Wind dynamics of a heterogeneous forest edge

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Motivation

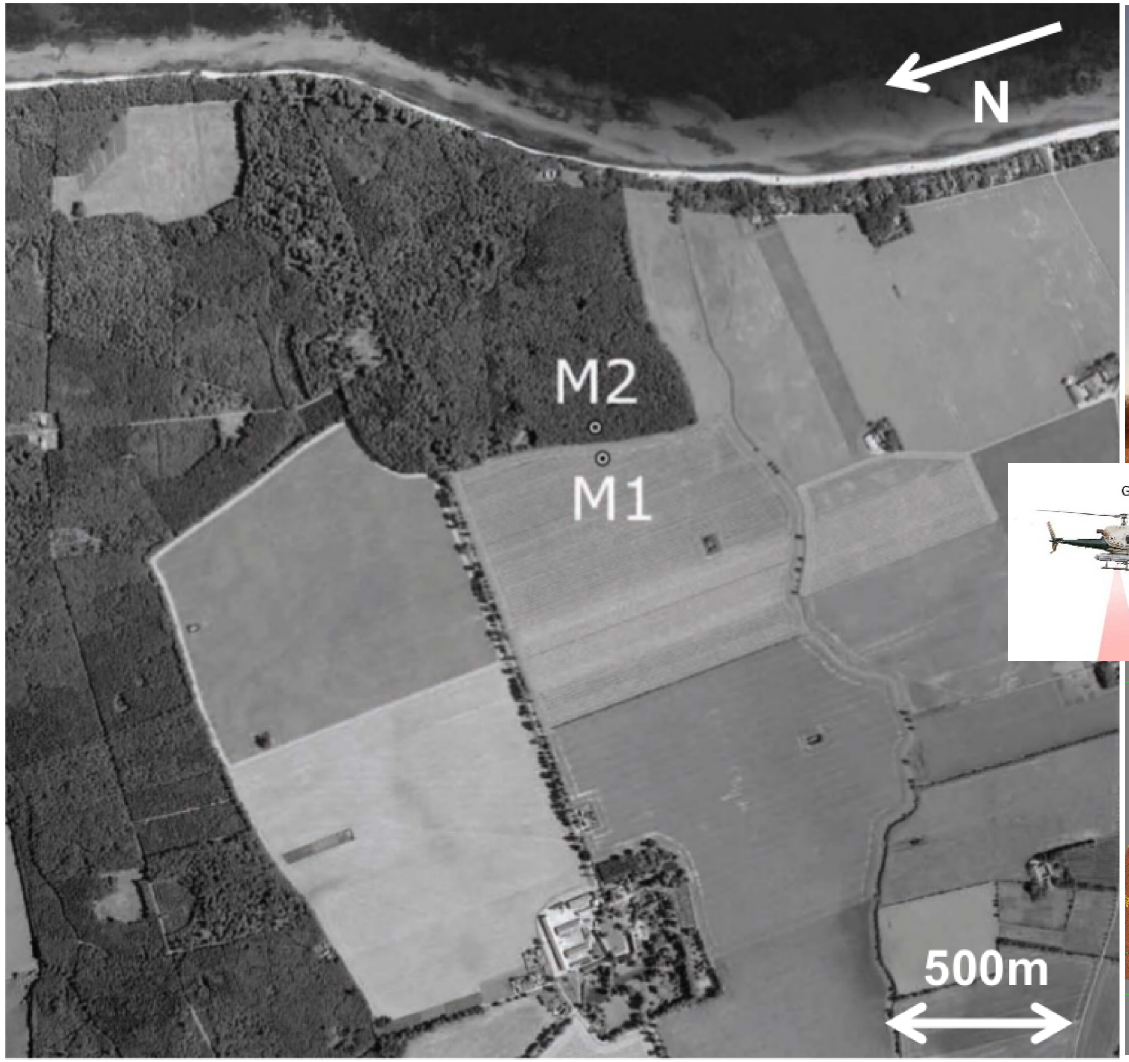
- Wind turbine siting $\rightarrow$ high shear and turbulence
- Previous studies focused on idealized homogeneous forest edge flows

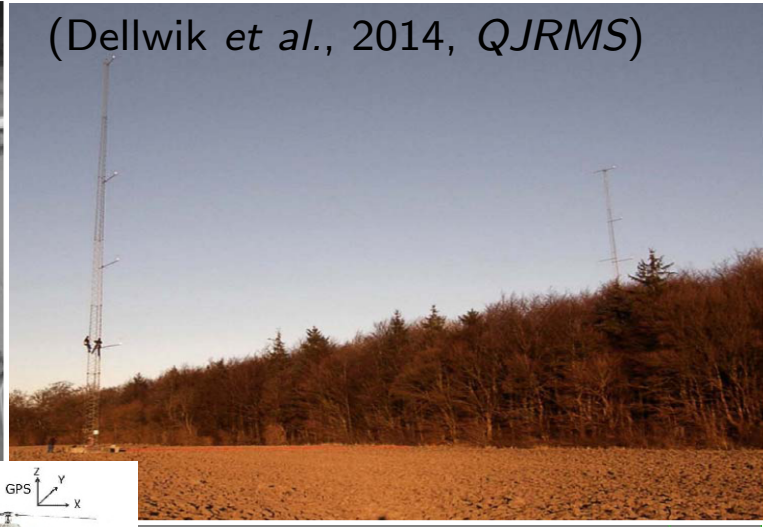
Effect of the tree-scale heterogeneities unknown

- This study: LES application on a specific site in Denmark to investigate the impact of the forest heterogeneities on the edge flow

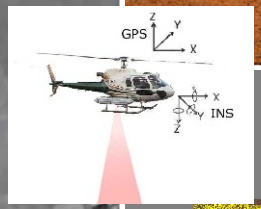
Field site

Helicopter-based high resolution scans ($> 10\ \mathrm{returns/m^2}$) $\rightarrow$ LES input

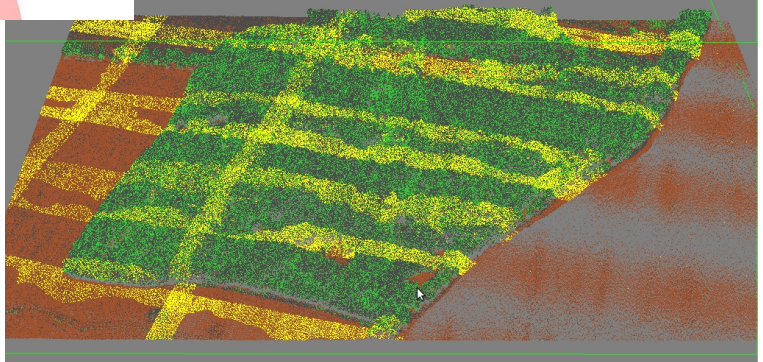




(Dellwik *et al.*, 2014, *QJRMS*)



$$F_D = -C_d a_f \sqrt{\tilde{u}_j \tilde{u}_j}\, \tilde{u}_i$$



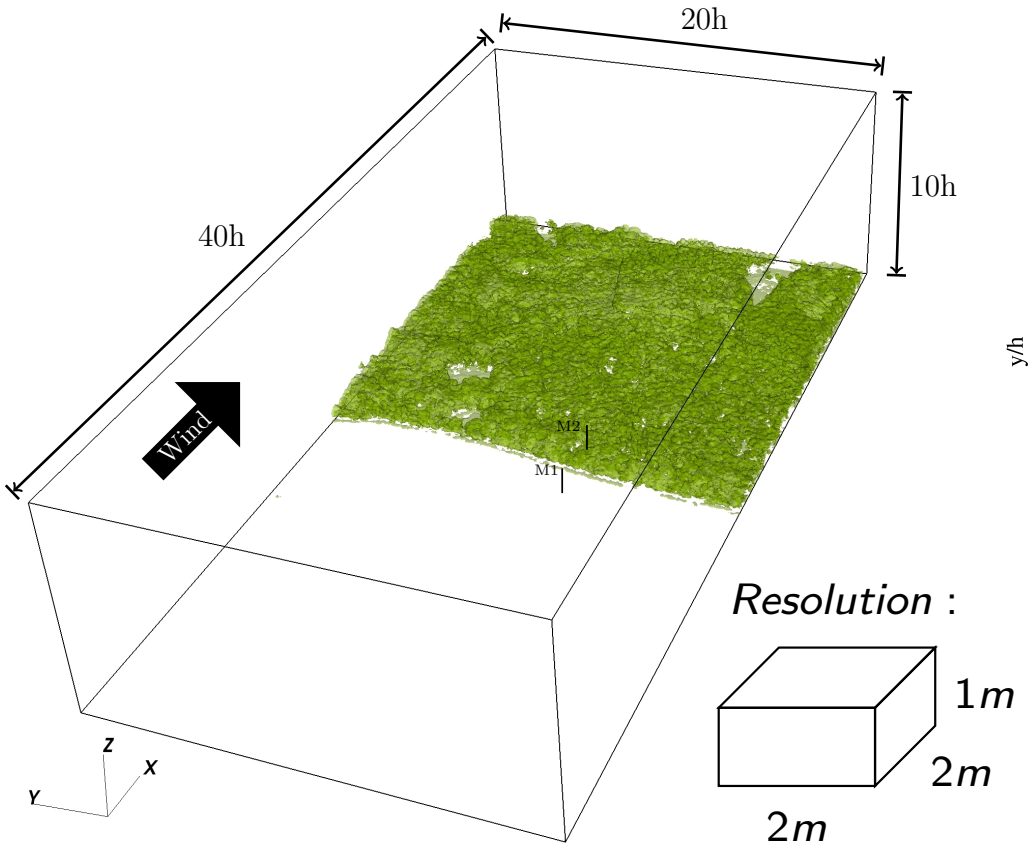
(Boudreault *et al.*, 2014, *in review*)

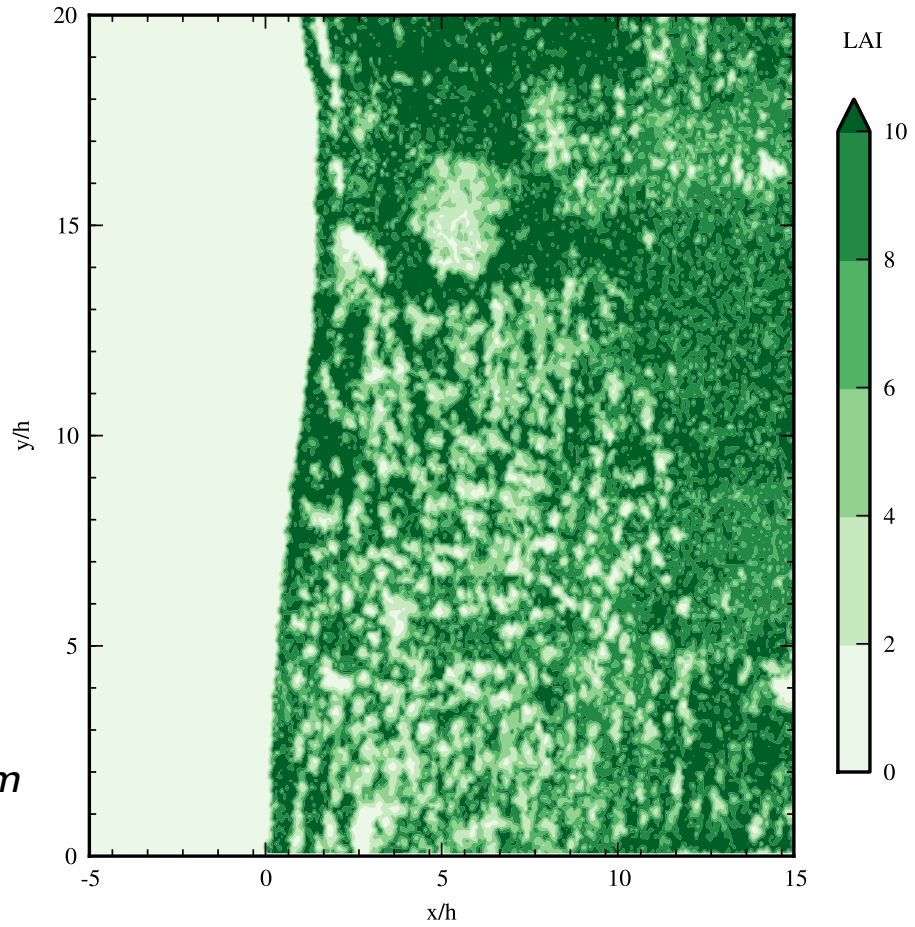
LES model

- Advanced Regional Prediction System (ARPS) code (Xue *et al.*, 1995, 2000, 2001)
- 1.5-order LES model
- Code modified to simulate flow within and above canopies (Dupont & Brunet, 2008, 2009; Dupont *et al.*, 2011)

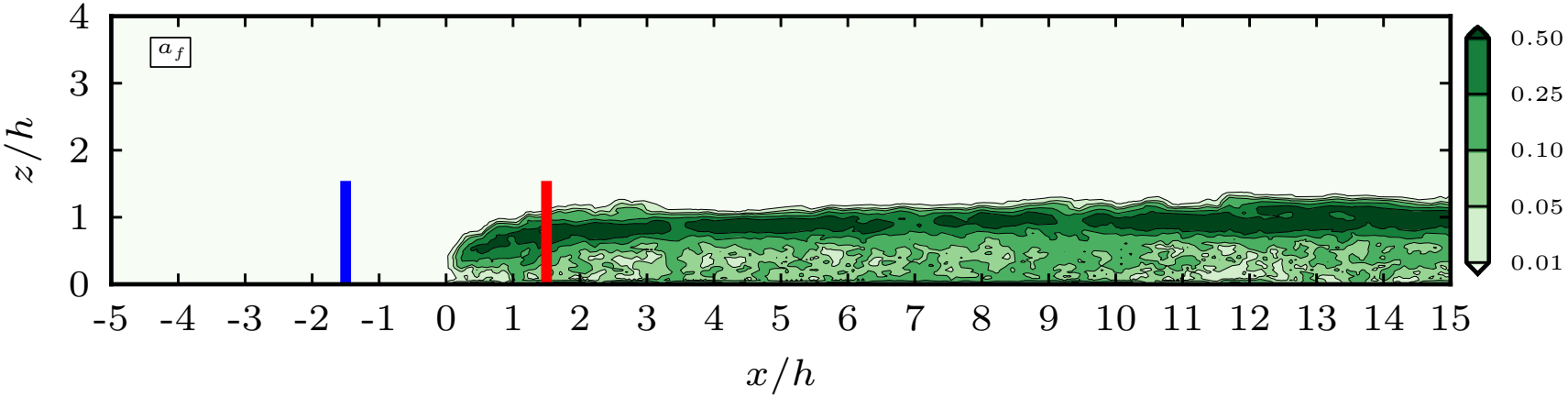
Domain

- Periodic conditions with mean u forcing at top boundary

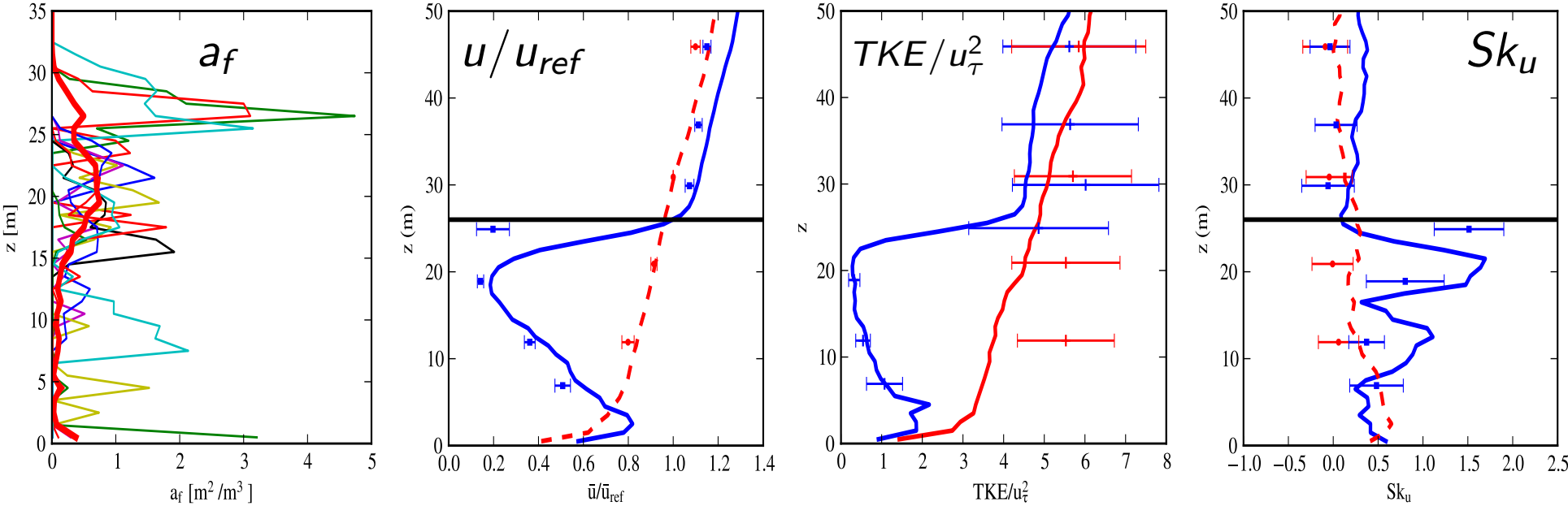




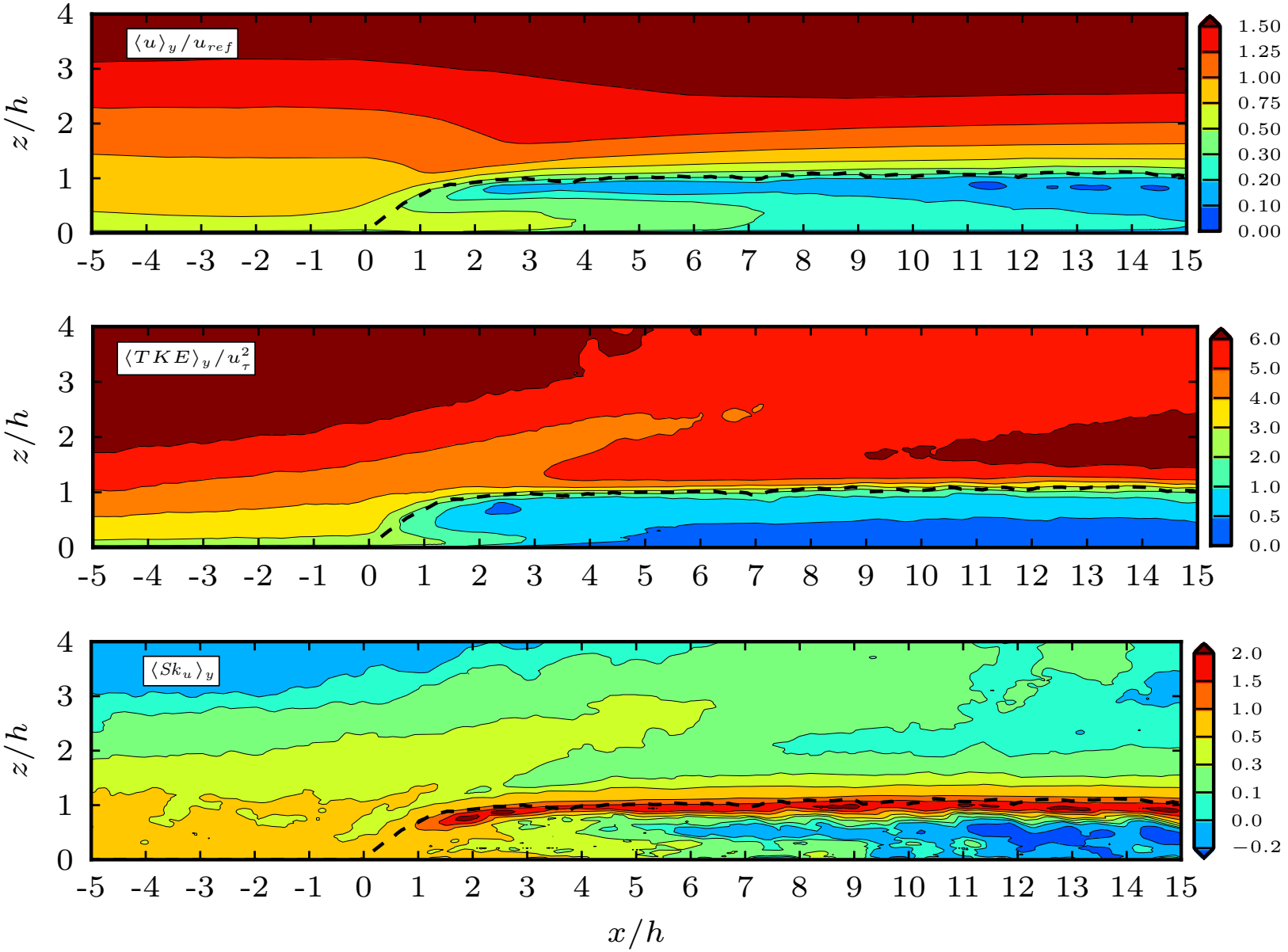
Model validation



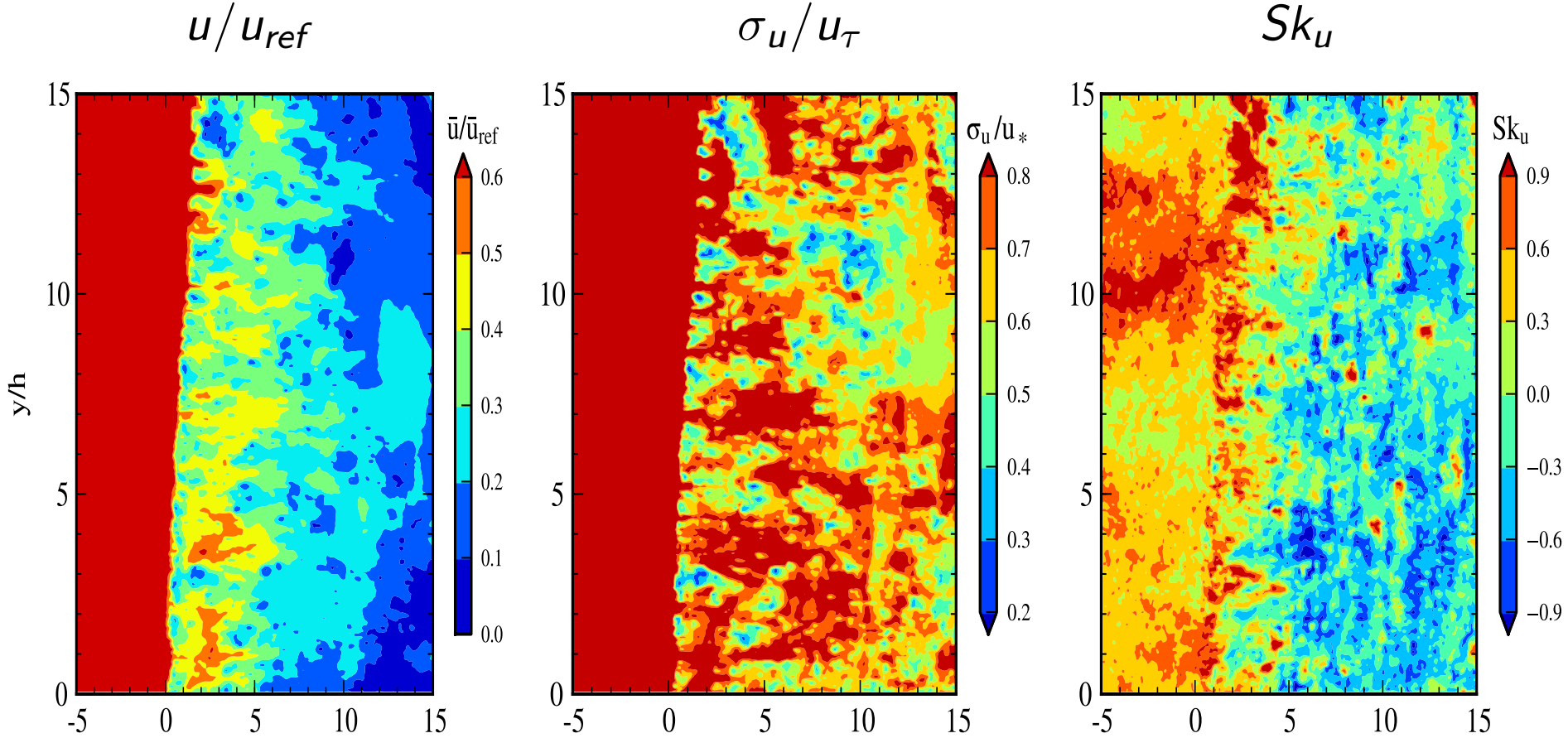
x: mast measurements —: LES results



2D mean edge flow



Mean flow at $z = 0.5h$



Dispersive fluxes

1- Time + horizontal averaging:

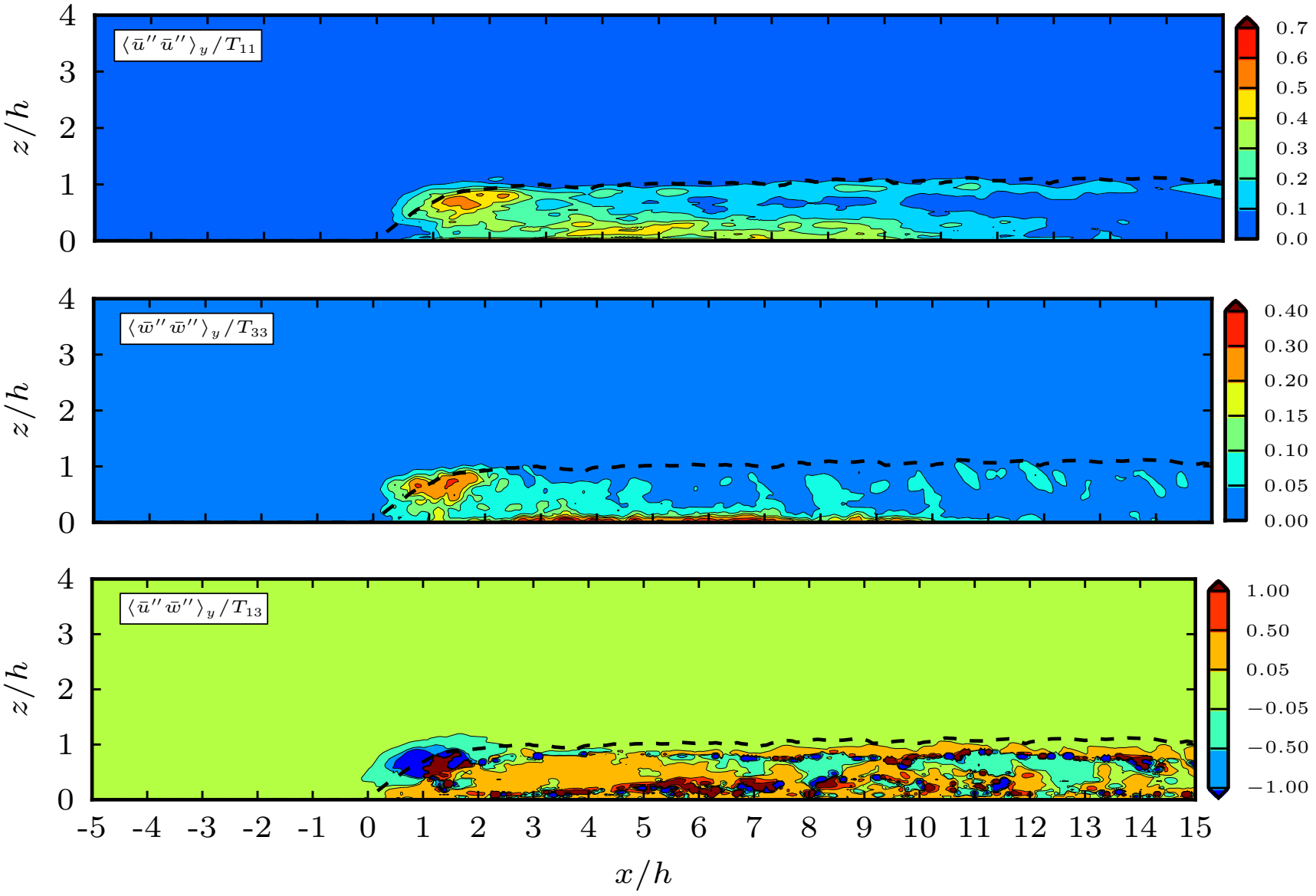
$$\phi_i' = \phi_i - \bar{\phi}_i,$$
$$\bar{\phi}_i'' = \bar{\phi}_i - \langle \bar{\phi}_i \rangle_{xy}.$$

2- Additional stresses arising from horizontal averaging:

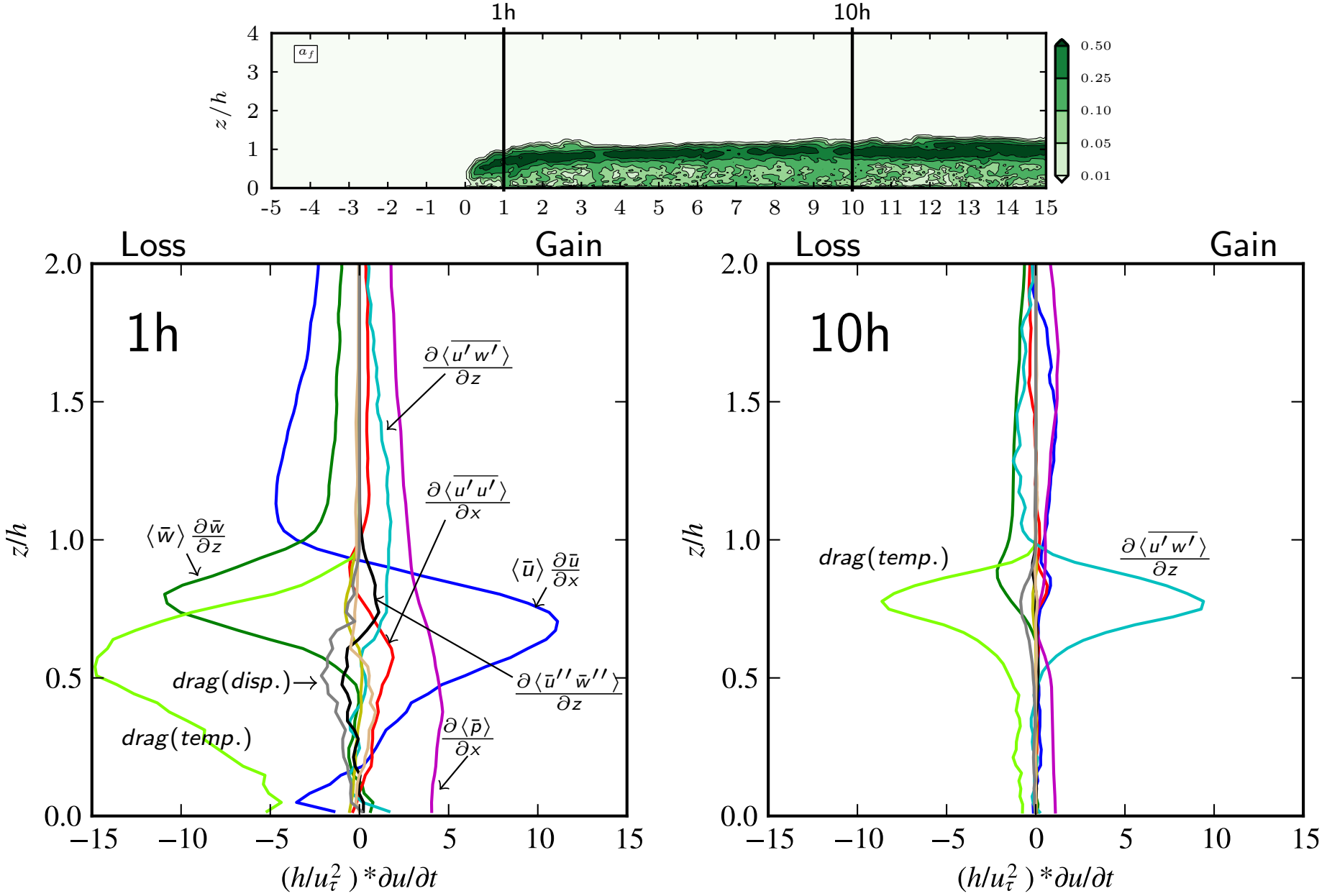
$$T_{ij} = \langle \overline{u_i' u_j'} \rangle + \langle \bar{\tau}_{ij} \rangle + \langle \bar{u}_i'' \bar{u}_j'' \rangle$$

3- Dispersive covariance: spatial correlation of quantities averaged in time but varying with position (Raupach and Shaw, 1982)

Magnitude of dispersive fluxes



u-component budget



Summary

1. Heterogeneous forest edge flow analysed
2. Good agreement with experimental measurements
3. Mean dynamics similar to homogeneous forest edge flow
4. Strong spatial variability was found
5. Tree-scale dispersive fluxes were observed
6. No significant contribution of dispersive fluxes was found in the mean u-component budget
7. Contribution of dispersive fluxes to turbulence budget to be investigated

Thank you for your attention!