Tai Group for Atmosphere-Biosphere Interactions

Impacts of ozone air pollution and temperature extremes on vegetation density and ecosystem health

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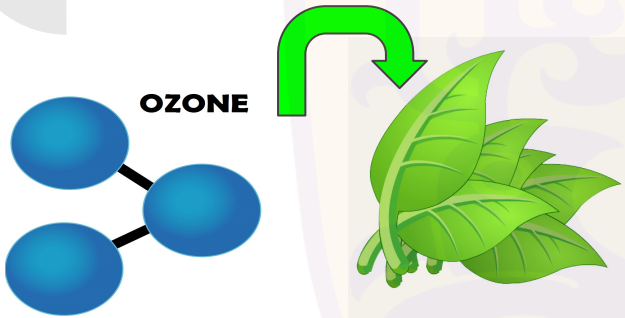
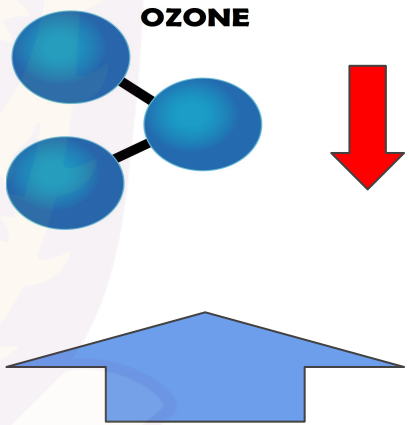
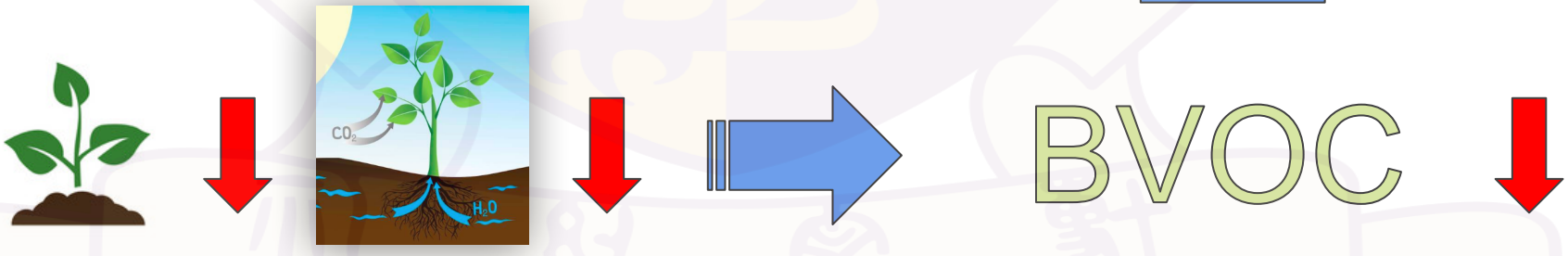
Introduction - Ozone

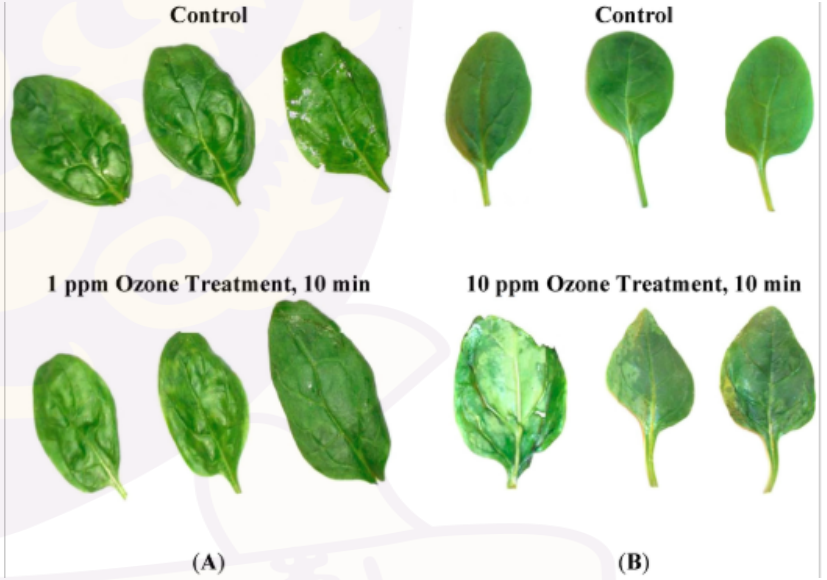






Ozone Damages

- Results from research on “Effect of Ozone Treatment on Inactivation of *Escherichia coli* and *Listeria* sp. on Spinach”
- (A) Impact of ozone exposure levels on visual quality of spinach when treated at 1 ppm ozone concentration for 10 min
- (B) Ozone injury/visual damage on spinach when exposed to 10 ppm ozone concentration for 10 min



Data

Leaf Area Index (LAI)

- Defined as total leaf area per unit ground area
- MODIS LAI in the US
- 1982 - 2011 (30 years)
- Summer (JJA)

Ozone Concentration

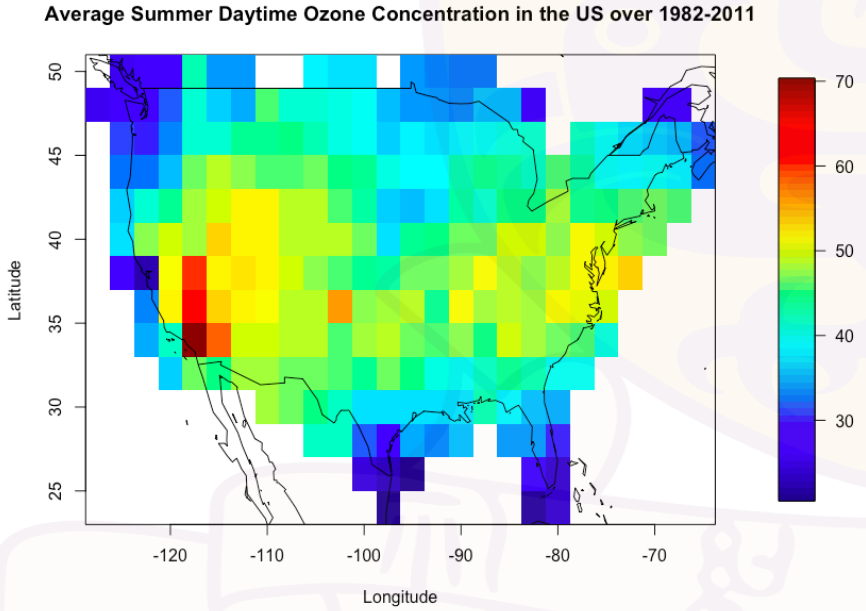
- United States environmental Protection Agency (USEPA)
- Hourly Ozone concentration measured by each site / monitor
- 1982 - 2011 (30 years)
- Summer (JJA)
- Daytime (08:00 - 19:59)

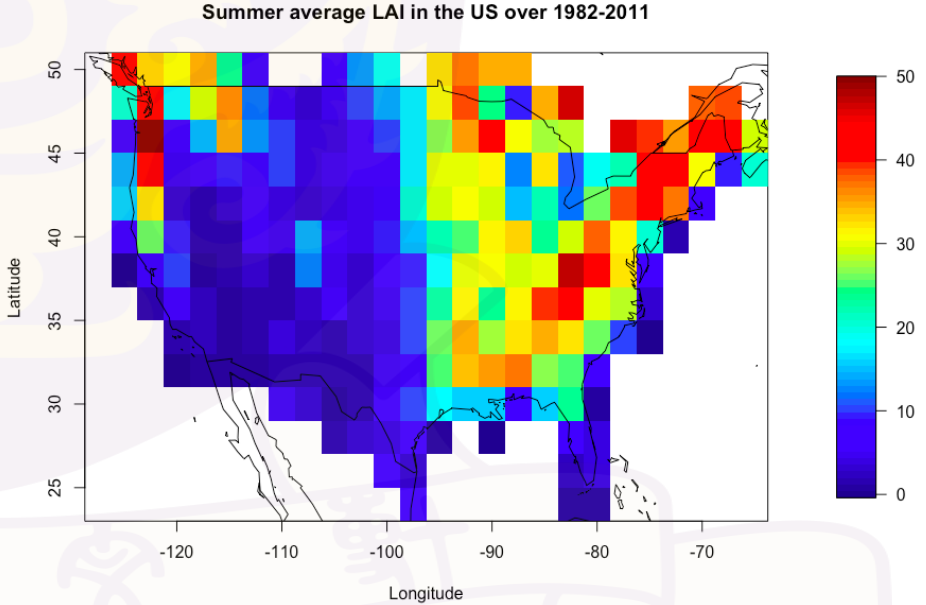
Temperature

- United States environmental Protection Agency (USEPA)
- Hourly temperature recorded by each site / monitor
- 1982 - 2011 (30 years)
- Summer (JJA)
- Daytime (08:00 - 19:59)

❖ All data are averaged to yearly means, gridded to 2x2.5 resolution and confined in the US

Ozone - LAI


Average Summer Daytime Ozone Concentration in the US over 1982-2011
Latitude
Longitude
50
45
40
35
30
25
-120
-110
-100
-90
-80
-70
70
60
50
40
30


Summer average LAI in the US over 1982-2011
Latitude
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50
45
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-120
-110
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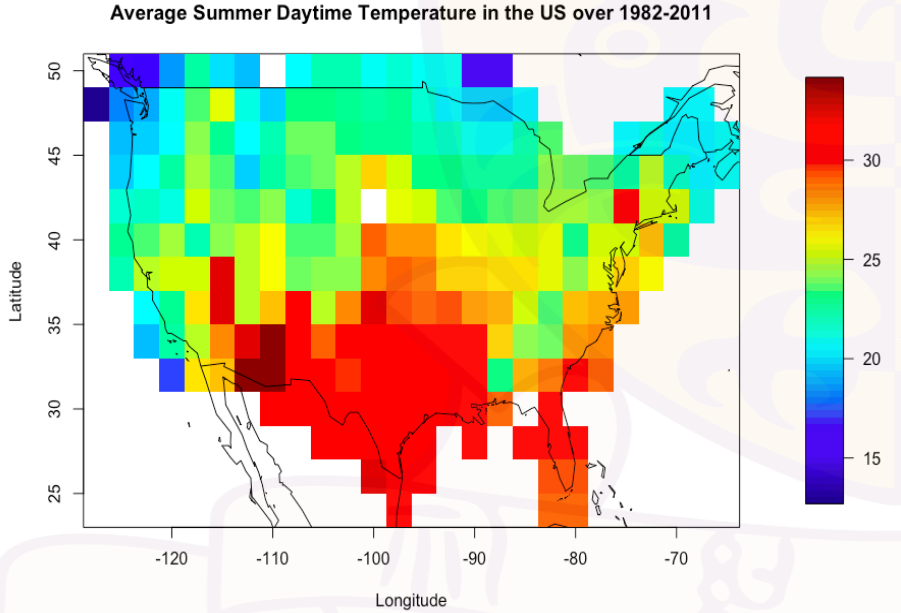
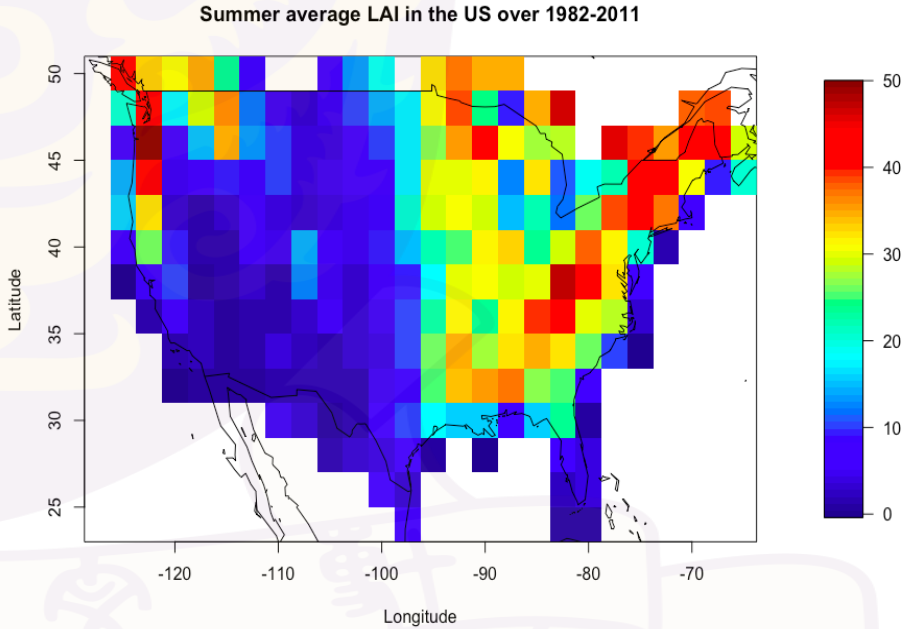
-90
-80
-70
50
40
30
20
10
0

Temperature - LAI

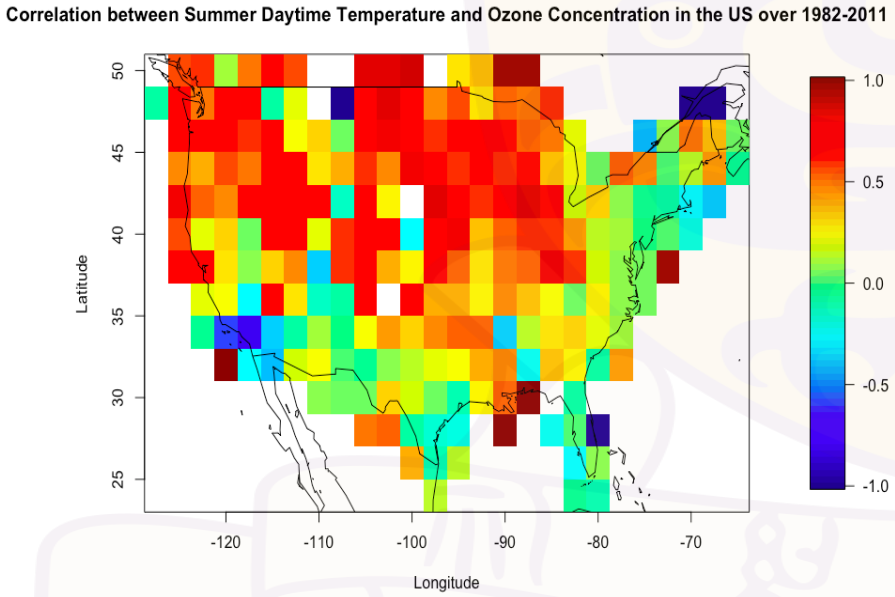


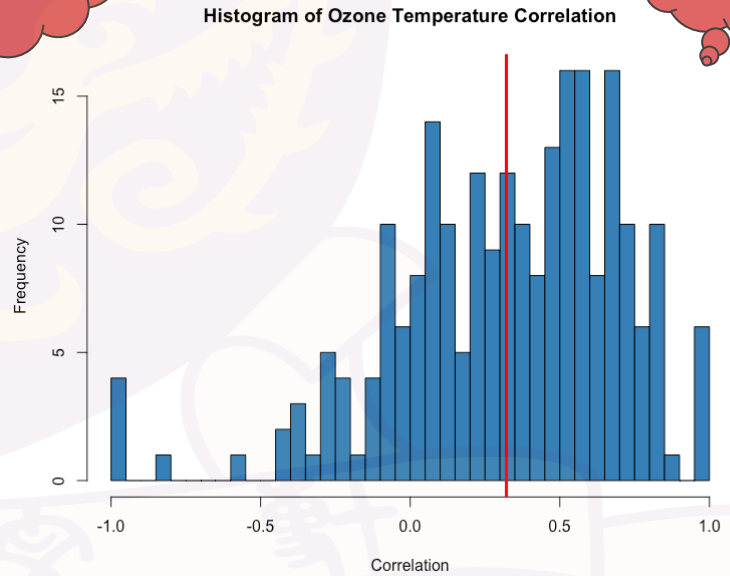


Ozone - Temperature

82%

0.32





Methodology

- Partial Derivative Linear Regression (PDLR)
- Assume ln(LAI) can be written as a function of ozone concentration and temperature
- Take derivatives
- Solve the equation to obtain ozone true sensitivity to ln(LAI)

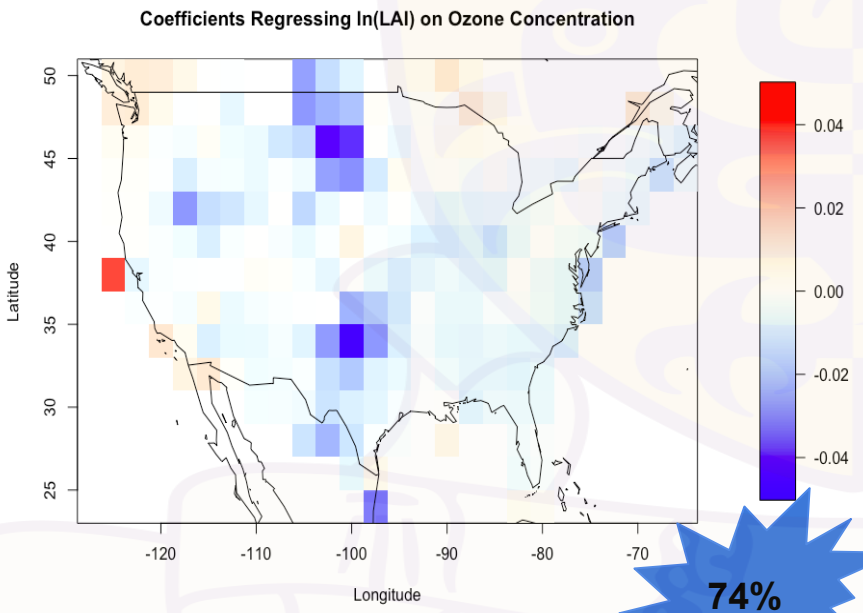
$$\frac{dlnL}{d[O_3]} = \frac{\partial lnL}{\partial [O_3]} + \frac{\partial lnL}{\partial T} \cdot \frac{dT}{d[O_3]}$$

$$\frac{\partial lnL}{\partial [O_3]} = \frac{dlnL}{d[O_3]} - \frac{\partial lnL}{\partial T} \cdot \frac{dT}{d[O_3]}$$

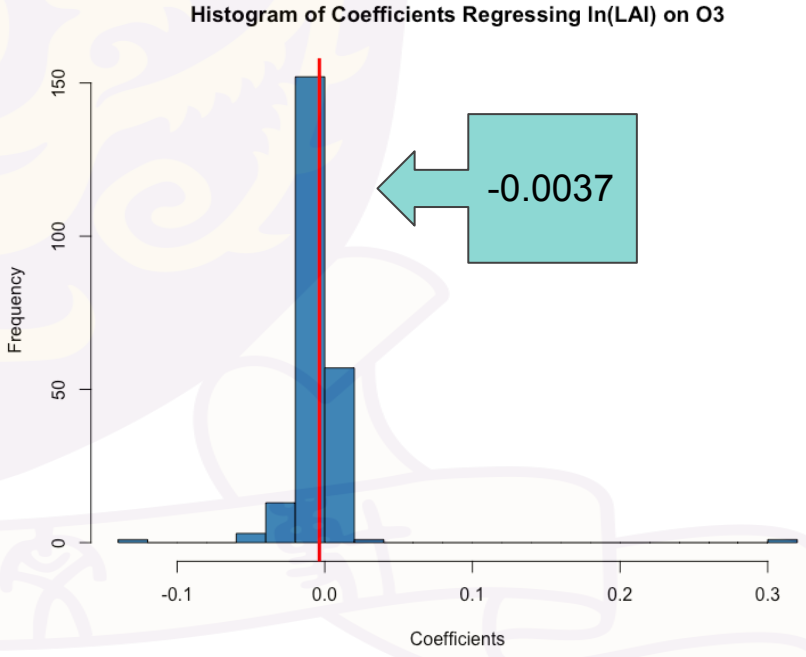
Ozone True Sensitivity

Temperature True Sensitivity

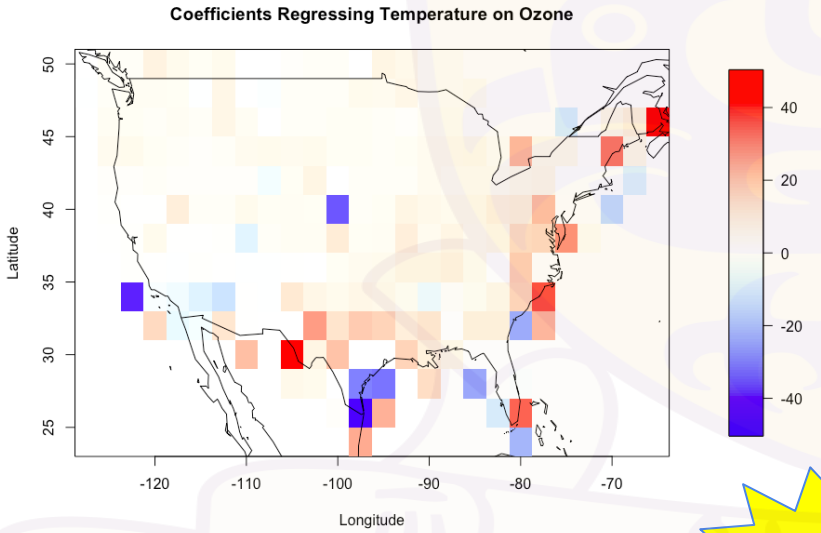
How ln(LAI) response to ozone concentration increases?

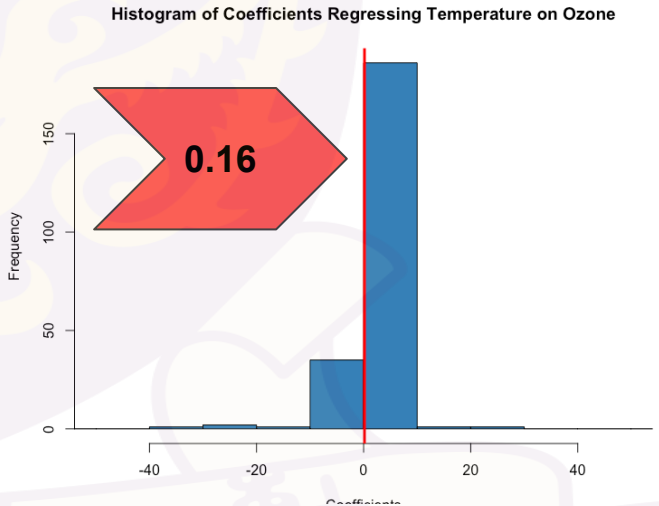


74%



How temperature response to ozone increases?





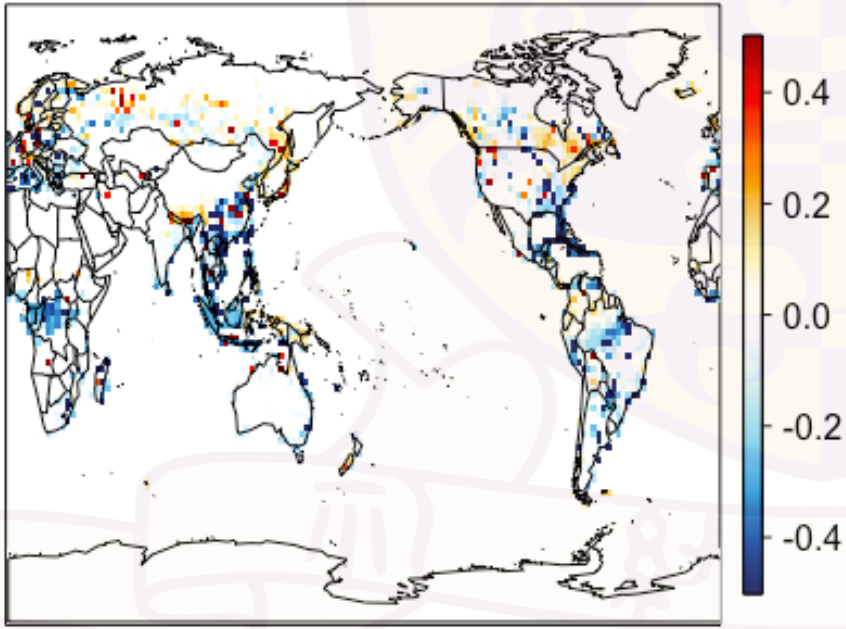
82%

Temperature True Sensitivity on ln(LAI)

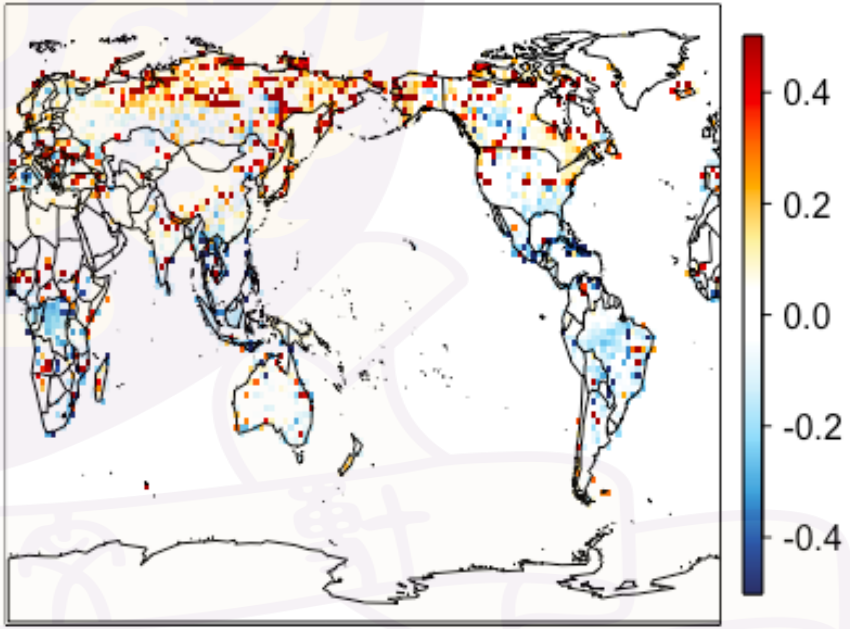
- Estimated using CLM4.5
- Simulated SP LAI changes when temperature increases 1 degree Celsius
- Take the difference between relative and absolute LAI changes to fix overestimating issues
- Temperature rise enhances boreal LAI but decreases tropical LAI

Temperature True Sensitivity on ln(LAI)

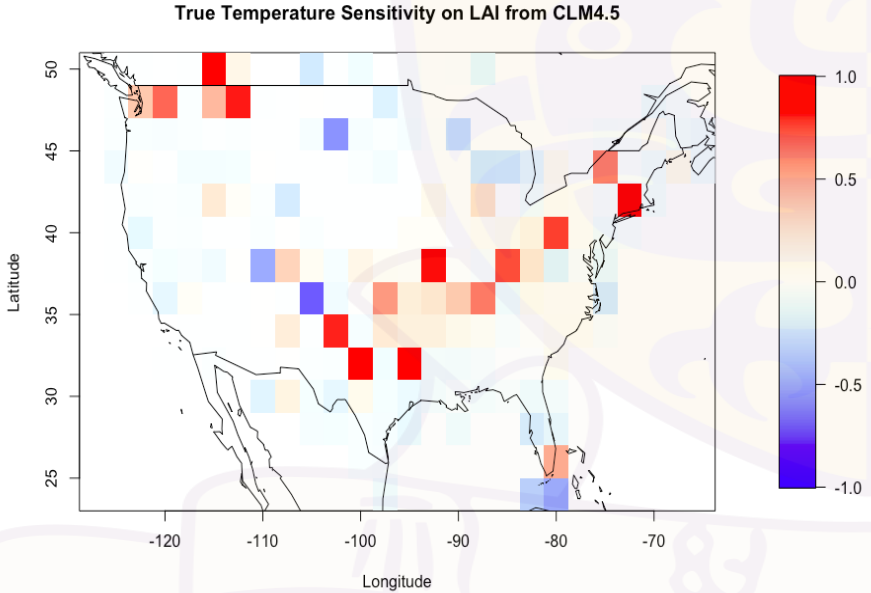
CLM45 ELAI difference, 20-39 yr

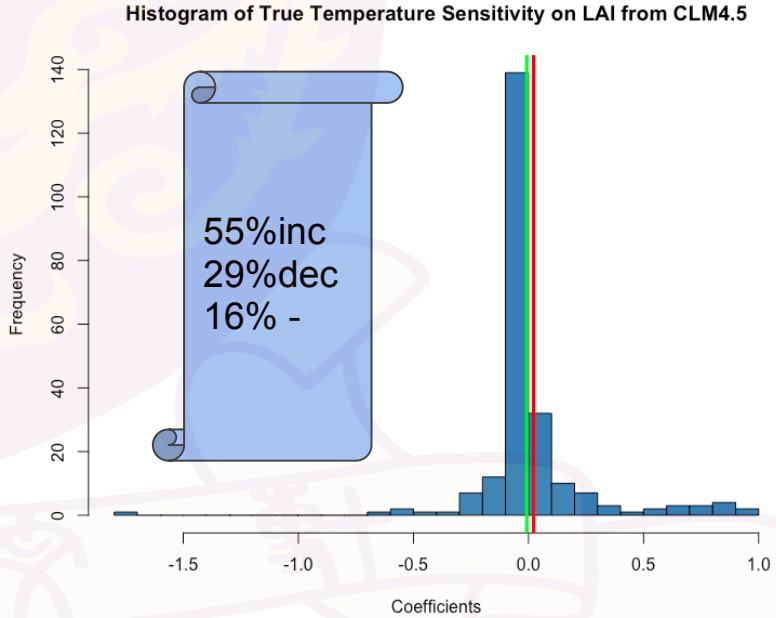


CLM45 ELAI change, 20-39 yr, from SP LAI



Temperature True Sensitivity on ln(LAI)





True Ozone Sensitivity on ln(LAI)

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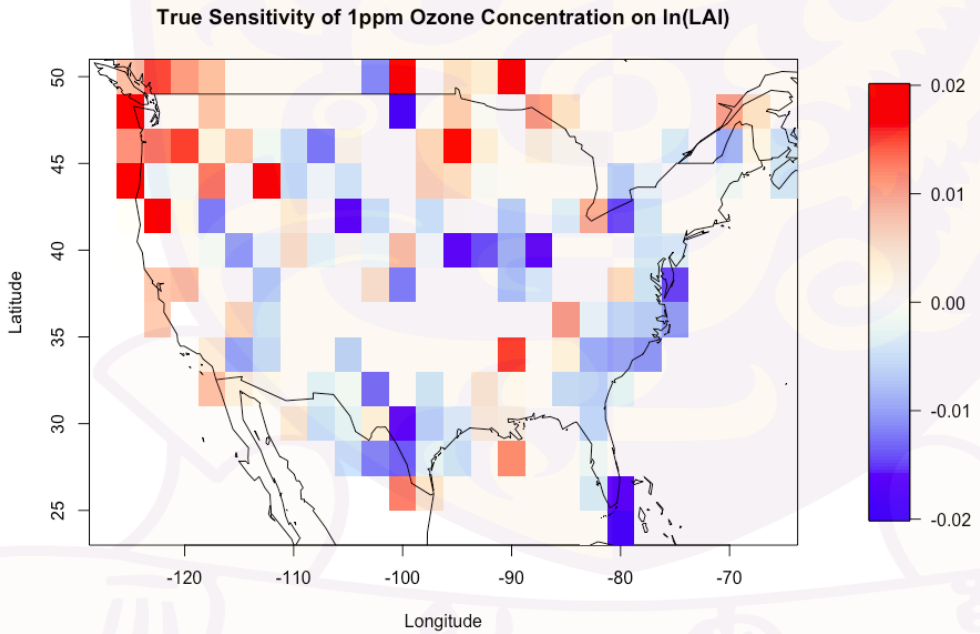
$$\frac{\partial lnL}{\partial [O_3]} = \frac{dlnL}{d[O_3]} - \frac{\partial lnL}{\partial T} \cdot \frac{dT}{d[O_3]}$$

True Ozone Sensitivity on ln(LAI)



60%

-0.003

Conclusion

- High ozone concentration decreases vegetation density in general even removed temperature effect
- Ozone positive impacts on vegetation density were unable to offset its negative impacts in most cases
- Ozone not only damages plant growth but also harmful to vegetation density
- May consider adding more confounding variables (ex. precipitation and CO_2 concentration) to further capture the true sensitivity of ozone on vegetation density