



Research In Applications for Commercial Pilot's Radar

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**HAIC-HIWC Science Team Meeting
Melbourne, AUSTRALIA
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Outline

- Why doesn't the pilot's radar "alert" on HAIC/HIWC conditions?
- Data collected and results "so far"
- What's needed and how to get there
- What's next?

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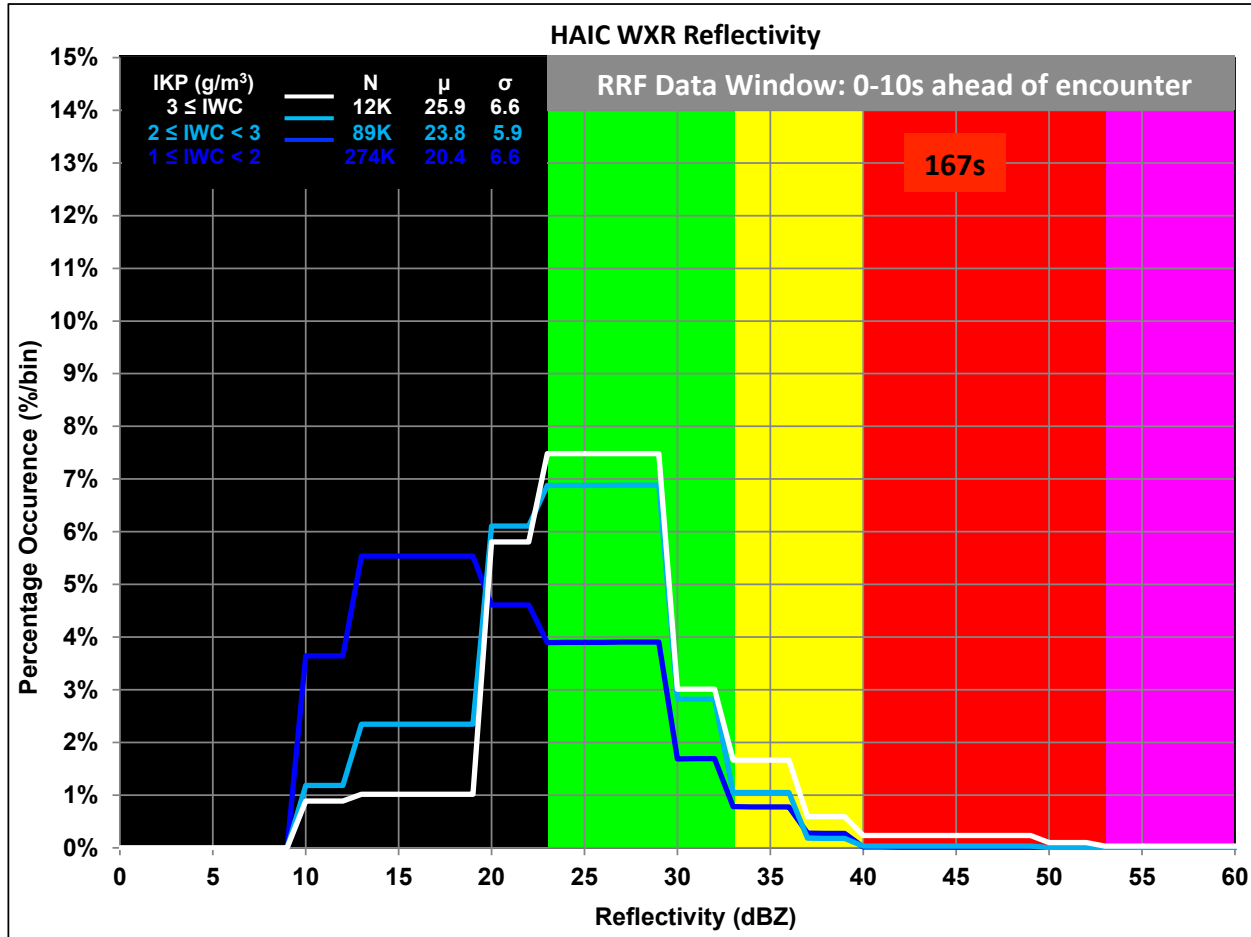


Why doesn't the pilot's radar "alert" on HAIC/HIWC conditions?

- HAIC/HIWC (as an aviation safety hazard) is still not well defined
– need both an intensity and duration component
- If we define HAIC/HIWC as $IWC \geq 3 \text{ g m}^{-3}$ and if further assume all this precipitates then a rain rate $\approx 2 \text{ in/hr}$ and corresponding NexRad RRF $\approx 50 \text{ dBZ}$ (RED/MAGENTA)
- Our first assessment (2010) suggested pilots were flying into regions of RED RRF but pilot statements were that the RRF was BLACK/GREEN in these regions. Flight testing has validated commercial pilot reports of LOW RRF while in HIWC.
- So our question became: How can we get $IWC \geq 3 \text{ g m}^{-3}$ and $RRF < 20$ or 30 dBZ



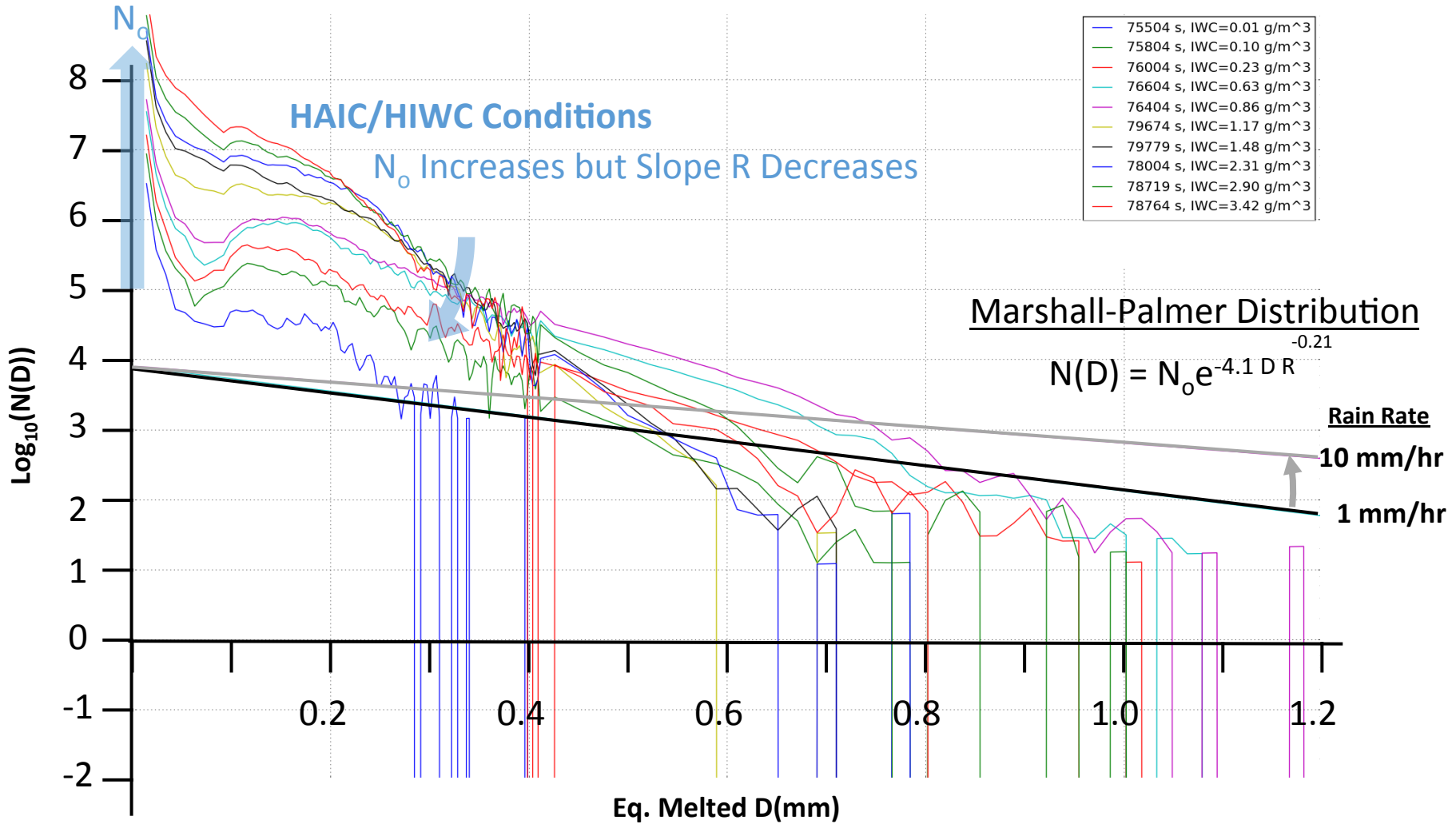
Data collected and results “so far”



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Reflectivity is more Significantly Impacted by Decreasing Slope

IWC (ie, Volume) Can Increase since N_0 Increases

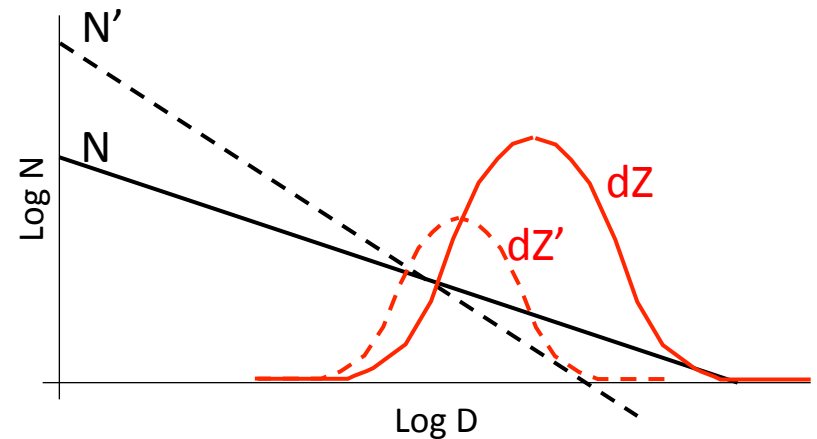
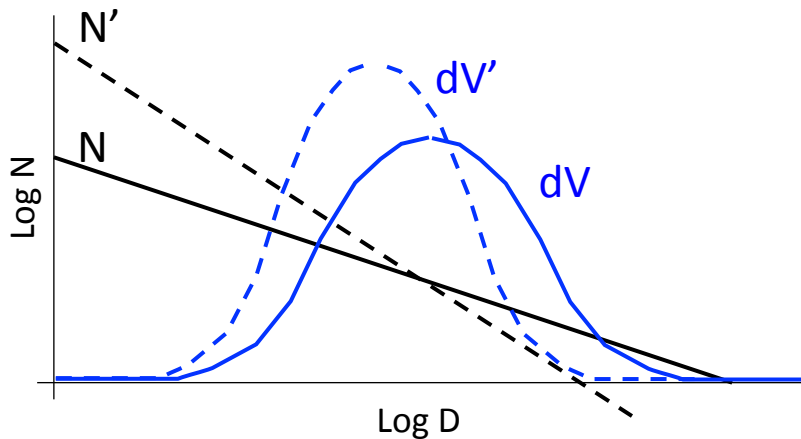
IWC is Volume (ie, D^3)

$$IWC = \rho \pi / 6 \int N(D) D^3 dD$$

EXAMPLE
USING
SPHERES

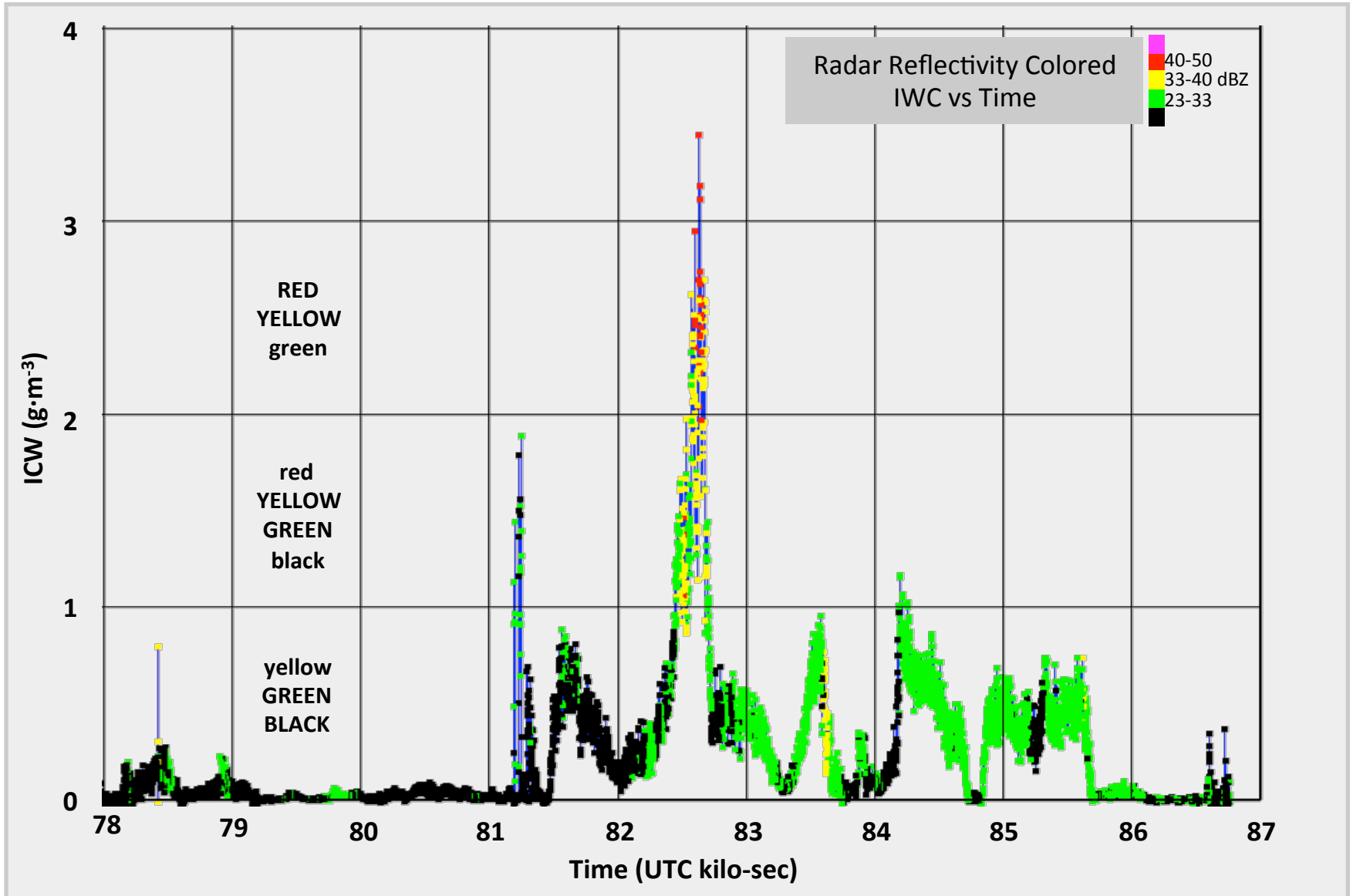
Radar Reflectivity (ie, D^6)

$$Z = \int N(D) D^6 dD$$





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- Our first assessment (2010) suggested pilots were flying into regions of RED RRF but pilot statements were that the RRF was BLACK/GREEN in these regions.
- So the question became: How can we get $IWC \geq 3 \text{ g m}^{-3}$ and $RRF < 20$ or 30 dBZ
- Flight test results show as much as 20dBZ reflectivity variability for the same IWC
- Reflectivity alone is insufficient to measure IWC by radar; instead:
 - a measure/estimate of the PSD is required for a true measure of IWC
 - or
 - a inferential process may indicate the increased probability for HAIC/HIWC combined with reflectivity this process may provide flight safety
 - or
 - radar combined with another sensor (maybe IR satellite imagery)

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What's needed and how to get there?

- Radar manufacturers are interested in providing HAIC/HIWC detection both Honeywell and Rockwell-Collins have product development engineers looking into HAIC/HIWC detection and hazard estimation
- Honeywell CZ is investigating an inferential process using reflectivity signatures and more info/results will be shared during our discussions on Cayenne results
- Rockwell-Collins is looking at alternative systems/processes that can measure the PSD
- For both companies, the main need is still – a better understanding of HAIC/HIWC, its characteristics, the meteorology that generates it, and knowledge of any consistent radar signatures that a detection algorithm could/should be based
- NASA has been providing technical guidance to our avionics colleagues
- we would like to provide them with IKP and PSD data
(for product development, not publishing)

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What's next?

- More detailed analysis using RDR-4000 measurements (both from B757 Cayenne and DC-8 Florida)
 - eliminate 10dBZ quantization issues
 - allow better filtering thereby isolating HIWC measurements
 - resolve questions regarding observed RRF differences
- Honeywell focused on 2016 flight demo for AIRBUS (others will brief details)
- NASA investigating multi-band radar
 - laboratory tests to validate concept
 - fabrication/assembly of flight hardware by EoCY
 - flight testing of MFR concept demonstrator in summer 2017

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