

Exploring dust impacts on tropical systems from the NASA HS-3 field campaign

Edward Nowottnick, Peter Colarco, Arlindo da Silva, Donifan Barahona

Abstract:

One of the overall scientific goals of the NASA Hurricane and Severe Storm Sentinel (HS-3) field campaign is to better understand the role of the Saharan Air Layer (SAL) in tropical storm development. During the 2012 HS-3 deployment, the Cloud Physics Lidar (CPL) observed dust within SAL air in close proximity to a developing Nadine (September 11, 2012). Throughout the mission, the NASA GEOS-5 modeling system supported HS-3 by providing 0.25° resolution 5-day global forecasts of aerosols, which were used to support mission planning. The aerosol module was radiatively interactive within the GEOS-5 model, but aerosols were not directly coupled to cloud and precipitation processes. In this study we revisit the aerosol forecasts with an updated version of the GEOS-5 model. For the duration of Hurricane Nadine, we run multi-day climate simulations leading up to each respective Global Hawk flight with and without aerosol direct interaction. For each set of simulations, we compare simulated dust mass fluxes to identify differences in SAL entrainment related to the interaction between dust aerosols and the atmosphere. We find that the direct effects of dust induce a low level anticyclonic circulation that temporarily shields Nadine from the intrusion of dry air, leading to a more intense storm.

Exploring Dust Impacts on Tropical Systems from the NASA HS-3 field campaign

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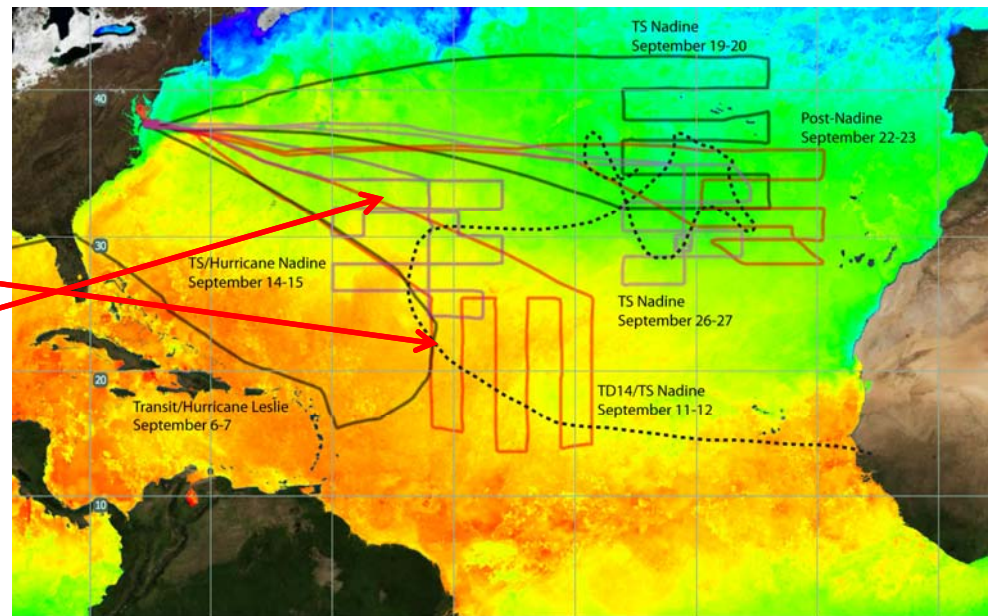
Motivation

HS-3 Science Goal: What impact does the large-scale environment, particularly the SAL, have on intensity?

- How does the direct radiative impact of dust influence storm dynamics during HS3?

Nadine (2012):

1. 9/11/12 – 9/12/12
 2. 9/14/12 – 9/15/12
- Tropical Storm on 9/10/12



Outline

1. The NASA GEOS-5 Model

1. Dust observations during Nadine (2012)

- Model comparisons to CPL & MODIS Aqua on 9/11 & 9/14

2. Simulations of Nadine

- Track & Diagnostics
- Proximity of dust to Nadine during development
- Low level impacts of dust absorption on Nadine's environment

3. Conclusions

The NASA GEOS-5 Modeling System

RESOLUTION: - $0.3125^{\circ} \times 0.25^{\circ}$ in the horizontal
- 72 hybrid-sigma levels in the vertical

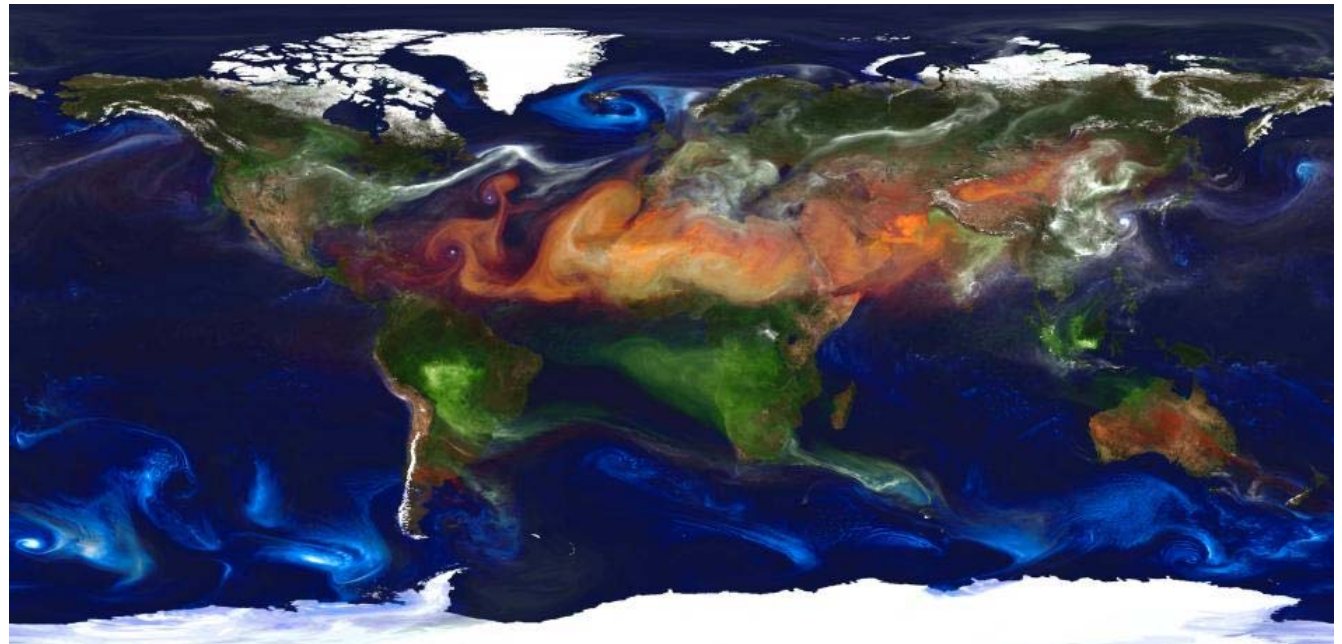
MODES: - assimilation (meteorology and aerosol optical thickness)
- free running climate model

AEROSOLS: - Goddard Chemistry, Aerosol, Radiation, and Transport (GOCART) model
- Dust, Seasalt, Sulfate, Black and Organic Carbon
- Direct radiative impacts of aerosols can be included

NADINE SIMULATIONS:

2 free running
climate simulations
with and without
aerosol direct
radiative feedback

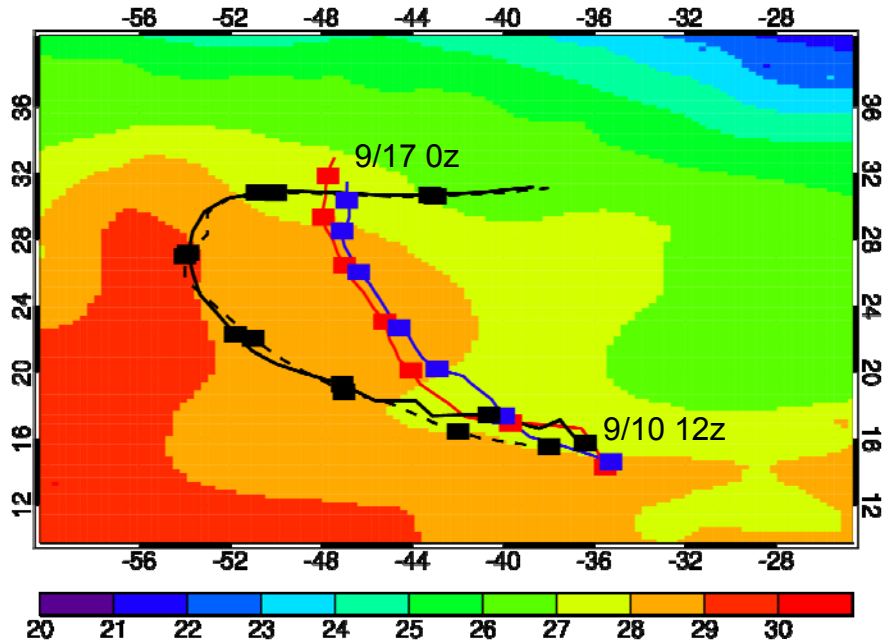
9/6/12 – 9/17/12



* GEOS-5 supported the HS-3 effort by providing daily dust forecasts for mission planning

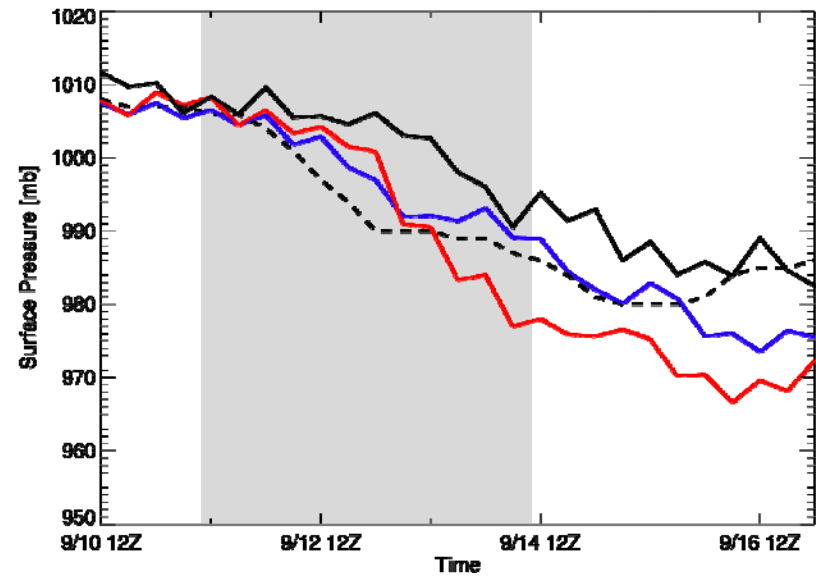
Nadine Track & Diagnostics

Track and SST [°C]

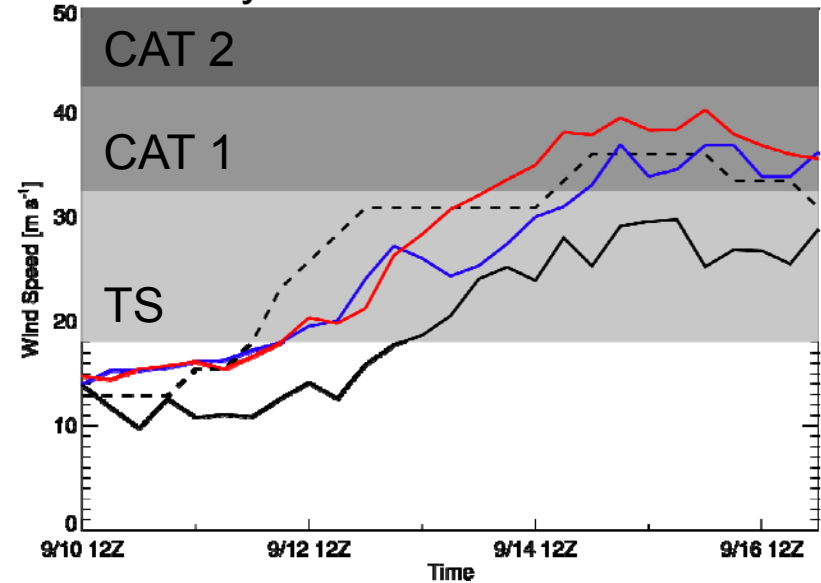


Observed (dashed)
 Assimilation
 Non-Interactive
 Interactive

Surface Pressure



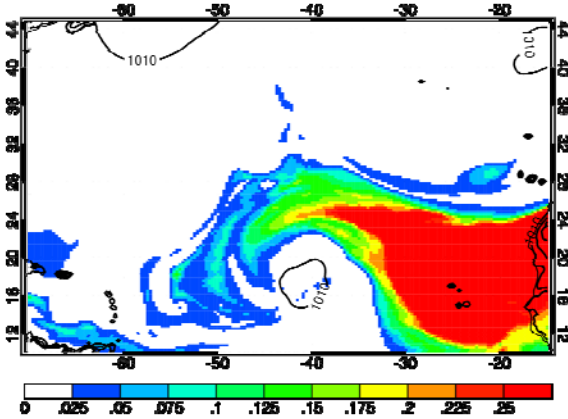
Intensity



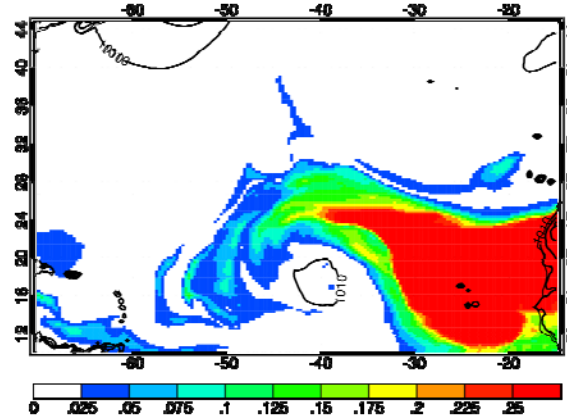
9/11/12 12z

Dust AOT & Surface Pressure [mb]

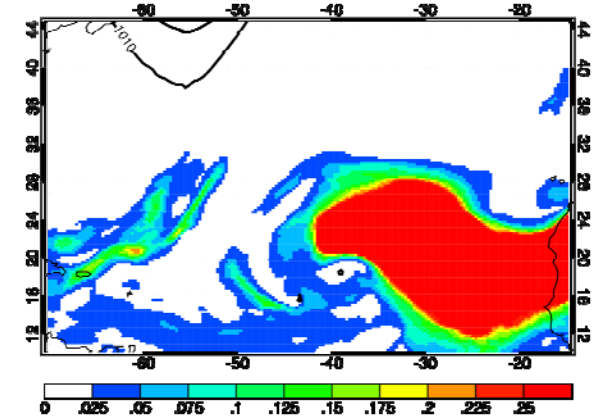
Interactive



Non-Interactive

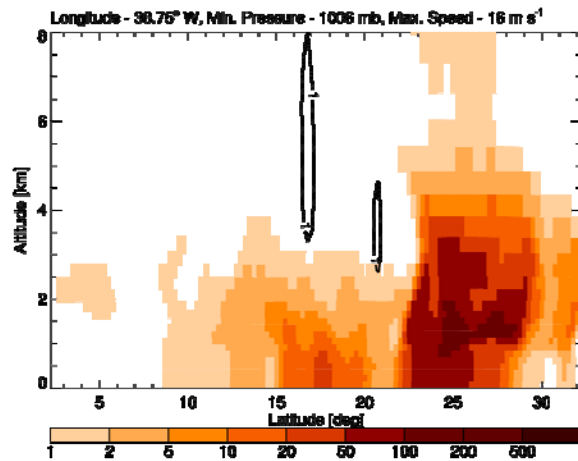


Assimilation

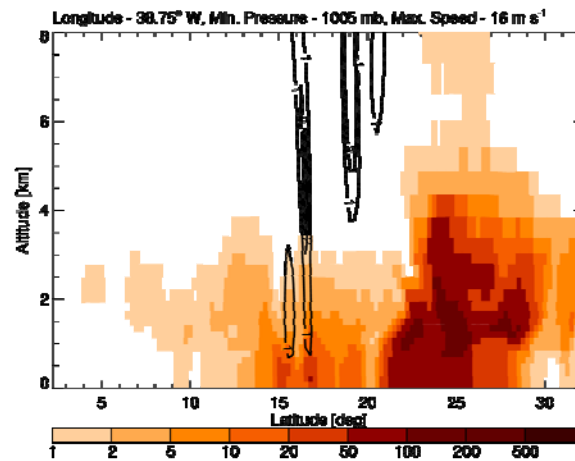


Dust Concentration [$\mu\text{g m}^{-3}$] & Vertical Velocity

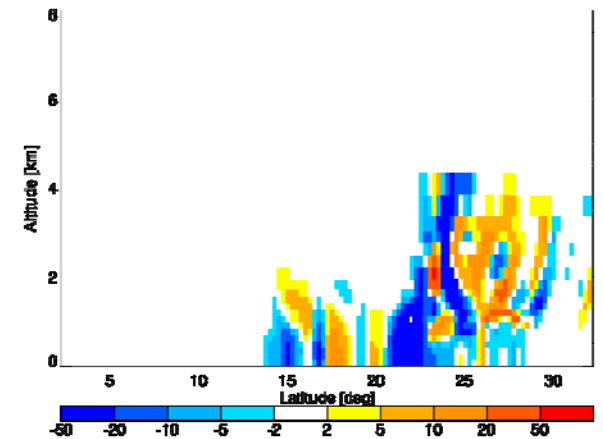
Interactive



Non-Interactive



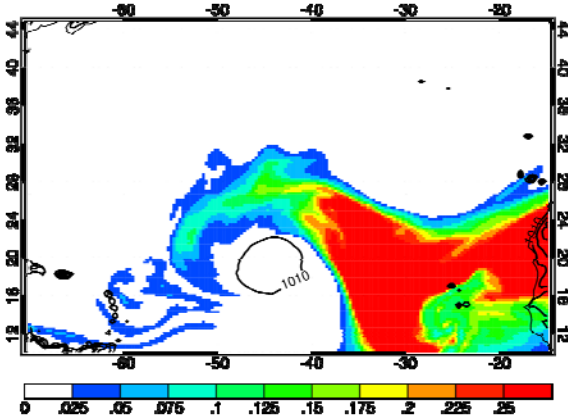
Dust Conc. [$\mu\text{g m}^{-3}$]
Difference (IA - NIA)



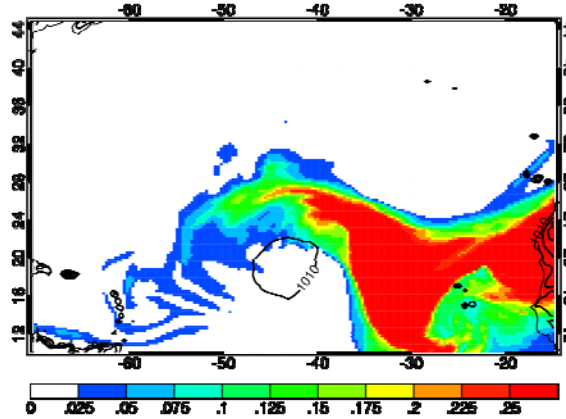
9/12/12 12z

Dust AOT & Surface Pressure [mb]

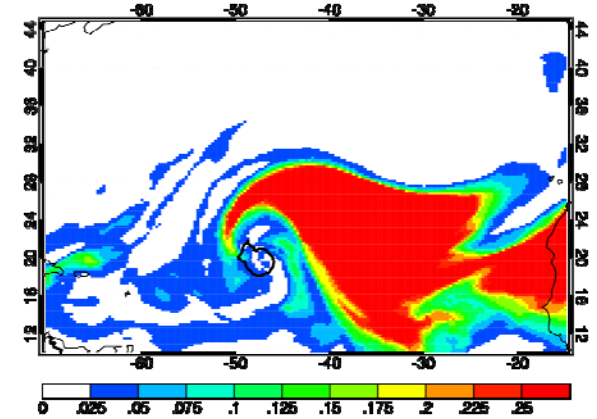
Interactive



Non-Interactive

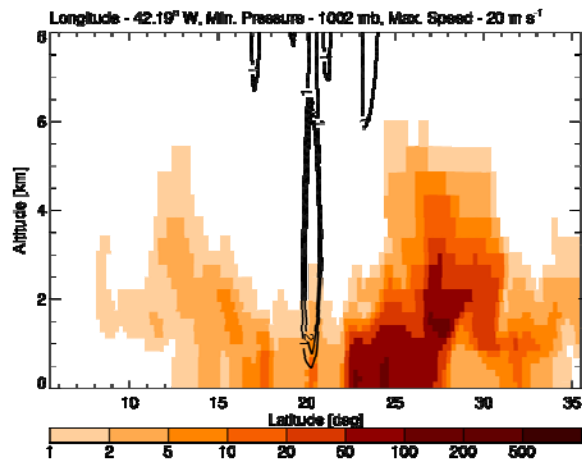


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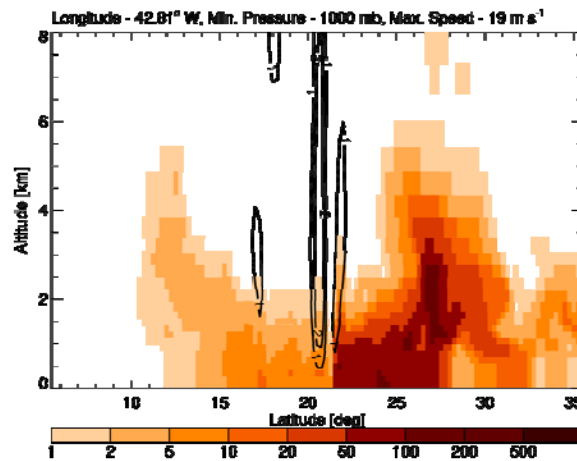


Dust Concentration [$\mu\text{g m}^{-3}$] & Vertical Velocity

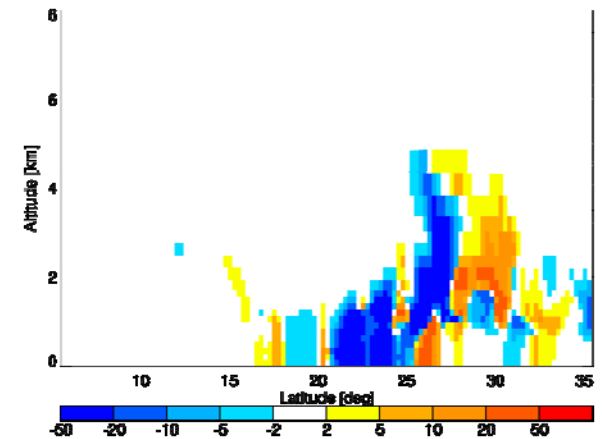
Interactive



Non-Interactive



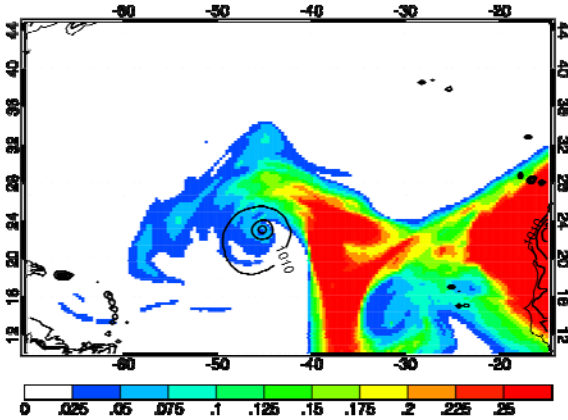
Dust Conc. [$\mu\text{g m}^{-3}$]
Difference (IA - NIA)



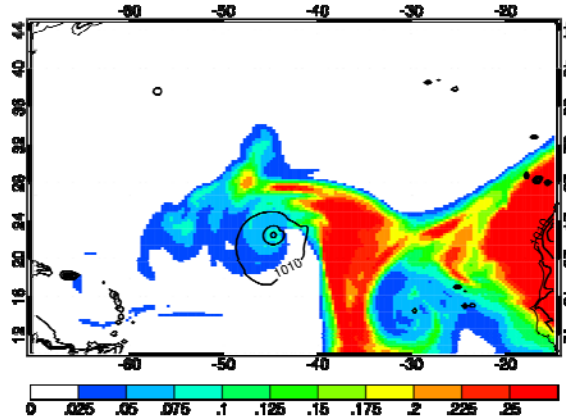
9/13/12 12z

Dust AOT & Surface Pressure [mb]

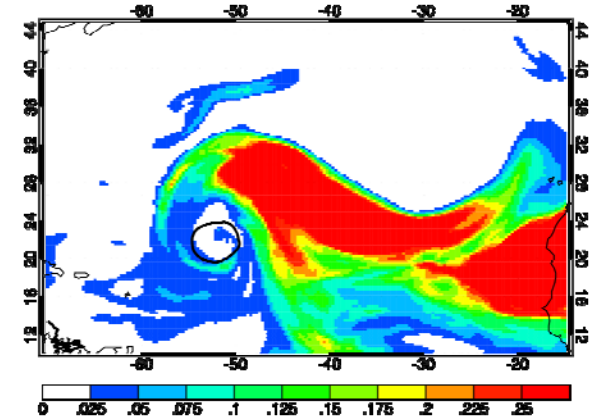
Interactive



Non-Interactive

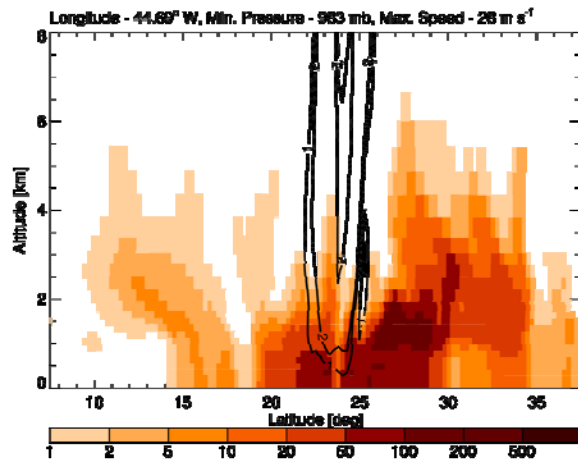


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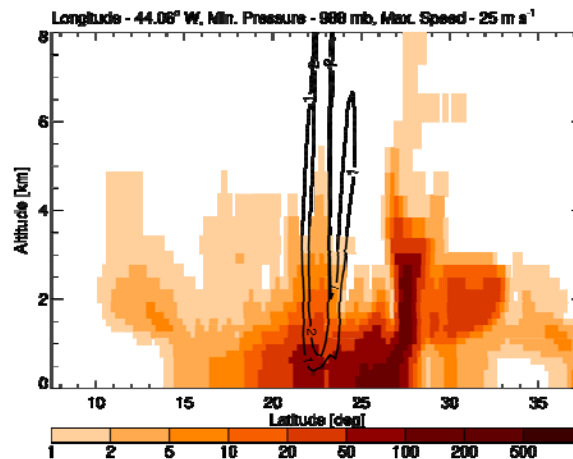


Dust Concentration [$\mu\text{g m}^{-3}$] & Vertical Velocity

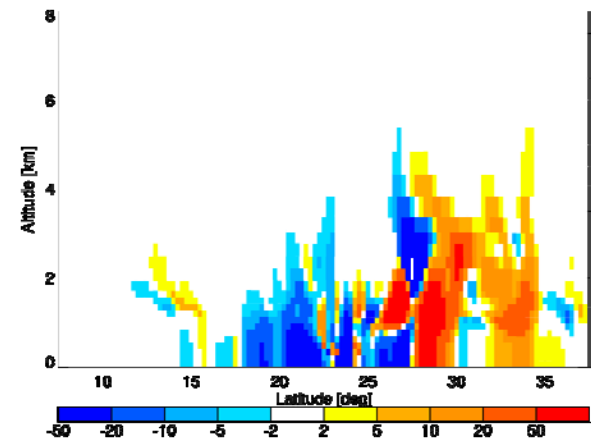
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Non-Interactive



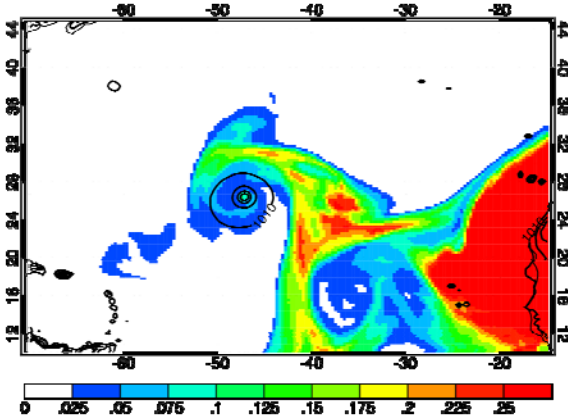
Dust Conc. [$\mu\text{g m}^{-3}$]
Difference (IA - NIA)



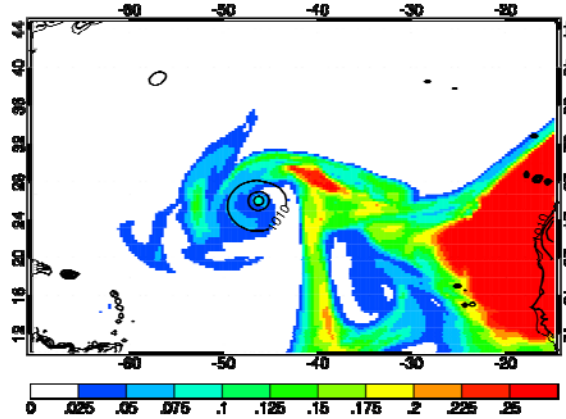
9/14/12 12z

Dust AOT & Surface Pressure [mb]

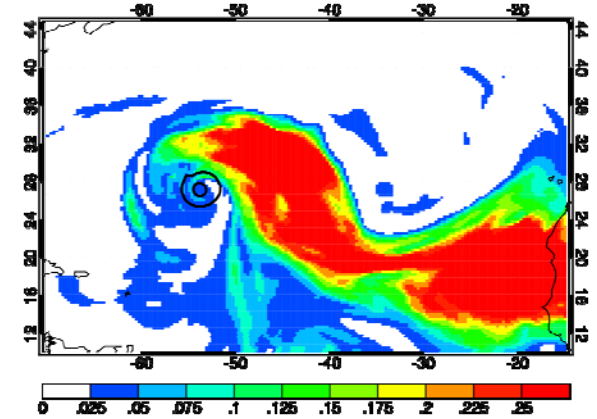
Interactive



Non-Interactive

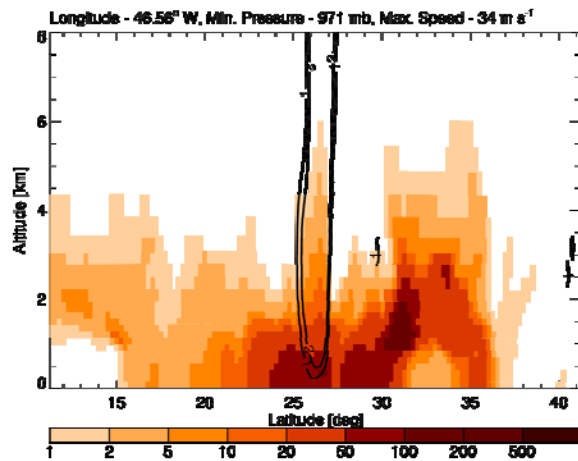


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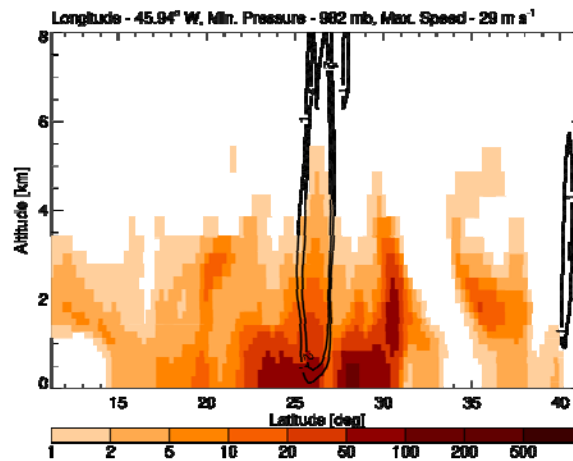


Dust Concentration [$\mu\text{g m}^{-3}$] & Vertical Velocity

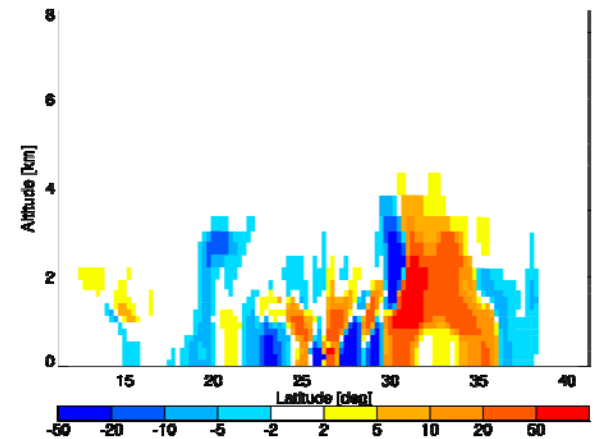
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Non-Interactive



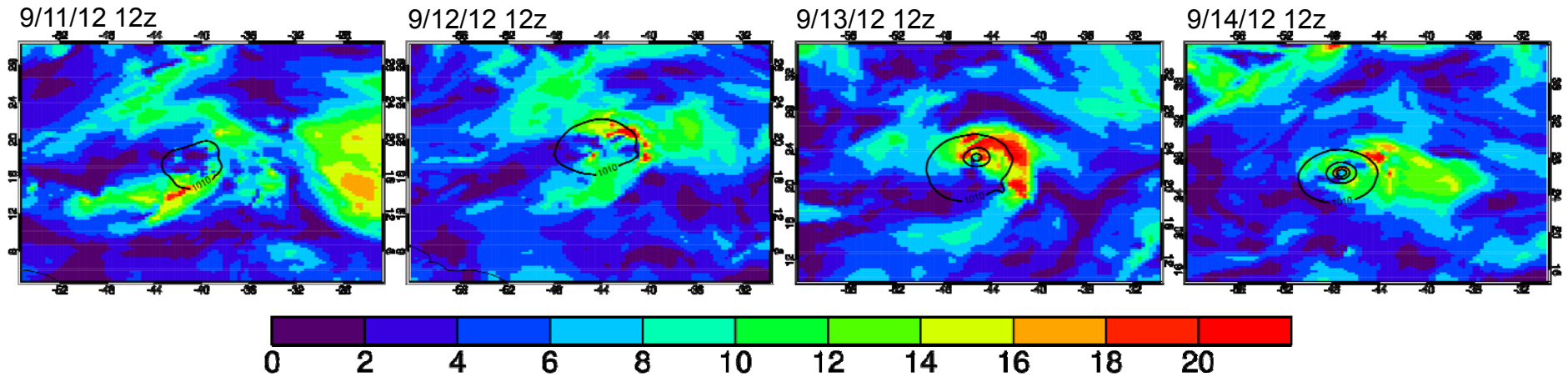
Dust Conc. [$\mu\text{g m}^{-3}$]
Difference (IA - NIA)



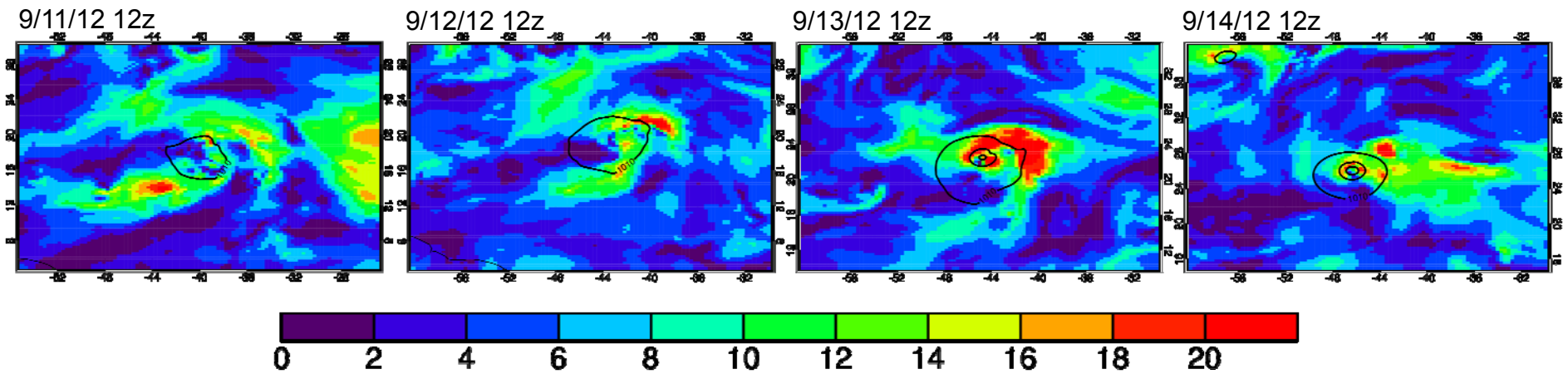
Dust Direct Effects on Nadine

1 km – 5 km Wind Shear [m s^{-1}]

Interactive



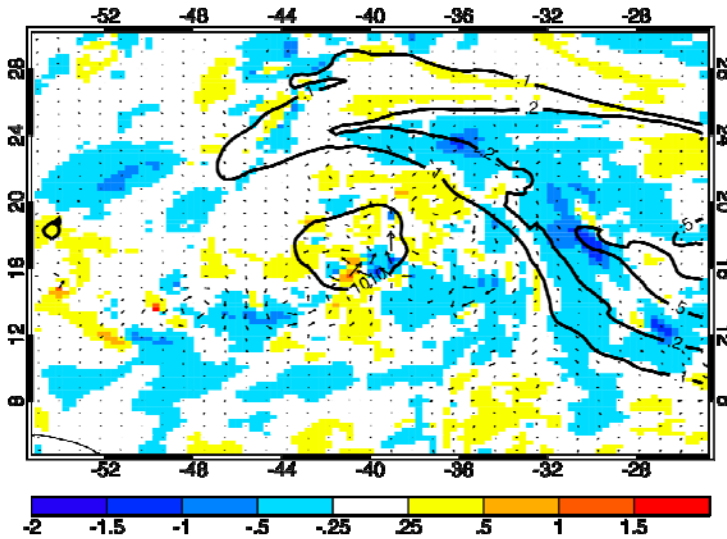
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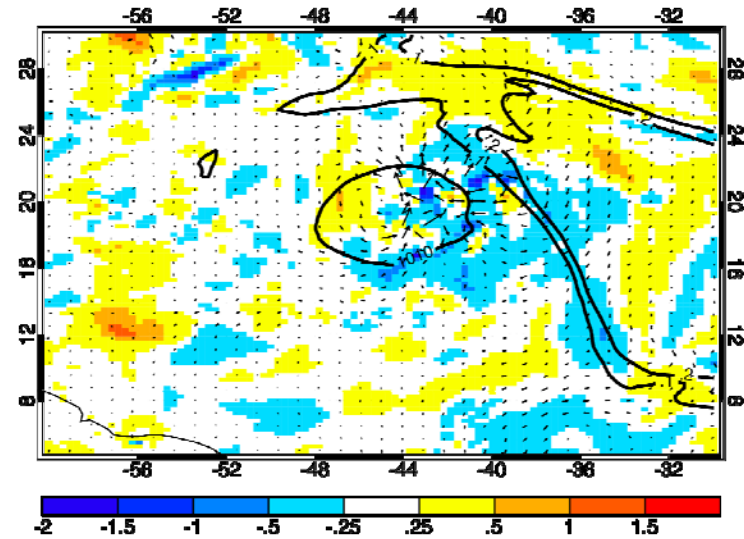
Dust Direct Effects on Nadine

1 km – 5 km Mean Temperature [$^{\circ}\text{C}$] and Wind Difference (IA – NIA) $\rightarrow 10 \text{ ms}^{-1}$

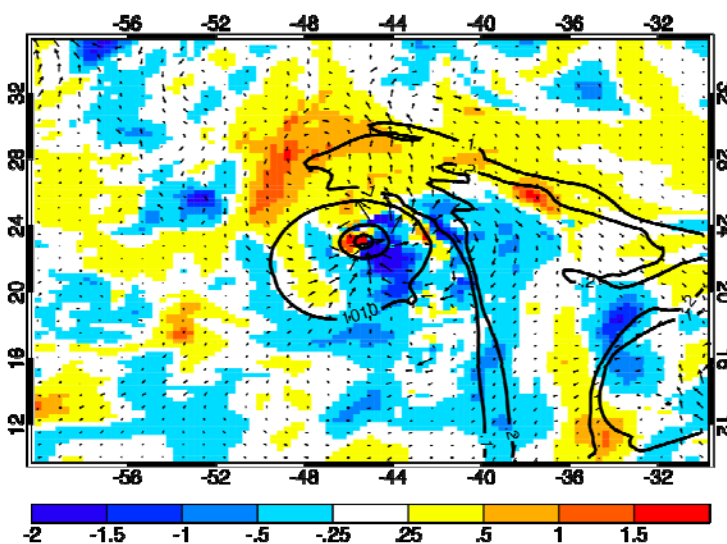
9/11/12 12z



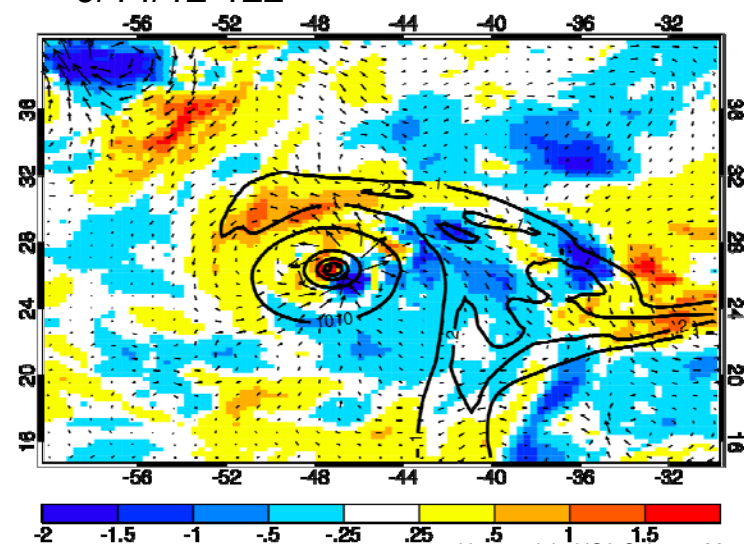
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9/13/12 12z



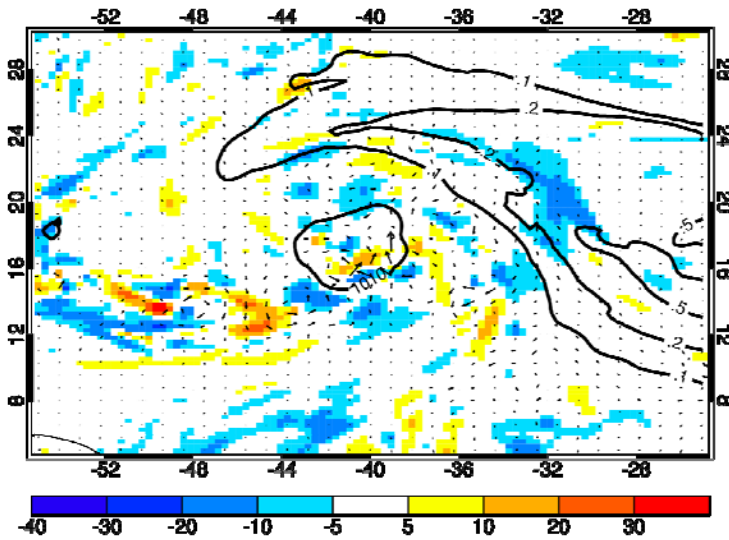
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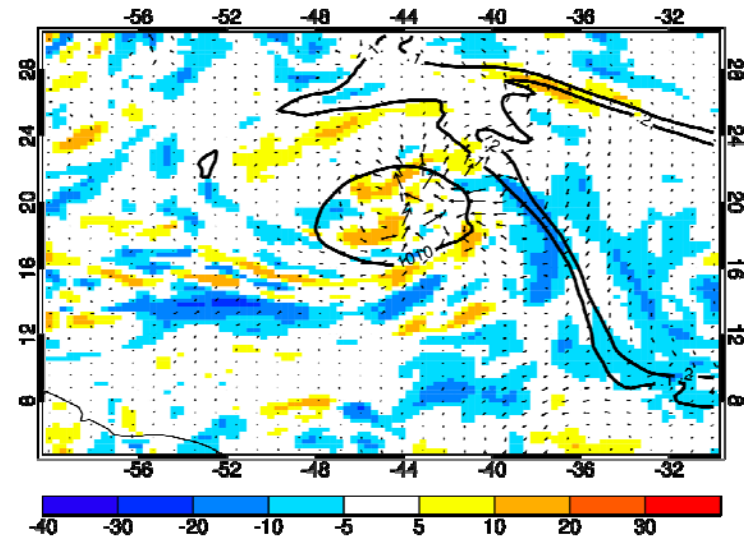
Dust Direct Effects on Nadine

1 km – 5 km Mean Relative Humidity [$^{\circ}\text{C}$] and Wind Difference (IA – NIA) $\rightarrow 10 \text{ ms}^{-1}$

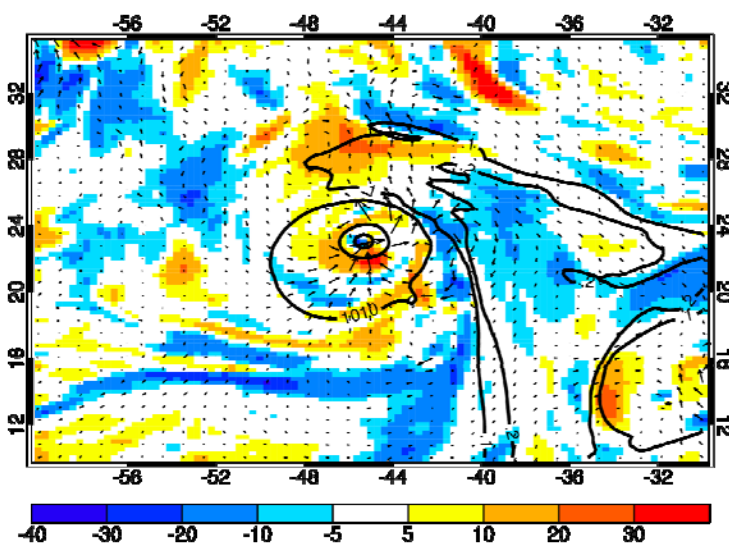
9/11/12 12z



9/12/12 12z



9/13/12 12z



9/14/12 12z

