INTERPRETATION OF SMALL PARTICLE SIGNATURES IN SATELLITE OBSERVATIONS OF CONVECTIVE STORMS

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ABSTRACT

Strong updrafts in mid-latitude convective storms eject supercooled water droplets into the tropopause and lower stratosphere (Wang, 2003). These droplets flash freeze at very low temperatures, causing them to be significantly smaller (< 20 μm) then the particles in the glaciated anvil top (> 35 μm). Using the Daytime Cloud Optical Microphysical Properties (DCOMP) retrieval (Walther, et al., 2012) applied to GOES-East data discrete minimain the effective radius retrieval are observed in the vicinity of the updraft core of thunderstorms. Several thunderstorms, which occurred between -84 W and -103.5 W and between 28 N and 46 N on April 25, 2008, May 10, 2008, May 22, 2008 and May 8, 2009, were analyzed for small particle signatures, which were compared to 30 dBzNEXRAD echo top height data. An example from June 27, 2008 over Illinois of an effective radius retrieval using MODIS data indicates several small particle signatures that were not observable in GOES retrievals. This example demonstrates the importance of spatial resolution in correctly identifying updraft-related small particle regions.

1. INTRODUCTION

Severe thunderstorms in the mid-latitudes can have updraft speeds up to 60 m/s which transport supercooled cloud droplets rapidly to the homogeneous freezing level. This mechanism results in water vapor being injected into the tropopause and lower stratosphere (Wang, 2003) and has been reproduced using the Wisconsin Dynamical/Microphysical Model (WISCDYMM) (Wang, 2004).

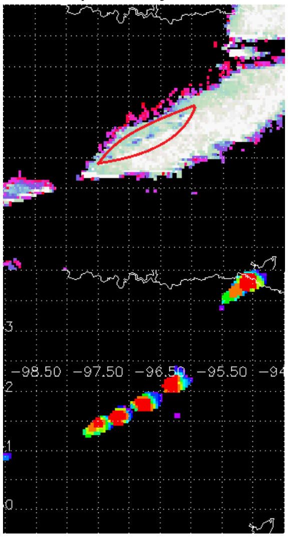
The smaller ice particles can be observed in satellite imagery using the DCOMP retrieval (Walther, et al., 2012), which uses one visible band channel (0.6 μm) and one near-infrared channel (1.6 μm, 2.2 μm, or 3.75 μm). The three NIR channels allow for the retrieval to be applied to data from any sensor with one of the three possible VIS-NIR band pairs. In our study we applied the retrieval to GOES-East and MODIS imagery.

Echo top heights (ETHs) show the maximum altitude of the 30 dBzisosurface. Higher heights are associated with stronger updrafts. The NEXRAD echo top heights are used to confirm that the small particle signatures (SPSs) in the satellite imagery were co-located with the most active regions of the storms.

2. EXAMPLE RESULTS AND VALIDATION

Figure 1a shows an effective radius retrieval plotted for a line of supercell thunderstorms in Texas on April 25, 2008. A line of small particle signatures is evident which are coincident with four strong updrafts, visible in the 30 dBz echo top heights (Fig 1b).

Figures 1a and 1b: Small particle signatures are indicated by the red circle on the left. Red-blue colors indicate particles <= 20 μm. Incident ETHs are shown on the right. The range is purple – red, 8 km – 15+ km, respectively.



In the initial analysis, the analyst identified small particle signatures (SPSs) in the satellite data and then counted the number of those which were incident with echo top heights above 8 km. Table 1 shows the analysis for April 25, 2008.

Table 1:

Time	SPSs	Incident ETHs
1745	0	0
1815	0	0
1845	1	1
1915	1	0
1945	0	0
2015	1	1
2045	5	2
2115	2	1
2140	6	4
2145	7	4
2155	**5**	**5**
2210	6	2
2215	8	6
2225	8	4
2240	7	4
2245	9	4
Totals	66	38
Percentage of SPSs incident with local ETH maxima	57.6	

3. SPATIAL RESOLUTION IMPORTANCE

The analysis revealed some strong updrafts in the ETHs did not have an incident SPS and vice versa. To confirm that this was a result of the course spatial resolution of the GOES imager, the DCOMP retrieval was run on MODIS imagery of a storm in Illinois on June 27, 2008. The 1 km MODIS resolution resulted in a significant increase in SPSs retrieved in comparison to the 4 km GOES imagery (not shown).

In the WISCDYMM model, as well asbrightness temperature imagery, it is noted thunderstorm updrafts are only 6 – 10 km in diameter. A single GOES pixel is 4 km (at nadir; 5 – 6 km over the US), so a SPS which falls within a GOES pixel will be found, but one which falls at the intersection of 2 or 4 pixels can be averaged out. The MODIS test case illustrates the importance of spatial resolution in detecting important cloud top features and GOES-R ABI should improve detection of SPSs.

4. REFERENCES

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