Convection and Land Cover Change

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Physical Response to Land Cover Change

Land cover change
Physical Response to Land Cover Change

Land cover change

Deforestation
Physical Response to Land Cover Change

Land cover change

Latent Heat flux
Sensible Heat flux

Deforestation

Latent Heat flux
Sensible Heat flux
Physical Response to Land Cover Change

Land cover change

Boundary Layer

Latent Heat flux

Sensible Heat flux

Deforestation

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Boundary Layer

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Latent Heat flux

Sensible Heat flux
Physical Response to Land Cover Change

More LH Flux → More Humid → Higher Relative Humidity at PBL

Boundary Layer

Land cover change

Deforestation

Boundary Layer

Latent Heat flux

Sensible Heat flux
Physical Response to Land Cover Change

More LH Flux → More Humid → Higher Relative Humidity at PBL

More SH Flux → Higher PBL → Cooler PBL Temperature → Higher Relative Humidity at PBL
Physical Response to Land Cover Change

Land cover change

But this is just part of the picture!
Physical Response to Land Cover Change

Land cover change

But this is just part of the picture! A **Local** part...
Scales of Influence: Local to Global
Scales of Influence: Local to Global

Local:
- **warmer** over grass during the day (reverse at night)
- Higher $\alpha$
- Less rough
- More SH

To Grass:
- Warmer over grass during the day
- Convection for both
Scales of Influence: Local to Global

Local:
- warmer over grass during the day (reverse at night)
- convection for both
- higher $\alpha$
- less rough
- more SH

To Grass

Synoptic to Global:

Boundary Layer

Mesoscale:

Sensible Heat flux

Latent Heat flux

warmer over grass during the day
(reverse at night)
convection for both
Scales of Influence: Local to Global

Local:
- Mesoscale: Synoptic
- Local:
  - Boundary Layer
  - Sensible Heat flux
  - Latent Heat flux
  - higher \( \alpha \)
  - less rough
  - more SH

Synoptic to Global:
- Warmer over grass during the day
  (reverse at night)
- Convection for both

To Grass
Land gradient

Scales of Influence: Local to Global

Local:
- **Mesoscale:**
  - Thermally induced circulation
  - higher $\alpha$
  - less rough
  - more SH

Local:
- **Grass**
  - warmer over grass during the day
  - (reverse at night)
  - convection for both

Synoptic to Global:
- **Land**
  - gradient
  - Trigger or grow existing cloud cover
Scales of Influence: Local to Global

**Local:**
- **Boundary Layer**
- **Sensible Heat flux**
- **Latent Heat flux**
- **Land**
- **Grass**
- **Warmer over grass during the day**
- **(reverse at night)**

**Mesoscale:**
- **Thermally induced circulation**
- **Trigger or grow existing cloud cover**

**Synoptic to Global:**
- **Upscale energy transfer** (moment., heat, water vapor)
- **for dry and moist conv.**
- **Planetary wave response and circulation changes**

*α*: higher, less rough, more SH for both dry and moist convection.
Different Approaches Per Scale

Synoptic to Global:

Mesoscale:

Local:
Different Approaches Per Scale

Synoptic to Global:

Mesoscale:

Local: Mixed Layer and Simple Column-type Models

(Manoli et al. 2016 GCB)
Different Approaches Per Scale

Synoptic to Global:

**Mesoscale:**

Large-Eddy Simulations

(mainly focusing on heterogeneity; not necessarily regarding land cover change)

Local:

(van Heerwaarden et al. 2014 JAS)
Different Approaches Per Scale

Synoptic to Global:

Mesoscale: Simulations (mainly focusing on heterogeneity; not necessarily regarding land cover change)

Local:

(van Heerwaarden et al. 2014 JAS)
Different Approaches Per Scale

Synoptic to Global:
Earth System Modeling (OUR FOCUS) and Regional Modeling

Perform some model runs with and without land cover change and see the effects

Mesoscale:

Local:

(Pittman et al. 2009 GRL)
Precipitation response due to land cover change
Precipitation response due to land cover change
Figure 2. Change in the JJA (left) latent heat flux (W m$^{-2}$), (middle) near-surface air temperature ($^\circ$C) and (right) precipitation (mm day$^{-1}$) from each model resulting from the land cover change (PD – PDv). Only areas where changes are significant at a 95% confidence using the modified t-test are shown.

Strong drying in one simulation and not others (Pittman et al. 2009 GRL)
Change in the JJA (left) latent heat flux (W m$^{-2}$), (middle) near-surface air temperature (°C) and (right) precipitation (mm day$^{-1}$) from each model resulting from the land cover change (PD – PDv). Only areas where changes are significant at a 95% confidence using the modified t-test are shown.

Different signs in certain regions

(Pittman et al. 2009 GRL)
According to LUCID:

- Different implementation of land cover change maps
- Different parameterizations in ET and crop phenology
What May be causing differences?

According to LUCID:

• Different implementation of land cover change maps
• Different parameterizations in ET and crop phenology

Need to consider the uncertainties in the overlying atmosphere model.
What May be causing differences?

According to LUCID:

• Different implementation of land cover change maps
• Different parameterizations in ET and crop phenology

Need to consider the uncertainties in the overlying atmosphere model

**Punch-lines**

Changes to convection scheme → significant precip response to land cover change

Specifically changing "one line of code" – **the triggering criteria**
The Different Simulations

There were two simulations performed:

**Default Trigger:** Deep convection happens when CAPE > 70 J/kg
The Different Simulations

There were two simulations performed:

**Default Trigger**: Deep convection happens when $\text{CAPE} > 70 \text{ J/kg}$

**New Trigger**: Deep convection activates when $\text{CAPE} > 70 \text{ J/kg}$ and

Convective inhibition $= 0$
The Different Simulations

There were two simulations performed:

**Default Trigger:** Deep convection happens when CAPE > 70 J/kg

**New Trigger:** Deep convection activates when CAPE > 70 J/kg

AND

Convective inhibition = 0

***NOTE:*** Inhibition defined by the Heated Condensation Framework

(Tawfik and Dirmeyer 2014 *GRL*; Tawfik et al. 2015a and 2015b *JHM*)
% Change in a land cover type
Decrease in forest cover and increased crop with regions of increased grass in the Southeastern US

(Chen et al. 2017 JHM)
Impact of Convection on Land Use Change

Change in Precip due to Land Cover Change

Default Trigger Response
CTRL2000 - CTRL1850

(Chen et al. 2017 JHM)
Impact of Convection on Land Use Change

Change in Precip due to Land Cover Change

**Default Trigger Response**
CTRL2000 - CTRL1850

**New Trigger Response**
HCF2000 - HCF1850

[mm/days]

(Chen et al. 2017 JHM)
Impact of Convection on Land Use Change

Number of days with > 1 mm

**Default Trigger Response**
CTRL2000 - CTRL1850

**New Trigger Response**
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Impact of Convection on Land Use Change

Number of days with > 1 mm

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**New Trigger Response**
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Which one should we believe more?
Exploring Coupled Model Processes

Decrease

Increase

Decrease

LH (W/m²)    SH (W/m²)    CAPE (J/kg)    θ_dif (K)    PRECT (mm)

CTRL   HCF

(Chen et al. 2017 JHM)
Exploring Coupled Model Processes

Decrease

Increase

the lower Mississippi River Basin

LH (W/m²)  SH (W/m²)  CAPE (J/kg)  \( \theta_{\text{def}} \) (K)  PRECT (mm)

CTRL  HCF

(Chen et al. 2017 JHM)
Exploring Coupled Model Processes

Decrease

Increase

the lower Mississippi River Basin

-0.90
-6.41
-25.91
-12.99
-29.72
-8.25
0.37
0.00
-0.12

LH (W/m²)  SH (W/m²)  CAPE (J/kg)  θ_dif (K)  PRECT (mm)

CTRL  HCF

(Chen et al. 2017 JHM)
Things to Consider with LULCC

**Synoptic to Global:** Perform some model runs with and without land cover change.

How believable are the responses when we know...?
Things to Consider with LULCC

Synoptic to Global: Perform some model runs with and without land cover change

How believable are the responses when we know…?

1. That the response sign can change when using different convective approaches

2. We aren’t capturing the intermediate scale (meso-iqssue processes) and in some cases are not sure about the local scale
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Moving Forward: Can I do more than complain about model spread and uncertainty?
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1. Provide some observed/expected precipitation response to land cover change beyond the limits of Mixed Layer and Single-Column model assumptions
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**Moving Forward:** Can I do more than complain about model spread and uncertainty?

1. Provide some observed/expected precipitation response to land cover change beyond the limits of Mixed Layer and Single-Column model assumptions.
2. Perhaps more LES modeling with direct applications to LULCC using land surface models from ESMs (like CLM…just saying).
Questions?