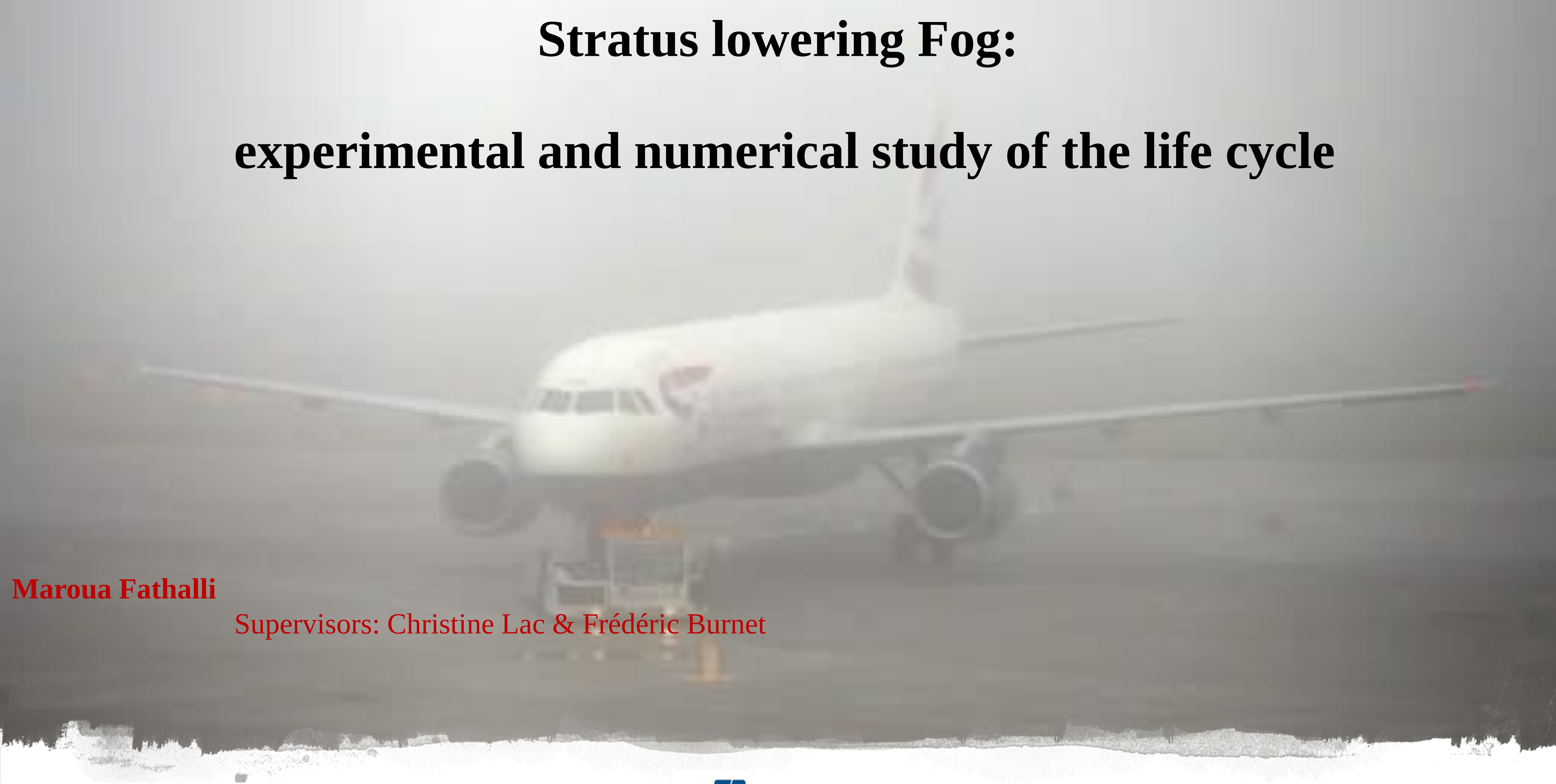
Stratus lowering Fog:

experimental and numerical study of the life cycle



Maroua Fathalli

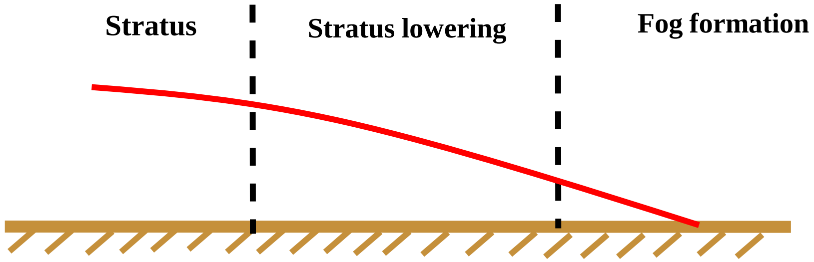
Supervisors: Christine Lac & Frédéric Burnet

GMEI/MNPCA & GMME

Introduction

The main types of fog :

- Radiative fogs (RAD).
- Advection fogs (ADV).
- **Fogs** due to **stratus lowering (STL)** (Stratus Transition lowering).



Numerical Weather Prediction (NWP)

- **AROME** => difficulties to correctly forecast stratus lowering.

  On a winter 2011 at Paris-CDG, (17 RAD, **20 CBL**, and 3 ADV fogs) were observed **(Philip, 2016)**.

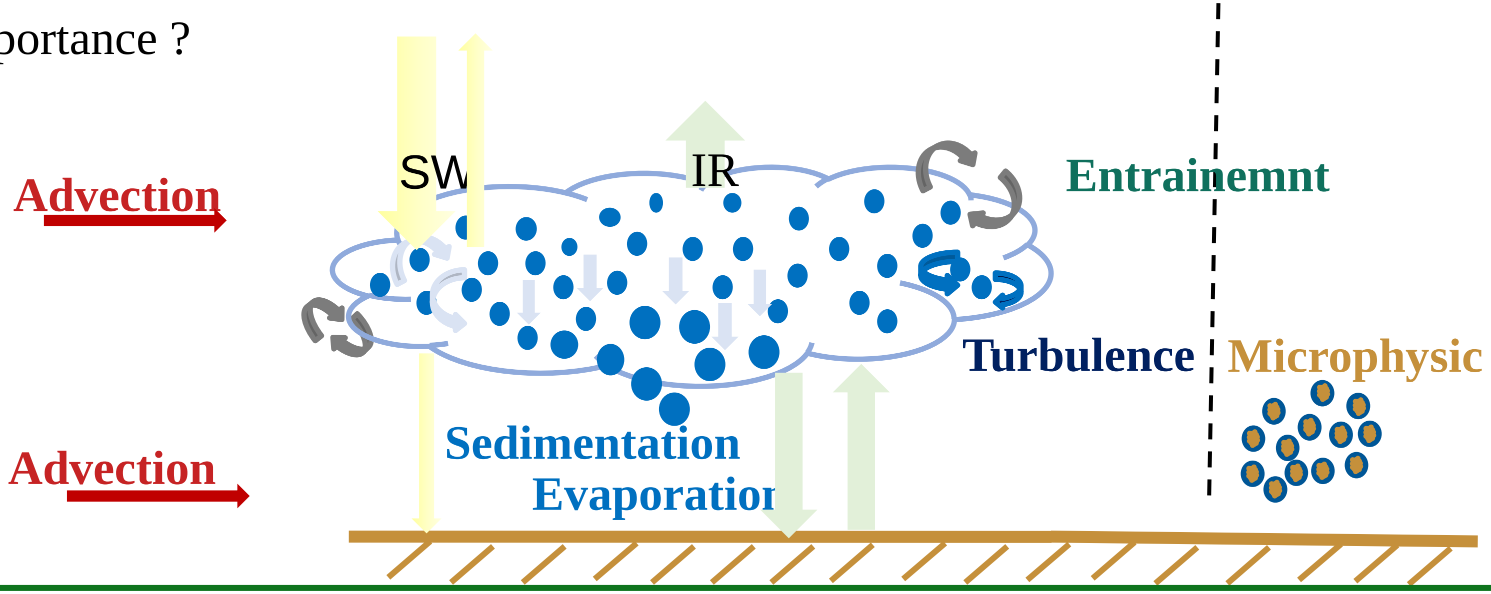
  → AROME simulates about 70% of RAD fogs and **30% of CBL fogs**.

What are the main processes leading to stratus lowering ?

Processes leading to fog by STL are poorly known:

- **Microphysics processes**
  - Radiative cooling at the top of stratus ⟶ droplet growth and settling (**Pilie et al., 1979**) ⟶ evaporation of droplets below stratus (**Dupont et al, 2012**).
- **Dynamic processes**
  - Large scale processes: subsidence, advection (**Koracin et al, 2001**).

What are their relative importance ?



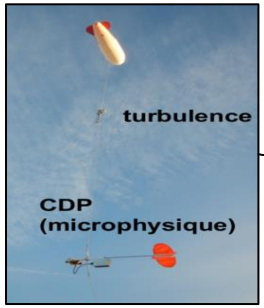
Objectives of PhD:

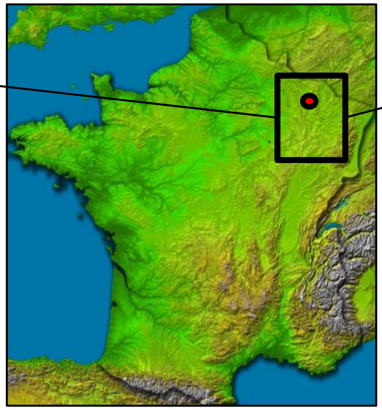
1. What are the main processes leading to fog by STL?
2. How to improve fog by STL forecasts in NWP?

- **BURE (Burnet et al.**.) field campaign in the north-east of France (2015/2016 - 2016/2017) .

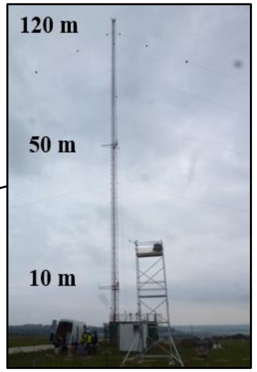
IOP 2 : 1st and 2nd Decembre 2016

Tethered balloon





In-situ measurements



Remote Sensing

Plan of the presentation

- Analysis of the observations and realism of the simulation with Meso-NH model.

- Process study to characterize the STL drivers.

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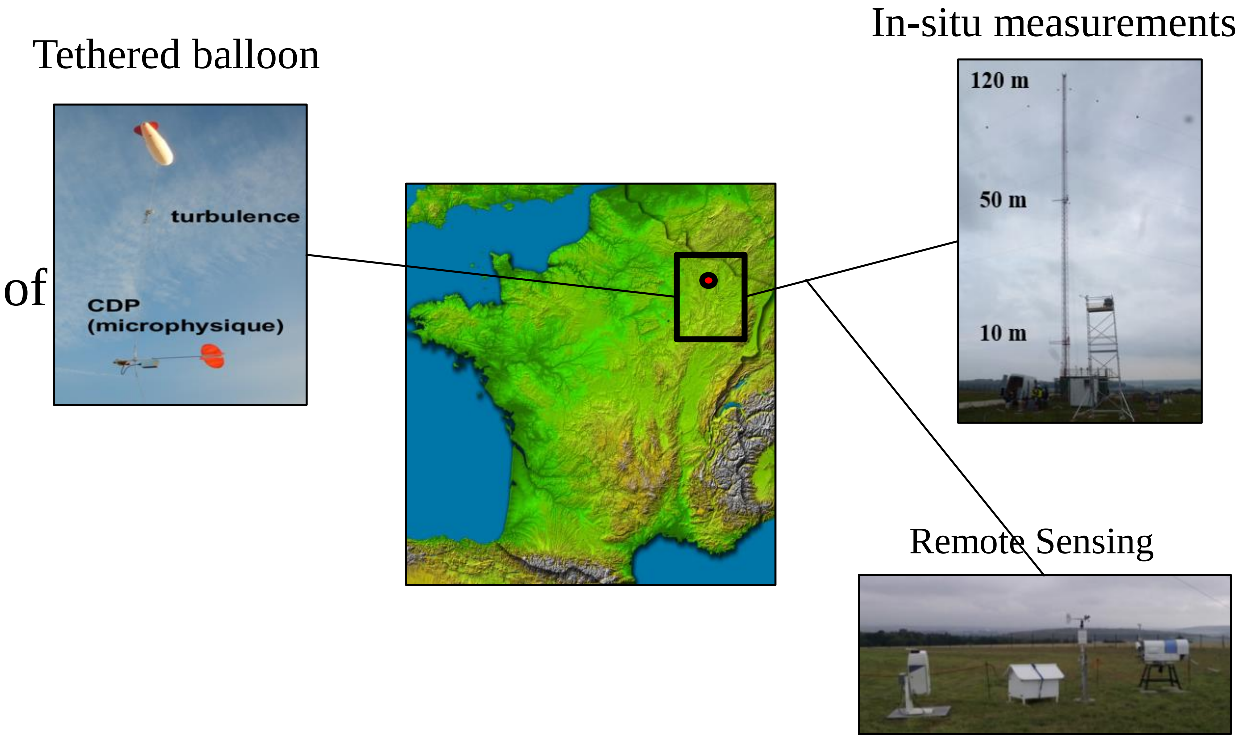

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- **Analysis of the observations and realism of the simulation with Meso-NH model.**
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Overview of the case study

IOP 2 : 1^{st} and 2^{nd} Decembre 2016

From 18:00 UTC to 22:00 UTC

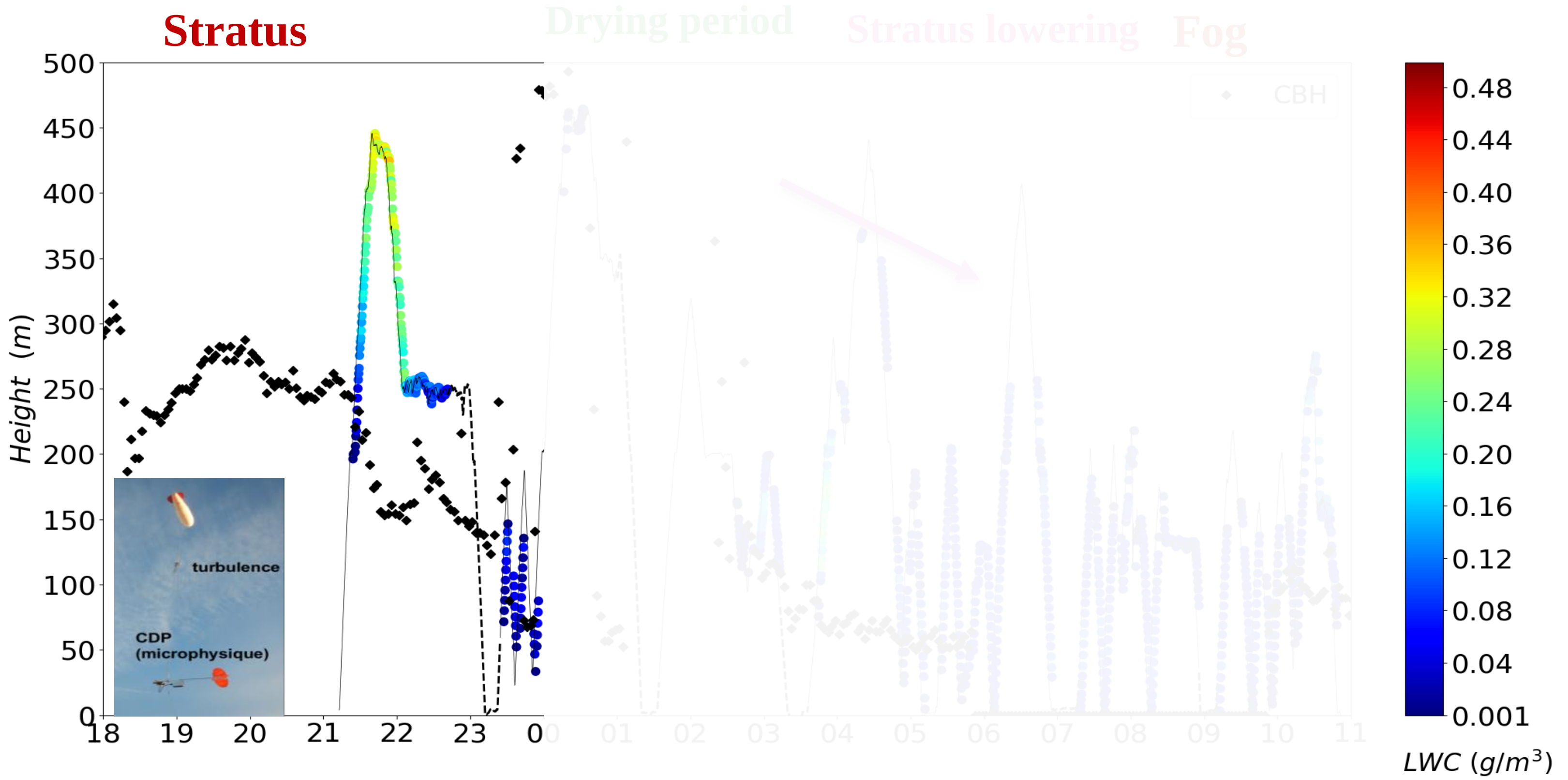
- Stratus base: From 300 m to 120 m

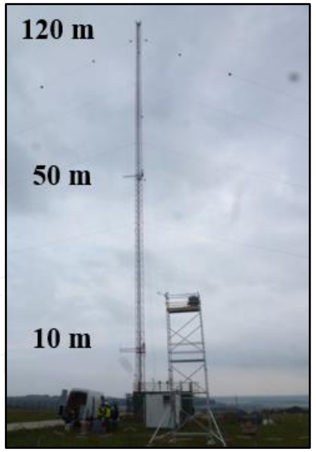
From 00:00 UTC to 02:30 UTC

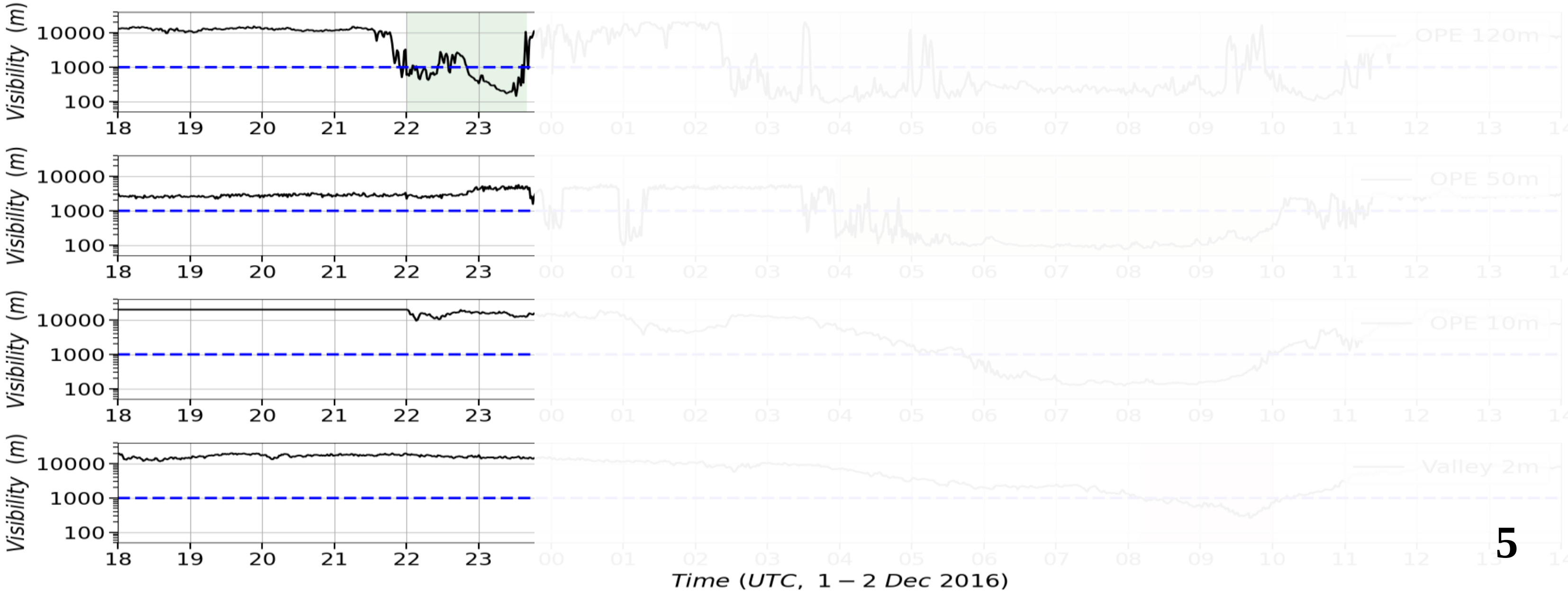
- Stratus base: From 500 m to 800 m
- Increase in visibility at 120 m

From 02:30 UTC to 10:00

- Stratus base: From 160
- Decrease in visibility a







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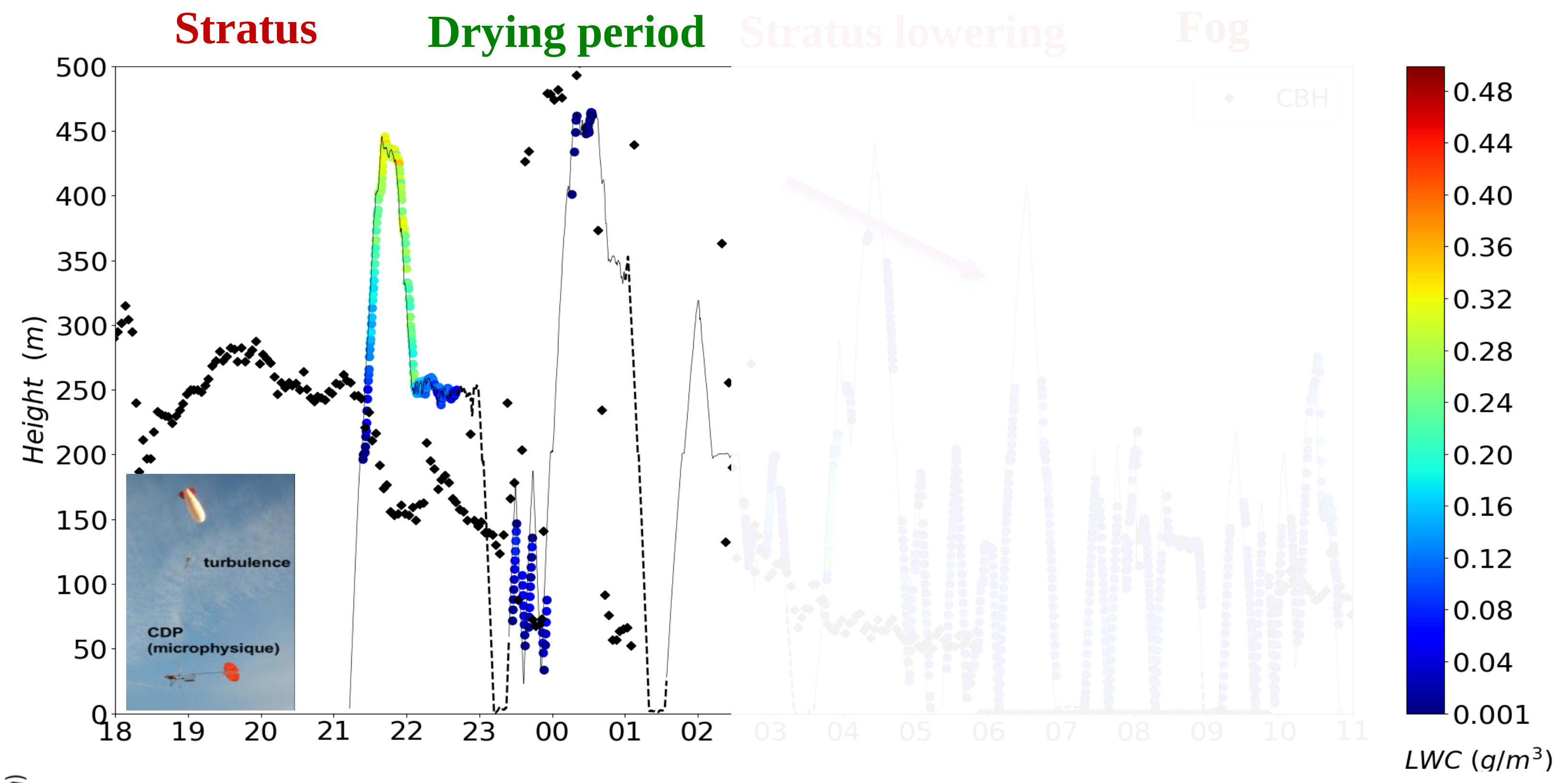

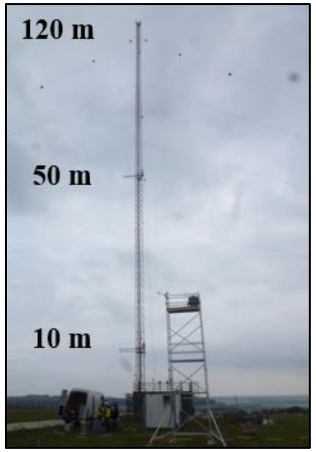

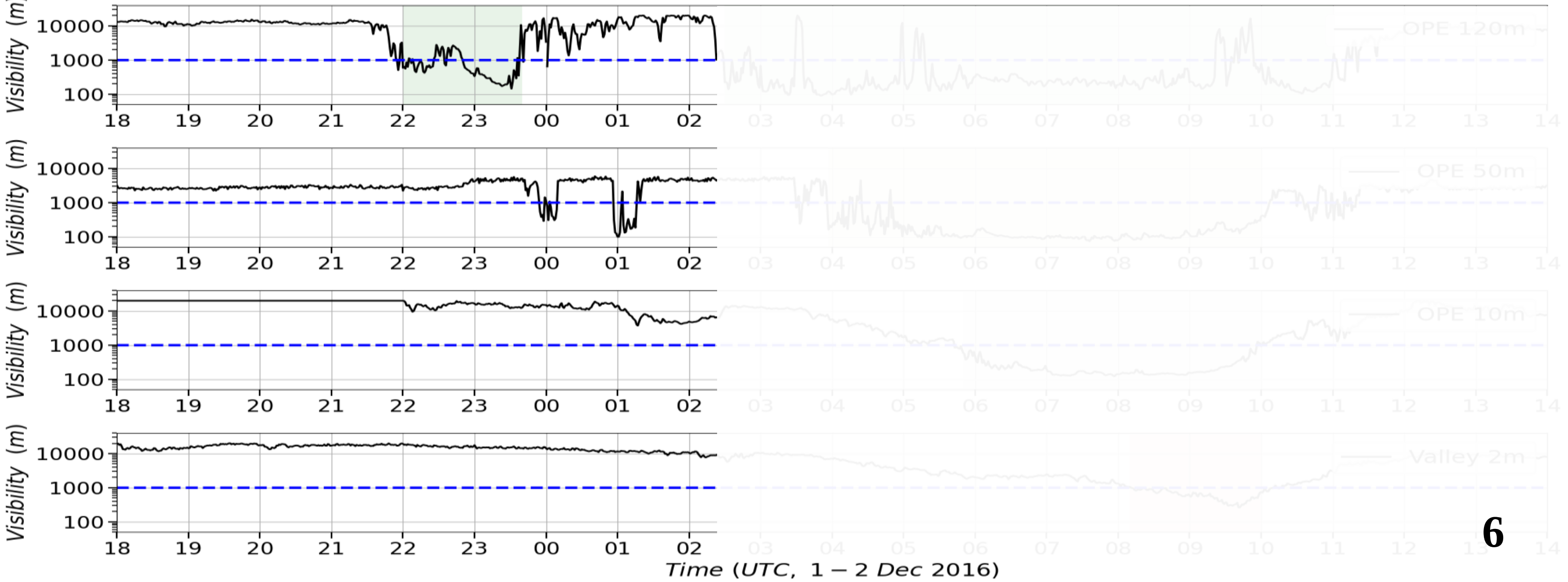

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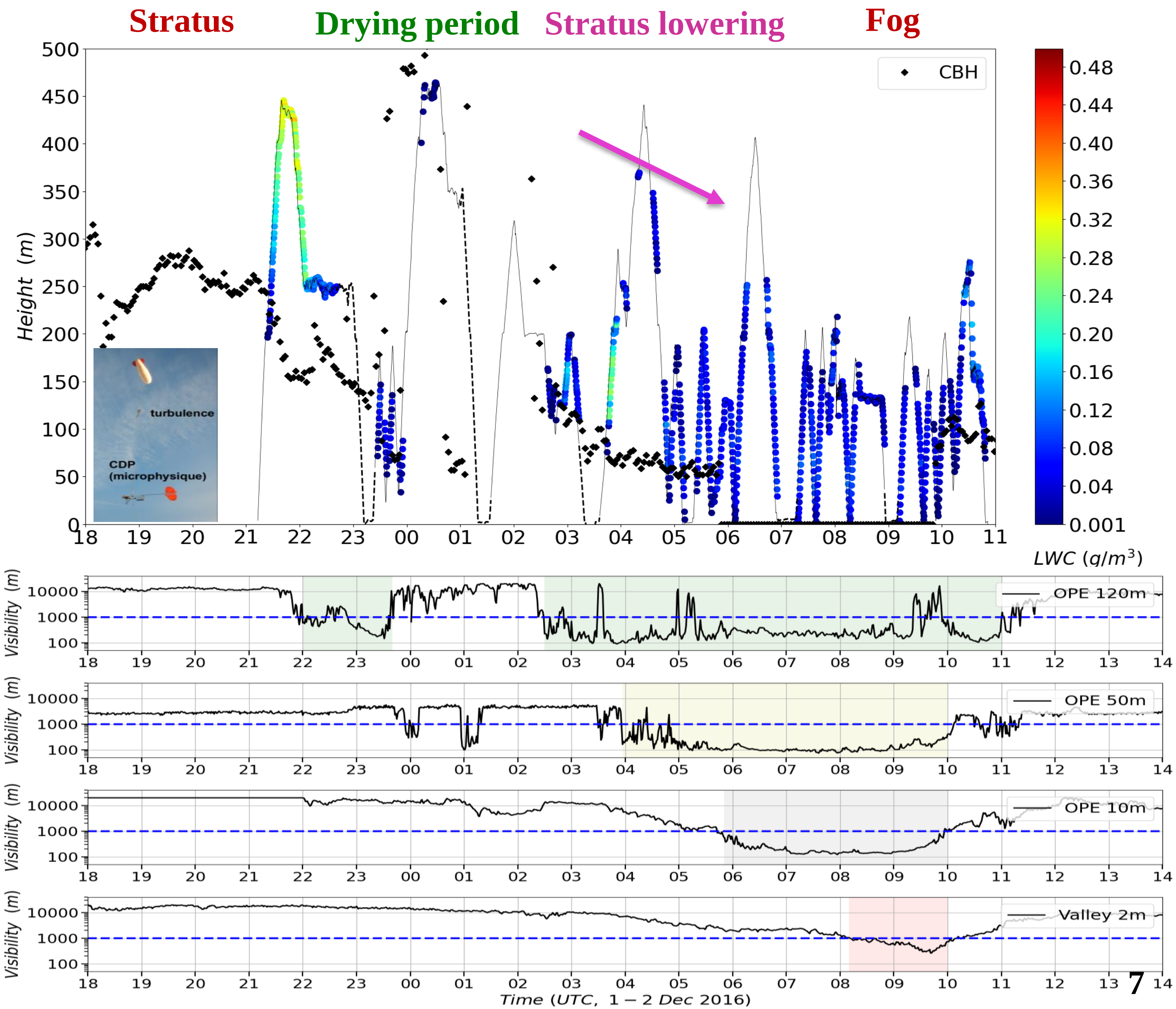
- Stratus base: From 160 m to 0 m
- Decrease in visibility at three level



Reference numerical simulation LIMA(two-moment)

Meso-NH
mesoscale non-hydrostatic model
Lac et al. (2018)

- Horizontal grid resolution: 500 m et 100 m with two-way nested grids.
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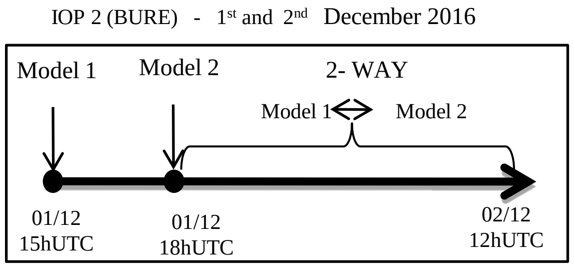

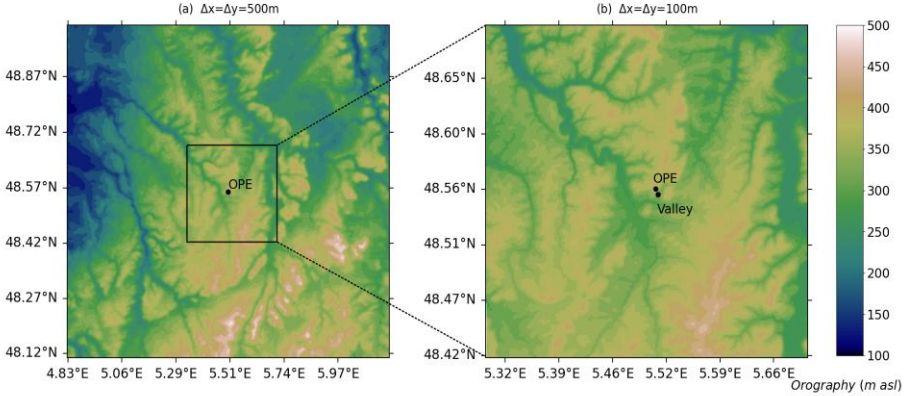

The stratus-fog evolution

Stratus formation at 23 UTC with a delay of 5h partially due to large scale conditions.

Drying period in obs and simul

Stratus lowering slowly

Fog formation with a **delay of 4hour**

Fog dissipation too early

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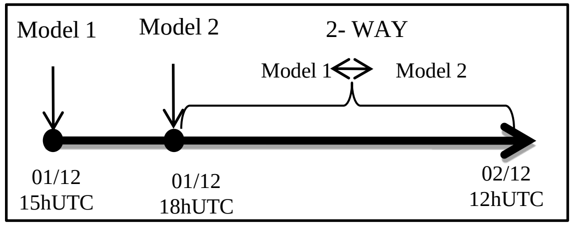

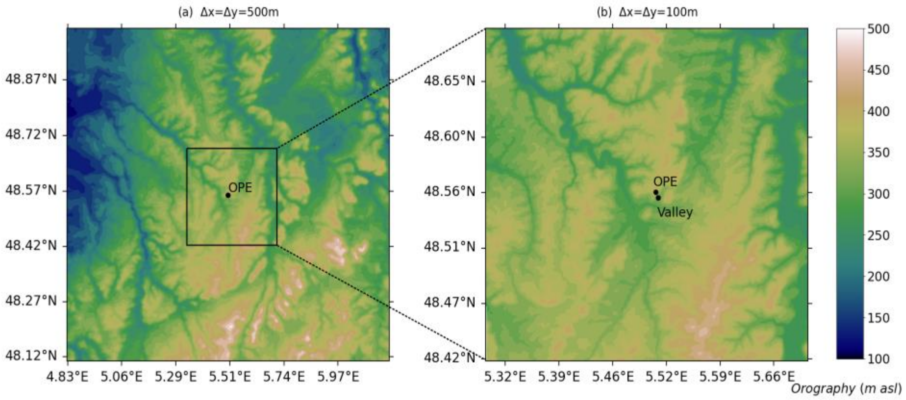

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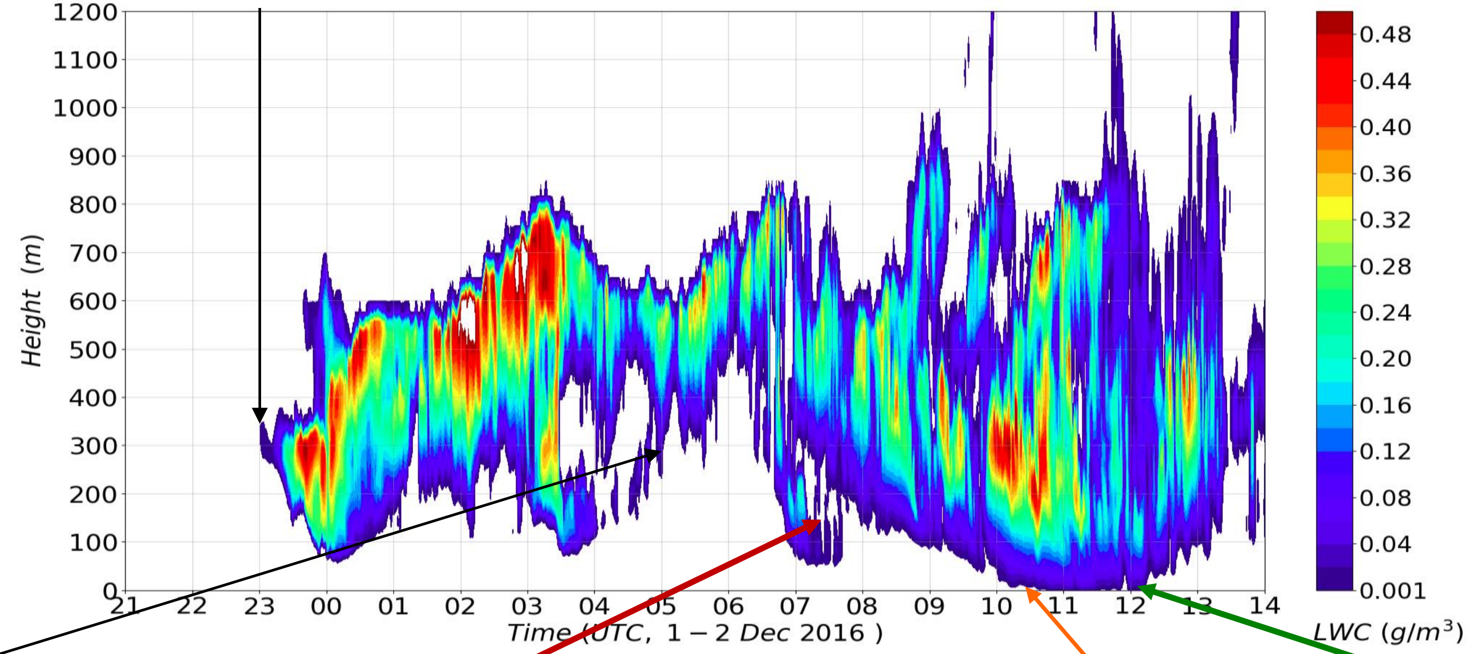

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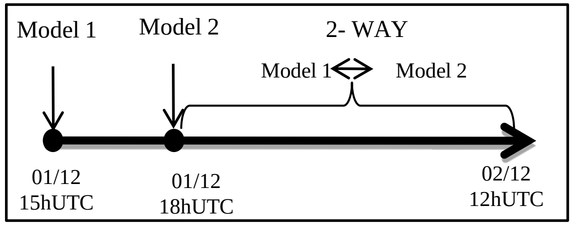

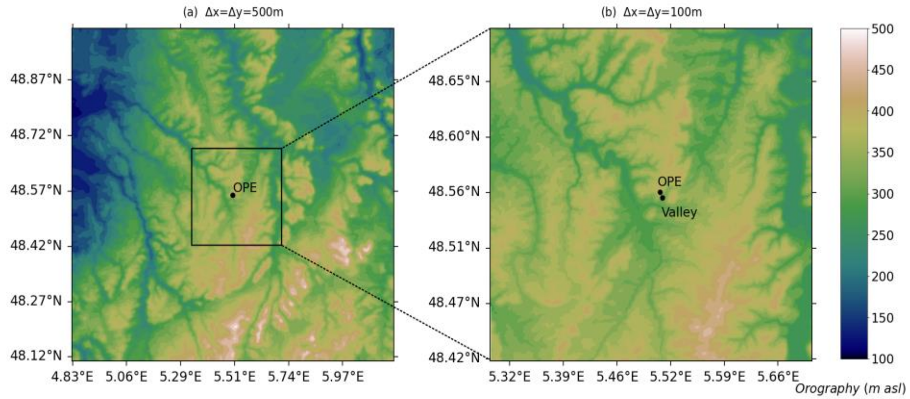

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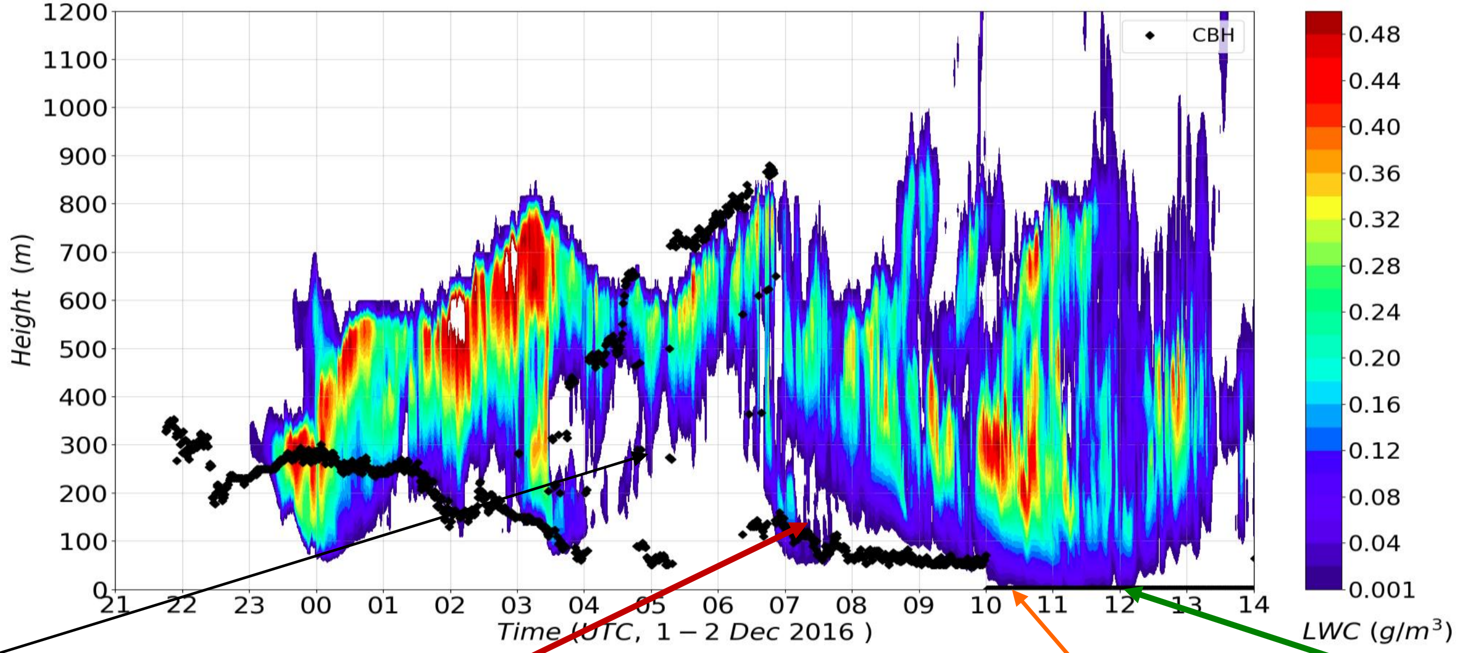
We delay the observations by **4 hours** to fit the simulation.



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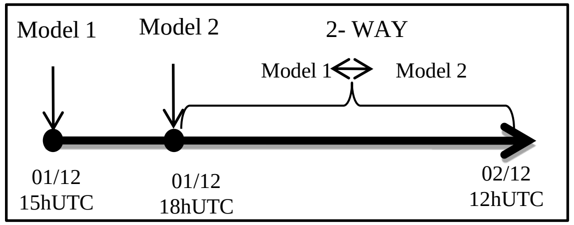

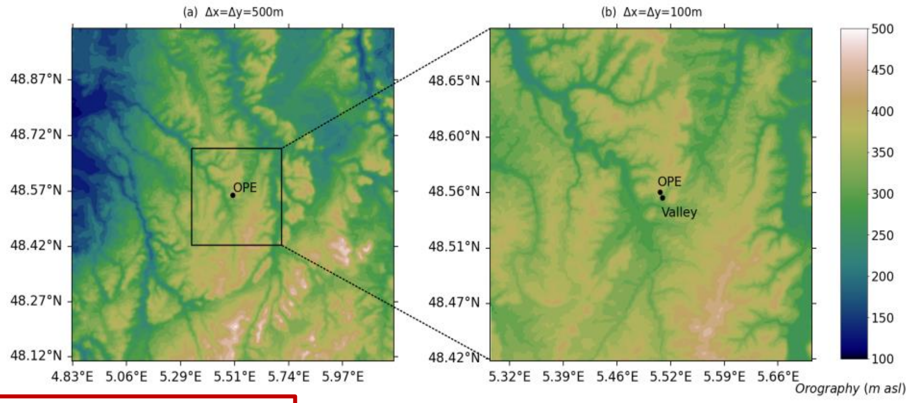

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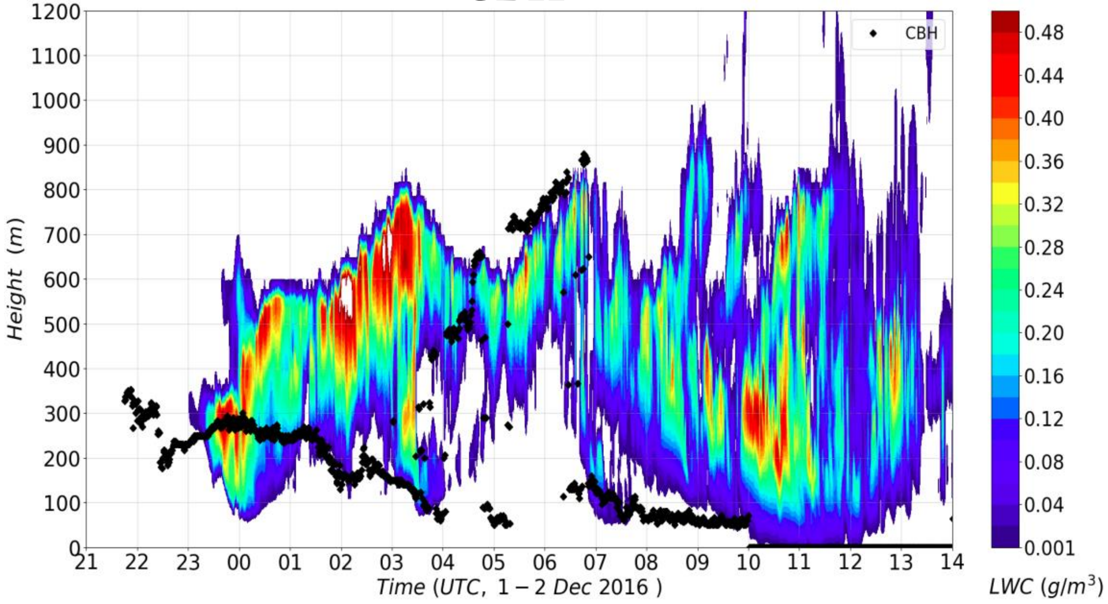
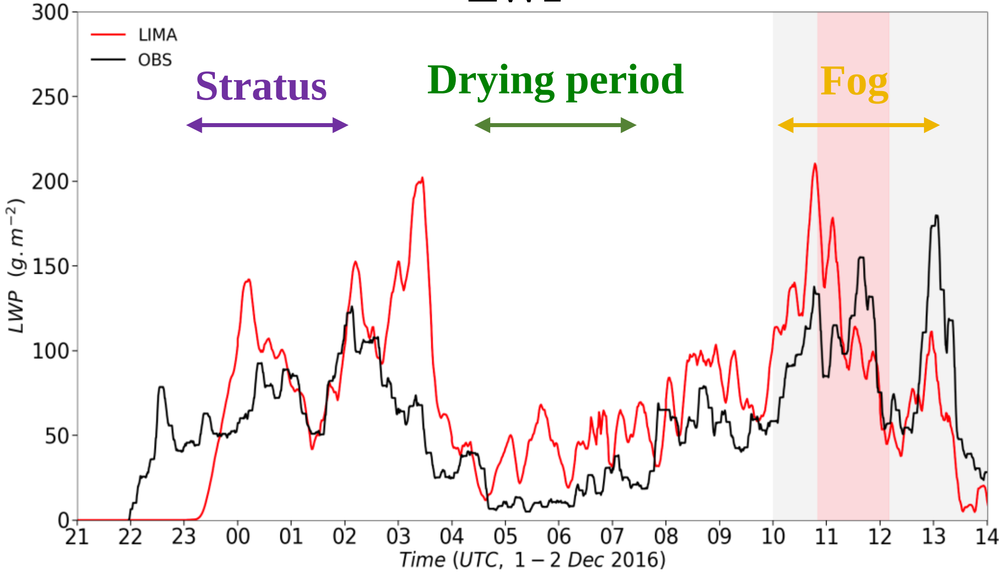
CBH



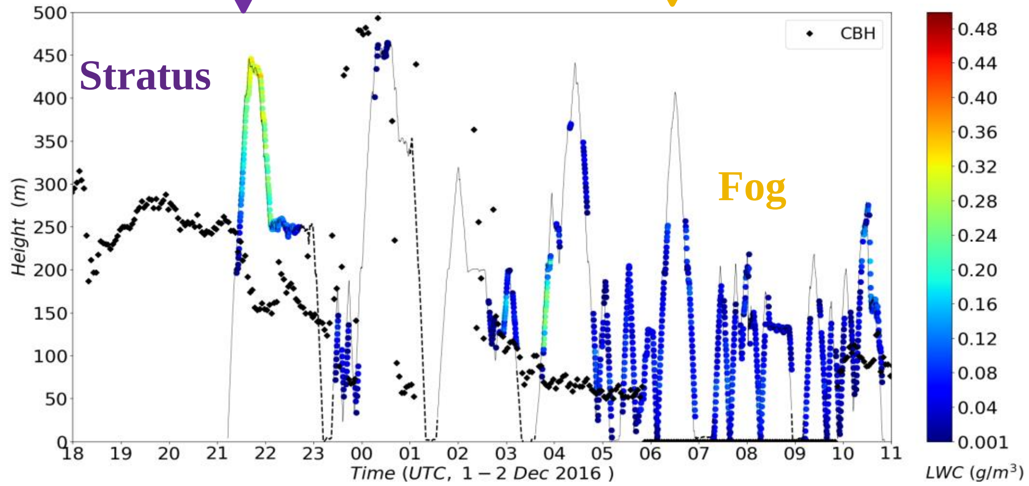
LWP



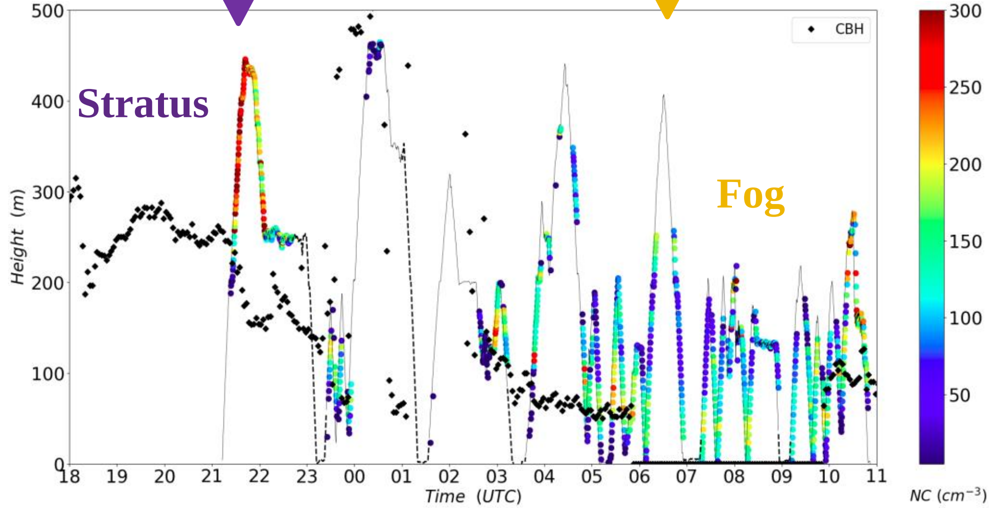
➢ Simulation well reproduce the LWP cycle .

Comparison to measurements

LWC ($g.m^{-3}$)

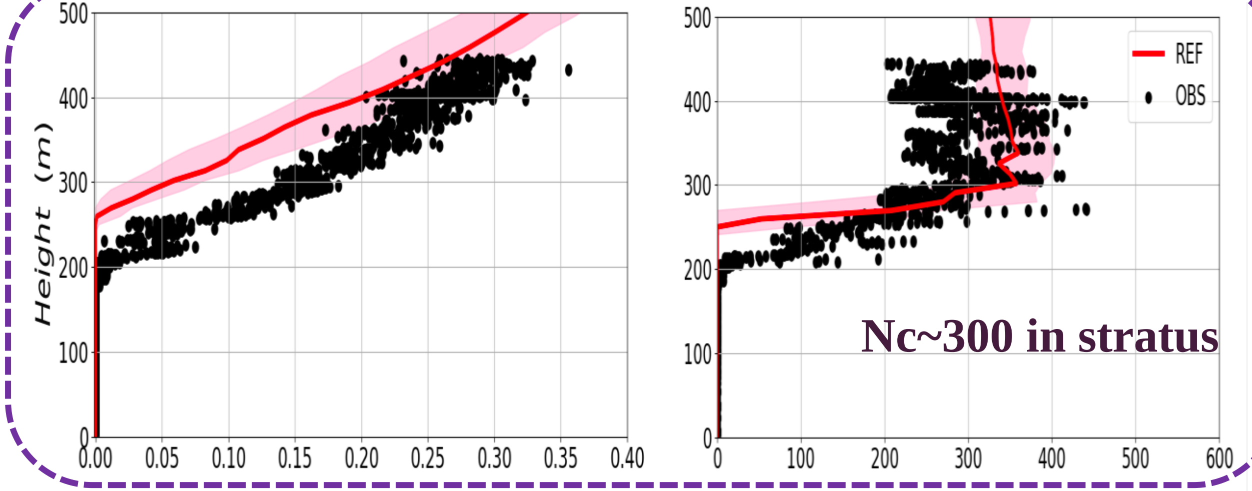


NC (cm^{-3})

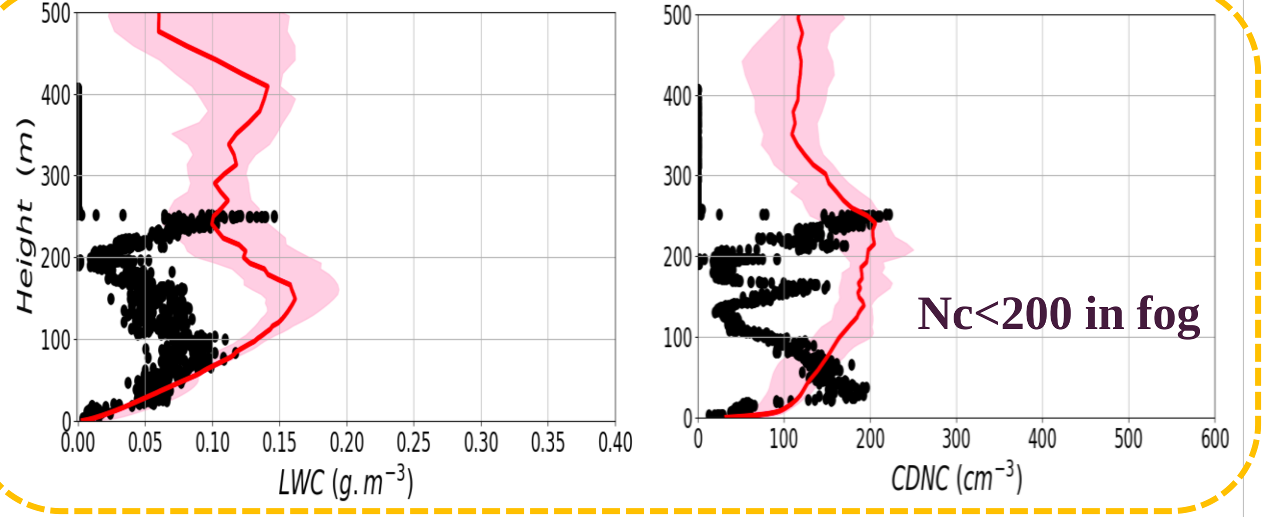


CDP measurements with tethered balloon and **LIMA**

Stratus

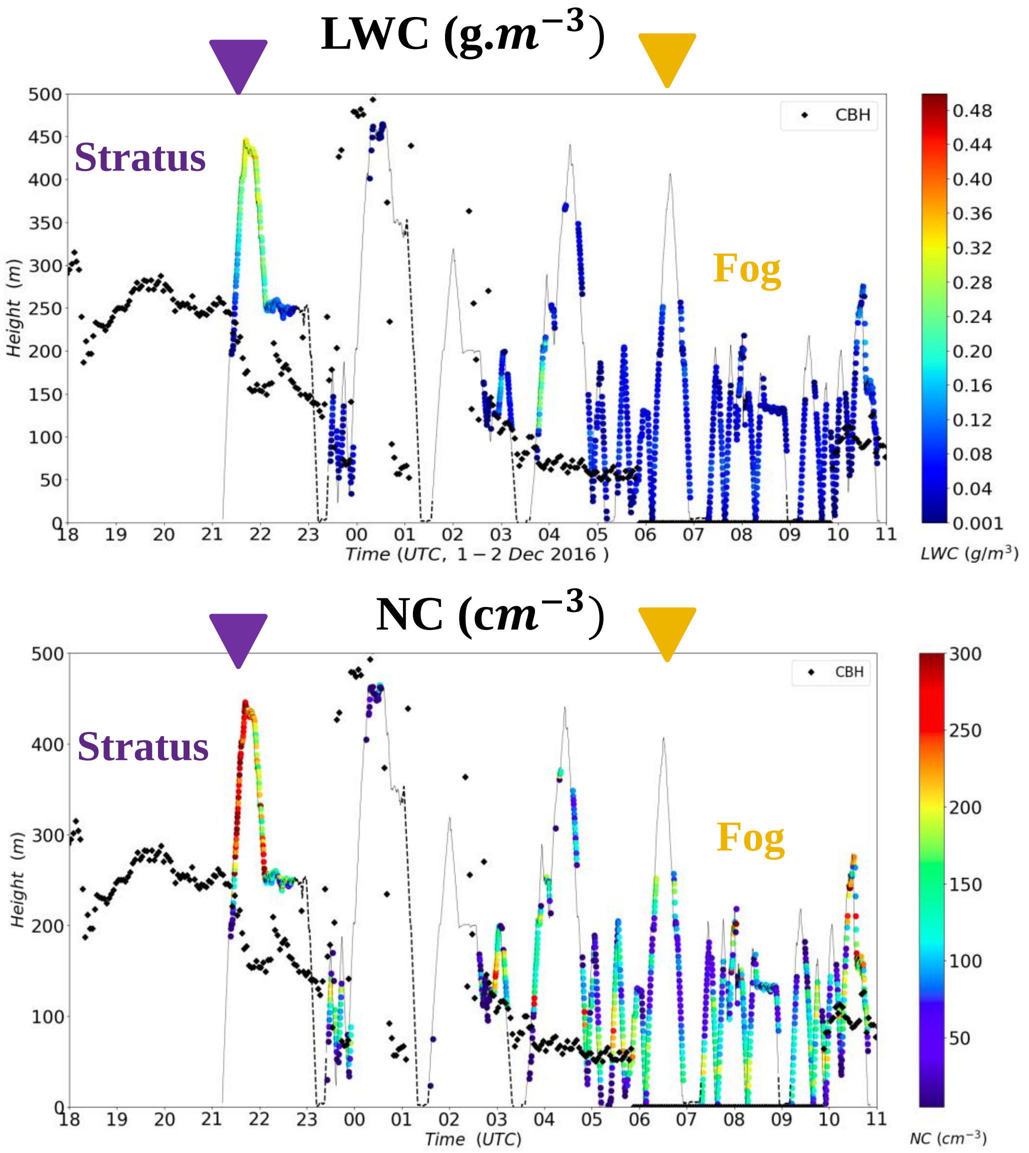


Fog



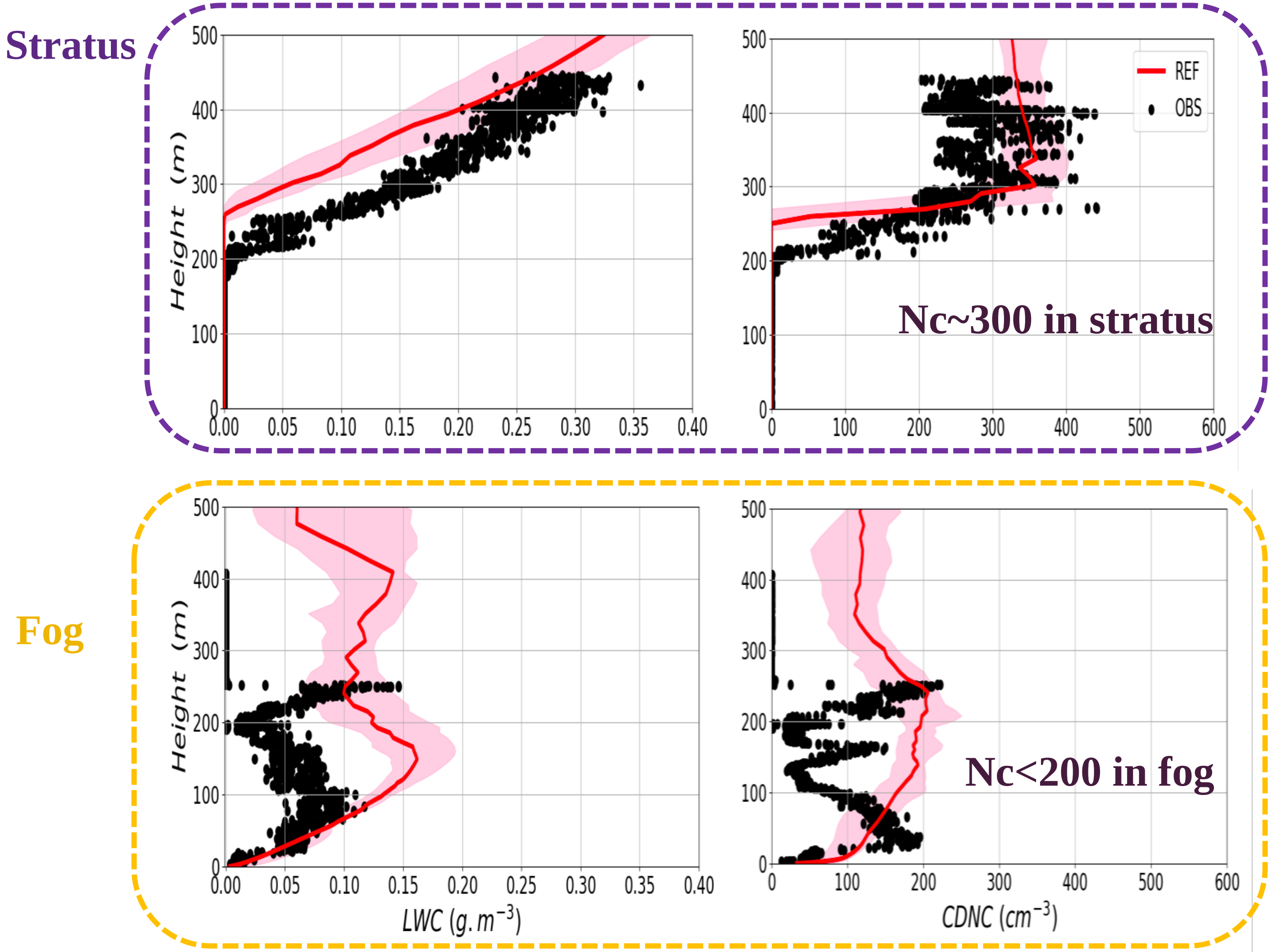
- Microphysical differences between stratus and fog.
- NC and LWC in good agreement with the observations.

Comparison to measurements



> An assumption of constant Nc **will not** be realistic

CDP measurements with tethered balloon and **LIMA**



> Microphysical differences between stratus and fog.

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- Analysis of the observations and realism of the simulation with the Meso-NH model.

✓ Despite the 4-hours delay due to the large-scale conditions, the **LIMA** simulation is in good agreement with the observations.

- Process study of STL.

- Analysis of the observations and realism of the simulation with the Meso-NH model.

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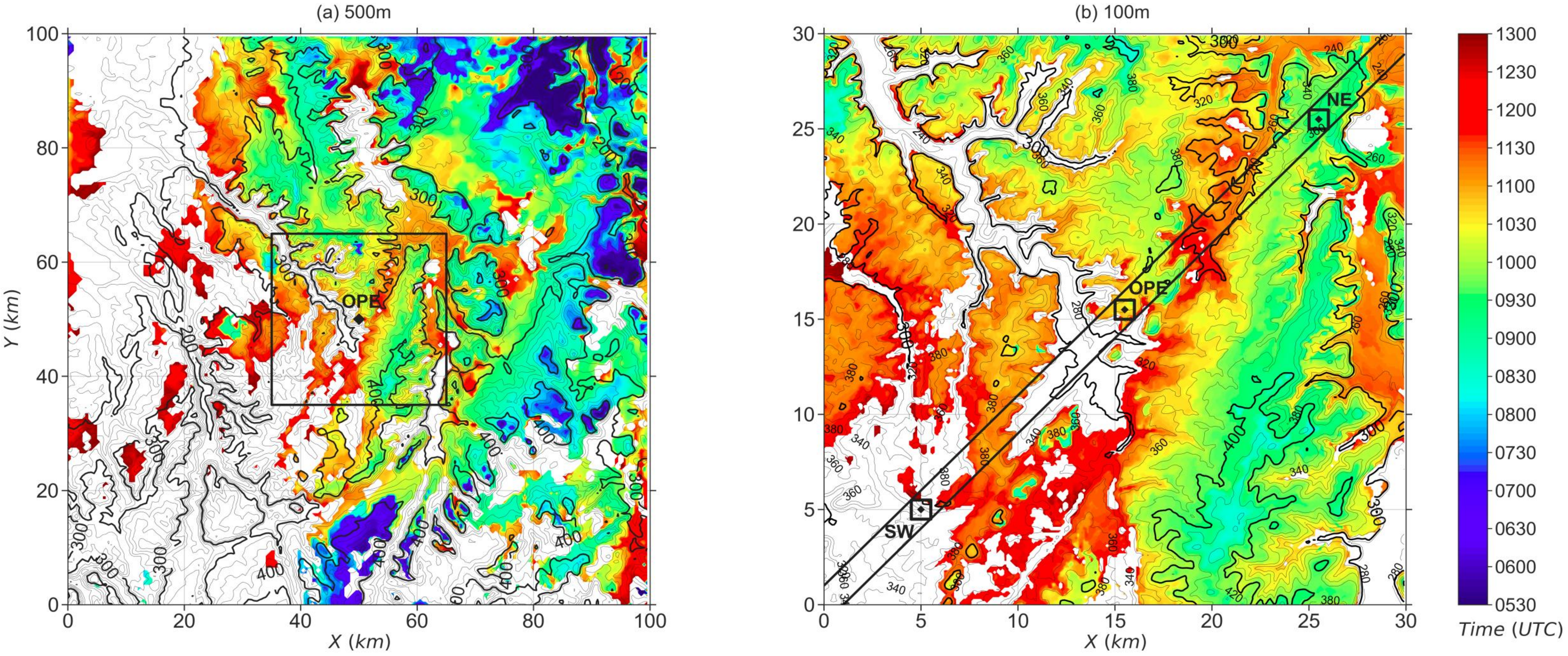
- **Process study of STL**

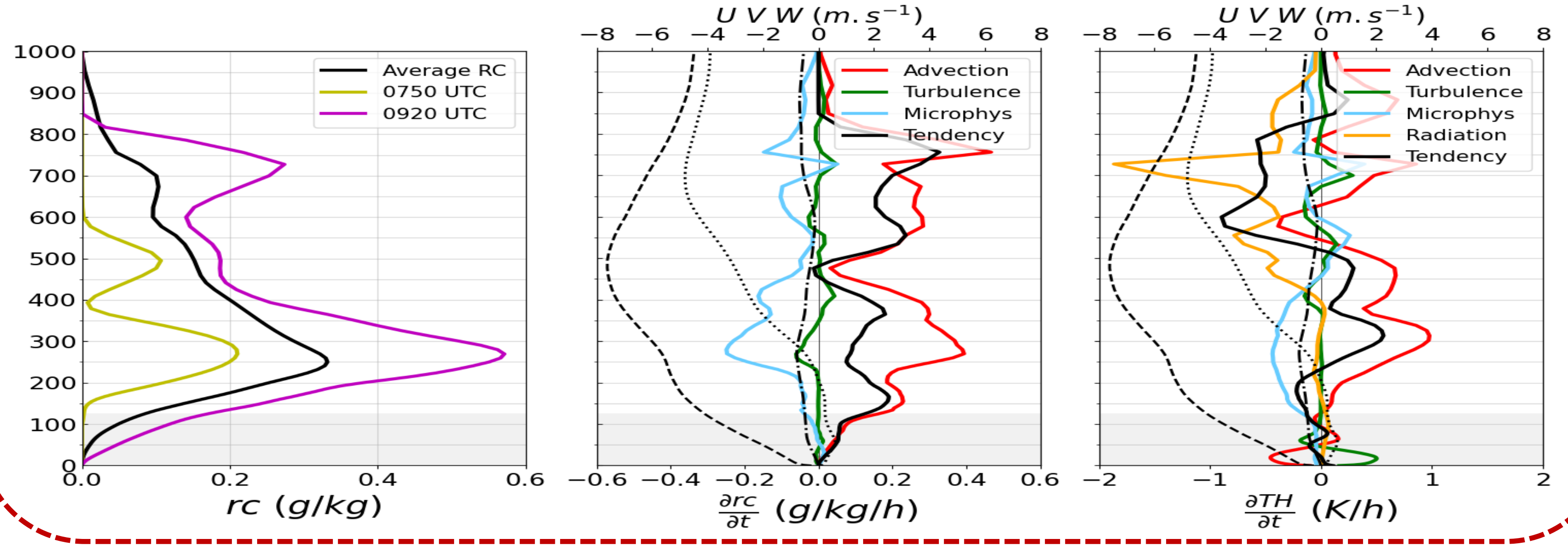
Fog onset time

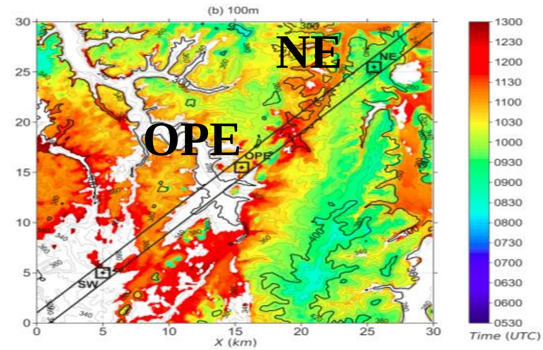


➢ The fog is formed in the north-east at 0530 UTC at the top of hills, and the formation propagates towards the south-west.

Budgets to better characterize the processes leading to stratus lowering

NE 0750 UTC - 0920 UTC





- Advection of rc

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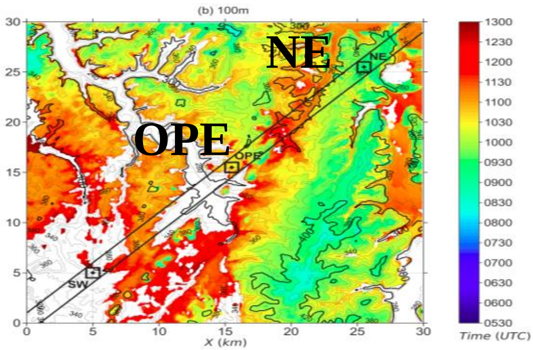

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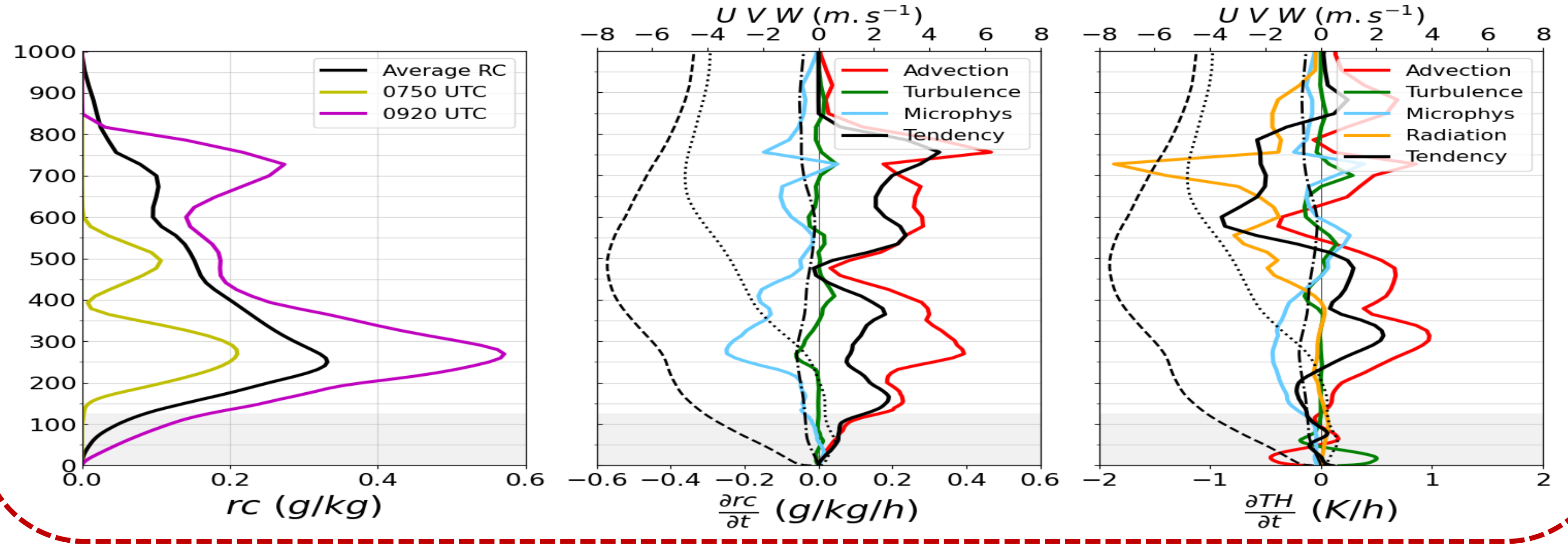

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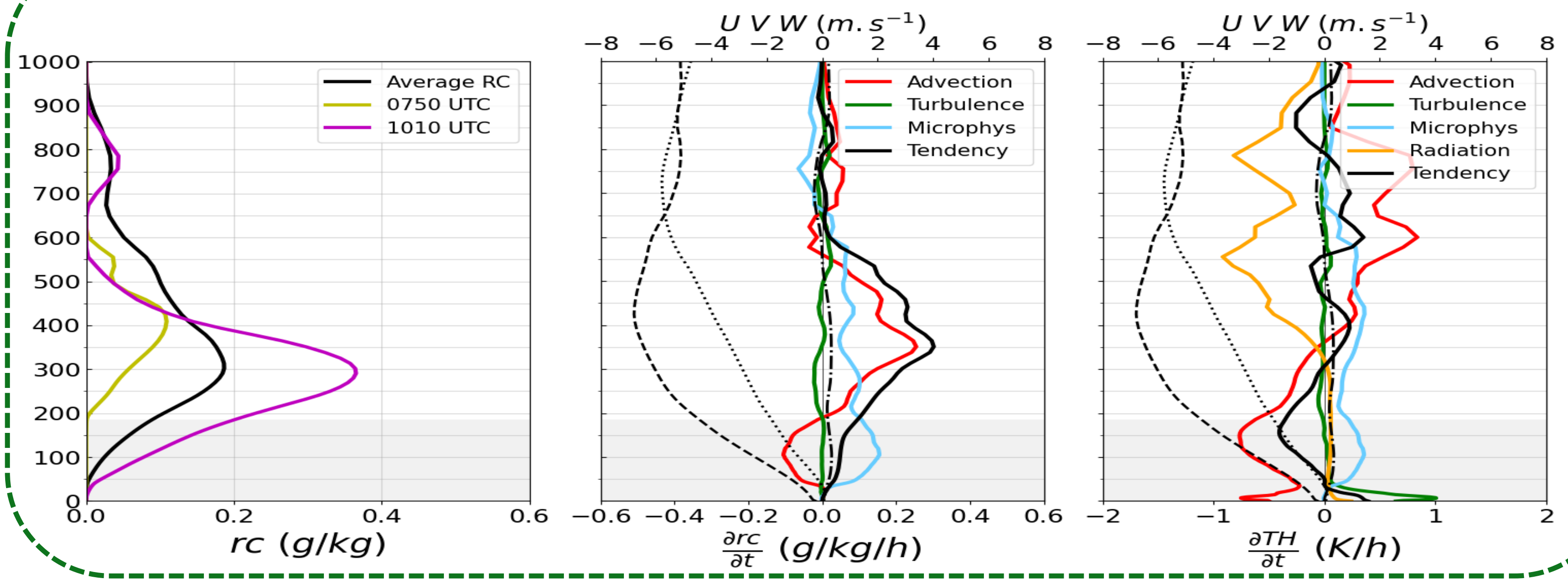
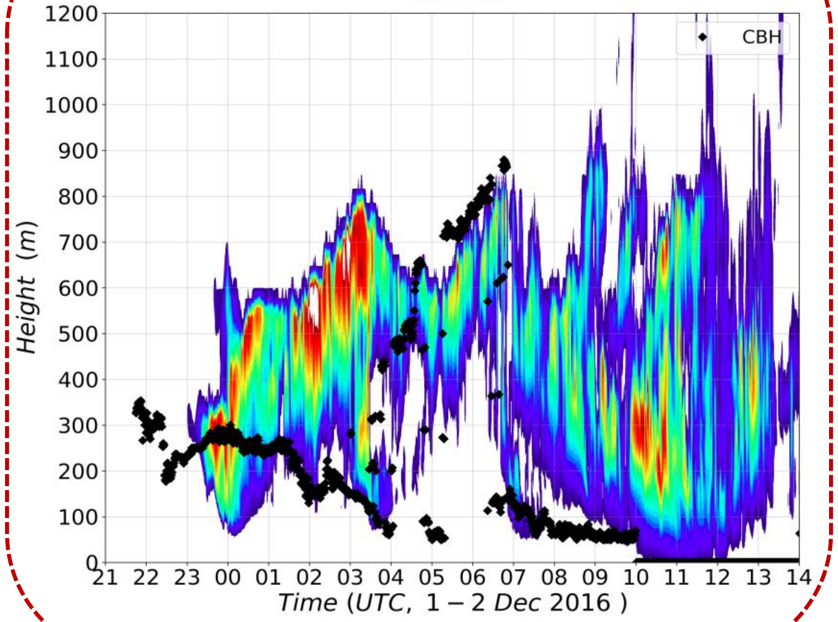


➢ Advection of cold air

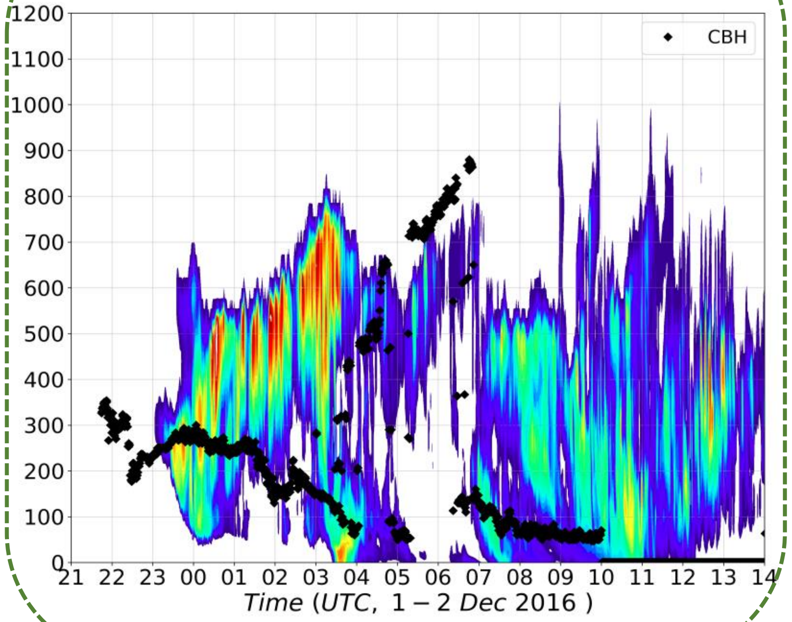
➢ The advection is the first process explaining the STL.

Impact of the microphysics: sensitivity test with one-moment ICE3

LIMA

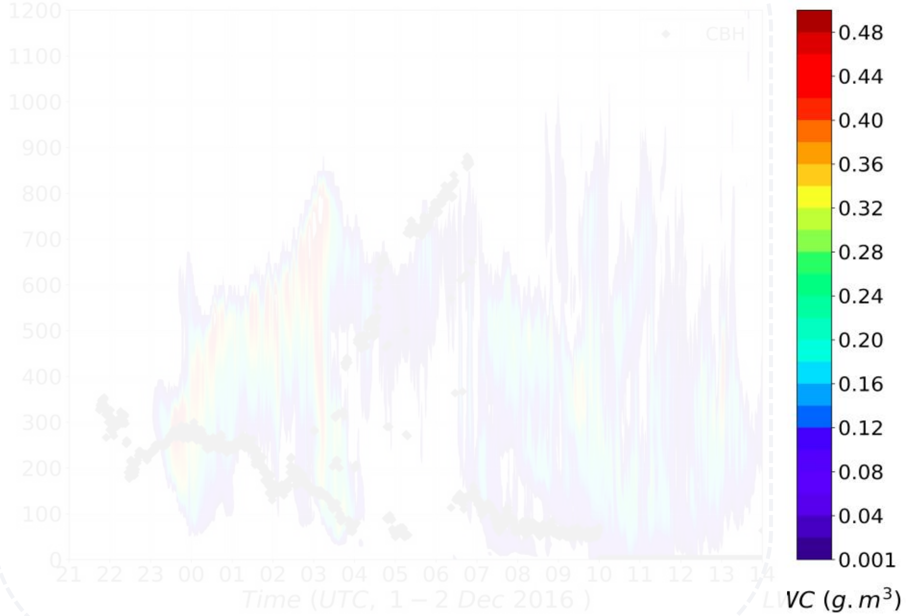


ICE3 N_c=100 cm^{-3}



N_c=100: Fog forms earlier

ICE3 N_c =300 cm^{-3}



N_c=300: Almost identical to LIMA

Impact of the microphysics: sensitivity test with one-moment ICE3

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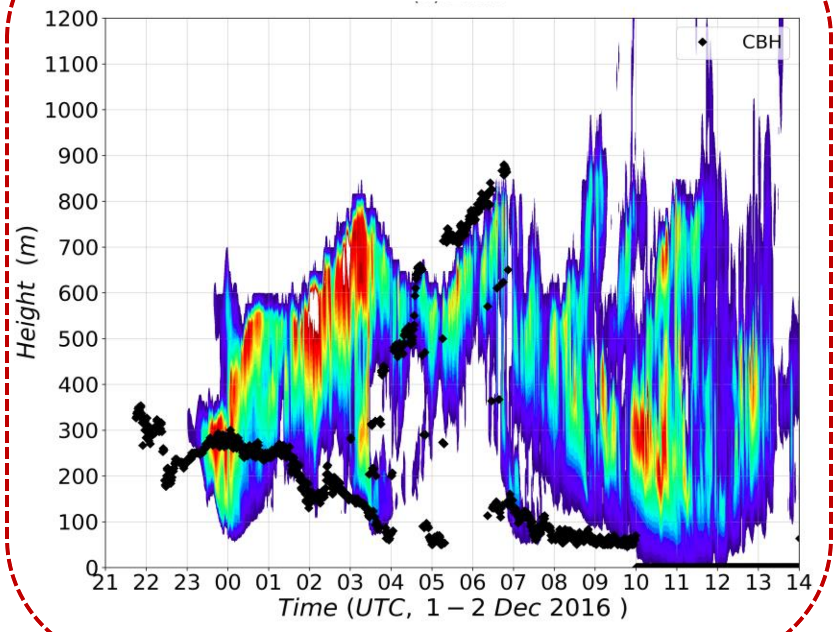

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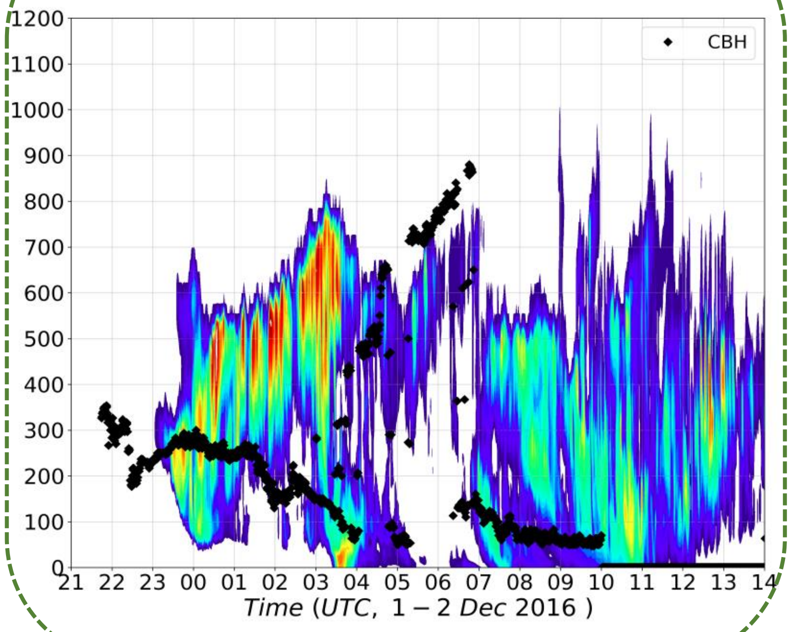

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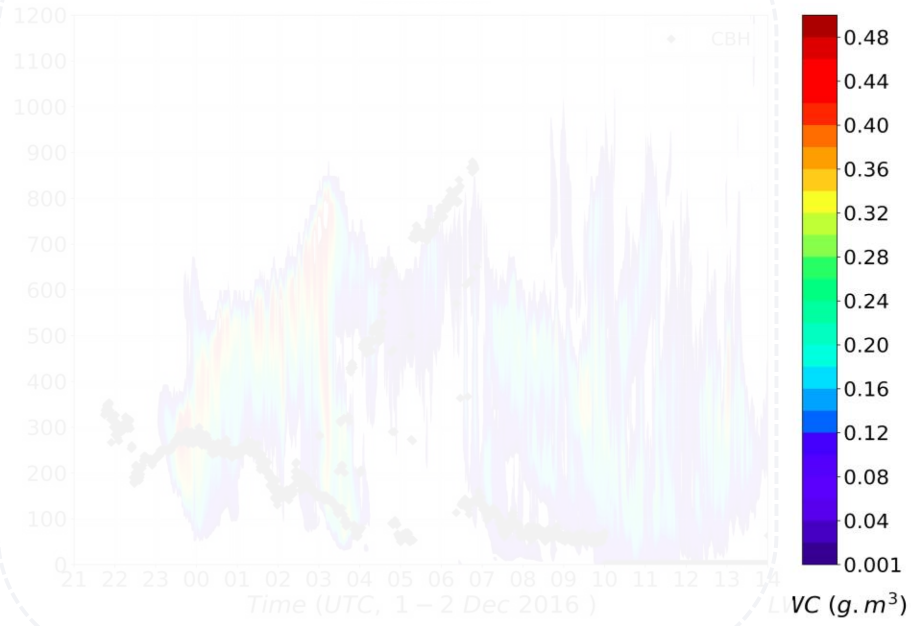

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N_c=300: Almost identical to LIMA

bigger droplets sediment and evaporates
below the stratus, favoring condensation

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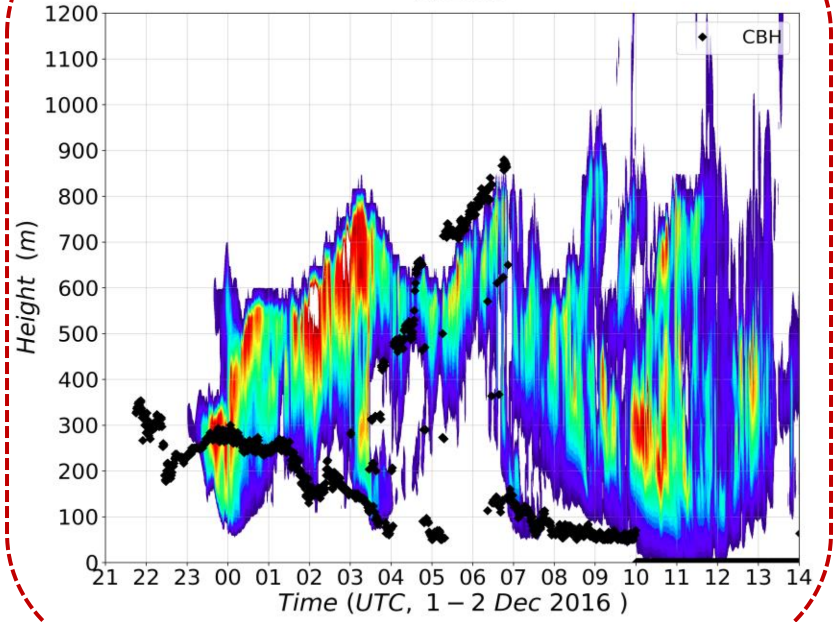

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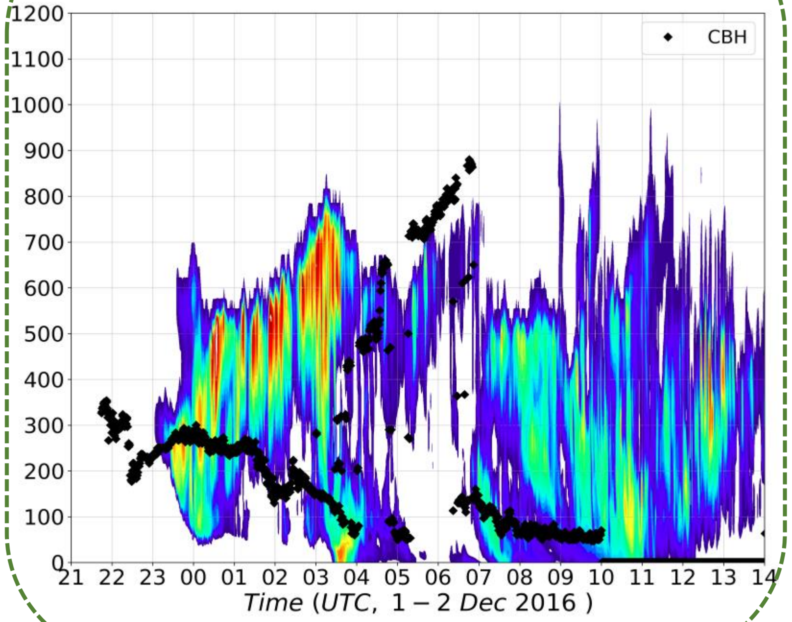

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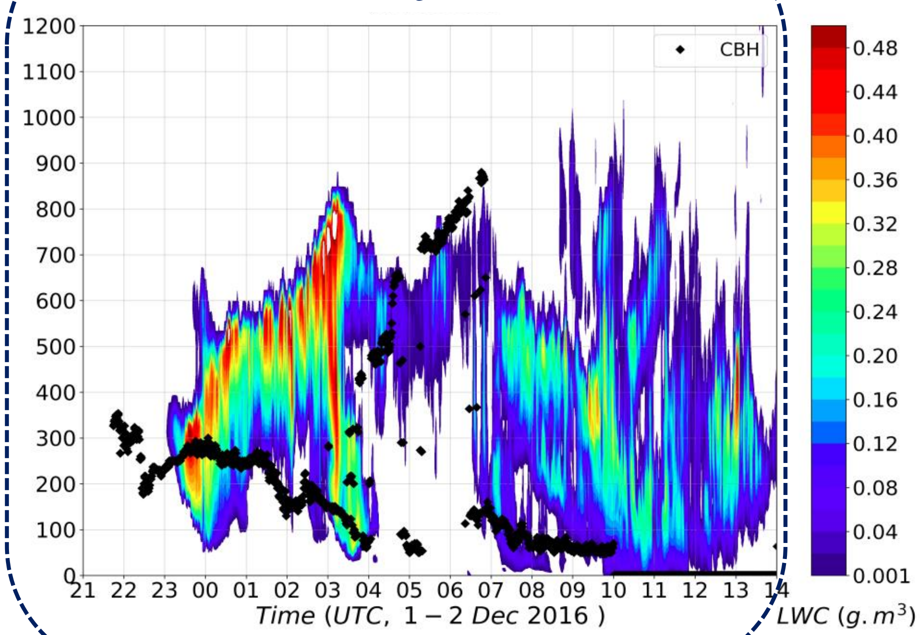

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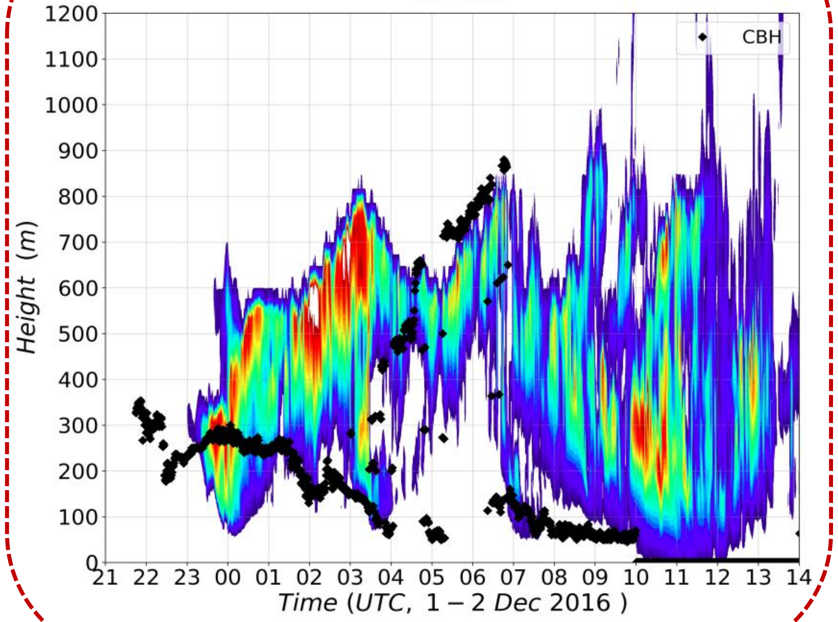

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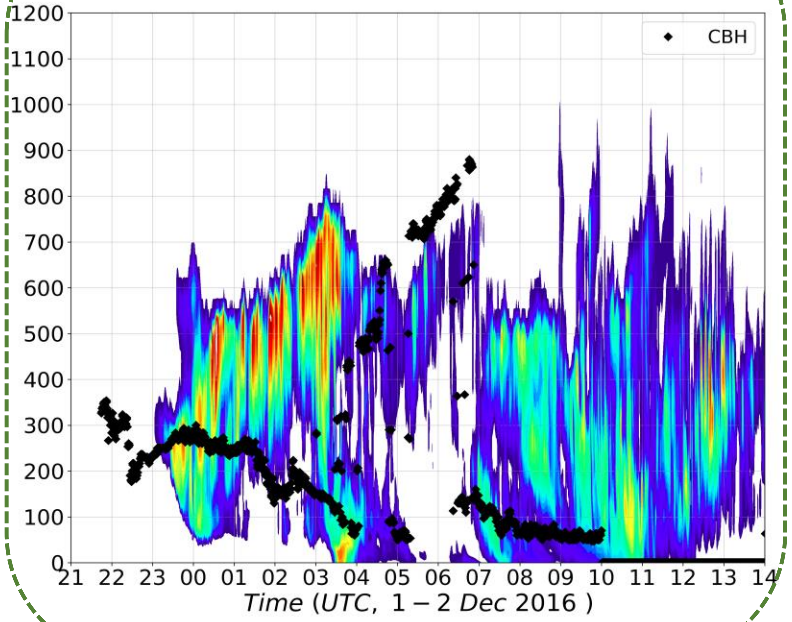

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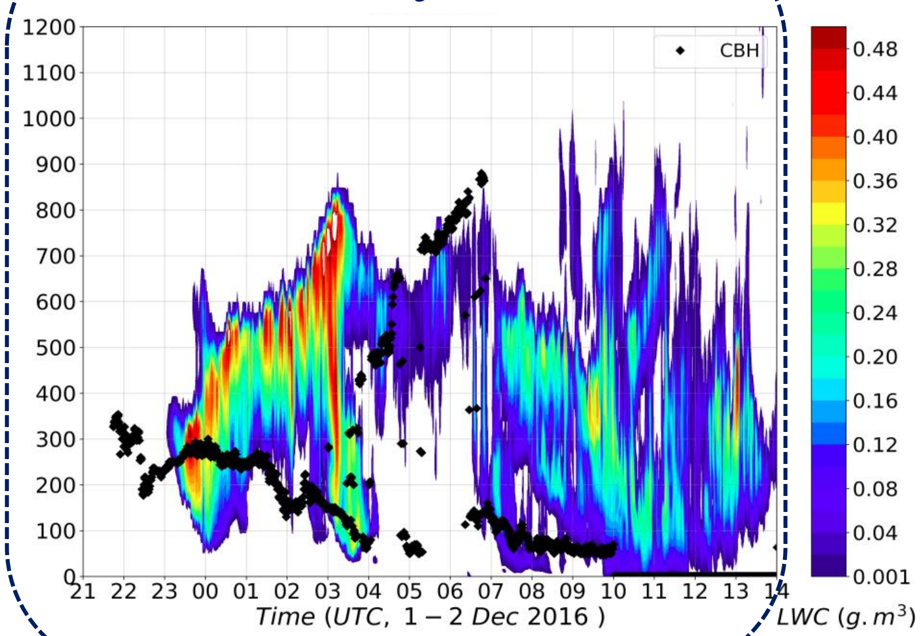

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➢ **Microphysics can accelerate the lowering (evaporation of droplets below stratus)**

Conclusion

What are the main processes leading to fog by STL?

1. Large-scale conditions: advection of clouds and cold air in the low levels
2. Evaporation of the droplets below stratus: can accelerate the lowering.

- Fathalli et al., in preparation

Perspective

How to improve fog by STL forecasts in NWP?

- Simulations of 40 cases of lowering and non-lowering stratus during Bure experiment with Meso-NH model: sensitivity tests on the vertical and horizontal grid, parameterizations (considering AROME configuration).

Thank you for your attention

maroua.fathalli@meteo.fr