

Lee Honors College Honors Thesis:

# The Effects of Increased Cycling on Local & Global Greenhouse Gas Emissions

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April 2017



WESTERN MICHIGAN UNIVERSITY

**Lee Honors College**



**WELCOME!**



# What we'll cover today

- I. Rationale for my Study
- II. Research Questions
- III. Methods
- IV. Results
- V. Discussion
- VI. Conclusions

# What Causes Climate Change?

- Variation in the sun's energy reaching Earth (over millennia)
- Changes in greenhouse gasses (GHGs), which trap heat in Earth's atmosphere
- Changes in the reflectivity of Earth's atmosphere and surface



$\text{CO}_2$  = 76% of global GHG molecules

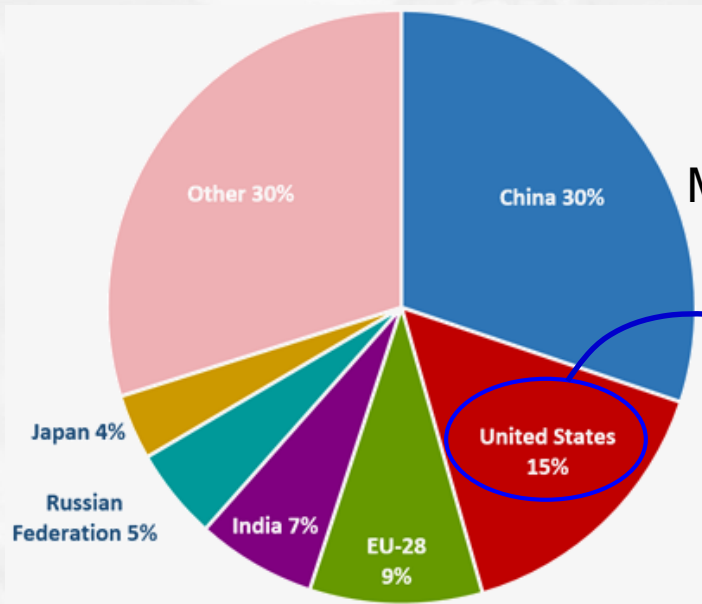
**97.5% of the world's climate scientists agree that humans are the primary cause of current climate change.**

**Adverse impacts will be proportional to future emissions**

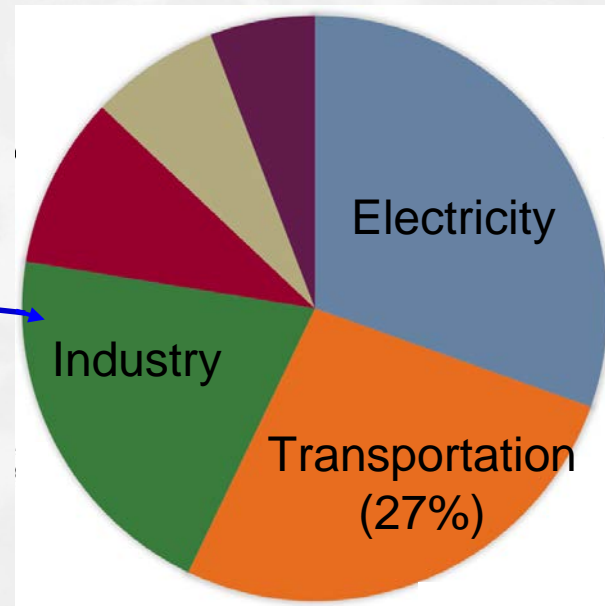
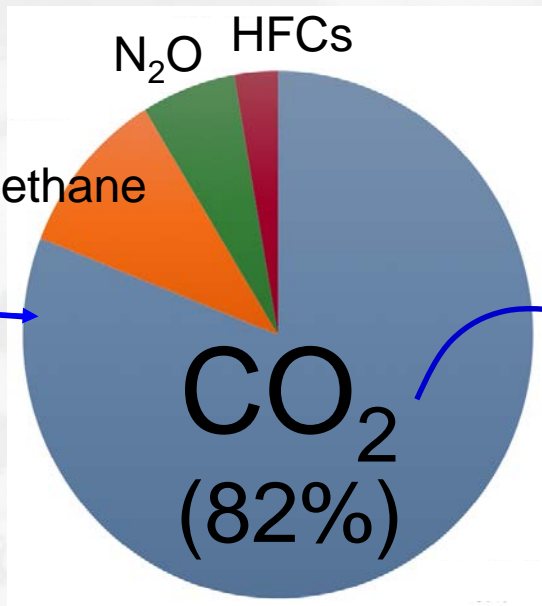


# How Am I Causing Climate Change?

Global CO<sub>2</sub> emissions in 2014



United States greenhouse emissions in 2014



# How Can I Cause Less Climate Change?

**I can be energy savvy:** unplug appliances, use LED light bulbs, leave the heat/AC off

**I can recycle:** recycle paper, plastics, glass, metals, and other materials

**I can be an activist:** volunteer time for climate action groups, take part in local/state political events

**However, I drive places. A lot of places. A lot of short distances too.**

Worst of all, I don't use this shiny new bike I just received nearly enough.....



**I can bike more:** switch from car commuting to bike commuting



# Can We Combat Climate Change with Bikes?

## Research Questions

1. **How many tons of CO<sub>2</sub> do WMU students add to the atmosphere by driving to and from class?**
2. **How much CO<sub>2</sub> emissions would be prevented by a plausible shift by WMU students to bicycle commuting?**
3. **What effect would a shift to bicycle commuting have on the year in which WMU achieves carbon neutrality?**
4. **If a similar shift to bicycle commuting occurred at all universities nationwide, would any adverse impacts of climate change be prevented?**



## Step One: Determine how many times per week/month/year WMU students drive to and from class

- Students on campus (from different dorm buildings/parking lots)
- Students off campus (from different living areas around Kalamazoo)
- Students drive multiple times a day to/from class

### **2014 WMU Office for Sustainability Transportation Survey included:**

- Proportion of students who drove individually or carpooled regularly
- How many times a day these students commuted every day of the week
- Where they commuted from
- Assumed where they parked on campus





# In 2014, there were 23,914 WMU students

The number of commutes differed among days

	None	1	2	3	4+
<b>Monday</b>	7.5%	18.9%	35.3%	20.4%	18.0%
<b>Tuesday</b>	6.79%	17.9%	34.57%	22.22%	18.5%
<b>Wednesday</b>	5.81%	19.2%	34.25%	22.63%	18.0%
<b>Thursday</b>	6.21%	17.39%	38.82%	20.5%	17.1%
<b>Friday</b>	19.37%	23.49%	31.11%	12.7%	13.3%
<b>Saturday</b>	50.69%	20.14%	18.06%	5.21%	5.9%
<b>Sunday</b>	52.31%	22.42%	15.66%	4.63%	5.0%

The number of days differed among semesters

	Fall	Spring	Summer I	Summer II
<b>Monday</b>	14	14	7	7
<b>Tuesday</b>	15	15	8	6
<b>Wednesday</b>	15	15	8	7
<b>Thursday</b>	14	15	7	8
<b>Friday</b>	14	14	7	8
<b>Saturday</b>	13	14	7	7
<b>Sunday</b>	13	14	7	7

- Totaled on-campus commutes per week & off-campus commutes per week
- Calculated commutes per academic year
- Scaled results up to whole WMU student body



## Step Two: Calculate total CO<sub>2</sub> emissions from WMU student car commuting

- According to the US Energy Information Administration, **burning one gallon of gasoline emits 19.64 lbs. of CO<sub>2</sub>**
- How much gas is burning per commute?



- Calculated CO<sub>2</sub> emissions for **three distinct scenarios**:  
I multiplied total distance driven (obtained from survey) by the three distinct average fuel efficiencies of 20 mpg, 25 mpg, or 30 mpg

# How many tons of CO<sub>2</sub> do WMU students add to the atmosphere by driving to and from class?

Calculated from 2014 emissions:

- WMU students driving in 2017 will emit 17,368 tons of CO<sub>2</sub>
- WMU staff driving in 2017 will emit 5,325 tons of CO<sub>2</sub>
- As a campus, drivers will emit **22,693 tons of CO<sub>2</sub>** in 2017



# Research Questions

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3. What effect would a shift to bicycle commuting have on the year in which WMU achieves carbon neutrality?
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# How much CO<sub>2</sub> emissions would be prevented by a plausible shift by WMU students to bicycle commuting?

First I calculated 9 different projections:

Carbon not emitted in 2017:

20 mpg w/ 10% compliance	7405 tons
20 mpg w/ 15% compliance	7593 tons
20 mpg w/ 20% compliance	7781 tons
25 mpg w/ 10% compliance	7280 tons
25 mpg w/ 15% compliance	7405 tons
25 mpg w/ 20% compliance	7530 tons
30 mpg w/ 10% compliance	7330 tons
30 mpg w/ 15% compliance	7480 tons
30 mpg w/ 20% compliance	7630 tons



# How much CO<sub>2</sub> emissions would be prevented by a plausible shift by WMU students to bicycle commuting?

Afterwards, I settled on my two realistic, achievable scenarios:

## Scenario 1:

10% biking compliance  
↑ 0.5% per year  
(average fuel efficiency 25 mpg)

## Scenario 2:

25% biking compliance  
↑ 1.5% per year  
(average fuel efficiency 25 mpg)



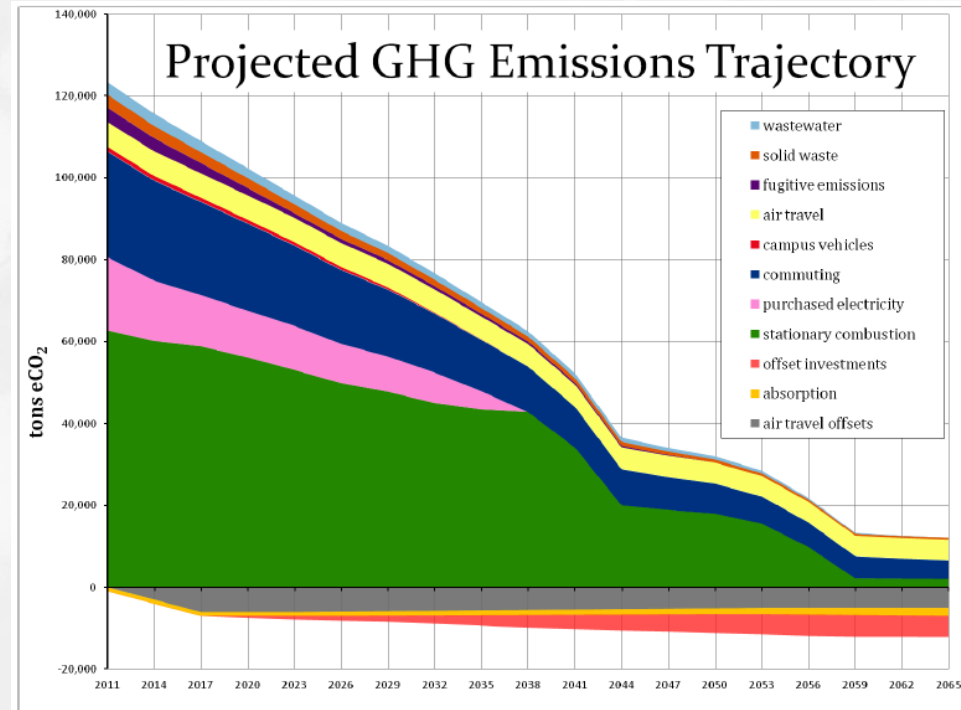
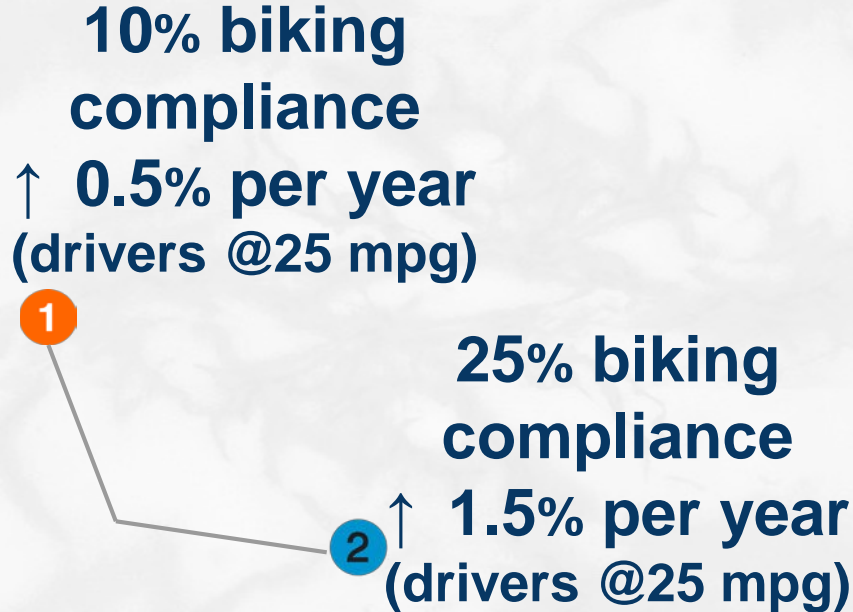
# Research Questions

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# What effect would a shift to bicycle commuting have on the year in which WMU achieves carbon neutrality?

- Next step: project my two sink scenarios on top of **WMU's 2012 Climate Action Plan**:

**WMU's Climate Neutrality goal = 2065**



## What effect would a shift to bicycle commuting have on the year in which WMU achieves carbon neutrality?

- Similar to the first 9 projections, I used Excel to calculate annual carbon sink for **Scenario 1** & **Scenario 2**
- This time, I had to pay attention to the extra variable of *growth rate per year*
- Once I had my formulas entered, for each year I individually subtracted the two new sink values from WMU's net emissions, monitoring when our emissions value reaches less than our sink value in each case



# Even a moderate shift to bicycle commuting would accelerate the rate at which WMU achieves climate neutrality

## Scenario 1

10% biking compliance

↑ 0.5% per year

(average fuel efficiency 25 mpg)

**WMU reaches carbon  
neutrality 4.5 years earlier**

WMU would emit **1,020 fewer tons**  
of CO<sub>2</sub> annually by 2065

U.S. would emit **861,900 fewer tons**  
of CO<sub>2</sub> annually by 2065

## Scenario 2

25% biking compliance

↑ 1.5% per year

(average fuel efficiency 25 mpg)

**WMU reaches carbon  
neutrality 6.5 years earlier**

WMU could be saving **2,550 tons**  
of CO<sub>2</sub> annually by 2065

U.S. would emit **2,154,750 fewer tons**  
of CO<sub>2</sub> annually by 2065



# Research Questions

1. How many tons of CO<sub>2</sub> do WMU students add to the atmosphere by driving to and from class?
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# If a similar shift to bicycle commuting occurred at all universities nationwide, would any adverse impacts of climate change be prevented?

- Quantified real world adverse impacts of climate change
- Compared the “business as usual” scenario with the “Paris Agreement” scenario
- Multiplied the difference in two scenarios by the proportional amount of carbon saved by nationwide compliance
- Gives us the proportional change to adverse conditions, **assuming emissions and adverse effects are correlated linearly**



# Quantifying real world adverse impacts of climate change

The Intergovernmental Panel on Climate Change (IPCC) has calculated various, internationally recognized, Representative Concentration Pathways (RCP) scenarios that project atmospheric health in multiple situations

RCP 8.5  $\approx$  SRES A1F

RCP 4.5  $\approx$  SRES B2

“Biz as Usual”

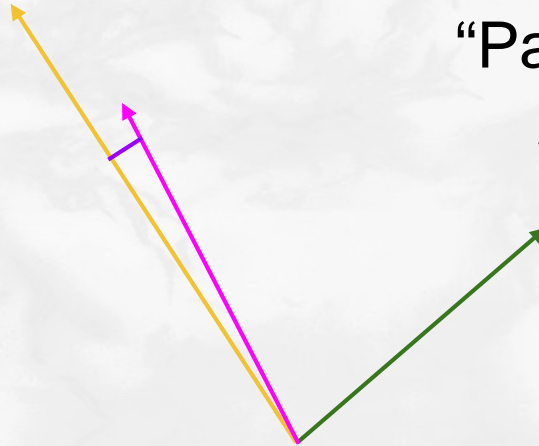
4° ↑ by 2100

1200 ppm

“Paris Agreement”

2° ↑ by 2100

550 ppm

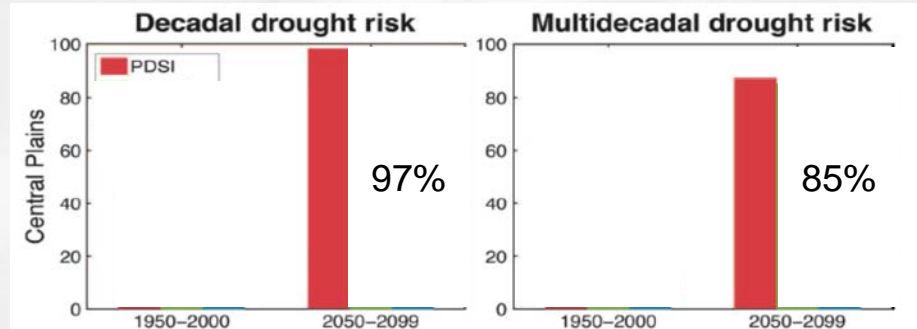




# Will increased bicycle commuting alter 21<sup>st</sup> century drought risk in the American Central Plains?

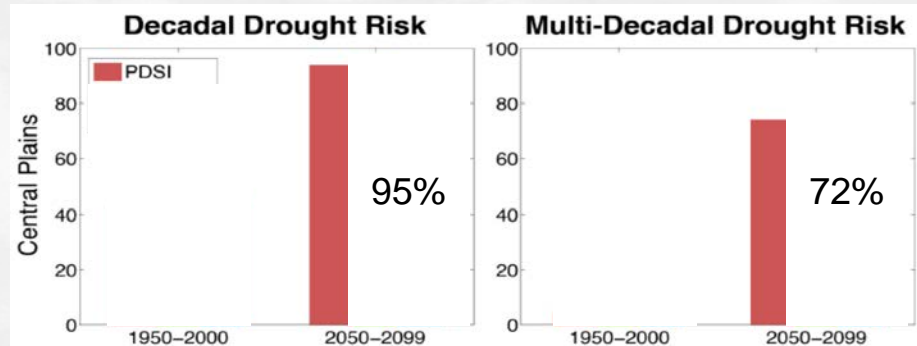
Cook et al. (2015) modelled the probability of decadal (11 yr.) and multidecadal (35 yr.) droughts from 2050-2100 under two emissions scenarios

RCP  
8.5



Effect on decadal  
drought probability:  
 $-2\% \times 0.00012 = -0.0002\%$

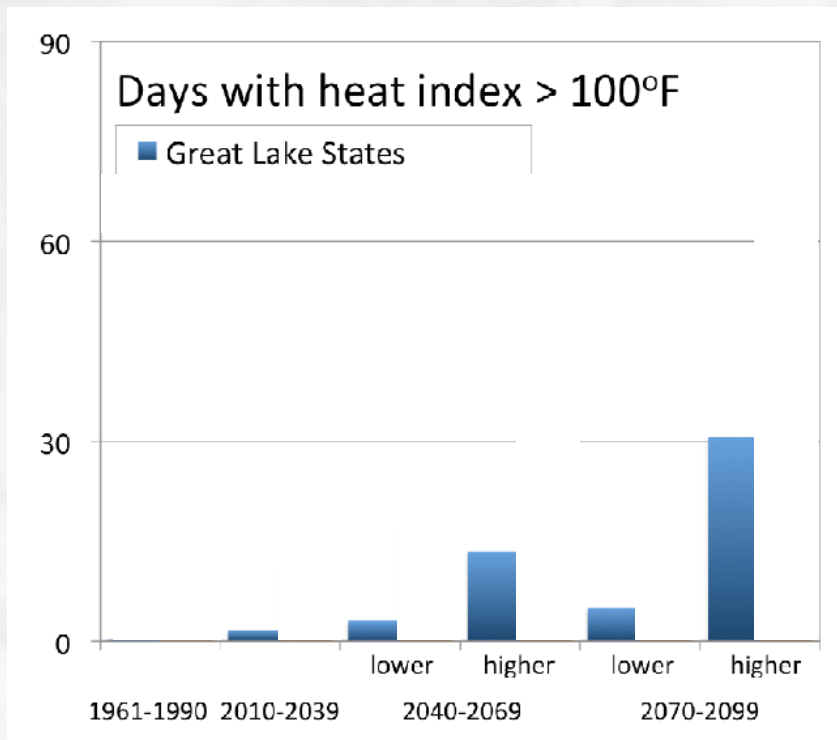
RCP  
4.5



Effect on multidecadal  
drought probability:  
 $-13\% \times 0.00012 = -0.0016\%$



# Will increased bicycle commuting alter 21<sup>st</sup> century drought risk in the American Central Plains?



## **Hot Days in Great Lakes states:**

(High A1F) 2040 - 2069 = 14 days per decade

(High A1F) 2070 - 2100 = 31 days per decade

(Low B1) 2040 - 2069 = 4 days per decade

(Low B1) 2070 - 2100 = 8 days per decade



# Will increased bicycle commuting alter 21<sup>st</sup> century drought risk in the American Central Plains?

## **Hot Days in Great Lakes states:**

(High A1F) 2040 - 2069 = 14 days

(High A1F) 2070 - 2100 = 31 days

(Low B1) 2040 - 2069 = 4 days

(Low B1) 2070 - 2100 = 8 days

## **Hot days prevented if all USA college students followed WMU's biking example:**

(High A1F) 2040 - 2069 = 0.00120 days

(High A1F) 2070 - 2100 = 0.00275 days

(Low B1) 2040 - 2069 = 0.00048 days

(Low B1) 2070 - 2100 = 0.00110 days

**Results are basically negligible**

# Will increased bicycle commuting alter 21<sup>st</sup> century heat wave risk across the American Midwest?

City	2070-2099	
	Lower	Higher
CHICAGO	4.22	27.44
CINCINNATI	1.44	21.44
CLEVELAND	0.33	11.11
DES MOINES	4.33	34.44
DETROIT	1.44	19.33
INDIANAPOLIS	2.11	24.56
MILWAUKEE	0.78	12.67
MINNEAPOLIS	1.89	19.67
ST LOUIS	11.11	59.89

(B1)

(A1F)

Difference in  
heat waves  
per decade

23.2

20.0

10.8

30.1

17.9

24.5

11.9

17.8

48.8

Proportional amount  
of carbon saved

0.00012

0.00012

0.00012

0.00012

0.00012

0.00012

0.00012

0.00012

0.00012

Heat waves prevented  
per decade

0.0011

0.0010

0.0005

0.0014

0.0009

0.0011

0.0006

0.0009

0.0023

Deaths prevented  
per decade

2.08

1.80

0.97

2.70

1.61

2.02

1.07

1.60

4.38

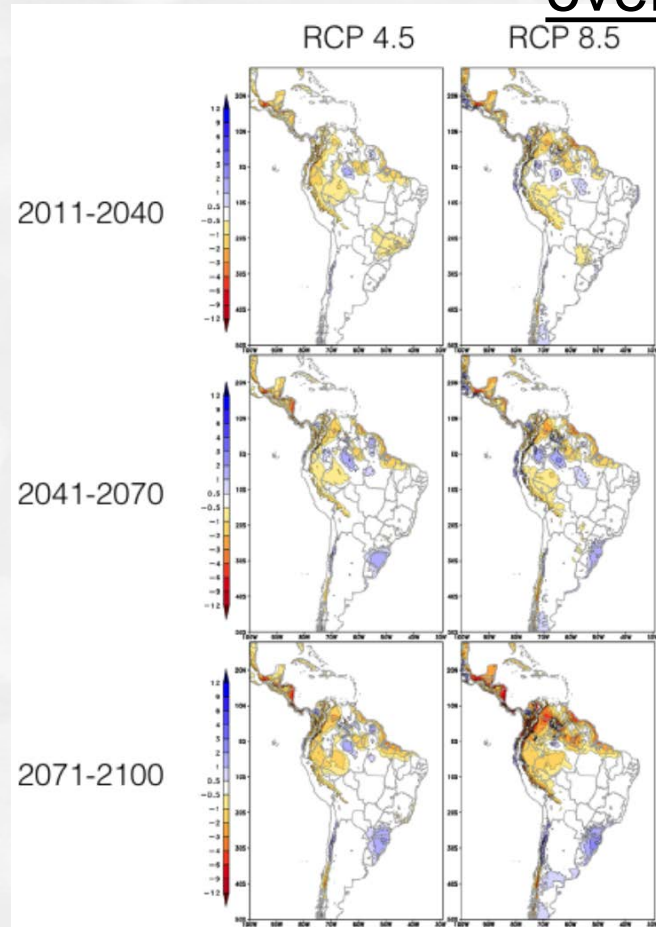
Chicago Heat Wave 1995 =  
739 deaths over five days

Total deaths prevented per decade = **19 people saved**

Hayhoe et al. (2009)



# Will increased bicycle commuting alter 21<sup>st</sup> century precipitation over the Amazon Rainforest?



Difference in summer  
mean precipitation (%)

	<u>Amazon Rainforest</u>	<u>Per season</u>
(Low RCP 4.5) 2011 - 2040	-0.000010	-0.000862
(Low RCP 4.5) 2041 - 2070	-0.000019	-0.001724
(Low RCP 4.5) 2071 - 2100	-0.000019	-0.001724
(High RCP 8.5) 2011 - 2040	-0.000024	-0.002155
(High RCP 8.5) 2041 - 2070	-0.000048	-0.004310
(High RCP 8.5) 2071 - 2100	-0.000048	-0.004310

**Over centuries, the Amazon  
could dry up...**

Chou et al. (2014)



Are we going to save the planet by cycling?

No.

# Citations:

- Pancella, Paul, and Harold Glasser. "Western Michigan University's 2012 Climate Action Plan." , 13 Apr. 2012. Accessed 20 Apr. 2017.
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Thank  
You