Testing the CLM-ml multilayer canopy model at a walnut orchard

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CESM Land Model Working Group
6 February 2023

With key contributions from:

John Finnigan (Australian National University)
Ian Harman (CSIRO)

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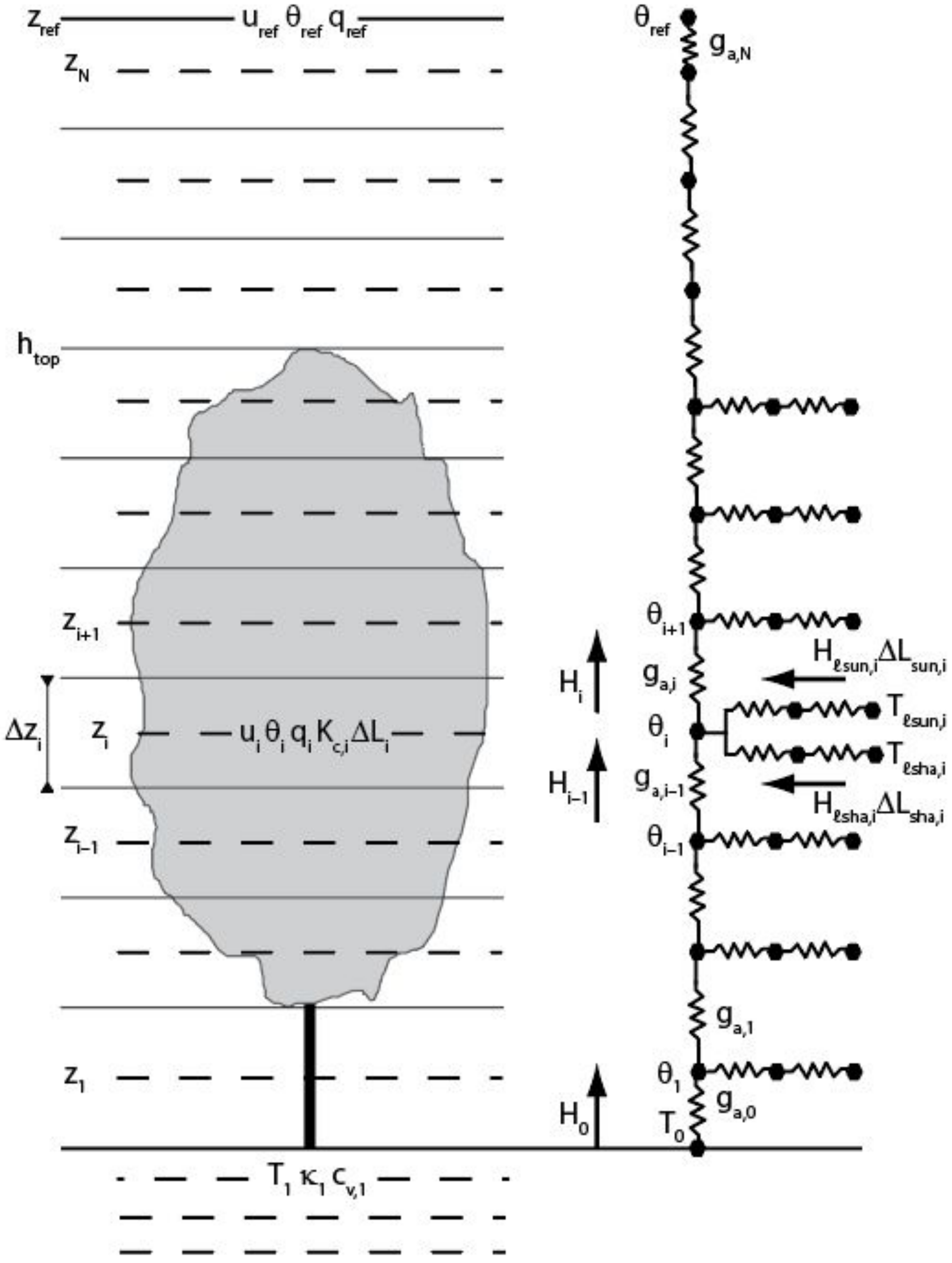


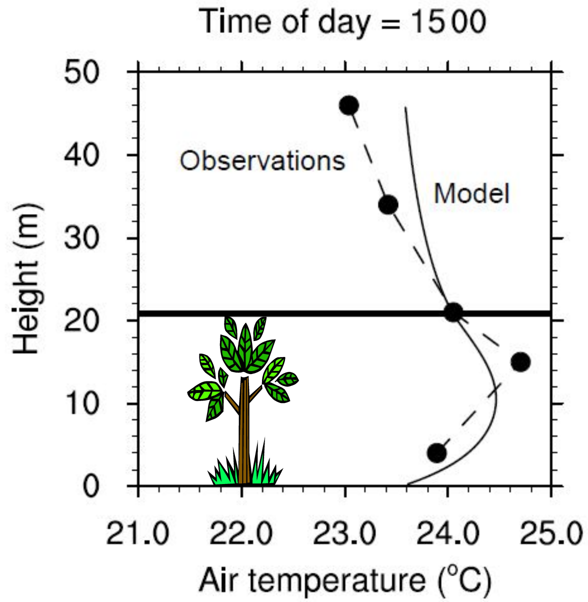
Multilayer canopy

The physics and physiology of the multilayer canopy are simpler and more consistent with theory (and directly observable) than is the CLM5 big-leaf canopy (with many ad-hoc parameterizations and much technical debt), *and it also enables new science*

Bonan, Williams et al. (2014) *Geosci. Model Dev.*, 7, 2193-2222

Bonan, Patton, et al. (2018) *Geosci. Model Dev.*, 11, 1467-1496

Bonan, Patton, et al. (2021) *Agric. For. Meteorol.*, 306, 108435



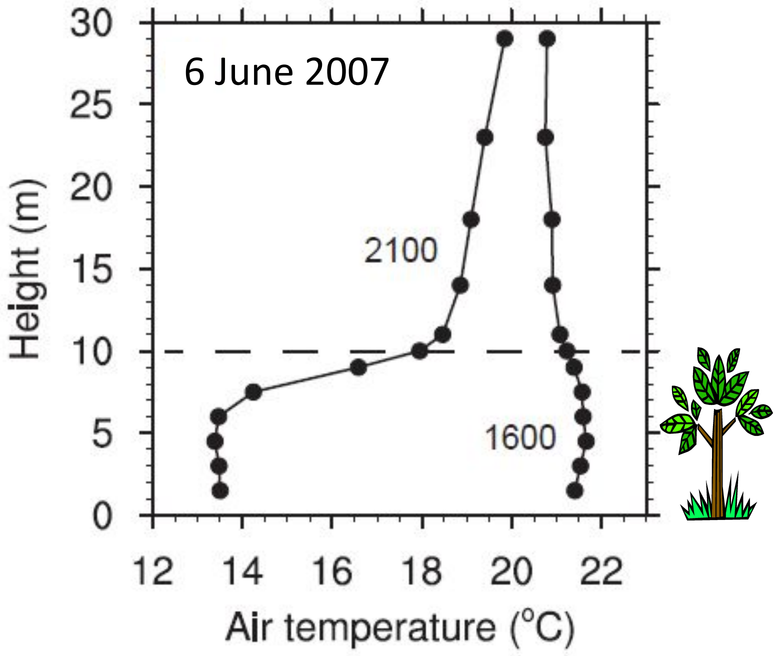
University of Michigan Biological Station

Observational datasets

THE CANOPY HORIZONTAL ARRAY TURBULENCE STUDY

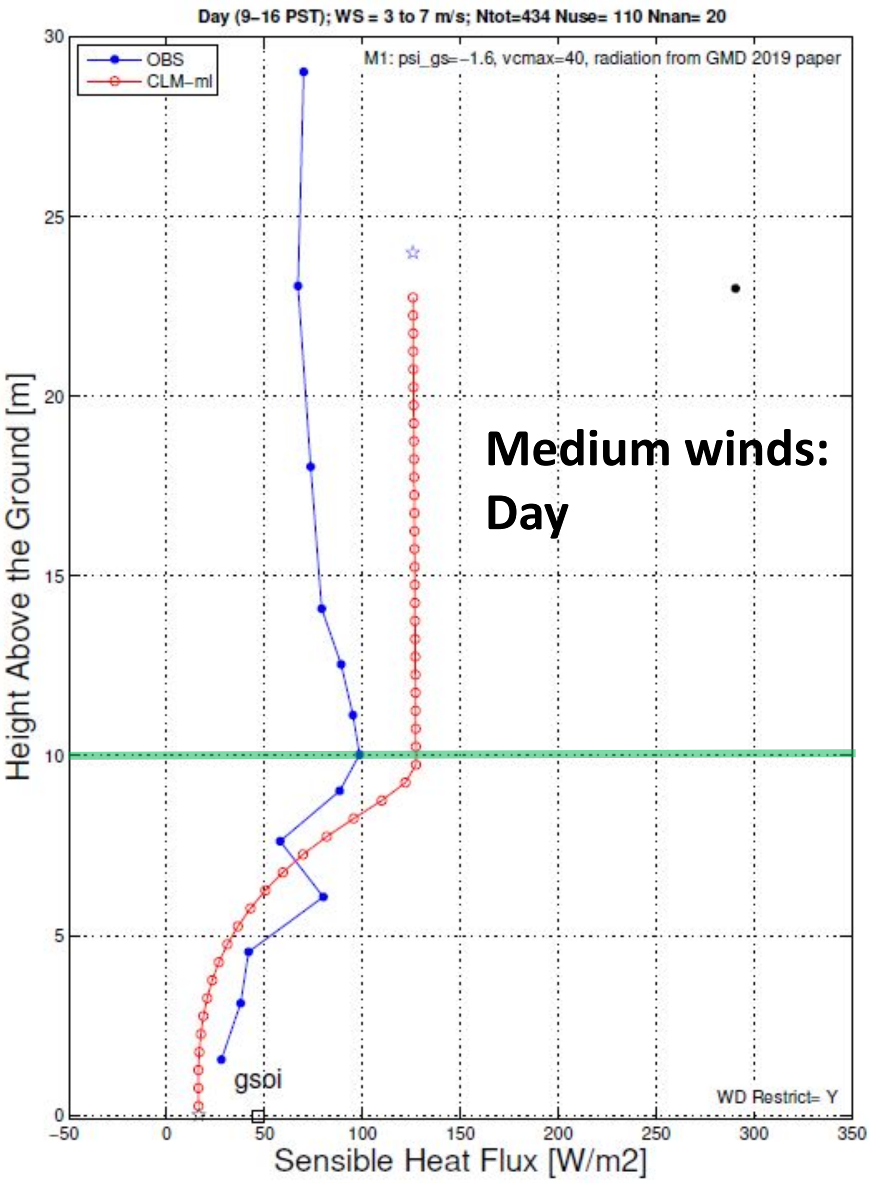
BY EDWARD G. PATTON, THOMAS W. HORST, PETER P. SULLIVAN, DONALD H. LENSCHOW, STEVEN P. ONCLEY, WILLIAM O. J. BROWN, SEAN P. BURNS, ALEX B. GUENTHER, ANDREAS HELD, THOMAS KARL, SHANE D. MAYOR, LUCIANA V. RIZZO, SCOTT M. SPULER, JIELUN SUN, ANDREW A. TURNIPSEED, EUGENE J. ALLWINE, STEVEN L. EDBURG, BRIAN K. LAMB, RONI AVISSAR, RONALD J. CALHOUN, JAN KLEISSL, WILLIAM J. MASSMAN, KYAW THA PAW U, AND JEFFREY C. WEIL

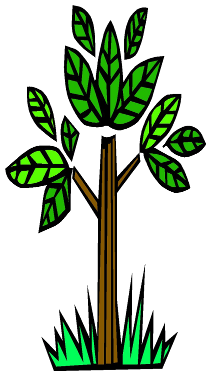
Patton et al. (2011) *BAMS*, 92, 593-611

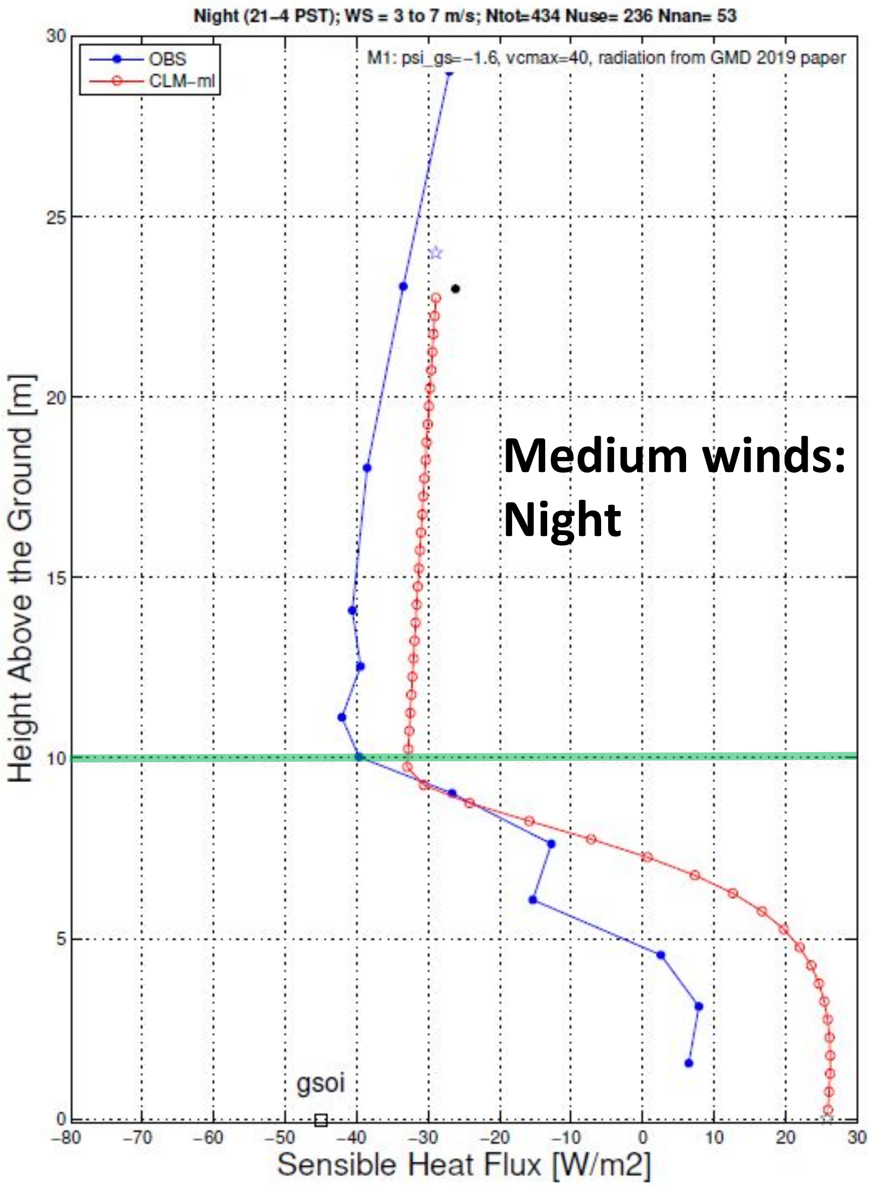


Simulations are for May 2007

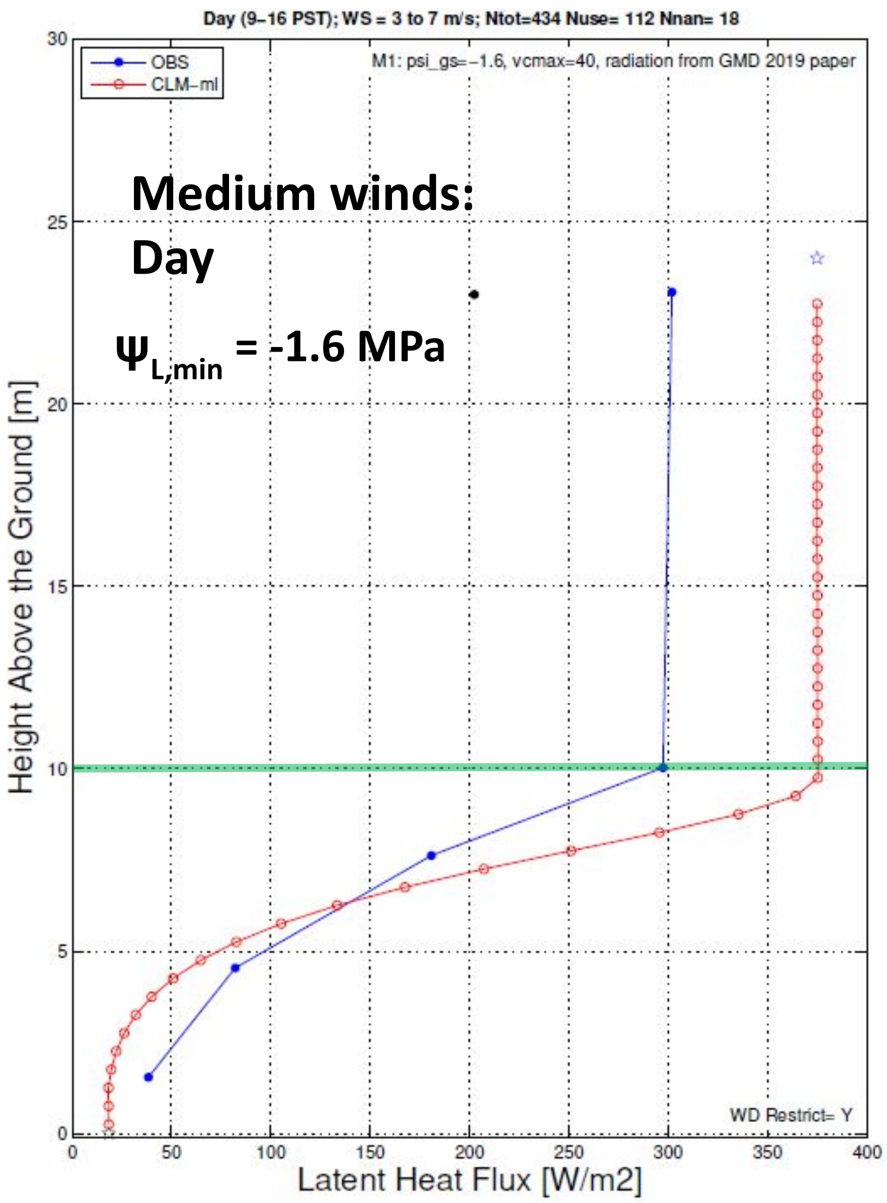
Sensible heat flux

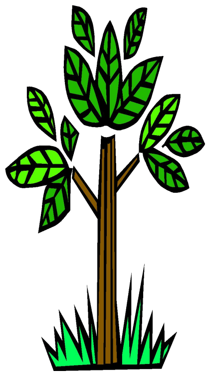


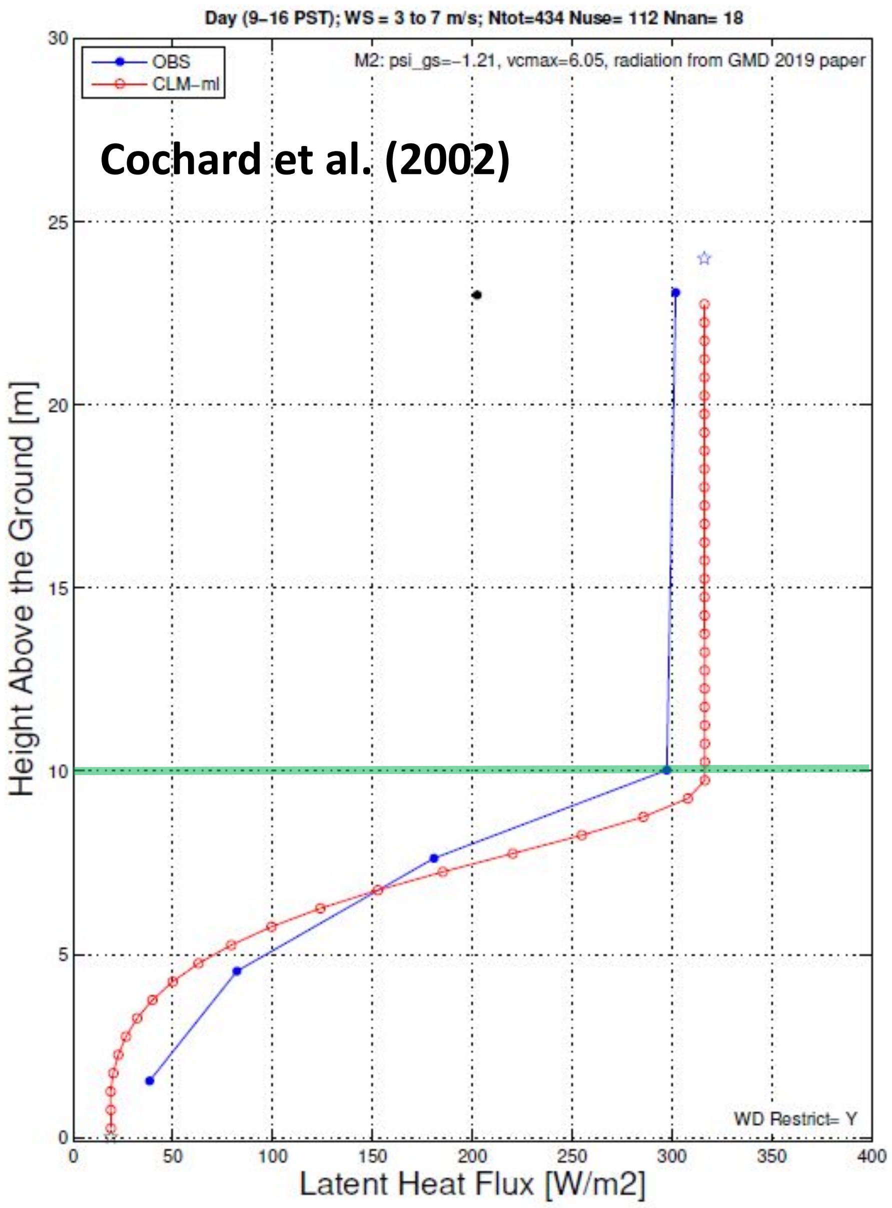




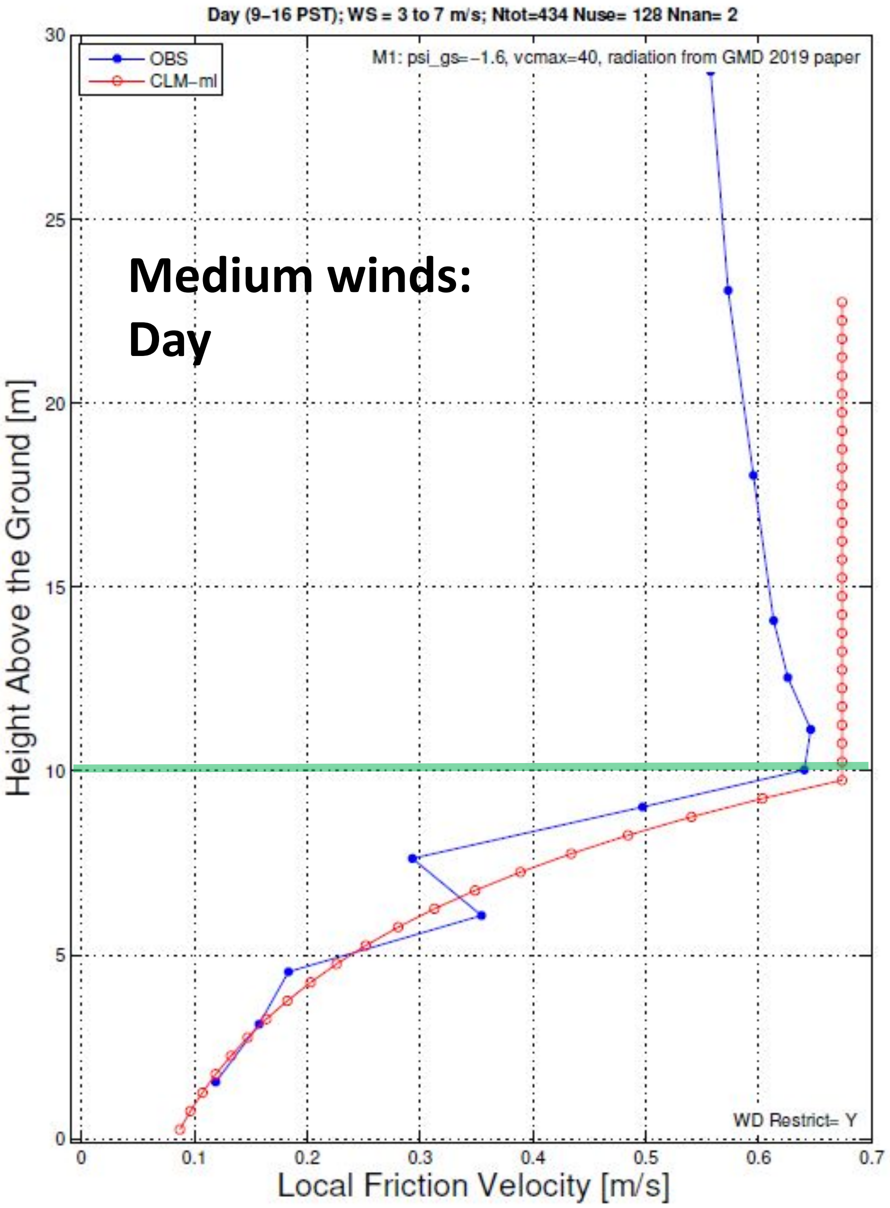
Latent heat flux

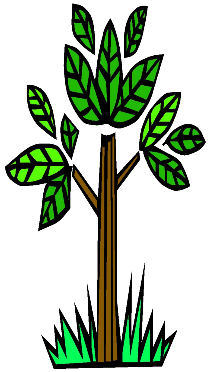




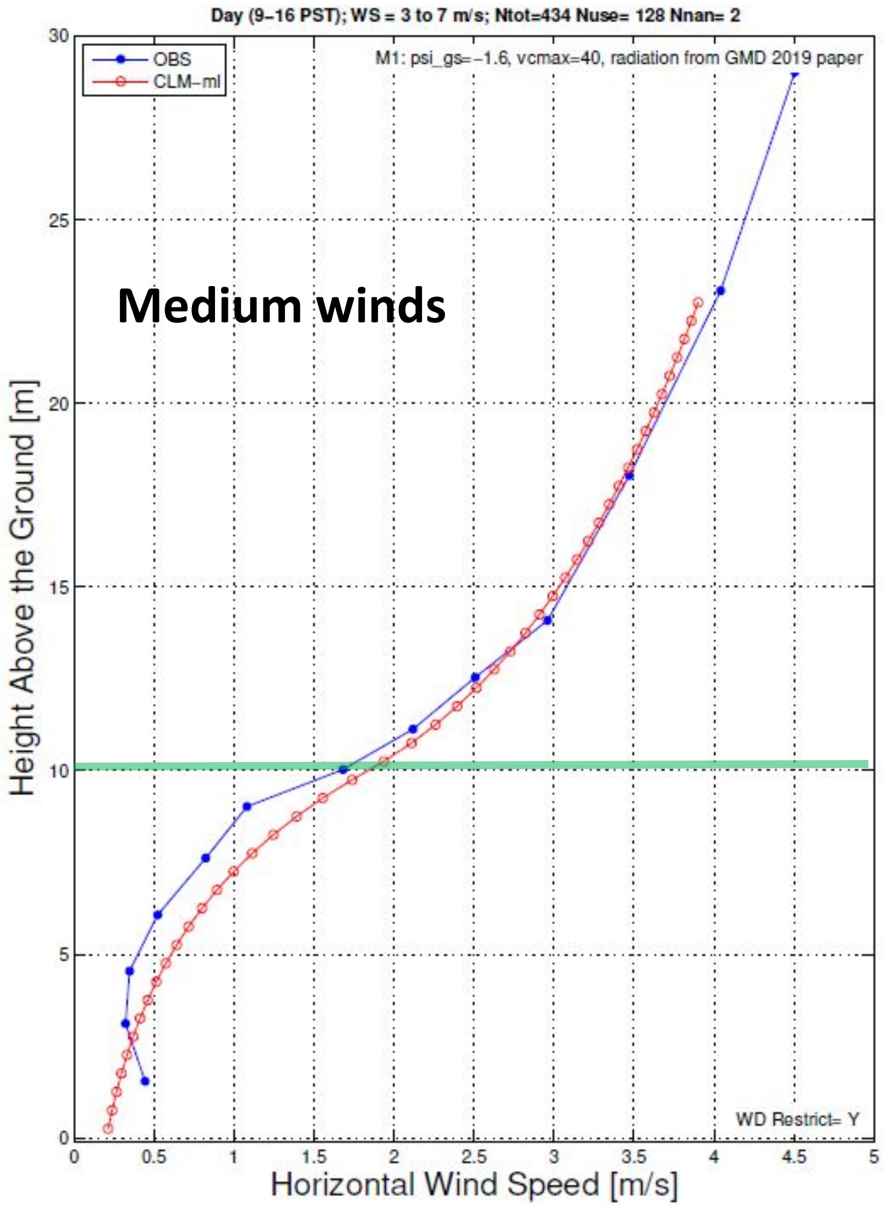


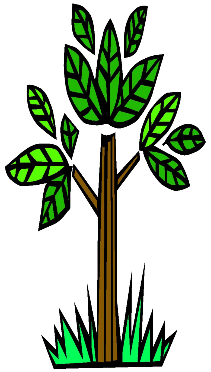
Friction velocity

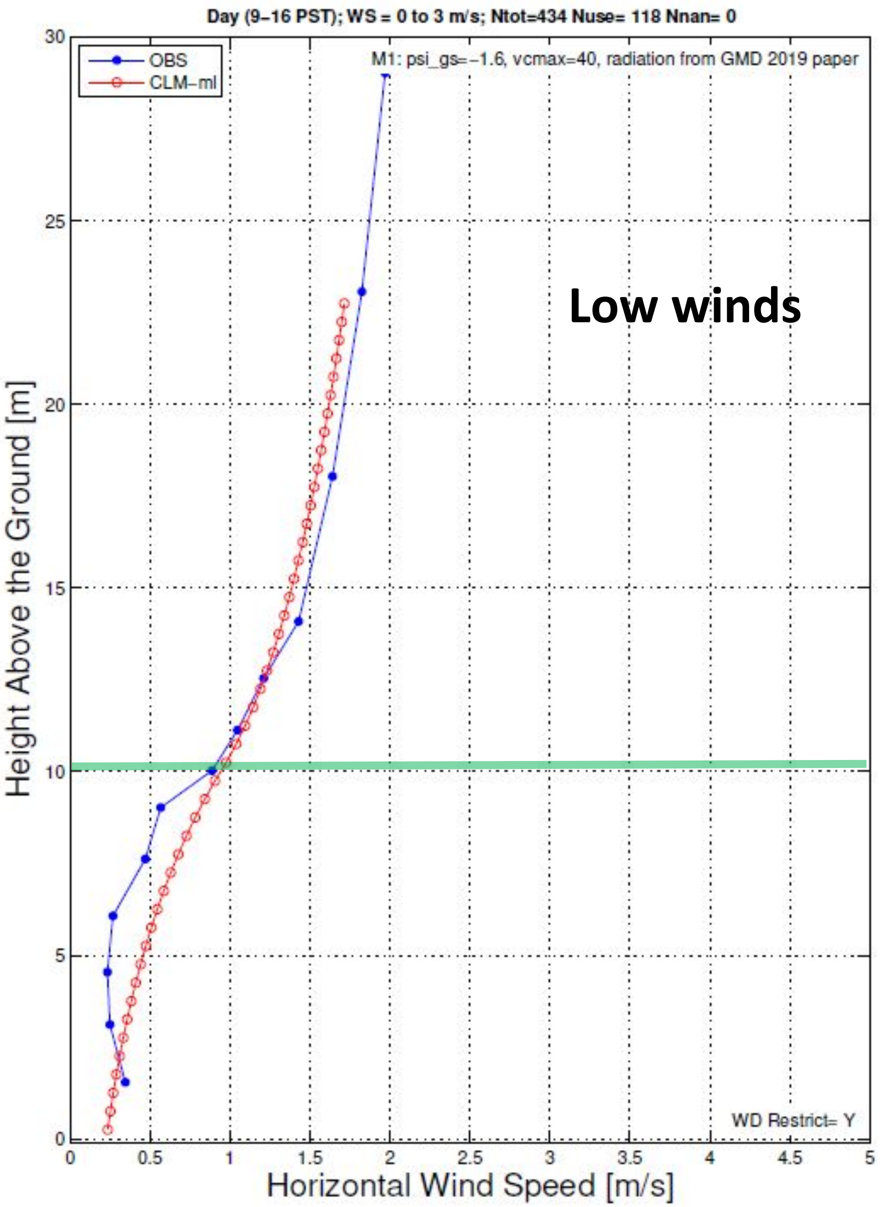




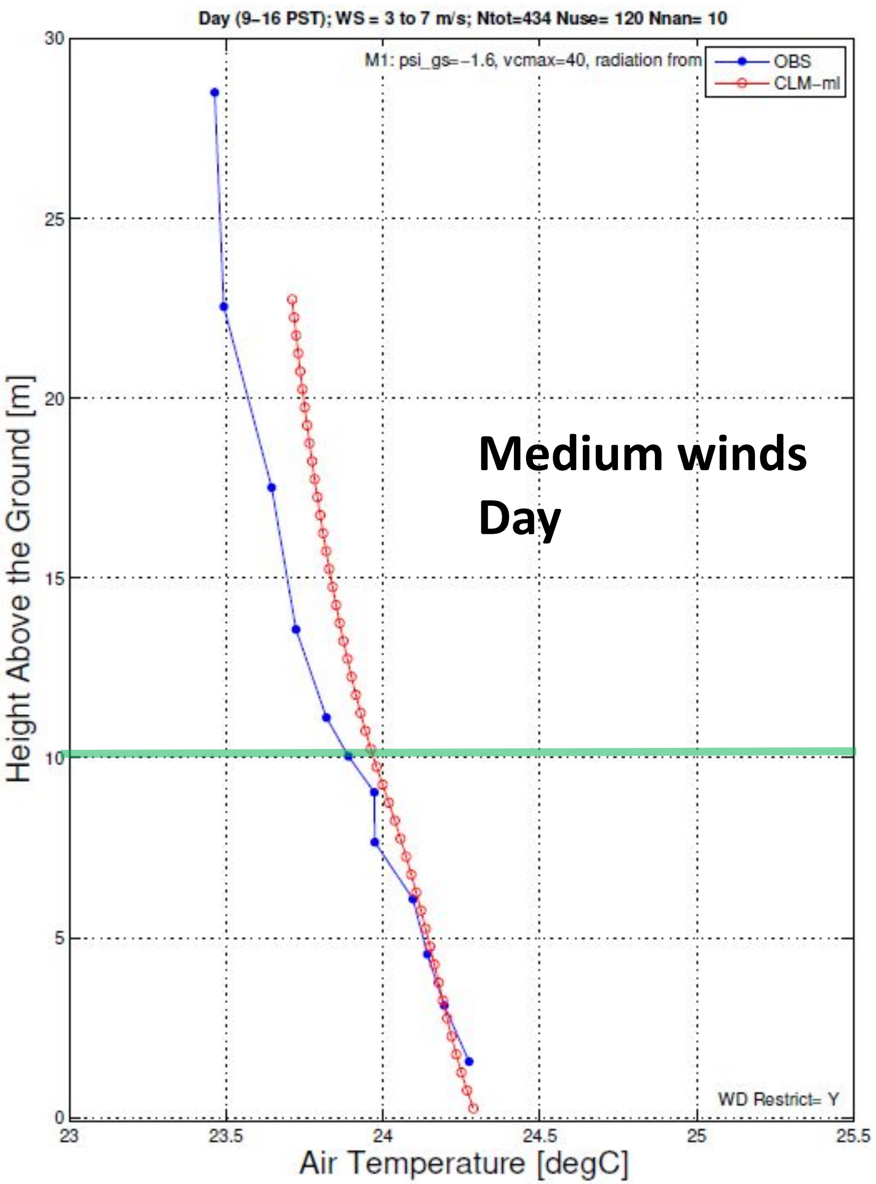
Wind speed

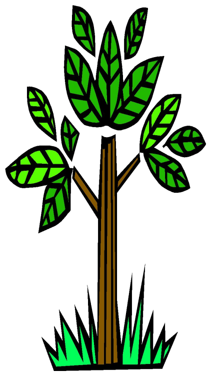

Day (9–16 PST); WS = 3 to 7 m/s; Ntot=434 Nuse= 128 Nnan= 2
OBS
CLM–ml
M1: psi_gs=–1.6, vcmax=40, radiation from GMD 2019 paper
Medium winds
WD Restrict= Y
Height Above the Ground [m]
Horizontal Wind Speed [m/s]
0
5
10
15
20
25
30
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

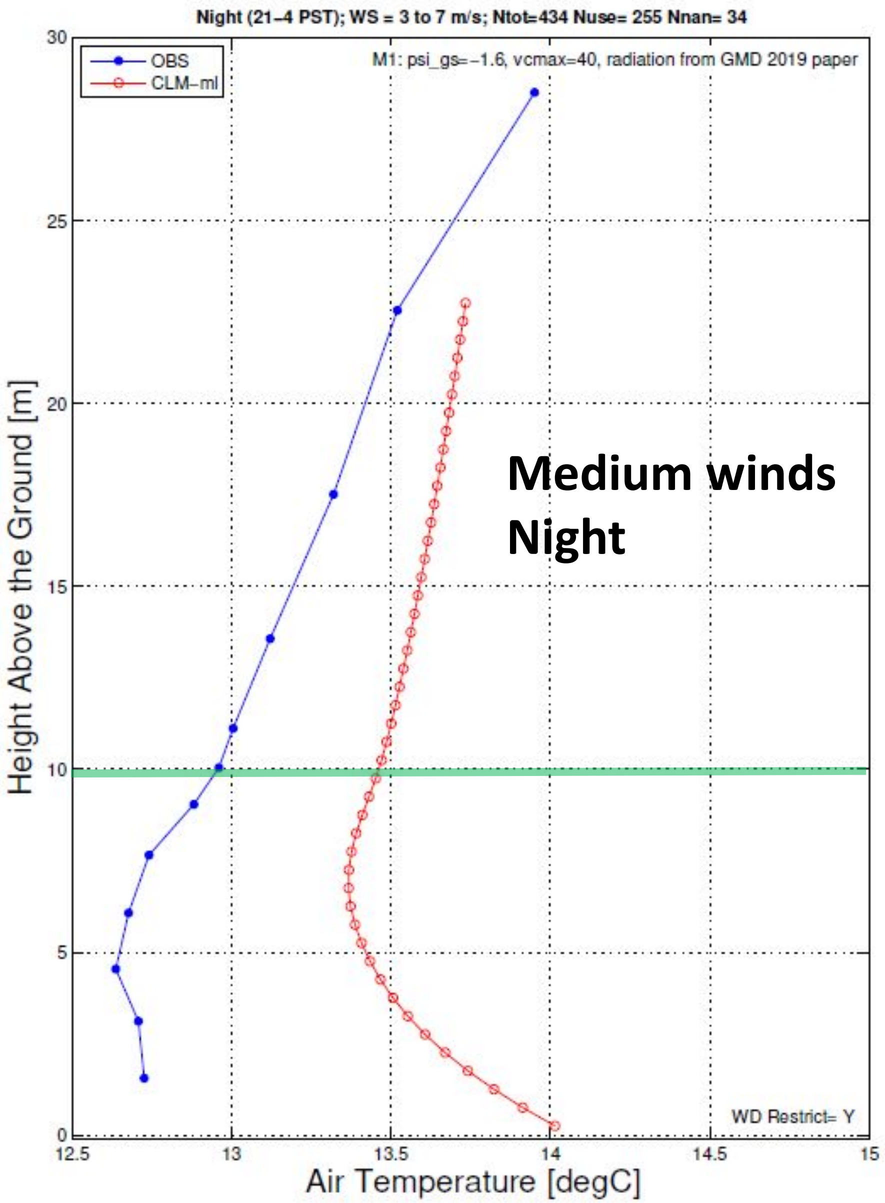



Day (9–16 PST); WS = 0 to 3 m/s; Ntot=434 Nuse= 118 Nnan= 0
OBS
CLM–ml
M1: psi_gs=–1.6, vcmax=40, radiation from GMD 2019 paper
Low winds
WD Restrict= Y
Height Above the Ground [m]
Horizontal Wind Speed [m/s]
0
5
10
15
20
25
30
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

Air temperature







Leaf gas exchange to constrain the model

Journal of Horticultural Science & Biotechnology (2006) **81** (3) 415–420

Tree water status and gas exchange in walnut under drought, high temperature and vapour pressure deficit

By A. ROSATI[1*], S. METCALF[2], R. BUCHNER[3], A. FULTON[3] and B. LAMPINEN[2]
[1]Istituto Sperimentale per l'Olivicoltura, via Nursina 2, 06049 Spoleto (PG), Italy
[2]Department of Plant Sciences, University of California, Mail Stop #2, One Shields Avenue, Davis, CA 95616, USA
[3]University of California Cooperative Extension, Tehama County, 1754 Walnut Street, Red Bluff, CA 96080, USA
(e-mail: adolfo.rosati@entecra.it)
(*Accepted 4 February 2006*)

	Vcmax ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)	iota ($\mu mol\ CO_2\ mol^{-1}\ H_2O$)
Default broadleaf deciduous tree	57.7	750
Observations	125	375

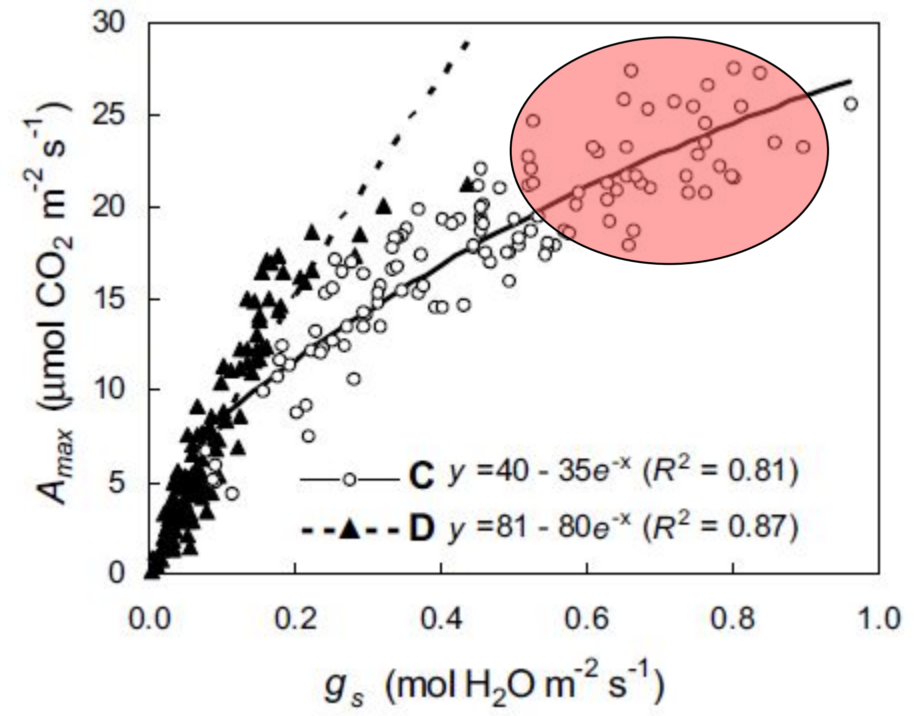
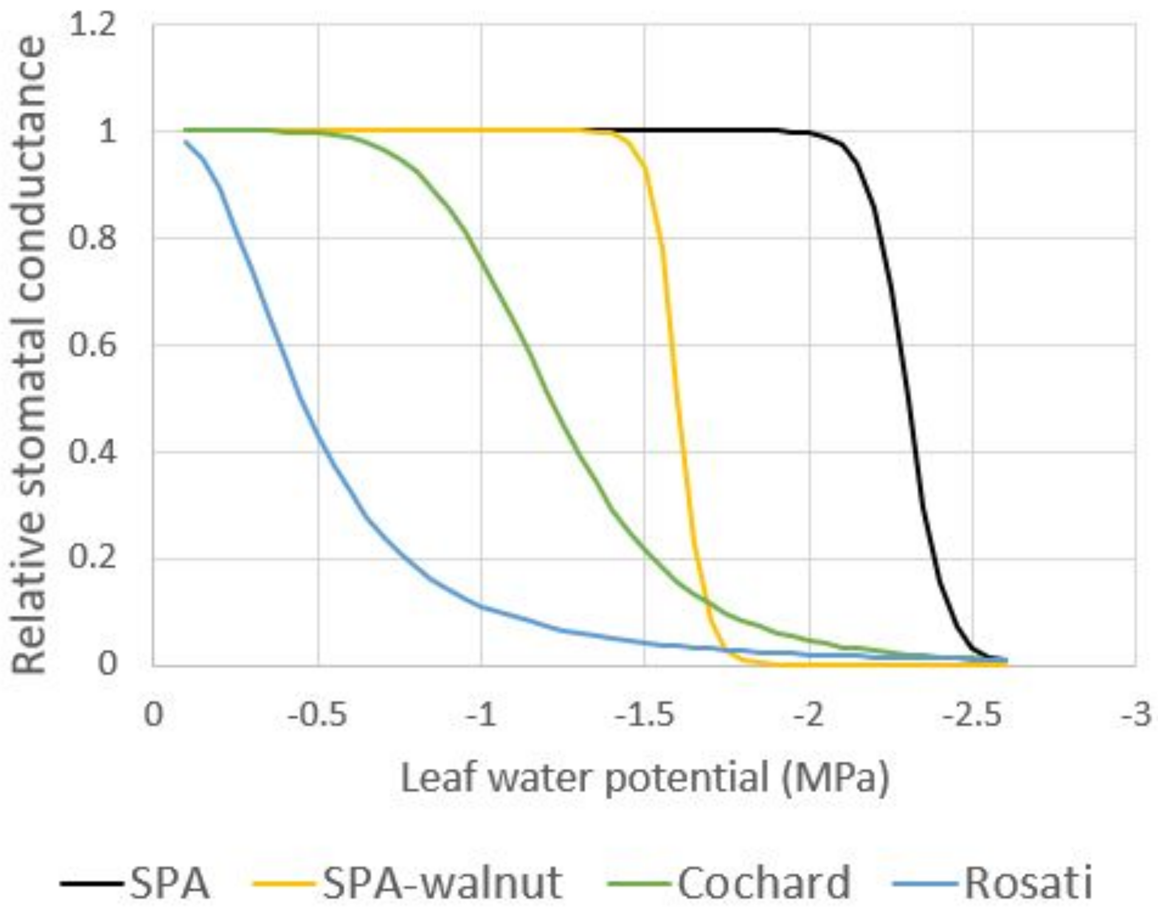


FIG. 2.
Relationship between light-saturated net CO_2 assimilation (A_{max}) and stomatal conductance (g_s), in droughted (D) and control (C) trees.

Stomatal response to leaf water potential



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[3]University of California Cooperative Extension, Tehama County, 1754 Walnut Street, Red Bluff, CA 96080, USA
(e-mail: adolfo.rosati@entecra.it)
(*Accepted 4 February 2006*)

Unraveling the Effects of Plant Hydraulics on Stomatal Closure during Water Stress in Walnut

Hervé Cochard*, Lluis Coll[1], Xavier Le Roux[2], and Thierry Améglio

Plant Physiology, January 2002, Vol. 128, pp. 282–290

Leaf optical parameters

Geosci. Model Dev., 12, 3923–3938, 2019
https://doi.org/10.5194/gmd-12-3923-2019

Geoscientific Model Development
Open Access
EGU

Evaluation of leaf-level optical properties employed in land surface models

Titta Majasalmi and Ryan M. Bright

	χ_L	ρ_{leaf}		τ_{leaf}		ρ_{stem}		τ_{stem}	
		VIS	NIR	VIS	NIR	VIS	NIR	VIS	NIR
CLM5	0.25	0.10	0.45	0.05	0.25	0.16	0.39	0.001	0.001
Observations	**0.59**	0.08	0.42	0.06	**0.43**	**0.21**	**0.49**	–	–

- Leaves are more horizontal and have higher transmittance in the NIR
- Stems have higher reflectance

No clean interface to surface fluxes in CTSM-CLM

clm_drv

CanopyInterceptionAndThroughfall

CanopySunShadeFracs

SurfaceRadiation

BiogeophysPreFluxCalcs

(CalcOzoneStress)

BareGroundFluxes

CanopyFluxes →

- SoilMoistStressMod
- FrictionVelocity
- PhotosynthesisHydraulicStress
- Photosynthesis
- Fractionation
- HumanIndexMod
- CalcOzoneUptake
- LUNAMod

(VOCEmission)

SoilTemperature

SoilFluxes

(depvel_compute)

SurfaceAlbedo

The kraken devouring the ship

Colossal octopus attacking a ship
(Pierre Denys de Montfort, 1801)

No clean interface to surface fluxes in CTSM-CLM

clm_drv

CanopyInterceptionAndThroughfall

CanopySunShadeFracs

SurfaceRadiation

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BareGroundFluxes

CanopyFluxes →

- SoilMoistStressMod
- FrictionVelocity
- PhotosynthesisHydraulicStress
- Photosynthesis
- Fractionation
- HumanIndexMod
- CalcOzoneUptake
- LUNAMod

(VOCEmission)

SoilTemperature

SoilFluxes

MLCanopyFluxes →

- Diagnostic calculation (in parallel with existing flux code)
- Does not overwrite CLM calculations
- Does not update soil temperature/moisture
- Implemented in CESM2.1 using source mods

(depvel_compute)

SurfaceAlbedo

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