

CESM Land Model Working Group

NEWSLETTER

Updates for CTSM users & developers

November 10, 2020

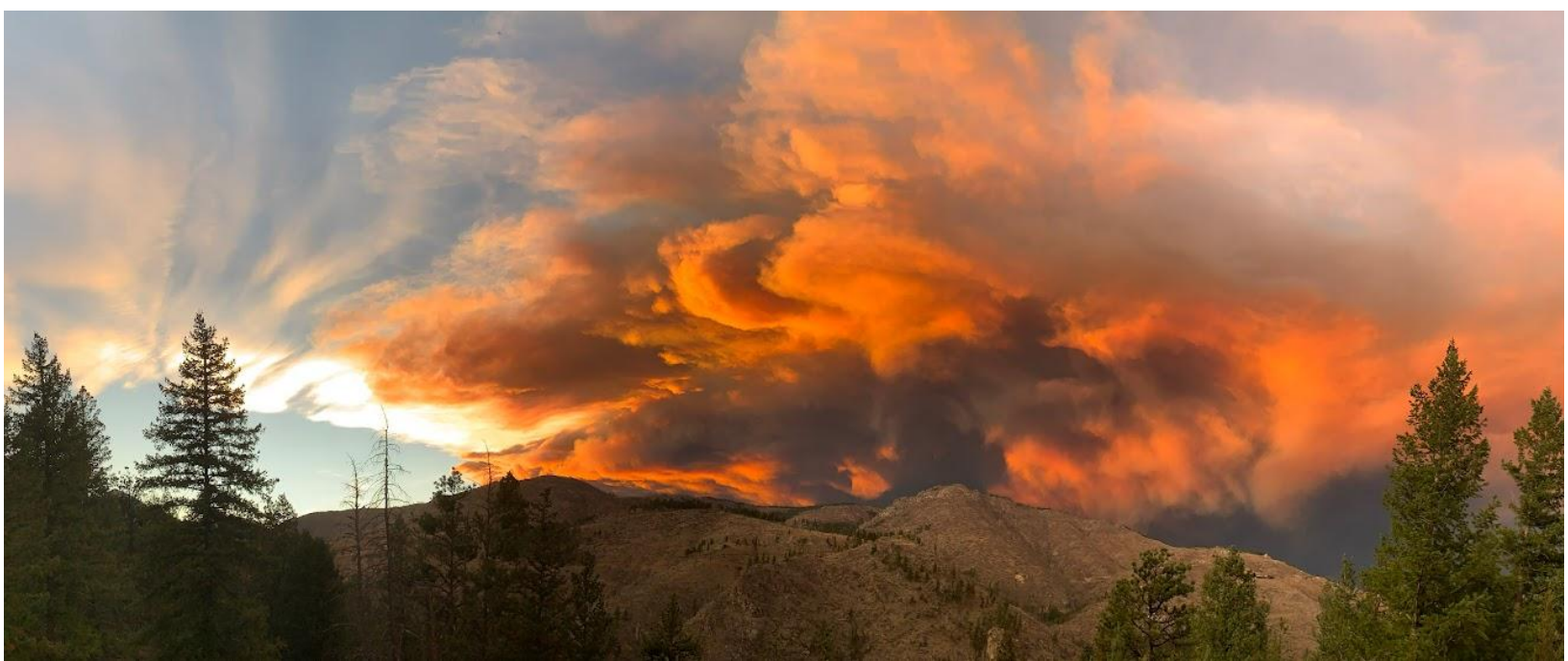


Photo: Danica Lombardozzi

Model Developments & Features

Ongoing efforts and directions:

CTSM6(FATES): We continue to work towards a full FATES integration in CTSM6 for CESM3 ([see github for discussion](#)). [Recent progress includes](#) development of FATES-SP and -no_competition modes as well as the development of other reduced complexity configurations for use in global simulations.

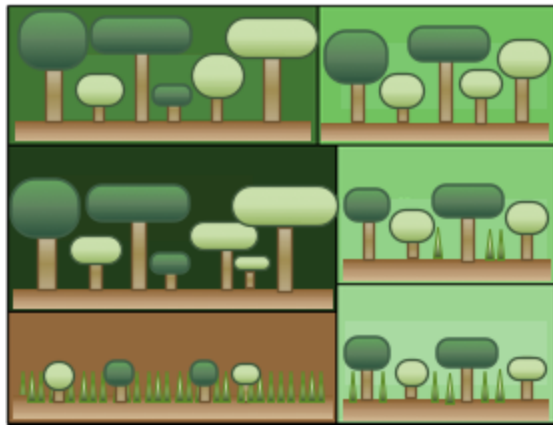


Image credit R. Fisher

Representative hillslope: Development and application of the [representative hillslope model](#), which enables simulation of the impacts of interconnected hillslope elements as well as slope and aspect on lateral water transfer and the surface energy budget, continues and is available for use. Please contact S. Swenson if you're interested in using this feature.

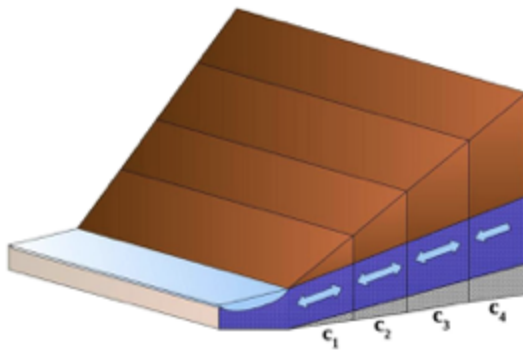


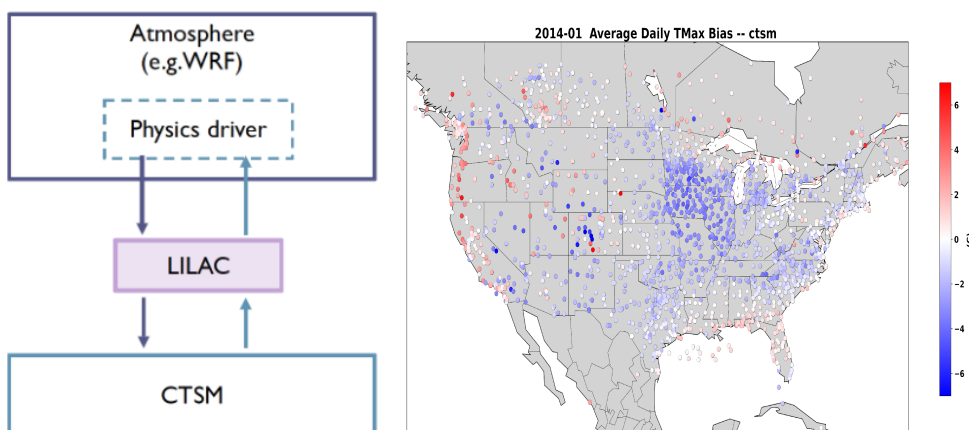
Image credit S. Swenson et al JAMES 2019

Single point capabilities: Developments to facilitate running single point simulations are in progress that will enable easier simulations with flux tower data (e.g. Plumber2 experiments and NEON sites).



Photo NEON Science STER Tower

WRF-CTSM: A beta version of WRF-CTSM, coupled with LILAC has been released for community use. [\[Release message\]](#) [\[User's guide\]](#). This release represents an important milestone along the path of land model unification at NCAR. Ongoing unification work includes development of a streamlined toolchain for new grid generation, one-way (and eventually two-way) nesting, and coupling to MPAS.



More information on ongoing efforts can be [found here](#), or by attending our virtual LWMG meeting in Spring 2021.

New Features (since CLM5 release)

- Runtime flexibility in setting the number of [landunits](#), [PFTs](#), and soil and [snow](#) vertical structure and number of layers
- Streamlined capability to run future climate simulations in CTSM land-only mode using anomaly forcing. Anomaly forcing data from CESM2 SSP1-2.6, SSP2-4.5, SSP3-7, and SSP5-8.5 simulations are available. [\[User's guide\]](#)
- Fast CTSM(NWP) [configuration](#) for use in Numerical Weather Prediction applications. CTSM(NWP) is ~10X faster than CTSM(BGC-Crop)

- Grid cell level checks for carbon and water balance

CESM2.2 release

This is a development release that focuses on the transition to the MOM6 ocean model and testing for CAM6 dynamical core configurations that enable simulations on variable resolution grids. Science updates for CTSM include:

- Option to simulate [two bioenergy crops](#) (switchgrass and miscanthus)
- Support for use of CTSM in numerical weather prediction (NWP) applications
- Bug fixes for [LUNA](#) and [FUN](#) modules
- Prescribed soil moisture

Additional information can be found at the [CESM2 webpage](#).

CTSM5.1 beta tag

On [ctsm/main](#) we are building CTSM5.1 physics. The following features have been implemented that introduce answer changing modifications to the CTSM physics package. We emphasize this is a development code that has not been scientifically validated, but we do encourage use of the main development branch for model development. Major development associated with this tag currently include:

- Bug fixes, improvements, and re-tuning to the [fire module](#), especially to improve deforestation and degradation fires
- Improvements to [Arctic/Boreal phenology & allocation](#)
- Updated [PFT optical properties](#) and [urban datasets](#)
- Moving [hard coded parameters](#) to the parameter file
- Revised [parameters for plant hydraulic stress](#)
- Patch for [wood stoichiometry](#) bug
- [CN-Matrix](#) calculations for ecosystem biogeochemistry (in progress).
- [Biomass heat storage](#) (in progress).
- [Snow burial](#) of vegetation (in progress).

Simulations & Activities

SSP extensions to 2300 with CESM2-WACCM

- [SSP5-8.5](#) & [SSP5-3.4 overshoot](#) completed.

- SSP1-2.6 in progress

- Data are published on ESGF (links above) and available on campaign storage (via casper)

/glade/campaign/collections/cmip/CMIP6/timeseries-cmip6/b.e21.BWSSP585extcmip6.f09_g17.CMIP6-SSP5-8.5ext-WACCM.001

/glade/campaign/collections/cmip/CMIP6/timeseries-cmip6/b.e21.BWSSP534osextcmip6.f09_g17.CMIP6-SSP5-3.4OSext-WACCM.001

TRENDY simulations

-Data are published on the [NCAR/DASH repository](#) and are also available on cheyenne

/glade/p/cgd/tss/people/dll/TRENDY2020_History

PLUMBER2 - CTSM is participating in this model intercomparison project sponsored by GEWEX GLASS that includes 170 Flux Tower Site simulations. We are submitting CTSM5(SP) and CTSM5.1(SP) simulations, which will be posted at www.modelEvaluation.org and are also available on Cheyenne at [/glade/p/cgd/tss/people/oleson/PLUMBER2](#)

CTSM Parameter Perturbation Experiment (PPE): Phase 0 (infrastructure work; exposing hard coded parameters, scripting, and code base); Phase 1 (one-at-a-time parameter perturbations underway) [[Project Description](#)].

Upcoming Events & Announcements

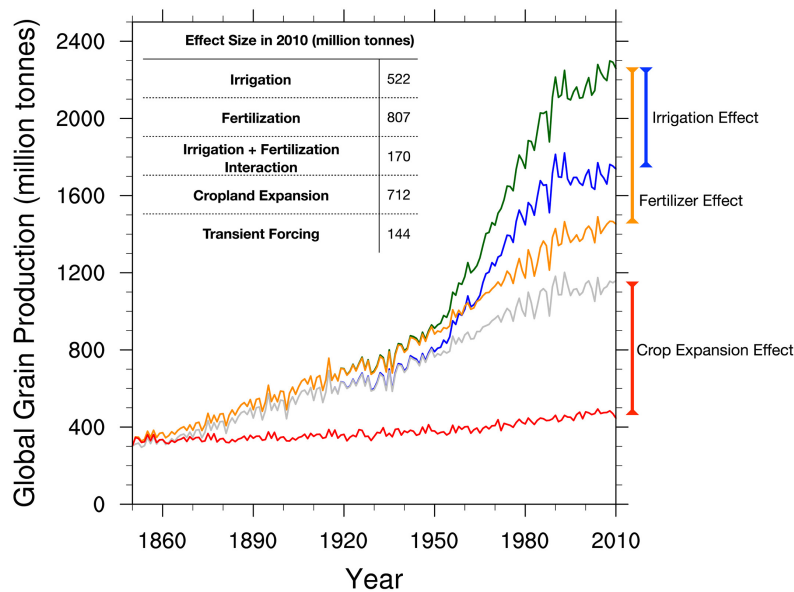
- A number of us will be virtually participating in AGU this year. Sorry we can't meet up for coffee, but look forward to hearing about your work.
- LMWG and BGCWG meetings - Virtually Feb. 23-25 2021
- CTSM tutorial, Fall 2021 (tentative)
- Bi-weekly CLM meetings take place Thursdays at 1:00 Mountain time. Please contact wieder@ucar.edu if you'd like to join in these meetings.

Science highlights

Selected papers:

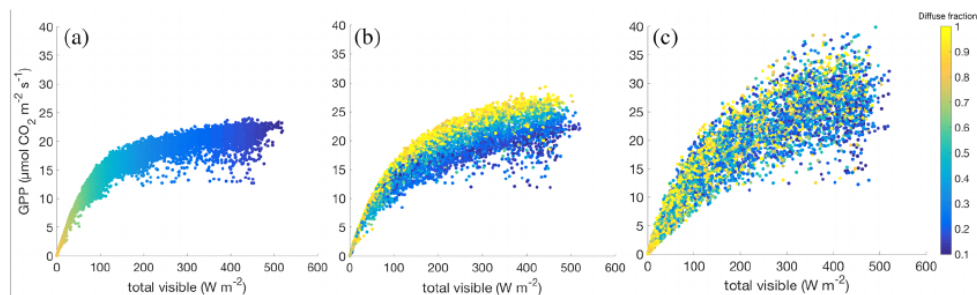
- Lombardozzi, D. L., Y. Q. Lu, P. J. Lawrence, D. M. Lawrence, S. Swenson, K. W. Oleson, W. R. Wieder, and E. A. Ainsworth, 2020: Simulating Agriculture in the Community Land Model Version 5. *Journal of Geophysical Research-Biogeosciences*, **125**. e2019JG005529. <https://doi.org/10.1029/2019JG005529>

This paper introduces the updated prognostic representation of agricultural management in CLM5 and CESM2. Lombardozzi and co-authors found that representing specific crop types, as well as irrigation and fertilization in CLM increases the amount of carbon that plants draw out from the atmosphere and also changes patterns of evapotranspiration.



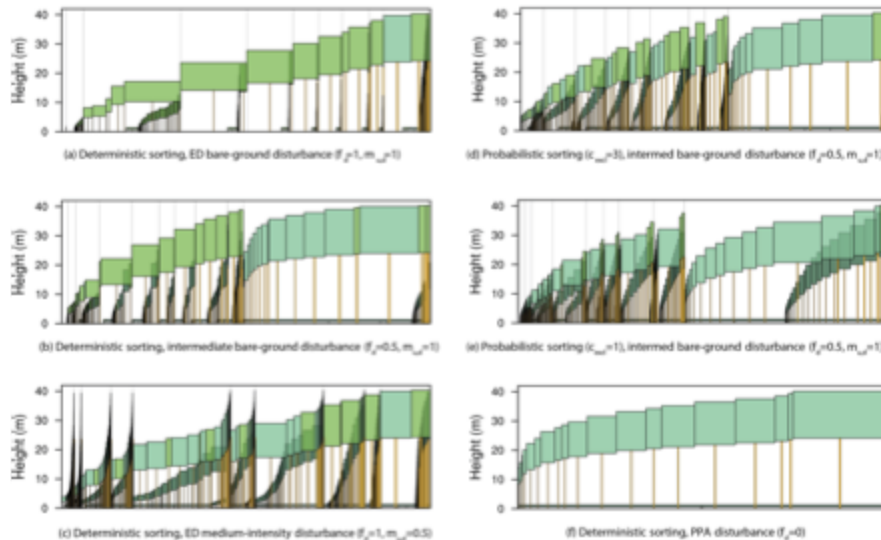
- Wozniak, M. C., G.B. Bonan, G Keppel-Aleks, and A.L. Steiner (2020). Influence of vertical heterogeneities in the canopy microenvironment on interannual variability of carbon uptake in temperate deciduous forests. *Journal of Geophysical Research: Biogeosciences*, **125**, e2020JG005658. <https://doi.org/10.1029/2020JG005658>

This paper looks at how different representations of canopy vertical structure influences carbon uptake at five temperate deciduous forest sites. Wozniak and co-authors found that different configurations of CLM cannot accurately simulate observed interannual variability of GPP, which may be related by their inability to capture the upper range of observed hourly GPP and diffuse light-GPP relationships.



- Koven, C. D., R.G. Knox, R.A Fisher, et al. 2020. Benchmarking and parameter sensitivity of physiological and vegetation dynamics using the Functionally Assembled Terrestrial Ecosystem Simulator (FATES) at Barro Colorado Island, Panama. *Biogeosciences*, **17**, 3017-3044. [doi:10.5194/bg-17-3017-2020](https://doi.org/10.5194/bg-17-3017-2020)

*This paper explores parameter sensitivity of model predictions from FATES, and compares results to observations from Barro Colorado Island in Panama. Koven and co-authors find that it is important to differentiate between plant traits, which are under competitive pressure in FATES, from those model parameters that are not and to better understand the relationships between plant traits and model parameter to characterize sources of uncertainty in vegetation demographic models. *You can also watch a video of trees growing in FATES at: <https://doi.org/10.5446/43627>!*



CLM5-Related Publications to date:

All CLM/CTSM publications in [2020](#)

Arora, V. K., A. Katavouta, R. G. Williams, C. D. Jones, V. Brovkin, P. Friedlingstein, J. Schwinger, L. Bopp, O. Boucher, P. Cadule, M. A. Chamberlain, J. R. Christian, C. Delire, R. A. Fisher, T. Hajima, T. Ilyina, E. Joetzjer, M. Kawamiya, C. D. Koven, J. P. Krasting, R. M. Law, D. M. Lawrence, A. Lenton, K. Lindsay, J. Pongratz, T. Raddatz, R. Seferian, K. Tachiiri, J. F. Tjiputra, A. Wiltshire, T. W. Wu and T. Ziehn (2020). "Carbon-concentration and carbon-climate feedbacks in CMIP6 models and their comparison to CMIP5 models." *Biogeosciences* **17**(16): 4173-4222 DOI: 10.5194/bg-17-4173-2020.

Bonan, G. B., D. L. Lombardozzi, W. R. Wieder, K. W. Oleson, D. M. Lawrence, F. M. Hoffman and N. Collier (2019). "Model Structure and Climate Data Uncertainty in Historical Simulations of the Terrestrial Carbon Cycle (1850-2014)." *Global Biogeochemical Cycles*

Chen, J. L., J. Wen, S. C. Kang, X. H. Meng, H. Tian, X. Ma and Y. Yuan (2020). "Assessments of the factors controlling latent heat flux and the coupling degree between an alpine wetland and the atmosphere

on the Qinghai-Tibetan Plateau in summer." Atmospheric Research **240**: 9 DOI: 10.1016/j.atmosres.2020.104937.

Chen, L. and P. A. Dirmeyer (2020). "Distinct Impacts of Land Use and Land Management on Summer Temperatures." Frontiers in Earth Science **8**: 12 DOI: 10.3389/feart.2020.00245.

Chen, M., C. R. Vernon, N. T. Graham, M. Hejazi, M. Y. Huang, Y. Y. Cheng and K. Calvin (2020). "Global land use for 2015-2100 at 0.05 degrees resolution under diverse socioeconomic and climate scenarios." Scientific Data **7**(1): 11 DOI: 10.1038/s41597-020-00669-x.

Cheng, S. J., P. G. Hess, W. R. Wieder, R. Q. Thomas, K. J. Nadelhoffer, J. Vira, D. L. Lombardozzi, P. Gundersen, I. J. Fernandez, P. Schleppi, M. C. Gruselle, F. Moldan and C. L. Goodale (2019). "Decadal fates and impacts of nitrogen additions on temperate forest carbon storage: a data-model comparison." Biogeosciences **16**(13): 2771-2793

Cheng, Y. Y., M. Y. Huang, M. Chen, K. Y. Guan, C. Bernacchi, B. Peng and Z. L. Tan (2020). "Parameterizing Perennial Bioenergy Crops in Version 5 of the Community Land Model Based on Site-Level Observations in the Central Midwestern United States." Journal of Advances in Modeling Earth Systems **12**(1): 24 DOI: 10.1029/2019ms001719.

Danabasoglu, G., J. F. Lamarque, J. Bacmeister, D. A. Bailey, A. K. DuVivier, J. Edwards, L. K. Emmons, J. Fasullo, R. Garcia, A. Gettelman, C. Hannay, M. M. Holland, W. G. Large, P. H. Lauritzen, D. M. Lawrence, J. T. M. Lenaerts, K. Lindsay, W. H. Lipscomb, M. J. Mills, R. Neale, K. W. Oleson, B. Otto-Bliesner, A. S. Phillips, W. Sacks, S. Tilmes, L. Kampenhout, M. Vertenstein, A. Bertini, J. Dennis, C. Deser, C. Fischer, B. Fox-Kemper, J. E. Kay, D. Kinnison, P. J. Kushner, V. E. Larson, M. C. Long, S. Mickelson, J. K. Moore, E. Nienhouse, L. Polvani, P. J. Rasch and W. G. Strand (2020). "The Community Earth System Model Version 2 (CESM2)." Journal of Advances in Modeling Earth Systems **12**(2): e2019MS001916 DOI: 10.1029/2019ms001916.

Devanand, A., M. Y. Huang, D. M. Lawrence, C. M. Zarzycki, Z. Feng, P. J. Lawrence, Y. Qian and Z. Yang (2020). "Land Use and Land Cover Change Strongly Modulates Land-Atmosphere Coupling and Warm-Season Precipitation Over the Central United States in CESM2-VR." Journal of Advances in Modeling Earth Systems **12**(9): 23 DOI: 10.1029/2019ms001925.

Ekici, A., H. Lee, D. M. Lawrence, S. C. Swenson and C. Prigent (2019). "Ground subsidence effects on simulating dynamic high-latitude surface inundation under permafrost thaw using CLM5." Geoscientific Model Development **12**(12): 5291-5300

Fisher, R. A., W. R. Wieder, B. M. Sanderson, C. D. Koven, K. W. Oleson, C. G. Xu, J. B. Fisher, M. J. Shi, A. P. Walker and D. M. Lawrence (2019). "Parametric Controls on Vegetation Responses to Biogeochemical Forcing in the CLM5." Journal of Advances in Modeling Earth Systems **11**(9): 2879-2895

Franks, P. J., G. B. Bonan, J. A. Berry, D. L. Lombardozzi, N. M. Holbrook, N. Herold and K. W. Oleson (2018). "Comparing optimal and empirical stomatal conductance models for application in Earth system models." Glob Chang Biol **24**(12): 5708-5723 DOI: 10.1111/gcb.14445.

Friedlingstein, P., M. W. Jones, M. O'Sullivan, R. M. Andrew, J. Hauck, G. P. Peters, W. Peters, J. Pongratz, S. Sitch, C. Le Quere, D. C. E. Bakker, J. G. Canadell, P. Ciais, R. B. Jackson, P. Anthoni, L. Barbero, A. Bastos, V. Bastrikov, M. Becker, L. Bopp, E. Buitenhuis, N. Chandra, F. Chevallier, L. P. Chini, K. I. Currie, R. A. Feely, M. Gehlen, D. Gilfillan, T. Gkritzalis, D. S. Goll, N. Gruber, S. Gutekunst, I. Harris, V. Haverd, R. A. Houghton, G. Hurtt, T. Ilyina, A. K. Jain, E. Joetzjer, J. O. Kaplan, E. Kato, K. K. Goldewijk, J. I. Korsbakken, P. Landschutzer, S. K. Lauvset, N. Lefevre, A. Lenton, S. Lienert, D. Lombardozzi, G. Marland, P. C. McGuire, J. R. Melton, N. Metzl, D. R. Munro, J. Nabel, S. I. Nakaoka, C. Neill, A. M. Omar, T. Ono, A. Peregon, D. Pierrot, B. Poulter, G. Rehder, L. Resplandy, E. Robertson, C. Rodenbeck, R. Seferian, J. Schwinger, N. Smith, P. P. Tans, H. Q. Tian, B. Tilbrook, F. N. Tubiello, G. R. van der Werf, A. J. Wiltshire and S. Zaehle (2019). "Global Carbon Budget 2019." Earth System Science Data **11**(4): 1783-1838

Holm, J. A., R. G. Knox, Q. Zhu, R. A. Fisher, C. D. Koven, A. J. N. Lima, W. J. Riley, M. Longo, R. I. Negron-Juarez, A. C. de Araujo, L. M. Kueppers, P. R. Moorcroft, N. Higuchi and J. Q. Chambers (2020). "The Central Amazon Biomass Sink Under Current and Future Atmospheric CO₂: Predictions From Big-Leaf and Demographic Vegetation Models." Journal of Geophysical Research-Biogeosciences **125**(3): 23 DOI: 10.1029/2019jg005500.

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Lawrence, D. M., R. A. Fisher, C. D. Koven, K. W. Oleson, S. C. Swenson, G. Bonan, N. Collier, B. Ghimire, L. van Kampenhout, D. Kennedy, E. Kluzek, P. J. Lawrence, F. Li, H. Y. Li, D. Lombardozzi, W. J. Riley, W. J. Sacks, M. J. Shi, M. Vertenstein, W. R. Wieder, C. G. Xu, A. A. Ali, A. M. Badger, G. Bisht, M. van den Broeke, M. A. Brunke, S. P. Burns, J. Buzan, M. Clark, A. Craig, K. Dahlin, B. Drewniak, J. B. Fisher, M. Flanner, A. M. Fox, P. Gentine, F. Hoffman, G. Keppel-Aleks, R. Knox, S. Kumar, J. Lenaerts, L. R. Leung, W. H. Lipscomb, Y. Q. Lu, A. Pandey, J. D. Pelletier, J. Perket, J. T. Randerson, D. M. Ricciuto, B. M. Sanderson, A. Slater, Z. M. Subin, J. Y. Tang, R. Q. Thomas, M. V. Martin and X. B. Zeng (2019). "The Community Land Model Version 5: Description of New Features, Benchmarking, and Impact of Forcing Uncertainty." Journal of Advances in Modeling Earth Systems **11**(12): 4245-4287

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Lu, X., Z. Du, Y. Huang, D. Lawrence, E. Kluzek, N. Collier, D. Lombardozzi, N. Sobhani, E. A. G. Schuur and Y. Luo (2020). "Full implementation of matrix approach to biogeochemistry module of Community Land Model version 5 (CLM5)." Journal of Advances in Modeling Earth Systems **n/a**(n/a): e2020MS002105 DOI: 10.1029/2020ms002105.

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Majasalmi, T. and R. M. Bright (2019). "Evaluation of leaf-level optical properties employed in land surface models." Geoscientific Model Development **12**(9): 3923-3938 DOI: 10.5194/gmd-12-3923-2019.

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Umair, M., D. Kim and M. Choi (2020). "Impact of climate, rising atmospheric carbon dioxide, and other environmental factors on water-use efficiency at multiple land cover types." Scientific Reports **10**(1): 13 DOI: 10.1038/s41598-020-68472-7.

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Wieder, W. R., D. M. Lawrence, R. A. Fisher, G. B. Bonan, S. J. Cheng, C. L. Goodale, A. S. Grandy, C. D. Koven, D. L. Lombardozzi, K. W. Oleson and R. Q. Thomas (2019). "Beyond Static Benchmarking: Using Experimental Manipulations to Evaluate Land Model Assumptions." Global Biogeochemical Cycles **33**(10): 1289-1309 DOI: 10.1029/2018gb006141.

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