

AIR POLLUTION IN COLD REGIONS

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Summary

This chapter provides an overview of the nature of the constituents in the atmosphere and the changes in concentrations of these constituents that is termed air pollution. The focus will be on the changes in the cold regions of the earth with emphasis on the polar areas, the Arctic and the Antarctic. Although there is limited anthropogenic activity in these areas, there are concentrations of atmospheric constituents that are above those levels that are likely to have been present before the start of the industrial revolution. These changes can be both qualitative and quantitative. The nature of the sources, transport, and chemical processes that lead to the pollution of these regions is described.

1. Introduction

The atmosphere is a complex chemical system that has evolved through interactions with the lithosphere, hydrosphere and biosphere. Gases and particles are exchanged between the surfaces of the land and water. There are gaseous and particulate emissions from plants and animals as well as from anthropogenic activities. They undergo complex chemical processing driven primarily by sunlight so that the cold regions of the world present unique circumstances because there are periods with no or so little sunlight as to halt photochemical processing. Although the atmosphere is not partitioned, there are physical impediments to vertical and horizontal mixing that permits the consideration of compartments that exhibit different physical and chemical behavior.

The troposphere is the lowest layer of the atmosphere; it begins at the surface and extends to between 7 km (23,000 ft) at the poles and 17 km (60,000 ft) at the equator, with some variation due to weather factors. The stratosphere extends from the troposphere's 7 to 17 km (23,000 – 60,000 ft) range to about 50 km (160,000 ft) with temperature increasing with height. The stratosphere contains the ozone layer, the part of the Earth's atmosphere that contains ozone in relatively high concentrations (parts per million levels). Above the stratosphere are the mesosphere and thermosphere, but these regions will not be discussed here.

The bulk of the atmosphere consists of nitrogen (78.0842%), oxygen (20.9463%), and argon (0.93422%) with significantly lower concentrations of CO₂ (0.03811%), CH₄ (0.0001745%), N₂O (0.00005%), and varying concentrations of water vapor (~0.25% over full atmosphere, typically 1% to 4% near surface). There are a number of minor species with much higher variability in their concentrations where the variability of the concentrations is inversely related to the reactivity. In cold regions, there are generally limited sources and at the lower temperatures, chemical reactions occur at lower rates. Thus, these regions, the Arctic and Antarctic, are generally thought to be relatively pristine in terms of the air quality. However, over the past 3 decades, measurements have been made characterizing the air quality in these regions and it has been found to have greater air pollution than had originally been believed. This chapter summarizes the nature of air quality in the Arctic and the Antarctic regions.

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Biographical Sketch

Dr. Philip K. Hopke is the Bayard D. Clarkson Distinguished Professor at Clarkson University and the Director of the Center for Air Resources Engineering and Science. Dr. Hopke is the past Chair of the Environmental Protection Agency's Clean Air Scientific Advisory Committee (CASAC), and he also chaired the CASAC Ambient Air Monitoring and Methods (AAMM) Subcommittee. In addition, he has served as an Science Advisory Board (SAB) Member. Professor Hopke is a Past President of the American Association for Aerosol Research, and was a member of the National Research Council's Congressionally-mandated Committee on Research Priorities for Airborne Particulate Matter and the Committee on Air Quality Management in the United States. He has previously served on five other NRC committees including the Committee on Risk Assessment of Exposure to Radon in Drinking Water. Professor Hopke received his B.S. in Chemistry from Trinity College (Hartford) and his M.A. and Ph.D. degrees in chemistry from Princeton University. After a post-doctoral appointment at M.I.T., he spent four years as an assistant professor at the State University College at Fredonia, NY. Dr. Hopke then joined the University of Illinois at Urbana-Champaign, rising to the rank of professor of environmental chemistry, and subsequently came to Clarkson in 1989 as the first Robert A. Plane Professor with a principal appointment in the Department of Chemistry. He has served as Dean of the Graduate School, Chair of the Department of Chemistry, and Head of the Division of Chemical and Physical Sciences before he moved his principal appointment to the Department of Chemical Engineering in 2000. In 2002, he was appointed to his current positions at Clarkson.