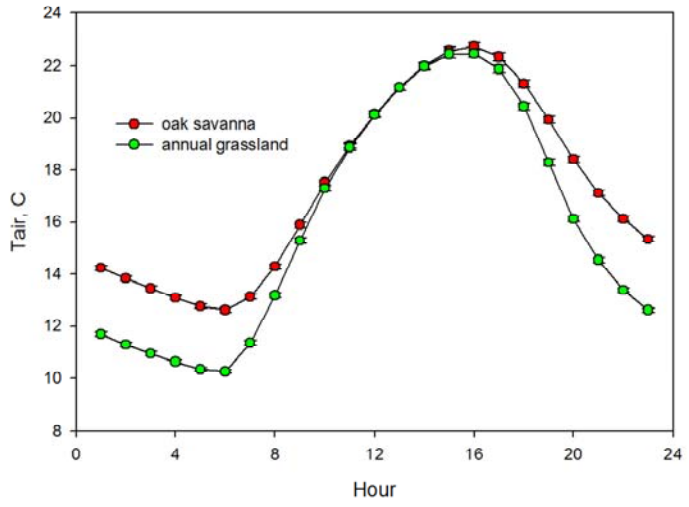
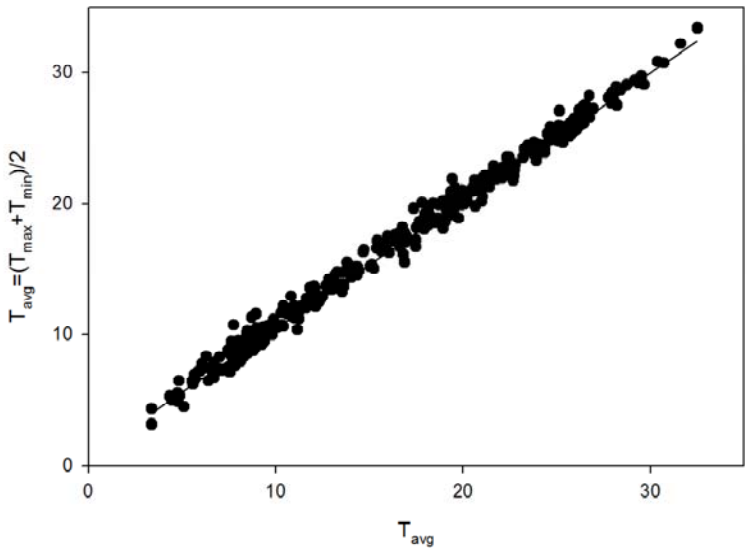
Lecture 13, Temperature and Thermodynamics, part III:

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

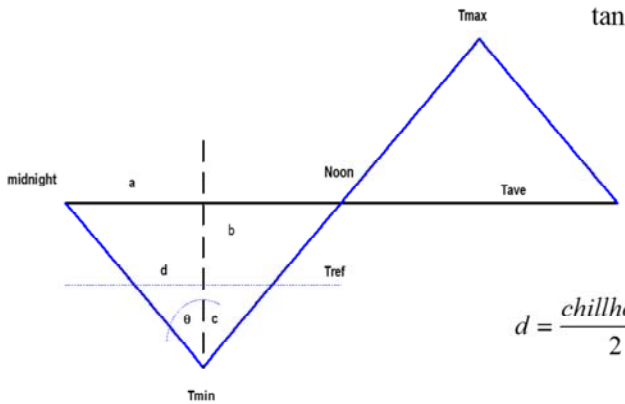
Mean Annual Diurnal Pattern at Two Contrasting Sites



slope 0.973, offset 0.738, r2 0.87

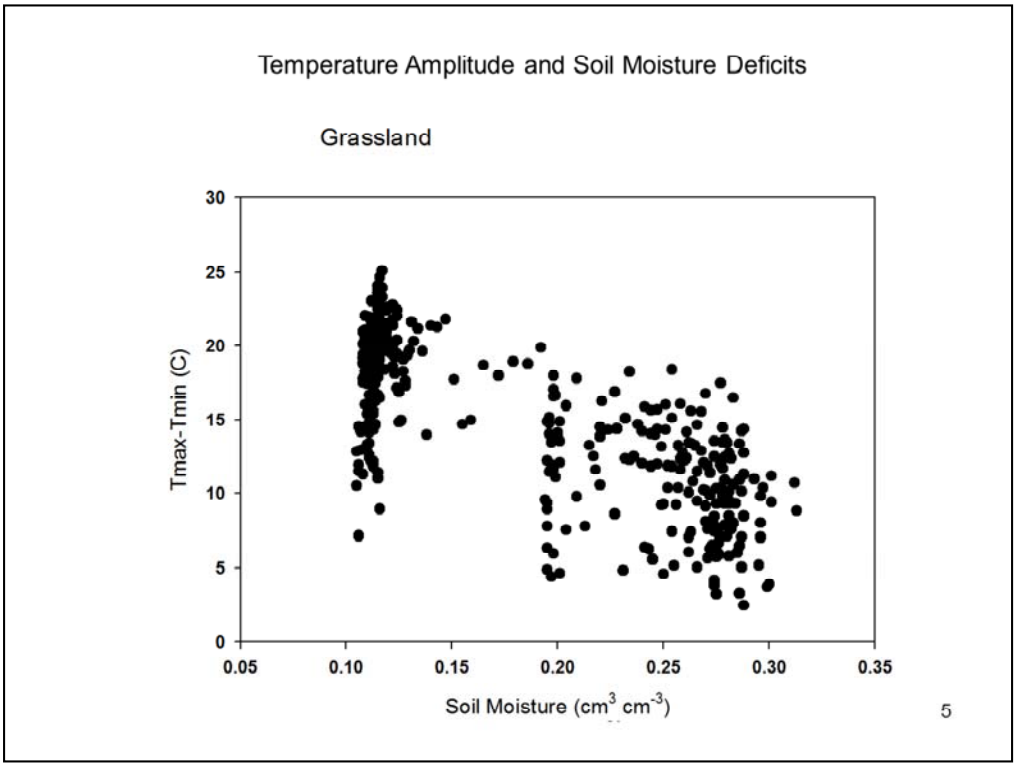


$$Chillhours = \sum_{0}^{24} T_{ref} - T(t)$$

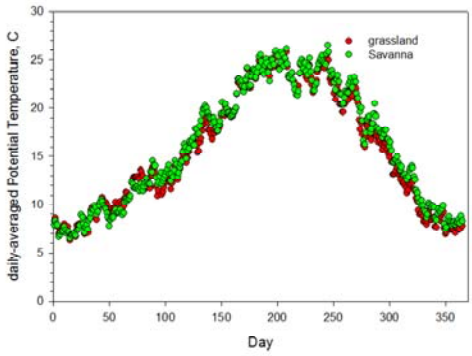


$$\tan\theta = \frac{a}{b} = \frac{6hr}{T_{ave} - T_{\min}}$$

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

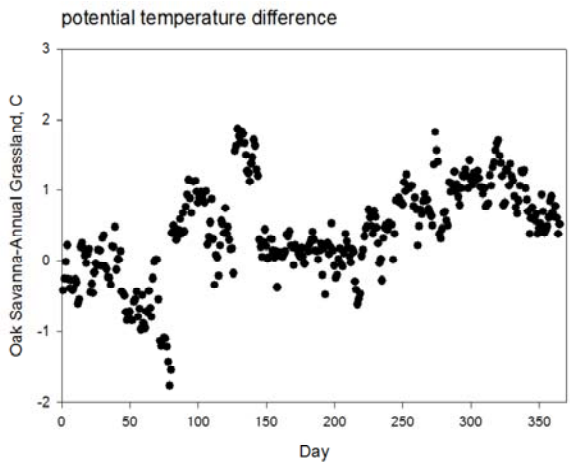

Temperature Amplitude and Soil Moisture Deficits
Grassland
Tmax-Tmin (C)
30
25
20
15
10
5
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Soil Moisture (cm3 cm-3)
5

Effects of Land Use on Temperature



Baldocchi and Ma, Tellus 2013

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



Baldocchi and Ma, 2013 Tellus

Differences in Mean
Annual Air Temperature
Open Land minus Forest

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

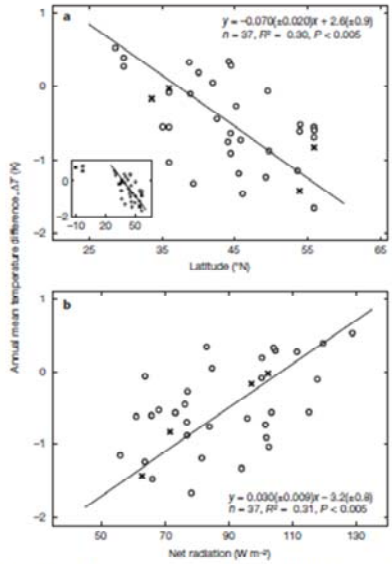
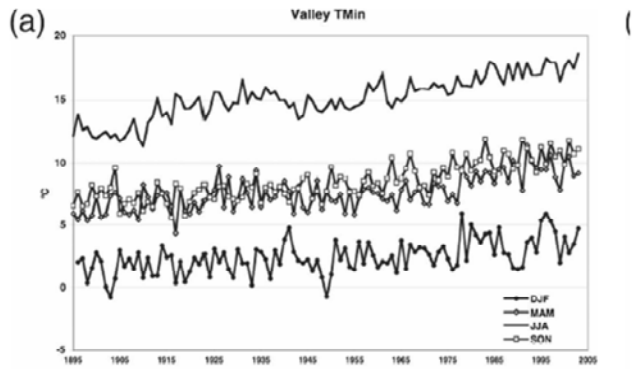


Figure 1 | Annual mean difference (open land minus forest) in surface air temperature. a, Correlation with latitude. **b,** Correlation with surface net

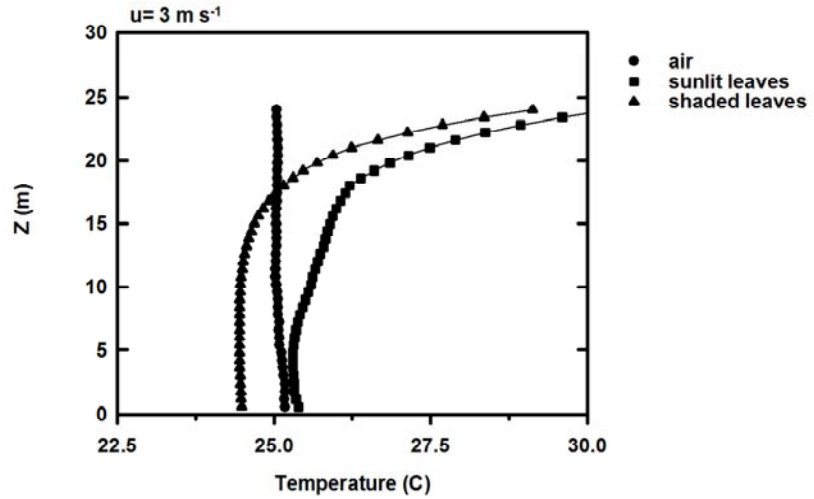
Lee et al 2011 Nature

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

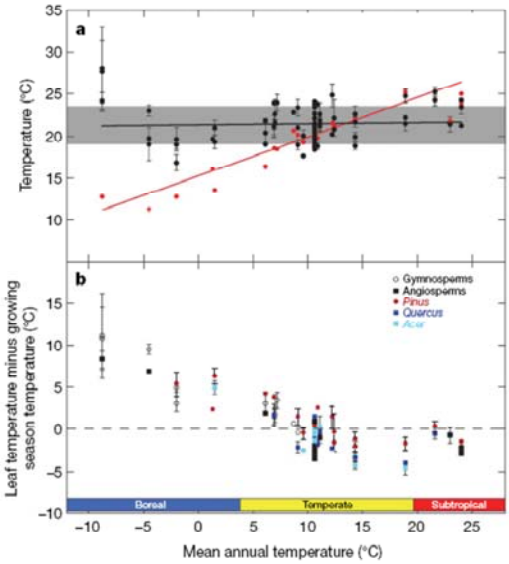


Christy et al., 2006 J Climate

Theoretical Temperatures in a Forest

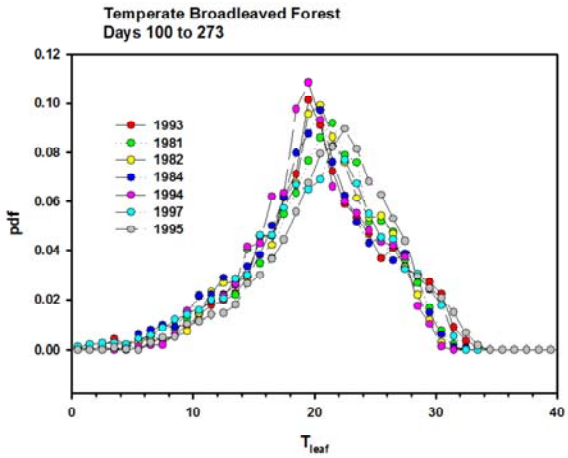


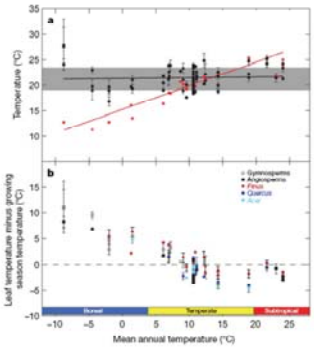
Is Mean Leaf Temperature Invariant?



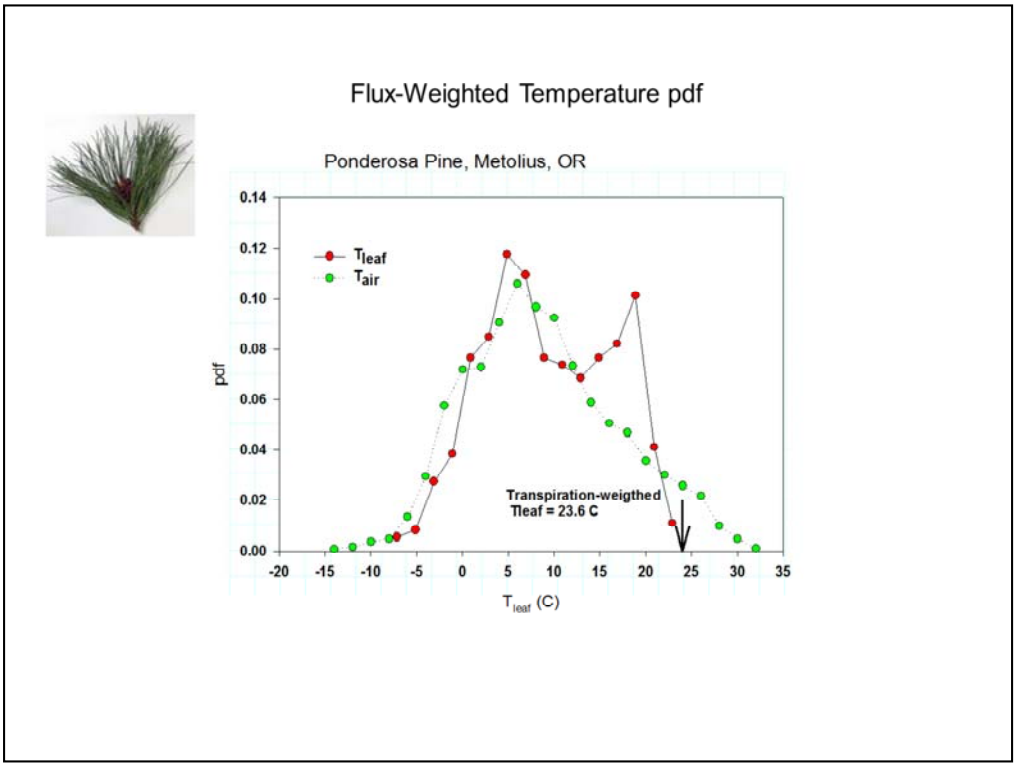
Helliker and Richter 2008 Nature

Leaf Temperature and Isotopes?



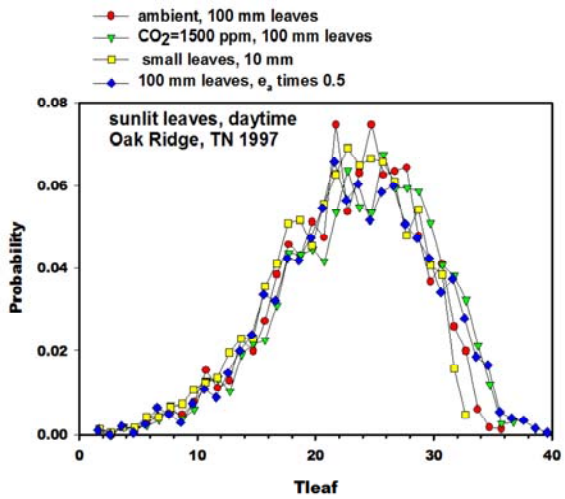


Helliker and Richter 2008 Nature



Flux weighted effect

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

Temperature, gridded databases

PRISM, http://www.prism.oregonstate.edu/

DAYMET, https://daymet.ornl.gov/

CalAdapt, http://cal-adapt.org/

US, Climate at a Glance
http://www.ncdc.noaa.gov/cag/

Global gridded data…

CRU, University of East Anglia

http://www.cru.uea.ac.uk/data

Mean Annual Air Temperature

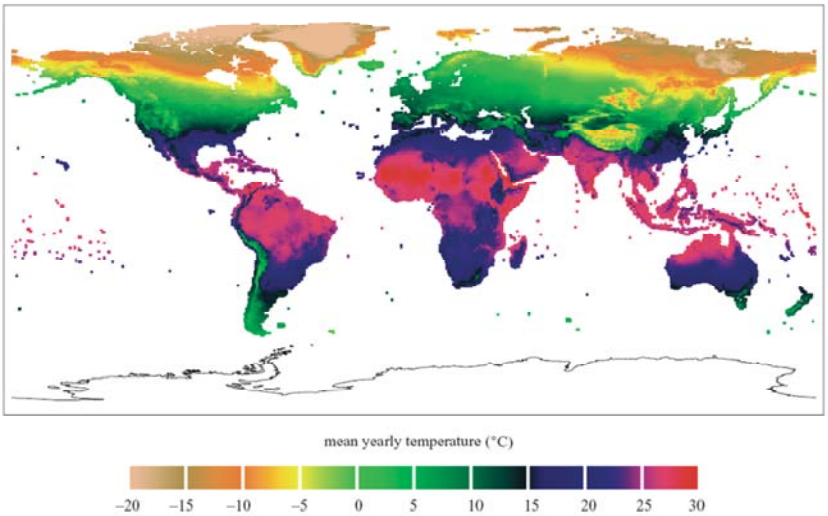
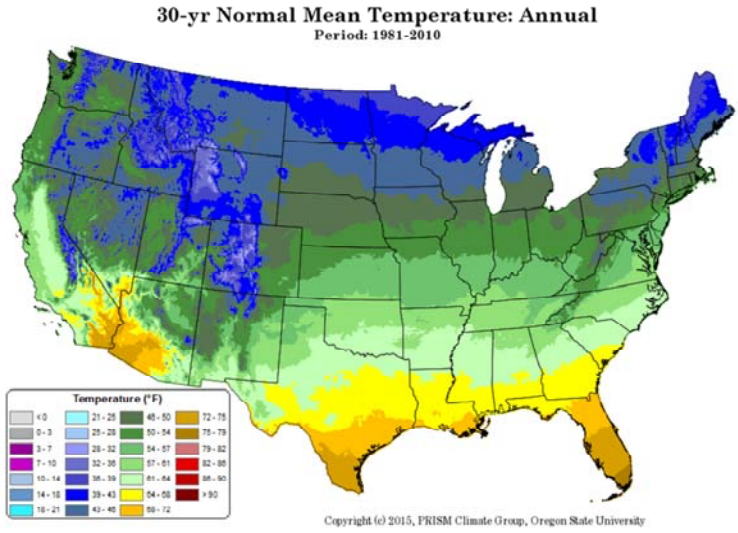
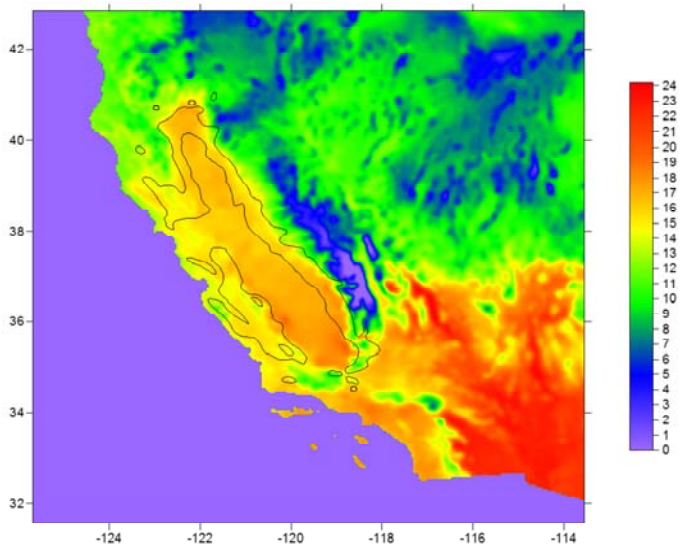


Figure 6. Mean annual temperature for 1901 to 1970. (Modified from New *et al.* 2000.)


30-yr Normal Mean Temperature: Annual
Period: 1981-2010
Temperature (°F)
Copyright (c) 2015, PRISM Climate Group, Oregon State University

California Average Temperature, 1971-2000

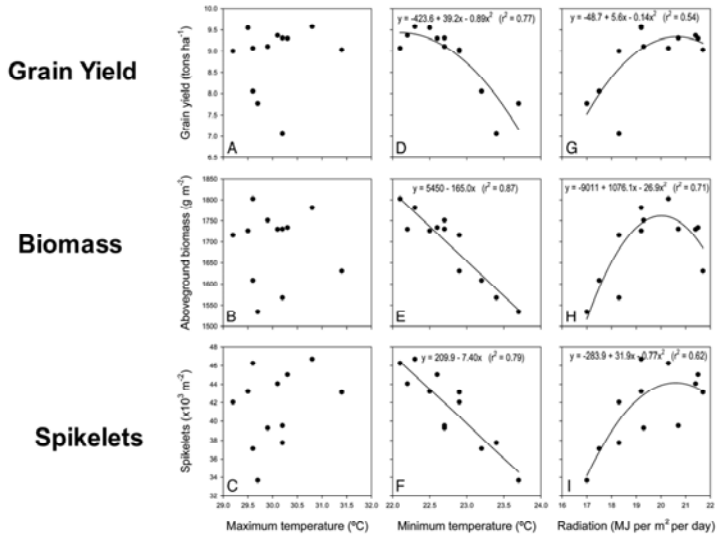


*Spatial Climate Analysis Service, Oregon State University, http://www.ocs.oregonstate.edu/prism/,

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.

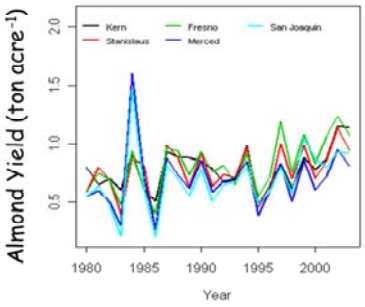
Role of Temperature Extremes on Rice

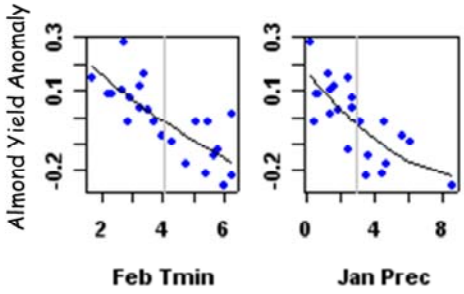


Peng et al PNAS, 2003 ESPM 129 Biometeorology 21

Peng et al PNAS

Role of Seasonal Statistics





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