FEWS for mitigating the impact of volcanic eruptions on air traffic

Roberto Gueli

**Should we be worried about the impact of volcanoes on air traffic?**

Mount Etna is one of the world's most active volcanoes, its altitude is 3357 m

Almost 1M people live within 30 km of the main craters

Etna was mainly an effusive volcano: 1983 eruption started from a fracture at 2800m, and lasted 131 days reaching 1100m and destroying several critical civil infrastructures

lives were never put at risk
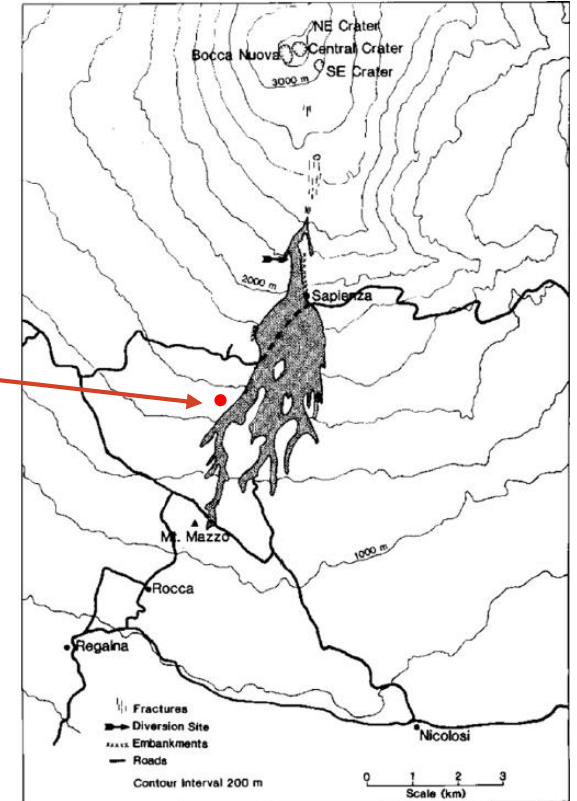
But surprisingly Etna's behaviour is changed, now paroxysmal events are usual

- **1995-2001, 150 events reported**
- **2011-2015, 40 events reported**
- **JAN-JUN 2022, 35 events reported**

(1) VOLCANO OBSERVATORY NOTICE FOR AVIATION (VONA)	
(2) Issued:	20220221/1127Z
(3) Volcano:	Etna 211060
(4) Current Color Code:	**RED**
(5) Previous Color Code:	red
(6) Source:	Etna Volcano Observatory
(7) Notice Number:	2022/0016/06C46
(8) Volcano Location:	3744N 01500E
(9) Area:	Italy
(10) Summit Elevation:	3300 m
(11) Volcanic Activity Summary:	LAVA FOUNTAIN IS OBSERVED AT SUMMIT CRATERS
(12) Volcanic cloud height:	EXTIMATED VOLCANIC CLOUD HEIGHT IS 10000 M AT THE TOP ABOVE SEA LEVEL
(13) Other volcanic cloud information:	ASH CLOUD MOVES TOWARD SE
(14) Remarks:	THE PHENOMENON IS OBSERVED BY VISIBLE AND THERMAL SURVEILLANCE CAMERAS
(15) Contacts:	*24/7 OE Control Room operator turnista@ct.ingv.it +39 095 7165800 *OE Director direttore.oe@ingv.it +39 095 7165800
(16) Next Notice:	A new VONA will be issued if conditions change significantly or color code changes. Volcano information and updates are posted at http://www.ct.ingv.it/it/vona.html

No relevant risk for people but ICAO recommends the flights have to AVOID, AVOID AVOID ash clouds

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How flight safety is currently managed, in case of ash cloud contaminated airspace:

ICAO Colour code	Status of activity of volcano
GREEN	Volcano is in normal, non-eruptive state. or, after a change from a higher alert level: Volcanic activity considered to have ceased, and volcano reverted to its normal, non-eruptive state.
YELLOW	Volcano is experiencing signs of elevated unrest above known background levels. or, after a change from higher alert level: Volcanic activity has decreased significantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened unrest with increased likelihood of eruption. or, Volcanic eruption is underway with no or minor ash emission [specify ash-plume height if possible].
RED	Eruption is forecasted to be imminent with significant emission of ash into the atmosphere likely. or, Eruption is underway with significant emission of ash into the atmosphere [specify ash-plume height if possible].

Etna is almost ever experiencing activities

2 milligrams/cubic meter

4 milligrams/cubic meter

The flight operator has to perform the Volcanic Ash Safety Risk Assessment - DOC 9974 ICAO
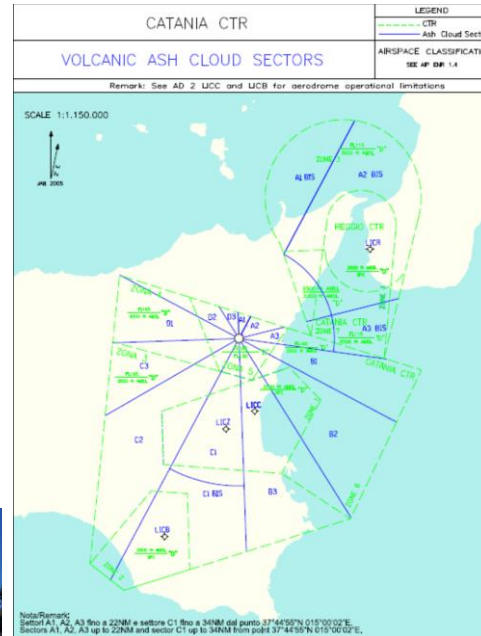
But these general rules shall not be applied to Catania Controlled air Traffic Region (CTR)

Sigonella

CONTAMINATED SECTOR	FLIGHT OPERATIONS	CATANIA APT MOV/h
A3-B1	SOME OPERATIONS SUSPENDED	REDUCED
B2	SOME OPERATIONS SUSPENDED	REDUCED
B3	**CATANIA APT CLOSED**	**CANCELLED**
C1	**CATANIA APT AND COMISO ATP CLOSED**	**CANCELLED**
C2-C3	COMISO APT CLOSED	REDUCED
D2-D3	NONE	UNCHANGED
A2	**REGGIO CALABRIA APT CLOSED**	**UNCHANGED**

- **24/12/2018 – flights canceleld 5, flights diverted 9**
- **26/01/2019 – flights canceleld 41, flights diverted 32**
- **19/02/2019 – flights canceleld 41, flights diverted 31**
- **21/02/2019 – flights canceleld 46, flights diverted 31**
- **10/11/2019 – flights canceleld 21, flights diverted 10**

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The consortium:

EtnaHitech S.C.p.A
www.eht.eu

Università degli studi di
MESSINA
www.unime.it

Istituto Nazionale di
Geofisica e Vulcanologia
www.ingv.it

S.A.C. Socieà Aeroporto
Catania S.p.A.
www.aeroporto.catania.it

Sielte S.p.A.
www.sielte.it

Università degli Studi
"Mediterranea" di REGGIO
CALABRIA
www.unirc.it

Università degli Studi di
CASSINO e del LAZIO
MERIDIONALE
www.unicas.it

Ieeng Solution S.r.l.
www.ieengsolution.it

Università degli Studi
"Parthenope"
di NAPOLI
www.uniparthenope.it

PROPLAST – Consorzio per
la Pomozione della Cultura
Plastica
www.proplast.it

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How to add to the contingency procedures ash-plume forecasting capabilities:

WRF-chem vs 3.6.1 is the Ash Transport and Dispersion model we choosed

Model Name:	ASH3D	ATHAM	FALL3D	FLEXPART	HYSPLIT	NAME	PUFF	WRF
Operational	X		X	X	X	X	X	
Topography	X	X	X	X	X	X	X	X
U advection	X	X	X	X	X	X	X	X
V advection	X	X	X	X	X	X	X	X
U diffusion	X	X	X	X	X	X	X	X
V diffusion	X	X	X	X	X	X	X	X
Sedimentation	X	X	X	X	X	X	X	X
Aggregation			X					
Chemistry		X	X	X	X	X		X
Fully Coupled								X

- PUFF is used by US Air Force
- MLDP0 is used by the Canadian VAAC
- HYSPLIT is used by NWS and NOAA

WRF "ETNA" domain:
- 3km grid resolution for parent domain
- 1km grid resolution for inner domain
- 40 vertical level
- CHEM Volcanic transport, dispersion and ash fall
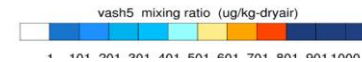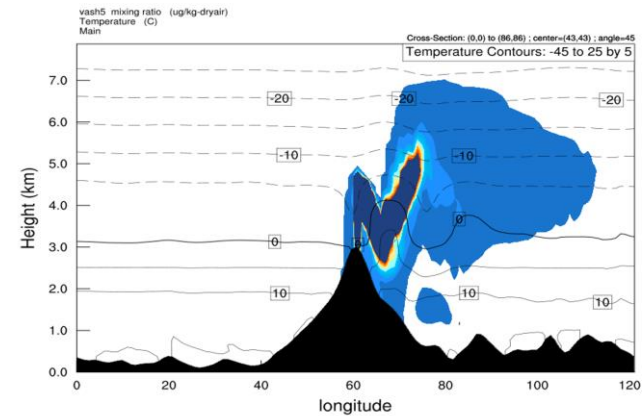
AEROMAT WRF-CHEM 3KM_Nest_1KM Domain Configuration

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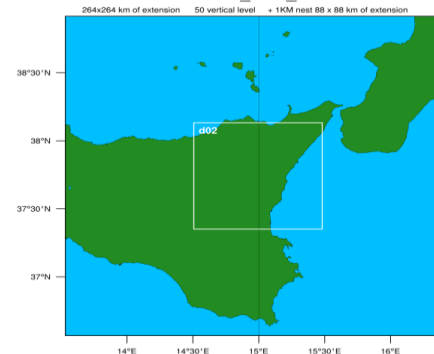
How to trigger the ash-plume forecast simulation:

Granulometria
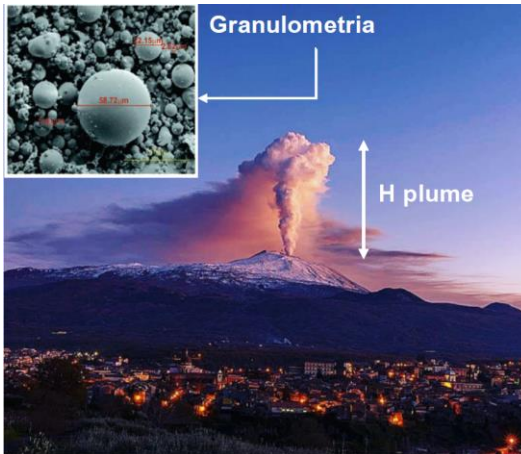
Ash Bin	μm	%
1	[1000–2000]	0
2	[500–1000]	4
3	[250–500]	10
4	[125–250]	50
5	[62.50–125]	34
6	[31.25–62.50]	2
7	[15.62–31.25]	0
8	[7.81–15.62]	0
9	[3.91–7.81]	0
10	[0–3.91]	0

3 scenarios:
- Hm=5500m
- Hw=0,7 Hm
- Hs = 1,5 Hm
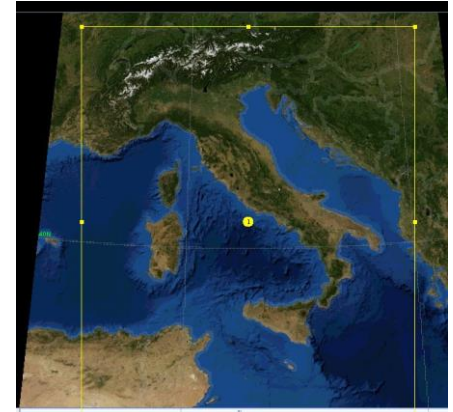
WRF-Sicilia AEROMAT RUN 2021-03-12_00:00:00
FL.240 wind speed + ash concentration mg/m^3 at 2021-03-12_08:00:00
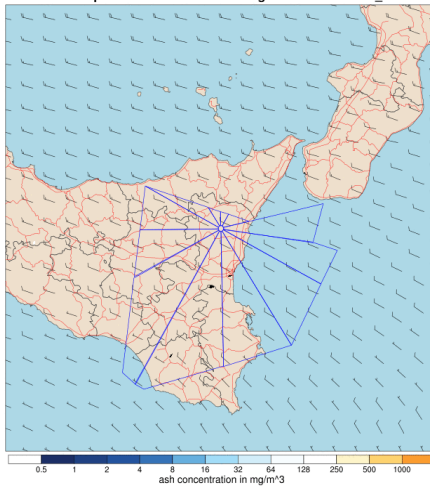
- Meteo T+96h forecast, 9km grid resolution
- Chem   T+48h forecast, 3km grid resolution
- Chem   T+24h forecast, 1km grid resolution
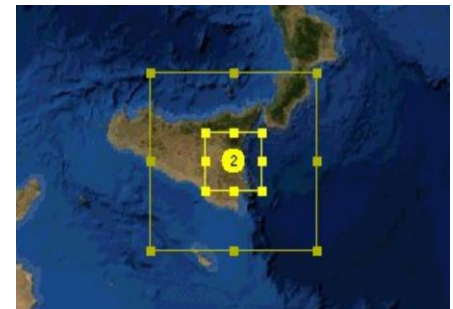
How the ash-cloud propagation forecast fits the observations:
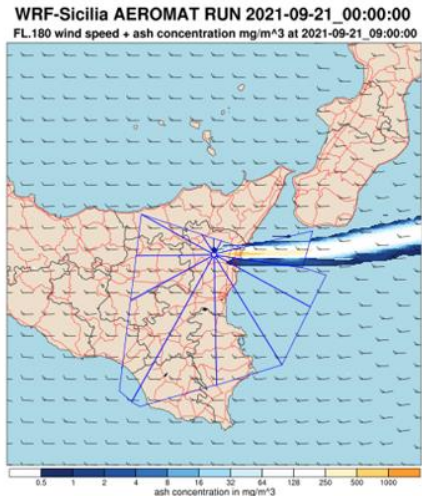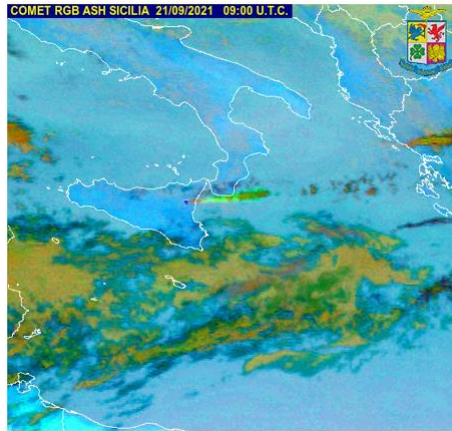
But we wanted the research goes quantitative, with Automatic Lidar and Celiometer (ALC)

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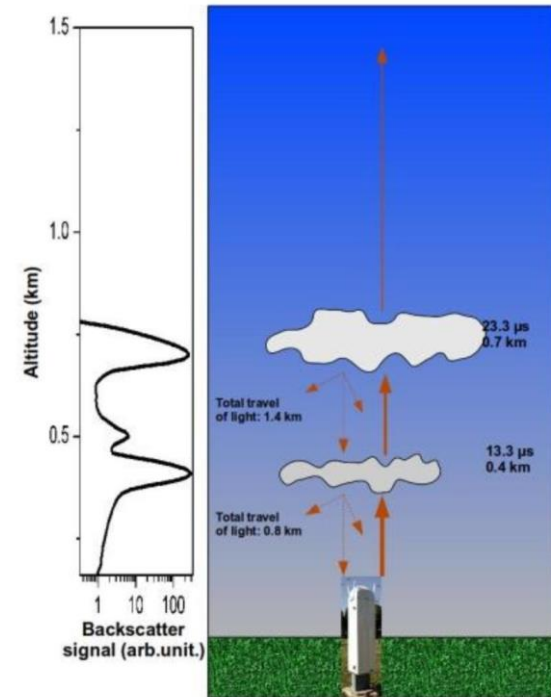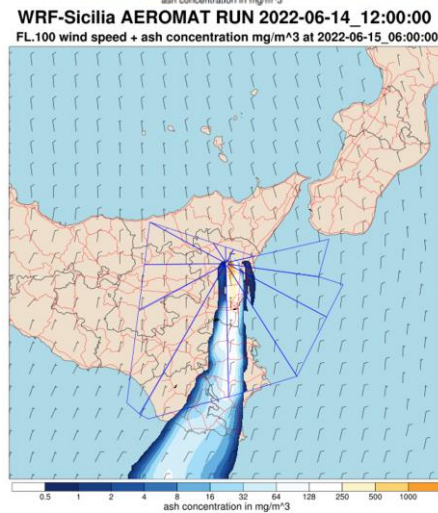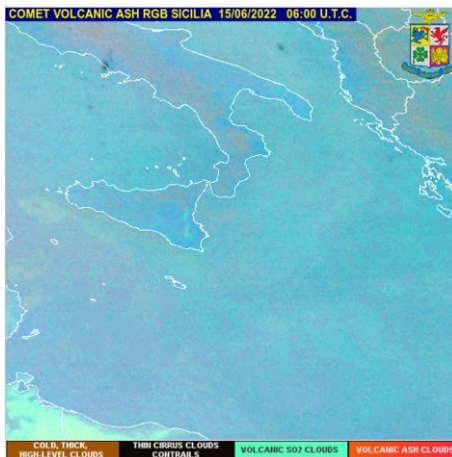
just after Eyjafjallajökull eruption a dense ALC network has been deployed:

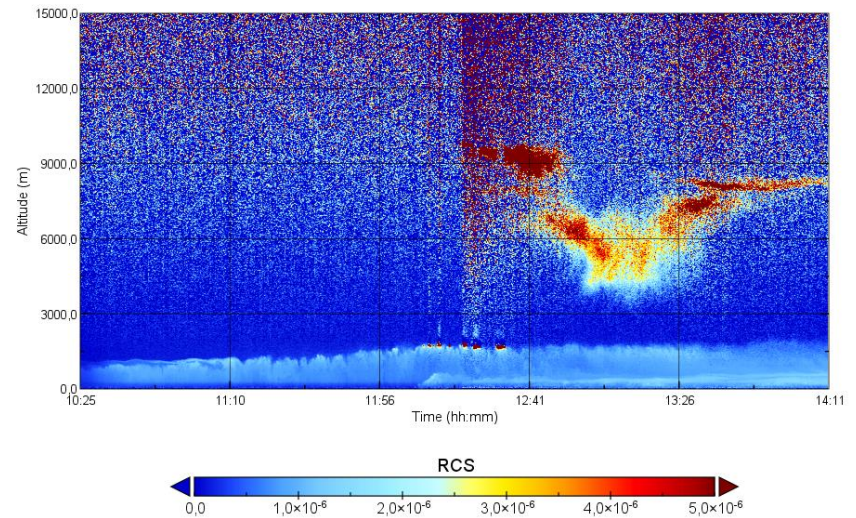- cloud base height
- mixing layer height
- aerosol vertical profile

But Italy and in particular Sicily is almost completely uncovered

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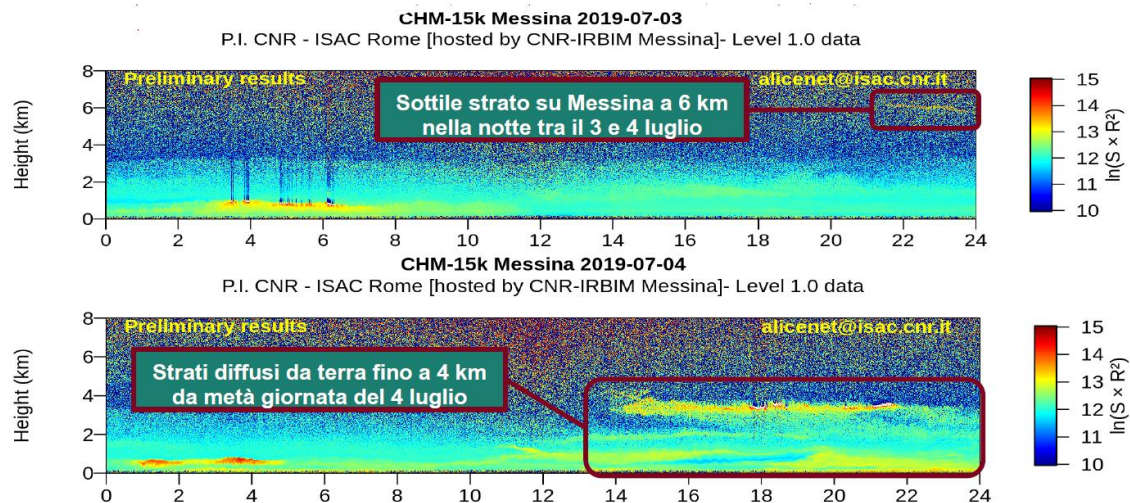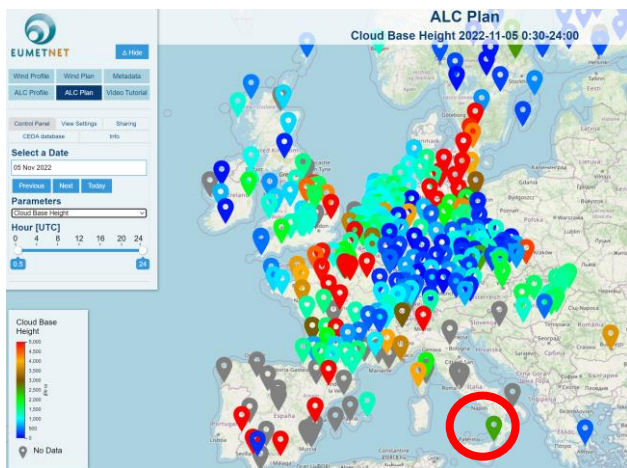
4 ALC have been installed around Etna:
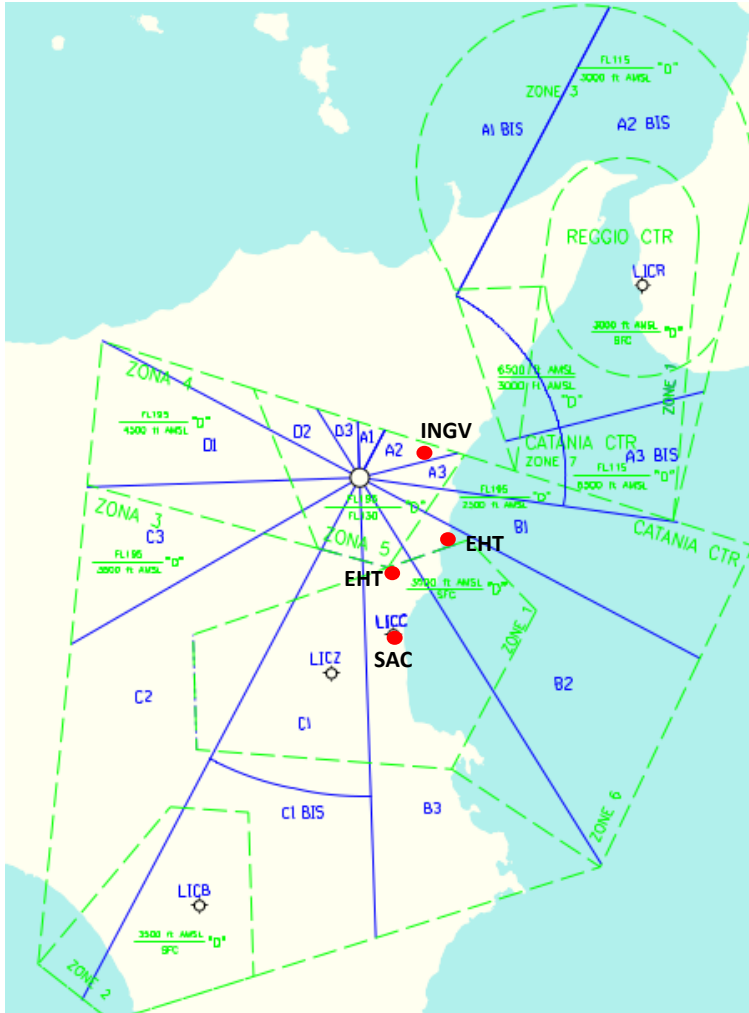
ALC ETNA1 - CATANIA 21/02/2022

now we are ready to go operational with Delft FEWS

- no eruption: 2 daily run of ash-plume ensamble forecast T+24

- eruption: ash-plume forecast T+12 based on actual data (VONA)

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Questions?