HARMONIA Workshop
WG3 Workshop for aerosol end user engagement
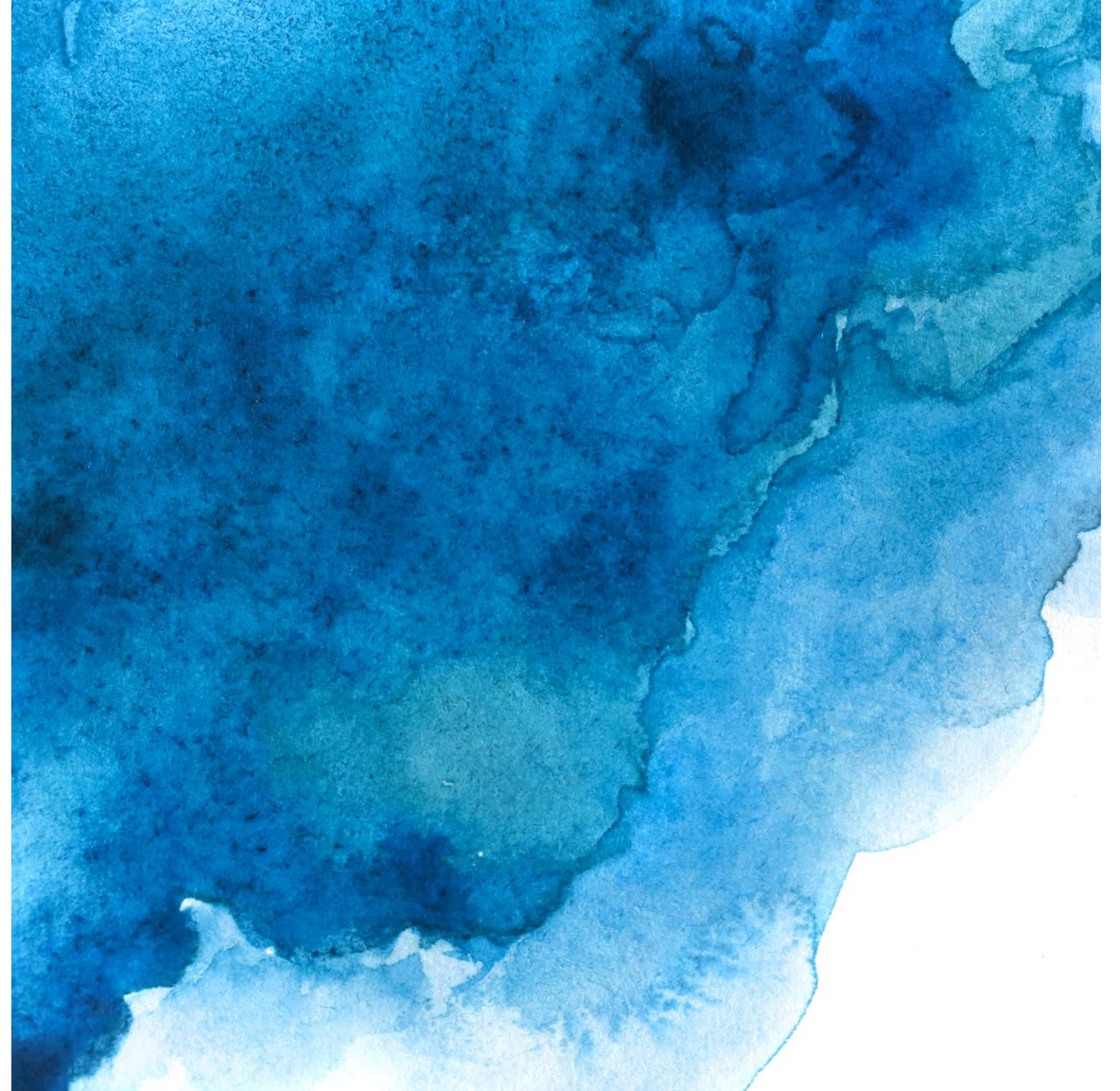**Academy of Athens 19-09-2023**

Aerosol observation
for the aviation sector

HOW DO AEROSOLS
AFFECT AIR TRAFFIC

OLYMPIA VASARDANI

AIR TRAFFIC CONTROLLER / HELLENIC CIVIL AVIATION
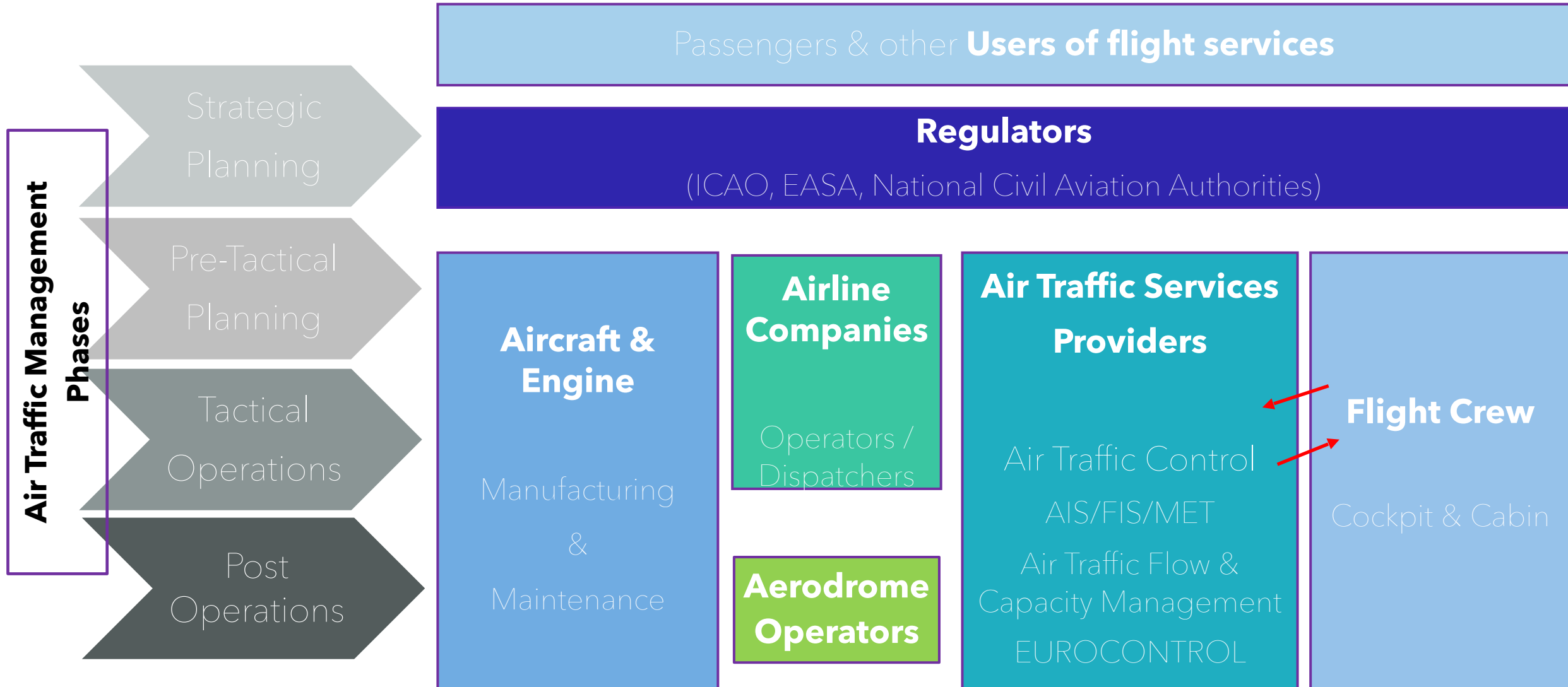AUTHORITY

PHD CANDIDATE / NATIONAL AND KAPODISTRIAN
UNIVERSITY OF ATHENS

Presentation overview

- Aviation Sector **Users**

- **Meteorological Information** for aviation

- Aerosol related Atmospheric **Phenomena** of interest for air traffic

- **Aviation** Sector **Needs**

Aviation Sector Users

Air Traffic Management Phases

Strategic Planning

Pre-Tactical Planning

Tactical Operations

Post Operations

Passengers & other **Users of flight services**

Regulators

(ICAO, EASA, National Civil Aviation Authorities)

Aircraft & Engine

Manufacturing & Maintenance

Airline Companies

Operators / Dispatchers

Aerodrome Operators

Air Traffic Services Providers

Air Traffic Control

AIS/FIS/MET

Air Traffic Flow & Capacity Management

EUROCONTROL

Flight Crew

Cockpit & Cabin

Meteorological information for aviation

Regulatory context

ICAO Annex 3 "Standards & Recommended Practices - Meteorological Codes" / **WMO Technical Regulations**
EU Regulation 2017/373 "Common requirements for providers of ATM/ANS"

Global / Regional

2 World Area Forecast Centers **(WAFCs)**
9 Volcanic Ash Advisory Centers **(VAACs)**
7 Tropical Cyclone Advisory Centers **(TCACs)**
7+5 International **OPMET databanks**
21 European NMHSs **(EUMENET)**

State / Local

National Meteorological Services **(NMSs)**

Meteorological Watch Offices **(MWOs)**

Aeronautical Meteorological Stations

Aerodrome Meteorological Offices

EUMETNET

D-1 Cross Border Convection Forecast
issued 30/08/2023 09:00 UTC, valid 31/08/2023

Thu 09-12Z

Thu 12-15Z
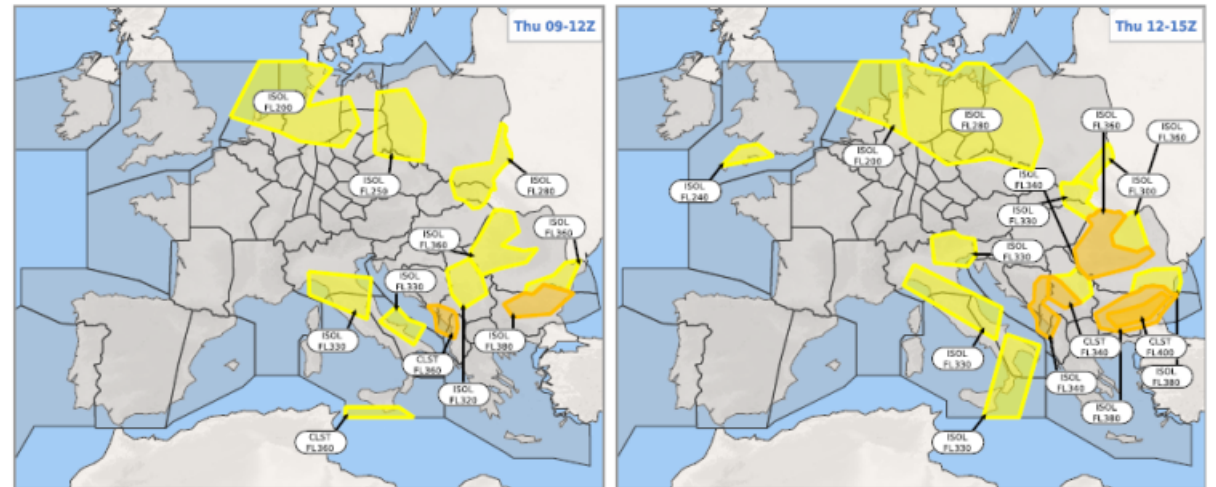
Source: EUROCONTROL Network Operations Portal

MET Info Classification

Tier 1: Essential info - **certified providers**
Tier 2: Additional info – **appropriate standards**
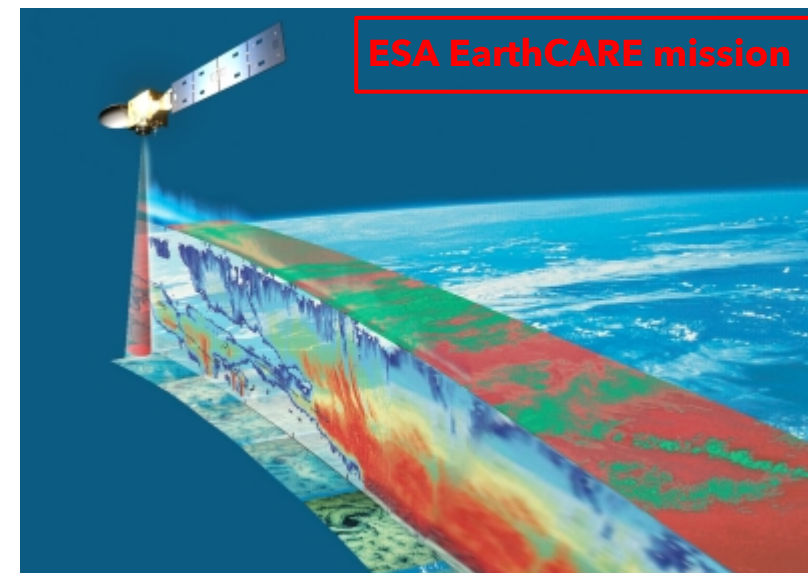**Tier 3**: MET info **not** for aviation purposes

(EASA, 2018)

Aerosol related
Operational and Safety
Atmospheric Hazards for Aviation

ESA EarthCARE mission

- **Volcanic Ash**
- **Fire Smoke**
- **Dust & Sand**

HALO lidar

Credit: NASA

Credit: ESA

Aerosol
Observation

Remote & In situ
Ground based
Space based
Airborne

AERONET sensors
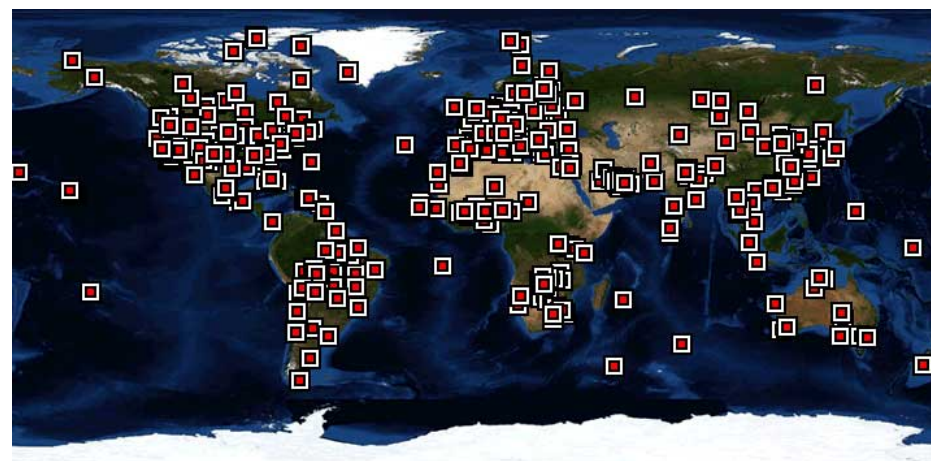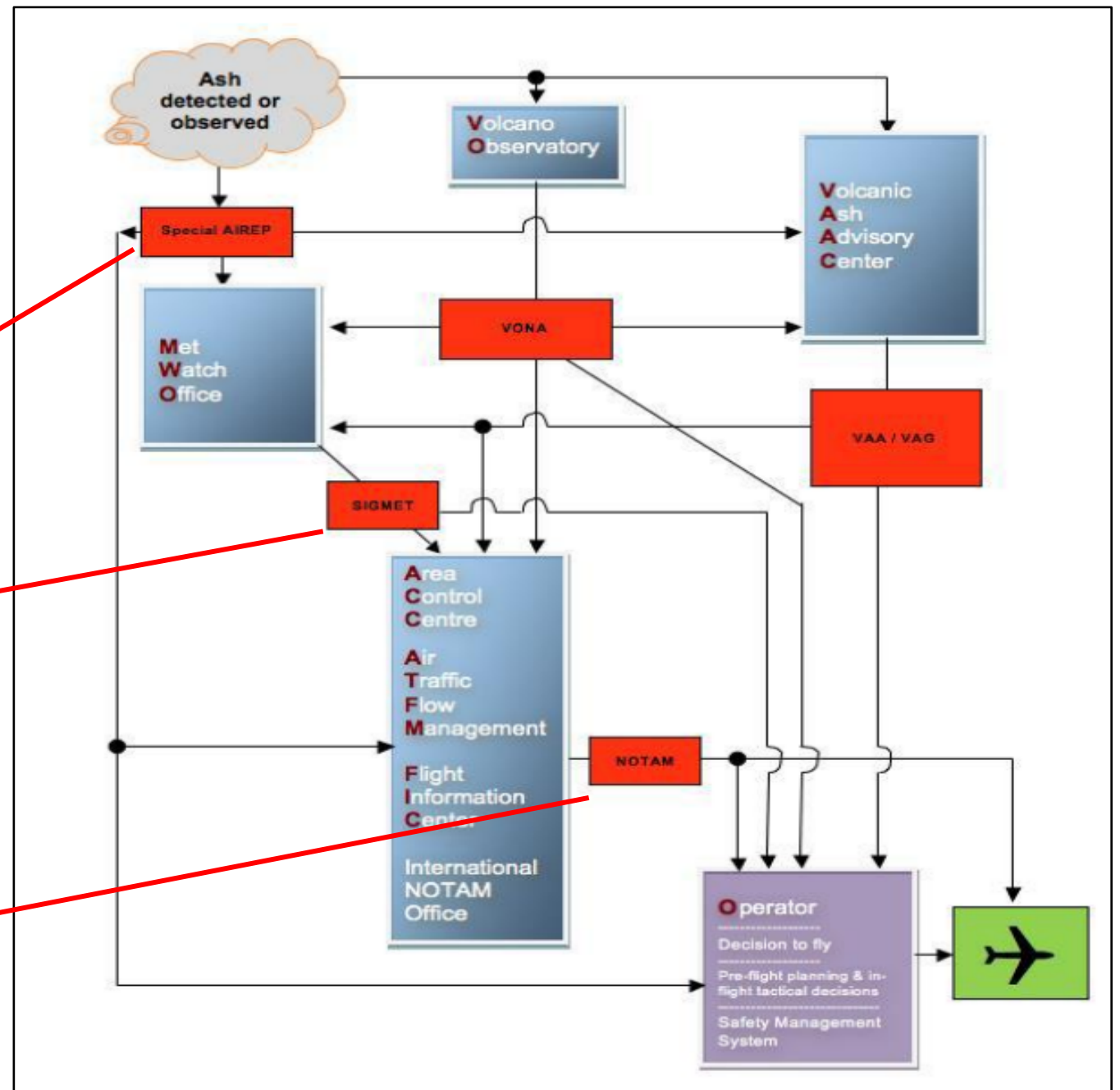
Credit: NASA

EARLINET
EARLINET sensors
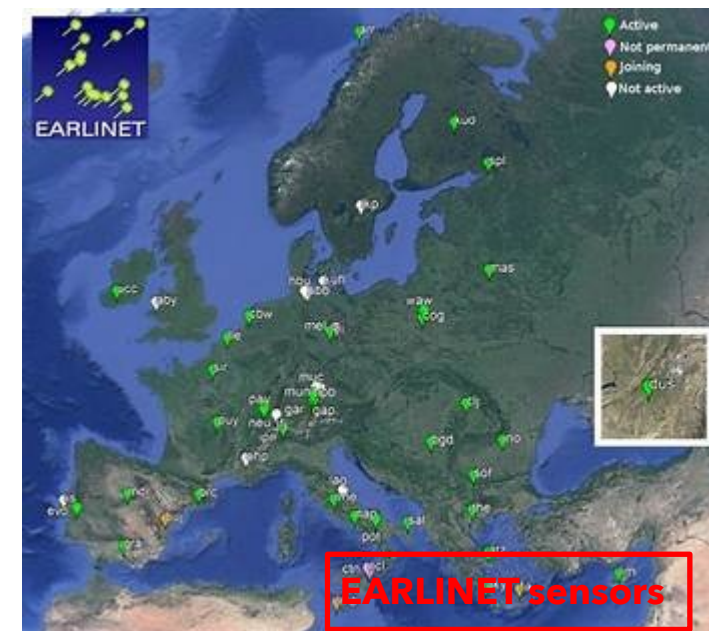
Credit: www.earlinet.org

Aviation Sector Volcanic ash Information flow

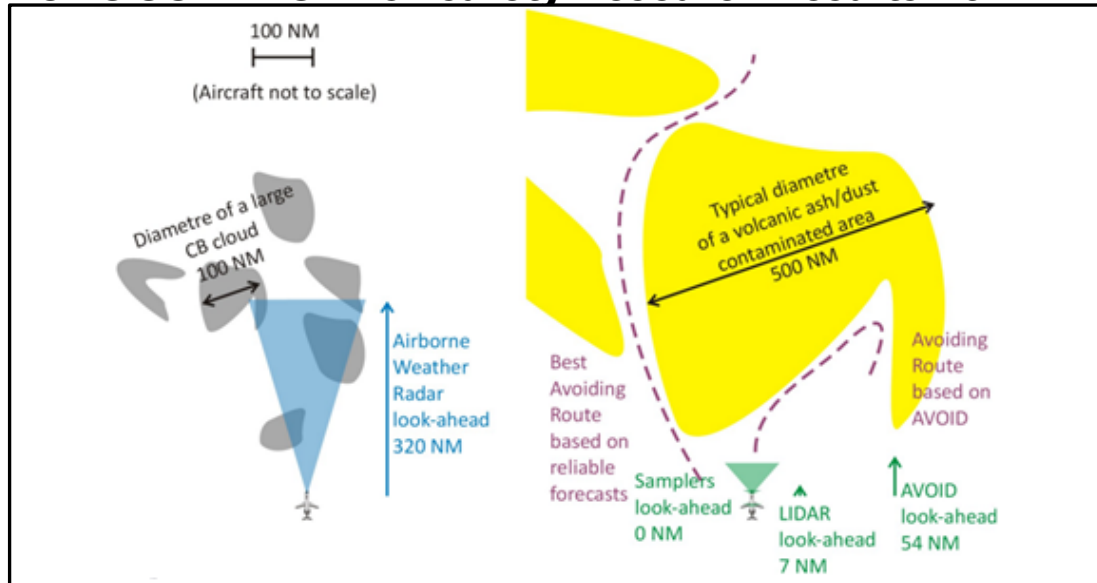**AIREP** : report from an **aircraft in flight**

SIGMET : issued **by a MWO** regarding occurrence or expected occurrence of specified **en-route weather phenomena** may affecting **safety of aircraft operations**

NOTAM : issued **by a NOTAM Office** regarding establishment, condition, or change in **any aeronautical hazard**, the timely knowledge of which is essential to personnel concerned with flight operations

On-board Detection System?

EUROCONTROL Ash safety Research Results 2011

100 NM

(Aircraft not to scale)

Diametre of a large CB cloud 100 NM

Typical diametre of a volcanic ash/dust contaminated area 500 NM

Airborne Weather Radar look-ahead 320 NM

Best Avoiding Route based on reliable forecasts

Avoiding Route based on AVOID

Samplers look-ahead 0 NM

LIDAR look-ahead 7 NM

AVOID look-ahead 54 NM

Credit: Univ. Politehnica of Bucharest & ROMATSA

On board weather radars (WXR)
are **not able to detect 'dry' phenomena**
such as volcanic ash or CAT

Concentration levels

Low Contamination: **[0.2 , 2] mg / m³**
Medium Contamination: **(2 , 4) mg / m³**
High Contamination: **[4, ∞) mg / m³**

(ICAO, EUR/NAT Volcanic Ash Contingency Plan, 2016)

Engine Exposure dose thresholds

Flight **safety** perspective Acceptable Dose **14.4 g s/m³**
equivalent to   **4 mg/m³ for 1 hour**
or   **0.2 mg/m³ for 20 hour**

(Ellis et al., 2021)

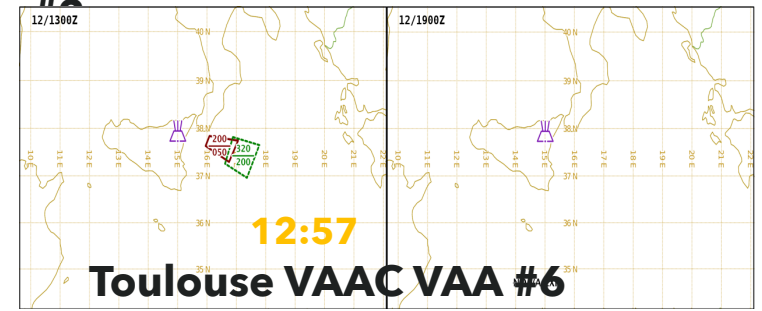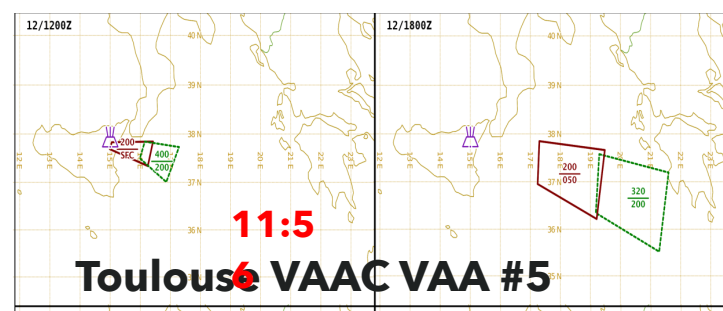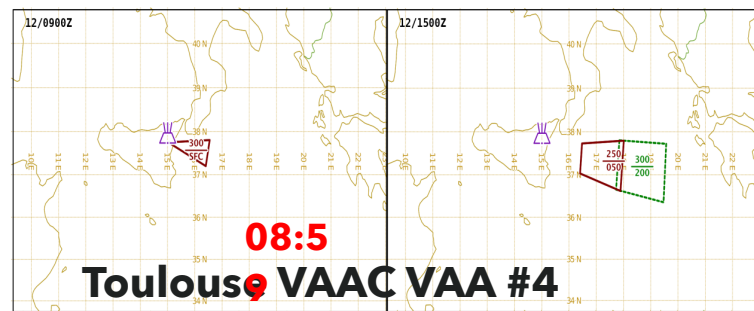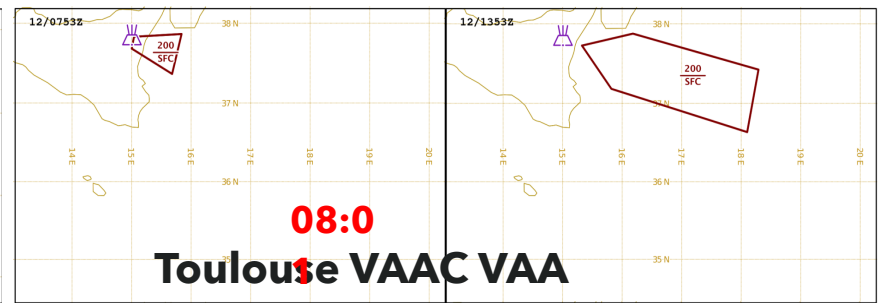Turbofan Engine "ingests" an average of **1.000.000 m³ of air** in **10 minutes** of flight
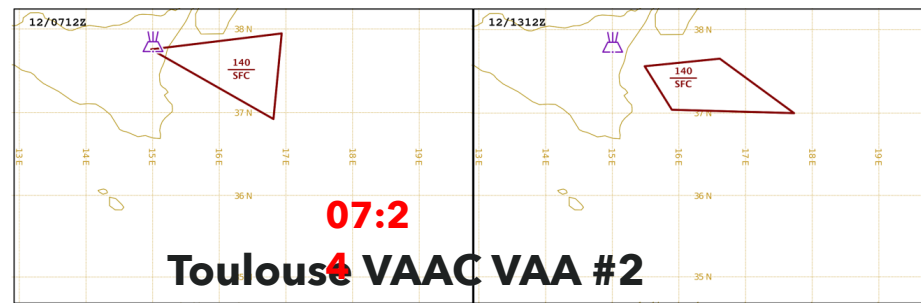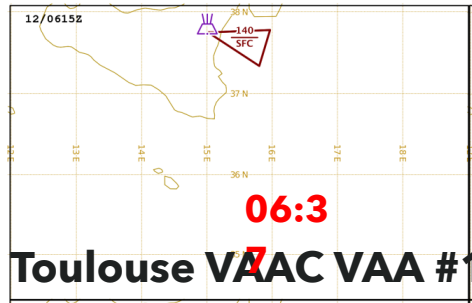

Jet aircraft engine intake

Source: www.istockphoto.com
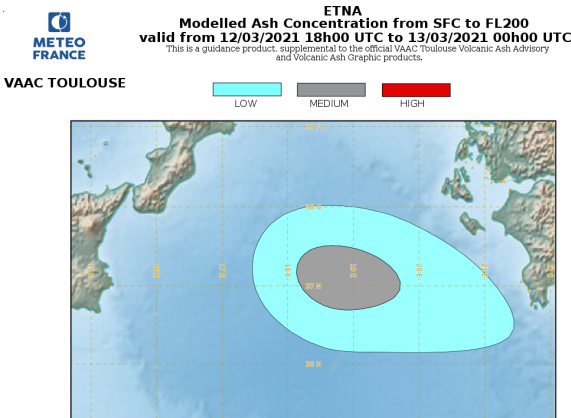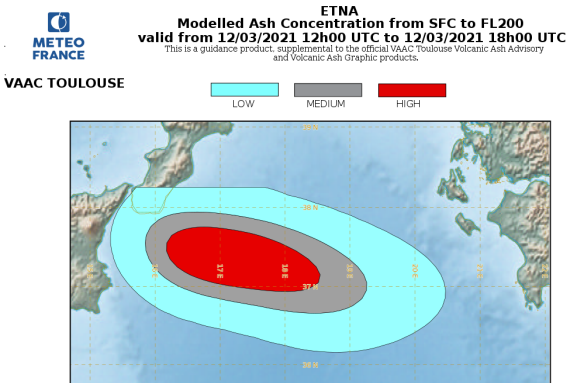
Etna eruption 12 Mar 2021
The aviation point of view

12 MAR 06:37 / 07:24 / 08:01/ 08:59 / 11:56 aviation colour code **RED** **12:57** aviation colour **ORANGE**

06:37
Toulouse VAAC VAA #1

07:24
Toulouse VAAC VAA #2

08:01
Toulouse VAAC VAA #3

08:59
Toulouse VAAC VAA #4

11:56
Toulouse VAAC VAA #5

12:57
Toulouse VAAC VAA #6
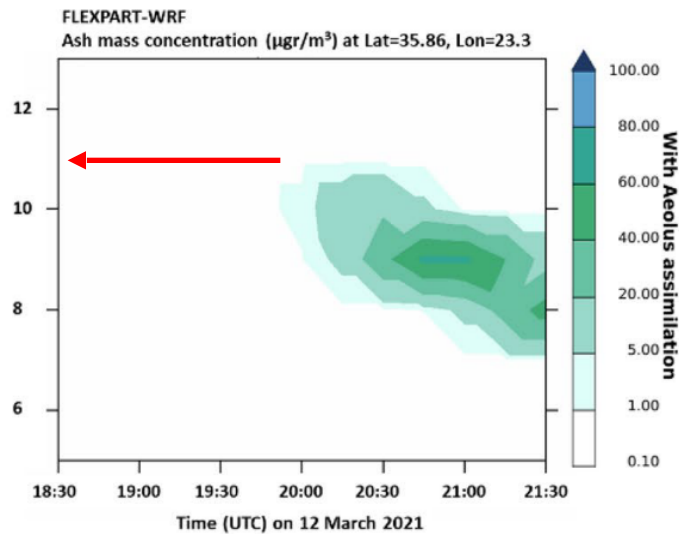
Information sources for Toulouse VAAC advisories:
INGV VONA, WEBCAMS, SAT IMAGERY

Next Advisory was issued
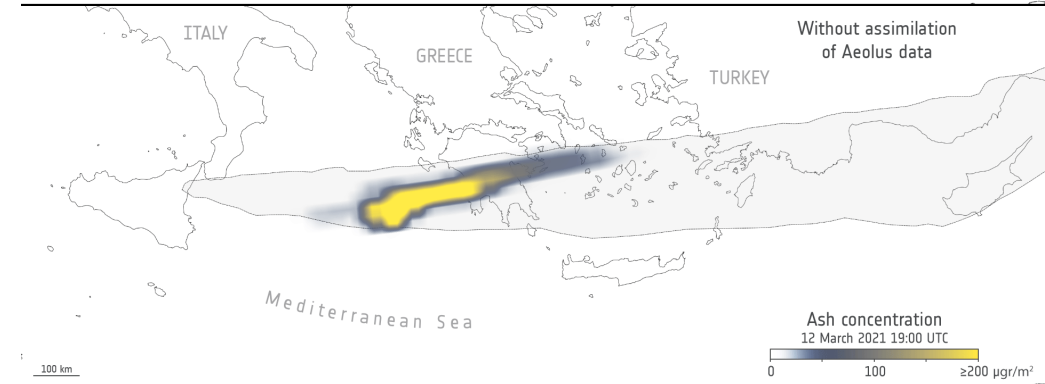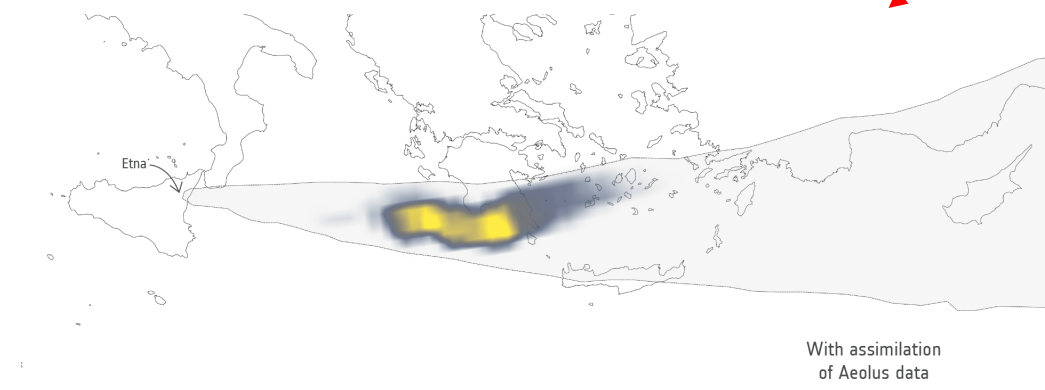on 14 MAR 22:52 UTC
for a new eruptive

Etna eruption 12 Mar 2021 Simulated shape & position of ash cloud
WITH and WITHOUT Aeolus data assimilation

VAAC Toulouse
Ash concentration charts

ETNA
Modelled Ash Concentration from FL200 to FL350
valid from 12/03/2021 12h00 UTC to 12/03/2021 18h00 UTC
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.

VAAC TOULOUSE

LOW   MEDIUM   HIGH

ETNA
Modelled Ash Concentration from SFC to FL200
valid from 12/03/2021 12h00 UTC to 12/03/2021 18h00 UTC
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.

VAAC TOULOUSE

LOW   MEDIUM   HIGH

ETNA
Modelled Ash Concentration from SFC to FL200
valid from 12/03/2021 18h00 UTC to 13/03/2021 00h00 UTC
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.

VAAC TOULOUSE

LOW   MEDIUM   HIGH

Modelled ash concentrations reached approx. 220 µg/m3 at the plume's center of mass and an altitude of 11 km (FL360)

FLEXPART-WRF
Ash mass concentration (µgr/m³) at Lat=35.86, Lon=23.3

With Aeolus assimilation

Time (UTC) on 12 March 2021

Ash column loading (µg/m2) over the PANGEA observatory in Antikythera, Greece

With assimilation of Aeolus data

Without assimilation of Aeolus data

ITALY   GREECE   TURKEY

Mediterranean Sea

100 km

Ash concentration
12 March 2021 19:00 UTC
0   100   ≥200 µgr/m²

Etna eruption 12 Mar 2021

Airways /Air Traffic Routes affected

Flights affected
"with & without Aeolus"

Athinai FIR / Hellas
UIR
ATS and RNAV Routes

Figure from AIP Greece ENR 6.1

Flights crossing the plume from 12 Mar 21:00 to 13 Mar 08:00
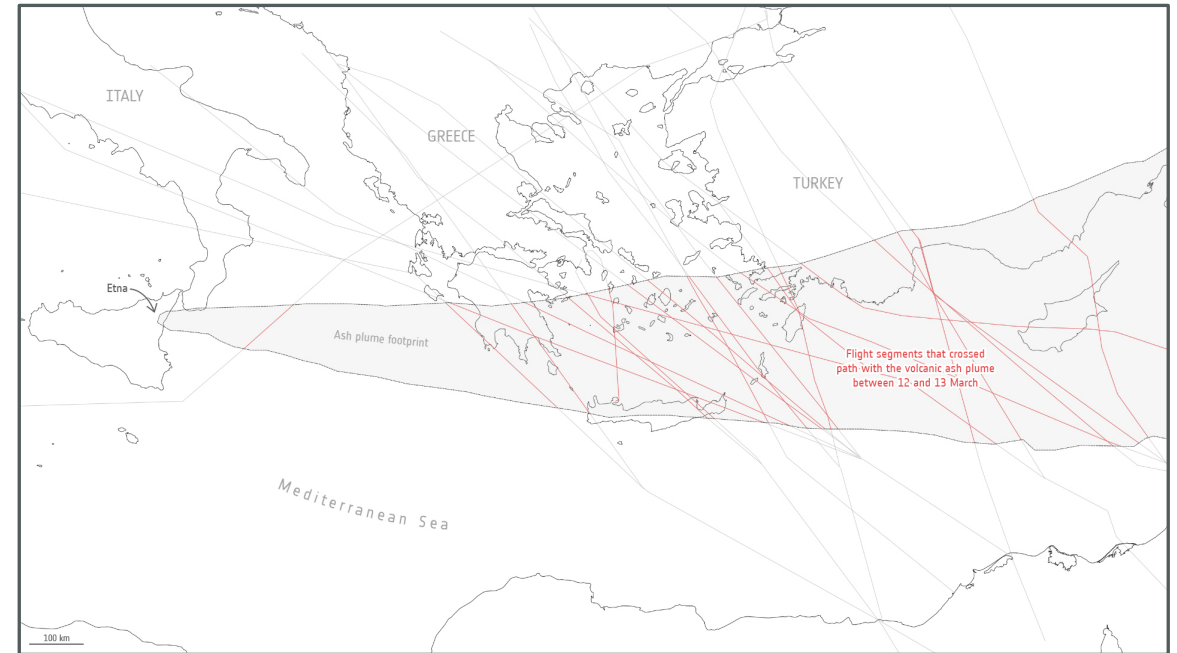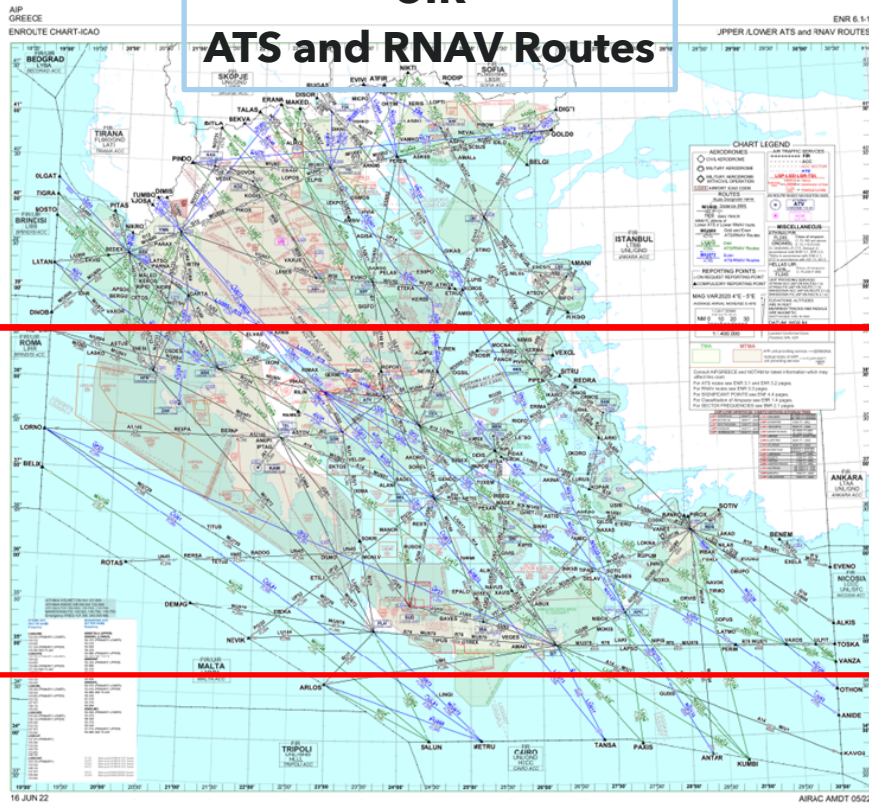
Mean value of time spent in the ash cloud is approx. **5min/flight** for flights affected with Aeolus data assimilation

No safety issue

according to concentration values estimates and engine dose thresholds

Wildfire Smoke

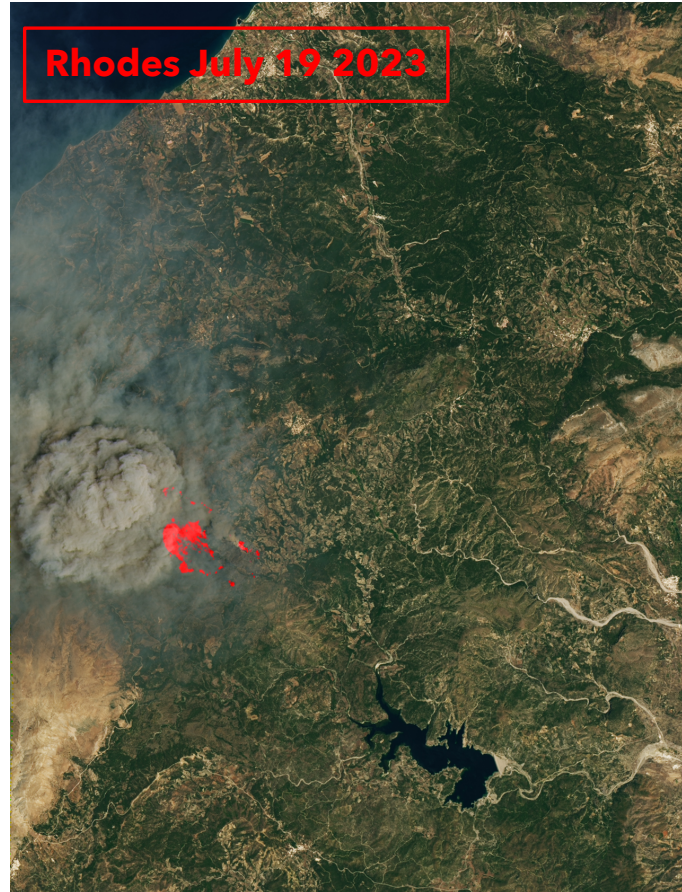# Impact on aviation operations

Fires contribute significant emissions of aerosols to the atmosphere

(WMO, Aerosol Bulletin, 2021)

Accurate weather predictions during wildfire events, need to **consider aerosols in the forecast**

Rhodes July 19 2023

Credit: NASA
Image acquired by Operational Land Imager(OLI) on Landsat 8

Alexandroupolis 2023

Credit: Getty images

- **Reduced Visibility**
- **High ambient Temperatures**
- **Pyrocumulus Clouds**
- **Strong** variable + gusty **Winds**

(SKYbrary Aviation Safety)

Our flights to and from Alexandroupoli Airport "Dimokritos" are operating as scheduled

Aug 21, 2023
Having evaluated the situation in Alexandroupolis, after the recent bushfires, we continue to operate as scheduled our flights to and from Alexandroupolis Airport "Dimokritos" (AXD)

(Airline Company press release)

Desert Dust and Sand

Dust storm aviation definition

Events in which **visibility is reduced to 1 km or less** as a result of blowing dust

(Bojdo et al., 2020)

Visibility < 500 m ⟺ **Dust Concentration 6 mg/m3**

Heraklion airport apron during dust storm March 2018

Source: www.luft.com

Figure from (Ellis et al. 2021)

General case

- Aircraft experience highest dust concentrations during **take off, landing, hold**
- Maximum dust ingestion of jet engines happens **near airports**
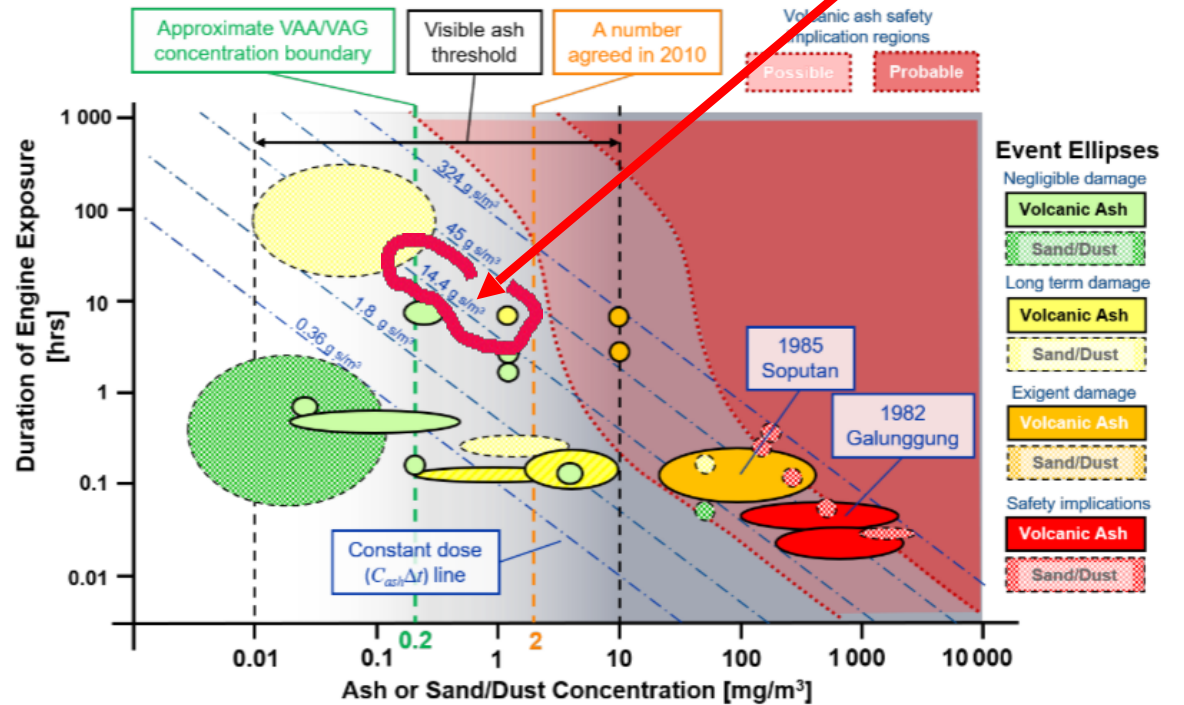- Dust encountered **during cruise flight** is a **negligible** fraction of total dust exposure time during engine lifetime

(Bézier C., 2021)

Needs for Improvement

-Dust forecasts to minimize the time when **low-visibility procedures** in airports are required

(Monteiro et al., 2022)

-Diurnal evolution of the dose to adapt departure-arrival time

-Vertical variability to adjust holding altitude

(Bézier C., 2021)

-Resolve properties such as **particle density** and **composition**

(Ellis et al. 2021)

Aviation Sector Users' needs

Regulators

safe and efficient flights with the **less possible impact on the environment**

global exchange of information to support automated decision process

Aircraft & Engine Manufacturing / Maintenance

data for atmospheric conditions expected during aircraft lifetime

post operations reports of conditions experienced

Airline Companies

timely forecast information to plan their fleet

real time weather info for tactical re-planning

Air Traffic Services Providers

timely forecast and updated real time info for the airspace they are responsible for

Flight Crews

forecast and continuous updates for their flight route

Aerodrome Operators

forecast and updated info for the aerodrome vicinity

Passengers

Safe and convenient flights with no delays

Thank you very much for your attention!