Impact of summer heat waves on forest productivity in Southern Australia

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Heat waves

• heat waves are becoming hotter, they last longer and occur more often.

• many ecological processes are more sensitive to climate extremes than to changes in mean states

• The impact of climate extremes on terrestrial ecosystems is poorly understood but important for predicting feedbacks to climate and climate change
Take away point

Nature paper of Adriaan Teuling 2010 has shown that European forests reduce the impact of HW (compared to grass lands).

I will show that large areas of Southern Australia respond rapidly to HWs and have reduced carbon uptake, ET and WUE. This likely leads to a rapid amplification of HWs.
Sites used in Southern Australia - ES

MW - Mediterranean Woodlands
  Gingin
  Great Western Woodlands
  Calperum

TW - Temperate Woodlands
  Wombat
  Whroo
  Cumberland Plains

TF - Temperate Forests
  Tumbarumba
Flux Climatology Background (2 – 6/1/2014)
**Time Periods**

heat wave  
phase 1: 01/01/2013 - 09/01/2013  
phase 2: 12/01/2013 - 18/01/2013

**Reference Data**

hourly - data from flux towers:  
02/1/2014 - 08/1/2014

daily - Bios2 output:  
phase 1: 01/01 - 09/01 [1982-2013]  
phase 2: 12/01 - 18/01 [1982-2013]
Time Periods

heat wave
phase 1: 01/01/2013 - 09/01/2013
phase 2: 12/01/2013 - 18/01/2013

Reference Data

02/1/2014 - 08/1/2014
Heat wave summer 2013
Heat wave summer 2013 – phase 1

MW
Gingin
GWW
Calperum
TW
WombatForest
Whroo
TF
Tumbarumba

z - score

temperature
soil moisture
Heat wave summer 2013 – phase 2

MW
Gingin
GWW
Calperum
TW
WombatForest
TF
Tumbarumba

z-score

temperature
soil moisture
Temperatures
VPD

![Graphs showing VPD over time for MW, BG, HW1, HW2, TW, and TF.](chart.png)
Flux Climatology Background (2 – 6/1/2014)

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<th>FsU</th>
<th>Fld</th>
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<th>Fn</th>
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Climatology (W/m²)
Energy Fluxes

- Background
- Heat wave phase 1
- Heat wave phase 2

Energy fluxes (W m⁻²)

- MW
- En
- Fe

Time (h)

0  6  12  18  24
Latent Heat Flux  HW / BG
Sensible Heat Flux  HW / BG
Bowen Ratio
Feedback on Temperature

T_HW: T_BG

T_HW - T_BG

Heat wave phase 1

Presented by

Presenter name
Feedback on Temperature

![Graph showing temperature data during heat wave phase 1](image)
Feedback on Temperature
Energy Fluxes Bios2 – obs (2013)
Carbon Fluxes Bios2 – obs (2013)
Carbon Fluxes

background

-1*NEE

MW

GPP

-1*NEE (background)

MW

sink

source

MW

carbon fluxes (g·m⁻²·d⁻¹)

time

heat wave phase 1

heat wave phase 2

TF

TW

MW
Gross Primary Productivity HW / BG
Respiration HW / BG
Net Ecosystem Exchange HW / BG
Carbon and Water Fluxes: ecosystem Water Use Efficiency
Conclusions

ENERGY
- most excess energy leaves the system through long-wave outgoing radiation and is not available to be partitioned into turbulent heat fluxes

WATER
- If water is available (radiation limited ecosystem, rain) ET is increased compared to background. In water limited ecosystems the Bowen Ratio is increased

CARBON
- Respiration generally increased
- Carbon uptake more reduced in water limited ecosystems
- Greater reduction of sink strength in water limited ecosystems

COUPLED WATER AND CARBON
- WUE generally decreased during heat wave
Conclusions

large areas of Southern Australia respond rapidly to HWs and have reduced carbon uptake, ET and WUE. This likely leads to a rapid amplification of HWs.
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