3D characterization of the fog microphysical properties during the SOFOG3D campaign and impacts on the fog life cycle : Observations and LES

PhD position **Theophane Costabloz** (May 2021 – 2024)

Supervision : F.Burnet, C.Lac

3D characterization of microphysical properties : observations and LES

*FCPLR **Théophane Costabloz**. Supervision: F. Burnet, C. Lac*

- 1st Part : Data Analysis in order to document the fog microphysical properties

Droplet size distribution (DSD) measured on 4 sites, tethered balloon, Unmanned Aerial Vehicles (UAV) …, synergy with Cloud Radar

-2nd Part : LES Simulations of the most documented IOP with Meso-NH thanks to grid-nesting up to 5m resolution

Validation and sensitivity tests

- Process Studies to analyze the key processes that explain the microphysical evolution during the fog life cycle.

Especially : - *Impact of surface heterogeneities on the fog microphysical properties*

- *Role of microphysics during the transition between an optically thin and thick fog.*

- *Impact of entrainment and turbulent mixing at the top.*

In Situ Microphysics : Plan

I) Optical Particle Counter

II) Overview IOP 11 and 14

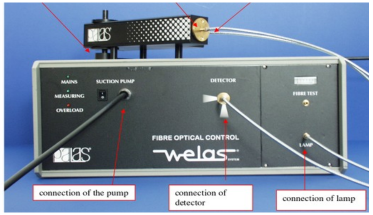
III) Adding Turbulence Probe

IV) Data Analysis IOP 11 and 14

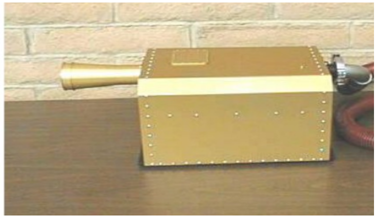
I) Optical Particle Counter

<u>Overview :</u>

Cloud Droplet Probe



Welas



Fog Monitor

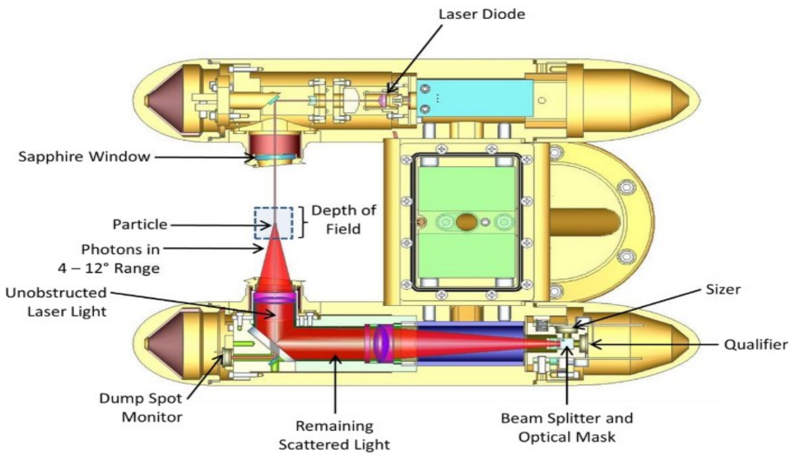
- Welas and Fog Monitor on the ground
- **Focus on Cloud Droplet Probe (CDP)**
- Modified version for tethered balloon
  ➡ Issue with the air sampling speed

CDP on tethered balloon

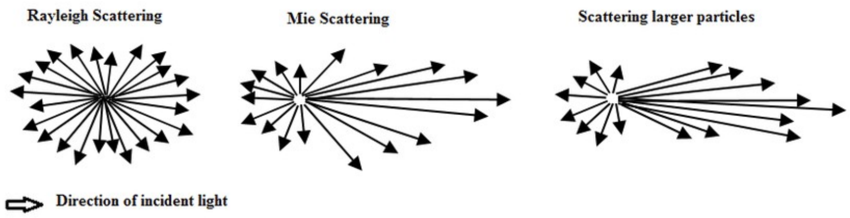
CDP data analysis on IOP 11 and 14

Cloud Droplet Probe Description and Calibration

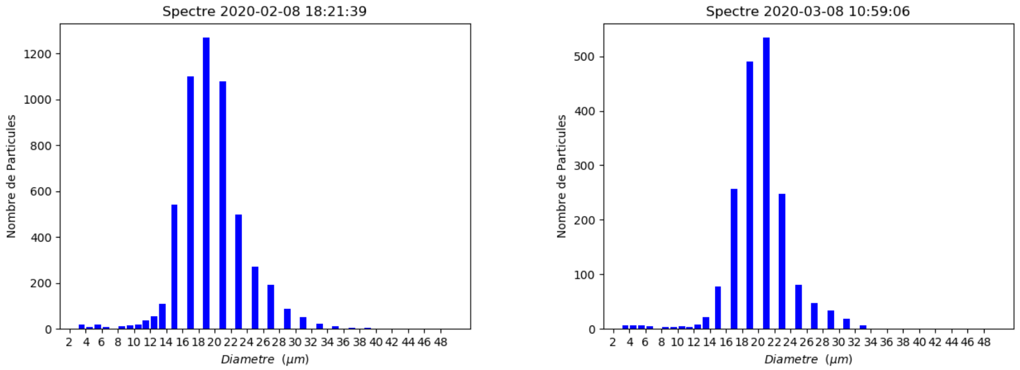
- Based on Mie Scattering
- Covers a diameter range from 2 to 50 µm
- Possesses 30 size classes
- Relevance of Calibration



CDP Components



Mie Scattering

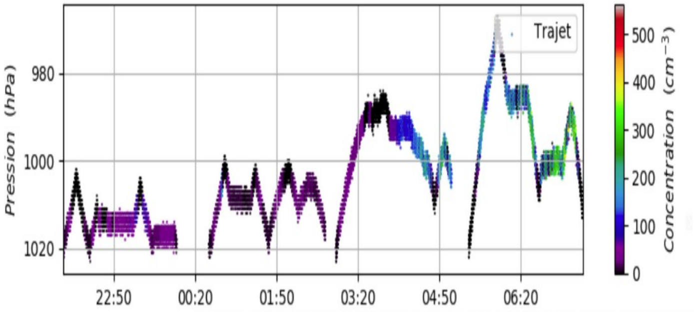


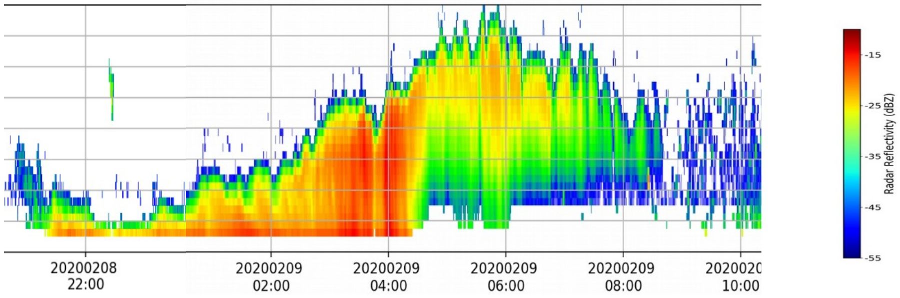
Calibration with pollen (20 µm) during IOP 11 (left) and IOP 14 (right)

II) Overview IOP 11 and 14

IOP 11 : 7-8th February 2020

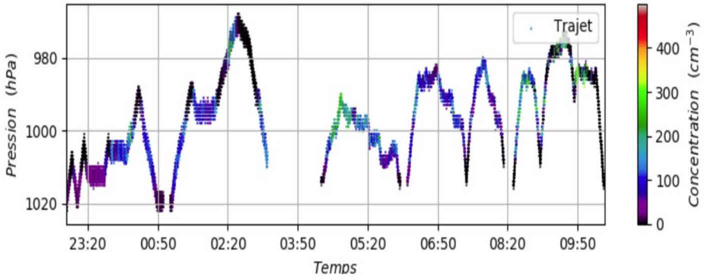
Pressure Evolution

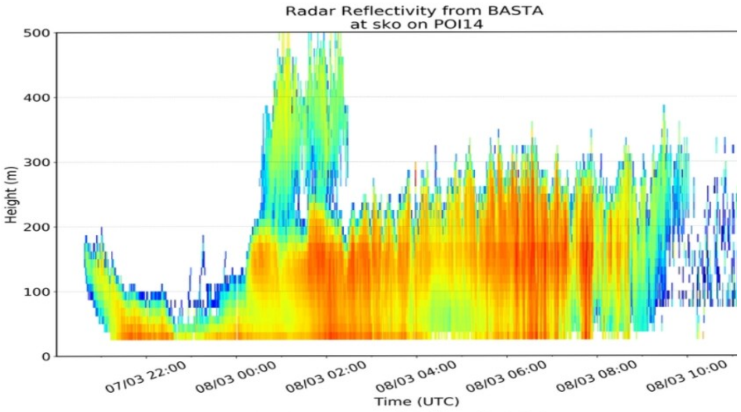




IOP 14 : 8-9th March 2020

Pressure Evolution

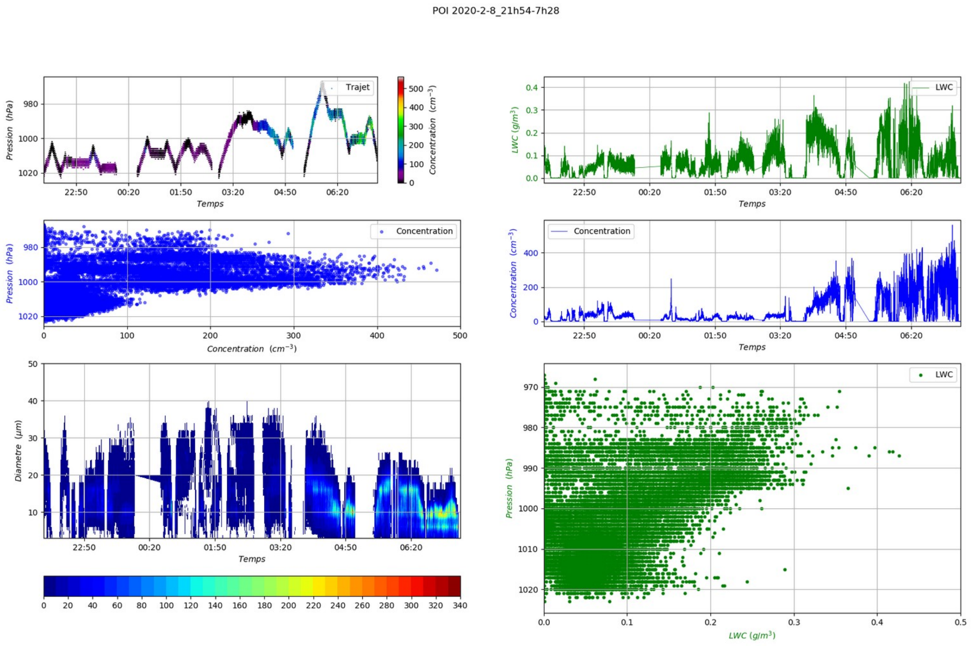




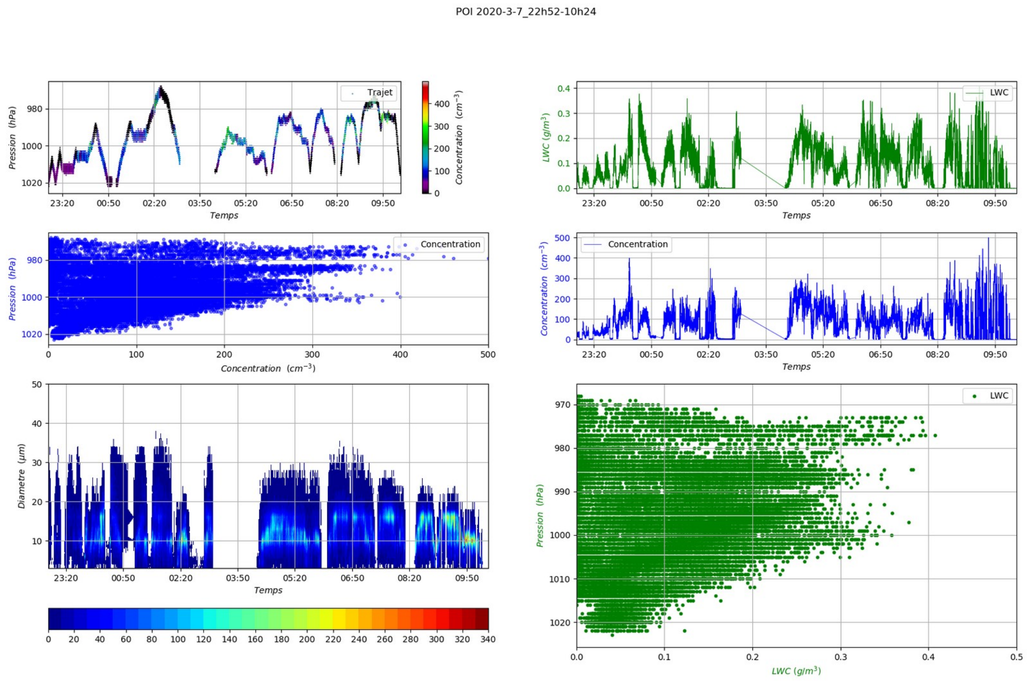
Radar Reflectivity from BASTA

➡ Need to divide into ascents, descents and constant height sections

II) Overview IOP 11 and 14



IOP 11 Overview



IOP 14 Overview

➡ Need to take wind speed into account, measured by the turbulence probe

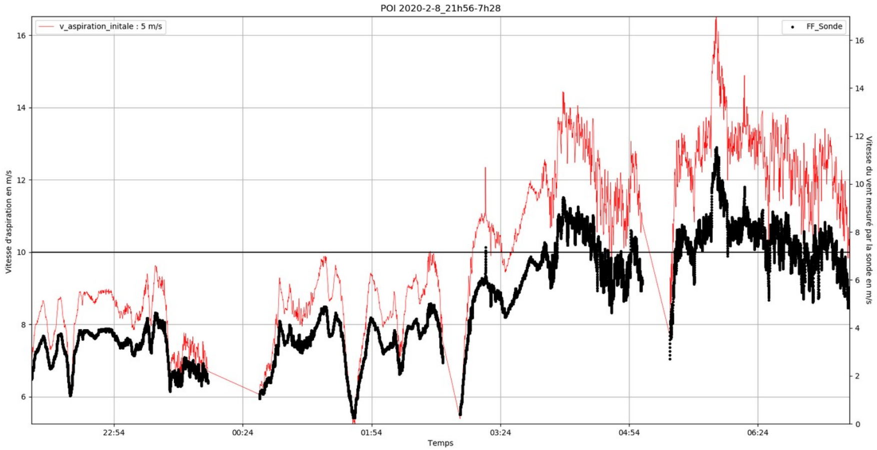
Tethered Balloon

Calculating a new air speed

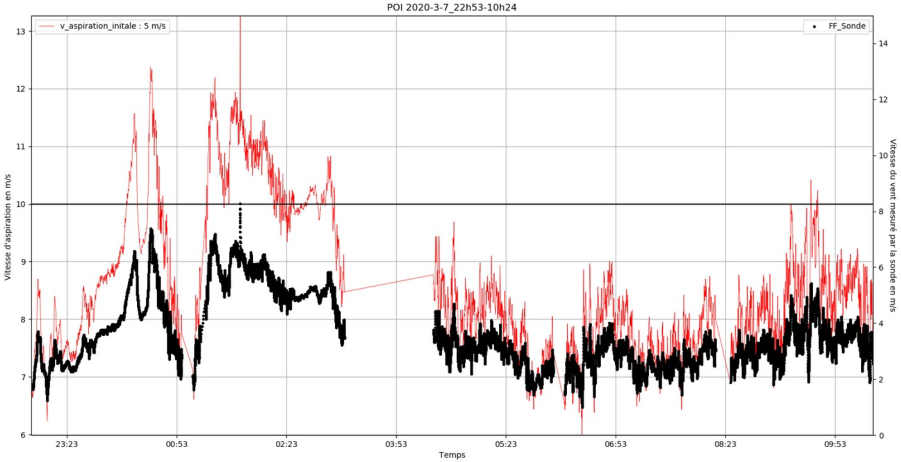
Concentration = $\frac{N_{particles}}{V_{sampling}}$ Where $V_{sampling} = S_{sampling} V_{air}$

- Initially : Constant air speed fixed to 10 m/s

With $V_{air} = \begin{Bmatrix} 10 \\ 5 + FF_{probe} \end{Bmatrix}$



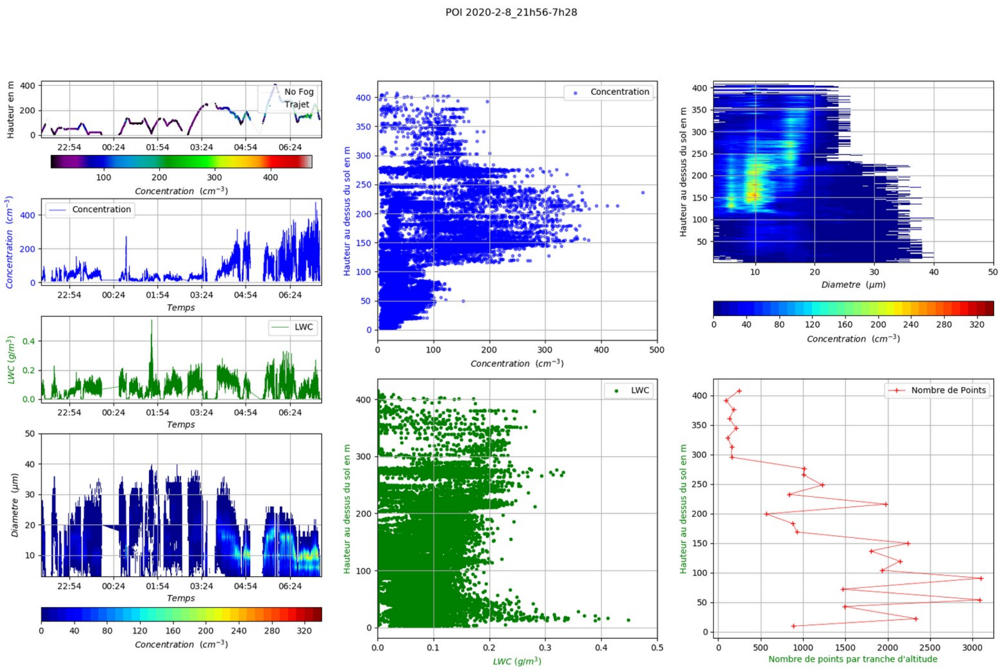
IOP 11 : Wind and Suction Speed Evolution



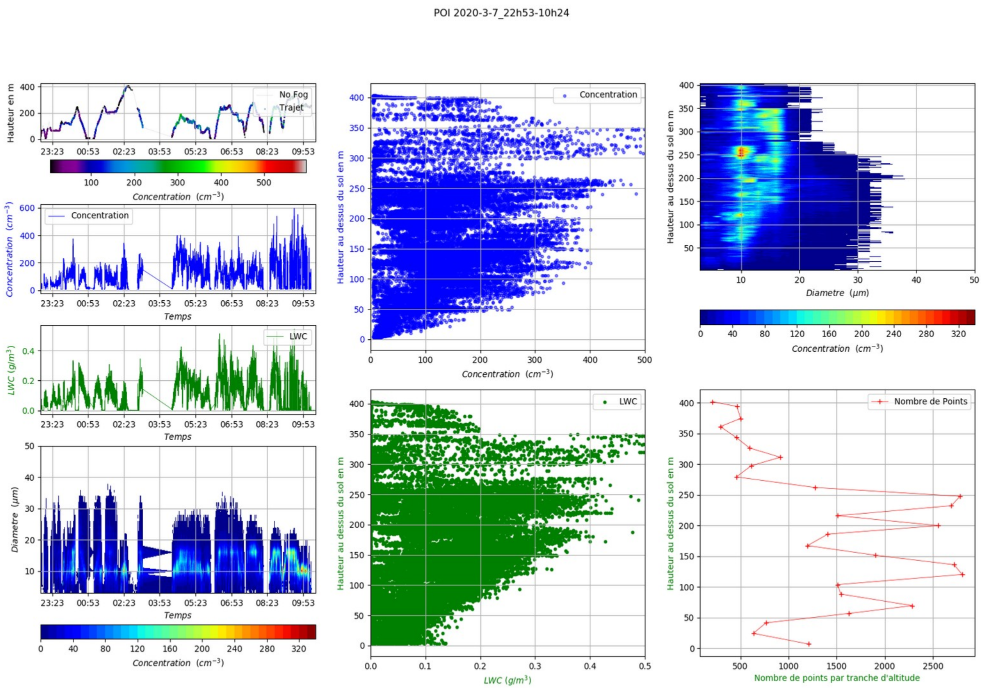
IOP 14 : Wind and Suction Speed Evolution

- Reduce to 5m/s to take wind speed into account

IV) New Overview with wind speed taken into account

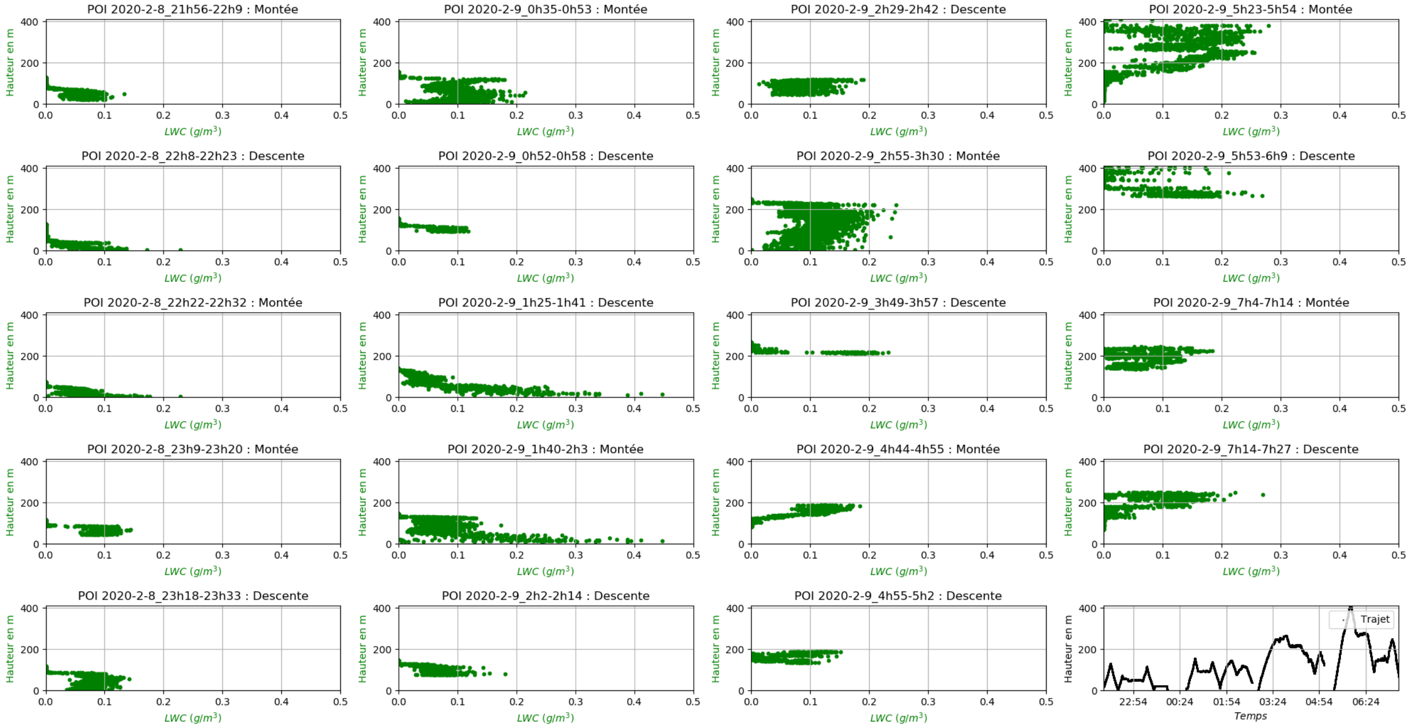


IOP 11 Overview



IOP 14 Overview

Filtering by Ascent and Descent : IOP 11



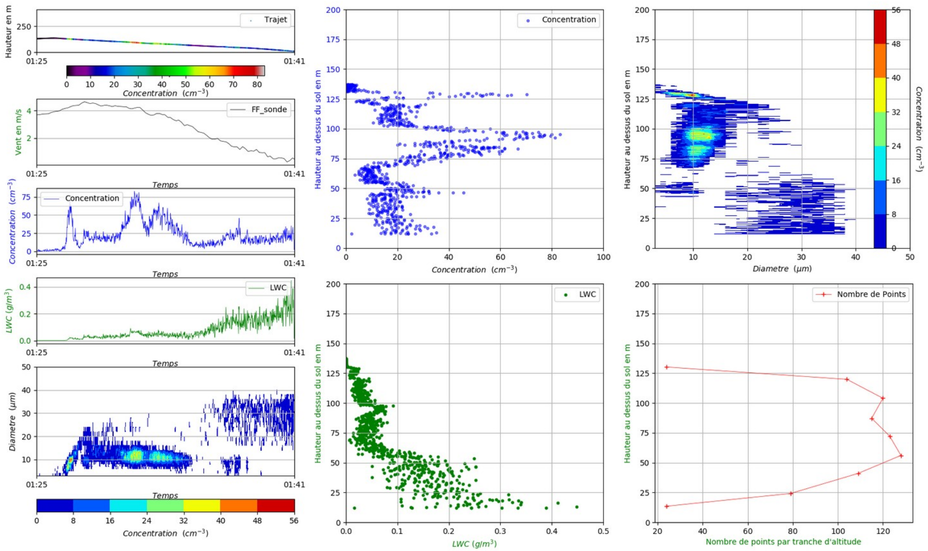
POI 2020-2-8_21h56-7h28

Liquid Water Content Vertical Profiles of all ascents and descents during IOP 11

Focus on one Consecutuve Ascent/Descent : IOP 11

POI 2020-2-9_1h25-1h41

LWP ~ 10,7

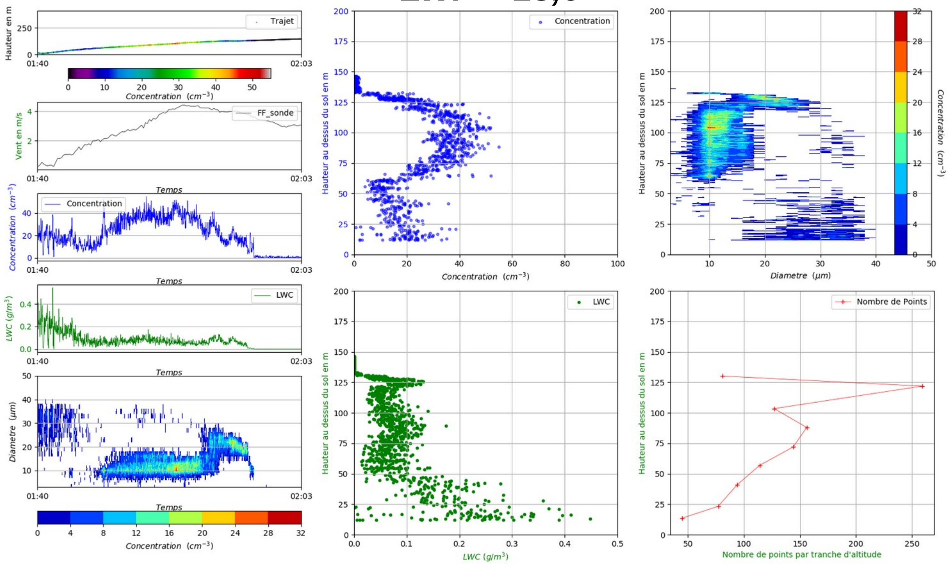


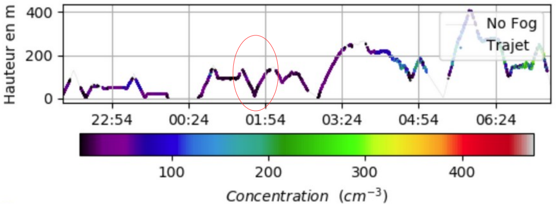
Descent : 01h25/01h41

Ascent : 01h40/2h03

POI 2020-2-9_1h40-2h3

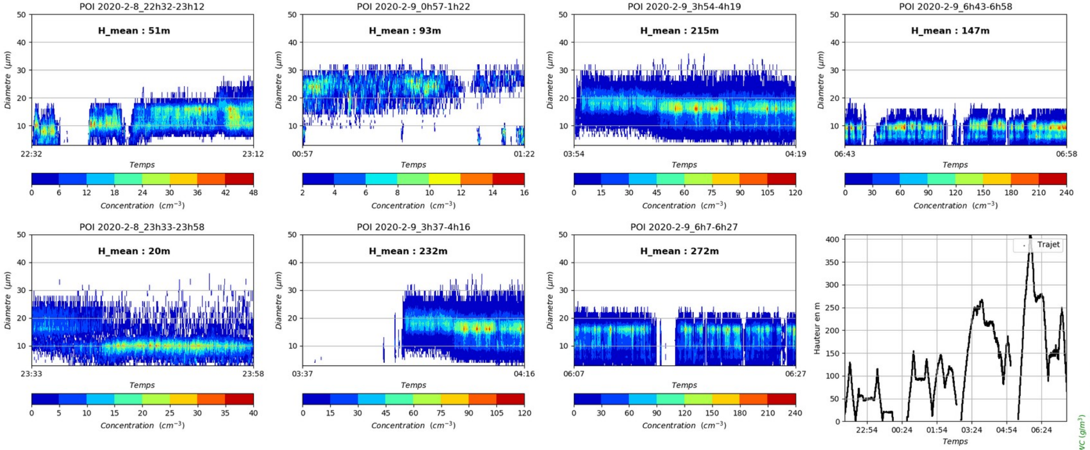
LWP ~ 13,6





Pressure Evolution

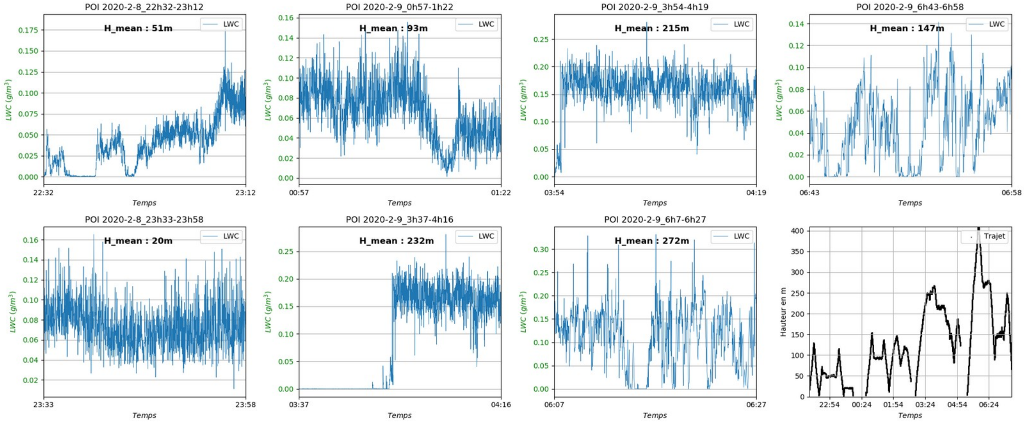
Filtering by Constant Height Section : IOP 11



POI 2020-2-8_21h56-7h28 : Palier

Focus on Diameter

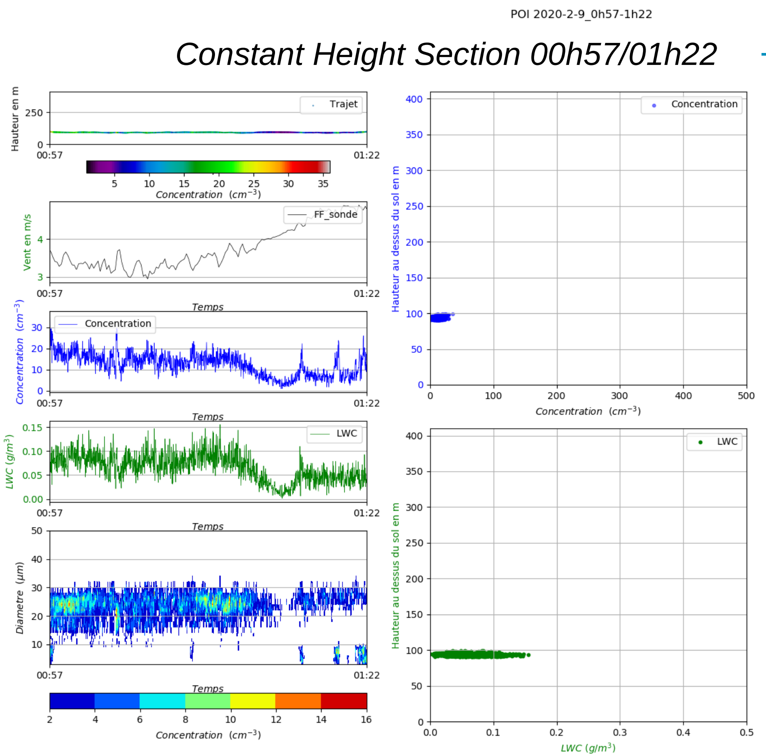
Focus on Liquid Water Content



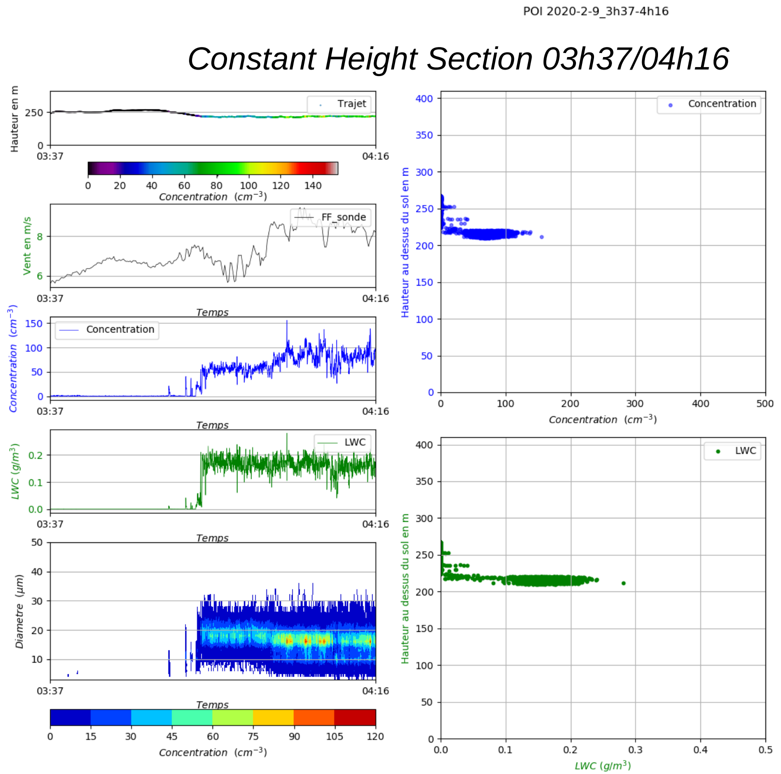
POI 2020-2-8_21h56-7h28 : Palier

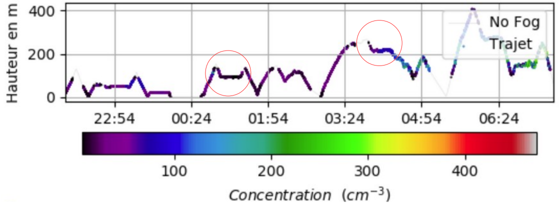
Focus on two Constant Height Sections : IOP 11

Constant Height Section 00h57/01h22



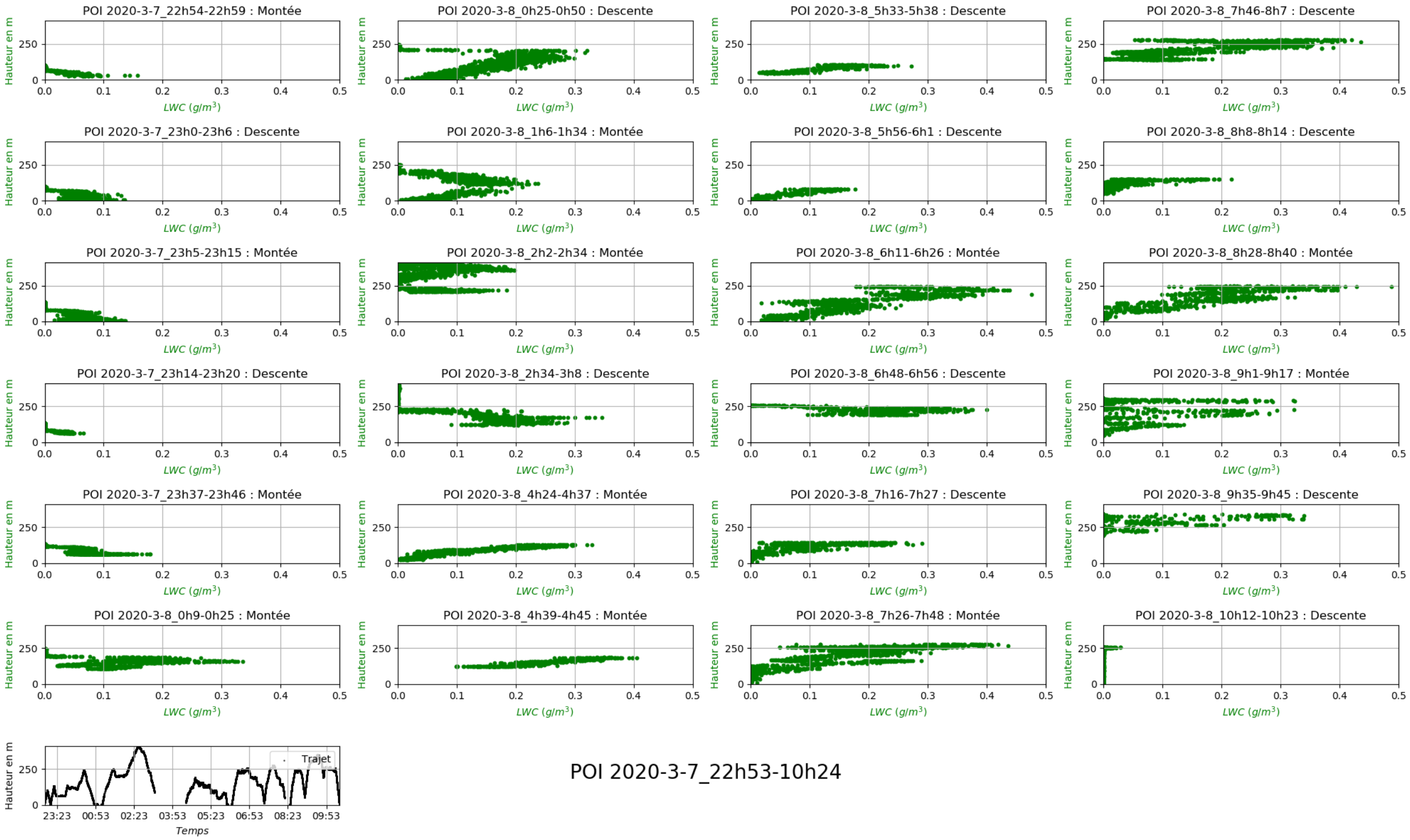
Constant Height Section 03h37/04h16





Pressure Evolution

Filtering by Ascent and Descent : IOP 14

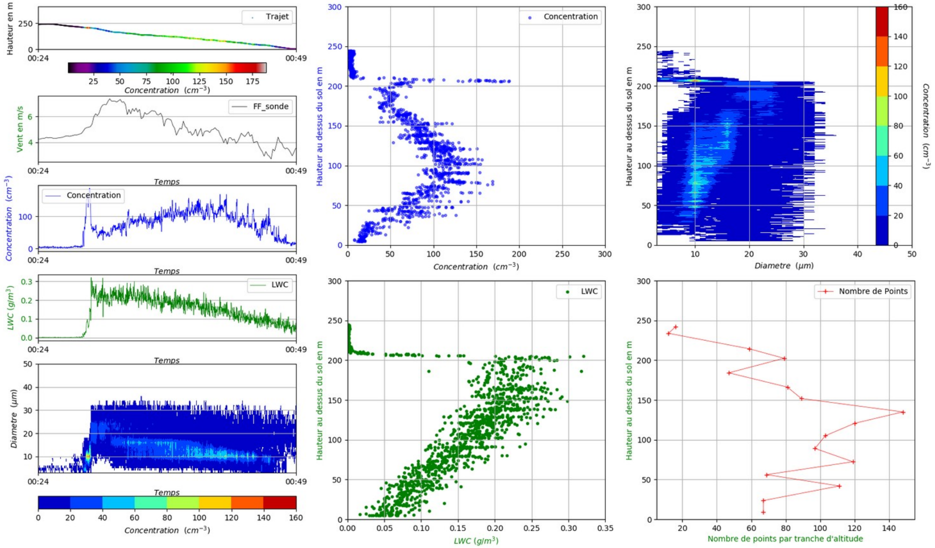


Liquid Water Content Vertical Profiles of all ascents and descents during IOP 14

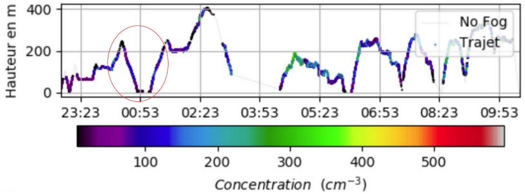
Focus on one Consecutuve Ascent/Descent : IOP 14

POI 2020-3-8_0h24-0h49

LWP ~ 34,5



Descent : 00h24/00h49

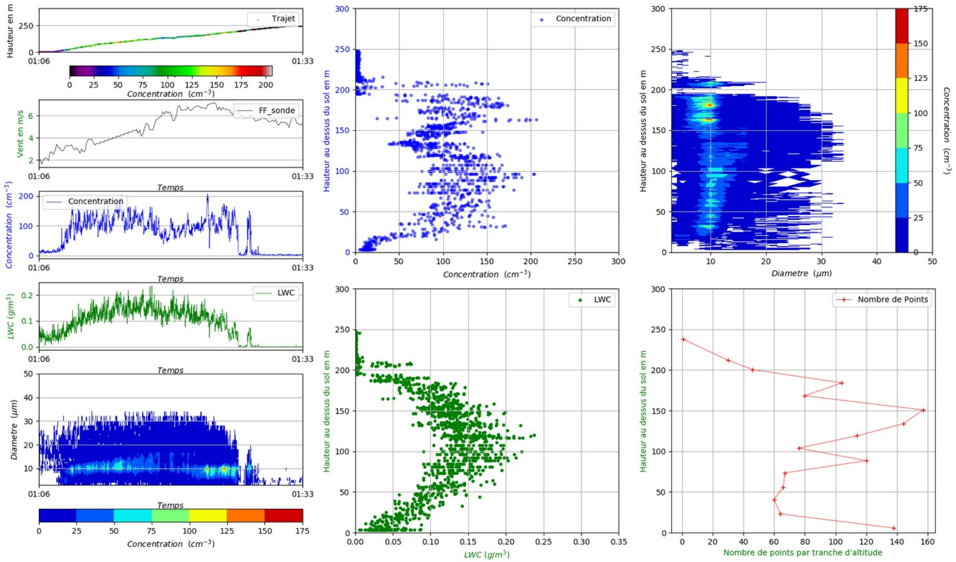


Pressure Evolution

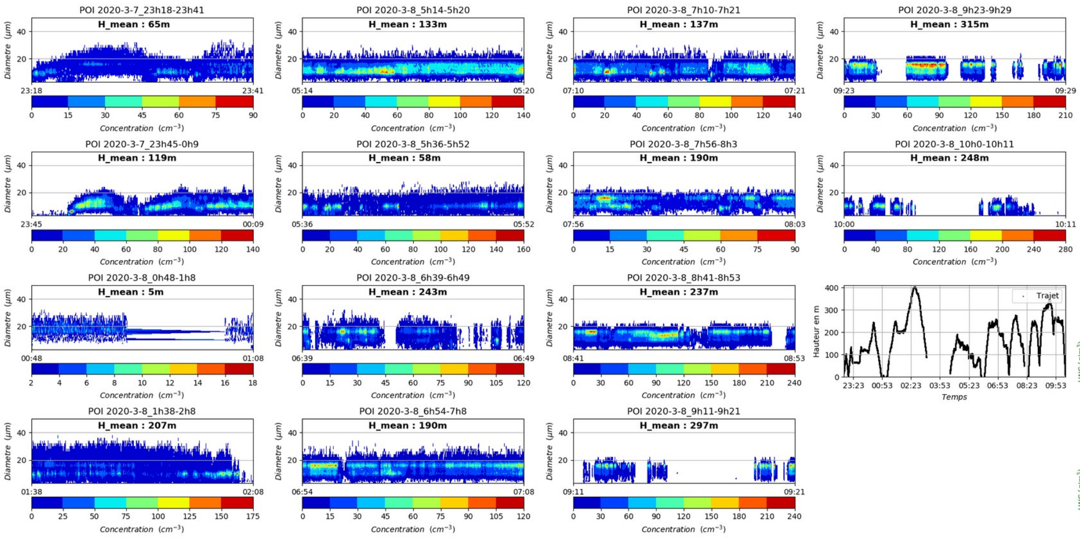
Ascent : 01h06/1h33

POI 2020-3-8_1h6-1h33

LWP ~ 23,8



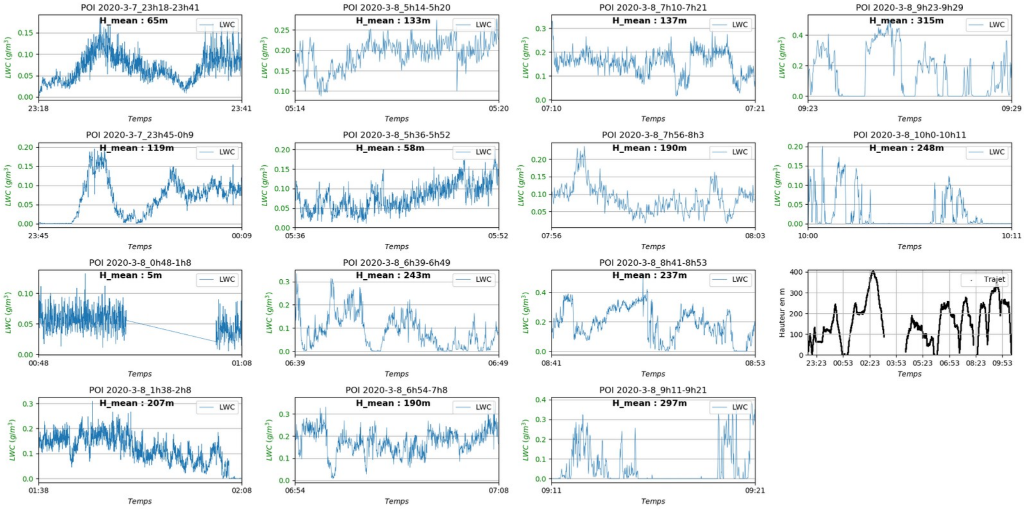
Filtering by Constant Height Section : IOP 14



POI 2020-3-7_22h53-10h24 : Palier

Focus on Diameter

Focus on Liquid Water Content

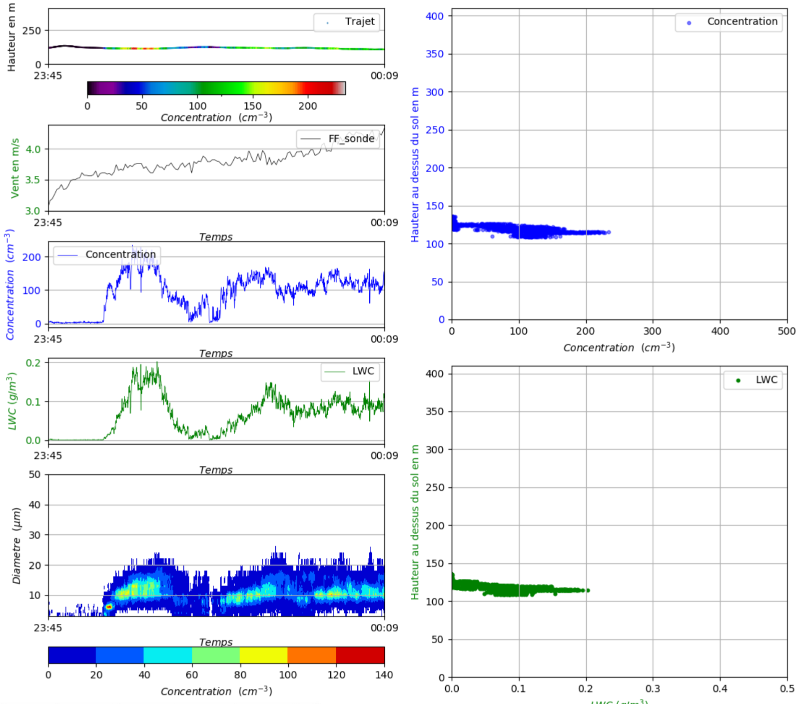


POI 2020-3-7_22h53-10h24 : Palier

Focus on two Constant Height Sections : IOP 14

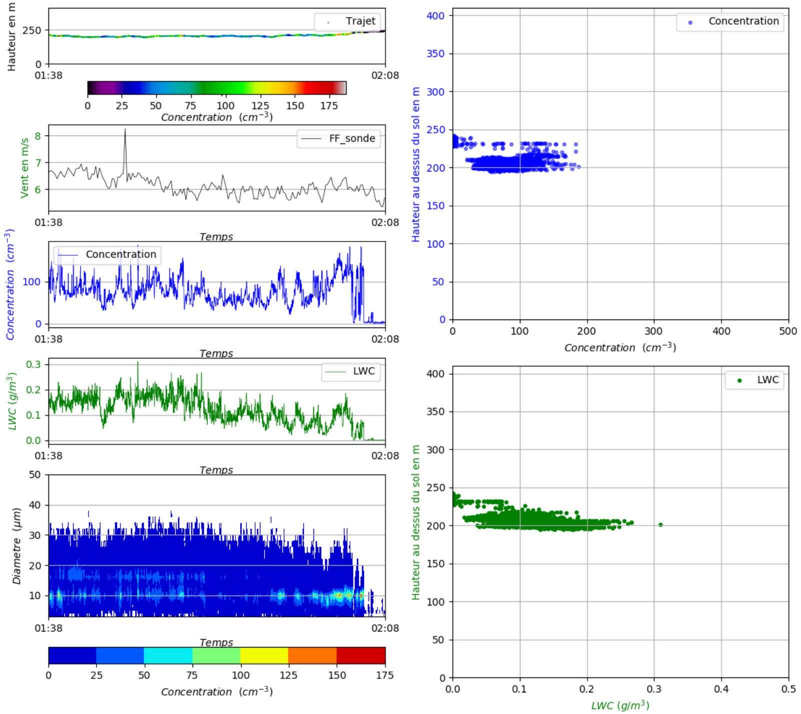
POI 2020-3-7_23h45-0h9

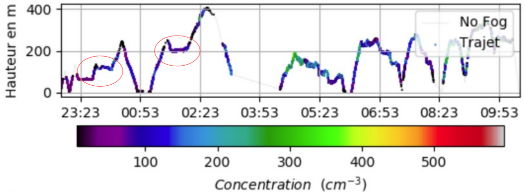
Constant Height Section 23h45/00h09 –



POI 2020-3-8_1h38-2h8

Constant Height Section : 01h38/02h08





Pressure Evolution

Summary and Future Work

- Summary:

- Need to take wind speed into account

- Significant variability of the droplets distribution in a short time frame temporally (constant height sections) and vertically (ascents and descents)

- Future Work:

- Data Analysis from IOP 6 (5 to 6th January 2020) with wind speed taken into account

- Validation with other OPC on the ground (Fog Monitor/Welas and Visibilimeter) and aloft (45m high Tower)

- Comparison with Liquid Water Path from the Microwave Radiometer.

- Compute statistics on Tethered Balloon and Ground Measurements on the 4 sites in order to explore the microphysics 3D heterogeneities.