Maximum Estimated Size of Hail (MESH)

Short Description

Estimate of the maximum hail size that can be expected.

Input Sources

Severe Hail Index (SHI)

Resolution

Spatial Resolution: 0.01 ^{o} Latitude (~1.11 km) x 0.01 ^{o} Longitude (~1.01 km at 25N and 0.73 km at 49N)

Temporal Resolution: 2 minutes

Product Creation

MESH is calculated by:

$$MESH(inch) = \sqrt{SHI}$$

where SHI is the "Severe Hail Index."

Strengths

Like all MRMS products, the use of multiple radars is more robust than single-site radar alone. It provides faster updates and helps the forecaster integrate data from multiple radars. It also compensates for cone-of-silence, beam broadening at far ranges, and terrain blockage.

The use of mesoscale model analysis data to derive temperature information allows the temperature fields to vary across the domain of interest. This is in stark contrast to applying a single temperature altitude proxy across the entire domain, as is often done for single radar calculations. Thus, MRMS data better captures gradients in the temperature fields over space and time.

Limitations

Like many of the other hail size estimation techniques, which use reflectivity and vertical temperature profile input, MESH has a tendency to underestimate hail size in:

- Highly-tilted storms embedded in strong, deep-layer shear.
- Left-moving supercells.

- Supercells which possess a giant Bounded Weak Echo Region (BWER). This is sometimes denoted by a low MESH value hole co-located with the BWER.
- Storms with low-density, dry hailstones.

Subject to the biases and deficiencies of the mesoscale model used to derive the vertical temperature profile.

Quality Control

This product is derived from the 3D Reflectivity Cube, which means non-hydrometeorological data has been removed including: Ground clutter, anomalous propagation (AP), chaff, interference spikes, and bioscatterers (e.g., angels and ghosts). However, bright band contamination remains.

References

Witt, A., M. D. Eilts, G. J. Stumpf, J. T. Johnson, E. D. Mitchell, and K. W. Thomas, 1998: An enhanced hail detection algorithm for the WSR-88D. Wea. Forecasting, 13, 286-303.

Severe Hail Index (SHI)

Short Description

The Severe Hail Index (SHI) is used to compute the Probability of Severe Hail (POSH) and Maximum Estimated Size of Hail (MESH).

Input Sources

3D Reflectivity Cube

Vertical temperature profile from the current operational NCEP/EMC mesoscale model (i.e., the RAP as of 2014).

Resolution

Spatial Resolution: 0.01° Latitude (~1.11 km) x 0.01° Longitude (~1.01 km at 25°N and 0.73 km at 49°N)

Temporal Resolution: 2 minutes

Product Creation

This version of SHI is computed using the same cell-based equations as in Witt et al. (1998), except that it is vertically integrated on a multiple-radar 3D grid. Thermodynamic data (0° and -20° C) are integrated from numerical model analysis fields.

Technical Details

To determine the presence of severe hail, an approach similar to the Vertically Integrated Liquid (VIL) algorithm was adopted. The first change involves using a reflectivity-to-hail relation, instead of a reflectivity-to-liquid-water relation as VIL does. The reflectivity data are transformed into flux values of hail kinetic energy (Ė) by:

$$\dot{E} = 5 \times 10^{-6} \times 10^{0.084Z} W(z),$$

where,

$$W(Z) = \begin{cases} 0 & \text{for } Z \leq Z_L \\ \dfrac{Z - Z_L}{Z_U - Z_L} & \text{for } Z_L < Z < Z_U \\ 1 & \text{for } Z \geq Z_U. \end{cases}$$

Here, Z is in dBZ, Ė is in J m^{-2} s^{-1}, and the weighting function W(Z) can be used to define a transition zone between rain and hail reflectivities. The default values for this algorithm are Z_L = 40 dBZ and Z_U= 50 dBZ. While the VIL algorithm filters out the high reflectivities associated with hail by having an upper-reflectivity limit of 55 dBZ, the Z–Ė relation functions in the opposite way, using only the higher reflectivities typically associated with hail and filtering out most of the lower reflectivities typically associated with liquid water (Fig. 1).

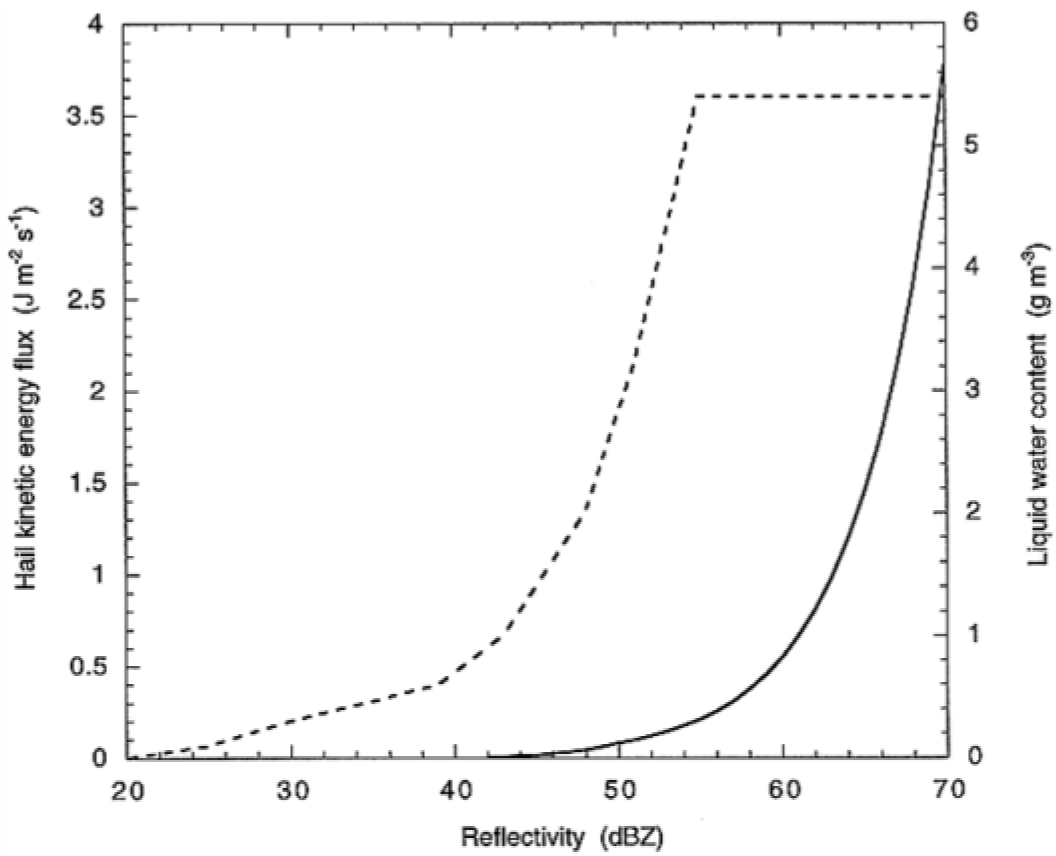

Fig. 1: Plot of hail kinetic energy flux (solid curve), and liquid water content (used to calculate VIL; dashed curve), as a function of reflectivity (Witt et al. 1998).

The second change involves using a temperature-weighted vertical integration. Since hail growth only occurs at temperatures < 0°C, and most growth for severe hail occurs at temperatures near -20°C or colder, the following temperature-based weighting function is used:

$$W_T(H) = \begin{cases} 0 & \text{for } H \leq H_0 \\ \dfrac{H - H_0}{H_{m20} - H_0} & \text{for } H_0 < H < H_{m20} \\ 1 & \text{for } H \geq H_{m20}, \end{cases}$$

,

where, H is the height above radar level (ARL), H_o is the height ARL of the environmental melting level (i.e., 0°C), and H_{m20} is the height ARL of the -20°C environmental temperature. Both H_o and H_{m20} are determined from temperature profiles in numerical model analysis fields.

All of the above leads to the following radar-derived parameter, which is called the Severe Hail Index (SHI). It is defined as:

$$SHI = 0.1 \int_{H_o}^{H_t} W_T(H_T)\dot{\mathrm{E}}\,\mathrm{dH},$$

where, H_T is the height of the top of the storm cell and $\dot{E}$ is calculated using the reflectivity profile of the grid point within the 3D Reflectivity Cube. The units of SHI are J m^{-1} s^{-1}.

Strengths

Like all MRMS products, the use of multiple radars is more robust than single-site radar alone. It provides faster updates and helps the forecaster integrate data from multiple radars. It also compensates for cone-of-silence, beam broadening at far ranges, and terrain blockage.

The use of mesoscale model analysis data to derive temperature information allows the temperature fields to vary across the domain of interest. This is in stark contrast to applying a single temperature altitude proxy across the entire domain, as is often done for single radar calculations. Thus, MRMS data better captures gradients in the temperature fields over space and time.

Limitations

Subject to the biases and deficiencies of the mesoscale model used to derive the vertical temperature profile.

Quality Control

This product is derived from the 3D Reflectivity Cube, which means non-hydrometeorological data has been removed including: Ground clutter, anomalous propagation (AP), chaff, interference spikes, and bioscatterers (e.g., angels and ghosts). However, bright band contamination remains.

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