Jobsheet

UW/CIMSS Cloud Top Cooling Rate Products

Objective:

- Demonstrate the prognostic utility of UW-Cloud Top Cooling Rates (UW-CTC) as a quantitative measure for the vigor of newly developing convective clouds, specifically relating UW-CTC rates to future NEXRAD observations.

Product Overview:

The University of Wisconsin Convective Initiation/Cloud-Top Cooling (UWCI/CTC) algorithm uses GOES-Imager observations to identify newly developing convective clouds with two sets of products. The first product is the convective initiation nowcast; specifically, these convective initiation nowcasts are for vertically growing convective clouds and hence cooling in infrared satellite observations, and are classified by their cloud top phase (warm water, supercooled/mixed, or ice phase). The second product is simply the GOES infrared window cloud-top cooling rate of the convective cloud. The infrared window brightness temperature cools with vertical cloud growth due to the fact temperature decreases with height. The UWCI/CTC algorithm is designed as a conservative algorithm, meaning the more significant newly developing convective clouds are targeted. Not every developing convective cloud that will achieve even moderate radar echoes are necessarily targeted. This design results in a low false alarm ratio and a moderate probability of detection (FAR and POD scores vary widely depending on what validation metric is used; see Sieglaff et al., 2011 and Hartung et al., 2012 for validation studies).

Development History

The UWCI/CTC algorithm was first evaluated at the 2009 SPC HWT and has been evaluated every year since. After the first year the algorithm was refined to further reduce false alarm ratio per suggestions from NWS forecasters. This work was completed and the UWCI/CTC algorithm was validated and published (Sieglaff et al., 2011). In 2010 and 2011, feedback from NWS forecasters indicated a preference for the cloud-top cooling (CTC) rate information over the convective initiation nowcasts because the CTC rate is a quantitative measure of the vigor of vertical cloud growth, while the nowcasts are simply yes/no classifications. As such, the focus of the UWCI/CTC algorithm no longer includes the convective initiation nowcasts, but rather the cloud-top cooling rates. Additionally, some forecasters hypothesized that the magnitude of the CTC rate should be correlated to future storm intensity with stronger vertical growth (larger UW-CTC rates) more often resulting in significant convection as opposed to weaker vertical cloud growth (smaller UW-CTC rates). As a result, the University of Wisconsin conducted an automated validation study of UW-CTC rates for 34 convective events over the central United States during 2008 and 2009. The study relates UW-CTC rates to future NEXRAD observations, including fields such as composite reflectivity, reflectivity at -10°C, Vertically Integrated Liquid (VIL), Maximum Expected Hail Size (MESH), and Echo Top Height. The most important results of the study are outlined in the following section and will be leveraged upon in the worksheet portion of this document.

Validation Study

Given the objective of using UW-CTC rates as a prognostic tool in severe weather events it is necessary to provide a short summary of relationships determined between UW-CTC rates and future NEXRAD observations in the validation study. The validation study related the maximum UW-CTC rate a storm achieved to the maximum value for a variety of NEXRAD fields. For the SPC HWT we are focusing on two NEXRAD fields, composite reflectivity and MESH, though forecasters are encouraged to consider any NEXRAD field they find useful. The sections below are very brief; full details of the validation study can be found in Hartung et al., 2012. It should be noted that the validation study grouped UW-CTC rates into three bins, weak convective growth, moderate convective growth, and strong convective growth. For this case study, given the explosive synoptic and mesoscale setup, most storms identified fell into the strong UW-CTC rate category.

- *Composite Reflectivity*
  - Below are the median leadtimes for maximum UW-CTC rate to various composite reflectivity thresholds. While leadtimes are generally small for moderate composite reflectivity, they increase substantially for significant reflectivity values. Additionally, the validation study confirmed the hypothesis that larger maximum UW-CTC rates (stronger vertical growth) are statistically more likely to produce more intense precipitation cores than those with smaller (weaker vertical growth) maximum UW-CTC rates.
    - 10 minute median leadtime to 35 dBZ
    - 25 minute median leadtime to 60 dBZ
    - 60+ minute median leadtime to 65 dBZ
- *Maximum Expected Size of Hail (MESH)*
  - Below are useful relationships between maximum UW-CTC rate and future MESH observations. The leadtimes below help give a forecaster, in the median sense, how far ahead a maximum UW-CTC rate will precede a variety of MESH thresholds. Additionally, the validation study revealed for storms that achieve any MESH and had the strongest UW-CTC rates (> -20K /15 min), the median MESH size is 1.00" (severe hail) with a 1σ MESH value of 2.00" for those same storms.
    - 28 minute median leadtime of 0.25" MESH
    - 45 minute median leadtime of 1.00" MESH
    - 60+ minute median leadtime of 1.25"+ MESH
    - 57% of storms that achieve at least 0.25" MESH were identified with a UW-CTC rate
    - 71% of storms that achieve at least 1.00" MESH were identified with a UW-CTC rate

Jobsheet Overview:

This jobsheet contains a sequential set of procedures that you will follow to view and observe the Cloud-Top Cooling output in the AWIPS environment. In addition, you will answer 21 questions along the way. Answers to these questions will be provided in the answer key document.

Instructions:

1. If AWIPS D2D is not currently open, double-click on the Launch AWIPS D2D icon to start up an AWIPS D2D session.

2. The product combinations for this jobsheet are located in an AWIPS procedure folder called **UW_CTC**. This can accessed from the D2D menu by **selecting File → Procedures → Open…**, selecting **UW-CTC** from the list, and clicking on the OK button. This will open up a new window called **Procedure – UW_CTC**

3. Select **4 panel plot** from the procedure window and click on the **Load** button to open the products into D2D. This will load a four-panel display of time-matched GOES Visible/UW-Instantaneous Cloud Top Cooling product (Upper-Left), KFDR 1km Composite Reflectivity (Upper-Right), Maximum Expected Size of Hail (Lower-Left), and Multi-Radar Vertically Integrated Liquid (VIL) (Lower-Right). You can browse through these products in the 4-panel plot or rotate through them using the 1,2,3 keys at the top of the keyboard. You can return to the 4-panel layout by right-clicking on the D2D map and selecting *Four Panel Layout*.

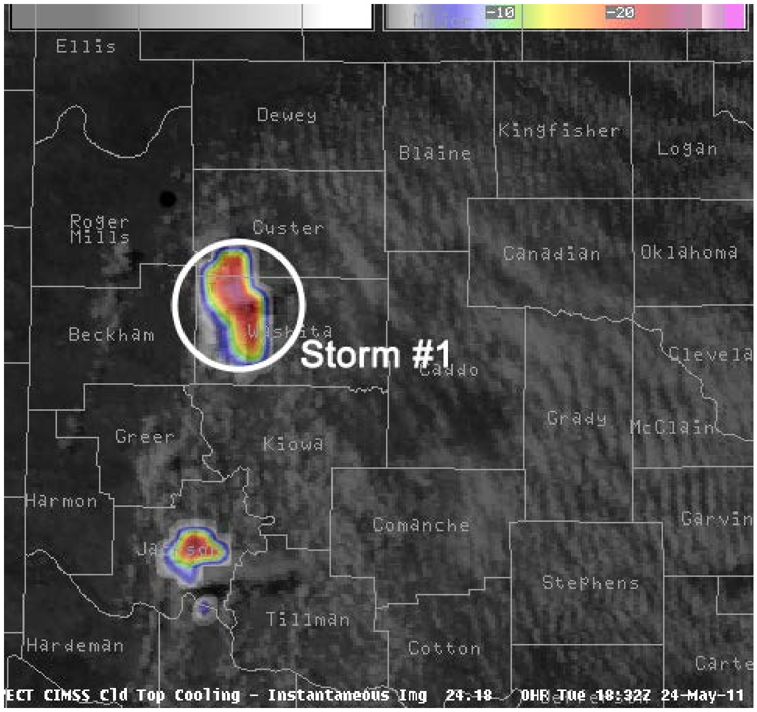
NOTE

This jobsheet will walk you through 4 storms that initiate in the WFO Norman domain between 1815 UTC and 2033 UTC. By default, the procedure may load a data window larger than the one defined here. For this exercise, you will focus your observations to the 1815 – 2033 UTC window.

STORM #1

1. Go to 1815 UTC in the data loop. The dryline is located over western Oklahoma at this time with cumulus beginning to develop along the dryline. A PDS tornado watch is issued for the region at 1750 UTC.

2. Advance to 1825 UTC; you will see the first developing storm of the day identified by the UW-CTC algorithm over western Washita County. See below for a screenshot of the initial storm location in D2D.



Please answer the following questions related to Storm #1 as you move back and forth in time relative to this storm:

Question 1: 1825 UTC is the first time Storm #1 is identified by the UW-CTC algorithm. What is the maximum cooling rate at this time?

Question 2: What is the maximum composite reflectivity at this time?

Question 3: If Storm #1 falls into the strong UW-CTC rate category (< -20 K /15 min), what is the first time this occurs?

Question 4: Assuming Storm #1 falls into the strong UW-CTC rate category, what is the composite reflectivity at 1841 UTC?

Question 5: What time does Storm #1 first achieve 0.25”+ MESH?

Question 6: What time does Storm #1 first achieve 1.00”+ MESH?

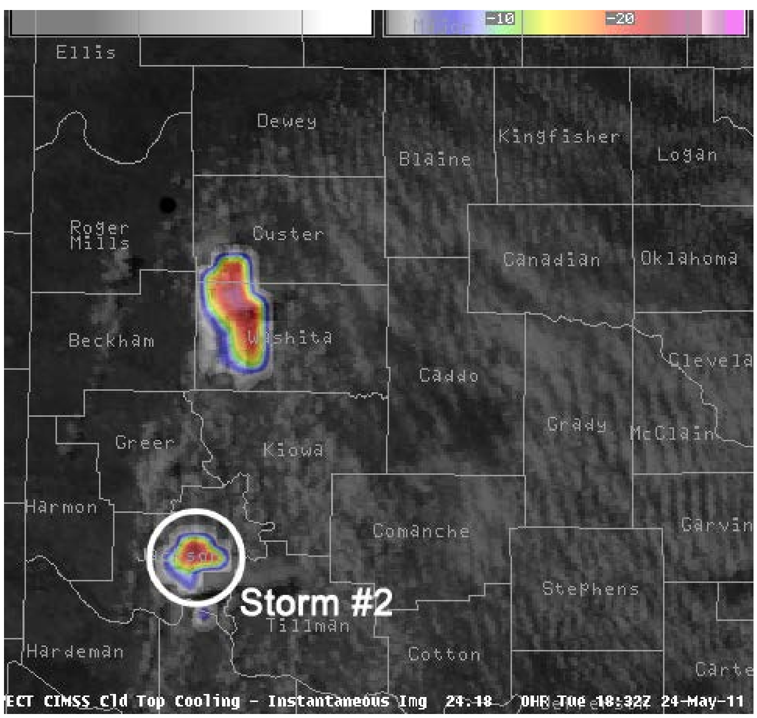
Question 7: What is the maximum composite reflectivity achieved for Storm #1, and at what time?

Question 8: What is the maximum MESH achieved for Storm 1, and at what time?

Open-Ended Question: Given the above UW-CTC rate information, UW-CTC rate/NEXRAD validation study highlights, and knowledge of meteorological conditions, can the UW-CTC rate information be used to increase severe thunderstorm warning leadtime? (The first severe thunderstorm warning was issued at 1903 UTC.)

STORM #2

1. Starting, again, at 1815 UTC in the data loop, advance to 1832 UTC. You will see another developing storm identified by the UW-CTC algorithm over Jackson County. See below for a screenshot of the initial storm location in D2D.



Please answer the following questions related to Storm #2 as you move back and forth in time relative to this storm:

Question 9: 1832 UTC is the first (and only) time Storm #2 was identified by the UW-CTC algorithm. What is the maximum cooling rate at this time?

Question 10: What is the maximum composite reflectivity at 1841 UTC?

Question 11: What time does Storm #2 first achieve 0.25"+ MESH?

Question 12: What time does Storm #2 first achieve 1.00"+ MESH?

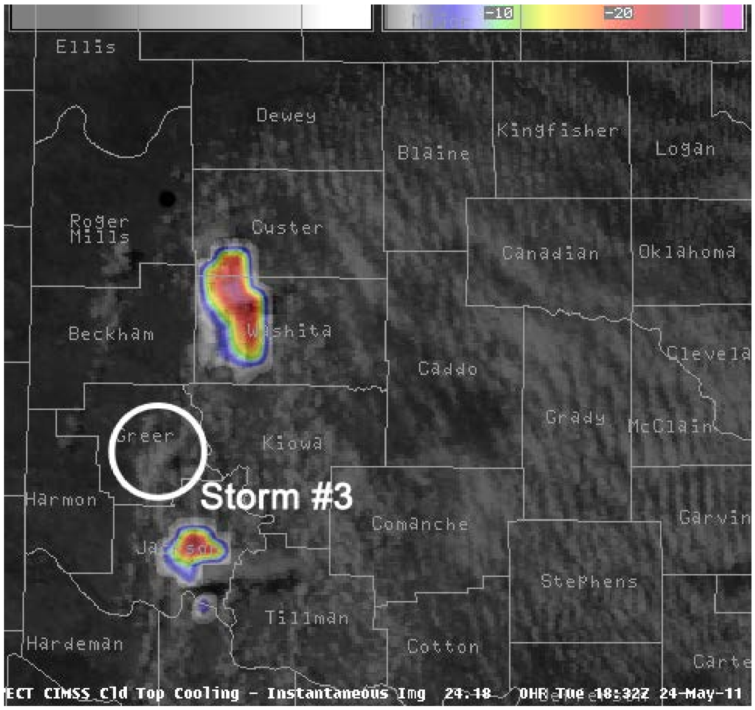
Question 13: What is the maximum composite reflectivity achieved for Storm #2, and at what time?

Question 14: What is the maximum MESH achieved for Storm #2, and at what time?

Open-Ended Question: Again, given the above UW-CTC rate information, UW-CTC rate/NEXRAD validation study highlights, and knowledge of meteorological conditions, can the UW-CTC rate information be used increase severe thunderstorm warning leadtime? (The first severe thunderstorm warning for this storm was issued at 1916 UTC and first severe hail report was at 1929 UTC).

STORM #3

1. Once again starting at 1815 UTC, advance to 1832 UTC and you will see a storm developing over Greer County. See below for a screenshot of the initial storm location in D2D.

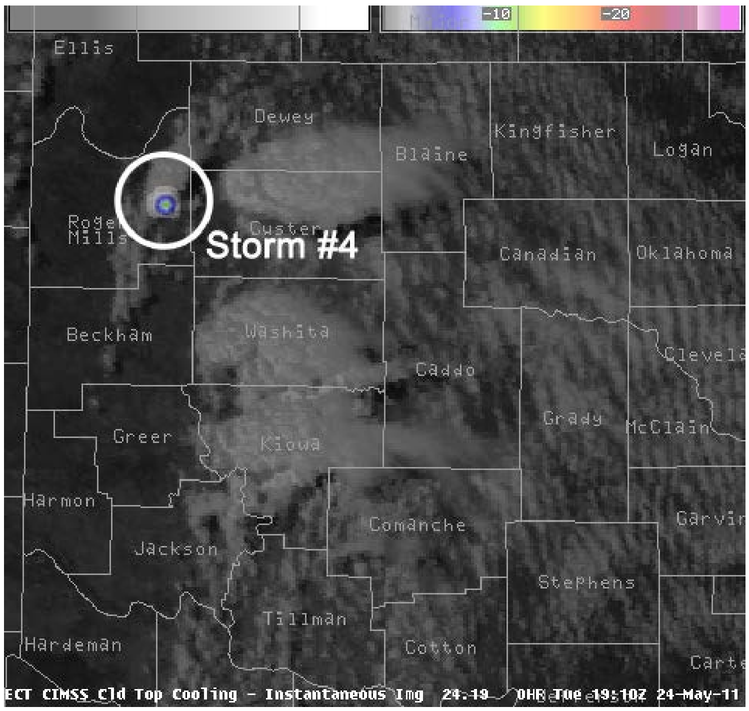


Please answer the following question related to Storm #3 as you move back and forth in time relative to this storm:

Question 15: Looping from 1815 – 1902 UTC, does the UW-CTC algorithm detect anything on this Greer County Storm?

STORM #4

1. Go to 1845 UTC in the data loop and advance to 1910 UTC. You will see a new storm developing over far eastern Roger Mills County to the west of Storm #1. See below for a screenshot of the initial storm location in D2D.



Please answer the following questions related to Storm #4 as your loop back and forth through time relative to this storm:

Question 16: 1910 UTC is the first (and only) time Storm #4 was identified by the UW-CTC algorithm. What is the maximum cooling rate at this time?

Question 17: What is the maximum composite reflectivity at this time?

Question 18: What time does Storm #4 first achieve 0.25”+ MESH?

Question 19: What time does Storm #4 first achieve 1.00”+ MESH?

Question 20: What is the maximum composite reflectivity achieved for Storm #4, and at what time?

Question 21: What is the maximum MESH achieved for Storm #4, and at what time?

Open-Ended Question: As you've probably determined by completing the above questions, relating Storm 4's maximum UW-CTC rate and eventual radar development is not as straightforward as Storms 1 and 2. In this case, the storm goes on to develop significant echoes by ~1930 UTC, but then another storm develops to the east of Storm 4 and that cell becomes the dominant, warned-on severe thunderstorm. The UW-CTC rate is still useful in this case as it provided lead-time ahead of the significant precipitation core, and likely, at least small, perhaps marginally severe hail. The mesoscale interactions between developing convective towers can at times complicate the use of maximum UW-CTC rate as a once vigorously developing thunderstorm can find itself in a less favorable environment due to other adjacent convective development. In this case what utility can the UW-CTC rate product provide for Storm 4?

Contact Information:

Please contact Justin Sieglaff and Lee Cronce (Justin.sieglaff@ssec.wisc.edu; Lee.Cronce@ssec.wisc.edu) with any questions, comments, etc. Two of the references listed below and mentioned in this document are under the peer review process, if you would like to have a copy of the submitted version of these papers, please contact us.

Also, upon completion of this worksheet, please email the completed version to us. We would like to see your answers and comments prior to HWT, which will help us refine our focus related to UWCI-CTC output for the HWT and the make the experience best for all involved.

Product References:

Hartung, D. C., J. M. Sieglaff, L. M. Cronce, and W. F. Feltz, 2012: An Inter-Comparison of UWCI-CTC Algorithm Cloud-Top Cooling Rates with WSR-88D Radar Data. *Submitted to Wea. Forecasting.*

Sieglaff, J. M., D. C. Hartung, W. F. Feltz, L. M. Cronce, and V. Lakshmanan, 2012: Development and application of a satellite-based convective cloud object-tracking methodology: A multipurpose data fusion tool. *Submitted to J. Appl. Meteor. Climatol.*

Sieglaff, J. M., L. M. Cronce, W. F. Feltz, K. M. Bedka, M. J. Pavolonis, and A. K. Heidinger, 2011: Nowcasting convective storm initiation using satellite-based box-averaged cloud-top cooling and cloud-type trends. *J. Appl. Meteor. Climatol.*, **50**, 110–126.