Pollution of the upper atmosphere by rockets

Journal	Space Science Reviews
Publisher	Springer Netherlands
ISSN	0038-6308 (Print) 1572-9672 (Online)
Issue	Volume 3, Number 2 / August, 1964
DOI	10.1007/BF00180267
Pages	275-316
Subject Collection	Physics and Astronomy
SpringerLink Date	Tuesday, November 23, 2004

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Received: 11 June 1964

Abstract This report estimates the amounts of various constituents that would have to be continually injected by rockets into the upper atmosphere in order to double the worldwide natural concentrations there. Involved in the calculations are: (a) the natural atmospheric abundances of constituents such as H_2O, CO_2, NO, Na, K, Li, H, etc.; (b) the residence times in various regions of the atmosphere, since these determine how rapidly a constituent will be removed; and (c) the chemical or photochemical stability of a substance exposed to the upper atmosphere environment. It is concluded that a doubling of the CO_2, H_2O, or NO content would require per year on the order of 10^3 to 10^5 Saturn-type rockets, each injecting 100 tons of exhaust above 100 km. On the other hand, a few hundred small rockets per year, each containing 10 kg of the chemical, would probably double the Na content; similarly, less than two such rockets per year would be expected to double the Li content. These last conclusions have implications for future tracer experiments using these substances.

The author is now an Associate Director of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. The work reported here was supported by the United States Air Force under Contract AF 49(638)-700 with the RAND Corporation. The views or conclusions contained in this paper should not, however, be interpreted as representing the official opinion of the United States Air Force.

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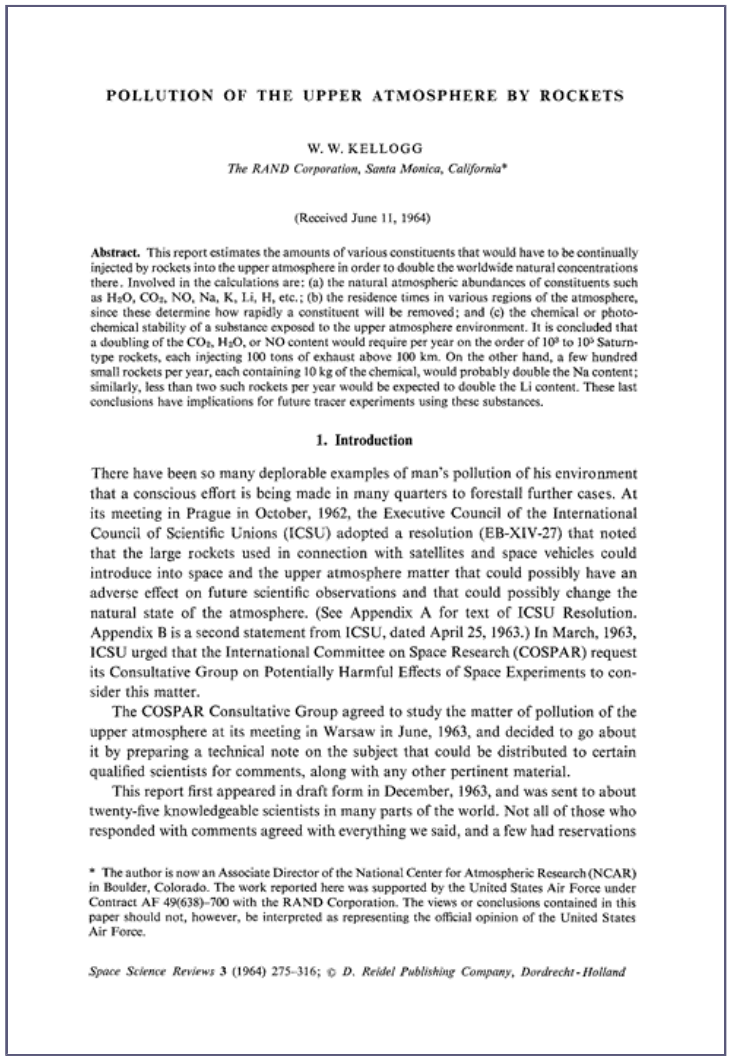

POLLUTION OF THE UPPER ATMOSPHERE BY ROCKETS

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(Received June 11, 1964)

Abstract. This report estimates the amounts of various constituents that would have to be continually injected by rockets into the upper atmosphere in order to double the worldwide natural concentrations there. Involved in the calculations are: (a) the natural atmospheric abundances of constituents such as H_2O, CO_2, NO, Na, K, Li, H, etc.; (b) the residence times in various regions of the atmosphere, since these determine how rapidly a constituent will be removed; and (c) the chemical or photochemical stability of a substance exposed to the upper atmosphere environment. It is concluded that a doubling of the CO_2, H_2O, or NO content would require per year on the order of 10^3 to 10^5 Saturn-type rockets, each injecting 100 tons of exhaust above 100 km. On the other hand, a few hundred small rockets per year, each containing 10 kg of the chemical, would probably double the Na content; similarly, less than two such rockets per year would be expected to double the Li content. These last conclusions have implications for future tracer experiments using these substances.

1. Introduction

There have been so many deplorable examples of man's pollution of his environment that a conscious effort is being made in many quarters to forestall further cases. At its meeting in Prague in October, 1962, the Executive Council of the International Council of Scientific Unions (ICSU) adopted a resolution (EB-XIV-27) that noted that the large rockets used in connection with satellites and space vehicles could introduce into space and the upper atmosphere matter that could possibly have an adverse effect on future scientific observations and that could possibly change the natural state of the atmosphere. (See Appendix A for text of ICSU Resolution. Appendix B is a second statement from ICSU, dated April 25, 1963.) In March, 1963, ICSU urged that the International Committee on Space Research (COSPAR) request its Consultative Group on Potentially Harmful Effects of Space Experiments to consider this matter.

The COSPAR Consultative Group agreed to study the matter of pollution of the upper atmosphere at its meeting in Warsaw in June, 1963, and decided to go about it by preparing a technical note on the subject that could be distributed to certain qualified scientists for comments, along with any other pertinent material.

This report first appeared in draft form in December, 1963, and was sent to about twenty-five knowledgeable scientists in many parts of the world. Not all of those who responded with comments agreed with everything we said, and a few had reservations

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