# Dust emissions over the Sahel associated with the West Africain Monsoon density current behaviour in the inter-tropical discontinuity region

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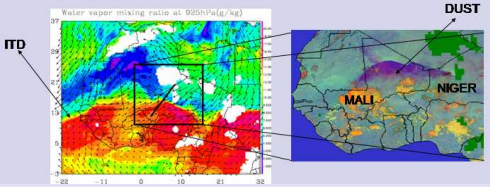
## RATIONALE & OBJECTIVES

- 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 the Sahel is highly variable on daily-to-seasonal timescales, but its somewhat abrupt northward shift occurring around the monsoon onset period in June marks the beginning of the rainy season in the Sahel.
- The dynamical system associated with the ITD is prone to dust emissions over West Africa which are linked to small-scale high-wind events, and are highest in June, in coincidence with the annual northward displacement of the ITD crossing over the dust hot spots in the Sahel (Engelstaedter and Washington 2007).
- In this presentation, the mechanisms associated with the dust emission and transport in connection with the monsoon flow and the ITD dynamics are analyzed by airborne lidars observations and mesoscale modeling.




## MEANS & STRATEGIES

| Case study | Observations | Analysis | Modelling |
|---|---|---|---|
| 7 July 2006 «ITD survey mission» of the AMMA SOP 2a1<br><br>2 Aircrafts were implemented:<br>SAFIRE F20<br>DLR F20 | Airborne Lidar: LEANDRE 2<br>AVAPS 4-channel dropsondes system<br>Airborne Doppler Lidar WIND<br>Calipso | ECMWF | MesoNH<br>+<br>Dust scheme<br><br>(Tulet et al., 2005)<br>(Grini et al., 2006) |

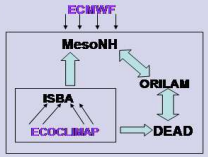

**The model:**

•**MesoNH** is a nonhydrostatic mesoscale model developed jointly by Meteo France and the Laboratoire d'Aérologie (Lafore et al., 1996)

•Dust emission is assumed by the "Dust Entrainment And Deposition" model **DEAD** imbedded in MesoNH, (Zender et al., 2003) and (Grini et al., 2006).

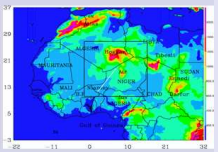
•The advection, wet and dry deposition schemes are provided by the **ORILAM** module of MesoNH (Tulet et al., 2003).

•MesoNH is coupled to the ISBA surface scheme which is initialized by **ECOCLIMAP**




**The simulation set up:**

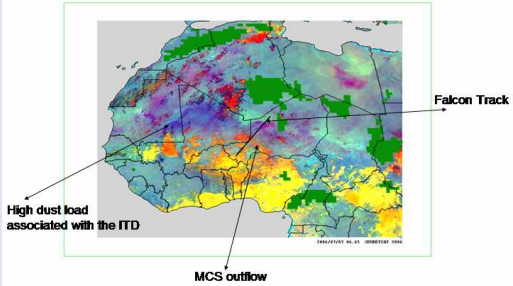
- Simulation over 10 days: 2-12 July 2006
- 1 domain:
  - Horizontal resolution: 20km 100x100 points
  - Vertical resolution: 62 levels are used, 35 levels are used within the PBL
- 3D initialisation: ECMWF analyses
- Nudging: 6 hourely timestep by the ECMWF analyses.



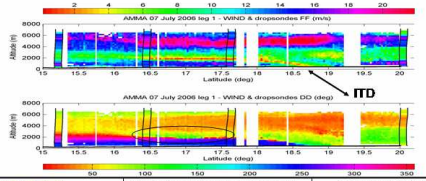
## RESULTS

### Dust load over West Africa on 7 July at 0645UTC

MSG-SEVERI: False-color image where purple and pink colors represent dust

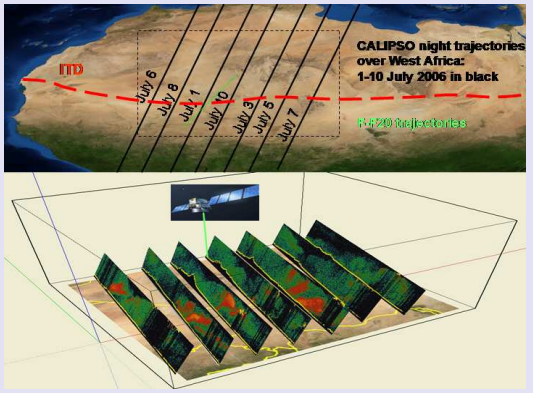



### WIND Doppler Lidar observations on 7 July at 06 UTC: Way out of Niamey

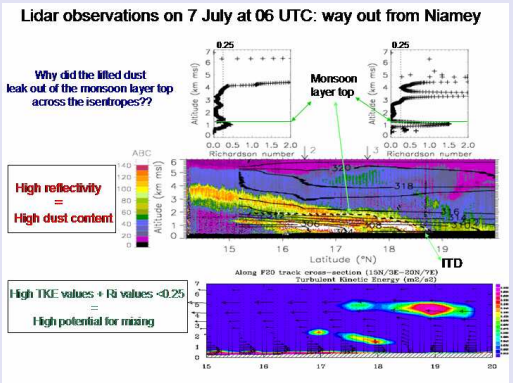



| Monsoon nocturnal flow/density current characteristics | Theoretical values in a shearless environment (Koch et al., 1991): Dropsonde-derived surface values | Observed values from WIND Lidar & dropsondes |
|---|---|---|
| Layer depth: | 1480 m | 1800 m |
| Propagation speed: | 9.8 m/s | 10.5 m/s (from ITD displacement during the round trip) |

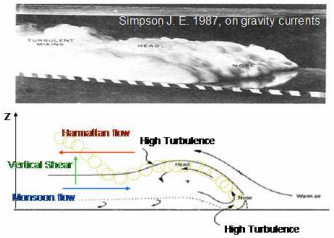
Note the strong vertical shear between the monsoon and Harmattan layers
➔ Increase the depth of the monsoon layer and the propagation speed




### Lidar observations on 7 July at 06 UTC: way out from Niamey

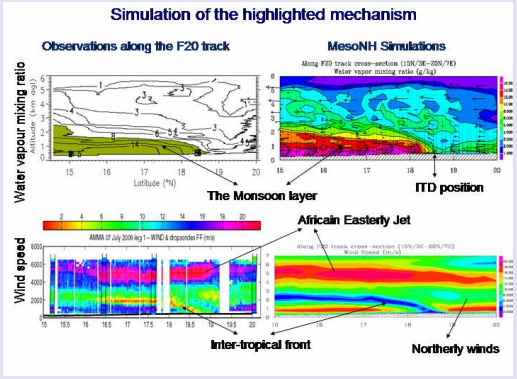



### Similarities with density currents

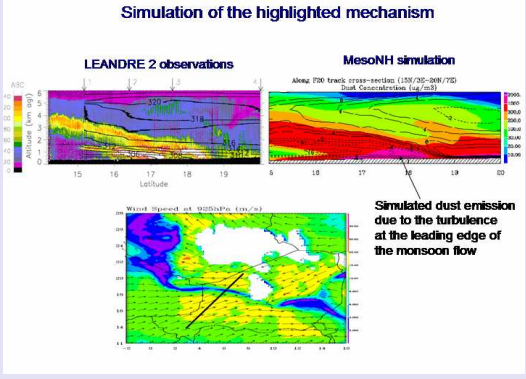



➔ Involved mechanisms:
- High winds and turbulence at the nose of the monsoon,
- Transport within the monsoon layer by the closed circulation at the head,
- Turbulence generated by the vertical shear away from the leading edge
  ➔ cross-isentropic transport in the wake of the density current.

### Simulation of the highlighted mechanism




### Simulation of the highlighted mechanism




## DISCUSSION & CONCLUSIONS

1- The Monsoon flow has a **density current behaviour** during nighttime. Dust emissions is generated by **the turbulence at the leading edge** of the monsoon density current,

2- Dust lifted at the nose of the monsoon flow is transported to the south within the monsoon layer by **the closed circulation at the head** of the monsoon density current,

3- During nighttime, cross isentropic transport is observed due to **the turbulence generated by the shear** between the monsoon and the Harmattan flows which gives dust emitted at the leading edge of the monsoon flow the potential to leak out from the monsoon layer and to be transported by the harmattan southward,

4- During daytime, the strong mixing of the Saharan boundary layer allows dust lifted at the leading edge of the monsoon flow to reach much higher levels and go to the long-range transport,

5- The newly identified mechanism for dust emissions over the Sahel during the monsoon season provides a possible explanation for the climatological results by Engelsteadter and Washington (2007), and may have an **impact on the radiative budget** over West Africa.

➔ Bou Karam et al., Submitted to QJRMS

6- Using a mesoscale model including a dust emission module we were able to **simulate the highlighted mechanism:**

➔ Bou Karam et al., in preparation

## ON GOING & PERSPECTIVES

1- Study the diurnal cycle of dust emission in the ITD region during the monsoon season over Niger in July 2006 (simulation):

➔ Bou Karam et al., in preparation

2- Study the diurnal cycle of the ITD before the monsoon onset over Benin in April 2006:

➔ Pospichal et al, in preparation

3- Quantify the dust emission by this mechanism during the monsoon season and compare it to mass fluxes emitted from source areas such as the Bodélé depression in Chad.

4- Study the intra seasonal variability of the ITD and its implications on dust emissions over West Africa.

5- Evaluate the radiatif forcing due to these dust emitted in the intertropical discontinuity region.