

Nov 1 8, 2026

2026 CLM Tutorial

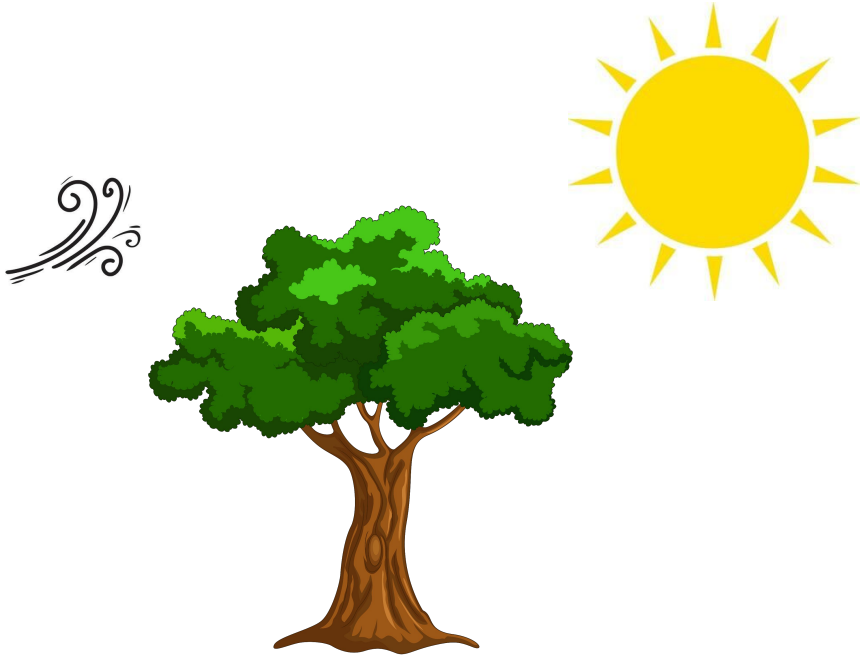
Model Initialization and spinup

Daniel Kennedy
djk2120@ucar.edu

What do we need to predict photosynthesis?



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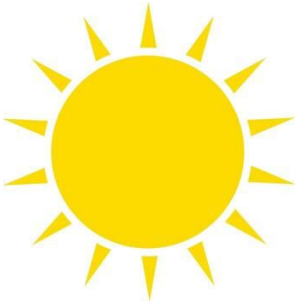


- Meteorology

What do we need to predict photosynthesis?





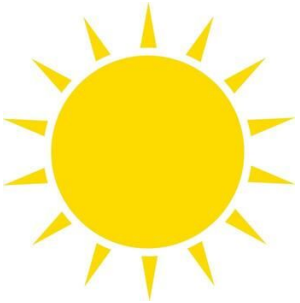


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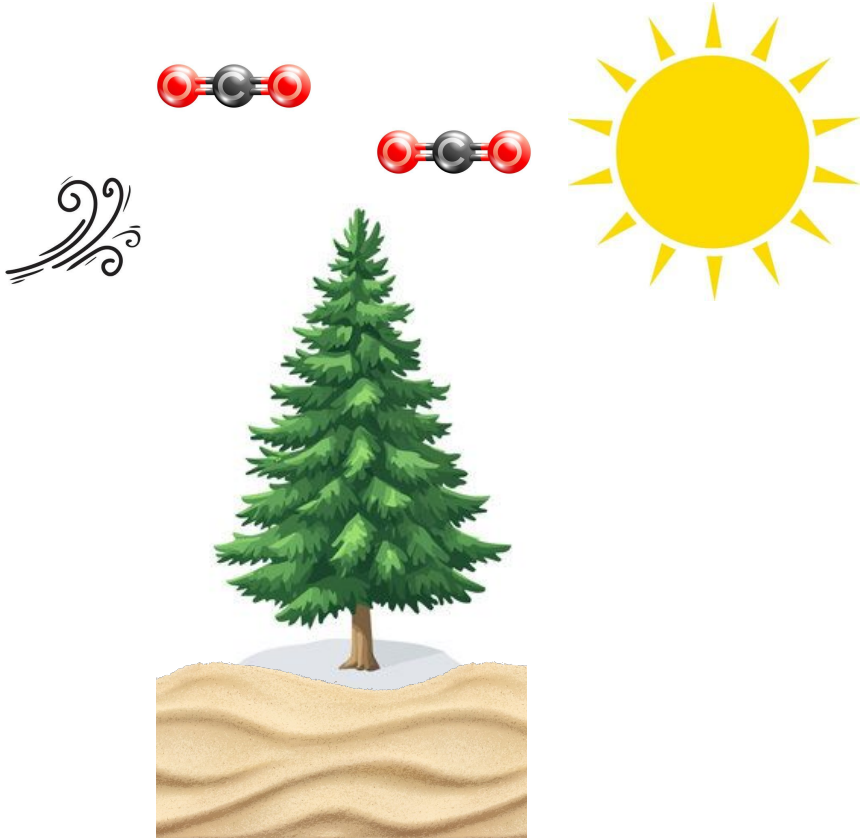






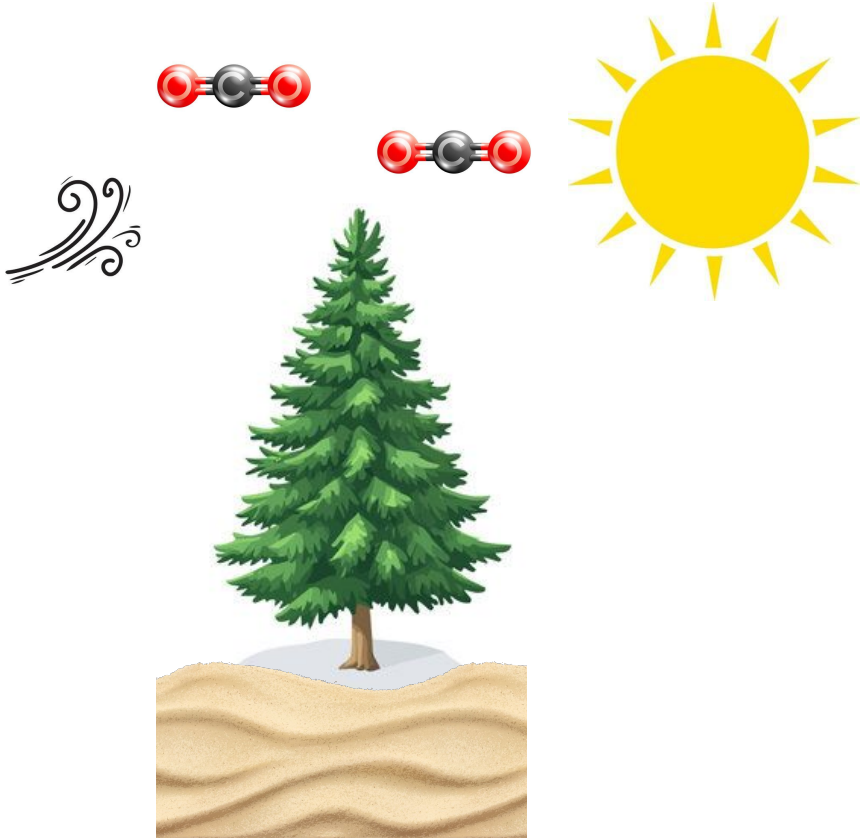
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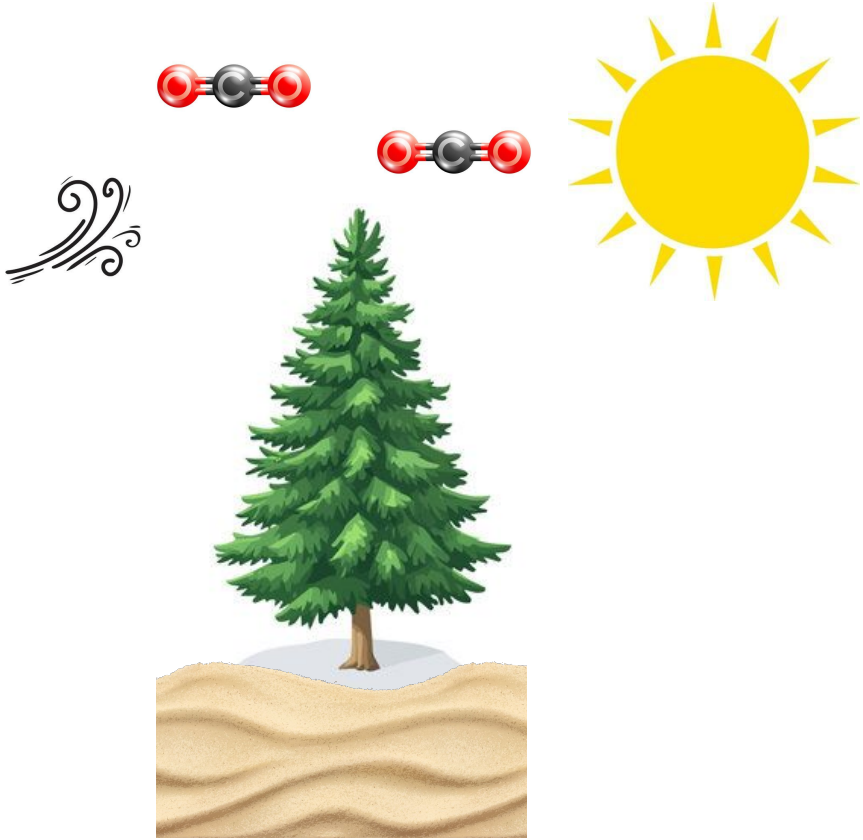
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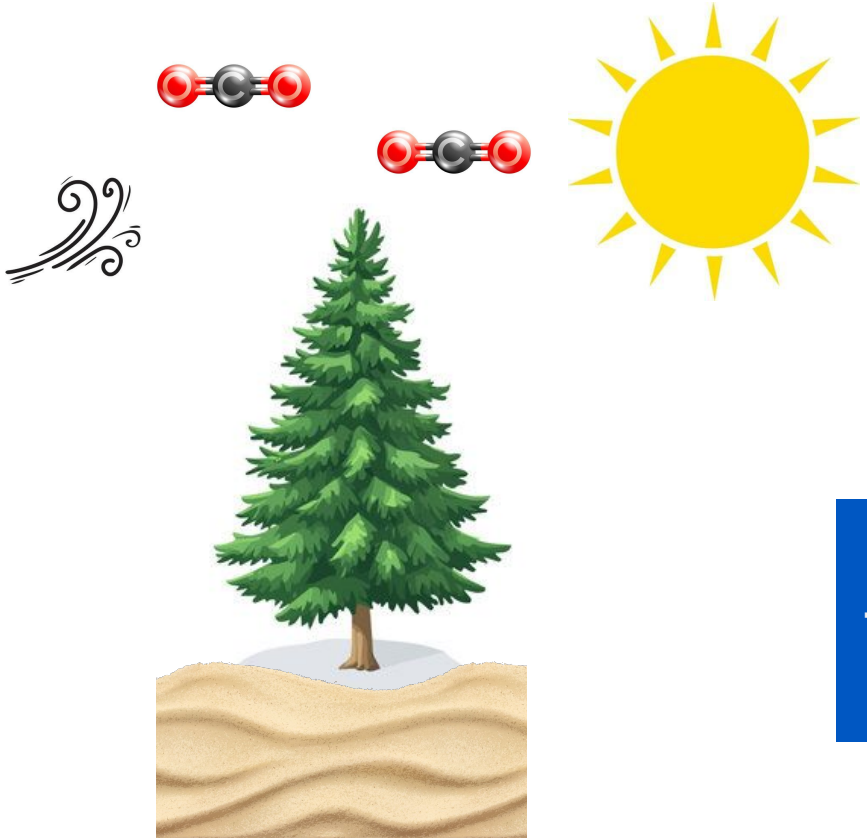
- Meteorology
- Surface dataset
- Secondary forcing
- Numerous key state variables

What do we need to predict photosynthesis?



- Meteorology
- Surface dataset
- Secondary forcing
- Numerous key state variables
  - leaf area
  - soil moisture
  - …

What do we need to predict photosynthesis?



- Meteorology
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Utilize the results from the previous timestep

Point to a restart file

module load nco
ncks -m example_case.clm2.r.0041-01-01-00000.nc | grep long_name

```
FSUN24_PERIOD:long_name = "" ;
FSUN24_VALUE:long_name = "24hr average of diffuse solar radiation" ;
FWET:long_name = "fraction of canopy that is wet (0 to 1)" ;
GDD0_NSTEPS:long_name = "number of accumulated steps for GDD0" ;
GDD0_PERIOD:long_name = "" ;
GDD0_VALUE:long_name = "growing degree-days base 0C from planting" ;
GDD10_NSTEPS:long_name = "number of accumulated steps for GDD10" ;
GDD10_PERIOD:long_name = "" ;
GDD10_VALUE:long_name = "growing degree-days base 10C from planting" ;
GDD8_NSTEPS:long_name = "number of accumulated steps for GDD8" ;
GDD8_PERIOD:long_name = "" ;
GDD8_VALUE:long_name = "growing degree-days base 8C from planting" ;
GDDPLANT_NSTEPS:long_name = "number of accumulated steps for GDDPLANT" ;
GDDPLANT_PERIOD:long_name = "" ;
GDDPLANT_VALUE:long_name = "growing degree-days from planting" ;
GDDTSOI_NSTEPS:long_name = "number of accumulated steps for GDDTSOI" ;
GDDTSOI_PERIOD:long_name = "" ;
GDDTSOI_VALUE:long_name = "growing degree-days from planting (top two soil layers)" ;
GSSHA:long_name = "shaded leaf stomatal conductance" ;
GSSHALN:long_name = "shaded leaf stomatal conductance averaged over 1 hour before to 1 hour after local noon" ;
GSSUN:long_name = "sunlit leaf stomatal conductance" ;
GSSUNLN:long_name = "sunlit leaf stomatal conductance averaged over 1 hour before to 1 hour after local noon" ;
H2OCAN:long_name = "canopy water" ;
H2OSFC:long_name = "surface water" ;
H2OSNO:long_name = "snow water" ;
H2OSOI_ICE:long_name = "ice lens" ;
H2OSOI_LIQ:long_name = "liquid water" ;
```

Point to a restart file

controlled by a CTSM namelist variable: ‘finidat’

grep finidat ~/cases/i1850_sp.basics/CaseDocs/lnd_in

finidat =
'/glade/campaign/cesm/cesmdata/inputdata/lnd/clm2/initdata_esmf/ctsm5.4/ctsm5.4.CMIP7_ciso_ctsm5.3.075_SP_f09_127_1850.clm2.r.0102-01-01-00000.nc'

Can be set:

- in user_nl_clm
- using the RUN_REFCASE xml variable
- in an input_data_list, that is referenced when you call ./case.build or ./preview_namelists

grep finidat ~/cases/i2000_fates_sp.basics/CaseDocs/lnd_in

finidat = ' '

Run from COLD START

in case you don’t have a good restart file

grep finidat ~/cases/i2000_fates_sp.basics/CaseDocs/lnd_in

finidat = ' '

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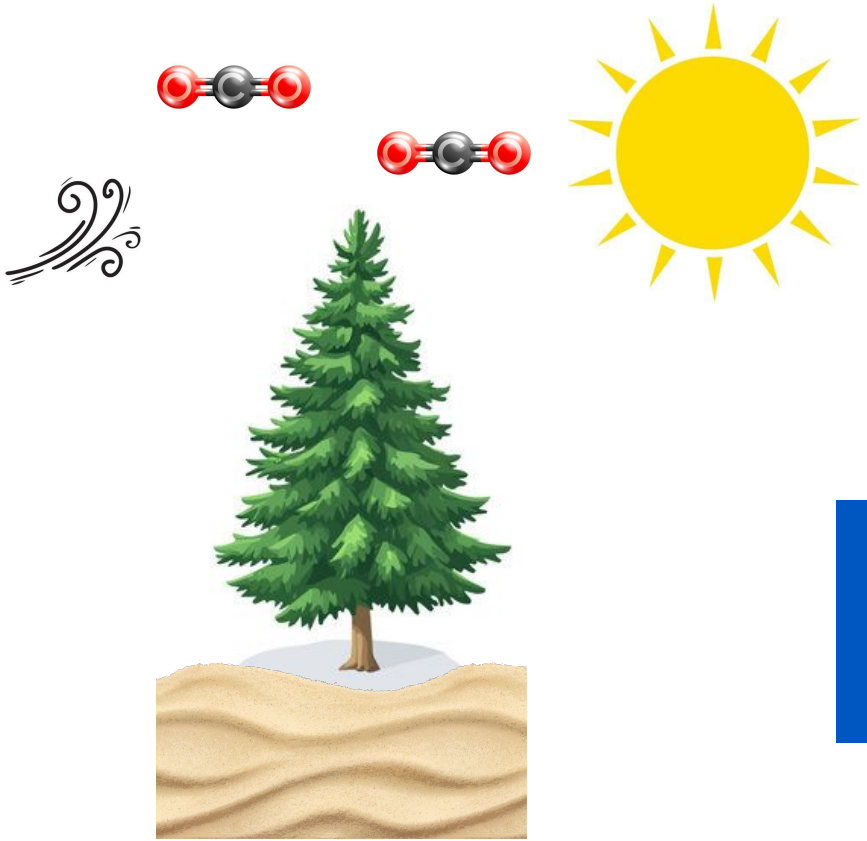
CTSM source code contains logic to
define initial values to all the state variables

CTSM / src / biogeophys / CanopyStateType.F90

Code Blame 667 lines (551 loc) · 30.2 KB

```
512     !------------------------------------------------------------------------
513     subroutine InitCold(this, bounds)
514       !
515       ! !ARGUMENTS:
516       class(canopystate_type) :: this
517       type(bounds_type), intent(in) :: bounds
518       !
519       ! !LOCAL VARIABLES:
520       integer  :: p,l,c,g
521       !------------------------------------------------------------------------
522
523       do p = bounds%begp, bounds%endp
524          l = patch%landunit(p)
525
526          this%tlai_patch(p)        = 0._r8
527          this%tsai_patch(p)        = 0._r8
528          this%elai_patch(p)        = 0._r8
529          this%esai_patch(p)        = 0._r8
530          this%stem_biomass_patch(p)= 0._r8
531          this%leaf_biomass_patch(p)= 0._r8
532          this%htop_patch(p)        = 0._r8
533          this%hbot_patch(p)        = 0._r8
534          this%vegwp_patch(p,:)     = -2.5e4_r8
```

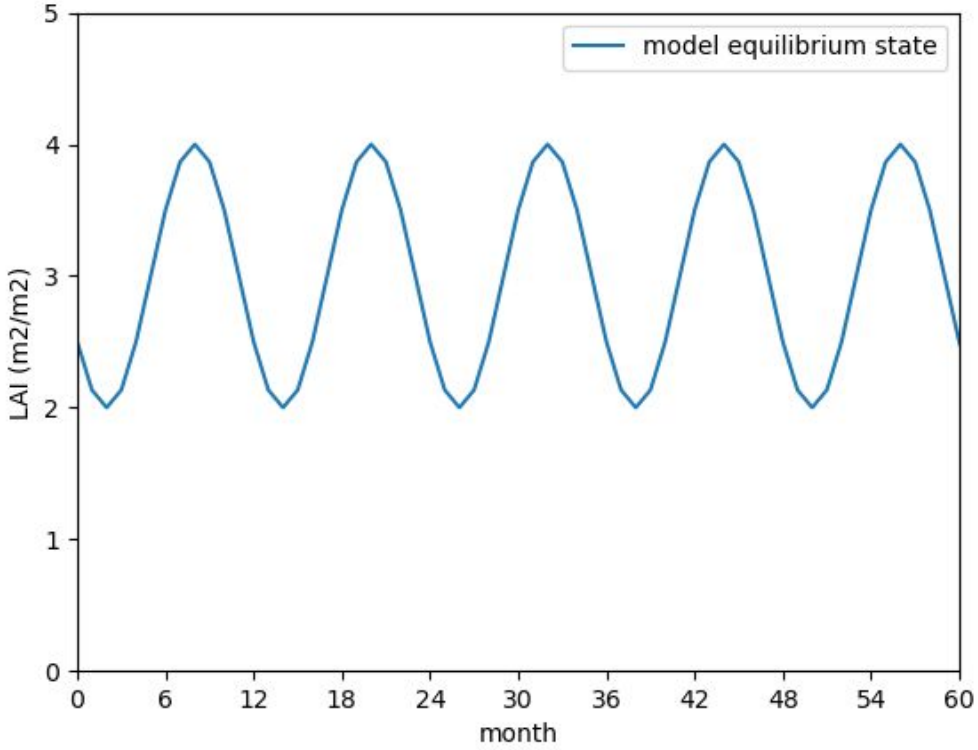
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- Surface dataset
- Secondary forcing
- Numerous key state variables
  - leaf area
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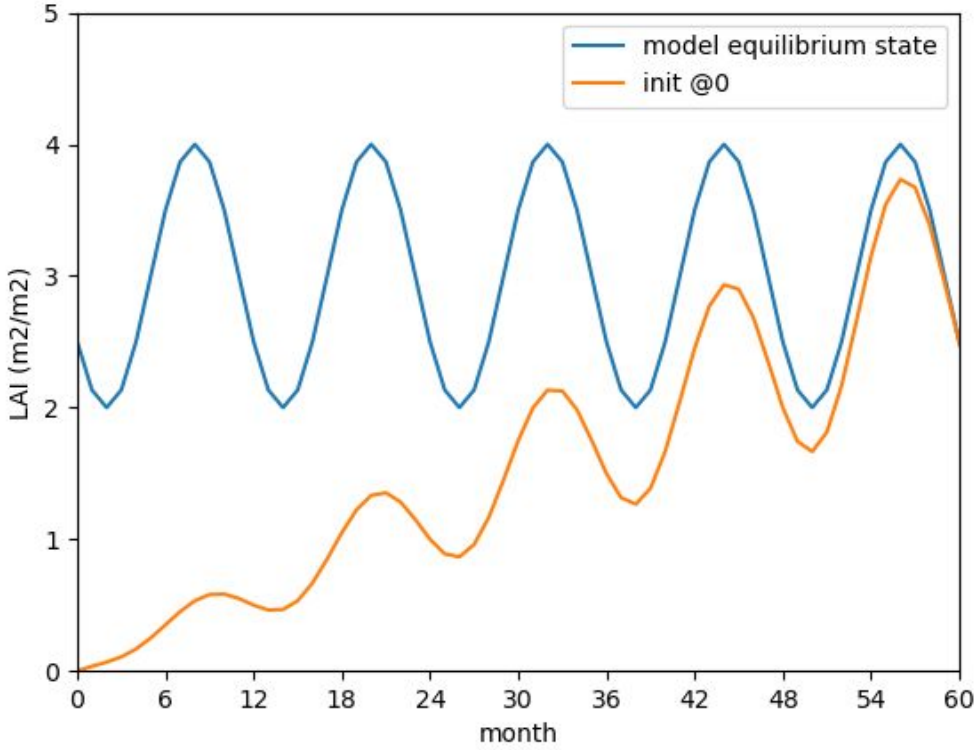
Initiate from cold start

Cold start in practice



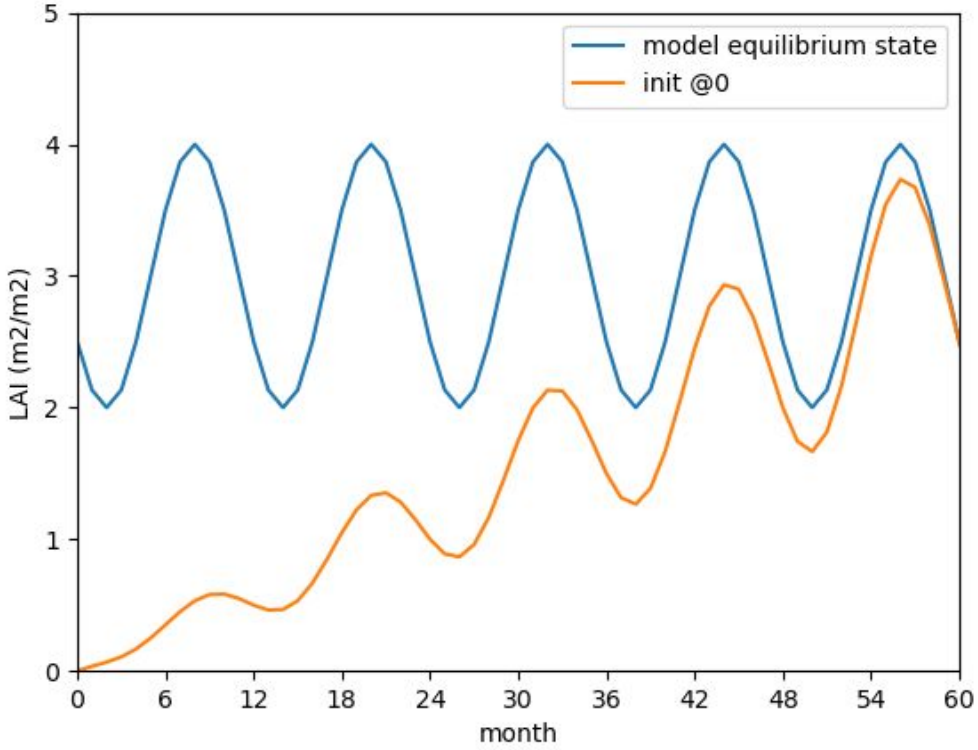
- Run the same forcing for many years, CLM will eventually reach an equilibrium state

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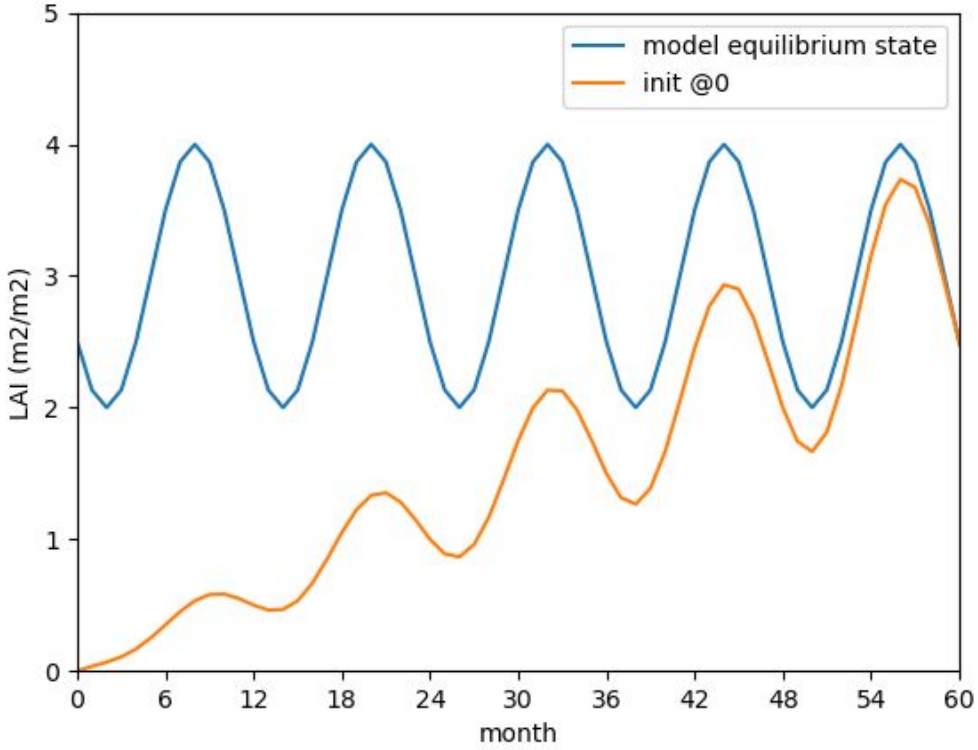
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- Same forcing, but initialize at 0

Cold start in practice



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- Apparent trend (drift)

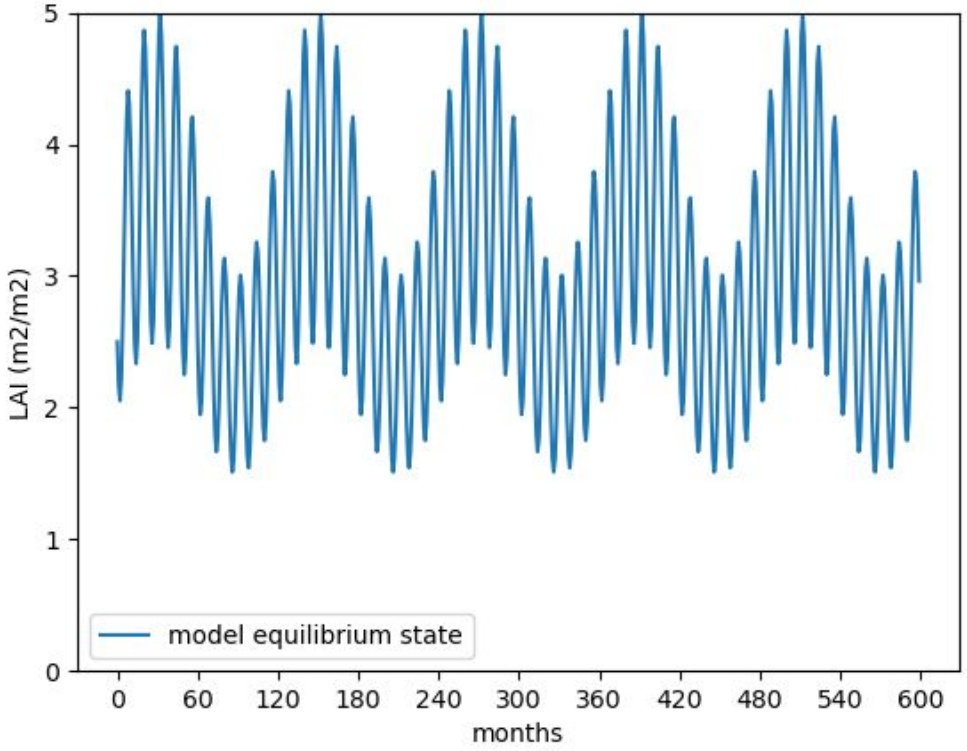
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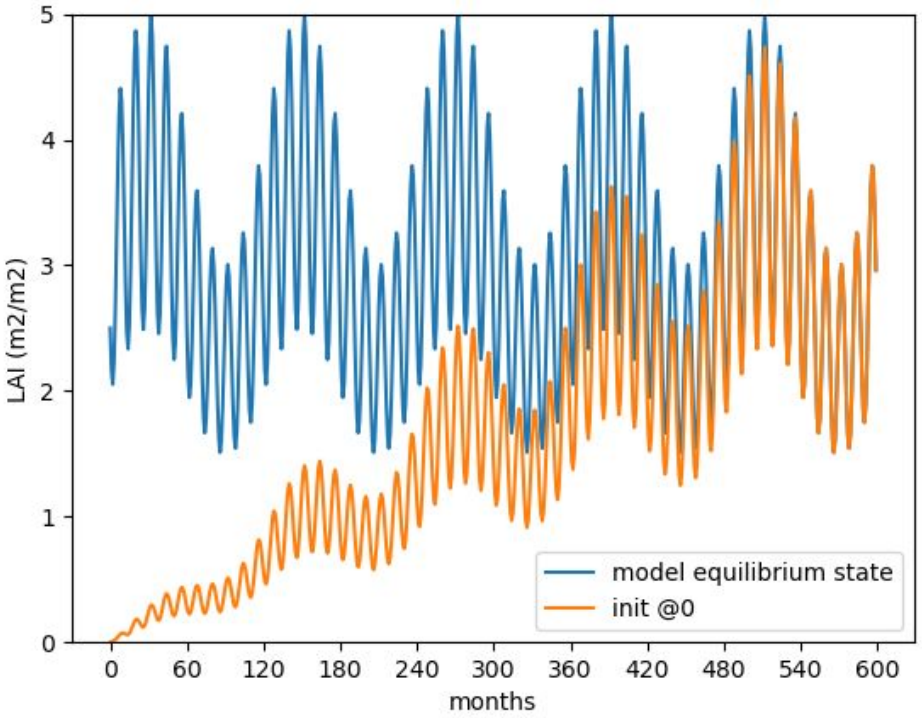
could we just make a better initial guess?

Cold start in practice



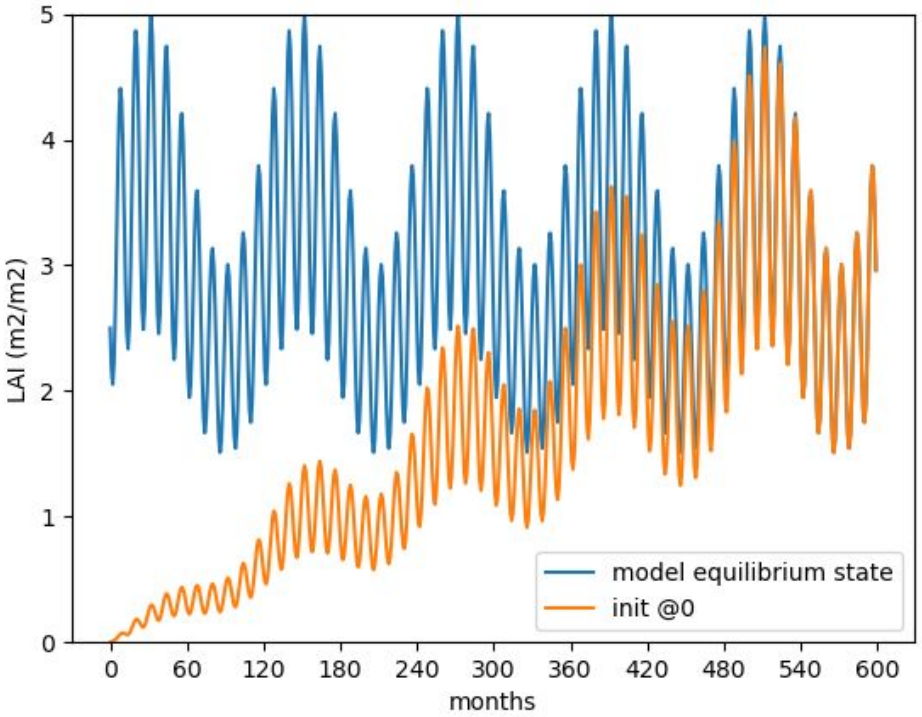
- We usually cycle over 10 or 20 years, instead of just repeating one year

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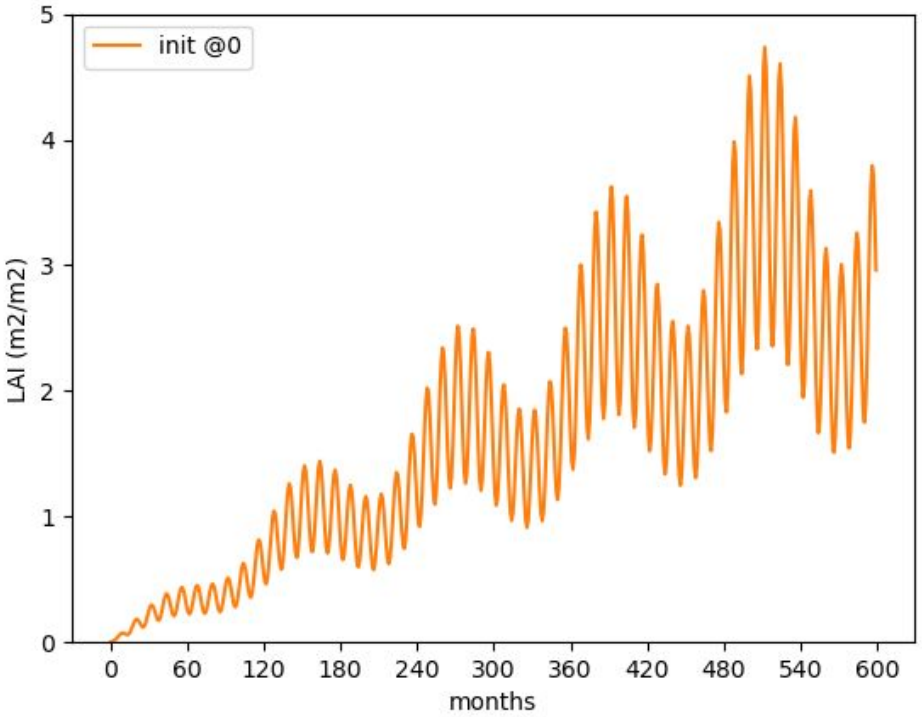
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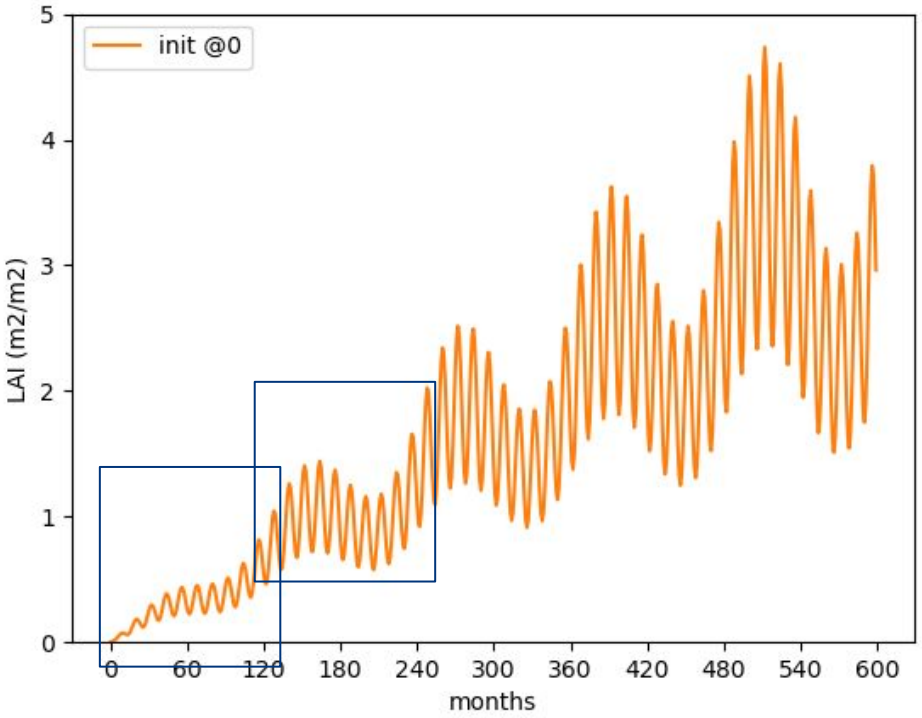
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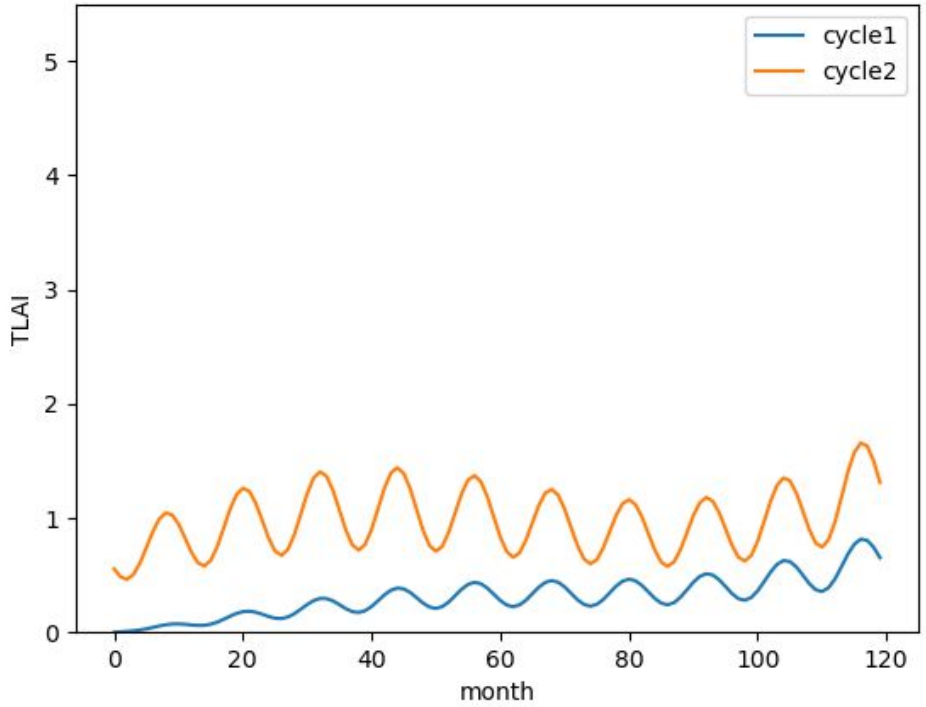
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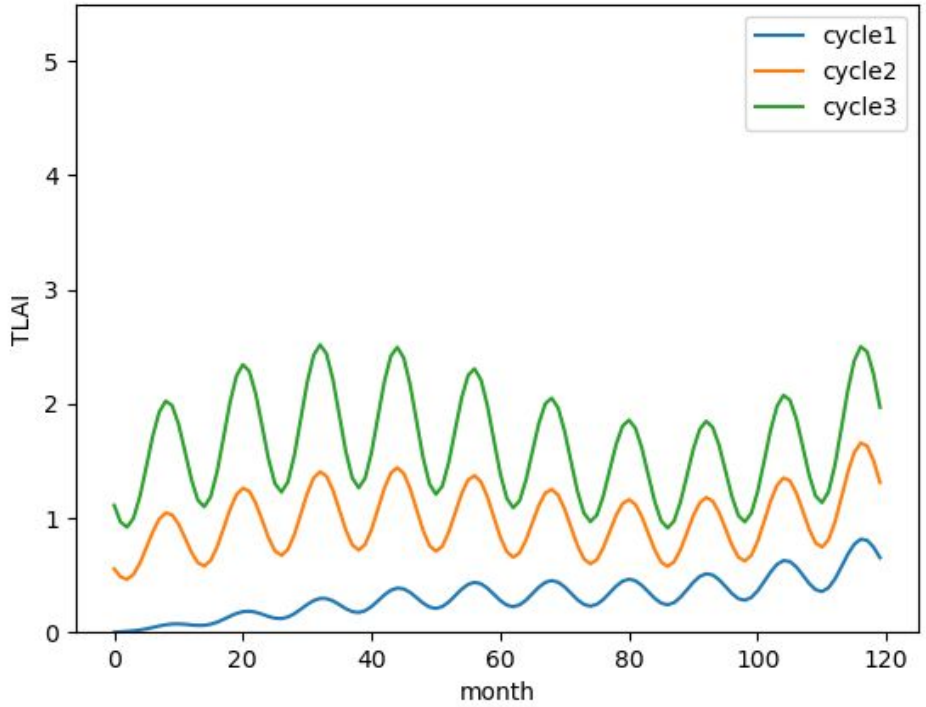
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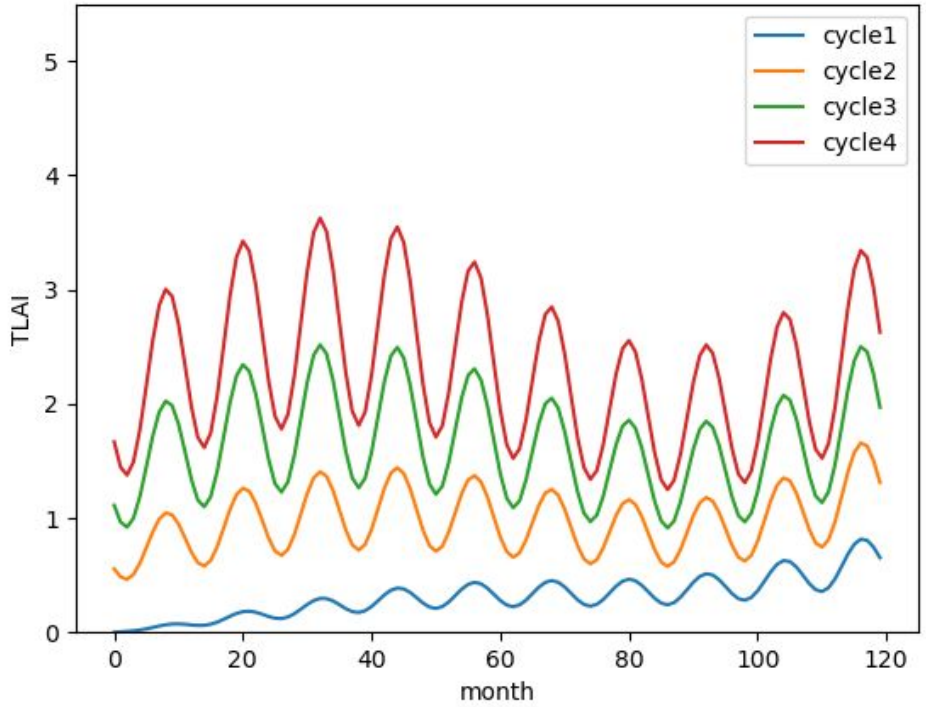
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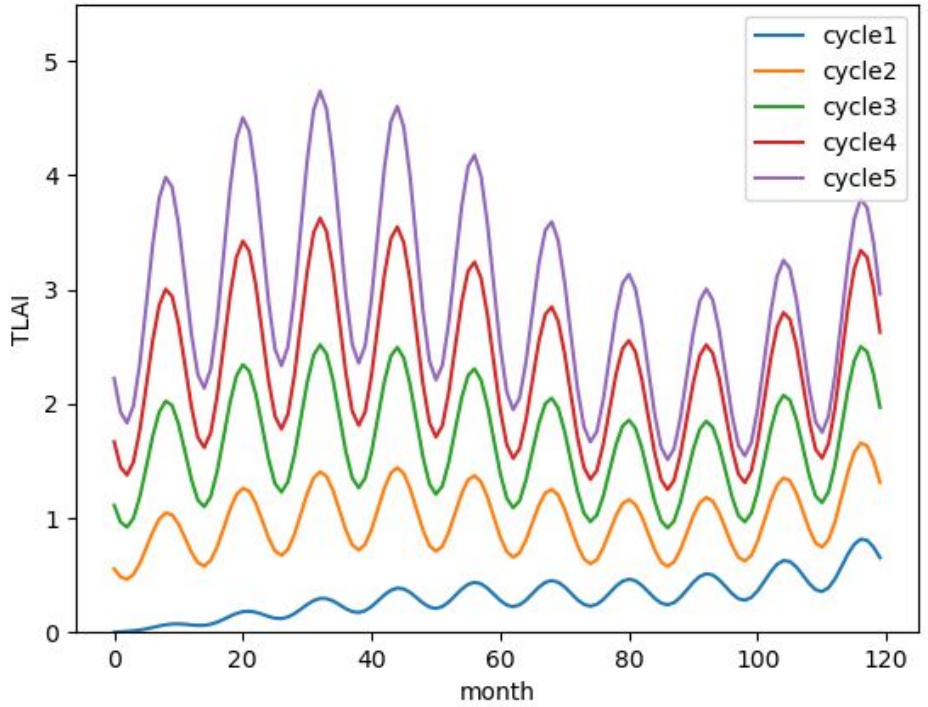
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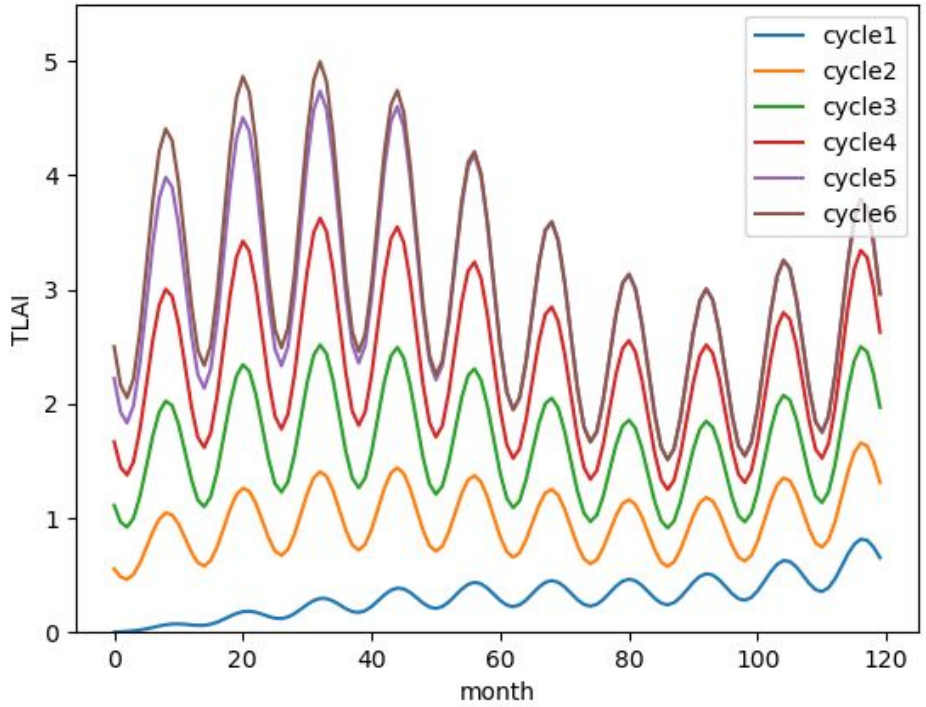
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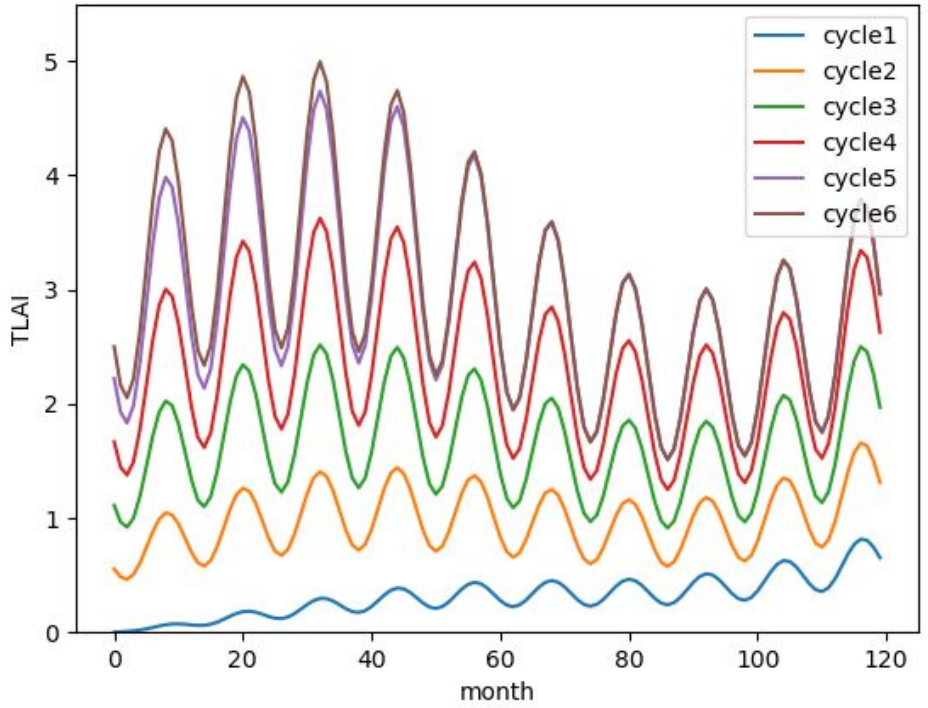
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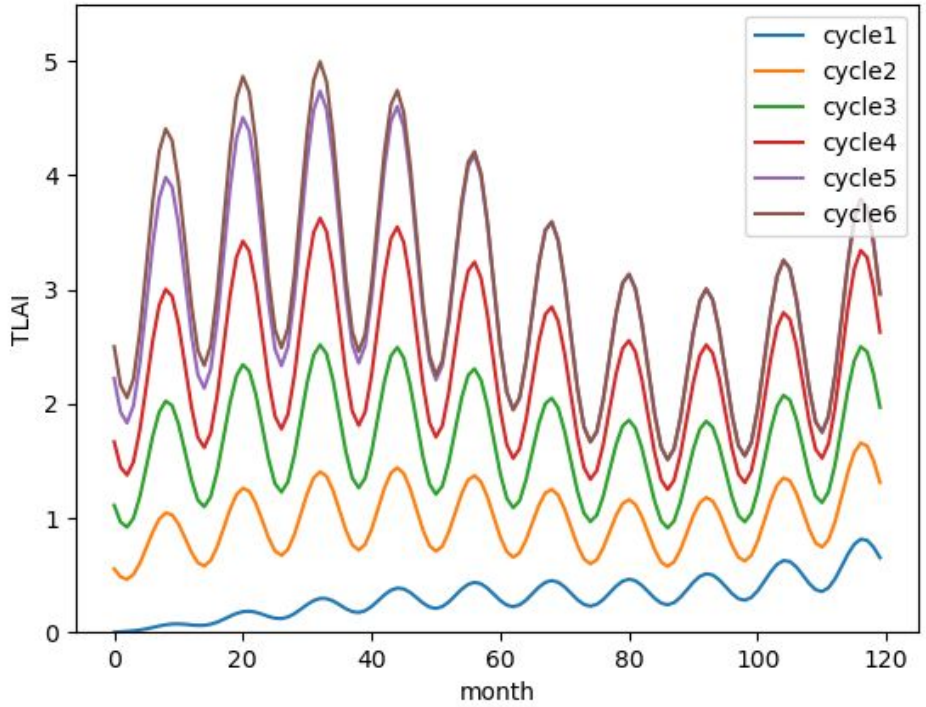
Cold start in practice



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cycle forcing very helpful for discerning equilibrium status

Cold start in practice



- We usually cycle over 10 or 20 years, instead of just repeating one year
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- Compare one cycle to the next, continue until the delta is small

Now you might create a hybrid case pointing to the restart from cycle6

SPINUP

A simulation to generate model initial conditions, often by cycling over a given forcing dataset until some equilibrium criteria are satisfied

When do we spin up?

- New forcing dataset
- New parameterization
- New parameter values
- New resolution
- …

Does not need to be from cold start



How many laps around the track?



Wide range

- Soil water (tens of years)
- Leaf area (hundred)
- Soil carbon (thousands)
    - [varies by region]

How many laps around the track?



Wide range

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Lower complexity modes spin up faster

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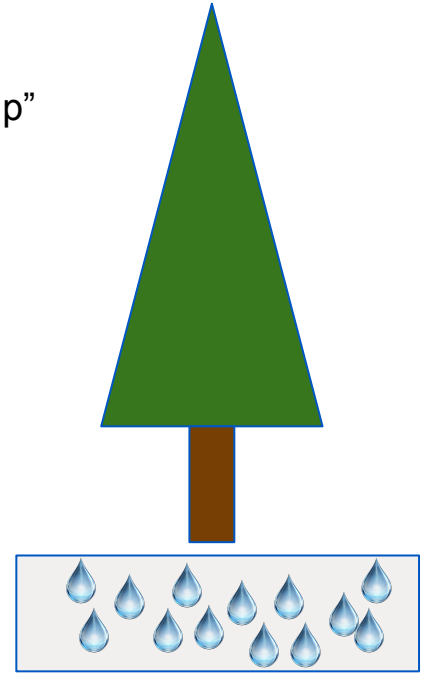
Special model configurations to spin up soils faster

- Accelerated Decomposition
  - `./xmlchange CLM_ACCELERATED_SPINUP='on'`
- Semi-analytical spin up (big-leaf only)
  - `./xmlchange CLM_ACCELERATED_SPINUP='sasu'`

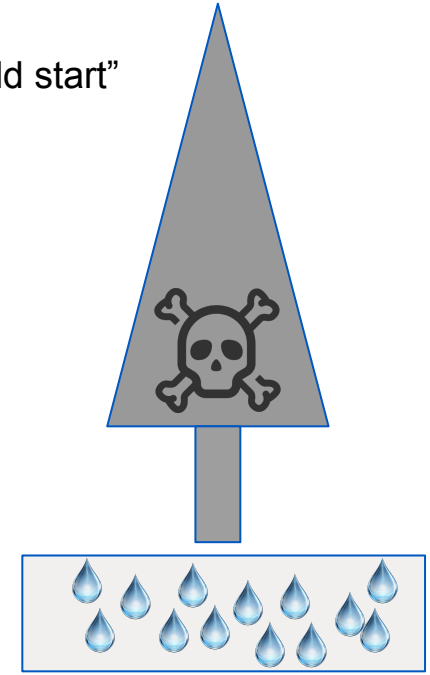
Equilibrated ≠ “correct”

But we generally assume it’s more “correct” than a disequilibrated state

“spun up”



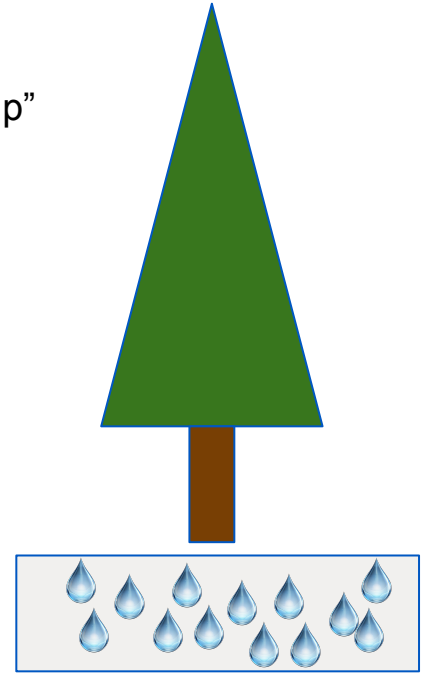
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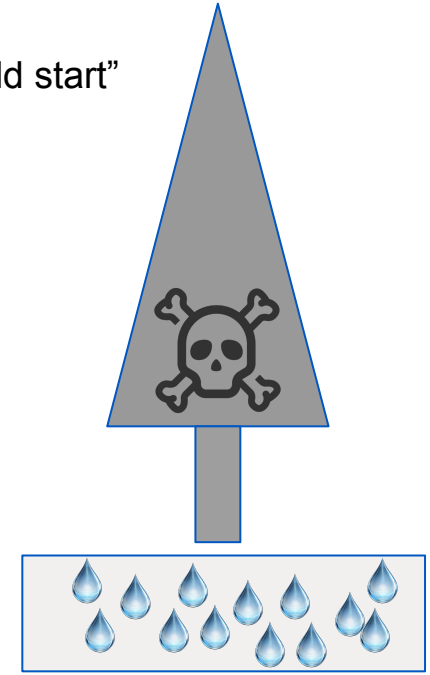
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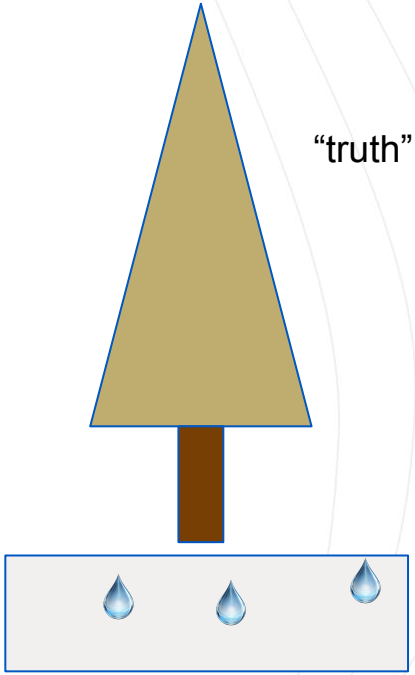
“spun up”



“cold start”



“truth”



Equilibrated ≠ “correct”

Single point simulation to compare to flux tower data (2001-2020)

How to generate initial conditions for year 2001?

- Cold start
- 20x Cycle 2001-2010 (AD on)
- 40x Cycle 2001-2010 (AD off)
- I2000 Compset

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1999 and 2000 weather may have been totally different from 2009 and 2010

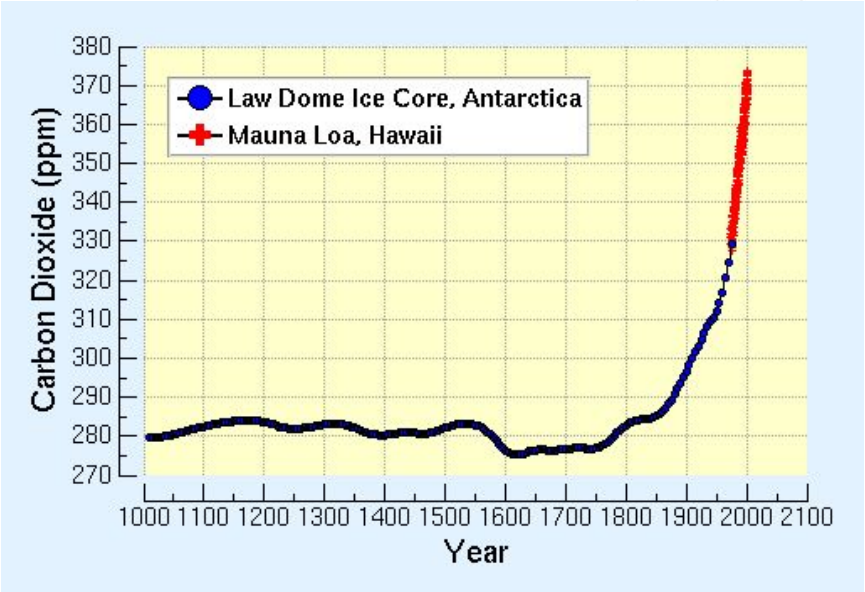
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600 years worth of 367ppm



Equilibrated ≠ “correct”

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Static land use data



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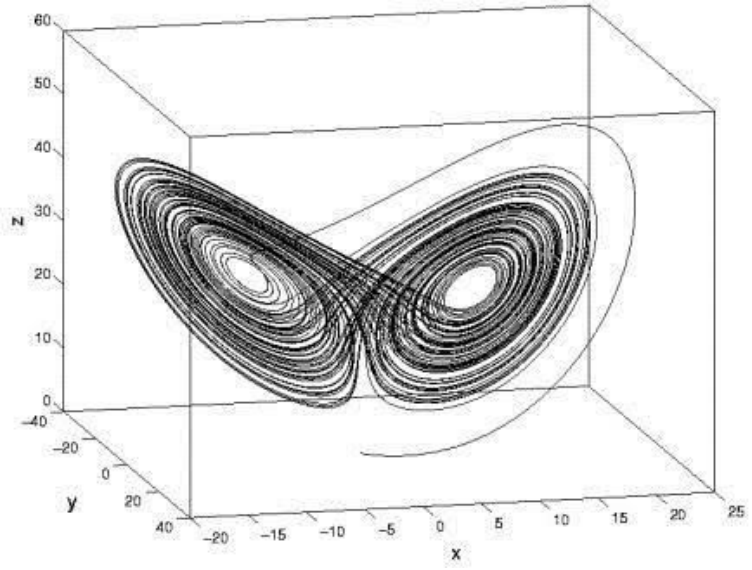
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- followed by
  - 1850-2000 IHIST

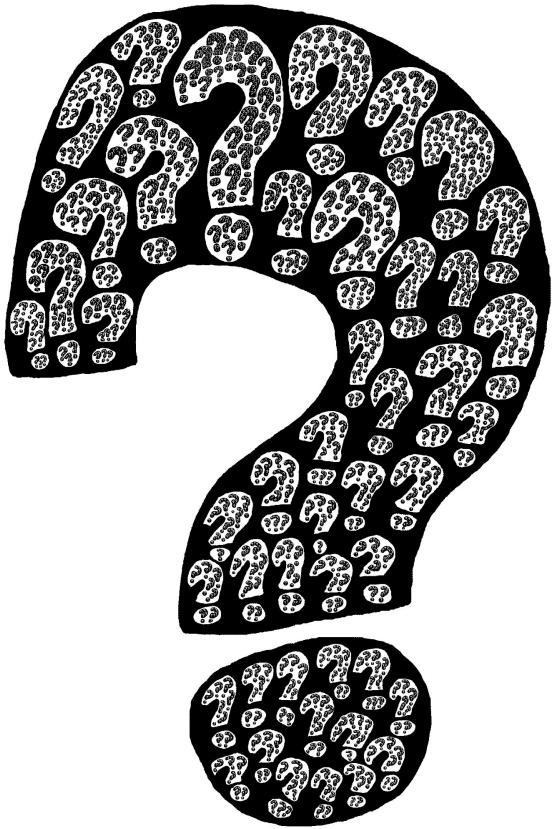
Try to make the lead in to the simulation look like the actual lead in to the simulation

Initial condition effects can be large



- Take a minute to think about initial conditions
- Are they consistent with the upcoming simulation?
  - model
  - resolution
  - parameters
  - forcing
- Can you measure the ‘drift’?
- Is a transient lead-in more appropriate than cycled?
- Can be fun to run an IC ensemble :)

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