LANFEX : Understand fog behaviour in a region of small hills

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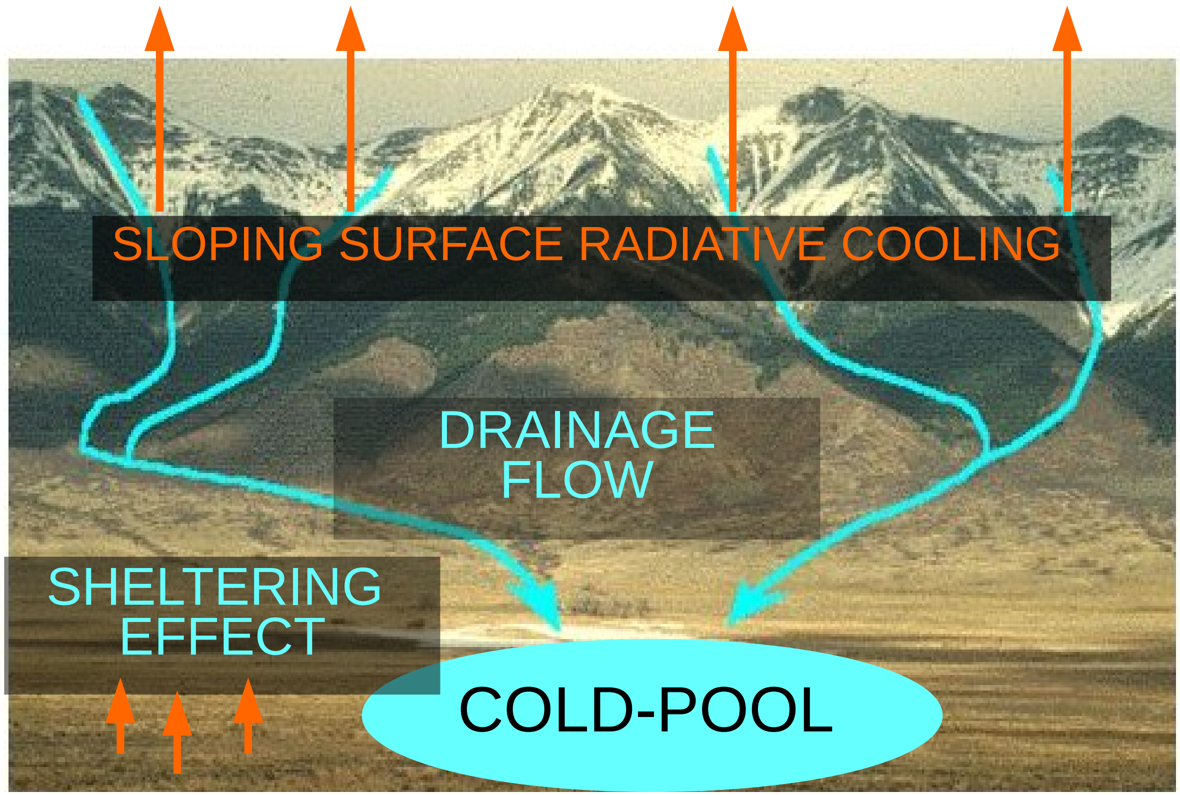
Introduction

Surface heterogeneities : topography
→ Local dynamic effects *(Catabatic winds, cold-pools, gravity waves, turbulence…)*
→ COULD TRIGGER THE LOCAL FOG OCCURRENCE

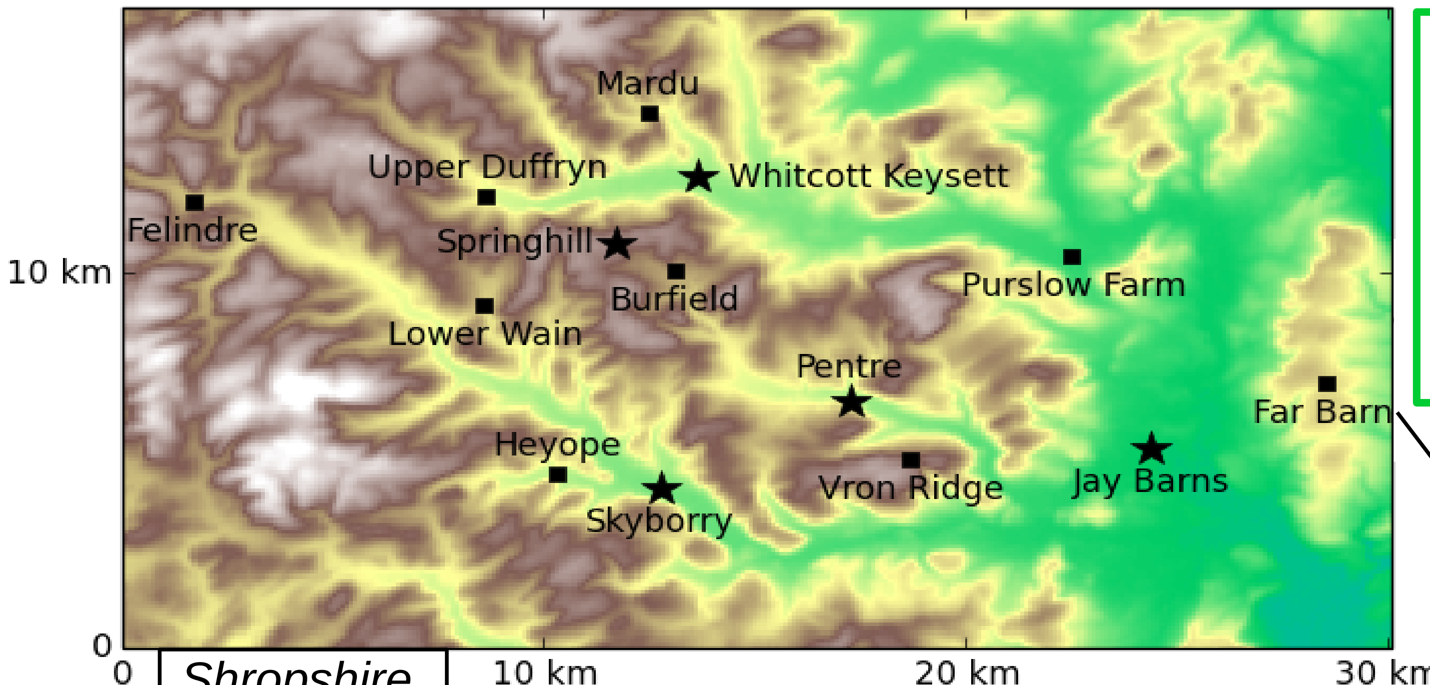


Impact of orography on fog with Large-Eddy Simulations and 2-moment microphysics

LANFEX

Local **A**nd **N**on-local **F**og **EX**periment

« Why a same air mass could lead to different fog conditions at different places ? »

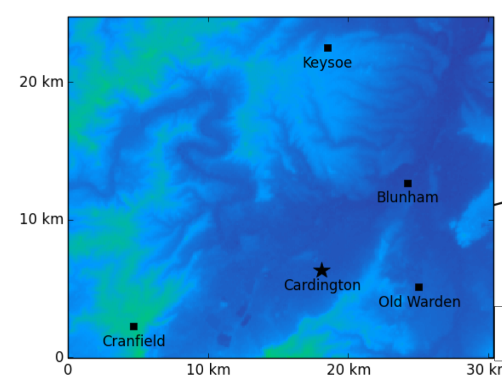


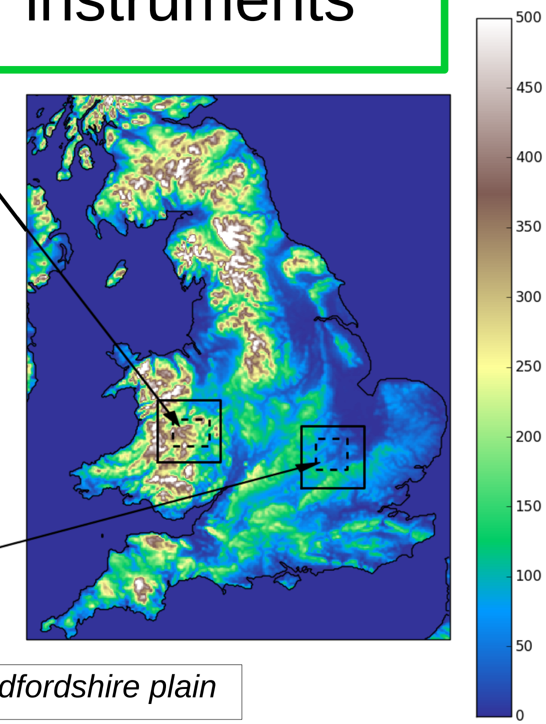
18 months
(2014 → 2016)

Large range of instruments

Shropshire hills

Complex valley network with differents meteorological conditions





Bedfordshire plain

LANFEX INSTRUMENTATION : SHROPSHIRE HILLS

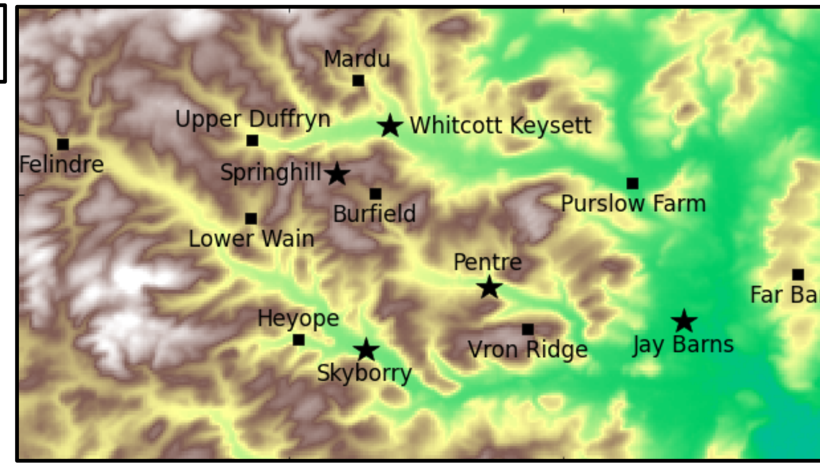
→ 3-D measurements of fog variability

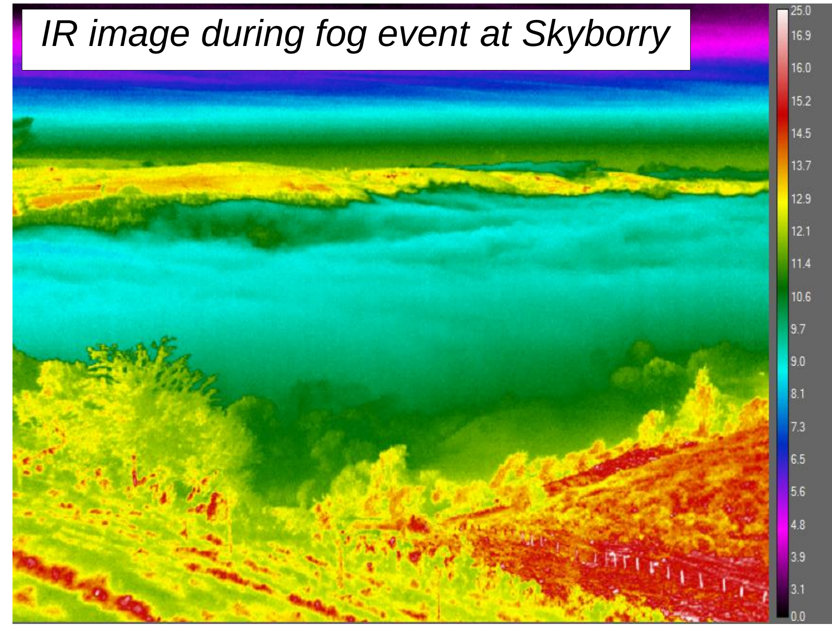
★ 5 MAIN SITES

- Flux towers (2→50m) / Surface energy balance
- Spectrometer / Radiometer / Ceilometer / LIDAR
- Radiosondes
- **Dewmeter** *(Price and Clark, 2012)*
- **IR camera (8-12 μm)**

■ 8 secondary sites

Fogmonitor : T, RH, wind at 1.2m





IR image during fog event at Skyborry

Fogmonitor station at Vron Ridge secondary site

Dewmeter
SETTLING + DEPOSITION+ DEW

50m mast at Skyborry main site

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I. Introduction

II. Comparison of Meso-NH simulation with Unified Model from Met Office

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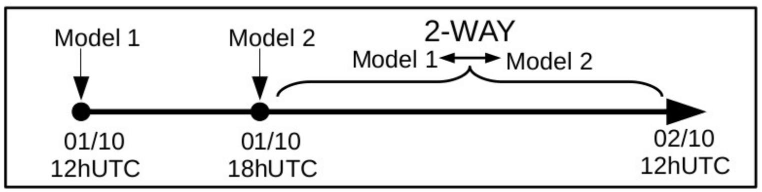
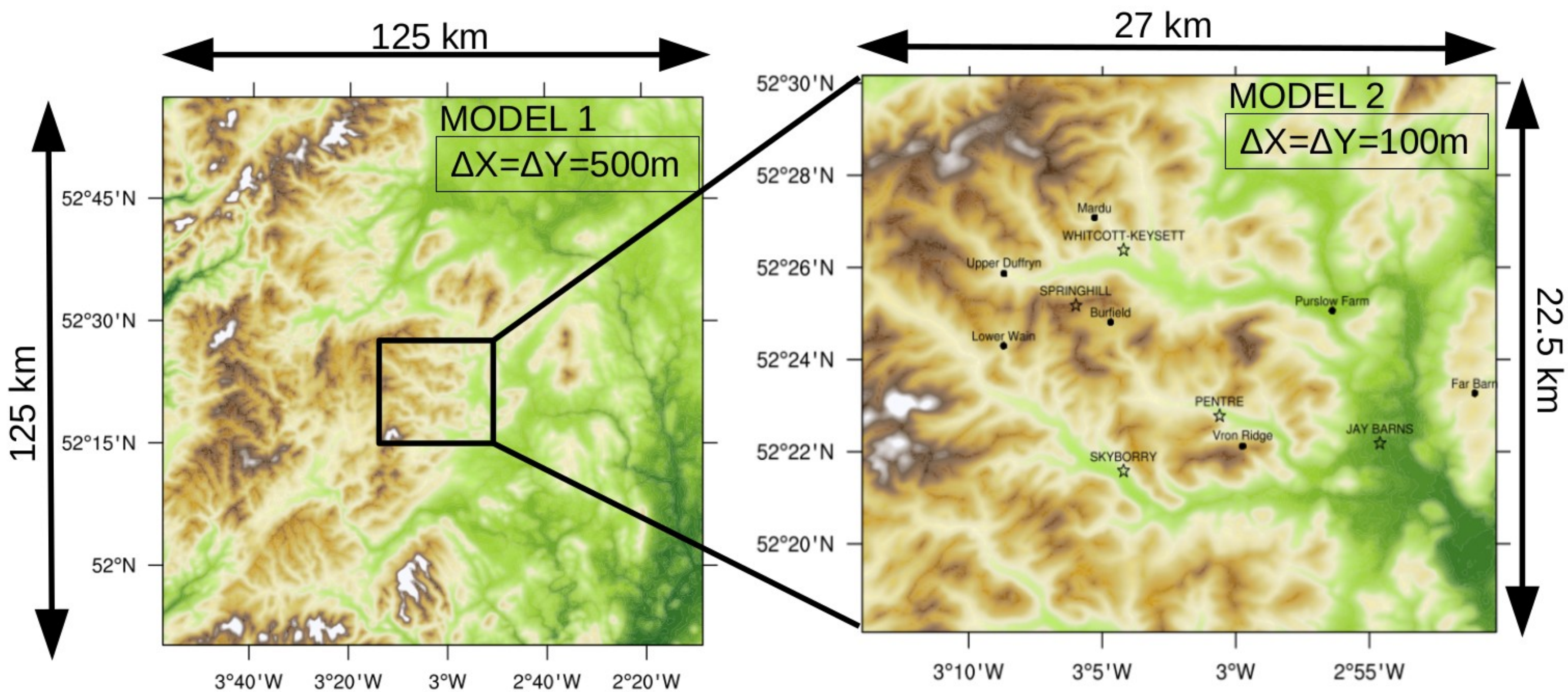
Meso-NH
mesoscale non-hydrostatic model

Downscaling method :
AROME 1.3km → LES resolution (~4m)

1st step : 1-moment microphysics + 100m resolution

IOP 12 → 1st-2nd October 2015

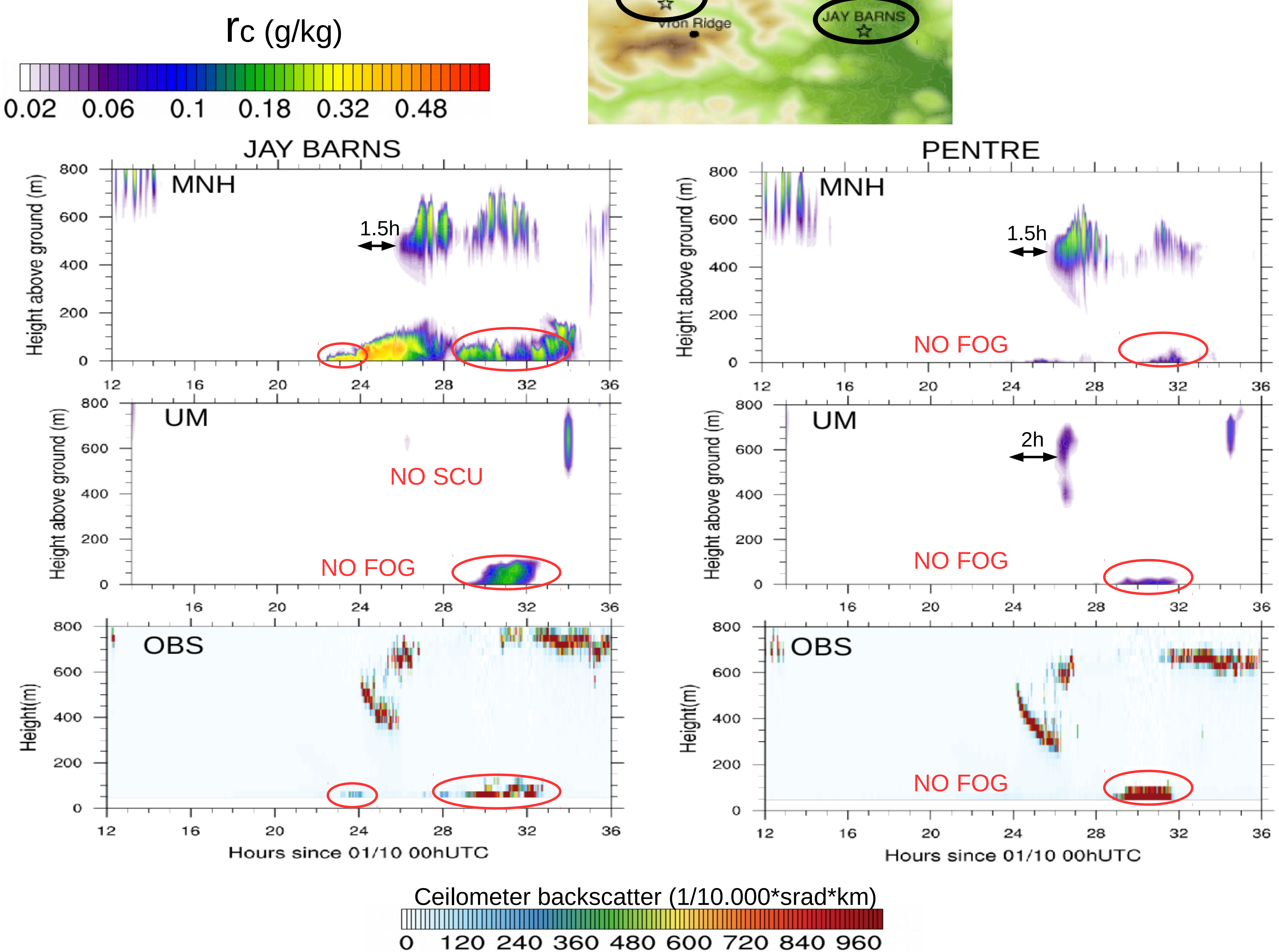




Intercomparison work between Meso-NH and Unified Model of Met Office on POI 12 of LANFEX

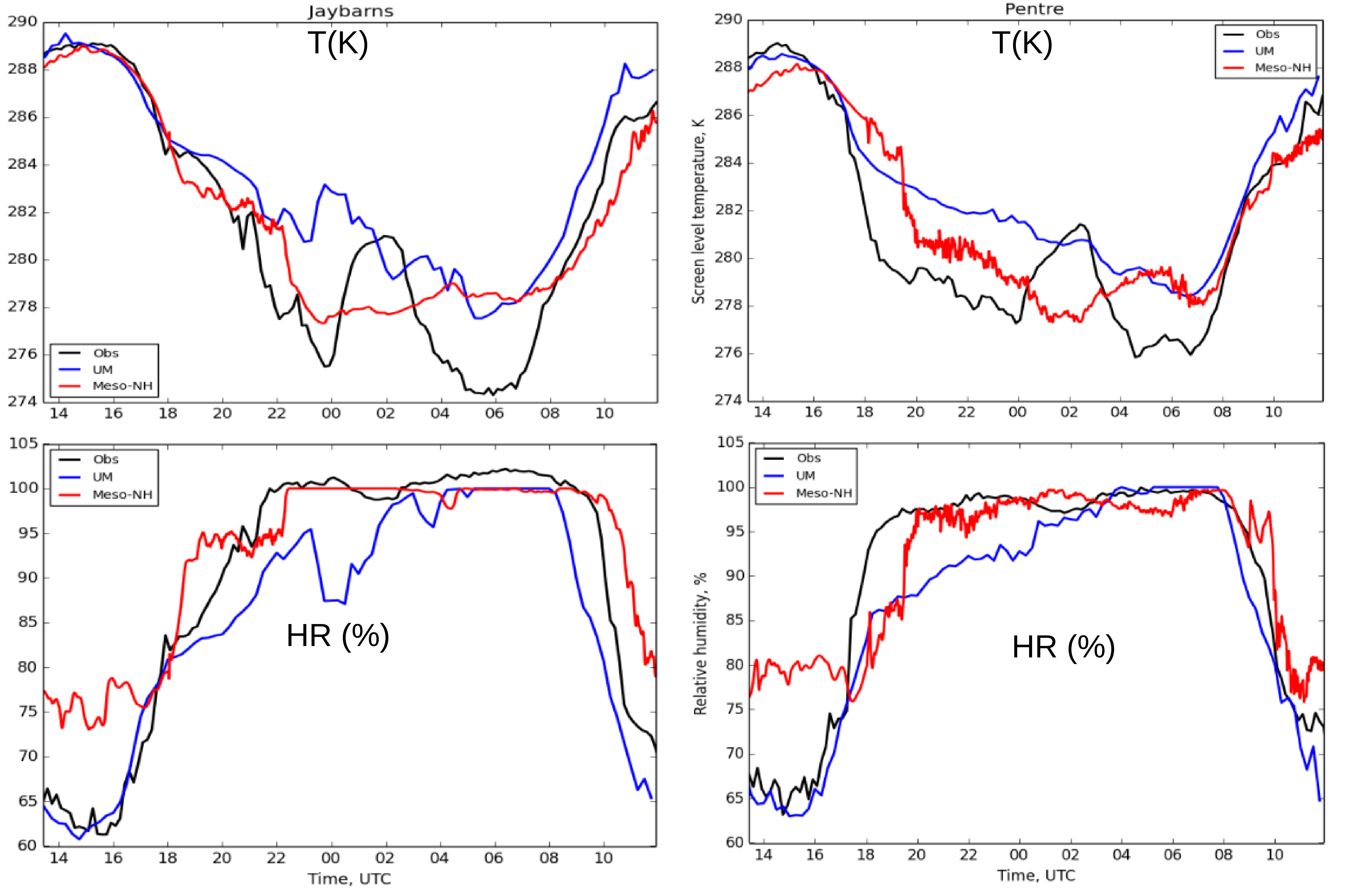
	Meso-NH 100m horizontal resolution 27*22.5 km	Unified Model 100m horizontal resolution 46*35 km
Initial/coupling conditions	01/10 12h : **AROME 1.3km + MNH 500m** **2-way after 18h** Coupling every hour	01/10 12h : **UK model 1.5km** **1-way after 13h** Coupling every 15mn
Vertical resolution	**1m [0,70m]** → stretch → 50m top (1400m) **148 levels**	**1m first level** → stretch → 50m at 950m **43 levels**
Turbulence scheme	3D turbulence (*Cuxart et al. 2001)* Deardorff (1980) mixing length	Blend : 1D (*Lock, 2000*) + 3D Smag. In SBL → more 3D Smag (more local terms)
Subgrid condensation scheme	**Constant RH_{crit} = 96 %** *De Rooy et al. 2010, HIRLAM newletter*	**RH_{crit} = 0.99 surf → 0.9 at 3.5km** **Constant above**
Surface	CORINE LAND COVER 100m + SURFEX **+ Drag effect of canopy** (*Aumond et al. 2008 ; Mazoyer et al. 2017)*	JULES scheme + Roughness length as a fraction of canopy height
Microphysical scheme	1-moment ICE3 **+ deposition** **Constant Nc = 300 #.cm^{-3}**	1-moment **Nc = 50 #.cm^{-3} below 50m** **+ 1 prognostic aerosol specie used to calculate Nc above 50m and diagnostic horizontal visibility** (*Clark et al. 2008)*

Time-evolution of vertical profiles



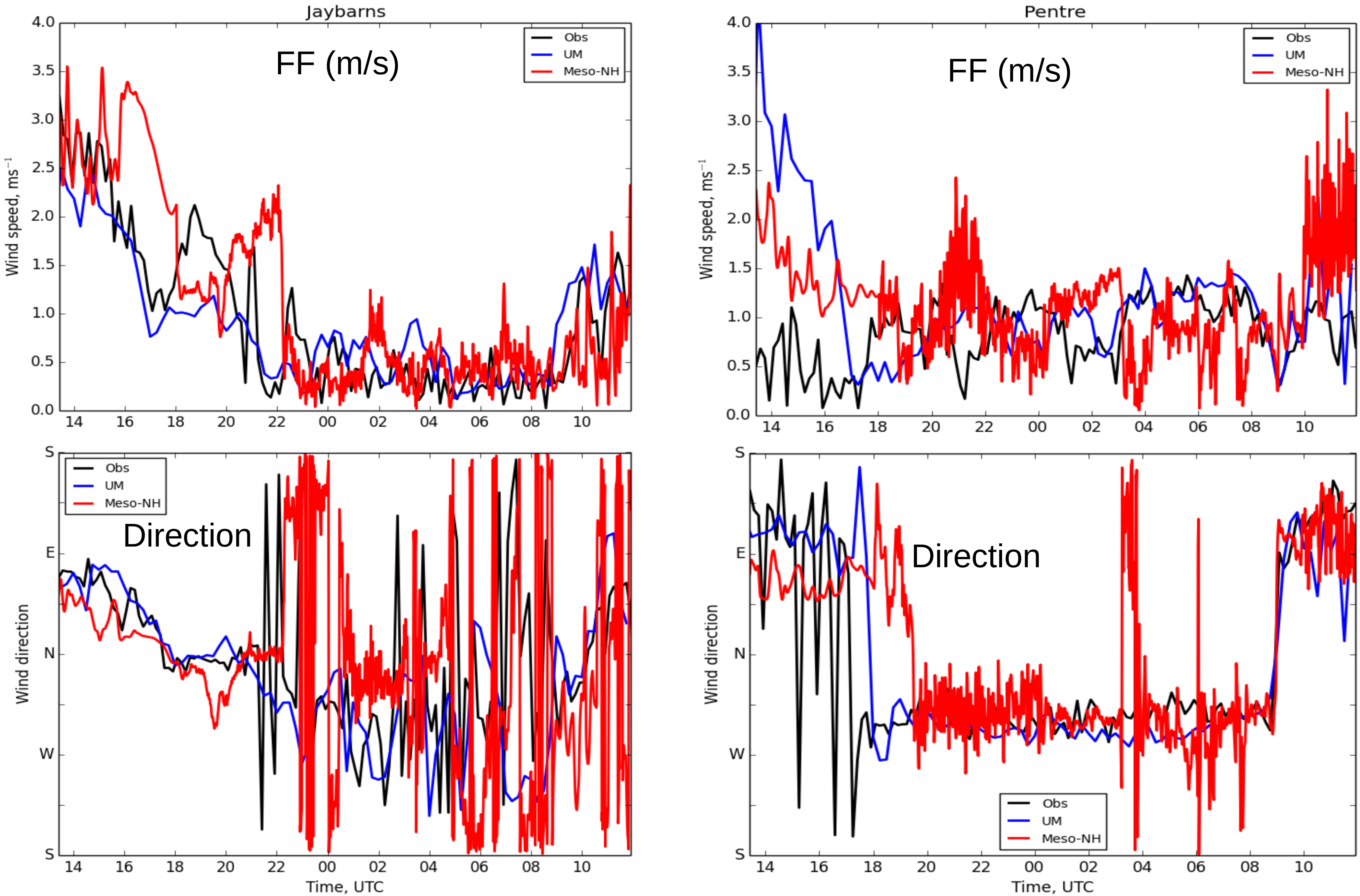
1.5m time-serie of temperature and relative humidity

OBS **MESO-NH** **UNIFIED MODEL**



1.5m time-serie of wind speed and direction

OBS **MESO-NH** **UNIFIED MODEL**



Intercomparison work between Meso-NH and Unified Model of Met Office

Main ingredients :

Subgrid condensation scheme

Large-scale fields

Vertical and horizontal resolution

Microphysics/aerosols (Boutle et al. 2017)

→ Nesting at 13hUTC to better capture the evening transition and drainage flow formations in narrow valleys

→ Intercomparison between MNH and UM pursued on an other IOP with 2-moment microphysics

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Meso-NH simulation with 2-moment microphysical scheme **LIMA** (*Vié et al. 2015*)

Droplets	Drops	Ice	Snow	Graupel	Hail
r_c	r_r	r_i	r_s	r_g	r_h
N_c	N_r	N_i			

Derived from ICE3 1-moment scheme

Prognostic evolution

r : mass mixing ratio ($kg.kg^{-1}$) N : number concentration ($\#.m^{-3}$)

Destinated to french operational forecast model AROME

Prognostic evolution of a **multimodal aerosol population**

Detailed **activation process**

No radiative impact of $N_{aerosols}/N_{droplets}$ at first step

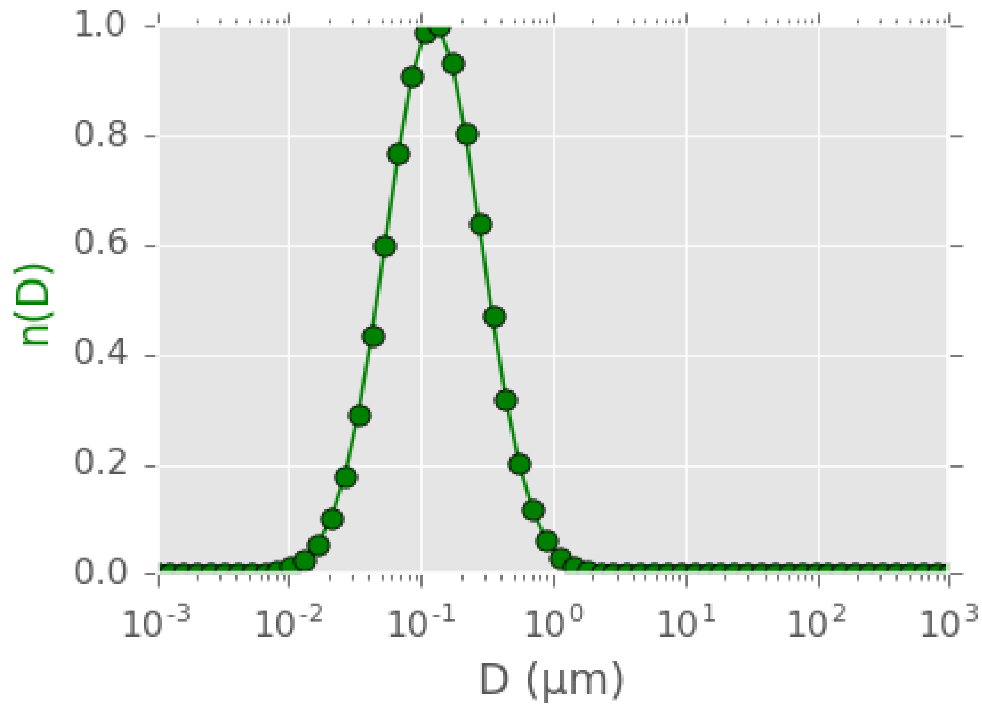
No subgrid condensation scheme

Initialization with realistic population

Sulfates (continental type)

D_m = 0.25 µm
σ= 1.6
N_i = 300 $\#.cm^{-3}$

Homogeneous on vertical

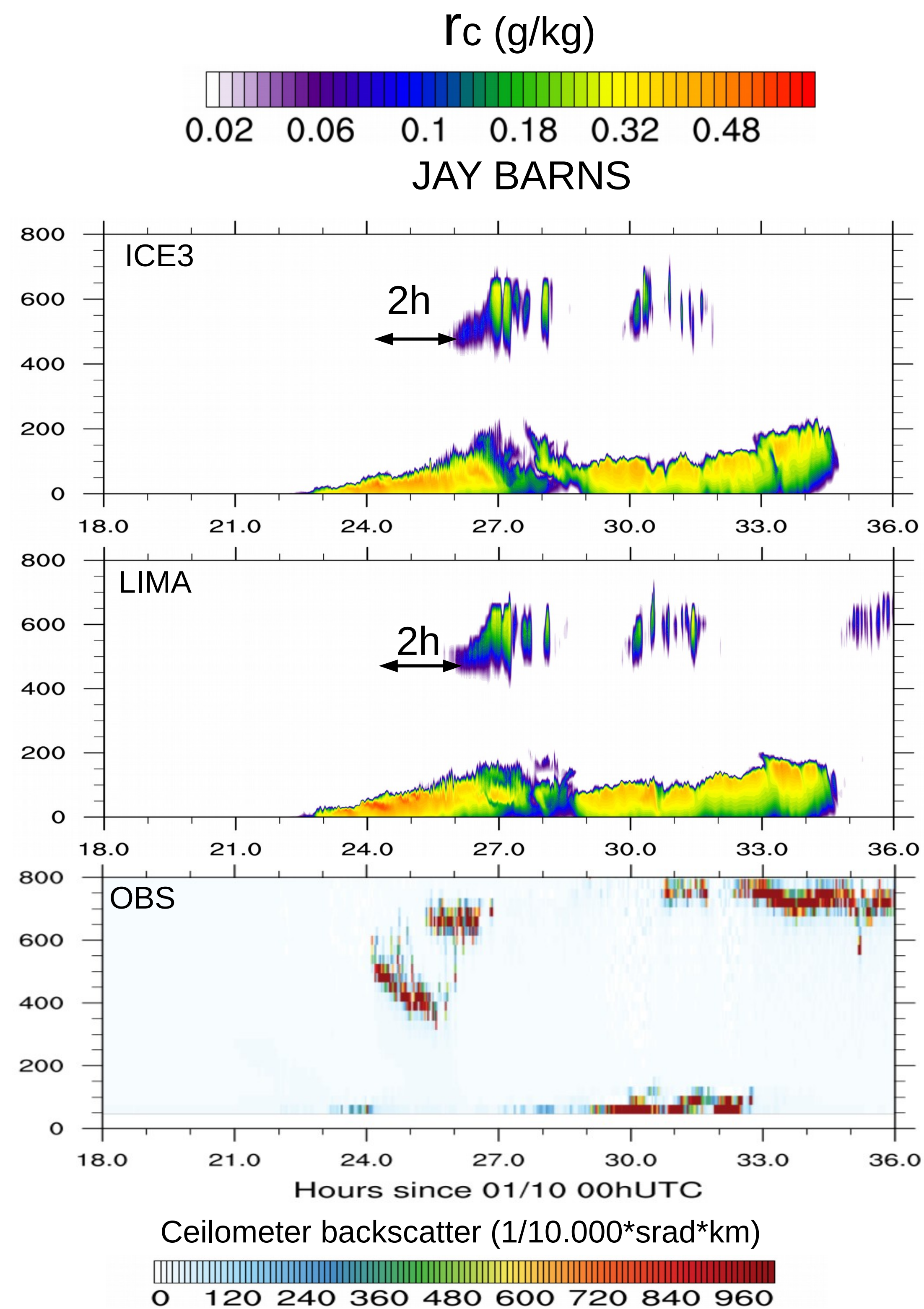


Comparison ICE3 - LIMA

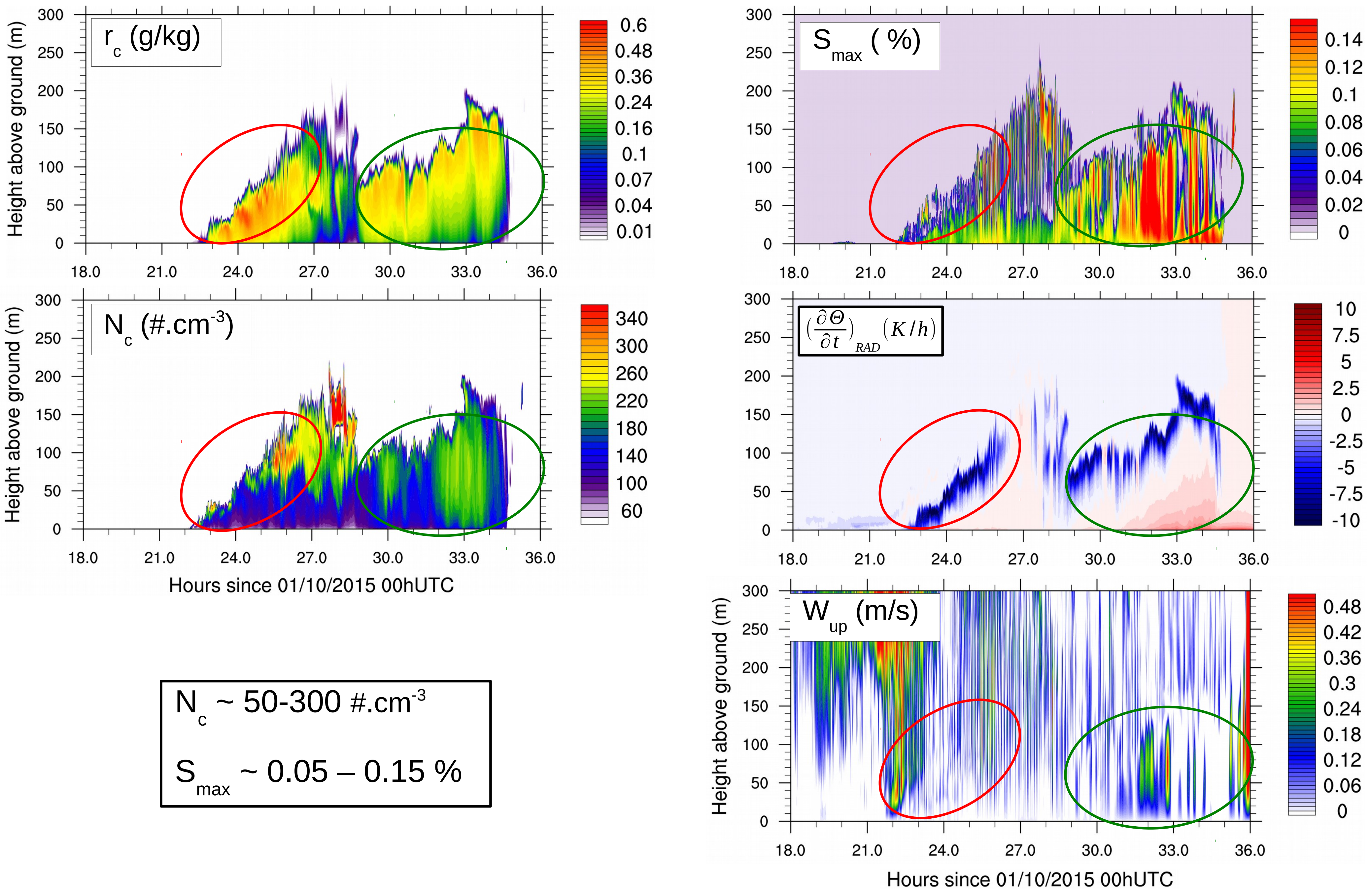
ICE3 : without subgrid condensation scheme

No impacts on fog life cycle and dynamics

Study of microphysics



Time-evolution of vertical profiles at JAY BARNS : 0-300m



N_c ~ 50-300 #.cm^{-3}

S_{max} ~ 0.05 – 0.15 %

2-moment microphysics LIMA for fog modelling

Dynamics conditions and fog life cycle unchanged compared to the use of 1-moment scheme

Realistic values of Nc and supersaturation
→ microphysical information

→ Sensitivity test to aerosol type : organics, more hydrophobic

→ Study of circulations on the dynamics and microphysics of fog

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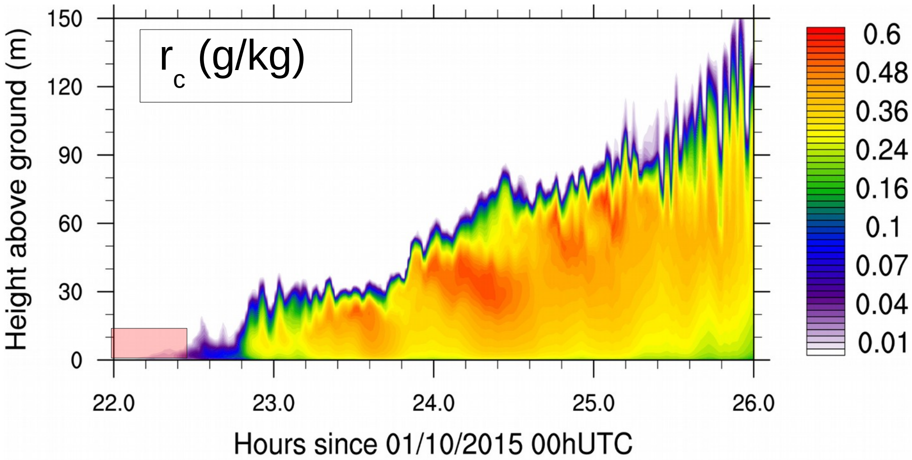
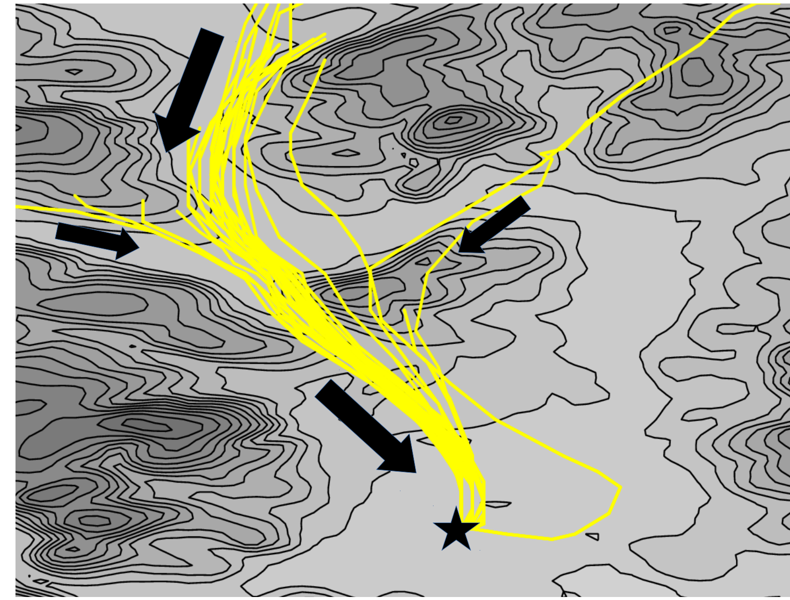
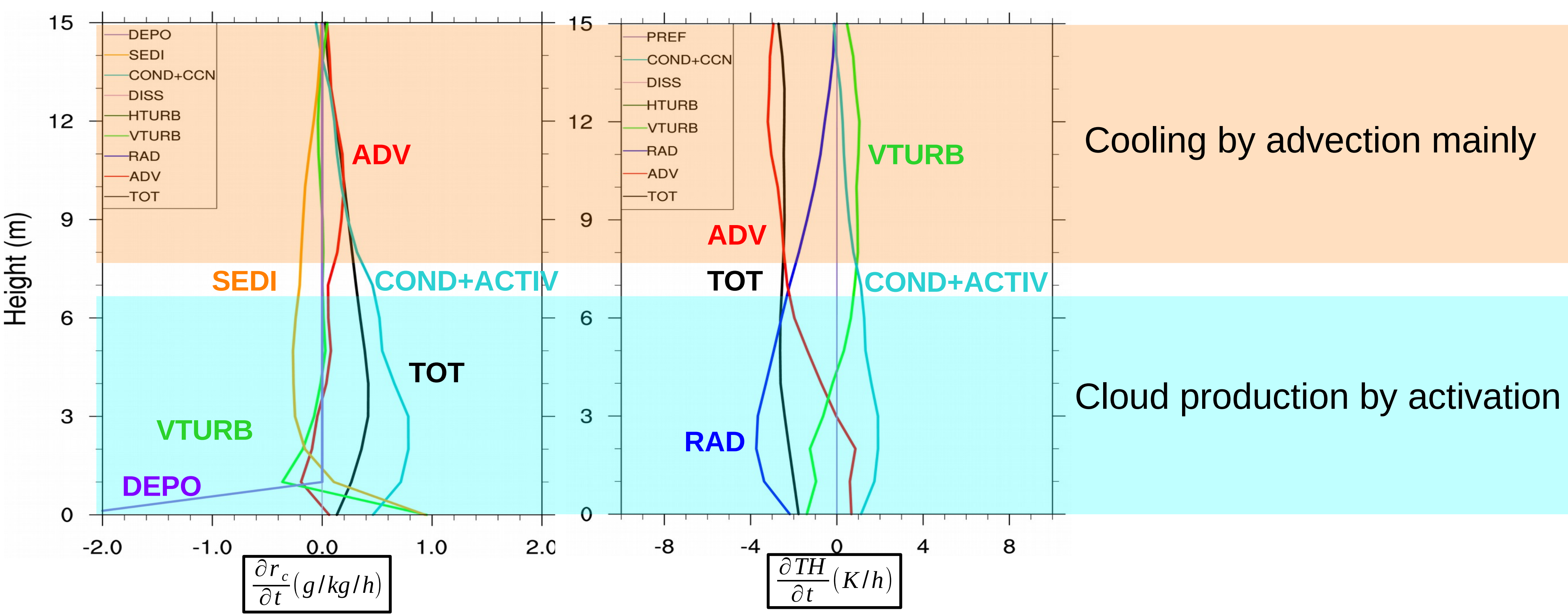
JAYBARNS : FORMATION
Averaged budgets on 22h00-22h30 UTC
+ retrotrajectories

Particles arrive at 22h20 between 0-15m at Jay Barns site

Influence of surroundings valleys + flow canalized by the topography



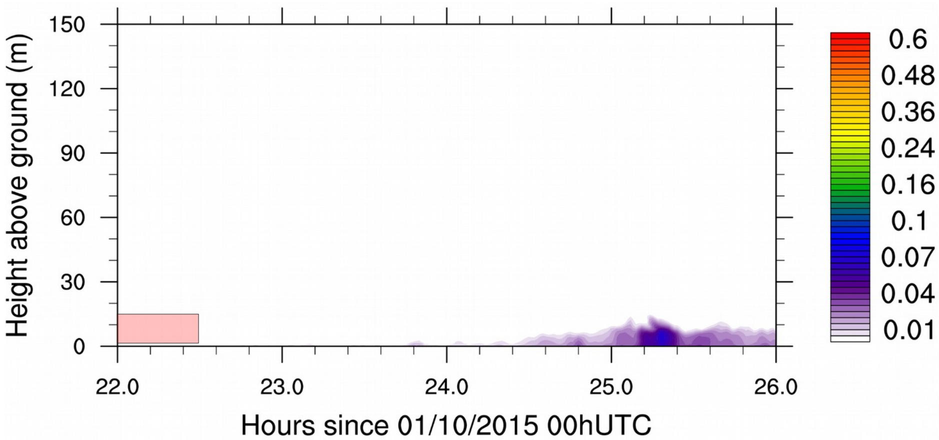


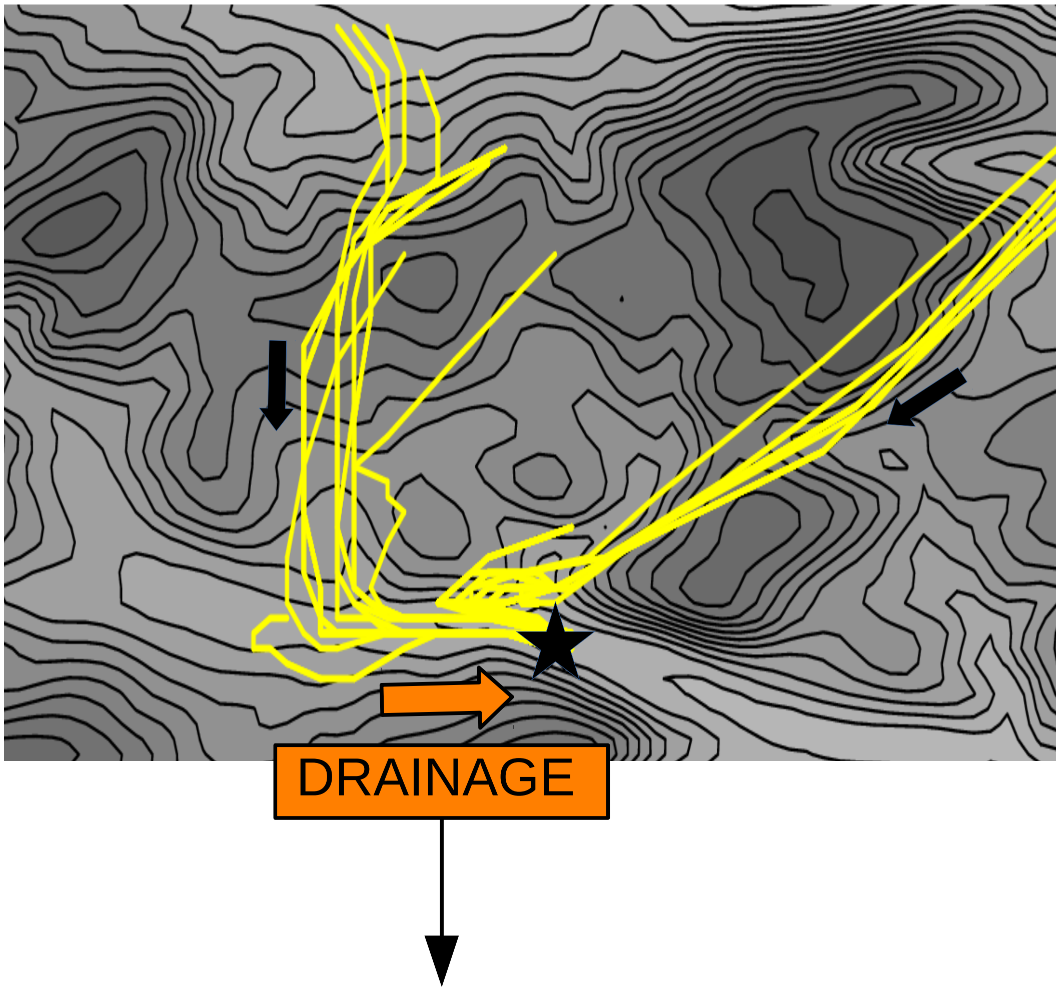


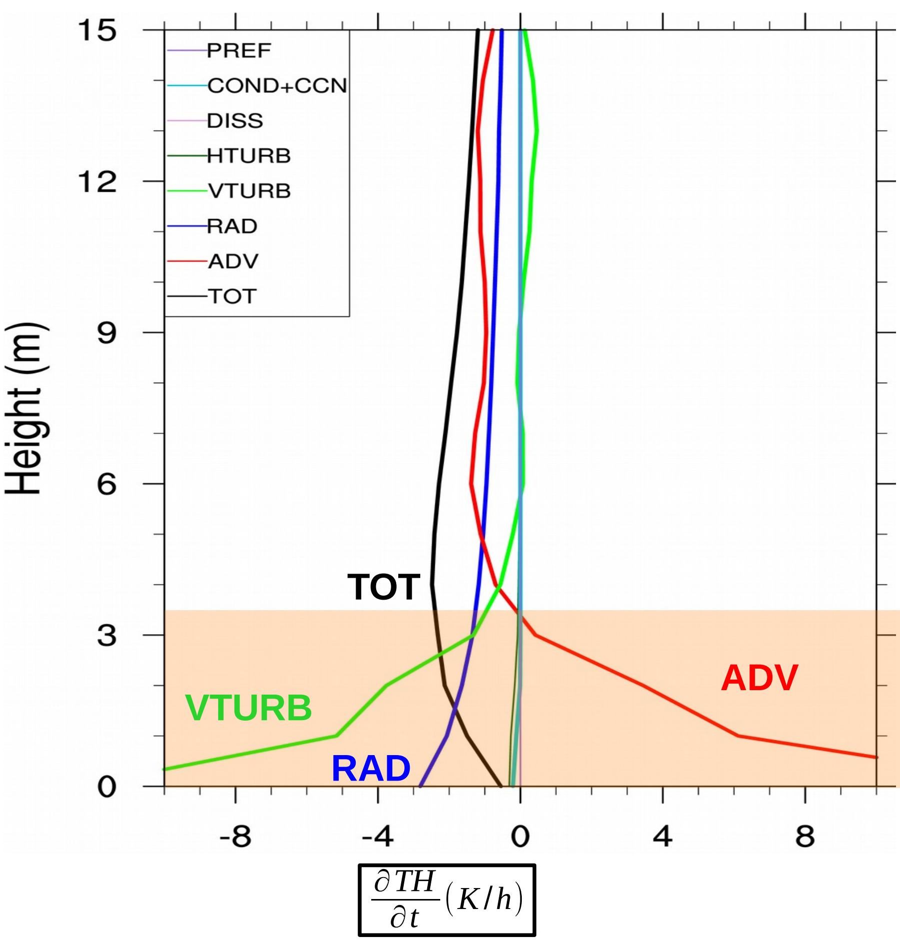
PENTRE : NO FOG
Averaged budgets on 22h00-22h30 UTC
+ retrotrajectories

Particles arrive at 22h20 on Pentre site between 0-15m

Drainage flow + influence of synoptic flow trapped in the valley







Heating by advection preventing condensation

CONCLUSIONS / PERSPECTIVES

INTERCOMPARISON MNH-UM

Allows to point out the weaknesses of each models

An other intercomparison will be carried out for another IOP at Cardington (same forcing/resolution) to focus on microphysics with observations

2-MOMENT MICROPHYSICAL SCHEME LIMA

No major change compared to other ingredients

Realistic microphysical information → study of impact of dynamics on microphysics

Further tests on aerosol characteristics + heterogeneous initialization

EFFECTS OF CIRCULATIONS ON FOG FORMATION

Advective processes seem to play an important role for the time of fog formation

Drainage flow in narrow valleys prevents fog formation

Even in a large valley, topography seems to impose its dynamic conditions

Focus on other stages of fog (development, mature at Jay Barns)

Better quantify the influence of flows on the fog conditions at each site


Thank you for your attention