Advanced ParFlow Short Course
CLM Activities

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Common Land Model

Activity 1: Finding Variables

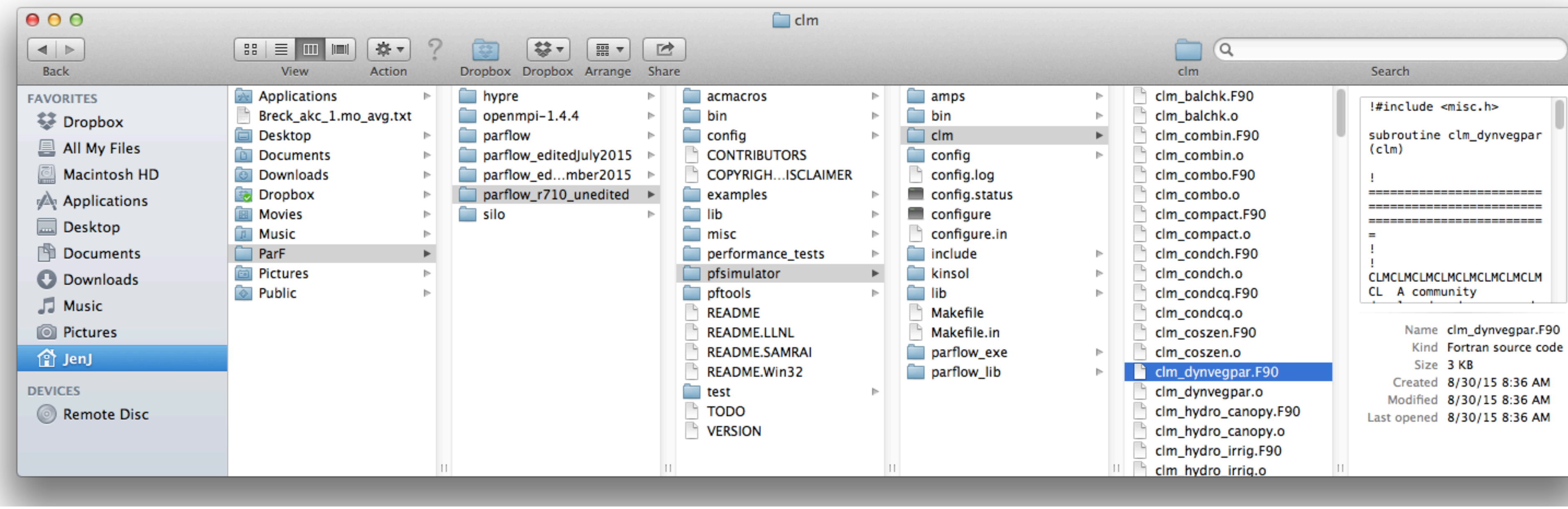
Developed by:
Jennifer Jefferson

Why should you know how to find variables in the CLM code?

- Inevitably, someone will ask: “How does the model compute *x*?”
- You want to change how the model computes *x*
- You want to know where a variable from the input file is used

Where do you search for variables?

pfsimulator – clm folder includes all CLM .F90 modules
parflow_lib folder includes solver_richards.c



How do you search for a variable?

(on a Mac)

- Type in name to search bar in Finder window
- Use `grep` (global regular expression print) command from terminal window

Variations of `grep`

- http://www.gnu.org/software/grep/manual/grep.htm

- -l list names of files
- -r recursively look through files in a given directory
- * wildcard symbol

- `grep` command is very similar on Linux
  http://www.tecmint.com/12-practical-examples-of-linux-grep-command/

  http://www.computerhope.com/unix/ugrep.htm

Let’s do an example:

sand

(from drv_vegm.dat)

1. Navigate to director to search in

2. Search for “sand” in Fortan files within the directory

```
clm — bash — 129×24
bash                                   bash
Last login: Tue May 17 09:51:53 on ttys000
Sonyas-MacBook-Air:pfsimulator JenJ$ cd /Users/JenJ/ParF/parflow_r710_unedited/pfsimulator/clm
Sonyas-MacBook-Air:clm JenJ$ grep "sand" *.F90
drv_clmini.F90:!@      clm%watsat(j) = 0.489 - 0.00126*tile%sand(j)*100.0 Stefan: followed Reed to make it consistent with PILPS
drv_clmini.F90:        xksat         = 0.0070556 *( 10.**(-0.884+0.0153*tile%sand(j)*100.0))
drv_clmini.F90:        clm%sucsat(j) = 10. * ( 10.**(1.88-0.0131*tile%sand(j)*100.0) )
drv_clmini.F90:        tkm           = (8.80*tile%sand(j)*100.0+2.92*tile%clay(j)*100.0) /  &
drv_clmini.F90:                        (tile%sand(j)*100.0+tile%clay(j)*100.0)          ! W/(m K)
drv_clmini.F90:        clm%csol(j)   = (2.128*tile%sand(j)*100.0+2.385*tile%clay(j)*100.0)/ &
drv_clmini.F90:                        (tile%sand(j)*100.0+tile%clay(j)*100.0)*1.e6     ! J/(m3 K)
drv_gridmodule.F90:     real(r8) :: sand(nlevsoi) ! Percent sand in soil
drv_pout.F90:     write(n,5)'Percent SAND               lay: ', l, drv_gridave(nch,mask,tile%fgrd,tile%sand(l), drv)
drv_readvegtf.F90:  real(r8) :: sand          !temporary value of input sand
drv_readvegtf.F90:                sand,              &
drv_readvegtf.F90:       grid(c-ix,r-iy)%sand(:) = sand
drv_readvegtf.F90:                tile(drv%nch)%sand(:) = grid(c,r)%sand(:)   !Percent sand in soil
drv_tilemodule.F90:     real(r8) :: sand(nlevsoi) ! Percent sand in soil (vertically average)
Sonyas-MacBook-Air:clm JenJ$
```

Example (sand)

```
clm — bash — 119×24
bash | bash | bash
Last login: Tue May 17 14:21:23 on ttys001
Sonyas-MacBook-Air:clm JenJ$ cd /Users/JenJ/ParF/parflow_r710_unedited/pfsimulator/clm
Sonyas-MacBook-Air:clm JenJ$ grep "csol" *.F90
clm_main.F90:  !     csol,watsat,sucsat,bsw,tkmg,tksatu,tkdry,hksat,wtfact,trsmx0
clm_thermalk.F90:          cv(i) = clm%csol(i)*(1-clm%watsat(i))*clm%dz(i) +   &
clm_typini.F90:     clm(k)%csol  (:) = NaN      ! heat capacity, soil solids (J/m**3/Kelvin)
clmtype.F90:       real(r8) :: csol  (nlevsoi) ! heat capacity, soil solids (J/m**3/Kelvin)
drv_clmini.F90:         clm%csol(j)   = (2.128*tile%sand(j)*100.0+2.385*tile%clay(j)*100.0)/ &
drv_clmini.F90:         clm%csol(j)   = drv%udef
drv_pout.F90:      write(n,5)'Heat cap of soil soilds     lay: ', l, drv_gridave(nch,mask,tile%fgrd,clm%csol(l), drv)
Sonyas-MacBook-Air:clm JenJ$ grep "tkmg" *.F90
clm.F90:               clm(t)%tksatu(k)        = clm(t)%tkmg(k)*0.57**clm(t)%watsat(k)
clm_main.F90:  !     csol,watsat,sucsat,bsw,tkmg,tksatu,tkdry,hksat,wtfact,trsmx0
clm_thermalk.F90:                dksat = clm%tkmg(i)*0.249**(fl*clm%watsat(i))*2.29**clm%watsat(i)
clm_typini.F90:     clm(k)%tkmg  (:) = NaN      ! thermal conductivity, soil minerals  [W/m-K]
clmtype.F90:       real(r8) :: tkmg  (nlevsoi) ! thermal conductivity, soil minerals  [W/m-K]
drv_clmini.F90:         clm%tkmg(j)   = tkm ** (1.- clm%watsat(j))
drv_clmini.F90:         clm%tksatu(j) = clm%tkmg(j)*0.57**clm%watsat(j)
drv_clmini.F90:         clm%tkmg(j)   = drv%udef
drv_pout.F90:      write(n,5)'Thermal conduct of soil min lay: ', l, drv_gridave(nch,mask,tile%fgrd,clm%tkmg(l), drv)
Sonyas-MacBook-Air:clm JenJ$
```

Example (sand)

Variable Name	sand
Description	percent sand in soil
Units	decimal (-)
Global or Local variable	global
Constant or varying?	Constant for each tile, can vary between tiles
CLM Modules	drv_clmini.F90 drv_gridmodule.F90 drv_pout.F90 drv_readvegtf.F90 drv_tilemodule.F90
If/Do statements?	For every soil layer (nlevsoi)
Additional comments	Sand used to compute variables clm%tkmg, clm%csol -> clm_thermalk.F90 -> heat capacity for ground heat flux

You do: Pick variable(s) you might be interested in, use `grep` command to find out more information

Vegetation	Ground	Atmosphere
efpot	eflx_evap_soi	forc_hgt_t
eflx_evap_tot	surfalb	hsub
fdry	zsno	displa
qflx_through	csoilc	co2, pco2
seasb	t_soisno	forc_pbot

You do: Find information about variable(s)

Variable Name	
Description	
Units	
Global or Local variable	
Constant or varying?	
CLM Modules	
If/Do statements?	
Additional comments	

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Variable Name	
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If/Do statements?	
Additional comments	

Tips

- Make sure lines are not commented out (!)
- Code updates are typically annotated with developers initials, for example:
  - RMM = Reed Maxwell
  - IMF = Ian Ferguson
  - NBE = Nick Engdahl
- Be careful of rabbit holes - some variables are more difficult to track down and follow than others
  - Find where variable is initialized
  - Look at flowchart to see order modules are called

Common Land Model

Activity 2: Testing Single Columns

Developed by:
Jennifer Jefferson

Note: Demo is for operation of PF-CLM from a local version installed on a Mac.

Why would you want to test CLM with single columns?

- Computationally cheaper than whole domain simulation
- Can quickly run simulation on laptop
- Isolate variable
- Obtain information about variable not output (by default) from CLM
- Isolate period of time or scenario
- Compare effect of change
- Clarify computation or conceptual understanding

Activity 2

(demo portion)

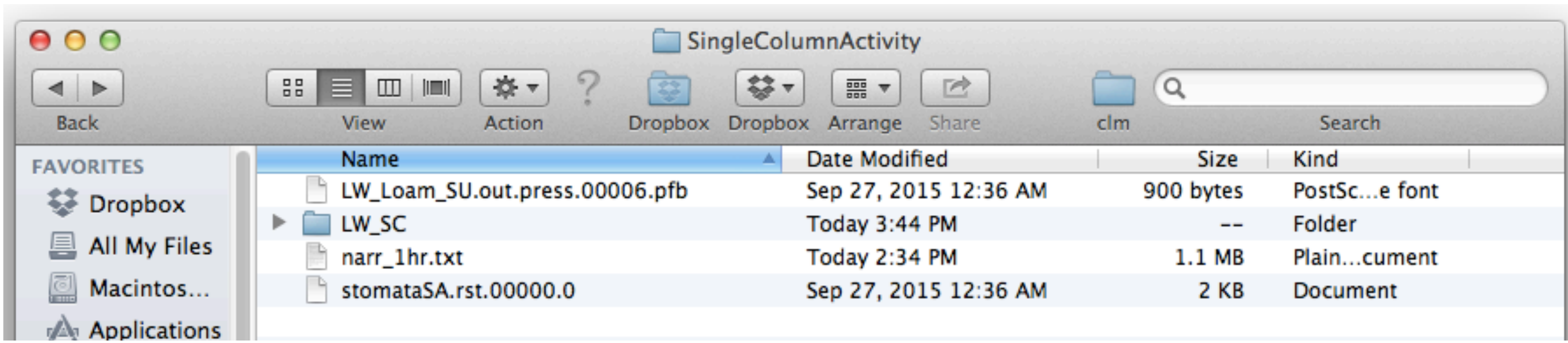
Goal: Output and plot 2 variables from CLM

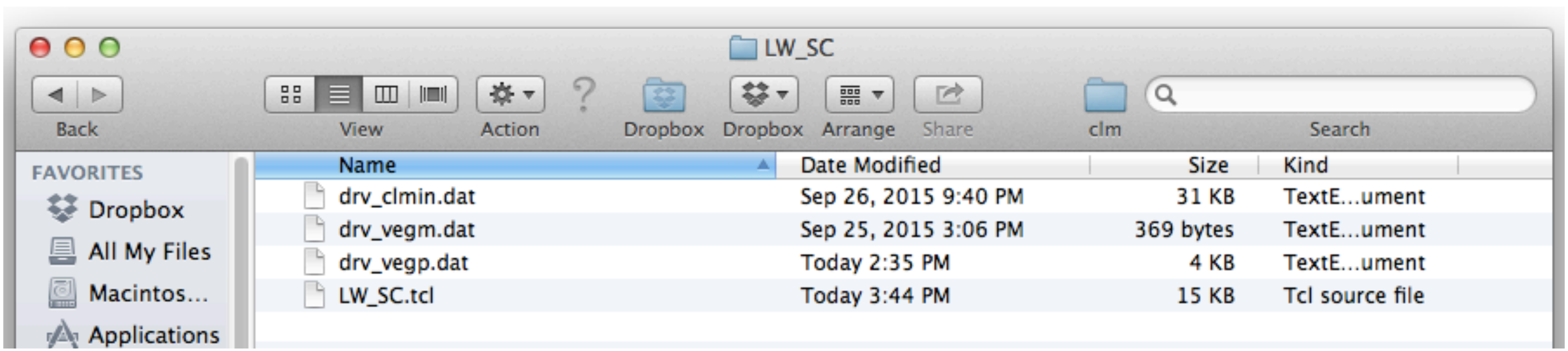
Variables of interest:

1. clm%btran – vegetation water stress (for transpiration)
2. taf – canopy air temperature

- Both variables are located in clm_leaftem.F90
- Neither variable is written out of the model

Step 1: Obtain (or locate) files in a folder called "SingleColumnActivity"

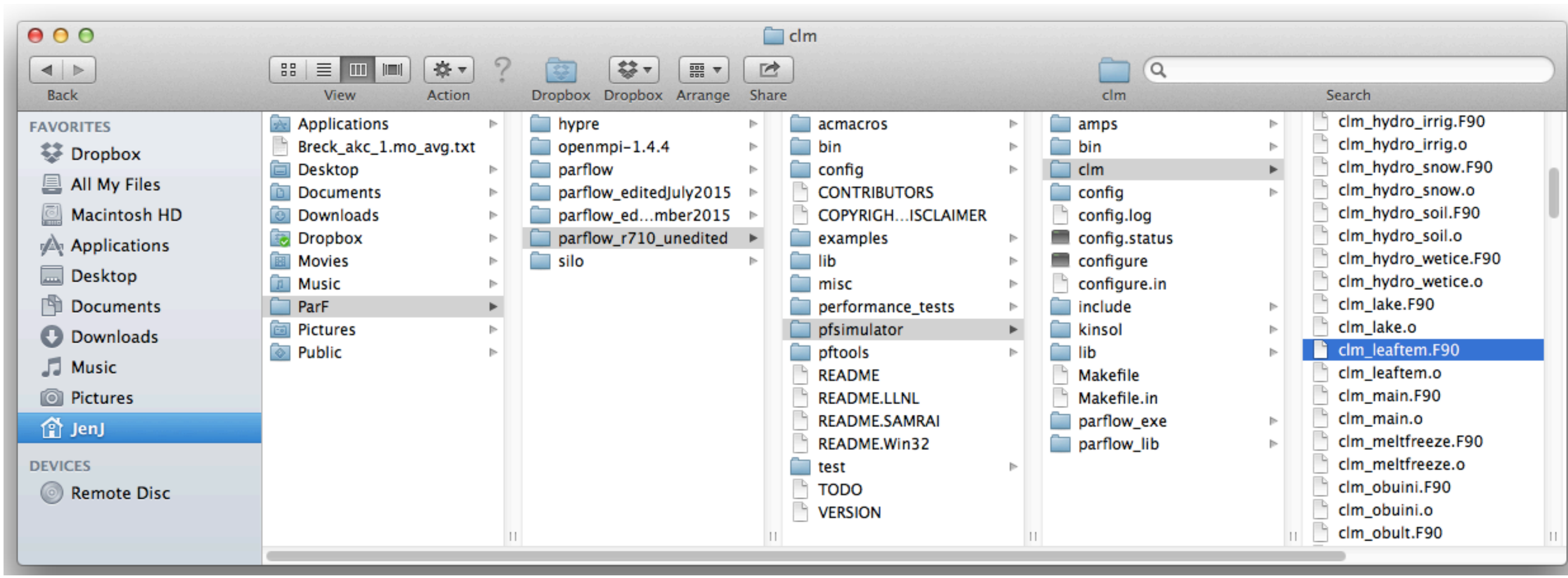




Put folder somewhere on your computer, but leave files in this arrangement.

Step 2: Add print statement to clm_leaftem.F90

- Navigate to clm_leaftem.F90



- Open the file and at the bottom of clm_leaftem.F90 add (will print to ...out.txt):

```
! Update dew accumulation (kg/m2)

clm%h2ocan = max(dble(0.),clm%h2ocan + (clm%qflx_tran_veg-clm%qflx_evap_veg)*clm%dtime)

print*,'111', clm%btran, taf

end subroutine clm_leaftem
```

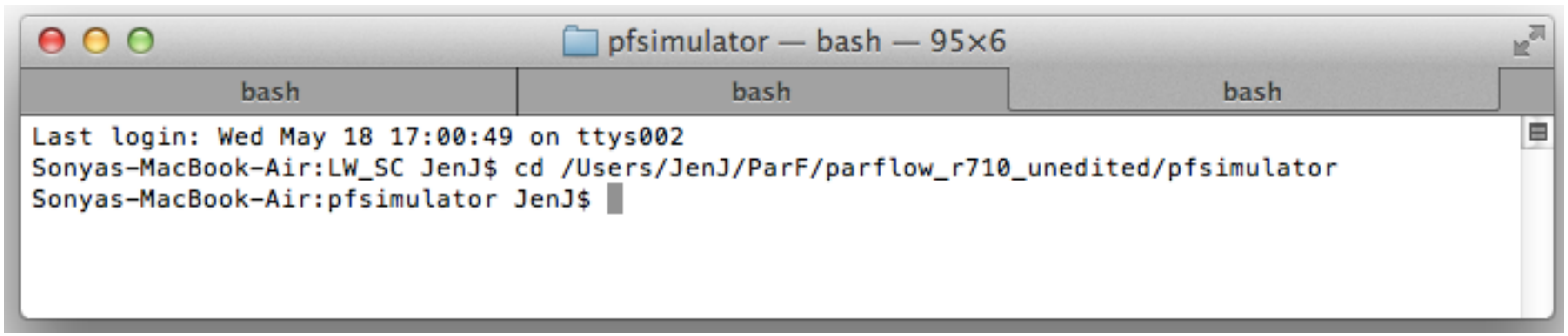
Tips

- Be thoughtful about placement of print statement
  - Not in a loop
  - Before final value is computed
- Select variables strategically so that you can make offline calculations
  - To duplicate output
  - Think ahead, if possible

Step 3: Recompile PF-CLM

- Open the terminal window
- Navigate to pfsimulator folder

  `cd ...`



- Recompile code by typing

  `make install`

Step 4: Run tcl script

- Open a new tab in the terminal window (command+t)
- Navigate to the “SingleColumnActivity – LW_SC” folder

```
cd ...
```

- Run tcl script

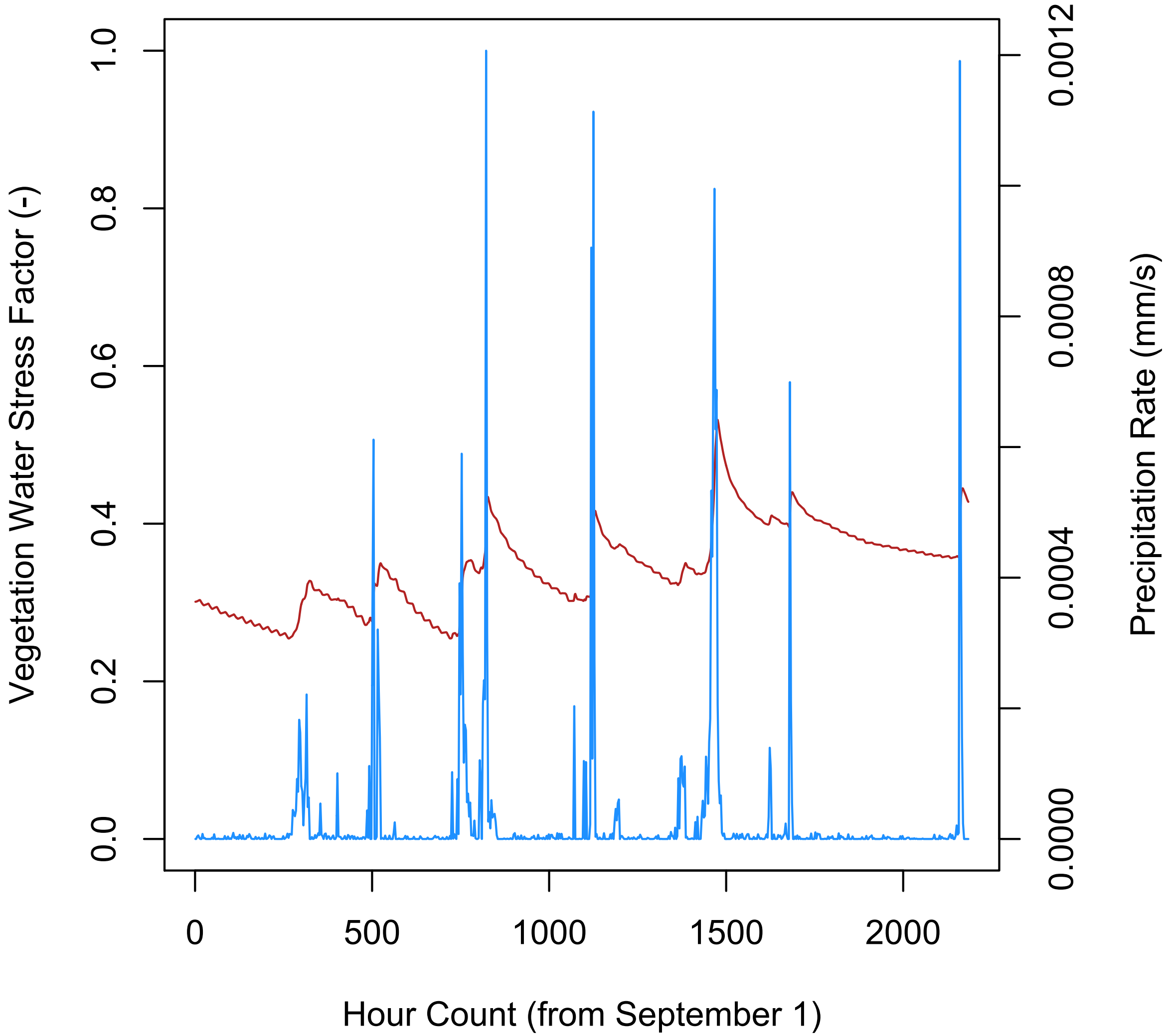
```
tclsh LW_SC.tcl
```

Step 5: Post-process data

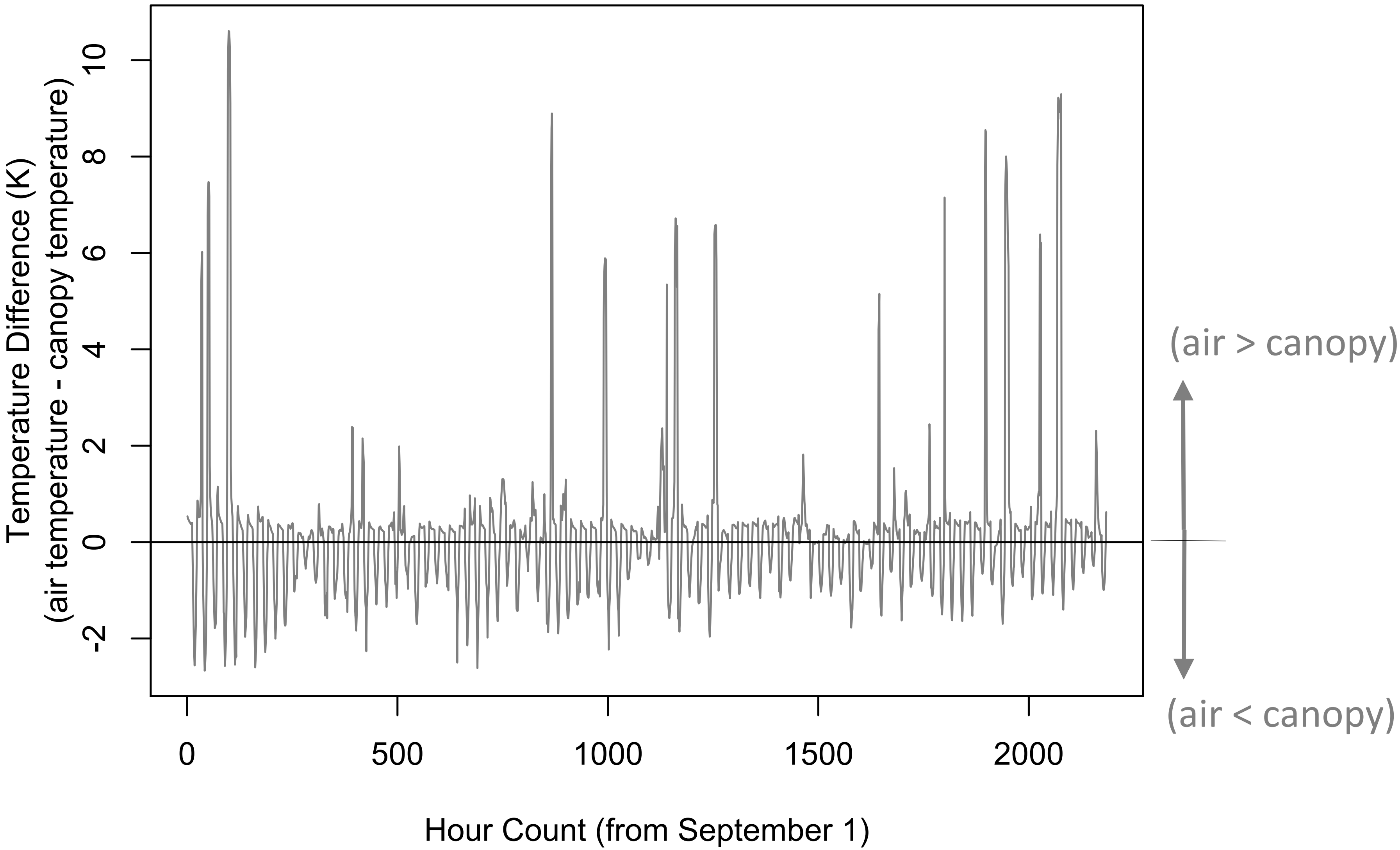
(I used R to load, compare and plot data)

(more moisture, does not limit photosynthesis as much)

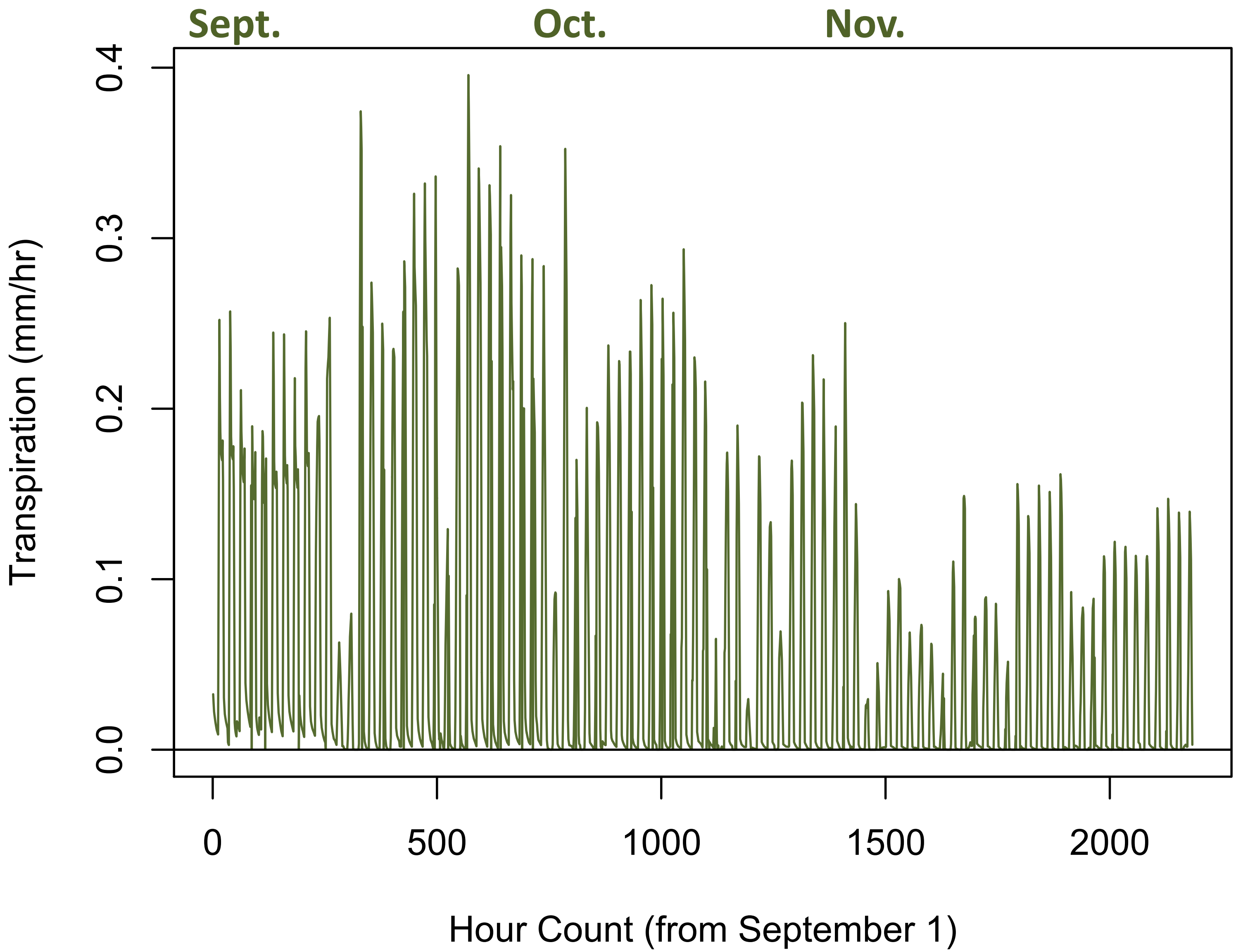
(less moisture, limits photosynthesis more)



Step 5: Post-process data



Step 5: Post-process data



Activity 2

(active portion)

Goal: Run a single column domain and plot variable from single file output

Example single column setup is provided:

1. .tcl script
2. (3) CLM files
3. 1D forcing file
   - Little Washita, OK
   - File begins on September 1, 1998 at 0 GMT (7pm CT August 31, 1998)
4. Pressure file
5. Restart file

(Some) Decisions to Make

1. How many time steps to simulate?

```
set stopt 2184.0

pfset TimingInfo.BaseUnit           1.0
pfset TimingInfo.StartCount         0
pfset TimingInfo.StartTime          0.0
pfset TimingInfo.StopTime           $stopt
pfset TimingInfo.DumpInterval       1.0
pfset TimeStep.Type                      Constant
pfset TimeStep.Value                     1.0
```

2. Restart or not?

```
#pfset ICPressure.Type                                 HydroStaticPatch
#pfset ICPressure.GeomNames                            domain
#pfset Geom.domain.ICPressure.Value                    -1.0
#pfset Geom.domain.ICPressure.RefGeom                  domain
#pfset Geom.domain.ICPressure.RefPatch                 z-upper

pfset ICPressure.Type                                 PFBFile
pfset ICPressure.GeomNames                            domain
pfset Geom.domain.ICPressure.FileName                 "LW_Loam_SU.out.press.00006.pfb"
pfdist "LW_Loam_SU.out.press.00006.pfb"
```

1. What CLM variable to plot?
   - See end of introduction slides for list and order