Storm Interrogation

AWOC Severe Track

ICSvr 3-V-B

VIL and VIL Density

VIL and VIL Density

Objectives:

- Understand how VIL is calculated
- Recognize that VIL and VIL density are not good indicators of severe hail

VIL: Calculations

- Reflectivity values at consecutive tilts are input into (h is height in meters between the 2 grid boxes):

$$3.44\times10^{-6}\left(\frac{Z_{low}+Z_{above}}{2}\right)^{4/7}\Delta h$$

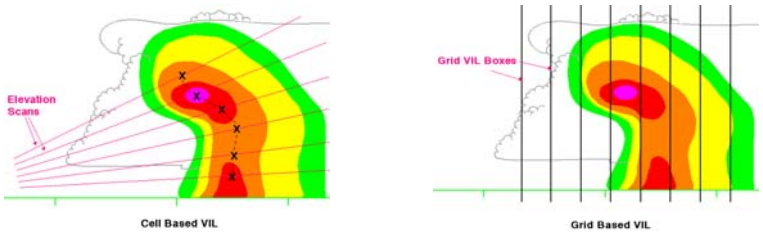
- 2 ways to sum up each of the above values throughout the depth of the echo returns:
  1. Cell based & 2. Grid based

•VIL is vertically integrated liquid.

•It was intended to “throw out” the contributions from ice, so warning sirens should be going off right off the bat for it’s usefulness for hail.

•VIL is calculated from the above equation.

VIL: Grid and Cell based



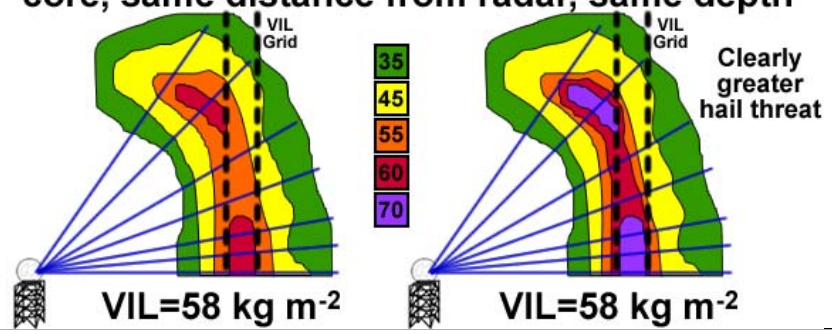
- Cell based (listed in SCAN tables): each vertical integration is done between cell centroids
- Grid based (what you can view in D2D): vertically stacked 2.2 x 2.2 nm boxes

Cell based VIL will have higher values than grid-based VIL as a result. Centroids will have higher reflectivity values. Cell based VIL depends on the accuracy of the SCIT algorithm. Grid Based VIL fails with fast moving storms or storms that are strongly tilted.

VIL: Calculations

- Caveat: In order to "filter out" hail as was originally the design, all reflectivity values greater than 56 dBZ are truncated to 56 dBZ
- Lower cap of 18 dBZ as well

2 Storms, idential shape and size of 55 dBZ core, same distance from radar, same depth



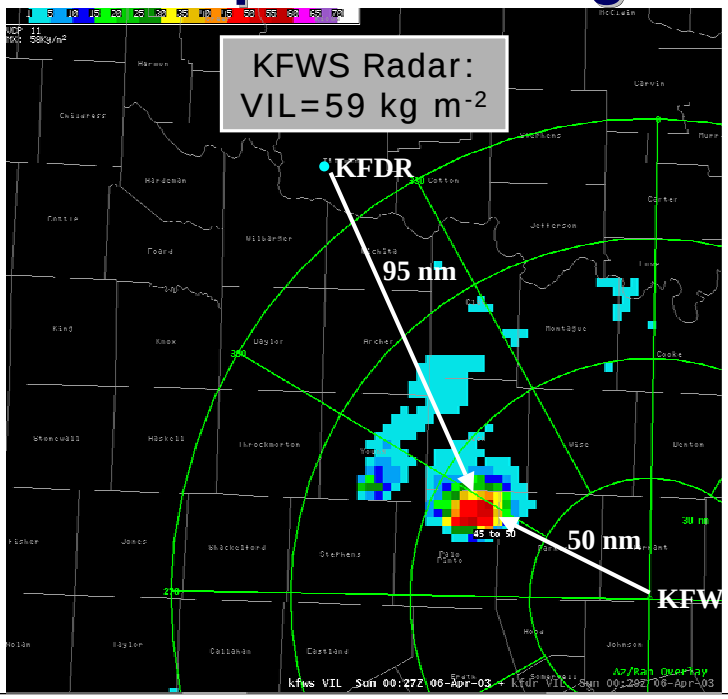
The problem of truncation becomes clear in this hypothetical storm. Both storms have identical extents of 55 dBZ, thus due to truncation their VILs are identical as well, even though the storm on the right is clearly more severe with several large areas of 70 dBZ.

VIL (legacy product)

- Cannot discriminate between severe and non-severe hail
  - Threshold of 50 kg m^{-2} has been shown to have nearly perfect POD of all hail larger than 2 inches in diameter, but FAR very high as well
- Problems: Highly dependent on environment, storm type, distance from radar

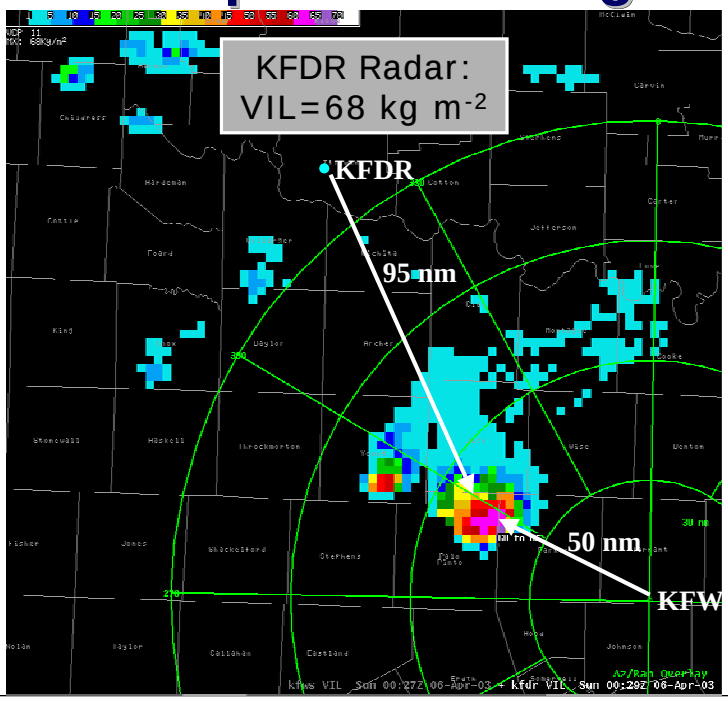
All thresholds only apply to the old “low res” VIL product. The new, high res VIL product is computed completely differently and new thresholds will have to be established. As will be shown shortly, 8-bit VIL values are much higher than the old 4-bit because they are not truncated at any upper limit.

Example: VIL Range



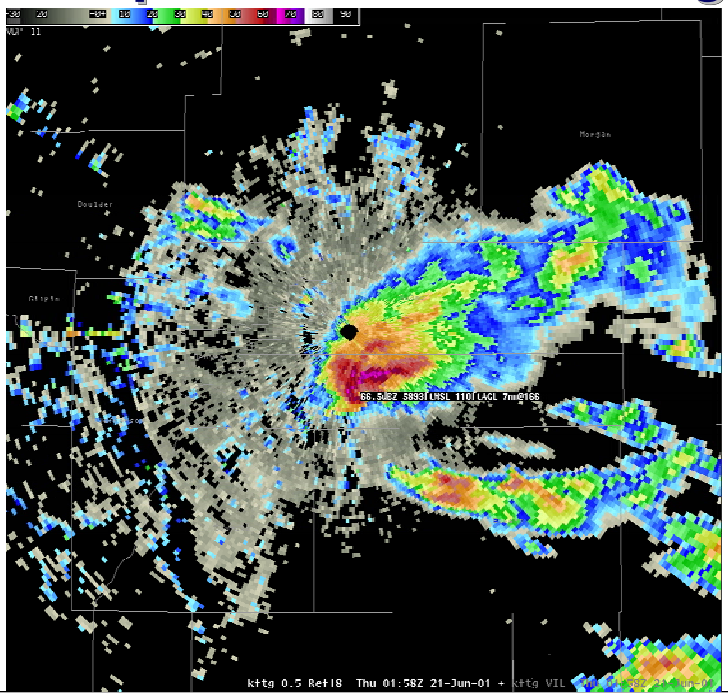
This and the following image displays the problems of VIL with range. In this particular case the storm was close enough to KFWS to get a better VIL measurement, but that will not always be the case across the country, as just 80 nm from a radar can really hurt the derivation of VIL. It should also be noted that storms very close to the radar will also have very unrepresentative VIL values. Baseball hail was falling out of the storm in Palo Pinto County. This particular supercell had a history of softball hail as well.

Example: VIL Range



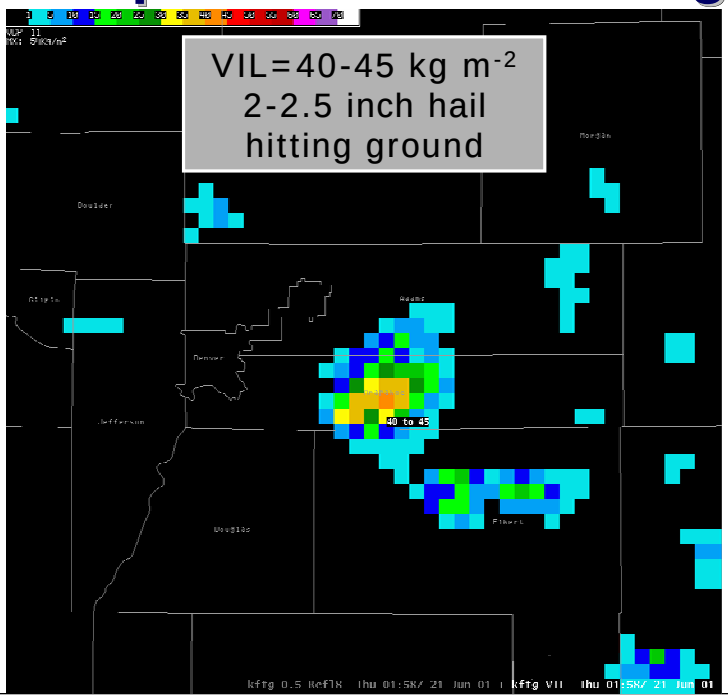
Here is Frederick radar at almost twice the distance to the storm as Ft. Worth, with much higher VIL values. That is typical of storms far from radar, as VIL is typically overestimated.

Example: VIL Close Range



This and the following radar image are taken just a few minutes after KFTG radome got pelted with 2.25 inch hail. 2 inch hail is pounding central Arapahoe County and Watkins right now.

Example: VIL Close Range

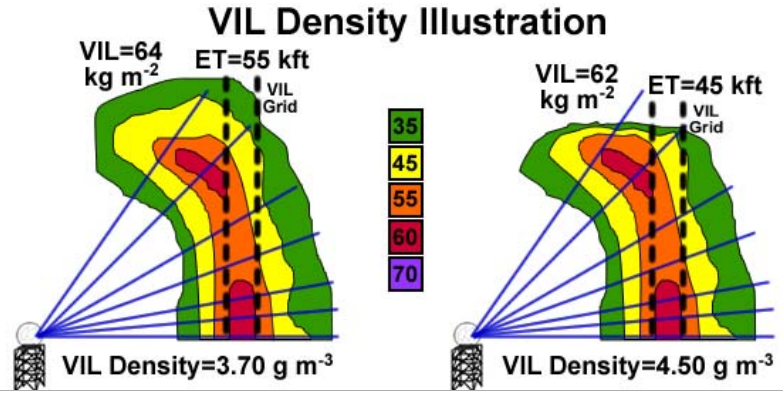


The storm is so close to the radar VIL is useless, with just 40-45 max indicated in spite of 70 dBZ at 100 feet off the ground. Any storm closer than 20-30 nm of the radar is going to have VILs that are lower than reality.

VIL Density

VIL Density= (VIL/Echo Tops) x 3280

- As VIL density increases, the hail cores tend to be deeper and more intense in the context of the storm. Unless:



•Remember that the echo tops product is capped at 18 dBZ

•3280 is the metric conversion from the kft echo top product

•In this hypothetical case, the reflectivity is packed near storm top, leading to a much higher VIL density. However, which storm is really more severe? Though VILs are nearly the same, the storm on the left extends much higher into the atmosphere, and thus at this time would pose a greater threat.

VIL Density Chart

Echo Top (kft)														
	70	0.70	0.94	1.16	1.40	1.64	1.87	2.10	2.34	2.57	2.81	3.04	3.27	3.51
	65	0.75	1.01	1.26	1.51	1.76	2.02	2.27	2.52	2.78	3.02	3.27	3.52	3.78
	60	0.82	1.09	1.36	1.64	1.91	2.18	2.45	2.73	3.00	3.27	3.55	3.81	4.09
	55	0.89	1.19	1.49	1.79	2.08	2.38	2.67	2.98	3.27	3.57	3.86	4.17	4.46
	50	0.98	1.31	1.64	1.96	2.29	2.62	2.95	3.27	3.60	3.93	4.26	4.58	
	45	1.09	1.45	1.81	2.18	2.55	2.91	3.27	3.64	4.00	4.36	4.73		
	40	1.23	1.63	2.04	2.45	2.86	3.27	3.68	4.09	4.50	4.91			
	35	1.41	1.87	2.34	2.80	3.27	3.73	4.21	4.67	5.14				
	30	1.64	2.18	2.73	3.27	3.82	4.36	4.91	5.46					
	25	1.96	2.62	3.27	3.93	4.58	5.23	5.89						
	20	2.45	3.27	4.09	4.90	5.72	6.54							
	15	3.27	4.43	5.46	6.55	7.64								
		15	20	25	30	35	40	45	50	55	60	65	70	75

VIL (g/kg)

1. VIL Density ≥ 3.5 has a 90% POD.
2. VIL Density ≥ 3.27 is a minimum threshold for 3/4 inch hail and works best for fast moving storms.
3. VIL Density ≥ 3.9 works best for slow moving vertically stacked storms.
4. In general, the greater the VIL Density the larger the hail size.

The thresholds listed above do a decent job for hail warning decision making with deep, moist, continental convection, especially when combined with reflectivity structure and heights of the strongest reflectivity in relation to the freezing, -20ºC, and EL. Again, with the advent of the new high res VIL product, this chart will have to be modified.

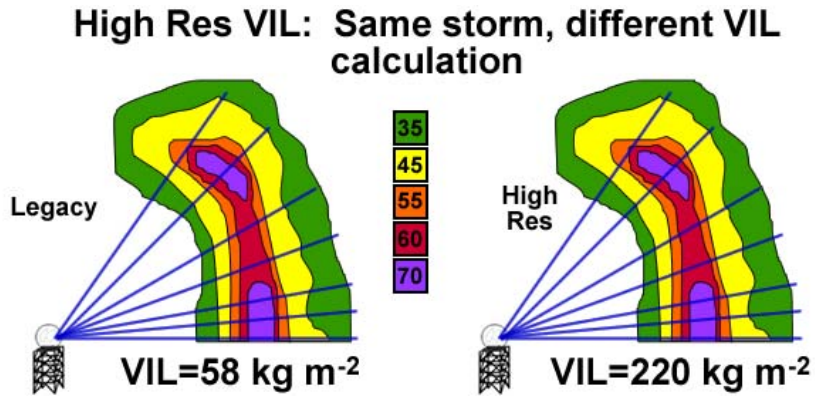
VIL Density

- Still depends on usefulness of VIL itself
- Edwards & Thompson (1998) found VIL Density unreliable because:
  1. Imprecision of ET product
  2. Differences in hail climatology
  3. Regional variances of the WSR-88D SWP algorithm

VIL denstiy depends on VIL, which all by itself is not a good way to determine the hail threat of a storm. Edwards and Thompson did an extensive study of over 400 hail events all across the country, and found both VIL and VIL density unreliable for severe hail detection and interrogation

High Res VIL

- No studies yet with warning thresholds, but calculation different than the legacy VIL
  - No upper or lower reflectivity truncation



Looking at the new 8-bit VIL product with hypothetical storms, two identical storms, 2 very different VIL values because of the lack of truncation in the new 8-bit product. The values you see displayed on D2D use the same color scale and values as the 4-bit legacy VIL product and **caps the values at 80 kg/m2**, so you aren't likely to see these types of values displayed graphically in D2D. The problem that arises is that most deep convective storms will have about 80 kg/m2 VIL, so this product isn't useful at all for hail threat diagnosis.

VIL / VIL Density Summary

- These products are not very useful in the context of hail detection when compared to base data and the HDA
- Understand VIL/VIL density limitations: distance to radar, environment, resolution, storm motion
- VIL of the Day? No way

VIL of the day struggles in that VIL is still used with it's many drawbacks, and then add to the fact that different environments can and typically do exist within the same radar umbrella on the same day, different storm structure can result in different hail threats even with similar VILs on the same day.

Investigate On Your Own

- Check out how VIL works for yourself:

  Click Here

  – Or enter into any browser window:
  http://wdtb.noaa.gov/courses/awoc/ICSvr3/jobsheet.html

This link takes you to the HDA/VIL jobsheet exercise. It's very informative.