# Preparation of the ADM-Aeolus mission using 355nm high spectral resolution Doppler LIDAR and a Doppler cloud radar

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ANR-DIP NAWDEX



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# Context

- Infer clouds and aerosol dynamics using airborne RADAR-LIDAR measurements
  - LIDAR-Doppler (HSR LNG), RADAR (RASTA) and Dropsonde measurements were performed during the Iceland NAWDEX/EPATAN campaign
  - LNG performed nadir wind measurements and at 37° off vertical during specific flights to simulate ADM-Aeolus observations

- Prepare future ADM mission : science and CAL/VAL operations in collaboration with DLR

**Present our airborne RADAR-LIDAR platform for cloud/aerosol dynamics**

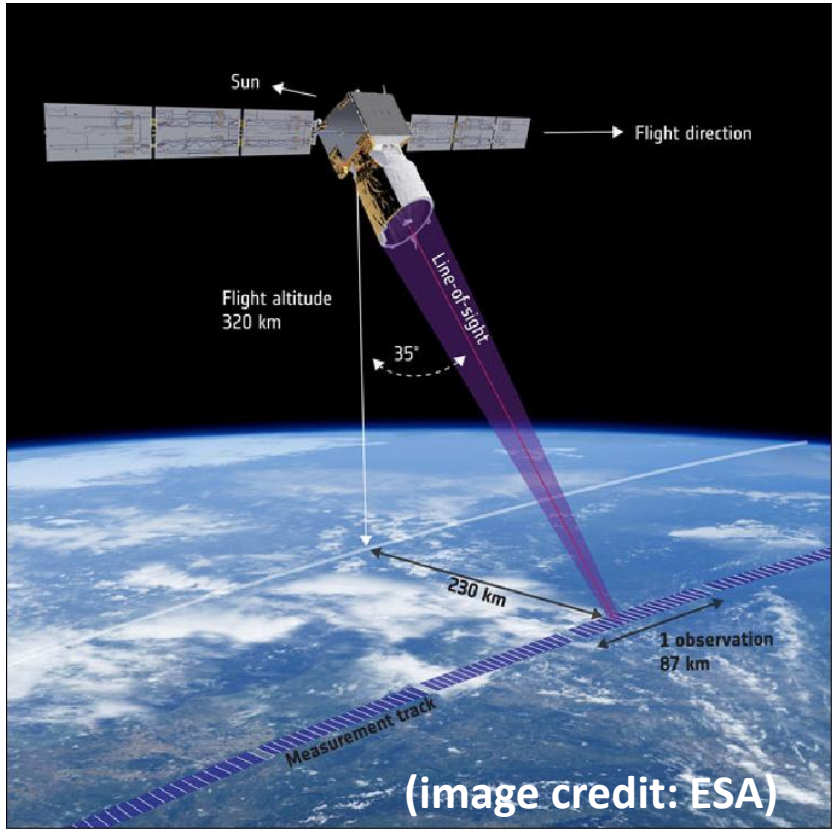
  - First results obtained from airborne data recorded during the Iceland campaign
  - RADAR and LIDAR wind measurements; assessment of retrieval uncertainties

# ADM-Aeolus mission

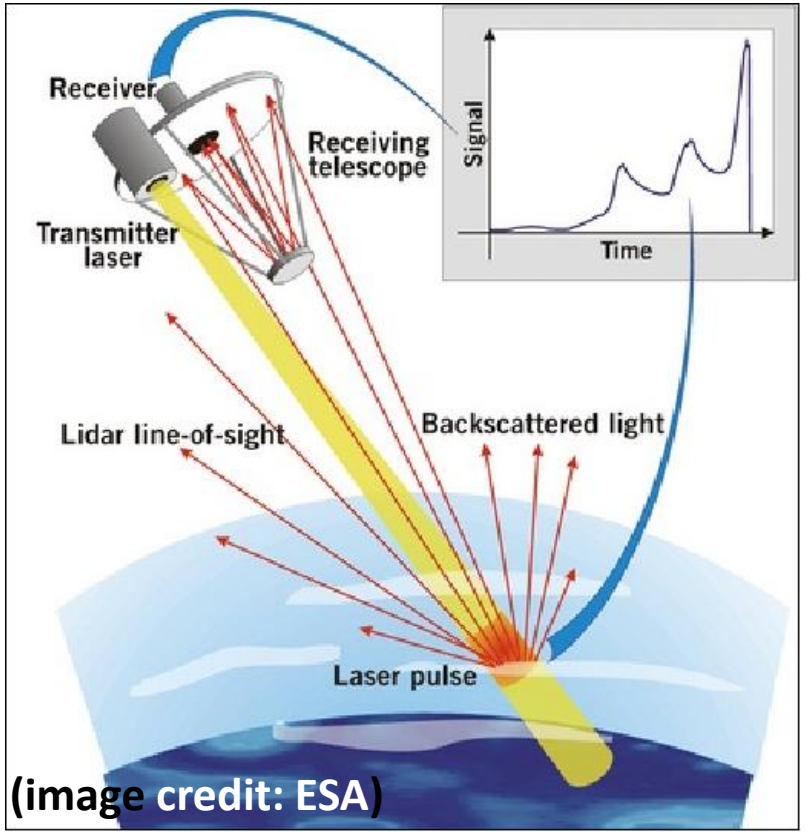
(https://directory.eoportal.org/web/eoportal/satellite-missions/a/aeolus)

**Main objective**: wind profile measurements for studying the dynamics of the atmosphere.

Observations will be performed with the Doppler Wind Lidar (**ALADIN**) at 355 nm.
Wind measurements will be obtained from Doppler shifts of backscattered lights by aerosols, clouds and molecules.




(image credit: ESA)

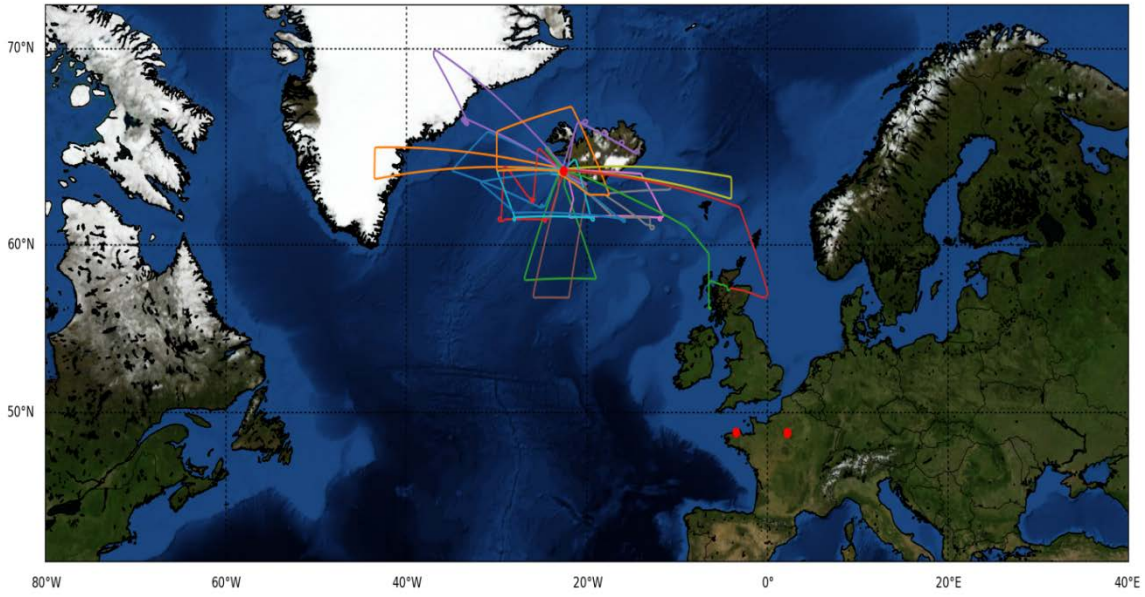



(image credit: ESA)

# NAWDEX/EPATAN Iceland campaign

**2016: N**orth **A**tlantic **W**aveguide **D**ownstream and impact **Ex**periment (Schäfler et al. 2018) / **E**arthcare **P**repar**AT**ion c**A**mpaig**N**

- Exploring the impact of diabatic processes on disturbances of the jet stream and their influence on downstream high-impact weather
- Prepare EarthCare: joint leg with radar and lidar and A-Train overpasses




The French Airborne **RA**dar-**LI**dar platform (**RALI**) was deployed on the **French SAFIRE F20** during the **Iceland campaign** for studying the microphysics and the dynamic of cloud and aerosols.

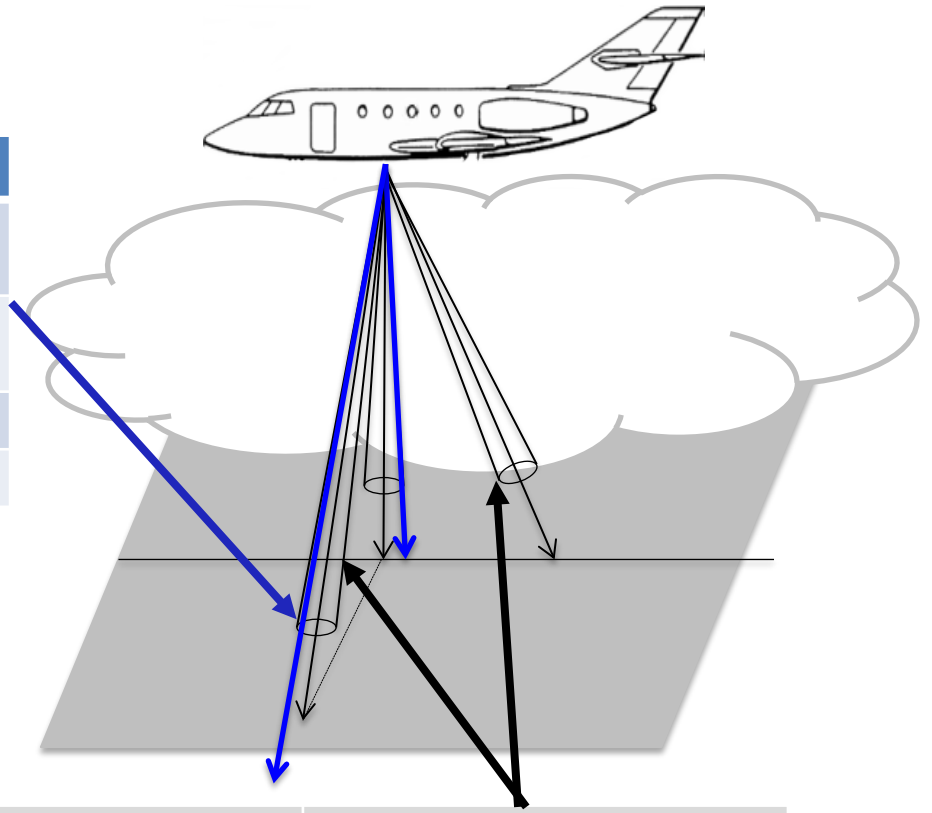
- **From 28th of September to 17th of October 2016**
- Number of scientific flights: **15**
- Number of scientific flight hours: **46.5**
- Number of released dropsondes: **59**
- Number of CloudSat-CALIPSO overpasses: **3**
- Number of co-located flights: **5**

# French F20 Payload - RALI

## Aircraft:

- Dassault Falcon 20 (SAFIRE)
- Endurance: **3.5 flight hours**
- Maximum cruising altitude: **13 km**

| LNG (ND : YAG pulsed 20Hz) | |
|---|---|
| Wavelength (nm) | measurements |
| 355 | β, High spectral resolution (MZI), δ, Doppler |
| 532 | Backscatter only |
| 1064 | Backscatter only |



## Payload:

- **High Spectral Resolution Doppler LIDAR** (355 nm), 532 and 1064 nm @ 37° and nadir pointing
- **Doppler Cloud Radar** (95 GHz) 3 antennas looking down
- IR radiometer CLIMAT (nadir brightness temperature **8-10-12 microns**)
- LW/SW fluxes
- Dropsonde launching (profiles of T, p, RH, u, v)
- Aircraft measurements (attitude, wind, T, p, RH)

| 3 antennas | RASTA characteristics |
|---|---|
| Frequency (GHz) | 95 (3.2 mm) |
| Vertical resolution (m) | 60 |
| Horizontal resolution (m) | 225 to 300 depending on aircraft speed |
| Range (km) | 15 |
| Integration time (ms) | 250 (measurement every 750ms for each antenna) |
| Energy (kW) | 2 (pulse 0.4µs) |
| Ambiguous velocity (m $s^{-1}$) | 8 |
| Antenna size (cm) | 45 (0.5° beam width) |
| Sensitivity at 1km (dBZ) | Down backward: ~-22 / Nadir: ~-30 / Down transverse: ~-26 |

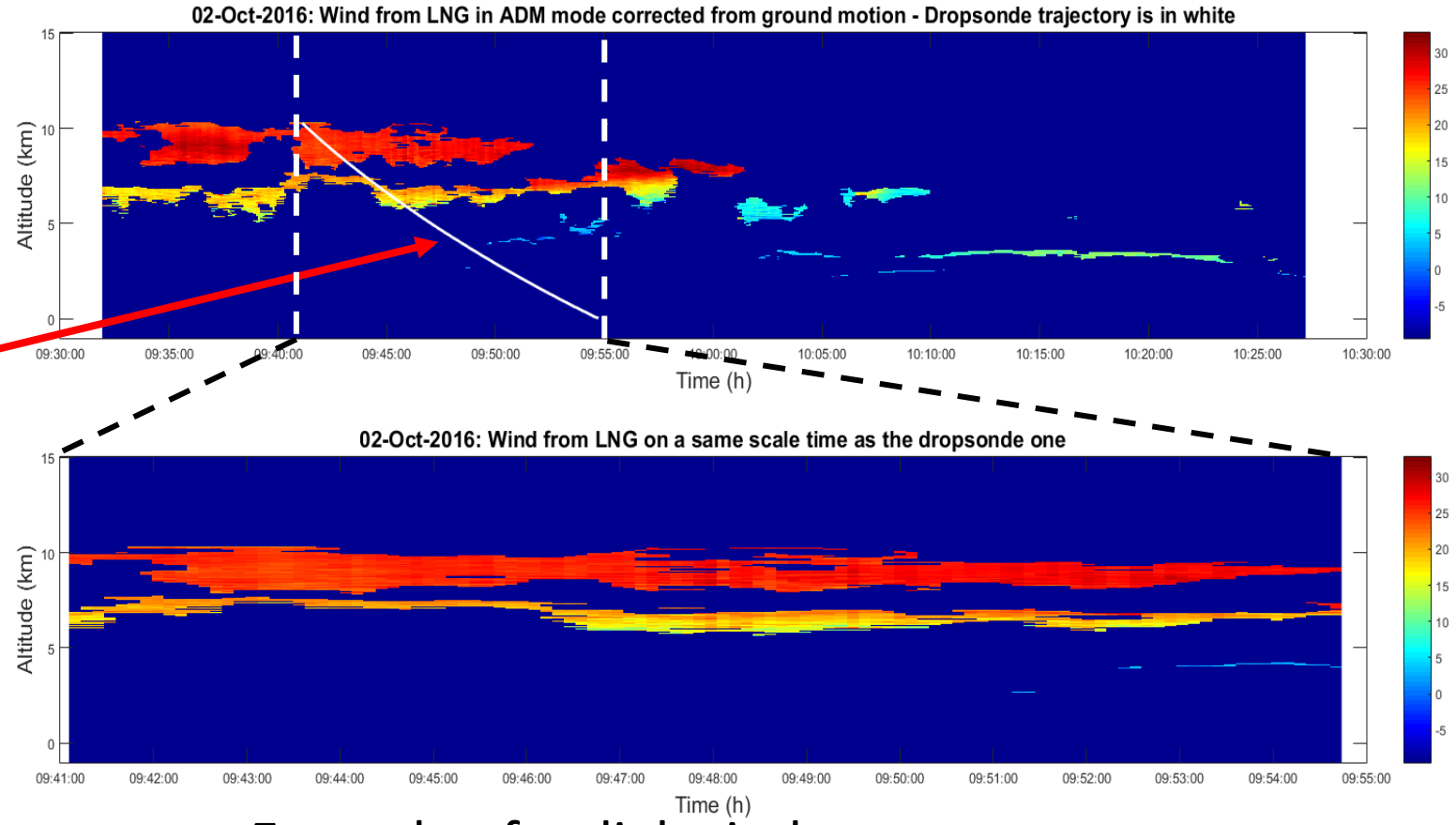
# Radial wind measured with LNG in ADM mode

Data recorded October 2, 2016 with LNG in ADM (37°) mode are considered.

LNG radial wind => corrected from ground motion (aircraft velocity).

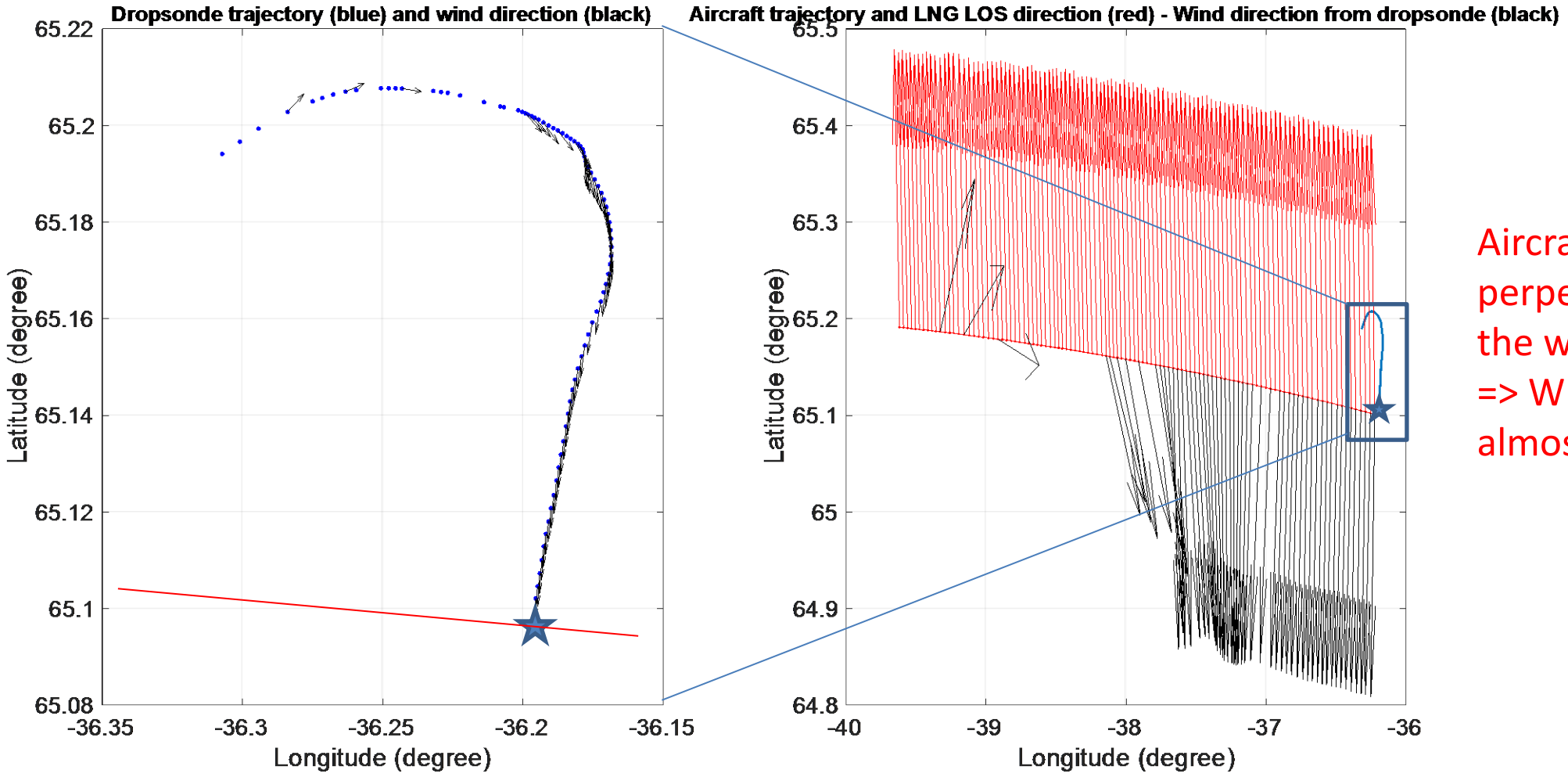
**dropsonde trajectory**

LNG measurements during dropsonde's fall-time.




Example of radial wind measurements recorded with LNG Oct 2, 2016.

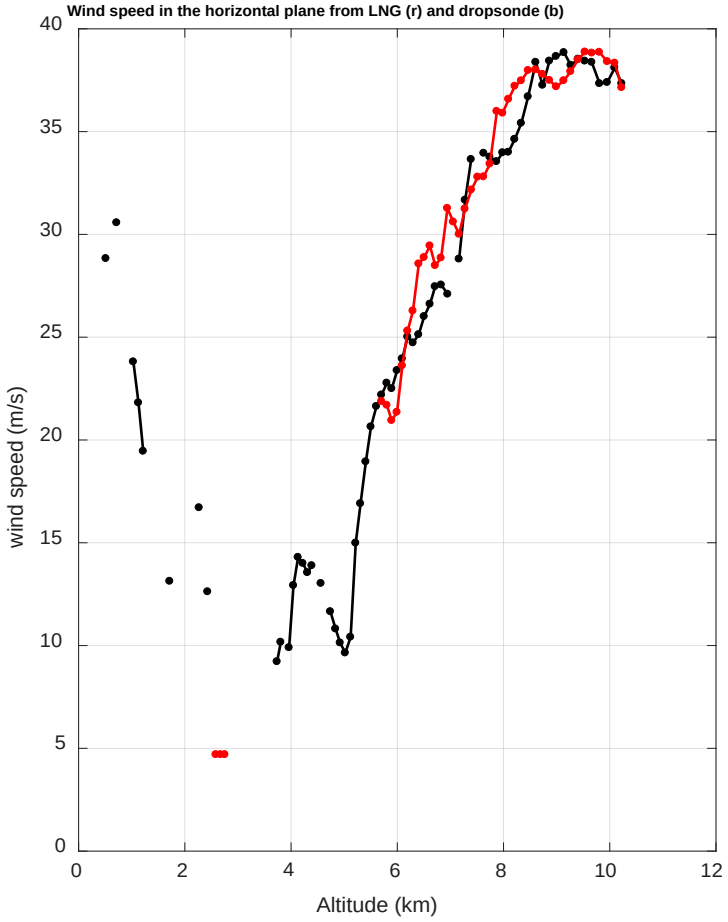
# Dropsonde and aircraft trajectories

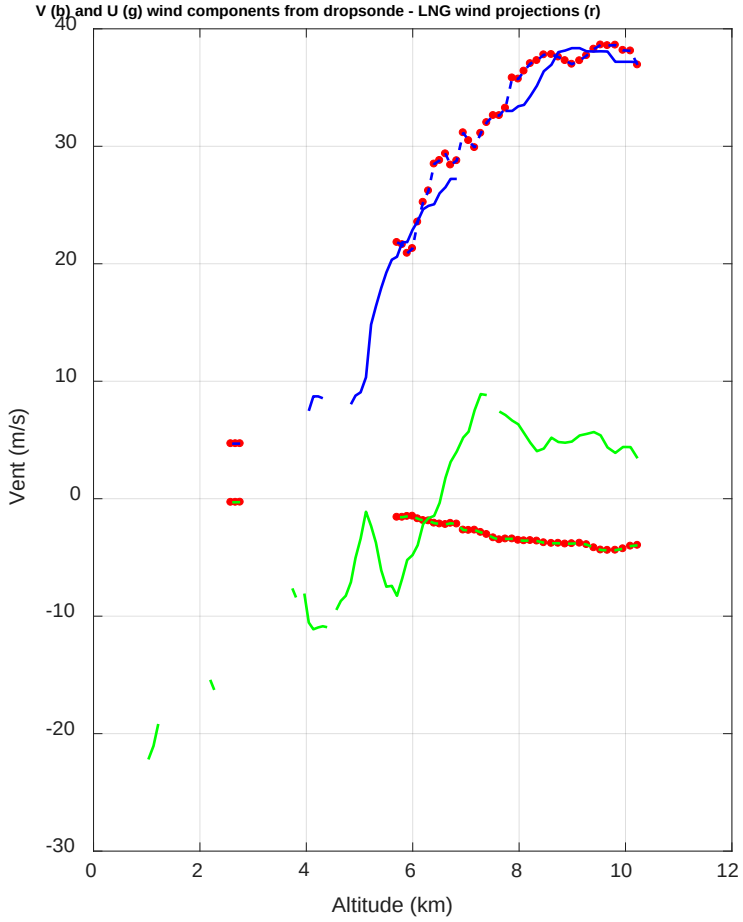



Aircraft was flying perpendicular to the wind direction => Wind and LOS almost collinear

**Wind direction** (**black vectors**) and **speed** are measured by the **dropsonde** over a limited field (left).
The LNG Light-Of-Sight (**red vectors in right side**) covers a larger field during the dropsonde fall time.

# Wind measurements from the dropsonde and LNG



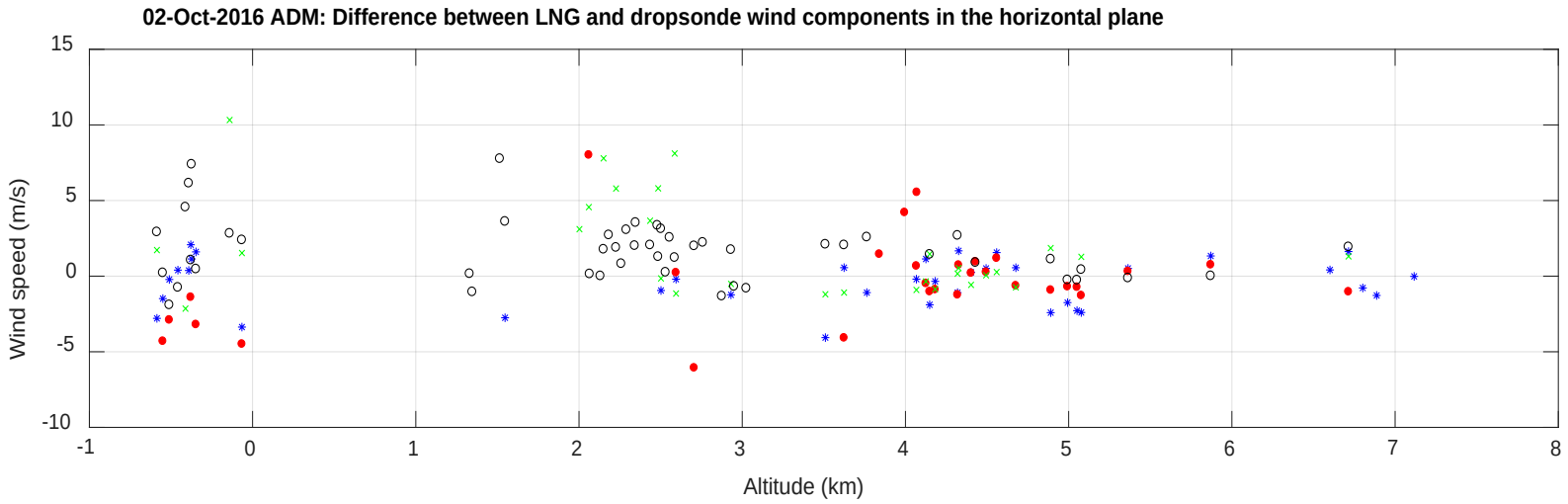



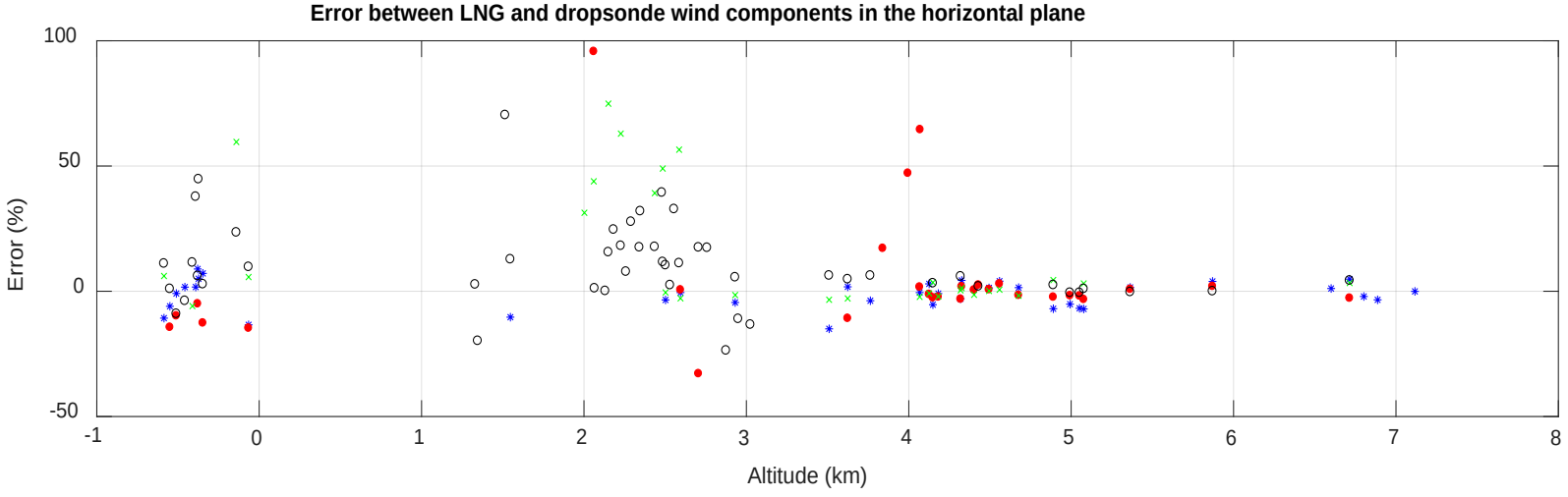

Meridional and Zonal winds components differ as expected

**Dropsonde horizontal wind speed recorded by the dropsonde (**black**) and LNG (**red**): they are very closes although <u>the vertical wind component is neglected</u>.**

# Differences of wind speed measurement between LNG and dropsonde– 1/2

**Wind speed difference** versus **altitude considering all dropsondes released during the ADM flight of Oct. 2, 2016**.



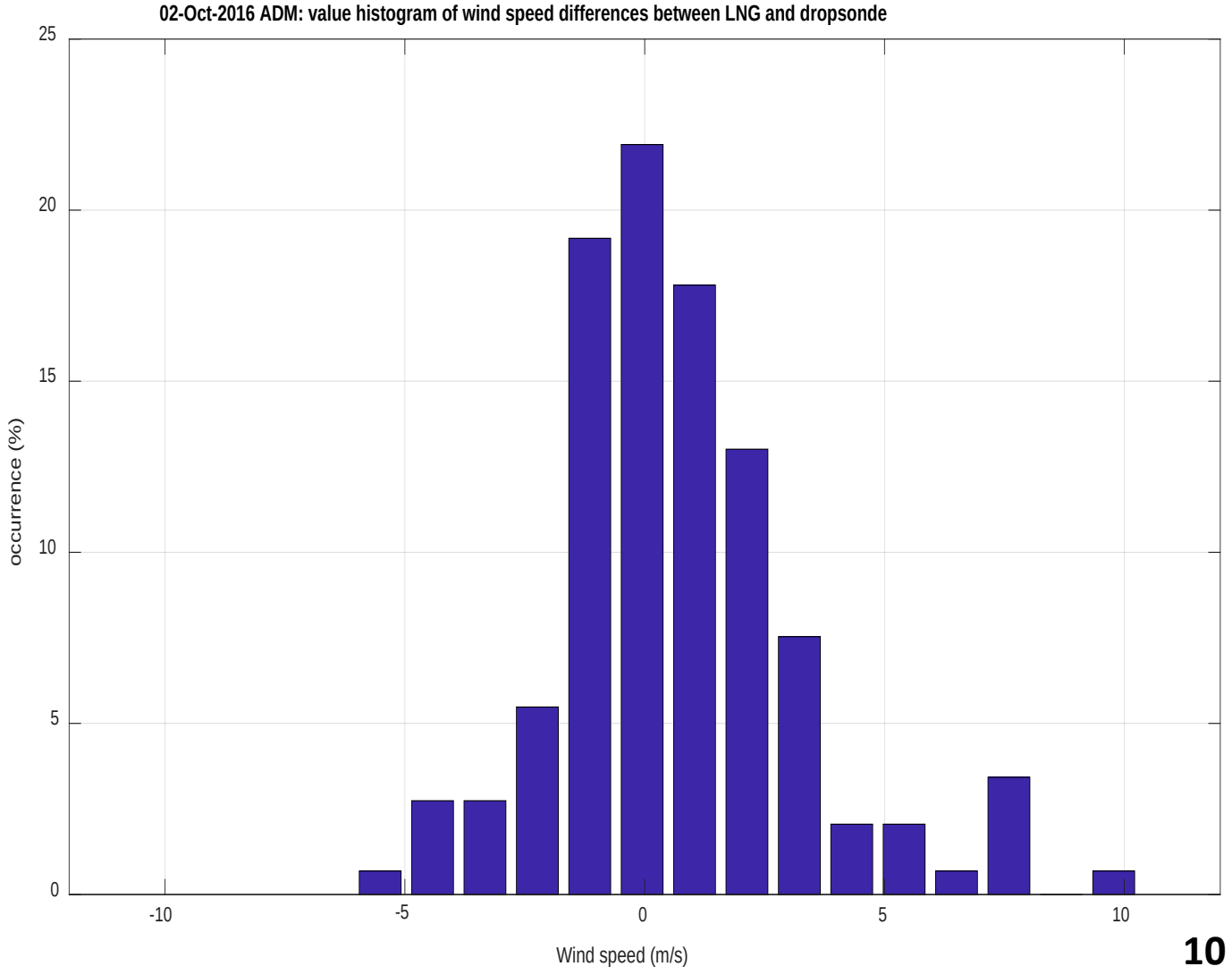




**Errors are small between 4 and 7 km, becoming greater at lower altitudes (lower SNR)**

# Histogram of wind speed differences between LNG and dropsonde – 2/2

**Histogram of wind speed differences** between LNG and dropsondes **is not symmetric** (not enough samples and error greater at lower altitudes): **a small bias** is then observed:

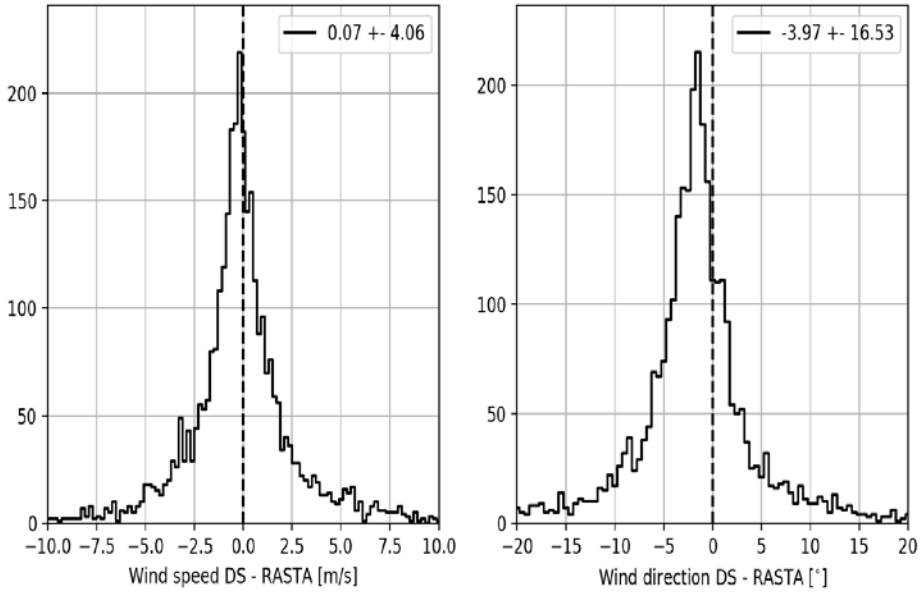
**0.7 +/- 2.6 m/s**



# RASTA WIND retrieval assessment

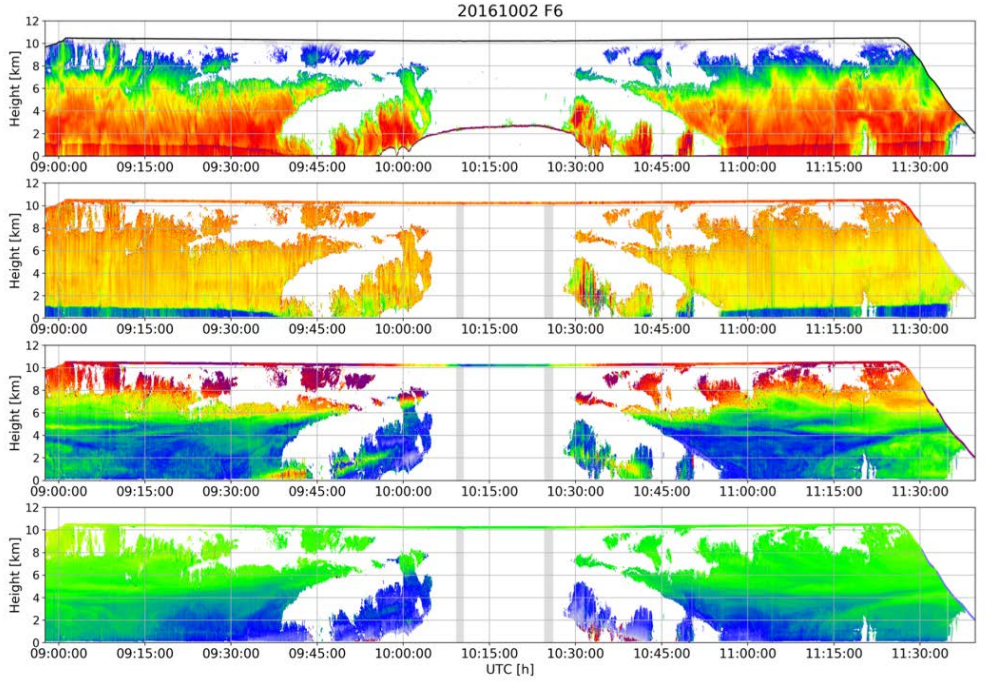
## RASTA against DS (**all flights**)

We use the dropsonde launch time with
a 10s window for RASTA measurements




Wind speed: 0.07 +- 4.06 m/s
Wind direction: -3.97 +- 16.53 °

**(Outliers not removed)**

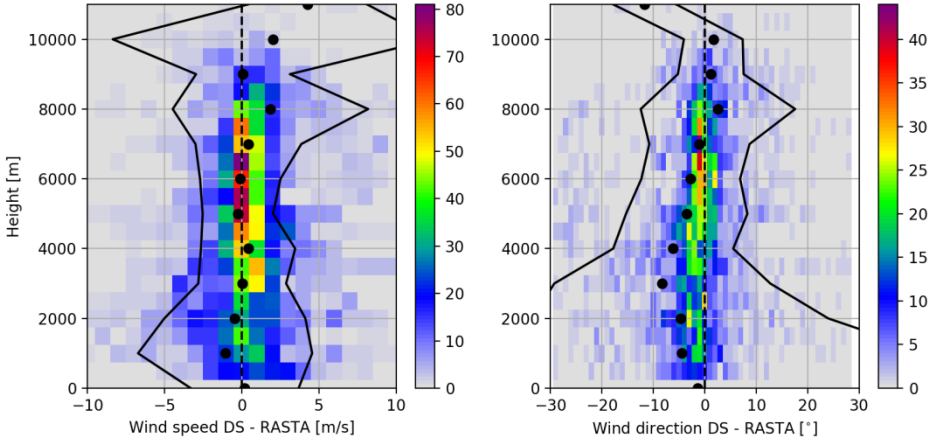



Radar reflectivity

Vertical velocity

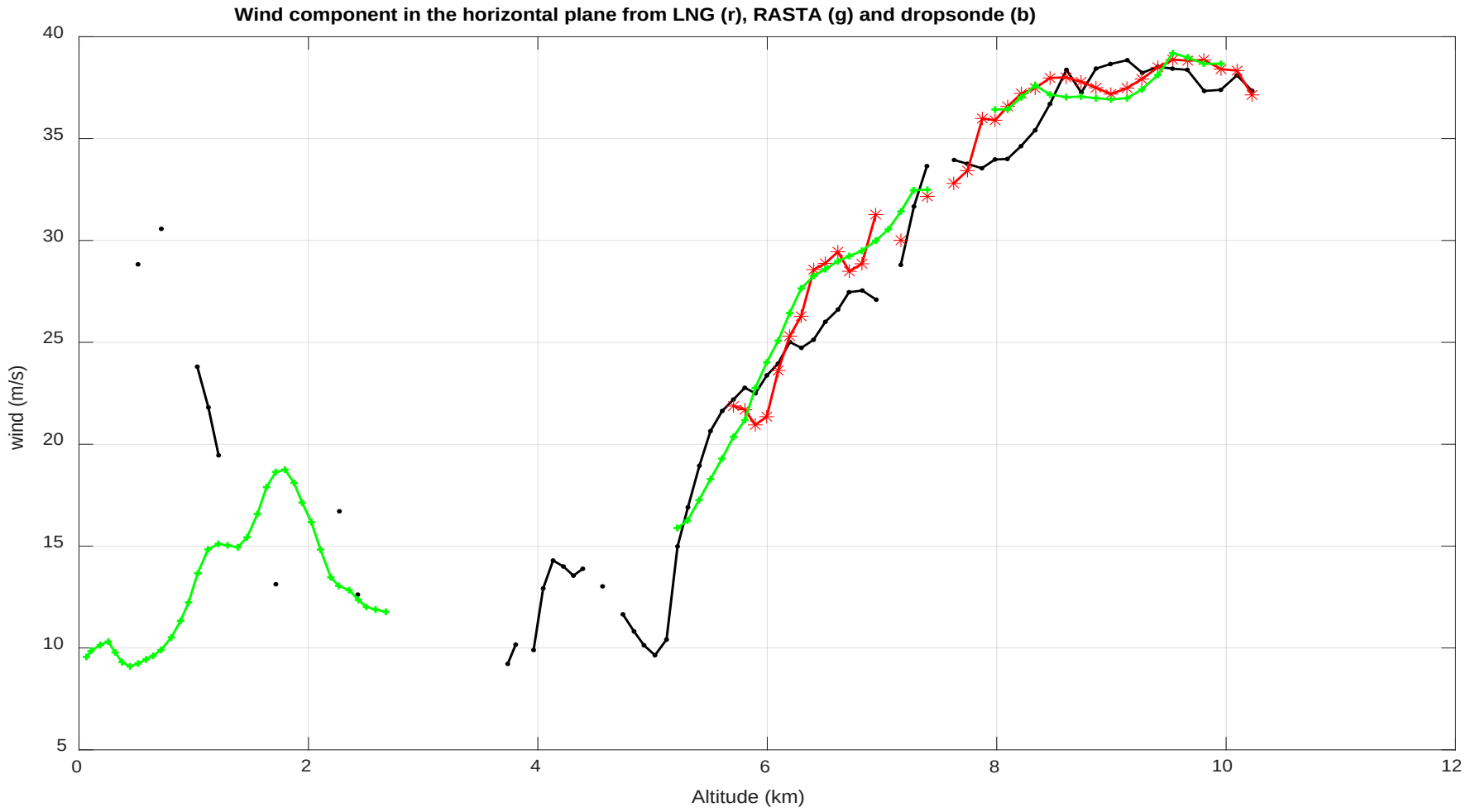
Horizontal
Wind speed

Horizontal
Wind direction




As a function of altitude

# Wind speed from LNG, RASTA and Dropsondes

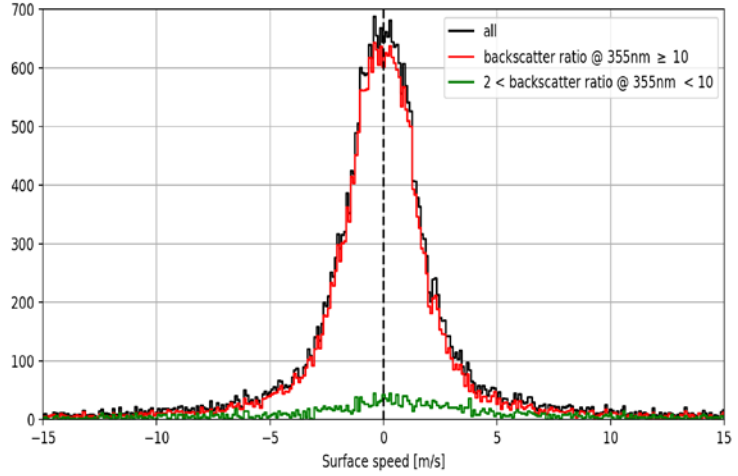


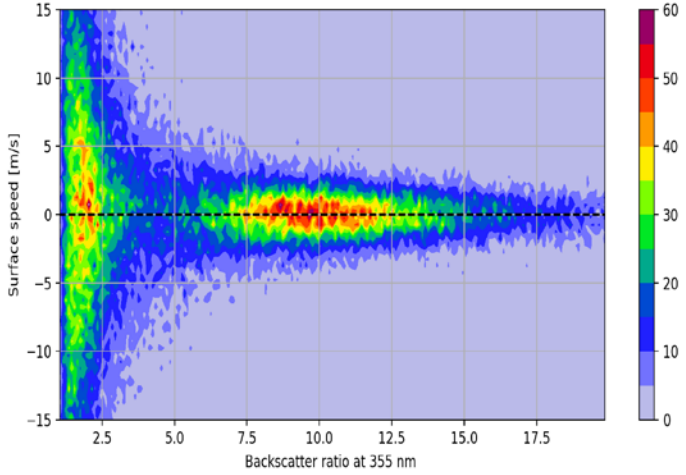

Wind from LNG (r), RASTA (g) and dropsonde (b): **a good agreement is observed**.

**Radar data** may be **considered** for comparison when **no dropsonde** during LNG measurements. **A synergistic study of concomitant measurements may be performed**.

# LNG Doppler assessment using ground echo and RASTA

Surface velocity (corrected for aircraft's motion)

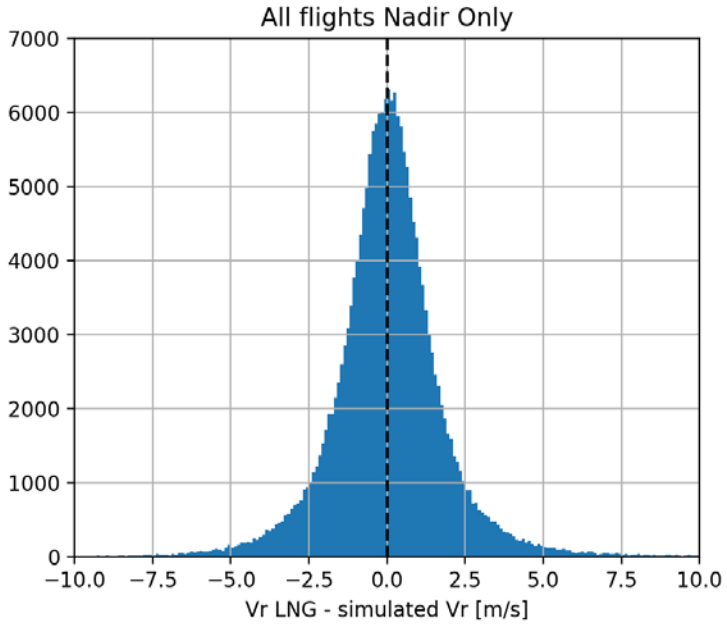


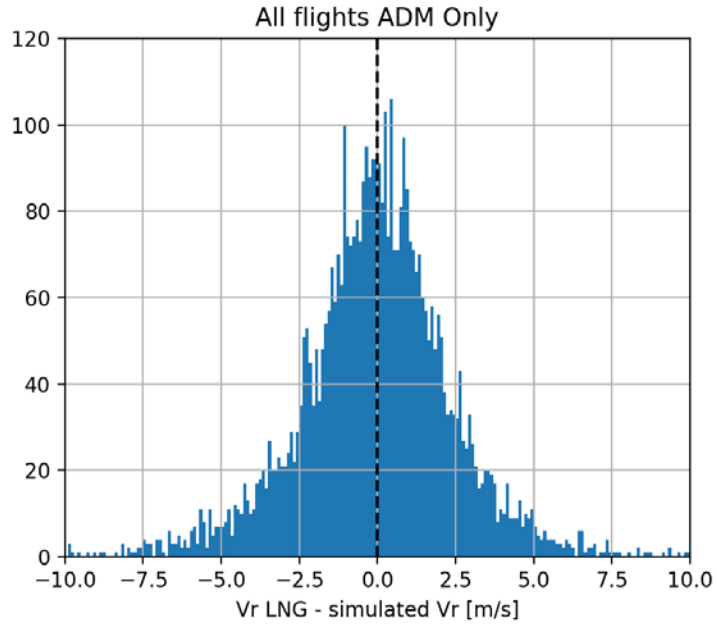




**Ratio < 10 : Bias +- std = 0.28 +-17.50 m/s**

**Ratio > 10 : Bias +- std = 0.09 +-10.88 m/s**

**Co-located RASTA wind retrieval (U,V,W)**
**=> simulate LNG LOS**




Bias +- std = 0.05 +- 2.78 m/s

Bias +- std = 0.04+- 2.97 m/s

# summary

- Ongoing data analysis of RALI observations performed during the Iceland EPATAN/NAWDEX campaign

- The slant-viewing LNG observations were used to mimic those from ADM-Aeolus: comparisons of retrieval started with dropsondes and radar wind measurements

- The results obtained from (LNG ADM) flights data recorded on October 2, 2016 were very closes with those obtained with RASTA and recorded with dropsondes.

- This study revealed:
  - A promising synergy between LNG and RASTA observations in semi-transparent clouds for cloud studies and validation of ADM-AEOLUS
  - Powerful instrumentation on-board the F20 for studying dynamics of aerosol and clouds