Saharan dust lofting by Haramattan and monsoon flows convergence: Mesoscale Modelling, CALIPSO and Airborne Lidar observations

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RATIONALE AND OBJECTIVES

The ITD (defined as the interface between the monsoon and harmattan flows near the surface) is a key feature of the West African monsoon (WAM) system. Its position over Sahel is highly variable on daily-to-seasonal timescales, but its somewhat abrupt northward shift occuring around the end of June (as determined from OLR or rainfall data) marks the beiginning of the rainy season in Sahel.

Dust production in the Sahel and Sahara regions are known to be connected with the occurence of large wind speeds at the surface. Winds associated with the WAM are also known for exhibiting a strong diurnal cycle (e.g. Parker et al., 2005). However, the maximum in wind speed is generally observed to be during the nighttime (0000-0600~UTC).

The ITD region, at the interface between the monsoon and harmattan flows is a convergence zone which intensity is particularly strong during the nighttime. Therefore, provided that it is located over or in the vicinity of dust sources, the dynamical system associated with the ITD should be prone to aerosol lofting.

In this presentation, the mechanims associated with the **Saharan dust lofting** and transport in connection with the inter-tropical discontinuity are analysed by **Calipso and airborne lidar observations** as well as mesoscale numerical modelling.

MEANS AND STRATEGIES

Experimental Strategy

The aerosol spatial distribution in the ITD region over Niger was documented by the SAFIRE (Service des Avions Français Instrumentés pour la Recherche en Environnement) Falcon 20 (F/F20) equipped with the airborne lidar LEANDRE 2 during the AMMA SOP 2a1 "ITD and SHL surveys" mission performed on 3, 7 and 10 July 2006 and by CALIPSO observations.

Models

- The Non Hydrostatic Mesoscale model **MesoNH** including a prognostic **dust scheme**. Mesonh simulations are driven by **ECMWF** analysis.
- Dust emission: The Dust Entrainment And Deposition module **DEAD** embedded in MesoNH.
- Surface scheme: **ISBA** initialized by ECOCLIMAP, FAO and GTOPO30.

Strategy

- One domain over west Africa centered at 20°N and 7°E
- 20-km horizontal resolution, 100 x 100 points
- 62 levels used on the vertical resolution starting at 30 m above the ground.
- Simulation over ten days between 2 and 12 of July 2006.
- Nudging every 6 hour.

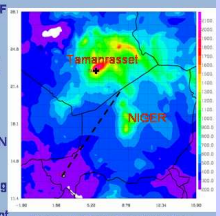
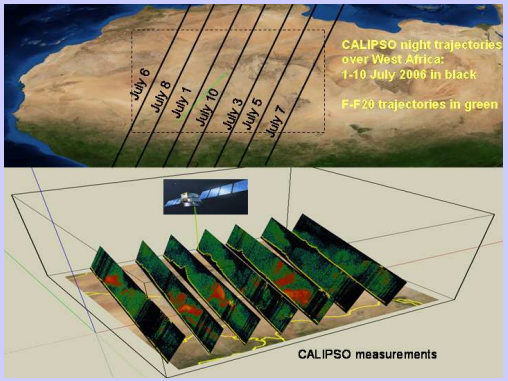


Figure 1: Meso-NH simulation domain and the F20 Track (dashed balck line)

RESULTS



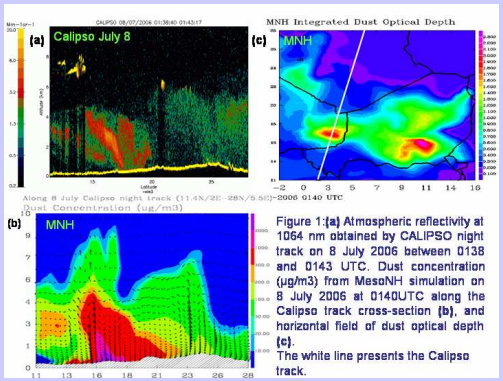


Figure 1:**(a)** Atmospheric reflectivity at 1064 nm obtained by CALIPSO night track on 8 July 2006 between 0138 and 0143 UTC. Dust concentration (µg/m3) from MesoNH simulation on 8 July 2006 at 0140UTC along the Calipso track cross-section **(b)**, and horizontal field of dust optical depth **(c)**. The white line presents the Calipso track.

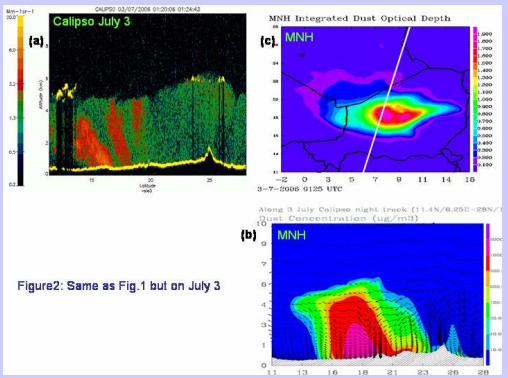


Figure2: Same as Fig.1 but on July 3

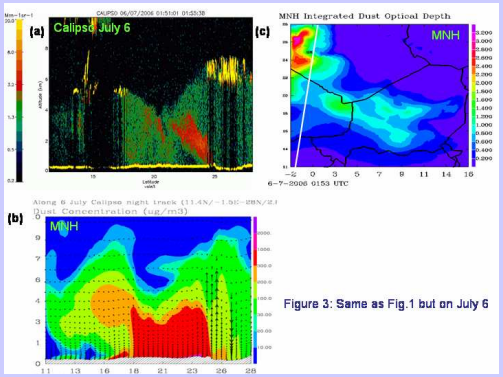


Figure 3: Same as Fig.1 but on July 6

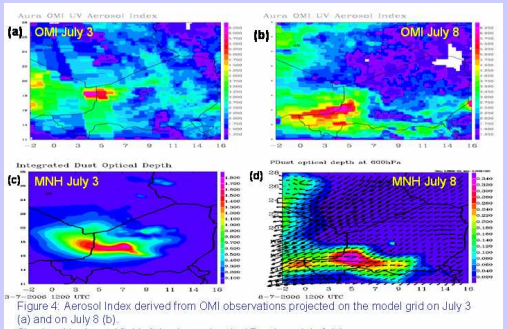


Figure 4: Aerosol Index derived from OMI observations projected on the model grid on July 3 (a) and on July 8 (b).
Simulated horizontal field of the Aerosol optical Depth on July 3 (c).
MNH horizontal field of dust optical depth integrated from the ground up to 600hPa superimposed on horizontal wind direction **field** at 600hPa (d)

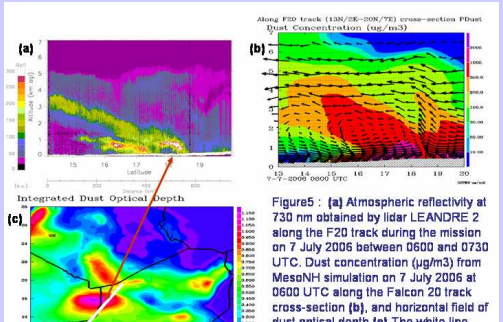


Figure5 : **(a)** Atmospheric reflectivity at 730 nm obtained by lidar LEANDRE 2 along the F20 track during the mission on 7 July 2006 between 0600 and 0730 UTC. Dust concentration (µg/m3) from MesoNH simulation on 7 July 2006 at 0600 UTC along the Falcon 20 track cross-section **(b)**, and horizontal field of dust optical depth **(c)**.The white line presents the F20 track (13°N/2°E - 20°N/7°E)

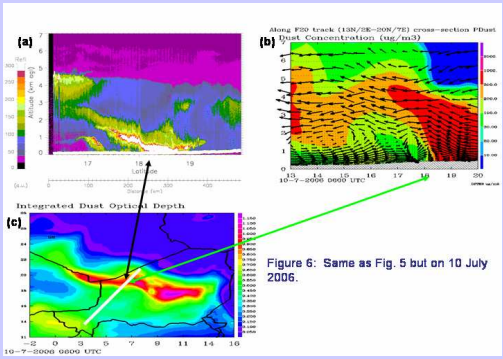


Figure 6: Same as Fig. 5 but on 10 July 2006.

DISCUSSION

Calipso measurements show that the SAL reached 5 km with a capping inversion limiting the diffusion of dust aerosol in the free troposphere above, consistent with Leandre 2 measurements during the 3 missions. This inversion is well reproduced in the MesoNH simulations .

Leandre 2 and Calipso observations show that the dust lofting is related to the harmattan for the majority of the studied days, but also to the monsoon flow which is the case on July 7.

The vertical structure and the space-time distribution of the dust plumes are rather well reproduced by simulations.

These aerosols lofted close to the ITD are observed to be transported towards the south above the monsoon layer. This is also seen in the simulations.

CONCLUSION AND PERSPECTIVES

CONCLUSION

Calipso observations allowed to extend the dataset of lidar measurements of dust lofting at the ITD which were documented with Leandre 2 during 3 days missions in July 2006.

The dust production and transport evidenced by lidar measurements were reproduced in mesoscale numerical simulations.

These simulations will allow to analyze the lofting mechanisms in details.

PERSPECTIVES

Using a synergy between observations and numerical simulations, we would like to:

1- Understand the origin of the ITD fluctuations in connection with the AEJ and the Lybian high,
2- Study the diurnal cycle of the ITD and its impact on the dust lofting,
3- Improve the representation of the SAL and the dust plumes by the model and from Calipso (profiles of extinction coefficient).
4- Quantify the Saharan dust flux associated with this mechanism in this region.
5- Quantify the radiative impact from the model using Calipso-Model synergy.