First numerical experiments towards assessing the impact of Aeolus wind assimilation on volcanic ash dispersion

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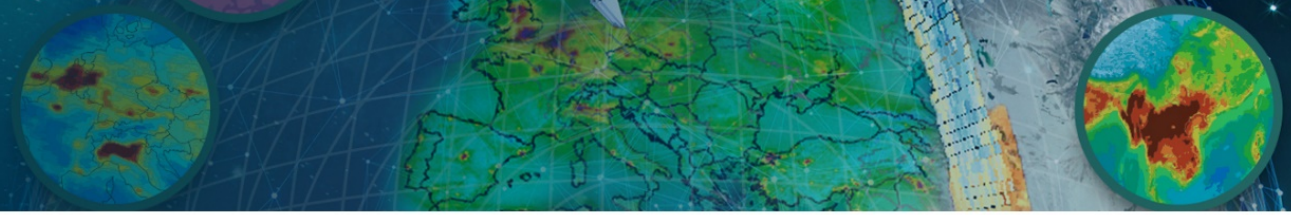
25/11/2021

Objective



- Volcanic ash dispersion forecasting is vital for aviation but challenging due to the wind accuracy needed in free tropospheric wind fields.
- Data assimilation of Aeolus by ECMWF provides improved meteorological fields for advection calculations in volcanic ash dispersion models.
- In the framework of the **NEWTON ESA study,** we examine potential improvements on aerosol forecasts due to Aeolus assimilated meteorological fields.
- Here, we examine the Aeolus impact on the dispersion of volcanic ash for a case of recent Etna eruption.

FLEXPART-WRF simulations: IFS data from MARS

IFS outputs [ECMWF]

from MARS Catalogue : https://apps.ecmwf.int/mars-catalogue/

Exp1: *hkwv*

Control without assimilating Aeolus

Exp2: *hkvt*

Assimilated Aeolus wind fields

Pressure Levels

ECMWF

MARS Catalogue

Date (29 values)	Time (4 values)	anoffset (2 values)	Level (25 values)	Parameter (11 values)
2021-03-06	00:00:00	3	1	Fraction of cloud cover
2021-03-07	06:00:00	9	2	Geopotential
2021-03-08	12:00:00		3	Ozone mass mixing ratio
2021-03-09	18:00:00		5	Relative humidity
2021-03-10			7	Specific cloud ice water content
2021-03-11			10	Specific cloud liquid water content
2021-03-12			20	Specific humidity
2021-03-13			30	Temperature
2021-03-14			50	U component of wind
2021-03-15			70	V component of wind

Current selection

levtype: ml, **pl**, sfc

type: 4v, **an**, fc, me, mfb, ofb

stream: **lwda**, lwwv

expver: hkv0, hkv1, hkv2, hkv3, hkv4, hkv5, hkv7, hkv9, hkva, hkvb, hkvc, hkvd, hkve, hkvf, hkvg, hkvi, hkvj, hkvk, hkvl, hkvn, hkvp, hkvq, hkvs, hkvt, hkvv, **hkvw**

Surface

ECMWF

MARS Catalogue

Date (30 values)	Time (4 values)	anoffset (2 values)	Parameter (80 values)
2021-03-06	00:00:00	3	2 metre dewpoint temperature
2021-03-07	06:00:00	9	2 metre temperature
2021-03-08	12:00:00		10 metre U wind component
2021-03-09	18:00:00		10 metre V wind component
2021-03-10			100 metre U wind component
2021-03-11			100 metre V wind component
2021-03-12			200 metre U wind component
2021-03-13			200 metre V wind component
2021-03-14			Albedo
2021-03-15			Angle of sub-gridscale orography

Current selection

levtype: ml, pl, **sfc**

type: 4v, **an**, fc, me, mfb, ofb

stream: **lwda**, lwwv

expver: hkv0, hkv1, hkv2, hkv3, hkv4, hkv5, hkv7, hkv9, hkva, hkvb, hkvc, hkvd, hkve, hkvf, hkvg, hkvi, hkvj, hkvk, hkvl, hkvn, hkvp, hkvq, hkvs, **hkvt**, hkvv, hkvw

Angela Benedetti
Mike Rennie

Data and Methodology

IFS outputs [ECMWF]

Exp1: *hkwv*

Control without assimilating Aeolus

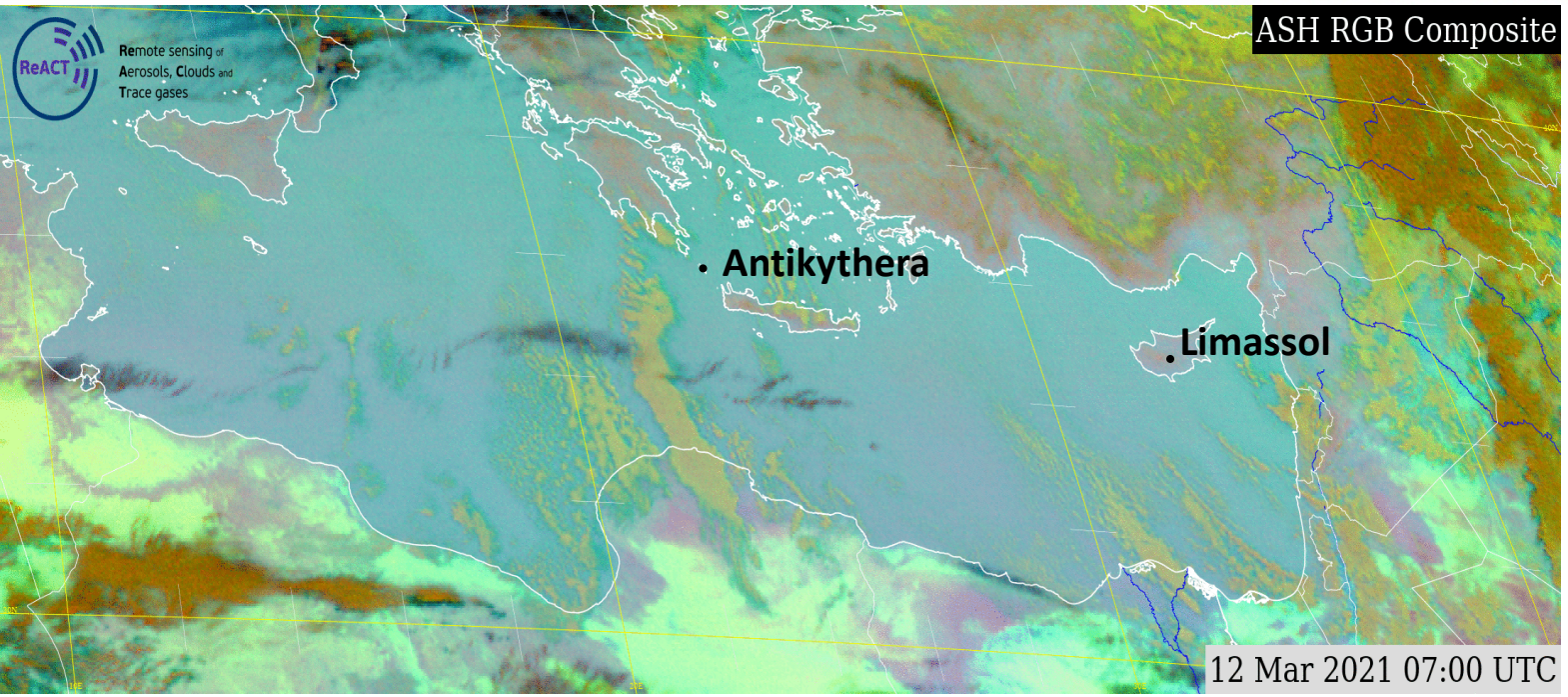
Exp2: *hkvt*

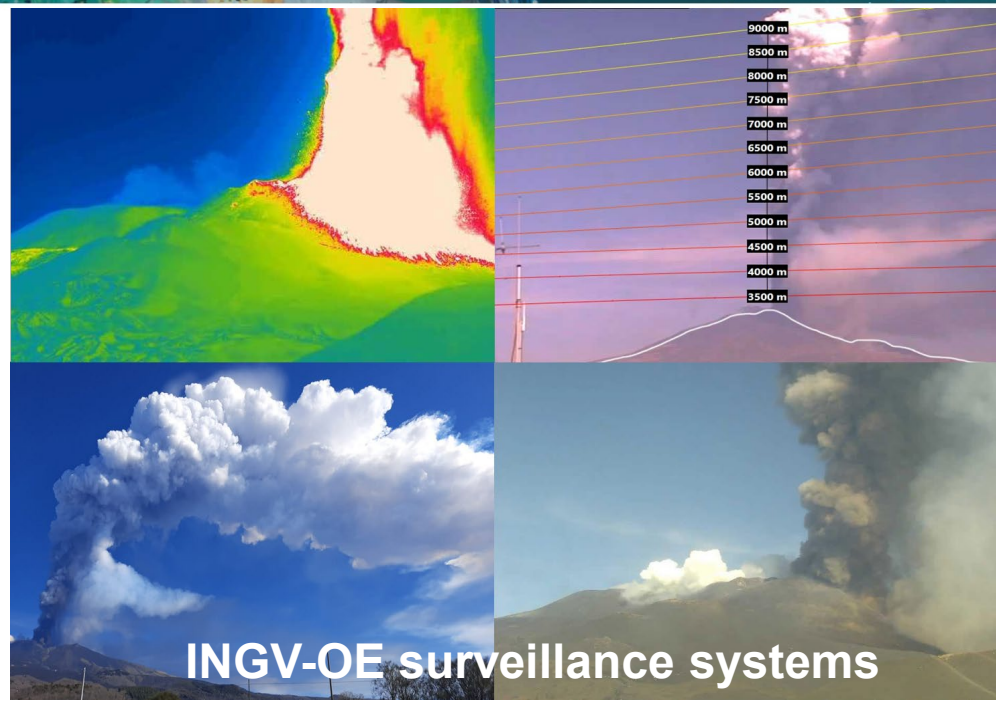
Assimilated Aeolus wind fields

Angela Benedetti
Mike Rennie

- Compare **FLEXPART-WRF** (Stohl et al., 2005; Pisso et al., 2019) ash simulations initialized with two sets of IFS outputs (**with** and **without** Aeolus)
- Use ground-based **Lidar profiles** for evaluating the different runs.

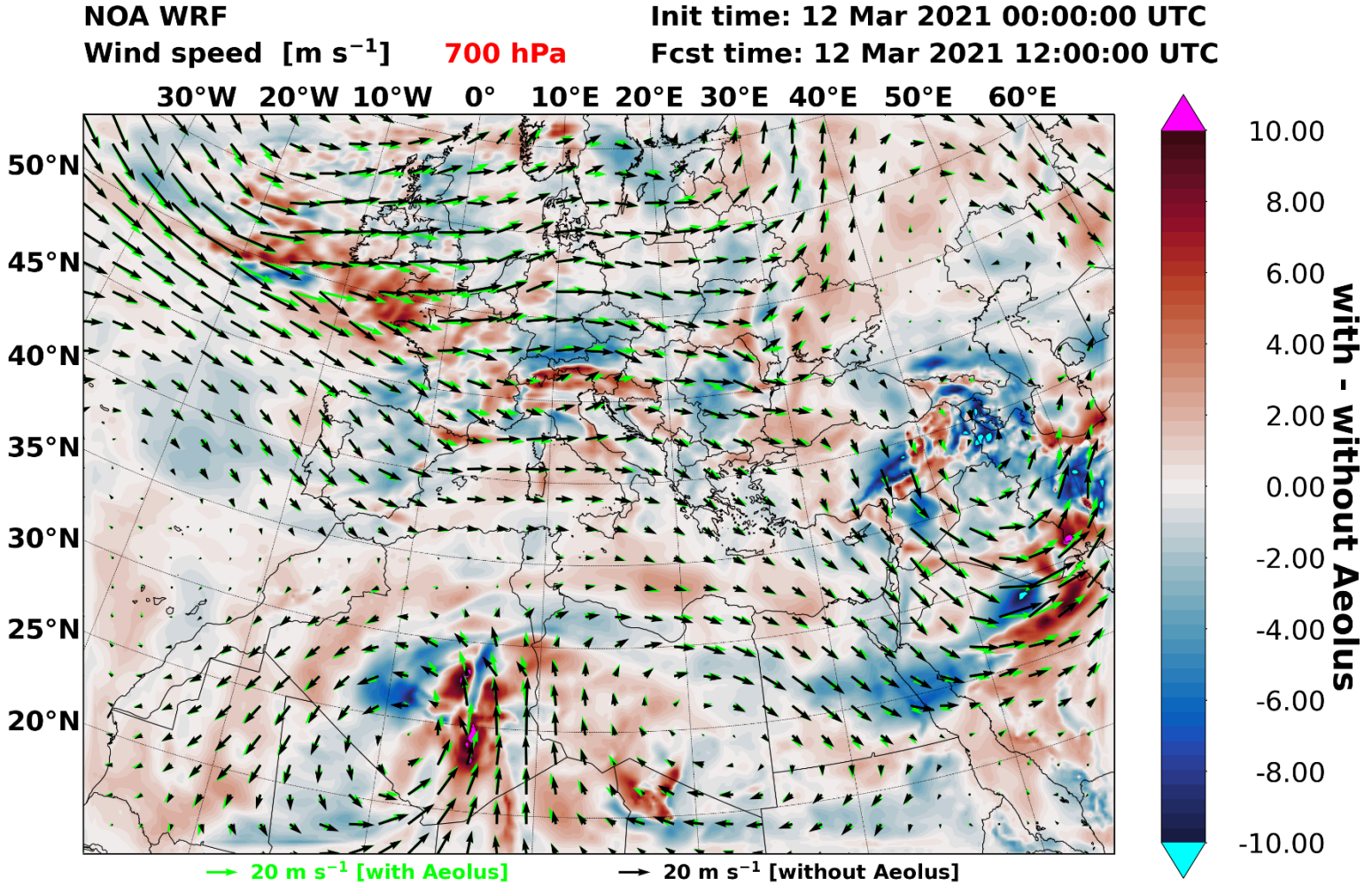
Etna case study on 12 March 2021





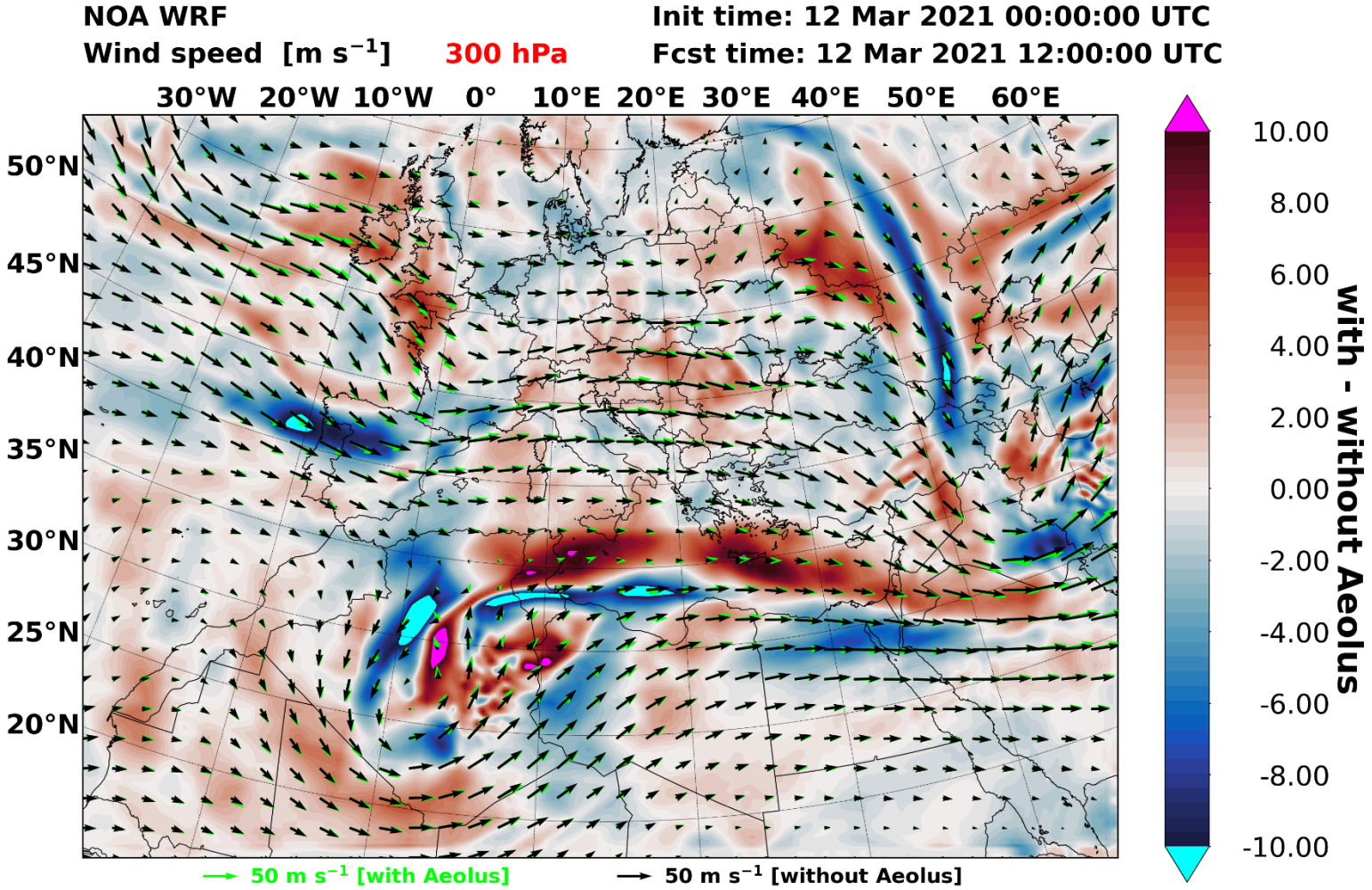
- Near-real-time **alerts** from Etna volcano eruptions (**INGV** observatory of Catania, Italy).
- Volcanic cloud is crossing Antikythera and Limassol lidar stations.
- **Input data are taken from INGV regarding the injection plume height and emission fields**

Differences in wind fields with/w-o Aeolus assimilation - 700hPa



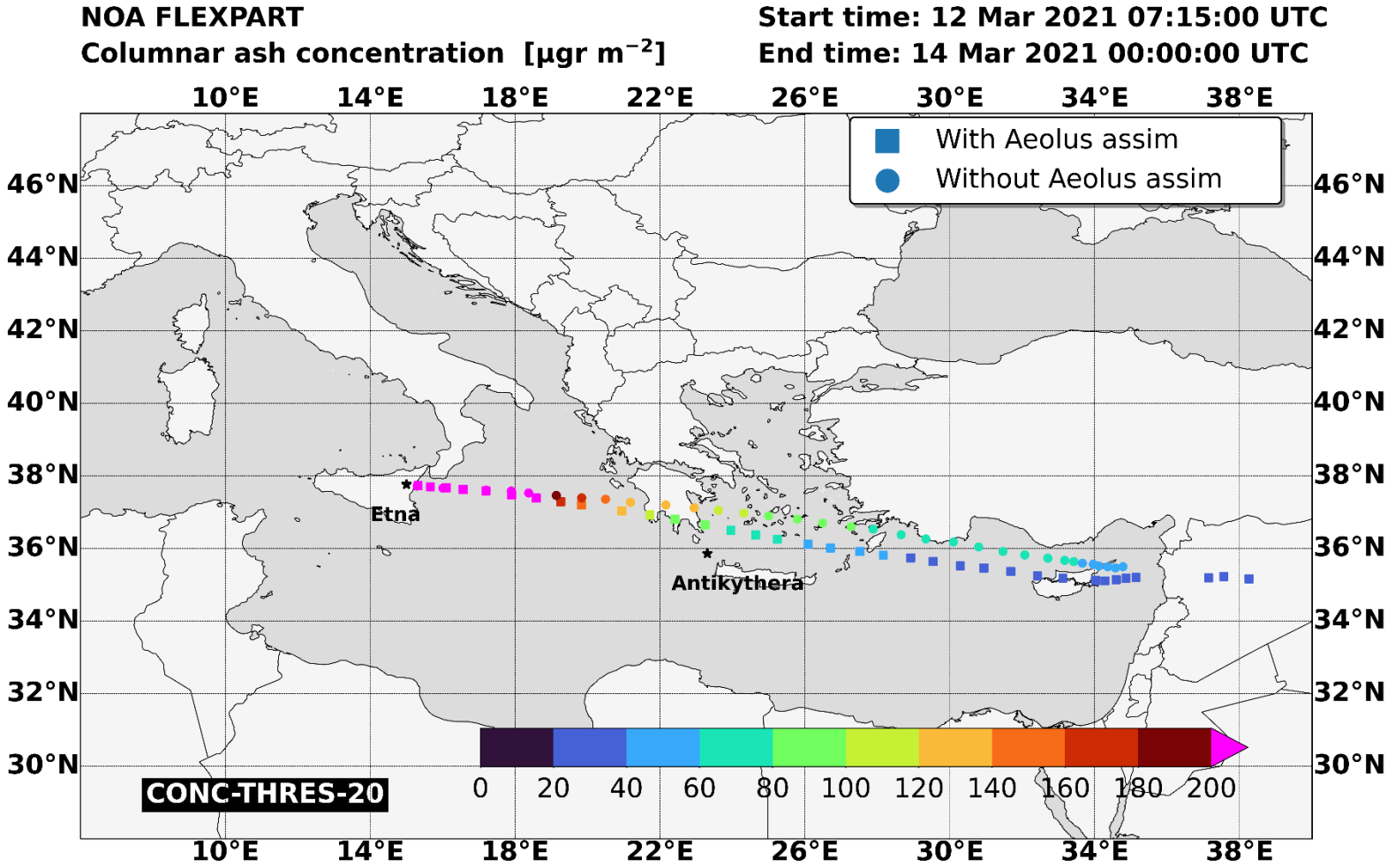
- Prevailing North-Westerly winds
- **Small differences** (0 to -1 m/s) in wind fields with/w-o Aeolus assimilation above the PANGEA-NOA station

Differences in wind fields with/w-o Aeolus assimilation - 300hPa



- Prevailing Westerly winds
- Wind fields of run **with Aeolus** are dominant above PANGEA-NOA station with respect to the control run.
- **Positive differences** (up to 8 m/s) in wind fields with/w-o Aeolus assimilation above PANGEA-NOA station

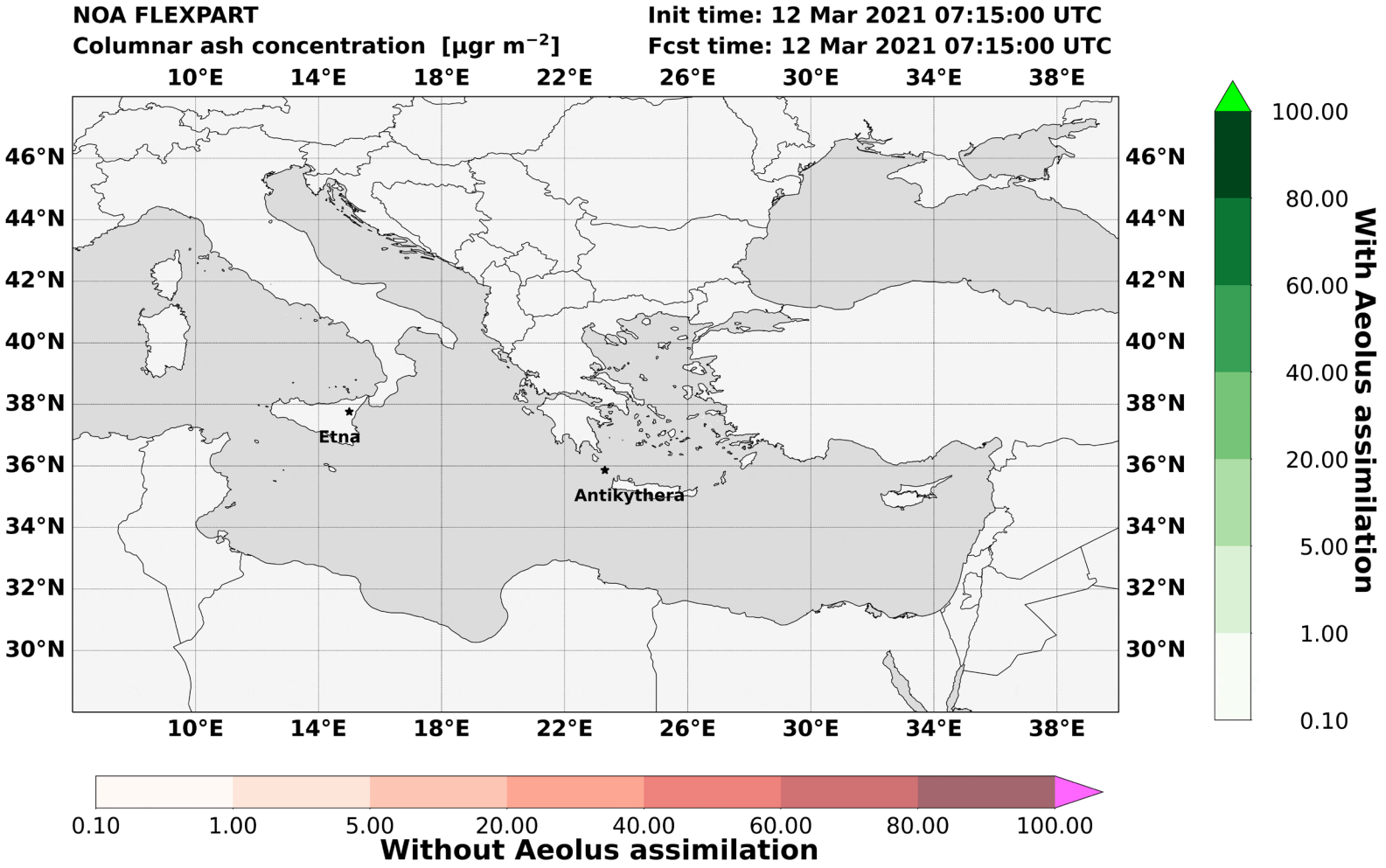
Etna case study on 12 March 2021



- Transport of the volcanic plume center of mass as simulated with Flexpart, using meteorological fields **with** (squares) and **without** (circles) Aeolus assimilation

- **Southward transport** of the volcanic plume center of mass **with Aeolus** assimilated wind fields with respect to the Control run.

Volcanic ash dispersion with/w-o Aeolus assimilation
12 March 2021



Ash plume **with Aeolus** assimilation:

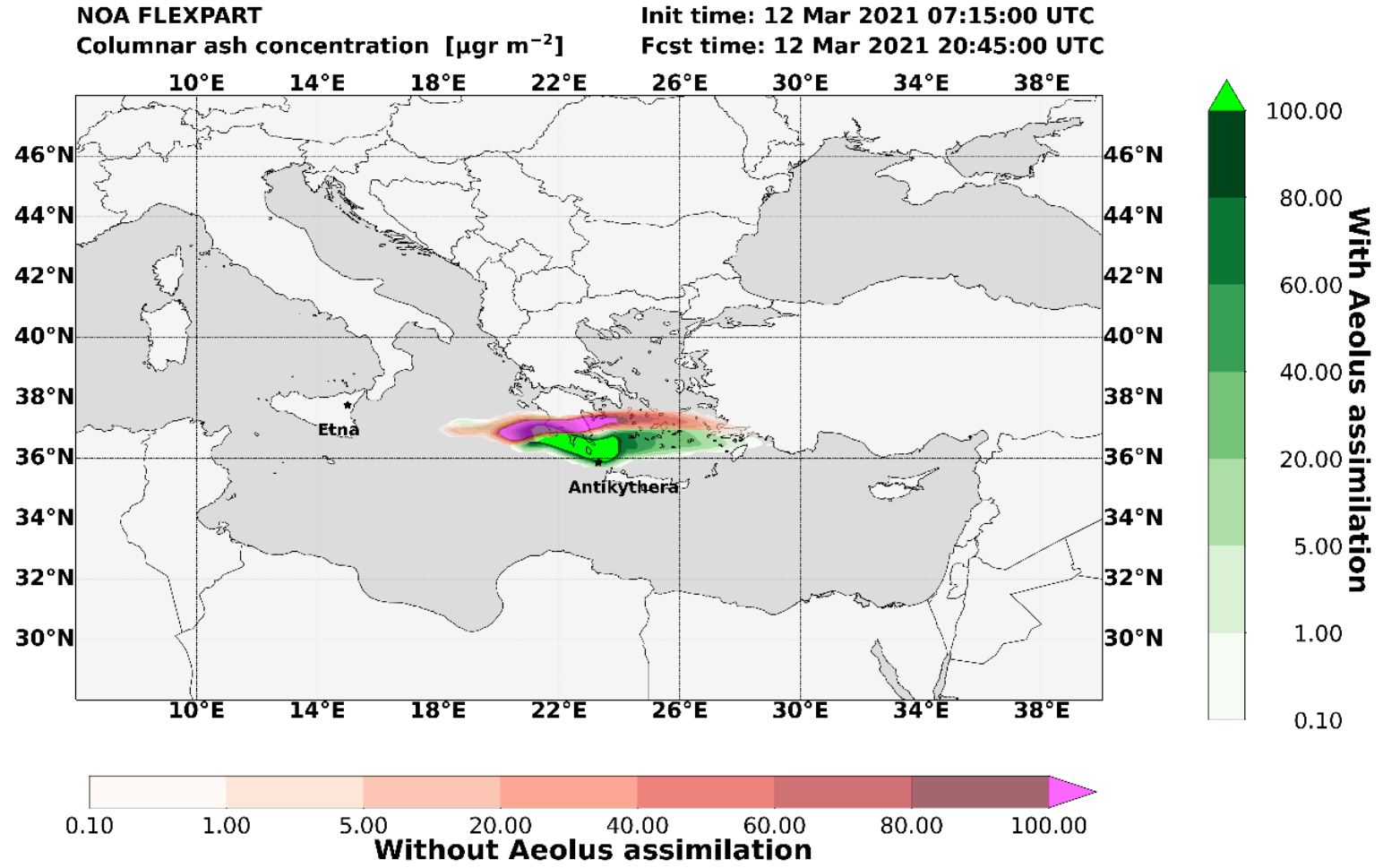
1) moves faster

2) has smaller concentrations and

3) expands Southwards

with respect to the **control run**

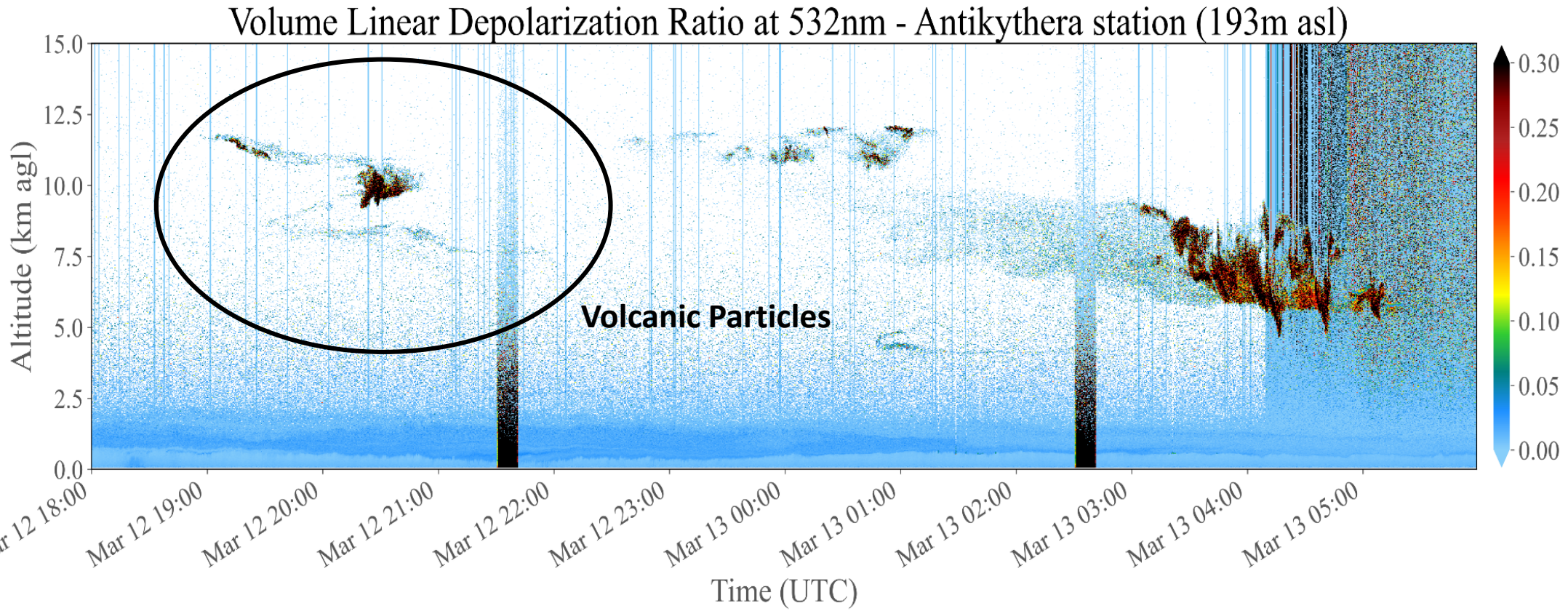
Volcanic ash dispersion with/w-o Aeolus assimilation (12 March 2021, 20:45 UTC)



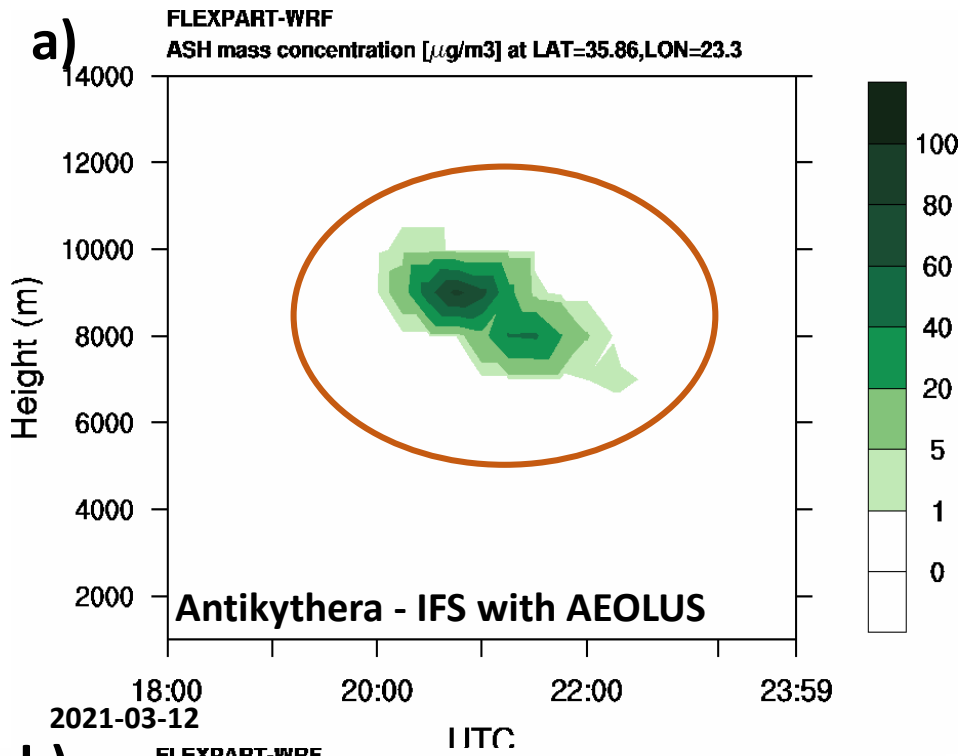
FLEXPART simulations of the volcanic ash columnar concentrations ($\mu g/m^{-2}$) originating from Etna, transported over Greece, using meteorological fields **with** (green) and **without** (red) Aeolus wind assimilation.

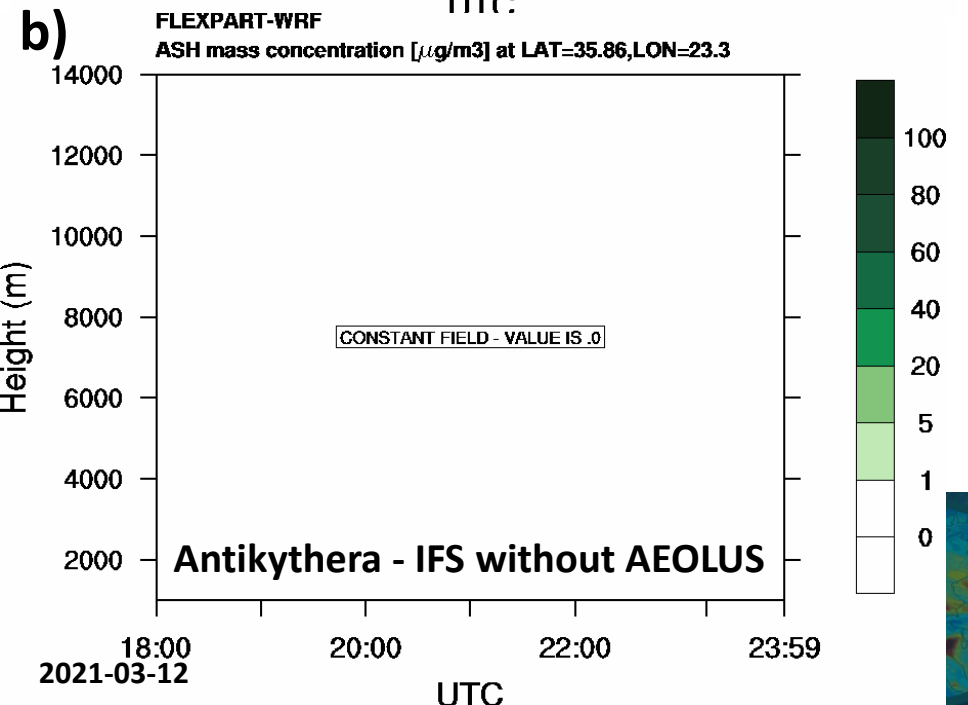
- Volcanic ash plume **with Aeolus** assimilated fields reaches Antikythera on 12th of March 2021, at 20:45UTC
- Expanding southwards when compared to the control run

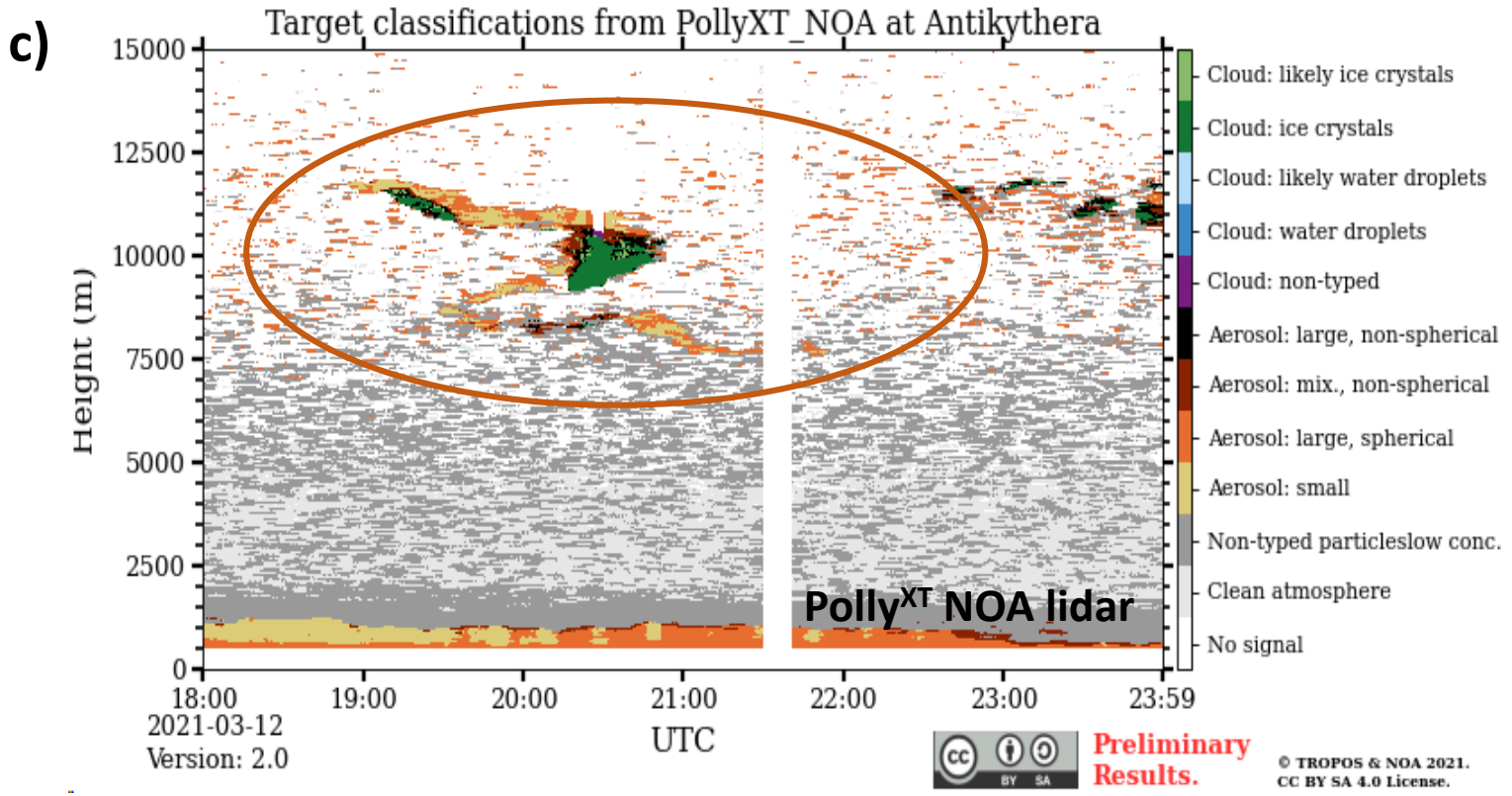
Volcanic particles - Etna eruption on 12 March 2021



Volcanic particles arrived above **PANGEA-NOA** (Panhellenic Geophysical observatory of Antikythera) station: on 12 March 2021, at 19:30 - 22:30 UTC



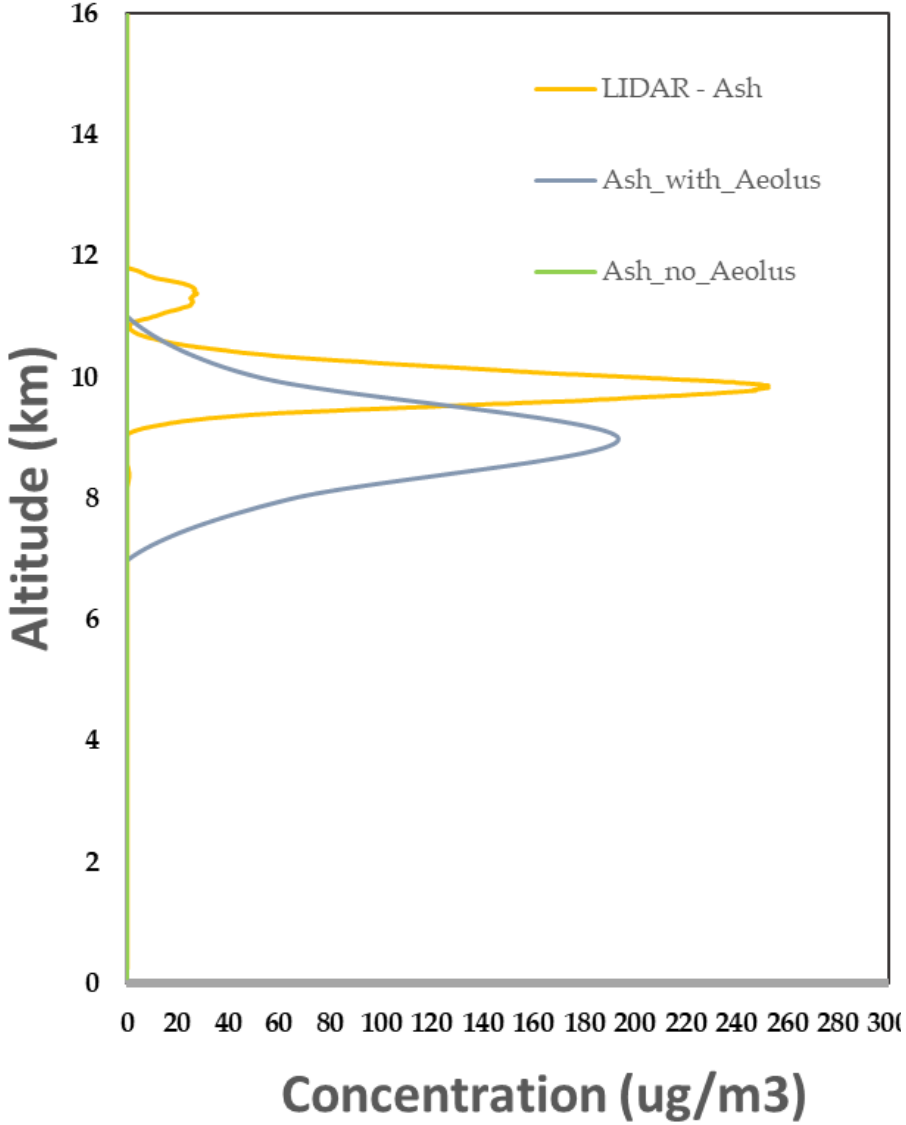




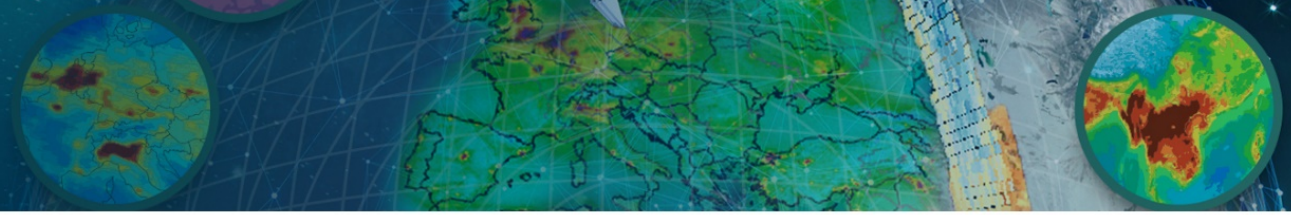
Vertical time-height cross-sections of volcanic ash distribution.

Ash concentrations **a) with** and **b) without** assimilation of Aeolus wind profiles and **c)** the time-height evolution of **Polly^{XT}-NOA lidar** observations at PANGEA station during **12 March 2021** (18:00 UTC) to **13 March 2021** (00:00UTC). Station elevation is at 193 m a.s.l.

Vertical profile of volcanic ash concentration



Ash concentrations calculated by the Polly^{XT} lidar measurements are *in good agreement* with the model when Aeolus winds are assimilated (no concentrations are revealed without Aeolus assimilation).



Aeolus dusk orbit 13 March 2021 15:25-15:29 UTC

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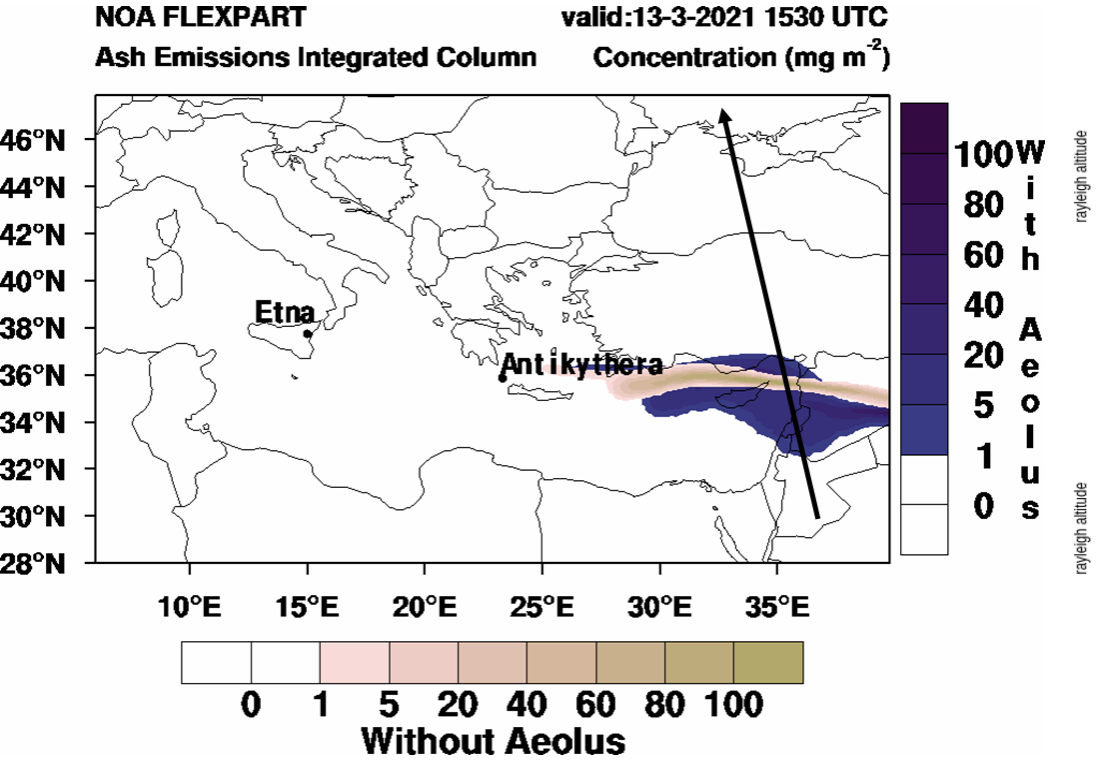
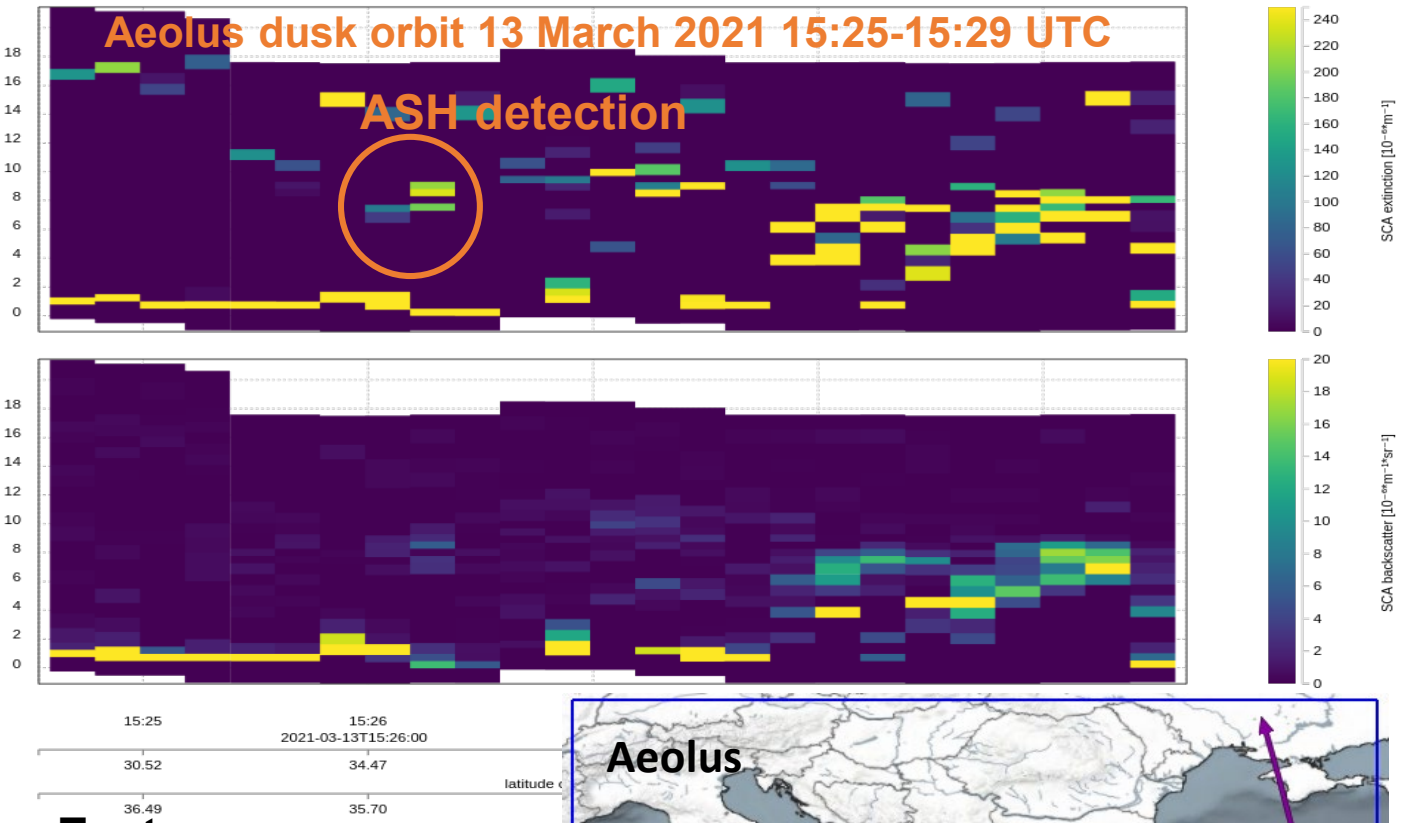
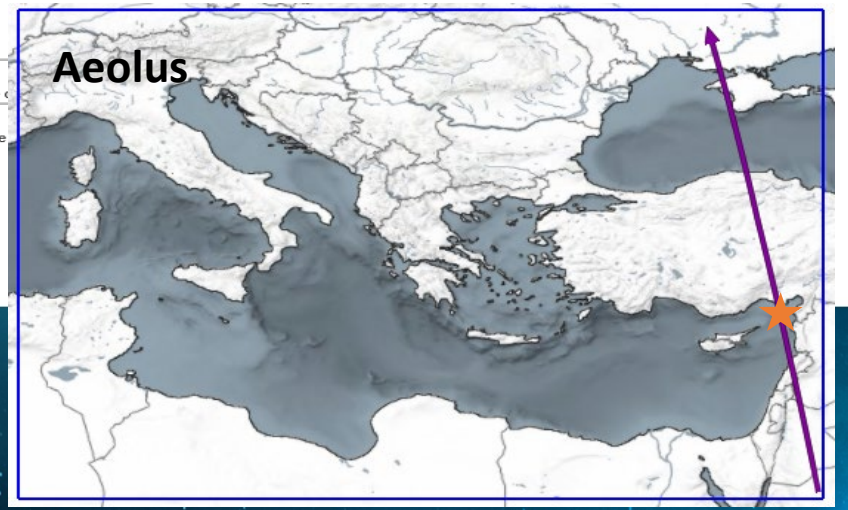
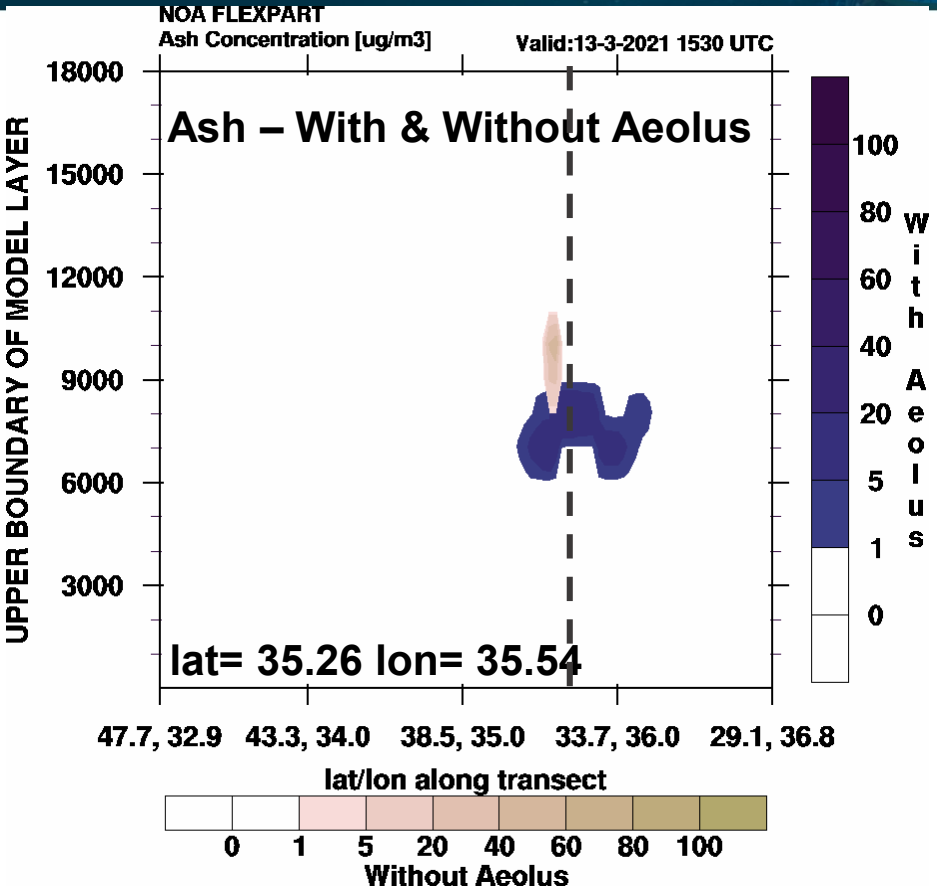


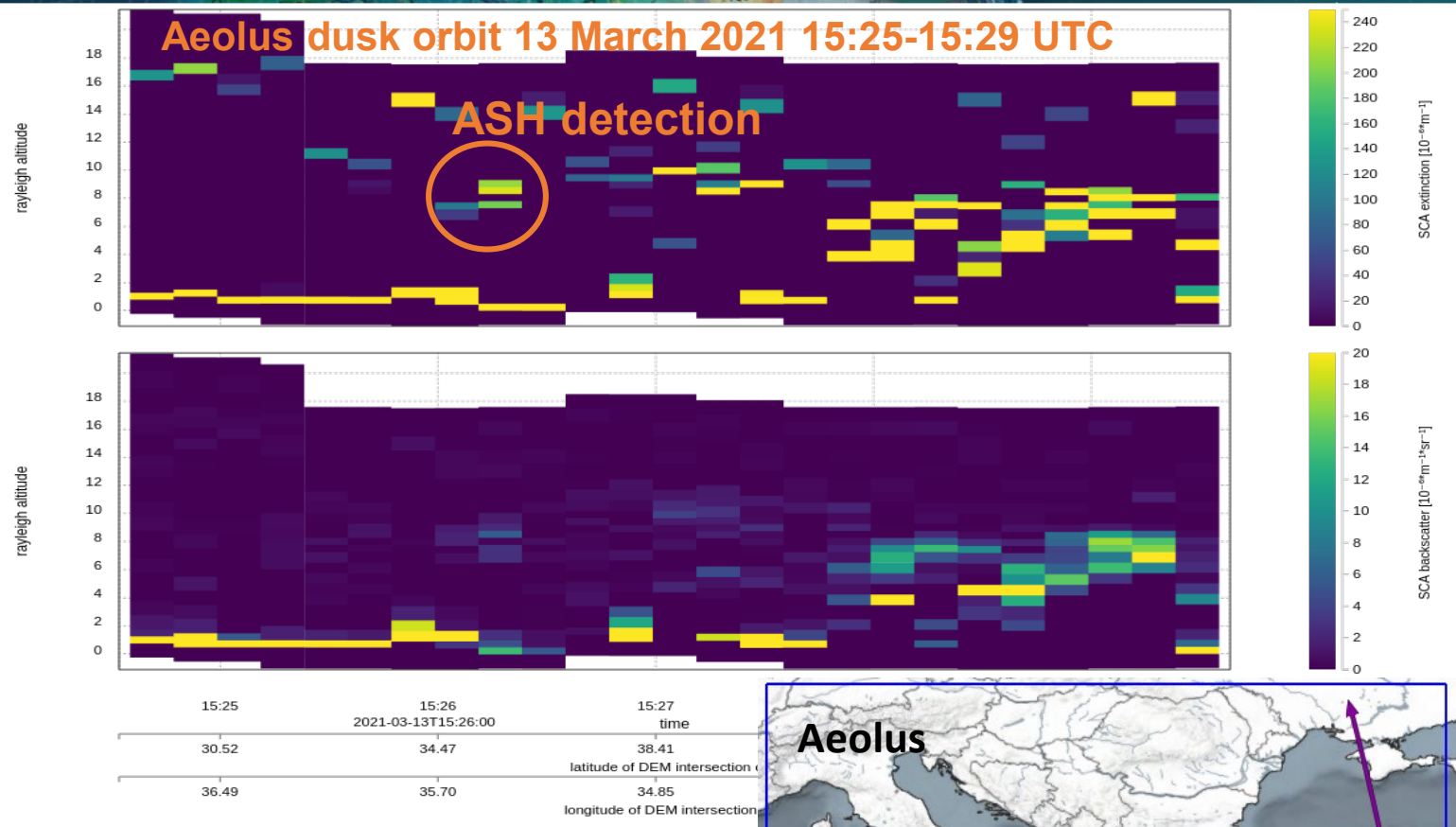




- Ash column concentrations transported over the Eastern Mediterranean acknowledging or not Aeolus wind assimilated fields
- Detection of the aerosol plume in the Middle East by Aeolus L2A data

Aeolus dusk orbit 13 March 2021 15:25-15:29 UTC

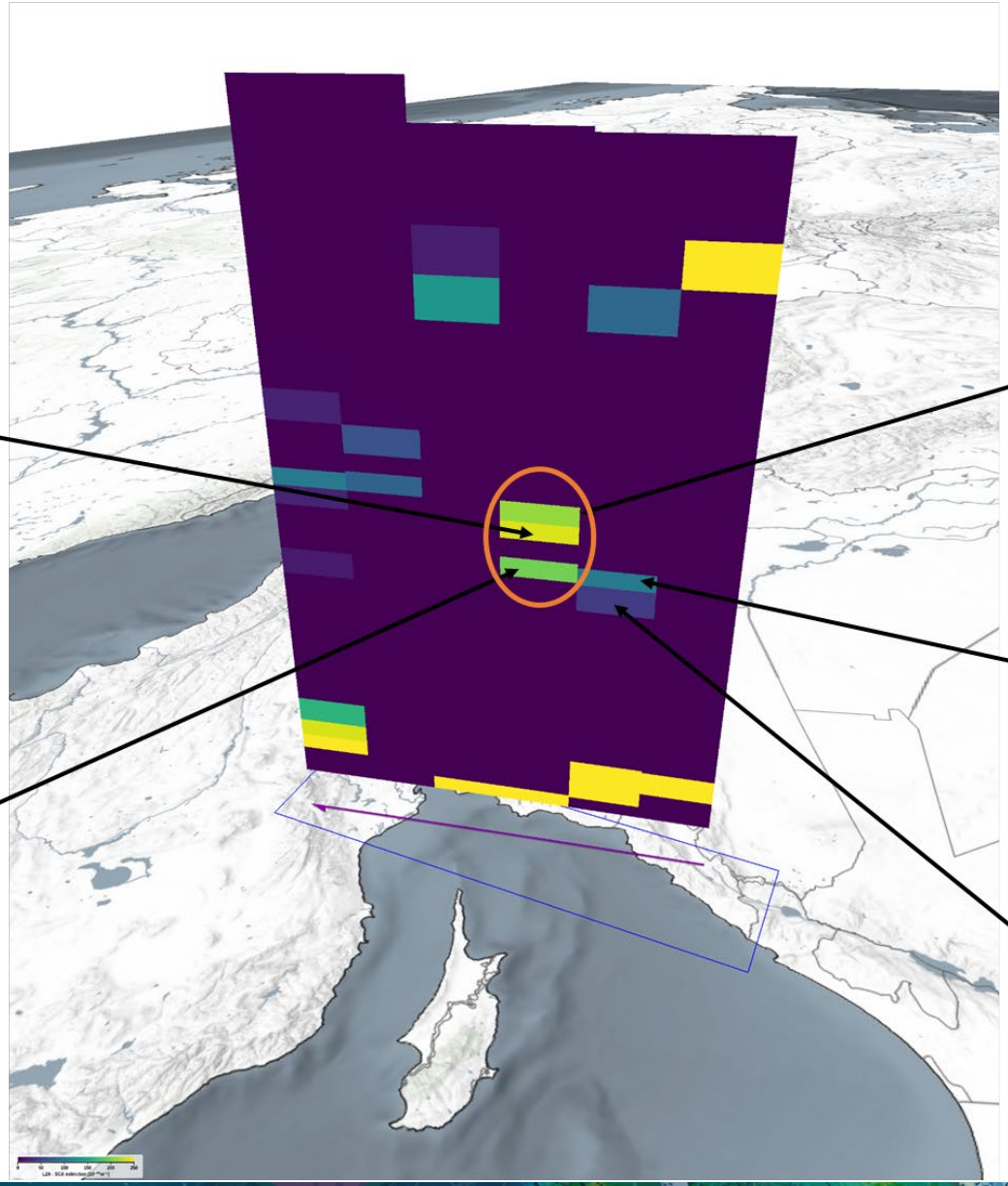




- Vertical time-height cross-sections of volcanic ash distribution.
- Ash concentrations detected with Aeolus are not depicted with the control model run.

13 March 2021
15:26 UTC

SCA Extinction



Lat: 35.26 N
Lon: 35.54 E
Bottom: 8.3 km
Top: 8.8 km
Alpha: 236.8 Mm^{-1}

Lat: 35.26 N
Lon: 35.54 E
Bottom: 8.8 km
Top: 9.3 km
Alpha: 210.9 Mm^{-1}

Lat: 35.26 N
Lon: 35.54 E
Bottom: 7.3 km
Top: 7.8 km
Alpha: 196.9 Mm^{-1}

Lat: 34.47 N
Lon: 35.70 E
Bottom: 7.2 km
Top: 7.7 km
Alpha: 101.8 Mm^{-1}

Lat: 34.47 N
Lon: 35.70 E
Bottom: 6.4 km
Top: 7.2 km
Alpha: 43.7 Mm^{-1}

Ongoing work and forthcoming actions

- Investigate the reasons of
  - the Southward expansion and
  - the mass loss

  of the ash plume with Aeolus assimilated wind fields.

- Apply quantitative inversion algorithms (e.g. Stohl A. et al 2011) to improve the predictions of volcanic ash fluxes from Etna eruptions and also the separation between different species constrained by ground-based and satellite observations (volcanic ash vs sulfates).

Acknowledgements

NEWTON team acknowledges support by ESA in the framework of Aeolus+Innovation (ESA AO/1-9544/20/I/NS).

The research leading to these results was supported through the European Research Council (ERC) under the European Community's Horizon 2020 research and innovation framework programme – ERC grant agreement no. 725698 (D-TECT)

This research was supported by data and services obtained from the PANhellenic Geophysical Observatory of Antikythera (PANGEA) of the National Observatory of Athens (NOA), Greece

We acknowledge support of this work by the project “PANhellenic infrastructure for Atmospheric Composition and climatE change” (MIS 5021516) which is implemented under the Action “Reinforcement of the Research and Innovation Infrastructure”, funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund)

We acknowledge the support of Stavros Niarchos Foundation

We acknowledge the support by EU H2020 E-shape project (Grant Agreement n. 820852).

Surveillance system of Etna is operated by INGV-OE and we thank all technicians and technologists involved in their maintenance.

THANK YOU!!