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Regional to Global Scale Atmospheric Effects of the Emerging Mainland Chinese Transportation System

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Abstract

This is the final report of a one-year, Laboratory Directed Research and Development (LDRD) project at Los Alamos National Laboratory (LANL). The People's Republic of China will be moving toward considerably increased use of motorized vehicles over the next human generation. Estimates are for a fleet of 100 million vehicles or more. Large increases in ozone and other types of pollution associated with automobiles will result and this will have significant impact across Asia and into the Pacific. In this project we have taken a continental scale approach in a two-dimensional photochemical model to estimate the ozone concentrations to be expected. Potential levels of nitrate/soot in aerosols and increase in carbon dioxide are also discussed. Major pollution problems are forecast for the Pacific Rim if Chinese projections for their automotive sector are realized.

Background and Research Objectives

Local surface travel needs in the People's Republic of China (mainland China) have traditionally been met largely by nonpolluting bicycles. A major automobile manufacturing/importing effort has begun in the country over the last decade, and planning documents indicate that the Chinese may strive to acquire more than 100 million vehicles early in the next century. By analogy with large automotive fleets already existing in the western world, both regional and global scale pollution effects are to be expected from the increase. The present work adopts the latest projections of Chinese automobile manufacture and performs some assessments of the extent of pollution generation.

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Importance to LANL's Science and Technology Base and National R&D Needs

Los Alamos National Laboratory (LANL) is active in systems and environmental modeling and has expressed its strategic commitment to continue development in this area of science through an Environmental Sciences Tactical Goal. The Laboratory is actively working as part of a DOE task on global warming and CO₂ mitigation. This project is a modest but quantitative approach taken toward the evaluation of one of the world's major pollution phenomena.

Scientific Approach and Accomplishments

Emphasis in this investigation was placed upon the oxidant ozone. Emissions of the precursor species nitrogen oxides and volatile organics for our model were constructed from data for the current automotive sector in the eastern portion of the United States. Ozone production is first estimated from measured values for continental/oceanic scale yields relative to precursor oxidation. The estimates are then corroborated through idealized two-dimensional modeling of the photochemistry taking place in springtime air flow off the Asian land mass and toward the Pacific Ocean.

Our results are presented in some detail in the two publications cited below. In summary, these indicate that the projected fleet sizes could increase coastal and remote oceanic ozone concentrations by tens of parts per billion in the lower troposphere. Influences on the tropospheric aerosol system and on the major greenhouse gas carbon dioxide are treated peripherally. Nitrogen oxides created during the vehicular internal combustion process will contribute to nitrate pollution levels measured in the open Pacific. The potential for soot and fugitive dust increases should be considered as the automotive infrastructure develops. Since the emerging Chinese automotive transportation system will represent a substantial addition to the global fleet and all the carbon in gasoline is eventually oxidized completely, a significant rise in global carbon dioxide inputs will ensue as well.

Some policy issues were treated preliminarily. The assumption was made that alterations to regional oxidant/aerosol systems and to terrestrial climate are conceivable. The likelihood that the Chinese can achieve the latest vehicle fleet goals is discussed, from the points of view of new production, positive pollution feedbacks from a growing

automobile industry, and known petroleum reserves. Vehicular fuel and maintenance options lying before the Chinese are outlined and compared. To provide some perspective on the magnitude of the environmental changes associated with an Asian automotive buildup, recent estimates of the effects of future air traffic over the Pacific Rim are described.

Publications

S. Elliott, et al., "Regional to Global Scale Atmospheric Effects of the Emerging Mainland Chinese Transportation System," Los Alamos National Laboratory Technical Report LA-13213-MS (1996).

S. Elliott, et al., "Atmospheric Effects of the Emerging Mainland Chinese Transportation System at the Regional Scale and Beyond," submitted to Journal of Atmospheric Chemistry, 1996.