

Impact of surface heat flux differences on mixed-layer height: ground-based remote sensing measurements at Yatir forest, Israel

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Background:

The 'canopy convective effect' (Rotenberg and Yakir 2010, 2011): **sensible heat fluxes are higher above the forest than above the desert:**

- higher energy input (albedo, longwave radiation)
- increased turbulence (higher surface roughness)

Research questions:

1. Does a **secondary circulation** develop between desert and forest ("desert breeze")?
2. Is the **mixed layer deeper** above the forest?

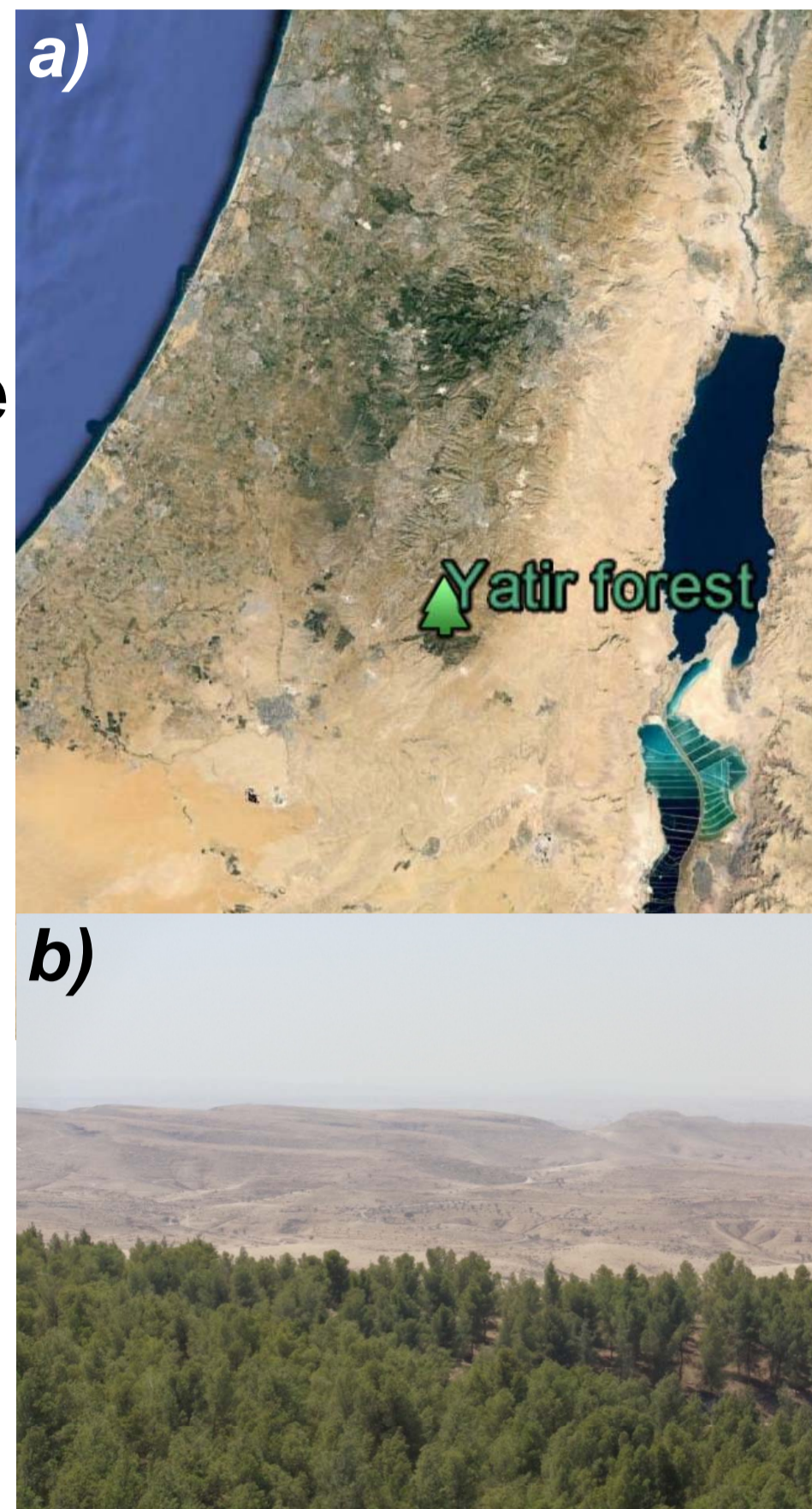


Fig. 1 Location of the Yatir forest (a) and picture of the southwestern edge of the forest (b)

Measurements:

- period of measurements at forest and desert sites: 21 Aug – 8 Sept 2013

- side-by-side comparison of CL51 and Streamline: 9/10 Sept 2013

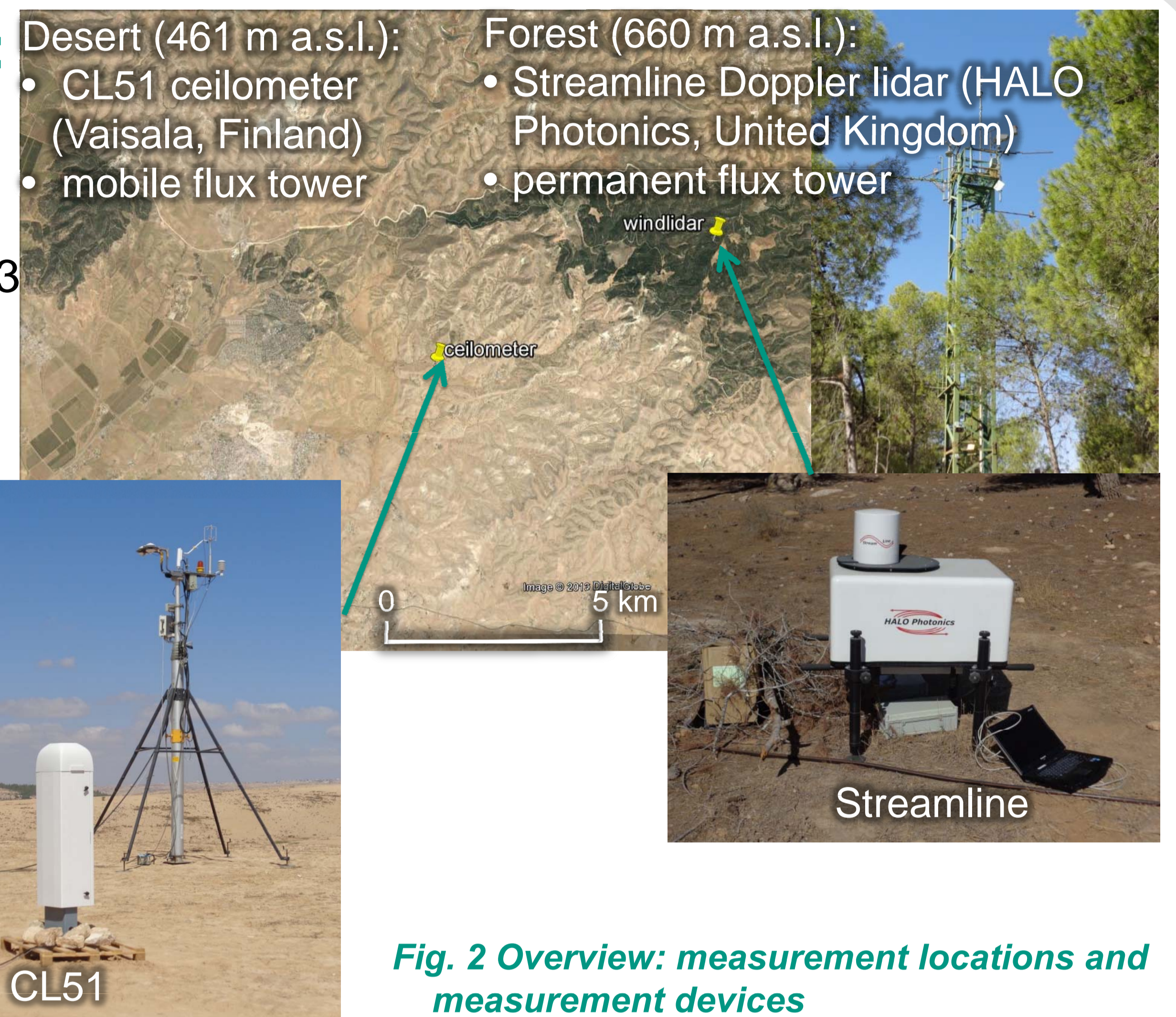
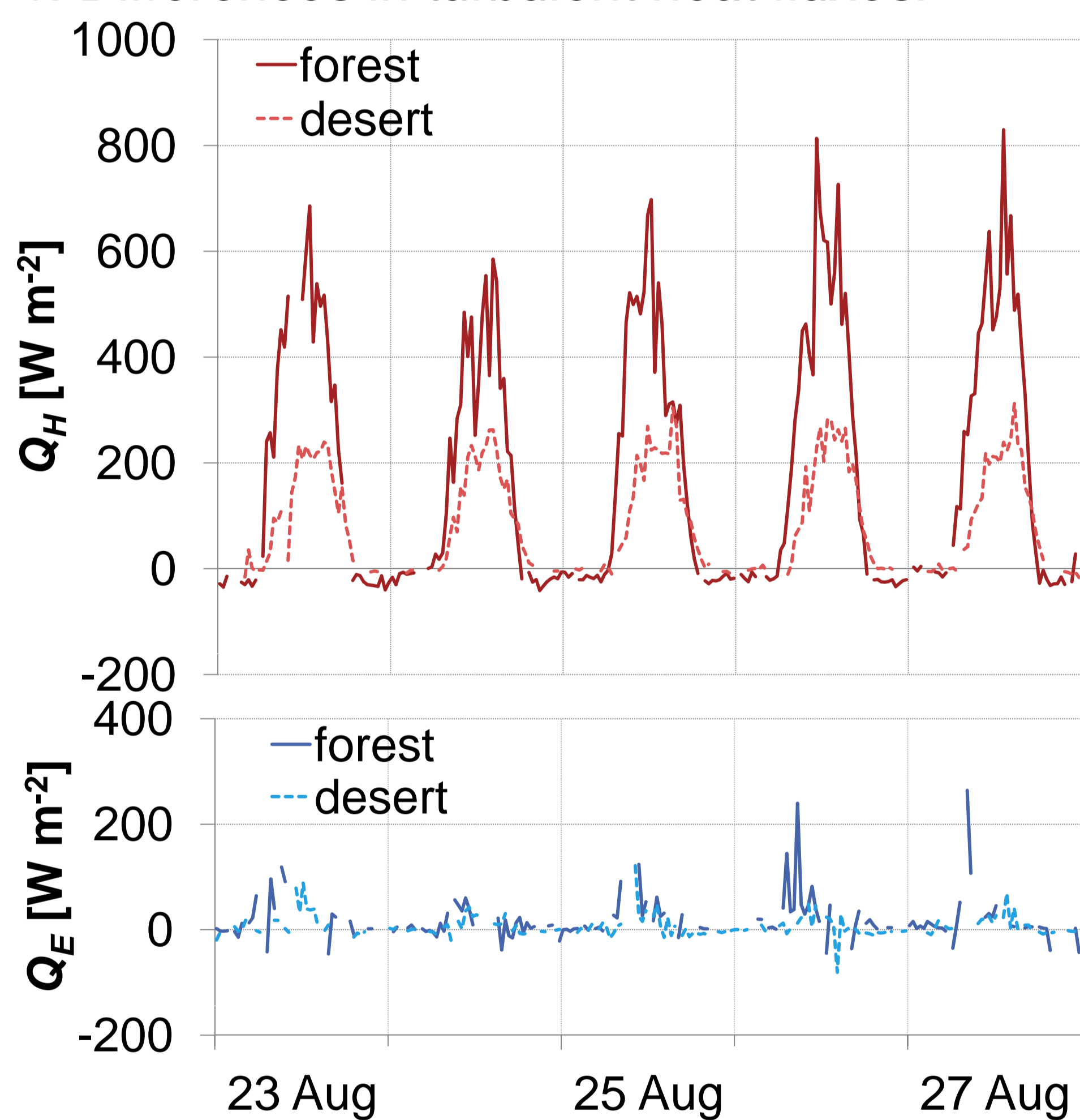


Fig. 2 Overview: measurement locations and measurement devices

Results:

1. Differences in turbulent heat fluxes:

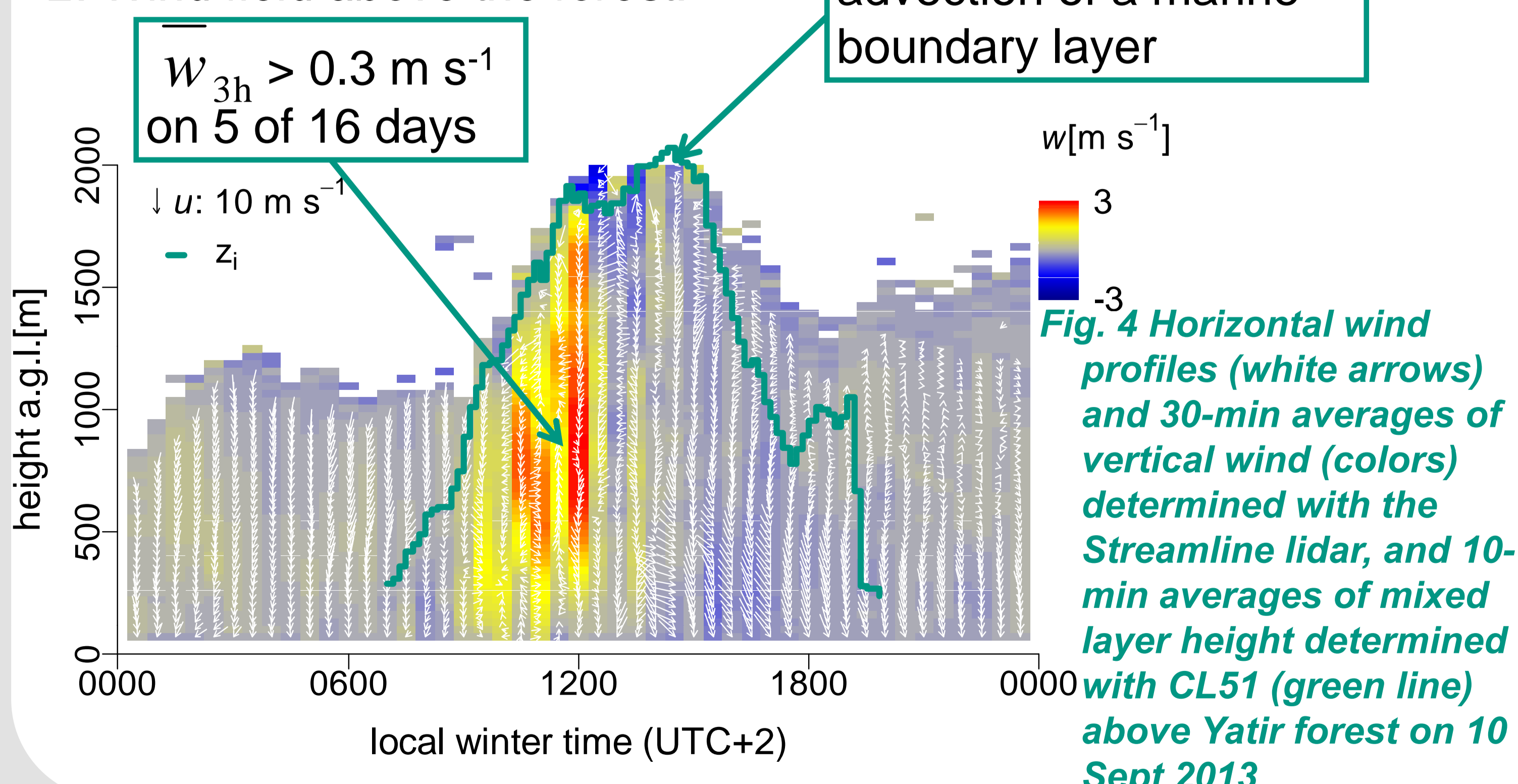


sensible heat flux:
~ 300 - 400 W m⁻²
higher above the forest

latent heat flux:
~ 0 - 100 W m⁻²
higher above the forest

Fig. 3 Turbulent fluxes of sensible (Q_H) and latent heat (Q_E) above the desert and the forest in the period from 23 Aug 2013 to 27 Aug 2013

2. Wind field above the forest:



advection of a marine boundary layer

$W_{3h} > 0.3 \text{ m s}^{-1}$
on 5 of 16 days

Fig. 4 Horizontal wind profiles (white arrows) and 30-min averages of vertical wind (colors) determined with the Streamline lidar, and 10-min averages of mixed layer height determined with CL51 (green line) above Yatir forest on 10 Sept 2013

3. Mixed layer heights:

Side-by-side comparison of CL51 and Streamline: daytime differences are not significant (Kolmogorov-Smirnov-Test)

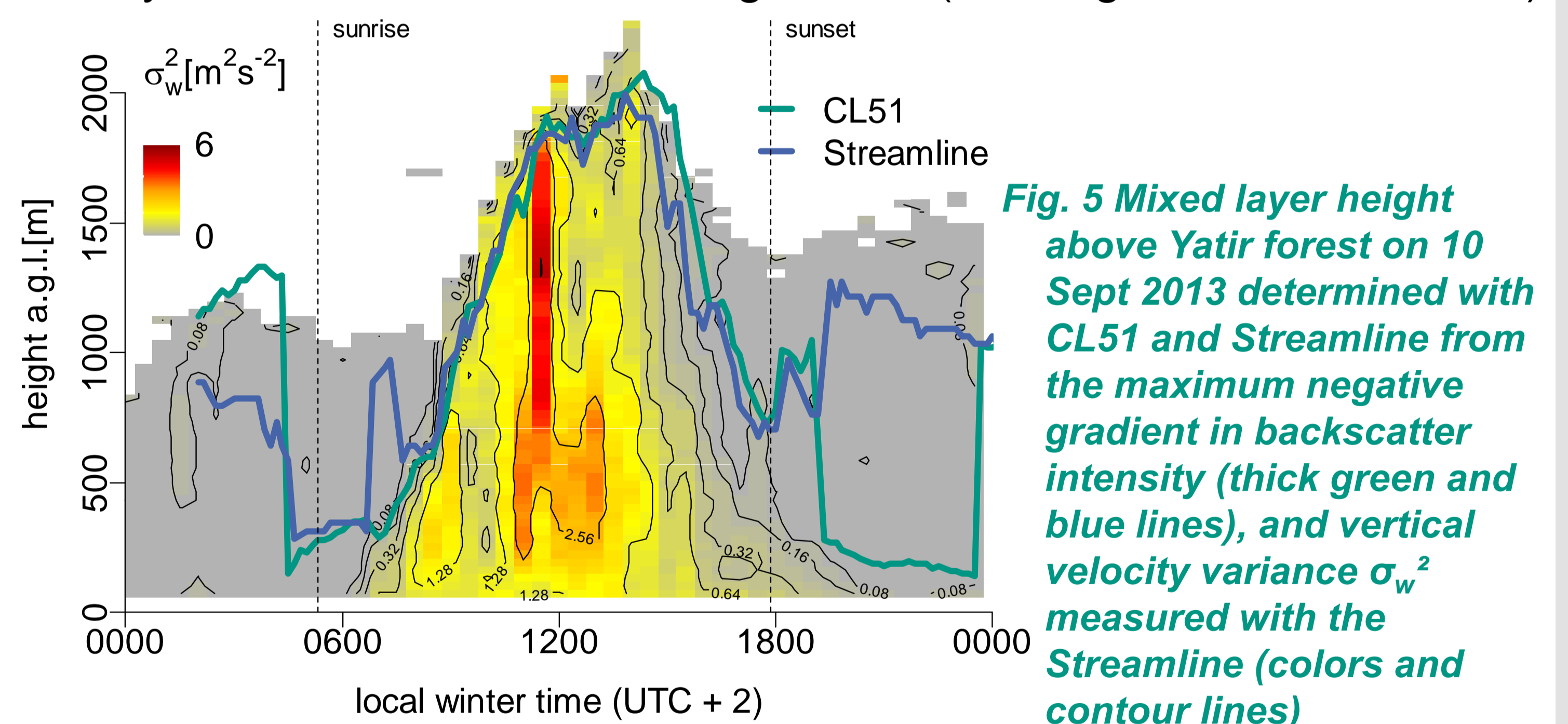


Fig. 5 Mixed layer height above Yatir forest on 10 Sept 2013 determined with CL51 and Streamline from the maximum negative gradient in backscatter intensity (thick green and blue lines), and vertical velocity variance σ_w^2 measured with the Streamline (colors and contour lines)

Comparison of mixed layer heights above forest and desert: **forest site lies at higher altitude**

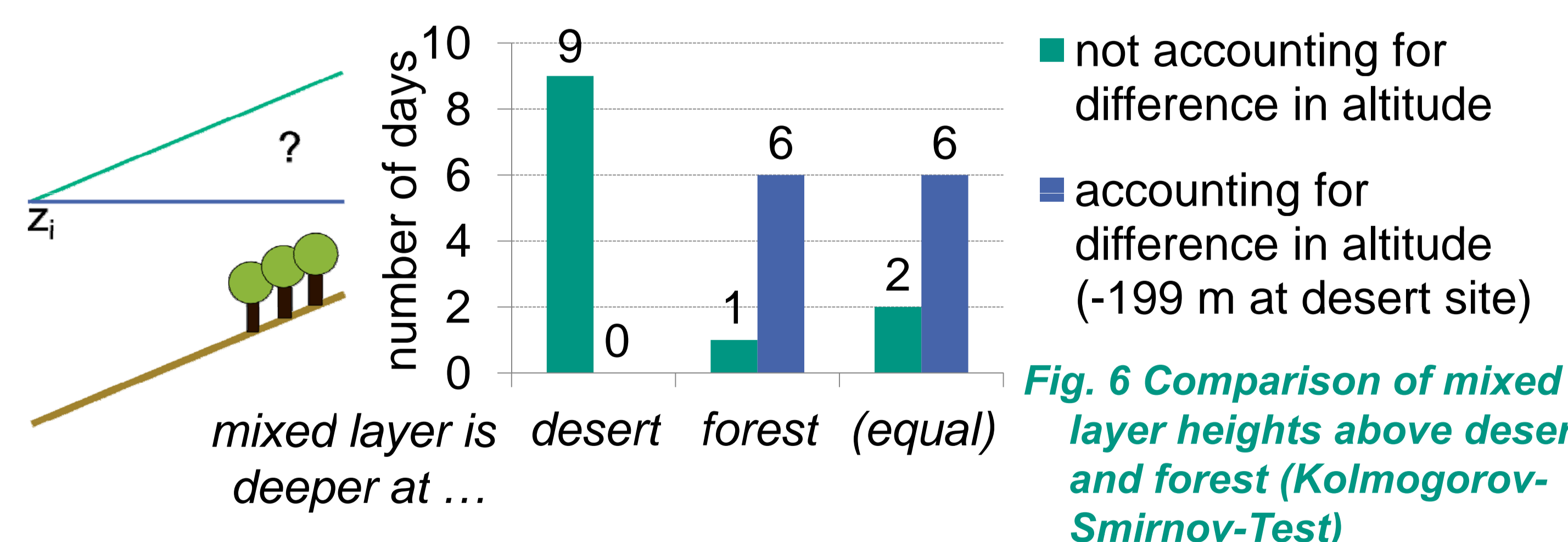


Fig. 6 Comparison of mixed layer heights above desert and forest (Kolmogorov-Smirnov-Test)

Summary:

1. Secondary circulation above the forest: strong **mean positive vertical wind** on 5 of 16 days during rise of mixed layer
2. Advection of a **marine boundary layer** in the afternoon
3. The **mixed layer is deeper above the forest** if it is assumed that the mixed layer would not follow the terrain

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Literature

Rotenberg, E., and D. Yakir, 2010: Contribution of semi-arid forests to the climate system. *Science*, **327**, 451-454.
Rotenberg, E., and D. Yakir, 2011: Distinct patterns of changes in surface energy budget associated with forestation in the semi-arid region. *Global Change Biology*, **17**, 1536-1548.