The Use of Red Green Blue (RGB) Air Mass Imagery to Investigate the Role of Stratospheric Air in a Non-Convective Wind Event

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The Problem

- Non-convective winds cause as many fatalities as thunderstorm straight-line winds
- Tropopause folds and the sting jet are responsible for non-convective winds, however the sting jet is only known to occur in North Atlantic Shapiro-Keyser cyclones
- The global distribution of sting jet cyclones is unknown and questions remain whether cyclones that impact the U.S. develop sting jet features
- Model PV analysis confirm the stratospheric air in RGB Air Mass imagery

Background

- Stratospheric intrusions and tropopause folds can be identified by high potential vorticity, warm, dry, ozone-rich air
  - 1.5–2 PVU represents the dynamic tropopause
  - Abruption folding of the tropopause is associated with a PV anomaly
- The sting jet is a mesoscale phenomena in Shapiro-Keyser cyclones where stratospheric winds originate and descend from the tip of the comma head (see Figs. 10 and 12 inset)
- The RGB Air Mass product is able to identify temperature and moisture characteristics surrounding synoptic features
- The product is created by combining multiple channels and channel differences

Event Analysis

- A low pressure system over the Ohio Valley merged with a system off the East Coast by 0000 UTC 09 February 2013
- At 0000 UTC the low pressure system developed a bent-back feature analyzed as an occluded front (compare to II and PV in Fig. 2)
- Two distinct storms the previous day, circled regions on Fig. 6 represent possible stratospheric air
- SSPORT AIRS Ozone Anomaly (Fig. 7) shows some high ozone values are classified as stratospheric air
- Anomalies were calculated as a percent of normal using AIRS Total Column Ozone and a satellite derived stratospheric ozone climatology
- Recent literature classifies stratospheric air as ozone values ≥125% of normal

- Positioning of the wind maximum relative to the conveyor belts in Fig. 10 is similar to the inert conceptual model
- As the DCB traversed, upper-level dry air descended and contributed to the high near-surface winds. CCB winds were distinct from the sting-jet like wind maximum
- Cross sections (Figs. 11 and 12) show the connection between the tropopause fold, descent of dry air, and high near-surface winds

Color

<table>
<thead>
<tr>
<th>Band/Band Diff</th>
<th>Physically Relates to...</th>
<th>Little contribution indicates...</th>
<th>Large contribution indicates...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Vertical water vapor difference</td>
<td>Moist upper levels</td>
<td>Dry upper levels</td>
</tr>
<tr>
<td>Green</td>
<td>Estimate of tropopause height based on ozone</td>
<td>Low tropopause, more ozone, polar air mass</td>
<td>High tropopause, less ozone, tropical air mass</td>
</tr>
<tr>
<td>Blue</td>
<td>Water vapor</td>
<td>Dry upper levels</td>
<td>Moist upper levels</td>
</tr>
</tbody>
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- Red/Orange → Vorticity/Jet/Stream, dry air pulled down on anticyclonic side of the jet
- Olive/Warm, moist air and mid-level clouds
- Green/Blue → warm moist upper level air

Summary

- AIRS ozone and model PV analysis confirm the stratospheric air in RGB Air Mass imagery
- Trajectories confirm winds south of the low were distinct from CCB driven winds
- Cross sections connect the tropopause fold, downward motion, and high near-surface winds
- Comparison to conceptual models show Shapiro-Keyser features and sting jet characteristics were observed in a storm that impacted the U.S. East Coast
- RGB Air Mass imagery can be used to identify stratospheric air and regions susceptible to tropopause folding and attendant non-convective winds

Figure 1. Conceptual model of Shapiro-Keyser cyclones where stratospheric winds originate and descend from the tip of the comma head. (Shapiro and Keyser 1990)

Figure 2. RGB Air Mass product recipe based off EUMETSAT RGB guidelines

Table 1. RGB Air Mass product recipe based off EUMETSAT RGB guidelines

- 13-km RAP analysis of frontogenesis (Fig. 13), shows features similar to the sting jet conceptual model
- Rapid weakening of the bent-back front creates a region of frontolysis
- Maximum winds are downstream of the frontolysis (see Fig. 13 inset)