The Puy de Dôme
Microphysics and Chemistry Station

1. Institution in charge of the field station

The Puy de Dôme microphysics and chemistry station is part of the *Observatoire du Physique du Globe de Clermont Ferrand* (OPGC) and run by the *Laboratoire de Météorologique Physique* (LaMP). The main objectives of the LaMP are focused on studying the interaction of aerosols, clouds and radiation. The research activities defined within this framework are:

- Performing experimental studies and developing new analysis methods and measurement techniques for aerosol and cloud characterizations and radiation measurements in order to validate existing modelling tools.
- Understanding the physico-chemical processes of clouds and developing parameterisations for their incorporation into models of greater scale.
- Modelling the dispersion of gas and/or aerosol plumes on a meso-scale to evaluate the impacts of anthropogenic emissions on the evolution of the atmospheric composition.
- Modelling the radiative interactions involving water vapour and clouds within the atmosphere and developing and testing parameterisations of cloud characteristics derived from satellite and airborne radiometric data.

2. Research interests / Particular competences

The Puy de Dôme (altitude 1465 m) station, located in the Auvergne region in the centre of France, has been developed and equipped in order to provide year-round monitoring of aerosols and gases, along with pertinent atmospheric parameters, and to contribute to a better understanding of relationship between aerosols, cloud droplets and ice. The Puy de Dôme is characterised by frequent formation of clouds at the summit which makes the station an ideal place for cloud studies. This station is completed by a below-cloud station (Opme) located at 700 m a.s.l.

Field studies in natural clouds are very rare and this is the main reason for which the set up of a microphysical and chemistry station at the top of the Puy de Dôme is truly unique. The study of all these processes requires the knowledge of the amount of the redistributed species after their wash-out, deposit and photo-dissociation by cloud and radiation processes. All such processes are strongly dependent on the particle distributions of cloud droplets and aerosols. The estimation of the influence of the liquid and solid phases requires chemical measurements in natural clouds both within the gas phase and within the liquid or solid phases. This estimation is used to validate (for the liquid phase) and develop (for the solid phase) some parameterization modules which can be included in large scale transport models.

New developments at the station include nanoparticle measurements and a comprehensive study of the biological content (bacteria and fungi) of cloud droplets.

3. Site description

a) Geographical information

Measurement site: Puy de Dôme
Country: France

Geographical coordinates:	45° 46’ 20’’ N, 2° 57’ 57’’ E
Altitude above sea level:	1465 m
In operation since:	1995
Main wind direction:	W / NW
Contact person:	Paolo Laj
Organisation:	Observatoire de Physique du Globe de Clermont-Ferrand

b) Available instrumentation / Monitoring activities

This station, ideally situated at cloud level on the summit of the Puy de Dôme, is equipped by the Laboratoire Physique Météorologique de Clermont-Ferrand (LaMP) for the studies of clouds and the atmospheric monitoring activities.
Monitoring activities are performed within national research networks for greenhouse gases (http://www.ipsl.jussieu.fr/services/Observations/fr/RAMCES/Protocoles_gaz.htm), cloud studies (http://wwwobs.univ-bpclermont.fr/atmos/orebeam/orebeampage1.htm), atmospheric radioactivity www.irsn.fr/opera/) and reactive gases and particles (http://www.aero.obs-mip.fr/PAES/accueil/paes_index.htm) as well as EU-funded research projects (http://www.vein.hu/CARBOSOL/). Given the meteorological conditions at the station, all systems are protected against lightning and frost and modified to resist to high wind speed and heavy snow fall.
The instruments are separated into several entities: 1) instruments operating on a 24 h basis, 2) instruments situated inside the wind tunnel which draws in cloud air during temporary campaigns, 3) complementary instruments (wind profiler radar, triple sodar) deployed at the station of Opme.

The instruments operating on a 24 h basis are:
(http://wwwobs.univ-bpclermont.fr/atmos/mesuresyst.htm)
- sensors for temperature, pressure and humidity of the air,
- 2D anemometers for wind speed and direction,
- Pyranometers for radiation (global, diffuse and Ultra-Violet) and the photo-dissociation rate of the nitrogen dioxide NO_2,
- Reactive gases O3, NO, NO2, NOy, CO
- Greenhouse gases CO2, CO2 isotopes
- Particle number concentration, and size distribution
- Particle chemical composition (major ions, OC/EC, organic speciation)
- Radon and both natural and artificial nuclides
- Liquid water content of clouds
- Effective radius of clouds
- Aethalometer

The instruments operating on a 24 h basis at Opme station:
- Stratosphere-troposphere radar
- Rain samplers
- natural and artificial nuceides
- Visible-IR radiometer

The instruments operating in the wind tunnel or in the cloud platform (require operators):
- Fast forward spectrometer probe (FSSP-100) counting probe based on the diffraction of a laser beam by each particle,
- Volatility Tandem Differential mobility analyser (V-TDMA)
- Humidity Tandem Differential mobility analyser (H-TDMA)
- Polar nephelometer: counting probe based on the spatial distribution measurement (diffraction pattern) of the light produced by a laser beam and perturbed by the particles (droplets or crystals),

- a 2D-C probe: counting probe based on the detection of the shadow of each particle projected by a laser beam on an linear array of photodiodes,
- a Gerber probe which continuously measures the liquid water concentration, the extinction coefficient and the effective radius of the cloud droplets,
- a CVI (Counterflow Virtual Impactor), which is an isokinetic inlet enabling to separate interstitial air (without droplets) from cloudy air. Probes sampling both outflow give, after the evaporation of all droplets, the composition in chemical species and in water vapour of the vapour and liquid (or solid) phases.
- Round jet Impactor (interstitial aerosols): complementary to CVI
- A CPI (Cloud Particle Imager)
- A series of droplet collectors
- HCHO analyser
- Ion chromatography, liquid phase DOC, Spectrophotometer, cloud photochemical reactors

c) Policy in relation to data availability / how to access data

The data base is available upon request. Acknowledgment required.

d) Web-site of the field station

http://wwwobs.univ-bpclermont.fr/atmos/pdd/visitepuydedome/accueil.htm

e) Access to the facility

The Puy the Dôme station is accessible by road all year round. From mid-october till April , the road is closed to general public and a 4-WD is required to get to the summit. It is located at about 15 km to the west of Clermont-Ferrand, the capital of the Auvergne. Clermont-Ferrand has an international airport, a train station, and can be reached by car from Paris (A71: 3h30), Toulouse (A 75:4h), Bordeaux (RN 89: 6h) and Lyon (A 72: 2h).

f) Scheduled scientific activities at the site

The scientific activities are performed both within EU funded and national projects.

g) Association to national, European and/or international Networks

Association with EMEP and GAW is currently under discussion.

The Puy de Dôme microphysical and chemistry station was equipped with financial support of:
- The *Institut National des Sciences de l'Univers* (INSU) which is an institute of the French Centre National de la Recherche Scientifique (CNRS)
- the French Ministry of the Environment
- the Auvergne District Administration
- the *Observatoire de Physique du Globe de Clermont*-Ferrand and the *Laboratoire de Météorologie Physique (*La.M.P.) which is associated with the CNRS. Both structures depend on the Université Blaise Pascal (U.B.P.) of Clermont-Ferrand.

h) Specific issues on collaboration

Field engineers and technician will be available at the station.
The Puy de Dôme is an ideal place for the study of clouds. The different inlets developed by LaMP can be connected to a series of instrumentation. In particular, the use of an aerosol mass spectrometer behing CVI and/or Interstitial inlet could be of great interest. In addition,

collaboration with aerobiologists and organic chemists would be a great interest to the scientific activities at the station.

i) Fee for using the facility

No access fee. Consumable cost (travel and electricity to be considered)
Accommodation is possible (beds, kitchen) but it is not a 4-star hotel…

j) Name and address of contact persons

Paolo Laj
Observatoire de Physique du globe de Clermont-Ferrand
Université Blaise Pascal / CNRS
24, avenue des Landais
63177 Aubière cedex, France
Tel.: ++33 (0)4 73 40 73 69
Fax.: ++33 (0)4 73 40 51 36
E-mail: p.laj@opgc.univ-bpclermont.fr
http://wwwobs.univ-bpclermont.fr/atmos/

Jean-Marc Pichon
Observatoire de Physique du globe de Clermont-Ferrand
Université Blaise Pascal / CNRS
24, avenue des Landais
63177 Aubière cedex, France
Tel.: ++33 (0)4 73 40 78 24
Fax.: ++33 (0)4 73 40 51 36
E-mail: j.m.pichon@opgc.univ-bpclermont.fr
http://wwwobs.univ-bpclermont.fr/atmos/

4. More pictures