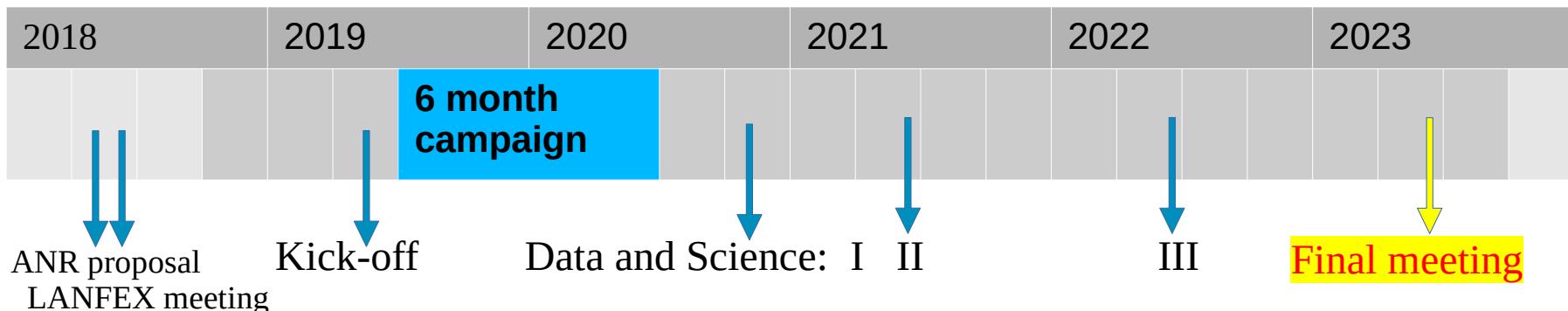


SOFOG3D Final Meeting

Main objective : review main results obtained so far and discuss plans for future projects.

- End of the project on Sept. 30, 2023



- report of the project : what have we done ? deliverables status
- What to do after ? Data to work for 10 years ... new projects ?
 - ▶ Discussion session this afternoon (IFDA conference this summer)

- High Impact of fog on transport :

- Specific research action started at Météo France (COP 2017-2021)
 - ▶ **Development of a high resolution version of the NWP model AROME-500m**

- **SOFOG3D field experiment and ANR project :**

- ▶ Evaluation of AROME-500 fog forecasts
- ▶ Improve our understanding of fog processes to derive refined parametrizations
 - => **3D high resolution LES simulations & experimental studies**
- ▶ New data assimilation trials



SOFOG3D Final Meeting : Agenda

Main objective : review main results obtained so far and discuss plans for future projects.

- 9h30 : Intro - update on the project - F. Burnet (15')
Update on the AERIS database – round table of data providers if needed.
- 9h45 : Task 1 report - F. Burnet (20)
- 10h05 : In situ microphysics and tethered balloon measurements - PhD T. Costaboz (30)
- 10h35 : Radiative closure - Internship A. Veau (15)
- 10h50 : coffee break (20)

- 11h10 : Observations of fog droplet deposition at Le Couye - J. Price (15)
- 11h25 : Radar measurements - Task 2 report - J. Delanoë (15)
- 11h40 : AROME forecast report - PhD S. Antoine /Y. Seity /R. Honnert (20)
- 12h00 : UKMO UM report - A. McCabe / J. Price (20)
- 12h30 : lunch break (1h30)

- 14h00 : Impact of heterogeneities - M. Taufour (20)
- 14h20 : Contrasting the evolution of radiation fog over a heterogeneous region - J. Thornton (20)
- 14h40 : Task 3 report - C. Lac (10)
- 14h50 : Role of thermodynamics and turbulence processes on the fog life cycle – C. Dione (20)
- 15h10 : Fog formed by Stratus lowering - M. Fathalli (20)
- 15h30 : Task 4 report - M. Haeffelin / C. Lac (10)
- 15h40 : coffee break (20)

- 16h00 : **General discussion :**
future analysis, prospective for future project and experiment (1h30)

<https://bluejeans.com/407939251/1326>

Review of the past year

- **Last Data and Science meeting III - 07/06/2022**
 - 12 talks ~ 25 people with ACCORD participants => see <http://www.umr-cnrm.fr/spip.php?article1086>
 - Data analysis : MWR network, Radar, aerosol and fog microphysics, LWC deposition at the MO site,...
 - Evaluation of AROME and UM models, 3D LES and heterogeneities, life cycle of developed fogs,...
- **1 PhD defense (March 2023) : Salomé Antoine – congratulations !!**
 - Improvement of fog forecast with AROME-500 (WAF-D-22-0071 - In review)
- **1 PhD in progress (May 2024) : Théophane Costabloz**
 - In situ microphysics and tethered balloon measurements
- **Post doc positions**
 - M. Taufour (12/2022) : 3D high-resolution LES with Meso-NH (C. Lac)
 - C. Dione (03/2023) : thermodynamics and turbulence processes on the fog life cycle (M. Haeffelin/ C. Lac)
 - M. Fathalli (11/2023) : St lowering fog (obs and simu) (F. Burnet / C. Lac / P. Martinet)
- **Master internship : A. Veau : radiative closure (Q. Libois)**
- **Conferences : (please send me relevant info if any)**
 - JSS 2022, EGU 2023, IFDA 2023, others ??
- **3 babies** : Agathe (P. Martinet), Hazel (J. Thornton) and Simeon (Q. Libois) - **congratulations !!**



Publication list

- **Already on-line published :** (See <http://www.umr-cnrm.fr/spip.php?article1086>)
 - Bell A. et al. : An Optimal Estimation Algorithm for the Retrieval of Fog and Low Cloud Thermodynamic and Micro-physical Properties, AMT, 15, 5415–5438, 2022.
 - Marquet, P. et al. : conservative thermodynamic variables in data assimilation: a case study using ground-based MWR measurements, AMT, 15, 2021-2035, 2022.
 - Martinet, P., et al. : MWR data paper : Database of temperature, humidity and LWP retrievals from a fog dedicated network of ground-based MWR", Bull. of Atmos. Sci. and Technology, 3, 6 (2022).
 - Vishwakarma, P., et al. : Climatology of estimated liquid water content and scaling factor for warm clouds using radar–microwave radiometer synergy, AMT, 16, 1211–1237, 2023.
- **Submitted / In review :**
 - Antoine, S., et al. : Evaluation of an improved AROME configuration for fog forecasts during the SOFOG3D campaign. Weather and forecasting, WAF-D-22-0215, in review
 - Thornton, J., et al. : Contrasting the evolution of radiation fog over a heterogeneous region in south-west France during the SOFOG3D campaign. QJRMS, in review, 2023.
 - Dione, C., et al. : Role of thermodynamic and turbulence processes on the fog life cycle during SOFOF3D experiment, EGUsphere [preprint], ACP, 2023, just submitted.
- **In preparation :**
 - Impact of MWR assimilation on AROME fog forecasts : G. Thomas / P. Martinet
 - Microphysics vertical profile and thin to thick transition : T. Costaboz / F. Burnet
 - Impact of heterogeneity and high resolution Meso-NH simulations : M. Taufour / C. Lac
 - UKMO modelling work : A Mccabe et al.
 - Overview of the campaign and main highlights : F. Burnet / all PI
=> work on it this summer before IFDA conference => fall 2023
 - MWR retrieval inter-comparison : P. Martinet + Univ. Cologne



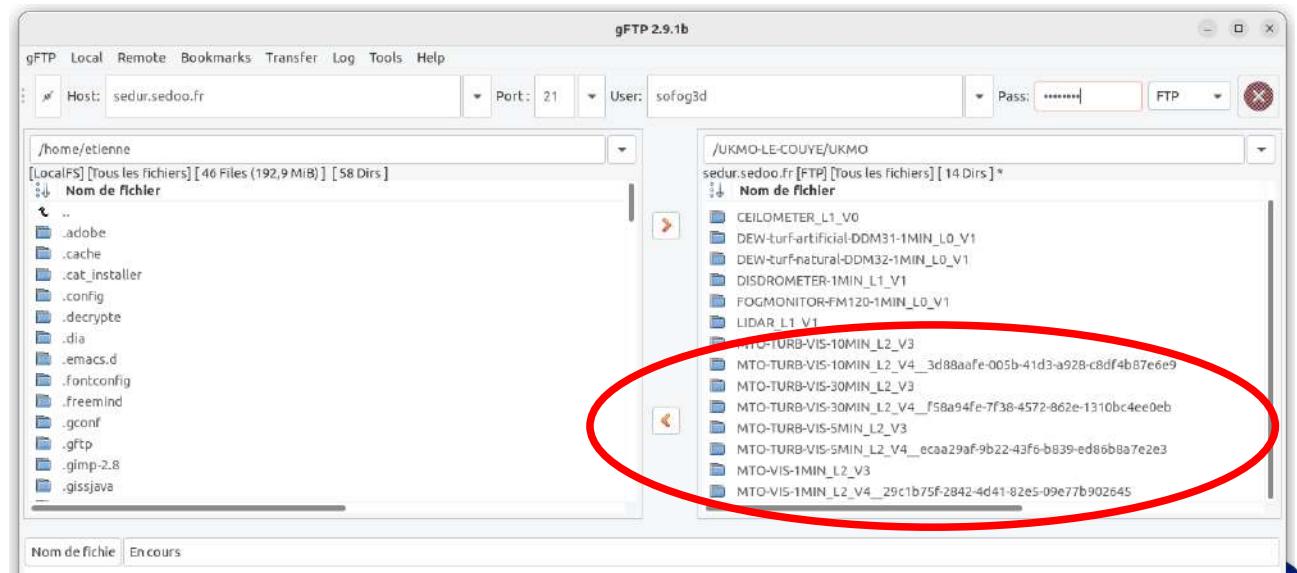
The database on AERIS



- **End of embargo in september** (data policy)
 - Open to everyone – no information of usage...
- **complete the database** and projet information
- <https://sofog3d.aeris-data.fr/catalogue/>
- AERIS contact : Damien Boulanger
[\(damien.boulanger@obs-mip.fr\)](mailto:(damien.boulanger@obs-mip.fr))
- Data deposit on the ftp site :
=> need to add __UUID at the end of the final repository name

The screenshot shows the AERIS data portal interface. At the top, there's a navigation bar with links for 'ACCUEIL', 'DATA POLICY', and 'ACCÈS AUX DONNÉES'. Below the navigation is a banner for the 'SOFOG3D' project, which is described as the 'South westFOGs 3D experiment for processes study'. The banner features a photograph of a forested hillside. Below the banner, there's a brief description of the project's objective to understand atmospheric processes and its role in the BreTAG project. A button labeled 'Accès aux données' is visible. The bottom of the page includes the AERIS logo and copyright information.

- **uuid provided by AERIS**



The database on AERIS

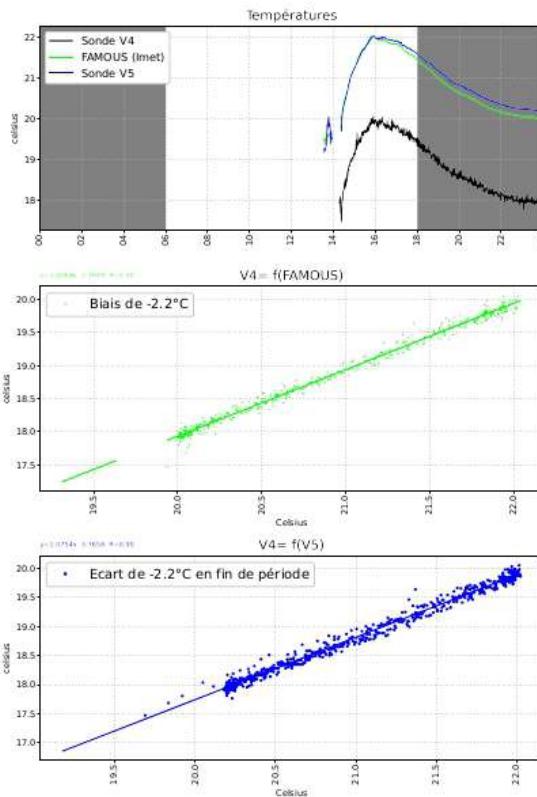
- Data deposit : need to add __UUID at the end of the final repository name
=> UUID is provided in the interoperability tab

The screenshot shows the AERIS Catalogue interface. On the left, there is a search bar with 'SEARCH' and 'RESET' buttons, and a sidebar with dropdown menus for 'Temporal extents', 'Spatial extents', 'Sites', 'Platforms', and 'Instruments'. The 'Instruments' section is expanded, showing categories like 'Current/Wind Meters', 'Not Applicable', 'Photon/Optical Detectors' (which is selected), 'Celiometers', 'Visibility Sensor' (which is checked), 'Positioning/Navigation', 'Pressure/Height Meters', 'Probes', 'Profilers/Sounders', and 'Spectrometers/Radiometers'. The main area displays a list of 24 results found, with the first item being 'SOFOG3D_BASTA-CHAMP_CNRM_VISI-3M-30SEC_L2'. To the right, a detailed view of the 'SOFOG3D_JACHERE_CNRM_VISI-TEMPS-PRESENT-3M-15SEC_L1' dataset is shown. The page includes tabs for 'INFORMATION', 'DOWNLOAD', 'STATISTICS', and 'INTEROPERABILITY'. An arrow points from the text '=> UUID is provided in the interoperability tab' to the 'INTEROPERABILITY' tab. The 'INTEROPERABILITY' tab contains sections for 'FAIR Principles' and 'UUID'. The 'UUID' section features a red oval highlighting the persistent identifier '5ff16a00-403f-4e45-606f-f6204f75184'. Below this, there are sections for 'Catalogue and Metadata API' with URLs for Swagger UI, JSON format via URL, and harvesting via CSV.

Tethered balloon temperature bias

- Discrepancy between RS and tethered balloon temperature
- Comparison with reference probes in January : inside and outside
=> **underestimation of 2.2 C**
- But uncertainties still remains => Theophane talk

INTERCOMP SONDES TURBULENTES Labo 4M le 16/01/2023



- Installation de la V4 et la V5 près du mât Météopole Flux.

- Mesure d'une t° tempé donnée par la sonde FAMOUS en plus de la Tempé de la sonde turbulente V5

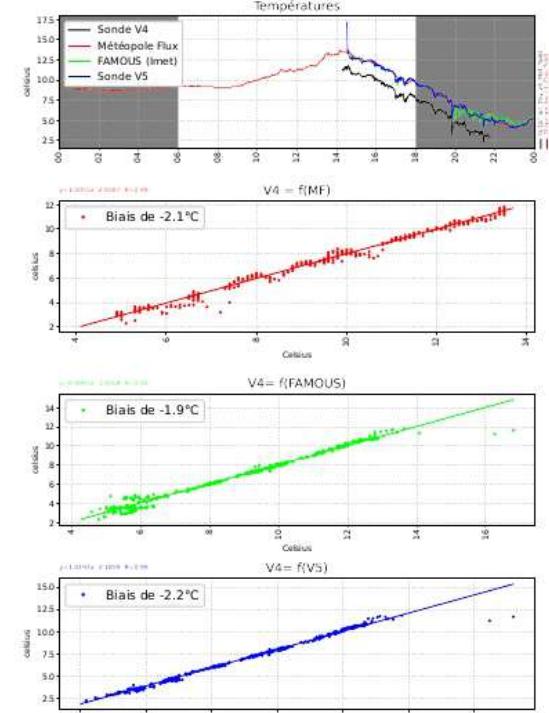
- Fonctionnement de la V4 de 14h à 22h le 03/01/23 (arrêt dû à un pb batterie).

- Conditions froides et humides avec brouillard au petit matin (pas d'info sur le brouillard dans la plage de fonctionnement de la V4)



(J.C. Etienne - GMEI/TRAMM)

INTERCOMP SONDES TURBULENTES champ METEOPOLE le 03/01/2023



1/1
06-06-2023 14:52 à l'heure normale universelle appliquée à l'intercomp_sondes_turbulentes_2023/graphiques/INTERCOMP_SONDRES_TURBULENTES_Janv_vera

Dataset status - AERIS

- Available datasets :

- **129 today on AERIS** (a bit more on FTP site)

- New datasets :

- V2 30 mn turbulence data MAIRE-SORE and JACHERE :
 - ▶ errors on TKE due to bad filtering of the wind
- V4 10s meteo. data tethered balloon : **temperature bias +2.2 C**
 - ▶ but uncertainty remains ... (new position of E. Moulin)
- V3 turbulence data tethered balloon (impact on fluxes negligible)

- UKMO data uploading in progress (J. Thornton and J. Price) : need to correct some file names

- Still missing / Data (re)-processing :

- tethered balloon :
 - ▶ cloud droplets and aerosols CDP + OPC + CCN (T. Costaboz, T. Bourrianne, C. Denjean)

=> **Validation still in progress** but CDP data provided for POI 11 and 14 for PhD studies
- microphysics network : FM100/120, ~~WELAS~~, PVM-100 (T. Costaboz, F. Burnet)

and aerosols at JACHERE site (T. Bourrianne, C. Denjean)

=> **Validation still in progress** : T. Costaboz and M2 Ines.
- UAV data : M. Goret just arrived in November and PANAME 2023 => Not done yet
- Lidar LB100 : new position of V. Unger => Not done yet

Type of measurements	Datasets
Core surface meteorological data	CNRM stations (11 datasets) Météo-France network (3 datasets)
Visibility	CNRM stations (16 datasets) Météo-France network (1 dataset)
Present weather	CNRM stations (8 datasets)
Turbulence measurements	CNRM tethered Ballon (1 dataset) CNRM surface stations (2 datasets)
Sounding	CNRM tethered Ballon (1 dataset) CNRM radiosounding (2 datasets) Météo-France network radiosounding (2 datasets)
Cloud radar BASTA	LATMOS and CNRM BASTA (8 datasets for 3 sites) Vertical and scan
Microwave radiometer	RPG, MeteoSwiss, RPG, LAERO, UKMO, ONERA, CNRM Radiometers (52 datasets for 7 sites)

Task1 Report

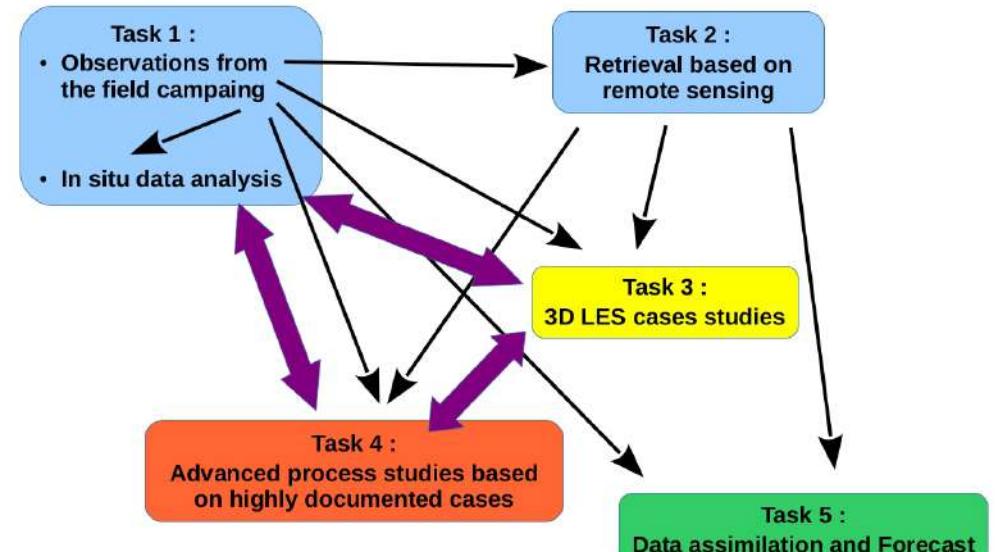
■ Objectives and main scientific questions of the ANR :

- Provide a **3D characterization of fog layer properties** with detailed observations of dynamics, radiation, microphysics and surface fluxes
- Processes study using **synergy between 3D high-resolution LES** and unprecedented detailed observations
 - Dynamics : **impact of surface heterogeneities** on spatio-temporal fog variability
 - Microphysics : **transition between thin and thick fog**, impact of aerosols
 - **St to fog transition** : local processes or mainly driven by large scale conditions
- **Data assimilation** of new local observations : MWR network and synergy with radar

■ Organisation :

Timetable of the project:

	18	2019		2020		2021		2022				
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1 : Field campaign and in situ data analysis												
1.1 Preparation												
1.2 Field campaign												
1.3 In situ data analysis (CDD)												
Task 2 : Fog retrievals based on remote sensing measurements												
2.1 Radar retrievals (CDD)												
2.2 Attenuation and closure study												
2.3 Improved MWR retrieval												
2.4 SEVIRI/MSG retrievals												
Task 3 : 3D high resolution LES												
3.1 : LES and validation (CDD)												
3.2 : Impact of heterogeneities												
3.3 : Impact of orography												
Task 4 : Advanced process studies based on highly documented cases												
4.1: Transition thin/thick												
4.3 : Ph D on St lowering												
4.2: Fog dissipation phase (CDD)												
Task 5 : Data assimilation and forecast												
5.1 Observations preparation												
5.1 Assimilation trial (CDD)												
Final report												



Planned Experimental strategy : KO meeting 2019

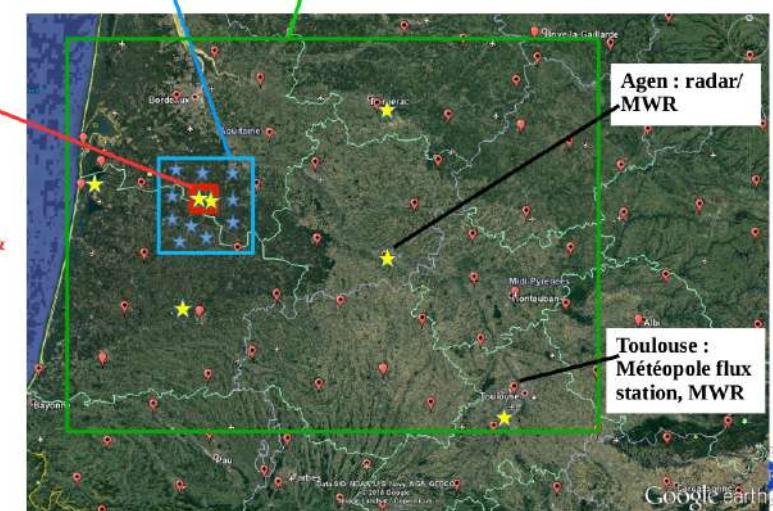
- 6 month experiment
- 3 nested domains
- Synergy in situ / teledetection
=> surface & vertical profiles



SOFOG3D experimental strategy

Surrounding domain 50 x 50 km with increased density in-situ sensors network (~ 15 surface met. stations, visibility, ceilometers, turbulence)

Larger domain 300 x 200 km (AROME-500m model) with in-situ sensors (~ 50 surface met. stations) and MWR (6 units ★) networks

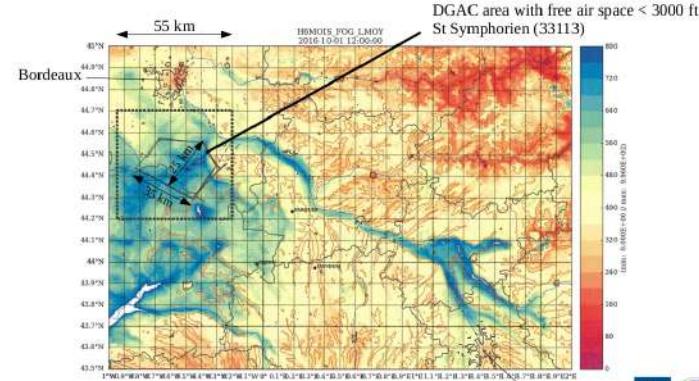


Field campaign :

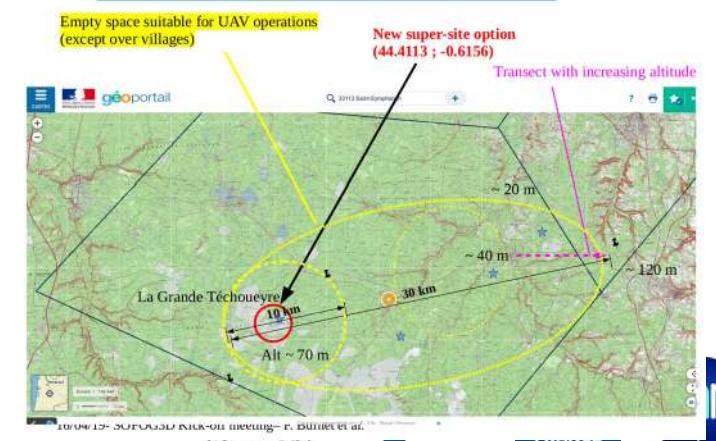
- Fall-winter 2019/20 in the South West of France:
Mont de Marsan : 80 events / year (340 h)
- Long term observation period :
automatic systems : RADOME met. Network (50), mobiles met. stations (20), remote sensing, instrumented mats (flux, microphysics),...
- Intensive Observation Periods :
radiosounding, tethered balloons, UAVs fleet
=> Objective : sample 10 à 20 events with favourable conditions



AROME fog forecasts (nb of hour) winter 2016-17



Selected supersite area



Observational set-up

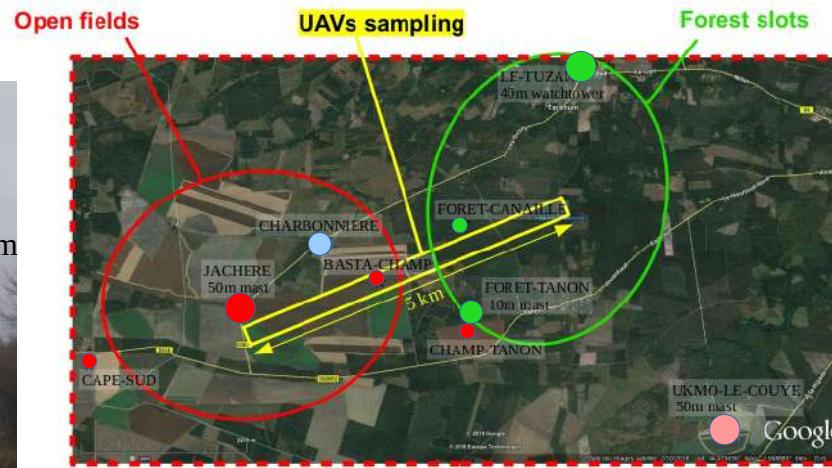
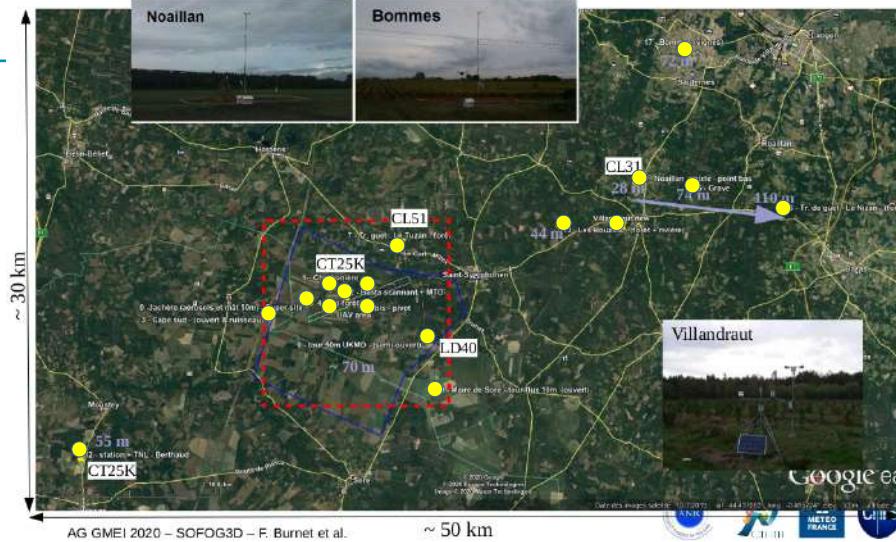
- MWR network : 8 units on 6 sites (2 radars)
- Surface network
 - 17 stations with 2 50m-masts

=> contrast forest / open fields
- Fluxes, aerosols and microphysics, lidars...
- Tethered balloon, RS, UAV



SOFOG3D surrounding domain : 7 sites (+ 10 super-site)

=> sol : 2 stations UMKO + 5 stations SAMHA de 4M + tour du Nizan

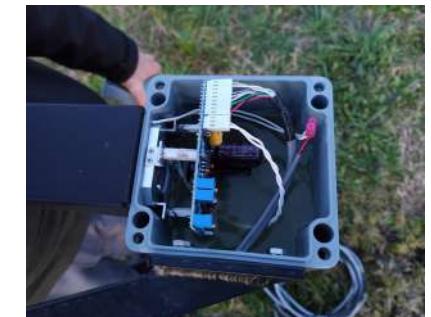
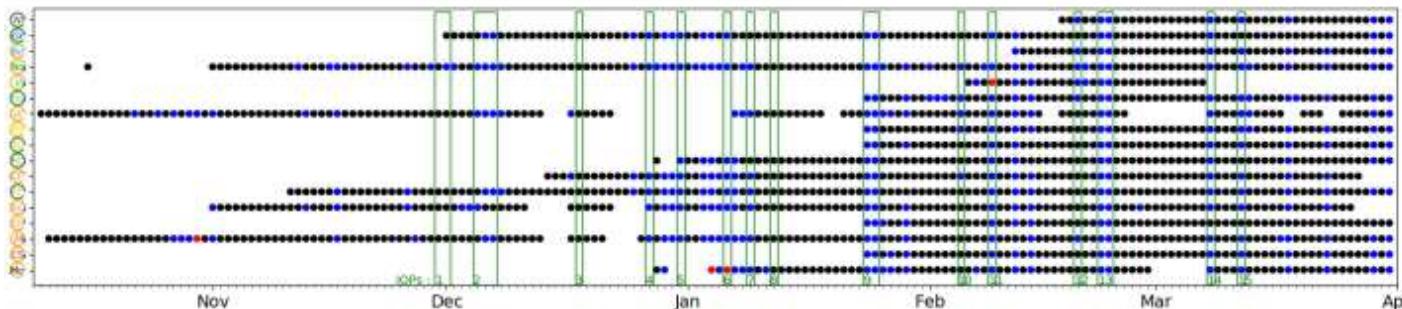


What didn't work - main difficulties

- **Amelie storm 3/11/2019** : lost of the CNRM 50m mast
- Lost of the tethered balloon during Xmas foggy period
- **Instrumental failure** : young visibilimeter network (18 units)
- **UAV** : CNRM team involved in EUREC4A, MétéoMatics canceled
- Meteorological conditions at the super-site :
 - few developed fog, very few St lowering...
- Tethered balloon sampling strategy : aerosols / droplets / turbulence
- **Very ambitious field campaing** but not enough people...
 - delays in instruments deployment, monitoring and maintenance
 - conflict between long term measurements and IOP operations
 - visibility, welas, UKMO met. station, dew, aerosols,....



(M. Taufour)



A successfull experiment anyway :

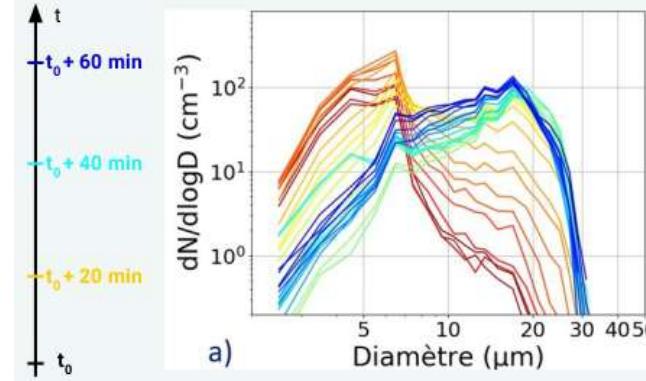
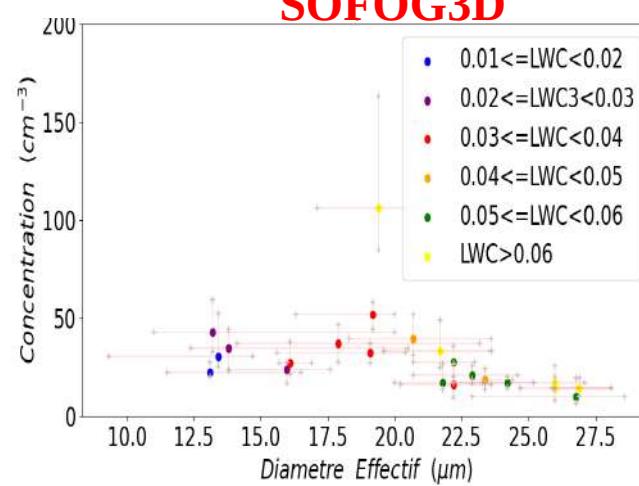
(T. Costabioz)

- **30 fog events** at the super-site
 - AROME-500 evaluation
 - Impact of surface heterogeneities
- **Microphysics properties** at Jachère site : low CDNC of large droplets

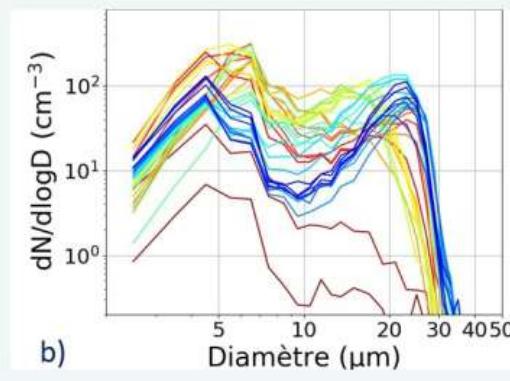
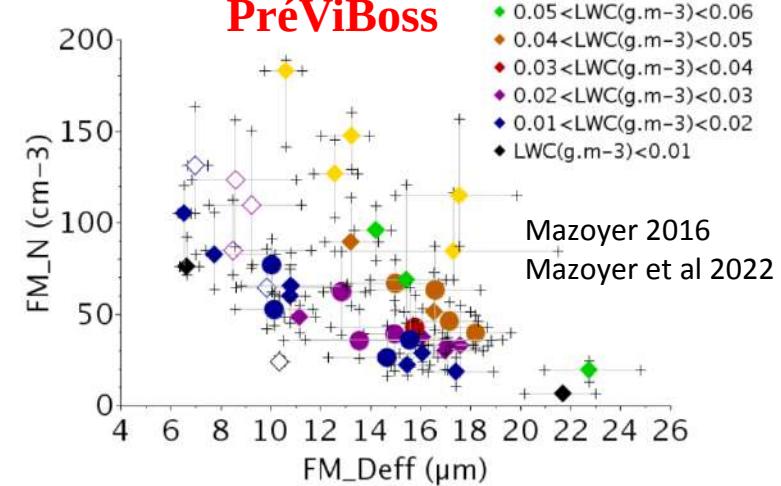


Many bimodal droplet size distributions

(I. Vongpaseut)



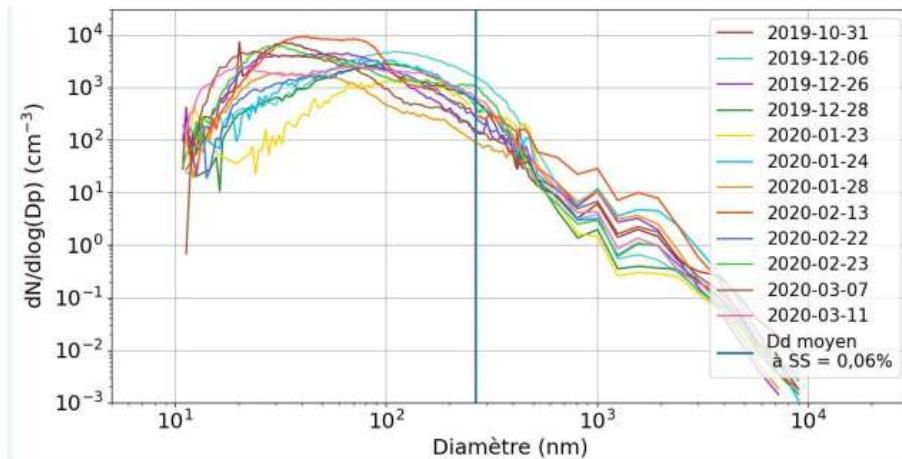
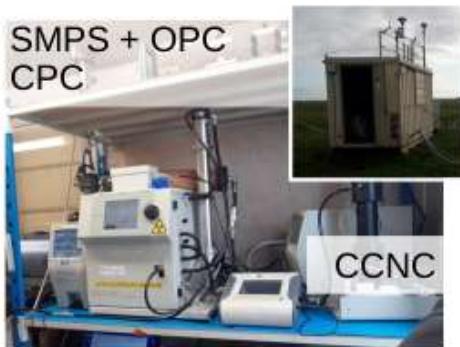
24/01/2020



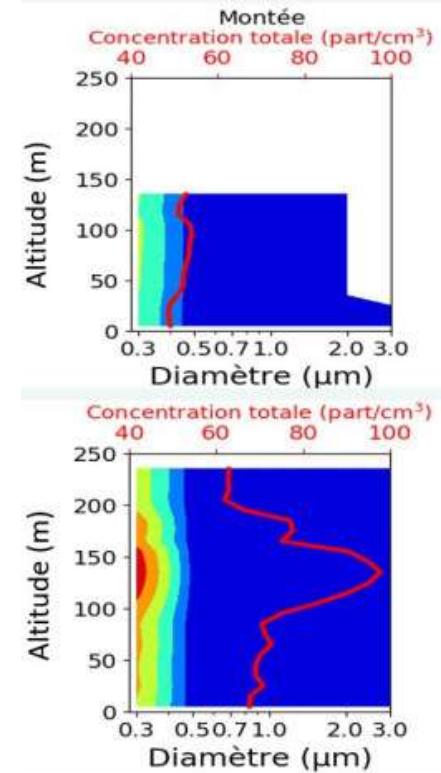
23/02/2020

A successfull experiment anyway :

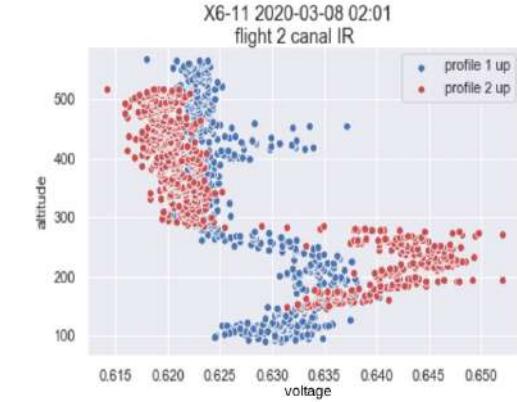
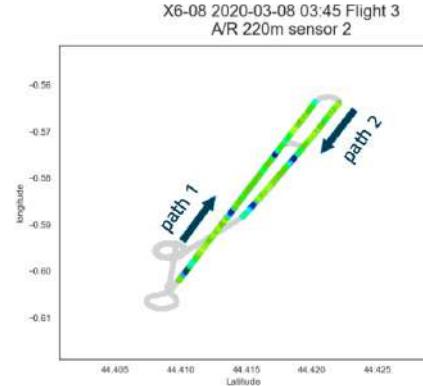
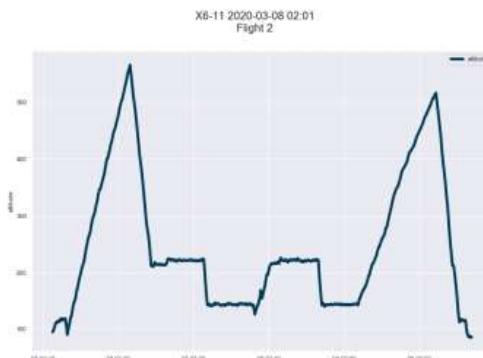
- **Microphysics, radiatives and hygroscopic properties of aerosols**
 - low concentration ($\bar{N}_a \sim 2500 \text{ cm}^{-3}$) (C. Denjean)
 - $0.19 < k < 0.38 \Rightarrow$ impact of organics



Vertical variability



- **Turbulence and surface fluxes >> LANFEX - (G. Canut)**
- **7 IOP with UAV flights - (G. Cayez / G. Roberts)**



IOP overview : 01/12/2019 => 12/03/2020

- **15 IOP => 20 nights of tethered balloon operations + RS:**

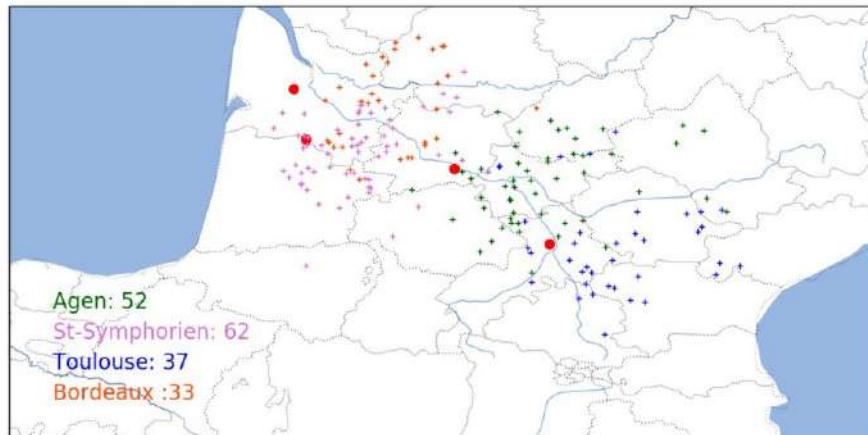
- 5 without fog (or just mist)
- 8 thin fogs with width $H \leq 50$ m
- 4 medium with $80 \leq H \leq 180$ m
- 3 thick $H \geq 200$ m : **IOP-6, 11 and 14**

5-6 Jan. (250m), 8-9 Feb. (250m) and 8-9 March (200m)

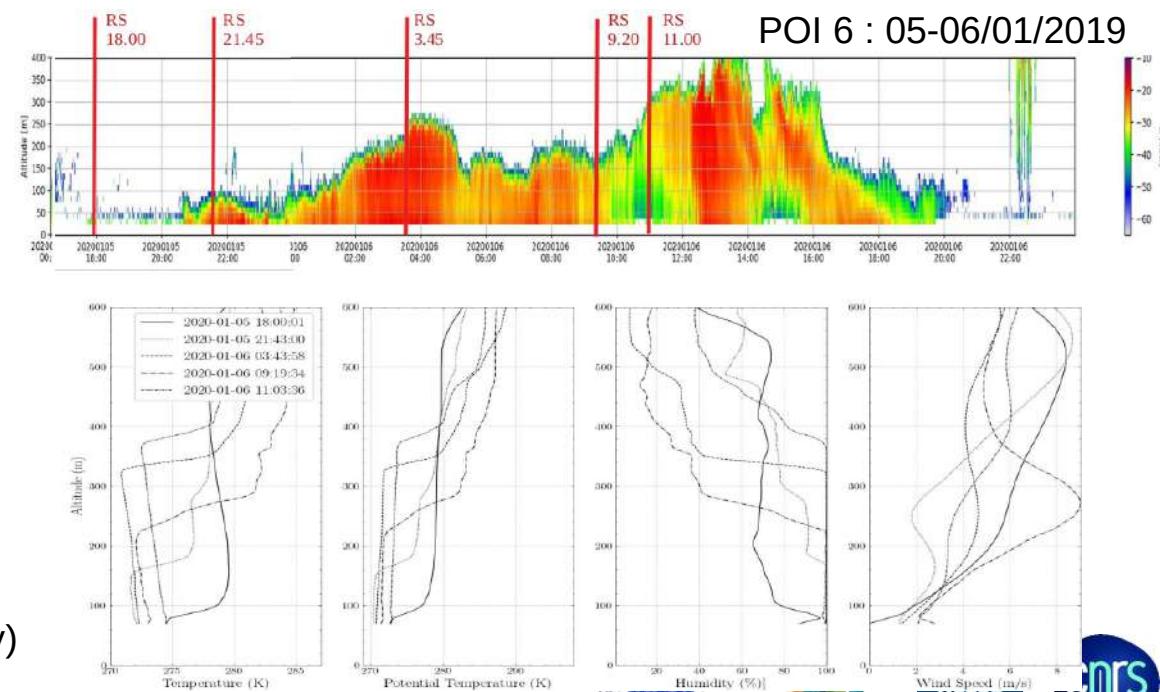
} **15 fog events**



- **184 RS** over the whole domain



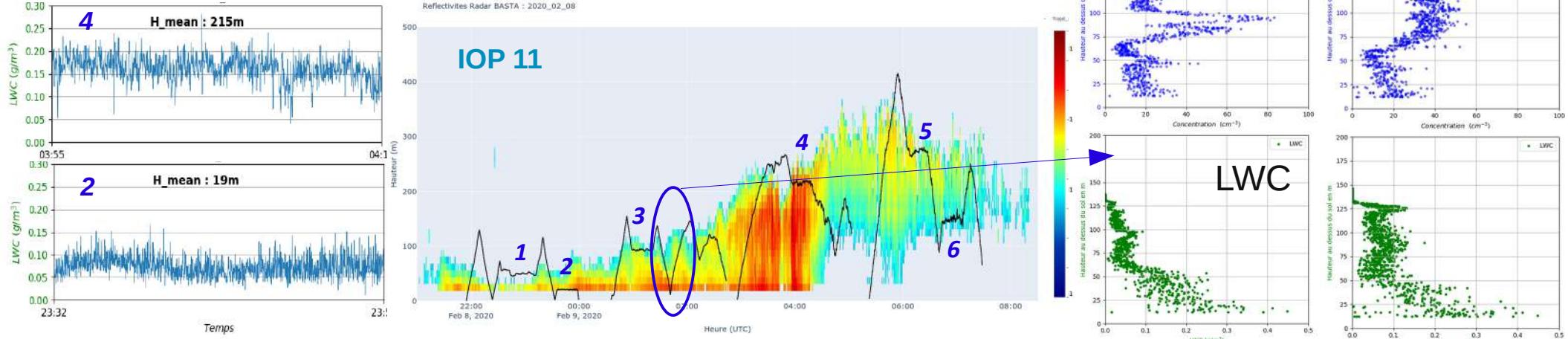
(A. Roy)



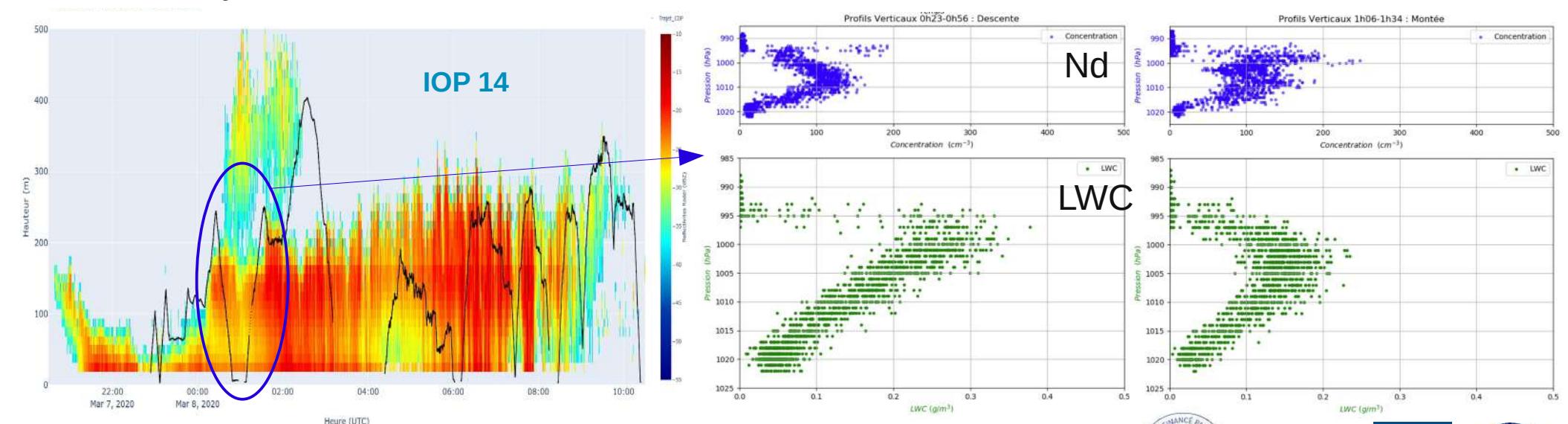
Vertical profiles of fog microphysics



- CDP below tethered balloon : contrast constant leg / profiles

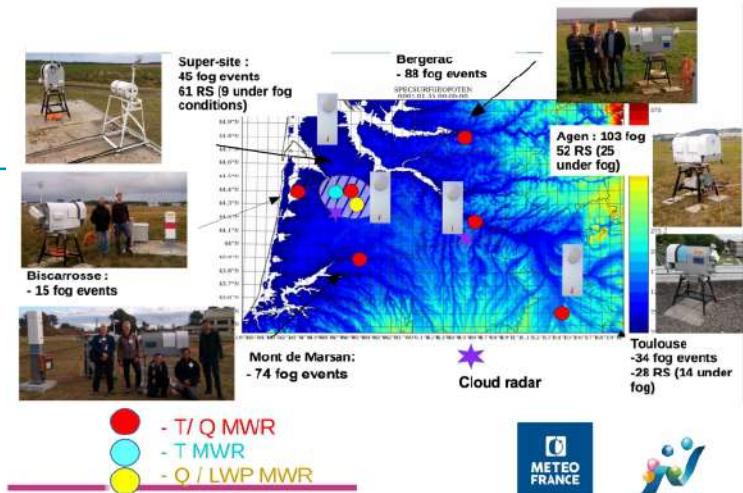


- Life cycle and thin to thick transition

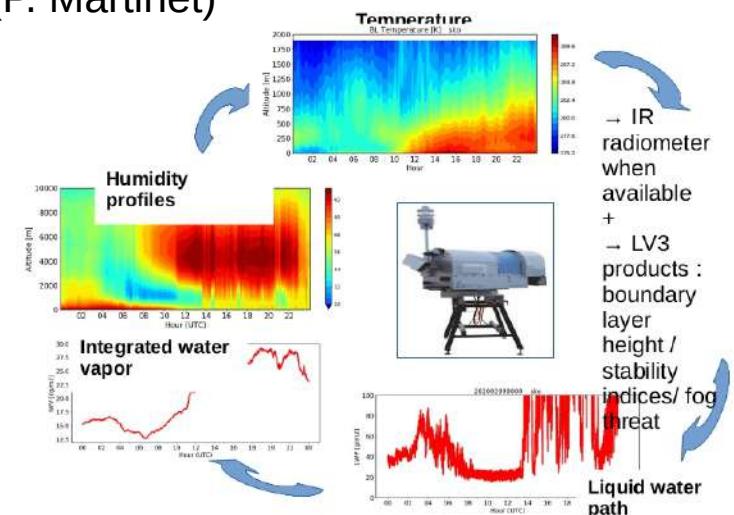


Remote sensing

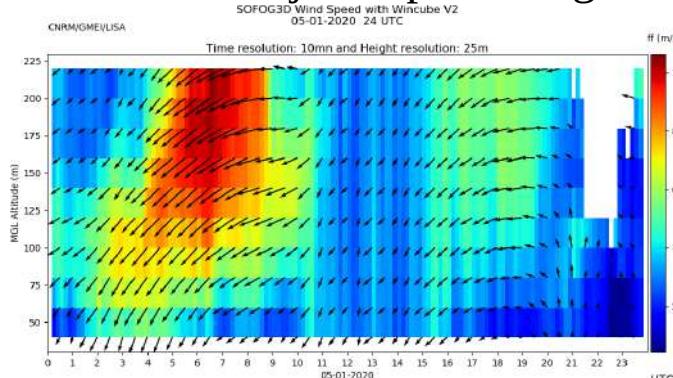
- Cloud radar - Task 2 (J. Delanoë)
 - Reflectivity profiles, CTH
- MWR network - Task 5 (P. Martinet)
 - temp. and humidity profiles, LWP
 - LWP closure with CDP data
 - 1D-Var assimilation MWR/Radar (PhD A. Bell)
 - Assimilation trials AROME 3D-VAR (G. Thomas)
- Ceilometer : CBH et backscattering profiles
- V2 wind lidar : wind profile and TKE
- Aerosol lidar LB100 => not used



(P. Martinet)

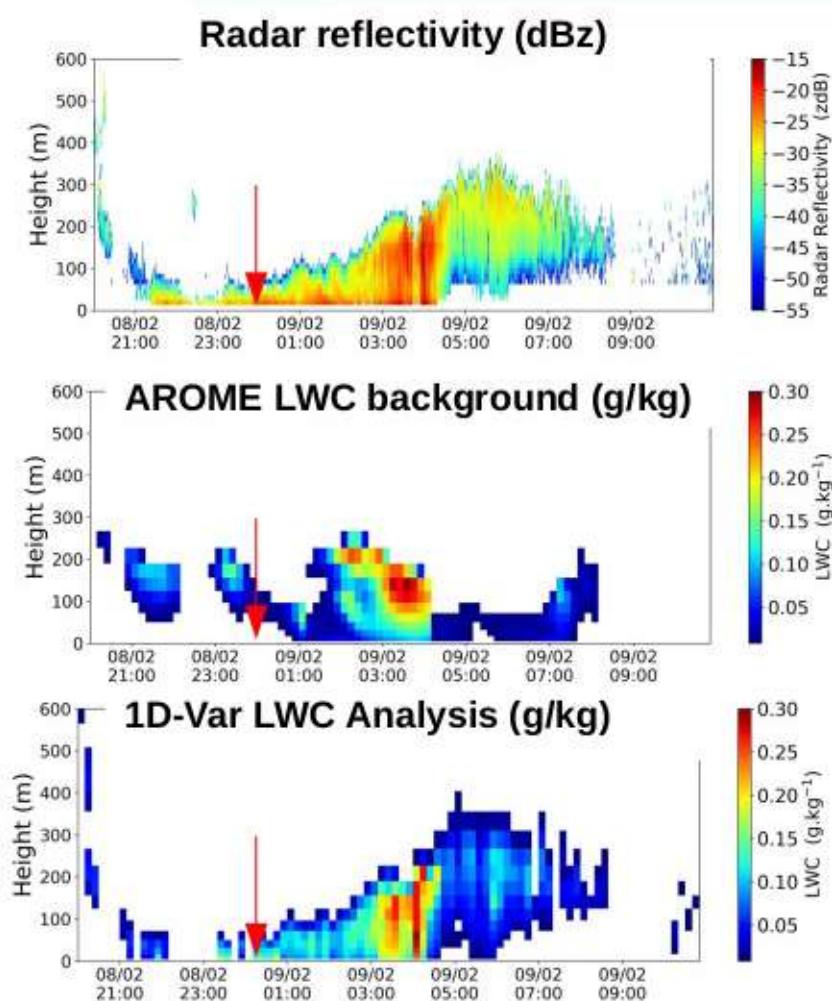


05/01 : Nocturnal jet stops the fog development

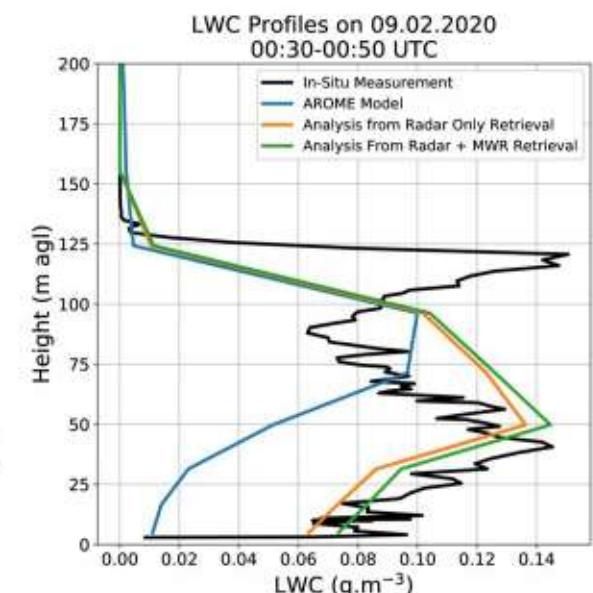
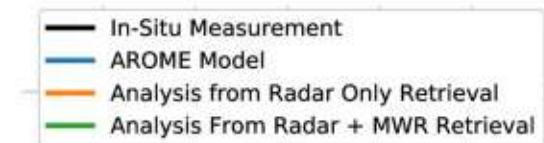


Radar / radiometer synergy - Task5

- 1D-Var data assimilation of combined cloud radar Z and MWR BT
(A. Bell, P. Martinet et O. Caumont) – Bell et al. ACP 2022



- Significant temporal and fog top heights errors in the AROME background profiles (nearest in time).
- 1D-Var retrievals much more **consistent** with the observed fog structures compared to the BASTA cloud radar.
- Good agreement between 1D-Var retrievals and in-situ CDP measurements



Task1 report – Deliverables

Sub-task 1.1 : Field campaign preparation

Sub-task 1.2 : Field campaign

D1.2.1 Conduct the six month field campaign with continuous monitoring and IOP operations

Done

D1.2.2 Database integrated in the AERIS web site at the end of the project

In progress

Sub-task 1.3 : in situ data analysis

D1.3.1 Analysis of energy budget closure and impact of heterogeneities on the residual.

Partially done – PFE L. Quinzain 2020

D1.3.2 Analysis of turbulence anisotropy parameter

Not done

=> LIAISE & MOSAI ANR data set

D1.3.3 Characterization of CCN activation spectra to prescribe CCN parameterization

Done – M2 S. Tinorua 2020,
M2 I. Vongpaseut 2022

D1.3.4 Aerosol absorption properties within fog

Partially done - M2 S. Tinorua 2020
Radiative closure – M2 A. Veau 2023

D1.3.5 Vertical profile of fog microphysics (droplet size distribution and LWC)

Done – PhD T. Costabloz
Thin to thick transition

D1.3.6 Analysis of entrainment-mixing processes at fog top

In progress - PhD T. Costabloz

Summary

- 15 fog events sampled with the tethered balloon (20 nights of operations, 180 RS)
=> **3 main events (IOP 6, 11 and 14)** but many interesting thinner cases
- Despite technical failures and difficult weather conditions :
 - synergy 94 GHz radar, MWR and in situ profiling with microphysics and turbulence
 - volume sampling with scanning radar and UAV flights with ~5 km legs
 - MWR network (6 sites) for assimilation
=> **promising data set to document 3D heterogeneities and conduct process studies**
- large amount of data to process, validate and analyze... will take some time
- **Many thanks** to all people involved in preparation, forecasts, operations, processing....

