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INFLUENCE OF SAL ON TROPICAL CYCLOGENESIS: COMPARATIVE STUDIES OF HELENE (2006) AND JULIA (2010)

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Outline

Introduction
Objectives
Research Methods
Case Descriptions
Preliminary Results
Summary
Future Work

Introduction

- Saharan Air Layer (SAL)
  - Intensely dry, warm and sometimes dust-laden layer of the atmosphere
  - Offshore, base at ~900-1800 m and the top is usually below 5500 m (Diaz et al. 1976)
- SAL has negative impact in TC development (Dunion and Velden 2004)
  - Enhancement of trade winds inversion (more stable atmosphere)
  - Enhancement of the local vertical shear due to the African Easterly Jet (AEJ)
  - Intrusion of dry air by the SAL
- Positive impact of the SAL on the microphysical level (Jenkins et al. 2008)
  - Cloud Condensation Nuclei (CCN) source, invigorating rain bands.
- Braun (2010a) found SAL to be a integral part of the environment at the TC formation

Objectives

- Better understanding of the SAL in terms of the microphysics of tropical cyclones formation.
- Find a correlation of AOD, lightning, and wind shear at the genesis stage.

Research Methods

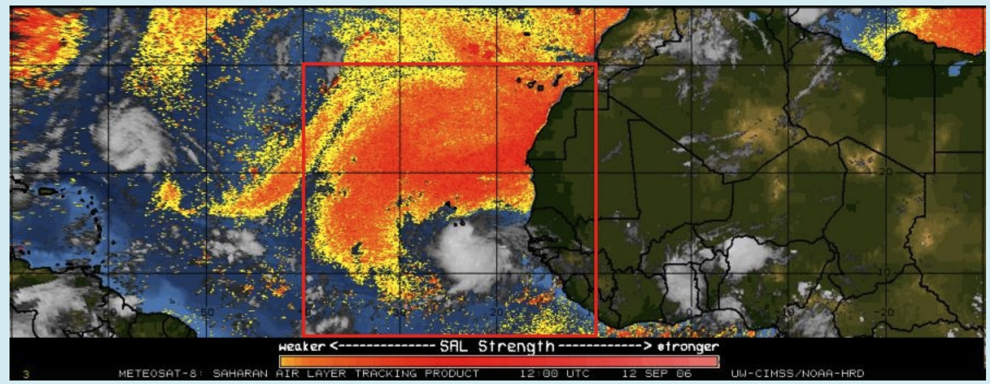
- Comparative Analysis
  - Two study cases: Helene (2006) and Julia (2010)
  - Field Campaigns data:
    - NASA African Monsoon Multidisciplinary Analyses (NAMMA) 2006

    (http://airbornescience.nsstc.nasa.gov/namma/)
    - Genesis and Rapid Intensification Processes (GRIP) 2010

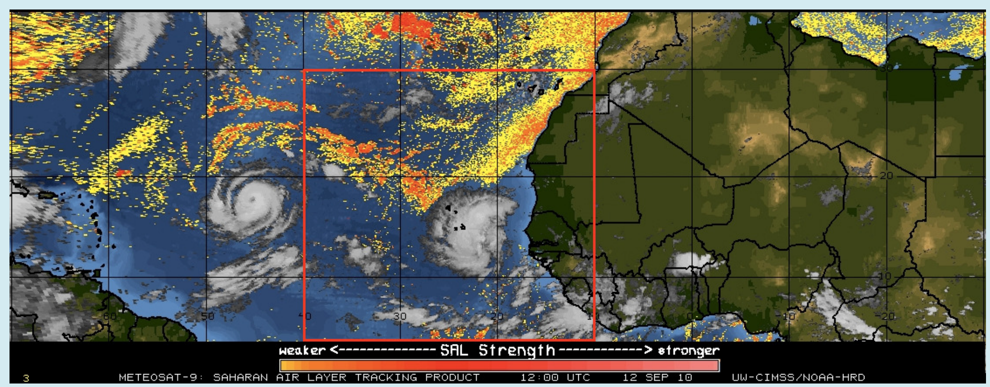
    (http://airbornescience.nsstc.nasa.gov/grip/)
  - METEOSAT-8, MODIS, and UK Met Office's lightning Arrival Time Difference (ATD)

Case Descriptions

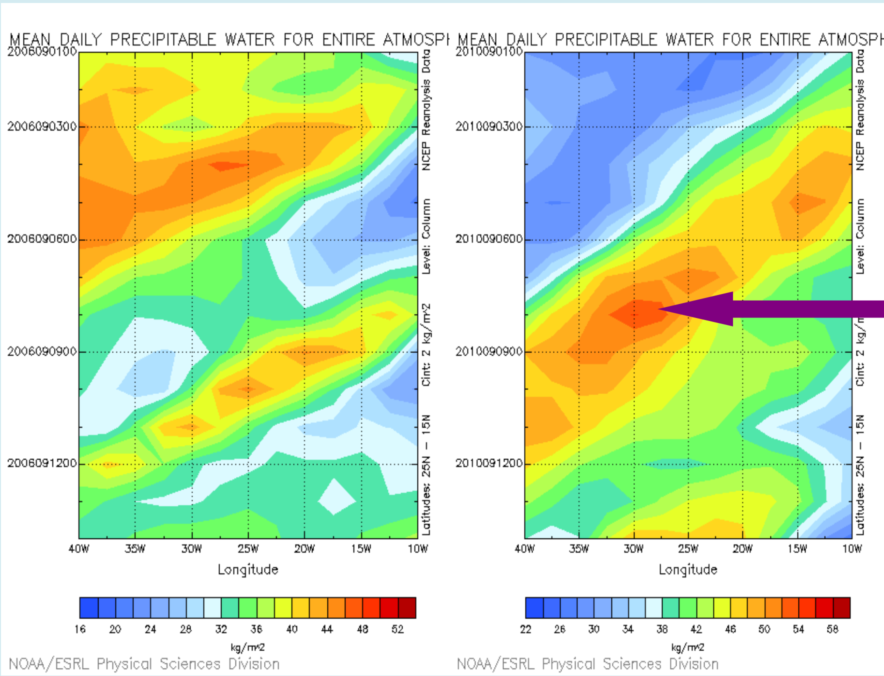
- **Helene (2006)**
  - Tropical Depression (TD) #8 on September 12, 2006 at 1200 UTC
    - Location: 11.9°N, 22°W
    - Pressure: 1007 hPa
    - Sustained winds: 12.9 ms^{-1}



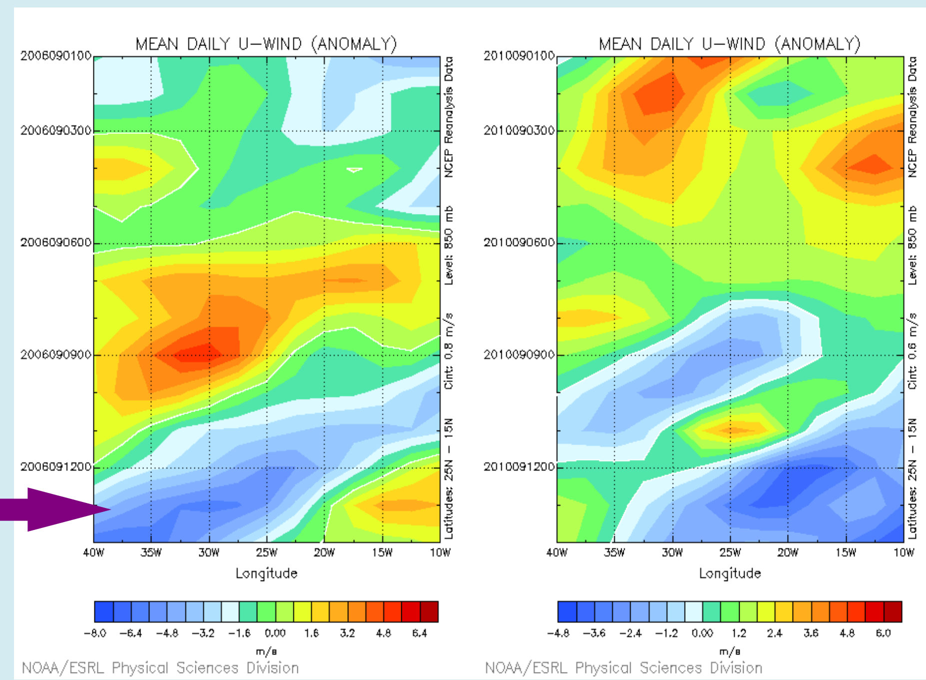
- **Julia (2010)**
  - TD #12 on September 12, 2010 at 0600 UTC
    - Location: 12.9°N, 20.5°W
    - Pressure: 1007 hPa
    - Sustained winds: 14.9 ms^{-1}



NCEP Reanalysis

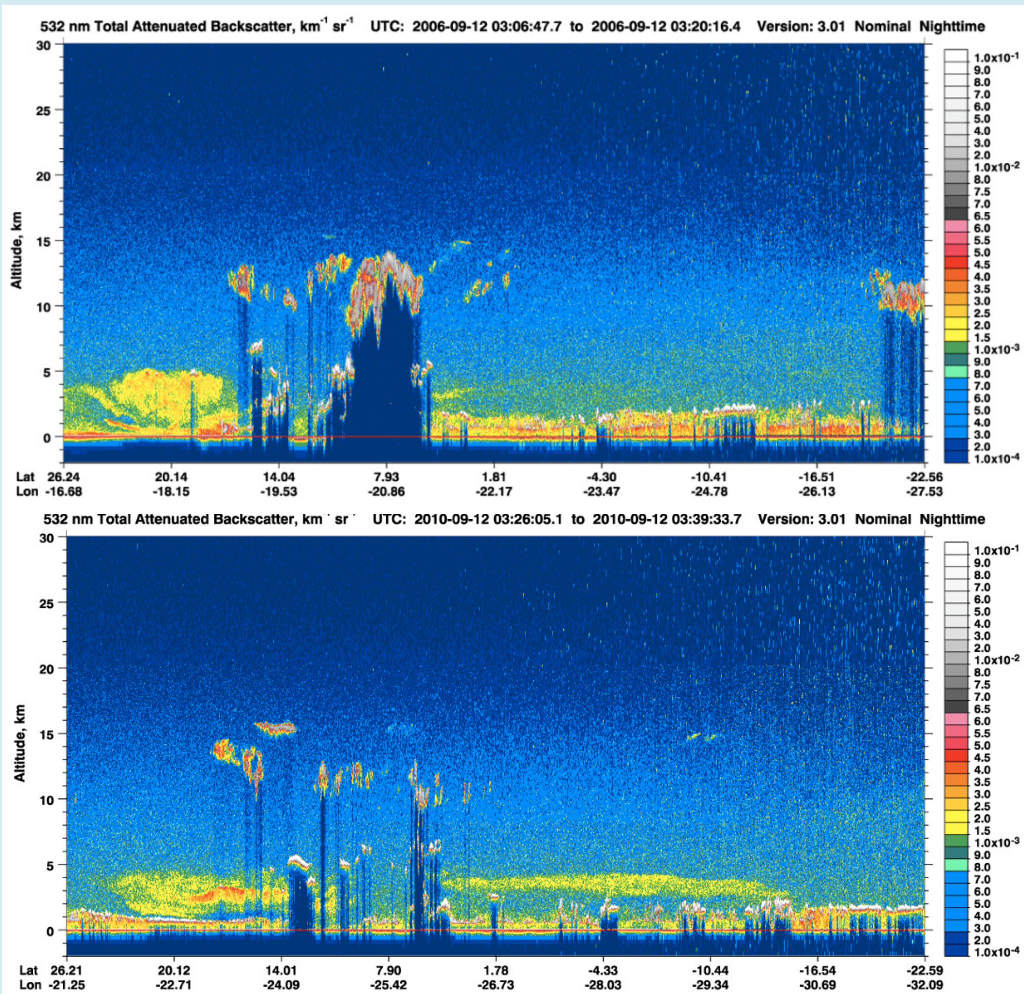


Higher Precipitation



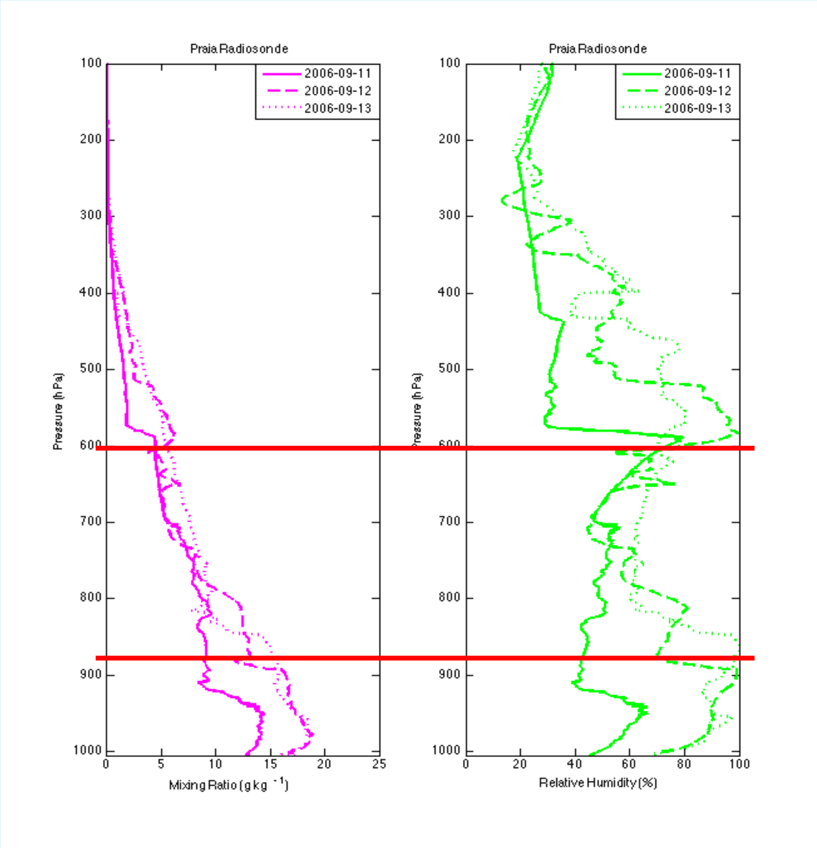
Stronger AEJ

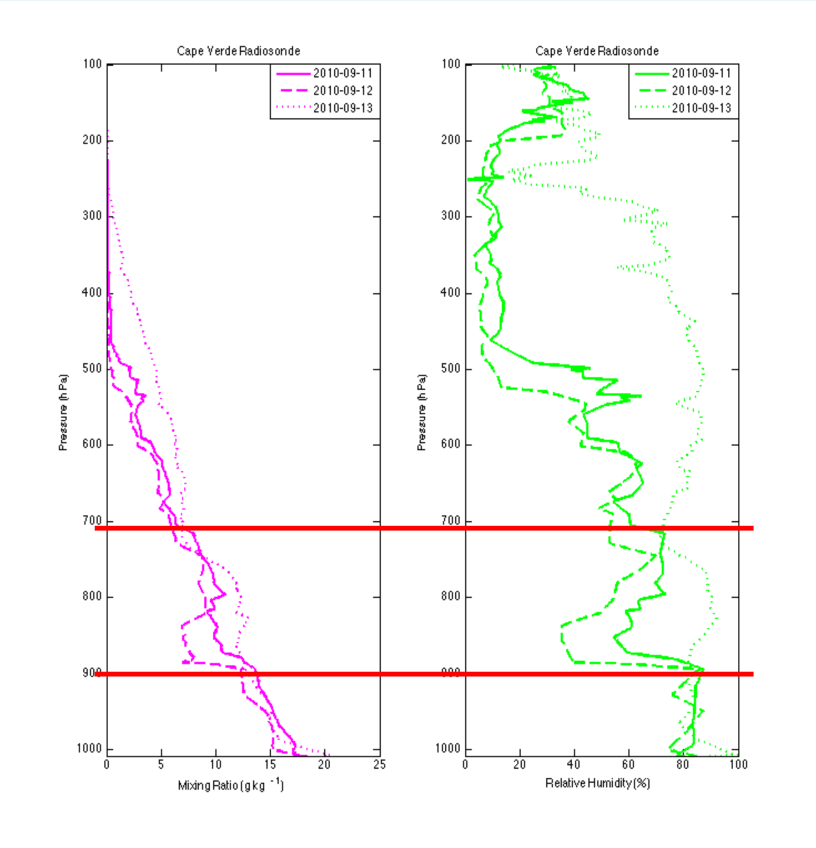
CALIPSO aerosol backscatter



- “Secondary” SAL layer seen in 2010

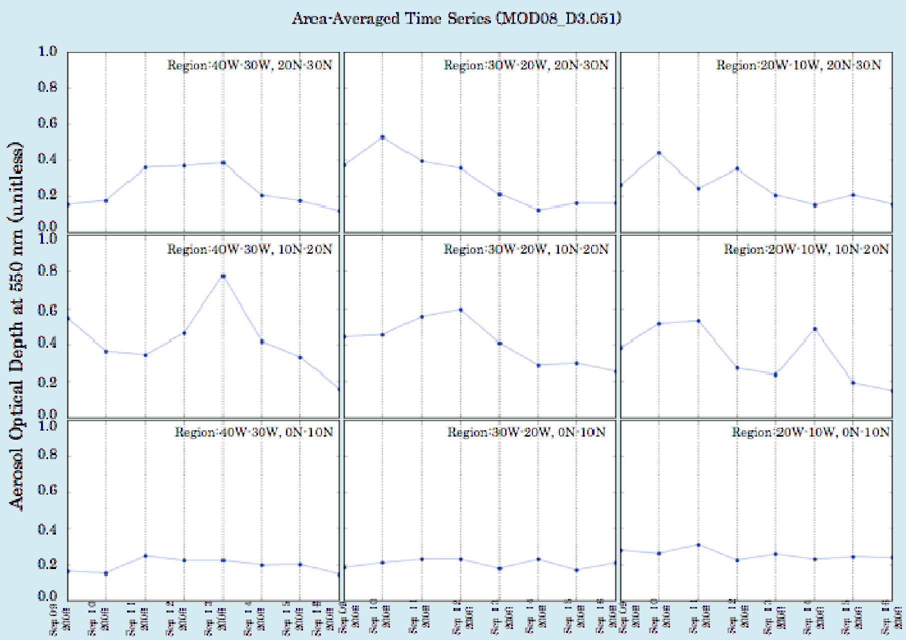
Radiosonde Analysis: Mixing Ratio and RH

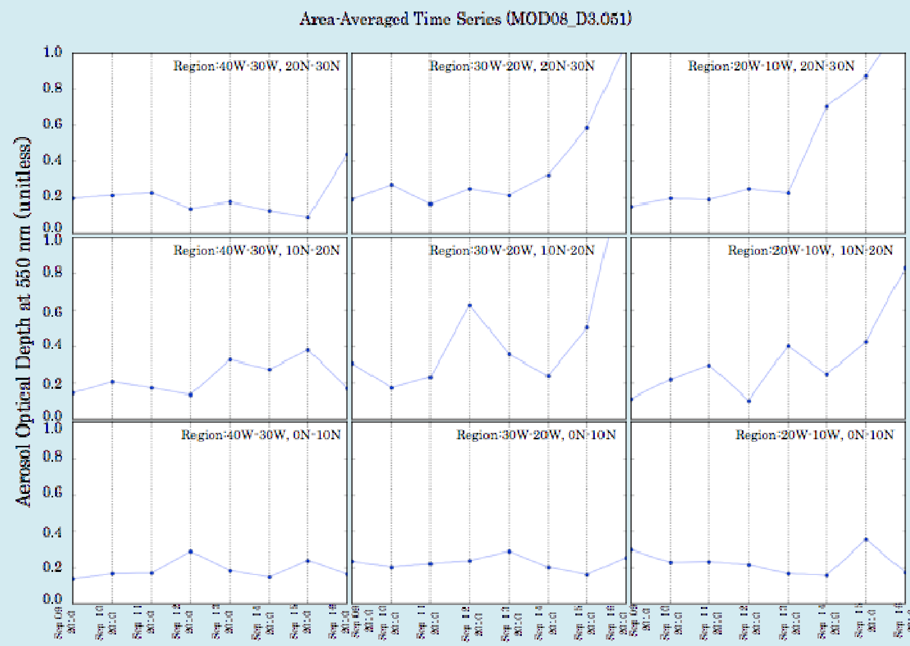




- Drier conditions at lower elevations in 2006
- “Secondary” SAL layer induces drier conditions in 2010
- Higher vertical development in 2010

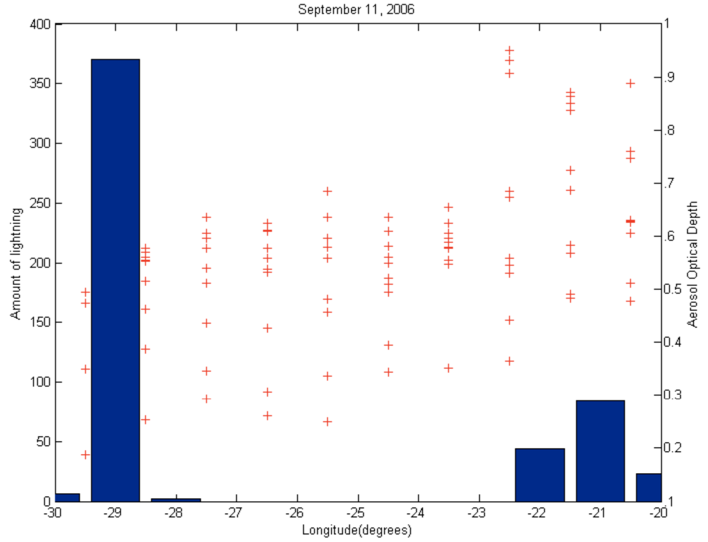
MODIS AOD Analysis

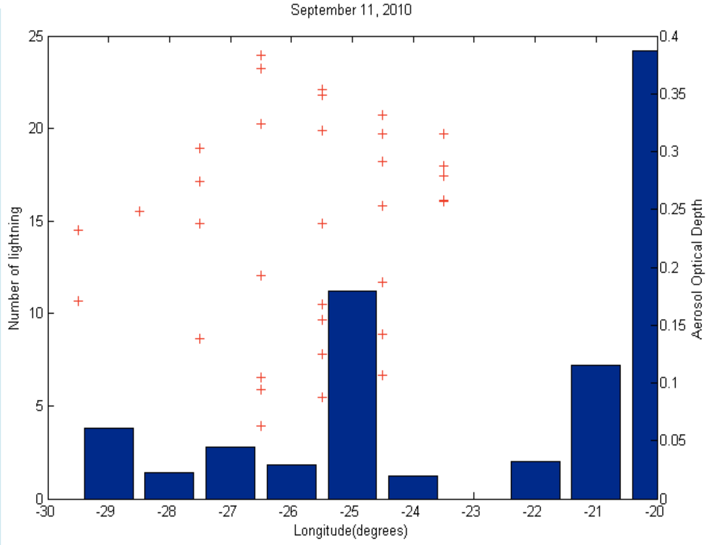


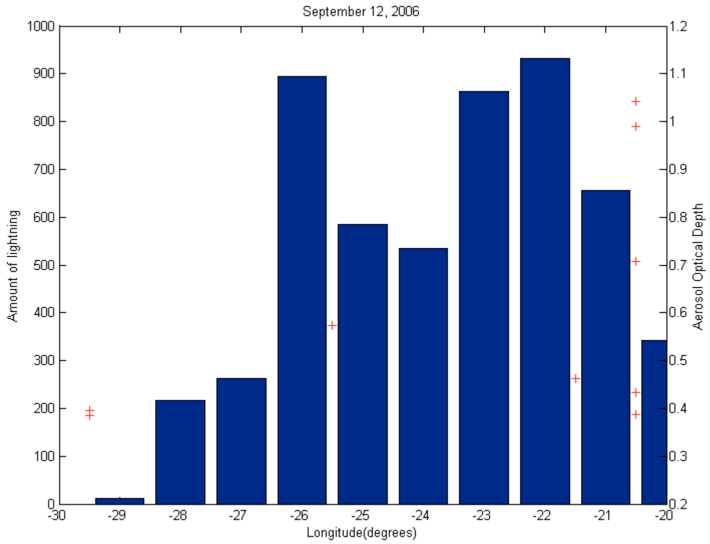


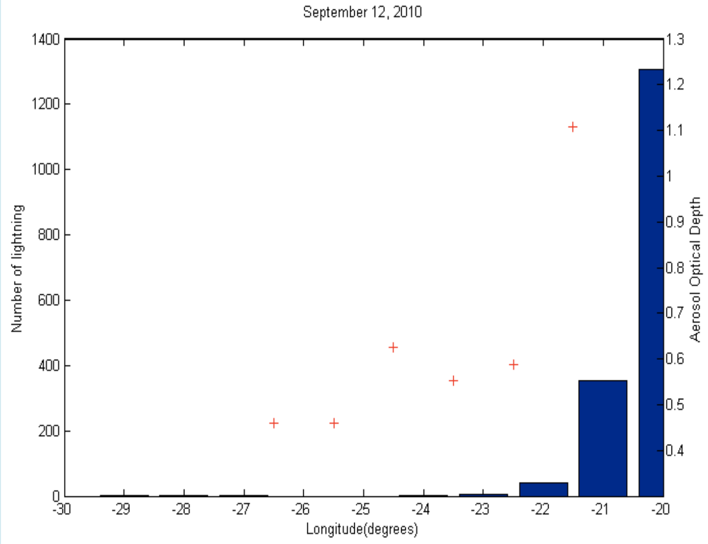
- Lower values of Aerosol Optical Depth on 2010 in comparison with 2006 over the selected days.

MODIS AOD vs. ATD









Radiosonde Analysis: Wind Shear and RH

Date	Wind Shear (m/s)	Relative Humidity 850 hPa (%)	Relative Humidity 700 hPa (%)
2006/09/01	4.1	73.7	61.0
2006/09/02	7.4	78.0	61.2
2006/09/03	-3.6	97.6	100.0
2006/09/04	2.2	87.3	40.4
2006/09/05	9.7	51.9	41.0
2006/09/06	8.5	43.4	39.3
2006/09/07	6.1	42.3	42.9
2006/09/08	-4.3	33.7	44.7
2006/09/09	2.0	85.7	76.2
2006/09/10	2.0	66.3	57.0
2006/09/11	-5.8	44.5	48.5
2006/09/12	11.7	74.1	47.1
2006/09/13	3.5	98.1	63.0
2006/09/14	2.1	86.0	51.5

Date	Wind Shear (m/s)	Relative Humidity 850hPa (%)	Relative Humidity 700hPa (%)
2010/09/01	0.9	19.5	29.4
2010/09/02	-8.8	18.2	26.7
2010/09/03	-1.8	22.3	20.3
2010/09/04	-1.0	11.2	63.6
2010/09/05	2.2	57.6	79.8
2010/09/06	0.3	45.7	58.6
2010/09/07	5.7	78.4	65.4
2010/09/08	-2.7	67.8	68.6
2010/09/09	-1.4	85.9	60.9
2010/09/10	-0.3	77.8	54.7
2010/09/11	-0.4	55.3	60.4
2010/09/12	-1.7	35.4	53.5
2010/09/13	2.5	87.4	72.8
2010/09/14	6.6	80.5	62.7

Prior: Wind shear of 5.8 m s^{-1}
During: ~ 11.7 m s^{-1}
After: ~ 3.5 m s^{-1}

Prior: Wind shear of 0.4 m s^{-1}
During: ~ 1.7 m s^{-1}
After: ~ 2.5 m s^{-1}

Summary

- Both systems develop under either stronger or weaker dust conditions.
- AOD and lightning data suggest that higher amounts of dust particles in the background environment could increase CCN that help the development of the system.
- Lower vertical wind shear (< ~ 2.6 m s^{-1})and lighter dust covered conditions in 2010 contribute to the vertical development of Julia.
- Data analyzed may not be able to establish a correlation between AOD, lightning, and wind shear.
- Overall the results in this study suggest that dust is a contributor but may not be a key factor to affect the formation.

Future Work

- Analyze a non-develop system under strong outbreak and weak outbreak conditions.

- The Weather Research and Forecast (WRF) chemistry model (WFR-CHEM)

Acknowledgements

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Questions?

Thank you!

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