Meteorology

Volcanic Ash

Overview

- Introduction to Volcanic Ash
- Properties of Volcanic Ash
- Volcanoes that effect US aircraft operations
- Hazards associated with Volcanic Ash
- Incidents and Impacts
- Forecast Products
- Dispersion Models
- Detecting Tools
  - Lidar
  - Satellities
- Acceptable Ash Concentrations
- Conclusions and Recomendations

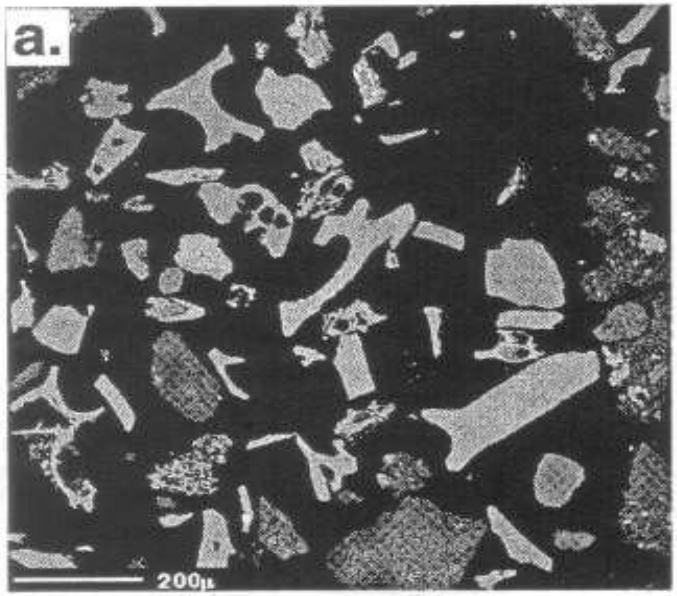
Introduction

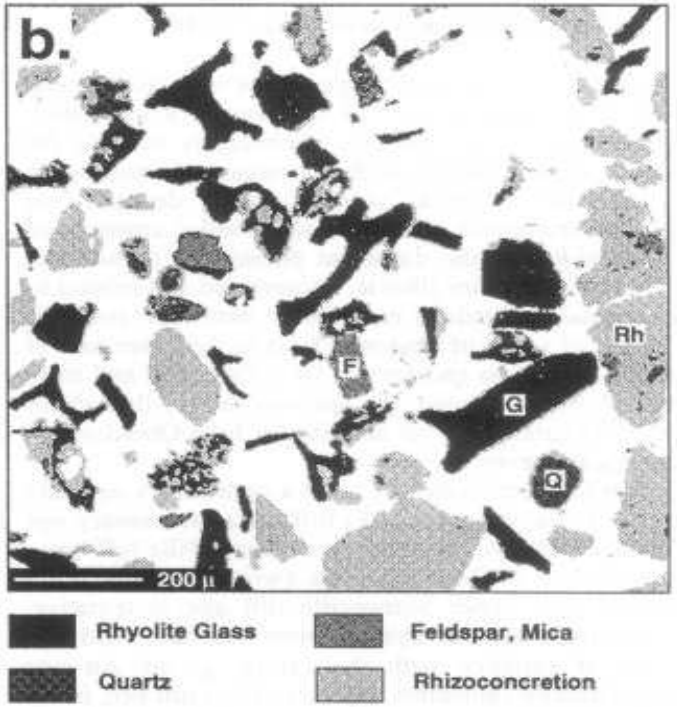
Volcanic Ash –

Fine particles of mineral matter from a volcanic eruption which can be dispersed long distances by winds aloft

Properties of Volcanic Ash

- Looks like soft harmless powder
- Actually comprised of volcanic rocks and glass
- Particles less than 2 mm in size
- Low density
- Capable of conducting electrical current





Volcanoes that effect US aircraft operations

- Ring of Fire
  - Aleutian Islands, Alaska
  - Popocatepetl, Mexico
- Soufriere Hills, island of Montserrat, Caribbean
- NOTE: Eruptions can occur anyplace the tectonic plates border each other

Hazards associated Volcanic Ash

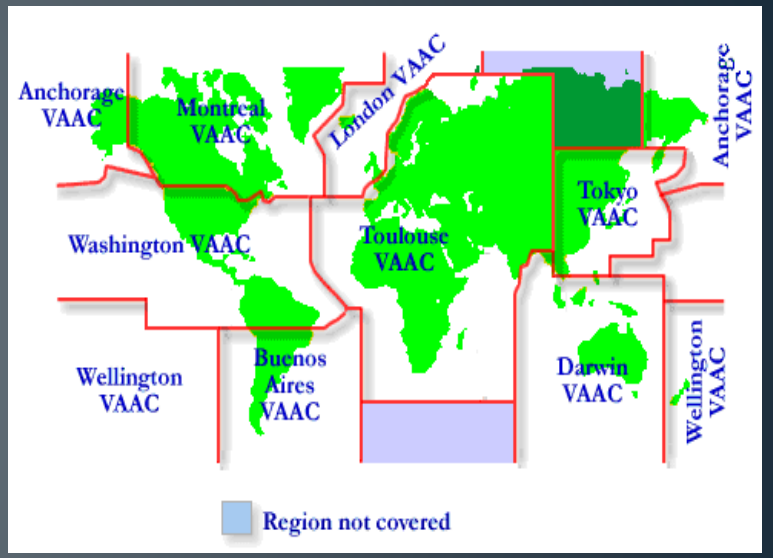
- Lost of Visibility
- Aircraft damage
  - Structure damage
  - Engine failure / damage
    - High temperatures melt ash into glass
    - Clogged tubes / intakes
  - Abrasions to external components
  - Contamination of aircraft interior

Aviation Incidents and Impacts

- KLM Flight 867 (Boeing 747-400) – December 15, 1989
  - Mount Redoubt, Alaska
  - Four engine failure
  - Descended more than 14,400 feet , before engine restart
  - $80 million dollars of damage done to aircraft
- British Airways Flight 9 (Boeing 747-236B) – June 24, 1982
  - Mount Galunggung, Indonesia
  - Four engine failure
  - Descended from 36,000ft to only 12,000ft before engine restart
- NASA Airborne Sciences research airplane (DC-8) - February 28, 2000
  - Mt. Hekla, Iceland
  - Flight crew had no indication of entering volcanic plume
  - No visible damage airplane
  - Internal inspection of engines revealed clogged turbine cooling passages
  - $3.2 million dollars of damage to engines
- Closure of European Airspace by London VAAC – April and May of 2010
  - EyjafjallajÖkull, Iceland
  - European models showed trace amounts of ash in atmosphere
  - No ash was visible.
  - Two month closure of airspace
  - CAA to investigate how much ash is to much ash.

Forecast Products

- Volcanic Ash Advisories (VAA)
  Volcanic Ash Advisory Center (VAAC)
  - Issued every 6 hours or sooner for ash active volcanoes
  - Text based
- Volcanic Ash Graphic (VAG)
  Volcanic Ash Advisory Center (VAAC)
  - Graphical representation of the VAA



- Volcanic Significant Meteorological Information (VA SIGMET)
  Meteorological Watch Offices
  - Issued only when necessary
  - Valid for no more than 6 hours.
  - Based on advisory information provided by the VAAC

Dispersion Models

- Numerical Atmospheric-Dispersion Modeling Environment (NAME)
  - London VAAC
- Modele de Chimie Atomspherique a Grande Echelle (MOCAGE)
  - Toulouse VAAC
- Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT)
  - Washingto VAAC
  - Valid for no more than 6 hours.
  - Based on advisory information provided by the VAAC
- Data that must be estimated for input into dispersion models that according to Lisk (2010) lead to inaccurate predictions
  - Height, diameter and time variance of the eruptive column
  - Initial ash concentration, particle distribution, and size of the particles
  - Amount of ash deposition close to the volcano, that is not available for transport

Detecting Tools

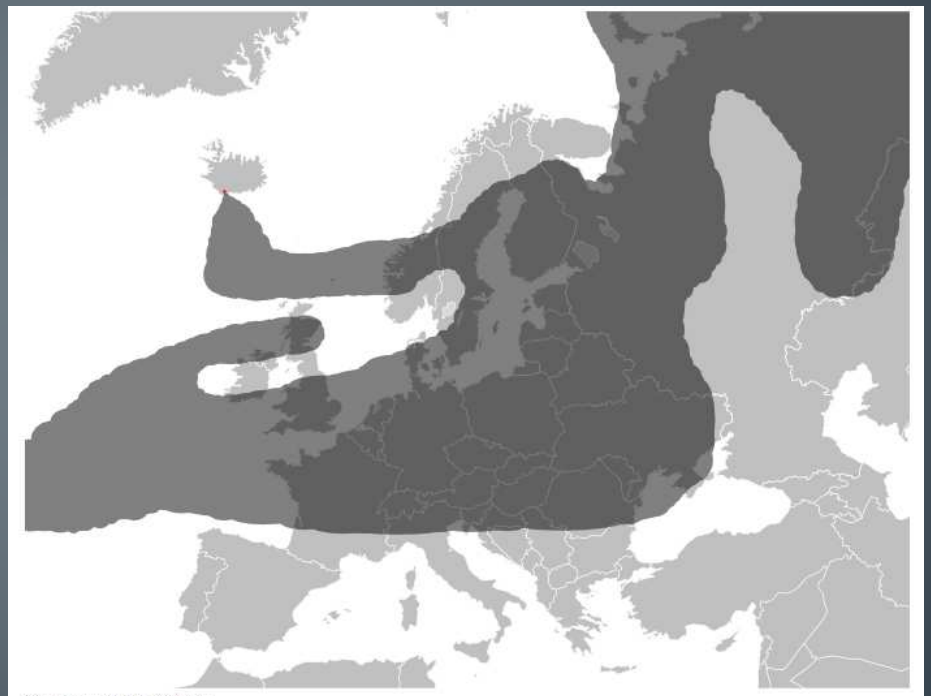
- Light detection and ranging (LIDAR)
  - Uses laser to illuminate a target allowing distance and size of particle to be measured.
  - Targets can be any size which is why its used for tiny ash particles
  - Can be mounted on the ground and pointed upward
  - Can be mounted on a satellite and pointed downward
  - Only instrument capable of providing a vertical distribution of aerosols in atmosphere

- Satellites
  - Visible and Infrared channels at variety of wavelengths
  - Use of multiple channels allows for distinction between clouds and ash.
  - Limited to only seeing the tops of ash plumes.
  - Satellites used include
    - Polar Operational Environmental Satellites (POES)
    - Geostationary Operational Environmental Satellite (GOES)
      - Current GOES N-P – 5 channels
      - Future GOES R

    - European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)
      - Current version – 12 channels
      - Future version – Meteosat Third Generation (MTG) - 16 channels & LIDAR

How much ash is to much ash

- On April 15, 2010, the Eyjafjallajökull Volcano erupted causing major interruption to air traffic across Europe
- Below is the London VAAC's dispersion model on April 17, 2010



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Eyjafjallajökull_volcanic_ash_17_April_2010.png (680 × 520 pixels, file size: 127 KB, MIME type: image/png)

- Note ash was not visible, trace amounts shown on dispersion model

How much ash is to much ash

- ICAO standards stated zero tolerance for volcanic ash
- Due to the zero tolerance, larger areas of Europe were deemed No Fly Zones
- Civil Air Authority (CAA) set out to determine how much ash is dangerous for aviation
  - Falcon Flight 19 on April 19th, 2010
  - British Airways Boeing 747 – 3 hour test flight
  - Both cases no damage found that would prohibit aviation operations
  - Results lead to CAA increasing acceptable levels of ash to
    - 0.002 grams per cubic meter initially
    - 0.004 grams per cubic meter eventually after further examination of data.
- Note as of July, 2010, ICAO recommendations still zero tolerance

Conclusions & Recomendations

- Better methods of detecting aerosols
  - Enhanced LIDAR
  - Dropsondes, Radiosondes, and Un-manned vehicles
- Development of technology to detect concentrations and diameters of initial eruptions for input into dispersion models
- Improved satellite technology with the inclusion of more channels
- Continued investigation of acceptable ash limits

Summary

- Introduction to Volcanic Ash
- Properties of Volcanic Ash
  - Abrasive, Low Density, Tiny Particle size, Silica (Glass)
- Volcanoes that effect US aircraft operations
  - Aleutian Islands, Popocatepetl
- Hazards associated with Volcanic Ash
  - Low Visibility, Engine Damage/Failure, Contamination,
- Incidents and Impacts
- Forecast Products
  - VAA, VAG, VA SIGMET
- Dispersion Models
  - NAME, HYSPLIT, MOCAGE
- Detecting Tools
  - Lidar
  - Satellities – POES, GOES, EUMETSAT
- Acceptable Ash Concentrations
  - Zero Tolerance vs 0.004 grams per cubic meter
- Conclusions and Recomendations

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Questions

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