Operational use of the AIRS Total Column Ozone Retrievals along with the RGB Air Mass product as part of the GOES-R Proving Ground

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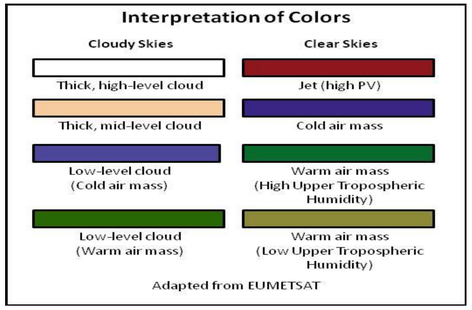
Introduction

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) Hydrometeorological Prediction Center (HPC) and Ocean Prediction Center (OPC) provide short-term and medium-range forecast guidance of heavy precipitation, strong winds, and other features often associated with mid-latitude cyclones over both land and ocean. As a result, detection of factors that lead to rapid cyclogenesis and high wind events is key to improving forecast skill. One phenomenon that has been identified with these events is the stratospheric intrusion that occurs near tropopause folds. This allows for deep mixing near the top of the atmosphere where dry air high in ozone concentrations and potential vorticity descends (sometimes rapidly) deep into the mid-troposphere.

Observations from satellites can aid in detection of these stratospheric air intrusions (SAI) regions. Specifically, multispectral composite imagery assign a variety of satellite spectral bands to the red, green, and blue (RGB) color components of imagery pixels and result in color combinations that can assist in the detection of dry stratospheric air associated with PV advection, which in turn may alert forecasters to the possibility of a rapidly strengthening storm system. Single channel or RGB satellite imagery lacks quantitative information about atmospheric moisture unless the sampled brightness temperatures or other data are converted to estimates of moisture via a retrieval process. Thus, complementary satellite observations are needed to capture a complete picture of a developing storm system. Here, total column ozone retrievals derived from a hyperspectral sounder are used to confirm the extent and magnitude of SAIs. Total ozone is a good proxy for defining locations and intensity of SAIs and has been used in studies evaluating that phenomenon (e.g. Tian et al. 2007, Knox and Schmidt 2005). Steep gradients in values of total ozone seen by satellites have been linked to stratosphere-troposphere exchange (WMO, 1985).

EUMETSAT Air Mass Product for Meteosat-9/SEVIRI

Color	Wavelengths	MIN	MAX	γ	Features
R	6.2 μm -7.3 μm	-25 K	0 K	1.0	Cyclogenesis, jet streaks, potential vorticity anomalies, mid-level and high-level cloud cover
G	9.7 μm -10.8 μm	-40 K	+5 K	1.0	
B	6.2 μm	243 K	208 K	1.0	



RGB Air Mass Product

The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) User Services Team has proposed a standard RGB Air Mass product based upon the Meteosat-9/SEVIRI instrument. This recipe has been applied to NASA's MODerate Resolution Imaging Spectroradiometer (MODIS) aboard the Terra and Aqua satellites. The false color air mass imagery provides for feature interpretation based upon the color assigned to each pixel. Combined, areas with similar colors correspond to synoptic or mesoscale features of interest.

AIRS Total Column Ozone Retrievals

NASA's Atmospheric Infrared Sounder (AIRS) aboard the Aqua satellite was used as the complementary hyperspectral instrument because of its collocation with the MODIS instrument its ability to produce high-quality ozone retrievals with a large swath width to capture synoptic features. Because AIRS is an infrared sounder, it is able to retrieve ozone during both day and night. One limitation to using AIRS is that it has difficulty retrieving in cloudy fields of view; however, this was not an issue in this study due to dry SAIs are typically cloud-free.

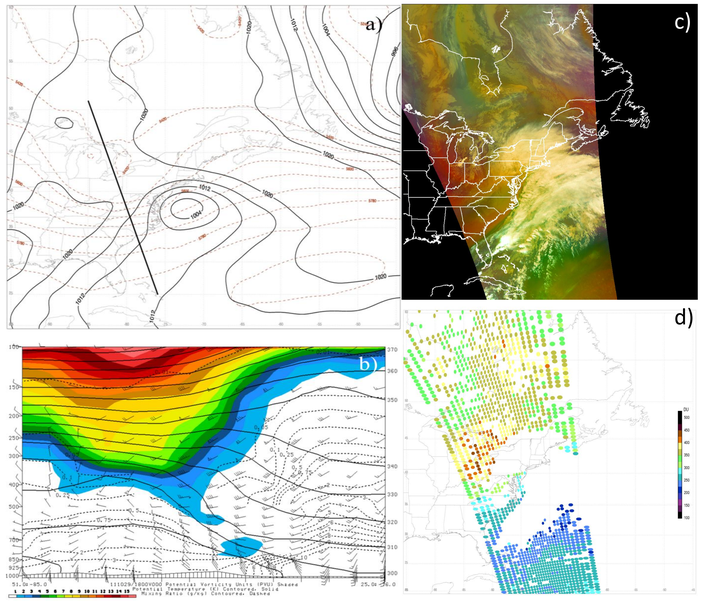


Figure 1: a) GFS analysis valid at 1800 UTC on 29 Oct 2011 for mean sea level pressure (solid black contours) and 500 hPa geopotential height (dashed brown contours) and b) vertical cross section (extent represented by black line in "a") showing potential vorticity (colored contours; PVU), Potential Temperature (solid lines; K), mixing ratio (dashed lines; gkg^{-1}), and winds (barbs; ms^{-1}), c) Aqua MODIS RGB air mass product valid at approximately 1800 UTC on 29 Oct 2011, d) total column ozone observations from AIRS valid at approximately 1800 UTC on 29 Oct 2011.

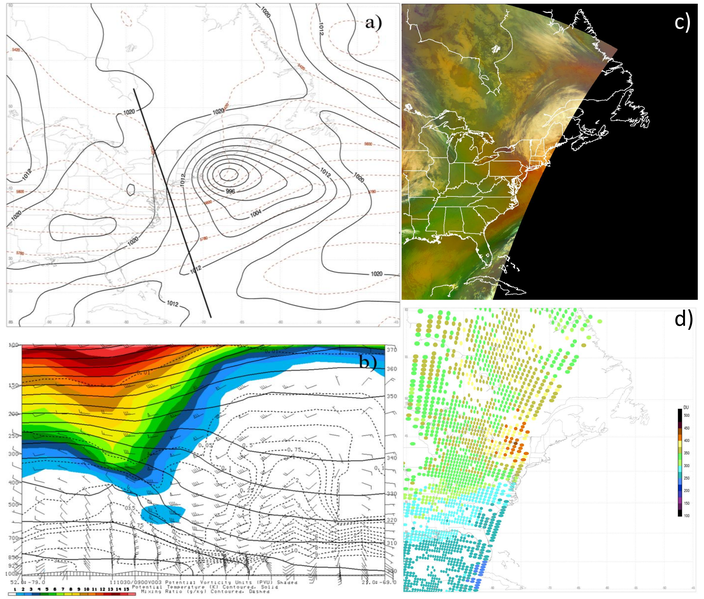


Figure 2: a) GFS analysis valid at 0900 UTC on 30 Oct 2011 for mean sea level pressure (solid black contours) and 500 hPa geopotential height (dashed brown contours) and b) vertical cross section (extent represented by black line in "a") showing potential vorticity (colored contours; PVU), Potential Temperature (solid lines; K), mixing ratio (dashed lines; gkg^{-1}), and winds (barbs; ms^{-1}), c) Aqua MODIS RGB air mass product valid at approximately 0800 UTC on 30 Oct 2011, d) total column ozone observations from AIRS valid at approximately 0800 UTC on 30 Oct 2011.

Case Study: October 2011 Nor'easter

An early season snowstorm affected much of the interior Mid-Atlantic and Northeast U.S. from 29-30 October 2011 producing a rare "white" Halloween. Snowfall totals ranged from 35 cm (14") in West Virginia to 81 cm (32") in western Massachusetts. There were 39 deaths attributed to the storm with over 3.3 million people left without power due to full-leaf trees falling on power lines. The storm also produced wind gusts over 20 ms^{-1} along the Mid-Atlantic and greater than 25 ms^{-1} gusts from Nantucket to Cape Cod. The storm underwent rapid cyclogenesis as it impacted the Eastern U.S. with the central pressure dropping from around 1012 hPa at 1200 UTC on 29 Oct 2011 to below 988 hPa by 1200 UTC on 30 Oct 2011.

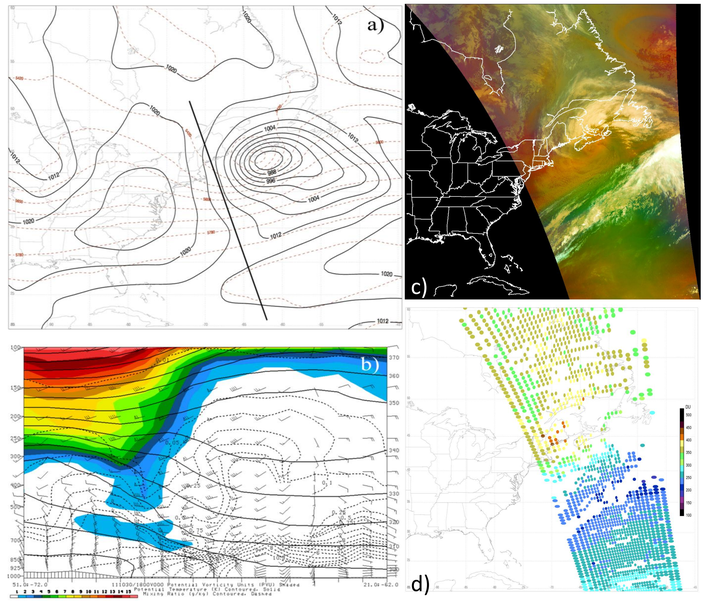


Figure 3: a) GFS analysis valid at 1800 UTC on 30 Oct 2011 for mean sea level pressure (solid black contours) and 500 hPa geopotential height (dashed brown contours) and b) vertical cross section (extent represented by black line in "a") showing potential vorticity (colored contours; PVU), Potential Temperature (solid lines; K), mixing ratio (dashed lines; gkg^{-1}), and winds (barbs; ms^{-1}), c) Aqua MODIS RGB air mass product valid at approximately 1800 UTC on 30 Oct 2011, d) total column ozone observations from AIRS valid at approximately 1800 UTC on 30 Oct 2011.

Case Summary

- The red coloring in the Air Mass product indicates a significant stratospheric intrusion associated with the 500 mb trough and leads to rapid strengthening of the surface low near the East Coast.
- The AIRS total column ozone retrievals continually show high amounts of ozone (greater than 350 Dobson Units) associated with the red-coloring in the Air Mass product and indicates a substantial stratospheric intrusion.
- The combination of these two products may provide significant added value when determining which storms will rapidly strengthen.