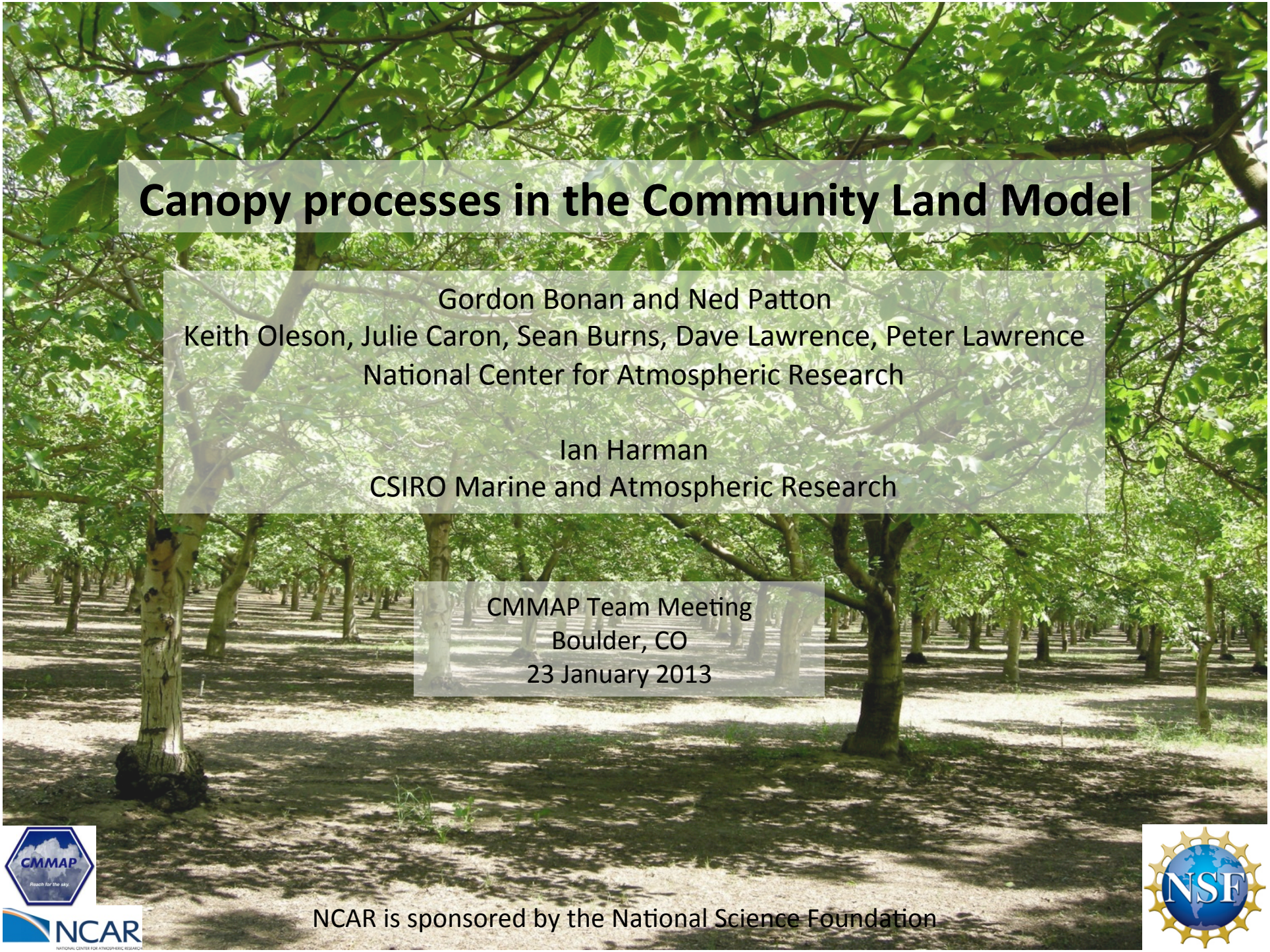


Canopy processes in the Community Land Model

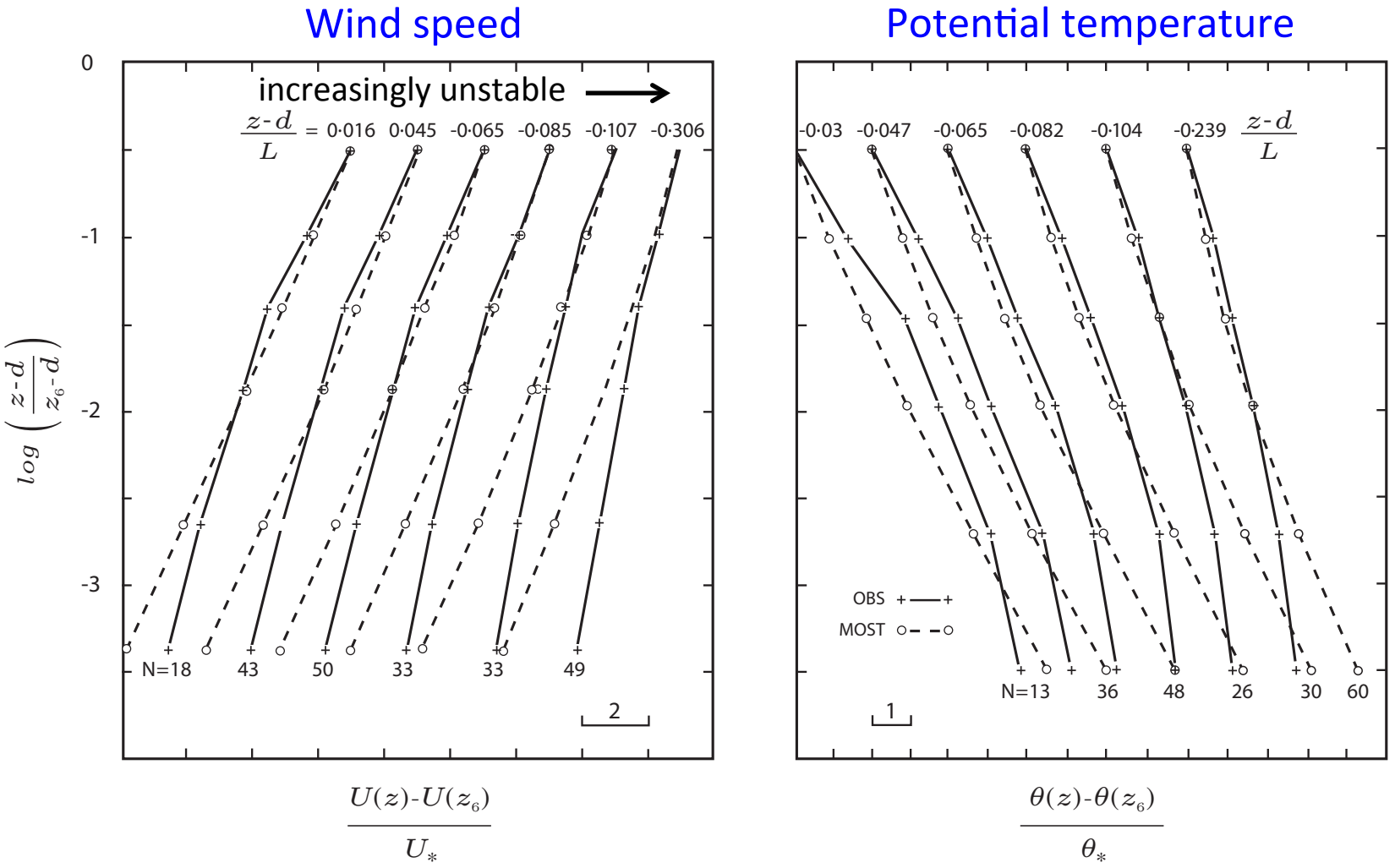
Gordon Bonan and Ned Patton
Keith Oleson, Julie Caron, Sean Burns, Dave Lawrence, Peter Lawrence
National Center for Atmospheric Research

Ian Harman
CSIRO Marine and Atmospheric Research

CMMAP Team Meeting
Boulder, CO
23 January 2013

NCAR is sponsored by the National Science Foundation

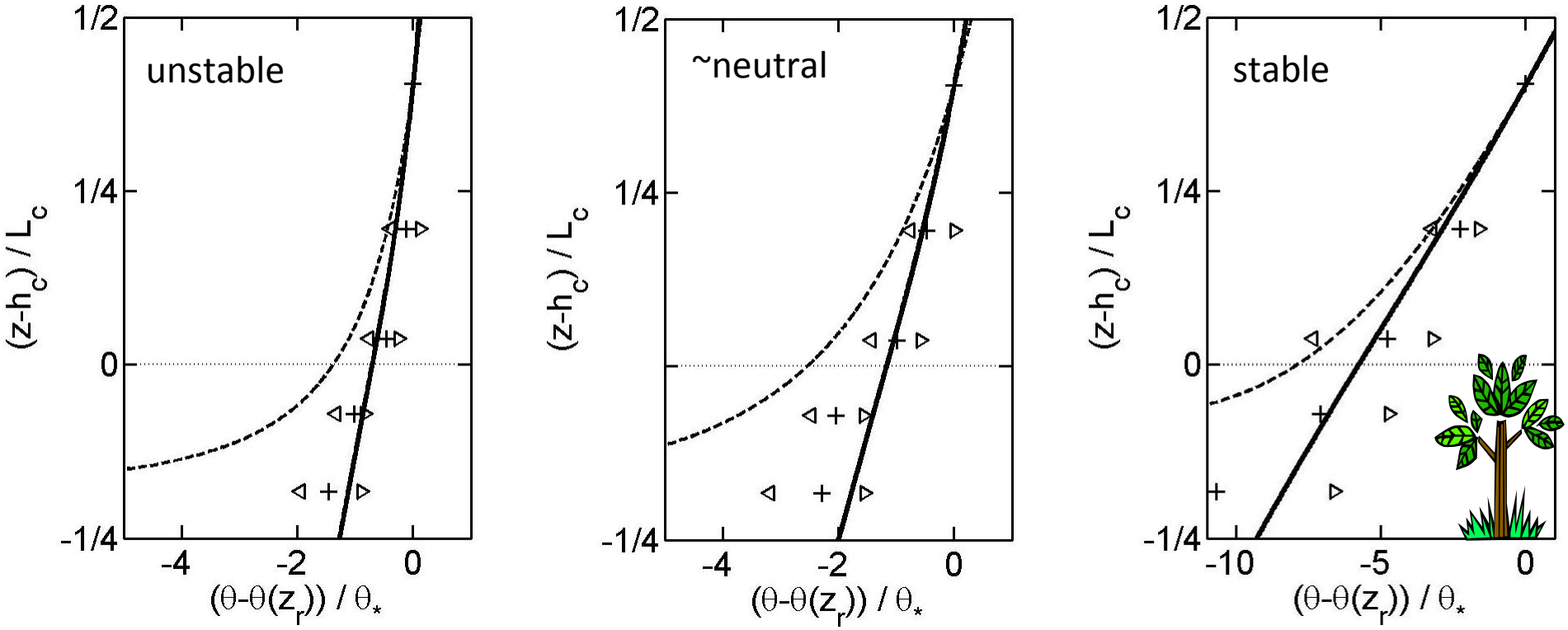
Canopy turbulence and the roughness sublayer



Flow within 2-3 canopy heights above/within tall (plant) canopies does not conform to Monin-Obukhov Similarity Theory (M-O); this region is called the roughness sublayer (RSL).

Raupach (1976), Chen and Schwerdtfeger (1989)

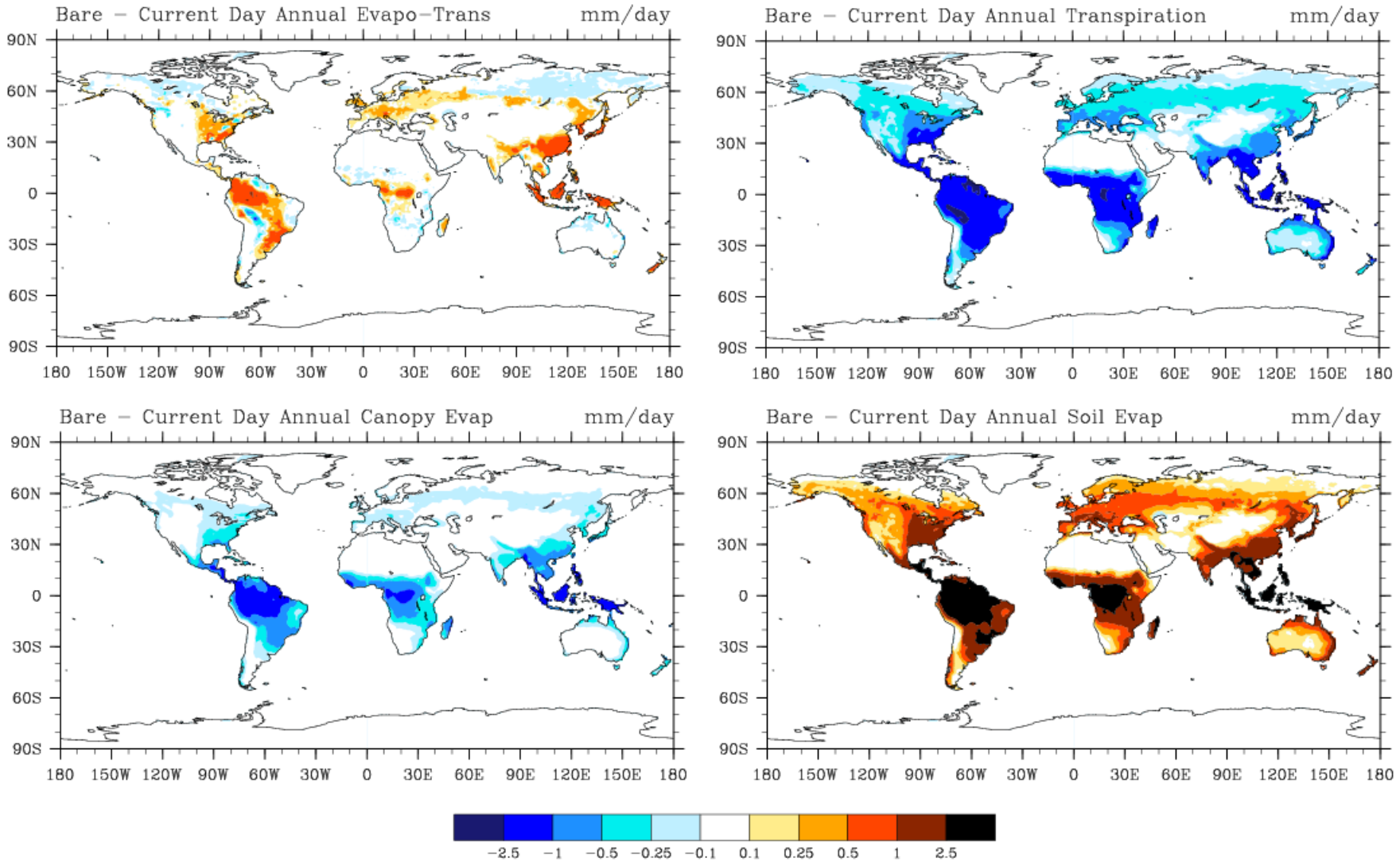
Comparison with observations - scalar profiles



Similar agreement for water vapor concentration but not for CO_2 concentration

Harman and Finnigan (2008)

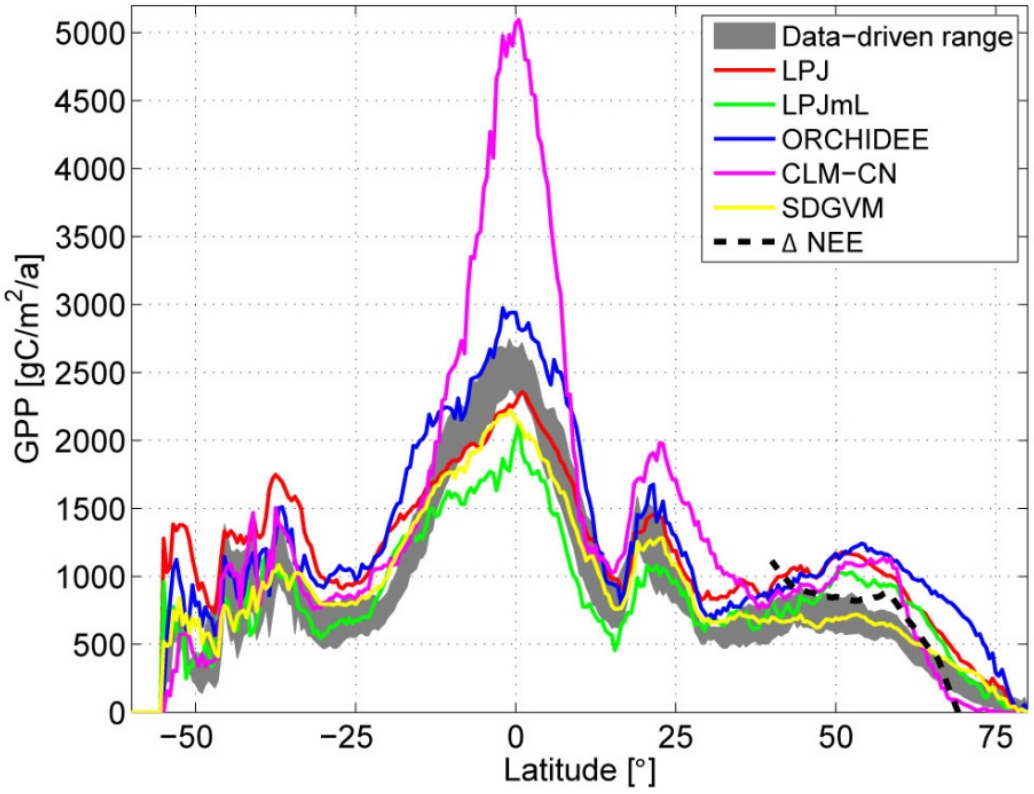
Offline CLM4: vegetation removal increases annual ET



(Peter Lawrence, NCAR)

GPP biases

CLM4 (purple line) overestimates annual gross primary production (GPP) compared with data-driven estimates and other models



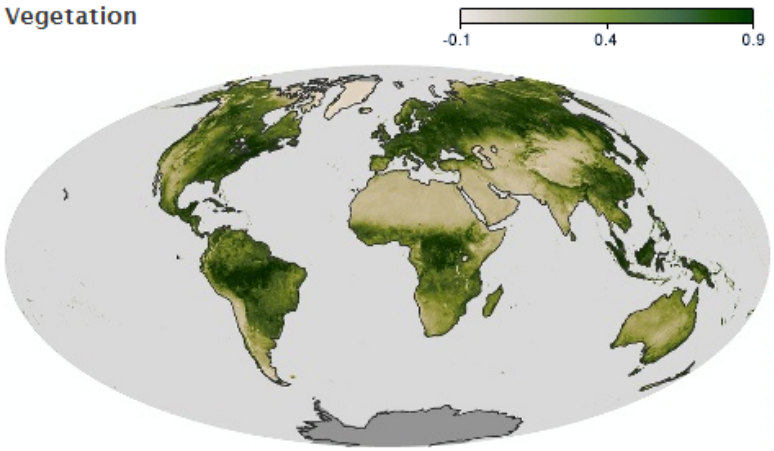
Beer et al. (2010) Science 329:834-838

Multi-scale model evaluation

Canopy fluxes

GPP, latent heat flux

AmeriFlux, FLUXNET
Light response curves
(Lasslop et al. 2010. GCB 16:187-208)



Global vegetation

GPP, latent heat flux

Jung et al. (2011) JGR, 116, doi: 10.1029/2010JG001566

Canopy processes

Theory

Numerical parameterization

Profiles of light, leaf traits, and photosynthesis

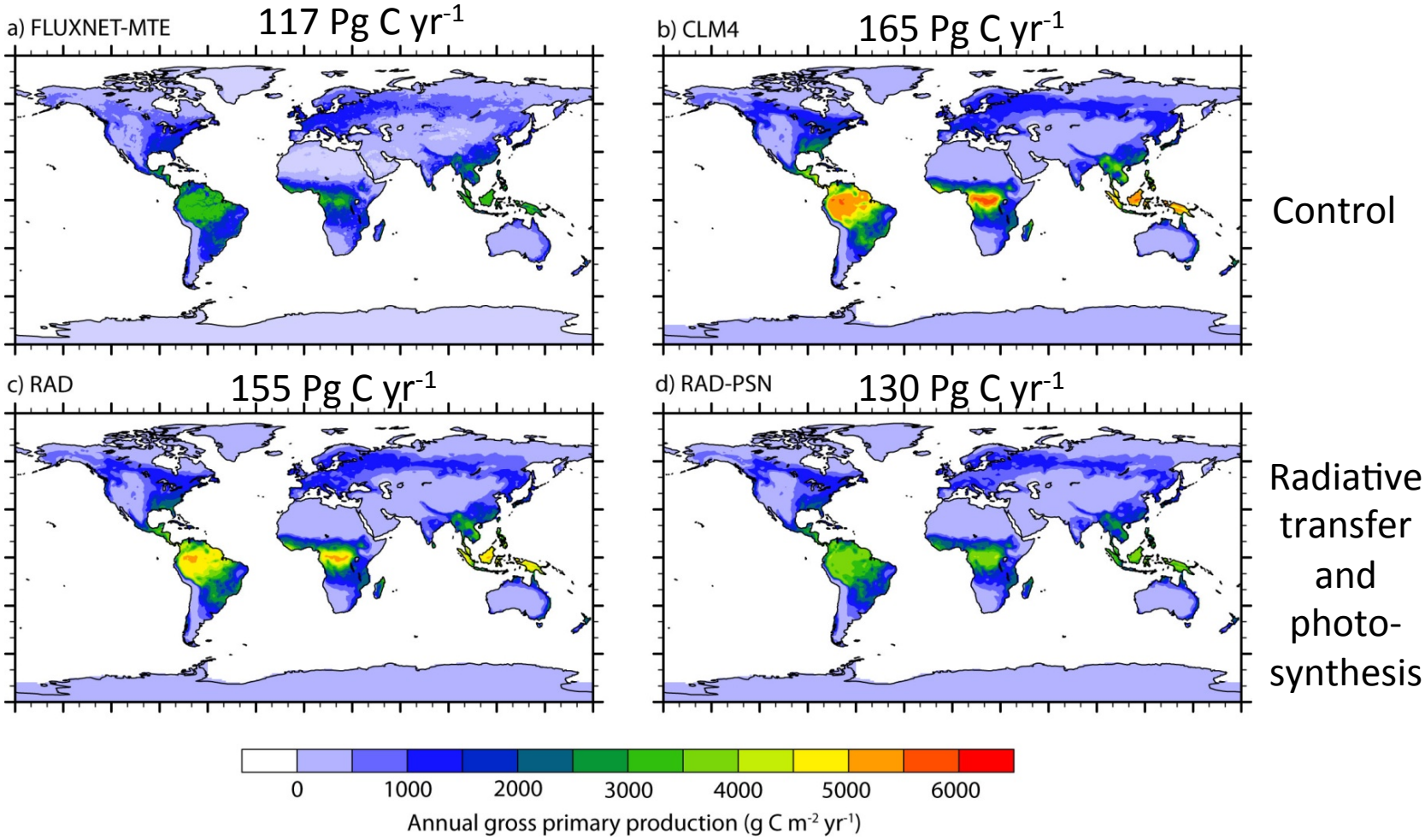
Leaf traits

Nitrogen concentration, V_{cmax}

Kattge et al. (2009) GCB 15:976-991

Global databases of leaf traits and eddy covariance flux datasets allow model testing with observations across multiple scales, from leaf to canopy to global

Gross primary production bias reduction

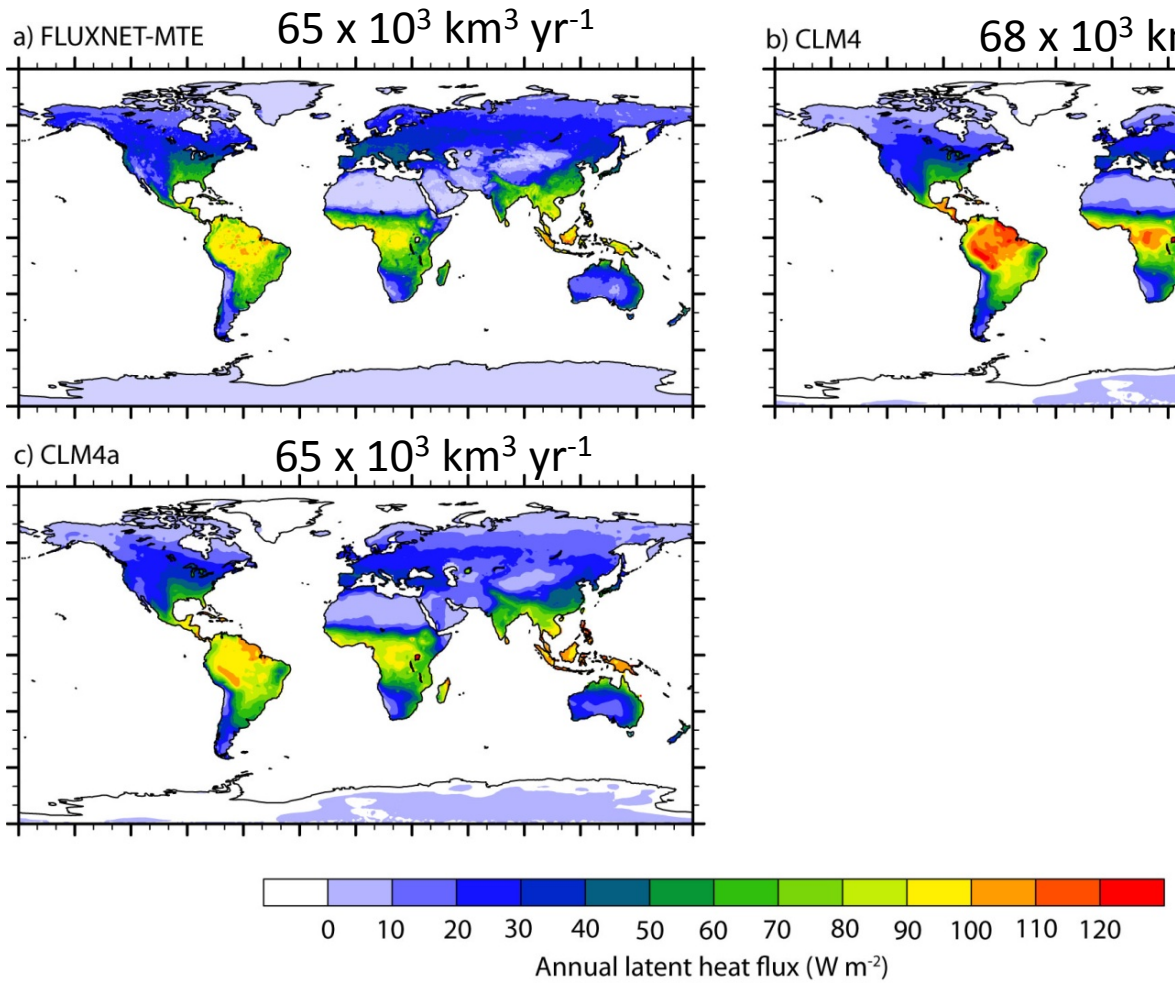


CLM4 overestimates GPP. Model revisions improve GPP. Similar improvements are seen in evapotranspiration

FLUXNET-MTE data from Martin Jung and Markus Reichstein (MPI-BGC, Jena)

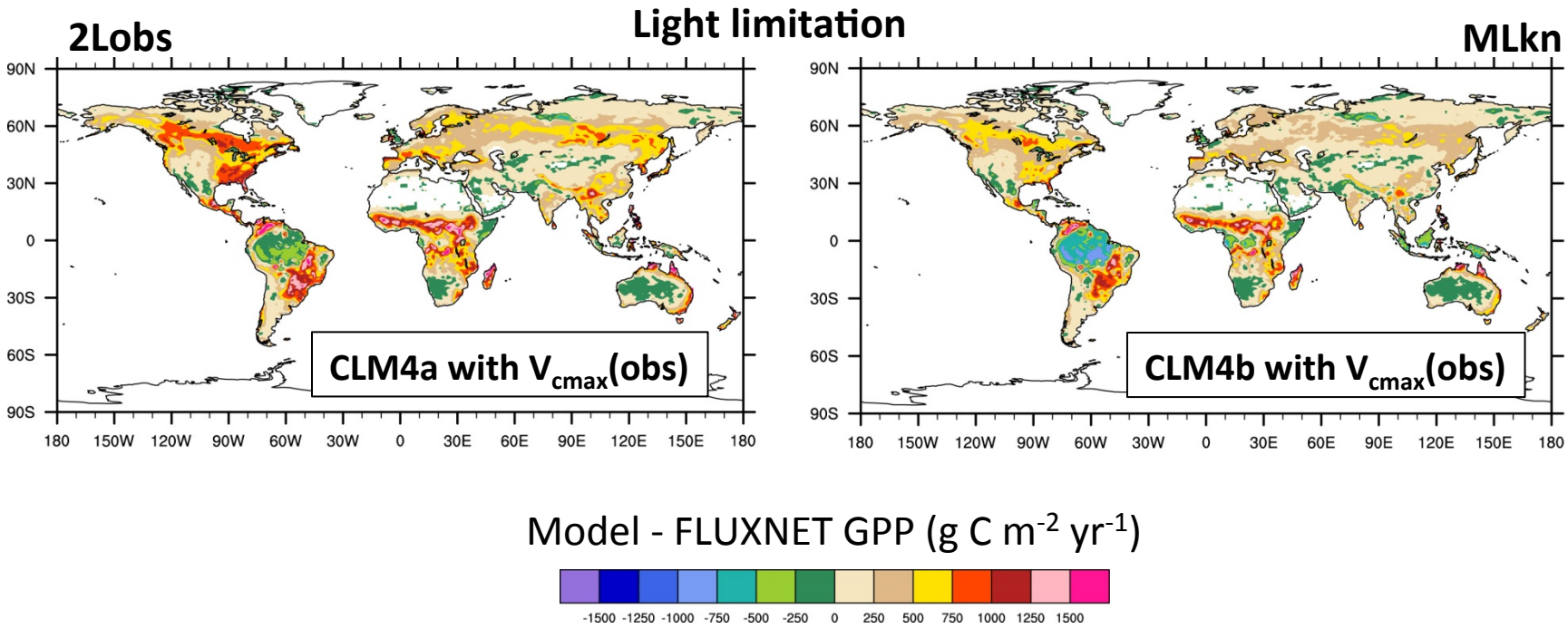
Bonan et al. (2011) JGR, doi:10.1029/2010JG001593

Improved annual latent heat flux

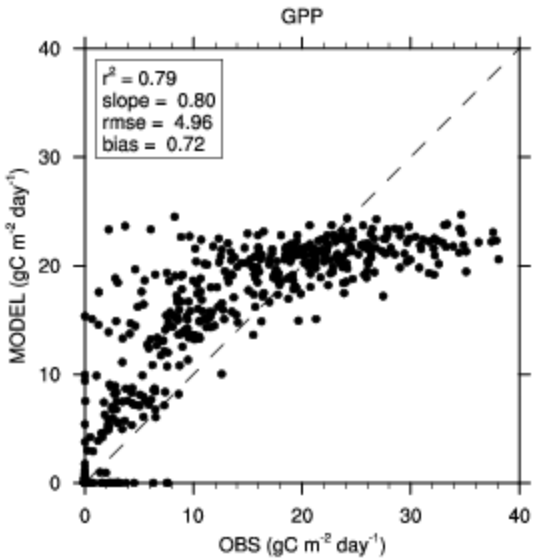


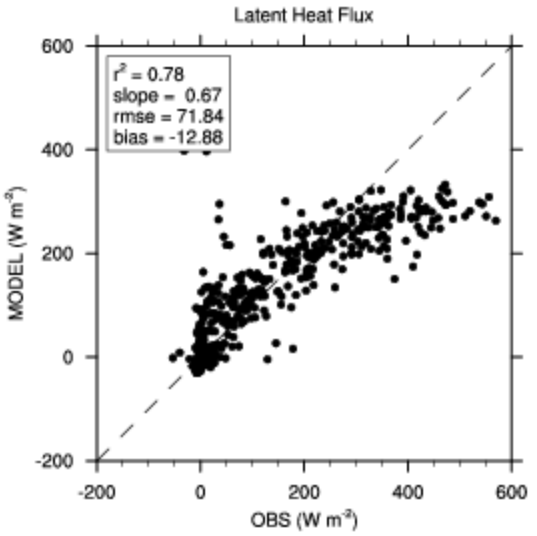
Model improvements (CLM4a) reduce ET biases, especially in tropics, and improve monthly fluxes

Bonan et al. (2011) JGR, doi:10.1029/2010JG001593

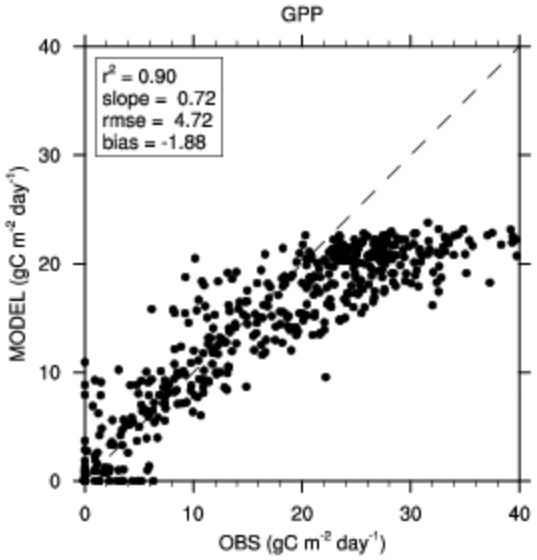

Light limitation
2Lobs
MLkn
90N
60N
30N
0
30S
60S
90S
180 150W 120W 90W 60W 30W 0 30E 60E 90E 120E 150E 180
CLM4a with V_{cmax}(obs)
CLM4b with V_{cmax}(obs)
Model - FLUXNET GPP (g C m^{-2} yr^{-1})
-1500 -1250 -1000 -750 -500 -250 0 250 500 750 1000 1250 1500

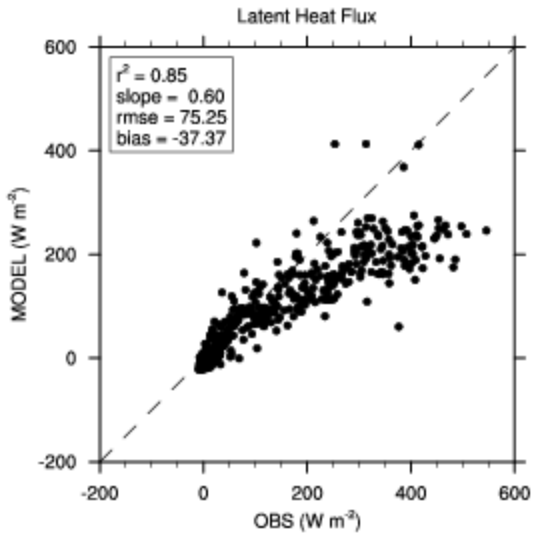
AMF_USMMS CLM45SCI11I, Observed Fluxes, DOY_182-212_2001



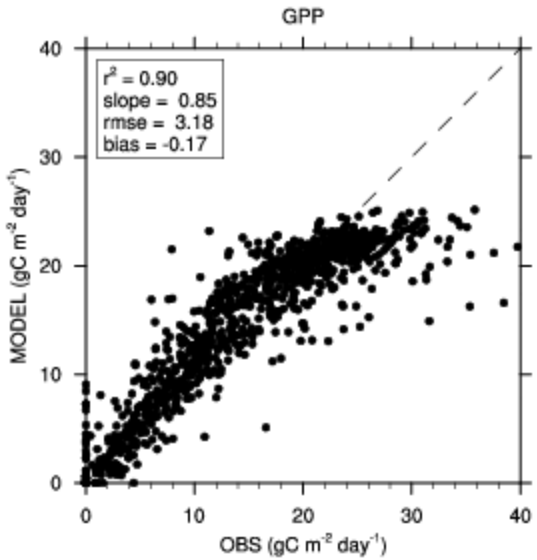


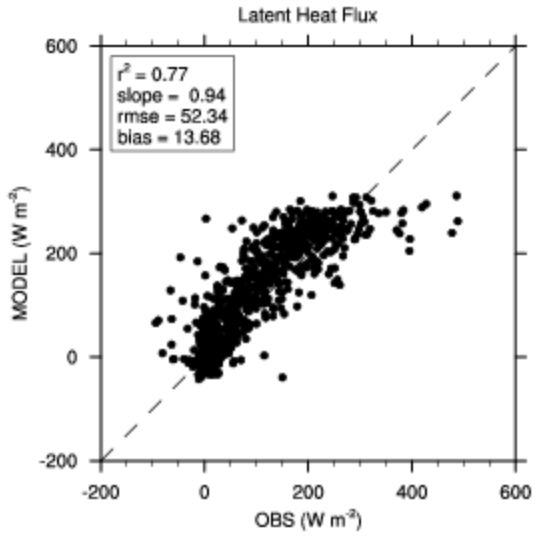
AMF_USHa1 CLM45SCI11I, Observed Fluxes, DOY_183-213_2000

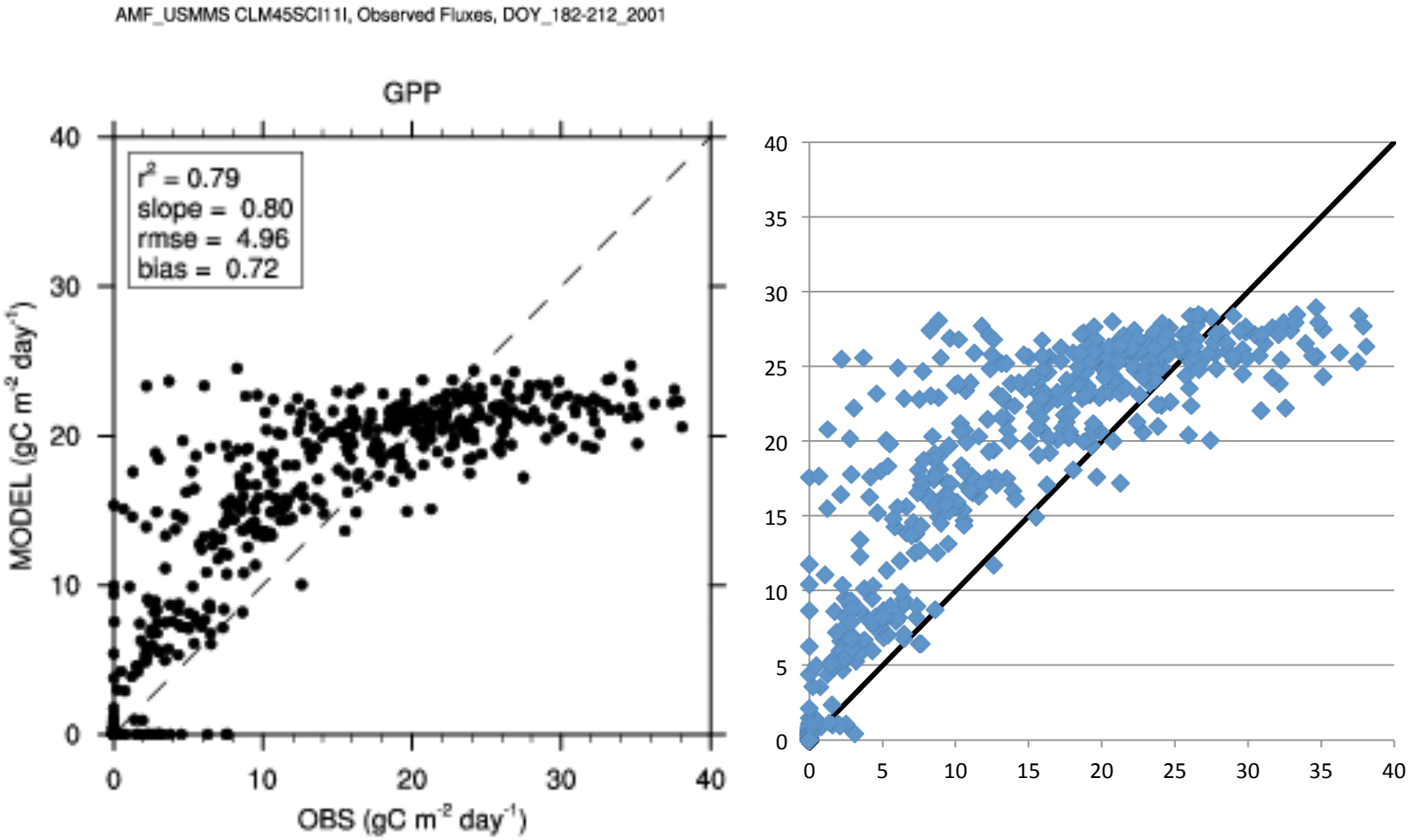




AMF_USHo1 CLM45SCI11I, Observed Fluxes, DOY_182-212_2003






AMF_USMMS CLM45SCI11I, Observed Fluxes, DOY_182-212_2001
GPP
r² = 0.79
slope = 0.80
rmse = 4.96
bias = 0.72
MODEL (gC m⁻² day⁻¹)
OBS (gC m⁻² day⁻¹)
0
10
20
30
40
0
5
10
15
20
25
30
35
40

Leaf-to-canopy scaling using two-leaf canopy

Plant, Cell and Environment (1997) **20,** 537–557

Simple scaling of photosynthesis from leaves to canopies without the errors of big-leaf models

D. G. G. DE PURY & G. D. FARQUHAR

Environmental Biology, Research School of Biological Sciences, Institute of Advanced Studies, The Australian National University, Canberra, ACT, Australia

ELSEVIER

Agricultural and Forest Meteorology 91 (1998) 89–111

AGRICULTURAL AND FOREST METEOROLOGY

A two-leaf model for canopy conductance, photosynthesis and partitioning of available energy I: Model description and comparison with a multi-layered model

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[a] *CSIRO Division of Atmospheric Research, PMB # 1, Aspendale, Vic 3195, Australia*
[b] *CSIRO Land and Water, FC Pye Laboratory, Canberra, ACT 2601, Australia*

REMOTE SENS ENVIRON 42 187–216 (1992)

Canopy Reflectance, Photosynthesis, and Transpiration. III. A Reanalysis Using Improved Leaf Models and a New Canopy Integration Scheme.

P. J. Sellers, J. A. Berry,† G. J. Collatz,† C. B. Field,† and F. G. Hall**
**NASA/Goddard Space Flight Center, Greenbelt and †Carnegie Institution, Stanford, California*