Potential consequences of volcanic eruptions on flying in a piston powered aircraft

General

Volcanic ash in order to be transported from recent eruptions in Iceland to the European continent must have a very low equivalent diameter (small size and low density, resulting in a low fall-out velocity) or it would fall down to earth and to the Atlantic Ocean rather rapidly. Ash coming over the European continent with an estimated particle size of about 1-10 microns (1 micron is equivalent to one thousandth of a millimeter) or smaller, could actually be identified as dust. This form of dust reaches a maximum altitude of about 35.000 feet, and aircraft flying above this altitude are not affected. The plume of ash remains inside the troposphere and is thus limited by the energy of the volcano.

For an updated map over the ash cloud and concentrations (new version published every 6th hour) go to: http://www.metoffice.gov.uk/aviation/vaac/vaacuk_vag.html
http://www.metoffice.gov.uk/corporate/pressoffice/2010/volcano/ashconcentration

While weather in one map may show the ash cloud from the ground up to FL 200, and a second map from FL 200 to FL 350, predictions of what is happening below FL 200 in general are only estimates, particularly from the ground up to 5000 feet GND.

If the ash cloud is invisible to the human eye in a clear dry sky below 5000 feet GND, it can be assumed that such an area is safe. This is because at altitudes from the ground up to 5000 feet GND there is a large amount of various other invisible particles and normal dust with particle sizes around 1-10 microns.

The ash particles transported to the European mainland are mainly in the form of silica, (silicon dioxide, SiO_2, quartz), i.e. as a “sand dust”. If heated over 1000 degrees C. the silica may transform into a crystalline material with ability to cut, wear, polish, and in certain cases attach to surfaces.

While such transformation may be more severe in turbine engines, these crystalline deposits may also develop in the combustion chambers of piston engines if engine air-filter fails, and then typically on spark-plugs in a similar way as if the engine did not have any air-filter.

Volcanic ash coalesces with rain and snow and precipitates to the ground, and then the soil handles the dust in the same way as ordinary dust. Only if the ash is deposited on the soil in the form of visible ash or dust it may be harmful, specifically to animals that may ingest the ash when eating grass etc. Breathing of visible ash by humans could also be harmful. Ash or high amounts of dust may contain small amounts of fluoride (mainly hydrogen fluoride, HF). Fluoride may be found in small amounts in tooth-paste in order to reduce caries.

Dust or ash on ~~a~~ painted surfaces, and particularly on acrylic windshields and windows, may cause damage to those surfaces. Always clean without delay aircraft surfaces with a vacuum-cleaner and afterwards with plenty of fresh water. Polish and wax afterwards. To avoid contamination of cleaning tools and accessories with ash or dust, store buckets inverted, wash and thoroughly dry towels, sponges, etc., and store them in a sealed plastic bag.

Aircraft flying at low altitudes in airspace suspected of being contaminated with volcanic ash, may be considered not affected when the ash cloud is invisible under a clear sky and without any detectable odours.

Impact on piston engines

Volcanic ash in the form of ordinary dry dust with particle sizes around 1-10 microns, may pass through the engine air-inlet filter and mix with the oil inside the engine after combustion.

While the engine oil filter may capture a portion of this ash, the majority of it may end up in the engine oil – in the same way as ordinary dust, lead deposits (from AVGAS 100 LL) and carbon deposits (from ordinary engine combustion) will do.

The ash may mix or get attached to other dust and form larger particles and be trapped inside the oil filter. If for any reason the oil filter gets clogged, modern piston aircraft engines have a bypass valve that allows the contaminated oil to be distributed in the engine.

It is possible to experience accelerated engine wear but this wear will not affect the engine immediately. Accelerated wear is a gradual process frequently experienced with aircraft operated in areas with frequent sand storms, or in general with dirty air as in industrial regions. Changing engine oil more frequently than normal schedules is recommended, and if oil contamination and/or accelerated wear is suspected following exposures to volcanic ash or dusty conditions, a spectrographic oil analysis could provide an indication of the contaminants and engine wear conditions.

Impacts on pitot tube, air sensing units, air gyroscopic instruments

Dry volcanic ash or dust with a particle size of 1-10 microns and in the form of silica should have a similar impact to ordinary sand or dirt dust on these systems. Current systems are usually protected to handle such conditions.

Impacts on propeller, wing leading edge surfaces, antennas, windshields etc

The impact may be the same as when flying through ordinary dust or dirt with some tarnishing on leading edge surfaces that may gradually develop, but should not be worse than ordinary wear and tear. The propeller can be abraded and polished but any decrease in performance should be insignificant and gradual, assuming that particle sizes does not exceed 1-10 microns and as long as the particles are dry and the concentration of particles is so low that the ash remains invisible.

Under certain circumstances and particularly in darkness, a corona discharge or halo may be visible around the propeller and wing tips when flying in air with volcanic ash. This is nothing dangerous and can also be observed in clean air where it is called precipitation static. If the aircraft is not properly equipped with static discharge wicks, radio reception for ADF can be interfered, and other radio signals as well might be blocked for reception in the aircraft. In extreme cases complete loss of VHF-communications, erroneous magnetic compass readings (up to 30 degree errors), high pitched squeal on audio with a motor boat sound, loss of all avionics and erratic instrument readouts may occur.

Dust and ash may also penetrate the aircraft electronic systems such as alternator, radios and navigation instruments.

Impact on pilots and passengers
There is nothing a person can do if the dust is not visible and there are no odours. You have to live with it as you have to do with ordinary dust, dirt, pollen and nano particles in the air.
If exposed for longer periods, health problems may develop in the same way as if you were living in a dusty environment or within an industrial region.
Ash and dust normally invisible may show up around flashes from strobe-lights even during day-time. If an area of dust and ash is penetrated it is likely that such particles will enter the aircraft cabin. Ash and dust may contain fluoride which in high concentrations is toxic and may harm skin and eyes.
The dust may also contain small amounts of rare metals that may cause allergic reactions, but such particles are usually not toxic.
Volcanic gases may also be spread around with the air. Such gases may have an acrid or sulphurous odour. If the dust is combined with an odour, for example sulphur, breathing such air shall be avoided as it may cause respiratory problems. The concentrations of such toxic gases and the high concentration of fluoride on the European mainland at about 3000 kilometres (1800 nautical miles) from Iceland, the volcanic source, may be considered negligible for ordinary healthy persons.

Avoid flying in precipitation, near rainy clouds or in IMC.
Rain and water falling through the sky from high altitudes will coalesce the ash from the contaminated air. This means that the concentration of ash will dramatically increase at lower altitudes during precipitation. Water and snow in the form of precipitation falling through the air may mix with the dust as well as with moisture and form a sort of a “clay”. Such clay may partially or totally block engine air-inlet/induction filters. Fuel injected piston engines usually have air filters that automatically or manually can be by-passed by the pilot (for example in Piper 31's and most Lycoming TIO 540 engines) if the filter is getting clogged. For carburetor engines, a bypass of the ordinary air filter can usually be arranged by using the carburetor alternate heated air source. In both cases unfiltered air usually will enter the combustion area and may cause excessive engine wear. Particles in the cylinder combustion chamber may also foul the spark plugs. Any such problems will easily be noticeable by a rough engine. Under such conditions landing of the aircraft should take place at the first opportunity. Over-leaning for a very short time may clear a fouled spark plug.
Ash or dust mixed with water or moisture may clog the pitot tube. In such a case the indicated airspeed may be affected and give sluggish readings, low speed readings and even higher than actual speed readings.
For aircraft with modern glass cockpit-technology, blocked air data sensors may actually cause several readings, such as airspeed, altimeter, climb and descend rate to be in error or give zero values at the same time. Thus it is imperative that the pilot well understands how the system work in his particular aircraft as what may become inoperative may change between various glass cockpit-systems.
Approximately correct airspeed without an air-speed indicator may be maintained through correct manifold pressure, propeller RPM and blade pitch, and known angle of attack.

If the static air pressure inlet for any reason gets clogged, this could result in incorrect altimeter and airspeed information. Most aircraft have an alternate static air pressure valve located under the instrument panel that may be manually operated.

If usage of the alternate static air pressure does not solve the problem, the glass over the vertical speed indicator dial can be broken in order to get the system to work properly. On pressurized aircraft the cabin should be de-pressurized before taking these actions.

Consequently -- avoid flying near clouds or when it is raining or in clouds where there is ash or dust in the air! Avoid flying in IMC or during darkness.

Post flight activities

After each flight in which volcanic ash or dust has been predicted or encountered, a careful inspection of the aircraft shall be made by the pilot. The airframe and cabin shall be inspected for any potential impact of the ash. Take a fine white moistened soft cloth and move easily around the aircraft surfaces and inside the cabin trying to trap any particles. Volcanic dust or ash on the cloth is a sign that penetration into contaminated areas has taken place and that other precautionary inspection activities are required.
Observe if any wear or erosion has taken place on aircraft leading edges or the wind-shield. Visually inspect the pitot tube, static air inlet, engine air inlet/induction filters, and fuel tank vents for damage, dust or dirt accumulations.
The engine compartment should be inspected and any wear by ash or dust on spark plug cables, electrical cables, fuel lines, oil hoses, accessories etc shall be observed.

If particles are found on the cloth or wear damage inside the engine compartment or elsewhere, inform the responsible mechanic without delays, and report any ash related incidents to the reporting services if available from your civil aviation authority. Make appropriate notes in the aircraft flight log book.

If found justified or in any doubt about the airworthiness of the aircraft, ground it for an inspection by a mechanic. Such an inspection, should among others include a borescope inspection of the cylinders, inspection of the air- and engine oil - filters. An inspection report should be drafted and an airworthiness declaration shall be issued at the end of the inspection.

The Decision to fly

This article has been prepared for information purposes only, and is intended to share the practical experience of the author. Continuing and future volcanic eruptions may pose flying conditions and hazards not covered by this article. In a nutshell, ultimately the pilot or operator is responsible for performing his or her assessment of risks and establish appropriate operational procedures, or remain on the ground until conditions improve.

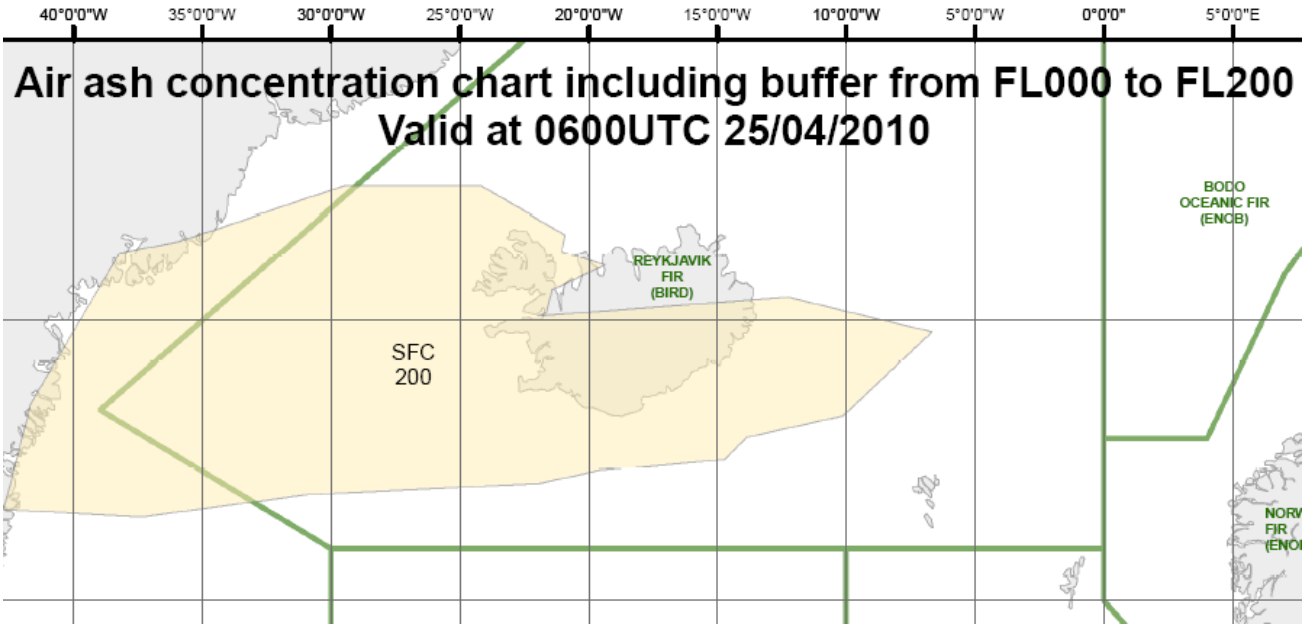
Perform a complete pre-planning of the flight, including a special pre-inspection of the aircraft if flown recently in volcanic ash. Consult with others precipitation and moisture data, such as SIGMETs, AICs, NOTAMs and the previous named WebPages from the London Meteorological Office. It is also quite common for authorities to designate restricted or dangerous areas where volcanic dust and ash are present. Special rules and regulations may also apply for aircraft maintenance, flight operations and access to the airspace. Based on the registry of your aircraft, the CAA of the country of aircraft registration may assign certain restrictions. So if your aircraft has a US registration but is operated in Europe you have to follow US regulations and regulations of the country (FIR) you intend to fly in.

For this particular volcanic eruption, Eurocontrol has assigned three different flying zones (Reference: Swedish AIC 8 2010.)

Zone 1:
Limited No-Fly Zone is an Area with a High Density Volcanic Ash Contamination.
A “No fly zone” - which includes the main area/core of the volcanic fallout, and normally with an additional buffer zone. The area is established on the basis of meteorological conditions where wind direction, humidity etc. will result in a high intensity of particles. Associated airspace restrictions/closures will be notified by NOTAMs.
Zone 1 is established by Volcanic Ash Advisory Centre (VAAC) and administrated by the Central Flow Management Unit (CFMU).

The criteria for Zone 1 have been agreed between transport officials from the EU-member states, Eurocontrol and turbine engine manufacturers. When in excess of 200 milligrams of volcanic ash per cubic meter of air, Zone 1 is established.

Information about Zone 1 inclusive by Eurocontrol calculated buffer zones, if any, can be obtained from HTTP://WWW.LFV.SE/LINKS/NOP-PUBLIC-PORTAL
or https://www.cfmu.eurocontrol.int/PUBPORTAL/gateway/spec/index.html
(Go to Network headline news – Volcanic ash)



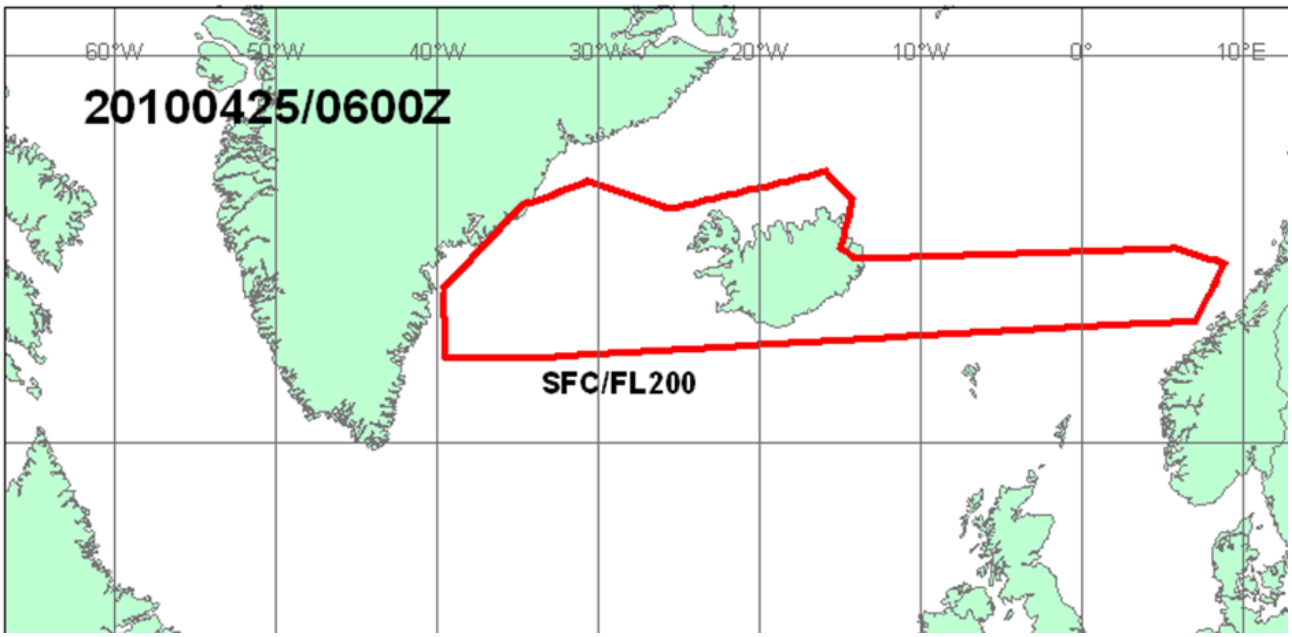
Above example: Zone 1 **(no flying zone)** April 25 at 06.00 UTC from surface up to FL200 **inclusive buffer zones** marked with yellow.

Zone 2:
Potential Contamination Zone is an Area with a Low Density Volcanic Ash Contamination. An area outside Zone 1 where flying can be conducted when actual conditions, risk assessment and test(s) can establish, that flights can be conducted at an acceptable level of safety and requires prior permission from the regional Authority. Areas affected by volcanic ash will be notified by SIGMETs. Prerequisites and requirements for flying in this area are given below.

Zone 2 is established as a contaminated zone published by the VAAC and forms the basis of the current ***restrictions, not including restrictions for Zone 1.***
As no information is given about concentrations, the Zone 2 as drawn below ***also contains*** *Zone 1.*

Information about Zone 2 and without concentrations of ash can be obtained from:

HTTP://WWW.LFV.SE/LINKS/VAAC-LONDON or
http://www.metoffice.gov.uk/aviation/vaac/vaacuk_vag.html

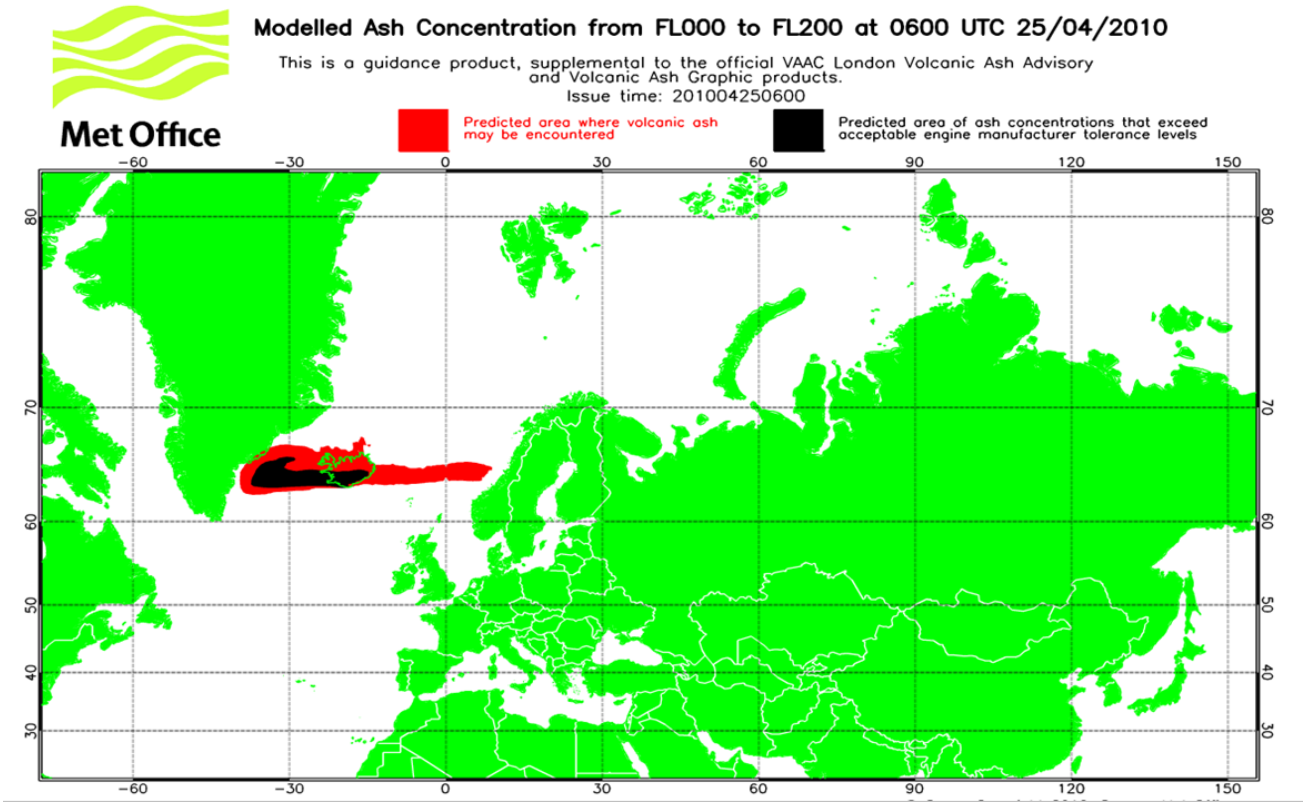


Above example shows area with volcanic ash and dust **without concentrations** – so this map **includes** *both Zone 1 and Zone 2 from surface up to FL 200.*

For the forecast of ash concentrations you have to go to:

http://www.metoffice.gov.uk/corporate/pressoffice/2010/volcano/ashconcentration

That map (example below) will show you Zone 1 and Zone 2 **without the buffer zones** (which normally are calculated by Eurocontrol, see earlier Zone 1 map) and is a guidance product.



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Red is essentially Zone 2 and black Zone 1. **Zone 1 is only calculated based on experience with turbine engines, i.e. with an ash particle concentration above 200 milligrams per cubic meter of air. It is not applicable to non-turbine powered aircraft such as piston powered aircraft.**

The Zone 1 and 2 may be over-flown in accordance with the considerations stated below.

After the VAAC (Volcanic Ash Advisory Centre) has issued the +6, +12, +18 hrs forecasts of contaminated areas, SIGMETs and NOTAMs based on the VAAC forecast will be issued.

For example, in Sweden aircraft without turbine engine/s, i.e. gliders, balloons and ***piston powered*** together with military, coastguard, police, ambulance may fly at own risk in Zone 1 and Zone 2 without special permission.

This information can be obtained from the latest NOTAMs as this example shows:

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TEMPORARY RESTRICTED AREA(S) ESTABLISHED IN SWEDEN FIR/UIR
    (DANGER AREA(S) OVER INTERNATIONAL WATERS) DUE VOLCANIC ASH.
    TWO TYPES OF AREAS APPLY - ZONE 1 AND ZONE 2
    ZONE 1
    REF: HTTP://WWW.LFV.SE/LINKS/NOP-PUBLIC-PORTAL
    (GO TO - NETWORK HEADLINE NEWS - VOLCANIC ASH)
    LATERAL AND VERTICAL LIMITS OF THE AREA(S) ARE DEFINED BY THE
    LATEST
    UPDATED VAAC ADVISORY (AIR ASH CONCENTRATION CHART) ISSUED BY
    VAAC LONDON.
    NO TRAFFIC ALLOWED EXCEPT MILITARY, COASTGUARD, POLICE,
    AMBULANCE, SAR AND OTHER ACFT NOT EQUIPPED WITH TURBINE ENGINE.
    FLIGHT IS CONDUCTED AT THE SOLE RISK OF THE OPERATOR.
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ZONE 2
REF: HTTP://WWW.LFV.SE/LINKS/VAAC-LONDON
LATERAL AND VERTICAL LIMITS OF THE AREA(S) ARE DEFINED BY THE
LATEST
UPDATED AND THE NEXT 6 HRS FCST OF VAAC ADVISORY FOR VOLCANIC
ASH ISSUED BY VAAC LONDON.
NO TRAFFIC ALLOWED EXCEPT FOR OPERATIONS WITH APPROVAL TO
OPERATE IN ZONE 2 AND MILITARY, COASTGUARD, POLICE, AMBULANCE,
SAR AND OTHER ACFT NOT EQUIPPED WITH TURBINE ENGINE. CONDITIONS
FOR APPROVAL LISTED AT
HTTP://WWW.TRANSPORTSTYRELSEN.SE/SV/NYHETSARKIV/INFORMATION-
TILL-OPERATORER/
APPLICABILITY
-ALL SWEDISH OPERATORS WITH EU-OPS AOC WITH TURBINE POWERED
AEROPLANES AND JAR-OPS 3 AOC WITH TURBINE POWERED HELICOPTERS.
-ALL SWEDISH REGISTERED TURBINE POWERED AEROPLANES AND
HELICOPTERS.
FOR OTHER OPERATORS PSE REFER TO NATIONAL REGULATIONS CONCERING
FLIGHT IN VOLCANIC ASH ZONE 2.
FLIGHT IS CONDUCTED AT THE SOLE RISK OF THE OPERATOR. GND-UNL.
14MAY10 0711 - 26MAY10 1200 (ES/1/A0297/10)
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A special assessment shall always be made before intentionally flying into and in a Zone 1 or Zone 2.
Risks and costs may be prohibitive.

All charts as presented above are calculations based on models. There is no guarantee they represent the real and actual situation. It could be much worse and a Zone 3 may actually be a Zone 2.

Zone 3:
Non-Contaminated Airspace is an Area Free of Volcanic Ash Contamination.
An area - free of contamination - where flights can be conducted without restrictions or special prerequisites.

Summary
If you enter a volcanic ash cloud, immediately execute a descending 180-degree turn to leave the cloud and transmit a report to the nearest ATS unit. A precautionary landing should be made at the nearest suitable airport if it is suspected that the engine has been adversely affected or that there is aircraft damage.
It is up to the individual to decide what he or she wants to do and what constitutes acceptable risks. Conduct your own risk assessment and follow operational procedures that address any remaining risks.
Low altitude daytime VFR flights in piston powered aircraft above the European mainland, about 1800 nautical miles away from the active volcano Eyjafjallajokull, with no visible ash or dust clouds, no rain in a clear dry sky and no abnormal odour in the air, should not pose any abnormal challenges.

But the decision to go or not to go is always up to the pilot in command.