

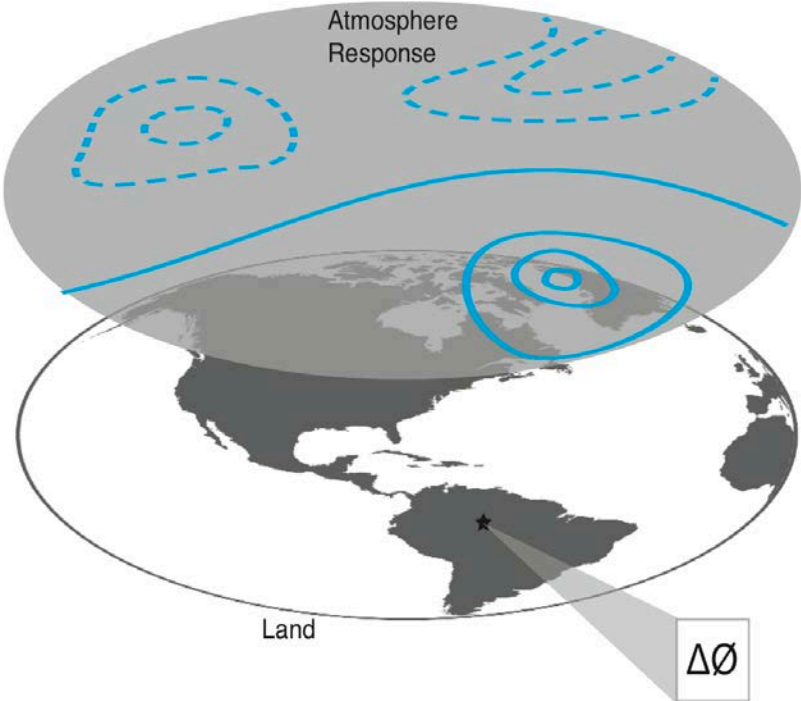
Atmospheric Perturbations Using a Simple Land Model

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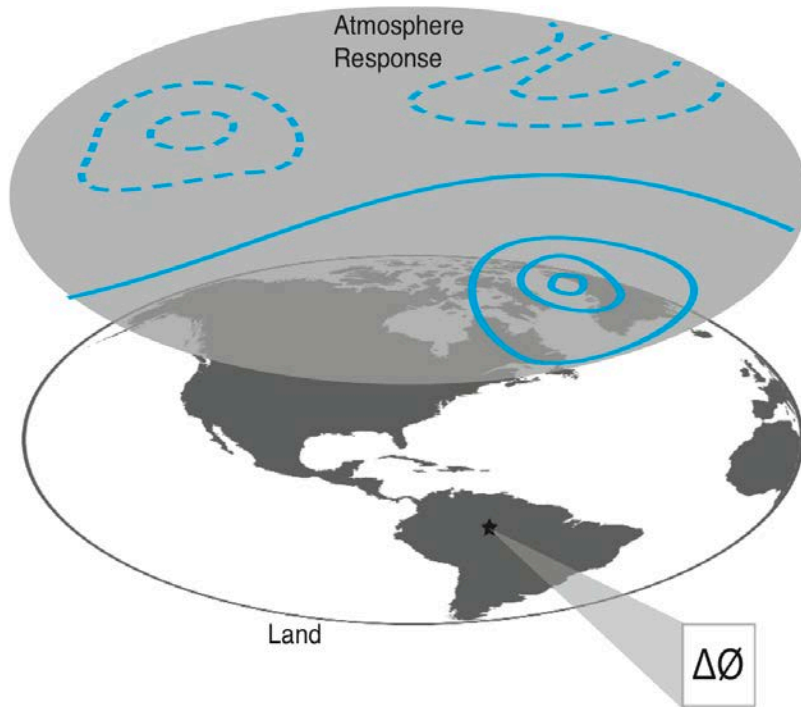
Goal: Test the global **sensitivity** of the atmosphere to local changes in the land surface

Climate Response to Land Change



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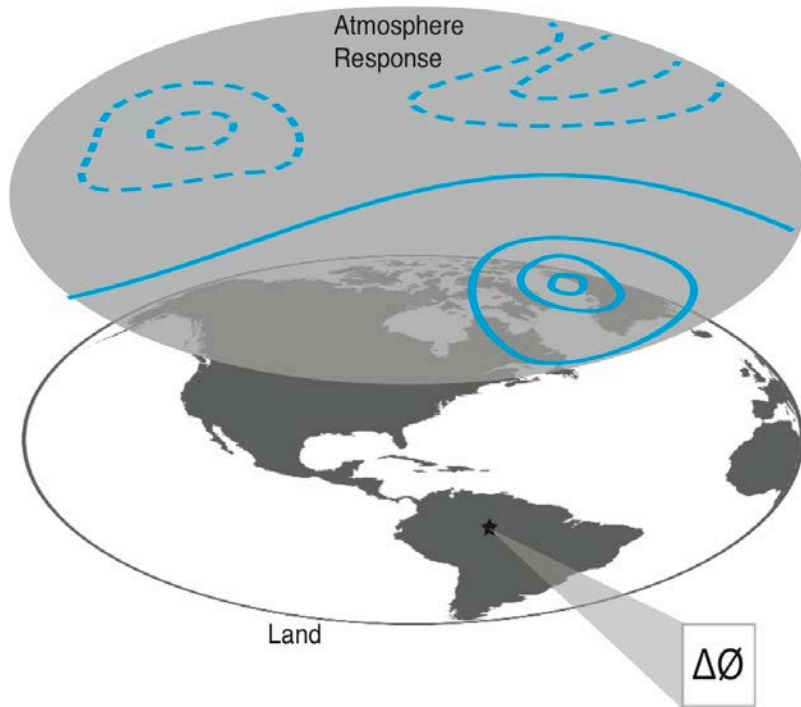
Climate Response to Land Change



1. Does the atmosphere care about changes in the land surface?

Goal: Test the global **sensitivity** of the atmosphere to local changes in the land surface

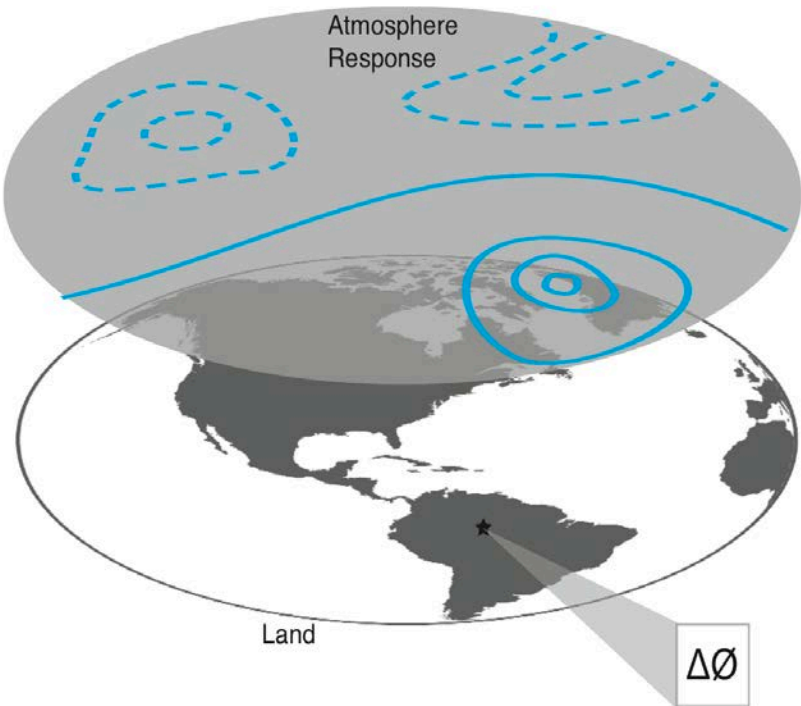
Climate Response to Land Change



1. Does the atmosphere care about changes in the land surface?
2. How much does it care?

Goal: Test the global **sensitivity** of the atmosphere to local changes in the land surface

Climate Response to Land Change



1. Does the atmosphere care about changes in the land surface?
2. How much does it care?
3. Where is does it care most, and about what?

↑
e.g. albedo vs. roughness

Already have some intuition of how land influences atmosphere in different locations

Green vs desert Sahara

(Charney et al. 1975)

Boreal forests warm
climate

(Bonan et al. 1992)

Tropical deforestation
warms + dries

(Shukla et al. 1990)

Mid-latitude forests
change global
circulation

(Swann et al. 2012)

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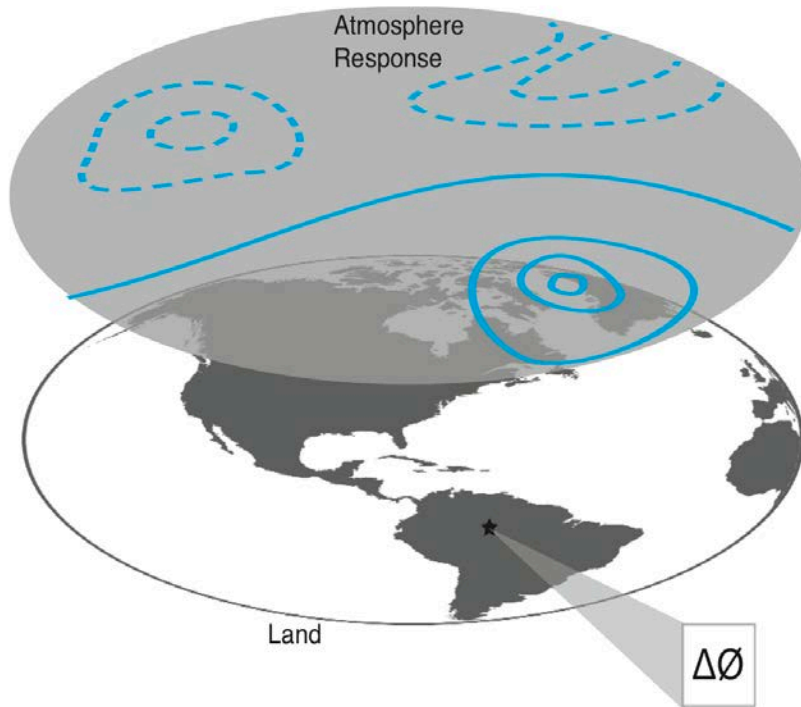
Mid-latitude forests change global circulation

(Swann et al. 2012)

➔ Want to systematically test the global sensitivity of the atmosphere to very controlled local changes in the land surface

Goal: Test the global **sensitivity** of the atmosphere to local changes in the land surface

Climate Response to Land Change



- Systematically perturb individual land surface properties at individual locations
 - Albedo
 - Roughness
 - Evaporative resistance

$$\frac{\partial \text{atm}}{\partial \phi}$$

Goal: Test the global **sensitivity** of the atmosphere to local changes in the land surface

Climate Response to Land Change

To do this: make **very** simplified land model to run in place of CLM

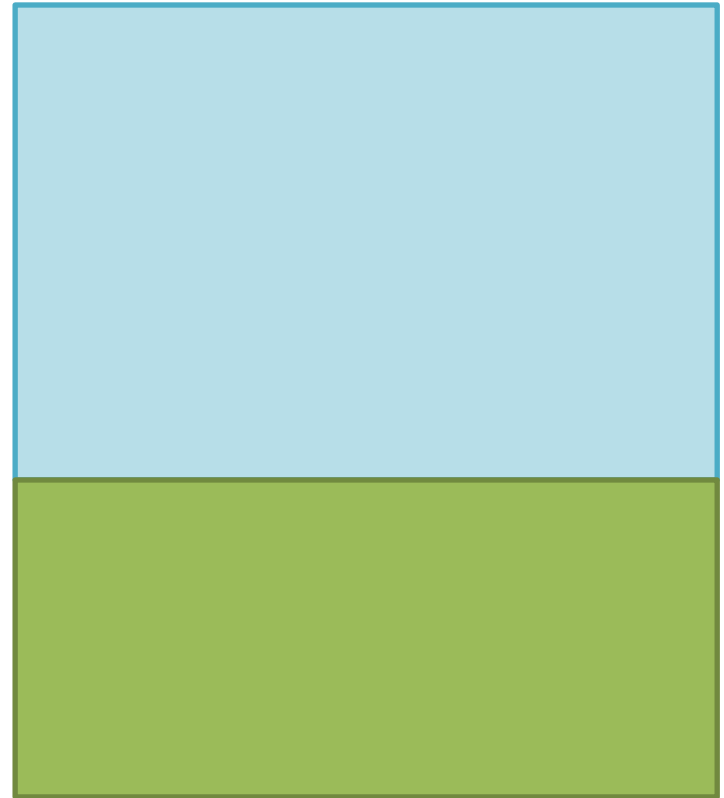
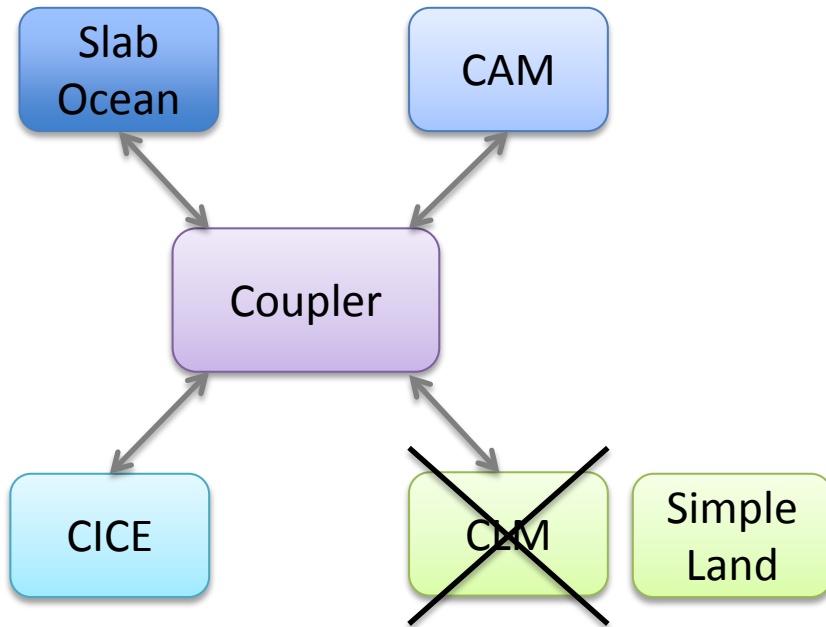
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Land

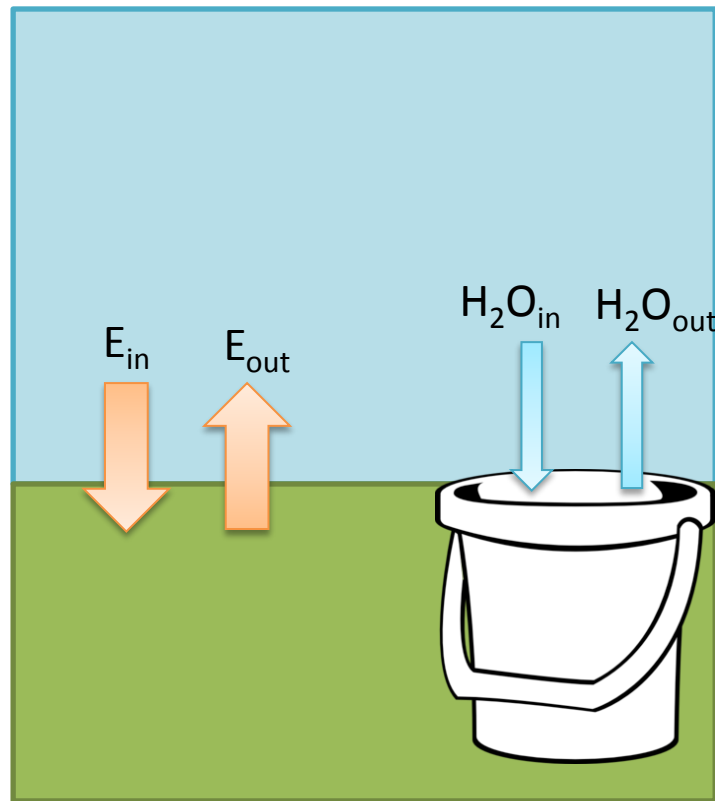
$\Delta \phi$

Simple Land Model for CESM



Simple Land Model for CESM

- Surface energy budget
- Bucket hydrology
- Tunable parameters
 - Albedo
 - Roughness
 - Bucket capacity
 - Evaporative resistance
 - Soil thermal properties



Leans heavily on LSM 1.0 (Bonan, 1996) and GFDL's LM2 Model (LaD; Milly & Shmakin 2002)

Why not just use CLM?

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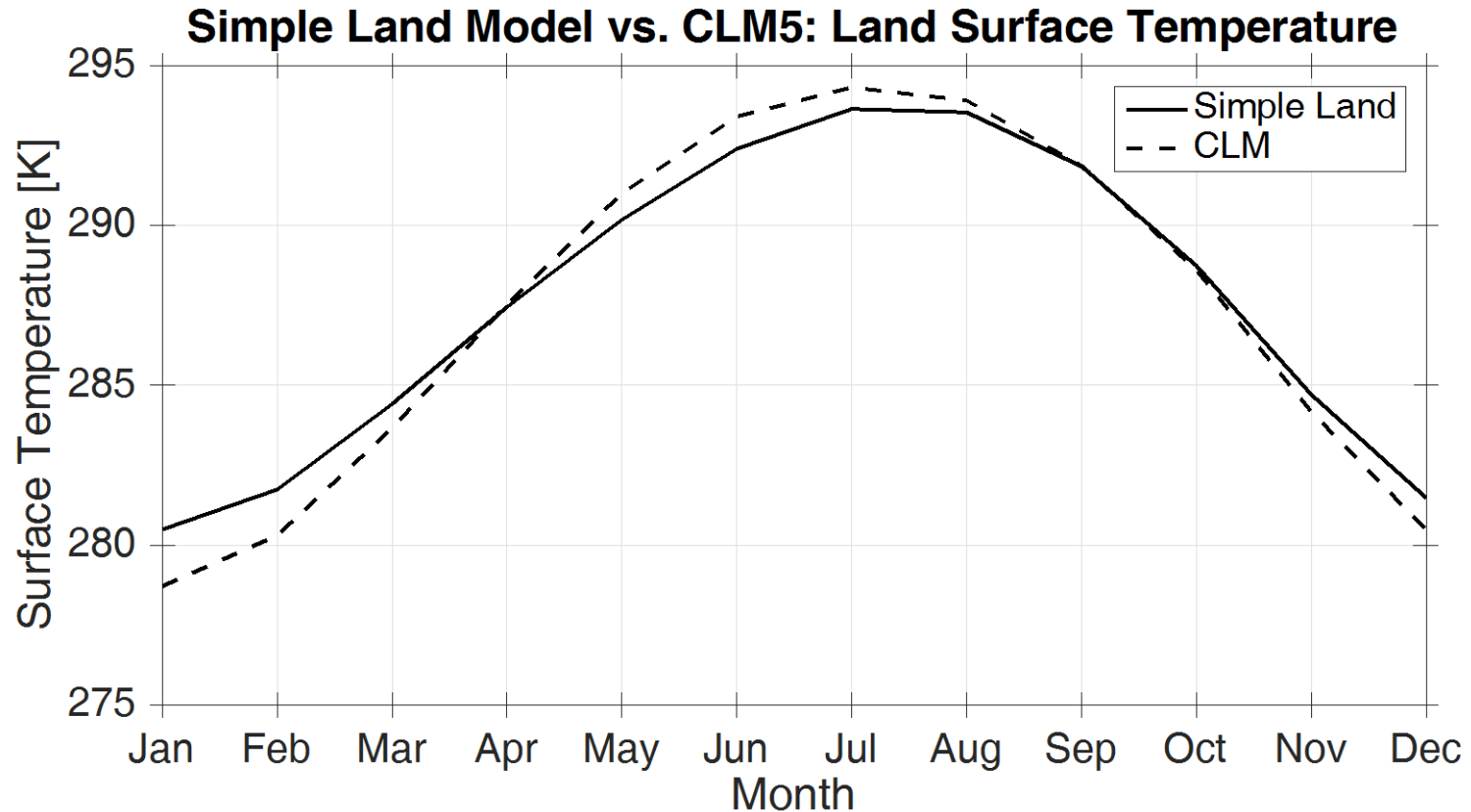
- Want model to be easily *tunable*.
- Want to understand (and control) exactly what is changing in the land surface.

Why not use data land?

Why not use data land?

- Still want surface to be able to respond to & interact with atmosphere:
 - Calculate surface energy budget
 - Limited by water availability
 - Snow impact on albedo (seasonality)
- Similar to the idea of using an aquaplanet

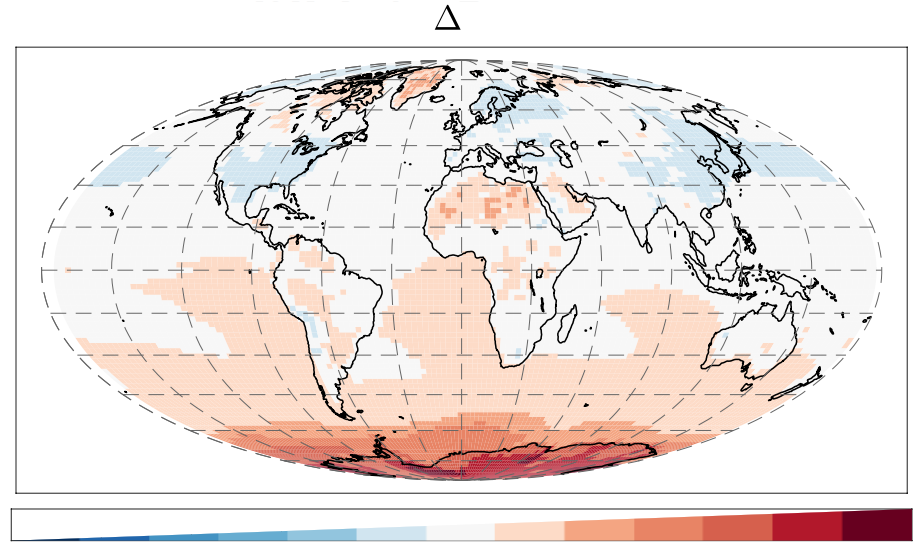
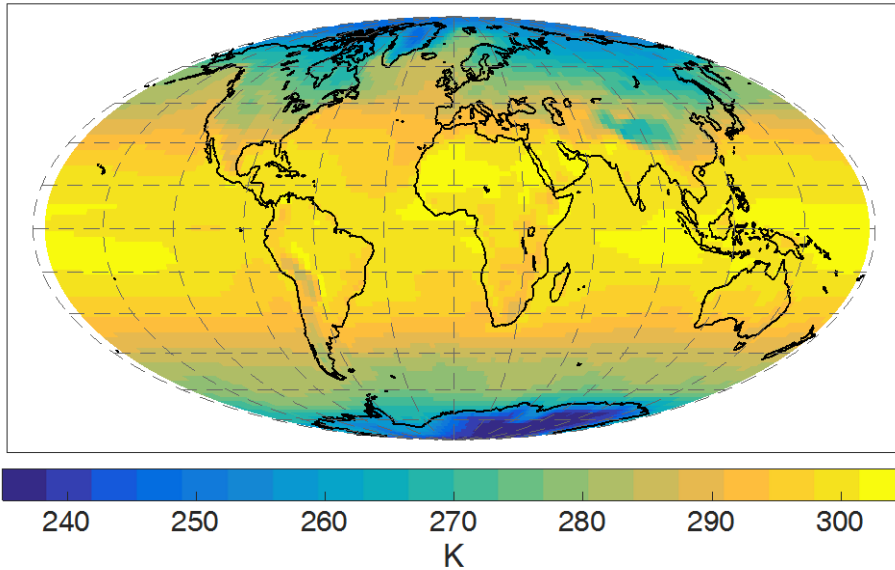
Simplest setup gives a reasonable representation of the land
(globally uniform land properties: e.g. all land points albedo = 0.2)



(Averaged over land areas only, excluding Antarctica)

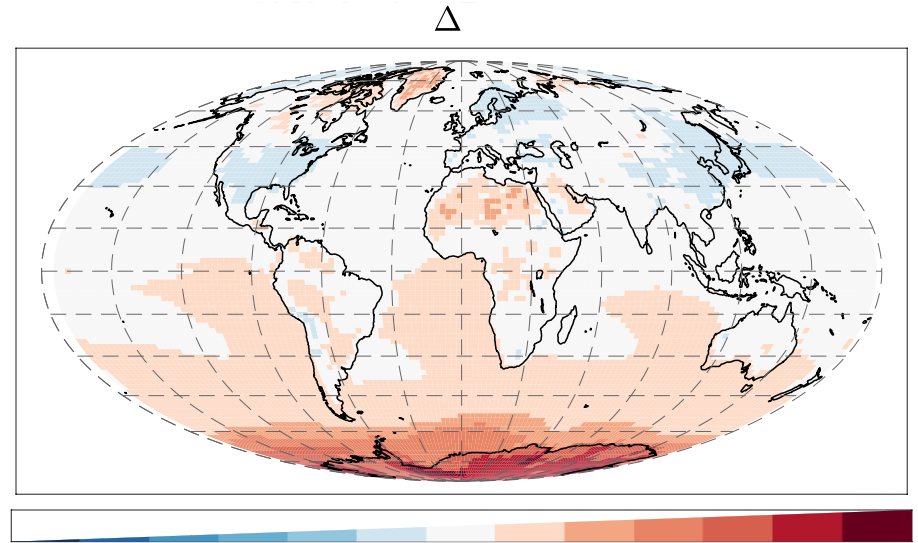
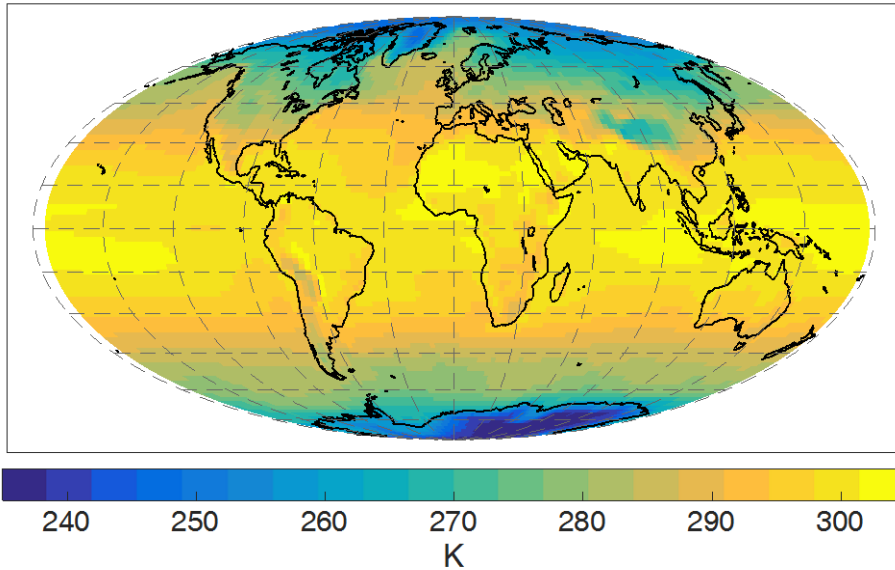
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Simple Land: Surface Temperature



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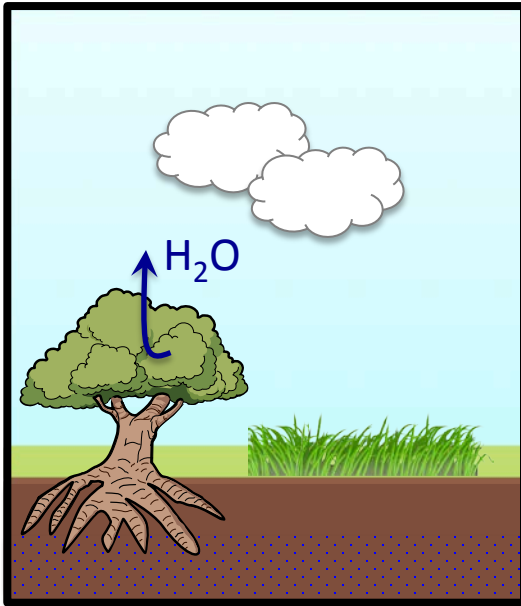
Have this simple model... what are we going to do with it?

Kinds of questions we'd like to use this model to answer:

- When forests replace grass, do clouds increase because of more upwards motion, or more water?

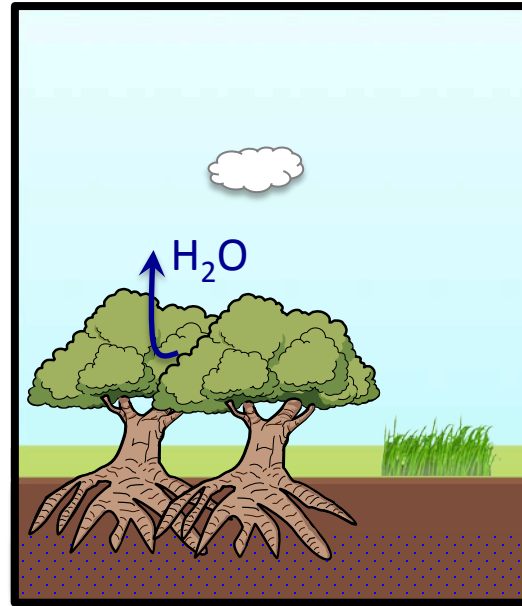
Have this simple model... what are we going to do with it?
➔ Tease apart the influence of individual surface parameters

Mid-latitudes



Small amount of
trees ↑ clouds

Mid-latitudes



Large amount of
trees ↓ clouds

Now we can isolate the
albedo vs. water use
effects on the
atmospheric response

Kinds of questions we'd like to use this model to answer:

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- What is $\frac{\partial T_{\text{local}}}{\partial(\text{albedo})}$, or $\frac{\partial T_{\text{local}}}{\partial(\text{evaporative resistance})}$?

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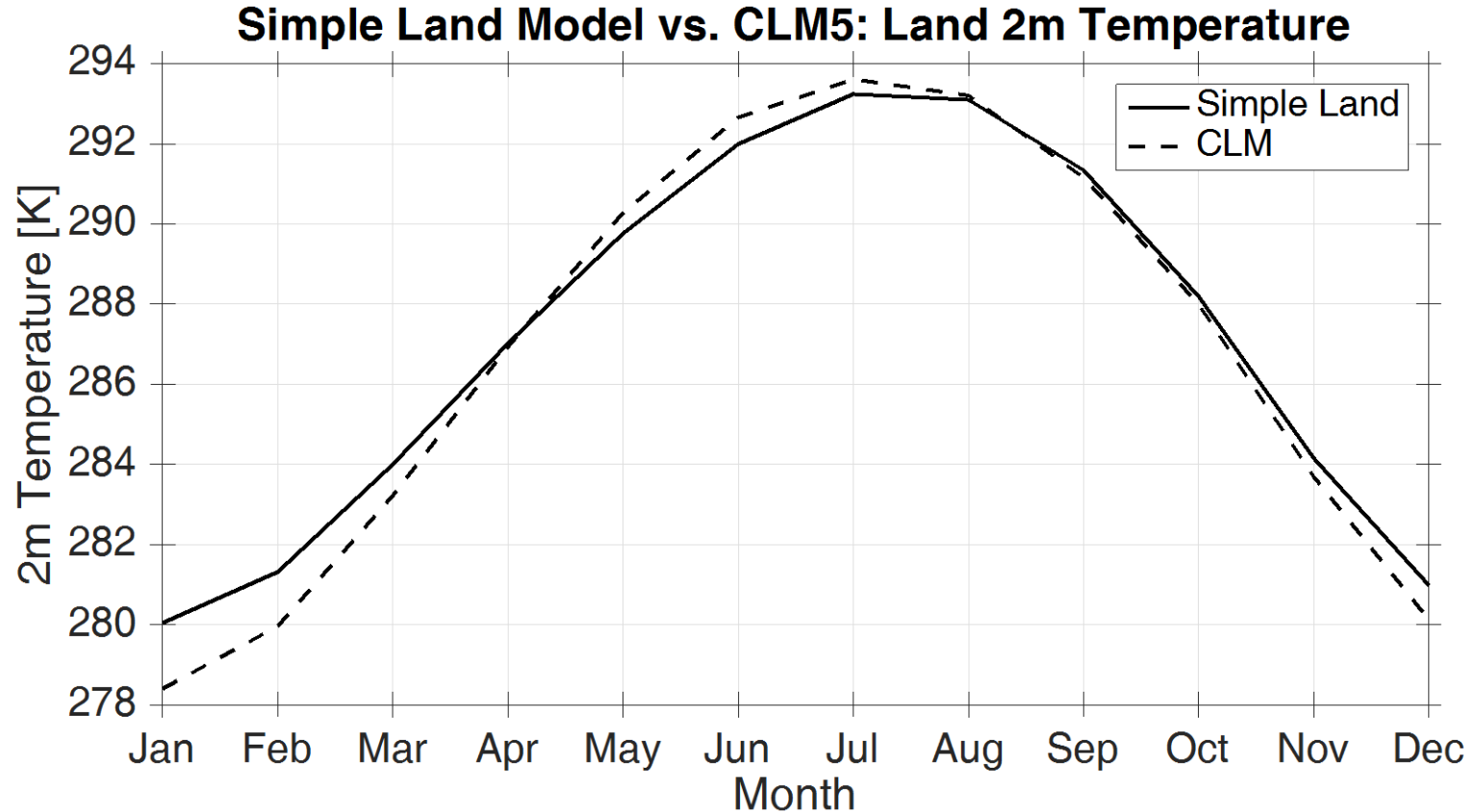
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➔ Hypothesis testing tool

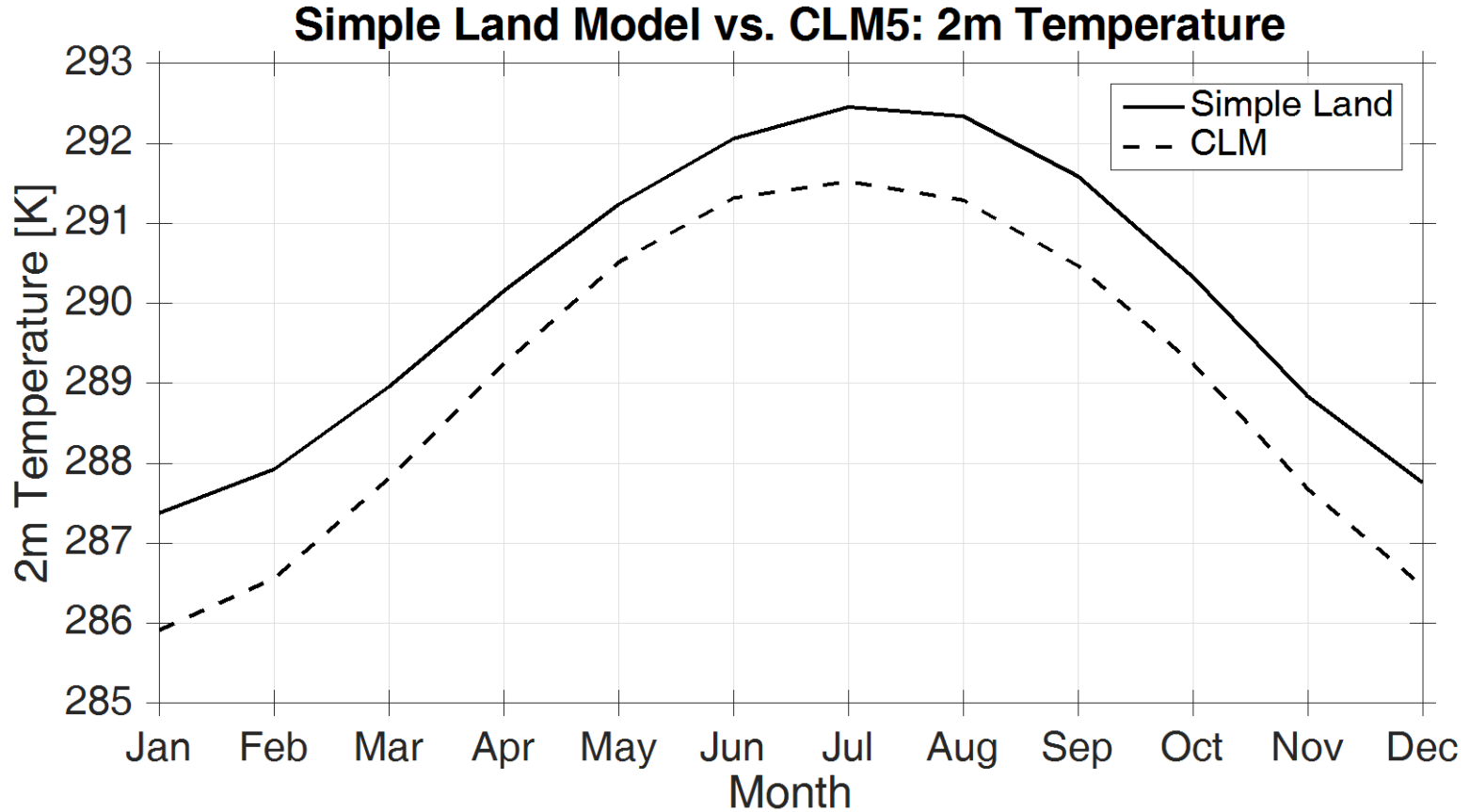
Summary:

- Have a simple land model for CESM.
- It seems to work.
- Fun tool, we're excited about it!

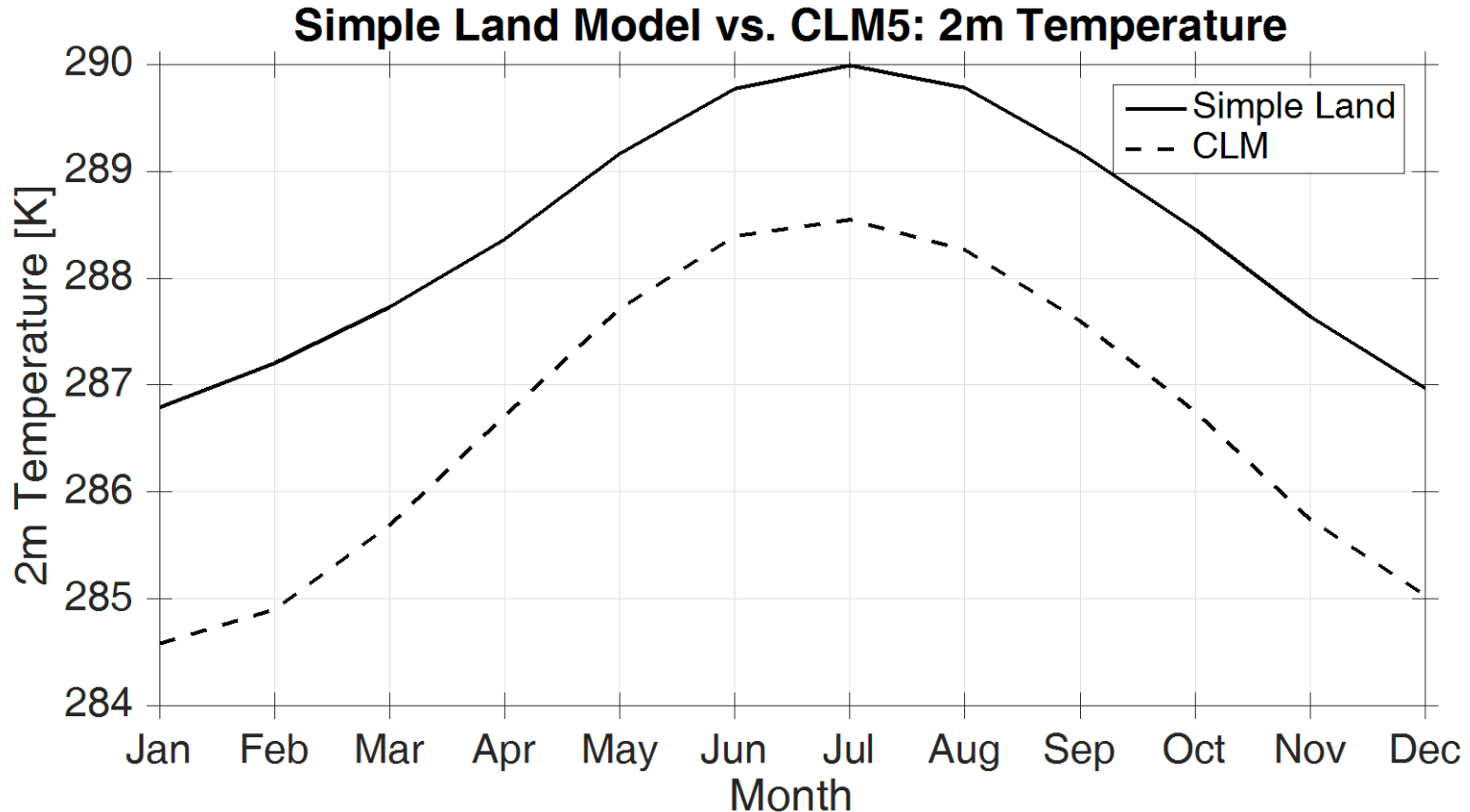
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Global average 2m T (land + ocean) *including* Antarctica (which got a lot darker -> warmer)

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Simple Land: Surface Temperature

CLM: Surface Temperature

