Alice Springs Mulga: Achievements and Outlook

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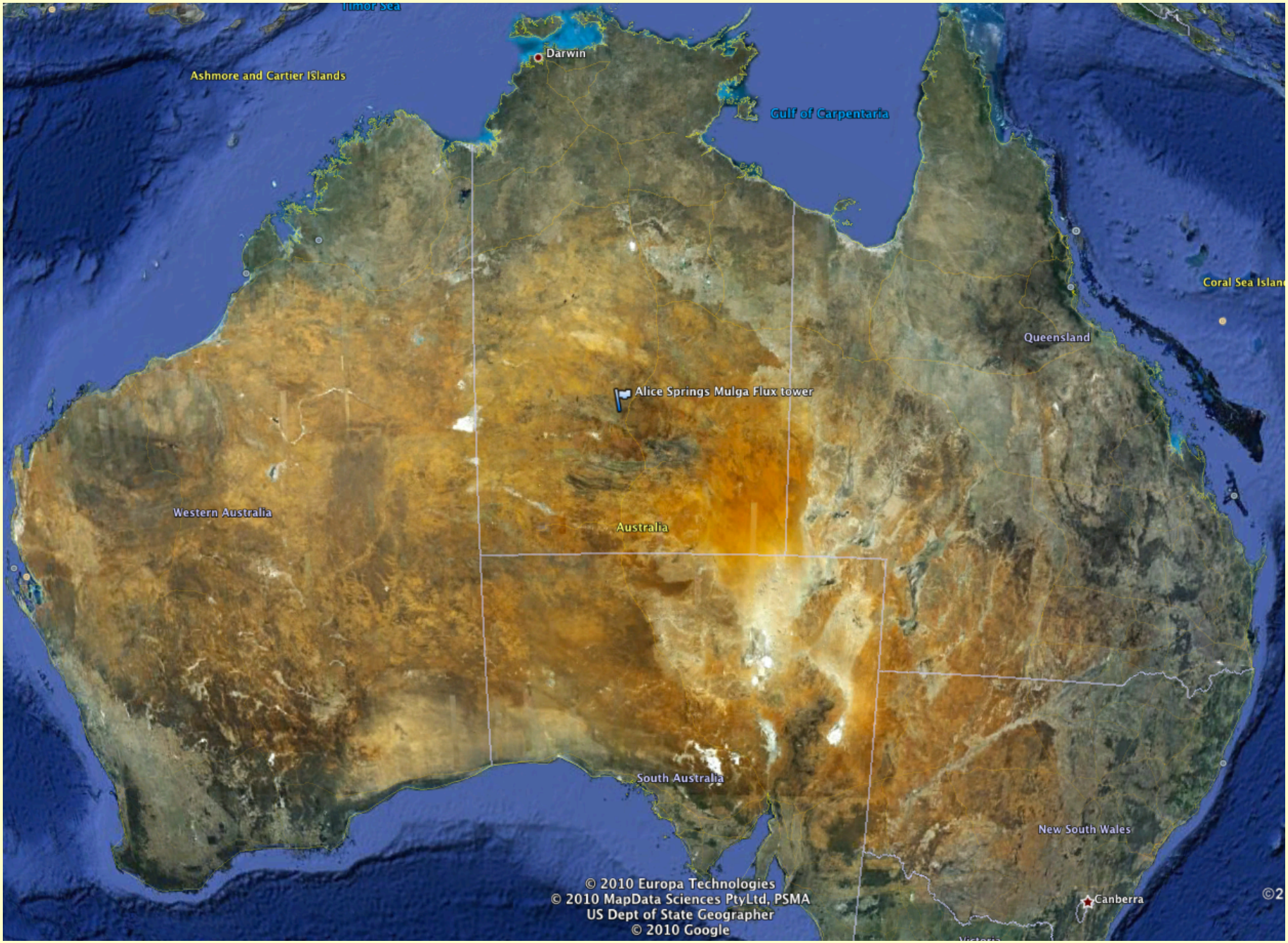
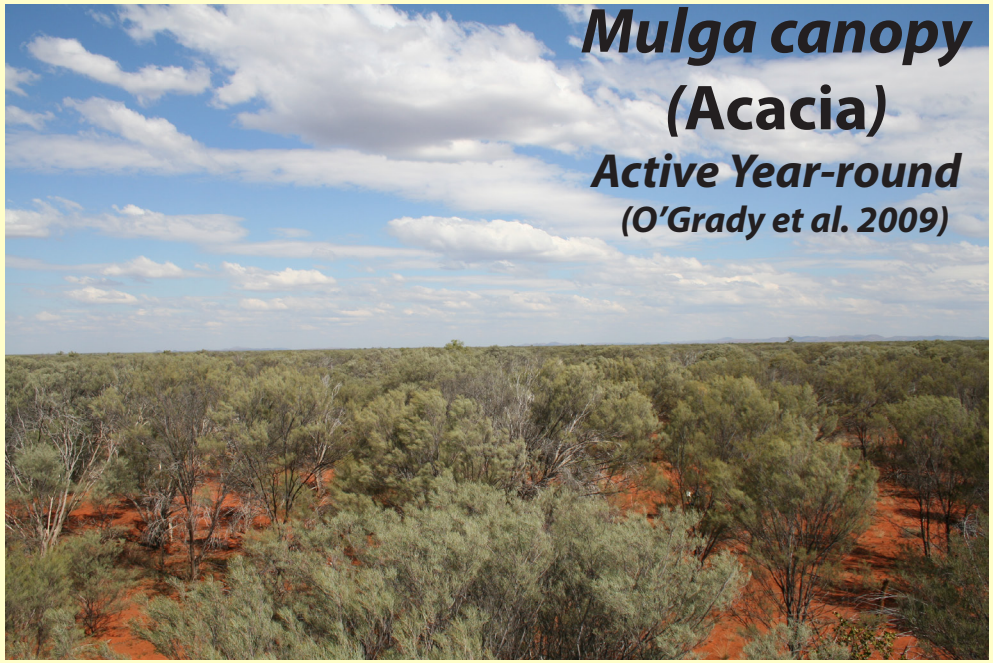
Alice Springs Mulga
Semi-arid Woodland

- Site
- Construction
- Data Processing

Alice Springs Mulga
Central Australia

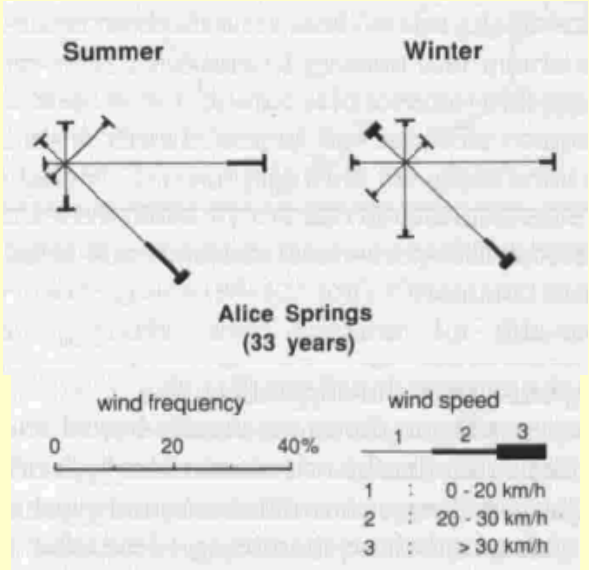


Site Characteristics
Alice Springs Mulga

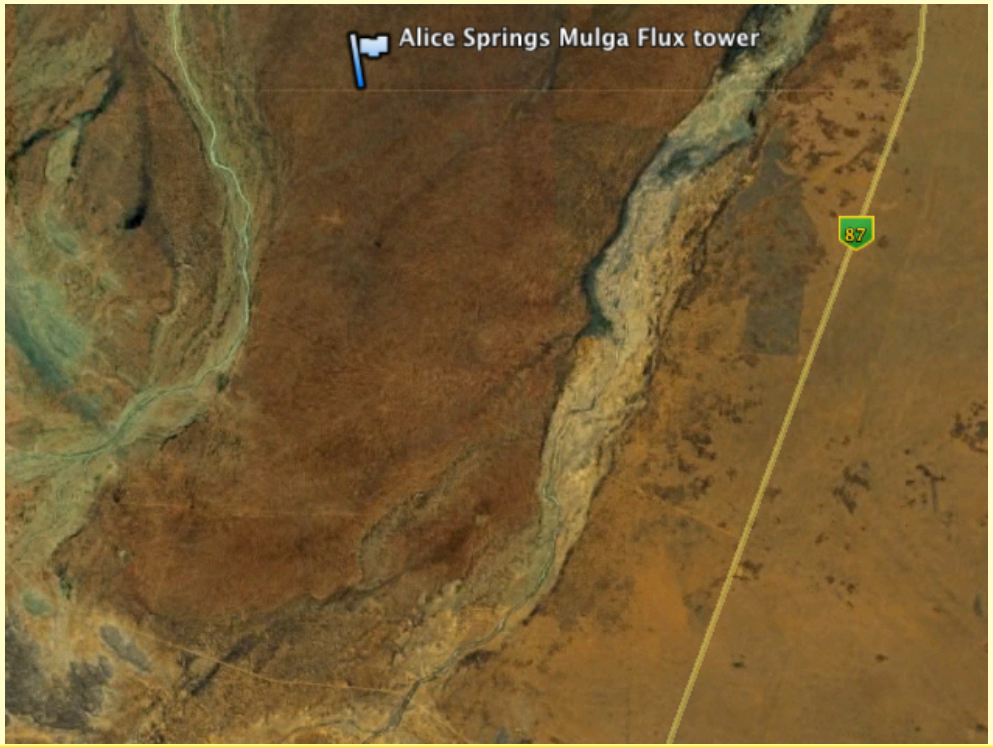


- Canopy height 6.5 m
- 606 m above sea level
- 200 km north of Alice Springs
- Near Ti Tree, NT
- Pine Hill Cattle Station
- Red sandy clay (50:50 sand:clay)
- Water table: 49 m deep
- Average precipitation: 305.9 mm per year
- 75 – 80% during the summer (Bowman et al. 2010)
- 2009: 100 mm, 2010: 750 mm (Territory grape farm)

Site Characteristics
Alice Springs Mulga



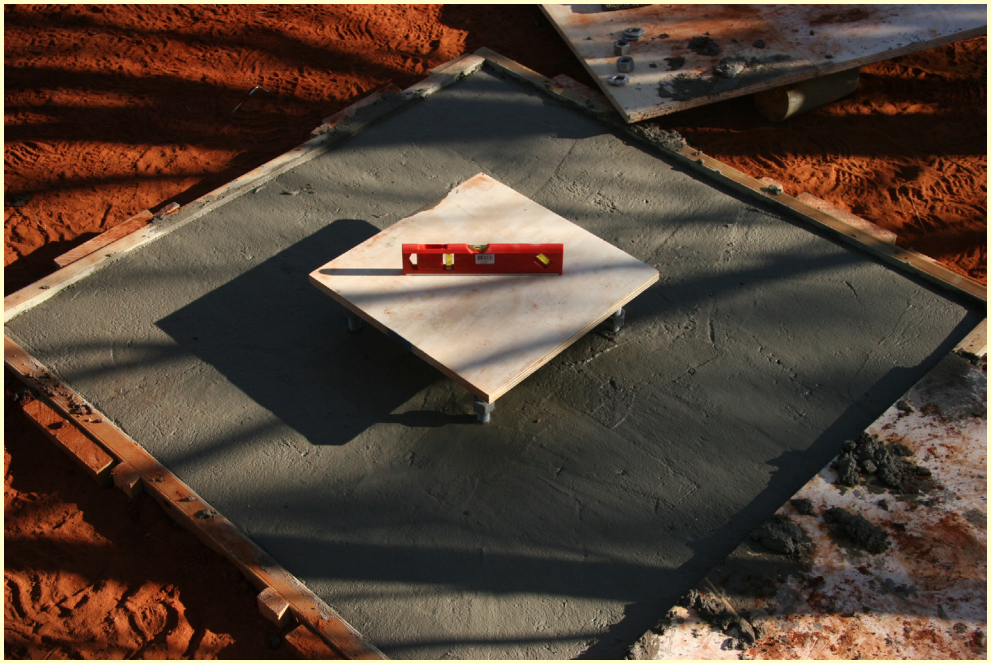
Chen et al. 1991



- ***Predominant wind directions:***
  - ***(South), Southeast, East***
- ***Bordered by:***
  - ***Hansen River on the West***
  - ***Woodforde River on the East***
- ***Woodland Extent:***
  - ***11 km East***
  - ***16 km South***
- ***Nearest BOM station:***
  - ***Territory Grape Farm***
  - ***45 km East Southeast***

Construction
July — August 2010

- **Tower:**
  - Height: 13.7 m
  - Steel construction
  - Tilt-up, fixed
- **Sensor direction:**
  - Into predominant wind direction (SE)
- **Measurement height:**
  - Radiation: 12.2 m
  - EC: 11.6 m
  - Temperature/RH: 11.6 m
  - 2D Wind Speed/Direction: 9.25 m
  - Tipping bucket rain gauge: 2.5 m
  - Barometric pressure: 1 m
  - Ground heat flux: 0.08 m
  - Soil temperature: 0.02 – 0.06 m
  - Surface soil moisture: 0 – 0.10 m



Construction

August & December 2010, March 2011

- **Soil moisture arrays:**
  - Bare soil
  - Mulga
  - Perennial understory
  - Depths:
    - Surface (0–10 cm; horizontal) (SWC reflectometers)
    - 10–30 cm (45° insertion) (TDR)
    - 60–80 cm (45° insertion) (TDR)
    - 100–120 cm (45° insertion) (TDR)
- **Telecommunications:**
  - Telstra NextG mobile modem
  - VPN
    - 10 Hz, 1-min, and 30-min datasets up-loaded every 5 minutes
    - Multiple hard drive backups on- and off-site
- **Power:**
  - 240 W Solar PV
  - 200 A-hr AGM (Glass mat) batteries
- **Canopy storage:**
  - Momentum, heat, humidity
  - 2 m, 4.25 m, 6.5 m

Data Processing
Level 2: QA/QC & Corrections

- **Python GUI, modified from script originally written by Peter Isaac**
  - Range check
  - Outlier check
  - CSAT & IRGA Diagnostic checks
  - Albedo constraints
  - Linear corrections
  - Empirical correction for soil water content*
  - Coordinate rotation
  - Massman correction for spectral attenuation*
  - Conversion of virtual F_H to F_H
  - Webb, Pearman & Leuning (1980) correction for flux effects on density measurements
  - Addition of soil heat storage to F_G*

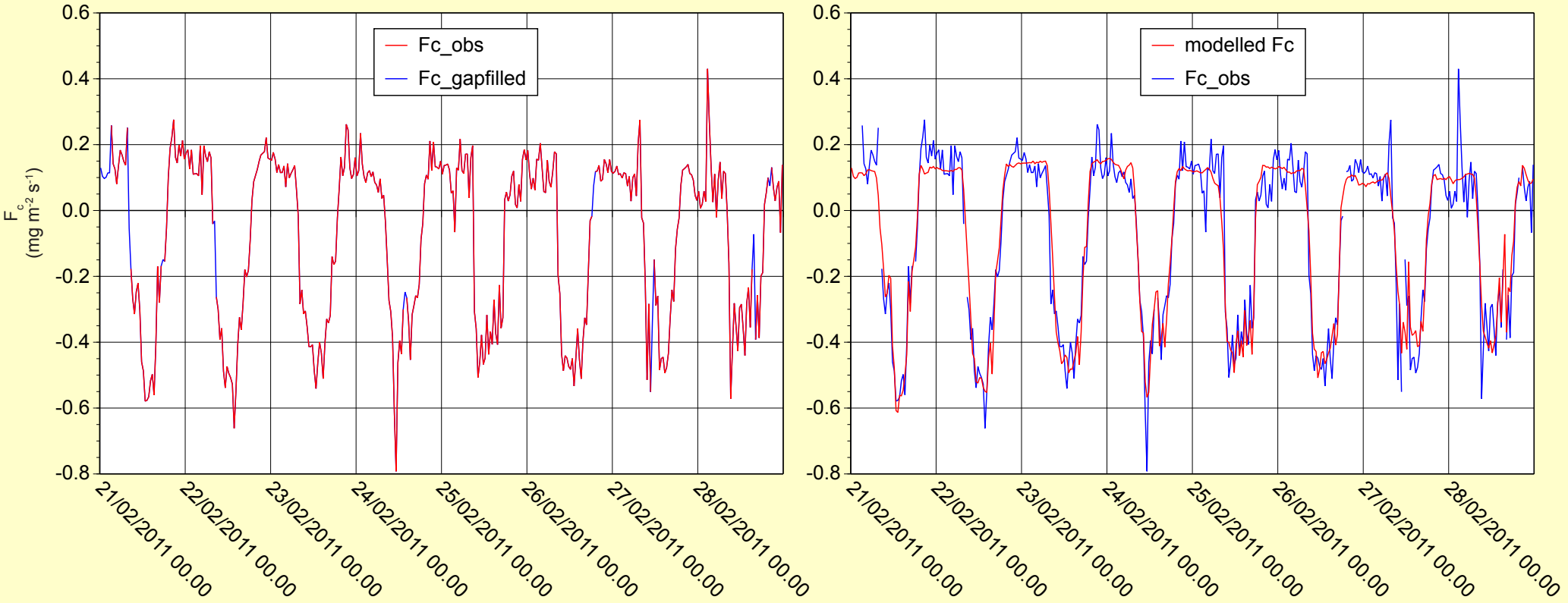
  - In-depth discussion Wednesday afternoon
  - * additional measurements required

```
def Massman(ds,zmd,angle,CSATarm,IRGAarm):
    '''Massman:  use L recalculated from corrected ustar and wT to correct
       for flux loss from spectral attenuation

    Correct covariances for flux loss from spectral attenuation using
    analytical expression in Eqn 4.3, Massman & Clement 2004.  z is referenced
    to the z0 as z - d.  Time constants are as defined in Massman 2000:
        alpha = 1;  0 < z / L <= 2, stable conditions
        alpha = 0.925;  z / L >= 0, neutral or unstable conditions
        b = 2 * pi * fx * tau_b
        p = 2 * pi * fx * tau_e
        fx = nx * (u / z)
        for scalars:
            nx = 0.085;   z / L <= 0
            nx = 2.0 - 1.915 / (1 + 0.5 * (z / L));  z / L > 0
        for momentum:
            nx = 0.079;  z / L <= 0
            nx = 0.079 * (1 + 7.9 * (z / L)) ^ 0.75;  z / L > 0
        tau_b = Tb / 2.8;  equivalent time constant associated with averaging
                           Tb is measurement interval in seconds
        tau_e = sqrt(sum(tau_i ^ 2));  equivalent time constant associated with
                                       sonic line averaging, scalar sensor line
                                       averaging, and sensor separation
        tau_i:
            sonic line averaging (momentum flux):
                lw / (2.8 * u)  horizontal
                lw / (5.7 * u)  vertical
            sonic line averaging (scalar flux):
                lw / (8.4 * u)
            scalar sensor line averaging:
                l_irga / (4.0 * u)
            lateral separation:
                l_lat / (1.1 * u)
            longitudinal separation:
                l_long / (1.05 * u)
            lwVert = 0.1 m
            lwHor = 0.058 m
            lwTv = 0.1155 m
            lIRGA = 0.125 m
            '''
```

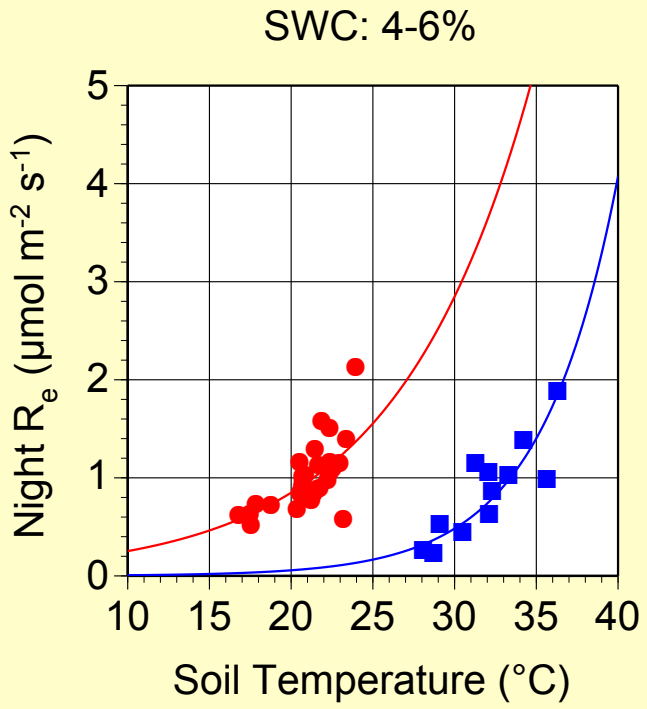
Data Processing
Level 3: Gap Filling, 10 days

- **Artificial Neural Network** (Abramowitz et al. 2005):
  - Self-Organising Linear Output (SOLO) Map (Hsu et al. 2002)
    - Self-Organising Feature Map (SOFM) Network (Input Classification)
    - Input-Output Prediction Map
  - SOFM: Normalised predictor variables (similar to PCA):
    - 7 Variables: F_g, F_{nr}, T_s, Θ_v, q, T_a & D
  - Input-Output Prediction Map (similar to mulitple regression):
    - Model F_c, F_E & F_H



Data Processing
Level 4: Carbon Partitioning and Daily stats

- **Carbon Partitioning:**
  - **Evaluation of F_c to partition between ecosystem respiration and gross primary production**
    - **Temperature**
    - **Soil moisture**
    - **Substrate**
- **Evapotranspiration:**
  - **Sum of daily gap-filled $\frac{F_E}{\lambda_v \cdot \rho_w}$ observations**
- **Bowen ratio:**
  - **Ratio of daily sums of F_H and F_E [MJ m^{-2}]**
- **Soil moisture, daily average**
- **Vapour pressure deficit, minima and maxima**
- **Air Temperature, minima and maxima**

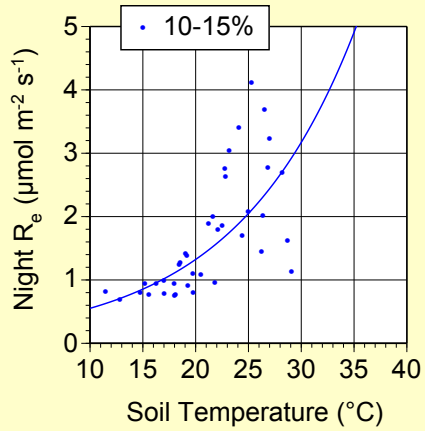


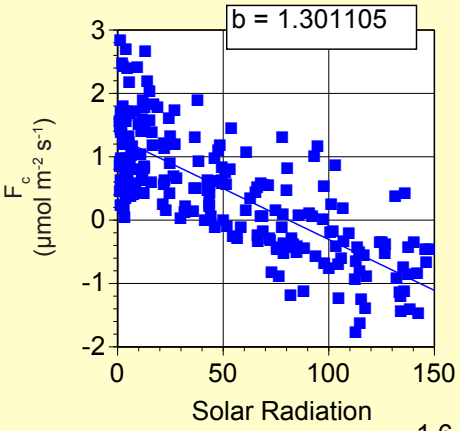
■ Nov-Jan: understory absent/growing

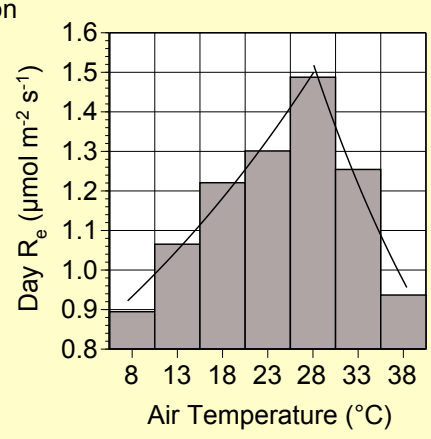
● Feb-May: Understory senescing

Data Processing
Carbon Partitioning, 6 months

- **Nocturnal R_e:**
  - Summed nighttime Level 2 F_c vs average nighttime soil temperature
  - Exponential (i.e., Q_{10}) temperature response
  - Θ_v classes:
    - 4–6%, 6–8%, 8–10%, 10–15%
    - $Q_{10} = 2.4$
- **Diurnal R_e:**
  - $F_{sd} = 0$ intercept in light response curve (F_c v F_{sd})
  - Temperature classes:
    - 5–11 °C, 11–16 °C, 16–21 °C, 21–26 °C, 26–31 °C, 31–36 °C, 36–42 °C
  - Bi-exponential, peak at 28 °C
- **Ecosystem Gross Primary Production (GPP):**
  - $GPP = R_e - F_c$ when $F_c < 0$
  - $GPP = 0$, diurnal $R_e = F_c$ when $F_c > 0$
- **Net Ecosystem Exchange (NEE):**
  - $NEE = R_e - GPP$







Additional Observations and Activities

Ecosystem and Physiological measurements

- Soil water and carbon fluxes (portable gas exchange chamber)
- Leaf water potential
- Leaf gas exchange
- Stem basal area
- Stem growth
- Litter production
- Leaf area index
- Stem hydraulic conductance
- Stable isotopes
- NDVI/EVI/Thermal photometry
- SVAT/LSM (CABLE) parameterisation