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# SOME ITEMS OF INTEREST FROM THE FIRST SYMPOSIUM ON VOLCANIC ASH AND AVIATION SAFETY

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There has been an increased interest in the issue of volcanic hazards and aviation safety among a broad group which includes commercial and military air operators, aircraft manufacturers, the Federal Aviation Administration, the U.S. Geological Survey, and the National Weather Service. The 1989-90 eruption of Redoubt Volcano in Alaska and the June 1991 eruption of Mt. Pinatubo in the Philippines has resulted in over 16 aircraft damaged; mostly 747 series commercial aircraft.

The first International Symposium on Volcanic ash and Aviation safety was held in Seattle Washington 9-11 July, 1991. Attendees at the meeting represented over 23 countries. There are 530 "active" volcanoes around the earth capable of injecting volcanic ash into the atmosphere; about 60 in any given year. It is truly a global problem. (Note: there are 43 volcanoes in the Alaska Region; approximately 8 % of the global total)

The symposium consisted of 88 papers delivered on topics that ranged from characteristics of volcanic eruptions and ash clouds; damage and impacts; communications and procedures; meteorology and ash cloud monitoring; and detection and tracking.

It is the forecaster who has the ultimate responsibility to accurately forecast and issue timely advisories on the movement of airborne volcanic debris. It was the experience of the forecasters in the Anchorage WSFO that there were deficiencies in information that greatly hampered their response. The forecaster had no information on (1) ash particle size and concentration; (2) initial height and horizontal extent of the ash plume into the atmosphere; (3) real-time vertical profile of the winds near and downstream of the volcano: and (4) rapid access to volcanic ash trajectory models. It is the purpose of this paper to highlight those items that directly relate to the forecaster and his/her needs in understanding and forecasting volcanic ash.

## Volcanoes and Ash

Volcanic eruptions that involve release of volcanic ash in the atmosphere have some common characteristics (see Figure). The first portion of the eruptive cloud column just above the volcano is called the gas thrust and protrudes into the atmosphere 1-2 km. This section of the column is a jet of material leaving the volcano vent. It is characterized by rapid deceleration and loss of coarse volcanic debris. The second portion of the column is called the convective thrust zone characterized by acceleration of the gases and small particles due to the heat energy. The ash /gas cloud ceases to accelerate vertically when the temperature of the cloud equals the ambient temperature of the air. The final

portion of the eruptive column is called the umbrella and it can push out horizontally upwind as well as downwind. In the case of Mt. St. Helens the umbrella pushed 40 km upwind. It is important that the forecaster recognize that volcanic ash can be upwind of the volcano and includes this area in the advisory. There is no known technology at this time that can be used to provide a reasonable estimate of the ash in the eruptive column. Thus the concentration and particle size of the ash in an eruptive column is unknown.

Aircraft Damage

It is of interest to the forecaster to understand the damage airborne volcanic ash can do to a jet engine. The following types of damage are listed in order of importance:

1. glassification of the ash and deposition on hot section components of the engine.

2. erosion of compressor and turbine components by the ash.

3. deposition on fuel nozzles and cooling parts (clogging).

4. windshield crazing causing loss of visibility.

5. deterioration of engine control system by electrical shorting, clogging of sensors, etc.

The most critical problem is glassification of the ash. The modern jet engine runs at temperatures approaching 2000 degrees F. This is well above the melting point of silicate, a major component of ash. The ash enters the engine, melts and coats the inside of the engine, covering nozzles, air vents, and other critical components. The engine quits running. Depending on concentration, this shutdown can occur as quickly as 1 minute (the case of the KLM 747 incident 150 km from Redoubt) or as long as 29 minutes (the recent case of a 747 1200 km from Pinatubo).

The forecaster must be aware of the location and presence of ash in the atmosphere regardless of particle size. Concentration is more important. It was the conclusion of the air industry at the symposium that these areas must simply be avoided at all costs. At this time there are no sensors onboard the aircraft to detect ash during flight. The only warning to the pilot is the presence of St. Elmo's fire around the windshield, wing tips and engines. This fire-like glow occurs because of the static charge associated with each ash particle. If ash concentration is high, the notice of St. Elmo's fire by the pilot may be too late for the pilot to take evasive action and save the engines from damage.

Ash Detection

The technologies identified as most important in detecting, monitoring, and tracking of airborne volcanic ash were satellite

imagery, radar, doppler wind profilers, and aviation reports (ACARS). Techniques have been developed to utilize NOAA AVHRR imagery to detect volcanic eruptive clouds in a variety of weather, and both day and night. The techniques use multiple infrared channels (bands 4 and 5) in the algorithms. In addition the imagery can be used to track the eruptive clouds as they move downwind. The use of weather radar (5 cm) to detect ash in the eruptive cloud has been established though there are some limitations; once the ash becomes dispersed and is consists of very small particles, the radar is unable to detect it. The radar's use is best near the volcano.

The wind profiler is an instrument that provides real-time winds near the volcano and at sites downwind. The air industry would like to see critical volcanoes instrumented with wind profilers along with other sensing equipment. Ready access to aircraft winds and temperature (ACARS) are critical in providing the forecaster with information on the wind field in the atmosphere and the ultimate movement of volcanic ash. The airlines are now aware of the importance of these data and are willing to make it available to the NWS in areas where it is not presently available.

Ash Trajectory Forecasting

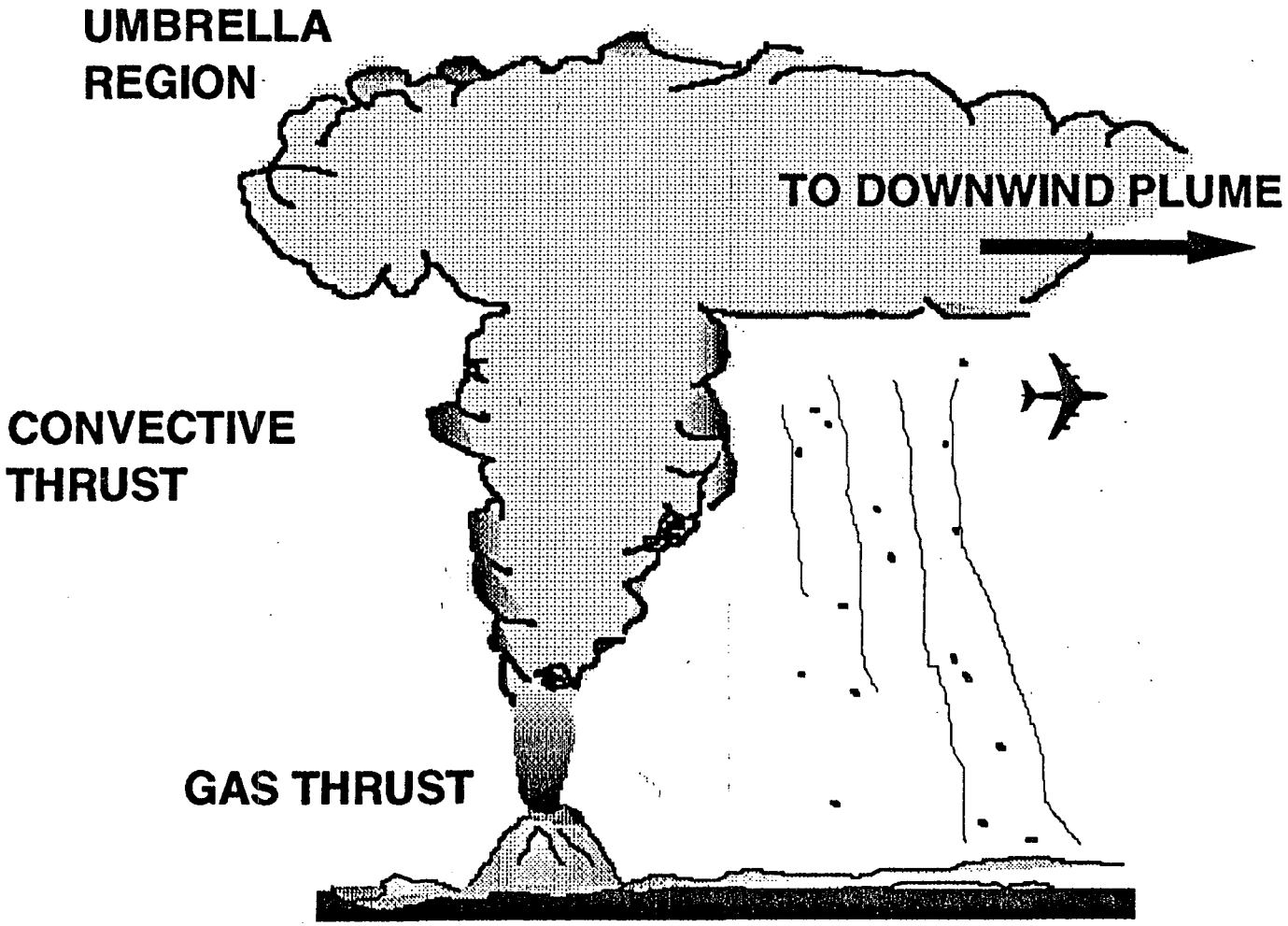
To assist the forecaster, new numerical models to improve the trajectory calculations were presented at the Symposium that will be used in Alaska. NOAA's Forecast Systems Laboratory has developed a Mesoscale Analysis and Prediction System (MAPS) for assimilating surface and tropospheric data every three hours and provide nowcasting. It uses isentropic coordinates in the free atmosphere and terrain-following coordinates near the ground. Isentropic coordinates are well suited for trajectory calculations because air remains on these surfaces in adiabatic flow. MAPS has been adapted for use in Alaska and will be available to the Alaskan forecasters this winter.

To provide for the larger scale and longer term trajectories, the Air Resources Laboratory is developing a model to simulate ash transport. MAPS will provide the initial conditions and short-term forecast data. The larger scale and longer term meteorological data will come from the NMC models. Dispersion and wet and dry deposition is included in the model. Output describes the ash cloud in both space and time. This model should be available to Alaskan forecasters this winter.

Summary

The state of knowledge about airborne volcanic ash is growing. Over the last 10 years, the number of volcanic eruptions has increased over the earth. This has spurred increased research activities. The results from this Symposium will be the baseline for future work. A Symposium Proceedings Volume to permanently record the papers and discussions during the meeting will be available this late fall. Scientific Services will insure that

copies of the proceedings are made available to the forecasters. With 43 volcanoes in Alaska and one likely going off each year, it is certain that forecasters in Alaska will face the responsibility to produce accurate and timely advisories of the ash movement.




# CHARACTERISTICS OF VOLCANIC ERUPTION COLUMNS