SOFOG3D Science Meeting

Effect of aerosols on fog life cycle

07/06/2022

Inès Vongpaseut
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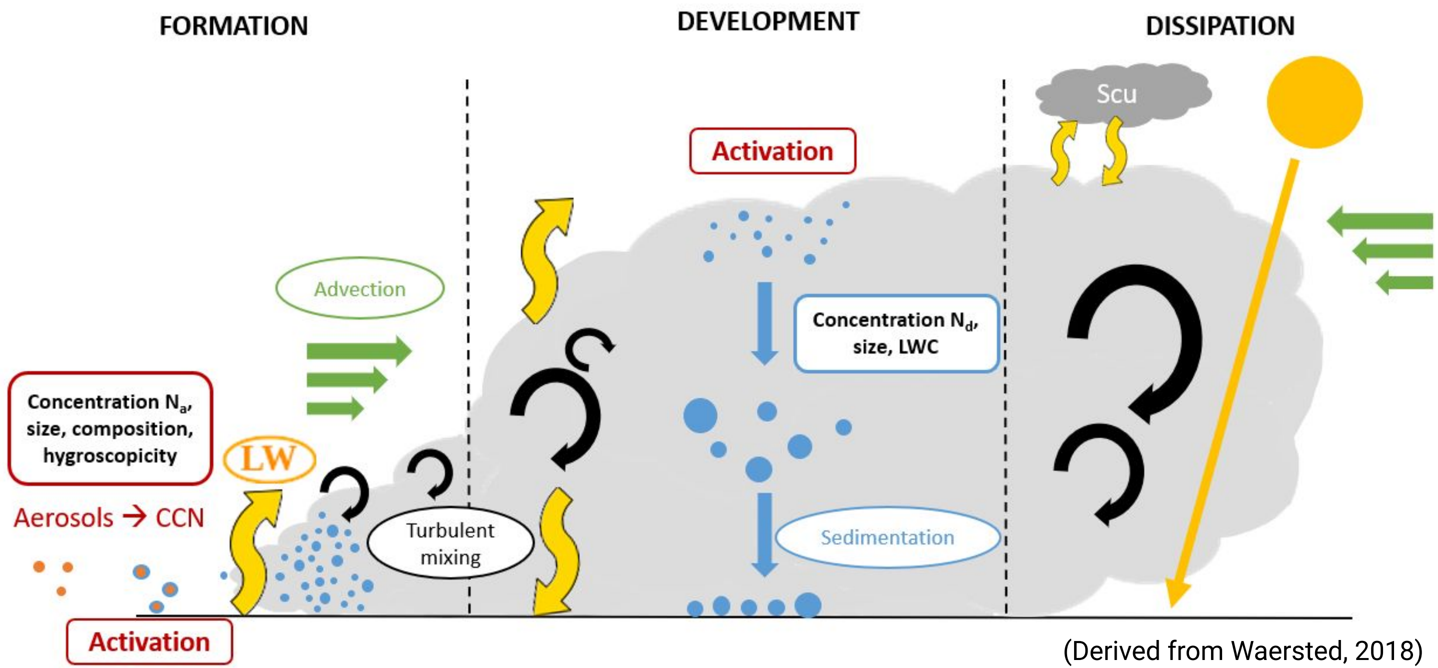
M2 Internship (February - July 2022)

Aerosols indirect effect



(Derived from Waersted, 2018)

Previous studies on the ground (Mazoyer 2016, Hammer 2014) in urban zone and (Wainwright 2021) in rural zone showed size and hygroscopicity dependance of activation of aerosol and the importance of supersaturations

- What are the **CCN activation** properties of aerosols as a function of their **vertical distribution** and their influence on the evolution of the microphysics?
- How does **supersaturation vary with altitude** in the cloud layer and how is it related to aerosols?

Internship goals

- Compare aerosol and droplets properties from **different conditions**, location to previous studies

- **Vertical variability** of activation parameters

- CCN closure study to determine fog **supersaturation**

- Documentation of **activation at the top of fog**

SOFOG3D measurement campaign

Experimental set-up at Jachère supersite

	Instrument	Parameter
Aerosols	**SMPS + OPC**	Particle size distribution (10,6 to 496 nm and from 0,3 to 10µm)
Aerosols	CCNC	CCN concentration at different supersaturations (SS)
	WELAS 2300	Size distribution of hydrated aerosols and of droplets
Fog	**FM120**	Particle size distribution (2 to 50 µm)
Fog	**Visibilimeter**	Visibility

Tethered balloon at Charbonnières

	Instrument	Parameter
Aerools	**OPC**	Particle size distribution (0,3 to 10µm)
Aerools	Mini-CCNC	CCN concentration at different SS
Fog	**CDP**	Particle size distribution (2 to 50 µm)
Meteo	**Turbulence probe**	Temperature, Pressure, RH, Wind

Data availability

Date	Ground (Jachère supersite)				Tethered balloon (Charbonnières)		
	SMPS	OPC	FM120	CCNC	OPC	CDP	Mini-CCNC
31/10/2019	V	V	V	X	X	X	X
05/12/2019	V	V	P	X	V	V	X
06/12/2019	V	V	V	X	V	V	X
26/12/2019	P	V	V	X	X	X	X
28/12/2019	V	V	V	X	X	X	X
08/01/2020	X	V	V	X	V	V	X
23/01/2020	V	V	V	V	X	X	X
24/01/2020	V	V	V	V	V	V	X
28/01/2020	V	V	V	V	X	X	X
08/02/2020	V	X	V	X	V	V	V
13/02/2020	V	V	V	V	X	X	X
22/02/2020	V	V	V	V	V	V	V
23/02/2020	V	V	V	V	V	V	V
07/03/2020	V	V	V	V	X	X	X
11/03/2020	V	V	V	V	V	V	V

Fog event and data availability

At the ground 12 events sampled by aerosol + droplets including 8 sampled by the CCNC

Tethered balloon : 8 events sampled by the OPC and CDP including 4 sampled by the mini-CCNC

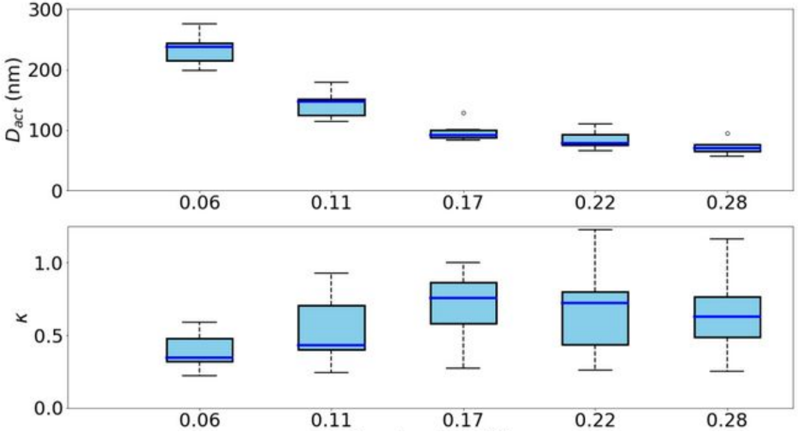
3 events sampled by all instruments : IOP 13 and IOP 15

Previous internship on impact of aerosol S. Tinorua

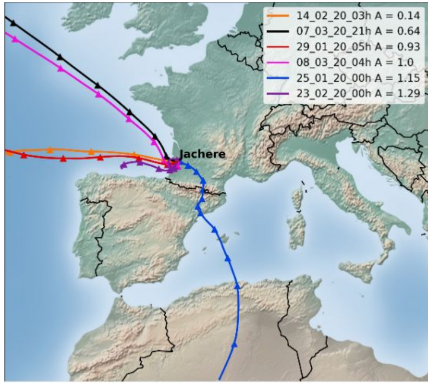
- Aerosols data validation on the ground
- Optical properties of aerosols : low absorption
- CCN closure study on the ground : $D_{act,mean}$ = 232.92 nm at SS= 0.06%

  κ_{mean} = 0.39

  VS PréviBoss κ = 0,17 +- 0,05 VS Wainwright 0,26 (SS= 0,1%)
- Different origin of air masses → different types of aerosols : marin (sulfate and sea salts) and one case of dust particles on 24/01/2020



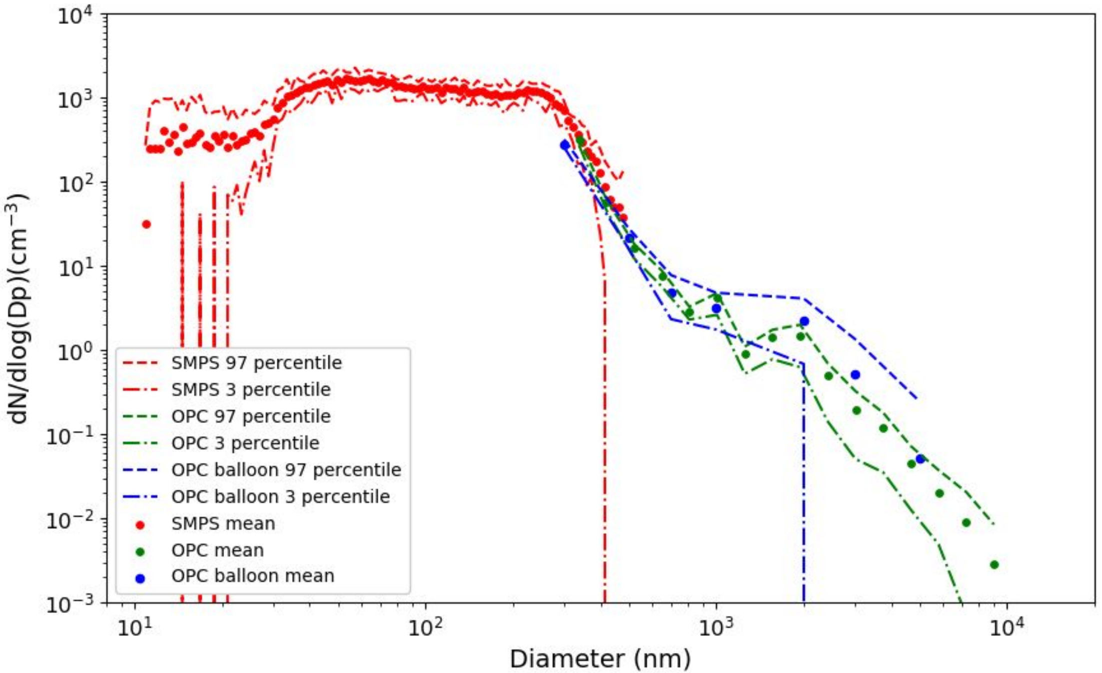
Supersaturation (%)



72h back-trajectories before fog event simulated with Hysplit model (NOAA)

Comparison of aerosols instruments : SMPS, OPC and OPC on tethered balloon

18h48-19h48 23/02/2020 : Aerosols particle size distribution



Comparison of ground aerosol measurements with tethered balloon measurements averaged over the first ten meters

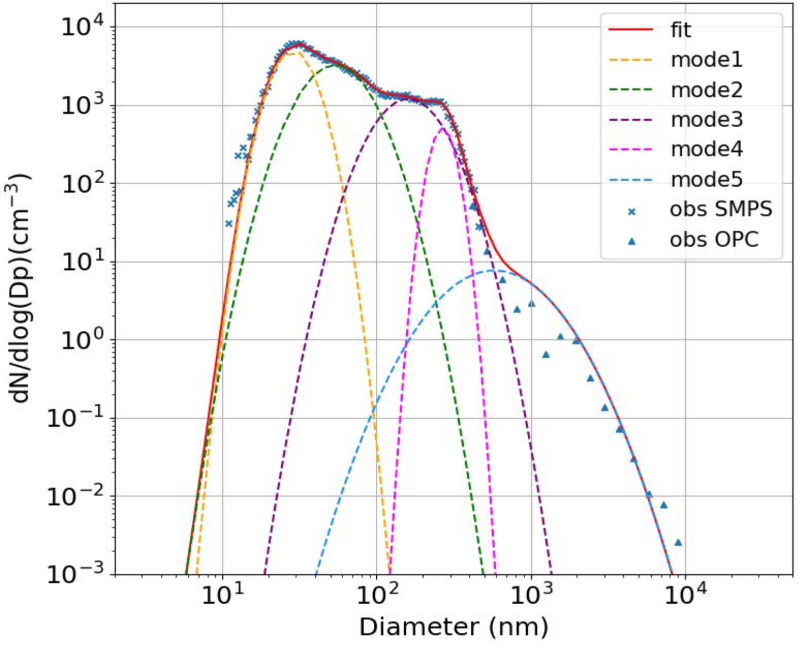
→ good agreement between SMPS + OPC (ground) and between ground and OPC (balloon)

Mode characterization

Aerosols size distribution were fitted using i lognormal distribution

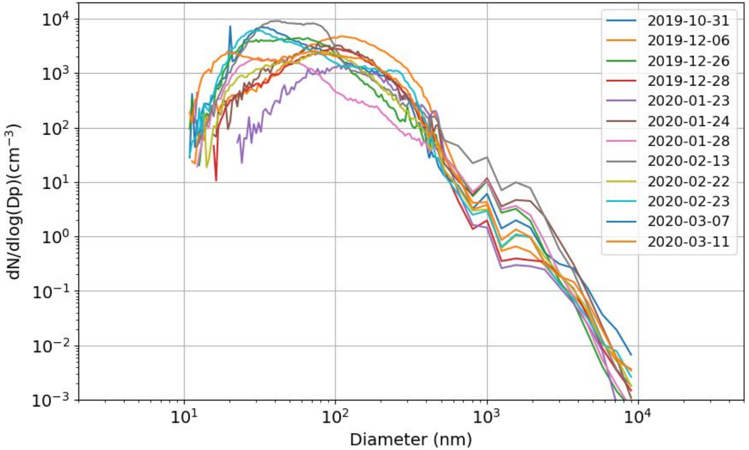
$$\frac{dN}{d\ln(D)} = \sum_i \frac{N_i}{\sqrt{2\pi}\ln(\sigma_i)} \exp\left(-\frac{\ln(D/D_{gi})^2}{2\ln(\sigma_i)^2}\right)$$

D_{gi} : geometric mean diameter
σ_i : geometric standard deviation
N_i : concentration of particles



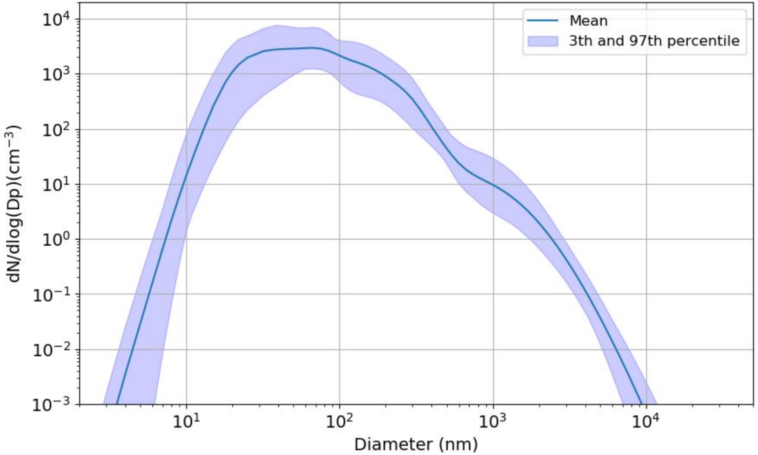
Aerosol size distribution average over 1 hour before the fog event (2020/02/23)

Overview of aerosols properties on the ground

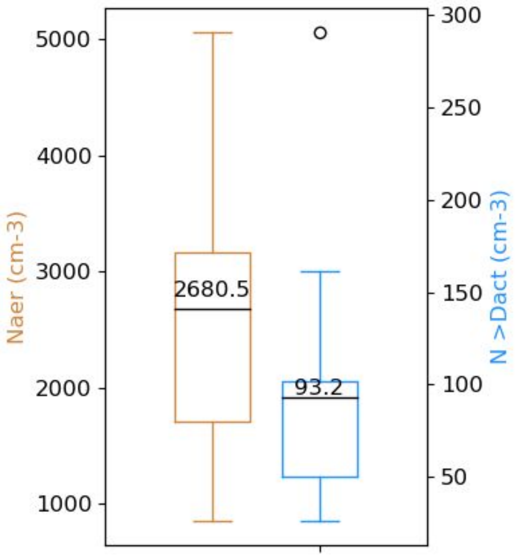


Aerosol size distribution averaged over 1 hour before different fog events

→ 3 to 5 modes of aerosols



Statistical analysis of aerosol size distributions



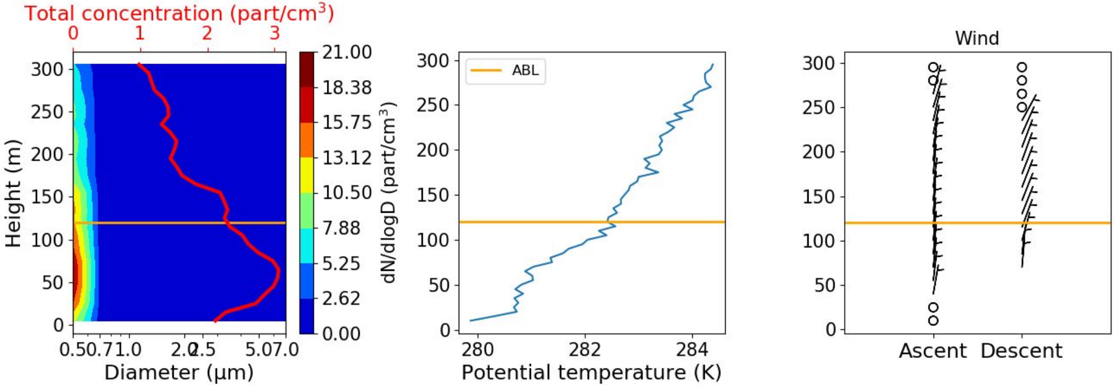
Mean = 2580,5 cm^{-3} // 99 cm^{-3}

Statistics of aerosols concentrations

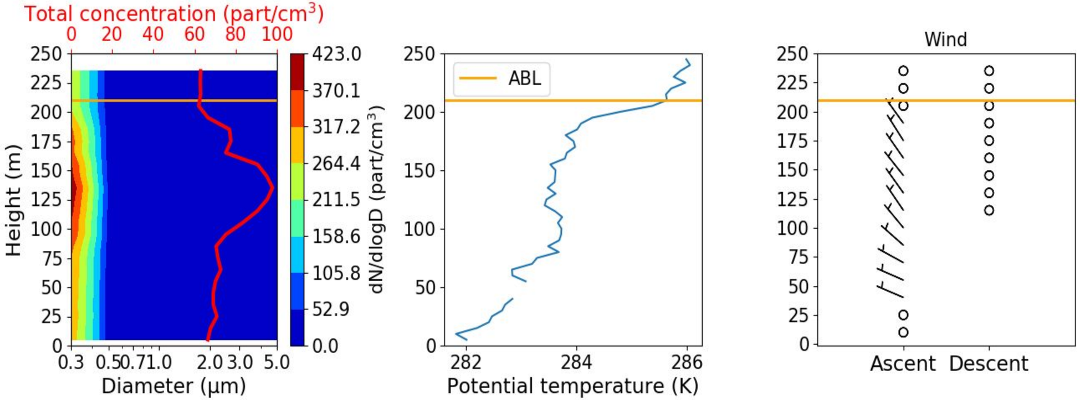
Wainwright : 2923,75 cm^{-3}
Hammer : 2800 cm^{-3}
(maximum of 12 800 cm^{-3})

Aerosol vertical distribution is not homogeneous

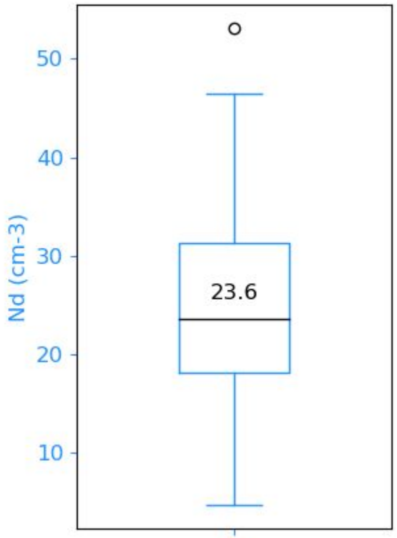
2019-12-05



2020-02-23



Low droplets concentration on the ground



Droplets concentration (N_d) during the 1rst hour of fog events

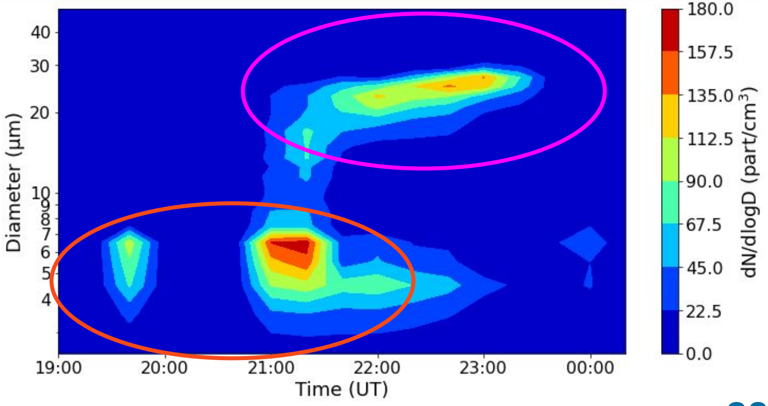
→ **Low droplets concentration**
Mean concentration = 25,75 cm^{-3}

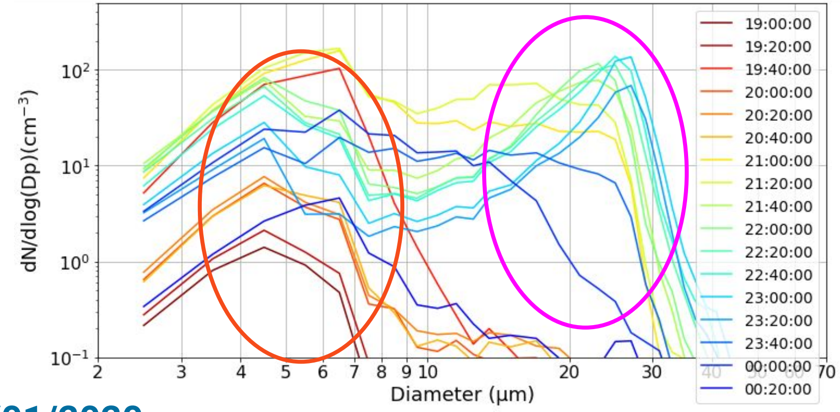
PréViBoss mean over the episode :
68 cm^{-3} (Mazoyer, 2016)

Correlated to mostly **bimodal** droplets size distributions

Contrasted droplets size distribution evolution

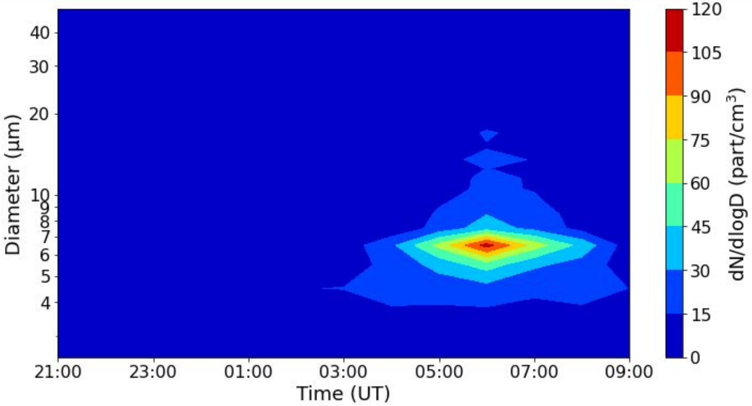
23/02/2020

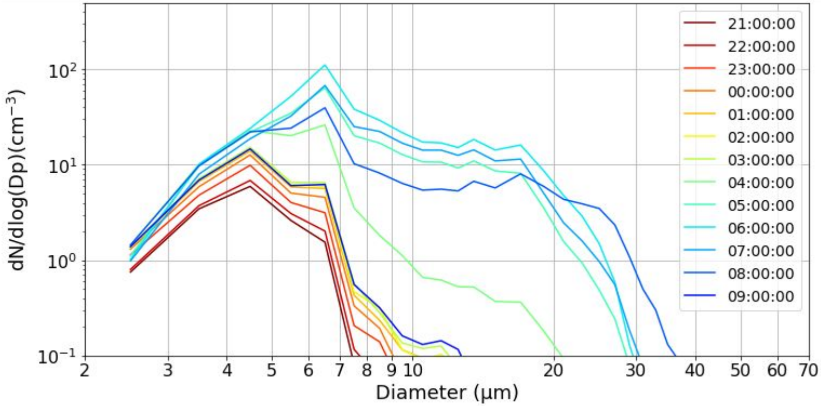




2nd mode distinct at ~28µm

28/01/2020



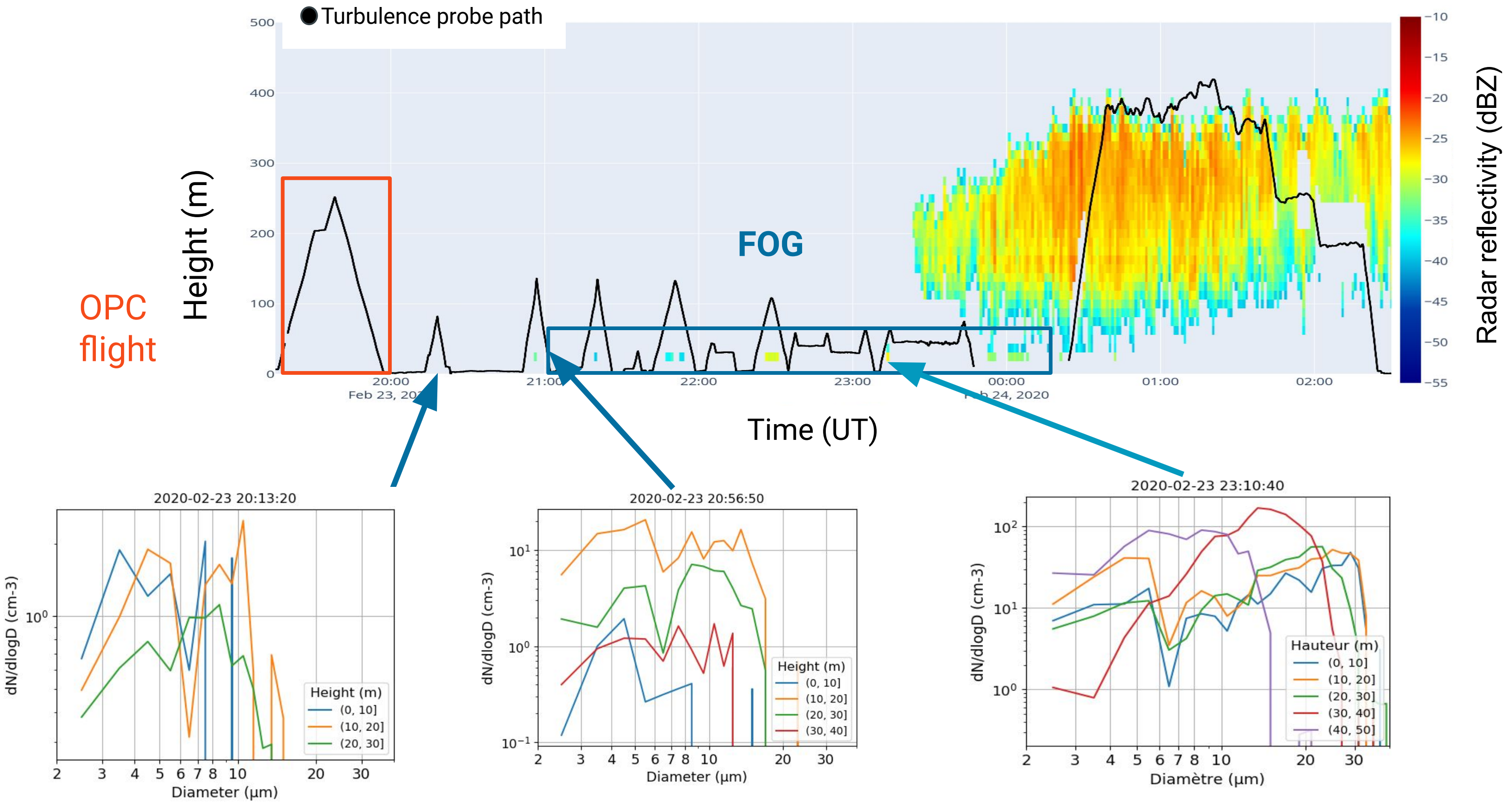


Low activation and slow development of second mode (~20µm)

Ongoing investigation of the link with aerosol properties with CCNC measurements

Vertical variability of activation into droplets

23/02/2020

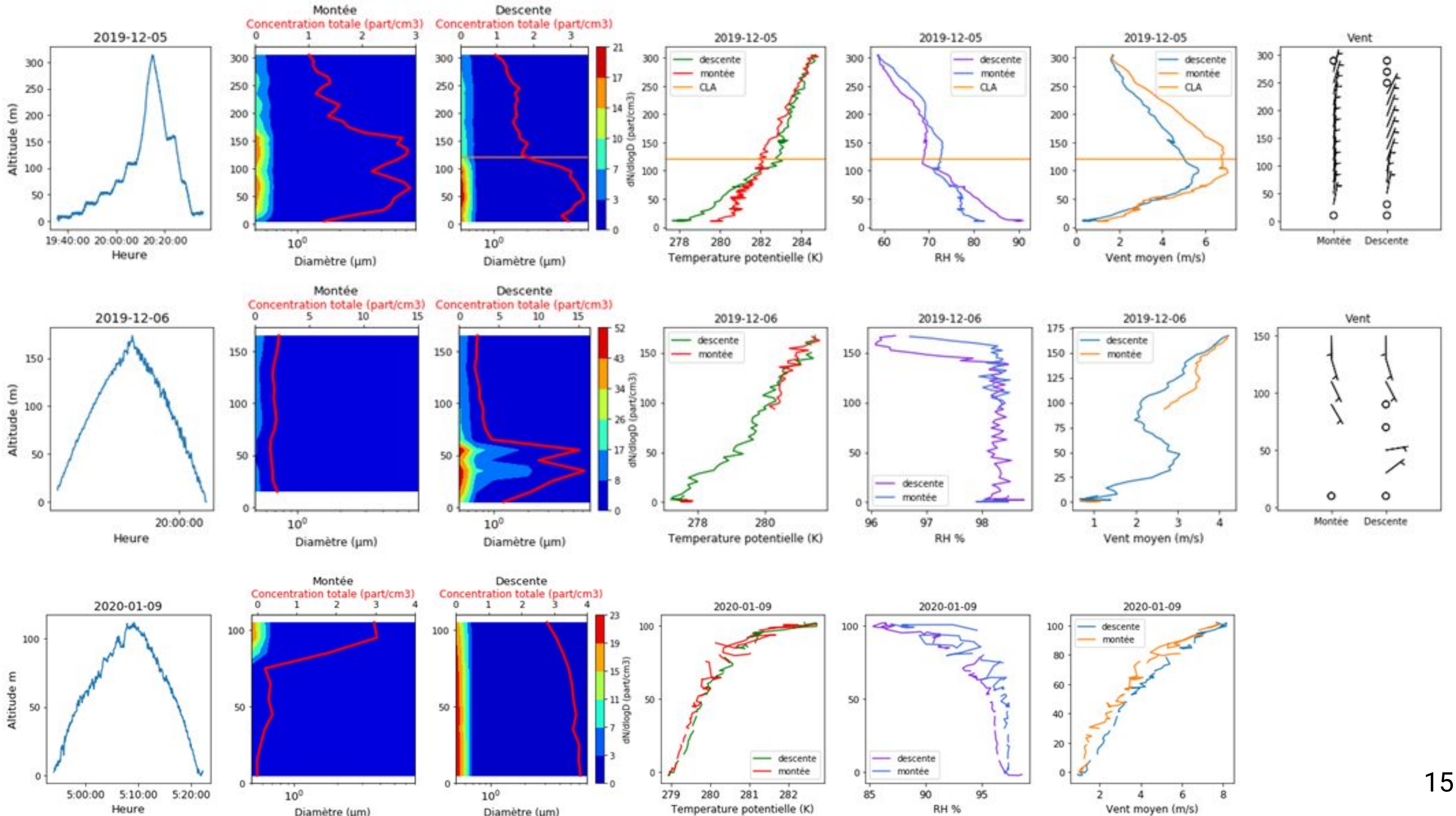


Activation at the beginning of the fog

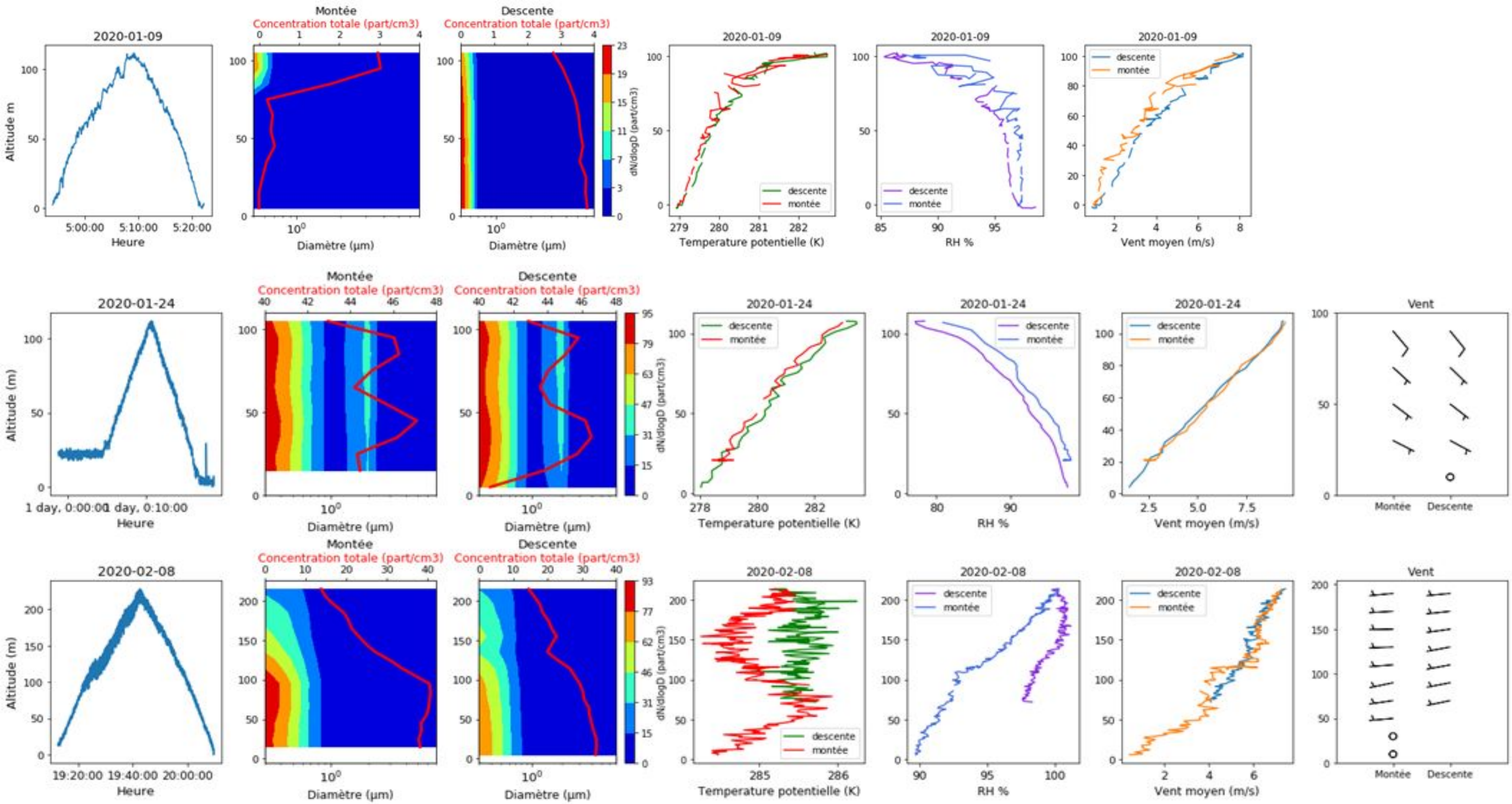
Activation at the top of the fog layer

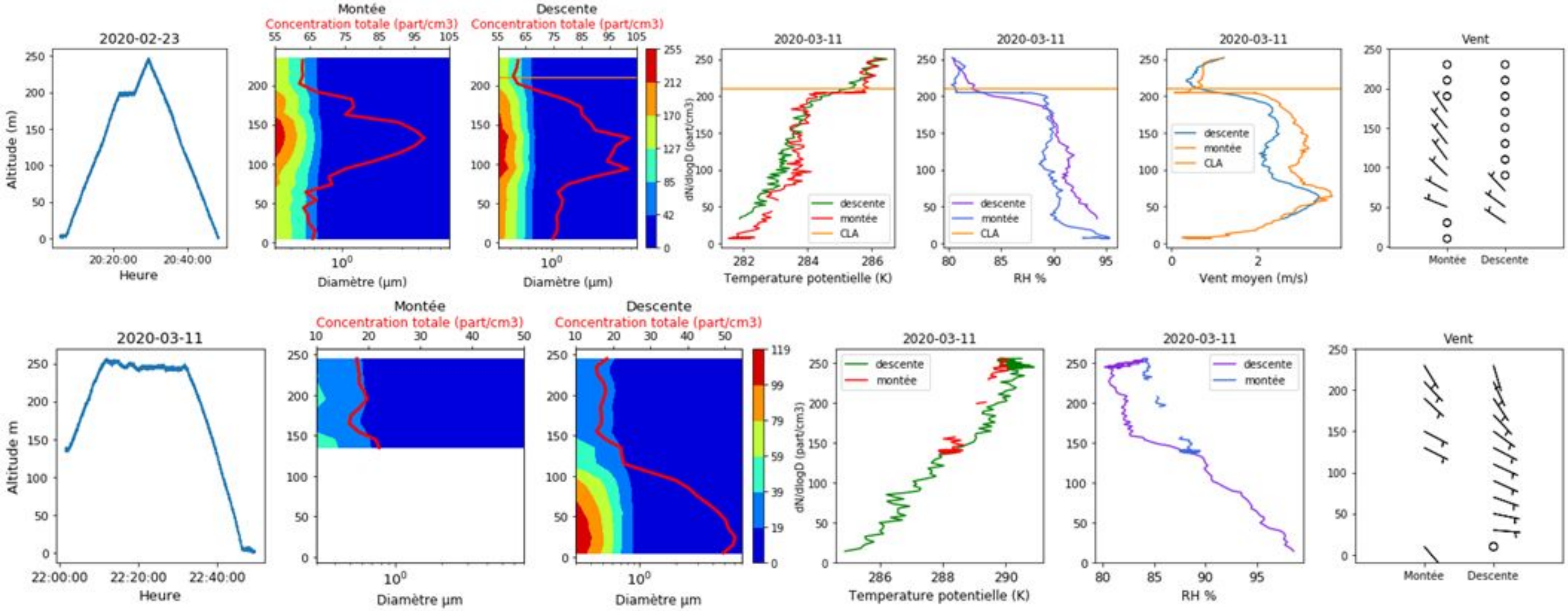
Future work

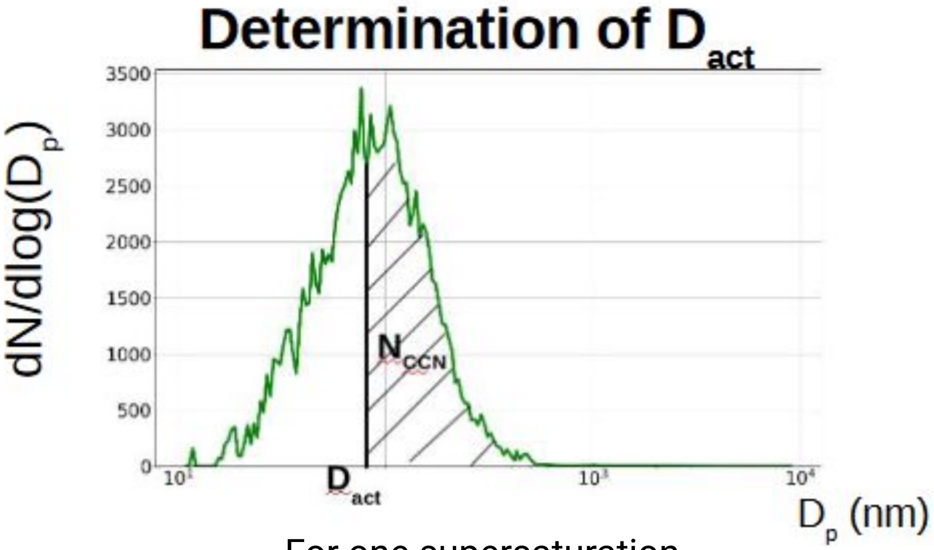
- Statistical study of aerosol and droplet properties over all fog events
- Determination of activation parameters and their vertical variability using CCNC data
- Determination of SS values as a function of altitude and documentation of activation at the top of the fog layer



2019-12-05
Altitude (m)
Heure
Montée
Descente
Concentration totale (part/cm3)
Diamètre (µm)
dN/dlogD (part/cm3)
Temperature potentielle (K)
RH %
Vent moyen (m/s)
descente
montée
CLA
Vent
2019-12-06
2020-01-09
Altitude m


2020-01-09
Altitude m
Heure
Montée
Descente
Concentration totale (part/cm3)
Diamètre (µm)
dN/dlogD (part/cm3)
Temperature potentielle (K)
RH %
Vent moyen (m/s)
descente
montée
2020-01-24
Altitude (m)
Heure
Vent
Montée
Descente
2020-02-08


2020-02-23
Altitude (m)
Heure
Montée
Descente
Concentration totale (part/cm3)
Diamètre (µm)
dN/dlogD (part/cm3)
2020-03-11
Temperature potentielle (K)
descente
montée
CLA
RH %
Vent moyen (m/s)
Vent
Montée
Descente
2020-03-11
Altitude m
Heure
Diamètre µm
Temperature potentielle (K)
RH %
Vent



For one supersaturation

Kappa-Kohler theory :

$$\kappa = \frac{4A^3}{27 D_{act}^3 \ln^2(SS_c)}$$

$$A = \frac{4\sigma_w M_w}{RT\rho_w}$$

- D_{act} : Minimal diameter of activation
- SS_c : Activation supersaturation
- σ_w : surface tension of water
- M_w : water molar mass
- ρ_w : water density

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