Talking Points

AACP
2024

Title Slide: Chauncey Shultz is the SOO at Bismarck ND, and he has viewed AACPs with severe weather during the warm season there. Kris Bedka is one of the World Leaders in research into AACPs and their relationship to severe weather

2. This is an animation – from GOES-14, so an oldie but a goodie – of visible imagery that shows the development of a strong and isolated thunderstorm. The advantage of identifying the Above-Anvil Cirrus Plume is that is associated with severe thunderstorm. In the absence of other observations – radar, for example – this can help you know where severe weather might be occurring. In concert with radar, it can give you extra confidence in warning issuance. Note the development in the animation of a smoky-like feature at cloud top, streaming to the northeast. That's the AACP. This animation can be viewed in a blog post at the CIMSS Satellite Blog: GOES-14 SRSOR: Storm-centered Loop of Supercell over the High Plains of Colorado — CIMSS Satellite Blog, CIMSS (wisc.edu)

3. What do I mean by an AACP? That's highlighted in this annotated image. It's a smoky-looking cirrus plume.

4. An AACP can be in the stratosphere, which means it'll be warmed than the cloud underneath it. It can be very thin, which means radiance from underneath might leak through. I find them easier to identify in visible than infrared imagery. Note this is GOES-14 imagery, with 4-km resolution, but I find the same difficulty in 2-km GOES-R imagery! Whatever infrared imagery is used, however, recognize that an AACP might be warmer, if it's in the stratosphere, or colder if it's in the troposphere at cloud top. If you go to the blog post shown above, you can view an animation of the infrared. Maybe the AACP is more apparent in that animation?

5. Investigation of AACPs has used a multi-instrument approach. Radar imagery tracks the storms and is combined with multispectral ABI data, radar imagery of storm rotation, updraft and microphysical data, ENTLN total lightning, Severe Weather reports and NWS watches/warnings (where appropriate) to identify severe storms and to analyze the AACP signature. The observations are taken at very high temporal resolution, and you get a four-dimensional view of the evolution of the thunderstorm.

6. AACPs correlate well with very strong updrafts, and wave breaking in and ice injection into the stratosphere (or upper troposphere). Plumes are a warm anomaly if the atmospheric thermal structure is well-behaved, that is, if there is a well-defined tropopause with warmer stratosphere above. You can find examples with cold AACPs however – be aware of that.

7. As noted, a Plume can be easy to find in visible imagery – especially when the Sun is low in the sky. The cirrus plume is thin, and (cold) infrared imagery can penetrate through from below, diluting the warm signal. The warm signal should originate from near the overshooting top. It's a very strong updraft that punches through the tropopause, causing wave-breaking.

8. Here is an animation, from 2300-2312 UTC of a strong storm over South Dakota that shows what a plume looks like in Visible imagery, in the sandwich product, and in two different IR enhancements.

Don't be afraid to tweak the enhancement to view the plume if you think it is present because its presence should make you more bullish on warning issuance. Can you view the development of the AACP? The strong updraft at the SW edge of this complex is generating one, and a cell that develops in the middle of this complex – the cell that eventually is warned on – starts to spew an AACP as well.

9. This still image from 2312 UTC includes a blue arrow pointing towards the AACP

10. Now we have an animation for 0000 to 0012 UTC – jumping ahead about an hour. The AACP at the southern end of the cell continues to expand. But pay attention to what's happening farther to the northeast as well! A strong updraft has developed that is starting to generate a plume.

11. Here's another example of an AACP from 2018, at a time when stereoscopic imagery could be used to view the storm, as noted at the linked-to CIMSS Satellite Blog Post: https://cimss.ssec.wisc.edu/satellite-blog/archives/29308

12. This slide annotates where the AACP on the previous slide exists, including infrared imagery. Again, the imagery can also be viewed in this CIMSS Satellite Blog Post: https://cimss.ssec.wisc.edu/satellite-blog/archives/29308

13. You can change the enhancement of the IR to better enhance the AACP (Or you can change the range of the IR enhancement too via the composite option choice in AWIPS)

14. Here's another try at a different enhancement. My thanks to Scott Bachmeier for these infrared imagery.

15. This shows CALIOP measurements (source: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015JD024111) across a plume from a different storm than just viewed. Note that the plume is between the two arms of the Enhanced V, and downwind of the OT that is the vertex of the Enhanced V. The region between the two very red arms of the Enhanced V is a cloud that is much higher that adjacent regions! This is the AACP – and the image on top shows the cloud protrusion ('E') in between the arms of the Enhanced V.

16. AACPs are relatively easier to find in visible imagery as I've said. If you have just a single IR image, it can be tough to view the AACP – animations make it somewhat easier. Or you might adjust the infrared enhancement. That might be a challenge if these AACP storms are in your CWA, but if it's a quiet night and AACPs are happening elsewhere, take some time to experiment. This image is from the Weather and Forecasting paper by Bedka et al. A link is below.

17. This is an excellent example of multiple severe storms and multiple plumes over the high plains. Visible imagery on the left, infrared on the right. I claim the plumes are easier to view in the visible, but experienced plume-finders might see them in the infrared as well.

18. Here are the warning polygons at a specific time – they are under the storms with plumes,

19. and observed severe weather also occurred near plumes. Remember: Plumes can be warmer than the enhanced Vs, key on that when you examine the IR imagery.

20. Scientific study on plumes and their relationship with severe weather required plume identification. This slide describes the methodology, and how the identified plumes correlated with observed severe

weather. Note that 10% of the storms (405) produced plumes in this study. 4200 did not. The study includes a lot of storms! The methodology for plume-identification (that used human experts) is listed.

21. How were plumes identified in the study? Examples are listed on this slide. You're heard/read some of this information already. Plumes can be warm, but some tropopause structures can lead to cold AACPs.

22. This figure shows why plume identification important? Look at the black lines in these slides, showing the path of storm tracks with plumes (compared to white: storm tracks with no plumes). Then look at the overlay of severe weather events! Winds, hail, tornado occur far more frequently on top of black lines (plumed storms) than on top of white. Severe reports cluster along the black lines that show where the plumed storms were moving!

23. Indeed, Plume storms produced 14x as many severe events as non-plumed storms. ¾ of all supercells generated plumes. 59% of the plumed storms were severe! 73% of the storms producing large hail, strong gusts, or tornadoes had plumes. They really do indicate the likelihood of severe weather.

24. **Use the Presence of a plume to increase your confidence in issuing a severe warning**! This is especially true if you're in a region of poor radar coverage! Of course, you want to use as much information as possible in your warning decision. The presence of a plume if one more powerful piece of pro-severe information.

25. IR and VIS imagery of plume-producing severe weather over North Dakota from 0031-0123. The presence of the plume should boost your confidence in issuing warnings, and maybe also for tagging the warning with higher gusts, or hail sizes, than you might otherwise consider given radar alone. A warning was issued at 0124 UTC. What in the satellite imagery convinces you that a warning might be issued.

26. Here's an image at the time of warning issuance. Can you view the multiple plumes, including the one associated with the warning? The warned storm also has a spectacular enhanced V!

27. The satellite imagery continues here from 0123-0149 UTC. Does the observation of 3.5" hail at 0149 UTC surprise you? Note in particular the very cold cloud top.

28. Here's the still image at 0149 UTC – the time when the hail was observed.

29. This animation goes from 0151-0213 UTC. How do you think the storm is evolving? I'm seeing some cloud top warming with the easternmost cell that is warmed, but the enhanced V still looks pretty good!

30. Now we'll look at the radar imagery with this storm. The difficulty with this storm is that it was some distance from the radar, meaning the low-level structure of the storm was very difficult to sample. This screen shows what you'll be seeing in the next animations.

31. We'll be focusing on this part of the storm (circled in yellow) – the one that is pretty far from the KMBX radar.

32. This animation is every 2 minutes from 0036 to 0124 UTC. This is also the same time as the first satellite imagery animation you've already seen. Note at once that the eastern cell splits. It's hard to see a specific signature in the radar though to pull a warning trigger, but one was issued at the end of the animation.

33. Here's the still image of the radar at warning issuance time.

34. And here's what the satellite imagery looked like at the time. As noted on the image, there is a significant parallax shift between the coldest cloud tops (suggested by the visible imagery being so bubbly) and the radar presentation of the storm – a whole different county!

35. The animation continues here from 0126 to 0138 – at which time the tag on the storm was increased to 1.5" Hail and 60 mph winds. And the satellite imagery is part of this animation too. Note the continued presence of the AACP! (We'll look at a still in a bit)

36. Here's a still image of the radar at the time of the tag increase.

37. With the satellite still here as well – the continued AACP is obvious. So is the parallax shift.

38. Continuing the animation from 0138 to 0152 UTC.

39. And here the animation moves from 0152 to 0212 UTC.

40. An MCS can also generate plumes, and the relationship between plume and observed severe weather remains. I will admit here that I have a hard time seeing the AACPs in this MCS cloudtop imagery. Maybe that would be easier with animations rather than still imagery.

41. How does the presence of an AACP relate to lead time in a warning. That's shown in the figure on the left. The black line shows the appearance of an AACP, the red line shows the time of the first Warning. AACP often showed up about 0-10 minutes before the warning issuance. So if you're itching to pull the trigger, maybe the presence of an AACP should help. If you don't have radar coverage, consider forefronting the presence of the AACP as something in your checkmark list of what has to happen before warning for severe weather might happen.

42. This series of slides shows Box/Whisker plots showing the relationship of the 40-dbZ echo-top height to tropopause height, and whether or not a plume is present. A plume storm is more likely to have 40 dbZ near the tropopause: Strong updraft!

43. There is a similar relationship with NEXRAD divergence. Both of these mean that large ice particles will rise higher into storms with plumes (relative to non-plumed storms).

44. But both plumed and non-plumed storms can be very electrically active,

45. and both can have very cold cloud tops. Do not rely on lightning and cold cloud tops alone to gauge severity.

46. Read all about it in a Weather and Forecasting paper. The link to the paper is here: https://journals.ametsoc.org/doi/full/10.1175/WAF-D-18-0040.1 A link to the satellite liaison blog post is here: https://satelliteliaisonblog.com/2019/06/24/use-of-goes-16-imagery-during-colorado-severe-weather-event-on-26-may-2019/ A link to another CIMSS Satellite Blog Post with AACPs is here: http://cimss.ssec.wisc.edu/goes/blog/archives/33140

47. Summary thoughts. AACPs are well-linked to severe weather, and their presence in warning operations should help build confidence in warning issuance.