The Trigger Algorithm for DPR Detection of NUBF and Multiple Scattering : Validation

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Introduction

Multiple scattering (**MS**) and non-uniform beam filling (**NUBF**) affect Global Precipitation Measuring Mission Dual-Frequency Precipitation Radar (DPR) Ku and Ka band reflectivity measurements. Certain recognizable features have been embedded in an automated approach to detect their occurrence, and perform retrievals that account for them to the extent that is possible.

The detection of such profiles is performed by a module called the 'Trigger' which performs a fast analysis of every profile based on relatively simple criteria in order to avoid unacceptable reduction in processing efficiency: the Trigger relies on all data from DPR (that is the Normal Scan, the Matched Scan, and the High-Sensitivity Scan) and produces an estimate of the probability of occurrence (and severity) of both phenomena.

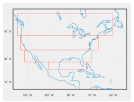
The retrieval of microphysical properties for profiles estimated to be affected by severe Multiple-Scattering is performed by flexible retrieval algorithm based on Optimal Estimation initialized with an ensemble of initial conditions compatible with the output of the Trigger. The retrieval module employs a forward operator which accounts for multiple scattering.

In order to assess the performance of the Trigger algorithm we have collected and collocated all available data from two Ground Weather Radar (GWR) datasets : the Nexrad-based MRMS geolocated to DPR footprints (P.-E. Kirstetter) and the Validation Network Data Products (Bob Morris) for the timespan from July 1st, 2014 to August 31st 2015 (i.e. GPM granule #1920 through #8553).

For the period of interest, the Trigger algorithm has produced 34695 Segments.

Segment = contiguous patch of DPR footprints flagged as Rain Present that satisfies either of the following 4 conditions:

1) At least 10 pixels were flagged as MS affected by the Trigger Module
2) At least 10 pixels were flagged as NUBF-affected by the Trigger Module
3) Any portion of the Segment falls within 60 km of one of the GWR contributing to the VNDP
4) Any portion of the Segment falls within the "MRMS domain" defined as in figure.



3730 Segments matched to VNDP or MRMS GRW data (**2740** MRMS only, **575** VNDP only, **415** both)

Trigger Module : Multiple Scattering Products

1) Presence of DWR Knee (as described in [1])
    1) 100% - A clear DWR keen (both "wide" in height and "deep" in dBZ)
    2) 50% - A DWR that is "wide" both not "deep" (i.e, <2dB above and <4dB below)
    3) 0% - No clear Knee was detected.
2) Presence of MS "Tail through the surface" (MSS)
    1) 100% - A clear "concave" (i.e. slope decreasing in range) tail can be detected through the range bins where the surface is.
    2) 90% - A tail is detected past the surface, but there is poor accuracy in assessing its concavity.
    3) 50% - A tail is possibly present but barely detectible.
    4) 0 % - No tail detected.

The primary MS product is a coarse (and qualitative) assessment of the probability of MS to be affecting the profile to levels that would alter the reflectivity profile by several dB.

Trigger Module : NUBF Products

1) Departure of the ratio of PIA_{Ka} / PIA_{Ku} from the expected range (4 to 8). [2]
    1) Mostly linked to the PIA SRT reliability.
2) Variability of $Z_{m,ka}$ between a profile and the 8 neighboring profiles (4 HS and 4 MS)
    1) Empty Fraction ("k"-weighted)
    2) Empty Fraction (average in the rain layer)
    3) Conditional standard deviation of Zm ("k"-weighted)
    4) Conditional standard deviation of Zm (average in the rain layer)

The primary NUBF product is not a probability of occurrence, rather an analog estimation of the Empty Fraction and of the conditional standard deviation of Zm.

Validation of Multiple Scattering detection

From **VNDP** : Big Ice Index = $10\log_{10}\left[\int_{BBtop}^{top} Z_{m,lin}(F_{LDG}+F_{HDG}+F_{HA}+F_{HR})w(h)dh\right]$

With w(h) = 1 for h > Bbtop + 1 km, 0.1 for Bbtop < h <= 1 km

$Z_{max(@<0°C)} \le 30$ dBZ

Bri \ MS	<10%	50%	>70%
< 25	148791	0	0
25-40	1	0	0
>40	0	0	0

No MS effects

$30 < Z_{max(@<0°C)} \le 40$ dBZ

Bri \ MS	<10%	50%	>70%
<25	11902	993	176
25-40	67	9	129
>40	0	0	69

$Z_{max(@<0°C)} > 40$ dBZ

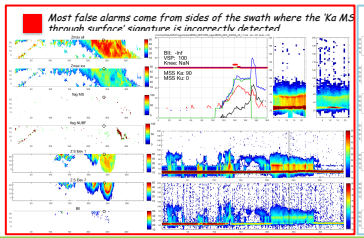
Bri \ MS	<10%	50%	>70%
<25	1609	235	5
25-40	143	26	70
>40	5	1	222

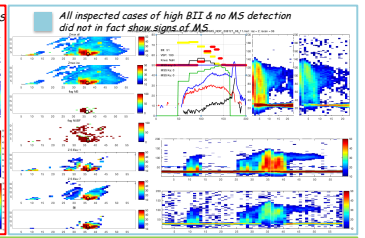
MS effects reliably detected in ~10% of the profiles

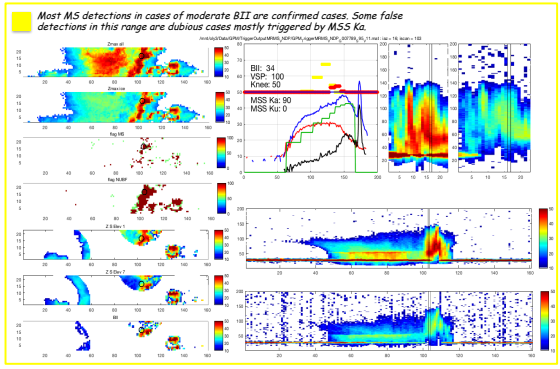
$Z_{max(@<0°C)} > 45$ dBZ

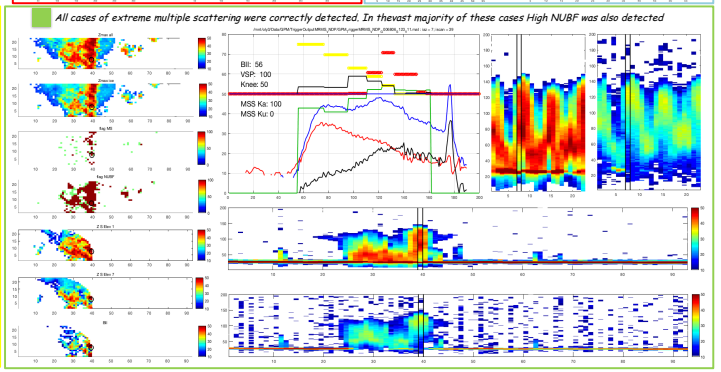
Bri \ MS	<10%	50%	>70%
<25	329	69	2
25-40	52	16	11
>40	2	1	128

MS effects reliably detected in ~25% of the profiles



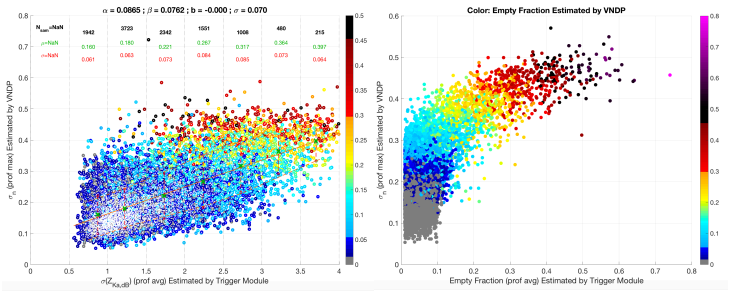






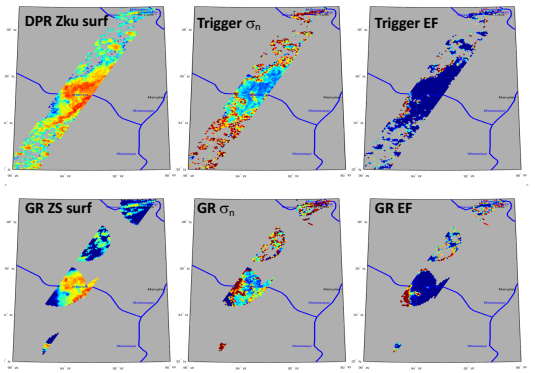
Validation of NUBF detection

From **VNDP** & **MRMS**: We use the standard deviation of S-band Zm normalized to the average (σ_n) and the Empty Fraction of DPR volume of resolution as estimated from the Ground Radar.



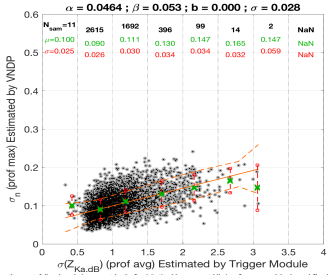
In footprints that are mostly filled , the algorithm shows some skill in estimating the variability of reflectivty.

For footprints that are not mostly filled, the estimation of Empty Fraction is most important to assess the variability of reflectivty within the footprint.



Example of 1 segment of collocated Trigger outputs and GV dataset

In footprints that are filled, the range of variability is limited to 0.2.

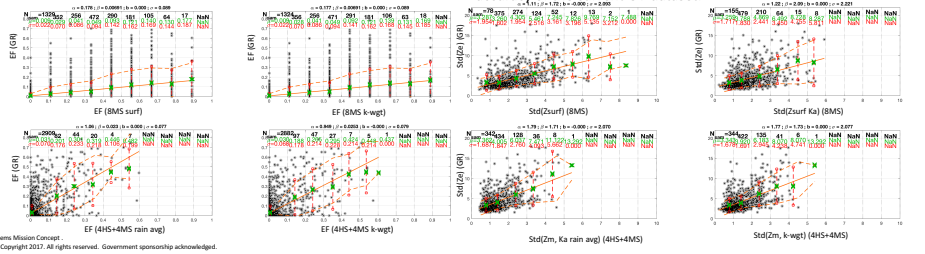


Comparison of NUBF estimations between 4HS+4MS and 8MS approaches.

(Preliminary – limited dataset)

Empty Fraction: 8MS shows very little skill, 4HS + 4MS shows good skill for EF > 0.2

Z variability: only minor improvement, but reaching the limit of the accuracy of the current GV dataset.



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