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A QUASI-PERMANENT UTLS AEROSOL OBSERVATORY ON SURF

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ABSTRACT

We suggest a quasi-permanent Aerosol Observatory be located in the upper deck of SOFIA to carry out routine measurements during normal periods, and to be available for measurements of stratospheric and/or upper tropospheric aerosols during special periods like the period following a volcanic eruption, a large forest fire or a disaster such as a nuclear accident.

RATIONALE

It is proposed that a quasi-permanent facility for the observation of upper troposphere and lower stratosphere aerosols be installed in the upper deck of the SOFIA aircraft. By "quasi-permanent" we mean a facility in which certain instruments would monitor the environmental aerosol on all SOFIA flights and other instruments could be very rapidly mounted in pre-existing facilities and used when they would be most valuable. For example, perhaps one would desire to use a particular instrument only rarely; nevertheless, the facility would be prepared to accept the instrument on a moment's notice. That means, the rack space, power, etc. would be part of the facility and the instrument could be "plugged in" whenever desired.

Such a facility would be extremely valuable in incrementing our knowledge of the very important upper troposphere - lower stratosphere (UTLS) region. Measurements of aerosols and important gases (ozone, CFC's, radon, etc.) could be carried out on a routine basis. This would be similar to the European MOZAIC program in which a few commercial aircraft have been outfitted to measure ozone. SOFIA would have the tremendous advantage over MOZAIC in that it would not be limited by the severe weight restrictions of MOZAIC.

However, the greatest value of the facility would be in cases when unexpected or unusual atmospheric perturbations take place. There have been several cases in the past twenty years when the scientific community lost opportunities to carry out valuable atmospheric observations due to the lack of an airborne aerosol observatory. In some other cases, the need to make the observations required a hasty and expensive aircraft campaign. We give three examples of situations in which the SOFIA SURF Aerosol Facility would be particularly valuable.

VOLCANIC CLOUDS

An example of a case in which the scientific community found itself unprepared was the eruption of Mt. Pinatubo in June 1991. A thick cloud of volcanic dust and gas quickly spread around the globe in a narrow band. This material then gradually spread towards the poles, enveloping the Earth. It is believed that during this time the nature of the cloud changed, starting out primarily as dust and then, due to the conversion of SO2 to sulfate and the nucleation of sulfuric acid particles, into a sulfate aerosol.

The Pinatubo volcanic cloud was so thick that SAGE II, the primary instrument for measuring the stratospheric aerosol, was not able to determine the extinction of the layer because the transmission was too low for the detector to measure. Unfortunately, the scientific community was not prepared for this event and not even a balloon was launched to study the properties of the layer during its early stages.

An airplane can not fly through a fresh volcanic plume, but after the initial ash plume has dissipated, airplanes can safely pass through the gas and aerosol remnants. From a scientific point of view, it is important to measure the formation and development of the sulfate aerosol. This might involve flying under a fresh plume and using lidar to measure the particle characteristics. After the ash has fallen out, the airplane could fly in the lower stratosphere and carry out in-situ studies of gas and particle properties.

It is conventional wisdom that a violent volcanic eruption inserts silicates and sulfur bearing gases into the stratosphere. Photolytic reactions then generate sulfuric acid that nucleates to form small particles. These sulfuric acid particles coagulate and grow and form the relatively long-lived volcanic cloud. However, recently it has been questioned whether or not silicates are a significant component of the early stratospheric cloud. Clearly it is important to climate modelers to know the composition of the particles, particularly in the important initial phase of the cloud. This can only be answered by in situ measurements. Furthermore, the amount of chlorine in a volcanic cloud is so great that one would expect the ozone layer to be essentially destroyed by it. This does not occur. It has been postulated that the chlorine is removed in the volcanic plume by dissolving into water droplets before the plume reaches the stratosphere. It would be interesting and valuable to measure the amount of chlorine in the stratosphere shortly after a volcanic eruption.

FOREST FIRES

A second example is the analysis of the stratospheric particulates inserted by forest fires. It has long been known that large forest fires can insert material into the stratosphere. Such material is organic in nature. The quantity and nature of this material has not been quantified. Recently there has been a great increase in interest in forest fires among the atmospheric community. The POAM satellite data has been used to show that high latitude fires inject organic materials into the stratosphere. (M. D. Fromm et al., 2000). Strangely, there seems to be little evidence of stratospheric injections of materials from tropical fires, such as the large fires in Indonesia a few years ago and the annual biomass burning in tropical Africa and Brazil.

Murphy et al. (1998) showed there is a layer of organic aerosols in the upper troposphere, below the tropopause, but these aerosols do not seem to get into the stratosphere. Why are they not observed in the stratosphere? It has been suggested that they are destroyed by the higher ozone levels.

DISASTERS

A third scenario illustrating the value of having a stratospheric aerosol observatory on SOFIA is afforded by the oil fires in Kuwait after the first gulf war. It was desired to carry out a study of the aerosols being inserted into the atmosphere; consequently an aircraft was quickly outfitted to carry out the analysis. Once again, had a quasi-permanent facility been available, this would have led to a savings in time and money. It is unfortunately true that given the present geopolitical situation, even worse scenarios are easily imagined. It is not unreasonable to fear that a disaffected group could ignite a nuclear weapon. If such an unfortunate event were to occur, it would be extremely important to be able to respond immediately and to measure the spread of radioactive aerosol particles.

Consequently, we suggest a quasi-permanent aerosol facility be set up in the upper deck of SOFIA.

INSTRUMENTATION

The suite of instruments envisioned for the Aerosol Facility can be characterized in one of three classes, namely, aerosol detectors, gas detectors and meteorological instruments. The aerosol detectors to be placed on board in the Facility are the following:

1. A set of *in-situ* particle counters such as a CAS instrument as used by Baumgardner
2. A lidar such as used by Ed Browell. It should have the capability to look both up and down.
3. A CN impactor such as used by Chuck Brock
4. An instrument to determine particle composition such as PALMS of Dan Murphy
5. A particle counter, such as the ring down spectrometer of Strawa.
6. The GAMS instrument of Zowodny

The gases to be measured include: sulfates, CO, CO2, methane, formaldehyde, total water and gas phase water, CFC's, hydrocarbons, radon.

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