Tropical cyclone outflow diagnostics as observed in GOES Rapid-Scan Atmospheric Motion Vector analyses

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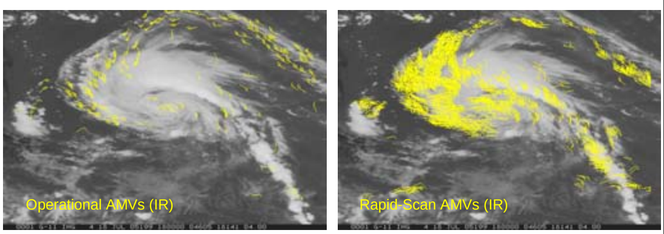
Introduction

Atmospheric motion vectors (AMV)s derived from GOES-11 rapid-scan (r/s) imagery were processed at CIMSS during selected tropical cyclone (TC) cases for the Tropical Cloud Systems and Processes (TCSP) project to investigate TC upper-levels during genesis and intensification. These datasets are analyzed onto a uniform grid using an iterative Barnes scheme that allows a tight fit of the dense r/s AMV observations. From these analyses, we diagnose the upper-level flow fields and kinematic quantities in the near environment of the selected TCs during genesis and stages of intensity fluctuations. Included in the analyses are AMVs assigned a height between 150 hPa and 200 hPa, and located within approximately 700 kilometers from the US National Hurricane Center best-track storm center.

GOES Rapid-Scan AMVs

Routine and operational AMVs are traditionally generated from geostationary satellite image triplets with 15, 30 or 60 minute intervals. During TCSP, co-located GOES-11 images were made available by NESDIS at intervals of 5-minutes. The improved consistency of cloud features and motion in the shorter time interval imagery allows for the derivation of higher-quality AMVs with greater density. CIMSS processed these datasets as frequently as hourly during TCSP TC events (the datasets are available through the TCSP data center). The figures below compare the GOES-11 operationally-produced AMVs to the r/s AMVs (both IR only) for one selected time period during Hurricane Emily (July 11th – 21st, 2005). Note the much increased coverage of the r/s dataset over and near the storm center.

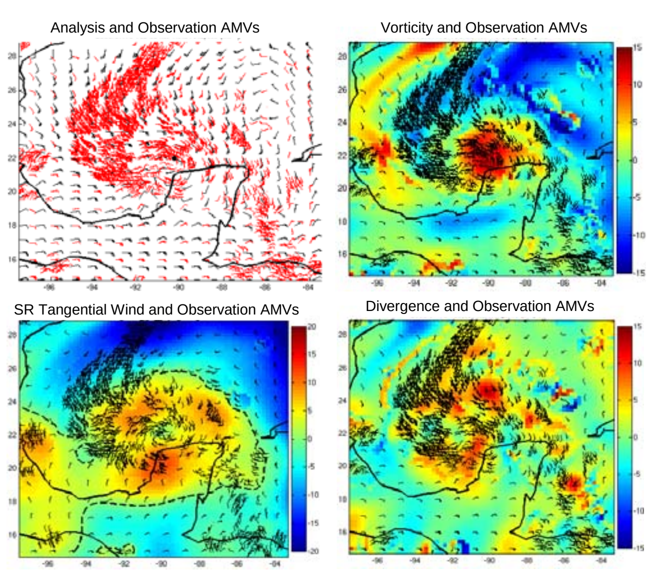
GOES-11 IR Imagery and derived 150 - 200 hPa AMVs.
Valid 18UTC July 18th, 2005



Analysis Method

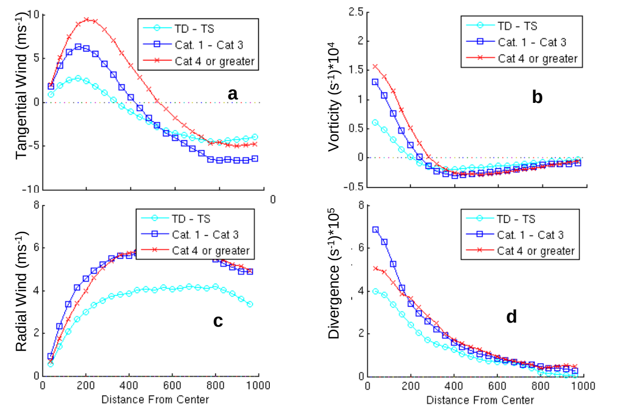
1) AMVs within approximately 700 kilometers from the center and between 150 - 200 hPa's are included in the analysis.
2) A multiple pass barnes scheme analyzes the observations onto a 0.2º grid. The passes start with a radius of influence of 500 km and step down to 62 km.
3) NOGAPS fields and a laplace filter are used in data-void regions.
4) Time series of various diagnostics are developed.

2-D Analysis Examples **(Valid 18UTC July 18th, 2005)**

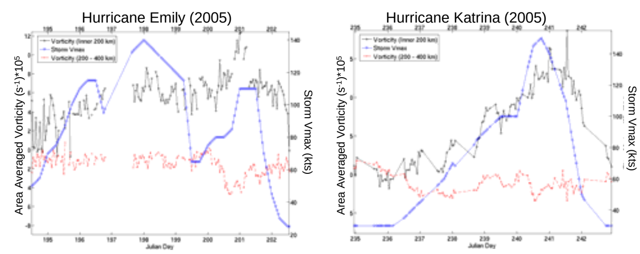


Relationship of Upper-level Quantities to Storm Intensity

To investigate the relationship between these analyzed upper-level quantities and Tropical Cyclone intensity it is necessary to create analyses for multiple storms. Using similar (r/s) data as part of a CIMSS/Navy collaborative study, composite analyses were created for Katrina, Rita, Wilma, and Ophelia and Eugene.



Azimuthally averaged profiles of upper-level: a) SR Tangential Wind b) Relative Vorticity c) SR-Radial Wind d) Divergence binned by intensity.



Trend analyses are also informative. Shown here are comparisons of inner and outer analyzed rings of vorticity and the storm maximum surface winds (Vmax) from Hurricanes Emily (left) and Katrina (right). Katrina's inner vorticity is well correlated (about 81%) with storm intensity (Vmax). Emily is less well-correlated (30%) over the duration of the storm, but captures the second intensification well (65% after day 200 (July 19th)). Although the outer vorticity isn't strongly correlated, the vorticity does become more negative at the storms' peak intensities.

Summary and Conclusions

High-resolution Atmospheric Motion Vectors (AMVs) derived from special GOES rapid-scanning operations can capture detailed flow features in the upper-level regions of tropical cyclones. We have presented just a few applications for using these data to investigate the behavior and evolution of upper level flow fields during tropical cyclone development. We plan on further studies by investigating asymmetries in the flow fields to examine if these asymmetries are related to intensity trends. Ultimately, these analyses could lead to a deeper understanding of how the upper levels respond or drive hurricane intensity change.

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