Examining the Effect of Tropical Cyclones on Atmospheric Chemistry Using a High-Resolution WRF-Chem Model

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INTRODUCTION

The transport of gases and aerosols to the upper troposphere/lower stratosphere (UTLS) has a substantial impact on Earth's climate. Thus, we need to improve our understanding of the vertical convective transport and long-range horizontal transport of chemical species that impact the atmosphere's radiative forcing. This includes the large scale convection associated with tropical cyclones (TCs). Little is known about the atmospheric chemistry of TCs, and few studies have addressed the chemical transport associated with them. The only comprehensive chemical investigation of a TC was a DC-8 flight during NASA's PEM West A mission through Typhoon Mireille. The SEAC\textsuperscript{4}RS dataset from TC Ingrid will help fill the gap of information regarding TC chemistry and build upon prior research using high-resolution chemical transport modeling.

OBJECTIVES

- Re-examine Typhoon Mireille (1991) and study TC Ingrid (2013) that occurred during SEAC\textsuperscript{4}RS using 3D high-resolution (1-2 km) chemical transport modeling in one of two ways:
  - (1) Using the Weather Research and Forecasting Chemistry (WRF-Chem) online chemical transport model
  - (2) Using the Advanced Hurricane WRF (DAVIS et al. 2008) and link it to a chemistry module
- Place flight data in context of overall simulated TC structure.
  - How representative is the chemical data from flights that have sampled TCs?
- Determine how well the in situ chemical data agree with WRF-Chem simulated structure.
- Compute vertical fluxes of key chemical species at various altitudes.
- Use the HYbrid Single Lagrangian Integrated Model (HYSLIPUT) to examine the role of TC convection in transporting chemical species to the UTLS.
- Compare the transports for the TCs with each other as well as with those from middle latitude convection.
- Compute vertical fluxes of key chemical species at various altitudes.
- Single out the effects of the different TCs, and compare the transport of gases and aerosols to the UTLS to their middle latitude counterparts.
- Examine the chemical behavior of the inner core of the eyewall and compare it to the outer areas of the TC with HYSLIPUT.

INITIAL MODEL CONFIGURATION

WRF-Chem 3.5

- IC and BC
  - 10 km resolution
  - 50 vertical levels and 4 soil levels
  - New Goddard longwave and shortwave physics
  - YSU PBL scheme
  - WSM 3 microphysics
  - Kain-Fritch CPS

SST

- CSFR on a 0.5° global grid at 3 levels pressure levels.
- Optimal distribution of SST (CIESM) dataset on a 0.25° global grid.
- Real-time, global, sea surface temperature (RTG, SST) analysis on a 0.5° global grid.
- *The SST was held constant throughout the simulation.

CASES

Typhoon Mireille

- MIREILLE
  - 25 SEPTEMBER 1991 06:00 UTC

Typhoon Ingrid

- INGRID
  - 13 SEPTEMBER 2013 18:00 UTC
  - 26 SEPTEMBER 2013 06:00 UTC

VERTICAL CROSS-SECTION AND TIME SERIES

- Moistening of the UT
- Ingrid does not extend as high as Mireille

FUTURE RESEARCH

- Use the most recent release of WRF-Chem for the TC simulations.
- Adjust the initial model configuration and parameterization schemes in WRF-Chem until it closely simulates observations.
- Experiment with the Grell-3D cumulus parameterization.
- Increase the horizontal resolution using a nested approach with 4 domains.
- (27, 9, 3, 1 km grid spacing)
- Analyze forward/backward trajectories using HYSLIPUT to increase our understanding of the role TCs play in distributing various chemical species.
- Use an integrated research approach by combining the simulations with satellite observations.
- The lack of chemical flight data has hindered research of TC chemical transport.
- The proposed research will help fill this gap of information by putting the flight data in context of overall simulated TC structure.

REFERENCES