TURBULENT EXCHANGE PROCESSES IN AND ABOVE TALL VEGETATION

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2. Footprint analysis
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1. The WALDATEM-2003 experiment

WALDATEM =
WAveLet Detection and Atmospheric Turbulence Exchange Measurements

- **May – July 2003**
- **FLUXNET site Waldstein Weidenbrunnen, GE1 (DE-Wei)**
- **50° 09' N, 11° 52' E, 775 m a.s.l.**
- **Spruce forest, $h_c \approx 19$m**
- **30-min-data: 3456**

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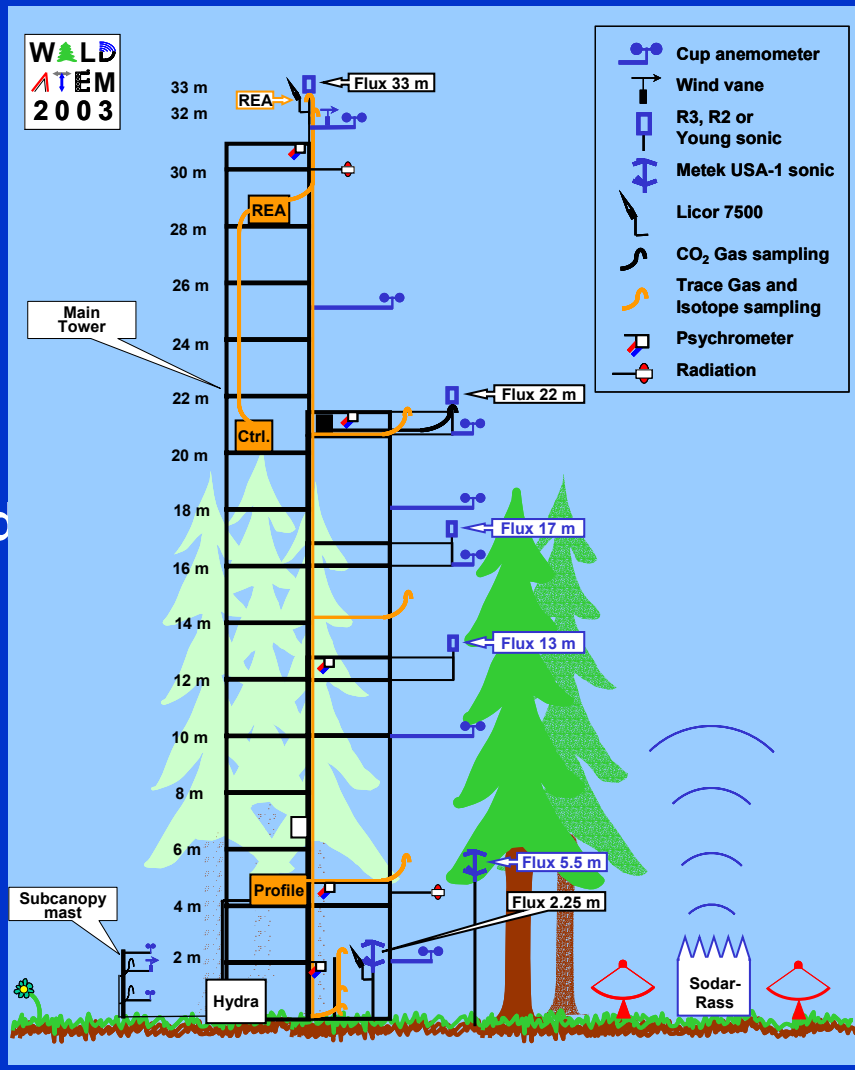
1. The WALDATEM-2003 experiment

- Sodar-RASS-System
- 32 m tower profiles:
  flux (7 levels),
  wind (7 levels),
  temperature-humidity (5 levels)
- Carbon dioxide fluxes (2 levels) and HREA system for ^{13}C-fluxes
- Vertical and horizontal carbon dioxide profile (17 points)
- Horizontal wind profile (advection, 3 masts)



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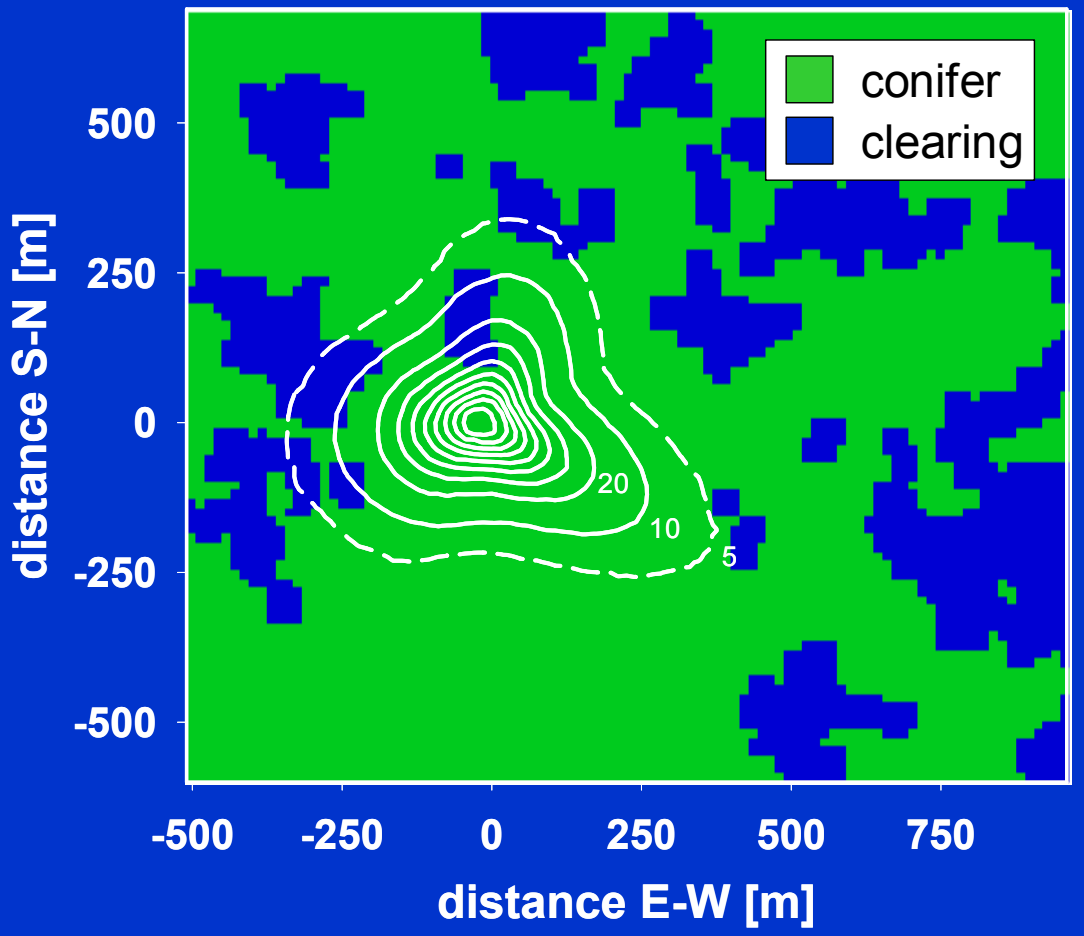
2. Footprint analysis

- Lagrangian model by Rannik et al. (2000, 2003)
- Area averaging of the roughness length according to Hasager & Jensen (1999)
- Combination of the footprint climatology with the 'landuse of interest' and flux data quality according to Foken & Wichura (1996)



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3. Coherent structures

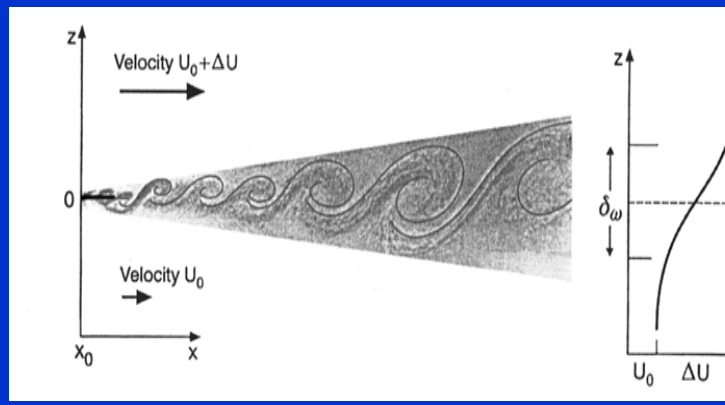
Duration of coherent structures is etermined by wavelet variance spectra V(a): Λ_x

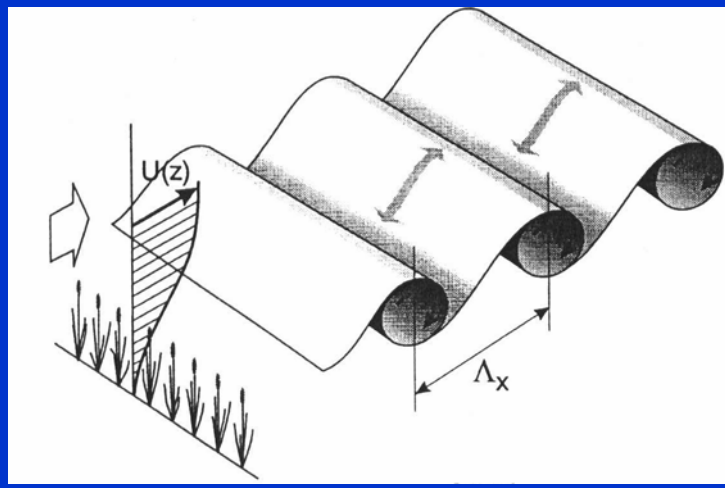
Shear length scales are determined rom cup anemometer profile:

$$L_s = {}^{\delta_w}\!/_{2} = \frac{u(h_c)}{\left({}^{\partial u}\!/_{\partial z}\right)_{z=h_c}}$$

Developed mixing layer: m = 7...10 ccording to Raupach et al. (1996) and innigan (2000)

$$\Lambda_x = m \cdot L_s$$





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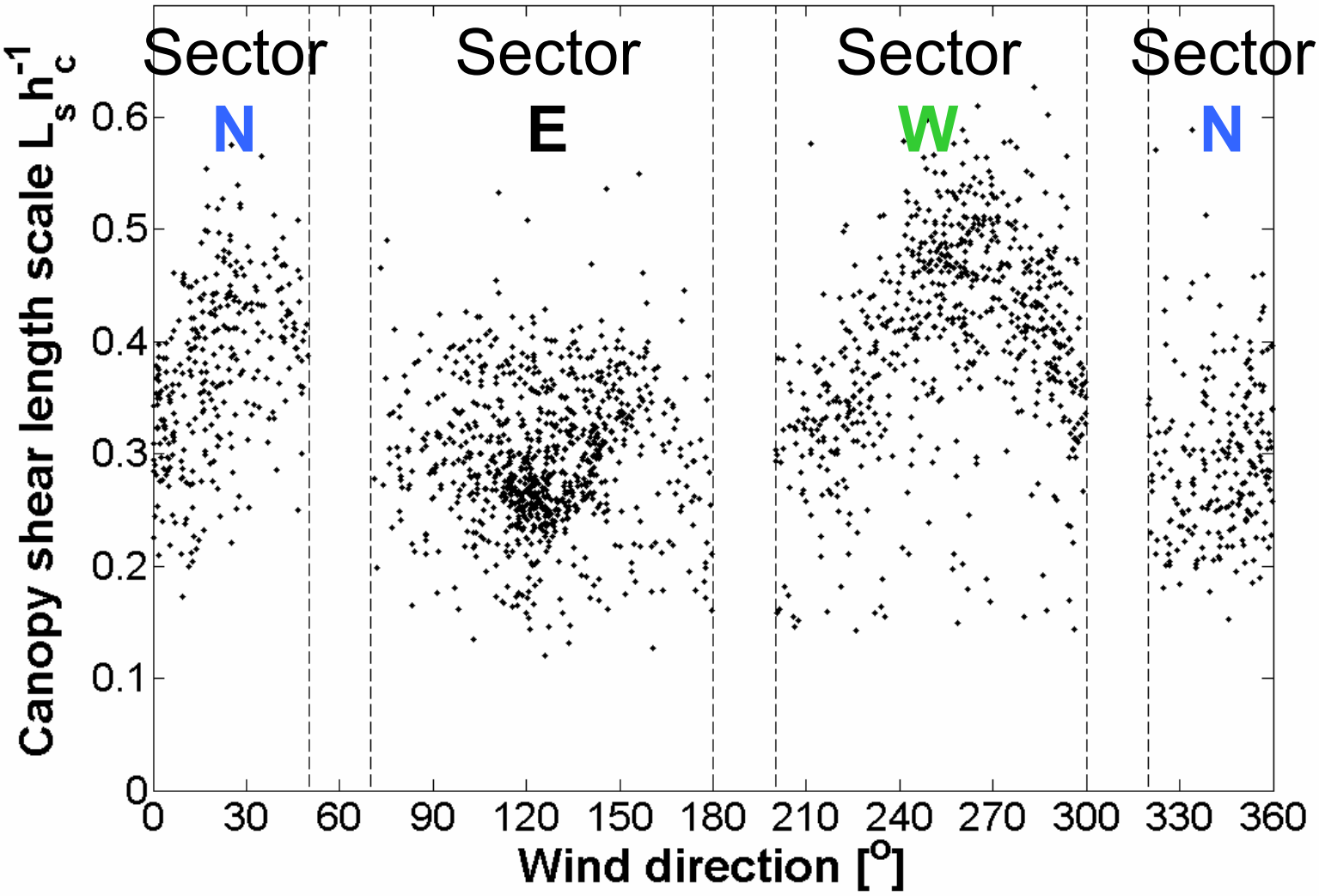

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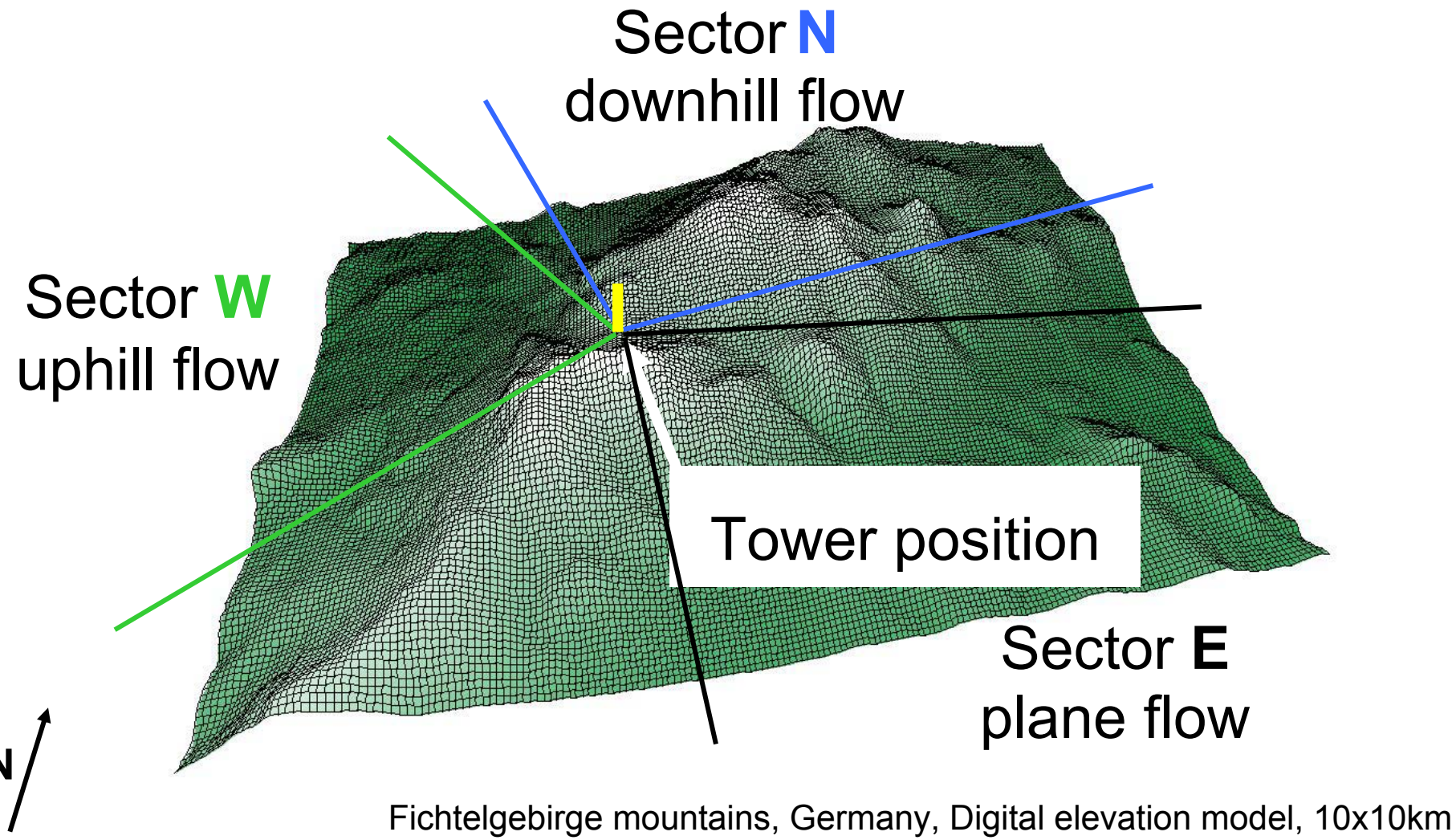

Fichtelgebirge mountains, Germany, Digital elevation model, 10x10km

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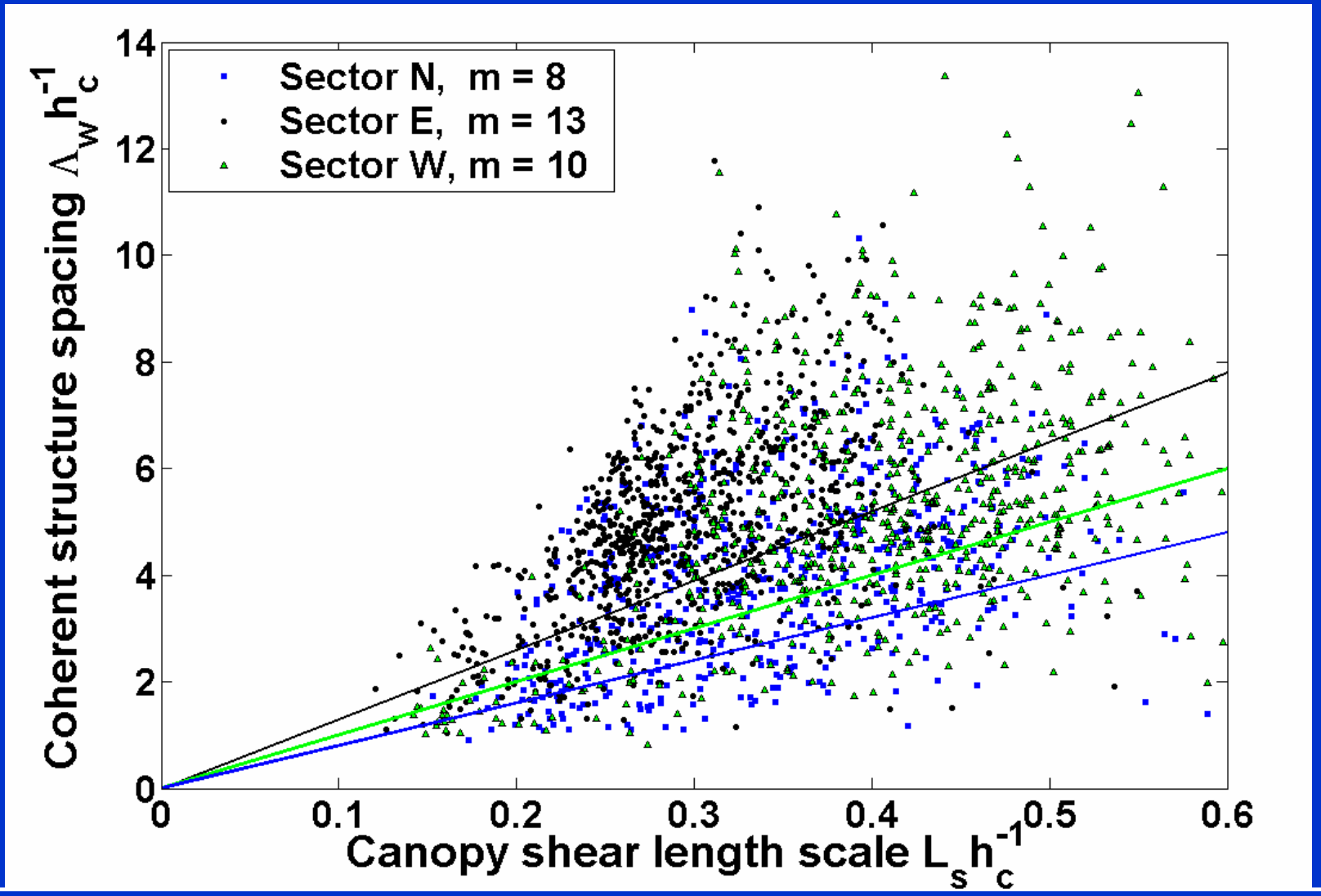

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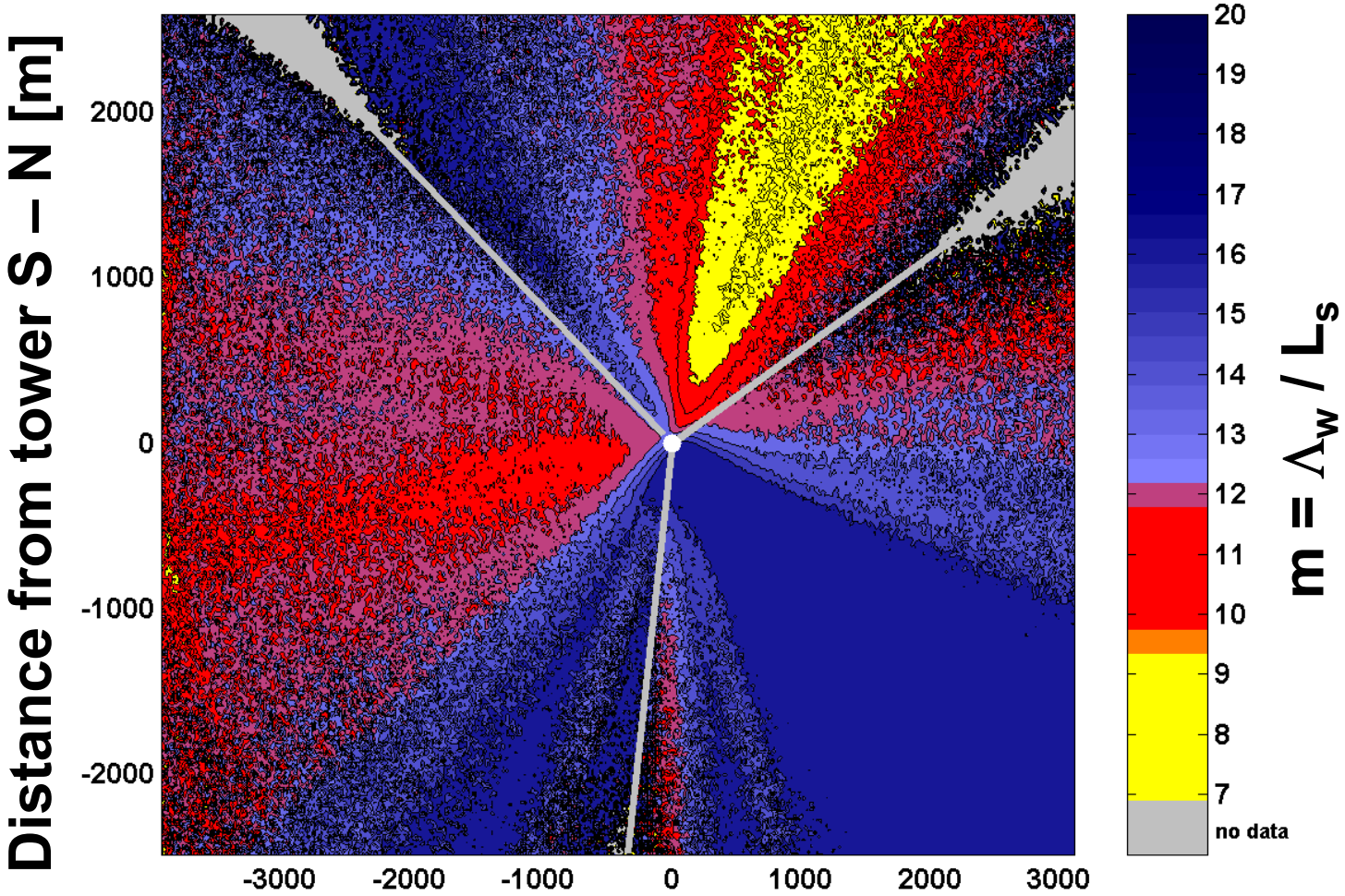

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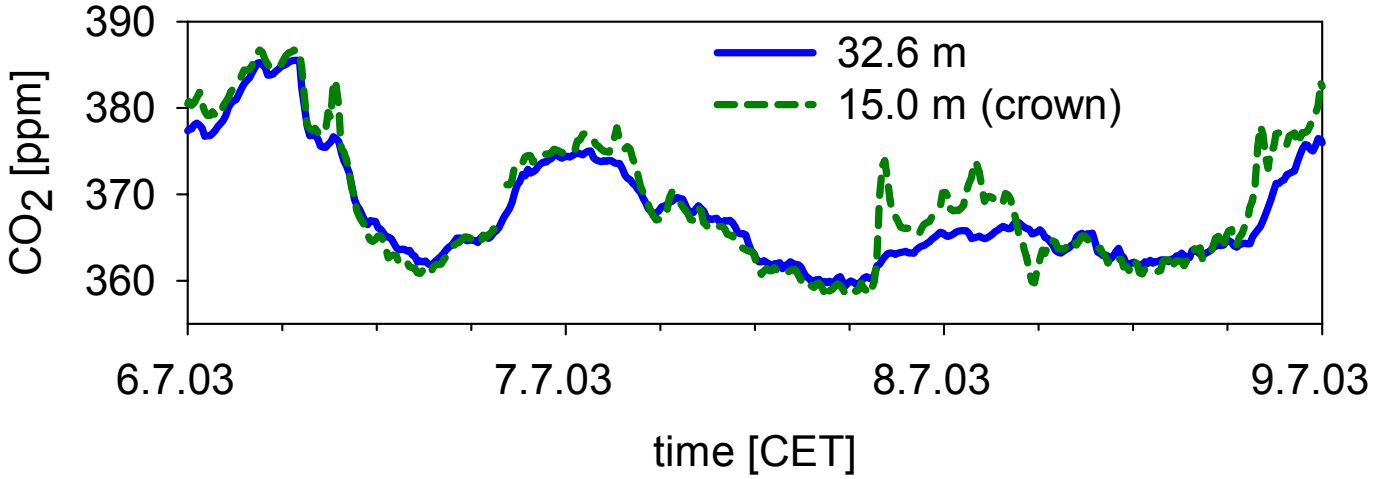
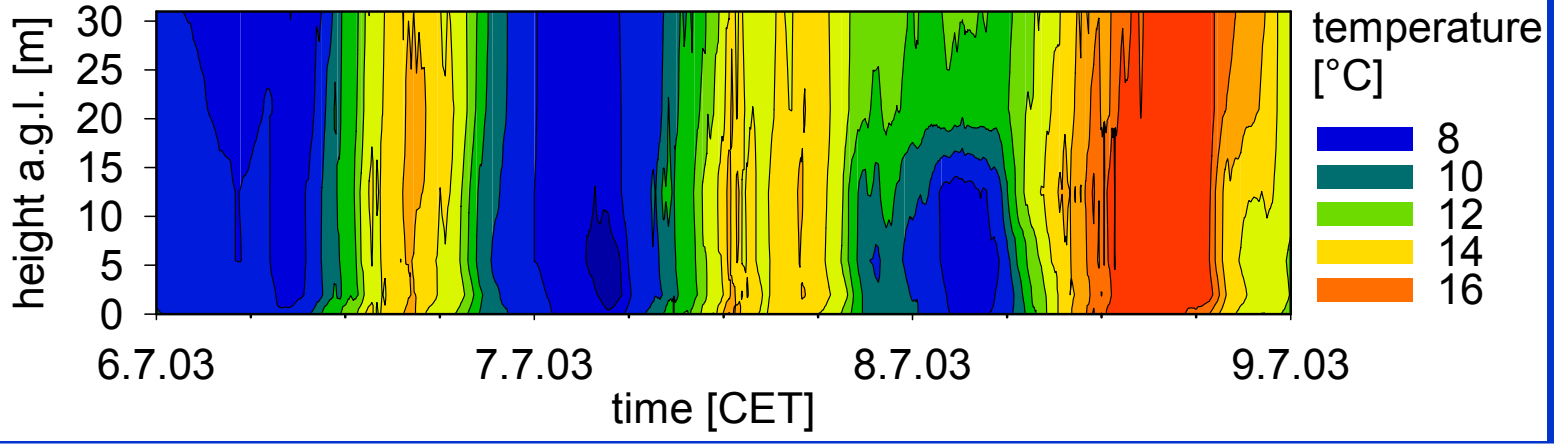
4. Carbon and carbon isotope fluxes





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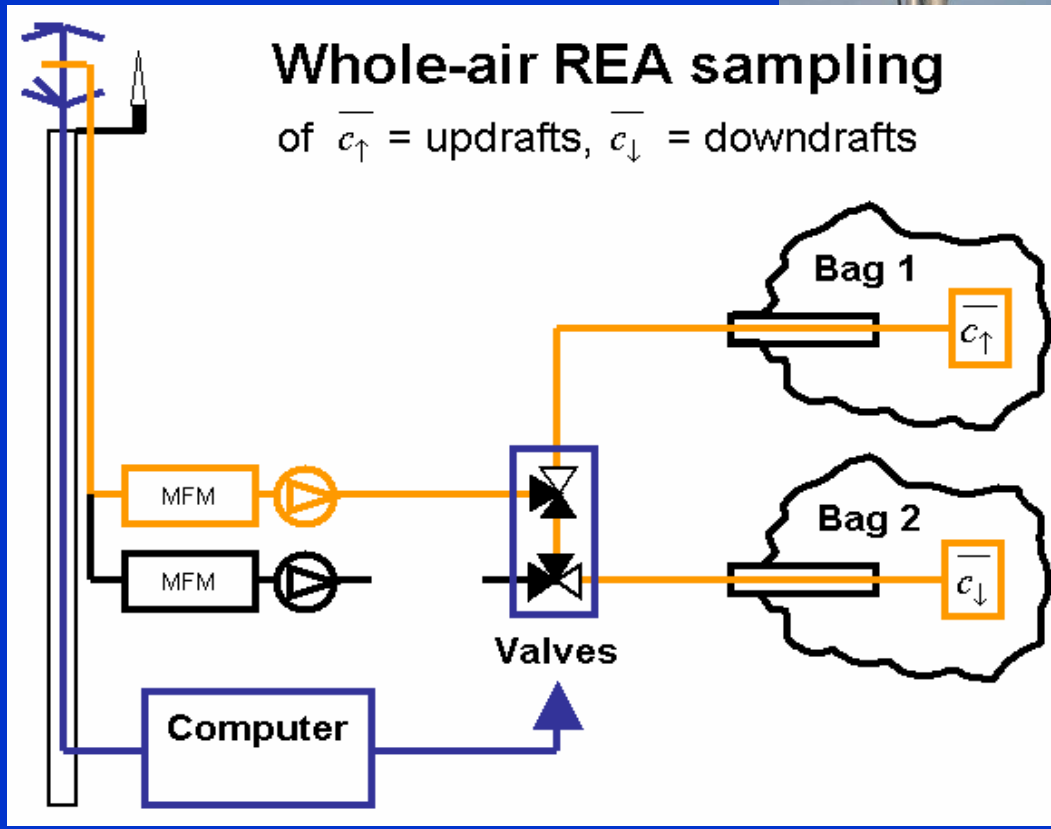
4. Carbon and carbon isotope fluxes

- **Carbon dioxide fluxes measured with Solent R3 and LiCor 7500**
- **^{13}C Carbon isotope fluxes measured with Whole air HREA system, estimated error: 10-20%**



$$F_{13C} = b_{CO2} \cdot \sigma_w (\overline{\delta^{13}C_\uparrow} - \overline{\delta^{13}C_\downarrow})$$

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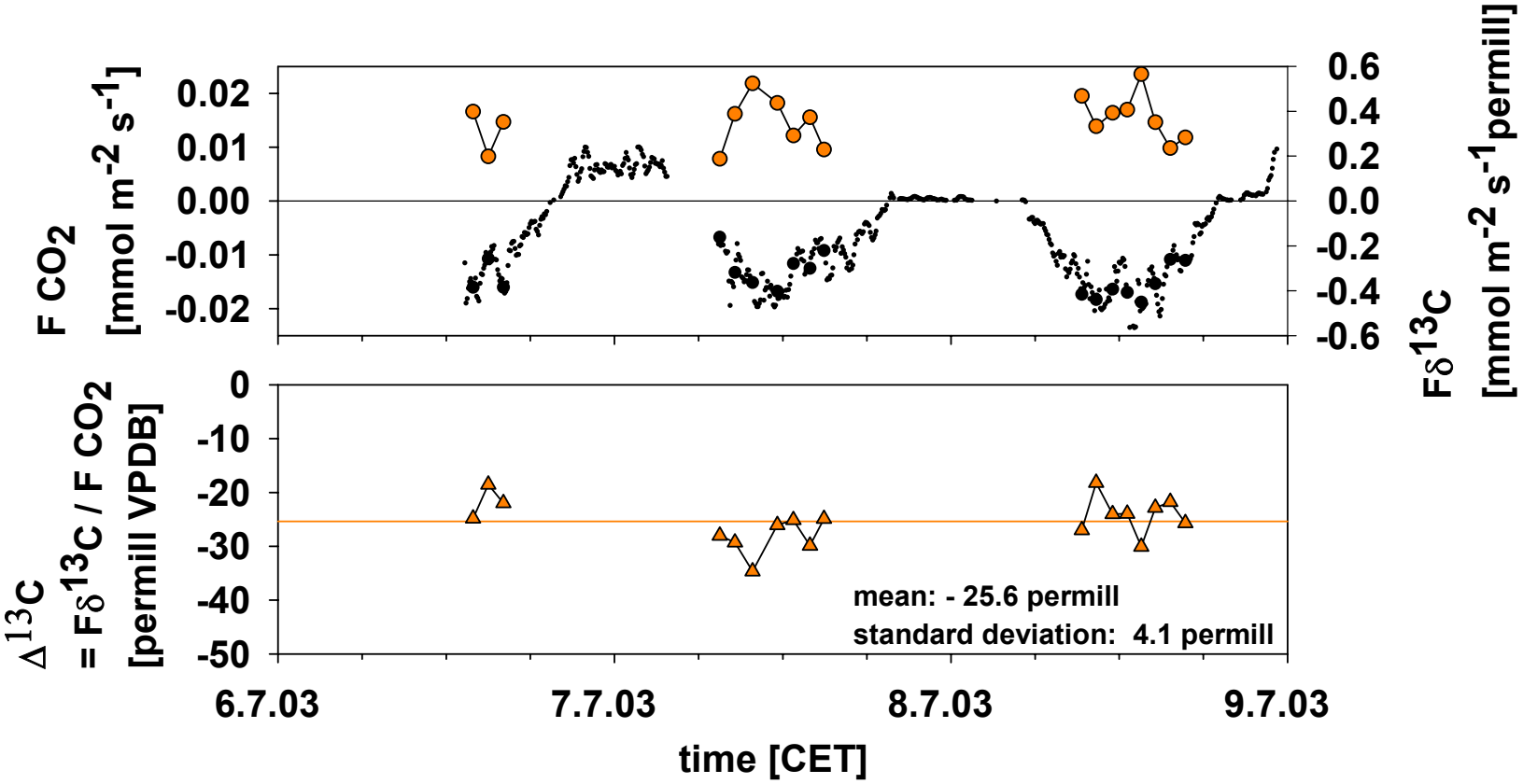

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5. Conclusions

- The footprint based quality assessment provides information on spatial structures in the data quality and the representative land use composition influencing the measurements.

- Wavelet analysis can reveal statistical properties of coherent structures, e.g. duration / size, separation.

- Statistical characteristics of coherent structures strongly depend on surface properties.

- CO_2 profile measurements illustrate the complex dynamic of gas exchange in and above a forest canopy (coupling / decoupling).

- Ecosystem ^{13}C isotope discrimination can by determined by isotope flux measurements using Whole-air REA sampling, when applying hyperbolic deadbands (10-20% error).

Further Results of WALDATEM-2003

- Thomas et al. (2004): 'Detection of coherent structures in high frequent time series of a monostatic Sodar-Rass system', ISARS, Cambridge, 12-16 July 2004.

- Göckede et al. (2004): 'Use of footprint modelling for the characterization of complex measurement sites', 26th AMS Symposium on Agricultural and Forest Meteorology, Vancouver, 26-30 Aug. 2004.

- Ruppert et al. (2004): 'Whole-air Relaxed Eddy Accumulation for the Measurement of Isotope and Trace-Gas Fluxes', SIBAE-BASIN Conference. Interlaken, Switzerland. 1-3 April 2004.

- Lüers et al. (2004): 'Mean profiles in a spruce forest during WALDATEM-2003', DACH Meteorological conference, Karlsruhe, 7-10 Sept. 2004.

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