Footprint synthesis
for the FLUXNET site
Waldstein/Weidenbrunnen (DE-Bay)
during the EGER experiment

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1 Introduction

This study presents the footprint analysis for the FLUXNET site Waldstein/Weidenbrunnen (DE-Bay). Two situations need to be distinguished: footprints calculated from measurements above a relatively undisturbed forest canopy, which was the typical situation prior to the year 2007. Secondly, footprints calculated from measurements above a disturbed forest canopy with large clearings due to the storm “Kyrill” on January, 18th 2008. Footprints from the undisturbed situation have previously been published (Göckede et al., 2005) in the context of CarboEurope related work. They are included for comparison purposes only. The main focus is on the footprint analysis after the storm during the EGER experiment in 2007 and 2008.

It should be noted that the aim of this study is the presentation of the footprint results for subsequent use and interpretation, not the interpretation itself.

2 Materials and Methods

2.1 Site

The FLUXNET site Waldstein/Weidenbrunnen (DE-Bay), 50° 08’ 31” N, 11° 52’ 01” E, is a hill site in the Fichtelgebirge Mountains in Southern Germany. The 23 m high Norway spruce stand is in the upper section of a hill, 775 m ASL, with a 2° slope facing SW (Figure 1). The site is described in detail in Gerstberger et al. (2004) and a summary of background data can be found in Staudt and Foken (2007). There are two tall towers at the site, one that has been used for FLUXNET measurements for several years, hereafter referred to as “main tower” or “MT”, and a second one, 50 m south-east of the first, which was set up in 2007, hereafter referred to as “turbulence tower” or “TT”.

2.2 Data sets

Data sets from three experiments were used. Firstly from the experiment “WAveLet Detection and Atmospheric Turbulence Exchange Measurement” (WALDATEM-2003), 28th of April to 03rd of August 2003 (Thomas et al., 2004), which corresponds to the situation prior to the storm (Göckede et al., 2005). Secondly from the experiment “ExchanGE processes in mountainous Regions” (EGER) Intensive Observation Period IOP1, 06th of September to 7rd of October 2007 (Serafimovich et al., 2008a). Thirdly from EGER
Figure 1: Map showing the terrain surrounding the measurement site.

Intensive Observation Period IOP2, 01\textsuperscript{st} of June to 15\textsuperscript{th} of July 2008. The latter two correspond to the situation after the storm (Serafimovich et al., 2008b).

The WALDATEM 2003 data set was collected at the main tower, for EGER IOP1 in 2007 and IOP2 in 2008 there are separate data sets from the main tower and the turbulence tower. For EGER IOP1 and IOP2, there is a separate analysis for the main tower and for the turbulence tower respectively. According to the recommendation of Göckede et al. (2004b) to use a minimum data set length of three months for the footprint synthesis, an extended analysis is presented for EGER IOP2 at the turbulence tower in addition to the period covering the Intensive Observation Period IOP2 itself. Information about the length and time of each data set can be found in Table 1.

2.3 Footprint model and footprint synthesis

The footprint synthesis presented in this study follows a site evaluation methodology using a combination of quality criteria of flux data and footprint analysis presented in Göckede et al. (2004a,b, 2006) and used in the context of the quality assessment of FLUXNET sites within the framework of CarboEurope, as described in Göckede et al. (2005).
Table 1: Date, length and number of 30-minute values \( n \) of meteorological data sets used for the footprint synthesis. “MT” refers to the main tower and “TT” refers to the turbulence tower.

<table>
<thead>
<tr>
<th>Data set</th>
<th>start date</th>
<th>end date</th>
<th>( n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGER IOP1 MT</td>
<td>14(^{th}) of Sept. 2007, 17:00</td>
<td>13(^{th}) of Oct. 2007, 18:30</td>
<td>1302</td>
</tr>
<tr>
<td>EGER IOP1 TT</td>
<td>19(^{th}) of Sept. 2007, 20:00</td>
<td>08(^{th}) of Oct. 2007, 06:30</td>
<td>873</td>
</tr>
<tr>
<td>EGER IOP2 MT</td>
<td>30(^{th}) of May 2008, 00:00</td>
<td>14(^{th}) of July 2008, 09:30</td>
<td>2103</td>
</tr>
<tr>
<td>EGER IOP2 TT</td>
<td>03(^{rd}) of June 2008, 11:00</td>
<td>15(^{th}) of July 2008, 23:30</td>
<td>1886</td>
</tr>
<tr>
<td>EGER IOP2 TT</td>
<td>09(^{th}) of May 2008, 21:30</td>
<td>20(^{th}) of Oct. 2008, 09:30</td>
<td>4265</td>
</tr>
<tr>
<td>WALDTEM MT</td>
<td>21(^{st}) of May 2003, 00:00</td>
<td>31(^{st}) of July 2003, 24:00</td>
<td>3380</td>
</tr>
</tbody>
</table>

The footprint model itself uses a stochastic forward Lagrangian algorithm (Thomson, 1987) of Langevin type (Wilson and Sawford, 1996) in the implementation by Rannik et al. (2003). The model accounts for fluxes within the canopy and three-dimensional turbulent diffusion. However, it is subject to the limitations of the “inverted plume assumption” (Schmid, 2002), i.e. it is limited to horizontally homogeneous conditions.

Meteorological input data for the footprint calculation were prepared using the TK2 software (Mauder and Foken, 2004), which also delivers the quality flags presented in this study. Quality flags are calculated according to Foken and Wichura (1996) in a revised version (Foken et al., 2004). Quality flag 1 is best, 9 is worst.

Roughness length \( z_0 \) information as input for the footprint model was prepared using the ”microscale aggregation model” from Hasager and Jensen (1999). Refer to Table 2 for actual \( z_0 \) values.

The synthesis of footprint and quality flags was done using the program “TERRAFEX” (Göckede et al., 2004b). The calculation of relative flux contribution from specific land use classes was done using the program “EXASITE” (Göckede et al., 2004b).

2.4 Model settings

Measurement height was 33 m at the main tower and 36 m at the turbulence tower. Data with quality flags from 1 to 9 were used, i.e. no filtering was applied. Roughness length \( z_0 \) values used for coniferous forest and clearings are given in Table 2.

The model was set up to distinguish three classes of atmospheric stratifi-
Table 2: Roughness length of land use classes according to Hasager et al. (2002) used as input for the ”microscale aggregation model” (Hasager and Jensen, 1999). The value of the class “Clearing, 2003” was increased relative to the recommended value for clearings of 0.3 to account for additional roughness due to bushes and small trees on the older clearings.

<table>
<thead>
<tr>
<th>Land use class</th>
<th>$z_0$-value [m]</th>
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<tr>
<td>Coniferous forest</td>
<td>1.8</td>
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<tr>
<td>Clearing, 2003</td>
<td>0.6</td>
</tr>
<tr>
<td>Clearing, 2007</td>
<td>0.3</td>
</tr>
</tbody>
</table>

cation according to the stability parameter $\zeta$, measured above the canopy at 33 m (main tower) and 36 m (turbulence tower). $\zeta$ is defined as $\zeta = (z-d)L^{-1}$ with measurement height $z$, displacement height $d$ and Obukhov-length $L$. The four classes used are

\[
\zeta = \begin{cases} 
  \text{unstable} & \text{for } \zeta < -0.0625 \\
  \text{neutral} & \text{for } -0.0625 < \zeta < +0.0625 \\
  \text{stable} & \text{for } +0.0625 < \zeta \\
  \text{all} & \text{for } -\infty < \zeta < +\infty 
\end{cases}
\]

2.5 Land use map

The land use map used for EGER IOP1 and IOP2 (see Figure 2) differentiates clearings present before and after the storm, respectively. It is based on image material from a flight on the 16th of March 2007. There are certain restrictions regarding the accuracy of shape and position of the clearings due to the tilted view of the image material. The spatial resolution of the derived land use map is 10 m. The land use map from Göckede et al. (2005) used for the WALDATEM experiment results shown in Section 6 is based on a satellite image classification with a spatial resolution of 30 m.
Figure 2: Land use map showing coniferous forest and clearings. “clearing 2003” refers to all clearings present in the year 2003, even if they are older. “clearing 2007” refers to clearings from wind throw and logging associated with the storm Kyrill on 18th of January 2007. Please refer to Appendix A for further information about logging activities related to the storm. X- and y-axis are distances in meters.
3 Results for EGER IOP1 2007

3.1 Footprint synthesis - main tower

Figure 3: Footprint climatology over land use map, EGER IOP1, main tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. The black cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
Figure 4: Footprint climatology and spatial quality flag features for friction velocity, EGER IOP1, main tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. Quality flags of the flux from 1 to 9 are color coded. The red cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
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3.2 Land use fractions - main tower

Figure 8: Relative contribution of different land use classes to the flux, EGER IOP1, main tower, for four classes of atmospheric stratification: all stratifications (top panel), unstable (second panel from top), neutral (third panel from top) and stable (bottom panel).
3.3 Footprint synthesis - turbulence tower

Figure 9: Footprint climatology over land use map, EGER IOP1, turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. The black cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
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3.4 Land use fractions - turbulence tower

Figure 14: Relative contribution of different land use classes to the flux, EGER IOP1, turbulence tower, for four classes of atmospheric stratification: all stratifications (top panel), unstable (second panel from top), neutral (third panel from top) and stable (bottom panel).
4 Results for EGER IOP2 2008

4.1 Footprint synthesis - main tower

Figure 15: Footprint climatology over land use map, EGER IOP2, main tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. The black cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
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4.2 Land use fractions - main tower

Figure 20: Relative contribution of different land use classes to the flux, EGER IOP2, main tower, for four classes of atmospheric stratification: all stratifications (top panel), unstable (second panel from top), neutral (third panel from top) and stable (bottom panel).
4.3 Footprint synthesis - turbulence tower

Figure 21: Footprint climatology over land use map, EGER IOP2, turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. The black cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
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4.4 Land use fractions - turbulence tower

Figure 26: Relative contribution of different land use classes to the flux, EGER IOP2, turbulence tower, for four classes of atmospheric stratification: all stratifications (top panel), unstable (second panel from top), neutral (third panel from top) and stable (bottom panel).
5 Results for EGER IOP2 (extended) 2008

5.1 Footprint synthesis - turbulence tower

Figure 27: Footprint climatology over land use map, EGER IOP2 extended, turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10% intervals. The outermost isoline indicates the area where 95% of the flux is coming from. The black cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
Figure 28: Footprint climatology and spatial quality flag features for friction velocity, EGER IOP2 (extended), turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10% intervals. The outermost isoline indicates the area where 95% of the flux is coming from. Quality flags of the flux from 1 to 9 are color coded. The red cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
Figure 29: Footprint climatology and spatial quality flag features for the CO$_2$ flux, EGER IOP2 (extended), turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10% intervals. The outermost isoline indicates the area where 95% of the flux is coming from. Quality flags of the flux from 1 to 9 are color coded. The red cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
Figure 30: Footprint climatology and spatial quality flag features for the sensible heat flux, EGER IOP2 (extended), turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10% intervals. The outermost isoline indicates the area where 95% of the flux is coming from. Quality flags of the flux from 1 to 9 are color coded. The red cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
Figure 31: Footprint climatology and spatial quality flag features for the latent heat flux, EGER IOP2 (extended), turbulence tower, for four classes of atmospheric stratification. White isolines show the relative flux contribution of the corresponding footprint area in 10 % intervals. The outermost isoline indicates the area where 95 % of the flux is coming from. Quality flags of the flux from 1 to 9 are color coded. The red cross indicates the position of the main tower, the white cross the position of the turbulence tower. The plot is a map projection. X- and y-axis are distances in meters.
5.2 Land use fractions - turbulence tower

Figure 32: Relative contribution of different land use classes to the flux, EGER IOP2 (extended), turbulence tower, for four classes of atmospheric stratification: all stratifications (top panel), unstable (second panel from top), neutral (third panel from top) and stable (bottom panel).
6 Results for WALDATEM 2003

This section shows the footprint analysis for the time before the storm according to Göckede et al. (2005) for comparison purposes.

6.1 Footprint synthesis - main tower

Figure 33: Footprint climatology over land use map, WALDATEM 2003, main tower according to Göckede et al. (2005). a) all stratifications, b) unstable, c) neutral, d) stable.
6.2 Land use fractions - main tower

Figure 34: Relative contribution of different land use classes to the flux, WAL-DATEM 2003, main tower for all atmospheric stratifications. x-axis: land use percentage, y-axis: relative frequency.
7 Conclusions

The deliberately brief conclusions are: the main part of the footprint for both towers before and after the storm is dominated by coniferous forest. However, after the storm Kyrill on the 18th of January 2007, the footprint might completely cover large clearings during stable atmospheric stratification, which account for a substantial part of the footprint under those situations.
References


A Appendix

The amount of wood cut before and after Kyrill is given in figure 35 and table 3.

**Figure 35:** Volume of wood cut before (blue) and after (red) Kyrill (in solid cubic meters).

**Table 3:** Volume of wood cut before and after Kyrill. Data source: Bayerische Staatsforsten, Mr. Stöcker.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coulissenhieb</td>
<td></td>
<td>119.95</td>
<td>881.04</td>
</tr>
<tr>
<td>Weidenbrunnen</td>
<td></td>
<td>80.36</td>
<td>408.07</td>
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<td>Köhlerloh</td>
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<td>89.61</td>
<td>1162.88</td>
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### Table 4: Volumes in the series “University of Bayreuth, Department of Micrometeorology, Arbeitsergebnisse”

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<th>Nr</th>
<th>Author(s)</th>
<th>Title</th>
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<td>1</td>
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<td>7</td>
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<td>Strukturanalyse der atmosphärischen Turbulenz mittels Wavelet-Verfahren zur Bestimmung von Austauschprozessen über dem antarktischen Schelfeis</td>
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<td>10/2000</td>
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<tr>
<td>13</td>
<td>Bruckmeier et al.</td>
<td>Documentation of the experiment EBEX-2000, July 20 to August 24, 2000</td>
<td>01/2001</td>
</tr>
<tr>
<td>14</td>
<td>Foken et al.</td>
<td>Lufthygienisch-bioklimatische Kennzeichnung des oberen Egertales</td>
<td>02/2001</td>
</tr>
<tr>
<td>16</td>
<td>Neuner</td>
<td>Berechnung der Evaporation im ÖBG (Universität Bayreuth) mit dem SVAT-Modell BEKLIMA</td>
<td>05/2001</td>
</tr>
<tr>
<td>17</td>
<td>Sodemann</td>
<td>Dokumentation der Software zur Bearbeitung der FINTUREX-Daten</td>
<td>08/2002</td>
</tr>
<tr>
<td>18</td>
<td>Göckede et al.</td>
<td>Dokumentation des Experiments STINHO-1</td>
<td>08/2002</td>
</tr>
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<tr>
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<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>20</td>
<td>Göckede et al</td>
<td>Characterisation of a complex measuring site for flux measurements</td>
<td>12/2002</td>
</tr>
<tr>
<td>21</td>
<td>Liebethal</td>
<td>Strahlungsmessgerätevergleich während des Experiments STINHO-1</td>
<td>01/2003</td>
</tr>
<tr>
<td>22</td>
<td>Mauder et al.</td>
<td>Dokumentation des Experiments EVA,GRIPS</td>
<td>03/2003</td>
</tr>
<tr>
<td>24</td>
<td>Thomas et al.</td>
<td>Documentation of the WALDATEM-2003 Experiment</td>
<td>05/2004</td>
</tr>
<tr>
<td>26</td>
<td>Mauder and Foken</td>
<td>Documentation and instruction manual of the eddy covariance software package TK2</td>
<td>12/2004</td>
</tr>
<tr>
<td>27</td>
<td>Herold et al.</td>
<td>The OP-2 open path infrared gas analyser for CO2 and H2O</td>
<td>01/2005</td>
</tr>
<tr>
<td>28</td>
<td>Ruppert</td>
<td>ATEM software for atmospheric turbulent exchange measurements using eddy covariance and relaxed eddy accumulation systems and Bayreuth whole-air REA system setup</td>
<td>04/2005</td>
</tr>
<tr>
<td>29</td>
<td>Foken (Ed.)</td>
<td>Klimatologische und mikrometeorologische Forschungen im Rahmen des Bayreuther Institutes für Terrestrische Ökosystemforschung (BITÖK), 1989-2004</td>
<td>06/2005</td>
</tr>
<tr>
<td>34</td>
<td>Metzger &amp; Foken et al.</td>
<td>COPS experiment, Convective and orographically induced precipitation study, 01 June 2007 – 31 August 2007, Documentation</td>
<td>09/2007</td>
</tr>
</tbody>
</table>

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<tr>
<th>Nr</th>
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<th>Title</th>
<th>Year</th>
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<tr>
<td>35</td>
<td>Staudt &amp; Foken</td>
<td>Documentation of reference data for the experimental areas of the Bayreuth Centre for Ecology and Environmental Research (BayCEER) at the Waldstein site</td>
<td>11/2007</td>
</tr>
<tr>
<td>36</td>
<td>Serafimovich et al.</td>
<td>ExchanGE processes in mountainous Regions (EGER): Documentation of the Intensive Observation Period (IOP1) September, 6th to October, 7th 2007</td>
<td>01/2008</td>
</tr>
<tr>
<td>38</td>
<td>Siebicke</td>
<td>Footprint synthesis for the FLUXNET site Waldstein/Weidenbrunnen (DE-Bay) during the EGER experiment</td>
<td>12/2008</td>
</tr>
</tbody>
</table>