1st LIAISE conference

Spatial temperature measurements using DTS in the LIAISE field campaign

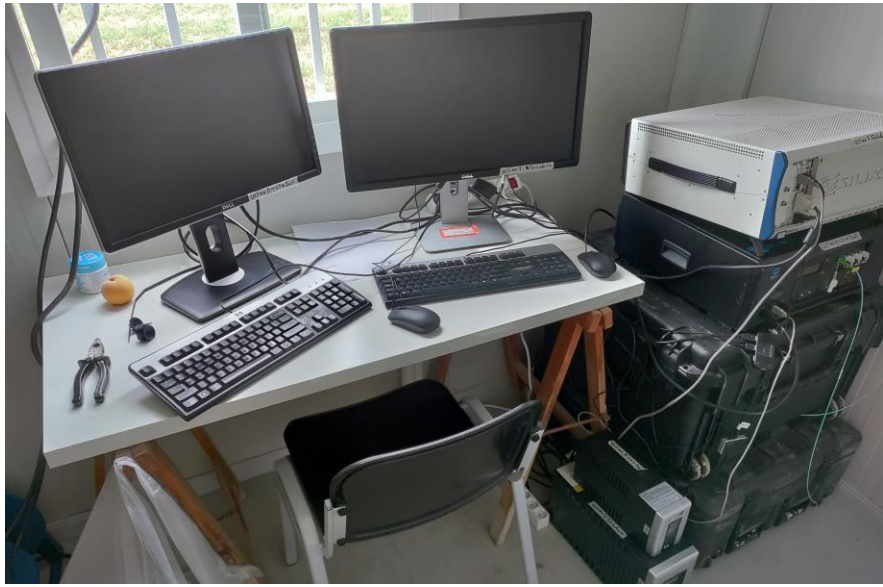
LIAISE-NL

Gijs Vis

Distributed temperature sensing (DTS)

- Fiber optics
- Raman backscattering
  - Temperature dependent
- Pulsed laser
  - Travel time

DTS measures no absolute temperature
Calibration with a reference is needed



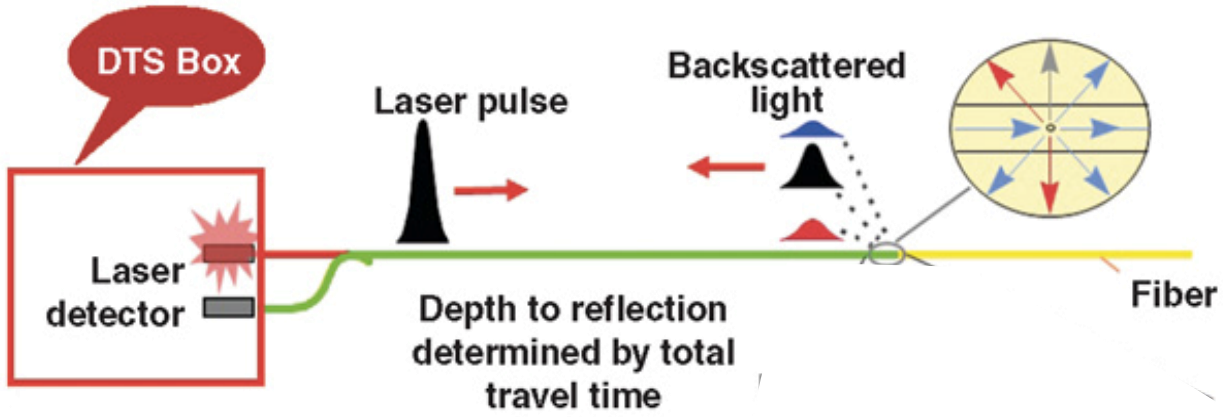


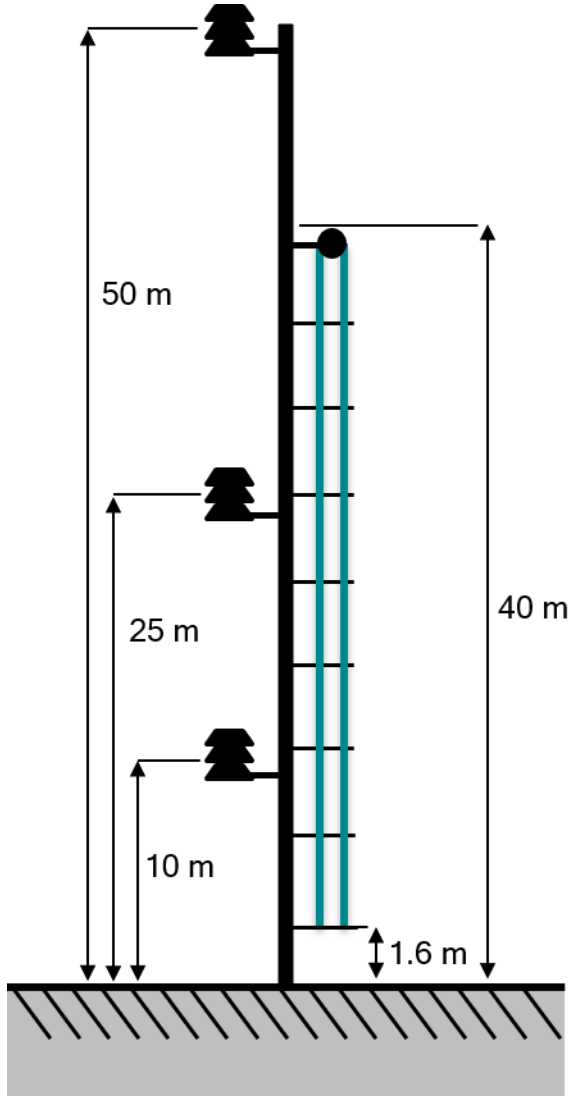
Image: Bart Schilperoort

1. Spatial temperature measurements

50 m mast

25.4 cm and 5 s resolution

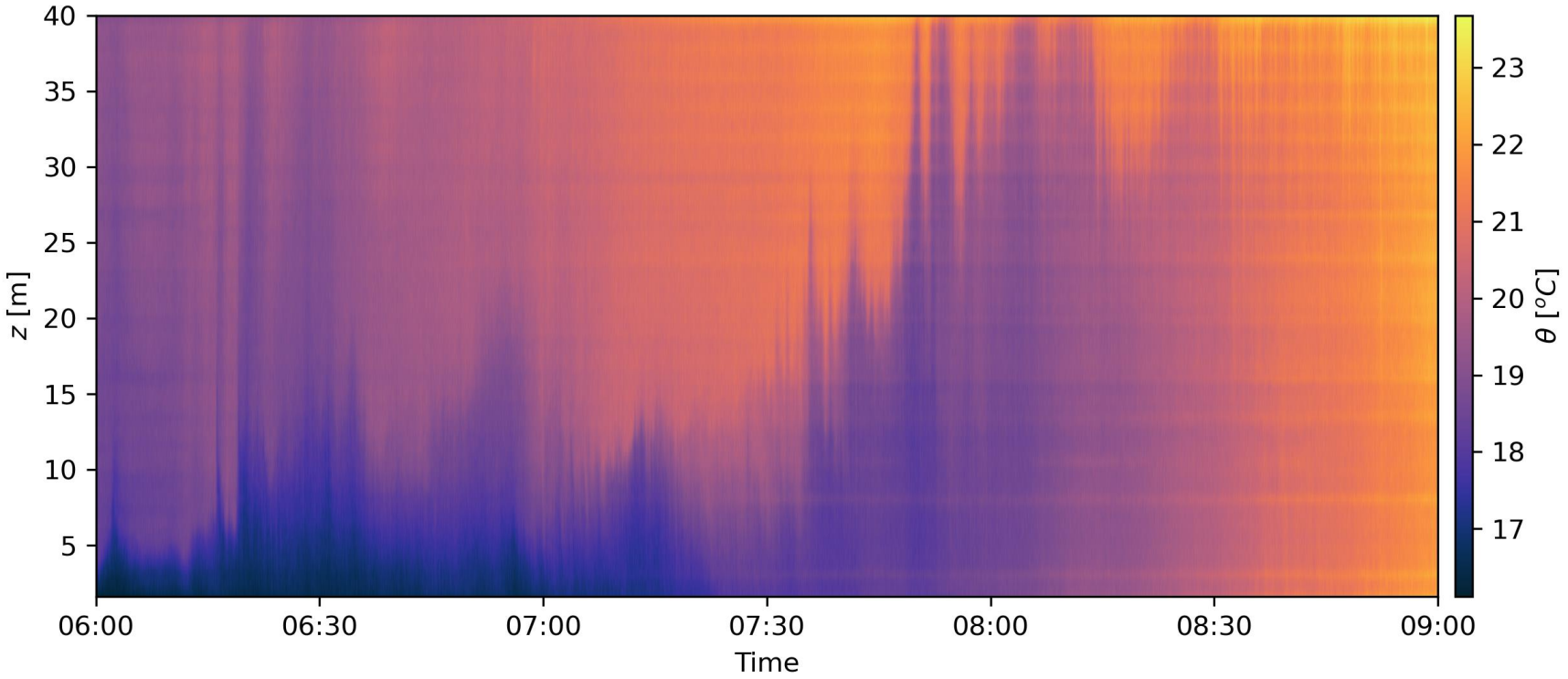
1.6 mm FO cable with Kevlar mantle



1. Spatial temperature measurements

Warm air advection

Measurement limitation: Solar radiative effects

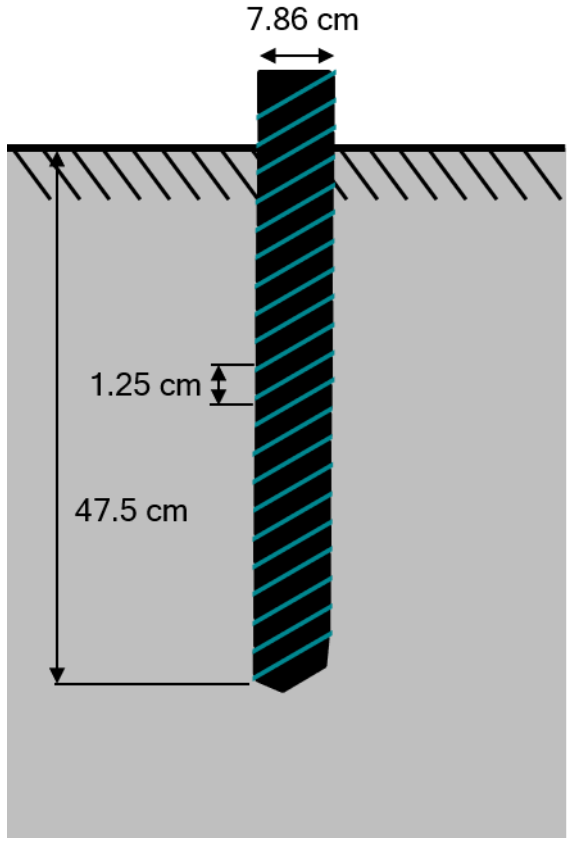


July 21

2. Spatial temperature measurements

Ground coil

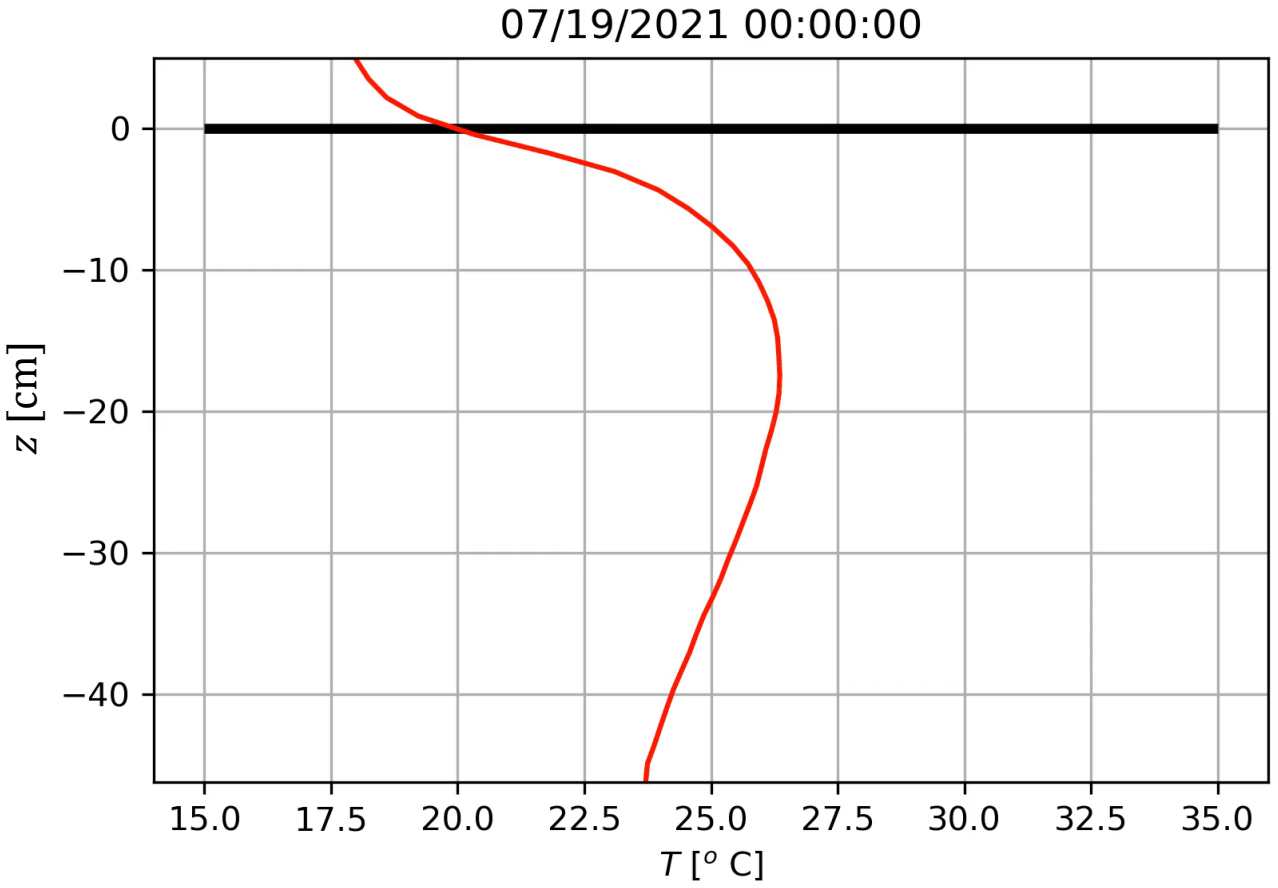
Coiling creates higher vertical resolution



2. Spatial temperature measurements

Soil temperature dynamics

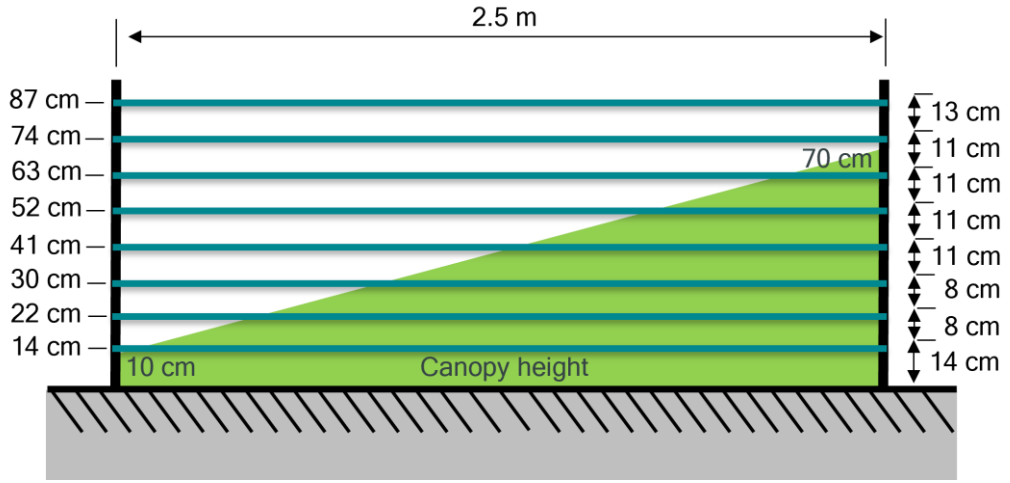
1 cm vertical resolution



3. Spatial temperature measurements

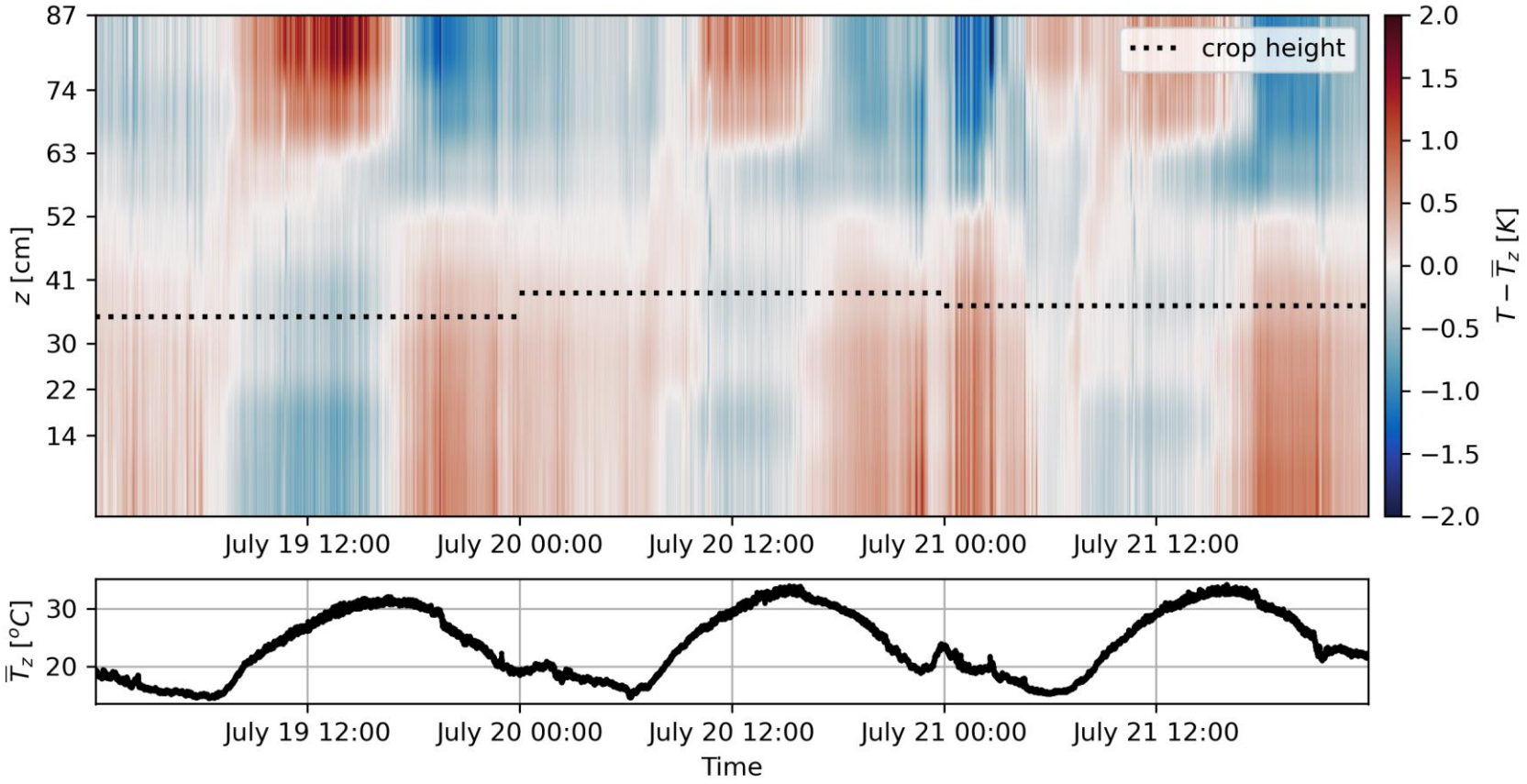
Canopy harp

Horizontally average for each height



3. Spatial temperature measurements

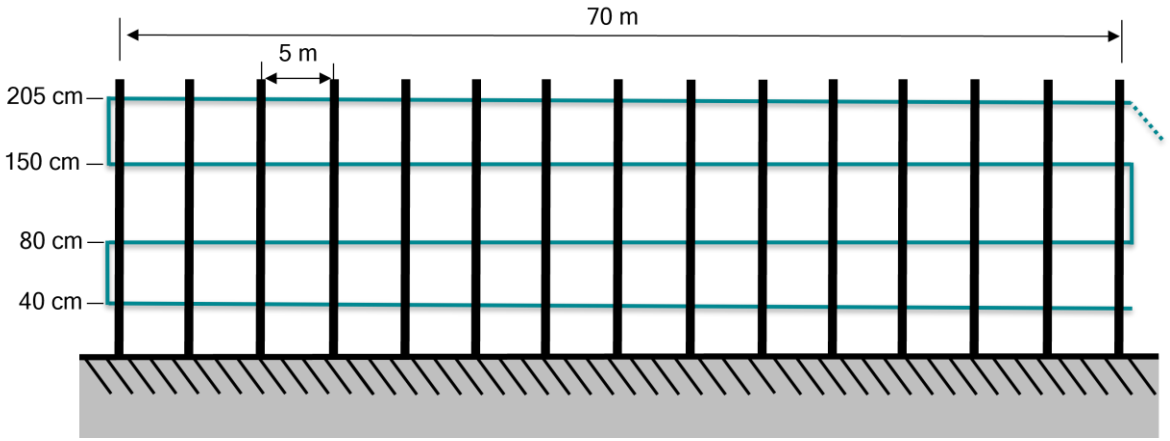
Canopy heat storage



4. Spatial temperature measurements

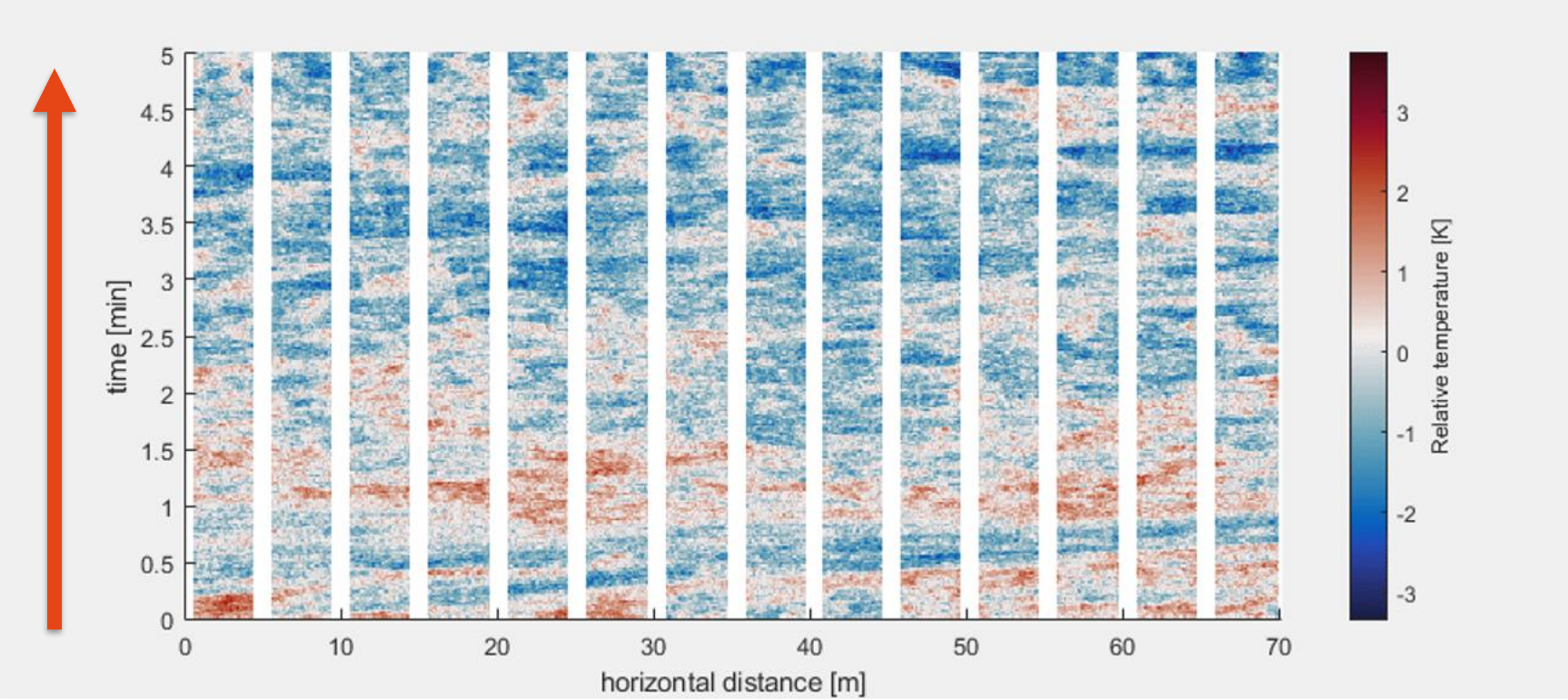
Turbulence harp

- 12.7 cm and 1 s resolution
- 0.5 mm acrylic fiber



4. Spatial temperature measurements

Turbulence harp



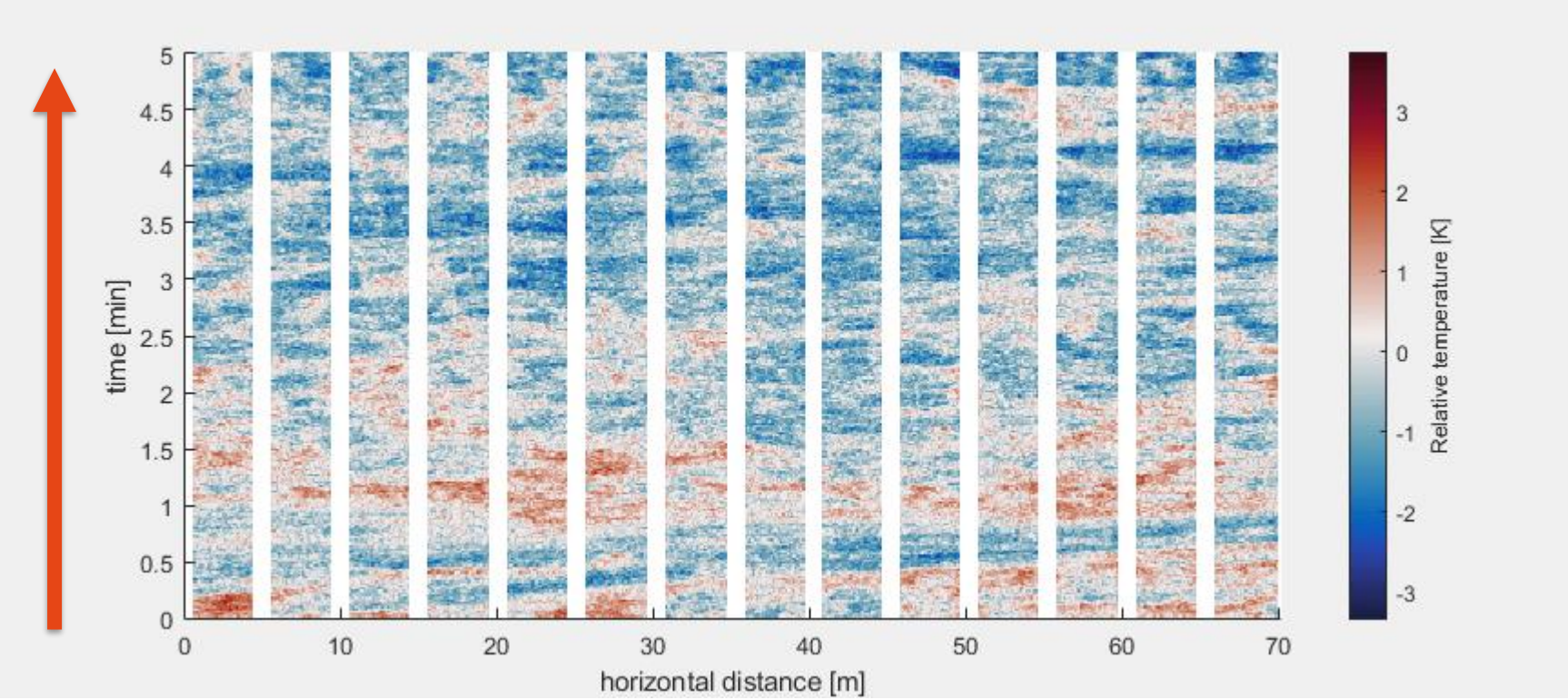
5 minutes of horizontal advection along the harp

(300 m at 1 m/s)

16 July
12:00-12:30 UTC

4. Spatial temperature measurements

Turbulence harp



5 minutes of horizontal advection along the harp

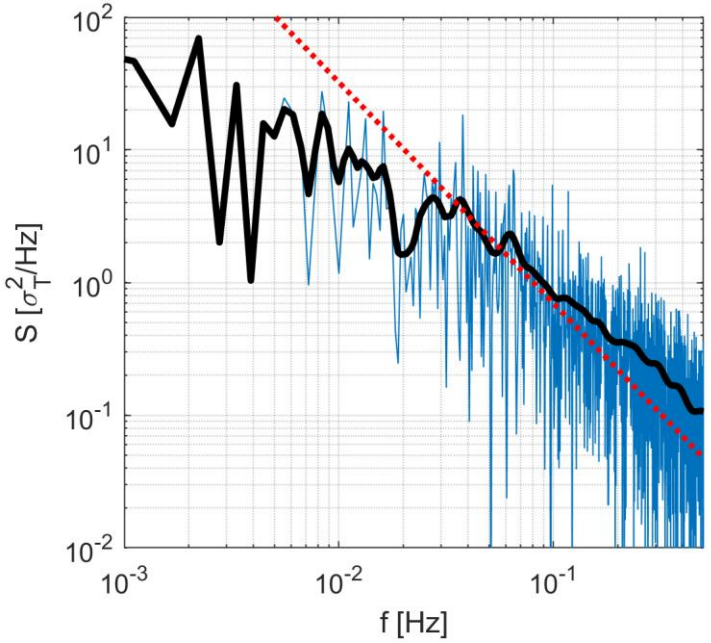
16 July
12:00-12:30 UTC

Turbulence analysis

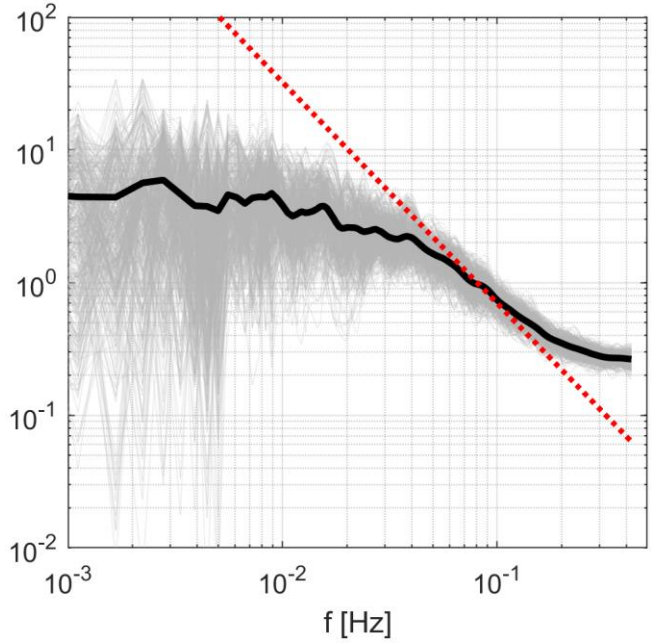
Turbulent temperature spectrum

- Highest resolved frequency 0.15 Hz

Sonic anemometer



DTS for z = 0.40 m



--- = -5/3 slope

Turbulence analysis

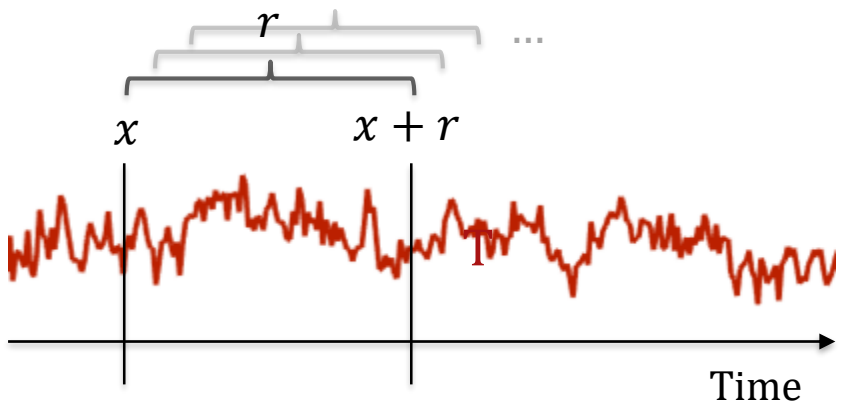
Turbulence harp

From time series to determining a turbulence parameter

Can distributed temperature sensing be used to resolve turbulence values over space and time?

- Structure parameter of temperature C_T^2
- Compare DTS values with sonic anemometer estimate

$$C_T^2 \overset{\text{def}}{=} \frac{\overline{[T(x) - T(x+r)]^2}}{r^{2/3}}$$

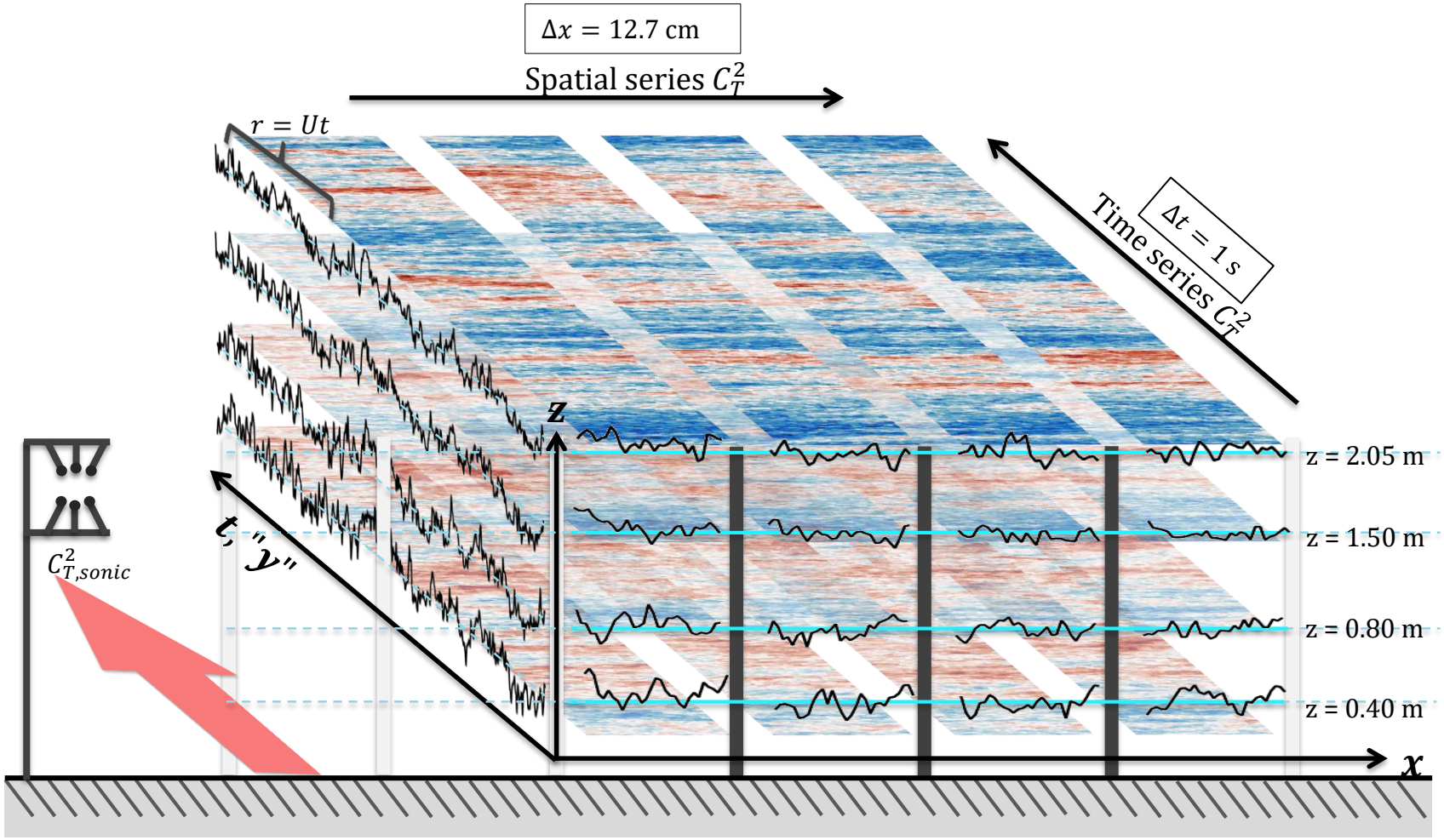


Turbulence analysis

Turbulence harp

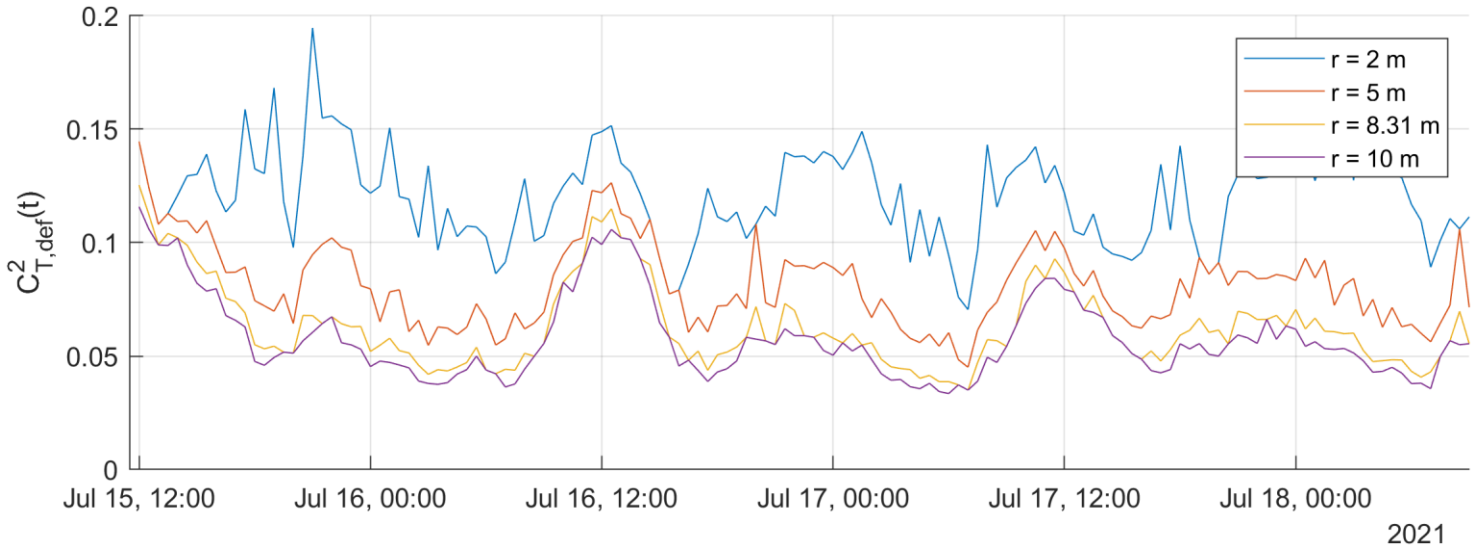
$$C_T^2 \stackrel{\text{def}}{=} \frac{\overline{[T(x) - T(x+r)]^2}}{r^{2/3}}$$

$$r = U\Delta t$$

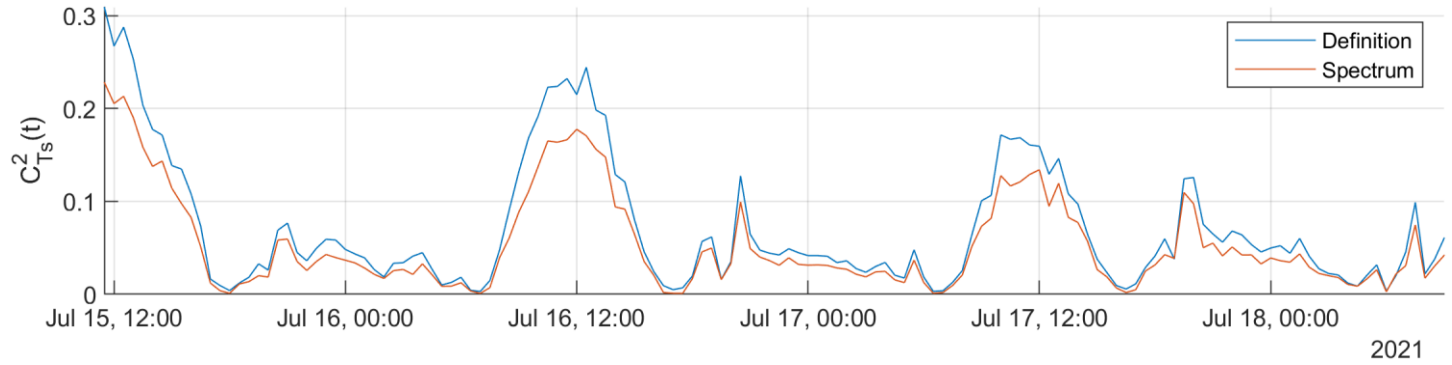


Turbulence analysis

Time data



DTS time data



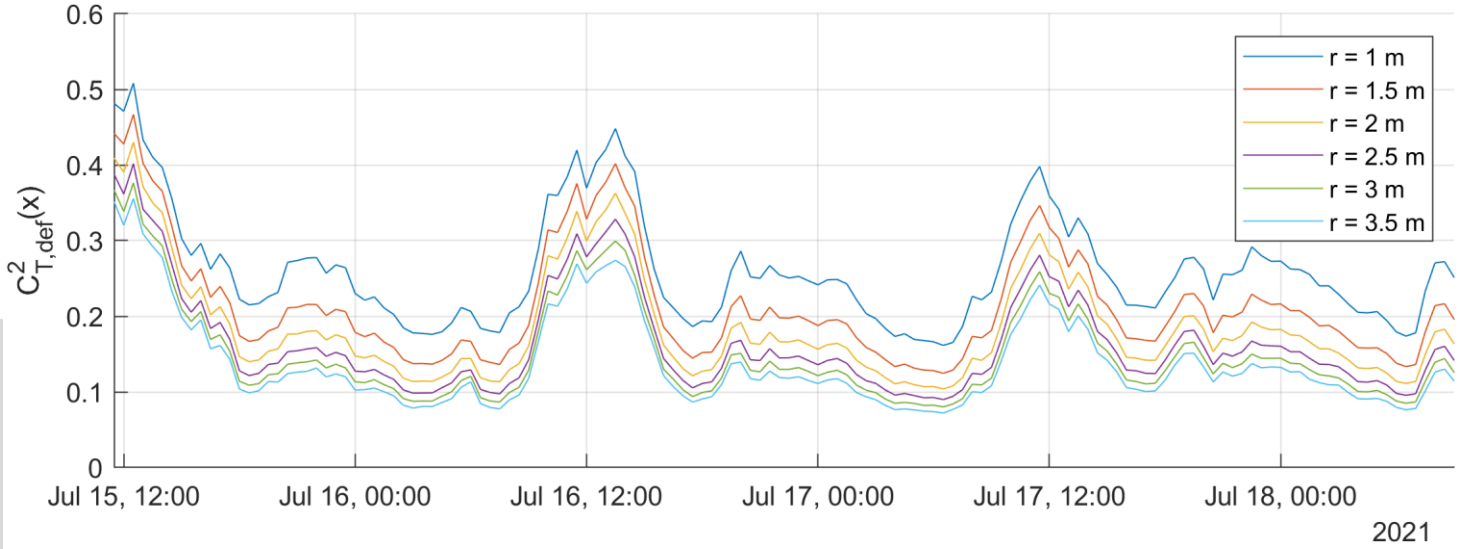
Sonic anemometer

Turbulence analysis

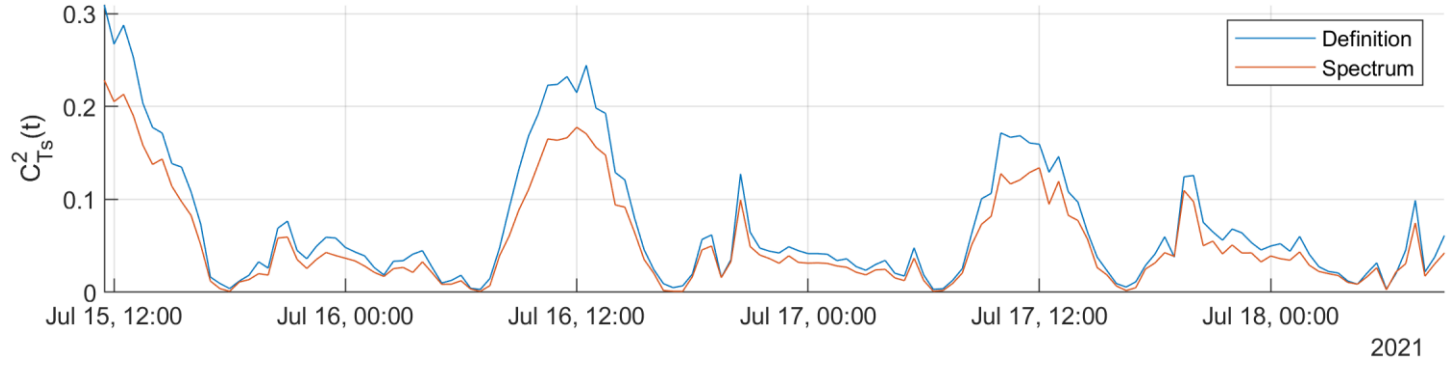
Spatial data

Novel approach

Agreement in trend, but with offset



DTS spatial data

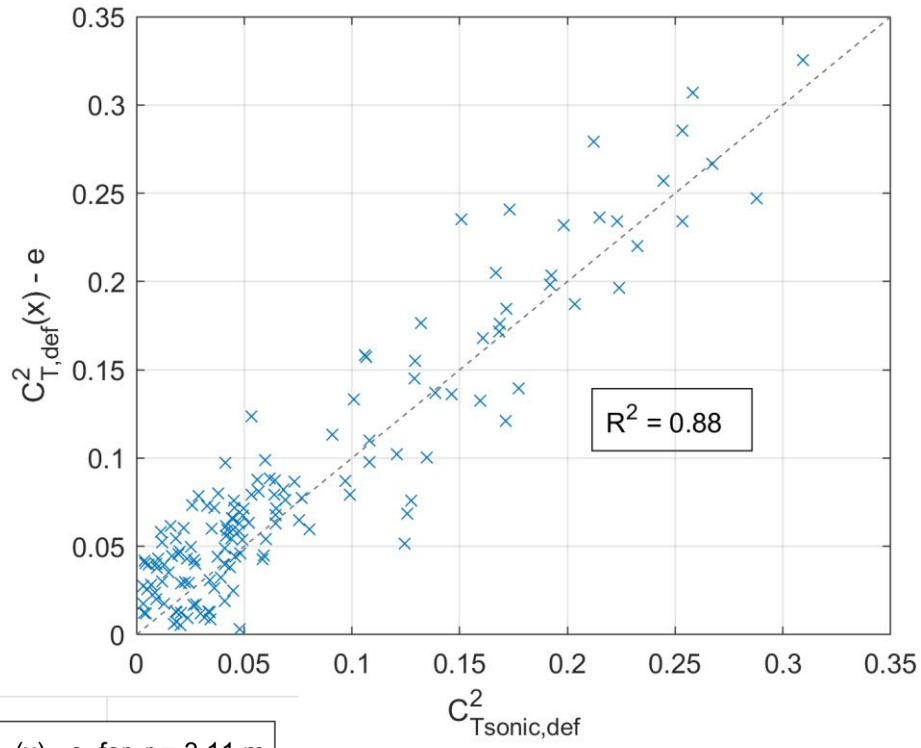


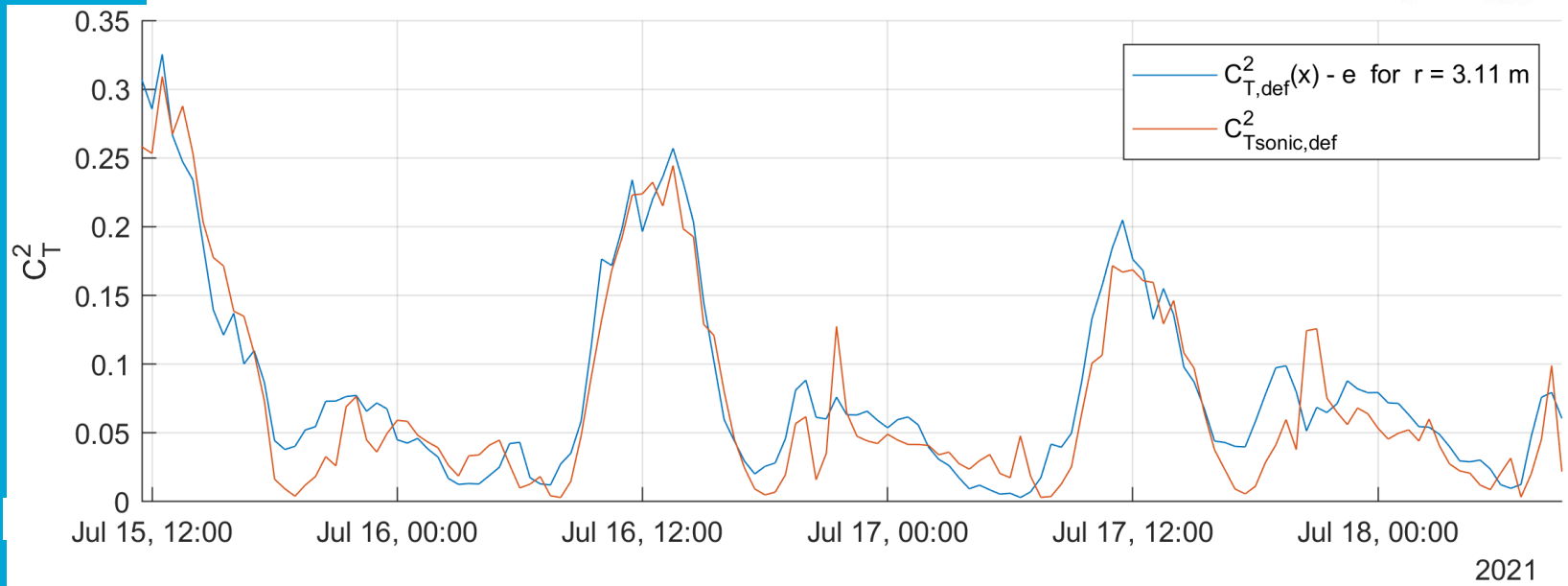
Sonic anemometer

Turbulence analysis

Spatial data

- Subtraction of noise floor yields correlated results ($R^2 = 0.88$)
- Noise floor cause
  - Instrument noise
  - Calibration limitations





Outlook

Instrumental issues

- Radiative effects on 50 m mast cable
- Quantify noise floor
- Use of sonic anemometer wind speed

Further analysis

- Using the mast profile as a (bottom) supplement to balloon profiles
- Determine ground heat flux with the (semi)-continuous ground coil profile
- Quantify the insulating effect of the canopy
- use DTS to interpret scintillation measurements

Conclusion

- Temperature profiles were measured on different vertical scales in the air, soil and canopy

- First step into turbulence analysis using DTS using a horizontal set-up
  - C_T^2 can be determined, despite a coarsely resolved turbulent temperature spectrum
  - Spatial series work better than time series for C_T^2 determination

- Dataset available for further research

Any questions?

Thank you for your attention

LIAISE-NL
Gijs Vis
g.a.vis@tudelft.nl