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Editorial

A Chemical Perspective on Climate: Emerging Research into Atmospheric Chemistry Impacts on Earth's Radiative Balance

Guest Editorial for the Accounts of Chemical Research special issue "New Frontiers in Chemistry—Climate Interactions".

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Human activities are changing the composition of the atmosphere and, as a result, Earth's climate. Understanding the extent of these changes and accurately predicting how our decisions and actions influence the magnitude of those changes require a detailed understanding of long-lived climate forcers in the atmosphere, including greenhouse gases, and short-lived climate forcers such as tropospheric ozone and aerosols. Atmospheric chemistry plays a central role in climate, dictating both the sources of many secondary climate forcers (e.g., secondary organic and inorganic aerosol and tropospheric ozone) and the lifetimes of both primary and secondary emissions. For example, the concentration of atmospheric hydroxyl radical (OH) controls the lifetime and thus radiative impact of many greenhouse gases. However, the concentration is controlled by a complex suite of reactions that are still under debate in the literature. This special issue highlights current research into chemistry—climate interactions.

One important theme addressed in this issue involves the role of surface—atmosphere exchange of chemical species. The biosphere, hydrosphere, and cryosphere all interact with the atmosphere as both sources and sinks of reactive trace gases, greenhouse gases, and particles. However, these interactions provide critical feedbacks: environmental conditions can impact the productivity and emissions by plants, while climatological effects can influence biodiversity and even ocean dynamics relevant to trace gas and sea spray emissions. The background conditions of the planet, that is, the concentration of species in the atmosphere before humans, are essential to quantify as they provide the boundary condition for understanding how human activities are influencing climate. However, as many of the papers in this special issue note, anthropogenic additions to the atmosphere influence surface—atmosphere exchange and atmospheric chemistry. Adding CO_2 or increasing temperature influences biosphere sources of volatile organic compounds, while the addition of NO and NO_2 radicals from fossil fuel and wildfire combustion sources influence oxidation radical chemistry and thus OH concentrations, ozone production rate, and secondary organic aerosol formation. Anthropogenic emissions also influence multiphase chemistry and acidity of aerosols and thus influence the ability of aerosols to take up water and act as cloud condensation nuclei.

Our understanding of the sources, sinks, and chemistry of both short- and long-lived chemical species has improved dramatically over the past several decades. These improvements can largely be attributed to the development of new measurement technologies used in field and laboratory experiments, as well as innovative modeling studies. Atmospheric chemistry experiments are becoming progressively more interdisciplinary as the role of microbes and plants as key levers in atmospheric chemistry and climate are slowly being revealed. The "lab-in-field" approach of *in situ* chemical kinetics experiments using flow reactors has provided insight into reactive trace gas and aerosol chemistry, while studies that bring real-world samples into laboratory environments have demonstrated the complex controls on ocean—atmosphere exchange and aerosol formation.

Despite these studies, gaps in our understanding of climate—chemistry interactions persist. These gaps limit our ability to understand human impacts on climate and predict how changes in policies will affect our future temperatures. Areas of particular need in the chemistry—climate field include feedbacks in biosphere—atmosphere exchange from increasing air pollutants and changing climate conditions, a deeper understanding of the chemistry of ocean surfaces and the interplay between marine biology and atmospheric chemistry, how the chemical evolution of aerosols in the atmosphere impacts their capacity to form clouds, and the intersection of policy and chemistry through studies of the influence of decision-making and social behavior on atmospheric composition and chemistry—climate interactions.

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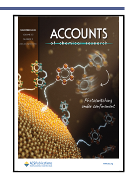

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