Metström

Measurement of turbulent exchange processes downstream a single tree trunk

Dr.-Ing. Veit Hildebrand, Dipl.-Ing. Thomas Eipper, Johannes Ende

Dresden, 08.09.2010

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Outline

1. Wind tunnel experiment during the first phase of Metström
   - Preparation of the wind tunnel model
   - First simulation of "Wildacker"

Outline

1. Wind tunnel experiment during the first phase of Metström
   - Preparation of the wind tunnel model
   - First simulation of "Wildacker"

2. Second phase
   - Measurement behind a single trunk
   - Measurement behind a single tree
   - Reference experiment
   - Measurement of dispersion processes

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TurbeEFA
Second phase
Laserscans

MetStröm

Outline

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Preparation
Results

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Preparation of the wind tunnel model

- Measurements take place in the boundary layer wind tunnel of the TU Dresden
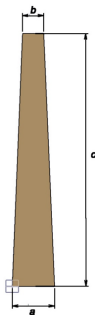- Dimensions of the test section: 1.2m high, 1.4m wide and 8m long

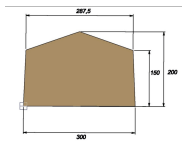Test section of boundary layer wind tunnel

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Preparation of the wind tunnel model
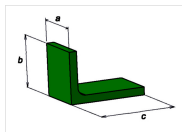# Adjustment of the boundary layer

- Initialized by counihan-generators with bases and roughness elements

Counihan-Generator

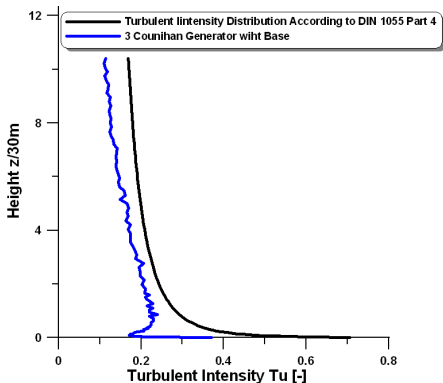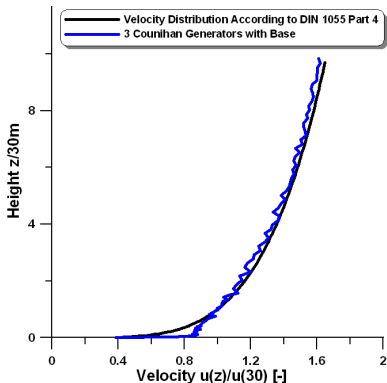

Base of a Counihan-Generator

Roughness element

Total set-up

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Preparation of the wind tunnel model
Adjustment of the boundary layer

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Preparation of the wind tunnel model
Boundary conditions

- Determination of the spatial correlation
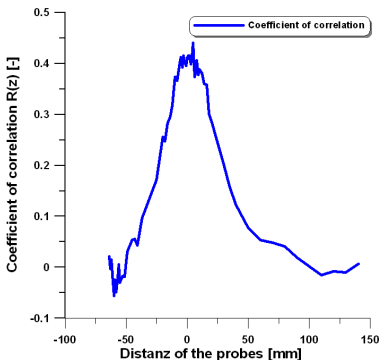- Coefficient of correlation:

$$R_K(z) = \frac{\overline{u_1' u_2'}}{\sqrt{u_1'^2 \cdot u_2'^2}}$$

$$R_K(z) = \frac{\sum_i (u_{1i} - \bar{u}_1) \cdot (u_{2i} - \bar{u}_2)}{\sqrt{\sum_i (u_{1i} - \bar{u}_1)^2 \cdot \sum_i (u_{2i} - \bar{u}_2)^2}}$$
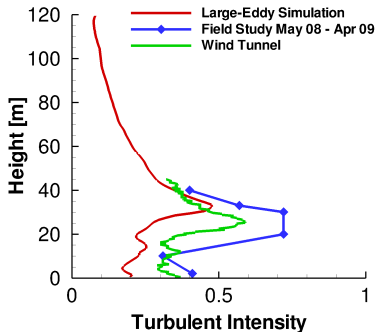
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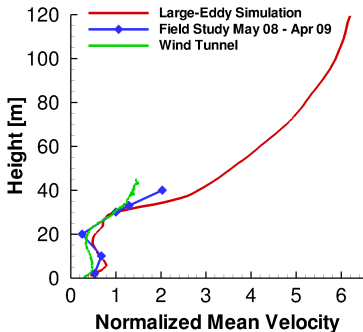TurbeEFA
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Preparation of the wind tunnel model
Boundary conditions

- Measurement with two Hot-Wire-Probes along the z-axis
- Refenrence height: 65mm

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First simulation of "Wildacker" Profiles for "Main Tower"

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Laserscans

Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

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Second phase

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TurbeEFA
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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

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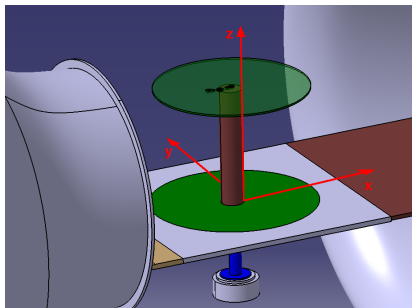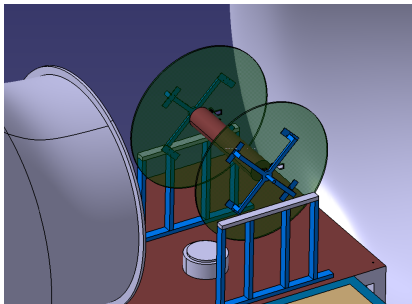
Measurement behind a single trunk

- Single trunks of a spruce, chestnut etc.
- 1550mm long, approx. 300mm wide
- Measurements of mean velocity and turbulent intensity around the trunk
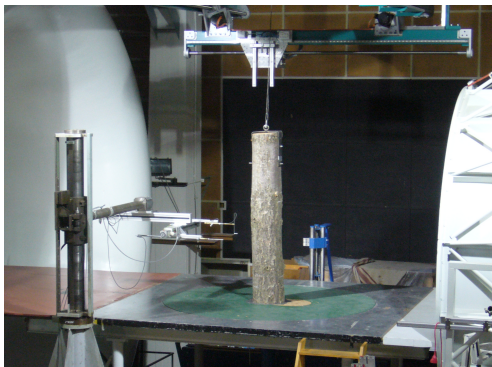

Trunk in horizontal assembling

Trunk in vertical assembling

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

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Measurement behind a single trunk

- Measurements take place in the low speed wind tunnel of the TU Dresden

Test preparation

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

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Measurement behind a single trunk
Test procedure

- Two trunks with different roughness

Trunk 1 (spruce)

Trunk 2 (pine)

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

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Measurement behind a single trunk
Test procedure

- Measuring methods: Hot-Wire-Anemometry (HWA) and Particle-Image-Velocimetry (PIV)
- Modification of angle of attack (-90° - 90°) and tilt angle (0° - 40°)
- Flow rates of 3 m/s, 5 m/s and 10 m/s
- Measuring height z=650mm

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Measurement of dispersion processes

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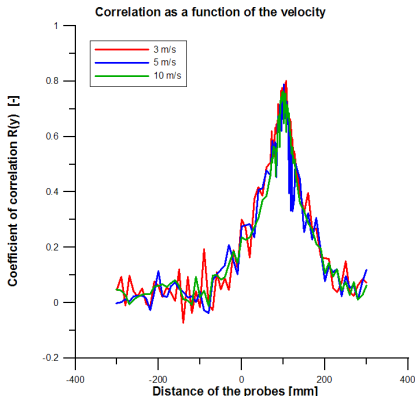# **Measurement behind a single trunk**
Measuring methods

- HWA: + High spatial and temporal resolution
    - Fluid flow is affected by the probes
    - Long testing time
- PIV: + Non-contact method
    + 2D flow field
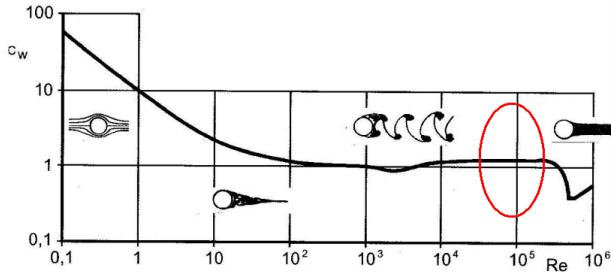   - Needs high memory capacity and
       processing power

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

Measurement behind a single trunk
Effect of the flow rate

- Measuring with two HWA-probes along the y-axis
- Reference position: y=100mm

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Measurement behind a single trunk
Flow around a smooth circular cylinder

Influence of the Reynolds number

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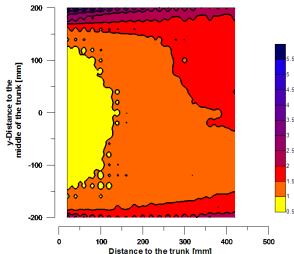Single Trunk
Single Tree
Reference Experiment
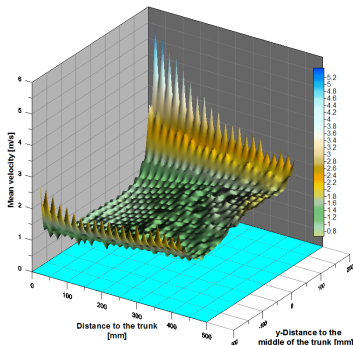Measurement of dispersion processes

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Measurement behind a single trunk
Effect of the surface roughness

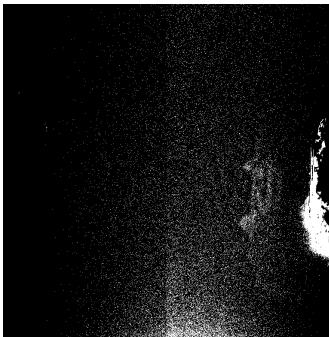- Measuring with two HWA-probes along the y-axis
- Reference Position: y=100mm

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes
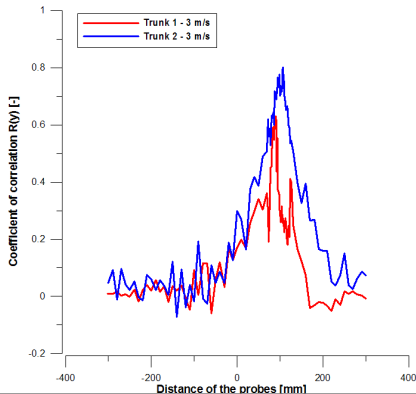
Measurement behind a single trunk
Flow field

- Measuring with one HWA-probe
- Area of 400mm times 400mm
- Mean velocity

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Measurement behind a single trunk
PIV data analysis

Scattered light of the particle

Raw data vector field

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Measurement of dispersion processes
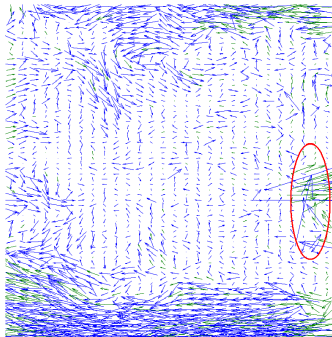
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Measurement behind a single trunk
PIV data analysis
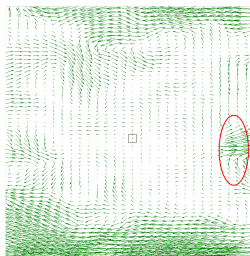
Smoothing method

Streamlines

Vorticity

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Measurement behind a single trunk
Structure of the data base

Projekt: Metström, Großer Beleg - Johannes Ende	
Instationäre Strömungsmessung bei der Anströmung zweier Baumstämme mittels HDA	
Verfahren:	
HDA:	Messung der Geschwindigkeitskomponente u in x-Richtung als Korrelationsmessung
Beschreibung der Messung:	
	Korrelationsmessung bei konst. Abstand x=200mm und Flächenmessung (400mm x 400mm)
	- für verschiedene Anströmgeschwindigkeiten (3 m/s, 5m/s, 10m/s)
	- für verschiedene Anström- und Kippwinkel
	- für verschiedene Korrelationskonfigurationen (0mm, 100mm, 200mm)
	Höhe der Messung am Stamm bei z=650mm
	Aufnahme von Zeitreihen über Dauer von 30 s bei Abtastfrequenz von 1250 Hz
	Baum 1: Fichte mittel-rauhe Oberfläche (Durchmesser ca. 35cm)
	Baum 2: Kiefer rauhe Oberfläche (Durchmesser ca. 33cm)
Allgemein:	
Ort:	NWK TU-Dresden
Versuchsaufbau:	Lagebeschreibung

Korrelationsmessung entlang x=200mmm						

Baum 1						

	Konfiguration 0mm		Konfiguration 100mm		Konfiguration 200mm	
	u=3m/s	u=5m/s	u=3m/s	u=5m/s	u=3m/s	u=5m/s
Winkel β=0°	Baum1 3ms 0°	Baum1 5ms 0°	Baum1 3ms 0°	Baum2 5ms 0°	Baum1 3ms 0°	Baum1 5ms 0°

Mean document

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Measurement behind a single trunk
Structure of the data base

Projekt: Metström, Großer Beleg - Johannes Ende	
Instationäre Strömungsmessung bei der Anströmung zweier Baumstämme mittels HDA	
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HDA:	Messung der Geschwindigkeitskomponente u in x-Richtung als Korrelationsmessung
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	- für verschiedene Korrelationskonfiguration (0mm, 100mm, 200mm)
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Allgemein:	
Ort:	NWK TU-Dresden
Versuchsaufbau:	Lagebeschreibung

Korrelationsmessung entlang x=200mmm						
Baum 1						
	Konfiguration 0mm		Konfiguration 100mm		Konfiguration 200mm	
	u=3m/s	u=5m/s	u=3m/s	u=5m/s	u=3m/s	u=5m/s
Winkel β=0°	Baum1 3ms 0°	Baum1 5ms 0°	Baum1 3ms 0°	Baum2 5ms 0°	Baum1 3ms 0°	Baum1 5ms 0°

Link to a single sheet

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Measurement behind a single trunk
Structure of the data base

Projekt: Metström, Großer Beleg - Johannes Ende						
instationäre Strömungsmessung bei der Anströmung des Baumstammes 1						
Verfahren:						
HDA:	Messung der Geschwindigkeitskomponente u in x-Richtung als Korrelationsmessung					
Allgemein:						
Ort:	NWK TU-Dresden					
Datum:	14.07.2010					
Durchführender:	Johannes Ende					
Parameter:						
Nennanströmgeschwindigkeit:	ū=3 m/s					
Kippwinkel des Stammes:	β=0°					
Anströmwinkel:	α=0°					
Konfiguration:	"0mm"					
Tagesdaten:						
Temperatur:	26,5 °C					
bar. Druck:	1009,3 hPa					
Kalibrier-Daten:						
Druckkalibrierung:	Druck-Kal_60Pa_20100714					
Kalibrierung Sonde1:	Sonden-1_20100714					
Kalibrierung Sonde2:	Sonden-2_20100714					
Messdaten						
Datei mit Mittelwerten:	Korr_3ms_0Grad_0Grad_0mm					
Datei mit Auswertung:	Korrelation_3ms_0mm					

Position der beweglichen Sonde 1				Mittelwerte über 30s		
x-Koordinate	y-Koordinate	Anström-geschwindigke	Reynoldszahl Re	bewegliche Sonde1	feststehende Sonde2	Dateien mit Zeitreihen
[mm]	[mm]	[m/s]	[-]	[m/s]	[m/s]	
200	300	3,18	69960	3,79	0,37	Korr_3ms_0mm_y=300mm
200	290	3,18	69960	3,67	0,42	Korr_3ms_0mm_y=290mm

Single sheet

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Measurement behind a single trunk
Structure of the data base

Link to a data sheet

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Measurement behind a single trunk
Structure of the data base

Data sheet

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes

Measurement behind a single tree

- Single tree at a scale of approx. 1:25
- Reinforced with liquid class (for example)
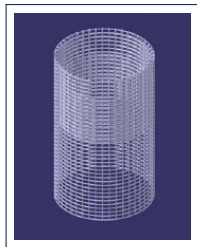- Measurements of mean velocity and turbulent intensity around the trunk
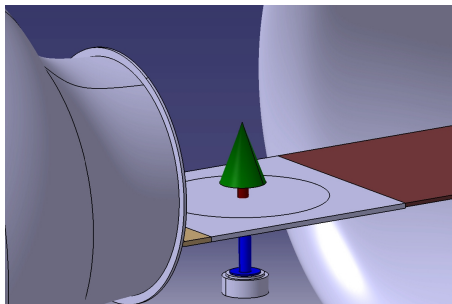
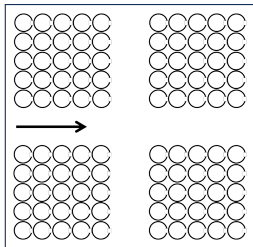Schematic assembling in the wind tunnel

Possible tree

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Single Trunk
Single Tree
Reference Experiment
Measurement of dispersion processes
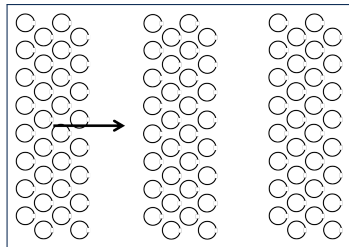
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Reference experiment

- Arrangements of model trees made of metallic mesh
- Metallic mesh: steel wires with 0.5mm diameter and mesh size of 3mm
- Measurements in, around and behind the arrangements


Model of metallic mesh

Possible arrangement

Possible arrangement

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Single Tree
Reference Experiment
Measurement of dispersion processes

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Measurement of dispersion processes

- Improvement of the experimental set-up
- Use of digital models of the topography and the canopy
- Implementation of contactless measurement technics

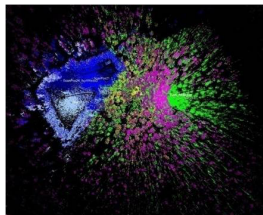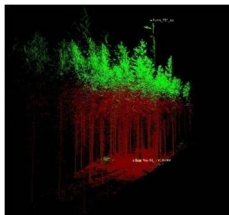
Model of the "Wildacker" in the wind tunnel
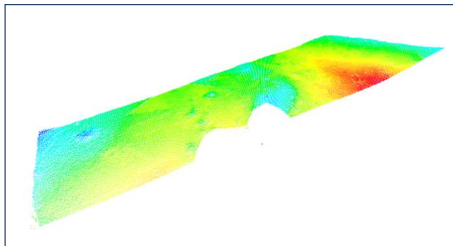
Digital model of the topography

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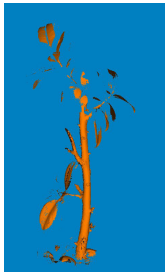# Terrestrial laser scanning

- Laser scan of the "Wildacker" from ground and the top of a tower
- Determination of point clouds
- Determination of leaf area index

Point clouds resulting from terrestrial laser scans

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Terrestrial Laser Scanning
Laser Scanning of Single Structures

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Laser scanning of single structures

- High resolution scans of smaler plants
- Structure of surface areas can be determined
- CAD-models can be produced out of the measurements

Indoor plant: picture (left),laser scan (middle) and the details (right)

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Terrestrial Laser Scanning
Laser Scanning of Single Structures

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Thank you for your attention.