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Utility of CrIS/ATMS profiles to diagnose extratropical transition

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ABSTRACT

Anticipating changes in hurricane intensity can be challenging in data sparse regions of the North Atlantic Ocean. Hyperspectral infrared retrieved profiles have the potential to provide a wealth of information about the vertical structure of thermodynamic characteristics of the atmosphere such as temperature and moisture which can impact hurricane intensity. Increased forecaster situational awareness and identification of moist or dry layers in the near-storm environment can indicate impending changes in storm intensity. This investigation demonstrates the utility and value of hyperspectral infrared retrieved profiles to diagnose thermodynamic characteristics of the near-storm environment to anticipate changes in hurricane intensity.

Introduction

The NASA Short-term Prediction Research and Transition (SPoRT; [1]) Center has worked closely with the NOAA Joint Polar Satellite System (JPSS) Proving Ground to investigate the utility of Cross-track Infrared Sounder/Advanced Technology Microwave Sounder (CrIS/ATMS) retrieved profiles to diagnose tropical to extratropical transition. This research has included an investigation of Hurricane Sandy 2012, Hurricane Arthur 2014, and Super Typhoon Atsani 2015. Lessons learned from case study analyses were used to develop training for NOAA National Weather Service (NWS) forecasters at the National Hurricane Center (NHC) to introduce the CrIS/ATMS retrieved profiles for this forecasting application. CrIS/ATMS retrieved profiles are processed through the NOAA Unique Combined Atmospheric Processing System (NUCAPS) algorithm (i.e. known as NUCAPS Soundings) and made available to NWS forecasters in the Advanced Weather Interactive Processing System (AWIPS) used in the operational environment. During the 2016 hurricane season, Hurricane Matthew was monitored and feedback was solicited from NHC forecasters on the utility of NUCAPS Soundings to anticipate extratropical transition.

Method

Extratropical transition (ET) is the process whereby a post-tropical cyclone undergoes conversion to a baroclinic vortex. Generally, an ET event is characterized by a two-stage process: (1) transformation stage and (2) extratropical stage. During the transformation stage, the tropical cyclone begins to respond to changes in the environment and begins losing tropical cyclone characteristics. Previous studies [2], used the appearance of the dry slot on satellite imagery to define the start of the transformation stage. Correlated with the dry slot, an upper-level potential vorticity anomaly may approach from the northwest and wrap around the storm, causing a decrease in intensity [3]. Therefore, forecasters can anticipate ET by identifying the dry slot and upstream potential vorticity anomalies on satellite imagery that may interact with a storm while also considering many other factors that lead to ET.

Forecasters at NHC typically analyze visible, infrared, and water vapor imagery from geostationary satellites, passive microwave imagery from polar orbiters, satellite-derived precipitable water and multispectral products such as the Air Mass Red, Green, Blue composite to anticipate ET. Although these products give forecasters an enhanced view of synoptic features important for ET, they do not provide the forecasters with information about the vertical distribution of temperature and moisture. Products such as NUCAPS Soundings can be explored to enhance the forecast process when anticipating ET and provide more information about the vertical structure of variables that are important in the process. Since NUCAPS Soundings are already in AWIPS and available to forecasters, this investigation explores the benefit of NUCAPS Soundings for forecasting unique events.

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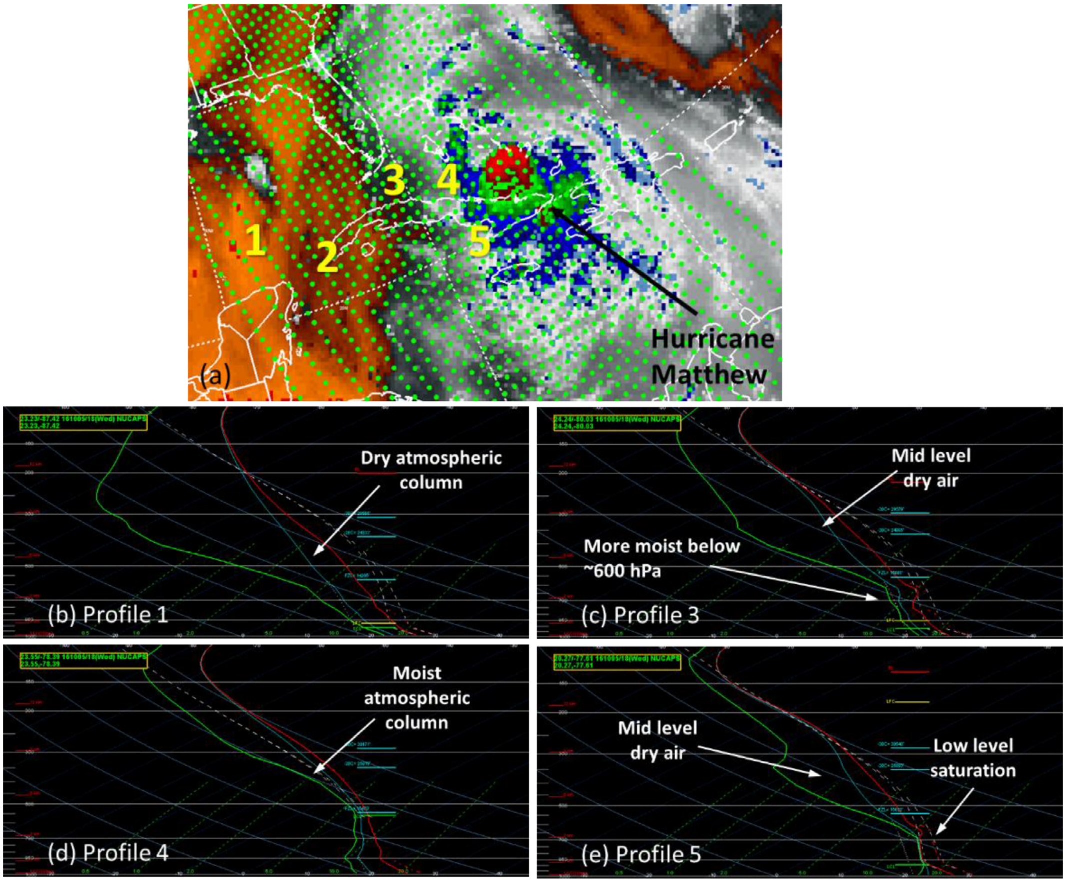

Fig. 1. a: 5 October 2016 1830 UTC Geostationary Operational Environmental Satellite-13 water vapor imagery and 1811 UTC NUCAPS Sounding locations (green dots) displayed in AWIPS. The subfigures (b), (c), (d), and (e) are NUCAPS Soundings in regions identified by the yellow numbers. b, c, d, and e: NUCAPS temperature (red line) and dew point (green line) profiles displayed in AWIPS at numbered locations in 1a. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Results and discussion

Geostationary Operational Environmental Satellite (GOES-13) water vapor imagery and NUCAPS Soundings are displayed in AWIPS in Fig. 1a. At this time period on 5 October 2016, upper level dry air was located west of Hurricane Matthew and abundant moisture surrounded the storm. Since water vapor imagery can only detect moisture characteristics in the mid- to upper-levels of the atmosphere, the NUCAPS Soundings can be analyzed to determine the vertical extent of the dry air. Profile 1 (Fig. 1b), located in the region of dry air west of the storm, shows the dry air extends throughout the atmospheric column. Profile 3 (Fig. 1c), reveals the mid-level dry air is still present but only extends down to 600 hPa. In contrast Profile 4, (Fig. 1d), reveals a relatively moist atmospheric column. Lastly Profile 5 (Fig. 1e) confirms the moist upper-level conditions in the imagery, but mid-level dry air is present below the moist layer. Previous analysis leveraging AIRS/AMSU Soundings for Sandy 2012 [4] and CrIS/ATMS NUCAPS for Arthur 2014 [5] revealed the same mid-level dry air signature in the hyperspectral infrared soundings which became more abundant as upper-level dry air intruded and descended into the near-storm environment. This preliminary example is presented to demonstrate how hyperspectral infrared Soundings could be utilized in conjunction with existing datasets to monitor the intrusion of dry air and anticipate associated changes in hurricane intensity.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.rinp.2017.12.006.

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