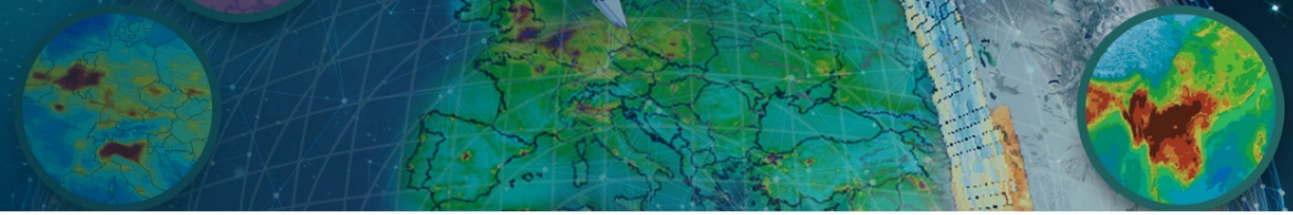
The NEWTON project: Advancing regional dust forecasts via Aeolus wind data assimilation

Antonis Gkikas and the NEWTON team

National Observatory of Athens [NOA]

25/11/2021

Outline



Overview of the NEWTON ESA project

EARLINET Covid-19 campaign [WRF-NOA]

Mediterranean desert dust outbreaks: October 2020 [WRF-Cyl]

Summary and future work

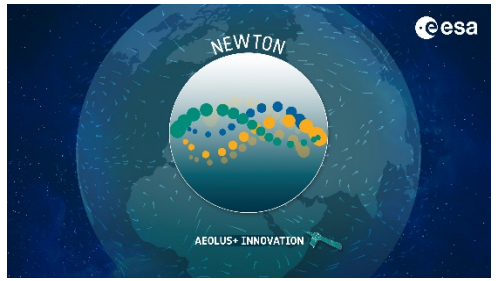
The NEWTON ESA project

NEWTON in a nutshell

ImproviNg dust monitoring and forEcasting through Aeolus Wind daTa assimilatiON

Participants

Contributors



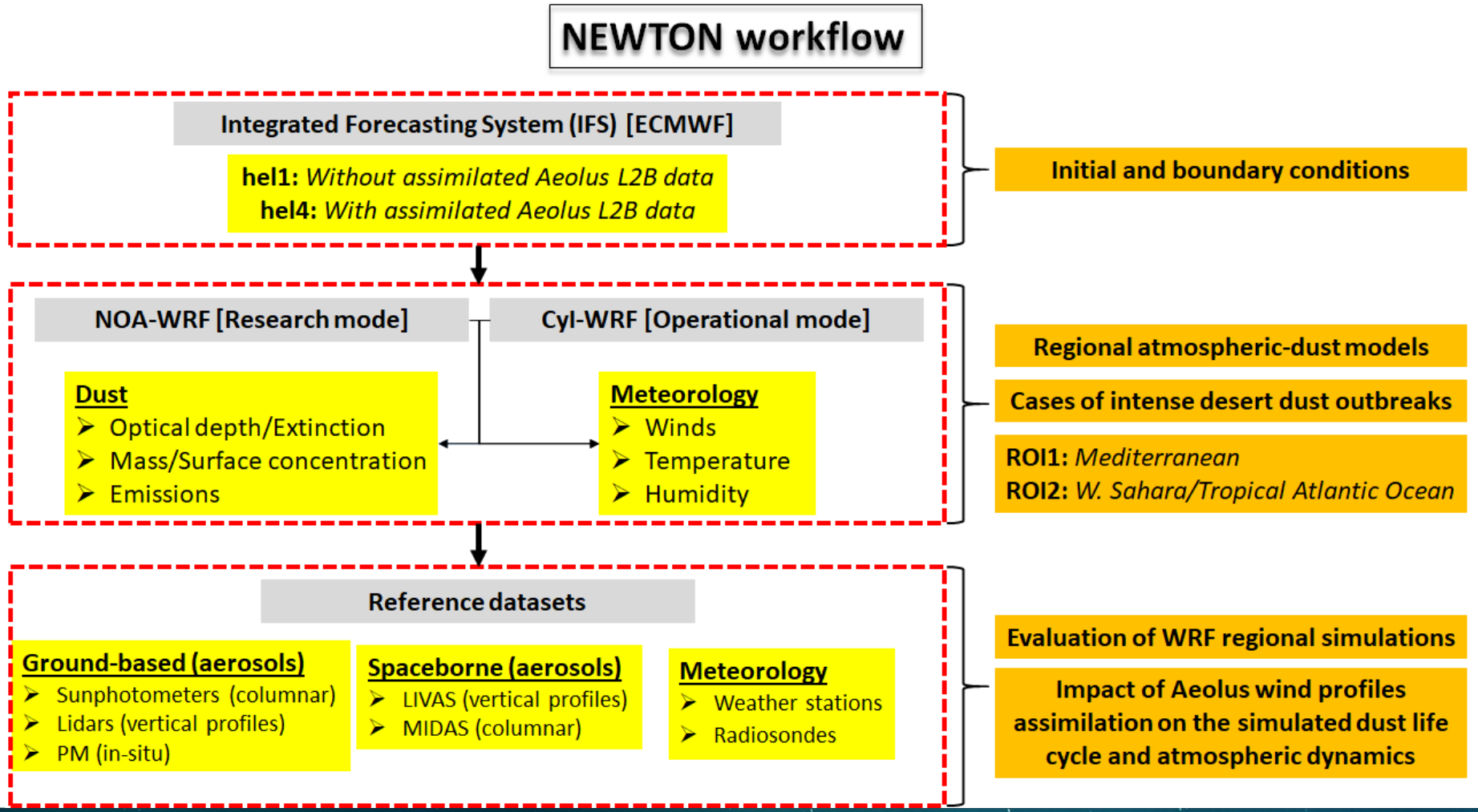
Scientific objectives

- ❑ Assess the potential **improvements** on short-term **dust forecasts** via **Aeolus wind data assimilation**
- ❑ Investigate the modifications on **dust emission** and **transport mechanisms**

Expectations

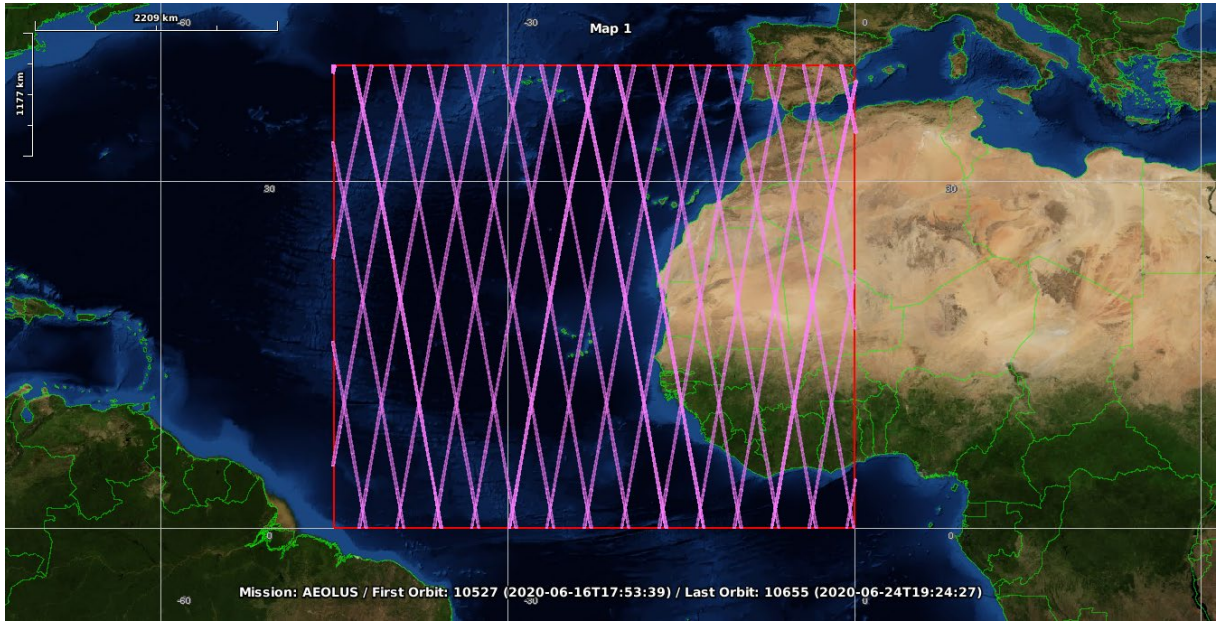
Highlight the benefits and the necessity of Aeolus on dust research

NEWTON workflow

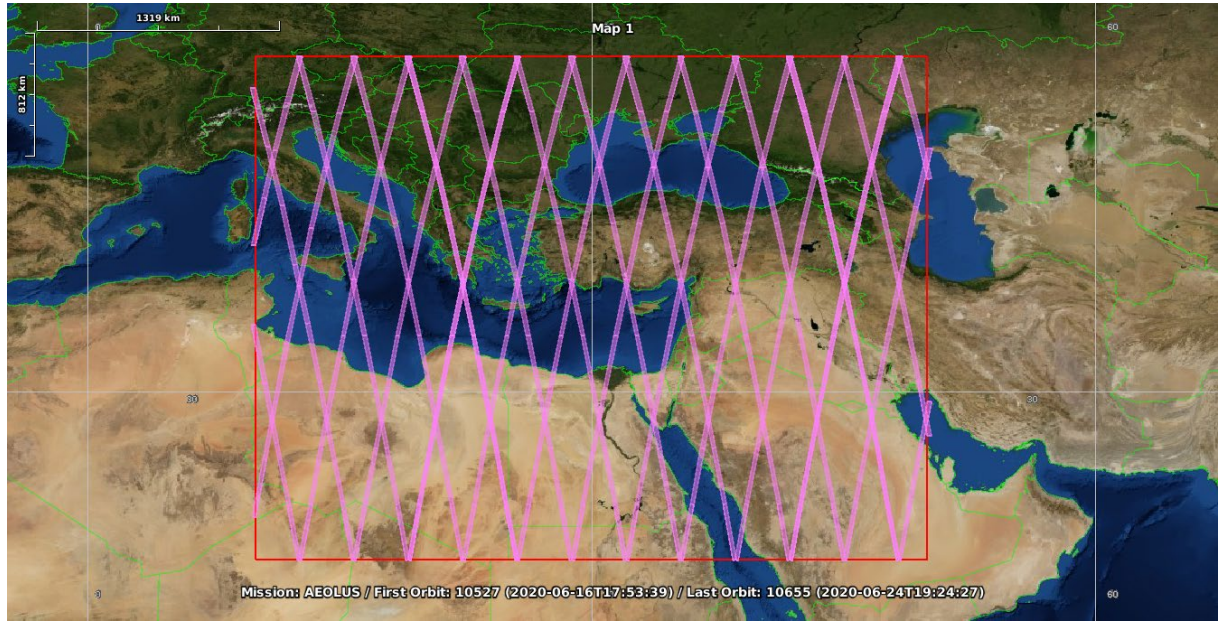


Regions of Interest [Aeolus wind profiles]

West Sahara – Tropical Atlantic Ocean



Eastern Mediterranean – Middle East



- ❑ Aeolus provides wind profiles above dust sources and dust “corridors”
- ❑ Feasibility to monitor wind 3D fields by Aeolus during the evolution phases of dust outbreaks

WRF regional dust simulations: IFS data from MARS

IFS outputs [ECMWF]

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

Exp1: *hel1*

Control without assimilating Aeolus

Exp2: *hel4*

Assimilated Aeolus Rayleigh-clear and Mie-cloudy HLOS winds

Pressure Levels

ECMWF ≡

MARS Catalogue Current activity

MARS Catalogue

Date (215 values)	Time (4 values)	anoffset (2 values)	Level (25 values)	Parameter (13 values)
2020-04-04	00:00:00	3	1	Divergence
2020-04-05	06:00:00	9	2	Fraction of cloud cover
2020-04-06	12:00:00		3	Geopotential
2020-04-07	18:00:00		5	Ozone mass mixing ratio
2020-04-08			7	Relative humidity
2020-04-09			10	Specific cloud ice water content
2020-04-10			20	Specific cloud liquid water content
2020-04-11			30	Specific humidity
2020-04-12			50	Temperature
2020-04-13			70	U component of wind

Current selection

levtype: ml, **pl**, sfc

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

stream: **lwda**, lwwv

expver: **hel1**, hel3, hel4, hele, heli, help, helz

Surface

ECMWF ≡

MARS Catalogue Current activity

MARS Catalogue

Date (216 values)	Time (4 values)	anoffset (2 values)	Parameter (80 values)
2020-04-03	00:00:00	3	Slope of sub-gridscale orography
2020-04-04	06:00:00	9	Snow albedo
2020-04-05	12:00:00		Snow density
2020-04-06	18:00:00		Snow depth
2020-04-07			Soil temperature level 1
2020-04-08			Soil temperature level 2
2020-04-09			Soil temperature level 3
2020-04-10			Soil temperature level 4
2020-04-11			Soil type
2020-04-12			

Current selection

levtype: ml, pl, **sfc**

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

stream: **lwda**, lwwv

expver: hel1, hel3, **hel4**, hele, heli, help, helz

Angela Benedetti
Michael Rennie

WRF regional dust simulations

IFS outputs [ECMWF]

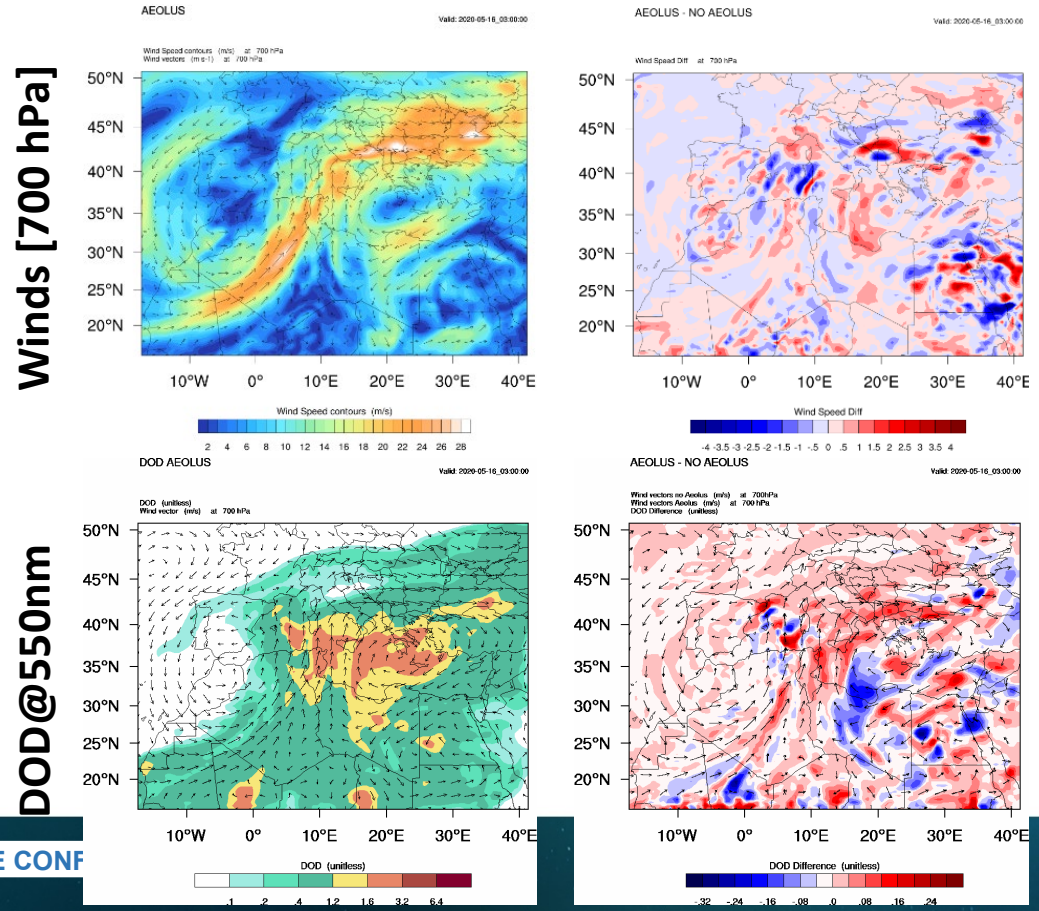
Exp1: *hel1*

Control without assimilating Aeolus

Exp2: *hel4*

Assimilated Aeolus Rayleigh-clear and Mie-cloudy HLOS winds

WRF simulations [NOA & Cyl]



Assessment analysis [Dust]

- **Ground-based**
  - ❑ PollyXT (profiling)
  - ❑ AERONET (columnar)
  - ❑ EMEP (near surface)
- **Spaceborne**
  - ❑ LIVAS (profiling)
  - ❑ MIDAS (columnar)

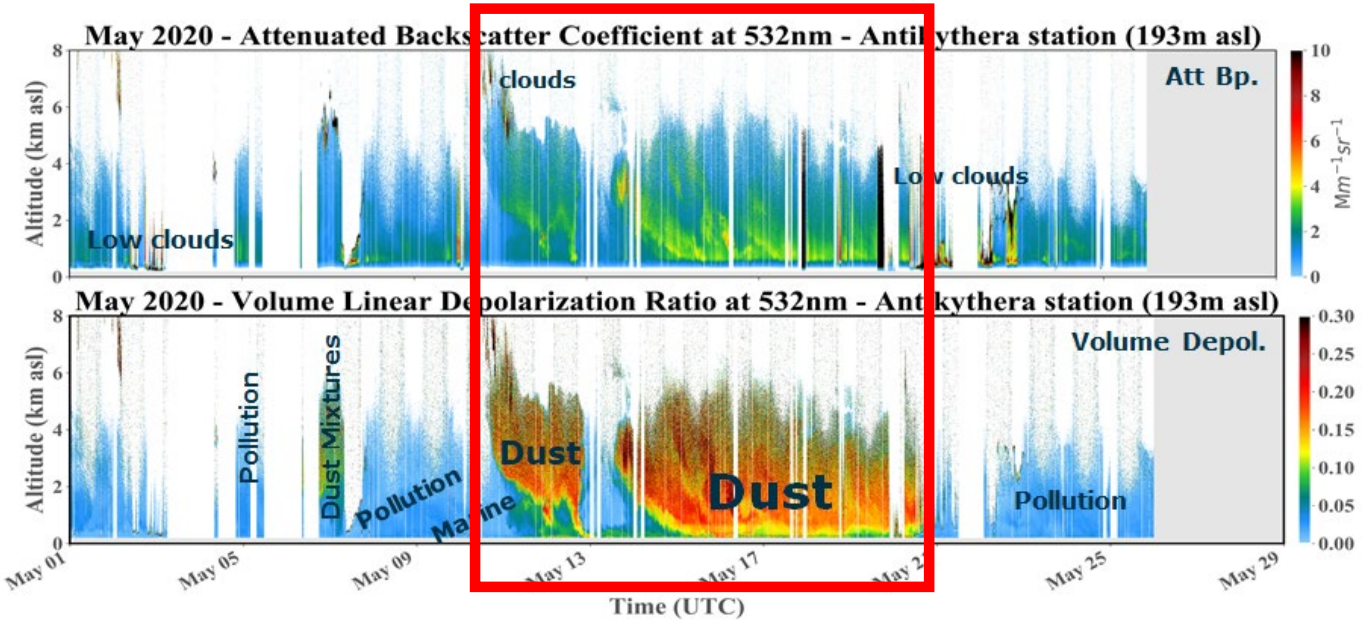
Angela Benedetti
Michael Rennie

EARLINET Covid-19 campaign [WRF-NOA]

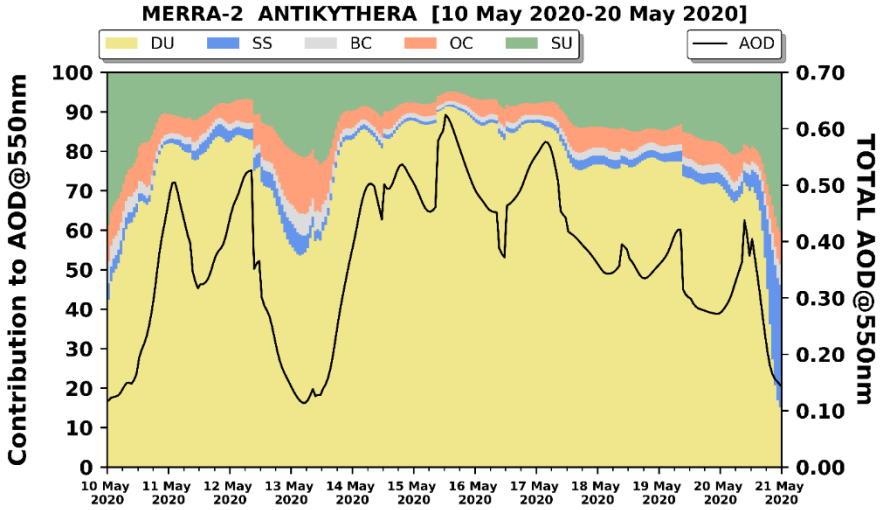
EARLINET Covid-19 campaign

Identification of dust outbreaks in the Mediterranean

Ground-based lidar observations



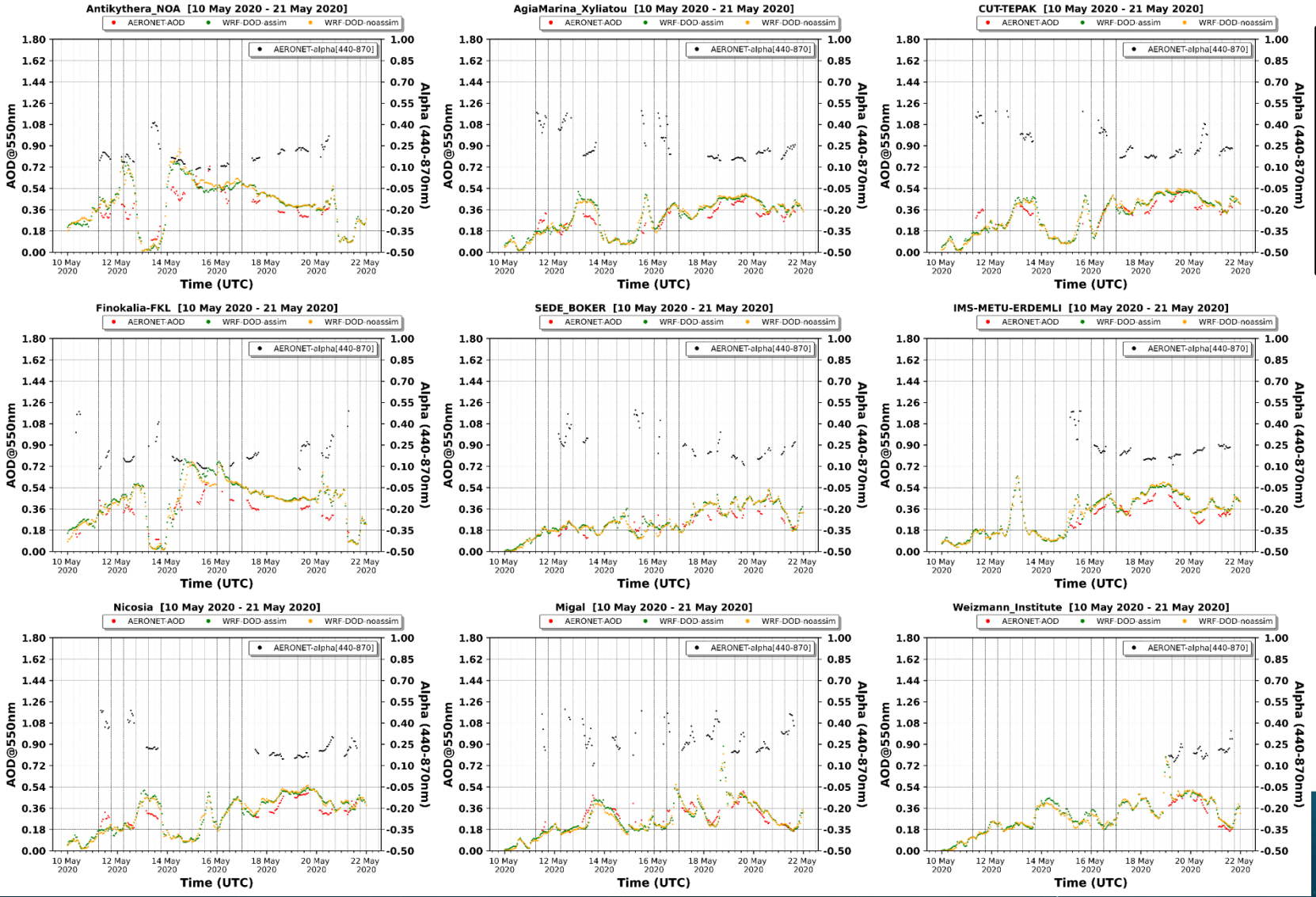
Reanalysis products [MERRA-2]



Consecutive dust outbreaks, extending up to 6 km, affected the broader Mediterranean basin, between 10/5 and 20/5, as indicated by ground-based lidars.

Dust aerosols' contribution, in optical terms, to the total aerosol load exceeds 70% in most of the time during the period of interest.

WRF-NOA vs AERONET



AERONET alpha (440-870nm)

AERONET DOD

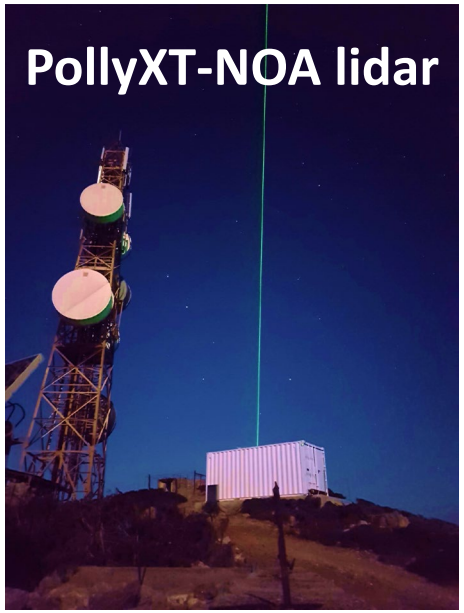
(AOD≥ 0.1 & alpha≤ 0.5)

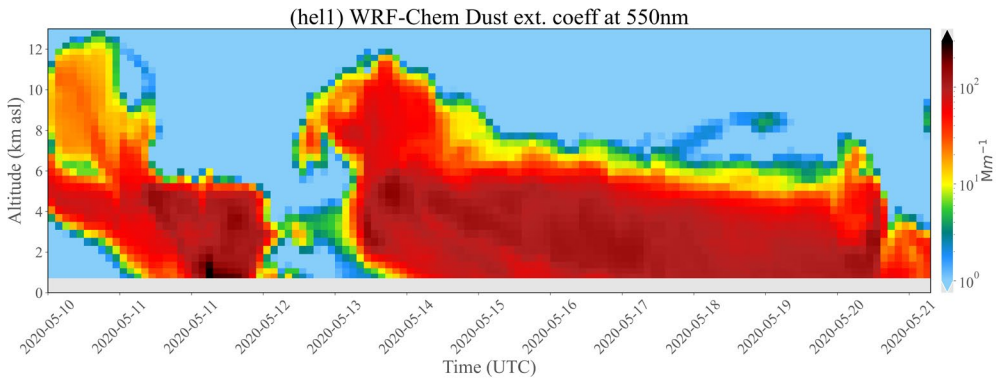
hel1 (noassim)

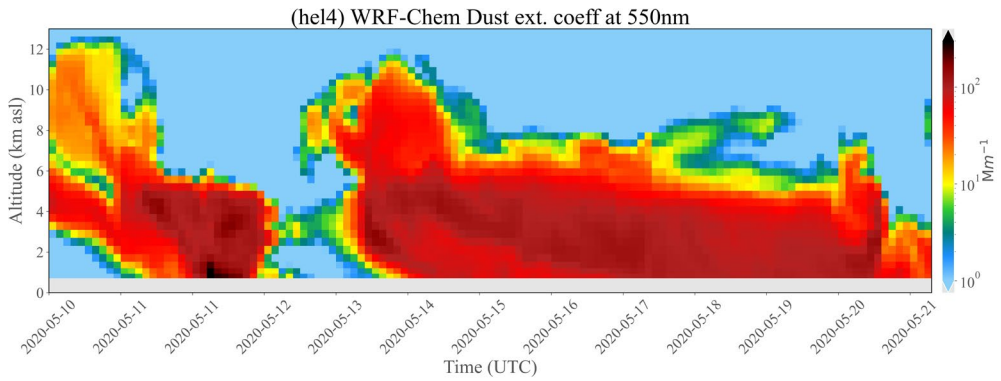
hel4 (withassim)

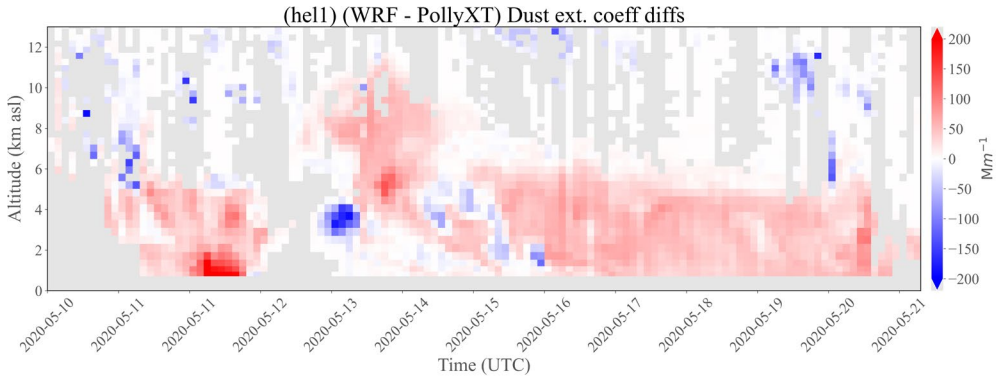
- **9 stations situated in the E. Mediterranean**
- **Very good agreement between WRF and AERONET DODs regardless which IFS outputs are used for the model initialization**

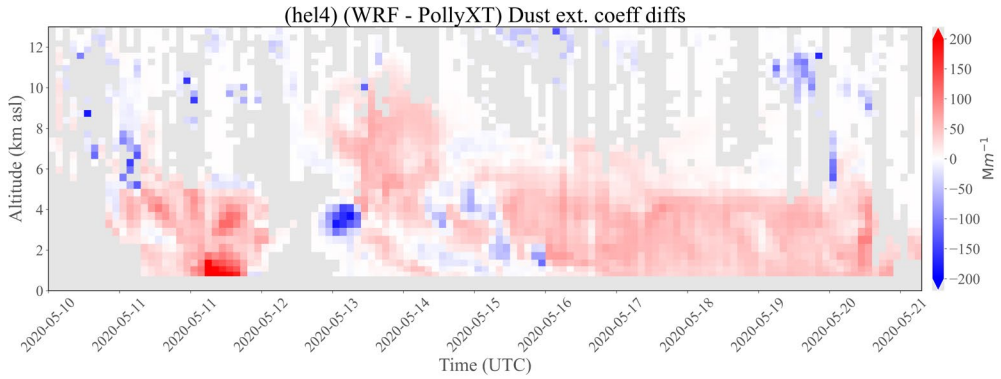
WRF-NOA vs Polly^{XT} [PANGEA | Antikythera]





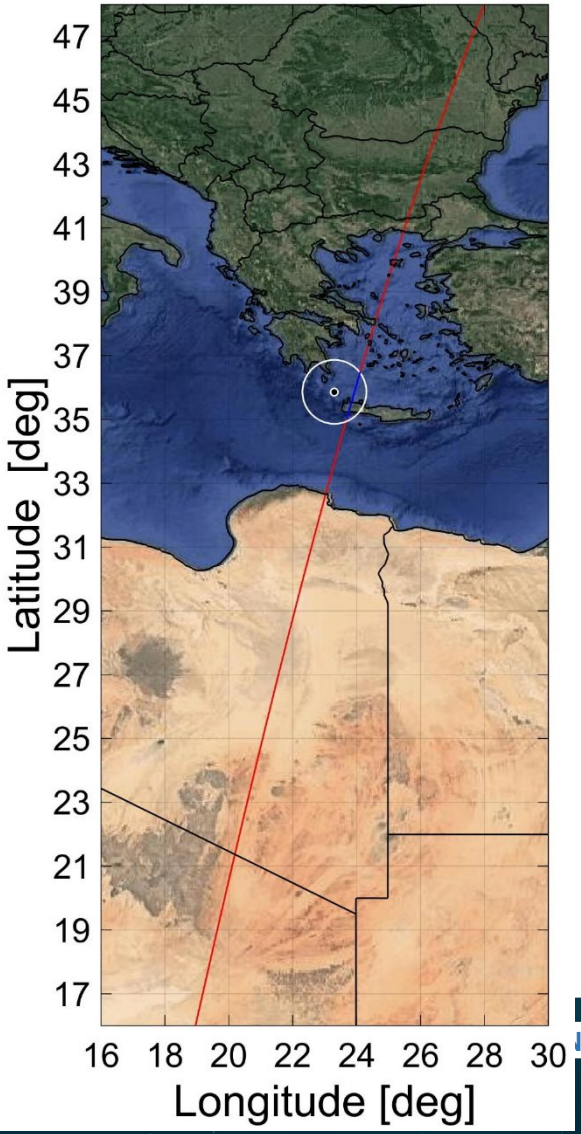


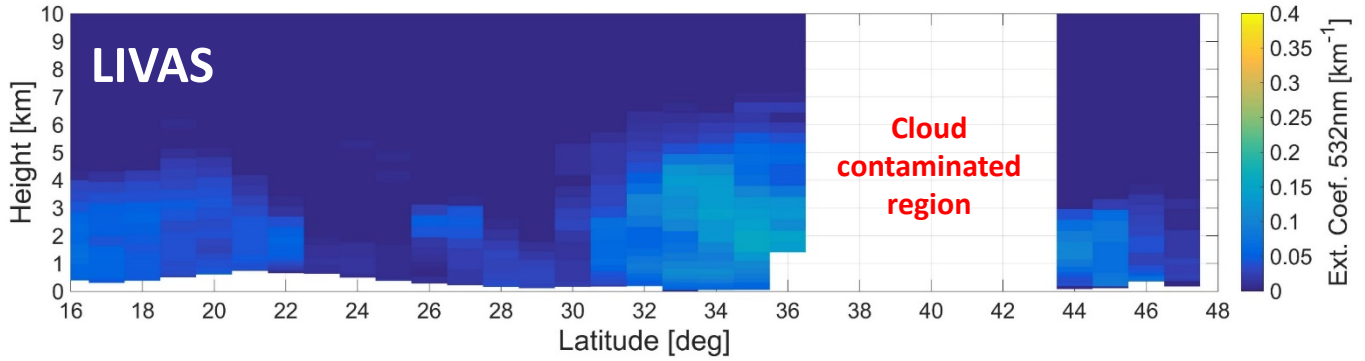


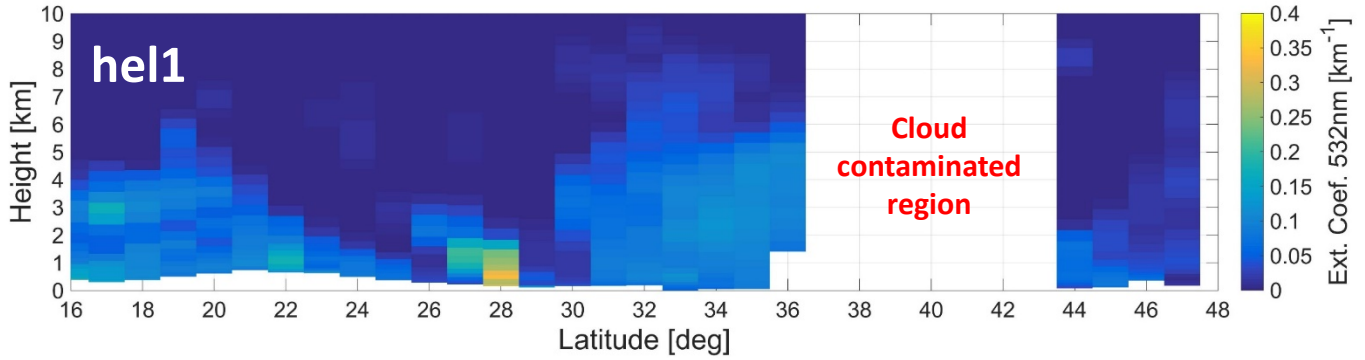


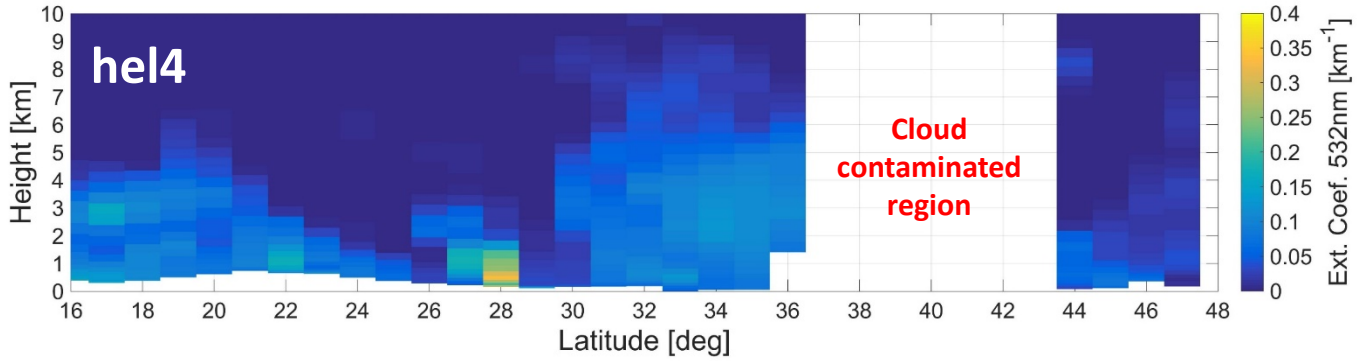
Common behavior between the model runs in terms of reproducing the vertical structure of dust layers

WRF-NOA vs LIVAS









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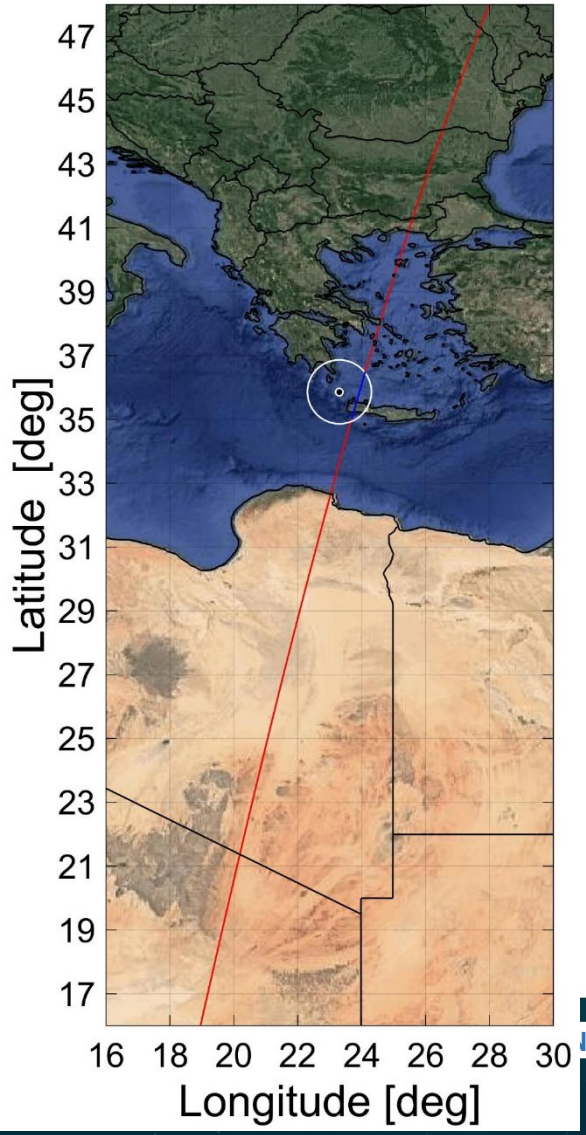
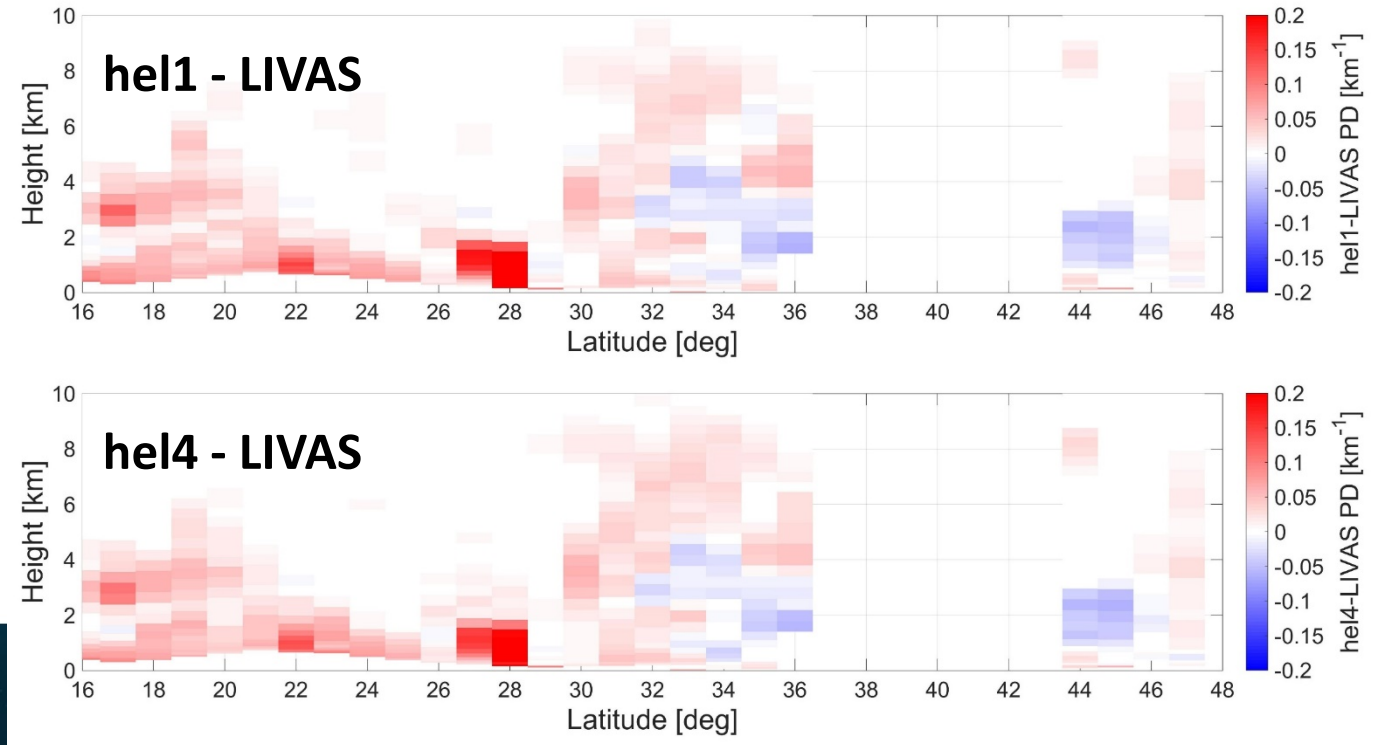
WRF-NOA vs LIVAS



- CALIPSO nighttime overpass across the E. Mediterranean
- Model overestimates dust extinction over Sahara whereas slight deviations against LIVAS are found in the SW Greece

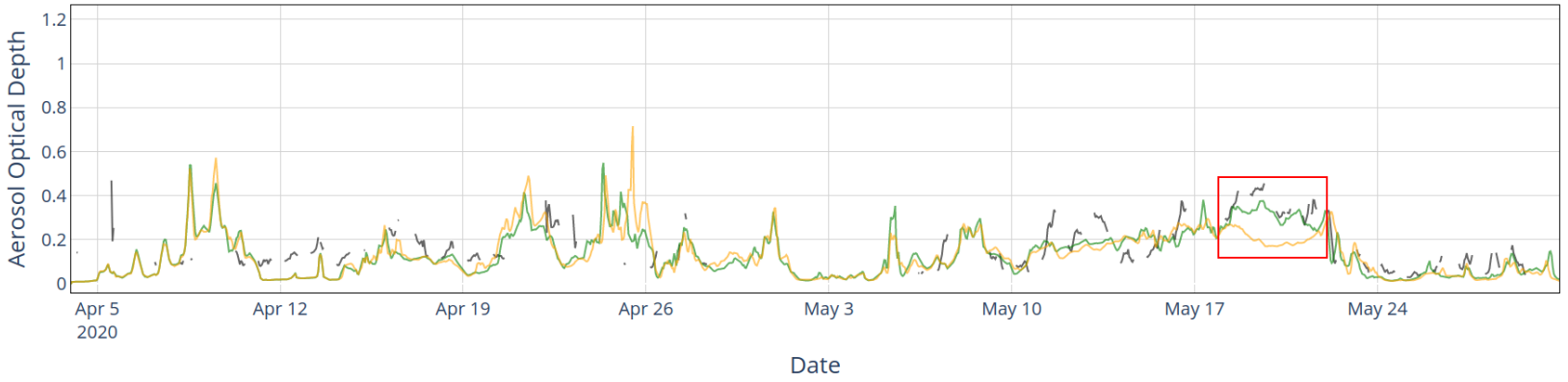
- **Almost identical results for hel1 and hel4 throughout the cross section**



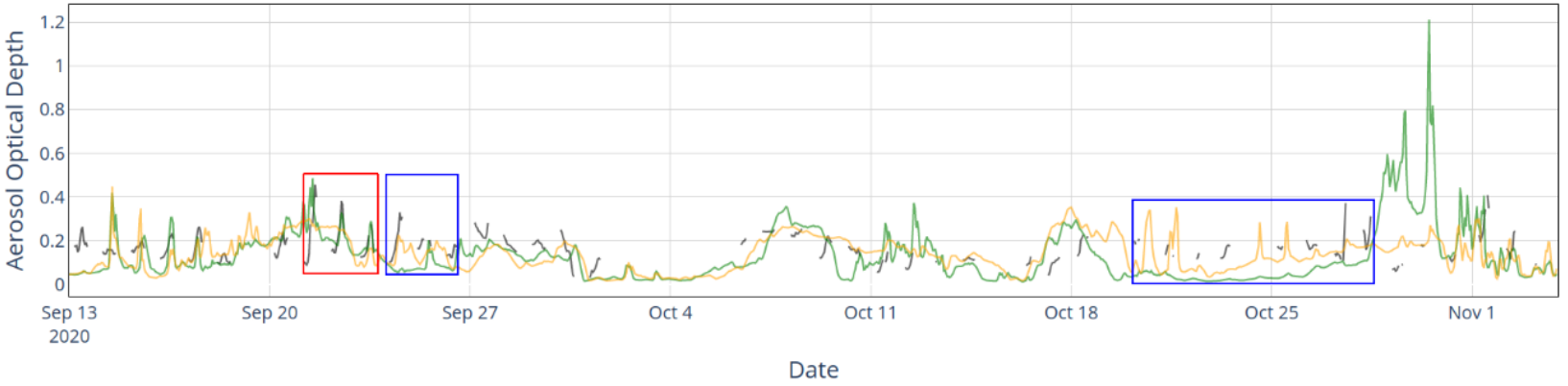
Mediterranean dust outbreaks: October 2020 [WRF-CyI]

WRF-Cyl vs AERONET

Spring 2020



Fall 2020

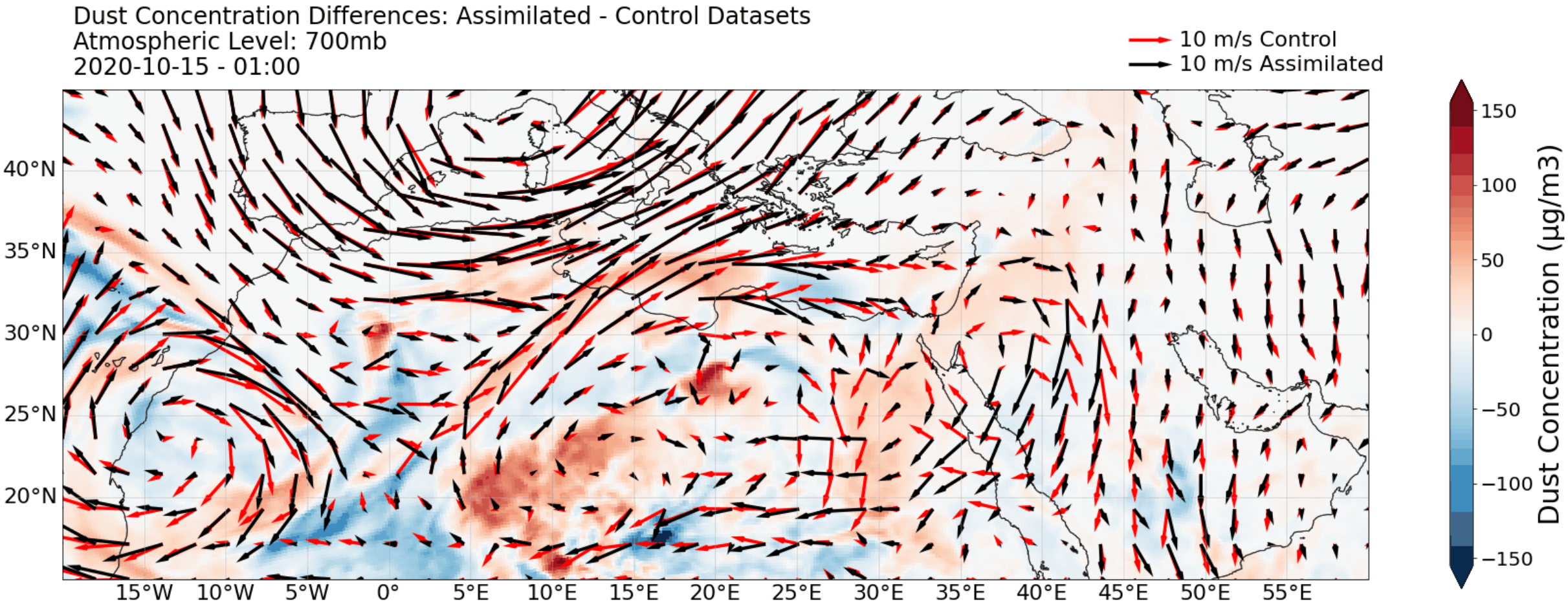


AERONET DOD (AOD≥ 0.1 & alpha≤ 0.5)
hel1 (noassim) **hel4 (withassim)**

- Common behavior between hel1 and hel4 experiment in spring in contrast to fall
- Better performance for the hel1 run (without Aeolus assimilation) **[red boxes]**
- Better performance for the hel4 run (with Aeolus assimilation) **[blue boxes]**

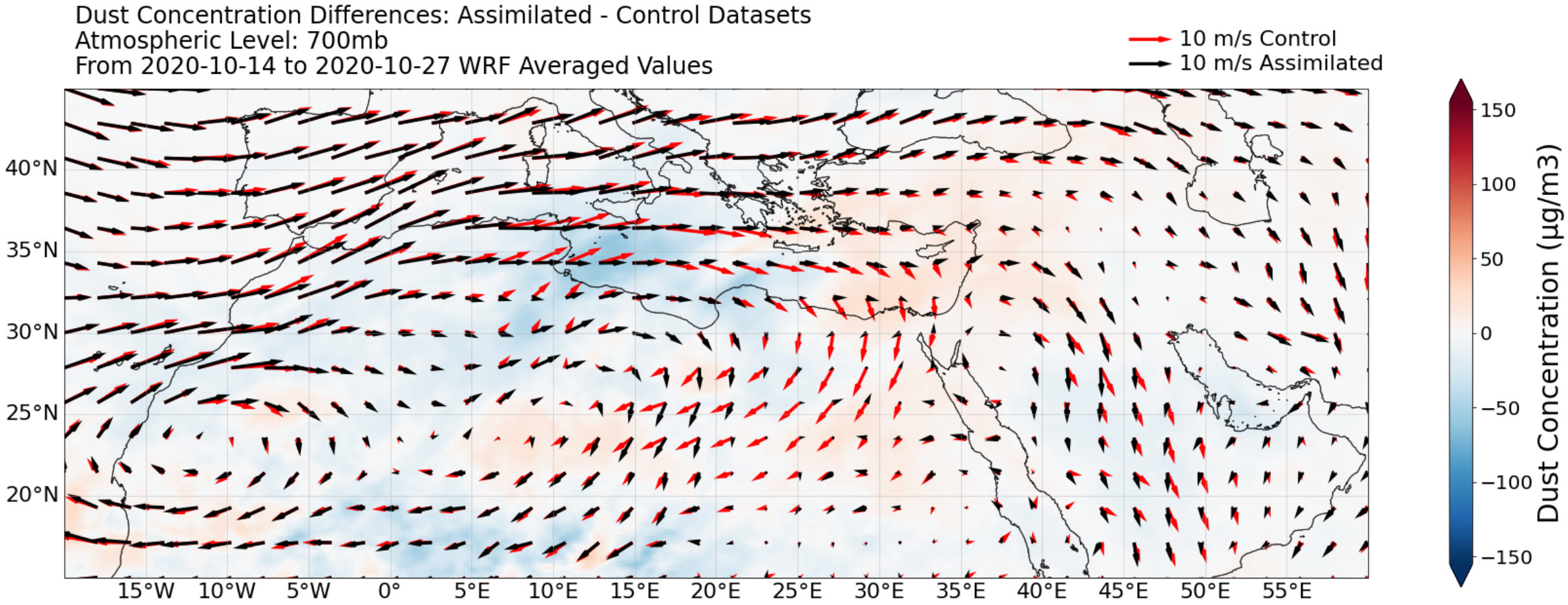
Period of interest: 14th – 27th October 2020

Wind patterns and dust concentration



Differences in wind speed/direction drive dust burden concentrations

WRF-Cyl vs AERONET



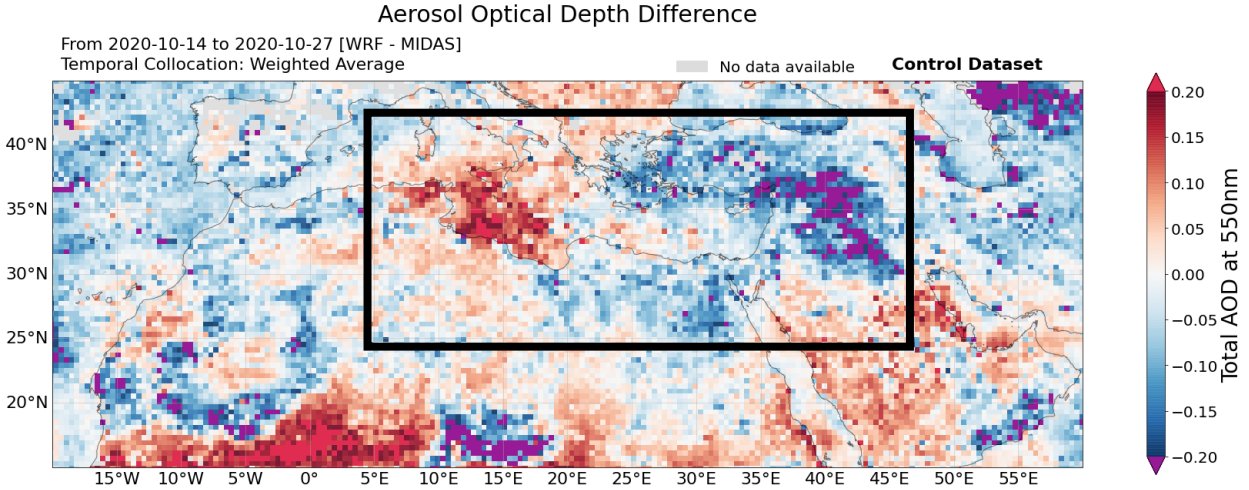
- Distinct patterns of positive/negative hel4-hel1 deviations
- Investigation of the synoptic patterns

WRF-Cyl vs MIDAS

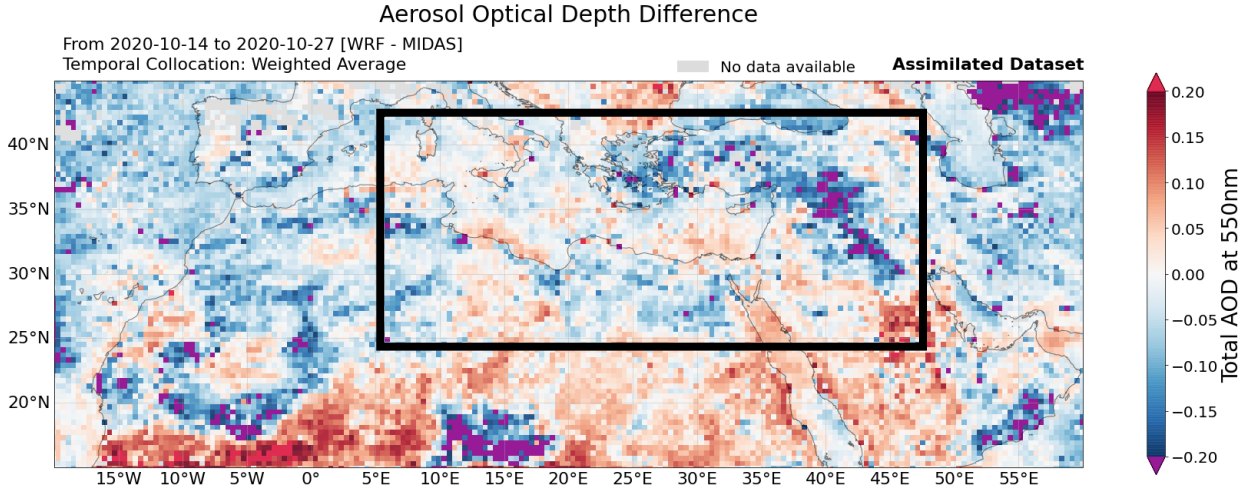
ModIs Dust AeroSol [MIDAS; Gkikas et al. (2021)]

- **Columnar dust optical depth (DOD) at 550 nm**
- **Spatial/Temporal resolution:** 0.1° x 0.1° / Daily
- **Spatial coverage:** Global (both over land and ocean)

WRF (without Aeolus wind assimilation)



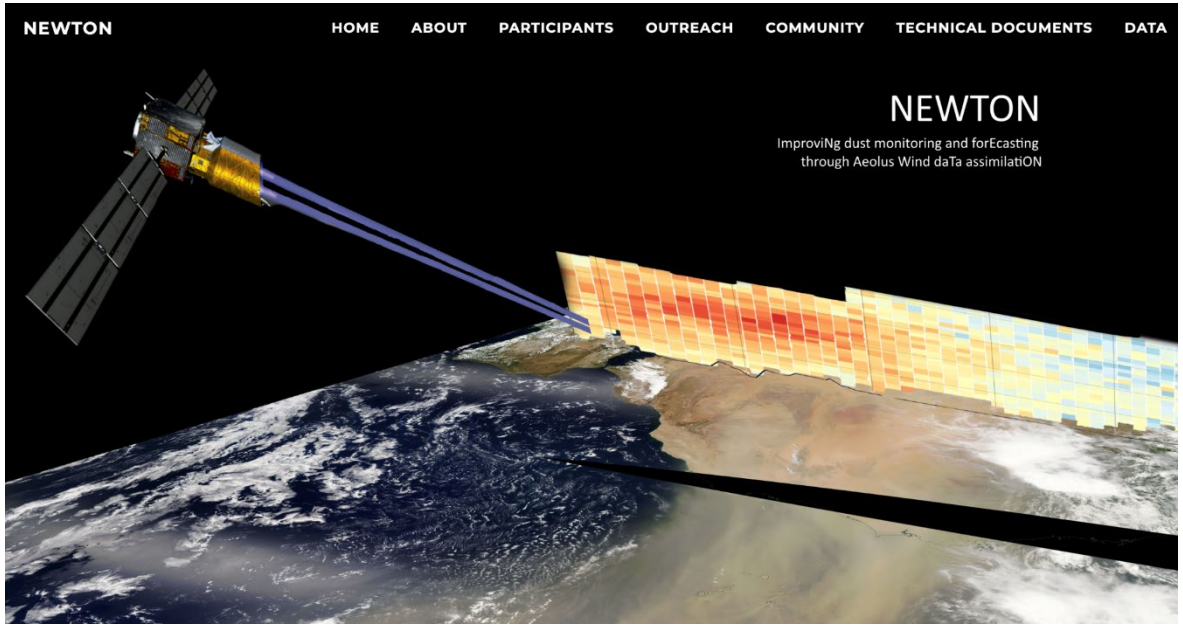
WRF (with Aeolus wind assimilation)



Evident improvement of the simulated AODs, thanks to Aeolus wind data assimilation, in areas where the dust activity is pronounced

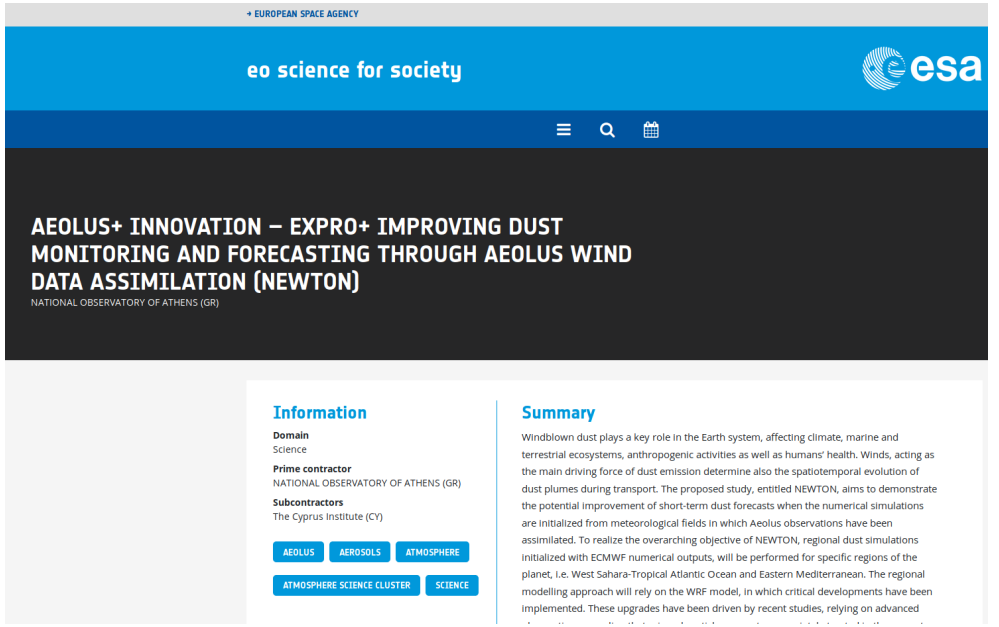
Dissemination

NEWTON webpage



http://newton.space.noa.gr/

NEWTON via EO4SOCIETY



https://eo4society.esa.int/

FACEBOOK

Recap – ongoing work

- The **improvement of dust forecasts**, via **Aeolus wind assimilation**, is **evident** but not **consistent** (i.e., dependency on space and time)
- Focus on the **Mediterranean dust outbreaks in October 2020** (e.g., meteorology, emissions, air mass trajectories)
- Preparation of the WRF experiments for the **W. Sahara – Tropical Atlantic Ocean [JATAC campaign; Cape Verde | September 2021]**
- **Development** of a **3D assimilation scheme for use** in the **WRF-NOA** model
- **Expanding (complementing) NEWTON research activities:**
  - ETNA case (Anna Kampouri; Oral presentation 4.1.1)
  - Sea salt aerosols (Emmanouil Proestakis; e-poster P1.3.2)

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