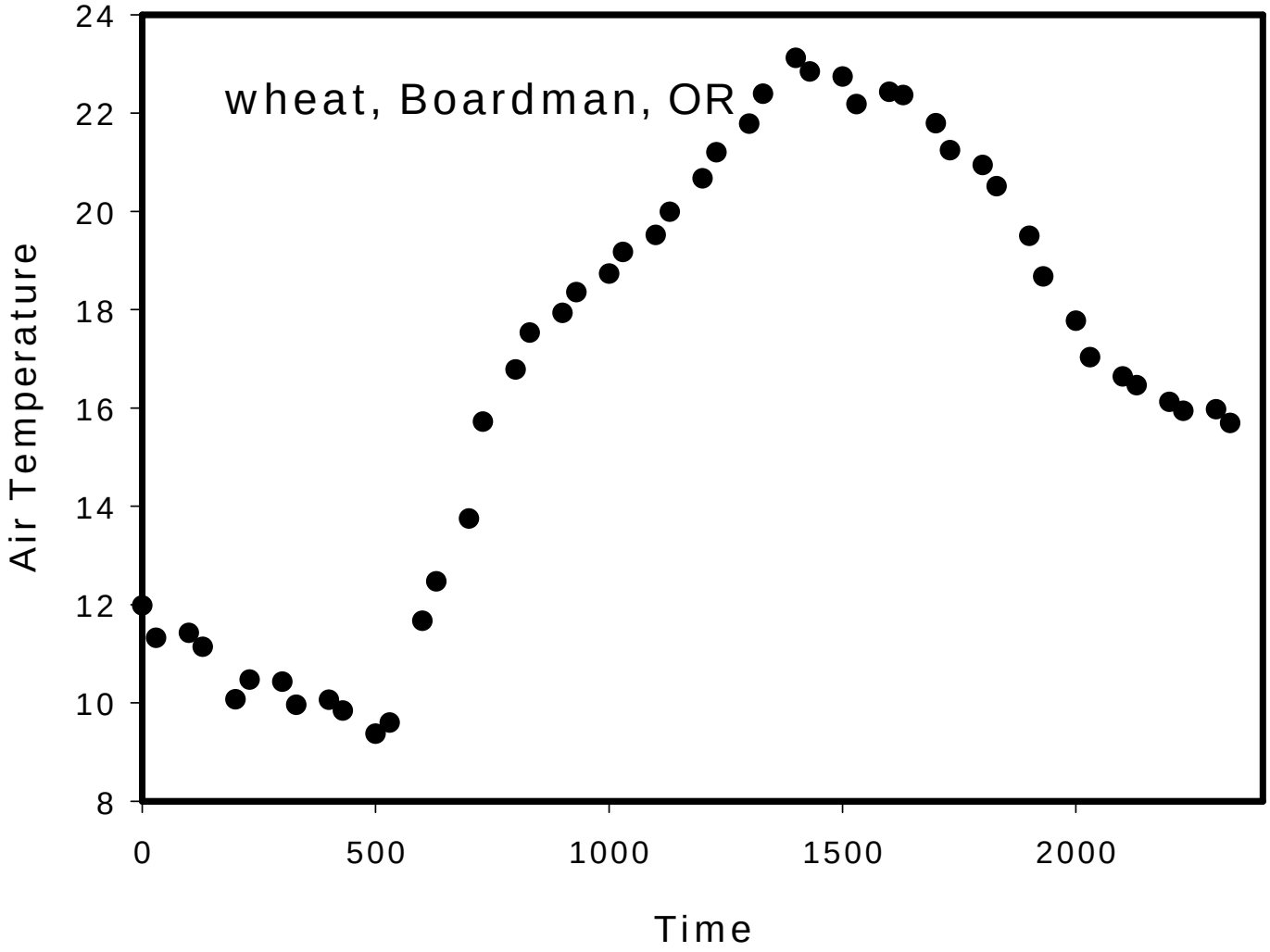
Lecture 13, Temperature and Thermodynamics, part III:

- Temperature and the Canopy Microclimate
  - Diurnal and Annual Patterns
  - Vertical Profiles
- Thermal Indices
- Agriculture and Microclimates

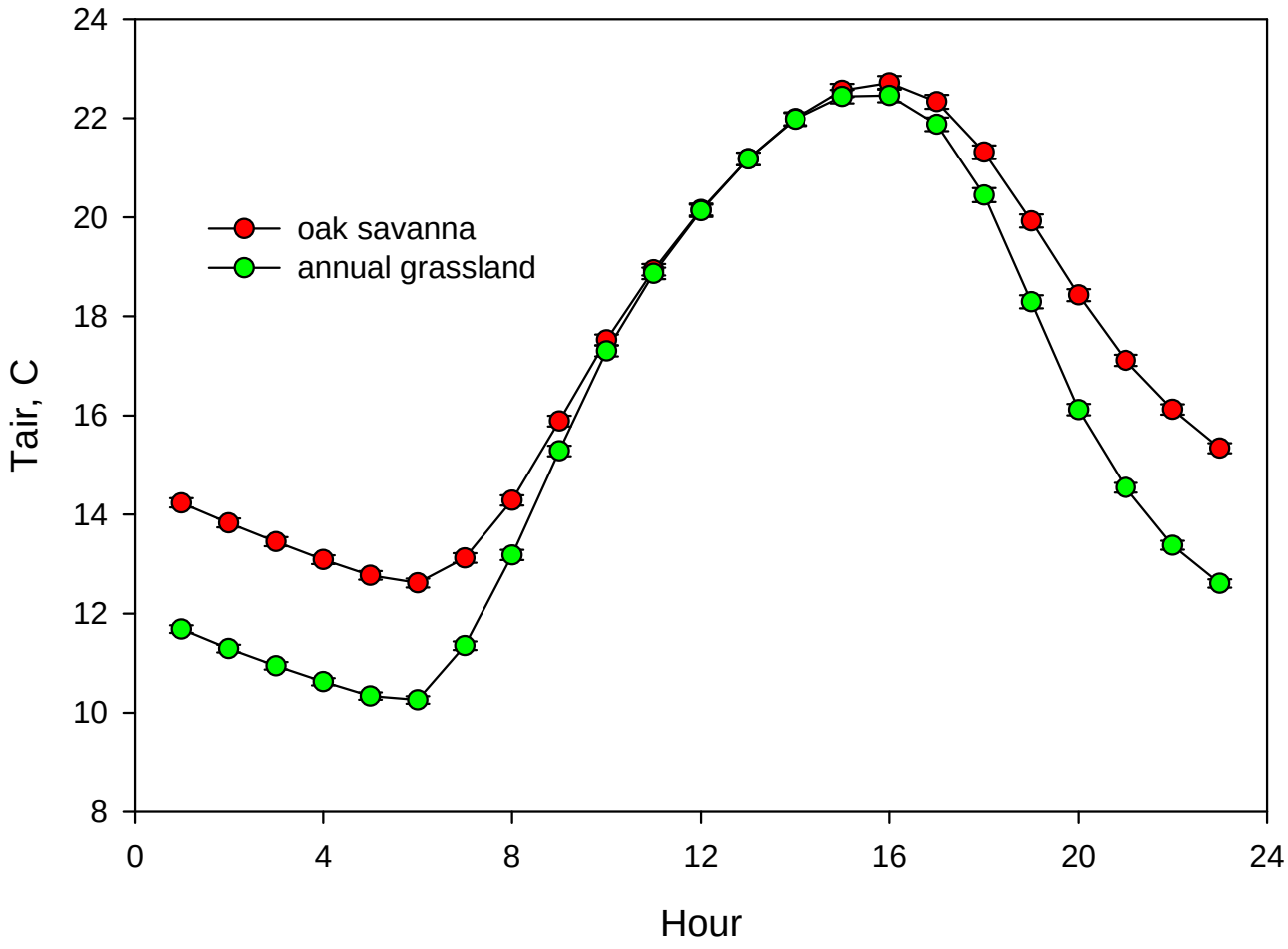
Summer Diurnal Pattern, Air Temperature over Wheat



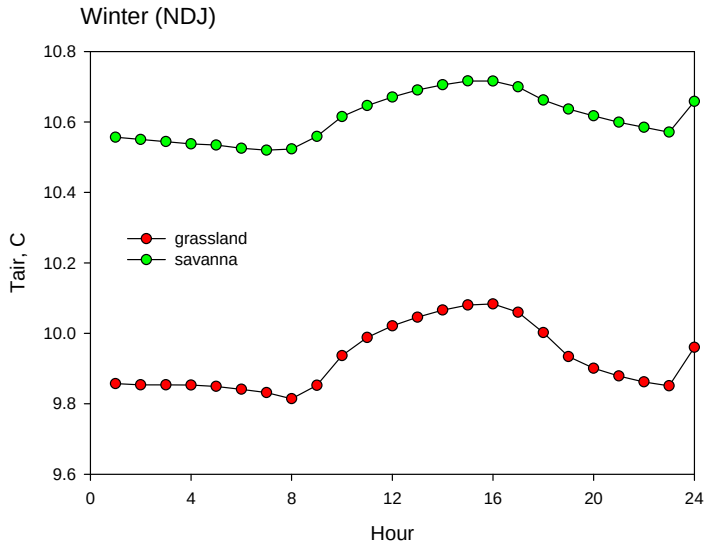
Tmeperature statistics, conditional stats

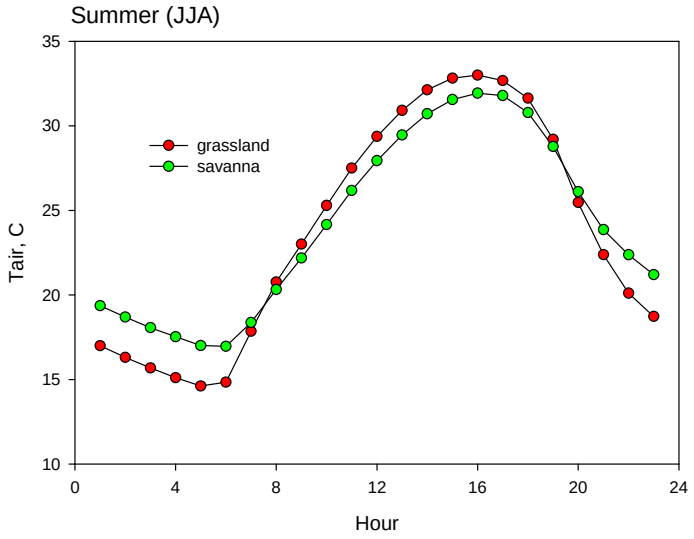
Day average, max, min, diurnal amplitude

Mean Annual Diurnal Pattern at Two Contrasting Sites



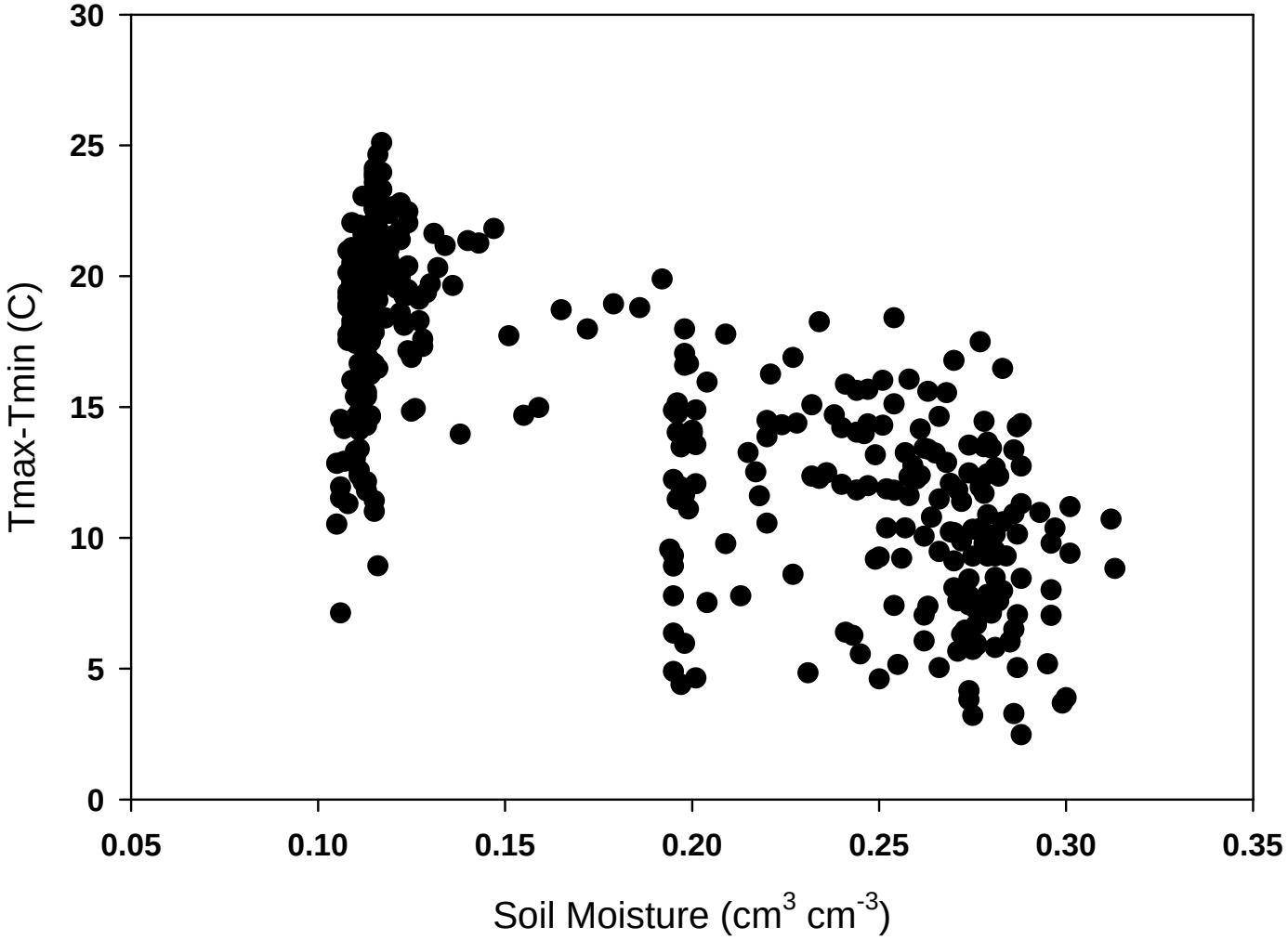
Mean Diurnal Patterns by Season



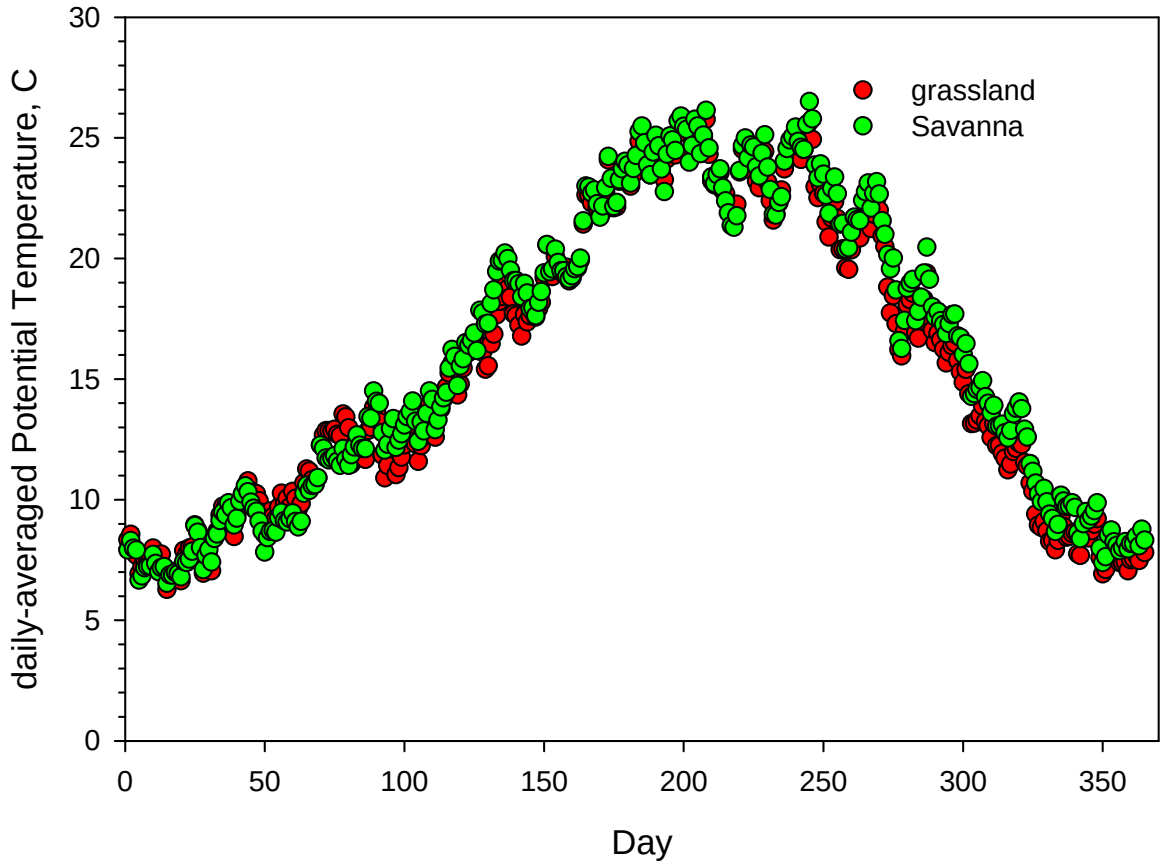


Temperature Amplitude and Soil Moisture Deficits

Grassland

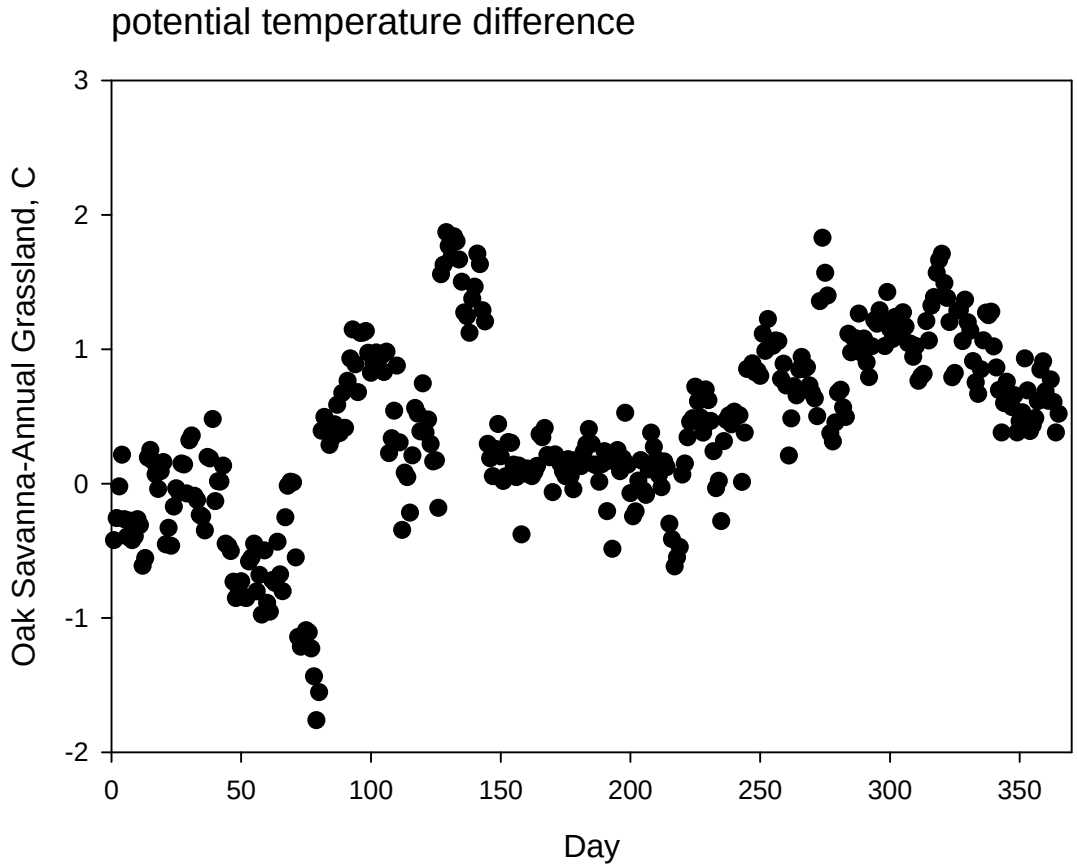


Effects of Land Use on Temperature



Baldocchi and Ma, unpublished

Who is Warmer/Cooler, Depends on Season, Roughness, Energy Balance and Physiological Status



Baldocchi and Ma, unpublished

Differences in Mean
Annual Air Temperature
Open Land minus Forest

Forests can be Darker, Absorb
More Energy and thereby be
Warmer than Nearby Grasslands

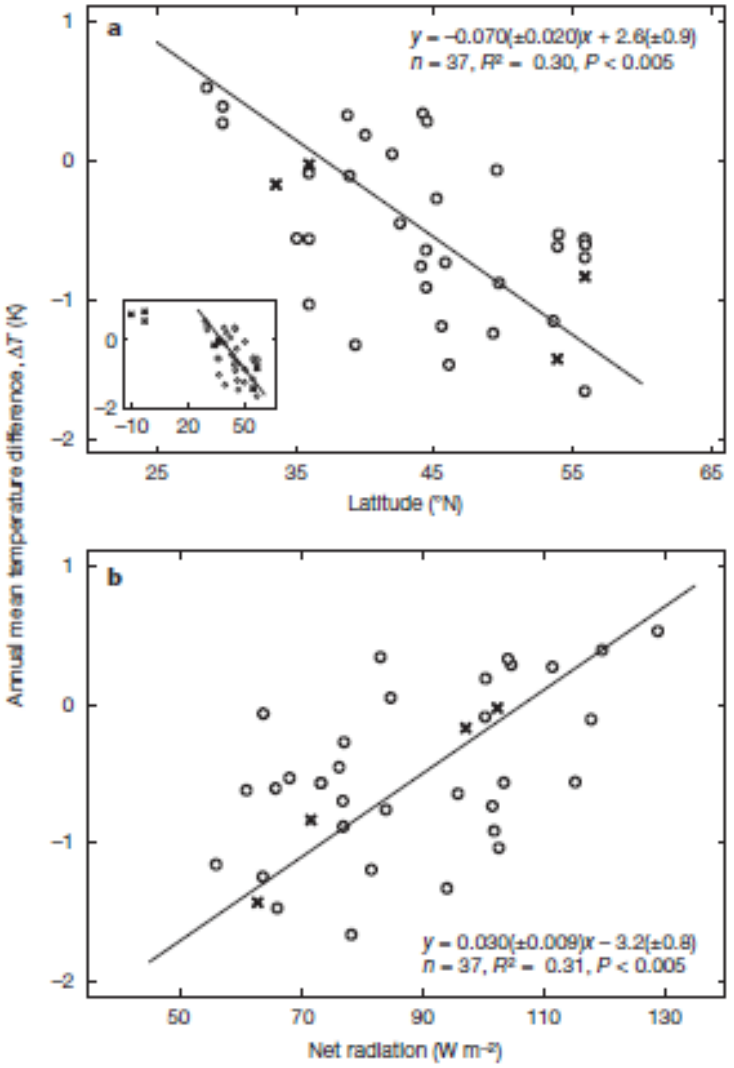
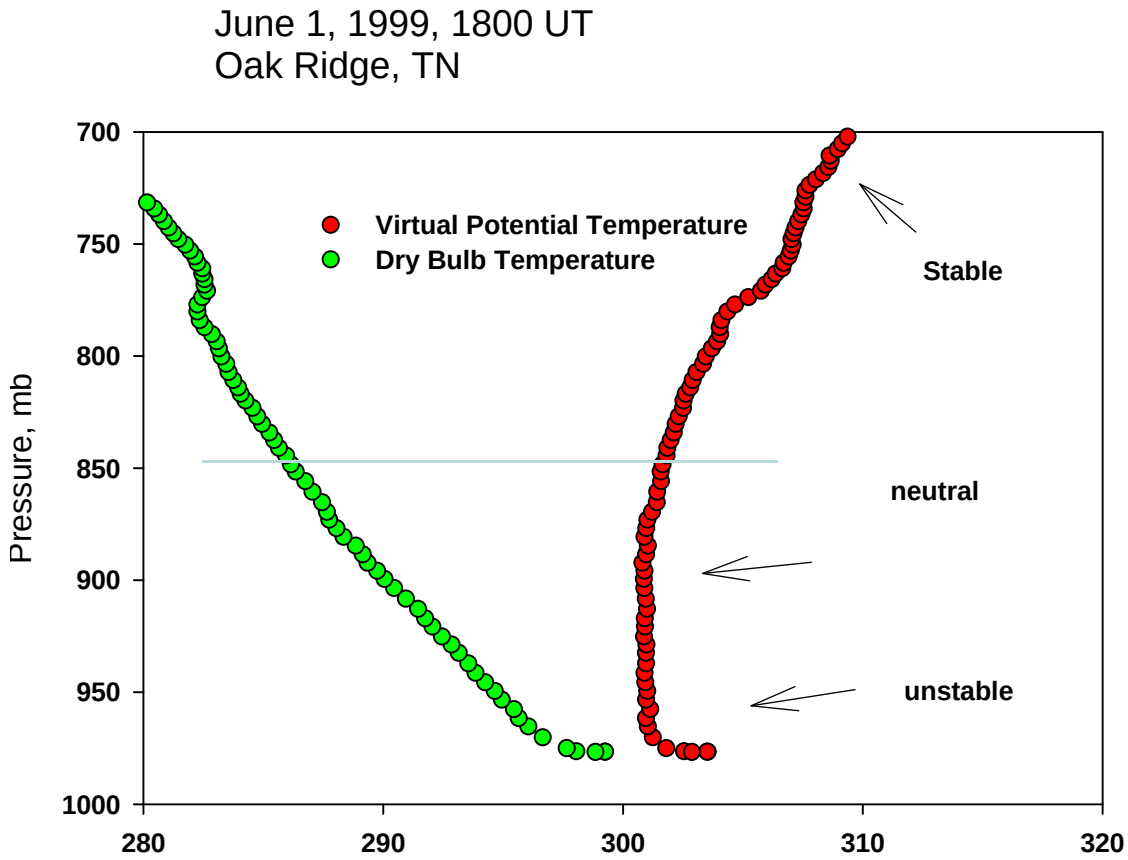


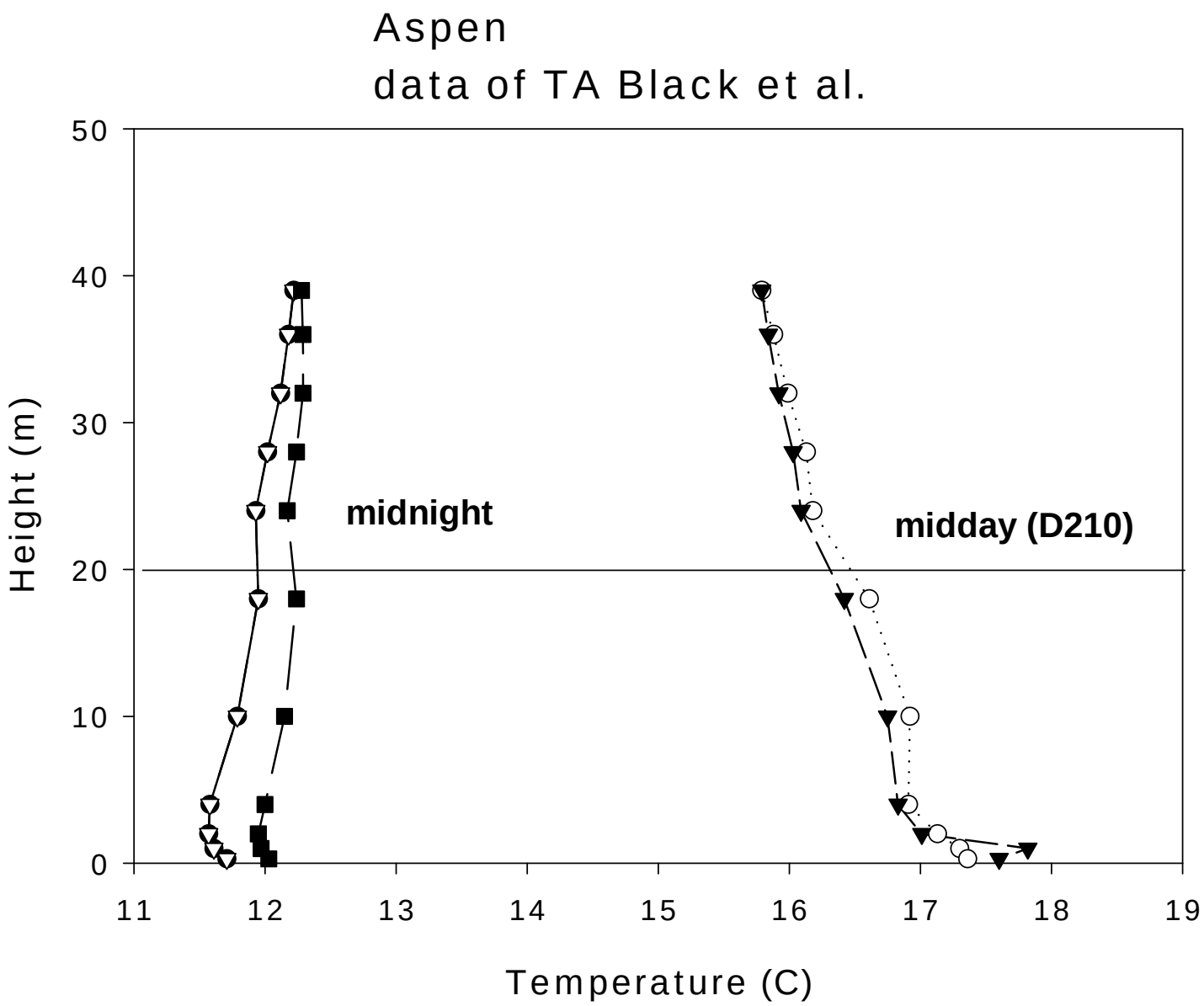
Figure 1 | Annual mean difference (open land minus forest) in surface air temperature. a, Correlation with latitude. b, Correlation with surface net

Lee et al 2011 Nature

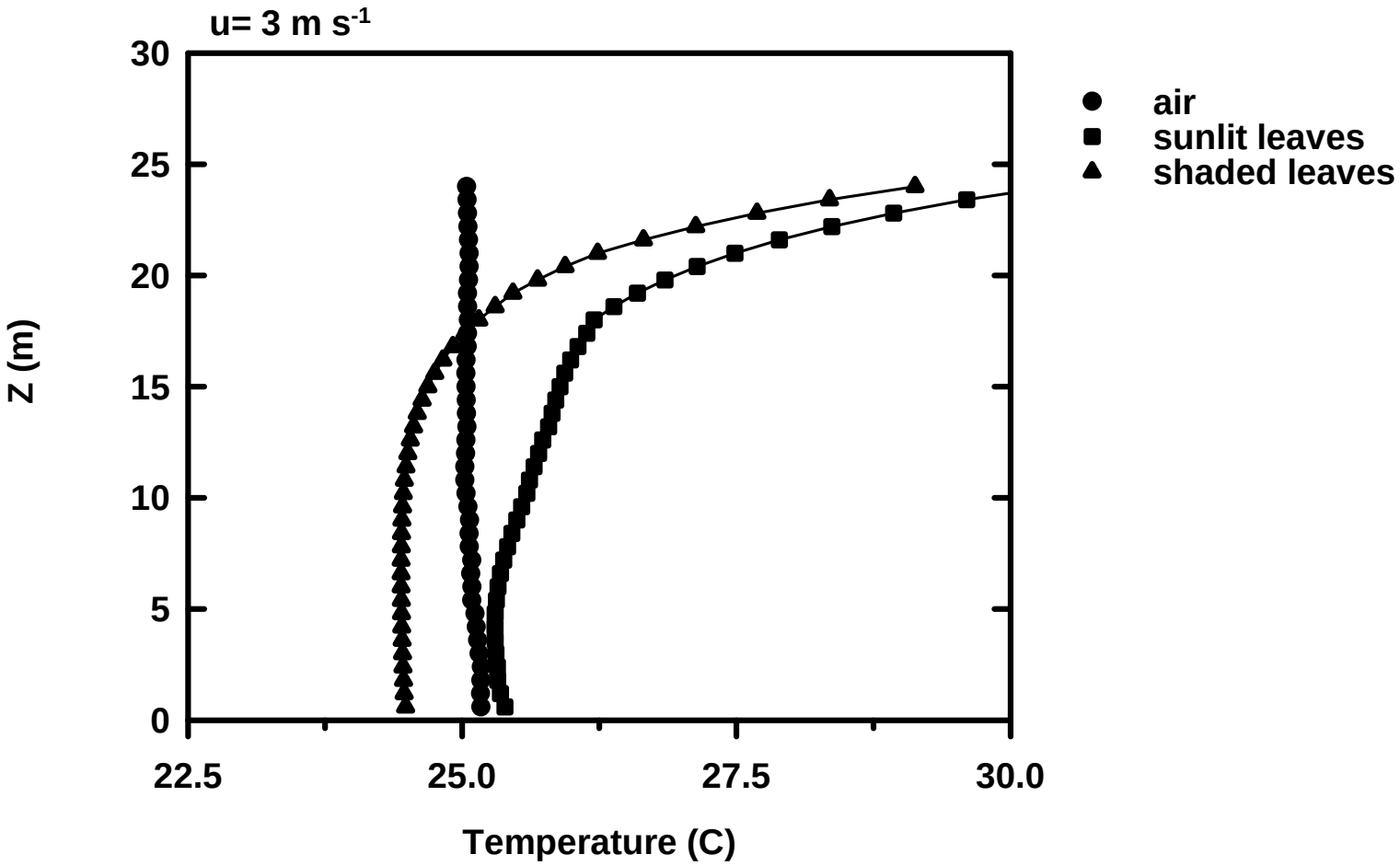
Profiles of Air and Potential Temperature



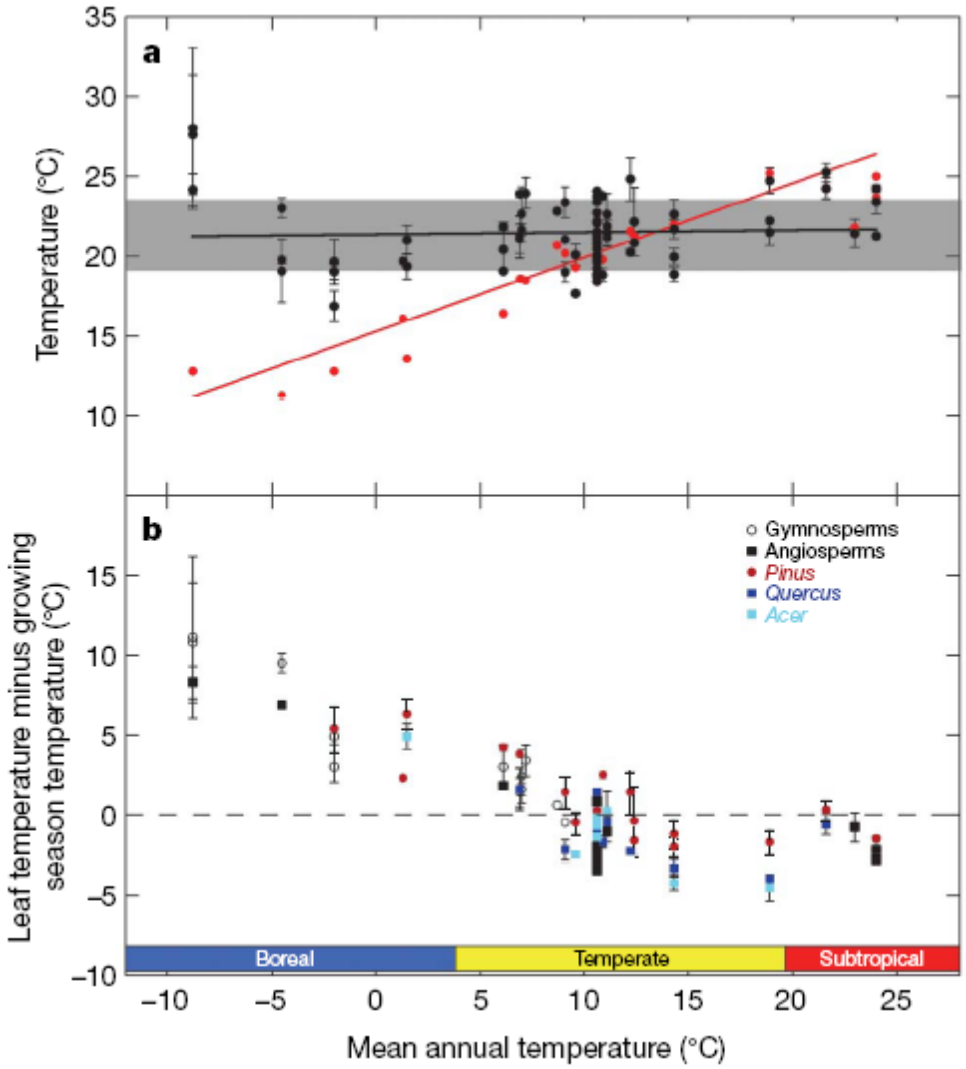
ESPM 129 Biometeorology


Aspen
data of TA Black et al.
Height (m)
50
40
30
20
10
0
11
12
13
14
15
16
17
18
19
midnight
midday (D210)
Temperature (C)

Theoretical Temperatures in a Forest

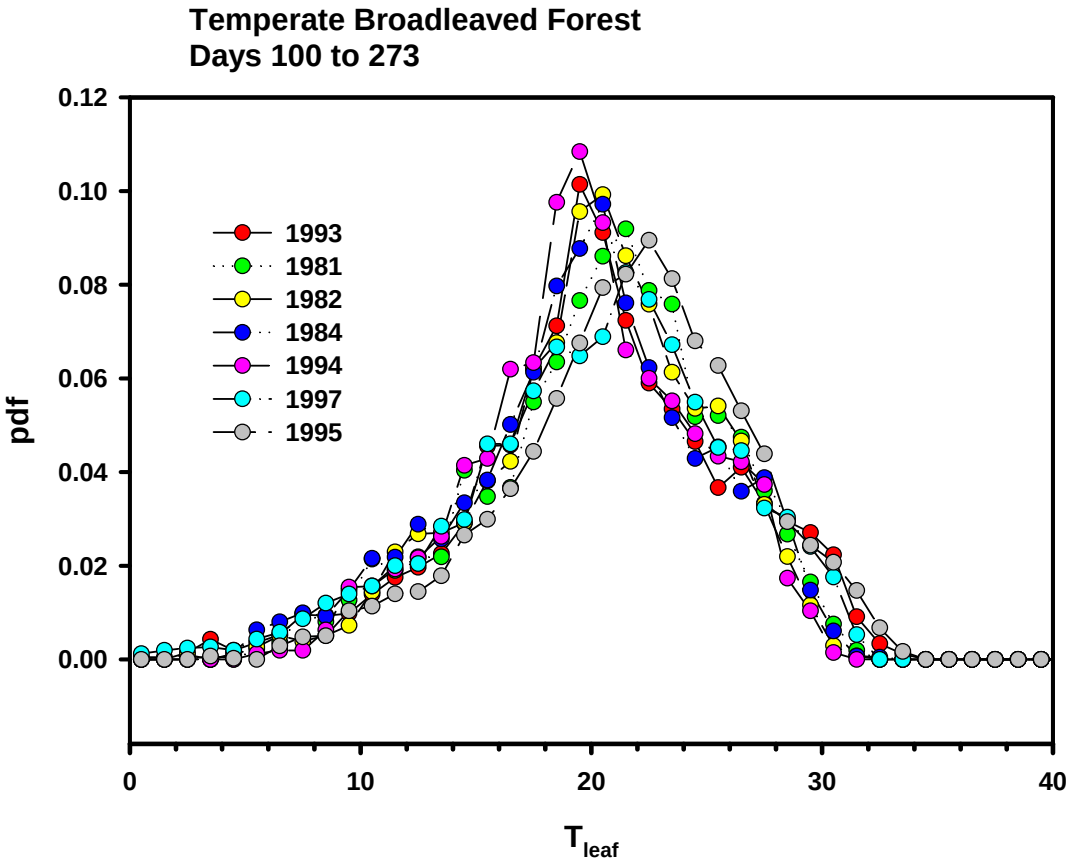


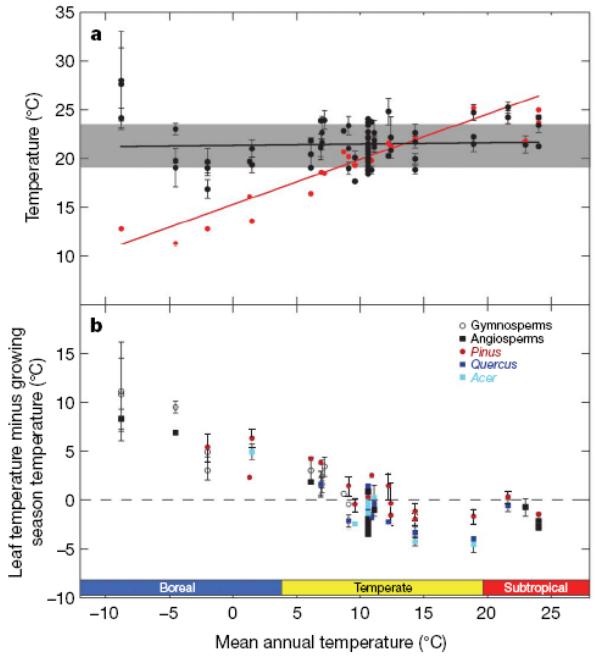
Is Mean Leaf Temperature Invariant?



Helliker and Richter 2008 Nature

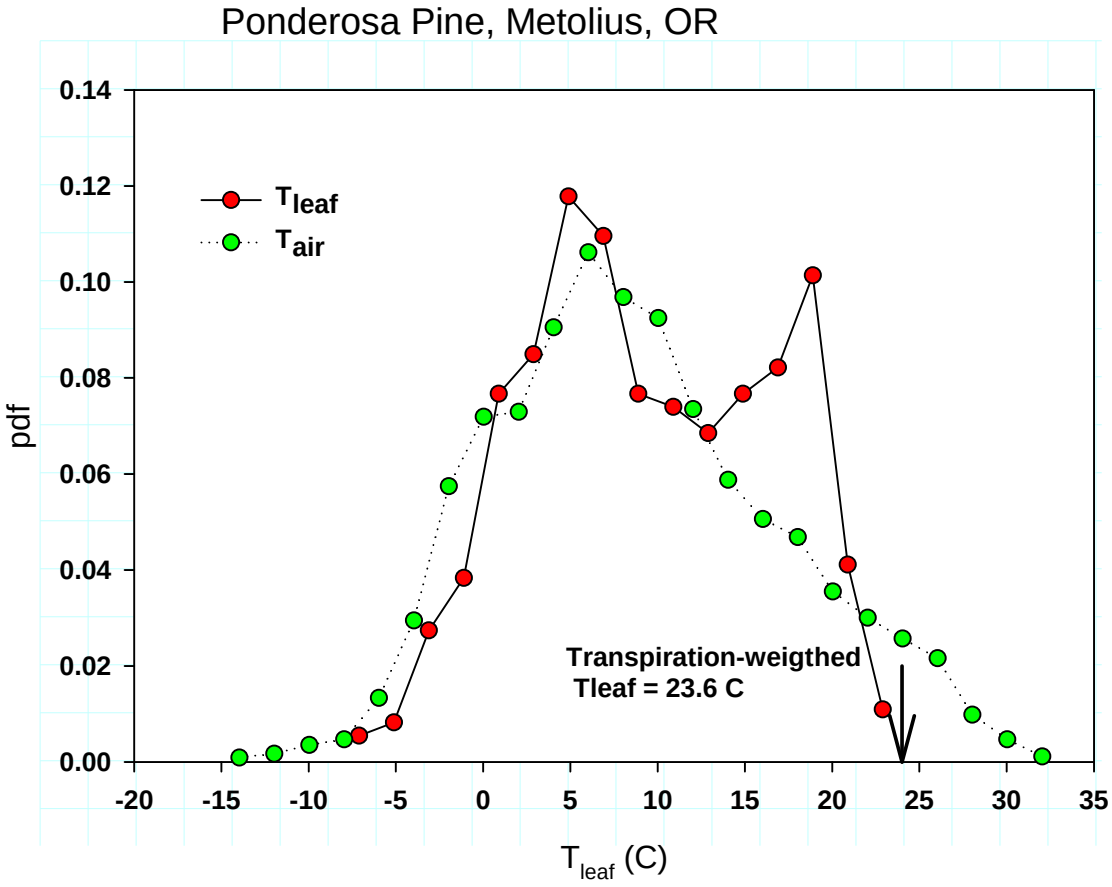
Leaf Temperature and Isotopes?



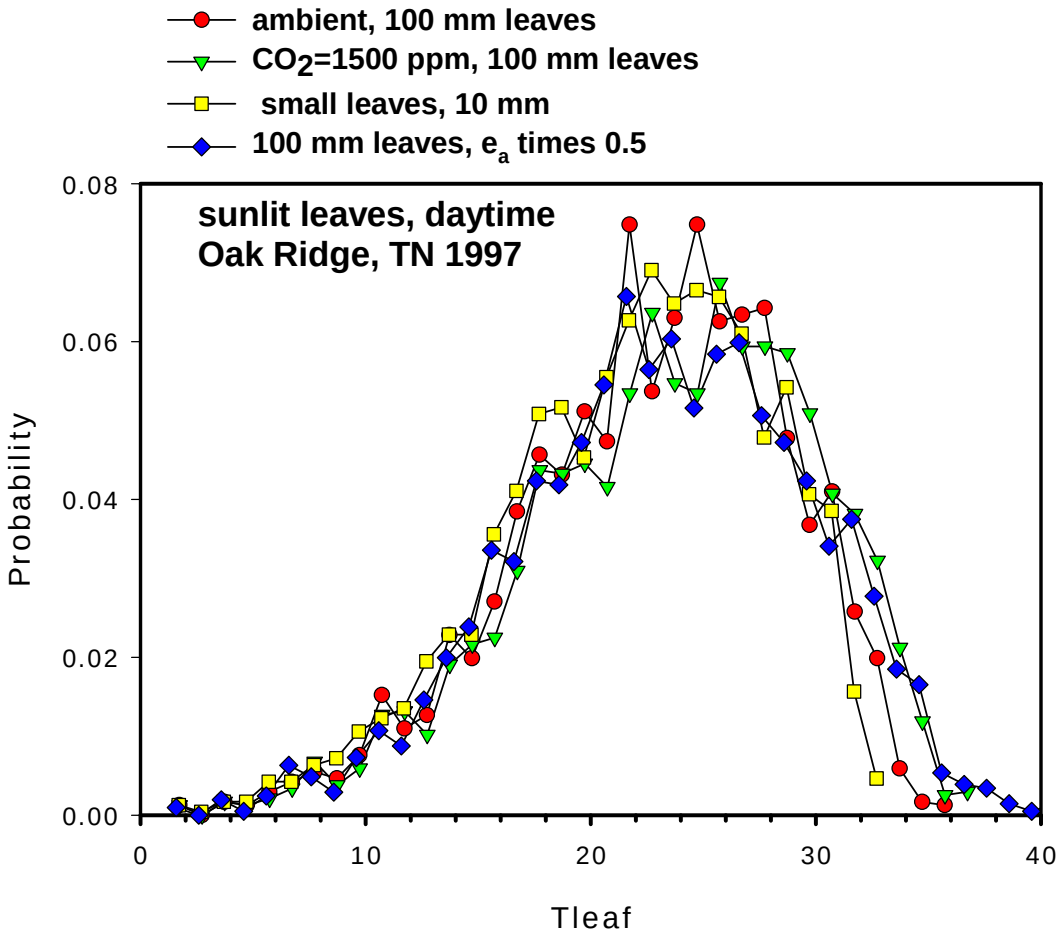


Helliker and Richter 2008 Nature

Flux-Weighted Temperature pdf



Role of Leaf Size and CO2 on Leaf Temperature



Energy Balance Feedbacks seem to Seek a Common Optimum
Evolutionary Adaptations Attempt to Avoid Extreme Stresses

Mean Annual Air Temperature

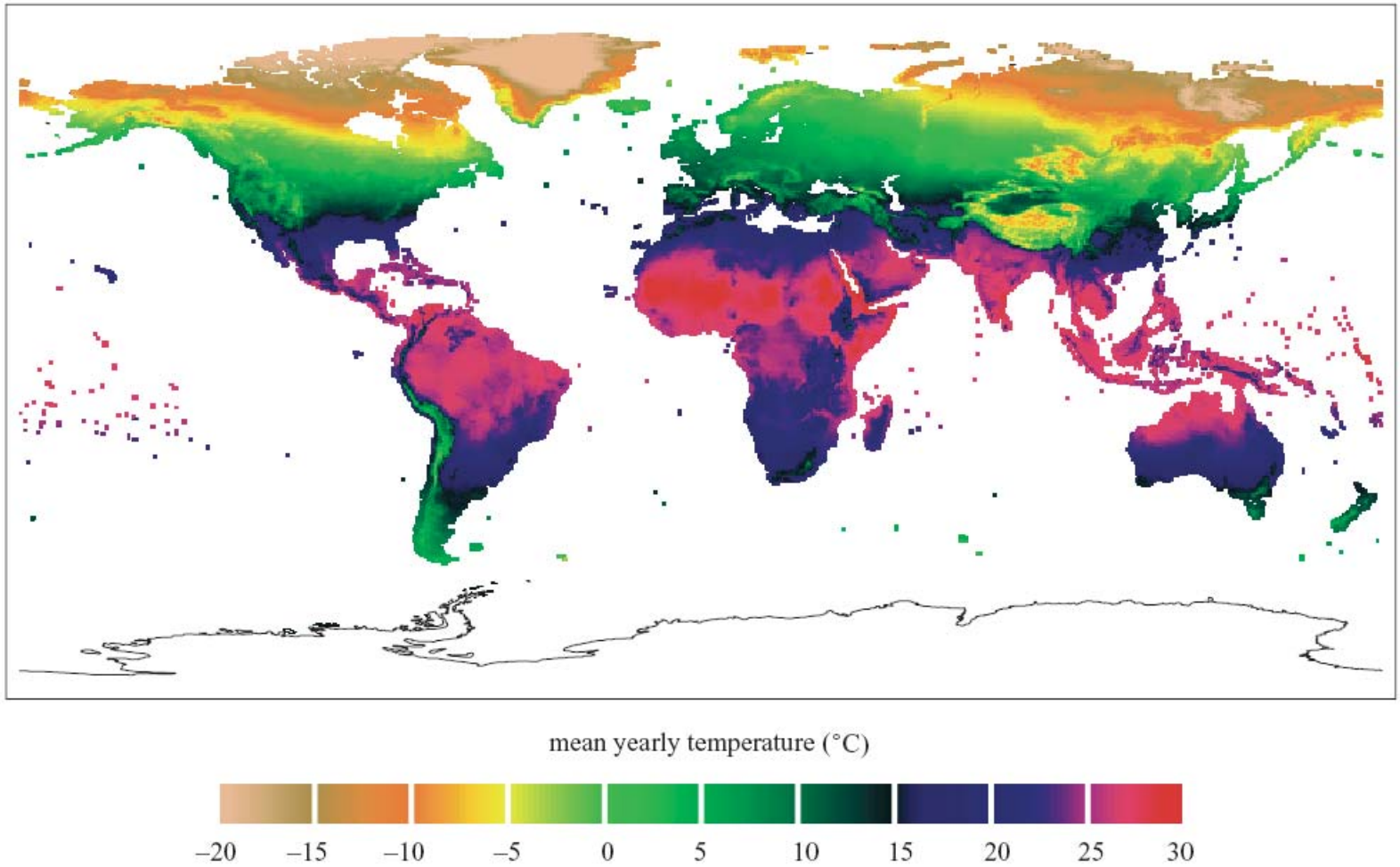


Figure 6. Mean annual temperature for 1901 to 1970. (Modified from New *et al.* 2000.)

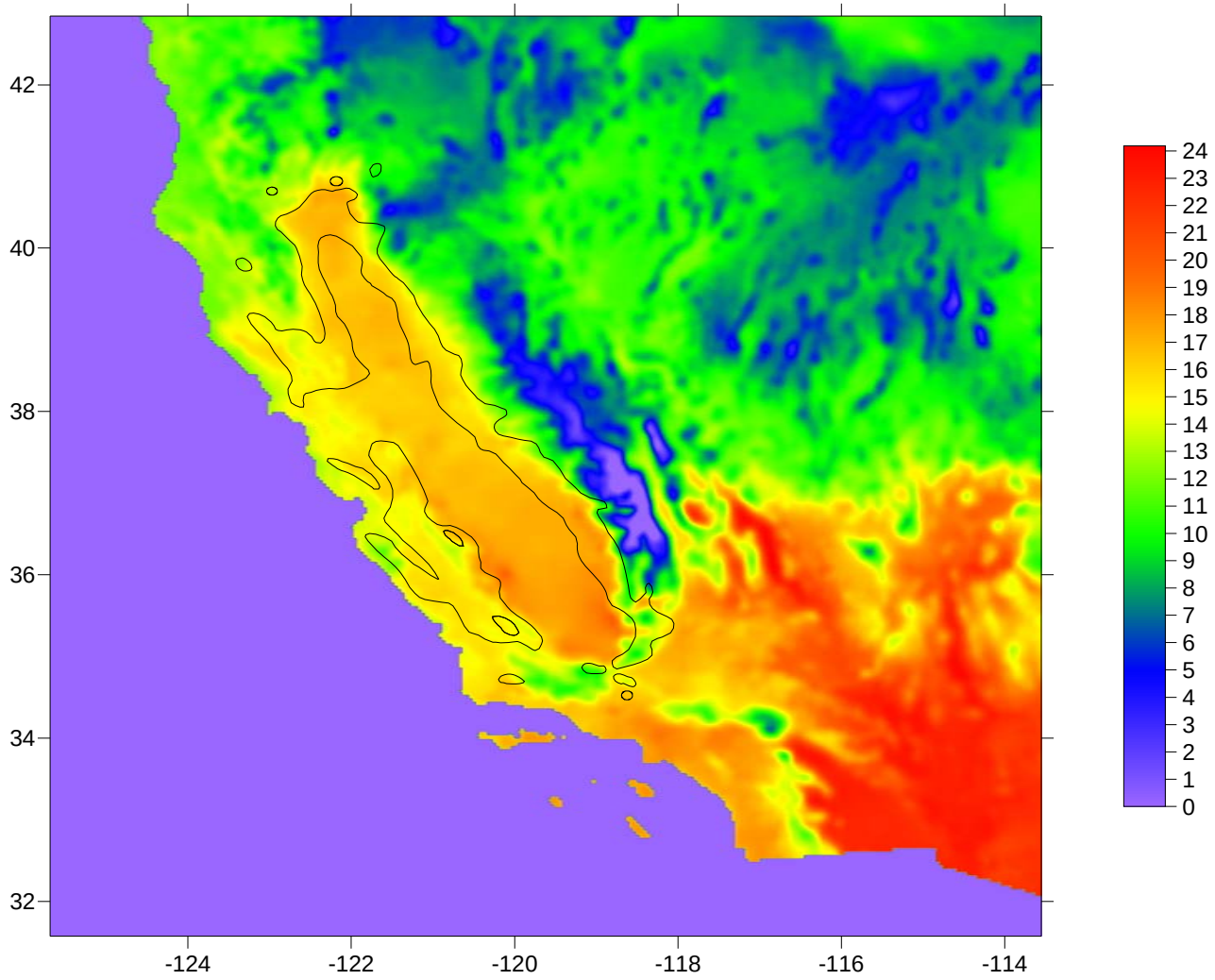
Temperature databases

PRISM
DAYMET
CalAdapt

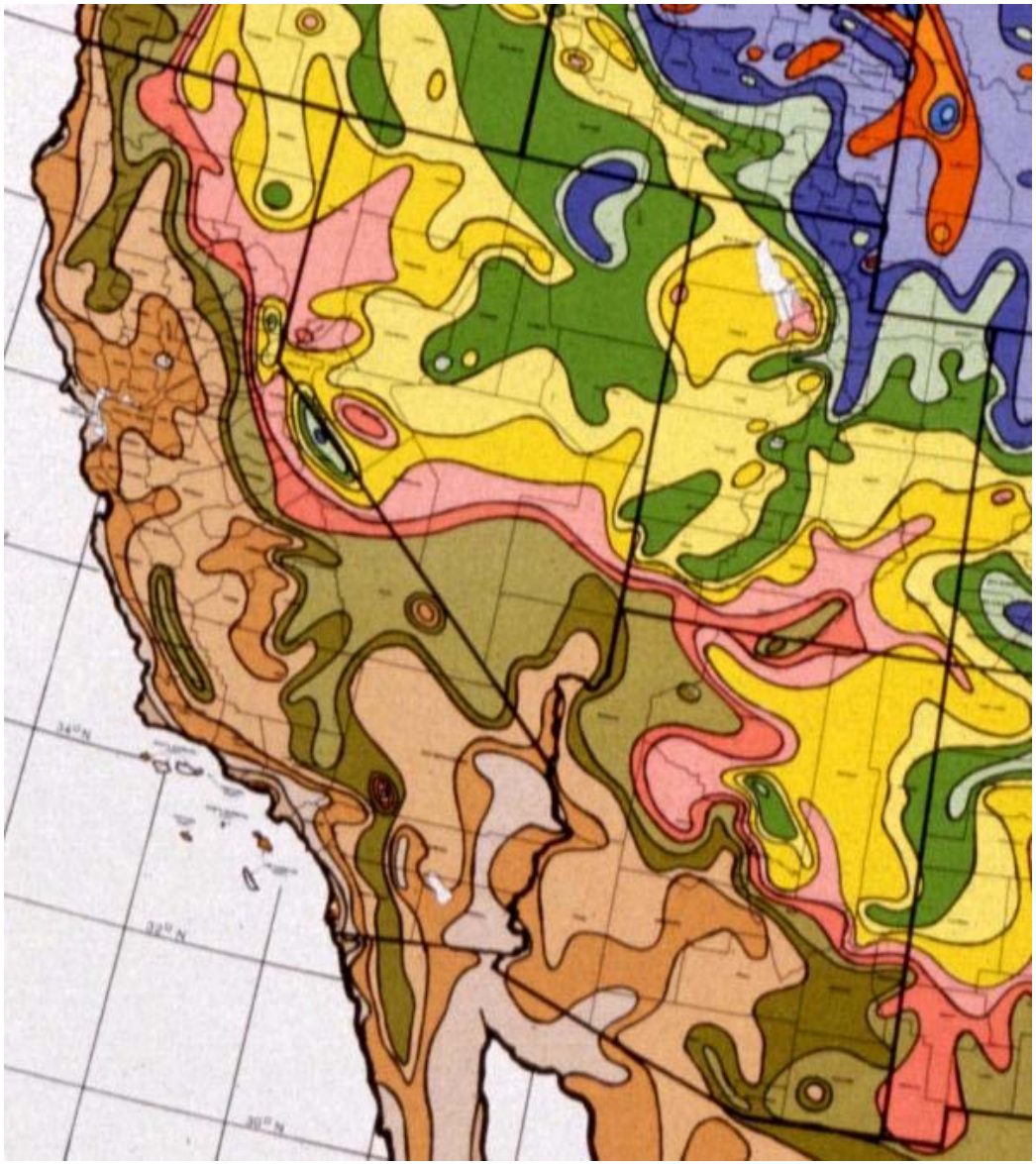
Global gridded data…

Reanalysis..

California Average Temperature, 1971-2000



“Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/,



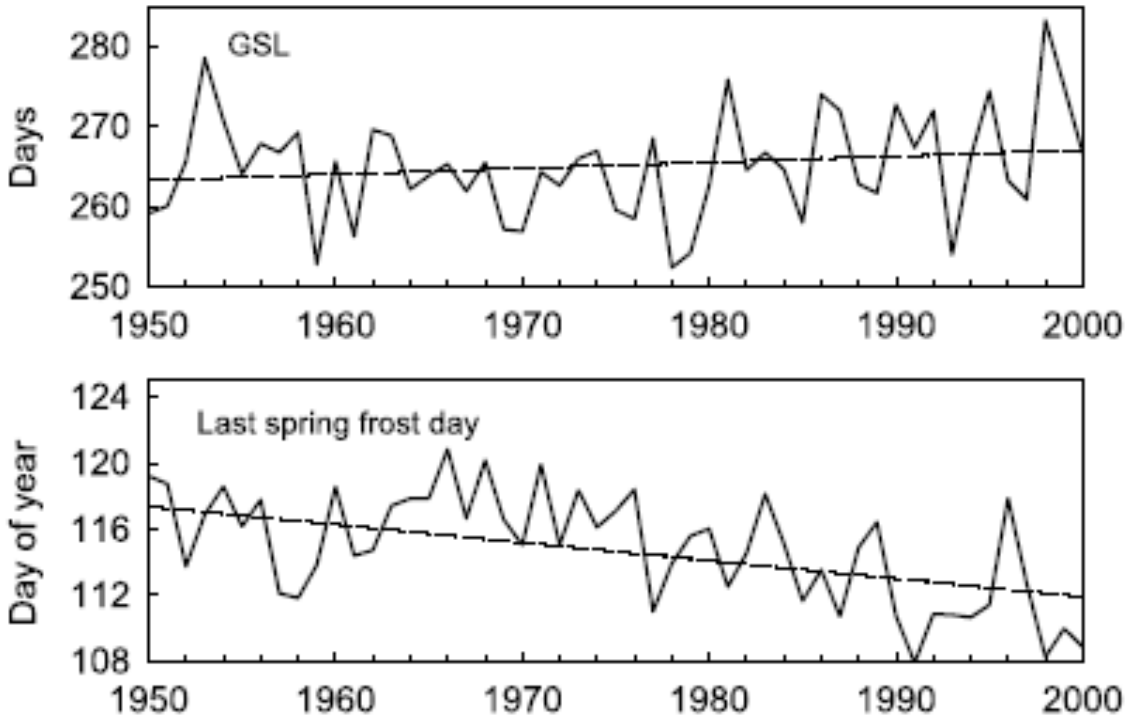
Average Annual
Minimum Temperature

ZONE	Temperature
1	Below -50 F
2a	-50 to -45 F
2b	-45 to -40 F
3a	-40 to -35 F
3b	-35 to -30 F
4a	-30 to -25 F
4b	-25 to -20 F
5a	-20 to -15 F
5b	-15 to -10 F
6a	-10 to -5 F
6b	- 5 to 0 F
7a	0 to 5 F
7b	5 to 10 F
8a	10 to 15 F
8b	15 to 20 F
9a	20 to 25 F
9b	25 to 30 F
10a	30 to 35 F
10b	35 to 40 F
11	Above 40 F

Summary

- Inside dense forests at night, the thermal stratification will be stable in the upper portion of the canopy, but can be unstable near the forest floor causing the layers to become decoupled.
- Simple trigonometric principles can be used to compute summed heat and chill hours based solely on maximum and minimum temperature measurements.

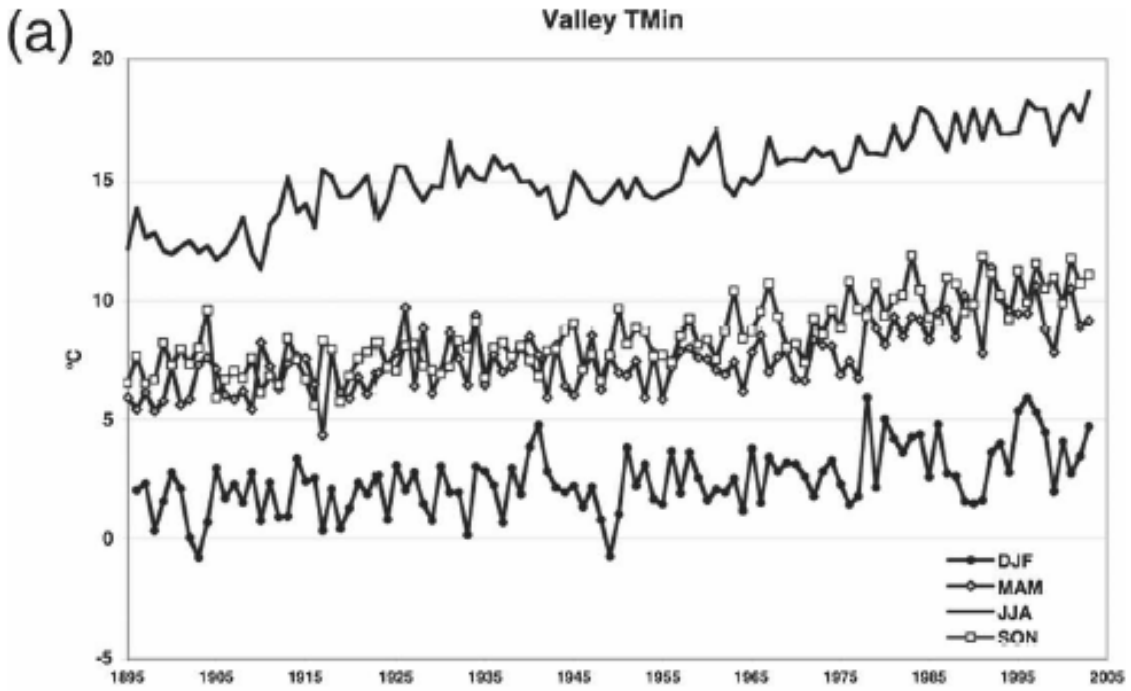
Trends in Growing Season Length and Last Frost Date



United States

Feng and Hu, 2004, J Theor Appl Clim

Central Valley Trends in Minimum Temperature: Partially Attributed to Land Use Change



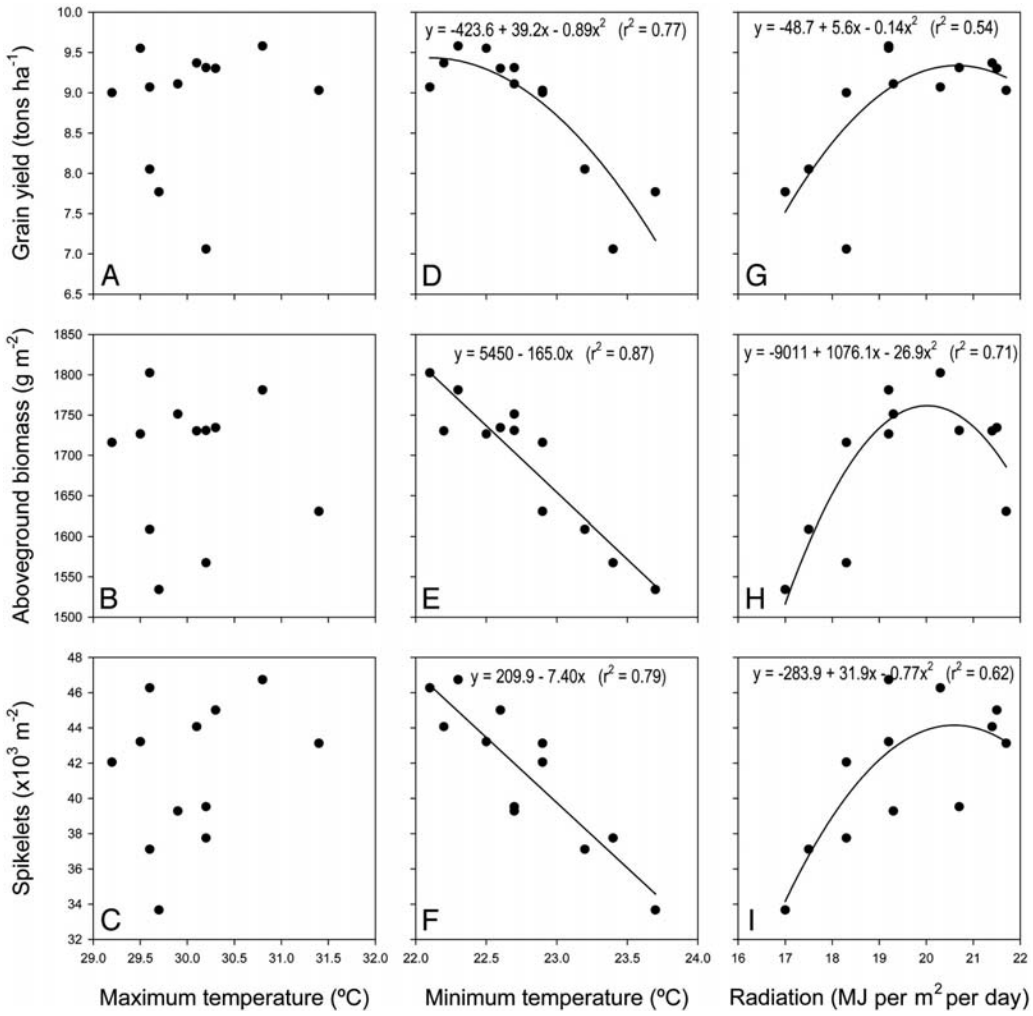
Christy et al., 2006 J Climate

Role of Temperature Extremes on Rice

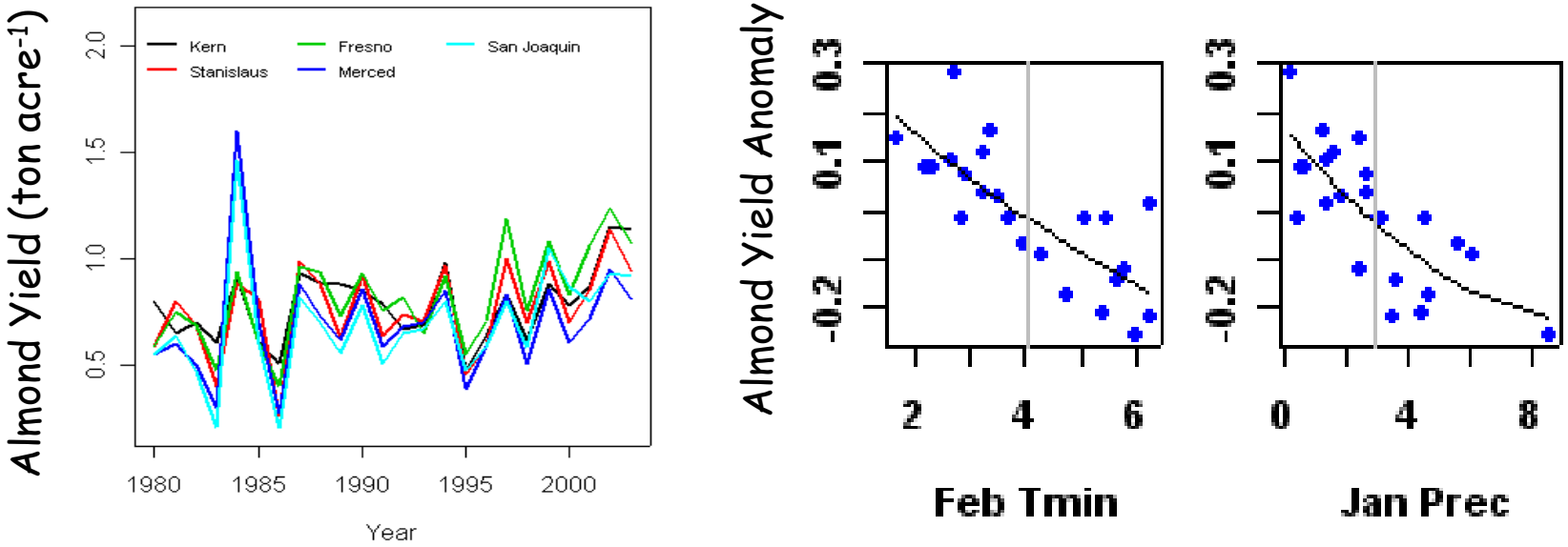
Grain Yield

Biomass

Spikelets

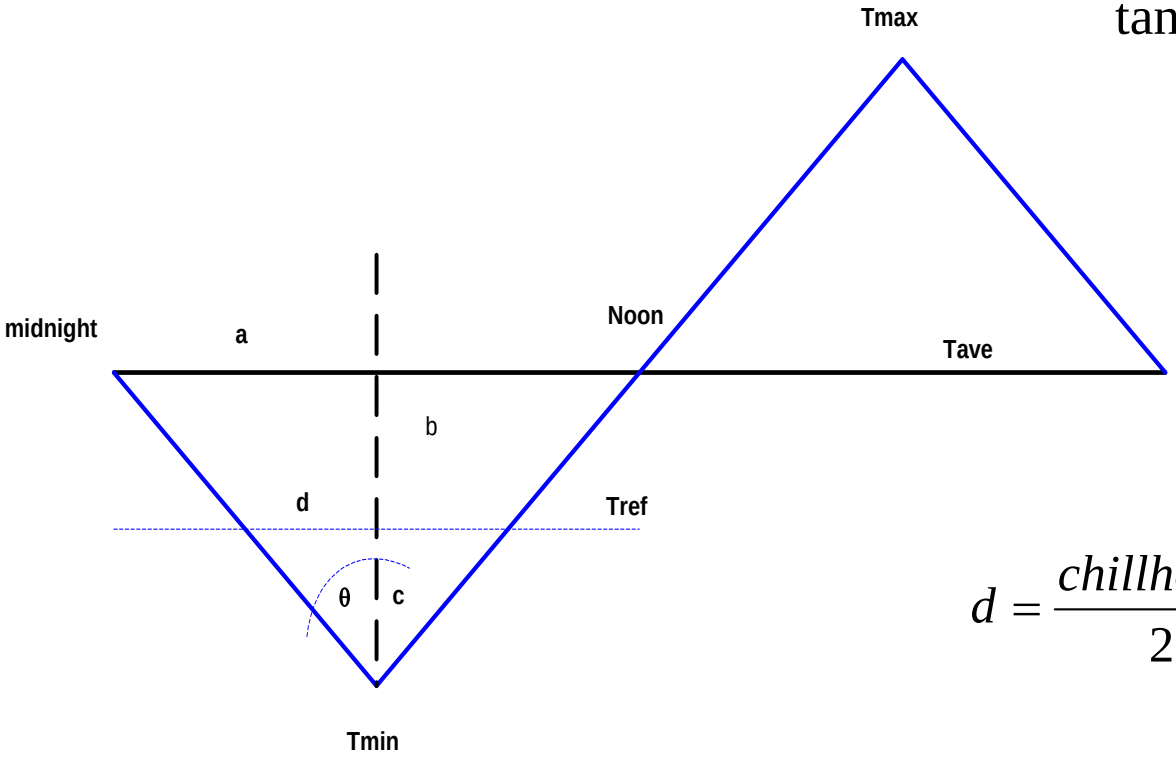


Role of Seasonal Statistics

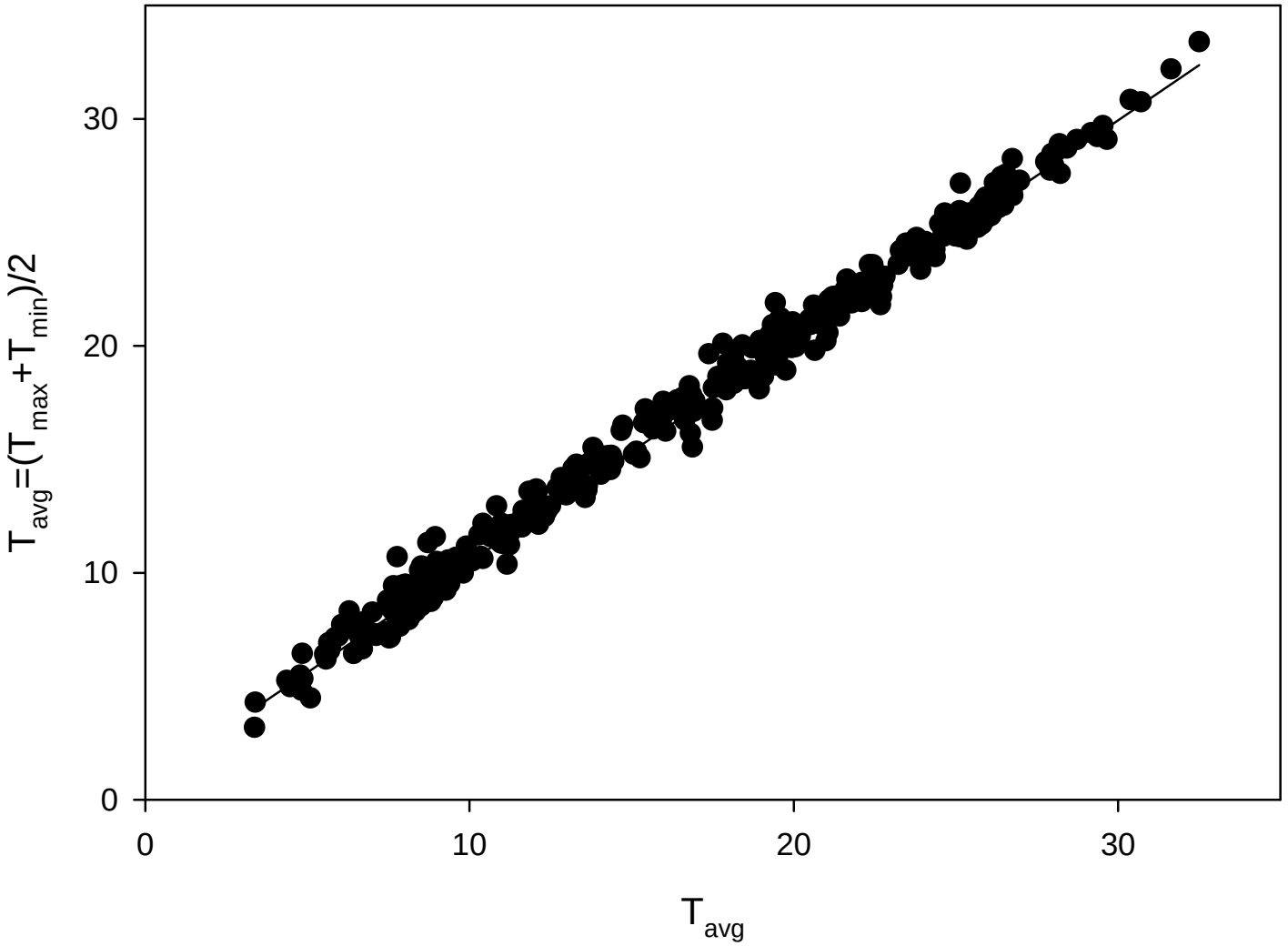


D. Lobell, Unpublished, Data source: CIMIS, NASS

$$Chillhours = \sum_{0}^{24} T_{ref} - T(t)$$



$$\tan\theta = \frac{a}{b} = \frac{6hr}{T_{ave} - T_{\min}}$$

$$d = \frac{chillhours}{2} = \tan\theta \cdot (T_{ref} - T_{\min})$$

slope 0.973, offset 0.738, r2 0.87