Presented by

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Cloud Microphysics – research status

RASTA Doppler cloud radar

Cloud Microphysics

- Reflectivity simulations (W-band and X-band)
- Retrieval method for ice cloud microphysics
- Versions comparison
- Assessment with convair data
- DARDAR check

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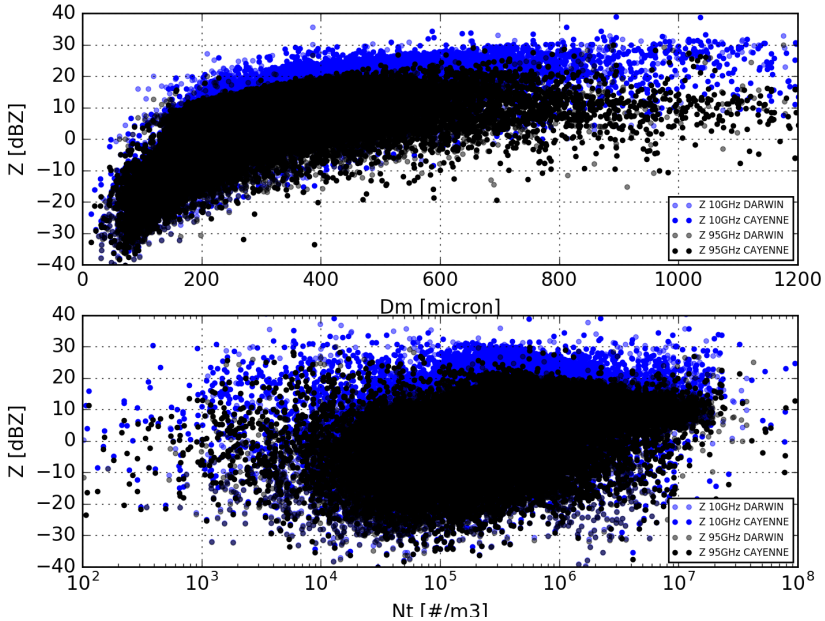
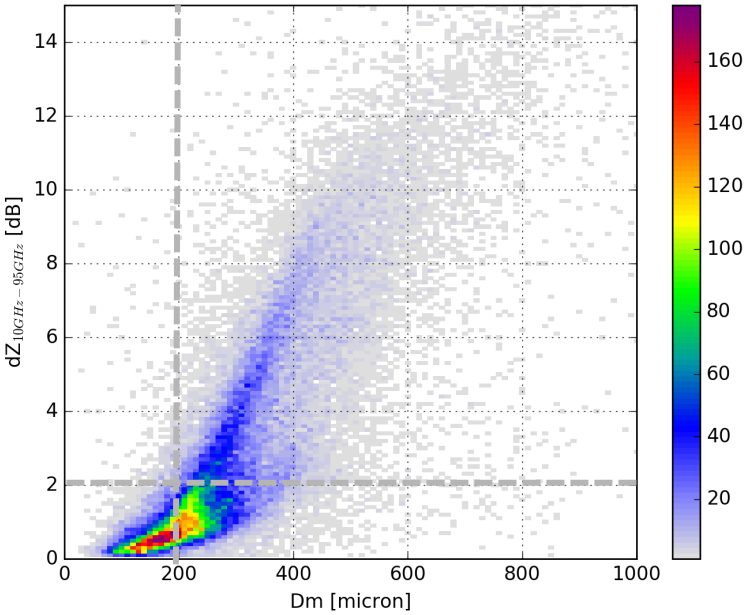
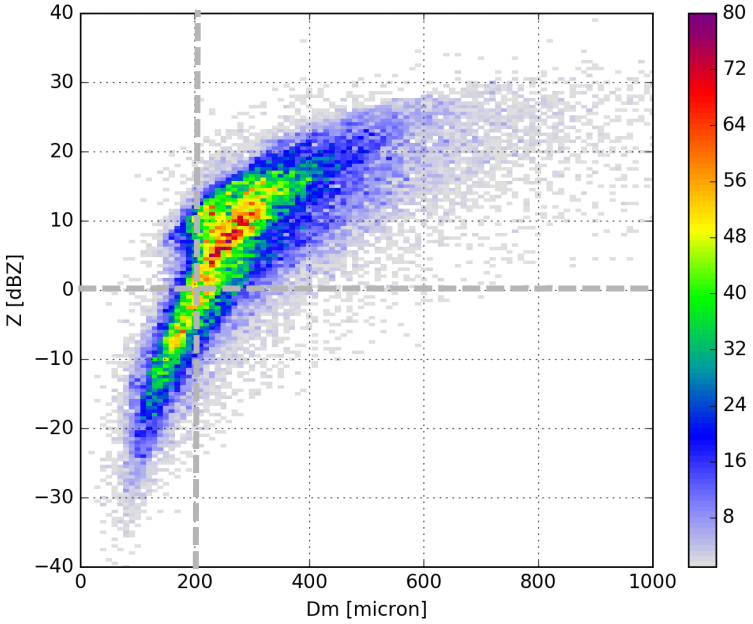
Reflectivity simulations







Consistent with convair NAWX measurements?

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Principle

Start with a first guess (X), simulate observations (Y=F(X)) and iterate until the difference between forward modelled observations and measurements is small enough

Account for radar attenuation, Doppler measurements constrain the retrieval as these measurements are not sensitive to attenuation

Z => concentration and diameter

Vz => diameter

<u>Inputs</u>

- Z, Vz and T

<u>Outputs</u>

- IWC, W
  - W => Vt => Dm
  - N_0^*, N_t, re, extinction

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Variational approach

$$\mathbf{Y} = \begin{pmatrix} \ln Z_1 \\ \vdots \\ \ln Z_n \\ Vz_1 \\ \vdots \\ Vz_n \end{pmatrix} = \begin{pmatrix} \frac{\partial \ln Z_1}{\partial \ln iwc_1} & \cdots & \frac{\partial \ln Z_1}{\partial \ln iwc_n} & \frac{\partial Vz_1}{\partial \ln iwc_1} & \cdots & \frac{\partial Vz_1}{\partial \ln iwc_n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial \ln Z_n}{\partial \ln iwc_1} & \cdots & \frac{\partial \ln Z_n}{\partial \ln iwc_n} & \frac{\partial Vz_n}{\partial \ln iwc_1} & \cdots & \frac{\partial Vz_n}{\partial \ln iwc_n} \\ \frac{\partial \ln Z_1}{\partial w_1} & \cdots & \frac{\partial \ln Z_1}{\partial w_n} & \frac{\partial Vz_1}{\partial w_1} & \cdots & \frac{\partial Vz_1}{\partial w_n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial \ln Z_n}{\partial w_1} & \cdots & \frac{\partial \ln Z_n}{\partial w_n} & \frac{\partial Vz_n}{\partial w_1} & \cdots & \frac{\partial Vz_n}{\partial w_n} \end{pmatrix} \mathbf{X} \begin{pmatrix} \ln iwc_1 \\ \vdots \\ \ln iwc_n \\ w_1 \\ \vdots \\ wz_n \end{pmatrix}$$

2 Unknowns and 2 measurements

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Variational approach

$$\mathbf{Y} = \begin{pmatrix} \ln Z_1 \\ \vdots \\ \ln Z_n \\ Vz_1 \\ \vdots \\ Vz_n \end{pmatrix} = \begin{pmatrix} \frac{\partial \ln Z_1}{\partial \ln iwc_1} & \cdots & \frac{\partial \ln Z_1}{\partial \ln iwc_n} & \frac{\partial Vz_1}{\partial \ln iwc_1} & \cdots & \frac{\partial Vz_1}{\partial \ln iwc_n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial \ln Z_n}{\partial \ln iwc_1} & \cdots & \frac{\partial \ln Z_n}{\partial \ln iwc_n} & \frac{\partial Vz_n}{\partial \ln iwc_1} & \cdots & \frac{\partial Vz_n}{\partial \ln iwc_n} \\ 0 & \cdots & 0 & \frac{\partial Vz_1}{\partial w_1} & \cdots & \frac{\partial Vz_1}{\partial w_n} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \cdots & 0 & \frac{\partial Vz_n}{\partial w_1} & \cdots & \frac{\partial Vz_n}{\partial w_n} \end{pmatrix} \mathbf{X} \begin{pmatrix} \ln iwc_1 \\ \vdots \\ \ln iwc_n \\ w_1 \\ \vdots \\ wz_n \end{pmatrix}$$

2 Unknowns and 2 measurements

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Variational approach

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Attenuation part

2 Unknowns and 2 measurements

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The forward models, a priori and jacobian

Forward models (based on DARWIN and CAYENNE in-situ)

- lnZ=f(lniwc,T)+att(lniwc,T)
- Vz=g(lniwc,T)+w

A priori

- IWC:
  - IWC-Z-T for a priori and first guess to speed up the process
- W:
  - w=0 +- 10 m/s

$$\frac{\partial Vz_i}{\partial \ln iwc_i} = \frac{\partial g(\ln iwc_i, T)}{\partial \ln iwc_i} \qquad \frac{\partial \ln Z_i}{\partial \ln iwc_i} = \frac{\partial f(\ln iwc_i, T)}{\partial \ln iwc_i}$$

$$\frac{\partial Vz_i}{\partial w_i} = 1 \qquad \frac{\partial \ln Z_{ij}}{\partial \ln iwc_{ij}} = -2|dr|\frac{\partial att(\ln iwc_i, T)}{\partial \ln iwc_i}$$

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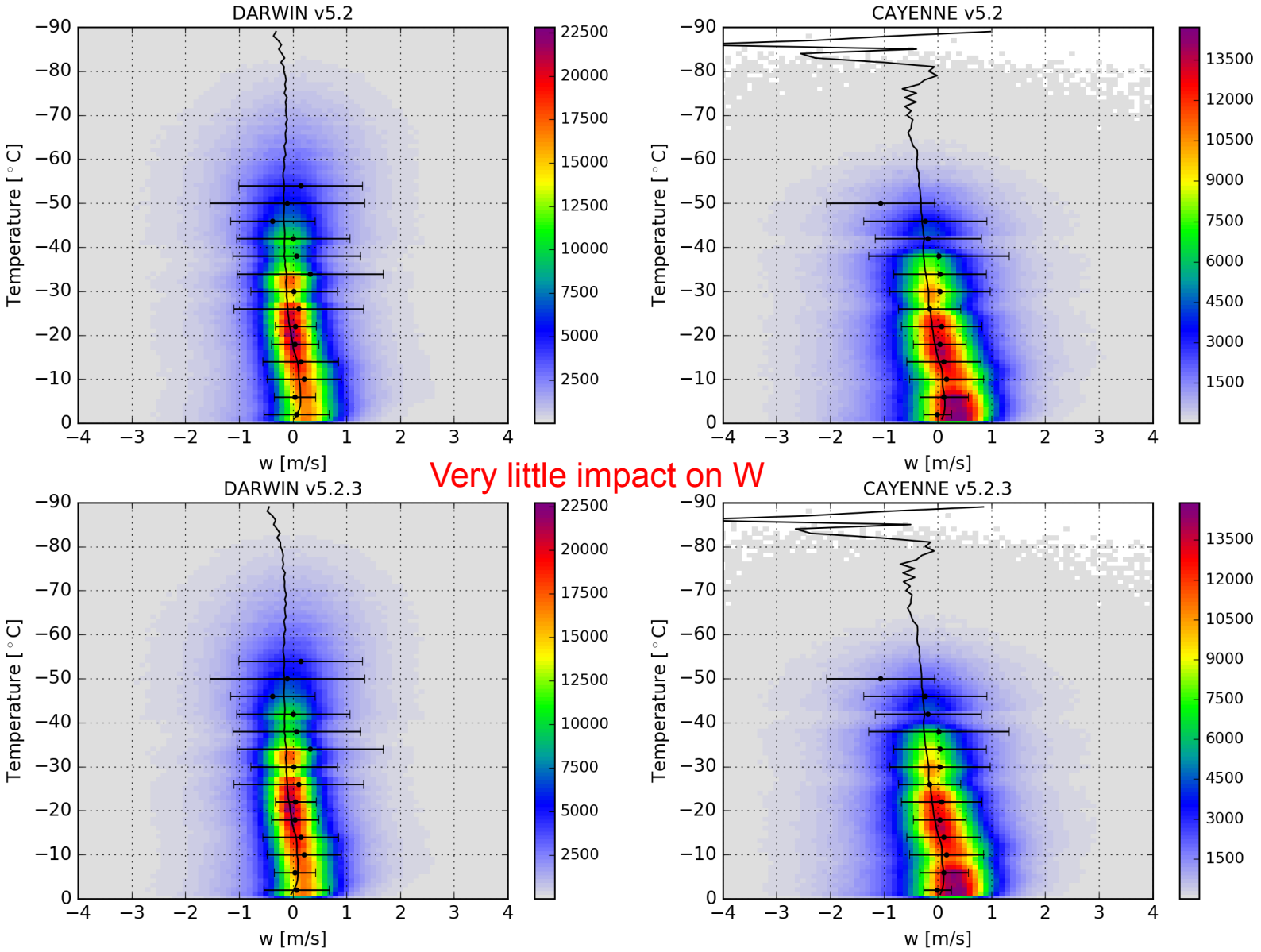
V5.2.1and V5.2.3 comparison



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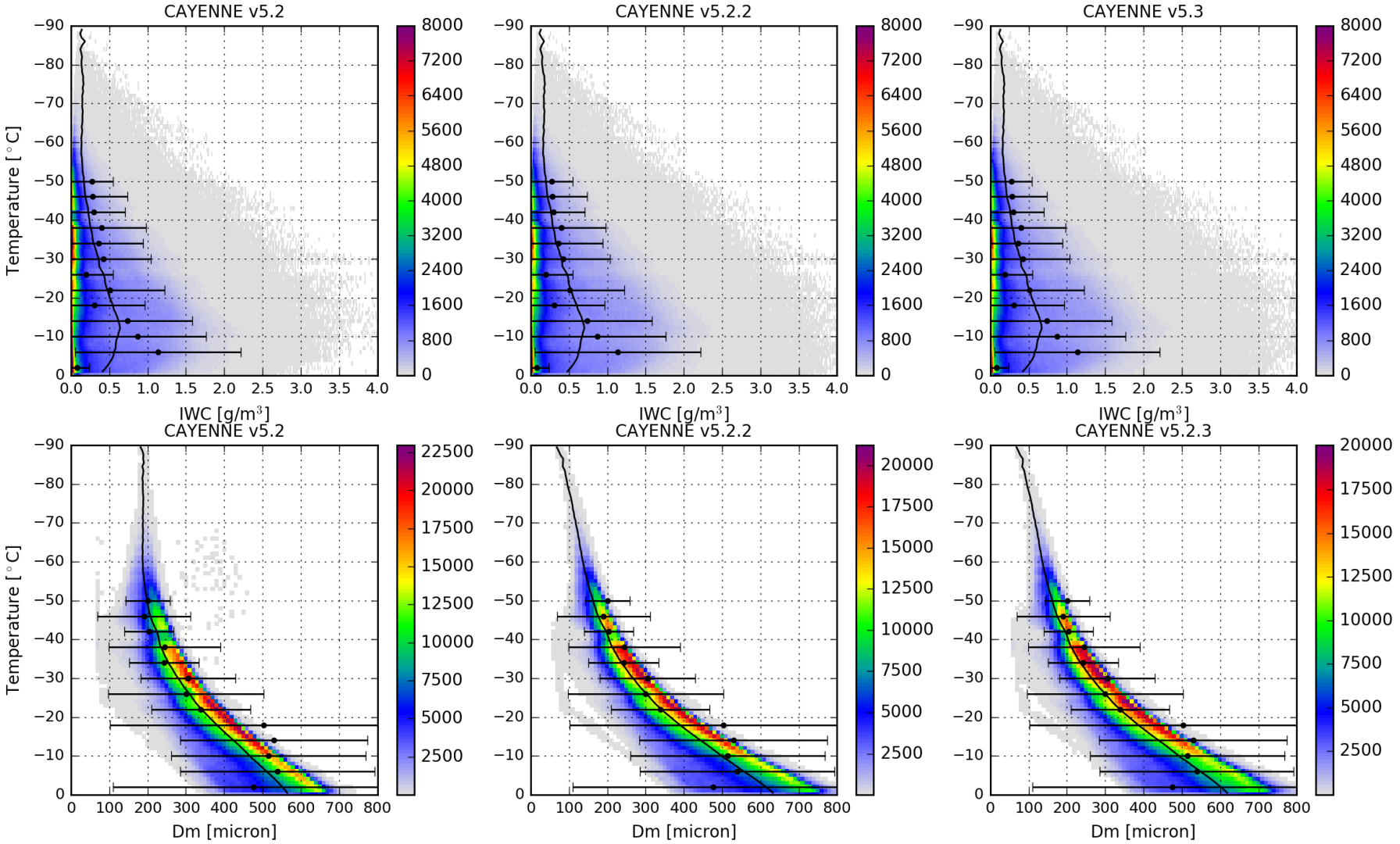

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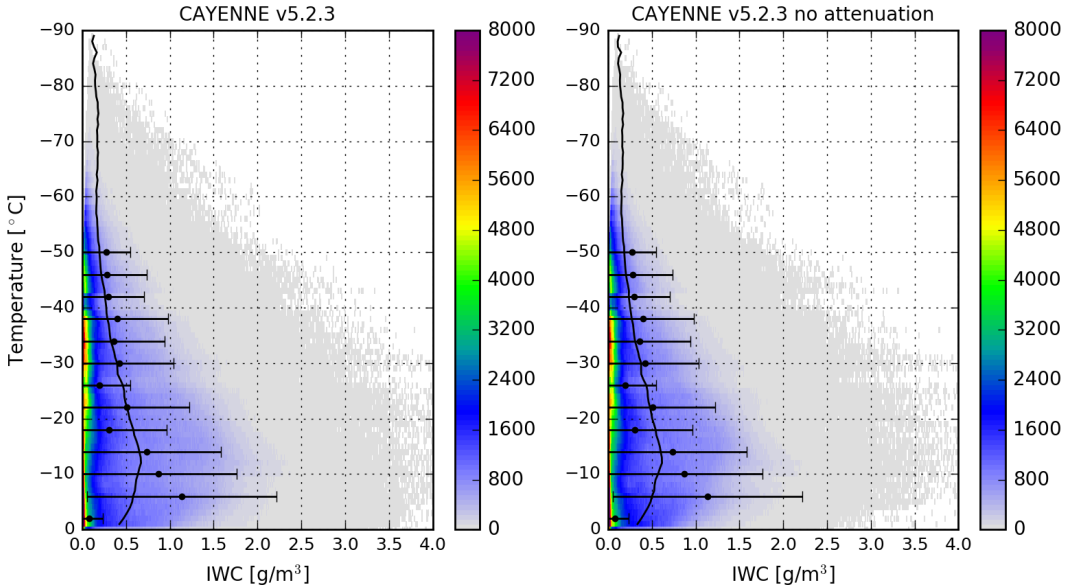
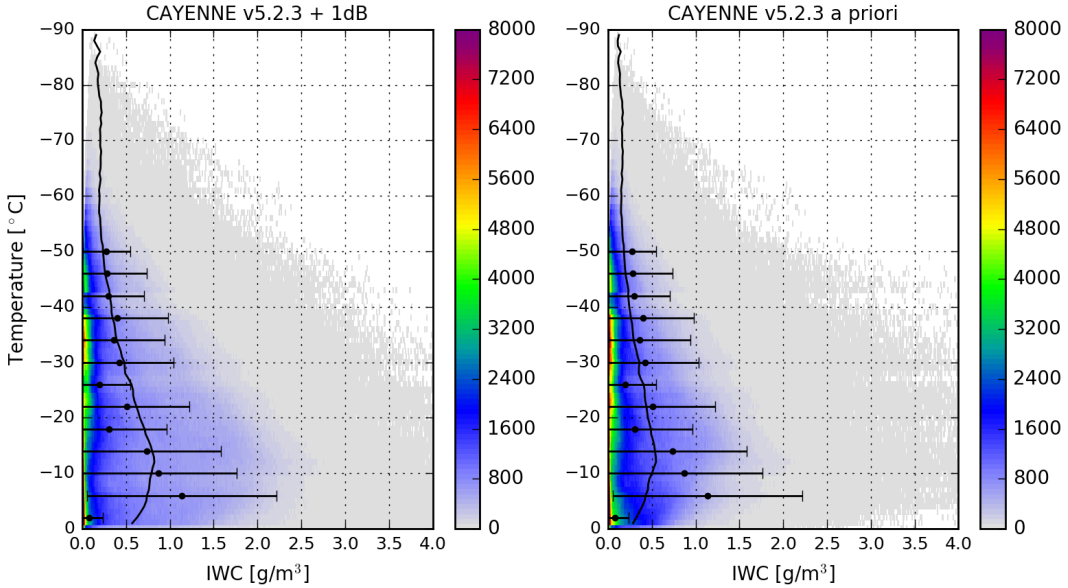
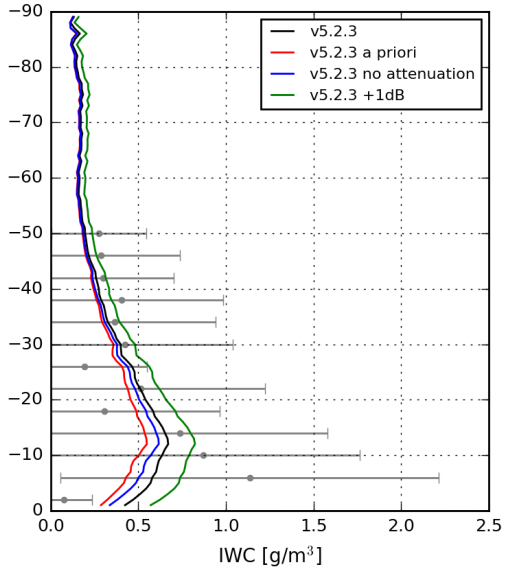
Sensitivity tests on v5.2.3



Impact of attenuation correction
Impact of + 1dB
Apriori IWC





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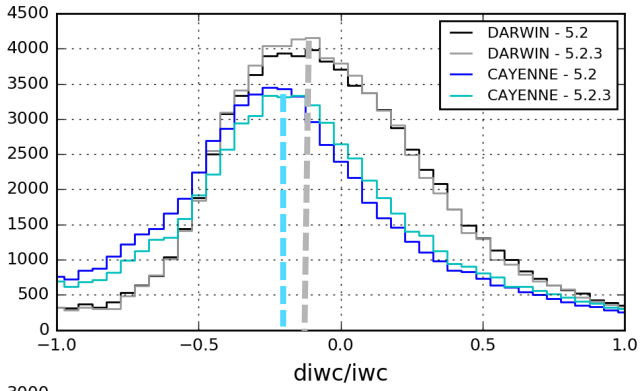

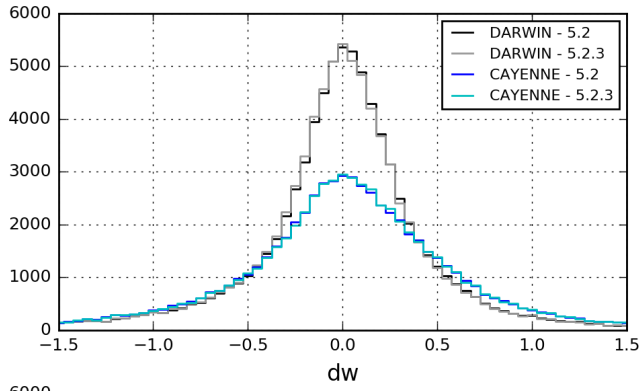

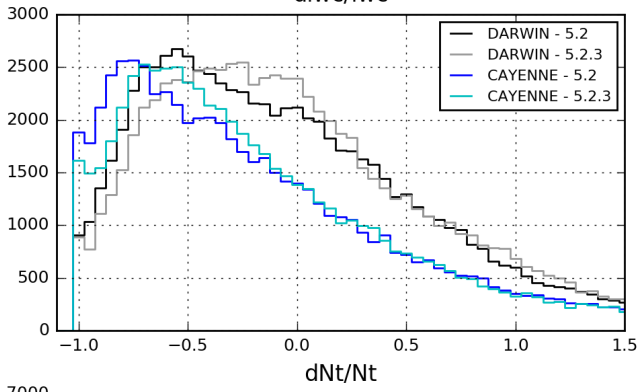

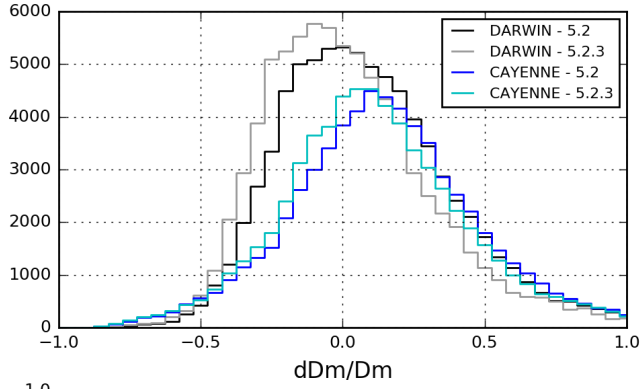

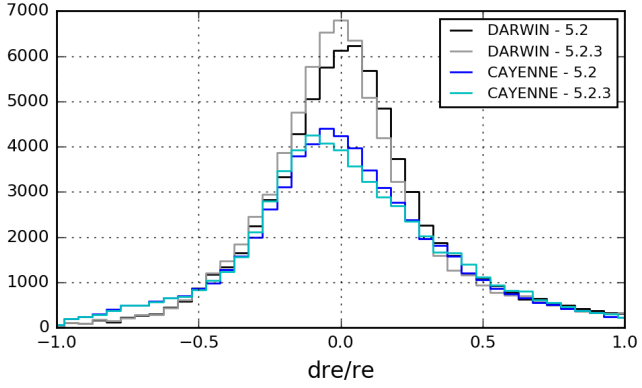

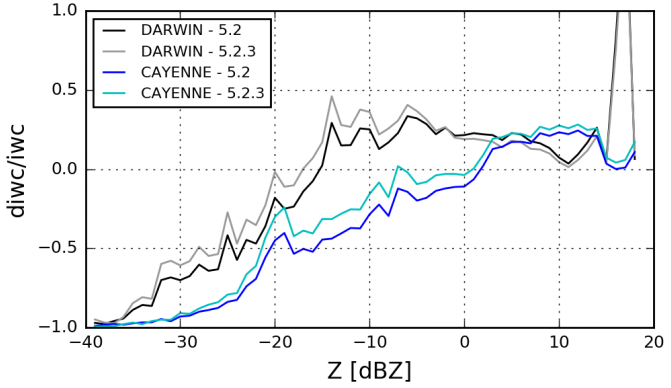

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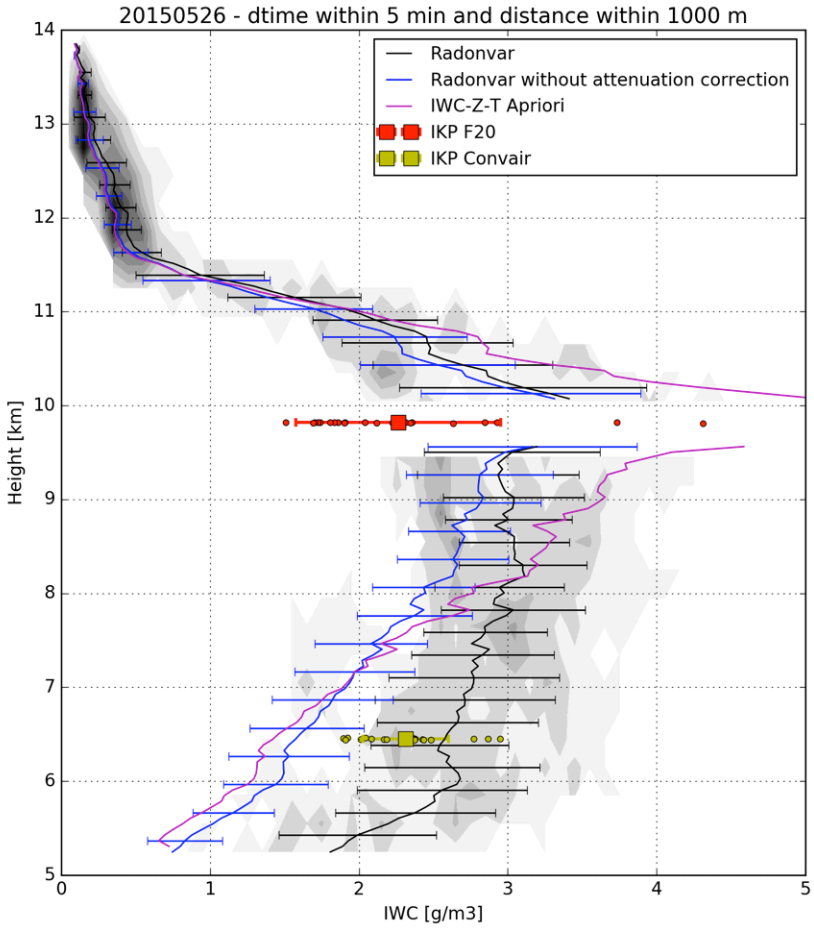
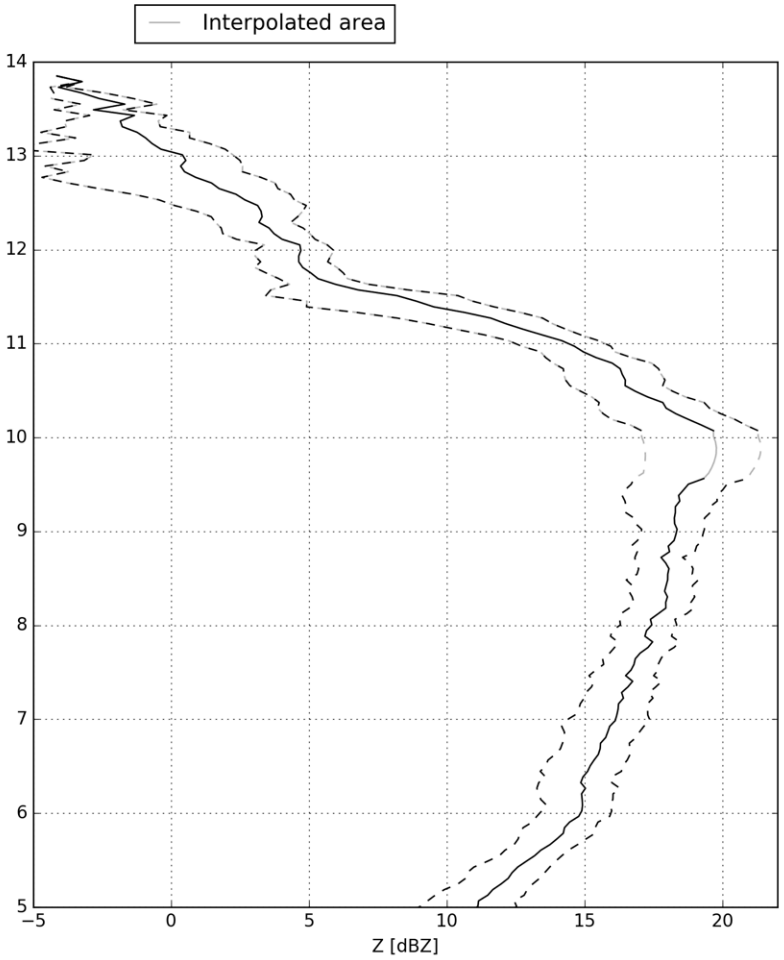
Profile assessment with convair data





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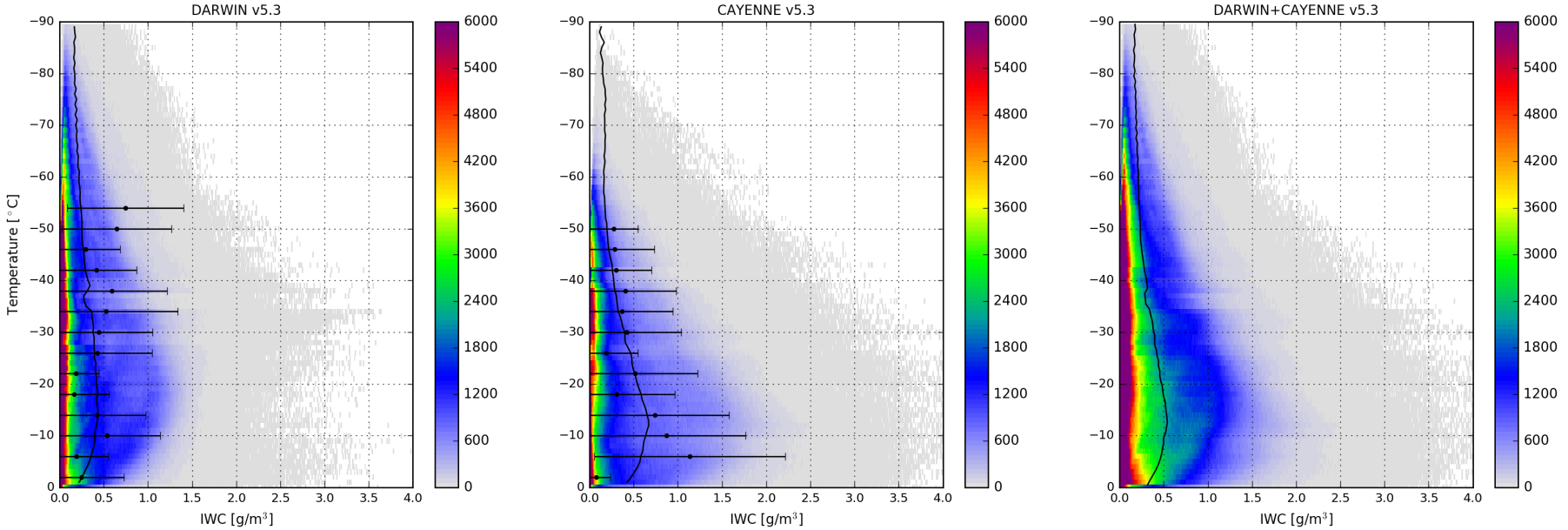
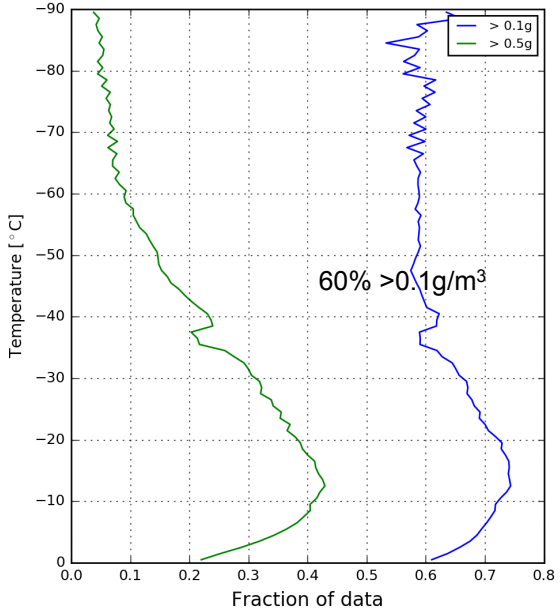
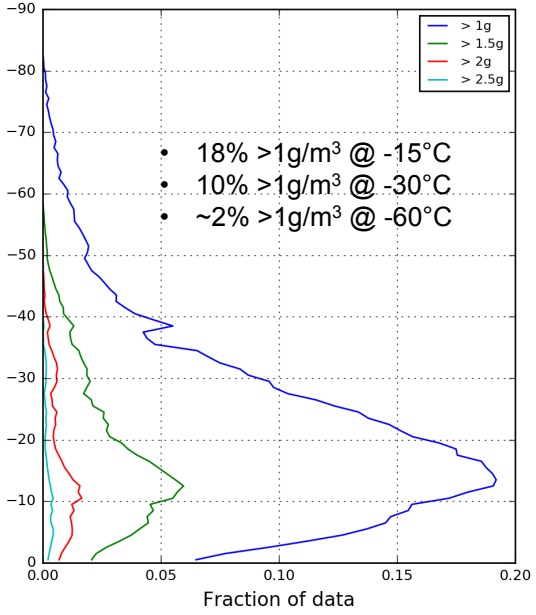
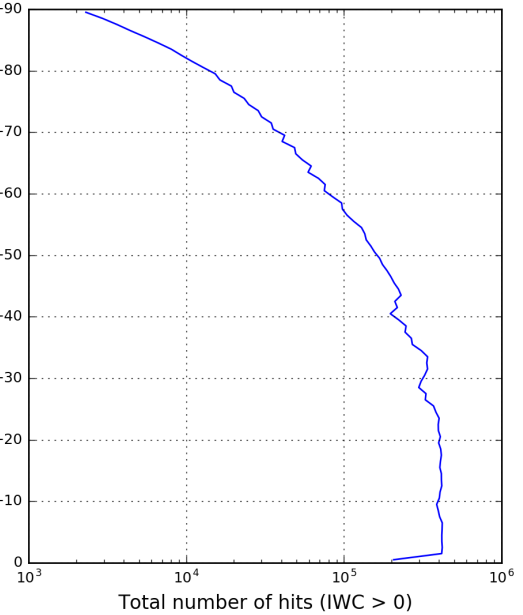
Results: IWC and temperature









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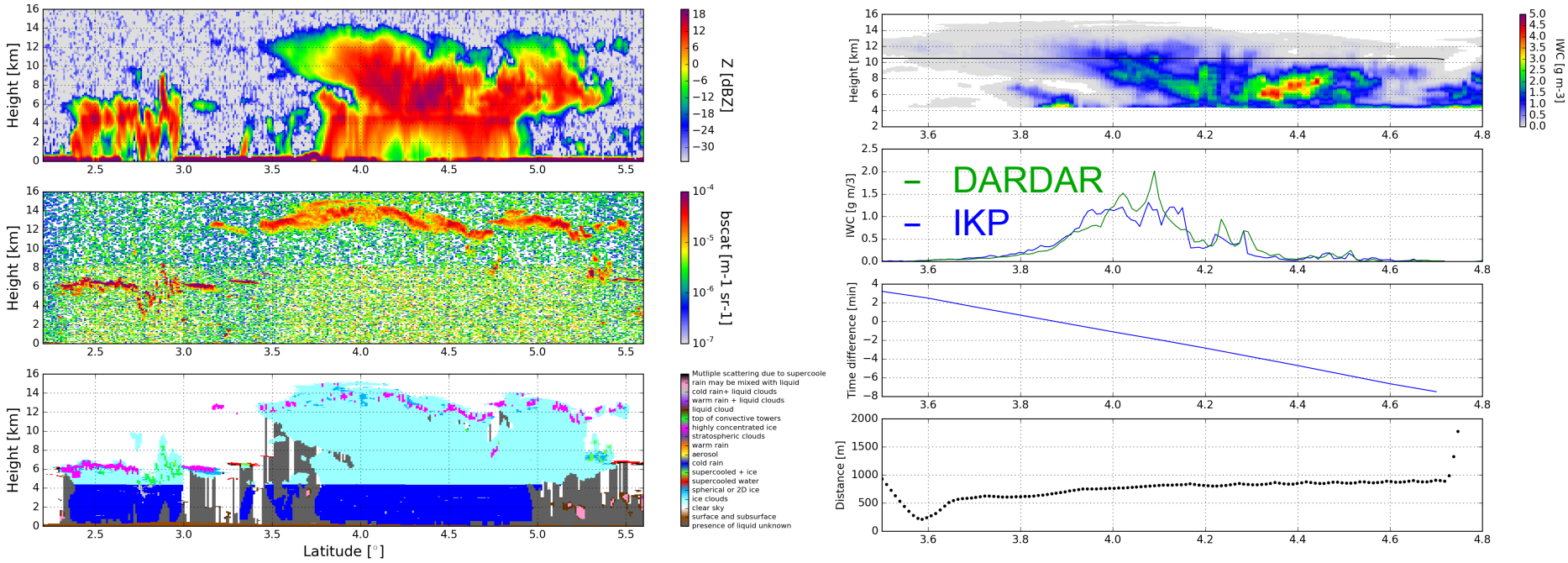
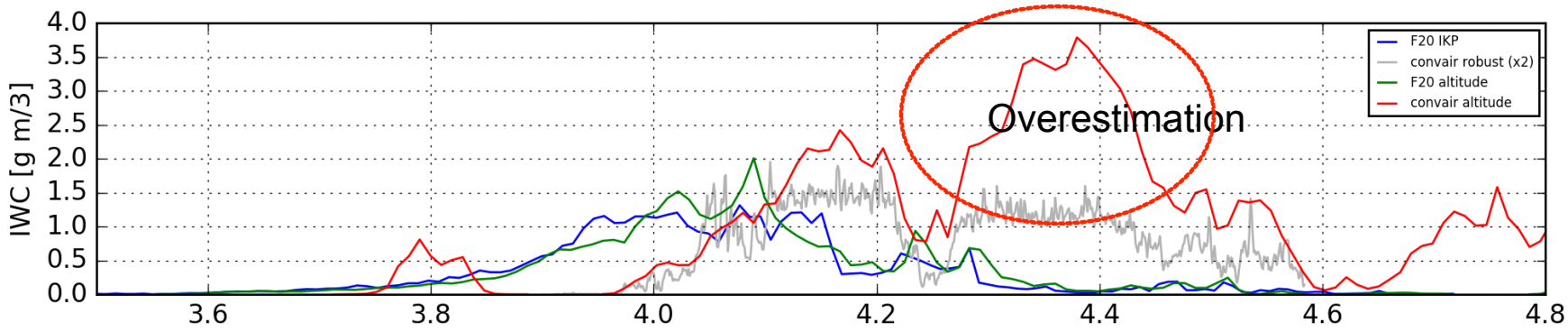
DARDAR check





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Next step…

- Evaluation of the attenuation correction using convair data
  - NAWX (W and X band) and IKP data

- More statistics using radonvar retrieval, appendix assessment

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High Altitude Ice Crystals (HAIC, 314314)

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