DYNAMIC AND RADIATIVE PROCESSES DRIVING THE STATUS – FOG TRANSITION

PRELIMINARY WORK

Jean-Charles Dupont[1], Philippe Drobinski[1], Thomas Dubos[1], Martial Haeffelin[1], Bertrand Carissimo[2], Eric Dupont[2], Luc Musson-Genon[2], Xiaojing Zhang[2]

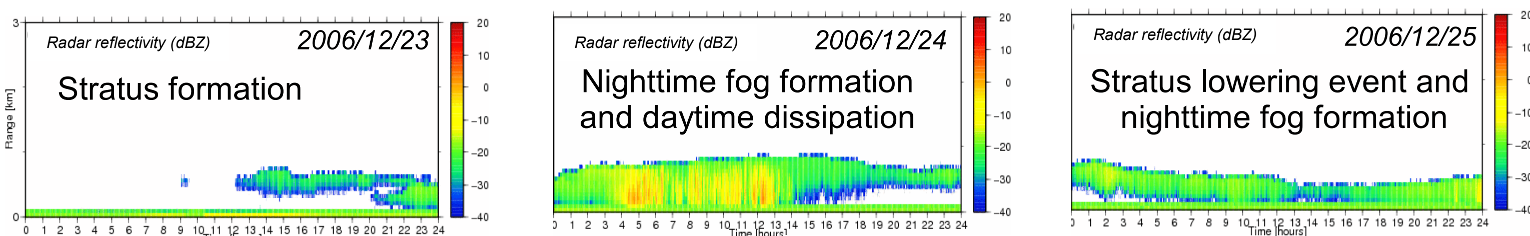
[1] Institut Pierre et Simon Laplace, Ecole Polytechnique, 91128 Palaiseau Cedex, France
[2] EDF R&D, CEREA, 78401 Chatou Cedex, France

*Contact:
jean-charles.dupont@ipsl.polytechnique.fr

1. Introduction

Fogs are weather conditions with significant socio-economic impacts, associated with increased hazards in road, maritime and air traffic and subsequent elevated constraints in transport regulation. The life cycle of fogs involves a complex composite of dynamical, microphysical and radiative processes that are still not fully understood ([1]). While current NWP models are able to forecast situations that are favorable to fog events, these forecasts are usually unable to determine the exact location and time of formation or dissipation. On the one hand, critical processes occur at micro scales that are unresolved by forecast models and must hence be correctly parameterized. On the other hand, current models do not take into account some of the key physical processes such as the microphysical and radiative roles of aerosols. A 6-month field experiment, named ParisFog ([2], [3]), was carried out in winter 2006-2007 outside Paris, France, to monitor simultaneously all key processes that drive formation and dissipation of fogs. ParisFog gathered a suite of active and passive remote sensing instruments to measure profiles of wind, turbulence, radiative properties as well in-situ sensors to monitor temperature, humidity, aerosol and fog microphysics and chemistry in the surface layer. All observations are gathered in the ParisFog database. A comprehensive characterization of fog and near-fog events sampled during ParisFog shows the large variability of observed situations, with predominant occurrences of radiation fogs and stratus lowering fog [4]. Key processes involved in the different situations of a stratus-fog event are discussed. By modeling this situation with Mercure_Saturne code developed by the Atmospheric Environment Teaching and Research Center (CEREA; http://cerea.enpc.fr/fich/mercure/mercure_anglais_web.html), we will be able to study in more detail the competing processes that affect the evolution of this long-lasting low stratus deck.

2. A Stratus Fog Event: 23-29 December 2006



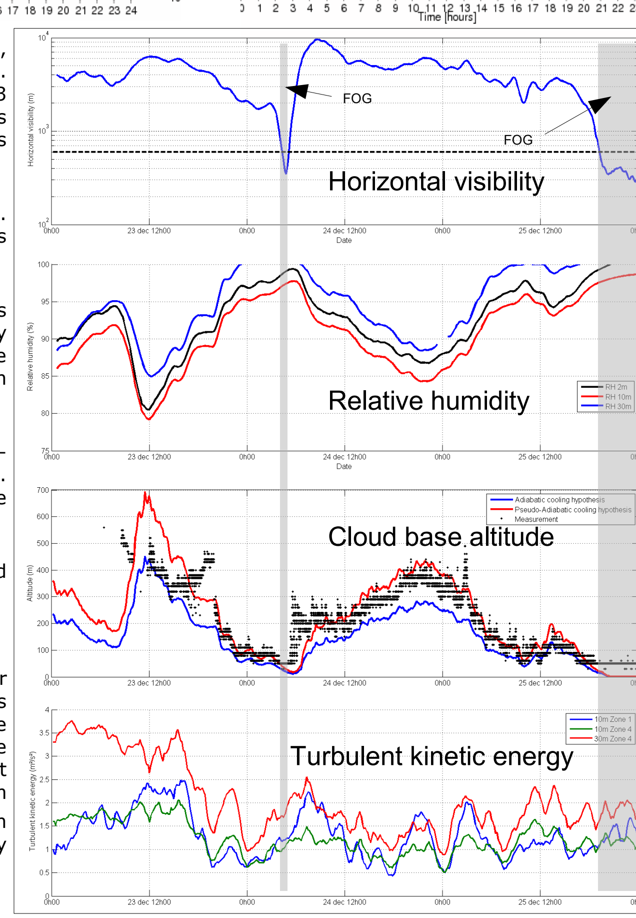
The 12-day period between 17 and 29 December 2006 is characterized by a large high, moving slowly eastward from England, over the North Sea towards Holland and France. After 5 days of mostly cloud-free skies, a very low altitude cloud deck appears on 23 December, persisting through 29 December. During this 7-day period, the visibility was reduced to below 5 km more than 75% of the time, while 5 fog events of "stratus lowering type" occurred and lasted a total of about 25 hours.

The large lowering and rising motions are not phased with the solar diurnal cycle. Several processes have been suggested to explain variations in near surface stratus cloud base heights.

- Radiative cooling at the top of the cloud destabilizes the cloud layer, which generates turbulent mixing. The sub-cloud layer is then cooled by mixing with the radiatively cooled air from the top of the cloud, lowering the condensation level and hence the base of the cloud. This phenomenon can be enhanced in case of drizzle through evaporation leading to humidification and cooling of the sub-cloud layer.

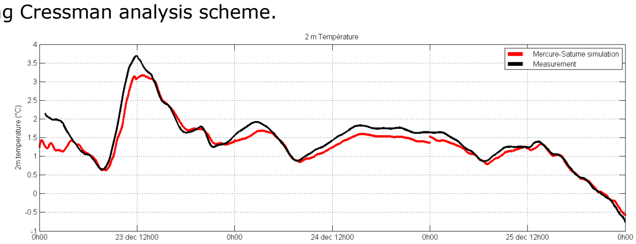
- A low-altitude stratus can also be coupled with the surface. In that case, the near-surface temperature and humidity will drive the altitude of the lifting condensation level. The necessary coupling between the stratus deck and the surface is driven by the moderate turbulence.

- Large-scale subsidence can also be a factor that will lead to lowering of both cloud base and top.



3. Numerical simulations

Mercure_Saturne code is here used in single column model which accounts for nucleation, self-condensation, evaporation/condensation and sedimentation processes [6]. Turbulence mixing is considered with the Louis [7] or k-epsilon turbulence closure and solar / infrared interaction between ground and cloud are considered. We apply the 1-D version of Mercure_Saturne with a high-resolution grid (x,y,z=30km, 30km et 2.6km, with 69 levels and z_0=2m). However, the horizontal pressure and advection term are treated as external influences. The initial and boundary conditions are obtained with atmospheric surface layer (ASL) method and deduced Radiosonde and Mat-Sonic by using Cressman analysis scheme.



4. Conclusions & Perspectives

- Key role of the surface turbulent fluxes during the stratus-fog transition;
- Good agreement between temperature and humidity obtained by measurement and 1D Mercure_Saturne numerical simulations;
- Vertical wind fields (inside and outside clouds) derived from radar will be analysed in future work;
- 1D numerical run will be generalized to calculate wind, temperatre and humidity vertical profiles;

References

[1] Gultepe, I., R. Tardif et al., 2007: Fog research: A review of past achievements and future perspectives. Pure Appl. Geophys. , **164**, 1121-1159.
[2] Elias, T., et al., 2009: Particulate contribution to extinction of visible radiation: Pollution, haze, and fog, Atmos. Res.
[3] Bergot, T., Haeffelin, M., et al., 2008: ParisFog: des chercheurs dans le brouillard *La Météorologie,* **62**.
[4] Haeffelin, M., et al., 2009 PARISFOG, shedding new light on fog physical processes, BAMS, accepted
[5] Haeffelin M., et al. 2005: SIRTA, a ground-based atmospheric observatory for cloud and aerosol research, Annales Geophysicae, **23**, 262-275
[6] Dunykerke, P. G., 1988: Application of the E–e turbulence closure model to neutral and stable atmospheric boundary layer, *J. Atmos. Sci.*, **45**, 865–880.
[7] Louis, J. F.: 1979: 'A Parametric Model of Vertical Eddy Fluxes in the Atmosphere', Boundary-Layer Meteorol., **17**, 187–202.