Impact of surface heterogeneities on the fog life cycle during the SOFOG3D fog experiment

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SOFOG3D meeting
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The SOFOG3D measurement campaign is:
- 6 months periods (from November 2019 to March 2020)
- 34 sampled fog episodes
- 15 IOPs
- 70 x 20 km² area
- 17 observation sites elevated from 28 m to 110m

Figure: color: ECOCLIMAP-SG database / circle: dominant Goggle-Earth cover
Experimental data

Comparison between forest and non-forest sites from the whole measurement database

Night fog occurrences

No impact on the fog occurrence of:
- longitude
- altitude
- vegetation cover

Figure: Stations from West to East, with Forest and Non-Forest
Experimental data

Comparison between forest and non-forest sites from the whole measurement database

Night fog occurrences

No impact on the fog occurrence of:
- longitude
- altitude
- vegetation cover

Caution

More measurements in the 2nd part of the winter
Experimental data

Comparison between forest and non-forest sites from the whole measurement database

**Figure:** Average deviation from the mean state during each fog episode at the different sites represented by their initials. The pie chart surrounding each initial represents the vegetation cover distribution within a 100m radius around the measurement point.

- Delayed initiation on forest sites
- No impact of ground cover during dissipation
- Shorter fog durations in forest
- Higher visibilities (3m) in the forest

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Experimental data

Comparison between forest and non-forest sites from the whole measurement database

- Delayed initiation on forest sites
- No impact of ground cover during dissipation
- Shorter fog durations in forest
- Higher visibilities (3m) in the forest
- Lower temperatures, humidities and wind speeds at the forest sites during the three hours preceding the fog formation

Figure: Average deviation from the mean state during each fog episode at the different sites represented by their initials. The pie chart surrounding each initial represents the vegetation cover distribution within a 100m radius around the measurement point.
Simulation analysis
Numerical set-up and sensitivity tests

Meso-NH (Lac et al., 2018) configuration on the most documented IOP (6-11-14):

- Initialization / Coupling: AROME-ARPEGE analyses or AROME-IFS forecasts
- Run 2-way grid nesting 500m (300×180pts) to 100m (600×400pts)
- 138 vertical levels (71 from 3m to 1km)
- Convective scheme: EDMF (Pergaud et al. 2009) for 500m domain
- EcRad
- Orography: SRTM 90m (dad 500m) 30m (son 100m)
- Land cover, surface: ECOCLIMAP-SG databases
- Turbulence: 1D at 500m, 3D at 100m (Cuxart et al. 2000)
- 2-moment microphysics: LIMA (Vié et al. 2016)
- Subgrig condensation scheme at 500m

Figure: a) orography over the 500m resolution domain, and b) ECOCLIMAP-SG (300 m) databases over the 100m resolution domain

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Simulation analysis

Sensitivity tests to measure the impact and define the best configuration

![Simulation analysis diagram](image)

**Figure**: a) all sites mean variability initiation versus dissipation time of fog, and b) mean variability of the visibility versus effective duration of the fog episode for observed available sites (black cross). The mean value for forest sites is represented by a triangle and by a point for other sites.

**Coupling files**
- AROME-ARPEGE analyses
- AROME-IFS forecast
- IFS

**Physics**
- Mixing length: BL89 (500m) vs DEAR (100m) vs HM21 (both)
- Microphysics: ICE3 vs LIMA

**Surface**
- ISBA-3L vs ISBA-DIF
- ECOCLIMAP-II vs ECOCLIMAP-SG
- Tree drag
- Tree drag + tree deposition
Simulation analysis

Sensitivity tests to measure the impact and define the best configuration

Figure: Temporal evolution of a) observed and b) simulated reflectivities (colors) by the vertical (logscale) doppler radar BASTA, and the total liquid water path (black line) from the HATPRO microwave radiometer

- The simulated reflectivity profiles are relatively close to the observations
- The simulated LWP is more important
Simulation analysis

Sensitivity tests to measure the impact and define the best configuration

Figure: Temporal evolution of a) observed and b) simulated reflectivities (colors) by the vertical (logscale) doppler radar BASTA, and the total liquid water path (black line) from the HATPRO microwave radiometer.
Simulation analysis
Sensitivity tests to measure the impact and define the best configuration

The model successfully reproduces the meteorological situation leading to fog formation: cooling, lower humidity, wind speed

- The cooling is too slow
- Delayed fog initiation
- Variability at the initiation and dissipation slightly underestimated

Figure: Temporal evolution of observed (plain lines) and simulated (dashed lines): a) visibility (m), b) 2 m temperature (degree Celsius), c) specific humidity (g/kg), d) and 10 m wind speed, from West to East at Moustey, Jachère, Forêt Tanon and Noaillan sites.
Simulation analysis

Difference Forest/non Forest in the 100m simulation for all the grid points

Figure: Averaged and differences (colors) of Forest (green) and NoForest (orange) grid points (over 80%): a) 10m wind speed b) droplets mixing ratio (2m, plain line, and 50m dashed line), c) 2m TKE (plain line), and its thermal (dashed lines) and dynamical (dotted lines) production, d) specific humidity, e) ground temperature (plain line) and humidity (dashed line), f) temperature, and g) Sensitive (plain line) and latent (dashed line) heat flux.

- Lower wind speed over F than NF like in the observations
- Higher TKE over F than NF (by shear)
- Lower T close to the ground over F than NF like in the observations, due to lower H, while soil T is higher and due to lower wind speed
- Lower humidity close to the ground over F than NF before fog initiation like in the observations even if LE is similar due to lower wind speed
- Cloud content is lower over F than NF like in the observation
Conclusion

Analysis of the 6 months campaign measurements
- Delayed fog initiations for the forest sites with higher visibilities
- Lower temperature, humidity and wind in forest sites

IOP simulations
- Sensitivity tests: strong impact of large-scale conditions on the fog cycle then the surface representation and physical parameterization
- Impact of the F/NF cover slightly underestimated in the simulation, probably due to insufficient spatial resolution
- But the F/NF distinction over all the grid points allows to reproduce the observations results and to better understand:
  - The lower H in F explains the lower T
  - The lower wind probably explains the lower cloud content
  - In agreement with Mazoyer et al. (2017) with a sheltering effect near the trees reducing the wind and increasing the TKE
Currently: Writing of a paper for QJRMS

Questions? Comments?
Annexe

study over the 34 fog episods

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June 12, 2023 12 / 18
Annexe

Dominant ground covers

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Table: Dominant (higher than 80%) land cover (F for Forest, NF for NoForest) observed within a 100m radius and obtained from the ecoclimap version II and ecoclimap second generation databases over the 100m on the simulation domain at 100m resolution.
Figure: a) mean variability initiation versus dissipation time of fog, and b) mean variability of the visibility versus effective duration of the fog episode for observed available sites (black cross). The mean value for forest sites is represented by a triangle and by a point for other sites. Colored dots, triangles, and crosses represent the simulated values for the different parameterization tests (legend in d) during IOP6. The same plots are produced for IOPs 11 (c-d) and 14 (e-f).
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IOPs reflectivities

Figure:

a) Time series of observed visibilities (m), b) initiation versus dissipation time of fog for available sites (colored letter), the mean values and variation is represented in black, and c) mean visibility versus total duration of the fog episode (colored letter) and effective duration (colored dots) at the different observation sites bottom for IOP6. The same plots are produced for IOPs 11 (d-f) and 14 (g-i).
Annexe
IOPs reflectivities

a) fog initiation IOP6

b) fog duration IOP6

c) fog initiation IOP11

d) fog duration IOP11
Figure: Temporal evolution of observed (plain lines) and simulated (dashed lines): a) visibility (m), b) 2 m temperature (degree Celcius), c) specific humidity (g/kg), d) and 10 m wind speed during IOP 11, from West to East at Moustey, Jachére, Forêt Tanon and Noaillan sites.
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IOP 14

Figure: Temporal evolution of observed (plain lines) and simulated (dashed lines): a) visibility (m), b) 2 m temperature (degree Celcius), c) specific water vapor humidity (g/kg), d) and 10 m wind speed during IOP 14, from West to East at Moustey, Jachére, Forêt Tanon and Noaillan sites.

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June 12, 2023 18 / 18