



Evaluating and Improving the Community Land Model's Sensitivity to Land Cover

LMWG-BGCWG-SDWG 2018 winter meeting

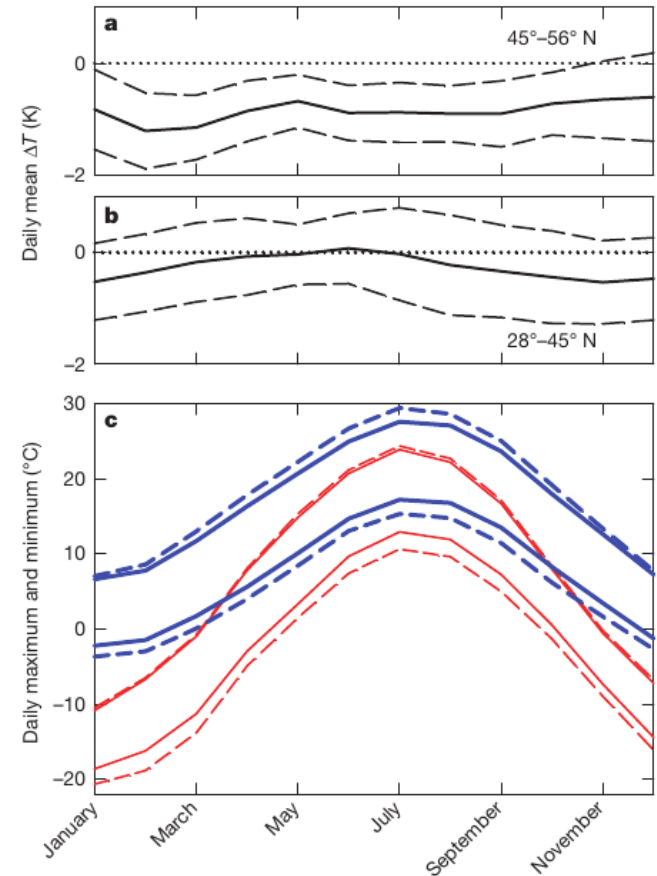
Ronny Meier and Edouard Davin, 06.02.2018

E-mail to ronny.meier@env.ethz.ch and/or edouard.davin@env.ethz.ch

Introduction

De- or reforestation impacts local climate through various biogeophysical effects:

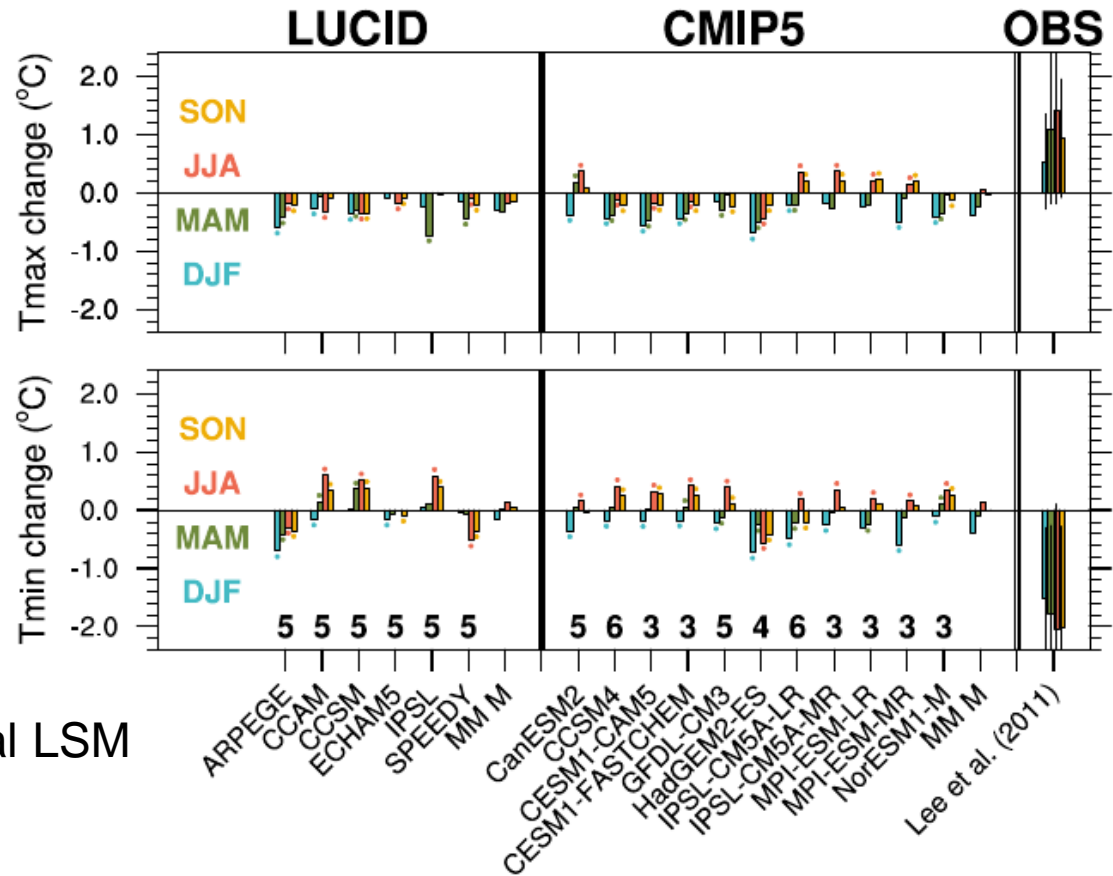
- Change in albedo
 - Different evaporative fraction
 - Change surface roughness
- Significant climatic impact that varies in space, diurnally, and seasonally



Lee et al. (2011)

Introduction

CMIP5 and LUCID revealed considerable discrepancies of representation of biogeophysical effects of deforestation amongst LSM



→ Evaluation of individual LSM necessary

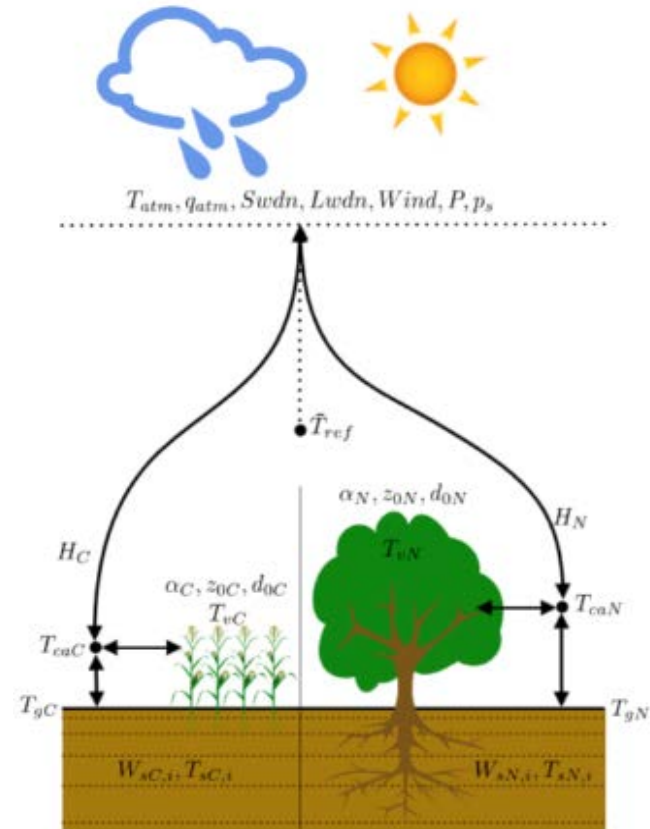
Lejeune et al. (2017)

Reference Data

Name	Variables	Method	Reference
MODIS	Albedo, LST (mean, max, min), ET	Remote sensing based	Li et al. (2015)
GLEAM	ET	Remote sensing based	Martens et al. (2017)
GETA	ET	Linear mixed effect model, in-situ obs. based	Ambrose et Sterling (2014)
FLUXNET sites	Varying	Eddy-covariance	

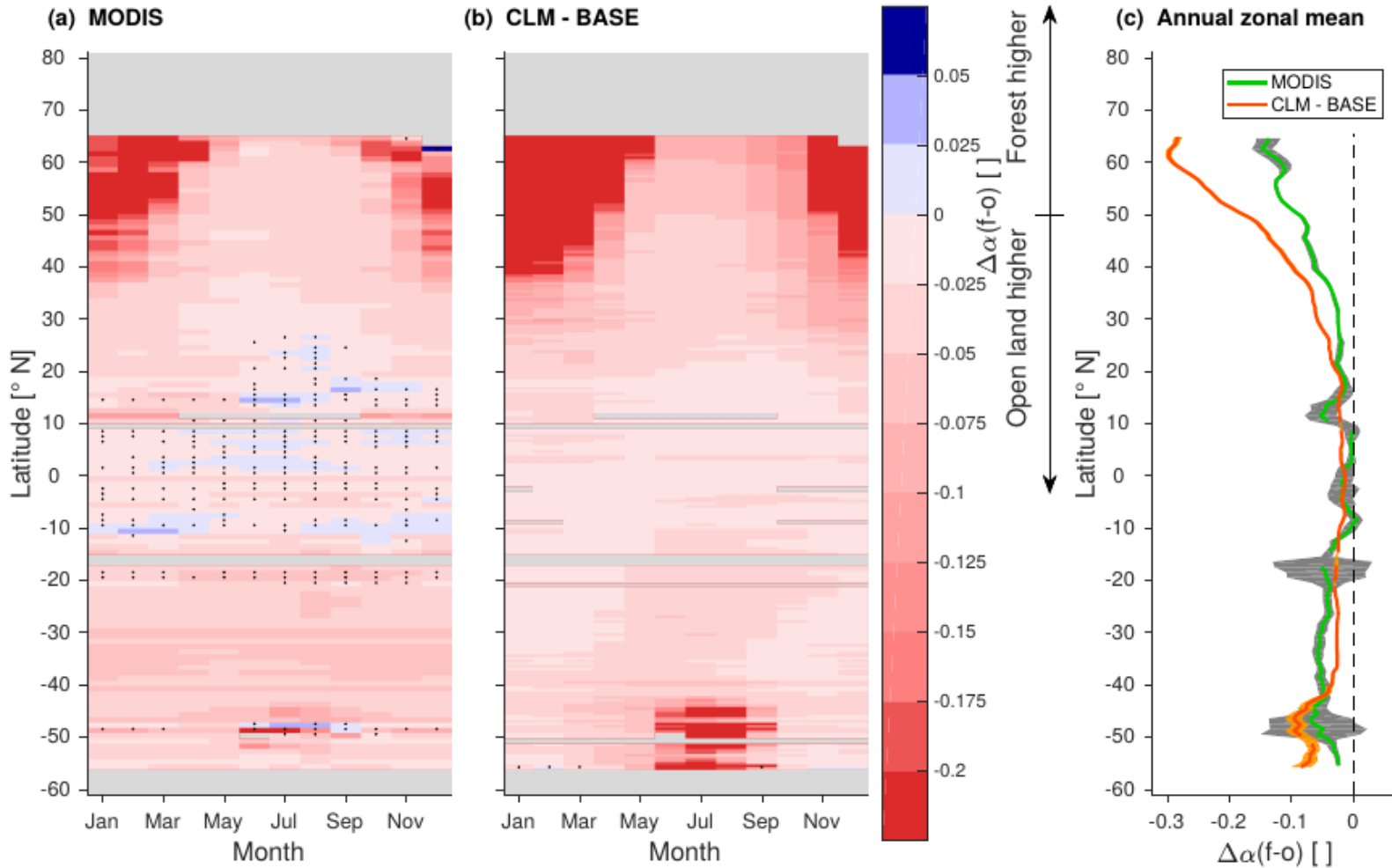
Methodology

- CLM 4.5, 0.5° resolution
- Offline, CRUNCEP forcing
- Static land cover map (2000)
- Sub-grid signal extraction (Malyshev et al. 2015)



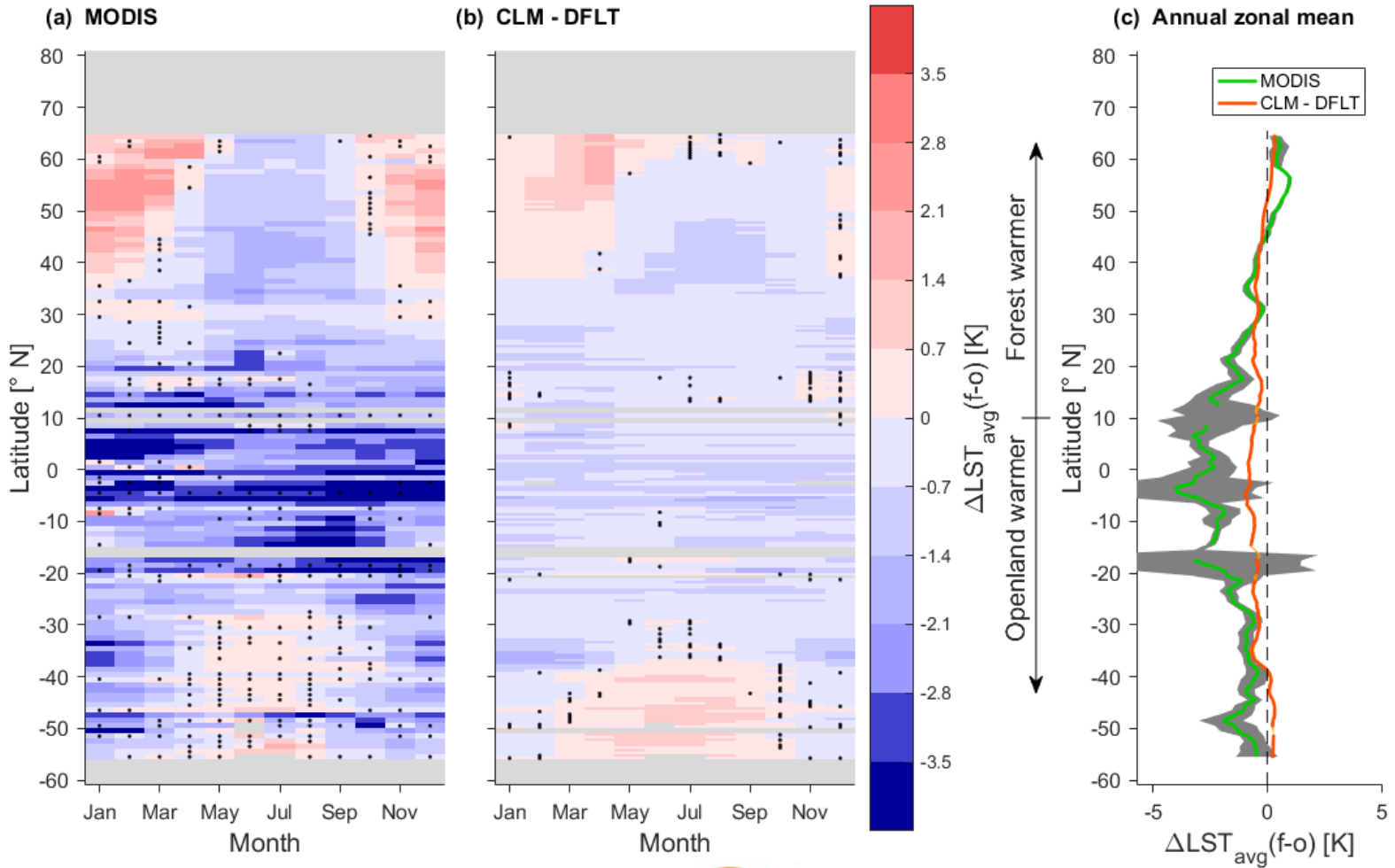
Malyshev et al. (2015)

Albedo



Meier et al. (submitted)

Land Surface Temperature

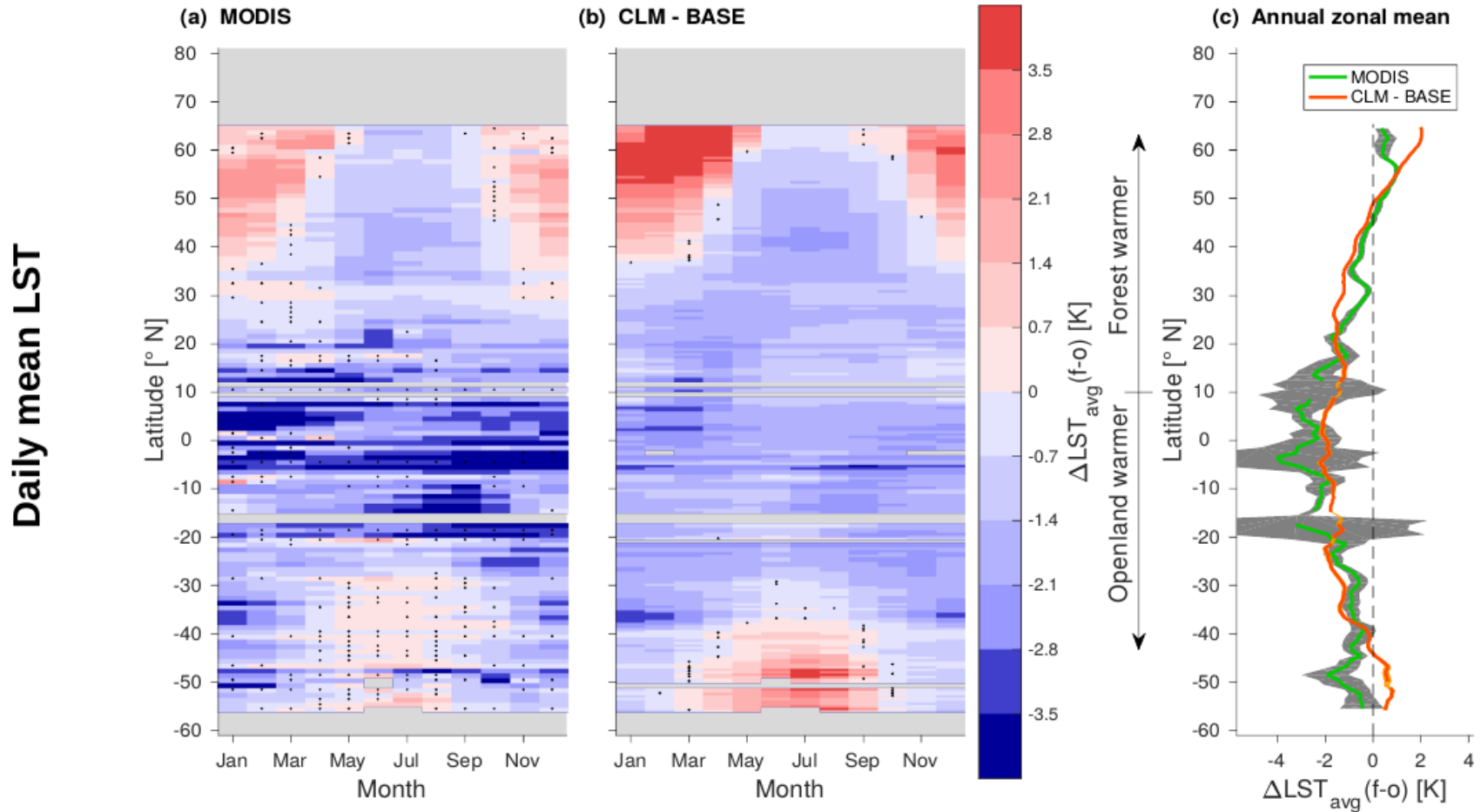


Well that doesn't look very good



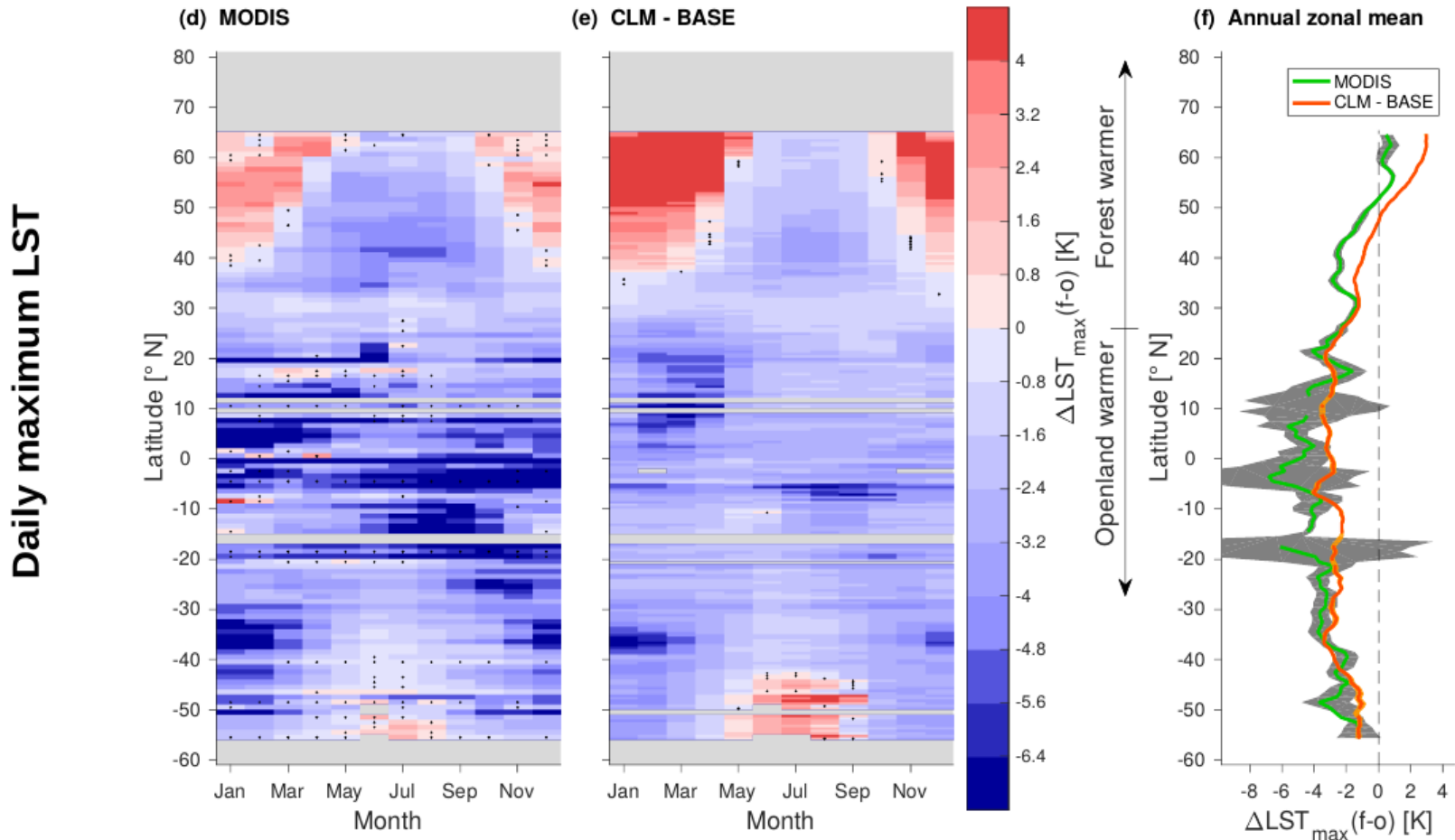
Meier et al. (submitted)

Land Surface Temperature (2nd try)



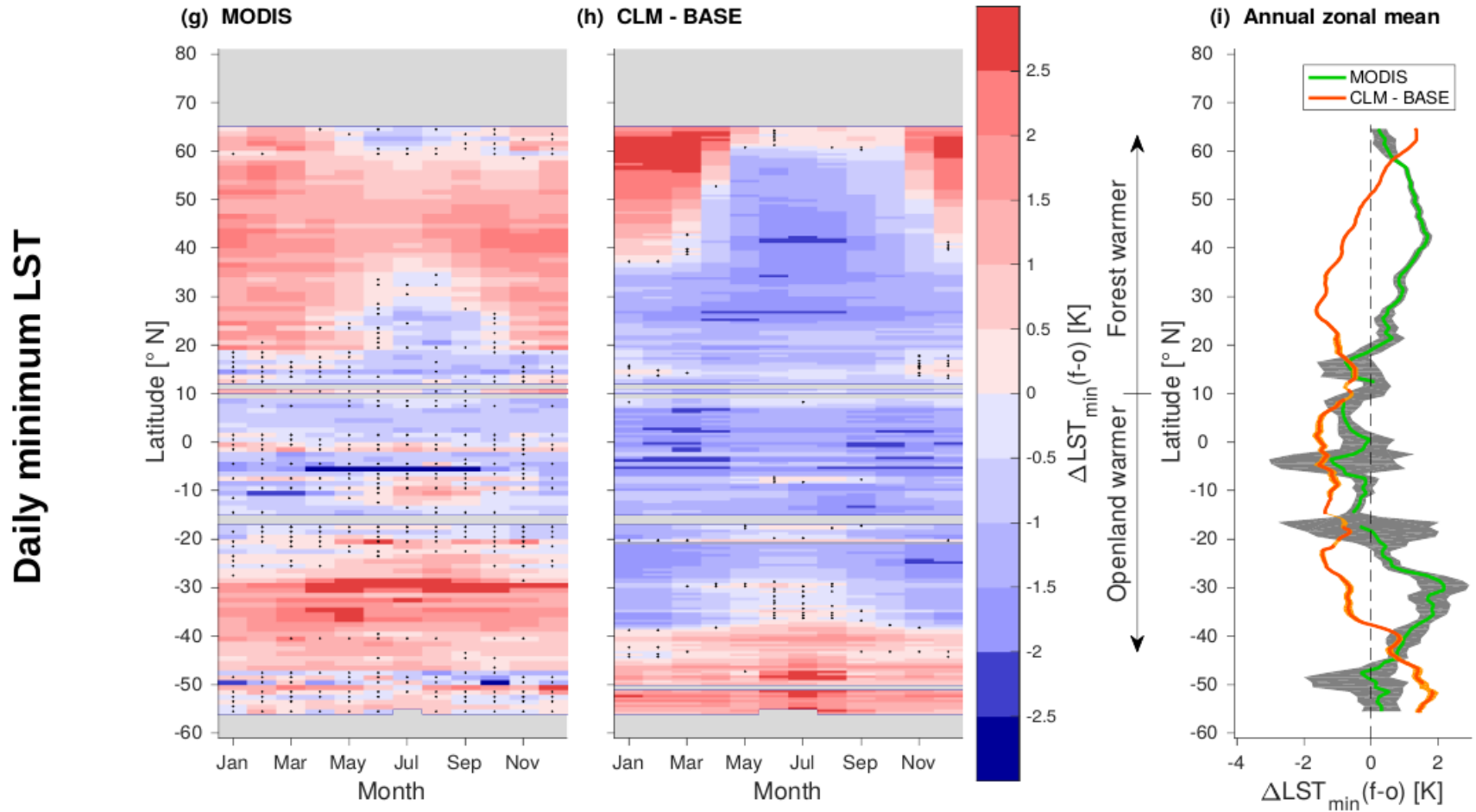
Meier et al. (submitted)

Land Surface Temperature (2nd try)



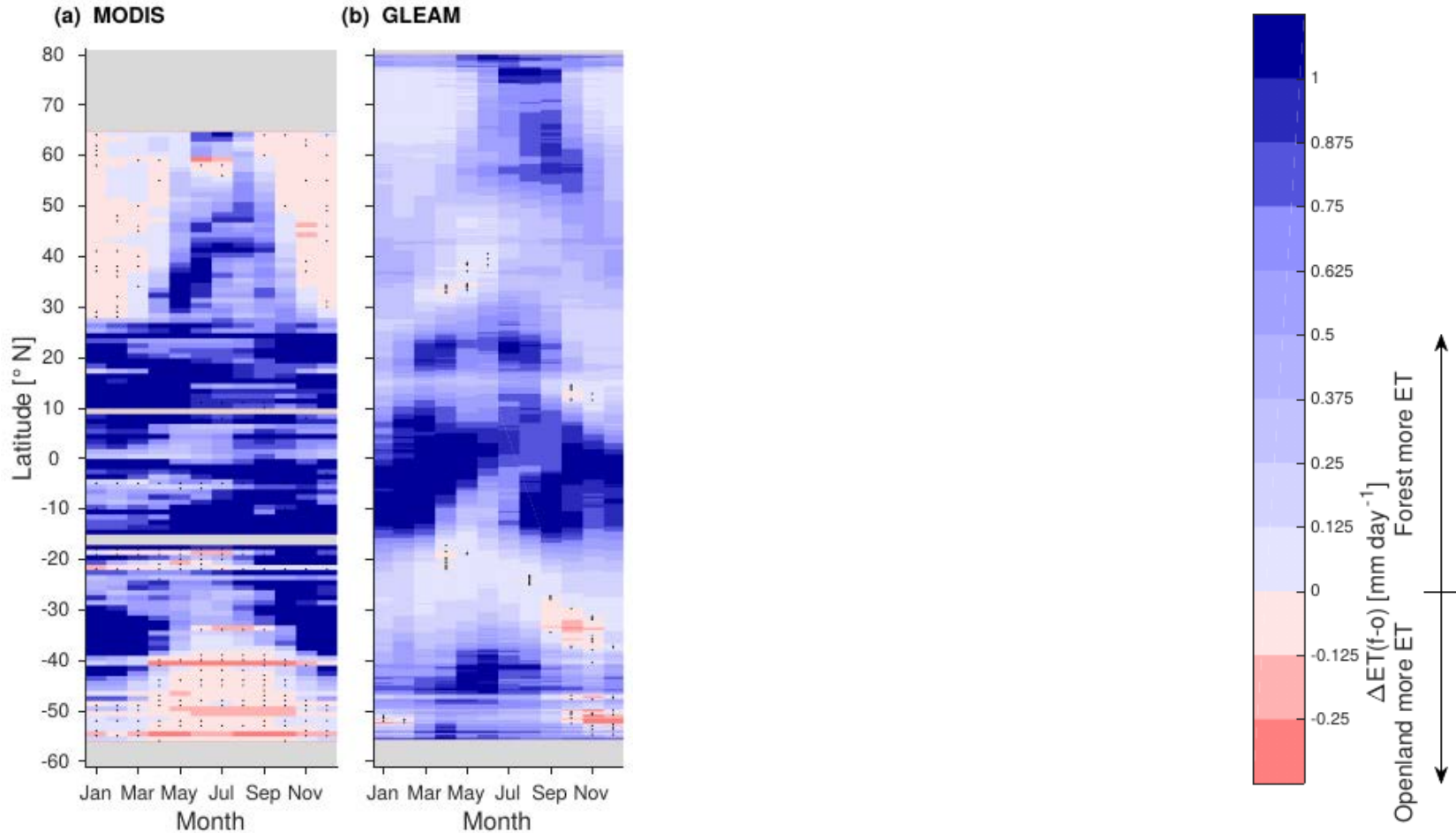
Meier et al. (submitted)

Land Surface Temperature (2nd try)



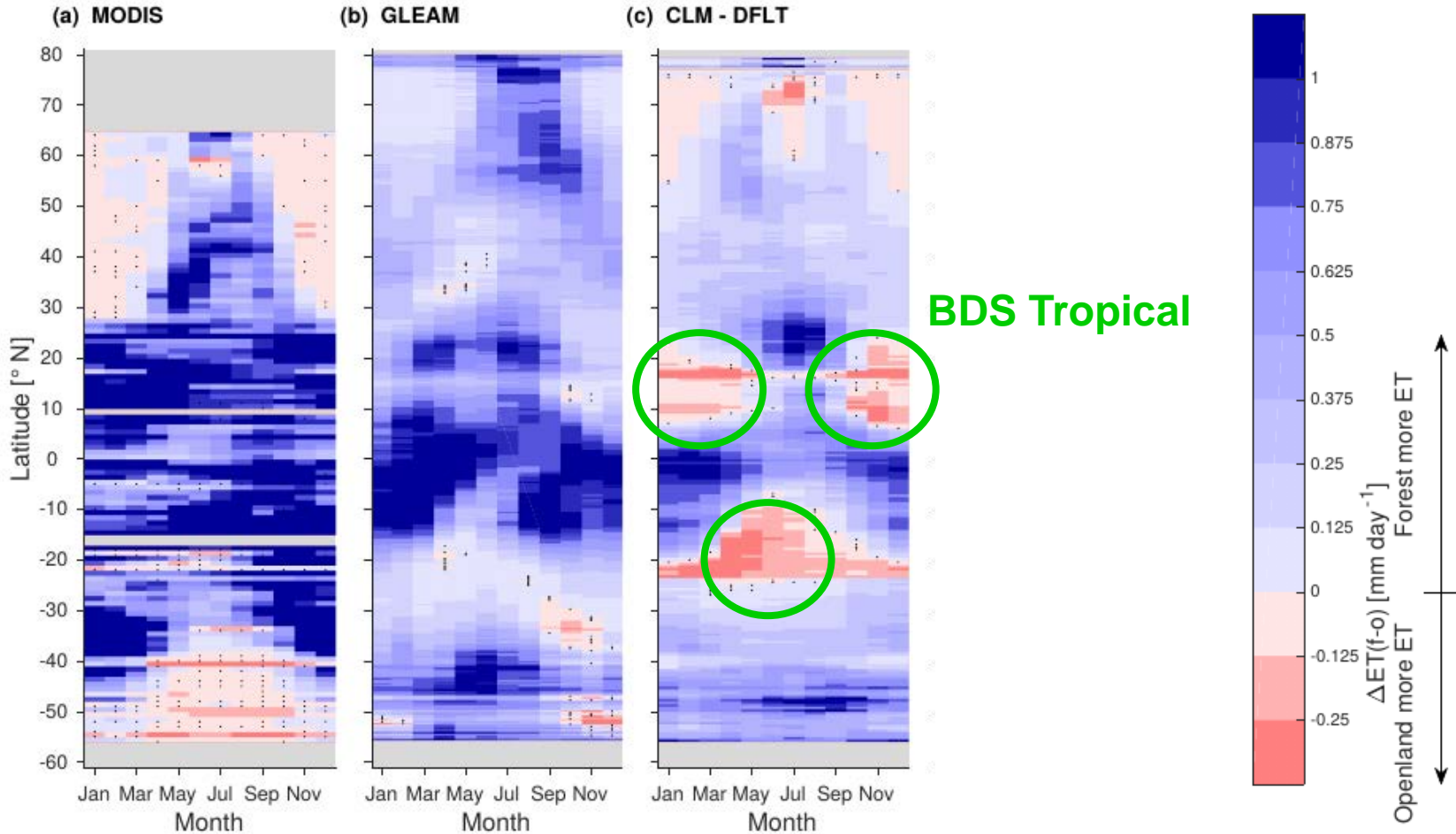
Meier et al. (submitted)

Separated SCs Have Not Only Advantages



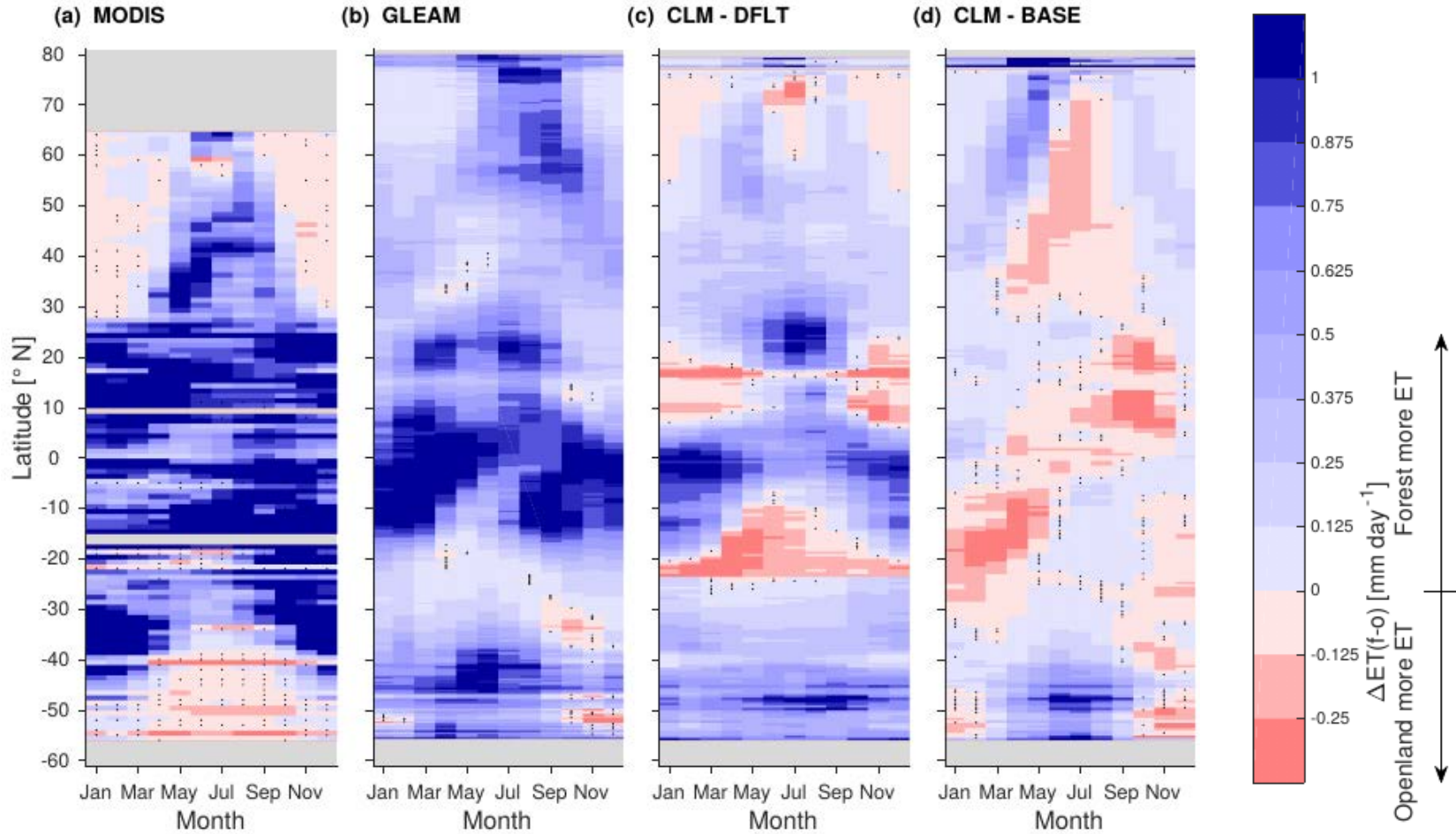
Meier et al. (submitted)

Separated SCs Have Not Only Advantages



Meier et al. (submitted)

Separated SCs Have Not Only Advantages



Meier et al. (submitted)

Sensitivity Experiments

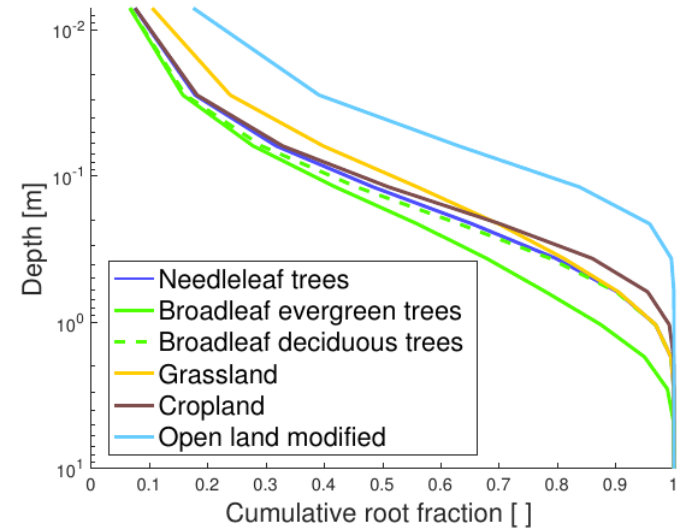
- Seasonal dynamics of forest ET not captured (Dry season increase)
- ET of C₄ grasses biased high

Study	Region	PFTs	Unit	Season	Obs.	BASE
Da Rocha et al. (2004)	Amazon	EBT	mm day ⁻¹	Dry	3.96	3.49
				Wet	3.18	3.57
				All	3.51	3.54
Von Randow et al. (2004)	Amazon	EBT	W m ⁻²	Dry	108.6	82.9
				Wet	104.5	113.9
		Grass		Dry	63.9	81.2
				Wet	83.0	113.9

Meier et al. (submitted)

Sensitivity Experiments

- Shallower roots for grass and crop

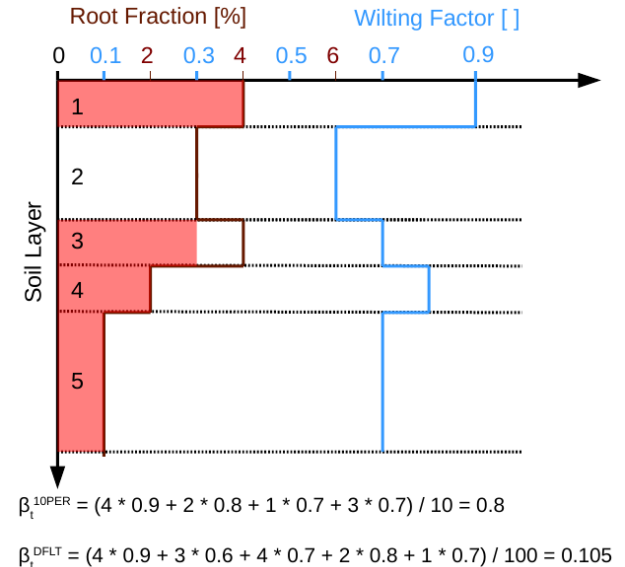


Study	Region	PFTs	Unit	Season	Obs.	BASE	ROOT
Da Rocha et al. (2004)	Amazon	EBT	mm day ⁻¹	Dry	3.96	3.49	3.49
				Wet	3.18	3.57	3.57
				All	3.51	3.54	3.54
Von Randow et al. (2004)	Amazon	EBT	W m ⁻²	Dry	108.6	82.9	82.9
				Wet	104.5	113.9	113.9
		Grass		Dry	63.9	81.2	56.0
				Wet	83.0	113.9	113.9

Meier et al. (submitted)

Sensitivity Experiments

- Dynamic plant water uptake
 - Plants extract water from 10% of roots where water is easiest available



Study	Region	PFTs	Unit	Season	Obs.	BASE	ROOT	10PER
Da Rocha et al. (2004)	Amazon	EBT	mm day ⁻¹	Dry	3.96	3.49	3.49	3.90
				Wet	3.18	3.57	3.57	3.57
				All	3.51	3.54	3.54	3.68
Von Randow et al. (2004)	Amazon	EBT	W m ⁻²	Dry	108.6	82.9	82.9	100.6
				Wet	104.5	113.9	113.9	113.8
		Grass		Dry	63.9	81.2	56.0	60.2
				Wet	83.0	113.9	113.9	113.9

Meier et al. (submitted)

Sensitivity Experiments

- Decreased light limitation for C₃ plants and increased for C₄ plants

Study	Region	PFTs	Unit	Season	Obs.	BASE	ROOT	10PER	LIGHT
Da Rocha et al. (2004)	Amazon	EBT	mm day ⁻¹	Dry	3.96	3.49	3.49	3.90	4.06
				Wet	3.18	3.57	3.57	3.57	3.64
				All	3.51	3.54	3.54	3.68	3.79
Von Randow et al. (2004)	Amazon	EBT	W m ⁻²	Dry	108.6	82.9	82.9	100.6	105.3
				Wet	104.5	113.9	113.9	113.8	116.2
		Grass		Dry	63.9	81.2	56.0	60.2	62.7
				Wet	83.0	113.9	113.9	113.9	106.1

Meier et al. (submitted)

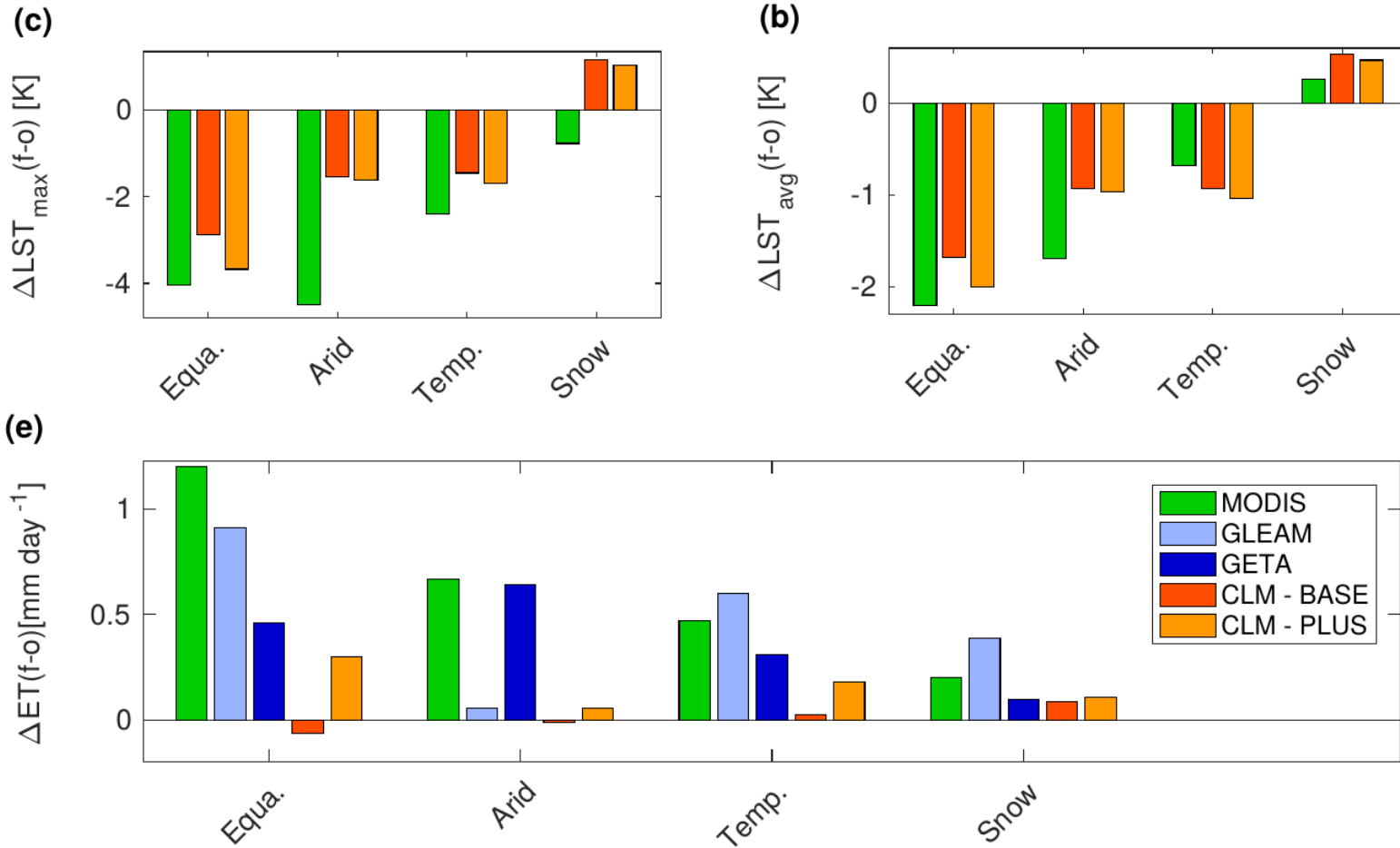
Sensitivity Experiments

- Chose V_{cmax} to alleviate ET averages compared to GETA 2.0 (Ambrose et Sterling; 2014)

Study	Region	PFTs	Unit	Season	Obs.	BASE	ROOT	10PER	LIGHT	PLUS
Da Rocha et al. (2004)	Amazon	EBT	mm day ⁻¹	Dry	3.96	3.49	3.49	3.90	4.06	3.48
				Wet	3.18	3.57	3.57	3.57	3.64	3.37
				All	3.51	3.54	3.54	3.68	3.79	3.40
Von Randow et al. (2004)	Amazon	EBT	W m ⁻²	Dry	108.6	82.9	82.9	100.6	105.3	90.8
				Wet	104.5	113.9	113.9	113.8	116.2	108.9
		Grass		Dry	63.9	81.2	56.0	60.2	62.7	64.7
				Wet	83.0	113.9	113.9	113.9	106.1	100.1

Meier et al. (submitted)

Performance of Tuned Version

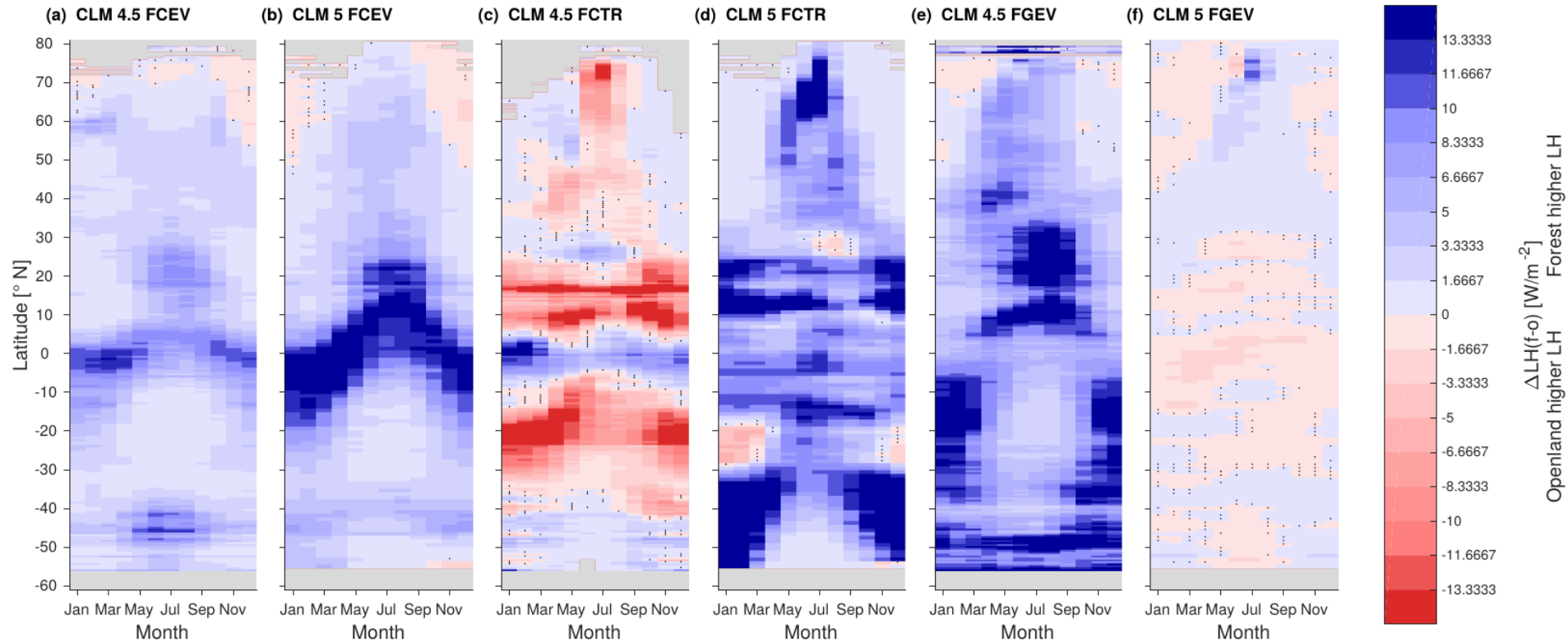


Meier et al. (submitted)

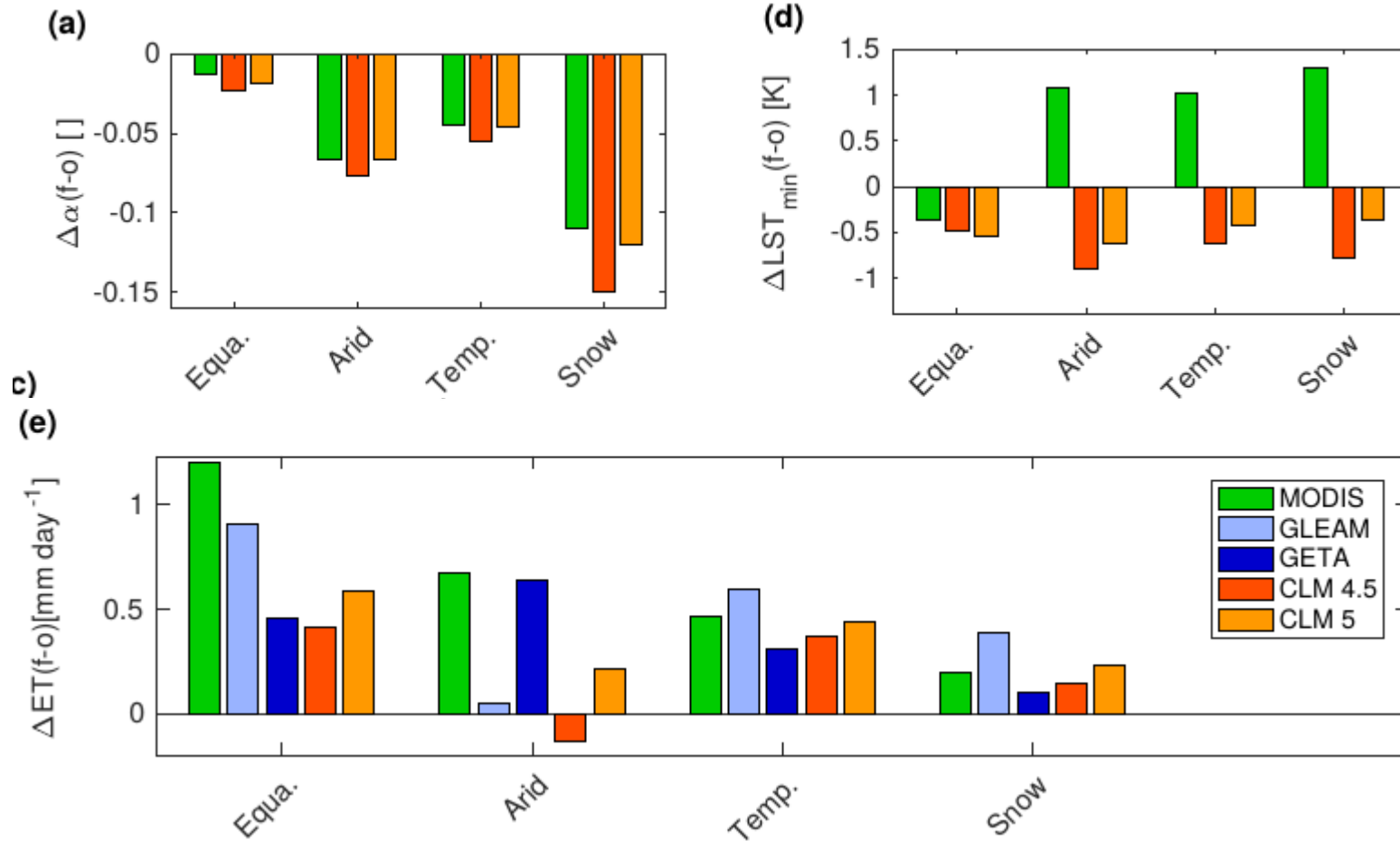
Conclusions

- Analysis on PFT level can bring interesting insights that are hidden on grid cell level
- For such an analysis soil column separation desirable
- Important tuning parameters for plant transpiration:
 - Root distribution → Changed in CLM 5
 - Dynamics of plant water uptake → Changed in CLM 5

Preliminary Results CLM 5



Preliminary Results CLM 5



References:

Ambrose, S. M. and Sterling, S. M.: Global patterns of annual actual evapotranspiration with land-cover type: Knowledge gained from a new observation-based database, *Hydrol. Earth Syst. Sc. Discuss.*, 11, 12 103–12 135, <https://doi.org/10.5194/hessd-11-12103-2014>, 2014.

Da Rocha, H. R., Goulden, M. L., Miller, S. D., Menton, M. C., Pinto, L. D. V. O., de Freitas, H. C., and e Silva Figueira, A. M.: Seasonality of Water and Heat Fluxes Over a Tropical Forest in Eastern Amazonia, *Ecol. Appl.*, 14, 22–32, <https://doi.org/10.1890/02-6001>, 2004.

Lee, X., Goulden, M. L., Hollinger, D. Y., Barr, A., Black, T. A., Bohrer, G., Bracho, R., Drake, B., Goldstein, A., Gu, L., Katul, G., Kolb, T., Law, B. E., Margolis, L. H., Meyers, T., Monson, R., Munger, W., Oren, R., Paw U, K. T., Richardson, A. D., Schmid, H. P. Staebler, R., Wofsy, S., and Zhao, L.: Observed increase in local cooling effect of deforestation at higher latitude, *Nature*, 479, 384–387, <https://doi.org/10.1038/nature10588>, 2011.

Lejeune, Q., Seneviratne, S. I., and Davin, E. L.: Historical Land-Cover Change Impacts on Climate: Comparative Assessment of LUCID and CMIP5 Multimodel Experiments, *J. Climate*, pp. 1439–1459, <https://doi.org/10.1175/JCLI-D-16-0213.1>, 2017.

Li, Y., Zhao, M., Motesharrei, S., Mu, Q., Kalnay, E., and Li, S.: Local cooling and warming effects of forests based on satellite observations, *Nat. Commun.*, 6, <https://doi.org/10.1038/ncomms7603>, 2015.

Malyshev, S., Shevliakova, E., Stouffer, R. J., and Pacala, S. W.: Contrasting Local versus Regional Effects of Land-Use-Change-Induced Heterogeneity on Historical Climate: Analysis with the GFDL Earth System Model, *J. Climate*, 28, 5448–5469, <https://doi.org/10.1175/JCLI-D-14-00586.1>, 2015.

Martens, B., Miralles, D. G., Lievens, H., van der Schalie, R., de Jeu, R. A. M., Fernández-Prieto, D., Beck, H. E., Dorigo, W. A., and Verhoest, N. E. C.: GLEAM v3: satellite-based land evaporation and root-zone soil moisture, *Geosci. Model Dev.*, 10, <https://doi.org/10.5194/gmd-2016-162>, 2017.

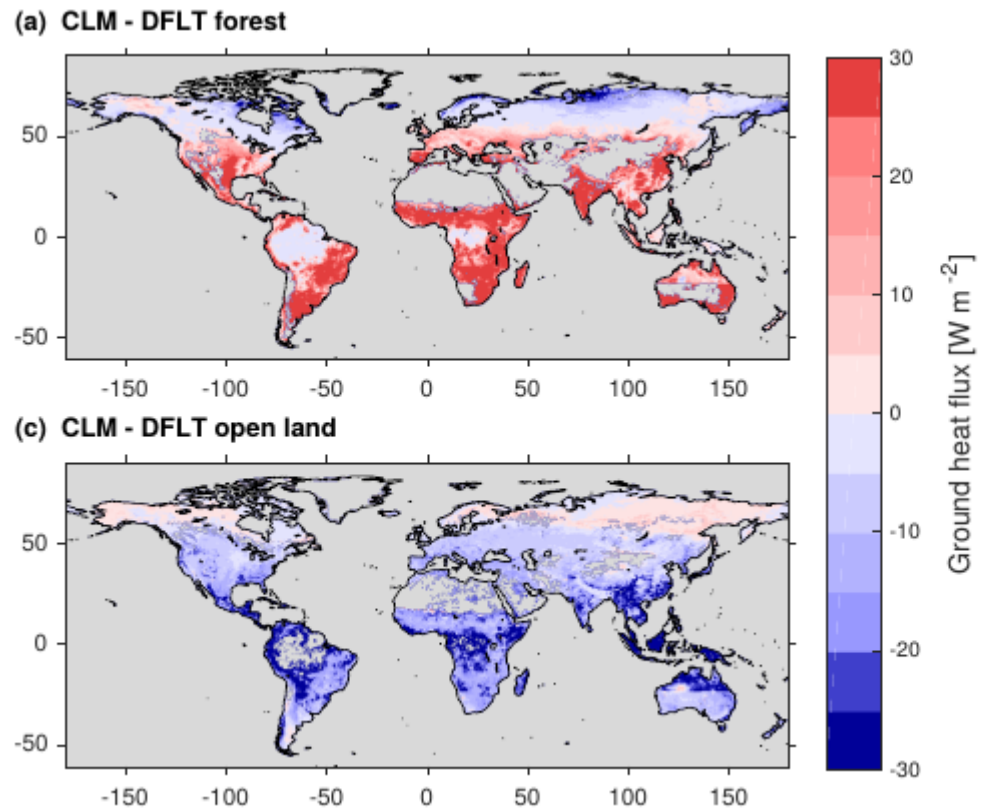
Meier, R., Davin, E. L., Lejeune, Q., Hauser, M., Li, Y., Martens, B., Schultz, N. M., Sterling, S., Thiery, W.: Evaluating and Improving the Community Land Model's Sensitivity to Land Cover, submitted to *EGU Biogeosciences*, 2017.

Schultz, N. M., Lee, X., Lawrence, P. J., Lawrence, D. M., and Zhao, L.: Assessing the use of subgrid land model output to study impacts of land cover change, *J. Geophys. Res.*, 121, 6133–6147, <https://doi.org/10.1002/2016JD025094>, 2016.

Von Randow, C., Manzi, A. O., Kruijt, B., de Oliveira, P. J., Zanchi, F. B., Silva, R. L., Hodnett, M. G., Gash, J. H. C., Elbers, J. A., Waterloo, M. J., Cardoso, F. L., and Kabat, P.: Comparative measurements and seasonal variations in energy and carbon exchange over forest and pasture in South West Amazonia, *Theor. Appl. Climatol.*, 78, 5–26, <https://doi.org/10.1007/s00704-004-0041-z>, 2004.

The Rescue: Separated Soil Columns

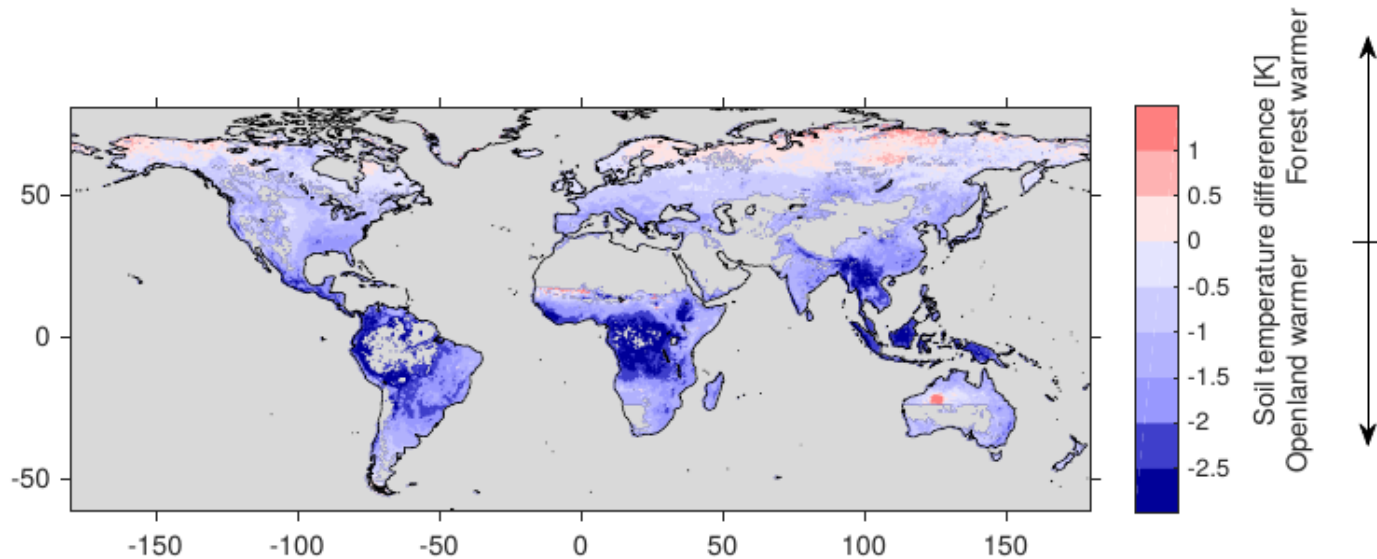
- By default PFTs share one SC → Lateral ground heat fluxes



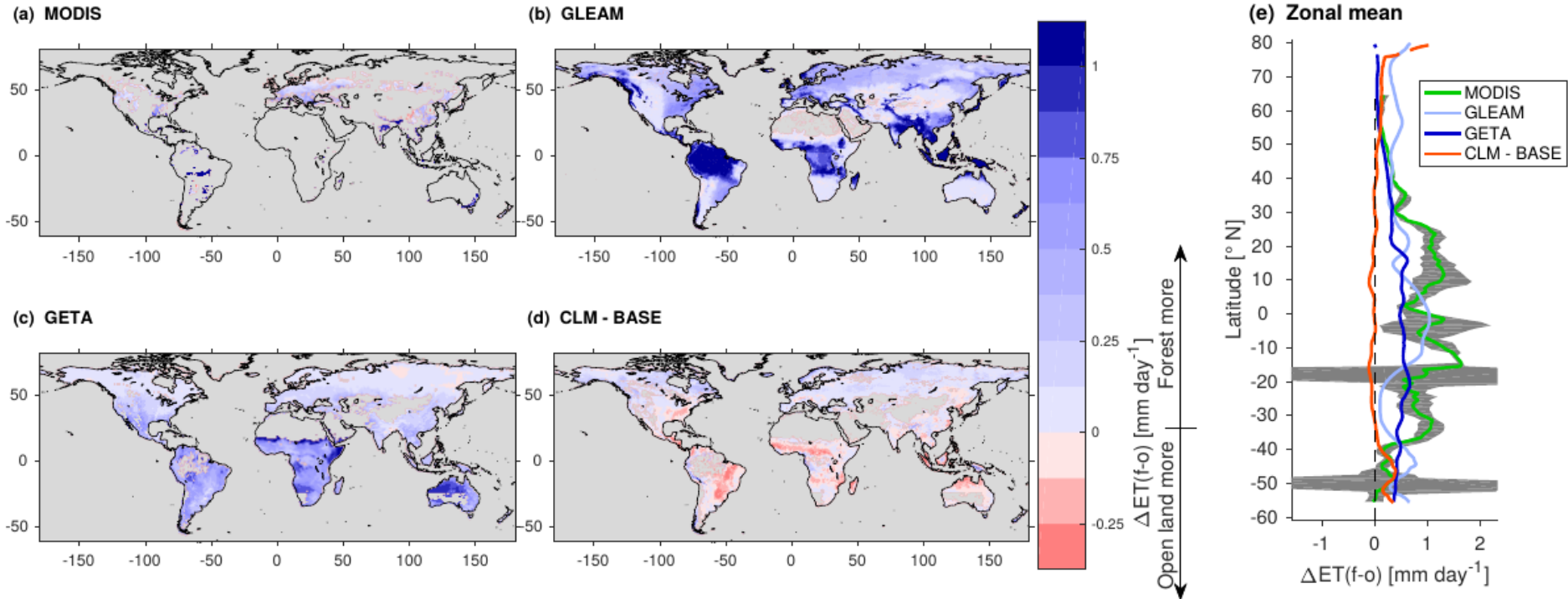
Meier et al. (submitted)

The Rescue: Separated Soil Columns

- By default PFTs share one SC → Lateral ground heat fluxes
- Separated SCs after Schultz et al. (2016) → No more lateral heat flux



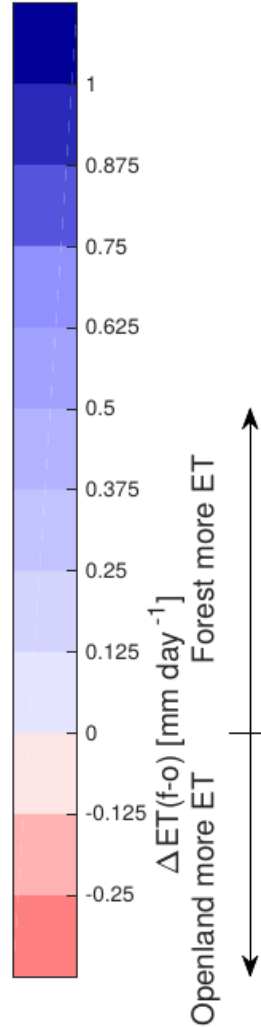
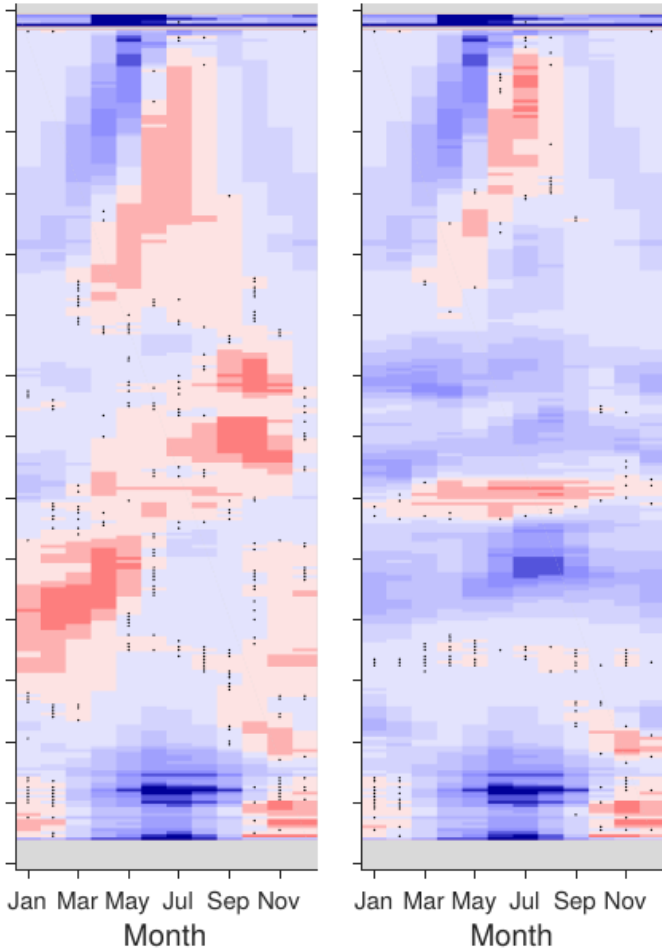
Meier et al. (submitted)



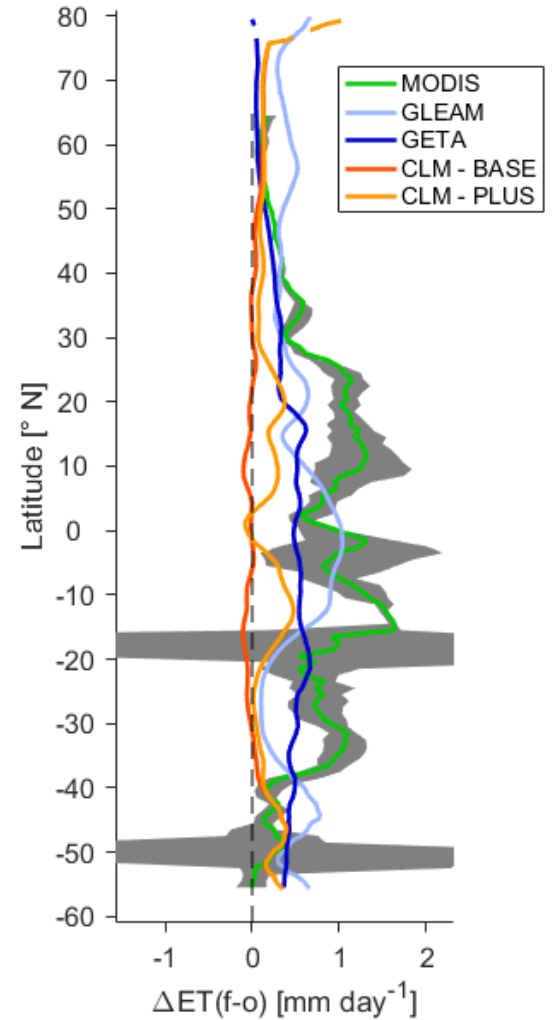
Performance of Tuned Version

(d) CLM - BASE

(e) CLM - PLUS



Zonal mean



Meier et al. (submitted)

