



# Earth observation synergies for the monitoring and forecasting of desert dust transport in the Mediterranean

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BEYOND Centre of Excellence for EO-based monitoring of Natural Disasters

[www.beyond-eocenter.eu](http://www.beyond-eocenter.eu)

Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS)  
National Observatory of Athens (NOA)

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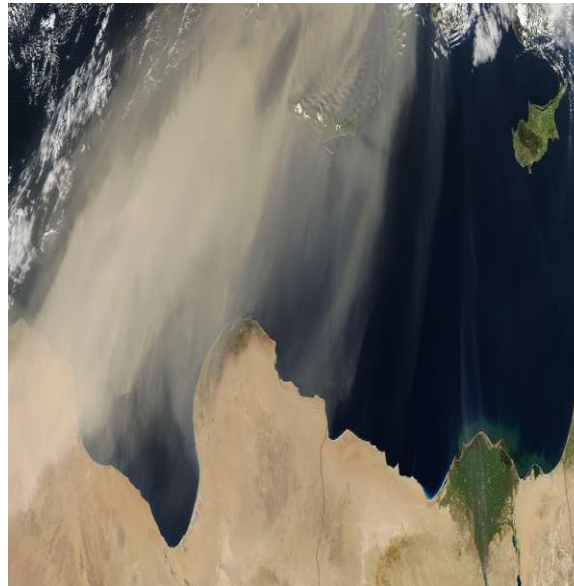


## Motivation: Atmospheric dust is a multi-scale multi-disciplinary problem

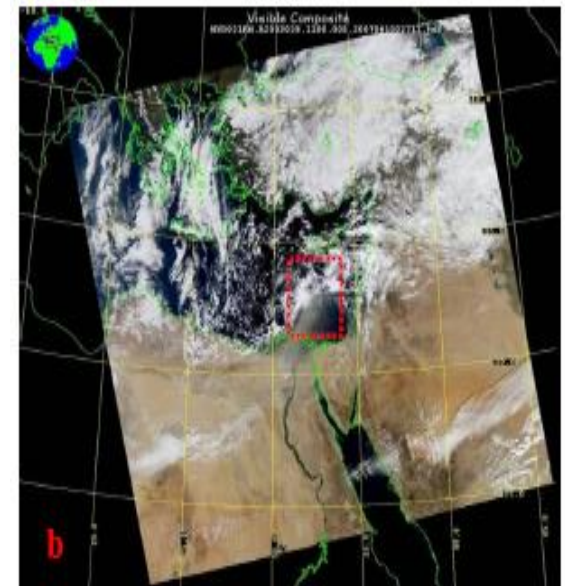
### Local Sand/dust storms (haboobs)



### Long Range Transport

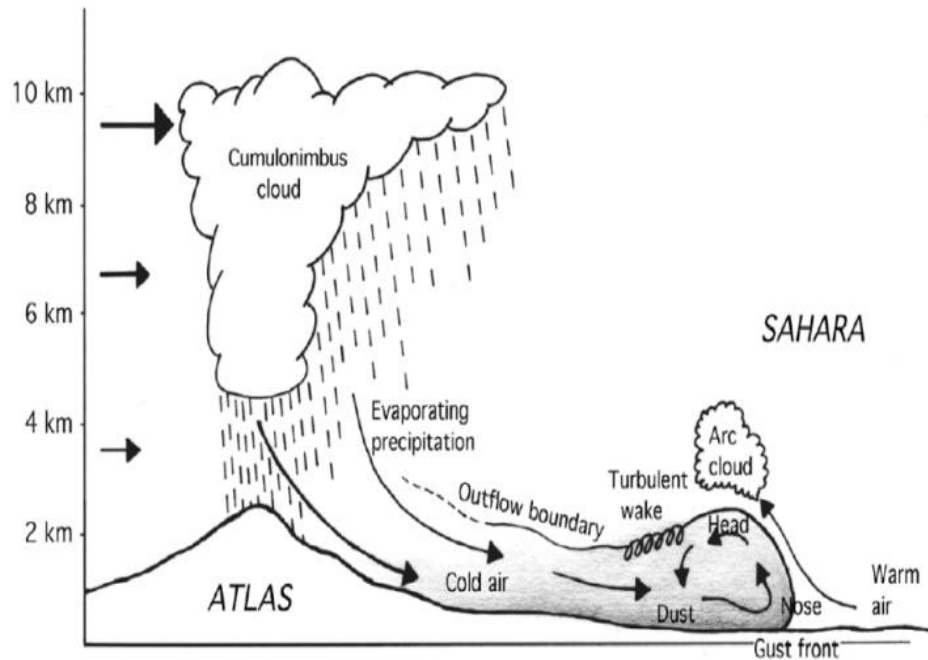


### Dust-cloud interactions



- A complete physics package and fine model grid space is often needed at both source and receptor areas as well as along the transport path
- Model, in-situ, remote sensing combinations

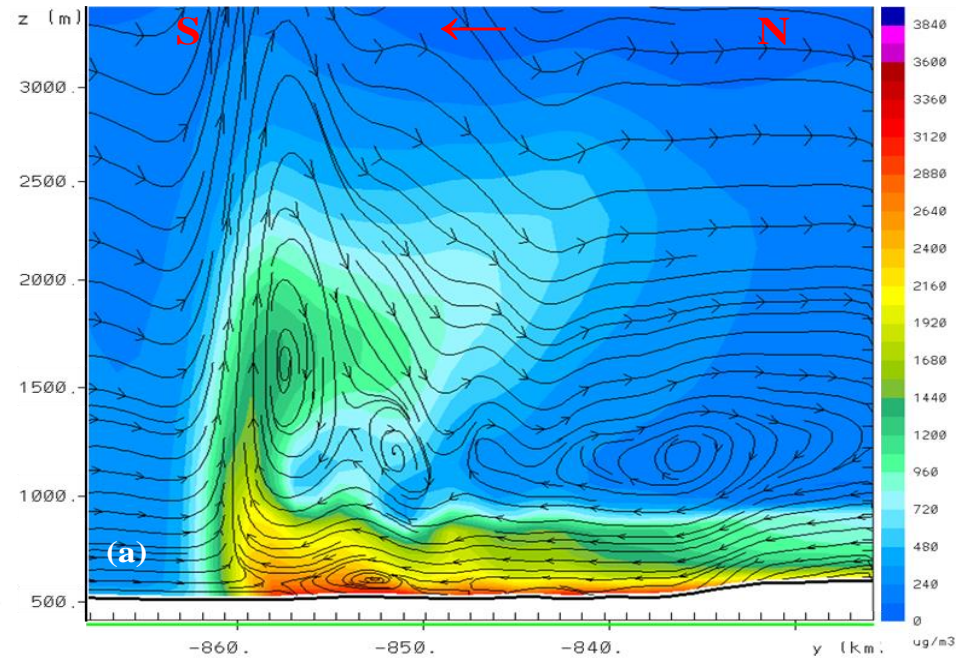
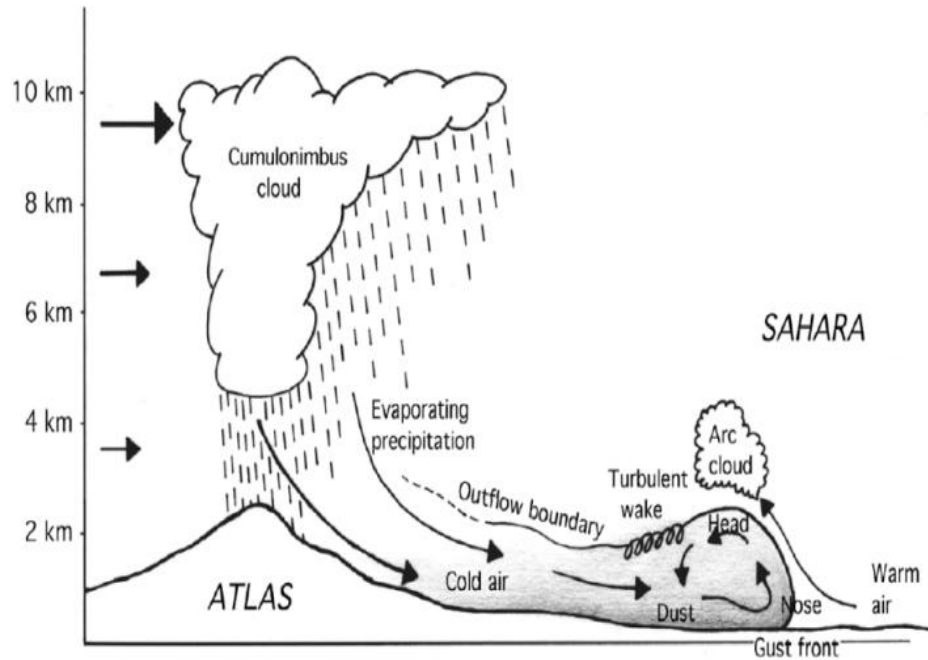
## Cool pools and “Haboobs”



**Knippertz, P., Deutscher, C., Kandler, K., Muller, T., Schulz, O., and Schutz L.: Dust mobilization due to density currents in the Atlas region. Observations from the Saharan Mineral Dust Experiment 2006 field campaign, *J. Geophys. Res.*, 112, D21109, doi:10.1029/2007JD008774, 2007.**



## Cool pools and “Haboobs”

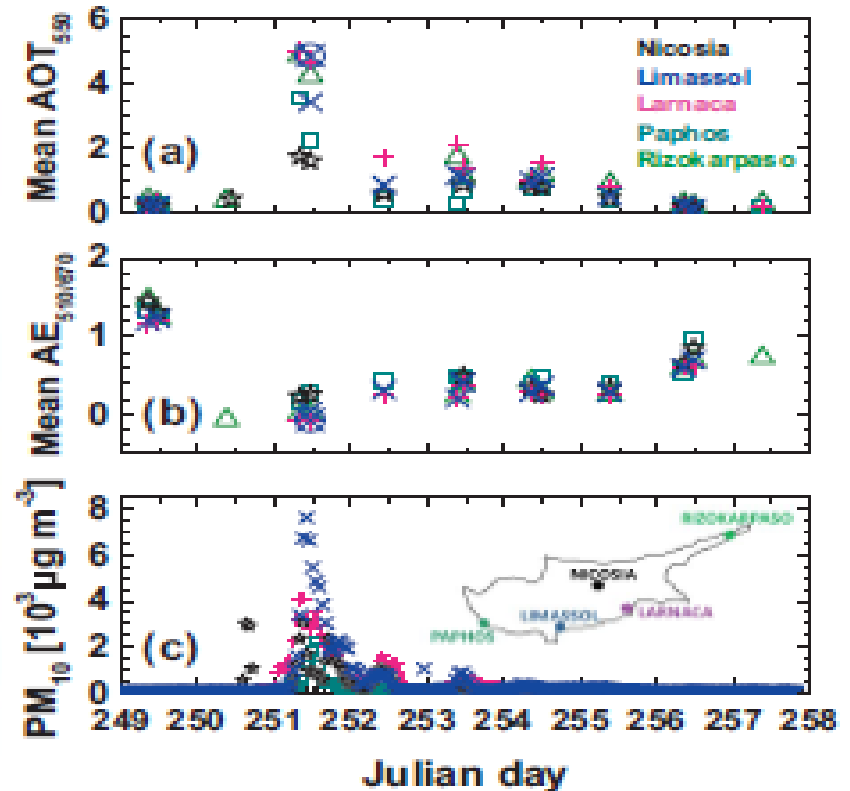
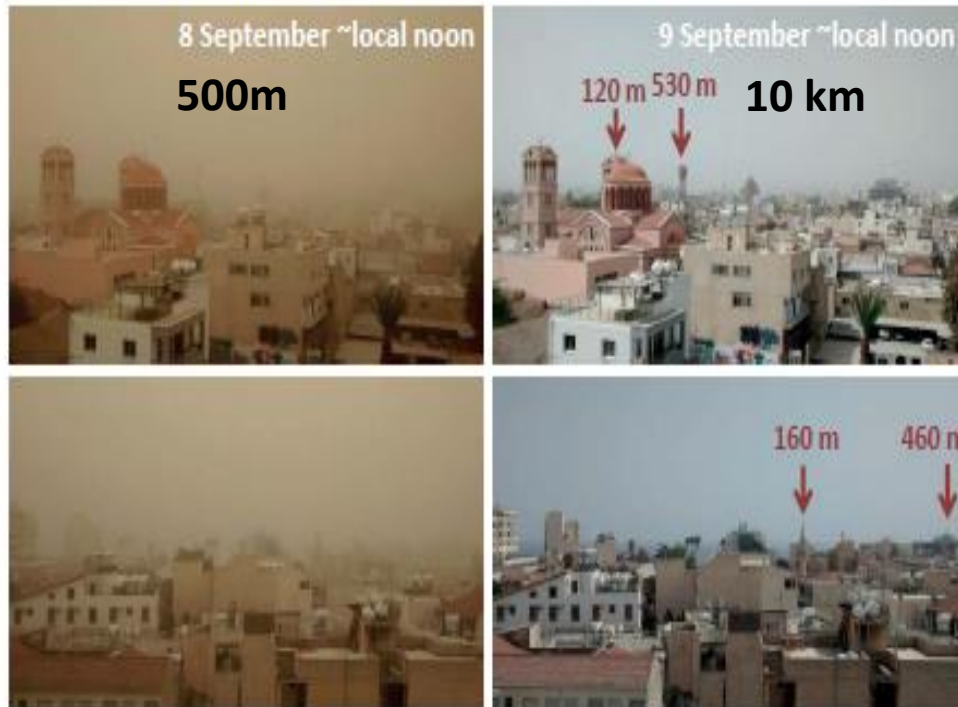


*Knippertz, P., Deutscher, C., Kandler, K., Muller, T., Schulz, O., and Schutz L.: Dust mobilization due to density currents in the Atlas region. Observations from the Saharan Mineral Dust Experiment 2006 field campaign, J. Geophys. Res., 112, D21109, doi:10.1029/2007JD008774, 2007.*

*Solomos S., G. Kallos, E. Mavromatidis, and J. Kushta, Density currents as a desert dust mobilization mechanism, ACP, 2012*

## A record-breaking dust event in Cyprus 8 September 2015

### horizontal visibility



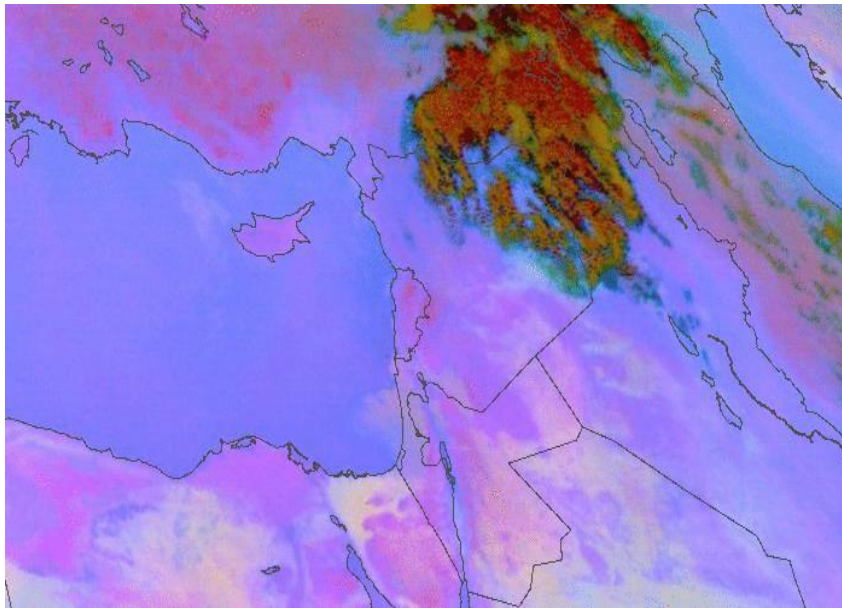
Photographs taken from the roof of CUT-TEPAK AERONET site in the city center of Limassol to the north (top) and south (bottom)

- MODIS mean 550 nm AOD
- MODIS Ångström exponent (510–670 nm)
- Hourly mean PM10 concentrations

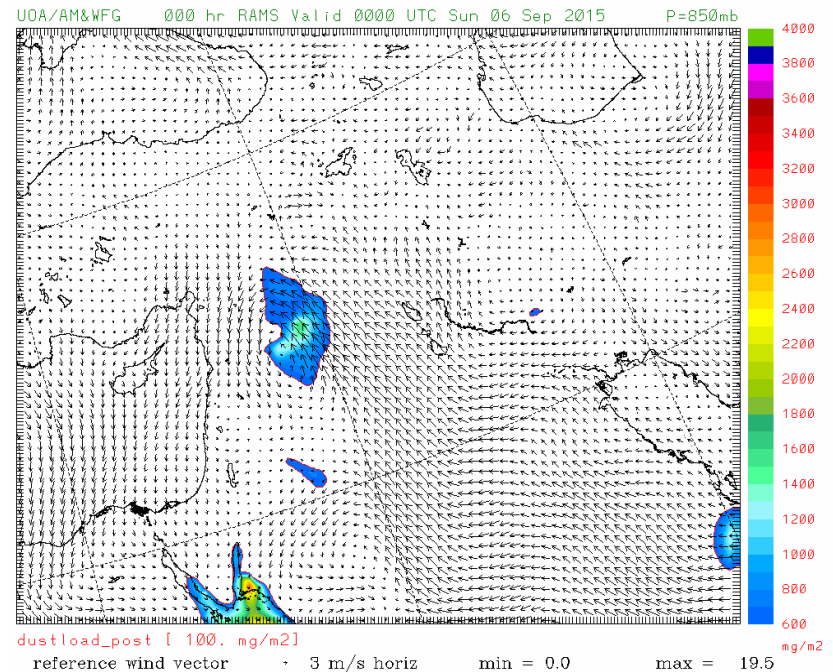
## Dust – Haboobs

A record-breaking Middle East haboob 6-13 September 2015

MSG / SEVIRI Satellite



RAMS model 20x20 km



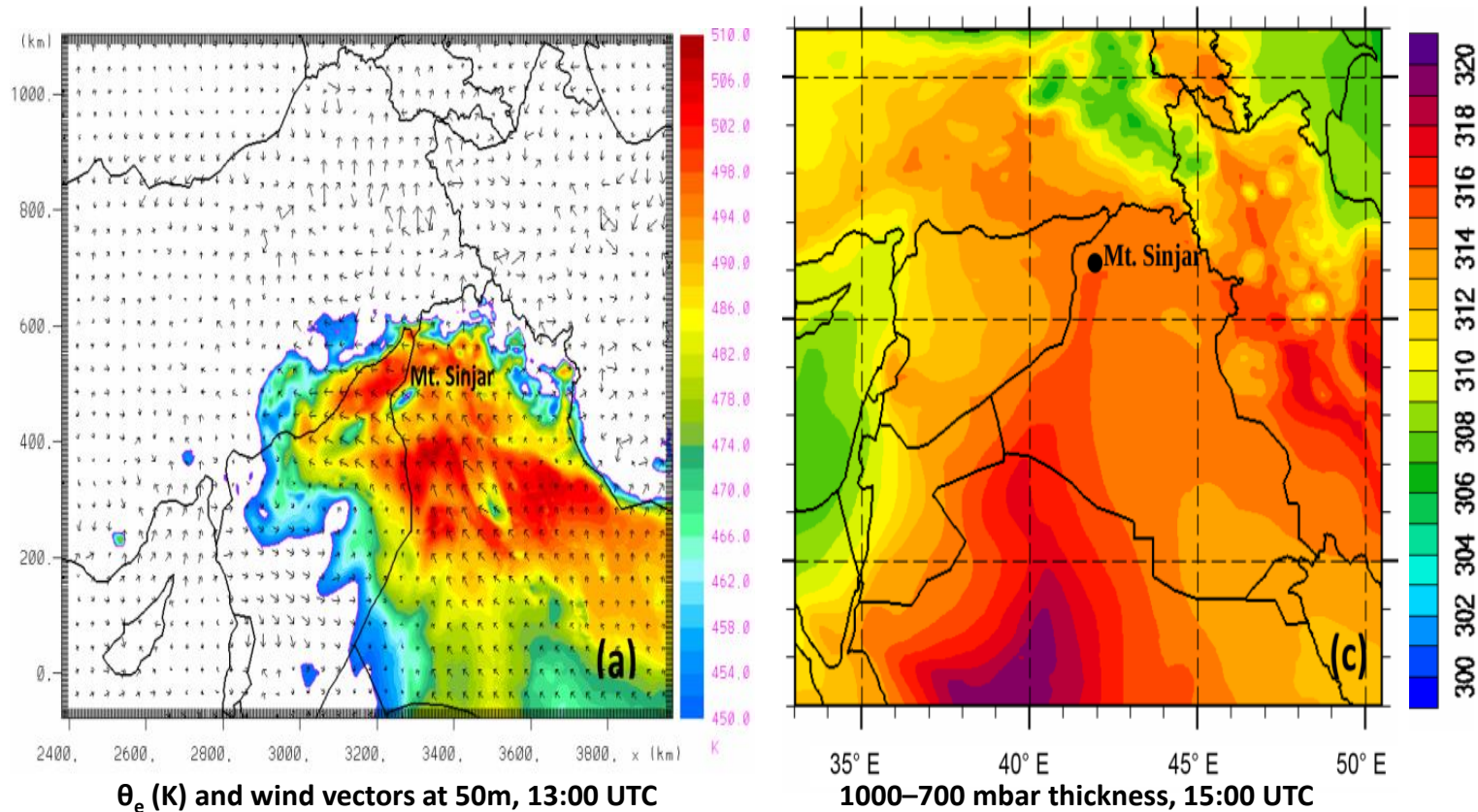
Severe convective downdrafts over the mountainous areas of East Turkey and North Iran resulted in mobilization of dust over Middle East and East Mediterranean.

We used the RAMS-ICLAMS model developed at the University of Athens (Solomos, S., Kallos, G., Kushta, J., Astitha, M., Tremback, C., Nenes, A., Levin, Z., ACP, 2011)



## 2x2 km model grid space over convective area

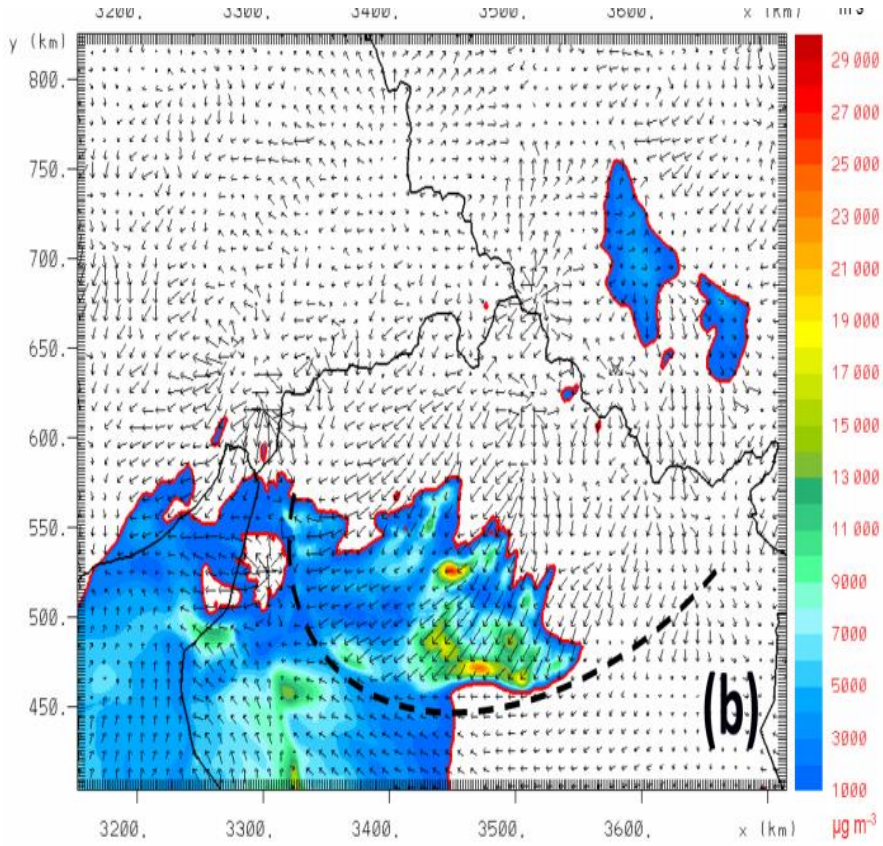
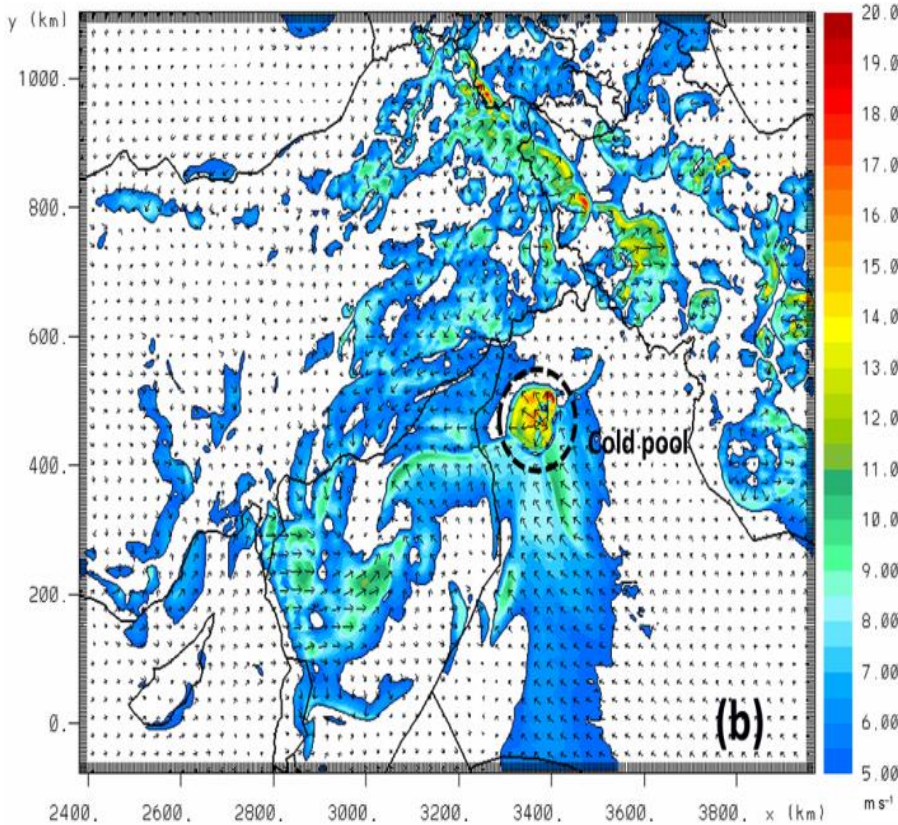
Transport of unstable air masses from Arabia and the Red Sea



## Convective storms trigger density currents and dust mobilization

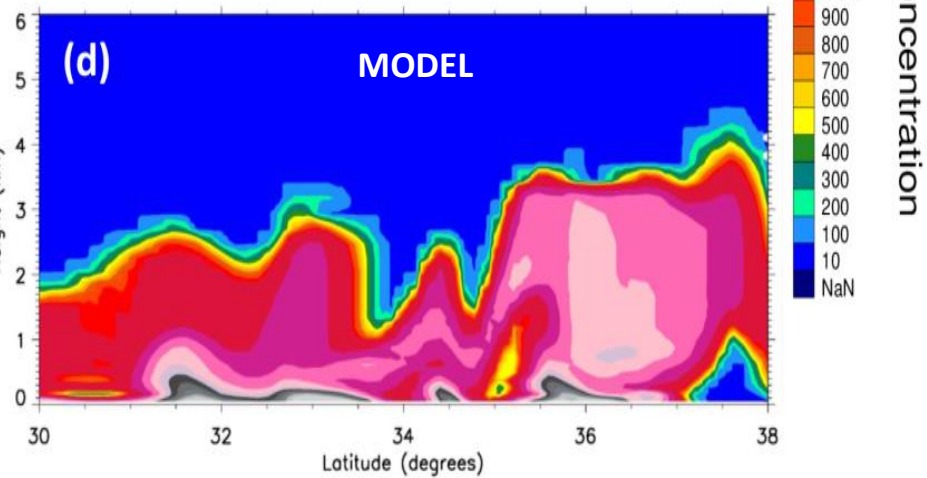
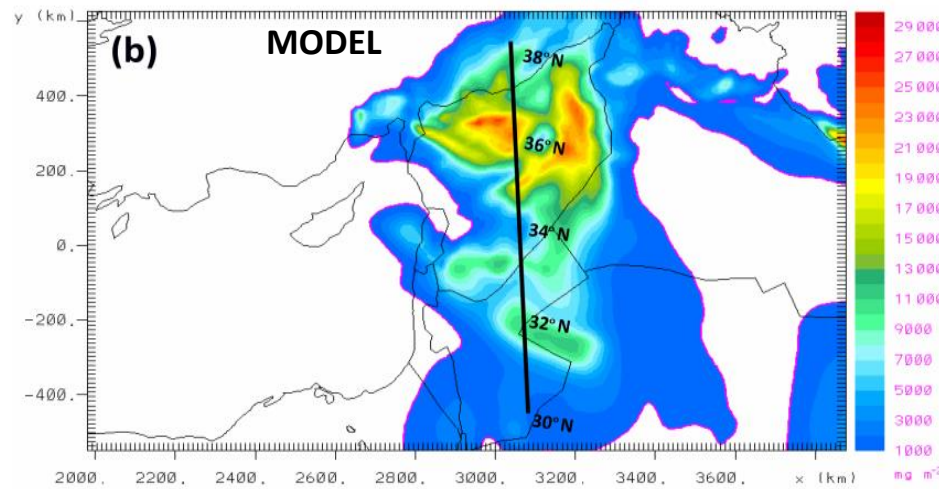
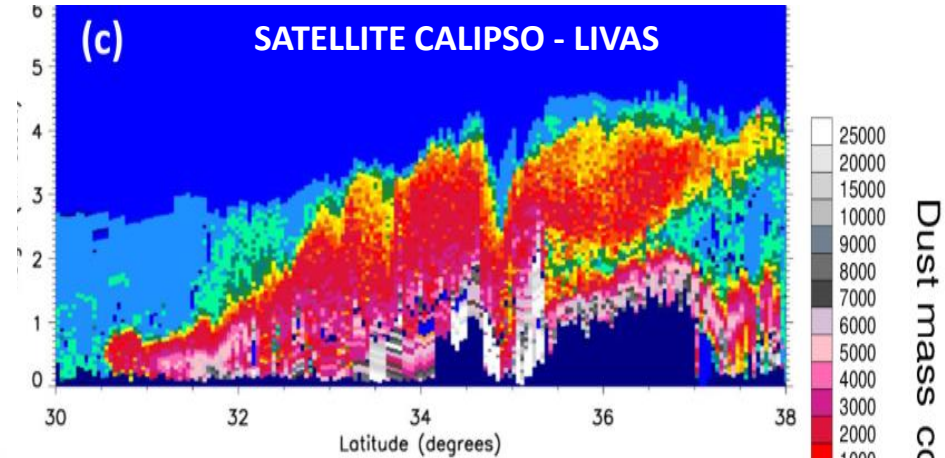
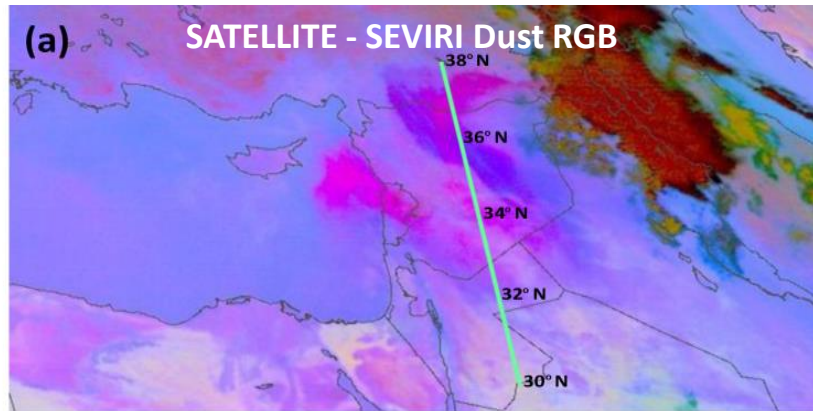
Model wind speed at 10m (m/s), 15:00 UTC

Surface dust concentration ( $\mu\text{g}/\text{m}^3$ ), 20:00 UTC





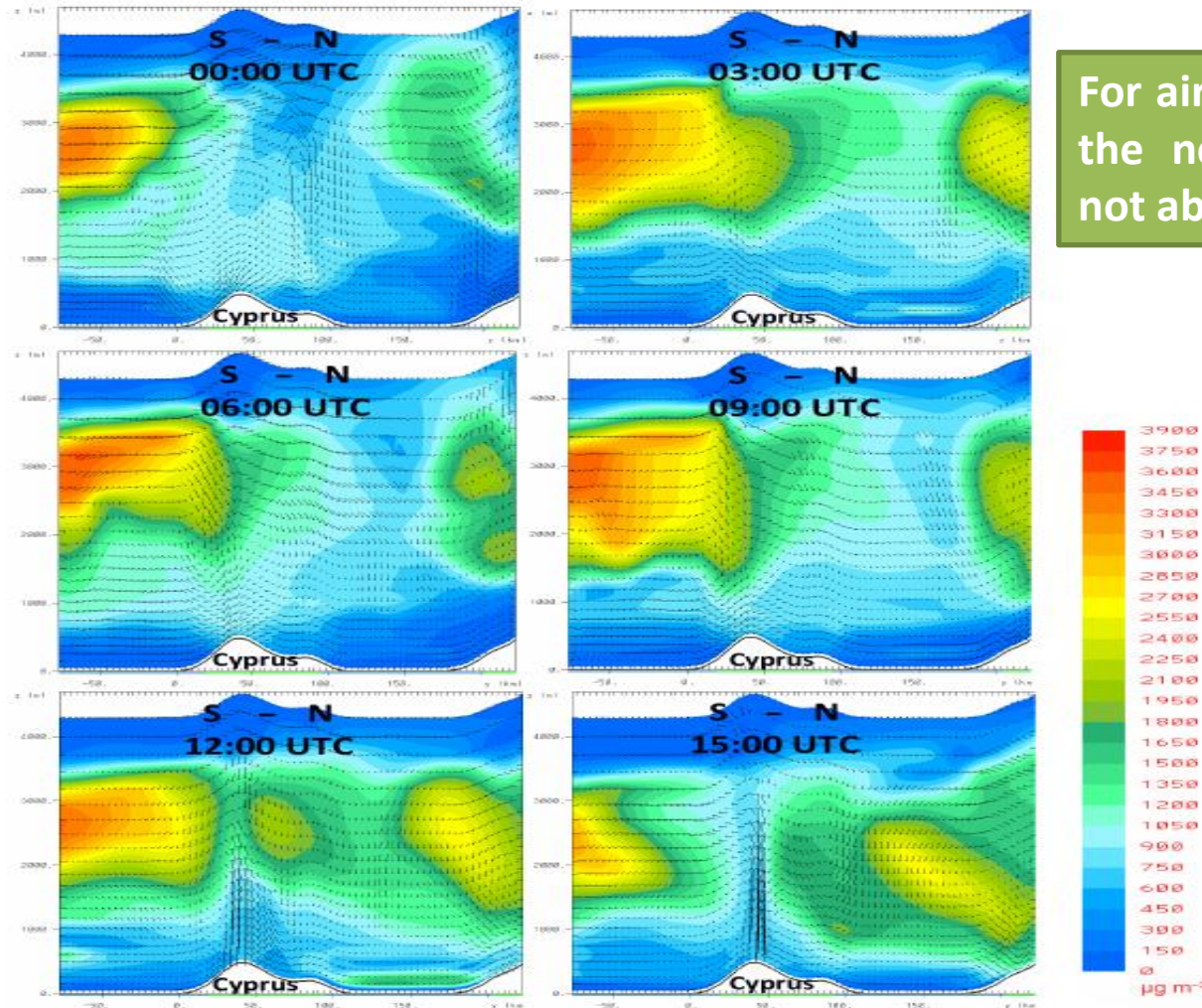
## Cold pool formations and comparison with SEVIRI and CALIPSO



Modeling and remote sensing analysis reveal the extraordinary nature of this event lying at the borders of our remote sensing and modeling capabilities

## Katabatic Winds - Downward mixing of dust due to Cyprus topography

For air-quality purposes we care about the near surface concentrations and not about the detached dust layers



We need high resolution modeling at both source (convective downdrafts) and receptor (katabatic winds).....

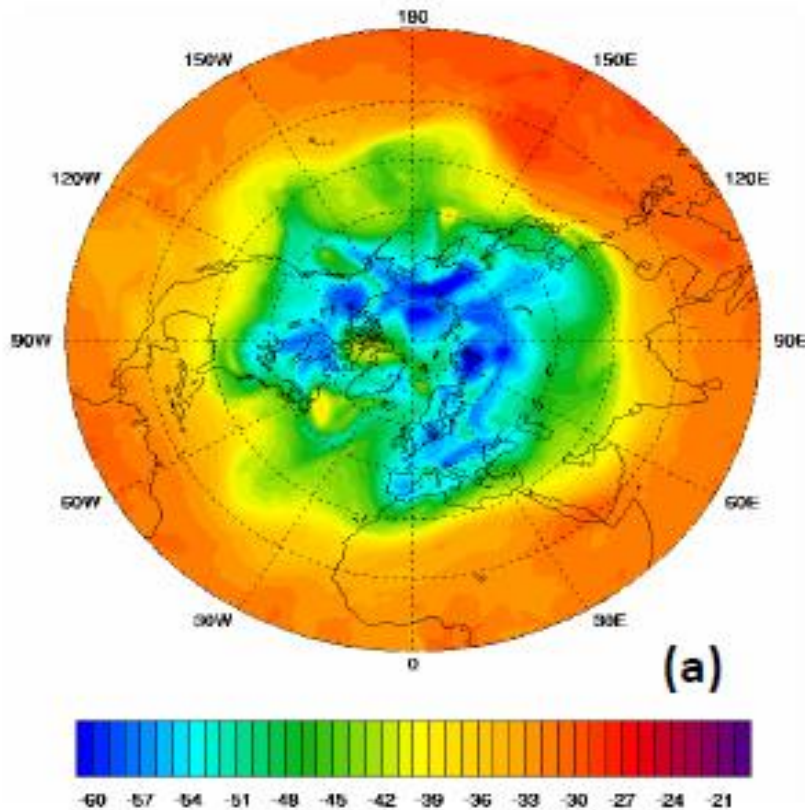
Vertical cross section (south–north) of modelled dust concentration over Cyprus during 00:00–15:00 UTC on 8 September 2015



## Another record breaking dust episode this time in Crete

Temperature at 300 hPa 21 March 2018, 12:00 UTC

### Polar vortex weakening



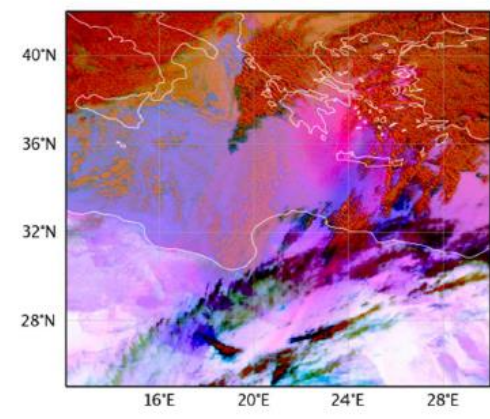
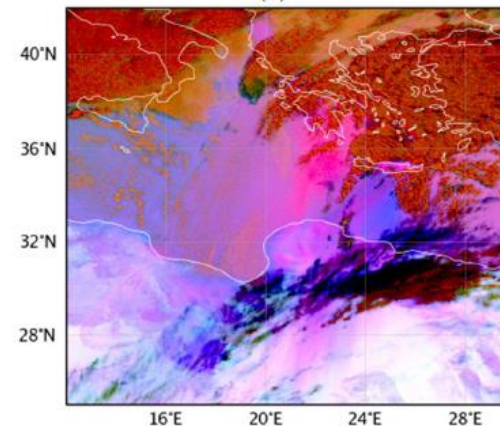
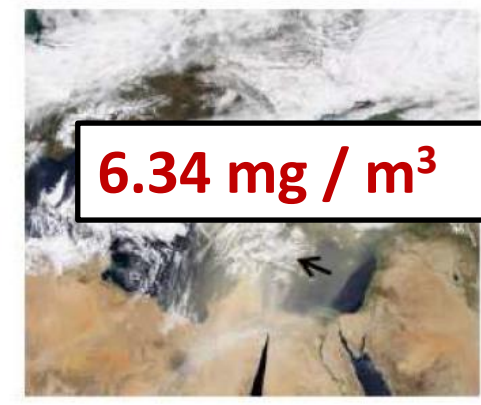
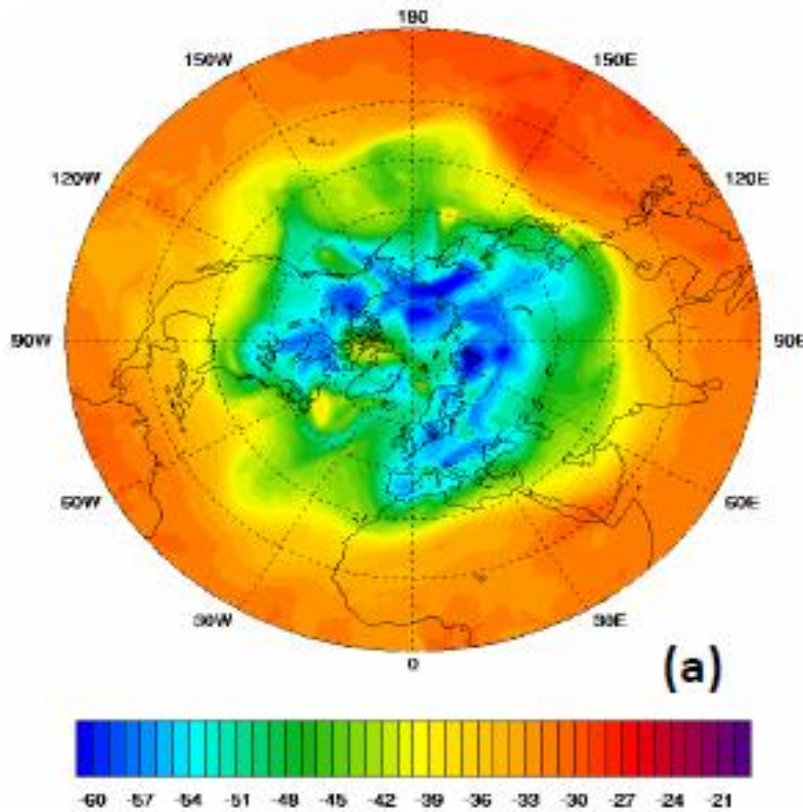
Solomos, S.; Kalivitis, N.; Mihalopoulos, N.; Amiridis, V.; Kouvarakis, G.; Gkikas, A.; Biniotoglou, I.; Tsekeri, A.; Kazadzis, S.; Kottas, M.; Pradhan, Y.; Proestakis, E.; Nastos, P.T.; Marenco, F. From Tropospheric Folding to Khamsin and Foehn Winds: How Atmospheric Dynamics Advanced a Record-Breaking Dust Episode in Crete. *Atmosphere* 2018, 9, 240., 2018



# Another record breaking dust episode this time in Crete

Temperature at 300 hPa 21 March 2018, 12:00 UTC

**Polar vortex weakening**

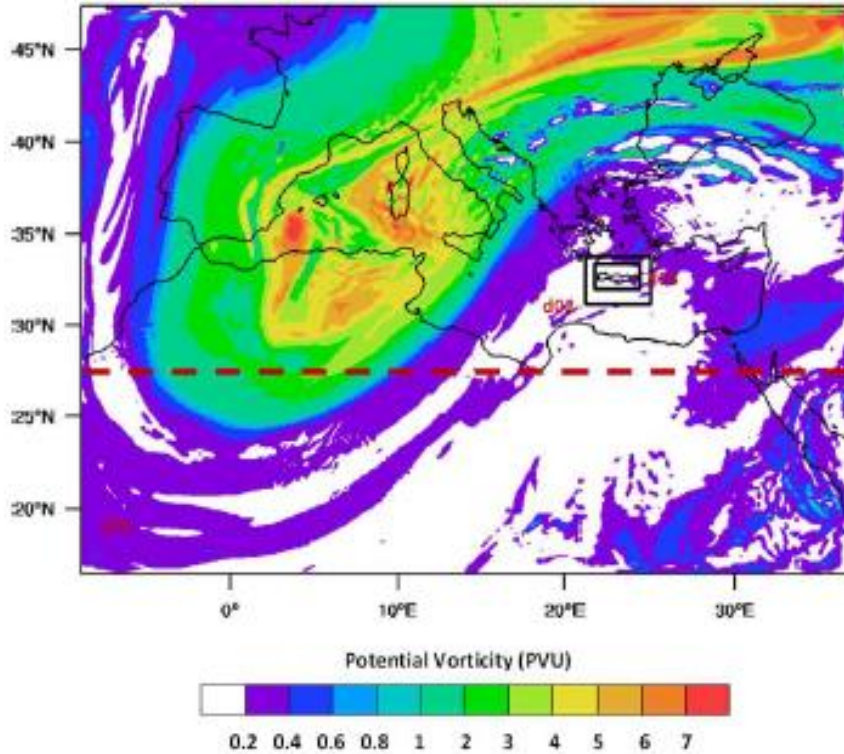


Solomos, S.; Kalivitis, N.; Mihalopoulos, N.; Amiridis, V.; Kouvarakis, G.; Gkikas, A.; Biniotoglou, I.; Tsekiri, A.; Kazadzis, S.; Kottas, M.; Pradhan, Y.; Proestakis, E.; Nastos, P.T.; Marenco, F. From Tropospheric Folding to Khamsin and Foehn Winds: How Atmospheric Dynamics Advanced a Record-Breaking Dust Episode in Crete. *Atmosphere* 2018, 9, 240., 2018

**We used WRF-Chem with GOCARD - AFWA dust scheme  
 1x1 km grid space over Crete**

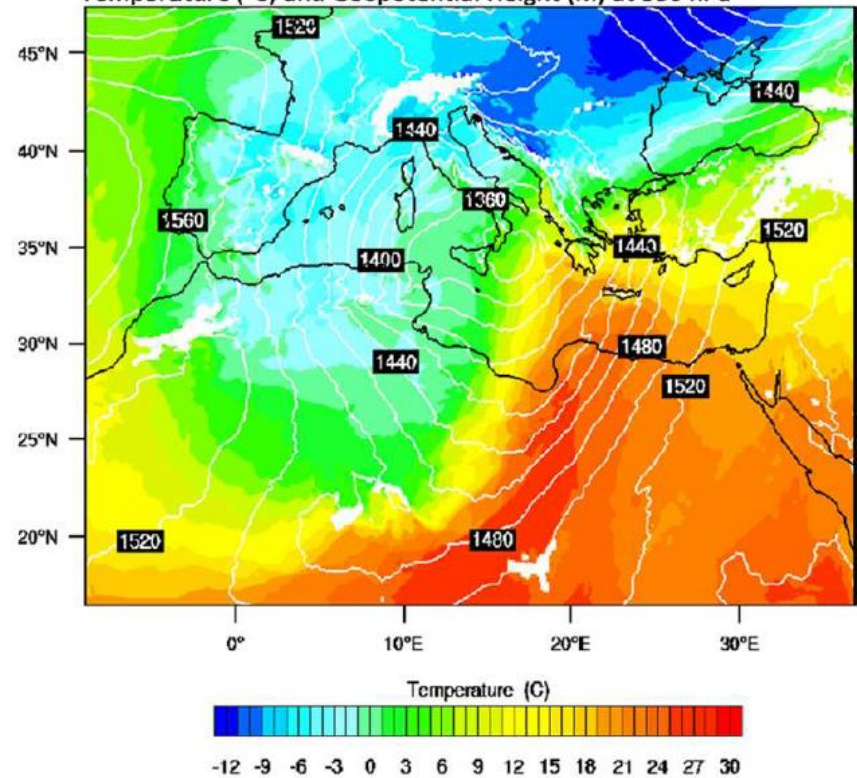
### Stratospheric air intrusion

Potential Vorticity (PVU) at the 315K isentropic  
 Surface, 22 March 06:00 UTC



### Baroclinic zone

Temperature (°C) and Geopotential Height (m) at 850 hPa



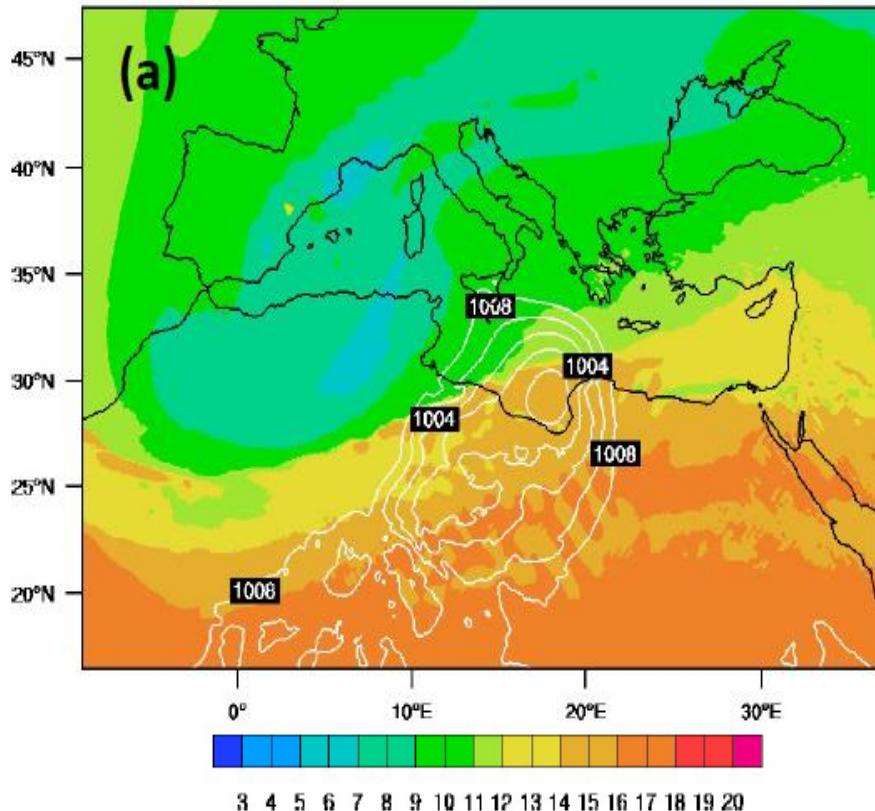


# From Tropospheric Folding to Khamsin and Foehn Winds

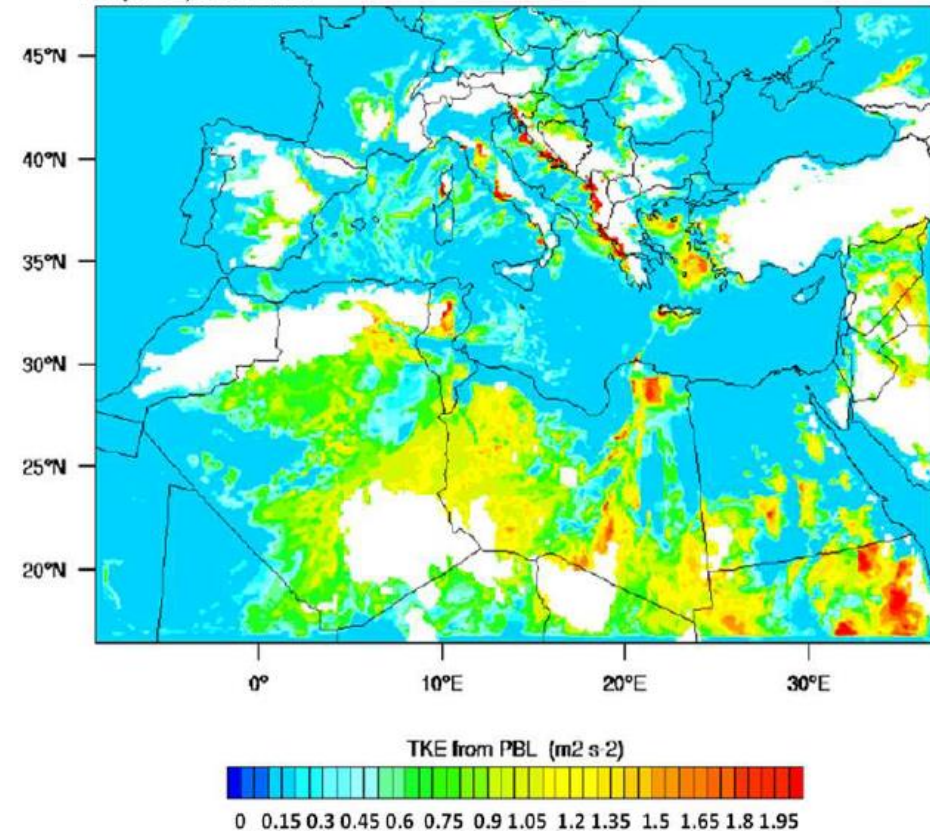
## Cyclogenesis at Gulf of Sirte

## Increased near surface turbulence

Geopotential height (km) at Tropopause (iso PV=2PVU) and slp (hPa)

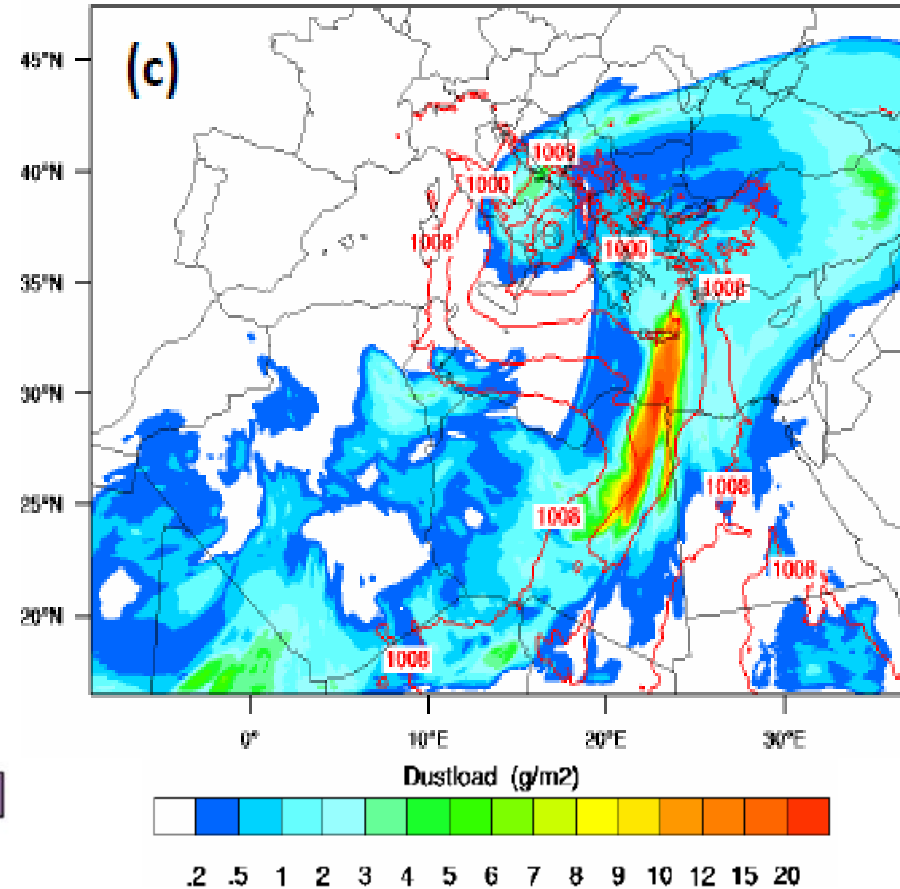
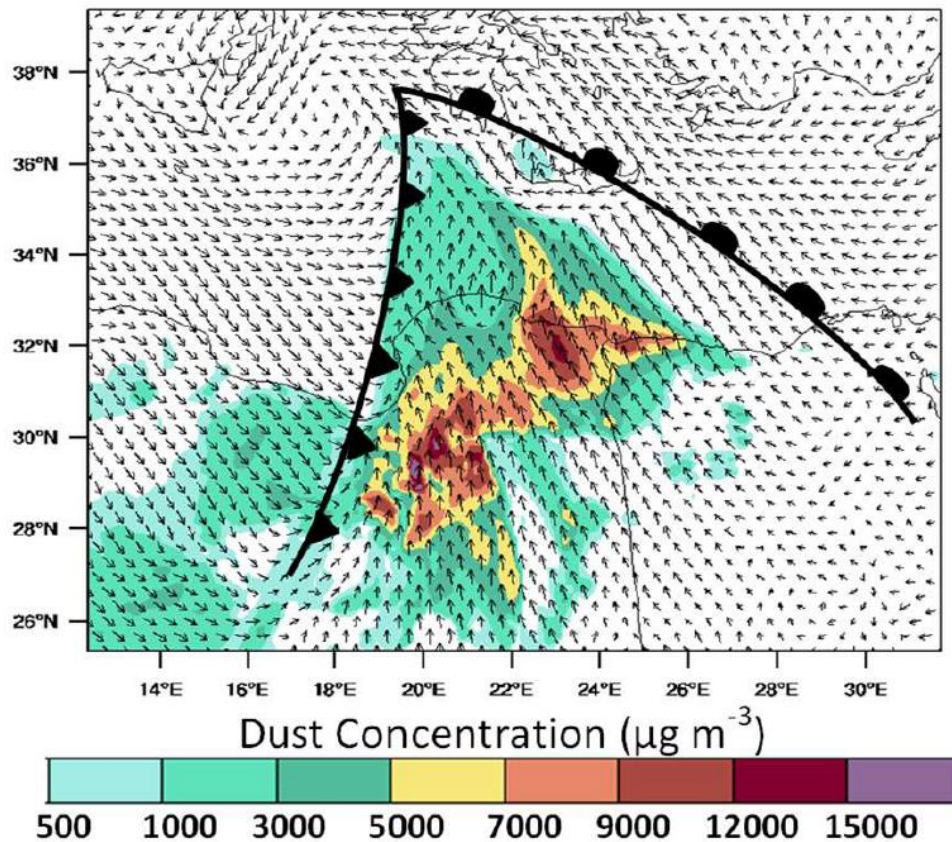


TKE ( $\text{m}^2 \text{s}^{-2}$ ) at 925 hPa





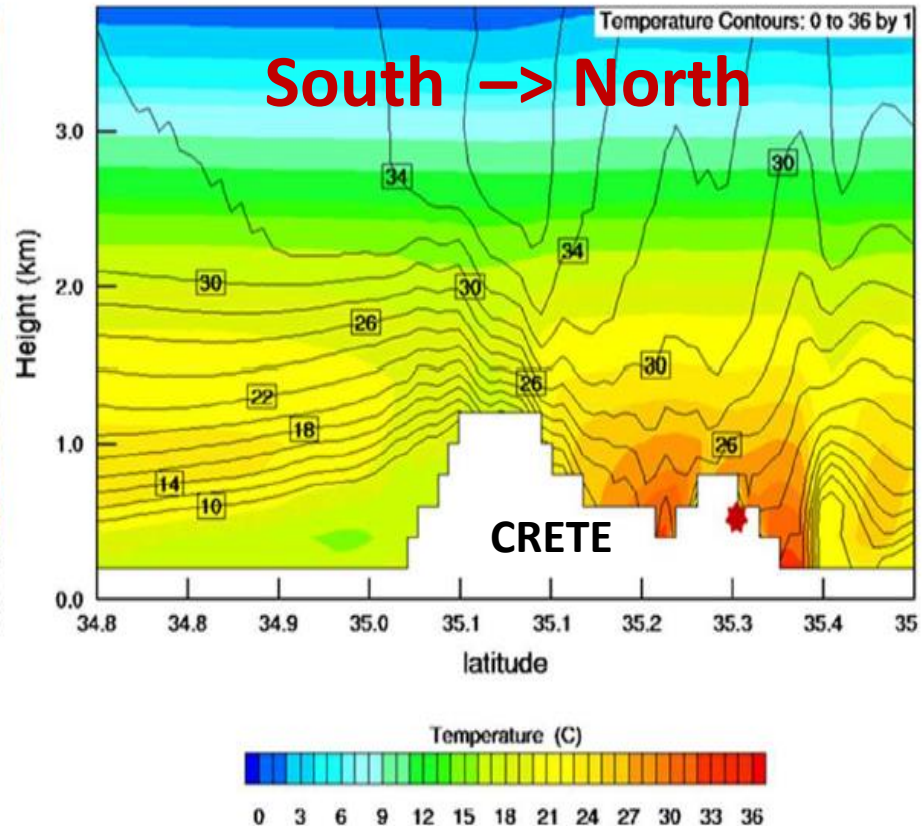
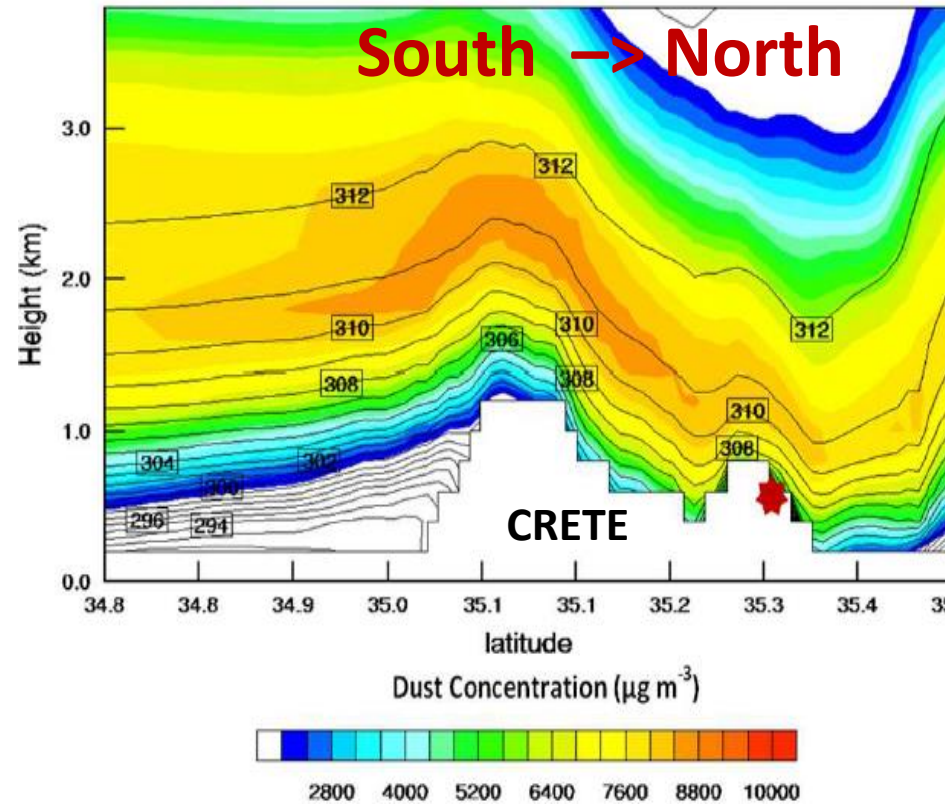
## Transport of dust inside the warm conveyor belt – Khamhsin wind



## Foehn wind transports dust on Crete surface

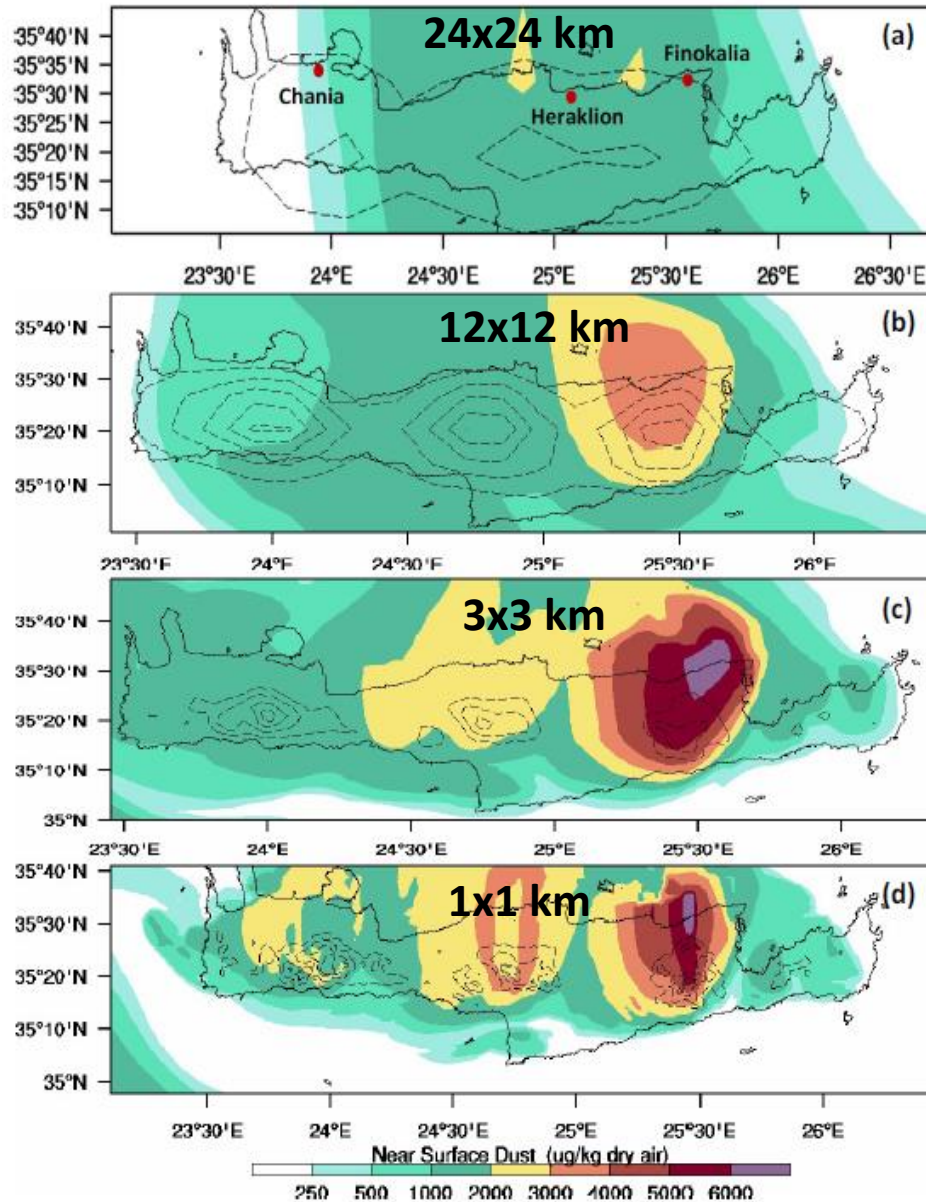
Dust concentration (color scale in  $\mu\text{g}/\text{m}^3$ ) and theta (contours in K)

Temperature (color scale in  $^{\circ}\text{C}$ ) and wind (contours m/s)

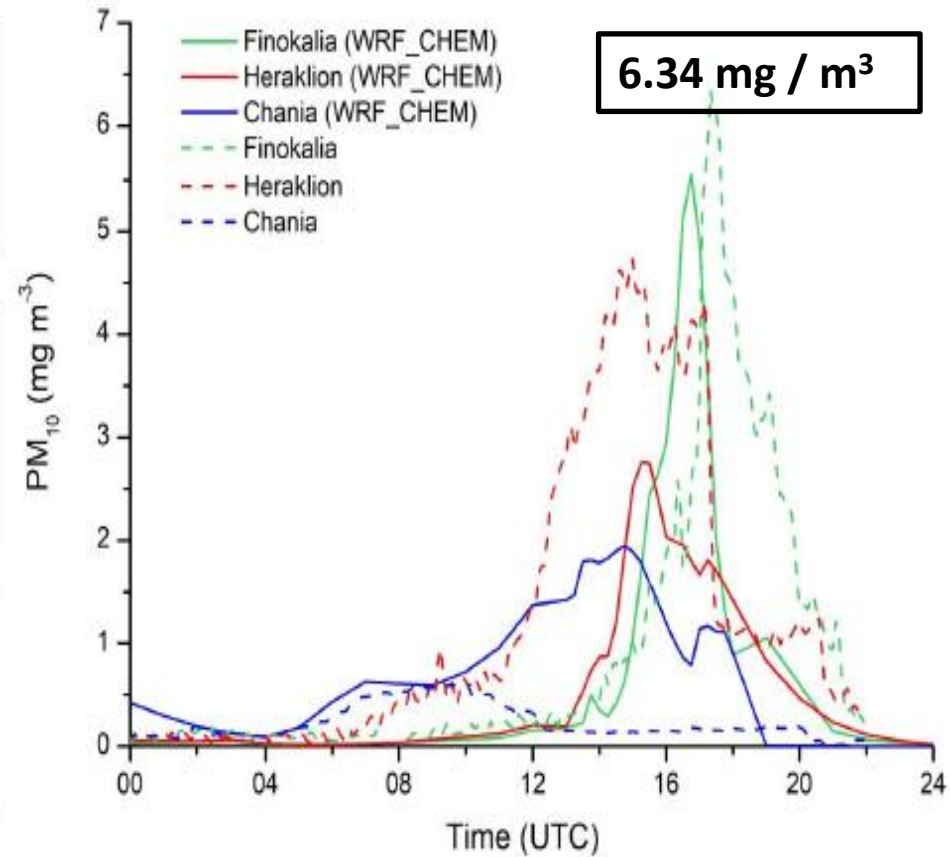


**Foehn wind at the lee side of Crete and downward mixing of dust**



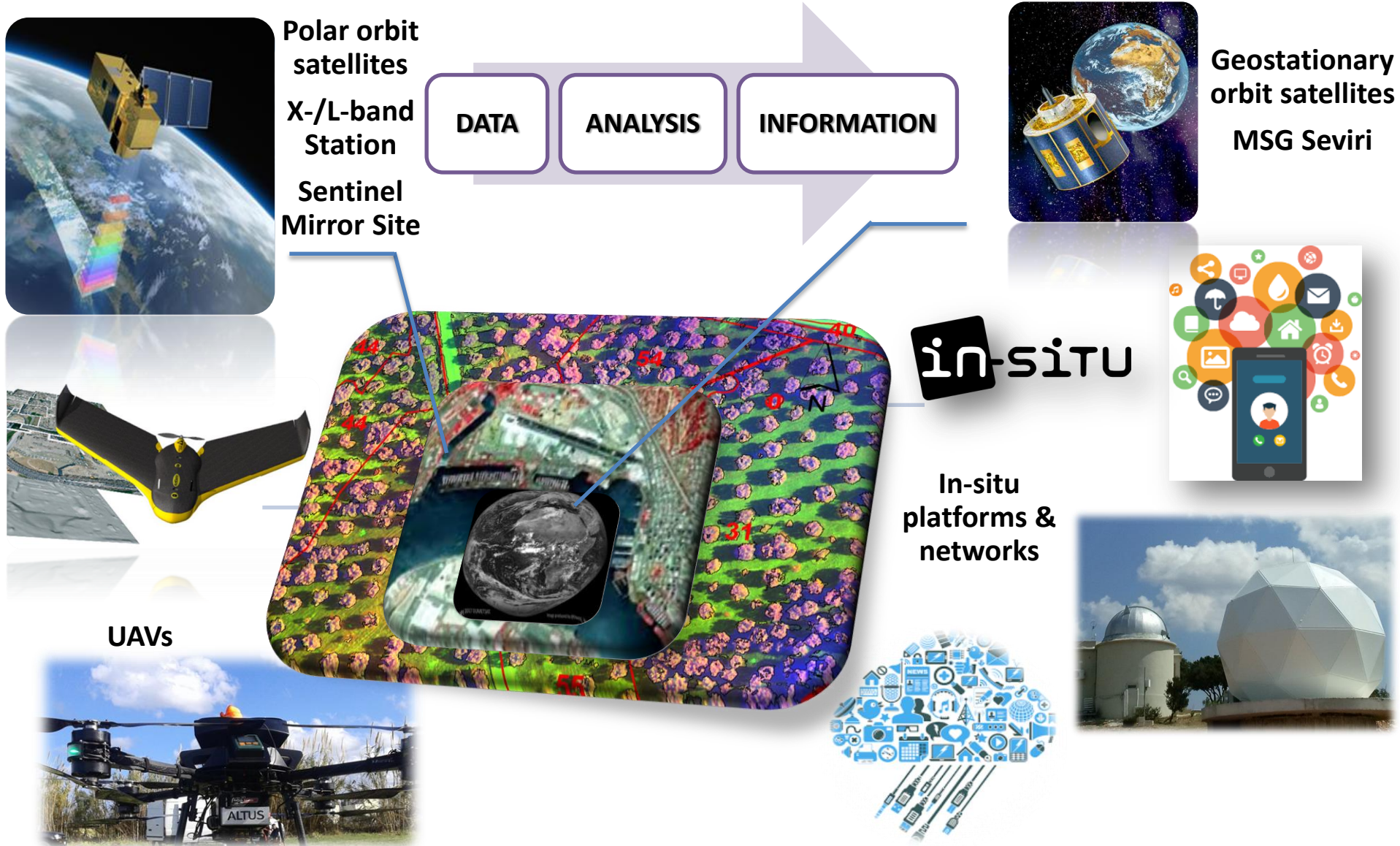


## Effects of model grid space on topography and surface dust resolution





# We need model – remote sensing Synergies





# Hellenic National Sentinel Data Mirror Site / ESA-NOA Agreement

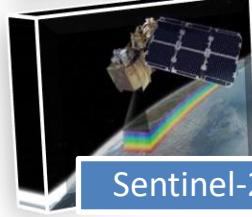


Sentinel Image Processing Toolbox Overview and Description Text

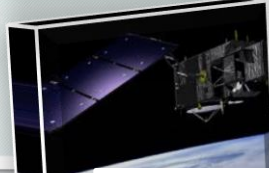
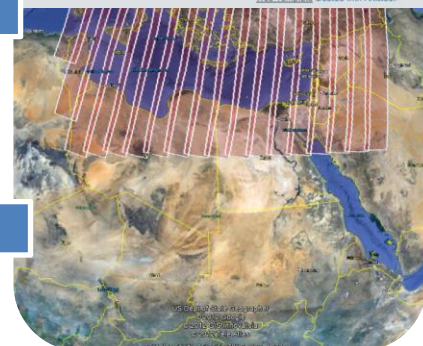
[View the Sentinel Processing Toolbox User Manual](#)



Sentinel-1



Sentinel-2



Sentinel-3

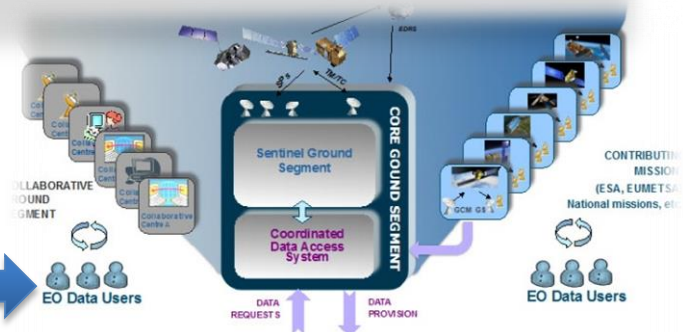


Sentinel-5p

**NOA Hellenic National Sentinel Data Mirror Site Team**  
 NOA Official: Prof. Kanaris C. Tsiganos, President of NOA  
 Scientific Coordinator: Dr. Haris Kontos, Research Director  
 WebMaster: MSc. Theodoros Herekakis, Research Associate  
 Development: MSc. Vassilis Tsironis, Research Associate  
 Curator: Mr. Vaggelis Papakirikou, Research Associate



National Observatory of Athens



<http://sentinels.space.noa.gr>

**Distributes 150-200 GB/day**  
**Operates non-stop 24/7**  
**Powered by the GRNET/GEANT Network Speed 150-200 Mbps**  
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# BEYOND EO Center of Excellence in Copernicus EMS



Regulation (EU) No 377/2014 - Copernicus

Copernicus Work Programme

Sendai Framework (UN)  
 for Disaster Risk Reduction 2015-2030

**COPERNICUS**  
 Emergency Management Service

Home | What is Copernicus | EMS - Mapping | EMS - Early Warning System

LATEST NEWS · 2017-03-08 | [EMS038] Post-disaster situation analyses of flood and landslides in Lima, Peru

**EMS - MAPPING**

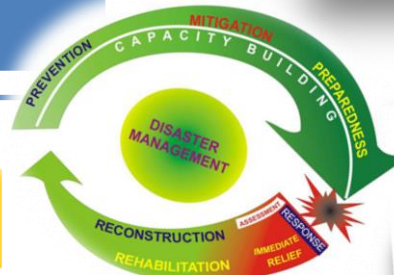
- Service Overview
- Who can use the service
- How to use the service
- Products: Rapid Mapping
- Products: Risk and Recovery
- Quality control / Feedback
- User Guide

**RAPID MAPPING**

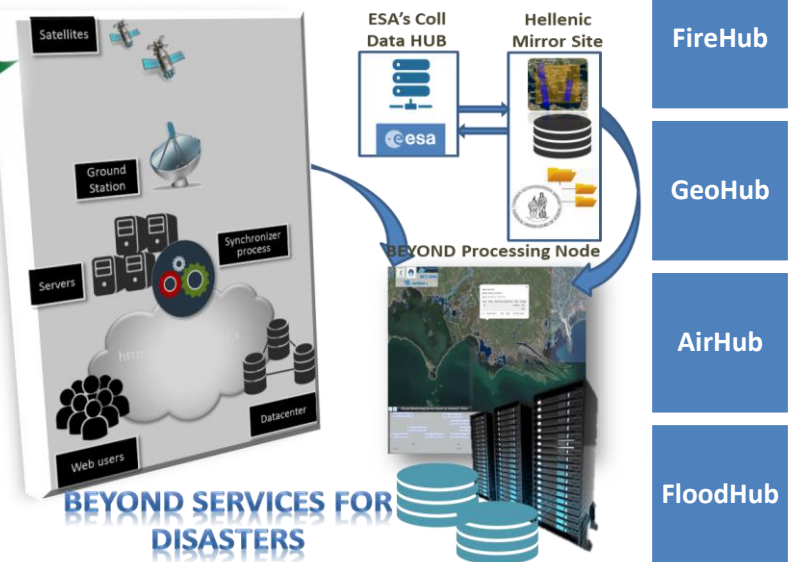
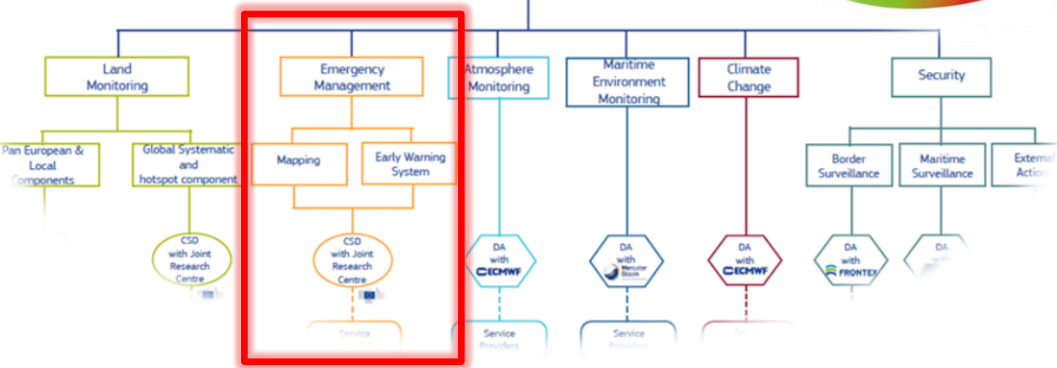
- List of Activations

**List of EMS Risk and Recovery Mapping Activations**

Act. Code	Title	Country/Terr.	Feed
EMS043	Tsunami risks assessment in Southern Italy	Italy	
EMS041	Forest fire risks assessment in Croatia	Croatia	
EMS040	Nation-wide asset mapping Finland	Finland	



## Copernicus Services



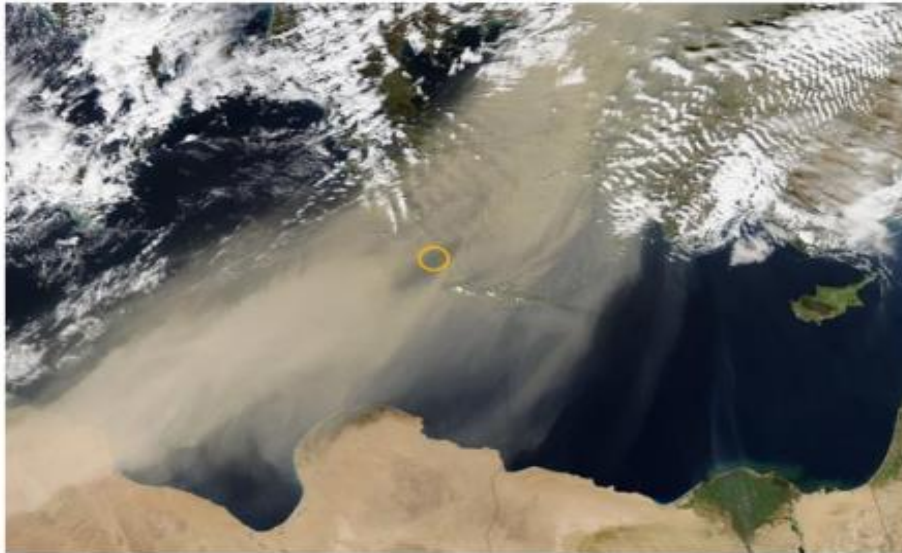


We also need basic science research



DTECT project - Vassilis Amiridis

Basic question : Why dust travels longer distances than expected?



National Observatory of Athens  
Climate Change Observatory in Antikythera



## Summary & Discussion

- Dust is a multi-scale atmospheric process
- Stratospheric intrusion, easterlies, cyclogenesis, katabatic winds, storm downdrafts....
- Improve modeling resolution and physics
- Remote sensing & In-situ & Modeling combinations
- ERC-DTECT project - intensive 5 year dust research in Antikythera

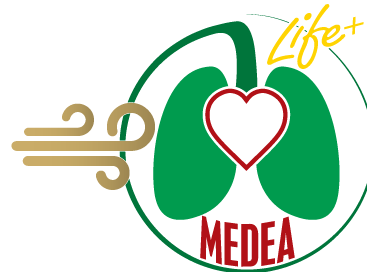
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## Thank You !

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