SURFACE AND AIRBORNE CONDENSATION NUCLEI MEASUREMENTS IN REMOTE AREAS

Laurence J. Budney

Army Electronics Command
Fort Monmouth, New Jersey

March 1968
Research and Development Technical Report
ECOM-2954

SURFACE AND AIRBORNE CONDENSATION NUCLEI
MEASUREMENTS IN REMOTE AREAS

by
Laurence J. Budney

March 1968

DISTRIBUTION STATEMENT (1)
This document has been approved for public release and sale; its distribution is unlimited.

ECOM
UNITED STATES ARMY ELECTRONICS COMMAND - FORT MONMOUTH, N.J.
NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government endorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.
SURFACE AND AIRBORNE CONDENSATION NUCLEI MEASUREMENTS IN REMOTE AREAS

by

Laurence J. Budney

Techniques and Exploratory Development Technical Area
Atmospheric Sciences Laboratory

March 1968

DA Task No. 1T0-14501B-53A-06-05

U. S. ARMY ELECTRONICS COMMAND
FORT MONMOUTH, NEW JERSEY

DISTRIBUTION STATEMENT (1)
This document has been approved for public release and sale; its distribution is unlimited.
Abstract

Condensation nuclei concentration measurements were made in the vicinity of Flagstaff, Arizona, during July 1966. The purpose of these measurements was to determine typical nuclei concentrations in the area and to correlate concentration with time of day, elevation, and weather conditions. The measurements were made both near the surface and from an aircraft.

From the aircraft measurements it was found that condensation nuclei concentrations decreased with elevation. There was no apparent difference between concentrations in clear air, clouds, or rain. The ground-level measurements, about one foot above the surface, indicated concentration of about 1000 to 1500 particles per cubic centimeter during sunrise and continuing for several hours thereafter. Sharp peaks in concentration occurred during the mid-day hours on each of the three days of ground-level measurements.
CONTENTS

INTRODUCTION 1

DISCUSSION 1

Data - 18 July 3
Data - 19 July 3
Data - 22 July 3
Data (Airborne) - 14-15 July 6

CONCLUSIONS 6

FIGURES

1. Condensation nuclei concentration versus time of day, 18, 19, 22 July 2
2. Condensation nuclei concentration versus elevation, 1700-1800 MST, 14 July. 4
3. Condensation nuclei concentration versus elevation, 1100-1200 MST, 15 July. 5
4. Condensation nuclei concentration versus elevation, 1400-1500 MST, 15 July. 7
INTRODUCTION

During July 1966, condensation nuclei concentration measurements were made with a one-expansion Aitken Counter in the vicinity of Flagstaff, Arizona.* Ground-level measurements were made during 18, 19, and 22 July in an attempt to correlate nuclei concentrations with time of day and weather conditions. The elevation at ground level was about 7000 feet.

Measurements were also made with the same counter aboard a C-47 aircraft on 14 and 15 July. In the aircraft, a hose for the air samples was run from an opening on the outside of the fuselage directly to the nuclei counter inside the aircraft. The outside opening was located where there was no exhaust contamination from the engines. The purpose of these airborne measurements was twofold: 1) to relate nuclei concentration with respect to elevation, and 2) to compare concentrations in clear air, clouds, and areas of rain.

DISCUSSION

Data were collected for three days on the ground at an elevation of approximately one foot. The data for the first two days of surface measurements (18 - 19 July) were collected in a remote pine forest a few miles west of Flagstaff; readings were taken in a large clearing in the shade of an isolated pine tree. The area was almost free of human contamination for several miles in all directions. However, there were cows and other wild life in the area. The only other known source of contamination in this area was from an occasional motor vehicle on the road by the test site. When vehicles did pass upwind, readings were temporarily discontinued.

The data for the third day, 22 July, were collected in another remote area about ten miles southeast of Flagstaff. This site was located near the

*The counter operates on the principle of a Wilson cloud chamber by growing water droplets on any nuclei available in the air sample being analyzed. In this particular counter, the degree of light extinction is believed to be proportional to the number of nuclei present.
Figure 1. Condensation nuclei concentration versus time of day, 18, 19, and 22 July.
bottom of a valley in a hilly, forested area. Here there was a low level of contamination similar to that at the first site. Figure 1 shows the data from ground observations in graphical form.

Data - 18 July

On 18 July, the day began clear and calm. By 1100 Mountain Standard Time (MST) cumulus development was beginning in the area and wind gusts up to about five knots were occurring. At the 1400-hour reading, the sky was mostly obscured by clouds, wind gusts had picked up a little more, and a small shower was beginning directly overhead, but had not yet reached the ground. From 1400 to 1600 hours, intermittent moderate showers occurred. By 1600 hours the activity had deteriorated to a high overcast and gradually dissipating light showers throughout the area. By 1800 hours, the sky was mostly clear and the wind nearly calm again. In Figure 1, note the increase in nuclei count before the showers and a decrease of about the same amount after the showers.

Data - 19 July

On the morning of 19 July, the onset of very light rain did not seem to affect the nuclei concentration. However, the reason for this may be that the sky was overcast since sunrise, the winds were almost calm, and convective activity was at a minimum. By 0930 hours, the rain had ended and the sun was shining about half the time. A light, southerly breeze with gusts to about six knots had developed by 1400 hours, and an area of thundershowers was forming over the mountains a few miles north of the site. By 1500 hours, a moderate shower on the southern fringe of the activity was visible, reaching the ground within a mile north of the site. This shower never reached the site except for a few drops of rain. No other showers came closer to the site.

The site was in the southerly wind inflow into this shower area until approximately 1530 hours, when the wind suddenly shifted to the northeast. This appeared to be a downdraft from the shower area. The showers gradually deteriorated to a thin, inactive, altostratus overcast by 1730 hours. No nuclei data taken after 1605 hours were accepted because of motor vehicle traffic upwind of the site. On this day (19 July) once again, the nuclei count increased substantially preceding the showers which occurred nearby. The nuclei count decreased substantially once the downdraft air hit the site.

Data - 22 July

July 22nd was a day of active cumulus development, but no showers occurred in the area. The nuclei count increased sharply around 1025 hours; this
Figure 2. Condensation nuclei concentration versus elevation, 1700-1800 MST, 14 July.
Figure 3. Condensation nuclei concentration versus elevation, 1100-1200 MST, 15 July.
may have been associated with a large cumulus developing overhead. Surface winds were very light throughout the time of high nuclei readings. Since this site was beneath a forest canopy, the winds could have been considerably stronger above the trees. After 1100 hours, the sun was shining about one-third of the time. Cumulus gradually dissipated later in the afternoon.

The possibility of the atmosphere being contaminated must always be kept in mind during surface measurements. Logging trucks were being operated within a mile of the July 22nd site and might have been operating near the first site as well, although none were seen. Also, variable winds could have carried contamination from the person operating the counter or from his own vehicle. Attempts were made to confine sources of contamination to positions downwind of the nuclei counter.

Data (Airborne) 14-15 July

Condensation nuclei concentration measurements were made aboard a C-47 aircraft during one flight on 14 July and two flights on 15 July. Figures 2, 3, and 4 show the concentration versus elevation on these flights. The data in the figures are segregated into clear air, "in-cloud," and rain area measurements. It is difficult to determine a difference between concentrations during each of these three weather conditions. However, the graphs do show a definite decrease of concentration with elevation.

Comparing the distribution of points on each of the graphs for 15 July, it appears that the convective updrafts distributed the higher surface concentration as much as 6000 feet above the surface by mid-afternoon.

CONCLUSIONS

Measurements about one foot above the surface indicated condensation nuclei concentrations of about 1000 to 1500 particles per cubic centimeter during sunrise and continuing for several hours thereafter. Sharp increases in concentration occurred during the mid-day hours on each of the three days (18, 19, 22 July) during which surface data were taken. The increases in concentration occurred during active cumulus development overhead and preceding the onset of showers. Towards evening, concentrations decreased towards their early morning values.

At any particular elevation, there is no apparent differences between clear air, "in-cloud," and rain area nuclei concentrations. However, concentrations do decrease with elevation. On the average, concentrations at the surface were roughly twice the concentration at elevations 6000 to 8000 feet above the surface.
**Abstract**

Condensation nuclei concentration measurements were made in the vicinity of Flagstaff, Arizona, during July 1966. The purpose of these measurements was to determine typical nuclei concentrations in the area and to correlate concentration with time of day, elevation, and weather conditions. The measurements were made both near the surface and from an aircraft.

From the aircraft measurements it was found that condensation nuclei concentrations decreased with elevation. There was no apparent difference between concentrations in clear air, clouds, or rain. The ground-level measurements, about one foot above the surface, indicated concentration of about 1000 to 1500 particles per cubic centimeter during sunrise and continuing for several hours thereafter. Sharp peaks in concentration occurred during the mid-day hours on each of the three days of ground-level measurements.
Condensation nuclei meteorology
Flagstaff, Arizona
Aiken counter

INST.

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (corporate author) issuing the report.

2. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

3. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

4. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis. Short phrases that characterize the report shall also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year. If more than one date appears on the report, use date of publication.

7. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

8. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

9a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

9b. a & d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system number, task number, etc.

9b. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers (either by the originator or by the sponsor), also enter these numbers.

10. AVAILABILITY LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(a) "Qualified requesters may obtain copies of this report from DDC."

(b) "Foreign announcement and dissemination of this report by DDC is not authorized."

(c) "U.S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through

(d) "U.S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through

(e) "All distribution of this report is controlled. Qualified DDC users shall request through"

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring (paying for) the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (U) or (D).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize the report and may be used as index entries for cataloging the report. Key words must be selected so that minimum classification is required. Identiﬁers such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical content. The assignment of links, rules, and weights is optional.