Development and Testing of the VAHIRR Radar Product

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Outline

• Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) Background
• Developing and Testing the Automated VAHIRR Product
• Summary
VAHIRR Background

• Previous Lightning Launch Commit Criteria (LLCC) overly restrictive
• VAHIRR resulted from 2000/2001 ABFM II project
  – Electric field magnitudes inside thunderstorm anvils compared to radar parameters
  – VAHIRR was best performing parameter
  – 3 kV/m or less electric fields deemed safe from triggered lightning
  – When VAHIRR ≤ 10 dBZ-km, chance of 3 kV/m or greater electric field is less than 1 in 10,000
• VAHIRR = Volume Averaged Radar Reflectivity X Average Cloud Thickness (within a Specified Volume)
• Specified Volume
  – Horizontal extent: 5.5 km N, S, E and W of the point
  – Bounded by freezing level on bottom, cloud on top
Developing the Automated VAHIRR Product

- Operationally, VAHIRR work-around uses existing radar products, is manually intensive and gives conservative values
- Applied Meteorology Unit (AMU) developed automated VAHIRR for WSR-88D
  - 1 km horizontal resolution
  - Vertical resolution varies due to:
    - Beam spreading with distance from radar
    - Non-evenly spaced elevation scans
  - 4-bit product: only 16 data levels displayed
- AMU testing of VAHIRR:
  - Synthetic data
  - Comparison with ABFM data
VAHIRR Testing – Synthetic Data

- **Purpose**
  - Demonstrate accuracy of product using artificial data

- **Tests conducted**
  - Cloud Top/Bottom
  - Freezing Level
  - Cone of Silence
  - Multiple Cloud Layers
VAHIRR Testing – ABFM Comparison

- **Purpose:** Compare AMU VAHIRR to ABFM VAHIRR
- **Methodology:**
  - ABFM VAHIRR values only available along aircraft’s flight track at 10-second intervals
  - AMU VAHIRR values displayed across entire radar coverage every volume scan (every 5-6 minutes in precipitation mode)
  - Values from both VAHIRR products compared for same location and volume scan, using AWIPS lat/lon
  - Data gathered from multiple days of ABFM project, to have a large and representative sample data set

ABFM Display

AMU VAHIRR Display

http://science.ksc.nasa.gov/amu
VAHIRR Testing – ABFM Comparison

- **Initial Results:**
  - Large differences found between AMU and ABFM VAHIRR products
  - 33% positive bias in AMU VAHIRR product
VAHIRR Testing – ABFM Comparison

- AMU created two products to investigate differences in VAHIRR values
VAHIRR Testing – ABFM Comparison

- Comparison of average cloud thickness
  - Poor agreement between AMU and ABFM
  - 23% positive bias in AMU’s average cloud thickness

![Graph showing comparison between VAHIRR and ABFM thicknesses]

\[ y = 0.2799x + 1.3768 \]

\[ R^2 = 0.1084 \]
VAHIRR Testing – ABFM Comparison

- Comparison of volume average reflectivity
  - Good agreement between AMU and ABFM
  - 8% positive bias in AMU’s volume average reflectivity

![Graph showing comparison between ABFM and VAHIRR volume average reflectivity.](image)
Testing the Automated VAHIRR Product
Investigating Differences Between Two Products

• Possible contributors to differences revealed in ABFM Comparison
  – Errors in lat/lon position of ABFM aircraft or VAHIRR values
  – Errors in calculating cloud heights
  – ABFM’s product uses reflectivity values at all levels to calculate cloud top and base, while AMU’s product only uses reflectivity values at or above the freezing level
  – Differences in vertical grid spacing
    • Compare cloud thickness, average reflectivity, and VAHIRR ratios as function of distance from radar (constant thickness)
    • Compare same ratios as a function of cloud thickness (constant distance from radar)
Summary

- The ABFM II project developed the VAHIRR product, leading to less restrictive Lightning Launch Commit Criteria.
- ABFM Comparison Test showed large differences between AMU’s and ABFM’s VAHIRR products.
- As a result, AMU is investigating the differences between the two products.
- VAHIRR work-around will be used until automated VAHIRR product is certified and passes all testing procedures.