Phenology in the CLM

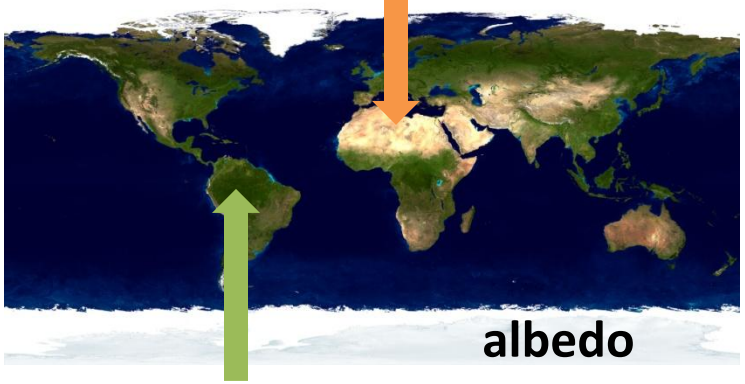
Kyla Dahlin

CLM Tutorial

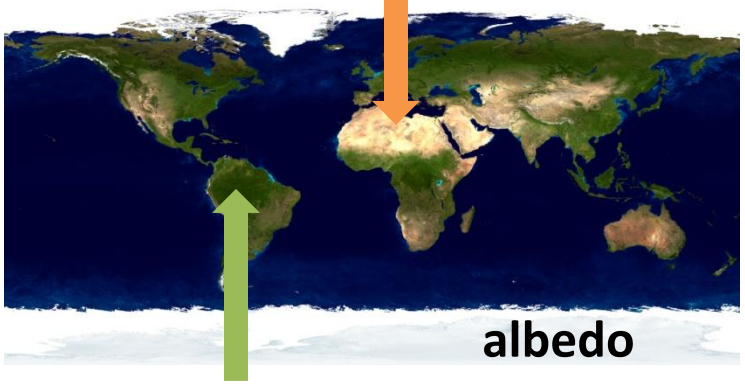
February 20, 2014

image credit: Forrest Copeland
talesfromthebigcountry.wordpress.com

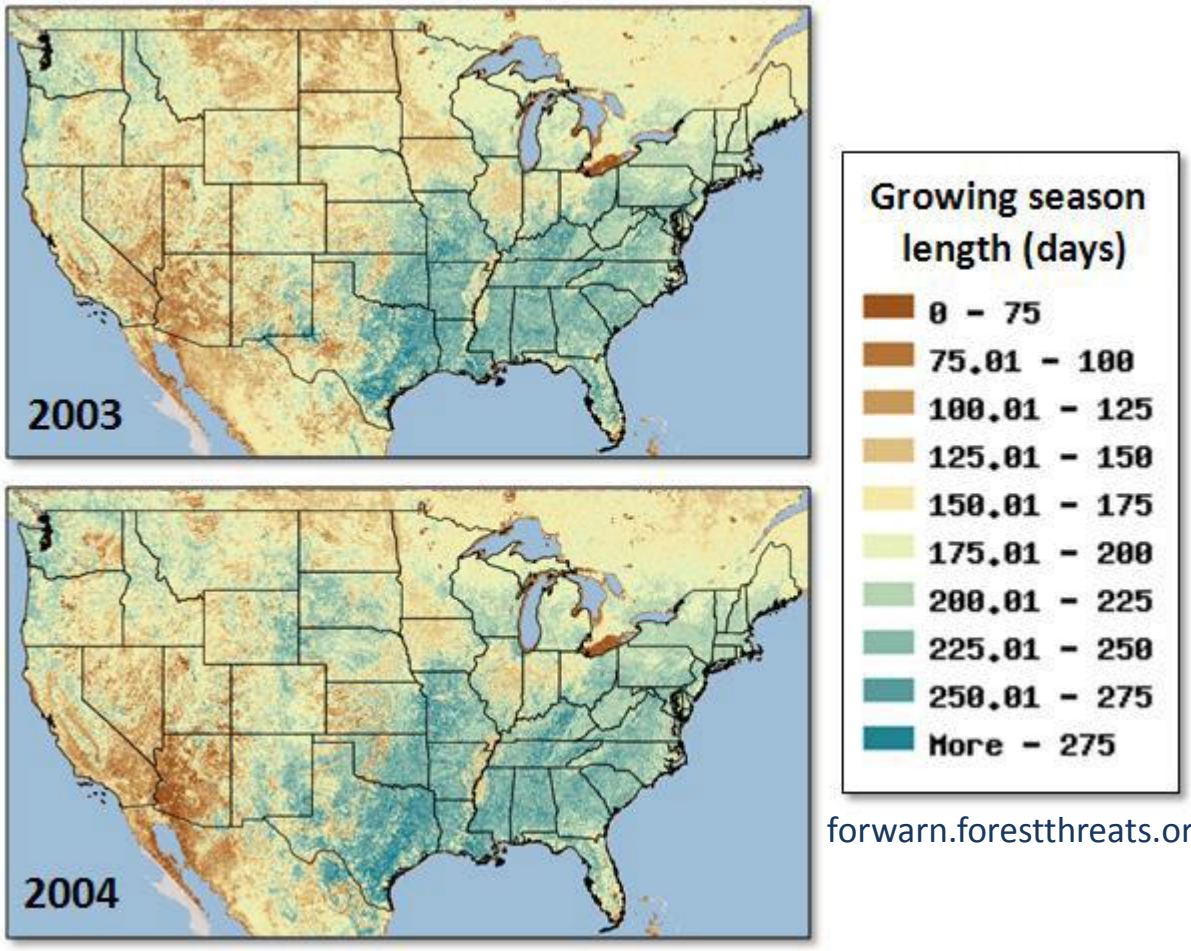
Plants matter to the climate!



Phenology matters to the climate!



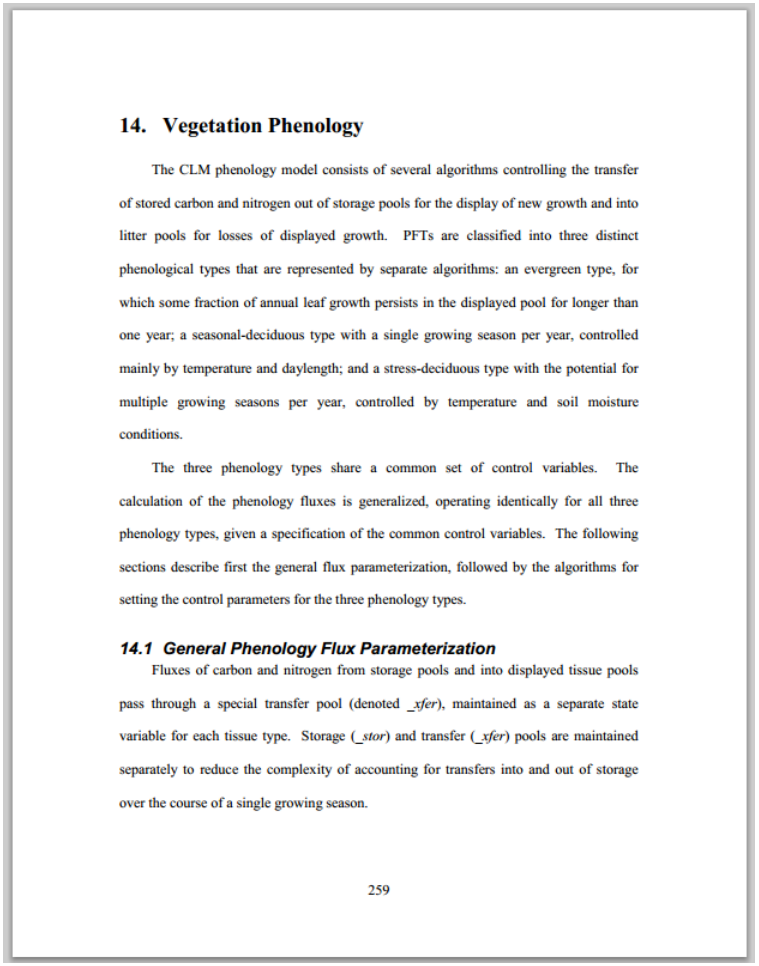
Satellites Measure Phenology



forwarn.forestthreats.org

How to Learn More…

http://www.cesm.ucar.edu/models/cesm1.2/clm/CLM45_Tech_Note.pdf



14. Vegetation Phenology

The CLM phenology model consists of several algorithms controlling the transfer of stored carbon and nitrogen out of storage pools for the display of new growth and into litter pools for losses of displayed growth. PFTs are classified into three distinct phenological types that are represented by separate algorithms: an evergreen type, for which some fraction of annual leaf growth persists in the displayed pool for longer than one year; a seasonal-deciduous type with a single growing season per year, controlled mainly by temperature and daylength; and a stress-deciduous type with the potential for multiple growing seasons per year, controlled by temperature and soil moisture conditions.

The three phenology types share a common set of control variables. The calculation of the phenology fluxes is generalized, operating identically for all three phenology types, given a specification of the common control variables. The following sections describe first the general flux parameterization, followed by the algorithms for setting the control parameters for the three phenology types.

14.1 General Phenology Flux Parameterization

Fluxes of carbon and nitrogen from storage pools and into displayed tissue pools pass through a special transfer pool (denoted *_xfer*), maintained as a separate state variable for each tissue type. Storage (*_stor*) and transfer (*_xfer*) pools are maintained separately to reduce the complexity of accounting for transfers into and out of storage over the course of a single growing season.

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Phenology in CLM

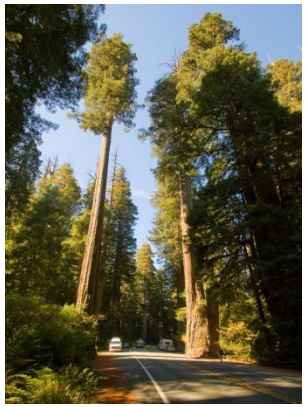
"The introduction of CN and its prognostic phenology as a standard way to run the model opens up exciting new avenues of research... Across much of the world, the correlations are high, indicating that the phenology scheme is reasonably representing the real world phenology. **However, there is clearly room for improvement with some regions showing low or even negative correlations**."

- Lawrence et al 2011 *JAMES*

Phenology in CLM

- **15** non-crop **plant functional types**
- **3** phenology algorithms
  - **evergreen**
  - cold deciduous
  - stress (= drought) deciduous

How does evergreen-ness work in CLM?

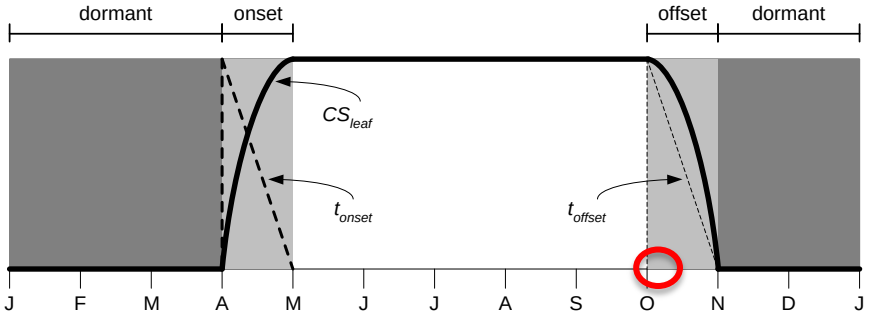


- All C and N allocated for growth in the current time step goes **immediately** to the displayed growth pool.
- **Litterfall** happens **continuously** as a function of leaf longevity (PFT specific).

Phenology in CLM

- **15** non-crop **plant functional types**
- **3** phenology algorithms
  - evergreen
  - **cold deciduous**
  - stress (= drought) deciduous

How does cold/seasonal decidousness work in CLM?



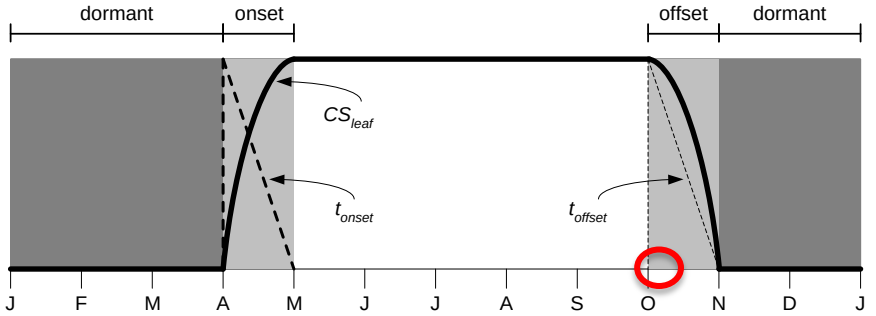
CLM4.5 Tech Note

- Start growing leaves if…
  - It's after the winter solstice and…
  - Temperature of 3rd soil layer is above freezing for an accumulation of days (# of days depends on avg. annual 2 m air temp)
- Onset period fixed at 30 days
- Start dropping leaves if…
  - Onset period is complete
  - Daylength is shorter than ~11 hrs
- Leaf drop period fixed at 15 days

Phenology in CLM

- **15** non-crop **plant functional types**
- **3** phenology algorithms
  - evergreen
  - cold deciduous
  - **stress (= drought) deciduous**

How does stress/drought decidousness work in CLM?
(in warm, long-day regions*)



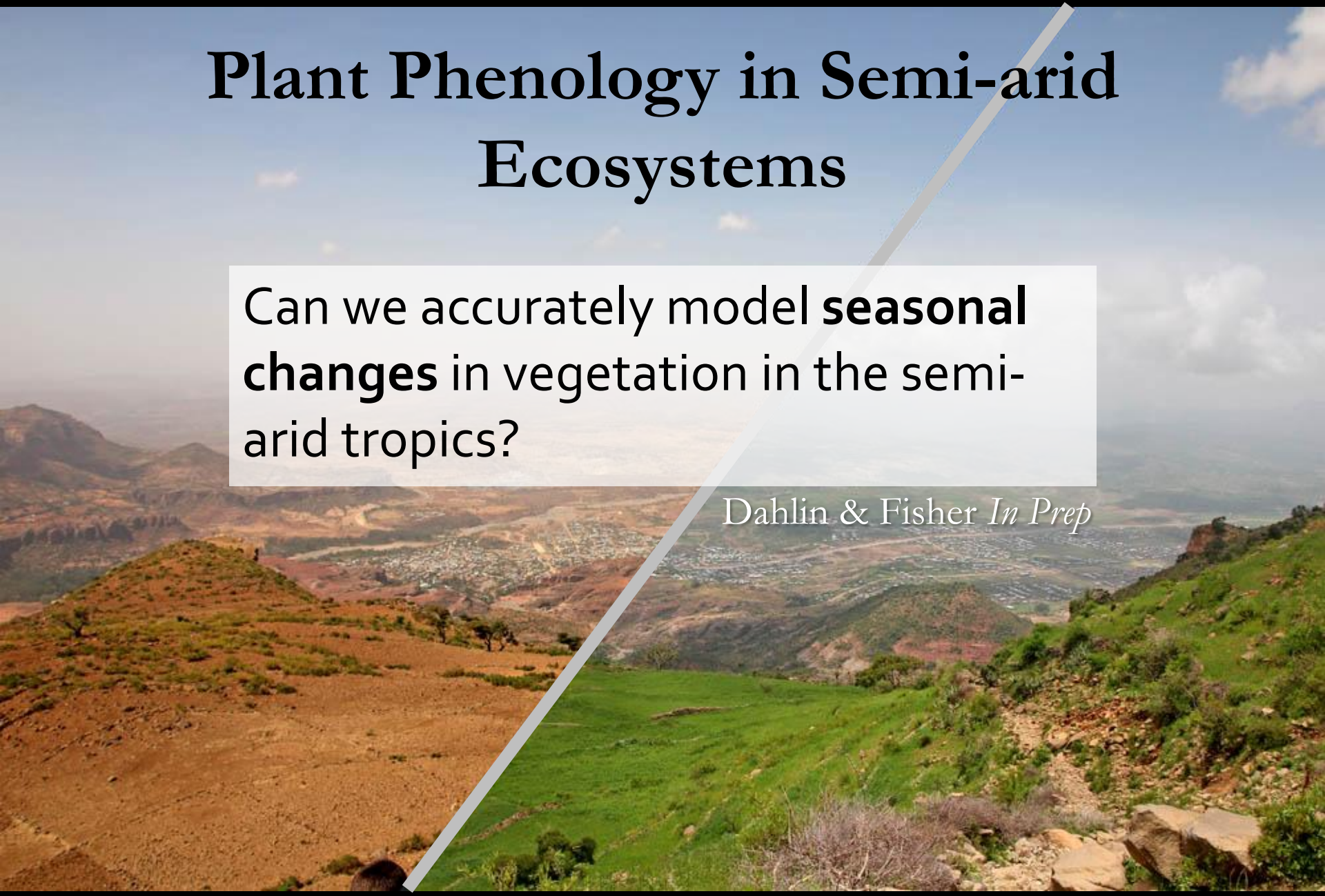
CLM4.5 Tech Note

- Start growing leaves if…
  - 3rd soil layer is wet (soil water potential > -2 MPa) for 15 days
- Onset period fixed at 30 days
- Start dropping leaves if…
  - Onset period is complete
  - 3rd soil layer is dry (soil water potential < -2 MPa) for 15 days
- Leaf drop period fixed at 15 days
- And stress deciduous plants can turn evergreen if conditions permit!

Plant Phenology in Semi-arid Ecosystems

Can we accurately model **seasonal changes** in vegetation in the semi-arid tropics?

Dahlin & Fisher *In Prep*



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Phenology in CLM

- **15** non-crop **plant functional types**
- **3** phenology algorithms
  - evergreen
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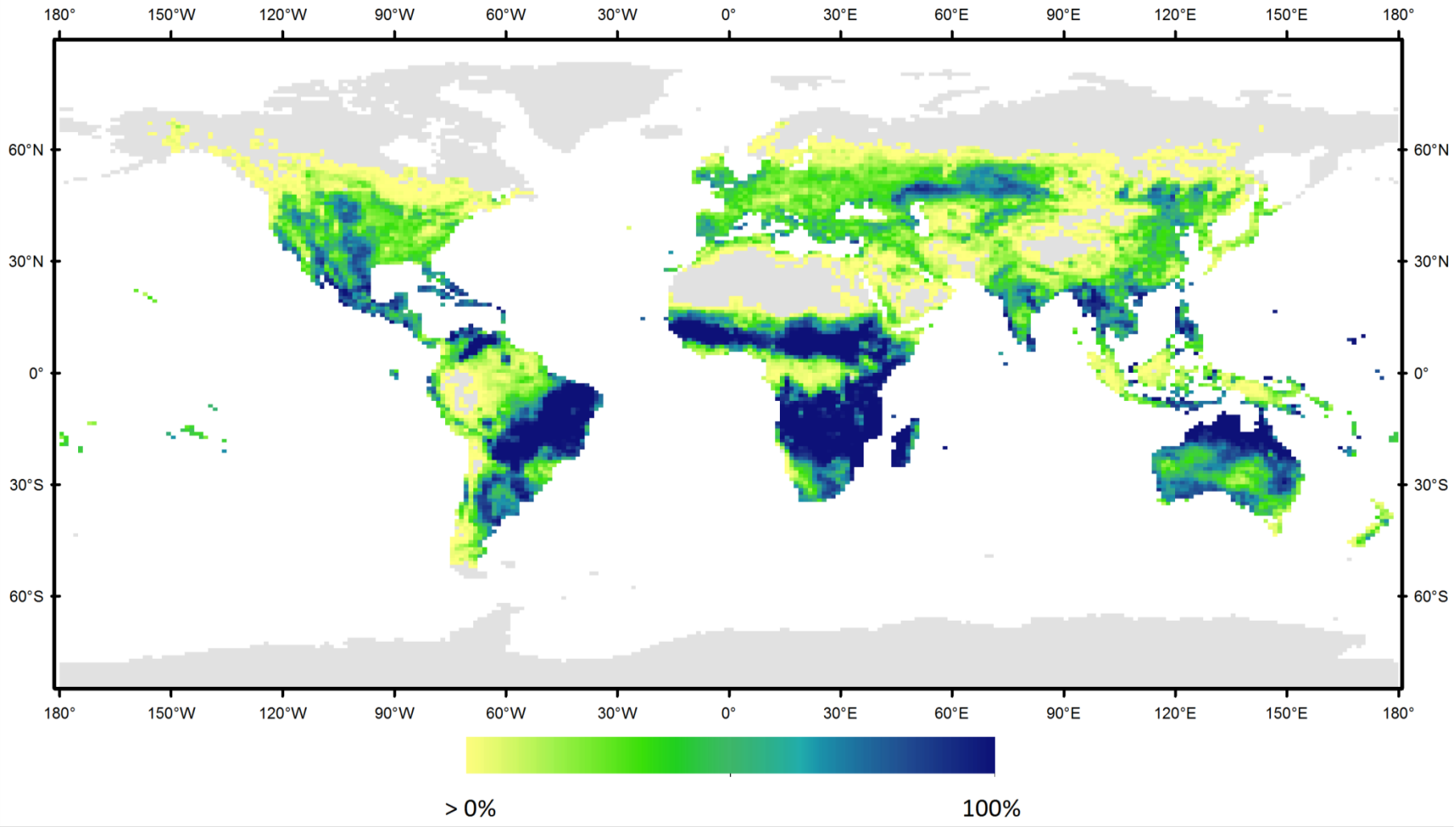
  - **stress (= drought) deciduous**

Where is CLM Stress Deciduous?



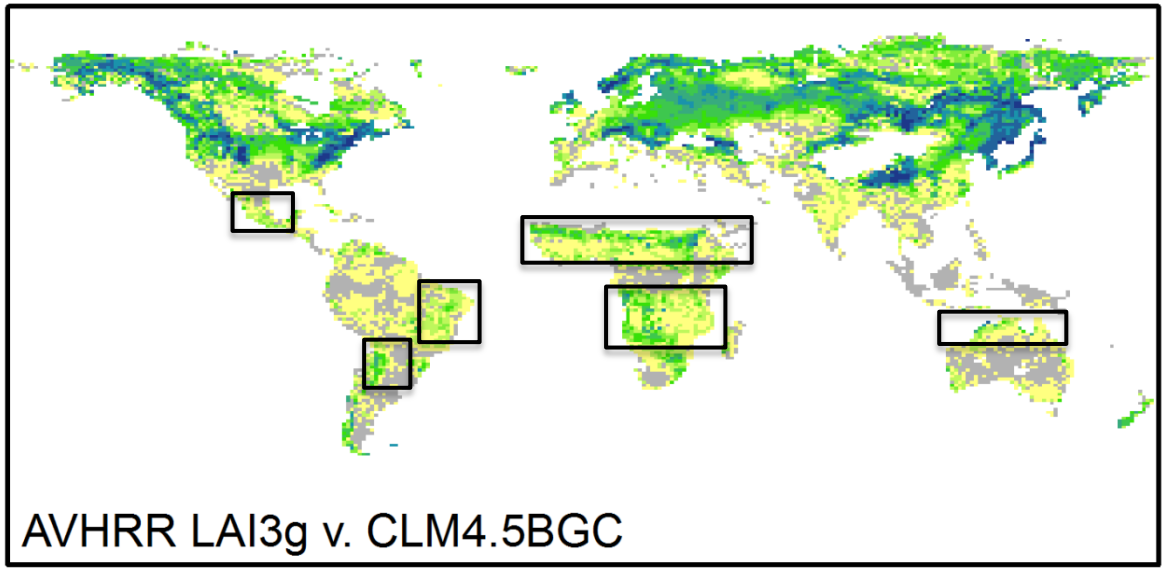
Questions

- How well does the stress deciduous phenology algorithm work in CLM? **[Leaf Area Index]**

  (compared to AVHRR-derived LAI3g for 1982-2010; Zhu et al 2013)

- Can we make it work better? (with relatively simple changes)

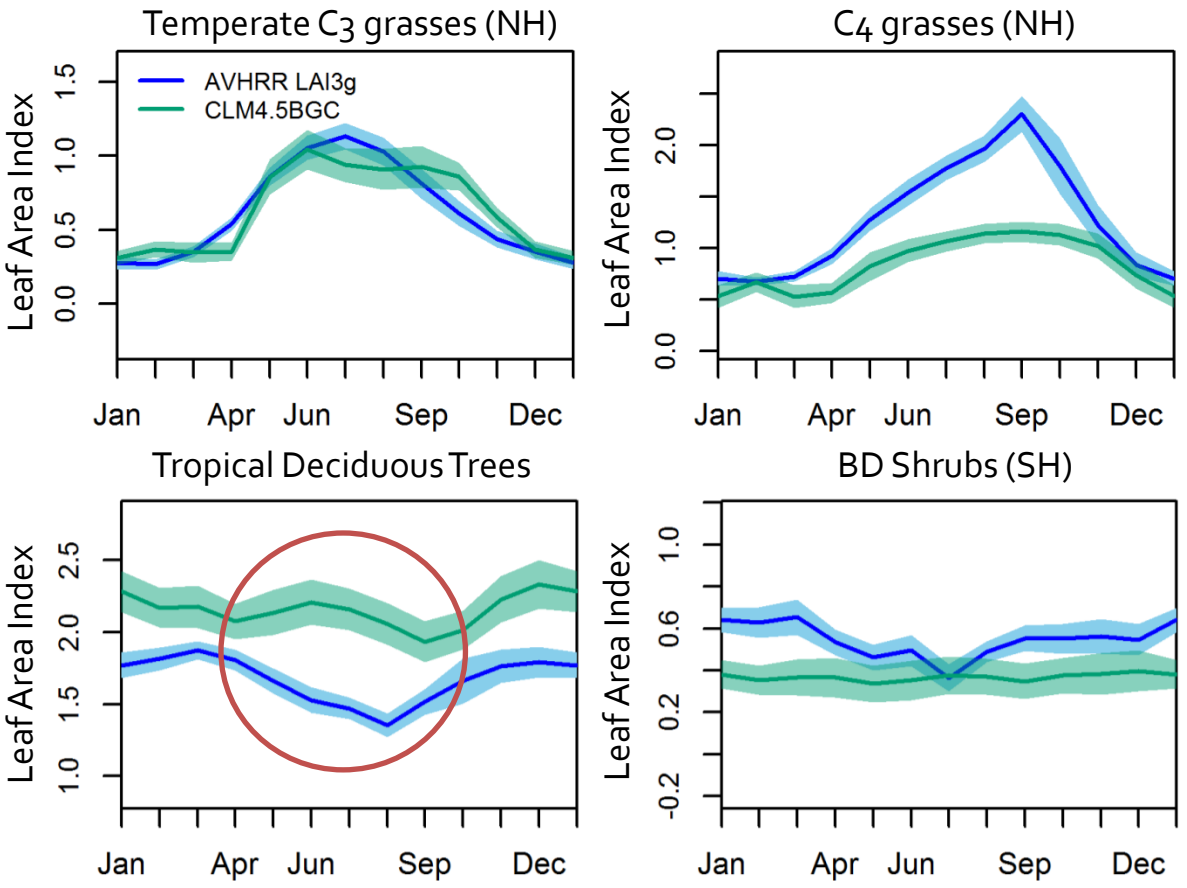
Correlations



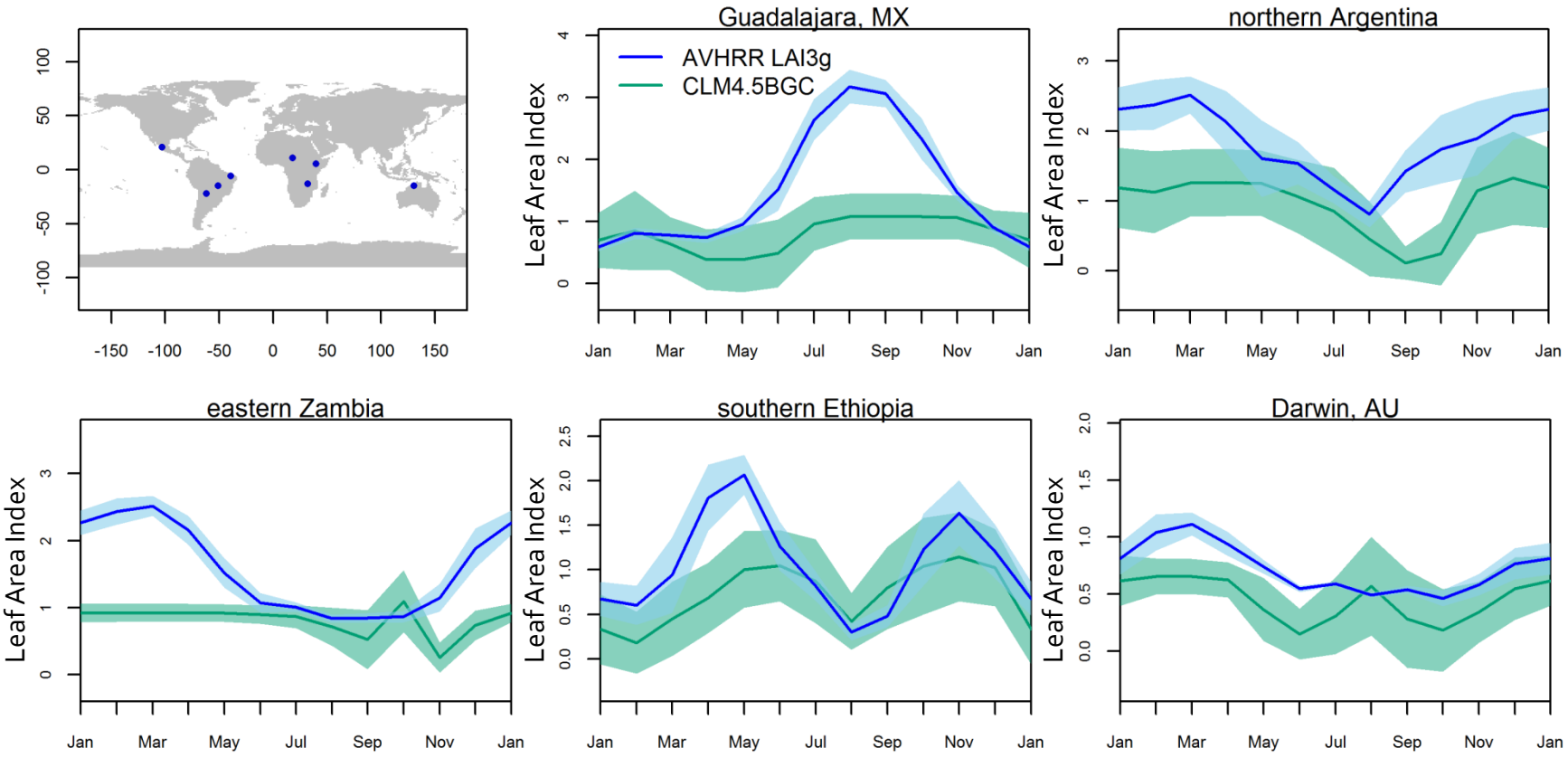
R^2

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1
- Not Significant

How well does the stress deciduous phenology algorithm work in CLM across different PFTs?



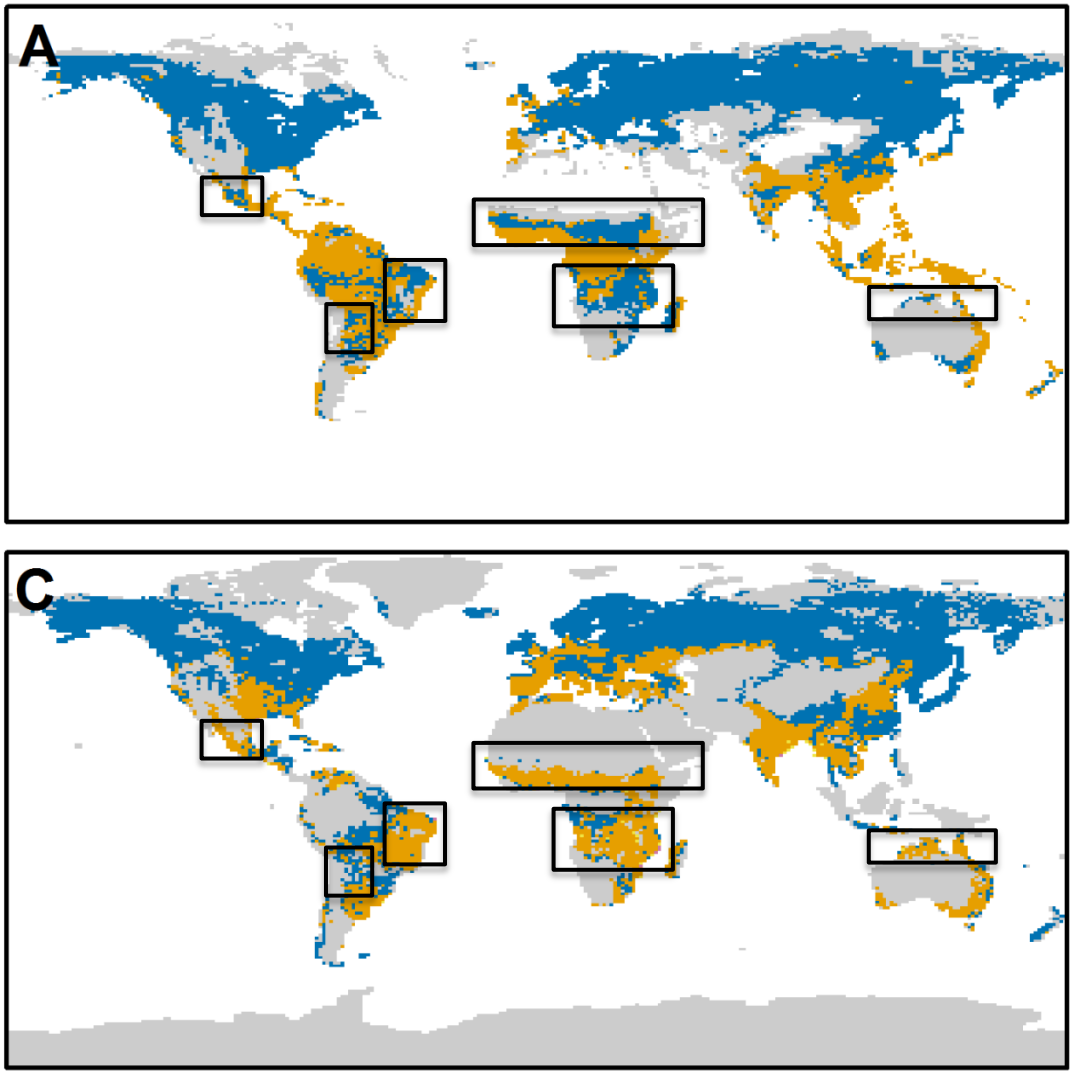
What about at single points?



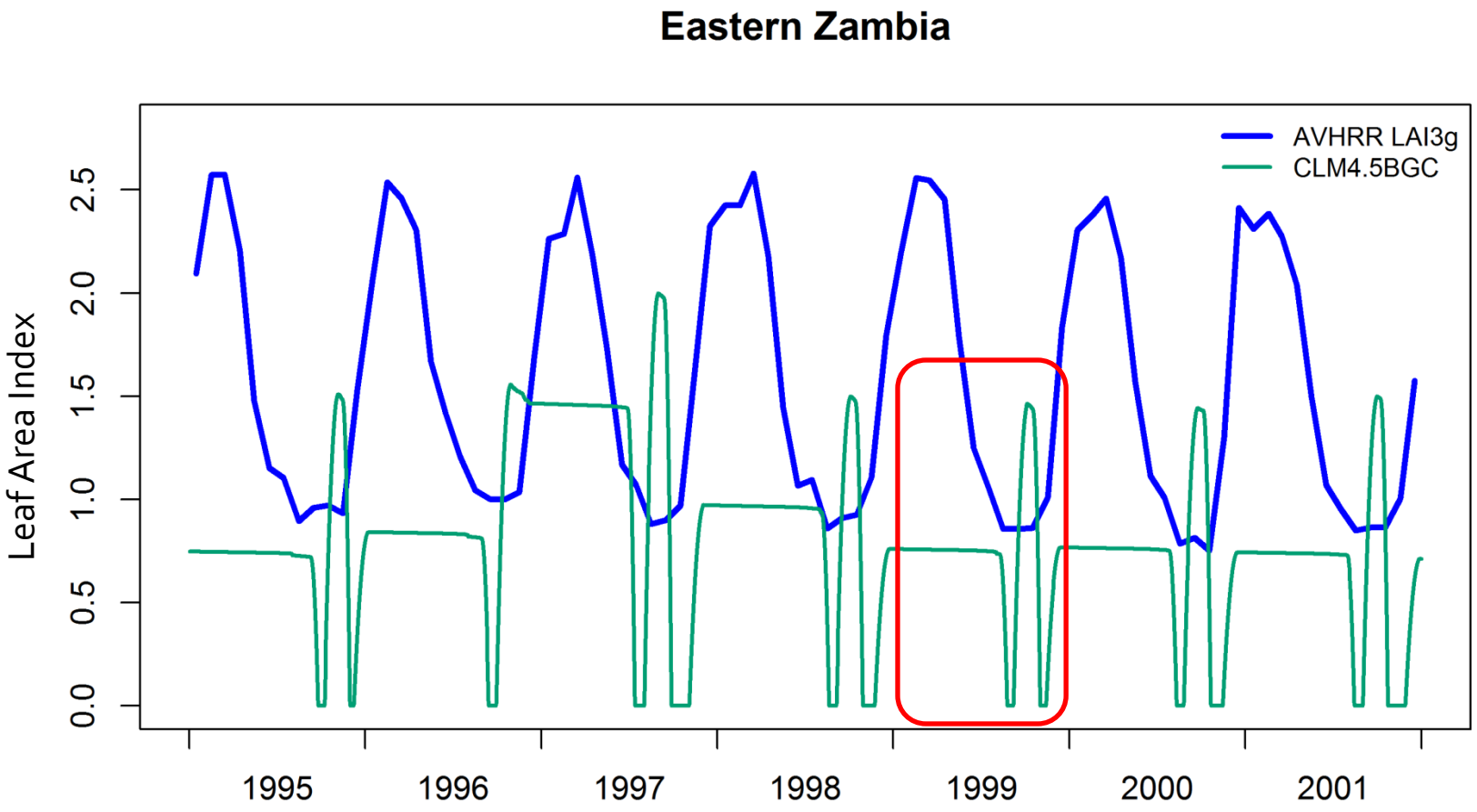
Counting Peaks

AVHRR LAI3g

CLM4.5BGC

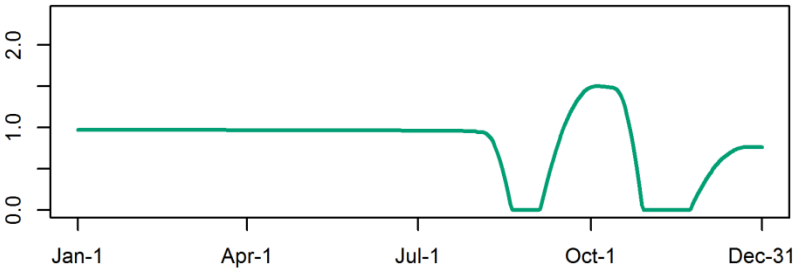


What about daily model output?

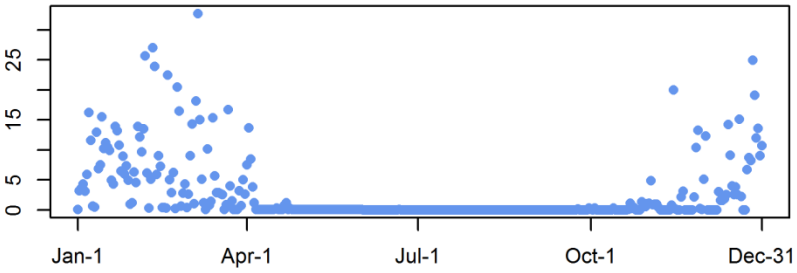


What's going on?

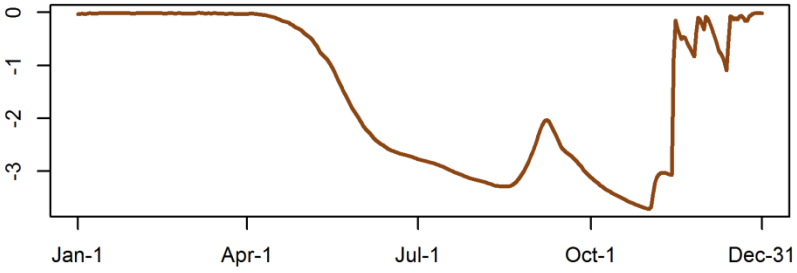
Leaf Area Index



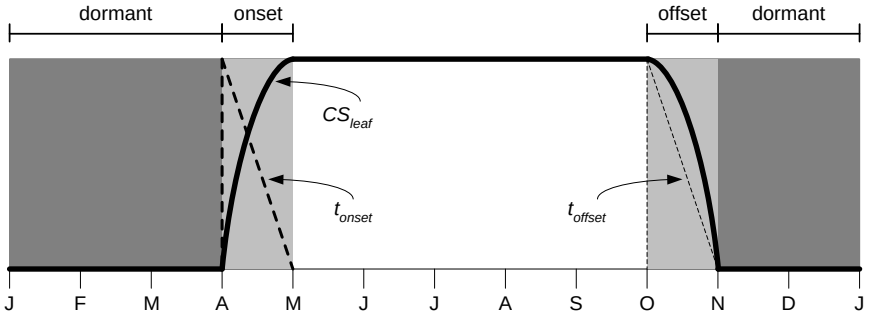
Rainfall (mm)



Soil Water Potential



How does stress decidousness currently work in CLM?
(in warm, long-day regions)



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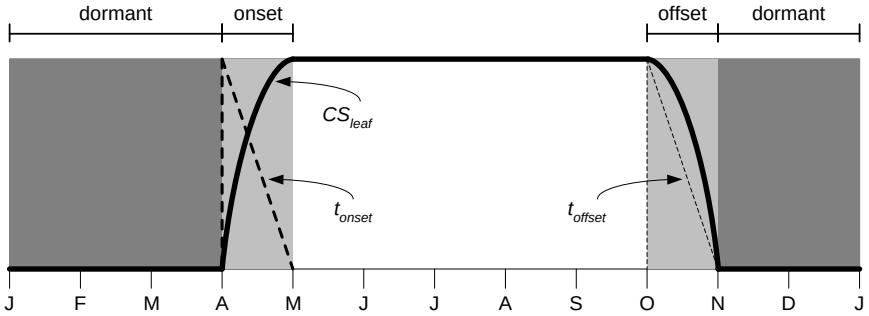
- Onset period fixed at 30 days
- Start dropping leaves if…
  - Onset period is complete
  - 3rd soil layer is dry (soil water potential < -2 MPa) for 15 days
- Leaf drop period fixed at 15 days

3 dimensional sensitivity analysis

How does stress decidousness currently work in CLM?

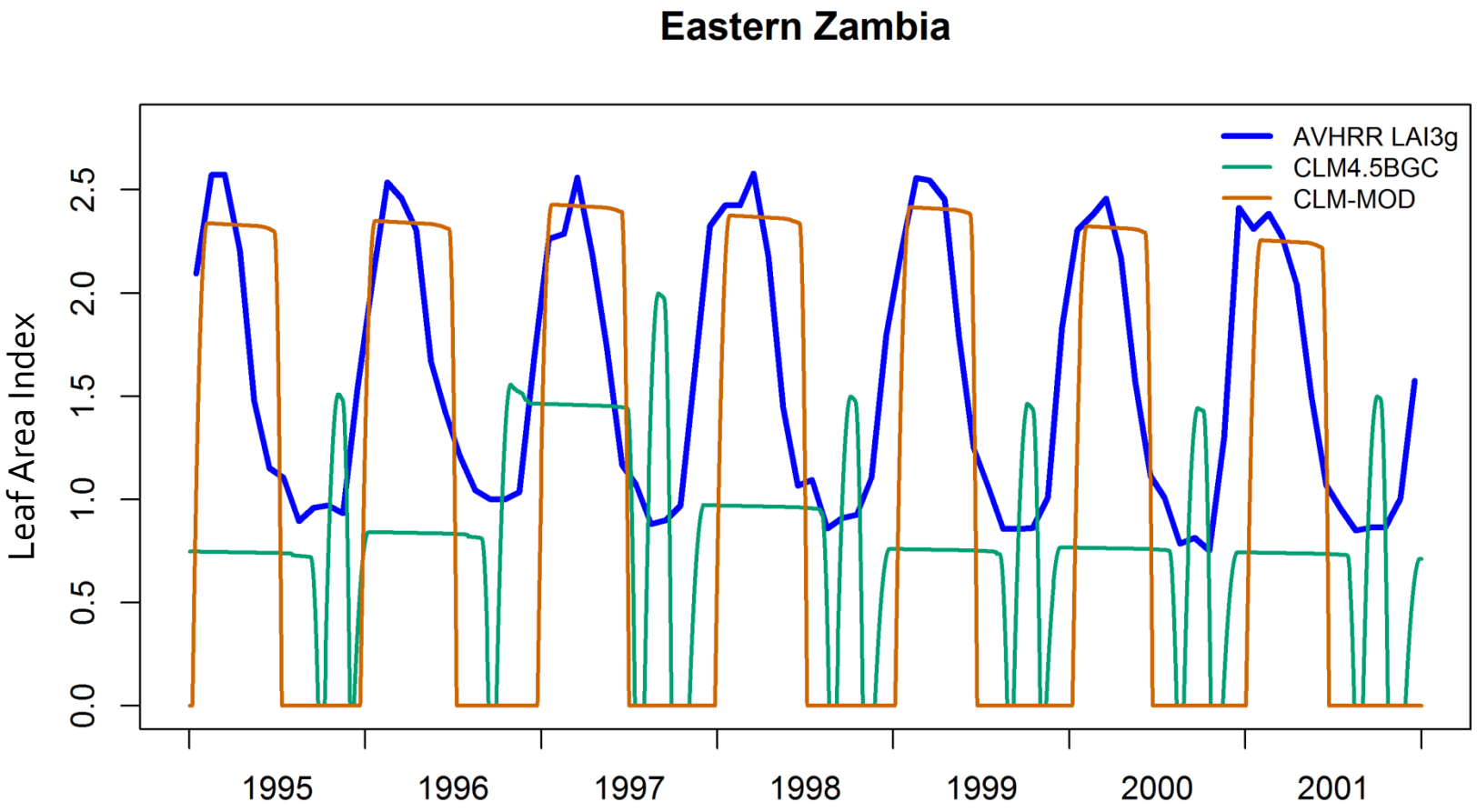
(in warm, long-day regions)



CLM4.5 Tech Note

- Start growing leaves if…
  - 3rd soil layer is wet (soil water potential > -2 MPa) for 15 days
  - **It RAINS! (20 mm in the past 10 days)**
- Onset period fixed at 30 days
- Start dropping leaves if…
  - Onset period is complete
  - 3rd soil layer is dry (soil water potential < -2 MPa) for 15 days
- Leaf drop period fixed at 15 days

It works (better)!



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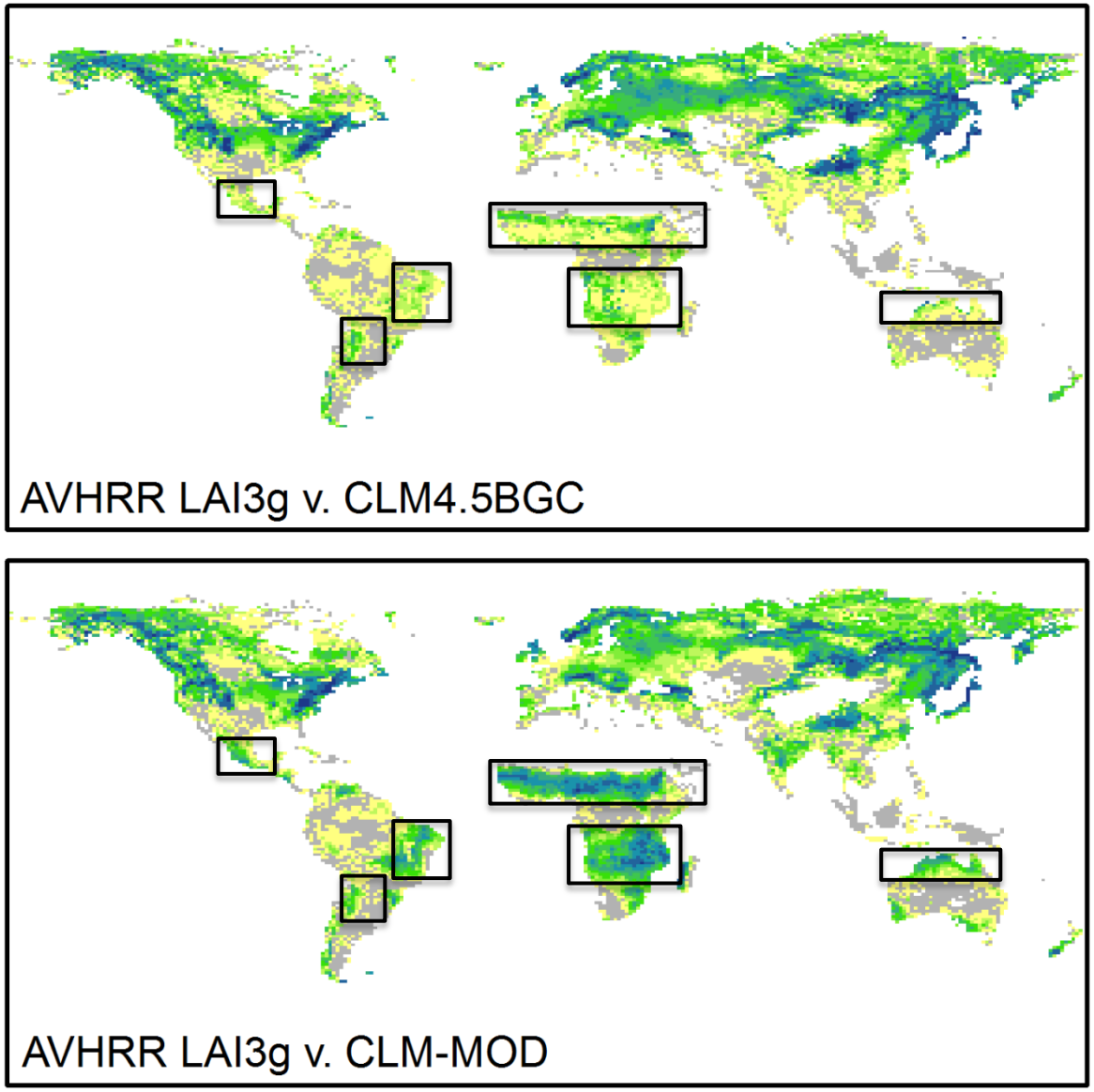
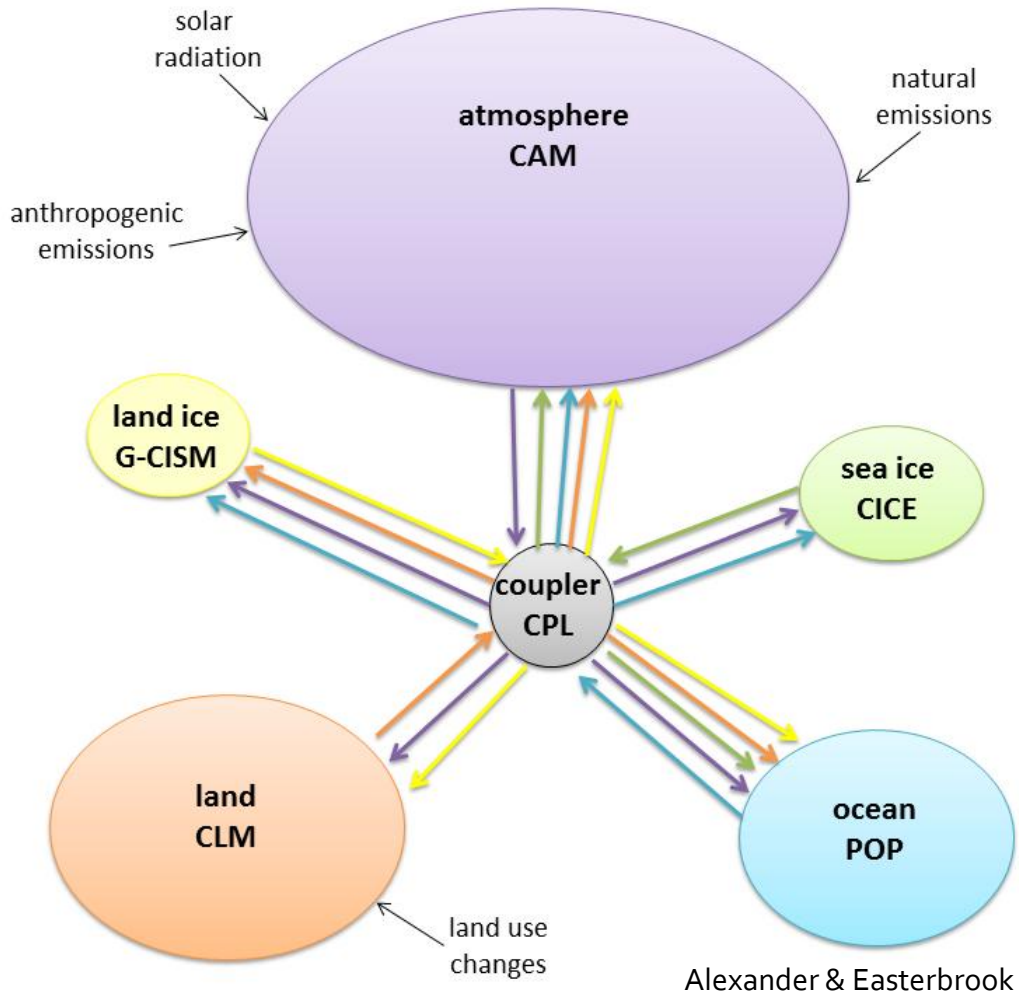


Conclusions

- In CLM leaves come on during the dry season due to **unrealistic upwards water movement** in the soil profile
- Delaying budburst until some **rain has fallen gives better agreement with the data**, both for magnitude and seasonal cycle of LAI in savanna regions

Dahlin & Fisher *In Prep*

What happens in a fully coupled run?



Alexander & Easterbrook 2011

Thanks!

Questions?

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@bristleweed

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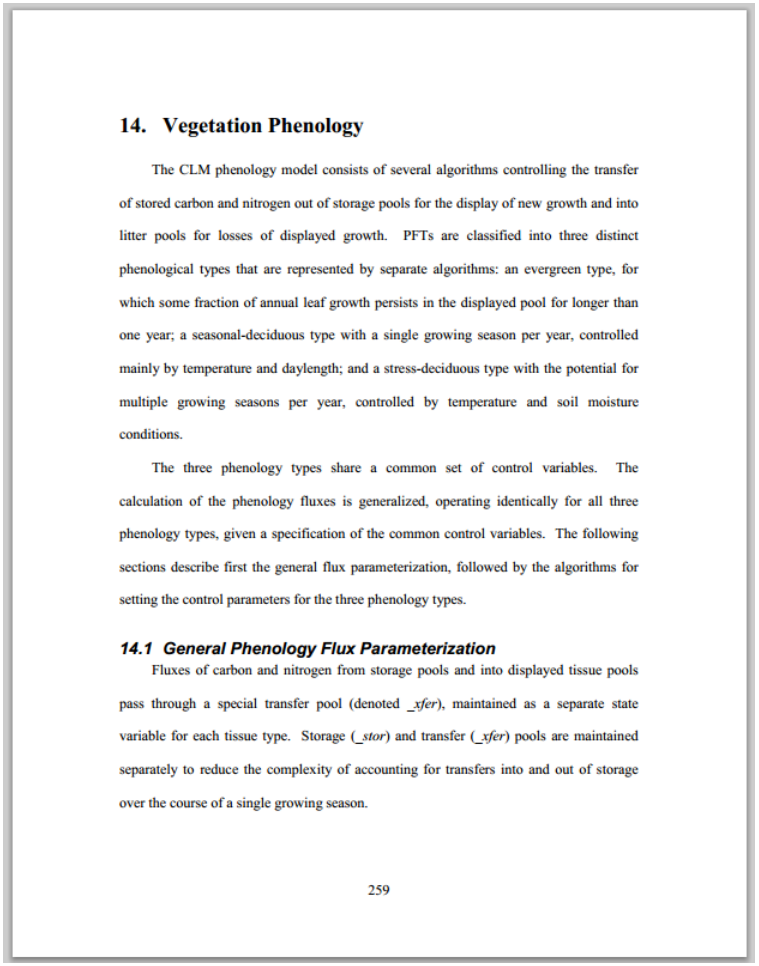

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