TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Forest, Geo and Hydro Sciences, Department of Hydrosciences, Institute of Hydrology and Meteorology, Chair of Meteorology

TurbEFA
Erste Ergebnisse des Freilandexperimentes

Ronald Queck, TUD

MetStröm WS Dresden, 09.09.2010

Ergebnisse von Freilandexperimenten

- Individual conclusion from the ADVEX campaigns
- WinCanop
- TurbEFA
  - Räumliche Repräsentativität der Messungen
  - Ballonaufstieg
- Ansätze zur Parameterschätzung C_D
- Mittlungsintervall
- Quellflächenexperiment
- **Schlussfolgerung**

Individual conclusion from the ADVEX campaigns

- Advection of energy and matter occurs even at sites which look very homogeneous

- There is a large scatter in the signal
  and the methods for measuring and modelling the phenomenon are still not satisfying

- A large part of the uncertainty occurs due to the limited knowledge about the spatial distribution of the quantities to determine, especially the wind field

Questions

How can we derive a more reliable wind field based on local measurements?

What are the key parameters to model the flow through the canopy?

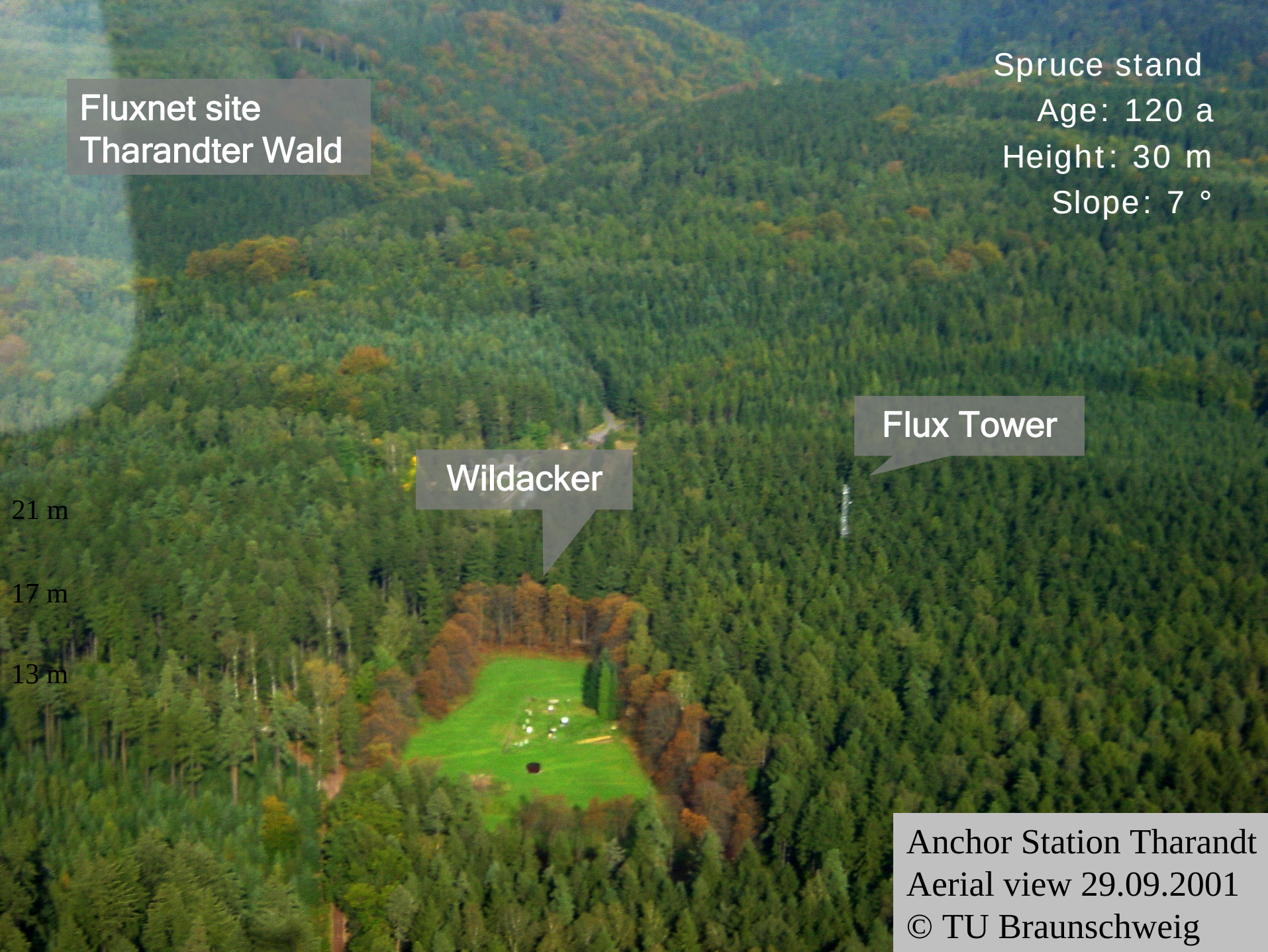
➔ Drag coefficient C_D and mixing length l_m

➔ C_D and l_m are mainly functions of the plant area density ***a***

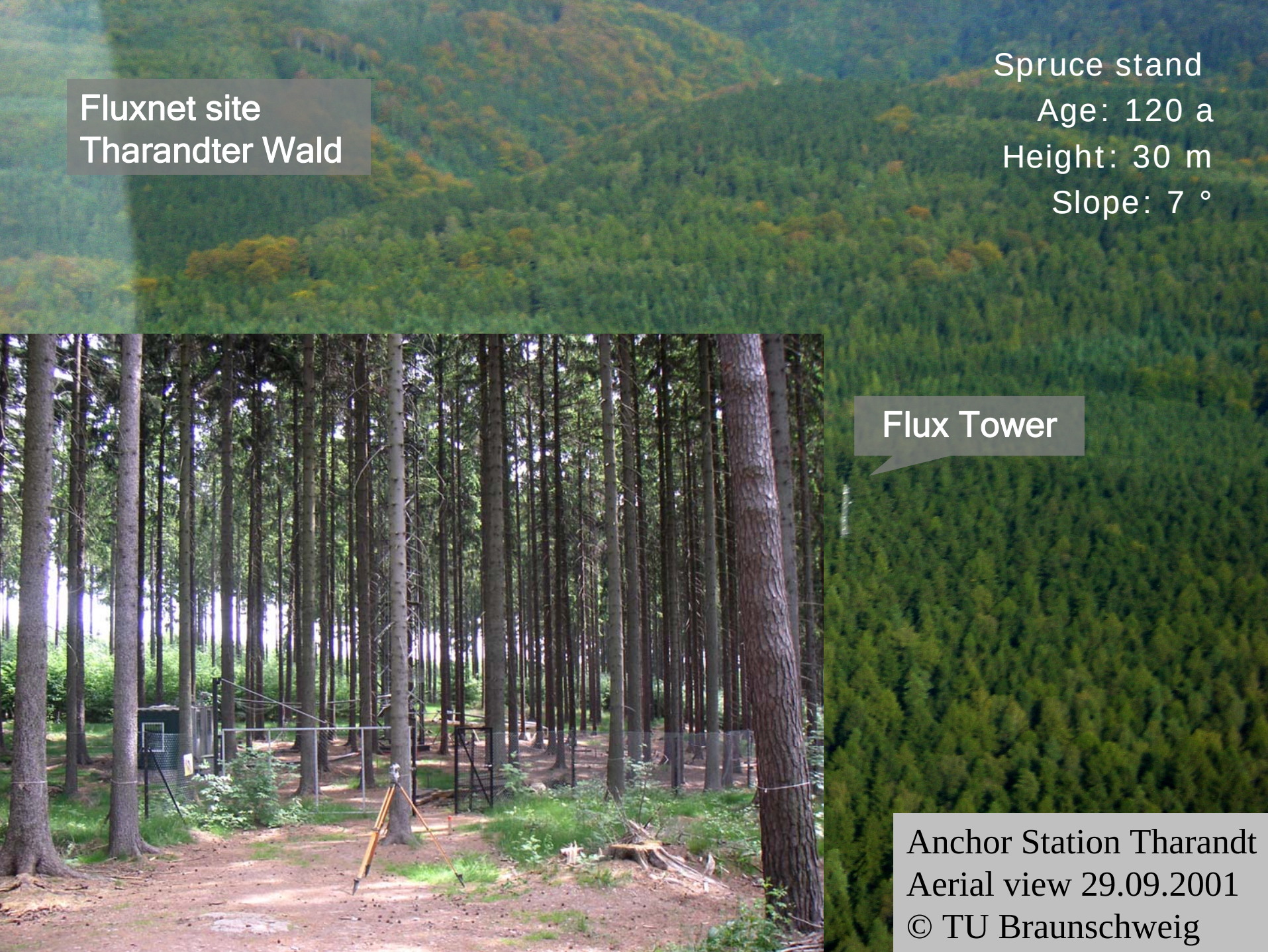
$$C_D = f(a, u, \zeta, \ldots)$$

?

$$l_m = f(a, u, \zeta, \ldots)$$



Anchor Station Tharandt
Aerial view 29.09.2001
© TU Braunschweig



Anchor Station Tharandt
Aerial view 29.09.2001
© TU Braunschweig

WinCanop - Experiment

At CEIP site Tharandter Wald (8/2007-11/2007)

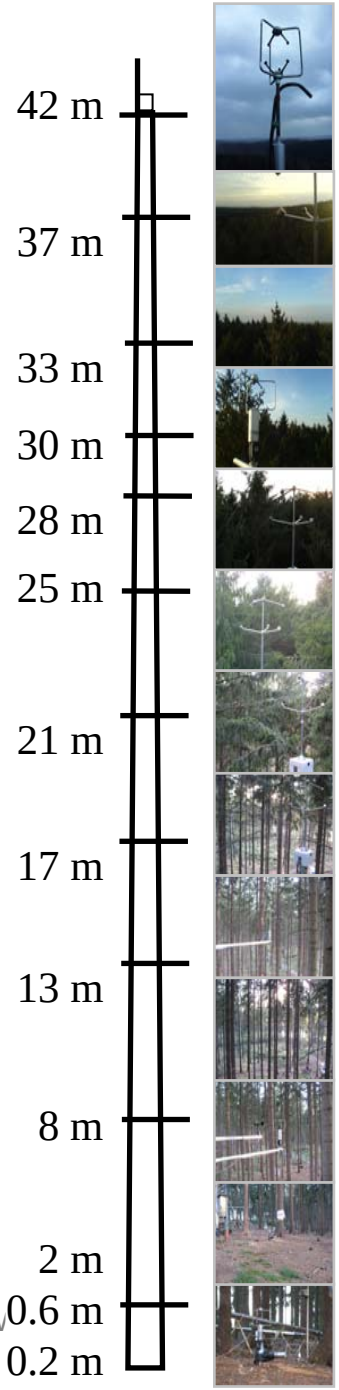
Setup / Measurements:

13 Sonics over a range of 42 m

LAI2000 (vertical res. 0.5 m)

Features of the horizontal wind speed:

- Inflection point in canopy height
- Secondary maximum of wind speed in trunk space
- Highest variability at the top of the canopy and lowest at the maximum of the plant area density



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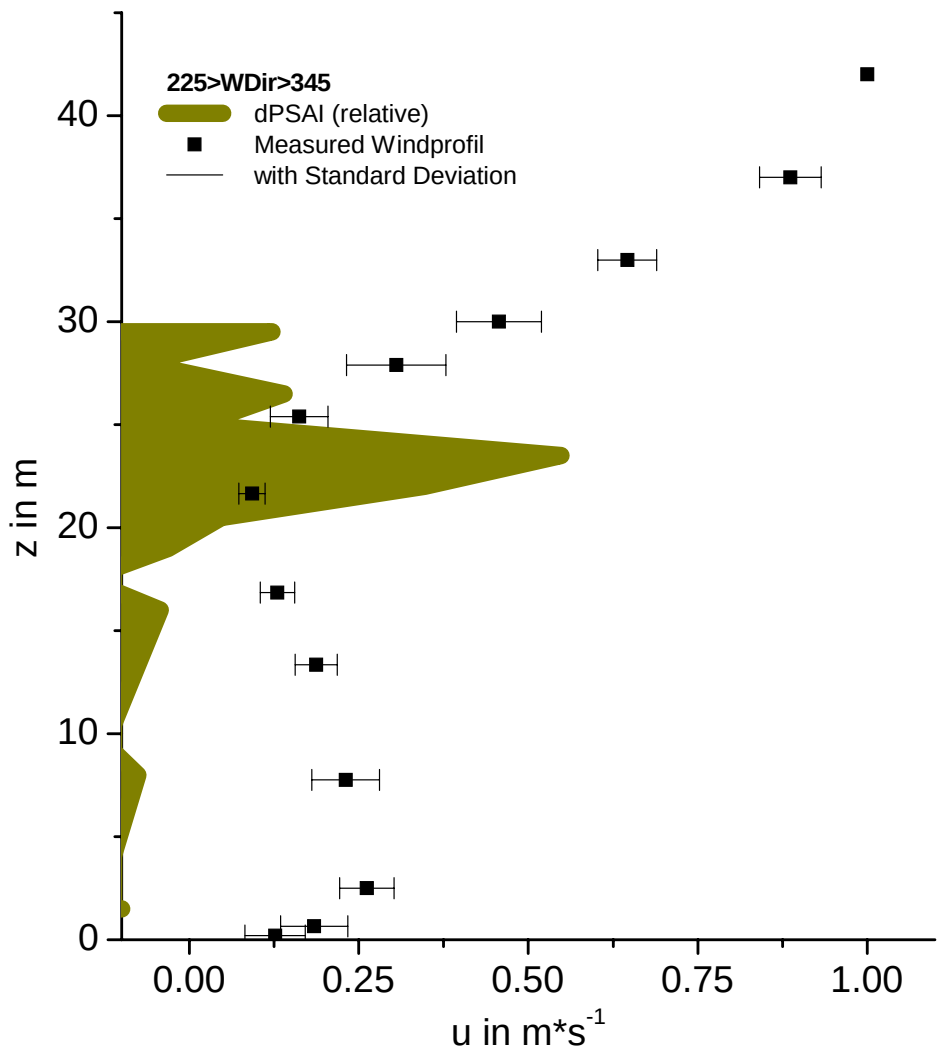
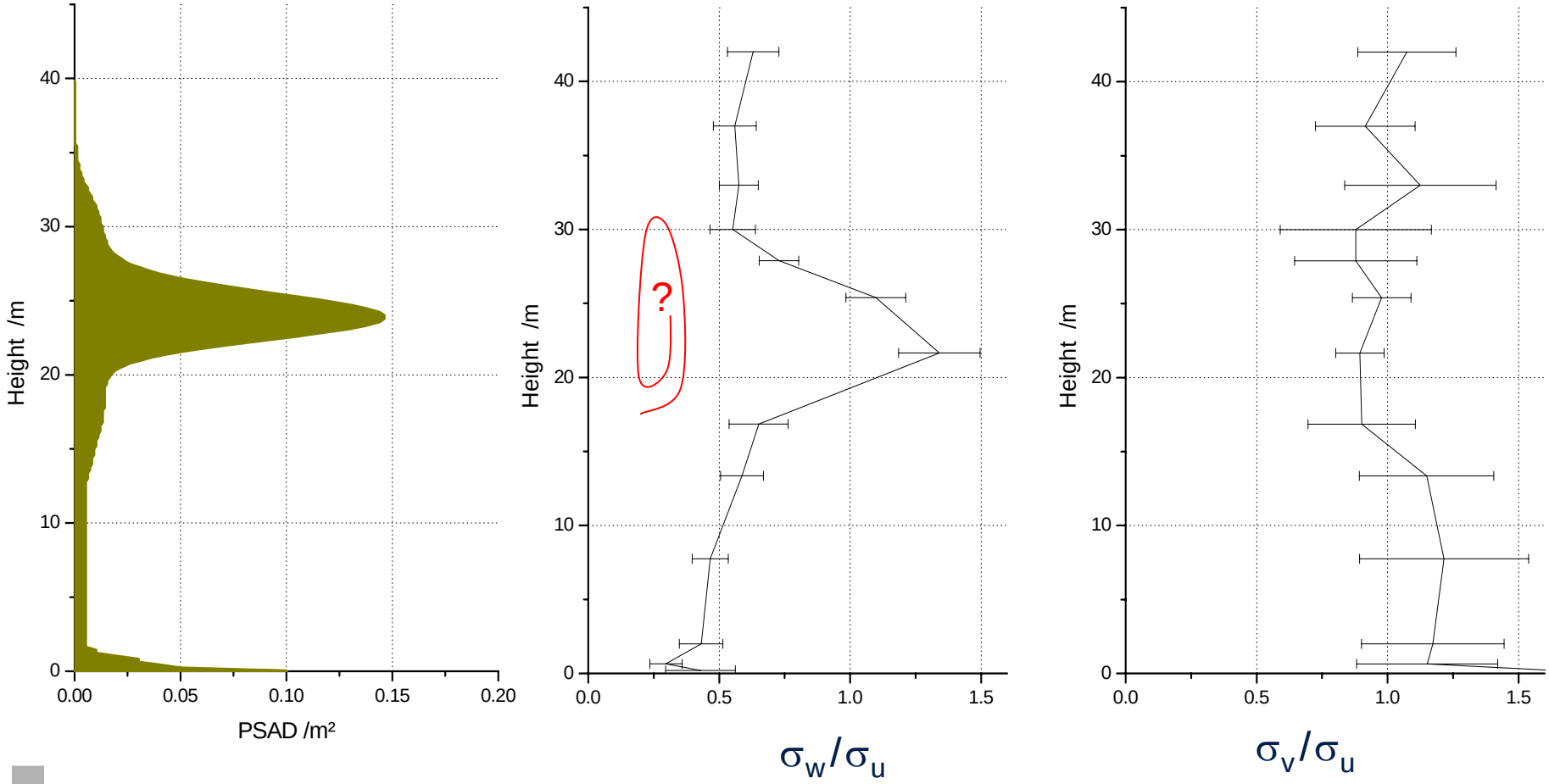


Profiles of standard deviations

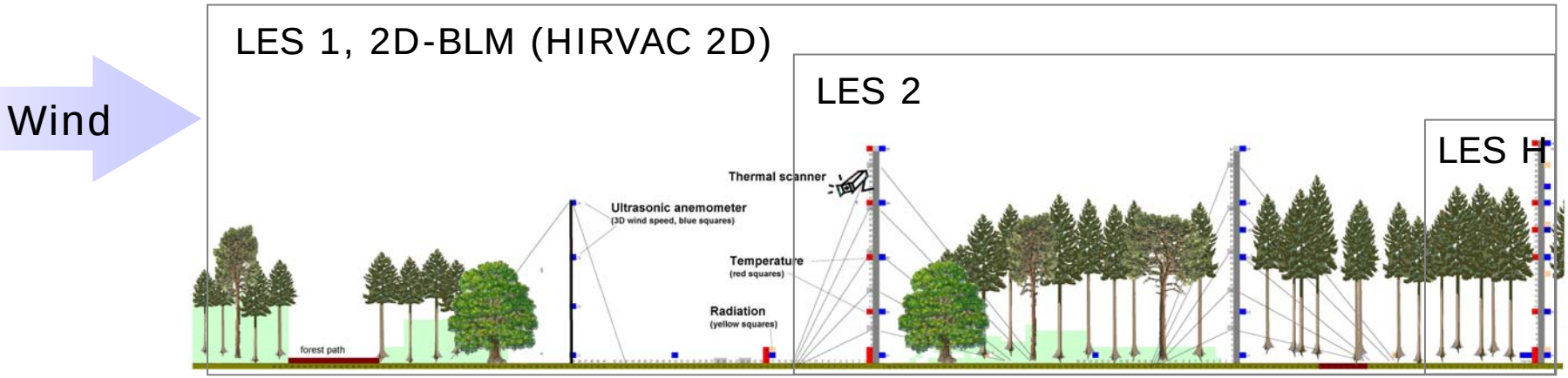


Project: Metström – TurbEFA

Turbulent Exchange processes between Forested areas and the Atmosphere

Field study

- Start: 01.04 2008
- “Real” data assessment



Masts at 4 positions on a west-east transect

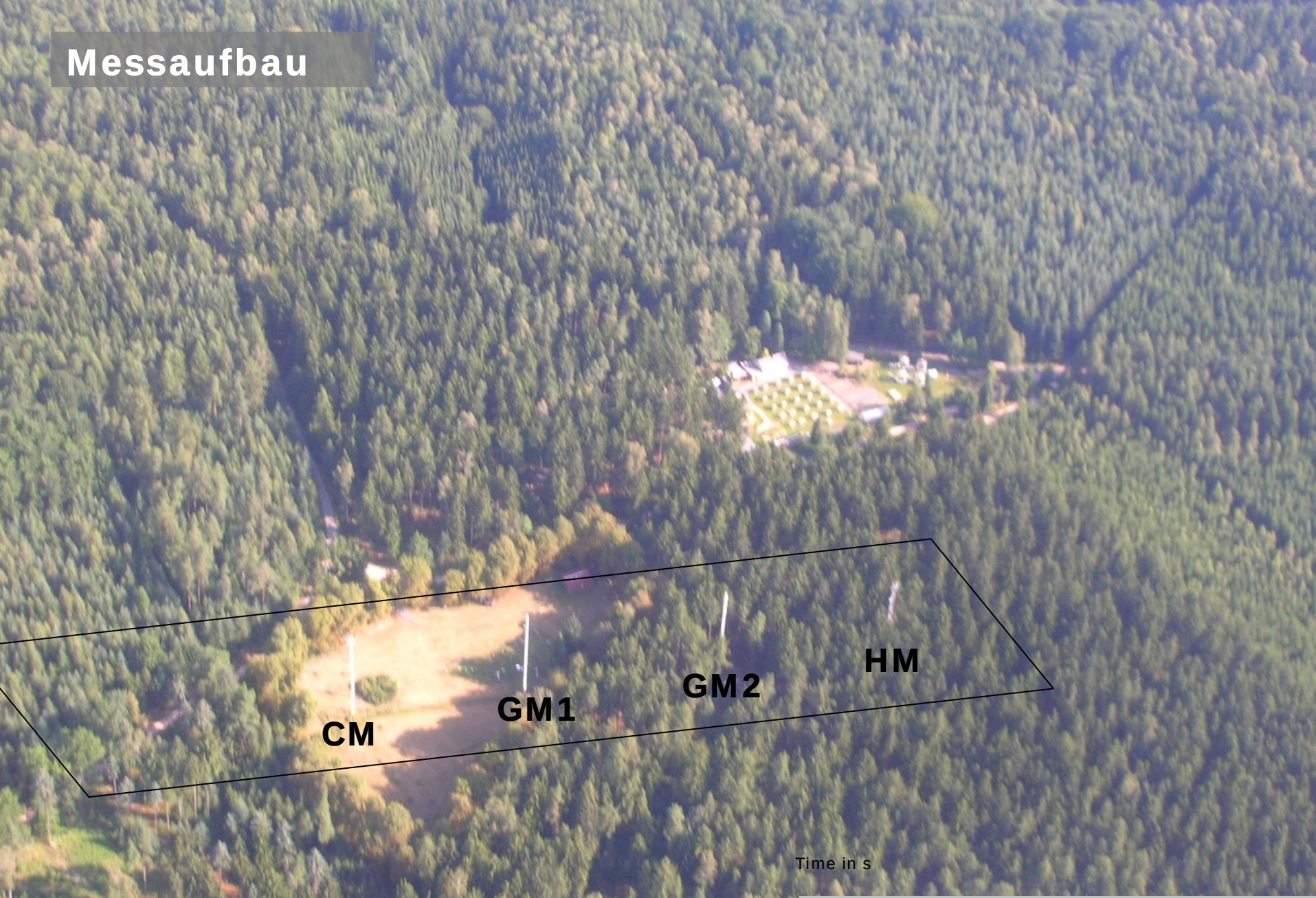
Distance: 50m - 60m

Heights: 30m, 40m, 40m, 42m

Instrumentation used in this study: 27 ultrasonic anemometers (Gill /Young/ Metek) on 32 positions

synchronous registration and storage of 20 Hz raw data from 5/2008 to 5/2009

Messaufbau



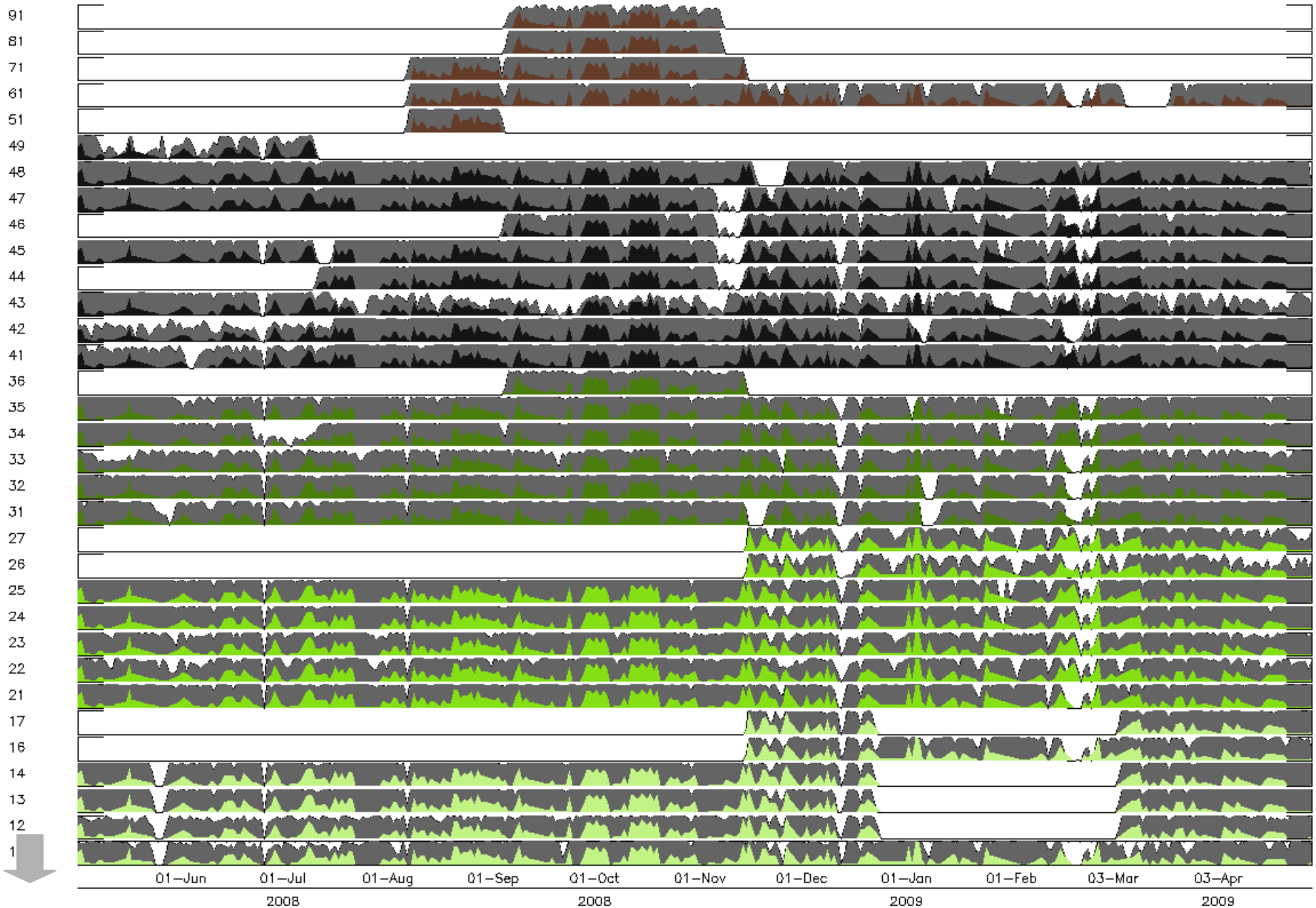
Masts and the model domain
(W. Junkermann, 07/2008)

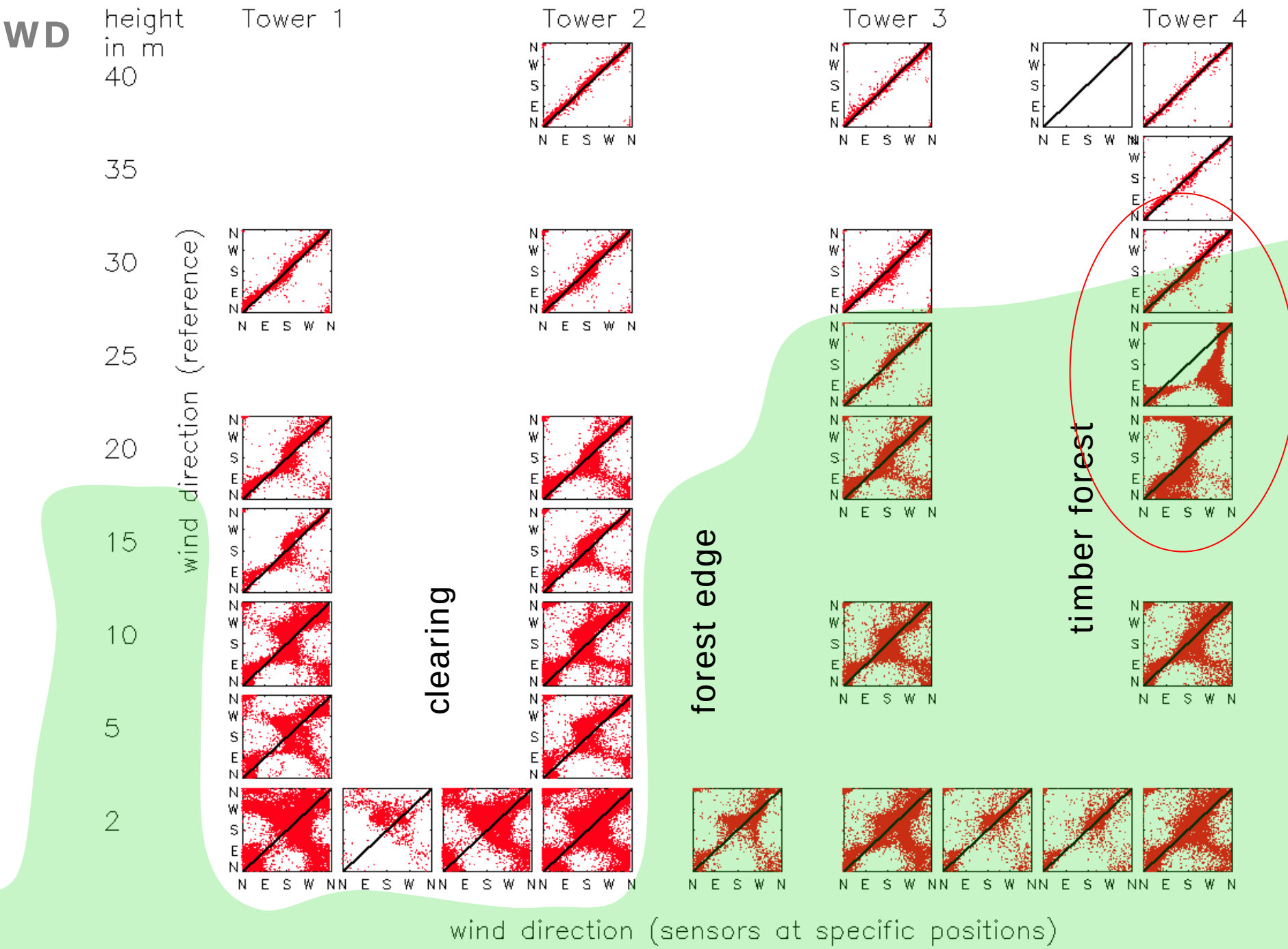
Messaufbau

Messaufbau

Sonic Data

8000 h -> neutrale Fälle (farbig) -> davon West Wind < 500 h

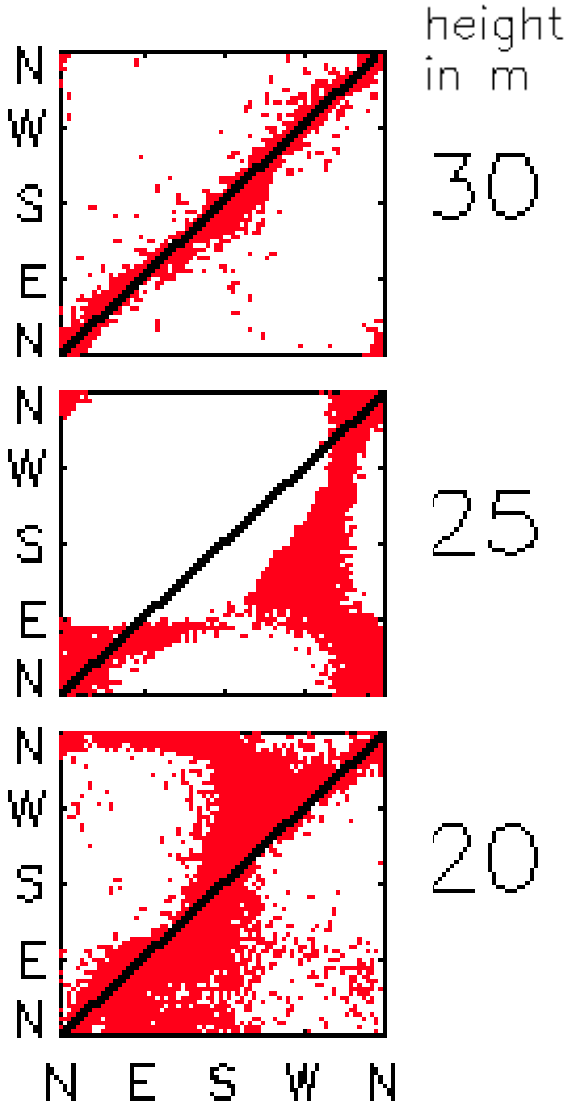



WD
height in m
Tower 1
Tower 2
Tower 3
Tower 4
40
35
30
25
20
15
10
5
2
wind direction (reference)
N W S E N
N E S W N
clearing
forest edge
timber forest
wind direction (sensors at specific positions)

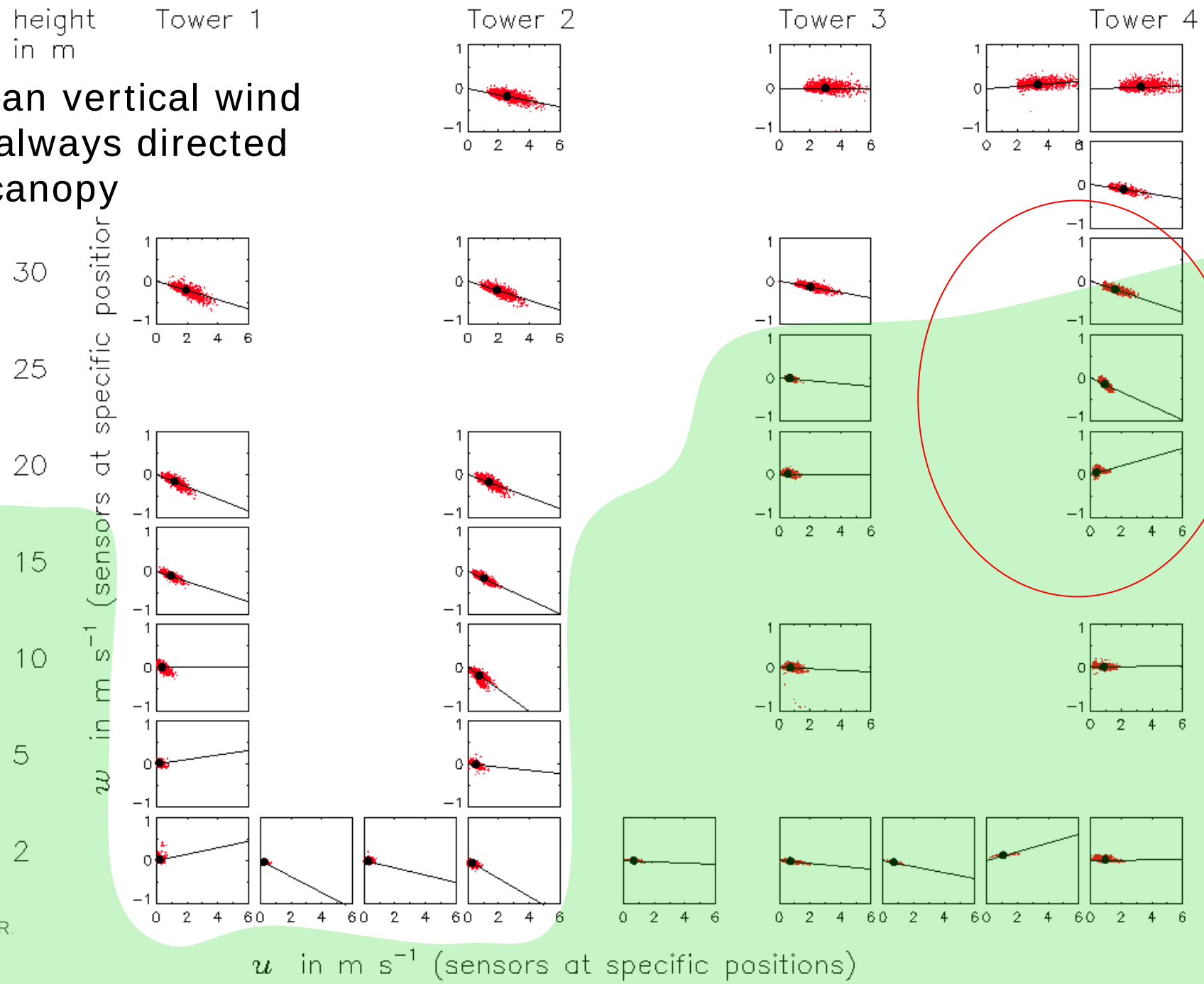
Spatial representativeness of wind measurements in dense canopies

- Wind direction is influenced by roughness elements near the sensor
- Vertical profiles of horizontal wind speed are very heterogeneous and depend on the wind direction
- Sensors (towers) are mostly placed at open spaces
  - ➔ Resulting in an overestimation of the wind speed

View to the west

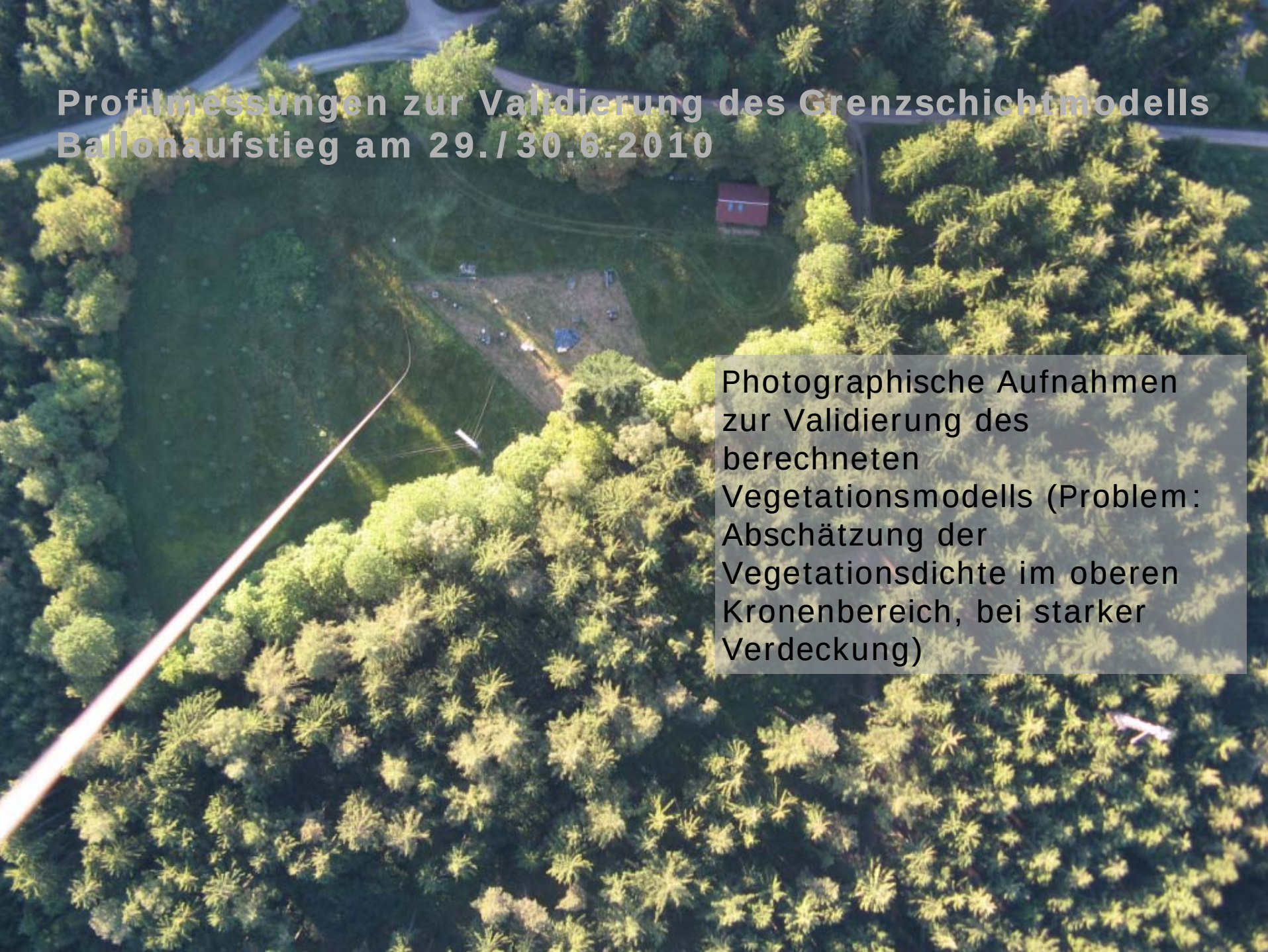


The mean vertical wind seems always directed to the canopy



R.

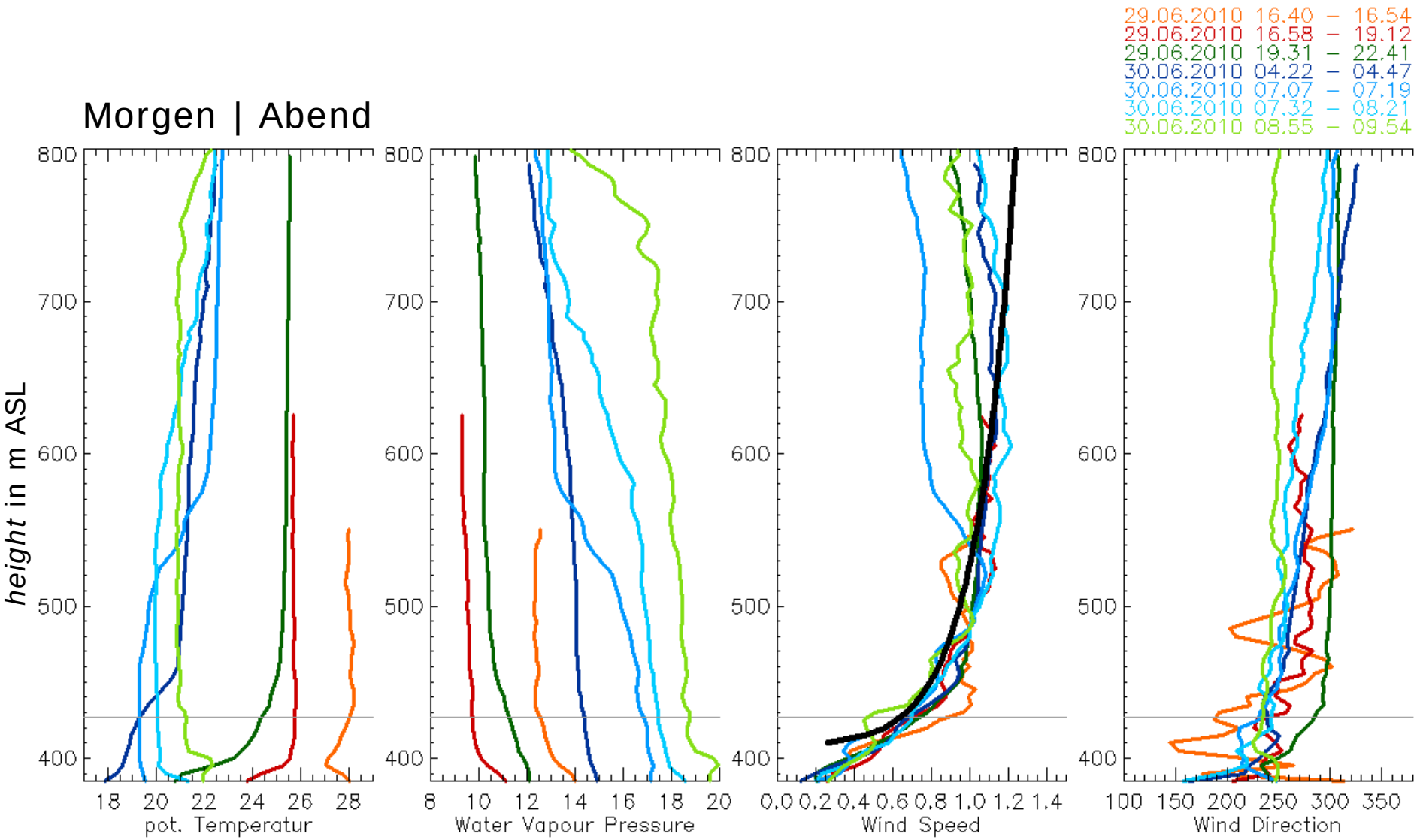
Profilmessungen zur Validierung des Grenzschichtmodells
Ballonaufstieg am 29./30.6.2010



Profilmessungen zur Validierung des Grenzschichtmodells
Ballonaufstieg am 29./30.6.2010

Photographische Aufnahmen zur Validierung des berechneten Vegetationsmodells (Problem: Abschätzung der Vegetationsdichte im oberen Kronenbereich, bei starker Verdeckung)

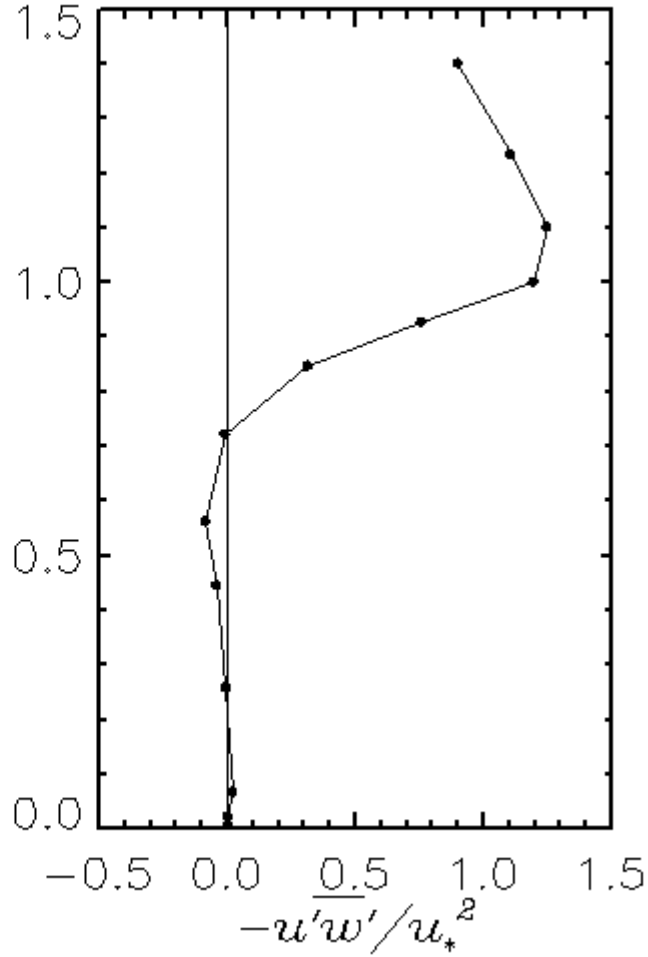
Profilmessungen zur Validierung des Grenzschichtmodells



Bestimmung von Modellparametern: Drag coefficient

$$\left| -\frac{d\overline{u'w'}}{dz} \right| = C_D(z)\,a(z)\,u^2(z)$$

$$\overline{U_i u} = \overline{\sqrt{u^2 + v^2 + w^2} \cdot u}$$

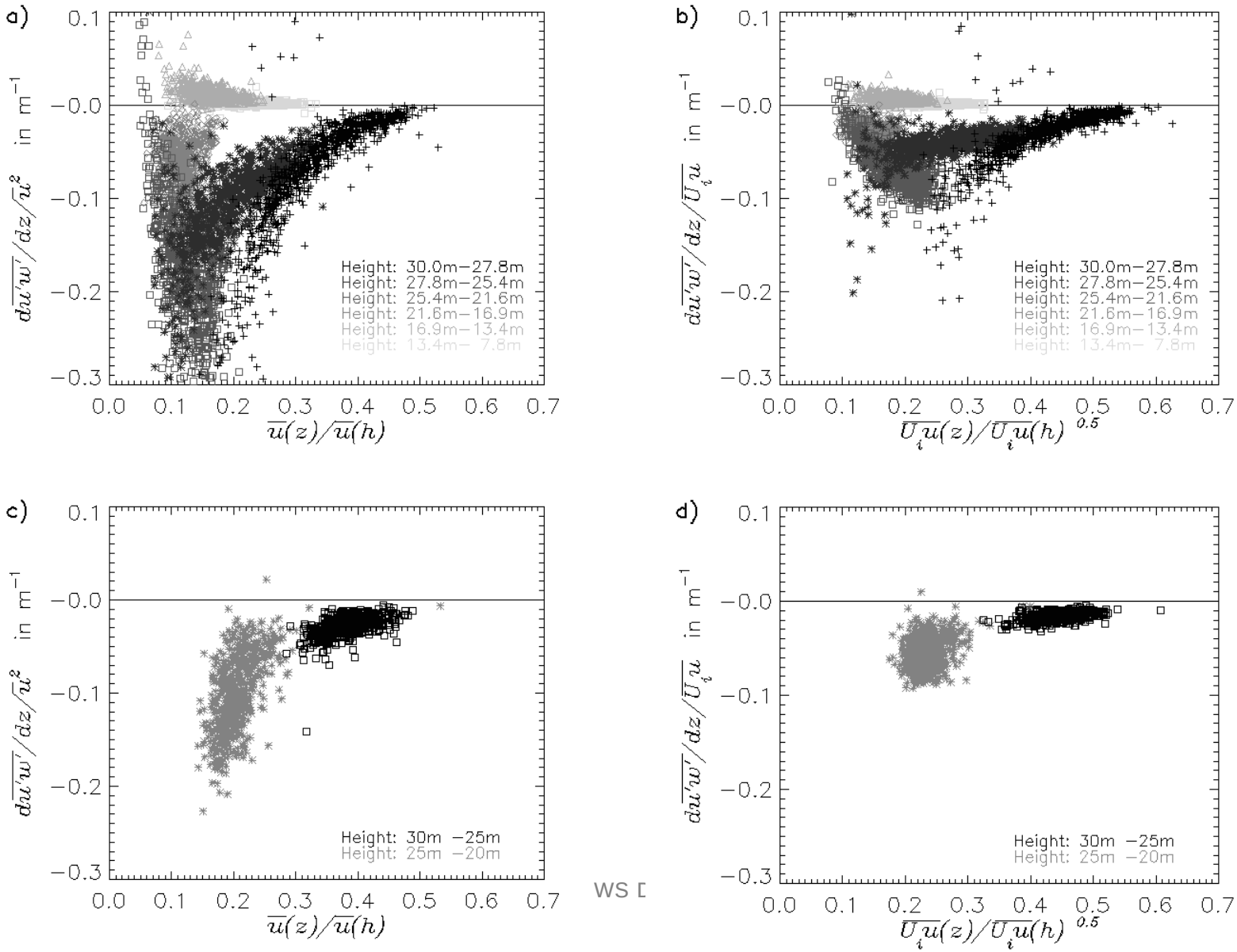


C_D: Abhängigkeit von der Windgeschwindigkeit

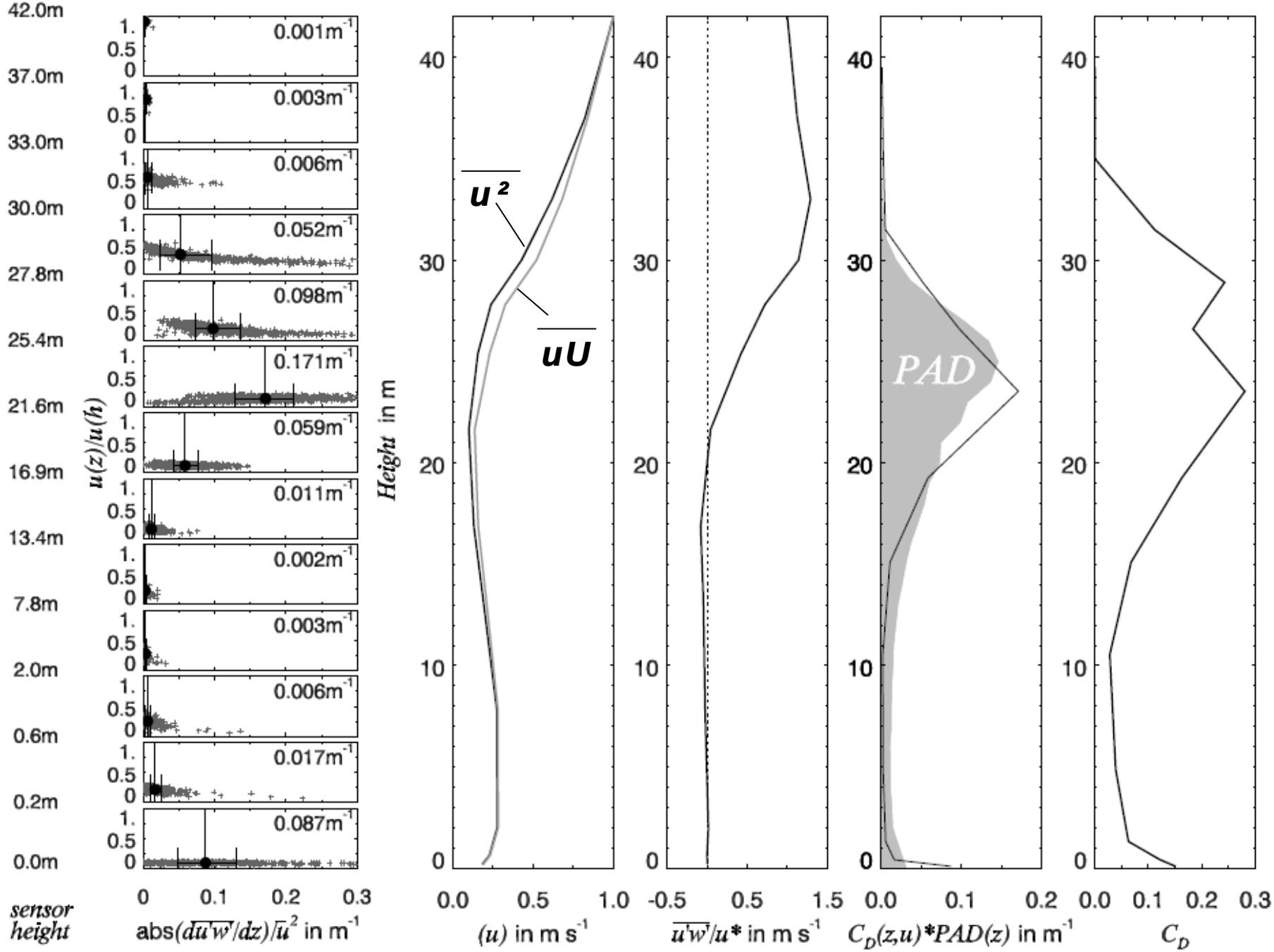
$\overline{u^2}$ $\overline{uU}$

WinCanop, 2007

TurbEFA 2008/09



C_D: Abhängigkeit vom PAD



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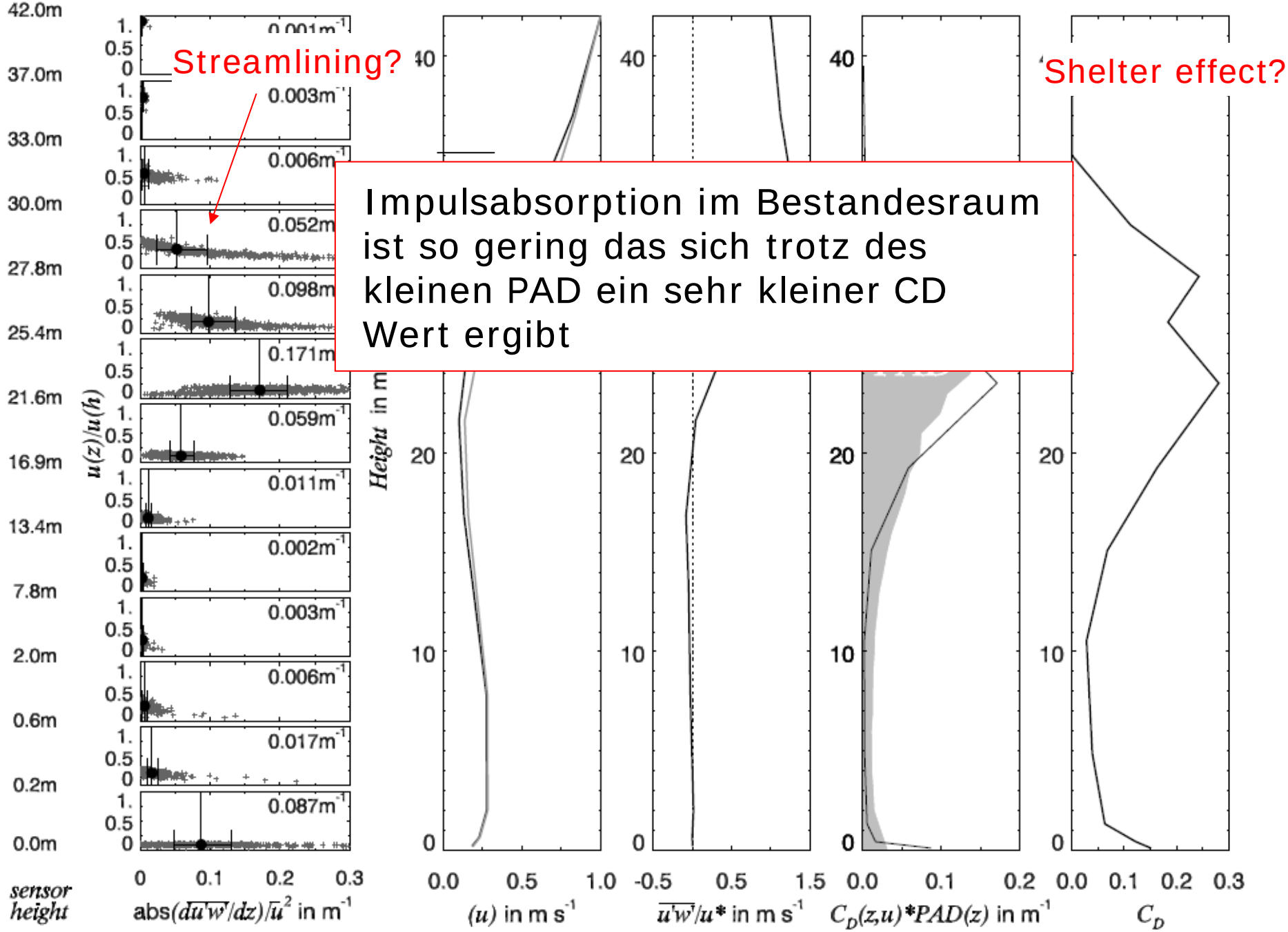
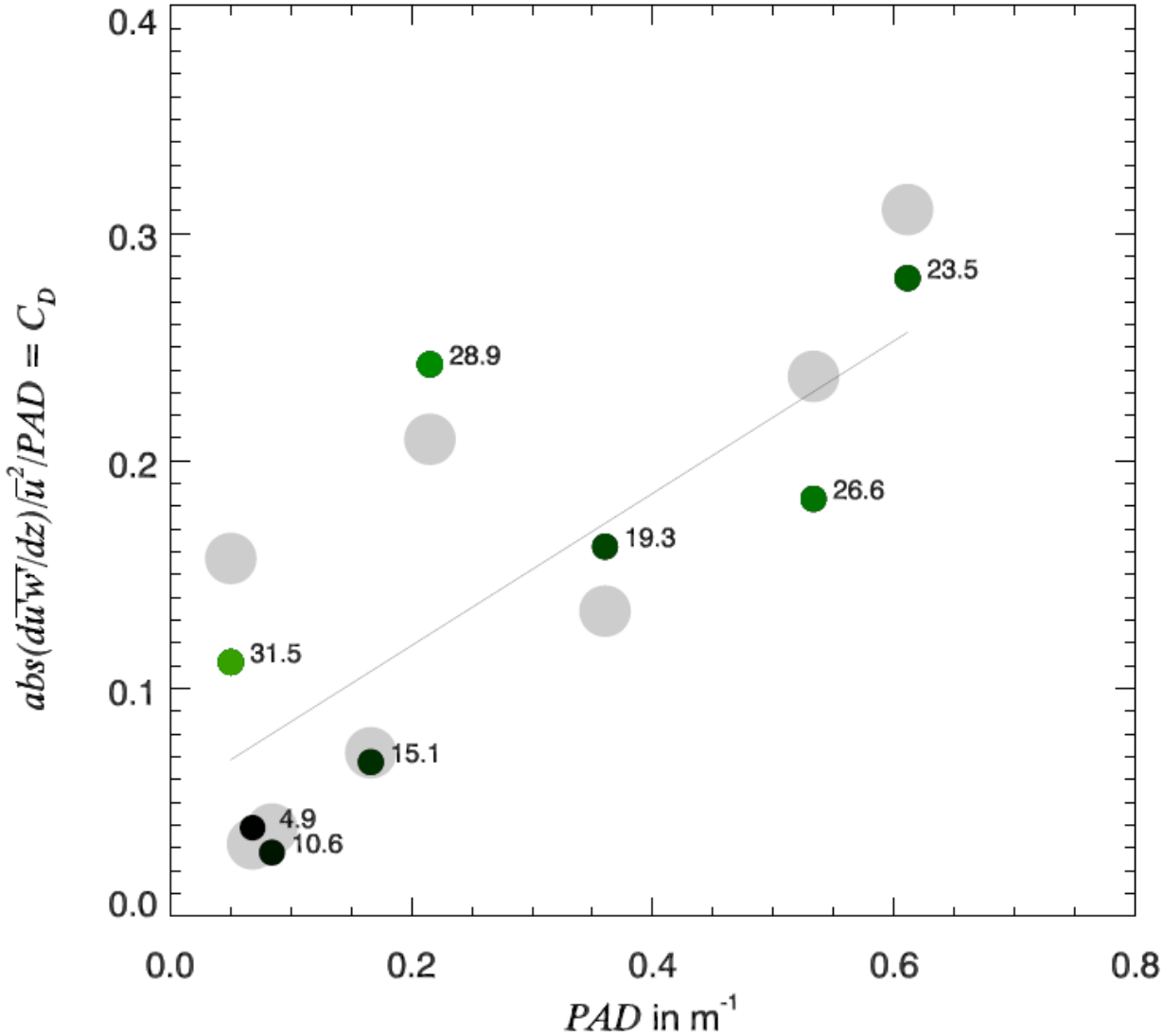


C_D: Abhängigkeit vom PAD

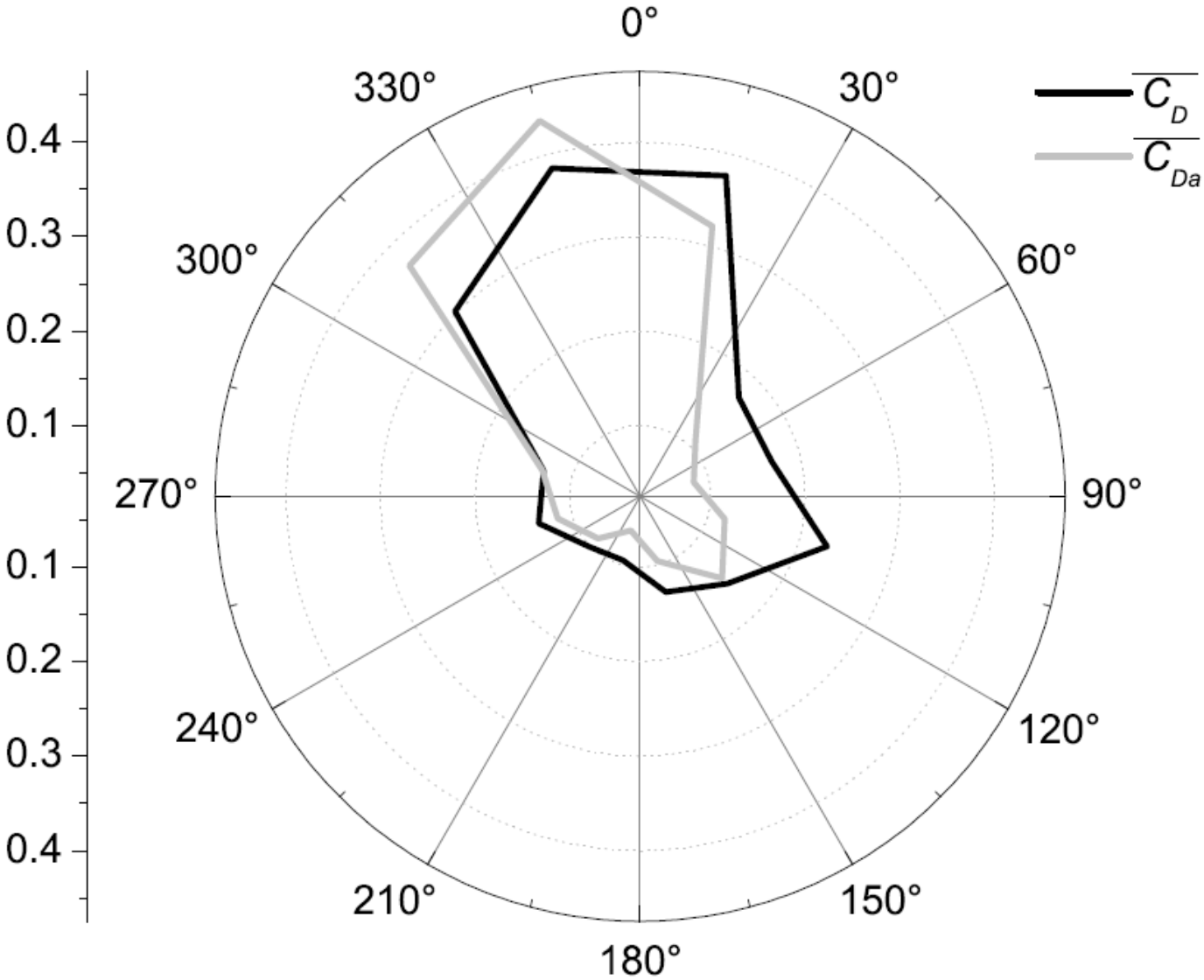
$$C_D = C_{D,0} PAD^n \overline{u}^m$$

$$n = 0.57$$

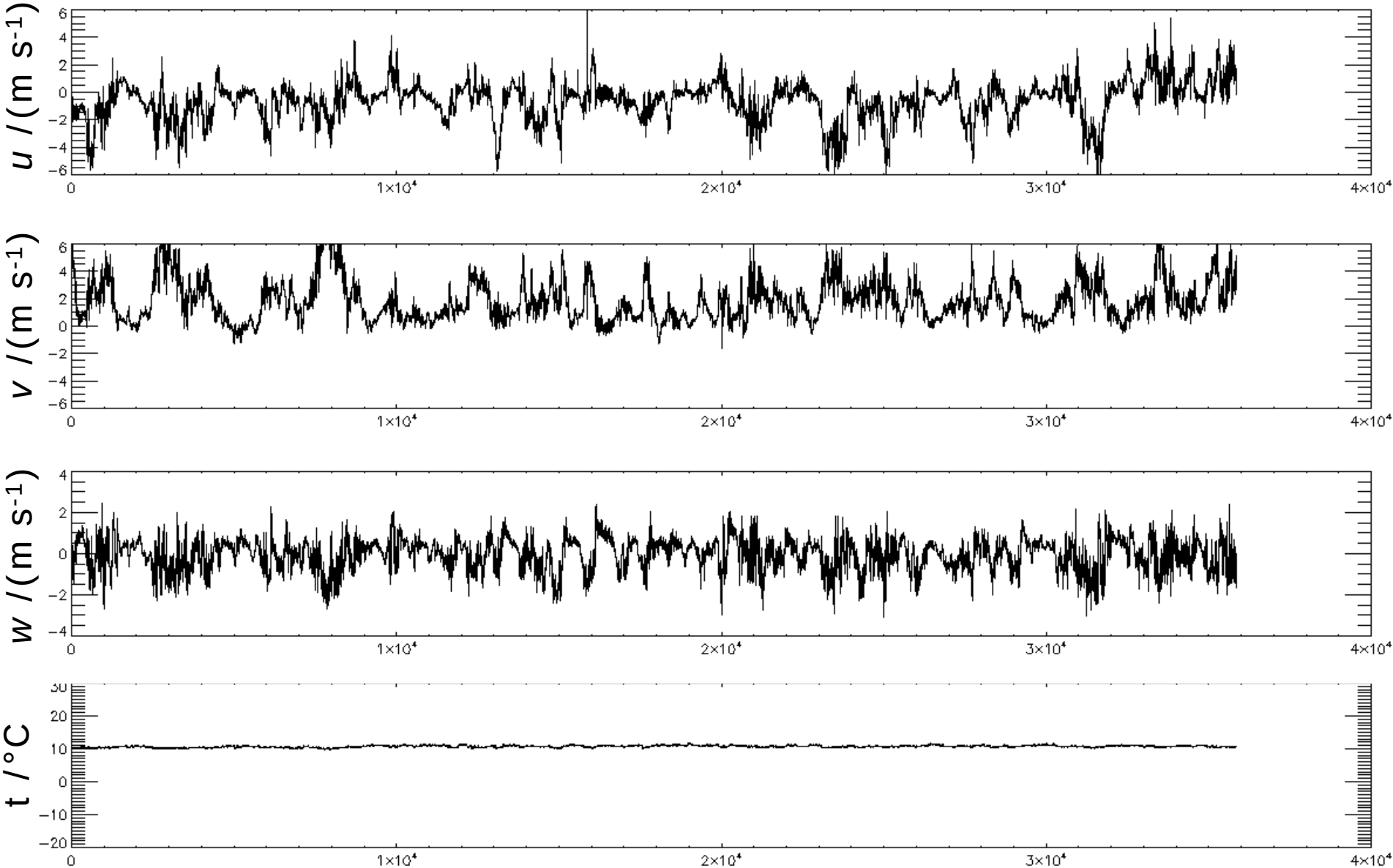
$$m = -0.8$$



C_D: Abhängigkeit von der Windgeschwindigkeit



Abhängigkeit statistischen Kenngrößen vom Mittlungsintervall



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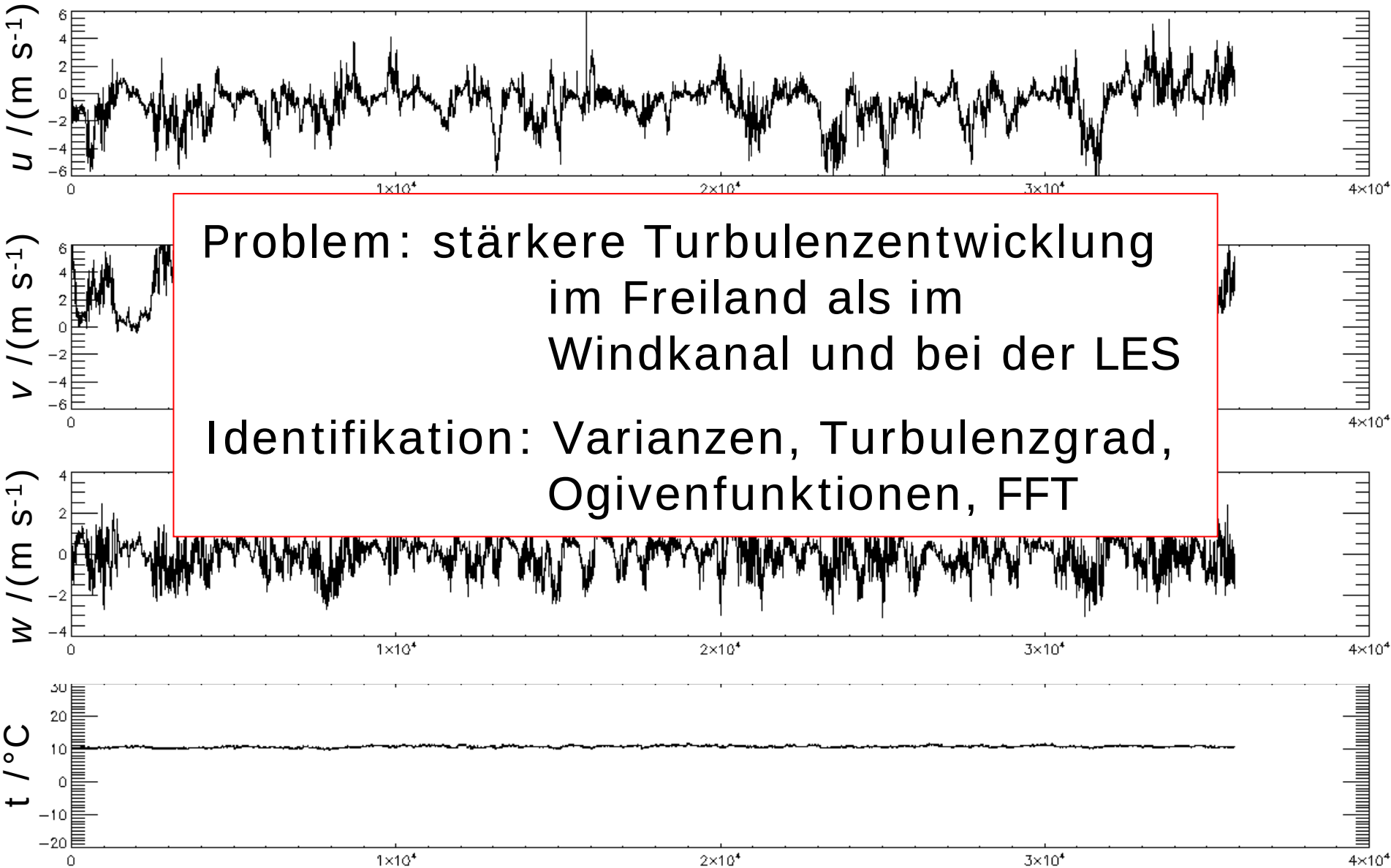


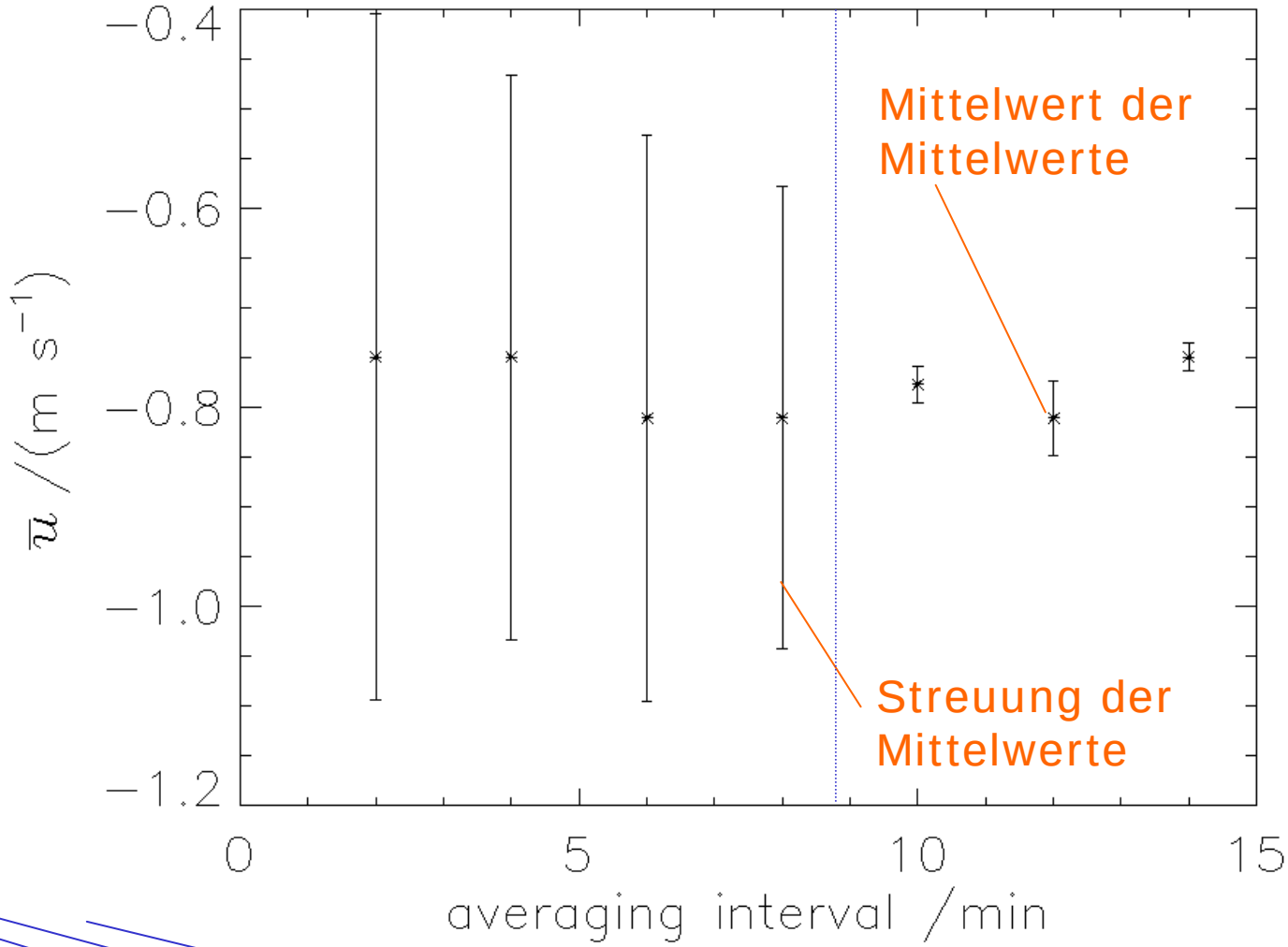
Problem: stärkere Turbulenzentwicklung im Freiland als im Windkanal und bei der LES

Identifikation: Varianzen, Turbulenzgrad, Ogivenfunktionen, FFT

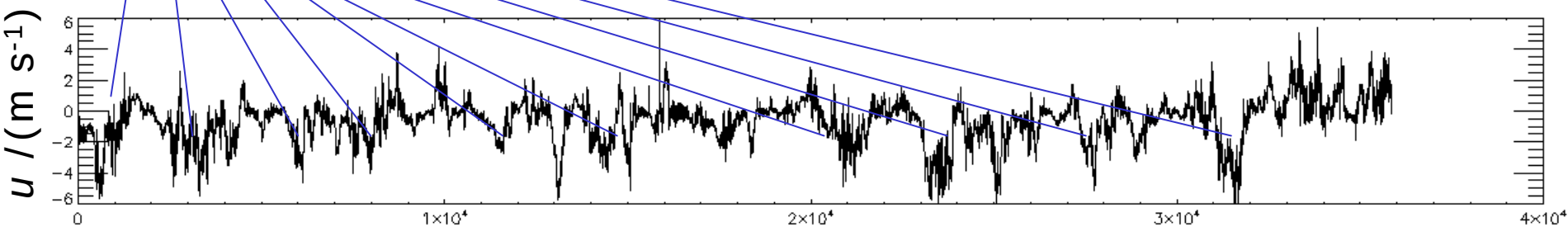
“Längswind”

Unterschiedliche Mittlungsintervalle

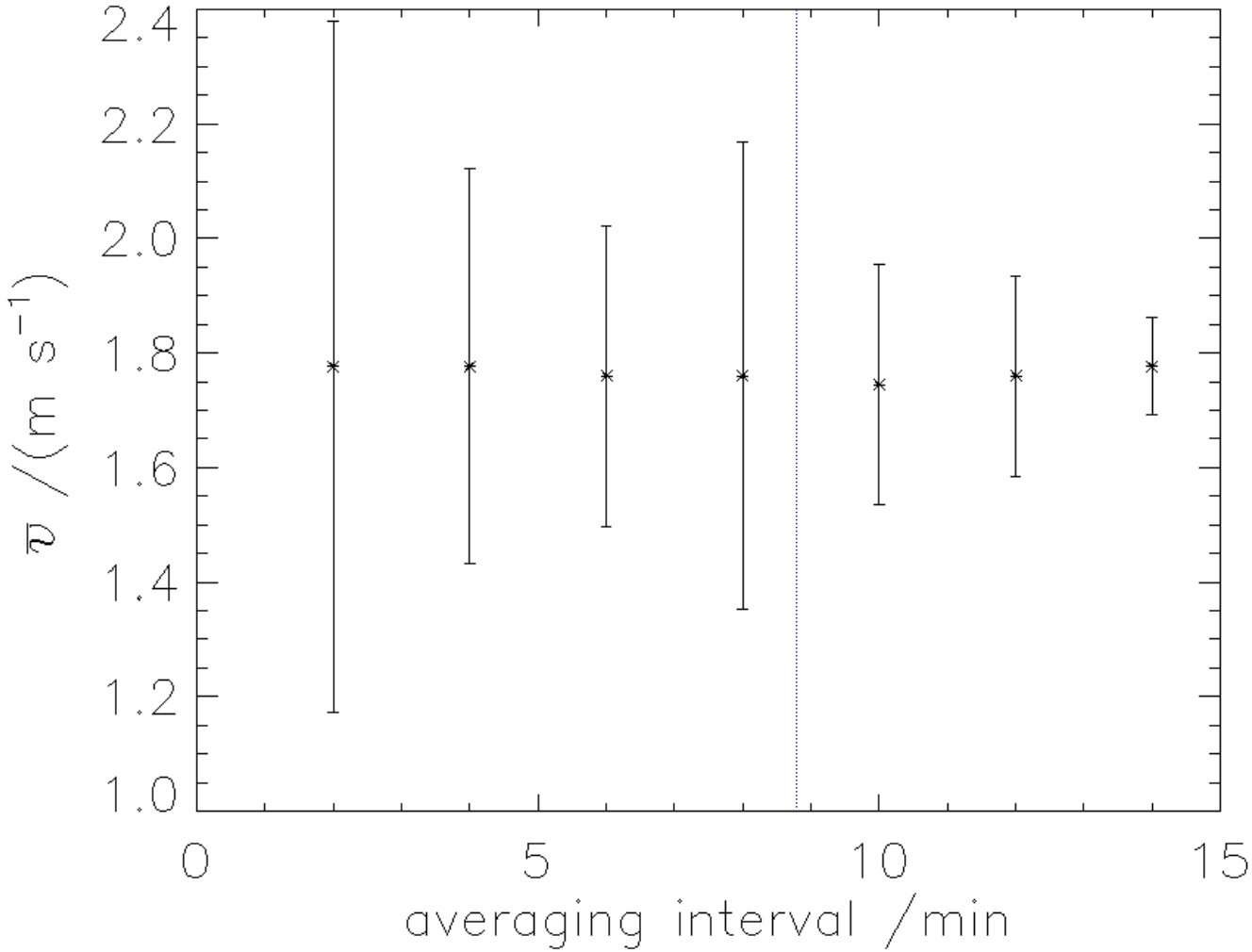
2 min … 14 min

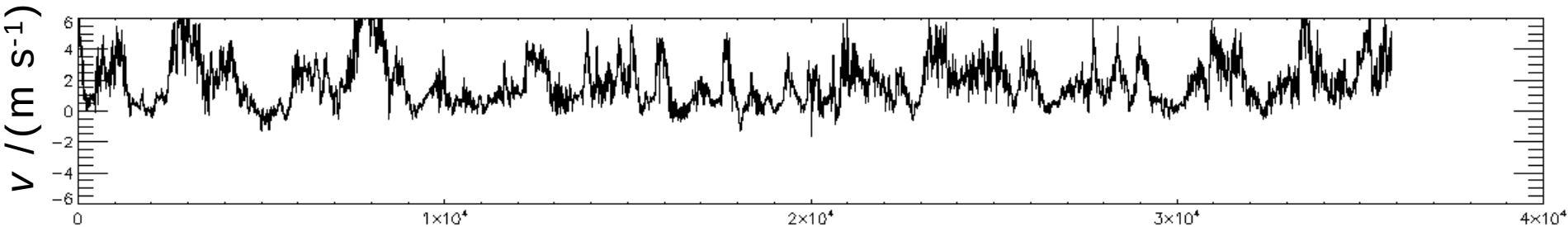


Böen im Frequenz-bereich von 2-8 min

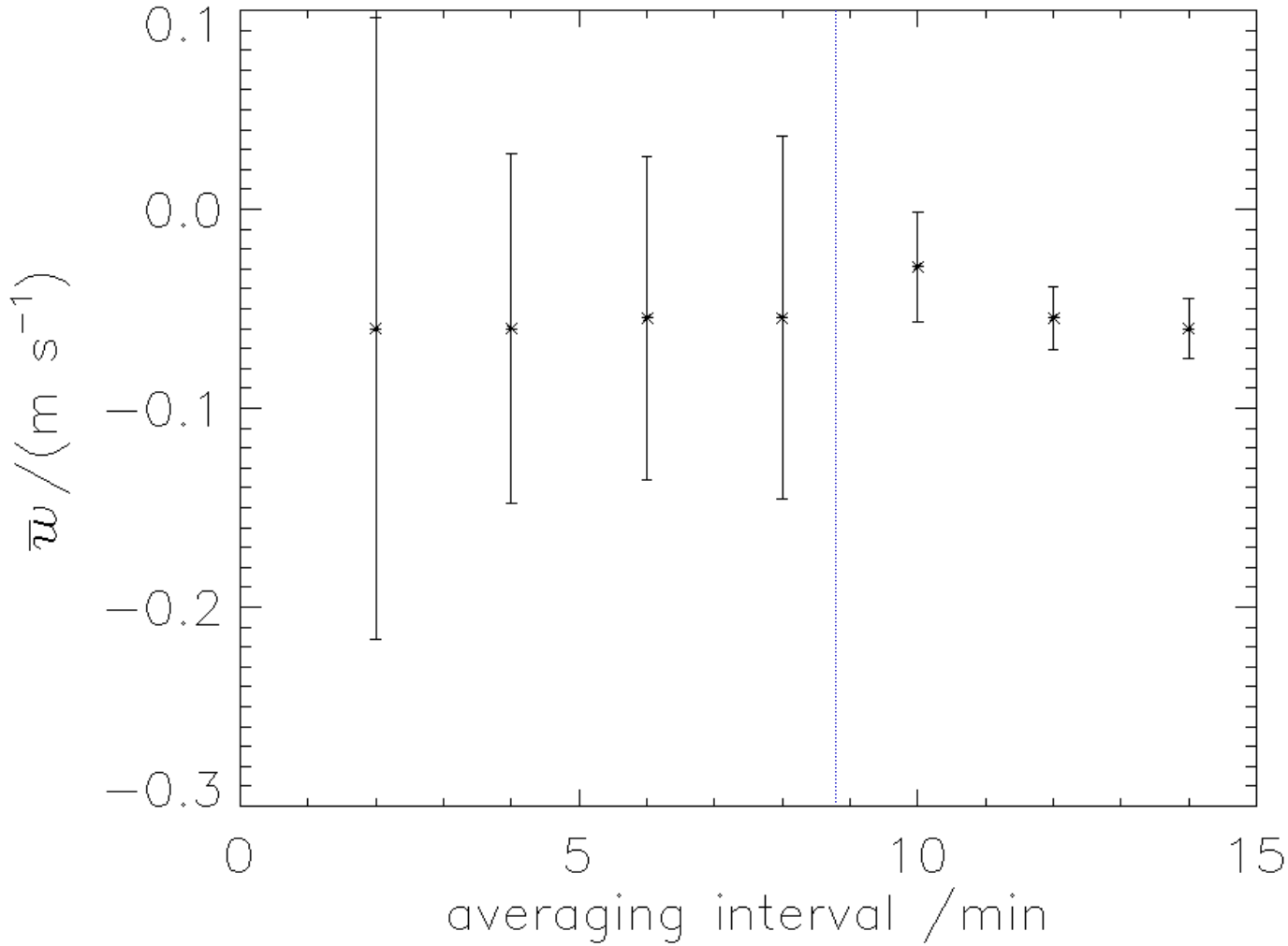


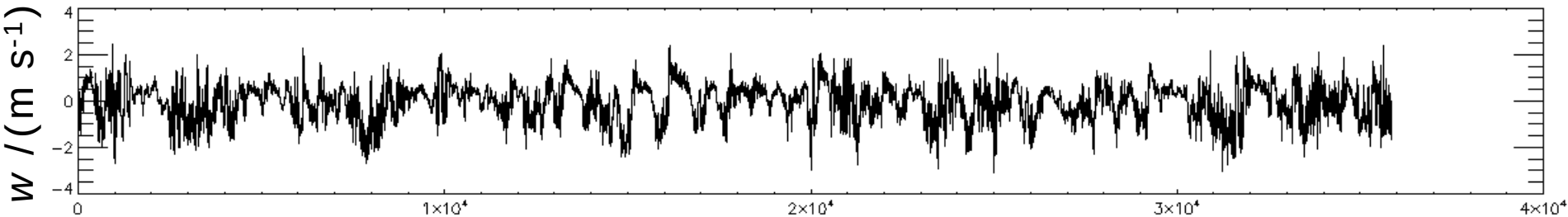
“Querwind’


2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
$\bar{v}$ /(m s^{-1})
0
5
10
15
averaging interval /min


v /(m s^{-1})
6
4
2
0
−2
−4
−6
0
1×10^4
2×10^4
3×10^4
4×10^4

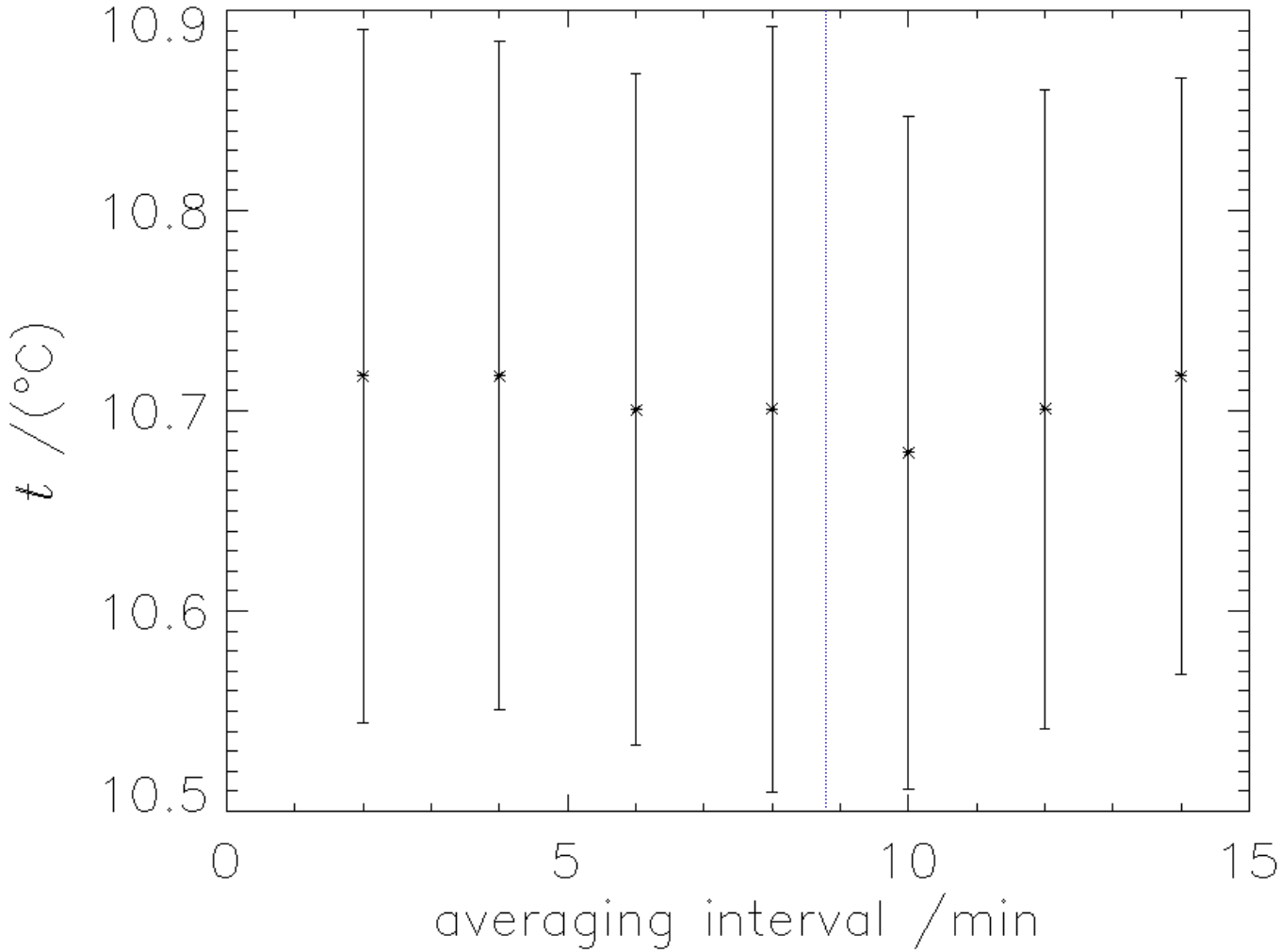
Vertikal Wind

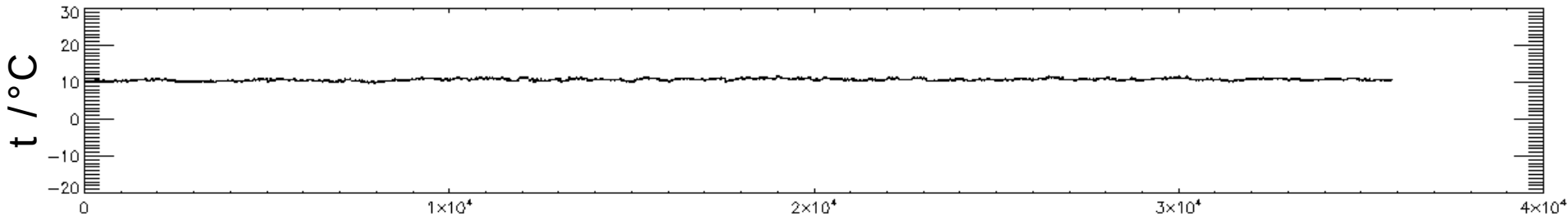




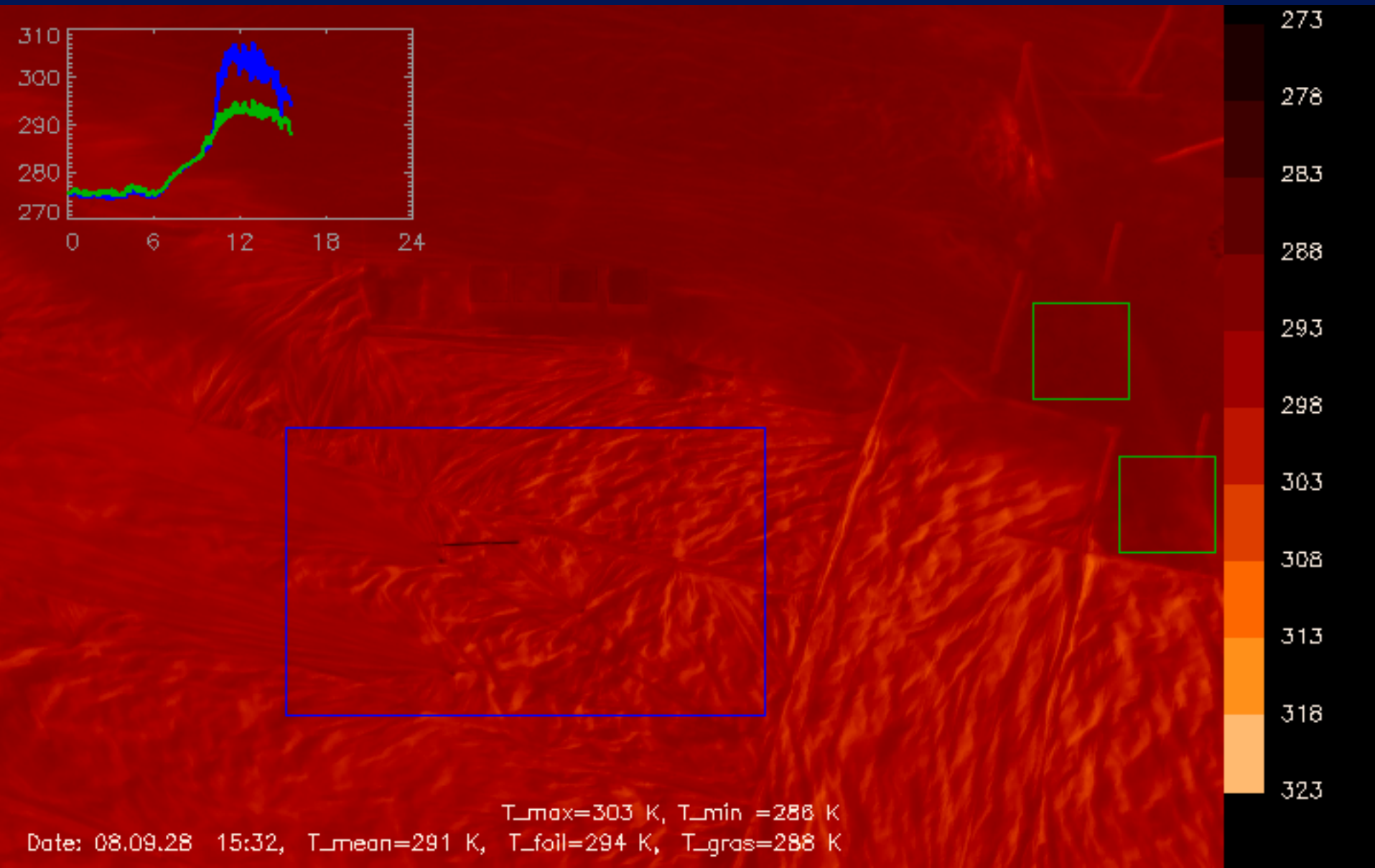
Temperatur

thermisch
homogener
Standort?





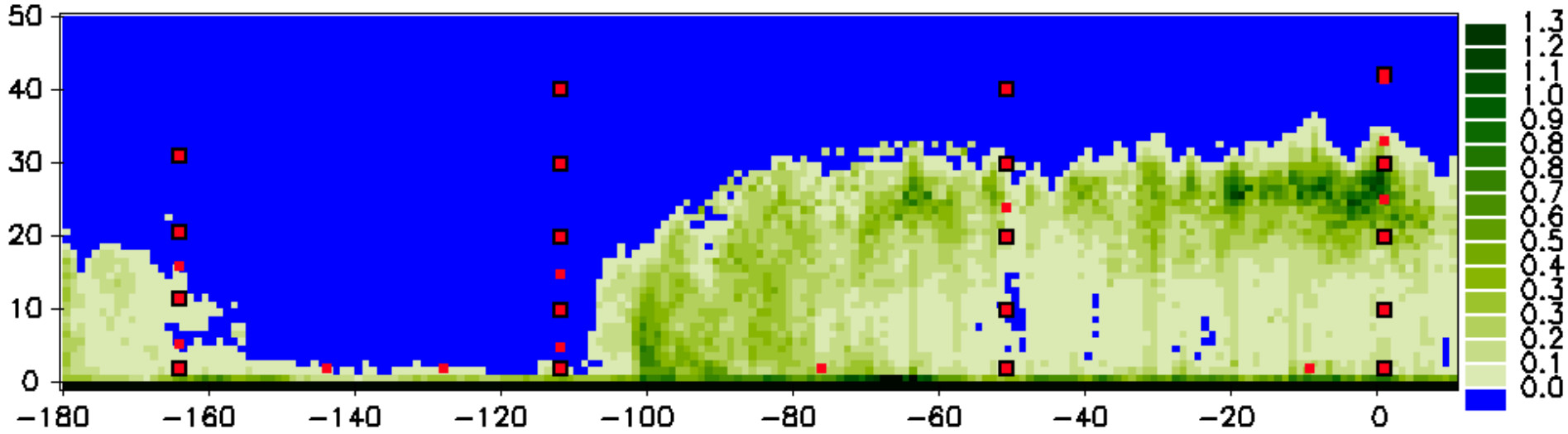
Quellflächenexperiment: Black Days



Schlussfolgerung und Fragen

- Lokale Windrichtung und –geschwindigkeit kann sich stark vom räumlich gemittelten Wind unterscheiden. Es wurden systematische Beeinflussungen im Kronenraum gefunden.
  - Können kleinskalige Modellierung (lokale Gitterverfeinerung) helfen die Messungen im Bestand zu interpretieren?

- C_D ist offensichtlich eine Funktion der Bestandesstruktur (und der Windgeschwindigkeit)
  - Kann das Quellvolumen für die lokale Turbulenz, die an einem Punkt im Bestand gemessen wird, aus der Modellierung bestimmt werden?



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- In den häufigsten Fällen wird in mit Mittlungsintervall von 30 min – 60 min der größte Teil der im Freiland auftretenden Turbulenz erfasst. Eine Verlängerung der Mittlungszeit (Ensemble Mittel) hat keine Senkung des Turbulenzgrades zur Folge.
  - Ist es sinnvoll Zeitreihen für einen Vergleich mit den Modellergebnissen durch geeignete Filter zu glätten (Böen entfernen?)?

Danke für Ihre Aufmerksamkeit