Monin-Obukhov Similarity Theory in the 2-m column of thermocouples at the small-scale heterogeneity site

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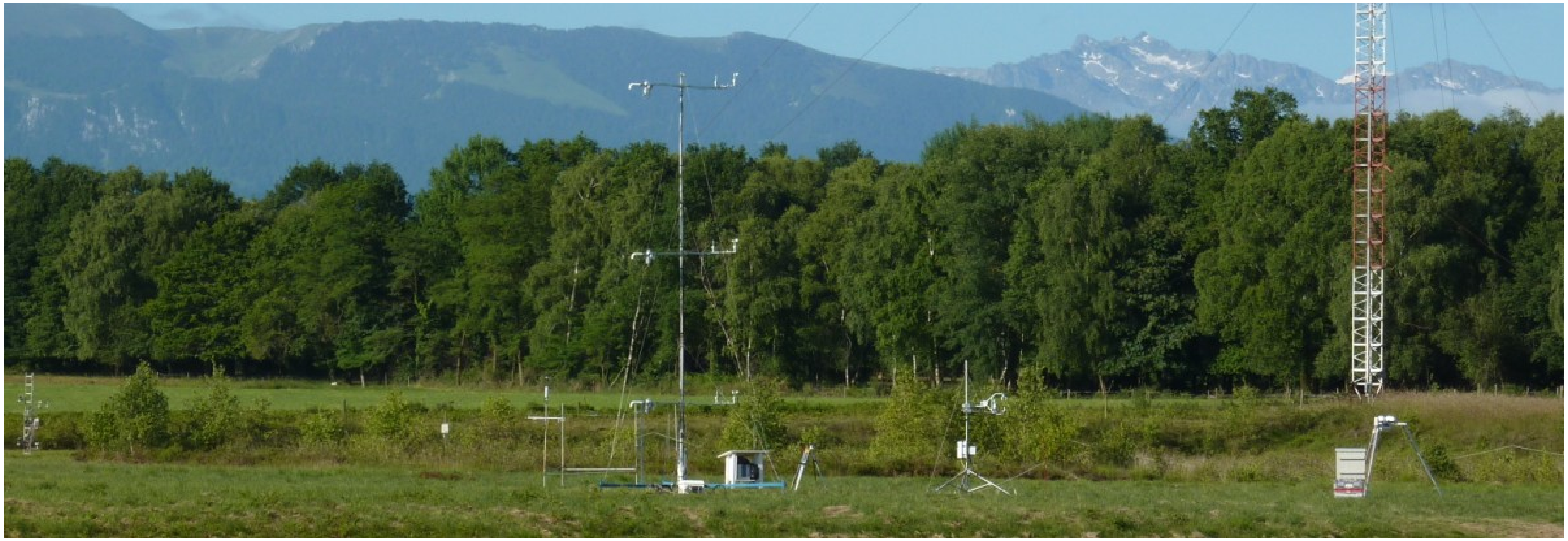


Introduction

Objective: Assessment of MOST in the lower surface layer at the SSH site of BLLAST campaign.

- Data:
  - Eight thermocouples within the first 2 m above ground level (AGL), Mallorca.
  - Eddy-covariance station at 1.95 m AGL, Bergen.

- Data requirements:
  - Steady state
    - Fair weather conditions
    - Excluding morning and evening transitions.
  - Horizontally homogeneous conditions: length scale required for an undisturbed fetch (Wyngaard, 2010):

$$L_x \gg \frac{\bar{u}}{u_*} z$$

Introduction (II)

Thermocouples:

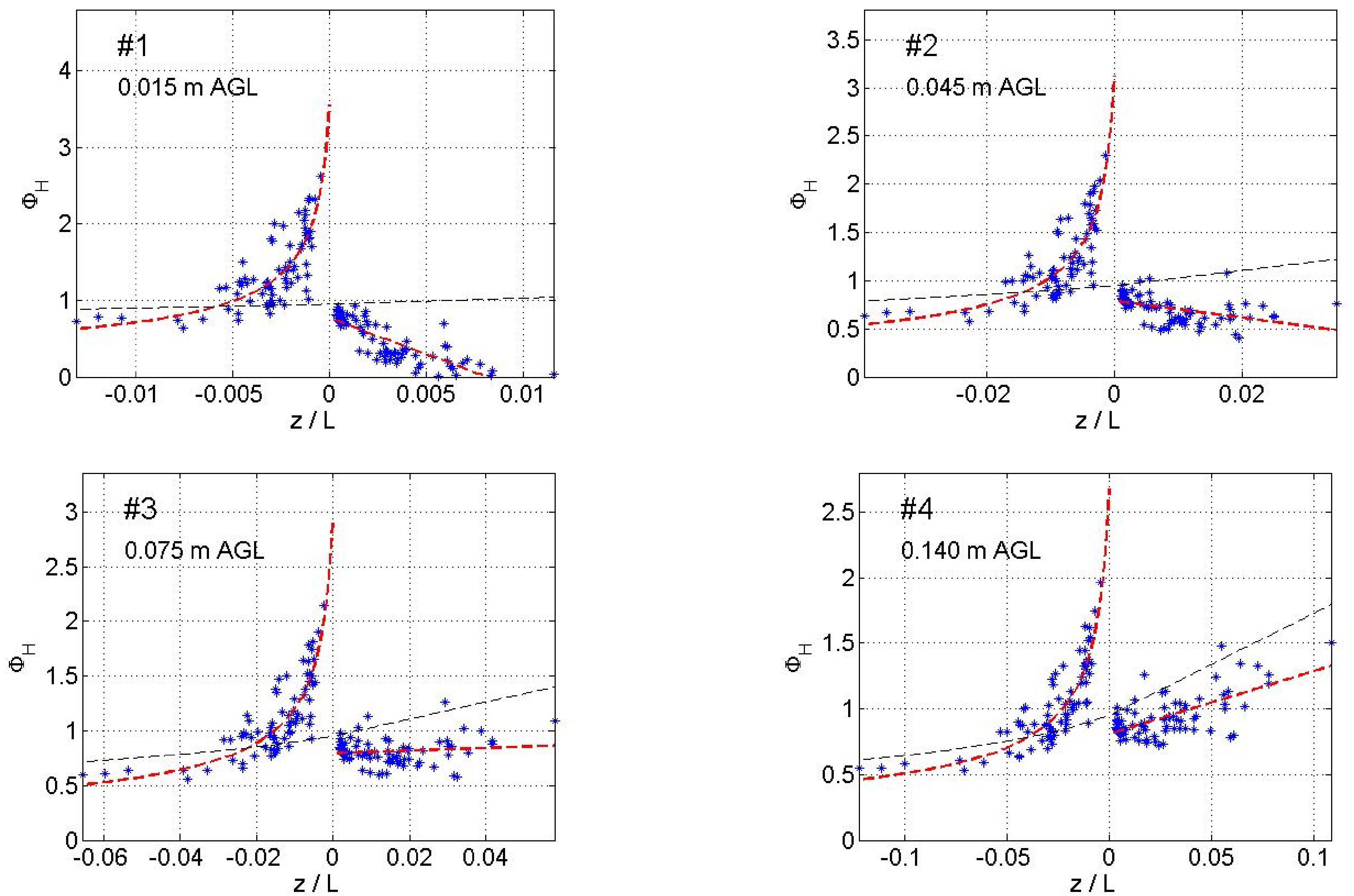
#	1	2	3	4	5	6	7	8
z (m)	0.015	0.045	0.075	0140	0.300	0.515	1.045	1.920
z/z_0	0.943	2.83	4.72	8.81	18.9	32.4	65.7	121

- For $z_0 \simeq 1.59 \pm 0.89$ cm.
- MOST is valid for $z/z_0 \gg 1 \Rightarrow$ We expect deviations for thermocouples #1–4.

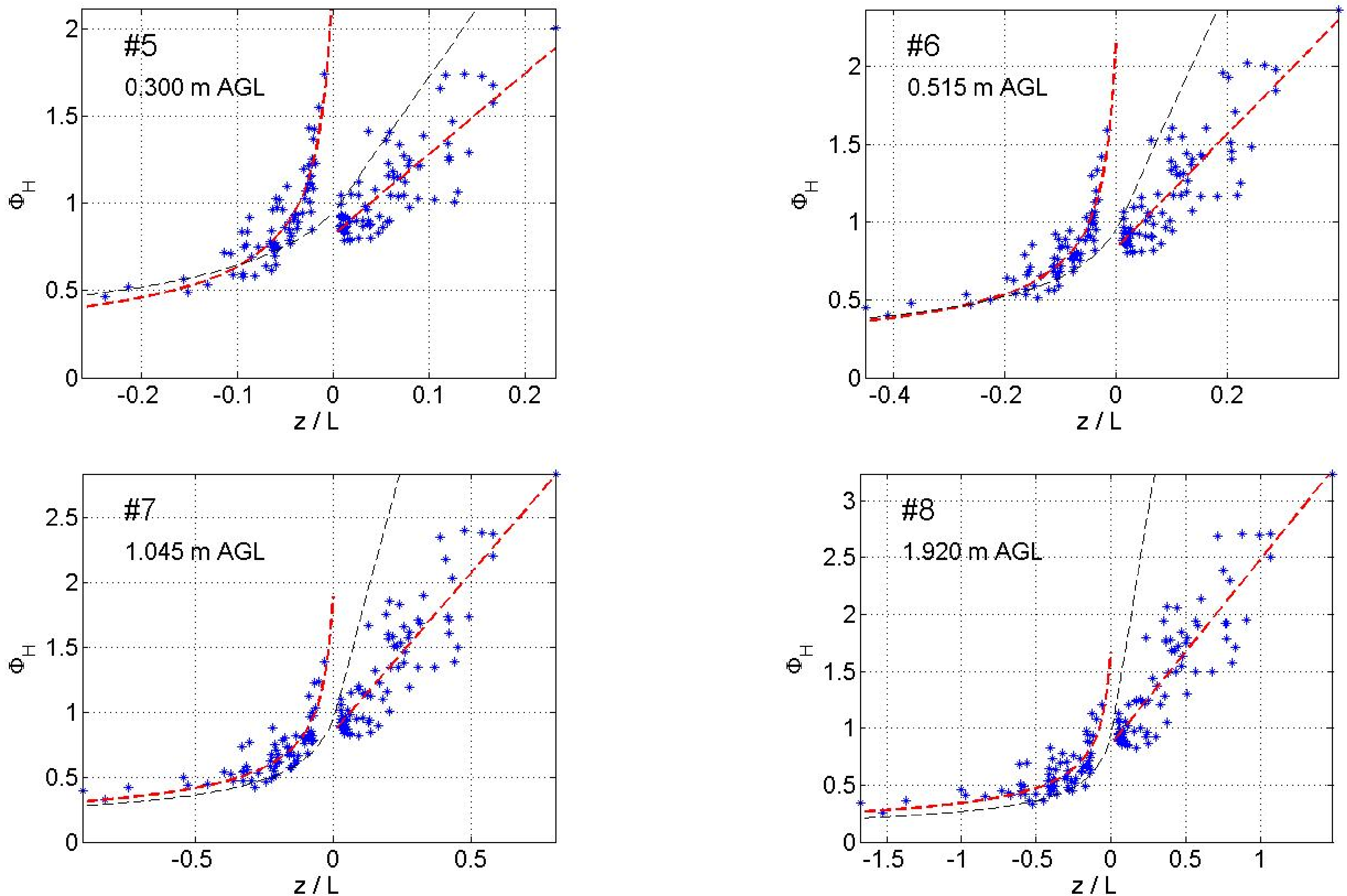
Averaging time periods: We select two different averaging time periods:

- 15 minutes
- 30 minutes

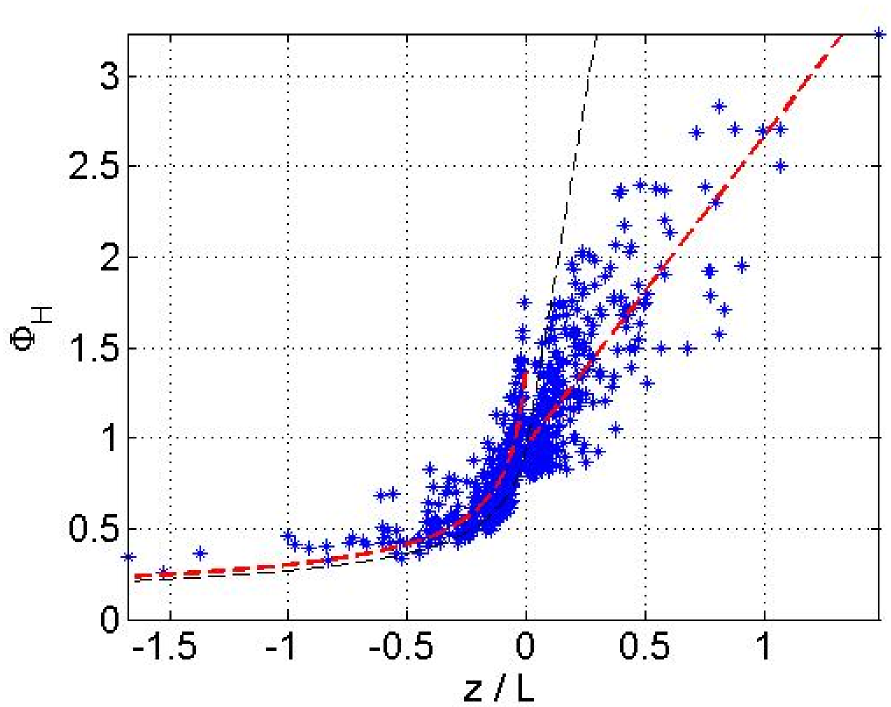
Results (Ia): MOST for each height



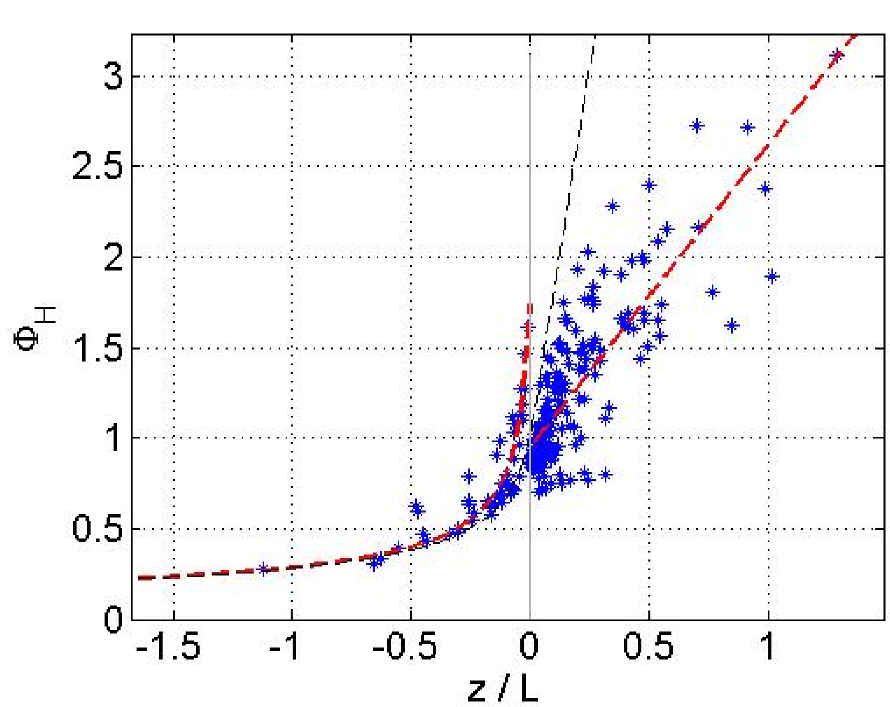
Results (Ib): MOST for each height



Results (II): MOST for the 4 uppermost heights



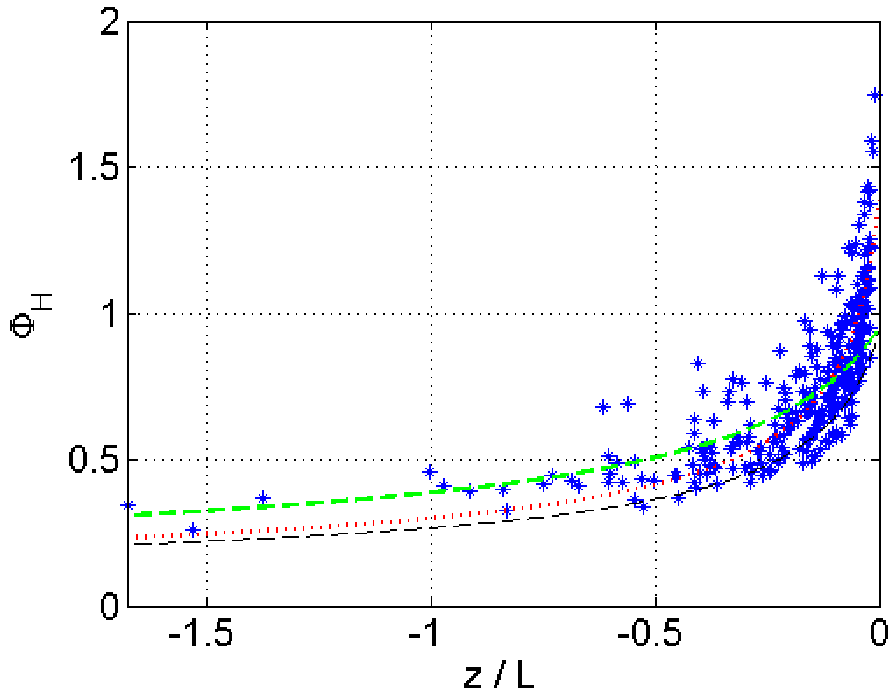
15 minutes



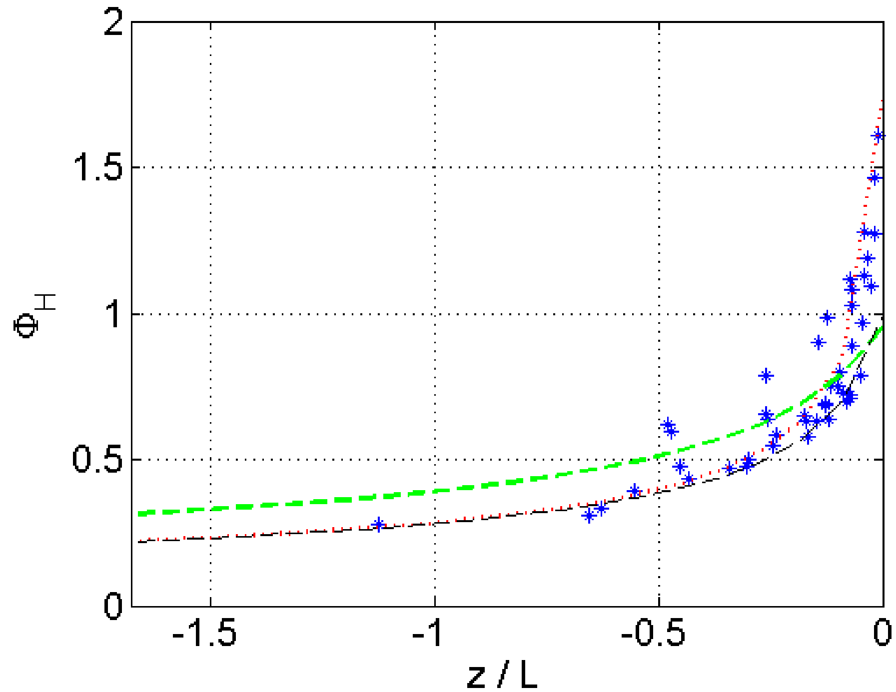
30 minutes

- Unstable case: Fitted curve adjusts to MOST for $\zeta < -0.3$ but $\Phi_H(0^-) \simeq 1.5$
- Stable case: The linear fit has a much smaller slope (22%), but $\Phi_H(0^+) \simeq 0.95$

Results (III): MOST for the 4 uppermost heights (Unstable)



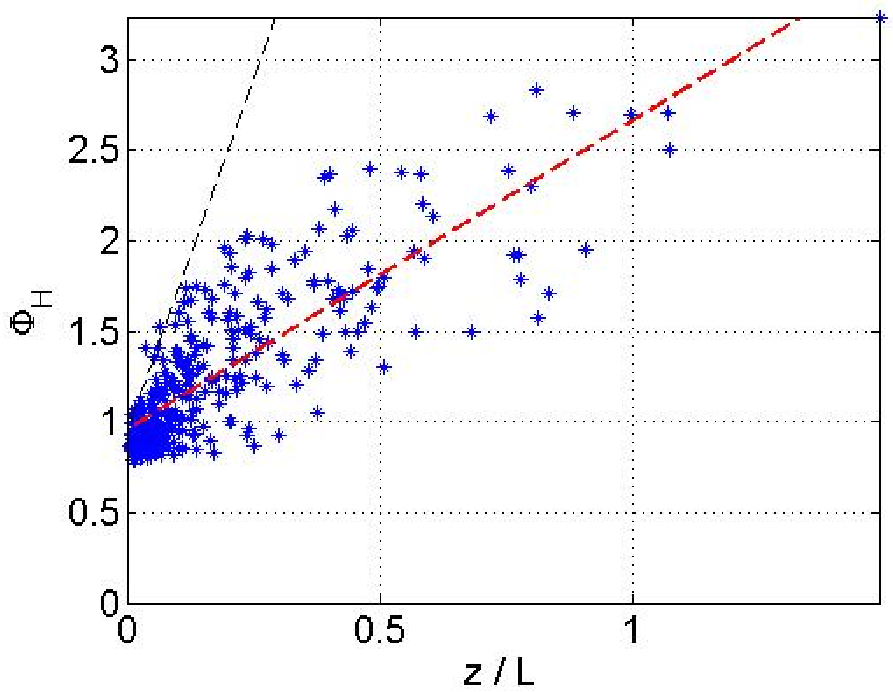
15 minutes

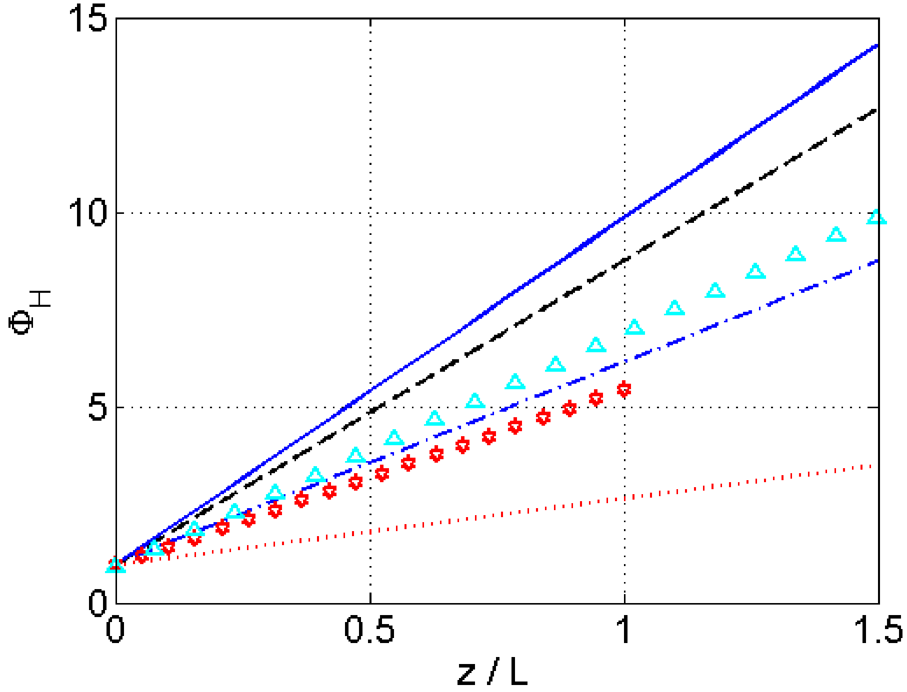


30 minutes

- A curved fitted to BLLAST data with $\Phi_H(0^-) = 0.95$ do not provide better results.
- All the curves fitted with 15 min averaged data do not agree with the 30 min averaged data.

Results (IV): MOST for the 4 uppermost heights (Stable)





Comparison of the results against different universal functions (from Foken, 2006).

Sources of error

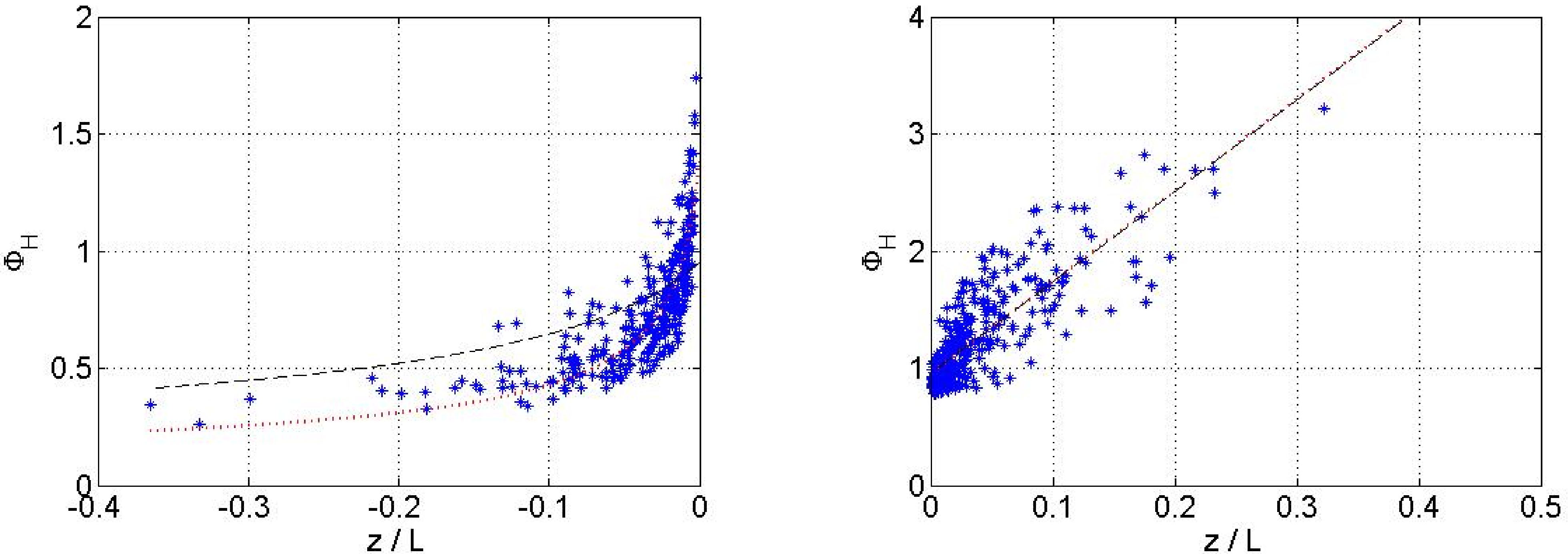
Högström (1988) summarized the possible reasons for the differences obtained experimentally:

1. Statistical uncertainty in the individual averaging time periods
2. Systematic instrumental inaccuracy
3. Inadequate upwind fetch
4. Systematic errors due to inadequate sampling
5. Limitations of MOST

Instrumental error: Can we meet MOST with our dataset by correcting the flux measurements?
We define two independent correction factors (a, b):

$$\widetilde{\overline{w'\theta'}} = a \cdot \overline{w'\theta'} \; ; \quad \widetilde{u}_* = b \cdot u_*$$

Results (V): MOST for the 4 uppermost heights (corrected)



- The averaged correction factors for the stable cases are $a = 2.16$ and $b = 2.15$.
- The linear fit to the corrected values meets MOST for the stable cases.
- The results are not improved for the unstable cases.

Preliminary conclusions

- The dataset provided by the 2-m column of thermocouples and the EC station at the SSH site do not follow MOST.

- Assuming horizontal homogeneity and steady conditions, these deviations can be produced by (i) systematic instrumental errors, (ii) uncertainty due to averaging time periods or (iii) limitations of MOST.
  - Unstable case: inadequate averaging period can not be discarded.
  - Stable case: A systematic error in the flux measurements could explain the deviation for heights $z > 30$ cm, assuming that half of the flux is not recorded (due to smaller eddies?).
  - For the first 15 cm above ground, MOST cannot be followed. In this layer, other phenomena related with radiation flux divergence, latent heat processes, etc. must play a role.

Acknowledgements

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