FACTORS INFLUENCING THE TRANSPORT OF BIOLOGICAL AEROSOL THROUGH THE ATMOSPHERE: AND THEIR INJECTION INTO IT

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ABSTRACT

The capacity to predict accurately the transport and deposition of biological aerosol introduced into the atmosphere is clearly an urgent military requirement.

Existing transport models do not adequately take account of some processes which can exercise a profound influence on aerosol transport. These include: dry deposition; wet deposition; cloud processing of aerosol; the effects of topography on aerosol deposition; and the (often profound) influence of naturally occurring electrostatic forces on the agglomeration and scavenging of aerosol particles.

Our objectives are to formulate reliable, quantitative descriptions of these processes which act to modify aerosol transport: so that these processes can then be adequately incorporated into models of the transport of biological aerosol through the atmosphere on all relevant scales.

The bursting of bubbles at the surface of the oceans, lakes and other stretches of water can cause the injection of massive quantities of biological aerosol into the atmosphere. The Earth's electric field can facilitate their redistribution and longevity in the atmosphere.

Our paper describes work conducted to date on these topics, together with future plans.

TRANSPORT OF BIOLOGICAL AEROSOL THROUGH THE ATMOSPHERE

It is crucially important, from a military standpoint, to identify, understand and be able to quantify the gamut of processes which act to modify the transport of biological aerosol through the atmosphere, over a wide range of spatial scales.

The dispersal and eventual deposition of aerosol introduced into or naturally resident in the atmosphere is a function of many parameters, such as the prevailing meteorological conditions, and the physical and chemical characteristics of the aerosol.

Existing transport models, designed to predict the movement of aerosol particles for a variety of meteorological scenarios, do not adequately take account of some other processes which can exercise a profound influence on aerosol transport. These include: dry deposition (deposition to ground in the absence of cloud); wet deposition (where the aerosol are scavenged by raindrops and thereby brought to ground); cloud processing of aerosol by cloud droplets (where the history of the droplets influences that of the aerosol particles they have captured); the effects of topography on aerosol deposition (where the shape of the terrain modifies crucial

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parameters such as turbulence, cloudiness etc); and the effects of naturally occurring electrostatic forces (where the efficiency with which aerosol particles agglomerate or are scavenged by raindrops can be profoundly enhanced).

We believe that unless and until the above-mentioned processes are quantitatively and accurately incorporated into transport models, these models cannot be trusted to provide reliable estimates of aerosol transport, and may in some circumstances be catastrophically wrong. Our program of work is designed to help remedy these deficiencies.

Our objectives are to engage in a program of modelling and examination of exisiting data sets in order to formulate reliable, quantitative descriptions of processes (outlined in the preceding section) which act to modify aerosol transport: so that these processes can then be adequately incorporated into models of the transport of biological aerosol through the atmosphere on all relevant scales.

These processes are:-

(1) Wet deposition of aerosol.
(2) Dry deposition of aerosol.
(3) Cloud processing of aerosol by liquid hydrometeors.
(4) The effects of topography on aerosol deposition.
(5) Influence of electrostatic forces on aerosol agglomeration.
(6) Influence of electrostatic forces on scavenging of aerosol by raindrops.

Our work, together with studies by other investigators, has demonstrated that each of the above six processes can have a significant (sometimes predominant) influence on aerosol transport in natural conditions.

Data on aerosol of all sizes measured will be examined. This includes the size-range 10 to 250 nanometres, of particular military interest. Since we are concerned with physical processes which act to modify aerosol transport, data obtained from our field studies on non-biological aerosol (with concomitant computations) will be equally relevant to biological aerosol.

NATURAL INJECTION OF BIOLOGICAL AEROSOL INTO THE ATMOSPHERE

Violent disruption of a liquid surface - such as occurs when seawater droplets are created by the breaking of waves or the bursting of the thinning, roughly hemispherical bubble-films created when air bubbles rise to the ocean surface: or when air bubbles burst at the surface of lakes, ponds and other stretches of water - is accompanied by significant electric charging of the huge numbers of droplets so produced. This process is an extremely efficient mechanisim of injecting biological aerosol into the atmosphere. Preliminary laboratory experiments indicate that the characteristic charges (positive & negative) acquired by the typically hundreds of droplets in the size-range 0.1 to several micrometers created when a bubble bursts are sufficiently large that the electrostatic forces on them in the Earth's fine-weather field at the ocean surface will greatly exceed the gravitational force to which they are subjected (i.e. $qE \gg mg$). Thus survival and upward motion through the atmosphere of the negatively charged aerosol (roughly half the total) will be facilitated electrostatically. If such sign selectivity occurs over natural liquid surfaces to the degree suggested by our first crude laboratory studies the preferential ascent of negatively charged biological aerosol should create - in conditions of medium and strong wind-speed - readily measurable perturbations in the Earth's electric field, the magnitudes of which should allow estimates to be made of the upfluxes of the aerosol. We propose to conduct a series of laboratory experiments designed to examine this possibility in more detail.

This work reinforces earlier indications that electrostatic forces can be useful practically in protecting personnel and structures from biological aerosol.