Wombat Forest Flux Tower
Data-processing
preliminary results
Carbon Balance
2010 – 2012

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Wombat Forest

- cool temperate dry sclerophyll forest
- *E. obliqua* (messmate stringybark), *E. rubida* (candlebark gum), *E. radiata* (narrow-leafed peppermint)
- climate: cool temperate to Mediterranean (warm & dry summers, cold & wet winters)
- yellow podzolic soil, silty clays overlying clays (from Ordovician marine sediments)
- 35 m tall EC- tower
- automated soil GHG chambers – FTIR system
- operating since late January 2010
Research Focus

- Carbon balance of a dry temperate sclerophyll forest & its strength as carbon sink/source
- Quantification of NEE, RE, GPP
- Quantification and contribution of soil CO₂ emissions to overall RE
- Quantification of soil non-CO₂ GHG exchange processes
- Seasonal, inter-daily, inter-annual variations
- Database for carbon- and land surface models
EC-Data Control & Processing

- instantaneous check of data – Real Time Monitoring Control (Jason Beringer):

- Data collection: Daily download via Maxon modem (Monash University)

- Quality Control on half-hourly data with Python 2.7.1. (EPD v7.0.2)
  current scripts: OzFluxQCv1.5.1. (Peter Isaac and James Cleverly)

  L1 – raw data (half hourly data for radiation, fluxes, met-data, extra sensors)

  L2 – range checks, diurnal checks, exclusions days/hours, diagnostics CSAT & Li-7500

  L3 – linear corrections for Ah, covariances of Ah and Cc,
  correction for 2D coordinate rotation,
  calculation of fluxes from covariances (Fc_wpl, Fe_wpl), calculation of Fn,
  merge series (Tair, Ah, Fd, Tsoil, SWC), WPL-correction,
  range checks of calculated fluxes
- power issues in 2010
- longest gaps: June 2010 – 16 days
  November 2010 – 17 days
- high rainfall in 2010 (1129 mm) and 2011 (1076 mm)

### Data Loss

<table>
<thead>
<tr>
<th>Start/End</th>
<th>Year</th>
<th>datapoints</th>
<th>power</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-Jan</td>
<td>2010</td>
<td>16608</td>
<td>2394</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>17520</td>
<td>189</td>
</tr>
<tr>
<td>1-May</td>
<td>2012</td>
<td>5808</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39936</td>
<td>2583</td>
</tr>
</tbody>
</table>

Daylesford (10.5 km from Wombat Forest site)

- Total Rainfall [mm]:
  - 730±32mm
EC-Data Gapfilling

- small gapfilling (up to 3 half hourly means) with linear interpolation

**Gapfilling of meteorological data**

- half-hourly meteorological data from nearest BoM station (Ballarat Aerodrome, 28km SW) & Wombat Forest FESA sites (Kevin Tolhurst, Markus Löw)
  - Tair, RH (Ah, VPD), atmospheric pressure, precipitation, WS, WD

- Radiation (Fsd, Fsu, Fld, Fln) gapfilled by **Ian McHugh**: model to proportional distribute daily incoming global radiation data from BoM (Ballarat/Daylesford) over a day in half-hourly steps

- soil moisture (SWC) and soil temperature (Tsoil) from CABLE-output by **Vanessa Haverd**

**Gapfilling of fluxes – with ANN (Jason Beringer, Statistica10)**

- trained model
- non-linear regressions, 5 models

<table>
<thead>
<tr>
<th>Flux</th>
<th>input variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fg</td>
<td>Fn, Tsoil, SWC</td>
</tr>
<tr>
<td>Fh</td>
<td>Tair, Ah, WS, Fa, SWC</td>
</tr>
<tr>
<td>Fe</td>
<td>Tair, Ah, WS, Fa, VPD, SWC</td>
</tr>
<tr>
<td>Fc</td>
<td>Fsd, Tair, VPD, Ah, WS, Tsoil, SWC</td>
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</tbody>
</table>
Partitioning with the NN (Jason Beringer)

- night-time Fc fluxes filtered for u* (0.4ms⁻¹)
- input variables for RE (over night & day-time data): Tsoil, SWC
- during day-time GPP = Fc - RE

Online EC-gapfilling and flux partitioning tool from M. Reichstein
(Max Planck Institute for Biogeochemistry http://www.bgc-jena.mpg.de/~MDIwork/eddyproc/)

- Method based on night-time NEE (= RE), its extrapolation to day-time and its short-term temperature sensitivity (10 days, ΔTair > 5°C)
  (Reichstein et al. 2005)
- temperature sensitivity:
  \[ RE = R_{ref} \times e^{E_0 (1/T_{ref}-1/T_0)} \]  (Lloyd & Taylor 1994)
- ustar-filtering applied (assumes correction for storage): 6 temperature classes – split into 20 ustar classes – determination of ustar treshold for each temperature class – was finally set to 0.4 ms⁻¹
Wombat Forest: Carbon Balance

Reichstein - Online tool

Jason - NN

7 day average (gCm$^{-2}$d$^{-1}$)

2010
2011
2012
2010
2011
2012
environmental drivers

daily averages
Ecosystem respiration and soil respiration

- RE – Online tool
- RE-NN
- Rsoil

Rsoil from FTIR soil chamber measurements
(gaps are filled with modified Lloyd & Taylor model which describes dependence on soil temperature and soil moisture, R2 = 0.78, Reichstein et al. 2003)
Wombat Forest: Carbon Balance

Partitioning with Online-tool

<table>
<thead>
<tr>
<th>Year</th>
<th>TC ha⁻¹yr⁻¹</th>
<th>RE</th>
<th>GPP</th>
<th>NEE</th>
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<tbody>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.2</td>
<td>22.6</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.4)</td>
<td>(-9.3)</td>
<td>(-3.9)</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td>10.8</td>
<td>22.1</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.0)</td>
<td>(-8.5)</td>
<td>(-3.5)</td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td>4.6</td>
<td>9.0</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.0)</td>
<td></td>
<td></td>
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</tbody>
</table>
early comparison with other sites in SE-Australia

wet sclerophyll forest
(old growth *E. regnans* forest)
Wallaby Creek (Musa Kilinc, PhD Thesis, 2009)

for 2006 with summer drought:

- **NEE**: -3.77 tC ha\(^{-1}\) yr\(^{-1}\)
- **RE**: 22.38 tC ha\(^{-1}\) yr\(^{-1}\)
- **GPP**: -26.15 tC ha\(^{-1}\) yr\(^{-1}\)

wet sclerophyll forest
(*E. delegatensis*)
Tumbarumba (van Gorsel Ozflux meeting 2011, Keith et al. 2012)

for 2009:

- **NEE**: -9.33 tC ha\(^{-1}\) yr\(^{-1}\)
- **RE**: ~ 20 tC ha\(^{-1}\) yr\(^{-1}\)
- **GPP**: ~ -28 tC ha\(^{-1}\) yr\(^{-1}\)
Wombat Forest: continuous net carbon sink: ~ 10 tC ha\(^{-1}\)yr\(^{-1}\) (?)

measurements during extraordinary wet years (>1000 mm) – optimal conditions

**underestimation of RE:**
- different partitioning approach (light response curve)
- clarify issues of drainage
- storage correction – profile system since February 2012 (Ian McHugh, 6 heights)

detailed analyses of environmental drivers for NEE, RE and GPP in the Wombat Forest

predicted climate changes in SE-Australia (warmer, less rainfall) – importance of measurements during drier periods

disturbance: prescribed burning planned Spring 2012 or Autumn 2013

complementary measurements: aboveground biomass – micro dendrometers, vegetation dynamics – ground based LIDAR

to sum up and future work
Thank you
for your attention!

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