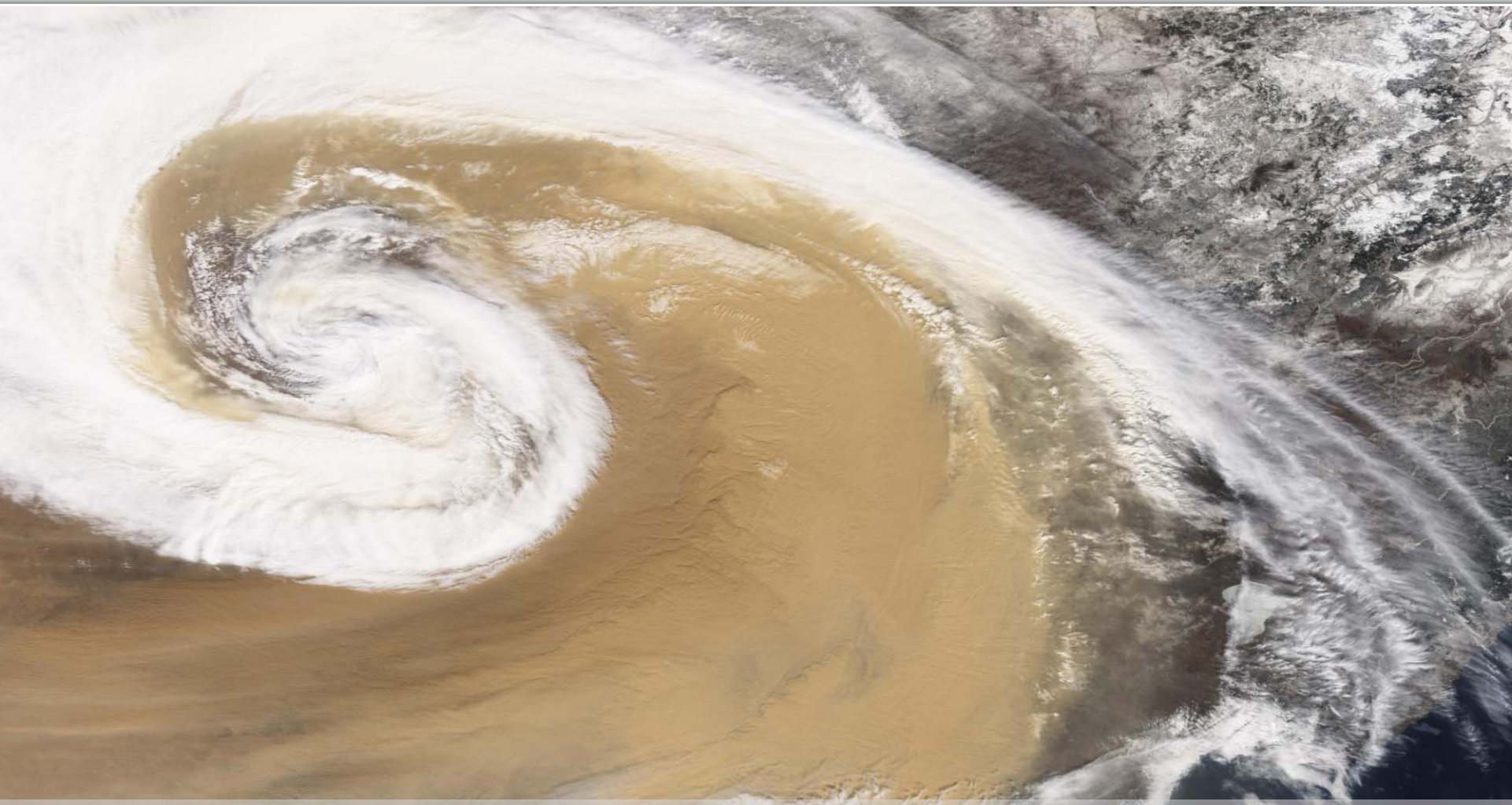
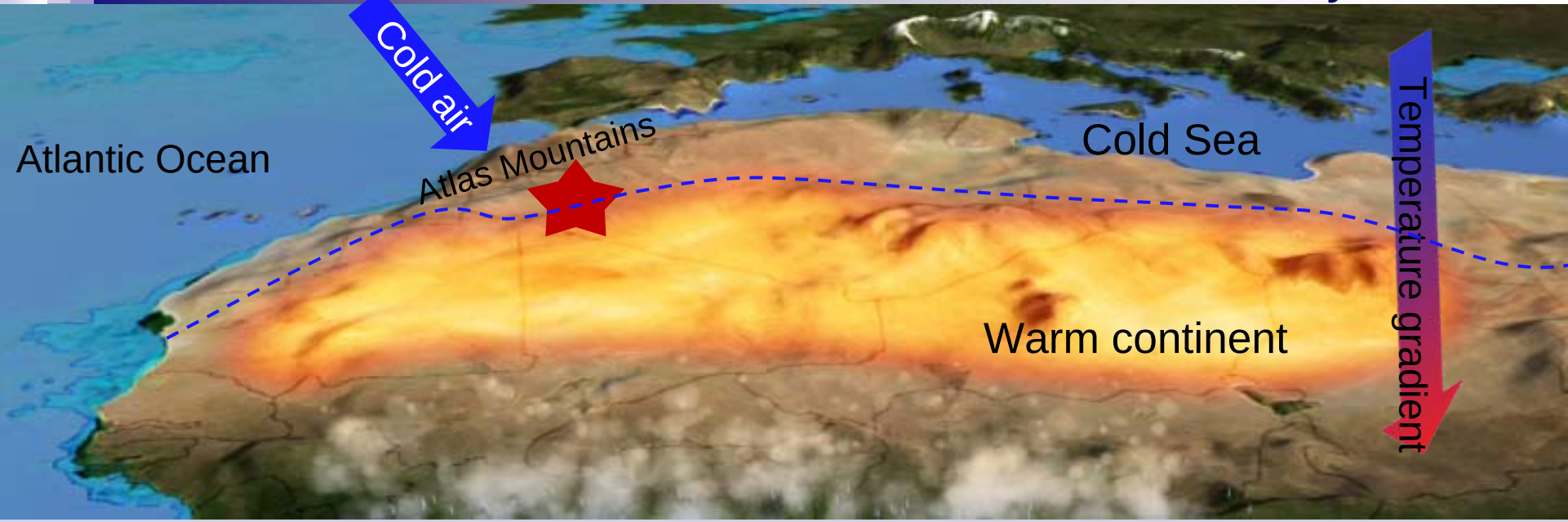
CALIPSO observations on dust emission and transport associated with Saharan cyclones: The February 2007 case.



Diana Bou Karam, Cyrille Flamant, Juan Cuesta, Jacques Pelon (LATMOS)
&
Earle Williams (MIT).

What are Saharan cyclones?



✓ Also called Sharav cyclones, Saharan depressions or Khamsin depressions are deep lows that form over **North Africa** in the leeward side east and south of the Atlas Mountains along the front between the cold air from high latitude and the warm African air.

✓ They occur **during spring** when the temperature contrast between the North African continent and the Mediterranean Sea is strongest due to the considerable increase in temperatures over the continent relative to the yet cold sea**.**

✓ The favorable conditions for the occurrence of the Saharan depressions:
- Strong meridional temperature gradient along the northern African coast,
- Subtropical jet stream related circulations and lee-effects of the Atlas Mountains.

Main characteristics of Saharan cyclones

✓ A **low pressure** at the surface of about **10 hPa**.

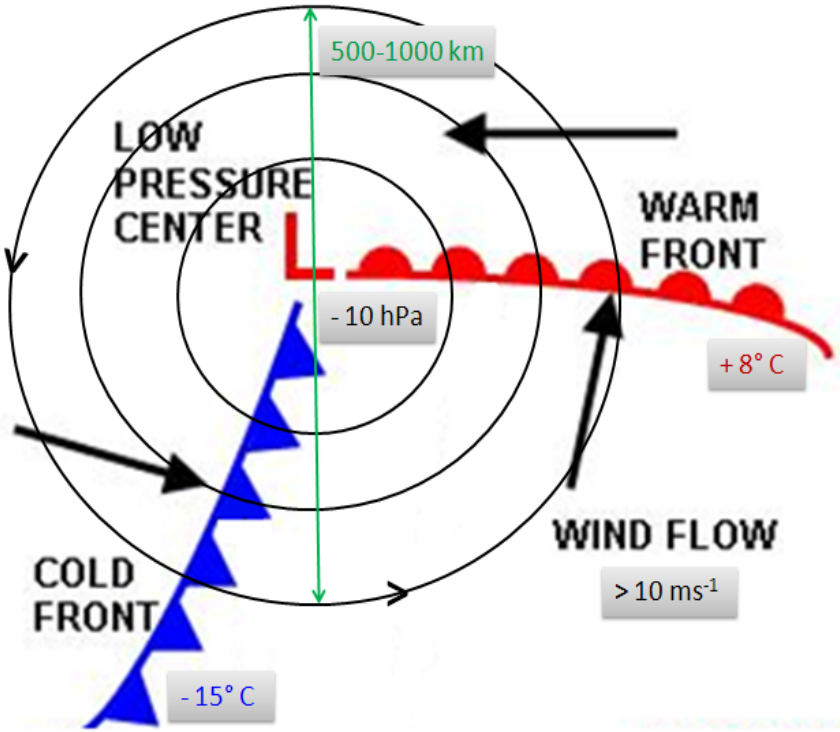
✓ A **warm front** to the east and north-east of the pressure low associated with high surface temperatures (an increase in surface temperature of **7-8° C**).

✓ A **cold front** to the west and southwest of the pressure low well defined at the surface and often characterized by a drop in surface temperatures of **10-20 °C.**

✓ A near surface **diameter** of the order of **500-1000 km** and a vertical extent of **3-5 km.**

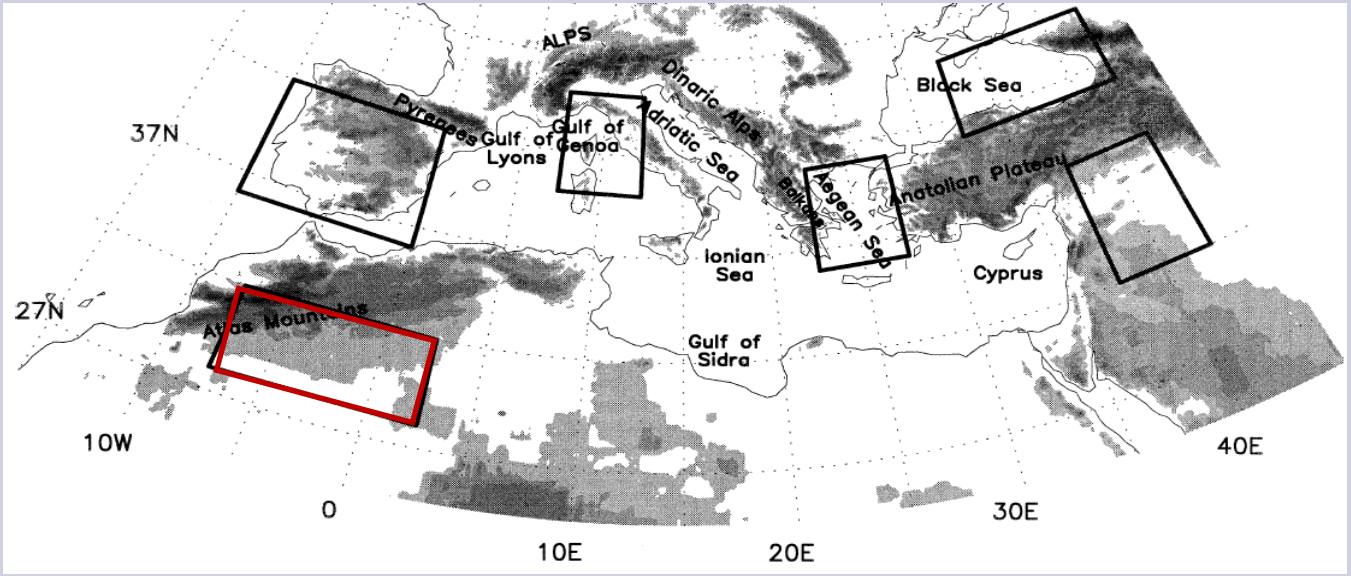
✓ The Sharav cyclones **move eastward** following the North African coast faster than **10 m s^{-1}**.

✓ They are associated with **hot and sandy southerly winds**.



Why to study Saharan cyclones?

✓ The most frequent type of Mediterranean cyclones: **~ 9 episodes/year.**



✓ Important synoptic features for **dust activity over North Africa** that have an influence at scales far beyond the regional one.

✓ At the origin of the most Saharan dust transport toward Europe and the Mediterranean Basin.

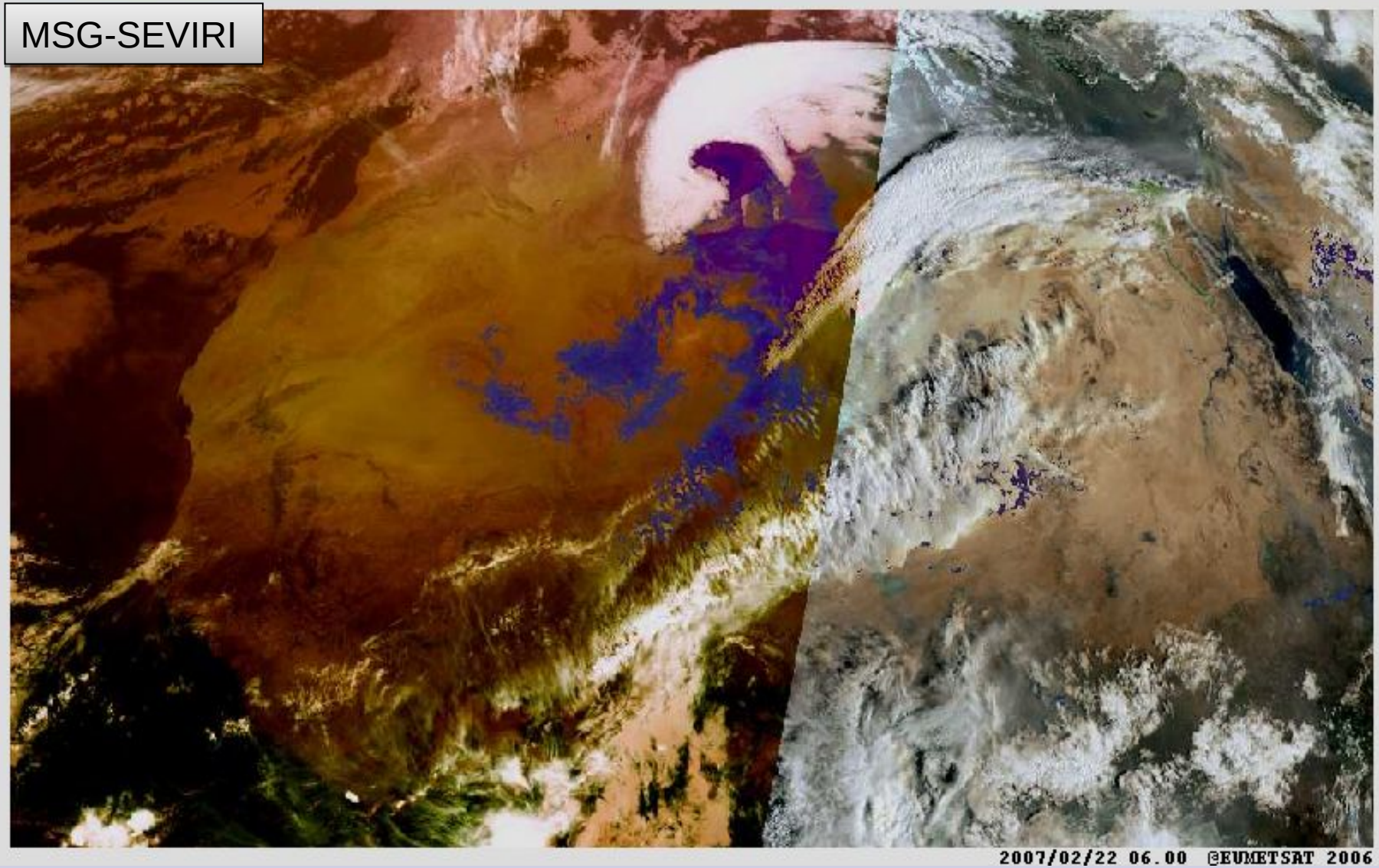
✓ They result in severe and often strong rainfall causing flooding and severe disruption to agriculture.

✓ The numerical prediction of Saharan cyclones is very important for the local populations and for the aviation.

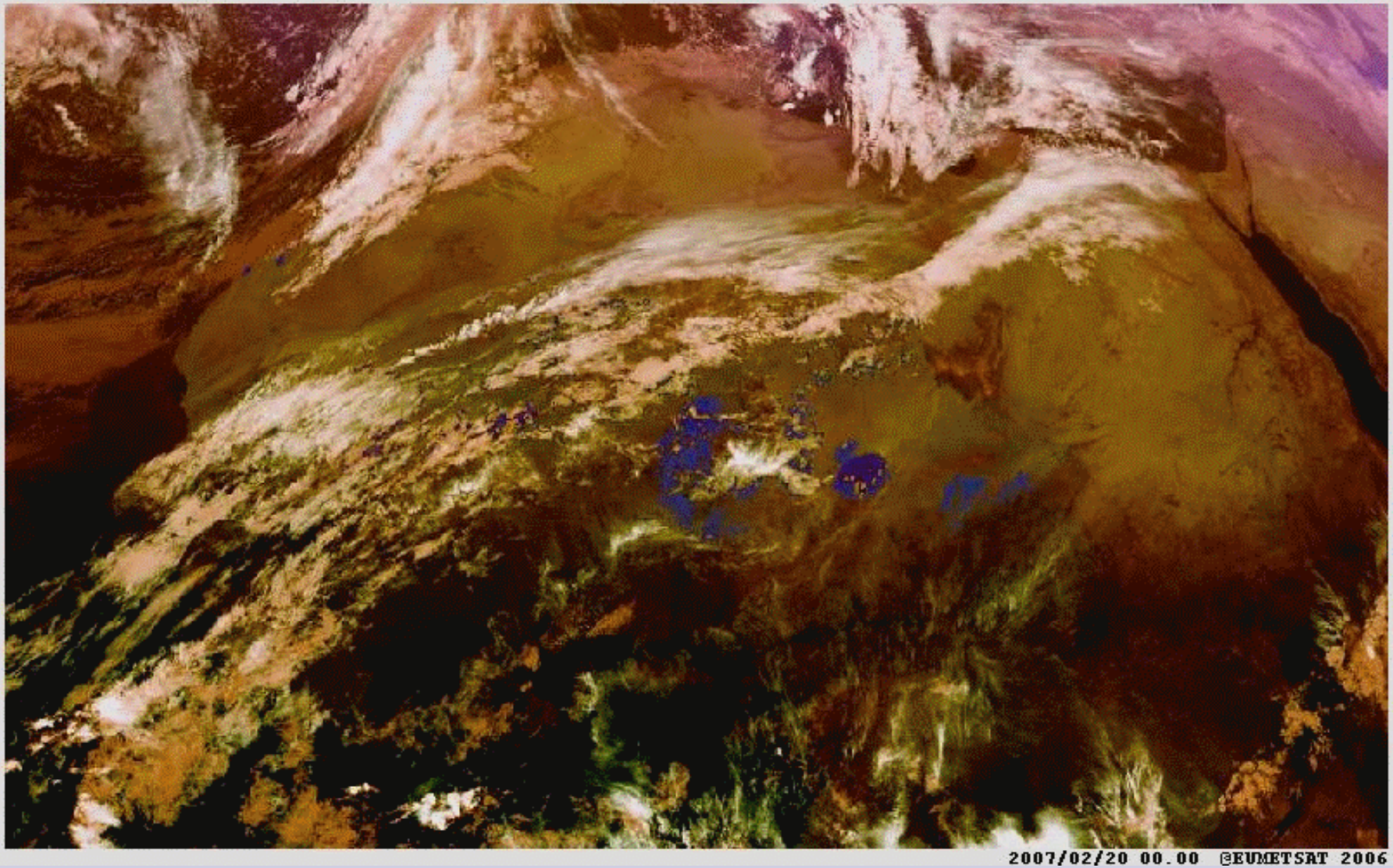
The Saharan cyclone on February 2007

Purple ➔ Dust

White ➔ Clouds



The Saharan cyclone on February 2007

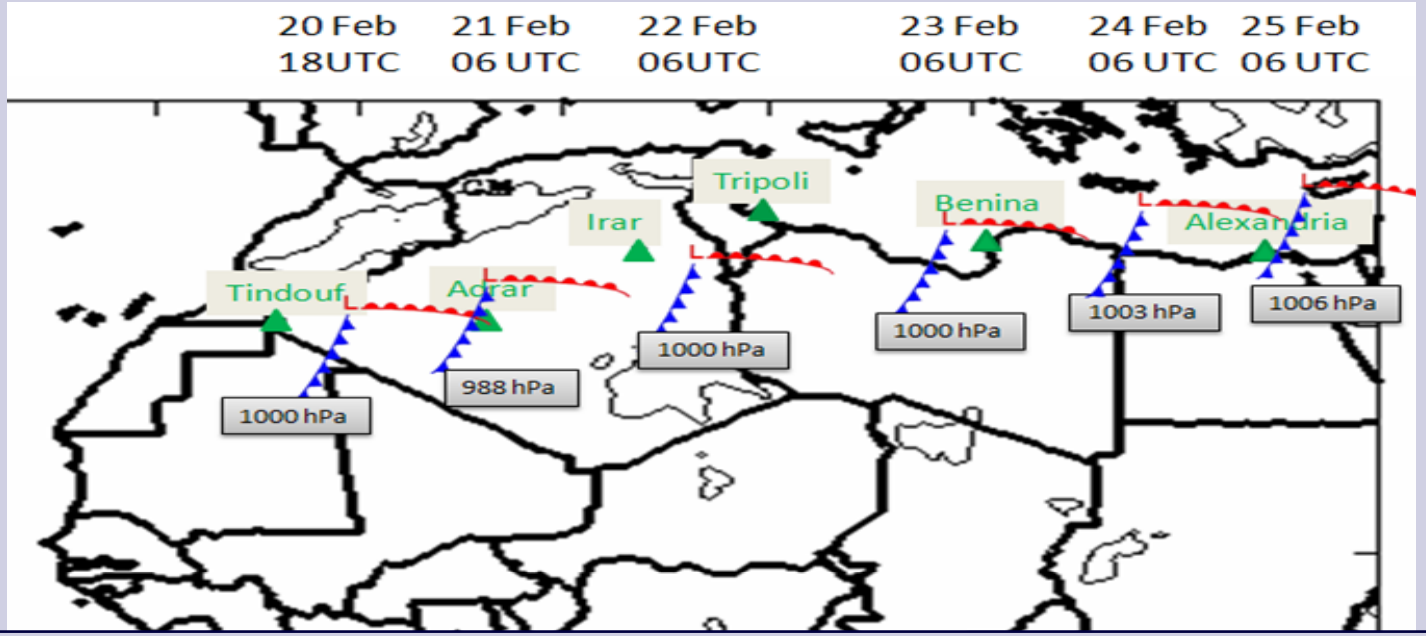


Aim of this study

Final goal: Evaluate the radiative impact of mineral dust on the cyclone dynamics, structure and longevity.

- Document the spatio-temporal distribution of dust and clouds during the Sharav event for the first time using a combination of satellite observations:
  - SEVIRI-MSG,
  - CALIPSO/CloudSat,
  - MODIS (Deep Blue).

- Characterise the cyclone from a dynamical point of view using the ECMWF analyses and ground based observations.

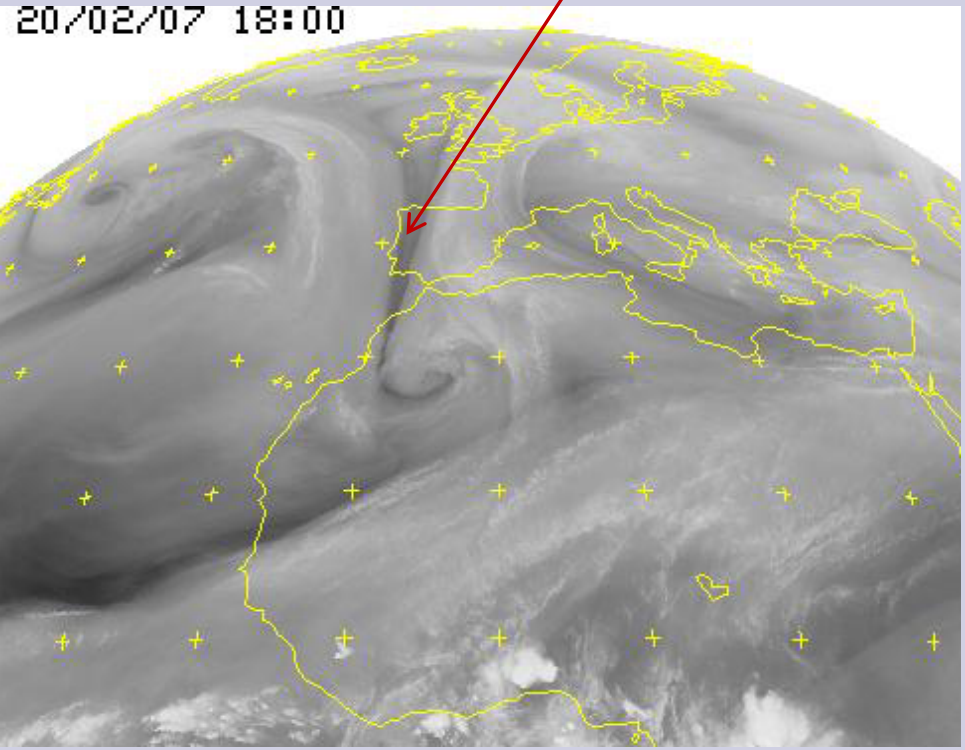


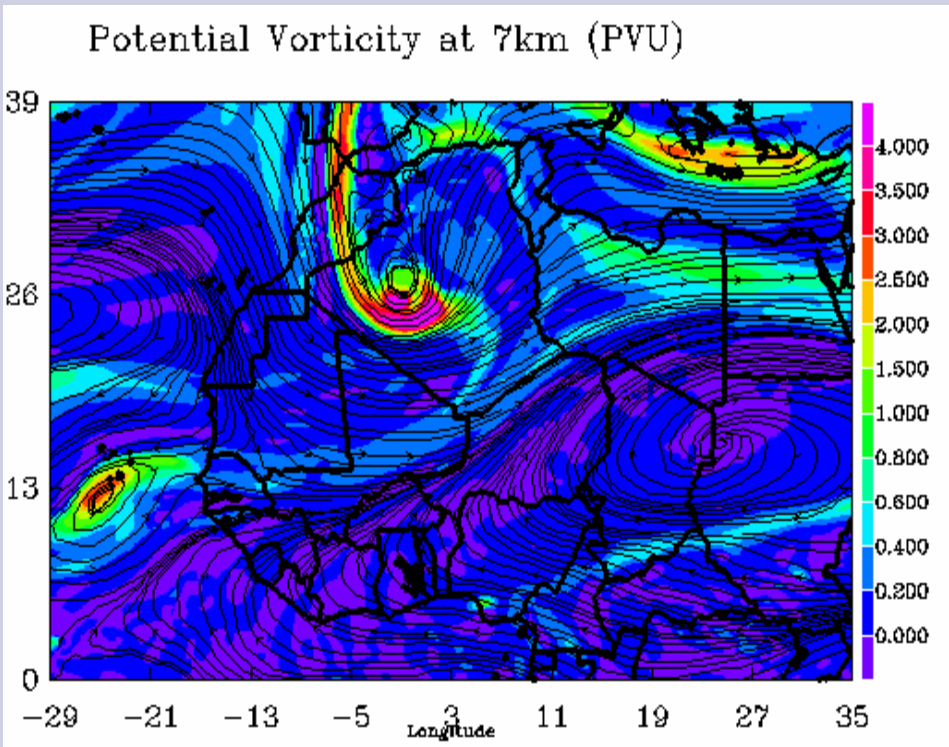
A- The cyclone characteristics and evolution between 20 and 25 February 2007

I- The initiation phase on 20/02/07 (1/2)

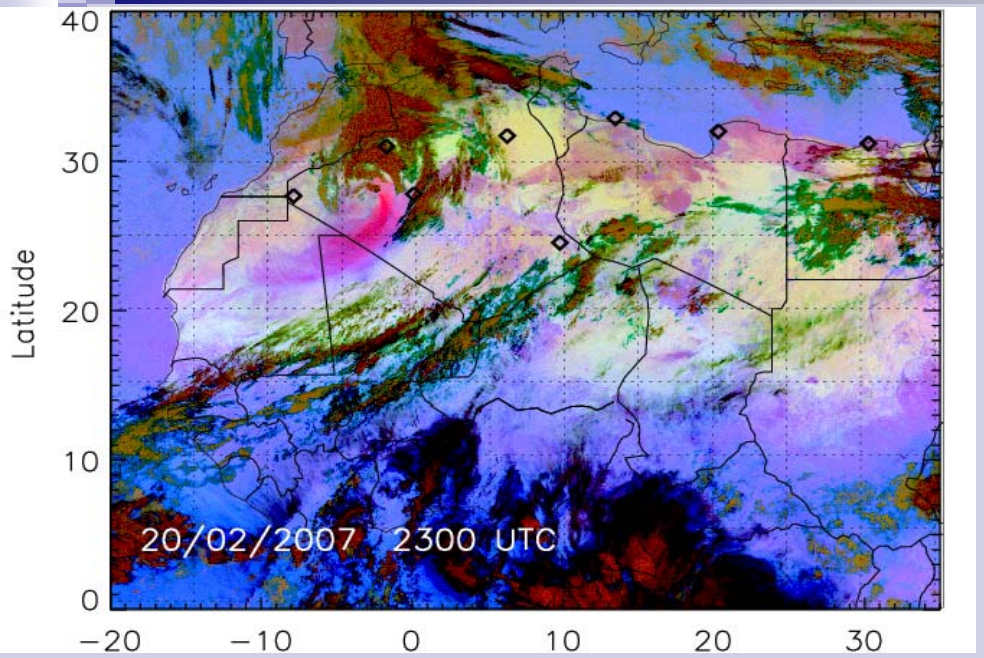
Cold air transported from the high latitudes into North Africa by the deep north-south oriented trough in the upper layers of the atmosphere.

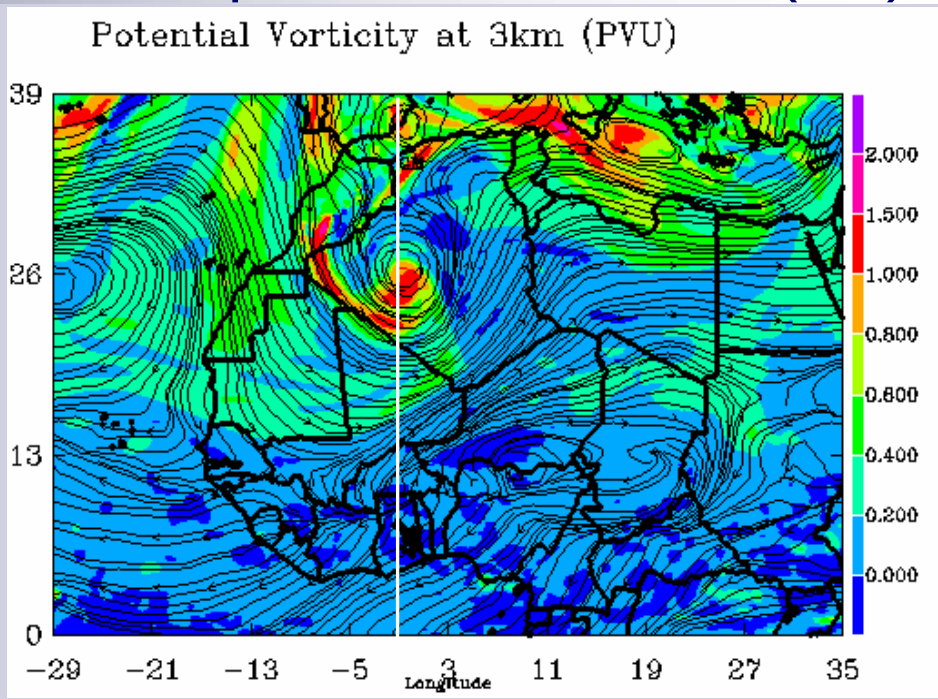
+ Orography blocking

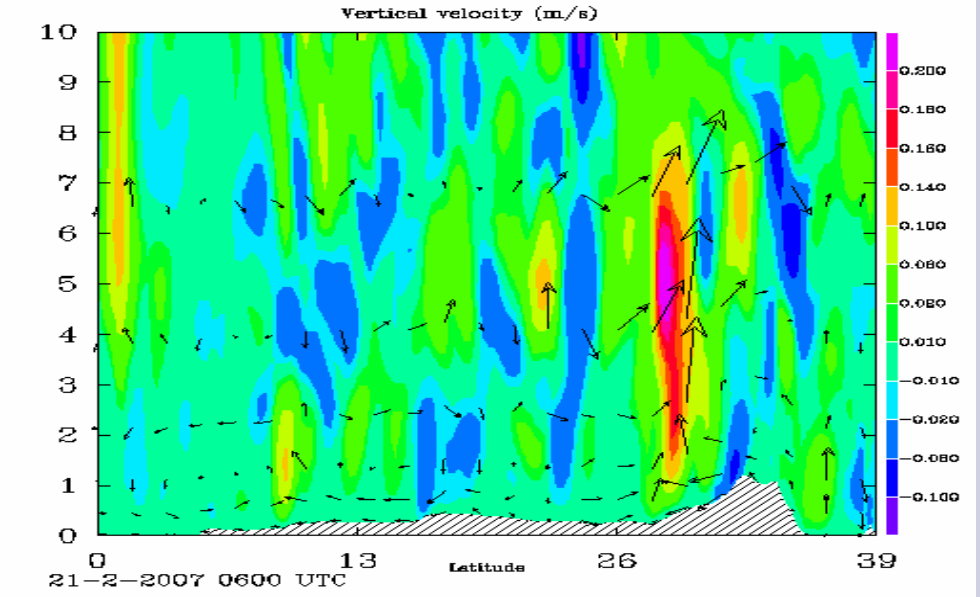




I- The initiation phase on 20/02/07 (2/2)







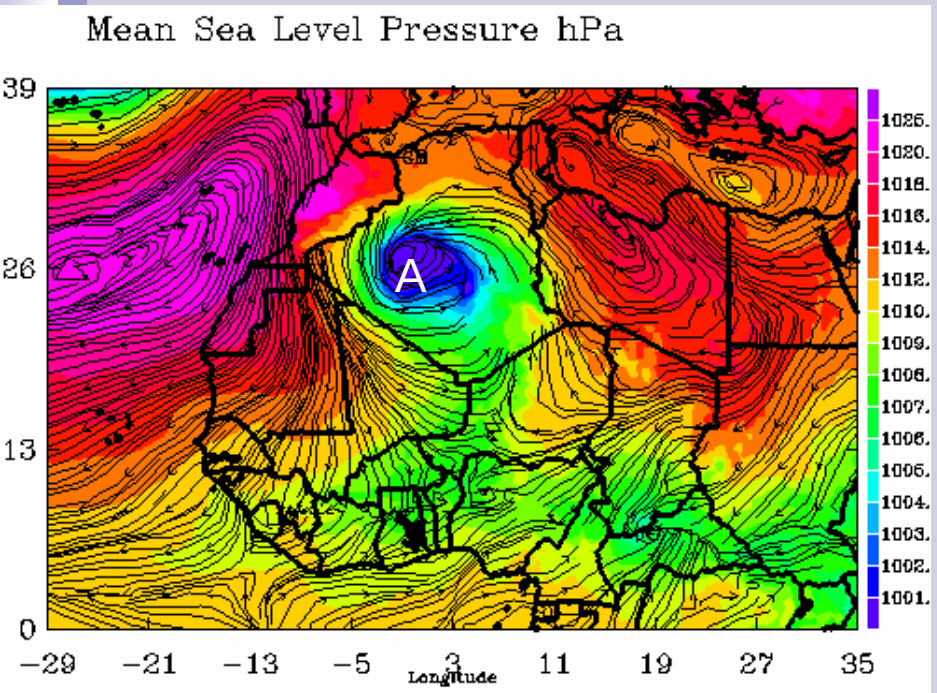
At the center of the cyclone:

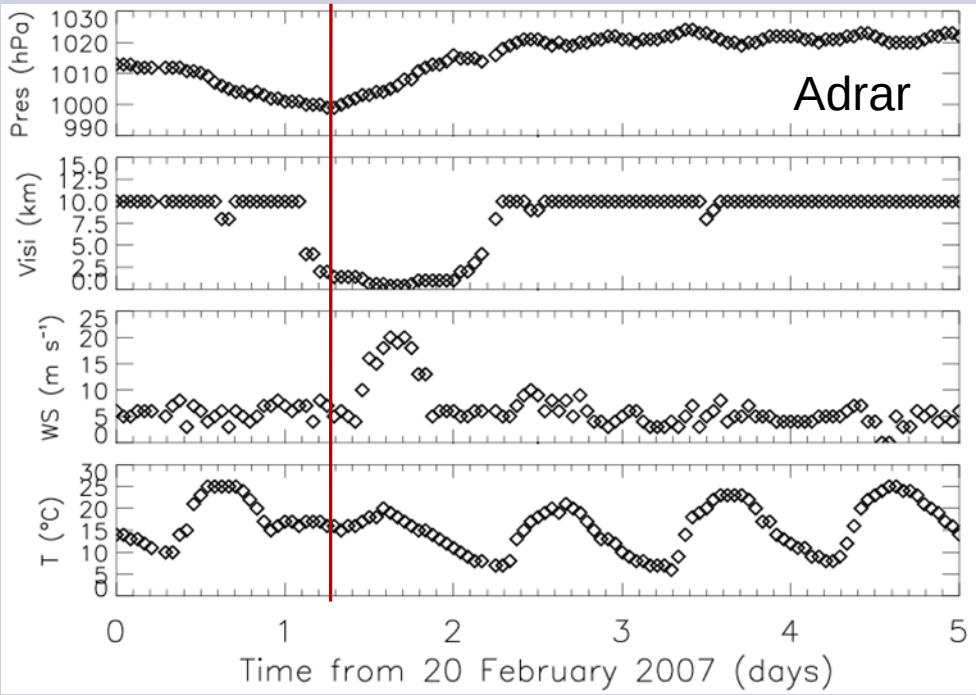
- PV = 1.5 PVU
- Vertical Velocity = 0.2 m/s
- Pressure low: 998 hPa

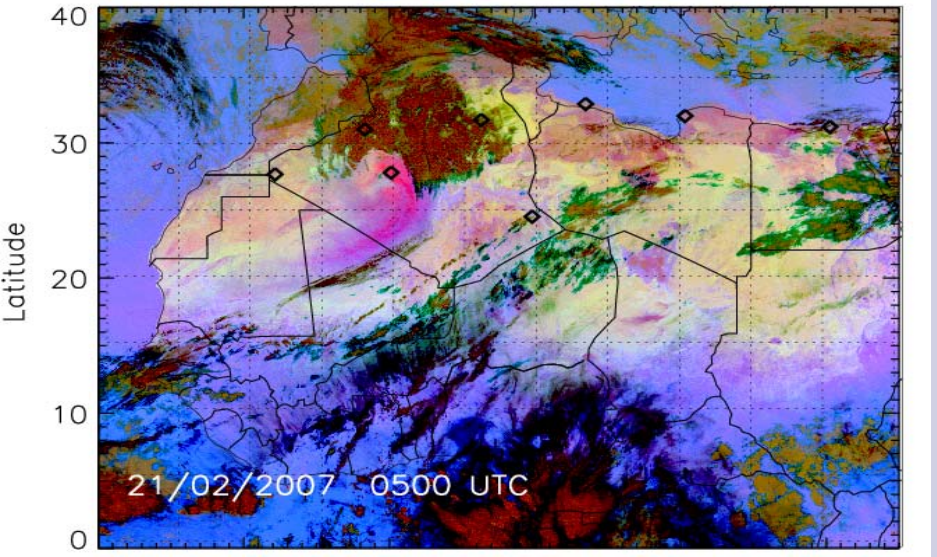
Around the eye of the cyclone:

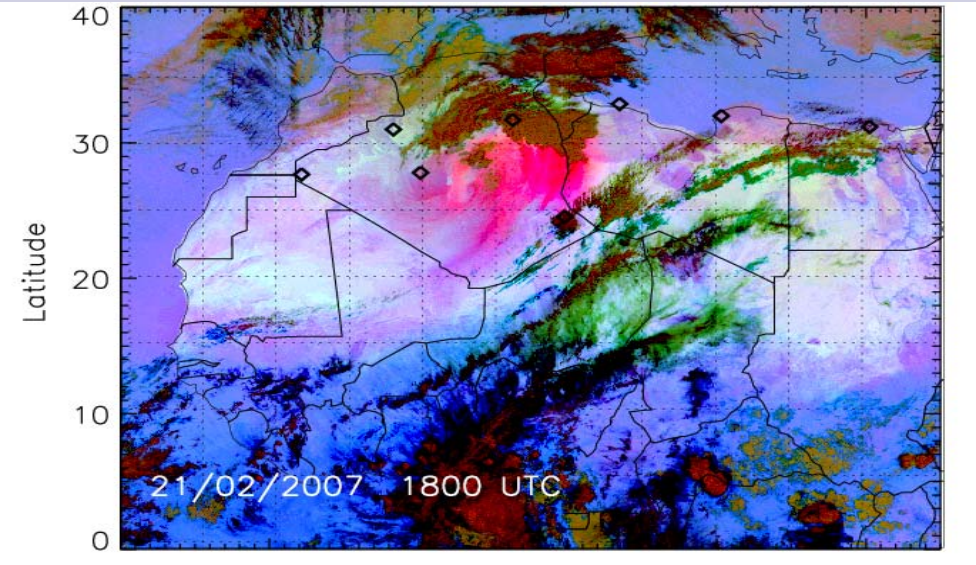
- Wind speed at 925 hPa = 20 m/s

II- The development phase

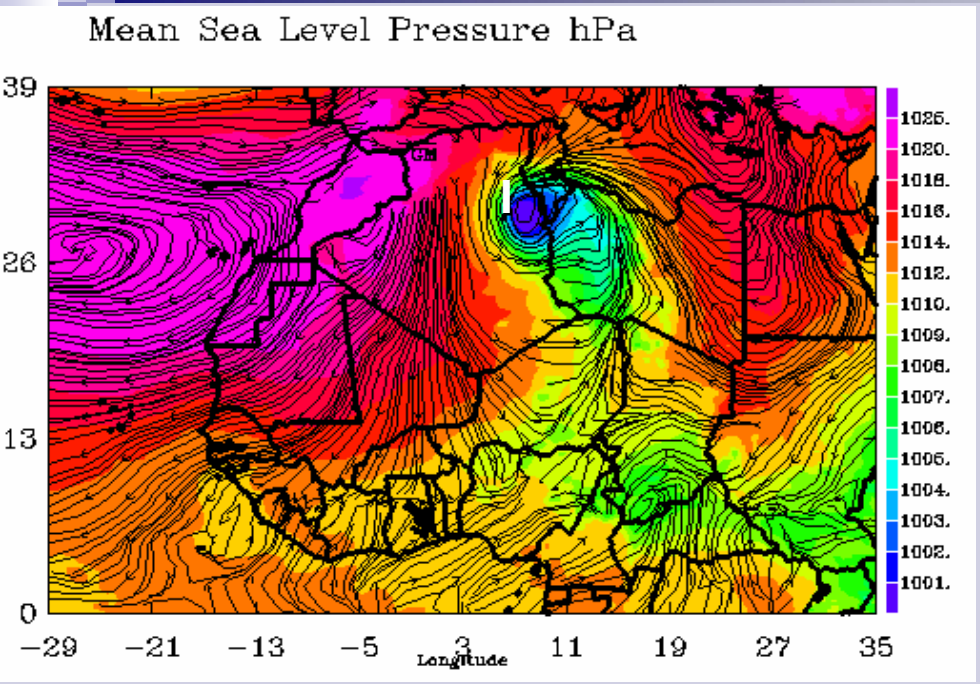


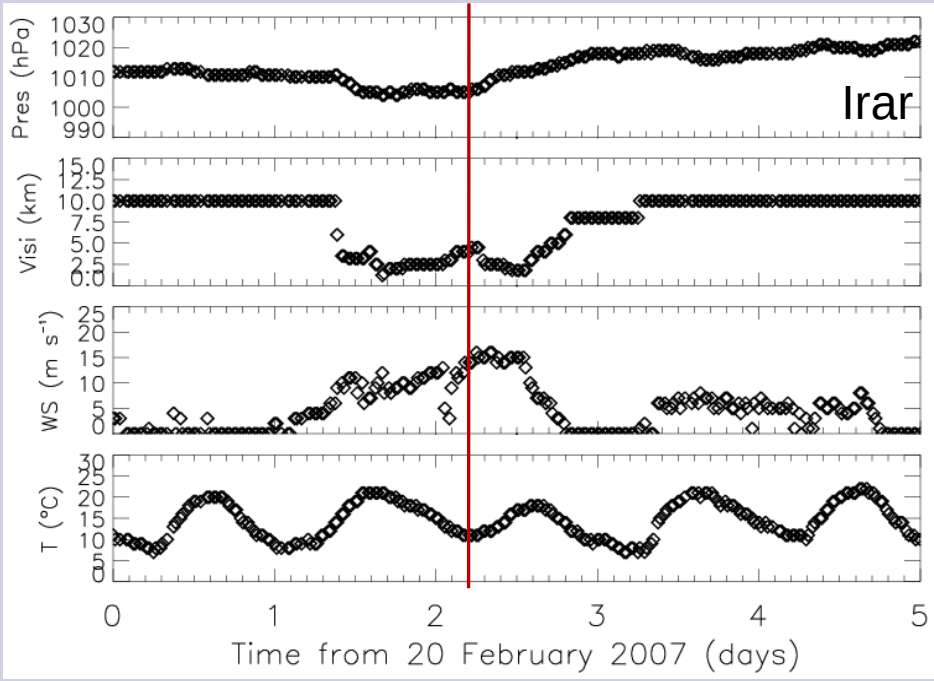


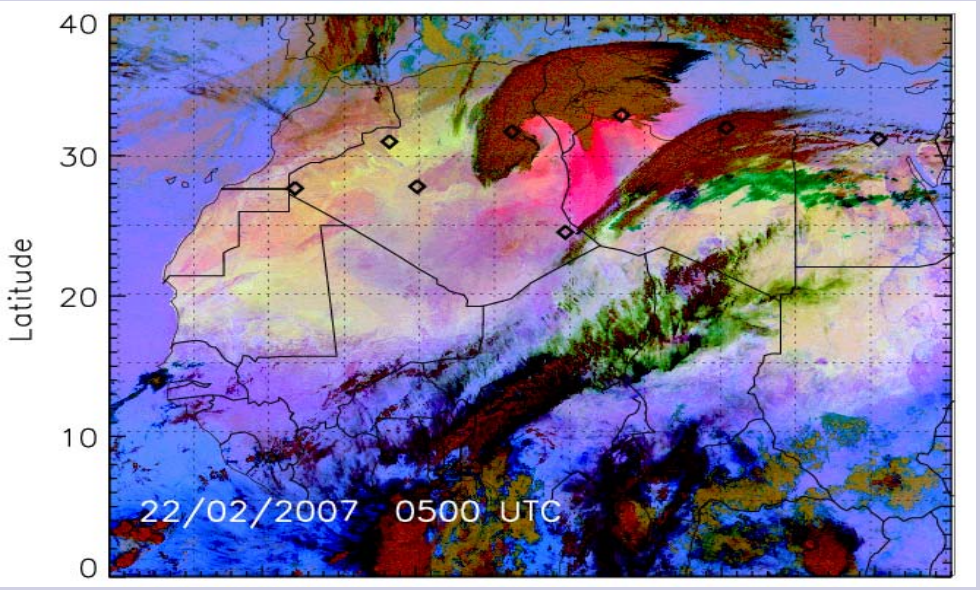


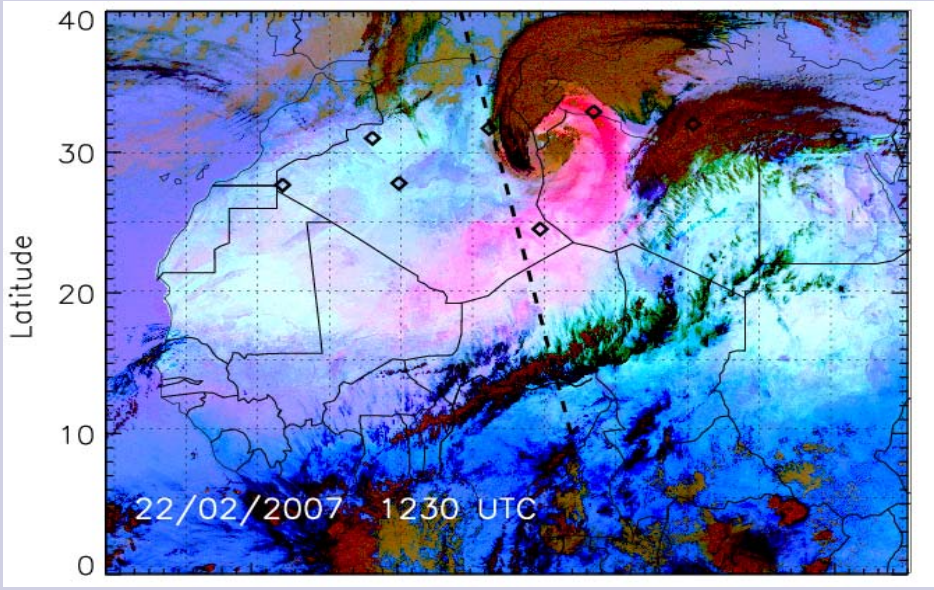


III- Migration over the continent

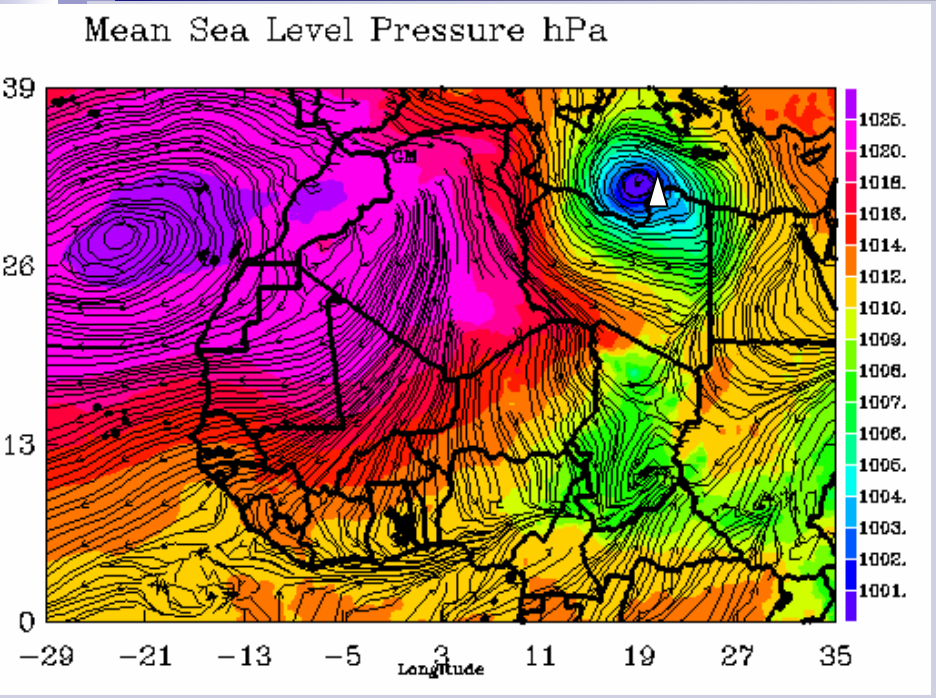


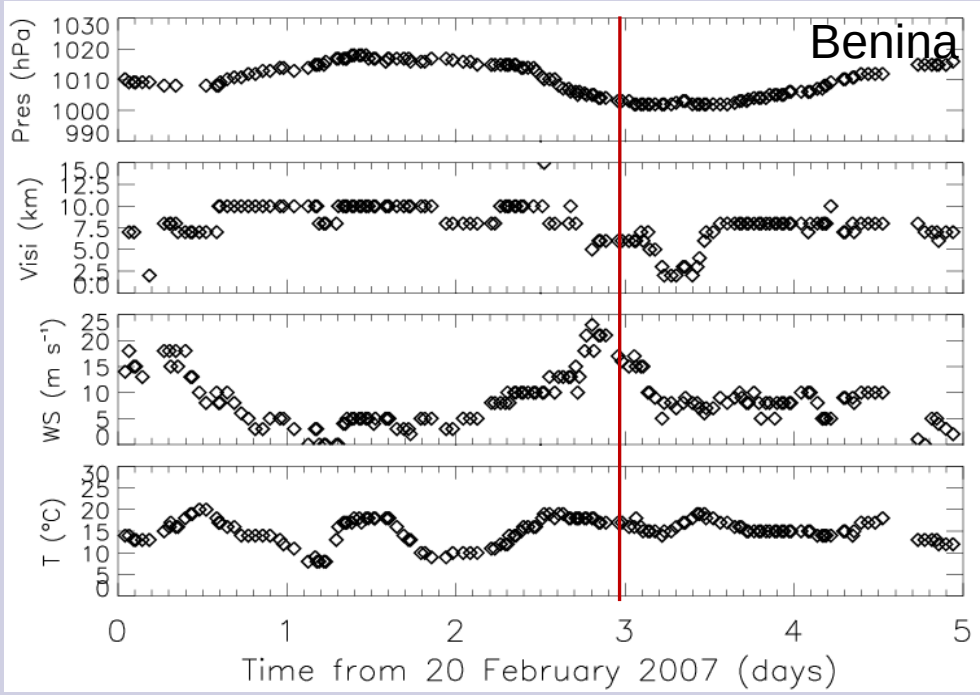


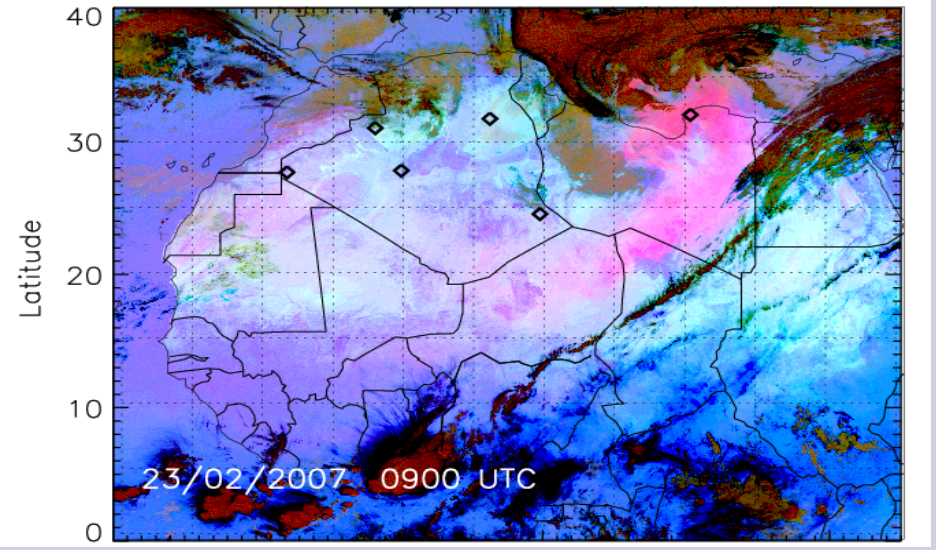


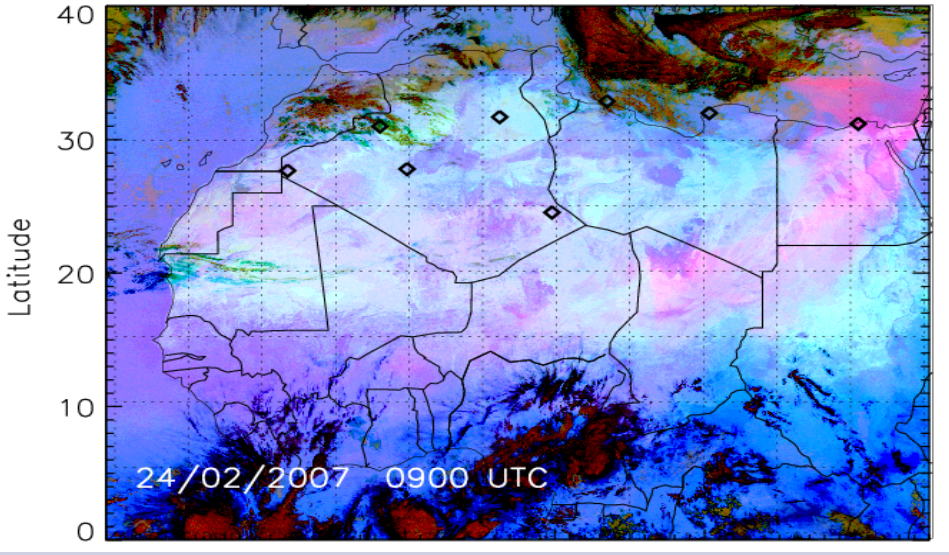


IV- Migration over the Sea





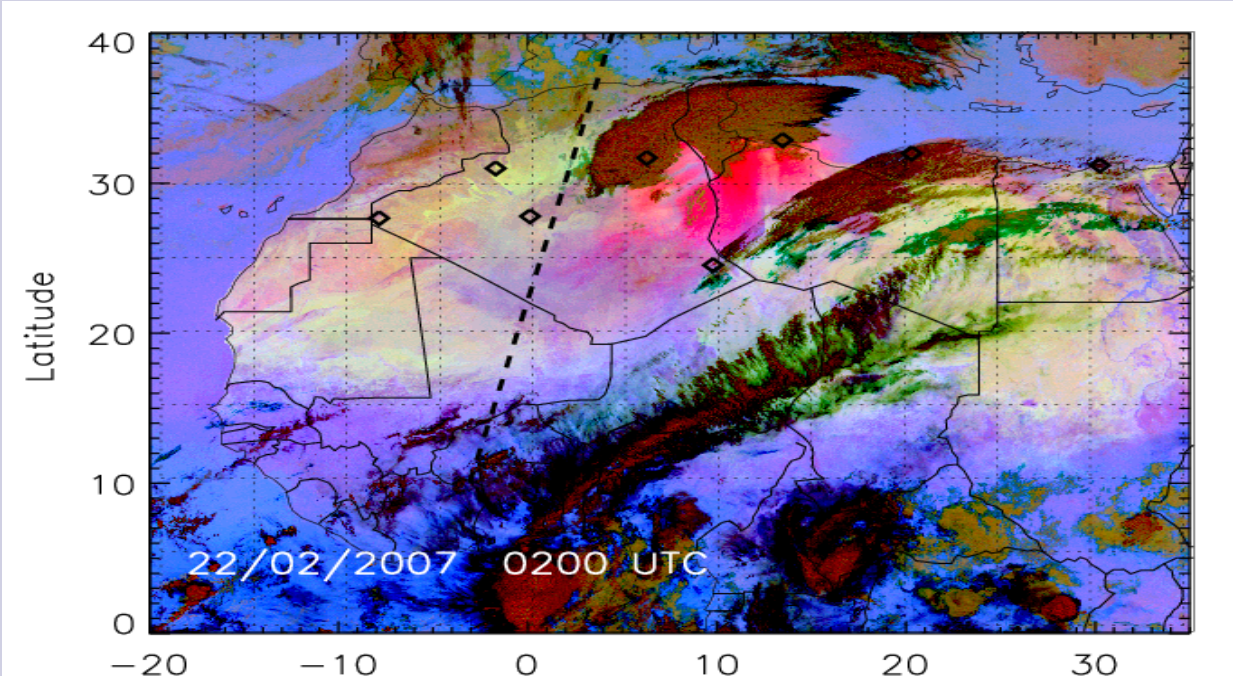




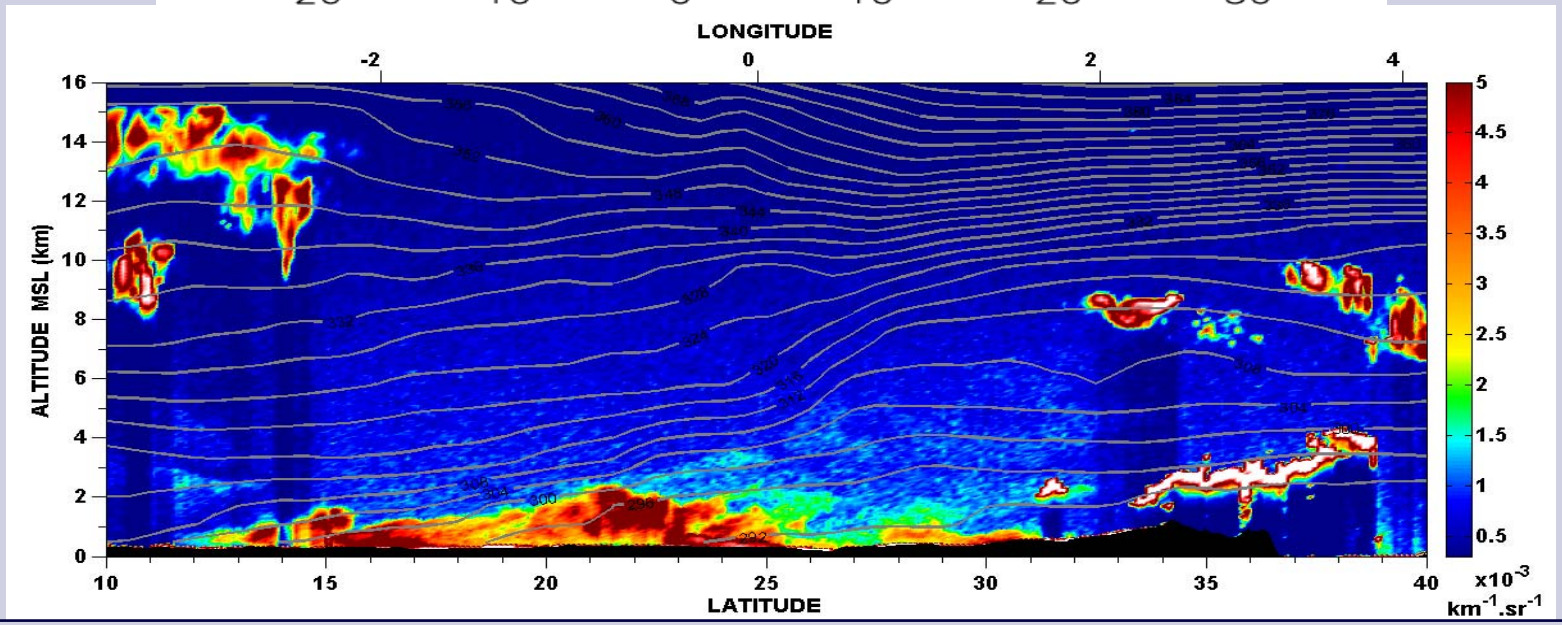
B- The spatio-temporal evolution of the dust storm

CALIPSO night track on 22 February 2007

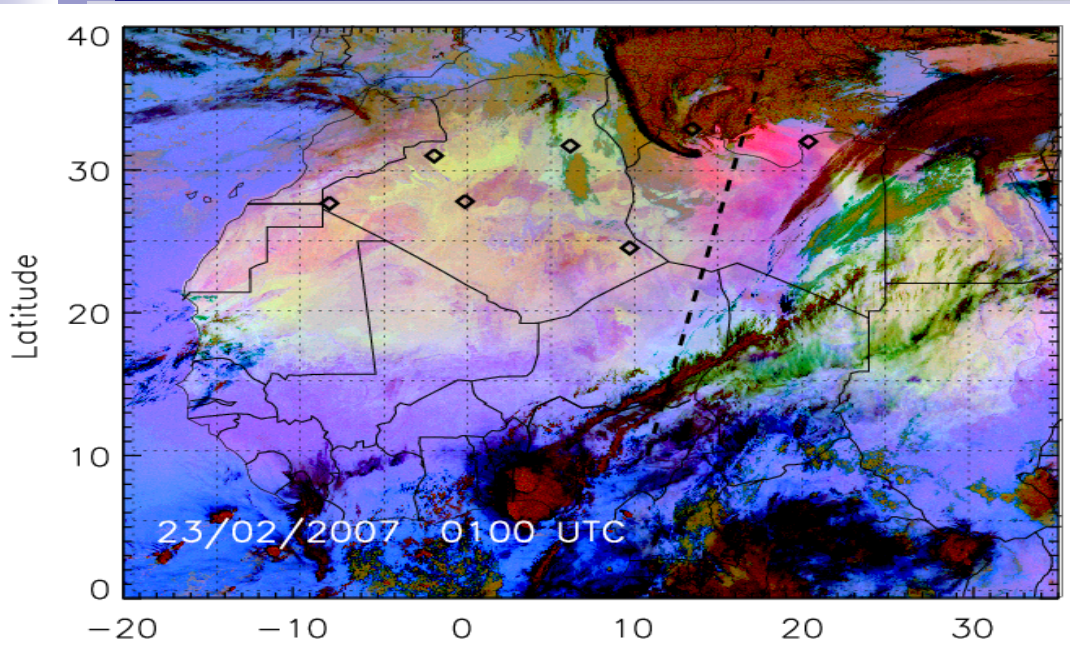
SEVIRI

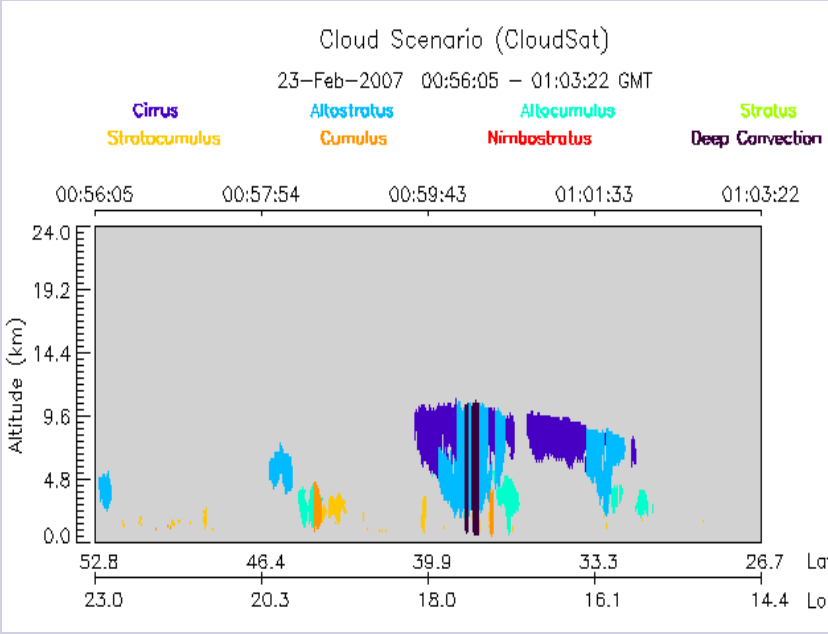


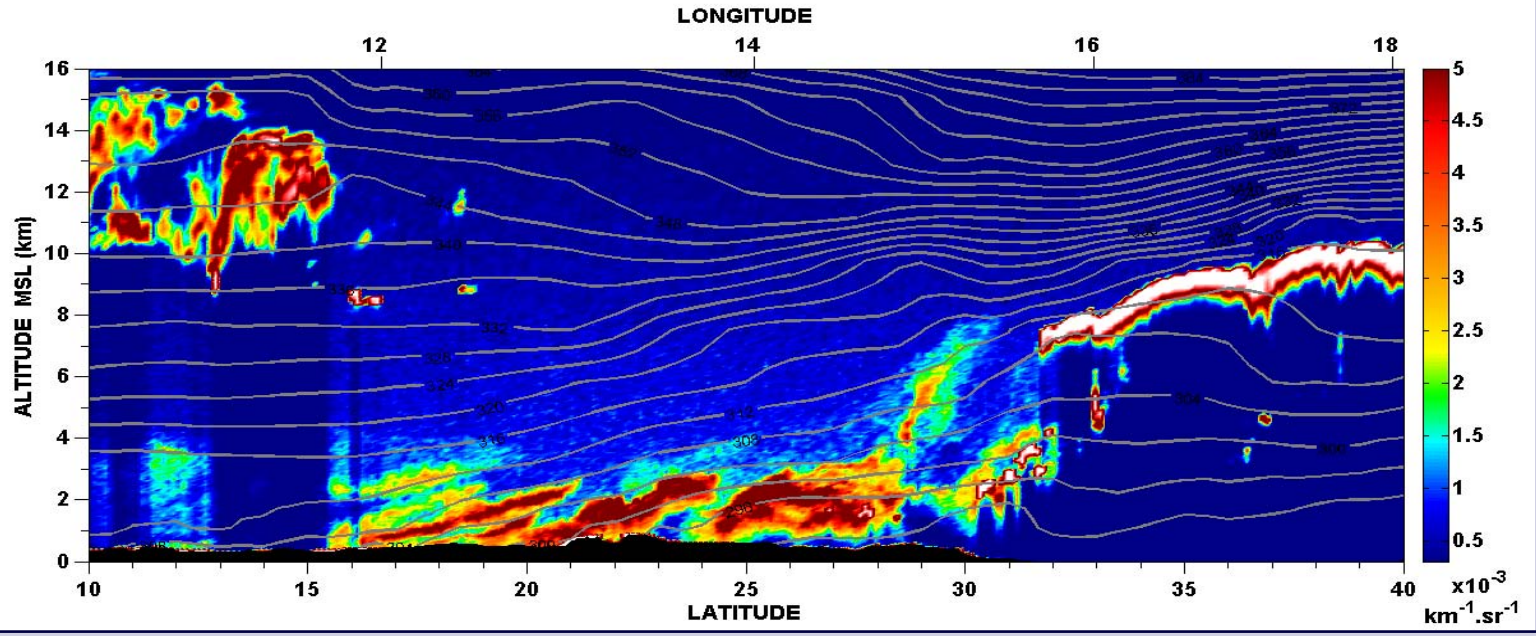
CALIPSO



CALIPSO night track on 23 February 2007

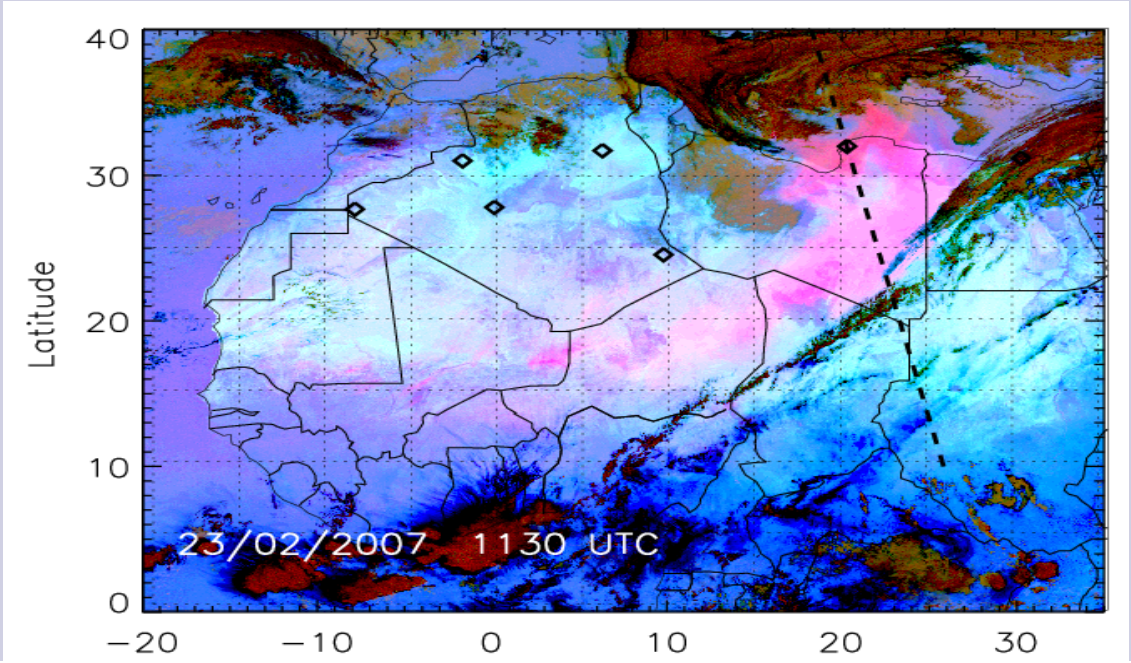




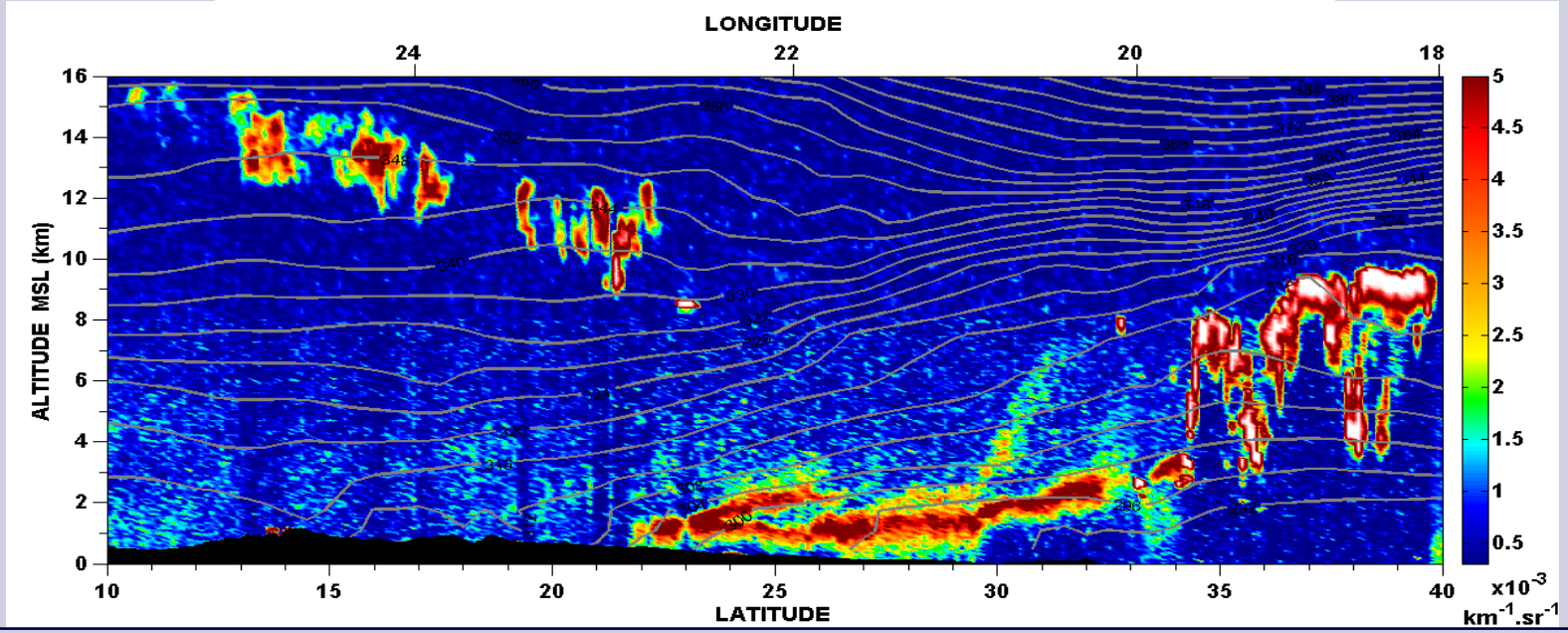


CALIPSO day track on 23 February 2007

SEVIRI

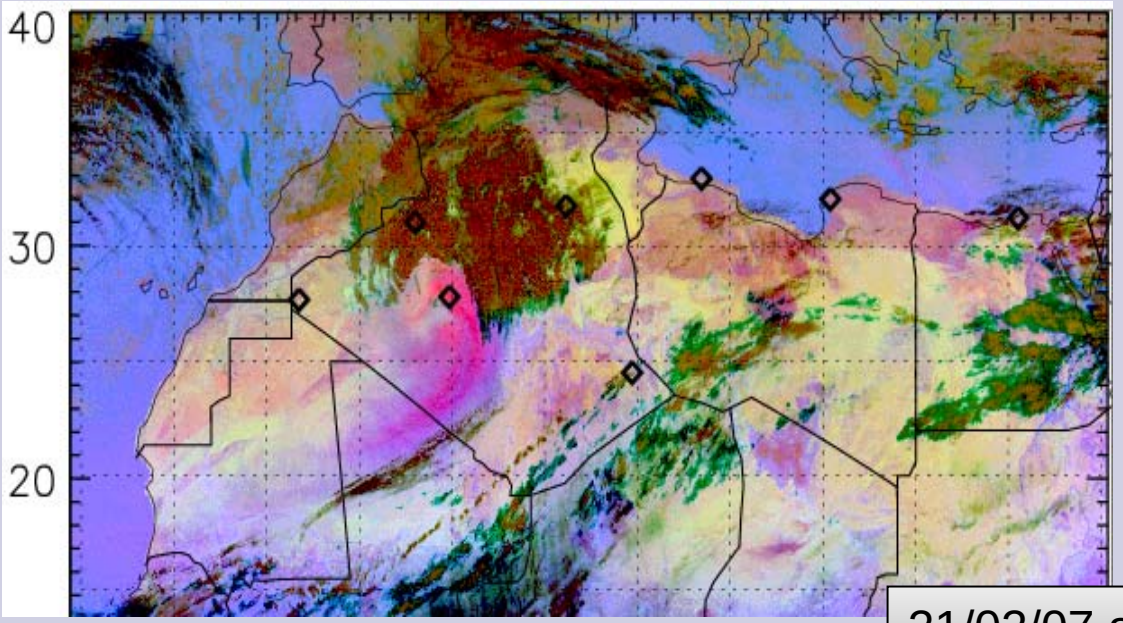


CALIPSO



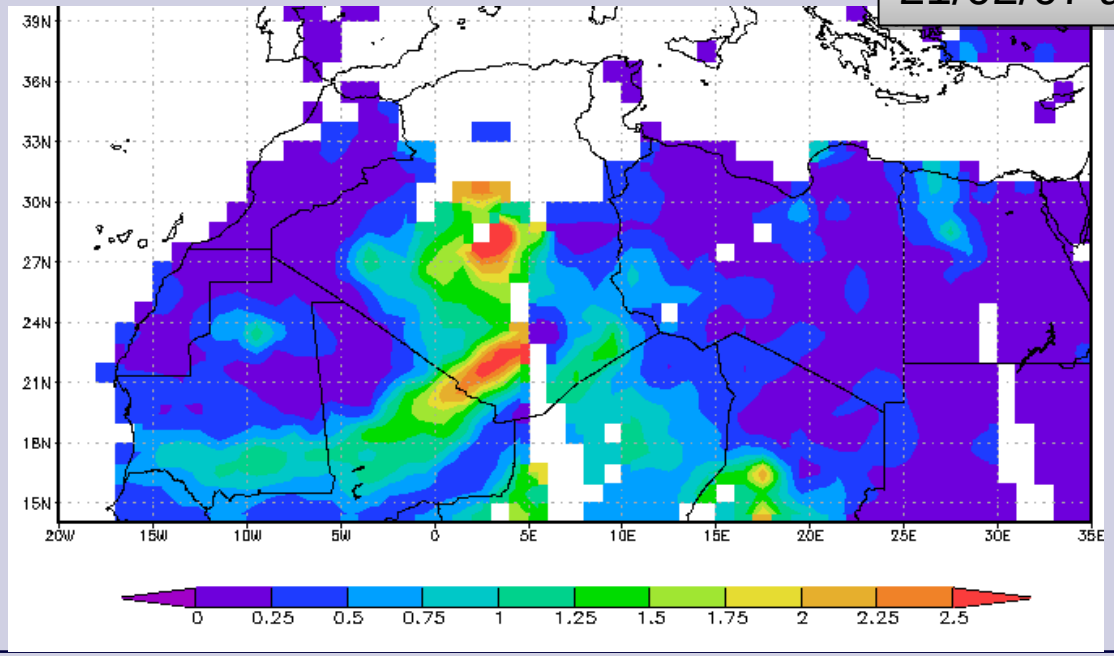
MODIS Deep Blue

SEVIRI



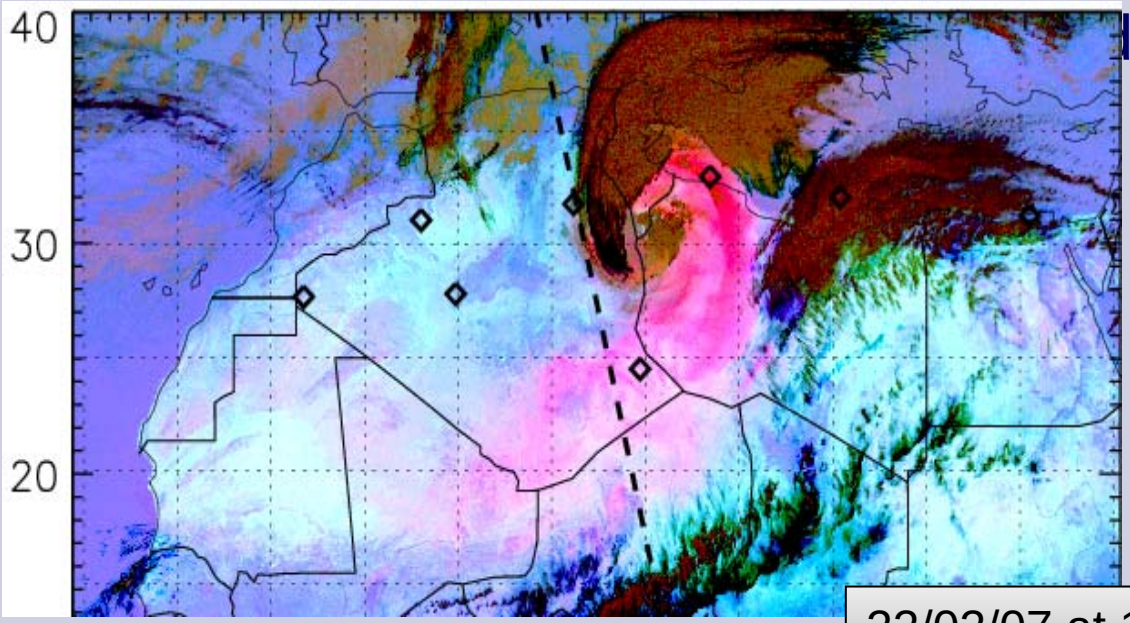
21/02/07 at 1230 UTC

MODIS



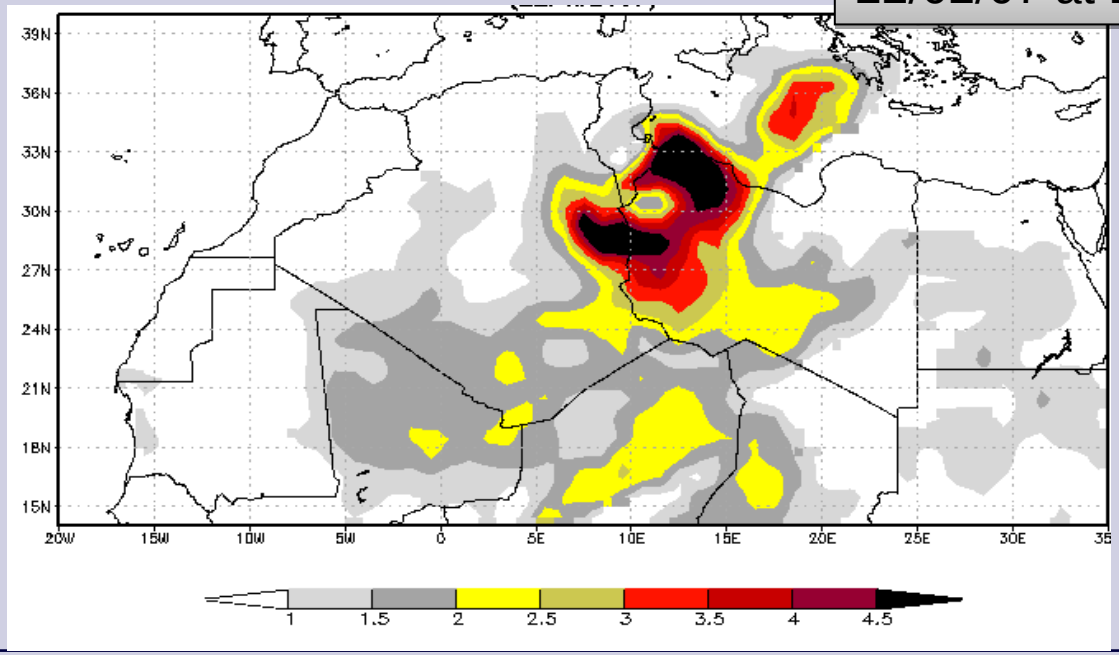
OMI Aerosol lex

SEVIRI



22/02/07 at 1230 UTC

OMI



Summary

➢ Examined the weather conditions accompanying the Sharav cyclone over 5 days on February 2007:

- ❖ Strong surface winds ➔ 20 m/s,
- ❖ Dramatic visibility conditions ➔ 0 km,

➢ Documented the spatio-temporal evolution of dust using a combination of satellite observations at high resolution:

- ❖ SEVIRI: The dust storm covered an area as large as 15° x 15°
- ❖ CALIPSO:
  - At first stage, heavy dusty layers were seen between the surface and 2-3 km in altitude,
  - The dust was transported into high altitudes up to 7 km ➔ Available for long range transport.
- ❖ CloudSat: Deep convection occurred in the northern part of the cyclone leading to heavy rainfall over this region.
- ❖ MODIS: The dust storm was associated with 2.5 Optical Depth.
- ❖ OMI: The Aerosol Index was > 4.5.

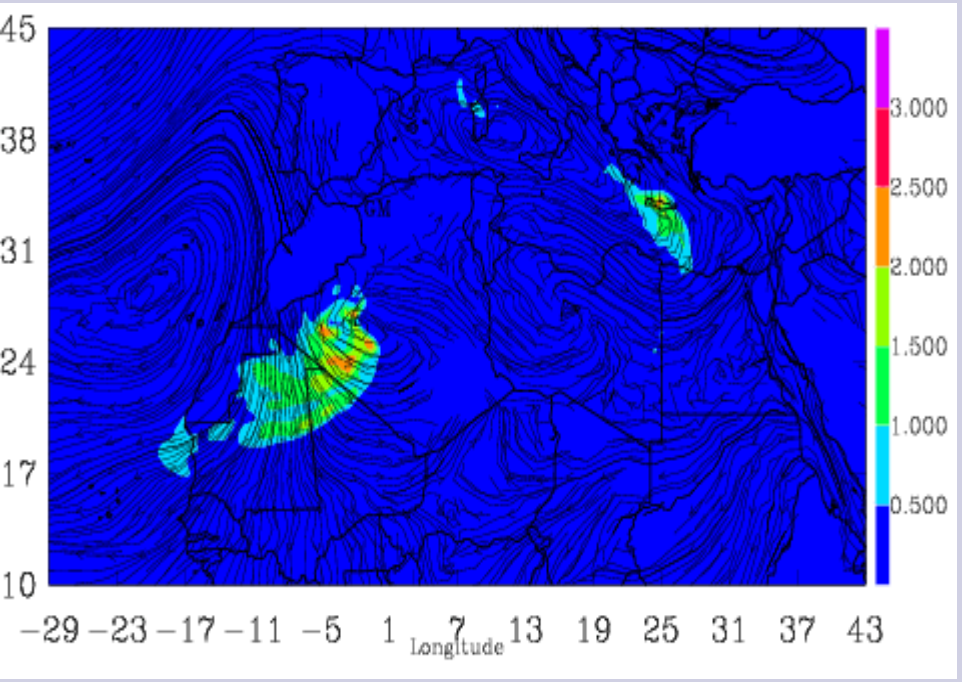
On going study

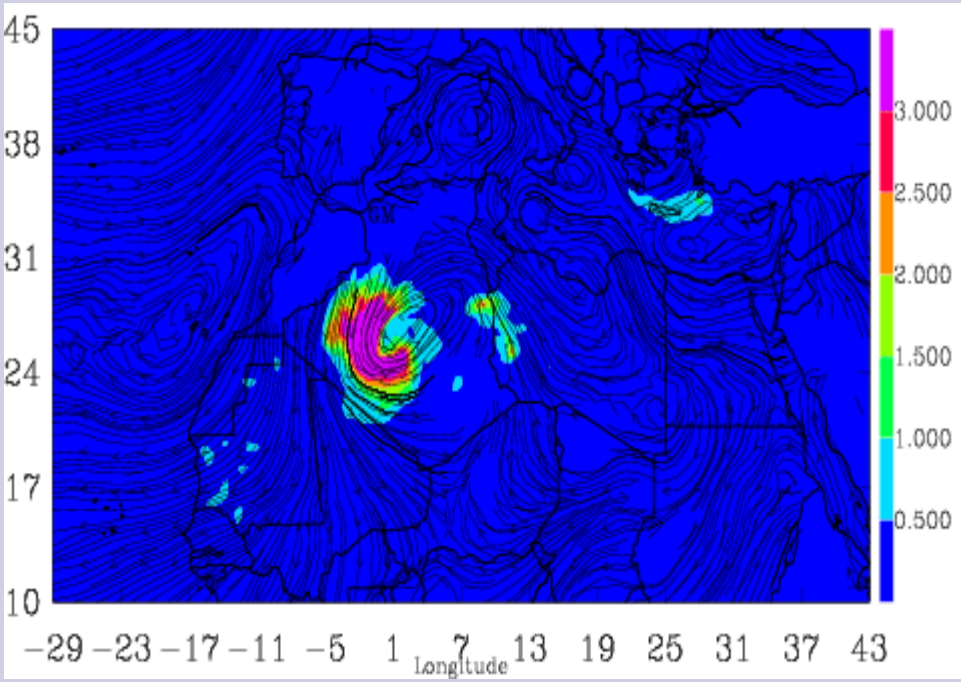
Evaluating the radiative impact of dust on the cyclone dynamics and lifetime

➔ Numerical simulations at high resolution (10 km) using MesoNH with and without dust

➢ First results from the simulation with dust:

Vertically integrated dust mass (g/m^2) on February 21 at 0000 UTC and 1100 UTC





➔ Good case to study the indirect effect of mineral dust.


Thank you for your attention!!