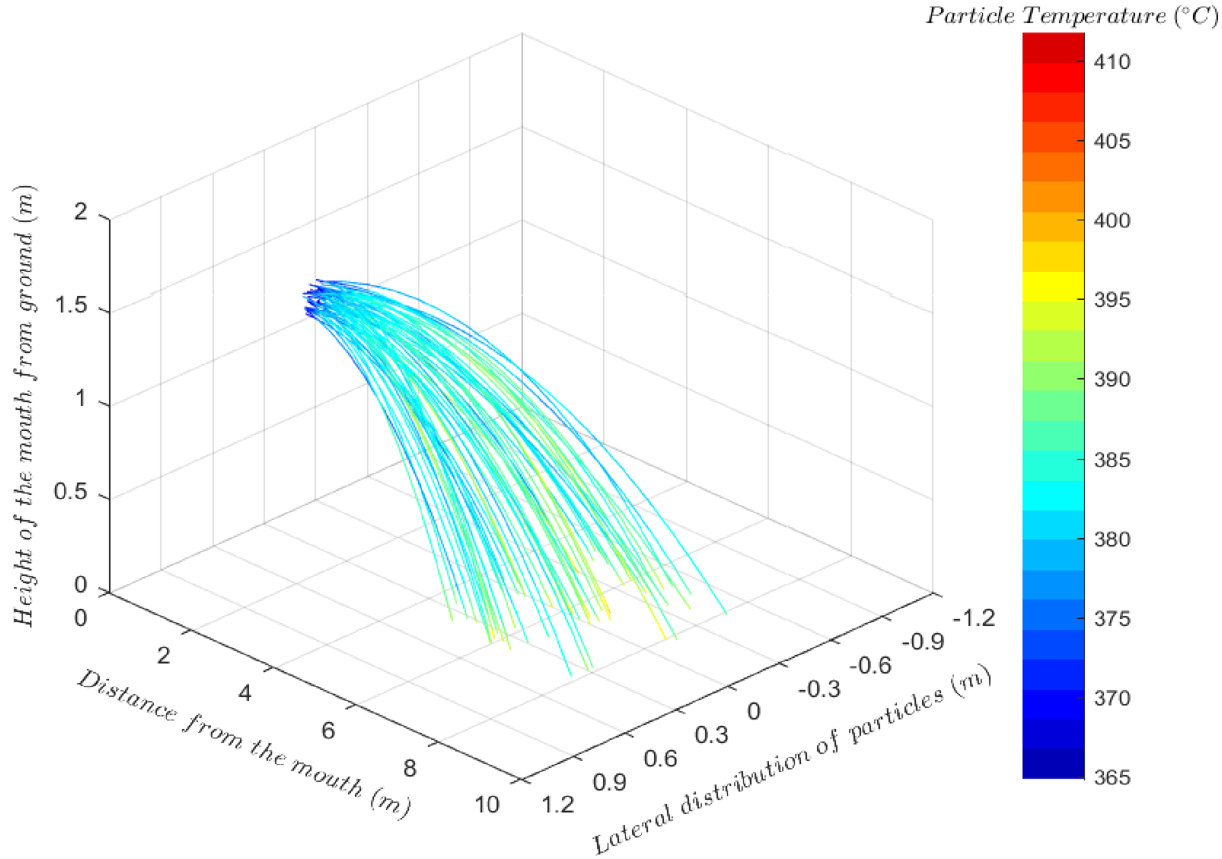
KEYWORDS:	MODIS, LPDAAC, vegetation
DATA LICENCE & ACCESS RIGHTS: *How do I attribute?*	CC-BY 3.0
SPATIAL COVERAGE & RESOLUTION:	1000 m resolution; Australia
TEMPORAL COVERAGE & RESOLUTION:	8 day composite; 2000 to ongoing
PRODUCTION STATUS:	Updated as available from USGS

Data Access   Back To Datasets

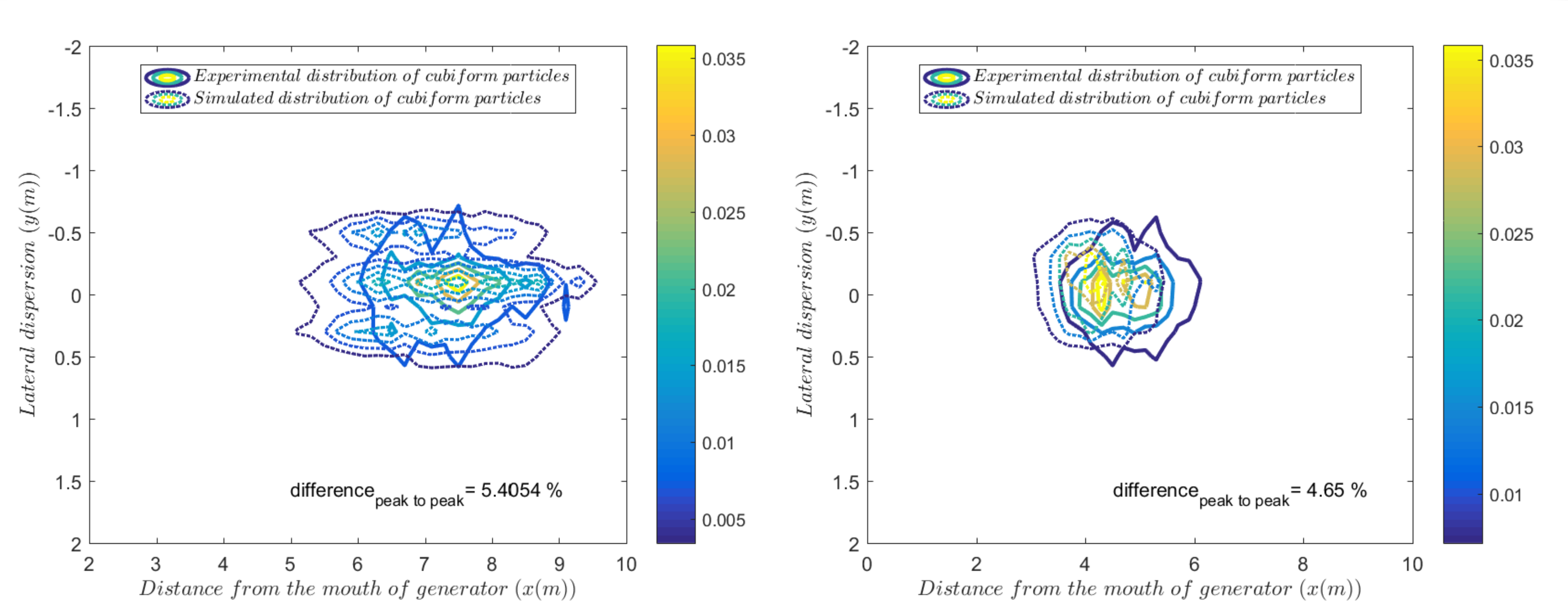
http://www.auscover.org.au/datasets/leaf-area-index-lai/

FIREBRAND DRAGON

BURNING PARTICLE LANDING SIMULATION



FIREBRAND DISTRIBUTION MODELLING

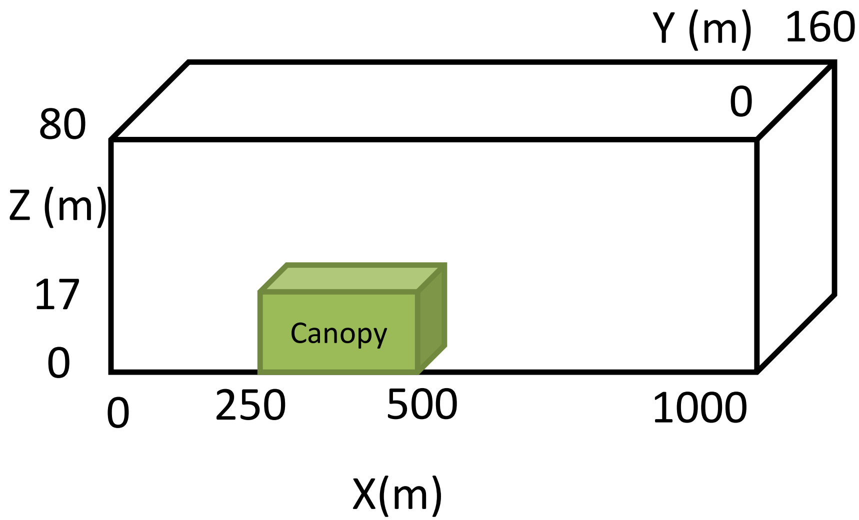


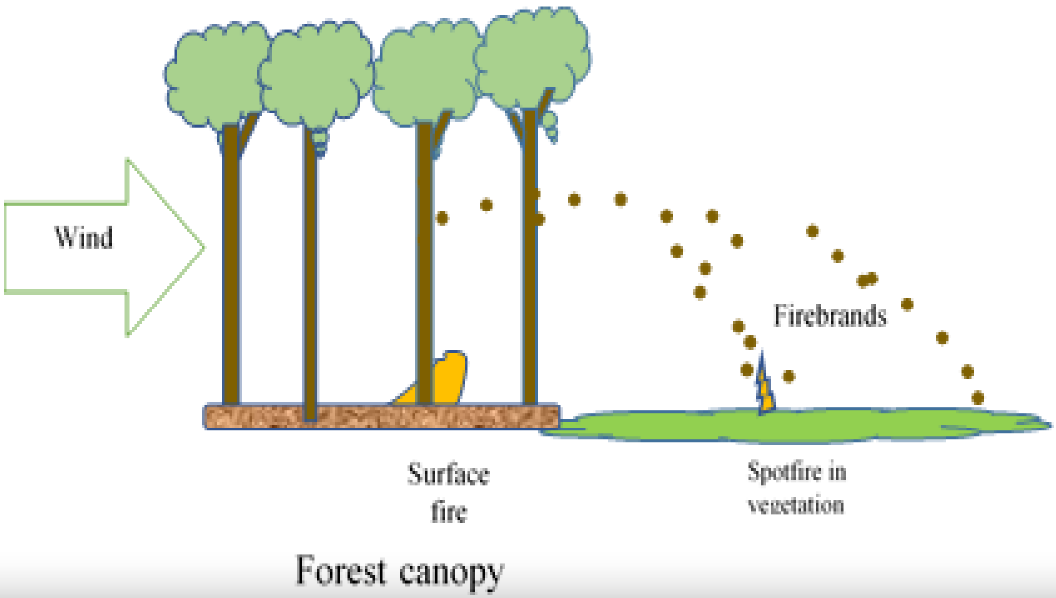
Non-burning particle

Burning particle

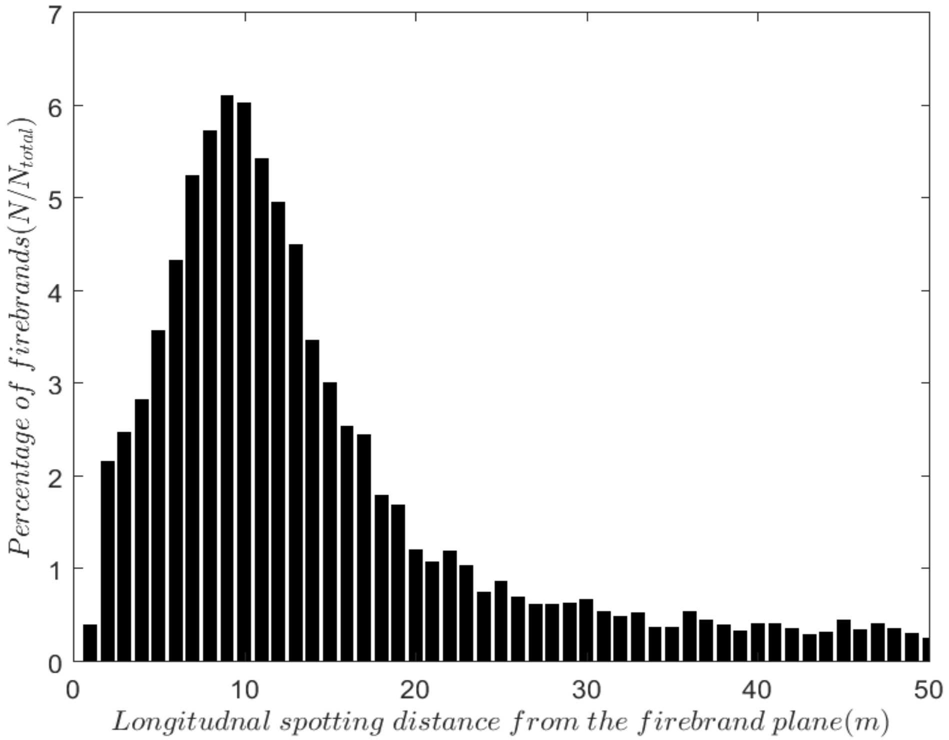
Cuboid particles - Reynolds No ~10^5

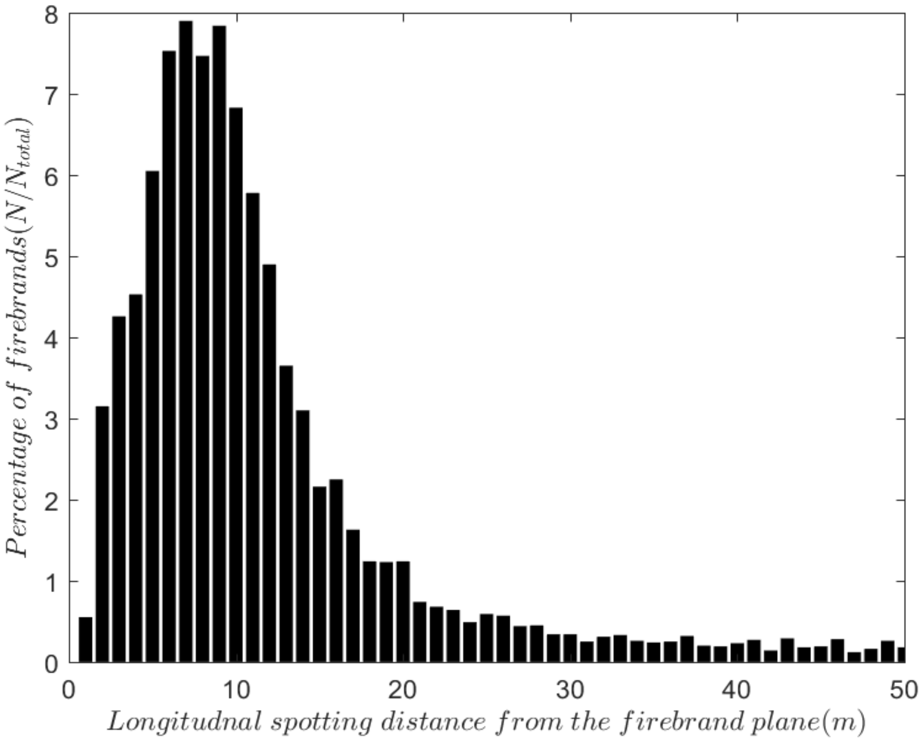
LARGE SCALE FIREBRAND SPOTTING





SPOTTING FIREBRAND-DIFFERENT SHAPE





Disk shape: 32mm x 32mmx 2mm

Cylindrical shape: Dia=3mm, L=18mm

Extension of Firebrand Modelling

1) Statistical model for operational models, such as SPARK
2) Inclusion of firebrand risk assessment in AS3959

FUTURE DIRECTIONS/ BENEFITS

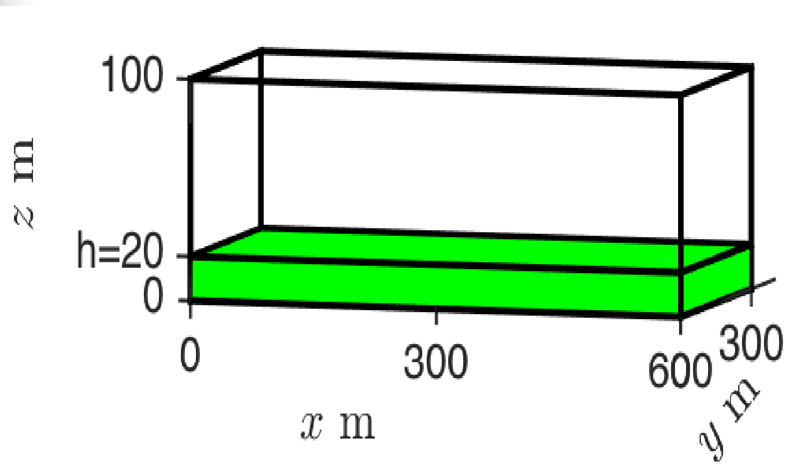
- Better understanding of different mode of grassfire and better RoS correlations
  - dependence on fuel load, humidity, ignition protocol, slope, patchyness
- Assessment of heat and firebrand loading on structures & appraisal of AS3959
- Development of statistical models for firebrand landing for operational models, such as SPARK
- Better operational wind reduction factor and sub-canopy wind model – utilization
- Potential risk modelling
  - Estimation of fire breaks, prescribed burning planning etc

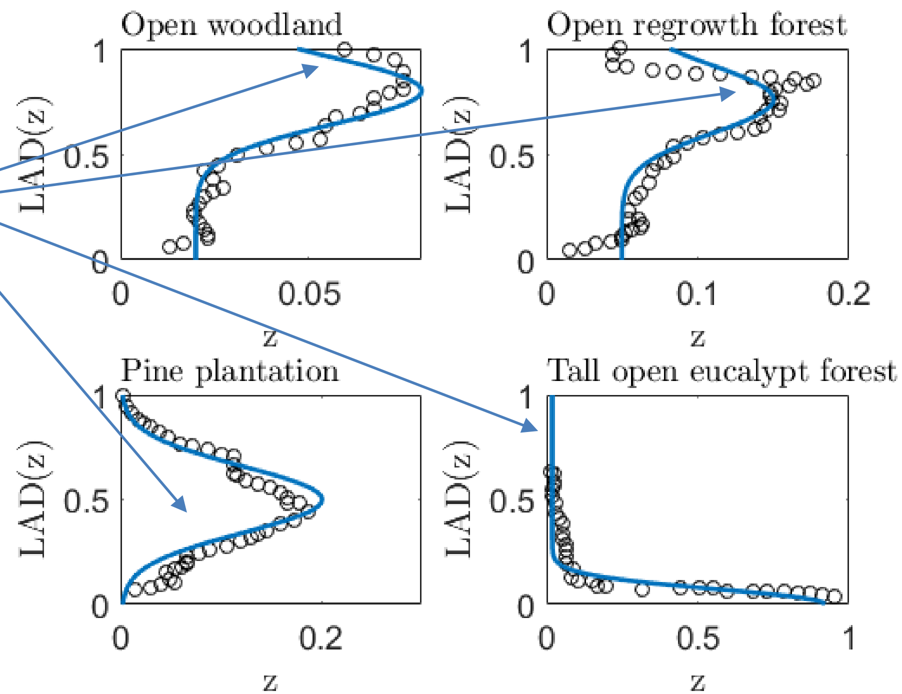
QUESTIONS?

WIND FLOW THROUGH VERTICALLY HETEROGENEOUS CANOPIES

Different values of A, B, μ, and σ^2

$$\textbf{LAD} = A \exp\left(-\frac{(z-\mu)^2}{\sigma^2}\right) + B$$





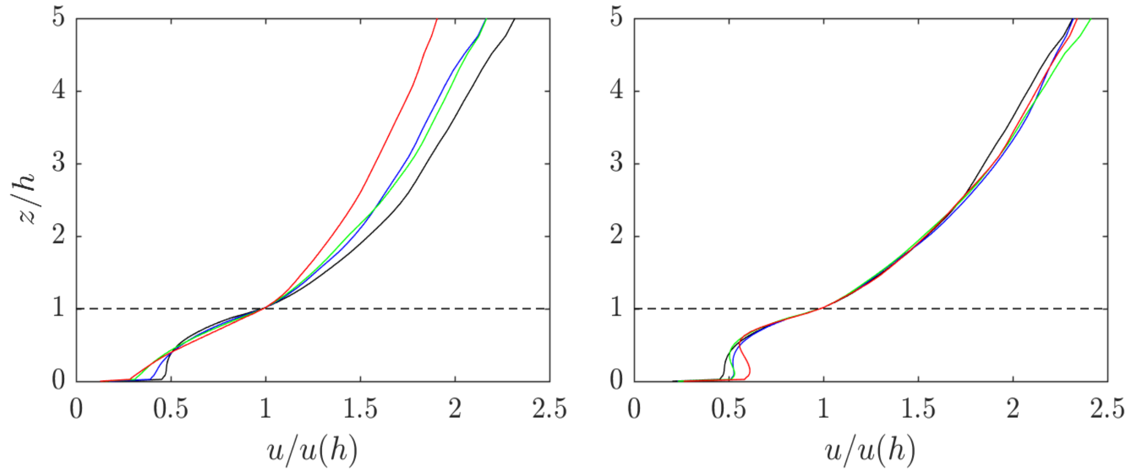
Data points extracted from: Moon, et al, "Sub-canopy forest winds: understanding wind profiles for fire behaviour simulation" Fire Safety Journal (2016)

sub-canopy *u*-velocity model of Inoue (1963) was improved by including a new parameter

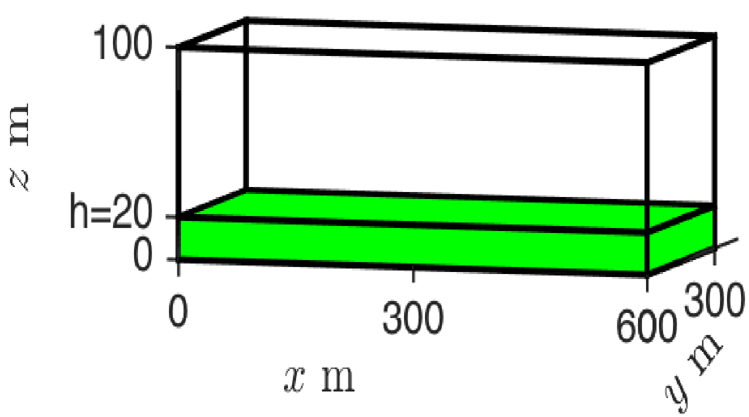
WIND FLOW THROUGH VERTICALLY HETEROGENEOUS CANOPIES

Results

Mean u-velocity profiles



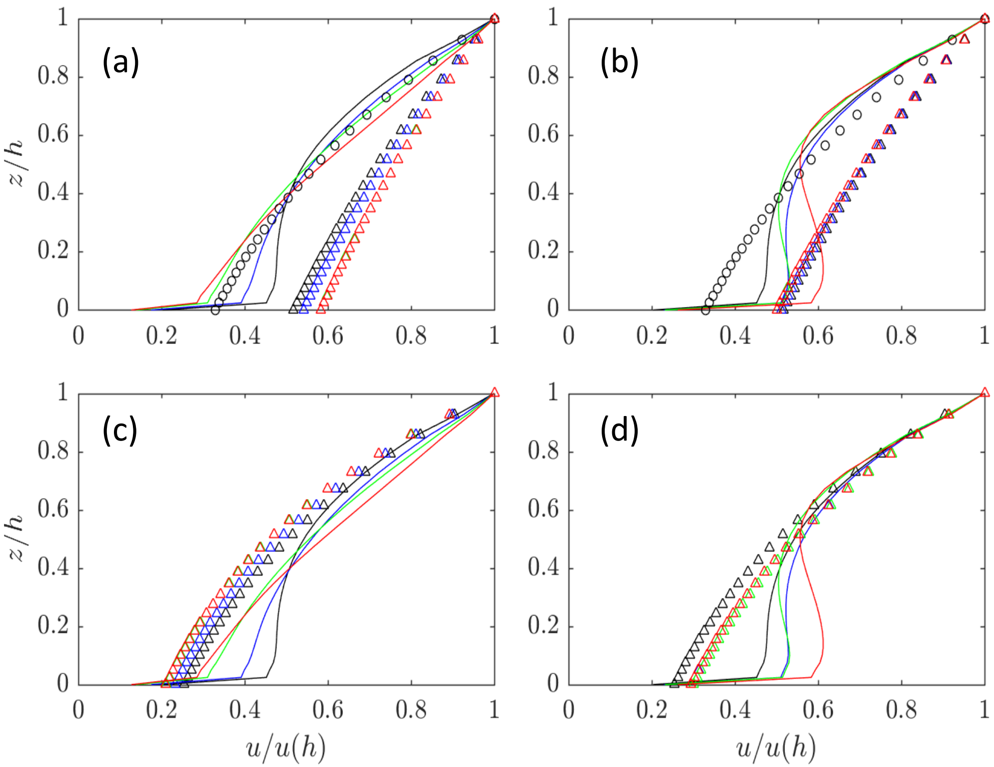
Mean u-velocity profiles normalised by the canopy top value. In (a) σ^2=0.325 is held constant and μ= 0.00 (red), 0.233 (green), 0.467 (blue), and 0.700 (black). In (b) μ=0.70 is constant and σ^2=0.325 (black – the same curve as in (a)), 0.233 (blue), 0.142 (green), and 0.050 (red).



WIND FLOW THROUGH VERTICALLY HETEROGENEOUS CANOPIES

Results

Improved sub canopy modelling



Modelled and simulated sub-canopy u −velocity profiles. (a and b) contain the modelled profiles using the simulated β(triangle symbols) and the observed β (circle symbol) of Harman and Finnigan [2007] and a constant mixing length based on LAI. The modelled profiles in (c and d) use the simulated β and $dLAI$.