



# **SUPERGEN Wind**

## **CFD Modelling of Wind Flow In And Around Forested Regions.**

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## Presentation Outline

- Supergen Wind
- Introduction to my research
- Wind characteristics and Resource Assessment
  - General concepts
  - The ABL
- Forests
  - Past work
  - Basic Theory
- Computational Fluid Dynamics (CFD)
  - What is it?
  - Forests and CFD
- Current and Future work

## SUPERGEN Wind

- EPSRC Flagship, Est. March 2006 as part of the Sustainable Power Generation and Supply (Supergen) programme
- *The Consortium is divided into 4 separate themes of research:*
  - *Theme W: Baseline Wind Turbine Performance*
  - *Theme X: Drive-train Loads & Monitoring*
  - *Theme Y: Structural Loads & Materials*
  - *Theme Z: Environmental Issues*

*"To undertake research to improve the cost-effective reliability and availability of existing and future large-scale wind turbine systems in the UK."*

## My Research

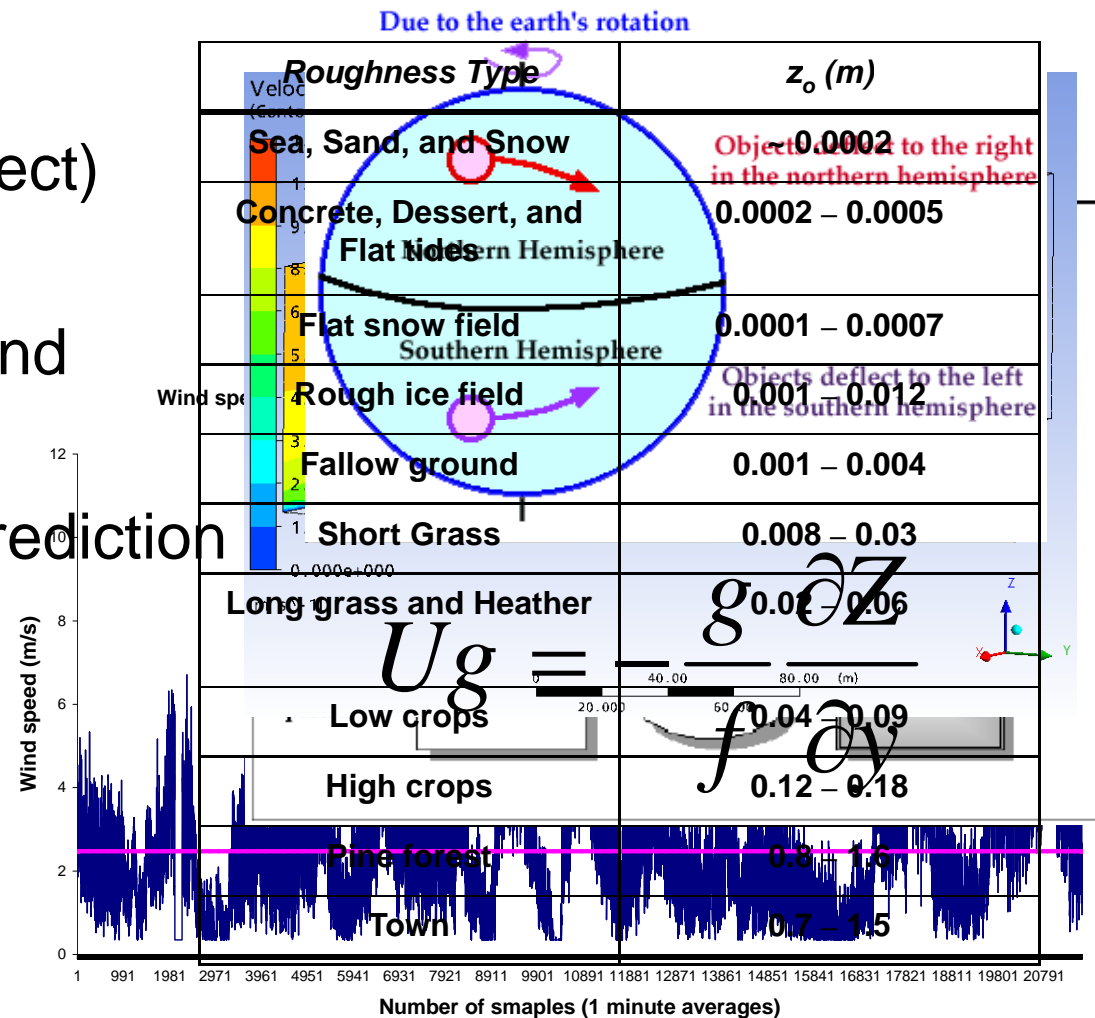
- Using CFD, Ansys CFX 11, to simulate effects of two complex terrain types
- Forests
  - Following on from work done by John Walshe (2003)
- Offshore
  - Looking at the thermal stratification and its effect on wind flow

## Justification For Research

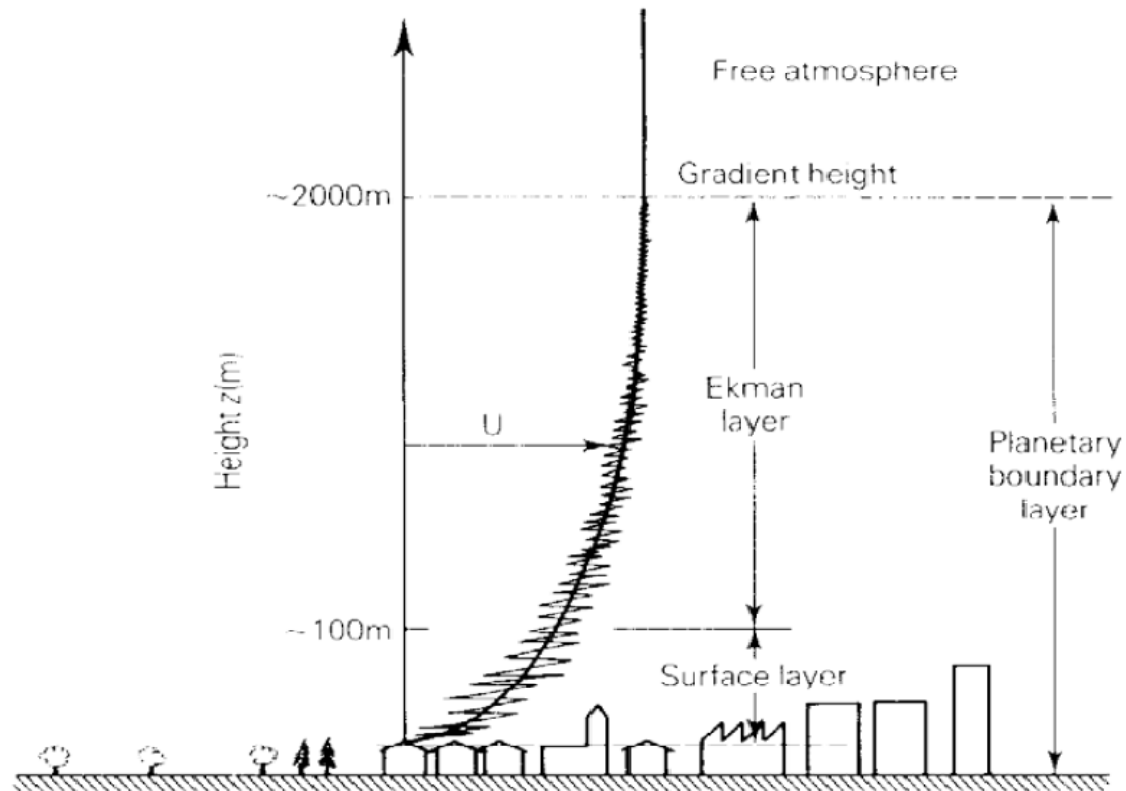
- Suitable, onshore, site selection becoming increasingly difficult
- So, more remote / less desirable sites being considered – forests being one of these!
- To be exploited to their full potential accurate prediction tools are necessary
- Resource assessment is one of, if not the, most important factor when applying for planning permission.

# Wind Characteristics and Resource Assessment

- Global wind patterns
- Coriolis Force (or effect)
- Geostrophic Wind
- Variable nature of wind
- Terrain type
- Two main types of prediction methods
  - Statistical
  - Physical



# The Boundary Layer

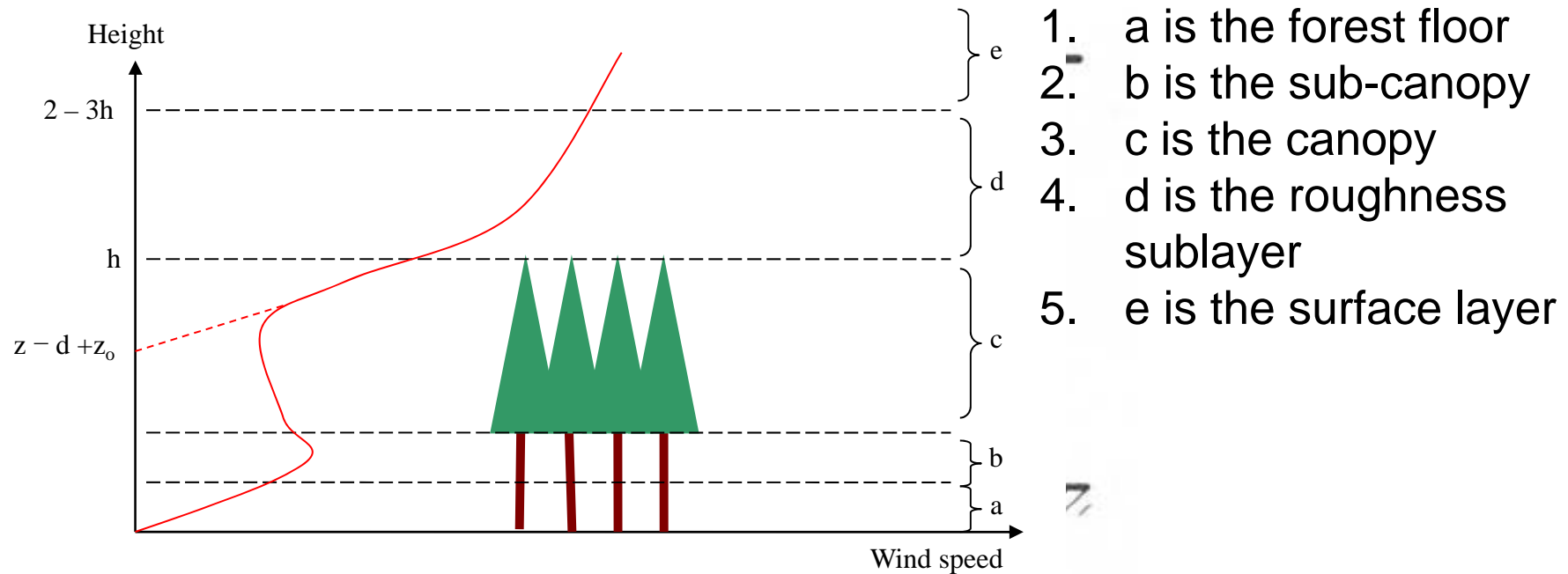


$$U(z) = \frac{U_*}{k} \left[ \ln\left(\frac{z}{z_0}\right) + \Psi_s\left(\frac{z}{L_s}\right) \right] \quad \text{Stability Function}$$

## Forests

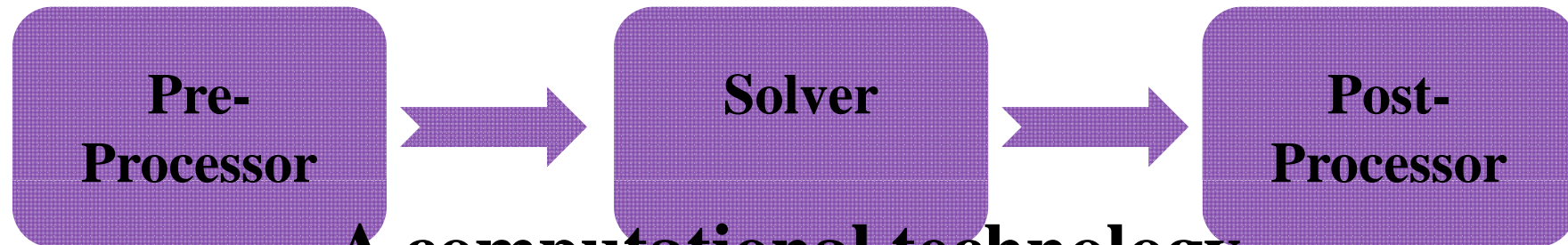
- A lot of work was done in the 80's and 90's
- Conclusions from this work indicated that added complexity and increased turbulence made them unsuitable for turbine installation
- Complexity of sites (remoteness, ease of access) makes detailed wind field studies difficult
- Advances in CFD and computing power mean more detailed research can be done to give better ideas about turbine placement.

## Forests continued



$$U(z) = \frac{U_*}{k} \left[ \ln \left( \frac{z-h}{z_0} \right) + \Psi \left( \frac{z-d}{L_s} \right) \right]$$

## What is CFD?

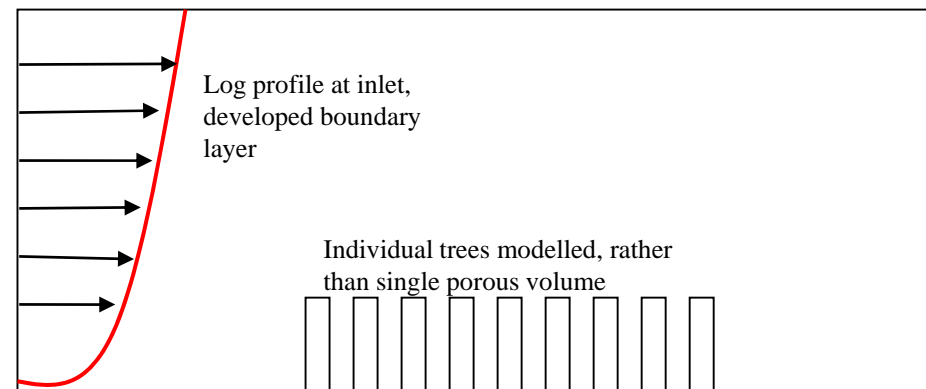
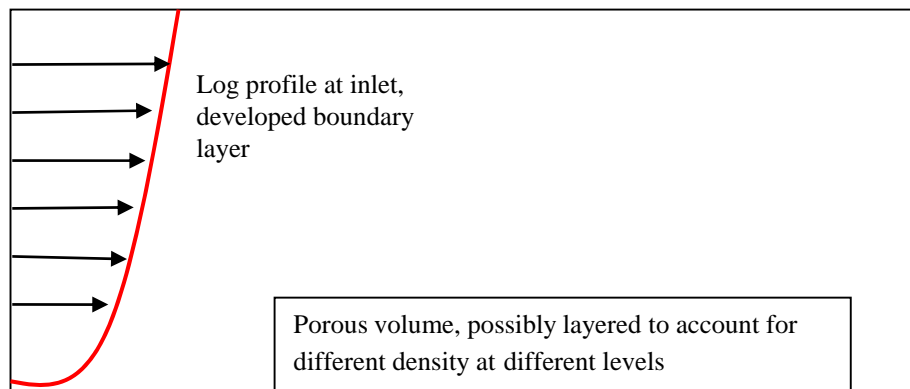


A computational technology that enables you to study the dynamics of things that

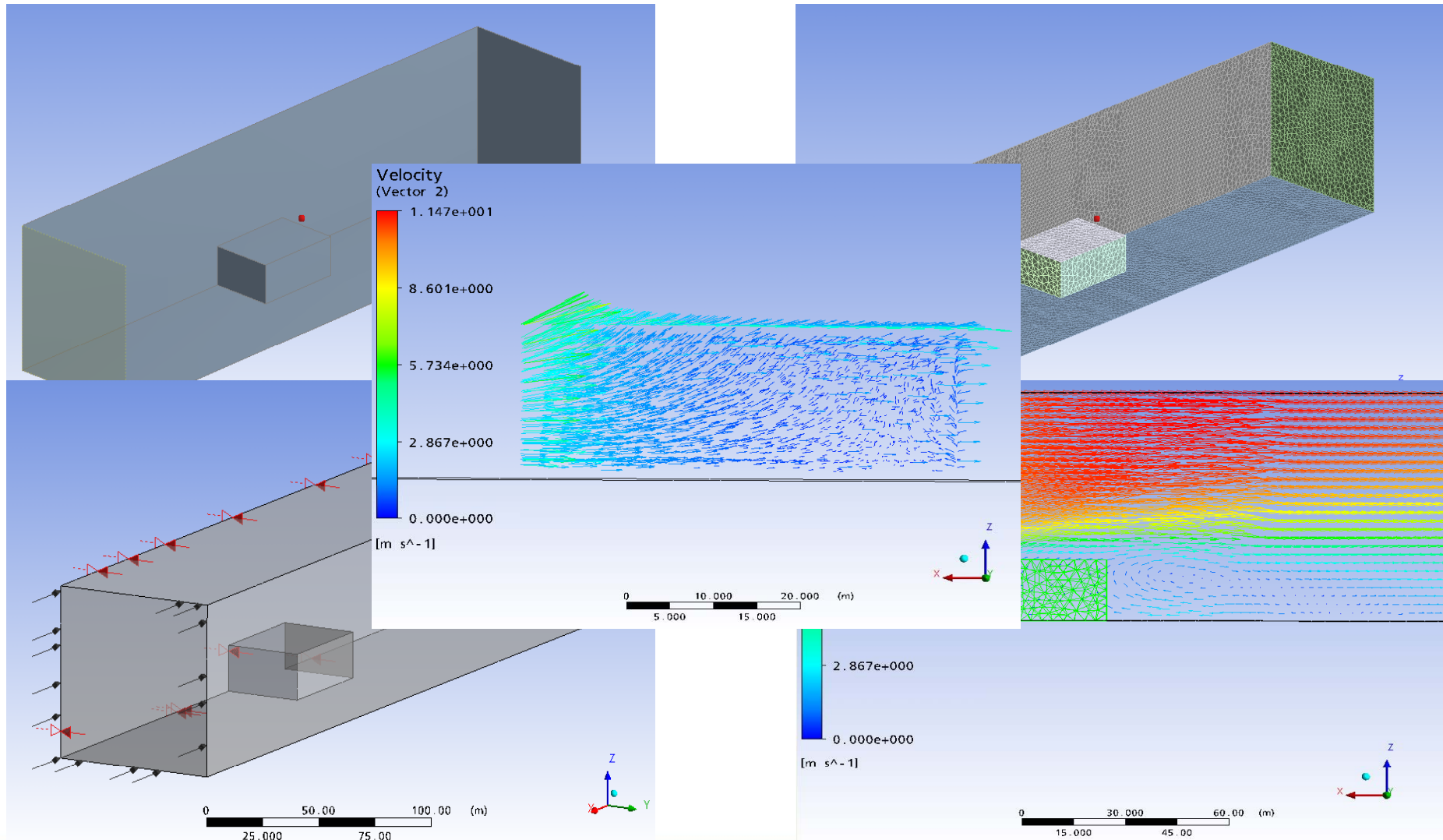
- Defining the geometry of the grid (a grid of interable elements) for simple 2D/3D plots
- Grid generation by the subdivision of the domain into a number of smaller non-overlapping sub-domains; a grid (or mesh) of cells (or control volumes or elements) for the subsequent mathematical manipulations.
- Solution of the algebraic equations (could be user defined)
- Selection of the physical and chemical phenomena that needs to be modelled.
- View manipulation
- Defining the fluid properties.
- Colour post script output.
- Specification of appropriate boundary conditions at cells which coincide with or touch the domain boundary.

## CFD Implementation Of A Forest

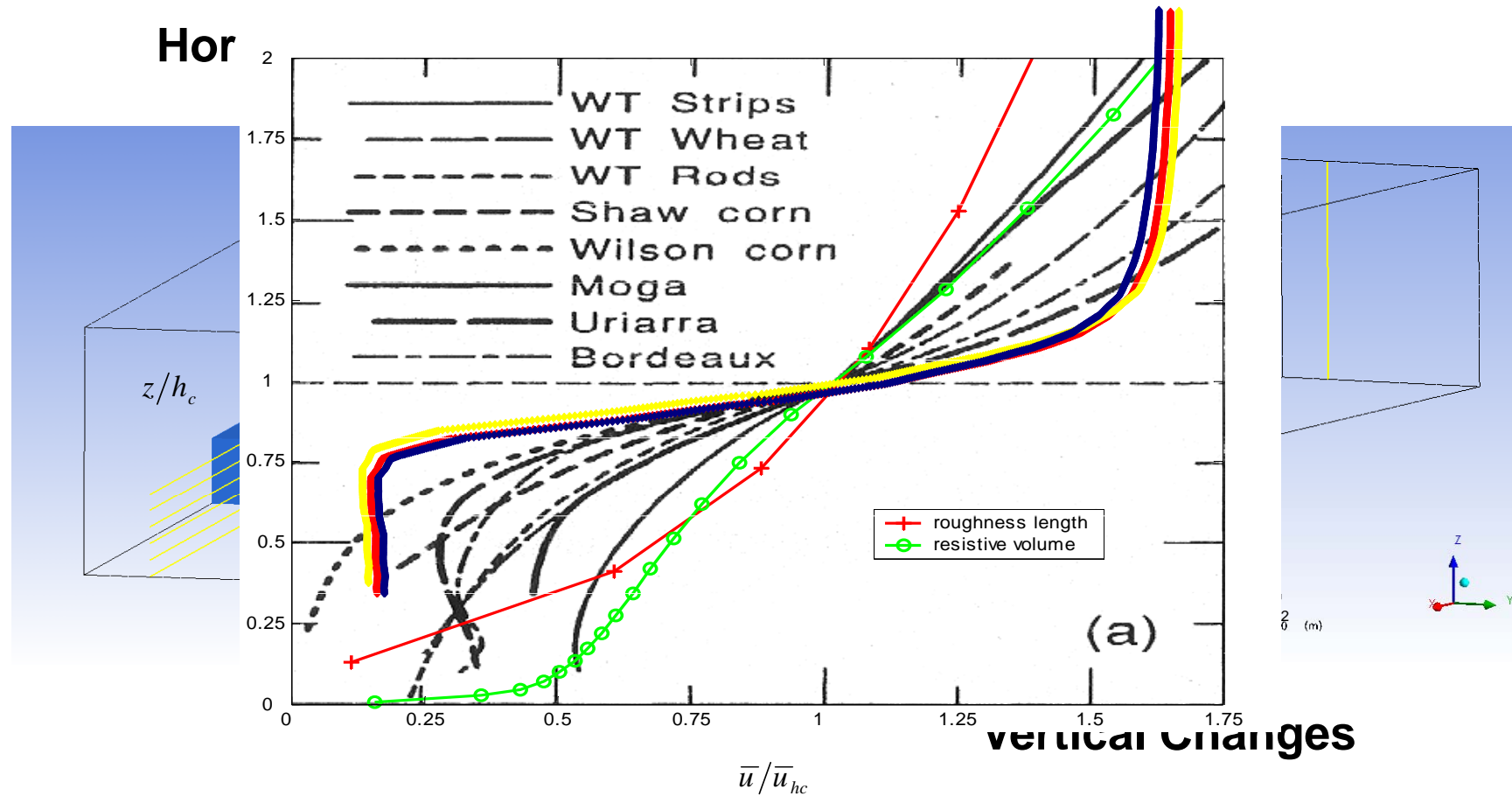
- Logarithmic wind profile with developed boundary layer as input
- Forest canopy modelled as a resistive porous volume (single/multiple), which can absorb momentum
- Inclusion of source/sink terms may be useful
- Investigation in to forest clear cuts also of interest.



# Initial CFD Attempts: What it Looks Like



# Plots



## Current Work

- EWEC 2009, Marseille 16<sup>th</sup> – 19<sup>th</sup> March:  
Poster Presentation
  - CFD Modelling and Validation of Wind Flow  
over A Forest Canopy
- ASME 3<sup>rd</sup> Int. Conference on Energy  
Sustainability, San Francisco 19<sup>th</sup> – 30<sup>th</sup> July:  
Abstract excepted
  - A Computational Fluid Dynamics Study of Wind  
Flow Across A Forest Edge

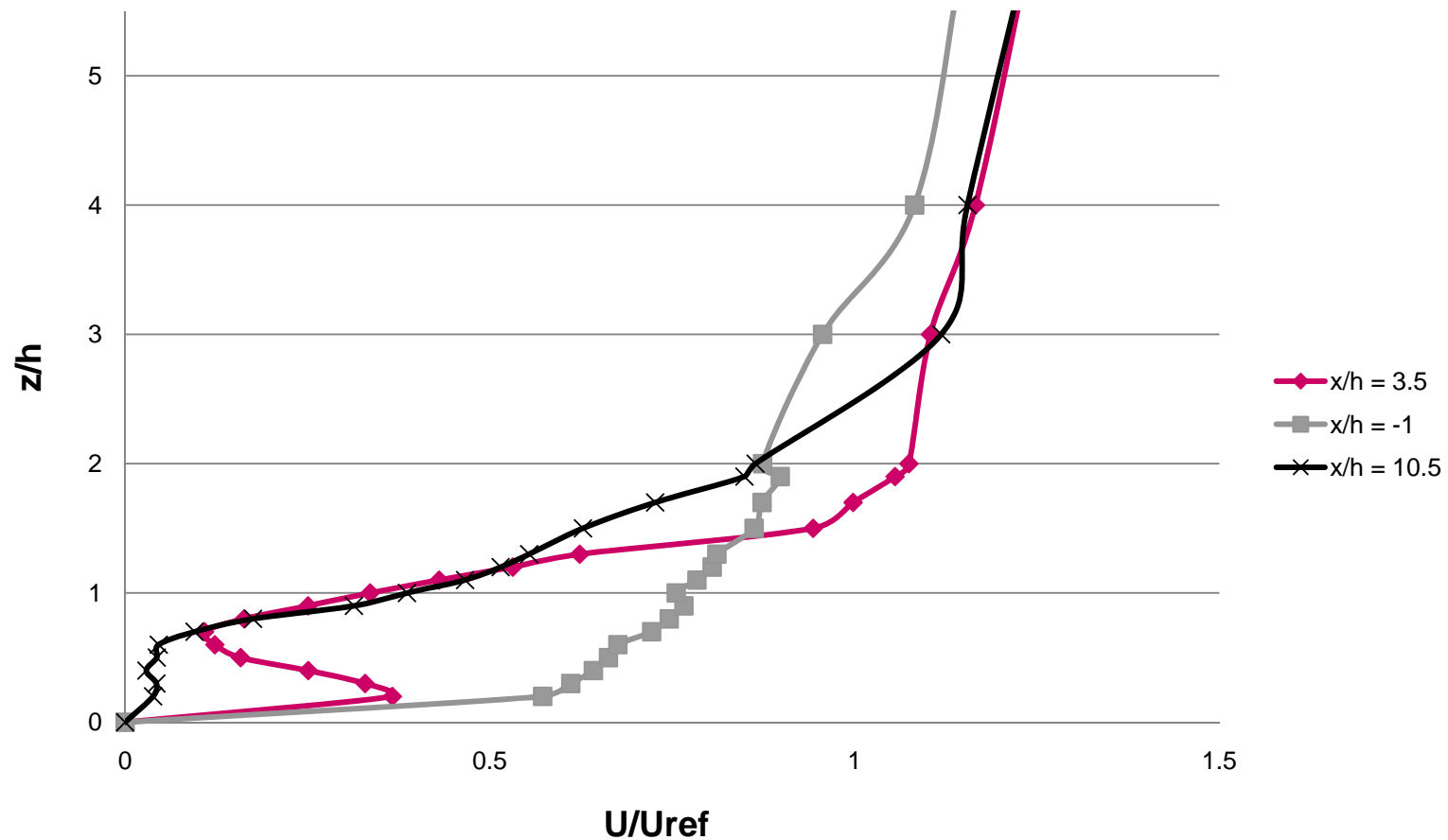
## EWEC 2009

### CFD Modelling and Validation of Wind Flow over A Forest Canopy



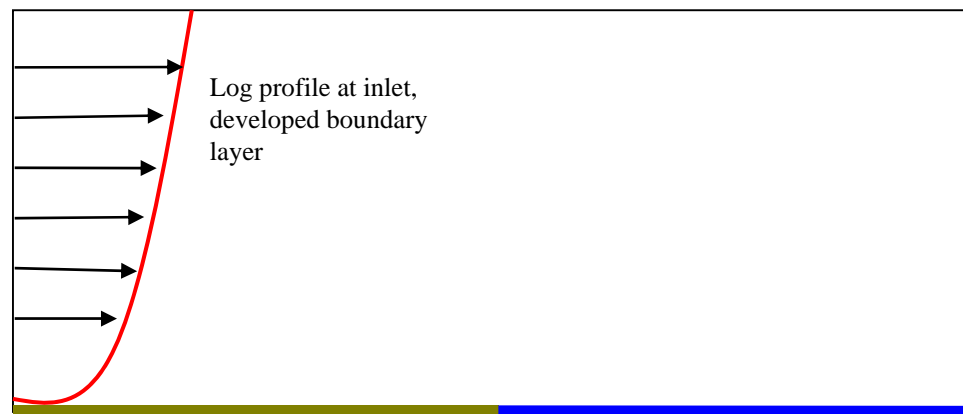
# ASME 3<sup>rd</sup> Int. Conference on Energy Sustainability

## A Computational Fluid Dynamics Study of Wind Flow Across A Forest Edge



## Future Work

- Continue to improve accuracy of forest CFD models through validation of field and wind tunnel data
- Work with Surrey University – Looking at physical (wind tunnel) modelling of forests
- Begin to look at modelling near offshore region?



Land region, heat source

Sea Region, different heat dissipation rate compared to that of land region.

## To Conclude...

- Initial modelling attempts have highlighted areas where improvements are needed!
- Data acquired needs detailed analysis
  - Hill Holt
  - Harwood Forest
- Detailed study of past models is needed
  - John Walshe's attempts at modelling forests
  - Montavon and Watson (for offshore)
- Conference papers will allow for some more detailed simulations to be ran and analysed
- Some initial modelling of land/sea interface are needed, should time permit.

**Any Questions?**

Thank you for your time!