High-Resolution Simulations of Fog with the 2-Moment Microphysical Scheme LIMA

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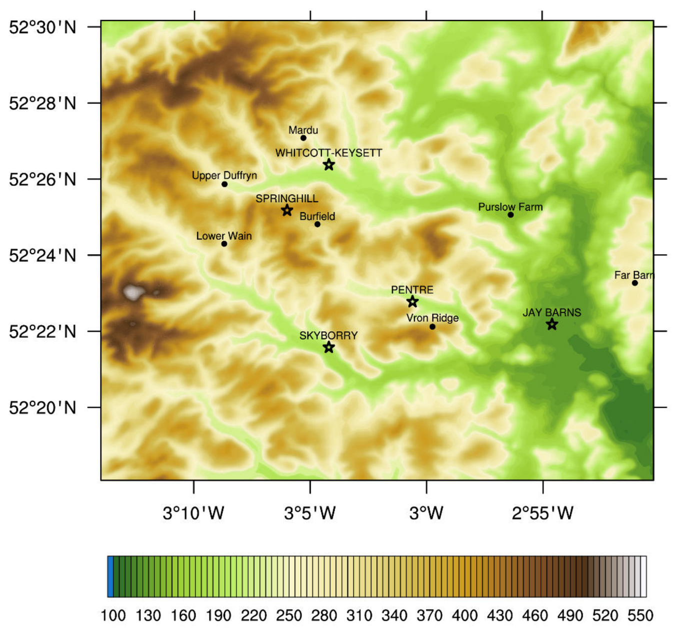
LANFEX CAMPAIGN

The Lanfex campaign *(Price et al. 2018)* was conducted by the UK MetOffice to **study the impact of complex orography and surface heterogeneities on fog** formation, life cycle and dissipation. Several instrumented sites sampled fog conditions in different Shropshire valleys.

➔ **What processes drive the fog life cycle over complex terrain ?**

➔ **What are the relative contributions from local and advective processes ?**

➔ **What is the impact of microphysics on fog life cycle ?**



Shropshire orography (m)

LES OF FOG WITH LIMA

The 2-moment LIMA microphysical scheme ***(Vié et al. 2016)*** **was used in the Meso-NH research model** ***(Lac et al. 2018)*****:**

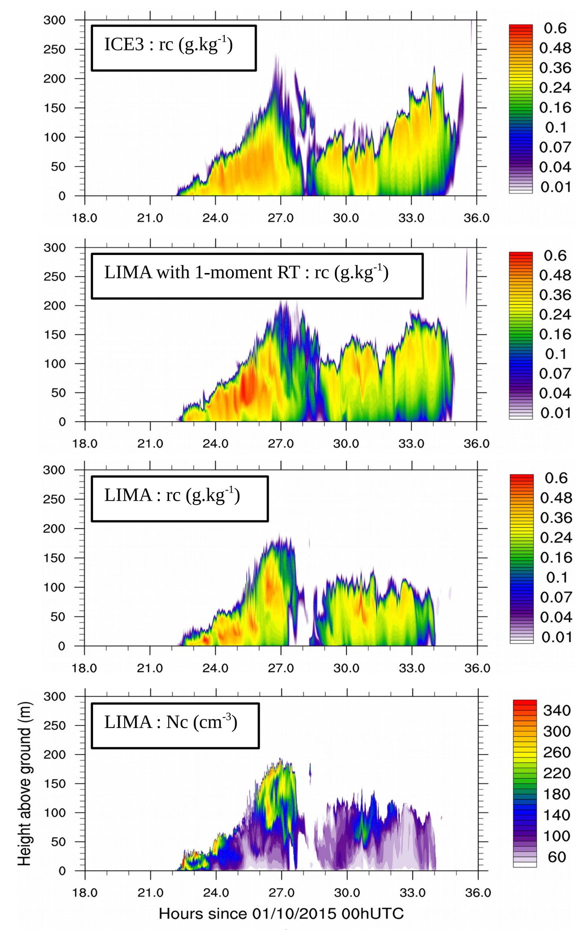
- Built upon ICE3, Météo-France's operational 1-moment scheme
- Prognostic **aerosol-cloud interactions**
- **Cloud droplets** sedimentation and **deposition** *(Mazoyer et al. 2017)*
- **Cloud optical properties** depend on both r_c and N_c

High resolution simulations of Lanfex IOP 12, 1-2 October 2015:

- 500 m → **100 m** (→ 20 m → 4 m) horizontal resolution
- **1 m vertical resolution** from 0 to 70 m, 148 levels up to 1400 m

Results :

- Realistic **small-scale circulations**
- Realistic cooling and **CCN activation at the top of the fog layer**
- LIMA improves fog if cloud optical properties depend on both r_c, N_c



Simulated fog at Jay Barns

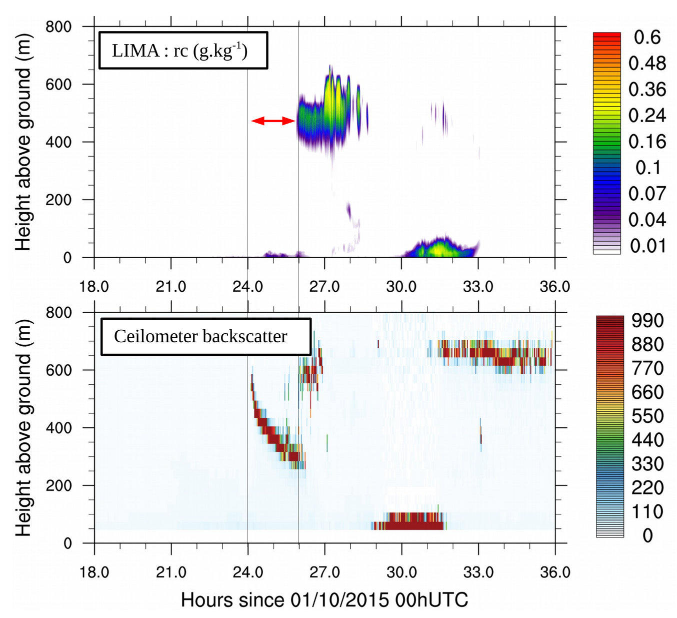
FOG IN A NARROW VALLEY: PENTRE

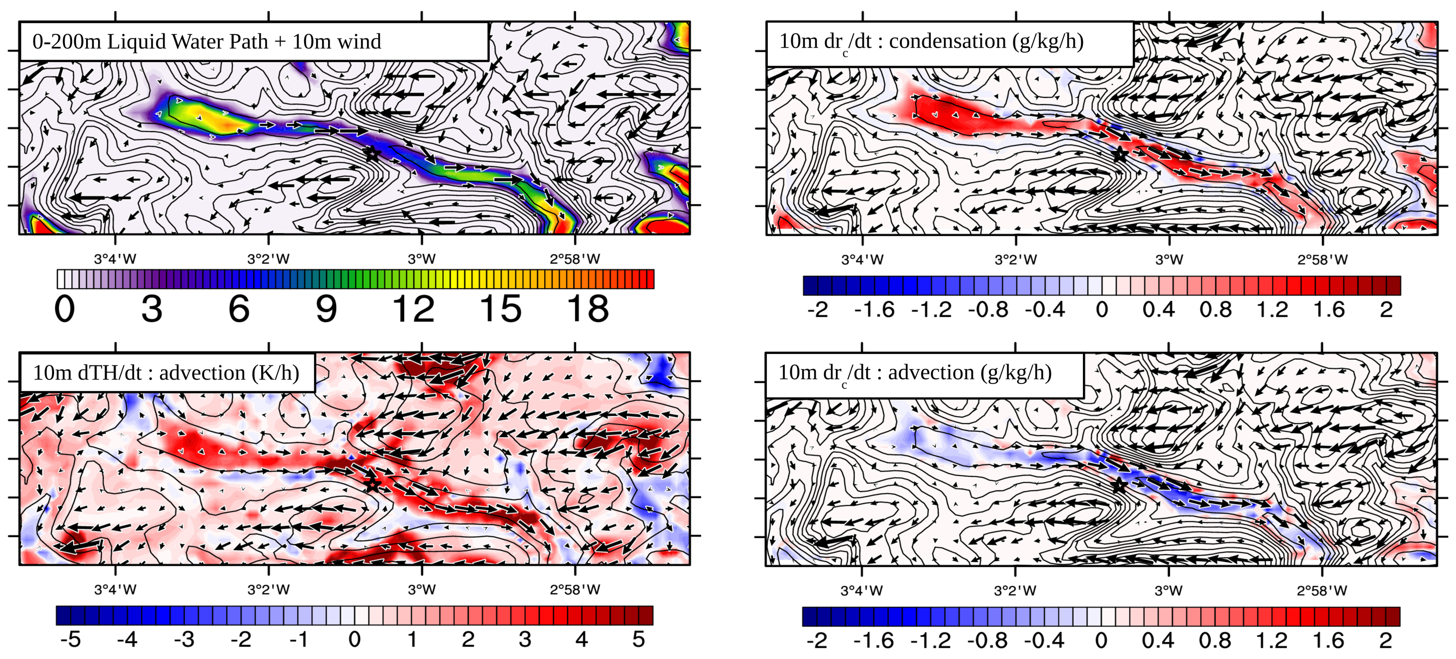
Fog conditions at Pentre supersite:

- Stratocumulus are observed at 0 UTC on 2015/10/2 and prevent fog onset until 5 UTC.
- Stratocumulus are 2 hours late in the simulation. Therefore, thin fog forms at 0:30 UTC on 2015/10/2 in the simulation, and dissipates by 2 UTC due to the longwave forcing by the stratocumulus. Fog forms again at 6 UTC (~1 hour too late), and has a correct height and lifetime.

Simulation of fog onset at Pentre, between 1 UTC and 2 UTC:

- Easterly synoptic flow on hilltops
- Westerly drainage current in the valley, associated with a positive advection of potential temperature
- Fog forms in the bottom of the Pentre valley (positive condensation tendency)
- Advection counterbalances the local formation of fog in the valley
- Fog at Pentre (located on the side of the valley) is mostly due to advection, and experiences evaporation locally
- The opposite effects of local (condensation) and non-local (advection) processes lead to thin fog in the narrow valley of Pentre





Average liquid water path, potential temperature and cloud droplets mixing ratio tendencies, between 1 UTC and 2 UTC on 2015/10/2.

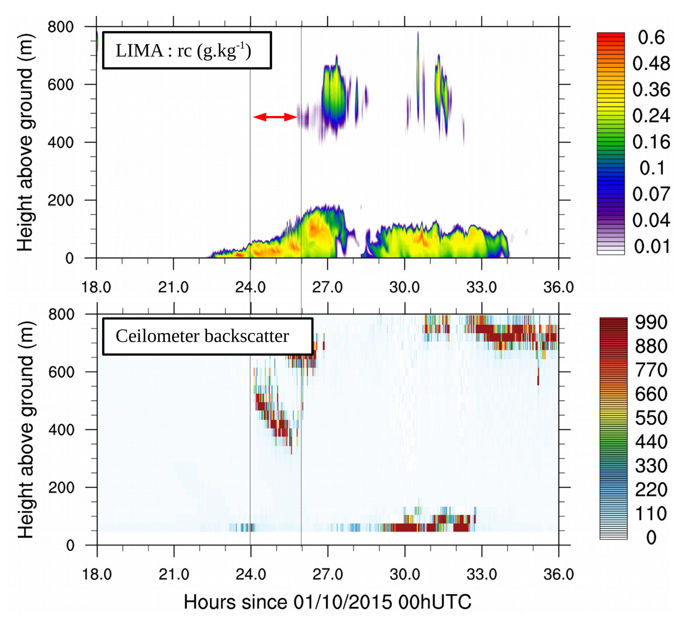
FOG IN A LARGE VALLEY: JAY BARNS

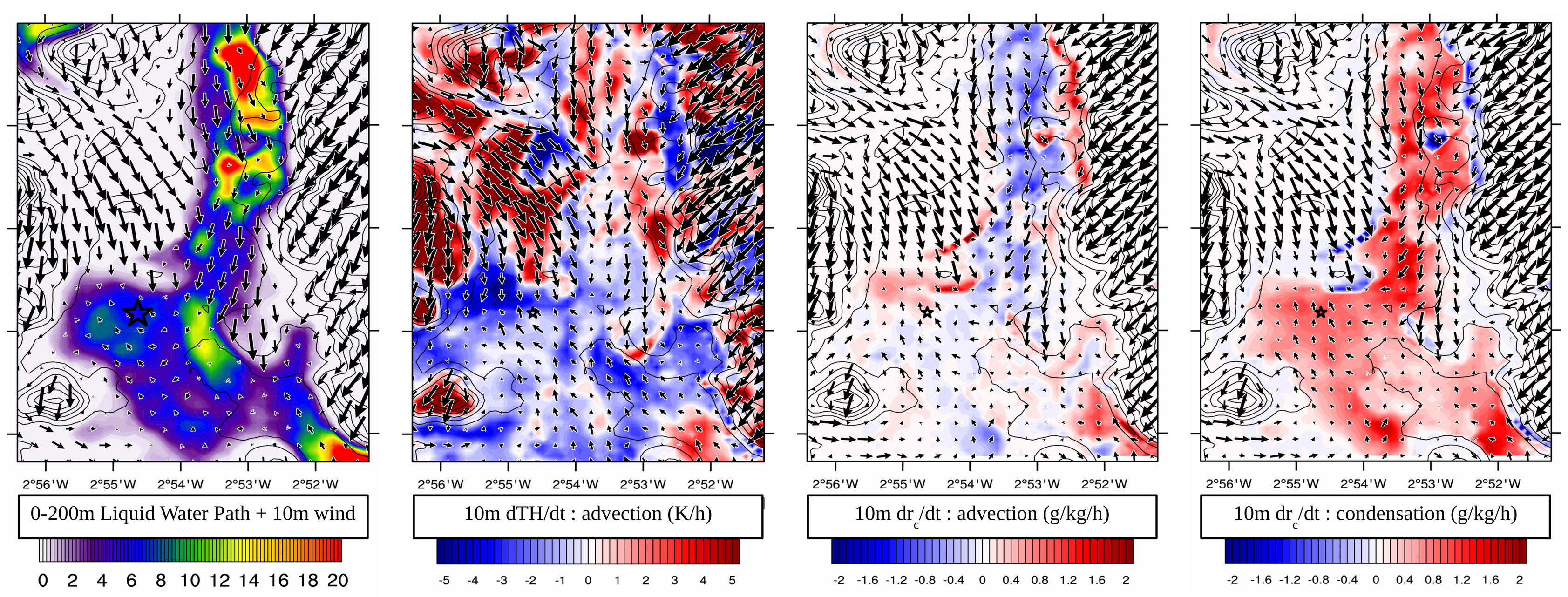
Fog conditions at Jay Barns supersite :

- Thin, intermittent fog is observed starting at 23 UTC on 2015/10/1, and dissipates when stratocumulus pass over the site at 0 UTC on 2015/10/2. Fog forms again at Jay Barns under clear sky conditions between 3 and 9 UTC.
- Stratocumulus are 2 hours late in the simulation. Fog forms after 22 UTC in the simulation (~1 hour too early), and transitions to deep fog while stratocumulus are not simulated. Fog dissipates around 3:30 UTC due to the stratocumulus longwave forcing, and forms again under clear sky conditions.

Simulation of fog onset at Jay Barns, between 22 UTC and 23 UTC:

- Northeasterly synoptic flow on hilltops
- Northwesterly flow from adjacent valleys in the northwest, northerly flow in the north, and very low wind in the south of the valley
- Local conditions are favourable to fog formation by condensation in most of the valley.
- Low advection in the south does not compete with condensation, which results in fog deepening and thickening at Jay Barns.
- Jay Barns is close to the convergence area, where the NW flow from adjacent valleys interacts with the weak S flow in the valley. Non resolved turbulence cloud explain that fog at JB is more intermittent/patchy than simulated.





Average liquid water path, potential temperature and cloud droplets mixing ratio tendencies, between 22 UTC and 23 UTC on 2015/10/1.

CONCLUSION

High-resolution simulation of fog with Meso-NH:

✔ **Good representation of small-scale circulations in most valleys**
✔ **LIMA → realistic representation of fog, with droplets activated at the top**
✔ **Using prognostic N_c and r_c to compute cloud optical properties yields best results**

In narrow valleys (Pentre):

✔ **Condensation happens at the bottom of the valley**
✔ **Opposite effects from advection and condensation/evaporation → thin fog**

In large valleys (Jay Barns):

✔ **Weak advection does not compete with local condensation → thick fog**
✔ **Conflict zone between drier advection and local condensation → intermittent fog**

➔ **Higher resolution simulations are needed to better represent small-scale flows in the narrowest valleys, and turbulent processes associated with flows interactions**

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