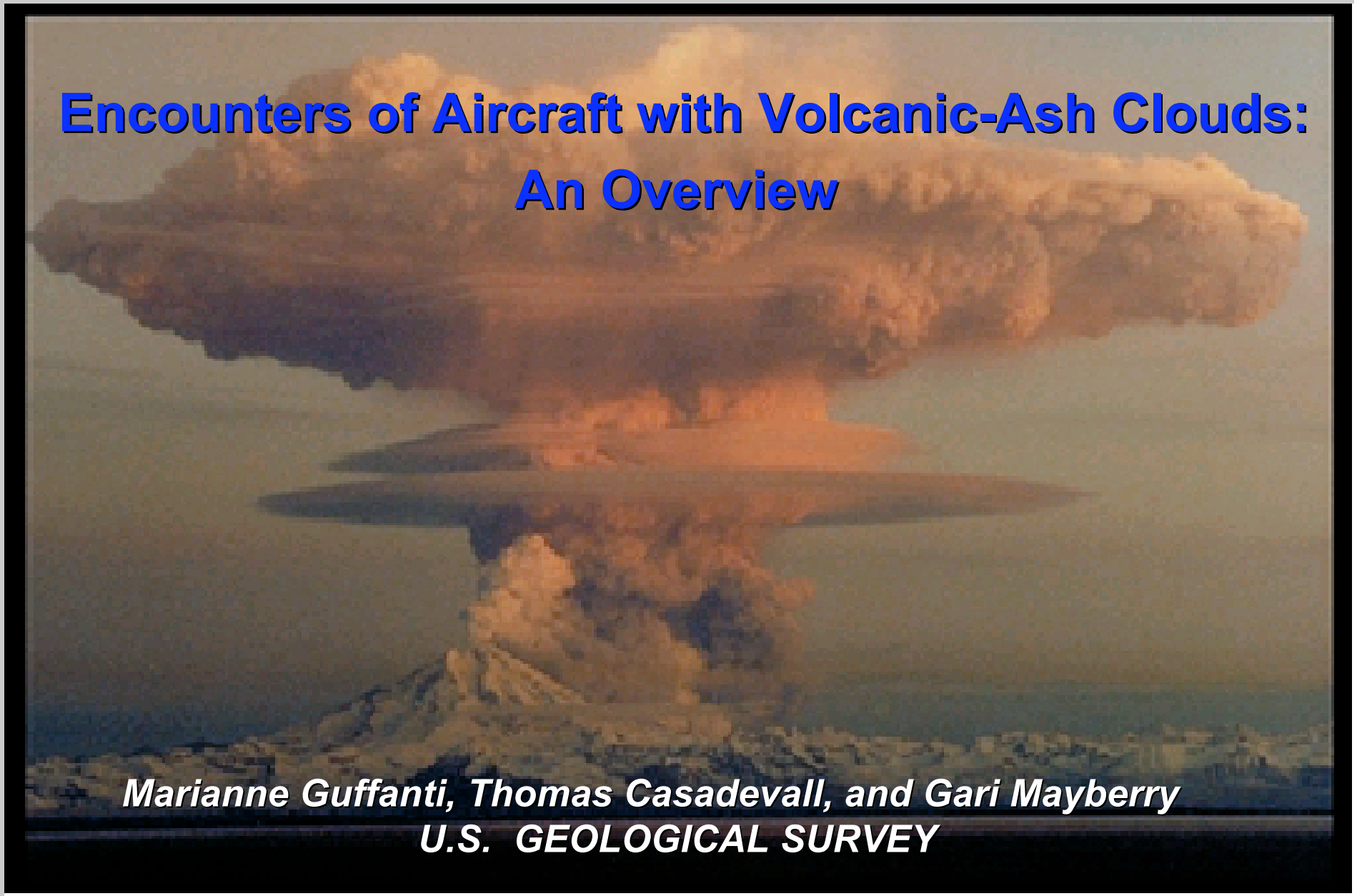

Encounters of Aircraft with Volcanic-Ash Clouds: An Overview

Marianne Guffanti, Thomas Casadevall, and Gari Mayberry
U.S. GEOLOGICAL SURVEY

Summary of reported encounters published in 2001 in ICAO Manual on Volcanic Ash, Radioactive Material & Toxic Chemical Clouds put together by Tom Casadevall (USGS) and Tom Fox (ICAO)

- 83 encounters from 1935 to 1993 are listed, along with information on the source volcanoes, eruption dates, aircraft types, and severity of the encounters.
- Preliminary mention of approximately another ~17 encounters from 1994 to 2000 in accompanying table.
- Additional 6 encounters known through 2003 & not in Manual. Most recent reported incident is July 2003 in Caribbean region.

USGS

From 1973 through 2003, 102 encounters have been reported – *minimum value because incidents are not consistently reported publicly.*

SEVERITY OF ENCOUNTER

Class 0: acrid odor, electrostatic discharge
Class 1: light cabin dust, EGT fluctuations
Class 2: heavy cabin dust, ext. & int. abrasion damage, window frosting,
Class 3: engine vibration, erroneous instrument readings, hydraulic-fluid contamination, damage to engine and electrical system
Class 4: engine failure requiring in-flight restart
Class 5: engine failure or other damage leading to crash

NO CLASS 5 ENCOUNTERS TO DATE

USGS

Most encounters (~75%) are Class 0-2

Class 4 Encounters:

- **7 cases involving temporary engine failure occurred from 1980-1991.**
- **Encounters happened 150 to 600 miles from volcanic sources (St. Helens, Galunggung, Redoubt, Pinatubo, Unzen).**
- **Durations of encounters from 2 to 13 minutes.**

In-flight multiple-engine failure in modern planes is extremely rare. Ash is main culprit.

(One other case due to fuel loss in 2000?)

USGS

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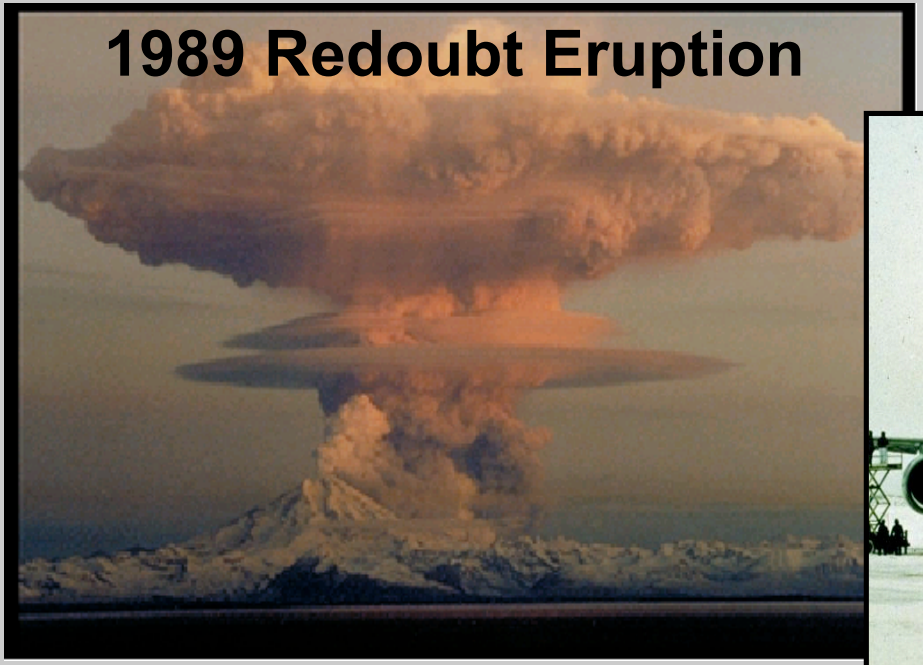
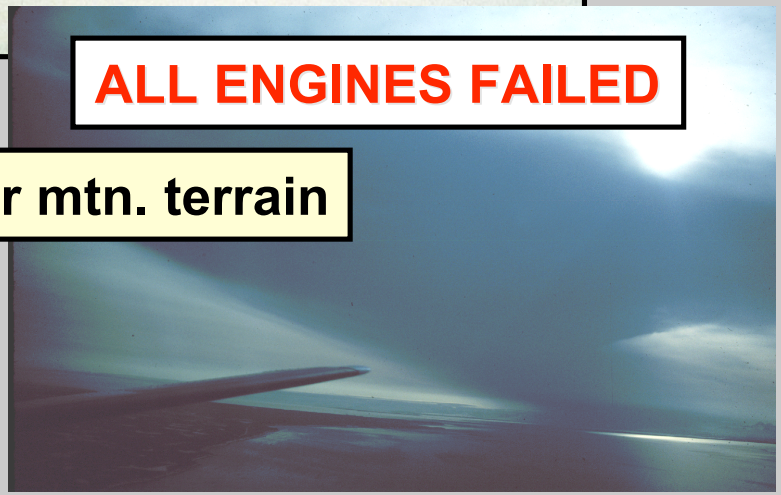


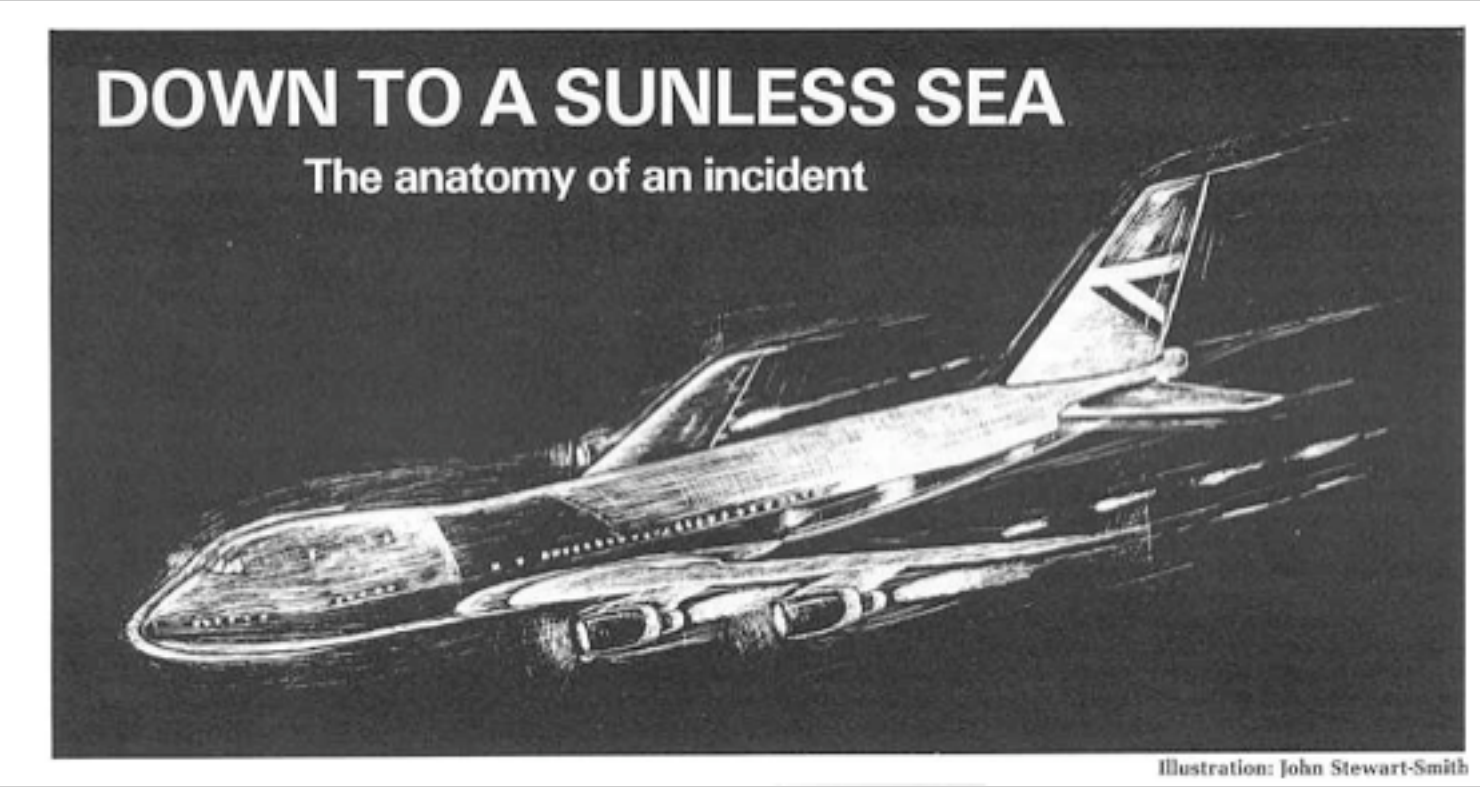


4 min. of powerless descent over mtn. terrain

*** Indonesia, 1982: 25,000 ft and 16 min. of powerless descent ***

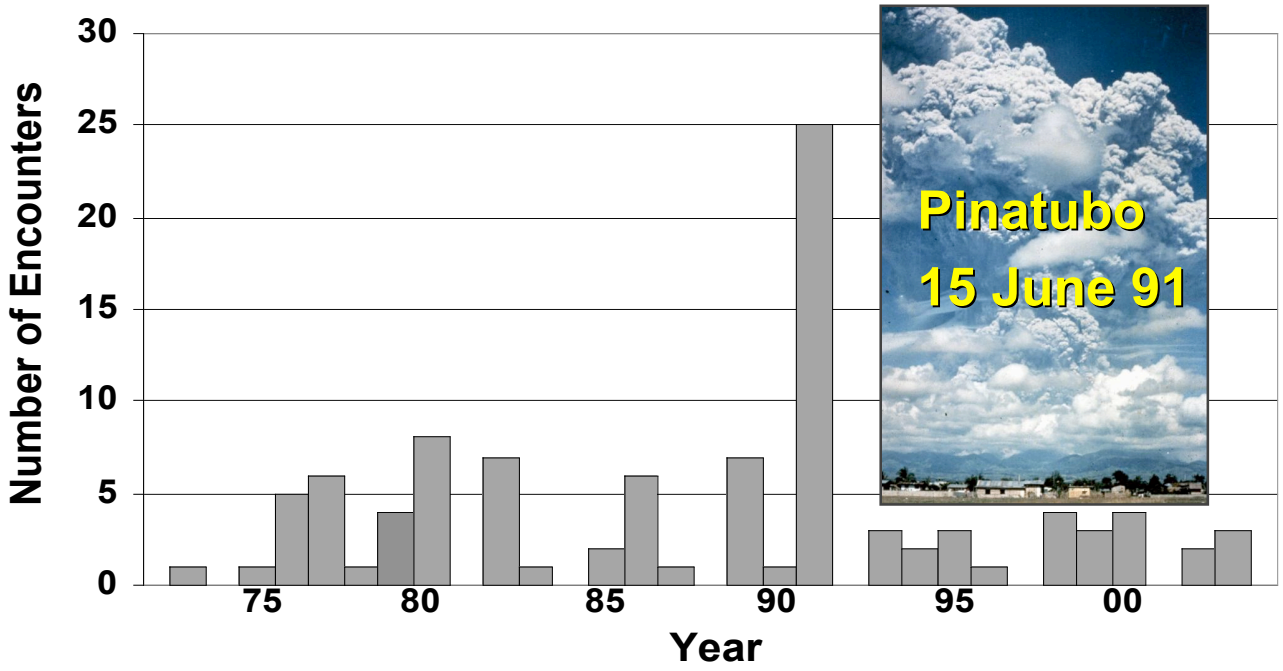
1982: British Airways Flight 009 became the world's largest glider, due to an encounter with the ash cloud from Galunggung volcano.

See: www.ericmoody.com



Encounter Frequency, 1973 – 2003

~2 encounters/yr (minimum) since Pinatubo



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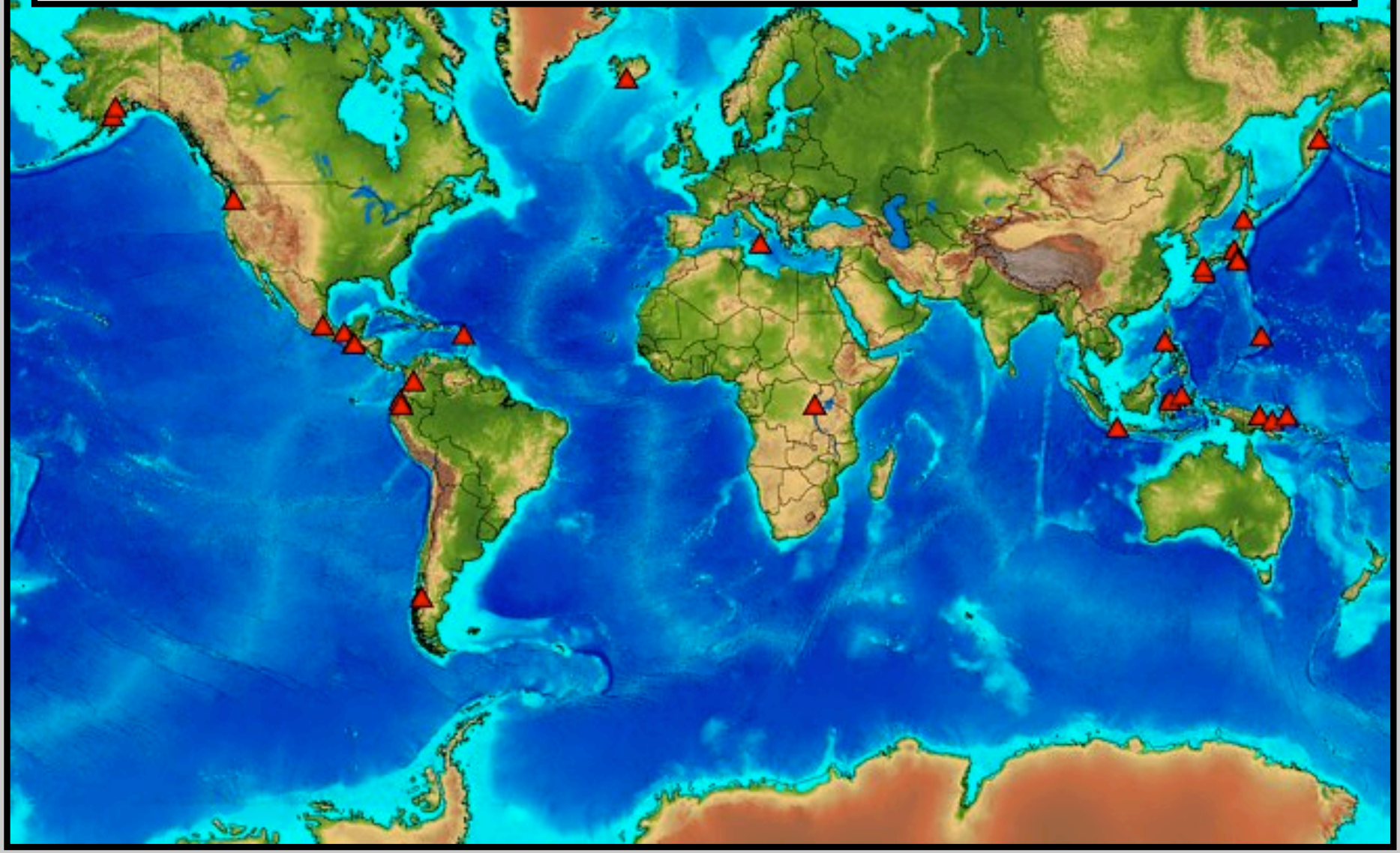
30 Volcanic Sources of Ash Clouds Encountered Since 1973



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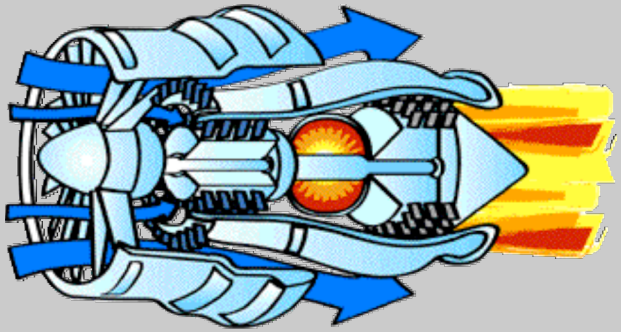
Volcanoes with highest number of encounters (≥5):

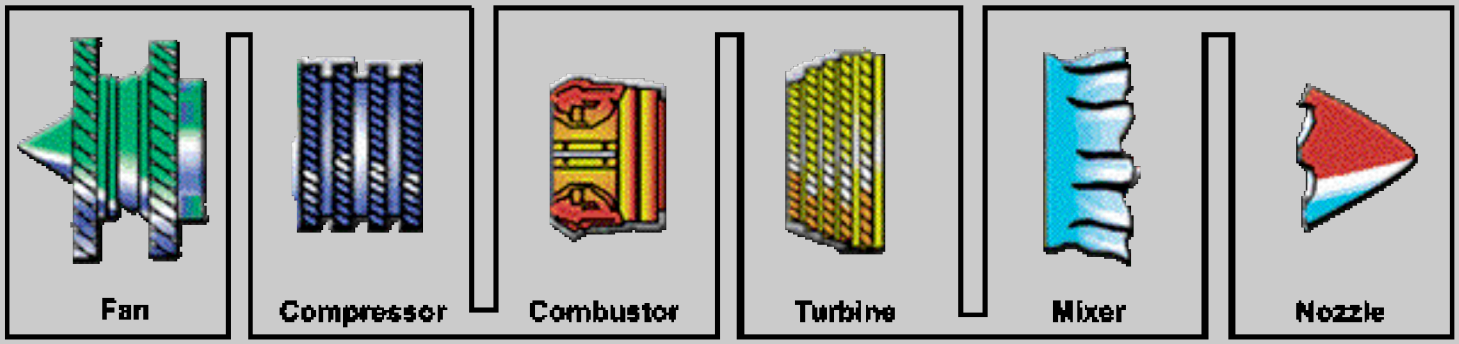
- Pinatubo, Philippines (1991)
- Sakura-jima, Japan (1977-1998)
- St. Helens, USA (1980)
- Augustine, USA (1976)
- Redoubt, USA (1989-1990)
- Galunggung, Indonesia (1982)

- For a given volcano, encounter severity may be:
  limited to a particular class (e.g, Sakura-jima, class 2)
  or range widely (e.g., Pinatubo and Redoubt, class 0 to 4).

- 747 is aircraft type most often involved in encounters –
  because it has been most commonly used aircraft in transoceanic flights over volcanic regions.

USGS

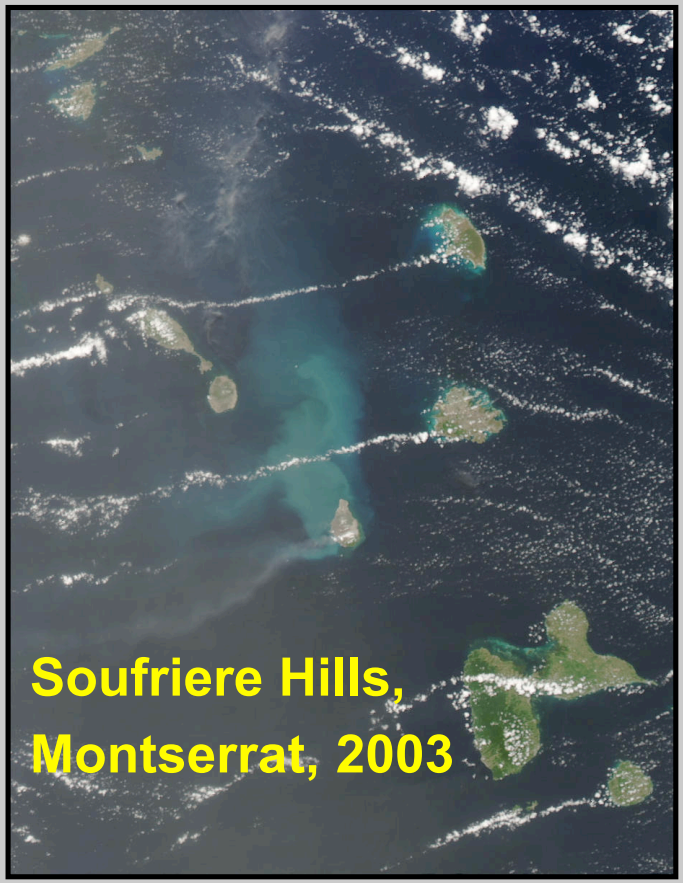


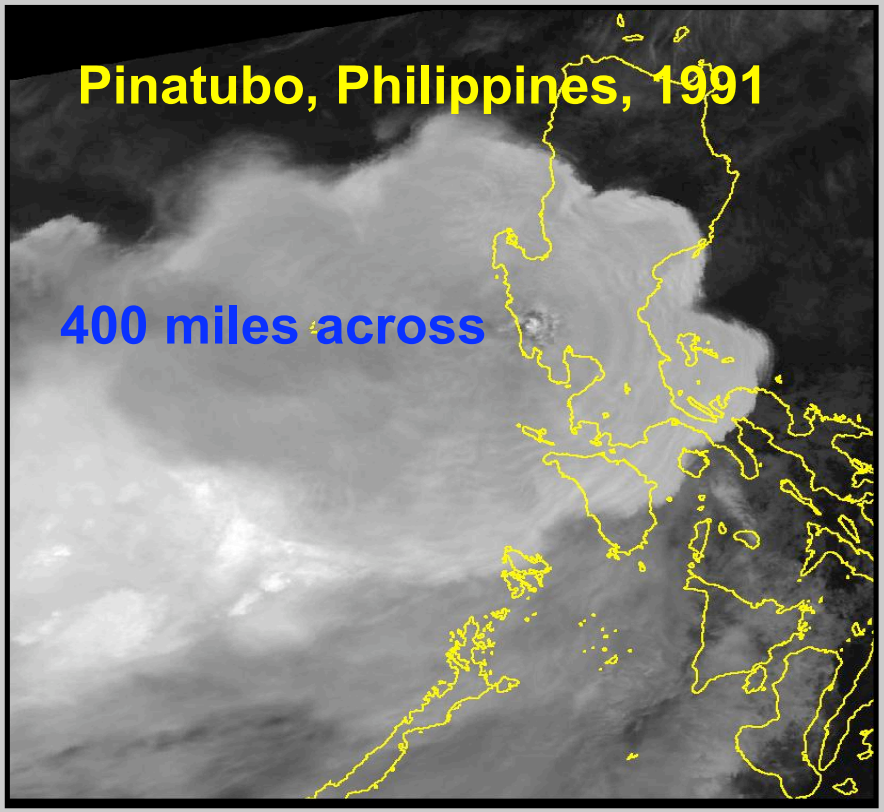


Combustion temperatures up to 2700°C

Volcanic glass melts at ~1000°C

Encounters result from large and small eruptions





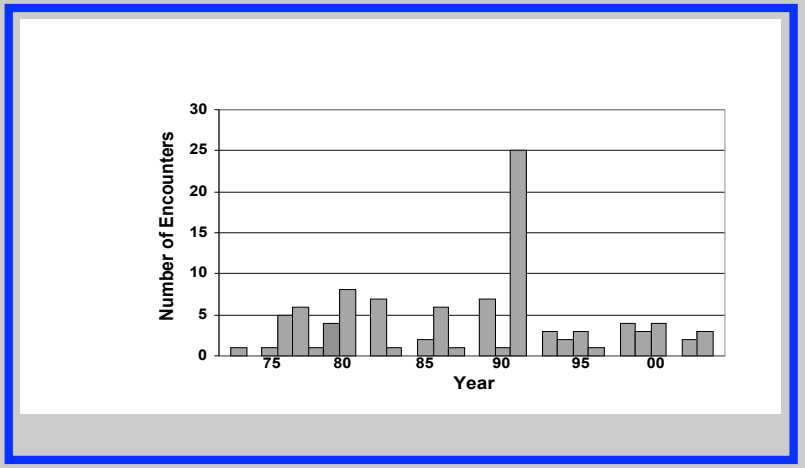
USGS

MITIGATION WORKS

- Near loss of fully loaded passengers jets caused people to act. Existing systems were adapted & missions evolved.
- Better tracking of ash clouds and faster, more reliable communication became possible with advances in technology.
- Fewer encounters (normalized for increased traffic) & lower severity; no crashes.

But Imperfectly .....

- Encounters have continued.



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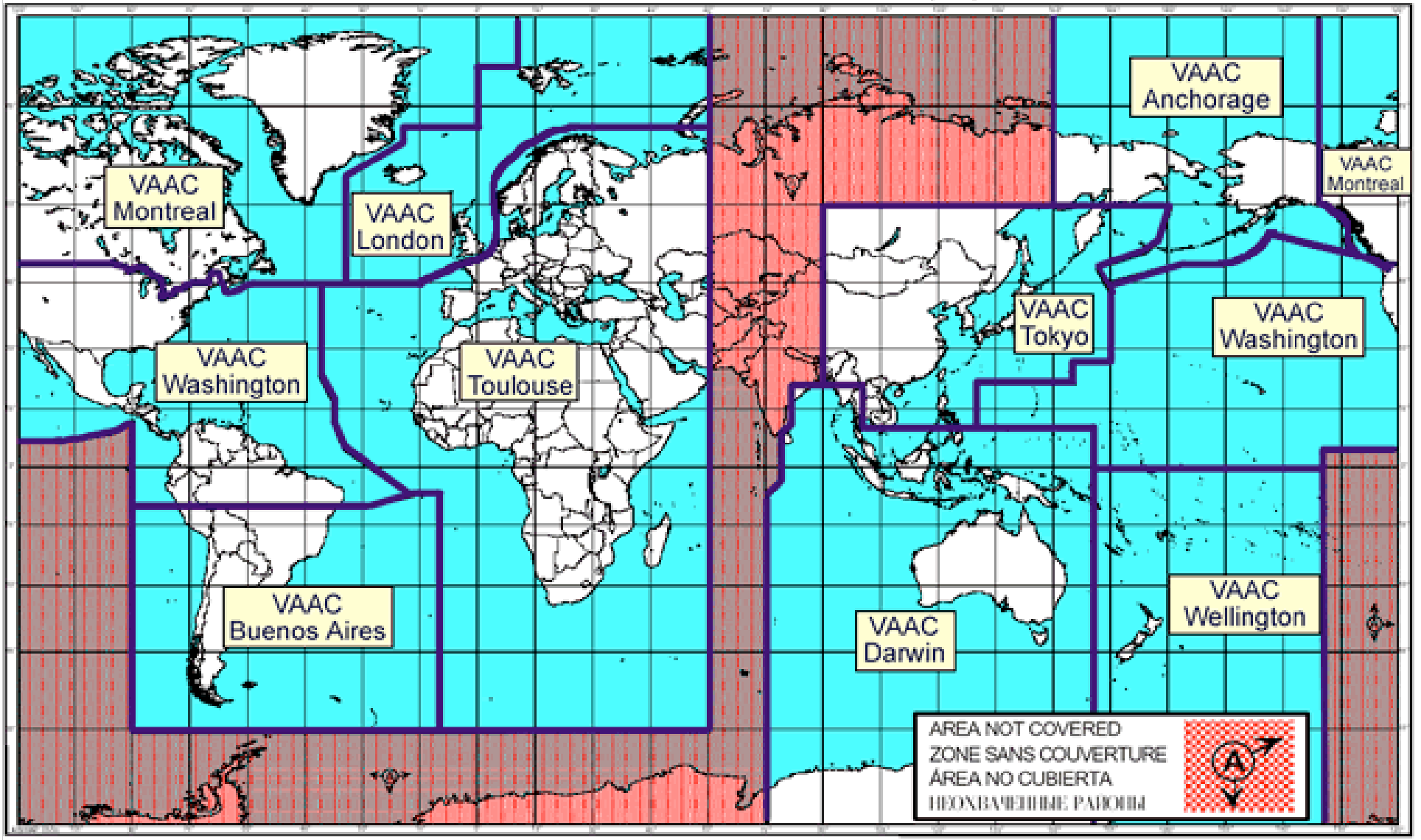

VAAC Montreal
VAAC London
VAAC Toulouse
VAAC Washington
VAAC Buenos Aires
VAAC Darwin
VAAC Tokyo
VAAC Anchorage
VAAC Montreal
VAAC Washington
VAAC Wellington
AREA NOT COVERED
ZONE SANS COUVERTURE
ÁREA NO CUBIERTA

Why do encounters continue to occur?

- Unexpected eruptions at unmonitored volcanoes; incomplete eruption reporting
- Limitations in methods of detecting ash clouds, including the time it takes to get satellite data.
- Limitations in forecasting cloud dispersion
- Breakdowns in information dissemination
- Inadequate training and hazard awareness

USGS

NASA Shuttle image of 1994 eruption of Rabaul Volcano, PNG

Information about ash/aircraft encounters documents the nature and extent of the risk to aviation and helps to refine mitigation efforts.

- **Additional data about encounters confirms recommended pilot actions in the event of an encounter and may lead to further refinements.**
- **Models of ash dispersion can be refined.**
- **Weaknesses in communication links can be identified and fixed.**
- **Training needs can be pinpointed.**

USGS

- **The USGS & Smithsonian Institution, in collaboration with Darwin VAAC, will continue to maintain a summary of reported encounters in the form of a queriable database that includes information about the source eruptions and encounter conditions.**

- **Data identifying the airlines or aircraft operators involved in encounters will not be included in the database.**

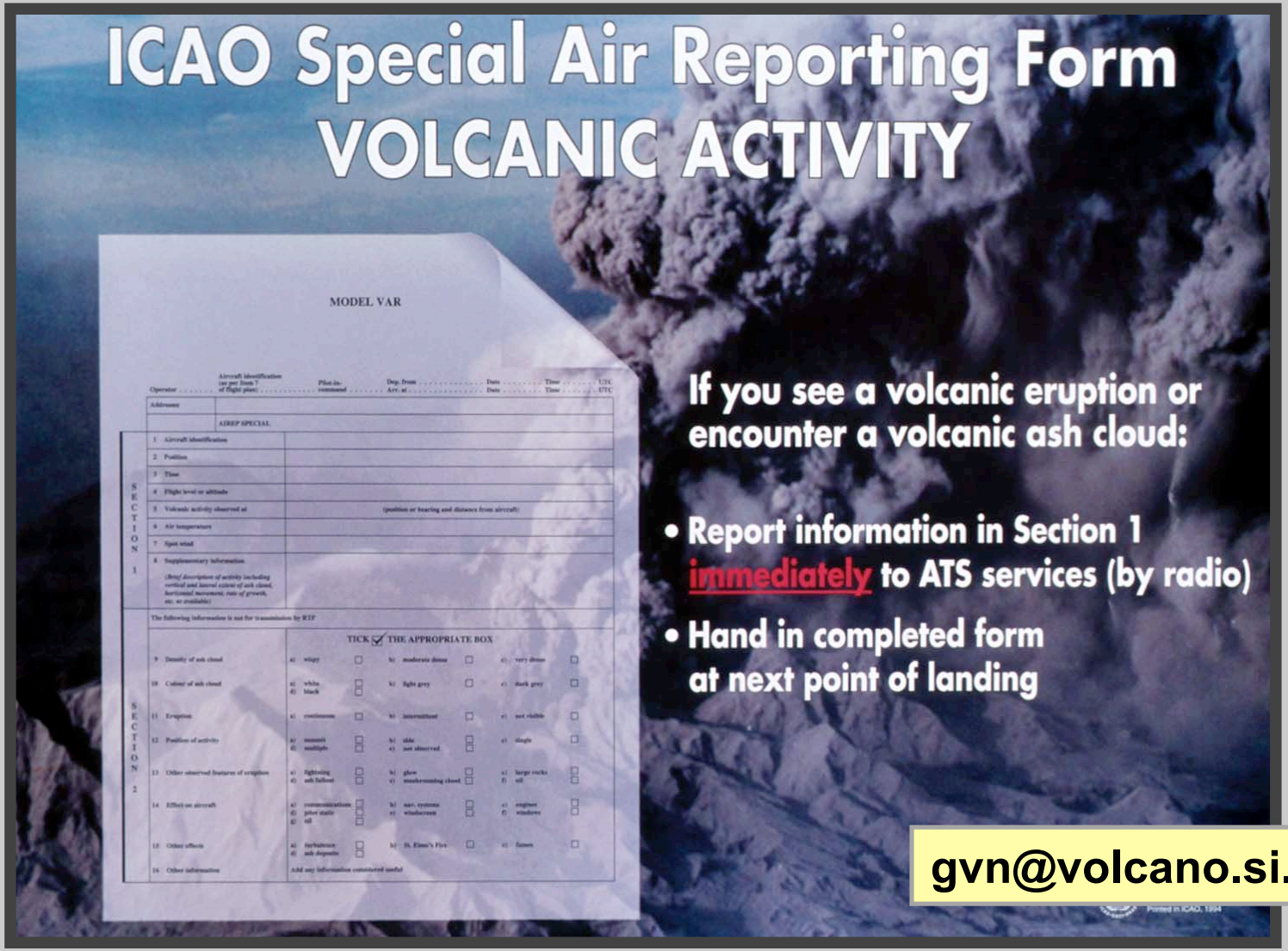
- **An updated summary of encounters will be provided to ICAO for publication in a future update of the 2001 Manual.**

USGS

Encounter Database Fields:

- unique incident number
- encounter date and time
- encounter lat/long and altitude
- aircraft type (not airline)
- severity of encounter
- damages and costs
- volcanic source, lat/long, Smithsonian ID number
- eruption date, time, duration, and column height
- volcanic explosivity index
- flight route info
- distance of encounter from volcanic source
- time between eruption and encounter
- source of satellite imagery
- issuance of SIGMETs and VAAs
- references

USGS



To ATS via radio & at next point of landing.

Also Smithsonian via email (gvn@volcano.si.edu)

Reporting Encounters:

- **ICAO Doc 4444 and Annex 3 refer to the VOLCANIC ACTIVITY REPORT (VAR) and provide a format.**

- **The issue is getting cooperation from pilots and Air Traffic Services to complete these reports and forward them to appropriate services and agencies for operational use and historical record-keeping (by the USGS & Smithsonian).**

USGS

Volcanic ash will persist as a serious aviation hazard: heavy traffic over volcanic regions, free-flight routing, ETOPS, larger hotter engines.

GLOBAL STRATEGY: quickly communicate information about explosive eruptions & locations of ash clouds to ATC, dispatchers, & pilots so clouds can be avoided.

INVOLVED PARTIES:

- **Airlines**
- **Air Traffic Agencies**
- **National Weather Services**
- **Scientists (Volcanologists, Meteorologists)**
- **WMO, ICAO, ALPA, etc.**

MITIGATION ELEMENTS:

1 – Volcano Monitoring & Eruption Reporting
2 – Ash Cloud Detection
3 – Forecasting Cloud Movement
4 – Communication
5 – Hazard Awareness

USGS

Resist complacency:

A perverse aspect of effective mitigation is that the prevention of bad outcomes can lead to an unwarranted complacency that the underlying hazard has been eliminated.

As our ability to prevent encounters improves to the point that even fewer incidents occur, we must not mistakenly conclude that no threat exists, but rather call for continued vigilance and support of broad-based mitigation capabilities.

USGS