Fragmentation of the landscape:
Impact on atmospheric flow and tree stability

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Context & Motivations

Wind damage is the most important disturbance to European forests.

Example from Storm Klaus in 2009:

- Directly destroyed 43.1 Mm^3 timber (14% of the standing volume)
- Direct cost to sector $>$ €1 billion, total economic loss $\sim$ €3 billion

Key Questions:

- Does fragmentation of forest landscape induce/increase turbulence?
- Is there a specific forest configuration that mitigates/enhances turbulence formation?

Fragmented landscape Experiments

The Different Configurations

Reference: Single Edge - M. Böhm & B. Gardiner, 2013

Fragmented Configurations:

	Configurations				
Number	1	2	3	4	5
Forest Width	8h	8h	8h	8h	8h
Gap Width	5,1h	10,2h	15,3h	20,4h	30,6h
Ratio Gap/Forest Width	**~ 1/2**	**~ 1**	**~ 3/2**	**~ 5/2**	**~ 7/2**

Wind Tunnel (WT)

The Pye Lab. Wind Tunnel, CANBERRA, Australia

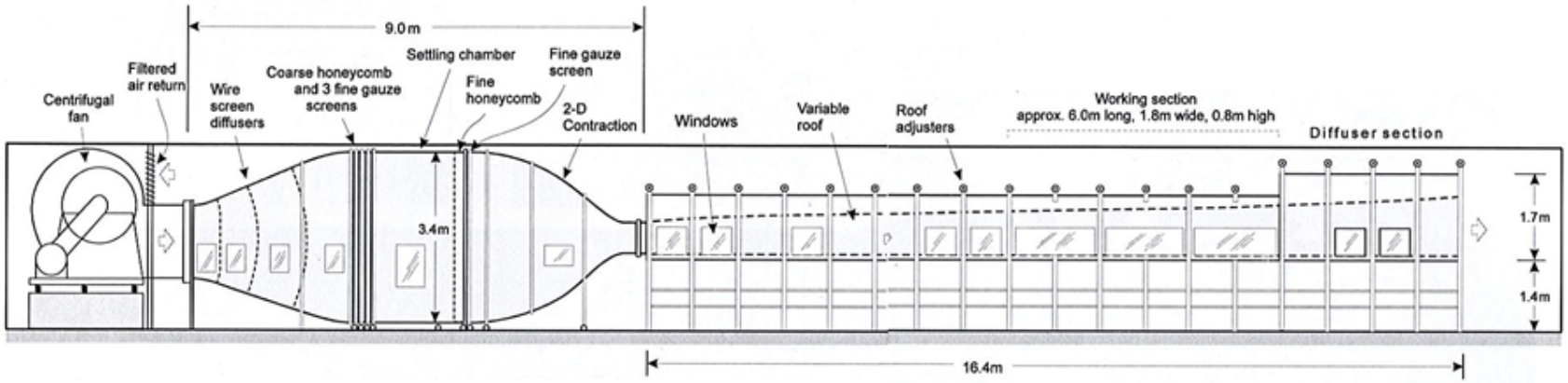


Diagram of the Pye Lab Wind Tunnel (taken from Böhm (2000), modified from Wooding (1968))

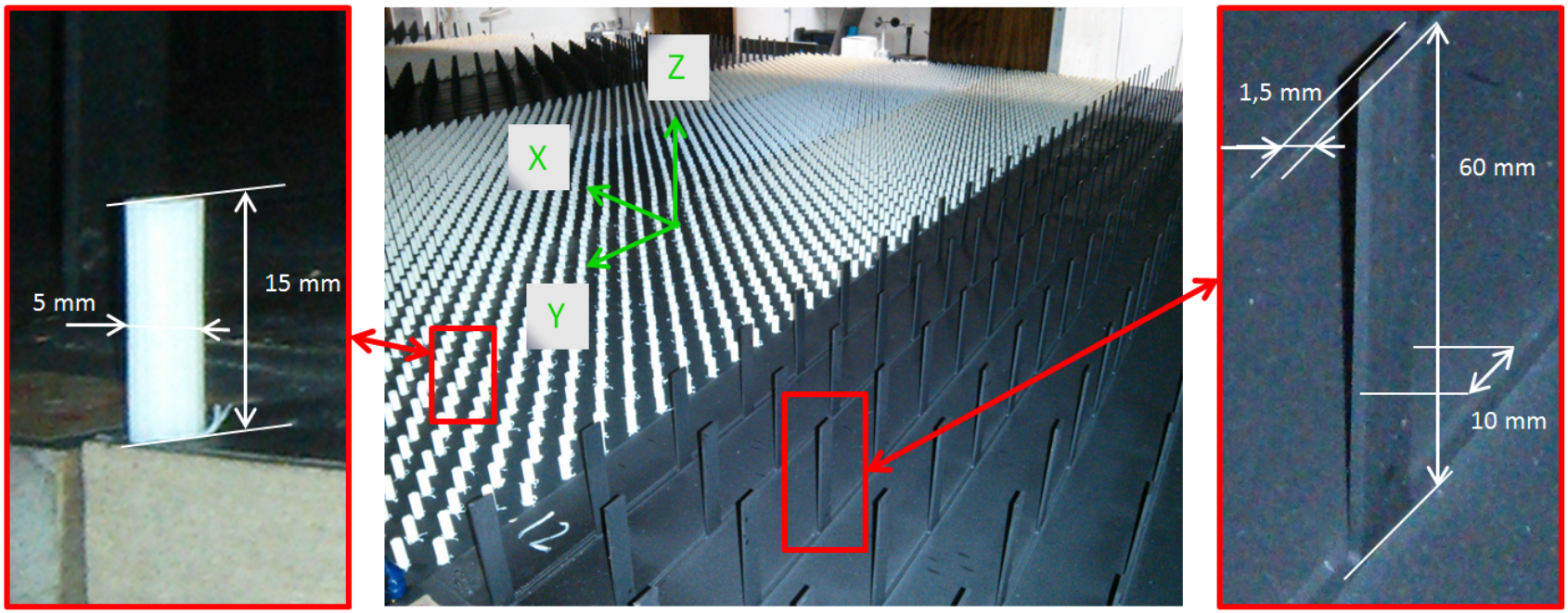
Dimensions of the working section:

- 16.4 m long
- 0.65 m tall
- 1.78 m wide

Wind Tunnel (WT)

The Black Tombstones Model

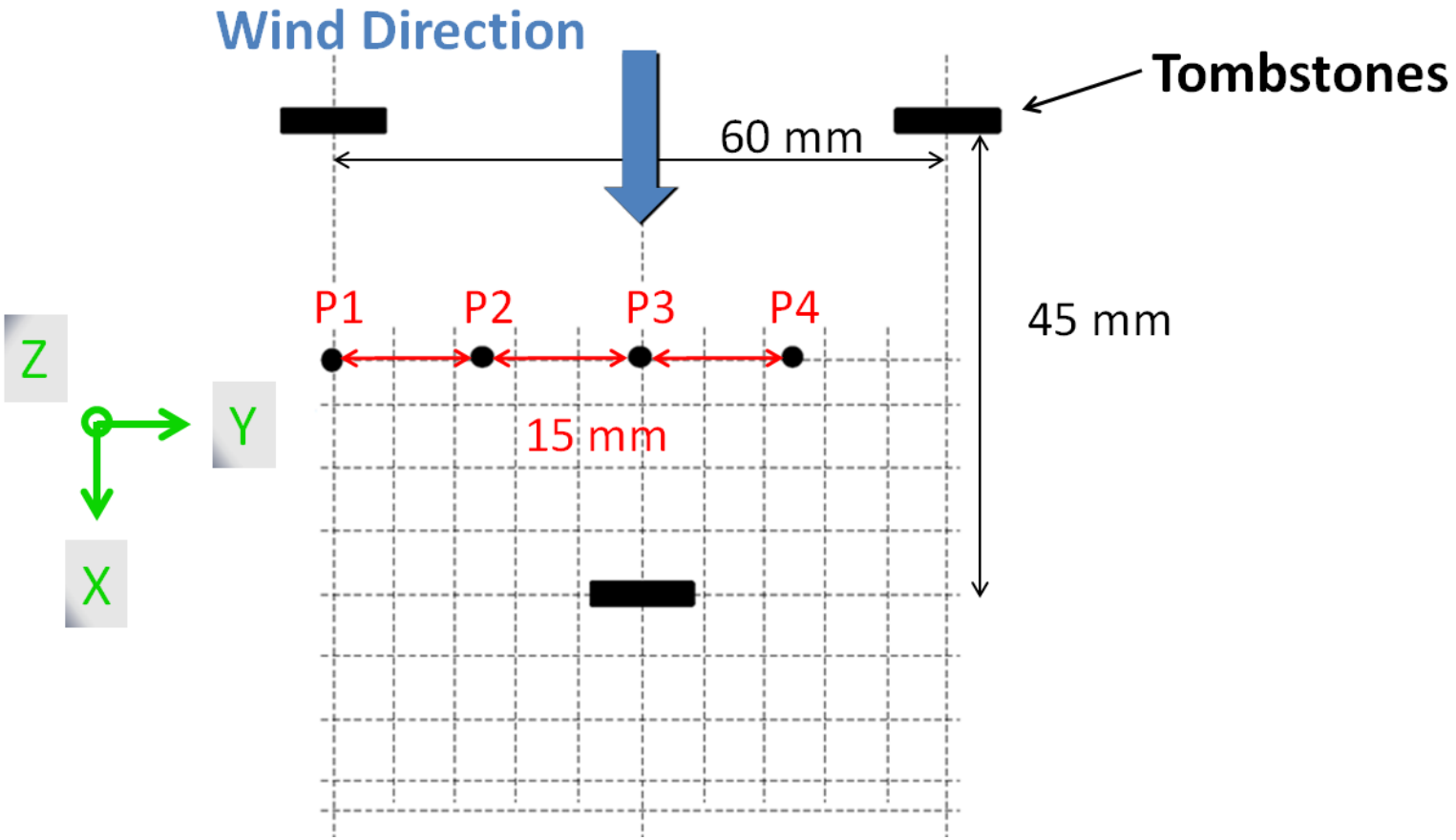
Pegs *Tombstones*



(Raupach et al., 1986)

Wind Tunnel (WT)

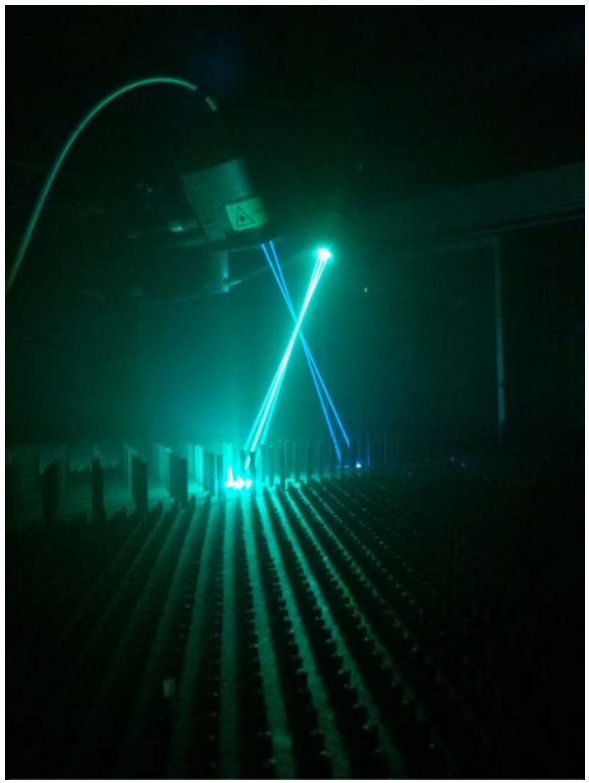
Spatial average

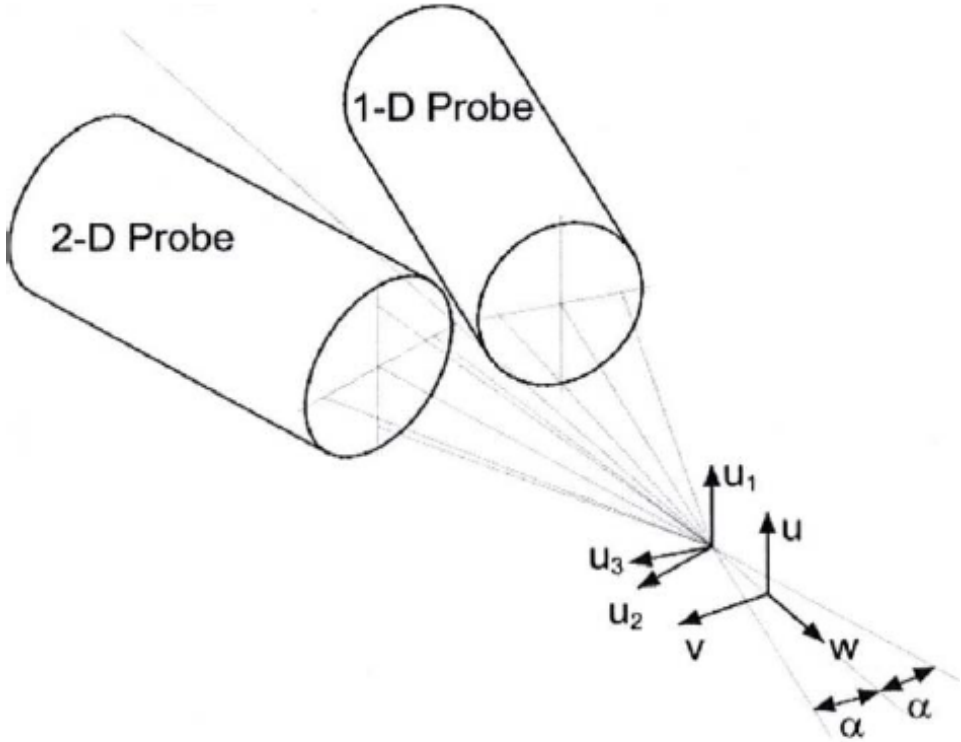


(Margi Böhm & Ian Harman, 2013)

Wind Tunnel (WT)

Laser Doppler Velocimetry (LDV)

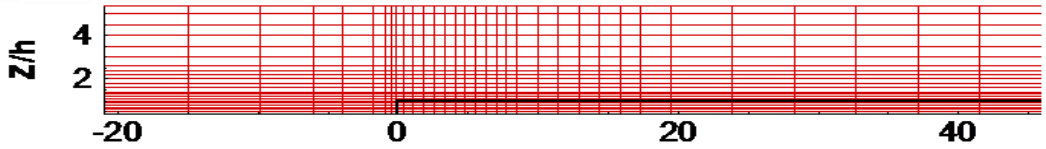




Fragmented landscape Experiments

The Different Configurations

Reference: Single Edge - M. Böhm & B. Gardiner, 2013



Fragmented Configurations:

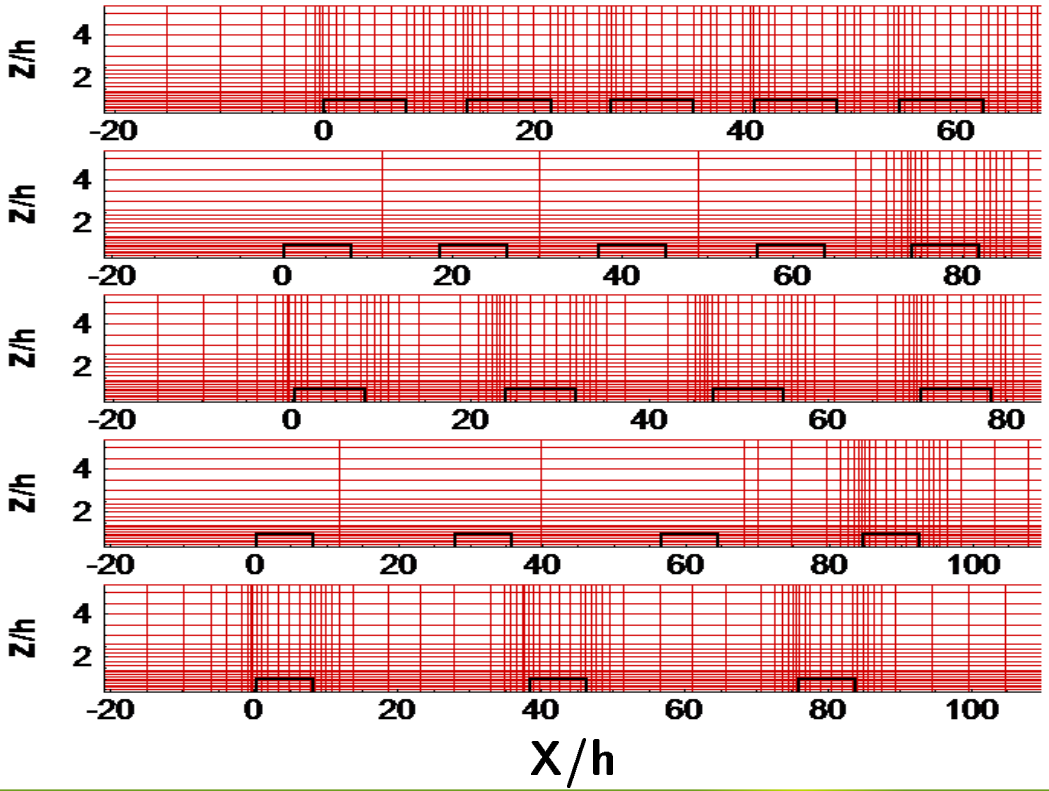
$\sim 1/2$

~ 1

$\sim 3/2$

$\sim 5/2$

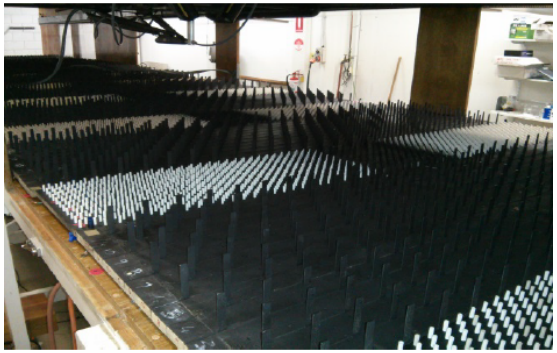
$\sim 7/2$



Fragmented landscape Experiments

The Different Configurations

Single Edge



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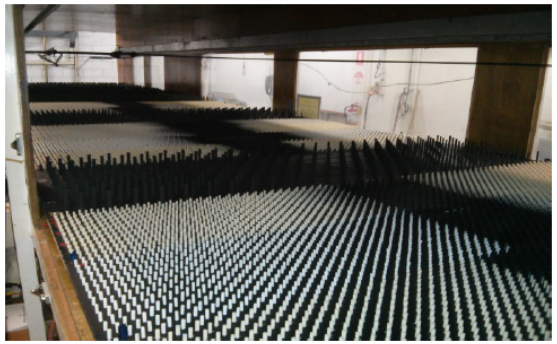


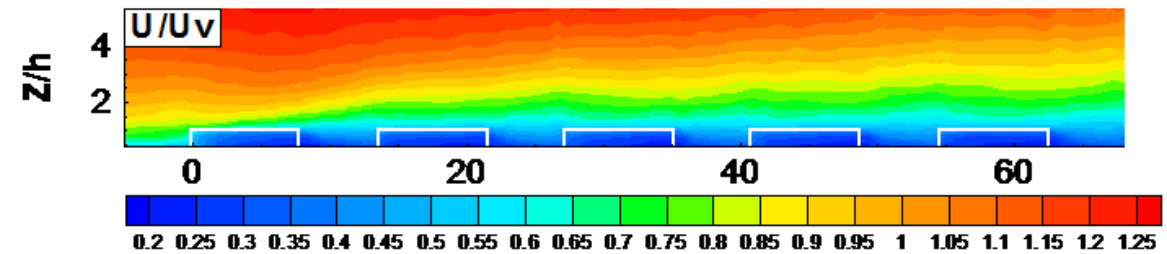
$\sim 5/2$

$\sim 7/2$

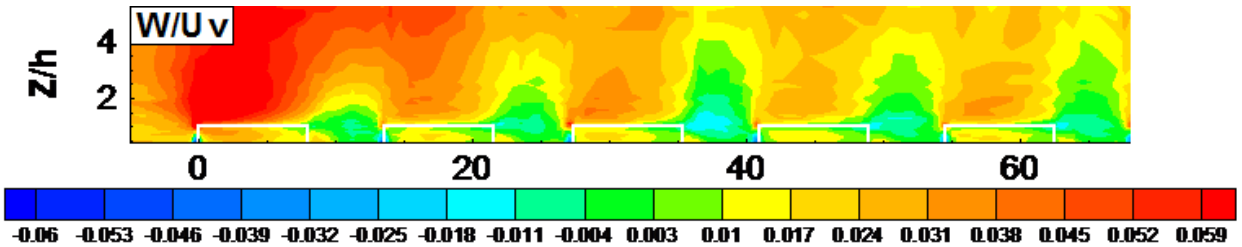
Results

Full development of the flow : Example for the ratio ($\sim 1/2$)

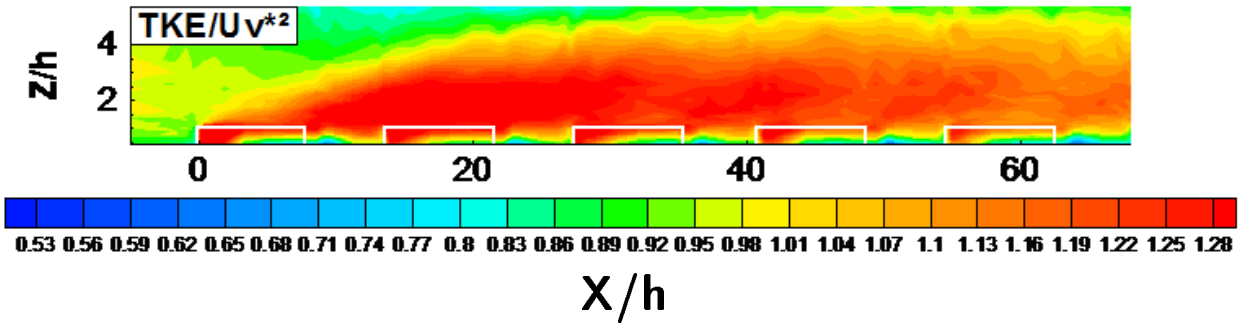
Mean Horizontal Wind Velocity U



Mean Vertical Wind Velocity W



Turbulent Kinetic Energy TKE



Mean velocities Normalisation

$$U_V = \int_z U dz$$

with U, mean horizontal wind velocity at $X/h = -21h$

Kinetic Energy Normalisation

$$U_V^* = \int_z U^* dz$$

with U^*, friction velocity at $X/h = -21h$

Results

Mean Horizontal Wind Velocity U over the last EDGE

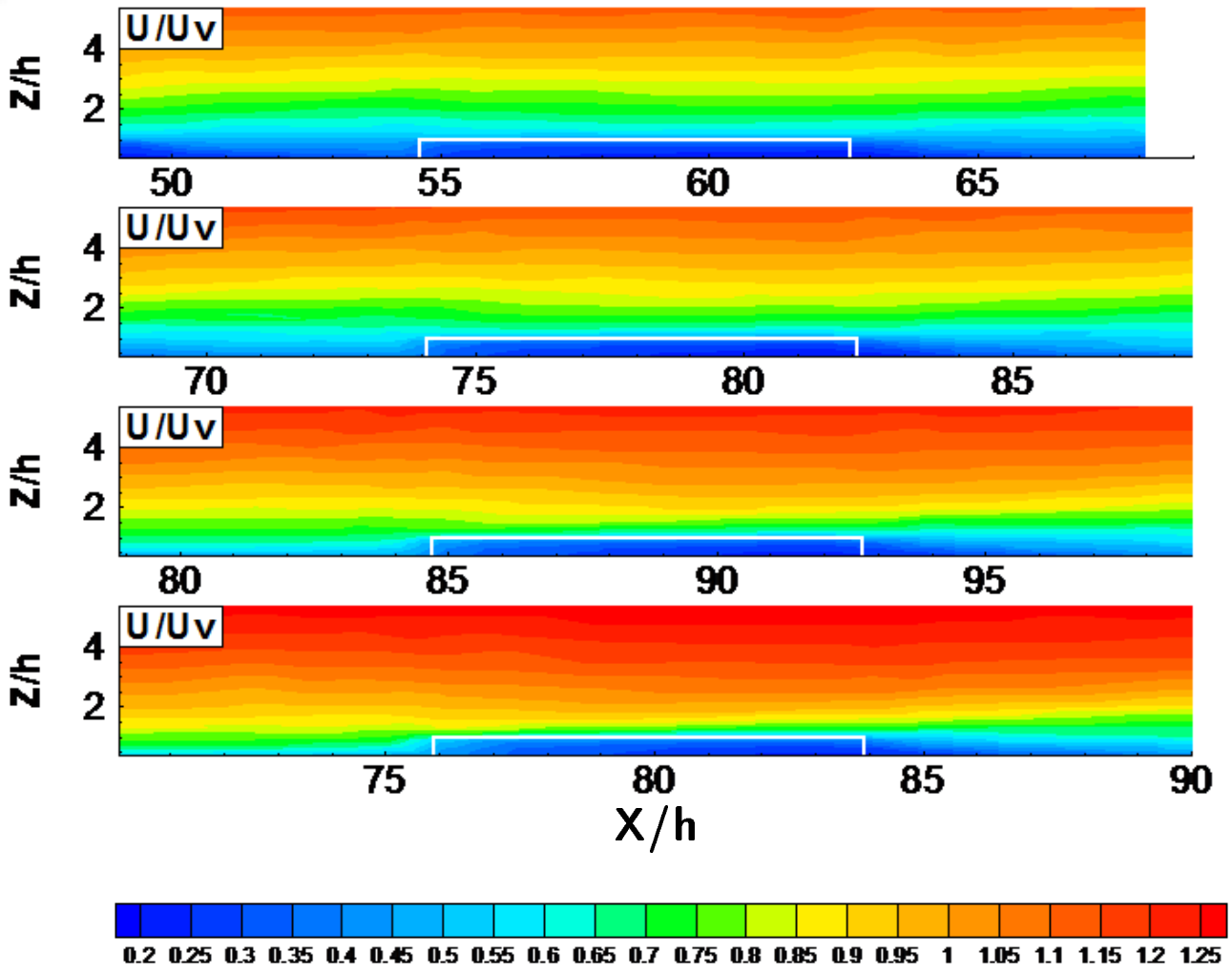
Ratio Gap/Forest Width

$\sim 1/2$

~ 1

$\sim 5/2$

$\sim 7/2$



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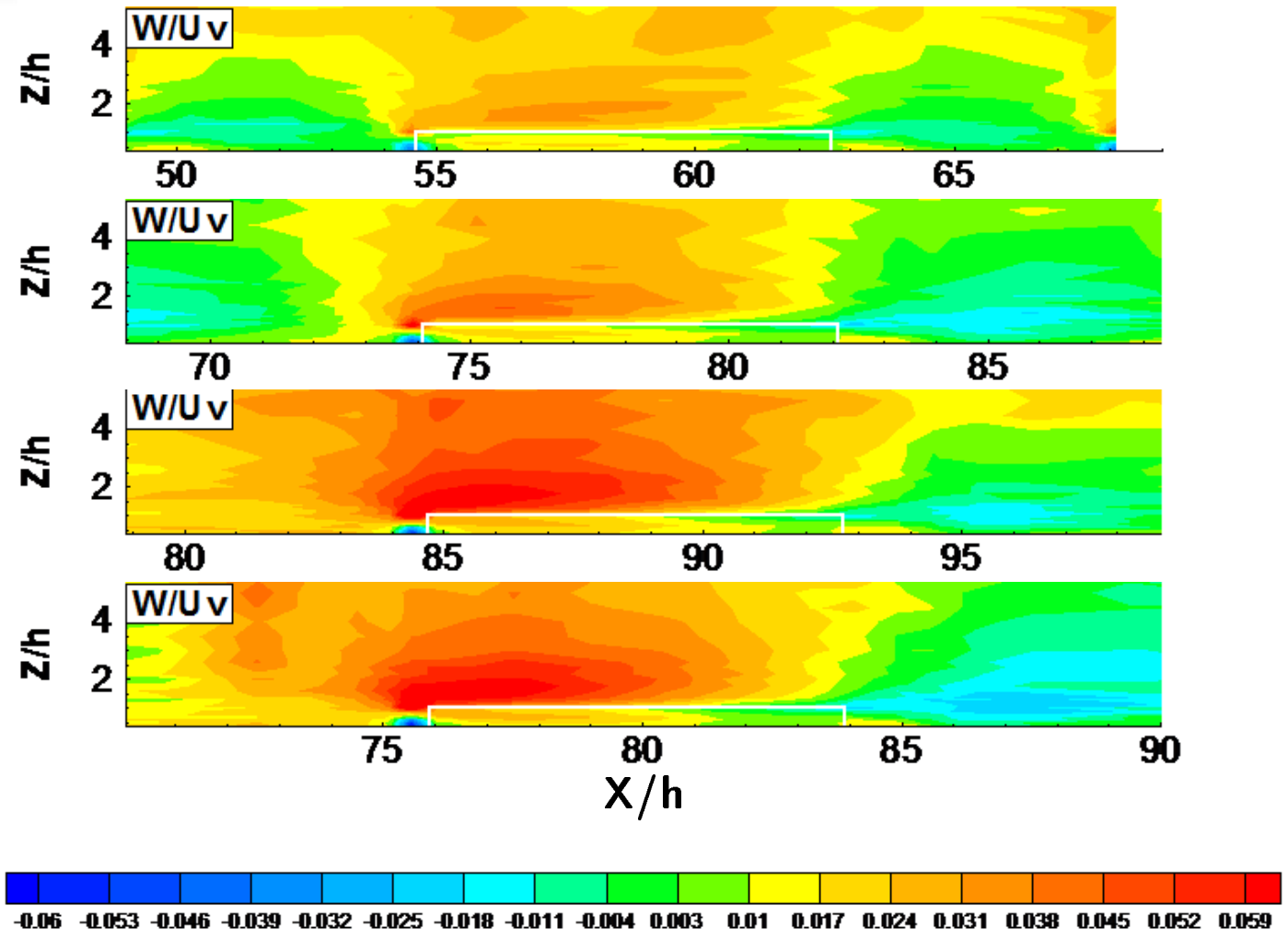

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Ratio Gap/Forest Width

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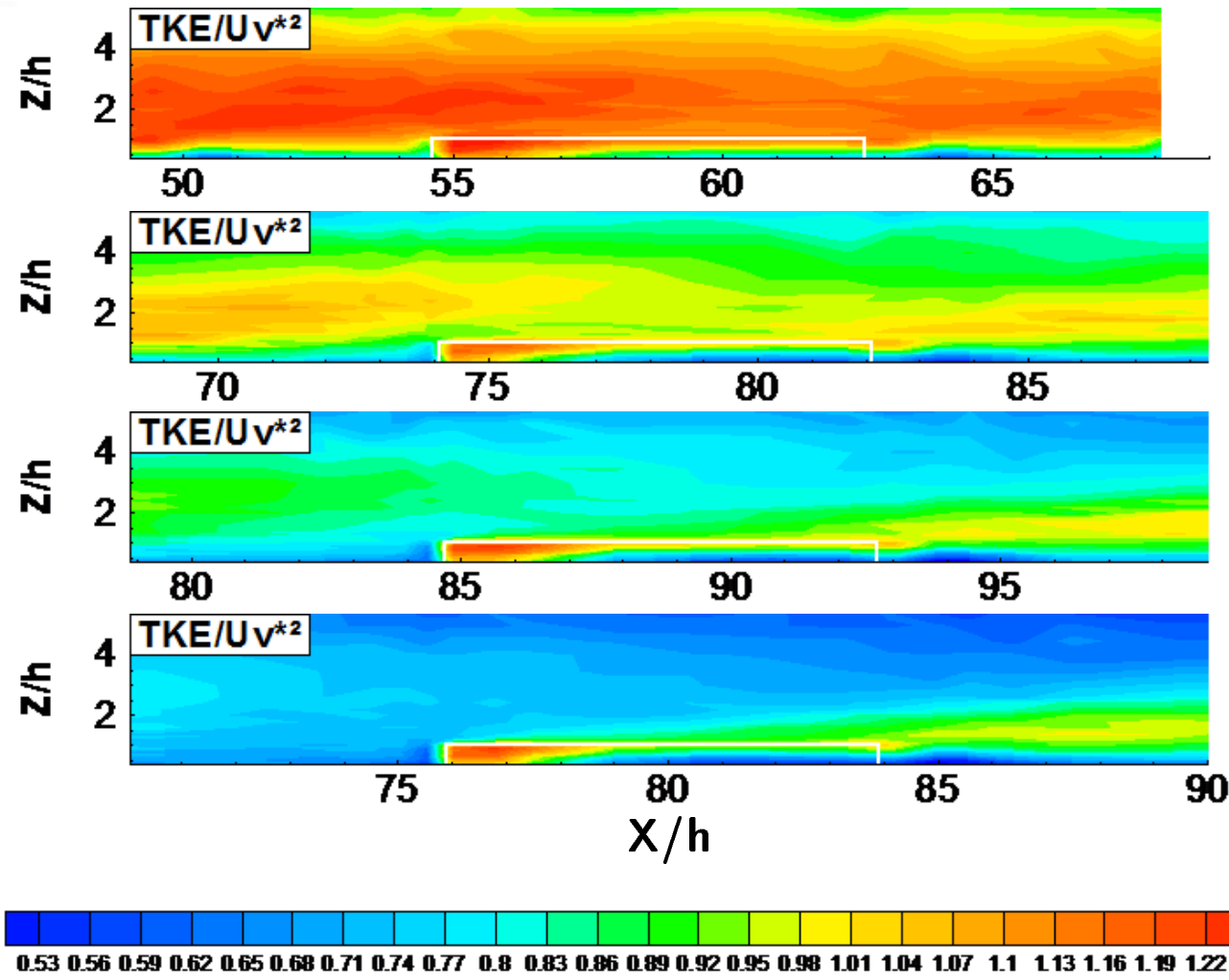


Results

Ratio of Turbulent to Mean Kinetic Energy TKE/U^2

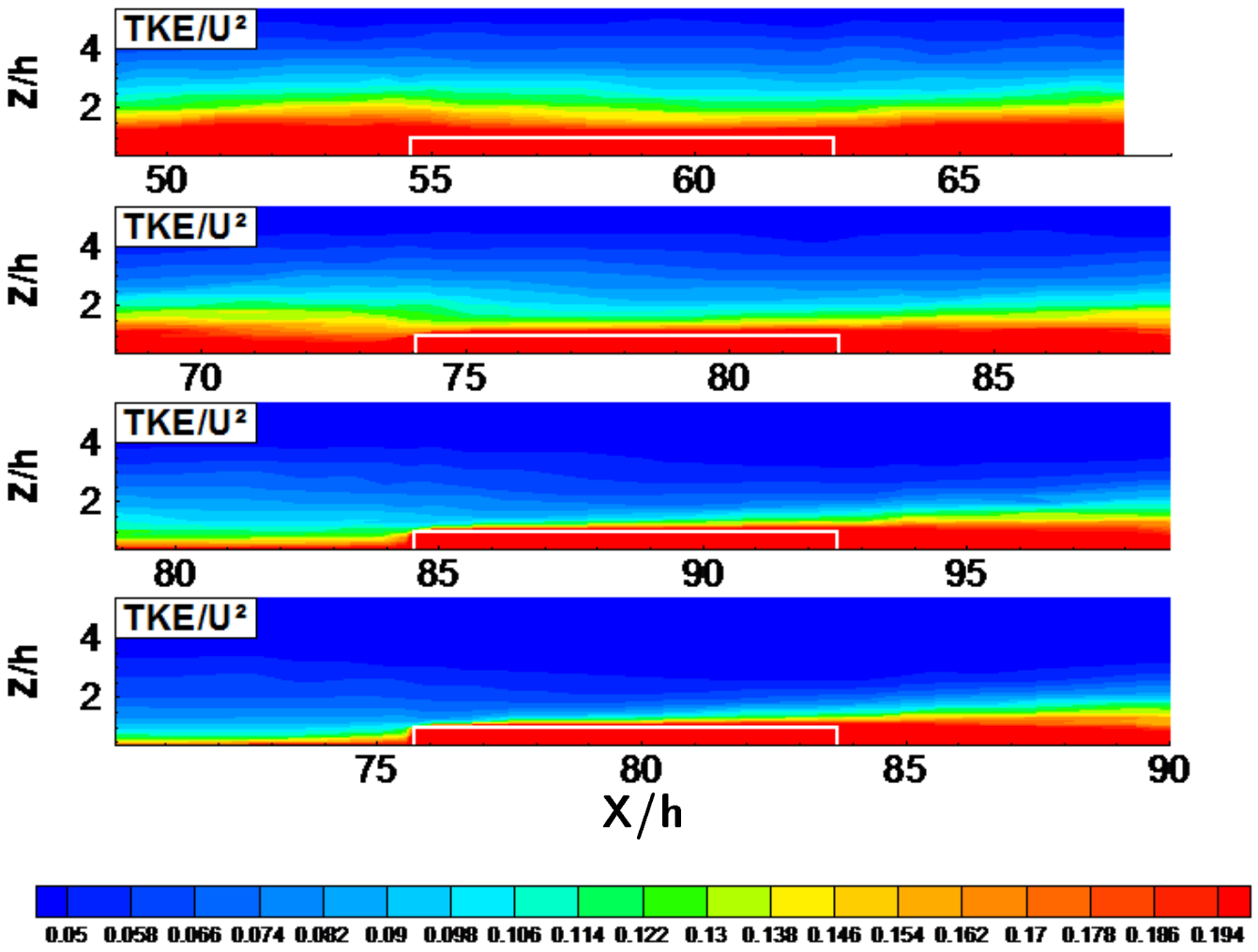
Ratio Gap/Forest Width

$\sim 1/2$

~ 1

$\sim 5/2$

$\sim 7/2$



Results

Maximum Gust Speed $U/U_V + \sqrt{TKE/U_V^2}$

Ratio Gap/Forest Width

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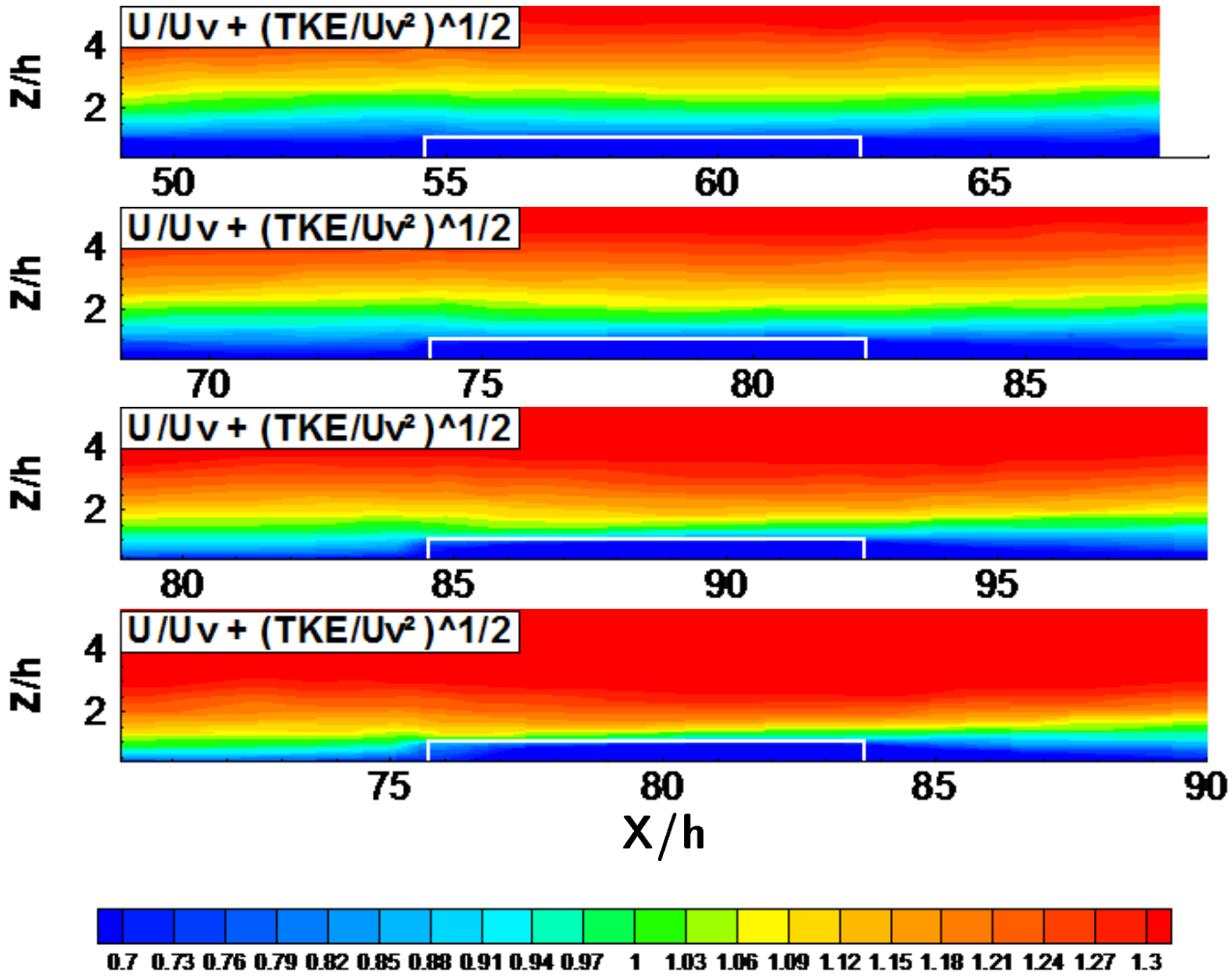
~ 1

$\sim 5/2$

$\sim 7/2$



CONCLUSION & FUTURE WORK

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- A detail set of Data on Fragmentation of the Landscape is now available
- U at tree top increases with the size of the gaps whereas TKE at tree top decreases
- With a small gap, turbulence intensity is higher but the maximum wind speed is larger with a big gap

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FUTURE WORK

- Validation in Fragmented Landscape cases of a large-eddy simulation (LES) model
- Using LES to predict the potential impact and risk levels of fragmentation on forest damage

Thank You For Your Attention

Acknowledgements:

INRA – Aquitaine Region – Labex Cote – CSIRO