The International SOFOG3D experiment

Task5 : Data assimilation and forecast

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The WP5 team members / partners

- CNRM/GMAP : Jean-François Mahfouf, Thibaut Montmerle, Nadia Fourrié
- CNRM/GMME : Olivier Caumont, Benoit Vié
- CNRM/GMEI : Alistair Bell, Vinciane Unger, Gilles André, Jean-Marie Donier, Thierry Douffet
- LATMOS : Julien Delanoe
- University of Cologne : Ulrich Löhnert
- IMAA-CNR, Italy : Domenico Cimini
- MeteoSwiss : Maxime Hervo
- ONERA : Thierry Huet
- Laboratoire d'Aérologie : Jean-François Géorgis
- RPG : Harald Czekala
- Attex : Mathias Schröder

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Motivation of the study

400 km

10 km

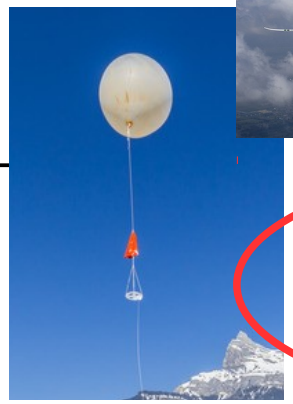
2 km

10 m

Satellite

Aircraft

Balloon



PBL : **observation gap**
temperature and humidity and microphysics 24/24

Weather station

Remote sensing :
-radar
- lidar

Fog

- Degraded **fog forecast** due to degraded **initial conditions** of the model in the BL

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Ground-based microwave radiometers

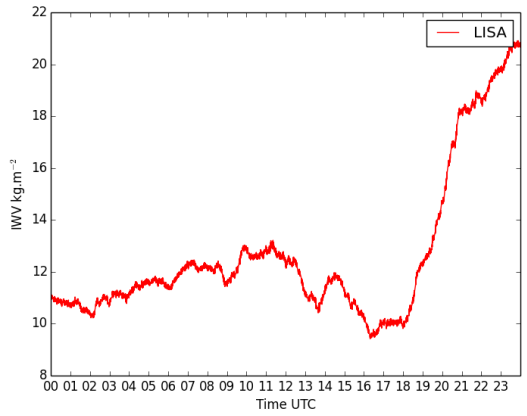
Continuous data in all-sky conditions: resolution of seconds to minutes

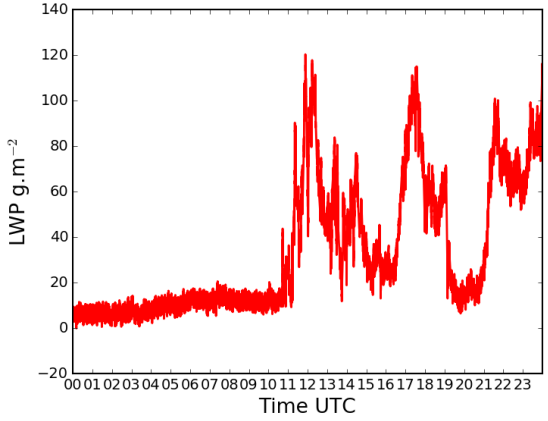
Information mainly residing in the **PBL**
3 main products

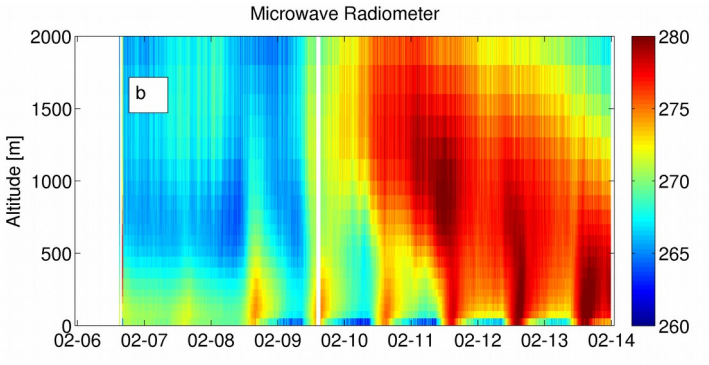
Low resolution **water vapor profile** but excellent path-integrated values

Path-integrated **liquid water**

Well resolved **temperature** profile in the **PBL**, low resolution above







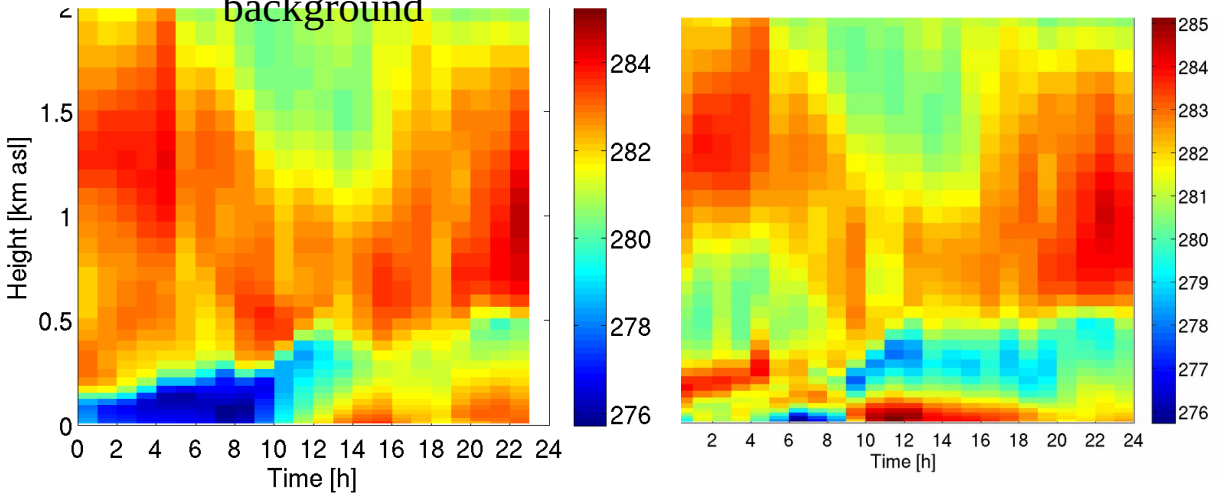
- LWP : most reliable method but no information on the **cloud vertical distribution**

MWR assimilation: expected impact on the model initial state

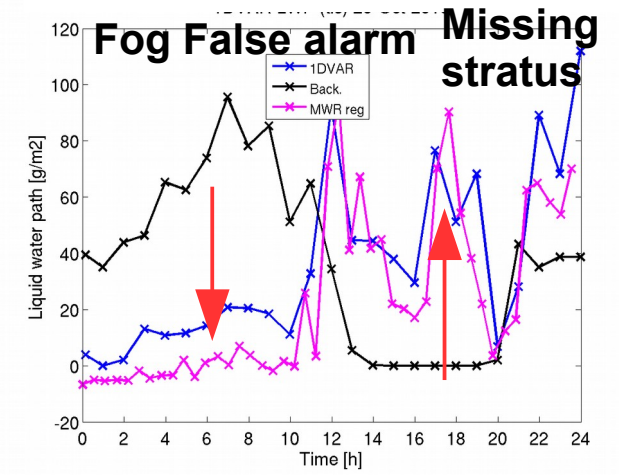
- Evaluation of the potential positive impact of the assimilation of MWR observations through a **1DVAR framework** (One-dimensional variational assimilation scheme)

Temperature Profiles 28102016

AROME 1h forecasts = background



LWP diurnal evolution

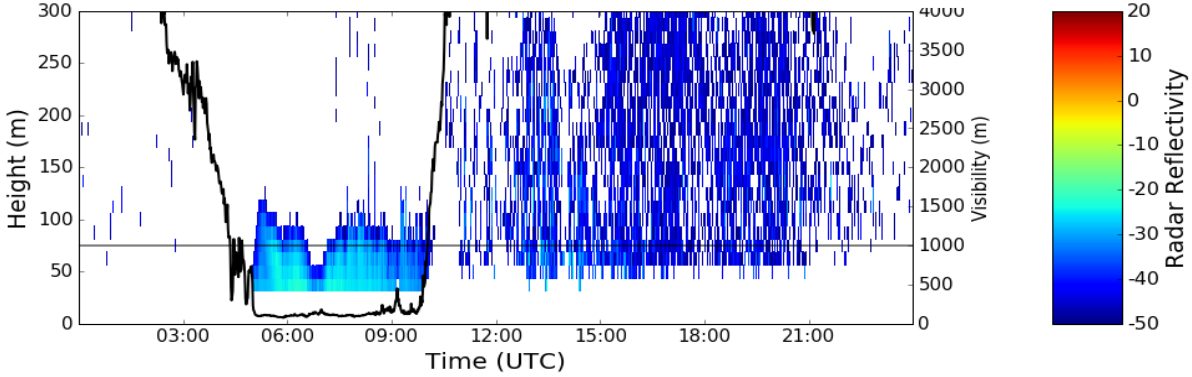


- Large impact on the temperature field with temperature increments up to 5 K during the radiative fog event (too thick and too persistent in the model)
- Large impact on the LWP field
- Neutral to slight positive impact on the humidity profile

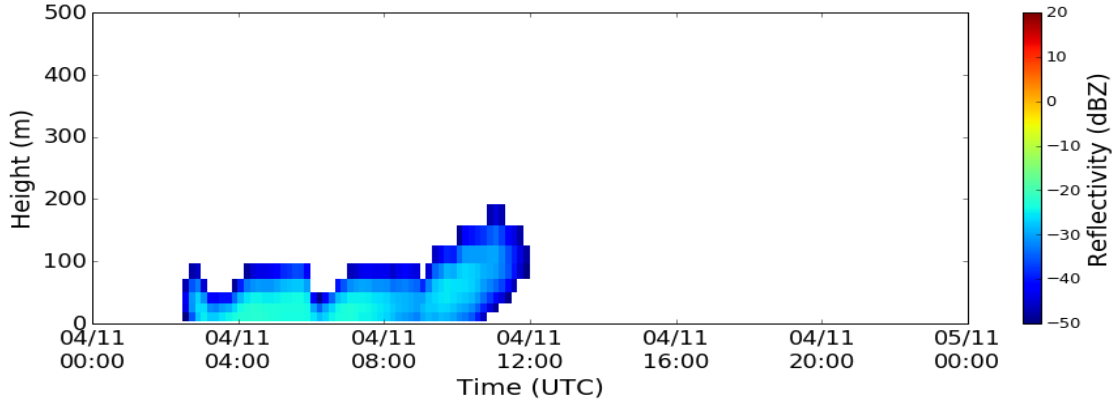
95 GHz cloud-radars

- Newly industrialized systems
- Sensitive to small **cloud** and **fog droplets**
- Offer new capabilities to access to fog **microphysical** properties and dynamics (Doppler velocity)
- Complementary information of that of MWR

Reflectivity observation (BASTA SIRTA)



Simulated reflectivity from AROME



A. Bell PhD thesis

Innovation in data assimilation scheme : the EnVar

- Météo-France (GMAP group) has developped for several years a new ensemble based variational assimilation scheme (**EnVar)**
- Flow dependent background-error-covariance matrix
- Possibility to include hydrometeors in control variables (2 PhD on going on that topic : Mayeul Destouches and Guillaume Thomas)
- Possibility of using 4D-EnVar instead of 3D-EnVar : take advantage of the high temporal resolution of MWR and cloud radars

From Thibaut Montmerle : l'En-Var pour les nuls

Scientific questions

- On what extent, a ground-based microwave radiometer network assimilated in newly developed ensemble variational data assimilation scheme (**EnVar**) can improve fog forecasts ?

- Needs to set-up for the first time a regional scale MWR network

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- 8 radiometer units to be deployed

Research laboratories / National Weather Services collaboration :

- Cologne: Ulrich Löhnert (HATPRO) : **T**, **Q, IWV, LWP**
- MeteoSwiss: Maxime Hervo/Alexander Haeffele (HATPRO, G2) : **T**, **Q, IWV, LWP**
- Laboratoire d'Aérologie : Jean-François Georgis (HATPRO, G2) : **T**, **Q, IWV, LWP**
- Météo France : Pauline Martinet/Vinciane Unger (HATPRO G3) : **T**, **Q, IWV, LWP**
- ONERA:Thierry Huet/ Xavier Boulanger (HATPRO): **T**, **Q, IWV, LWP**
- Met Office: Jeremy Price (RPG HumPro) : **Q, IWV, LWP**

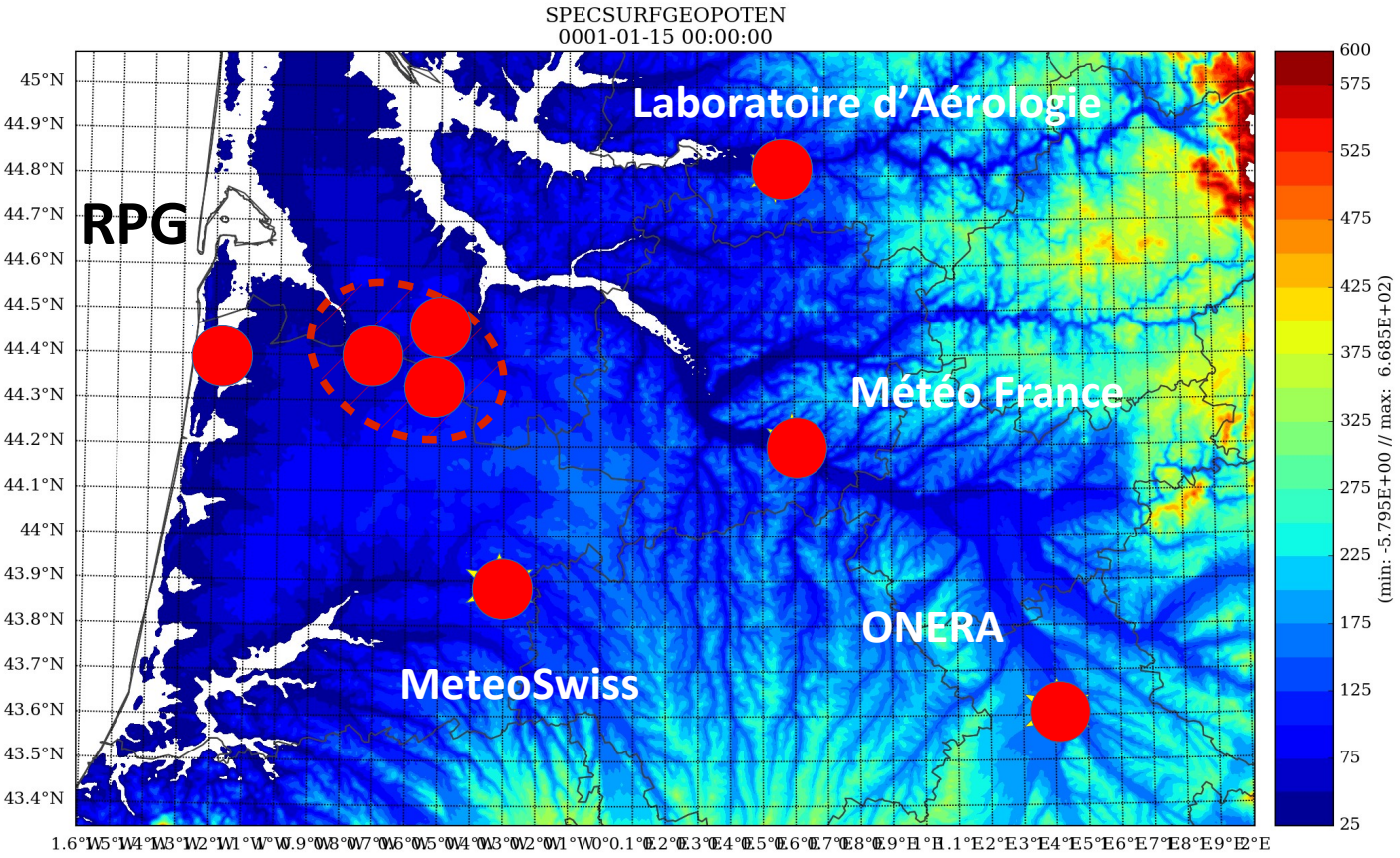
Industrial Collaboration :

- Attex,MTP-5: Mathias Schroder : **T** (0-1000m)
- RPG HATPRO G5 : Harald Czekala : **T**, **Q, IWV, LWP**

MWR network instrumental deployment strategy

Super-site

Cologne
University
Met-Office
Attex

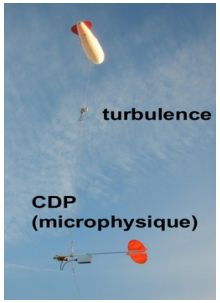


- Strategy based on GMAP team long experience in reanalysis (HyMex) and last conclusions from Hu et al 2017 (OSSE wind profilers) :*an even distribution covering a larger region is more beneficial than a dense network concentrated in a small aread*
- Denser network on the west side to constrain humid air advection from the West /ocean

Scientific questions

- What variables/parameters about fog forecasts are improved thanks to the assimilation of a MWR network: fog onset/dissipation times, fog diurnal cycle, vertical depth ?

- Validation/evaluation strategy by using intensive in-situ observations during IOP, demand on increase RS launchings

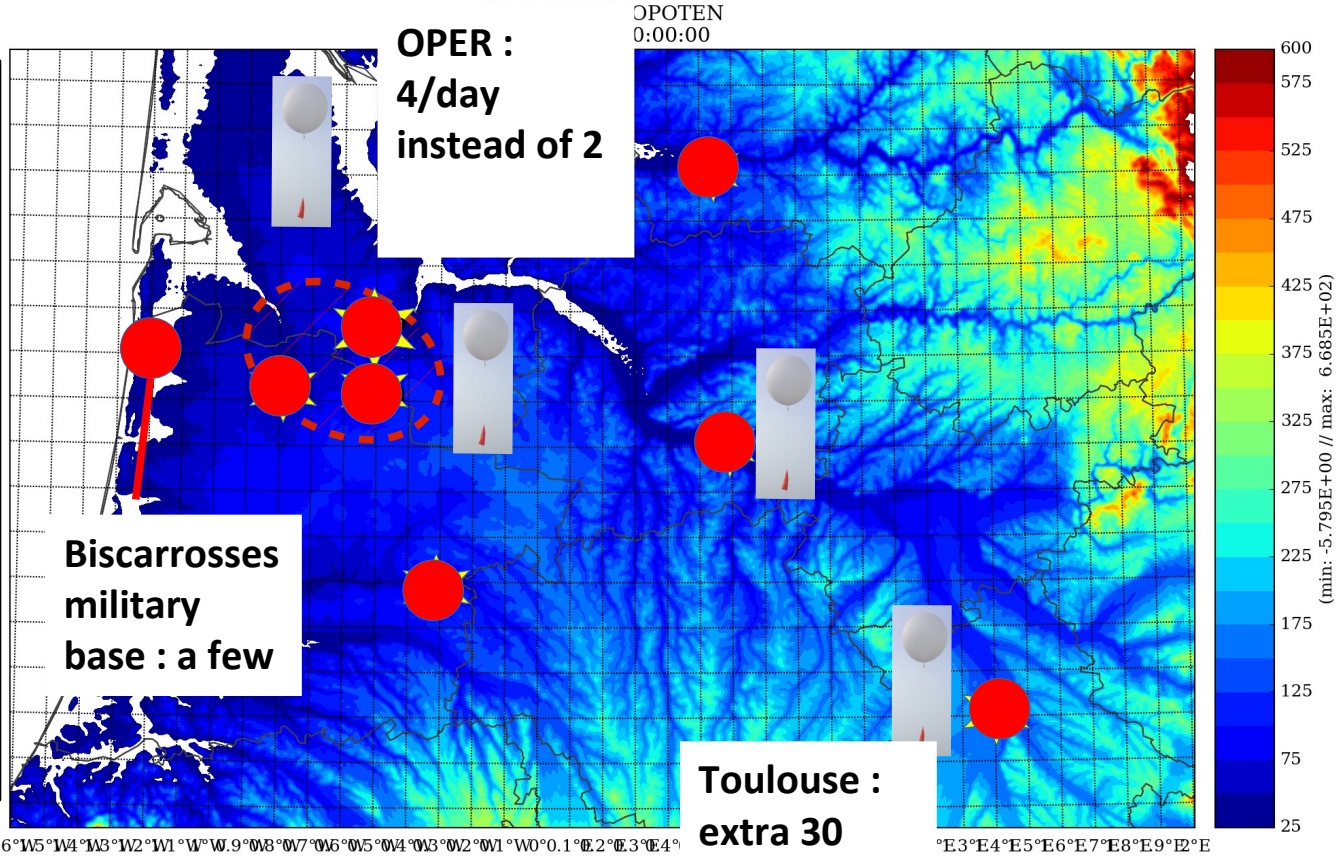


-~ 100 Radiosonde (every 4 to 6 hours during IOPs)

- Tethered ballons : LWC profiles

- UAVS (spatial heterogeneity, T, Q)

- Towers (T, Humidity, microphysics)



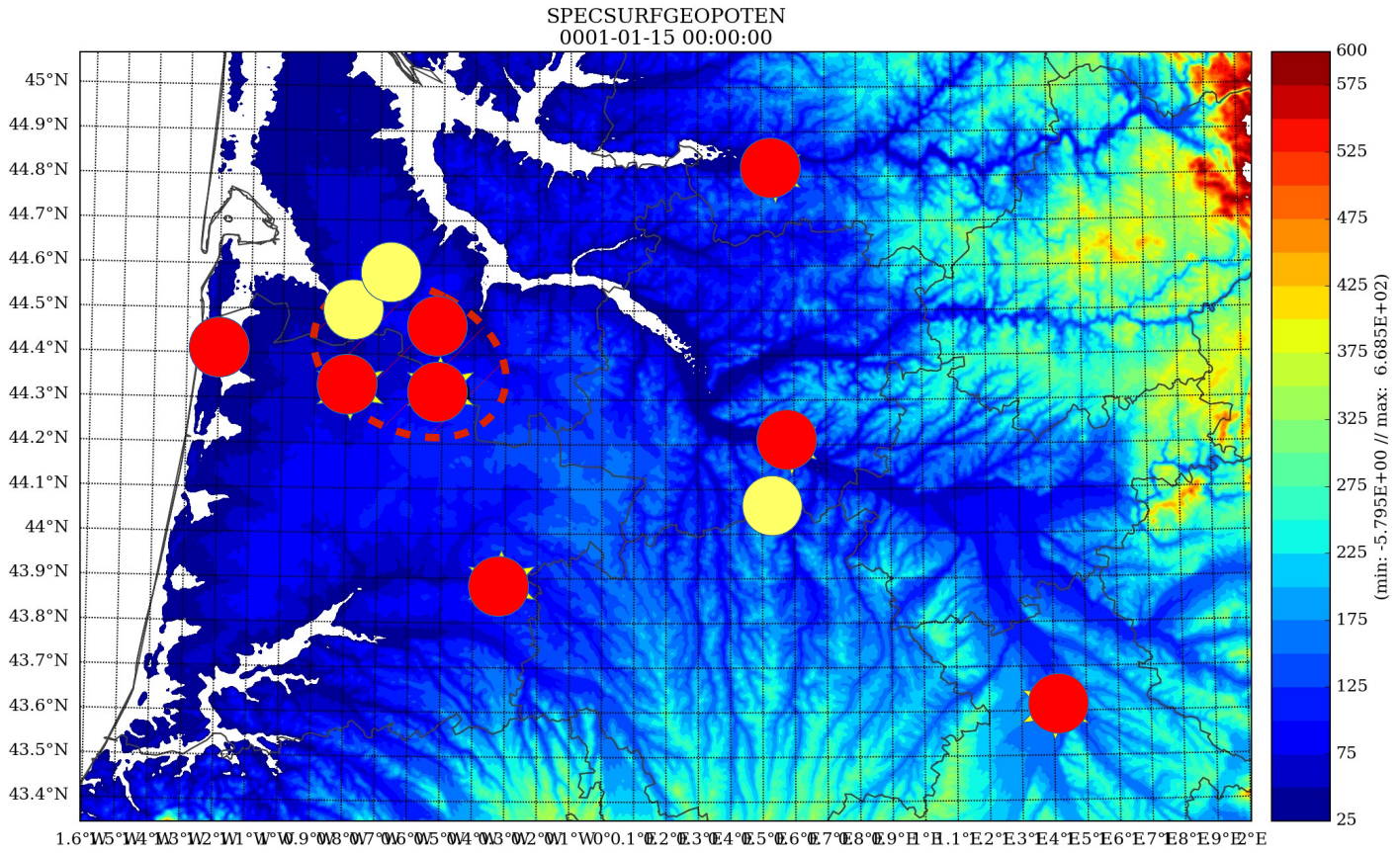
Scientific questions

- What variables/parameters about fog forecasts are improved thanks to the assimilation of a MWR network: fog onset/dissipation times, fog diurnal cycle, vertical depth ?

- Use of remote-sensing observations for forecast evaluation with a focus on spacial extent

MWR

Cloud radar



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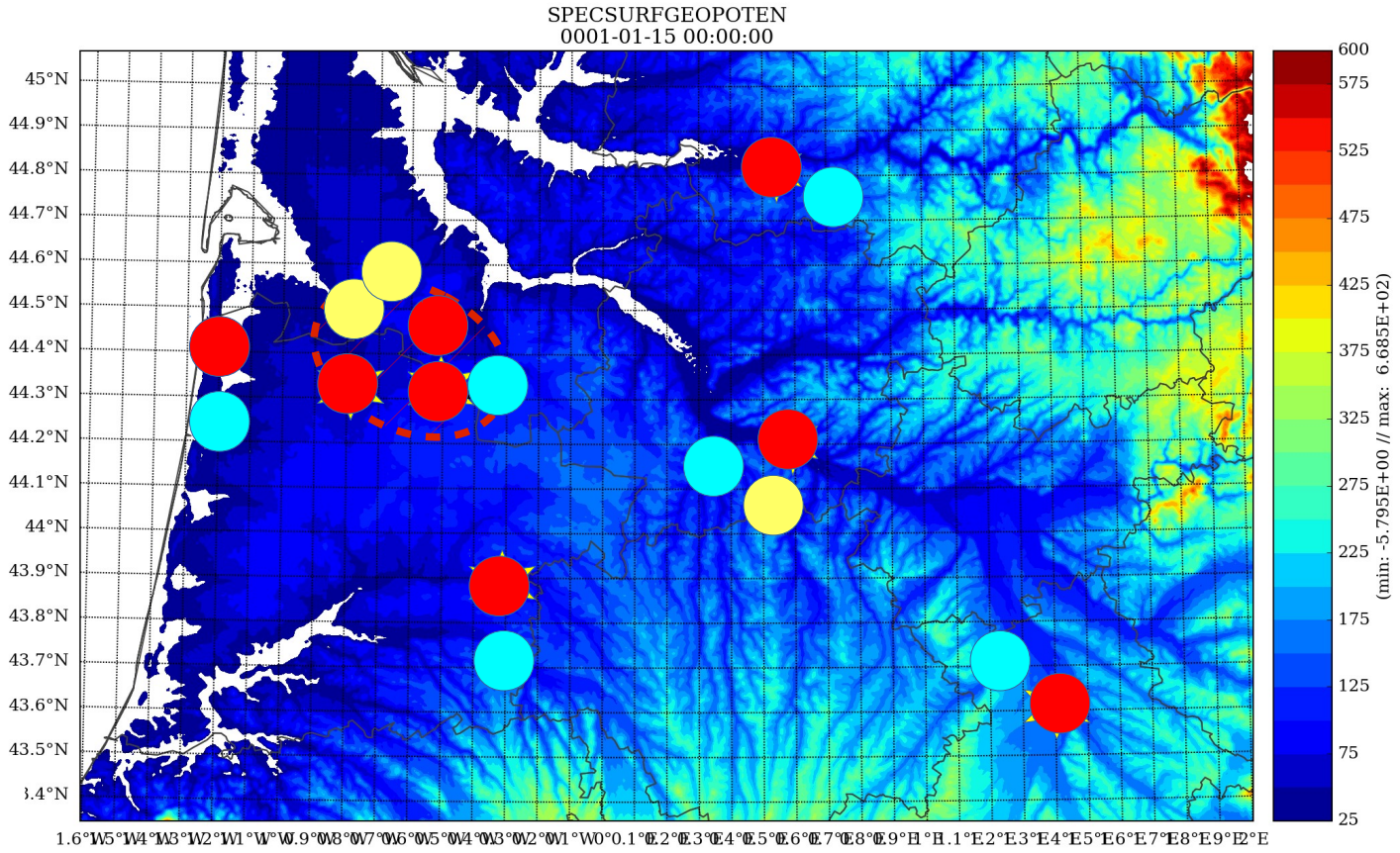
MWR

Cloud radar

ceilometer

+ use of satellite data

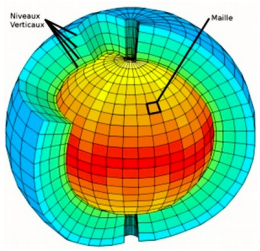


Scientific questions

- What is the most important parameter between vertical or temporal resolution to improve fog forecasts ?

- Data assimilation denial experiments : OSE (Observing System Experiments

3D-EnVar AROME



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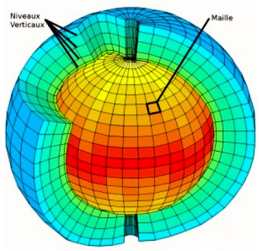
CTRL RUN

3D-EnVar AROME



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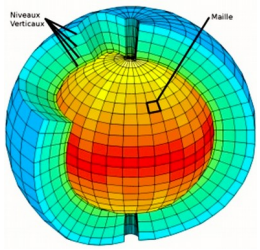
- Intensive Radiosondes
- UAVs (T, Q profiles) : after validation

3D-EnVar AROME



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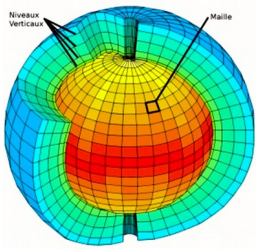
- MWR retrieved profiles at the same temporal resolution as RS/ UAVs

4D-EnVar AROME



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- MWR retrieved profiles at high temporal resolution ~ **10min**

Scientific questions

- What are the most relevant meteorological quantities to be initialized (temperature, humidity, hydrometeors) for improving fog forecasts ?

→

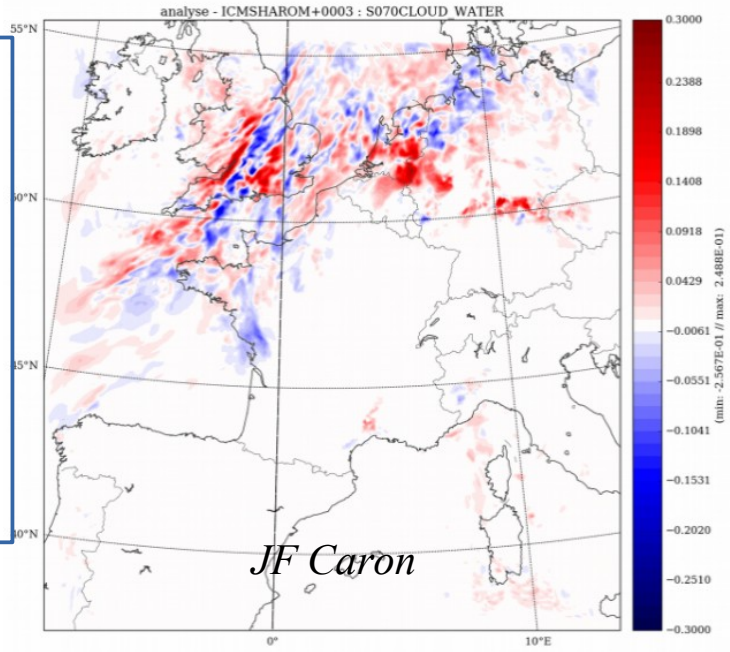
- Retrieval of LWC profiles with cloud radar synergy (A. Bell PhD)
- OSE experiments : temperature / humidity profiles and temperature / humidity / LWP information
- Possible thanks to the sampling of cross-covariances between T/Q variables and hydrometeors by the En-Var

Combination of MWR and Cloud radar to derive LWC profiles (A. Bell PhD)

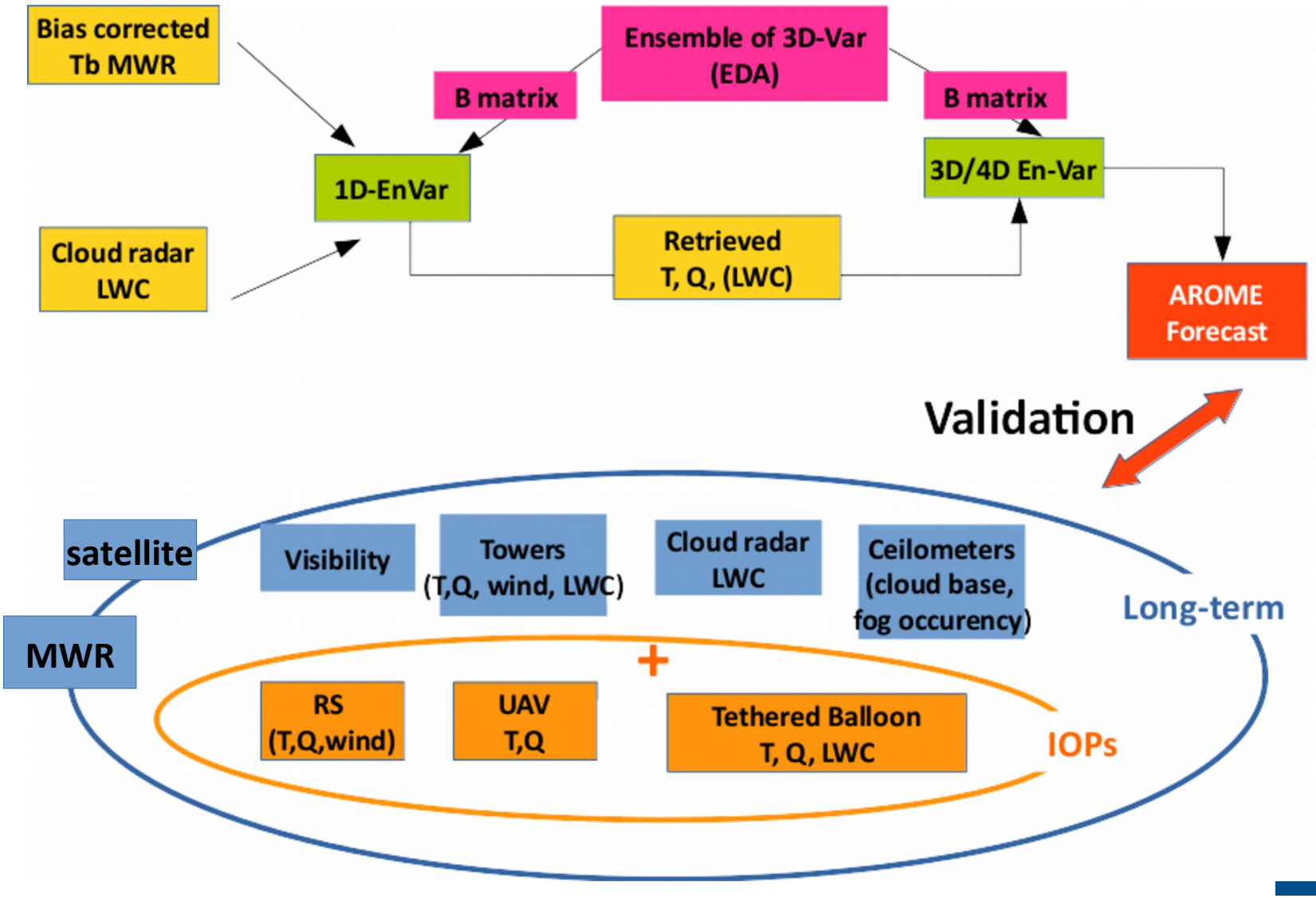
+

LWC increment in the model withouT assimilation of LWC sensitive obs → Cross-covariances ! GMAP dev (JF Caron courtesy)

Cloud water (g/kg) @ L70



WP5 : Summary of the work-plan



Additional use of the MWR network

- Forecast evaluation : AROME 500m (Salome Antoine PhD thesis) + daily evaluation of AROME OPER 1.3 km short-term-forecasts (Coll. GMAP/PROC)

- Better understanding of the spatio-variability of fog vertical structure at a regional scale (~300 km) and capability of AROME to statistically represent this variability

- Improved key fog parameter retrievals (temperature, humidity, water and microphysics, fog dynamics) based on the combination of cloud radar and MWR measurements (WP2 with LATMOS and SIRTA)

- PE-ARO : detection of « fog object » + use of the PE-ARO for process studies by the identification of the sources of errors and the perturbation of the physical parameterizations and initial conditions. (Coll. Laure Raynaud GMAP/RECYF)

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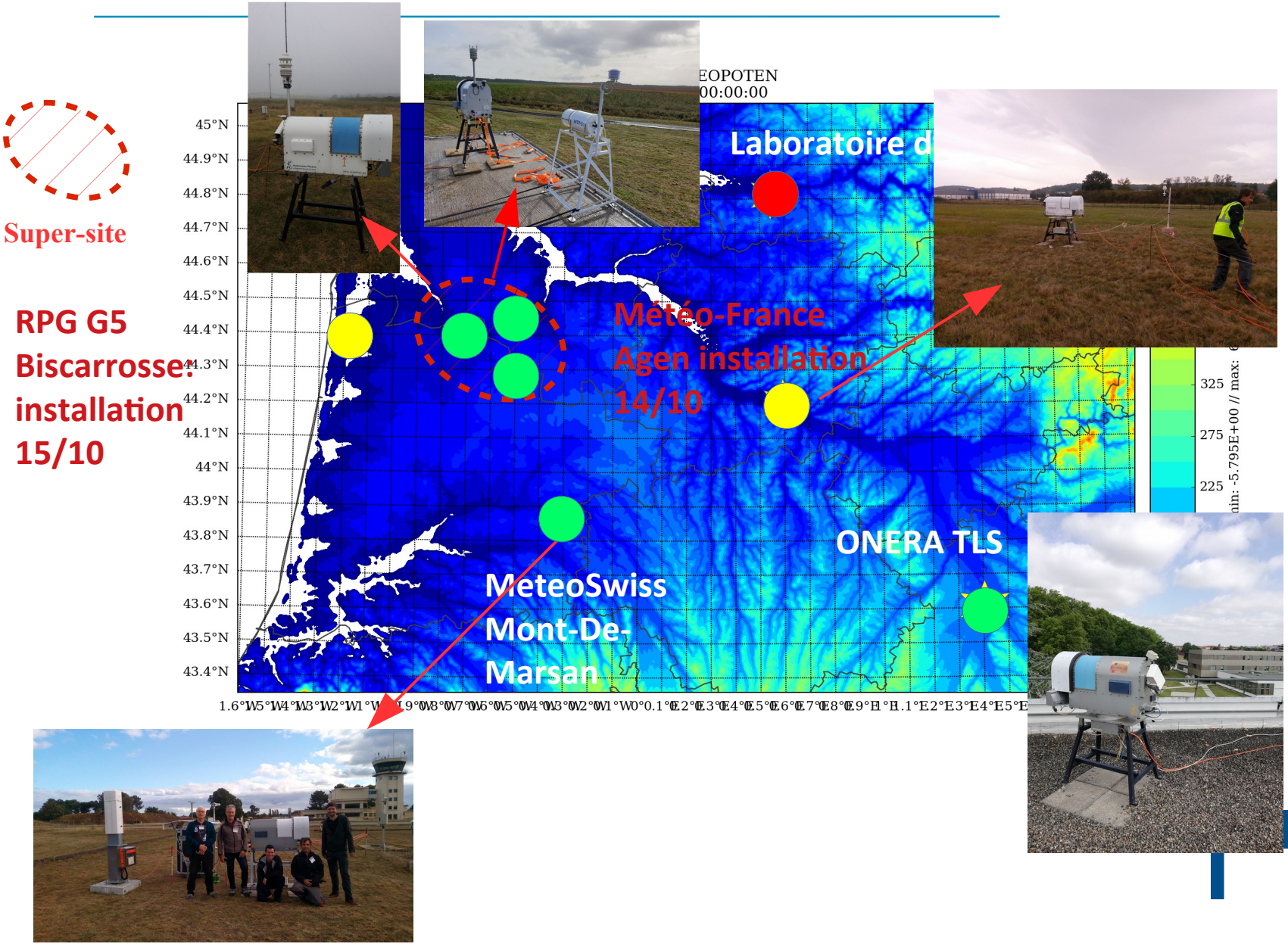
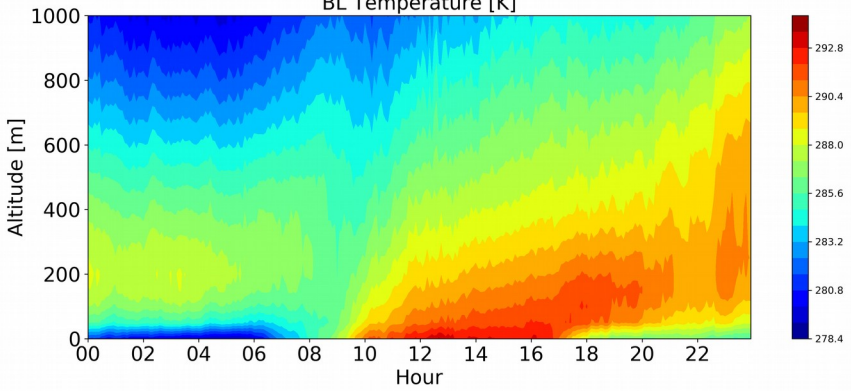
The MWR network : current status (5 MWR running, 2 to be installed)

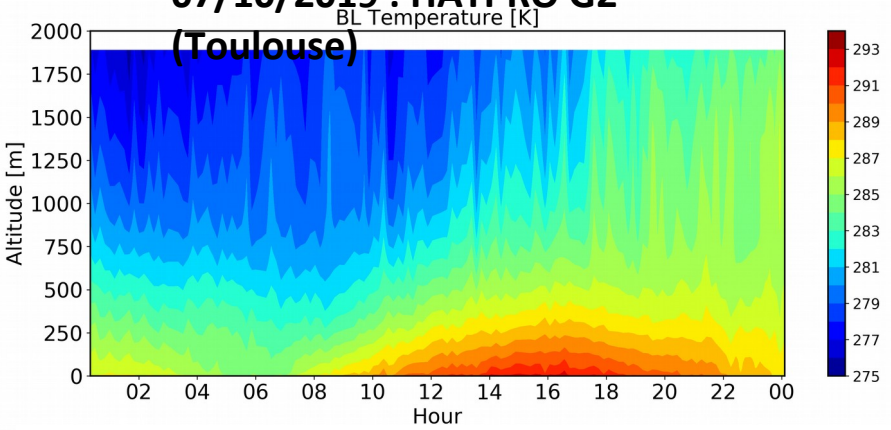


Current status : First data

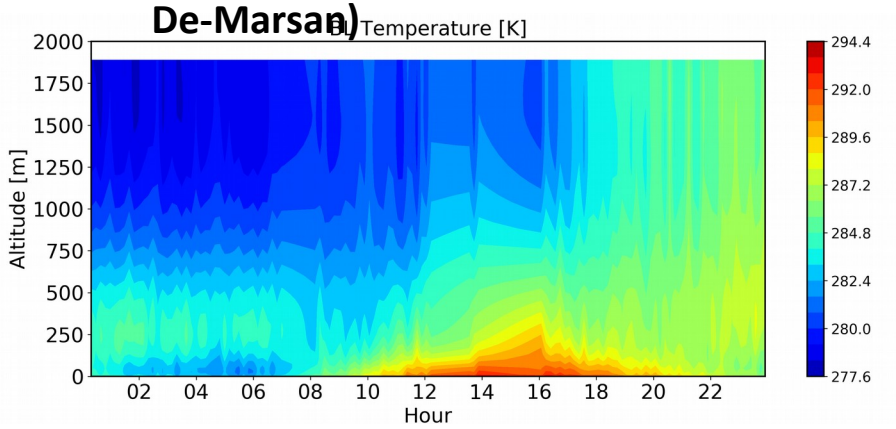
07/10/2019 : MTP-5 (Super-Site)



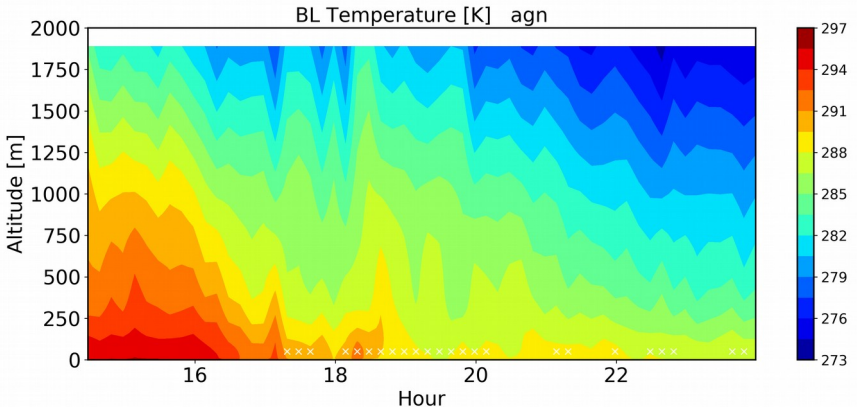
07/10/2019 : HATPRO G2 (Toulouse)



07/10/2019 : HATPRO G5 (Mont-De-Marsan)



14/10/2019 : HATPRO G3 (Agen)

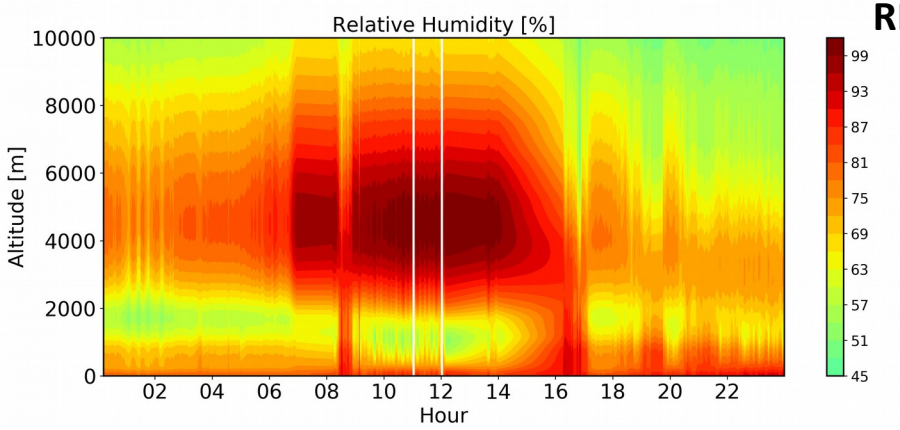


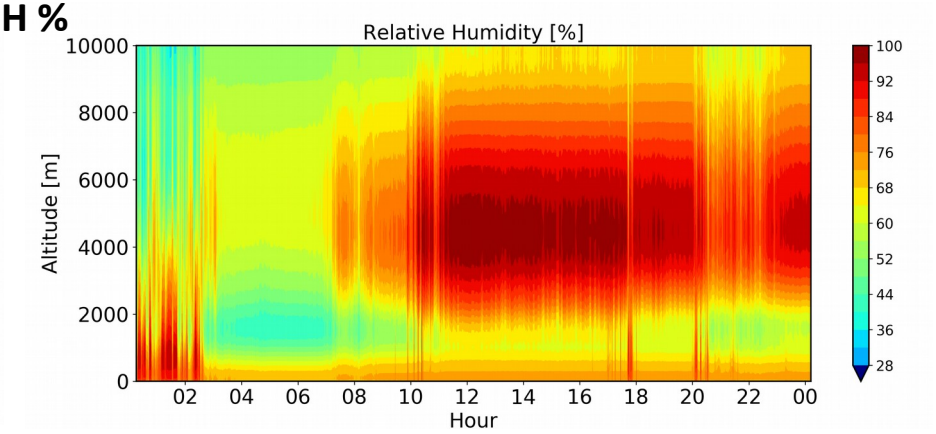
Current status : First data

07/10/2019 : HATPRO G5 (Mont-De-Marsan)

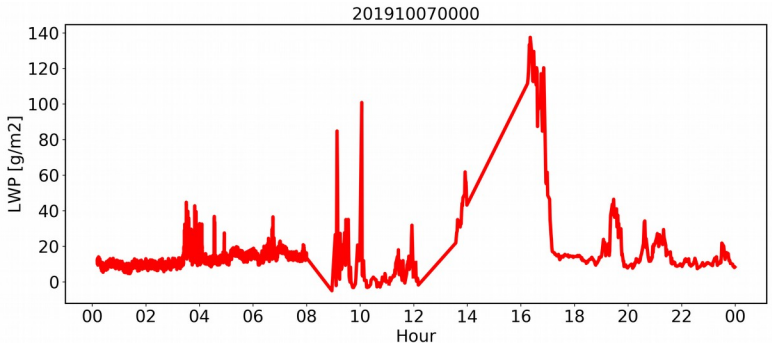
07/10/2019 : HATPRO G2 (Toulouse)

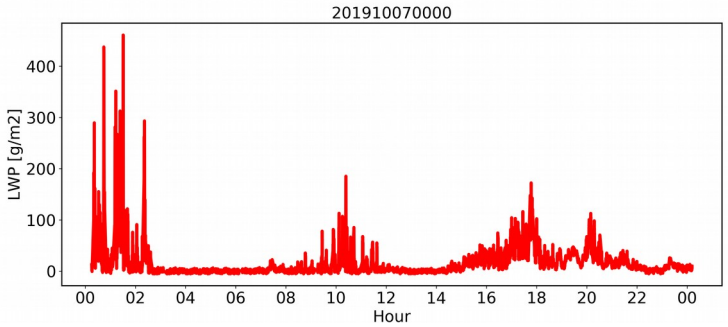
RH %



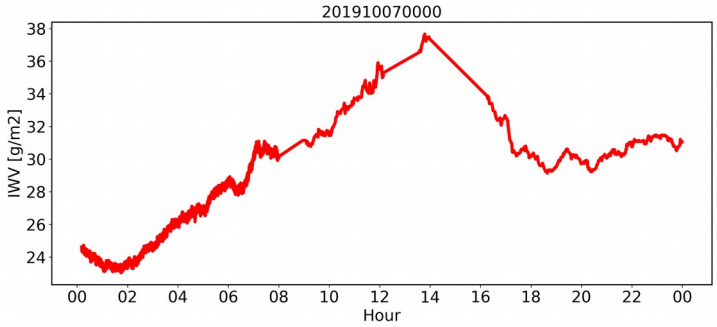


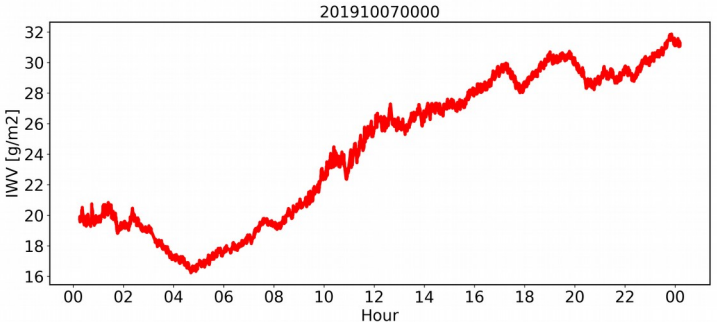
LWP (g/m2)





IWV (kg/m2)





A big thank to all the technical team !

Thanks for your attention !
Questions ?