RASTA, AN AIRBORNE TOOL FOR CLOUD STUDIES

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RASTA's objectives

- Cloud processes, case study
  - Doppler and reflectivity measurements
  - Ice water content, size of hydrometeors
  - Dynamics of the cloud system (vertical and horizontal)
- Satellite evaluation/validation (CloudSat) + airborne demonstrator (EarthCare/DYCECT)
- Synergy with in situ measurements (validation/improvement) :
  - radar+insitu => extend the range of the in-situ measurements
- Tropical campaigns:
  - MT-AFRICA (August 2010, 11 flights)
  - MT-MALDIVES (Nov-Dec 2011, 12 flights)
  - HAIC-DARWIN (Jan-Feb 2014, 22 flights)
  - HAIC-Cayenne (May 2015, 16 flights)
- Middle Lat campaigns
  - LNG-CALIPSO (Nov 2010)
  - HYMEX (Sept Nov 2012)
- Polar campaign
  - POLARCAT (2008)

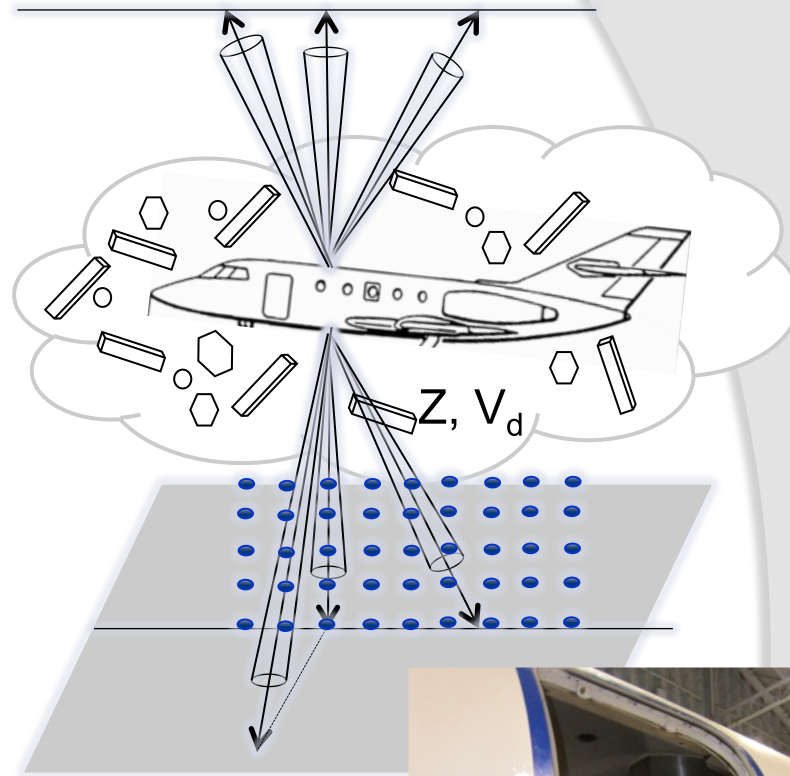
RASTA characteristics

	RASTA (Doppler radar)
Wavelength (Frequency)	3.2 mm (95.04 GHz)
Vertical resolution (m)	60
Range (km)	15
Integration time (ms)	250
Energy	2kW
Ambiguous velocity (m s-1)	8
Sensitivity	~-40dBZ@1km (depends on config)
FALCON speed (m s-1)	150-200

RASTA

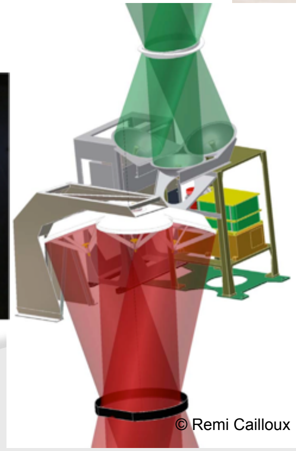
RASTA configuration:

- Airborne W-band radar @94 GHz (sensitivity -25 -40dBz depending on configuration)
- Doppler: radial velocity
- Multi-antenna (5 to 6) configuration



Why several antennas?

- Doppler velocity along 6 different directions => cloud wind retrieval: U, V, W+Vt
- Vertical velocity measured => combined with reflectivity we can retrieve ice cloud properties (RadOnvar)



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LATMOS

- Wind
- Microphysics

Retrieval techniques

Cloud Wind

Cloud WIND

Antenna angles

Radar measurements (reflectivity + doppler velocity)

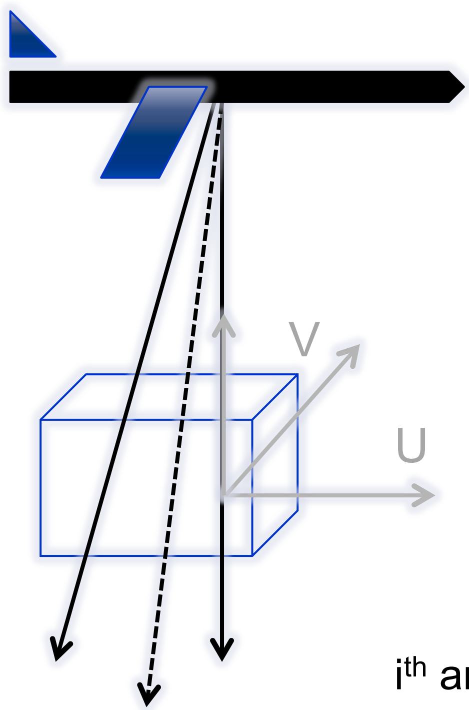
Coordinates of the data (lat/lon/height)

→

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

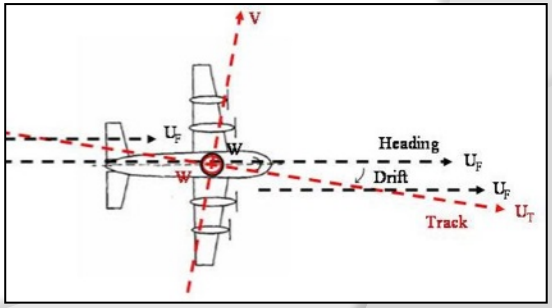
Vertical slices

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



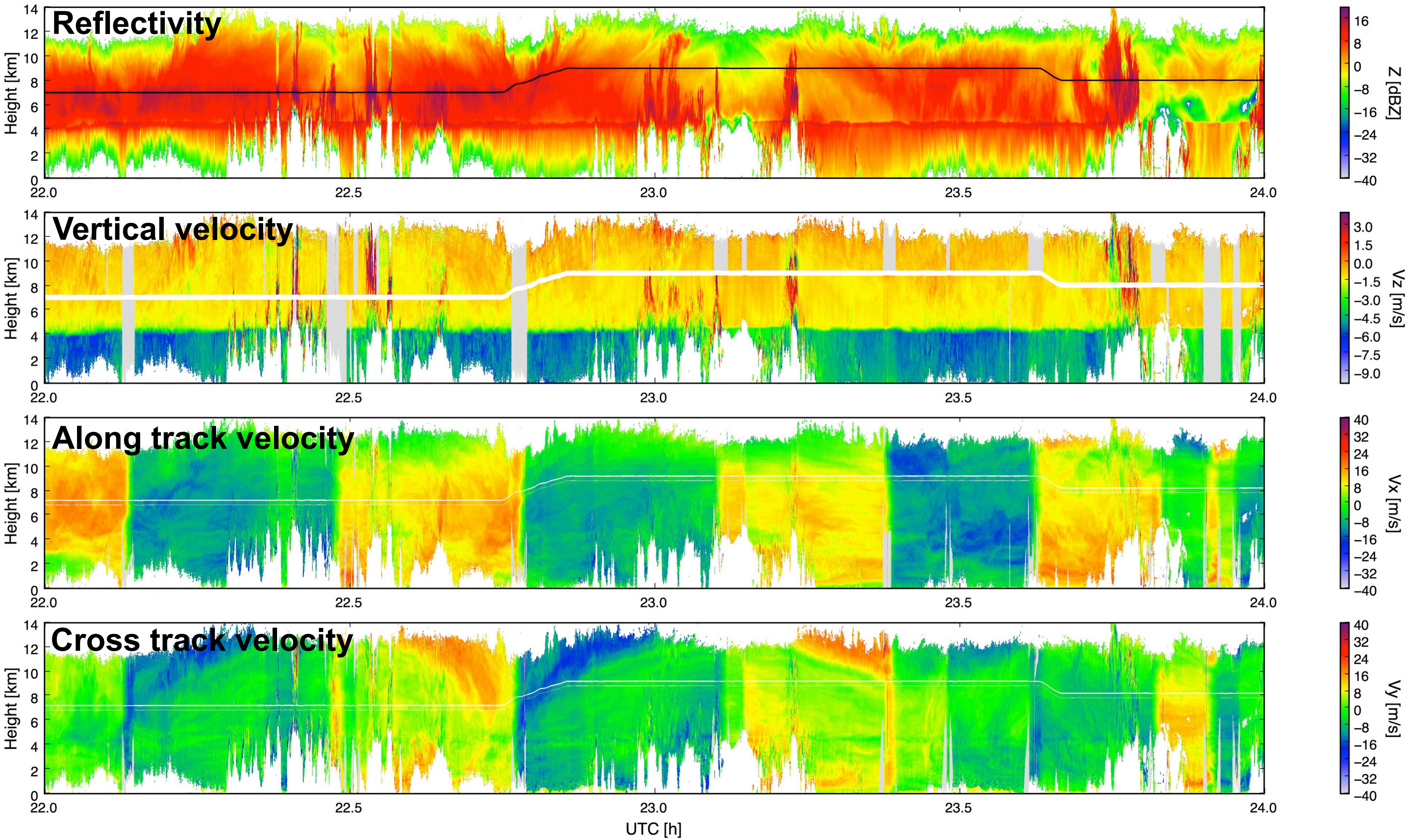
Variational approach, we iterate on U, V, Vt+W until computed Vr is close enough to measured Vr (minimisation)

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



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

Retrieval examples



Cloud microphysics

From RASTA measurements to ice microphysics

Based on the RadOn technique (Delanoë et al., 2007, JAMC)

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 relationship between A(D) and M(D) exponents

$V_T = f(Z, D_m, T)$

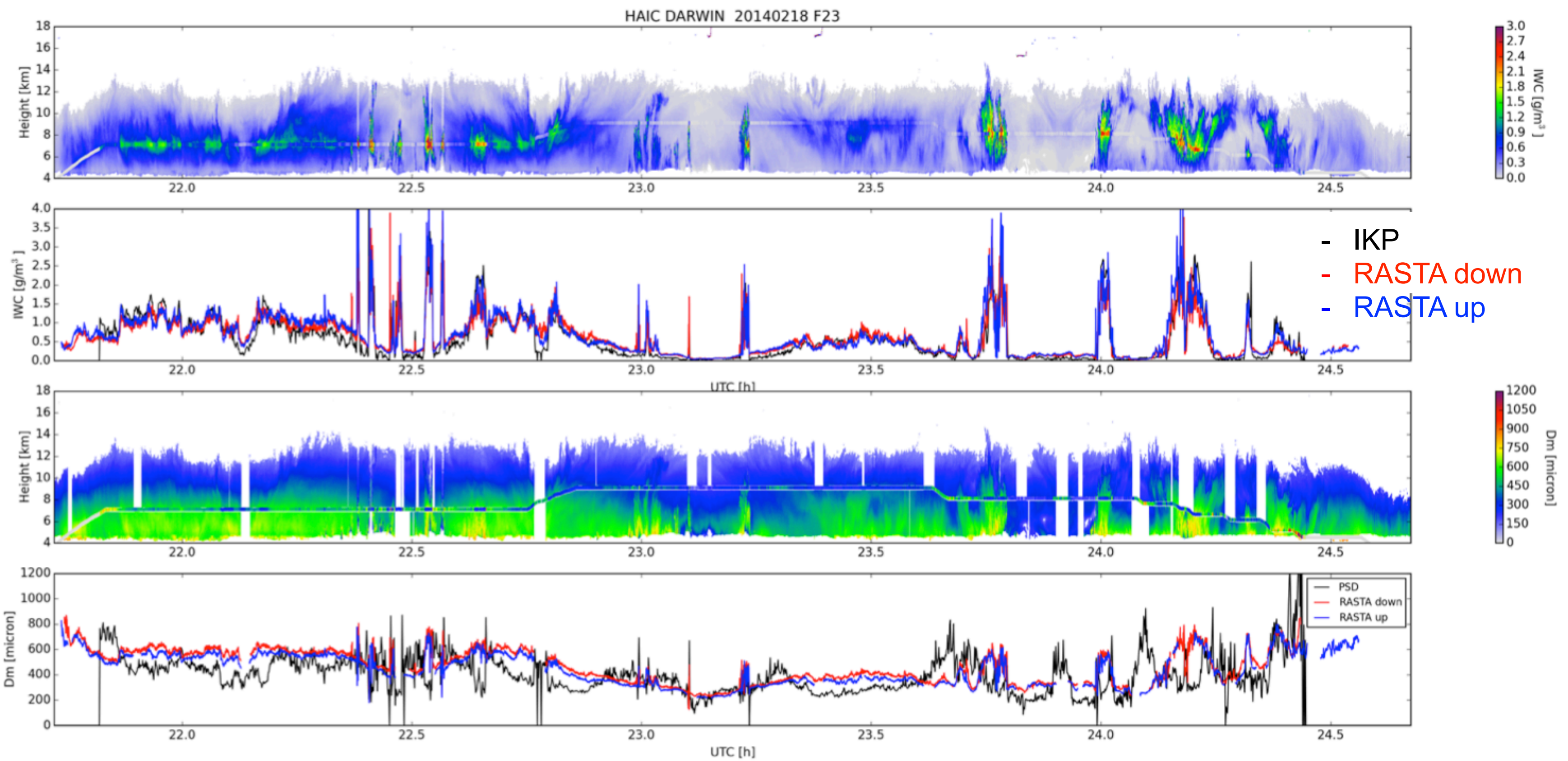
IWC can be retrieved using IWC-Z-T relationships (Protat et al 2015, submitted). Based on RASTA and IKP measurements

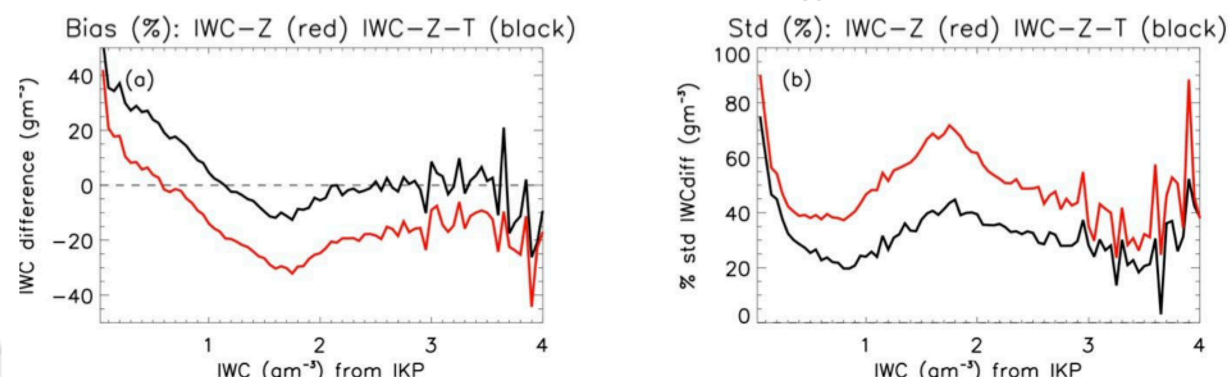
Outputs :

IWC, D_m, W

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

IWC example– validation during HAIC





Protat et al. 2015

Validation at aircraft's altitude:

- In-situ probes (2DS-PIP, LAMP)
- Isokinetic probe (IKP, NASA) => bulk IWC measurements

RASTA products

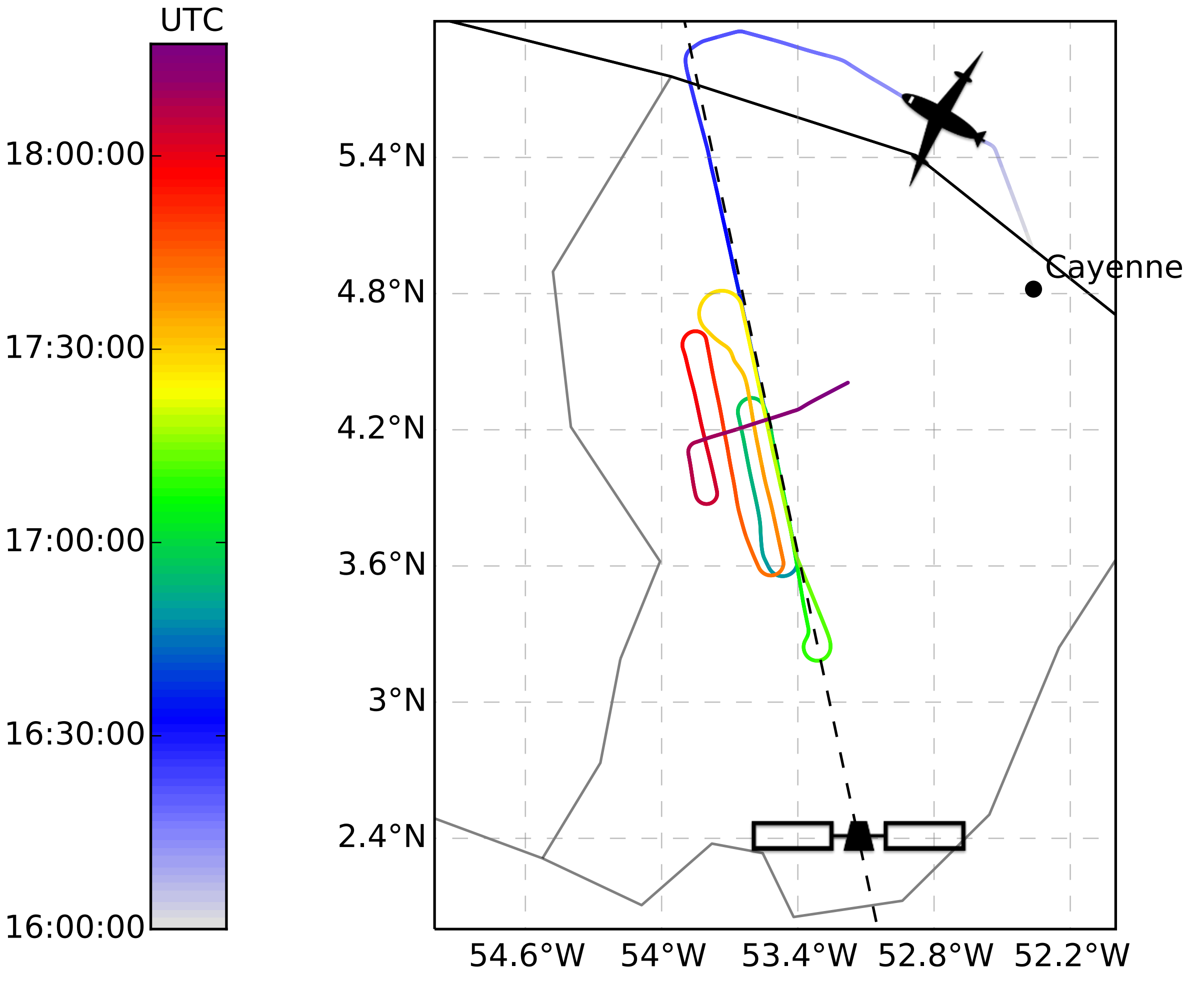
data	description
One file per antenna (Instrument oriented)	
L0	netcdf file containing Z and Doppler velocity uncorrected. 1.2 s horizontal / 60 m vertical
L1	netcdf file containing Z (calibrated) and Doppler velocity uncorrected. 1.2 s horizontal / 60 m vertical
L2	netcdf file containing Z (calibrated) and Doppler velocity (aircraft velocity component removed, unfolded). Radar gates are geo-located. Interpolation between upper/lower domain and correction of reflectivity near the aircraft. Z is corrected near the aircraft. 1.2 s horizontal / 60 m vertical
Geophysical products (variational techniques)	
3D WIND	V_z (vertical velocity), V_x (along track velocity), V_y (cross track velocity)
Ice cloud microphysics	IWC, D_m (mean volume diameter), Re (effective radius), W (vertical air motion), Vt (ice terminal fall speed)

RASTA synergy

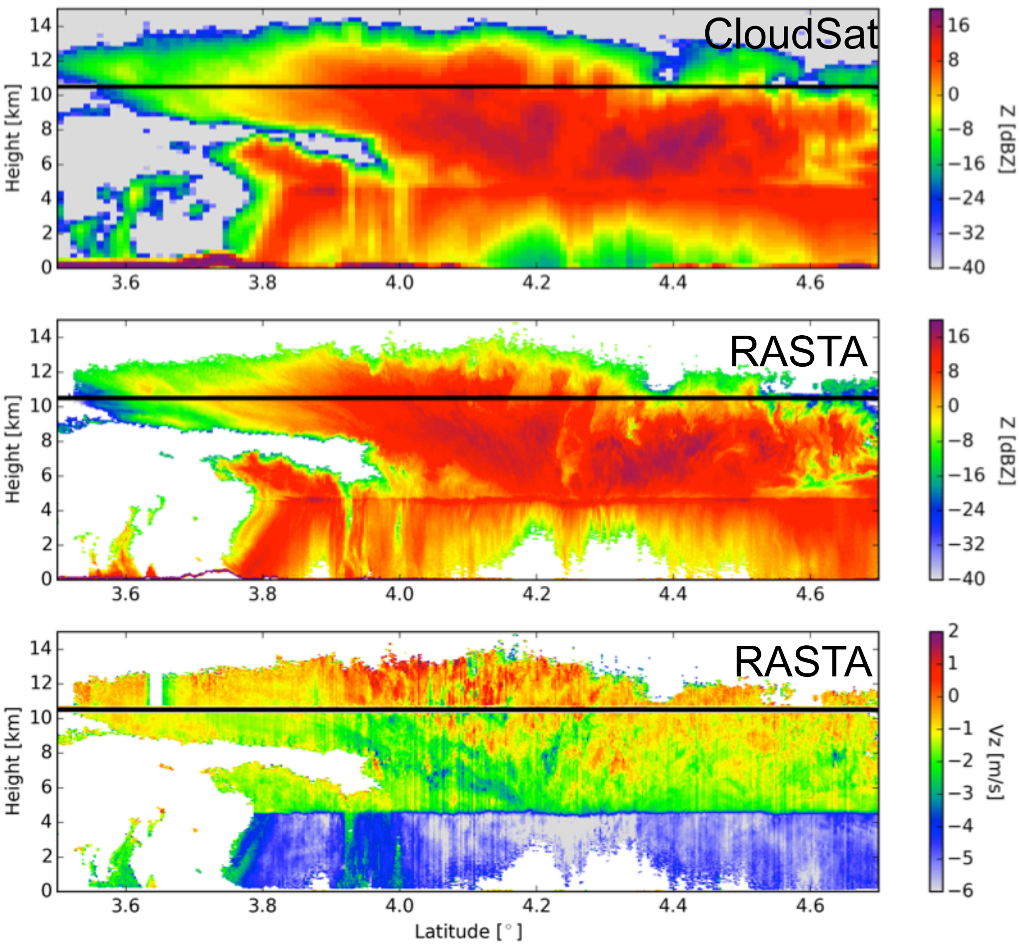
- RASTA+LNG radar-lidar
  - Ice/liquid detection
  - Size + concentration of ice particle
  - Cloud and aerosol
- RASTA + in-situ
  - In-situ information is extended using radar retrieval
  - Closure Z and in-situ => Mass-size-relationship / IWC retrieval
- RASTA + passive microwave
  - Integrated constraint => ice and rain

RASTA and CloudSat

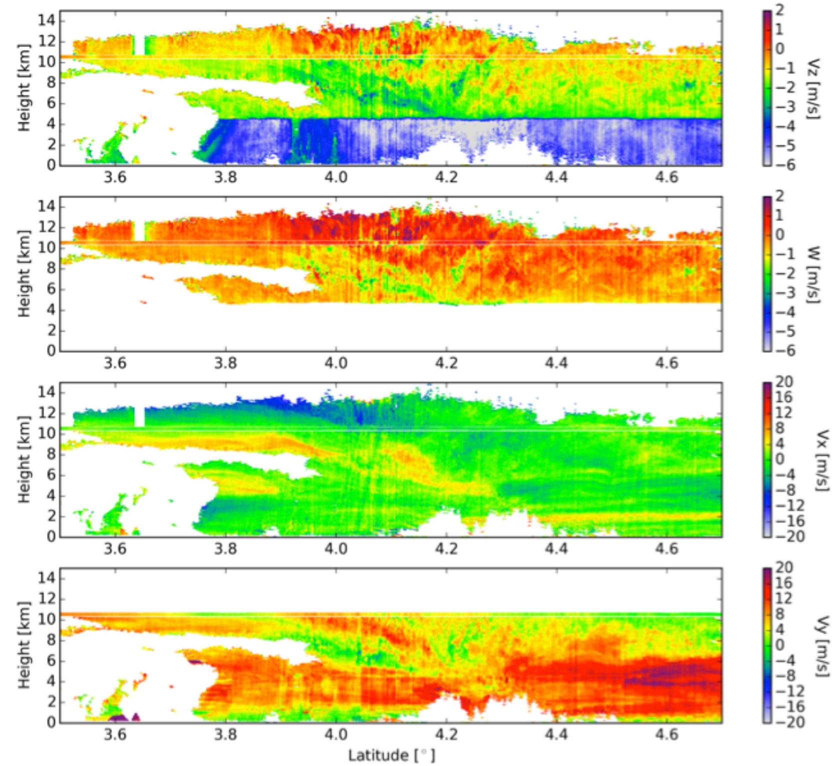
CloudSat – F15 16/05/2015



CloudSat – F15 16/05/2015



RASTA



RASTA evolutions

- Future campaigns
  - RALI campaign (Dec 2015)
  - NAWDEX (Fall 2016)
- Technical evolution
  - New acquisition system
  - New switches
  - Polarimetric capability (starting in 2016)