



# ESA-JAXA Pre-Launch EarthCARE Science and Validation Workshop

13 – 17 November 2023 | ESA-ESRIN, Frascati (Rome), Italy

Assimilation of different aerosol products of the EarthCare mission during the CAL/VAL program

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# The EarthCARE mission



## Scientific objectives:

- Improvement of the vertical distribution of natural and anthropogenic aerosols on a global scale
- Improve our understanding of cloud-aerosol-radiation interactions (NWP and climate purposes)
- Derivation of profiles of atmospheric radiative heating and cooling



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## For this contribution :

- Improvement of the vertical distribution of natural and anthropogenic aerosols on a global scale
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- Derivation of profiles of atmospheric radiative heating and cooling



We will try to address some key points regarding the use of EarthCARE data:

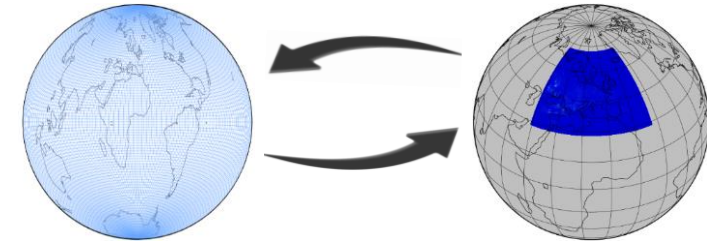
- How can data assimilation contribute to the validation of EarthCARE aerosols observations ?
- What added value can EarthCARE data give to better characterize aerosols at global scale ?
- Can the use of EarthCARE aerosol observations within a global assimilation system add value compared to all existing data ?
- How EarthCARE data could help to improve the model parametrizations using data assimilation ?
- What kind of information could EarthCARE bring to the assimilation system during extreme events (e.g., desert dust outbreaks, wildfire events or volcanic eruptions) ?

# The assimilation system



→ It is developed within the MOCAGE model: the chemical transport model of Météo-France covers both troposphere and stratosphere with gases and aerosols:

- 47 vertical levels (from the ground up to 5 mbar : ~40m near the surface till ~800m in the stratosphere)
- Global:  $2^\circ \times 2^\circ$  ;  $1^\circ \times 1^\circ$  and  $0.5^\circ \times 0.5^\circ$
- Regional:  $0.5^\circ \times 0.5^\circ$  ;  $0.2^\circ \times 0.2^\circ$  and  $0.1^\circ \times 0.1^\circ$



→ Assimilated products

- AOD observations:
  - Many wavelengths (>20: UV-IR) are implemented in MOCAGE for AOD assimilation
- Lidar profiles :
  - The observation operator is able to solve the lidar equation for:
    - Wavelengths: 355, 532, 1064 nm
    - Quantities: the backscattered lidar signal, the extinction coefficient ( $\alpha$ ), the backscattering coefficient ( $\beta$ )
    - Geometries: Satellite, ground-based or aircraft (up or down) lidars

## AOD

## Lidar Profiles

Atmos. Meas. Tech., 9, 5535–5554, 2016  
www.atmos-meas-tech.net/9/5535/2016/  
doi:10.5194/amt-9-5535-2016  
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Atmospheric  
Measurement  
Techniques  
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### Aerosol data assimilation in the chemical transport model MOCAGE during the TRAQA/ChArMEx campaign: aerosol optical depth

Bojan Sič<sup>1,2</sup>, Laaziz El Amraoui<sup>1</sup>, Andrea Piacentini<sup>2</sup>, Virginie Marécal<sup>1</sup>, Emanuele Emili<sup>2</sup>, Daniel Cariolle<sup>2</sup>,  
Michael Prather<sup>3</sup>, and Jean-Luc Attié<sup>1,4</sup>

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Revised: 20 September 2016 – Accepted: 22 September 2016 – Published: 22 November 2016

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https://doi.org/10.5194/amt-13-4645-2020  
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Atmospheric  
Measurement  
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### Aerosol data assimilation in the MOCAGE chemical transport model during the TRAQA/ChArMEx campaign: lidar observations

Laaziz El Amraoui<sup>1</sup>, Bojan Sič<sup>1,a</sup>, Andrea Piacentini<sup>2</sup>, Virginie Marécal<sup>1</sup>, Nicolas Frebourg<sup>1,a</sup>, and Jean-Luc Attié<sup>1,3</sup>

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Correspondence: Laaziz El Amraoui (laaziz.elamraoui@meteo.fr)

Received: 10 December 2019 – Discussion started: 28 January 2020

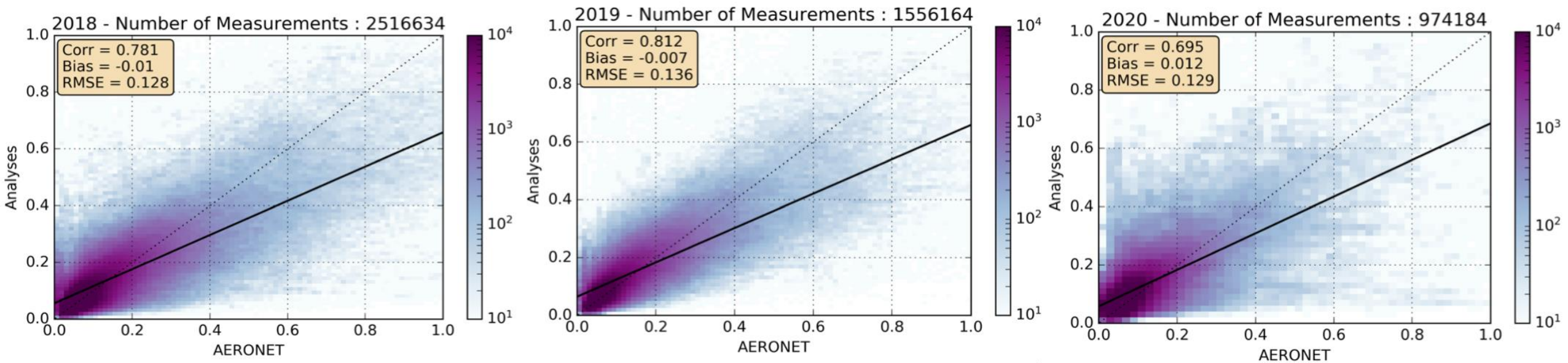
Revised: 8 July 2020 – Accepted: 21 July 2020 – Published: 2 September 2020



# Assimilation of AOD (MODIS)

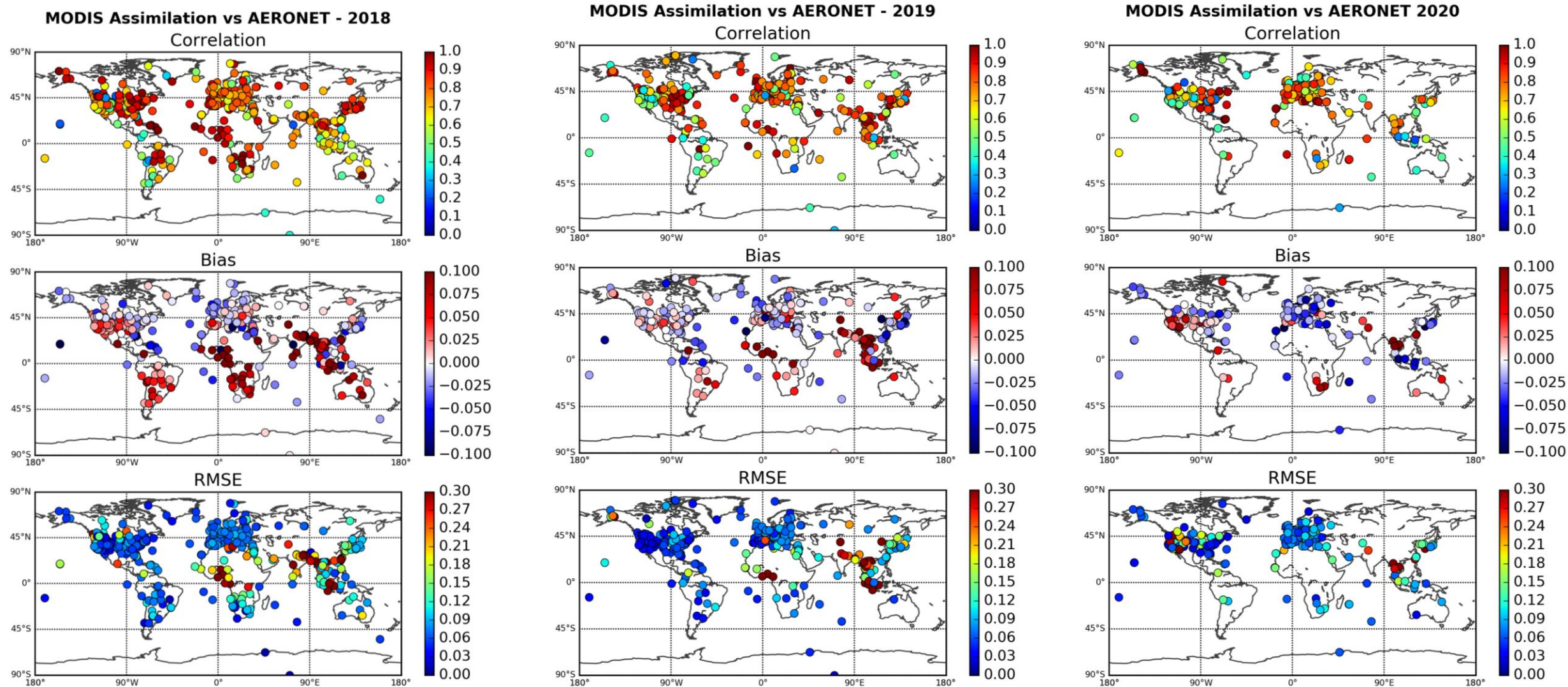


- The assimilation system is operational since January 2020
- Validation of MODIS AOD assimilation for many years and for specific events:



➔ Overall good agreement of assimilated fields compared to AERONET

# Assimilation of AOD (MODIS)





# Assimilation of AOD (MODIS)

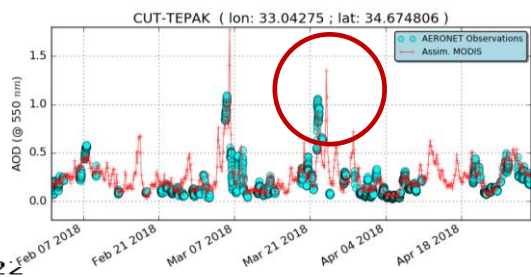


## Saharan dust Outbreak over Greece (March 2018)

THE WATCHERS  
EARTH CHANGES SEVERE WEATHER SPACE WEATHER SPACE RESEARCH  
SWX Center Reach Us Register Monday, March 2, 2020 10:36 UTC

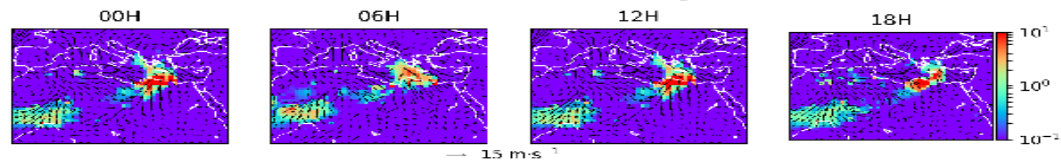
### Severe dust storm hits Crete, Greece

Posted by Teo Blašković on March 23, 2018 at 09:36 UTC (1 year ago)  
Categories: Dust and haze, Dust storms, Featured articles

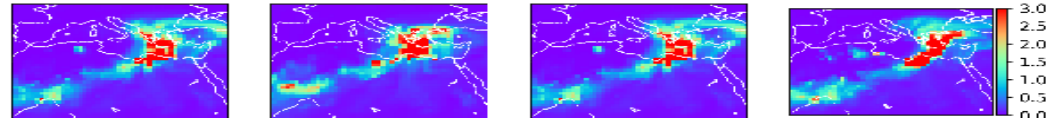


20180322

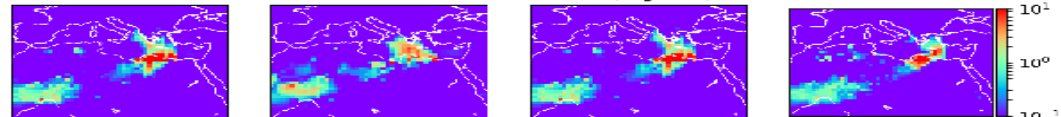
### a) Surface Desert Dust Concentration ( $\text{mg}\cdot\text{m}^{-3}$ )



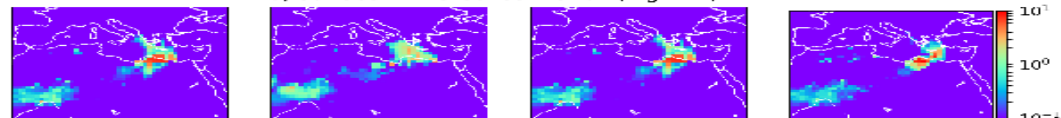
### b) Desert Dust AOD



### c) Surface PM10 Concentration ( $\text{mg}\cdot\text{m}^{-3}$ )



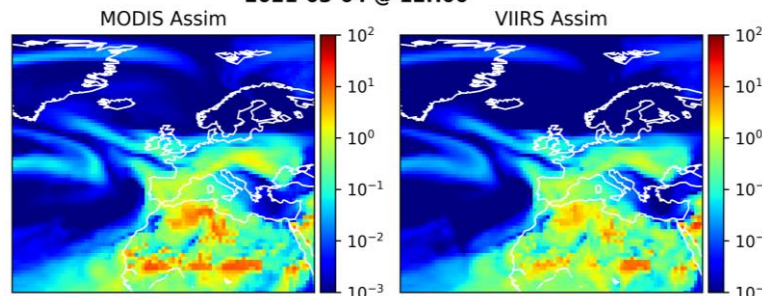
### d) Surface PM2.5 Concentration ( $\text{mg}\cdot\text{m}^{-3}$ )



## Desert dust event over France (February - March 2021):

Desert Dust Total column ( $\text{g}/\text{m}^2$ )

2021-03-04 @ 12H00



## Le Monde

PLANÈTE - POLLUTIONS

Quand les poussières de sable du Sahara arrivent en France, ce n'est pas sans conséquences sur la santé

Ce phénomène se produit pour la troisième fois en moins d'un mois. Les particules transportent notamment virus et autres agents pathogènes.

Par Stéphane Mandard

Publié le 03 mars 2021. Mise à jour le 04 mars 2021



## Pollution event due to dust transport over China (March 2021)

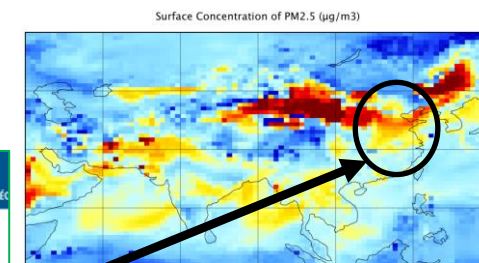
LA TRIBUNE  
PARTAGERS | CÉLÉBRITÉ  
ECONOMIE BOURSE ENTREPRISES & FINANCE TECH VOS FINANCES IDÉES RÉGIONS CARRIÈRES VIDÉO

La capitale chinoise Pékin enveloppée par un épais nuage de poussière

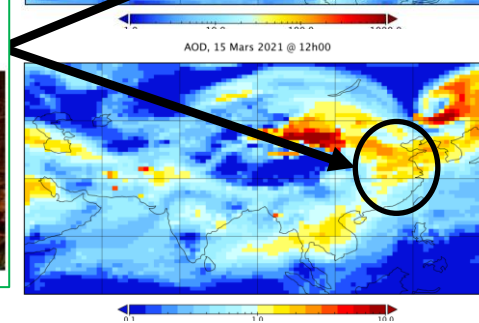
Reuters, 15/03/2021



(Credits : Thomas Peter)



PM2.5  
**+10 fois**  
**la norme**



AOD  
**~3**

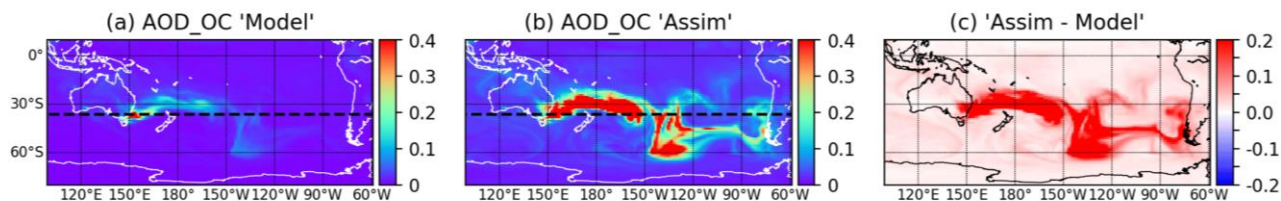


# Assimilation of AOD (MODIS)

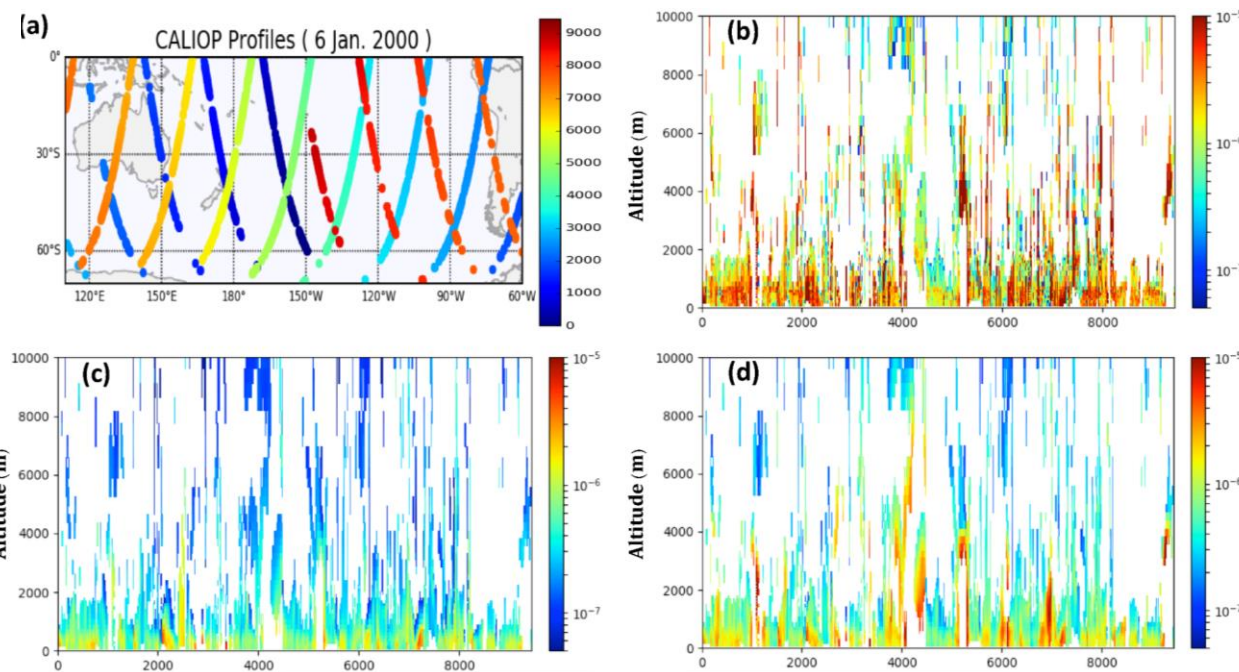
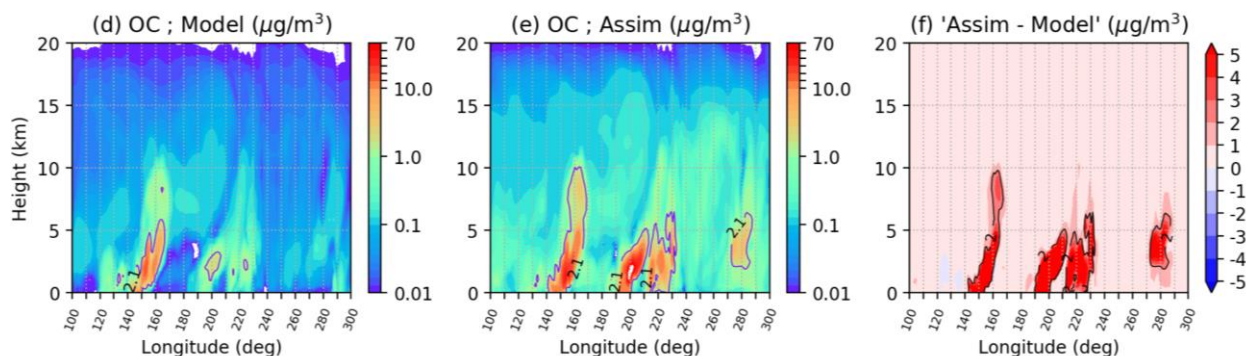


## Australian Wildfires: Nov – Dec 2019

January 6, 2020 @ 12h00



- (a): CALIOP trajectory
- (b): Backscatter coefficient (CALIOP)
- (c): Backscatter coefficient (Model)
- (d): Backscatter coefficient (MODIS Assimilation)



*El Amraoui et al., 2022*

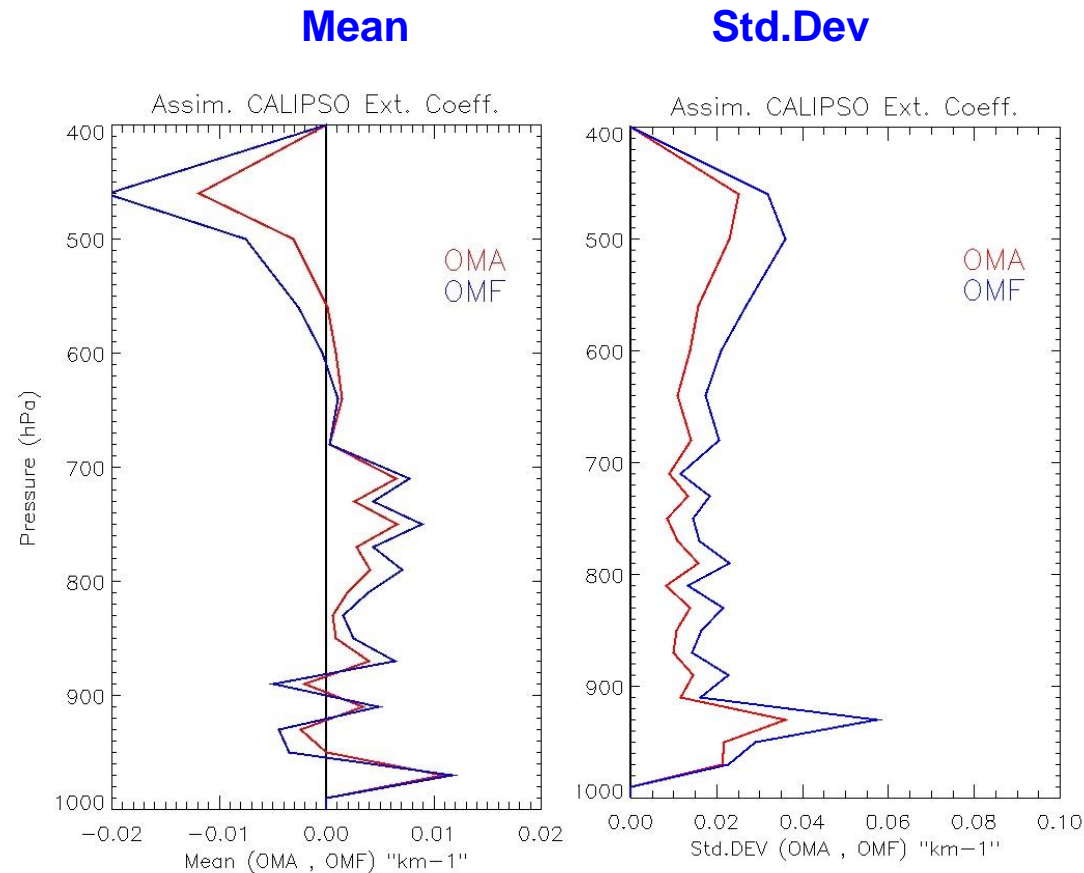
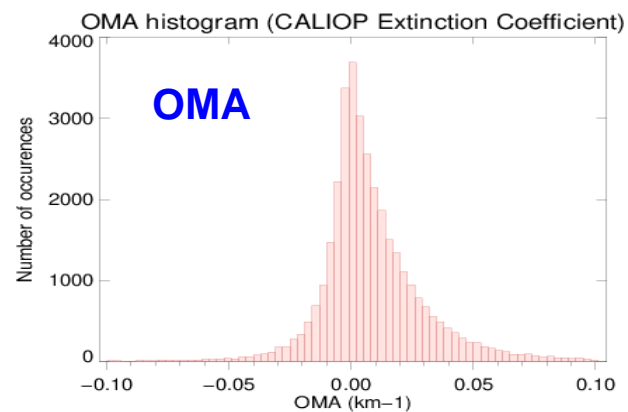
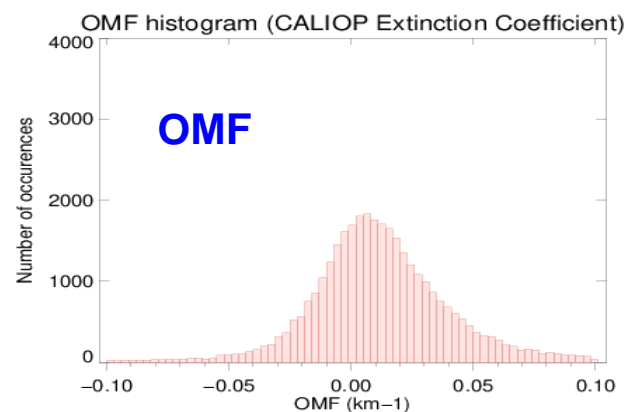
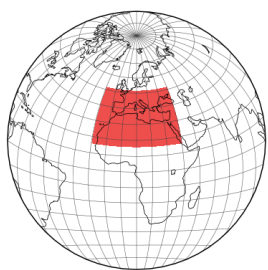
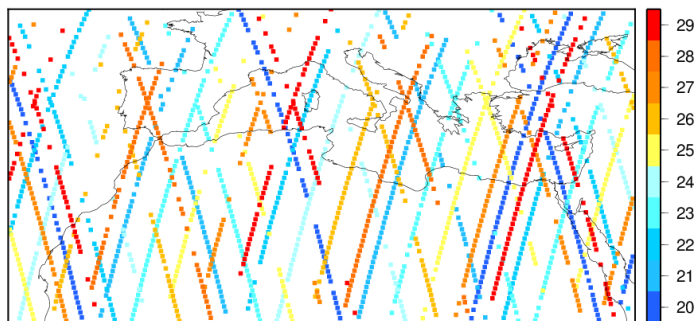


# Assimilation of CALIOP lidar profiles



## Assimilation exercise :

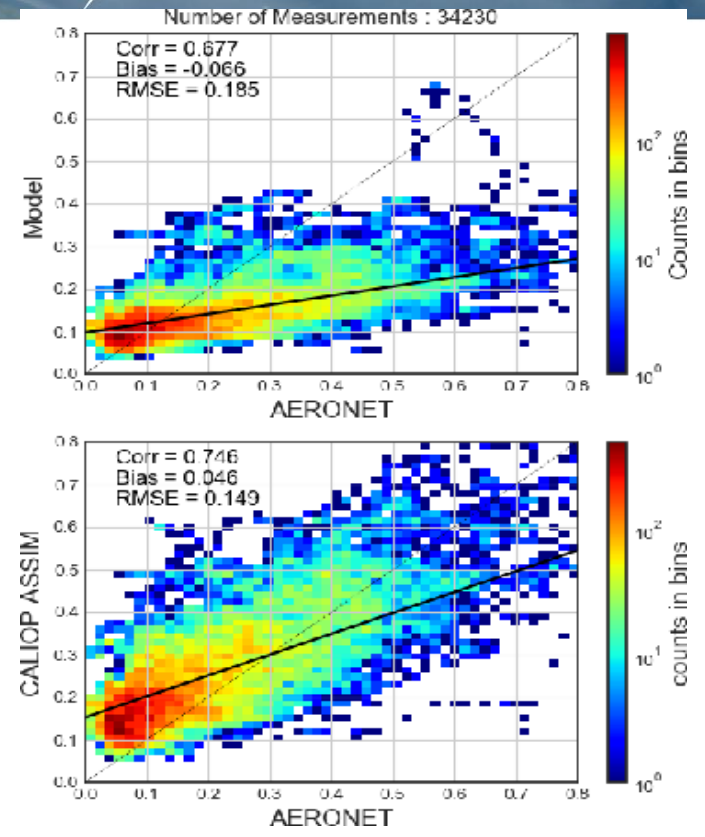
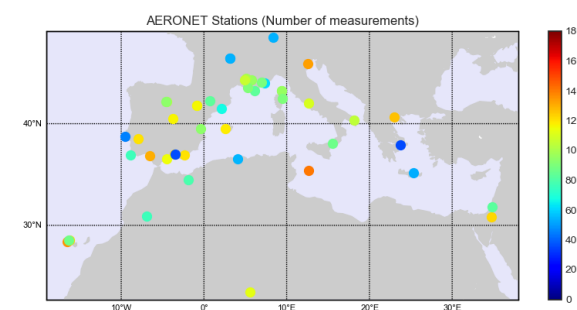
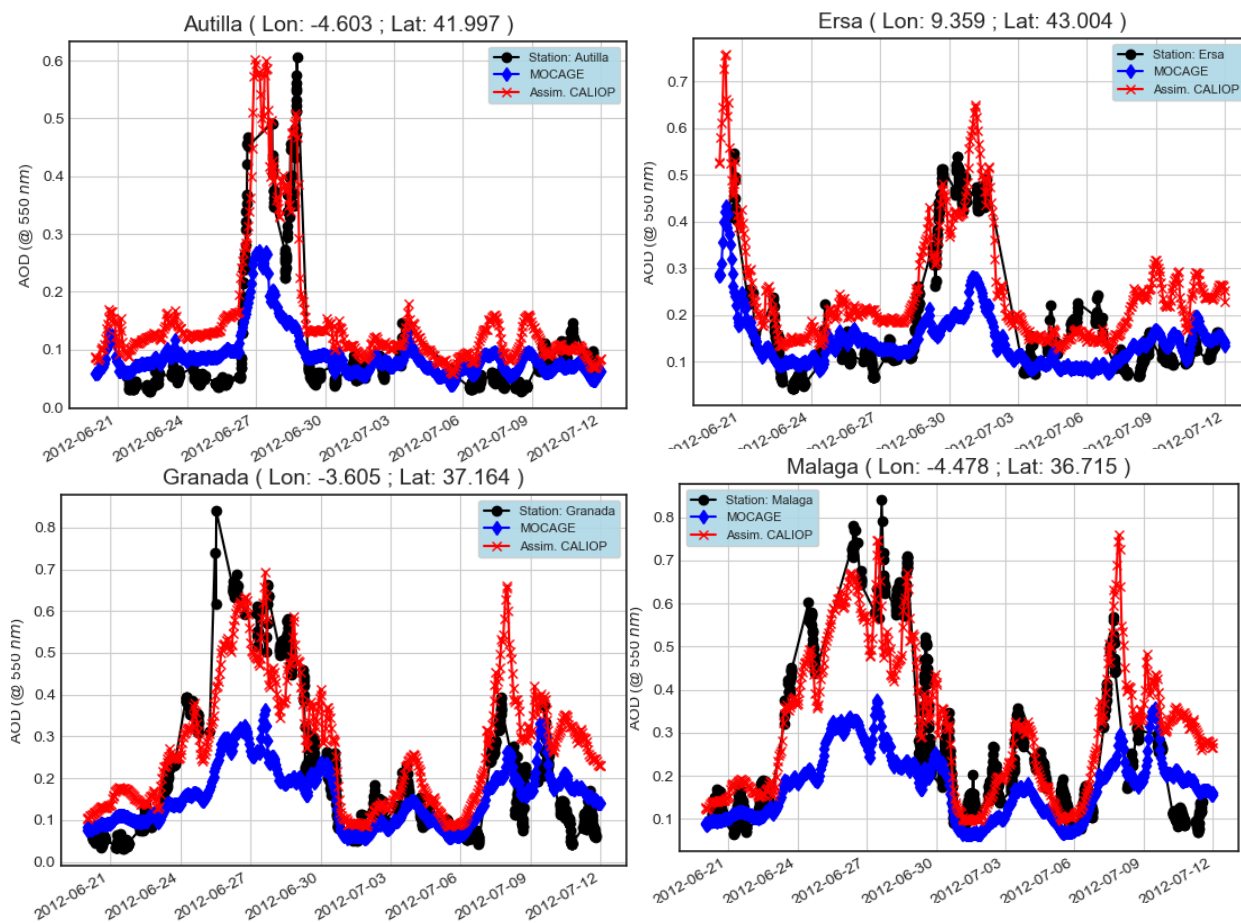
- TRAQA-2012 (20-29 June)
- Saharan Dust Outbreak over The MB
- Extinction Coefficient



# Assimilation of CALIOP lidar profiles



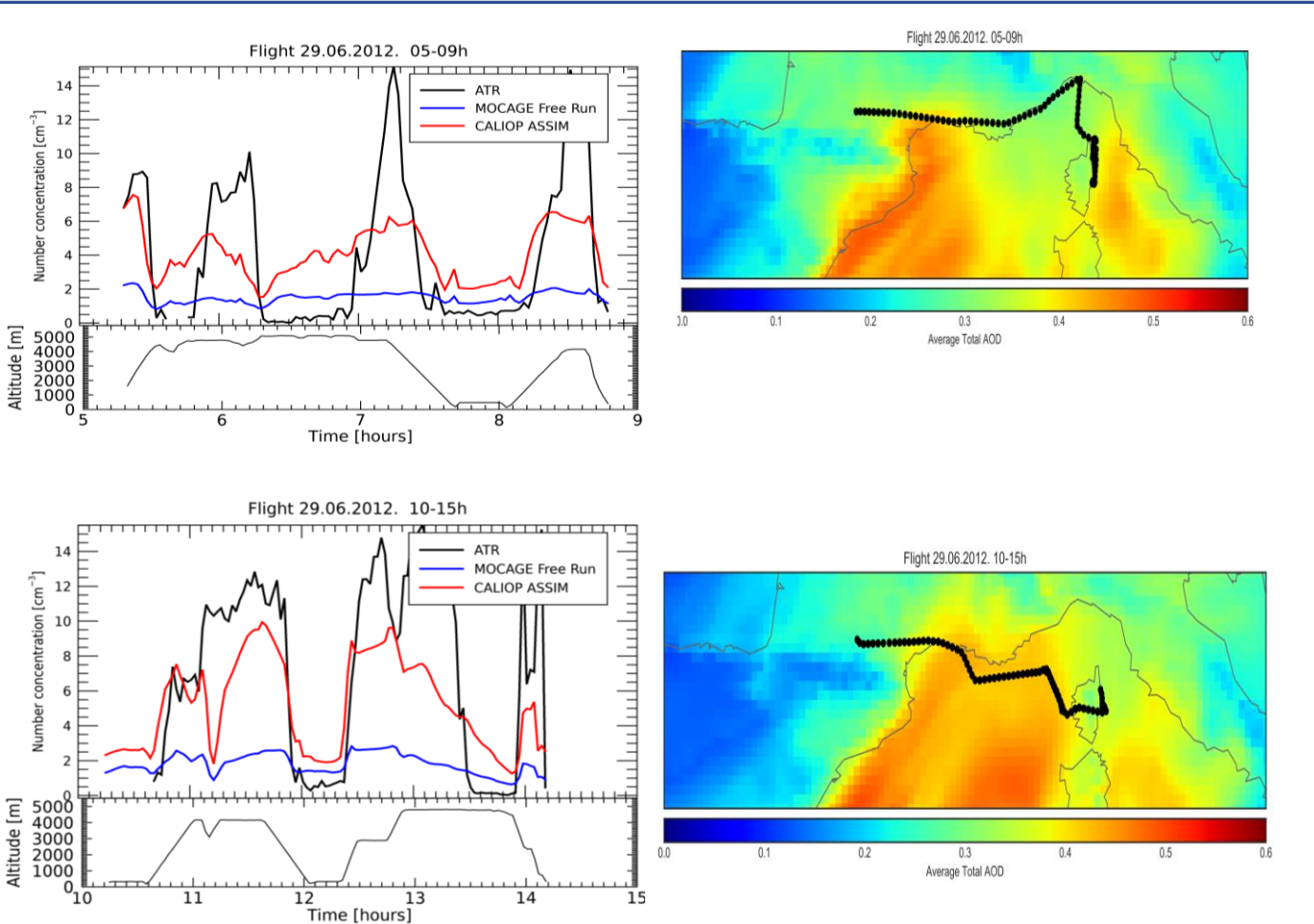
- Comparison with AERONET AOD observations



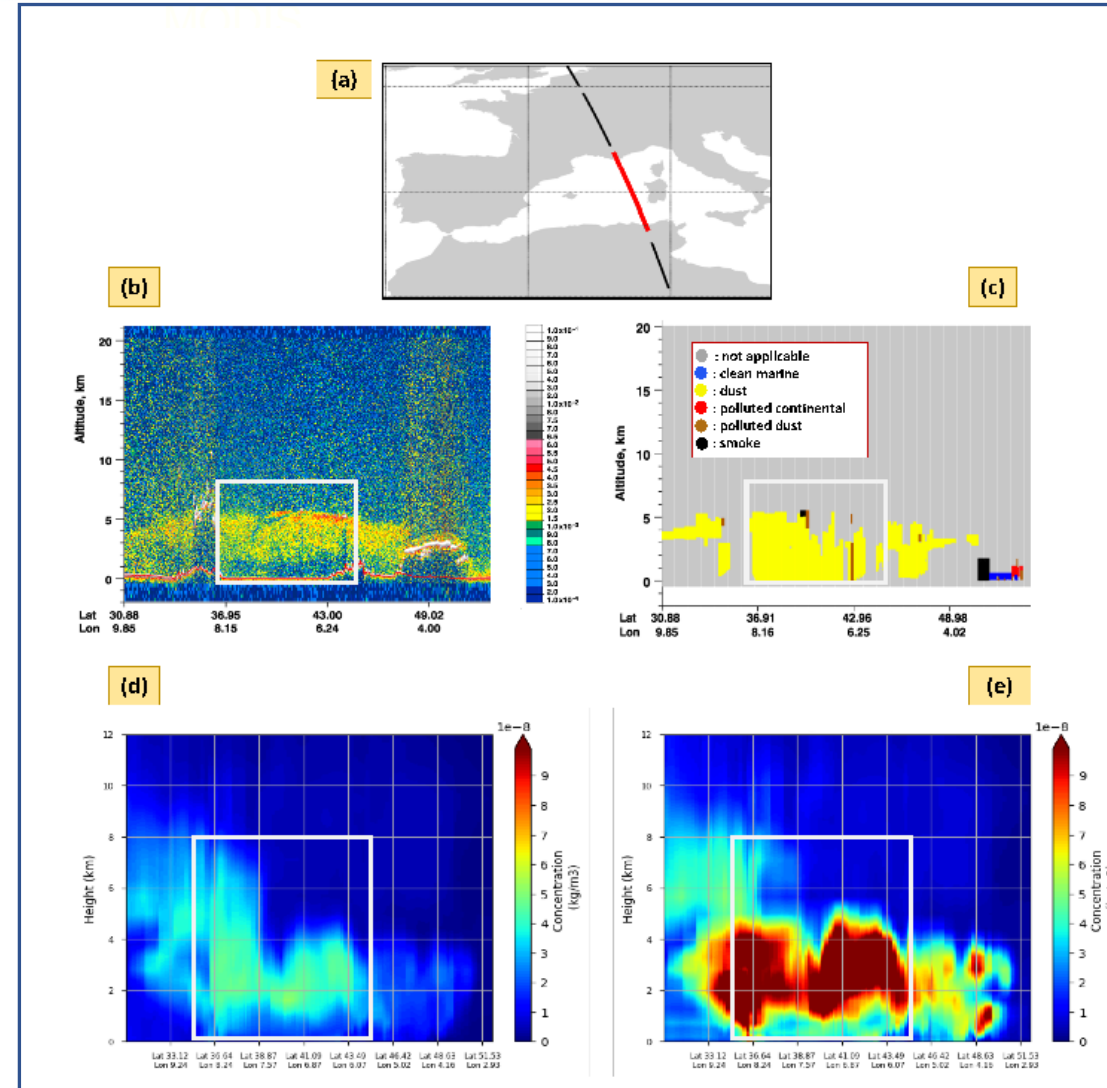
N <sub>obs</sub>	MOCAGE free run			CALIOP Assimilation		
	Correlation	Bias	RMSE	Correlation	Bias	RMSE
34230	0.677	-0.066	0.185	0.746	0.046	0.149



# Assimilation of CALIOP lidar profiles



El Amraoui et al., 2020





The modelling and assimilation activities during the EarthCare CAL/VAL will have as objectives :

- Assessment of the vertical structure of EarthCare products (compared to modelling fields & other observations)
- How the EarthCare products can constrain the models at global scale via data assimilation → compared to independent observations performed during the CAL/VAL period
- Evaluation of the added-value of EarthCare observations within a Global Observation System using data assimilation (taking into account other observations)