Hyperspectral Infrared Sounding within 3-Dimensional Cloud Structures

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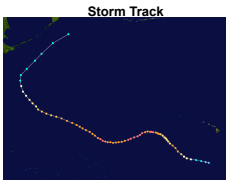
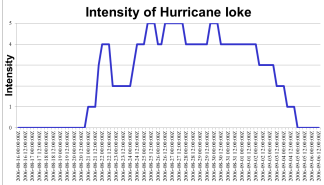
Introduction

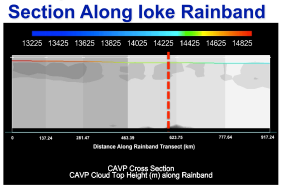
The sensitivity of hyperspectral IR sounders is shown to provide unique insight into tropical cyclones. The purpose of this study is to investigate the relationship between hurricane intensity and the temporal changes in cloud structure and water vapor distribution of the storm and its environment. The CIMSS Cloud Amount Vertical Profile (CAVP) and Dual Regression algorithms are used in this analysis of Hurricane/Super Typhoon Ioke at various points in its life cycle. Great potential exists for this type of analysis using the future geostationary hyperspectral sounders, e.g. MTG IRS or GMW STORM. This analysis uses AIRS L1B radiances from Aqua overpasses.

CASE Study Hurricane Ioke

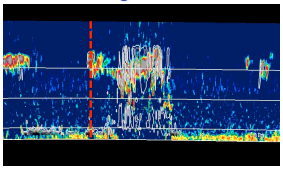




Example McIDAS-V Cross-Section Along Ioke Rainband



Example McIDAS-V Cross-Section Along CALIPSO Track

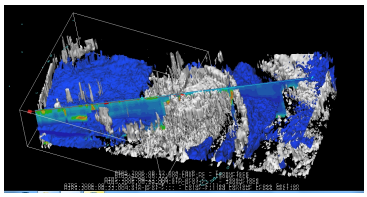


Distant rainband from Hurricane Ioke at 0030Z on 22 August 2006
Left: Cross section of CAVP along rainband transect overlain with cloud top height along transect.
Right: CALIPSO 532nm total attenuated backscatter overlain with CAVP contours.
Red dashed lines are used to indicate intersections of CAVP cross-section and CALIPSO path.

CIMSS Dual Regression and CAVP Products in McIDAS-V

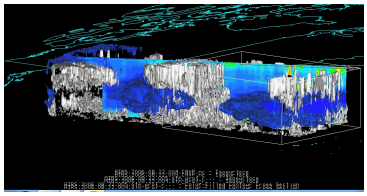
Hurricane Ioke

Cloud – White
RH (15%) –Blue
RH cross-section



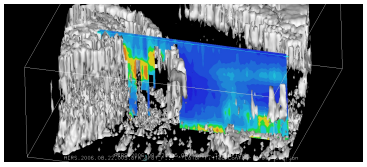
RH (15%) –Blue

Dry Air Wrapping Around cyclone



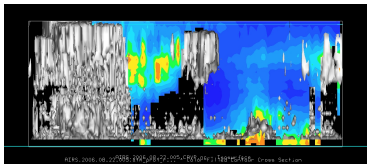
Rainband Environment

RH vertical Cross-section

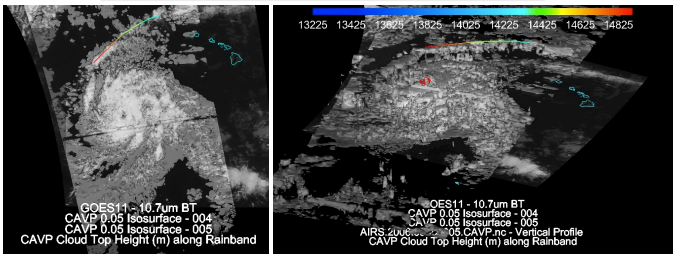


Rainband Environment

Moist air – Inside
Dry air - Outside



Hurricane Ioke 3D Cloud from AIRS CAVP Product

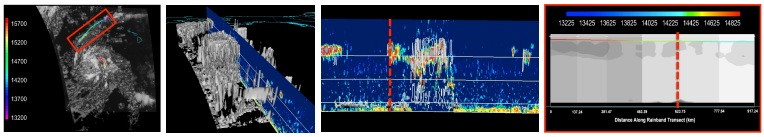


Hurricane Ioke at 0030Z on 22 August 2006
Left: Top view of UW-CAVP 0.05 isosurface over GOES-11 10.7um brightness temperature satellite imagery. A rainband cross-section transect is colored by cloud top height, as determined by CAVP vertical profiles.
Right: Same as left, but shown in 3-D from the southeast.

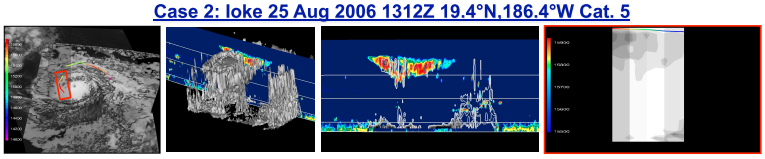
Results

The path of Hurricane Ioke across the Central Pacific in October 2006 was intersected by overpasses of the NASA Aqua satellite with the MODIS and AIRS sensors. Several cases of varying storm intensity were selected along the track to investigate the relation of remotely sensed cloud geometry to intensity. The CAVP product was compared with CALIPSO passes to check for consistency in cloud top heights of rainbands, when possible.

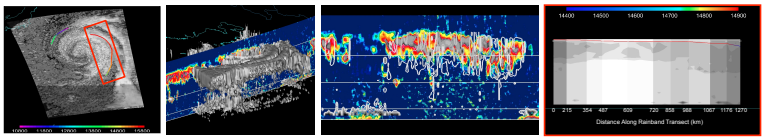
Case 1: Ioke 22 Aug 2006 0030Z 13.6°N,192.9°W Cat. 4



Case 2: Ioke 25 Aug 2006 1312Z 19.4°N,186.4°W Cat. 5



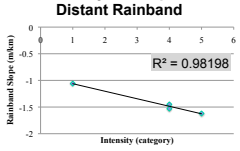
Case 3: Ioke 04 Sept 2006 0318Z 29.6°N,149.2°W Cat. 1



First column: Top view of UW-CAVP 0.05 isosurface over satellite imagery. Rainband cross-section tracks are colored by cloud top height, as determined by CAVP vertical profiles. **Second column:** CALIPSO 532nm total attenuated backscatter (TAB) running through CAVP granule. **Third column:** CALIPSO 532nm TAB overlaid with CAVP contours. **Fourth column:** Cross section of CAVP along rainband transect indicated by a red box in column one, overlaid with cloud top height along transect. Red dashed lines are used to indicate intersections of CAVP cross-section and CALIPSO path.

Table 1: Ioke Latitude/Longitude/Date/Time/Intensity/RB Slope

DATE	TIME	LAT	LON	CAT	RAINBAND SLOPE (m/km)	RAINBAND TYPE*
22 Aug 06	0030Z	13.6	192.9	4	-1.68	Secondary
					-1.53	Distant
25 Aug 06	1312Z	19.4	186.4	5	-1.21	Secondary
					-1.62	Distant
28 Aug 06	1200Z	16.6	177.2	4	-1.45	Distant
04 Sep 06	0318Z	29.6	149.2	1	-1.18	Secondary
					-1.06	Distant



Rainband type based on figure from Houze 2010, p. 384.

Conclusions

- McIDAS-V was used to determine the slope of the cloud top along hurricane rainbands.
- The slope of the cloud top along the spiral arm of a secondary or distant rainband was found to have a characteristic value between -1 m/km and -2 m/km.
- The variation of this value with time is hypothesized to correlate with cyclone intensity. The distant rainband slope shows the best correlation in cases thus far.
- Measurements of distant rainbands using CAVP have less inherent error than measurements of primary and secondary rainbands (which occur closer to the eye).
- McIDAS-V has been used to integrate the CAVP and Dual Regression products.
- Application of these methods to tropical cyclones will be made during the 2012 Atlantic Hurricane season in support of the NASA Venture Class HS3 mission.

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