METEO FRANCE

SOFOG3D

SOuth west FOGs 3D experiment for processes study

South West of France during wintertime 2019-20

F. Burnet, et al.
Météo-France, CNRM, GMEI

Kick-off meeting - 16/04/2019
Toulouse

Context

- Due to the high **economical impact** of **fog** on **transport** (aviation, marine and land), a specific research action started at Météo France for 5 years (2017-2021)

  => Development of a high resolution version of the Météo-France NWP model : AROME-500m

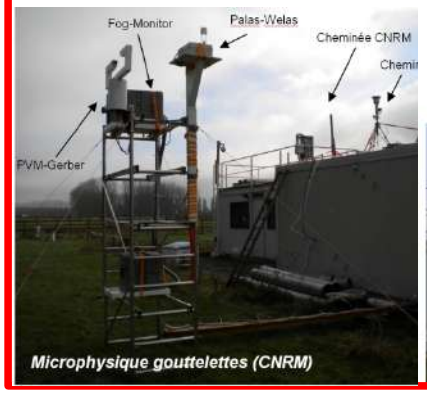
- SOFOG3D field experiment
  - Evaluation/validation of AROME-500m
  - improve our understanding of fog **processes to derive refined parameterizations** :

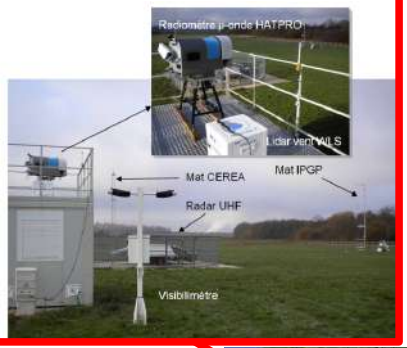
    => 3D high resolution LES simulations (~m)

    => experimental studies
  - new data assimilation tests

Recent fog experiments in France

PARISFOG 2006-07, PREVIBOSS 2010-13
SIRTA (Palaiseau)



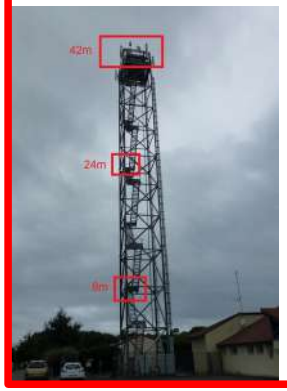


Remote sensing and ground-base microphysics

Bure 2015-17, OPE ANDRA (Meuse)

Vertical profiles of microphysics, remote sensing and water depostion

Magescq 2013-14 (Landes)



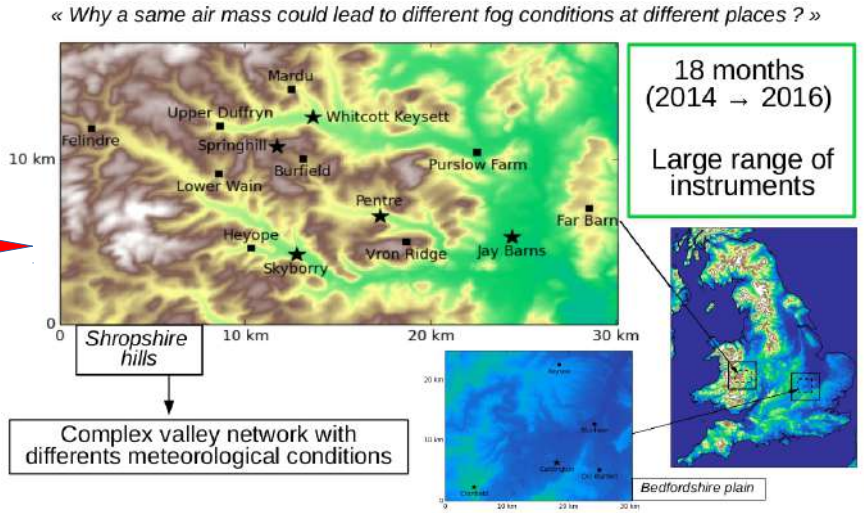
Vertical profiles of microphysics

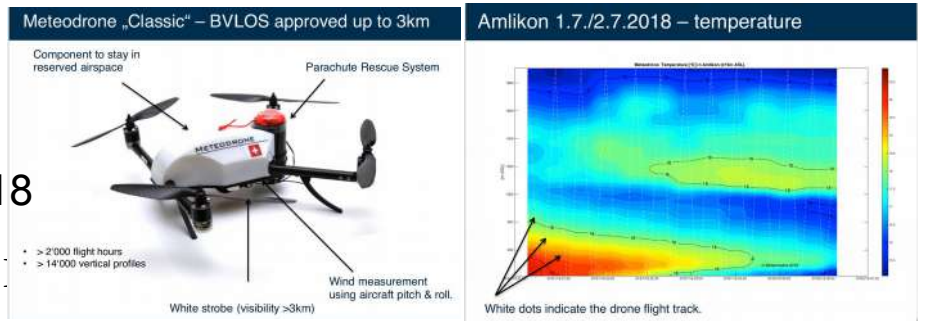
=> Need : **3D caracterization of fog layer properties** with detailed observations of **dynamics, radiation, microphysics and surface fluxes**

Collaborations

- **Météo France / CNRM** :
  - Experimental group : G. Canut, A. Dabas, C. Denjean, P. Martinet, A. Paci and G. Roberts
  - Modelling group : T. Bergot, R. Honnert, C. Lac, Q. Libois, Y. Seity , B. Vié
  - Assimilation group : N. Fourrié, J.-F Mahfouf, T. Montmerle
- **SOFOG3D** ANR project :
  - IPSL/LMD (M. Haeffelin, SIRTA/ParisFog)
  - IPSL/LATMOS (J. Delanoë, BASTA)
- French lab / organisms :
  - IRSN, INRA, IFSTTAR (LRPC), LA...
- **UKMO** (PI. J. Price, LANFEX)
- MWR Network (TOPROF COST action) :
  - Univ. de Cologne (U. Löhnert),
  - MeteoSwiss (A. Haeffele)
  - CNR-IMAA (D. Cimini)
- MétéoMatics (C. Schluchter)

J . Price - LANFEX

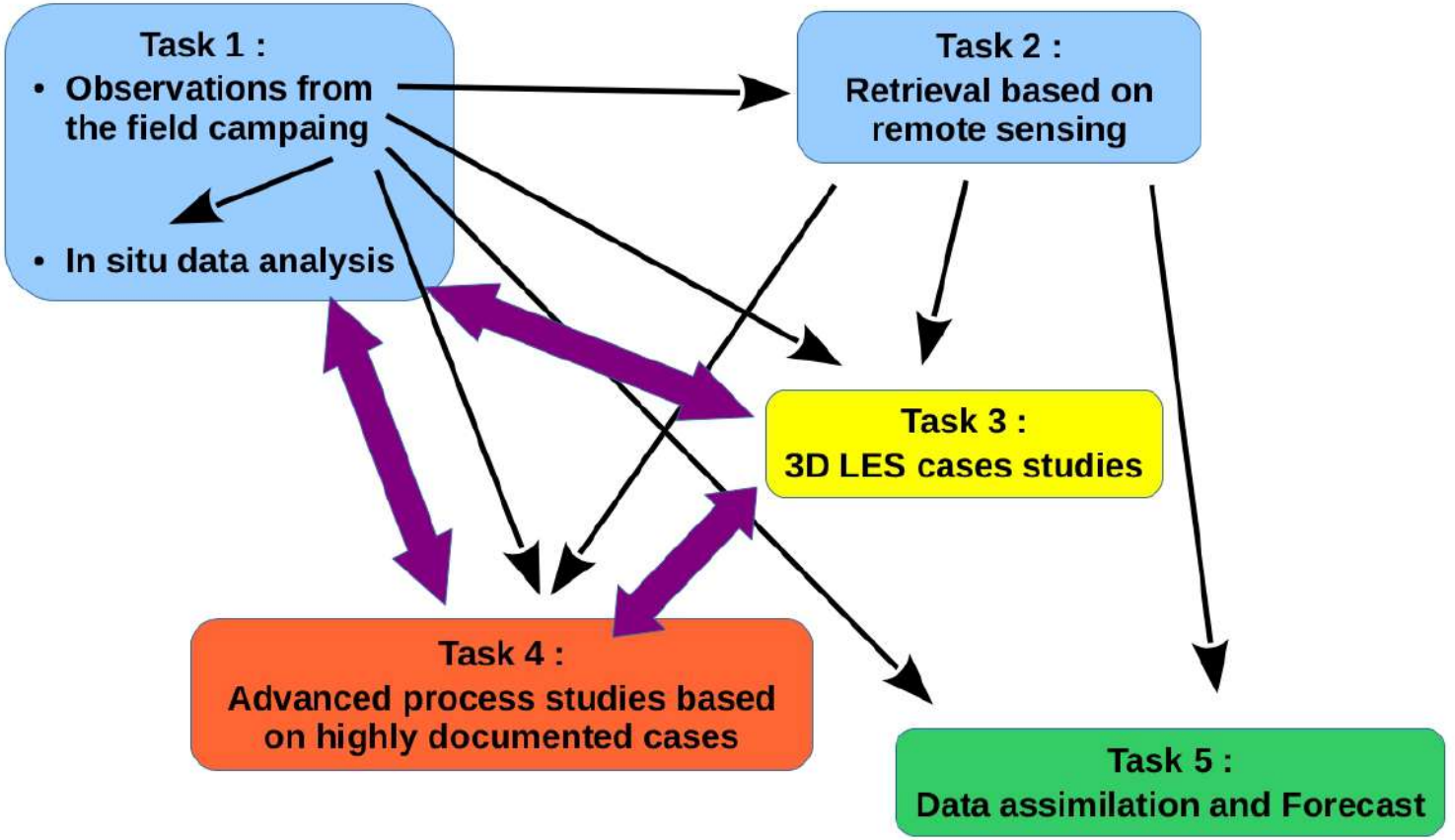




ISARRA 2018

ANR SOFOG3D – 4 years (01/10/2018-2022)

- **Consortium** :
  - Météo-France/CNRM, Toulouse - F. Burnet (PI)
  - IPSL/LMD, Palaiseau - M. Haeffelin
  - IPSL/LATMOS, Guyancourt - J. Delanoë
- **Budget :** 490 k€ (5 * 1 year Post Doc)
- **Organisation** :



Main scientific questions

- **Provide a 3D caracterization 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** : what are the impacts of turbulent eddies near the ground induced by surface heterogeneities on the spatio-temporal variability of the fog ?
    - Impact of entrainment and turbulent mixing at the top of the fog layer
  - Microphysics **:**
    - **Is transition between thin and thick fog mainly driven by microphysics ?**
    - Impact of aerosols, evaluate improvement of the two-moment scheme LIMA
  - **Stratus to fog transition :** do microphysics and local processes induced by orography and surface type influences St lowering or is it mainly driven by large scale conditions ?

- **Data assimilation of new local observations :**
  - MWR network and synergy with radar 95 GHz

ANR SOFOG3D – 4 years (01/10/2018-2022)

- Timeline :

Quick-off meeting (today)

6 months campaign

Timetable of the project:

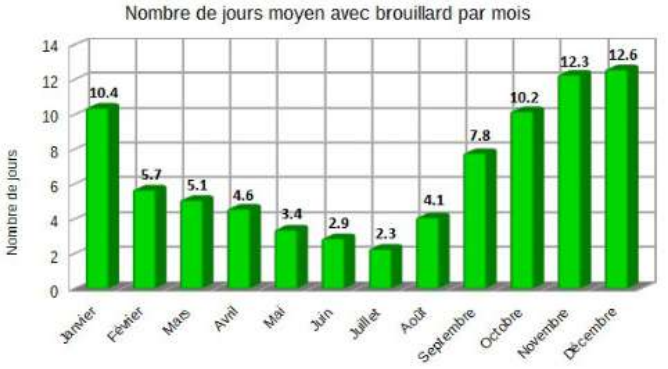
	18	2019				2020				2021				2022		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1 : Field campaign and in situ data analysis																
1.1 Preparation																
1.2 Field campaign																
1.3 In situ data analysis (CDD)																
Task 2 : Fog retrievals based on remote 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																

2 Ph D :

A. Bell

M. Fathalli

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, thetered balloons, UAVs fleet
  => Objective : sample **10 à 20 events with favourable conditions**

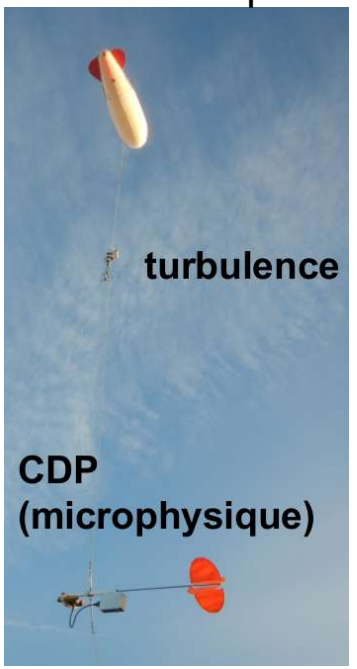
Mât de 50 m

Flux

Dépôt

Télémètre, Radiomètre, Radar

Ballon captif



RS et flottes de drones

Measured parameters

In situ sensors

- Meteorological conditions : pressure, temperature, humidity and 3D wind
- Radiation budget
- Visibility
- Aerosol optical, microphysical and hygroscopic properties
- Heat and momentum fluxes (ground and 50/10 m towers)
- Water deposition
- Microphysical vertical properties : tethered balloons, towers

Remote sensing

- Deployment of a small MWR network (around 6 units)
- W-band radars : reflectivity and Doppler Velocity
- Aerosol lidars and ceilometers
- Doppler lidars

+ UAVs fleet, tethered balloon, instrumented towers

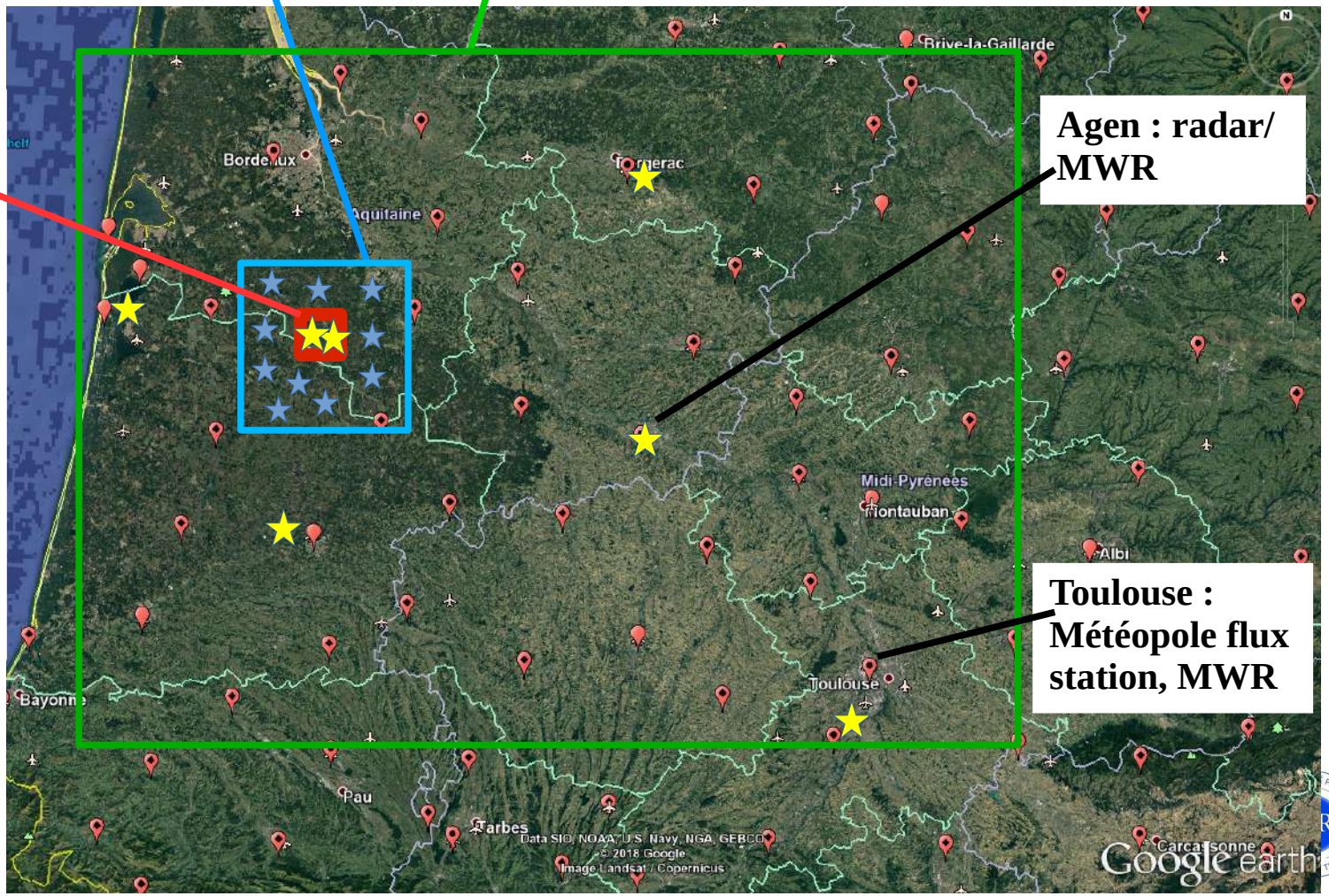
=> 4D description (spatial, temporal, and vertical) of the fog layer with a fine resolution

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

Super-site 10 x 10 km:
- radar/MWR/lidars
- tethered balloon
- UAVs fleet
- 10 met. stations
- 50 m mast (2)
- 3 areas with : heat and turbulent fluxes (ground & 10m), radiation budget, aerosol and fog microphysics, water deposition, visibility, ceilometers



Dense network of weather stations

- **AROME-500 m validation : RADOME network too coarse**
  50 stations => every ~20 to 50 km and a few visibility measurements (< 10)
  => need to increase the density in nested domains :
  ~ 10 stations on the surrounding domain 50 x 50 km => ~10 to 15 km
  ~ 10 stations on the supersite => ~2 to 3 km

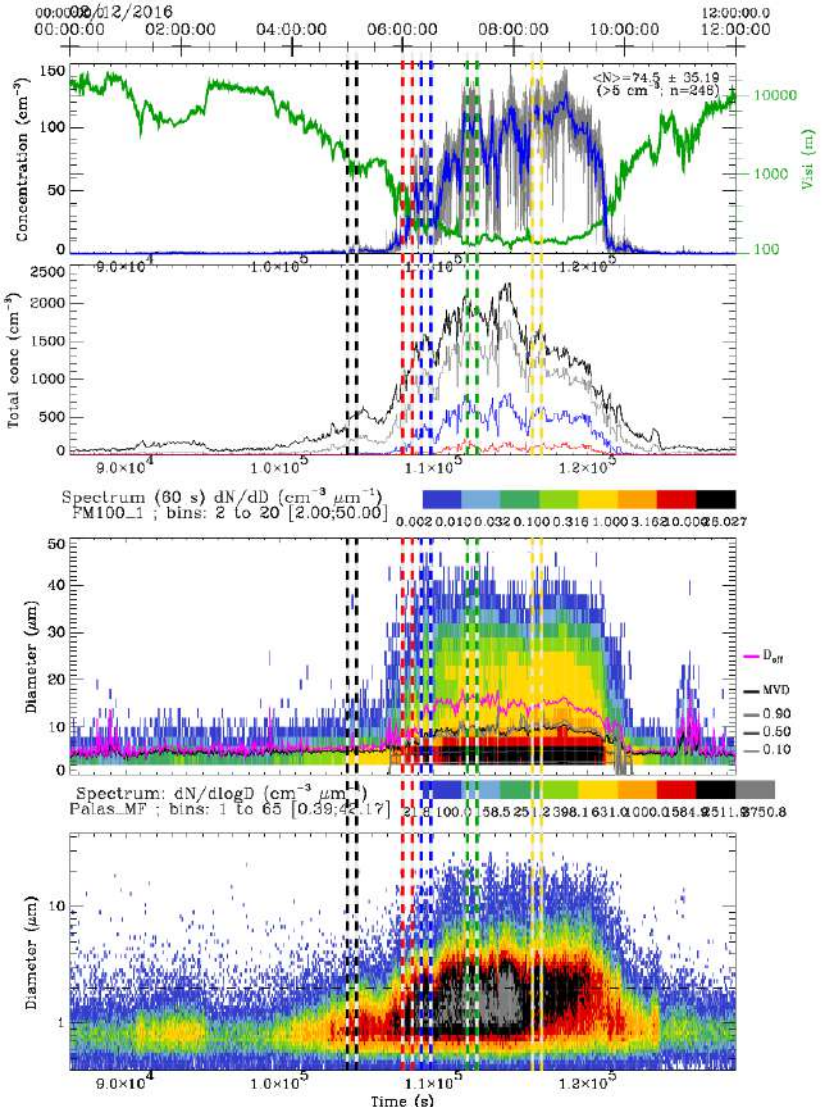
- Processes studies : **3D HR LES validation** => local / advection

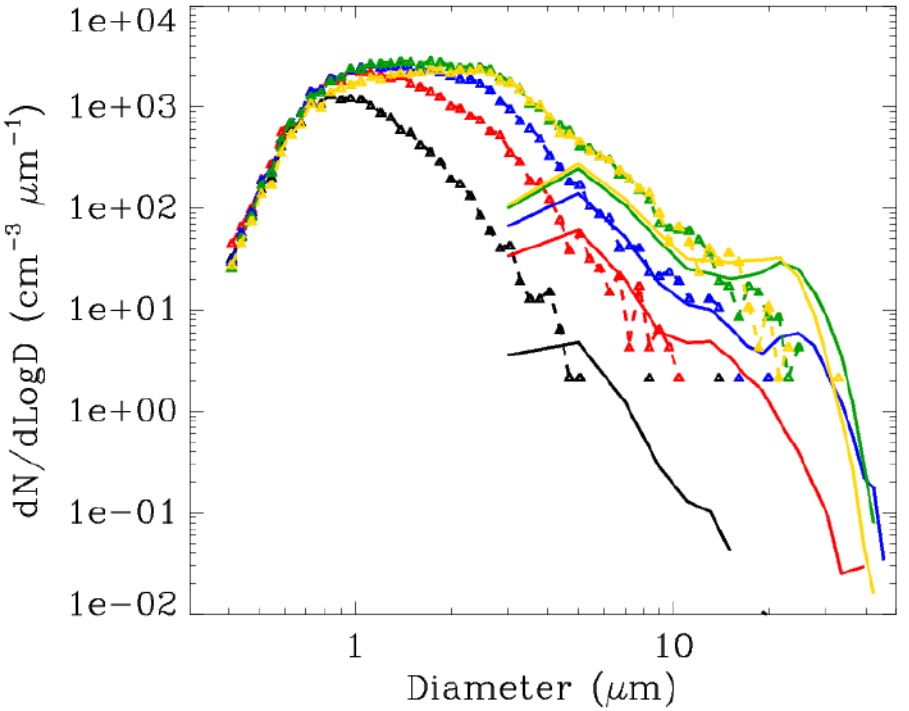
=> CNRM :
- 10 mobile stations (P, T, U, 10m wind, radiation, visibility, soil T),
- a few ceilometers (> 6)

=> UKMO :
- 10 mobile stations
- one 50-m mast at the supersite

Microphysics

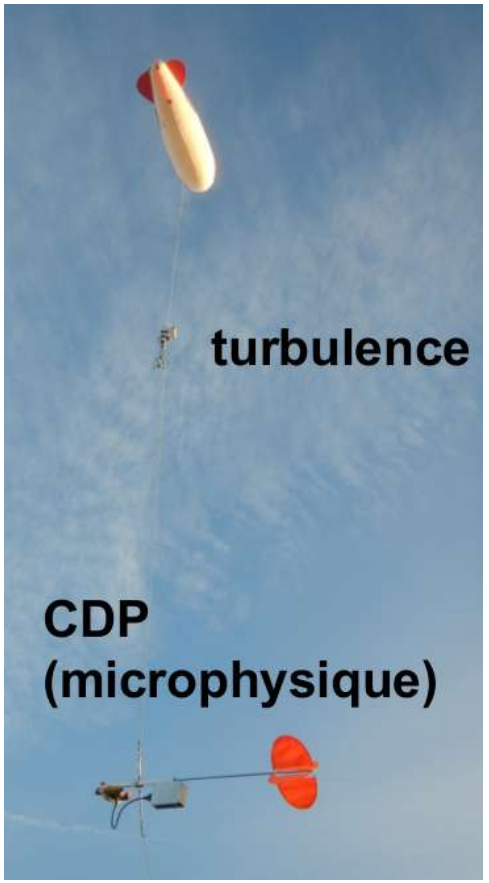
- 3 (Welas + FM-100/FM120)
  + FM120 UKMO
- 2 PVM
- 1 CDP mât 50m



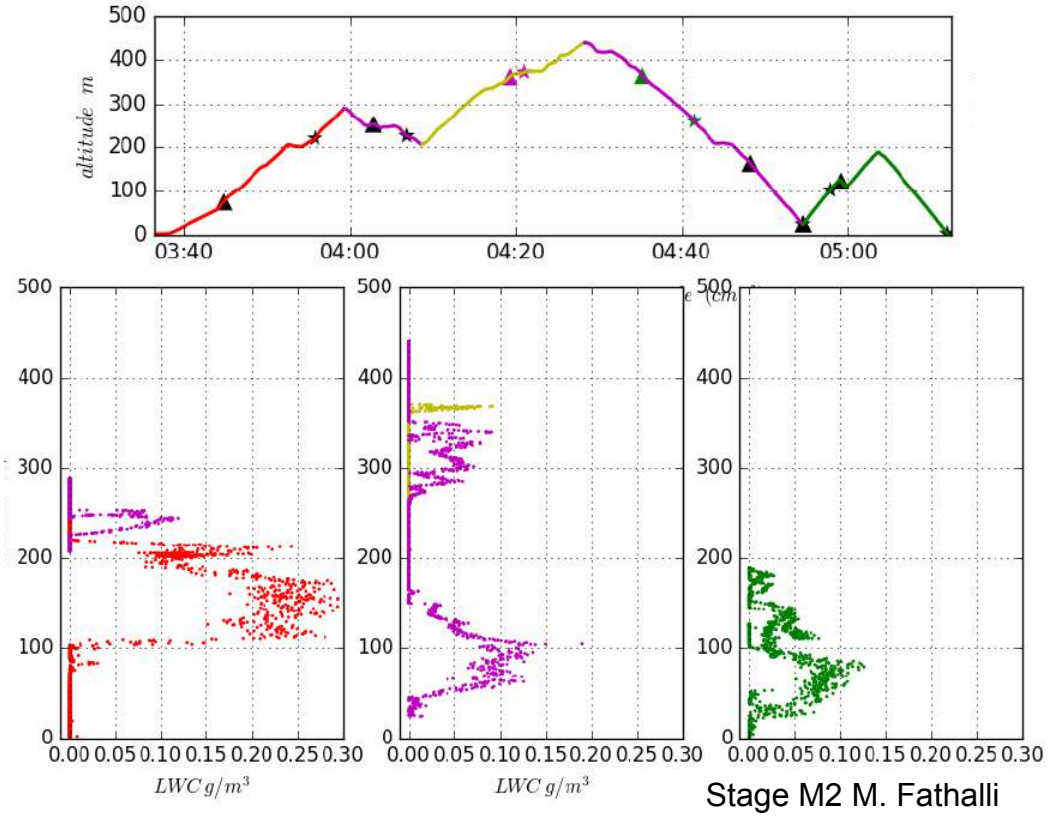


Tethered balloon

- **In situ vertical profile**
  - Thermodynamics, turbulence and microphysics (aerosol, droplets, CCN)
  - Measurements in specific regions (cloud top, etc...)
- **=> tower / balloon synergy**



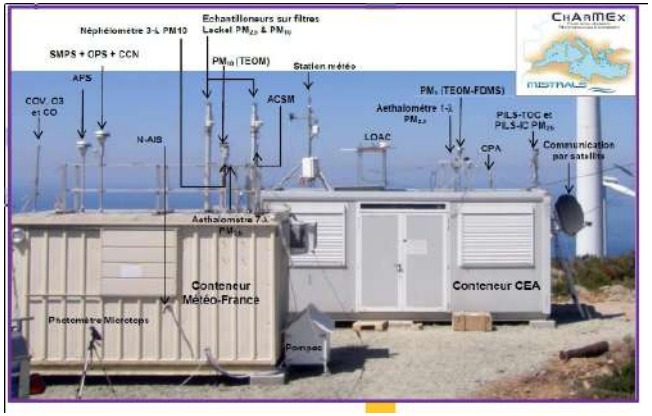
Profils verticaux LWC mesuré par le CDP :



Stage M2 M. Fathalli

Aerosol properties

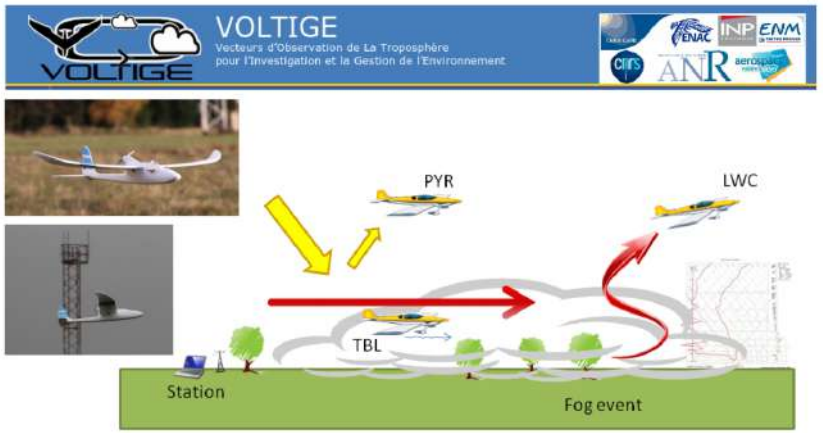
- **Main zone** of the super site :
  - total concentration CPC
  - size distribution SMPS [10-496] nm, OPC [0.3, 10 µm]
  - aborbing properties (nephelometer and CAPS)
  - hygroscopicity (CCN chamber)
- **Secondary zones :**
  - OPC
- **Tethered balloon :**
  - OPC
  - mini CCN
- **UAVs fleet :**
  - OPC



G. Roberts et al.

UAVs fleet : 3D exploration

- Vertical profile and horizontal mapping
  => heterogeneities during the fog life cycle



X6 (Skywalker) :

2 kg
2 h
60 km/h
Zmax=4 km


Backscatter cloud sensor


aerosol inlet


optical particle counter

Xeno (Multiplex) :

700 g
45 min
Zmax=1 km

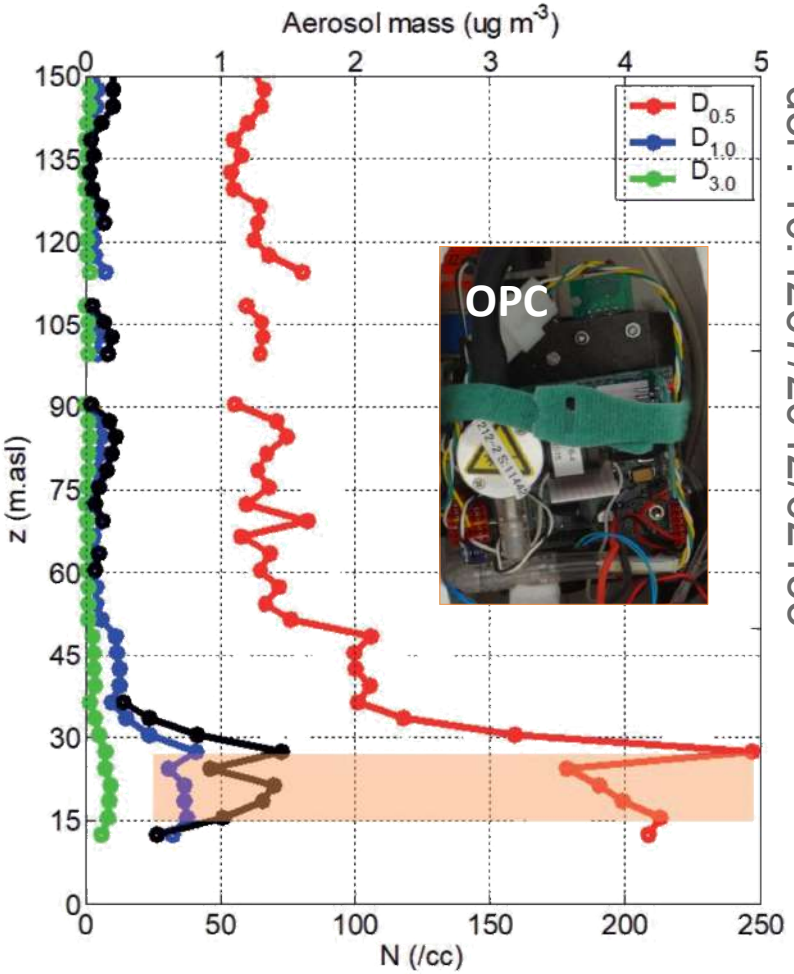
P,T,U,vent


Video camera

UAVs fleet : 3D exploration

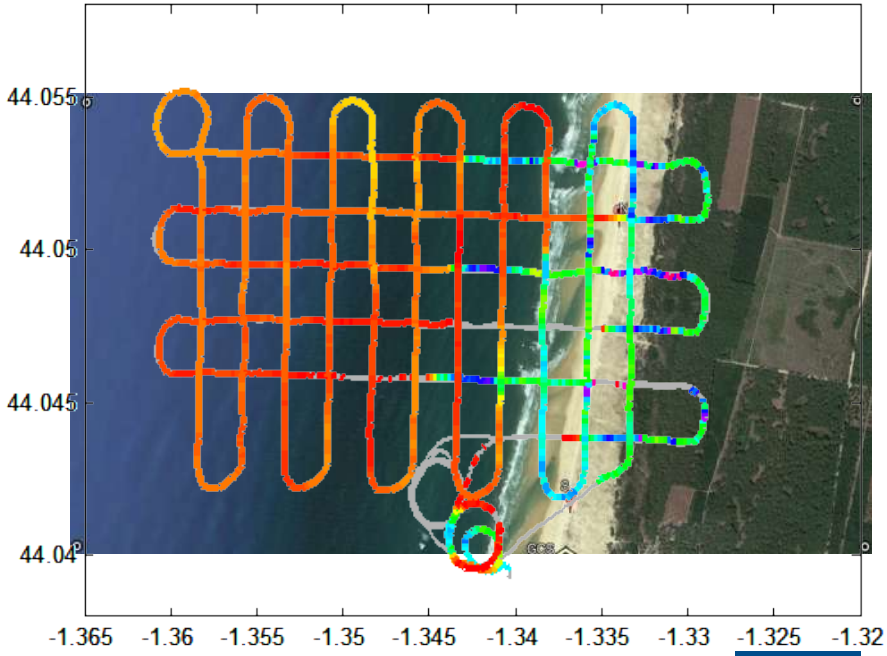
G. Roberts et al.

- Aerosol profiles over the surf zone



Roberts et al., La Météorologie, doi : 10.4267/2042/62453

Surface temperature :(RAW data)



From MIRIAD experiment (12/2016) at Montalivet

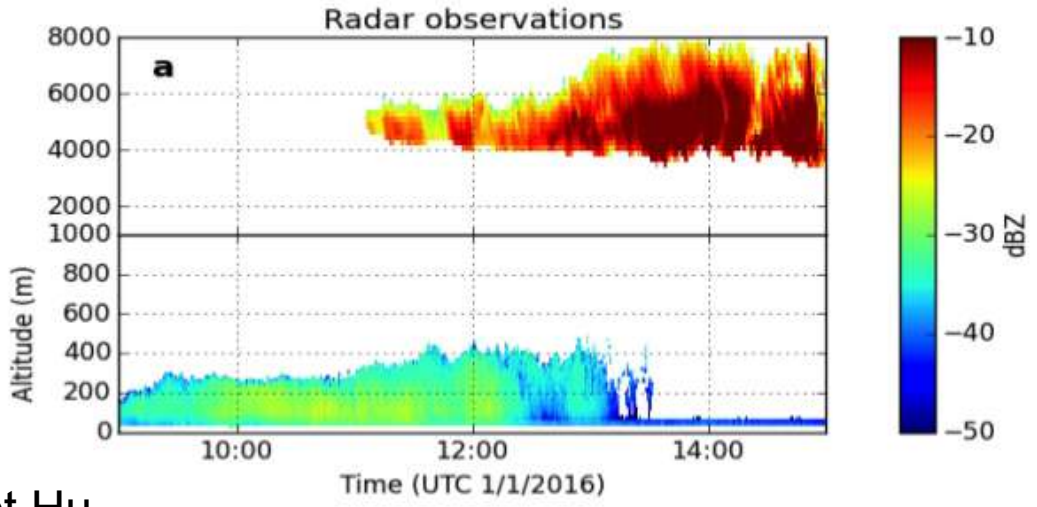
MIRIAD

Synergie BASTA - radiomètre

WP2 – J. Delanoë et al.
WP5 – P. Martinet et al.

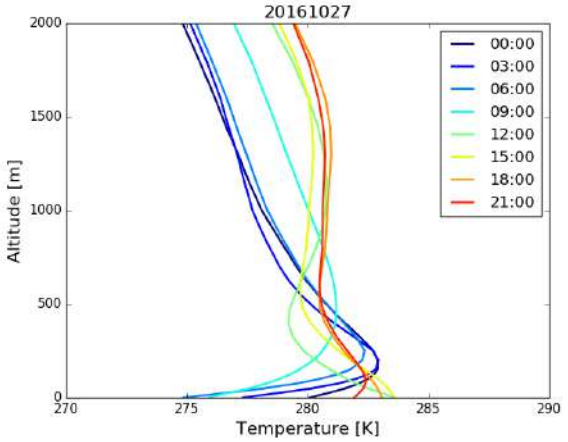
- Caractérisation profil pour les processus et assimilation pour prévisions

  - Radar : réflectivité et vitesse Doppler => sommet, microphysique

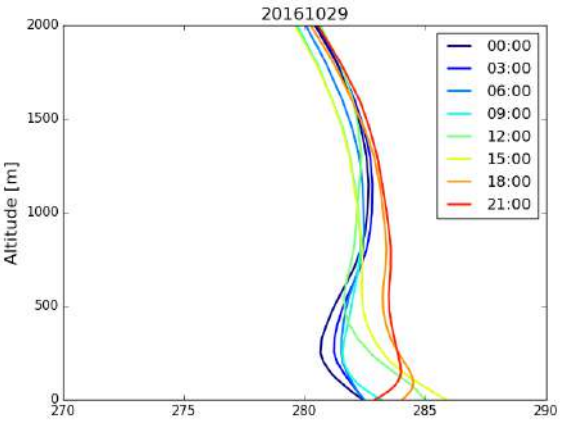


  - Radiomètre : LWP et profils T et Hu

Radiatif développé

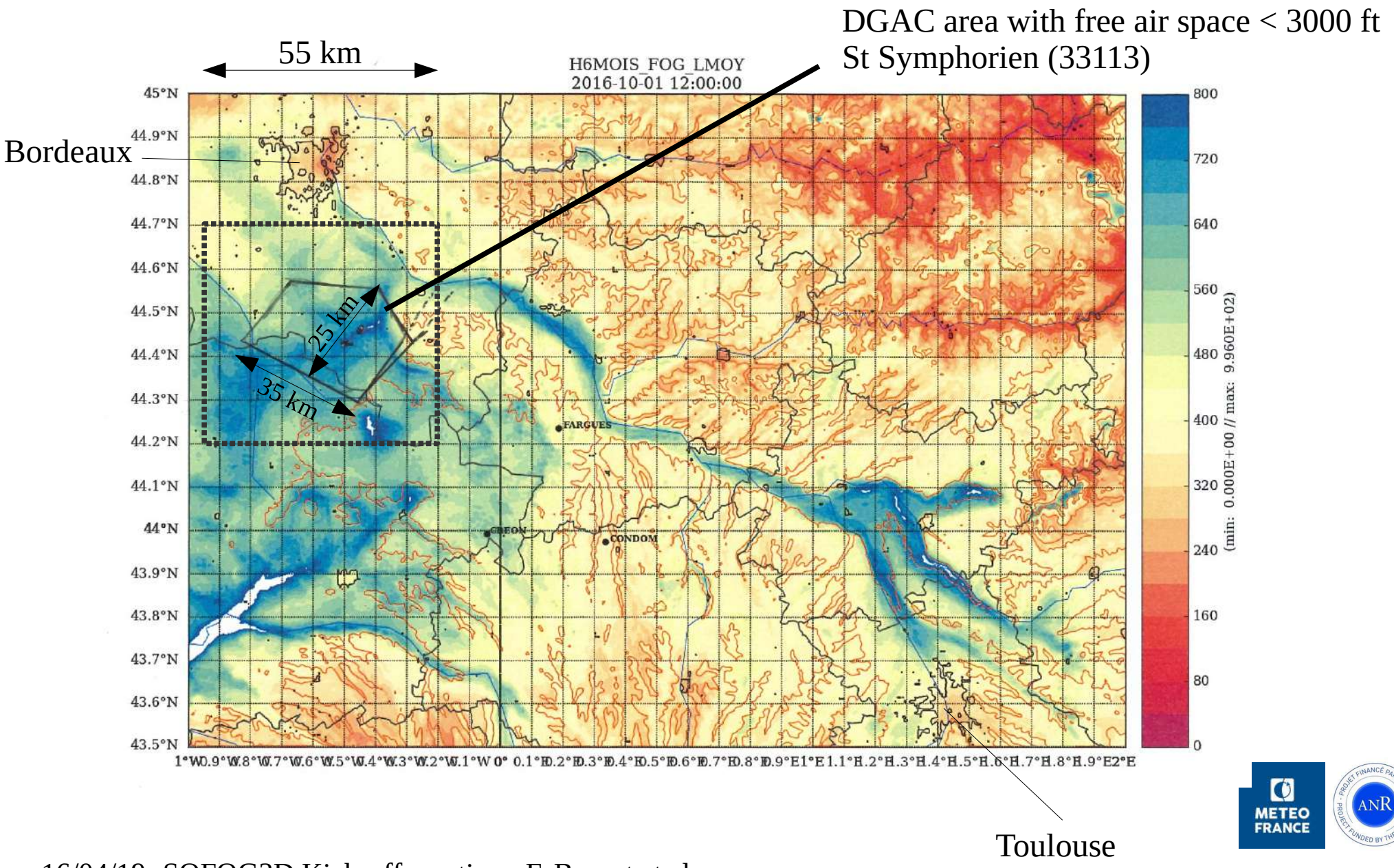


Affaissement de stratus



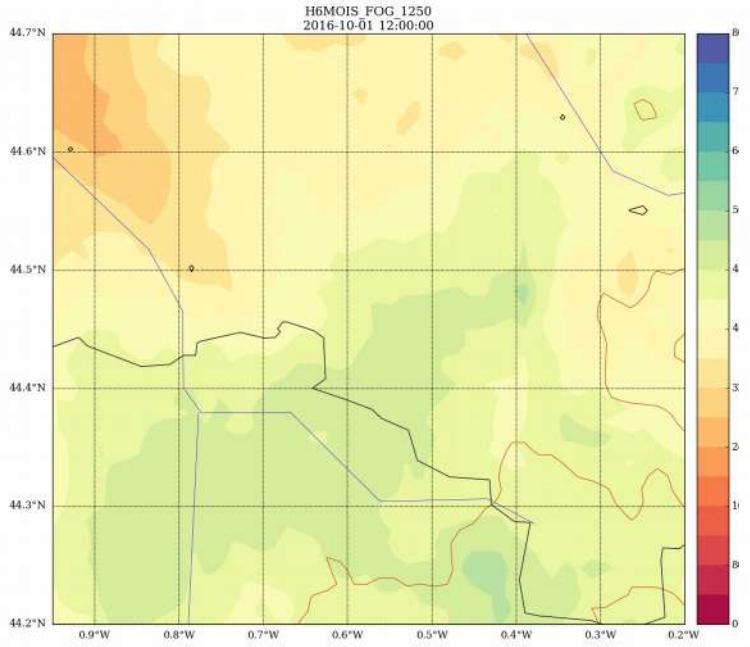
Super site selection :
AROME fog forecasts (nb of hour) winter 2016-17

(C.Zecchin)

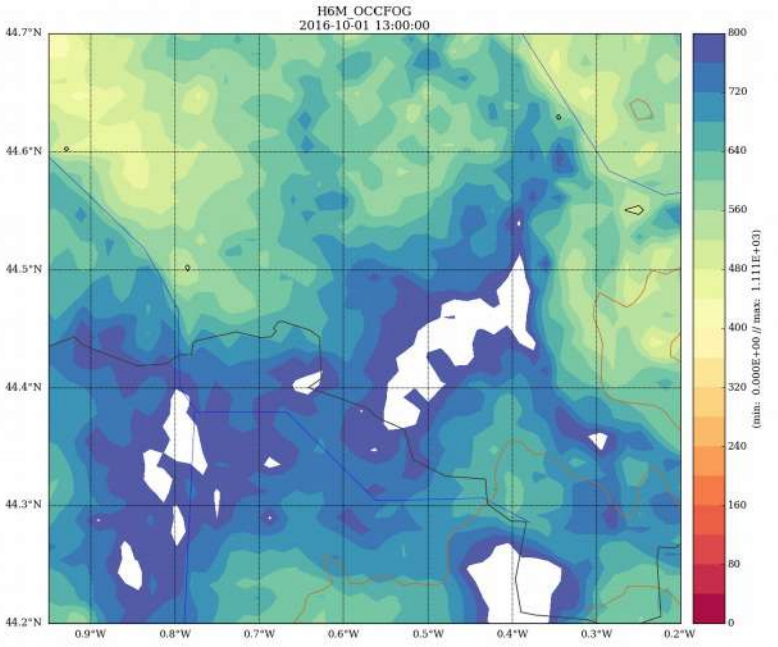


AROME fog forecasts (nb of hour) winter 2016-17

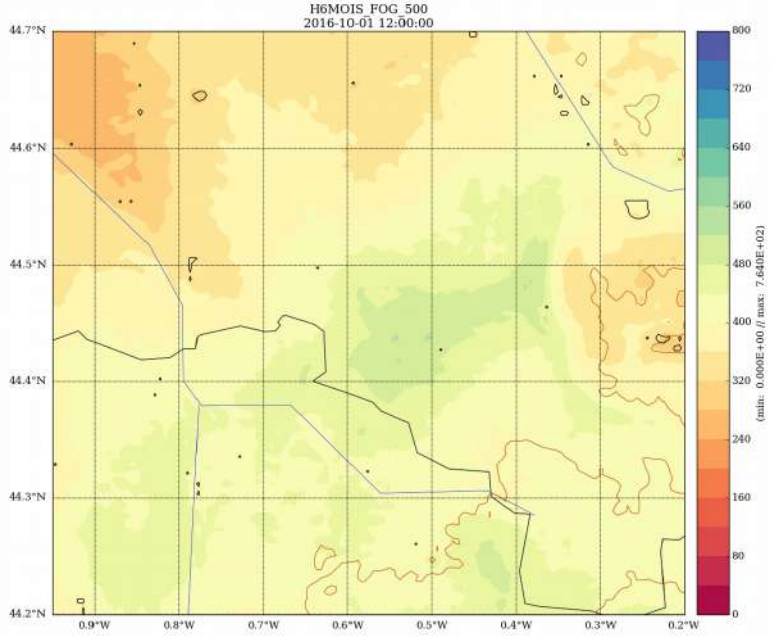
1250m resolution : 90 vertical levels



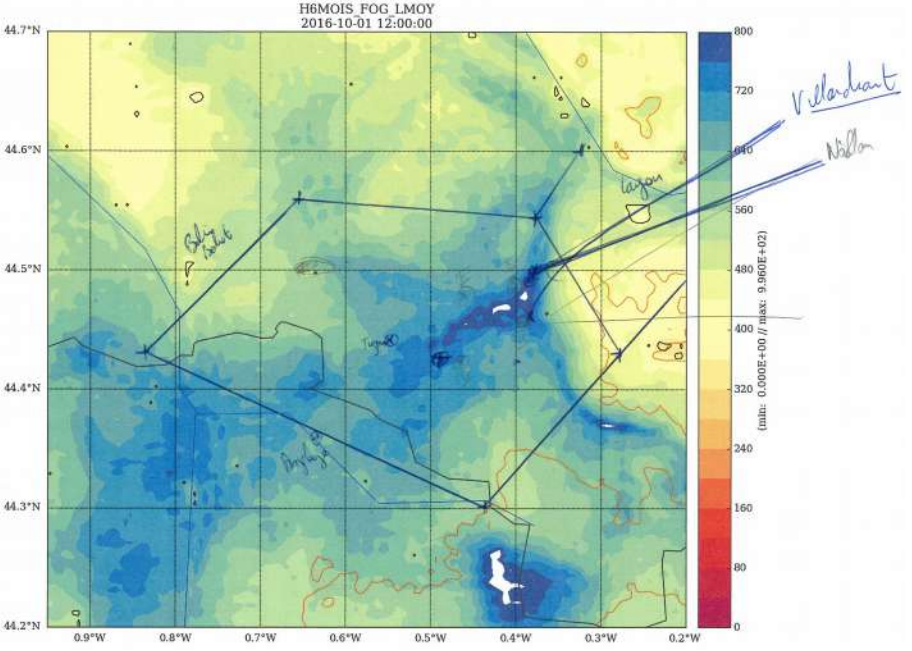
156 levels



500m resolution : 90 vertical levels



156 levels



Selected supersite area

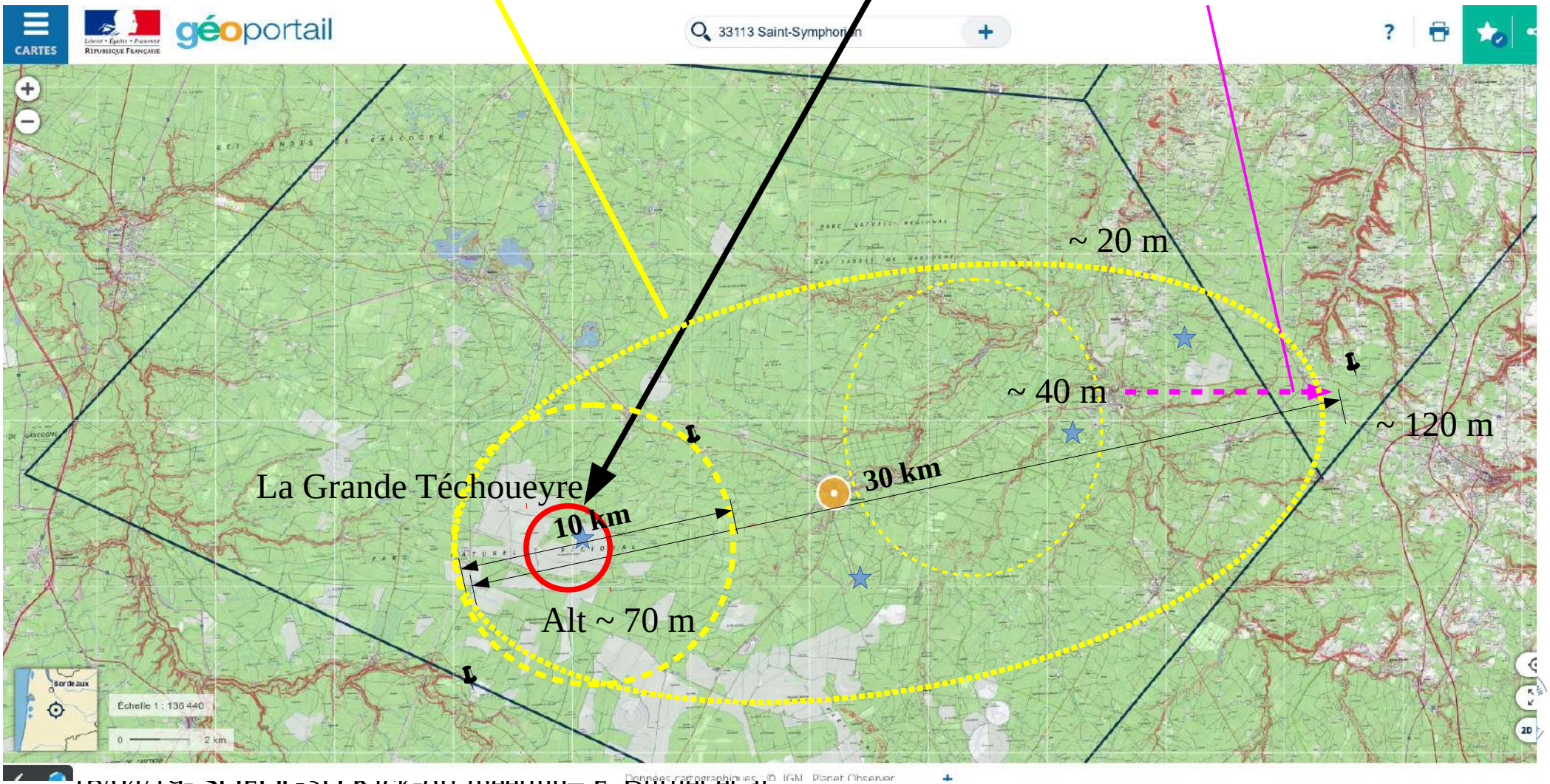
40m antennas/watchtower

met. station + visi.

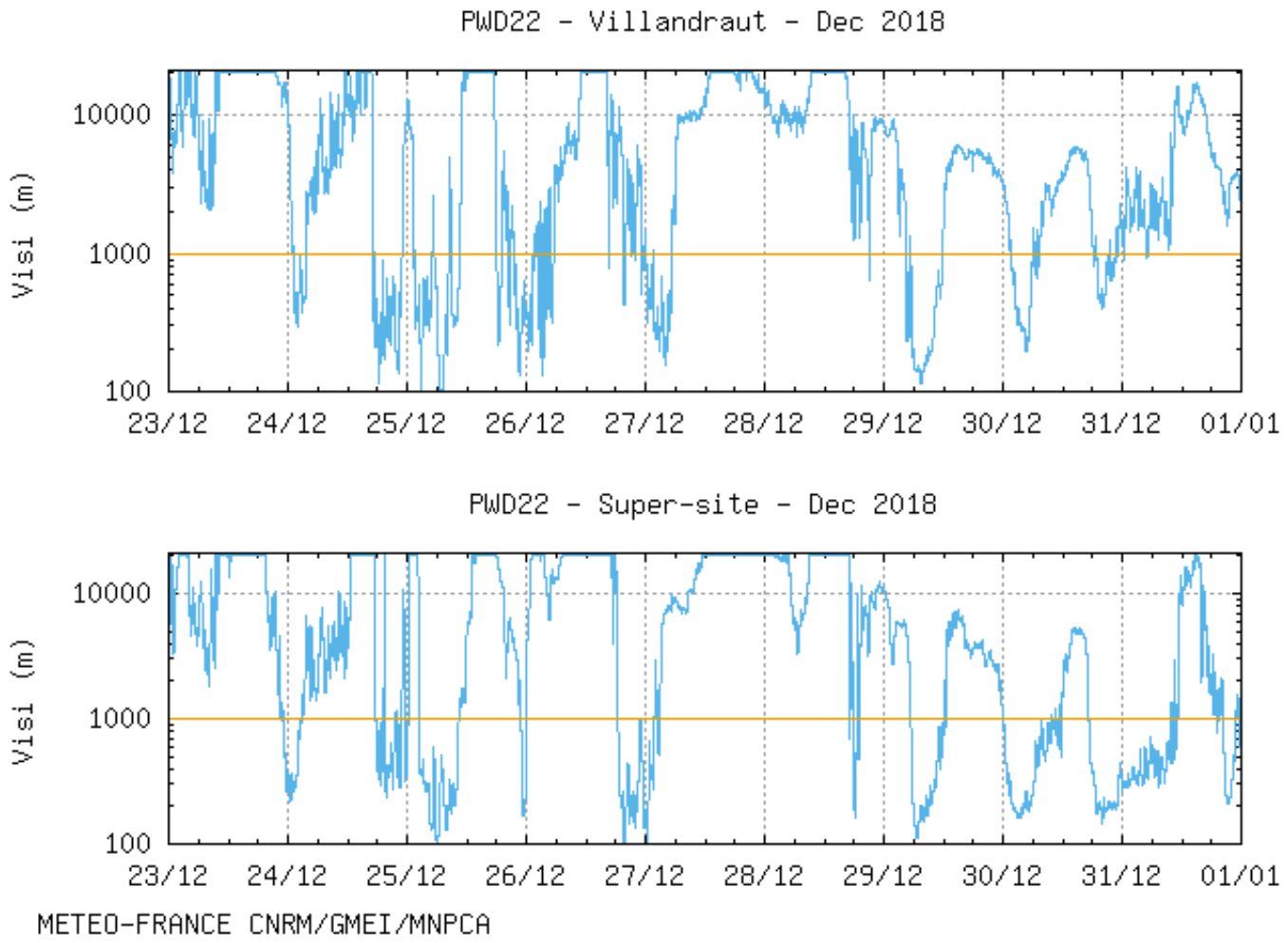
Empty space suitable for UAV operations
(except over villages)

New super-site option
(44.4113 ; -0.6156)

Transect with increasing altitude



Pré-campagne hiver 2018-2019

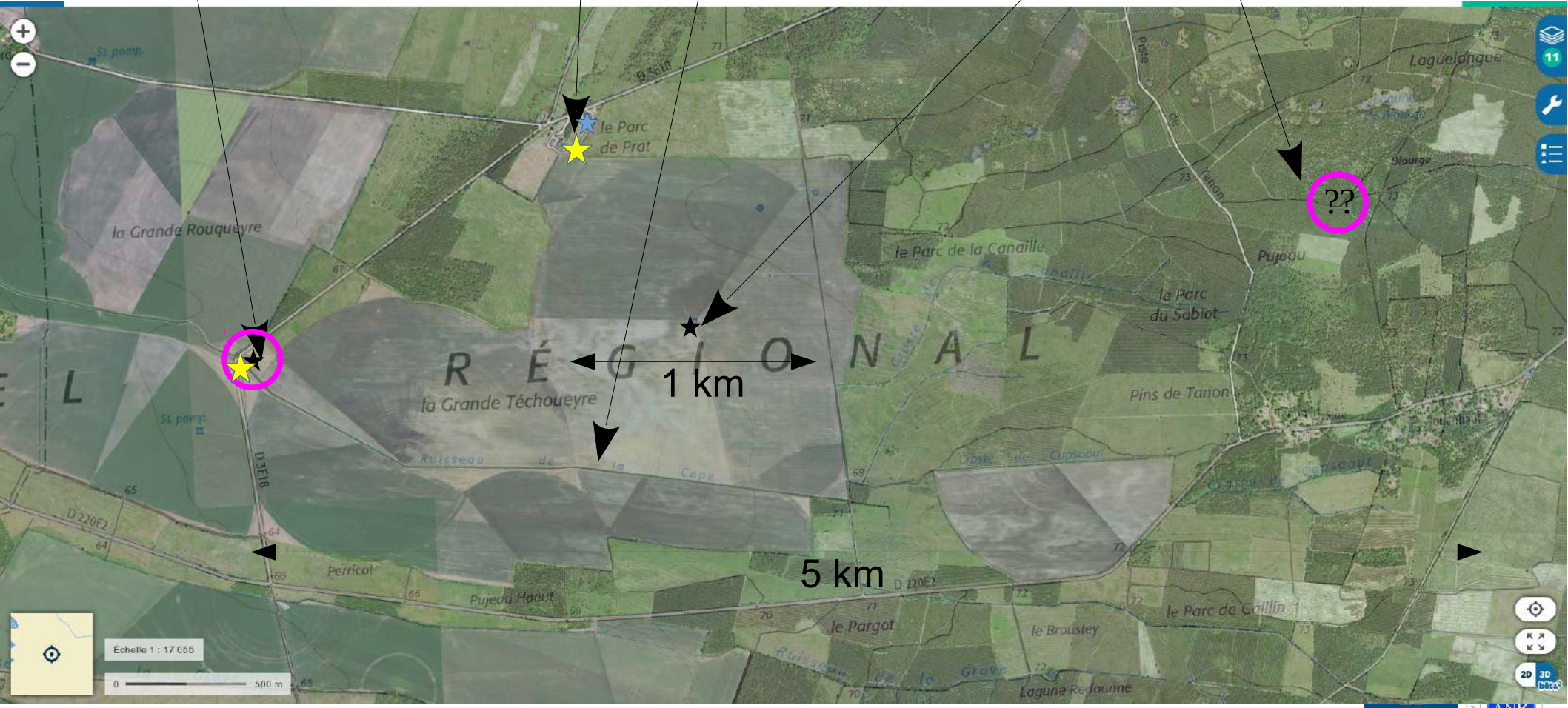


Super site : 3D fog life cycle

- 50m mast 2 (flux) in a forest slot to find somewhere .....

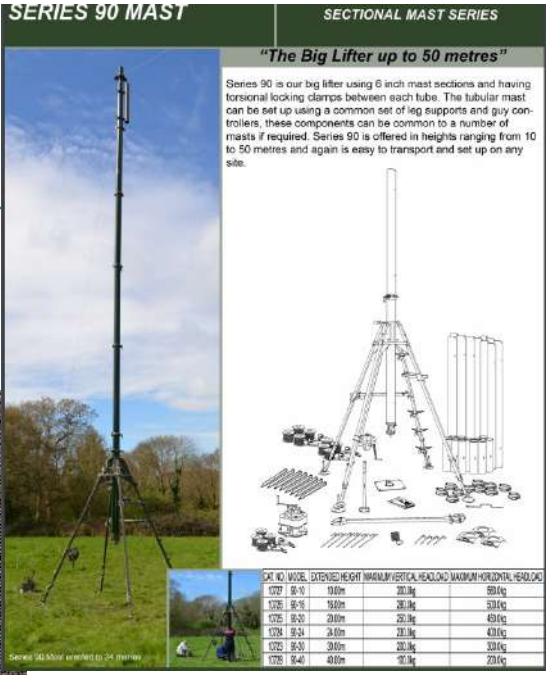
- Radar 95 GHz / MWR, Lidars
- Tethered balloon

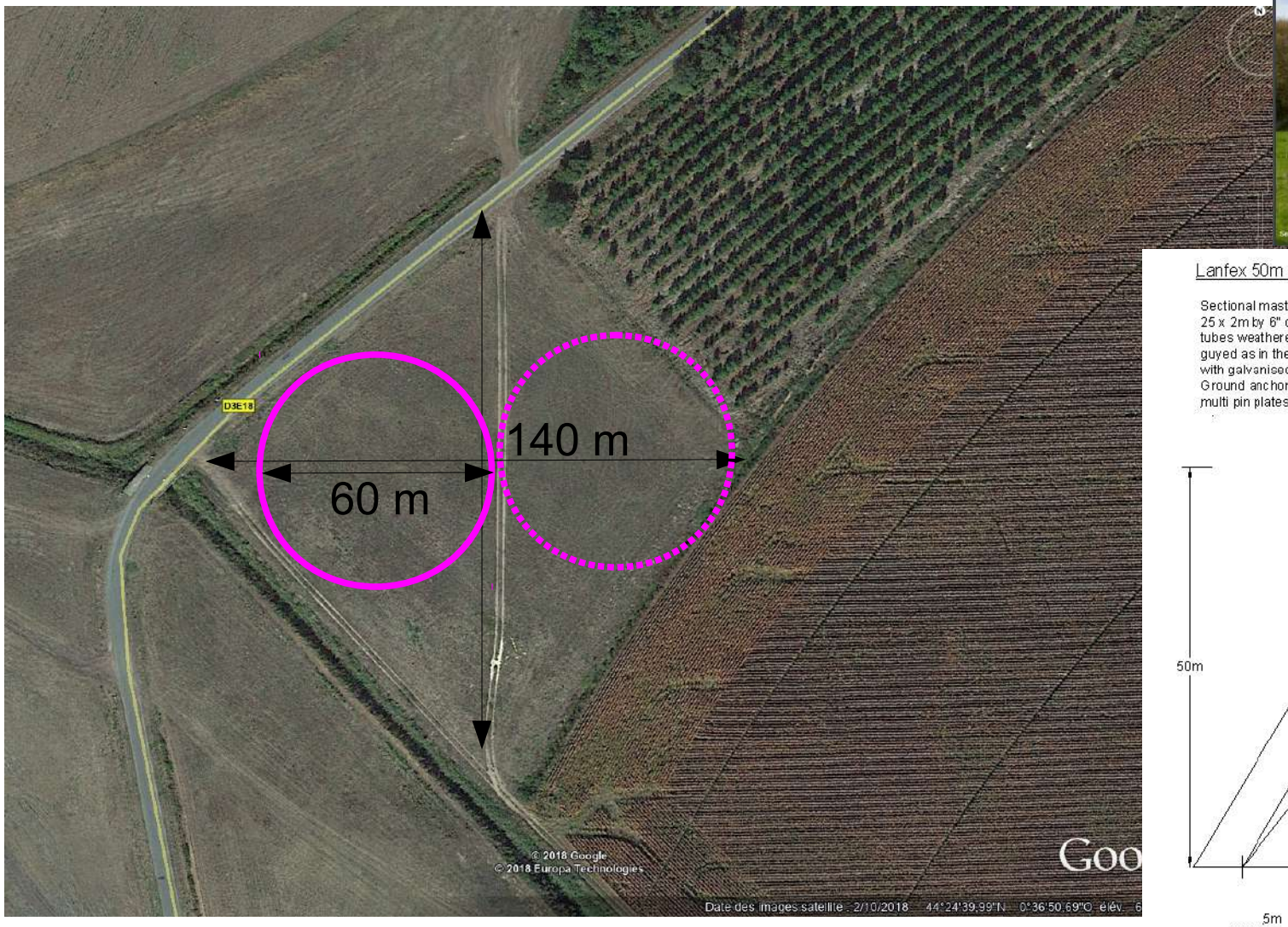
- Aerosol shelter
- 50m mast 1 (flux, CDP)
- **UAVs fleet terrain**
- radar 95 GHz scannant

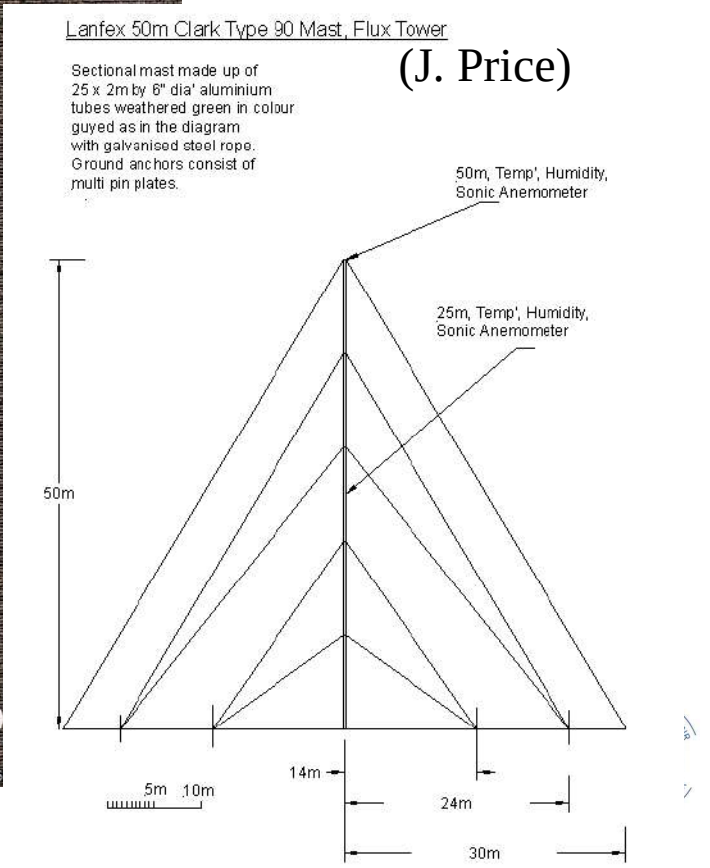


Super-site 50m mast 1

- Aerosol shelter
- 50m mast 1 (flux, CDP)







UAV flight zone 1

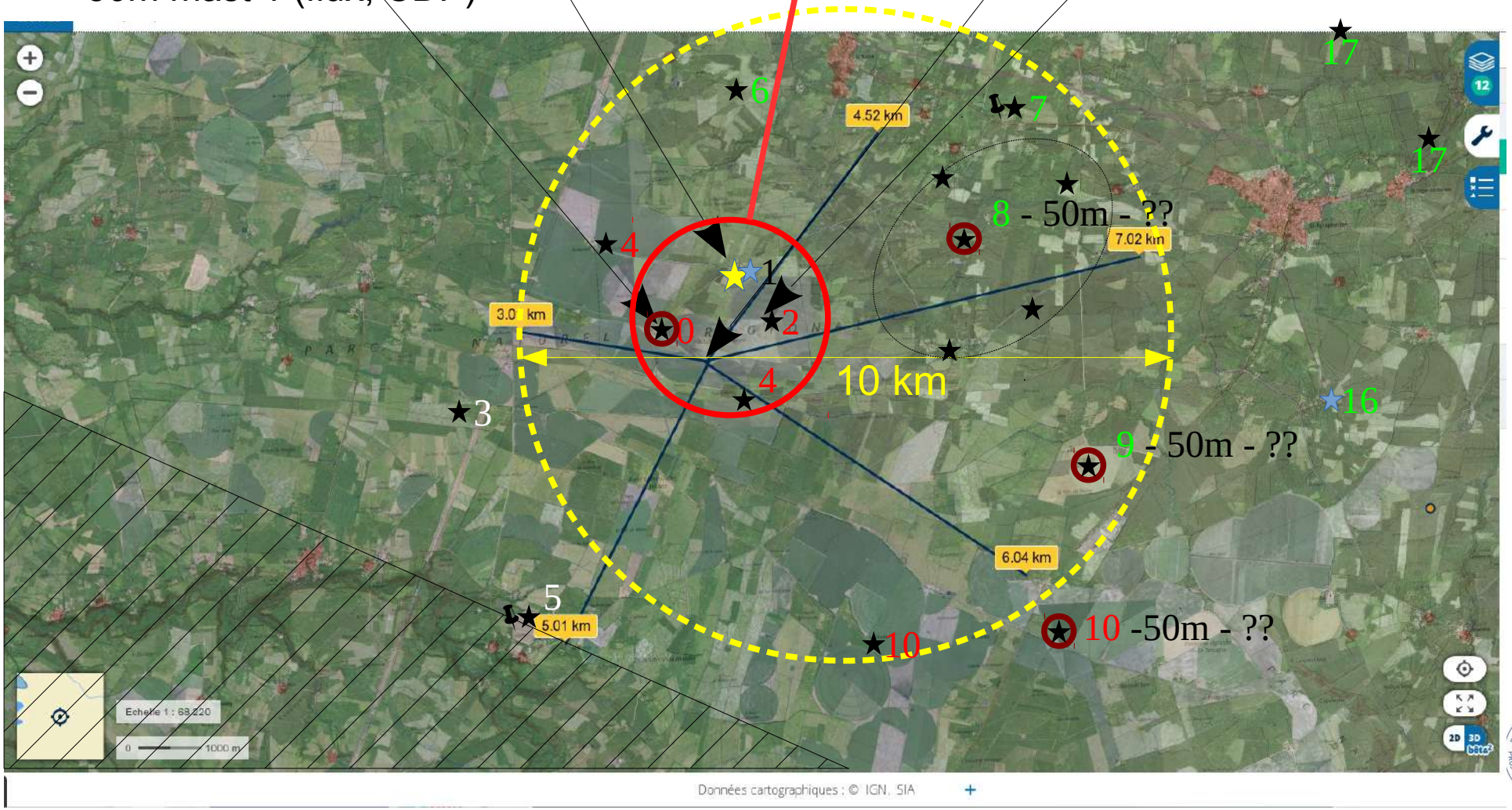
40m antennas/watchtower

met. station + visi. 2018

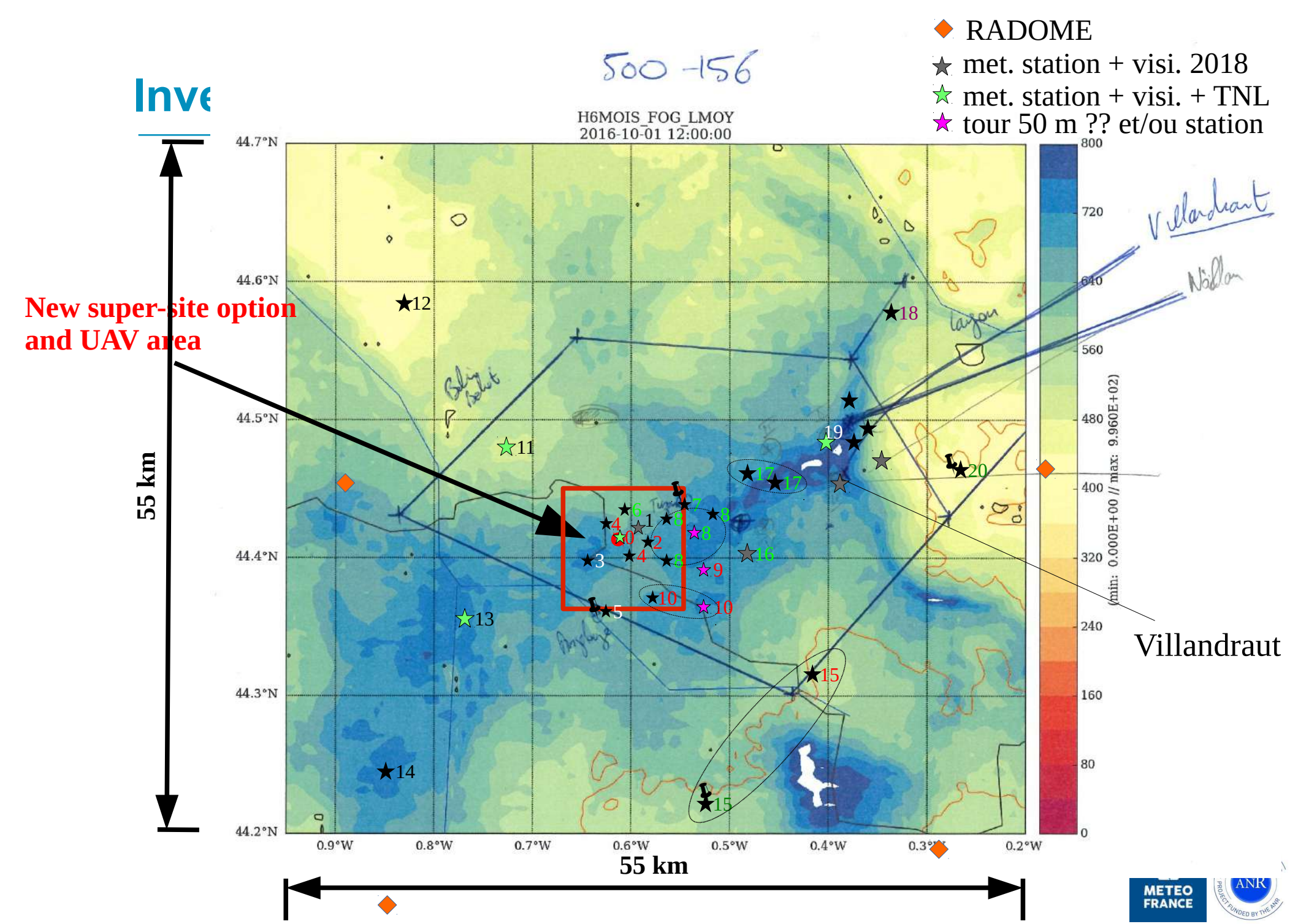
- Radar 95 GHz / MWR, Lidars
- Tethered balloon
- Aerosol shelter
- 50m mast 1 (flux, CDP)

Super-site

- **UAVs fleet terrain**
  - radar 95 GHz scannant



Inve

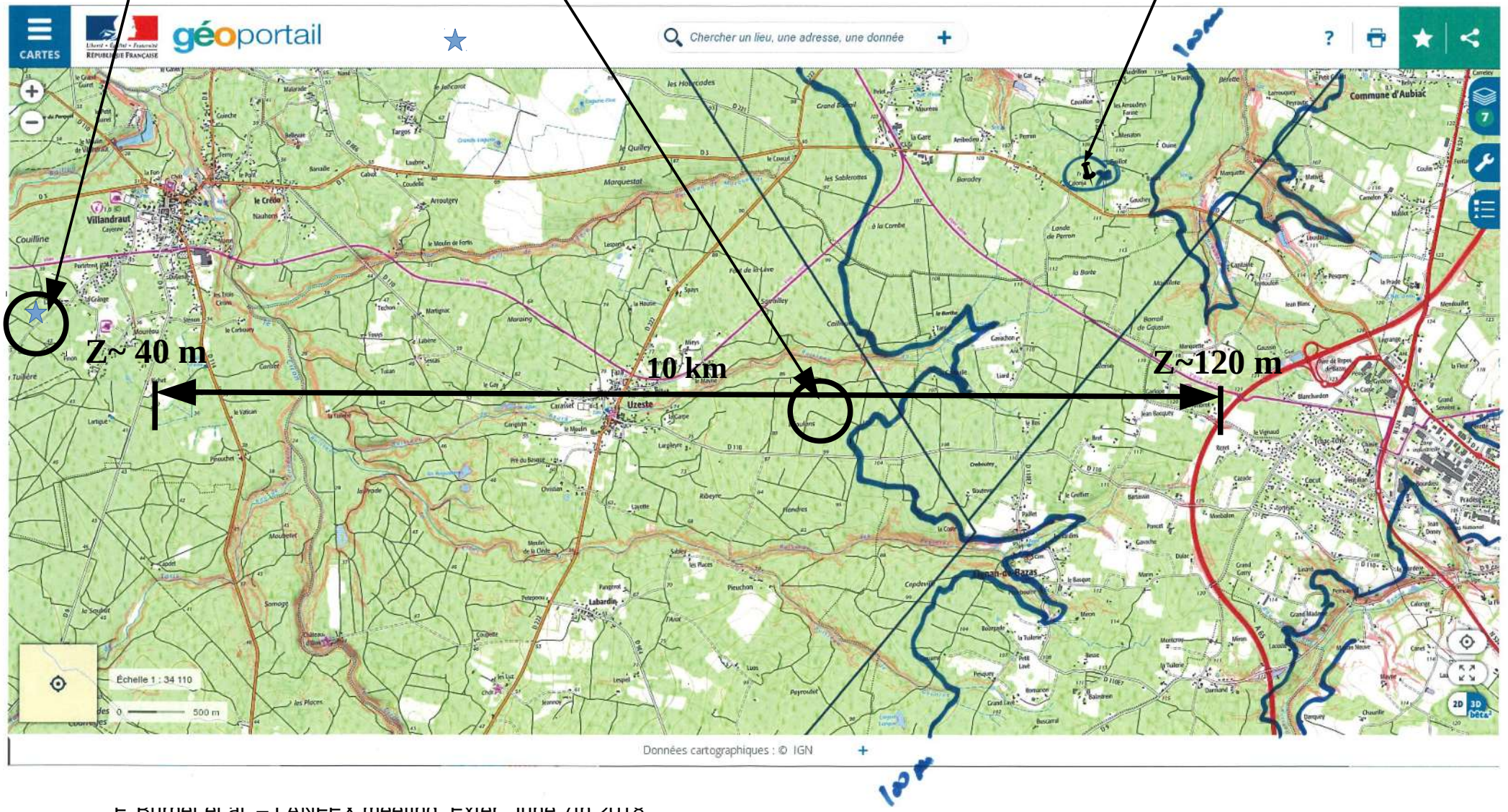

RADOME
met. station + visi. 2018
met. station + visi. + TNL
tour 50 m ?? et/ou station
500 -156
H6MOIS_FOG_LMOY
2016-10-01 12:00:00
New super-site option
and UAV area
55 km
55 km
Villandraut
44.7°N
44.6°N
44.5°N
44.4°N
44.3°N
44.2°N
0.9°W
0.8°W
0.7°W
0.6°W
0.5°W
0.4°W
0.2°W
800
720
640
560
480
400
320
240
160
80
0
(min: 0.000E+00 // max: 9.960E+02)

Transect vith increasing altitude

40m watchtower

★ met. station + visi.
Possible secondary site with one 50m tower ?

Flux site to find somewhere ?



Organization

- Networks of instruments should be deployed between => **01/10/2019 and 31/03/2020**

  ☑ Super-site (power access fixed => to be done)

  ☑ Radars strategy

  ☑ MWR network strategy

- **In progress :**
  - **site search** for the **2nd 50-m and of the 10-m flux mats**
    - Open area / small pine forest contrast. Distance ~ 5 to 6 km
  - **site search** for the **20 mobiles stations** and the **6 ceilometers**
    - Use of existing watchtowers / antennas for visi network (larger scale domain)
  - UAV long range flight derogation => 5 km radius (S2 < 1km)
    - ZRT requested for test flights in May-June

- **Intensive observation periods** (radiosoundings, tethered balloons, UAVs fleet) will be triggered through **forecast alerts** in real-time during this period.

Forêts des Landes ....









et al.

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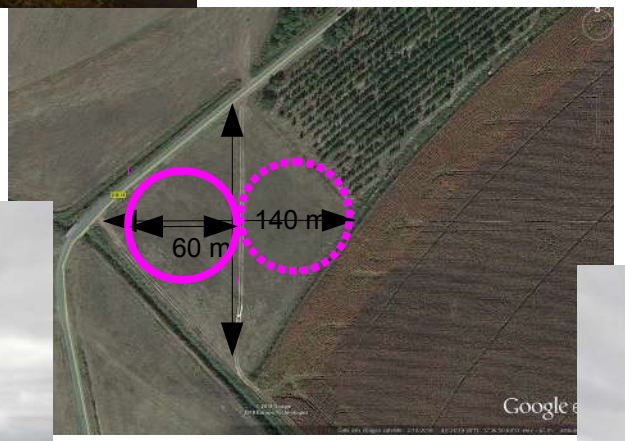

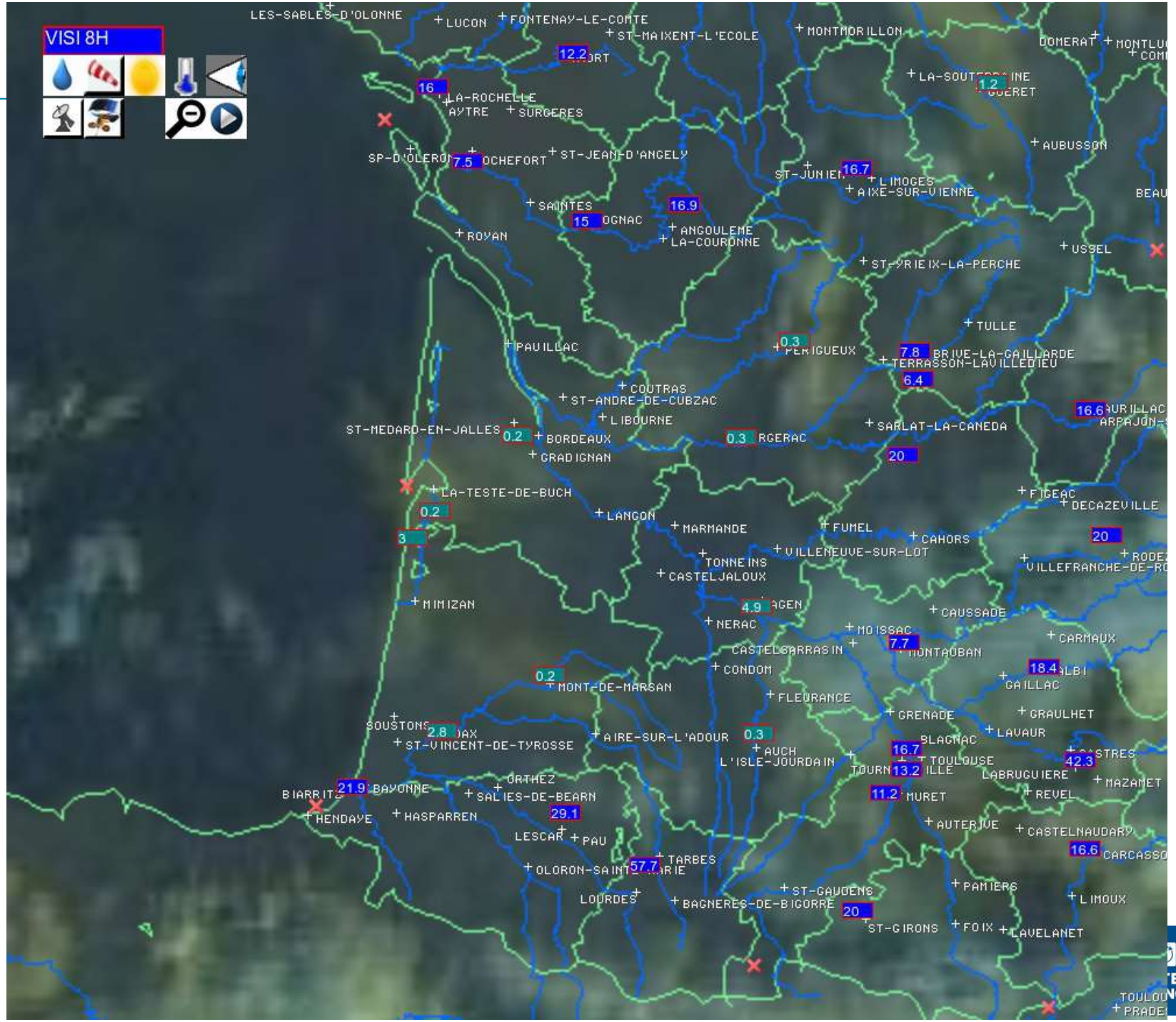
VISI 8H
LES-SABLES-D'OLONNE
LUCON
FONTENAY-LE-COMTE
ST-MAIXENT-L'ECOLE
MONTMORILLON
LA-ROCHELLE
AYTRE
SURGERES
ROCHEFORT
ST-JEAN-D'ANGELY
SAINTES
ROYAN
ANGOULEME
LA-COURONNE
LIMOGES
AIXE-SUR-VIENNE
AUBUSSON
USSEL
ST-YRIEIX-LA-PERCHE
TULLE
PAULLAC
PERIGUEUX
BRIVE-LA-GAILLARDE
TERRASSON-LAVILLEDIEU
COUTRAS
ST-ANDRE-DE-CUBZAC
LIBOURNE
ST-MEDARD-EN-JALLES
BORDEAUX
GRADIGNAN
SARLAT-LA-CANEDA
LA-TESTE-DE-BUCH
LANGON
MARMANDE
FUMEL
CAHORS
FIGEAC
DECAZEVILLE
VILLENEUVE-SUR-LOT
TONNEINS
CASTELJALOUX
MIMIZAN
NERAC
CAUSSADE
MOISSAC
CARMAUX
CASTELSARRASIN
MONTAUBAN
CONDOM
GAILLAC
MONT-DE-MARSAN
FLEURANCE
GRENADE
GRAULHET
LAVAUR
SOUSTONS
DAX
ST-VINCENT-DE-TYROSSE
AIRE-SUR-L'ADOUR
AUCH
BLAGNAC
L'ISLE-JOURDAIN
TOULOUSE
LABRUGUIERE
MAZAMET
ORTHEZ
BIARRITZ
BAYONNE
SALIES-DE-BEARN
REVEL
HENDAYE
HASPARREN
MURET
AUTERIVE
CASTELNAUDARY
LESCAR
PAU
TARBES
OLORON-SAINTE-MARIE
CARCASSO
LOURDES
ST-GAUDENS
BAGNERES-DE-BIGORRE
PAMIERS
LIMOUX
ST-GIRONS
FOIX
LAVELANET
PRADES