Ph.D. Defense Announcement
Steven Brey
June 20, 2019 at 9:00am

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Ph.D. Defense

Thursday, June 20, 2019
9:00am

Defense
ATS West Seminar Room (121 ATS West)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Emily Fischer (Advisor)
Elizabeth Barnes (Co-advisor)
Jeffrey Pierce
Monique Rocca (Ecosystem Science and Sustainability)

Planning for an Unknown Future: Incorporating Meteorological Uncertainty into Predictions of the Impact of Fires and Dust on US Particulate Matter

Exposure to particulate matter (PM) pollution has well documented health impacts and is regulated by the United States (U.S.) Environmental Protection Agency (EPA). In the U.S. wildfire smoke and wind-blown dust are significant natural sources of PM pollution. This dissertation shows how the environmental conditions that drive wildfires and wind-blown dust are likely to change in the future and what these changes imply for future PM concentrations.

The first component of this dissertation shows how human ignitions and environmental conditions influence U.S. wildfire activity. Using wildfire burn area and ignition data, I find that in both the western and southeastern U.S., annual lightning- and human-ignited wildfire burn area have similar relationships with key environmental conditions (temperature, relative humidity, and precipitation). These results suggest that burn area for human- and lightning-ignited wildfires will be similarly impacted by climate change. Next, I quantify how the environmental conditions that drive wildfire activity are likely to change in the future under different climate scenarios. Coupled Model Intercomparison Project phase 5 (CMIP5) models agree that western U.S. temperatures will increase in the 21st century for representative concentration pathways (RCPs) 4.5 and 8.5. I find that averaged over seasonal and regional scales, other environmental variables demonstrated to be relevant to fuel flammability and aridity, such as precipitation, evaporation, relative humidity, root zone soil moisture, and wind speed, can be used to explain historical variability in wildfire burn area as well or better than temperature. My work demonstrates that when objectively selecting environmental predictors using Lasso regression, temperature is not always selected, but that this varies by western U.S. ecoregion. When temperature is not selected, the sign and magnitude of future changes in burn area become less certain, highlighting that predicted changes in burn area are sensitive to the environmental predictors chosen to predict burn area. Smaller increases in future wildfire burn area are estimated whenever and wherever the importance of temperature as a predictor is reduced.

The second component of this dissertation examines how environmental conditions that drive fine dust emissions and concentrations in the southwestern U.S. change in the future. I examine environmental conditions that influence dust emissions including, temperature, vapor pressure deficit, relative humidity, precipitation, soil moisture, wind speed, and leaf area index (LAI). My work quantifies fine dust concentrations in the U.S. southwest dust season, March through July, using fine iron as a dust proxy, quantified with measurements from the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network between 1995 and 2015. I show that the largest contribution to the spread in future dust concentration estimates comes from the choice of environmental predictor used to explain observed variability. The spread between different environmental predictor estimates is larger than the spread between climate scenarios or intermodel spread. Based on linear estimates of how dust concentrations respond to changes in LAI, CMIP5 estimated increases in LAI would result in reduced dust concentrations in the future. However, when I objectively select environmental predictors of dust concentrations using Lasso regression, LAI is not selected in favor of other variables. When using a linear combination of objectively selected environmental variables, I estimate that future southwest dust season mean concentrations will increase by 0.24 $\mu g\ m^{-3}$ (12\%) by the end of the 21st century for RCP 8.5. This estimated increase in fine dust concentration is driven by decreases in relative humidity, precipitation, soil moisture, and buffered by decreased wind speeds.