Presented by

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W-band radar research update

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RADONVAR : Radar only variational algorithm including attenuation correction

A NEW METHOD FOR RETRIEVING ICE CLOUD PROPERTIES

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

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

Variational approach

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

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2 Unknowns and 2 measurements

Variational approach

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Attenuation part

2 Unknowns and 2 measurements

The forward models, a priori and jacobian

Forward models

- 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

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

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

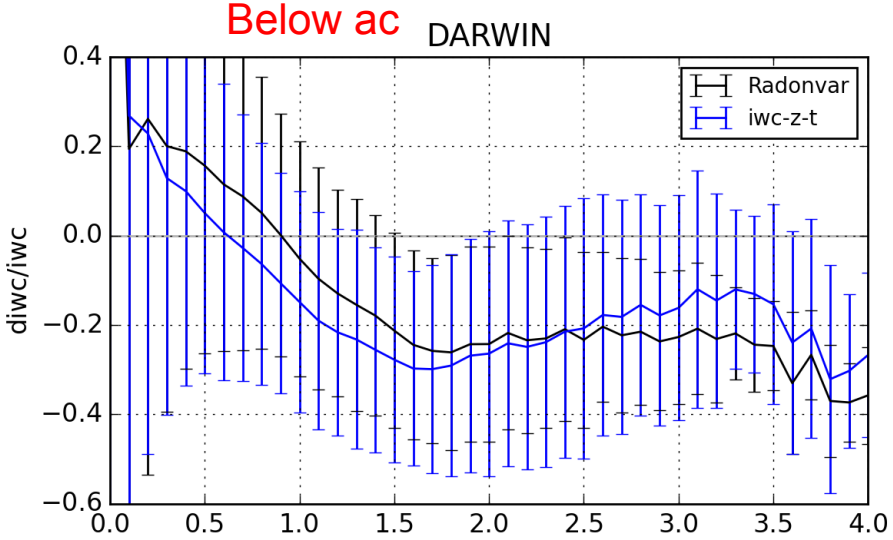
Radonvar evaluation

- Microphysical model based on IKP-insitu data collected during DARWIN campaign

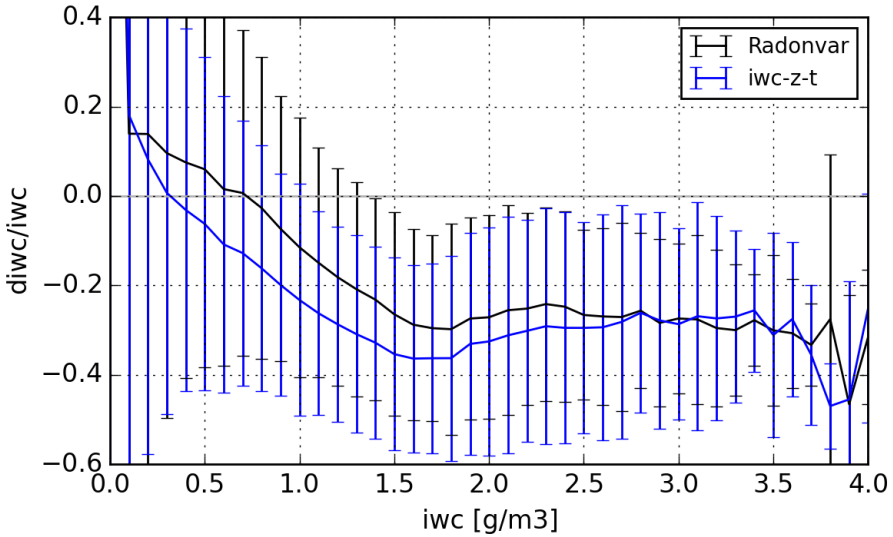
- Evaluation using IKP data from DARWIN and CAYENNE

Radonvar evaluation at ac altitude

Below ac

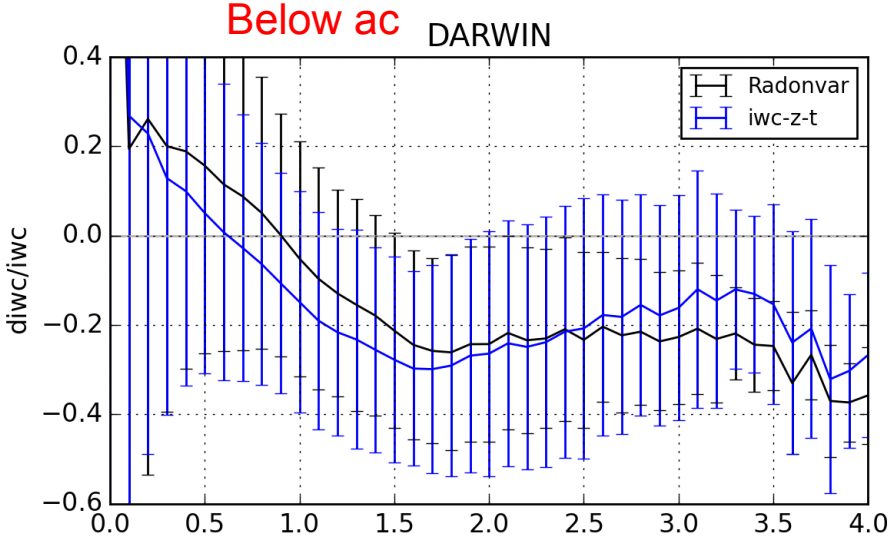


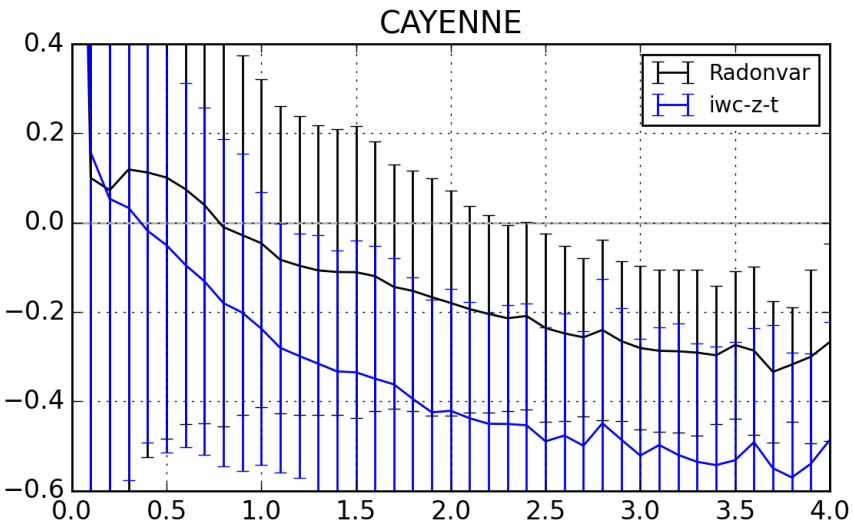
Above ac



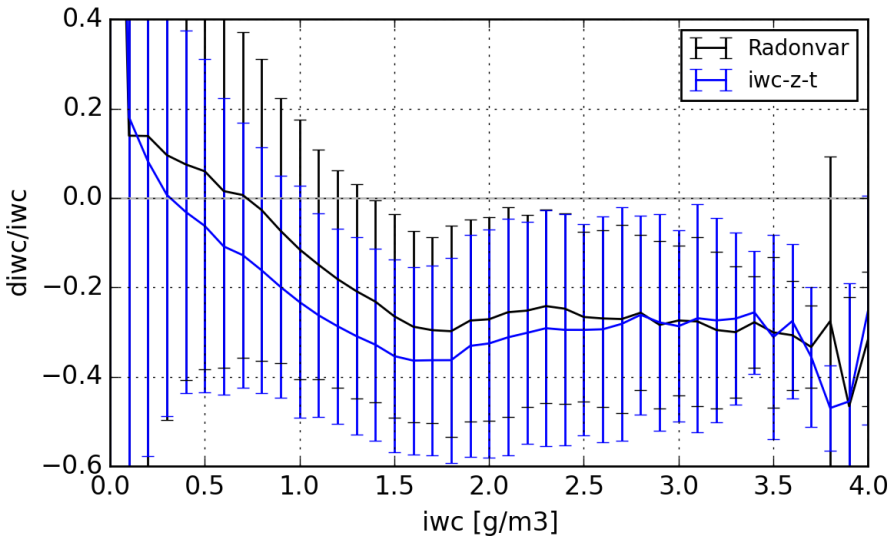
Radonvar evaluation at ac altitude

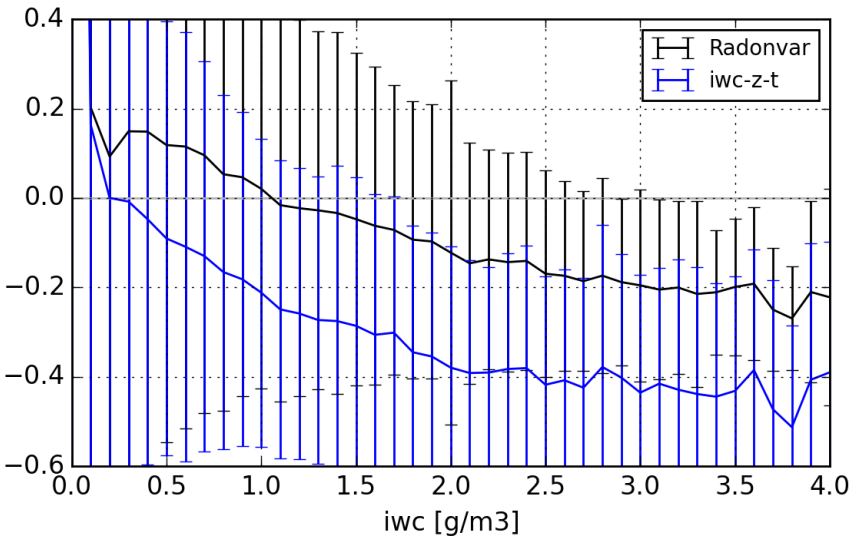
Below ac



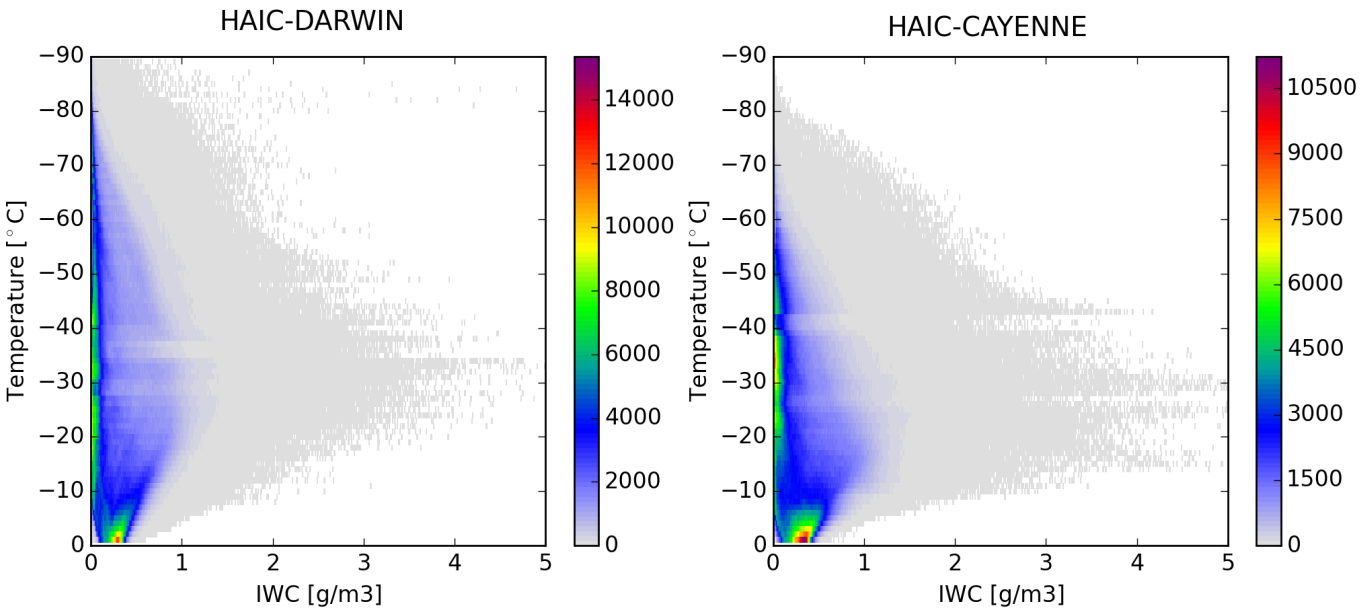


Above ac



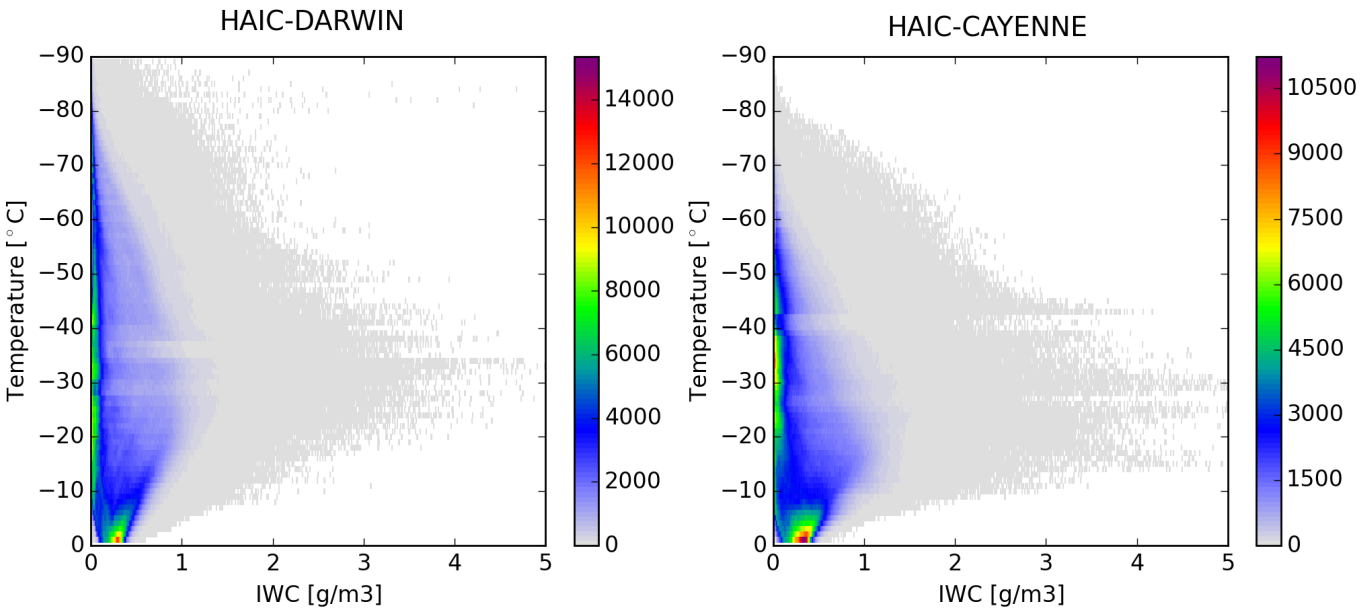


IWC distribution, radonvar (att) vs IWC-Z-T

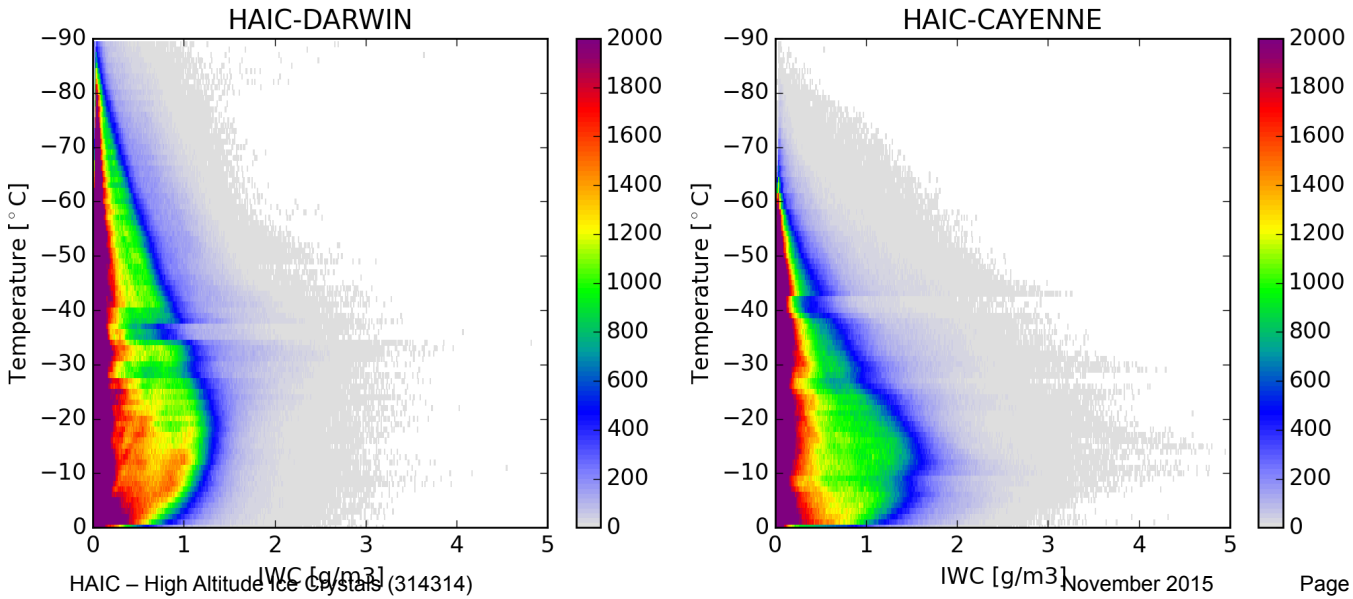


IWC-Z-T

IWC distribution, radonvar (att) vs IWC-Z-T

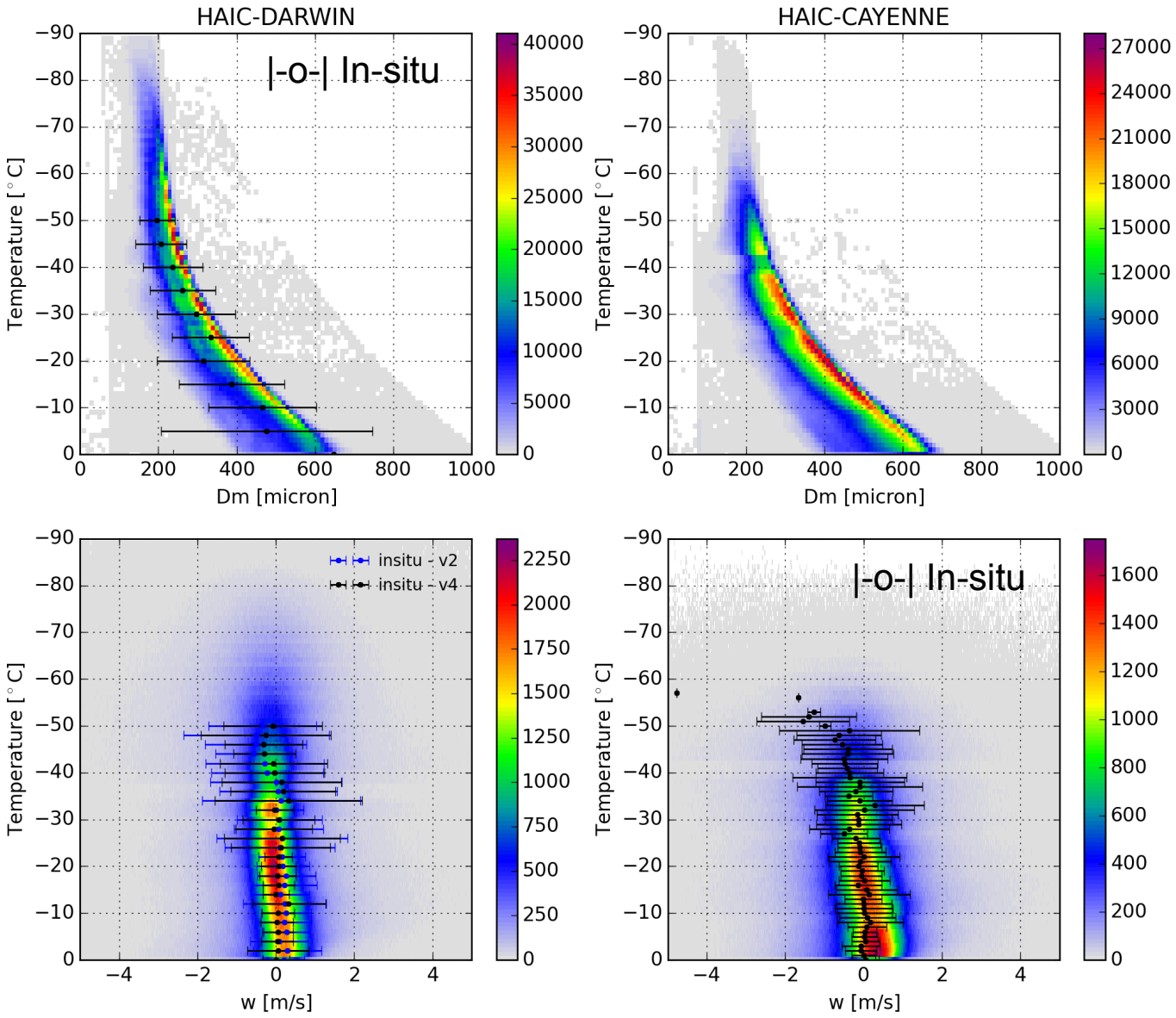


IWC-Z-T



Radonvar with attenuation correction

Dm and W evaluation



Work to be done

- Check w retrieval near melting layer / improve retrievals near the melting
- Check Z (no att) at different altitudes
- Validation off ac altitude using Cayenne measurements (IKP and Z from Convair)
- X-band reflectivity simulations

High Altitude Ice Crystals (HAIC, 314314)

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