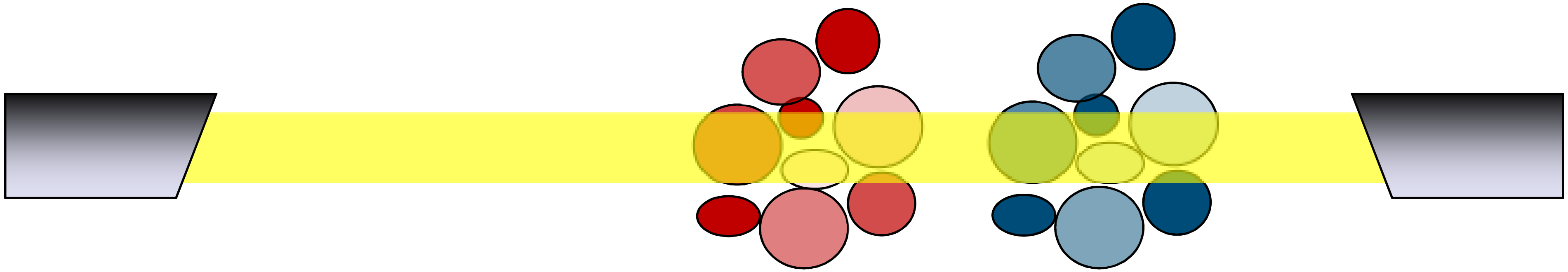
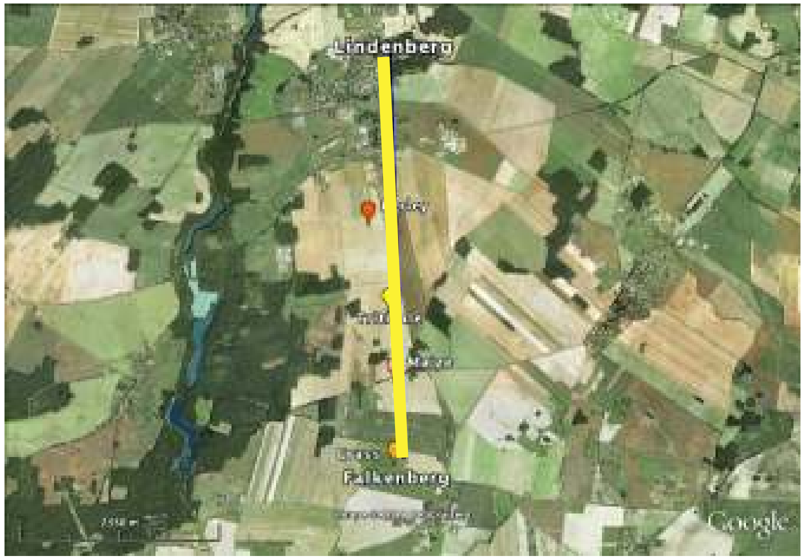
On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft



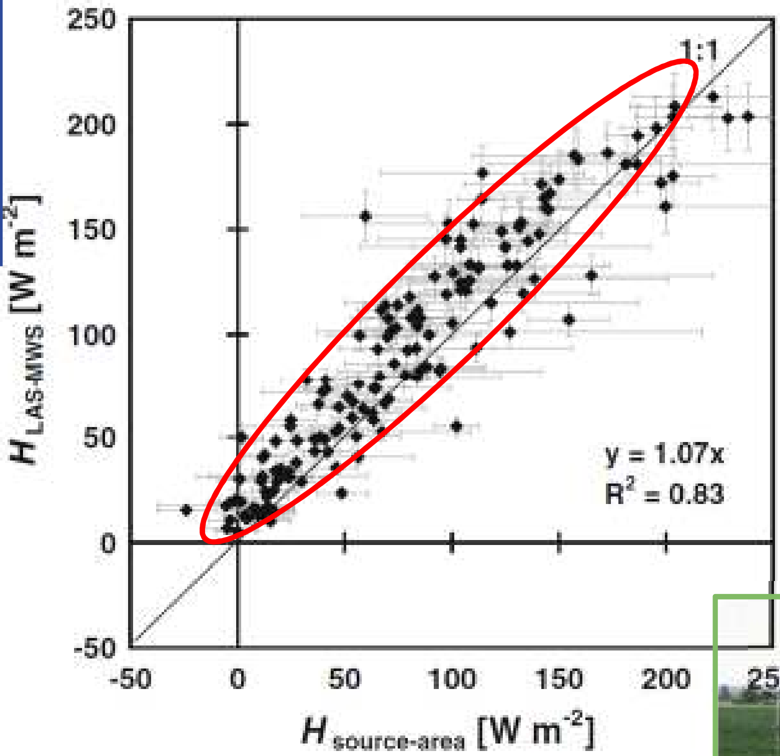
- Miranda Braam (DWD-WU)
- Frank Beyrich (DWD Lindenberg)
- Arnold Moene (WU Wageningen)
- Jens Bange (EKUT Tübingen)
- Andreas Platis (EKUT Tübingen)
- Sabrina Martin (TUB Braunschweig)
- Björn Maronga (LUH Hannover)



Lindenberg area

Why? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

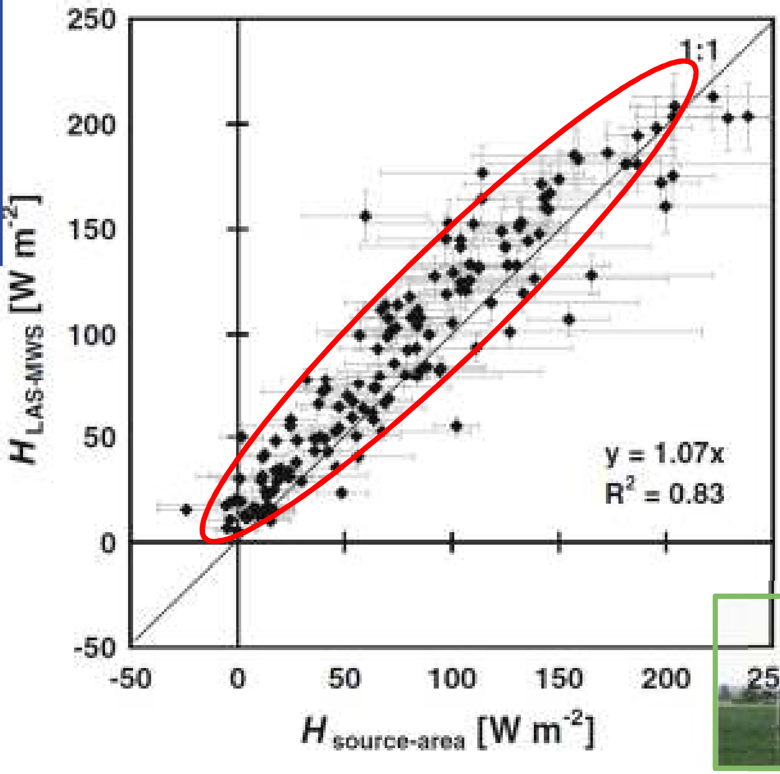
Previous results: LITFASS-2003

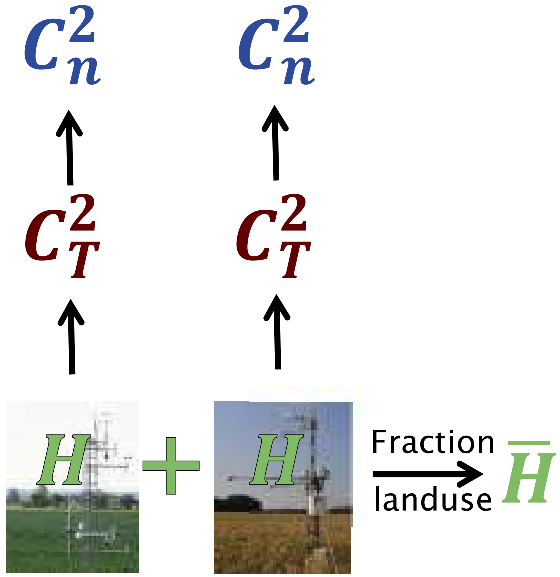


Meijninger *et al.* 2006

Why? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

Previous results: LITFASS-2003

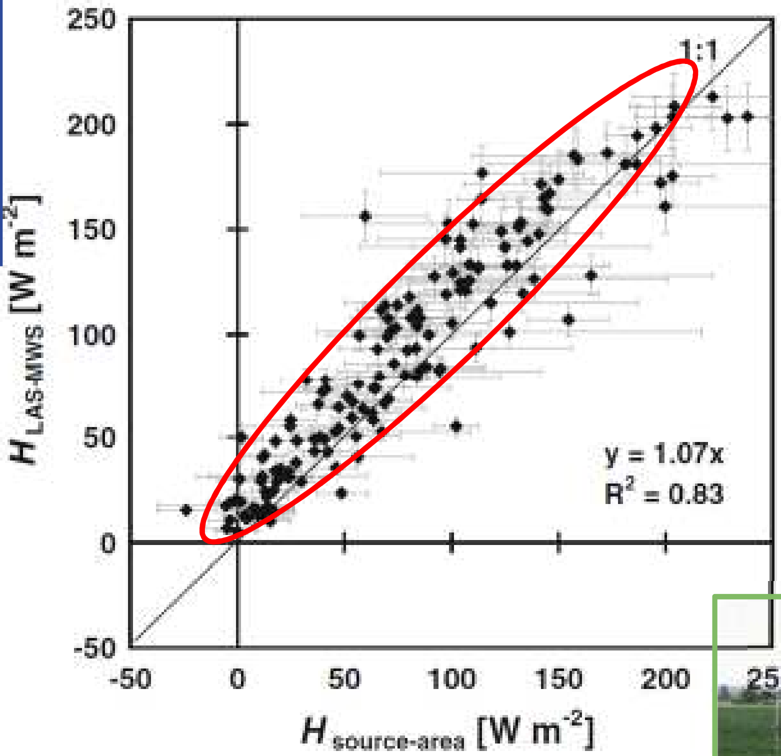


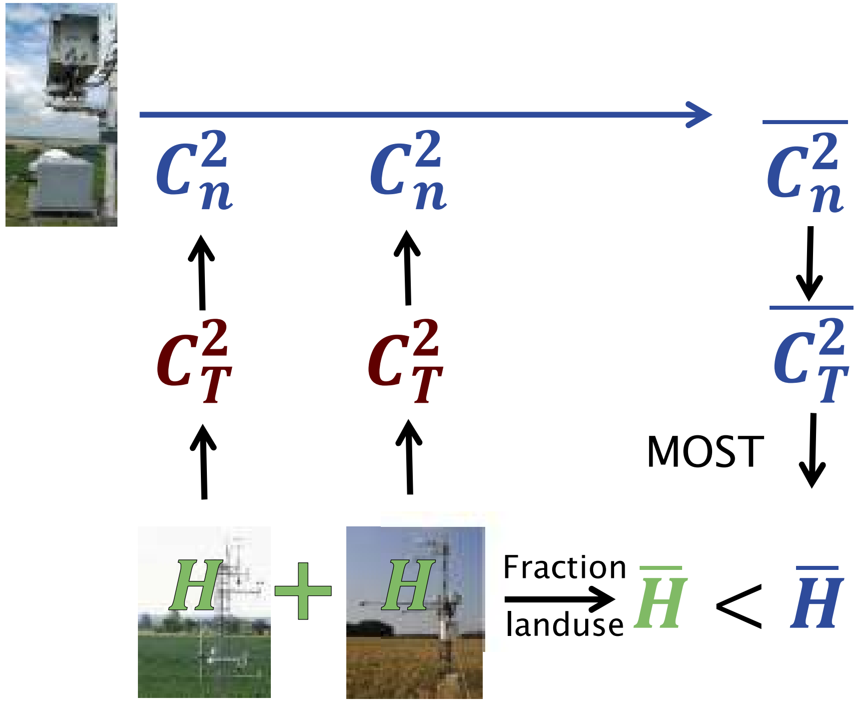


Meijninger *et al.* 2006

Why? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

Previous results: LITFASS-2003





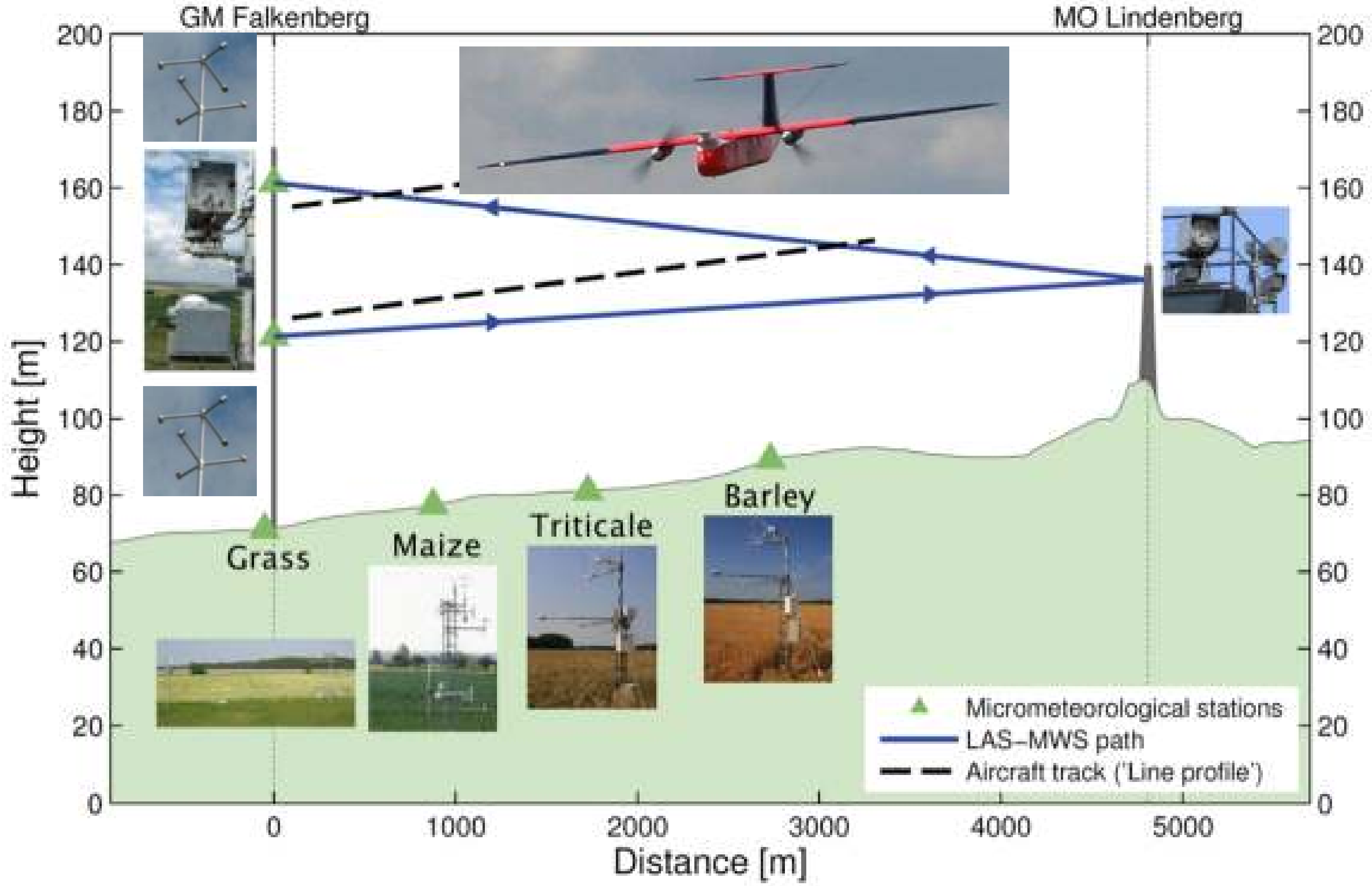
Meijninger *et al.* 2006

How? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

New campaign: LITFASS-2009

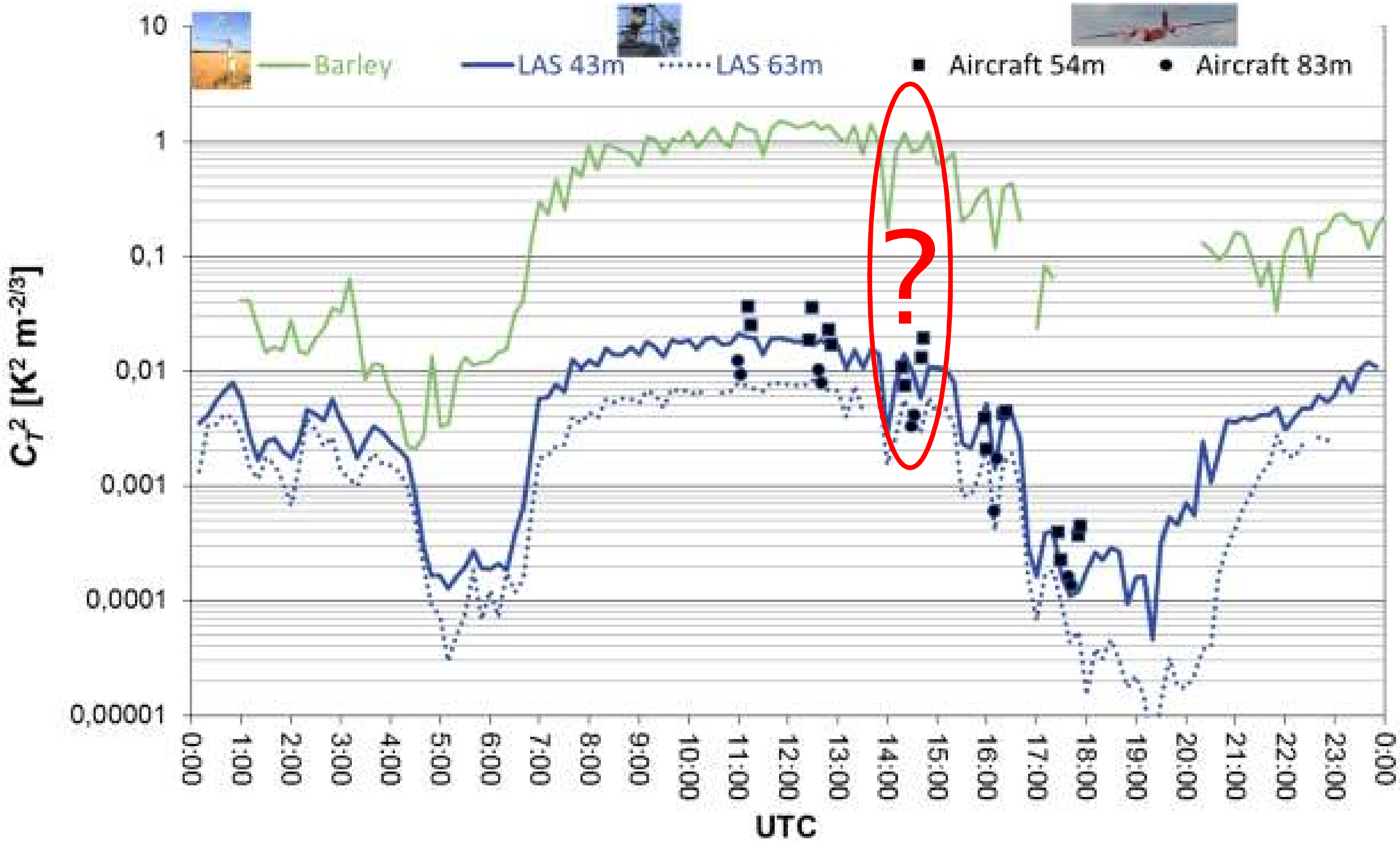
$z_{\mathrm{eff}} = 63$ m

$z_{\mathrm{eff}} = 43$ m



What? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

First results – "quick overview": LITFASS-2009

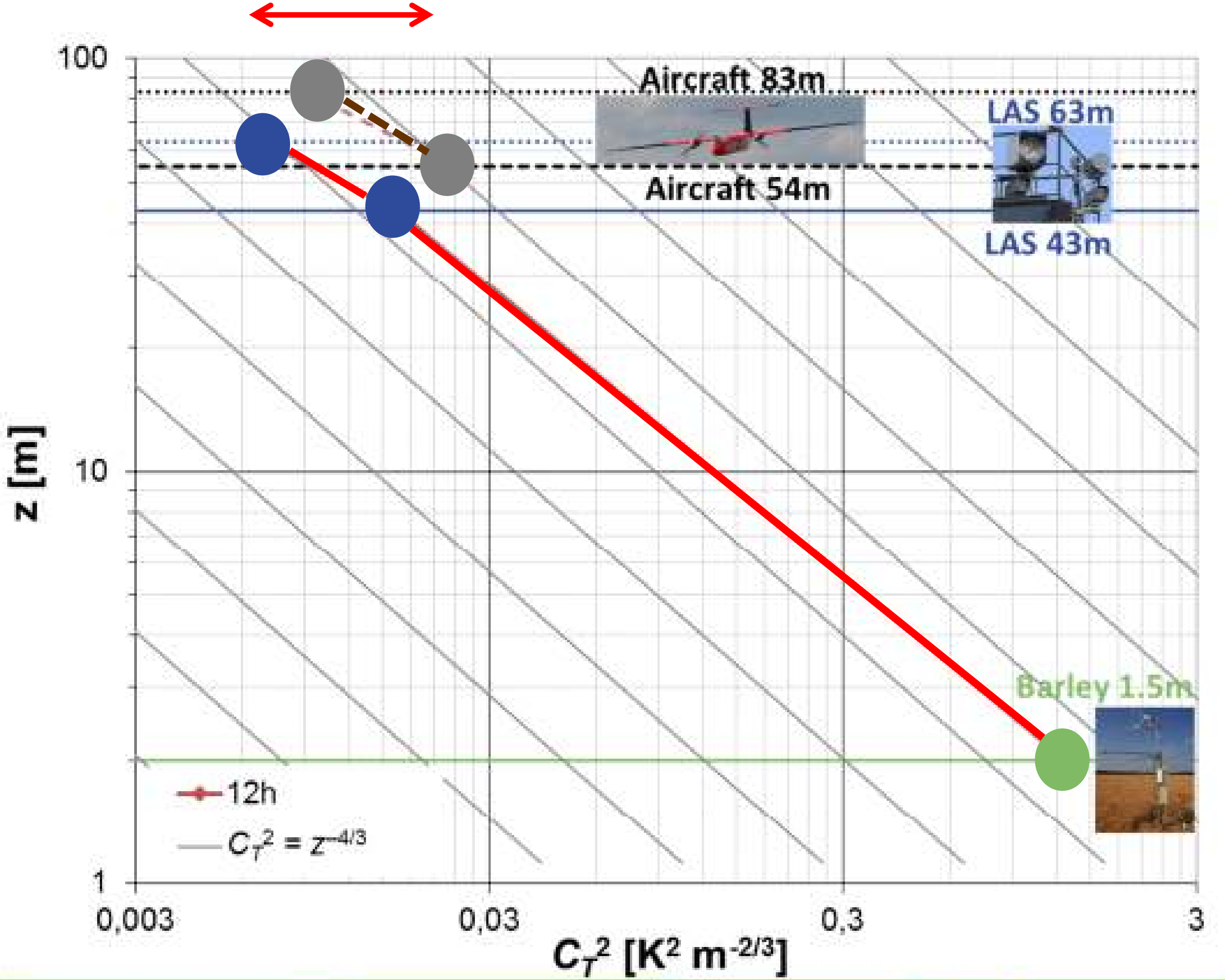


13-07-2009

Beyrich *et al.* 2012

Deutscher Wetterdienst – Wetter und Klima aus einer Hand | DWD | Eberhard Karls Universität Tübingen | Technische Universität Braunschweig | Leibniz Universität Hannover | Wageningen Universiteit – Wageningen UR

What? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

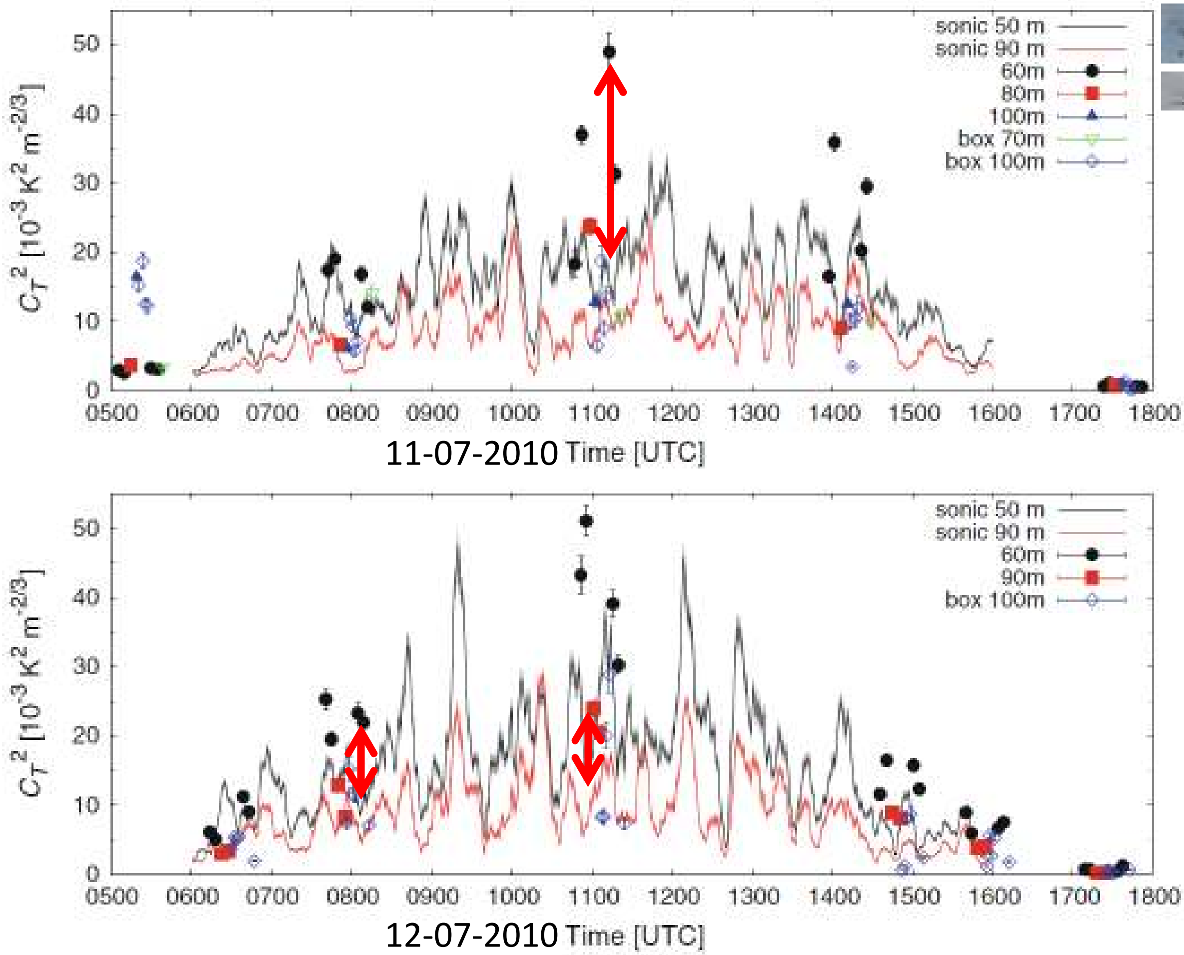


C_T^2 aircraft > C_T^2 LAS

Beyrich *et al.* 2012

What? On the discrepancy in simultaneous observations of C_T^2 by scintillometers, sonics and unmanned aircraft

First results: LITFASS-2010



C_T^2 aircraft > C_T^2 EC

Van den Kroonenberg *et al.* 2012

Conclusions so far…

LITFASS-2009

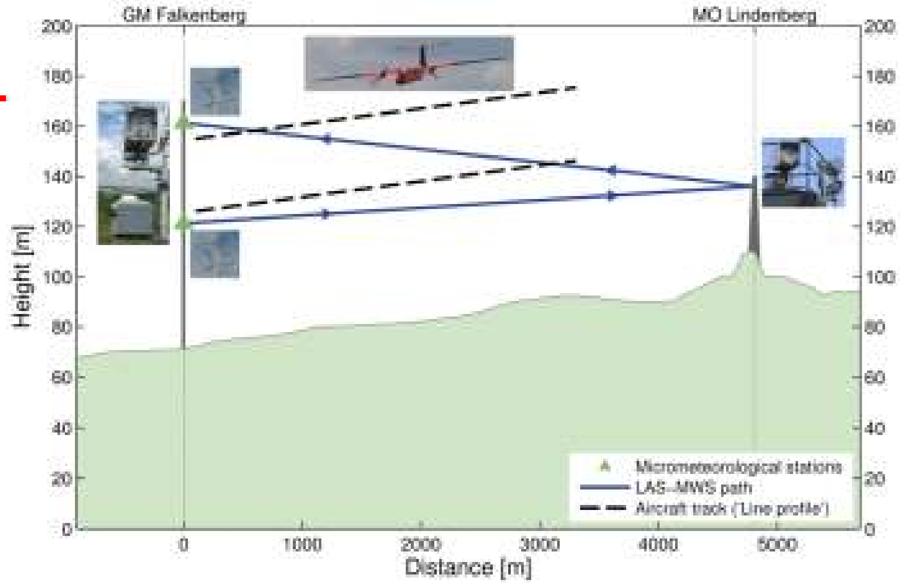
C_T^2 aircraft $\approx 2\ C_T^2$ LAS

One day
"quick overview"

LITFASS-2010

C_T^2 aircraft $\approx 2\ C_T^2$ EC

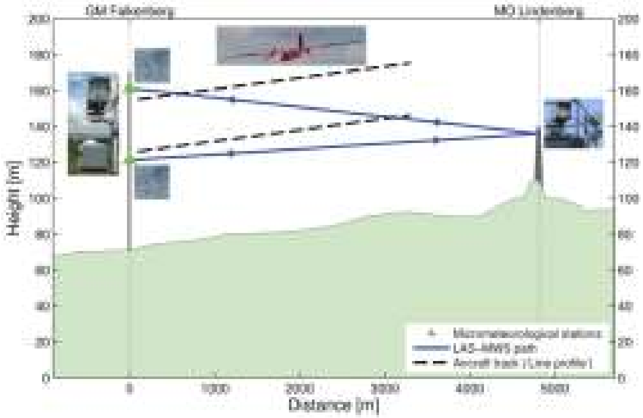
No C_T^2 LAS



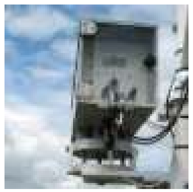
This study

On the discrepancy of C_T^2

- More days
- More validation data (EC & LAS)
- Normalizing to $z = 50$ m



- Elaborate data processing



  - Saturation correction
  - $C_n^2 \rightarrow C_T^2$: Humidity correction
  - Synchronising averaging times

  - Path-weighting function of LAS
  - Mathematical methods

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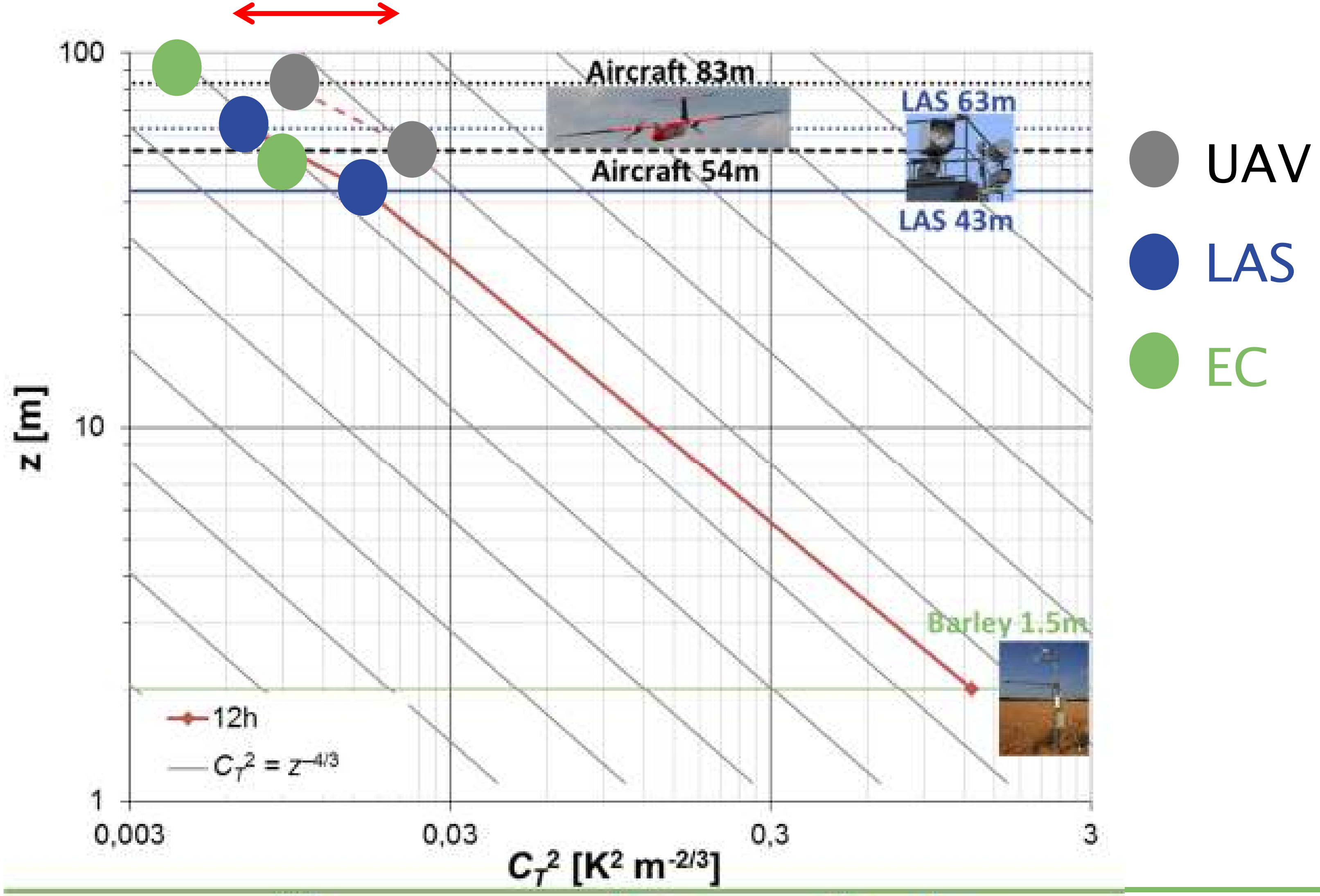
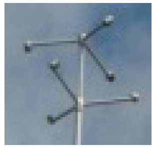
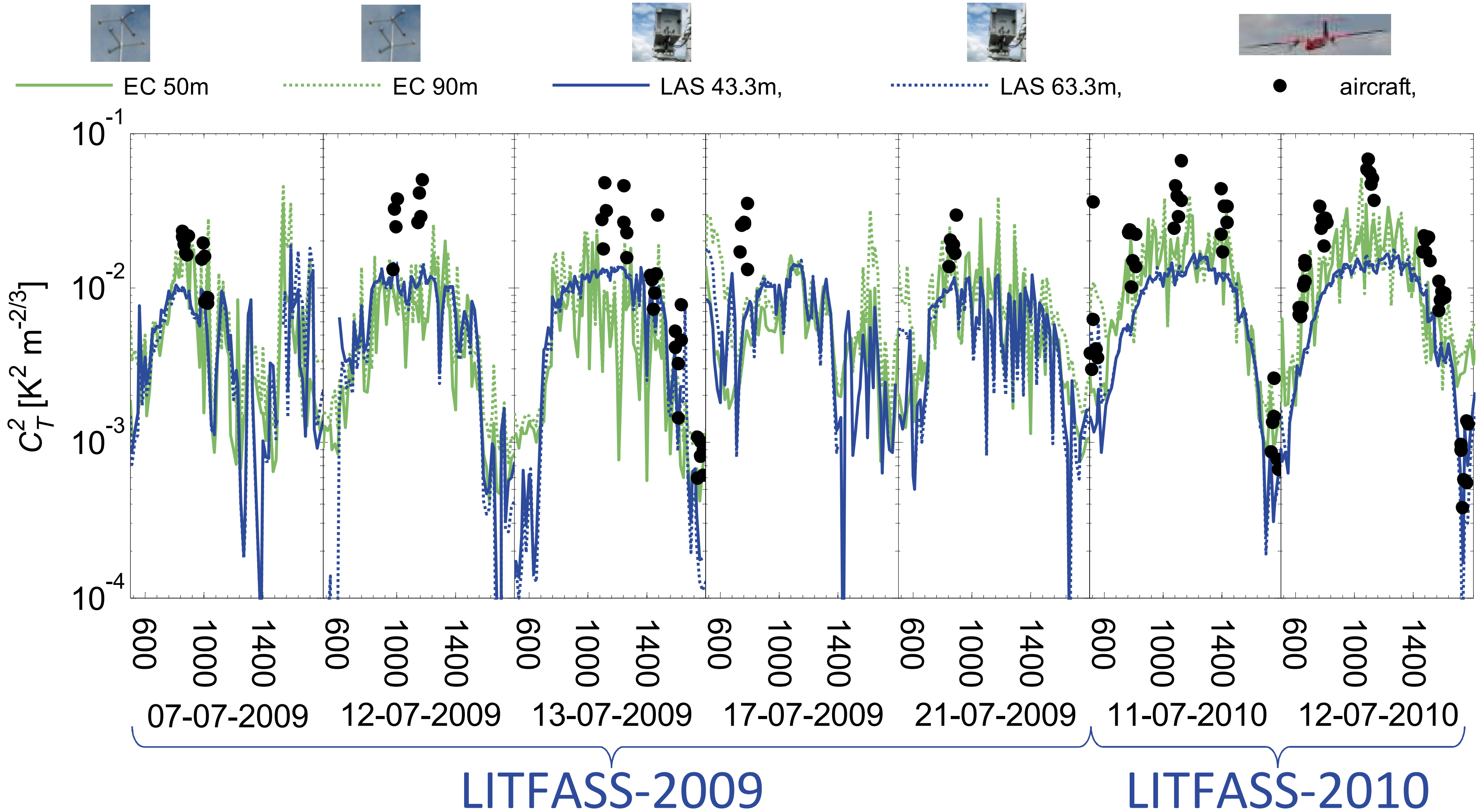
Elaborate data processing
normalizing to $z = 50$ m



Results

normalizing to z = 50 m





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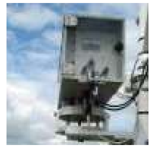
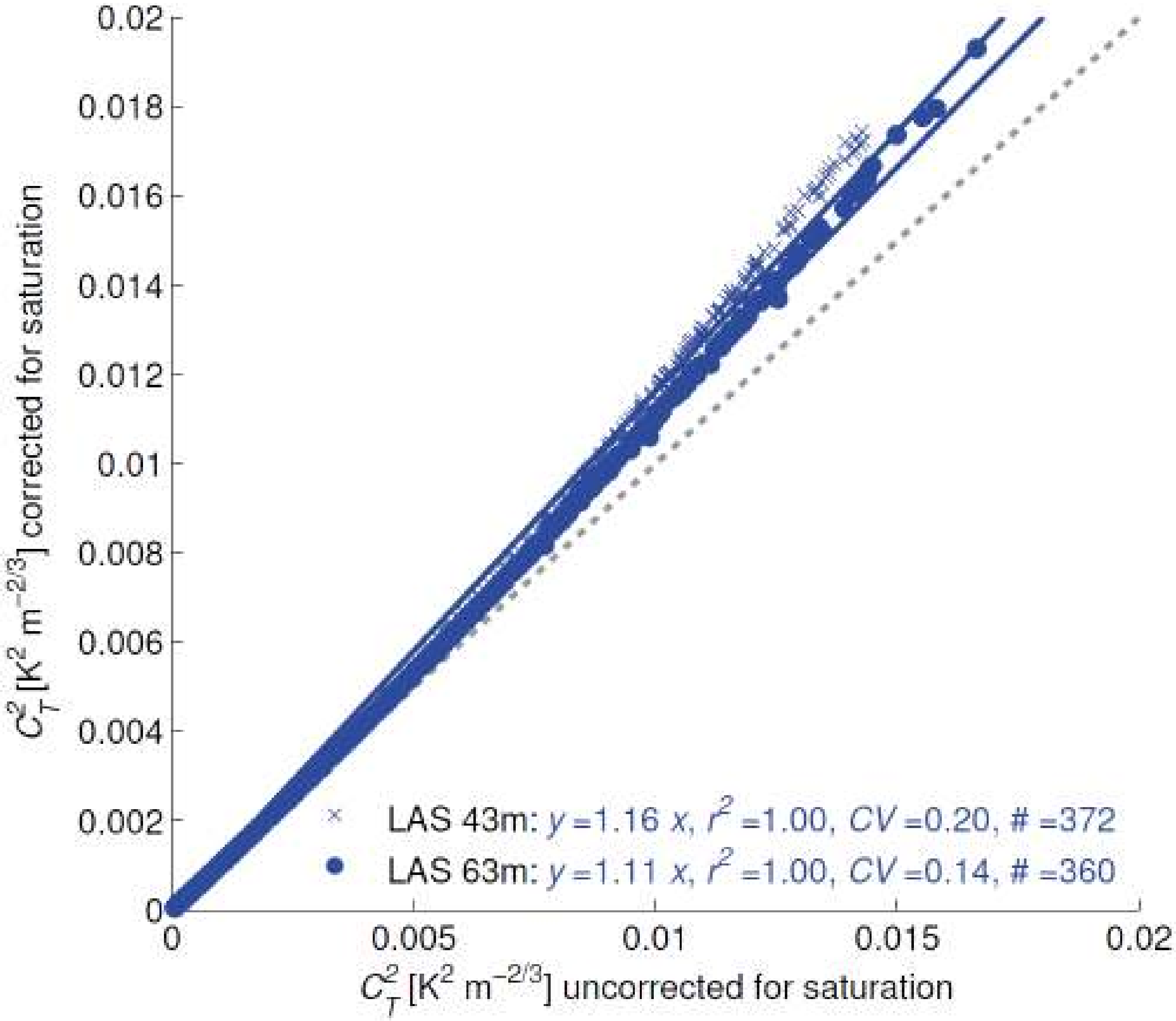
Elaborate data processing

C_n^2: Saturation correction



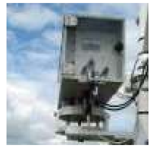
- Clifford correction method
  Kleissl *et al.* 2010
  Clifford *et al.* 1974

- LAS:
  - 43 m: +16%
  - 63 m: +11%



Elaborate data processing

$C_n^2 \rightarrow C_T^2$: Humidity correction



$$C_n^2 = A_T C_T^2 + A_{Tq} C_{Tq} + A_q C_q^2$$

1. Extra Microwave Scintillometer (MWS) two wavelength method

- cov($\ln I_{LAS}$, $\ln I_{MWS}$) (Lüdi et al, 2005)
- R_{Tq} (Hill)

LITFASS-2009
@ 43 m

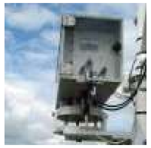
2. Extra EC (Moene, 2003)

- R_{Tq}, σ_T and σ_q
- R_{Tq}, β
- $\boldsymbol{\beta}$

LITFASS-2009
LITFASS-2010
@ 43 m
@ 63 m

Elaborate data processing

$C_n^2 \rightarrow C_T^2$: Humidity correction



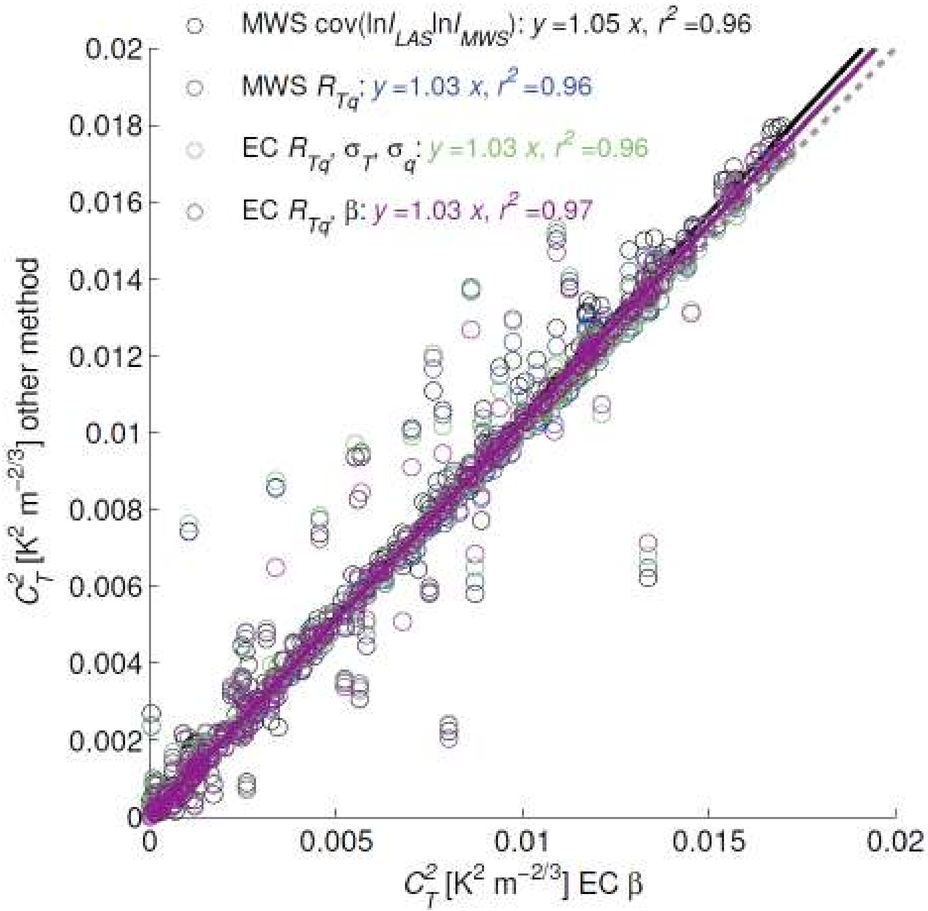
$$C_n^2 = A_T C_T^2 + A_{Tq} C_{Tq} + A_q C_q^2$$

1. Extra MWS
   two wavelength method

- $\text{cov}(\ln I_{LAS}, \ln I_{MWS})$
- R_{Tq}

2. Extra EC

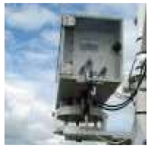
- R_{Tq}, σ_T and σ_q
- R_{Tq}, β
- $\boldsymbol{\beta}$



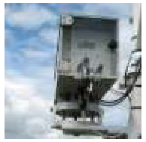
LAS: +5%

(relative to standard Bowen correction)

Elaborate data processing
Synchronizing averaging times

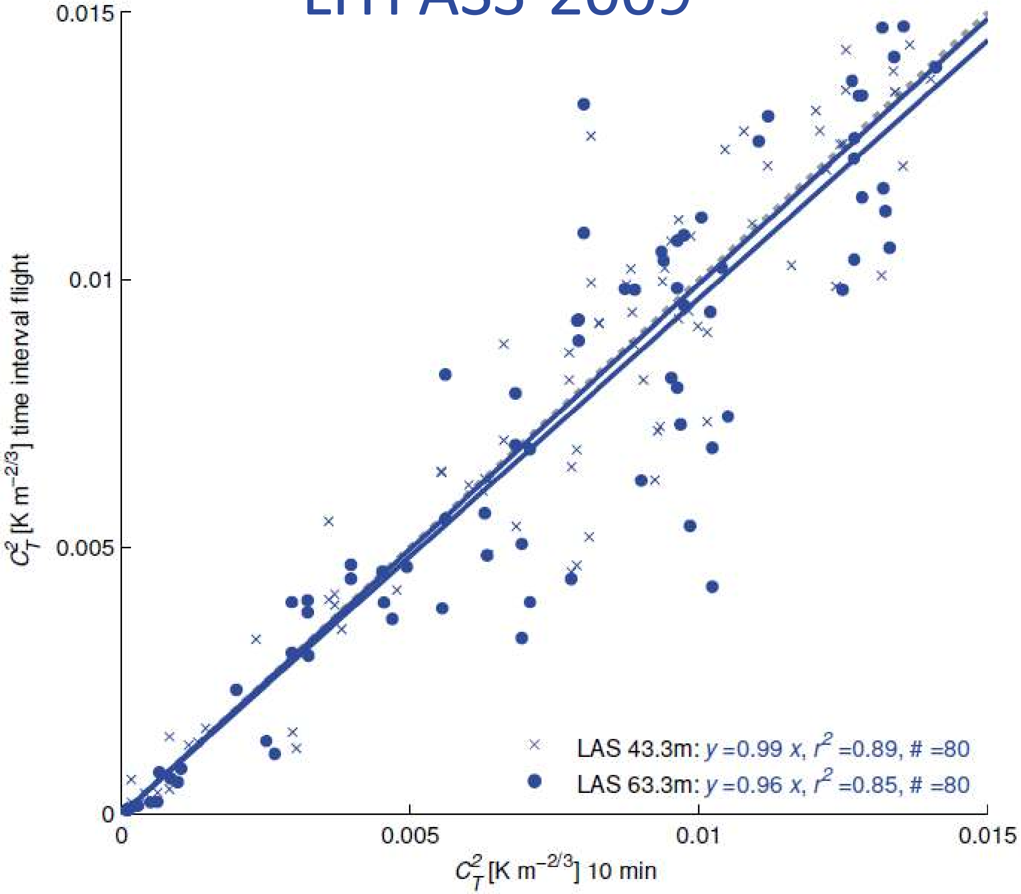


Normally:



10 or 30 min

approx. 2min

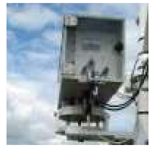


LAS:

- 43m: -1%
- 63m: -4%
- uncertain

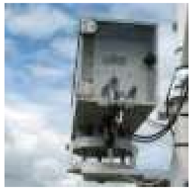
This study

On the discrepancy of C_T



- Other days
- Extra validation with EC
- Normalizing to $z = 50$ m
- Elaborate data processing

C_T^2 aircraft $\approx 2C_T^2$ LAS

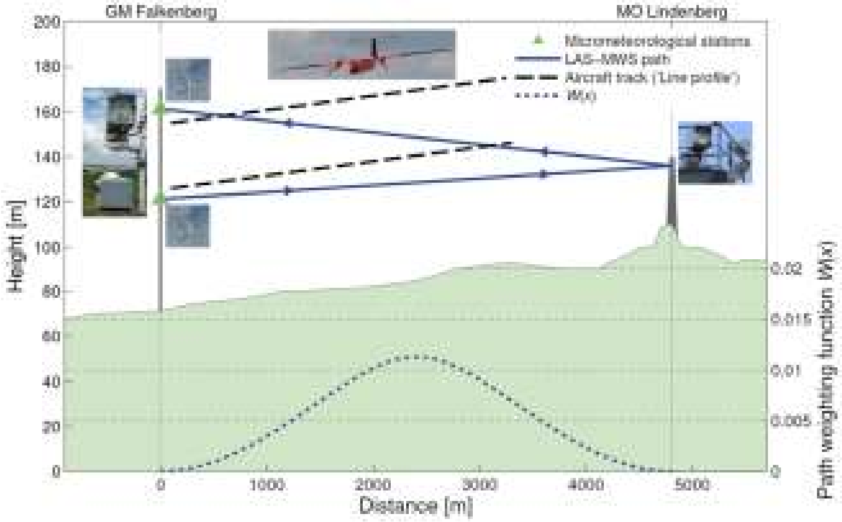


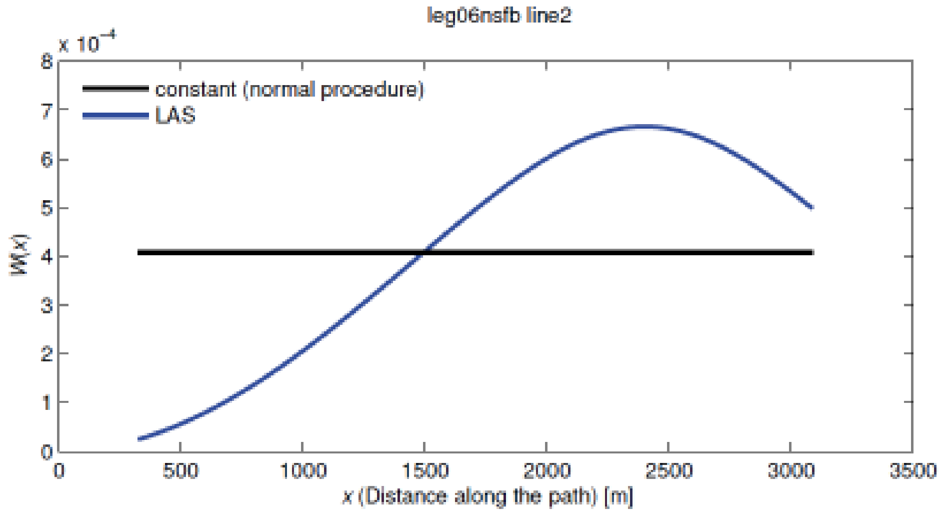
- Saturation correction — C_T^2 LAS $+15\%$
- $C_n^2 \rightarrow C_T^2$: Humidity correction — C_T^2 LAS $+5\%$
- Synchronising averaging times — C_T^2 LAS 0%

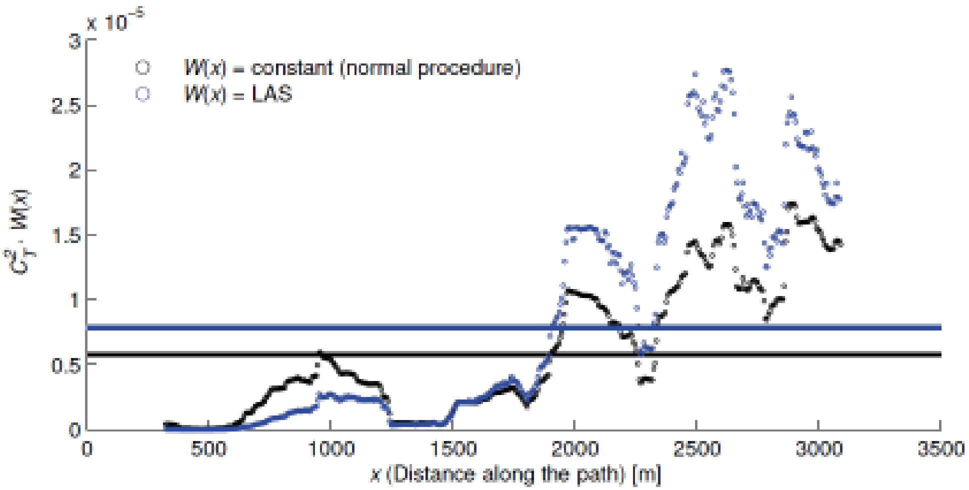
- Path-weighting function of LAS
- Mathematical methods
- Effect of flight speed

Elaborate data processing

path weighting function LAS

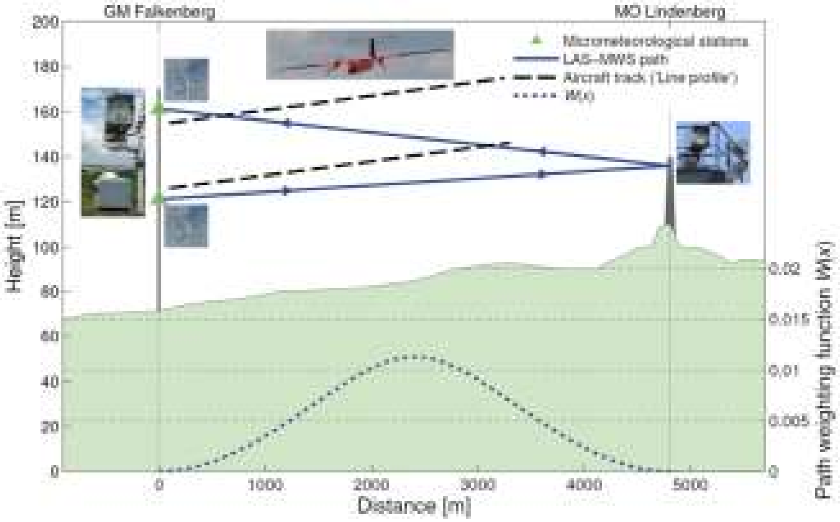


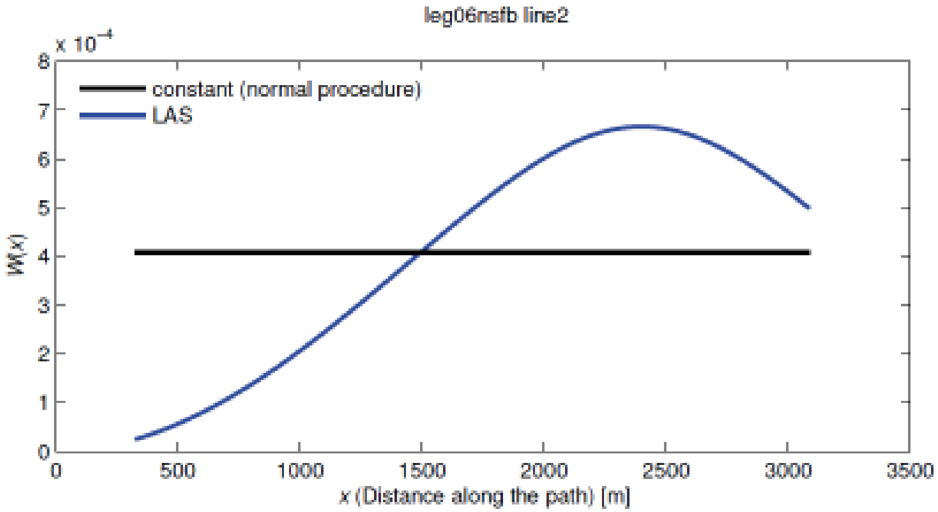


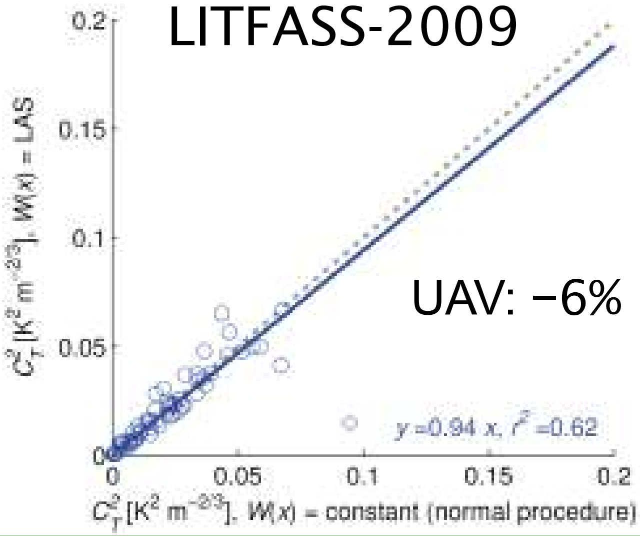


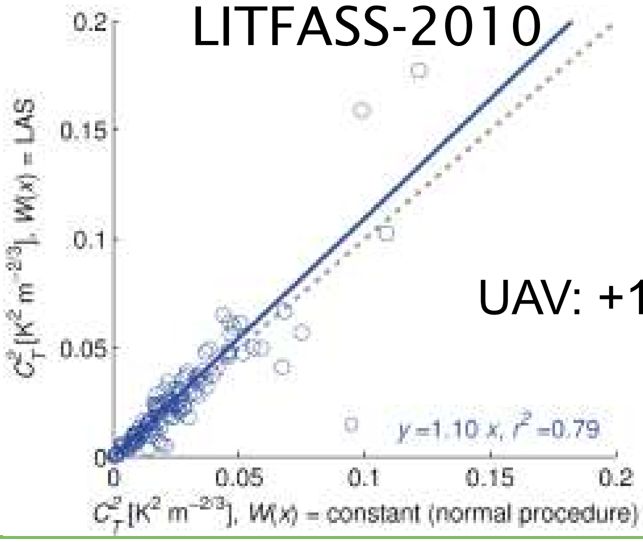
Elaborate data processing

path weighting function LAS



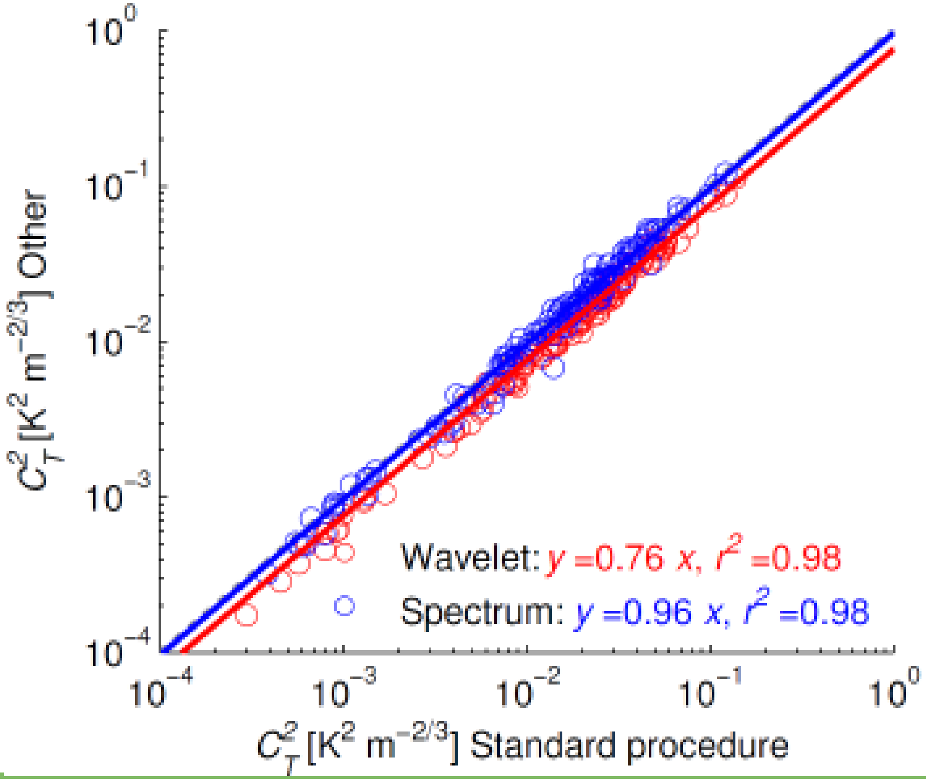






Elaborate data processing
other mathematical methods

- Standard procedure — van den Kroonenberg *et al.* 2012
- Spectrum procedure
- Wavelet procedure — Moene & Gioli 2008

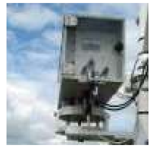


UAV: −14%

UAV: −4%

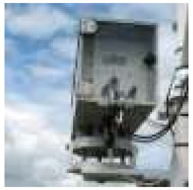
This study

On the discrepancy of C_T^2



- Other days
- Extra validation with EC
- Normalizing to $z = 50$ m
- Elaborate data processing

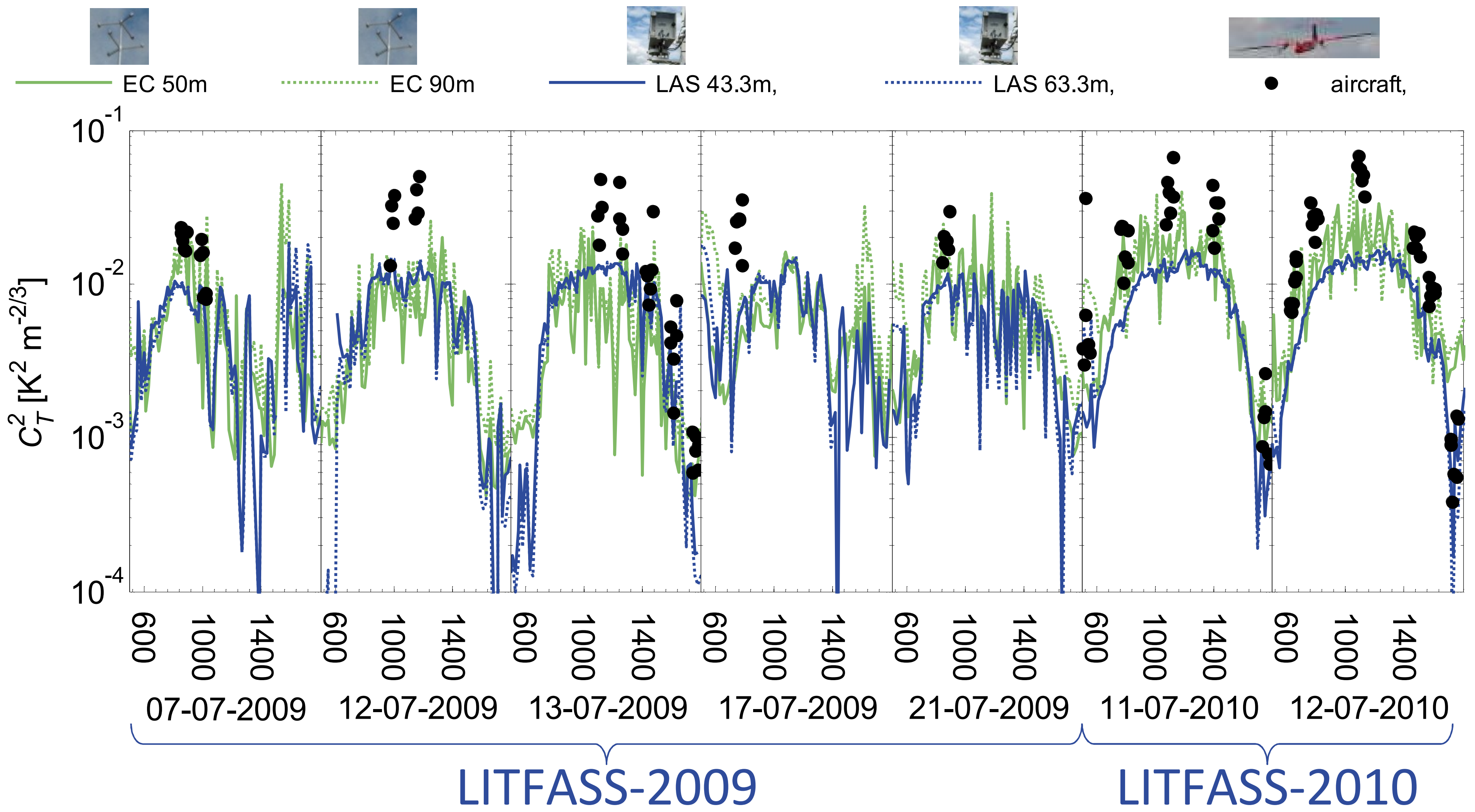
C_T^2 aircraft $\approx 2 C_T^2$ LAS



- Saturation correction — C_T^2 LAS $+15\%$
- $C_n^2 \rightarrow C_T^2$: Humidity correction — C_T^2 LAS $+5\%$
- Synchronising averaging times — C_T^2 LAS 0%

- Path-weighting function of LAS — C_T^2 aircraft $\pm 10\%$
- Mathematical methods — C_T^2 aircraft $\pm 15\%$

Results



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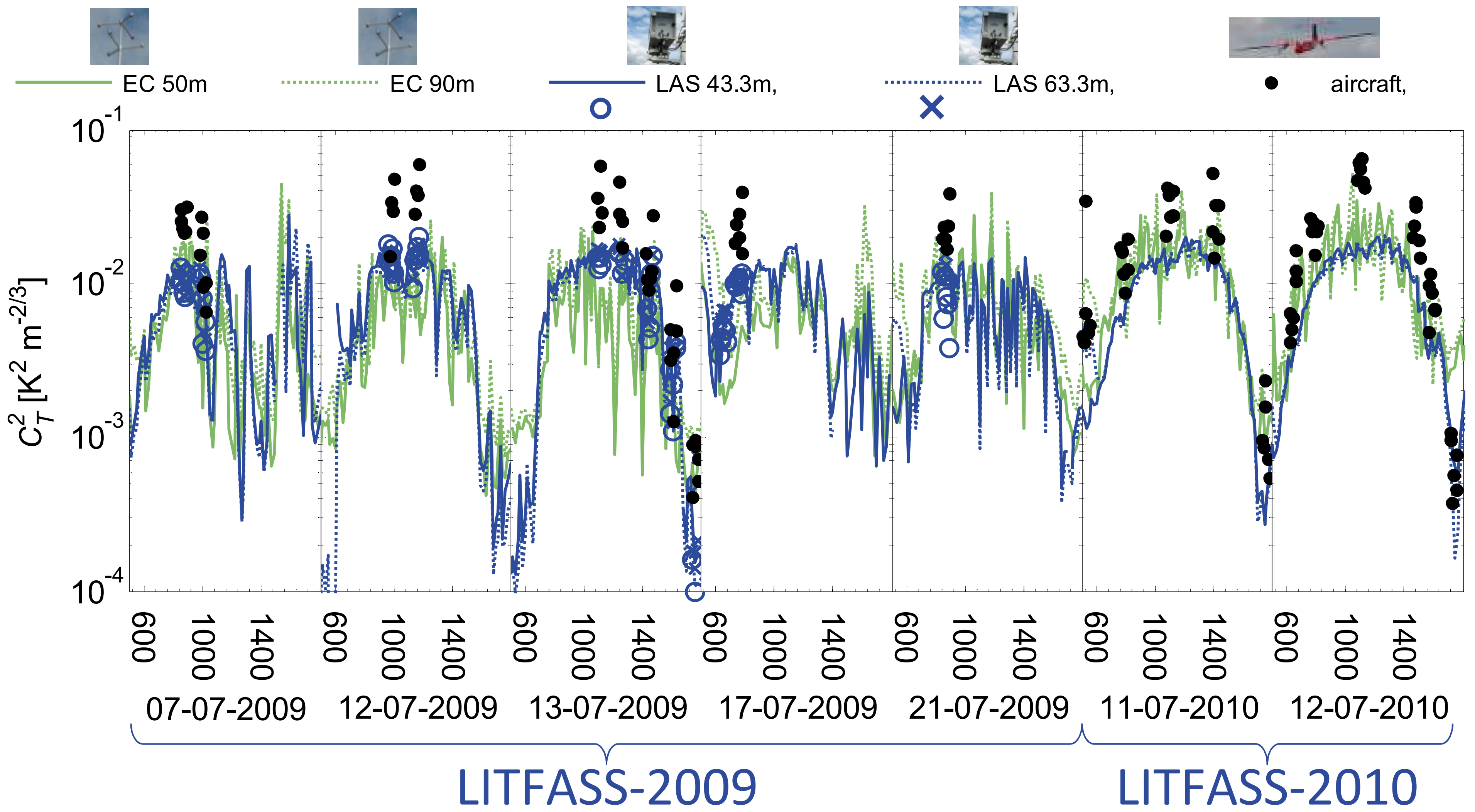
Results

all corrections/processing implemented



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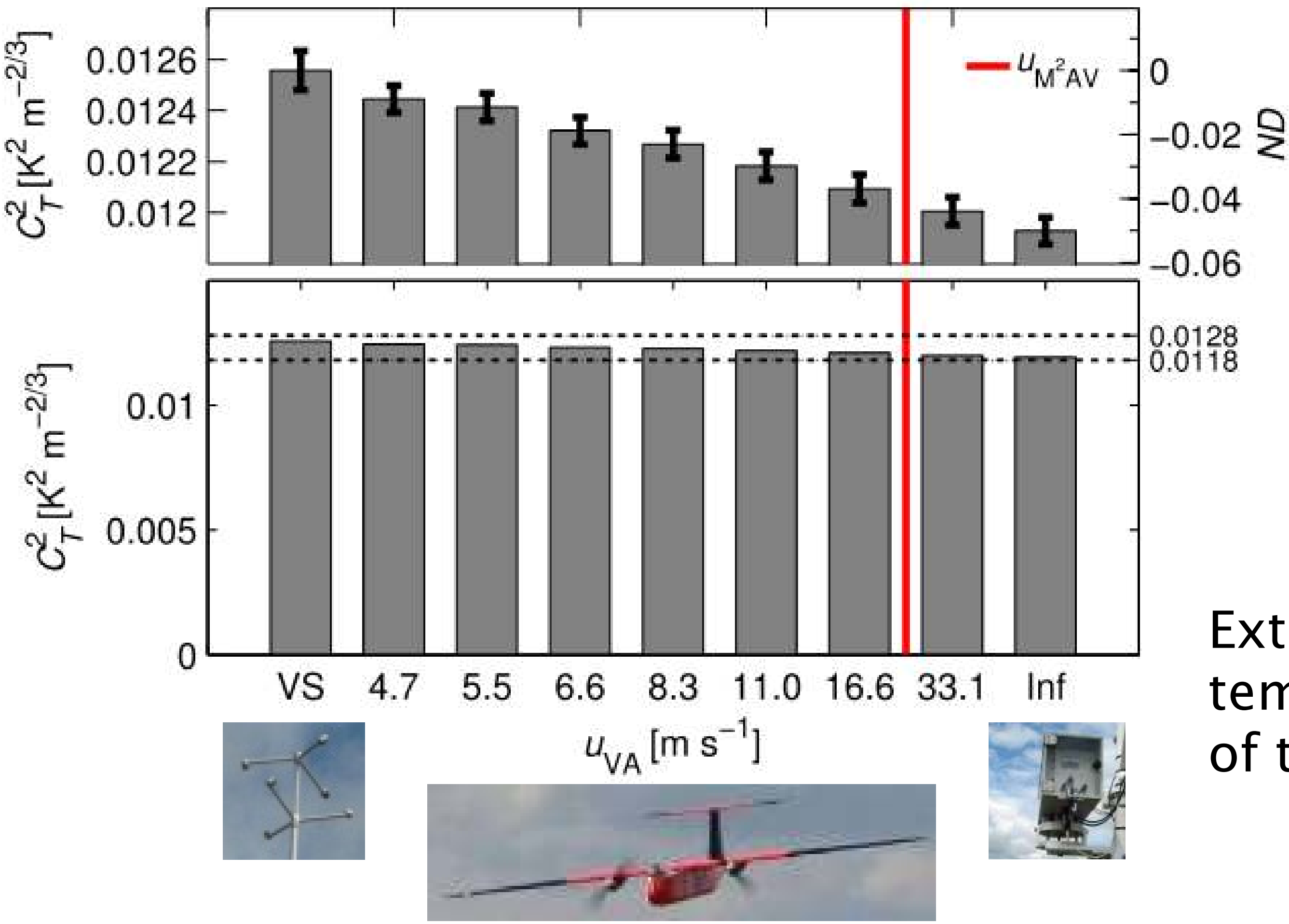
Effect of translation speed of sensor

- High-resolution LES of LITFASS area ($\Delta x = 3.1$ m, $\Delta z = 2$ m)
- Virtual sensors at different speeds:
  0 ms^{-1} : virtual sonic
  5-33 ms^{-1} : virtual UAV
  ∞ ms^{-1} : virtual LAS
- Does structure parameter depend on choice of platform translation speed?

Effect of translation speed of sensor



Extra variance due to temporal development of turbulence

Conclusions

- C_T^2 aircraft $> C_T^2$ LAS, $> C_T^2$ EC also valid at other days
- More elaborate data processing does not decrease differences significiently
- Additional experiments are needed to better understand line-mean C_T^2 and link with scintillometer signal