WP3 : 3D Large Eddy Simulations (LES) and impact of heterogeneities
Leader : C. Lac (CNRM)
Task 3.1 : LES and validation (T0+24 - T0+36)

- Run of the most documented cases with Meso-NH model from AROME analysis with grid-nesting downscaling up to 5m resolution → Post-Doc 12 months

Tests of the recent advances in parametrizations :

- **SURFEX** (Masson et al., 2013) ISBA-Diff – ISBA-MEB (Boone et al., 2017) vegetation scheme – HR surface data base

- Radiation : **ecRad** (Hogan and Bozzo, 2016) with 14 SW bands and improved radiative optical properties (Jahangir et al.)

- Microphysics : **LIMA** 2-moment scheme (Vié et al., 2016)
  Initialization of aerosols from OPC and SMPS
Recent improvement of the activation process in LIMA

\[ \frac{dS}{dt} = \psi_1 w - \psi_2 \frac{dr_c}{dt} + \psi_3 \frac{d\theta}{dt} = 0 \rightarrow S_{\text{max}} \rightarrow N_{\text{CCN, activés}} \]

\[ \frac{dS}{dt} = \psi_1 w - \psi_2 \frac{dr_c}{dt} + \psi_3 \left| \frac{d\theta}{dt} \right|_{\text{RAD}} \]

: corrections proposed by Thouron et al. (2012)

LIMA ~ ICE3
LIMA with prognostic sursaturation

LANFEX IOP1

Hours since 24/11/2014 00 UTC

(Ducongé PhD, 2019)
Task 3.2 : Impact of heterogeneities (T0+30 - T0+42)

- To better understand how surface heterogeneities interact with turbulence:
- Are the heterogeneities in the fog life cycle between the sites a consequence of vegetation heterogeneities? LES and observations

- What is the impact on TKE budget? anisotropy of turbulence? Surface energy budget?
- Use Meso-NH-SURFEX as a laboratory: impact of modification of vegetation characteristics on the fog life cycle
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 (Sabatier et al., 2018), scanning 95GHz Doppler radar.

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

(Ducongé et al., 2019)
Towards Large-Eddy Simulations of surface heterogeneities impact on fog with Meso-NH

Quentin Rodier, Marie-Adèle Magnaldo, Christine Lac

SOFOG3D data & science meeting
9 November 2020
First results for T 3.1 and 3.2:

- Work from Marie-Adèle Magnaldo (March → August 2020 master’s thesis), CNRM

Objectives

- Identify the IOPs with heterogeneities of the fog life cycle between the sites
- Statistical evaluation of the heterogeneities during the campaign → Select one IOP representative of the statistics with numerous measurements
- Configure Meso-NH with refining resolution and run a reference simulation
- Are the heterogeneities reproduced at 100m?
- Outlook
Outline

- Identify the IOPs with heterogeneities of the fog life cycle between the sites

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- Outlook
IOPs with heterogeneities

- 15 IOPs
- 3 observed deep fog (height > 200m): IOP6 (5-6 Jan.), IOP11 (8-9 Feb.), IOP14 (7-8 Mar.)
- Focus on 4 ground stations

(ref: Geoportail.gouv.fr)
IOPs with heterogeneities

- 15 IOPs
- 3 observed deep fog (height > 200m): IOP6 (5-6 Jan.), IOP11 (8-9 Feb.), IOP14 (7-8 Mar.)
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(ref: Geoportail.gouv.fr)
IOPs with heterogeneities

- Focus on 4 ground stations

Orography from 90m resolution SRTM

- SuperSite and Microphi-foret very close
- Noaillan down to a small river valley
Selection of an interesting case

- POI 6: 5-6 Jan.

Visibility (m)

Fog lifetime: **Noaillan** < **Microphi-foret** ~ **SuperSite** < **Moustey**

Mean visibility (< 1km): **Noaillan** > **Microphi-foret** ~ **SuperSite** ~ **Moustey**
Selection of an interesting case


 Visibility (m)

Fog lifetime: Noaillan < Microphi-foret < SuperSite < Moustey
Mean visibility (< 1km): Noaillan > Microphi-foret ~ SuperSite ~ Moustey
Selection of an interesting case

- **POI 14 : 7-8 March**

Fog lifetime:
- **Noaillan** < **Microphi-foret** ~ **SuperSite** < **Moustey**

Mean visibility (< 1km):
- **Noaillan** > **Microphi-foret** ~ **SuperSite** > **Moustey**
Outline

- Identify the IOPs with heterogeneities of the fog life cycle between the sites

- **Statistical evaluation of the heterogeneities during the campaign → Select one IOP representative of the statistics with numerous measurements**

- Configure Meso-NH with refining resolution and run a reference simulation

- Are the heterogeneities reproduced?

- Outlook
Selection of an interesting case

- Statistical metrics for the longest fogs (> 3h without intermittency) ⇒ 6 events

Fog lifetime: **Noaillan** < **Microphi-foret** ~ **SuperSite** < **Moustey**
Mean visibility (< 1km): **Noaillan** > **Microphi-foret** ~ **SuperSite** > **Moustey**
Selection of an interesting case

- Statistical metrics for the longest fogs (> 3h without intermittency) ⇒ 6 events

Fog lifetime: Noaillan < Microphi-foret ~ SuperSite < Moustey
Mean visibility (< 1km): Noaillan > Microphi-foret ~ SuperSite > Moustey

- The 3 selected IOPs are in agreement with the statistics
- IOP14 presents strong heterogeneities and numerous available observations (UAV, tethered balloon with turbulence ...
Outline

- Identify the IOPs with heterogeneities of the fog life cycle between the sites

- Statistical evaluation of the heterogeneities during the campaign → Select one IOP representative of the statistics with numerous measurements

- Configure Meso-NH with refining resolution and run a reference simulation
  - Meso-NH 500m vs AROME 500m
  - Meso-NH 100m

- Are the heterogeneities reproduced at 100m?

- Outlook
Fine scale Simulations of POI 14

- Downscaling approach towards the LES of stable boundary layer which needs metric resolution

- 3 Méso-NH simulations
  - D1: 500m hor. Resolution ~ AROME-SOFOG
  - D2: 100m
  - D2-D3: two-way grid-nesting 100m + 20m
Meso-NH configuration

- Surface: fully coupled with SURFEX (Masson et al. 2013): ISBA-3L, TEB

- Microphysics: one-moment ICE3
  (prognostic mixing ratios + fixed droplets concentration = 300 cm$^{-3}$)

- Turbulence (Cuxart et al. 2000): TKE + mixing length
  1D for MESONH-500 with BL89
  3D for MESONH100 and MESONH100-20 with Deardorff

- Radiation: ECMWF with RRTM for LW and Fouquart-Bonnel for SW

- Vertical resolution is 2.3m at the ground (138 levels)
Observations at the SuperSite

- Beginning of the fog = 21h30
- End of the fog = 7h
- Radar: **no cloud above** the fog
The visibility is under-estimated (Kunkel formula)

MESONH-500 shows a temporary dissipation
- The temporary dissipation also exists in AROME 500.
The temporary dissipation can be explained by clouds formed above the fog at 500m but not at 100m.

These clouds do not exist (radar).

A resolution of 100m is necessary.
Outline

- Identify the IOPs with heterogeneities of the fog life cycle between the sites

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- **Configure Meso-NH with refining resolution and run a reference simulation**
  - Meso-NH 500m vs AROME 500m
  - Meso-NH 100m

- Are the heterogeneities reproduced at 100m?

- Outlook
Satisfying variability but underestimation of the visibility (⇒ Kunkel formula, 1-moment)
The orography can explain the longer duration and the lower visibility at Moustey (river valley) compared to the Supersite.
Impact of land cover on wind speed

Database used: Ecoclimap II (1 km global resolution)

Wind speed at z=2m

Agricultural fields + shrubs fractions

⇒ The wind speed increases where rugosity drops
Impact of land cover on wind speed

Wind speed (m/s) at 10m at Microphi-foret

⇒ However, the wind speeds is overestimated over the forest
⇒ need a better resolution of land cover and the forest drag
**Impact of land cover on cloud mixing ratio**

- In agricultural fields

- In forests

Low impact on these 4 sites
Conclusion

- The IOP14 as a deep (~200m) and long (> 6-7h) fog is an interesting case to study fog heterogeneities between sites.

- The 500m resolution with MesoNH and AROME produces a fog disruption due to unrealistic upper level clouds.

- Higher resolution seems promising to reproduce heterogeneities between sites.

- The simulated visibility variability is well represented at 100m resolution but needs a 2-moment scheme to be more realistic (impact of droplet concentration variability).
Outlook (Postdoc position open)

- Sensitivity study to:
  - Tree drag parametrization
  - Higher resolution land cover with Ecoclimap-SG (300m) and LAI with LDAS (Land Data Assimilation System)
  - Orography at 30m resolution with new SRTM-30m
  - Microphysics with LIMA (+ initialization from observed aerosols)
  - Turn on droplets deposition on trees and grass

- Towards LES resolution (20m + 5m)

- Complete the analysis with turbulence and microphysics observations from UAV, tethered balloon, MWR

- Run the LES configurations to other POIs