WP3 : 3D Large Eddy Simulations (LES) and impact of heterogeneities

Leader : C. Lac (CNRM)

Photo F. Burnet

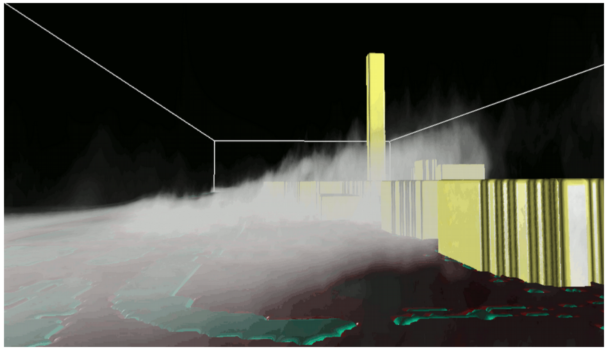
LES

- Most of the eddies are resolved : Pope (2000) : $TKE_{resolved} > 80\ \%\ TKE_{total}$

  Stable boundary layer : Δx = a few meters (Beare and McVean, 2004)

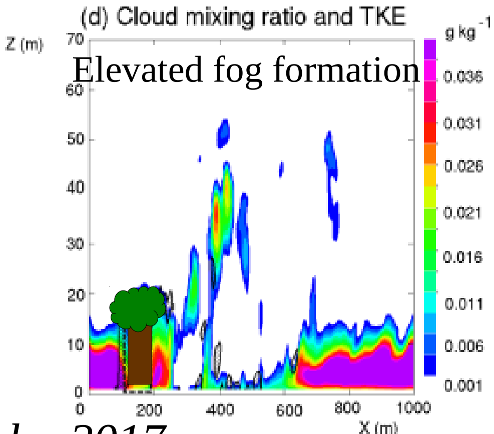
  Importance of the vertical resolution for fog : $\Delta z \sim 1$ m
- A way to conduct process studies, to better understand physical processes and to improve parametrizations
- First LESs of fog : Nakanishi (2000), Porson et al. (2011), Bergot (2013) : with homogeneous canopies
- LESs of fog with surface heterogeneities : Bergot et al. (2015) (Buildings), Mazoyer et al. (2017) (Trees) using a drag force approach

CDG airport



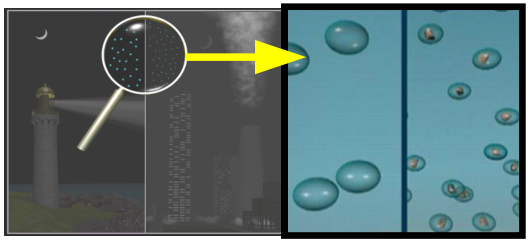
Bergot et al. , 2013

SIRTA site

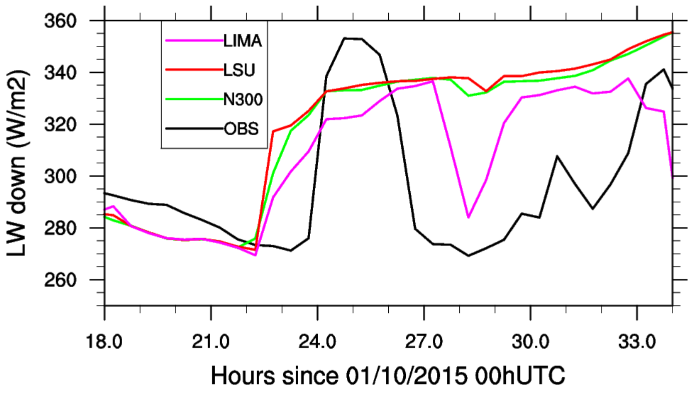


Mazoyer et al. , 2017

LES of fog : reference but uncertainties



- **Microphysics** :
  - 2-moment microphysical scheme neccssary to take into account aerosols for activation and the radiative effect of droplet concentration (Nc) : NEED of VALIDATION
  - Nc could be overestimated → thick fog : ACTIVATION process

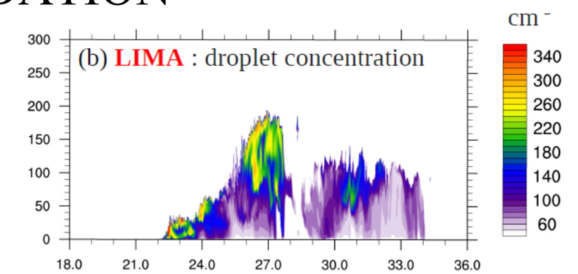


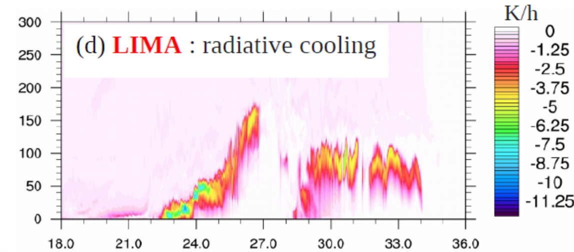
LIMA **without** radiative impact of Nc

ICE3

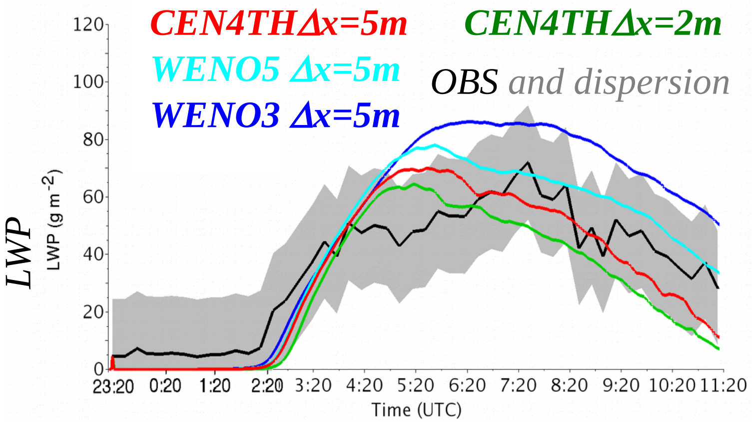
LIMA **with** radiative impact of Nc

Duconge et al., to be submitted





- **Top-entrainment** :
  - Eddies are smaller than in the fog layer
  - Strong impact of numerical transport schemes
- **Surface processes and impact of heterogeneities :**
  - Orography, Vegetation types

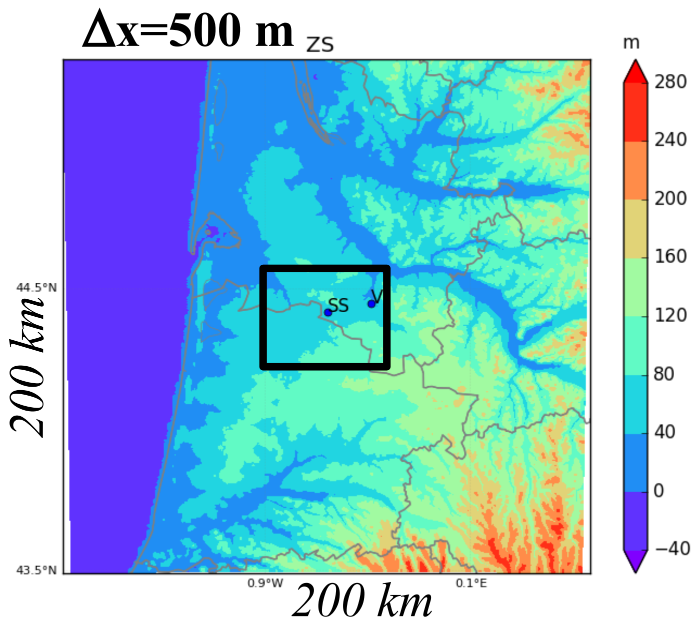


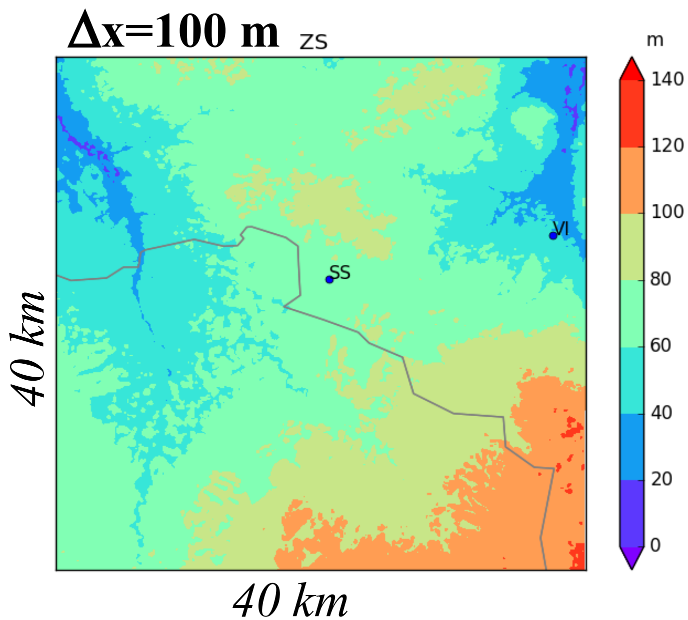
LES = a valuable aid but needs validation with measurement

LES of fog (Lunet et al., 2017)

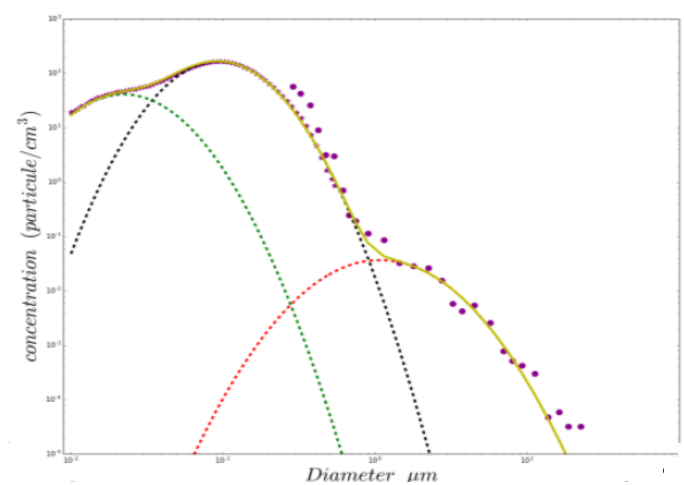
Task 3.1 : LES and validation (T0+24 - T0+36)

- Run of the most documented cases with **Meso-NH model** (Lac et al., 2018) from **AROME analysis** with **grid-nesting** downscaling → **Post-Doc 12 months**





Δx=20 m + Δx=5 m

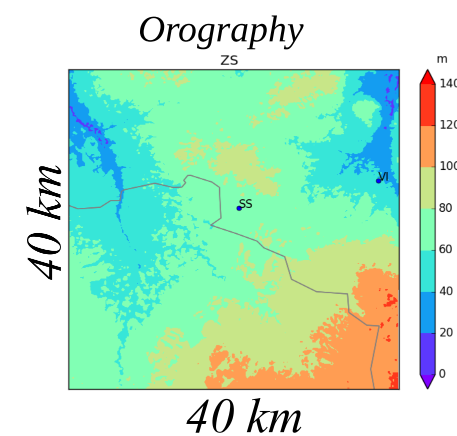


- Microphysics : **LIMA** 2-moment scheme (Vié et al., 2016)
  Initialization of aerosols from OPC and SMPS
- Radiation : **ecRad** (Hogan and Bozzo, 2016) with 14 SW bands and improved radiative optical properties (Jahanghir PhD)
- **SURFEX** (Masson et al., 2013) ISBA-Diff vegetation scheme – HR surface data base

Task 3.2 : Impact of heterogeneities (T0+30 - T0+42)

- To better understand how surface heterogeneities interact with turbulence :

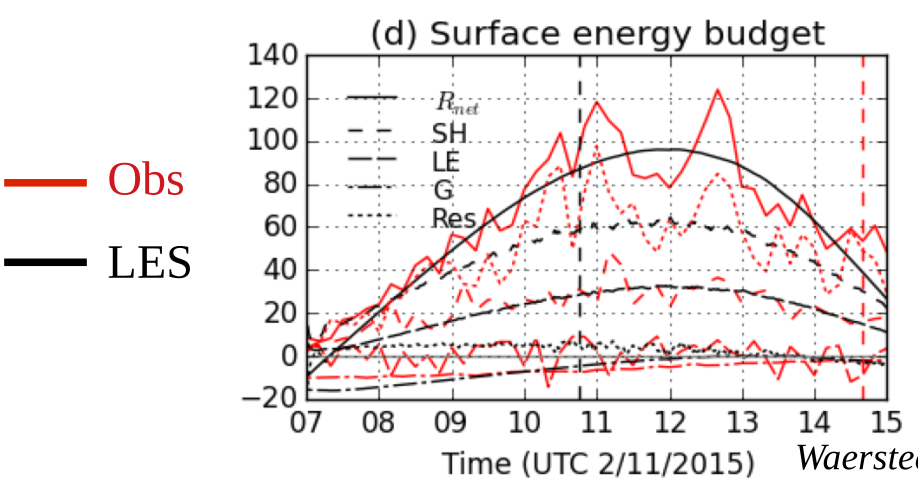
  - 3 D mapping of the super-site with 3 different vegetation types



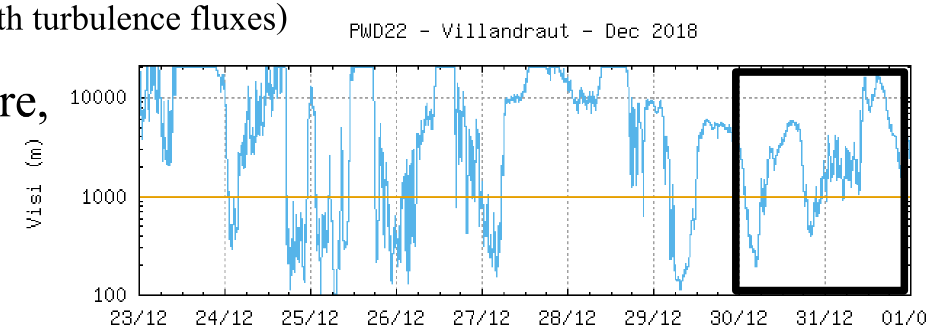
  - Use Meso-NH-SURFEX as a laboratory : impact of modification of vegetation characteristics on the fog life cycle

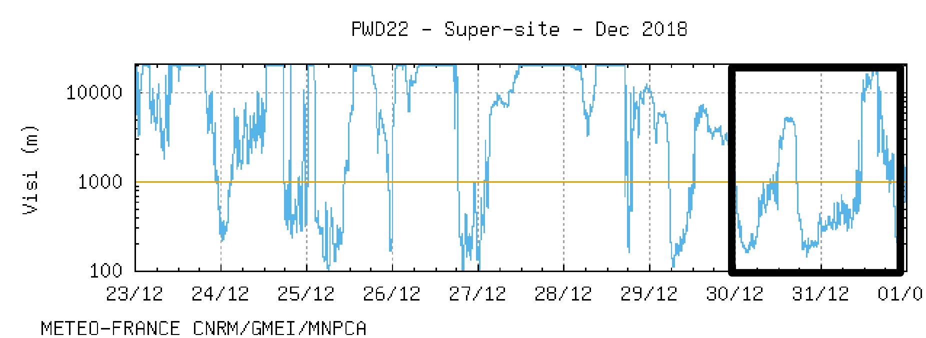
  - TKE budget, anisotropy of turbulence (flux masts with turbulence fluxes)

  - Surface energy budget to minimize the non closure, consistency with LES



Waersted, 2018



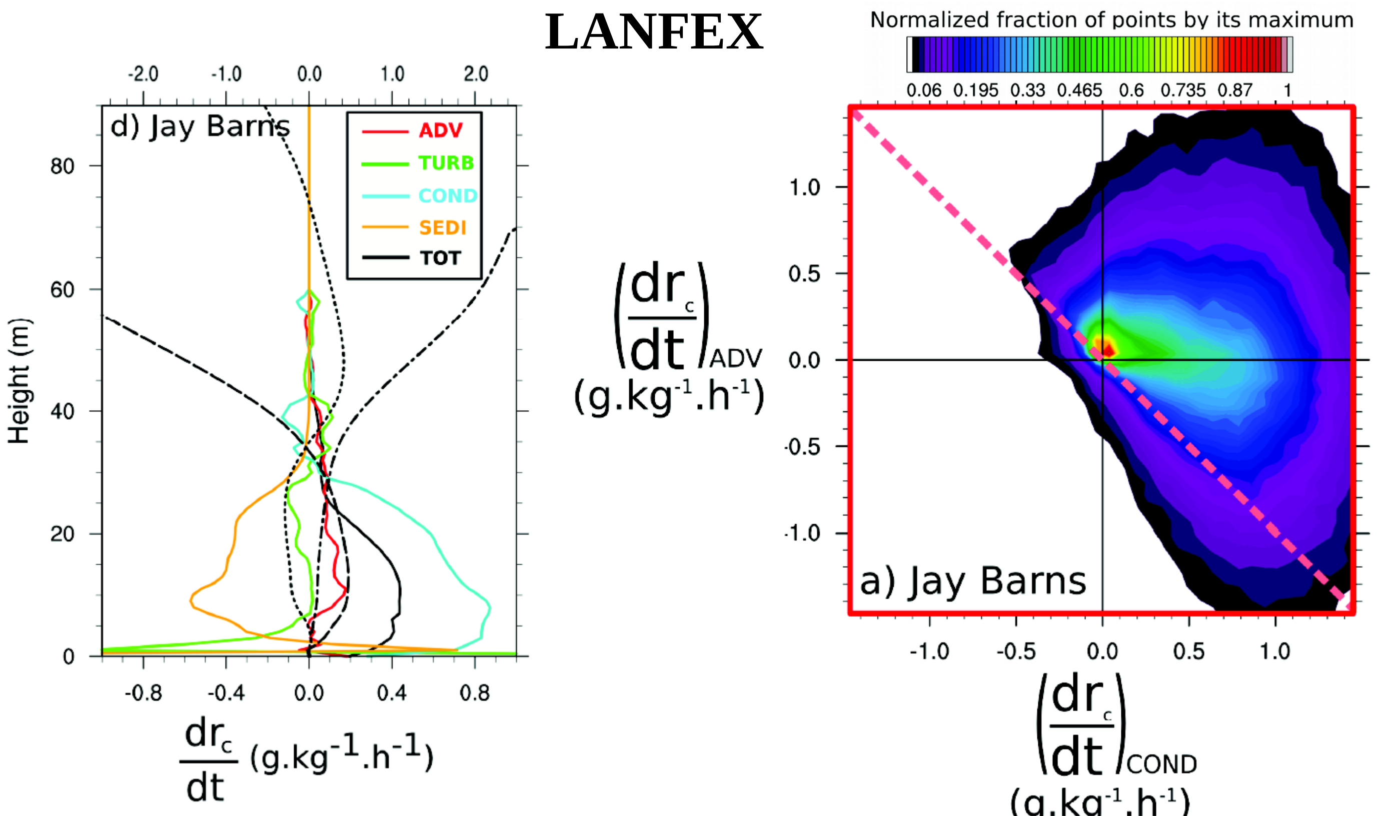


Task 3.3 : Impact of orography and advective processes (T0+30 - T0+42)

- Local circulations studied with scanning Doppler wind lidar, Doppler wind lidar profiler, scanning 95GHz Doppler radar . Thermal IR imaging.

Scanning Doppler wind lidar in Passy experiment

- LES to quantify local and non-local contributions to the cloud mixing ratio budget



Duconge et al., to be submitted

WP3 : 3D Large Eddy Simulations (LES) and impact of heterogeneities

Questions ?

WP4 : Advanced process studies

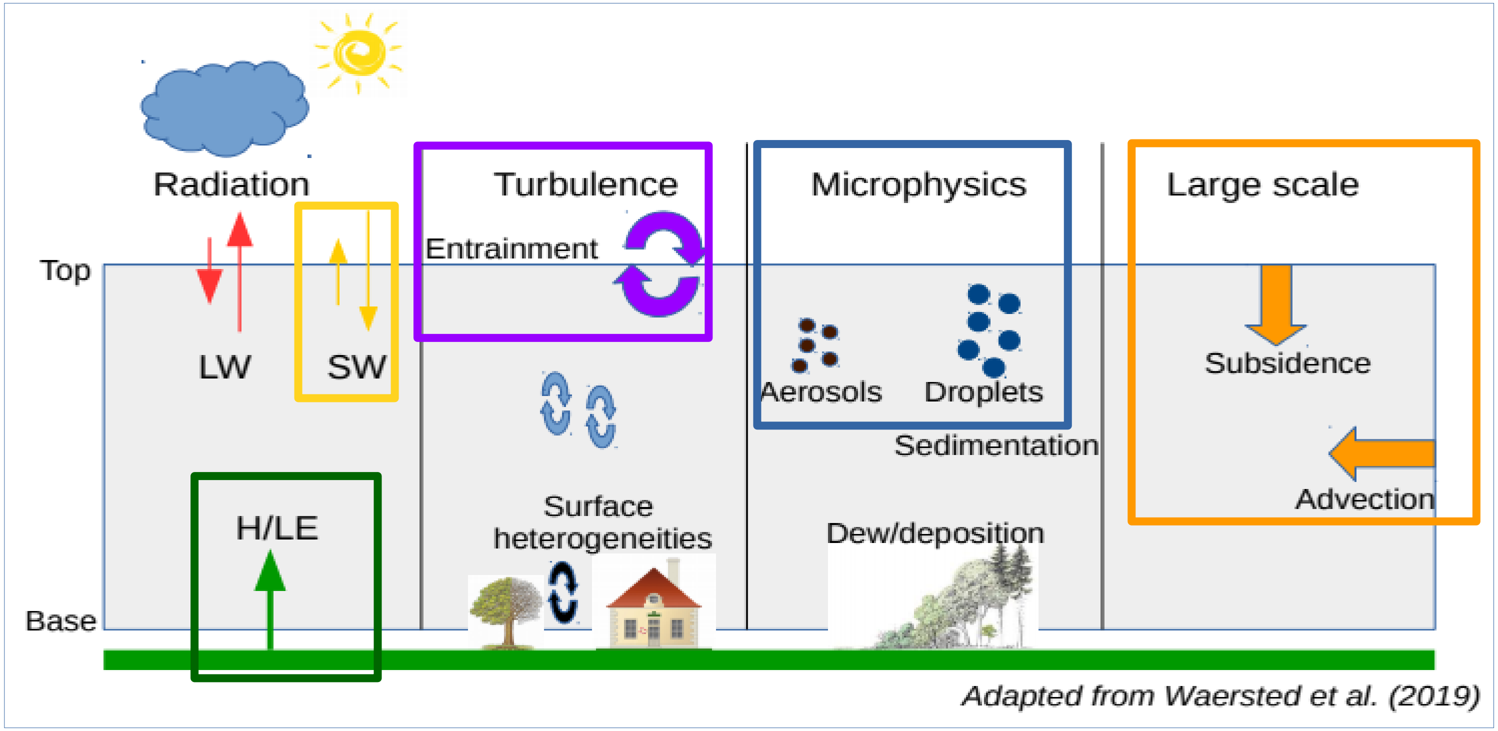
Leaders : M. Haeffelin (IPSL) and C. Lac (CNRM)

- To better understand **contrasts** leading to radically different fate in fog life cycles :

  - **Shallow stable fog *vs* deep adiabatic fog**
  - **Stratus lowering into fog *vs* stratus persisting aloft**
  - **Daytime fog dissipation or lifting *vs* daytime fog persistence**

  Using measurements and LES

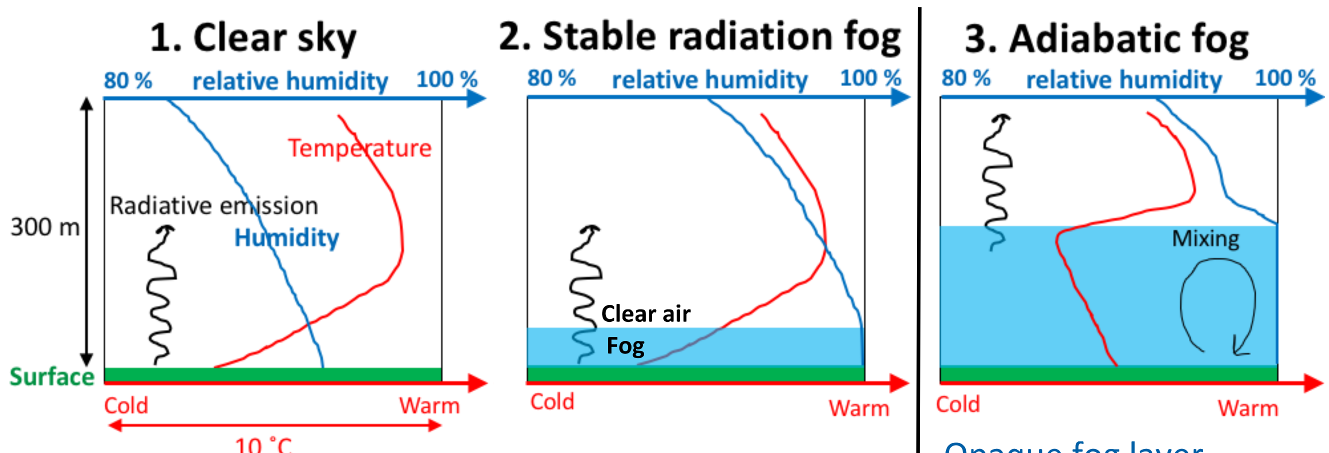
Processes mainly investigated :



Task 4.1 : Transition thin/thick fog – Entrainment at fog top (T0+30 - T0+42)

- Transition from mist to thin fog : Aerosol hydratation
- Transition from optically thin to thick fog : Aerosol growth and activation process : aerosol measurement and improvement of the activation parametrization ;

  Better understanding of effect of vertical stability and mixing on the transition.
- Once fog is thick, quantification of entrainment with thermodynamical and microphysical in-situ observations (tethered ballon, UAV, MWR) and LES
  - Impact of humidity and temperature profiles above the fog on entrainment
  - Impact of entrainment on microphysics



Radiative cooling of the surface

–> Stable temperature profile (increasing with height)

–> Little vertical mixing

Opaque fog layer

–> Only fog top cools

–> Neutral temp. profile

–> Well-mixed fog layer

Task 4.3 : Fog dissipation phase (T0+30 - T0+42)

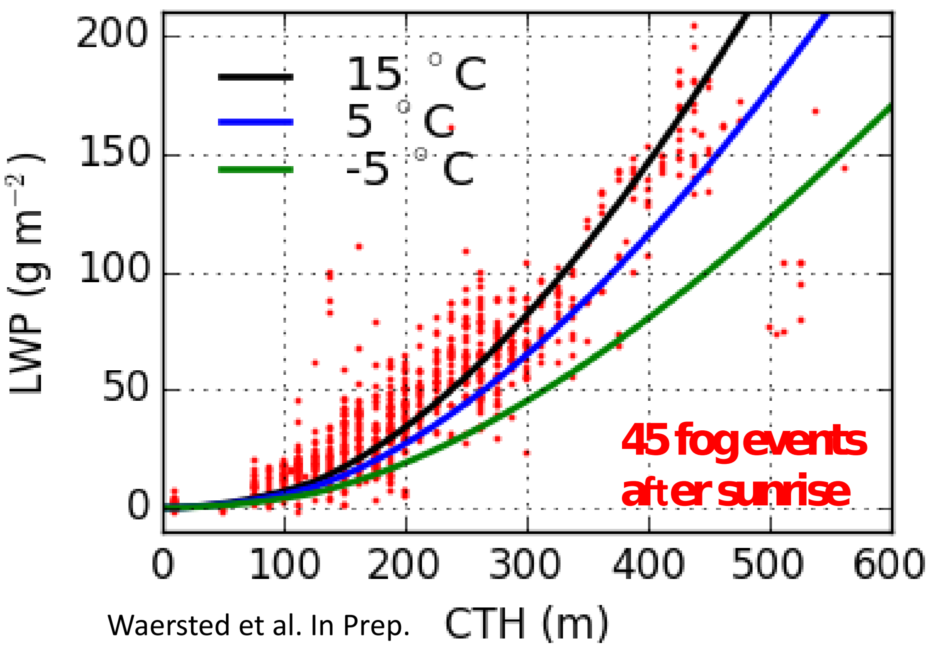
Evolution of the LWP budget and LWC profile to quantify and analyse the contribution of fog-top entrainment, subsidence, radiative cooling, radiative absorption (spectrophotometer measurements), droplet deposition/sedimentation and energy budget at the fog base.

The LWP budget will be derived from LES simulations and detailed observations as input to diagnostic conceptual models (Waersted et al., 2019)

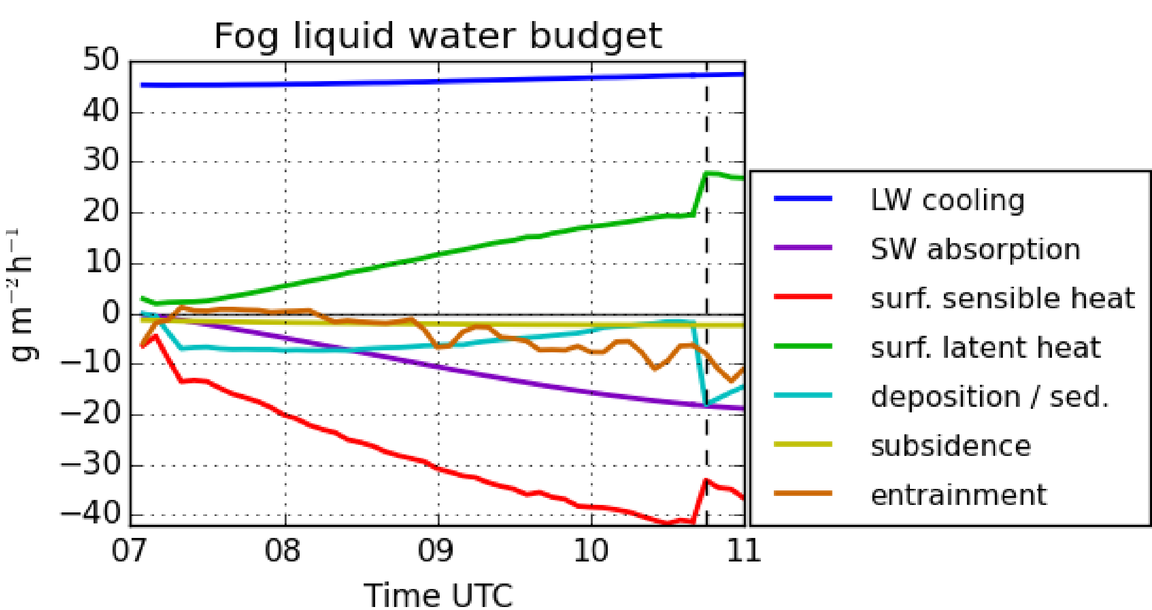
→ **Post-Doc 14 months :**

- LWP budget for each documented fog case
- Sensitivity of fog life cycle to key variables driving major processes

Critical LWP



Waersted et al. In Prep.



Waersted et al. 2019a

Task 4.2 : Stratus-to-fog transition

Maroua Fathalli PhD