Slide 1: Title Slide. First 4 developed the algorithm, last 2 developed the cloud typing that is important for the algorithm. The first version of the training focused on the Convective Initiation. This second version focuses more on cloud-top cooling (CTC) because forecasters said they found that product more useful.

Slide 2: Goals of CTC: Capture the most significant convection, and relate it to future NEXRAD signals. The Cartoon shows why satellite can give you information before radar can. Consider as you look at this image how the cloud physics at the top of the cloud might be changing with time as clouds glaciate. Vertical cloud growth – detected from satellite by cooling brightness temperatures – is what UWCI and CTC key on.

Slide 3: The history of this product. It has been tested several times at HWT, and the feedback from those tests drove the subsequent development of the product. Specifically, advances to work through cirrus were developed, and a relationship between CTC and NEXRAD radar features was explored for the development of 'Version 2' of the product. CI and CTC products use multispectral GOES Imager data (Versions 1 and 2) and Optical Depth retrievals (Version 2).

Slide 4: Information about UWCI. Note that it is timely: results show up quickly in AWIPS. Spatial coverage: CONUS East of Rockies (GOES-East) and Rockies/West and Hawaii (GOES-West). Cloud-top cooling strength is well-correlated with future NEXRAD signals. Cirrus is still an inhibiting factor for the product at night – but in the daytime, changes in Cloud Optical depth (A product that uses the visible channel) mitigate cirrus effects.

Slide 5: When should you use the product with caution? As time between imagery increases relative to the cloud growth, UWCI becomes more diagnostic than prognostic. UWCI also more diagnostic in true mT airmasses (meaning you lose the good lead times in the predictions). Temporal problems with advanced detection should be mitigated by GOES-R's superior temporal resolution. Even if the convection is growing very rapidly, you retain the information in the cloud-top cooling about the subsequent NEXRAD features. In other words, if the convection is popping very quickly, so that each 15 minutes a nearly-mature tower is up, the one that cools the most rapidly is the one most likely to develop strong convective features in NEXRAD fields.

Slide 6: Box Averaging is used in UWCI computation. What is it and how does it influence UWCI? Most important points: 7x7 average brightness temperature is computed for cloudy pixels only. Various cloud types in each of the 7x7 boxes are kept track of. New cloud features can enter that 7x7 box, but there are tests to reduce the effect of those changes. You want to see the cooling due to vertical cloud growth and screen out the cooling due to horizontal cloud motions.

Slide 7: Big box (13x13) and little box (7x7) used in box averaging. Along each perimeter point in big box, little box averaging of cloudy pixel brightness temperature is computed. (Cloudiness determined by cloud typing). Little box averaging also done in center 7x7 pixel, and the average temperatures for each – inside 7x7 box and coldest 7x7 box along the perimeter – are compared. If inside box is cooler than perimeter boxes at previous time, then inside box cooling is not caused by advection and is legitimate convective cooling. If a temperature along the edge – it just has to be at one point – is colder than the central pixel value at a later time – it's usually 15 minutes later for standard GOES scanning schedules – then cooling at that center pixel is assumed to arise from horizontal advection and that cooling is ignored. At each pixel along the perimeter, the 'little box' computation is done: The mean temperature of the *cloudy pixels* is computed, and the number of pixels of each cloud type within the box are counted. This is done both for the time 'now' and for the time immediately before – usually 15 minutes unless you're in RSO/SRSO, or for the 6 times daily when a Full Disk image is scanned. Again, the center pixel in the little box must be colder than all the little-box averages at the previous time to assume that vertical convective cloud growth is occurring.

Slide 8: Example imagery: 4-km (nominal) resolution IR imagery at 1545 and 1602 UTC, 2009 day 168 (June 17)

Slide 9: These four slides show the main points of the algorithm, and example imagery. The color-enhanced original image, the box-averaged values (Black values are clear), the cooling relevant for the observation time (note that only 'strong' cooling – more than 4 K/15 minutes is shown per the colorbar), and the filter cooling (from which advective cooling has been filtered using the Big box/Little Box technique). This is for cloud-top cooling. If you were to then diagnose convective initiation (UWCI product), you would see how the cloud phase is changing within the 7x7 box at the center pixel. Note the cloud-top cooling that is diagnosed in north-central Kansas. This is a growing convective tower that bears watching.

Slide 10: What happens to the feature that CTC keyed in on? It develops into a severe storm.

Slide 11: Slide(s) that describes Cloud typing and how it relates to UWCI / CTC computations. This slide shows the input into the cloud-typing, and the cloud types produced. Some of them are uninteresting from the point of view of Convective Development, and are subsequently ignored. The other cloud types are tracked and used to help diagnose how the convection is evolving. Again, if cirrus clouds are present, cloud-top cooling/Convective initiation cannot be detected at night (because the presence of cirrus suggests glaciation – that is, mature convection), but cloud-top cooling can still be computed during the day if Optical Depth changes are used.

Slide 12: Reminder slide of the data used to compute cloud-top cooling and UW Convective initiation.

Slide 13: Feedback from HWT – and from WFOs – convinced the algorithm developers to perform further studies. The main complaint re: Version 1 was that convective development under cirrus clouds was ignored. Further, there was a desire to see how the signal – cloud-top cooling – related to future NEXRAD fields. Can you use the CTC to predict where the most intense VIL will occur, for example? The original algorithm shut down when cirrus clouds were present because detected cooling was ambiguous. Using the Optical Depth changes allows convective growth under thin cirrus to be monitored during the day (when optical depth can be computed). If the cirrus is too optically thick, however, you cannot monitor the convective growth underneath.

Slide 14: Examples!

Slide 15: Kansas example from Slide 9. CTC zeroes in on the developing cell that eventually goes severe.

Slide 16: Texas dryline case from 4/29/2009 – note that cloud-top cooling (filtered to remove advective effects) and CI are both available in AWIPS/N-AWIPS. Frame 1 shows the cooling – inferred vertical cloud growth, Frame 2&3 show the CI designations that take cloud phase changes into account, and Frame 4 shows how the UWCI predictions give a nice lead time to development of strong radar echoes. Note that this is version 1 of the algorithm. Those non-detects due to cirrus are detected with version 2 because the cirrus overlaying the convection is sufficiently thin that optical depth changes can be monitored.

Slide 17: Filtered CTC over Kansas … 60 minutes before 2.75" hail!

Slide 18: Very small feature – just a couple pixels of CTC at 0245Z, strong radar reflectivity at 0311 Z

Slide 19: Case over Iowa from AWIPS. CTC and CI Likely 2 hours before lightning strikes.

Slide 20: Case from Iowa from summer of 2010. This shows a broken Cu field north of convection – which tower will fire first? Step through the loop and you'll find out. The CI/CTC algorithm keys on a developing tower that eventually supports an enhanced V structure.

Slide 21: An example of convection developing under a band of cirrus clouds. The 'Version 1' algorithm did not detect the growing towers because of the cirrus shield above. But there are changes in cloud optical depth that allow you to infer cloud growth where cooling is occurring. The insets at the end show the changes in cloud optical depth and the developing convection.

Slide 22: An example of the 'Version 1' algorithm. In this example, strong convection develops but is not detected because of the cirrus shield. The only detection occurs in regions where cirrus is not present.

Slide 23: AWIPS will show you where the ice mask is, if you're wondering why convection is not being detected.

Slide 24: By using the change in Cloud Optical Depth in this case, better detection of the developing convection occurred.

Slide 25: Given a cloud-top cooling event exists, what does that mean for future NEXRAD reflectivity? The relationships between CTC and NEXRAD are shown using Box-and-whisker plots as described on frame 2 of this slide. CTC is subdivided into Weak, Moderate and strong cooling, and there is a clear relationship between the cooling now and the max composite reflectivity that develops. There is also a relationship between the lead time to composite reflectivity, especially for very strong cooling, which leads to high composite reflectivity after about an hour. There is a similar relationship between maximum cloud-top cooling rate and the reflectivity at the -10C isotherm. Note that CTC is a conservative algorithm, designed to really highlight the strongest growing towers; this is at the sacrifice of detecting modestly-growing towers. There is also a correlation between the CTC and the Maximum Expected hail Size (MESH). This series of slides ends with conclusions, and some references.

Slide 26: If you are away from your AWIPS station, CI products are available online as well. You can also create loops of data, or look at older data from this page.

Slide 27: Conclusions (again). This slide also includes very important ideas on how to use this product in the operational environment. CTC is a piece of information that you should combine with your knowledge of the synoptic and mesoscale environments and with the history of development to give you a better feel for which developing towers will need to be watched in the near future. There are also, on the last frame of this slide, urls that have more information.

Slide 28: How do you get CI products in AWIPS? Use the instructions on this webpage.