Ph.D. Defense Announcement
Sagar Rathod
Monday, June 13, at 12:00 p.m. MT

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Ph.D. Defense

June 13, 2022
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Defense
ATS Large Classroom (101 ATS) or Teams

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Tami Bond (Adviser, Mechanical Engineering)
Jeffrey Pierce (Adviser)
Emily Fischer
A. Scott Denning
Ryan Scott (Political Science)

Earth, Humans, and Metals: Investigating the role of iron and other metals in the atmospheric, oceanic, and energy systems

Metals such as copper and iron have formed an integral part of human civilization's growth since the Bronze and the Iron ages. Of these metals, iron is of particular importance because of the roles it plays in the Earth system and because it is emitted in more quantity than other metals from human activities. Iron in the particle form affects the atmospheric radiative budget by absorbing solar radiation while it is suspended in the air, and it affects the oceanic nutrient cycle by enhancing phytoplankton growth when it falls in iron-limited ocean areas. Moreover, iron and other metals also form a central part of almost all renewable energy devices such as solar panels and wind turbines, but the mining and smelting activities to obtain these metals lead to emissions of air pollutants such as particulate matter, which have impacts on human health and climate. In this presentation, I will discuss how human activities such as fossil fuel combustion influence the Earth's atmospheric radiative and oceanic biological systems via the iron pathway, and how the projected growth of renewable energy could drive particulate matter emissions via the metal mining and smelting pathway.

The first part of this presentation explores two Earth system impacts, direct radiative forcing and marine net primary productivity change, by particulate iron released into the atmosphere from human activities such as fossil fuel combustion and mineral ore processing. We evaluate the influence of present-day anthropogenic iron emissions on these two mechanisms using emission inventories with iron representation and an atmospheric transport model. Overall, we find that even with the upper bounds in emissions and modeling, both present-day direct radiative forcing and marine net primary productivity by anthropogenic iron emissions are globally small but can be regionally large.

Anthropogenic iron emission causes noticeable atmospheric warming over regions with more coal combustion and smelting, and it sustains more than 15% of total phytoplankton growth in the iron-limited North Pacific Ocean.

The second part of this presentation explores the particulate matter emissions from mining and smelting to obtain metals for the projected future growth of solar photovoltaics, wind turbines, and electric vehicles in two scenarios, business-as-usual and rapid decarbonization. We also examine the inequalities in emissions due to how metal resources are geographically distributed, and the role of abatement in mitigating the overall emissions and the inter-regional inequalities. We find that rapid decarbonization could lead to a faster reduction of global anthropogenic particulate matter emissions than the business-as-usual case, even when accounting for the increase in contribution from mining and smelting. Moreover, the application of proper abatement could reduce more than 90% of the mining and smelting emissions, and also reduce the inter-regional inequalities in emissions in both the energy scenarios.

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