

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

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Thanks to

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Outline

SeaWiFS - February 26, 2000

Santa Maria (Azores)

- Introduction
- Approaches
- Progress

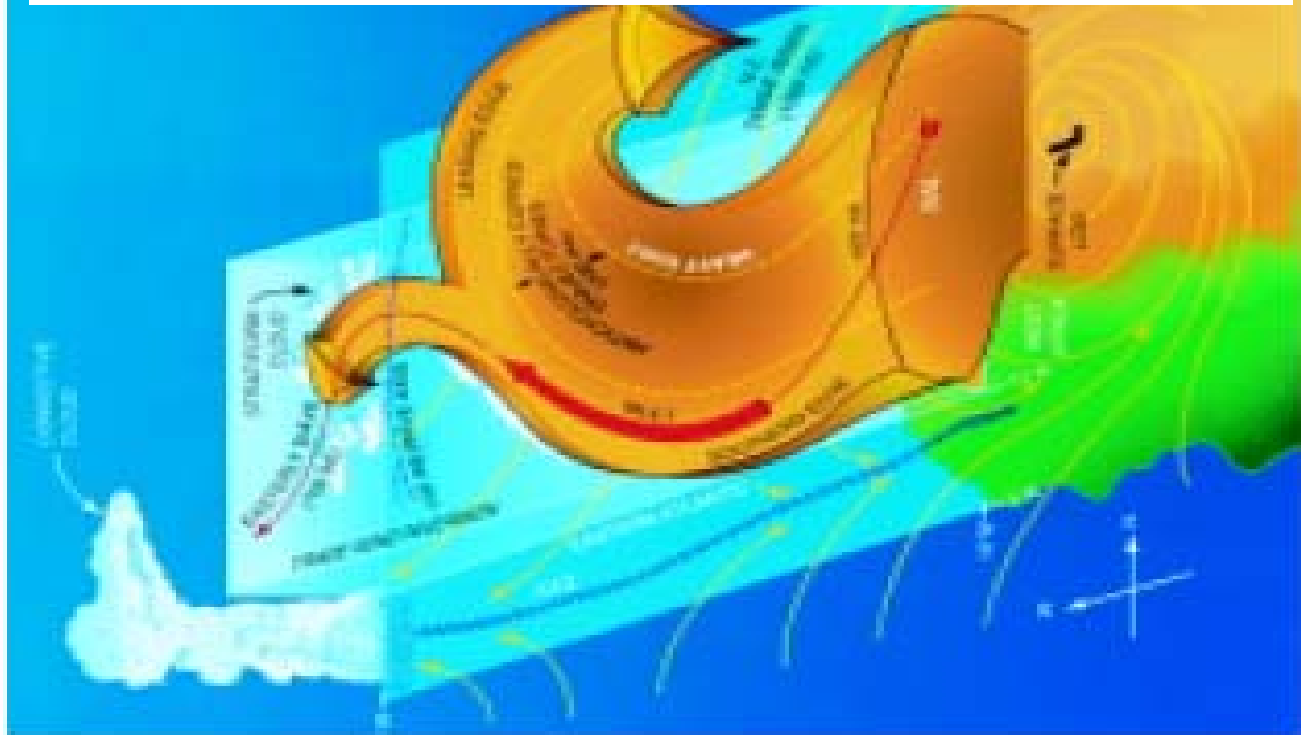
Canary Islands



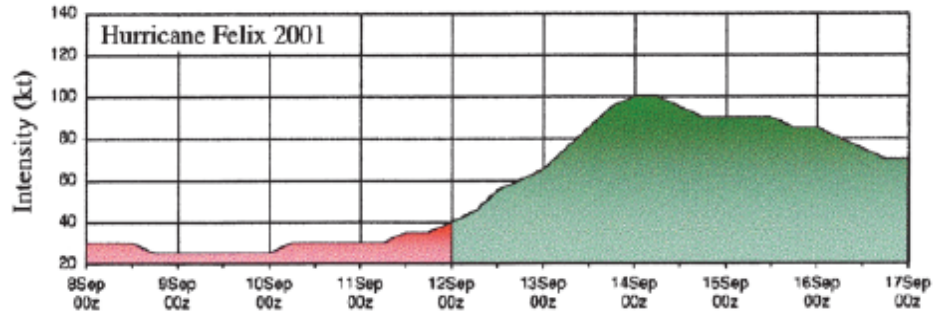
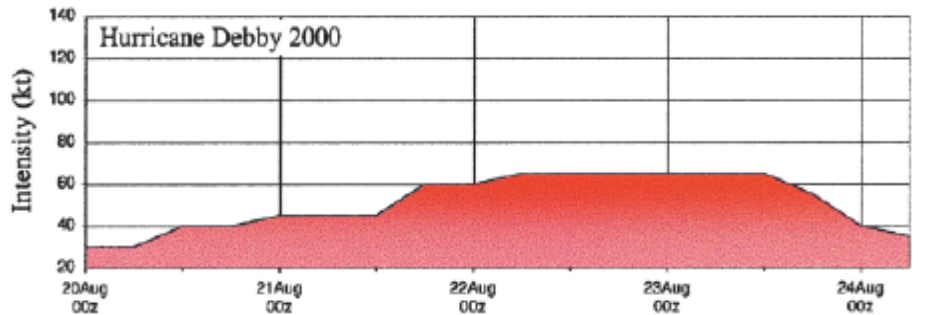
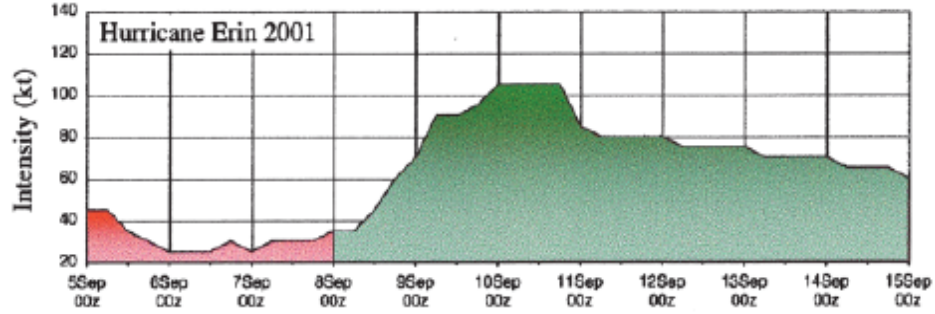
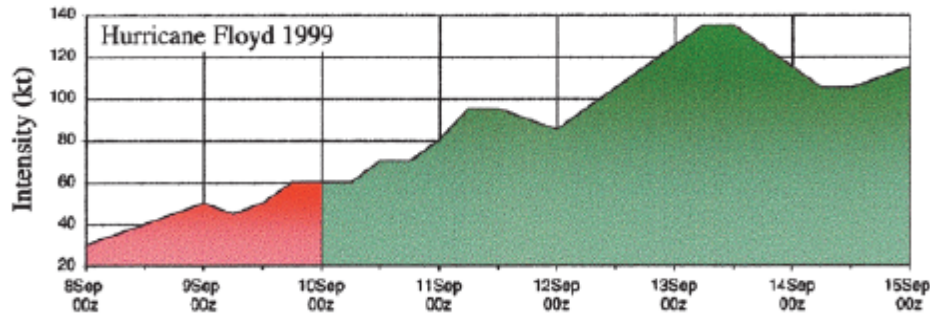
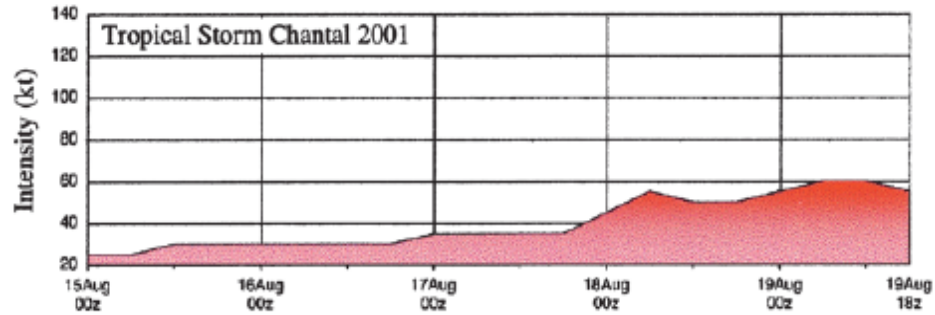
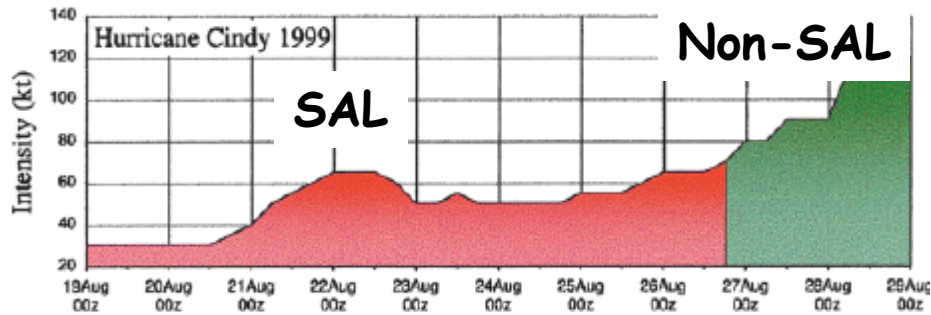
Saharan Air Layer Conceptual Model

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



SAL & Hurricanes/TCs



Impact of SAL on TC Activities

Through dynamical and thermodynamical processes

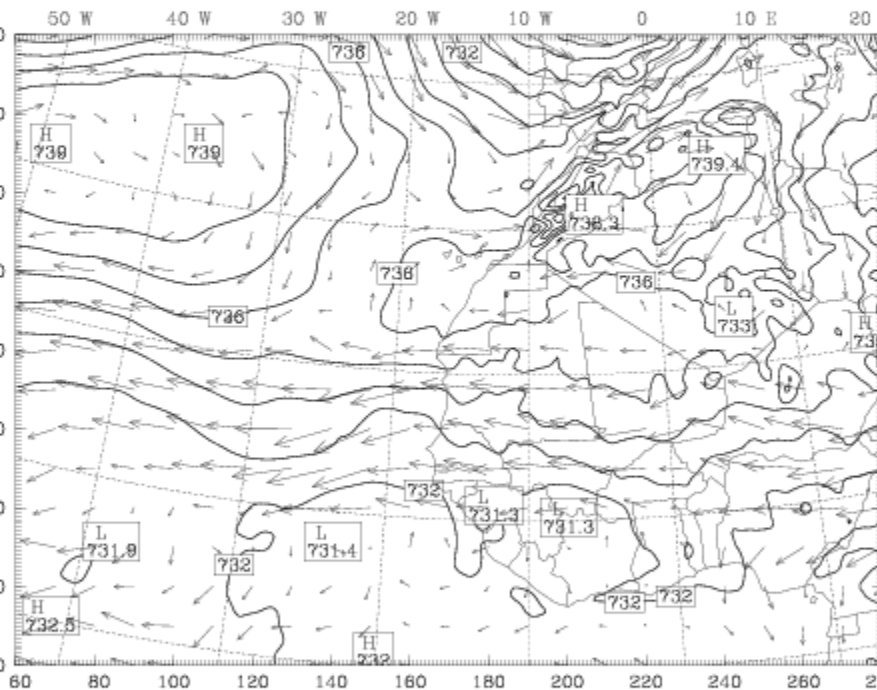
- The entrainment of dry, stable air into storms, promoting evaporatively driven downdrafts in TCs
- Vertical shear - MLEJ due to warm SAL air
- Trade wind inversions, stabilizing the atmosphere
- Dust-cloud-radiation interaction, modifying TC development

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

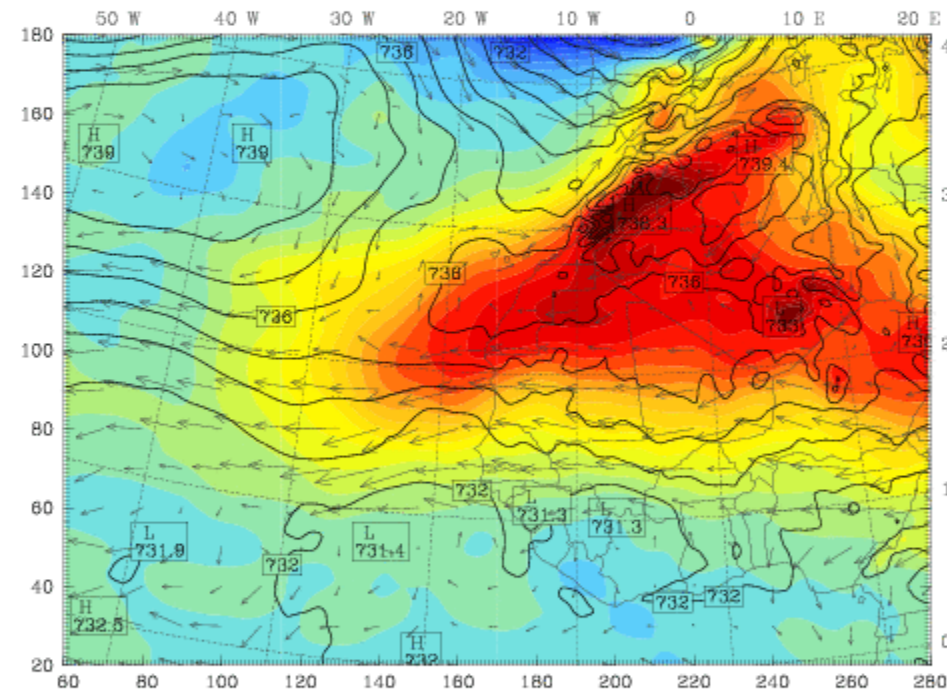
Chantal (2001)

Integrated dust

1.5 km T



Model info: V3.6.1 KF-2 MRP PBL Simple ice 30 km, 37 levels, 30 sec



Model info: V3.6.1 KF-2 MRP PBL Simple ice 30 km, 37 levels, 30 sec

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

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

$$C = \mu c$$

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

c : dust

S_c : sedimentation

E_c : Source / Sink

NAMMA, 2006

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

<i>Wave #</i>	<i>Observed date</i>	<i>Development</i>
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.

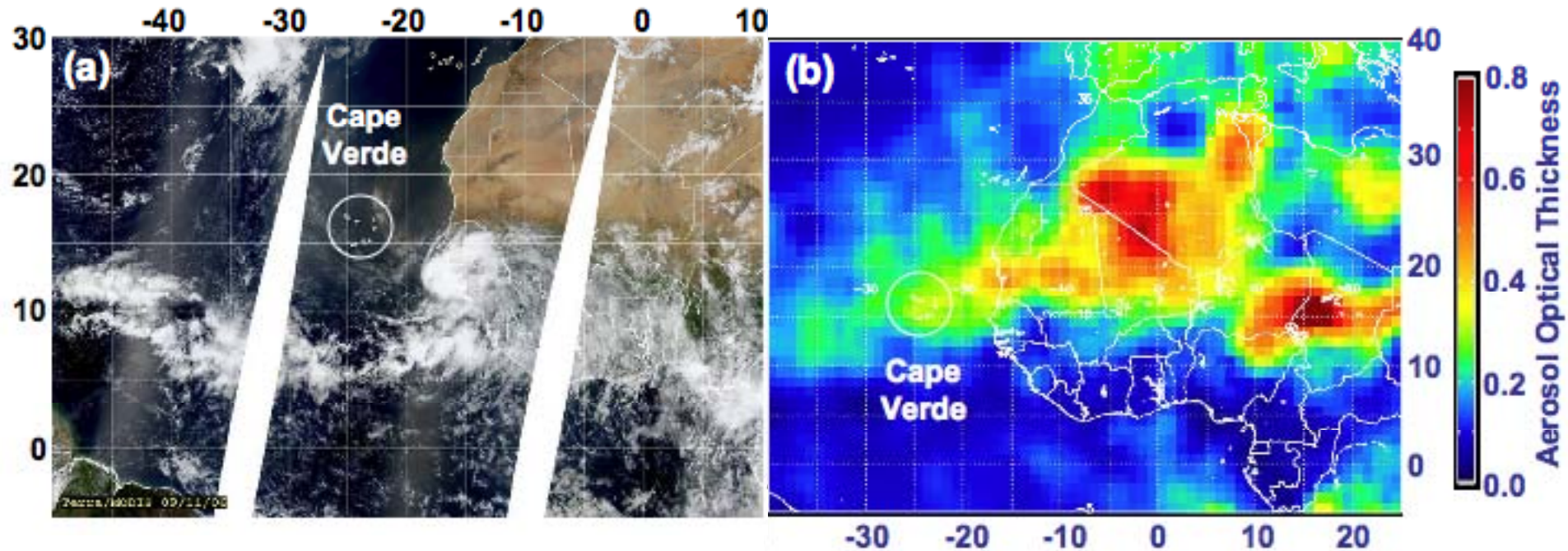
Satellite Observations

<i>instruments</i>	<i>Observations</i>
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

<i>Instruments</i>	<i>Observations</i>
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

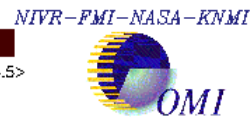
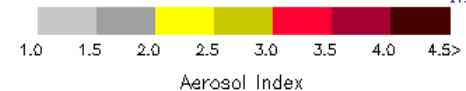
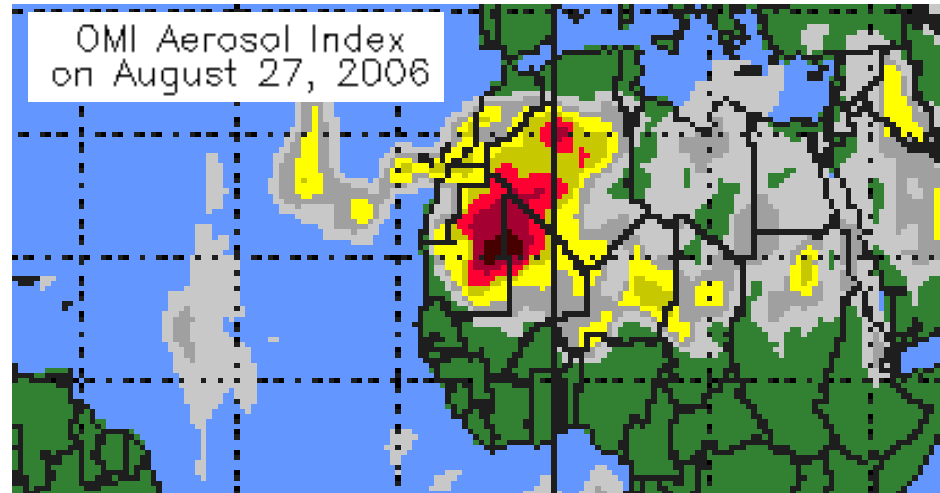
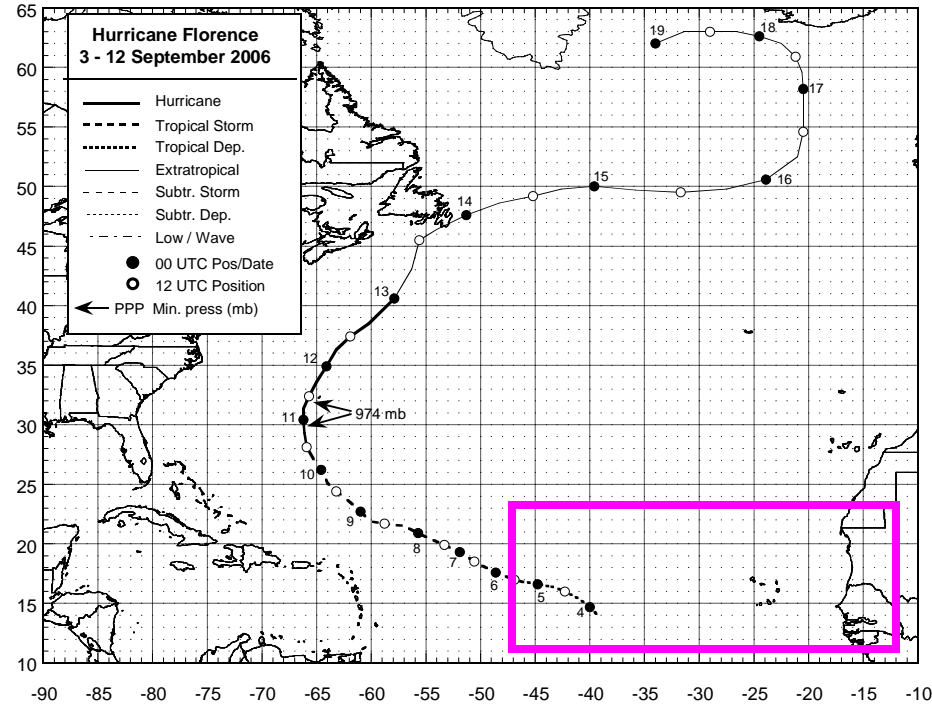
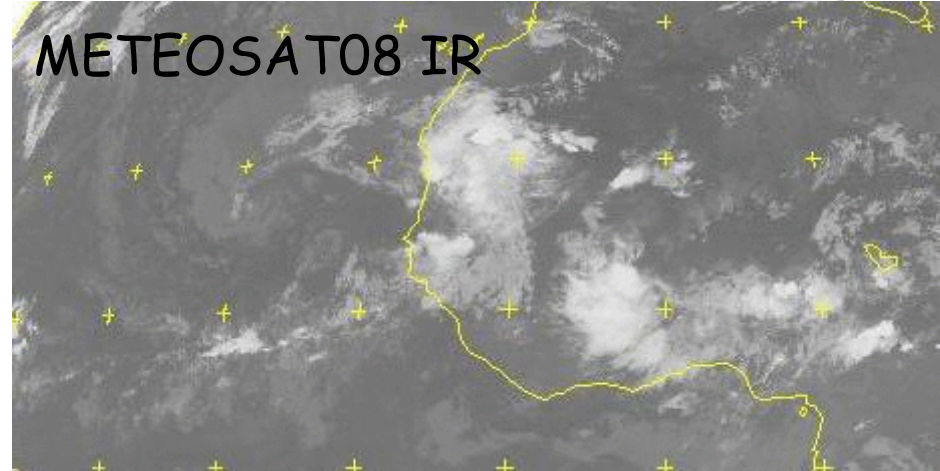
Sep 05-14 averaged, 2006
aerosol optical thickness
(MODIS/Deep-Blue algorithm)

(Courtesy S.-C. Tsai, NASA)

Hurricane Florence (Sep 3-12, 2006)

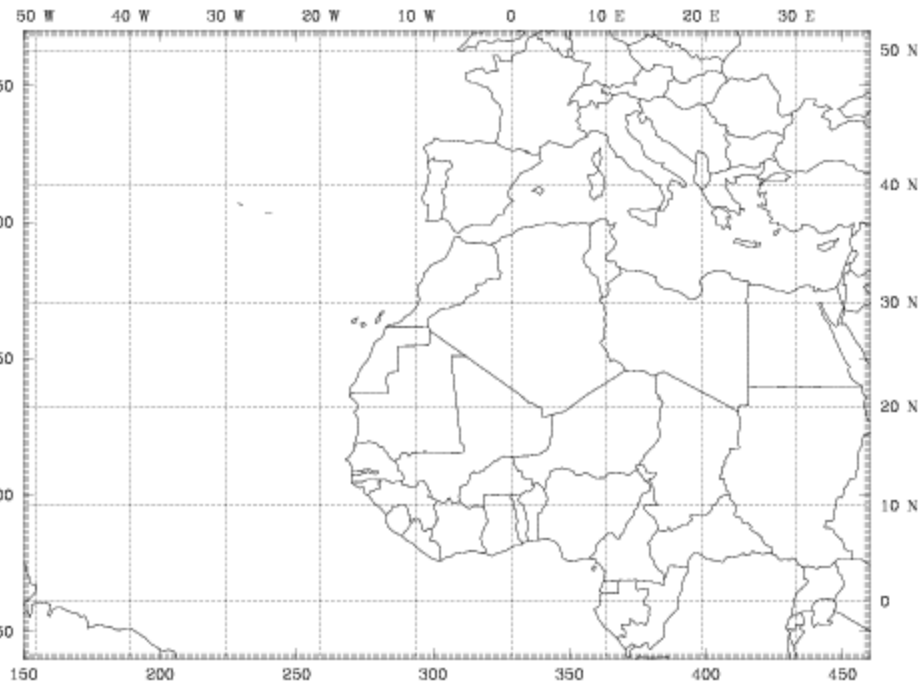


MSG01 IR 10.8 27/08/06 00:00



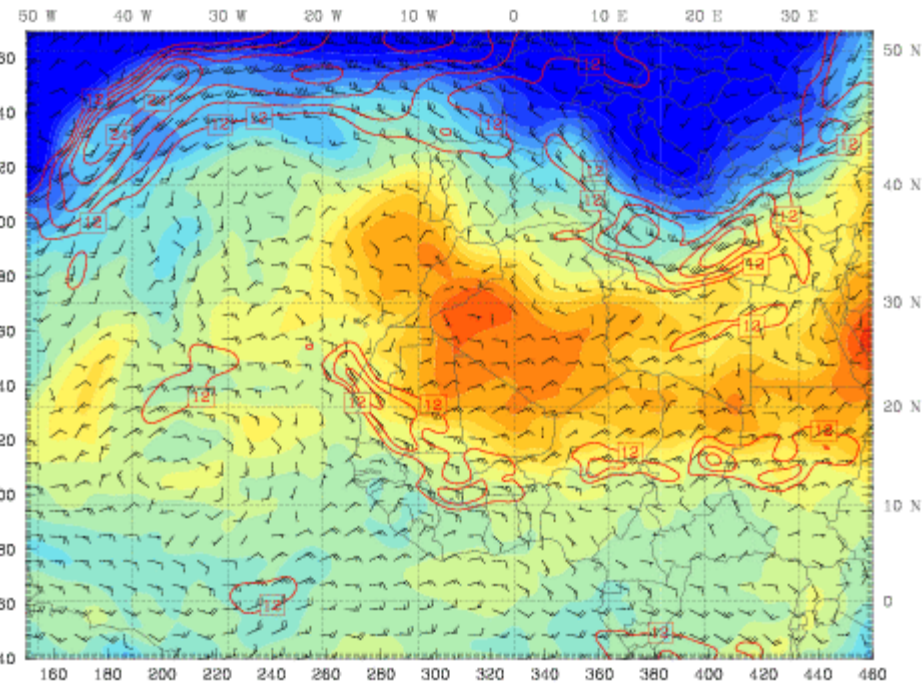
96h Simulation Results (every 6h)

Integrated dust & hydrometeors



Model Info: V3.0.1.1 KP MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

3km T and winds

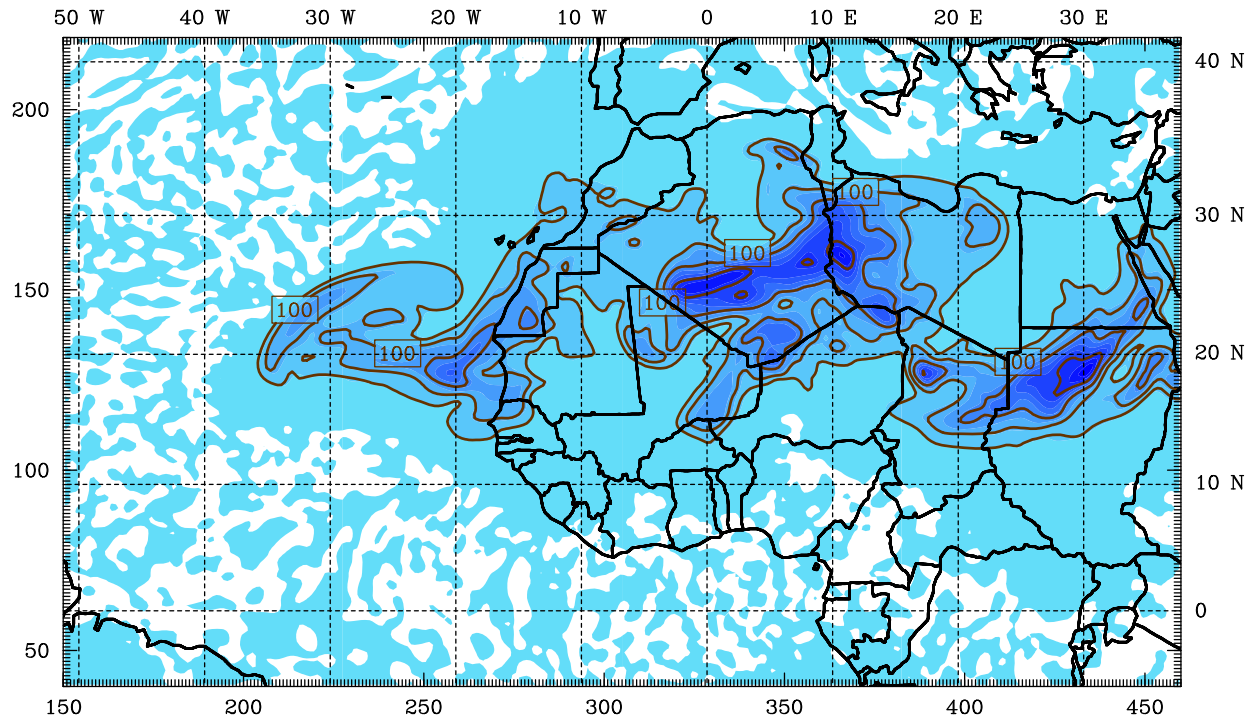


CONTOURS: UNITS= $m s^{-1}$ LOW= 12.000 HIGH= 24.000 INTERVAL= 3.0000
BARB VECTORS: FULL BARB = $5 m s^{-1}$

Model Info: V3.0.1.1 KP MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

Surface Net Downward Heat Flux (84h)

DRM - NDRM



CONTOURS: UNITS=X 1000 ug^{-2} LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000

-300 -270 -240 -210 -180 -150 -120 -90 -60 -30 0 $W m^{-2}$

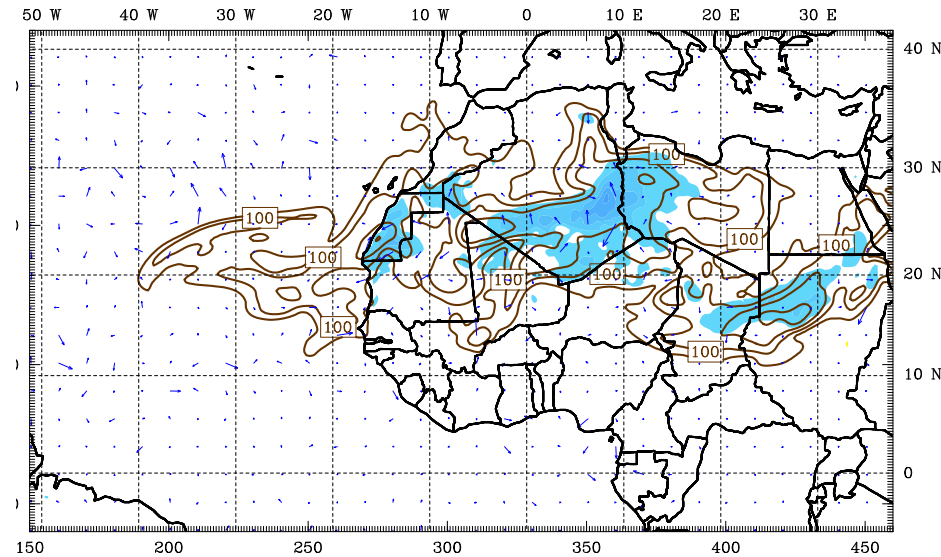
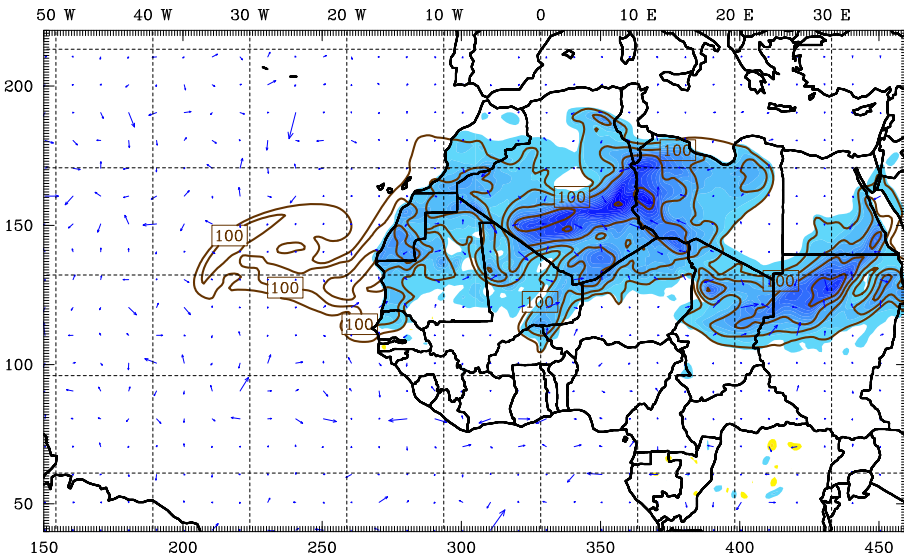
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LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

Surface T & Integrated DUST

DR - NDR

84h

96h



MAXIMUM VECTOR: 2.1 m s⁻¹ →
CONTOURS: UNITS=X 1000 ug⁻² LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 K
Model Info: V3.0.1.1 KF MRF PBL Lin et al Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

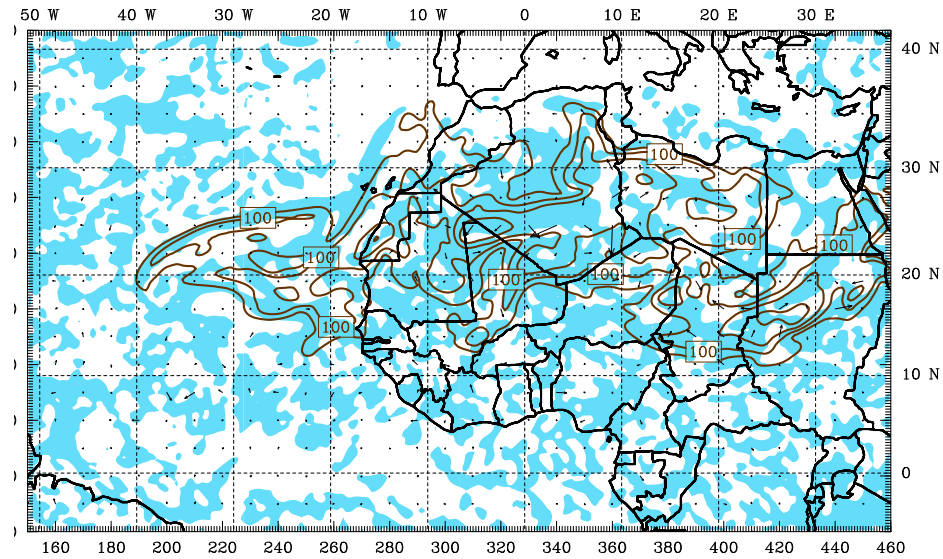
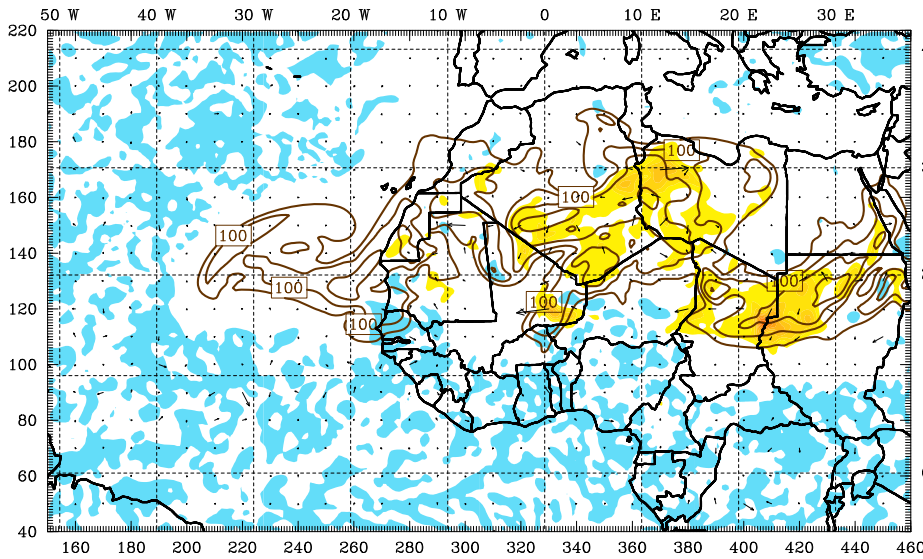
MAXIMUM VECTOR: 1.9 m s⁻¹ →
CONTOURS: UNITS=X 1000 ug⁻² LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-2.5 -2 -1.5 -1 -0.5 0 .5 1 1.5 2 2.5 3 3.5 4 4.5 5 K
Model Info: V3.0.1.1 KF MRF PBL Lin et al Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

3km T & Integrated DUST

DR - NDR

84h

96h



Model Info: V3.0.1.1 KF MRF PBL Lin et al Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

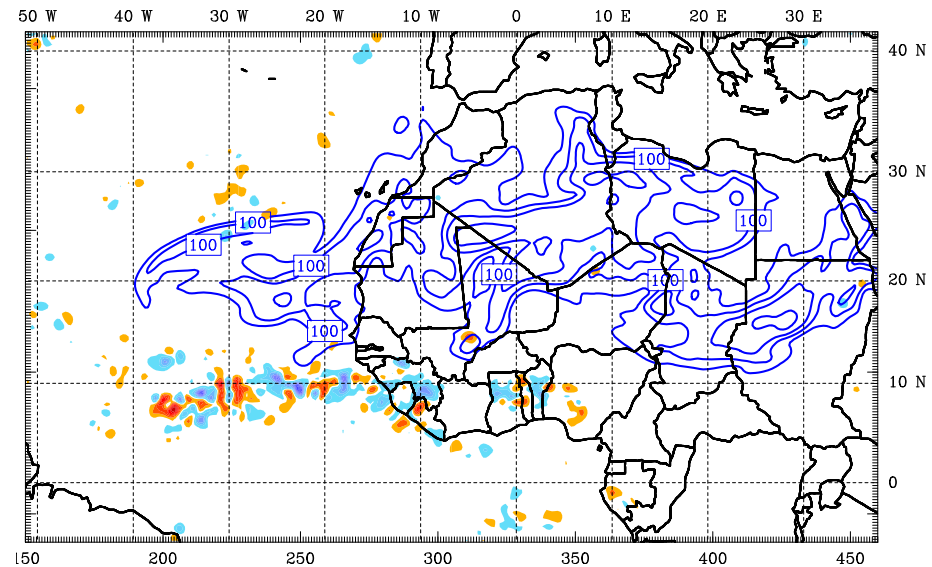
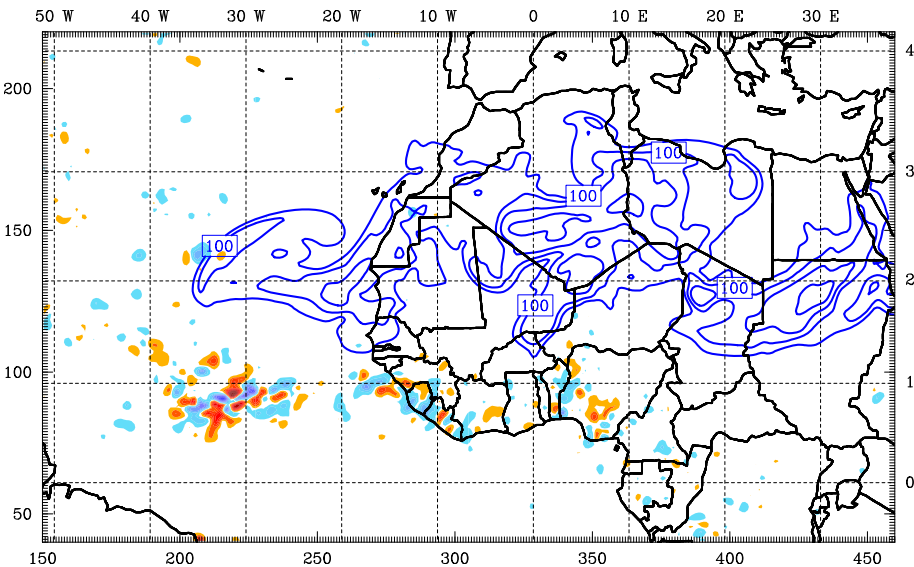
Model Info: V3.0.1.1 KF MRF PBL Lin et al Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

Integrated Cloud+Ice & DUST

DM - NDM

84h

96h



CONTOURS: UNITS=X 1000 ug⁻² LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-0.46 -0.38 -0.3 -0.22 -0.14 -0.06 .02 .1 .18 .26 .34 .42 .5 mm
Model Info: V3.0.1.1 KF MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

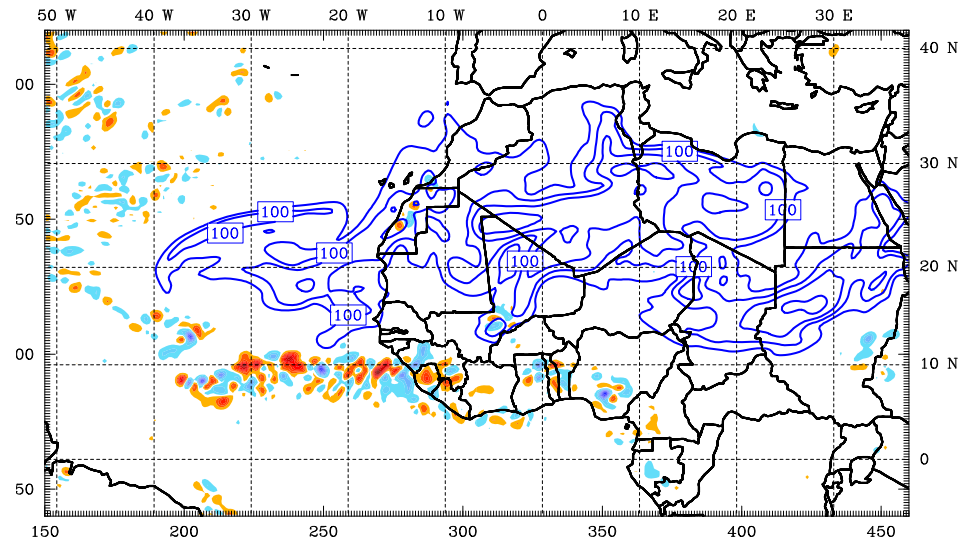
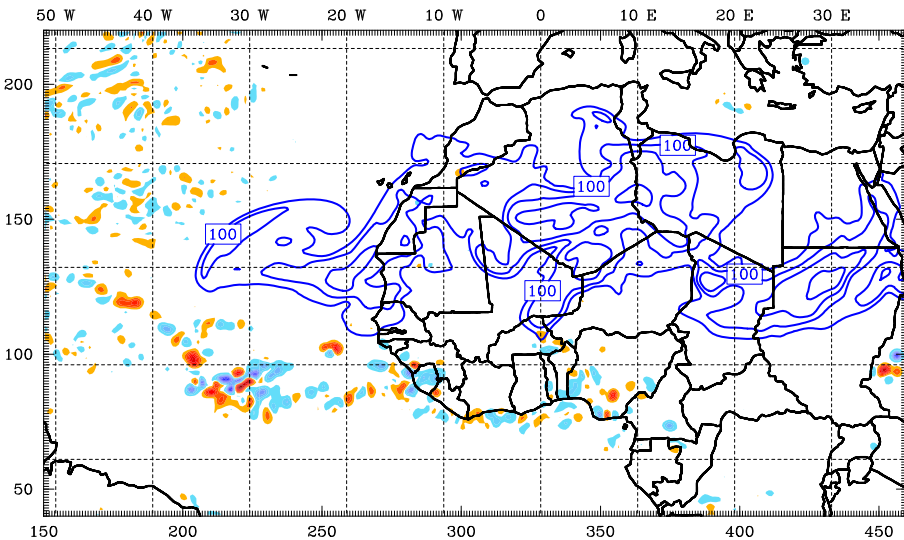
CONTOURS: UNITS=X 1000 ug⁻² LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-0.46 -0.42 -0.38 -0.34 -0.3 -0.26 -0.22 -0.18 -0.14 -0.1 -0.06 -0.02 .02 .06 .1 .14 .18 .22 .26 mm
Model Info: V3.0.1.1 KF MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

Integrated Precipitation & DUST

DM - NDM

84h

96h



CONTOURS: UNITS=X 1000 ug-2 LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-0.19 -0.15 -0.11 -0.07 -0.03 0.01 0.05 0.09 0.13 0.17 mm
Model Info: V3.0.1.1 KF MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

CONTOURS: UNITS=X 1000 ug-2 LOW= 50.000 HIGH= 400.00 INTERVAL=X 2.0000
-0.19 -0.15 -0.11 -0.07 -0.03 0.01 0.05 0.09 0.13 0.17 mm
Model Info: V3.0.1.1 KF MRF PBL Noah LSM 30 km, 30 levels, 120 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor