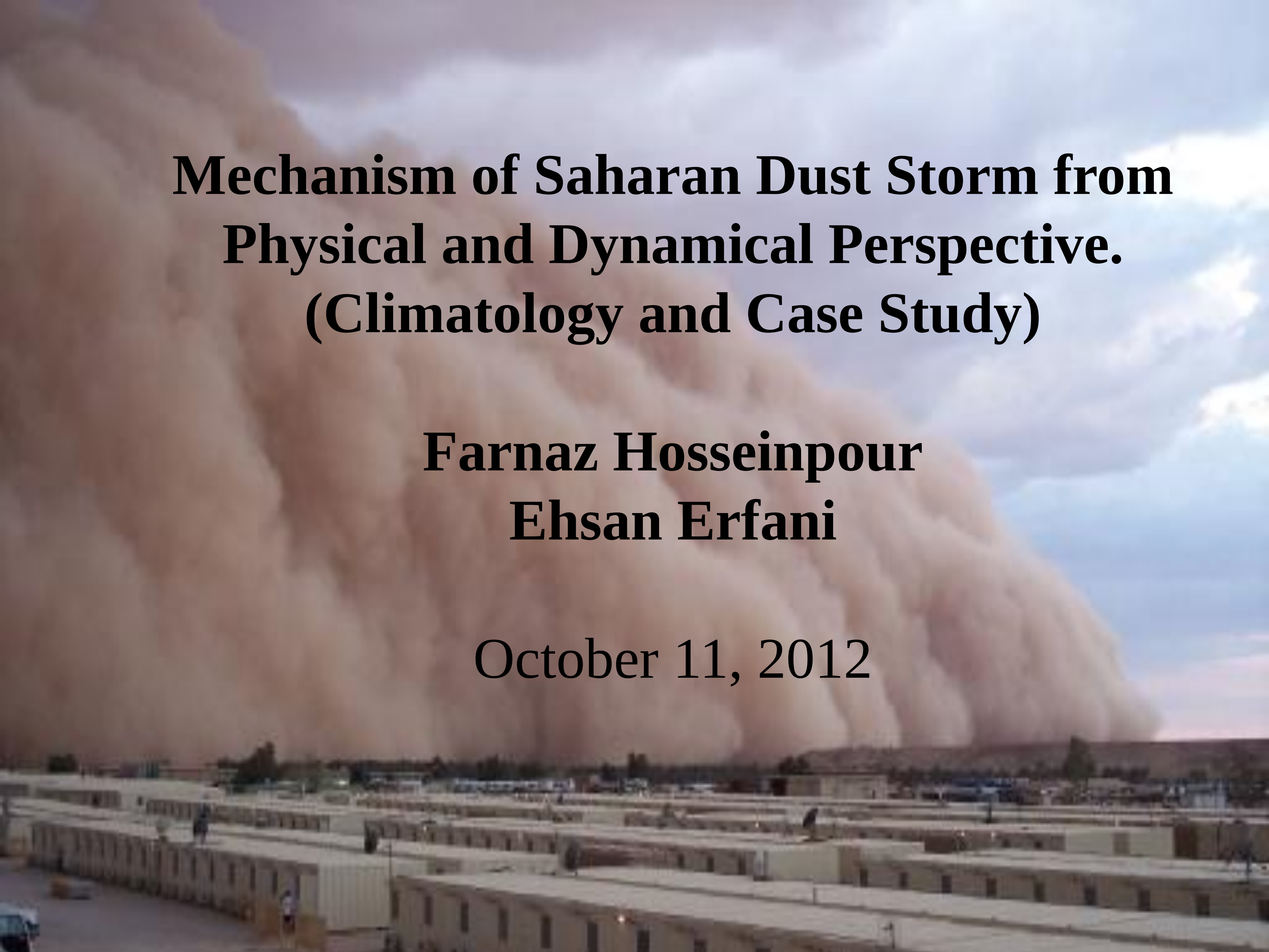


Mechanism of Saharan Dust Storm from Physical and Dynamical Perspective. (Climatology and Case Study)

Farnaz Hosseinpour
Ehsan Erfani

October 11, 2012

Methodology:

- Saharan dust storm case study during June 23-27, 2012:

MODIS: AOD and Angstrom exponent.

LIDAR: Backscatter 532 and 1064 nm.

Back trajectory, Dust Plume Model, and AERONET data sets.

MERRA: wind speed, vorticity, and omega.

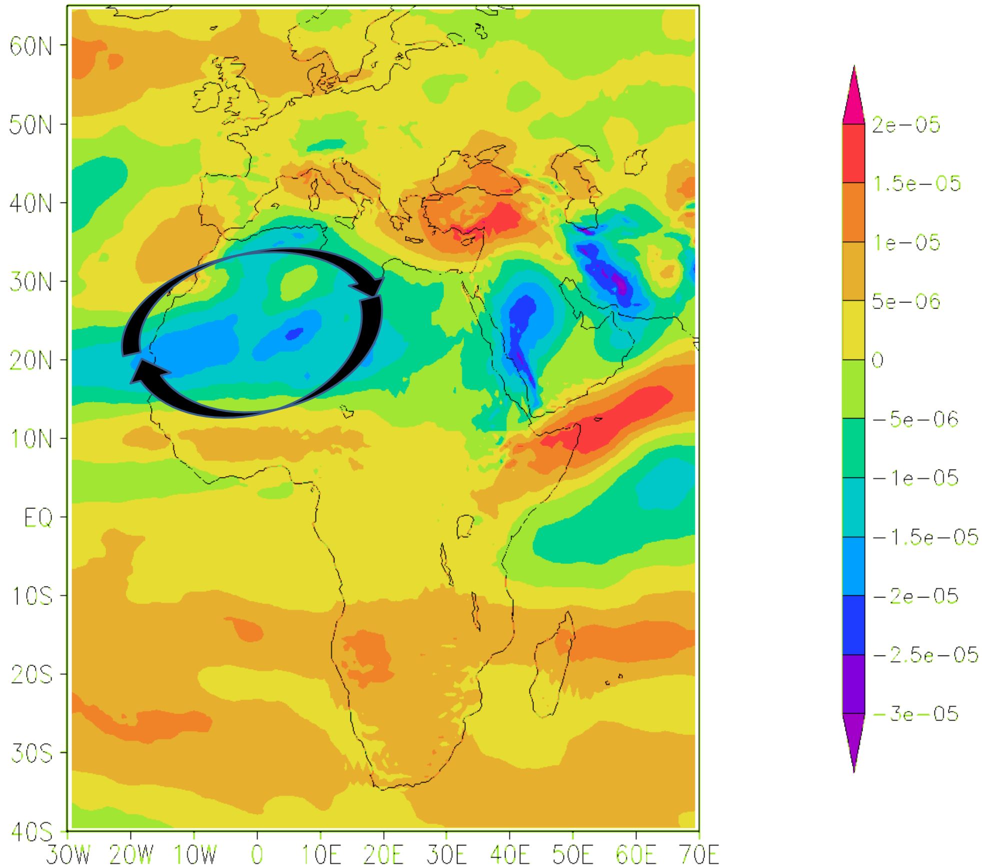
- Climatological study:

Long-term averaging over entire time period of MODIS data set

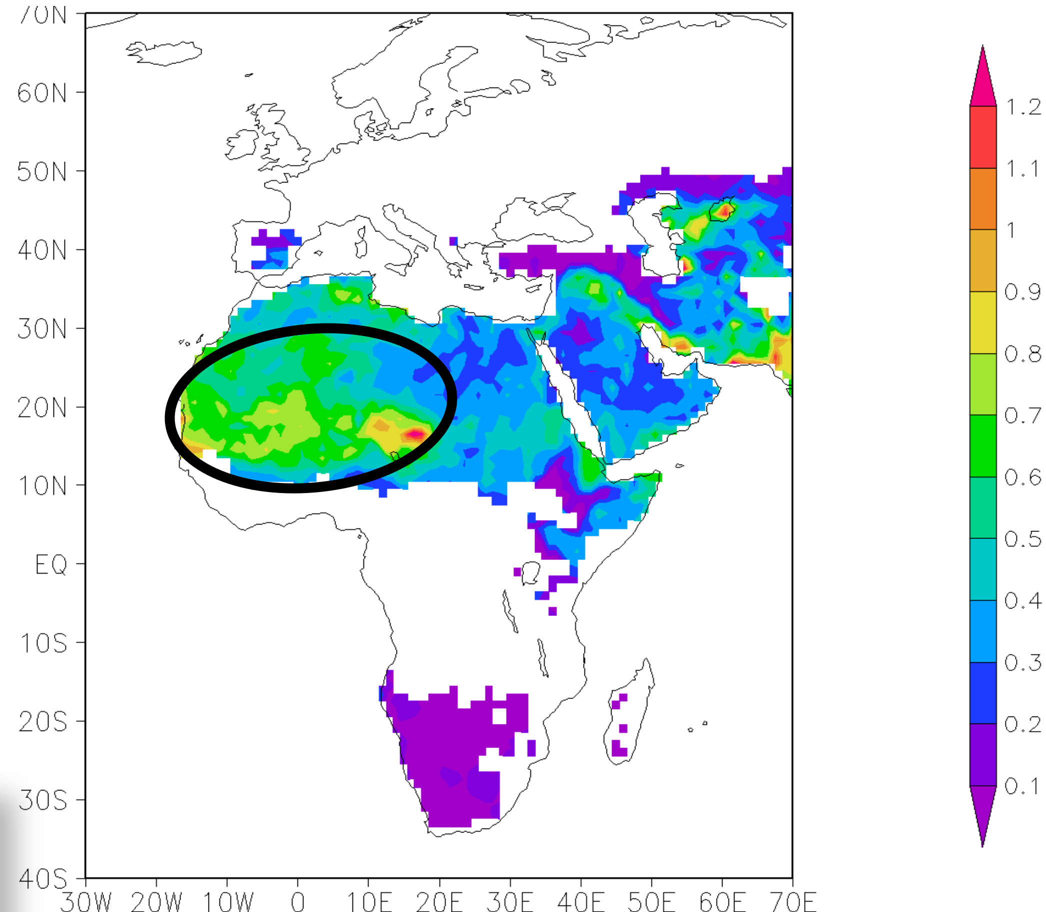
(June 2000-2012).

Long-term averaging over entire time period of Modern-ERA Retrospective Analysis For Research And Applications (MERRA) data set (June 1979-2012).

Long-term averaged Vorticity (s^{-1})
at 500 hPa for June (1979-2012)



Long-term averaged Deep Blue AOD (Wm^{-2})
at 550 nm over land for June (2000-2012)

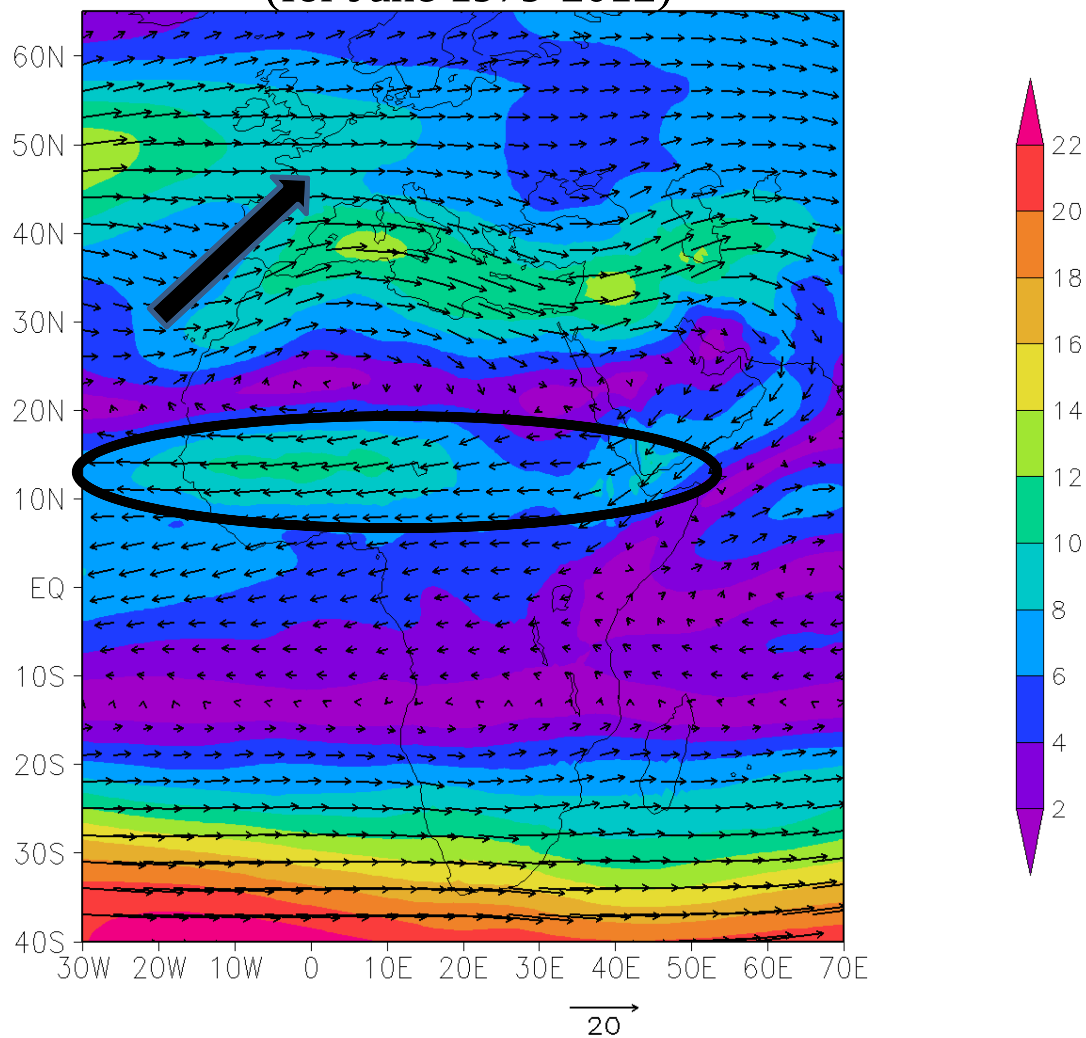


Remarkable AOD over western Saharan indicates more concentration of dust particles accompanied with Anti-cyclonic vorticity, which blocks the aerosols.

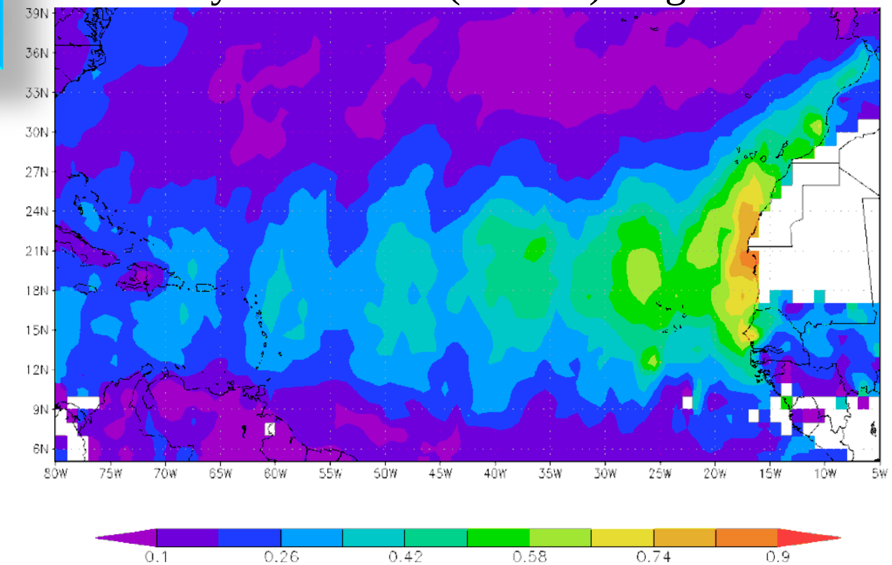
- African easterly jet and trade winds are associated with the westward propagation of the elevated Saharan dust across the Atlantic Ocean during the NH warm season.
- Saharan dust transport toward Mediterranean Sea and Europe via Rossby waves.

Longitudinal transport of African dust

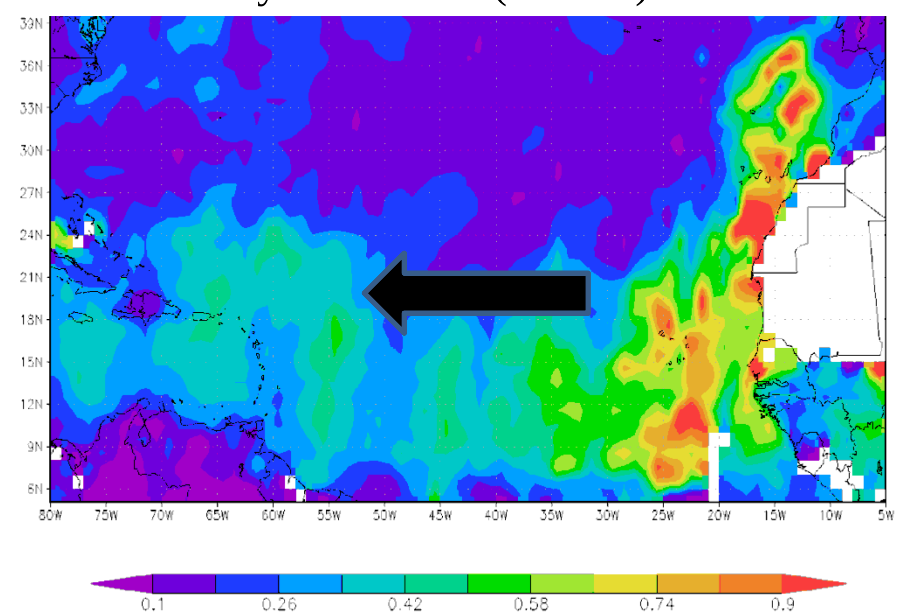
Long-term averaged wind speed at 500 hPa (for June 1979-2012)



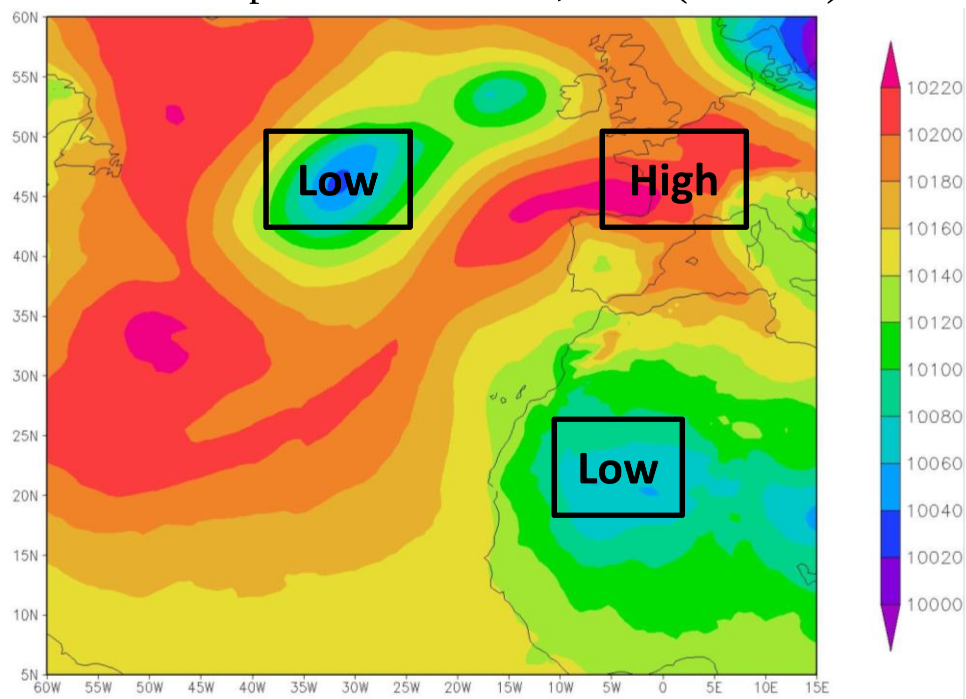
Monthly mean AOD (550 nm) August 2012



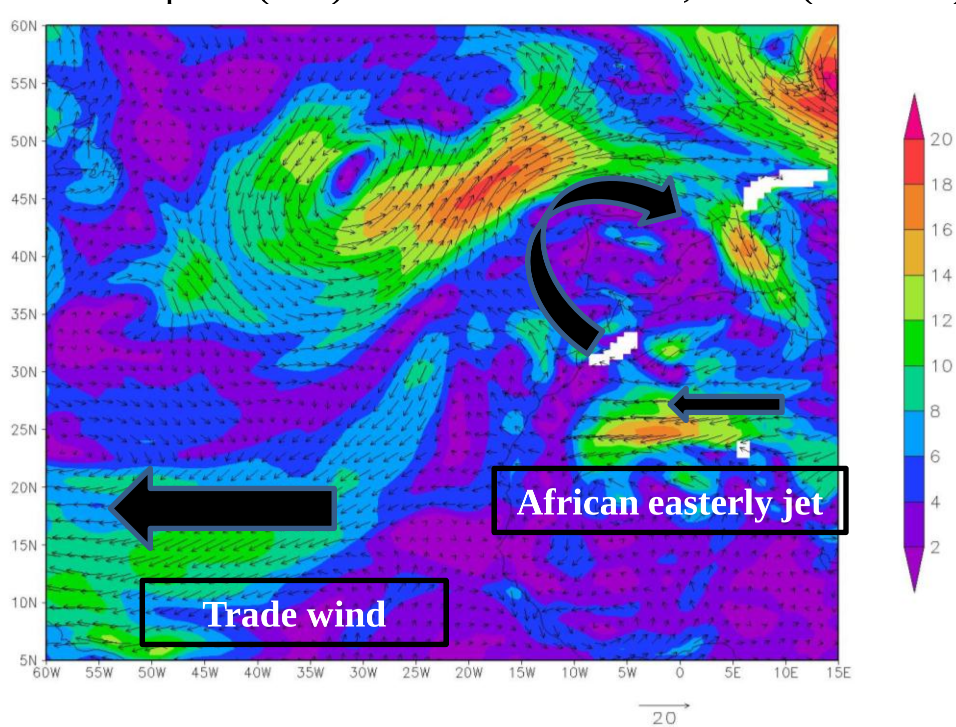
Monthly mean AOD (550 nm) June 2012



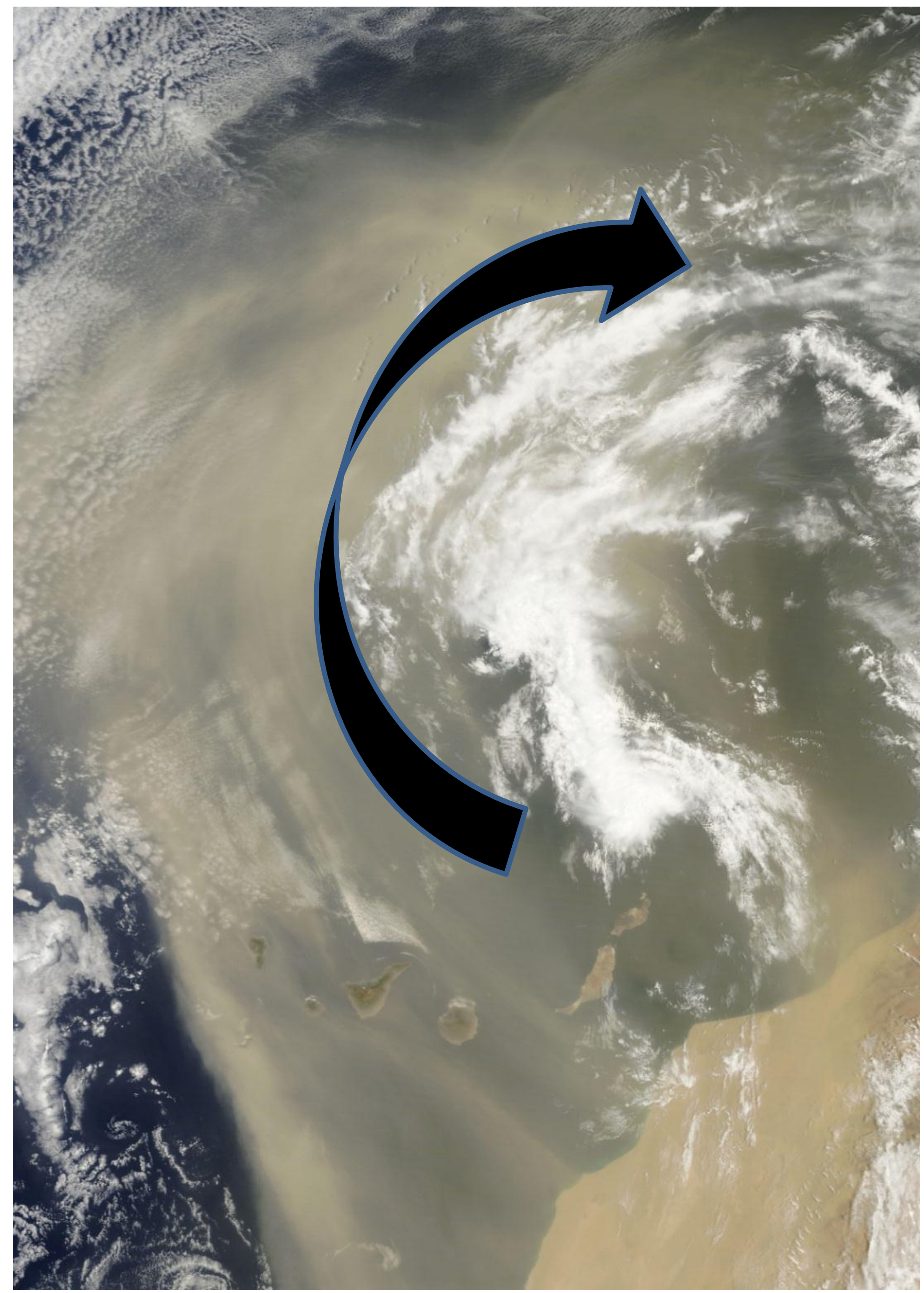
Sea level pressure/ June 26, 2012 (00 UTC)



Wind speed (m/s) at 850 mb/ June 26, 2012 (12 UTC)

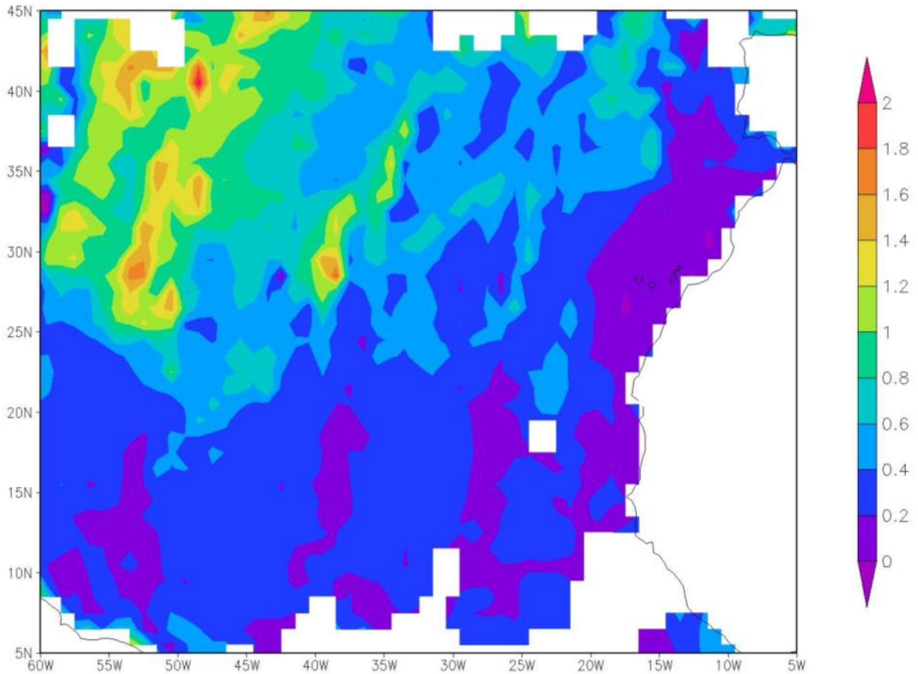


North-west Africa (June 26, 2012)

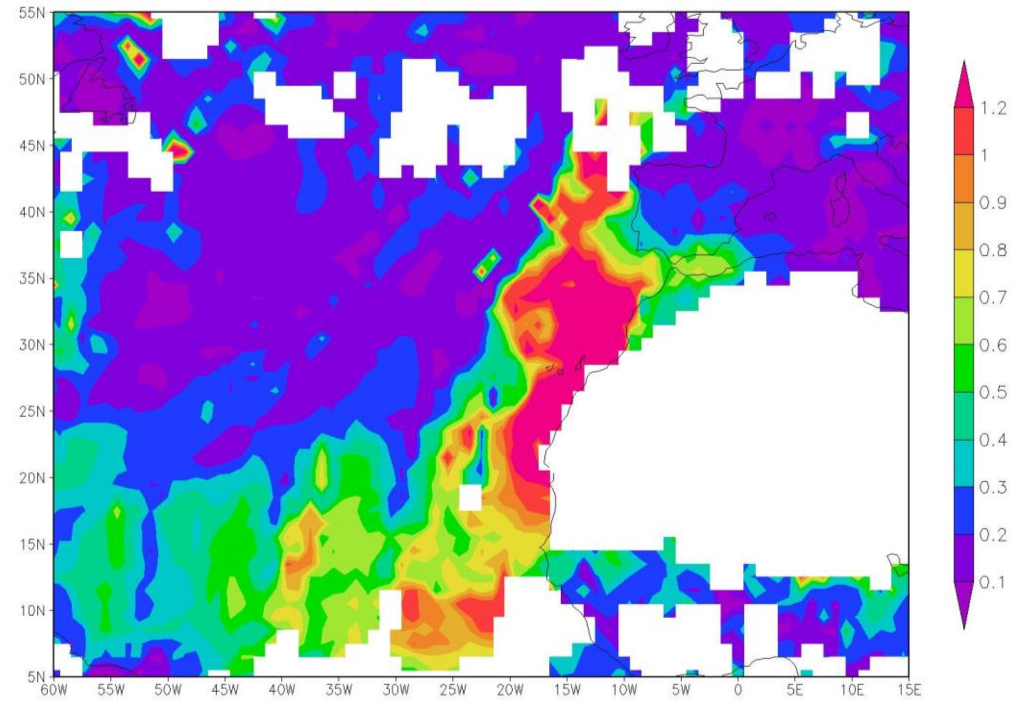


Latitudinal transport of African dust

Angstrom exponent 550/865 nm
(averaged over 23-27 June 2012)



AOD at 550 nm
(averaged over 23-27 June 2012)

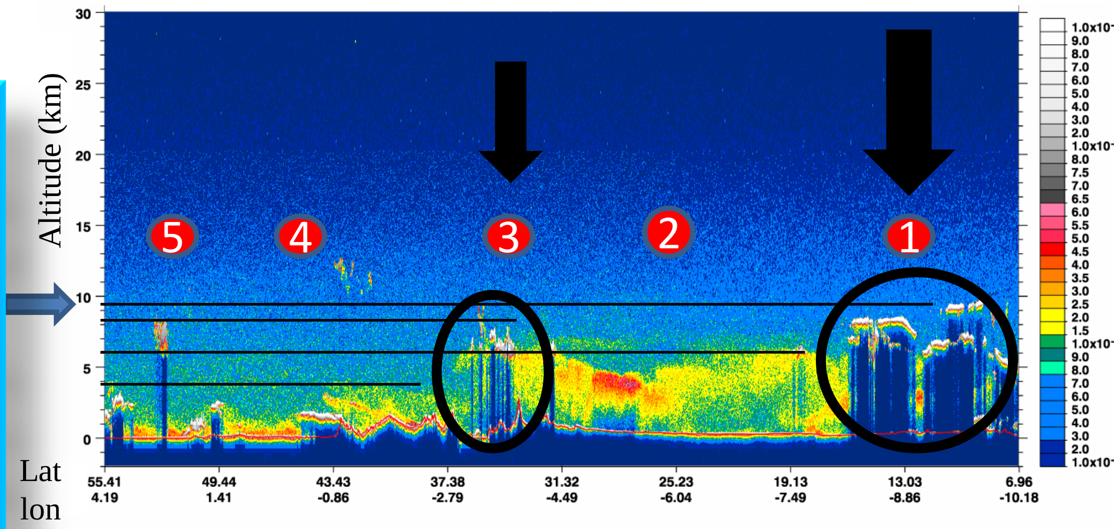


High AOD and low angstrom exponent related to dust particles.

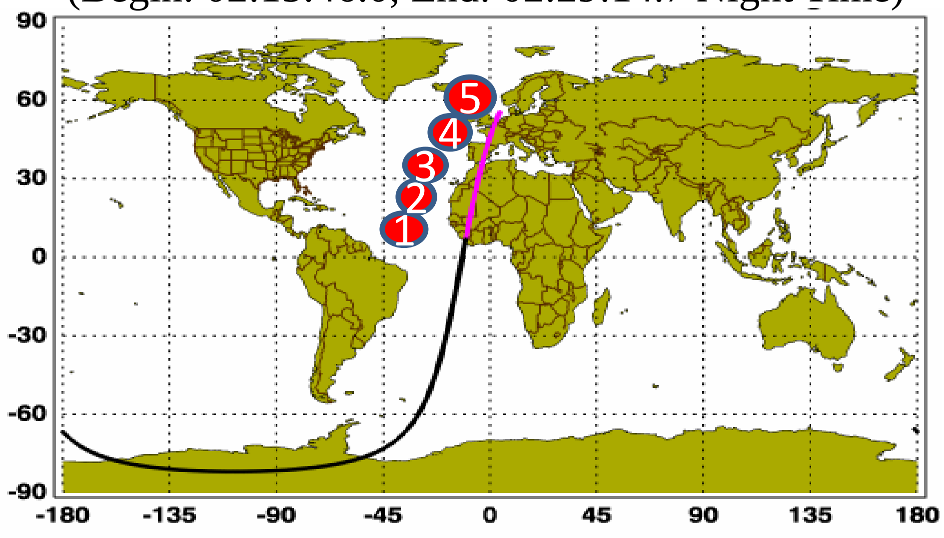
Vertical distribution of African dust

- Dust particles may not exist under the tropopause due to the domination of subtropical jet streams
-Vertical transport of dust particles troposphere over the African western tropics and western Mediterranean are related to convective systems cell (Regions 1 and 3)
- Elevated dust over Saharan is accompanied with African easterly jet at 500 hPa (Region 2)

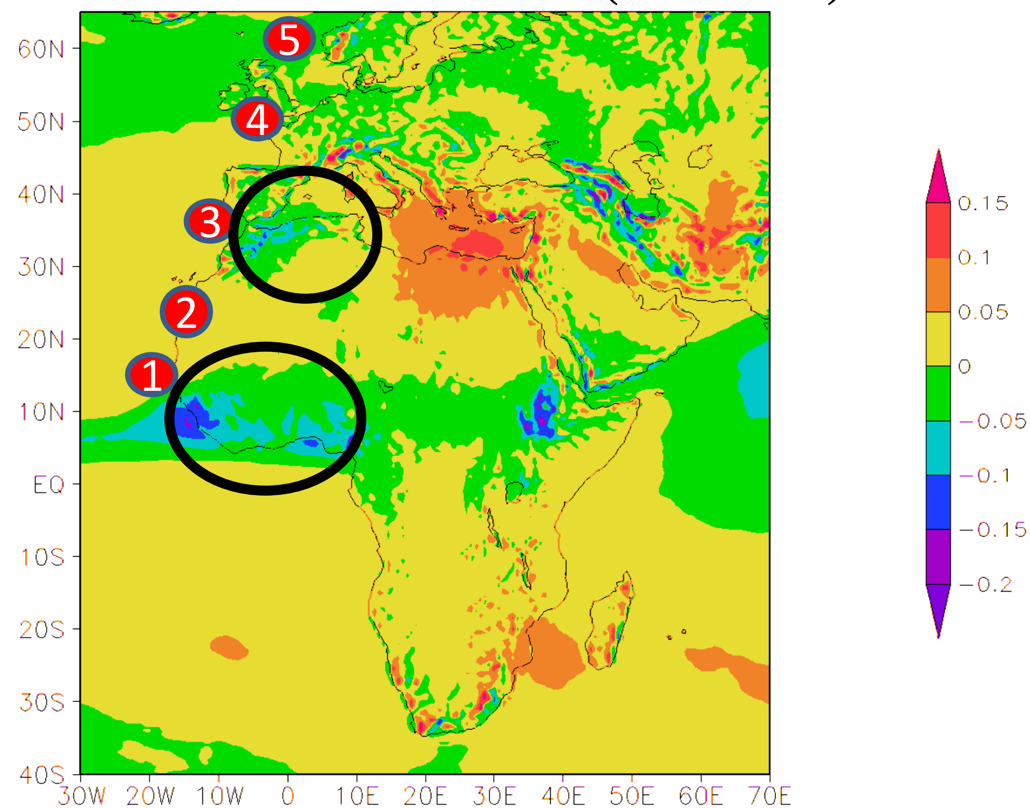
Total attenuated backscatter 532 nm



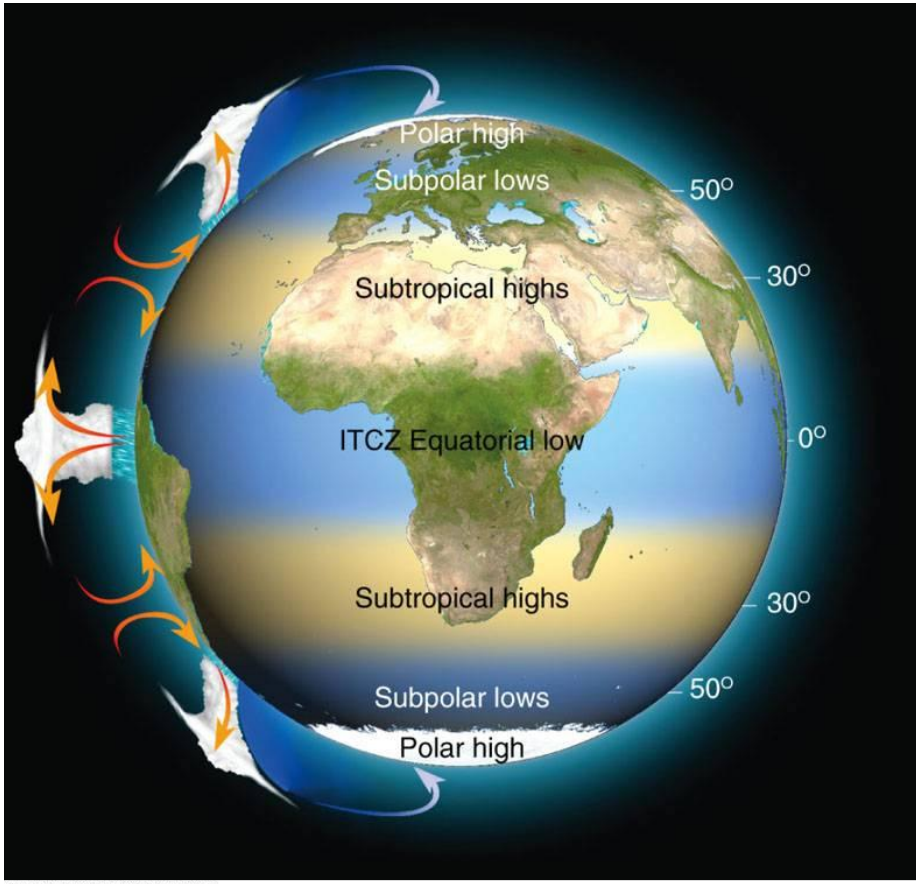
CALIPSO Lidar signal (June 23, 2012)
(Begin: 02:15:46.0, End: 02:29:14.7 Night Time)



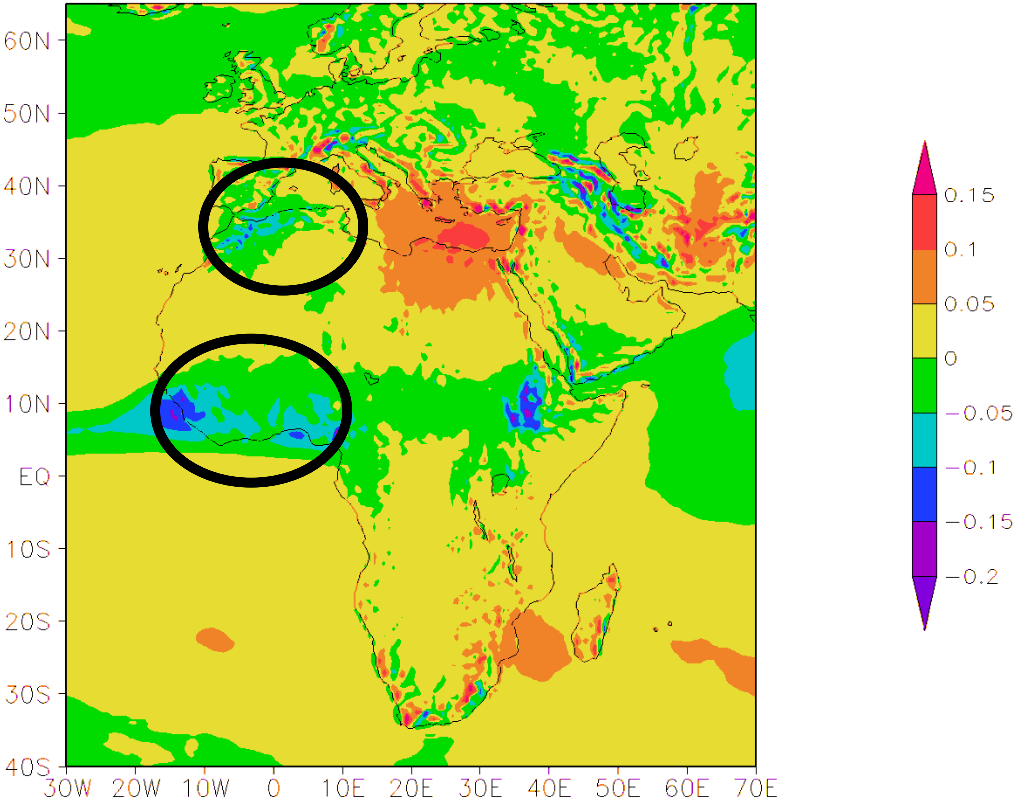
long-term averaged of omega in June
based on MERRA data sets (1979-2012)



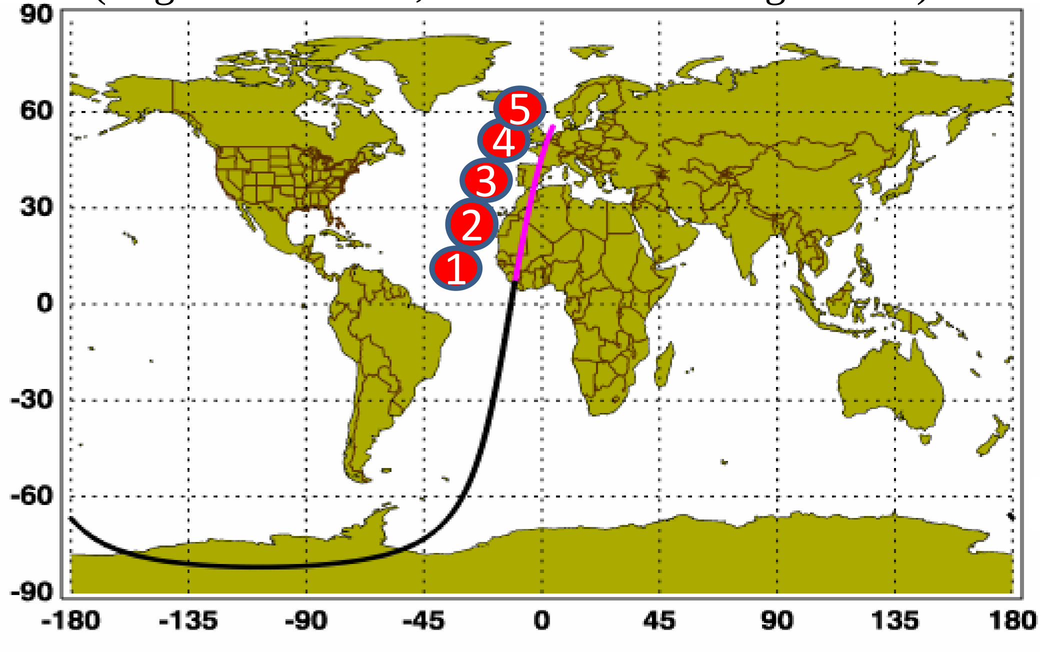
General circulation over Africa



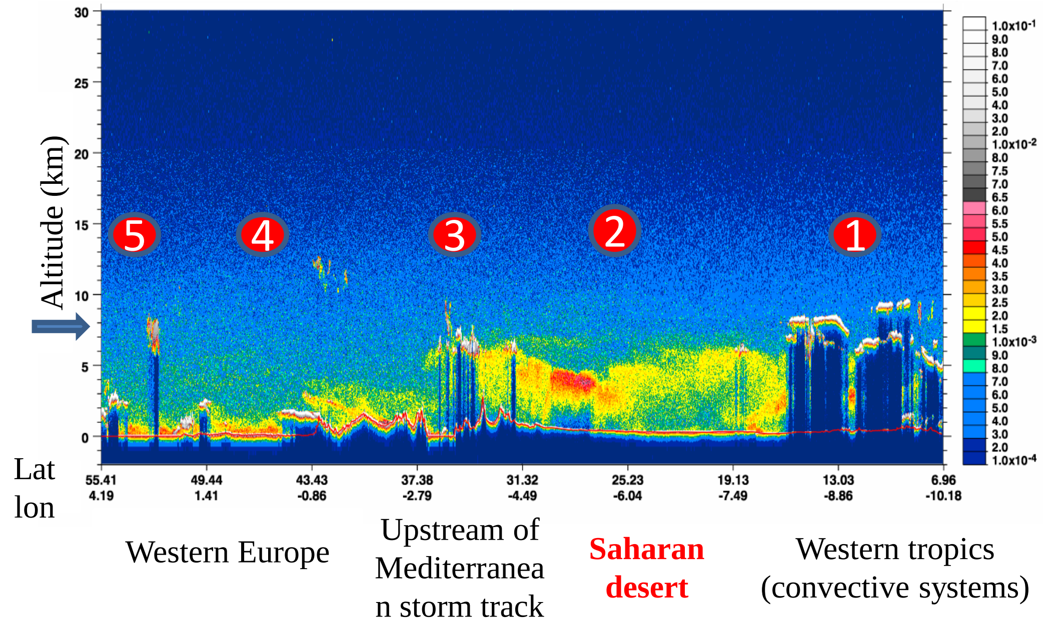
long-term averaged of omega in June based on MERRA data sets (1979-2012)



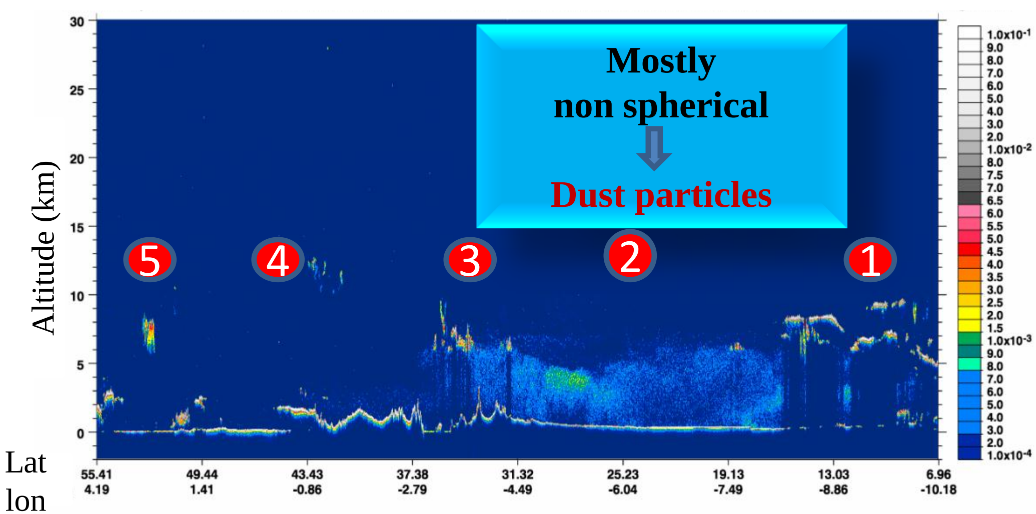
CALIPSO Lidar signal (June 23, 2012)
(Begin: 02:15:46.0, End: 02:29:14.7 Night Time)



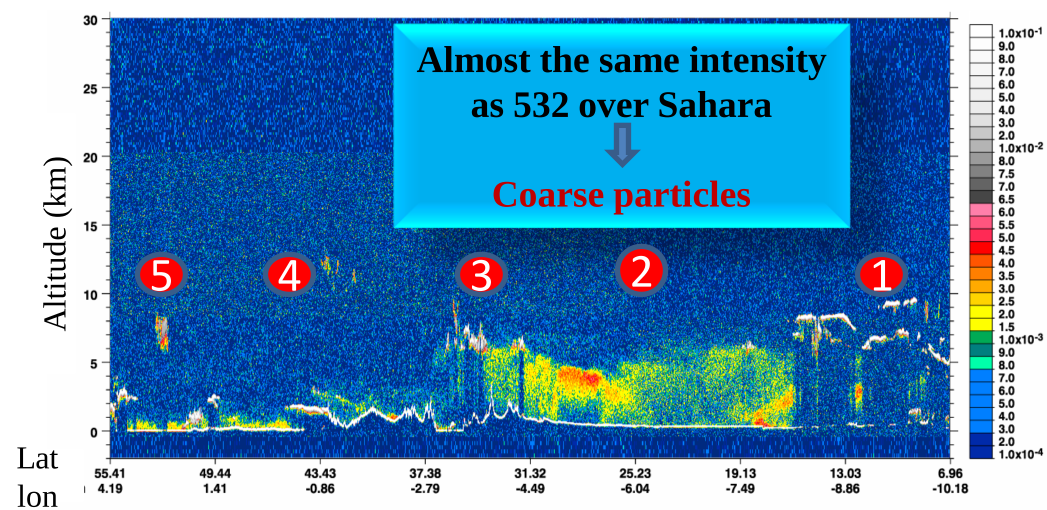
Total attenuated backscatter 532 nm

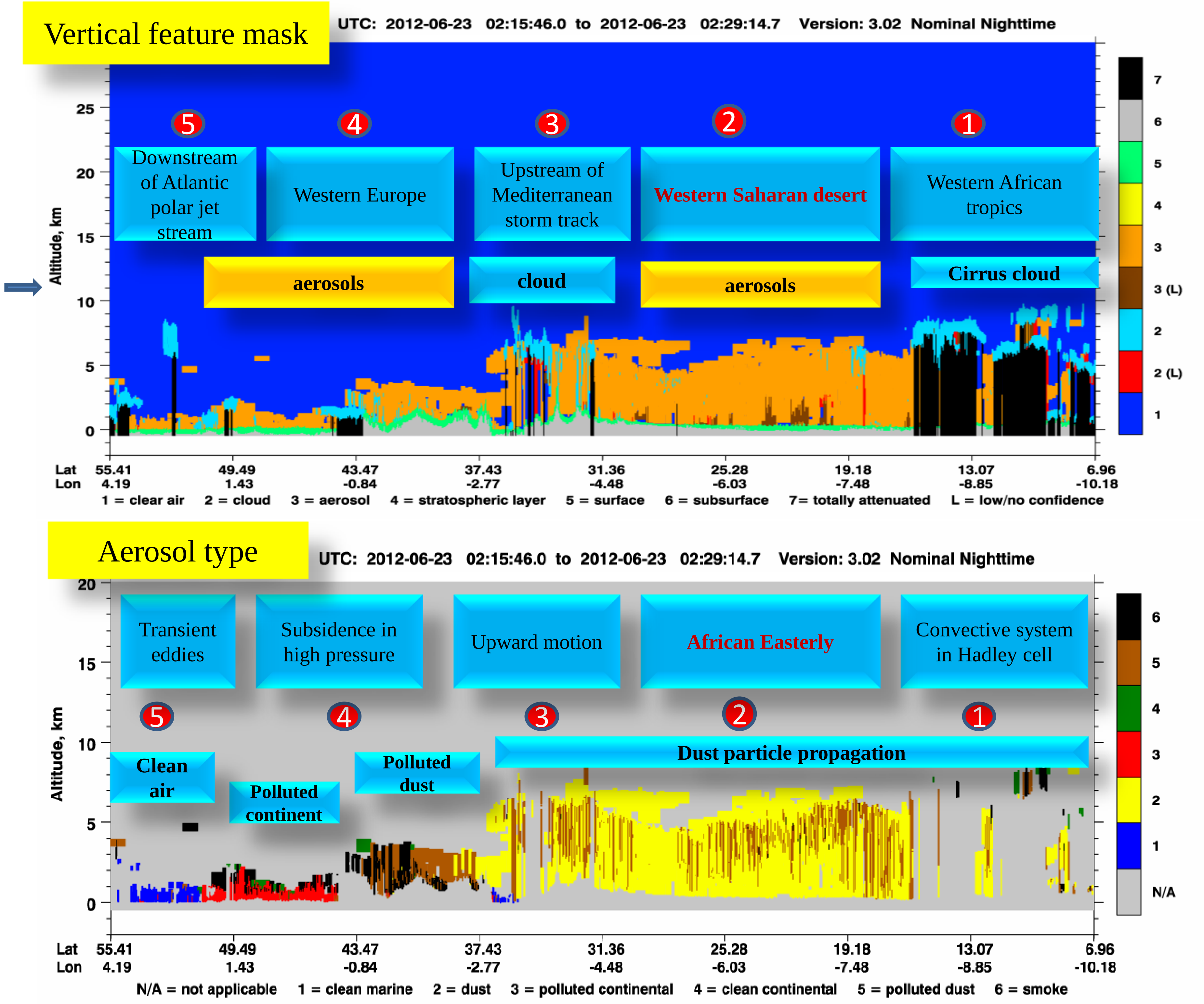


Perpendicular attenuated backscatter 532 nm



Total attenuated backscatter 1064 nm



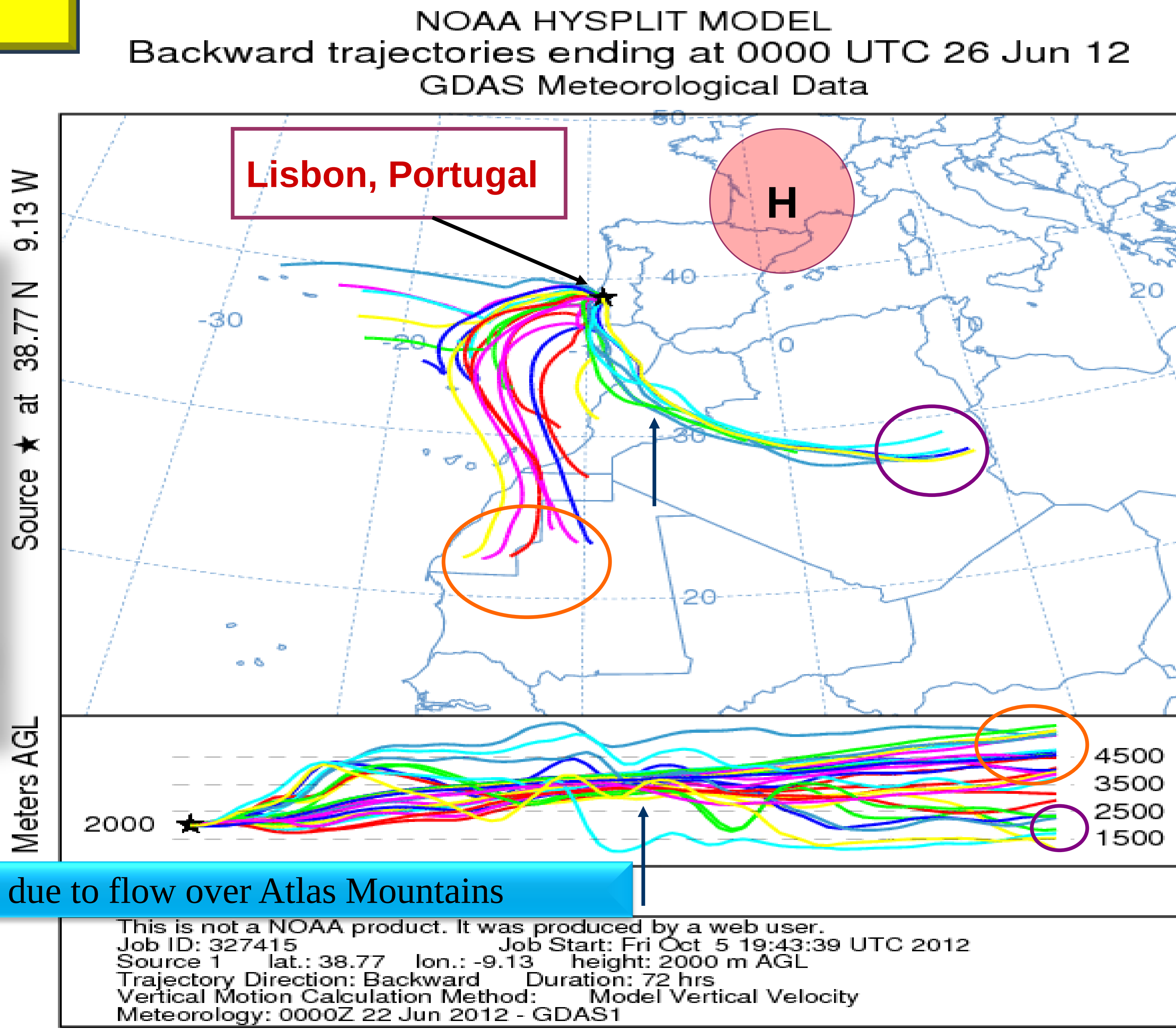

Vertical feature mask
UTC: 2012-06-23 02:15:46.0 to 2012-06-23 02:29:14.7 Version: 3.02 Nominal Nighttime
Altitude, km
25
20
15
10
5
0
5
4
3
2
1
Downstream of Atlantic polar jet stream
Western Europe
Upstream of Mediterranean storm track
Western Saharan desert
Western African tropics
aerosols
cloud
aerosols
Cirrus cloud
7
6
5
4
3
3 (L)
2
2 (L)
1
Lat 55.41 49.49 43.47 37.43 31.36 25.28 19.18 13.07 6.96
Lon 4.19 1.43 -0.84 -2.77 -4.48 -6.03 -7.48 -8.85 -10.18
1 = clear air 2 = cloud 3 = aerosol 4 = stratospheric layer 5 = surface 6 = subsurface 7= totally attenuated L = low/no confidence
Aerosol type
UTC: 2012-06-23 02:15:46.0 to 2012-06-23 02:29:14.7 Version: 3.02 Nominal Nighttime
Altitude, km
20
15
10
5
0
Transient eddies
Subsidence in high pressure
Upward motion
African Easterly
Convective system in Hadley cell
5
4
3
2
1
Clean air
Polluted continent
Polluted dust
Dust particle propagation
6
5
4
3
2
1
N/A
Lat 55.41 49.49 43.47 37.43 31.36 25.28 19.18 13.07 6.96
Lon 4.19 1.43 -0.84 -2.77 -4.48 -6.03 -7.48 -8.85 -10.18
N/A = not applicable 1 = clean marine 2 = dust 3 = polluted continental 4 = clean continental 5 = polluted dust 6 = smoke

Back trajectory

End Height: 2000m

Duration: 72 h

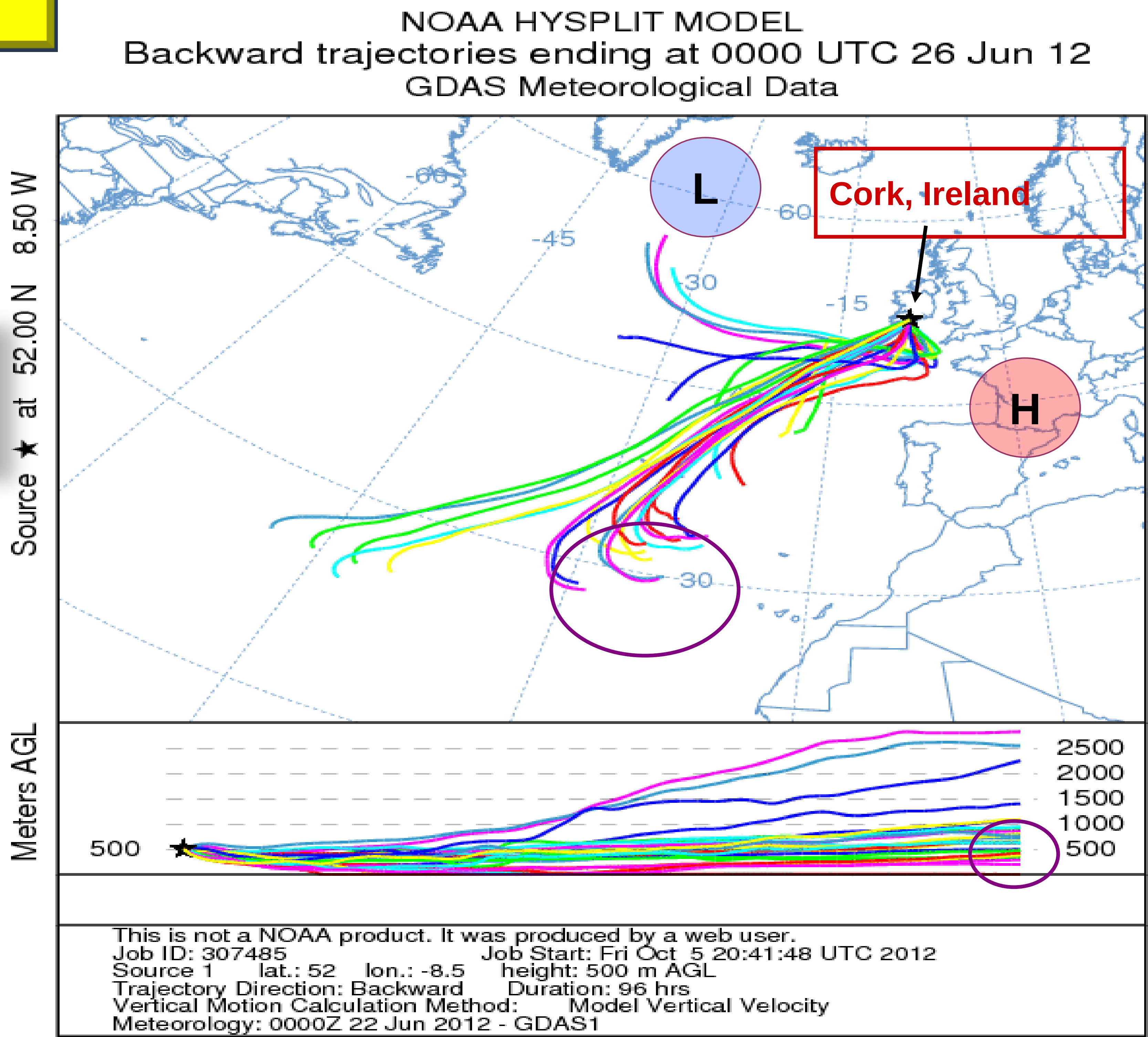
End time: 26 Jun 2012



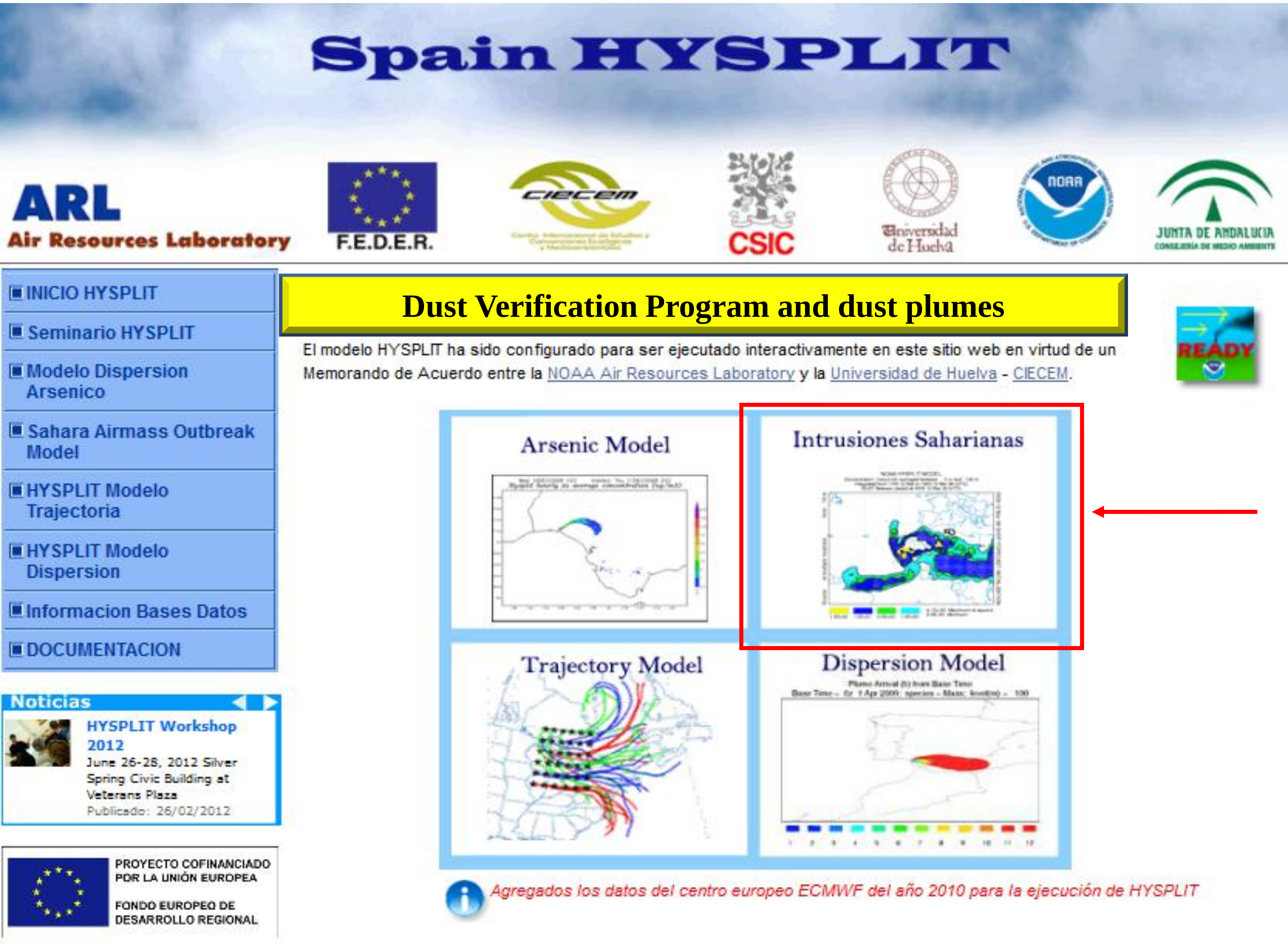
Waves possibly due to flow over Atlas Mountains

Back trajectory

End Height: 500m



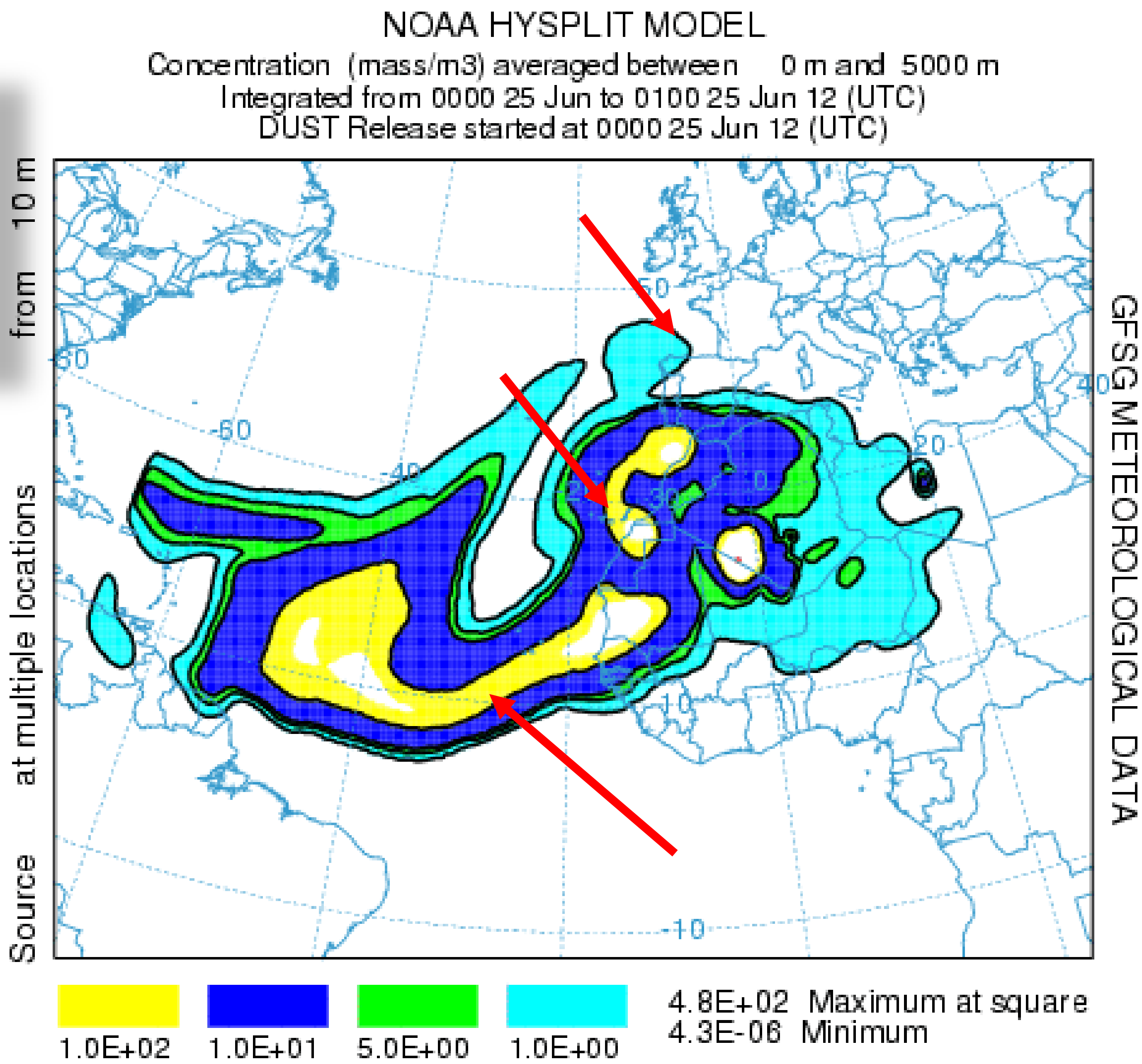
Dust Verification Program and dust plumes



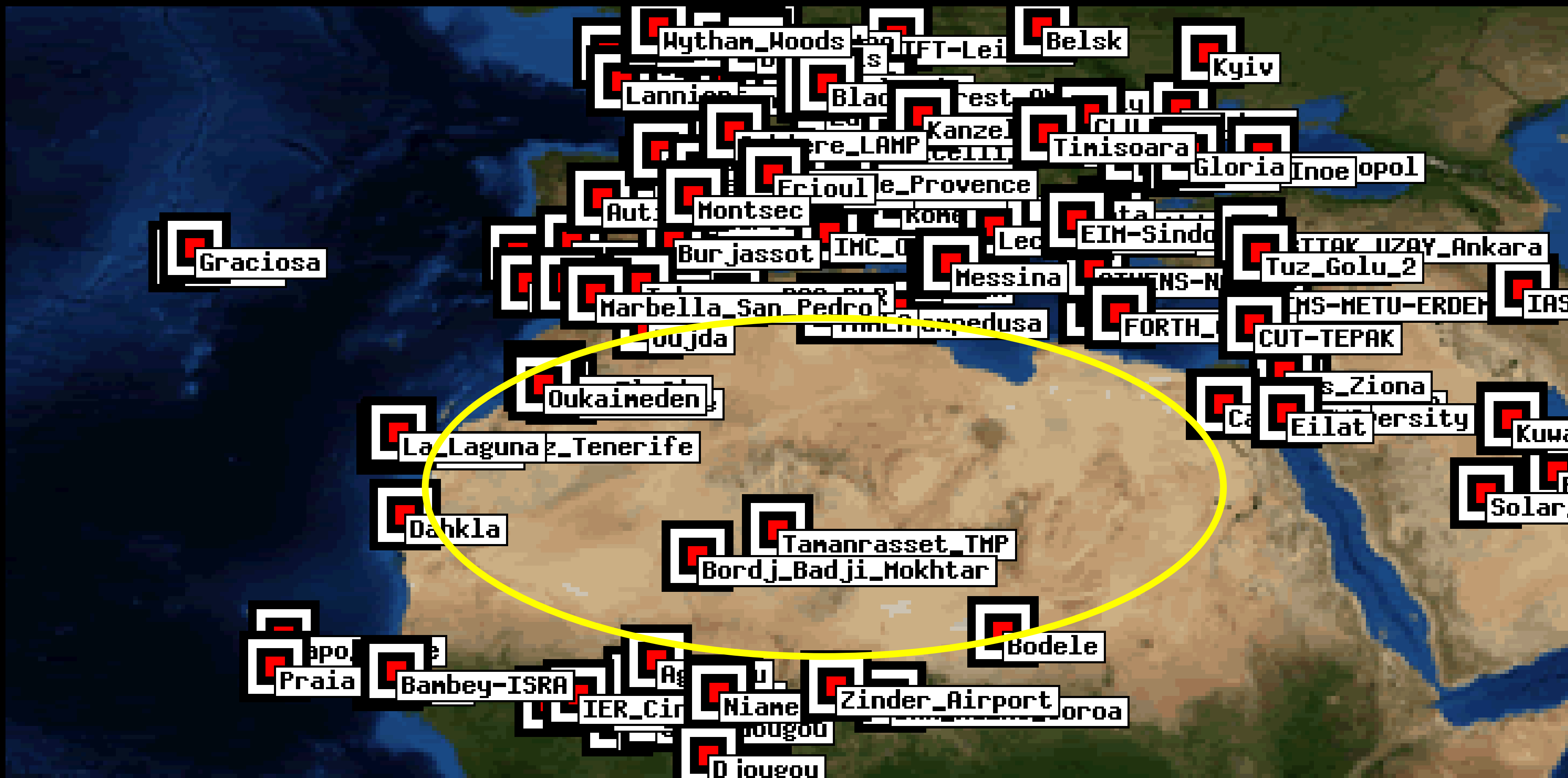
Dust Verification Program and Dust Plumes

Concentration between 0-5000 m

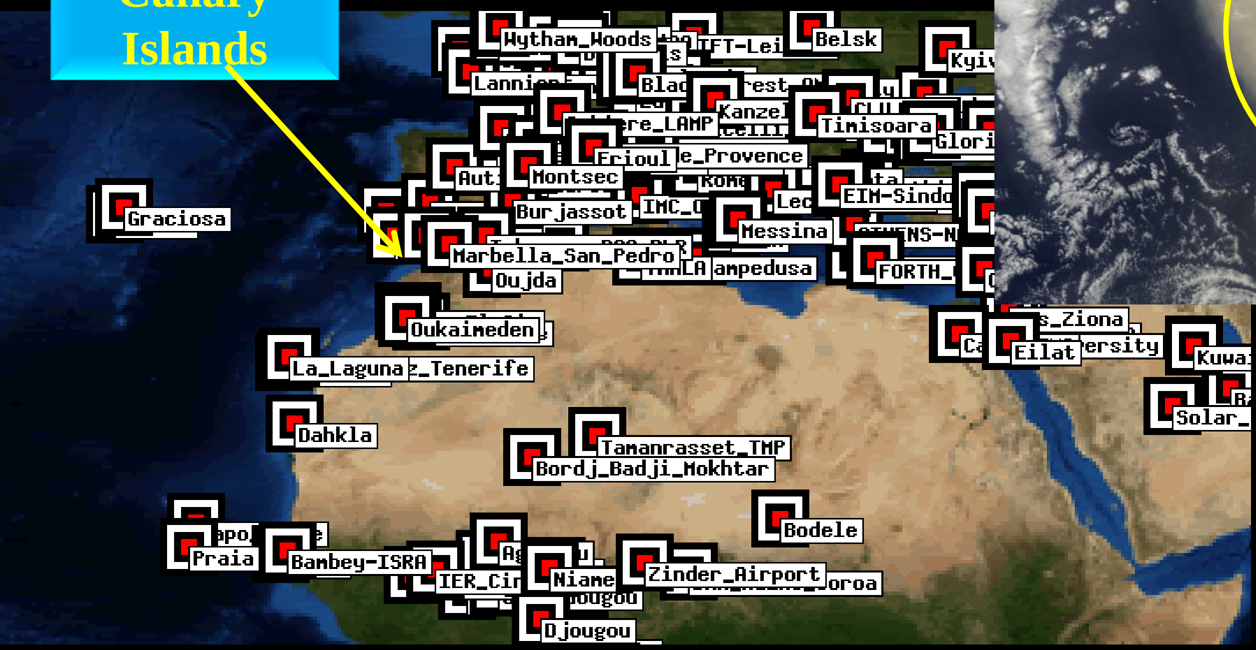
Start time: 06/25/2012

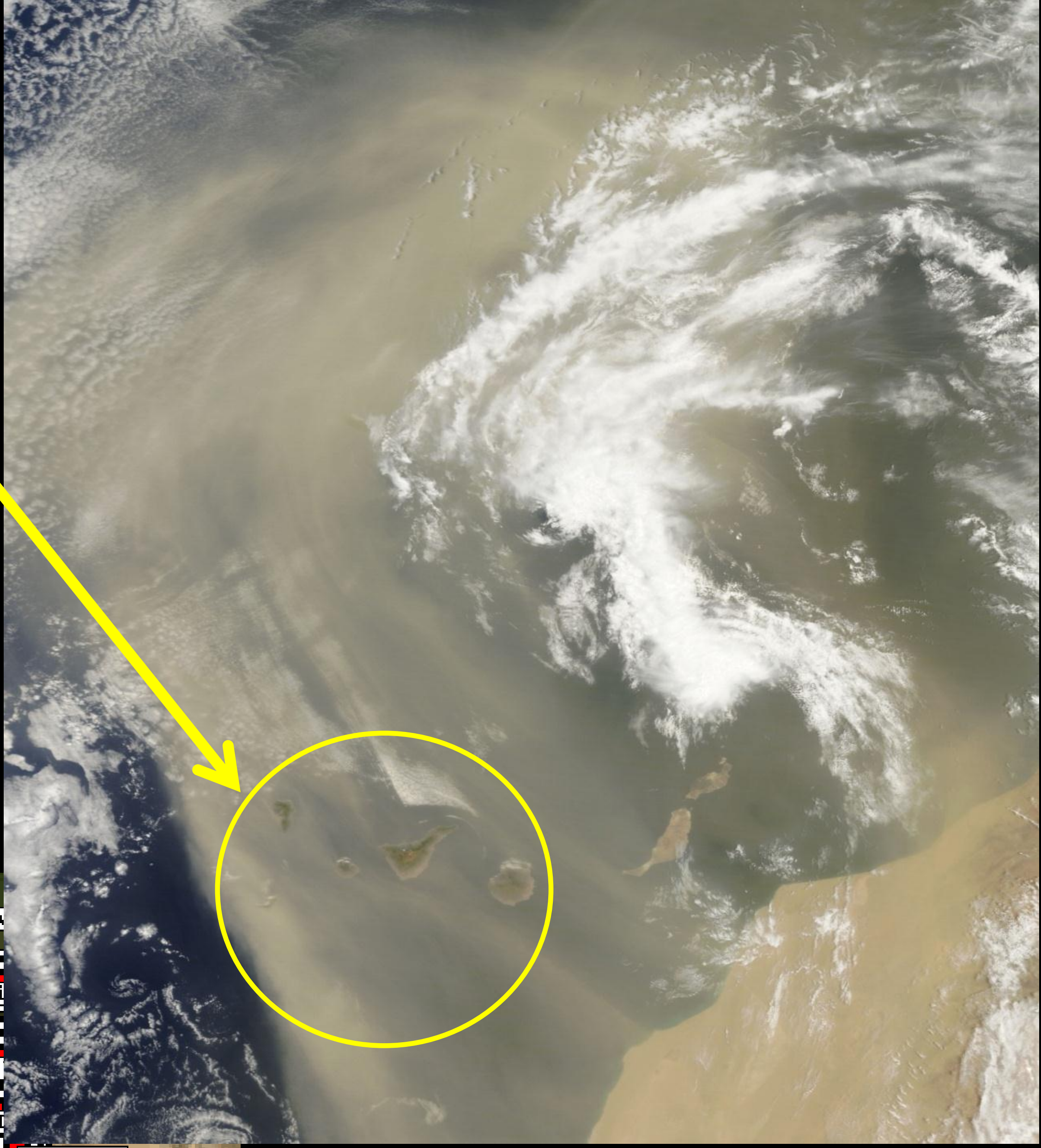


AERONET Station Map



Canary Islands



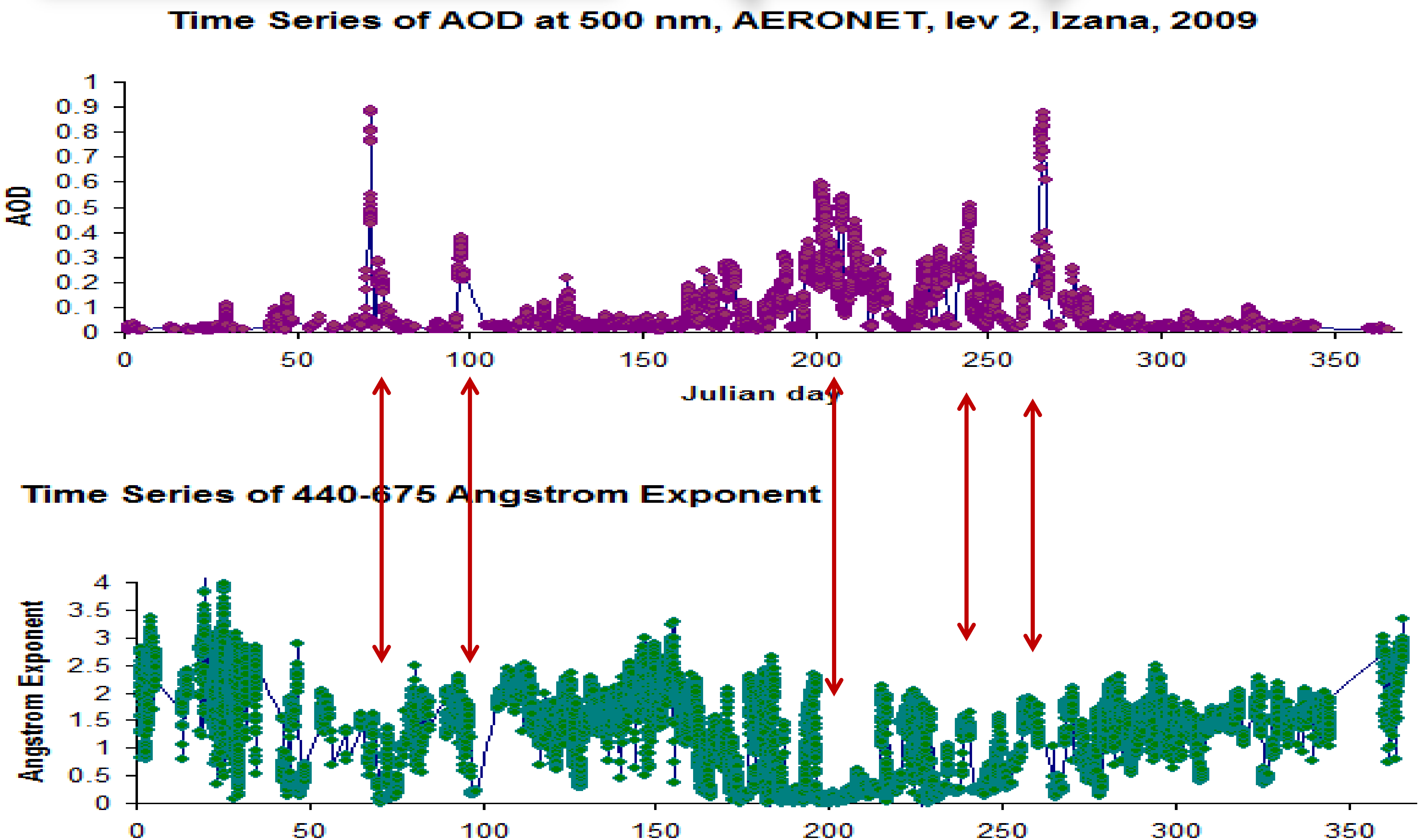



Africa
Izana Station
Santa Cruz de Tenerife
El Rosario
Candelaria
Güímar
28.30932° , -16.49906°
Fasnia
Tacoronte
La Matanza de Acentejo
Santa Úrsula
Orotava
Los Realejos
Tenerife
Canary Islands
Tenerife Island
- Populous
- Subtropical climate
- Cloud-free sky
- Above inversion layer
Image © 2012 GRAFCAN
© 2012 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Google
Google earth

High AOD and low angstrom exponent related to dust particles during warm season.

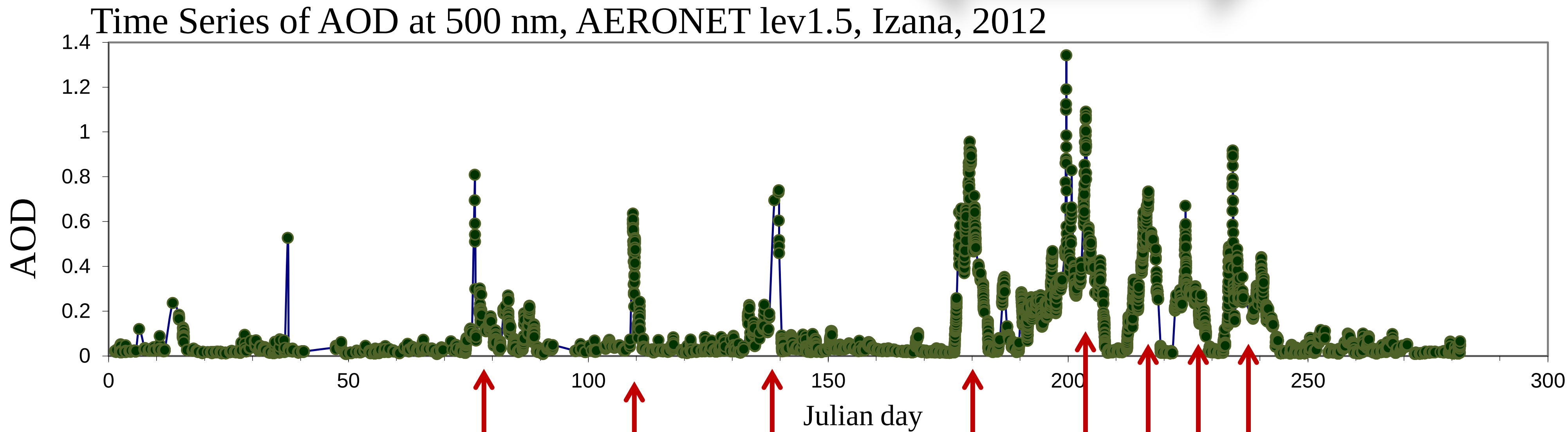
JJA

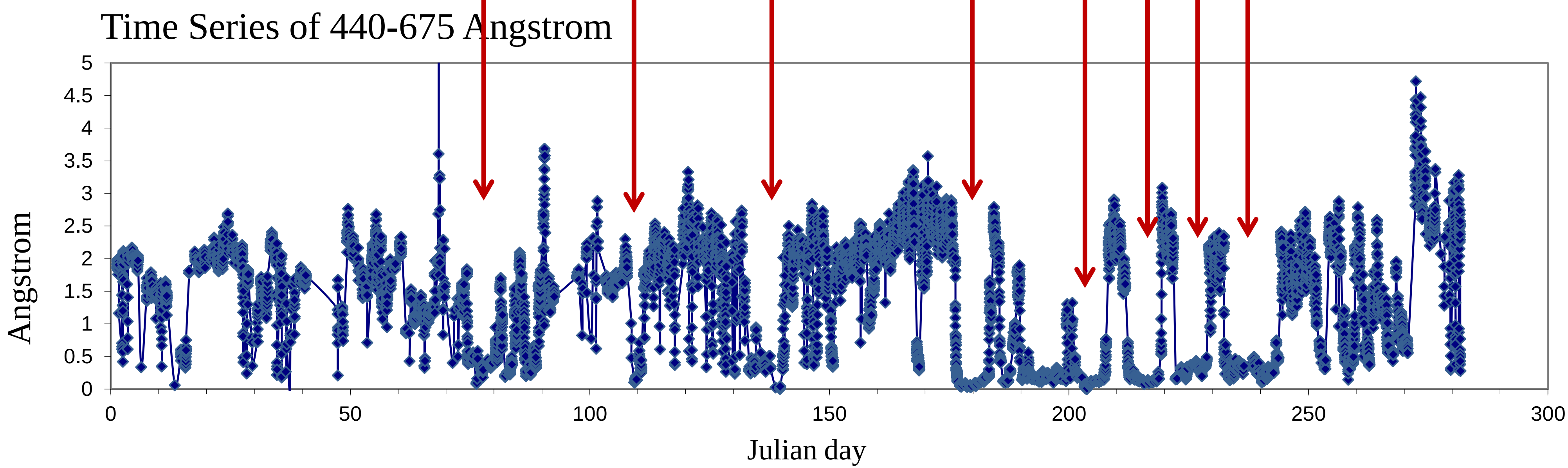
AERONET Data Analysis



AERONET Data Analysis

JJA

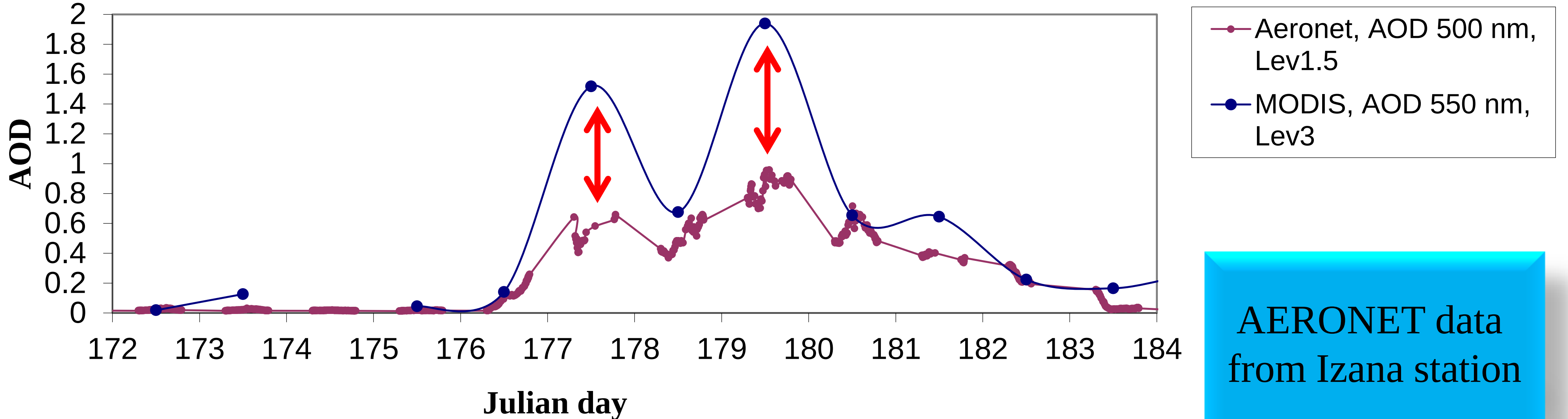




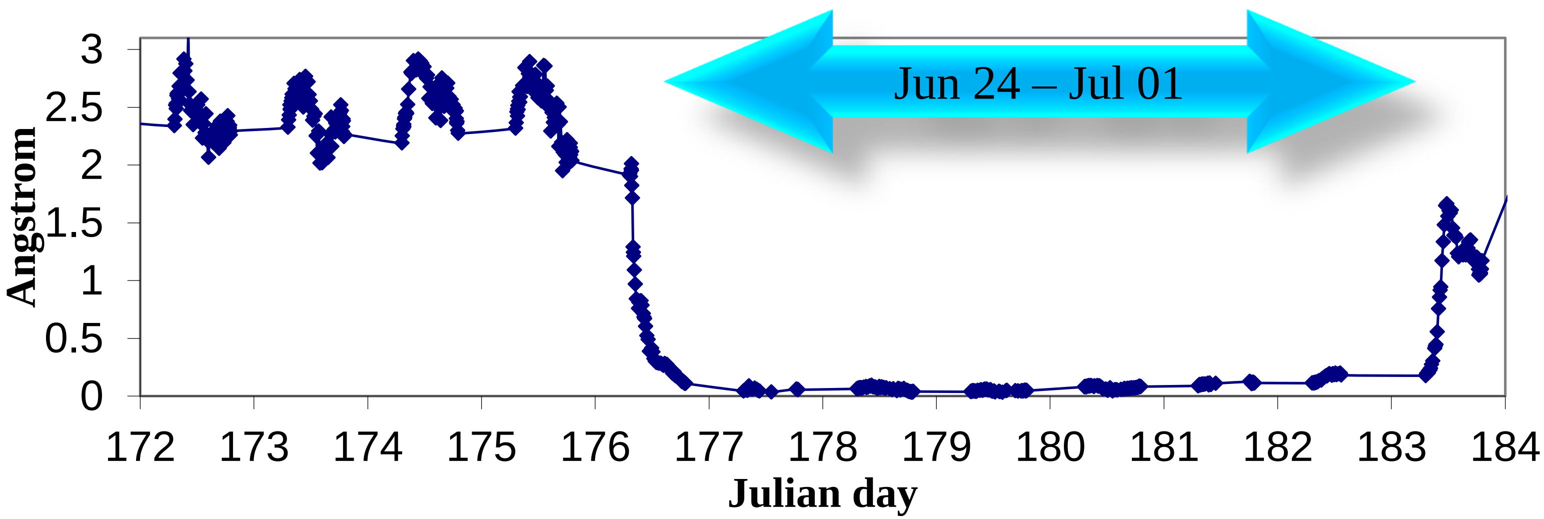
Comparison of MODIS and AERONET

AERONET represents lower values for dust AOD compared to MODIS.

Time Series of AOD, Jun20-Jul02 2012



440-675Angstrom by AERONET Lev1.5



AERONET data from Izana station

MODIS data: a box of 1 X 1 including Izana station

Conclusion:

1- Remarkable AOD over western Saharan indicates more concentration of dust particles accompanied with Anti- cyclonic vorticity, which blocks the aerosols.

2- African easterly jet and trade winds are associated with the westward propagation of the Saharan dust across the Atlantic Ocean during the NH warm season .

3- Saharan dust transport toward Mediterranean Sea and Europe via Rossby waves. Back trajectory and dust plumes confirm the northward expansion of Saharan dust particles.

4- Dust particles may not exist under the tropopause due to the domination of subtropical jet streams.

5- Convective systems in Hadley cell elevate the dust particles to upper troposphere over the African western tropics and western Mediterranean.

6- Elevated dust over Saharan is accompanied with African easterly jet at 500 hPa.

7- AERONET represents the lower values for dust AOD. This indicates that AERONET might underestimate dust AOD.