Has computational fluid dynamics (CFD) proved to be useful for greenhouse design?

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Research by WUR Horticulture

- Energy / closed greenhouses
- Crop health
- Labour
- Light
- Greenports/ relation greenhouse industry and urban environment

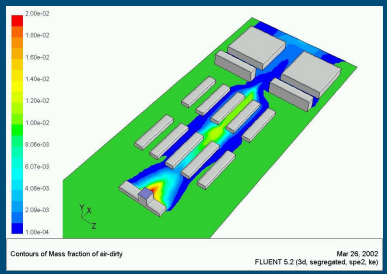
Examples of projects

- Greenhouse as energy source
- Closed greenhouse/Airco greenhouse
- Mobysant
- Zig Zag Covering material
- Harvesting robotics
- Optimal environmental control
- Sensor development

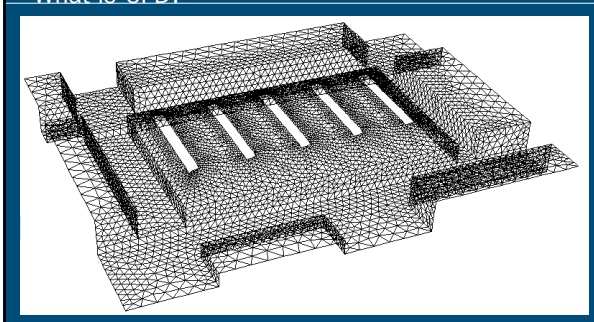
What is CFD?

What is it?

A powerful tool to simulate heat and mass flow in a geometry.



What is CFD?



Conservation laws

- Continuity equation: the mass entering a fluid element must be equal to the mass leaving
- Conservation of momentum: Newtons second law
- Conservation of energy: the first law of thermodynamics

What is CFD?

What is it?

A powerful tool to simulate heat and mass flow in a geometry.

How does it work?

The geometry is split up in small sections; the continuity equations are solved for the sections.

What are the advantages?

- New concepts can be exploited
- no costly, time-consuming experiments
- simulation of extreme conditions

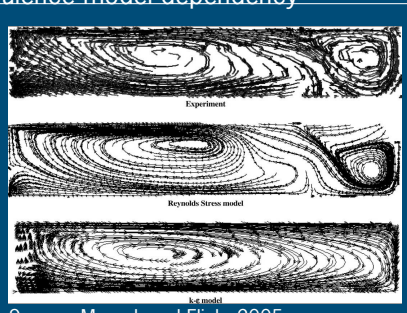
Commercial software available

- Ansys CFX
- Ansys Fluent
- Phoenics
- CFD2000

Important aspects using CFD

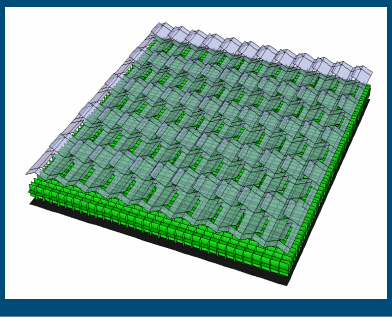
- What should be determined?
- Turbulence model
- Geometry: what to incorporate and 2D or 3D
- The size and structure of the mesh
- The boundary conditions

Turbulence model dependency

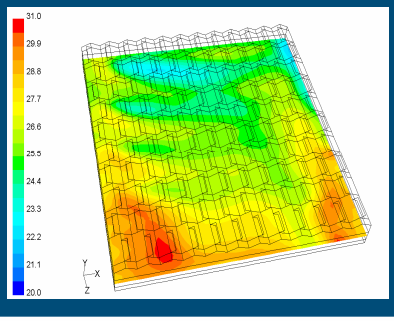


Source: Moureh and Flick, 2005

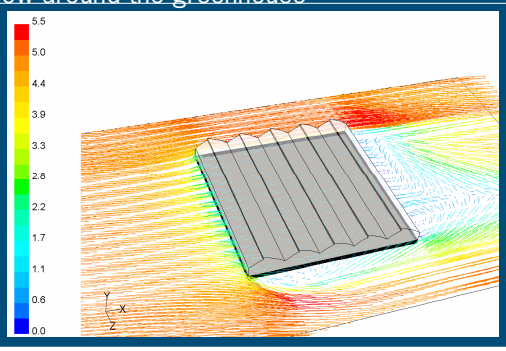
Presenting CFD results



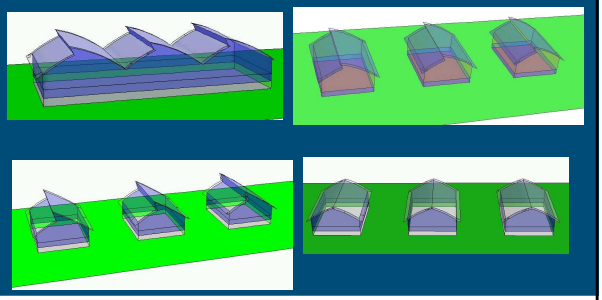
Temperature distribution



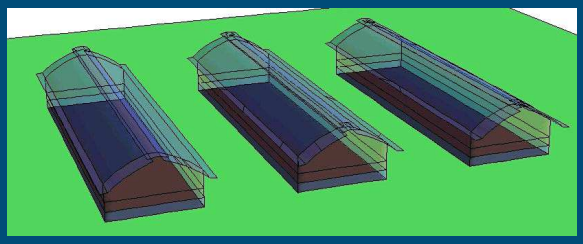
Flow around the greenhouse



Procult: optimal design for Indonesia

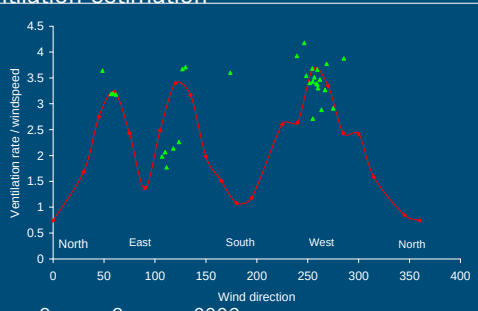


Final design Procult



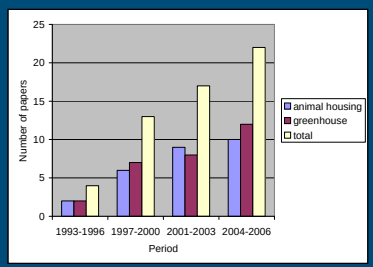
Test site Indonesia

Ventilation estimation



Source: Campen, 2003

Number of papers published



Source: T. Norton *et al., 2007*

Conclusions

- The setup of the CFD calculation is crucial
- The comparison between CFD calculations and experiments looking at ventilation rates are within 20%
- Experiments are needed to verify the calculations
- CFD is a good tool to compare several designs
- Modeling large greenhouses is difficult

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Thank you for your attention!

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