Presented by

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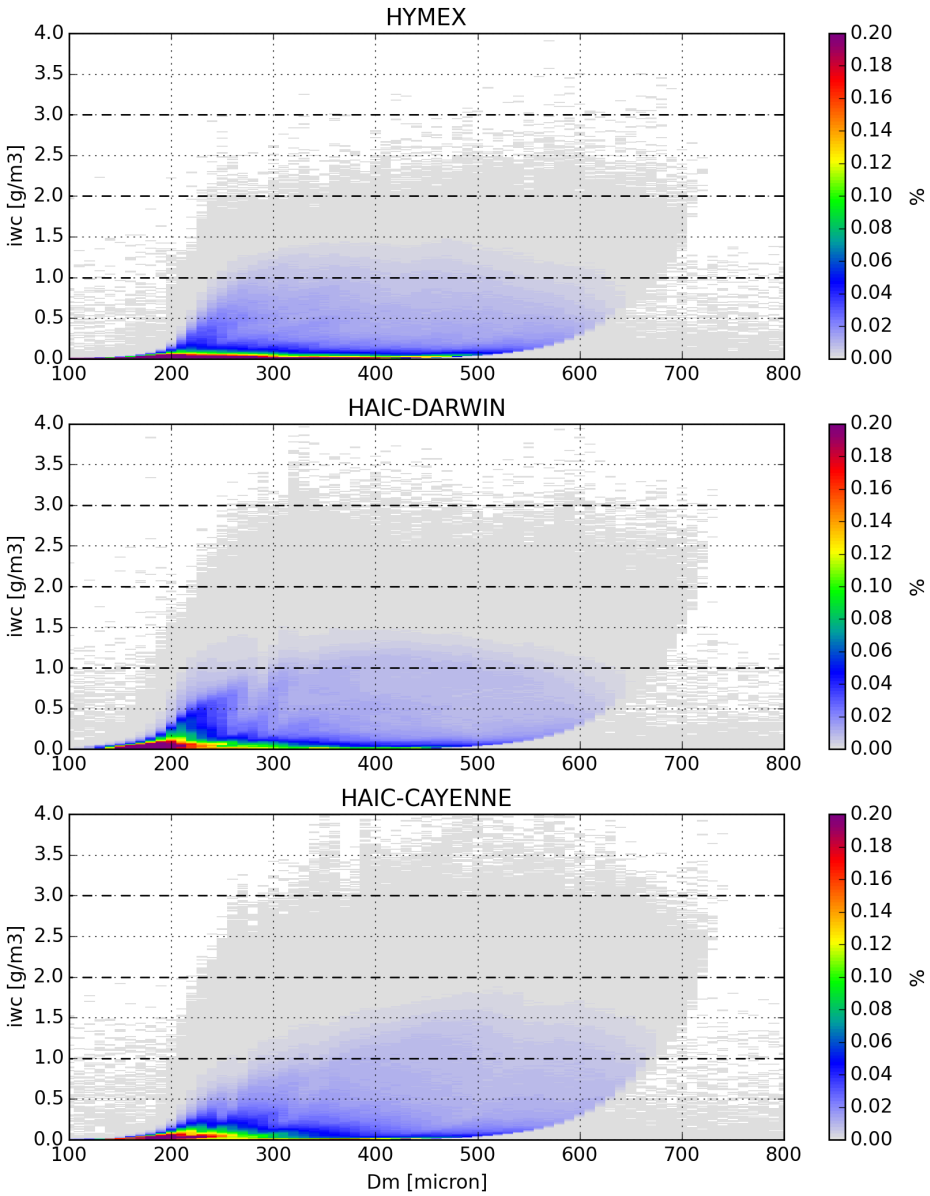
W-band measurements of the HIWC environment

09/11/2015

Unique contributions of cloud radars in this project

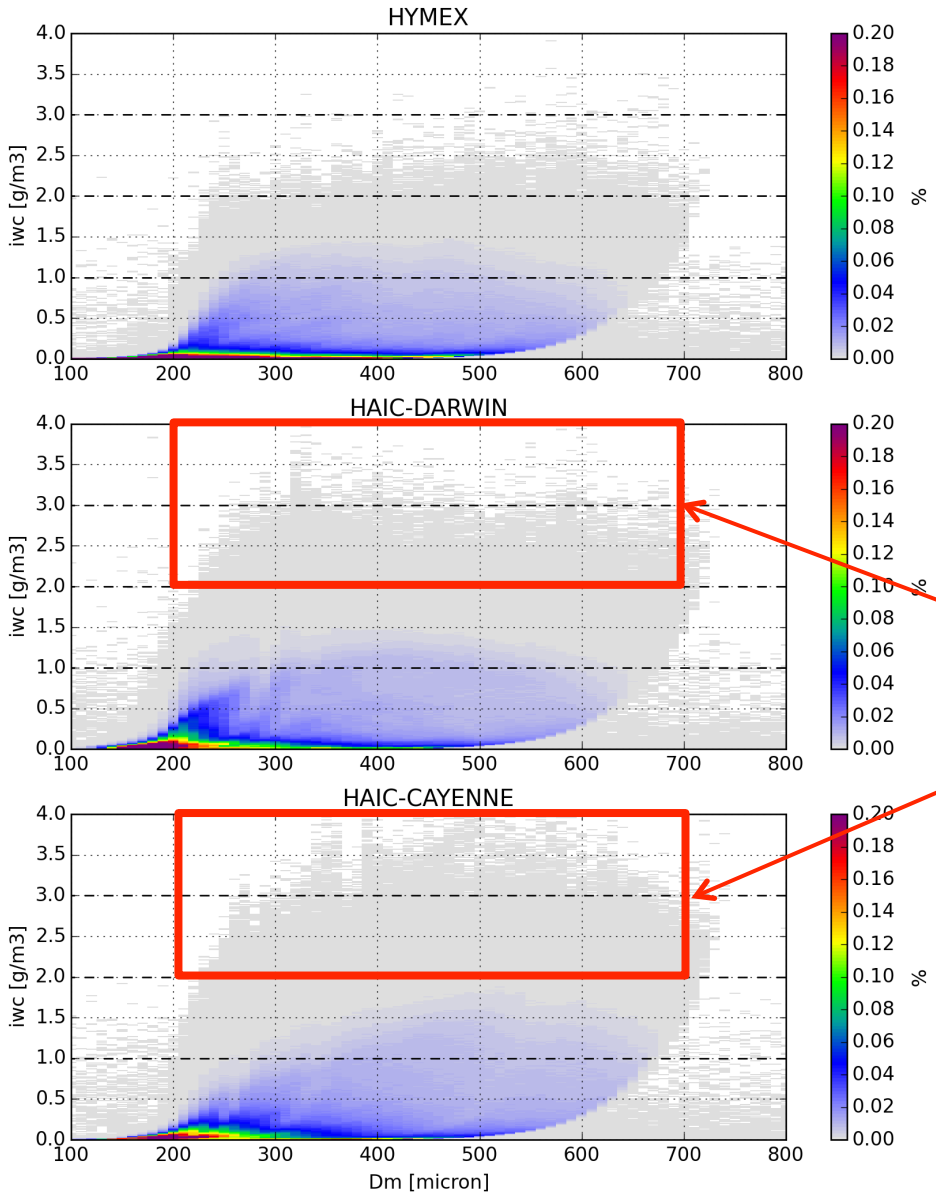
- Provides IWC(T) and MMD (T) for each IKP IWC and PSD MMD at ac altitude. Much greater number of samples + many temperatures not even characterized with IKP & PSD. => extend in-situ measurements
- Provides convective index / vertical air motion
- Provides other microphysical parameters : terminal fall speed, visible extinction, number concentration, effective radius to complement process studies using IWC and MMD.
- Provides reference for satellite W-band and passive remote sensing characterization of HIWC at global scale
- Provides reference for nowcasting tools (ALPHA, RDT)
- Provides 3D dynamical and microphysical reference for high-resolution models

IWC-Dm from radar measurements



IWC-diameter relationships for several campaigns

IWC-Dm from radar measurements



IWC-diameter relationships for several campaigns

High IWC conditions

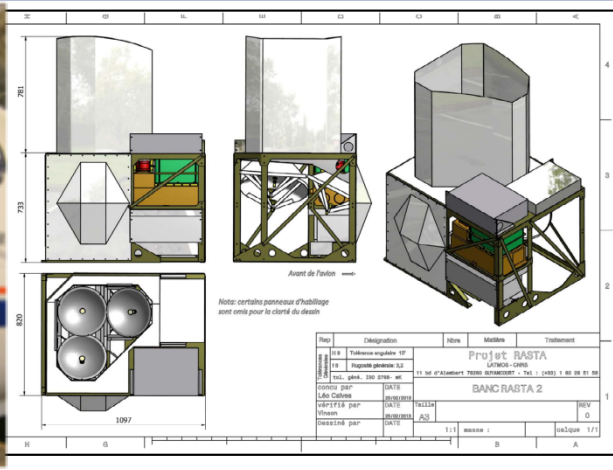
RASTA-F20

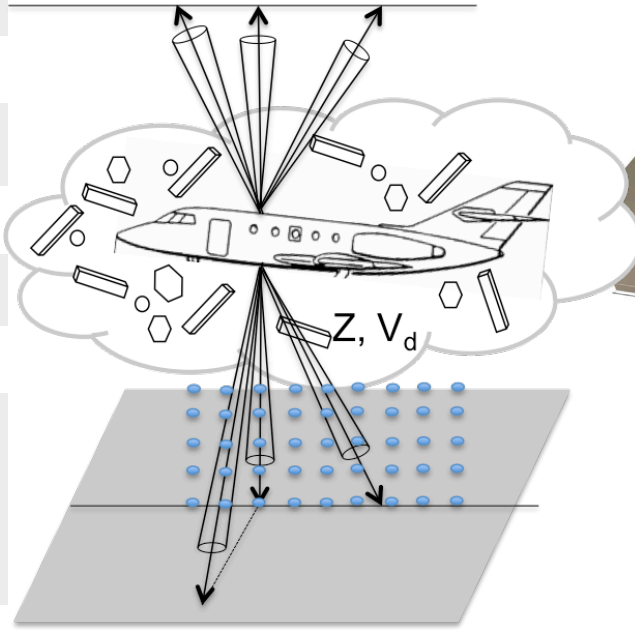
RASTAII - Description

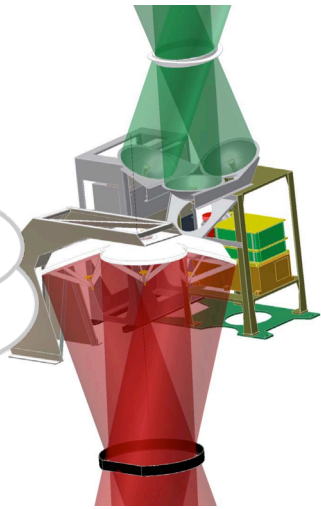
Cloud radar operating at 95 GHz (same as CloudSat)

- Unique feature is the 5-antenna system (only 2 flights with 6 antennas)
- Allows for 3D wind retrieval + cloud microphysics retrieval (including IWC)

5-6 antennas	
Frequency (GHz)	95 (3.2mm)
Vertical resolution (m)	60
Horizontal resolution (m)	225 to 300 depending on aircraft speed
Range (km)	15
Integration time (ms)	250 (measurement every 1.5 s for each antenna)
Energy (kW)	2 (pulse 0.4µs)
Ambiguous velocity (m s^{-1})	8
Antenna size (cm)	30 to 45 (0.7°/0.5° beam width)
Sensitivity at 1km (dBZ) – to be updated after calibration flight	• Down backward: -30 • Nadir: -30 • Down transverse: -30 • Zenith: -23 • Up backward: -30 • Up transverse: -19
Weight (kg)/dimensions (cm)	110/82x102x150







Cloud wind retrieval

Antenna angles

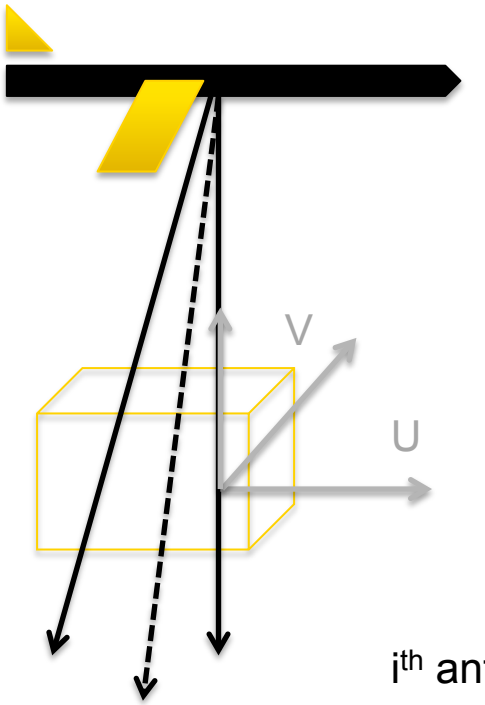
Radar measurements
(reflectivity + doppler velocity)

Coordinates of the data (lat/lon/height)

Wind field (3D) U,V,W
+
Terminal fall velocity Vt

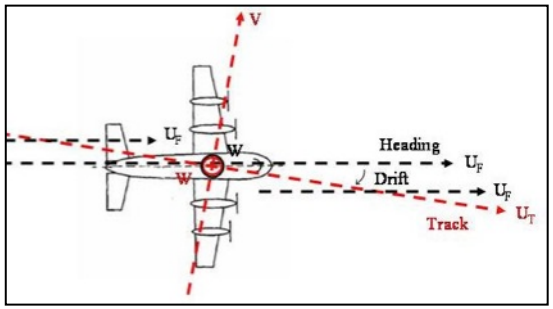
Vertical slices

- **U component:**
along the aircraft fuselage, positive towards the aircraft nose
- **V component:**
perpendicular to the aircraft fuselage



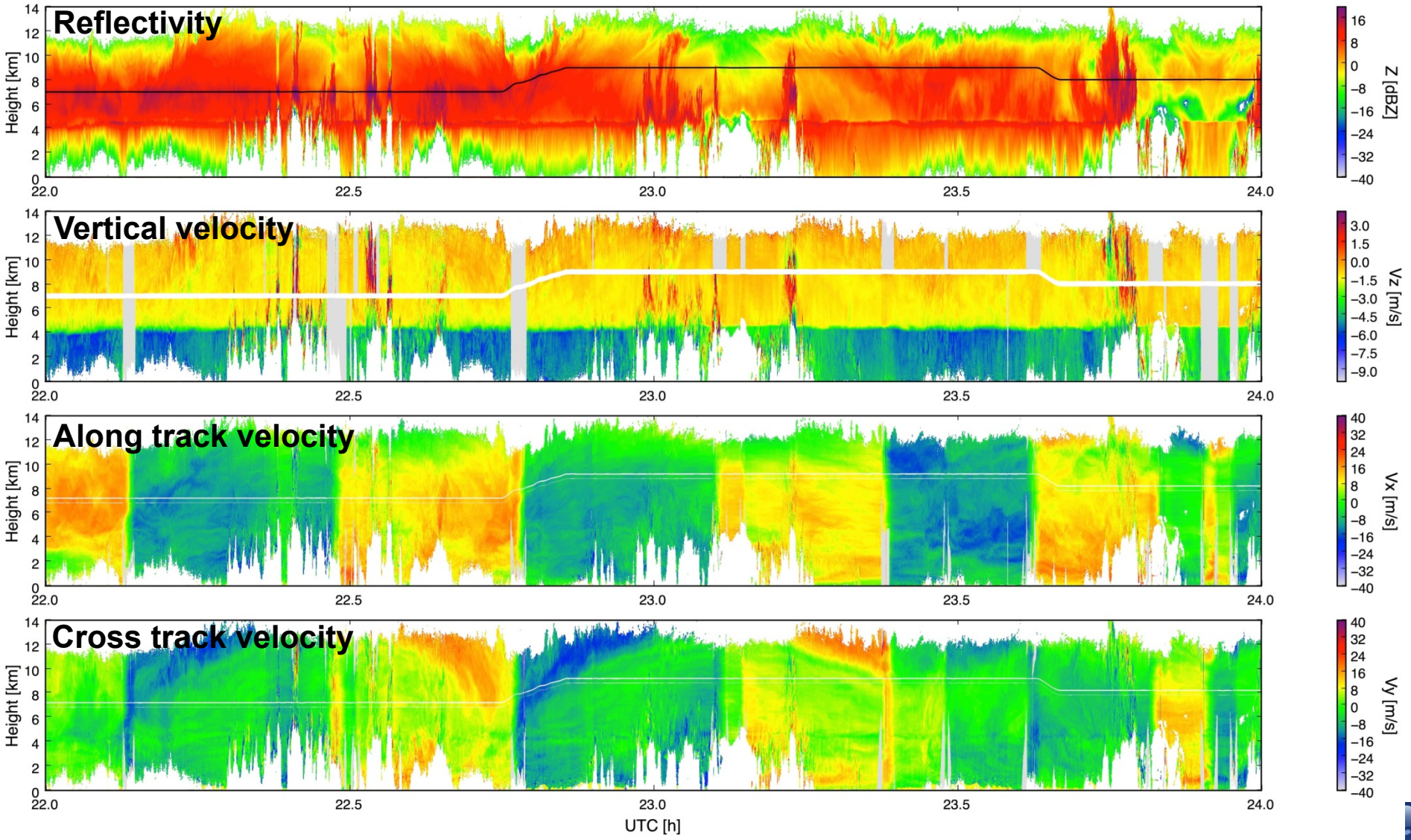
Variational approach, we iterate on U, V, Vt+W until computed Vr is close enough to measured Vr (minimisation)

$$\begin{cases} Vr_i = U_T * \cos(\lambda_i + 90 - Track) * \cos(\varphi_i) \\ +V * \sin(\lambda_i + 90 - Track) * \cos(\varphi_i) \\ +(W + Vt) * \sin(\varphi_i) \\ \dfrac{W}{H} = \dfrac{\partial U_T}{\partial X} + \dfrac{\partial V}{\partial Y} + \dfrac{\partial W}{\partial Z} \end{cases}$$

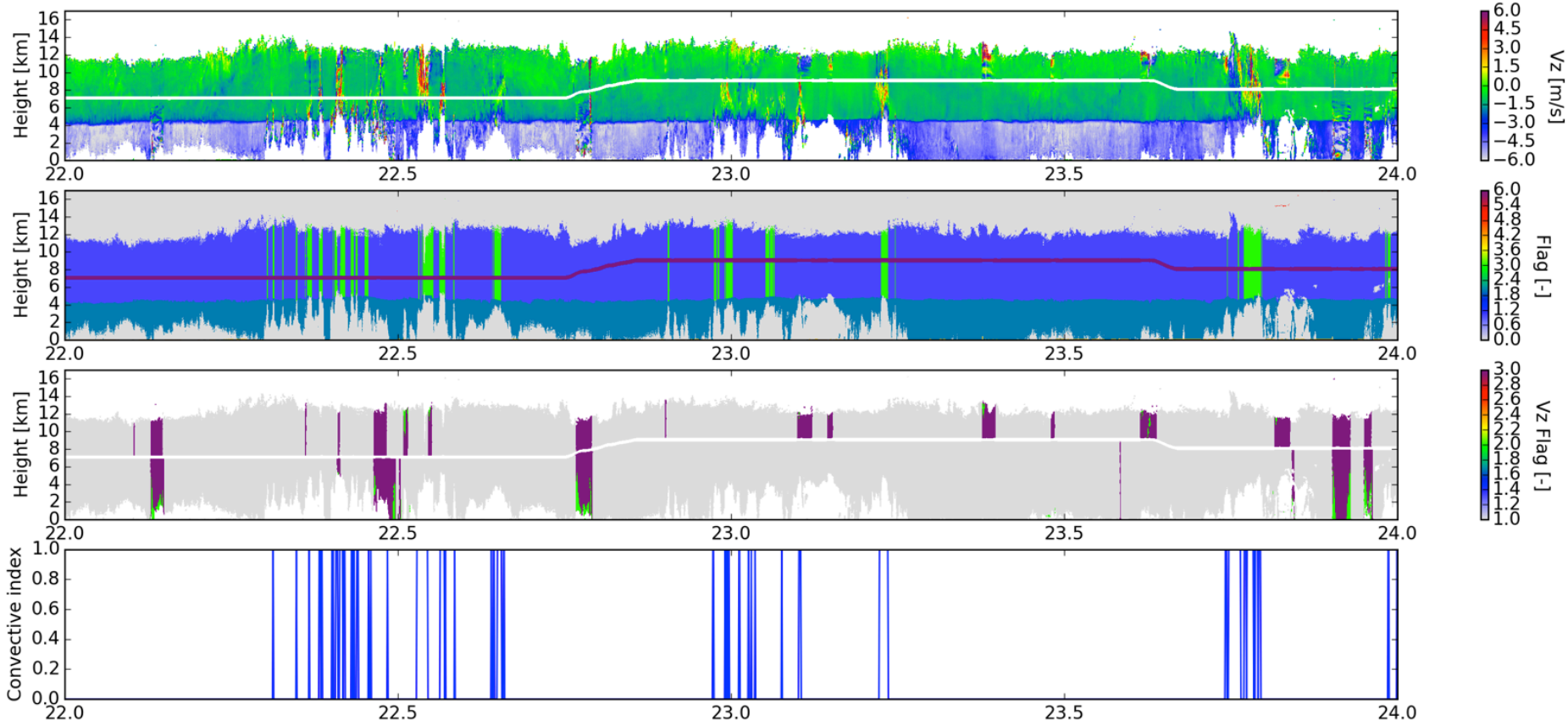


i^{th} antennas, V_r radial velocity, Φ_i elevation, λ_i azimuth, H constant

Cloud wind retrieval example



Convective Index - Attenuation flag



Vz flag: 1: good confidence / 2: should not be used / 3: could be used but carefully

Attenuation flag: 0 no cloud / 1 ice / 2 rain (attenuated) / 3 ice but likely attenuated / 4 ground / 5 ghost ground / 6 interpolated

From W-band measurements to Ice Microphysics

RADONVAR technique

- Inputs :
- Z, Vz = (W+V_T) from RASTA (V_T : ice terminal fall speed, W: vertical air velocity), Temperature

- Microphysical model :
- Statistical relationship between V_T , Z and IWC derived from IKP
- CNRS/LAMP PSD-derived relationships between A(D) and M(D) exponents
- V_T = f (Z, D_m, T)

‣ IWC can also be retrieved using IWC-Z-T relationships (Protat et al 2015, submitted). Based on RASTA and IKP measurements at flight level. IWC-Z-T is used as a priori values

- Outputs :
- IWC, W

→ Then Dm, N0*, R_{eff}, extinction, N_T … can be calculated

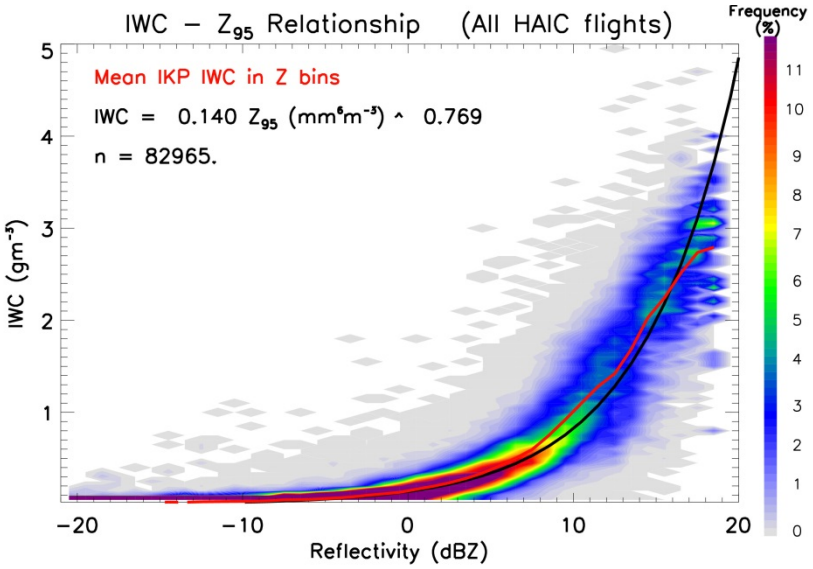
→ New version accounting for ice attenuation (cf research update talk)

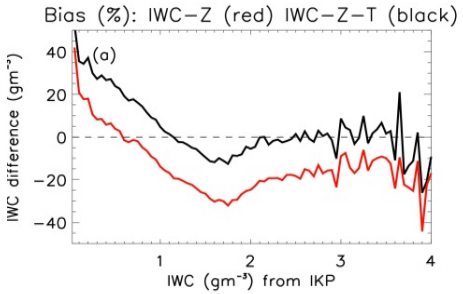
Simple IWC – Z – T : how accurate ?

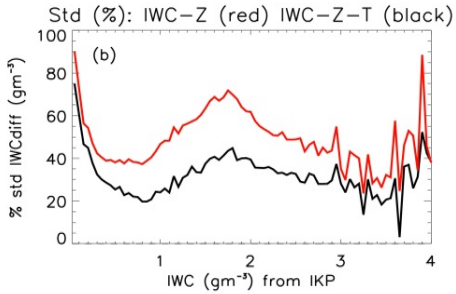
Protat et al. (2015, submitted to JAMC)

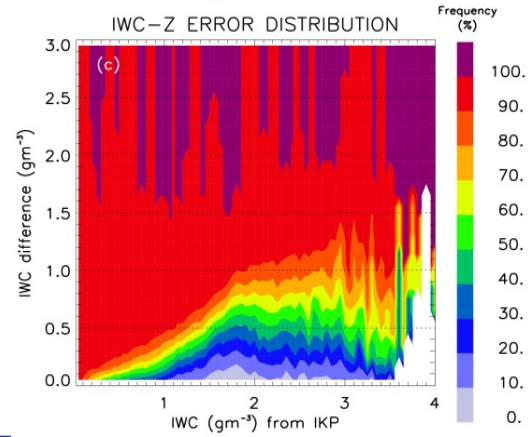
Main results :

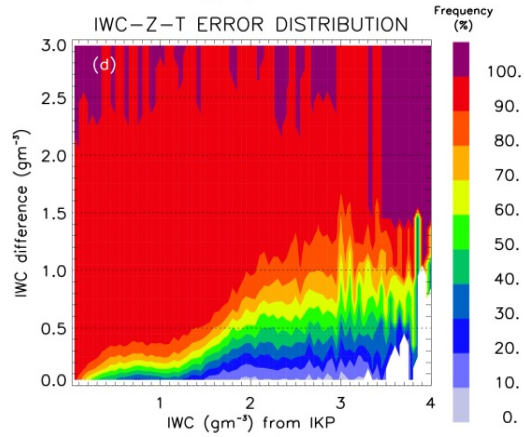
- IWC – Z relationship well defined but varies a lot with T
- IWC can be obtained from Z and T with less than 20% bias and 40% std
- Using convective / stratiform classification (convective index with RASTA) reduces these errors further for convective regions (10% bias, 30% std)
- Larger errors in the [-10 °C - 0°C] range.
- Darwin dataset :



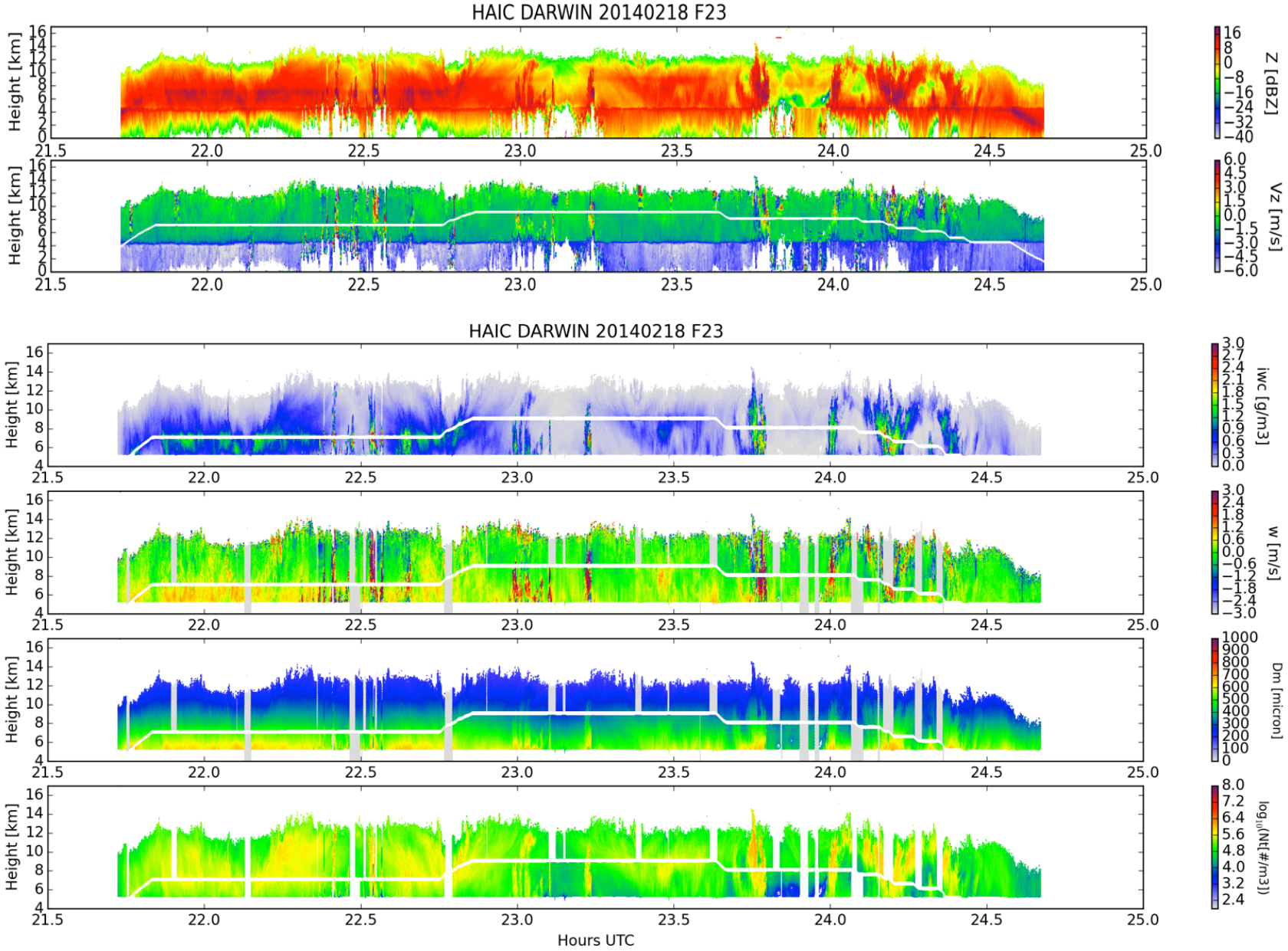




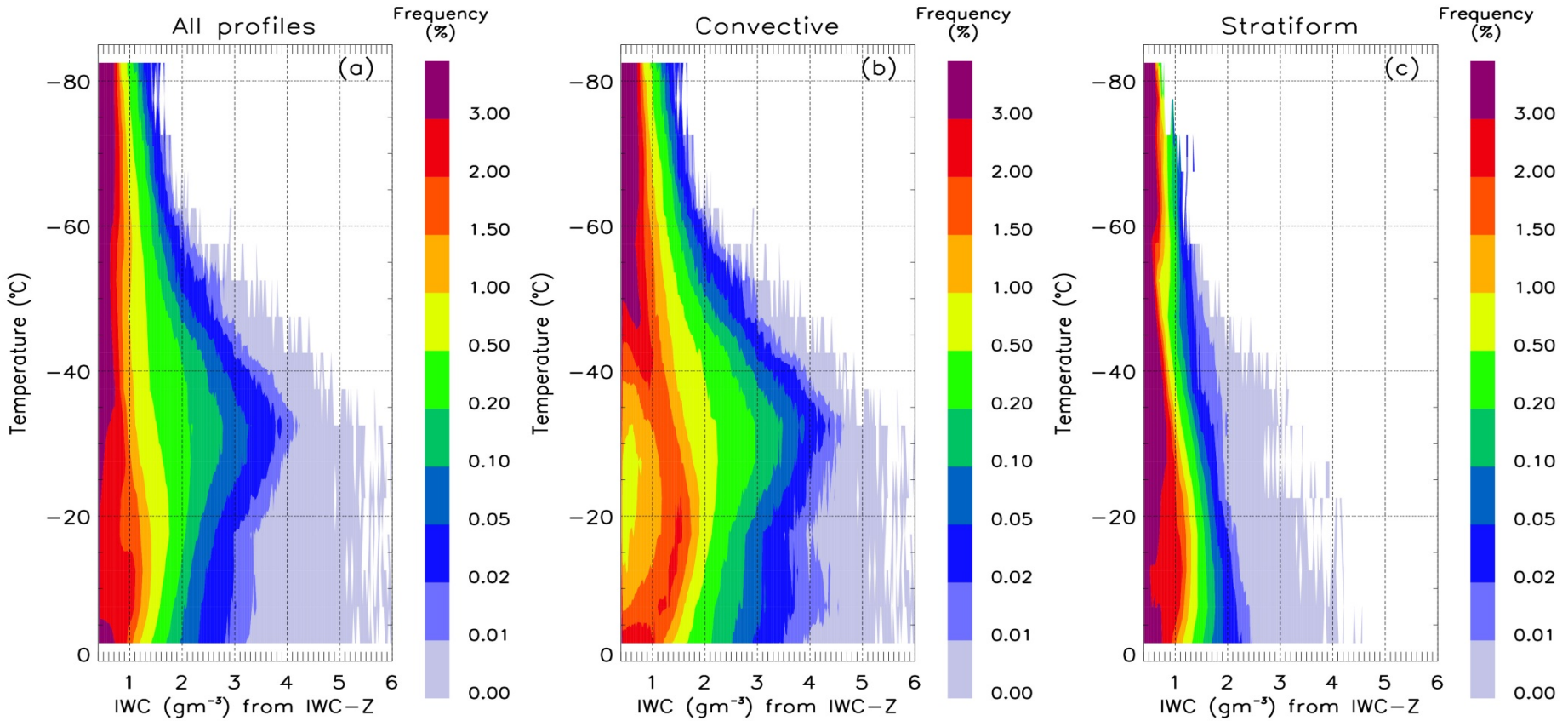




More elaborated Radonvar technique



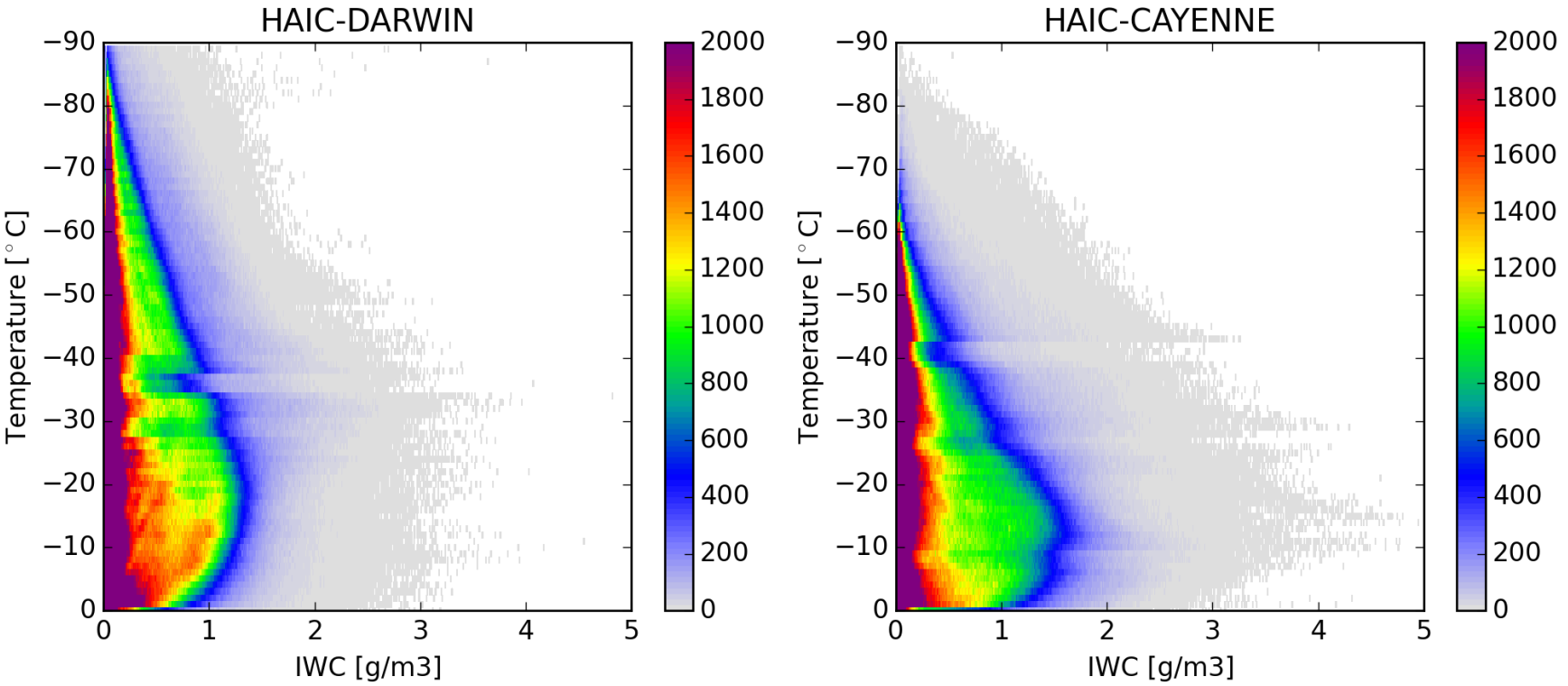
Darwin IWC stats with RASTA IWC-Z-T



IWC > 4 gm^{-3} (5 gm^{-3}) not found at all at temperatures colder than -50°C (-35°C)
IWC > 4 gm^{-3} exclusively found in convective profiles
IWC > 3 gm^{-3} almost exclusively found in convective profiles for T < -25°C
At the -50°C level IWC > 1.5 gm^{-3} exclusively found in convective profiles !

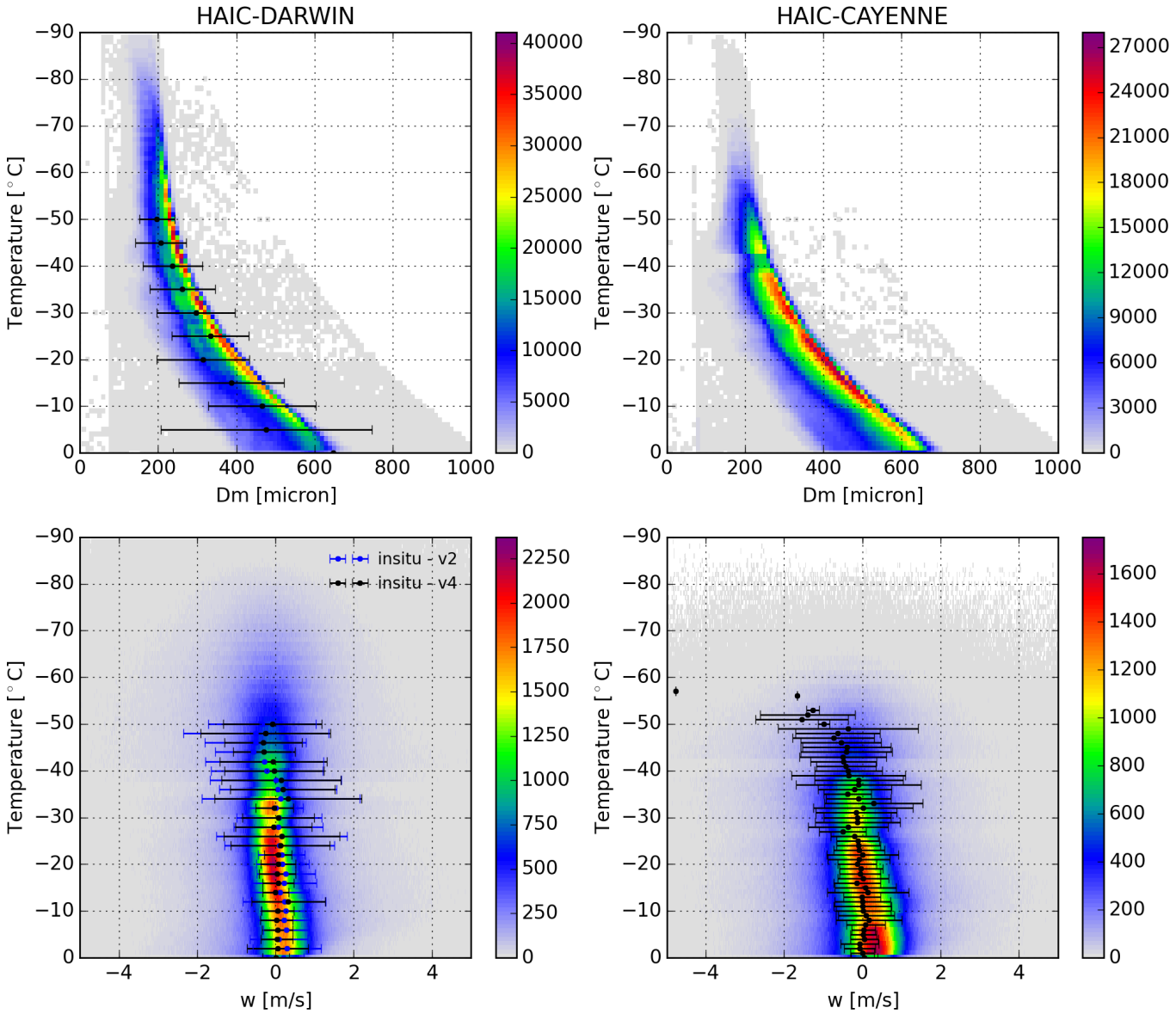
IWC stats: Darwin versus Cayenne

- IWC from radonvar technique based on RASTA measurements (all flights) => including attenuation correction



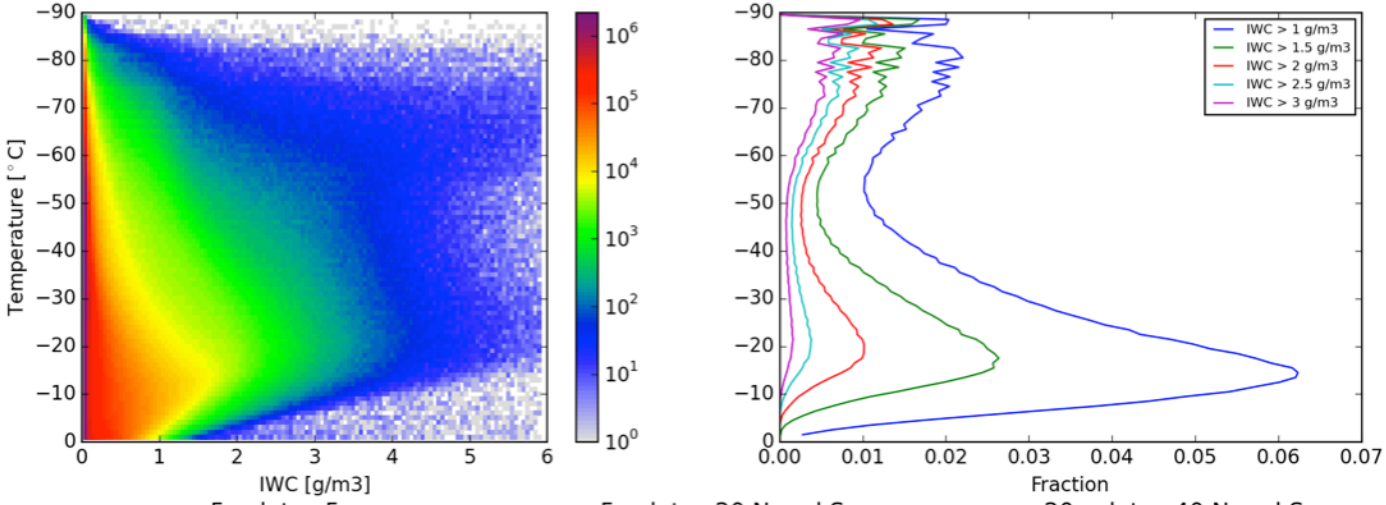
Preliminary

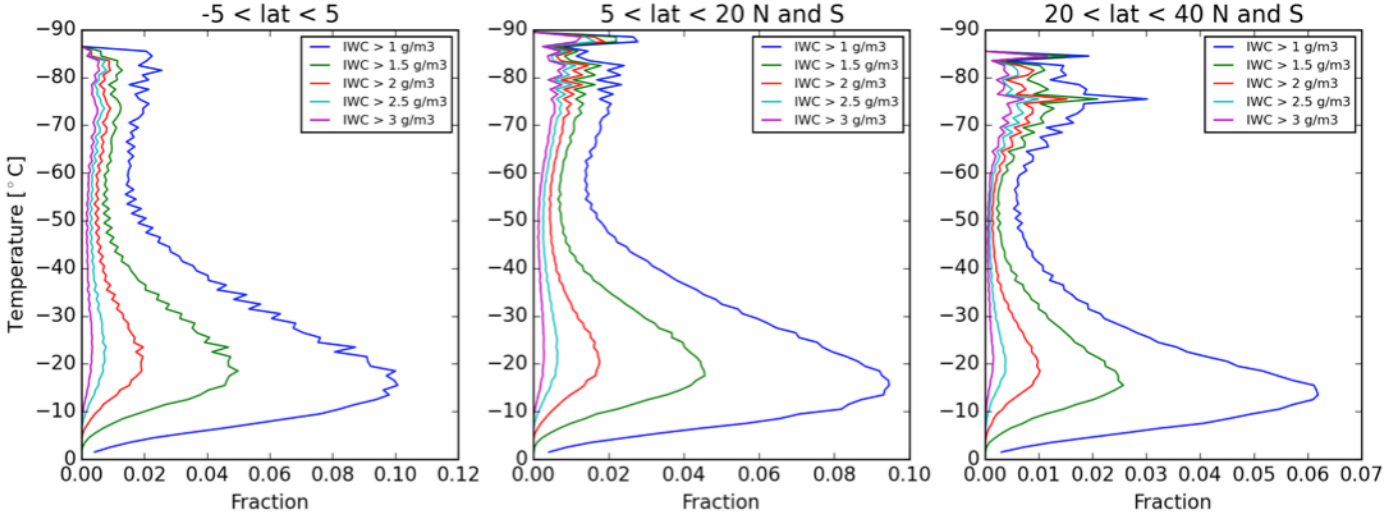
W and Dm stats: Darwin versus Cayenne



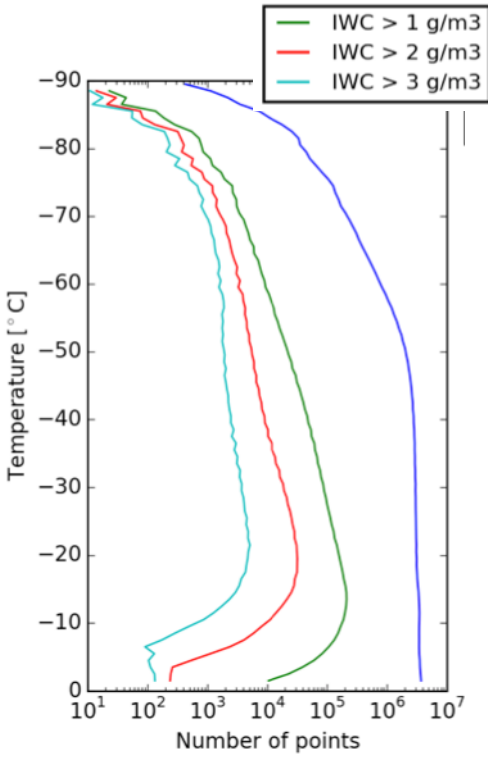
From HAIC-HIWC to the global scale: CloudSat !

- We use the same IWC-Z-T relationship (the one derived from RASTA and IKP)





About 2 years of data



High Altitude Ice Crystals (HAIC, 314314)

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