COLD-RING AND COLD-U/V SHAPED STORMS

Version: 18 May 2009
What are the “cold-ring” and cold-U/V shaped storms?

Appearance and terminology
Example of cold-ring shaped storms and basic terminology

25 June 2006, Czech Republic and Austria
Example of cold-U/V (enhanced-V) shaped storm and basic terminology

26 May 2007, Germany
Necessity to apply appropriate image color enhancement !!!

This particular brightness temperature range (BT 240-200K) of the color enhancement is suitable for most of European convective storms; however in some cases or for other geographic regions it may need range adjustment ...
Terminology of the cold-ring shaped storms

Sometimes alternatively called as “doughnut shaped storms” …

Wrong concept !!!
**Terminology of the cold-ring shaped storms:**

Central warm spot (CWS) is NOT to be compared to or be interpreted as an eye of a tropical storm! Totally different features, different scales !!!
Terminology of the cold-U/V (enhanced-V) shaped storms:

Originally revealed and documented in early 1980’s in the U.S.A. (Great Plains region) in the NOAA/AVHRR and GOES IR imagery. From the beginning called **enhanced-V** feature, which reflects the fact that these were observed in enhanced IR imagery ...
Terminology of the cold-U/V (enhanced-V) shaped storms:

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In Europe first (???) documented for the 18 August 1986 case (NOAA9, 13:30 UTC, Czech Rep.):
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Presently – namely in Europe – preferred term cold-U (or cold-V, or cold-U/V), which stresses the nature of this feature.

The actual shape of the feature – resembling more U or V – depends on several factors (namely the amount of wind shear, scanning geometry, storm maturity, used enhancement, ...) and has no real physical significance.

Therefore, the name cold-U can be used for both of the forms, regardless of the actual appearance.
Terminology, general comments

Both types of these storms (cold-ring and cold-U/V shaped ones) belong to a more common category, to storms exhibiting some form of embedded warm spots at their tops, typically located downwind of overshooting tops or longer-lived elevated “domes”, penetrating the tropopause into the warmer lower stratosphere.
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Shortly lasting embedded warm spots (EWS) are quite common, forming in the lee of individual overshooting tops, and typically disappearing after decay of their “parent” overshooting top. Therefore, life cycles of EWS are closely related to the life cycles of overshooting tops, typically lasting 10 – 20 minutes, or even less.
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If the individual overshooting tops keep repeatedly penetrating the cloud top in the same area, or if they form an longer-lived elevated dome, a more stable and larger EWS can form, resulting in cold-ring or cold-U/V shaped storm.
Examples of a smaller-scale or short-lived embedded warm spot (EWS)
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Notes on overshooting tops

Possible problems when trying to link EWS to overshooting tops:

• Not every overshooting top when observed in visible bands corresponds to a local brightness temperature (BT) minimum (can be explained by heating of the overshooting top’s skin temperature during its decay, collapse).

• Not every local BT minimum can be matched to an overshooting top in visible imagery – probably due to existence of other cloud top phenomena which can also result in local BT minimum, or illumination conditions.
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In general, still not much known about the overshooting tops themselves, about their life cycles, characteristics need for improvement of conceptual models of the overshooting tops, based on satellite rapid scan (GOES, MSG/MTG) and radar observations ...
Cold-ring shaped storms:

Examples
Examples of cold-ring shaped storms
Examples of cold-ring shaped storms

See also: http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20070702_convection/20070702_convection.html
Examples of cold-ring shaped storms

See also: http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20080520_convection/20080520_convection.html
Examples of cold-ring shaped storms
Examples of cold-ring shaped storms

Romania - Ukraine

See also: http://convection.satreponline.org/cases/april08/index.php
and: http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20080422_convection/20080422_convection.html
Examples of cold-ring shaped storms
Examples of cold-ring shaped storms

United Arab Emirates, Saudi Arabia & Oman

See also: http://oiswww.eumetsat.org/WEBOPS/iotm/iotm/20080809_convection/20080809_convection.html
Cold-U/V (enhanced-V) shaped storms

Examples
Examples of European cold-U/V shaped storms
Examples of European cold-U/V shaped storms
Examples of European cold-U/V shaped storms
Examples of European cold-U/V shaped storms
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MODIS Aqua, 2008-08-02 12:15 UTC
Examples of European cold-U/V shaped storms
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Cold-U/V (enhanced-V) shaped storms

Conceptual models
The enhanced-V feature studies from early 1980’s showed a very close correlation with severe weather or supercells. However, this feature alone does not automatically classify a storm as a supercell.

If observed, it indicates a possible severity of the storm, but it does not prove the severity! Nevertheless, due to the high correlation with severe weather, this feature has big significance in nowcasting, and should be well known to forecasters!
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Mechanism of the cold-U and CWA couplet formation: still not quite well, unambiguously explained – several different mechanisms. For details of these see the original papers, addressing this topic.
Cold-U shaped storms

Wake effects


Cold-U shaped storms

References:


Cold-U shaped storms

Jumping cirrus

(T. T. Fujita)

Cold-U shaped storms

Gravity wake breaking mechanism  (P. K. Wang, T. P. Lane, ...)

- Fujita’s “jumping cirrus” & the above-anvil plumes

**Cold-U shaped storms**

*Other possible explanations (discussed either in the past, or recently):*

- **“Transparency effects”** ... partial IR transparency of the cloud top at the warm area region, thus the radiance originating at the lower, warmer layers inside the cloud;

- **“Warm-dome mechanism”** ... higher elevated storm dome (not the overshooting tops themselves!!!), residing in the warmer lower stratosphere for a sufficiently long period, thus its “skin temperature” warmed up by the environmental air;

- **“Plume-masking mechanism”** ... warmer above-anvil plume partially “masking” the downwind parts of the cold anvil cloud top - in combination with EWS (Setvák et al.)
Cold-U shaped storms

References:


Cold-ring shaped storms

Characteristics and conceptual model(s)
Main characteristics:

- **Temperature difference between the cold ring and CWS:**
  several K and higher, typically up to 10 – 12 K in MSG imagery, depending on the embedded overshooting tops temperature (which by itself relies on “phasing” of the overshooting tops activity with the satellite scan cycle)

- **CWS size:**
  from several SEVIRI pixels across, up to about ~ 50 km

- **CWS duration:**
  from presence in one single MSG image up to 1 hour or more (for one specific CWS) ... related to the “parent” overshooting tops characteristics

No formal quantitative definition of the cold-rings and CWS in terms of their IR brightness temperature (BT) characteristics, shape and size, duration ...
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... but the warm spot’s size, magnitude and duration seem to be related to storm’s severity (based on several Central European cases from last years, documented by other colleagues) – in agreement with the U.S. studies from 1980’s, addressing the “enhanced-V” features.
**Suggestion:**

A storm should be classified as a cold-ring shaped one, only if the cold ring and CWS persist as a well-defined, continuous feature for at least $\sim 30 - 45$ (???) minutes, to exclude the cases of transient EWS forming in the lee of single overshooting tops.

The shorter-lived cases might be labeled only as a storm with EWS, having much lower significance for nowcasting.
25 June 2006 - cold ring shaped storms, Czech Republic and Austria

Evolution of the cold-ring feature
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Evolution of the cold-ring feature
Interpretation of the cold-ring shaped storms:

The cold-ring (and cold-U) shapes themselves represent only the cold anvil top background, crucial are the characteristics and interpretation of the embedded warm spot (CWS, CWA, DWA), presence of which gives the storm its characteristic cloud-top appearance !!!
Discussion of the central warm spot (CWS)

*In principle, three possible explanations of the warm area, similar to those of the cold-U shaped storms:*

1. Partial IR transparency of the area, thus the radiance originating at the lower warmer layers;

2. wake effects, or gravity wave breaking effects, similar to those assumed to be the explanation of the cold-U/V (enhanced-V) shapes and CWA couplets, including the “jumping cirrus”;

3. higher elevated tops, residing in the warmer lower stratosphere for a sufficiently long period of time, thus warmed by the environmental air ... “warm dome” mechanism

(or any combination of these).
Discussion of the central warm spot (CWS)

To decide among these it is necessary to know (as accurately as possible) the cloud top height and its microphysical composition ...

Necessitates the use of radar (and lidar) cloud-top observations
25 June 2006 - cold ring shaped storms, Czech Republic and Austria

Radar cross-section C-D and CAPPI 15.5 km after parallax shift shown in the IR10.8 BT image. The C-D plane was chosen to intersect the CWS and the highest overshooting tops.
Radar cross-sections (along line C-D) of the 25 June 2006 storm top
Radar cross-sections (along line C-D) of the 25 June 2006 storm top

1330 (CWS, outlined by the IR10.8 BT ~ 215 K)

1340

1350
Radar cross-sections (along line C-D) of the 25 June 2006 storm top
The CWS began to develop at the downwind side of the overshooting tops area ("dome"), expanding downwind. At the later stage, it propagated also to the upwind side of the dome, persisting shortly even after decay of the dome. Therefore, the "warm dome" mechanism by itself can NOT explain the presence of the CWS.
Appearance of the cold ring, CWS and the overshooting tops in various satellite-based products:

- brightness temperature difference IR13.4 – IR10.8
- brightness temperature difference WV6.2 – IR10.8
- SAFNWC cloud top height product
2008-06-25 1340 UTC  (MSG1 1330, radar 1340)
2008-06-25 1355 UTC (MSG1 1345, radar 1400)

Parallax shifted CAPPI 16 – 17 km
2008-06-25 1410 UTC (MSG1 1400, radar 1410)

Parallax shifted CAPPI 16 – 17 km
2008-06-25 1425 UTC (MSG1 1415, radar 1430)

Parallax shifted CAPPI 16 – 17 km

WV6.2 - IR10.8

IR13.4 - IR10.8

SAFNWC CTH
No trace of the high overshooting area (the “dome”) in any of the above shown products ...

- in the IR10.8 band, at the upwind side it has similar temperature as the lower cold-ring area, while at the downwind side it is a part of the CWS
- for this reason, it also can NOT be revealed in any of the BTD products
- similarly, for the same reason also the SAFNWC CTH fails detecting it

These products, broadly used for overshooting tops detection, can be used only for the “regular” storms (with short-lived overshooting tops), while the really severe storms with long-lived elevated domes are likely to escape their detection by these methods !!!
Radar cross-sections (along line E-F) of the 25 June 2006 storm top
The IR transparency can be instantly excluded as well, since the CWS is partially located above the radar high-reflectivity region, and also at the downwind side of the dome the anvil does not exhibit any decrease of the radar reflectivity.
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What these methods can not fully exclude is a presence of warmer thin cirrus downwind of the dome (Fujita’s “jumping cirrus”, or the above-anvil plumes), which is beyond detection capabilities of most of ground-based radars.
Link between the cold-ring and cold-U shaped storms:

Resemblance of the cold-ring shaped storms to the cold-U shaped storms, in some cases difficult to decide between these (no formal distinction between them, absence of formal quantitative definitions).

Several cases of form transition: from a cold-ring shaped storm to a storm with cold-U feature (not the opposite!).

Several cases of both types of storms in the area: in these cases the cold-U shaped storm seems to be a right-mover compared to the cold-ring shaped ones »»» same environment, but different storm-relative winds.
Link between the cold-ring and cold-U shaped storms:

In general, in Europe much higher frequency of the cold-ring shaped storms, while in the U.S. Great Plains much higher frequency of the cold-U shaped storms. This might be a result of wind shear climatology...

Latest modeling results seem to confirm that wind shear is indeed crucial for the actual shape of the cold feature – cold rings forming in weaker shear, while cold-U shapes demand stronger shear. Both forms demand thermal inversion above the tropopause.
What next?

- Modeling of similar cases ... cold-ring versus cold-U shaped storms (the role of storm environment, wind shear); RTM studies.

- Special attention to storms exhibiting cold-shape transitions, and to the role of plume-masking mechanism ...

- Use of MSG rapid scan data (5 minute intervals) ...

- Use of CloudSat and CALIPSO observations: might significantly help, but a timing problem – overpass of these satellites is too close to local noon, usually before the onset of any significant convection.

- More attention to the overshooting tops themselves !!!
For some of the cases shown here you will find additional movie files (showing the evolution of these storms), downloadable from the course web page.