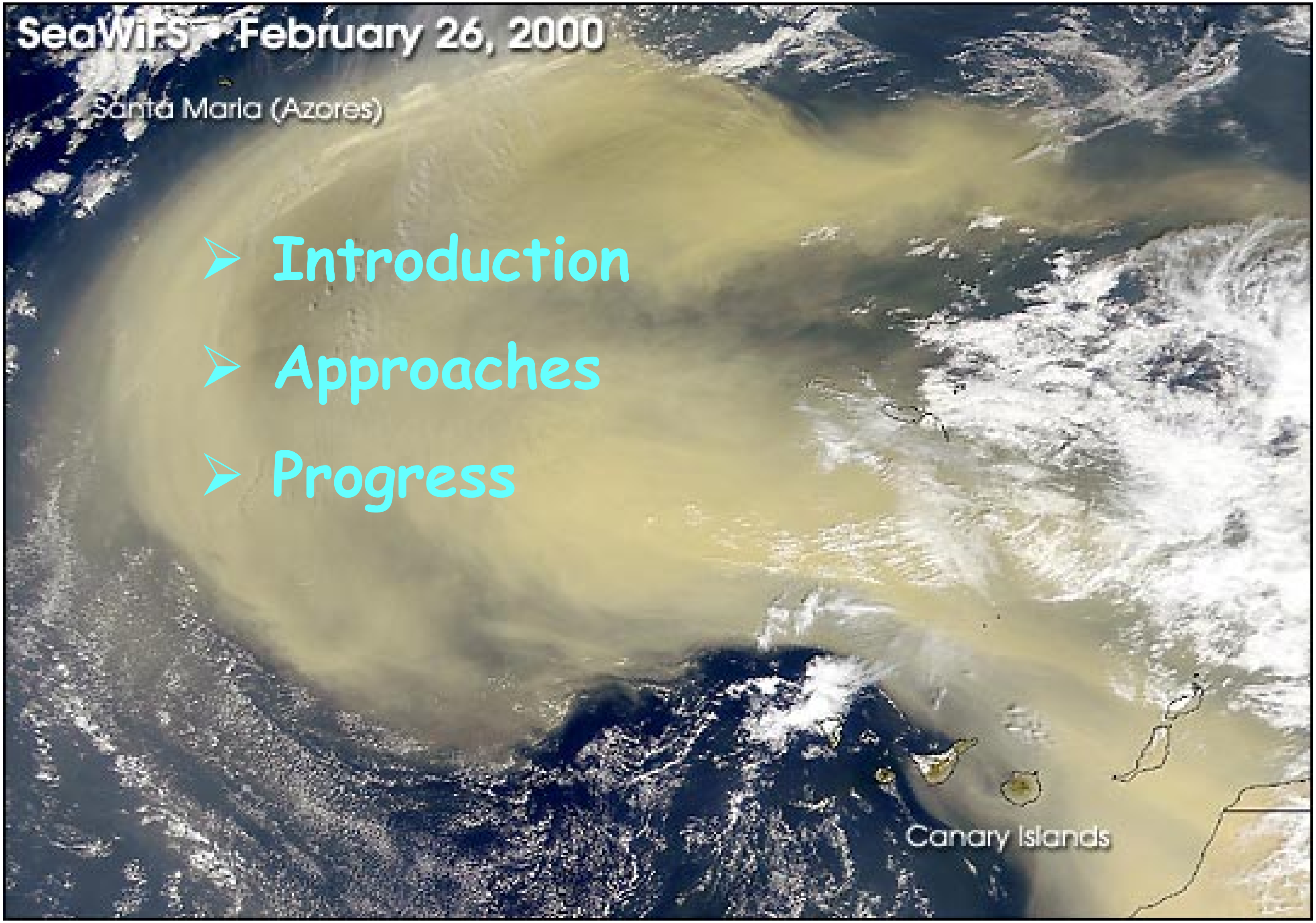
# The Impact of Saharan Air Layer on Tropical Cyclone Genesis and Intensification

**S.-H. Chen**

**UC Davis**

Thanks to
C.-T. Cheng, S.-H. Wang, S.-C. Tsai, M.-D. Jou, and J.-P. Chen

# Outline

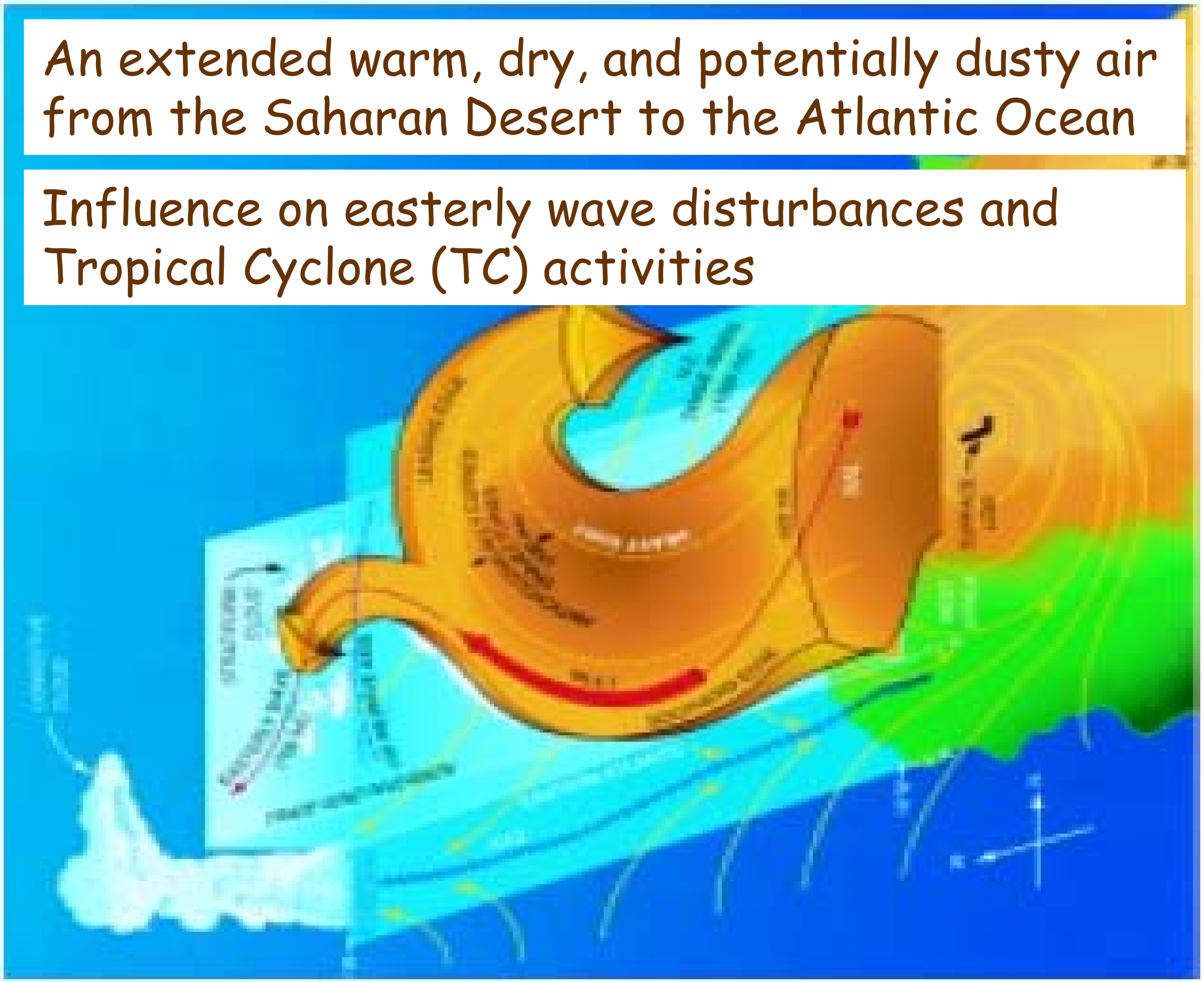



- Introduction
- Approaches
- Progress

# Saharan Air Layer Conceptual Model

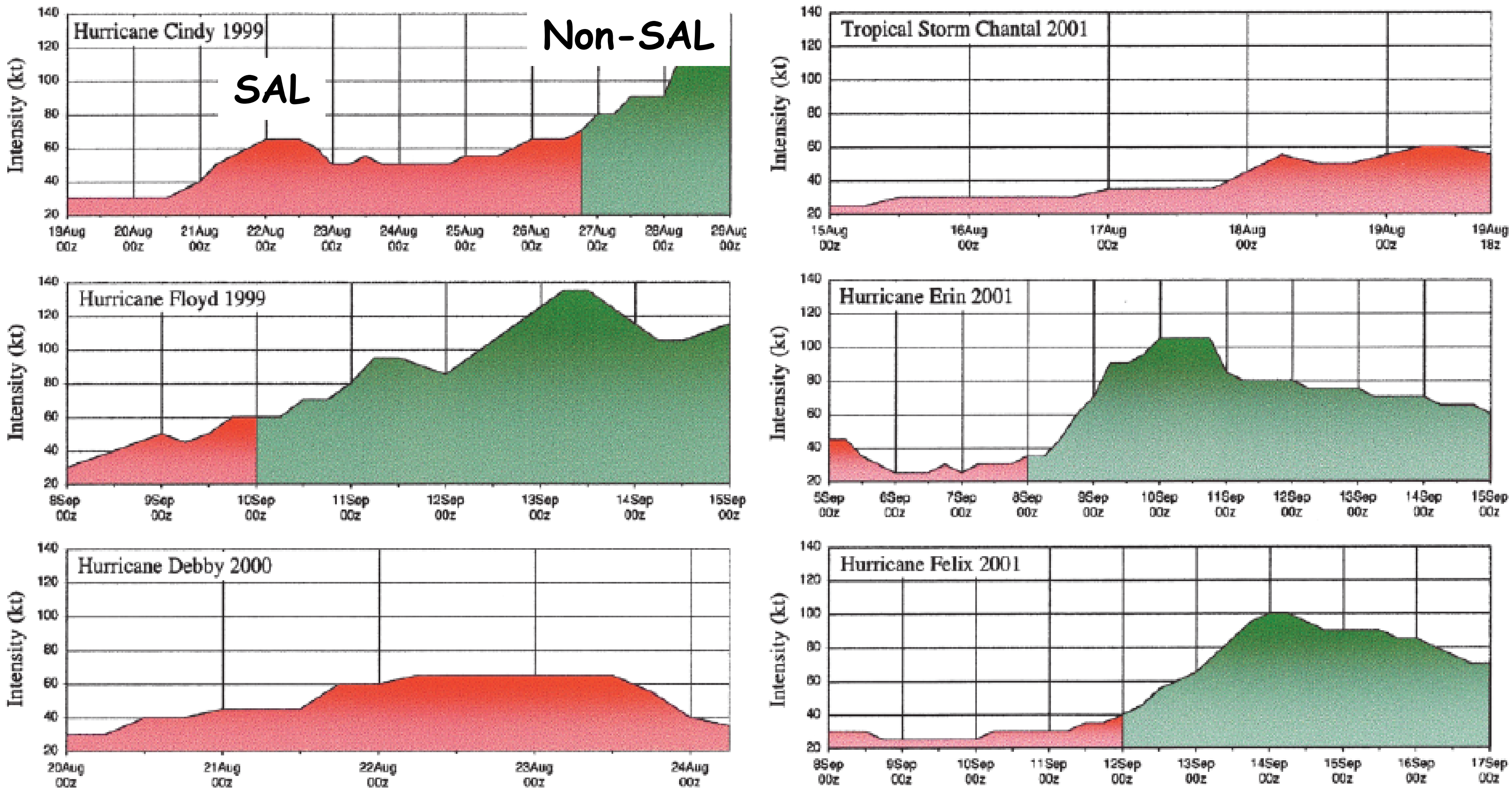
An extended warm, dry, and potentially dusty air from the Saharan Desert to the Atlantic Ocean

Influence on easterly wave disturbances and Tropical Cyclone (TC) activities



Karyampudi et al. 1999 BAMS

# SAL & Hurricanes/TCs




Dunion and Velden 2004, BAMS

# Impact of SAL on TC Activities

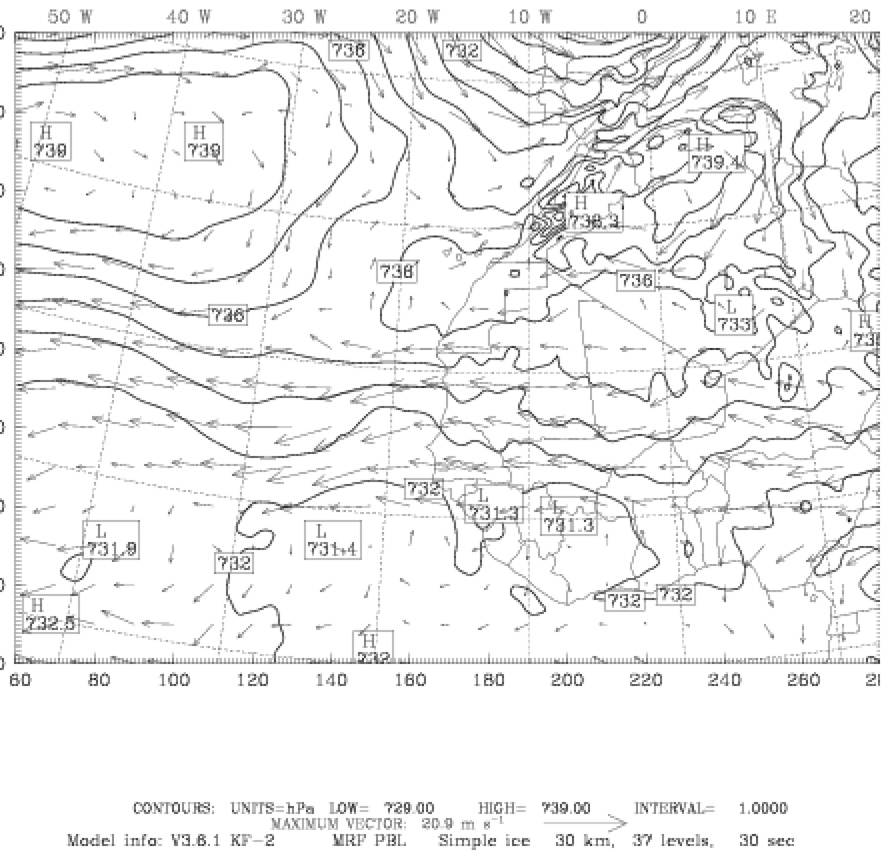
**Through dynamical and thermodynamical processes**

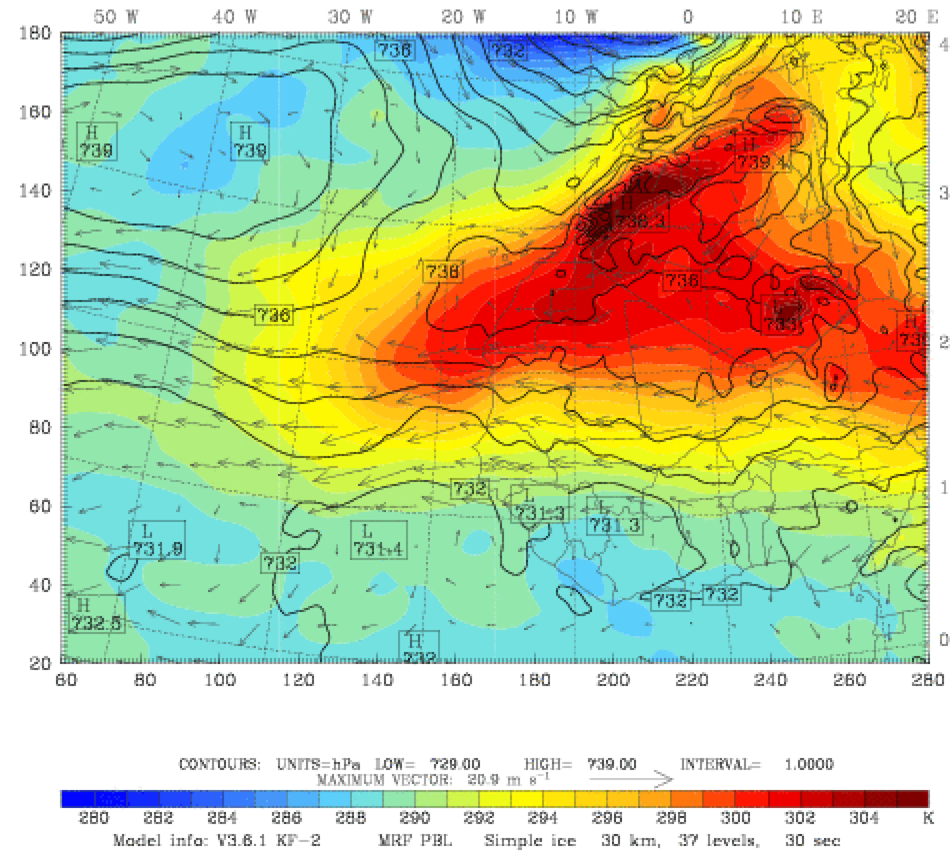
- The entrainment of dry, stable air into storms, promoting evaporatively driven downdrafts in TCs
- Vertical shear - MLEJ due to warm SAL air
- Trade wind inversions, stabilizing the atmosphere
- Dust-cloud-radiation interaction, modifying TC development

# 1.5-km T, 4km Winds, Dust, 2.8 km-P (MM5)

## Chantal (2001)

**Integrated dust** | **1.5 km T**



# Objectives

To study the influence of SAL on TC genesis and intensification in terms of its warm and dry air, vertical shear induced by MLEJ, and Saharan dust. The role of environmental stability and moisture in TC genesis will also be investigated.

# Approaches

- Study dust characteristics & improve dust mobilization parameterization using observations
- Develop and evaluate an on-line dust model
- Evaluate the impact of assimilating observations on TC simulations
- Study the impact of SAL on TC genesis and intensification
  - SAL structure and intensity
  - Wave's/TC's environment, e.g., shear, instability, etc.
  - Intrusion of SAL into TSs and its consequence
  - Dust-cloud-radiation effects

# Development of WRF Dust Model

WRF + Dust continuity equation

$$\frac{\partial C}{\partial t} = -\nabla \bullet \vec{V}C + c_{pbl} + c_{cov} + S_c + E_c$$

$$C = \mu c$$

$$\mu = p_{hs} - p_{ht}$$

$$c : dust$$

$$S_c : se\dim entation$$

$$E_c : Source / Sink$$

# NAMMA, 2006

DC-8 aircraft flew 13 missions from 19 Aug to 12 Sep 2006, and seven AEWs were identified

| *Wave #* | *Observed date* | *Development* |
|---|---|---|
| 1 | August 19 and 20 | Pre-Ernesto |
| 2 | August 23 | Debby (TS) |
| 3 | August 25 and 26 | Non-developing |
| 4 | September 1 | Non-developing |
| 5 | September 3 and 4 | Pre-Gordon |
| 6 | September 8 and 9 | Non-developing |
| 7 | September 12 | Helene |

# Observations that Will Help

- To study dust characteristics & improve dust mobilization parameterization
  - surface winds, dust concentration, size distribution, etc.
- To improve initial conditions for numerical simulations
  - winds, T, moisture, pressure, etc.
- To evaluate model performance
  - winds, T, moisture, dust concentration, microphysics, rainfall, etc.

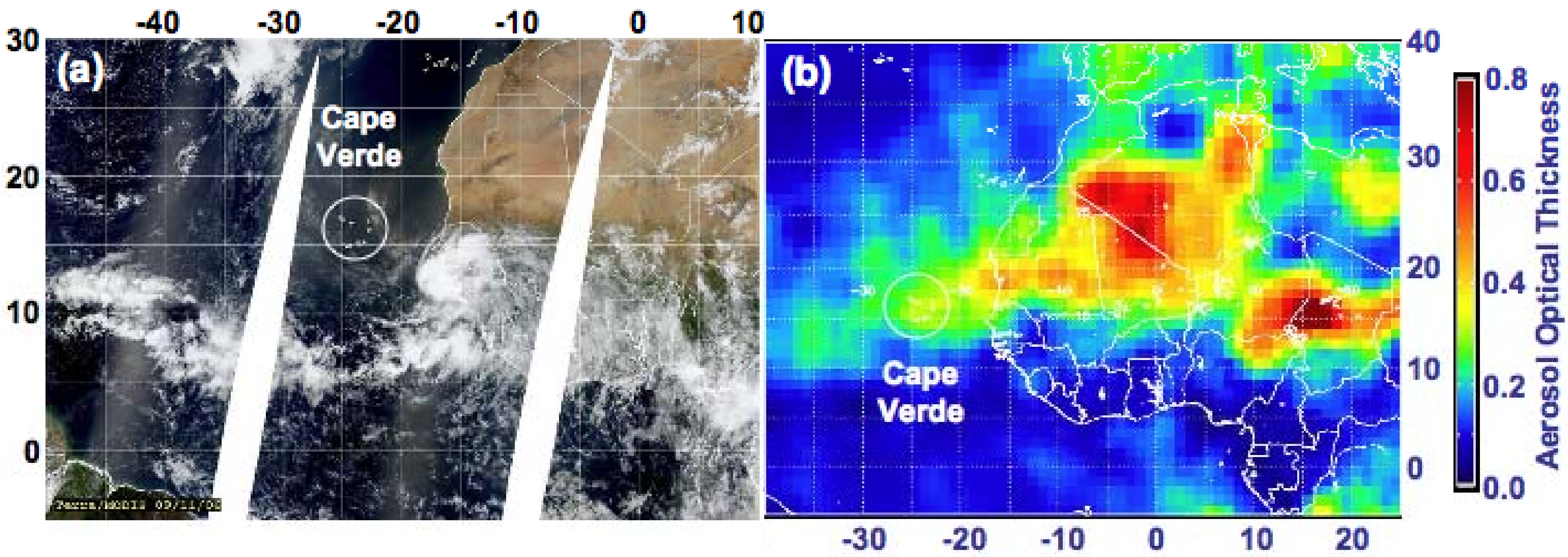
# Satellite Observations

| *instruments* | *Observations* |
| --- | --- |
| MODIS | Total precipitable water (TPW) or soundings |
| QuikSCAT | Surface wind vectors |
| AIRS | TPW or soundings |
| SSM/I | Surface wind speed and TPW |
| AMSU | Temperature profiles |

# NAMMA Observations

| *Instruments* | *Observations* |
|---|---|
| Dropsondes | Pressure, wind, temperature, mixing ratio |
| Lidar (Atmos. Sensing Experiment) | Mixing ratio |
| Meteoro. Measurement Sys. | Pressure, temperature, wind |
| Radiosondes (Praia, Cape Verde) | Pressure, wind, temperature, mixing ratio |
| Radiosondes (Kawsara, Senegal) | Pressure, wind, temperature, relative humidity |

# NAMMA (2006)

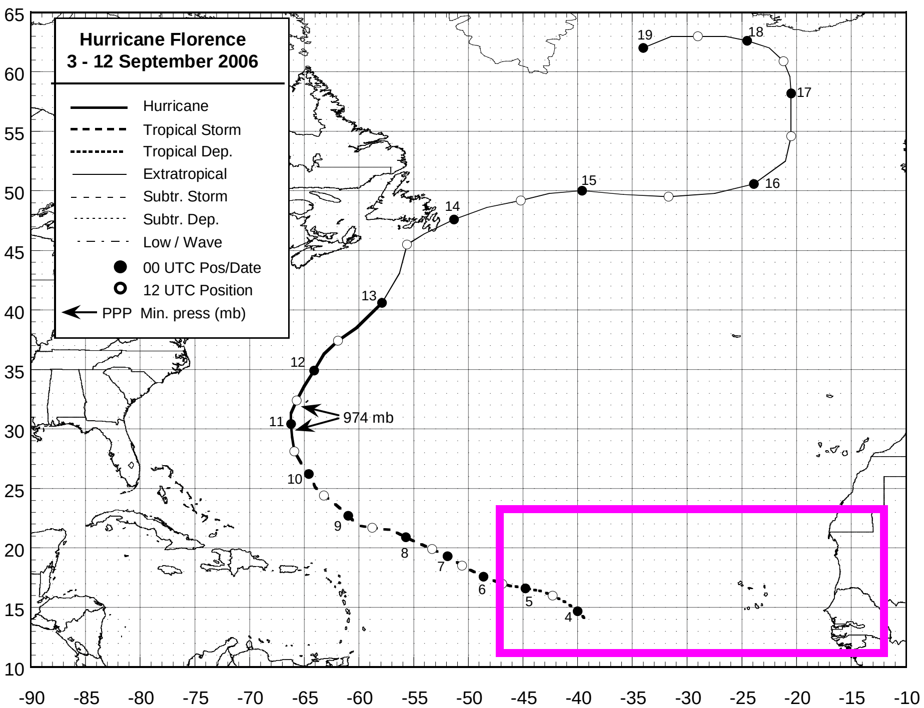


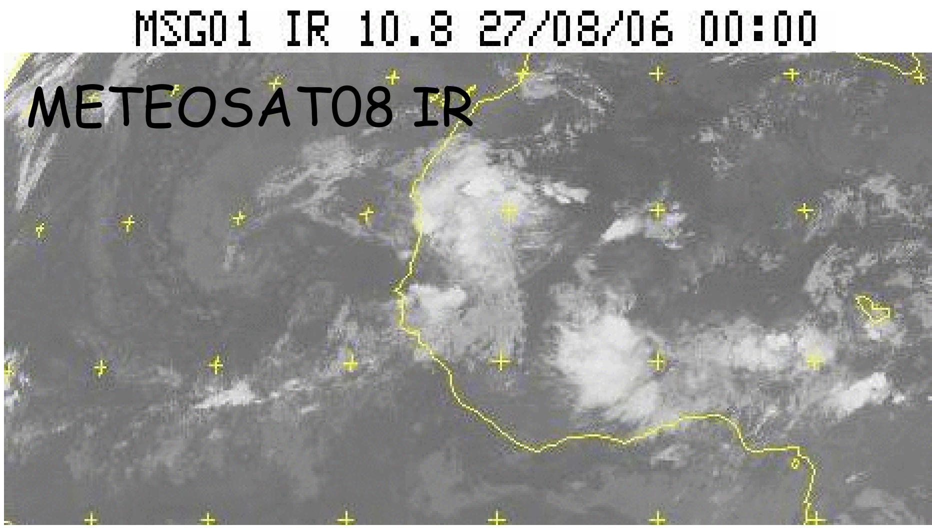

MODIS/Terra on Sep 11, 2006 Saharan dust outbreak passing over Cape Verde

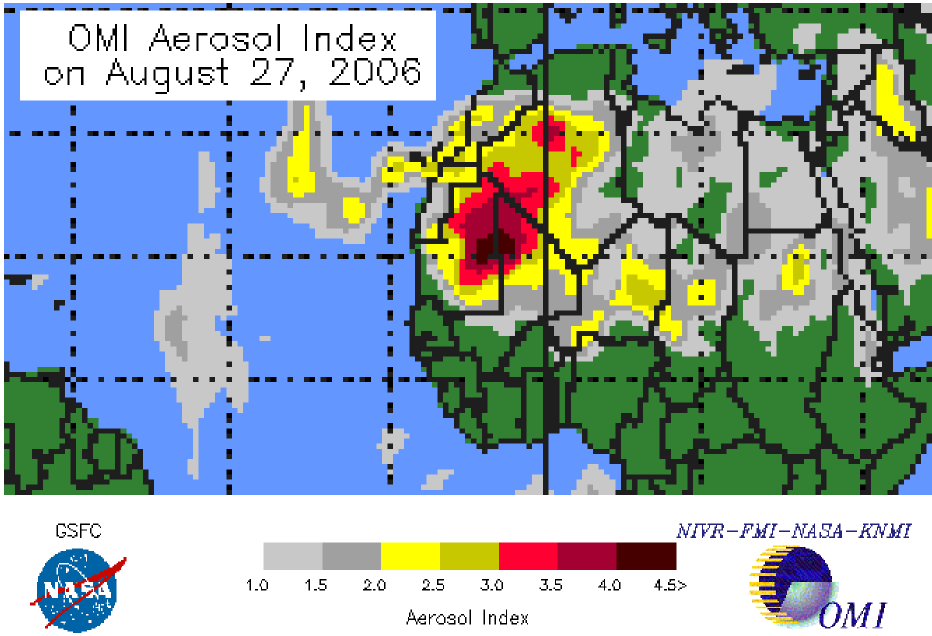
Sep 05-14 averaged, 2006 aerosol optical thickness (MODIS/Deep-Blue algorithm)

(Courtesy S.-C. Tsai, NASA)

# Hurricane Florence (Sep 3-12, 2006)

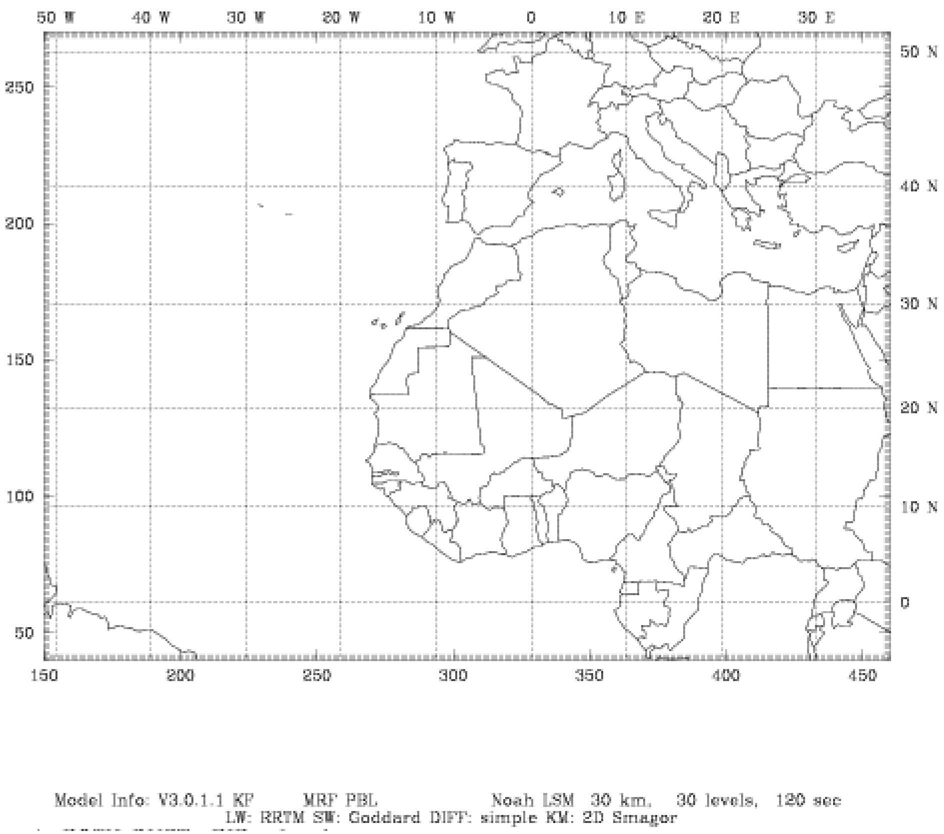


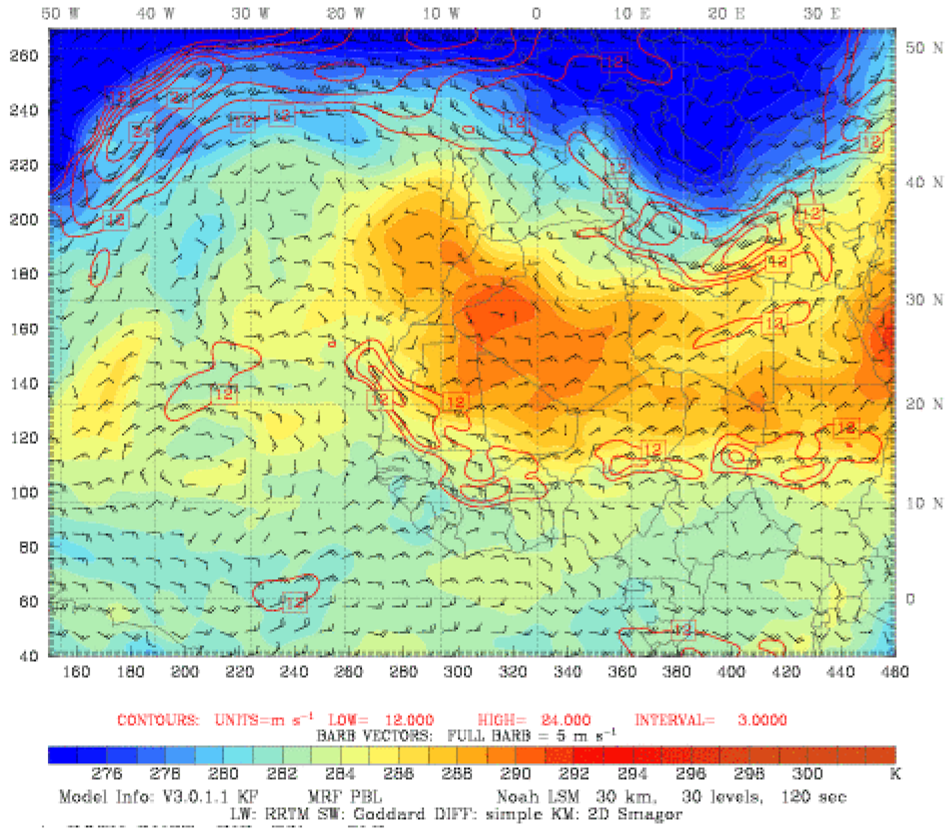



# 96h Simulation Results (every 6h)

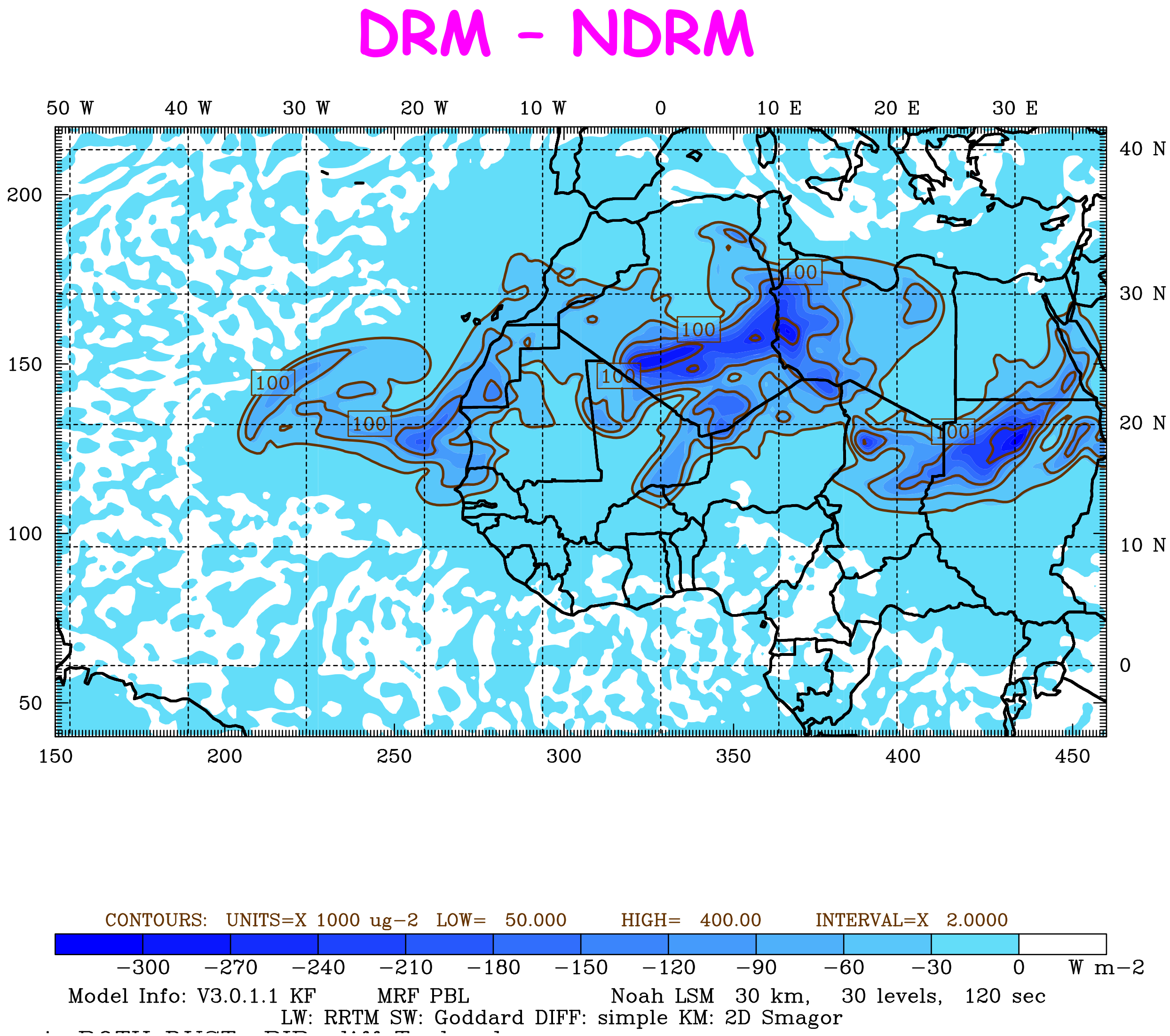
Integrated dust & hydrometeors




3km T and winds



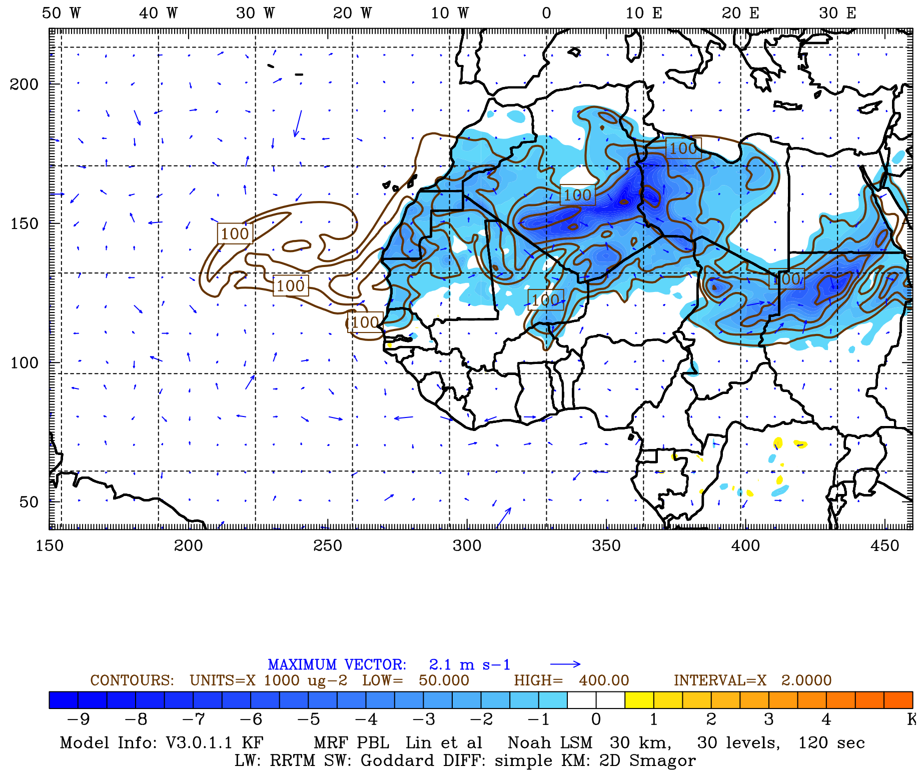
# Surface Net Downward Heat Flux (84h)



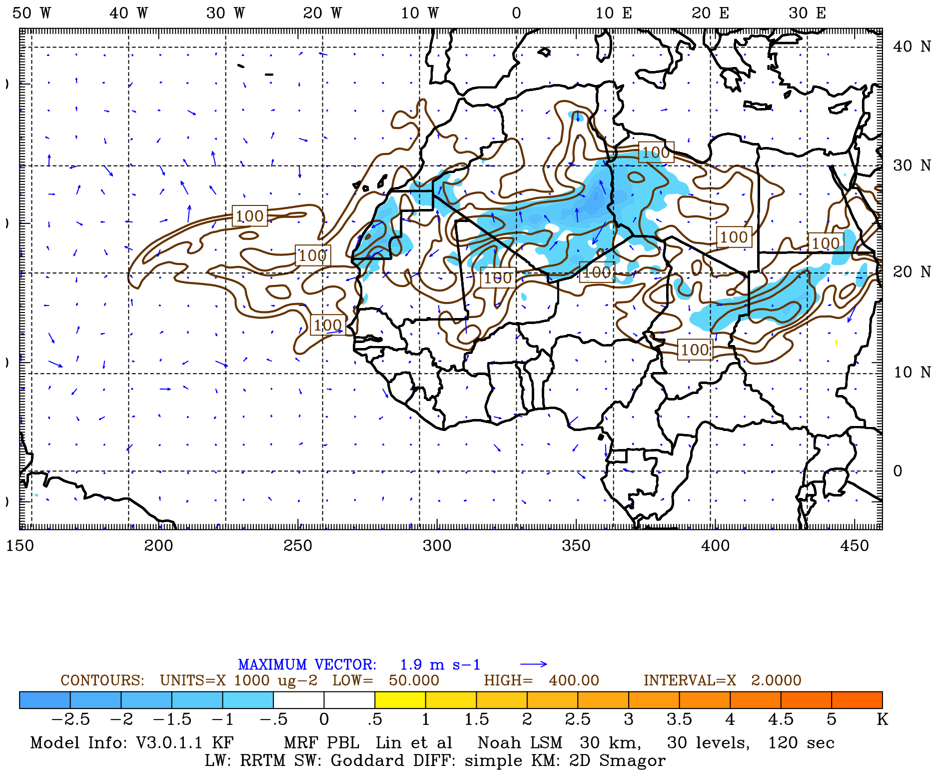
# Surface T & Integrated DUST

## DR - NDR

**84h**



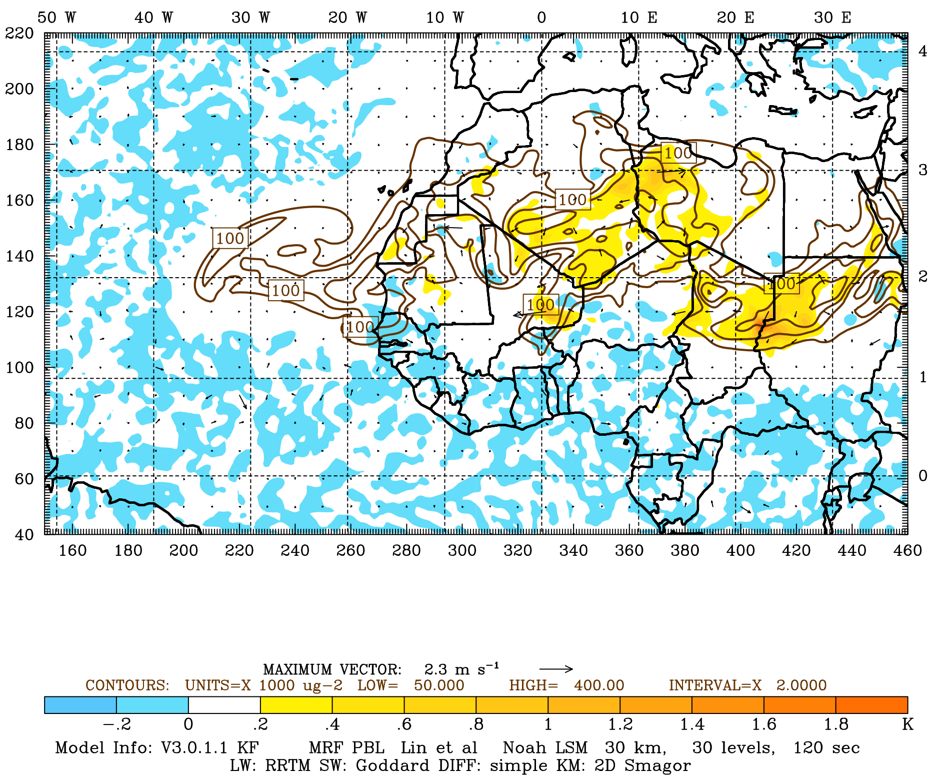

**96h**



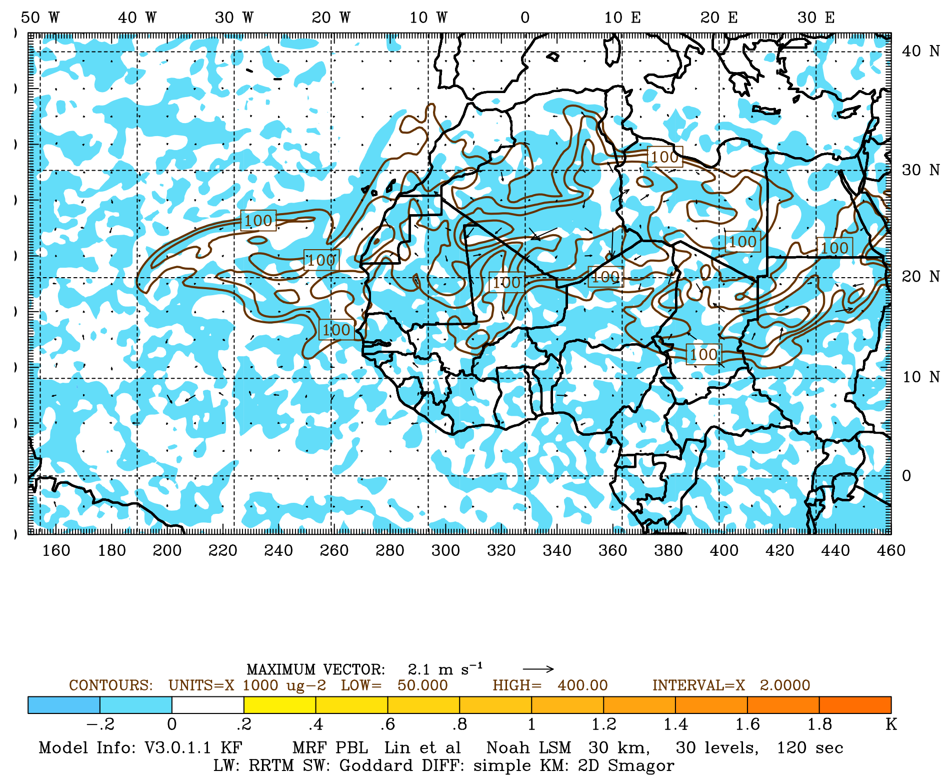
# 3km T & Integrated DUST

## DR - NDR

### 84h



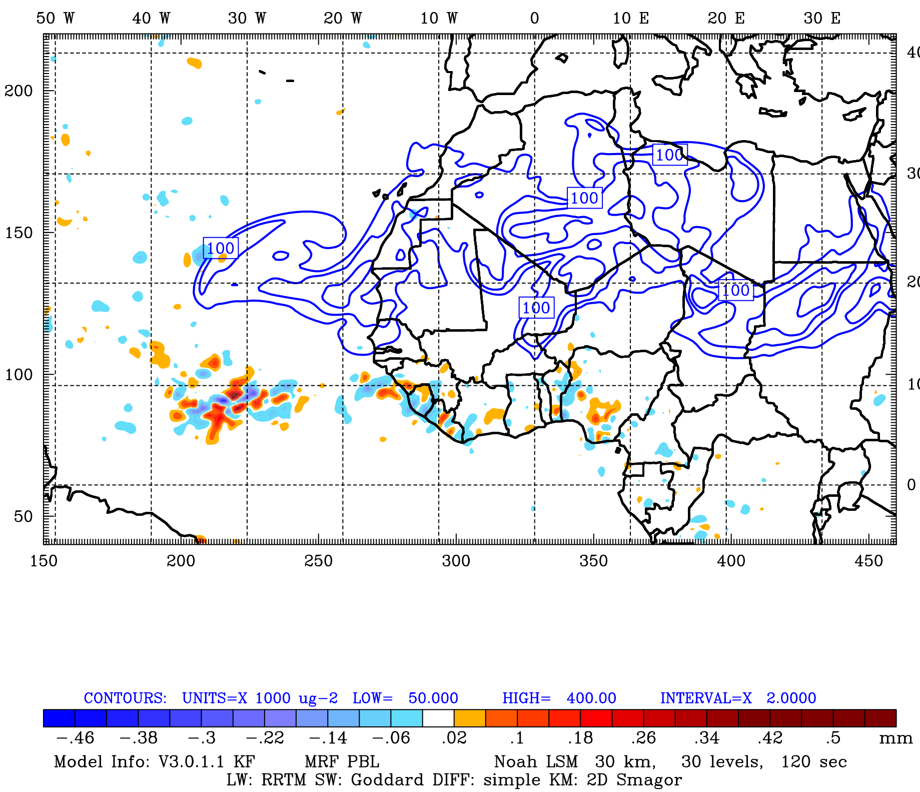

### 96h



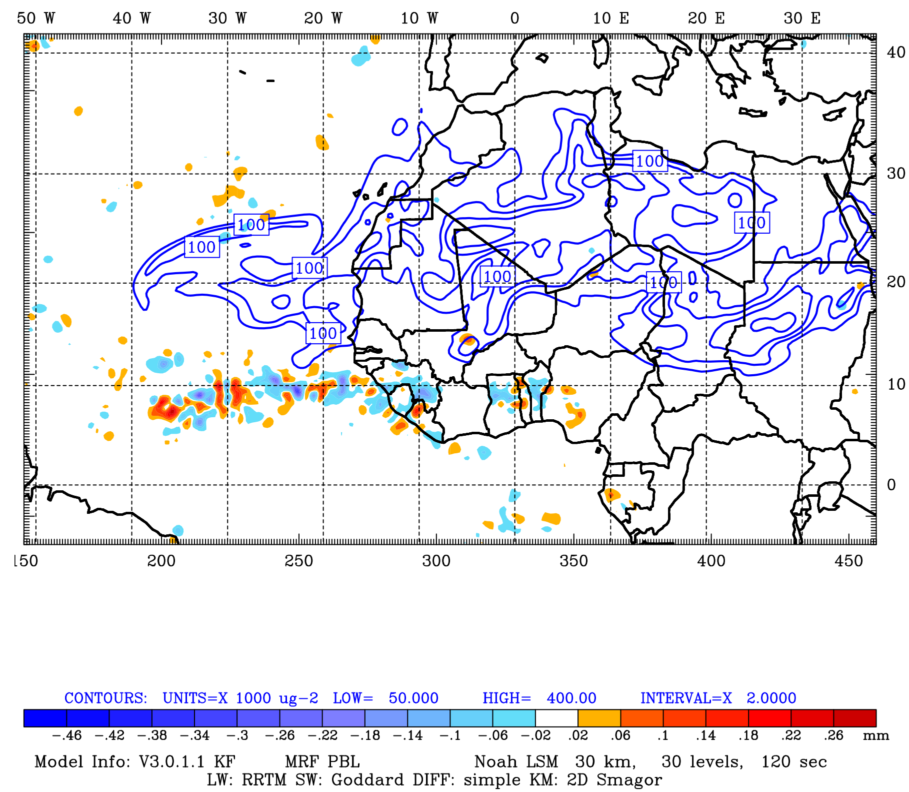
# Integrated Cloud+Ice & DUST

## DM - NDM

**84h**



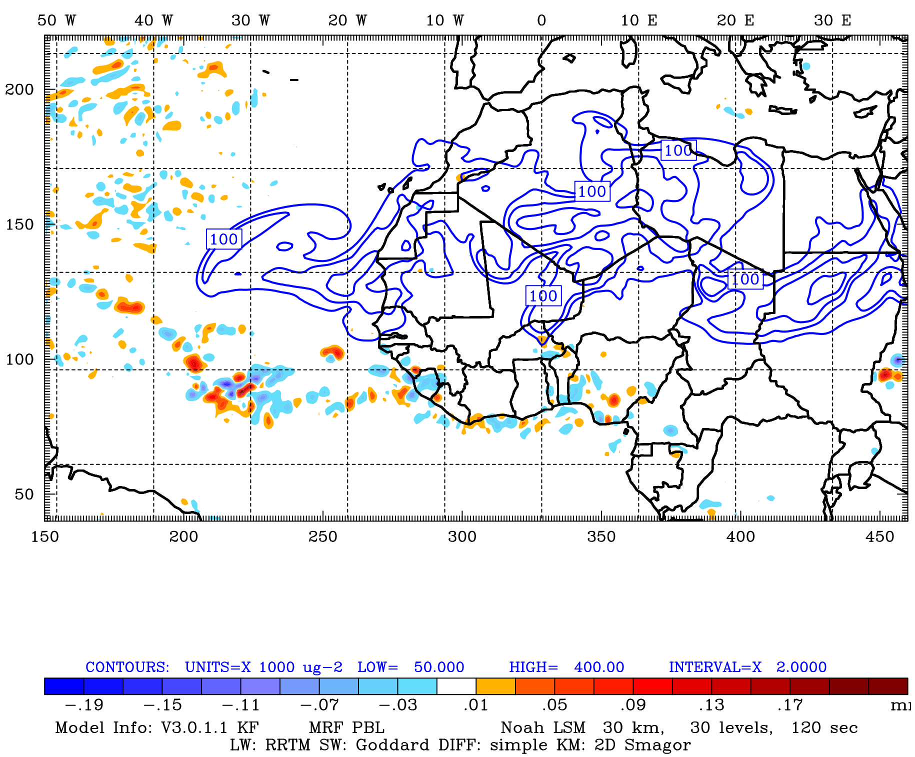

**96h**



# Integrated Precipitation & DUST

## DM - NDM

### 84h




### 96h